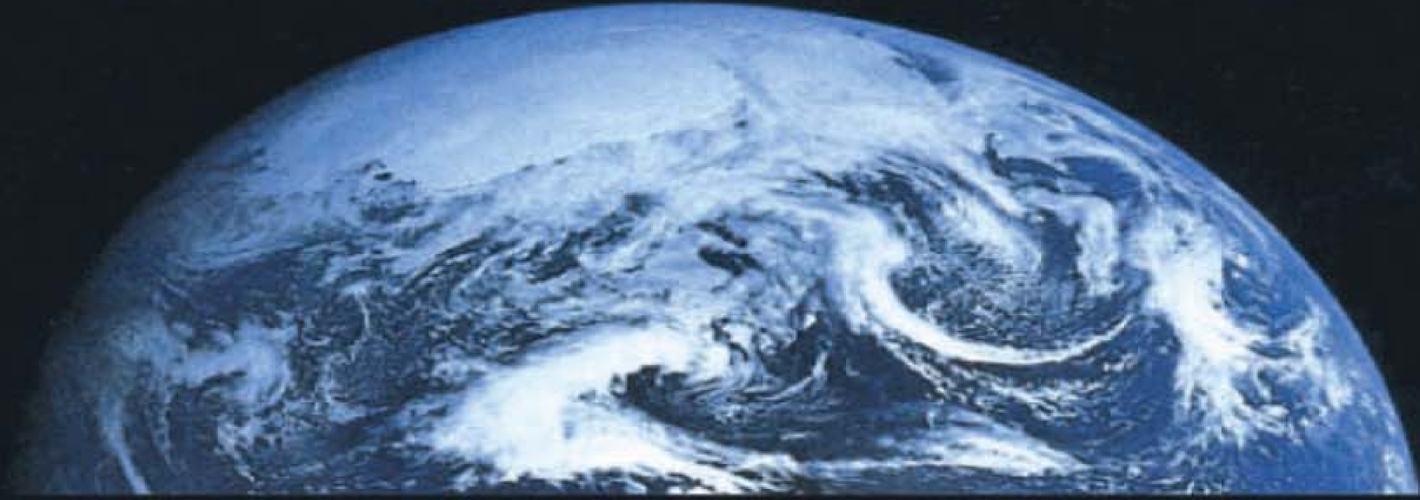


A Contribution to understanding the regional impacts of global change in South America

Pedro Leite da Silva Dias
Wagner Costa Ribeiro
Lucí Hidalgo Nunes

Instituto de Estudos Avançados da Universidade de São Paulo

II Regional Conference on Global Change: South America

REALIZATION

Instituto de Estudos Avançados da Universidade de São Paulo

EXECUTIVE COMMITTEE

President Pedro Leite da Silva Dias, IEA, PROCAM e IAG/USP
Lucí Hidalgo Nunes, IG/UNICAMP
Wagner Costa Ribeiro, PROCAM e FFLCH/USP

SCIENTIFIC COMMITTEE

Aldo da Cunha Rebouças, IEA/USP
Carlos Afonso Nobre, INPE/CPTEC e ABC
Cristiane Derani, UNISANTOS/UEA
Eliezer Martins Diniz, FEARP/USP
Emílio Lebre La Rovere, Centro Clima – COPPE/UFRJ
Fábio Feldmann, FPMC
Hilton Silveira Pinto, CEPAGRI/UNICAMP
Ilana Wainer, IO/USP
João Lima Sant'Anna Neto, FCT/UNESP, Presidente Prudente
João E. Steiner, IEA e IAG/USP
José Galizia Tundisi, IIE e ABC
José Goldemberg, SMA/SP e ABC
Lucí Hidalgo Nunes, IG/UNICAMP
Luiz Gylvan Meira Filho, IEA/USP
Luiz Pinguelli Rosa, COPPE/UFRJ e FBMC eABC
Marcelo Hiroshi Nakagawa, IPT/SP
Maria Assunção Faus da Silva Dias, INPE/CPTEC e IAG/USP
Mônica Ferreira Amaral Porto, EPUSP
Paulo Eduardo Artaxo Netto, IF/USP
Pedro Leite da Silva Dias, IEA, PROCAM e IAG/USP
Reynaldo Victória, CENA/USP
Thelma Krug, INPE e IAI
Umberto Giuseppe Cordani, IG/USP e ABC
Wagner Costa Ribeiro, PROCAM e FFLCH/USP
Waldir Mantovani, EACH/USP Leste
Wanda Maria Risso Gunther, FSP/USP

SCIENTIFIC SUPPORT

Academia Brasileira de Ciências - ABC
Associação Brasileira de Climatologia – ABClima
Associação dos Pesquisadores do Projeto LBA - APLBA
Centro Clima, COPPE/UFRJ
Centro de Previsão de Tempo e Estudos Climáticos do Instituto Nacional de Pesquisas Espaciais–INPE/CPTEC
Faculdade Latino Americana de Ciências Sociais – FLACSO Brasil
Fórum Brasileiro de Mudanças Climáticas
Fórum Paulista de Mudanças Climáticas e Biodiversidade
Instituto de Eletrotécnica e Energia da USP – IEE/USP
Instituto de Pesquisas Tecnológicas de São Paulo – IPT/SP
Instituto Internacional de Ecologia – IIE
Instituto Oceanográfico da USP – IO/USP
Inter-American Institute for Global Change Research
Programa de Pós-Graduação em Ciência Ambiental - PROCAM/USP
Sociedade Brasileira de Meteorologia – SBMET
UNESP
UNICAMP – Grupo de Mudanças Globais

A Contribution to understanding the regional impacts of global change in South America

Pedro Leite da Silva Dias
Wagner Costa Ribeiro
Lucí Hidalgo Nunes

University of São Paulo
Institute of Advanced Studies

EDITORS

Pedro Leite da Silva Dias – President - IEA, PROCAM and IAG/USP
Wagner Costa Ribeiro – PROCAM and FFLCH/USP
Lucí Hidalgo Nunes- IG/UNICAMP

PUBLISHING

Instituto of Advanced Studies - IEA/USP

PRODUCTION

Inês Iwashita - IEA/USP

EDITORATION

Lilian Ribeiro

São Paulo - 2007

FICHA CATALOGRÁFICA

Ficha catalográfica elaborada pelo Departamento Técnico do Sistema Integrado de Bibliotecas da USP

A contribution to understanding the regional impacts of global change in South América / Pedro Leite da Silva Dias ; Wagner Costa Ribeiro ; Lucí Hidalgo Nunes. — São Paulo : Instituto de Estudos Avançados da Universidade de São Paulo, 2007.
412 p. ; 21 x 29,7 cm.

II Regional Conference on Global Change in South America; 6-10 november 2005.

ISBN 978-85-7314-039-2

1. Impactos ambientais-América do Sul. 2. Mudança climática-América do Sul. I. Silva Dias, Pedro Leite da. II. Ribeiro, Wagner Costa. III. Nunes, Lucí Hidalgo.

CDD 577.4

Depósito Legal na Biblioteca Nacional, conforme Decreto Nº 10.944, de 14 de dezembro de 2004.

SUMMARY

I I. SOCIAL IMPACTS ON REGIONAL CLIMATIC CHANGES

INTRODUCTION

The analysis of the Global Warming and its consequences is one of the main challenges for the scientific community. Most of the climate specialists have no doubt that the planet is warming. However, it is necessary to quantify the warming and identify the causes of the global mean temperature increase, as well as the consequences it might bring to life and to the physical processes on earth. The concept of vulnerability also deserves to be discussed. Combined with the concept of environmental risk, it offers an instrument to mitigate adjustments associated with global warming.

The uncertainty on the magnitude of the global warming and the regional impacts will persist on the foreseeable future and further research is necessary for elucidating the complex functioning of the climate system. Even among scientists that admit that the natural processes are the primary cause of warming, greater is the number of those that acknowledge human action as its accelerator. This is a key reason for establishing an international agreement to control greenhouse gases emissions.

The global scale of the phenomenon demands an international response. That is why the United Nations Conference for the Environment and Development, held in Rio de Janeiro in 1992, established the UN Framework Convention on Climate Changes and the Conference of the Parties (COPs), among them the Kyoto Meeting of 1997. The Kyoto Protocol defined limits for the rules for the emission of greenhouse gases for the countries with the largest historical emissions.

Global Warming now stands as one of the main goals of foreign policy negotiators and is the main focus of several political negotiations with the purpose of controlling the emissions of greenhouse gases. Despite the political difficulties, the Kyoto Protocol was implemented before the prescribed deadline. Even considering all the fragilities of the international environmental order that have been pointed out, some results start to appear.

The impacts of the global warming may be already observed, especially on a local scale and will occur with greater frequency in the future, though in different ways across the planet. The Southern Hemisphere countries may suffer significant changes in the volume and distributioin of precipitation, for instance, which may affect food production chains, among other systems. This would engender new immigration trends to urban areas, worsening the social inequality of the South American Metropolitan areas.

Part of the coastal population will have to coexist with the sea level rise. Others, such as the population living at the foothills of the Andes, will be faced with serious difficulties in water resources management, because the main water source in the slow melting of the glaciers that are disappearing. The perception of global warming and its consequences for the great majority of the population has been rising, but for part of the society it still appears as something distant that will occur at least a hundred years into the future. Anyway, it is necessary to prepare the population to the changes that might emerge due to the environmental modifications, among them the atmospheric and ocean warming.

Along a year and a half we dedicated a substantial time in the organization of a meeting of specialists from different areas to discuss the current understanding of global warming issues and its implications, in order to gather updated information to be disseminated among a wider community composed of policy makers, environmentalists, scientists, students and the press. As a result of such effort, the II Regional Conference on Global Changes in South America took place between 6-10 November 2005. The main goal of the meeting was to encourage the interaction between natural and social scientists so that each one in his/her own area of knowledge, could evaluate the status of the scientific understanding of the impact of global warming in South America. The event gathered around 600 people, with approximately 120 posters and 70 oral presentations.

With this book we offer to the public the contributions of most of the invited participants, who provided their opinions in round table debates and conferences during the meeting.

The book is organized in two parts:

I. Modelling and regional climatic change in terrestrial and aquatic ecosystems;

II. Social Impacts on regional climatic changes.

In the first part the reader will find texts regarding some consequences of warming already confirmed in the Amazon Region, Patagonia and the Cerrado in Central Brazil. Moreover, readers will be exposed to the models and methods employed by researchers to measure the impacts and to design future scenarios of the regional changes resulting from global warming. In this part of the book there are contributions on the possible consequences to agriculture.

In the second part the reader will find contributions to the analysis of the regional impacts of global warming on human health, urban water supply, energy generation and the foreign affairs in the perspective of a comprehensive international agreement on climatic changes, the societal perception to global changes, the vulnerability and risk in urban areas and the economic dimensions, including opportunities offered by the Clean Development Mechanism of the Kyoto Protocol.

Finally, conclusions and recommendations are produced, among which we highlight the uncertainties in relation to the consequences of the regional impact of global warming, a need for more research and the necessity to stimulate the debate so that these changes may be acknowledged and assimilated without greater social disruption.

Last, we would like to express our appreciation to the members of the Scientific Committee for appointing several invited speakers, for suggesting relevant themes for discussions, for analysing the material submitted for poster presentation and for the lively discussion during the conference.

Pedro Leite da Silva Dias
Wagner Costa Ribeiro
Lucí Hidalgo Nunes

I. MODELLING AND REGIONAL CLIMATIC CHANGE IN TERRESTRIAL AND AQUATIC ECOSYSTEMS

USE OF REGIONAL CLIMATE MODELS IN IMPACTS ASSESSMENTS AND ADAPTATIONS STUDIES FROM CONTINENTAL TO REGIONAL AND LOCAL SCALES. THE CREAS (Cenários Climáticos REgionalizados de Mudança de Clima para América do Sul) INITIATIVE IN SOUTH AMERICA

JOSÉ ANTÔNIO MARENGO
INPE/CPTEC

INTRODUCTION

Regional Climate Models (RCMs) are useful tools for generating high resolution climate change scenarios for use in climate impacts and adaptation studies. Coupled Atmosphere-Ocean Global Climate Models (AOGCMs) are the modeling tools traditionally used for generating climate change projections and scenarios. However, the horizontal atmospheric resolution of present day AOGCMs is still relatively coarse, order of 300 km, and regional climate is often affected by forcings and circulations that occur at smaller scales. As a result, AOGCMs cannot explicitly capture the fine scale structure that characterizes climatic variables in many regions of the world and that is needed for many impact assessment studies.

The issue of the spatial resolution in scenarios must be put in the context of other uncertainties of climate change. Studies and analyses of climate change impact and adaptation assessments recognize that there are a number of sources of uncertainty in such studies which contribute to uncertainty in the final assessment. The importance of high resolution climate scenarios for impacts and adaptation studies remains to be thoroughly explored in Brazil and South America. High resolution scenarios developed from regional climate model results have been applied to impacts assessments only in the past five years in various parts of the world, as in North America and Europe as part of international projects. Most of these activities have linked to implementation of scenarios for the UNFCC National Communications on Climate Change at the country level. In studies so far, mainly concerning agriculture and water resources, significant differences in the estimated impacts based on spatial resolution are found. So far it has been explicitly demonstrated that the necessary adaptation measures varies with the spatial resolution. And of course, this point could be deduced from the fact that the level of impacts varies. Therefore, there is a need for regional climate change scenarios in South America.

REGIONAL MODELING STRATEGY

This section presents an overall discussion of the principles, objectives and assumptions underlying the different techniques today available for deriving regional climate change information. Table 1 provides a summary of climate scenario techniques that rely on the various techniques described below. Coupled atmosphere-ocean global climate models (AOGCMs) are the modelling tools traditionally used for generating climate change projections and scenarios (Mearns et al. 2003). Global model provides: (a) initial conditions – soil moisture, sea surface temperatures, sea ice; (b) lateral meteorological conditions (temperature, pressure, humidity) every 6-8 hours; (c) Large scale response to forcing (100s kms). Regional model provides finer scale response (10s kms)

Table 1 - The role of some types of climate scenarios and an evaluation of their advantages and disadvantages according to the five criteria listed below the Table. . Note that in some applications a combination of methods may be used (e.g. regional modelling and a weather generator). (Modified from Mearns et al., 2001).

Scenario type or tool	Description/Use	Advantages*	Disadvantages*
Climate Model based Direct AOGCM outputs	-Starting point for most climate scenarios -Large-scale response to anthropogenic forcing	-Information derived from the most comprehensive, physically based models (1, 2) -Long integrations (1) -Data readily available (5) -Many variables (potentially) available (3), (2, 4) information	-Spatial information is poorly resolved (3) -Daily characteristics may be unrealistic except for very large regions (3) -Computationally expensive to derive multiple scenarios (4, 5) -Large control run biases may be a concern for use in certain regions (2)
High resolution/stretched grid (AGCM)	Providing high resolution information at global/continental scales	-Provides highly resolved information (3) -Information is derived from physically-based models (2) -Many variables available (3) -Globally consistent and allows for feedbacks (1,2)	-Computationally expensive to derive multiple scenarios (4, 5) -Problems in maintaining viable parameterizations across scales (1,2) -High resolution is dependent on SSTs and sea ice margins from driving model (AOGCM) (2) -Dependent on (usually biased) inputs from driving AOGCM (2)
Regional models	Providing high spatial/temporal resolution information	-Provides very highly resolved information (spatial and temporal) (3) -Information is derived from physically-based models (2) -Many variables available (3) -Better representation of some weather extremes than in GCMs (2, 4)	-Computationally expensive, and thus few multiple scenarios (4, 5) -Lack of two-way nesting may raise concern regarding completeness (2) -Dependent on (usually biased) inputs from driving AOGCM (2)

Statistical downscaling	**Providing point/high spatial resolution information**	**-Can generate information on high resolution grids, or non-uniform regions (3) -Potential for some techniques to address a diverse range of variables (3) -Variables are (probably) internally consistent (2) -Computationally (relatively) inexpensive (5) -Suitable for locations with limited omputational resources (5) -Rpid application to multiple GCMS (4)**	**-Assumes constancy of empirical relationships in the future (1, 2) -Demands access to daily observational surface and/or upper air data that spans range of variability (5) -Not many variables produced for some techniques (3, 5) -Dependent on (usually biased) inputs from driving AOGCM (2)**

(*) Numbers in parentheses under Advantages and Disadvantages indicate that they are relevant to the numbered criteria described. The five criteria are: 1) Consistency at regional level with global projections; 2) Physical plausibility and realism, such that changes in different climatic variables are mutually consistent and credible, and spatial and temporal patterns of change are realistic; 3) Appropriateness of information for impact assessments (i.e. resolution, time horizon, variables); 4) Representativeness of the potential range of future regional climate change; and 5) Accessibility for use in impact assessments.

The horizontal atmospheric resolution of present day AOGCMs is still relatively coarse, order of 300 km, and regional climate is often affected by forcings and circulations that occur at smaller scales (Giorgi and Mearns 1991). As a result, AOGCMs cannot explicitly capture the fine scale structure that characterizes climatic variables in many regions of the world and that is needed for many impact assessment studies. Therefore, different ‘’regionalization” techniques have been developed to enhance the regional information provided by AGCMs and AOGCMs and to provide fine scale climate information. To date, most impact studies have used climate change information provided by equilibrium AGCMs or coupled AOGCM simulations without any further regionalization processing. This is primarily because of the ready availability of this information and the relatively recent development of regionalization techniques.

For some applications, the regional information provided by AOGCMs may be sufficient, for example when sub-grid scale variations are weak or when assessments are global in scale. In fact, from the theoretical view point, the main advantage of obtaining regional climate information directly from AOGCMs is the knowledge that internal physical consistency is maintained. However, by definition, coupled AOGCMs cannot provide direct information about climate at scales smaller than their resolution, neither can they capture the detailed effects of forcings acting at sub-grid scales (unless parameterized). Therefore, in cases where fine scale processes and forcings are important drivers of climate change the use of regionalization techniques is essential and recommended to the extent that it enhances the information of AOGCMs at the regional and local scale. The "added value" provided by the regionalization techniques depend on the spatial and temporal scales of interest, as well as on the variables concerned and on the climate statistics required.

What is commonly known as dynamic downscaling refers to as nested RCM model into a AOGCM. The AOGCM provide initial conditions and time-dependent lateral meteorological boundary conditions to drive high-resolution RCM simulations for selected time periods of the global model run (e.g. Dickinson et al. 1989; Giorgi 1990). Sea surface temperature (SST), sea ice, greenhouse gases (GHG) and aerosol forcing, as well as initial soil conditions, are also provided by the driving AOGCM. Some variations of this technique include forcing of the large scale component of the solution throughout the entire RCM domain (e.g. Kida et al., 1991; Zorita and von Storch, 1999)

To date, this technique has been used only in one-way mode, i.e. with no feedback from the RCM simulation to the driving AOGCM. The basic strategy underlying this one-way nesting approach is that the AOGCM is used to simulate the response of the global circulation to large scale forcings and the RCM is used: 1) to account for sub-AOGCM grid scale forcings (e.g. complex topographical features and land cover inhomogeneity) in a physically-based way, and 2) to enhance the simulation of atmospheric circulations and climatic variables at fine spatial scales. The nested regional modelling technique essentially originated from numerical weather prediction, but is by now extensively used in a wide range of climate applications, ranging from paleoclimate to anthropogenic climate change studies. Over the last decade, regional climate models have proven to be flexible tools, capable of reaching high resolution (down to 10-20 km or less) and multi-decadal simulation times and capable of describing climate feedback mechanisms acting at the regional scale.

A number of widely used limited area modeling systems have been adapted to, or developed for, climate application. The main theoretical limitations of this technique are the effects of systematic errors in the driving large scale fields provided by global models (which is common to all downscaling methodologies using AOGCM output) and the lack of two-way interactions between regional and global climate. In addition, for each application careful consideration needs to be given to some aspects of model configuration, such as physics parameterizations, model domain size and resolution, and the technique for assimilation of large scale meteorological forcing (e.g. Giorgi and Mearns 1991, 1999).

An additional consideration is that in order to run an RCM experiment, high frequency (e.g. 6-hourly) time dependent AOGCM fields are needed. These are not routinely stored because of the implied mass-storage requirements, so that careful coordination between global and regional modelers is needed to design nested RCM experiments.

The study of future impacts necessarily requires scenarios of climatic change, and, since the worst impacts of any future climate change are likely to arise from fine scale extremes in weather phenomena, these scenarios should also contain a high level of regional detail. Additional key science issues need to be investigated such as the importance of compatible physics in the nested and nesting models. Measures of uncertainty across the multiple runs will be developed by geophysical statisticians

APPLYING REGIONAL CLIMATE CHANGE SCENARIOS TO IMPACT STUDIES: EXPERIENCES IN SOUTH AMERICA: THE CREAS PROJECT

While results from regional model experiments of climate change have been available for about ten years, and regional climate modelers claim use in impacts assessments as one of their important applications, it is only quite recently that scenarios developed using these techniques have actually been applied in a variety of impacts assessments such as of temperature extremes (Hennessy et al., 1998; Mearns, 1999); water resources (Hassell et al., 1998; Hay et al., 2000; Leung and Wigmosta, 1999; Wang et al., 1999; Stone et al., 2001, 2003; Wilby et al., 1997, Pennell and Barnett, 2004); agriculture (Mearns et al., 1998, 1999, 2000, 2001; Thomson et al., 2001) and forest fires (Wotton et al. 1998). Prior to the past few years, these techniques were mainly used in pilot studies focused on increasing the temporal resolution and spatial scale (e.g., Mearns et al., 1997; Semenov and Barrow, 1997).

One of the most important aspects of this work is determining whether the high resolution scenarios actually lead to significantly different calculations of impacts compared to the coarser resolution GCM from which the high resolution scenario was partially derived. This aspect is related to the issue of uncertainty in climate scenarios, an issue not explicitly addressed by all of the studies cited above. In many articles the authors adopted the high resolution (RCM) scenarios without comments regarding the use of high resolution versus low resolution information.

An initiative from Brazil has been the implementation of CREAS (Regional Climate Change Scenarios for South America – Marengo, 2004). CREAS is being established as consequence of a GEF-Ministry of Environment/PROBIO lead by CPTEC in Brazil for studies on impacts of climate change in natural ecosystems in Brazil (PROBIO). Additional funding for CREAS comes from the GOF CLIMATE CHANGE & ENERGY PROGRAMME: BRAZIL: Using Regional Climate Change Scenarios for Studies on Vulnerability and Adaptation in Brazil and South America. This project aims to provide high resolution climate change scenarios in the three most populated basins in South America for raising awareness among government and policy makers in assessing climate change impact, vulnerability and in designing adaptation measures.

The downscaling of climate change scenarios follows the methodology developed by the Hadley Centre (Jones et al. 2004). This centre has developed a regional climate model HadRM3 that can be run on a PC and can be applied easily to any area of the globe to generate detailed climate-change predictions. This modelling system, PRECIS (Providing Regional Climates for Impacts Studies) is freely available to groups of developing countries so that they can develop climate-change scenarios at national centres of expertise (Jones et al. 2004).

The global models to be used are the Hadley Centre HadAM3P (Gordon et al. 2000, Cox et al. 1999, Pope et al. 2000). The HaDAM3P model included the atmospheric version of the Hadley Centre HadAM3P forced with the SST anomalies generated by the oceanic component of the HadCM3 coupled model, that are available for the periods 1961-90 (present climate) and 2071-2100 for the A2 and B2 scenarios. Previously, a validation text will be made for the 1961-90 present climate using various gridded data sets.

Besides the HadAM3P, we use the ECHAM 5 AOGCM. As part of the CREAS initiative we use various regional models (Eta/CPTEC, RegCM3, and HadRM3-PRECIS) that are being run at this time at CPTEC. The RAMS models is going o be used at FUNCEME for downscaling of climate Change Scenarios in Northeast Brazil. The MM5 regional model is being run at the CIMA/UBA in

Argentina for South America South of 20S also using the HadAM3P. This effort is part of the Argentinean contribution for the National Communication on Climate Change. The REMO regional model is being run at the Max Planck Institute in Germany using the ECHAM 5 AOGCM as boundary condition, and this effort is part of the EU-CLARIS project. All of this is illustrated in Fig. 1.

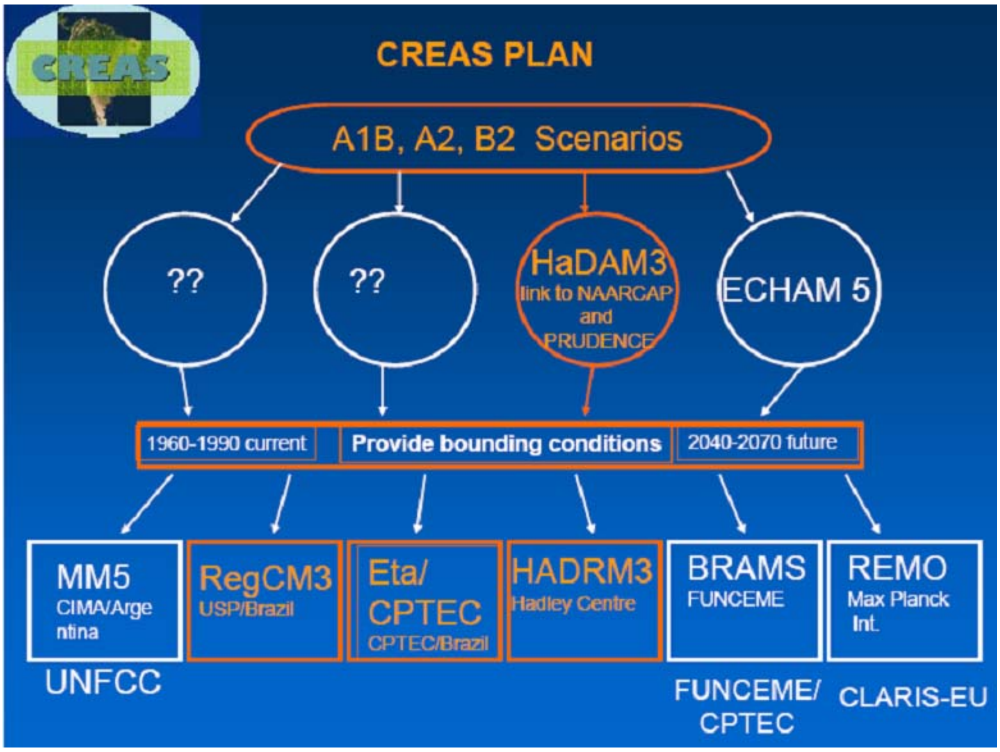


Figure 1 - Schematic view of CREAS. Circles shown the global models used, and squares show the regional models used for CREAS (in orange) and also as part of other initiatives from Argentina and the EU-CLARIS project (Marengo 2004).

The analysis of the global and regional models constitutes a multi-model approach that includes the analysis of each regional model and then using cluster analyses to identify groups with similar patterns, and additional techniques for weighting the influence of the different models. Statistical techniques such as empirical orthogonal function, correlation, and cluster analyses, etc., will be applied to model simulations as well as to observed data. Additional key science issues will be investigated such as the importance of compatible physics in the nested and nesting models. Measures of uncertainty across the multiple runs will be developed by geophysical statisticians. Since much more of the uncertainty in regional climate change is derived from the global models than the regional models, the project would also concentrate its resources on fewer regional models and should get data from more global models. After tests we have selected 3 regional models for vulnerability and impact studies. Fig. 2 shows the strategy for CREAS, detection studies are implemented from the regional climate change scenarios, and that includes validation, assessments and trends analyses for mean variables and extremes. After that, maps, CDs and other products will be produced. The climate change scenarios will also be used for development and applications, such as impacts of climate change in various sectors of society, vulnerability assessments and adaptation and mitigation measures. All these products will be then be available to the society and the government.

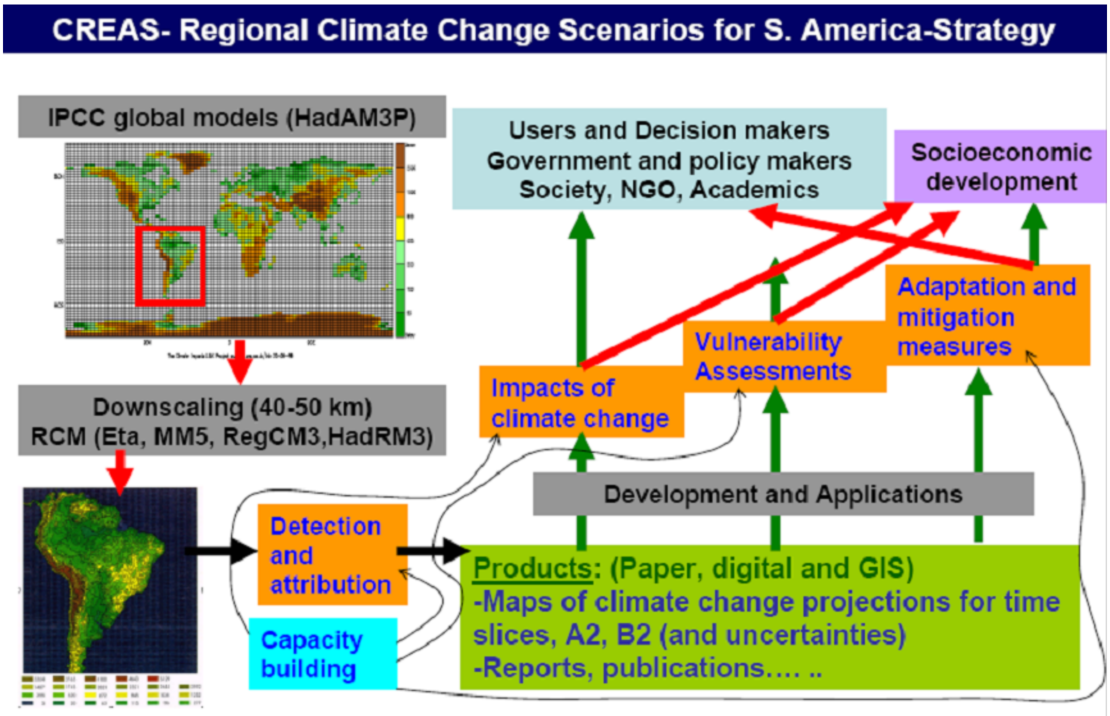


Figure 2 - Schematic view of CREAS project for regionalization of future climate change scenarios in South America and applications to various sectors of society (Marengo 2004).

PROGRAMS EXPLORING REGIONAL CLIMATE CHANGE SCENARIOS AND MULTIPLE UNCERTAINTIES IN OTHER REGIONS

Various international projects are already working with regional climate scenarios for studies of detection, and assessments of impacts and vulnerability. In Europe, the PRUDENCE-*Prediction of Regional scenarios and Uncertainties for Defining EuropeaN Climate change risks and Effects* (PRUDENCE 2004) project and in North America, by the NARCCAP-*North American Regional Climate Change for Assessment Program* (Leung et al 2004, Mearns et al. 2004). Both PRUDENCE and NARCCAP use the HAdAM3P as global model that forces various regional models from meteorological services and research institutions. Other global models from the US are planed to be used NARCCAP. Typically, a present day (e.g. 1960-1990) and a future climate (2070-2100) time slice are simulated to calculate changes in relevant climatic variables. So far CREAS will use the HadAM3P available at CPTEC now, and if other global models are available then we will use it for downscaling.

CREAS has strong links with NARCCAP and we are currently coordinating runs and analyses so we can compare and complement climate projections for the Americas. Various institutions in Brazil and South America have confirmed interests in the regional model output from CREAS. We expect collaboration from other institutions in Brazil and from universities and research centers from other countries in South America. Interactions are also expected with various sectors of the government that would need future climate change scenarios for applications and assessments studies (agriculture, human health, tourism, generation of hydroelectricity, etc).

CREAS OBJECTIVES:

1. To produce high resolution climate change scenarios for 2071-2100 for South America
2. To assess the uncertainty in South American regional climate change scenarios produced by various regional climate models.
3. To quantitatively assess the risks arising from changes in regional climate over South America,
4. To estimate changes in extremes like intense rainfall, heat waves, flooding and wind storms, by providing a robust estimation of the likelihood and magnitude of the changes
5. To demonstrate the value of the wide-ranging scenarios by applying them to impacts models focusing on effects on adaptation and mitigation strategies for key sectors (agriculture, conservation, hydroelectricity, health, tourism, etc.)
6. To provide climatic information usable to assess socio-economic and policy related decisions for which such improved scenarios could be beneficial, and to interact with government agencies, policy makers and stake holders for assessments of vulnerability

INSTITUTIONS PARTICIPANT IN CREAS

1. Centro de Previsão de Tempo e Estudos Climático, CPTEC/INPE, Brazil (lead institution)
2. Empresa Brasileira de Pesquisas Agropecuaria EMBRAPA, Brazil
3. Centro de Energia Nuclear Aplicada a Agricultura, CENA/USP, Brazil
4. Instituto de Astronomia, Geofisica e Ciencias Atmosfericas, IAG/USP, Brazil
5. Instituto Nacional de Pesquisas da Amazonia INPA, Brazil
6. Universidade de Viçosa, UFV, Brazil
7. Fundação Osvaldo Cruz, FIO, Brazil
8. Fundação Brasileira de Desenvolvimento Sustentável, FBDS, Brazil
9. Centro de Investigaciones del Mar y la Atmosfera, CONICET/CIMA, Argentina
10. IDEAM, Colombia
11. Universidad Nacional del Centro del Peru, Peru
12. SENAMHI, Peru

……….

Policy-oriented research can address various questions, but will usually be aimed at providing advice on the range of possible climate change impacts on a system so that possible adaptations may be planned. Because the output of such research is linked to decision-making (clients will be mainly government and industry), it is very important that the climate scenarios be plausible and that key uncertainties be represented in the output. In such cases, use of high resolution may be considered essential if coarse resolution scenarios are a priori implausible (e.g., due to topographic effects or the inability to resolve extreme events), or may be considered not important if coarse resolution scenarios are plausible and the uncertainty in outcome associated with resolution is considered small relative to other uncertainties.

Perhaps the major contribution of the future regional climate change scenarios generated by CREAS will be the possibility of developing indices of vulnerability for key sector of the economy in Brazil to climate change, as well as the identification of socioeconomic indicators or climate change impacts. The major goal is to provide input for the development of a national policy of environmental and socioeconomic assessments of climate change impacts in key regions, such as natural ecosystems, large cities and economically important regions of Brazil and South America.

ACKNOWLEDGEMENTS

CREAS is funded by MMA/BIRD/GEF/CNPq (PROBIO Project), IAI (IAI CRN055-PROSUR), and the UK Global Opportunity Fund-GOF Project Using Regional Climate Change Scenarios for Studies on Vulnerability and Adaptation in Brazil and South America.

REFERENCES

Cox, P., R. Betts, C. Bunton, R. Essery, P.R. Rowntree, and J. Smith, 1999: The impact of new land surface physics on the GCM simulation of climate and climate sensitivity. *Climate Dynamics* 15: 183-203.

Dickinson, R.E., R.M. Errico, F. Giorgi and G.T. Bates, 1989: A regional climate model for western United States. *Clim. Change*, **15**, 383-422.

Giorgi, F., 1990: Simulation of regional climate using a limited area model nested in a general circulation model. *J. Climate*, **3**, 941-963.

Giorgi, F. and L.O. Mearns, 1991: Approaches to the simulation of regional climate change: a review. *Rev. Geophys*., **29**, 191-216.

Giorgi, F. and L.O. Mearns, 1999: Regional climate modelling revisited. An introduction to the special issue. *J. Geophys. Res*., **104**, 6335-6352.

Gordon, C., C. Cooper, C.A. Senior, H. Banks, J.M. Gregory, T.C. Johns, J.F.B. Mitchell and R.A. Wood, 2000: The simulation of SST, sea ice extents and ocean heat transports in a version of the Hadley Centre coupled model without flux adjustments. *Climate Dynamics* 16: 147-168.

Hassell and Associates, 1998: Climate Change Scenarios and Managing the Scarce Water Resources of the Macquarie River. Australian Greenhouse Office, Canberra, 113 pp.

Hay, L.E., R.L. Wilby, and G.H. Leagesley, 2000: A comparison of delta change and downscaled GCM scenarios for three mountainous basins in the United States. *Journal of the American Water Resources Association*, **36**, 387-397.

Hennessey, K.J., P.H. Whetton, J.J. Katzfey, J.L. McGregor, R.N. Jones, C.M. Page, and K.C. Nguyen, 1998: Fine Resolution Climate Change Scenarios for New South Wales. Annual mReport, 1997/98, CSIRO, Australia, 48pp.

Jones, R., Noguer, M., Hassell, D., Hudson, D., Wilson, S, Jenkins G., Mitchell, J (2004) Generating high resolution climate change scenarios using PRECIS. Met Office Hadley Centre, Exeter UK, 40 pp.

Kida, H., T. Koide, H. Sasaki and M. Chiba, 1991: A new approach to coupling a limited area model with a GCM for regional climate simulations. *J. Met. Soc. Japan.*, **69**, 723-728.

Leung, R. (2004) Initial results from the North American Regional Climate Change Assessment Program. 12/16/2004. AGU Fall Meeting, San Fransisco, USA.

Leung, L. R., and M. S. Wigmosta, 1999: Potential climate change impacts on mountain watersheds in the Pacific Northwest. *J. American Water Resources Association* **35**, 1463-1471.

Mearns, L. (2004) NARCCAP North American Regional Climate Change Assessment Program A Multiple AOGCM and RCM Climate Scenario Project over North America. 12/17/2004. AGU Fall Meeting, San Francisco, USA.

Marengo, J (2004) Mudanças Climáticas Globais e Efeitos sobre a Biodiversidade-Caracterização do clima atual e definição das alterações climáticas para o território brasileiro ao longo do Século XXI: CREAS (Cenários REgionalizados de Clima para América do Sul). Encontro dos coordenadores dos subprojetos apoiados pelo PROBIO, Brasilia, DF, 27 a 29 de Outubro 2004.

Mearns, L.O, W. Easterling, and C. Hays, 1998: *The Effect of Spatial Scale of Climate Change Scenarios on the Determination of Impacts: An Example of Agricultural Impacts on the Great Plains.* Proceedings of the International Workshop on Regional Modelling of the General Monsoon System in Asia, Beijing, October 20-23, START Regional Center for Temperate East Asia. TEACOM Report No. 4, 70-73.

Mearns, L.O., T. Mavromatis, E. Tsvetsinskaya, C. Hays, and W. Easterling, 1999: Comparative responses of EPIC and CERES crop models to high and low resolution climate change scenarios. *J. Geophys. Res*., **104**(D6), 6623-6646.

Mearns, L. O., 2000: The importance of spatial scale of climate scenarios for regional climate change impacts analysis: Implications for regional climate modelling activities. In *Preprints of the tenth PSU/NCAR Mesoscale User's Workshop*, 21-22 June 2000, Boulder CO. Mesoscale and Microscale Division, National Center for Atmospheric Research: Boulder, pp. 127-130.

Mearns, L. O., W. Easterling, C. Hays, and D. Marx, 2001: Comparison of agricultural impacts of climate change calculated from high and low resolution climate model scenarios: Part I. The uncertainty due to spatial scale. *Climatic Change*, **51**, 131-172.

Mearns, L. O., Giorgi, F., Shields, C., L. McDaniel, 2003: Climate scenarios for the Southeast US based on GCM and regional modelling simulations. *Climatic Change*. **60**, 7-35.

Parnell, W. P., and T. P. Barnett, (eds.) 2004: Special Issue of Climatic Change on The Department of Energy's Accelerated Climate Prediction Demonstration Project. *Climatic Change* (accepted, to appear 2004).

PRUDENCE (2004) Prediction of Regional scenarios and Uncertainties for Defining EuropeaN Climate change risks and Effects. Description of work. Available from http://prudence.dmi.dk.

Pope, V. D., M. L. Gallani, P. R. Rowntree and R. A. Stratton, 2000: The impact of new physical parametrizations in the Hadley Centre climate model — HadAM3. *Climate Dynamics*, 16: 123-146.

PRECIS (2002): PRECIS-Providing Regional Climates for Impacts Studies. The Hadley Centre Regional Climate Modelling system. Hadley Centre, Exeter, UK. 29 pp.

Semenov, M.A. and E. Barrow, 1997: Use of a stochastic weather generator in the development of climate change scenarios. *Clim. Change*, **35**, 397-414.

Stone, M. C., R. H. Hotchkiss, C. M. Hubbard, T. A. Fontaine, L. O. Mearns, and J. G. Arnold, 2001: Impacts of Climate Change on Missouri River Basin Water Yield. *J. of American Water Resources Association,* **37**(5), 1119—1130.

Stone, M. C., R. H. Hotchkiss, and L. O. Mearns, 2003: Water yield responses to high and low spatial resolution climate change scenarios in the Missouri River Basin. *Geophys. Res. Lett.,* **30,** 1186-1189.

Wang, Q.J., R.J. Nathan, R.J. Moran, and B. James, 1999: *Impact of climate Changes on the Security of the Water Supply of the Campaspe System*. Proceedings of the 25th Hydrology and Water Resources Symposium, Vol. 1, 6-8 July 1999, Brisbane, Institution of Engineers, Australia, Water99 Joint Congress, pp. 135-140.

Whetton, P.H., J.J. Katzfey, K.J. Hennesey, X. Wu, J.L. McGregor and K. Nguyen, 2001: Using regional climate models to develop fine resolution scenarios of climate change: An example for Victoria, Australia. *Clim. Res*., **16**, 181-201.

Wilby, R.L. and T.M.L. Wigley, 1997: Downscaling general circulation model output: a review of methods and limitations. *Prog. Phys. Geography*, **21**, 530-548.

Wotton, B.M., B.J. Stocks, M.D. Flannigan, R. LaPrise, and J-P Blanchet, 1998: Estimating future 2xCO2 fire climates in the boreal forest of Canada using a regional climate model. In: *Proceedings of Third International Conference on Forest Fire Research and the 14th Conference in Fire and Forest Meteorology*. University of Coimbra, Portugal, pp. 1207-1221.

Zorita, E. and H. von Storch, 1999. The analog method as a simple statistical downscaling technique: comparison with more complicated methods. *Journal of Climate*, **12**, 2474-2489.

GLOBAL CLIMATE CHANGE AND ITS IMPACT ON THE GLACIERS AND PERMAFROST OF PATAGONIA, TIERRA DEL FUEGO AND THE ANTARCTIC PENINSULA

JORGE RABASSA
CADIC-CONICET
Universidad Nacional de la Patagonia-San Juan Bosco,
Tierra del Fuego, Argentina

GLOBAL CLIMATE CHANGE

Global Climate Change (GCC) can be recognized at the global level through rising mean annual or seasonal temperature, rising or diminishing regional precipitation, rising global sea level and a general increase in the frequency and intensity of extreme meteorological events.

The impact of GCC has been observed in Patagonia, Tierra del Fuego, and the Antarctic Peninsula, particularly since 1978, when the Andean glaciers started to retreat. These impacts have increased in intensity with time. The cited regions are characterized by their high vulnerability, derived from their location in the Southern Hemisphere, their extreme climates, and high intrinsic climatic variability. Their geographical location with respect to the southern oceans and the Antarctic Circum-Polar Current is also very relevant to this problem.

When discussing GCC, natural climatic variability is in fact being considered, together with anthropogenic perturbation of the atmosphere, both in the lower atmosphere or troposphere as well as in the stratosphere. The Sun is the essential source for heat at the Earth's surface. The atmosphere, containing certain gas molecules, retains a portion of the incoming solar energy, before radiating it back into outer space. This mechanism is known as the "greenhouse effect". This observable fact causes higher global temperatures than expected according to the distance of Earth from the Sun. If not for this greenhouse mechanism, our planet would be much colder than it is, with permanent and extensive ice caps descending from the poles to very low latitudes. The Earth greenhouse effect, which has been active at least since Late Precambrian times (>600 million years ago), has had a great influence on the occurrence and development of life, because it has allowed and preserved the existence of the oceans and it has affected the evolution of terrestrial organisms, both plants and animals. Earth's mild but efficient greenhouse effect contrasts with the tremendous effect on Venus, where the thick atmosphere keeps a boiling surface where no free water is present. The greenhouse effect is almost totally absent on Mars where the atmosphere has virtually disappeared and no greenhouse effect exists today.

The climatic variability of the Earth, as revealed by the geologic record, has been very significant at all time scales in its planetary history. Glaciations occurred several times from the Precambrian, Ordovician, Carboniferous, and Permian, to the Late Cenozoic, particularly during the last 10 million years. In contrast, exceptionally warm and wet tropical climates, developed during Mesozoic times, especially during the Jurassic and Cretaceous (IPCC, 2001; Berner, 1997). During this time, no polar ice caps existed, and dinosaurs lived in very high latitudes, probably even beyond the position of the polar circles, perfectly adapted to long polar nights or they developed migration strategies.

Climatic variability also has been very significant in the studied regions during the Quaternary (roughly the last 2 million years) due to modifications of certain parameters of the Earth's orbit, such as its eccentricity, obliquity of the terrestrial axis, and the equinoccial precession. These regular modifications are known as the Milankovitch cycles, after a Serbian astronomer and climatologist who predicted these changes in the early 20th century. The variations have been particularly relevant to mankind during the Late Pleistocene (120 to 15 thousand radiocarbon years ago [^{14}C ka B.P.]), the Late Glacial (15-10 ^{14}C ka B.P.), and all through the Holocene (the last 10 ^{14}C ka B.P.) until present times.

CO_2 atmospheric concentration has varied significantly during the history of the Earth, being related to changes in the extent of continental surfaces and terrestrial ecosystems, the orbit of the Earth, global climate, temperature of the oceans, and volcanic activity. But, no major, large-scale changes have been generated by human activity until recent times, with perhaps the exception of agricultural development in the earliest Holocene (Ruddiman, 2005). Instrumental records showing the increase in CO_2 due to the burning of fossil fuels exist only for the past half century.

The natural climatic variability of the Earth is now superimposed with man-induced climatic modifications, particularly since the Industrial Revolution, about 1850 AD. Since this date, CO_2 and other greenhouse gases emissions have been increasing due to fossil fuel combustion, to the extensive development of agriculture and cattle raising and the reduction of forest areas and other vegetated portions of the landscape, which act as natural sinks for excess CO_2.

Information provided by the International Panel for Climate Change (IPCC, a United Nations organization) shows that human influence on atmospheric composition is enormous, not only of the CO_2 content, but also concerning methane and nitrous oxide. Greenhouse gases in the atmosphere have increased dramatically after 1850 AD, reaching concentrations that had never been attained in human history, as shown by measurements in Arctic and Antarctic ice cores. These gases, both of natural or man-made origin, have a large greenhouse effect due to their relative molecular size, physico-chemical properties, and atmospheric concentrations. Other gases are also important, such as tropospheric ozone and artificial halocarbonates (the so-called CFCs). All information herein presented has been extensively discussed in IPCC (2001) and the reader is referred to their website (*www.ipcc.ch*).

CO_2 is the most important of the greenhouse gases, although its total concentration in the atmosphere is less than 1%. The present CO_2 concentration, about 380 ppm, is the greatest of any amount that has been documented for the last 20 million years, since the middle Miocene and before the Alpine-Andean orogeny deeply modified global climate. This modern concentration was achieved with an increase of only 30% with respect to the atmospheric content of the last 1000 years. Growing CO_2 concentration has been accompanied by a sharp increase in mean annual global temperature, reaching a historical maximum in 1998, the warmest year in the last millennium according to the IPCC 2001 report.

Global temperatures during the last few centuries have varied significantly due to changes in solar activity ("solar spots"), which exhibits an extensive minimum between 1650 and 1720 AD (known as the Maunder Minimum) and again between 1790 and 1840 AD (the Sporer Minimum). During these times, total solar radiation received at the Earth's surface was reduced. These minima were responsible for lower global temperatures known as the "Little Ice Age". After 1840, solar activity returned to normal conditions, with the usual 11-year cycles.

Since 1850 AD and in the 20th century, global temperature increased constantly. However, short cooling episodes around 1910, 1945, and 1970 caused the glaciers of the world to advance in the

40s and the 70s. The last year of general glacier advance in the Swiss Alps was 1977, while the last advance of glaciers in Northern Patagonia occurred in 1978. Glaciers have been receding since then.

In recent years, global mean annual temperature has increased considerably, with the exception of 1992, following the explosion of the Pinatubo Volcano in the Philippines, which sent enormous amounts of volcanic ash into the stratosphere, thus partially blocking the incoming solar radiation and cooling the atmosphere.

In regional terms, winter temperatures for the last 50 years have increased in the Arctic and Sub-Arctic regions and the Antarctic Peninsula, with the exception of the Labrador/Greenland area. Summer temperatures have gone up, particularly in the Antarctic Peninsula, Northeastern Africa and the Mediterranean Sea.

The impact of GCC may be both socially and economically harmful and beneficial in human terms, both socially and economically, depending on the different geographical areas involved or the kind of human activities considered. For example, among the beneficial impacts of GCC for South America is the displacement of the southern areas toward more benign climates and the southwestward widening of the agricultural frontier in the Argentine Pampas. However, the negative impacts are clearer and stronger, such as loss of biodiversity and forest mass, degradation of ecotonal fringes, higher frequency of extreme hydrological events such as flooding and drought, reducing or dissapearing permafrost conditions in the Andean ranges above the tree line, dissecation of wetland and peatland ecosystems, rising climatic snowline, and fast recession of mountain glaciers and snowfields (IPCC, 2001).

The IPCC has studied these impacts and their regional distribution (IPCC, Third Annual Report, 2001) and prepared models that predict global and regional climatic and environmental conditions for the remaining portion of the 21st century. These probabilistic mathematical models have been arranged based on a large variety of global and regional, tentative scenarios, according to possible social, technological, and economic development of mankind. Each scenario takes into consideration the cultural, political, and technological variables which would expand, maintain or reduce greenhouse gas emissions in the future. Models predict possible consequences for the global and regional climate, and their influence on ecosystems, agroecosystems, and society. Once these consequences have been identified, impact mitigation processes are proposed to regional governments and international organizations.

The impact of climatic change is larger where regional vulnerability is higher. These conditions are particularly significant in Latin America and the polar zones (IPCC, 2001). For Latin America, the IPCC opinion could be summarized as follows:

1) The adaptative capacity of the human systems is low, particularly with respect to extreme climatic events and vulnerability, is very high.

2) Glacier volume loss and recession would negatively impact surficial runoff in those areas where glacial melting is an important water source.

3) Floods and droughts will occur more frequently, with increasing sedimentary load and water quality degradation.

4) An increase in tropical cyclone intensity would have an effect on life, property, and ecosystem hazards generated by strong rain storms, flooding, wind, and extreme events.

5) Crop yields will decrease in most of Latin America, even if CO_2 favorable effects are taken into consideration. Subsistence agriculture in certain regions will be at risk.

6) The geographic distribution of infectious diseases will expand polewards and also to higher areas. Exposure to diseases such as malaria, dengue fever and cholera will increase.

7) Coastal human population, economic activities, infrastructure and mangrove ecosystems will be negatively affected by rising sea level.

8) Rate of biodiversity loss will increase.

In the polar zones, and particularly in the Antarctic Peninsula, IPCC scientists indicated that (IPCC, 2001):

1) The natural systems in the polar zones are highly vulnerable to climatic change and the present ecosystems have a low adaptative capacity.

2) It is expected that the polar zones will be among those with larger and stronger impact, particularly in the Antarctic Peninsula and the Southern Seas.

3) Changes in climate have an impact on lesser extension and thickness of sea ice, increasing coastal erosion, permafrost melting, changes in ice sheets and platforms and the distribution of ice-related species.

4) Some ecosystems may be adapted to the climate change by the replacement of species by migration and ecosystem composition, and perhaps by increase in total productivity. Ice marginal systems providing habitat for certain species are endangered.

5) The polar zones have climatic change conduction mechanisms which, once triggered, will continue for centuries, even after greenhouse gas concentrations have been stabilized. Irreversible impact is expected on ice platforms, global oceanic circulation and sea level rise.

If a big portion of meltwaters from Antarctic ice merges with the ocean, sea level would rise significantly. The West Antarctic Ice Sheet alone has enough water to raise the ocean by 5 meters. A one-meter rise would be expected to cost the Netherlands alone 10 billion USD to defend their coastal lowlands. Likewise, the cost of sea rise impact in Bangladesh could be measured in the lives of the millions who live on the fertile, coastal, deltaic lands (Shepherd *et al.*, 2005).

CLIMATE OF THE 21ST CENTURY AND ITS IMPACT ON GLACIERS

According to the IPCC (2001), the climate of the XXIst century will be characterized by increasing global mean annual temperatures and, as a consequence, a slow but constant rising sea level. Mean annual temperature in the year 2100 would increase between a minimum of 1.4 °C and a maximum of 5.8 °C, above 1990 conditions, including the statistical errors of the method used. This temperature increase would push a global sea level rise between 0.2 m and 0.7 m. A probabilistic analysis of the studied conditions indicates that the lower 95% confidence boundary is located at 0.9°C and the upper 95% is at 4.8 °C (Jacoby *et al.*, 2001; quoted in “The Economist”, April 7, 2001, p. 74), with a median of 2.5 °C and a highest probability at 2.0 °C. Even these middle values are very important in terms of mean annual temperature variability, a climatic parameter of known high predictability. A similar increase in temperate latitudes during the Hypsithermal period (around 8000-6000 ^{14}C years B.P., middle Holocene) is considered to be responsible for the global Flandrian transgression, the flooding of coastal areas all around the world and the development of the “Diluvian” myth in many cultures of the world.

Today, there are many acting proofs of active climate change, temperature elevation, and sea level rising at all latitudes. In addition to all instrumental records, one of the most dramatic examples of global climate change impact is its effects on glaciers and sea ice.

THE PATAGONIAN AND FUEGIAN GLACIERS

Regional snow line or permanent snow line is defined as the lowest elevation on the landscape (particularly, mountain landscape) at the end of the melting season (usually the beginning of fall) with snow that accumulated during the last winter. The equilibrium line is its position on the surface of a certain, temperate-based glacier. In the case of Patagonia and the Antarctic Peninsula, increasing mean annual temperatures, particularly summer temperatures, have had sizeable effects on the position of the regional snow line, and thus, the equilibrium line, forcing its rising by more than 200 m during the last 20 years in Patagonia and Tierra del Fuego, and perhaps up to 100 m in some areas of the Antarctic Peninsula. This has forced a general recession of most of the Patagonian and Fuegian glaciers, mainly due to loss of accumulation area, rising temperatures at the glacier snout elevation, and increase of ice calving in lakes or the sea. The general recession of the Patagonian glaciers has been observed over the last 20 years (Aniya and Enomoto, 1986), when these scientists observed, between 1944 and 1984, a maximum recession of around 2.5 km at two calving glaciers. Also, the glacier surface lowered from 40 to 120 m during the last 40 yr. In a more recent paper, Aniya (1999) estimated that the Patagonian glaciers contribution to sea-level change by increased melting was 1.93 ± 0.75 mm for the last 50 years, which is 3.6% of the total sea-level change. Analyses of climatic data from meteorological stations located around the icefield revealed a slight increase in air temperature and a decrease in precipitation over the last 40 to 50 yr (Aniya, 1999).

The famous Perito Moreno Glacier (Parque Nacional Glaciares, province of Santa Cruz, southernmost Patagonia [and probably its Chilean counterpart neighbor Pio XI Glacier as well (Rivera and Cassassa, 1999)] is a very particular case, because it keeps advancing actively year after year, blocking Brazo Rico, a branch of Lago Argentino, generating an ice wall that later collapses when the accumulated water pressure in the southern side of the wall exceeds the ice resistence. When the wall breaks, it is a stunning event, which is greatly appreciated by tourists and naturalists from all over the world who come in large numbers to see this event, which occurs not every year. This anomalous behaviour is most likely not related to climatic factors, but to internal, glaciological forcing, or to recurrent, small magnitude seismic events, though large enough to induce glacier sliding. At the Pio XI Glacier, Rivera and Cassassa (1999) have estimated that this glacier has advanced significantly in past decades probably due to surging and the regional equilibrium line altitude (ELA) variations in relationship with glacier morphology; however, these authors affirmed that constant ELA rising will lead to a rapid decline of this glacier in the future. In the Torres del Paine National Park, Rivera and Cassassa (2004) have established that the total area loss of the glaciers in this park has been of 62.2 km^2, 8 %

of the original ice area present in 1945, with a maximum ice thinning of up to 7.6 m per year during the period studied.

The Upsala Glacier, the largest in Argentina and one the biggest in South America and the Southern Hemisphere outside of Antartica, is undergoing a clear, catastrophic recession both in its front and thickness. Its frontal recession has reached up to 8 km only during the last decade (Figures 1, 2 and 3). The floating portion of its tongue partially collapsed after the photograph of Figure 1 was taken, allowing a much deeper penetration of the boats sailing into this fjord-like branch of Lago Argentino. Between April 1999 and October 2001, the glacier front has been fluctuating seasonally about a 400 m distance, in contrast to the dramatic recession of previous years. During this period, the Upsala Glacier's west terminus had a net advance of around 300 m. Satellite images were used to determine recent calving speeds and confirmed the increased calving-rate/water-depth relationships (Skvarca *et al.*, 2003). The behaviour of this glacier is probably related to the loss of most, if not all, of its floating tongue in Lago Argentino, with a temporary reactivation of its grounded portion.

A similar destiny is threatening most of the smaller, mountain glaciers and discharge ice tongues from the surviving ice sheets in Patagonia and Tierra del Fuego: the Northern Patagonian Ice Sheet, Southern Patagonian Ice Sheet, Darwin Cordillera Ice Sheet and some other smaller ice caps in the Magellanic Archipelago. On the Argentine side of the Isla Grande de Tierra del Fuego, the Alpine glaciers of the Fuegian Andes are in sharp, violent retreat. See, for example, the photographs corresponding to the Martial Glacier and the Alvear Este Glacier (Figures 3 to 11). Most likely, around the year 2020 A.D., most of these glaciers will have vanished, generating a priceless loss of pristine environments, water resources, alpine wetlands, scenic and tourism resources, as well as their natural, scientific and cultural legacy.

In Northern Patagonia, the consequences have been similar. The Río Manso Glacier (Cerro Tronador, a dormant Pliocene volcano in the Nahuel Huapi National Park, Northern Patagonia; lat. 41°S) has been the subject of detailed mapping and glaciological and dendrochronological studies (Rabassa *et al.*, 1978; Brandani *et al.*, 1986). This glacier is a regenerated ice tongue, formed below a very tall ice fall, where ice blocks drop from the upper, local ice cap. This lower tongue is debris covered and has undergone a dramatic collapse during the last 30 years (see Figures 12 to 15). In a nearby valley, the Lower Cone of the Castaño Overo Glacier was the topic of a graduate thesis in Geography (see Bertani *et al.*, 1986; Fig. 16 and 17), but it has already vanished as a permanent ice body, due to intense summer melting. Thus, in only 20 years, a focus of scientific, geographical and glaciological studies is lost forever.

Finally, the Casa Pangue Glacier, Cerro Tronador, Chile (Figure 17) is the largest glacier in Northern Patagonia, with a regenerated, lower ice tongue, formed beneath huge ice falls in the western slope of Cerro Tronador. This lower portion of the glacier is totally debris covered. Debris cover was between 1.0 and 2.0 metres thick, continuous and stable, when described in 1979 for the first time. It was so steady and firm that it allowed, in the recent past, for formation of in-transit moraines and soil development, on which a mature, full-grown, almost exact replica of the regional forest (the Valdivian Rain Forest) grew, perhaps since the Little Ice Age (Rabassa *et al.*, 1981). This forest moved downslope for decades (up 60 yr-old trees were cored for dendrochronological studies) as the ice moved, at a very slow rate. It disappeared sometime in the 1990s, as the melting of the underlying ice created unstable soil conditions and the trees lost support, fell down and died. This puzzling ecosystem, probably unique in the World, vanished forever as a result of a strong, regional warming trend. This was the first victim of GCC and global warming in the region, and represents the extinction of a matchless, irreplaceable natural community. The appropriate question is: who is going to pay for the loss of this breathtaking piece of nature?

In neighboring areas, Larsen (2004) concluded that ice thinning rates from 1995 to 2000 in the Patagonian glaciers were more than double those of the previous two decades, thus extending the observation of these phenomena to a much larger region.

The Patagonian and Fuegian glaciers have probably existed and survived continuously for at least the last 100,000 years, since the beginning of the last glaciation. However, they have been gravely injured by man-induced climate change in the last 200 years, since the "Little Ice Age". Their fading will generate enormous damage and economic loss to Patagonian tourism activities, which are today partially dependent upon their survival and perpetuation.

In other regions of Argentina, such as the central Argentine Andes, and particularly the irrigated vineyards of the Cuyo piedmont areas, and in other parts of the World as well (Central Chile; Sierra Nevada de Santa Marta, Colombia [Rabassa *et al.*, 1993]; Tibet; Eastern Africa, etc.), seasonal melting of glaciers and snowfields has an intense contribution to agricultural irrigation or they provide fresh water resources in settled areas. For example, the city of Ushuaia, Tierra del Fuego, the southernmost city in the World, is fully reliant upon glacier meltwater for fresh water supply. Also, the glaciers of the Glaciares National Park of Southern Argentina have been acknowledged as a World Mankind Heritage Site in the UNESCO program, purportedly an enduring, everlasting, perpetual recognition. Amazingly, mankind itself has doomed them in a very short time, probably before full scientific research can be accomplished.

THE ANTARCTIC PENINSULA

The impact of GCC on the Antarctic Peninsula truly deserves a special comment. As a consequence of higher temperatures, the ice barriers or ice-shelves of the Weddell Sea in the eastern side of the Antarctic Peninsula have partially collapsed in recent years (and for the first time at least in 100,000 years) calving colossal icebergs named "ice islands", that are tens of km long and thousands of square km in size. Oceanographic studies show that the Larsen-B ice shelf had not experienced a history of full recession and reformation at least since the Last Glacial Maximum. The identification of ice rafted stones may mark the break-up event, which was recorded first in 1999 associated with countless icebergs and complete shelf breakdown (Domack *et al.*, 2002). In the summer of 1995, 1,600 km^2 moved out from the Larsen A Ice Shelf. Several years later, in February 2002, 3,200 km^2 vanished from the Larsen B Ice Shelf. Iceberg generation was largely increased after these events.

Preliminary studies of sediment cores from the front of the Larsen B Ice Shelf suggest that this break up event is unprecedented in the time since an ice sheet last occupied the entire continental shelf, roughly 12,000 years B.P (see the website www.nsidc.org/iceshelves/larsenb2002 and related links). The ice shelf collapse is attributed to recent warming trends (Domack *et al.*, 2005). Likewise, the breakage of the Larsen ice shelf has induced very fast glacier surge advances, placing more terrestrial ice in direct contact with sea water, increasing the total meltout runoff, and thus powerfully contributing to sea level rise (De Angelis and Skvarca, 2003). For more quantitative data, look for the Antarctic Glaciological Data Center (AGDC) at the United States National Snow and Ice Data Center (NSIDC) archives (www.nsidc.org).

Ice barriers, such as the Larsen Ice Shelf, would probably be incapable of regeneration in foreseeable times. In the Antarctic Peninsula, the climatic, regional snow line has also risen, predominantly along its western coast as much as 100 m to 200 m during the last 15-20 years. This is clearly verified by the occurrence of recently exposed bedrock surfaces, which have been ice covered at least since the Last Glacial Maximum, around 25,000 years ago. These expanding exposed rocky areas at or near sea level during the Austral summer have forced a large expansion of the areas for colonization by penguins and other marine birds. This fact will positively stimulate an increase in their populations, probable migrations, and other ecological consequences difficult to forecast, since these birds compete with certain marine mammals, such as cetaceans and crab-eater seals, for the same food resources.

Increasing regional snow line elevations would also trigger a steady fading of many snow fields, small glaciers and local ice caps in the lowlands as well as in adjacent islands, underfed by the decrease of their accumulation basins, increasing glacial sliding and marginal calving and collapse, augmented ice melting with marine salinity alteration, and partial permafrost melting. Cook *et al.* (2005) recognized the distribution of receding glacier fronts in the Antarctic Peninsula for the last 60 years. They identified a pattern associated with atmospheric warming and a southern displacement of the latitudinal separation between receding and advancing glaciers with time. According to these authors, the average change of the ice front position moved from +40 m/yr (advancing) in 1945 to -60 m/yr (receding) in 2004. The total proportion between advancing to receding glaciers passed also from 61/39 (1945) to 32/95 (2004). The Sjogren Glacier, on the eastern Antarctic Peninsula, has retreated 13 km since 1993, when the Prince Gustav Ice Shelf collapsed. Moreover, all observed glaciers north of lat. 64° S receded during that period, proving that those ice bodies located at northernmost positions in the Southern Hemisphere are more vulnerable to climate change. Accelerated sea level rise of up to 0.2 mm per year has been detected from the melting of West Antarctica glaciers, which are contributing around 250 km^3 of ice annually into the sea, which is 60% more than the amount of snow accumulating in their nourishment areas (Thomas *et al.*, 2004). This region already accounts for more than 20% of the total global sea level rise.

PERMAFROST

A steady decline during the last decades of the thickness and a lowering of the frozen surface under permafrost conditions, and a consequent expansion of its active layer (the seasonally ice free upper portion of the soil) would generate serious structural problems in high mountain building and roads, general increase of surficial runoff, and probably an increase in frequency and intensity of mass movement catastrophic events. A project to measure the environmental and atmospheric variables in the permafrost zone of the Fuegian Andes above the tree line is presently under development by CADIC, Ushuaia, and the Departamento de Geografia, Universidade de Santiago de Compostela, Spain.

FINAL REMARKS

Global warming may force changes in the latitudinal position, power, and individuality of the Antarctic Circumpolar Current. These modifications due to GCC and a vast input of fresh water into the southern oceans due to extensive ice melting may cause unforeseen oceanographic, climatic, and ecological alterations in the southern portion of South America.

For many years, GCC impacts have been noted to in the high latitude regions. Patagonia, Tierra del Fuego, and the Antarctic Peninsula may become outstanding examples of these circumstances and a heartbreaking and voiceless proof of environmental damage induced by careless human activities. The never-ending, escalating burning of fossil fuels within the wealthy, industrial societies, the accelerating use of fossil fuels in the rest of the World, particularly China and India, and the swift deterioration of carbon reservoirs in most Earth regions will be accountable for the loss of the invaluable Patagonian and Fuegian glaciers and snow fields and a serious damage to the terrestrial and marine environments of the Antarctic Peninsula.

ACKNOWLEDGEMENTS

The author is particularly indebted to Professor Dr. Wagner Costa Ribeiro and colleagues of the Department of Geography, University of São Paulo, São Paulo, Brazil, for their invitation to participate in the II Conferência Regional sobre Mudanças Globais, held in this city in November 2005, as well for their generous contribution to finance travel and residence expenses.

The final version of this paper was prepared while the author was an International Visiting Scholar of the University of Illinois at Urbana/Champaign (UIUC) at the Illinois State Geological Survey (ISGS), in April-June 2006. The author is deeply grateful to Dr. William W. Shilts, ISGS Director, and Dr. E. Donald McKay III, Chief ISGS Scientist, as well as to many other distinguished colleagues at ISGS, for the openhanded invitation and for providing a magnificent atmosphere for scientific research. The author also wishes to thank Dr McKay and Dr Richard C. Berg (ISGS) for reviewing a preliminary draft of this paper, correcting the English text and suggesting many valuable modifications.

The content of this paper does not necessarily represent the opinion of ISGS or UIUC in these subjects. The usual disclaim applies to all aspects of this contribution.

REFERENCES

Aniya, M. and H. Enomoto, 1986. Glacier variations and their causes in the Northern Patagonia Icefield, Chile, since 1944. Arctic and Alpine Research, 18 (3): 307-316.

Berner, R.A., 1997: The rise of plants and their effect on weathering and atmospheric CO_2. Science, 276, 544-546.

Bertani, L., A. Brandani and J. Rabassa, 1986. Fluctuations of Castaño Overo Glacier in Northern Patagonia since the beginning of the XVIth Century. In: Proceedings of the International Symposium on glacier massbalance, fluctuations and runoff, AlmaAta, USSR, 1985; “Data of Glaciological Studies” No. 57, pp.192196; Russian version: pp. 6772. Academy of Sciences of the USSR, Moscow.

Brandani, A., J. Rabassa, J. Boninsegna and D. Cobos, 1986. Glacier fluctuations during and since the Little Ice Age and forest colonization: Monte Tronador and Volcán Lanín, Northern Patagonian Andes. In: Proceedings of the International Symposium on glacier massbalance, fluctuations and runoff, AlmaAta, USSR, 1985; “Data of Glaciological Studies”, No. 57, pp.196205; Russian version: pp. 7283. Academy of Sciences of the USSR, Moscow.

Cook, A.J., A.J. Fox, D.G. Vaughan and J.G. Ferrigno, 2005. Retreating glacier fronts in the Antarctic Peninsula over the past half-century. Science, 308: 541-544.

De Angelis, H. and P. Skvarca, 2003. Glacier surge after ice shelf collapse. Science, 299: 1560-1562.

Domack, E., R. Gilbert, G. Berger, D. Tewksbury, S. McCallum, E. Backman, K. McMullen, D. Duran, A. McCloskey, and A. Rubin, 2002. Marine geological survey off the Larsen B Ice Shelf: Cruise NBP-01-07 (December 2001 to January 2002). In: “Antarctic Peninsula climate variability: an historical and paleoenvironmental perspective”, Hamilton College, New York, 3-6 April 2002.

Domack. E.R., D. Duran, A. Leventer, S, Ishman, S. Doane, S. McCallum, D. Amblas, J. Ring, R. Gilbert, and M. Prentice, 2005. Stability of the Larsen Ice B Shelf on the Antarctic Peninsula during the Holocene epoch. Nature, 436 (4): 681-685.

IPCC, 2001. Third Assessment Report (TAR). IPCC. Vol. 1: Climate Change 2001: Working Group I: The Scientific Basis; Vol. 2: Climate Change 2001: Working Group II: Impacts, Adaptation and Vulnerability; Vol. 3: Climate Change 2001: Working Group III: Mitigation; Vol. 4**:** Climate Change 2001: Synthesis Report. Published by IPCC and Cambridge University Press, UK. Available from www.ipcc.ch.

Larsen, J., 2004. Glaciers and Sea Ice Endangered by Rising Temperatures. Earth Policy Institute, 1350 Connecticut Ave. NW, Suite 403, Washington, DC 20036. Available at: www.earth-policy.org.

Rabassa, J., S. Rubulis and J. Suarez, 1978. Los glaciares del Monte Tronador, Parque Nacional Nahuel Huapi, Río Negro, Argentina. Anales de Parques Nacionales, 14: 261316. Buenos Aires.

Rabassa, J., S. Rubulis and J. Suarez, 1981. Moraine in-transit as parent material for soil development and the growth of Valdivian Rain Forest on moving ice: Casa Pangue Glacier, Mount Tronador (lat. 41° 10’ S), Chile. Annals of Glaciology, 2: 97-102.

Rabassa, J., L. De Lasa and F. Siciliano, 1993. Glacier and permanent snow field inventory in Sierra Nevada de Santa Marta, Colombia. Quaternary of South America & Antarctic Peninsula, 8 (1990): 119134, A.A. Balkema Publishers, Rotterdam.

Rivera, A. and G. Cassassa, 1999. Volume changes on Pio XI Glacier, Patagonia: 1975-1995. Global and Planetary Change, 22: 233-244.

Rivera, A. and G. Cassassa, 2004. Ice elevation, areal and frontal changes of glaciers from National Park Torres del Paine, Southern Patagonia Icefield. Arctic, Antarctic and Alpine Research, 36 (4): 379-389.

Ruddiman, W.F., 2005. How did humans first alter global climate? Scientific American, March 2005, 8 pp.

Shepherd, A. *et al.* (several authors), 2003. Larsen Ice Shelf has progressively thinned. Science, 302: 856-859.

Skvarca, P., B. Raup and H. De Angelis, 2003. Recent behaviour of Glaciar Upsala, a fast-flowing calving glacier in Lago Argentino, southern Patagonia. Annals of Glaciology, 36 (1): 184-188.

Thomas, R. *et al.* (17 authors), 2004. Accelerated sea-level rise from West Antarctica. Science, 306: 255-258.

FIGURE CAPTIONS

Figure 1 - Upsala Glacier, calving ice front in Brazo Norte, Lago Argentino, Glaciares National Park, province of Santa Cruz, Argentina, 1981 (Photo: J. Rabassa).

Figure 2 - A mountain glacier, tributary of Upsala Glacier from the western slope of the valley, seen from several km from the south, 1981. Note the upper surface of Upsala Glacier front at the foreground of the photograph, illustrating the position of the ice front at that time, proximal to the ship from where this photo was taken (Photo: J. Rabassa).

Figure 3 - The same tributary, now seen from the north, 2004. The Upsala Glacier calving ice front had receded more than 8 km in that period, allowing boats to sail the Lago Argentino to locations that were not reachable in 1981.

Figure 4 - Monte Alvear East Glacier, Fuegian Andes, lat. 54° S. Southern portion of the ice margin as seen in February, 2004. Note the relatively small size of the ice cave at the left portion of the glacier front and the dimension of the rocky outcrop straight away to the right of it. Photo: J. Rabassa.

Figure 5 - The ice cave shown in Figure 1, February 2004. Note the small, illuminated area at the far end of the cave. Photo: J. Rabassa.

Figure 6 - Monte Alvear East Glacier. Southern portion of the ice margin as seen in February, 2005. Note the enlarged size of the ice cave, the emergence of a large boulder in the ice wall directly to the right of it, which was previously unobserved in the 2004 photograph, revealing a significant ice front recession of several meters. Note also the exposure of dark ice remains beneath the whithish, more recent ice, to the left of the ice cave. This debris-rich, dark ice is a very old ice remnant, clearly pre-Little Ice Age, perhaps thousand years old, even perhaps from the Last Glacial Maximum (25,000 years ago). The actual age of these ice remains has not been yet investigated. Regrettably, it is likely that it will melt away before suitable sampling can be fully accomplished. The rocky outcrop to the right has increased in size as well, as the ice front receded. Photo: J. Rabassa.

Figure 7 - The ice cave shown in Figure 3, February 2005. Note the larger illuminated area at the far end of the cave. Photo: J. Rabassa.

Figure 8 - Monte Alvear East Glacier. Southern portion of the ice margin as seen in February, 2006. Note the much bigger size of the ice cave at the left portion of the ice front, with sizeable thinning of the ice at the top of the cave. The large rock boulder that was uncovered in 2005 has fallen down from the ice wall, and it is now on the ground (see Figure 6), indicating that ice front retreat from the 2005 position is several meters or more. The dark ice remnant underneath the whithish ice, to the left of the ice cave, is more exposed than the year before. The rocky outcrop to the right has increased in size and exposure as well. Photo: J. Rabassa.

Figure 9 - The ice cave shown in Figures 5 and 7, February 2006. Note the much larger extent of the ice cave. The ice tunnel is now much shorter and wider than in previous years. This site is popular for tourism, and trekking excursions are commercially offered to the "Alvear Ice Caves". It is very likely that in 2007 there will be no more ice caves to be visited here. Photo: J. Rabassa.

Figure 10 - The Martial Glacier, Fuegian Andes, Ushuaia, lat. 55° S, as seen from CADIC. 1987. Photo: J. Rabassa.

Figure 11 - The Martial Glacier, 2004. Note the significant ice thinning, the exposure of large rock outcrops unseen before in the central part of the cirque glacier and the breaking apart of the glacier into two or more, smaller ice bodies. Photo: J. Rabassa.

Figure 12 - Recent fluctuations of the Río Manso Glacier, Cerro Tronador, Nahuel Huapi National Park, lat. 41° S, Northern Patagonia, Argentina, in 1972. Debris covered, regenerated lower ice tongue. Photo: J. Rabassa.

Figure 13 - Río Manso Glacier, 1982. Note the significant retreat of the ice front from the valley marginal moraines, and the building of a small-scale, abandoned lateral moraine on top of marginal kame deposits. Photo: J. Rabassa

Figure 14 - Río Manso Glacier, 1998. Note the further recession of the ice from the 1982 position and the formation of a new, marginal lake with many icebergs. Photo: J. Rabassa

Figure 15 - Río Manso Glacier, 2002. The marginal lake is now very extensive and the ice front has receded significantly toward the left of the image, and the dark ice at the right of the photograph has vanished. Photo: J. Rabassa

Figure 16 - The Castaño Overo Glacier, Cerro Tronador, Nahuel Huapi National Park, lat. 41° S, Northern Patagonia, Argentina, as seen in 1975. A regenerated lower ice cone, formed by ice avalanches from the upper glacier, seen at the top of the photograph. Photo: J. Rabassa

Figure 17 - The Castaño Overo Glacier, 1987. The same ice cone as in Figure 16. Note the large rocky outcrop that has been exposed in the central portion of the cone. This ice cone disappeared as a permanent ice body sometime during the 1990 decade. Photo: J. Rabassa

Figure 18 - The Casa Pangue Glacier, Cerro Tronador, Chile. This is the largest glacier in Northern Patagonia, with a regenerated, lower ice tongue, which is totally debris covered. This debris cover was between 1.0 and 2.0 metres thick. See the glacier ice exposed beneath the debris cover along the large crevasse shown in the picture. The debris cover allowed past formation of in-transit moraines, on which a soil and a mature, full-grown, almost exact replica of the regional forest (the Valdivian Rain Forest) developed, perhaps since the Little Ice Age (Rabassa *et al.*, 1981). These trees, which moved very slowly downslope with the ice for decades, disappeared forever in the 1990s, as the melting ice made unstable the soil surface and the plants lost support. At the lower right for scale, the late Jorge Suarez, a distinguished mountaineer, friend and colleage, climbing the ice ridge towards the in-transit moraines, may be seen. Photo: J. Rabassa (1979).

REGIONAL EFFECTS OF GLOBAL CHANGES IN TERRESTRIAL ECOSYSTEMS: AMAZONIA

PETER MANN DE TOLEDO
INPE/Rede Geoma/MCT

IMA CÉLIA GUIMARÃES VIEIRA
Museu Paraense Emílio Goeldi/MCT

INTRODUCTION

Understanding the dynamics of terrestrial ecosystems through time and space has implications for those scientific fields dealing with environmental sciences. Additionally, a better picture of the natural processes acting on regional scales also enhances global change awareness by different societies. Multidisciplinary approaches focusing on both diagnostic and predictive research agendas, such as ecological characterization, biodiversity distribution patterns and ecosystem modelling, have been recently growing under scientific scrutiny at least in the last 20 years.

The consequences of ongoing disturbances into future responses of major terrestrial and aquatic systems are yet to be satisfactory revealed by science. A broad characterization of the present day patterns of most continents can be pictured as human-dominated ecosystems where the energy flow through the different trophic levels are mainly controlled by strategies of food production with significant implication into the worldwide biological productivity balance. Such pattern has being steadily growing since the industrial revolution in the late 1800s. Most altered terrestrial ecosystems are dominated by few plant species, few herbivores, with an unnatural release into the atmosphere of high levels of carbon dioxide trough fossil fuels emissions and the dominance of one herbivore, that is, the human species. The endemic biota is usually constrained from its original space showing strong alteration and reduction of its initial distribution limits prior to disturbance. Thus, the energy flux pattern has direct influence under biomass distribution. As a measure of the extension of human alteration upon natural habitats in a global perspective only 1/6 of the world's natural landscapes are accounted as unaltered. Among these pristine systems tropical rainforests are still the dominant high-productivity ecosystems preserved from human actions of land conversion. Despite retaining significant portions of undisturbed areas, the tropical lowlands, such as the Amazon rainforest, have been seriously threatened in the last 10 years due to an intense land cover change producing large extensions of land conversion.

The present day environmental conditions are unique regarding Earth's biological evolutionary history. Such unusual situation has stimulated debates and research programs concerning human-driven disturbances in the environment. A complete understanding focused on historical processes and present patterns of the Earth biomes is necessary to fully comprehend and predict the possible effects of further environmental changes in a 10-100 year term period.

In order to fully understand the ongoing processes on natural ecosystems and its influence under multi-scaled changes of environment it is necessary to combine both historical and ecological data focusing on the measure of the extent and duration of the causes and effects. For example, the northern neotropical biota is still under the influence of the Great American Biotic Interchange event that has been established since the rise of the Panamanian bridge around 3 million years ago. This paper combines a general overview with new data on both geological and ecological phenomena that might have influence in the response of biological systems of the Amazon region into future global changes. Finally, we also present a proposal of research topics in selective priority areas for future studies.

HISTORICAL DATA AS ANALYTICAL TOOLS FOR UNREVEALING TERRESTRIAL ECOSYSTEMS STRUCTURE THROUGH TIME

In order to understand the present day biogeographical pattern and the diversity of ecological units of such large area as the Amazon Region, it is necessary to consider the historical events and the sequencing of the successive factors acting as selective pressures. The comprehension of the major historical geology events that took place on a local area or in larger portions of a terrestrial ecosystem is crucial to correlate the causalistic factors with the prevailing environmental conditions and biological characteristics in a chronological perspective. The combination of geological data of a specific landscape with the biological information provides opportunities for new interpretation and insights on understanding effects of climate changes with important implications for conservation and land-use issues. The main methodological challenge is to compare similar signals under different scales (Brown, 1996; Brown & West, 2000).

This body of information is also useful to the comprehension of the modern community structures and may be applied in ecosystem management studies under a global change perspective. As stated by Margules & Austin (1995), there is a need to create a reliable database that represents the biota regarding the establishment of recent and past geographic ranges, helping toward the formulation of strong biological models for monitoring and predicting species shifts and decline. The presentation of feasible proposals to avoid extinction of species, as well as the rapid decrease of modern populations, should be based on a multi-disciplinary approach including i) ecological field studies, ii) knowledge on the broad patterns of biogeographical ranges and iii) control of the species climatic tolerance requirements. In this particular matter, the recognition of the temporal and spatial scales are necessary pre-requisites while putting together research projects that aim to identify past and future responses to environmental changes and/or stability. For example, macroevolutionary processes of South American mammals can only be understood if there is a reasonable knowledge based on solid body of data of the major paleobiogeographical events that took place in this southern hemisphere continent (Pascual, 1996). These are required steps in the interpretation and understanding of the biogeographical and community structure patterns of ancient and recent mammals. One should also be aware that scale discrepancies caused by differences in size of geographical study area and the number of its taxonomic components may affect on the direct comparisons of structural patterns between local communities and continental faunas and plant composition (Kauffman, 1995; Ruokolainen et. al. 2005). However, information provided by different research fields such as community stability and complexity, equilibrium diversity dynamics and modern fauna response patterns to global change (Currant, 2000; Hooker, 2000; Pascual, 1996; Whybrow and Andrews; 2000), can be integrated under a conservation perspective by the callibration of data into an appropriate scale regarding the ecosystems under study. In this regard, understanding the past and modern response of plants and animals communities is a crucial task.

Living communities are thought to display two different strategies towards long-term environmental changes. The Gleasonian model (Gleason, 1926) predicts that a species responds in an independent way toward the shifts of either physical factors or changes in the biological components of the ecosystem, being driven mainly by the necessity to meet its specific physiological needs. Conversely, the Clemensian model (Clemens, 1916) states that tightly linked communities change as a more broad and intact biogeographical unit in response to environmental perturbations. In this latter case, there are necessary coevolution processes taking place on such assemblages of species. Despite under criticism both hypotheses still bring interesting debate into the scientific theater under which process is most adequate to analyzed community stability and changes through time (Colinvaux, 2005; Lyons, 2005).

Historical data on Pleistocene terrestrial mammals (Graham, 1994; Graham et. al., 1998) has favored the Gleasonian hypothesis, that although evolutionary models using recent and extinct mammalian patterns of community structure, known as the habitat-theory (Vrba, 1992) are best fitted under an integrated long-term biota/environment shift scenario. Both ecological patterns have been considered as effective adaptive strategies in maintaining the production of offsprings and avoiding extinction, and should be considered under a more comprehensive conservation studies. Such analytical approach can be applied as a case study in Amazonia to uncover the hotly debate of the impact of climate changes into past forest fragmentation.

PAST GLOBAL CHANGE AND THE RESPONSE OF BIOLOGICAL SYSTEMS IN AMAZONIA

Since the early stages our planet history has shown cycles of drastic temperature changes alternating cooler and warmer phases that varied in duration and intensity. Focusing into the last 2 million years, there is strong scientific evidence available on both planetary and regional scales that allow a reasonable comprehension of the main drivers responsible for past global changes. Such causal factors include both geological and biotic phenomena and their respective feedback interactions. The planet is under the influence of an enhanced cooling trend since Plio-Pleistocene times. However, in the past 18,000 years the Earth System is going through an inter-glacial interval. Such climatic cycles have being established since the early stages of the Quaternary. Fossil data has shown an increase of 4° C in temperature around the equator since the last glacial period being followed by high precipitation levels in the entire tropical region (Colinvaux, 2005). Historical data has also demonstrated that biological systems respond to climate changes in terms of productivity and community dynamics under different levels of CO_2 concentration, temperature and precipitation.

The present arrangement of the modern biota is still responding to a recent temperature shift under the recent climatic event, where lower temperature and precipitation rates have been a dominant trend worldwide. Therefore, in a macroscopic perspective, a 20,000 years time frame is a relatively short period while comparing with the overall evolutionary history of past speciation events. The actual species distribution and population dynamics demonstrate that present day biological systems are still unstable in terms of adaptation, extinction-immigration events and co-evolutionary processes (Kauffmann, 1995; Stehli & Webb, 1995). Moreover, congruent information based on molecular clock and paleobiogeographical patterns from different groups of modern vertebrates, such as mammals, frogs, birds and siluriform fishes suggest the Miocene ages as a chronological limit on which major speciation events took place in Amazonia (Patton & Silva, 2005 and references therein).

As a word of caution, the understanding of the effects of these environmental parameters on a regional scale is still on progress worldwide, and much information is still needed in order to obtain a conclusive overall picture, especially regarding tropical environments. At the same time, it is expected that different biological groups react independently toward regional environmental and physical changes of the landscape, which implies in distinct response towards adaptation thresholds leading to speciation or extinction events. Such endeavour is still challenging for tropical rainforests biomes, as in the case of most Amazonian Region.

Evidence based on phylogeography studies and current distribution of modern mammalian fauna attest responses to past environmental conditions that have shaped modern community composition (Toledo et. al. 1999; Costa, 2004; Patton & Silva, 2005;). Distribution patterns of plant species caused by climatic shifts in Amazonia might have furnished conditions to animal dispersion. Following such line of though, recent findings of megafauna components of South American in Central Amazonia, specifically giant ground sloths and mastodonts, that are considered to have unhabited savanna-like formations (Toledo, 1996; Cartelle, 1999; Vivo and Carmignotto, 2004), has pushed forward the hypotheses of the existence of open areas in the Amazon Basin related to environmental changes (Rossetti et. al. 2004) especially climatic-related. Moreover, consistent geological evidence (Mörner et. al., 2001; Rossetti et. al., 2005,a, b) have been gathered to demonstrate that major changes throughout Amazonia occurred since the last 5 million years with direct impact on the shaping of landscapes in response to tectonism, arid-umid climatic shifts and river system patterns. It is likely that such drastic changes in the terrain might have influence the biota while posing new conditions and adaptive challenges on both open and closed plant physiognomies. Therefore, geological evidence shows that tropical South America has been under dramatic dynamism, especially in the last 2 million years. However, such hypotheses of forest expansion and retraction in Pleistocene and stable and unstable physical conditions regarding evolutionary scenarios for the luxurious biodiversity of Amazonian biome is far from being a consensus, and much scientific debate has been put into this issue (Haffer, 2001; Haffer & Prance, 2002; van der Hammen & Hoogmienstra, 2000; Mayle et. al. 2000; Irion et. al.; 2005; Colinvaux; 1996; 2005; Brown; 2005).

Future research projects and the building of comprehensive datasets will certainly unreveal such intriguing mystery for science: the processes responsible for the generation of species and maintenance of such high diversity. It is a consensus, on basis of a multitude of geological and palynological evidence, that the last pulse of Amazonian forest expansion which determine the present limits due to more equable climatic conditions occurred since the last 4,000 years. In this regard, it is also interesting to note that the first paleoindians arrived in the South American continent from Asia by around 10,000 years. Therefore, it is quite plausible to assume that humans have witnessed and even probably contribute in some minor and local extent to the transformation of modern ecosystem patterns.

MODERN AMAZONIAN ECOSYSTEMS AND CHANGING ENVIRONMENTAL DRIVERS

The Brazilian territory is characterized in modern times, since the Holocene, by its variety of landscapes, which can be divided into two major domains: open- and closed-environments. The first one is formed by savanna-like ecosystems, such as the *Cerrado*, *Pantanal*, *Campos Sulinos* and *Caatinga*, that occupy most of the central and southern portions of the country. The closed habitats encompass a large variety of forested physiognomies, which are mainly distributed along the entire Amazon Basin area. The other closed environment is the Atlantic rainforest extending along the coastal areas. The Amazonian rainforest can be roughly divided into two main subsets: the *Terra Firme* forests which occupy most of the high lands and hilly countries of the Amazon Basin, and the *Várzea* forests along the river flood plain systems. These luxurious plant physiognomies are controlled by distinct combination of several environmental conditions, specially high temperatures with low seasonal variations. Secondarily savanna-like environments also occur as spotty enclaves in different portions of the Amazon region, and are specially controlled by specific edaphic conditions, and may contain evidence of past community changes.

According to Ruokolainen et. al. (2005) the level of current knowledge of plant species distribuition and diversity patterns in Amazonia is still incomplete. Also there are several aspects that might influence on species distribution such as climate, seasonality and amount of precipitation and biogeographical factors, besides inherent historical signals. Lewis et. al (2004a) while analyzing several plots along an east-west transect across the entire Amazon basin, observed that in the last couple of decades there has been a steadily growth of biomass due to an increase of resource availability becoming and important carbon sink mechanism. Moreover, it also can be observed a relative higher biomass increase in the eastern forests in comparison with other counterparts of the biome. Probable causes are related to equable climate conditions.

Today's land use pattern in Amazonia is characterized by an intense transformation of forest conversion into agricultural land. Such pattern are directly linked to geopolitical aspects involving development strategic actions (Becker, 2005) with direct impact into global changes (Fearnside, 2003). So far almost 25% of the natural forested biome has been transformed, and we can observe an intense pulse of human activities in the last five years. This present scenario has generated great concerns on the scientific community regarding the levels of sustainability of resources management and its consequences to the biological community entities related to ecological issues, such as resilience of the natural systems under such large-scale and short-term disturbance. For example, the yearly average destruction of the rainforest of 25,000 square kilometres has affected the different ecoregions that compose the Amazon biome. Severe losses in biodiversity species and specimens have been accounted for (Vieira et. al., 2005).

Chapin III et. al.(2001) have recently realized a global analysis on the potential response of biodiversity to changing environment drivers. These authors attempted to identify the major factors that influence biodiversity gains and losses, such as: habitat disturbance and fragmentation, introduction of exotic species, overexploitation of local constituents of the biodiversity, pollution, climate change, protected areas, abatement policies, restoration efforts and sustainable use of natural resources. Dirzo (2001) noted that the main cause for tropical forest destruction and reduction of biodiversity levels is human activity through unappropriate land use techniques, especially to area loss and forest insularization by deforestation and fragmentation. In this case, climate change, further changes in carbon dioxide, nitrogen deposition and invasion of exotic species are still of relatively minor impact. In a different study Lewis et. al (2004b) established 10 potential drivers that might receive influence under global change and with direct impact into the tropical rainforests dynamics. These are: temperature, precipitation, solar radiation, climatic extremes, atmospheric CO_2 concentrations, nutrient deposition, O_3/acid depositions, hunting, land-use change and increasing density of lianas. Moreover, they also grouped four categories of drivers that might have serious impact on the biodiversity of Amazonia if maintained a business as usual approach by western societies: i) decadal-scale natural climatic oscillations; ii) fossil fuel emissions and resulting climate change; iii) increasing industrialization in the tropics; and iv) further integration of forest products and land into expanding national and international market economies. In both studies a worrisome picture is portrayed if any action will be launched towards to minimize impacts on both regional and global scales.

DEFORESTATION AND LONG TERM EFFECTS ON FOREST ECOSYSTEMS

Deforestation and conversion to agriculture are considered a great concern for the Amazonian environment as well as to the continental and global climate, as a result of changing surface properties, effects on rainfall and emissions of carbon dioxide. Also, the livelihood of many people inhabiting the region is threatened by the effects of these changes. Evidence is increasing that global climate change has direct and long-term effects on the functioning and sustainability of the current vegetation cover of the Amazon basin, with potentially dangerous feed-forward effects (Cox et al., 2000), and there is paleoclimate evidence that the forests of eastern and south western Amazonia are close to a critical point in which a minor extension of the length of the dry season could turn large expanses of forest into savanna (Mayle et. al., 2000).

For many years the Amazonian farmers have been using fire to clear forested areas for agriculture and pasture as part of extensive land use strategies. More recently ranchers are combining the use of fire with tractor associated to a *correntão* (a forest clearing device using strong naval chains that are hooked to bulldozers which clears large areas by tumbling trees in a rapid pace). Such strategies are currently being used to remove primary forest and to have rapid access to agricultural purposes in public lands. Over the past 25 years they have deforested 650,000 km^2 (INPE 2004) and most part of these areas have been converted to pastures.

In the *Terra Firme* forests of the Amazon, traditional shifting cultivation systems involved a short period of cultivation of annual crops followed by a relatively long fallow period. Those secondary forest vegetation accumulates carbon and nutrients, which are then released by a subsequent burn (Johnson et al. 2000). Ash from biomass burning fertilizes planted crops and pasture grasses, but productivity declines steadily after a few years lead to land abandonment and further clearing. Subsequent forest regrowth partially offsets carbon emissions from deforestation, but is often repeatedly cleared and burned (Hughes et al 2000). Recent studies (Vieira et al 2004; Zarin et al 2005) showed that repeated reburning substantially diminishes the resilience of forest regrowth, resulting in a ~50% reduction in carbon accumulation.

Forest regrowth in the Brazilian Amazon constitutes a significant component of the regional carbon balance (Houghton et al 2000), and also serves to restore hydrological functions (Nepstad et al 2000), plant and animal habitats (Vieira et al, 1996; De Walt et al 2003; Baar et al, 2004) and landscape connectivity (Metzger 2003). Even after many years of abandonment areas with moderate land use can recover 30-35% of floristic composition (compared with primary forest) and 60% of biomass after 70 years of succession (Table 1; Figure 1) (Vieira et al 1996; Vieira et al 2004).

Table 1 - Carbon stocks and species richness in two abandoned plots in Pará, eastern Amazonia.

	ZONA BRAGANTINA	PARAGOMINAS
Years since abandonment	70	14
Land use intensity	Moderate	High
Species richness	30-35%	5%
Carbon stock	50-60%	8%

Ecosystem State*

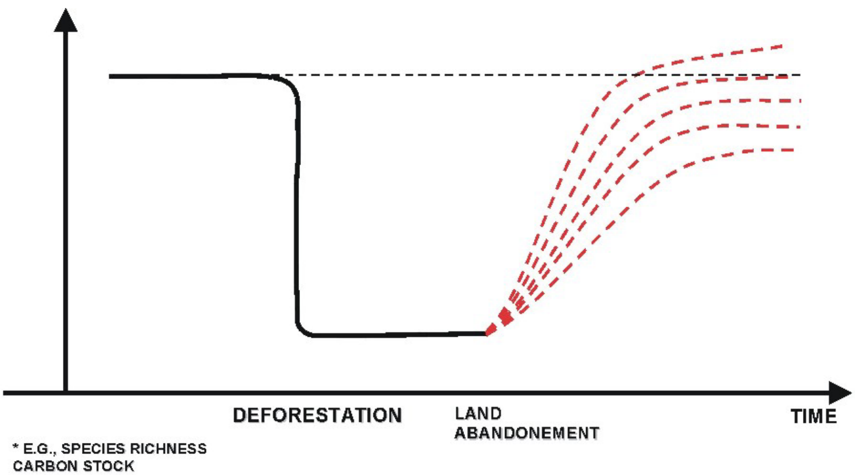


Figure 1 - A simple model to show levels of recuperation of C stock and species richness in abandoned plots in Pará, eastern Amazonia.

As one can see from Table 1 increasing land-use intensity can diminish the rate of post-abandonment carbon accumulation, and that overgrazed pastures can result in a significant lag before forest re-establishment can begin on these areas. Generally the forest regrowth is slower on abandoned pastures compared to shifting cultivation fallows, however some analysis of that hypothesis showed no systematic differences in carbon accumulation, probably because both cattle ranching and shifting cultivation encompass a wide range of land-use intensity and land-use history that difficults our interpretation. Slower regrowth rates in areas of intense land use may be due to soil compaction and/or degradation of the seed bank (Uhl et al. 1988).

According to our experience and studies, the increased incidence of fire and the mechanization in pastures or soybean plantations have a perverse effect for the future of Amazonian forests by diminishing the resilience of forest regrowth. It leads to heavily degraded areas that are better appropriate for permanent conversion to intensive agriculture, agroforestry or tree plantations. Returning them to “native” Amazonian forest for conservation objectives, probably will require significant ecological restoration efforts. Where fires and mechanized agriculture were used intensively, the scenario is a degraded, fire-prone landscape, with poor biological diversity.

Despite of the amount of data and models on Amazonian ecosystems as a result of many studies including the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA) (www.lba.cptec.inpe.br) only analysis that accounts for the vulnerability of coupled human-environment systems with diverse linkages can assess how the system as a whole is sensitve and resilient to deforestation and other hazards. This recognition has lead to the development of conceptual frameworks for global environmental change and sustainability science (Turner et al., 2003). An important lesson is that a focus limited to perturbations is insufficient for understanding the impacts on and responses of the affected system. It is also necessary to consider the strategies in which systems amplify or attenuate the impacts of the hazard, and the role of social structures, political economy and institutions. This indicates that the capacity of the Amazon ecosystems to support climate change and land-use pressure need to be better evaluated. Here we can adress some important questions:

How is regional climate affected by the pattern and scale of land-use changes? How are these changes likely to feed back on vegetation and its resilience? Can regional climate change induced by tropical deforestation imply ‘savannisation’ of parts of Amazonia?

Which are the patterns and mechanisms of land-use change, which feedback mechanisms will affect future land use change patterns, and what will be the consequences for future land use changes and the livelihood of the population of the Amazon region?

Finally, which are the most important vulnerabilities and risks of irreversible changes in the Amazon environment, where are these located, but also, where and to which threats it is more resilient? Can these insights on resilience be used to define options for regional development?

CONCLUDING REMARKS

Untangling the complex treads of biological diversity, reconstructing the major speciation events and community dynamics in both beta and gamma diversity levels require a multi-disciplinary approach under different spatial and temporal scales. In this case, as shown by the geological perspective, it is also important to consider all aspects of positive and potential misleading information due to background and/or incompleteness of data acquisition problems. On this regard, information from past events is usually incomplete and a complementary cross-check with other disciplines and recent data is needed, without necessarily becoming trapped by circular reasoning. Bringing together past and modern information of natural systems is highly welcome while dealing with global change issues. Such practice allows organize information of both biotic and physical processes in an historical and causal manner turning out to be useful in habitat characterization for conservation purposes and public policies.

On the other hand, to analyze the vulnerability of modern ecosystems and those human-induced environments in Amazonia against natural hazards and other risk factors a temporal and spatial integrated modelling approach should be applied as well. Background information of environmental signals that are vulnerable under distinct land use change on different climate scenarios should explicitly focus on the variation within the landscape. This approach will result in: (1) a quantitative exploration of the role of mechanisms in land use change for the typical landscapes of the Amazon, and (2) an integrated land use change model that can be used to define options for regional development. Integrative research programs in natural systems under the paradigm of sustainable territories is seen here as a must necessary priority while optimizing resources and compiling comprehensive and complementary scientific information.

REFERENCES

Baar, R. Cordeiro, M.R., Denich, M. & Folster, H. 2004. Floristic inventory of secondary vegetation in agricultural systems of East-Amazonia. *Biodiversity and Conservation* **13**, 201-528.

Becker, B K. 2005. Amazônia: Geopolítica na virada do III milênio. Garamond Universitária. 168 pp.

Brown Jr., K.S. 2005. Geologic, Evolutionary, and Ecological Bases of the Diversification of Neotropical Butterflies: Implications for Conservation. In Tropical Rainforests. Past, Present & Future (E. Bermingham, C. W. Dick and C. Moritz, eds). University of Chicago Press: 166-201.

Brown, J. H. 1995. Macroecology. University of Chicago Press, Chicago.

Brown, J. H. and G. B. West. 2000. Scaling in Biology. Oxford University Press. 350 pp.

Cartelle, C. 1999. Pleistocene mammals of the Cerrado and Caatinga of Brazil. In Mammals of the Neotropics. The Central Neotropics. Volume 3. Ecuador, Peru, Bolivia, Brazil. (J. F. Eisenberg and K. H. Redford). University of Chicago Press. 27-48

Chapin III, F. S.; O. E. Sala; E. Huber-Sannwald. 2001 Global Biodiversity in a Changing Environment. Scenarios for the 21st Century. Ecological Studies 152. Springer, 376 pp.

Clemens, F. E. 1916. Plant sucession, an analysis of the development of vegetation. Carnegie institute of Washington Publication 242:1-512.

Colinvaux, P. 2005. The Pleistocene Vector of Neotropical Diversity. In Tropical Rainforests. Past, Present & Future (E. Bermingham, C. W. Dick and C. Moritz, eds). University of Chicago Press. 78-106.

Colinvaux, P. 1996. Quaternary environmental history and forest diverstiy in the neotropics. In: Evolution and environment in tropical America. (Jackson, J.B.C.; Budd, A.F.; and Coastes, A.F. eds.). The University of Chicago Press: 359-405.

Costa, L. 2004. The historical biology between Amazon and the Atlantic Forest of Brazil: a study of molecular phylogeography within small mammals. Journal of Biogeography, 30:71-86.

Cox, P. M., R. A. Betts, C. D. Jones, S. A. Spall and I. J. Totterdell (2000). "Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model (vol 408, pg 184, 2000)." *Nature* **408**(6813): 750-750.

Currant, A. 2000. Mammaliannn response to global change in the later Quaternary of the British Isles. . In. Biotic response to global change. (Culver, S. J. and Rawson, P. F. eds.). Cambridge University Press 367-378.

Dirzo, R. 2001. Tropical forests. In: Chapin III, F. S.; O. E. Sala; E. Huber-Sannwald. 2001 Global Biodiversity in a Changing Environment. Scenarios for the 21st Century. Ecological Studies 152. Springer: 251-276.

Fearnside, P. M. 2003. A floresta amazônica nas mudanças globais. INPA. 134 pp.

Gleason, H. A. 1926. The individualistic concept of the plant association. Bullettin of the Torrey Botanical Club 53:7-26.

Graham, R. 1994. Faunmap. A database documenting Late Quaternary distributions of mammal species in the United States. Scientific Papers Illinois.

Graham, R.; Lundelius,; D. Graham, M.A.; Schroeder, E.; Toomey, R.; Anderson, E.; Barnosky, A.; Burns, J.; Churcher, C.; Grayson, D. MacDonald, H. G. 1996. Spatial response of mammals to Late Quaternary environmental fluctuations. Science 272: 1601-1606.

Haffer, J. 2001. Hypotheses to explain the origin of species in Amazonia. In: Diversidade Biológica e Cultural da Amazônia (I.C. G. Vieira; J. M. C. Silva; D. C. Oren; and M. A D'Incao, eds). Museu Paraense Emílio Goeldi, Belém: 45-118.

Haffer, J. and G. T. Prance. 2002. Impulsos climáticos da evolução na Amazônia durante o Cenozóico: sobre a teoria dos Refúgios da diferenciação biótica. Estudos Avançados: (46) 175-209.

Hooker, J. J. 2000. Paleogene mammals: crises and ecological change. In. Biotic response to global change. (Culver, S. J. and Rawson, P. F. eds.). Cambridge University Press 333-349.

Hughes, R.F., Kauffman, J.B. & Cummings, D.L. 2000. Fire in the Brazilian Amazon. Dynamics of biomass, C, and nutrient pools in regenerating forests. *Oecologia* **124**, 574-588.

INPE. Monitoramento da floresta amazônica brasileira por satélite – Projeto Prodes (2004). Available at http://www.inpe.br

Irion, G; M. Rässänen; N. Melo; C. Hoorn; W. Junk; and F. Wesselingh. 2005 D. Rossetti, P. M. Toledo, A. M Góes, new geological framework for western Amazonia (Brazil) and implications for biogeography and evolution, Quaternary Research 63 (2005) 78-89. Letters to Editor. Quaternary Research 64: 279-282

Johnson, C.M., Zarin, D.J. & Johnson, A.H. 2000. Post-disturbance aboveground biomass accumulation in global secondary forests. *Ecology* **81**, 1394-1401.

Kauffman, D. M. 1995. Diversity of New World mammals: universality of the latitudinal gradients of species and bauplans. Journal of Mammalogy 76:322-334.

Lewis, S. L.; O. L. Phillips; T. R. Baker; J. Lloyd; Y. Mahli; S. Almeida; N. Higuchi; W. F. Laurance; D. A. Neill; J. N. M. Silva; J. Terbough; A. T. Lazama; R. V. Martinez; S. Brown; j. Chave; C. Kuelber; P. N. Vargas; and B. Vincetti. 2004a. Concerted changes in tropical forest structure and dynamic evidence from 50 South American plots. Philos. Trans. R. Soc. Lond. B. Biol. Sci., 359, 421-436.

Lewis, S. L.; Y. Mahli; and O. L. Phillips. 2004b. Fingerprinting the impacts of global change on tropical forests. Philos. Trans. R. Soc. Lond. B. Biol. Sci, 359, 437-462

Lyons, S. K. 2005. A Quantitative model for assessing community dynamics of Pleistocene Mammals. American Naturalist, 16 (6):E168-183.

Margules, C. R. and Austin, M. P. 1995. Biological models for monitoring species decline: the construction and use of databases. In. Extinction Rates (Lawton, J. H. and May, R. M. eds) Oxford University Press :183-196

Mayle, F. E.; R. Burbridge, and T. J. Killeen. 2000. Millenial-scale dynamics of southern Amazonian rain forests. Science 290:2291-2294

Metzger, J.P. 2003 Effects of slash-and-burn fallow periods on landscape structure. *Environmental Conservation* **30**, 325-333.

Mörner, N. A.; D. F. Rossetti; and P. M. Toledo. 2001. The Amazonian rainforest only some 6-5 million years old. In: Diversidade Biológica e Cultural da Amazônia (I.C. G. Vieira; J. M. C. Silva; D. C. Oren; and M. A D'Incao, eds). Museu Paraense Emílio Goeldi, Belém: 3-8.

Nepstad, D.C., Moutinho, P. & Markewitz, D. 2001 In Biogeochemistry of the Amazon Basin (Eds. McClain, M.E., Victoria, R.L. & Richey, J.E.)139-155 Oxford University Press, New York.

Pascual, R. 1996. Late cretaceous-Recent land-mammals an approach to south american geobiotic evolution. Mastozoologia neotropical 3(2):133-152.

Patton, J.L., and M. N. F. Da Silva. 2005. The history of amazonian mammals: mechanisms and timing of diversification. **In** Tropical Rainforests. Past, Present & Future (E. Bermingham, C. W. Dick and C. Moritz, eds). University of Chicago Press: 107-126.

Rossetti, D. F.; P. M. Toledo; H. M Moraes-Santos; and A. E. A. Santos Jr. 2004. Reconstructing habitats in central Amazônia using megafauna, sedimentology, radiocarbon, and isotope analyses. Quaternary Research, 61: 289-300

Rossetti, P. M. Toledo, A. M Góes, 2005. New geological framework for western Amazonia (Brazil) and implications for biogeography and evolution. Quaternary Research 63:78-89.

Rossetti, D. F.; P. M. Toledo; and A. M. Góes. 2005. Reply to Letter to the Editor. Irion, G; M. Rässänen; N. Melo; C. Hoorn; W. Junk; and F. Wesselingh. 2005 D. Rossetti, P. M. Toledo, A. M Góes, new geological framework for western Amazonia (Brazil) and implications for biogeography and evolution, Quaternary Research 63 (2005) 78-89. Letters to Editor. Quaternary Research 64: 279-282. Quaternary Research 64: 280-282

Ruokolainen, K; H. Tuomisto; and R. Kalliola. 2005. Landscape heterogeneity and species diversity in Amazonia. . In Tropical Rainforests. Past, Present & Future (E. Bermingham, C. W. Dick and C. Moritz, eds). University of Chicago Press: 251-270.

Stehli, F. G. and Webb, S. D. 1985. The Great Biotic Interchange. Plenum Press. Vol. 4 Topics in Geobiology.

Toledo, P. M. 1998. Locomotory patterns within the Pleistocene Sloths. Museu Paraense Emílio Goeldi, Belém. 192 pp.

Toledo, P.M.; Melo, C. C. S.; Moraes-Santos, H. M.; Diniz, F. M.; and Oliveria, M. F. 1999.

Paleoecology of the Serra dos Carajás mammalian fauna. Ciência & Cultura. 51(3/4): 311-317.

Turner, B. L., R. E. Kasperson, P. A. Matson, J. J. McCarthy, R. W. Corell, L. Christensen, N. Eckley, J. X. Kasperson, A. Luers, M. L. Martello, C. Polsky, A. Pulsipher and A. Schiller2003. "A framework for vulnerability analysis in sustainability science." Proceedings of the National Academy of Sciences of the United States of America **100**(14): 8074-8079.

Uhl, C., Buschbacher, R. & Serrão, E.A.S. 1988.Abandoned pastures in eastern Amazonia. I. Patterns of plant succession. *J. Ecol*. **76**, 663-681.

Van der Hammen, T., and H. Hooghiemstra. 2000. Neogene and Quaternary history vegetation, climante, and plant diversity in Amazonia. Quaternary Science Reviews19:725-742.

Vieira, I. C. G.; R. Salomão; N. Rosa; D. Nepstad and J. Roma. 1996. Renascimento da floresta no rastro da agricultura. Ciência Hoje, 20: 38-45.

Vieira, I. C. G; A S. Almeida; E. A Davidson; T. A Stone; C. J R. Carvalho and J. B. Guerrero. 2004. Classifying successional forests using Landsat spectral properties and ecological characteristics in eastern Amazônia. Remote Sensing Environment; 87 (4) 470-481.

Vieira, I. C. G.; Silva, J. M. C; and P. M. Toledo. 2005. Estratégias para evitar a perda de biodiversidade na Amazônia. Estudos Avançados, USP, 19 (54): 153-164.

Vivo, M. and A P. Carmignotto. 2004. Holocene vegetation change and the mammal faunas of South America and Africa. Journal of Biogeography. 31: 943-957.

Vrba, E. S. 1992. Mammals as a key to evolutionary theory. Journal of Mammalogy, 73(1):1-28.

Webb, S. D. 1978. A history of savannah vertebrates is the New World. Part II. South America and the Great Interchange. Annual Reviews Ecological Systems. 9:393-426.

Whybow, P. J. and Andrews, P. 2000. Response of Old World terrestrial vertebrate biotas to Neogene climate change. . In. Biotic response to global change. (Culver, S. J. and Rawson, P. F. eds.). Cambridge University Press 350-366.

Zarin, D.; E. A. Davidson; E. Brondizio; I. C. G. Vieira; T. A. Sá; T. Feldpausch; E. A. G. Schwer; R. Mesquita; E. Moran; P. Delamonica; M. J. Dewey; G. C Hurtt; C. Salimon and M. Denich. 2005. Legacy of fire slows carbon accumulation in Amazonian forest regrowth. 3(7): 365-359.

GLOBAL CHANGE: THE CERRADO FIRES

HELOISA SINATORA MIRANDA

MARGARETE NAOMI SATO

Departamento de Ecologia

Universidade de Brasília, Brasília

The Cerrado covers approximately 25% of the Brazilian territory and occupies almost 20^o of latitude inside the Brazilian territory, extending from the margin of the Amazonian forest to the southern states of São Paulo and Paraná. The climate is tropical, Köppen's Aw, but Cwa in the southern sites. The mean annual precipitation varies from 1100 mm to 1600 mm and is seasonal with a wet season lasting from October to April and a marked dry season from May to September. The average annual temperatures are 18 - 28 ^{o}C (Dias 1992). The soils of the area are dystrophic, with low pH, high aluminum content and most are oxisols (Haridasan 1994).

The Cerrado vegetation is characterized by a ground layer of grasses, small palms, shrubs and crooked trees. Although many physiognomic forms have been described for the Cerrado vegetation (Eiten 1983), campo limpo, campo sujo, cerrado *sensu stricto* (cerrado *s.s.* or cerrado) and cerradão are the most commonly known. The campo forms occupy aproximately 12% of the Cerrado area, the cerrado *sensu stricto* 53% and cerradão 8%. Several less common forms of vegetation account for the remaining area (Dias 1992). Campo limpo and campo sujo are both dominated by grasses but campo limpo presents no woody plants while there are some scattered shrubs and small trees in areas of campo sujo. Where the wood layer becomes denser the vegetation is called cerrado, a closed scrub with scattered trees as tall as 8 to 10 m high and canopy closure varying from 20% to 50% (Ribeiro & Walter 1998). Cerradão can be either an open-canopy arboreal woodland with trees up to 15 m high and a dense grass underlayer (few shrubs) or a closed-canopy forest with a dense woody underlayer and sparse grasses. The canopy closure varies from 50% to 90% (Ribeiro & Walter 1998).

Fire is a common feature of the Cerrado, as it is for most savanna ecosystems. Fires set by man (Christopher *et al.* 1998) or lightning (Ramos-Neto & Pivello 2000; Medeiros & Fiedler 2004) are common in the Cerrado region, and have been for thousands of years. Salgado-Labouriau & Ferraz-Vicentini (1994) reported the occurrence of fire as early as 32400 years BP in the region of Crominia (GO). The natural fire frequency is unknown for the Cerrado region but the current frequency is estimated to vary between 2 to 4 years (Coutinho 1982, 1990). Fire is used in agriculture, either to transform the native vegetation into crop fields or to manage natural (more open cerrado forms) or planted pastures (Klink & Machado 2005). Although the Cerrado vegetation presents fire-adaptive traits such as thick corky bark (Eiten 1994), vegetative insulation (Rachid-Edwards 1956), tubers and underground stems (Rawitscher & Rachid 1946), frequent fires may result in mortality of the woody vegetation (Rocha e Silva 1999; Sato 2003; Medeiros & Miranda 2005) and can affect seedling establishment (Matos 1994; Hoffmann 1998), altering the structure, the composition and the functioning of the system, especially the fluxes of CO_2 and water (Santos *et al.* 2003; Quesada *et al.* 2004).

Until recently the Cerrado area was sparsely populated. The population practiced subsistence agriculture in small clearings, on more fertile soils like cerradão and gallery forest areas and raised cattle open cerrado areas (Ratter *et al.* 1997). From the mid 1950's, extensive areas of native vegetation were replaced by pastures and crop fields. In the 70's the area of pasture in the Cerrado region was

10 million hectares and at the end of the 80‘s there was an increase of 300% in the area of pasture (Sano *et al.* 1999). In 1994, one quarter of the total area of the Cerrado was occupied by pastures, approximately 45 to 50 million hectares (Macedo 1995). Klink & Machado (2005) estimated that in the last 35 years almost 84 million hectares of the Cerrado vegetation were replaced by crops or pastures.

Although the replacement of this extensive area of native vegetation may result in major alterations in the energy, water and carbon fluxes, as well as in the carbon stock in the ecosystem, in this chapter we will consider only the effects of fire in native Cerrado vegetation on the global change.

CERRADO BIOMASS AND FIRE CHARACTERISTICS

There are few detailed studies quantifying the Cerrado's biomass, especially those for the denser forms (cerrado denso and cerradão). The aboveground biomass reported in the literature varies from 3.8 Mg/ha to 16.6 Mg/ha for the campo forms (Meirelles 1981; César 1980; Rosa 1990; Dias 1994; Andrade 1998; Castro & Kauffman 1998; Ramos-Neto 2000; Cardoso *et al.* 2000a,b; Ottmar *et al.* 2001). The large range of biomass reflects mainly the difference in the species composition of the ground layer and time since last fire. In campo limpo the grasses are the main component of the vegetation and the density of each grass species present in the area may have a large effect on the biomass. *Tristachya leiostachya* is the dominant species in Emas National Park (GO) and may reach 3.0 m height (Ramos-Neto 2000). The biomass of a campo limpo with *T. leiostachya* protected from fire for 2 years is 13.0 Mg/ha, three times greater than the biomass of campo limpo protected from fire for 1 year (3.8 - 3.9 Mg/ha) in which *Echinolaena inflexa* is the dominant species (Ottmar *et al.* 2001). As a consequence of the low decomposition rate of the grasses, time since last fire will result in a build up of dead biomass. Dead grasses represented 72% of the biomass of a campo limpo protected from fire for 5 years (Dias 1994) and 65% of ground layer biomass of a campo sujo protected from fire for 20 years (Andrade 1998). The high density of dead grasses in the open forms of Cerrado may favor the occurrence of frequent fires.

For the denser forms of Cerrado the biomass ranges from 9.9 Mg/ha to 71.9 Mg/ha (Santos 1988; Silva 1990; Sambuichi 1991; Pivello & Coutinho 1992; Imaña-Encinas *et al.*1995; Abdala *et al.* 1998; Vale 2000; Costa & Araújo 2001; Ottmar *et al.* 2001; Sato 2003). This large range of biomass may reflect the variability across the vegetation forms, the large variability in tree density within a given physiognomic form, different sampling methodologies, seasonality or time since last fire. Few authors measured biomass by weighing the trees (Santos 1988; Silva 1990; Pivello & Coutinho, 1992; Imaña-Encinas *et al.* 1995; Abdala *et al.* 1998; Vale 2000). Even in these cases differences in sampling methodologies make comparisons difficult. Santos (1988) and Silva (1990) included the leaves in the total weight and Vale (2000) considered only the branches and stems. During the wet season, the leaves represent 5.0% of the total biomass of trees and shrubs and 3.8% during the dry season (Santos 1988; Silva 1990). Not including the ground layer in the biomass estimates for may lead to an underestimation of as much as 10 to 26% for cerrado *sensu stricto* and cerrado denso (Castro & Kauffman 1998; Abdala *et al*. 1998; Ottmar *et al.* 2001; Sato 2003).

Only recently detailed studies on root biomass and root distribution have been presented for the Cerrado vegetation. Total root biomass increases in the gradient from campo limpo (16.3 Mg/ha) to cerrado denso (52.9 Mg/ha). For all physiognomies more than 70% of root biomass are in the first 50 cm of soil and show a significant decrease with depth (Castro & Kauffman 1998; Abdala *et al.*

1998; Oliveira 1999). The differences in the sampling methodology and the variability in the proportion of woody and ground vegetation inside the same physiognomic form may be responsible for the differences in root mass for the same physiognomy (Table 1). The large root:shoot rate indicates that the roots represent the larger component of the carbon stock for the Cerrado vegetation.

Table 1 - Root biomass and root:shoot ratio in different physiognomies of Cerrado

Campo limpo	Campo sujo	Cerrado	Cerrado denso	Depth (m)	Years without	Reference
Total root biomass (Mg/ha)						
16.3	30.1	46.6	52.9	0 - 2	> 18	Castro & Kauffman (1998)
		33.4		0 - 6		Abdala *et al.* (1998)
	16.4*		27.4	0 - 8	24	Oliveira (1999)
Root:shoot ratio						
5.6	7.7	2.6	2.9			Castro & Kauffman (1998)
		1.0				Abdala *et al.* (1998)

Depth = 0 to 4.5 m

The Cerrado fires are surface fires consuming mostly the fine fuel of the ground layer (grasses, leaves and live or dead stems with diameter smaller than 0.6 mm – Luke & McArthur 1978). The vegetation of the ground layer represents more than 90% of the fuel consumed during the fires (Miranda et al. 1996, 2002). Considering that the flame height for savanna fires is, on average, between 2.0 and 2.8 m (Frost & Robertson 1987), only the leaves of the lower branches will be consumed during the fire. Most of the leaves will be damaged by the hot air flow and will fall within a few days after the fire (Nardoto 2000). The rise in temperature is sharp and of low duration with maximum values in the range of 85 ^{o}C to 884 ^{o}C (Miranda *et al*. 1993), depending on the quantity and quality of the fine fuel, its vertical distribution, the fuel water content, time since last rain and the weather conditions at the time of the fire. A small increase in soil temperature during the fires has been reported (Coutinho 1978; Miranda et al. 1993; Dias 1994; Castro Neves & Miranda 1996) and mostly for the first 1 cm of depth. For depths below 5 cm almost no alteration is registered (Miranda et al. 1993; Dias 1994; Castro Neves & Miranda 1996).

THE CERRADO FIRES AND THE CARBON STOCK

The consumption of the fine fuel of the ground layer varies from 75% to 98%, with the highest values measured in campo sujo areas (Miranda *et al*. 1996; Castro & Kauffman 1998). The vegetation of the ground layer presents a fast recovery after fire events. Almost 70% of the pre-fire value of biomass is recovered within one year after the fire event. Batmanian & Haridasan (1985) have shown that 18 months after a fire the biomass of the ground layer vegetation reaches the pre-fire values. The recovery of the biomass will be faster when the fire is closer to the rainy season (Meirelles 1981; Andrade 1998). Although frequent fires may cause mortality of the woody vegetation in campo sujo areas (Rocha & Silva 1999; Medeiros & Miranda 2005), the ground layer biomass, mainly grasses, accounts for 40% to 83% of the total biomass (Ottmar *et al*. 2001). Neto *et al.* (1998) reported that there was no difference in the pre-fire biomass of the ground layer of a campo sujo (18 years without fire) and that measured after three biennial prescribed fires. The fast recovery of the ground layer in campo sujo areas is important when considering the absorption of the carbon emitted during Cerrado fires. In agreement with biomass estimates, Silva (1999) and Santos *et al.* (2003), measuring carbon flux over burned and unburned campo sujo areas, estimated that two years is the time needed for the absorption of carbon lost during a campo sujo fire.

Sato (2003), measuring mortality of woody vegetation in areas of cerrado *sensu stricto* submitted to biennial fires at different times during the dry season, has shown that the loss of carbon from the burned area will depend upon the timing and frequency of fire. Sato (2003) estimated the biomass of the woody vegetation with the equation presented by Abdala *et al*. (1998) and ground layer biomass by means of the dry weight as described by Ward *et al.* (1992). The carbon content of the biomass was considered 0.40 for dead biomass and 0.45 for live biomass (IPCC 1996). Two contiguous plots of 10 ha each were used in the study and were burned at the beginning (June) and middle (August) of the dry season. In 1992, before the first prescribed fires, the vegetation was protected from fire for 18 years and the carbon stock was 11,5 Mg//ha (Table 2). As observed for campo sujo, two years after the 1992 prescribed fires the carbon stock almost reached the pre-fire level in both areas, 11,27 Mg/ ha in the June plot and 10,63 Mg/ha in the August plot. However, a reduction in the carbon stock of the aboveground vegetation can be observed after five biennial fires. The loss of carbon is greater in the plot burned in the middle of the dry season (Table 2). Carbon fluxes measured above cerrado *sensu stricto* have shown that the vegetation is a sink of carbon at a rate of 1,4 to 2,6 Mg/ (ha.year) (Miranda *et al.* 1996; Breyer 2001; Maia 2003). At these rates the time needed for the August plot to recover the carbon lost would be greater than that for the plot burned in June. The differences in the loss of carbon between the two plots are related to the lower mortality of woody vegetation during fires at the beginning of the dry season, i.e. closer to the natural fire season (Ramos-Neto & Pivello 2000; Medeiros & Fiedler 2004). As the dry season advances, frequent fires result in higher mortality rates and in a large number of individuals that suffer topkill (Sato 2003). A large number of the woody species of the Cerrado vegetation renew their leaves and flower during the dry season (Oliveira & Gibbs 2000; Rivera *et al.* 2002) and the replenishment of the vegetative organs damaged during the late dry season fires may result in a depletion of nutrients and as a consequence in an increase in the mortality rate of the basal sprouts of those individuals that suffered topkill (Cardinot 1998).

Table 2 - Carbon stock in the above ground biomass of cerrado *sensu stricto* protected from fire for 18 years and submitted to biennial prescribed fires in the beginning (June) and middle (August) of the dry season since 1992, at the Reserva Ecológica do IBGE, Brasília, DF. (Modificado de Sato 2003)

	Carbon (Mg/ha)					
	June			August		
	Live biomass	Dead biomass	Total	Live biomass	Dead biomass	Total
Protected for 18 years						
Trees	5,99	0,23	**6,22**	6,62	0,21	**6,83**
Shrubs	0,56	0,1	**0,66**	0,6	0,12	**0,75**
Ground layer	3,02	1,6	**4,62**	2,36	1,31	**3,67**
Total	**9,57**	**1,93**	***11,5***	**9,61**	**1,64**	***11,25***
After one biennial fire						
Trees	6,37	0,47	**6,84**	4,38	1,63	**6,01**
Shrubs	0,2	0,04	**0,24**	0,18	0,03	**0,21**
Ground layer	1,84	2,35	**4,19**	1,76	2,65	**4,41**
Total	**8,41**	**2,86**	***11,27***	**6,32**	**4,31**	***10,63***
After five biennial fires						
Trees	5,81	0,79	**6,6**	3,78	0,81	**4,59**
Shrubs	0,12	0,1	**0,21**	0,09	0,08	**0,17**
Ground layer	1,62	1,75	**3,37**	1,94	0,98	**2,29**
Total	**7,55**	**2,64**	***10,18***	**5,81**	**1,87**	***7,68***

Considering that most of the carbon stock in the Cerrado vegetation is in the root system, that Cerrado fires are surface fires consuming mostly the vegetation of the ground layer and the leaves of the lower branches of the trees, that in almost two years the biomass of the ground layer reaches values similar to pre-fire values and that the mortality rate of the woody vegetation will increase as the dry season advances, the contribution of the Cerrado fires to the regional climatic changes will depend upon the physiognomic form being burned as well as the frequency and timing of the fires.

REFERENCES

Abdala, G. C.; Caldas, L. S.; Haridasan, M. & Eiten, G. 1998. Above and belowground organic matter and root:shoot ratio in a cerrado in Central Brazil. *Brazilian Journal of Ecology* **2:**11-23.

Andrade, S. M. A. 1998. *Dinâmica do combustível fino e produção primária do estrato rasteiro de áreas de campo sujo de cerrado submetidas a diferentes regimes de queima.* M. Sc. Thesis. Universidade de Brasília, Brasília, Brazil.

Batmanian, G. J. & Haridasan, M. 1985. Primary production and acummulation of nutrients by the ground layer community of cerrado vegetation of central Brazil. *Plant and Soil* **88:**437-440.

Breyer, L. M. 2001. *Fluxos de energia, carbono e água em áreas de cerrado* sensu stricto *submetidas a diferentes regimes de queima*. Dr. Thesis. Universidade de Brasília, Brasília, Brazil.

Cardinot, G. K. 1998. *Efeitos de diferentes regimes de queima nos padrões de rebrotamento de* Kielmeyera coriacea *Mart. e* Roupala montana *Aubl., duas espécies típicas do Cerrado*. M. Sc. Thesis. Universidade de Brasília, Brasília, Brazil.

Cardoso, L. C.; Crispim, S. M. A.; Rodrigues, C. A. G. & Baroni Júnior, W. 2000a. Biomassa aérea e produção primária do estrato herbáceo em campo de *Elyonurus muticus* submetido à queima anual, no Pantanal. *Pesquisa Agropecuária Brasileira* **35:**1501-1507.

Cardoso, L. C.; Crispim, S. M. A.; Rodrigues, C. A. G. & Baroni Júnior, W. 2000b. Composição e dinâmica da biomassa aérea após queima em savanna gramíneo-lenhosa no Pantanal. *Pesquisa Agropecuária Brasileira* **35:**2039-2316.

Castro, E. A. & Kauffman, J. B. l998. Ecosystem structure in the Brazilian Cerrado: a vegetation gradient of aboveground biomass, root mass and consumption by fire. *Journal of Tropical Ecology* **l4:**263-283.

Castro-Neves, B. M. & Miranda, H. S. 1996. Efeitos do fogo no regime térmico do solo de um campo sujo de Cerrado. In: *Impactos de Queimadas em Áreas de Cerrado e Restinga*. H. S. Miranda; C. H. Saito & B. F. S. Dias (orgs.). ECL/UnB, Brasília. p.20-30.

César, H. L. *Efeito da queima e corte sobre a vegetação de um campo sujo na Fazenda Água Limpa, Distrito Federal, Brasília.* M. Sc. Thesis. Universidade de Brasília, Brasília, Brazil.

Christopher, S. A.; Wang, M. A.; Berendes, T. A.; Welch, R. M. & & Yang, S. K. 1998. The 1985 biomass burning season in South America: satelite remote sensing of fires, smoke and regional radiative energy budgets. *Journal of Applied Meteorology* **37:**661-678.

Costa, A. A. & Araújo, G. M. 2001. Comparação da vegetação arbórea de cerradão e de cerrado na Reserva do Panga, Uberlândia, Minas Gerais. *Acta Botanica Brasilica* **15:**63-72.

Coutinho, L. M. 1978. Aspectos ecológicos do fogo no cerrado. I-A temperatura do solo durante as queimadas. *Revista Brasileira de Botânica* **1:**93-97.

Coutinho, L. M. 1982. Ecological effects of fire in Brazilian cerrado. In: *Ecology of Tropical Savannas*. B. J. Huntley & B. H. Walker (eds.). Springer Verlag, Berlin. p.273-291.

Coutinho, L. M. 1990. Fire in the ecology of the Brazilian Cerrado. In: *Fire in the tropical biota - ecosystem processes and global challenges.* J. G. Goldammer (ed.). Ecological Studies Vol. 8A. Springer Verlag, Berlin. p.82-105.

Dias, B. F. S. 1992. Cerrado: uma caracterização. In: *Alternativas de desenvolvimento dos cerrados: manejo e conservação dos recursos naturais renováveis.* B. F. S. Dias (org.). FUNATURA/IBAMA, Brasília, p.15-26.

Dias, I. F. O. 1994. *Efeitos da queimada no regime térmico do solo e na produção primária de um campo limpo de cerrado.* M. Sc. Thesis. Universidade de Brasília, Brasília, Brazil.

Eiten, G. 1983. *Classificação da vegetação do Brasil*. CNPq, Brasília.

Eiten, G. 1994. Vegetação. In: *Cerrado: ocupação e perspectivas*. M. N. Pinto (org.). EDUNB/ SEMATEC, Brasília, Brazil. p.321-344.

Frost, P. G. & Robertson, F. 1987. The ecological effects of fire in savannas. In: *Determinants of Tropical Savannas*. B. H. Walker (ed.). IRL Press Limited, Oxford. p.93-140.

Haridasan, M. 1994. Solos. In: *Cerrado: ocupação e perspectivas*. M. N. Pinto (org.). EDUNB/ SEMATEC, Brasília, Brazil. p.321-344.

Hoffmann, W. 1998. Post-burn reproduction of woody plants in a neotropical savanna: the relative importance of sexual and vegetative reproduction. *Journal of Applied Ecology* **35:**422-433

Imaña-Encinas, J; Paula, J. E. & Sugimoto, N. 1995. Análise fitossociológica do cerrado da Fazenda Narflora. *Pesquisa Agropecuária Brasileira* **30:**577-582.

IPCC. 1996. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook.*

Klink, C. A. & Machado, R. B. 2005. Conservation of the brazilian cerrado. *Conservation Biology* **19:**707-713.

Luke, R. H. & McArthur, A. G. 1978. *Bushfires in Australia*. Australian Canberra, Government Publishing Service.

Macedo, M. C. M. 1995. Pastagens no ecossistema Cerrados: pesquisas para o desenvolvimento sustentável. In: *Anais da 22ª reunião anual da Sociedade Brasileira de Zootecnia e Simpósio sobre pastagens nos ecossistemas Brasileiros: pesquisas para o desenvolvimento sustentável.* SBZ, Brasília, Brazil. p.28-62.

Maia, J. M. F. 2003. *Balanço de energia e fluxo de carbono em uma área de cerrado que sofreu queima acidental*. Dr. Thesis. Universidade de Brasília, Brasília, Brazil.

Matos, M. R. B. 1994. *Efeito do fogo sobre os regenerantes de* Blepharocalyx salicifolius *H.B.K. (Myrtaceae) em cerrado aberto, Brasília, DF.* M. Sc. Thesis. Universidade de Brasília, Brasília, Brazil.

Medeiros, M. B. & Fiedler, N. C. 2004. Incêndios florestais no Parque Nacional da Serra da Canastra: desafios para a conservação da biodiversidade. *Ciência Florestal* **14:**157-168.

Medeiros, M. B. & Miranda, H. S. 2005. Mortalidade pós-fogo em espécies lenhosas de campo sujo submetido a três queimadas prescritas anuais. *Acta Botanica Brasilica* **19:**493-500.

Meirelles, M. L. 1981. *Produção primária e suas relações com fatores ambientais em pastagem artificial e campo sujo de cerrado queimado e natural.* M. Sc. Thesis. Universidade de Brasília, Brasília, Brazil.

Miranda, A. C.; Miranda, H. S.; Dias, I. O. & Dias, B. F. 1993. Soil and air temperatures during prescribed Cerrado fires in Central Brazil. *Journal of Tropical Ecology* **9:**313-320.

Miranda, A. C.; Miranda, H. S.; Lloyd, J.; Grace, J.; Francey, J. A.; Mcintyre, J.; Meir, P.; Riggan, P.; Lockwood, R. & Brass, J. 1996. Carbon dioxide flux over a cerado *sensu stricto* in central Brazil. In: *Amazonian deflorestation and climate.* J. H. S. Gash; C. A. Nobre; J. M. Roberts & R. L. Victoria (eds.), Institute of Hidrology. p.353-363.

Miranda, H. S.; Rocha e Silva, E. P. & Miranda, A. C. 1996. Comportamento do fogo em queimadas de campo sujo. In: *Impactos do Fogo em Áreas de Cerrado e Restinga*. H. S.

Miranda, C. H. Saito & B. F. S. Dias (orgs.), ECL/UnB, Brasília. p. 1-10.

Miranda, H. S.; Miranda, A. C. & Bustamante, M. M. C. 2002. The fire factor. In: *The Cerrados of Brazil: Ecology and Natural History of a Neotropical Savanna.* Oliveira, P. S. & Marquis, R. J. (eds.) Columbia University Press, NY, USA. p.51-68.

Nardoto, G. B. 2000. *Efeito de queimadas na mineralização de nitrogênio e em processos de ciclagem de nutrientes em uma área de cerrado* sensu stricto. M. Sc. Thesis. Universidade de Brasília, Brasília, Brazil.

Neto, W. N.; Andrade, S. M. A. & Miranda, H. S. 1998. The dynamics of the herbaceous layer following prescribed burning: a four years study in the Brazilian savanna. In: *Proceedings of 3rd International Conference on Forest Fires Research*. D. X. Viegas (ed.) Coimbra, Portugal. **2:**1785-1792.

Oliveira, P. E. & Gibbs, P. E. 2000. Reproductive biology of woody plants in a cerrado community of Central Brazil. *Flora* **195:**311-329.

Oliveira, R. S. 1999. *Padrões sazonais de disponibilidade de água nos solos de um cerrado e um campo sujo e evapotranspiração.* M. Sc. Thesis, Univerisidade de Brasília, Brasília, Brazil.

Ottmar, R.; Vihnanek, R. E.; Miranda, H. S.; Sato, M. N. & Andrade, S. M. A. 2001. *Stereo photo series for quantifying Cerrado fuels in Central Brazil.* Volume I. Gen. Tech. Rep. PNW-GTR-519. USDA-FS, Northwest Research Station. Portland, OR.

Pivello, V. R. & Coutinho, L. M. 1992. Transfer of macro-nutrients to the atmosphere during experimental burnings in an open cerrado (Brazilian savanna). *Journal of Tropical Ecology* **8:**487-497.

Quesada, C. A.; Miranda, A. C.; Hodnett, M. G.; Santos, A. J. B.; Miranda, H. S. & Breyer, L. M. 2004. Seasonal and depth variation of soil moisture in a burned open savanna (campo sujo) in central Brazil. *Ecological Applications* **14:**S33-S41.

Rachid-Edwards, M. 1956. Alguns dispositivos para proteção de plantas contra a seca e o fogo. *Boletim da Faculdade de Filosofia, Ciências e Letras. USP*, 209, *Botânica* **13:**39-68.

Ramos-Neto, M. B. 2000. *O Parque Nacional das Emas (GO) e o fogo: implicações para a conservação da biologia.* Ph. D. Thesis, Universidade de São Paulo, São Paulo, Brazil.

Ramos-Neto, M. B. & Pivello, V. R. 2000. Lightning fires in a Brazilian savanna national park: rethinking management strategies. *Environmental Management* **26:**675-684.

Ratter, J. A.; Ribeiro, J. F. & Bridgwater, S. 1997. The Brazilian Cerrado vegetation and threats to its biodiversity. *Annals of Botany* **80:**223-230.

Rawitscher, F. & Rachid, M. 1946. Troncos subterrâneos de plantas brasileiras. *Anais da Academina Brasileria de Ciências* **18:**261-280.

Ribeiro, J. F. & Walter, B. M. T. 1998. Fitofisionomias do bioma Cerrado. In: *Cerrado: ambiente e flora.* S. M. Sano & S. P. Almeida (ed.). Embrapa Cerrado, Planaltina. p.89-166.

Rivera, G.; Elliott, S.; Caldas, L. S.; Nicolossi, G.; Coradin, V. T. R. & Borchert, R. 2002. *Trees* **16:**445-456.

Rocha e Silva, E. P. 1999. *Efeito do regime de queima na taxa de mortalidade e estrutura da vegetação lenhosa de campo sujo de cerrado*. M. Sc. Thesis. Universidade de Brasília, Brazil.

Rosa, C. M. M. 1990. *Recuperação pós-fogo do estrato rasteiro de um campo sujo de cerrado.* M. Sc. Thesis. Universidade de Brasília, Brasília, Brazil.

Salgado-Laboriau, M. L. & Ferraz-Vicentini, K. R. F. 1994. Fire in the Cerrado 32000 years ago. *Current Research in the Pleistocene* **11:**85-87.

Sambuichi, R. H. R. 1991. *Efeitos de longo prazo do fogo periódico sobre a fitossociologia da camada lenhosa de um cerrado em Brasília, DF.* M. Sc. Thesis. Universidade de Brasília, Brazil.

Sano, E. E.; Barcellos, A. O. & Bezerra, H. S. 1999. *Área e distribuição espacial de pastagens cultivadas no cerrado brasileiro.* Boletim de Pesquisa 3. Embrapa Cerrados, Planaltina, Brazil.

Santos, A. J. B.; Silva, G. T.; Miranda, H. S.; Miranda, A. C. & Lloyd, J. 2003. Effects of fire on surface carbon, energy and water vapour fluxes over campo sujo savanna in central Brazil. *Functional Ecology* **17:**711-719.

Santos, J. R. 1988. *Biomassa aérea da vegetação de cerrado: estimativa e correlação com dados do sensor "thematic mapper" do satélite Landsat.* Ph. D. Thesis, Universidade Federal do Paraná, Curitiba, Paraná, Brazil.

Sato, M. N. 2003. *Efeito a longo prazo de queimadas na estrutura da comunidade de lenhosas da vegetação do cerrado* sensu stricto. Dr. Thesis. Universidade de Brasília, Brasília, Brazil.

Silva, F. C. 1990. *Compartilhamento de nutrientes em diferentes componentes da biomassa aérea em espécies arbóreas de um cerrado.* M. Sc. Thesis. Universidade de Brasília, Brazil.

Silva, G. T. 1999. *Fluxos de* CO_2 *em um campo sujo submetido a queimada prescrita.* M. Sc. Thesis. Universidade de Brasília, Brasília, Brazil.

Vale, A. T. 2000. *Caracterização da biomassa lenhosa de um cerrado* sensu stricto *da região de Brasília para o uso energético.* Ph. D. Thesis. UNESP, Botucatu, São Paulo, Brazil.

Ward, D. E.; Susott, R. A.; Kauffman, J. B.; Babbit, R. E; Cummings, D. L.; Dias, B.; Holben, B. N.; Kaufman, Y. J.; Rasmussen, R. A. & Setzer, A. W. 1992. Smoke and fire characteristics for cerrado and deforestation burns in Brazil: BASE-B experiment. *Journal of Geophysical Research* **97:**14601-14619.

RECENT CLIMATIC CHANGES ON THE WEST COAST EXTRATROPICAL REGION OF SOUTH AMERICA (CHILE)

PATRICIO ACEITUNO

BENJAMIN ROSENBLUTH

JUAN PABLO BOISER

Departamento de Geofísica/Universidad de Chile, Santiago – Chile

JUAN QUINTANA

CLAUDIA VILLARROEL

Dirección Meteorológica de Chile, Santiago - Chile

INTRODUCTION

The main factors that define the climate characteristics on the extra-tropical west coast of South America (20 °S - 55 °S) are the Subtropical Eastern-South Pacific Anticyclone and the migratory systems associated to the westerly circulation in mid-latitudes. The Humboldt cold stream, in addition to the coastal cold water upwelling forced by winds, predominantly from the south, contribute to the existence of a remarkable atmospheric stability in subtropical latitudes, and to a large thermal homogeneity throughout the coast. The Andes mountain range constitutes another significant influence factor on the regional climate, isolating the western subtropical side of the continent from the influence of air masses from Atlantic origin, specially to the north of 35°S (Figure 1), and intensifying the precipitation during the passage of frontal systems as a result of the upward motion of humid and unstable air masses originated in Pacific. Also, this mountain range acts as a great storage of water resources that remains retained in the snow form during the winter to free itself later by melting during the warm season.

The spatial distribution of the precipitation regime in the western continental extra-tropical border is determinant for defining the landscape, the population concentration and the development of the productive system of this region. The annual precipitation increases from north to south, from almost total rain absence in the arid region at about 25°S (Atacama Desert) to more than 4000 mm/year in the islands facing the Pacific Ocean at approximately 45°S (Figure 1). In the subtropical region the precipitation regime is characterized by the Mediterranean type, with a humid season during the winter and dry in the summer. South of 42°S, where the precipitation regime is relatively homogenous throughout the year, a strong zonal gradient is observed due to the moist condition windward of the Andes (annual precipitation greater than 4000 mm/year) and the considerably drier region leeward of the Andes, where the precipitation is an order of magnitude smaller.

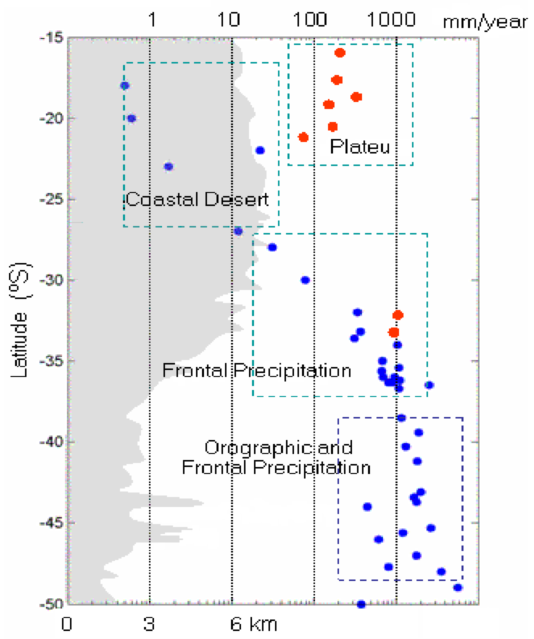


Figure 1 - Profile of the annual precipitation in the west part of South America between 15ºS and 50ºS (upper scale). Circles in blue (red) indicate locations located at heights above 2000 m above sea level.. Areas in gray represent a schematic profile of the highest summits on the mountain range of the coast (lower scale). (Courtesy of R. Garreaud).

The interannual climate variability has been studied mainly with respect to the control exerted by the Southern Oscillation, presenting significant evidence of unusually rainy winters in the latitudinal band 30°S - 35°S under El Niño conditions in the equatorial Pacific and precipitation deficit during La Niña events . Recent studies shows that this type of relation also occurs during the austral spring (September/October/November - SON) in the latitudinal band 35°S - 40°S, whereas the inverse relationship, characterized by precipitation deficit during the EL Niño events, characterizes the latitudinal band 40°S - 42°S during the austral summer (Montecinos and Aceituno, 2003).

CHANGES IN THE PRECIPITATION REGIME AND ASSOCIATED FACTORS

In contrast to the observations in the eastern sector of the subtropical region of the continent, where the precipitation has significantly increased in the most recent decades (Mud et al., 2000; Montecinos et al., 2000), Central Chile shows a prevailing negative tendency up to the 70's (Quintana, 2004). Figure 2 shows the changes of the spatial structure in the linear tendency of the annual precipitation in the 30 years period. In general Figure 2 shows that the tendency in the subtropical region (30°S -

39°S) tends to be opposed to the observed tendency in mid-latitudes. Thus, up to the 70's a slightly negative tendency characterizes the region between 33°S - 39°S continuing up to the 80's between 37°S and 41°S. This evolution contrasts with the observed precipitation tendency in the region around 43°S.

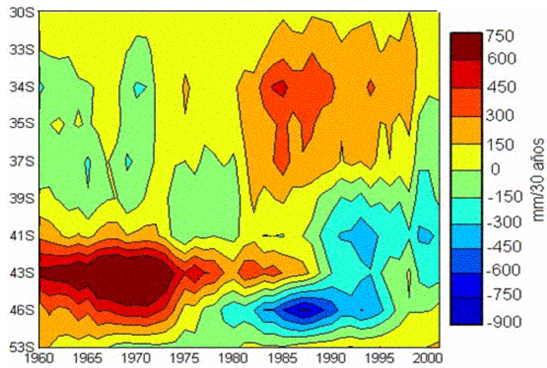


Figure 2 - Linear tendency of the annual precipitation (mm/30 years) for moving periods of 30 years between 1930 and 2000, based on regional precipitation indices of the western side of South America between 30°S and 53°S. The horizontal scale indicates the last year of every period of 30 years (note that the latitude scale is not linear).

Significant changes in the spatial structure of the linear tendency are identified after the 70s, with the opposite trend of the previous period. In this way the period of 30 years ending in the 80's shows a positive tendency in the subtropical region that contrasts with a significant opposite tendency in the region around 46°S. In qualitative terms, this structure is maintained when the 30 years periods include years in the 90's, although indicating a weakening of the positive tendency in the subtropical region and an expansion towards the north until approximately 39°S where a negative tendency in the annual precipitation is observed. Figure 3 shows the meridional structure of the linear tendency of the annual precipitation in the 1970-2000 period. To the north of 34°S the annual precipitation was approximately stationary in this period, whereas in the center-south region and southern Chile (38°S - 43°S) a significant negative tendency is identified. One of the most important factors that control the annual precipitation cycle in the western coast of South America, as well as its variability in all time scales is the intensity and location of the Subtropical Anticyclone of the Eastern South Pacific (SAESP).

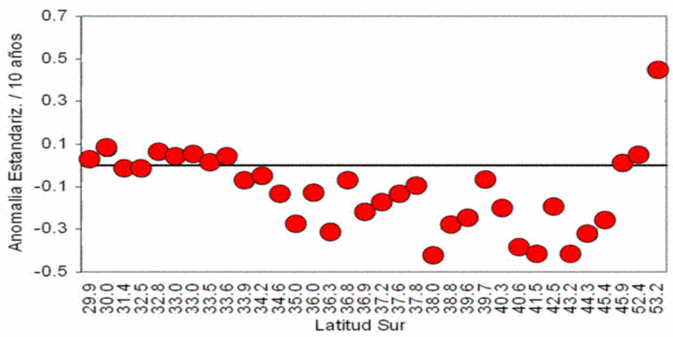


Figure 3 - Linear tendency of the annual precipitation in pluviometric stations of Chile (30ºS - 53ºS) in the period 1970 - 2000. The tendencies express changse in standardized units every 10 years. The values with above 0.30/decade magnitude are significant with a level of 95% confidence.

During the summer the anticyclone moves to the south, together with other elements of the hemispheric circulation, imposing stable conditions that lead to the dryness of the regional climate during this time of year. In the winter the anticyclone moves towards the north, favoring the occasional displacement of frontal systems that are responsible for most of the precipitation events during the rainy season. Figure 4 shows the time evolution of an intensity index of the SAESP that is based on monthly averages of the atmospheric pressure in stations located in the north and central regions of Chile and in the Island Juan Fernandez and Pascua Island (Quintana, 2004). Consistently with the change towards the warm phase of the Southern Oscillation and of the Pacific Decadal Oscillation in the middle of the 70s, a significant weakening of the anticyclone is identified in this figure during the 80s and 90's. This evolution is, on the other hand, consistent with the slightly positive tendency that was observed in the Central Chile precipitation during these decades, as discussed later. The reinforcement of the SAESP during the most recent period could be part of a new change in the circulation pattern, this time towards the cold phase of both the Southern Oscillation and the Pacific Decadal Oscillation.

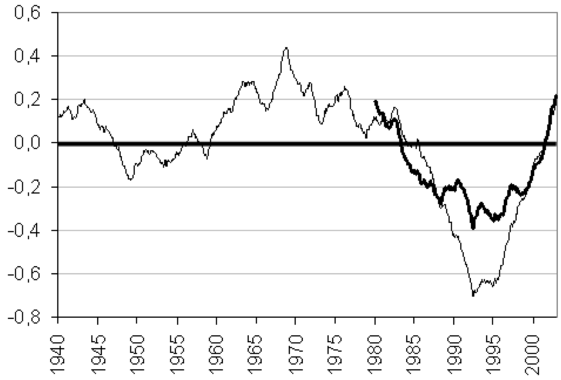


Figure 4 - Moving average of 10 years of the standardized intensity of the intensity of the subtropical anticyclone of the southeastern of the Pacific (SAESP). Thick line: intensity during 1970-2002 on the basis of monthly information of atmospheric pressure in 6 stations in the North and Central regions of Chile, beyond a station in the Island Juan Fernandez (33,0 ºS, 80,0 ºW) and another one in Pascoa Island (27,1 ºS, 109,3 ºW). Thin line: intensity during 1930 - 2002 based on monthly data of atmospheric pressure in Santiago (33.5ºS, 70.7ºW). The values are indicated at the end of every period of 10 years.

CHANGES IN THE TEMPERATURE REGIME

The evolution of annual averages of daily extreme temperatures (maximum and minimum) between 1961 and 2004 in 16 Chilean weather stations located between 18ºS and 53ºS are analyzed in the section. One of the main and widespread characteristic in these time series is the relatively sharp temperature increase observed in the mid 70's, that coincides with the beginning of a period characterized by a greater frequency of events El Niño and with a transition towards the warm phase of Pacific Decadal Oscillation, as discussed in the previous section. This behavior, that reveals the existence of relatively fast changes in the Pacific atmosphere-ocean system behavior in the decadal time scale, is displayed in Figure 5 in relation to the evolution of the annual averages of daily extreme temperatures in four seasons on the northern region of Chile. A similar analysis made for each one of the indicated stations in Table 1, shows that the change of the extreme temperatures regime in the middle of 70's was particularly strong in the central and southern region of Chile (37ºS-41ºS) where the period previous to 1976 was marked by a significant negative temperature tendency (Rosenbluth et al., 1997).

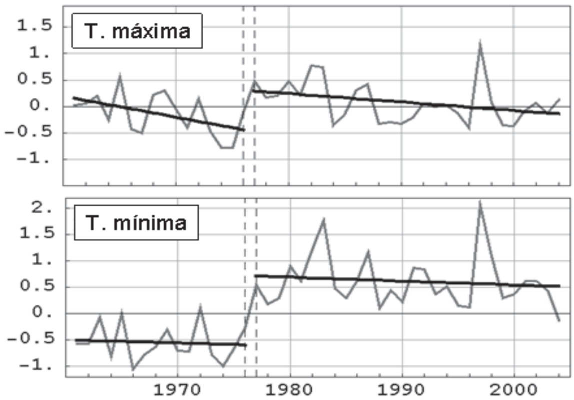


Figure 5 - Annual average of the daily maxima and minimum temperatures anomalies in four seasons of the North region of Chile between 1961 and 2004: Antofagasta, 23.4ºS; Copiapó, 27.3ºS; Vallenar, 28.6ºS; La Serena 29.9ºS. The anomalies were calculated with respect to the period 1961-1990. The straight lines indicate the linear regressions for periods 1961 - 1976 and 1977 - 2004.

In agreement with the previous discussion, it is reasonable to separate the tendency analysis for periods previous and later to 1976. Table 1 and Figure 6 shows the annual averages of the tendencies of daily extreme temperatures between 1976 and 2004. In the coastal region to the north of 30ºS the annual average of minimum temperature remained relatively stationary, with the exception of a pair of stations that show opposite sign tendencies (+0.24ºC/decade in Arica and -0.12 ºC/decade in Vallenar). With respect to the daily maximum temperature regime, this region is characterized by a negative tendency (with a rate between -0.1ºC and -0,6ºC/decade), that could be conditioned by changes in the coastal stratiform cloudiness regime that characterizes this region. Both daily minimum and maximum temperature regime are strongly altered during the El Niño events when very significant increases with respect to the climatologic average are registered.

Table 1 - Linear tendencies (°C/decade) of the the annual averages of daily extreme temperatures (maxima and minim) during period 1976 - 2004.

Estación	Lat.°S	Lon.°W	T. mínima °C/década	T. máxima °C/década
Arica	18,3	70,3	0,24	-0,49
Iquique	20,5	70,2	-0,02	-0,55
Antofagasta	23,4	70,4	0,03	-0,14
Copiapó	27,3	70,4	0,05	0,00
Vallenar	28,6	70,8	-0,12	-0,17
La Serena	29,9	71,2	0,02	-0,21
Santiago - Q.N.	33,4	70,7	0.05	0,18
Curicó	35,0	71,2	0,15	0,20
Chillán	36,6	72,0	0,15	0,05
Concepción	36,8	73,0	0,04	0,11
Temuco	38,7	72,6	-0,02	0,14
Valdivia	39,6	73,0	0,12	-0,01
Osorno	40,6	73,0	0,11	-0,03
Puerto Montt	41,4	73,0	-0,12	0,04
Coyhaique	45,6	72,0	0,10	-0,06
Punta Arenas	53,0	70,8	-0,02	0,15

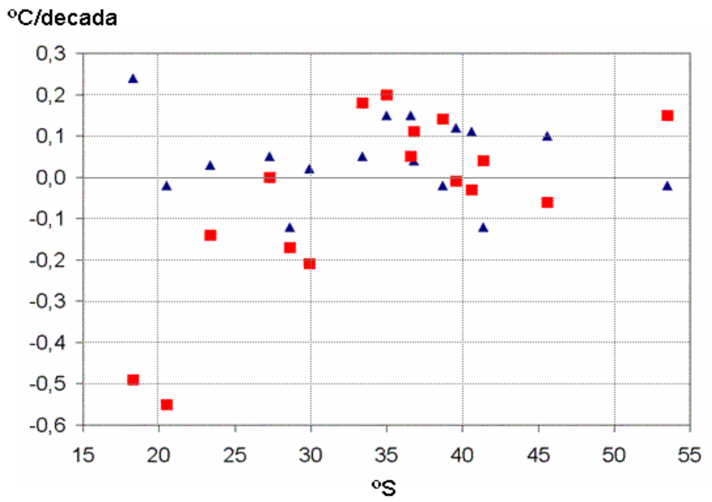


Figure 6 - Linear tendency (ºC/decade) of the the annual averages of daily extreme temperatures in Chilean stations (18ºS - 53ºS) in period 1976 - 2004. The squares and triangles represent the maxima and minimum temperature, respectively.

In Figure 6 it is shown that in Central Chile (33ºS - 38ºS) the period 1976- 2003 was characterized by moderate positive tendencies (less than +0.2ºC/decade) both in the annual average of daily minimum and maximum temperature. On the other hand, in stations to the south of 38ºS, prevails a stationary regime of the maximum temperature (with exception of the series of Temuco at 38.7ºS and Punta Arenas at 53.0ºS that show a linear tendency of order +0,15ºC/decade) and tendencies that varies approximately between +0.1ºC and -0.1ºC/decade in daily minimum temperature annual average.

The change in the temperature regime of the middle 70s', illustrated in Figure 5, is also observed in the evolution of some parameters that quantify the frequency of occurrence of extreme conditions. Figure 7 shows the evolution of the annual percentage of warm nights in 5 stations in northern Chile located between 18ºS and 30ºS. One warm night is defined by the minimum temperature equal or larger than the 90% percentile of the distribution of the minimum temperature corresponding to the respective date. A significant increase in the percentage of warm nights after 1976 is noticed in Figure 7, with vales in excess of 40% during the El Niño episodes of 1982-83 and 1997-98.

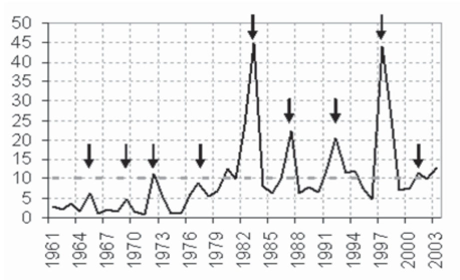


Figure 7 - Average of the annual percentage of warm nights (minimum temperature equal or larger than the 90% percentile of the distribution corresponding to the respective date) in 5 stations of the northern coast of Chile between 18ºS and 30ºS (Arica, Iquique, Antofagasta, Copiapó and La Serena). The geographical coordinates of the stations are indicated in Table 1.

The linear tendencies in the annual frequency of warm and cold nights (when the minimum temperature is less than the 90% and 10% percentile, respectively) during period 1961-2003 are shown in Figure 8. A coherent pattern of increase (decrease) in the frequency of warm (cold) nights is noticed, what has been also detected in previous studies (Vincent et al., 2005).

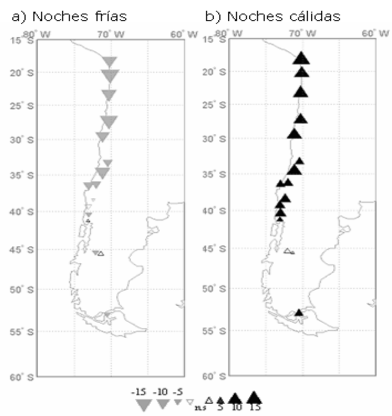


Figure 8 - Linear tendencies of the annual frequencies of warm and cold nights in period 1961 - 2003 expressed by the number of days per decade. The positive tendencies (negative) are indicated with triangles pointing upwards (downwards). The tendencies that are statistically significant are indicated with full triangles: positive in black and negative in gray.

Nevertheless, these results clearly indicate that these tendencies do not reflect a gradual change and are associated with the relatively abrupt change, already mentioned in the temperature regime. This conclusion is confirmed by the results presented in Figure 9 that shows the absence of significant tendencies in the frequency of warm nights when the periods 1961 - 1976 and 1977 – 2003 are computed separately.

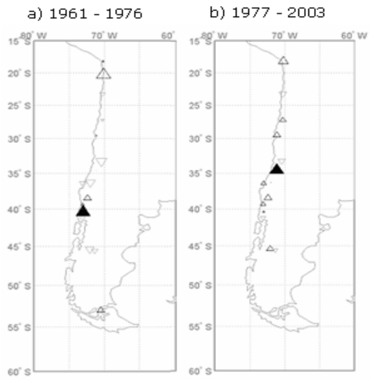


Figura 9 - Identical to Figure 8, but for the linear tendencies of the annual frequency of warm nights in periods 1961 - 1976 and 1977 - 2003

CONCLUSIONS

The recent climatic change in the extra-tropical region of the western coast of South America has been significantly conditioned by the functioning the coupled ocean-atmosphere system in the Pacific Ocean that manifested as a large regime change in middle of the 70's and that was reflected by a greater frequency of El Niño events, in a transition towards the warm phase of the Decadal Pacific Oscillation and in the weakening of the intensity of the Eastern South Pacific Subtropical Anticyclone. During the period after 1976 the annual precipitation does not show a significant tendency in the subtropical region between 30ºS and 34ºS but a significant decrease in the Center-South region of Chile (38°S - 43°S). In addition, it is an interesting to point out that most of the models that project the climatic scenarios for the XXI Century due to the increase of the greenhouse gases effect also suggest decreasing precipitation in this same region. With respect to the evolution of the near surface temperature, a linear tendency of +0.2°C/decade was observed in the annual averages of the maximum and minimum temperatures in the Central Region of Chile (33°S - 38°S) during period after 1976. On the other hand, in the arid coast between 18°S and 30°S, the minimum temperature regime has remained approximately stationary during this period, whereas the annual average of daily maximum temperature presented a significant decrease in most of the stations. The analyzed series of daily extreme temperatures for the region to the south of 38 ºS do not reveal tendencies during the most recent decades.

CLIMATE VARIABILITY AND CHANGE: PAST, PRESENT, AND FUTURE

ANTONIO J. BUSALACCHI
Earth System Science Interdisciplinary Center
University of Maryland, College Park, MD

The World Climate Research Programme (WCRP) was established in 1980, under the joint sponsorship of International Council for Science (ICSU) and the World Meteorological Organization (WMO), and has also been sponsored by the Intergovernmental Oceanographic Commission (IOC) of UNESCO since 1993. The objectives of the programme are to develop the fundamental scientific understanding of the physical climate system and climate processes needed to determine to what extent climate can be predicted and the extent of human's influence on climate. The programme encompasses studies of the global atmosphere, oceans, sea and land ice, and the land surface which together constitute the Earth's physical climate system. WCRP studies are specifically directed to provide scientifically founded quantitative answers to the questions being raised on climate and the range of natural climate variability, as well as to establish the basis for predictions of global and regional climatic variations and of changes in the frequency and severity of extreme events.

The WCRP project on Climate Variability and Predictability (CLIVAR) builds on the legacies of the WCRP core projects for the Tropical Ocean Global Atmosphere (TOGA) and the World Ocean Circulation Experiment (WOCE) of the 1980's and 1990's. As the largest and most comprehensive of the WCRP core projects, CLIVAR has as its mission, "to observe, simulate and predict Earth's climate system, with focus on ocean-atmosphere interactions, enabling better understanding of climate variability, predictability and change, to the benefit of society and the environment in which we live". The research agenda for CLIVAR spans studies of seasonal to interannual climate predictability, monsoon circulations, decadal climate variability, paleoclimate, and the anthropogenic influence on climate that underpins the Intergovernmental Panel on Climate Change (IPCC). In particular, this international research programme investigates climate variability and predictability on time-scales from months to decades and the response of the climate system to anthropogenic forcing. Research interests and activities within CLIVAR include studies of climate phenomena such as El Nino, monsoon circulation, North Atlantic Oscillation, decadal climate variability and the ocean thermohaline circulation. VAMOS serves as that part of the program where research on the atmosphere-ocean-land coupling come together in support of studying the variability of the monsoon and warm season precipitation over the Americas.

The specific objectives of CLIVAR are:

- To describe and understand the physical processes responsible for climate variability and predictability on seasonal, interannual, decadal, and centennial time-scales, through the collection and analysis of observations and the development and application of models of the coupled climate system, in cooperation with other relevant climate-research and observing programmes.

- To extend the record of climate variability over the time-scales of interest through the assembly of quality-controlled paleoclimatic and instrumental data sets.
- To extend the range and accuracy of seasonal to interannual climate prediction through the development of global coupled predictive models.
- To understand and predict the response of the climate system to increases of radiatively active gases and aerosols and to compare these predictions to the observed climate record in order to detect the anthropogenic modification of the natural climate signal.

The science and implementation plans for CLIVAR were developed in the late 1990's. Delegates from 63 countries, consisting of 250 scientists, policy makers, and program managers, met in Paris at UNESCO on December 2-4, 1998 to review the 15-year CLIVAR science and implementation plans. Individual national contributions to CLIVAR were introduced at that time. The actual implementation of CLIVAR began in earnest in 1999. An International CLIVAR Project Office (ICPO) in Southhampton, UK coordinates the implementation of CLIVAR together with a Scientific Steering Group and a series of panels and working groups. The success of CLIVAR to date is a testimony to the dedication of the ICPO leadership, its scientific staff officers, and the members of the CLIVAR scientific community who have served on CLIVAR panels and working groups.

The first International CLIVAR Scientific Conference was held in Baltimore, June 21-25, 2004 and consisted of the world's leading climate scientists and was the WCRP's largest scientific conference to date. Approximately five years into the project, the Conference provided an opportunity to take a retrospective look at the project's progress over its initial phase and, as a result, determine the future directions for CLIVAR between now and 2013. The scientific gathering in Baltimore enabled the community to discuss such issues as global versus regional perspectives of climate monitoring and prediction. For example, the tools needed to monitor and predict climate increasingly recognize the interconnected global nature. Hence, climate scientists around the world are developing global Earth System models and global Earth System data assimilation systems. Remotely-sensed observations of the coupled climate system provide a global context. Yet, many of the basic observations that feed into data assimilation systems are local observations be they TAO buoys or ARGO floats. Furthermore, the impact that climate predictions have on society are local impacts, be it of relevance for the farmer in Africa or the water manager in Asia. Of the key challenges for CLIVAR over the coming years is the development of a framework where the interactions between local and global scales are fully exploited. This will benefit both our scientific understanding of climate and the impact climate science can have on society as a whole.

For example, the scientific objectives of CLIVAR on decadal to centennial time scales are to describe and understand decadal to centennial climate variability and predictability through the analysis of observations and the modeling of the coupled climate system, to extend the record to decadal to centennial variability through paleoclimatic studies, data archeology, reanalysis of atmospheric and oceanic data, and to develop and implement appropriate observing, computing, and data archiving and dissemination programs needed to understand the mechanisms of decadal to centennial climate variability and predictability in cooperation with other relevant climate research and observing programs. The principal research areas of CLIVAR on this time scale include the Pacific and Indian Oceans Decadal Variability, Tropical Atlantic Variability, the North Atlantic Oscillation, the Atlantic Thermohaline Circulation, and Southern Ocean Climate Variability.

The CLIVAR DecCen principal research area on the Pacific and Indian Oceans Decadal Variability provides the major link with the CLIVAR objectives on seasonal to interannual climate variability. On decadal time scales, climate variations in the Pacific and Indian Oceans involve all latitudes. They include a modulation of ENSO, lower frequency variations, and possible trends in the coupled climate system. It has been noted that there are distinctly different patterns for interannual and longer term variability in global sea surface temperature. For example, the North Pacific Ocean SST anomaly is stronger for the pattern of decadal and longer term variability than for the interannual which is dominated by ENSO. Regression analyses for Pacific Ocean sea surface temperature and 500 mb pressure indicate that the decadal mode contains the strong variability of North Pacific SST that correlates most strongly with the PNA teleconnection pattern while the interannual variability of SST characteristic of ENSO correlates with a more zonal atmospheric pattern. Western boundary currents such as the Kuroshio are also of special interest because they transport large amounts of mass and heat poleward relatively rapidly, and therefore provide a critical feedback mechanism in some theories of decadal modes of coupled ocean atmosphere interaction. In contrast to the Pacific Ocean, the database in the Indian Ocean is poor; therefore, knowledge of decadal variability in and around the Indian Ocean is poor as well.

A major emphasis of this principal research area is an interdecadal Pacific climate mode that extends over the whole of the Pacific Ocean in a fairly simple spatial pattern that may modulate ENSO on decadal time scales. A current hypothesis for its maintenance that CLIVAR is investigating include subtropical gyre feedbacks on the atmosphere, tropical/subtropical interactions through both the atmosphere and the ocean, and a null hypothesis regarding the excitation of a basic mode of the atmosphere which is imprinted on the ocean. The evaluation and generation of new hypotheses will require focused process experiments and a commitment to the global survey and monitoring of the Pacific. The proposed processes that will need to be investigated with respect to an interdecadal Pacific climate mode include investigation of the upper ocean variability through the thermocline, feedbacks with the atmosphere, mixed layer formation and maintenance, connection from the mixed layer to the interior via subduction, and the subsurface advection of thermal anomalies.

Much of the CLIVAR DecCen focus is centered in the Atlantic Ocean basin. With respect to Tropical Atlantic Variability, extensive research in the last 30 years has indicated a strong link between various climate related impacts occurring in countries surrounding the tropical Atlantic basin and sea surface temperature anomalies in the tropical Atlantic Ocean. For example, the well-known droughts of northeast Brazil have been shown to be closely related to anomalously warm/cold sea surface temperature anomalies in the tropical north/south Atlantic. Droughts in sub-Saharan Africa are often found to be associated with a broad band of negative/positive sea surface temperature across tropical north/south Atlantic. Rainfall variability in the central American/Caribbean region also appears to be related to tropical North Atlantic sea surface temperature fluctuations. Of particular importance to the rainfall in northeast Brazil, and to a lesser extent in the Sahara region of Africa, is the variation of the interhemispheric sea surface temperature gradient. Empirical analyses indicate the sea surface temperature anomaly pattern in the tropical Atlantic Ocean exhibits a meridional mode with opposite values on either side of the thermal equator.

Two competing hypotheses have been put forward to explain the variability of the cross equatorial sea surface temperature gradient. One hypothesis is that decadal variations of the interhemispheric sea surface temperature gradient stem from regional ocean/atmosphere positive feedbacks involving primarily sea surface temperature and wind induced latent heat flux. Under this scenario when there is warm sea surface temperature north of the equator there is a corresponding low sea level pressure and weakened northeast trade winds. This results in a northward cross-equatorial wind anomaly. Coincident with this, low sea surface temperature, high sea level pressure, and strengthened southeast tradewinds exist south of the equator. Although this air-sea interaction hypothesis assumes that the circulations on both sides of the equator are related, it does not require that sea surface temperature changes in each hemisphere be simultaneous as in a perfect SST dipole. What is fundamentally important is the variability of the interhemispheric SST gradient. Correlation and empirical analyses also suggest that the sea surface temperature in the tropical North Atlantic may also be under the external influence of ENSO variability from the Pacific Ocean, and as will be discussed later, the influence of the North Atlantic Oscillation from higher latitudes.

The other hypothesis for tropical Atlantic variability views the development of SST anomalies on either side of the equator as being dynamically independent and controlled by processes in each hemisphere. If SST anomalies occur independently on either side of the equator, the variation of interhemispheric SST gradient may not have preferred time scales. This hypothesis postulates that variability of the cross equatorial SST gradient is largely stochastic or preferentially controlled by one hemisphere over the other.

Similar to the situation in the Indian Ocean, the lack of a sufficient observation data base has hampered progress in elucidating these scientific questions in the tropical Atlantic. This is being partially addressed by the Pilot Research Moored Array in the Tropical Atlantic (PIRATA). This joint Brasil-France-US observational initiative PIRATA has existed since 1997 with the full array being in place in the later part of 1999. This moored array is an extension of the TAO Array in the tropical Pacific Ocean. It consists of approximately 12 moorings including one zonal mooring section along the equator and two meridional mooring sections, one along 38°W between 4°N - 15°N, and the other along 10°W between 10°S - 2°N. This array provides well resolved time series measurements of surface heat and moisture fluxes, SST and salinity, and subsurface thermal and current structures down to 500 m. Just recently, a Southwest Extension was successfully initiated and deployed by Brasil. Both Northeast and Southeast extensions are envisioned for the year ahead.

At higher latitudes in the Atlantic Ocean, the North Atlantic Oscillation is a principal research area of study. The NAO is a large scale alternation of atmospheric mass with centers of action near the Icelandic Low and Azores High. The high index phase of the NAO is characterized by an intense Icelandic Low with a strong pressure ridge to the south and is associated with strong mid-latitude westerlies. The converse is true for the low index phase of the NAO. Time series analysis of the NAO index indicates that this oscillation is broad band in frequency with spectral peaks at periods of 24, 8, and 2-3 years, as well as multi-decadal energy. At long periods the NAO index indicates a decadal alternation in the amplitude since the late 19th century with low-index extrema during the 1960's and high-index extrema from 1900-1930 and in the 1990's. There is also evidence that the multi-decadal signal has been amplifying with time. Multi-variate, linear regression analyses between the NAO index and Northern Hemisphere surface temperature indicate that 50% of the December-March temperature variance is accounted for by a combination of the NAO and Southern Oscillation variability, of which one-third of this signal is attributed to the NAO. Taken together these modes of variability account for the majority of the warming in the past 20 years. Hence, a major goal of CLIVAR is to study the extent to which these interannual to decadal changes in the NAO index are predictable.

As the dominant mode of the atmospheric behavior in the North Atlantic sector, the NAO is associated with large systematic amplitude patterns in anomalies of precipitation, wind speed, latent heat, sensible heat, and SST over much of the extratropical north Atlantic. These include changes in the Atlantic storm track fluctuations, the number of winter storms, the strength of the mid-latitude westerlies, and their impact on significant wave height within the ocean. Changes in ocean circulation related to the NAO include temperature and salinity fluctuations in the Greenland-Labrador Sea, the convection strength of Labrador Sea water, and sea ice discharge out from the Arctic Ocean.

A key unresolved question with respect to the NAO is whether observed anomalies in oceanic conditions represent a passive response to decadal changes in the atmospheric circulation, or whether they feed back to force decadal and longer period oscillations in the NAO. For example, the low phase of the NAO is associated with warming of subpolar SST in the north Atlantic, and conversely cooler SSTs during the high phase of the NAO. It has also been noted that the oceanic transport of the Gulf Stream and North Atlantic Current appears to lag the NAO index by approximately 4 to 5 years. Thus, the modeling and prediction studies of the NAO are geared toward determining whether the variability simulated in models is fundamentally coupled, whether one component of the climate system drives variability in another, whether simulated variability modes are related to observed variations and whether modes of variability once identified are predictable. The complimentary field program for the NAO in CLIVAR is largely determined by the need to confirm and quantify the factors which redistribute, protract or amplify the SST anomaly field of the North Atlantic sector such as the variability of North Atlantic heat fluxes and storage, water mass conversion processes in the subpolar north Atlantic, and the Arctic response to NAO forcing.

In addition to the North Atlantic Oscillation, study of the North Atlantic thermohaline circulation is another principal research area of CLIVAR. Research on this topic is needed because the oceanic heat transport in the Atlantic Ocean has an obvious and well-known impact on climate. This is of direct interest to CLIVAR DecCen to the extent that variations of the thermohaline circulation on decadal to centennial time scales lead to changes in SST and ocean heat transports. Observations have shown that the water mass distributions in the subpolar North Atlantic change on decadal time scales. In particular, convection activity in the source regions for the deep thermohaline circulation has been observed to undergo substantial changes on decadal time scales. In the late 1960's, for example, intense convection down to 3,500 m occurred in the Greenland Sea. In contrast, the Labrador Sea convection was tightly capped by a lense of fresh water that had built up at the surface. At lower latitudes there was intense production of 18° water in the Sargasso Sea region. Twenty five years later during the early 1990's an opposite scenario was operant. At this time there was minimal convection in the Greenland Sea down to 1,000 m, whereas convection was at record intensity in the Labrador Sea down to 2,300 m and penetrated the North Atlantic Deep Water sublayer. At lower latitudes there was minimal production of 18° water within the Sargasso Sea.

Paleooceanographic data show that climate changes have occurred sometimes very rapidly in the geological past and were associated with changes in the thermohaline circulation such as the formation of North Atlantic Deep Water. Model results suggest that a collapse of the thermohaline circulation within less than 10 years is dynamically possible and can be triggered by changes in surface conditions leading to fresher and/or warmer SST in high latitudes. In response to such a "polar halocline catastrophy" strong cooling has been simulated over the North Atlantic (basin averaged 2° C, regionally 5° C in European regions). In addition to sudden changes, coupled models indicate that multi-decadal thermohaline circulation variations of moderate amplitude have a feedback on atmospheric climate. These oscillations with a time scale of approximately 40 to 60 years involve large scale interactions between Arctic fresh water and ice export, the intensity of the East Greenland Current, and fluctuations of the intensity of the thermohaline circulation in the North Atlantic. In such studies, the intensity of the thermohaline circulation has been shown to lag anomalous sea surface temperature in the Greenland Sea by 10 years. On these time scales simulated surface fresh water anomalies propagate into the Labrador Sea via the East Greenland Current and inhibit convective overturning.

Moving to the Southern Hemisphere, the Southern Ocean provides the only deep ocean link between major ocean basins. As such, it helps to shape the global ocean stratification, it plays a unique role in coupling the ocean to the atmosphere and cryosphere, and it plays a central role in global sea level. Specific aspects of the CLIVAR research on Southern Ocean Climate Variability include the Antarctic Circumpolar Current (ACC) that connects the major ocean basins permitting a global-scale thermohaline circulation and providing an inter-ocean communication route for heat and freshwater climate anomalies. Upwelling of Circumpolar Deep Water poleward of the ACC provides the site of major venting of deep oceanic heat into the atmosphere and associated cryosphere. The Southern Ocean also couples the ocean and atmosphere within the subantarctic belt and its polar-extrapolar communication of heat, freshwater and CO_2 through the production of Antarctic Intermediate Water and Subantarctic Mode Water, which spread northward injecting cool low salinity water into and along the base of the main thermocline helping close the hydrological cycle. Yet even deeper, the production of very cold dense Antarctic Bottom Water dominates the lower two kilometers of the global ocean to an average temperature well below the coolest temperatures possible from the North Atlantic Deep Water. At the surface, the Antarctic sea ice fields represent a highly mobile and variable surface property whose distribution and characteristics may play a major role in the global radiative budget and thus global climate. Lastly, the large-scale coherent variability of the atmospheric circulation over the Southern Ocean and the mechanisms of these variations and their geographic communication, are directly involved in the propagation of anomalies across the various climate zones of interest to CLIVAR.

For practical considerations not all of the Southern Ocean climate related issues can be covered by CLIVAR. Rather, CLIVAR is focused on addressing variability in the Antarctic Circumpolar Current, variability of Subantarctic Mode Water and Antarctic Intermediate Water, coupled variability of deep water formation, sea ice and the atmosphere, the formation mechanism of Antarctic Bottom Water, and the variability in the Antarctic Circumpolar Current. For example, the variability in the Antarctic Circumpolar Current is a key area of interest for studies of the Southern Ocean thermohaline circulation. The best documented large scale pattern displaying coherent variability over a variety of time scales is the Antarctic Circumpolar Wave which manifests itself as an eastward propagating anomaly in sea ice extent, sea surface temperature, sea level pressure, and meridional wind stress. Whether or not this represents a physical mode of the coupled climate system will require additional data analysis, observations (sea-ice extent, ice thickness, vertical profiles of temperature and salinity), model verification and process studies of these recently discovered patterns. Such studies will be needed to establish if there are indeed formal modes, to establish the spatial extent and connectivity in the ocean, atmosphere, and sea-ice, to determine their dominate/controlling physical mechanisms, and to determine if the surface signal penetrates to the intermediate or deep layers in the ocean.

Can you add comments on the the relationship between CLIVAR and IPCC? It would make a nice connection with the “Future” in the title.

On longer time scales, the climate of our planet has been comparatively stable over recent past millennia but is very likely to undergo substantial changes due to human influence. As the 2005 hurricane season in the US demonstrated, detailed prediction of future climate including estimation of the changes in climate extremes and the risk of rapid climate changes are key policy issues. Joint with the Joint Scientific Committee of the WCRP, the CLIVAR Working Group on Coupled Modelling (WGCM), closely interacting with other global change programmes and the IPCC seeks to help address these challenging questions and to advance our understanding of natural climate variability through coupled climate modeling and climate change prediction by:

- Fostering the development of coupled climate models by organisation of model intercomparisons and utilisation of available instrumental records and paleo-climatic data for model validation and diagnosis of shortcomings
- Promoting co-ordinated experimentation with coupled models aiming to understand natural climate variability on decadal to centennial time scales and its predictability, and to predict the response of the climate system to changes in natural and anthropogenic forcing

ACTIVITIES:

COUPLED MODEL INTERCOMPARISON PROJECT (CMIP)

CMIP is one of the most important and longstanding activities in this area, having been started in 1995. It aims at systematic analysis of features of global coupled model simulations of present-day climate (control runs) and designated climate sensitivity experiments. The standard CMIP experiment involves comparing a control run to a simulation with a uniform rate of increase of carbon dioxide concentrations of 1% per year. CMIP Coordinated Experiments are elective and involve groups participating in focused sensitivity experiments to address processes in the coupled climate system. The first such experiments are aimed at examining the sensitivity of model simulations of the overturning of the world ocean to marked inputs of freshwater such as occurred at the end of the last ice age or which could arise as a result of continued increase of concentration of greenhouse gases. CMIP subprojects (of which some 28 are currently active) have produced a large number of peer reviewed publications, contributed significantly to the IPCC Third Assessment Report, and are playing a key role in the upcoming IPCC Fourth Assessment Report. A CMIP-related activity will involve collection and analysis of the most recent standard CMIP simulations, as well as 20th, 21st and 22nd century simulations for the IPCC Fourth Assessment Report (AR4).

DETECTION AND ATTRIBUTION OF CLIMATE CHANGE

With the unprecedented effort of international modelling groups to perform the model simulations mentioned above, detection and attribution analyses will also accelerate as the new model simulations of 20th century climate are being analysed for the AR4. It is expected that a wider range of detection/ attribution quantities will be examined in AR4 to provide stronger evidence for man's influence on climate.

NEW ACTIVITIES

CLOUD FEEDBACK INTERCOMPARISON EXPERIMENT

The representation of clouds and cloud feedbacks is one of the key problems in climate modelling. The Cloud Feedback Intercomparison Experiment (CFMIP) will address the ability of coupled models to simulate these processes. The aim is to help us understand, to the fullest extent possible, the representation of cloud feedbacks in coupled models, the factors that affect modelled cloud feedback, how cloud parameterizations affect these feedbacks, and how to relate the modeled feedbacks to observations. More widely, the US CLIVAR-led Climate Process Modeling and Science Teams (CPTs) are working to link more closely specific process-oriented research on phenomena such as ocean mixing and atmospheric deep convection with coupled model development.

FUTURE PLANS

In future the WGCM will foster cooperation with the IGBP GAIM (Global Analysis, Integration and Modelling) to work towards Earth System Models e.g. including the carbon cycle and chemistry. The goal is the construction of more comprehensive and efficient climate models that will in time provide more accurate predictions, quantifying the uncertainty in these predictions, more realistic simulations of past climates and more confident scenarios of future climates.

PALEO-ENVIRONMENTAL CHANGE IN AMAZONIA DURING THE LGM AND FOR BRAZIL DURING THE MID-HOLOCENE

DIETER ANHUF
Physical Geography University of Passau

HERMANN BEHLING
Albrecht-von-Haller-Institute of Plant Sciences, Department of Palynology and Climate Dynamics
University of Göttingen

MARIE-PIERRE LEDRU
Institut de Recherche pour le Development (IRD)
Institut des Sciences de l'Evolution CC 61
Université de Montpellier 2

FRANCISCO WILLIAM DA CRUZ JUNIOR

IVO KARMANN
Instituto de Geociências/Universidade de São Paulo

ANA LUIZA ALBUQUERQUE

RENATO CAMPELLO CORDEIRO

ABDELFETTAH SIFFEDINE

BRUNO TURCQ
Departamento de Geoquímica/Universidade Federal Fluminense

JOSÉ ANTÔNIO MARENGO
Instituto Nacional de Pesquisas Espaciais (INPE)
Centro de Previsão de Tempo e Estudos Climáticos (CPTEC)

PAULO EDUARDO OLIVEIRA
Laboratório de Geociências/Universidade de Guarulhos

LUIZ CARLOS RUIZ PESSENDA
Centro de Energia Nuclear na Agricultura (CENA)
Universidade de São Paulo

TATIANA JORGETTI

PEDRO LEITE DA SILVA DIAS
Instituto de Astronomia e Geofísica/Universidade de São Paulo (USP)

ILANA WAINER
Instituto de Oceanografia/Universidade de São Paulo (USP)

INTRODUCTION

Climate, climate changes, and climate predictability have become increasingly more important within social and scientific discussions since 1990. Climate changes, induced naturally or by human activities, have direct implications on our environment and therefore on human society. The knowledge of an enhanced human influence on the atmosphere and the earth's climate since the beginning of the 20th century has led to global collaboration to analyze the dimension, the causes and the consequences of the anthropogenically induced climatic change (Houghton et al. 2001) in order to predict the possible implications on future climate developments. This also includes a better understanding of natural variability and stability of the climate system in general. In order to model the climate system of the earth, either forwards into the future or backwards into the past, it is necessary to understand the Earth's system, especially the interactions between atmosphere, biosphere and ocean.

In order to verify the ability of global circulation models (GCMs) to simulate the changes in regional climate under different boundary conditions, key periods of the past were selected worldwide (COHMAP 1988). The Last Glacial Maximum (LGM) (18,000 ± 1000 ^{14}C yr BP) and the mid-Holocene are the two key periods adopted by the Paleoclimate Modeling Intercomparison Project (PMIP-IGBP-PAGES) (Joussaume and Taylor, 1995). The LGM represents an experiment with enlarged ice sheets and low atmospheric CO_2. The mid-Holocene represents by contrast an orbital forcing experiment, with perihelion in northern summer/autumn and a greater-than-present axial tilt.

Paleoclimate model reconstructions failed for South America mainly because of the scarcity of modern climate data and the sparse regional coverage of paleoclimate data (Farreira et al., 1999; Prentice et al., 2000). Special focus of this paper is the regional development of vegetation and climate of the Amazon and adjacent areas during the LGM that is not represented in the models. Amazonia covers the largest continuous tropical lowland forest area. Tropical forests contain as much as 40% of the carbon stored in terrestrial biomes and are home for up to 90% of all living species (Ozanne et al., 2003). As the Amazon basin provides 20% of the total fresh water worldwide, a reliable reconstruction of the ecological conditions - prevailing under different climatic scenarios in the past - is essential in achieving major progress in environmental modeling.

As the number of well-dated paleoecological sites has increased considerably during the last few years, at least since the last COHMAP and BIOME (Prentice et al., 2000) evaluations, the paper provides a much needed update of past ecological conditions and climates within the South American tropics and subtropics for the last 21,000 years.

MODERN CLIMATE AND VEGETATION OF BRAZIL

South Brazil comprises the states of Rio Grande do Sul (RS), Santa Catarina (SC), and Paraná (PR), and SE-Brazil includes São Paulo (SP), Minas Gerais (MG), Rio de Janeiro (RJ), and Espirito Santo (ES). The modern potential natural vegetation cover in S and SE Brazil is composed by primary forest ecosystems such as the tropical Atlantic rainforest, the *Araucaria* forest, the semi-deciduous forest, the Cerrado (dense woodland), and the Campos vegetation which is a primary grassland (Fig. 1).

The Atlantic rainforest occurs in S and SE Brazil as a 100-250 km small belt in the coastal lowlands along the Atlantic Ocean, and on the coastal eastern slopes of the Serra Geral and Serra do Mar Mountains. The frost-sensitive Atlantic rainforest reaches down to the southern region of SC-State. The climate is warm and humid without any or only a short dry period of less than 2 months. The annual precipitation ranges from 1250-3000 mm and even above that in the higher mountains (Table 1).

Subtropical Araucaria forest is found in S Brazilian highlands between 24° and 30°S (1000-1400 m elevation) and in SE Brazil in small isolated patches between 18° and 24°S (1400–1800 m elevation). The climate is temperate and humid without a pronounced dry season, precipitation ranges between 1400 and 2400 mm (Table 1).

The tropical semideciduous forest is found further inland in SE Brazil in regions with an annual dry season of 3-5 months and annual rainfall between 1000 and 1500 mm (Table 1).

The cerrado, a tropical savanna which includes several physiognomic vegetation types (Grassland: Campo limpo, grassland with small shrubs or small trees: Campo sujo, open or closed low tree and/or shrub woodland: campo cerrado, tree and shrub woodland with 2-5 m-tall trees and an open tree canopy: cerrado in the strict sense, and arboreal woodlands with 5-15 m-tall trees with a semi closed or closed tree canopy: cerradão) is distributed primarily in the Centre-East (Mato Grosso do Sul (MS), Mato Grosso (MT), Goiás (GO), the Federal District (DF) and the North East (Bahia (BA), Piaui (PI), Maranhão (MA) of Brazil and also the eastern part of Northern Brazil (Tocantins (TO) and Pará (PA) covering ca. 1.8 million km^2 (Fig. 1). The average annual precipitation in most of the cerrado region reaches between 1,000 and 1,750 mm with a dry season of 5 to 6 months. Cerrado also occurs in the northern part of SE Brazil (São Paulo, Minas Gerais).

Another type of savanna dominates the northern hemispheric regions, called the Llanos Orientales in Colombia or Llanos de Orinoco in Venezuela. The main difference to the classical cerrado formation is the long time inundation of those sites every year. A homologue of the Llanos is the Brazilian Pantanal. Palynological sites from the Llanos savanna formation were included into our analysis to detect possible changes of the extension of the Amazon rain forest area along its modern border.

The floristic composition of the extensive cerrado area is not homogeneous and has contact zones with other vegetation types such as the Amazon rain forest and also the semi deciduous forest (Ratter et al. 1996).

Table 1 - Relation between climate and vegetation (after Behling 1998)

Vegetation	**Climate Dry season**	**Precipitation (mean annual) in mm)**	**Temperature (min. / max.) in °C**
Campos	0 - 1	<1,400 - ~2,000	-10 to +36
Araucaria forest	0 - 1	>1,400 - 2,400	-10 to +38
Atlantic rain forest	0 - 2	1,250 - >3,000	>±0 to +42
Semi deciduous forest	3 - 5	1,000 - 1,500	>10 <15 to +38
Cerrado	5 - 6	1,000 - 1,750	>15 to +38
Amazon rain forest	0 - 2	1,500 - >3,000	>15 to +38

The Amazon rain forest of Brazil today has an extension of about 3,5 Million km^2. The most obvious aspect of this vegetation type is its enormous living biomass and the extremely high biodiversity. Tropical rain forests are well structured with 3 to 4 different height levels; single trees (emergent) can reach 50 meters and more. Its canopy is closed, and less than 3% of the incoming sunlight reaches the forest floor (Anhuf and Rollenbeck 2001). The climate is hot and humid without any or only a short dry period of less than 2 months. The annual precipitation ranges from 1500 - >3000 mm and even higher along the eastern slopes of the Andes.

THE LGM IN TROPICAL SOUTH AMERICA

AMAZON BASIN

The Amazon rainforest evolution during the glaciations of the Quaternary has been strongly debated during the last decade. The discussion – whether there was fragmentation of the forest or not – opened new ideas on how global climatic changes could impact the tropical rain forests. Two types of hypothesis emerged: 1) the Amazonian rain forest was fragmented in refugia islands or its areal extension remained relatively stable. 2) Its floristic composition was submitted to species re-associations because of connections with the Andean, Tepuyan, and Atlantic rainforest ecosystems. Both hypotheses came to the conclusion that the forest was different from the one we observe today and that it experienced transformations in distribution and floristic composition during the last glaciation (Colinvaux et al., 1996, Colinvaux and De Oliveira, 2001; Van der Hammen and Hooghiemstra, 2000, Van der Hammen, 2001; Haffer and Prance, 2001).

Only seven pollen records located in the Amazonian rain forest area including the Amazon fan date back to the last glacial maximum (Table 1): Katira (9°S, 63°W), Carajás (6°S, 50°W), Hill of Six Lakes (0°16'N, 66°4'W), Maicurú (0°30'S, 54°14'W), Laguna Bella Vista (13°37'S, 61°33'W), Laguna Chaplin (14°28'S, 61°04'W), ODP site 932 (5°13'N, 47°2'W (Van der Hammen and Absy, 1994; Absy et al., 1991; Siffedine et al., 2001; Colinvaux et al., 1996; Santos et al., 2001; Bush et al., 2004; Colinvaux and De Oliveira, 2001; Mayle et al., 2000; Haberle and Maslin 1999).

A ^{14}C yr BP date of 18,500 at Katira is related to high frequencies of grass pollen and an almost total disappearance of arboreal pollen, while the ^{13}C values indicate the dominance of tropical grasses and colluvial sedimentation indicates even an incomplete vegetation cover (Absy and Van der Hammen 1976, Van der Hammen and Absy 1994). The Hill of Six Lakes has been intensively investigated since 1996 by Colinvaux and his colleagues showing that forest taxa dominated the vegetation cover also during the LGM (Bush et al. 2004). Mayle et al. (2000) report from Laguna Chaplin that savanna communities dominated the respective area continuously between 40,000 and 2240 ^{14}C yr BP. Haberle and Maslin (1999) published results from a deep-sea core from the Amazon fan covering the last 50,000 years. The authors pointed out that no general change in Amazon ecosystems were detected but they also did not contradict to the possibility of a moderate extension of savanna ecosystems up to 32% of the entire catchment area.

The following records show a hiatus in sedimentation between respectively 23,000 and 13,000 ^{14}C yr BP (Carajas), 30,000 and 16,000 ^{14}C yr BP or between 25,690 and 17,410 ^{14}C yr BP (Maicuru), and 38,600 and 11,030 ^{14}C yr BP (Laguna Bella Vista). This hiatus is associated with a lack of deposition of organic material during thousands of years (Ledru et al., 1998) and /or strong erosive conditions.

Table 2 - Sites providing dated information of LGM ecological conditions based on pollen or plant macrofossil data within the Amazon Basin (01-08) and the Amazon fan (09)

No.	Site	Location	Eleva-tion (a.s.l.)	Actual climate	Actual vegetation	18 000 14C yr BP Climate	18 000 14C yr BP Vegetation	Reference
01	Laguna el Pinal	4°08'N/71°23'W	180	1200-2000 mm	4-5 dry months	Grass savanna and gallery forests with Mauritia palms	Less rainfall than today or longre dry season	Behling and Hooghiemstra 1999
02	(Colombia)	0°16'N/66°41'W	savanna	250-300	> 3 000 mm	no dry season	Tropical Rainforest	Colinvaux et al. 1996, Santos et al. 2001, Bush et al. 2004
03	Lagoa Pata	0°30'S/54°14'W		5°C cooler,	Drier: Lake level	decrease		Colinvaux and De Oliveira 2001
04	Lagoa Gragao	6°20'S/50°25'W	Rainforest	Expansion of Araucaria + Weinmannia	550	2 000-2 500 mm	3 months little rain	Absy et al. 1991,
05	Lagoa Verde	9°S/63°W	Forest	?	Hiatus	700	1 500-2 000 mm	Siffedine et al. 2001
06	(Seis Lagos)	8°21'S/63°57'W	3 months little rain	Tropical Rainforest,	Edaphic savannas	>30% less rain	Hiatus	v.d.Hammen and Absy 1994
07	Maicuru	13°37'S/61°33'W	Savanna expansion before and after	<200	2 000-2 500 mm	Tropical Rainforest	Very dry	Freitas et al. 2001
08	Carajas	14°28'S/61°04'W	1000-1500 mm	Dry grass savanna at 18 500 yrs B.P.	80-150	1 800-3 500 mm	3-4 months little rain	Mayle 2000
09	Katira	5°13'N/47°2'W	Forest	Wetter	Cooler?	Forest	210	Mayle 2000

BORDER AND SURROUNDING AREAS OF THE BRAZILIAN AMAZON BASIN

Cerrado-humid forest transitions

Carbon isotopes (^{12}C ^{13}C ^{14}C) of soil organic matter were used to evaluate and establish the chronology of past vegetation of patches of Cerrado surrounded by rainforest in the states of Rondônia and Amazonas. At the base of the soil profiles, between 17,000 and 9000 ^{14}C yr BP (km 46: 16,940±140 ^{14}C yr BP), ˜^{13}C values reflect C3 plants documenting presence of forest (Freitas et al., 2001). ˜^{13}C data also indicate that savanna grasses (C4 plants) have influenced significantly the composition of the vegetation reflecting drier climates after 9000 ^{14}C yr BP (Pessenda et al., 1998).

Northern neotropical savannas: Llanos Orientales

The LGM in the Llanos Orientales in Colombia in the Laguna El Pinal region (4°08'N/70°23'W) was characterized by savanna vegetation and with very few woody taxa. The respective vegetation reflects the driest climatic conditions of the last 18,000 years (Behling and Hooghiemstra 2001).

SUMMARY OF THE RESULTS FOR THE LGM IN AMAZONIA

From the pollen and few geochemical records in the Amazon basin including the Amazon fan that date back to the LGM we have clear indication of a cooler climate with average temperature 4.5°±1°C or 5°±1°C lower than that of today for the region and the northeastern Brazil (Van der Hammen and Hooghiemstra, 2000; Bush et al., 2001; Stute et al., 1995). This fact might be responsible for the appearance of mountainous species like *Alnus* and *Podocarpus* in lowland Amazonian forest sites including the Amazon fan during the LGM (Haberle and Maslin, 1999).

In the analysis of the cores obtained between BR 319, km 46 north of Porto Velho (8°21'S, 63°57'W) to the South including Katira (less than a hundred kilometers further south) , Laguna Bella Vista, and Laguna Chaplin (14°28'S, 61°04'W) a clear change in the LGM vegetation cover appears. Forest in northern Rondônia, savanna at Katira, a hiatus at Bella Vista but clear indication of savanna vegetation at the southernmost end at Laguna Chaplin of this transect.

Nevertheless, an inconsistent picture of the LGM vegetation conditions in the Amazon basin remains. The point of view that claims that the Amazon lowland forests were not replaced by savanna during the LGM (Colinvaux and De Oliveira, 2001; Bush et al., 2002; Haberle and Maslin, 1999), versus the other view that the Amazon evergreen forest border on the northern hemisphere was located probably about 200 km further south and that the same border on the southern hemisphere was located probably 300 km further north during the LGM (Van der Hammen and Hooghiemstra, 2000; Behling, 2002) The latter was also corroborated by paleovegetation simulations (Cowling et al., 2001).

PALEOVEGETATION MAP OF AMAZONIA FOR THE LGM

The present distribution of the natural vegetation in tropical South America is linked very closely to the climatic water-budget of the continent. The amount of precipitation as well as the duration and the intra-annual distribution of the rain depend on the condition of the most important water vapor sources the tropical and southern Atlantic. Of minor importance are the water vapor sources from the Pacific and the Indian Ocean, respectively. In addition, intense moisture recycling from tropical lowland forest can also provide an important source of moisture in this region (Salati, 1987). It is clear that in years with extreme warming in the tropical Pacific - typical of El Niño conditions - rainfall in the northern Amazon regions and Northeast Brazil would be lower than normal, and in some cases can even produce droughts, as in 1925-26, when extensive forest fires in Amazonia killed many rubber collectors (Meggers, 1994).

Pflaumann et al. (2003) have published SST reconstructions of the Atlantic ocean during the LGM. During northern glacial summer (May to September) along the equatorial Brazilian coast, between 4°N and 4°S, a distinct tongue of cool water (<18°C) penetrated from the Southeast, originating in the Benguela Current off SW-Africa, and extended to the western Atlantic beyond 30°W. The temperature differences along the northern Brazilian coast (LGM minus modern) were 2°– 3°C below the modern SST's.

The eastern Brazilian coast south of 10°S to 30°S has experienced only a minor SST decrease of about 1°-2°C (LGM minus modern)(Niebler et al., 2003). Thus, the largest part of the Amazon Basin (central, western and southwestern Amazon) did not suffer seriously from a decrease in water vapor transport into the continent (Baker et al., 2001b) while the northern part of the basin was influenced by a limited water vapor input from the Atlantic and the Caribbean during LGM northern summer. As today there are significant connections between the SST's and the precipitation system, such connections must have also existed during the LGM. They permit a reconstruction of the precipitation available during the LGM. Accordingly, the daily evaporation rates are about 4 mm over a 27°C warm water body and 1 mm over a water body at 17-18°C (Baumgartner and Reichel, 1975). Therefore, equatorial SST anomalies during northern glacial summer (between –8°C in the eastern Atlantic and –2° to –3°C in the western Atlantic) may have caused a precipitation decrease of up to 30 to 40% with a considerable amount of precipitation during northern summer within the areas of Uaupes, Belém, Santarem, Salvador, Recife/Olinda) and a decrease of about 20% at the stations with considerable amount of precipitation during southern summer (Manaus, Porto Velho, Cuiaba).

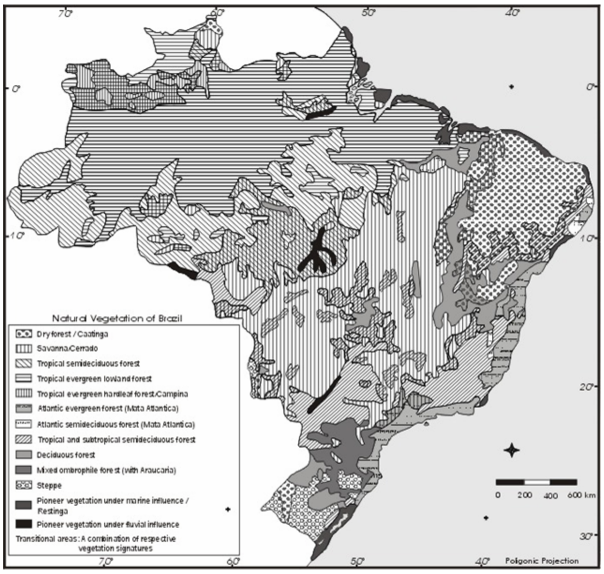


Figure 1

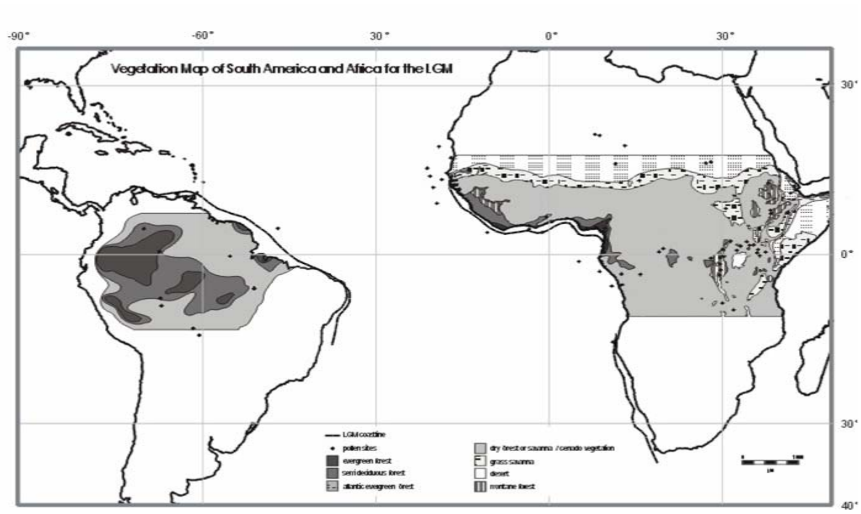


Figure 2 - Vegetation Map of South America and Africa for the LGM

But, based on the new LGM SST reconstructions in the Atlantic Ocean there probably was no general reduction of rainfall throughout the entire basin. During the NH-summer a significant rainfall reduction has to be assumed for the LGM due to the cooler tropical Atlantic during that season. An overall rainfall reduction of about 40% in comparison to the contemporary values was extrapolated for the northwestern, the “Dry Corridor” and the northeastern part of the Amazon Basin comparable to the map by Van der Hammen and Hooghiemstra (2000). The central part (west of the “Dry Sector” and between 0°N and 10°S), the western, and southwestern part (west of 70°W and south of 10°S) probably experienced only a minor rainfall reduction due to the almost unchanged Austral summer SST’s of the tropical Atlantic during the LGM. Accordingly, a general rainfall reduction of about 20% during the LGM austral summer is suggested for these respective regions in the Amazon basin. Thus, the most obvious difference in the present map from the earlier interpretations is the extension of the humid evergreen and semi deciduous forests.

All the findings from the published pollen and geochemical data agree with the reconstructed LGM map showing more open (probably dry forest or savanna like) vegetation in northern Amazonia (Bush et al., 2002). The minor precipitation decrease in the western, central and southwestern parts of Amazonia of up to 20% is consistent with the survival of humid tropical forests in southern Amazonia (between Humaitá and Porto Velho), also confirmed along an ecosystem transect in the Amazon State between Humaitá and Lábrea (along BR 319).

There is only one principle disagreement between the new map and the available pollen sites. The Katira data record for LGM requires a considerably higher rainfall reduction than 20% to explain the pollen data. Van der Hammen and Hooghiemstra (2000) have calculated a reduction of 50-60% necessary to explain the pollen data, although LGM in the Katira record includes only five pollen samples and therefore has to be taken with caution (Mayle et al., 2000).

However, the data show that we have a dry southern Amazonia and a dry eastern Cordillera (Mourguiart and Ledru 2003a+b) and a relatively wet Altiplano during the LGM. This antagonism could be inferred by a reduction in summer moisture from the Atlantic inducing a decrease in precipitation and evapotranspiration over Amazonia and a northward shift of southern convective bands (westerlies) with stonger winter precipitations on the Altiplano reaching the latitude of Titicaca (Garreaud and Wallace 1998, Vuille and Amann 1997, Wainer 2005). The main aspect is that in contrast of today these two regions received distinctly different moisture sources during the LGM (Burbridge et al., 2004) – today both from the tropical Atlantic but during the LGM the Altiplano received a reasonable part of its precipitation through intensified snow precipitation originating from the Pacific (Vuille and Ammann, 1997; Wainer et al., 2005).

Based on our reconstruction the tropical humid forest area (including evergreen and semi-deciduous forest types) was reduced to 54% of their present-day extension in Amazonia. The remaining part (46%) probably was composed by transitional mosaics containing dry forests and savannas.

THE MID-HOLOCENE ECOLOGICAL CONDITIONS IN BRAZIL AND SELECTED SURROUNDING AREAS

SOUTHERN BRAZIL LOWLANDS

The tropical Atlantic rainforest of the southern Brazilian coastal lowlands became already established since the late Glacial (Behling and Negrelle 2001). The expansion of the Atlantic rainforest into the higher elevated coastal slopes was later and occurred during the early Holocene (e.g. Serra da Boa Vista; Behling 1995). Two other sites from the southernmost coastal area (Lagoa dos Patos (30°50'S/ 50°59'W) and Terra de Areia (29°33'/50°03'W) only provide data for a younger period after the regression of the Atlantic Ocean, but it seems to be obvious that full tropical forest expansion started after 5000 ^{14}C yr B.P, probably at about 4120±90 ^{14}C yr B.P. like at Terra de Areia with high temperatures and heavy rainfall (Neves and Lorscheitter 1995).

The pollen record from Sao Francisco de Assis, located in the lowland campos region of southern Brazil (Rio Grande do Sul State) indicate grassland with very little gallery forest, reflecting warm and dry climatic conditions during the mid Holocene period (Behling et al 2005). The expansion of gallery forest started after 4600 ^{14}C yr B.P and especially after 1600 ^{14}C yr B.P, indicating a change towards wetter climatic conditions.

SOUTHERN BRAZIL HIGHLANDS

Paleoenvironmental studies from the *Araucaria* forest and Campos regions of the southern Brazilian highlands documented large-scale environmental changes during the late Quaternary. Paleoenvironmental data from Paraná (Serra Campos Gerais (9 in Table. 2): Behling 1997), Santa Catarina (Serra do Rio Rastro (6), Morro da Igreja (7), Serra da Boa Vista (8): Behling 1993, 1995) and Rio Grande do Sul (Aparados da Serra (3): Roth and Lorscheitter 1993; São Francisco de Paula: Behling et al. 2001) show that extensive areas of Campos vegetation existed on the highlands throughout the late-Glacial and early to mid-Holocene times. The similar sequence of vegetation changes from those different sites indicates that the change of paleoenvironmental conditions on the southern Brazilian highlands was regional (Behling 2002). This vegetation reflects warm and relatively dry climates with an annual dry season of probably about 3 months and annual precipitation lower than 1400 mm (Behling 1997b, Behling et al. 2004). The records also suggest that small populations of *Araucaria* were probably only present in refugia of deep and protected valleys since the glacial period. Initial expansion of *Araucaria* forests on the highlands started from gallery forests about 3600 ^{14}C yr B.P. but full expansion replacing the campos vegetation is found in RS and SC only after 1000 and in PR after 1500 ^{14}C yr B.P. (Behling et al. 2004).

SOUTHEAST AND CENTRAL BRAZIL: SEMI DECIDUOUS FOREST AND CERRADO

The Lakes Pires, Nova, and Silvana (Behling 1995b, Behling 2003, Rodriges-Filho et al. 2002) are located 250 km from the Atlantic Ocean in the recent semi-deciduous forest region of the Atlantic lowlands. During the early Holocene from 9720-5330 ^{14}C yr B.P. Lago do Pires show cerrado vegetation with some gallery forest indicative of low precipitation and a dry season of ca. 6 months in the Atlantic lowlands. Subsequently, between 5530 and 2780 ^{14}C yr B.P. semi-deciduous forest expanded markedly and replaced the remaining cerrado. The similar vegetation changes recorded at Lagoa Santa, Lago dos Olhos, Lagoa Silvana, and Lagoa Nova document larger areas of cerrado during the mid-Holocene reflecting a seasonal climate with 5-6 dry months (Behling and Hooghiemstra 2001).

The pollen records from Salitre and Serra Negra are from inland sites about 750 km from the Atlantic Ocean between 1050 and 1170 m asl. In Salitre, after 8500 ^{14}C yr B.P., the *Araucaria* forest which dominated the region at the beginning of the Holocene between 10,000 and 8500 ^{14}C yr B.P. was replaced by a mesophytic semideciduous forest, suggesting a warmer and drier climate than before but humidity was comparable to recent times (Table 1). After 4000 ^{14}C yr B.P. the climate became comparable to modern condition with a slightly longer dry season now allowing also cerrado vegetation to settle. (Ledru 1993, Ledru et al. 1998). At Serra Negra during most of the Holocene, the regional vegetation was dominated by a mosaic of cerrado and semi deciduous forest, indicative of a seasonal climate like today. The differences between Salitre and Serra Negra are caused by different elevation (Ledru et al. 1996). During the mid-Holocene Salitre must have been located within the level of elevated condensation. Above and below this zone precipitation decreased considerably explaining the occurrence of a mosaic of cerrado and semi-deciduous forests on higher elevation (Serra Negra) during the mid-Holocene.

Two pollen records from palm swamps in the cerrado region of central Brazil are available: Aguas Emendadas (Barberi 1994, Salgado-Labouriau et al. 1998) and from Cromínia (Ferraz-Vicentini and Salgado-Labouriau 1996, Salgado-Labouriau et al. 1997). The return of moist climatic conditions started after 7220±50 ^{14}C yr B.P. at Aguas Emendadas (no pollen were preserved before 8000 ^{14}C yr B.P.). A transitional phase lasted until about 5000 ^{14}C yr B.P. developing *Mauritia* palm swamps and suggesting an increase in moisture. But the dry season remained longer because only during the late Holocene, vegetation and climate were similar to present-day conditions. The swamp near Cromínia is also indicating a transitional phase during the respective time. A dry climate prevailed until 6500 ^{14}C yr B.P. with a dry season up to 7 months and since 5000 ^{14}C yr B.P. the modern vegetational composition is found in this region.

NORTHERN CENTRAL, NORTHEASTERN, WESTERN BRAZIL AND BOLIVIA: CAATINGA, CERRADO / AMAZON RAIN FOREST TRANSITION

Lagoa da Confusão (10°38'S/49°43'W) is located in Tocantins State. The modern vegetation is cerrado and transition vegetation types to Amazonian rain forest. The distance to closed Amazon forest is about 100 km. The vegetation cover during the mid-Holocene was almost unchanged in comparison to today (Behling 2002).

Vegetation dynamics in northeastern Brazil (Maranhao State) around Lago de Caço were interpreted that there was an expansion of woody savanna vegeation between about 9000 and 4000-3000 ^{14}C yr B.P. probably related to the presence of drier climate (Ledru et al. 2001, Pessenda et al. 2004).

Significant vegetation changes are reported from the transition between Amazonian rainforest and cerrado/savanna from the southern Amazonian forest border in Rondônia during the mid-Holocene. Three transects from Vilhena to Humaitá (700 km), from Porto Velho to Humaitá (200 km), and from Humaitá to Lábrea (50 km) have been investigated (Pessenda et al. 1998, Freitas et al 2001, Gouveia et al. 1997). The savanna biome occupied the whole area of the transect between Vilhena and Pimenta Bueno at about 6000 ^{14}C yr B.P. Pimenta Bueno is today located within the forest zone, indicating a remarkable regression of the forest frontier of about 200 km in southeastern Rondônia at that time. Along the transect between Porto Velho and Humaitá the mid-Holocene development is more complex, but in general it reflexes the same tendency as between Vilhena and Pimenta Bueno.

The picture is not so different at the southwestern edge of the Amazon rainforest in Bolivia. The available two sites there (Laguna Bella Vista: 13°37'S/61°33'W and Laguna Chaplin: 14°28'S/ 61°04'W) are nowadays located within the tropical rainforest. Laguna Bella Vista is found today 120 km north of the southern limit of humid evergreen Amazonian forest. Laguna Chaplin almost represents that respective border, characterized by a seasonal climate with 1400-1500 mm of precipitation per year. During the mid-Holocene, Laguna Bella Vista was covered by a grass-dominated savanna (Poaceae over 40%, Moraceae under 25%) and was subjected to frequent fires (Mayle et al. 2000, Burbridge et al. 2004). Forest communities containing a mixture of evergreen and semi-deciduous species only began to expand after 6000 ^{14}C yr B.P. Laguna Chaplin shows the same picture, indicating a drier climate than today. The expansion of tropical rainforest at Laguna Chaplin is even younger than that around Laguna Bella Vista (about 3000 ^{14}C yr B.P.). Summarizing, it has to be accepted that the Amazon rainforest border in eastern Bolivia was positioned at least 120-150 km further north than it can be localized today.

AMAZONIA

Coastal savannas of Northern Brazil

At Lago Arari (0°39'S/49°70'W) at 6250 ^{14}C yr B.P. there is a marked change from a more or less closed to open swamp savanna and forest (Absy 1985). At Lagoa da Curuça (0°46'S/47°51'W) the pollen spectra is indicative of closed and dense Amazonian rainforest. The presence of mangrove vegetation at 6700 ^{14}C yr B.P. at Lago Aquiri (3°10'S/44°59'W) indicates that the Atlantic coast migrated deeply inland. Amazon rain forest occurred behind the mangrove zone. Lago Crispim was covered by a species rich, dense and tall coastal Amazon rainforest (Behling and Da Costa 2001).

The coastal vegetation changes are more related to sea level changes and are therefore less or not indicative for climate changes with respect to the zonal vegetation. The inlands were covered by closed and dense Amazonian rainforest. Therefore the coastal areas are not included into the general discussion on environmental changes due to climate oscillations further on.

Amazon Basin

At the core of the swamp of Carajás mountain (6°35'S/49°30'W), located within the respective "Dry Corridor", the pollen analysis detected a general opening of the humid forest between 8000 and 4000 ^{14}C yr B.P., probably caused by rapid alternation of dry and humid periods throughout the Holocene. Nevertheless, even the drier periods are characterized by the absence of typical savanna taxa (Siffedine et al 2001).

From Manaus region (Lago Calado: 3°16'S/60°35'W), Behling et al. (2001) report a permanent tropical rainforest. The higher presence of *Alchornea*, *Macrolobium* after 7700 ^{14}C yr B.P. documents the increase of várzea forest in the area, is reflecting higher Amazonian water level (Behling and Costa 2001). Also at Rio Curuá, located in the eastern Amazon Basin (1°44'07"S/51°27'47"W), a highly diverse terra firme forest with only minor areas of várzea and igapó was developed during the mid-Holocene indicating no major changes in comparison to today except the marked increase of várzea forest area after about 3000 ^{14}C yr B.P. (Behling and Costa 2000).

The Lake Pata pollen record in Northwestern Amazonia shows dense Amazon rain forest with several marked vegetation changes during the mid-Holocene (Colinvaux et al. 1996, De Oliveira 1996). The basic pollen composition was constant since the Last Glacial Maximum. All of the respective arboreal pollen represents forest elements. Poaceae pollen was generally below 2%, but during the mid-Holocene their representation reached 8% in one sample (Bush et al. 2004).

Also at Lake Dragão arboreal pollen types dominated during the mid-Holocene reflecting continuous tropical forest coverage although the pollen concentration was lowest at that time (Bush et al. 2004). The authors interpret their findings in the way that the respective inselberg in the northwestern Amazon region experienced an increased seasonality or decreased moisture availability during that time.

Neotropical savannas

Northern Neotropics (Llanos Orientales of Colombia)

The increase of the forested area in the records of Laguna Angel (4°28'N/70°34'W) at 5260 ^{14}C yr B.P., Laguna Sardinas (4°58'N/69°28'W) at 6390 ^{14}C yr B.P., and Laguna Carimagua (4°04'N/70°14'W) at 5570 ^{14}C yr B.P. reflect a change from dry early Holocene conditions to wetter conditions during the mid-Holocene. The early Holocene (9000 to 6000 ^{14}C yr B.P.) was the driest period since the Last Glacial Maximum. The savanna of the Llanos Orientales extended probably at least 100 km further south during the early Holocene period between early and late Holocene, reflecting significantly drier climatic conditions compared with today.

CONCLUSIONS AND DISCUSSION

This study focuses on the reconstruction of the major forest ecosystems in Brazil during the mid-Holocene. Based on 68 pollen records for these neotropical ecosystems, vegetational shifts have been reconstructed and changes in forest area have been estimated.

Table 3 - Sites in Brazil and surrounding areas of tropical South America providing dated information of ecological conditions based on pollen or plant macrofossil data

Southern Brazilian Lowlands: Campos, Restinga/Atlantic Rainforest

No.	Site	Location	Elevation (a.s.l.)	Actual climate	Actual vegetation	6,000 14C yr BP Climate	6,000 14C yr BP Vegetation	Reference
1	Sao Franzisco de Assis	29°35'S/55°13'W	100	1200-2000 mm Warm temperate humid climate	Lowland campos	Warm and dry conditions	Campos vegetation	Behling et al. 2005
2	Volta Velha	26°04'S/48°38'W	5	1875 mm no dry season	Dense Atlantic rainforest	Humid climate	Dense Atlantic Rainforest	Behling and Negrelle 2001
3	Poço Grande	26 25'S/48 52'W	10	1875 mm no dry season	Dense Atlantic rainforest	Humid climate	Likely: Dense Atlantic Rainforest	Behling 1993, 1998

Southern Brazilian Highlands: Campos / Araucaria forest / Atlantic Rainforest

4	Aparados da Serra	29°25'S/50-°W	1000	2,400 mm, no dry season, Warm and humid, 14,5°C	Campos / Araucaria forest mosaic on the highlands, tropical rainforest in valleys	Warm + dry	Campos, Araucaria in small gallery forest	Roth and Lorscheitter 1993
5	São Francisco de Paula	29°24'S/50-°34'W	900	2,456 mm, no dry season, Warm and humid, 14,5°C	Campos / Araucaria forest mosaic on the highlands	Warm + dry, 30-40% less precipit-ation	3 dry months	Behling et al. 2001
6	Cambará do Sul	29°03'S/50-°06'W	1040	No pollen conserved	Likely: Campos, Araucaria in small gallery forest	2,400 mm, no dry season, Warm and humid, 14,5°C	Araucaria forest	Behling et al. 2004
7	Serra do Rio Rastro	28°23'S/49-°33'W	1420	Warm + dry, 30-40% less precipitation	3 dry months	Campos, Araucari-a in small gallery forest	About 2,000 mm, no dry season, cool and humid, 14 °C	Behling, 1993, 1995a
8	Morro da Igreja	28°11'S/49-°52'W	1800	Campos / Araucaria forest mosaic on the highlands, tropical Atlantic rainforest on Atlantic facing slopes	Warm + dry	3 dry months	Subtropical Campos, Araucaria in small gallery forest	Behling, 1993, 1995a
9	Serra da Boa Vista	27°42'S/49-°09'W	1160	About 2,000 mm, no dry season, cool and humid, 12-14 °C	Campos de Altitude, Araucaria forest mosaic on the highlands, tropical Atlantic rainforest on Atlantic facing slopes	Warm + dry	3 dry months	Behling, 1993, 1995a
10	Serra Campos Gerais (Paraná)	24°40'S/50-°13'W	1200	Subtropical Campos, Araucaria in small gallery forest	About 2,000 mm, no dry season, warm and humid, 15 °C	Campos / Araucari-a forest mosaic on the highland-s, tropical Atlantic rainforest in valleys	Warm + dry	Behling, 1997b
11	Morro de Itapeva	22°47'S/45-°32'W	1850	3 dry months	Subtropical Campos, expansion of Weinmania	1,250-1,-500 mm, no dry season, 16.7°C	Campo sujo, Araucaria forest mosaic on the highlands, tropical Atlantic rainforest in valleys	Behling, 1997a

Southeast and central Brazil: Araucaria forests, semideciduous forests and cerrado

12	Lago dos Olhos	19º38'S/43-º54'W	730	1381 mm,	Semi-decid-uous forest /	cerrado mosaik	Strongly seasonal precipitatio-n	Mosaic of Cerrado and semi deciduous forest
13	semi-h-umid	Lagoa Silvana	19°31'S/4-2°25'W	250	De Oliveira 1992	Semi-d-eciduou-s forest /	cerrado mosaik	5-6 dry months
14	1,250 mm, 4-5 dry months, 20°C	Salitre	19°S/46°4-6'W	970	Campo cerrado / semi deciduous forest	Rodrige-s-Filho et. al. 2002	Semi-deci-duous forest /	cerrado mosaik
15	?1,500 mm	4 dry months	Lagoa Serra Negra	19ºS/46º57-'W	Warmer and 2 dry months	Semi deciduo-us forest	Ledru 1993, Ledru et al. 1994 + 1996	Semi-deciduous forest and cerrado
16	1170	1600 mm	3-5 dry months	Lagoa Nova	Climate almost like today	Semi deciduo-us forest and cerrado	De Oliveira 1992	Semi- deciduous forest /
17	17°58'-S/42°1-2'W	390	1,000-1,5-00 mm 3-5 dry months,	20-26°C	cerrado mosaik	5-6 dry months	Campo cerrado, dense grass, gallery forests	Behling 2003

Central Brazil: Cerrado

18	Cromínia	17°17'S/4-9°25'W	710	1750 mm 4-5 dry months	Cerrado / semi-decidu-ous forest mosaic	Semi-humid, temperature like today 6-7 dry months	Cerrado / Caatinga mosaic	Ferraz-Vicentini and Salgado-Labouriau 1996; Salgado-Labouriau et al. 1997
19	Aguas Emenda-das	15°S34'/4-7°35'W	1040	4-5 dry months	Cerrado / semi-deciduous forest mosaic	Temperature like today 5-6 dry months	Cerrado	Barberi 1994; Salgado-Labouriau et al. 1998

Northern central and northeastern Brazil: Cerrado / Amazonian Rainforest transition

20	São Franzisco River	10°24'S/43°13'W	480	400-800 mm 7-8 dry months	Semi-deciduous forest / palm swamp forest		Mosaic of gallery forest, Cerrado and Caatinga	De Oliveira et al. 1999
21	Lagoa da Confusão	10°38'S/49°43'W	180	?1600 mm, 5 dry months	Cerrado/rainforest transition	?1600 mm, 5 dry months	Cerrado; rain-forest increase	Behling 2002
22	Vilhena	12°42'S/66°07'W			Cerrado	Drier Warmer	Cerrado/Sav-anna	Pessenda et al. 1998
23	Pimenta Bueno I	11°49'S/61°10'W			Cerradão/Forest transition	Drier Warmer	Savanna	Pessenda et al. 1998
24	Pimenta Bueno II	11°46'S/61°15'W			Forest	Drier Warmer	Forest	Pessenda et al. 1998
25	Ariquemes	10°10'S/62°49'W			Forest	Drier Warmer	Forest	Pessenda et al. 1998
	Transect BR 319							
26	Forest (5)	8°43'S/63°58'W	80-150	1800-3500 mm 3-4 months little rain	Forest	Drier Warmer	Forest	Freitas et al. 2001
27	Forest (46)	8°21'S/63°57'W	80-150	1800-3500 mm 3-4 dry months	Forest	Drier Warmer	Forest/Savan-na transition	Freitas et al. 2001
28	Forest (68)	8°12'S/63°53'W	80-150	1800-3500 mm 3-4 months little rain	Forest	Drier Warmer	Forest/Savan-na transition	Freitas et al. 2001
29	Savanna (80)	8°11'S/63°49'W	80-150	1800-3500 mm 3-4 months little rain	Savanna	Drier Warmer	Savanna/For-est transition	Freitas et al. 2001
30	Savanna (82)	8°10'S/63°48'W	80-150	1800-3500 mm 3-4 months little rain	Savanna	Drier Warmer	Savanna/For-est Transition	Freitas et al. 2001
31	Forest (100)	8°06'S/63°39'W	80-150	1800-3500 mm 3-4 months little rain	Forest	Drier Warmer	Forest/Savan-na transition	Freitas et al. 2001
32	Forest (111)	8°03'S/63°31'W	80-150	1800-3500 mm 3-4 months little rain	Forest	Drier Warmer	Forest/Savan-na transition	Freitas et al. 2001
33	Forest (142)	7°56'S/63°20'W	80-150	1800-3500 mm 3-4 months little rain	Forest	Drier Warmer	Savanna/For-est transition	Freitas et al. 2001
34	Savanna (154)	7°54'S/63°18'W	80-150	1800-3500 mm 3-4 months little rain	Savanna	Drier Warmer	Savanna/For-est transition	Freitas et al. 2001
35	Forest (161)	7°50'S/63°13'W	80-150	1800-3500 mm 3-4 months little rain	Forest	Drier Warmer	Savanna/For-est transition	Freitas et al. 2001
36	Savanna (172)	7°47'S/63°09'W	80-150	1800-3500 mm 3-4 months little rain	Savanna	Drier Warmer	Savanna/For-est transition	Freitas et al. 2001
37	Forest (178,5)	7°44'S/63°06'W	80-150	1800-3500 mm 3-4 months little rain	Forest	Drier Warmer	Savanna/For-est transition	Freitas et al. 2001
38	Forest (179)	7°43'S/63°06'W	80-150	1800-3500 mm 3-4 months little rain	Forest	Drier Warmer	Savanna/For-est transition	Freitas et al. 2001
39	Savanna (188)	7°38'S/63°04'W	80-150	1800-3500 mm 3-4 months little rain	Savanna	Drier Warmer	Savanna/For-est transition	Freitas et al. 2001
	Humaitá	(km 200)						
40	Km 205			1800-3500 mm 3-4 months with rain < 50mm	Savanna	Drier Warmer	Savanna	Gouveia et al. 1997
41	Km 217			1800-3500 mm 3-4 months with rain < 50mm	Savanna	Drier Warmer	Savanna	Gouveia et al. 1997
42	Km 218			1800-3500 mm 3-4 months with rain < 50mm	Savanna/Forest transition	Drier Warmer	Savanna	Gouveia et al. 1997
43	Km 220			1800-3500 mm 3-4 months with rain < 50mm	Forest	Drier Warmer	Savanna/For-est transition	Gouveia et al. 1997
44	Km 250			1800-3500 mm 3-4 months with rain < 50mm	Forest	Drier Warmer	Forest	Gouveia et al. 1997
	Lábrea							
45	Noel Kempff Laguna Bella Vista		210	1500 mm	Tropical Rainforest/ Dry deciduous forest	Drier than today	Savanna (grass)	Mayle 2000
46	Noel Kempff Laguna Chaplin		210	1500 mm	Tropical Rainforest/ Dry deciduous forest	Drier than today	Savanna (grass)	Mayle 2000
47	Lagoa do Caço		120	1,400 - 1,500 mm 5-6 dry months, ?25°C	Restinga/Cerrado/gall-ery forests	1400 - 1500 mm 5 dry months,	Restinga / Cerrado/galle-ry forest	Ledru et al. 2001; Siffedine et al. 2003 ; Pessenda et al. 2004

Amazon region

48	Carajas	6°20'S/5-0°25'W	700	1500-2000 mm 3 months little rain	Tropical Rainforest, Edaphic savannas	Marked Variability	Tropical Rainforest	Absy et al. 1991; Siffedine et al. 2001
49	Lago Surara	4°9'S/61°-46'W	76		Igapó forest	Relatively dry at 5240±100		Absy 1979
50	Lago Calado	0°39'S/4-9°70'W	23	? 2100 mm no dry season	Tropical Rainforest	Low Amazon water level, drier, less precipitation	Tropical Rainforest	Behling et al. 2001
51	Lago do Aquiri	3°10'S/4-4°59'W	10	2000 - 3250 mm 3 dry months	Swamp savanna / rainforest mosaic	1400 - 1500 mm 5 dry months	Mangrove, Data available only until 6,700 14C yr BP	Behling and Costa 1997
52	Rio Curuá	1°44'S/5-1°27'W	3	2500 mm no dry season	Tropical Rainforest (terra firme, várzea, igapó)	2500 mm 4 months with less rainfall	Tropical Rainforest, swamp forest	Behling and da Costa, 2000
53	Lagoa da Curuçá	0°46'S/4-7°51'W	35	2000 - 2500 mm 3 dry months	Tropical Rainforest	Warm and humid, 3 dry months, ?2200 mm	Tropical Rainforest, rare mangroves	Behling 1996, Behling 2001
54	Lago Crispim	0°46'S/4-7°51'W	1-2	?2200 mm, 3 dry months, warm and humid, 26°C	Tropical rainforest and restinga mosaic	Warm and humid, 3 dry months, ?2200 mm	Restinga, mangrove, Tropical Rainforest,	Behling and da Costa 2001
55	Pantano de Mônica	0°42'S/7-2°04'W	160	> 3000 mm, no dry season	Tropical rainforest / edaphic savannas	Stronger seasonality	Tropical rain-forest, different composition than today	Behling et al. 1999
56	Lago Arari	0°39'S/4-9°70'W	0	no dry season, 4-5 months less rain	Tropical rainforest / restinga		Open forest / savanna	Absy 1985
57	Maicuru	0°30'S/5-4°14'W	550	2000-2500 mm 3 months little rain	Forest		Forest	Colinvaux and De Oliveira 2001
58	Lagoa Dragão (Seis Lagos)	0°16'N/6-6°41'W	250-300	2900 mm, no dry season	Tropical Rainforest	Increased seasonality, less moisture	Tropical Rainforest	Bush et al. 2004
59	Lagoa Pata (Seis Lagos)	0°16'N/6-6°41'W	250-300	2900 mm, no dry season	Tropical Rainforest	Increased seasonality, less moisture	Tropical Rainforest	Bush et al. 2004
60	Mariñame	0°44'N/7-2°04'W		no dry season	Tropical rainforest	Stronger seasonality	Varzea forest	Urrego 1994, 1997
61	Lago Ayauchi (Ecuador)	2°05'S/7-8°01'W	500	2000 - 3000 mm no dry season	Tropical rainforest	No major changes	Tropical rainforest	Bush and Colinvaux 1988
62	Lago Kumpaka (Ecuador)	3°02'S/7-7°49'W	700		Tropical rainforest			Liu and Colinvaux 1988
63	Lagoa Itui	00°26'N/-63°20'W	100	2300 mm, 3-4 months with less rainfall	Tropical rainforest / Amazonian caatinga mosaic	No major changes	Mauritia swamp	Carneiro et al. 2005 (in press)

Northern Hemisphere savannas (Llanos de Colombia)

64	Laguna Sardinas Llanos Orientales (Colombia)	4°58'N/69°28'W	80	1200 - 2800 mm 4-5 dry months, warm and humid tropical climate	Savanna	Wetter climatic conditions, cool, (3-4 dry months)	Increase of forest taxa, after 6,390 14C yr BP	Behling and Hooghiems-tra 1998
65	Laguna Angel Llanos Orientales (Colombia)	4°28'N/70°34'W	200	1200 - 2800 mm 4-5 dry months, warm and humid tropical climate	Savanna	Driest period	Maximum of savanna expansion	Behling and Hooghiems-tra 1998
66	Laguna el Pinal (Colombia)	4°08'N/71°23'W	180	1200-2000 mm 4-5 dry months	Grass savanna and gallery forests with Mauritia palms	Less rainfall than today or longer dry season	savanna	Behling and Hooghiems-tra 1999
67	Laguna Carimagua (Colombia)	4°04'N/70°14'W	180	1200-2000 mm, 4-5 dry months	Grass savanna and gallery forests with Mauritia palms	Less rainfall than today or longer dry season	savanna	Behling and Hooghiems-tra 1999
68	Laguna Loma Linda (Colombia)	3°18'N/73°23'W	310	2000-2500 mm, 4 dry months	Transition zone between Amazon rainforest and Savanna	Increase in precipitation and/or shorter dry season	Marked Increase in rainforest and gallery forest taxa after 6,000±390 14C yr BP	Behling and Hooghiems-tra 2000

The network of data points is still small in view of the huge area under consideration, but available pollen records allow an approximate estimation on past forest cover increase or reduction. For regions with no or little data, available data points have been used to interpolate for the entire forest regions.

The Amazon rainforest is the largest forest ecosystem in South America (fig. 1). It extends between 2600 and 3500 km from the Andes to the Atlantic Ocean. The maximum extension from north to south is between 1300 and 2000 km. According to Harcourt and Sayler (1996), the Amazon rain forest covers an area of about 5,600,000 km^2. Brazil hosts about 4,000,000 km^2 of potential tropical rainforest whereof until today 3,500,000 km^2 survived. The lack of data still allows much speculation on the Amazon rain forest history. An overview of the Holocene history of the South American savanna regions north and south of the equator allow an approximation of the Amazon rainforest extension during that time. The early to mid-Holocene was drier in most of the South American savannas than during the late Holocene periods thus the distribution of savanna vegetation was much larger during that time. Based on pollen data, the Amazon rain forest of the northern hemisphere, compared to the modern potential natural distribution, was probably about 100 km further south during the mid-Holocene. In the southern hemisphere, the shift was comparable, probably about 100 km further north for the mid-Holocene. Due to the isotope analysis from Rondônia, the savanna extension in the southeastern Amazon basin may have extended even up to 200 km further northwest than today. The estimated reduced area for the mid-Holocene, compared to the modern area, is about 610,000 km^2 (2600x100 and 3500x100km, respectively). There was probably no reduction in the western region (Andean border)(Bush et al. 2004) and the northeastern Atlantic region due to the higher precipitation rates in these regions.

The natural extension of the Atlantic rain forest is a 100-200-km broad and 3200-km-long coastal strip from Natal in northeastern Brazil to Porto Alegre in southern Brazil. The estimated potential natural Atlantic rainforest area including the semi-deciduous forest, which is found under drier conditions further inland, is 1,500,000 km^2 (www.mre.gov.br; Behling 2002). From this area is the Atlantic rainforest about 480,000 km^2. The Atlantic rainforest area was probably, in northeastern Brazil, smaller during the mid-Holocene than today. The estimated area is about 250,000 km^2 (3200x80km).

The tropical semi-deciduous of the east Brazilian region occurs in large areas mainly in southeastern Brazil and further north in the form of a small belt between the Atlantic rainforest and Cerrado vegetation. The modern potential natural semi-deciduous forest covered an area of about 770,000 km^2 (Fundação S.O.S. Mata Atlântica, 1992). During the mid-Holocene, large areas of present-day potential natural semi-deciduous forest were covered by cerrado. The estimated areas of semi-deciduous forest are about 500,000 km^2 for the mid-Holocene (Behling 2002).

Consequently, the Cerrado region was extended due to the shrinking of the rainforest area by 350,000 km^2, due to the decrease of the Atlantic rainforest area by about 230,000 km^2 and the restricted semi-deciduous forest by another 680,000 km^2, totaling about 3,360,000 km^2 in comparison to 2,125,000 km^2 in modern days. The Cerrado had an extension during the mid-Holocene almost equivalent to the modern-day extension of the Amazon rainforest dominating Brazil by 40% of the whole country.

The subtropical *Araucaria* forest occurs on the south Brazilian highland between latitudes 24° and 30° S primarily at elevations between 1000 and 1400 m and, in southeastern Brazil, in small isolated Islands between 18° and 24° S and in elevations between 1400 and 1800 m. The original distribution of the Brazilian *Araucaria* forest is estimated at about 200,000 km^2. Pollen analytical studies from southern Brazil show that huge areas of grassland (Campos) were still found during the mid-Holocene. Initial expansion of *Araucaria* forest started from gallery forests along the rivers about 3000 ^{14}C yr B.P. Therefore it is suggested that the *Araucaria* forest area was not larger than 10% of the modern potential natural area, that means 20,000 km^2 during mid-Holocene times (Behling 2002).

Also from the Caatinga ecosystem a lack of data still allows much speculation of their history. Considering what presumably has happened in the surrounding forest ecosystems, it seems to be justified to suggest that the extension of the Caatinga ecosystem did not change basically from modern-day extension (about 700,000 km^2).

REFERENCES

Absy, M.L. and Van der Hammen, T., 1976. Some paleoecological data from Rondônia, southern part of the Amazon basin. Acta Amazonica 6, 293-299.

Absy, M.L. 1985: Palynology of Amazonia: the history of thze forests as revealed by the palynological record. In: Prance, G.T. & Lovejoy, T.E. (Eds.) Amazonia, Pergamon Press, 72-82.

Amand, L.K., 2000. An ocean ice – advances in the estimation of past sea ice in the Southern Ocean. GSA Today 10 (3), 1-6.

Anhuf, D., Ledru, M-P., Behling, H., Da Cruz Jr., F.W., Cordeiro, R.C., Van der Hammen, T., Karmann, I., Marengo, J.A., De Oliveira, P.E., Pessenda, L., Siffedine, A., Albuquerque, A.L. , Da Silva Dias, P.L. Paleo-Environmental Change in Amazonian and African Rainforest during the LGM. Paaeogeography, Palaeoclimatology, Palaeoecology. (submitted)

Baker, P. A., C. A. Rigsby, G. O. Seltzer, S. C. Fritz, T. K. Lowenstein, N. P. Bacher, and C. Veliz. 2001a. Tropical climate changes at millennial and orbital timescales on the Bolivian Altiplano. Nature 409, 698-701.

Baker, P. A., G. O. Seltzer, S. C. Fritz, R. B. Dunbar, M. J. Grove, P. M. Tapia, S. L. Cross, H. D. Rowe, and J. P. Broda. 2001b. The History of South American Tropical Precipitation for the Past 25,000 Years. Science 291, 640-643.

Barberi, M. 1994: Paleovegetação e paleoclima no Quaternário tardio da vereda de Águas Emendadas. Master's thesis. Universidade de Brasília, Brasil.

Baumgartner, A., Reichel, E., 1975. The World Water Balance. Elsevier, New York, p.179.

Behling, H., 1995a. Investigations into the Late Pleistocene and Holocene history of vegetation and climate in Santa Catarina (S Brazil). Vegetation History and Archaeobotany, 4, 127-152.

Behling, H., 1995b. A high resolution Holocene pollen record from Lago do Pires, SE Brazil: Vegetation, climate and fire history. Journal of Paleolimnology, 14, 253-268.

Behling, H., 1996. First report on new evidence for the occurrence of Podocarpus and possible human presence at the mouth of the Amazon during the Late-glacial. Vegetation History and Archaeobotany, 5 (3), 241-246.

Behling, H., 1997a. Late Quaternary vegetation, climate and fire history from the tropical mountain region of Morro de Itapeva, SE Brazil. Palaeogeography, Palaeoclimatology, Palaeoecology 129 (3-4), 407-422.

Behling, H., 1997b. Late Quaternary vegetation, climate and fire history in the Araucaria forest and campos region from Serra Campos Gerais (Paraná), S Brazil. Review of Palaeobotany and Palynology 97,109-121.

Behling, H., 1998. Late Quaternary vegetational and climatic changes in Brazil. Review of Palaeobotany and Palynology 99, 143-156.

Behling, H., 2002. Late Quaternary vegetation and climate dynamics in southeastern Amazonia inferred from Lagoa da Confusao in Tocantins State, northern Brazil. Amazoniana XVII (1/2), 27-39.

Behling, H., 2002a. South and southeast Brazilian grasslands during Late Quaternary times: a sythesis. Palaeogeography, Palaeoclimatology, Palaeoecology, 201, 1-9.

Behling, H., 2002b, Carbon storage increases by major forest ecosystems in tropical South America since the Last Glacial maximum and the early Holocene, Global and Planetary Change 33, 107-116.

Behling, H. 2003. Late glacial and Holocene vegetation, climate and fire history inferred from Lagoa Nova in the southeastern Brazilian lowland. Vegetation History and Archaeobotany 12, 263-270.

Behling, H. and Hooghiemstra, H., 1998. Late Quaternary paleoecology and paleoclimatology from pollen records of the savannas of the Llanos Orientales in Colombia. Palaeogeography, Palaeoclimatology, Palaeoecology, 139, 251-267.

Behling, H. and Hooghiemstra, H., 1999, Environmental history of the Colombian savannas of the Llanos Orientales since the Last Glacial Maximum form lake records El Pinal and Carimagua, Journal of Paleolimnology 21, 461-476.

Behling, H. and Hooghiemstra, H., 2000. Holocene Amazon rain forest - savanna dynamics and climatic implications: high resolution pollen record Laguna Loma Linda in eastern Colombia. Journal of Quaternary Sciences, 15, 687-695.

Behling, H. and Hooghiemstra, H., 2001. Neotropical savanna environments in space and time: Late Quaternary interhemispheric comparisons. In: Markgraf, V. (ed.), Interhemispheric Climate Linkages, Academic Press, pp. 307-323.

Behling, H. and Lichte, M., 1997, Evidence of dry and cold climatic conditions at glacial times in tropical Southeastern Brazil, Quaternary Research 48 (3), 348-358.

Behling, H. and Da Costa, M.L., 2000. Holocene environmental changes from the Rio Curuá record in the Caxiuanã regio, eastern Amazon basin. Quaternary Research 53, 369-377.

Behling, H. and Da Costa, M.L., 2001. Holocene vegetational and coastal environmental changes from the lago Crispim record in northeastern Pará State, eastern Amazonia. Review of Paleobotany and Palynology 114, 114-155.

Behling, H. and Negrelle R.R.B., 2001, Late Quaternary tropical rain forest and climate dynamics from the Atlantic lowland in southern Brazil, Quaternary Research 56, 383-389.

Behling, H., Lichte, M. and Miklos, A. W., 1998, Evidence of a forest free landscape under dry and cold climatic conditions during the last glacial maximum in the Botucatú region (São Paulo State), Southeast Brazil, Quaternary of South America and Antarctic Peninsula 11, 99-110.

Behling, H., Berrio, J.C. and Hooghiemstra, H., 1999. Late Quaternary pollen records from the middle Caquetá river basin in central Colombian Amazon. Palaeogeography, Palaeoclimatology, Palaeoecology 145, 193-213.

Behling, H., Arz, H. W., Pätzold, J. and Wefer, G., 2000. Late Quaternary vegetational and climate dynamics in northeastern Brazil, inferences from marine core GeoB 3104-1. Quaternary Sciences Reviews, 19, 981-994.

Behling, H., DePatta Pillar, V., Orlóci, L., and Girardi Bauermann, S., 2004. Late Quaternary Araucaria forest, grassland (Campos), fire and climate dynamics, studied by high-resolution pollen, charcoal and multivariate anlysis of the Cambara do Sul core in southern Brazil. Palaeogeography, Palaeoclimatology, Palaeoecology 203, 277-297.

Behling, H., DePatta Pillar, V., and Girardi Bauermann, S., 2005. Late Quaternary grassland (Campos), gallery forest, fire and climate dynamics, studied by pollen, charcoal and multivariate analysis of the São Franzisco de Assis core in western Rio Grande do Sul (southern Brazil). Review of Paleobotany and Palynology 133, 235-248.

Burbridge, R., Mayle, F.E., Killeen, T.J, 2004. Fifty-thousand-year vegetation and climate history of Noel Kempff. Mercado National Park, Bolivian Amazon. Quaternary Research, 61, 215-230.

Bush, M.B. Colinvaux, P.A. 1998: A 7000 year vegetational history from lowland Amazon, Ecuador. Vegetatio, 76: 141-154.

Bush, M.B., Stute, M., Ledru, M.-P., Behling, H., Colinvaux, P., De Oliveira, P.E., Grimm, E.C., Hooghiemstra, H., Haberle, S., Leyden, B.W., Salgado-Labouriau, M.-L., and Webb, R., 2001. Paleotemperature estimates for the lowland Americas between 30 S and 30 N at the last glacial maximum. In: Markgraf, V. (ed.), Interhemispheric climate linkages. Academic Press, San Diego, pp. 293-306.

Bush, M.B., Miller, M.C., De Oliveira, P.E., and Colinvaux, P.A., 2002. Orbital forcing signal in sediments of two Amazon lakes. Journal of Paleolimnology 27, 341-352.

Bush, M.B., De Oliveira, P.E., Colinvaux, P.A., Miller, M.C., and Moreno, J.E., 2004. Amazonian paleoecological histories: one hill, three watersheds. Palaeogeography, Palaeoclimatology, Palaeoecology 214, 359-393.

Bush, M.B., Silman, M.R., and Urrego, D.H., 2004. 48,000 Yaers of climate and forest change in a biodiversity hotspot. Science 303, 827-829.

Carneiro, A.F., Behling, H., Rosique, Th., and Schwartz, D. (in press) Dynamique holocène d'une depression marécageuse interdunaire (Rio Negro, Amazonie Brésilienne).

Cohen, J.C.P., Silva Dias, M.A.F., and Nobre C.A., 1995. Environmental conditions associated with Amazonian Squall lines: a case study. Monthly Weather Review 123, 3163-3174.

COHMAP Members, 1988. Climatic changes of the last 18000 years: observations and model simulations. Science 241, 1043-1052.

Colinvaux, P.A., De Oliveira, P.E., Moreno, J.E., Miller, M.C., and Bush, M.B., 1996. A long pollen record from lowland Amazonia: Forest and cooling in glacial times. Science 274, 85-88

Colinvaux P.A. and De Oliveira P.E., 2001. Palaeoecology and climate of the Amazon basin during the last glacial cycle. Journal of Quaternary Science 15, 347-356.

Cordeiro, S.H. & Lorscheitter, M.L. 1994: Playnology of Lagoa dos Patos sediments, Rio Grande do Sul. Brazil. J. Paleolimnol. 10, 35-42.

Cowling, S.A., Maslin, M.A., Sykes, M.T., 2001. Paleovegetation simulations of lowland Amazonia and implications for neotropical allopatry and speciation. Quaternary Research 55, 140-149.

Farreira, I., Harrison, S.P., Prentice, I.C., Ramstein, G., Guiot, J., Bartlein, P.J., Bonnefille, R., Bush, M., Cramer, W., v.Grafenstein, U., Holmgren, K., Hooghiemstra, H., Hope, G., Jolly, D., Lauritzen, S.-E., Ono, Y., Pinot, S., Stute, M., Yu, G., 1999. Tropical climates at the Last Glacial maximum: a new synthesis of terrestrial paleoclimate data. I. Vegetation, lake levels, and geochemistry. Climate Dynamics 15, 823-856.

Ferraz-Vicentini, K.R. & Salgado-Labouriau, M.L. 1996: Palynological Analysis of a palm swamp in Central Brazil. Journal of South American Earth Science 9, 207-219.

Figueroa, S.N. and Nobre, C.A., 1990. Precipitation distribution over central and western tropical South America. Climanálise 5(6), 36-45.

Fisch, G., Marengo, J., Nobre, C., 1998. Uma revisão geral sobre o Clima da Amazonia. Acta Amazonica 28, 101-126.

Freitas, H.A.de, Pessenda, L.C.R., Aravena, R., Gouveia, S.E.M., Ribeiro, de S., and Boulet, R., 2001. Late Quaternary vegetation dynamics in the southern Amazon basin inferred from carbon isotopes in soil organic matter. Quaternary Research 55, 39-46.

Fundação S.O.S. Mata Atlantica, 1992. Mata Atlantica. Fundação S.O.S. Mata Atlantica, São Paulo.

Garreaud, R., Wallace, J. M., 1998. Summertime incursions of midlatitude air into subtropical and tropical South America. Mon. Wea. Rev. 126, 2714-2733.

Gersonde, R., Abelmann, A., Brathauer, U., Becquey, S., Bianchi, C., Cortese, G., Grobe, H., Kuhn, G., Niebler, H.-S., Segl, M., Sieger, R., Zielinski, U., Fütterer, D. K., 2003. Last glacial sea surface temperatures and sea-ice extent in the Southern Ocean (Atlantic-Indian sector): A multiproxy approach. Paleoceanography 18(3), 1061, 10.1029/2002PA000809.

Grimm, A.M., Silva Dias, P.L., 1995. Analysis of tropical-extratropical interactions with influence functions of a barotropic model. Journal of Atmospheric Sciences 52(20), 3538-3555.

Grimm, E.C., Lozano-García, S., Behling, H., and Markgraf, V., 2001. Holocene Vegetation and Climate Variability in the Americas. In: Markgraf, V. (ed.), Interhemispheric Climate Linkages, Academic Press, pp. 325-370.

Gouveia, S.E.M., Pessenda, L.C.R., Aravena, R., Boulet, R., Roveratti, R., and Gomes, B.M., 1997. Dinâmica de vegetações durante o Quaternário recente no Sul do Amazonas, Indicada pelos isótopos do Carbono 12C, 13C, 14C) do solo. Geochimica Brasiliensis 11 (3), 355-367.

Haberle, S.G., Maslin, M.A., 1999. Late Quaternary vegetation and climate change in the Amazon basin based on a 50,000 year pollen record from the Amazon fan, ODP site 932. - Quaternary Research 51, 27-38.

Haffer, J., Prance, G.T., 2001. Climatic forcing of evolution in Amazonia during the Cenozoic: On the refuge theory of biotic differentiation. Amazoniana 16(3/4), 579-607.

Harcourt, C.S. and Sayler, J.A., 1996. The conservation atlas of tropical forests. The Americas. Simon and Schuster, New York.

Houghton, J.T., Ding, Y., Griggs, D.J., Noguer, M., Van der Linden, P., Dai, X., Maskell, K., Johnson, C.I. (eds.), 2001. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change; Cambridge University Press, Cambridge, p. 944.

IBGE, 1993. Mapa de Vegetação do Brasil. Rio de Janeiro.

Joussaume S. and Taylor K.E., 1995. Status of the Paleoclimate Modelling Intercomparison Project (PMIP). In: Proceedings of the First International AMIP Scientific Conference 15. -19. May 1995. Monterey, CA, p. 532.

Ledru, M.-P., 1993. Late Quaternary environmental and climatic changes in central Brazil. Quaternary Research 39, 90-98.

Ledru, M.-P., 2002. Late Quaternary History and Evolution of the Cerrados as Revealed by Palynological Records. In: Oliveira, P.S. and Marquis, R.J. (eds.), The Cerrados of Brazil: ecology and natural history of a neotropical savanna. Columbia University Press, New York, 33-50.

Ledru, M.-P., Braga, P.I.S, Soubies, F., Fournier, M., Martin, L., Suguio, K., and Turq, B., 1996. The last 50,000 years in the Neotropics (Southern Brazil) evolution and climate. Palaeogeography, Palaeoclimatology, Palaeoecology 123, 239-257.

Ledru, M.-P., Bertaux, J., Sifeddine, A., and Suguio, K., 1998. Absence of last glacial maximum records in lowland tropical forests. Quaternary Research 49, 233-237.

Ledru, M.-P., Salgado-Labouriau, M.L., Lorscheitter, M.L., 1998. Vegetation dynamics in southern and central Brazil during the last 10,000 yr B.P.. Review of Palaeobotany and Palynology 99, 131-142.

Ledru, M.-P., Campello Cordeiro, R., Landim, J.M.D., Martin, L., Mourguiart, P., Siffedine, A., and Turq, B., 2001. Late-glacial cooling in Amazonia inferred from pollen at Lago do Caço, northern Brazil. Quaternary Research 55, 47-56.

Liu, K.-B. And Colinvaux, P.A., 1988. A 5200-year history of Amazon rain forest. J. Biogeogr. 15, 231-248.

Marchant, R., Behling, H., Berrio, J.C., Cleef, A., Duivenvoorden,J., Hooghiemstra, H., Kuhry, P., Melief, B., Van Geel, B, Van der Hammen, Th., Van Reenen, G., and Wille, M., 2001. Mid- to Late-Holocene pollen-based biome reconstructions for Colombia. Quaternary Science Reviews 20, 1289-1308.

Marengo, J., Nobre, CA., 2001. The Hydroclimatological framework in Amazonia. In: Richey, J., McClaine, M., Victoria, R. (eds.), Biogeochemistry of Amazonia, Oxford University Press, Oxford, pp. 17-42.

Mayle, F.E., Burbridge, R., and Killeen, T.J., 2000. Millennial scale dynamics of southern Amazonian rainforests. Science 290, 2291-2294.

Meggers, B.J., 1994. Archaeological evidence for the impact of Mega-Nino events on Amazonia during the past 2 millenia. Climatic Change 28(4), 321-338.

Mourguiat, Ph., Ledru, M-P., 2003a. Last Glacial Maximum in an Andean cloud forest environment (Eastern Cordillera, Bolivia). Geology 31(3), 195-198.

Mourguiat, Ph., Ledru, M-P., 2003b. Reply to: Baker, P.A., Bush, M., Fritz, Sh., Rigsby, C.A., Selzer, G., and Silman, M. Last Glacial Maximum in an Andean cloud forest environment (Eastern Cordillera, Bolivia): (published online: July 2003, Geology, e26-e27.

Neves, P.C.P. and Lorscheitter, M.L., 1995: Upper Quaternary paleoenvironments in the northern coastal plain of Rio Grande do Sul. Brazil. Quat. S. Am Antarct. Peninsula 9, 39-67.

Niebler, H.S., Arz, H.W., Donner, B., Mulitza, S., Pätzold, J., Wefer, G., 2003. Sea-surface temperatures in the equatorial and South Atlantic Ocean during the Last Glacial Maximum (23-19 ka). Paleoceanography 18(3), 1069, 10.1029/2003PA000902.

De Oliveira, P.E., 1992. A plalynological Record of late Quaternary vegetational and climatic change in southeastern Brazil. Ph.D. thesis. The Ohio State University, Columbus, p. 238.

De Oliveira, P.E., Barreto, A.M.F., and Suguio, K., 1999. Late Pleistocene/Holocene climatic and vegetational history of the Brazilian caatinga: the fossil dunes of the middle Sao Francisco River. Palaeogeography, Palaeoclimatology, Palaeoecology 152, 319-337.

Pessenda L.C.R., Gomes B.M., Aravena R., Ribeiro A.S., Boulet R., and Gouveia S.E.M., 1998. The carbon isotope record in soils along a forest-cerrado ecosystem transect: implication for vegetation changes in the Rondonia state, southwestern Brazilian Amazon region. The Holocene 8(5), 599-603.

Pessenda L.C.R., Ribeiro A.S., Gouveia S.E.M., Aravena R., Boulet R., and Bendassolli, J.A., 2004. Vegetation dynamics during the late Pleistocene in the Barreirinhas region, Maranhao State, northeastern Brazil, based on carbon isotopes in soil organic matter. Quaternary Research 62, 183-193.

Pflaumann, U., Sarnthein, M., Chapman, M., d'Abreu, L, Funnell, B., Huels, M., Kiefer, T., Maslin, M., Schulz, H., Swallow, J. van Kreveld, S., Vautravers, M., Vogelsang, E., Weinelt, M., 2003. Glacial North Atlantic: Sea-surface conditions reconstructed by GLAMAP-2000. Paleoceanography 18(3), 1065, 10.1029/2002PA000774.

Prentice, I.C., Jolly, D. and BIOME 6000 participants, 2000. Mid-Holocene and glacial-maximum vegetation geography of the northern continents Africa. Journal of Biogeography 27(3), 507-520.

Rao, V. B., and Hada, K., 1990. Characteristics of rainfall over Brasil. Annual variations and connections with the Southern Oscillation. Theor. Appl. Climatol. 42, 81-91.

Ratisbona, L.R., 1976. The Climate of Brazil. In: Schwerdtfeger, W. (ed.), Climates of Central and South America, Elsevier, Amsterdam/Oxford/New York, pp. 219-291.

Ratter, J.A., Bridgewater, S., Atkinson, R. and Ribeiro, J.F., 1996. Analysis of the floristic composition of the Brazilian cerrado vegetation II: Comparison of the woody vegetation of 98 areas. Edingburgh Journal of Botany 53, 153-180.

Roth, L. & Lorscheitter, M.L. 1993: Palynology of a bog in Parque Nacional de Aparados da Serra. East Plateau of Rio Grande do Sul. Brazil. Quat. S. Am Antarct. Peninsula 8, 39-69.

Salati, E., 1987. The forest and the hydrological cycle. In: Dickinson, R.E. (ed), The Geophysiology of Amazonia, Wiley, New York, pp. 273-296.

Salati, E., and Voce, P., 1984. Amazon basin: A system in equilibrium. Science 225, 128-138.

Salati, E., Dall'Ollio, A., Matsui, E., and Gat, J., 1979. Recycling of water in the Amazon basin: An isotopic study. Water Resource Res. 15, 1250-1258.

Salati, E., Nobre C.A., and dos Santos, A.A., 2001. Amazonian deforestation: regional and global issues. Amazoniana 16 (3/4), 463-481.

Salgado-Labouriau, M.L., Casseti, V., Ferraz-Vicentini, K.R., Martin, L., Soubiès, F., Suguio, K. & Turcq, B. 1997: Late Quaternary vegetational and climatic changes in cerrado and palm swamp from Central Brazil. Paleogeogr., Paleoclimatol., Paleoecol. 128, 215-226.

Salgado-Labouriau, M.L., Barberi, M., Ferraz-Vicentini, K.R. and Parizzi, M.G., 1998: A dry climatic event durino the late Quaternari of tropical Brazil. Review of Paleobotany and Palynology 99, 115-129.

Santos, G., Cordeiro, R. C., Silva Filho, E. V., Turcq, B., Fifield, L. K., Gomes, P. R. S., Hausladen, A., and Sifeddine, A., 2001, Chronology of atmospheric mercury in Lagoa Da Pata basin, upper Rio Negro region of Brazilian Amazon. Radiocarbon 43 (2), 801– 808.

Sifeddine A., Martin L., Turcq B., Volkmer-Ribeiro, C., Soubiès F., Campello Cordeiro R., and Suguio K., 2001, Variations of the Amazonian rainforest environment: a sedimentological record covering 30,000 years, Palaeogeogr., Palaeoclimatol., Palaeoecol. 168, 221-235.

Stute, M., Forster, M., Frischkorn, H., Serejo, A., Clark, C.F., Schlosser, P., Broeker, W.S., Bonani, G., 1995: Cooling of Tropical Brazil (5°C) during the Last Glacial Maximum. Science 269, 379-383.

Suguio, K., Martin, L., Bittencourt, A.C., Bittencourt, A.C.S.P., Dominguez, J.M.L., Flexor, J-M., and De Azevedo, A.E.G., 1985, Fluctuacões do nivel do mar durante o Quaternario superior ao longo do litoral Brasileiro e sus imlicacões na sedimentação costeiro, Revista Brsasileira de Geosciencias 15, 273-286.

Teeuw, R.M. and Rhodes, E.J., 2004. Aeolian activity in northern Amazonia: optical dating of late Pleistocene and Holocene paleodunes. J. Quaternary Sci. 19, 49-54.

Tissot, C. & Marius, C. 1992: Holocene evolution of the mangrove ecosystem in French Guaina: a playnological study. In: Singh, K.P., Singh J.S. (Eds.): Tropical Ecosystems: Ecology and Management. Wiley & Sons, New Dehli, p. 333-347.

Turcq, B., Albuquerque, A.L.S., Cordeiro, R.C., Sifeddine, A., Simoes Filho, F.F.L., Souza, A.G., Abrão, J.J., Oliveira, F.B.L., Silva, A.O., and Capitâneo, J., 2002. Accumulation of organic carbon in five Brazilian lakes during the Holocene. Sedimentary Geology 148, 319-342.

Urrego, L.E., 1994/1997: Los bosques inundables del medio Caquetá: Caracterizacion y sucesion. In: Estudios en la Amazonia Colombiana/Studies on the Colobian Andeas, XIV. Tropenbos Columbia, Bogota.

Van der Hammen, T. and Absy, M.L., 1994. Amazonia during the last glacial. Palaeogeogr., Palaeoclimatol., Palaeoecol. 109, 247-261.

Van der Hammen, T. and Hooghiemstra H., 2000. Neogene and Quaternary history of vegetation, climate, and plant diversity in Amazonia. Quaternary Science Review 19, 725-742.

Van der Hammen, T., 2001a. Ice age in tropical South America: what was it really like? Amazoniana 16 (3/4), 647-652.

Van der Hammen T., 2001b. Paleoecology of Amazonia. In: Guimaraes Viera I.C. et al. (eds.), Diversidade biológica e cultural da Amazônia", p. 19-44. Museu Paraense Emilio Goeldi, Belém.

Veloso, H.P., Rangel Filho, A.L.R., Lima, J.C.A., 1991. Classificação da vegetação brasileira, adaptada a um sistema universal. Instituto Brasileiro de Geografía e Estatística. Rio do Janeiro, Brazil.

Vuille, M. and Ammann, C., 1997. Regional snowfall patterns in the high, arid Andes. Climatic Change 36, 413-423.

Wainer, I., Clauzet, G., Ledru, M-P., Brady, E., Otto-Bliesner, B., 2005. Last Glacial Maximum in South America: Paleoclimate proxies and model. Geophysical Research Letters 32, L08702, doi:10.1029/2004GL021244.

Wijmstra, T.A. & Van der Hammen, T. 1996: Palynological data on the history of tropical savannas in northern South America. Leidse Geol. Mededelingen. 38, 71-90.

IS THE AMAZON FOREST A SITTING DUCK FOR CLIMATE CHANGE? MODELS NEED YET TO CAPTURE THE COMPLEX MUTUAL CONDITIONING BETWEEN VEGETATION AND RAINFALL

ANTONIO DONATO NOBRE
Instituto Nacional de Pesquisas da Amazônia

There is much evidence indicating that South America east of the Andes may have had a relatively stable climate, free of ice cap or desertification forest shut-downs for at least 25 thousand years (Baker et al 2001, Colinvaux & Oliveira 2000, Colinvaux et al 2000), and possibly for much longer (Hooghiemstra et al 2002). The extraordinary diversity of life forms found in its three most extensive biomes, Amazon and Atlantic forests and the savannas, supports the indication of long term climate stability (Hooghiemstra et al 2002). The South American mega fauna, relatively devoid of four footed grazing herbivores when compared to the African or North American ones, indicates that for sufficiently long periods South America might have had relatively small areas of savanna (Vivo & Carmignotto 2004). There is biological evidence as well that Atlantic and Amazon forests have been connected (Costa 2003). However, whether South America enjoyed a continuous forest cover over millions of years or if it was subjected to periods of partial aridity has not been established without doubt (Colinvaux et al 2000, Haffer & Prance 2001).

Extensive forests, covering most of the continent, requires wet climates or, at least, a less seasonal rainfall distribution. Long dry seasons create a role for fire in opening up forest areas that can be colonized by savannas. Conversely, short or absent dry seasons will favor forest over savannas. The history of vegetation cover in South America is thus relevant as proxy for the understanding of the complex biome-atmosphere interactions.

SOUTH AMERICA CIRCULATION AND POTENTIAL VEGETATION–RAINFALL COUPLING MECHANISM

Baker et al (2001), in trying to understand paleoclimates from evidence left in the muddy bottom of the Titicaca lake on the Andean plateau, verified that wet years in the Titicaca often corresponds with wet years in the Amazonian lowlands. Although cautioning against generalizing that wetness on Titicaca equals conditions in the jungles to the east, the authors emphasized that most evidence points to a connection. Equatorial convection would be the main driving force through the Hadley circulation and via trade winds for the pumping of water vapor from the Atlantic over to South America (Poveda & Mesa 1996, P.Nobre pers. comm..). Regional South American circulation most of the time connects the climates in the lowlands with the ones of the Andean highlands. The Titicaca records could thus reflect the moisture transported across the lowlands from the Atlantic. Vegetation on the lowlands should therefore have an intimate relationship with this long-range continental moisture transport.

From these and other indirect lines of evidence, such as patterns of intense and widespread rainfall over the forested surfaces in contrast to much weaker rainfall over non-forested or ocean areas at equivalent latitudes (Simpson et al 1996, TRMM data), it is possible to infer that the lowland rainforests must have powerful effects on maintaining a strong tropical Atlantic –> South America moisture convergence, promoted by the Amazonian rainfall convective chimneys (Zhou & Lau, 1998). The Large Scale Biosphere Atmosphere Experiment in Amazônia (LBA) has amassed an impressive volume of data from which several lines of evidence for rainfall mechanisms are emerging. In a synthesis of these tendencies, it is possible to recognize the following processes:

UNDISTURBED RAINFOREST CONDITION (*GREEN OCEAN, SENSE* ANDREA ET AL 2004)

1) Air masses from the equatorial Atlantic enter the South American continent through the wide northern portal, from Maranhão through Guyana (Vera et al 2004, Marengo et al 2004);
2) Laden with moisture, these air masses are the ultimate vapor source for lowland rainfall;
3) The forest canopy intercepts from 12 to 16% of rainfall, and up to 25%, depending on the season, returning the moisture back to the atmosphere (Cuartas et al subm);
4) Rainforests keep the soil surface very porous; throughfall infiltrates, recharging the soil moisture reservoir. This supplies root absorption for plant transpiration (40% of the rainfall), the largest source for returned atmospheric moisture (Tomasella et al subm);
5) When the soil moisture reservoir is satisfied the surplus infiltrates deeper, recharging the groundwater (Hodnett et al subm). The ground water discharges to the streams and rivers and maintains river flow in the dry season;
6) Therefore, continuous rainforest cover in the lowlands represent a huge evaporative surface, which keeps westward migrating air masses humid;
7) Forests emit their own volatile organic carbon based CCNs (cloud condensation nuclei), a very effective spiking of the atmosphere for producing copious but gentle rainfall (Claeys et al 2004, Andrea et al 2004);
8) Forest cover also prevent excess aerosols to disrupt the radiative balance that could affect convection (Koren et al 2004) and excess CCNs that could disrupt the warm rainfall mechanism of item 7 (Andrea et al 2004);
9) Moist air masses travel 4,000 km or more over the green carpet before they reach the Andes (Marengo et al 2004).

DISTURBED RAINFOREST CONDITION (*ADVANCE BRAZIL*, LAURANCE ET AL 2001)

1) Moist air masses continue entering through the Amazon portal (though Cox et al 2000 and other modeling studies speculate on a change in this circulation with global warming);
2) Without the forest cover, many more CCNs will be airborne, so rainfall still happens where there is sufficient water vapor (Andrea et al 2004), such as in coastal areas;
3) But much reduced evapotranspiration and lack of canopy interception, associated with soil compaction and increased runoff, will change the water balance to favor drainage against evaporation that returns moisture to the atmosphere (Cuartas et al subm);

4) Drained water returns to the Atlantic basin, leaving the Amazon system and South America earlier than in the undisturbed condition;

5) Air masses which rained down grow progressively drier as they move further inland (Gorshkov et al 2000);

6) Aridity might develop inland, including in the highlands where the Titicaca is located (Baker et al 2001)

The conundrum generated by extrapolation these processes is the following:

Is drought inland only caused by an anomalous Atlantic surface temperature and connected remote disruption of convection over parts of the Amazon, or, even with a strong moisture entrance, the lack of forest would still result in drought to the west of South America?

Responding this question with an understanding of processes appears crucial to develop predictive capacity concerning the fate of South America rainfall with progressive rainforest destruction. The strong ongoing drought in western Amazônia might have developed from both effects, a warmer than normal north Atlantic and deforestation associated with extensive smoke over pristine rainforest. If this is the case, how much do these factors interact?

DRY-SEASON EVAPOTRANSPIRATION, RAINFALL AND SUSCEPTIBILITY TO FIRE

The Amazonian rainforest has evolved elaborate strategies to cope with seasonal water shortage and sporadic drought. Having deep roots usually assures a continuous water supply to the canopy even when water vapor in the troposphere is in harsh scarcity (Nepstad et al 2004). In the Amazon it has been measured an almost continuous evaporation behavior throughout the dry season, indicating deep access to soil moisture (Hodnet et al subm, Cuartas et al subm). The evaporated moisture is, in an undisturbed condition, an important source for dry season rainfall, which happens through small and frequent rain events. These weak rain events from rainforest recycled water are crucial to promote vertical redistribution of moisture within the forest, guaranteeing that the litter layer will remain moist and non-flammable (Nepstad et al, 1999 & 2004). Wet litter layer throughout the dry season or across a sporadic drought prevent the outbreak of fires, keeping the forest resistant in the long run to the incursion of savannas. Conversely, if the litter layer becomes flammable by progressive lack of dry-season rainfall, the event of fire will initiate an ecological domino effect that in few years will disrupt completely the rainforest and lead to significant loss of biodiversity and biomass (Cochrane et al 1999, Nepstad et al 1999, Siegert et al 2001, Laurance & Williamson 2001).

Smoke, soot and dust have been shown to interfere and disrupt the normal (green ocean) cloud formation and rainfall (Ramanathan et al 2001 , Koren et al 2004, Andrea et al 2004). With enough water vapor in the air, excess CCNs provided by these disturbance sources will lead to the development of deeper convective clouds and strong thunderstorms (Andrea et al 2004). But during dry season or drought episodes, the scarcity of water vapor will result in suppression of those small albeit crucial dry-season rainfall events (Rosenfeld 2001). The ongoing strong drought episode in western Amazonia is coincident and associated with very high levels of smoke and soot originated from widespread rainforest destruction in the arch of fire. The ensuing complete rainfall suppression lead parts of pristine forests in Acre and Amazonas states to reach the point of litter flammability and, with the human encroachment, have had sufficient ignition to burn uncontrollably. This excess CCN effect in the disruption of dry-season/drought rainfall and eventual destruction of pristine rainforest has not yet being duly accounted for.

AMAZONIA RAINFALL MODELING: INTEGRATING BIOLOGY WITH METEOROLOGY

In order to capture complex feedbacks between rainfall, vegetation and the effects of human interference in the system there is a pressing need for models to better articulate and integrate distinct processes and scales (Field & Avissar 1998, Foley et al 2003). Approaches in hydrology (Chahine 1992), forest structure and function (Cramer et al 2001), plant physiology, biogenic gas emissions and atmosphere chemistry (Monson & Holland 2004), aerosols and CCNs (Ramanathan et al 2001), disturbance (Nepstad et al 2004), atmosphere dynamics (for ex. Pielke et al 1992) and cloud microphysics (Khain et al 2000) need to be effectively integrated in comprehensive modeling efforts.. Some global circulation models are starting to follow this path through the incorporation of aerosol dynamics and atmosphere chemistry (for ex. the Hadley Center).

But for the Amazon case, and particularly for the connections between plant physiology – voc/water emissions – ccns formation and cloud/rainfall dynamics, the challenge is to develop, validate and test coupled models with minimal amount of “coupled” observational data. It is likely that until integrated experiments and measurement campaigns are organized, rainfall-biology models will only indicate qualitative links and relationships. But the simple understanding of how biological inputs to the atmosphere can potentially regulate rainfall will be a great leap in understanding, leading to qualified demands in terms of validation data. It is clear that without a functional rainfall-biology sub-model the forest response to climate change or to local disturbance cannot be properly resolved in conventional climate models where vegetation role is simply parameterized.

IS THE RAINFOREST IN AMAZONIA GOING TO DRY OUT AND DIE?

Over thousands or likely millions of years the rainforest of South America has evolved its luxuriant biota without signs of having been shut-down by climate extremes, like aridity or freezing. Over the same span of time, however, it is very unlikely that external climate forcing remained equally benign, especially considering orbital, cosmic and other known drivers for planetary scale stern climate changes. The resulting question then is how in the face of formidable external adversity has this magnificent biome resisted extinction? Today there are enough lines of evidence that the biosphere cannot only resist, but, in fact, it can alter, modulate and even regulate its own environment (Pielke et al 1998, Foley et al 2003, Gorshkov et al 2004). South American rainforests are among the most massive, diverse and complex land biomes on the planet. From the green ocean rainfall mechanism being elucidated by the LBA studies one can envision how these forests could possibly regulate the climate. Controlling rainfall means also controlling convection, which in turn means interfering with a powerful energy conveyor belt: the Hadley circulation (Poveda & Mesa, 1996). Through rainfall regulation the biology could set the pace of tropical Atlantic trade winds (P.Nobre pers. comunication), dragging inland needed ocean moisture. That was then, with a cooler and tightly regulated greenhouse atmosphere (Gorshkov et al 2000, Cowling et al 2004).

How will this mechanism function now with a warming atmosphere and dwindling rainforests?

Some of the direct effects of anthropogenic disturbance on the rainforest ability to regulate rainfall, with its local consequences, have been discussed above. The ability of the biome to resist climate change, however, is today under great stress. New global integrated models that couple atmosphere, oceans and land vegetation through implementation of carbon and physiology sub-models have almost consistently shown an upcoming doomsday climate scenario for the Amazon basin (Betts et al 1997, Cox et al 2000, Cramer et al 2001, Cox et al 2004, Betts et al 2004). In those studies, progressive change in the inter-tropical convergence zone, similar to that occurring in strong *El Niño* years, will create a progressively longer "dry season" over considerable large areas.

Prolonged dry season cannot be dealt indefinitely by the biome, and dieback will ensue after soil moisture reaches a critical low level. Dieback in the Amazon means massive release of carbon to the atmosphere, feeding back on greenhouse warming, which in turn aggravates the drought forcing. Although controversial, these model results may in fact be optimistic because they lack an implementation of a rainfall-biology sub model, as suggested above. On one hand, the green ocean condition means a relatively much stronger resilience to external forcing (in a cooler atmosphere). On the other hand, the deforestation and the effects of pervasive smoke may mean a much weaker capacity to deal with external climate forcing. Therefore, the projected time span of decades for dieback in those modeling exercises may be much shorter, once the green ocean is being virulently destroyed and remaining islands of rainforests affected by pervasive smoke.

In conclusion, an undisturbed luxuriant rainforest does appear to have some means of resisting climate change, at least that might have been the case in a previous colder atmosphere. Not considering for now the important effect of hotter temperatures on tree physiology, the ability to manipulate the water cycle by pristine forests could mean these ecosystems would be able to resist at least to the extent of what is predicted by the climate-carbon models. But a rainforest reduced and fragmented by human action may not survive the onslaught of climate change for more than a few years. We may witness in our lifetimes the destruction of this biome's integrity, one that had survived glaciations but not the chainsaw and the torch.

ACKNOWLEDGEMENTS

Carlos Nobre, Foster Brown and Martin Hodnet for suggestions and detailed review of the manuscript. Paul Baker, Victor Gorshkov and Anastasia Makarieva for comments and useful discussions. Robert Harriss, Lynn Margulis for inspiration.

REFERENCES

Andreae MO., D. Rosenfeld, P. Artaxo, AA. Costa, GP. Frank, KM. Longo, MAF. Silva-Dias, **Smoking Rain Clouds over the Amazon**, *Science*, Vol 303, Issue 5662, 1337-1342 , 2004

Baker PA., GO. Seltzer, SC. Fritz, RB. Dunbar, MJ. Grove, PM. Tapia, SL. Cross, HD. Rowe, JP. Broda, **The History of South American Tropical Precipitation for the Past 25,000 Years**, *Science*, Vol 291, Issue 5504, 640-643 , 2001

Betts RA., PM. Cox, M. Collins, PP. Harris, C. Huntingford, CD. Jones, **The role of ecosystem-atmosphere interactions in simulated Amazonian precipitation decrease and forest dieback under global climate warming** *Theoretical and Applied Climatology*, Volume 78, Numbers 1-3 157 – 175, 2004

Betts RA., PM. Cox, SE. Lee, FI Woodward, **Contrasting physiological and structural vegetation feedbacks in climate change simulations**, *Nature* 387, 796 – 799, 1997

Chahine MT., **The hydrological cycle and its influence on climate**, *Nature* 359, 373 – 380, 1992

Claeys M, B Graham, G Vas, W Wang, R Vermeylen, V Pashynska, J Cafmeyer, P Guyon, MO. Andreae, P Artaxo, W Maenhaut, **Formation of Secondary Organic Aerosols Through Photooxidation of Isoprene**, *Science*, Vol 303, Issue 5661, 1173-1176 , 2004

Cochrane MA., A. Alencar, MD. Schulze, CM. Souza, DC. Nepstad, P. Lefebvre, EA. Davidson, **Positive Feedbacks in the Fire Dynamic of Closed Canopy Tropical Forests** *Science* Vol 284 p 1832-1835 (1999)

Colinvaux PA., PE. De Oliveira, **Paleoecology and climate of the Amazon basin during the last glacial cycle** *Journal of Quaternary Science*, Volume 15, Issue 4 , Pages 347 - 356

Special Issue: Quaternary Climate Change and South America . 2000

Colinvaux PA., PE. De Oliveira, MB. Bush, **Amazonian and neotropical plant communities on glacial time-scales: The failure of the aridity and refuge hypotheses**, *Quaternary Science Reviews* 19 (2000) 141-169

Costa LP., **The historical bridge between the Amazon and the Atlantic Forest of Brazil: a study of molecular phylogeography with small mammals**, *Journal of Biogeography*, 30, 71–86 (2003)

Cox PM, Betts RA, Jones CD, Spall SA, Totterdell IJ **Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model**. *Nature* 408:

184–187 (2000)

Cox PM, RA. Betts, M. Collins, PP. Harris, C. Huntingford, CD. Jones, **Amazonian forest dieback under climate-carbon cycle projections for the 21st century,** *Theor. Appl. Climatol*. 78, 137–156 (2004)

Cowling SA., RA. Betts, PM. Cox, VJ. Ettwein, CD. Jones, MA. Maslin, SA. Spall, **Contrasting simulated past and future responses of the Amazonian forest to atmospheric change** One contribution of 17 to a Theme Issue 'Tropical forests and global atmospheric change' *Philosophical Transactions: Biological Sciences* Issue: Volume 359, Number 1443 / Pages: 539 – 547, 2004

Cramer W, A Bondeau, F. I Woodward, I. C Prentice, R A. Betts, V Brovkin, P M. Cox, V Fisher, J A. Foley, A D. Friend, C Kucharik, M R. Lomas, N Ramankutty, S Sitch, B Smith, A White, C Young-Molling, **Global response of terrestrial ecosystem structure and function to CO_2 and climate change: results from six dynamic global vegetation models**, *Global Change Biology* Volume 7 Issue 4 Page 357 - 2001

Cuartas LA., J. Tomasella, AD. Nobre, MG. Hodnett, MJ. Waterloo, JC. Múnera, **Interception water-partitioning Dynamics for a Pristine Rainforest in Central Amazonia: Marked Differences Between Normal and Dry Years**, Submitted to *Agricultural and Forest Meteorology*.

Field CB., R. Avissar, **Bidirectional Interactions between the Biosphere and the Atmosphere - Introduction** *Global Change Biology* special issue Volume 4 Issue 5 - Page 459 (1998)

Foley JA., MH. Costa, C. Delire, N. Ramankutty, P. Snyder, **Green surprise? How terrestrial ecosystems could affect earths climate** *Front Ecol Environ*; 1(1): 38–44 (2003)

Gorshkov VG., VV. Gorshkov, AM. Makarieva, **Biotic regulation of the environment: key issue of global change**. Springer-Verlag, London, UK. 2000.

Gorshkov VG., AM. Makarieva, VV. Gorshkov, **Revising the fundamentals of ecological knowledge: the biota–environment interaction**, *Ecological Complexity,* 1:17–36 (2004)

Haffer, J; Prance, GT, **Climatic forcing of evolution in Amazonia during the Cenozoic: On the refuge theory of biotic differentiation** *Amazoniana*. Vol. 16, no. 3-4, pp. 579-607. (2001)

Hodnett MG., Tomasella J., Cuartas LA., Waterloo MJ., Nobre AD., Munera C., Mota de Oliveira S., Nascimento AHM, Goncalvez GS, **Processes of streamflow generation in a forested ferralsol catchment in central Amazonia**, Submitted to *Hydrological Processes*.

Hooghiemstra H, T. Van der Hammen, A. Cleef, **Evolution of forests in the northern Andes and Amazonian lowlands during the Tertiary and Quaternary** *in* Guariguata M & G Kattan, eds. Ecology of Neotropical Rainforests. Ediciones LUR, Cartago, Costa Rica, 2002

Khain A., Ovtchinnikov M., Pinsky M., Pokrovsky A., Krugliak H., **Notes on the state-of-the-art numerical modeling of cloud microphysics** *Atmospheric Research*, Volume 55, Number 3, , pp. 159-224(66) (2000)

Koren I, YJ. Kaufman, LA. Remer, JV. Martins, **Measurement of the Effect of Amazon Smoke on Inhibition of Cloud Formation**, *Science*, Vol 303, Issue 5662, 1342-1345 , 2004

Laurance WF., MA. Cochrane, S. Bergen, PM. Fearnside, P. Delamônica, C. Barber, S. D'Angelo, T. Fernandes, **The Future of the Brazilian Amazon**, *Science*, Vol 291, Issue 5503, 438-439 , 2001

Laurance WF., GB. Williamson, **Positive Feedbacks among Forest Fragmentation, Drought, and Climate Change in the Amazon** *Conservation Biology* Volume 15 Issue 6 Page 1529 - (2001)

Marengo JA., WR. Soares, C. Saulo, M Nicolini, **Climatology of the Low-Level Jet East of the Andes as Derived from the NCEP–NCAR; Reanalyses: Characteristics and Temporal Variability** *Journal of Climate* Vol. 17, No. 12, 2004

Monson RK., EA. Holland, **Biospheric Trace Gas Fluxes and their Control over Tropospheric Chemistry**, *Annu. Rev. Ecol. Syst*. 32:547–76 2001

Nepstad D., P. Lefebvre, UL. da Silva, J. Tomasella, P. Schlesinger, L. Solórzano, P. Moutinho D. Ray, JG. Benito, **Amazon drought and its implications for forest flammability and tree growth: a basin-wide analysis**, G*lobal Change Biology* Volume 10 Issue 5 Page 704 - 2004

Nepstad DC, A Verissimo, A Alencar, C Nobre, E Lima, P Lefebvre, P Schlesinger, C Potter, P Moutinho, E Mendoza, M Cochrane, V Brooks, **Large-scale impoverishment of Amazonian forests by logging and fire** *Nature* 398, 505-508 1999

Pielke RA., WR. Cotton, RL. Walko, CJ. Tremback, WA. Lyons, LD. Grasso, ME. Nicholls, MD. Moran, DA. Wesley, TJ. Lee, JH. Copeland, **A comprehensive meteorological modeling system—RAMS** *Meteorology and Atmospheric Physics* Volume 49, Numbers 1-4 Pages: 69 – 91 (1992)

Pielke RA., R. Avissar, M. Raupach, AJ. Dolman, X. Zeng, AS. Denning, **Interactions between the atmosphere and terrestrial ecosystems: influence on weather and climate** *Global Change Biology* Volume 4 Issue 5 Page 461 (1998)

Poveda G, Mesa OJ, **Feedbacks between Hydrological Processes in Tropical South America and Large-Scale Ocean–Atmospheric Phenomena**, Journal of Climate, vol 10, p 2690-2702, 1996.

Ramanathan, V., PJ. Crutzen, JT. Kiehl, D. Rosenfeld, **Atmosphere, aerosols, climate, and the hydrological cycle**, *Science*, 294(5549), 2119– 2124, 2001.

Rosenfeld D., Y. Rudich, R. Lahav, **Desert dust suppressing precipitation: A possible desertification feedback loop**, *PNAS* vol. 98 no. 11 5975–5980 (2001)

Increased damage from fires in logged forests during droughts caused by El Niño

Siegert F., G. Ruecker, A. Hinrichs, AA. Hoffmann, **Increased damage from fires in logged forests during droughts caused by El Niño** *Nature* 414, 437-440 (2001)

Simpson J., C. Kummerow, W. -K. Tao, R. F. Adler, **On the Tropical Rainfall Measuring Mission** (TRMM), *Meteorology and Atmospheric Physics*, Volume 60, Numbers 1-3 Pages: 19 – 36, 1996 (data in http://www.eorc.jaxa.jp/TRMM/index_e.htm)

Tomasella J., MG. Hodnett, Cuartas LA., AD. Nobre, MJ. Waterloo, JC. Múnera, **The water balance of a forested tropical basin near Manaus: Impacts of the interanual variability of climate on the hydrological cycle**, Submitted to *J. of Hydrology*

Vera C., W. Higgins, J. Amador, T. Ambrizzi, R. Garreaud, D. Gochis, D. Gutzler, D. Lettenmaier, J. Marengo, C. R. Mechoso, J. Nogues-Paegle, PL. Silva Dias, C. Zhang, **Towards a Unified View of the American Monsoon Systems**, submitted *Journal of Climate*, special issue on 1st International CLIVAR Science Conference, (2004)

Vivo M, AP. Carmignotto, **Holocene vegetation change and the mammal faunas of South America and Africa** *Journal of Biogeography* 31, 943–957 (2004)

SOUTHERN SOUTH AMERICA CLIMATE IN THE LATE TWENTY-FIRST CENTURY: ANNUAL AND SEASONAL MEAN CLIMATE WITH TWO FORCING SCENARIOS

MARIO N. NUÑEZ
Centro de Investigaciones del Mar y la Atmósfera
(CIMA-CONICET/UBA)
Bueno Aires, Argentina

SILVINA SOLMAN
Departamento de Ciencias de la Atmósfera y los Océanos (UBA)
Buenos Aires, Argentina

INTRODUCTION

The Second National Communication of Argentina for Climate Change (SNCACC) aimed to advance in the climate impact research for the region. In this context, climate change simulations of Southern South America climate were performed using a regional climate model (RCM) nested in a time slice of long term (240 years) atmospheric general circulation model (AGCM) experiments.

Two 10-year scenario simulations are performed for the period 2081-2090, one for the SRES A2 and the other for the SRES B2 emissions scenarios (IPCC 2000). The regional model used in the present work is the version 3.5 of the MM5 (Fifth generation Penn State/NCAR Mesoscale Model). The large scale fields needed to produce lateral boundary conditions for the MM5 simulations are obtained from corresponding time slice experiments with the global atmospheric model HadAM3P (Pope et al. 2000). The length of the simulations was 10 years to give a reasonable idea of the mean climate change. According to Jones et al. (1997) the minimum length needed to obtain an estimate of the climate change signal is ten year due that a 10-year simulation captures about half of the variance of the true regional climate change response.

We investigate the average change in climatic variables and the change in the annual cycle and the results represent a new focus area (South America) within the context of nested regional climate simulations, mostly because RCM experiments have become available mainly for the European region, USA and Australia.

The focus here is on the simulated climate changes; in particular those in surface temperature and precipitation, the two variables most used in impact assessment studies. Nevertheless, we also examine the changes in the sea level pressure and in the circulation structure to better understand the surface climate change signal. Both the time mean conditions and aspects of the annual cycle are studied. The control simulation (1981-1990) climates are studied in detail in Solman, Cabré y Nuñez (2005) and are not discussed here. The changes produced in the A2 y B2 experiments are intercompared to examine how regional climate change pattern depend of the greenhouse gases emissions forcing scenarios. The changes simulated by the nested MM5 and driving HadAM3P are then intercompared to evaluate the relative importance of the lateral boundary forcing in determining the regional climate change signal.

MODEL AND EXPERIMENT DESIGN

The regional climate model used for the present study is the MM5 v 3.5. It was tested to perform climate simulations in the study region through a set of sensibility experiments including convection schemes, surface processes and integration domain among others. The "quasi-observational" (NCEP/NCAR reanalysis, Kalnay et al., 1996) boundary conditions have been used to run the sensibility experiments. The model grid interval is 50 Km (average), and its domain covers southern South America and surrounding oceans, to avoid the lateral boundary conditions being over the complex topography of the region. The model uses a vertical configuration of 23 sigma levels.

The experiment design follows Jones et al. (2001): The conductive HadAM3P model drives the corresponding MM5 experiment for the period 1981-1990. For the simulation scenarios, greenhouse gas emissions are specified from the A2 and B2 emission scenarios as boundary conditions for the conductive model and it drives the RCM for the time slice 2081-2090. For the regional model simulations, the surface and lateral boundary conditions used (or calculated) by HadAM3P are directly interpolated onto the MM5 grid.

The geopotential height, relative humidity, temperature, zonal and meridional wind components require lateral boundary conditions that are taken from the global atmospheric model (HadAM3P). The variables at the boundary are updated every 6 hours, with a linear interpolation between successive updates at each MM5 time step. At the surface, temperature, humidity and sea level pressure are also updated each 6 hours. The sea surface temperature and sea ice are updated monthly. In addition, soil temperature and soil humidity at 10 and 200 cm are also updated monthly. The lateral meteorological boundary conditions were provided on a coarser grid than the original HadAM3P one and more specifically on a 2.5° latitude by 3.75° longitude grid.

As usually done in the thematic literature, we refer here to the term "change" as the difference between the selected climatic statistics in the scenario (2081-2090) and reference (1981-1990) simulations.

RESULTS

CHANGES IN THE MEAN CLIMATE

Mean sea level pressure and 500 hPa geopotential height

In this section changes in the 10-year annual and seasonal mean climate are analyzed. First of all we discuss the changes in large scale circulation pattern over southern South America as described by sea level pressure (SLP) and 500 hPa geopotential height fields.

Changes in time mean sea level pressure are shown in Figure 1 for summer (DJF, December-January-February) and winter (JJA, June-July-August) and for the annual mean. The changes in DJF are largely similar between the two scenario simulations showing a cell of increasing pressure centered southward in the southern Atlantic Ocean and southern Pacific Ocean. In relation to the pressure distribution in the control run, this indicates a southward extension of the summer mean Atlantic and Pacific subtropical highs. There are quantitative differences between both emission scenarios. The simulated changes are larger for the A2 than the B2 scenario, although with few qualitative differences.

The associated change in circulation aloft shows (Figure 2) a strong high pressure cell over southern South Atlantic Ocean mainly during summer for both scenario simulations. In JJA we find a pattern of circulation change with an increase of 500 hPa height over northern Argentina, Paraguay, northern Chile, Uruguay and southern Brazil. This is because of the lower tropospheric warming in the scenario simulations, which implies a thicker lower atmosphere.

Westerly winds in low levels will be less intense (not shown) in both scenarios.

Surface air temperature

The changes in DFJ, JJA and annual mean surface air (2 m level) temperature are shown in Figure 3. For both the A2 and the B2 scenarios, the warming pattern is similar but with some qualitative and quantitative differences. The simulated changes are larger for the A2 than the B2 scenario. In the two scenario runs, the warming in southern Brazil, Paraguay, Bolivia and northeastern Argentina are larger in winter and mainly in spring. In Paraguay, southern Brazil and northern Argentina the warming peaks in spring when it locally reaches 6 ° C in A2 simulation and 4.0 ° C in the B2 simulation. In the southern Argentina and Chile warming reach 2.5 ° C for the A2 scenario and less than 2.0 ° C for the B2 scenario. Both simulations show a large increase in the maximum temperatures in northern Argentina, Paraguay, Bolivia and southern Brazil, reaching 6 ° C in A2 scenario (not shown). For minimum temperatures, both scenarios show same patterns as in the maximum temperatures, but with a reduced warming area. The warming peaks in spring reaching 5.0 ° C in a patch in southern Brazil for A2 simulation (not shown).

Precipitation

The changes in DFJ, JJA and annual mean precipitation are shown in Figure 4. There are large seasonal and geographical variations in the change, and also some substantial differences between A2 and B2. Like temperature and sea level pressure, precipitation changes generally less in the B2 than in the A2 simulations, but mostly to the same direction. However, some qualitative differences between the two forcing scenarios also occur.

The B2 simulation shows a general increase in precipitation in southern Brazil, Paraguay, Bolivia, Uruguay, northern Argentina and northern Chile, with some decrease patches in precipitation in southern Brazil, northern Chile, southern Peru, northwestern and northeastern Argentina and in the Patagonia. The A2 simulation shows a similar geographical pattern of the changes in precipitation, but with extended areas with decrease in precipitation mainly in Chile. There are few quantitative differences between both emission scenarios. Both simulations show a general increase in precipitation in northern and central Argentina especially in summer and fall and a general decrease in precipitation in winter and spring. In fall the simulations agree on a general decrease in precipitation in southern Brazil. This reflects changes in the atmospheric circulation during winter and spring and most probably reflects the different changes in mean sea level pressure. A particularly large local difference in precipitation change occurs at the west cost of South America, where the steep orography makes the precipitation very sensitive to the Andes mountains representation by this and all models. Most of the projected changes are mostly in the same direction as in the present climate (Ciappesoni, Fernández and Nuñez, 2005). The B2 simulation shows a general increase in precipitation in southern Brazil, Paraguay, Bolivia, Uruguay, northern Argentina and northern Chile, with some decrease patches in precipitation southern Brazil, northern Chile, southern Peru, northwestern and northeastern Argentina and in the Patagonia. The A2 simulation shows a similar geographical pattern of the changes in precipitation, but with extended areas with decrease in precipitation mainly in Chile.

There are few quantitative differences between both emission scenarios. Both simulations show a general increase in precipitation in northern and central Argentina especially in summer and fall and a general decrease in precipitation in winter and spring. In fall the simulations agree on a general decrease in precipitation in southern Brazil. This reflects changes in the atmospheric circulation during winter and spring. A particularly large local difference in precipitation change occurs at the west cost of South America, where the steep orography makes precipitation many sensitive to the mountain parameterization in this (and all) model.

SUMMARY AND CONCLUSIONS

In this paper, we analyzed the climatic changes simulated over southern South America region under two IPCC emission scenarios (A2 and B2) for the period 2081-2090 with respect to the reference period 1981-1990. The simulations are performed with the regional climate model MM5 using forcing lateral boundary conditions from time-slice simulations with the HadAM3P global atmospheric model. Our primary conclusions can be summarized as follows:

In all seasons, southern South America undergoes warming in both the A2 and B2 scenarios. Minimum changes in the Mean Temperature are projected for summer and fall over the domain of simulations (2.5 - 3.5 ° C in the A2 simulation).

Maximum changes in the Mean Temperature are projected for winter and spring over the domain of simulations (2.5 - 5.0 ° C in the A2 simulation).

The precipitation changes vary substantially from season to season and across regions in response to changes in large scale circulations. Seasonal changes in precipitation in Argentina are projected for summer and fall seasons (west and humid Pampas increase approximately 180 mm maximum per season in the A2 simulation).

Maximum monthly changes for February, March, April, November and December in Precipitation.

B2 simulation shows a similar geographical pattern of the changes in temperature and precipitation, with quantitative differences between both emission scenarios.

Changes in mean sea level pressure show a cell of increasing pressure centered somewhere in the southern Atlantic Ocean and southern Pacific Ocean, mainly during summer and fall in the Atlantic and in spring in the Pacific. In relation to the pressure distribution in the control run, this indicates a southward extension of the summer mean Atlantic and Pacific subtropical highs.

The broad patterns of change in the nested regional climate model MM5 and driving HadAm3P fields are generally consistent each other, as can be expected from the strong influence of the boundary forcing on the regional model simulation. In summer, however, significant differences in the temperature and precipitation change can be found between the models. This could be due to the local physical processes.

REFERENCES

Ciappesoni, H. H**.,** A. E. Fernández y M. N. Nuñez, 2005: Impactos de la urbanización y de los cambios en el uso de la tierra en Argentina. CD Anales IX Congreso Argentino de Meteorología (CONGREMET IX), 9 páginas, ISBN 987-22411-0-4.

Jones, R. G., J. M. Murphy, M. Noguer and A. B. King, 1997**:** Simulation of climate change over Europe using a nested regional climate model. Comparison of driving and regional model responses to a doubling of carbon dioxide concentration. Q. J. R. Meteorol. Soc. 123:265-292.

Kalnay, E. and coauthors, (1996). The NCEP/NCAR 40-Year Reanalysis Project. *Bull. Amer. Meteor. Soc., 77*,437-431.

Pope, V. D., M. L. Gallani, P. R. Rowntree, R. A. Stratton (2000): The impact of new physical parameterizations in the Hadley Centre climate model. Clim. Dynam 16:123-146.

Solman, S., M. F. Cabré y M. Nuñez, 2005: Simulación del clima actual sobre el sur de Sudamérica con un modelo regional: Análisis de los campos medios y el ciclo anual. CD Anales IX Congreso Argentino de Meteorología (CONGREMET IX), 9 páginas, ISBN 987-22411-0-4.

THE VARIABILITY IN PRECIPITATION AND THE EXPANSION OF SOYBEN CROP IN BRAZIL: POSSIBLE SCENARIOS UNDER THE HYPOTHESIS OF CLIMATIC CHANGES

JOÃO LIMA SANT´ANNA NETO
Departamento de Geografia da FCT/UNESP,
Campus de Presidente Prudente, São Paulo

IVAN RODRIGUES DE ALMEIDA
Embrapa/Soja - Londrina, Paraná

INTRODUCTION

Agriculture is one the activities of greater risks among the sectors of economy caused either by external factors as political and market instability or by internal factors as the simultaneity of tasks such as field preparation, seedlings, crop growing treatments, pest control, weed control and harvest, all in a short period of time, in addition to the necessity of a greater coordination of activities in production systems with more than one annual harvest.

From one angle, the behavior of external factors is more predictable when the supply and demand of the products, the volume of world supply and the financial capacity of the States in granting financial support are known; from another angle, to obtain the maximum productive potential of a crop it is necessary that a combination of factors and internal processes of production occur in harmony of time and space, i.e., a circumstance of desirable events that not always occur with frequency in nature.

Agriculture in Brazil has produced great transformations in the landscape with the incorporation of many new areas, the introduction of new crops, the creation of new urban relations and the establishment of new fluxes in circulation of people, products and capitals.

The technical and scientific progress achieved by human ingenuity also propitiated agriculture to be explored in regions with most dissimilar soils, however, it was not totally capable of significantly reducing the relation of its dependence on the attributes of climate, which differentiates the regions with more or less increase in agricultural activities.

Certain regions offer components that build up capital, among them the climate, but also bear a stress on their natural resources, eventually generating environmental disrupts and social inequalities.

In this aspect the Brazilian agriculture, since the colonial period was always oriented towards exportation, having among its main products the sugar-cane, coffee and currently soybean. Introduced in the Southern Region it expanded from the State of Rio Grande do Sul towards the north in 1960, involving the western part of the State of Santa Catarina and Parana, the old coffee regions of northern Parana, the south and north region of the State of Sao Paulo, the so called triangle region of Minas Gerais, all the Center-Western Region of the country, and recently advancing towards the North and North-East of Brazil.

Soybean is an excellent foodstuff due to its nutritional characteristics and adapted in a most adequate way to the capitalist mode of diffusion, holding a catalyzing role in many segments of the agricultural, cattle raising and industrial sectors.

In the combination of agricultural products it leads the list of exported goods generating dividends for the States and the country. The main producer-states are the states of Mato Grosso, Parana, and Rio Grande do Sul.

Soybean has the status of a *commodity* and its exploitation is subordinated to fluctuations of international supply and demand. In spite of Brazil's participation as the second world producer, the international prices are fixed according to the USA production.

The progressive increase of world demand and the availability of vast agricultural areas in the country have stimulated an augment of production, in many occasions without considering the ecological support in determined environments as well as the social and economic consequences of an unbalanced growth.

The agents directly involved in the soybean-culture expansion process (researchers, environmentalists, national and international speculators), from the small capitalist producer to large industrial corporations, all or them recognize the climate as a determinant input for the success of such enterprise.

In the so called Legal Amazon Region, these agents with different levels of influence and political-economic power either converge or diverge according to each involved category. Such interests reveal a conflict of opinions which require a broader debate by the society on what kind of development is desirable for the country and its regions.

With a well defined rainfall season and a low precipitation variability, the State of Mato Grosso presents a scenario capable of substantial adjust in the participation of the States in the agricultural production of the country, at a cost (economic, ecological and social) that we are not yet capable of determining. Considered the dimensions of the State, the public apparatus constituted by roads, communication and energy are restrictive due to their precarious conditions. The enthusiasm to establish new structures and adjust these deficiencies may constitute a counterbalance to the necessity of preserving the isolation of indigenous societies and the preservation of environmental units.

In the Southern Region, the limitations of spatial order, given the total territorial occupation, lead to other problems linked to competitiveness and production scale, subjected to a more accentuated climatic variability. The environmental issue is also a recent aspect caused by the increase in the incorporation of new areas with low aptitude for annual crops .

The importance of relations between the society and nature can be identified by the differences between the dynamical adverse effects of the climate and its reflections on spatial organization. These same effects acquire a variable intensity according to the capacity of social groups in minimizing them, according to technological capacity and economic development.

Soybean in Brazil, being a summer crop, presents a vegetative period extending from October to December for planting and from January to March for harvest. According to the diverse cultivars, the cultivation may extend to 120/150 days.

The vegetative period of the year is propitious due to abundant rainfall and high temperatures in the main producing regions. Recent studies demonstrated that the correlation between precipitation and productivity of the crop varies between l0% (Mato Grosso) and 30% (Rio Grande do Sul).

Thus, alterations in the precipitation regime, as those pointed by many scenarios of climatic change (IPCC,2004) may deeply compromise the productivity and profitability of soybean, unleashing disrupting processes in social, economic and environmental dynamics.

METHODOLOGICAL PROCEEDINGS

Using the Databank "Atlas Brazil" available in the Geo-referenced Processing of Information System-SPRING (CAMARA, 1996) and the Information Plan "Municipalities 97 2500000", which contains the political limits of the municipal base established for the year of 1997 in the scale of 1:2500000, the borders of the geographical micro-regions were established by IBGE (Brazilian Institute of Geography and Statistics) (Fig.1).

Later on, the vectors of this plan were imported to the system of geographical information Idrisi (EASTAMAN, 1997) and re-structured in a combination of files for an integration among data bank, interpolation of precipitation data, reclassification into precipitation strips and state borders.

The production data and the harvested soybean area, from 1990 onwards, were obtained in the IBGE System of Automatic Retrieving (SIDRA), available in www.sidra.ibge.gov.br. The data of the Parana State, in the period previous to this year, were obtained at SEAB, of the Rio Grande do Sul State at the EMATER in www.emater,tche.br; and the data of Mato Grosso recovered in the Statistical Annuary of the State, available in www.anu.seplan.mt.gov.br.

The data of daily precipitation were obtained at the Agencia Nacional de Águas – ANA (National Water Agency), by means of the System of Hydrological Information- HydroWeb. In each state around 100 of precipitation measuring stations were consulted and the combination of precipitation data were complemented in stations equipped with rain gauges- IAPAR. These data were re-structured in electronic spreadsheets, filling in the blank periods, with a new consistence for doubtful data and the total sum of defined temporal segments was calculated.

The daily data were disposed in tabular way so that each day represented one register and each column represented a station. Individually and by grouping of neighboring stations it was possible to verify the set of precipitation pattern in a sequence of days, using the application of formats that distinguish different levels of precipitation.

A file was generated with the values of precipitation in each temporal segment (months and ten days periods) for groups of precipitation stations of each state. In sequence this file was associated to a file of geographic coordinate points of precipitation stations and an interpolation was effected resulting in an image representing the spatial distribution of precipitation in each sector of the respective state.

The algorithm of interpolation (a mathematical process for estimation of unknown values in a plan starting from control points or observed values) available in the Idrisi uses the method of " the inverse of square distance" which establishes a weigh to the values of the six nearest neighboring points.

For the States of Rio Grande do Sul and Parana, the total average of the micro-regions collection was fixed close to 80%, caused by a more distributed participation of other units in the production of soybean or located close to this limit. As a consequence of this effect an alternation of participation among a few units was observed, largely in the state of Parana.

It needs do be observed that, to the contrary of what occurs when dry periods and droughts are observed, the situations in which precipitation excess has a direct negative effect in the productivity of a crop are minimal. In general they are due to other associated problems such as incidence of pests or losses by harvest difficulties causing a decrease in performance and devaluation in the quality of the product (GÖPFERT, 1993).

Figure 1 - Geographic Micro-Regions according to States.

Thus, temporal segments in daily, ten days periods, monthly, seasonal and annual attend to different analysis. A general perception should be kept in mind that dry periods (or with small precipitation) and rainy periods sustain a relation (means and deviations) on the local pattern or on biological dependence of each organism.

To represent the monthly accumulated precipitation, a scale of currently used colors was adopted to indicate the quantification of biomass obtained by orbital sensors in the spectral strip of red and infra-red (NDVI- Normalized Difference Vegetation Index).

THE SOYBEAN CROP AND THE CLIMATIC CHARACTERISTICS

The world production of soybean is around 200 million tons. The area occupied by the crop in the world if of approximately 87,8 million hectares. The five largest producers are responsible for 90% of the world production: USA, Brazil, Argetina, China and India. (Fig. 2).

Brazil is the second largest producer, responding for almost 25% of the world total. The agro-industrial complex of soybean moves approximately US$ 6 billion (10 % of the exchange revenues). It occupies an area of 22 million ha (around 220.000 km²) – an area equivalent to the State of São Paulo (Fig. 3)

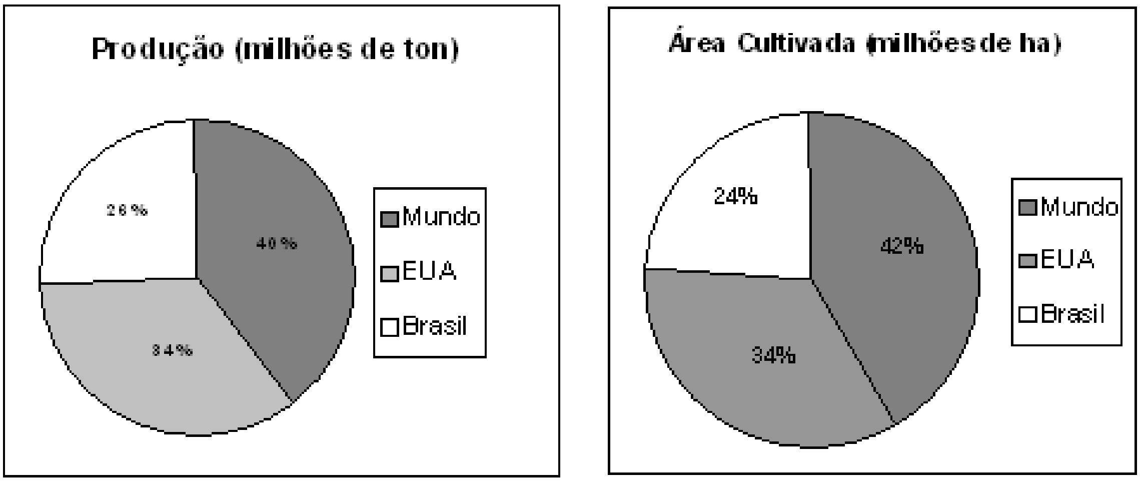


Figure 2 - Production and cultivated area of soybean crop in the world. Production (millions of tons) - Cultivated Area (million of ha)

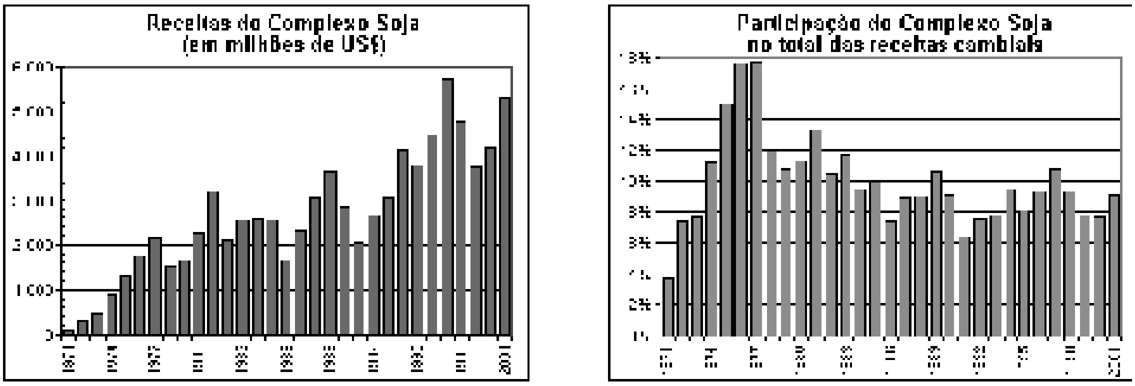


Figure 3 - The income o the soybean complex in the world market Incomes of the soybean complex (millions of US$)- Participation of the Soybean Complex in the total of exchange market revenues

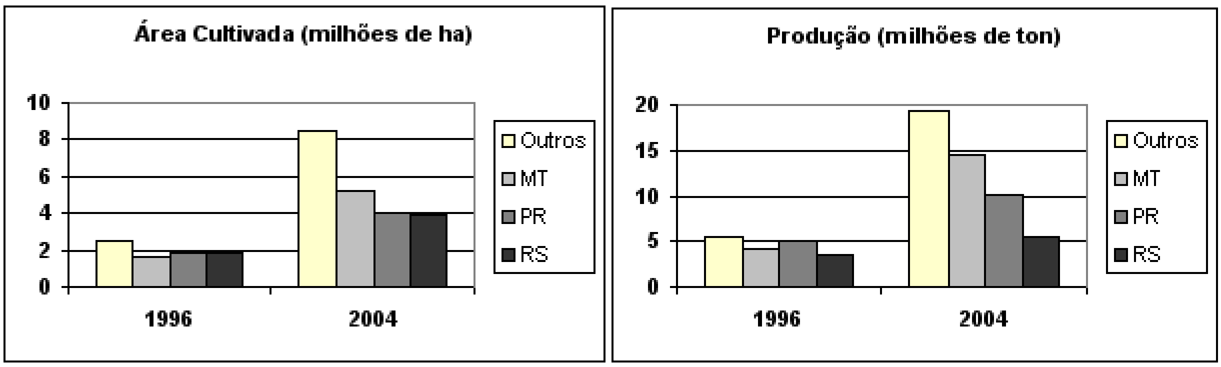


Figure 4 - Production and cultivated area of soybean in Brazil

The territorial limits adopted are restricted to the three main producing States. In a given moment the States of the Southern Region, Rio Grande do Sul and Parana led the volume of soybean production in Brazil, a position that currently belongs to the State of Mato Grosso, in the Center-Western Region. Currently, around two thirds of the soybean produced in Brazil comes from these three States.

The State of Rio Grande do Sul is the state that presents a more homogeneous climatic unity all over its territory, classified as Temperate, Super-Humid, Mild Mesothermic (means between 10° and 15°C) without well defined dry periods during the seasons. (Fig. 5)

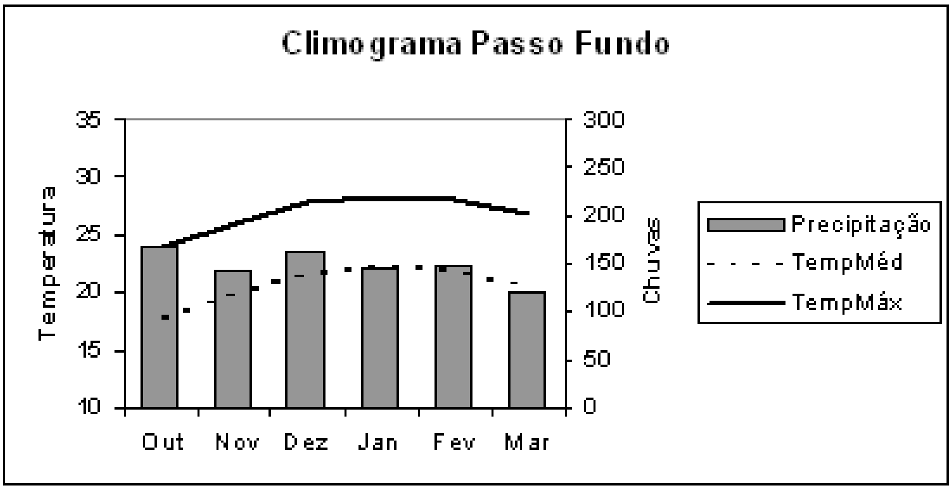


Figure 5 - Passo Fundo , RS - climogram - rains - precipitation - mean temperature – maximum temperature

The Climate of the Southern Region of Brazil is controlled by conflicting masses of FPA (frontal systems), responsible for circa 70% of annual rains. Further than that, Inverted Troughs and Convective Systems of Mesoscale also produce severe episodes (intense rainfall). In years in which the ENSO (El Nino) phenomenon is manifested, there is a strong interference in the distribution of rainfall. The mean temperatures in the Spring-Summer period vary between 17 and 22° and the average monthly precipitation is between 100 and 150 mm.

The State of Parana climate is controlled both by conflicting masses of FPA (frontal systems), responsible for around 70% of annual precipitation as by tropical systems, localized as it is in an area of zonal transition of Climates. Besides, the Inverted Troughs the Convective Systems of Mesoscale and the ZCAS (Convergence Zone of the South Atlantic) also produce severe episodes (intense rainfall).

Just as in Rio Grande do Sul, in the years when the ENSO phenomenon ifs manifested, there is a strong interference in the distribution of precipitation. The mean temperatures in the Spring-Summer period vary between 20 and 25°C and the average monthly precipitation vary between 150 and 200 mm. (Fig. 6)

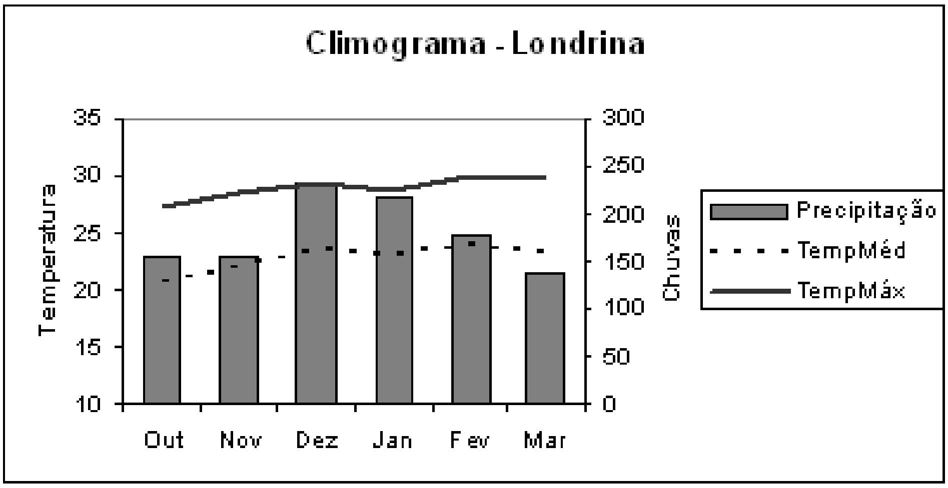


Figure 6 - Climogram of Londrina, Parana – rains – precipitation – mean temperature– max. temperature

Referring to the State of Mato Grosso, this classification confers the Tropical Central Brazil Humid and Warm semi-Humid (means superior to 18° C in all months) with three to five dry months. In its northern portion it is modified to Equatorial Warm Super Humid which differentiates by a shorter dry period (one to two months).

The Climate of Mato Grosso is typically tropical of the "monsoon" type, with a season of abundant precipitation and another dry season. The Cyclonic Vortices of high levels coming from the Pacific cause an intense convection associated with instability caused by sub tropical jet streams. The high pressure of Bolivia engendered from the strong convective warming of the atmosphere actuates in the summer months as well as the ZCAS are producer systems of pluvial genesis. The mean temperatures vary between 25, 27°C and the precipitation achieves values between 200 and 250 mm. monthly. (Fig. 7)

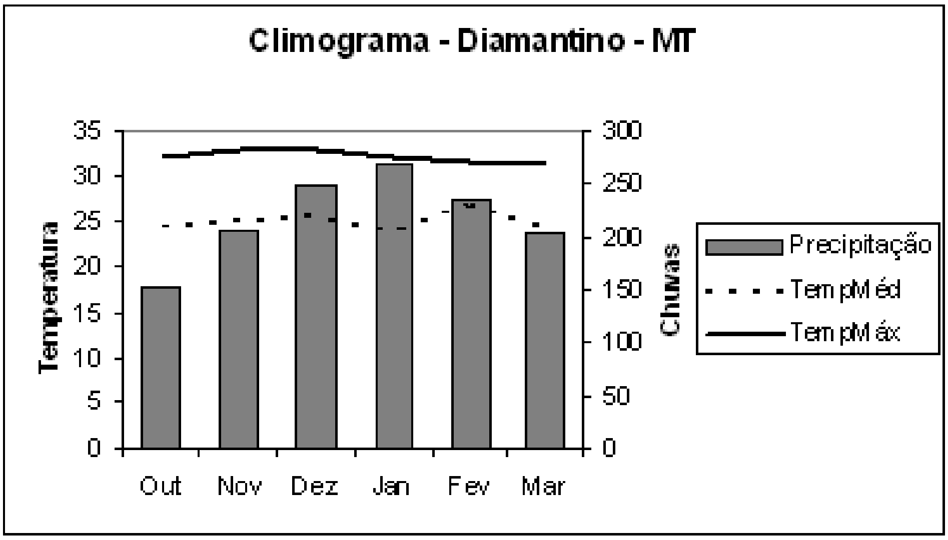


Figure 7 - Climograma of Diamantino, Mato Grosso

Monteiro (1973) demonstrates the importance of understanding the genetic factors in the participation of air masses and in the formation of types of weather over the territory, proposing a quantitative representation of these factors expressed by indexes and frequency. In this aspect, Nimer (1989,1990) argues that both the South Region as the Centro-West possess low indexes of precipitation variability.

In the same way, he comments that for the Centro-West Regions the "annual deviations of rainfall are not as large as the ones from other tropical regions of Brazil, as it happens in the Northeast Region". He does not call the due attention to the origin of the differences and considers only the condition of tropicality for both regions.

However, he emphasizes that more than 70% of the total precipitation accumulated in the year period concentrates in the months of November and March, as a result of the action of Tropical Instability Systems (IT), and that the positive deviations in this period are the ones that carry serious consequences when they put enormous excesses of water at the disposition of the surface flows, rising the potential for erosion of soils and fluvial floods.

The regime of distribution of rainfall represented in Fig. 8 for some localities of the three states, allow to visualize that this concentration is common to all the state of Mato Grosso, while there is a more homogeneous distribution in all months for Rio Grande do Sul, and in the northern part of the state of Parana there occurs a reduction of the totals in the winter period which is a characteristic of a transition zone between the tropical and subtropical..

From one angle, besides the well defined concentration of rainfall during Summer and Spring in the state of Mato Grosso, an emphasis should be put on the high means of the accumulated monthly total of circa 200mm. From another angle, if there is a regularity in precipitation annual distribution for the southern states, these values are always below the limit verified in the state of Mato Grosso, implying in more significant effects for agricultural activities when there is an occurrence of negative deviations.

The coefficient of monthly variation in precipitation denotes that to the contrary of what Nimer (1989,1990) affirms in reference to seasonal regularity of rainfall, there is a variability that may induce deviations of 40 to 80% of the normal precipitation, particularly among the months of October to April. In spite of showing a relative regularity during all the year for the localities of the South Region, it is a significant datum when indicating that the deviations may be both positive and negative.

Between the months of May and September the values are higher in the localities of the state of Mato Grosso; however, it should be emphasized that this kind of measuring represents the dispersion of the values around the average. As in this period the means have an almost null value in this region, a great distortion on the registers of rainfall is denoted in this period. Thus, more than a disadvantage in this type of representation, this datum is able to ratify the character of a dry season at the end of autumn and during the winter in Brazilian Centro-West region.

Stressing the role that these deviations represent for agricultural activity, the negative ones may cause more expressive impacts in those localities that present a mean precipitation inferior to the evaporation demand of the atmosphere or smaller than the evapotranspiration potential of a crop. In this way, considering the mean precipitation around 100mm in the center-south portion of southern Rio Grande do Sul and the superior coefficient of variation during the vegetative period of the summer crops (from December to April), it is noted that this State presents higher risks of frustration in the productivity of agricultural harvests.

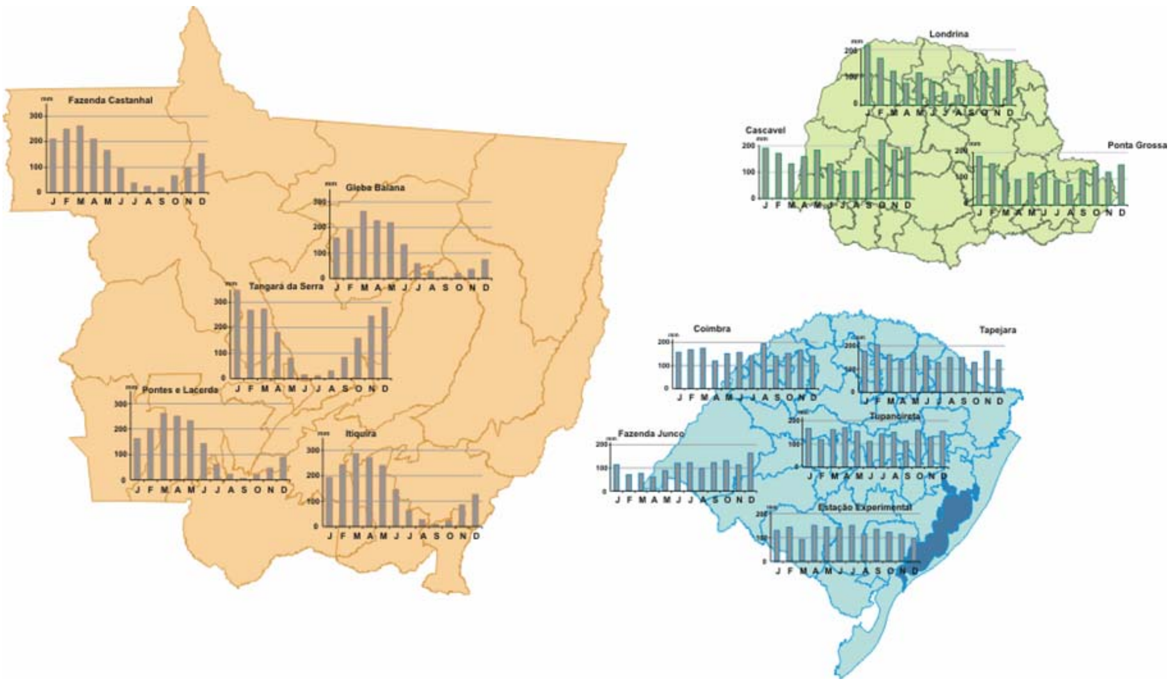


Figure 8 - Monthly distribution of precipitation for the States of RS, PR and MT

THE AGRICULTURAL CALENDAR

The farmer's decision to choose the best period to initiate the installation of his crops depends on a combination of variables which define the mean agricultural calendar of a region. Some of these variables involve basically a previous planning, and in other cases an opportunity of ideal conditions not always predictable. The farmer is a professional that works in an activity normally under economical, structural and environmental risks.

The month of November presents, for most of the country, the ideal thermo-photo-periodical conditions (beginning of the rainy season), providing the best genetic good use of the soybean crop.

Later cultivation in the month of December has been avoided, because these cultivations are more susceptible to insect attacks (bedbugs) that have multiplied since the beginning of the process. During the harvest, these insects migrate to the nearby plantations, causing the increase of costs with the application of insecticides.

Fig 9 illustrates the most critical period of hydro deficiency in a soybean culture, considering the normal development of cultivars belonging to the group of 116 to 125 days maturation, initiating their flowering period, in average, 50 days after seeding. Even with the superposition of phases, due to realization of the seeding at different dates, probably between January and February, defining a time lag which may identify the impacts that may affect the productivity and other performance components. This same calendar may practically be applied to the State of Mato Grosso, as it is the most indicated, in search of a better performance, for most of the cultivars developed in this state (FUNDAÇÃO MT, 2004).

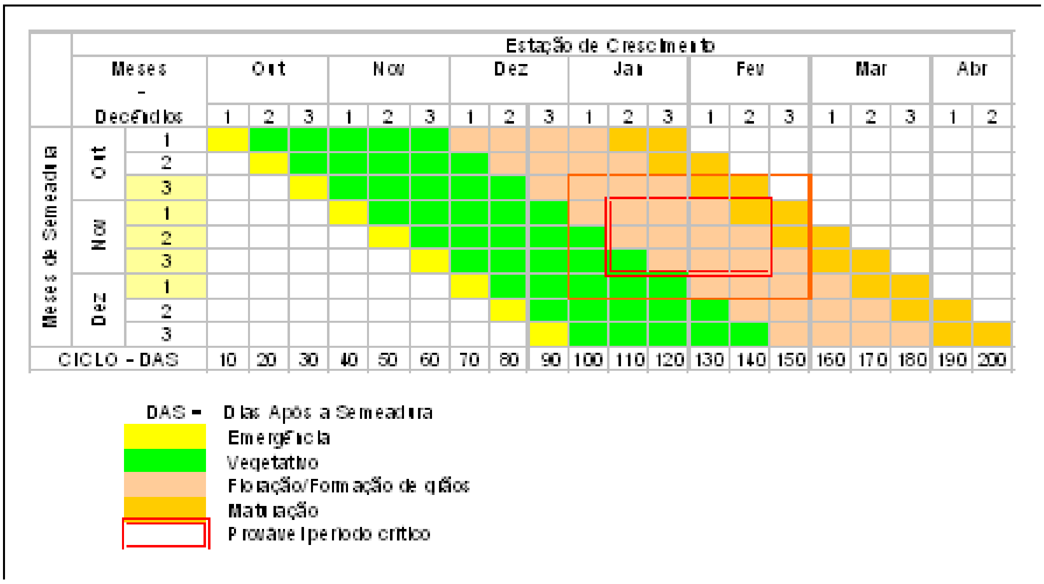


Figure 9 - Mean agricultural calendar for soybean crop -Growth season – DAS-Days after seeding –germination- vegetative- flowering/formation of grains- maturation – probable critical period

According to Fontana et all. (2001), the agricultural mean calendar for soybean crop in the state of Rio Grande do Sul also comprises this same period, the harvest being extended to May.

BIOLOGICAL ASPECTS AND CLIMATIC DEMANDS

The cultivated soy (*Glycine max)* is an herbaceous annual plant classified in groups of maturation, determined by the life cycle that may vary from 70 to 180 days, counted from the emergence until maturation. These groups are generally denominated as early, semi-early, medium, semi-late and late cultivars. However, in number of days these groups are not concordant among cultivars and among different adaptation regions, i.e., the same cultivar may reach different cycles according to conditions of management, and mainly caused by soil and climate conditions between distinct regions. According to the cultivars inscribed in the National Register of Cultivars (TECNOLOGIAS, 2002) the limit of 120 days can be attributed to the early and semi-early groups and superior to 130 days for the late and semi-late groups.

Compared to other crops, the soybean can be considered as one of the most rustic, since it can develop a series of other mechanisms to adjust to adverse variations of environment, such as the reduction of leaf areas (by reduction of the length and number of leafs) or alteration of the angle of exposition to sunlight to reduce the transpiration rate.

However, looking forward in economical gains, some phases are more critical for a total production success or high benefits. According to Table 1, the most water consuming phase is comprehended from flowering to grain formation.

Considering the mean vegetative cycle of soybean and the consumption of water through daily evapotranspiration in a hypothetical situation, a soybean culture may present an approximate demand of 700 mm of precipitation during the growth period, two thirds of this total being consumed in the reproductive phase. Thus, between the end of December and the beginning of March a little more than 450 mm of rainfall would be necessary for the restitution of water to the soil, as an ideal condition for the complete development of the crop during the period of more need of water.

Table 1 – Hydro demand of soybean in function of development phase

Subperiods	daily evapotranspiration (mm
Seedling- emergence	2,2
Emergence-start of flowering	5,1
Start of flowering-appearance of pods	7,4
Appearance of beans- 50% of yellow leafs	6,6
50% of yellow leafs-maturation	3,7

According to the previous example, the temperature associated to other factors may also induce alterations in the development of the culture, as well as establishing conditions for the incidence of insects, pests or deceases carried by microorganisms (bacteria, fungus). When near to the base-temperature of the culture (15°C) the development may be retarded. Above 30° a process of stress may occur by excess of transpiration as well as high temperatures at night may induce loss of energy in the respiration process. According to Berlato (1981), the most apt regions in the world for soybean are those with the warmest mean of the warmest month superior to 20,° a situation obtained in all Brazilian territory.

The technological potential for the achievement of greater productivity is attributed to the seed (cultivar). This comprehension is partly justified since the seed materializes the final result of a complete process of research for the generation of new cultivars.

HISTORICAL AND ECONOMIC ASPECTS

In the evolution of the area destined to soybean crop for the three states in a period of 24 years, (Fig. 10) allows to verify that there was practically no soybean cultivated in the state of Mato Grosso. Only two periods were more significant with a decrease of the harvested area, occurring between 1989 and 1991 and 1996, however, with a rate of higher increase of 34% per year, considering all the series. Only from 1986 onwards the increase of the harvested area in the state became more stable with values around l0%.per year. This effect is not observable in the states of Parana and Rio Grande do Sul since the cultures are established with stable production.

To the contrary, though in smaller proportion, the state of Rio Grande shows three phases of decline in the harvested area (1980-83, 1985-87, 1990-92 and 1995-96) starting from l979, when it reached the largest harvest among all states, presenting a negative growth of -1% per year, showing instability during all the series.

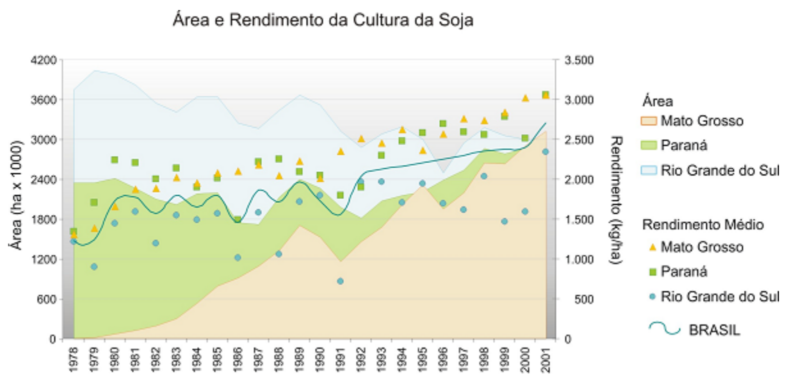


Figure 10 - Evolution of the areas and mean performance of soybean culture.

The state of Parana shows an intermediary situation, very similar to Rio Grande in a first phase, and to Mato Grosso in another phase. These two moments are more distinct before and after the year of 1992. First, when the variations were similar to Rio Grande and second, when the growth was similar to Mato Grosso, achieving a total near three million hectares of harvested area.

The first phase (1978-1991) can be described as of tendency to decline for Rio Grande do Sul, of stability for Parana and of growth for Mato Grosso. In the second phase (from 1992 on) it is denoted an increase for Parana (3,8% per year), being more accentuated for Mato Grosso (11% per year), and of stability for Rio Grande do Sul (-0,04% per year).

The dynamics of the evolution of the cultivated area with soybean reveals that if for the state of Mato Grosso this increase of the area results from the incorporation of new areas, for the states of Parana and Rio Grande do Sul it indicates a reorganization in the agricultural-cattle raising sector, since there were no virgin areas to be appropriated in these two states.

Still for Rio Grande do Sul there occurs if not a retraction in the cultivation of soybean, at least a stagnation of the activity. This dynamic may also suggest other interferences such as the migration of capital and work mainly with origin in Rio Grande having as destination the state of Mato Grosso. It should be recognized that the economy of Mato Grosso is a result of the expansion of the agricultural frontier to the interior of the country, achieved due to enterprises of large companies and with government stimulus, based on official programs such as the POLOCENTRO (Duarte, 1989).

Another indication of the stagnation in the state of Rio Grande do Sul is verified in the evolution and dispersion in the values of mean performance which did not accompany the same rhythm of the other states and stood behind the Brazilian mean. In the state of Parana, Almeida (2000) verified that the occurrence of a more expressive decrease in the performance is associated to climatic events such as dry periods, like in the agricultural years of 1977/1978, 1978/1979, 1985/1986, 1987/1988 and 1990/1991.

This sequence of years, complemented by the years 1996, 1999 and 2000 was more critical for the performances of this culture in the state of Rio Grande do Sul, accompanied in these variations by the Brazilian means which, beginning in 1992, became more stable and little influenced by the variability of the Rio Grande performance, possibly due to the contribution of the production of other states that began to show a greater representation in the national production. In the last years, the state of Parana was affected only in the year 2000.

Thus, the apparent greater climatic variability demonstrated by the state of Rio Grande may be another factor to reach the levels of performance of Parana and Mato Grosso. In this same perspective, there is an effort to evidence the inter-annual variability of the performance within each phase. The series was divided in three segments, each with its respective mean to minimize the effect in the amplitude reached from the beginning to the end of the series.

The consideration of a distinct performance mean in each phase is necessary because along the series there was a rise in the performance (MT- 55%, PR- 37% and RS- 32%) in consequence of genetic improvement and the development of new techniques in the management of the culture adapted to tropical regions, generating contrasts that may lead to a wrong interpretation of the observed phenomenon.

Through deviations of the average, dividing the series in three segments of eight years (1078 to 1985, 1986 to 1993 and 1994 to 2001), the state of Mato Grosso reveals, in the first segment, a negative deviation superior to 20% in the first two years, a consequence of the phase of introduction of the culture in the state and a technology of production still in consolidation, which became credible in the decade of 1980. In the two following phases, it presents a negative deviation superior to 10% only in the years 1990 and 1995 with a constant rise of the visible performance at the final of each phase. The same way as the increase of areas, the results of the performances also show stability and a gradual growth, with less evidence of extreme deviations from one year to the other.

In a more accentuated way, the contrary is occurring in the state of Rio Grande, which presents years with performance varying close to the mean in all series, alternated with years of expressive fall and relative increase. Considering the harvest in this state the expectations and the frustrations are great in respect to the harvest's end result and the income of the producers with succeeding years with alternating profits and losses.

For soybean, the variation between a planted area and the harvested area is not verified as it occurs with other crops, when there occurs such deviations as significant as those found by Ely et all.(2003) who observed variations up to 17% of areas planted with corn and not harvested in consequence of drought. This indicates that the performance component, the height of insertion of pods is not a parameter in a decision to renounce harvesting. However, this option (height of stems) leads to more losses in the field and concentration of impurities in the harvested product, due to the low stature of the plants that did not develop normally in the vegetative phase and the impossibility of the machinery to harvest near the soil, without mixing with it.

Though in smaller rating than the state of Rio Grande do Sul, the state of Parana also reveals deviation that impair the production , the most evident having occurred in the years 1978,1979,1986, 1991,and 1992. In the year 2000, in spite of the deviation being close to the mean, if maintained the tendency of growth of the previous year, the total production of the state could have reached 8,3 million tons, i.e., 16% superior to what was harvested.

The panorama of the evolution of soybean culture in the three researched states demonstrates an evident growth in the area and in performance, as well as an inter-annual variability possibly affected by the variations in the climate. However, the production and performance occurred in a heterogeneous way in space, expressed by different intensities of appropriation and use of space, also with the influence of the climate for each year and in different regions. In general, the cultivations of soybean occupy a third of the total areas destined to temporary cultivations, presenting a significant participation. The concentration of the production on the quantity of establishments reveals that the state of Mato Grosso exceeds in fourteen times the state of Rio Grande do Sul and by eight times the state of Parana, demonstrating that the distribution of income does not occur in an equitable way. This difference is not significantly misrepresented considering the comparative superiority of prices obtained by producers in the South Region, in detriment of the costs of transportation in the Center-West Region.

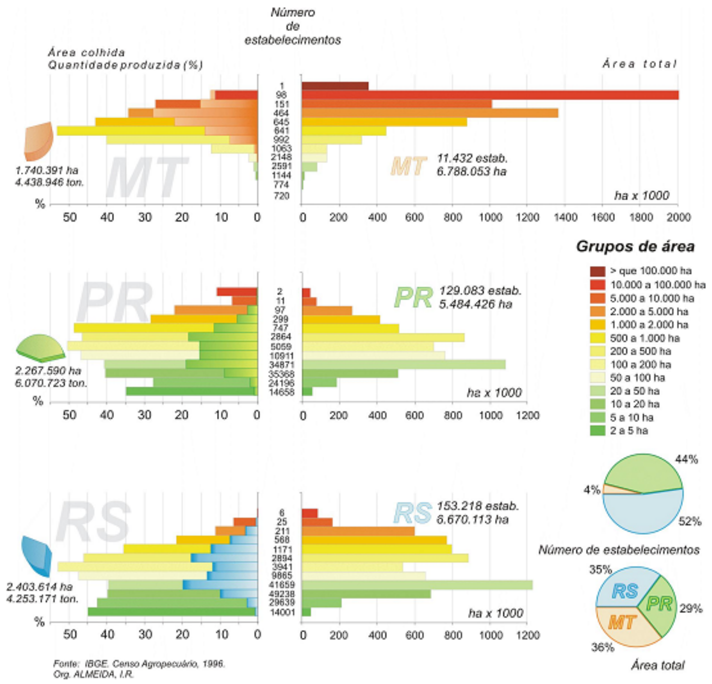


Figure 11 - Number of establishments- total area with temporary cultivations and the harvested area with soybean in the states of MT, PR and RS (owner with condition of producer).- harvested area –number of establishments –groups of area.

Thus, all comparisons amid these three states, overall those of the South Region in relation to the state of Mato Grosso should take into consideration the diverse spatial, structural and social dimensions involved. The land distribution contrasts presented in a state scale can also be evidenced in larger or smaller degree in the respective geographic micro-regions, considered the development and specialization that an agricultural activity may induce in the spatial production of a region.

This statement can be compared by the analysis of the Gini index with its graphic representation and the curve of Lorenz, which show the degree of land concentration and are obtained by the relation of percentages accumulated between the number of establishments and the total of their areas. These indicators presented in fig. 12 show that the difference among the three states are very distinct, prevailing the value of 0.86 for Mato Grosso.

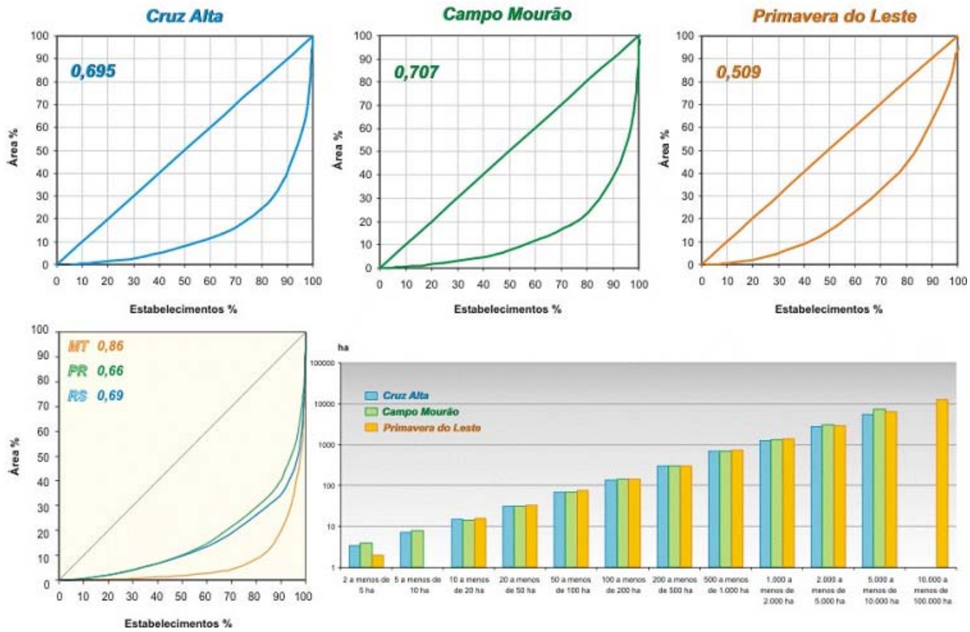


Figure 12 - Gini Index- Curve of Lorenz and mean area of the establishments – Cruz Alta (Rio Grande do Sul) – Campo Mourao (Parana) and Primavera do Leste (Mato Grosso).

While in Mato Grosso 12% of the establishments with an area superior to a thousand hectares detain 83% of the state's lands intended to temporary cultivation, in Parana this relation is of 0,5% of the number of establishments for 15% of the area group, and in Rio Grande do Sul, of 0,3% for 24%, respectively. Thus, above the limit of this area group , the concentration is much greater in the states of the South Region than in Mato Grosso, and that in spite of not occupying most of the state's land, proportionally, the quantity of establishments is much smaller.

For this reason the social conflicts may be justified deriving from these contrasts that generate a pressure for land and labor, currently independent of the productive or non-productive condition of the establishments. According to Diniz (1984) this pressure is also a result of an emigration of southern farmers towards other regions of the country, observed by the occupation of the western frontiers of the Northeast, where the soybean culture is the main cultivation.

The recent history of the state of Mato Grosso also indicates that an expressive contingent of its population had its origin in the emigrants from the South. This process of social mobility creates and recreates, constructs and destroys new spaces, transforming in some way all the involved agents, either those that go away and those that stay and those that arrive and welcome (GOETTERT, 2000).

The new possibility of local political autonomy and the new tributary arrangement with fiscal decentralization, stimulated by the promulgation of the 1988 Constitution, generated a phenomenon of intense emancipation of the localities with an increase of 25% in the number of municipalities all over the country.

In spite of the absolute quantity of new municipalities created between the years of 1988 and 2000 being inferior in the states of the South, in Mato Grosso these municipalities have the characteristic of having emerged due to the fast dynamics in the incorporation of the regional space, in a planned and oriented way in some cases, not entirely caused by the expansion of old settlements (TOMIO, 2002).

Thus, the pursuit for power among the social agents that participated and were concerned with the incorporation and occupation of the Mato Grosso space was based on the stimulus and in the conflict of interests that go beyond the objectives and necessities of the local agents.

The dynamics of occupation of this space, which puts at risk an unknown patrimony in all its potential towards a sustained development, should not be dissociated from the processes of development of the rest of the country. This development occurred with local and regional conflicts and should be projected with the intention of reducing social contrasts and subordinated to legislation, demonstrating concern with the ecological conservation of the regions.

PERFORMANCE, REGIME AND DISTRIBUTION OF SOYBEAN

All comparative analysis of a meteorological element should have as parameter a known pattern of value. The last climatologic normal, established by the means of 1961 to 1990, shows that precipitation may overcome 400 mm of monthly rainfall accumulated in Brazil during the Spring and Summer seasons.

Due to the continental dimensions of this country, these values may present significant amplitudes among the regions, overall between the North and Northeast, as well as the variations of one element during a period. Thus, the climatologic normal presents the expected mean conditions, considering a distribution among the habitual limits of occurrence.

However, the climate is one of the most arbitrary constituents of nature, presenting very different conditions in any temporal segment of analysis, annual, seasonal or monthly.

If an analysis does not clearly expose the relations that it intends to develop, according to the borders and chosen limits, the adopted temporal segment may lead to a wrong interpretation, because it can not always capture the distributions that occur in minor periods or among the segments.

Thus, the mean yield of a culture at the end of the harvest, expressed by a relation between the produced quantity and the harvested area, is the final result of the interaction of an extensive combination of variables. In general, the economic variables respond directly to the application of capital and technology and the structures equalized by the conditions of management in adapting the larger potential of performance of the culture to the ecological and environmental characteristics of a region.

The rainfalls accomplish the function of maintaining the water in the soil which is present in all physiological processes of the plants. Therefore, there are periods in which its lack becomes more critical, as in the phases of flowering and grain filling, directly affecting the culture production.

The regime may in this situation denote in which period there was water deficiency that may have influenced the management conditions, either complicating a better adaptation of the periods of installation of the cultivations and the initial development of the culture, or affecting the development of the components of performance, in the reproductive period of the plant. Thus, these circumstances of the regime can only be captured in more details in smaller temporal segments than the monthly one.

The distribution and spatial variability of rainfall may distinguish the possible reflexes that influence the culture's yield, considering the harmony of the previous environmental conditions, during and after the biological necessities of the culture in a determined moment.

If the necessity of ideal and simultaneous conditions among determined factors is recognized by the producers, for example, among neighbor cultivations or by the differences in result when distributed in different epochs, these results will also be differently shown among regions and micro-regions.

With the objective of orienting the analysis, the observation and description of the sequence of images intend to draw attention to the correlation between phases of development that are critical to water deficiency (the case of soybean crop) and the main activities executed in the field for the management of the cultivation. The seedlings perform a fundamental role in assuring the complete establishment of the cultivations when effected in proper conditions of humidity in the soil. The vegetative development when occurring in prolonged periods of water stress engenders a reduced growth of the plants and, as a consequence, a reduction of the productive potential. The flowering and grain filling are the most critical phases for any period of water deficit with direct effects on the final yield, affecting the components of performance both in the number and size of the pods, as well as in the quantity and weigh of the grains.

Each harvest, according to the agricultural year for each state, involves the months of October to March, represented by the figures of performance, and of the monthly and ten days accumulated precipitation. Thus it is possible to make comparisons with the climate normal of precipitation and identify the occurrence of deviations, as well as those disguised in the monthly period, but detected in the ten days segment.

RIO GRANDE DO SUL

1985/1986 Harvest:

The most significant characteristic of this harvest was a long dry period between the last ten days of October and the first ten days of December, delaying the installation of the cultivation (Fig. 13). In the month of November and beginning of December, when it should have been seeded, the rainfall was not sufficient to initiate the cycle of the culture with an accumulated volume of precipitation below 25mm enduring in most parts of the state

In the two following periods of the month of December, the precipitation was spatially irregular, clearly distinguishing one region from the other. The summer of 1986 presented a certain temporal irregularity indicated by the concentration of rainfall in the second ten days periods of the months of January and March and in the first of February. Thus, in the monthly accumulation, there occurred totals near the climate normal.

Considering the effects that the total precipitation could have influenced the performance of the soybean culture in this harvest, it can be deduced that it was affected both by the low quality of the installation of the cultivation in a dry period which did not allow an adequate development of the plants, as by a late installation (final part of December) which reduced the productive potential of the culture.

Although certain micro-regions near Cruz Alta presented a modestly superior performance, they can be situated in the category of the inferior limit of a second class harvest. Therefore, most of the production area of soybean in Rio Grande was disturbed in all its extension, harvesting less than 1400 kg per hectare.

1990/1991 harvest:

Of all the analyzed series, this harvest was the one that presented the greatest spatial homogeneity in the representation of performance according to the micro-regions, configured by a class of smaller yields (fig. 13). It also is emphasized for being the agricultural year of minor production of soybean culture in the micro-region of Cruz Alta, as well as for all the State of Rio Grande.

The initial phase of the installation of the cultures suffered no setback from lack of water, all monthly totals being superior to climatology normal. Starting from the last ten day period of December until the month of February two drought periods occurred separated by the occurrence of rainfall in the third 10 days period of January. The total accumulated precipitation for January corresponds practically to the total registered in its last ten days period characterizing a significant spatial variability between the north and the south of the state, and also temporal, due to the brief concentration in the period of most necessity of the culture, comprehended by its reproductive development.

The western portion of the main soybean production region presented a restoration of rainfall close to the normal of March, however, subsequent to the prospect of a better good use by the culture. Judging from the fact that the mean agricultural calendar for soybean in Rio Grande had been favored by normal conditions in the initial phase of installation and development of the cultivation, the period of flowering and grain formation coincided with the interval of December to March, when there was verified an occurrence of water deficiency. Thus, the intense negative effect caused on the production and yield of the soybean culture was the manifestation of an adverse climatic condition combined with a critical period of water requirement so that the plants could not express its productive potential.

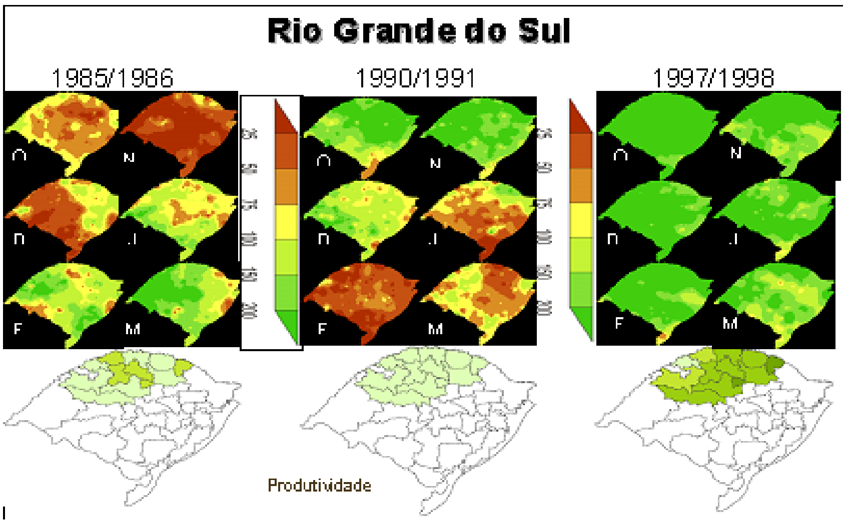


Figure 13 - Yield, productivity and rainfall variability for the state or Rio Grande do Sul.

1997/1998 harvest:

The agricultural year of 1997/1998 was characterized as the most rainy (Fig.13) and all months presented precipitation deviation superior to climatology normal, a fact associated to the positive effects of the ENOS phenomenon (EL NINO).

Referring to the month of October, it can be said that rainfall was excessive, since all ten days periods presented for most of the state, accumulated totals of precipitation superior to 75mm. This effect practically continued in November, with a brief interruption between the last ten days period until the second of December. From this time onwards a pair of consecutive more humid ten days periods where interrupted by one less humid until the end of March. As to the effects on production, this period of rainfall superior to the climatology normal for the state, was also positive for the general performance, assuring one of the best harvests. Compared to the previous years, for a larger number of micro-regions, the yield reached an intermediary class of 2000 to 2400 kg. per hectare.

However, the same effect was not verified in the micro-regions of Santo Angelo, Santa Rosa, and Tres Passos. These presented an inferior performance compared to the combination of all micro-regions.

PARANA

1985/1986 harvest

The first year in the series of analysis of the charts of precipitation and performance of soybean culture in the state of Parana shows that the ideal conditions for the installation of the cultivations were not totally satisfactory, to the contrary of the period of flowering and grain formation in January and February (fig 14).

In the months of October and November, the rainfall showed an irregular spatial pattern, sometimes achieving totals close to the climatology normal, sometimes presenting a negative deviation. In the month of December, however, it rained half of the accumulated expected for this month, aggrieving the conditions of development of the culture, to initiate the reproductive stage. However, if the monthly analyzed data did not denote the ideal expected for the season, the period between the last ten days period of October and the first of November, was more propitious for the installation of the cultivations, since it was a more humid interval which accumulated most of the rainfall amid the two months, guaranteeing the establishment of the culture.

From this moment onwards until the second ten days period of January there was a period of water deficiency in promoting the full development of the cultivations. In sequence, the distribution of precipitations became more regular during the ten days periods, with no imposition of any kind of restriction to the termination of the soybean cycle.

For the micro-regions which participated in the state production in more than three percent, the yielding classes pointed to values inferior to 2000 kg. per hectare. Historically, the state productivity in this harvest was situated as one of the lowest, while in the micro-region of Campo Mourão also presented the lowest yield of its series. The micro-regions of Foz do Iguaçu and Toledo were denoted by low yield as consequences of more prolonged droughts, being situated in areas where this effect was more constant.

In spite of a certain water restriction, less intense than what was verified in Rio Grande do Sul, the explanation for such a reduced state productivity can be inferred from a a significant reduction of 20% of the planted area in relation to the previous year, and to the expected low investment for the cultivation caused by political and economic context of that year, marked by a recent change in governmental system and economical adjustments for the control of the high inflation occurring in that period;

1990/1991 harvest:

Alternated periods of rainy ten days periods with other less humid, favored the water recovering in the soil and allowed the development of activities with machineries in the fields. Thus the precipitation rhythm was maintained until the second ten days period of December (Fig 14), assuring the ideal conditions for the installation of the cultivations.

From the last ten days period of December until the beginning of March, two droughts interposed by rainfalls in the third ten days period of January and the first of February spoiled the state production of that harvest. The Parana middle west was mostly affected, since it only got the rainfalls in January and the total accumulated in February practically coincided with the first ten days prolonged period, approximately 20 days of drought. To the exception of the spatial irregularity verified in February all the months presented a precipitation pattern very close to climatology normal, however concentrated in a very reduced period, not allowing the soils a maintenance of the field’s capacity.

In this harvest the spatial patterns of the yields maintained a similarity with the precipitation pattern, especially compared to the month of February. The micro-regions of the southwest to the northeast of the state, according to the same alignment of the less humid regions in this month, were classified as the lowest performances, while the micro-regions of Ponta Grossa and Telemaco Borga reached more elevated yields. Beyond the negative climatic aspect, the political and economic conjuncture with another change of government and the lack of resources due to and “Economical Blockade Process,” induced a reduction of 13% of the total cultivated area in the state in relation to the previous year and limited the possibilities of investments.

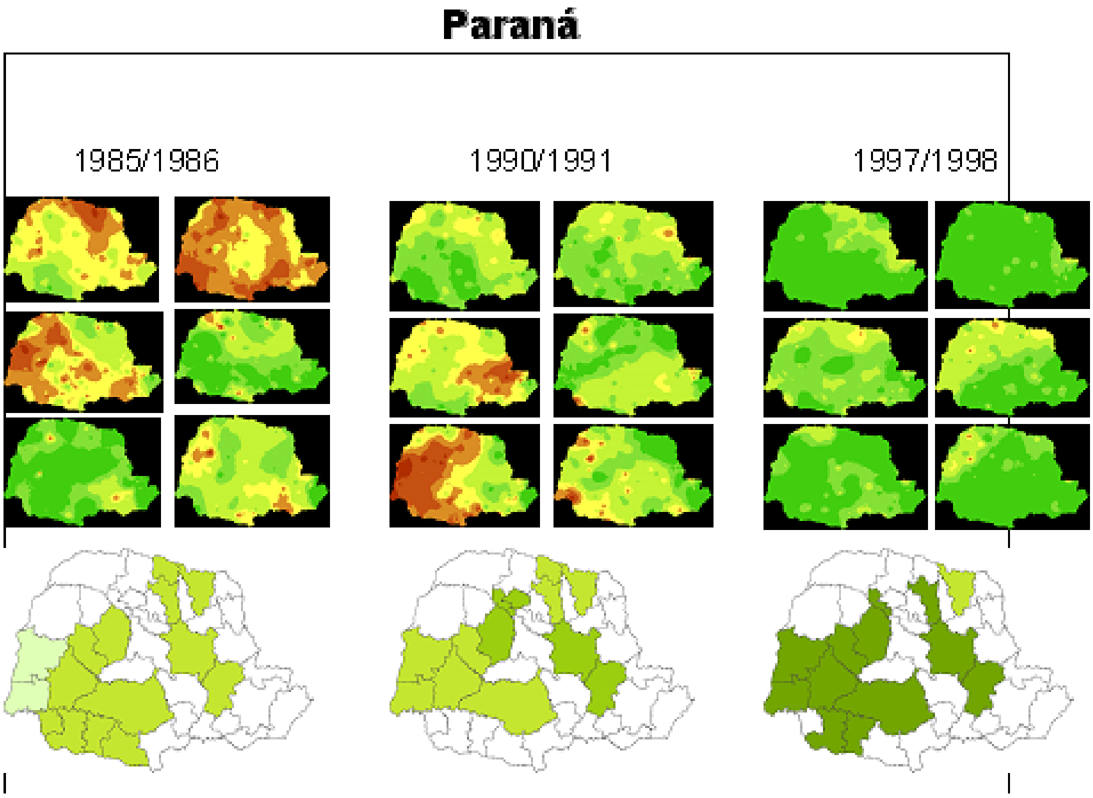


Figure 14 - Parana – performance, productivity and precipitation variability for the state of Parana.

1997/1998 harvest

With the exception of the second ten days period of January and the first of March, all ten days periods of the agricultural year 1997/1998 presented totals superior to 50mm for most areas of the state (Fig. 14). Thus there was no period that could cause stress to the plants for lack of water. The total of micro-regions presented were responsible for 75% of soybean production of the state and except for the micro-region of Cornelio Procopio, they reached a mean yield of 2680kg per hectare grouping in the fourth class of performance. The anomalies in precipitation resulted from the negative phase of the EL NINO phenomenon and developed according to the typical pattern for the South Region of the country, characterized by totals in precipitation above de climatology normal.

The predictability and greater knowledge of the impact or this phenomenon suggests, according to CUNHA (1999), an adequacy in the management of the crop (choice of cultivars resistant to pests and not susceptible to lodging) in function of humidity excess and more investment and use of technology that can be potentially favored by the good availability of water.

MATO GROSSO

The state of Mato Grosso deserves a special consideration for having all of its series analyzed in combination. There was no agricultural year with negative precipitation deviation or temporal segments with droughts that justified an analysis in separate.

In all the series of the observed agricultural years, the combination of the presented micro-regions participated with more than 90% of the soybean production of the state of Mato Grosso, with a prominence for the micro-regions of Alto Teles Pires and Parecis which, on average, contributed with more than 22% of the produced total, followed by the micro-regions of Rondonopolis and Primavera do Leste with 16% and 12% repectively.

The more apparent characteristic of month precipitation was the small spatial and temporal variability accumulate during the growing season of soy bean culture, with frequent totals superior do 150 mm for almost the totality of the state's area (Fig.15). The precipitation accumulated in the ten days periods also presented the same pattern, without the inter-occurrence of drought for more than twenty consecutive days, as verified in the states of Parana and Rio Grande do Sul. This observation does not discard the occurrence of droughts in the region neither the effect of tropicality engendering a more accentuated evapotranspiration; however, it is considered that these have been less intense than those verified in the South Region.

The month of October is the only that evidenced a variability that can be distinguished from the others, justified by the seasonality between the rainy and dry seasons which characterizes the bioma (regional ecosystem) of the "cerrados" (type of original vegetation) in the Center-West Region. The micro-region of Alto Pantanal, was also the bio-geographical region that frequently presented the inferior accumulated precipitation of the state. In all the series, the state of Mato Grosso also did not present yields inferior to 1400 kg per hectare, the lower values being concentrated in the beginning of soybean planting activity, denoting the phase of introduction of the culture in the state and the technological pattern at the time. There were no reflexes of phenomena of great scale like the ENOS (El Nino) acting over the region, according to those verified in the South Region, demonstrating the climatic stability of the atmospheric systems that actuate on the state. Thus, the technological component that promoted the progressive increase of the performances along the series remains more clearly discriminated, since there was no occurrence of adverse factors that could have negatively altered the gains of productivity.

Considering the evolution of the state production, in the years 1090, 1991 and 1996, there was a decrease due to reduction of the planted area. For the micro-region of Primavera do Leste this same reaction occurred only in l991 and 1996. From this last year onwards the variations in area did not influence the result of the production caused by following increases in performance or a possibility of maintenance of a pattern in the productivity of most of the micro-regions (FIG.15)

In the same sense and rhythm that the crop was introduced and new areas were incorporated there were rising increases in performance until the year of 1995. This observation is particularly visible in the micro-regions of Alto Teles Pires, Canarana and Parecis due to the dimension of its territories and the advance of the agricultural frontier still in process.

From this time onwards a pattern of production superior to 2400kg per hectare was established for all micro-regions. Thus, it can be inferred that the recently incorporated areas got an application of capital equivalent to the more traditional areas to respond in productivity in the same way of the other micro-regions.

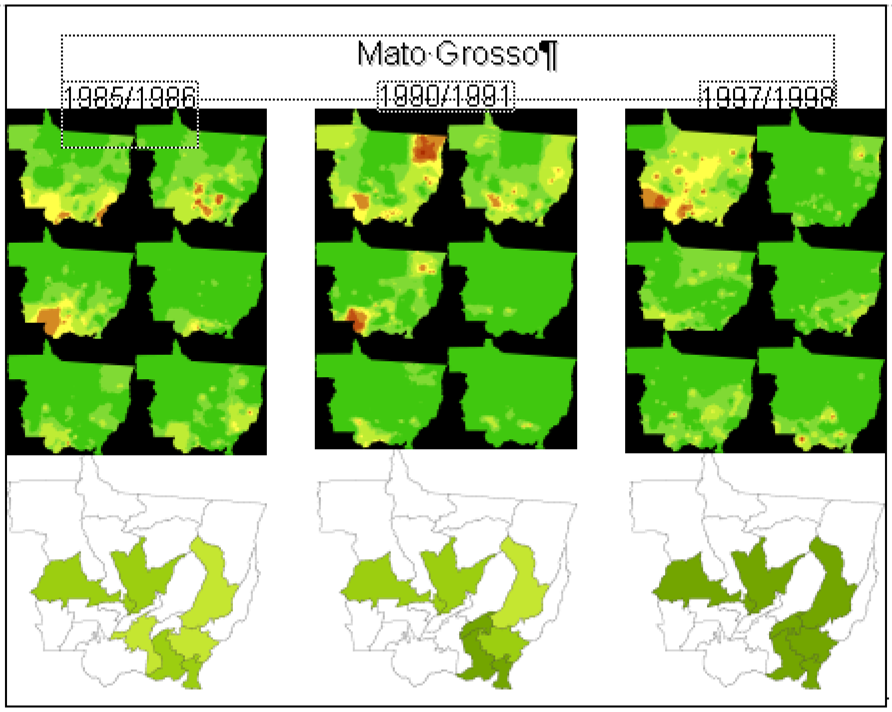


Figure 15 - Yield, productivity and vainfall variability for the state of Mato Grosso

In spite of possessing a statistics of production and soybean cultivated area previous to the year 1989, the analysis of the micro-region of Primavera do Leste, formed only by the municipalities of Campo Verde and Primavera do Leste, would have small significance due to the fact that having been created in this period, they were originally constituted with the territory of many neighboring municipalities. However, due to its smaller dimension in relation to other micro-regions of the same state and the smaller variation of the total occupied area (circa 22%) is was easier to make observations on the climatic rhythm and it was not subjected to variations in the dynamics of occupation.

DISCUSSION OF THE RESULTS

In the state of Rio Grande do Sul and especially in the micro-region of Cruz Alta, the periods of seedlings in the years of 1987/1988, 1995/1996 and 1998/1999 were noticeable for their long periods of dry climate but not as intense as in 1985/1986, lasting from the third ten days period of October to practically the first of January. In this last case it can be stated that the conditions of humidity in the soil, observed in the second ten days period of October to the beginning of seedling activities were not sufficient to guarantee the full development of the culture in the period subsequent to the dry conditions. Thus, the production of the State of Rio Grande do Sul began from a late seeding, effected after the second ten days period of December, when the northern part of the state presented more regular rainfall.

The years that presented longer dry climate in the reproductive period of the plant were 1988/89 (from February until the second ten days period of March), 1990/1991 and 1993/1994. In these three years the initial phase of installation was propitious according to a better distribution of rainfall in the period. However, the severity of the two periods of dry climate in the year of 1990/1991 was not reduced by the rainfall of the third ten days period of January, impacting with the most expressive yield decrease of the series. In 1993/1994, in spite of the short period of dry climate in relation to the former two years, the affected vegetative phase probably reduced one of the components of performance caused by the abortion of the flowering process.

In the year of 1988/1989, to the contrary, the period of verified dry climate does not seem to have affected the performance of the cultivations, since the production and the final yield both of the whole state as of the Cruz Alta micro-region presented a rise. In this case, the previous favorable conditions, mainly due to water reserve accumulated in the month of January and the stage of reproductive development in an advanced phase in February, assured that the negative effect of the dry period was not so intense.

Over all, four years were considered under water restriction in the cultivation installation phase (1985/86. 1987/88, 1995/96, and 1998/99) and three in the reproductive development phase (1988/89, 1990/91, and 1993/94).

The harvests of the years of 1986/87, 1989/90, 1991/92, 1992/93, 1994/95, 1996/97, 1997/98, 1999/2000 and 2000/2001 were considered without the occurrence of water deficiency. Separately analyzed and in rising order they discriminate the progressive increase of performance in the series and indicate that among 56% of the years considered as favorable to soybean production in the state of Rio Grande do Sul, these years may have obtained superior performance.

Beyond the uncertainty of success in agricultural activity and political and economic variables, the low capacity of a better good use of the more propitious years is due to the effect of variability in the recovery and loss of production, which prevents a capitalization of the sector and a more sustainable growth.

In Rio Grande, the culture of soybean does not present a perspective of rising areas. The productivity has fluctuated between 1,5 and 2,0 ton/ha. The agricultural basis is strongly manifested by small and medium sized farms. The dependency on precipitation rhythm is around 30%. The variability of rainfalls is high and the dry periods present significant frequency.

For the state of Parana and the micro-region of Campo Mourão, the years considered as critical during the seedlings period were 1985/86, 1988/89, 1994/95 and 1998/99 (month of November).

In 1985/1986 the precipitation verified between October and November allowed the installation of part of the cultivations in the state and the rest had the opportunity of installation in a later period, at the third ten days period of December, especially in the western region of the state, which registered the smaller yield.

In 1988/1989, in spite of water restriction in November, the water accumulated at the end of October was able to assure the initial development of the cultures that were seeded till the first ten days period of this month. From the emergence till the emission of the first leafs, the plants demand a minimum amount of water, as well as the lack of surface humidity induces the growth of roots in a deepening process in the search for water. However, this condition was not sufficient and in the period of flowering and grain filling, when there was even an excess of rainfall, the harvest could have shown a higher performance.

The dry period verified in 1994/1995, given the previous conditions of installation of the cultures as well as the initial phase of reproduction, did not impact negatively on the yields. Like the description of the previous paragraph, due to bland intensity of rain falls, the root system could have been stimulated.

The dry period of 1998/1999 was also well defined in all November, and the good distribution of rainfalls in the month of October contributed to the saturation of the soils. As in the previous cases, the installation was assured and the adverse period was overcome. The years that presented more extended dry periods in the reproductive phase were consecutive as 1989/1990, 1990/1991 and 1991/1992. In these three years the initial phase of installation was also propitious, with no water restriction that could slow down the initial development of the cultivations.

The severity of the dry period presented in the year of 1990/1991 affected specifically two moments and distinct spaces in the state of Parana. The first was during the flowering period practically all over the state and the second, after the occurrence of rainfall in the center-east portion in the phase of grain filling. In this case, the production was obstructed both in its formation as in its development, however less intensely than in Rio Grande do Sul, having reached superior performances, with prominence to the micro-regions of Campo Mourão, Floraí, Maringa, Ponta Grossa and Telemaco Borga, better supported by the rainfalls of January and February.

In 1989/1990, the hydro restriction coincided with the period of grain filling, mainly in the center-north portion of the state, during the month of February. In 1991/1992, this same pattern of spatial distribution occurred during the month of January, in the flowering period. In both cases there was an obstruction, then the development and final performance.

The harvests of the years of 1986/87, 1987/88, 1992/93,1993/94, 1995/96, 1996/97, 1997/98 1999/2000 and 2000/2001 were considered without periods of hydro restriction in the most important phases for soybean culture and also evidenced a progressive increase of the yields along the years. If the years of l994/95 and 1998/99 are aggregated, then the dry periods were less intensive and it may be considered that 69% of the years were favorable for the production of soybean in the state of Parana. But the years with hydro deficiency both in the initial phase as in the reproductive period, except the year 1985/86, constituted four consecutive years that affected the micro-regions in different ways and the Campo Mourão micro-region in 1991/92.

The soybean culture in Parana is close to its territorial limit. The productivity has varied from 2,0 to 3,0 kg/ha. The land structure is based in big rural farms, with high capital investment and new technologies. The influence of rainfall variability is approximately of 20%. The western and northwestern regions are the most susceptible do summer droughts.

In the state of Mato Grosso and especially in the micro-region of Primavera do Leste periods of drought were not characterized, either in the initial phase of installation neither in the grain filling or the reproductive phases.

To the contrary, it was possible to verify many consecutive ten days periods with excess of water, as in the years of 1987/88, 1990/91 and 1993/94, among others.

Thus, it can be observed that hydro surpluses not characterized as down-pours, do not reflect in a negative way in the analyzed phases.

In the state of Mato Grosso the climatic conditions favored the achievement of high performances in a short period of time, compared to the other states with more tradition in the cultivation of soybean. This condition also showed a potentiality for a better good use of technological capacity employed via utilization of adapted cultivars and management and new systems of cultivation.

The managerial characteristics applied on the territorial production units and the positive response to intensive application of capital assure the producers of this state a minor risk of failure, allowing long term planning of the activity in relation to market conditions and for the management of the units.

In other words, this also means that the installation of the cultivations is not so dependent on general humidity conditions of the soil (necessary to assure the germination, emergence and development of the plants) to initiate the seedlings, since the uncertainty of droughts in the initial phase is very reduced.

In the big farms where the good use of time, the dimension of labor hands and equipments are differential factors in the decrease of production costs, the minor climatic variability helps the programming and scheduling of the units, as well as the monitoring and management of the cultivations according to the development phases.

Thus, since the estate of Mato Grosso joins a combination of factors that assure a position of competitive advantage in relation to other states, it may also achieve in a short time a limit for the gains per yield due to the horizon imposed by technology and by the productive potential of the soybean culture.

In the state of Mato Grosso, soybean still counts with enormous available territorial expansion. A great part of the rural units are represented by immense land estates with juvenile soils and regular climate. The mean productivity has risen year after year, between 2,5 and 3,0 ton/ha. The regularity of tropical rainfalls assures the success of harvesting.

The soybean culture if also dependent on the precipitation rhythm . Mato Grosso, the biggest producer in Brazil, responsible for 15% to the world total production has been the scenario of a significant decrease in precipitation in the last five years. The rise in temperatures and reduction of rainfall may be associated to global warming and Amazonian deforestation. If this hypothesis is confirmed, the productivity and the profitability of soybean will go through a significant reduction with a high level of impact on the economy of Brazil and on foodstuff security.

REFERENCES

ALMEIDA, Ivan R. de. **Variabilidade pluviométrica interanual e produção de soja no Estado do Paraná**. Presidente Prudente, 2000. 130p. Dissertação (Mestrado em Geografia) – FCT/UNESP, Campus de Presidente Prudente.

BERLATO, Moacir A. **Bioclimatologia da soja**. In: MIYASAKA, S.; MEDINA, J.C. ed. A soja no Brasil. Campinas: ITAL, 1981. p.175-184.

BRASIL. Ministério de Minas e Energia. Agência Nacional de Águas. Disponível em: <http://hidroweb.ana.gov.br/>. Acesso em: 4 jun. 2001.

CAMARA, Gilberto; SOUZA, R. C. M; FREITAS, U. M.; GARRIDO, J.; MITSUO Jr., F. **SPRING: Integrating remote sensing and GIS by object-oriented data modeling**. Computers & Graphics, 20: (3) 395-403, May-Jun 1996.

CENSO agropecuário de 1995/1996. Disponível em: www.sidra.ibge.gov.br/bda/acervo.

CUNHA, Gilberto R. da., DALMAGO, G. A., ESTEFANEL, V. **ENSO influences on wheat crop in Brasil**. In: Revista Brasileira de Agrometeorologia, Santa Maria, v.7, n. 1, p. 127-138, 1999.

DUARTE, Aluízio C. O Centro-Oeste na organização regional do Brasil. In: BRASIL. IBGE. **Geografia do Brasil**: região Centro-Oeste. Rio de Janeiro: IBGE, 1989, p. 15-20.

EASTMAN, J. R. **Idrisi for Windows: User's guide**. Version 2.0. Clark University. Wordester, MA. 1997.

ELY, Deise F.; ALMEIDA, Ivan R. de; SANT'ANNA NETO, João L. **Implicações políticas e econômicas, variabilidade climática e o rendimento da cultura do milho no estado do Paraná**. In: Revista do Departamento de Geociências, Londrina: UEL. Londrina, v. 12, n. 1, 2003.

EMBRAPA. **Recomendações técnicas para a cultura da soja no Paraná 1998/99**. Londrina: 1998. 201p. (EMBRAPA-CNPSo. Documentos, 119).

FONTANA, Denise C. et al. **Monitoramento e previsão da safra de soja 1999/2000 no Brasil**. Porto Alegre: CEPSRM/UFRGS, 2001. (Série D. Relatório Técnico, 005/01).

FARIAS, José R. B.; ALMEIDA, Ivan R. de.; GARCIA, Antonio. **Zoneamento agroclimático da cultura da soja para o Estado do Paraná**. Londrina: EMBRAPA-CNPSo, 1997. 84p. (EMBRAPA-CNPSo. Documentos, 102).

FUNDAÇÃO MT. Fundação de Apoio à Pesquisa Agropecuária de Mato Grosso. **Boletim técnico de soja 2004**. Rondonópolis: Fundação MT, 2004. 228p.

GOETTERT, Jones D. **O vôo das pandorgas**: migração sulista para Rondonópolis-MT. Presidente Prudente, 2000. 372p. Dissertação (Mestrado em Geografia) – FCT/UNESP, Campus de Presidente Prudente.

GÖPFERT, H.; ROSSETTI, L.A.; SOUZA, J. **Eventos generalizados e seguridade agrícola**. Brasília: IPEA, 1993. 65p.

HESPANHOL, Antonio. N. A expansão da agricultura moderna e a integração do Centro-Oeste brasileiro à economia nacional. **Caderno Prudentino de Geografia**, Presidente Prudente, n. 22, p. 7-26, 2000.

IBGE. **Perfil dos municípios brasileiros - Meio ambiente 2002**. Rio de Janeiro. 2005. 394p.

IBGE. **Produção agrícola municipal – culturas temporárias e permanentes**. Rio de Janeiro, v.29, 2002. 88p.

IBGE. **Produção agrícola municipal – culturas temporárias e permanentes**. Rio de Janeiro, v.30, 2003. 93p.

IBGE. **Produção agrícola municipal - Cereais, Leguminosas e Oleaginosas 2004**. Rio de Janeiro. 2005.

MATO GROSSO. Anuário Estatístico do Estado de Mato Grosso. Disponível em www.anu.seplan.mt.gov.br/anuarios6890/lista.php>. Acesso em 13 nov. 2004.

MONTEIRO, Carlos A. de F. – **A dinâmica climática e as chuvas no Estado de São Paulo: estudo geográfico sob a forma de Atlas**. São Paulo: IGEOG/USP, 1973.

NIMER, Edmon. Clima. In: BRASIL. IBGE. **Geografia do Brasil**: região Centro-Oeste. Rio de Janeiro: IBGE, 1989, p. 23-34.

NIMER, Edmon. Clima. In: BRASIL. IBGE. **Geografia do Brasil**: região sul. Rio de Janeiro: IBGE, 1990. v. 2. p.151-187.

PRODUÇÃO de soja referente ao período. Disponível em: www.emater.tche.br. Acesso em: 13 nov. 2004.

SEAB. Secretaria da Agricultura e do Abastecimento/Departamento de Economia Rural. **Perfil da agropecuária paranaense**. Curitiba: DERAL. 2003

SEAB. Secretaria da Agricultura e do Abastecimento/Departamento de Economia Rural. Acompanhamento de Situação Plantio/Colheita. Disponível em: www.pr.gov.br/seab>. Acesso em: 13 nov. 2004.

TECNOLOGIAS de produção de soja – região central do Brasil 2003. Londrina: Embrapa Soja: Embrapa Cerrados: Embrapa Agropecuária Oeste: ESALQ, 2002. 199p.

TOMIO, Fabricio R. de L. **A criação de municípios após a Constituiçáde de 1988**. In: Revista Brasileira de Ciências Sociais. v.17, n. 48. 2002.

CLIMATIC CHANGE AND THE AGRICULTURAL SECTOR IN SOUTH EAST SOUTH AMERICA

GRACIELA ODILIA MAGRIN
INTA - Instituto de Clima y Agua. 1712, Castelar. Argentina

INTRODUCTION

Projected changes in climate which include higher atmospheric CO2 concentration, higher temperatures and changes in precipitations could severely affect the agricultural systems. The general assumption is that temperature increments in mid latitudes would lead to shorter growing season, lower biomass production and lower grain yields. In contrast, an atmosphere with higher CO2 concentration would result in higher photosynthesis rate and more efficient water use by crops (Acock and Allen, 1985), although there is still uncertainty about the overall effect of CO_2 on yield because of interactions with temperature, water and nutrients (Gregory et al., 1999). Increases/decreases in precipitation would benefit/detriment areas with dry/wet climates, and would aggravate problems in zones with water excess/deficits. In conclusion, the impacts of climate change on crops yields will be the result of a balance between these negative and positive effects on plant growth and development.

Currently, there is sufficient scientific evidence that climate change is already affecting agricultural systems in several regions of the world (IPCC, 2001). South Eastern South America (SESA), is one of the world's zone were significant changes in climate and crop production were detected during the last part of the 20th century. These changes were characterized by increases in precipitation (up to 50% in some areas), decreases in maximum temperature especially during spring and summer; and increases in minimum temperature during almost all the year (Castañeda and Barros, 1994; Barros et al 2000; Pinto et al., 2002; Bidegain et al., 2005; Magrin et al., 2005).

In the Argentina's Pampas region these changes in climate, specially increases in precipitation, led to increases in rainfed yields. Comparing the period 1950-70 with 1971-1999 increases in rainfed yields attributable to changes in climate (isolated by using crop simulation models with the same production technology) were 38% in soybean, 18% in maize and 13% in wheat (Magrin et al., 2005).

Even if registered climate change has benefited crop yields, it has been also contributing to important changes in land use that are threatening the systems sustainability. Over the last three decades the region was subject to an agricultural intensification principally as a result of soybean expansion. Only in Argentina the soybean planted area increased from 6 Mha in 1995 to 14Mha in 2003, and some projections indicate that this trend would continuous in the near future (Maarten Dros, 2004).

In this report we present different assessments of potential impacts of climate change on crop yields in the SESA region, as well as some adaptive measures taking into account the tools used, and discussing some uncertainties in the level of confidence of obtained results.

CLIMATIC SCENARIOS:

Changes projected in climate are highly dependent on GCM, socio economic scenarios and obviously the time slice considered. Projections (Figure 1) presented in the TAR (IPCC, 2001) indicate that by the end of the century global temperature could increase between 1.2 and 5.8°C depending on the socioeconomic scenario considered.

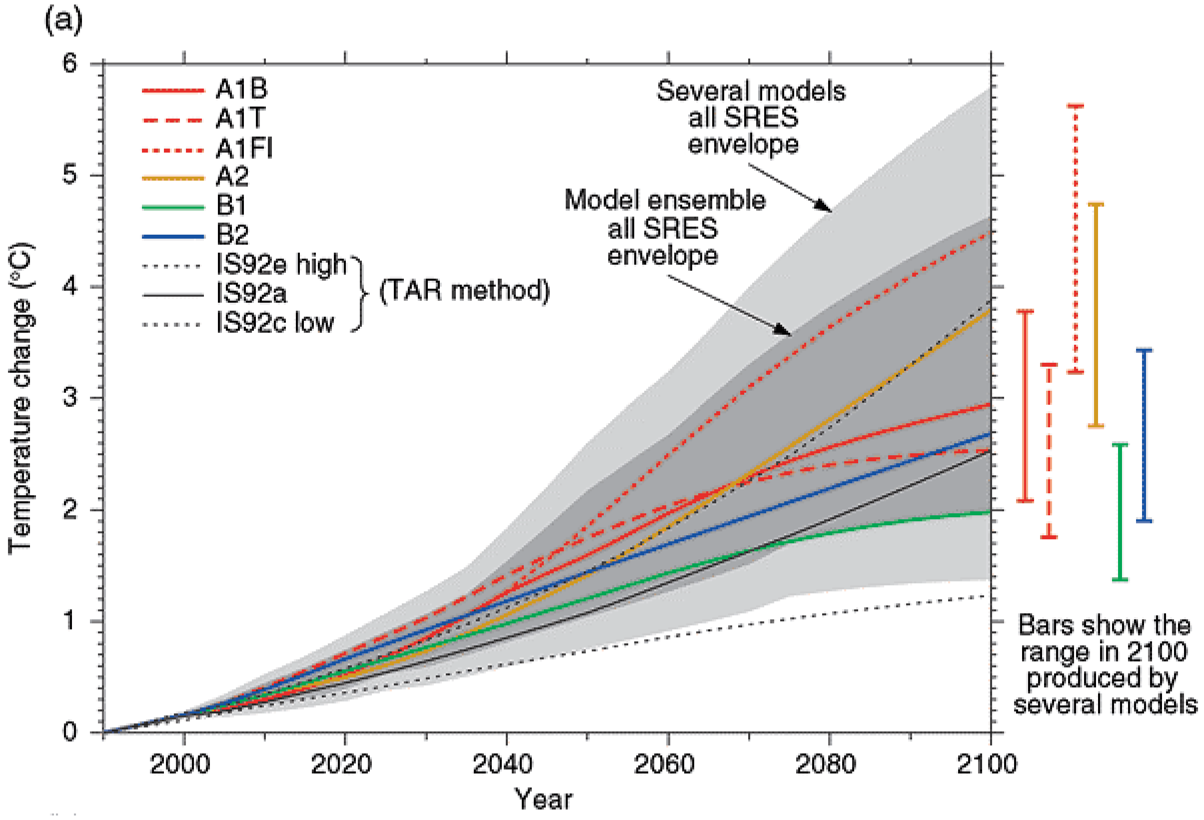


Figure 1 - Global mean temperature projections for the six illustrative SRES scenarios using a simple climate model tuned to a number of complex models with a range of climate sensitivities. Also for comparison, following the same method, results are shown for IS92a. The darker shading represents the envelope of the full set of thirty-five SRES scenarios using the average of the model results (mean climate sensitivity is 2.8°C). The lighter shading is the envelope based on all seven model projections (with climate sensitivity in the range 1.7 to 4.2°C). The bars show, for each of the six illustrative SRES scenarios, the range of simple model results in 2100 for the seven AOGCM model tunings. (Source IPCC 2001)

Temperature projections for six sites located in SESA (Azul, Tres Arroyos, Santa Rosa y Peregamino en Argentina; La Estanzuela en Uruguay y Passo Fundo en Brasil) based on HadCM3 show that mean temperature would increase an average of 0.9ºC, 2.1ºC and 3.4ºC by 2020, 2050 and 2080, respectively for SRES A2 scenario. Corresponding figures for SRES B2 are: 0.8ºC, 1.7ºC and 2.6ºC (Figure 2).

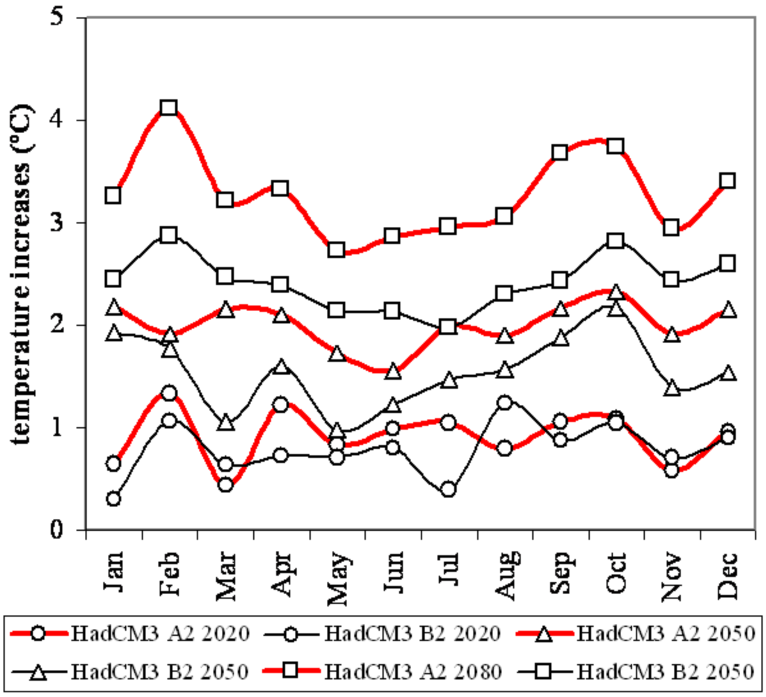


Figure 2 - Mean increases in monthly temperature projected by HadCM3 SRES A2 B2 scenarios several for 2020, 2050 and 2080 in 6 sites located in the SESA region. .

Despite of differences between sites, precipitation projections by HadCM3 show a trend to increase during the warm semester (October-March), and to decrease during the coldest months (May-Aug). Changes in precipitation were stronger in the climate model runs for the 2050 and 2080 time periods (Figure 3).

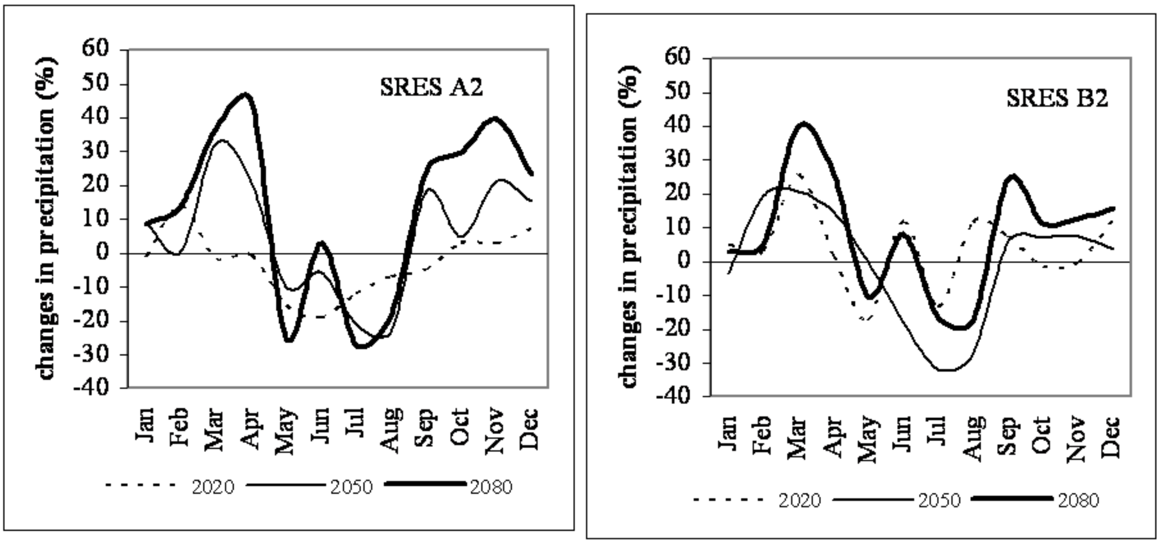


Figure 3 - Monthly changes projected in precipitation (%) for the 2020s, 2050s and 2080s (compared with current values) under the HadCM3 SRES A2 and B2 scenario. Values represent the mean for 6 sites located in SESA.

CROP MODELS:

In the countries involved in this review, crop simulation models included in DSSAT (Tsuji et al, 1994) were used to assess the potential impacts of climate change on crops yields as well as to evaluate some adaptive measures. They are process-based models and use simplified functions to express the interactions between crop growth and the major environmental factors that affect crops (i.e., climate, soils, and management).

These models were designed to have global applications, and work independent of location, season, crop cultivar, and management system. They simulate the effects of weather, soil water, genotype, and soil and crop nitrogen dynamics on crop growth and yield. Most of them were developed as tools in agricultural management, particularly for providing information on the optimal amounts of input (such as fertilizers, and irrigation) and their optimal timing.

Modelled processes include phenological development, growth of vegetative and reproductive plant parts, extension growth of leaves and stems, senescence of leaves, biomass production and partitioning among plant parts, and root system dynamics. The models include subroutines to simulate the soil and crop water balance and the nitrogen balance. The primary variable influencing each phase of plant development is temperature. Potential dry matter production is a function of intercepted radiation; the interception by the canopy is determined by leaf area. The dry matter allocation to different parts of the plant (grain, leaves, stem, roots, etc.) is determined by phenological stage and degree of water and nitrogen stress. Final grain yield is the product of plant population, kernels per plant, and kernel weight. In addition, these models are able to account for the effect of elevated carbon dioxide on plant functioning.

DSSAT models have been exhaustively tested in the region at the plot and at the field level with rather low estimation errors (Guevara & Meira, 1995; Meira & Guevara, 1995; Travasso & Magrin, 2001; Sawchik, 2000, de Siqueira et al., 2000), and they were used to assess the impacts of interannual climate variability and climate change in the agricultural sector (Magrin et al., 1997, 1998; Travasso et al., 1999; Magrin and Travasso, 2002; de Siqueira et al, 2000; Sawchik, 2001).

IMPACTS OF CLIMATIC CHANGE:

a) Potential Yield

In crops growing under non limiting water and nutrients conditions, grain yields are defined by temperature, radiation and CO2 concentration. The potential yield of a crop can be thought as the product of the rate of mass accumulation multiplied by the duration of growth. The rate of biomass accumulation is principally influenced by the light intercepted by plants over a wide optimum temperature range. However, the duration of growth for a particular cultivar is usually almost inversely proportional to temperature (Ritchie and NeSmith, 1991). Moreover, increases in CO2 concentration lead to higher photosynthetic efficiency contributing to increase the mass accumulation.

In the Argentina's Pampas region, simulations under non limiting water and nutrient conditions using current climatic inputs and incremental scenarios (+1ºC, +2ºC and +3ºC) were used to obtain the relationships between potential yield variations and temperature increases under 330 ppm and 550 ppm CO_2 (Figure 4).

Under 330 ppm CO_2 concentrations, increases in temperature lead to reductions in wheat (7.4% per ºC) and maize (4.7% per ºC) potential yields. Inversely in soybean, temperature increases lead to slight increases in crop yield (Figure 4).

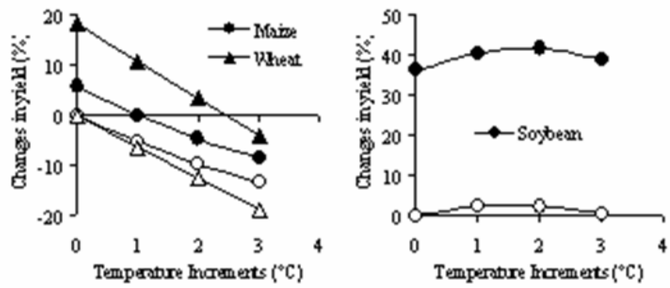


Figure 4 - Relationships between relative changes in wheat, maize and soybean yields (as percentage of mean actual values for the Pampas Region) and temperature increases (ºC) under two CO_2 concentration: 330 ppm (open circles) and 550 ppm (filled circles).

Under 550 ppm of CO_2 concentration, and considering the beneficial effect of CO_2 on crop production, maize, wheat and soybean potential yields would be benefited increasing on average 5%, 16% and 35% respectively (Figure 4), partially reversing the temperature effects. Threshold temperature increments, where the actual potential yield could decrease, were 1ºC for maize and 2.8ºC for wheat. Soybean yields would be benefited by increments up to 3ºC.

In both cases the observed crop yield reductions are likely to occur because of reductions in the length of the crop growth cycle in response to temperature increments. Relations between temperature increments and the longitude of maize, wheat and soybean growth cycle in the central part of Argentina shows a rate of decrease in crop cycle near to 5 days per ºC in wheat, and 4 days per ºC in maize (Magrin & Travasso, 2002).

b) Rainfed yields:

Under rainfed conditions, precipitation becomes a crucial factor when determining changes in yield. Several studies under rainfed conditions were done in the middle of the 90s using GISS, GFDL and UKMO predictions for 2100. According to these results (Table 1), wheat, barley and maize yields will be seriously reduced even when CO2 effects are considered. In contrast soybean yields tend to increase up to 40%, with the exception of UKMO projections in Argentina which predict an important decrease in summer precipitation in the main zone devoted to soybean.

Table 1 - Potential changes in rainfed yields under GISS, GFDL, and UKMO scenarios for 2100.

Region	Crop	Climate Scenario	Yield impact (%)
Uruguay *(Baethgen, 1994)*	Wheat Barley	GISS, GFDL, UKMO	-30 -40 to -30
Brasil *(de Siqueira et al., 1994)*	Wheat Maize Soybean	GISS, GFDL, UKMO	-50 to -15 -25 to -2 +10 to +40
Argentina and Uruguay (9sites) *(Baethgen & Magrin, 1995)*	Wheat	UKMO	-5 to -10
Argentina (1 site) *(Sala and Paruelo, 1994)*	Maize	GISS, GFDL, UKMO	-36 to -17
Argentina Mean for Pampas Region *(Magrin et al., 1997)*	Wheat Maize Soybean	GISS, GFDL, UKMO	-8 to -3 -16 to -8 -22 to +18

Recently, a global study (Parry et al., 2004) evaluates the impact of HadCM3 projections under several SRES scenarios (A1FI, A2a, A2b, A2c, B1a and B2a) for the time periods 2020, 2050 and 2080 and considering countries regional crops yield (wheat, rice, maize and soybean). According to these results (Figure 5) in SESA under the warmer scenario (A1FI) and without considering CO2 effects crops yield could decreases up to 5% by 2020, between 5 and 30 % by 2050 and 30% by 2080. When CO2 effects are considered the figures are +2.5 to -2.5% for 2020, +10 to -2.5% for 2050 and -2.5 to -5 for 2080.

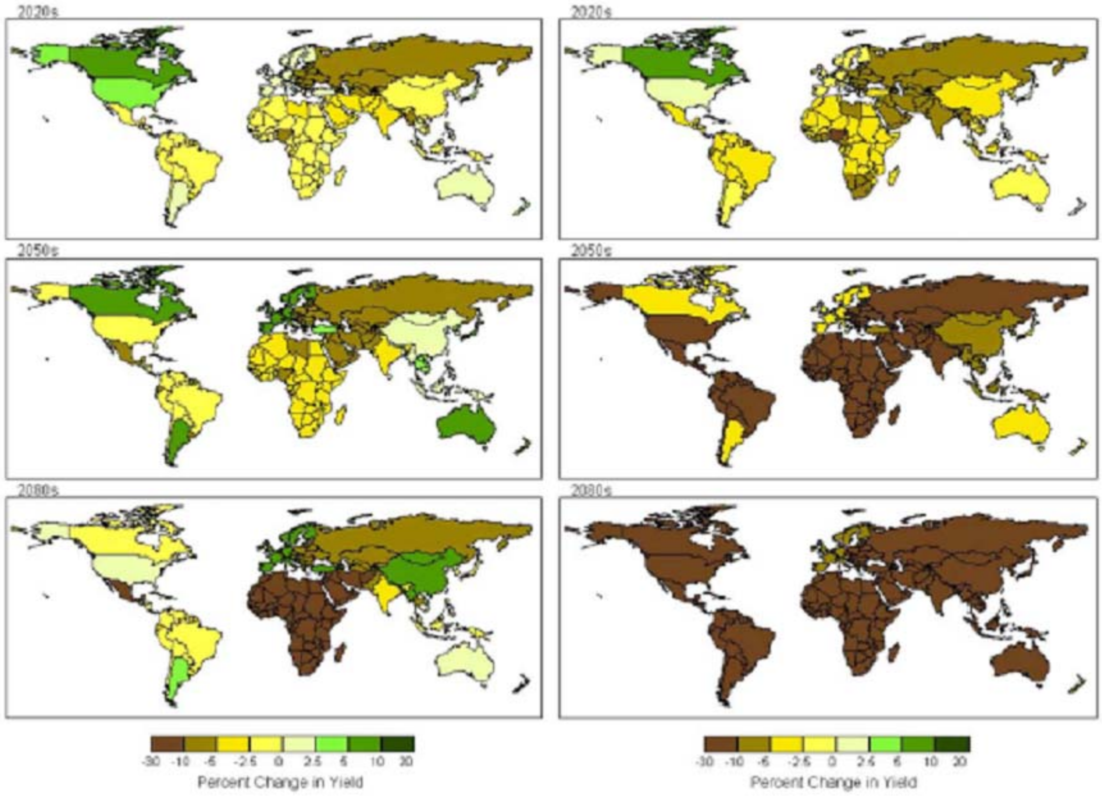


Figure 5 - Potential changes (%) in national cereal yields for the 2020s, 2050s and 2080s (compared with 1990) under the HadCM3 SRES A1FI scenario with and without CO2 effects. (Source: Parry et al., 2004)

A more specific study (Travasso et al., 2005) assessed the impact of HadCM3 SRES A2 and B2 scenario in maize and soybean yields for 2020, 2050 and 2080 in 6 sites located in SESA (Table 2). According to these results, when CO2 effects are not considered, maize yields could increase near 8% or decrease near 12% depending on the site, the time slice and the SRES scenario considered. The figures for soybean are increases near 11% and decreases near to 22%. When CO2 effects are considered yields could increase between 0% and 33% in maize and 1% and 63% in soybean.

Table 2 - Rainfed yield changes (%) in maize and soybean yields for the 2020s, 2050s and 2080s (compared with current yields) under the HadCM3 SRES A2 and B2 scenarios with and without CO2 effects in 6 sites of SESA: Santa Rosa, Argentina (SR), Tres Arroyos, Argentina (TR), Azul, Argentina (AZ), Pergamino, Argentina (PE), La Estanzuela, Uruguay (UY) and Passo Fundo, Brasil (PF). (Source Travasso et al., 2005)

	HadCM3 A2						HadCM3 B2					
Site	Without CO2 effects			With CO2 effects			Without CO2 effects			With CO2 effects		
	2020	2050	2080	2020	2050	2080	2020	2050	2080	2020	2050	2080
	Maize Rainfed											
SR	8.4	-0.2	-1.5	11.8	9.2	10.1	-4.2	-4.7	-1.6	2.5	2.7	8.4
TA	-3.0	-1.2	-8.6	10.6	12.9	18.0	-11.6	-10.8	-11.7	1.5	2.9	5.2
AZ	-1.2	4.6	-2.3	9.3	15.3	15.6	-2.3	0.0	-1.6	1.7	8.9	11.4
PE	-5.5	-3.3	-4.5	0.4	7.7	11.5	-4.9	-6.5	-8.7	0.1	2.5	5.0
LE	-9.0	1.0	-0.8	8.4	17.6	33.4	-6.1	-4.9	-4.8	12.1	7.1	14.5
PF	0.2	-5.0	-4.0	5.8	2.3	8.1	2.7	-0.9	-0.8	10.3	3.9	6.9
	Soybean Rainfed											
SR	10.5	0.5	-4.9	38.1	48.6	60.1	-8.5	-3.8	-6.5	14.1	34.9	42.3
TA	0.6	1.1	-4.6	27.7	51.6	62.5	-15.3	-9.7	-13.8	6.4	28.5	34.5
AZ	-0.6	-0.3	-4.4	23.9	44.0	53.9	0.5	-8.9	-11.4	23.1	26.2	34.1
PE	-5.0	-6.9	-22.0	17.2	35.3	26.7	-8.7	-13.5	-18.3	10.2	18.8	22.6
LE	-8.5	3.2	-13.7	14.4	45.0	43.9	-17.6	-4.8	-11.4	1.2	35.3	27.0
PF	-4.3	-17.1	-15.7	20.9	25.5	43.2	1.8	-4.3	-9.8	26.8	33.3	38.6

In Brazil (de Siqueira et al., 2000) future climate scenarios projected by GISS models resulted in wheat grain yield reductions near 31%, especially for the Central-South regions. For maize grain yield reductions averaged 16%, projecting expressive reductions for Northeast and Northern regions. Soybean presented positive responses with average increase in yield near 27%. National grain supply projections are negative for wheat and maize and positive for soybeans, being the Central-South and the South regions more sensitive for the projected climate changes, especially near 2050-2060 (530 and 555 ppm CO_2). For the other regions (Central, Northeast and North) the impacts were less expressive due to lower cultivated areas.

Despite differences of climate change impacts according to the GCM, the SRES scenario, the time slice, the crop and the site considered, it seems clear that in the future and all over the region soybean could be the less affected crop, especially when CO2 effects are considered.

However there is still uncertainty about crop responses to CO_2 enrichment under field conditions in the long term. Most of experiments have been carried out in controlled or semi-controlled conditions and there are still doubts related to interactions among crops, weeds, pests, water, nutrients, etc. under climate change. Research of the last few years had suggested that the initial stimulation of photosynthesis observed when plants grow at elevated CO_2 may be counterbalanced by a long-term decline in the level and activity of photosynthetic enzymes as the plants acclimate to their environment, an event referred to as 'down-regulation'. Recently published results from a field experiment that lasted more 14 years (Adam et al., 2004) with Citrus aurantius (sour orange), and included treatments of 400 and 700ppm CO_2 indicated that in fact long-term CO_2 enrichment can result in photosynthetic down-regulation in leaves of trees, even under non-limiting nitrogen conditions. Acclimation to CO_2 enrichment is not included in crop models that we used in our study.

ADAPTATION:

To improve future potential crop production some adaptive strategies could be carried out. An important issue here is that increasing temperatures act to modify the dates of last frosts that are currently controlling crop calendars. Extended frost-free periods would allow longer duration of crop cycles and could contribute to improved grain production under changed conditions. In this context, the less difficult strategy to obtain longer growth duration should be to modify crop calendars.

A recent study (Travasso et al., 2005) demonstrated that under rainfed conditions earlier planting dates led to increased maize yields under HadCM3 A2 and B2 SRES scenarios, especially for 2050 and 2080, although there were differences among sites. Earlier planting dates contributed to longer planting-flowering periods and earlier maturity dates. This measure would allow maize crops to develop under more favorable thermal conditions, increasing the duration of the vegetative phase which in turn would benefit the obtained grain number and hence the crop grain yield. An additional possible advantage of earlier planting dates is related to the anticipation of crop maturity and therefore the harvest. Under current planting dates maize crops are usually harvested during March- April or later, depending on the region. Future climate scenarios are projecting important increases in rainfall for these months (see Figure 3) which could constrain harvest. This issue is not taken into account by the CERES model, and therefore the impact of earlier sowing dates could be even higher under the climate conditions predicted by the HadCM3.

Other adaptation measures reported for Argentina are related to the development of genotypes with longer growth cycle, which could be better adapted to temperature raise. For this purpose, increasing the photoperiod sensitivity in wheat and the duration of the juvenile phase in maize could be some probable strategies (Magrin & Travasso, 2002).

According to the impacts cited in this report, with rather simple adaptation measures or even without adaptation soybean will be the less affected crop in the future, even if CO_2 effects are not considered. That could promote further expansion of soybean planted areas. This issue requires attention because it could be very risky for the agro-ecosystems sustainability. Soybean is a high nutrient extractive crop with low level of crop residues, so the monoculture leads to negative Nitrogen and Carbon balances. Some management measures were proposed as a way to preserve the natural resources. Crop-pastures rotations, that used to be the main rotation in the Pampas, are one of the possibilities to improve and preserve soil organic matter balances and, thus, soil C and N (García, 2004). In South Brazil, Costamilan. & Bertagnolli (2004) recommend a three year's crop rotation including the sequence oats/soybean, wheat/soybean and spring vetch/maize.

Another adaptation measure that could be more reliable because of the economics returns is related to the destination of crop production. Oliverio & Lopez (2005) analyzed two possible scenarios to estimate Argentina's crops production in 2015. The first one in which they extrapolated the actual trend in planted areas (with increasing importance of oilseeds, specially soybean) and a second one in which they proposed a maximum ratio of 2,5:1 between oilseeds and cereals promoting the so called "transformation in origin" as a way to contribute to both, the sustainability of agricultural systems and economic returns. Transformation in origin means that part of the production (for example of maize) remains at the place were it was produced and is used to feed animals or for local industry, adding value to the primary product, instead of the traditional sell as commodity which implies in some cases important costs of transportation to ports and fiscal retentions, among others. Assuming that half of the maize production is transformed in origin economic benefits could be more than duplicated.

Finally, in the systems where the land is rented, the land lord could extend the contracts (for example 4 years) with the condition that the tenant take the compromise of including other crop than soybean at least during one year (G. Lopez, personal communication).

REFERENCES:

Acock B., L.H. Allen Jr. 1985. Crop responses to elevated carbon dioxide concentrations. p 33-97. In B.R.Strain and J.D.Cure (ed.). Direct effects on increasing carbon dioxide on vegetation. U.S.DOE/ER-0238. Dep. Energy, Washington DC.

Adam, N.R., Wall, G.W., Kimball, B.A., Idso, S.B., Webber, A.N. 2004. Acclimation Of Photosynthesis In Leaves Of Sour Orange Trees Grown At Elevated Co2 For 14 Years.. New Phytologist. 163:341-347

Baethgen, W.E., 1994: Impact of climate change on barley in Uruguay: yield changes and analysis of nitrogen management systems. In: Implications of Climate Change for International Agriculture: Crop Modeling Study [Rosenzweig, C. and A. Iglesias (eds.)]. U.S. Environmental Protection Agency, Washington, DC, pp. 1-13.

Baethgen, W.E., and G.O. Magrin. 1995. Assessing the Impacts of Climate Change on Winter Crop Production in Uruguay and Argentina Using Crop Simulation Models. In C. Rosenzweig, L.H.Allen, Jr., L.A Harper, S.E. Hollinger, and J.W. Jones (eds.) *Climate Change and Agriculture: Analysis of Potential International Impacts.* American Society of Agronomy Special Publication 59, Madison WI.

Barros, V. M.E. Castañeda and M, Doyle .2000: Recent precipitation trends in Southern South America to the East of the Andes: an indication of a mode of climatic variability. Chapter of the book "Southern Hemisphere Paleo and Neoclimates. Concepts, Methods, Problems". Springer.

Bidegain M**,** R.M. Caffera, F. Blixen, V. Pshennikov, J.J. Lagomarsino, E.A. Forbes, G.J. Nagy, 2005. Tendencias Climáticas, Hidrológicas y Oceanográficas en el Río de la Plata y Costa Uruguaya. In: El Cambio Climático en el Río de la Plata. Eds. Barros V., A. Menéndez, G.J. Nagy, Capítulo 14: 137-143, CIMA-CONICET-UBA, Buenos Aires, Mayo, 2005.

Castañeda, M. E. and Barros, V. 1994 ..Las tendencias de la precipitación en el Cono sur de America al este de los Andes. 1994. Meteorológica. pp 23-32.

Costamilan, L.M. & P.F. Bertagnolli. 2004. Indicações técnicas para a cultura de soja no Rio Grande do Sul e em Santa Catarina – 2004/2005. / - Passo Fundo, RS : Embrapa Trigo, 2004. 170 p. ; 21 cm. (Sistema de Produção, 1)

de Siqueira, O.J.F., J.R.B. Farías, and L.M.A. Sans, 1994: Potential effects of global climate change for Brazilian agriculture: applied simulation studies for wheat, maize and soybeans. In: Implications of Climate Change for International Agriculture: Crop Modeling Study [Rosenzweig, C. and A. Iglesias (eds.)]. EPA 230-B-94-003, U.S. Environmental Protection Agency, Washington, DC, USA.

de Siquiera, O., S. Steinmetz, M. Ferreira, A.Castro Costa and M.A.Wozniak 2000. Climate changes projected by GISS models and implications on brazilian agriculture. Revista Brasileira de Agrometeorologia, Santa Maria, v. 8, n. 2, p. 311-320

García, F. 2004. "Fertilizers to sustain the production of 100 million tonnes of grain in Argentina ". Available at www.INPOFOS.org

Gregory, P.J., J.S.I. Ingram, B. Campbell, J. Goudriaan, L.A. Hunt, J.J. Landsberg, S. Linder, M. Stafford Smith, R.W. Sutherst, and C.Valentin, 1999. Managed production systems. Chapter 9. In: The Terrestrial Biosphere and Global Change. Implications for natural and managed ecosystems, Eds., B. Walker, W. Steffen, J. Canadell, and J.Ingram, Cambridge University Press, Cambridge, England

Guevara, E, Meira, S. 1995. Application of CERES-Maize model in Argentina. Second International Symposium on Systems Approaches for Agricultural Development (SAAD2). Los Baños- IRRI. Philippines.

IPCC. 2001. IPCC Third Assessment Report.

Joensen, L. & M.W. Ho. 2004. La paradoja de los transgénicos en Argentina. Revista del Sur, Nº 147/148. www.redtercermundo.org.uy.

Kimball, B.A., Kobayashi, K., Bindi, M., 2003. Responses of agricultural crops to free-air CO2 enrichment. Adv. Agron. 77, 293-/368.

Maarten Dros, J. 2004. Managing the Soy Boom; two scenarios of soy production expansion in South America. Commissioned by WWF Forest Conversion Initiative. AID Environment. 67p

Magrin, G., Travasso, M.I, Díaz, R. and Rodríguez, R..1997. Vulnerability of the Agricultural Systems of Argentina to Climate Change. Climate Res., 9:31-36.

Magrin G.O., Díaz R.A., Travasso M.I., Rodriguez G., Boullón D., Nuñez M., Solman S. 1998. Vulnerabilidad y Mitigación relacionada con el Impacto del Cambio Global sobre la Producción Agrícola. En Proyecto de Estudio sobre el Cambio Climático en Argentina, proyecto ARG/95/G/31-PNUD-SECYT, (*eds.* Barros V., Hoffmann J.A., Vargas W.M.), (290 pp).

Magrin, G.O., M. I. Travasso. 2002. An Integrated Climate Change Assessment from Argentina (Chapter 10) ***In***: Effects of Climate Change and Variability on Agricultural Production Systems. Otto Doering III; J.C.Randolph; J.Southworth and R.A.Pfeifer (Eds). Kluwer Academic Publishers, Boston. 296pp.

Magrin, G.O., M.I. Travasso and G.R. Rodríguez. 2005. Changes in climate and crop production during the 20th century in Argentina. Climatic Change Vol. 72, Numbers 1-2, 229 – 249.

Meira, S, and E. Guevara. 1995. Application of SOYGRO model in Argentina. Second International Symposium on Systems Approaches for Agricultural Development (SAAD2). Los Baños- IRRI. Filipinas.

Oliverio, G. & G.Lopez. 2005. El desafío productivo del complejo granario argentino en la próxima década. Potencial y Limitantes. Fundación Producir Conservando. Available at www.producirconservando.org.ar

Parry, M.L , C. Rosenzweig, A. Iglesias, M. Livermore, G. Fischer. 2004. Effects of climate change on global food production under SRES emissions and socio-economic scenarios. Global Environmental Change 14: 53–67

Pinto Hilton S., Eduardo D. Assad, Jurandir Zullo Jr e Orivaldo Brunini. 2002. Mudanzas climáticas. O aquecimento global e a agricultura. http://www.comciencia.br/

Ritchie, J.T., and D.S. NeSmith, 1991. Temperature and crop development. In: Modeling Plant and Soil Systems. Agronomy Monograph Nº 31. pp. 5-29. Eds., J. Hanks and J.T. Ritchie ASA, CSSA, SSSA Publ. Madison, WI, USA.

Sala, O.E. and J.M. Paruelo, 1994: Impacts of global climate change on maize production in Argentina. In: Implications of Climate Change for International Agriculture: Crop Modeling Study [Rosenzweig, C. and A. Iglesias (eds.)]. U.S. Environmental Protection Agency, Argentina chapter, Washington, DC, pp. 1-12.

Sawchik, J. 2001. Vulnerabilidad y adaptación del maíz al cambio climático en el Uruguay. Available at www.inia.org.uy/disciplinas/agroclima/publicaciones/ambiente/

Travasso, M.I., Magrin, G.O. and Grondona, M.O. 1999. Relations between climatic variability related to ENSO and maize production in Argentina. Proc. 10th Symposium on Global Change Studies, 10-15 Jan. 1999, Dallas, TX, by the AMS, Boston, MA. pp.67-68.

Travasso, M.I., G.O. Magrin. 2001.Testing Crop Models at the Field level in Argentina. pp. 89-90. ***In***: Proc. 2nd International Symposium "Modelling Cropping Systems". July 16-18 2001. Florence, Italy.

Travasso, M.I., G. O. Magrin, W. E. Baethgen, J. P. Castaño,G. R. Rodriguez, J. L. Pires, A. Gimenez, G. Cunha, M. Fernandez. 2005. Adaptation measures for maize and soybean in South Eastern South America. AIACC Adaptation Synthesis (submitted)

Tsuji, G.Y., G. Uehara and S. Balas (eds.). 1994. Decision Support System for Agrotechnology Transfer (DSSAT). IBSNAT. Department of Agronomy and Soils. University of Hawaii. Honolulu, HI.

GLOBAL CHANGE AND PLANT DISEASES

RAQUEL GHINI
Embrapa Meio Ambiente

INTRODUCTION

The importance of the environment on the development of plant diseases has been known for centuries (Colhoun, 1973). It is known that the environment can influence the growth and susceptibility of the host plant, the reproduction, dispersal, survival, and activities of the pathogen, as well as the interaction between the host plant and the pathogen. For this reason, global change represents a serious threat to agriculture, because they can promote significant alterations in the occurrence and severity of plant diseases. Such alterations may represent serious economic, social, and environmental consequences. Analyzing these effects is essential for the adoption of mitigating measures, in order to avoid future damages (Ghini, 2005). In the past, several epidemics that occurred in Brazilian agriculture could have been avoided or have their damages reduced if studies would have been carried out for the adoption of preventive measures.

Plant pathogens are ubiquitous, both in natural and managed systems, and may change the structure and functioning of ecosystems (Agrios, 1988; Malmström & Field, 1997). They are among the first organisms to show effects of climatic change due to their large populations, ease of multiplication and dispersion, and short time between generations (Scherm *et al.*, 2000). Thus, they form an essential group of bioindicators that need to be evaluated with regard to the impacts of climatic change, since they are one of the most important factors responsible for yield reductions, and may jeopardize the sustainability of the agroecosystem.

Global change may alter the current phytosanitary problems of Brazilian agriculture. Certainly, in the near future, modifications will occur in the relative importance of each plant disease. The economical impact could be positive, negative, or neutral, because changes may decrease, increase, or have no effect on different pathosystems, in each region. Mitigation strategies must take all these possibilities into consideration. For crops with higher loss risks, obtaining resistant varieties should be started as soon as possible, since this strategy requires long time for development. In addition, in face of global change effects on biological and chemical control, new strategies must be studied (Chakraborty, 2001).

There are few published papers about the effects of global change on plant diseases. Tests conducted in controlled environments may characterize isolated effects of certain environmental factors on pathogen-host interactions. With respect to assays conducted under field conditions, the few available papers have been conducted in the Northern Hemisphere. Little is known about effects on polycyclic diseases, which are responsible for significant losses in agriculture due to the occurrence of severe epidemics. In general, these diseases cannot be studied in controlled environments, because results are generally not representative.

In face of the threats represented by global change to plant protection, in the coming years it will become necessary to study this subject in detail. The main focus to be approached will be how global change manifested by the increased concentration of carbon dioxide (CO_2), increase in temperature, and alterations in precipitation could affect plant diseases.

EFFECTS OF CLIMATIC CHANGE ON THE CYCLE OF PATHOGEN-HOST RELATIONSHIPS

The classic disease triangle illustrates one of the paradigms of Plant Pathology, which establishes the conditions for the development of diseases, i.e., the interaction between the susceptible host, the virulent pathogen, and the favorable environment (Fig. 1). Consequently, the disease does not occur if one of the components is eliminated. This triangular relationship is an exclusive trait of Plant Pathology, in comparison with the Veterinary and Medicine segments, because terrestrial plants possess little thermal storage capacity, and immobility prevents them from escaping from adverse environments (Francl, 2001).

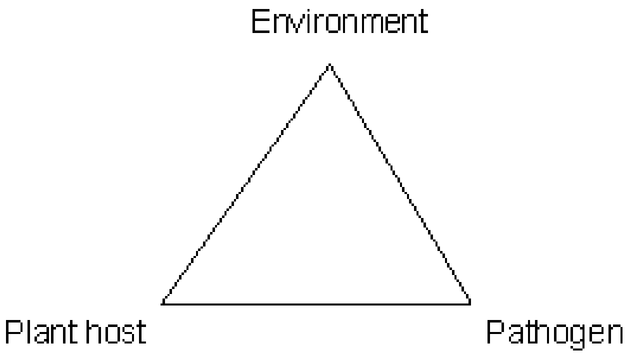


Figure 1 - Disease triangle showing the interaction between the essential elements that determine the occurrence of a plant disease.

Another aspect to be considered is that the alteration of a given climatic factor may have positive effects on one part of the disease triangle, and a negative effect on another. In addition, the effects may also have contrary behaviors in the various stages of the pathogen's life cycle (Coakley, 1995). Therefore, only a complete analysis of the system can define whether the disease will be stimulated or not.

The environment can influence all stages of development, both of the pathogen and of the host plant, as well as of the disease, at the various steps of the pathogen-host relationships cycle. In addition to these, it may also affect other organisms with which the plant and the pathogen interact, like endophytic, saprophytic, or antagonistic microorganisms. Thus, in an area where both the host plant and the pathogen are present, the appearance and development of the disease are determined by the environment. Important diseases can become secondary if the environmental conditions are not favorable. The relations between climate and diseases are so intense that they are routinely used for forecasting and managing epidemics, because fluctuations in the severity of diseases are determined, through the years, mainly by climatic variations.

The global change may have direct and indirect effects both on pathogens and on host plants and on the interaction between both. With regard to plant pathogens, their geographic distribution, for example, is determined by the temperature ranges over which the microorganism can grow, but many species prevail only in regions where temperature and other climatic factors are close to optimal values to allow rapid development (Lonsdale & Gibbs, 1994). Temporal distribution may be affected as well. Several pathogens, especially those that infect leaves, show fluctuations with regard to their incidence and severity throughout the year, which can be frequently attributed to climatic variations. Many of these pathogens are favored by increased moisture during the growth season, due to an increase in the production of spores. On the other hand, diseases such as powdery mildews are favored by low humidity conditions. The favorable conditions are specific for each pathosystem, and thus cannot be generalized.

In many cases, an increase in precipitation allows greater dispersion of propagules by raindrops. A reduction in the number of days with rain during summer, for example, can decrease the dispersion of several pathogens. Winds also play an important role on the dissemination of propagules, in both the short and the long range. Factors related to air turbulence, intensity, and direction of winds can also influence the release, transport, and deposition of inoculum.

The direct effects of climatic change can also be observed on the survival stage of pathogens. Pathogens of annual or perennial plants with deciduous leaves, for example, have to withstand long periods of time in the absence of available host plant tissues. In such cases, the survival stage is essential to ensure the presence of inoculum for the following cycle of the disease. Conditions during the winter season, for example, are important to determine the success of saprophytic survival.

Climatic change can also have direct effects on the host plant. One of the mechanisms involved is a change in plant predisposition, which consists in the modification of its susceptibility to diseases by external factors, i.e., non-genetic factors, which act before infection (Schoeneweiss, 1975).

The development of a plant results from the interaction between its genotype and the environment. Thus, climate change interfers with the morphology, physiology, and metabolism of plants, resulting in alterations in the occurrence and severity of diseases. Certainly the nature of the host plant (for example, annual or perennial; C3 or C4) and the pathogen (soil-borne or shoot-infecting; biotrophic or necrotrophic) determines what the impacts of climatic change will be: positive, negative, or without effect. Supposed morphological and physiological alterations that may occur and affect pathogen-host interactions include a reduction in the density of stomata, greater accumulation of carbohydrates in leaves, greater layer of waxes and epidermal cells, with an increase in fiber content, production of papillae and silicon accumulation in appressoria penetration sites, and increase in the number of mesophyll cells (Chakraborty *et al.*, 2000a). Elevated CO_2 changes the onset and duration of stages in pathogen life cycles. The latent period, i.e., the period between inoculation and sporulation, can be changed, as well as the reproduction capacity of some pathogens. Therefore, the mechanisms of resistance of host plants can be more easily overcome, as a result of accelerated development of pathogen populations (Chakraborty, 2001).

Manning & Tiedemann (1995) analyzed the potential effects of increased atmospheric CO_2 on plant diseases, based on the responses of plants in this new environment. An increase in the production of plant biomass, i.e., increases in shoots, leaves, flowers, and fruits, represent a higher amount of tissue that can be infected by plant pathogens. Increased carbohydrate contents may stimulate the development of pathogens that depend on sugars, such as rusts and powdery mildews. Increases in canopy density and plant size can promote greater growth, sporulation, and dissemination of leaf infecting fungi, which require high air humidity, but not rain, such as rusts, powdery mildews, and necrotrophic fungi. An increase in crop residues could mean better conditions for the survival of necrotrophic pathogens. A reduction in the openings of stomata can inibit stomata-invading pathogens, such as rusts, downy mildews, and some necrotrophic pathogens. Reductions in the vegetative period of plants, with early harvest and senescence, can reduce the infection period of biotrophic pathogens and increase that of necrotrophics. Increases in root biomass increase the amount of tissue to be infected by mycorrhizae or soil-borne pathogens, but can compensate losses caused by pathogens. Greater root exudation can stimulate both pathogens and antagonists (plant growth promoters). Such alterations may have great influence on the development of epidemics.

Other organisms that interact with the pathogen and the host plant can also be affected by climatic change, resulting in modifications in the incidence of diseases. Diseases that require insects or other vectors may undergo a new geographic or temporal distribution, which will be the result of the environment-plant-pathogen-vector interaction (Sutherst *et al.*, 1998). Increases in temperature or the incidence of droughts can extend the area of occurrence of the disease into regions where the pathogen and the plant are present but the vector still has not exerted its action. Mycorrhizal fungi, endophytic microorganisms, and nitrogen-fixing microorganisms can also suffer the effects of climatic change, ensuing alterations in the severity of diseases.

Most papers dealing with the effects of the environment on plant diseases have been conducted with pathogens that attack the aerial part of the plant, but soil-borne pathogens can also undergo significant changes. Soil temperature, for example, affects the activity of rhizobacteria that induces soil suppressiveness to *Fusarium oxysporum* f. sp. *ciceris*, the causal agent of wilt in chickpea (*Cicer arietinum*), in addition to affecting the inoculum potential of the pathogen (Landa *et al.*, 2001).

IMPACTS OF CLIMATIC CHANGE ON PLANT DISEASES

The impacts of climatic change on plant diseases can be expressed under different aspects. The most likely effects of climate change are on damages caused by diseases, on the geographical distribution of diseases, on the efficacy of control methods, and on other organisms that interact with the plant, such as mycorrhizae, rhizobacteria, antagonists, and endophytic organisms, among others (Chakraborty *et al.*, 2000a; Chakraborty, 2001).

DAMAGES CAUSED BY DISEASES

The effects of climatic change on the damages caused by diseases are determined by the interactions of a large number of factors which, directly or indirectly, influence the occurrence and severity of diseases. However, an increase in the severity of a given disease, caused by a climatic change, does not necessarily implicate increased losses (Luo *et al.*, 1995).

In seven out of fourteen reports found involving necrotrophic phytopathogenic fungi, the disease increased as CO_2 concentration increased (*Fusarium nivale,* in rye; *Fusarium oxysporum* f. sp. *cyclaminis,* in cyclamen; *Fusarium* sp., in wheat; *Cladosporium fulvum,* in tomato; *Colletotrichum gloeosporioides,* in *Stylosanthes scabra*; *Seiridium cardinale*, in *Cupressus sempervirens;* and *Plasmodiophora brassicae*, in cabbage, according to Osozawa *et al*., 1994; Manning & Tiedemann, 1995; Chakraborty *et al*., 1998; Chakraborty *et al*., 2000b; Paoletti & Lonardo, 2001); in four, the disease was not affected (*Pythium splendens* and *Thielaviopsis basicola*, in *Poinsettia*; *Botrytis cinerea*, in cyclamen; and *Sclerotinia minor,* in lettuce, according to Manning & Tiedemann, 1995); and in two there was a reduction (*Rhizoctonia solani*, in sugar beet and *Phytophthora parasitica*, in tomato, according to Manning & Tiedemann, 1995 and Jwa & Walling, 2001); however, in one the results were contradictory (*Rhizoctonia solani*, in cotton, according to Runion *et al*., 1994). For biotrophic fungi, of ten papers published, seven reported that the disease increased (*Ustilago hordei*, in barley; *Ustilago maydis*, in corn; *Puccinia striiformis*, *Puccinia graminis tritici*, and *Puccinia recondita tritici*, in wheat; *Puccinia coronata*, in oat; and *Puccinia dispersed*, in rye, according to Manning & Tiedemann, 1995); disease reduction was reported in only one (*Sphaerotheca pannosa*, in rose plants, according to Manning & Tiedemann, 1995), and different results were reported in two (*Erysiphe graminis*, in wheat and barley, according to Thompson *et al*., 1993, and Hibberd *et al*., 1996, respectively). These results demonstrate the lack of information on the subject, although fungi are the most studied group. In addition, the effects of CO_2 on the increase or reduction of diseases depend on specific characteristics of the pathosystems.

Open-top chambers (OTC) were installed at Embrapa Meio Ambiente to evaluate the effects of increases in the concentration of CO_2 on epidemiological parameters of plant diseases (Fig. 2). Six open-top chambers were constructed, having circular aluminium structure (2m diameter X 2m tall), sides covered with transparent plastic, and automated CO_2 concentration control. In three of them CO_2 is injected until it reaches twice the concentration in the environment, as evaluated inside the other three chambers. The monocyclic components evaluated are incubation period, latent period, percentage of leaf area with lesions, frequency of infection, infectious period, and sporulation.

Figure 2 - Open-top chambers installed at Embrapa Meio Ambiente, Jaguariúna, SP, Brazil.

CHANGES IN THE GEOGRAPHICAL DISTRIBUTION OF DISEASES

The increase in the planet's temperature alters the agroclimatic zones and directly interferes with the geographic distribution of plant diseases. A few scant examples of this type of study can be found in the literature (Carter *et al.*, 1996; Boag *et al.*, 1991; Brasier & Scott, 1994; Brasier, 1996).

In Brazil, Ghini *et al*. (2005) and Hamada *et al*. (2005) obtained maps of the spatial distribution of nematodes (races 1, 2, and 4 of *Meloidogyne incognita* in coffee) and the coffee leaf miner (*Leucoptera coffeella*) for current and future scenarios focused on the 2020's, 2050's, and 2080's (extreme scenarios A2 and B2). The future scenarios were obtained from the average of five models (ECHAM4, HadCM3, CGCM1, CSIRO-Mk2b, and CCSR/NIES), made available by IPCC-DDC (2004). The maps were prepared by means of models for the prediction of the number of annual generations of the nematode and leaf miner (Jaehn, 1991; and Parra, 1985), with a spatial resolution of 0.5 × 0.5 degrees of latitude and longitude, using a Geographic Information System (GIS).

The geographic distribution maps obtained for the probable number of generations of *M. incognita* and coffee leaf miner under the future scenarios demonstrate that there could be an increase in infestation when these are compared with the present climatic condition, based on the average of the last 30 years (Fig. 3 and 4). In general, for the 2020's and 2050's, there is little difference between the probable number of annual generations of coffee leaf miner obtained for the A2 and B2 scenarios. These differences are pronounced for the 2080 period, i.e., there is a larger area of the country with a higher number of generations under the A2 scenario than under B2.

A similar tendency was obtained for the coffee *M. incognita* strains, i.e., an increase in the number of annual generations will occur in future scenarios. Races 1 and 2 showed more intense development than race 4, as can also be observed in the current scenario. Because this is a soil-borne plant pathogen, the most important control method consists in the adoption of preventive measures, avoiding the introduction of the nematode in the area. However, after its establishment, a control strategy must be organized, because infestation seriously compromises productivity.

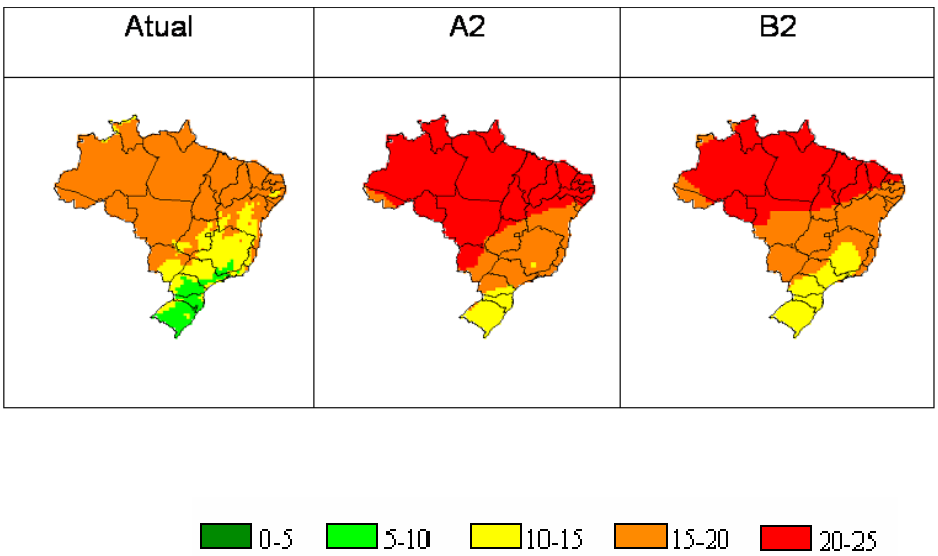


Figure 3 - Maps for the likely number of annual generations of coffee leaf miner (*Leucoptera coffeella*) in current and future scenarios (A2 and B2 focused on the 2080's) in Brazil.

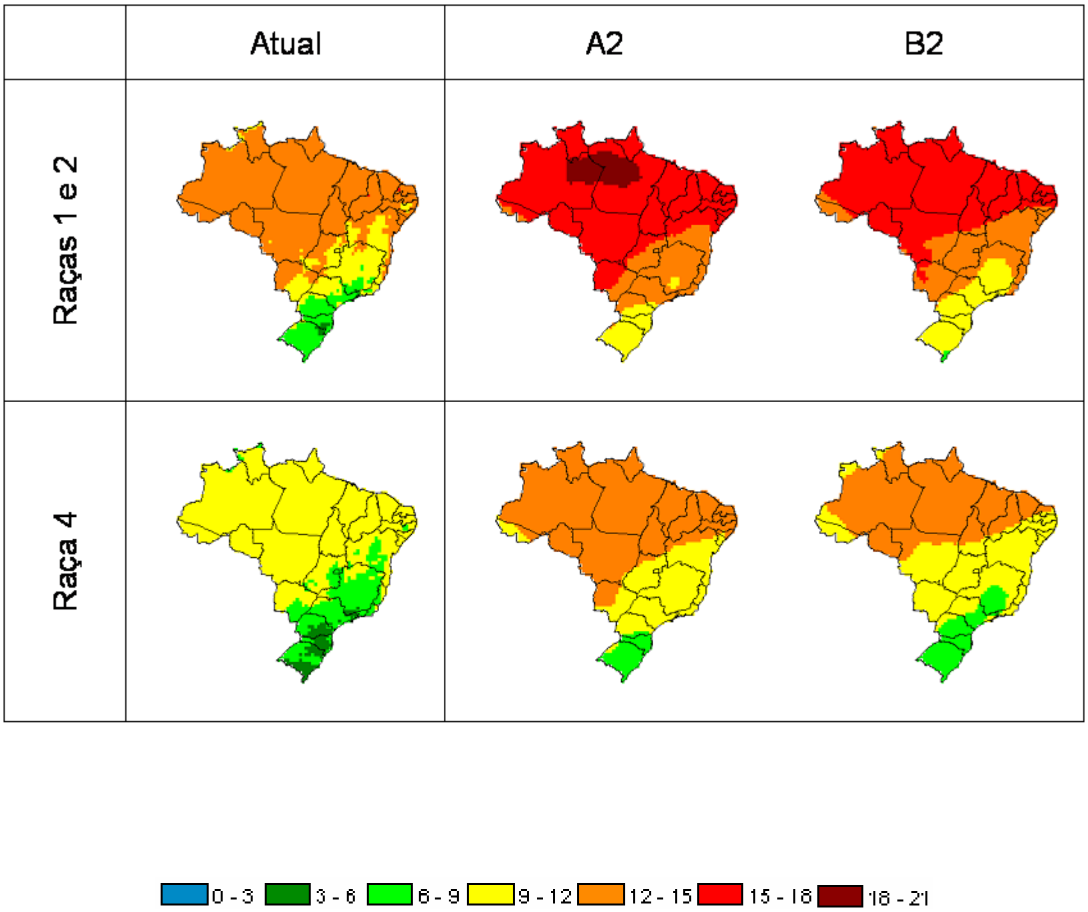


Figure 4 - Maps for the likely number of annual generations of *Meloidogyne incognita* races 1, 2, and 4 in coffee in current and future scenarios (A2 and B2 focused on the 2080’s) in Brazil.

EFFECTIVENESS OF CONTROL METHODS

All types of plant disease control are affected by climatic conditions. Changes in precipitation, for example, relative to the duration, intensity, and frequency of rains, have an effect on chemical control. If intense rains occur during the post-application period, many fungicides, for example, could have their effectiveness compromised.

Alterations in the composition of the atmosphere, and in temperature and precipitation, among others, could modify the phyllosphere and rhizosphere microbiota communities that act on the natural biological control of plant diseases. This mode of control can hardly be quantified; however, it is a known fact that it is frequent and its effects are significant.

A direct consequence of the modifications caused by climatic change on pathogen-host relationships occurs in plant genetic resistance to diseases. Many modifications in plant physiology may change the mechanisms of resistance of cultivars obtained both by traditional methods and by genetic engineering. Some forms of resistance can be more affected than others. However, the greatest threat to genetic resistance consists in the acceleration of pathogen cycles, which may undergo changes in all life stages as CO_2 increases. Some papers have verified that, despite the occurrence of a delay in initial development and a reduction in host penetration, established colonies develop at a greater rate, and an increase occurs in the multiplication of the pathogen in the tissues of the plant (Hibberd *et al.*, 1996; Chakraborty *et al.*, 2000a). A more intense multiplication of the pathogen, in connection with a favorable microclimate, due to greater development of plants, favors the occurrence of epidemics.

FINAL CONSIDERATIONS

Maintaining the sustainability of agricultural systems directly depends upon plant protection. In a few years, climatic change may alter the present scenario of plant diseases and their management. These changes will certainly have effects on productivity. Therefore, studying the impacts on important plant diseases is essential to minimize yield and quality losses, helping in the selection of strategies to work around problems (Chakraborty *et al.*, 2000a).

Another important aspect is that diseases constitute one of the components of the agroecosystem that can be managed. An immediate necessity exists for determining the impacts of changes on economically important diseases. Plant pathogenic bacteria, for example, are responsible for serious damages in several crops, and there is only one paper in the literature evaluating the effects of increases in CO_2 concentration on diseases caused by this group (Jiao *et al*., 1999). Secondary diseases must also be studied, since they can assume greater importance. However, in addition to this, plant disease specialists must go beyond their own subject matters and situate the impacts on diseases within a wider context that would involve the entire system.

The zoning of diseases by using climate parameters allows the evaluation of their possible geographic distributions within predicted climatic scenarios. This type of study can be particularly apropriate for exotic pathogens, since it allows an evaluation of their geographic distribution in new regions and the intensity of the importance that the pathogen may take on (Coakley, 1995). However, the lack of available information about the effects of the environment on the occurrence of diseases makes it difficult to use this type of work. Little is known about the environmental factors governing secondary pathogen communities, which could assume a significant importance in future scenarios (Clifford *et al.*, 1996).

Coakley & Scherm (1996) listed some of the most important difficulties found in studies on the effects of global climatic change and plant diseases. Among them, the following are worth noting: the continuous uncertainty about the precise magnitude of the climatic change that will occur in the next 25 to 50 years; the possibility that complex interactions will occur between climatic change components; a limitation of the knowledge about how these changes on a large scale and in the long term will affect the biological processes that take place at the regional and local scales, in a short period of time; and the issue of separating direct effects (for example, on the pathogen) from indirect effects (for example, by the effect on biological control agents or changes in the physiology of the host plant).

Researches intended to assess the effects of global climatic change on plant diseases must be carried out in an interdisciplinary fashion, preferably by means of international programs. The complexity of the processes involved and their interrelations require communication between professionals in the various areas concerned. Communication networks via the Internet have been formed among persons interested on this subject; as a consequence, several direct and indirect benefits have been accomplished (Scherm *et al.*, 2000). Thus, duplicated efforts are avoided and the spread of information and the establishment of partnerships are facilitated.

REFERENCES

AGRIOS, G.N. **Plant pathology**. 3.ed. New York: Academic Press, 1988. 803p.

BOAG, B.; CRAWFORD, J.W.; NEILSON, R. The effect of potential climatic changes on the geographical distribution of the plant-parasitic nematodes *Xiphinema* and *Longidorus* in Europe. **Nematologica,** v.37, p.312-323, 1991.

BRASIER, C.M. *Phytophthora cinnamomi* and oak decline in southern Europe. Environmental constraints including climate change. **Annales des Sciences Forestières,** v.53, p.347-358, 1996.

BRASIER, C.M.; SCOTT, J.K. European oak declines and global warming: a theoretical assessment with special reference to the activity of *Phytophthora cinnamomi*. **Bulletin OEPP/ EPPO Bulletin,** v.24, p.221-232, 1994.

CARTER, T.R.; SAARIKKO, R.A.; NIEMI, K.J. Assessing the risks and uncertainties of regional crop potential under a changing climate in Finland. **Agricultural and Food Science in Finland,** v. 5, n.3, p.329-350, 1996.

CHAKRABORTY, S. Effects of climate change. In: WALLER, J.M.L.; WALLER, S. J. (Ed.). **Plant pathologist's pocketbook**. Wallingford: CAB International, 2001. p. 203-207.

CHAKRABORTY, S.; MURRAY, G.M.; MAGAREY, P.A.; YONOW, T.; O'BRIEN, R. G.; CROFT, B.J.; BARBETTI, M.J.; SIVASITHAMPARAM, K.; OLD, K.M.; DUDZINSKI, M.J.; SUTHERST, R.W.; PENROSE, L.J.; ARCHER, C.; EMMETT, R.W. Potential impact of climate change on plant diseases of economic significance to Australia. **Australasian Plant Pathology,** v.27, p.15-35, 1998.

CHAKRABORTY, S.; TIEDEMANN, A.V.; TENG, P.S. Climate change: potential impact on plant diseases. **Environmental Pollution,** v.108, p.317-326, 2000a.

CHAKRABORTY, S.; PANGGA, I.B.; LUPTON, J.; HART, L.; ROOM, P.M.; YATES, D. Production and dispersal of *Colletotrichum gloeosporioides* spores on *Stylosanthes scabra* under elevated CO_2. **Environmental Pollution,** v.108, p.381-387, 2000b.

COAKLEY, S.M. Biospheric change: will it matter in plant pathology? **Canadian Journal of Plant Pathology,** v.17, p.147-153, 1995.

COAKLEY, S.M.; SCHERM, H. Plant disease in a changing global environment. **Aspects of Applied Biology,** v.45, p.227-238, 1996.

COLHOUN, J. Effects of environmental factor on plant disease. **Annual Review of Phytopathology,** v.11, p.343-364, 1973.

FRANCL, L.J. **The disease triangle**: a plant pathological paradigm revisited. Disponível em: <http://www.apsnet.org/education/InstructorCommunication/TeachingArticles.../Top.htm>. 2001. Acesso em: 05 fev. 2003.

GHINI, R. **Mudanças climáticas globais e doenças de plantas**. Jaguariúna: Embrapa Meio Ambiente, 2005. 104p.

GHINI, R.; HAMADA, E.; PEDRO JÚNIOR, M. J.; GONÇALVES, R. R.; PEREIRA, D.A.; MARENGO, J.A. Efeito de mudanças climáticas globais sobre a distribuição espacial de *Meloidogyne incognita* e do bicho-mineiro do cafeeiro. **Fitopatologia Brasileira**, v.30, Suplemento, p.169, 2005.

HAMADA, E.; GHINI, R.; PEDRO JÚNIOR, M.J.; MARENGO, J.A. **Efeito de mudanças climáticas globais sobre a distribuição espacial do número provável de gerações do bicho-mineiro do cafeeiro**. Trabalho apresentado no CBAgro 2005- XIV Congresso Brasileiro de Agrometeorologia, 18 a 21/7/2005, Unicamp, Campinas/SP.

HIBBERD, J.M.; WHITBREAD, R.; FARRAR, J.F. Effect of elevated concentrations of CO_2 on infection of barley by *Erysiphe graminis*. **Physiological and Molecular Plant Pathology,** v.48, n.1, p.37-53, 1996.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. **Climate change 2001**: the scientific basis IPCC WG I, TAR., 2001. 881p. Disponível em: <http://www.ipcc-wg2.org/index.html>. Acesso em: 27 ago. 2004.

JAEHN, A. Determinação da constante térmica das raças 1, 2 e 4 de *Meloidogyne incognita* em cafeeiro. **Nematologia Brasileira**, v.15, p.135-142, 1991.

JIAO, J.; GOODWIN, P.; GRODZINSKI, B. Inhibition of photosynthesis and export in geranium grown at two CO_2 leves and infected with *Xanthomonas campestris* pv. *pelargonii*. **Plant Cell Environ**., v.22, p.15-25, 1999.

JWA, N.S.; WALLING, L.L. Influence of elevated CO_2 concentration on disease development in tomato. **New Phytologist,** v.149, n.3, p.509-518, 2001.

LANDA, B.B.; NAVAS-CORTÉS, J.A.; HERVÁS, A.; JIMÉNES-DÍAS, R.M. Influence of temperature and inoculum density of *Fusarium oxysporum* f. sp. *ciceris* on suppression of Fusarium wilt of chickpea by rhizosphere bacteria. **Phytopathology**, v.91, n.8, p.807-816, 2001.

LONSDALE, D.; GIBBS, J.N. Effects of climate change on fungal diseases of trees. In: FRANKLAND, J.C.; MAGAN, N.; GADD, G.M. (Ed.). **Fungi and environmental change**. Cambridge: Cambridge University Press, 1994. p. 1-19.

LUO, Y.; TEBEEST, D.O.; TENG, P.S.; FABELLAR, N.G. Simulation studies on risk analysis of rice leaf blast epidemics associated with global climate change in several Asian countries. **Journal of Biogeography,** v.22, p.673-678, 1995.

MALMSTRÖM, C.M.; FIELD, C.B. Virus-induced differences in the response of oat plants to elevated carbon dioxide. **Plant, Cell and Environment,** v.20, n.2, p. 178-188, 1997.

MANNING, W.J.; TIEDEMANN, A.V. Climate change: potential effects of increased atmospheric carbon dioxide (CO_2), ozone (O3), and Ultraviolet-B (UV-B) radiation on plant diseases. **Environmental Pollution,** v.88, n.2, p.219-245, 1995.

OSOZAWA, S.; IWAMA, H.; KUBOTA, T. Effect of soil aeration on the occurrence of clubroot disease of crucifers. **Soil Science and Plant Nutrition,** v.40, n.3, p. 445-455, 1994.

PAOLETTI, E.; LONARDO, V. di. Seiridium cardinale cankers in a tolerant *Cupressus sempervirens* clone under naturally CO_2-enriched conditions. **Forest Pathology,** v.31, n.5, p.307-311, 2001.

PARRA, J.R.P. Biologia comparada de *Perileucoptera coffeella* (Guérin-Mèneville, 1842) (Lepidoptera, Lyonetiidae) visando ao seu zoneamento ecológico no Estado de São Paulo. **Revista Brasileira de Entomologia**, v.29, n.1, p.45-76, 1985.

RUNION, G.B.; CURL, E.A.; ROGERS, H.H.; BACKMAN, P.A.; RODRÍGUEZ-KÁBANA, R.; HELMS, B.E. Effects of free-air CO_2 enrichment on microbial populations in the rhizosphere and phyllosphere of cotton. **Agricultural and Forest Meteorology,** v.70, n.1-4, p.117-130, 1994.

SCHERM, H.; SUTHERST, R.W.; HARRINGTON, R.; INGRAM, J.S.I. Global networking for assessment of impacts of global change on plant pests. **Environmental Pollution,** v.108, p.333-341, 2000.

SCHOENEWEISS, D.F. Predisposition, stress, and plant disease. **Annual Review of Phytopathology,** v.11, p.193-211, 1975.

SUTHERST, R.W.; INGRAM, J.S.I.; SCHERM, H. Global change and vector-borne diseases. **Parasitology Today**, v.14, p.297-299, 1998.

THOMPSON, G.B.; BROWN, J.K.M.; WOODWARD, F.I. The effects of host carbon dioxide, nitrogen and water supply on the infection of wheat by powdery mildew and aphids. **Plant, Cell and Environment,** v.16, p.687-694, 1993.

IMPACTS OF GLOBAL WARMIN IN THE BRAZILIAN AGROCLIMATIC RISK ZONING

EDUARDO DELGADO ASSAD
Embrapa Agriculture Informatics

HILTON SILVEIRA PINTO
Cepagri/Unicamp

JURANDIR ZULLO JUNIOR
Cepagri/Unicamp

INTRODUCTION

The Agricultural Zonning is an official program coordinated by the Brazilian Ministry of Agriculture since 1995 with the main objective of minimize the high risk of losses caused by climatic events in Brazilian agriculture (AYOADE, 2001), that was about 16.27% during summer and 21.64% in winter, according to GÖEPFRERT et al. (1993). This program decreased the annual losses from about US$150.000.000 before 1996 to US$500.000 after that, increased the national productivity and became an important instrument of agricultural politics.

According to IPCC (2001), the global average temperature can increase from 1.0ºC to 5.8°C in this century. This can change the hydrologic cycle, increasing the potential and real evapotranspiration and modifying the consumption of water by the plants. A new climate condition can modify the spatial distribution of main crops that are cultivated in Brazil and affect the national economy.

Based on the scenarios of climate change presented by the Intergovernmental Panel on Climate Change (IPCC, 2001), the EMBRAPA (Brazilian Agricultural Research Corporation) and CEPAGRI/ UNICAMP (Center of Meteorological and Climatic Research Applied to Agriculture – State University of Campinas) prepared new zonings using the currents methodology and climate data in order to assess the effects of possible climate changes in the Brazilian agriculture.

CLIMATIC CHANGES AND PLANT BEHAVIOR

According to AYOADE (2001), it is possible to point out the following relationships between the plant physiology and the temperature:

All crops have minimum, maximum and optimal thermal values for its phenological phases since the air and surface temperature affect the growth of plants;

The lethal temperatures are normally placed between 50°C and 60°C;

Plants adapted to tropical conditions can be strongly affected by low temperatures even above the freezing point;

High temperature values can destroy the vegetal protoplasm, increase the transpiration tax and dry the plant.

According to PINTO et al. (2003), the Report of the Work Group II (WGII) of the IPCC, “Summary for Policymarkers - Impacts, Adaptation and Vulnerability - of the IPCC (2001)”, is extremely vague when assessing the possible impacts of global climate change in the behavior of agricultural crops”. Therefore, with reference to adaptation of plants in the “average latitudes” and the consequence in productivity, the report only affirms that climatic change will lead to general positive answers for minor variations than some degrees and negative answers generalities for more that some centigrade degrees.

METHODOLOGY

The assessment of climate change was based on the same methodology used in the agricultural zoning that corresponds to an integration of crop growth models, data of climate and soil, tools of GIS (Geographical Information Systems) and frequencial analysis of the crop water stress index called ISNA and defined according to Equation (1) (ASSAD & CUNHA, 2001).

$$ISNA = ETR / ETM \qquad (1)$$

Where ETR is the real evapotranspiration and ETM is the maximum evapotranspiration (conditions in which the water is enough for a growth and development without restrictions and with the tax of maximum evapotranspiration of a healthy crop that grows in great areas under excellent conditions of agrononomic handling and irrigation).

It is important to emphasize that ETR = ETP when there is no water stress and, therefore, ETR d” ETP.

The simulations were made for nine 10-days periods from October 1st to December 31 using time series having at least 15 years of daily precipitation. These periods were chosen since the best yields are normally obtained when the sowing is done during the months of October, November and December. One cycle length was chosen for each crop based on the values available in the literature. In the case of soybean, for example, it was used a cycle length of 120 days based on the values proposed by FARIAS et al. (2001).

Three types of soil were defined according to the available water capacity (CAD) estimated in function of the effective depth of the root systems: 30mm (Type I), 50mm (Type II) and 70mm (Type III). The soil types I, II and III were described by ANDRADE JÚNIOR et al. (2001) and SILVA & ASSAD (2001) and are presented in Table 1.

Table 1 - Soil Types

Type	% of Clay	Soil	CAD
I	< 15%	Quartzpsamments	30mm
II	> 15% and < 35%	Yelow Red Oxissoils	50mm
III	> 35%	Red-Yellow or dark red Argisols	70mm

The crop coefficients (Kc) used to estimate the water consumption in each phenological phase were obtained in BERLATO et al. (1986) and DOORENBOS & KASSAM (1979). The consumption of water was simulated using the model BIPZON proposed by FOREST (1984). The values of ISNA used to classify the planting periods as suitable, unsuitable and intermediate for soybean, corn, upland rice and beans are presented in Table 2.

Table 2 - Values of ISNA used to classify the planting periods.

Class	Crop			
	Soybean	Corn	Upland Rice	Beans
Suitable	> 0.65	> 0.55	> 0.65	> 0.60
Unsuitable	<0.55	<0.45	<0.55	<0.50
Intermediate	>0.55 and <0.65	>0.45 and <0.55	>0.55 and <0.65	>0.50 and <0.60

Maps showing the the areas with high, low and medium climatic risk for each crop, planting date, soil type and cycle length were prepared using the GIS tools as presented by ASSAD & SANO (1998).

RESULTS

In all simulated cases, the biggest decrease of suitable area was always obtained for planting in sandy soils with an increase of 5.8°C in the average temperature: from 3,403,085km^2 to 572,515km^2 for soybean (decrease of 75%), from 4,662,284km^2 to 2,916,664km^2 for corn (decrease of 37%), from 4,786,270km^2 to 3,073,634km^2 for beans (decrease of 36%) and from 3,814,409km^2 to 1,863,127km^2 for upland rice (decrease of 51%). More detailed results are presents in Tables 3, 4, 5 and 6.

Table 3 - Suitable area for planting soybean (in km^2 and %) considering three soil types (medium, sandy and clay) and four climate scenarios: current and with an increase of 1°C, 3°C and 5.8°C in the average temperature.

Soil Type		**Medium**		**Sandy**		**Clay**	
Unit		**km²**	**%**	**km²**	**%**	**km²**	**%**
Climate Scenario	**Current**	3.403.085	100	2.246.963	100	4.277.859	100
	+1ºC	2.934.040	86	1.934.397	86	3.964.606	93
	+3ºC	2.197.683	65	1.443.263	64	3.089.636	72
	+5.8ºC	1.097.025	32	572.515	25	1.859.495	43
Planting Date		November 01-10		November 11-20		November 01-10	

Table 4 - Suitable area for planting beans (in km^2 and %) considering three soil types (medium, sandy and clay) and four climate scenarios: current and with an increase of 1°C, 3°C and 5.8°C in the average temperature.

Soil Type		**Medium**		**Sandy**		**Clay**	
Unit		**km²**	**%**	**km²**	**%**	**km²**	**%**
Climate Scenario	**Current**	5.397.365	100	4.786.270	100	5.722.890	100
	+1ºC	5.238.039	97	4.532.408	95	5.612.058	98
	+3ºC	4.821.513	89	3.978.153	83	5.264.249	92
	+5.8ºC	4.195.496	78	3.073.634	64	4.838.790	85
Planting Date		November 21-30		December 01-10		November 21-30	

Table 5 - Suitable area for planting corn (in km^2 and %) considering three soil types (medium, sandy and clay) and four climate scenarios: current and with an increase of 1°C, 3°C and 5.8°C in the average temperature.

Soil Type		**Medium**		**Sandy**		**Clay**	
Unit		**km²**	**%**	**km²**	**%**	**km²**	**%**
Climate Scenario	**Current**	5.113.071	100	4.662.284	100	5.329.825	100
	+1°C	5.029.334	98	4.504.038	97	5.236.272	98
	+3°C	4.768.501	93	3.954.298	85	5.018.830	94
	+5.8°C	4.350.405	85	2.916.664	63	4.755.838	89
Planting Date		November 21-30		November 21-30		November 21-30	

Table 6 - Suitable area for planting upland rice (in km^2 and %) considering three soil types (medium, sandy and clay) and four climate scenarios: current and with an increase of 1°C, 3°C and 5.8°C in the average temperature.

Soil Type		**Medium**		**Sandy**		**Clay**	
Unit		**km²**	**%**	**km²**	**%**	**km²**	**%**
Climate Scenario	**Current**	4.690.459	100	3.814.409	100	5.104.334	100
	+1°C	4.484.011	96	3.379.329	89	4.931.068	97
	+3°C	3.954.298	84	2.561.100	67	4.531.819	89
	+5.8°C	3.143.726	67	1.863.127	49	3.833.355	75
Planting Date		November 21-10		November 11-20		November 21-30	

Figures 1 to 4 show the spatial distribution of suitable (green), unsuitable (red) and intermediate (yellow) for corn planted in a medium soil from October 1st to October 10th in four climate scenarios.

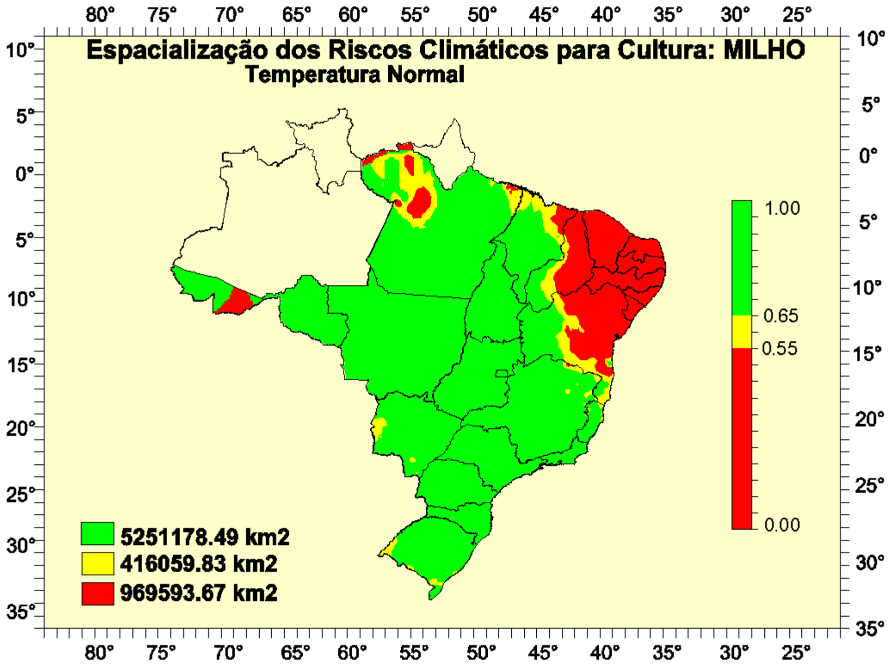


Figure 1 - Spatial Distribution of Suitable (green), Unsuitable (red) and Intermediate Areas for Planting Corn in Medium Soils from October 1st to October 10th Considering the Current Climate Situation

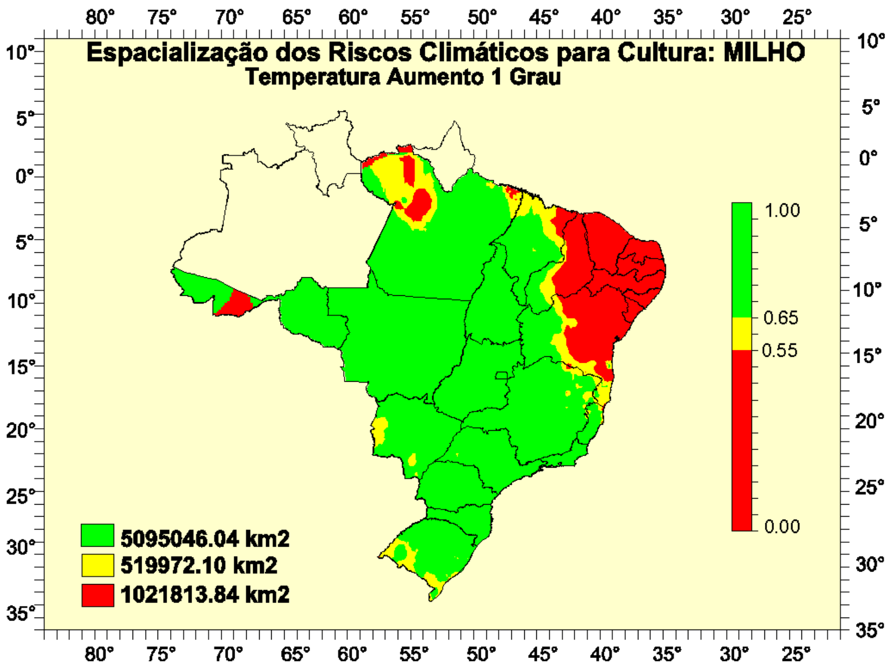


Figure 2 - Spatial Distribution of Suitable (green), Unsuitable (red) and Intermediate (yellow) Areas for Planting Corn in Medium Soils from October 1st to October 10th Considering an Increase of 1°C in the Average Temperature.

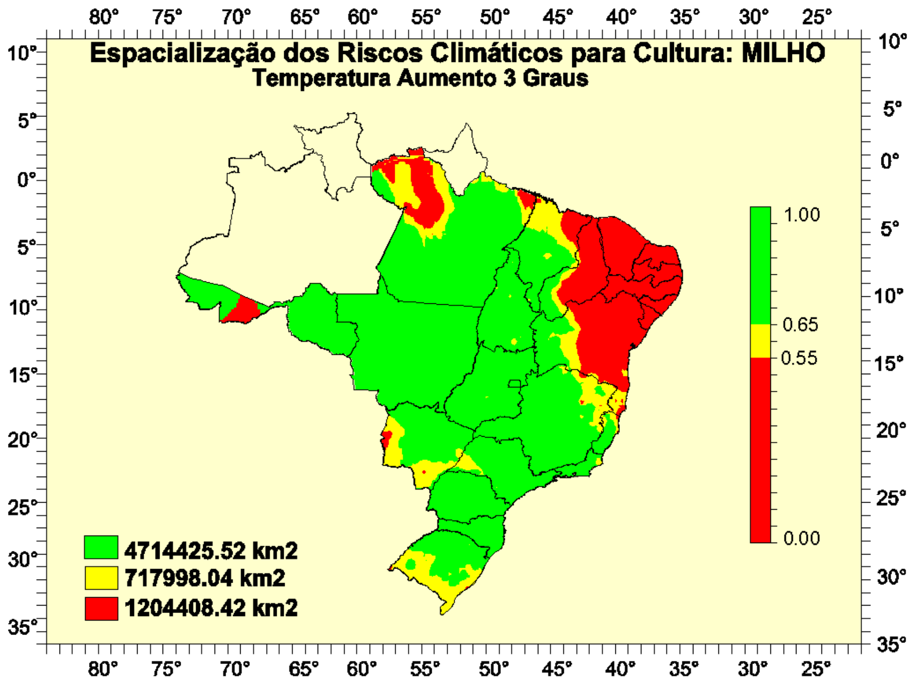


Figure 3 - Spatial Distribution of Suitable (green), Unsuitable (red) and Intermediate (yellow) Areas for Planting Corn in Medium Soils from October 1st to October 10th Considering an Increase of 3°C in the Average Temperature.

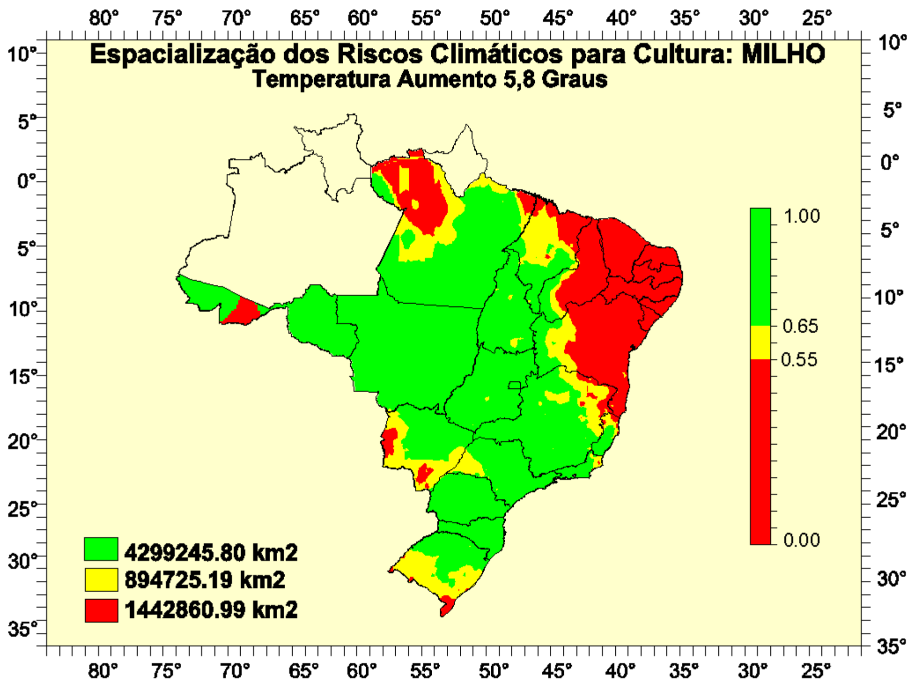


Figure 4 - Spatial Distribution of Suitable (green), Unsuitable (red) and Intermediate (yellow) Areas for Planting Corn in Medium Soils from October 1st to October 10th Considering an Increase of 5.8°C in the Average Temperature.

CONCLUSIONS

The south, north-east and south-east regions showed to be much more sensible to the increasing of the average temperature than the center-west region in all simulations done. This means that the spatial distribution of national production can change from the south and south-east regions towards the center-west region if the average temperature increases in the next decades. The results presented here and others similars to these one are available on the Agritempo's web page at www.agritempo.gov.br/cthidro.

REFERENCES

ASSAD, E. D., Sano, E. E. "**Sistemas de Informações Geográficas – aplicações na agricultura"**. 2ª edição, revisada e ampliada – Brasília: Embrapa – SPI/ Embrapa – CPAC, 1998.

ASSAD, E. D., CUNHA, G. R. "Uma visão geral do número especial da RBA sobre zoneamento agrícola no Brasil". In: **Revista Brasileira de Agrometeorologia**. Universidade Federal de Fitotecnia. v. 9, n. 3, p. 377-385. 2001 (Número especial).

AYOADE, J.O. "**Introdução à climatologia para os trópicos"**. 6ª edição. Rio de Janeiro: Bertrand Brasil, 2001.

BERLATO, M.A., MATZENAUER, R., BERGAMASC, H. "Evapotranspiração máxima da soja, relações com a evapotranspiração calculada pela equação de Penman, evaporação de tanque classe "A" e radiação solar global". **Agronomia Sulriograndense**, Porto Alegre, v. 22, n. 2, p.243-259, 1986.

DOORENBOS, J., KASSAM, A. H. "**Yield response to water".** Roma: Food and Agriculture Organization of the United Nations – FAO, 1979. (Irrigation and Drainage paper, 33).

FARIA, J.R.B. *et al.* "Caracterização de risco de déficit hídrico nas regiões produtoras de soja no Brasil". In: **Revista Brasileira de Agrometeorologia**. Universidade Federal de Fitotecnia. v. 9, n. 3, p. 377-385. 2001 (Número especial).

FOREST, F., 1984; Simulation du bilan hydrique des cultures pluviales. résentation et utilisation du logiciel BIP. *Montpellier: IRAT-CIRAD*, 63p.

GÖEPFERT, H., ROSSETT, L. A., SOUZA, J. "**Eventos generalizados e seguridade agrícola"**. Brasília: IPEA, 65 p.1993.

IPCC – INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. **Climate Change 2001** – The Scientific Basis – contribution of the Work Group I to the Third Assessment Report of the IPCC. Cambrige University Press, 2001.

I I. SOCIAL IMPACTS ON REGIONAL CLIMATIC CHANGES

REGIONAL CLIMATE CHANGE AND HUMAN HEALTH IN SOUTH AMERICA

ULISSES E. C. CONFALONIERI
FIOCRUZ

INTRODUCTION

Recent large-scale extreme weather events have not just stimulated further scientific debate on the possible role played by anthropogenic changes in the global climate in determining these events but have also called the attention of the public at large for the risks posed by an altered climate system. The high number of fatalities associated to these events – highly publicized in the media – has shown how severe the population health impacts of these events can be. The European heat wave in 2003 claimed about 30,000 lives,15,000 in France alone (Hemon & Jougla, 2004; Kovats & Koppe, 2005); hurricane Katrina killed at least 1000 people in the southern US in the current year. However, other more subtle biological changes seem to be also occurring worldwide associated to global climate change, some of which are relevant for public health (see section IV).

The health committe of the IPCC Third Assessment Report (IPCC, 2001) has concluded that:

· An increase in the frequency or intensity of heat waves will affect mostly older age groups and the urban poor.
· Any regional increases in climate extremes (storms, floods, cyclones, etc.) associated with climate change would cause physical damage, population displacement, and adverse effects on food production, freshwater availability and quality, and would increase the risks of infectious disease epidemics, particularly in developing countries.
· Climate change will cause some deterioration in air quality in many large urban areas.
· Changes in climate, including changes in climate variability, would affect many vector-borne infections, through ecosystem and other changes.
· Climate change represents an additional pressure on the world's food supply system and is expected to increase yields at higher latitudes and lead to decreases at lower latitudes. This would increase the number of undernourished people in the developing world
· In some settings, the impacts of climate change may cause social disruption, economic decline, and displacement of populations. The health impacts associated with such social-economic dislocation and population displacement are substantial

In this paper a brief review is made of climate and weather as determinants of health and of the scientific approaches for the study of these impacts. Then the regional vulnerability of South America – especially of Brazil – to the impacts of climate is presented and the possible adaptation measures to mitigate these impacts are briefly considered. As case studies, climatic influences on infectious diseases (especially vector-borne diseases) are presented.

THE ROLE OF CLIMATE IN PUBLIC HEALTH

There is a complex relationship between climate change and health outcomes and climate change can affect human health through a wide diversity of pathways (Mc Michael et al.,2003). Therefore, climate is but one of many influences on health and it is often difficult to separate these influences from that of other factors. Furthermore, several other non-climatic determinants of human health, which may be closely interrelated, may also be themselves influenced by climate.

Overall, impacts of climate change on human health will depend not only on the type, intensity, frequency and distribution of the climatic hazards but also on the ability of the ecological systems to buffer climate factors and, especially, on the social vulnerability of the population.

If we take the example of vector-borne diseases, a category of human infections with complex cycles in the environment – as well as highly sensitive to climate fluctuations – we can envisage the complexity of the pathways involved and the relative role of climate in determining risks. (Fig 1)

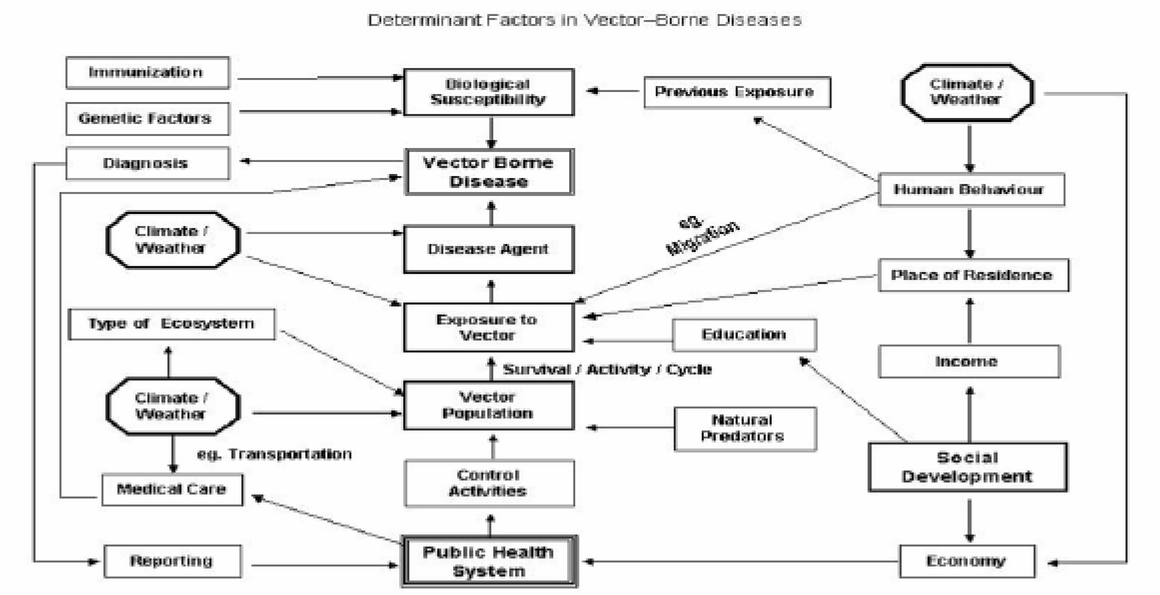


Figure 1

The final stage for human infection is the exposure to an infected vector (e.g. mosquitoes). Human exposure is determined by a combination of factors, ranging from demographics, education and behavior to place of residence, travel and work. These factors, associated to others that condition the capacity of communities to respond to the impacts, determine the social vulnerability of the group.

Vector population abundance, densities and distribution are affected both by natural factors (climate; predators; ecosystem composition, etc.) as well as by human interventions, especially vector control activities, land use and land cover changes and public education for individual protection. The role of climate (temperature; humidity; rainfall) in regulating vector populations is through direct interference in breeding, survival, rate of development and biting activities. Climate and weather factors are also important in regulating the timing of the developmental cycle of many pathogens in their vectors (Kovats et al., 2001).

Climate may change disease risks indirectly by influencing social phenomena such as human migration and, consequently, the exposure to vectors. Another indirect influence of climate is through changes in natural ecosystems, affecting habitats and ecological processes and, therefore, other animal species involved in disease cycles (section IV).

Finally, climate factors – especially extremes – can affect public health and transportation infrastructures, which impacts on the quality and availability on medical care (prevention of disease spread) and vector control activities.

SCIENTIFIC APPROACHES TO THE PROBLEM

As can be seen from the example above there are several challenges in the study of climate-health linkages and this issue can be approached from different perspectives, often on a complementary way. The approaches range from observational and experimental studies to mathematical modeling. They can be summarized as follows (NRC, 2001):

1. Observational-based analyses of past or present events in nature, including retrospective and prospective analyses of natural variations; retrospective analysis of historical trends and interregional comparisons.

In the retrospective analysis of natural variations past temporal trends of climate variability and disease are treated as empirical analogues of future changes and usually relies on time-series analysis of fluctuations in specific climate variables and health outcomes.

Prospective observations of natural variations either rely on routinely collected data from surveillance and monitoring systems or intensified observations to create a prospective sampling.

The retrospective analysis of historical trends is similar to the analysis of natural variations but it compares the trends or slopes of change during the period of observation. This method usually requires long time series of observations (NCR,2001).

The approach of interregional comparisons of natural spatial patterns of disease incidence and climate seeks consistent similarities and differences among regions over a specified time period and it assumes that other non-climate conditions are similar in the regions under study.

Experimental studies may be useful especially for infectious diseases and may be conducted either in the field or in the laboratory. These manipulative studies are aimed at understanding the mechanisms by which climate variables impacts parts of an infectious disease transmission system but do not address the complex interactions that might actually occur under normal conditions.

2. Cross-cutting methods: risk assessments and integrated assessments.

Risk assessment is the characterization and estimation of potential health effects associated with exposure of an individual or population to hazards. It is a four-stage process involving hazard identification; dose-response analysis; exposure assessment and quantitative risk characterization.

Although this framework has been originally developed to assess the risk of environmental contaminants, it can be used to study the influence of climate factors on disease risk. However, weather and climate variability do not fit well the conventional research model partly because there is no easily identified unexposed control group and little variation in exposure between individuals in a geographic region (Woodward & Scheraga, 2003).

An Integrated Assessment is a structured process of using knowledge from various disciplines and/ or stakeholders such that integrated insights are made available to decision makers (Rotmans, 1998) and the major goal is to provide insights that can not be gained from traditional, single disciplinary research. It provides a framework for working though the causal chain from climate dynamics to climate impacts to policy response strategies (NRC, 2001).

Although it is considered a useful approach to adequately characterize the complex interactions and feedbacks among the various facets of environmental changes on a global scale it has some weaknesses such as the high level of integration; the inadequate treatment of uncertainties; absence of stochastic behavior and limited possibilities for calibration and validation.

3. Mathematical Modeling

The modeling approaches for the analysis of climate-health linkages can be classified in two categories: mechanistic models (or process-based) and empirical-statistical models. Mechanistic models use theoretical knowledge of underlying biophysical mechanisms to simulate the health impacts of changes in climate and quantitative interactions among multiple variables and feedback processes can be explicitly considered.

Empirical-statistical models are based on relationships between climate and disease-related variables that have been estimated from observational studies. Although this approach relies little on underlying mechanisms and is not explanatory in nature it is often simpler to use and less data demanding.(NRC, 2001)

These two basic classes of models are not mutually exclusive and no single approach is clearly superior (or is likely to be sufficient) for the creation of reliable predictive models. Modeling is considered to be one of the several methods employed to conduct an integrated assessment.

VULNERABILITY TO CLIMATE

Blaikie et al (1994) have defined vulnerability as “the characteristics of a person or a group in terms of their capacity to anticipate, cope with, resist and recover from the impacts of a climatic disaster”. Another definition is “the product of the physical exposure to a natural hazard and the human capacity to prepare for and to recover from the negative impacts of disasters “.

Vulnerabilty is one of the components of “risk”, defined as the probability of the occurrence of a given hazard. The other component of Risk is the *Hazard*, which can be defined as the physical or biological factor associated with climatic phenomena and which can affect health negatively. These climatic hazards can be direct, such as temperature, humidity, flood water or, more frequently, mediated through ecological or social pathways. As an example of the former we can mention environmental changes triggered by climate which affect disease vectors or food production. Social phenomena affected by climate and which are relevant for health are migration, social conflict, post-traumatic stress and economic deprivation.

A recent study has analyzed the vulnerability of the Brazilian population to the impacts of climate (Confalonieri et al, 2005). This work has adopted a conceptual framework of vulnerability based on a Exposure/Response model modified from Bohle & Watts (see details in Confalonieri, 2003).

For the quantification of the vulnerability a specific methodology was used and a synthetic (compound) *General Vulnerability Index* was developed from weighted averages of specific indices of vulnerability in three components: social, epidemiological and climatic. The social vulnerability component included indicators on demography, housing , income , education , sanitation and access to health care. The epidemiological component included data on the distribution, incidence, mortality, cost and control of climate-sensitive endemic infectious diseases (malaria, leishmaniasis, dengue fever, cholera, hantavirus and leptospirosis).

The climatic component used measures of climatic anomalies, especially those linked to extremes of precipitation.

The Vulnerability Index (values ranging from 0 to 1),was developed on a State basis using routine governmental statistics for the period 1996-2001.

The General Vulnerability Index (IVG) obtained has shown that the most vulnerable parts of the country are located in the semi-arid northeastern region, especially in the states with the lower social and economic development rates (Fig 2).

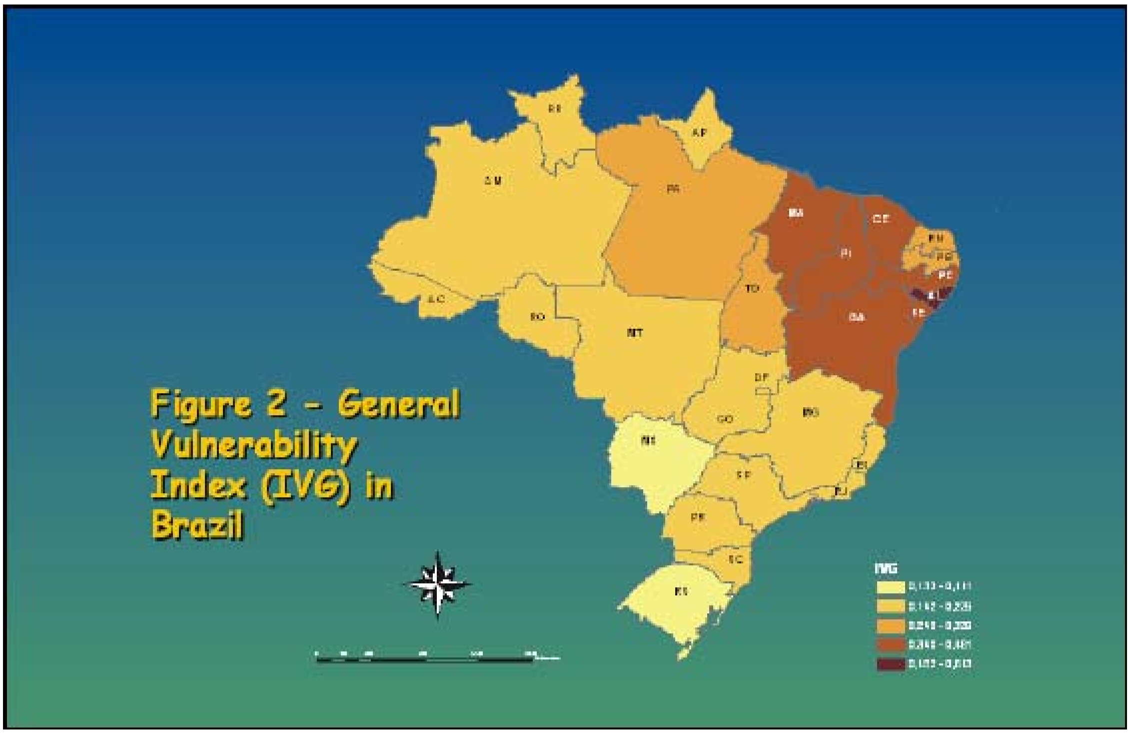


Figure 2

ADAPTATION TO CLIMATE

Adaptation to climate change involves a set of policies, measures and strategies to reduce current and future societal vulnerability and ameliorate adverse impacts of climate.

Societies have inherent capacities to adapt to climate change and both societies and individuals have adapted to climate change over the course of human history. In many instances it was done in response to individual events but sometimes it was done in anticipation of changes.

Adaptation is a dynamic social process and many factors condition the effectiveness of strategies for adapting to climate change.Two of the most fundamental factors are the social acceptability of options for adaptation as well as the technical-economic feasibility of the proposed measures. The most important barriers to the development and implementation of adaptation measures are in developing countries.

The adaptation process can take place at different scales: international level responses, national level, community and individual levels.

A recent overall assessment of the general adaptation measures for the health impacts of climate in Brazil was made (Confalonieri, 2005). The most important findings were:

1. It is necessary a reduction of the primary determinants of social vulnerability, such as poverty, illiteracy etc., through public policies
2. The health outcomes requiring most attention in adaptation programs are the endemic infectious diseases, with environmental linkages, and unintentional injuries associated to climate extremes
3. The most vulnerable populations to the impacts of extreme weather events are located in the large metropolitan areas and in water-stressed areas (the semi-arid northeast)
4. There is a need for the improvement of the efficiency of the control programs targeted to those climate-sensitive diseases of widespread distribution, such as malaria and dengue fever
5. It is necessary an increase of the awareness of the general population related to the possible impacts of climatic change, through public education
6. Development of schemes of environmental monitoring targeted to specific factors and selected localities and regions, for the detection of early signals of ecosystem changes driven by climate (eg. phenology; species distribution)
7. Development of early warning systems incorporating weather and climate forecast and epidemiological surveillance

CLIMATE, ECOSYSTEMS AND VECTOR-BORNE DISEASES

Vector borne infections (VBDs) are those transmitted by the bite of infected arthropod species, such as mosquitoes, ticks, triatomine bugs and flies. The distribution and abundance of vector species and their vectorial capacity are critical factors for the actual transmission of pathogens and the risk of human infections will be determined by the degree of contact between human hosts and infected vectors.

VBDs are among the most important health outcomes to be associated with climatic changes due to their widespread occurrence and sensitivity to climatic factors.

Climate change can affect vector-borne disease in several ways (Kovats et al., 2001), namely:

a) survival and reproduction rates of vector in turn determining their distribution and abundance;

b) intensity and temporal pattern of vector activity (particularly biting rates) throughout the year;

c) rates of development, survival and reproduction of pathogens within vectors.

It is expected that ecosystem responses will be one mediator of the potential effects of changes in climate on infectious diseases, especially vector-borne diseases

A wide variety of ecological trends are associated with the long term warming trend that has been occurring over the past century (Hughes, 2000;McCarty, 2001;Walther et al., 2003; Parmesan & Yohe, 2003; Root et al, 2003).

The extent and magnitude of climate-driven changes in human and animal infectious diseases mediated by ecological systems, will be determined by two major factors:

a) The nature (functional; structural); type, extent and magnitude of the ecosystem responses to climate change;

b) The degree of association between the components of the cycle of the disease (infectious agents; arthropod vectors; invertebrate intermediate hosts and vertebrate animal reservoirs) to the natural biological systems.

The range of possible ecological changes varies from the ecosystem level, to the community, species and population levels.Climate change may induce in a given region, the replacement of an entire ecological system by another adapted to the new condition of temperature and rainfall. One example would be the “savanization” of the tropical forests in South America.

Less radical changes in ecosystems would involve alterations in community composition; geographical distribution of a species; in abundance or seasonality of reproduction or migration of species. All these may be relevant to a specific disease dynamics and the more complex a disease cycle is (e.g. involving arthropod vectors and vertebrate reservoirs) the more likely is it to be affected. But even changes limited to the abiotic elements of an ecosystem, such as the water cycle, can change the dynamics of water-borne infections (no other animal species involved).

A drastic change in the abundance and or distribution of a given species of reservoir of natural infections can affect the maintenance of the cycle of pathogens which depend on a few species of vertebrate to persist in endemic form in natural system. This is the case of yellow fever virus which is maintained by mosquitoes and monkey species in tropical forests of the Americas.

Some infectious disease agents such as influenza A viruses; West Nile Fever viruses and *Borrelia sp* causing Lyme disease are maintained in wild birds and changes in migration of bird species, induced by climatic and ecosystem changes (Sillet et al., 2000; Mills, 2005) may have an impact in the epidemiology of these diseases.

Another example is the indirect influence of climate on the amplification of arbovirus infections which have wild birds as reservoir hosts, such as the encephalitides (Saint Louis; Eastern Equine and West Nile). Enzootic amplification is necessary to achieve mosquito infection rates sufficient to cause human epidemics and it is facilitated by extended droughts which make mosquitoes and susceptible birds to congregate in selected refuges (water bodies), increasing transmission (Shaman et al., 2002). Climate change-induced modifications in wetland ecosystems and on the frequency/ timing of droughts could significantly affect the dynamics of these diseases.

In regard to the differences in the cycles of infections, two basic situations can be found:

a) Disease cycles that are intimately tied to the natural environment in its entire distribution range and which have not adapted to anthropic environments;

b) Diseases that are more ubiquitous and have cycles in both natural biological system and anthropic landscapes, such as agricultural systems or even urban areas.

In the former case (diseases confined to natural systems) the cycle are more vulnerable to climate-driven changes in ecosystems and infections may die out if the pathogen is not able to adapt to the new conditions. For the more ubiquitous disease cycles drastic changes in habitats and ecological niches may cause disease extinctions on a local or regional scale due to changes in populations of vectors or reservoirs but human risks may persist in anthropic environments.

Ultimately, however, actual infections in human populations will be linked to specific exposures which may be driven by a wide range of factors, especially social, economic and behavioral factors.

REGIONAL SCENARIOS AND PROBLEMS

The extent to which human health of the South American population will be at risk due to a changed global climate will be determined by two basic factors:

a) the expected regional patterns of climate change in the continent

b) the vulnerability profile of its population, in different sub-regions and localities

Very few studies have adressed the possible impacts of climate change in South America; most of the published “regional” literature deals with links between climate variability (seasonal and interannual) and infections or the impacts of weather extremes (IPCC, TAR, 2001).

A recent review of regional climate-health linkages has included aspects of the South American continent (Githeko et al., 2000).The most relevant topics reported for South America were on the effects of climate variability, especially extremes of precipitation, on dengue fever and malaria.

There are some evidences of the relationships between the cyclical phenomena of climate variability El Niño-Southern Oscillation and some health outcomes in the region. These include malaria (Poveda et al., 2001 ; Gagnon et al, 2002); dengue fever (Gagnon et al, 2001); diarrhoeal diseases (Checkley et al,1999); kala-azar (Franke et al., 2002); bartonellosis (Huarcaya et al, 2004) as well as accidents due to weather extremes (PAHO, 2000; WMO,1999)

Other climate-health relationships were reported regionally such as an increase in leptospirosis after a hurricane (Sanders et al, 1999) and Chagas disease vector distribution related to temperature and humidity (Carcavallo, 1999).

There are no reliable regional scenarios for climate change due to uncertainties related to different general circulation models (Nobre, 2004). However, all climatic models and scenarios point to a significantly hotter climate in the region. However this temperature increase would change the hydrological cycle which would result in an increase in the frequency and intensity of extreme weather events (Nobre, loc. cit.). An assessment was made of the possible climate-driven changes in the major biomes of Brazil which have pointed to either expansion or retraction of the Amazonian forest, the central savannah and the northeastern scrubland, according to different climatic scenarios available (Oyama & Nobre, 2003; 2004).

A global estimate, measured by the indicator DALY (Disability Adjusted Life Years) was made for the impacts of climate in the year 2000, for the following health outcomes: cardiovascular disease deaths; diarrhoea episodes; malaria and dengue cases; fatal unintentional injuries and non-availability of recommended daily calorie intake (Campbell-Lendrum et al., 2003). For the Latin American and Caribbean region a total of 92,000 DALYs was estimated, mostly attributed to the impacts of floods. It was the second lowest regional total estimated, just above the figure estimated for the developed countries (8,000 DALYs).

Some recent studies on global climate scenarios and infectious disease risk have included data from South America (Hales et al, 2002 ; Lieshout et al., 2004).

Lieshout et al (2004) developed a global model of malaria transmission to estimate the potential impacts of climate change on seasonal transmission and population at risk of the disease. The climate scenarios were derived from the Hadley Centre model HasCM3 runs with four SRES emission scenarios. Additional population at risk due to climate change are projected to some parts of the world, including areas around the southern limit of the disease in South America. The assessment also pointed to a decrease in the transmission season in areas where reductions in precipitation are projected by the model, such as the Amazon and Central America.

One study also suggested that climatic warming could cause a southward extension of the area of distribution of malaria (Carcavallo & Curto de Casas, 2000)

Hales et al. (2002) used an empirical model and incorporated future projections of climate to estimate changes in the geographical limits of dengue fever transmission and the size of populations at risk. They have found that the annual average vapour pressure (a measure of humidity) was the most important individual predictor of the current distribution of the disease. The forecast geographical distribution of dengue transmission based on climate projections for 2080-2100 (CCG CMA2 model) projected an increase in the probable areas of dengue trransmission in South America, mostly to the southern and eastern part of the current distribution but, to a lesser extent, also to the western and northern parts.

Major climate-driven changes in the geographical distribution of of large biomes in South America would have consequences for the epidemiology of focal infectious diseases. Several endemic infectious diseases in S. America have have cycles in natural ecosystems due to the association of their pathogens with vector species (eg mosquitoes) and wild vertebrate animals, which act as reservoirs of infection.

This is the case of malaria in the Amazon; cutaneous leishmaniasis in forest systems; kala-azar and plague in semi-arid systems; Chagas disease, hantavirus pulmonary syndrome and viral hemorrhagic fevers in agricultural ecotones

(interface of cultivated areas with natural systems). Changes in the epidemiology of these diseases will be determined by the magnitude and type of climate impacts on these systems, such as range contraction or expansion; changes in composition etc.An important role will also be played by other non-climatic drivers of ecosystem change, such as land use.

CONCLUDING REMARKS

The South American region may be considered vulnerable to the health impacts of climate change for several reasons, namely:

1. The social profile of its population, with a high poverty rate, as well as poor infrastructure and governance problems, prevents the development of efficient responses to hazards generated by climate change.

2. Historically, natural variability in climate, such as the events observed during the El Niño, has shown how adversely can population health in the region be affected by climate, through many mechanisms

13. It has densely populated large metropolitan areas which, due to their geographic, demographic and social characteristics make them especially vulnerable to the impacts of climate, especially from extreme events such as storms, associated to landslides or floods.

14. It has a long coasline, where much of the population is concentrated. Some parts of it are especially at risk for the impacts from sea-level rise.

15. It has a varied and extensive range of natural ecosystems harbouring natural foci of infections, which may be disturbed by a changing climate

16. There is generally a poor awareness of the population (and also of governments at different levels) of the health and other risks posed by a changed climate. This contributes to difficulties in implementing adaptation measures for health protection.

17. It has agriculture as an important economic activity. Since agricultural production is one of the sectors most likely to be affected by climate change, it may cause an increase in nutritional problems regionally.

18. There are not adequate specific early warning systems as well as surveillance and monitoring schemes in place to protect the economy and the health of the population at large, from the climatic hazards.

REFERENCES

Blaikie, P. et al. 1994. At Risk Natural Hazards, People's Vulnerability and Disasters. Routledg*e*, London, XIV, 284 pp.

Bohle, H.G. Watts, M.J., 1993.The space of Vulnerability: The causal structure of hunger and famine. *Progress in Human Geography, 17(1):43-67*

Campbell-Lendrum, D., A. Pruss-Ustun, and C. Corvalan, 2003: How much disease could climate change cause? In: Climate Change and Health: Risks and *Responses. WHO/WMO/UNEP, Geneva*

Carcavallo, R. U., 1999. Climatic factors related to Chagas disease transmission. *Mem. Inst. Oswaldo Cruz., 94, Supl. I:367-369*

Carcavallo, R. & Curto de Casas, S., 2000.Some Health impacts of global warming in South America: vector-borne diseases. *J. Epidemiol., 6(4 –supl):S-153-S-157*

Checkley, W.; Epstein, L.D. ; Gilman, R.H. et al, 1999. Effect of El Niño and ambient temperature on hospital admissions for diarrhoeal diseases in Peruvian children. *Lancet, 355:442-450*

Confalonieri, U.E.C., 2003.Variabilidade climática, vulnerabilidade social e saúde no Brasil. *Terra Livre,* S. *Paulo, 19-1(20):193-204.*

Confalonieri, U.E.C., 2005. Mudanças Climáticas e Saúde Humana, pp 166-171, In: Poppe, M.K & la Rovere, E.L, Mudança do Clima, Vol. 1, *Cadernos NAE, número 3, Brasília*

Confalonieri, U.E.C. et al, 2005.Análise da Vulnerabilidade da População Brasileira aos Impactos Sanitários da Mudança Climática. Relatório Final de Projeto de Pesquisa, FIOCRUZ, Rio de Janeiro, 97 pp.

Franke, C.R., M. Ziller, C. Staubach, and M. Latif, 2002: Impact of the El Nino/Southern Oscillation on visceral leishmaniasis, Brazil. *Emerg Infect Dis, 8(9): 914-7.*

Gagnon, A.S, et al., 2002. The El Niño Southern Oscillation and malaria epidemics in South America. *Int. J. Biometeorol., 46:81-89*

Gagnon, A.S., A.B.G. Bush, and K.E. Smoyer-Tomic, 2001. Dengue epidemics and the El Nino Southern Oscillation. *Climate Research, 19(1): 35-43.*

Githeko, A. K.; Lindsay, S. W.; Confalonieri, U.E.C.; Patz, J. A**.,** 2000. Climate change and vector-borne diseases: a regional analysis*. Bull. of the World Health Organization, 78 (9): 1136-1147.*

Hales, S., N. de Wet, J. MacDonald, and A. Woodward, 2002: Potential effect of population and climate changes on global distribution of dengue fever: an empirical model. *Lancet,* 360: 830-834.

Hemon, D. & Jougla, E., 2004. La canicule du mois d'aout 2003 en France. *Rev. Epidemiol. S. Publ., 52(1):3-5*

Huarcaya, C.E. et al., 2004. Influencia del fenomeno El Nino en la epidemiologia de la bartonelosis humana en los Departamentos de Ancash y Cusco entre 1996-1999. *Rev. Med. Herediana, 15:4-10*

Hughes, L., 2000. Biological consequences of global warming: is the signal already apparent? *TREE, 15:56-61*

Iintergovernmental Panel on Climate Change (IPCC). Climate Change 2001: Third Assessment Report (Vol II), Cambridge Univ. Press, Cambridge, UK

Kovats, R.S & Koppe, C, 2005. Heat waves: past and future impacts on health, Ch. 8, pp 136-160, In: Ebi, K.L et al (Eds). Integration of Public Health with Adaptation to Climate Change. Lessons Learned and New Directions. Taylor & Francis, London

Kovats, R.S., D.H. Campbell-Lendrum, A.J. McMichael, A. Woodward, and J.S. Cox, 2001: Early effects of climate change: do they include changes in vector-borne disease? *Philos Trans R Soc Lond B Biol Sci, 356(1411): 1057-68.*

Lieshout, M., R.S. Kovats, L. M.T.J., and P. Martens, 2004: Climate change and malaria: analysis of the SRES climate and socio-economic scenarios. *Global Environmental Change, 14: 87-99.*

McCarty, J.P., 2001. Ecological consequences of recent climate change. *Conserv. Biol., 15:320-331*

McMichael, A.J., C.-L. DH, C. Corvalan, F., K.L. Ebi, A.K. Githeko, J.S. Scheraga, and A. Woodward (eds.), 2003. *Climate Change and Human Health. Risk and Responses. World Health Organization, Geneva.*

Mills, A.M., 2005. Changes in the timing of spring and autumn migration in North American migrant passerines during a period of global warming. *IBIS, 147:259-269*

National Research Council, 2001. *Under the Weather. Climate, Ecosystems and Infectious Diseases. National Academy Press, Washington, DC, 146 pp*

Nobre, C. A., 2005. Cenários de Mudança Climática para a América do Sul na década de 2090-2100, pp 152-158, In: Poppe, M.K & la Rovere, E.L, Mudança do Clima, Vol. 1, *Cadernos NAE, número 3, Brasília*

Oyama, M.D. & Nobre, C.A., 2003. A New climate-vegetation equilibrium state for tropical South America. *Geophys. Res. Letters., 30(23):2199-2203*

Oyama, M.D. & Nobre, C.A., 2004. A Simple potential vegetation model for coupling with the Simple Biosphere Model (SiB). *Rev. Brasil. Meteorol., 19(2):203-216*

PAHO, 2000. Crónica de Desastres: Fenómeno El Nino 1997-1998. Panamerican Health Organization, Washington, DC

Parmesan, C. & Yohe, G., 2003. A Globally coherent fingerprint of climate change impacts across natural systems. *Nature, 421:37-42*

Poveda, G., W. Rojas, M. Quinones, I.D. Velez, R.I. Mantilla, D. Ruiz, J.S. Zuluaga, and G.L. Rua, 2001: Coupling between annual and ENSO timescales in the malaria climate association on Colombia. *Environmental Health Perspectives, 109(5): 307-324.*

Root, T.L. et al., 2003. Fingerprints of global warming on wild animals and plants. *Nature, 421:57-60*

Rotmans, I., 1998.Methods for IA: the challenges and opportunities ahead. *Environm. Model. Assessment., 3(3):155-179*

Sanders, E.J., J.G. Rigau-Perez, H.L. Smits, C.C. Deseda, V.A. Vorndam, T. Aye, R.A. Spiegel, R.S. Weyant, and S.L. Bragg, 1999: Increase of leptospirosis in dengue-negative patients after a hurricane in Puerto Rico in 1996 [correction of 1966]. *Am J Trop Med Hyg, 61(3), pp. 399-404.*

Shaman, J.; Day, J.F & Stieglitz, M., 2002. Drought-indiced amplification of Saint Louis encephalitis virus, Florida. *Emerg. Inf. Dis., 8(6):575-580*

Sillet, I.S.; Holmes, R.T. & Sherry, T.W., 2000. Impacts of a Global Climate cycle on population dynamics of a migratory songbird. *Science, 288:2040-2042*

Walther, G.R. et al., 2003. Ecological Responses to Climate Change. *Nature, 416:389-395*

WMO/UNEP/UNESCO/ICSU, 1999. The 1997-1998 El Niño: a scientific and technical perspective. WMO number 905, Geneva

Woodward, A. & Scheraga, J., 2003.Looking to the future: challenges for scientists studying climate change and health, Ch. 4, pp 61-78, In: McMichael et al., *Climate Change and Human Health. Risks and Responses, WHO/WMO/UNEP*

HEALTH AND GLOBAL CHANGES IN THE URBAN ENVIRONMENT

RAUL BORGES GUIMARÃES
Departamento de Geografia
Universidade Estadual Paulista, Campus Presidente Prudente

INTRODUCTION

The debate over global changes has been taking out more and more space in the media, highlighting a series of recent facts: the reduction in size of polar glaciers, the long-standing droughts and excessive rains which affect some regions, as well as the emergence of new diseases, and the resurgence of old ones. Evidently, alongside the kind of journalism which is committed to the dissemination of information and making these facts clear, there has always been a certain sensationalist approach to these topics among those who are more worried about selling newspapers, or getting higher ratings on television. In these cases, it is as if we are being presented to entirely breaking news, and what we can observe is the dissemination of a feeling of insecurity before the degree of uncertainty of the near future.

During its short lifespan on Earth, the human species has brought about profound changes to the air, to the water, to the ground, to other living things and to the interactions among these elements. Temperate forests were largely felled in the 18th and 19th centuries. During the 20th century, such deforestation was transferred to the tropical forests, which have already lost half their original size, and whose burning has responded for 30% of the carbon volume which has accumulated in the atmosphere. Every year, the erosion of the soil is equivalent to the whole of the area used for wheat plantations in Australia (Myers,1994).

In highly industrialized countries, such as United States, the quantity of energy used *per capita* was 30 times higher in the year 2000 than before the beginning of the Industrial Revolution. The urban and industrial areas where there is intense consumption of fossil fuels have presented an annual flux of energy, in kilocalories by square, a hundred times higher than that of natural estuary ecosystems, coral reefs and tropical forests, and a thousand times higher than that of the natural ecosystems of open seas and mountain regions (Myers,1984).

It is estimated that by the year 2050 mankind will be employing approximately the same amount of energy consumed by all other living things together! Another marked characteristic of these transformations provoked by industrialization is the large scale production of thousands of new chemical products which have produced dejects containing nitrogen, lead, sulphur, mercury, and caustic soda (Teixeira et al, 2003). Because of that, natural cycles are no longer intact. How long will our land environment resist the impact provoked by industrial society?

In the specific case of this text, the question which is posed refers to the new challenges that these global changes have placed on the health sector. To tackle these questions, two ideas will be developed here. The first of them looks for answers in the very history of diseases, which have developed over a period of great climatic variations. That is, it is understood that the key to the future might be in the investigation of the past, in that capacity of adaptation which ancient communities had upon facing adverse situations (Teixeira et al, 2003). In the second part of the text, one starts from the idea that, if there is the possibility of some kind of future for this changing planet, this is being just gestated .by the needy populations which managed to survive, in precarious conditions, in the urban outskirts of the poorer countries.

THE ADAPTABILITY OF MAN

Bacteria, which are among the main agents causing disease, have existed for at least 3.8 billion years. On the other hand, our oldest ancestor showing evidences of bone disease was the *Homo erectus* from 800.000 years ago. Anatomically, modern human beings are practically the same as these ancestors. The same 20.000 pairs of genes still control the biological manifestations of human nature, conserving the same organic reactions before environmental stimuli (Dubos, 1989).

As long as there is time for the re-establishment of a state of balance, human communities have shown an enormous potential for adaptability, mobilizing to this end two important mechanisms: homeostasis and adaptations of the phenotype. In the former, the living things establishes as state of balance within a certain environment. The latter, on the other hand, are those which are not transmitted to their offspring, but are a response to the environment (such as the tanning of the skin).

Like the other species, the first human beings have had to wander as a result of the ice age, but, unlike some of them, they have adapted to the changes and have survived what is now known as the Great Ice Age. The role of human behaviour in the evolution of virulence has been widely recognized, as a result of their social trajectory being determined and of the time for diseases to be transmitted (Ewald,1993).

Known as 'the Great Ice Age', the Quaternary was characterized by long periods of glaciations, separated by intervals with warmer temperatures, such as the present one (Salgado-Laboriau, 1996). Several studies have shown that certain plagues and epidemics would be linked to these climatic changes, which have taken human communities from this state of balance and have altered the world distribution pattern of diseases (Ewald, 1993). For the first time, these changes will be taking place in a world which is more urban and unequal, and that issue demands some reflection regarding the specificity of this new context.

HEALTH IN THE URBAN ENVIRONMENT

Cities have always been, since their origin, centres of innovation, of new opportunities and of learning. It is in the city that medicine has developed and where most health services have been installed. Despite being the source of great achievements, cities have also been characterized by inequalities in living conditions of their inhabitants and intense social conflicts.

At no other moment were these contrasts so marked as during the Industrial Revolution. For the first time in the history of mankind, the city was transformed in the *locus* of production, adding economic power to its already existing political and cultural power, something which had unprecedented reflexes in urban life (Lefèbvre, 1983).

The presence of factories subverted urban order, helping to quickly deteriorate the living conditions of city dwellers. The growing density of buildings, the reduction of green areas, and river pollution have resulted in a kind of predatory appropriation of urban spaces with alarming indexes of insalubriousness, which was soon reflected by mortality rates in several cities of Great Britain, the cradle of Industrial Revolution.

The proliferation of cholera epidemics in cities was a health problem, which put the British population at risk, forcing authorities to gradually turn to the issue of health. Several investigation committees, formed by doctors and representatives of local governments, made a complete picture of sanitary conditions in working-class neighbourhoods public.

Such a situation was not typical of Great Britain, only. In France, Prussia, United States, and wherever else the factory system had developed, living conditions of working-class neighbourhoods were equally alarming. New York slums presented living conditions so perverse as those described by Engels (1975) with poorly-lit rooms and dozens of people sharing a few square metres. In Manhattan, in the year of 1895, around 75% of the population of 2 million people lived in only 43.000 houses of insalubrious rooms, with an average of 35 people per building (Allen,1992).

The urbanisation took on a general and explosive character in the 20th century, propelled by industrialization. Urban populations went from 14% in 1900 to a level of 40% in the 1990’s, and the trend is for this to go over the 50% mark in the beginning of the 21st century.

By the end of the 20th century, urban populations in Asia, Latin America, and Africa have grown three times faster than those of Europe, United States and Japan. In the 21st century, one million people will be living in slums or shanty towns, without access to sewage and running water.

The fastest rate in urban growth is that of Africa. Even if the African urban population is still a minority, it is calculated that by the year 2025 it will have surpassed the proportion of all the other continents together. Such intense urbanisation in poorer countries has a price: social contrasts in the urban space all over the world are increasingly marked. Large cities have concentrated all the riches and all the poverty, justice and crime, health and disease. Never before have social inequalities been so marked, and the current trend is that these inequalities will grow even worse. There are over 600 million people living in cities in a situation of absolute poverty. For a growing number of people, life in the large urban centres has become synonymous with unemployment, violence, precarious living conditions, traffic jams and pollution.

THE FUTURE IS NOW

The work of Milton Santos is witness to a new historical period, which has consolidated on a planetary scale as from the 1970s. If during urban-industrial periods the human species, created their own flux of energy through the burning of fossil fuels, in this new period Milton Santos calls technical-scientific, the engine behind the transformation of nature is no longer that of the industrial machine, but rather that of information, which strengthens the bonds between science and production.

At present, according to Santos (1996) command power finds itself more and more centralised in distant and higher instances, which shows an asymmetry in the relationships between social actors, located and articulated at several hierarchical levels. At a local level, one has the place where phenomena take place, and which can be referred to as the scale of action. At a wider level, whether is that the of state-nation or even the world system, one has command position, which is the scale of the operating forces.

Because of such characteristics, a new type of poverty has been created all over the world (and which is different from that of earlier periods), resulting for the growing loss of decision power at the local level (Santos, 2000). The crisis in the international financial system, dating back to the end of the 70s and early 80s, has resulted in several cut-backs in resources destined to urban projects, helping deteriorate even further the living conditions of low-income populations all over the world.

If mortality rates have been falling in large cities since the Industrial Revolution, these rates are generally higher in the majority of the greater cities than in the smaller towns and rural communities. This is true for several kinds of neoplasis, respiratory and circulatory diseases, and psychiatric diseases, among others. Sound and air pollution and a lifestyle characterised by psycho-social stress are among the highest risk factors in city life.

Contradictorily, these places have also become stronger by means of public policies at the local level, which aim to face this process of social exclusion. From these local actions, the constitution of a basis for living is sought in such a way that it enhances the efficiency of public policies at the service of civil society and the collective interest. (Santos, 1993).

On the other hand, the insertion of inhabitants from these mega-cities in poorer countries into the world economy is unequal. There are a few who have been inserted in the world circuit of high technology and capital, reaping the benefits of newer forms of consumption and information circulation. Those are the people who make use of banking, commerce, and the export industry services as well as telecommunications, by means of remote and electronic circuits via satellite or the World Wide Web.

Once inserted in these high-technology circuits, many of these people remain unaware of the problems which have been generated by this consumer society. They live on, believing that their power of purchasing will keep them safe from any adversity. Why worry about the rise in average temperature and the longer droughts if one can live in air-conditioned environments? Why worry about the scarcity of water if one can stock bottles of this valuable liquid from increasingly famous brands? Why look after their own health if they can afford the best doctors and beds in state-of-the-art hospitals?

In the meantime, the greater part of the urban population of the poorer countries still works in traditional sectors or have become part of what is called 'the informal economy'. It is the city of queues, of street vendors and of clandestine transportation by van drivers, suffering the difficulties, the overall lack of resources in medical emergencies or in places to study.

These are people able to do things, to overcome obstacles and to learn in the most adverse situations. Because they have been submitted to extreme events - such as floods, the wide-ranging daily temperatures in precarious living conditions, and the scarcity of water or food - they are permanent living proof of tolerance and of the potential for adaptation of the human species.

On the other hand, a new challenge is posed by diseases which had been banished over a century of ago from our society - such as cholera, yellow fever and dengue fever – and which have experienced a resurgence in our present society, having become widely disseminated in the urban environment, topped by the emergence of chronic-degenerative diseases, of violence and of AIDS. We need to advance in our understanding of a totally new concept of health, which not only fights violence, malnutrition and tuberculosis, but also promotes a better life for all citizens.

Thriving on the employment of energy sources and synthetic chemical elements, world economy has made few people rich while impoverishing the Earth and most of their inhabitants. If it is true that high-technology agriculture produces incredibly abundant harvests, it is also true that 66 per cent of the grain being reaped is used to make food for animals, while one in every six inhabitants of the planet suffers from chronic hunger (Myers, 1994).

It is estimated that 500 million cars circulate all over the world, of which 80% are in United States and in Europe. In the metropolitan region of Los Angeles, there are more cars than in China and India, Indonesia and Pakistan altogether! At the same time that in rural regions of Kenya people survive with only 5 litres of water per day - when the minimum recommended by the World Health Organisation is 80 litres per day per person - 30.000 litres of water are used to produce one single car!

The charges consumer society imposes on the environment continue to grow, with urban development and expansion of industrial activity in several parts of the world. It is not possible for the planet to withstand the same patterns of consumption of North Americans if these are spread to the nearly 6 billion people. Mankind needs to find alternative ways for economic development, without losing sight of improving the quality of living and the health of all people, in a sustainable fashion.

Who will be better prepared to live in a situation where the current model has collapsed? Who will survive in a black-out environment, should it not become viable to maintain this energy matrix based on the burning of fossil fuels?

The power of purchasing of those that have closed themselves in the high-technology circuits will not do them any good. According to Dubos (1999), the capacity of the adaptation of species owes itself to the arc of possibilities that each one establishes to find alternatives before adverse situations. And it is here that we go back again to those spaces of learning, found in the solidarity of life in urban outskirts. The future has begun and it belongs to the poor.

REFERENCES

ALLAN, Tony. *História em revista*. Rio de Janeiro: Abril Livros, 1992.

DUBOS, , René. *El hombre en adaptación*. México: Fondo de Cultura Económica, 1989.

ENGELS, Friedrich. *A situação da classe trabalhadora em Inglaterra*. Lisboa: Presença, 1975.

EWALD, Paul W. The Evolution of Virulence. *SCIENTIFIC AMERICAN,* April 1993.

GATRELL, Anthony C. *Geographies of health*. Oxford: Blackwell Publishers, 2002.

LEFÈBVRE, Henri. *La revolución urbana*. Madrid: Alianza Editorial, 1983.

MYERS, Norman (coord). *Gaia – el atlas de la gestion del planeta*. Madrid: Hermann Blume Ediciones, 1994.

SALGADO-LABOURIAU, Maria Léa. *História ecológica da Terra*. São Paulo: Edgard Blücher, 1994.

SANTOS, Milton. *O espaço do cidadão*. São Paulo: Nobel, 1993.

SANTOS, Milton. *A natureza do espaço*. São Paulo: Hucitec, 1996.

SANTOS, Milton. *Por uma outra globalização*. São Paulo: Record, 2000.

TEIXEIRA, Wilson et al. *Decifrando a Terra*. São Paulo: Oficina de textos, 2003.

POTENTIAL EFFECTS OF THE GLOBAL CLIMATE CHANGE ON SOME VECTOR AND RODENT BORNE DISEASES. EXAMPLES FOR ARGENTINA

SUSANA ISABEL CURTO
Consejo Nacional de Investigaciones Científicas y Técnicas(CONICET)
Centro de Investigaciones Epidemiológicas (CIE)
Academia Nacional de Medicina - Buenos Aires.

ANIBAL EDUARDO CARBAJO
Unidad de Ecología de Reservorios y Vectores de Parásitos
Departamento de Ecología, Genética y Evolución
Facultad de Ciencias Exactas y Naturales
Universidad de Buenos Aires

Climate Change effects on human health predictions are general and speculative. Many of these impacts can be considered to produce "direct effects" on humans; for example extreme temperatures (heat waves) or ultraviolet rays (UVR). Large exposition to heat waves can modify the morbidity and mortality rates in cardiovascular and respiratory diseases. They could be exacerbated with no wind conditions or when high levels of humidity and intense solar radiation exist. Heat waves become a deep problem especially in big cities where heat retention by buildings and absence of ventilation retard night cooling process (heat island).

Another direct effects concern ultraviolet rays. The decrease of the O^3 in the stratosphere would reduce the absorption of the UVR (great part of the UV-B and the biggest energy in the UV-C). The intense exposition to UV-B is dangerous for living beings because essential molecules such as the genetic material (DNA) absorb them. It could be the cause of serious damages as skin cancer, lesions in the conjunctive and crystalline (eye diseases and cataracts). It could also alter the immunology system of organisms. This process has been corroborated in animals in infections originated by Herpes simplex virus, Leishmania, Candid and Mycobacterias. The effects on vaccines effectiveness remain unknown.

Extreme events like hurricanes and flooding might also be considered as direct effects, and their consequences in health are obvious.

The "indirect effects" (Fig 1) of Global Climatic Change on health are based on changes in the ecosystems which might change the distribution of living beings (Parmesan et al. 2000).

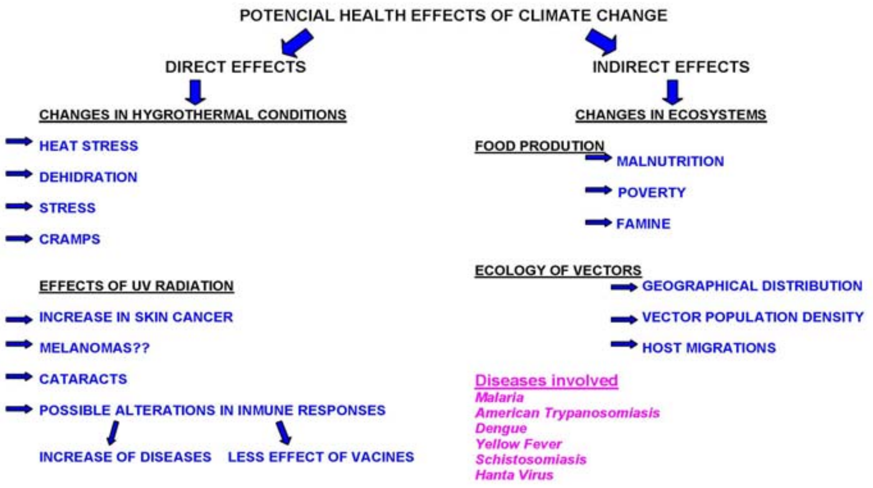


Figure 1 - Indirect effects of Global Climatic Change on health

Temperatures and rainfall changes have consequences on soil humidity that can affect the suitability for crops. However the impact on food production is uncertain because predictions suggest earnings and lost in different parts of the world (McMichael et al. 1996).

Vector and rodent born diseases transmission depends on many complex and interacting factors like human population density, housing type and location, availability of screens and air conditioning on habitations. We can also mention human behaviour, availability of reliable piped water, sewage and waste management systems, land use and irrigation systems, availability and efficiency of vector control programs, and general environmental hygiene. If all these factors are favourable for transmission, several meteorological factors may influence the intensity of transmission (e.g., temperature, relative humidity, and precipitation patterns). These factors influence the transmission dynamics of a disease and play a role in determining whether endemic or epidemic transmission occurs.

Ecology and transmission of vector and rodent born diseases constitute a complex dynamic process, which sometimes is unique for each disease and each place. Some of them spread through an intermediate "vector" organism (e.g., mosquito, flea or tick) while some others may infect other species (especially mammals and birds, called reservoirs). Vector organisms do not regulate their internal temperature and therefore they and their parasites are sensitive to external temperature and humidity. Reservoirs although they can regulate temperature are affected indirectly by changes produced in their habitats.

Very high temperatures are lethal to the mosquito and the parasite. In areas where mean annual temperature is close to the physiological tolerance limit of the parasite, a small temperature increase would be lethal to the parasite, and malaria transmission would therefore decrease.

The analysis of Global Climatic Change effects on the biology of vectors is generally based in the hypothesis that the increment of the temperature would accelerate the metabolic processes. Consequently this vectors would need a bigger quantity of food. These may directly effect on life cycles and population density. At the same time parasites would accelerate their development stadiums and therefore their infection capacity. Changes in temperature and rainfall would influence both in the activity and dispersion of vectors and in the development time of parasites they are able to transmit. Based on these concepts that higher temperatures would increase biting frequency, accelerate parasite development time and lower vector life expectancy (Martens et al. 1997) proposed that the global areas of malaria and dengue transmission would to expand towards the subtropics and higher altitudes, while schistosoma transmission area would shrink. The stronger effect in transmission intensity would be seen in the low or no transmission fringe along more than in actual endemic areas, which coincides with the findings of (Githeko et al. 2000). Also the modelling of dengue transmission areas as a function of vapour pressure showed a probable expansion in its geographic distribution according to future change scenarios (Hales et al. 2002).

In South America the southern limits of malaria distribution may be affected by climate change. The southern geographical distribution limit of a major malaria vector in South America (*An. darlingi*) coincides with the mean isotherm of 21°C (Fig. 2). The distribution of *An. albitarsis* (a weak malaria vector) and the historical records of malaria are also related to temperature: both are limited by the 16ºC isotherm (Figs. 3 and 4); this vector is also limited by precipitations bellow 1000mm.

If temperature and rainfall increase in Argentina, *An. darlingi* may extend its distribution in southern Argentina; on the contrary, if rainfall decreases, conditions may become unfavourable for *An. darlingi* (Carcavallo and Curto de Casas 1996). The historical geographical distribution of *An. darlingi* in Argentina is typically sporadic and with very few discoveries, although the epidemics of the Argentinean NE are attributed to its presence. An increase of temperature and rainfall could extend their geographical area toward the interior of the country following the current isotherm of 17ºC (Carcavallo and Curto de Casas 1996).

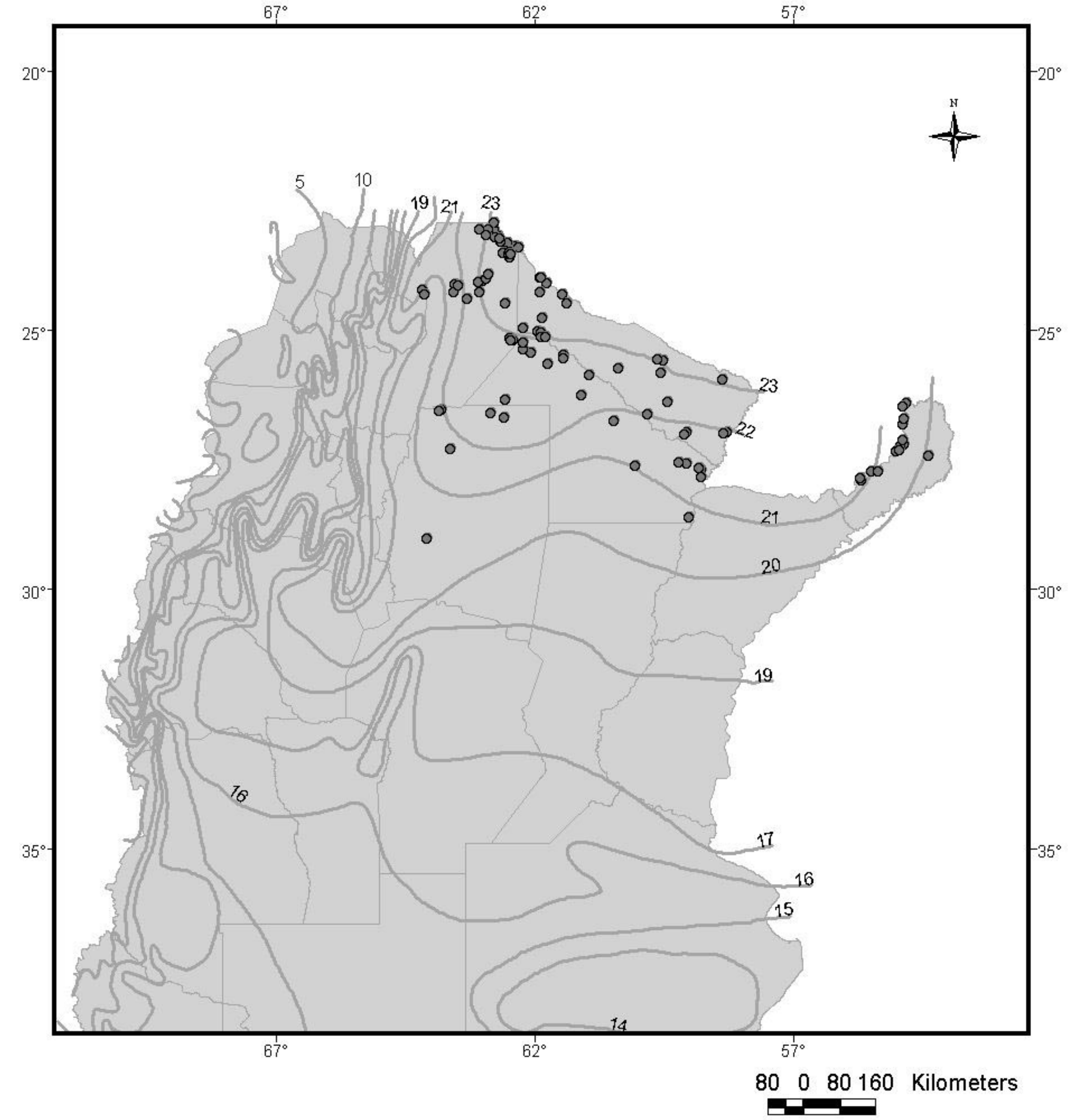


Figure 2 - Distribution of *Anopheles darlingi* (circles) in Argentina and mean annual temperature isotherms (ºC).

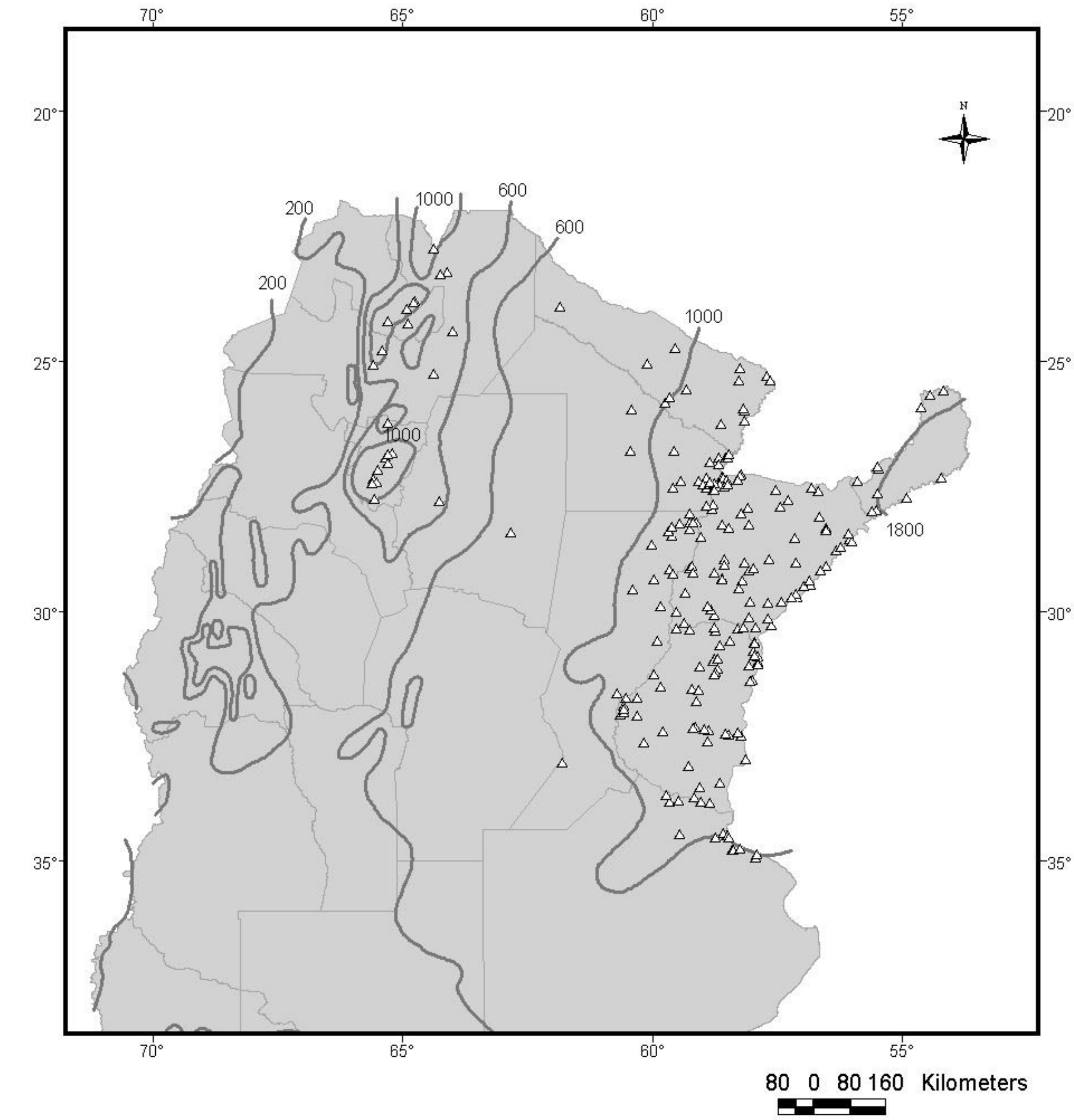


Figure 3 - Distribution of *Anopheles albitarsis* (triangles) in Argentina and annual precipitation contour lines (mm).

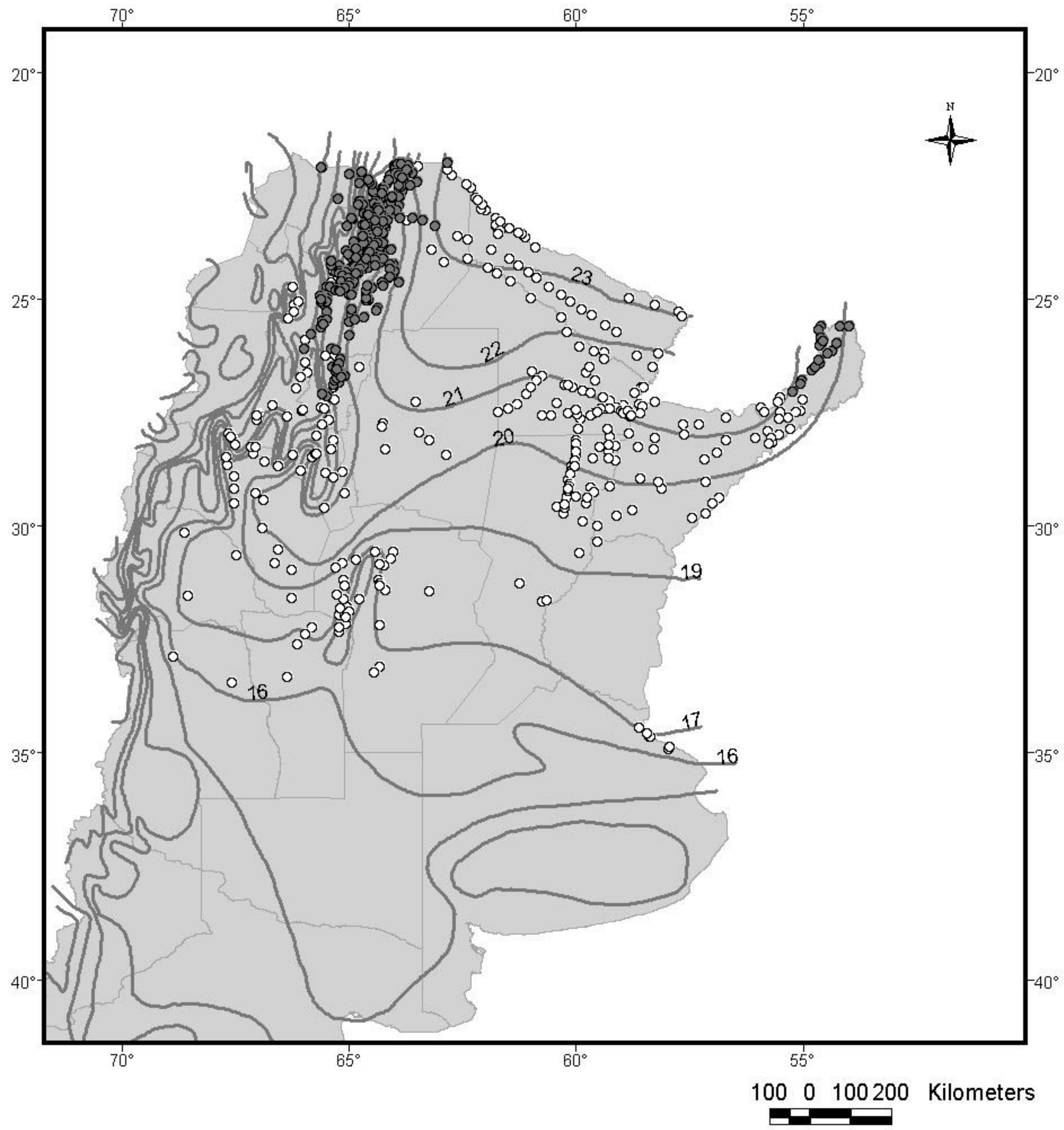


Figure 4 - Distribution of malaria historical *cases* (1890-2003, circles) in Argentina and mean annual temperature isotherms (ºC). Grey circles indicate cases between 1970 and 2003.

In Argentinean NW the malaria vector is *An. pseudopunctipennis*. Its breeding places (hills which altitude varies between 200 and 1800 meters) are fresh and clean waters with slow movement, little streams or irrigation canals with green algae Spyrogyra sp. (Fig. 5). An increase of temperature would be related with the lengthening of its transmission period (Fig. 6).

A reduction of malaria endemic areas in Argentina has been achieved in the last 30 years (Fig. 4) but malaria might established again in all its historical distribution and even southerly under prolonged climatic pressures and other environmental-demographic changes if a strong public health infrastructure is not maintained.

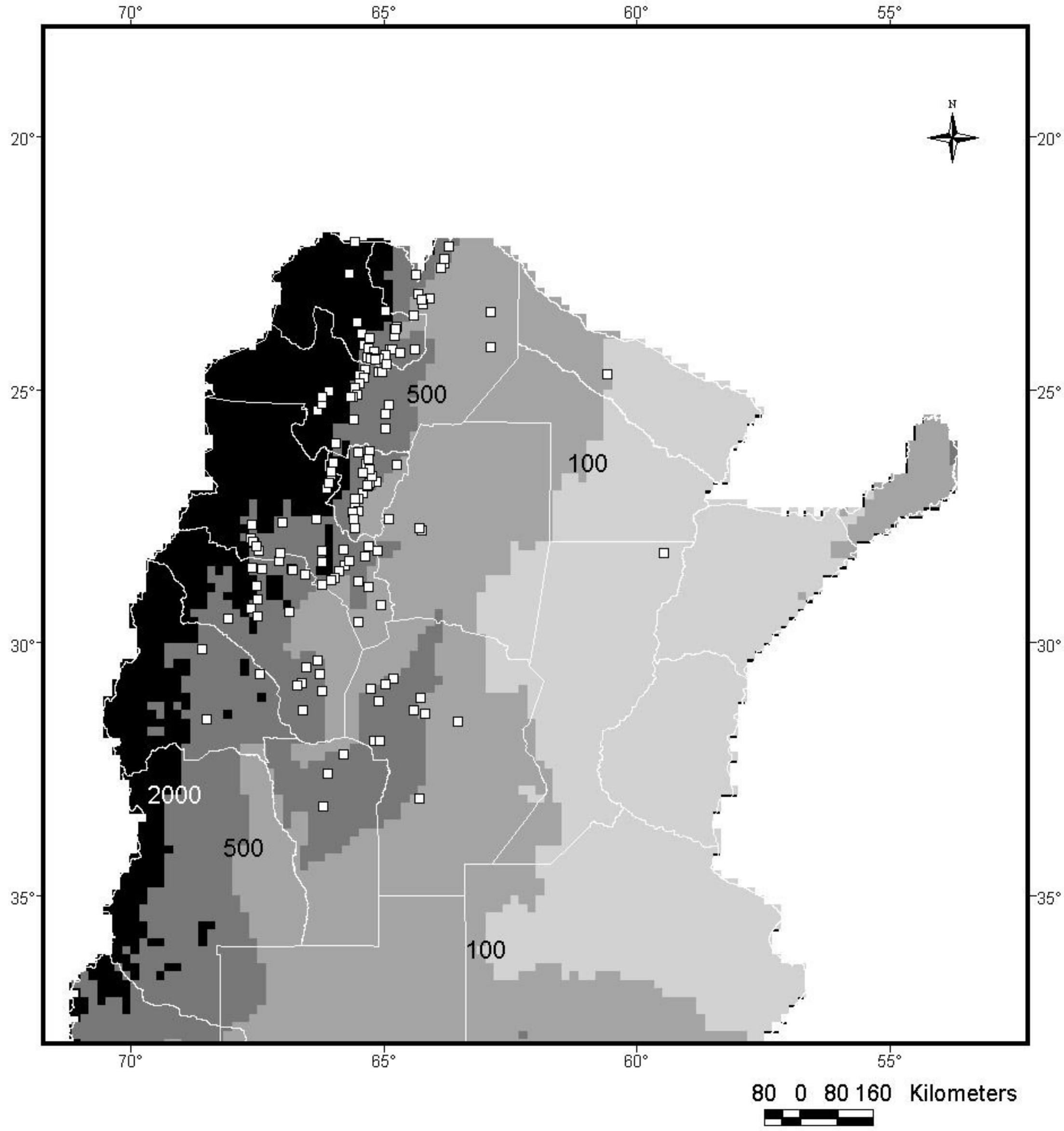


Figure 5 - Distribution of Anopheles pseudopunctipennis (squares) in Argentina and altitude (meters above sea level).

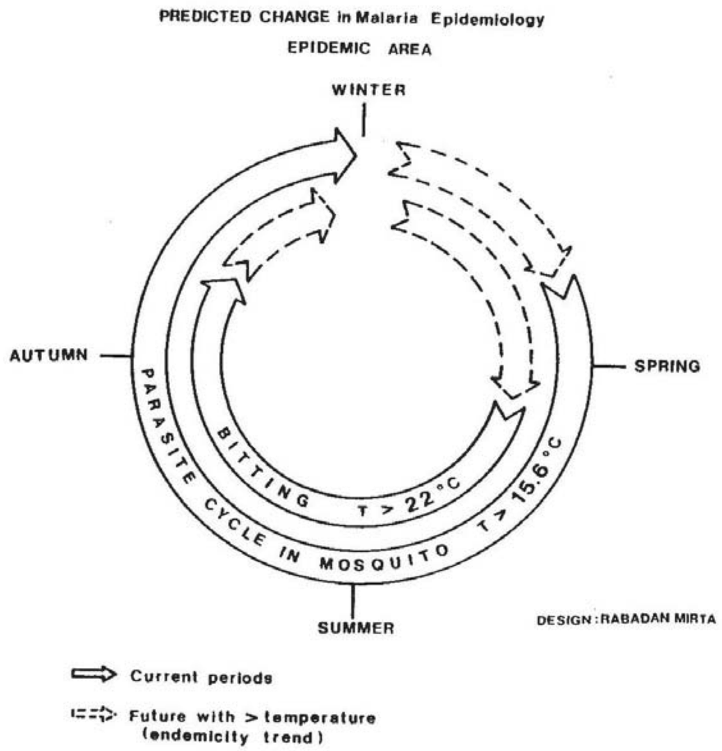


Figure 6 - Predicted changes in malaria epidemiology in endemic areas if temperature increases. (Carcavallo et al. 1995).

Urban vectors as *Aedes aegypti* might be further related to other factors than climatic due to its domestic breeding characteristics. Its population growth is also related to environmental order (availability of containers) and human behaviour (water storage). It should be noticed that other effects might influence the potential expansion predicted by climate change. For example, it has been observed in Buenos Aires City, which lies close to the southern limit of the vector distribution and has temperate climate, that extremely urbanized areas are reflective to *Aedes aegypti* (Carbajo et al. 2006). This is not the case in tropical cities, where more urbanization leads to higher abundances of the vector (Braks et al. 2003).

Climate changes will not come alone, as a big human population growth is also expected in the years to come. This growth might imply enough changes in health status to worry about; population is growing faster in the undeveloped world and mainly in urban areas, what can affect the rate of urbanization. Concerning dengue transmission in temperate zones, urbanization might increase to levels unfavourable for the mosquito, which might compensate for the higher temperatures that would favour it.

The American Tripanosomiasis and Leishmaniasis also present risk of extending their distribution (Houghton et al. 1995; McMichael et al. 1996).

Triatomine bugs transmit Chagas disease, many species are wild, but some are domestic. Regarding the species of wild triatomines an increase of the temperatures can extend its geographical distribution in latitude and altitude.

Temperature affects the major components of the vector life cycle. If temperatures exceed 30°C and humidity does not increase sufficiently, the bugs increase their feeding rate to avoid dehydration.

If rainfall and humidity increased there could be a phitogeographical modification toward humid subtropical formations. This could produce the substitution of some species by others. On the other hand, if a decrease in humidity happens, the biological cycles would shorten, extending the geographical distribution and increasing its population density. However, triatomines live inside host's refuges that provide them a microclimate that tempers the macroclimatic factors.

Changes would be less significant for *Triatoma infestans* because of its domestic habitat; inside the houses humans buffer temperature and humidity. If indoor temperatures rises, vector species in the domestic environment may develop shorter life cycles and higher population densities (Carcavallo and Curto de Casas 1996).

The control of the vectors by means of chemical can also be affected since there is a direct effect of the temperature on the action of the insecticides; some have bigger effect at high temperatures and others at smaller. Another possible effect is the development of resistance to insecticides; an increase in the number of generations by year produced by higher temperatures or more favourable conditions might accelerate the selection of resistant triatomines.

Various rodent-borne diseases are dependent on environmental conditions and food availability that determine rodent population size and behaviour. Explosions of rodents in South America have been associated with bamboo flowering and posterior seed production and also with increased rainfall after El Niño periods (Jaksic and Lima 2003).

Hantavirus is a disease that affects rodents and can be accidentally transmitted to humans. Exposition to the virus is higher for field workers, campers and other persons in close contact with the environment where the rodents live.

In the United States the increase in precipitations associated to El Niño produced an increase in rodent populations and risk of transmission (Engelthaler et al. 1997). In southern Chile and Argentina its main reservoir is the long tailed mouse *Oligoryzomys longicaudatus*. Although its temporal distribution has not been associated to rainfall, the population growth rate of this rodent has been related to the Antarctic Oscillation Index and indirectly to Southern Oscillation Index (SOI). Negative SOI were related to El Niño years and to higher abundances of the rodent, which might represent higher risk of hantavirus transmission (Murua et al. 2003). Although higher rainfall might be associated with higher abundances of the rodent, and thus higher risk, the geographic distribution of the rodent is associated to cold temperature (Carbajo y Pardiñas 2007); higher temperatures might produce a shrinking of this distribution towards the tropics, and so would the risk area.

Changes in human behaviour, clothing, exposition to vectors, migrations and changes in agricultural border, in crops, deforestation, as well as livestock types would bring new ecological changes that could modify the extension of the geographical distribution of some vectors as well as their interaction in the ecosystem.

Ecosystem-level effects like the ones produced by predators population or competitors changes can also be affected by the climatic changes varying in consequence in their outcome regarding diseases.

It is an essential but complex task to determine how all of these factors will interact and affect the risk of vector- and rodent-borne diseases In the future. Long term studies and multidisciplinary approaches are essential to understand the processes and to plan measures to mitigate climate change hazardous effects.

In this respect, when mitigation measures are planned, it should be considered that resources are scarce even to maintain basic health services. Thus if overall public health conditions do not improve, investment in climatic change mitigation might become more difficult to obtain or simply be unfounded when compared to other basic needs.

BIBLIOGRAPHY

Braks, M., N. Honorio, R. Lorenco-de-Oliveira, S. Juliano and L. Lounibos (2003). "Convergent habitat segregation of *Aedes aegypti* and *Aedes albopictus* (Diptera: Culicidae) in Southeastern Brazil and Florida." Journal of Medical Entomology **40**(6): 785-794.

Carbajo, A. E., S. I. Curto, and N. J. Schweigmann. 2006. Spatial distribution pattern of oviposition in the mosquito Aedes aegypti in relation to urbanization in Buenos Aires: southern fringe bionomics of an introduced vector. Medical and Veterinary Entomology 20:209-218.

Carbajo, A. E., and U. F. J. Pardiñas. 2007. Spatial distribuition model of the Hantavirus reservoir, the long-tailed colilargo (Oligaryzomys longicaudatus), in Argentina. Journal of mammalogy.

Carcavallo, R., S. Curto de Casas and J. Burgos (1995). "Blood-feeding diptera: epidemiological significance and relation to the climate change." Entomología y Vectores **2**(2 y 3): 35-60.

Carcavallo, R. U. and S. I. Curto de Casas (1996). "Some Health Impacts of Global Warming in South America: Vector-Borne Diseases." Journal of Epidemiology **6**(4): 153-157.

Engelthaler, D. M., M. Fink, C. E. Levy and M. J. Leslie (1997). "The reemergence of Aedes aegypti in Arizona." Emerging Infectious Diseases **3**(2).

Githeko, A., S. Lindsay, U. Confalonieri and J. Patz (2000). "Climate change and vector-borne diseases: a regional analysis." Bulletin of the World Health Organization **78**(9): 1136-1147.

Hales, S., N. d. Wet, J. Maindonald and A. Woodward (2002). "Potential effect of population and climate change on global distribution of dengue fever: an empirical model." The Lancet **360**: 830-834.

Houghton, J. T., L. G. Meira Filho, B. A. Callander and N. Harris, Eds. (1995). Climate Change. The Science of Climate Change. Contribution of WorkingGroup I to the Second Assessment Report of the Intergovernmental Panel on Climate Change, WHO/UNEP., Cambridge University Press.

Jaksic, F. and M. Lima (2003). "Myths and facts on ratadas: Bamboo blooms, rainfall peaks androdent outbreaks in South America." Austral Ecology **28**: 237-251.

Martens, W., T. Jetten and D. Focks (1997). "Sensitivity of malaria, schistosomiasis and dengue to global warming." Climatic Change **35**: 145-156.

McMichael, A., M. Ando, R. Carcavallo, P. Epstein, A. Haines, et al. (1996). Human Population Health. Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change Scientific-Technical Analysis. R. T. Watson, M. C. Zinyowera and R.H.Moss. Cambridge and New York, Cambridge University Press**:** 880.

Murua, R., L. A. Gonzalez and M. Lima (2003). "Population dynamics of rice rats (a Hantavirus reservoir) in southern Chile: feedback structure and non-linear effects of climatic oscillations." Oikos **102**(1): 137-145.

Parmesan, C., T. Root and M. Willig (2000). "Impacts of extreme weather and climate on terrestrial biota." Bulletin of the American Meteorological Society **81**(3): 443-450.

EFFECTS OF GLOBAL WARMING ON HUMAN HEALTH: AN APPROACH FROM "RE-EMERGENT" DECEASES IN BRAZIL

FRANCISCO MENDONÇA
Universidade Federal do Paraná - UFPR

INTRODUCTION

The intensification of climatic warming of the Earth constitutes nowadays one of the main issues of society. The consequences of this process on the life of men rise countless questionings, some of them emphasizing those linked to human health.

Analyzing the global climatic changes, and particularly the intensification of climatic warming, demands the involvement of an important combination of different and complementary knowledge. Thus, this problematic which involves simultaneously the natural dimension of the planet and the human society that inhabits it, demands an interdisciplinary perspective to its study.

In this context, the approach here elaborated involves many aspects related to climatology, medical geography, health and to epidemiology, constituting an incursion into studies of public health. Developing an analysis on the history of the interaction between the climate and the incidence of certain deceases in the recent past, the text intends to propitiate a look onto the future of human kind, as well as contribute to the control of determined infirmities resultant from processes of interaction between man and the environment.

In the ambience of the present text there emerges a perspective that, ounce occurring an intensification of global warming associated to atmospheric humidification on distinct locations of the planet, the repercussions of the new climatic conditions in the incidence of deceases, particularly the transmissible ones, will develop a new geography. The expansion of the current circumstance of tropical condition towards more elevated latitudes and altitudes will correspond to an equal expansion of the so called "tropical deceases", one speculates.

GLOBAL WARMING OR COOLING?

The evolution of terrestrial atmosphere registers quite different physical-chemical conditions along the natural history of the planet. Concerning temperature conditions, one of the main climatic elements, its evolution did not occur in uniform and linear manner, warmer periods being followed by other less warm and/or cool. The greenhouse effect of terrestrial atmosphere, that is, the imprisonment of solar heat by the gaseous layer of the planet is a natural process and constitutes one of its most important characteristics. The apprehension that nowadays afflicts human society, is characterized as an intensification of the low atmosphere warming, particularly of the troposphere which is the layer where the main interactions between man and the air are processed.

Temporally differentiated scales allow a better comprehension of the process of atmosphere warming and, according to Nieuwolt and McGregor (1998:311) the global climatic changes can be of long (more than 20 000 years) or of short duration (between 100 and 20 000 years). According to these authors, the climatic changes had its origin related to external causes as well as internal factors, human activities and also the phenomenon that strongly calls the attention of society in current times (intensification of global warming) reuniting these three causes particularly manifested in the last two centuries. The more recent debates on the issue of the intensification of global warming are generally concordant with the thesis that the intensification of the planetary greenhouse effect would be directly related to the pattern of production and consumption of Modern society. The rise in the volume of warming gases in the high troposphere – derived in its quasi totality from human activities (mostly industry and agriculture) and associated to the destruction of the stratospheric ozone layer, would be provoking a considerable transformation of atmospheric composition and consequently of its mechanism of gases. This variation would lead to a warming of the air whose most alarming predictions indicate a rise of 1,5° C to 6 °C in the mean temperature of the planet circa the year of 2100, above the current mean temperature which is of 16,5°C (IPCC,2004). Both the intensity as the temporal and spatial differentiation of the phenomenon constitutes real challenges to scientists of the present, even believing that the most expressive changes will occur on the medium and high latitudes. In this perspective the tropical and equatorial areas will register well less thermal impacts than in the higher ones.

The conception of future scenarios concerning climatic changes is still very speculative, overall due to the difficulty of a complete and satisfactory comprehension of the dynamism of the atmosphere in its conception of moving corpus (Monteiro 1994) and to the quasi unpredictability of the evolution of human activities subjected as they are to political, cultural, and even of natural intervention factors in its accomplishment. Based in the analysis of volcanic eruptions Molion (1994) insisted on the thesis that a cooling of the planet is occurring and not a warming; however, this has been a perspective contrary to the creed of most researchers in all the world. Nieuwolt and McGregor (1998:311) clarify, in respect to this thesis, that the impact of volcanic eruptions varies spatially (North America and Northwest Pacific) and temporally (days, months or years following the eruption) and the reductions of temperature are practically null in the computation of planetary warming. Beltrando and Chemery (1995) moreover include that the effects and duration of aerosols action thrown by volcanic eruptions in the atmosphere are still scantly recognized.

When it comes to the thesis of planetary cooling the role of Pacific Decadal Oscillation (PDO) has to be mentioned, a phenomenon that actuates as a thermo regulator of the terrestrial atmosphere deriving from the impact of the Pacific waters on the atmosphere. To the contrary of the decadal succession of differentiated temperatures, related to the eleven years solar cycles, an anomalous sequence of five decades of warming would have taken place between the end of the forties and the nineties clarifying the warming observed with much clearness in final decades of the twentieth century. Thus, from 1997-1998 on, a new era of cooling has begun, as it is believed that three decades of thermal reduction in relation to the previous ones would be initiating in the current period. However, it has to be considered that this cooling of the next decades would not imply in a thermal reduction towards lower temperatures, or else, the warming would be maintained in the current levels.

However, despite contaminated with questionings, to the effect of this study, the prevalent conviction is that an intensification of the troposphere warming is a current and near future fact, and urgent actions should be taken.

EFFECTS OF CLIMATIC CHANGES ON HUMAN SOCIETY

The global climatic changes will result in new and differentiated spatial arrangements on the surface of the Earth and in the life of mankind. Even though speculative the influence of planetary warming on the conditions of health and deceases of the population should be seriously considered, since according to Czeresnia and Ribeiro (2000:12), "the epidemiological consequences of this intense process of transformations are radical and unpredictable. The emergence of new deceases, which may manifest, also as fatal and devastating epidemics, is not only a fictional possibility".

Positive and negative effects of the intensification of atmospheric warming are prognosticated by many specialists, although the negative ones are much more expressive and incomparably more worrying than the first.

An elevation in the fertility of plants resulting from the greater fixation of carbon in the plants and soils as a consequence of the increase o CO2 in the atmosphere and the expansion of agricultural areas of the planet – mainly on medium and high latitudes and the humidification of currently semi arid areas due to an increase of rainfall as well as in hygrometry would be among the chief positive effects of climatic change.

The list of negative effects is, however, well ahead of the positive ones. One of the most preoccupying is the volumetric expansion of ocean waters (elevation of sea temperature between 1,4 and 5,8°C between 1990-2100) which, associated with partial defrost of glaciers and polar icecaps would result in an elevation of sea level of 0,4 to 1,5m, which implicates in the relocation of a significant part of humanity that now lives in coastal regions (Legget, 1992).

Contrary to the expansion of agricultural zone of the planet on the temperate strip, resulting in an increase of agricultural production, the current tropical-equatorial zones will witness a reduction of their agricultural areas and register a decrease in its productions. The worsening of the social crises by now so difficult for the Tropical World would be associated to the new climatic conditions, as a consideration of Mendonça et alii (2002), since the rising demand for techniques and technologies would leave many people as prisoners of climatic changes.

Situations of conflict between peoples and nations can be unleashed as consequences of problems related to famine, drought and lack of means. These new conditions may cause forced dislodging and migration of populations, as in similar situations the societies are witness to a complex sequence of problems of different intensity, but with damaging results to a large portion of their members.

It also has to be considered that the population increase is occurring simultaneously to the intensification of global warming. In this sense, the effects of climatic changes will impact over a larger number of men, as the areas of environmental natural risks are gradually getting more densely inhabited. This intensifies the population vulnerability to impacts of the climate. However it is exactly among the poor inhabitants that the more victimized by extreme climatic events will be found.

The results of climatic changes on conditions of health of the population demands a special analysis in the present text.

CLIMATE AND HEALTH: EFFECTS OF THE INTENSIFICATION OF ATMOSPHERIC WARMING

The climate performs an important influence on man and society. Living in permanent interaction with the air that encircles him, mankind has endured positive and negative effects from this gaseous envelope around himself and society (Mendonça, 2001). Many of the deceases that reach men result from interactions between his body and the climate, and it is comprehensible that in conditions of climatic change there also occurs an alteration in the epidemiological profile of the population. (Besancenot, 2001; Reiter, 2001).

Effects of global warming on human health, considers Gatrel (2002), will happen in a long term, to the contrary of effects resulting from extreme climatic episodes that occur in short and extremely short term. In this particular case it has to be noted that there is a direct interaction between the impacts of natural order phenomena and the socio-economic-technological conditions of the diverse human societies; the less endowed ones are more exposed to risks and therefore more vulnerable than effluent societies from rich and developed countries.

Even considering that the tropical and equatorial zones will suffer less impacts with the intensification of planetary warming, it is believed that an increase of many endemic deceases will occur in this part of the planet, besides the expansion of areas of occurrence of many of the most known tropical illnesses, simultaneously with the expansion of warmer areas into higher latitudes and altitudes. Very intense heat and cold waves may be accompanied by a rise in the indexes of mortality due to cardiovascular infirmities as well as brain-vascular and respiratory ones, to say nothing about the well known problems of skin cancer and vision cataracts.

Besancenot (2001) points that the morbid-mortality deriving from climatic warming would be related to six differentiated factors, all presenting interactions among them, which are: rising of the sea level, meteorological paroxysms, aggression by heat, effects on reproduction, atmospheric pollution, and other. According to this author, the alteration of forests through global warming would reflect on pollens and allergens on humid zones and the deceases transmitted by vectors, and this would induce allergies and illnesses transmitted by vectors. Thus, “It is to expect, for example, an intensification of rhinitis and asthma as well as the rise in temperatures will conduce a dislocation of the area of repartition of numerous plant species some of them strongly allergenic, while the rising frequency of warm sunny weather, manifested by excessive rainfall will augment the quantities of pollens liberated in the air.(…)” (Besancenot (2001: 121)

Deceases transmitted by vectors, as well as chronic ones, would be strongly influenced by the intensification or warming, rising the indexes of morbid-mortality of the population. One speculates on the elevation of kidney calculus incidence, premature birth rates and prenatal mortality, multiplication of intoxications (due to bad conservation of foods) or still a rising risk of contamination in the systems of acclimatizing and/or humidification through various microorganisms… “ in fact, all depends on the brutality with which the warming would operate” (Besancenot, 2001: 123).

When considering climatic changes related to planetary greenhouse effect Haines (1992): 140) affirmed that “many deceases, like malaria, trypanosomiasis, leishmaniasis, filariasis, amoebiasis, onchocerciasis, schistosomiasis, and various verminosis , nowadays restricted to tropical zones, have a relation with the temperature and could theoretically be affected by climate change”. The temperature also has a relation with many other non- parasitical contagious deceases as yellow fever, dengue and other virus illnesses transmitted by arthropods, bubonic fever, dysenteria and other diarrhea affections.

Haines (1992), in a prognostic perspective, hypothesizing on the impacts of global warming and climate change on the society, also observed that these may be more expressive in terms of catastrophes associated to extreme events as storms and famine. He considered problems linked to mental health deriving from bursting of dams with obits of survivors and the projection of future situations as the elevation of the sea level.

The interactions between planetary warming and health conditions have been invariably conceived as of two categories: direct and indirect implications (Hufty, 1997; Besancenot. Op Cit;Gatrel, 2002). The direct ones will result in: intensification of thermo stress, cardio vascular, brain vascular, respiratory, metabolic, psychic problems as well as others as effects of weakening of thermo regulators of the organism (in the summer), appearance of illnesses of the respiratory apparatus cardio sickness in medium and high latitudes (in the winter).

Concerning to indirect implications the effects "will be felt as produced by ecological conditions more or less favorable to survival, multiplication and development of such and such pathogenic germs, or else from such vector-insect of this germ" (Besancenot, Op.Cit: 121). The tropical region of the planet is particularly sensible to indirect implications of the intensification of global warming, since the exuberant biodiversity of this part of the Earth is responsible for a large quantity of vectors of many deceases. In Brazil, due to its geographical characteristics, the incidence of deceases as malaria, yellow fever, leptospiriasis , meningitis, cholera, leishmaniasis, etc. might have its rates elevated in a scenario of climatic changes as the warming tendency currently speculated.

CLIMATE AND DENGUE: INTERACTIONS BETWEEN THE GLOBAL WARMING AND THE EXPANSION OF THE DECEASE IN A REGIONAL SCALE – SOUTH REGION OF BRAZIL

The dengue, a viral illness that strikes human beings, responds indirectly to the effects of the climate. The direct effect of climatic conditions on this illness is observed on the virus (*Flavivirus)*and its vector – the mosquitoes *Aedes aegypti and albopictus.* It is a tropical decease and the common area of its occurrence has been Asia and Central and South America, where more than 100 million cases are related each year with circa 20 thousand obits. It is a decease whose control is based in the care with the environment , considering that there is no vaccine to control it, representing a serious problem of public health and an important challenge for many nations (Reiter, 2001).

Ounce infected the develops body pain, fever, discomfort, etc. However, once stung for the second time, the individual may develop the hemorrhagic dengue, a type of occurrence that can be lethal. In a specific condition " the World Health Organization indicates that the hemorrhagic form affects particularly children and that the mortality is around 5 per cent, registering 24000 cases per year. Fast urbanization, population migration, the resistance of the mosquitoes to insecticides and the inadequate stocking of clean water are implicating factors for the incidence of dengue" (Gatrel, 2002: 247).

The distribution of the mosquitoes, the frequency of their bites and the incubation period of the virus are affected both by thermo conditions of the air as by rainfall, by furs, etc. At a temperature of 27°C, for example, the incubation period of decease in the human organism is of 10 days, and at 37°C it is of 7 days. Gatrel (2002) affirms that a rise at the order of 2°C in the temperature of the planet points to an expansion of dengue to areas as the south of Europe (Spain and Greece) and the south of the

USA. High latitudes are nowadays free of this decease due to low temperatures, however, as it happens with malaria, a global climatic change may favor the expansion of its occurrence area (Reiter, 2001).

Very recent studies related to dengue has shown its geographic expansion to areas until now not included as endemics to the illness such as the north of Argentina (and the region of Buenos Aires – (Bejaran et alii, 2002) and portions of the South Region of Brazil (Figure 1 and Table 1). Considering that some of the localities in this part of the country has presented a rise in the incidence of this illness, particularly the State or Parana with an intensification of native cases (Graphic 1) and the first registers in the city or Curitiba (the coldest of Brazilian capitals – Mendonça, 2001) in the year of 2002 (Paula, 2002, Fernandes de Oliveira,2003), the following questions are made:

a) How does regionally occur the spatial and temporal distribution of the dengue?

b) What relations evidence the interaction between dengue and the climatic regional conditions?

c) The increase in registering of dengue cases in the region would be evidencing the effects of an intensification of global warming in a regional scale?

Figure 1 - Southern region of Brazil

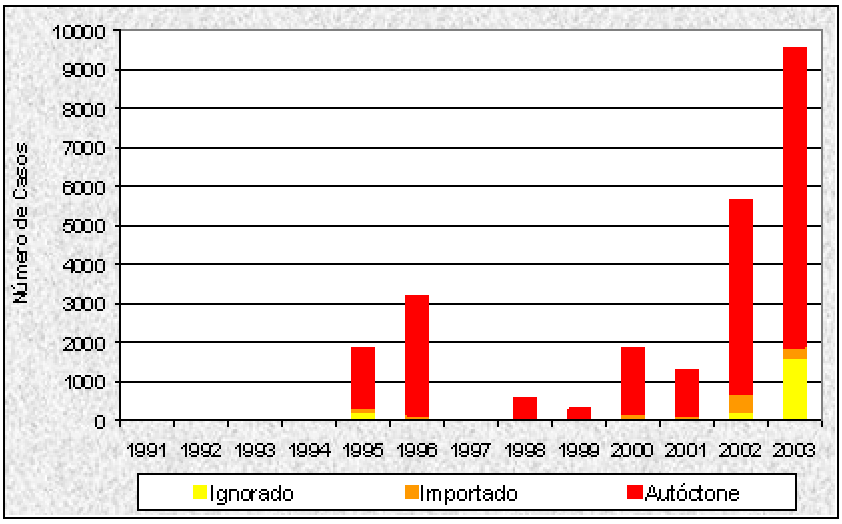
Table 1

DENGUE – VARIAÇÃO ANUAL
(Hospitalizações) – Região Sul do Brasil (1998-2003)

Ano	Paraná	Santa Catarina	Rio Grande do Sul	Total	Coef.* Inc.
1998	17	1	2	20	0.08
1999	6	2	0	8	0.03
2000	22	4	5	31	0.12
2001	24	4	5	33	0.13
2002	308	40	35	383	1.53
2003	468	10	4	482	1.92
1998/2003	845	61	51	957	0.64
%	88.30	6.37	5.33	100.00	

* Coeficiente por 100.000 habitantes
Fonte: Datasus

Graphic 1 - Evolution of dengue occurrence in the paraná State - 1991 - 2003



Fonte: Sec. Estado da Saúde do Paraná e SINAN.

These, among other issues, conduce to the analysis of the effects of climatic changes, particularly to the intensification of the warming on the South Region of Brazil. It is necessary to consider the social, political, economical and cultural dimensions of public health problems, as the case of dengue epidemics are not focused in this paper. This option does not mean an approximation to the approach with the focus of natural determinism; it only centralizes the focus in the interaction of the decease with the climate, conceiving it as one of the many elements and factors that concur to the decease in a determined reality.

Analyzing the meteorological data of innumerous localities in the south region of Brazil, some of them related to a century period, most of them referring to the last fifty years, a tendency towards the increase of temperatures in all the region can be observed. In general terms it is estimated that in the last forty years the mean regional temperature has risen circa 1,3° C, followed by an increase of the total rainfall annual averages.

To illustrate these results the data were statistically treated through the linear tendency and the polynomial tendency. In the first exercise a linear tendency was observed in around 90% of the analyzed localities, a fact that reflects the general tendency of atmosphere warming of the planet on a regional scale. The graphics of figure 2, 3 and 4 relative to the evolution of mean temperatures of in the localities of Curitiba, Paranagua, Londrina and Campo Mourão in the State of Parana, and Florianopolis, São Joaquim and Chapeco in the State of Santa Catarina, and of Porto Alegre, Sao Luiz Gonzaga, Santa Maria and Bom Jesus in the State of Rio Grande do Sul verify these results. The rainfall regional tendencies (Figures 5, 6 and 7) confirm the concept that an increase of humidity would occur associated to the intensification of warming, shown in the increase of precipitation.

However, when treated with the application of polynomial tendency, the graphics of mean temperatures of the same localities (Figures 8, 9 and 10) as well as those referent to regional precipitation evolution (Figures 11, 12 and 13) reveal a tendency to the warming/humidification in most of the localities only towards the end of the observed period (middle part of the nineties). After the years of l996-1097 most of them show a tendency towards a reduction of the mean temperatures, a fact that, contradictory to the conclusions presented in the above paragraph , confirms the speculation of some scientist in what concerns the beginning of a cooling period of the planet starting at the end of the nineties. The intensification of global climatic warming and its manifestations in regional scales, with the application of these statistics, stirs up the scenario of speculations and questionings on the present problems under study, since differentiated results were found.

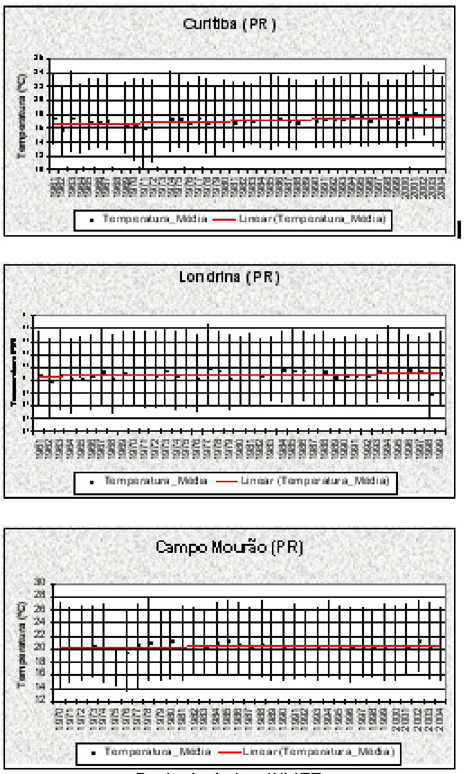
Parallel to the intensification of regional warming a rise in the incidence of dengue was observed in the region. The three states presented rising registers of dengue both in what concerns the imported cases as in the native ones. In the years 2002 and 2003 , the last one the warmest in the last decades, registered most important epidemics of dengue in the country, since only in the State of Parana around 12000 cases were confirmed (around 9000 of them of native origin in the municipality of Londrina). Considering that the confirmed cases are typified in only approximately 30% of the total of infected people, it is estimated that more than 30 000 people acquired the decease in that year, characterizing a strong epidemics.

If the two cases present such an intense correlation, particularly due to the decade of l990 being one of the warmest of the last times with the indexes of the decease enormously increasing in the country, it cannot be affirmed yet that one (climate) justifies in a complete way the evidence of the other (dengue). For an assertion of such order it is necessary to get deeper into the analyzes of the data, nevertheless with a large amount of cautiousness since the climate alone could not explain the existence and intensification of this decease. As for correlations there is no doubt that they exist, but they should be approached through complex contexts, taking into consideration the political variables (public health policies), economical (social classes), cultural (ways of life) and generally social ones involved in the process. It remains, overall, a historic argument to be verified: would a cooling phase really be initiating? If positive, the predictions and the models for the future reality would have to be checked.

FINAL CONSIDERATIONS

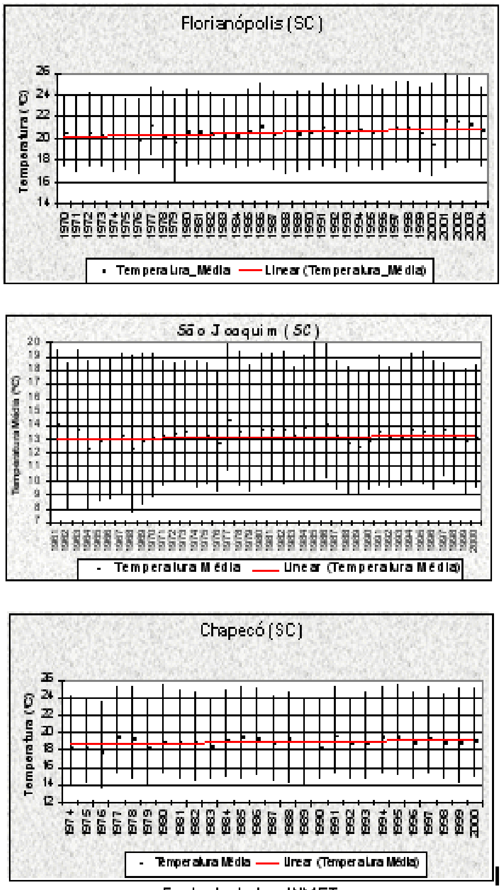
Beyond the positive and negative effects drawn from the intensification of the global warming above mentioned, others should be associated such as the flooding of widespread areas, impacts on agriculture, migration of different activities towards more elevated latitudes and altitudes and many others. The focus here elaborated favored the effects on human health, giving prominence to the Tropical World and particularly to Brazil.

The perspective of natural determinism was not recommended here as an elaborate analysis since it has been sufficiently criticized in the sense of not laying the foundation for the renewal of the studies on the interaction between society and nature. However "(…) It needs to be said: the action of the ambience is incontestable: it performed its role in the configuration of the physical and mental diversities of mankind. But is has to be admitted, at the same time, that its action are not imperious to the point of determining, in all cases, a rigid specialization. (…)"(Sorre, 1984: 71).



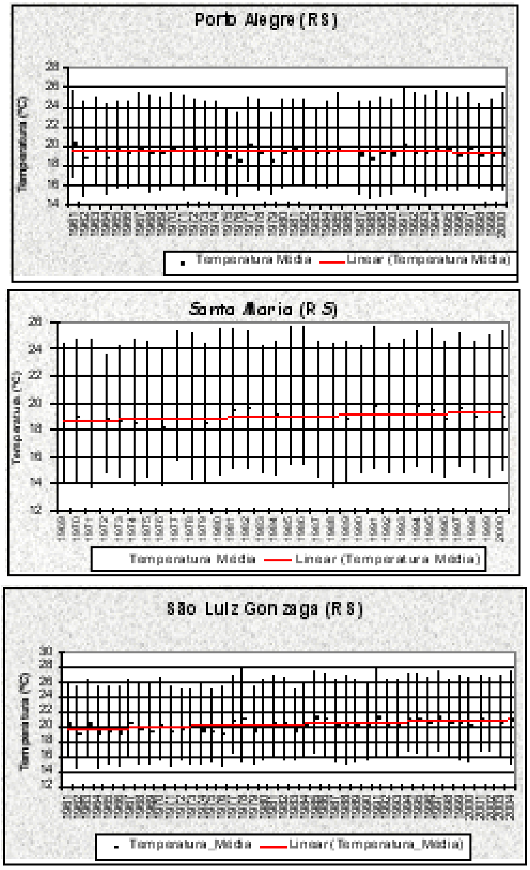
Fonte de dados: INMET

Figure 2 - Thermal evolution in the Paraná State (Linear Tendency)



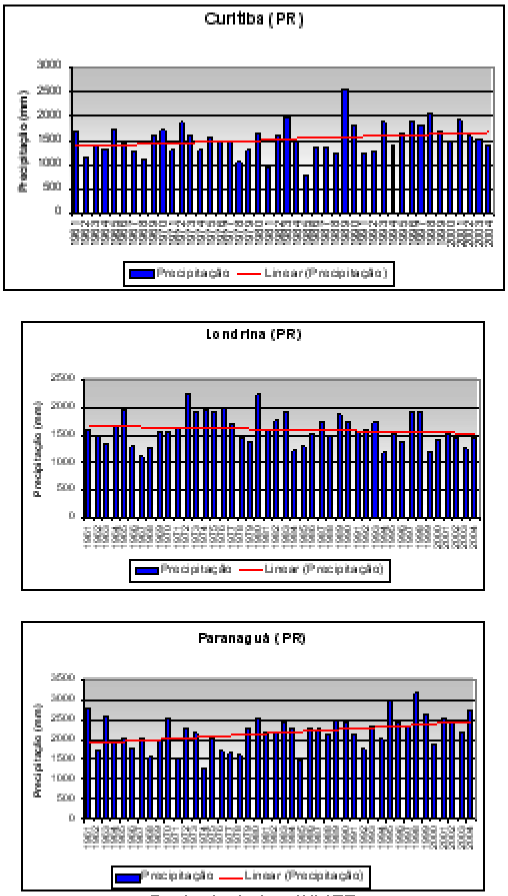
Fonte de dados: INMET

Figure 3 - Thermal evolution in the Santa Catarina State (Linear Tendency)



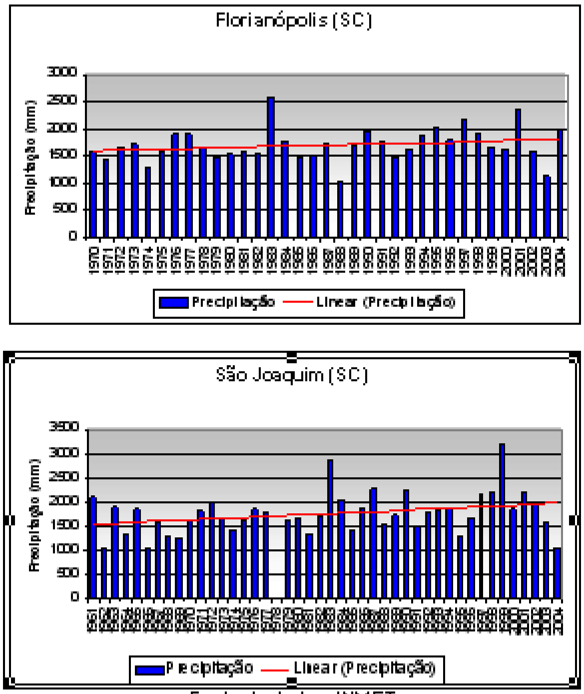
Fonte de dados: INMET

Figure 4 - Thermal evolution in Rio Grande do Sul State (Linear Tendency)



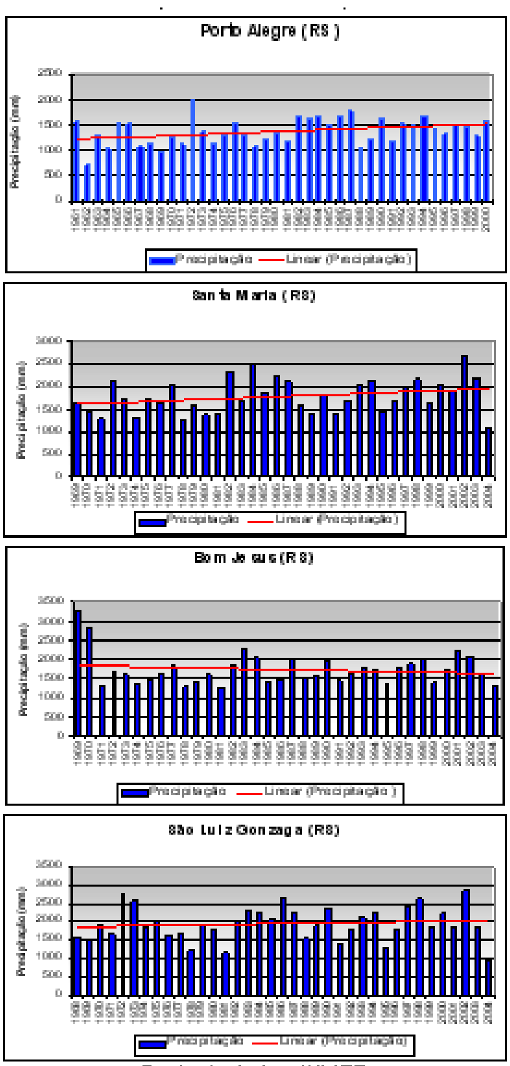
Fonte de dados: INMET

Figure 5 - Rainfall evolution in the Paraná State (Linear Tendency)



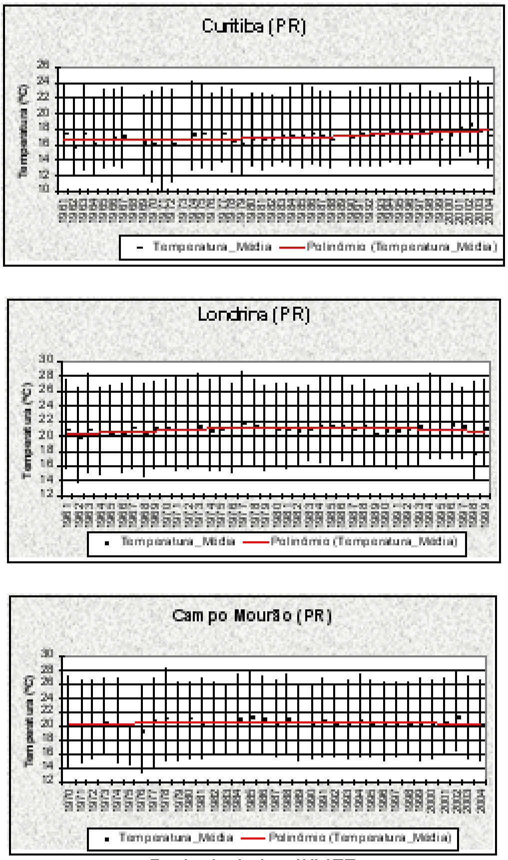
Fonte de dados: INMET

Figure 6 - Rainfall evolution in the Santa Catarina State (Linear Tendency)



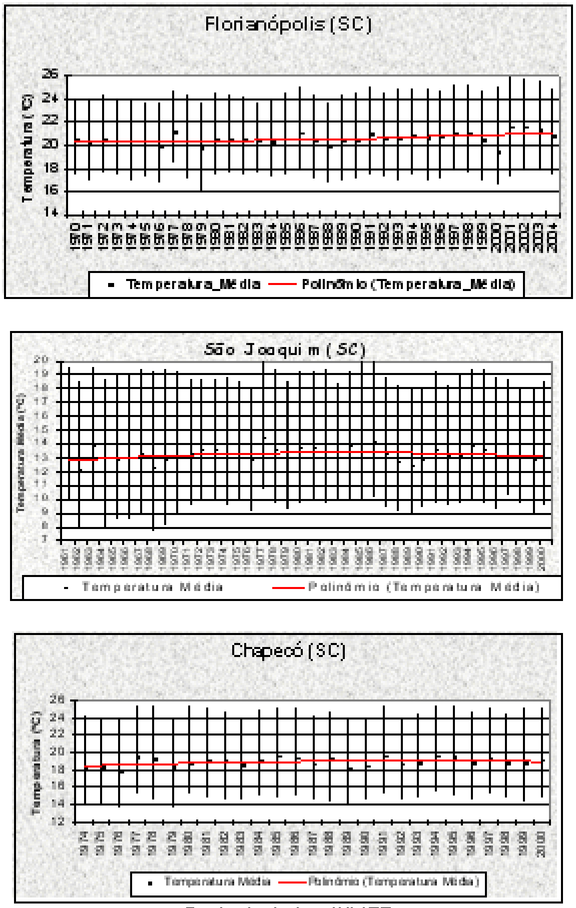
Fonte de dados: INMET

Figure 7 - Rainfall evolution in the Rio Grande do Sul State (Linear Tendency)



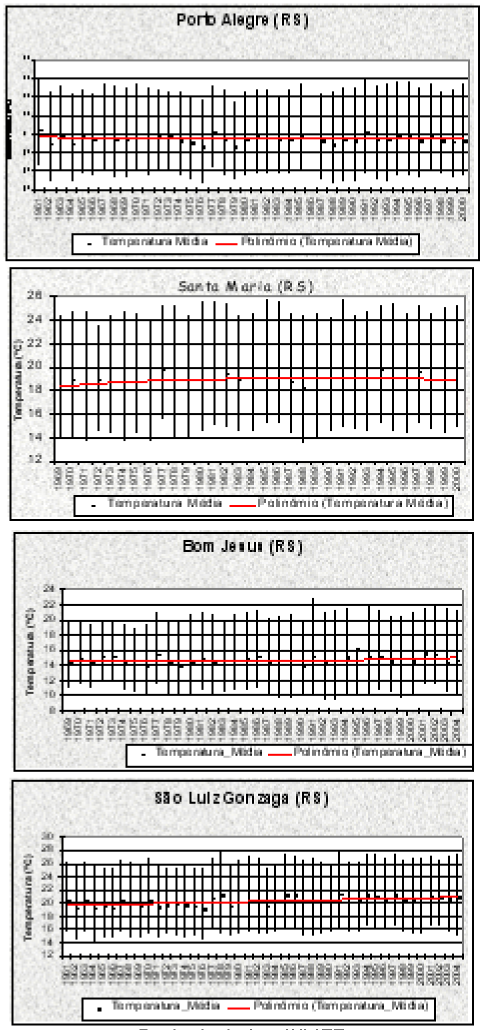
Fonte de dados: INMET

Figure 8 - Thermal evolution in the Paraná State (Polynomial Tendency)



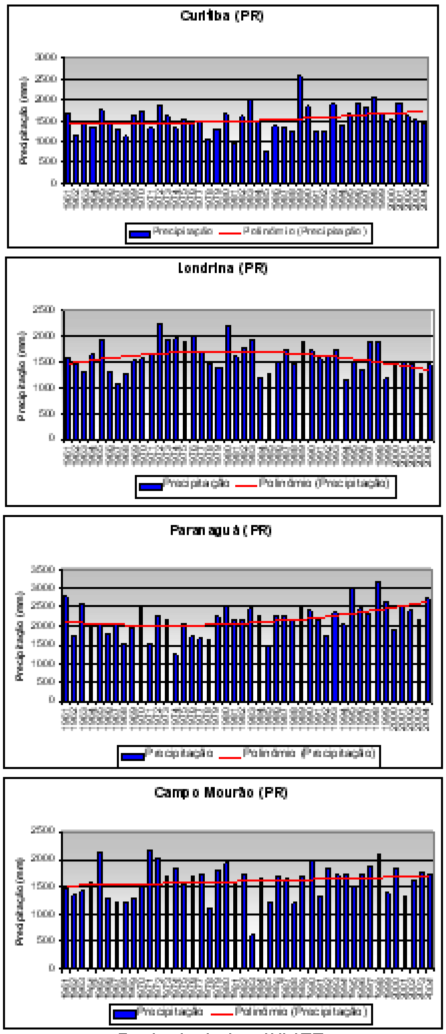
Fonte de dados: INMET

Figure 9 - Thermal evolution in the Santa Catarina State (Polynomial Tendency)



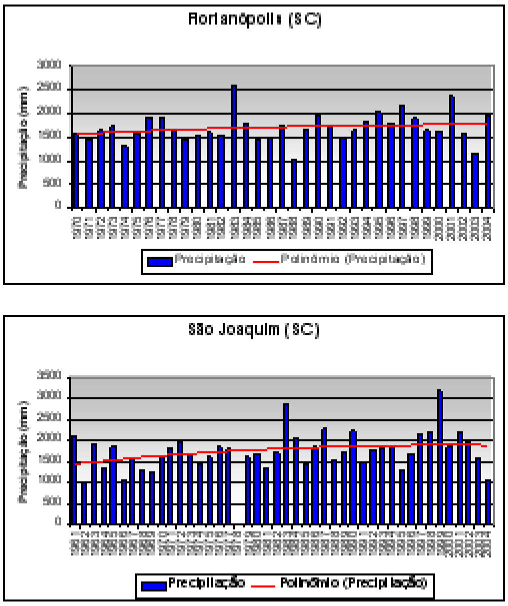
Fonte de dados: INMET

Figure 10 - Thermal evolution in the Rio Grande do Sul State (Polynomial Tendency)



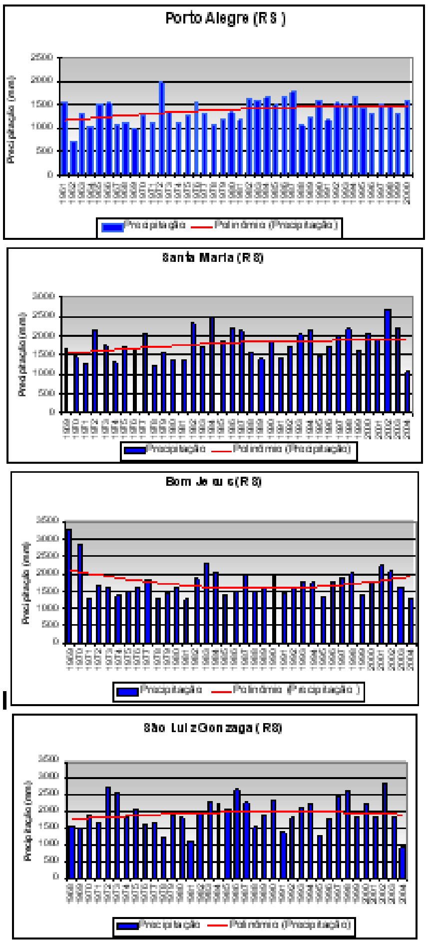
Fonte de dados: INMET

Figure 11 - Rainfall evolution in the Paraná State (Polynomial Tendency)



Fonte de dados: INMET

Figure 12 - Rainfall evolution in the Santa Catarina State (Polynomial Tendency)



Fonte de dados: INMET

Figure 13 - Rainfall evolution in the Rio Grande do Sul State (Polynomial Tendency)

The global climatic changes and its most worrying demonstrations – the intensification or the warming process at the low atmosphere of the planet, points both to positive as for negative changes in the landscape and conditions of mankind's life on the surface of the planet. The negative implications are the most important, as its effects indicate the development of general conflicts in the right to use determined natural resources (soils, forests, potable water, etc.). In a very special manner they also indicate new conflicts related to geographic expansion and the intensification of certain infirmities; among them an emphasis should be put on the tropical ones (parasite, vector and human being factors), infectious and parasitical ones whose incidence depends directly on climatic conditions.

The intensification of global warming is, however, involved in considerable uncertainties and speculations, overall when its causes are discussed. The thesis of a cooling period as sequential to a period of successive decades of warming is not totally discarded; this strengthens the speculative scenario on the evolution of terrestrial atmosphere in the initiating century. In such a context precaution should be the most correct attitude to be taken by society; therefore many initiatives can be implemented such as reduction of consumption and deforestation, as examples. A stability of the mean temperature of the Earth or a reduction of the predicted levels will result in maintenance of good conditions of life in the planet, even in the creation of new ones; such adaptations and changes tend to be manifested directly in the conditions of the inhabitant's health.

Concerning the climatic changes in the southern portion of Brazil an analysis of meteorological data reveals contradictory results. The linear statistics point to an intensification of climatic warming associated to an increase of annual precipitation averages, which assists the thesis of regional warming as a reflex of global warming. When polynomial statistic is applied, to the contrary, a tendency to the cooling in the middle of the nineties is observed, an aspect that reflects the conviction of some scientists that a decadal cooling of the terrestrial atmosphere is initiating. The data on dengue confirm all over the region, that although with spatial differentiation, there was an increase of the incidence, particularly in the nineties, the warmest decade of the XX century. Even though a datum helps in the analysis of another, it should not be taken as descriptive, since innumerous factors for the comprehension of this decease are connected to the climate.

Anyway it seems to be obvious that the more reality is analyzed the more or less intense warming of the troposphere will reflect on mankind in a differentiated manner; the evidence of an inequality in wealth and accessibility clearly sets most of human beings in a situation of disadvantage and therefore of greater vulnerability to the impacts of global changes. The reality shows that it is necessary to urgently do something in the sense of stopping the planetary warming; it also evidences that this will not happen while the concentration of wealth and social injustice remain at the levels that illustrate the present moment of humanity. With the persistence of these disparities the negative scenarios of global change may be more striking and unexpected than one may speculate.

REFERENCES

BEJARAN, R. et al. Aplicación de la predicción meteorológica para el pronostico de la abundancia potencial del Aedes aegypti en Buenos Aires. **Revista Terra Livre**, n.20, São Paulo, Brasil: AGB, pp. 171-178.

BELTRANDO, G. e CHMERY, L. **Dictionnaire du climat**. Paris: Larousse, 1995. (

BESANCENOT, J-P. **Climat et santé**. Paris: PUF, 2001. (Medicine et société).

CERESNIA, D. e RIBEIRO, A. M. O conceito de espaço em epidemiologia: uma interpretação histórica e epistemológica. **Cadernos de Saúde Pública**, Set 2000, vol.16, no.3, p.595-605. ISSN 0102-311X

CONFALONIERI, U. Global environmental change and health in Brazil: Review of the present situation and proposal for indicators for monitoring these effects. in: HOGAN, D.; TOLMASQUIM, M. T. **Human dimension of global environmental change – Brazilian perspectives**. Rio de Janeiro: Academia Brasileira de Ciências, 2001. (pg.79-97).

COSTA FERREIRA, M. E. e LOMBARDO, M. A. A questão climática e a ocorrência de malária na área de influência do reservatório de Itaipu – PR – Brasil. In: **Boletim Climatológico**, ano 2, n. 3, FCT/UNESP, Campus de Presidente Prudente, julho de 1997, p. 187-193.

FERNANDES DE OLIVEIRA, M. M. **A dengue em Curitiba: Uma análise geográfica do surto de 2002**. Curitiba: UFPR, 2003. Monografia de conclusão de curso de graduação em geografia.

GATREL, A. C. **Geographies of health: An introduction**. Oxford: Blackwell Publishers Ltd, 2002.

HAINES, A. Implicações para a saúde. In: LEGGET, J. (Editor responsável). **Aquecimento global** – O relatório do Greenpeace. Rio de Janeiro: Editora da Fundação Getúlio Vargas, 1992, p. 135-148.

HUFTY, A. Les climats urbains. Le climat et la santé. In: DUBREUIL, V.; MARCHAND, J.P. (Org.). **Le climat, l'eau et les hommes** – Ouvrage en honneur à Jean Mounier. Rennes/France: Presses Universitaires de Rennes, 1997. p. 113-128.

INIGUEZ ROJAS, L. Geography and health: themes and perspectives in Latin America. **Cadernos de Saúde Pública**, out./dez. 1998, vol. 14, no. 4, p.701-711.

IPCC – International Panel on Climate Change. www.ipcc.ch/officialdocuments. 2004.

LEGGET, J. (Editor responsável). **Aquecimento global** – O relatório do Greenpeace. Rio de Janeiro: Editora da Fundação Getúlio Vargas, 1992.

MCGREGOR, G. R. and NIEUWOLT, S. **Tropical climatology – An introduction to the climates of the low latitudes.** Chichester/England: John Wiley and Sons, Second edition, 1998.

MENDONÇA, F. Aspectos da interação clima – ambiente – saúde humana: Da relação sociedade-natureza à (in)sustentabilidade ambiental. in: **RA'E GA – O espaço geográfico em análise**, v. 4, n. 4, 2000, pg.85-100.

______________________ **Clima e criminalidade**: Ensaio analítico da correlação entre a temperatura do ar e a criminalidade urbana. Curitiba: Editora da ufpr, 2001.

MENDONÇA, F. et al. A intensificação do efeito estufa planetário e a posição dos países no cenário internacional. **RA´E GA – O espaço geográfico em analise**, n. 5, ano V, Curitiba-PR, Editora da UFPR, 2001. p. 99-124.

MOLION, L. C. B. Efeitos de vulcões no clima. **Caderno de Geociências**, n. 12, out-dez,, 1994, p. 13-24.

MONTEIRO, C. A.F. **Clima e excepcionalismo –** Conjecturas sobre o desempenho da atmosfera como fenômeno geográfico. Florianópolis: Editora da UFSC, 1991.

PAULA, E. V. P**. Relatorio de Pesquisa**. Curitiba-PR: UFPR-PRPPG-IC, 2003. Inédito.

REITER, P. Climate change and mosquito-borne disease. **Environmental health perpective**, volume 109, suplemento 1, março de 2001. p. 141-161.

ROUQUAIROL, M. Z. **Epidemiologia e saúde**. Rio de Janeiro: Medsi, 1993.

.SERRES, M. La phylosofie et le climat. In: **Colloque de Lassay**: "Pollution, atmosphere, ozone, effet de serre, deforestation...". Paris: Larousse, 1989. (pp.50-61).

SORRE, M. A adaptação ao meio climático e bio-social – geografia psicológica. In: MEGALE, J. F. (Org.). **Max Sorre**. São Paulo: àtica, 1984. (Coleção Grandes Cientistas Sociais, 46).

WOODWELL, G. M. Os efeitos do aquecimento global. In: LEGGET, J. (Editor responsável). **Aquecimento global** – O relatório do Greenpeace. Rio de Janeiro: Editora da Fundação Getúlio Vargas, 1992, p. 106-120.

THE POLITICAL ECOLOGY OF WATER UNCERTAINTY AND INEQUALITY: A SOCIOLOGICAL CONTRIBUTION

JOSÉ ESTEBAN CASTRO
Senior Lecturer in Sociology
School of Geography, Politics and Sociology
5th Floor Claremont Bridge Building
University of Newcastle

INTRODUCTION

The challenges posed by water management activities have become increasingly global in scope since the 1970s. This qualitative change is a reflection among other crucial issues of the worsening situation of the world's aquatic ecosystems and of the rising global awareness about the unsustainability characterizing the prevailing model of development. It is also a reflection of the conflicts arising from the protracted social inequalities affecting the access to water for essential human uses and from the inefficiency, ineffectiveness, and inefficacy affecting water management activities in many regions, not just in the poorer countries. In this regard, since the 1970s the international community has launched significant and far-reaching policy initiatives, which include tackling desertification, controlling water pollution, developing conflict prevention initiatives in the light of ongoing and potential water conflicts, monitoring and preventing water-related threats and hazards (ranging from the impact of floods and other disastrous climatic events to the persistence, revival and emergence of water-related diseases), to overcoming the deficiencies and inequalities in the allocation and distribution of water for essential human use in urban and rural areas affecting particularly less developed countries[1].

Unfortunately, despite the important efforts made in recent decades, there is a growing consensus that in many areas of activity the struggle for reducing ecological unsustainability and limiting the negative impact of water-related threats and hazards is being lost in many countries. As an example, let us consider the goal of guaranteeing universal access to essential water and sanitation services, which continues to be a main target of the international community. The goal of universalizing these services was restated in the late 1970s, when the aspiration to provide essential volumes of safe water to every human being on earth by 1990 was endorsed by the United Nations[2].

---

[1] See "Milestones 1972 - 2003: from Stockholm to Kyoto" at UNESCO's Water Portal (http://www.unesco.org/water/wwap/milestones/index.shtml). Among other landmark initiatives, the Conference on Water and the Environment held in Dublin in January 1992 as a preparation meeting for the 1992 UN Conference on Environment and Development (UNCED) (The Earth Summit), Rio de Janeiro, produced a set of Guiding Principles, the "Dublin Principles", and a 40-page Action Agenda which have provided guidelines for water resources development, management and conservation. The UNCED endorsed Agenda 21, which incorporated the Dublin Principles as part of its Chapter 18, "Protection of the Quality and Supply of Water Resources", and came to constitute the baseline for sustainable development, including water resources. On UNCED and Agenda 21, see the web resources at the United Nations Department of Economic and Social Affairs, Division for Sustainable Development (http://www.un.org/esa/sustdev/documents/agenda21/index.htm).

[2] The 1977 UN Water Conference in Mar del Plata, Argentina, which led to the International Drinking Water Supply and Sanitation Decade (1980-1990), declared that everyone has "the right to have access to drinking water in quantities and of a quality equal to their basic needs". The Decade was officially closed by the Global Consultation held in New Delhi in 1990, which produced the New Delhi Statement calling for "some [water] for all rather than more for some" (UN, 1980; 1990).

Unfortunately, and despite significant progress made in many areas, that goal was not achieved. As a matter of fact, current estimates show that at the beginning of the twentieth first century around 17 per cent of the world population still lacks access to safe water while around 40 per cent has no access to adequate sanitation[3]. Moreover, while the goals for 1990 had been to guarantee universal access to essential volumes of water, the current targets as expressed in the UN Millennium Development Goals (MDGs) adopted in 2000-2002 have been reduced to halving the proportion of the world population without access to these services by 2015 (UN, 2000, 2002). Although from a certain perspective the new goals may be more "realistic", in practice this means that the international community is prepared to accept that a large proportion of human beings will continue to suffer disease and death from preventable water-related infections perhaps for decades to come. Furthermore, a recent evaluation of the progress made in relation to the MDGs shows that even these limited objectives will not be achieved in many of the poorest countries (WHO, 2005: 27).

There is increasing recognition that, to a large extent, the main causes for this unacceptable state of affairs are neither technical nor "natural" but rather have, broadly speaking, a social and political nature. This has important implications for water-related academic and techno-scientific endeavours and highlights the crucial need for meaningful and effective interdisciplinarity in the fields of research and practice related to water management. In this regard, although a high degree of sophistication has been reached in the techno-scientific fields related to water, such as hydrology, engineering, or biotechnology applied to water management, we are still very far from plainly understanding the historical, socio-economic, cultural and political processes underpinning the "water crisis". On the one hand, these are long-term processes, which are often impervious to well-intentioned policy efforts directed at enhancing the sustainable management of water in specific areas of activity. On the other hand, and despite increasing global concerns about the trans-temporal transference of environmental risks such as the progressive depletion of water sources threatening large tracts of the planet, in practice water policies directed at tackling these threats have had a very limited impact so far while the rapid deterioration of aquatic ecosystems continues unabated (EUWATER, 2005). This gap between the techno-scientific and socio-political fields of knowledge, we claim, may contribute to explain why the enormous technological progress made in relation to water in recent decades has not been reflected in more sustainable, efficient, effective and efficacious practices of water management. In this connection, it is increasingly recognised that there is a need for establishing a balance between the technical, socio-economic, and political aspects of water management activities, which remain artificially split in practice, and also in much of the specialised literature. Correspondingly, the development of genuinely interdisciplinary approaches that may help in developing water management practices which are socially, politically, and environmentally sustainable, is one the most urgent challenges facing the international community. The aim of this chapter is to contribute in fostering a much needed debate on these issues.

[3]The estimated figures are that 1.1 billion people have no access to safe drinking water and 2.4 billion people lack basic sanitation services (EC, 2002a,b).

WATER UNCERTAINTY, CONFLICT, AND THE GOVERNANCE DEBATE

One particular area that requires urgent efforts towards inter-disciplinary coordination relates to the uncertainties and conflicts emerging around the management of water and water services. Linking water with uncertainty has become increasingly common. For instance, most examples given in current debates on risk and "manufactured uncertainty" are related to different sorts of environmental hazards among which water-related disasters and threats are paramount (e.g., Beck, 1992; 1995; McGranahan et. al., 2001). Perhaps, the most dramatic expression of this development are the political and ideological struggles that have taken place since the 1980s around the impact of the global warming associated with greenhouse gas emissions which has been blamed for a wide array of environmental threats ranging from the increasingly more frequent and destructive typhoons, floods, hurricanes and man-driven desertification processes to the re-emergence of old (once thought eradicated) and new water-related epidemic diseases, including malaria, dengue, and cholera[4].

International concern on these issues has led to a wide variety of efforts aimed at assessing the dimension and scale of these risks in the search for adequate approaches to limit their negative impacts (Kasperson et. al, 1995; 2001; UNEP-UNICEF-WHO, 2002; WHO, 2003a,b; WHO-Europe, 2003; UNESCO, 2003; UNICEF, 2005). One of the common threads across these diverse initiatives is the widespread recognition of the need for "sound" and "effective water governance" for achieving the objectives of the international community in relation to water and water-related services (ADB, 1995; EC, 2000, 2002b; GWP, 2003; Camdessus, 2003; UNDP, 2004). However, despite the apparent agreement on the crucial importance of "governance", as discussed later this debate is marred by conceptual ambiguity and by the very nature of the process of democratic governance. On the one hand, the concept of governance is subject to underlying confrontations between rival and often incompatible intellectual and political traditions to the point that there is no consensus about what governance means, although this is often blurred by the assertive use of the concept in mainstream public policy documents[5]. On the other hand, governance itself is a political process characterized by the democratic confrontation of rival political projects grounded on antagonistic, often irreconcilable, values and principles. We come back to this problem later on.

---

[4] We cannot address these political and ideological confrontations in this brief chapter, but let us illustrate the question by mentioning the fact that the very existence of a qualitative change in the process of global warming as well as its impacts are rejected by powerful scientific and political sectors. A notorious but by no means unique source of denial of the threats posed by global warming are the publications of the Cato Institute (http://www.cato.org), an influential US think tank. Their position regarding such international initiatives like the Kyoto treaty can be summarised in the words of one of their leading environmental scientists: "Let's save citizens' money. Let's allow them to invest in the future, take the risks, and reap the rewards. Better to do that than to tax them to solve a problem that is not all that imminent and will, in any case, resolve itself faster if we just get out of the way (Michaels, 1998). These words were written before Hurricane Katrina, but the line of analysis has not changed, as illustrated by a recent comment by another senior researcher at the Institute: "The Kyoto accord has nothing to do with Katrina: Kyoto would have a negligible impact on global temperatures even if the Europeans complied with it. Nor have hurricanes become stronger and more frequent in recent decades" (Bandow, 2005).

[5] In general, we often refer in this article to "mainstream" policy documents, authors, or institutions. This makes reference in particular to the prevailing public policies that have been the priority of the international financial institutions (e.g. World Bank), aid agencies (e.g. USAID), and OECD countries, including notoriously the policies of deregulation, liberalization, and privatization implemented worldwide since the 1980s. We are aware that there are different approaches within this overall policy trend, and that there is no monolithic position even inside the institutions that have been at the forefront of these policies. Nevertheless, the evidence shows that despite the complexity of current debates, the directionality of public-policy reform programmes continues to be structured around the same principles and the institutions are largely oblivious to criticism and the experience of failure.

In relation to the problem of risk, it can be argued that the ultimate water uncertainty concerns the availability of freshwater for essential human uses. In particular, water needed for agriculture, which currently accounts for about 70 per cent of the world's freshwater consumption (estimates indicate that in developing countries, and also in some developed countries, irrigation uses up to 85 per cent of freshwater abstracted), poses a crucial challenge (World Bank, 2004: 5, 14). For instance, while food experts argue that maintaining food security will demand an increase of 15 to 20 percent in water withdrawals until the year 2025 (UNESCO, 2003; FAO, 2003), environmentalists claim that to stop desertification and preserve already stressed aquatic ecosystems water abstractions should be significantly reduced[6]. It is difficult, with our current level of knowledge and technology, to foresee how we could possibly achieve food security and environmental sustainability simultaneously. In this regard, one of the initiatives being developed to tackle the challenge is the application of biotechnology to water management, which includes the transference of genetic traits to crops for increasing their tolerance to water stress and therefore fostering water security in agriculture (OECD-WPB, 1996, 1999; MSSRF, 1999; WCW, 1999). The latter is a daring attempt at using biotechnology as a tool for water demand management, and is being developed by multinational companies like Monsanto. As the "father of the Green Revolution" and Nobel Laureate Norman Borlaug put it,

> Scientists are gaining the ability to insert genes (into plants) that give biological defense against diseases and insects...and convey genetic traits that enable crops to better withstand drought conditions. With this powerful new genetic knowledge, scientists have the capability to pack large amounts of technology into a single seed (CBI, 2000).

Clearly, not everyone in the scientific community shares Borlaug's optimistic perspective and even leading pro-biotechnology researchers have warned that given the limited knowledge about the physiological, biochemical or genetic determinants of water stress tolerance in plants and micro-organisms more research is needed before this technology can be used to manipulate water stress resistance (WCW, 1999). These concerns have become widespread as a result of the scientific, political, economic and ethical discussions elicited by recent developments in the field of biotechnology —or genetic engineering as some critics prefer to call it. The debate has come to encompass not only the trans-temporal transference of risk associated with the new technology, but also other trans-dimensional consequences of current and prospective actions similar to those arising from the production of new techno-species through diverse combinations of organic and inorganic material ranging from transgenic animals to DNA-based computer systems (Martins, 1996; 1998; 1998a). An important consequence of this development for our debate concerns the question of social awareness and participation in relation to these processes, which is a central component of the process of democratic governance. How are the risks associated with these technologies communicated to the wider public? How does the public participate in the process? What are the mechanisms in place to protect the current and future generations from these risks? These problems are at the heart of the process of governance, although they may seem to be far removed from the daily experience of most people, particularly in developing countries, where more basic needs like securing access to a few litres of water per day constitute an already daunting task.

[6] Dramatic examples of this situation are the Dead Sea in the Middle East (Friends of the Earth, 2006), and the Aral Sea in Central Asia (Altyev, 2006), which are rapidly disappearing as a result of extensive irrigation and water-consuming industrial activities.

In this regard, and moving back to the most basic water needs of human beings, although total freshwater is certainly a crucial and legitimate consideration, a closer examination of the problem shows that availability as such is not (and may not be in the foreseeable future) the most important problem. The evidence suggests that, at least in terms of overall water volumes, there is enough freshwater for every human being[7]. Therefore, it can be argued that the real water uncertainty concerns our capacity to ensure universal access to safe water volumes for basic human needs. In this connection, there is increasing consensus that in most countries the failure to satisfy this basic requirement of life is mainly the result of a crisis in "water governance" (WWF, 2003). Unsurprisingly, this crisis of water governance is being increasingly expressed in the form of intra- and inter-national social and political conflicts around the control and allocation of water and essential water services.

WATER CONFLICTS

The prospect that social and political conflicts over the distribution and allocation of water will increasingly "become a key part of the 21st-century landscape"[8] is regularly restated by international leaders. For instance, in February 2006 the British government issued a dramatic warning about the increased likelihood of "wars over water" and announced that its military forces must be prepared to intervene in "humanitarian disaster relief, peacekeeping and warfare" related to dwindling natural resources, particularly water[9]. This is not entirely surprising given that over the last few decades international security experts have warned that water was becoming more important than oil as a potential source of conflicts around the world (Gleick, 1993, 2000). These authors point to the fact that global freshwater sources are unevenly and irregularly distributed, that some regions of the world are extremely water-short, and that water bodies are often shared by two or more countries. It is estimated that fewer than 10 countries control about 60 percent of the world's freshwater sources, while about 300 river and lake basins and a large number of groundwater aquifers are shared by two or more countries (Ohlsson, 1992; Samson and Charrier, 1997). Understandably, there is agrowing body of literature on "water conflicts", which emphasises the so-called non-military aspects of international security (e.g. elements which can become a target for military action), among which water and water systems rank very high. Likewise, other authors have explored the role of environmental change as a cause of acute conflict, and water issues are a central topic in this literature (Homer-Dixon, 1991).

[7] Of course, this situation varies across regions and countries, but we are considering here the minimum volumes of water needed to satisfy basic needs. For a detailed assessment of global water availability see: UNESCO (2003); UN-Habitat (2003); Gleick et. al. (2004). Also check for updated information at UNESCO's World Water Assessment Programme (www.unesco.org/water/wwap).

[8] Hans van Ginkel, UN Under-Secretary general, at the Stockholm Water Symposium, 13 August 2001 (Financial Times, 14 August 2001, p. 6.).

[9] "Armed forces are put on standby to tackle threat of wars over water", The Independent, London, 28 February 2006.

However, most of this scholarship has tended to focus on actual or potential international confrontations arising from the control and management of water, to the relative neglect of the crucially important intra-national dimension of water conflicts. In particular, governments increasingly face the threat of social and political conflicts arising from growing demands for adequate and regular amounts of safe water, which is an essential factor in ensuring the universal human right to "a standard of living adequate for […] health and well-being"[10]. These conflicts range from peaceful demands to the authorities, demonstration, mass parades, and other forms of civic protest including civil disobedience such as non payment of taxes or water bills, to more direct confrontations involving in the extreme the destruction of property (e.g. destruction of water infrastructure) and even the loss of human lives (normally the lives of the protesters). These forms of water conflict have become widespread in many countries, particularly in Latin America, but have also been recorded across the globe[11].

There is a growing body of literature dealing with these problems, including a number of studies focusing on "water security" that highlight the implications and contradictions inherent in how water management activities treat water either as a "natural resource", as a "commodity", or as an "entitlement" (Webb et. al., 1998). These authors are more concerned with the correlation between "poverty", "gender", and "ethnicity", among other factors, and how these social cleavages impinge on water insecurities affecting large sectors of the world's population. Thus, their work has somecommonalities with the "environmental entitlements approach", which draws on Amartya Sen's work on the links between poverty and famines (Sen, 1981; Mearns, 1995; Gasper, 1993; Gore, 1993).

An alternative framework for the study of water conflicts is provided by political ecology,[12] which is concerned with the study of "ecological distribution conflicts" (Guha and Martínez Alier, 1997: 31). Political ecological approaches have inspired an expanding body of water research (Swyngedouw et. al., 2002) on a number of problems ranging from the links between conflicts over the provision of urban water services and the process of global capital accumulation (Swyngedouw, 1999, 2004) to the multidimensional character of water struggles arising from neoliberal water reform policies (Laurie et. al., 2002; Laurie 2006). Within this broad framework, our own work has focused on the interrelations between intra-national water conflicts and the long-term development of citizenship (Castro, 2006), which focuses on the structural processes underpinning social and political water inequality. As mentioned above, although formally the ultimate water uncertainty is if there is enough freshwater in the world to satisfy the needs of every human being, in fact, the most crucial question concerns the fairness in the access and distribution of water. In relation to this, it is a well documented fact that water poverty and

---

[10] Article 25, Universal Declaration of Human Rights.

[11] Just to mention a few works that deal with the topic: Shiva (2002), Barlow and Clarke (2002), Bouguerra (2003).

[12] I use here a broad definition of "political ecology" but some of the authors considered may not see themselves as political ecologists.

inequality are not the result of "natural" water scarcity[13]. Borrowing Amartya Sen's conclusions about the analogous problem of famine, "scarcity is the characteristic of people not having enough […], it is not the characteristic of there not being enough. While the latter can be the cause of the former, it is one of many causes." (Sen, 1981,: 1) In Sen's perspective, the key for understanding why people starve does not reside in food availability per head given that famines can occur even without any decline in food output or availability per head (Sen, 1990: 37). Rather, he argues that independently of its particular causes (for example droughts, floods, general inflationary pressure, sharp recessionary loss of employment, and so on) a famine reflects widespread failure of entitlements on the part of substantial sections of the population, a situation that can also be the outcome of many different causes (*id*. p. 36.). In short, the main problem is not so much the availability of food, but rather the capacity that individuals and families have to establish command over it, a situation that he termed the "acquirement problem".

Sen's argument about the independence between food output per capita and starvation casts light on the analogous problem of widespread water-related diseases and death caused by the lack of access to essential volumes of safe water. Adequate volumes of water availability (or even water distribution) per head in a given country or region does not ensure that individuals and families have a fair and adequate access to water services. For instance, the average volume of water supplied daily in the Mexico City Metropolitan Area (MCMA) is around 300 litres per capita per day [pcpd], well above the internationally accepted minimum standard of 100 litres and certainly above the minimum daily requirements for human survival. However, while some areas of the city record levels of pcpd water consumption averaging over 1000 litres, millions of metropolitan dwellers located in the poorer neighbourhoods have access to an average of 5-10 litres pcpd during long periods, and the water available to them is often unsafe for personal consumption and much more expensive (Castro, 2006).

Despite the formal categorization of water as a public good that has oriented the provision of public water and sanitation services since the late nineteenth century in the Western world, in practice –and particularly for the large share of the poor in less developed countries– water has become one of the essential commodities that individuals and families need to secure for survival. Unfortunately, the formal recognition of the right to water does notensure access to this vital resource on a regular basis. Formal rights can be bestowed on people, for instance the right to shelter, to health care, or, to safe water services, but this does not guarantee that people will have a sustained provision of these goods and services. Protracted structural processes continue to be the main factor underpinning water poverty and inequality and the ensuing social and political confrontations that take the form of intra-national water struggles.

[13] The evidence shows that water stress and conflict often happen in a context of abundant water resources. For example, Guayaquil, the largest city in Ecuador, is crossed by the fresh waters of the river Guayas, but 35 per cent of the population has no access to safe water, and the city is subject to chronic water shortages. A protracted structure of social inequality, clientelist politics, and collusion between the authorities and private water entrepreneurs are among the main factors that explain the deficiencies of the city's water systems which underpin much social and political unrest. The description can be easily generalized to many cities in less developed countries (see, for instance, Swyngedouw, 1999, 2004; McGranahan et. al, 2001; UN-Habitat, 2003; Castro, 2006).

WATER CONFLICT AS AN OBJECT OF KNOWLEDGE

The production of relevant knowledge about water conflicts requires the interdisciplinary exploration of the interlinks between physical-natural and socio-political processes. Although the evidence shows that water conflicts are largely autonomous from physical-natural and technological conditions, it has been very difficult to achieve interdisciplinary explanations that bring out the interwoven character of the social and "natural" processes involved. In addition to the already mentioned slow progress in the production of knowledge about water in the social sciences, there is a high fragmentation of the existing knowledge along the lines of entrenched "epistemic cultures" that continue to develop largely unconnected from each other (Knorr Cetina, 1999). The study of water conflicts offers both an excellent example of this fragmentation and an opportunity to develop genuine interdisciplinary approaches to the problem.

In this connection, in our studies of water conflicts in Mexico during the 1980s and 1990s we explored how the main *epistemic subjects*[14] involved in water management activities understand and explain water conflicts (Castro, 1995; 2006). For the sake of the analysis we derived from the empirical research the existence of three epistemic subjects: *the water expert*, mainly water engineers and others directly involved in the techno-scientific aspects of water management, *the water functionary*, who are members of the bureaucratic and policy-institutional apparatuses in charge of water management activities, and the *critical social scientist*, referring broadly to the work of social scientists producing knowledge about water from a critical perspective such as contemporary political ecology[15]. The evidence suggests that when these different subjects address the question of "water conflicts" they do so from very distinctive and often unconnected perspectives. Each of these subjects is characterized by a particular approach, a distinctive rationality, and an epistemic structure that underpins their construction of very different observables[16] to identify and explain "water conflicts". Table 1 illustrates schematically the diverse paths of each epistemic subject in their understanding of "water conflicts".

[14] Epistemic subjects understood as holders and producers of distinctive bodies of knowledge in relation to "water" as an object of scientific enquiry, who may be embodied in institutions, in working teams as well as in individuals. We borrow the concept of epistemic subject from Jean Piaget (Piaget, 1971: 138-140).

[15] Here "critical" stands in opposition to "mainstream" or "conservative" (conservative of the status quo) social scientists. We come back to this later on in our brief discussion of the governance debate.

[16] The concept of 'observable' encapsulates an epistemological position: the object of knowledge is not given but it is rather the result of the action of knowing carried out by a particular subject. Both the action and its outcome, the observable, are determined by preexisting cognitive structures. See Piaget (1978), pp. 43-6; (1977), pp. 342-6.

Table 1 - Water conflicts and epistemic subjects

Epistemic subject	Rationality	Observables	
Water expert	Techno-scientific	Quantitative variables Physical-natural and technical conditions and drivers	"Water conflicts"
Water functionary	Policy-administrative	Bureaucratic norms Electoral and party-political considerations	
Critical social scientist	Socio-political	Power configurations Structural inequalities	

For instance, when the Mexican water experts elaborating the 1981 National Hydraulic Plan tried to predict "conflicts over water in the main Mexican cities" until the year 2000, they grounded their analysis on quantitative observables (SARH, 1981: 50). They were interested in the interactions between water availability, demand, supply, consumption, cost and population, urban and industrial growth over the next two decades. They tried to predict urban water conflicts from a techno-scientific perspective, whereby conflict was conceptualized as the result of the lack of expected correspondence between quantitative variables. In contrast, when the functionaries think about water conflicts they normally work with very different observables. They work within a rational framework marked by policy-bureaucratic and often (in Mexico at least) party-political interests (e.g. the impact of water conflicts on electoral prospects) and, therefore, their observables are for instance the recurrent events of urban social protest over the poor quality of the water services or the civil disobedience of water users who have decided not to pay their bills in protest for a recent hike in the tariff. A graphical example comes to my mind: in a conference about water problems in Mexico City in December 2003 the former Under-Secretary of Regulation at the Secretariat for Environment and Natural Resources (SEMARNAT) was interrupted at the start of his presentation by an urgent phone call: indigenous peasants had just taken his office in protest against a water-transfer scheme that threatened to further disrupt water resources in their region[17]. As the example illustrates, the water functionary must deal with processes that fall outside the technical domain of the expert, such as "popular discontent", "the social and economic characteristics of the population" that create conditions for water troubles, or the inherent contradictions between "the economic, social, psychological and environmental values of water" (SARH, 1981: 14).

In turn, as already explained, the critical social scientist is concerned with the daunting task of making observable the intertwining between the social regularities and physical-natural processes that are at the heart of water conflicts. For instance, and remaining with the Mexican example, from the socio-political rationality of this subject one of the key areas of inquiry into the roots of water conflict are the socio-economic mechanisms that drive the process of inclusion/exclusion in relation to the access to safe and adequate water services. In the Mexico City Metropolitan Area two of the key mechanisms have been the status of land tenure and the technical-geographical feasibility for the provision of the services: to gain access to networked water services people must have a legal title to their land, to be "regularized", borrowing from the policy jargon. Regularization also refers to the technical feasibility of bringing the services to the neighbourhood[18]. On the basis of these requirements, the population is categorized into "regularized" and "non-regularized", although the actual outcomes of the inclusion/exclusion process are largely subject to the arbitrariness of the authorities and other power holders within the communities. In the last analysis, though, these socio-economic regularities and their legal-formal facade determine who is and who is not entitled to have formal access to the water services. Thus, a dense weave of social interactions, among which property relations are paramount, operates as the mechanism governing the inclusion or exclusion of individuals and families from accessing water services. However, this fundamental divide is clouded in the undifferentiated, abstract-universal jargon of the water authorities that address people as "water users", "service claimants", "customers", and so on, and if we remain within the framework of water experts and functionaries the social character of water management remains unobservable. More importantly, crucial factors underpinning the emergence of "water conflicts" are overlooked or at best reduced to physical-natural or technical determinations, and the inclusion of the social dimension in mainstream research and policy continues to be little more than whitewashing and lip servicing.

As stated before, there is increasing recognition that the "water crisis", of which intra-national water conflicts are just one expression, is mainly a crisis of water governance. Unfortunately, although the use of the concept of "governance" often assumes a shared understanding, in fact there exist underlying confrontations between rival theoretical bodies of knowledge and political and cultural traditions for which governance has entirely different meanings. Moreover, much of the mainstream debate on the topic has been aimed at depoliticising the processes under discussion and presenting them as mainly (or even merely) "technical" in nature, probably in the belief that depoliticising water management activities would provide opportunities for abating or at least controlling water conflicts. For instance, in specific reference to water management, governance has been defined as the "range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services" (GWP, 2003). This is a useful definition in practical terms,

[17] The author was present in that session but I prefer to keep the name of the functionary anonymous. It can be said that his reaction reflected the fact that such event was not entirely unexpected and was certainly not surprising: he smiled and went on with his talk. This is a common feature of Mexican water politics.

[18] It is estimated that about ten million people in the MCMA, especially in the State of Mexico, live in urban areas developed illegally. Most of these settlements are also located in land considered unsuitable for the provision of public services (Rowland *et. al.*, 1996: 191).

but the emphasis here is placed on the institutional arrangements characterizing water management activities, while the relationship between these arrangements and socio-political processes is lost. In this regard, we argue that although the value of overcoming conflict situations and creating an "enabling environment" for achieving the goals set by the international community should not be overlooked, this cannot be achieved by depoliticising the processes encapsulated in the concept of "governance". To this controversial subject we turn next.

THE GOVERNANCE DEBATE

The concept of governance was first developed in economic analysis for the study of corporations and later adopted in political science to address the emergence of new forms of government and regulation beyond traditional state hierarchies and market systems (Hirst, 1994; Held, 1995; Amin, 1997). In relation to environmental issues, a large literature has been developed reflecting the ongoing debate about the transformations undergone in the field of "natural resources management" since the 1980s. Perhaps, one of the key elements in this body of literature —largely inspired by the neoliberal perspective on state reform, although not reducible to the neoliberal framework— has been the acknowledgement of the multi-layered and multi-sector character of management regimes. According to these authors, "governance" systems are composed by the classic forms of vertical authority embodied in the state (principle of hierarchy) in different combinations with the characteristic management regimes of the private sector (driven by market competition) and "civil society" (the voluntary sector driven by reciprocity)[19]. Accordingly, the model of multi-scale governance would be characterised by a combination of hierarchical structures, participatory dynamics, associative action, and market mechanisms, and would be based mainly on a culture of dialogue, negotiation, active citizenship, subsidiarity, and institutional strengthening (EC, 2001).

In this regard, a crucial aspect of the governance debate is the relation between the "manufactured uncertainties" characterising what the German sociologist Ulrich Beck has termed the "risk society" (Beck, 1992; 1992b; 1998) and citizenship. Among other developments characterizing the risk society it is worth highlighting the progressive inflation of citizenship rights and duties, which now include "technological", "ecological", and "environmental" citizenship, just to mention the most relevant for this discussion (Frankenfeld, 1992; Steenbergen, 1994; Newby, 1996; Mehta, 1998). This debate has contributed to further specifying and expanding the traditional categories of citizenship (civil, political and social rights) as laid out by the British sociologist T. H. Marshall (Marshall, 1992). Nevertheless, there are important questions concerning governance and citizenship in the risk society which remain either obscure, unanswered or overlooked in the literature. For instance, who are (would be) the social and political subjects (the citizens) of the risk society? If risk is about awareness of ever more sophisticated and multifarious hazards and dangers, and if the subjects of the risk society are to be defined in terms of their risk consciousness, does not it mean that the risk society also entails more sophisticated and multifarious forms of production and reproduction of social inequality? How could a fair and universal access to participation in the vital information processes required to grasp a "safety" level of risk consciousness be ever reached in the present (and, presumably,

[19] UNDP (1997); Picciotto (1997) See also the concept of "interest governance" proposed by Streeck and Schmitter in relation to what these authors consider a fourth model of social order, the associative model, which would be at work alongside the traditional orders embodied in the state (hierarchy), the community (participatory dynamics) and the market (free competition) (Streeck and Schmitter, 1985).

future) context of increasing quantity and complexity of the information units? And, would not it also mean that, in the foreseeable scenarios, both the actual impact of hazards and dangers and the widening spectrum of possible choice trajectories will follow a (predictably) much skewed pattern of distribution, as already suggested by the actual impact of most large-scale disasters such as floods, droughts, and preventable water-related epidemics? In this regard, the new social divisions characterizing the risk society resemble what Manuel Castells has called the “network society”, a new mode of development where “global networks of wealth and power connect nodal points and valued individuals throughout the planet, while disconnecting, and excluding, large segments of societies, regions, and even entire countries” (Castells, 1996: 24-25).

In this perspective, the contribution made by the mainstream governance approach to the analysis of intra-national conflicts —often the result of people’s reactions against exclusion and social inequality— has been very modest. In particular, if one remains within the scope of this literature it is very difficult to deepen the analysis of conflicts beyond their techno-bureaucratic dimensions. Moreover, it can also be argued that the main contribution made by this literature has been the lending of a theoretical —perhaps even ideological— framework to the unprecedented expansion of market mechanisms to almost all spheres of human interaction, including environmental management, and water management in particular. Thus, despite the fact that the mainstream governance debate formally acknowledges the increasingly multi-scale and multi-polar character of management regimes, in the last analysis this approach has privileged market mechanisms and their agents, which have been allocated a leading role among the other components of the governance complex. To a large extent, it can be argued that the consensus emerging from this literature has contributed to legitimating the particular socio-economic and political processes that have fostered the pre-eminence of capitalist competition over the other governance realms such as the state or civil society, in the context of a technocratic model of development. Perhaps the best example of this process can be found in the consensus generated by this literature in favour of the privatisation (that is, the sanction of private property rights) and commodification of nature as key instruments for controlling risks such as the depletion of natural resources (water, forests, air, fisheries, etc.). In the particular case of water services, since the 1990s the policies of liberalization, de- and re-regulation and privatisation of water utilities have exacerbated existing intra-national conflicts or even generated new ones around the globe (Castro and Laurie, 2004). In Latin America, Africa, and Asia, for instance, open opposition to these policies has been widespread and has become one of the symbols of what some authors have termed “counter-hegemonic globalization” (Sousa Santos, 2005).

Figure 1 - Protests against water services privatization at the 2003 World Water Forum in Porto Alegre

The mainstream understanding of governance ignores the basic fact that governance is a political process predicated on the ongoing confrontation between rival political projects. Governance results from the interaction between the key power holders, the state, large businesses, political parties, civil and other organizations representing sectoral interests (e.g. workers' unions, religious organizations, peasant movements, etc.), international agencies (e.g. international financial institutions and other agents of the process of "global governance"), and other relevant actors. Although the process of governance has been often presented in the literature as a balanced partnership between equals, in fact there are fundamental asymmetries of power and knowledge between the actors which determine the characteristics and direction of the overall process. Moreover, the large majorities outside the formal process of governance can also exercise a powerful influence, as illustrated precisely in relation to intra-national water conflicts. Such policies as the commodification of essential water and sanitation services are often implemented with almost complete disregard for the opinions, values, and preferences of the population, in the understanding that people must accept the decisions already taken by national and international technocrats. However, this prevailing approach to water policy completely neglects the basic fact that the underlying social processes involve the development of substantive citizenship and democracy, and the struggle for meaningful social participation and control over decision-making processes. In the case of water, this involves for instance social and political confrontations around how water and essential water services are to be governed, by whom, and for whom. These problems are at the heart of the process of counter-hegemonic, truly democratic, water governance, and they underpin to a large extent the worldwide mushrooming of intra-national water conflicts.

CONCLUSION

Our conclusion draws on the perspective of the third epistemic subject, the critical social scientist, which stems from a long-standing tradition in the social sciences concerned with developing the appropriate cognitive structures for making observable such structural regularities as cyclical social conflicts —whether in relation to water or not. However, the task of elaborating adequate explanations of the causes and consequences of water uncertainty and inequality requires the development of further inter-disciplinary coordination between the intellectual domains of, for instance, water engineers, hydrologists, and social scientists, which to date has been a slow and relatively fruitless endeavour. The existing gap between the intellectual domains developed by techno-scientists and critical social scientists concerned with social inequality and struggle remains a major obstacle to achieve this goal. The persistence of this obstacle continues to hamper our full understanding of "water conflicts'', and consequently diminishes the chances we may have to avoid their negative consequences, which almost systematically affect the most vulnerable sectors of the population.

In this connection, there is a need for adopting a critical perspective of the undifferentiated character assigned in the official jargon of the water authorities to the population as claimants, users or consumers, which neglects the existence of fundamental social divisions underpinning water insecurity and inequality. Thus, a truly inter-disciplinary approach to the problem must strive to make observable those processes that create and reproduce the structural socio-economic inequalities that continue to preclude a large sector of the world's population from accessing essential basic services, and subject the most vulnerable to disproportionately unequal negative impacts of water related threats and hazards. This kind of approach requires addressing "water conflicts" as an object of knowledge on its own right, which constitutes a crucial step towards transforming the unacceptable reigning conditions. Our work seeks to make a contribution towards this daunting venture by fostering higher levels of coordination between the different cognitive structures and epistemic cultures involved in the production of knowledge about water.

ACRONYMS

ADB	Asian Development Bank
CBI	Council for Biotech Information
DNA	Deoxyribonucleic acid
EC	European Commission
EUWATER	European Network for a New Water Culture
FAO	Food and Agriculture Organization
GWP	Global Water Partnership
MCMA	Mexico City Metropolitan Area
MDGs	Millennium Development Goals
MSSRF	M.S. Swaminathan Research Foundation
OECD-WPB	Organization for Economic Co-operation and Development – Working Party on Biotechnology
SARH	Secretariat of Agriculture and Hydraulic Resources (Mexico)
SEMARNAT	Secretariat of Environment and Natural Resources (Mexico)
UNCED	United Nations Conference on Environment and Development (The Earth Summit 1992)
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WCW	World Commission on Water for the 21st Century
WHO	World Health Organization
WWF	World Water Forum

REFERENCES

Amin, A. (1997), Beyond Market and Hierarchy: Interactive Governance and Social Complexity, Cheltenham: Elgar.

Altyev, T. (2006), "Address of the Chairman of the Executive Committee of the International Fund on the Aral Sea (http://enrin.grida.no/aral/aralsea/english/obr/obr.htm) (accessed May 2006).

Asian Development Bank (ADB) (1995), "Governance: sound development management", Manila: ADB.

Bandow, D. (2005), "Federal failure in New Orleans", Cato Institute (8 September 2005) (http://www.cato.org/pub_display.php?pub_id=4638).

Barlow, M., and T. Clarke (2002), Blue Gold: The Fight to Stop the Corporate Theft of the World's Water, New York: New Press.

Beck, U. (1992), Risk Society, London: Sage.

Beck, U. (1992b), "From industrial society to risk society", in Theory, Culture and Society, vol. 9, #1, pp. 97-123.

Beck, U. (1995), Ecological Enlightenment, Atlantic Highlands, N. J.: Humanities Press.

Beck, U. (1998), "Politics of risk society", in J. Franklin (ed.) The Politics of Risk Society, Cambridge and Oxford: Polity Press, pp. 9-22.

Bouguerra, M. L. (2003), Les Batailles de l'Eau. Pour un Bien Commun de l'Humanité, Paris : Les Editions de l'Atelier.

Camdessus, M. (Chair) (2003), Financing Water for All. Report of the World Panel on Financing Water Infrastructure, World Water Council, Global Water Partnership, (http://www.worldwatercouncil.org/download/CamdessusReport.pdf).

Castells, M. (1996), The Rise of the Network Society. The Information Age: Economy, Society and Culture, vol. I, Cambridge and Oxford: Blackwell.

Castro, J. E. (2006), Water, Power, and Citizenship. Social Struggles in the Basin of Mexico, Houndmills, Basingstoke and New York: Palgrave-Macmillan.

Castro, J. E. (1995), "Decentralization and modernization in Mexico: the case of water management", Natural Resources Journal, , Vol. 35(3), pp.: 461-487.

Castro, J. E. and N. Laurie (2004), "Cross-comparative report on the Socio-political and Cultural Dimension", PRINWASS Research Project, European Commission, Fifth Framework Programme, INCO-DEV, Contract PL ICA4-2001-10041 (http://users.ox.ac.uk/~prinwass/).

Council for Biotech Information (CBI) (2000), "Biotechnology Can Help Protect The Environment", Reference No.: 3229, 24 April 2000, Council For Biotech Information http://www.biotechknowledge.com/showlib.php3?uid=3229&country=us.

European Commission (2000), "The European Community's Development Policy. Communication from the Commission to the Council and the European Parliament", (http://europa.eu.int/eur-lex/en/com/cnc/2000/com2000_0212en01.pdf).

European Commission (2001), "Achieving sustainable and innovative policies through participatory governance in a multi-level context", Progress Report, Framework V – Programme Project, Brussels: European Commission.

European Commission (2002a), EU Water Initiative: Water for Life. Health, Livelihoods, Economic Development, Peace, and Security, Brussels (http://europa.eu.int/comm/research/water-initiative/index_en.html).

European Commission (2002b) Water Management in Developing Countries: Policy and Priorities for EU Development Cooperation. Communication from the Commission to the Council and the European Parliament, (http://europa.eu.int/eur-lex/en/com/cnc/2002/com2002_0132en01.pdf).

European Network for a New Water Culture (EUWATER) (2005), European Declaration for a New Water Culture, Saragossa: New Water Culture Foundation: EUWATER (http://www.unizar.es/fnca/euwater).

Food and Agriculture Organization (FAO) (2003), Review of World Water Resources by Country (Aquastat), Rome: FAO (http://www.fao.org/waicent/faoinfo/agricult/agl/aglw/aquastat/main/index.stm).

Frankenfeld, Ph. (1992), Technological Citizenship: a Normative Framework for Risk Studies, in Science, Technology and Human Values, Vol. 17, pp. 459-484.

Friends of the Earth (2006), Projects – the Dead Sea (http://www.foeme.org/projects.php?ind=21) (accessed May 2006).

Gasper, D. (1993), "Entitlements analysis: relating concepts and contexts," in Development and Change, Vol. 24: pp. 679-718.

Gleick, P. H., N. L. Cain, D. Haasz, Ch. Henges-Jeck, C. M. Hunt, M. Kiparsky, M. Moench, M. Palaniappan, V. Srinivasan, and G. H. Wolff (2004), World's Water 2004-2005. The Biennial Report on Freshwater Resources, Washington DC: Island Press.

Gleick, P. H. (2000), "Water conflict chronology", Oakland: Pacific Institute for Studies in Development, Environment and Security.

Gleick, P. H. (1993), "Water and conflict: fresh water resources and international security", International Security, Vol. 18, #1, pp. 79-112.

Global Water Partnership (2003), "Effective Water Governance. Learning from the Dialogues", (http://www.gwpforum.org/gwp/library/Effective%20Water%20Governance.pdf), GWP.

Gore, C. (1993), "Entitlement relations and 'unruly' social practices: a comment on the work of Amartya Sen," in Journal of Development Studies, Vol. 29 #3, pp. 429-460.

Guha, R. and J Martínez Alier (1997), Varieties of Environmentalism. Essays North and South, London: Earthscan.

Held, D. (1995), Democracy and the Global Order: from the Modern State to Cosmopolitan Governance, Cambridge: Polity Press.

Hirst, P. (1994), Associative Democracy: New Forms of Economic and Social Governance, Cambridge: Polity Press.

Homer-Dixon, Th. F. (1991), "On the threshold: environmental changes as causes of acute conflict", in International Security, vol. 16, #2, pp. 76-116.

Kasperson, J. X., and R. E. Kasperson (eds.) (2001), Global Environmental Risk, Tokyo, New York and Paris: United Nations University Press & Earthscan.

Kasperson, J. X., R. E. Kasperson, and B. L. Turner II (eds.) (1995), Regions at Risk. Comparison of Threatened Environments, Tokyo, New York, Paris: United Nations University Press.

Knorr Cetina, K. (1999), Epistemic Cultures. How the Sciences Make Knowledge, Cambridge, Mass., and London: Harvard University Press.

Laurie, N., Radcliffe, S. and R. Andolina, R. (2002), "The new excluded 'indigenous'?: The implications of multi-ethnic policies for water reform in Bolivia", in R. Seider (ed.), Multiculturalsim in Latin America. Indigenous Rights, Diversity and Democracy, Houndmills, Basingstoke and New York: Palgrave-Macmillan, pp. 252-276.

Laurie, N. (ed.) (2006), Special Issue on "'Pro-poor' water: past present and future scenarios", in Geoforum, (in press).

Marshall, T.H. [1950] (1992), "Citizenship and social class", in T.H. Marshall and T. Bottomore, Citizenship and Social Class, London and Concord, Mass.: Pluto Perspectives, pp. 3-51.

Martins, H. (1996), Hegel, Texas e Outros Ensaios de Teoria Social, Lisbon: Século XXI.

Martins, H. (1998), "Technology, modernity, politics", in J. Good and I. Velody, The Politics of Postmodernity, Cambridge: Cambridge University Press, pp. 150-181.

Martins, H. (1998a), "Risco, incerteza e escatologia —reflexões sobre o *experimentum mundi* tecnológico em curso", in Episteme, vol. 1, #1, pp. 99-121.

McGranahan, G., P. Jacobi, J. Songsore, Ch. Surjadi, and M. Kjellén (2001), The Citizens at Risk. From Urban Sanitation to Sustainable Cities, London: Earthscan.

Mearns, R. (1995), "Environmental entitlements: towards empowerment for sustainable development," in N. Singh, and V. Titi (eds.), Empowerment: Towards Sustainable Development, London: Zed Books.

Mehta, M. (1998), "Risk and decision making: a theoretical approach to public participation in techno-scientific conflict situations", in Technology and Society, Vol. 20, #1, pp. 87-98.

Michaels, P. J. (1998), "The consequences of Kyoto", in Policy Analysis, No. 307, Cato Institute (http://www.cato.org/pub_display.php?pub_id=1167&full=1).

M.S. Swaminathan Research Foundation (MSSRF) (1999), "Biotechnology and water security", Chennai, Madras, India, http://www.mssrf.org.sg/d99-biotech-water.html.

Newby, H. (1996), "Citizenship in a green world: global commons and human stewardship", in M. Bulmer and A. Rees (eds.), Citizenship Today. The Contemporary relevance of T. H. Marshall, London: UCL Press, pp. 209-221.

Organization for Economic Co-operation and Development (OECD) – Working Party on Biotechnology (WPB) (1999), Health Policy Brief. Molecular Technologies for Safe Drinking Water, http://www.eawag.ch/publications_e/proceedings/oecd/Proceedings.html, Paris: OECD.

Organization for Economic Co-operation and Development (OECD) – Working Party on Biotechnology (WPB) (1996), Biotechnology for Water Use and Conservation. The Mexico '96 Workshop, Paris: OECD.

Ohlsson, L. (ed.) (1992), Regional Case Studies of Water Conflicts, Göteborg: Peace and Development Research Institute (PADRIGU), University of Göteborg.

Piaget, J. (1978), The Development of Thought. Equilibration of Cognitive Structures, Oxford: Basil Blackwell.

Piaget, J. (1977), The Grasp of Conciousness, London: Routledge and Kegan Paul.

Piaget, J. (1971), Structuralism, London: Routledge and Kegan Paul.

Picciotto, R. (1997), "Putting institutional economics to work: from participation to governance" in Ch. K. Clague (ed.), Institutions and Economic Development: Growth and Governance in Less-developed and Post-socialist Countries, Baltimore and London: John Hopkins University Press, pp. 343-67.

Rowland, A. and P. Gordon (1996), "Mexico City: no longer a leviathan?," in A. Gilbert (ed.) The Mega-City in Latin America, Tokyo and New York: United Nations University Press, pp. 173-202.

Samson, P., and B. Charrier (1997), "International freshwater conflict. Issues and prevention strategies", Geneva: Green Cross International.

Secretaría de Agricultura y Recursos Hidráulicos (SARH), Comisión del Plan Nacional Hidráulico (1981), Plan Nacional Hidráulico, Mexico City: SARH.

Sen, A. (1990), "Food, economics, and entitlements," in J. Drèze and A. Sen (eds.), The Political Economy of Hunger, Oxford: Clarendon Press, pp. 34-52.

Sen, A. (1981), Poverty and Famines. An Essay on Entitlement and Deprivation, Oxford: Clarendon Press.

Shiva, V. (2002), Water Wars. Privatization, Pollution, and Profit, Cambridge MA: South End Press.

Sousa Santos, B de, and C. A. Rodríguez-Garavito (2005), "Beyond neoliberal governance: The World Social Forum as subaltern cosmopolitan politics and legality", in B. de Sousa Santos and C. A. Rodríguez-Garavito (eds.), Law and Counter-Hegemonic Globalization: Toward a Subaltern Cosmopolitan Legality (http://www.ces.fe.uc.pt/bss/documentos/chapter2.pdf).

Steenbergen, B. (1994), "Towards a global ecological citizen", in B. Van Steenbergen (ed.), The Condition of Citizenship, London: Sage, pp. 141-152.

Streeck, W. and Ph. Schmitter (1985), Private Interest Government, London: Sage.

Swyngedouw, E. A. (2004), Social Power and the Urbanization of Water: Flows of Power, Oxford: Oxford University Press.

Swyngedouw, E. A. (1999) Flows of Power: Nature, Society and the City, Oxford: Oxford University Press.

Swyngedouw, E. A., Maria Kaïka, and J. E. Castro (2002), "Urban water: a political-ecology perspective", in Built Environment, Vol. 28, #2, pp. 124-137.

United Nations (UN) (2002), "Key Commitments, Targets and Timetables from the Johannesburg Plan of Implementation", World Summit on Sustainable Development, Johannesburg (http://www.johannesburgsummit.org/html/documents/summit_docs/2009_keyoutcomes_commitments.doc).

United Nations (UN) (2000), Millennium Declaration, New York: UN (http://www.un.org/millennium/summit.htm).

United Nations (UN) (1990), "The New Delhi Statement: 'Some for all rather that more for some'", Global Consultation on Safe Water and Sanitation for the 1990s, New Delhi, (10-14 September 1990): UNDP and the Government of India.

United Nations (UN) (1980), International Drinking Water Supply and Sanitation Decade: Report of the Secretary General, New York: UN.

United Nations Children's Fund (UNICEF) (2005), Water, Environment, and Sanitation (http://www.unicef.org/wes/).

United Nations Development Programme (UNDP) (2004), Water Governance for Poverty Reduction. Key Issues and the UNDP Response to Millennium Development Goals, New York: UNDP.

United Nations Development Programme (UNDP) (1997) Governance for Sustainable Human Development, New York: UNDP (http://magnet.undp.org/policy/default.htm).

United Nations Environment Programme (UNEP), United Nations Children's Fund (UNICEF), and World Health Organization (WHO) 2002, Children in the New Millennium: Environmental Impact on Health, (http://www.who.int/water_sanitation_health/hygiene/settings/millennium/en/index.html).

United Nations Educational, Scientific, and Cultural Organization (UNESCO) (2003), World Water Development Report, Paris: UNESCO Publishing.

United Nations - Habitat (2003), Water and Sanitation in the World's Cities: Local Action for Global Goals, London: Earthscan.

Webb, P. and M. Iskandarani (1998), "Water insecurity and the poor", Discussion Papers on Development Policy, Bonn: Center for Development Research.

World Bank (2004), Water Resources Sector Strategy. Strategic Decisions for World Bank Engagement, Washington: The World Bank (http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2004/06/01/000090341_20040601150257/Rendered/PDF/28114.pdf).

World Commission on Water for the 21st Century (WCW), The Biotechnology Panel (1999), "Inter-disciplinary Dialogue on "Climate, Biotechnology and Food and Water Security"", Chennai, Madras, India, February 4-5, 1999.

World Health Organization (WHO) (2005), Health and the Millennium Development Goals, Geneva: WHO (http://www.who.int/mdg/publications/MDG_Report_08_2005.pdf).

World Health Organization (WHO) (2003a), "Emerging Issues in Water and Infectious Disease", Geneva: WHO (http://www.who.int/water_sanitation_health/emerging/en/).

World Health Organization (WHO) (2003b), "Health in Water Resources Development", Geneva: WHO (http://www.who.int/water_sanitation_health/resources/en/).

World Health Organization – Regional Office for Europe (WHO-Europe) (2003), "Dealing with uncertainty: how can the precautionary approach help protect the future of our children?", in Fourth Ministerial Conference on Environment and Health, Stockholm, 26-27 June 2003 (http://www.who.dk/document/eehc/2ndigoprepmeet_11.pdf).

World Water Forum III (2003), Proceedings, Kyoto: WWF.

POTENTIAL IMPACT OF CLIMATIC CHANGES IN THE ELECTRO-ENERGETIC SECTOR

AFONSO HENRIQUE MOREIRA SANTOS
Professor of Universidade Federal de Itajubá and
Researcher of Centro de Excelência em Recursos Naturais e Energia – CERNE

ADRIANA SANTOS PEIXOTO CORRÊA

ANA CAROLINA SILVEIRA PERICO

LEOPOLDO UBERTO RIBEIRO JUNIOR

MARCO AURÉLIO RAPHUL AZEVEDO GARCIA
Researches of Centro de Excelência em Recursos Naturais e Energia – CERNE

INTRODUCTION

The global average temperature of the planet in the surface has elevated from 0.6 to 0.7°C during the last 100 years, with accentuated change since the sixties. The last decade has presented the three hottest years of last 1000 years of the World recent history.

Today, by means of the systematic analysis of the Intergovernmental Panel on Climate Change (IPCC), there is a reasonable consensus that the global warming observed in the last 100 years is caused by accumulated emissions of GHG (Green-House Gases), since the Industrial Revolution, and not by eventual natural variability of climate. (NAE, 2005)

The climate global change has being manifested of different ways, detaching the global warming, the higher frequency and intensity of extreme climatic events, changes in the rain systems, perturbations in the marine flows, retraction of glaciers, and elevation of the sea levels. It is required the immediate implantation of measures minimizing these emissions, in order to avoid consequences still more serious for energetic and hydric sectors, which will be the central topic of this job.

THE CLIMATIC CHANGES AND BRAZIL

Brazil and the other developing countries are the most vulnerable to climate changes, because they have lower capacity of responding to the variability and their economy is highly associated to the natural resources.

In figures 1 to 3, based in *Economy & Energy*, the balances of GHG emissions for Brazil, including the subdivision by sectors, are presented.

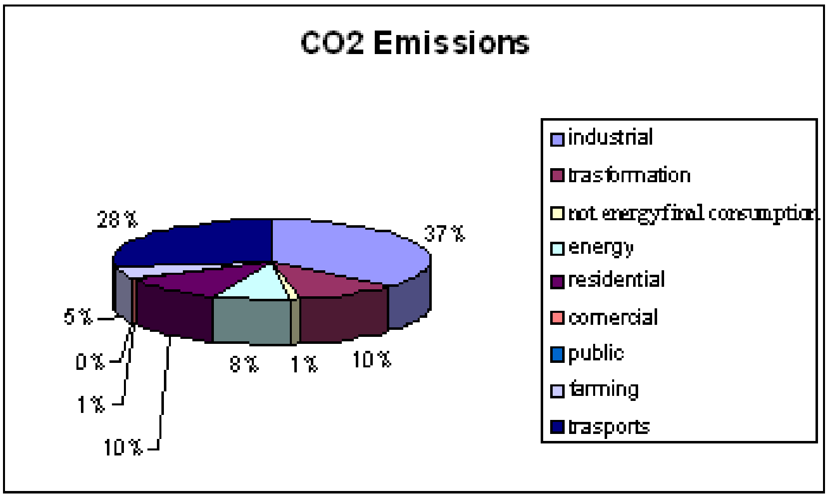


Figure 1 – Emissions of Carbon dioxide (excluding biomass) by sector for year 2002
Emissions Caused by greenhouse effect associates to the use of the energy

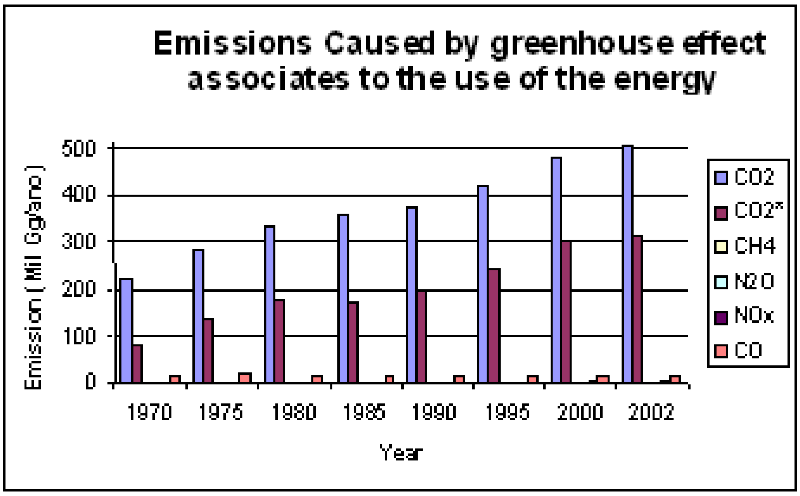


Figure 2 – Emissions causing Green-house Effect, associated to the use of energy

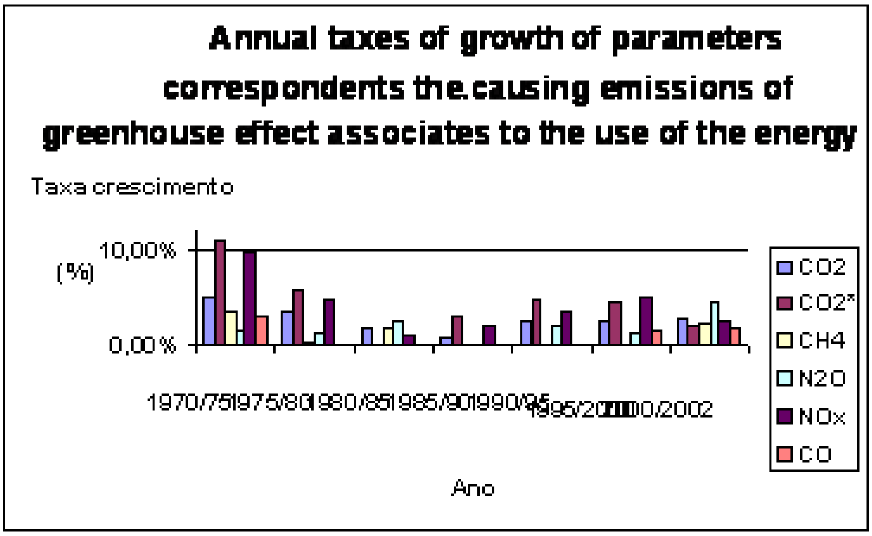


Figure 3 – Rates of annual growing

DEMAND OF ENERGY

During the last decades, with the great technological advancement, the demand for energy is growing in a significant way. The studies of EPE – Company of Research and Energy (2005), show that the elasticity of income of the electric power consumption in relation to PIB - Gross National Product is greater than 1, coming to the value of 3.75 during the Eighties. The figure 4 compares the elasticity-income of the energy consumption in Brazil with other countries in the world. It shall be noticed that the value of the elasticity in Brazil is practically the double of the world-wide average.

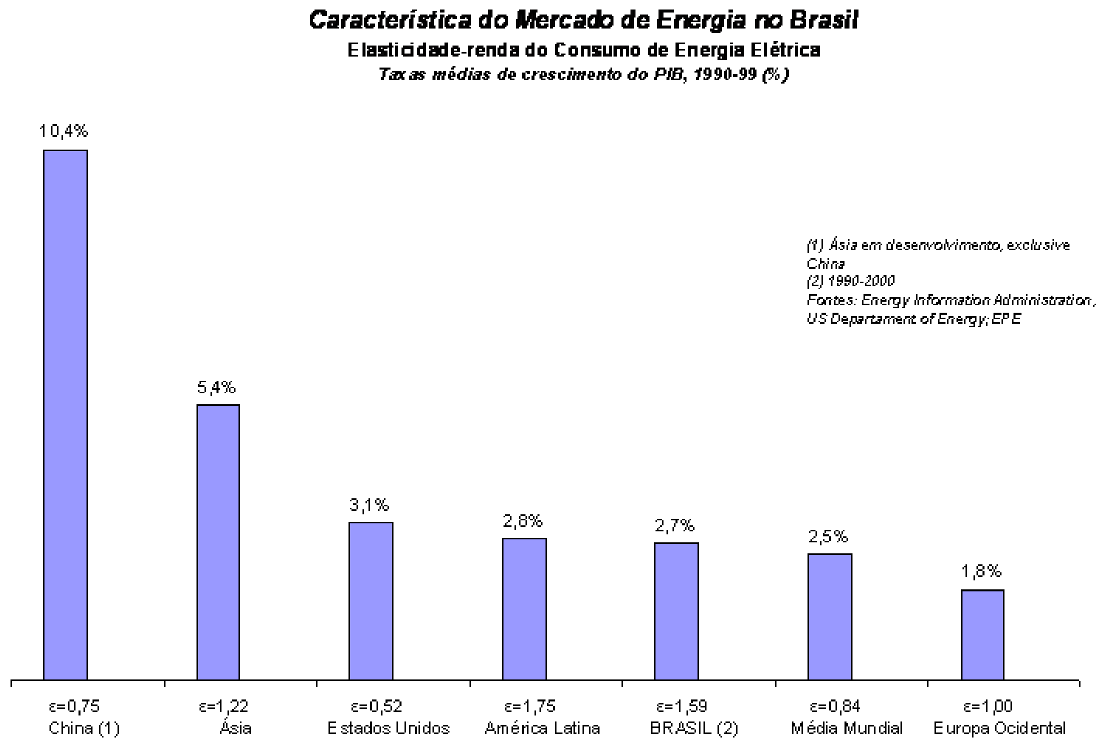
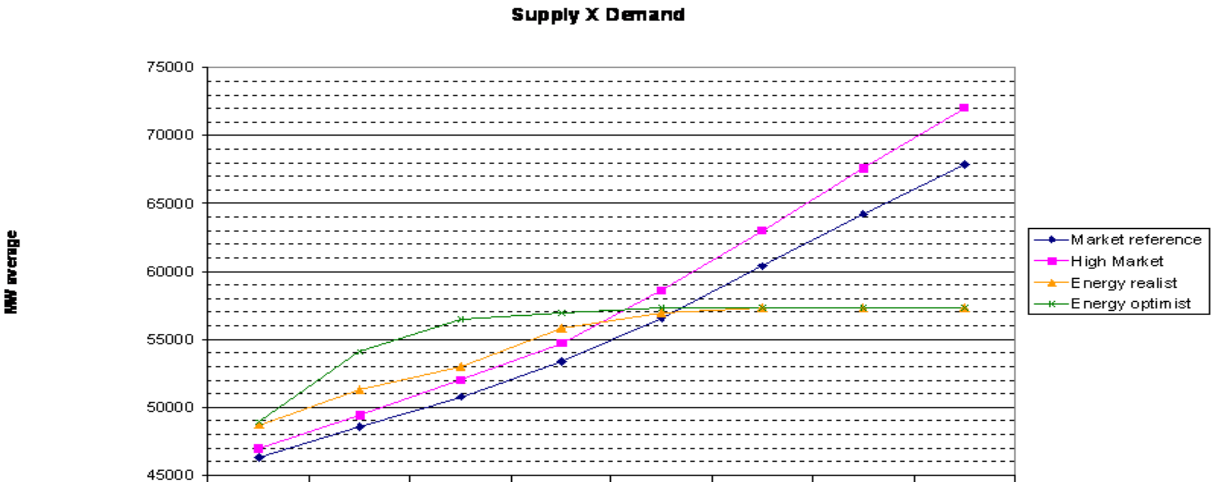


Figure 4 – PIB and the elasticity-income of the energy consumption. (Source: EPE, 2005)

According to G. LAMBERT-TORRES (2004), a rise in temperature in the order of 1ºC represents an increase in the energy consumption of about 1%. According to a study elaborated by TUCCI, (2002), as prognostics it is foreseen that the surface average temperature is projected for rising from 1.4 to 5.8º C between 1990 and 2100, being highly probable that practically all earth areas will warm more quickly than the average, mainly in the north hemisphere with high latitudes and cold weather, while in the south hemisphere, it will occur the opposite.

In this context, it is shown that the horizon of study of the electric sector is of at most 30 years, being that, after 10 years, the factors of uncertainty are very high, such as: macroeconomic scenario, microeconomic scenario, expansion of supply, growth of PIB, etc, making that the prediction of rise in temperature in 1° (one degree) become poorly significant for long-term projections.

The figure 5 presents a projection for scenarios of energy demand and supply until year 2010, where it is possible to notice the increment in the thermoelectric participation in the SIN.



	2005	2006	2007	2008	2009	2010	2011	2012
Market reference	46327	48557	50784	53355	56526	60380	64216	67867
High Market	46971	49411	52031	54729	58600	62979	67563	72031
Energy realist	48.704	51.312	52.996	55.818	56.949	57.327	57.327	57.327
Energy optimist	48.919	54.082	56.464	56.949	57.327	57.327	57.327	57.327

Year

Figure 5 – Projection of energy supply and demand until 2010.

The energy rationing, occurred in June 2001, demonstrated the impact of a process of making energetic efficient, where the post-rationing demand did not return to the pre-rationing highest level, representing a reduction in the permanent demand, of around 10%, resulting in gains of efficiency in the industrial processes, replacement of the illumination systems by efficient lamps. The figure 6 shows this effect in the energy consumption and the projection performed by LCA Consultores for next years.

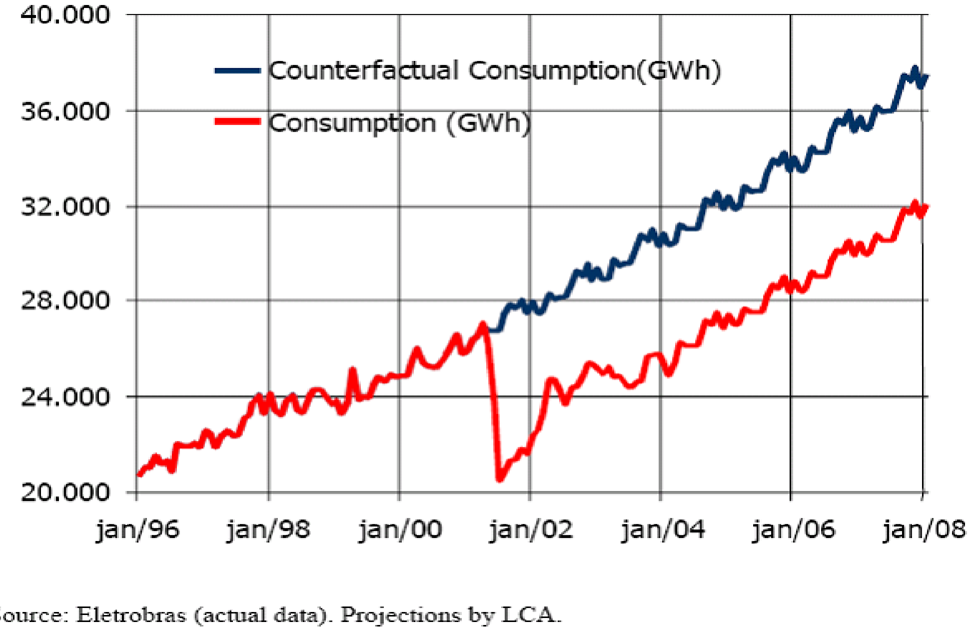


Figure 6 – Effect of rationing in the energy consumption.

ENERGY SUPPLY

In Brazil, water is used for different purposes, such as: human provisioning, quench of animal's thirst, irrigation, tourism, leisure, etc. However, many times these uses are concurrent, generating conflicts between user sectors, or even environmental impacts, as those arising from the electrical sector. Our energetic matrix which is composed, in its great majority by hydric generation, and the remaining part being distributed between thermal, aeolic and nuclear generation, causing a competition for exploiting the use of water in the country. Thus, to know the hydrologic behavior is a basic instrument for managing the hydric resources.

Nowadays, the prediction of outflows in the reservoirs of the National Interconnected System (SIN) is an essential activity of the System National Operator (ONS) in function of the information's need for the optimization process of the electrical system centralized dispatch.

The ONS uses different patterns of prediction which are appropriated to the characteristics of the basin studied. These models are based mainly on the historical information of rivers' outflow in different pluviometer posts and of series of outflows to the hydroelectric power plants' reservoirs.

Nevertheless, during the last decades, this behavior considered by many people as cyclic, is suffering modifications due to changes occurred in the climate. This change may be permanent, which characterizes a modification in the climate, or seasonal, which has a climatic variability.

According to studies of IPCC (2001 b), among the main impacts caused, we can say that the average temperature of sea in a global level is growing since 1861. In the twenty century, the temperature has risen about 0.6 ± 0.2 °C. This warming has occurred mainly in two periods: 1910 – 1945 and 1976

– 2000. Concerning the precipitation, there is a growth of 0.5 to 1% by decade in the twenty century for the most of medium and high latitudes of North Hemisphere. Probably the precipitation has increased from 0.2 to 0.3% by decade in the tropical region between 10º N and 10º S.

According to studies developed by TUCCI (2002), in the Paraná River basin, the behavior of outflows has growth about 30% between the Seventies and Nineties, if compared to the previous years. However, it is not really known the causes of these changes, since they could be originated from three sources: climatic change, climatic variability, change in the basin, such as ground waterproofing, which may causes significant changes in the coefficient of superficial flowing off (C).

However, these changes may cause a reduction in the hydric supply and consequently, some effect such as: possible reduction in the potential of agricultural production, increase in the number of people subject to diseases of hydric propagation, increase of risk of inundations.

In the specific case of electric sector, the "NEWAVE", the current operation model of the sector, is based on hydrological conditions with statistic prediction depending on the historic series and on the meteorological forecast. Due to the characteristics of the Brazilian electrical system and to the relatively small historic series of hydrology, the uncertainties associated with the hydrological series shall have a more detailed follow-up.

In this way, the present decisions influence the future operation. Due to this dynamics, the uncertainty related to outflows, associated to the uncertainty concerning the energy demand, makes the NEWAVE a problem essentially stochastic, and coupled in the space, that is, the water delivered or retained in a reservoir influences another plant downstream. So, the model is highly vulnerable and sensible to climatic changes or modifications that may occur.

THE NATIONAL INTERCONNECTED SYSTEM (SIN)

Installed capacity and supply of electric power.

The SIN - responsible for supplying about 98% of the Brazilian market of electric power - is predominantly operated with hydroelectric power plants. The production of gases by the hydroelectric plants is still an uncertain theme; the only certainty is that emissions are lower if compared to the thermal ones.

According to Santos e Almeida (2002), a 10 ha lake associated to a plant of 10 MW, would produce in 30 years 300 tons of cabon. While a large plant, such as Furnas, would generate 1.200.000 tonnes of carbon. Based on this, we can say that for small plants, the effect in the climate may be disregarded, but the same is not effective for large plants.

According to conferences presented by Soliano, the installed capacity of the national electric sector was higher than 90.4 GW, with an increment of more than 8 GW, in the years 2003/2004. From this total, 3.2 GW were installed with hydroelectric power plants and 4.1 GW with conventional thermoelectric power plants.

In 2004, the installed capacity with thermoelectric power plants has duplicated in relation to 2003, occurring the inverse with the hydroelectric power plants, which in 2004 had their participation in the total of new plants reduced. In 2003, the participation of the hydroelectric power plants in the total of increments of installed capacity was of 51% and, in 2004, it represented only 27%.

In 2004, the SIN has reached 87.6 GW of installed capacity, representing about 97% of the national electric sector's installed capacity (90.4GW) and about 87% of the sector total (98.6 GW), including the importation of installed capacity. The figure 7 shows the percentage distribution of the installed capacity of SIN by energy source and the table 1 shows the total production by type of fuel.

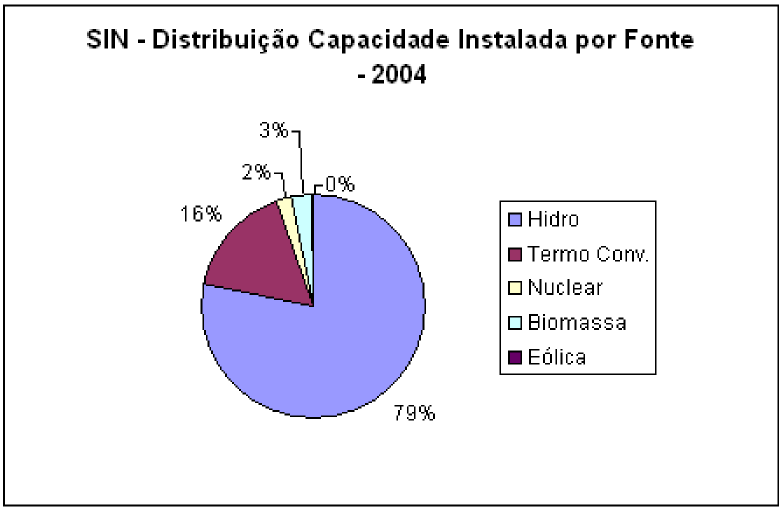


Figure 7 – Percentage distribution of the SIN's installed capacity by energy source. (Source: Mines and Energy Ministry – MME).

Table 1 – Total production by kind of fuel (GWh)

Origin	2002	2003	2004
Hydroelectric	238.517,6	253.815,0	268.178,4
Itaipu	76.899,8	83.007,2	83.788,3
Diesel Oil	43,8	0,0	0,0
Fuel Oil	3.371,6	863,5	382,2
Natural gas	8.929,2	9.182,0	14.449,9
Coal	5.062,1	5.239,3	6.346,1
Nuclear	13.849,5	13.357,9	11.582,6
Total	346.673,6	365.465,0	384.727,6
Emergency	24,8	51,5	398,7
Copene/Relan	5,2	0,0	0,0
Full Total	346.703,6	365.516,4	385.126,3

Source: ONS – Relevant Data 2003

EMISSIONS OF GREENHOUSE GASES IN SIN

The SIN is not a great emitting agent of Green-House Gases (GHGs). This is due to the fact that around 95% of the Brazilian electricity is generated by hydroelectric and thermal nuclear power plants. The figure 8 and table 2 represent the generations by source in the SIN and the emissions factors associated to the fossils sources.

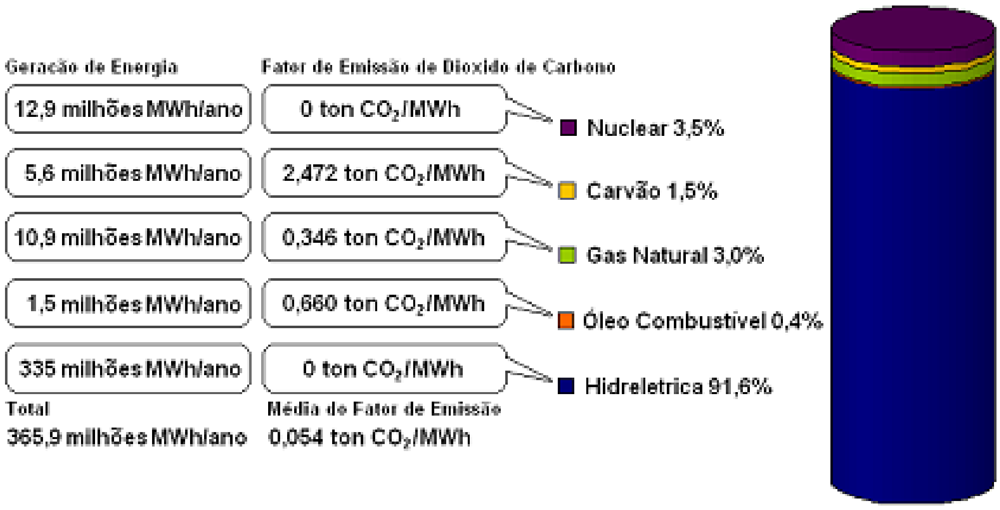


Figure 8 – Generation by source in the SIN and emissions factors by fossils sources. (Source: Data of ONS)

Table 2 – Factor of carbon (CO_2) emission

Coefficients of Emission		
Source:	**CO_2**	**Unit**
Natural gas	2,057	$kgCO_2/m^3$
Fuel Oil	3,075	$kgCO_2/kg$
Coal	3,062	kgCO2/kg
Diesel Oil	3,101	$kgCO_2$ /kg

ELECTRIC POWER RATIONING AND EMISSIONS IN THE SIN

As shown in figure 9, the emissions of carbon gas (CO_2) in 2004 were lower than those observed in 1999, after having reached very high levels in 2001, during the rationing period.

In 2001, the emissions of CO_2 in the SIN duplicated in relation to 2004, with values going from 7.242 Gg to 14.510 Gg. These numbers are compatible with the sector reality in years 2000, 2001 and part of 2002 which, in function to the shortage of energy providing from hydraulic origin, has encouraged toput the thermoelectric power plants in operation with the Priority Thermoelectric Program (PPT) and with the program of emergency thermals.

In year 2003, it was noticed an important reduction in the emissions of CO_2 in the SIN, whose level was the lowest registered since 1999. In 2004, the emissions have grown again, reaching a level of 12.818 Gg, lower only to year 2001, when it reached 14.520 Gg. The generations of natural gas plants were responsible for 6.445 Gg and the coal plants for 6.061 Gg.

The figure 10 shows the evolution of the conventional thermal generation in Brazil in a period of 5 years and the table 3 lists the factors of green-house effect gases emission for thermoelectric plants.

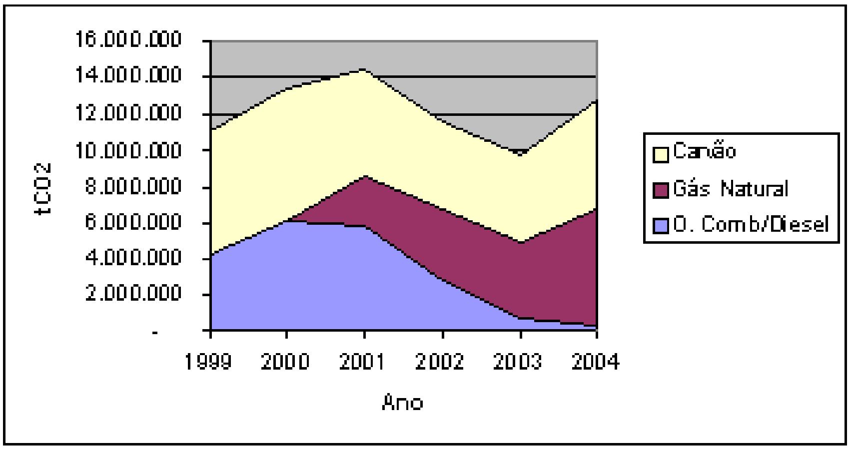


Figure 9 – Evolution of the GHGs emissions.

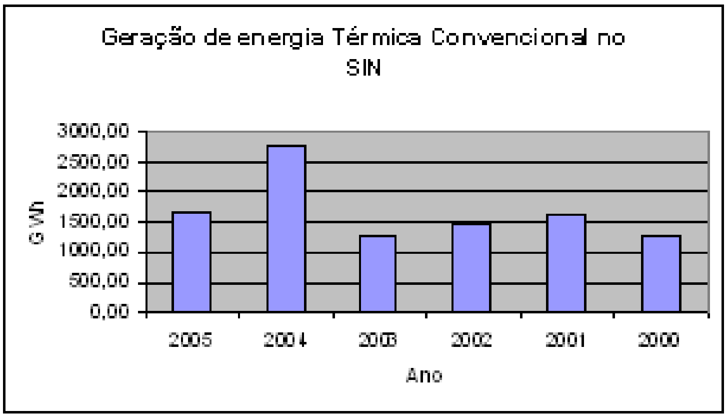


Figure 10 – Evolution of the conventional thermal generation. Source: ONS, 2005.

Table 3 – Factors of green-house gases' emission for thermoelectric power plants

SOURCE:	FACTORS OF EMISSION (g/GJ OF CONSUMED ENERGY)			
THERMOELECTRIC PLANTS	CO_2	CO	CH_4	NO_2
GN boilers	56.100	19	0.1	267
Cycles combined with gas turbines	56.100	32	6.1	187
Simple cycles with gas turbine	56.100	32	5.9	188
Residual petrol boilers	77.350	15	0.7	201
Boilers of destilled petrol	74.050	15	0.03	68
Coal in fluidzed bed	nd	98	nd	140
Coal, tangential burning	94.600	14	0.6	330
Pulverized coal	94.600	14	0.6	857
Boilers for wood	26.260	1473	18	112

Source: World Bank (1997), apud Lora (2000).

PROINFA AND THE REDUCTION OF EMISSIONS

PROINFA (Programme of Incentives for Alternative Electricity Sources) is an instrument for diversifying the national energetic matrix, ensuring greater reliability and safety to energy supply. In its activities, 13 millions of MWh will be generated. From this total, the Small Hydro Power Plants will be responsible for the production of 6.8 millions of MWh, the aeolic plants will be responsible for 3.8 millions of MWh and the biomass undertakings for 2.8 millions of MWh.

The distribution of these undertakings has expressed the regional distribution of the energetic sources, with the majority of these Aeolic undertakings located in the Northeast region, the Small Hydro Power Plants in the Central West region, the biomass undertakings in the Southeast region and the South region with a most balanced distribution of undertakings, according to figure 11.

Figure 11 – Location of the PROINFA undertakings (Small Hydro Power Plants, Aeolic and Biomass).

Considering factors of emissions and the PROINFA reference energies, the reductions of emissions in SIN could reach a volume higher than 2.8 millions of tonnes of CO_2/year, as shown in the table 4.

Table 4 – Potential of the CO_2 reduction with the PROINFA Activities

System	Volume of reduction	Percentage	Unit
South	1.58 millions	55 %	tonneCO2/year
SE / CO	681.6 thousand	24 %	tonneCO2/year
NE	598 thousand	21 %	tonneCO2/year

IMPACT IN THE OPERATION

According to previously mentioned, from seventies, the Paraná River basin had an outflow increment of about 30%. So, this part of the text aims to analyze the consequence of these changes in the energy generation.

The firm energy of the Paraná River basin hydroelectric plants cascade is in the order of 27GW, for an installed power of the order of 50 GW. For calculating the firm energy, it is taken into account the critical period of the electrical sector between 1949 and 1956, in order to use the worst hydrology of the data historic. However, when analyzing the historic hydrologic data, it is observed that the average inflow has grown in a significant way from the Seventies.

Analyzing the firm energy with the use of a mobile window of 20 years since the historic beginnig, 1931, until 2001, it is observed that the firm energy of the basin grows in a significant way from the Seventies, as shown in the table 5.

Table 5 – Average outflow and Firm energy for periods of 20 years of the data historic

First year	Final year	Average Outflow Energy [MW.month]	Firm Energy [MW.month]	AverageThermal Generation [MW.month]
1931	1951	31604	29312	1645
1936	1956	29999	27775	2253
1941	1961	30628	27721	1863
1946	1966	31953	27723	1680
1951	1971	31522	27723	1785
1956	1976	33252	29482	784
1961	1981	34691	29482	784
1966	1986	37805	29481	701
1971	1991	38839	35851	0
1976	1996	40299	35849	0
1981	2001	40651	35851	0

Comparing the periods 1936 – 1955 (Figure 12) and 1981-2001 (Figure 13), it is observed an increase of 30% of Paraná River Basin's firm energy.

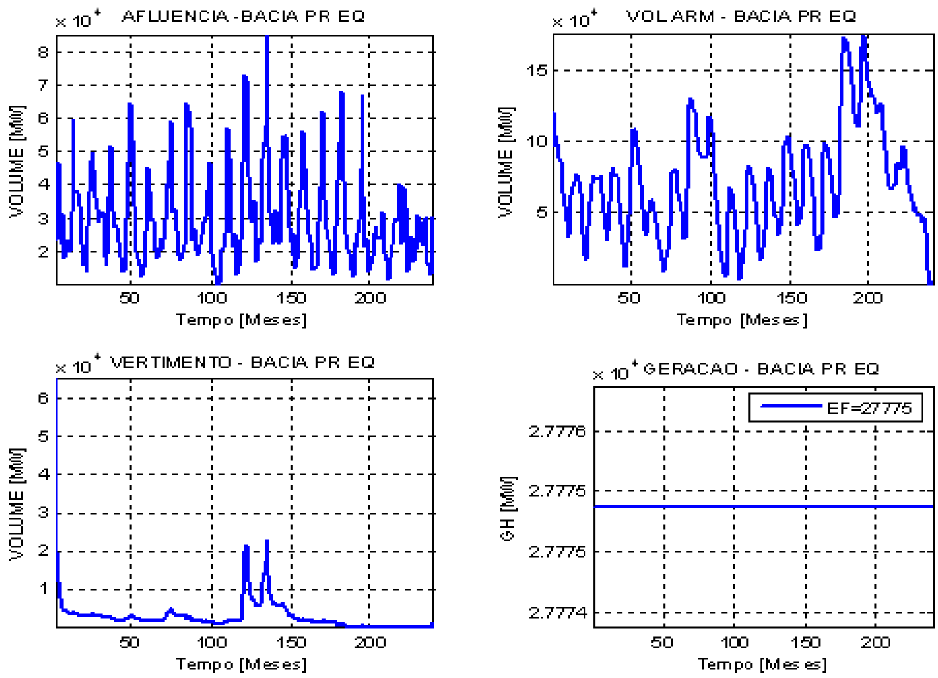


Figure 12 – Paraná River Basin’s Firm Energy (1936-1955)

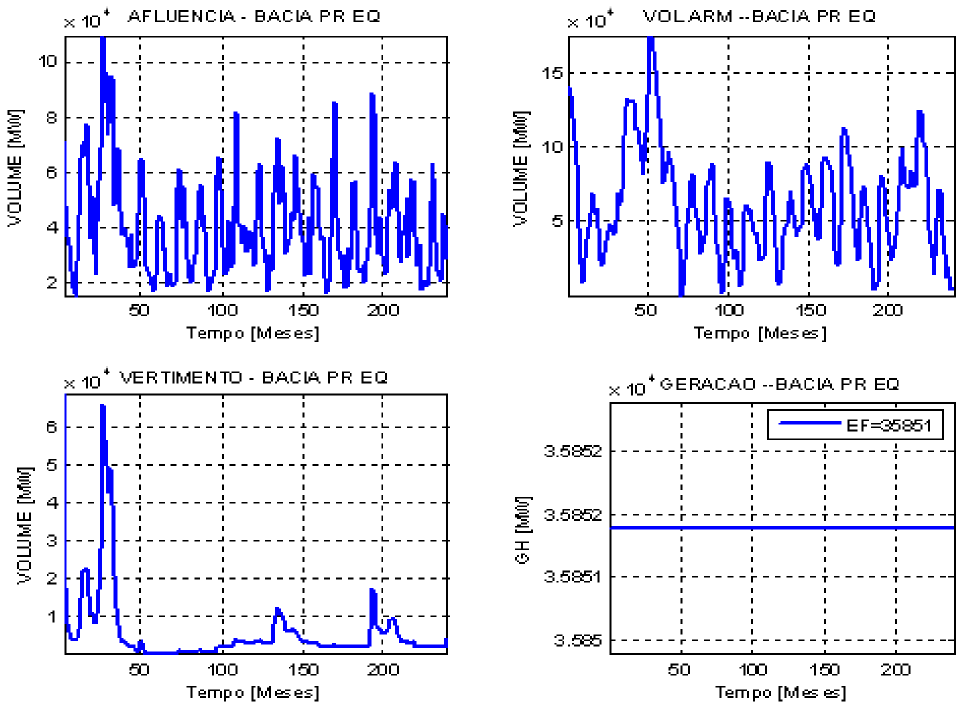


Figure 13 – Paraná River Basin’s Firm Energy (1981-2001)

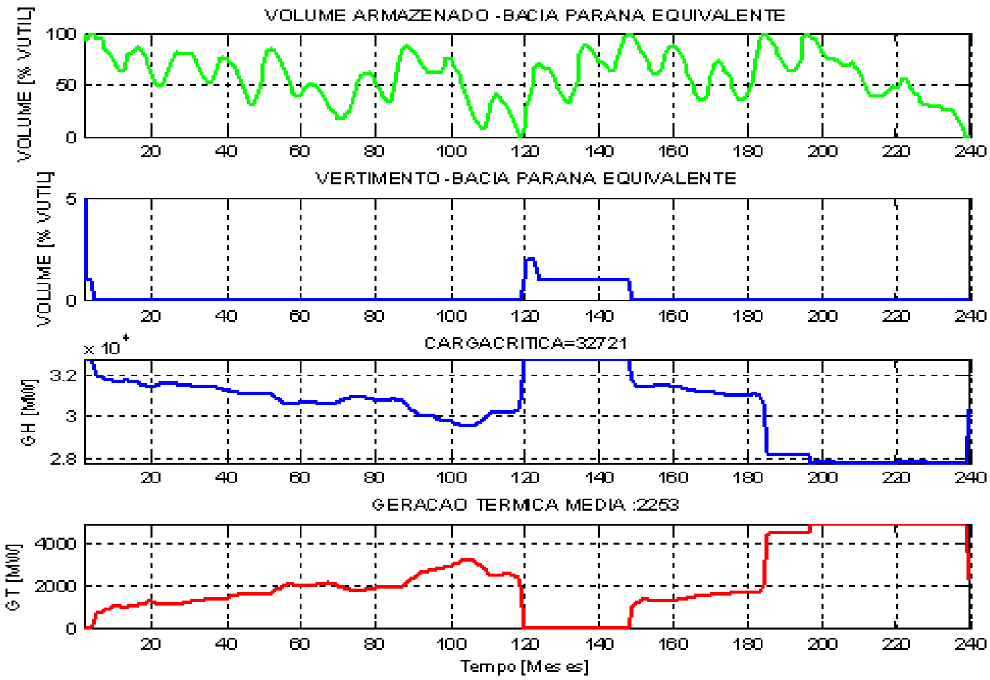


Figure 14 – Thermal Complementarity (1936-1955)

Considering the market as the firm energy of the Paraná River basin added of 5000 MW, we have a market of 32.7 GW. So, simulating the operation of a flexible thermo-electric plant of 5 GW (about 10% of the installed power of Paraná River Basin), it is observed, by means of figures 14 and 15, that the need of this thermoelectric power plant generate power for supplying the market associated to this system occurs only in the periods before 1971. From this date, this thermoelectric plant does not generate, initiating a medium affluence greater than those existing in the previous periods. Then, there is an average thermal generation of 2253 [MW month] between 1936 and 1955, and null generation between 1981 and 2001.

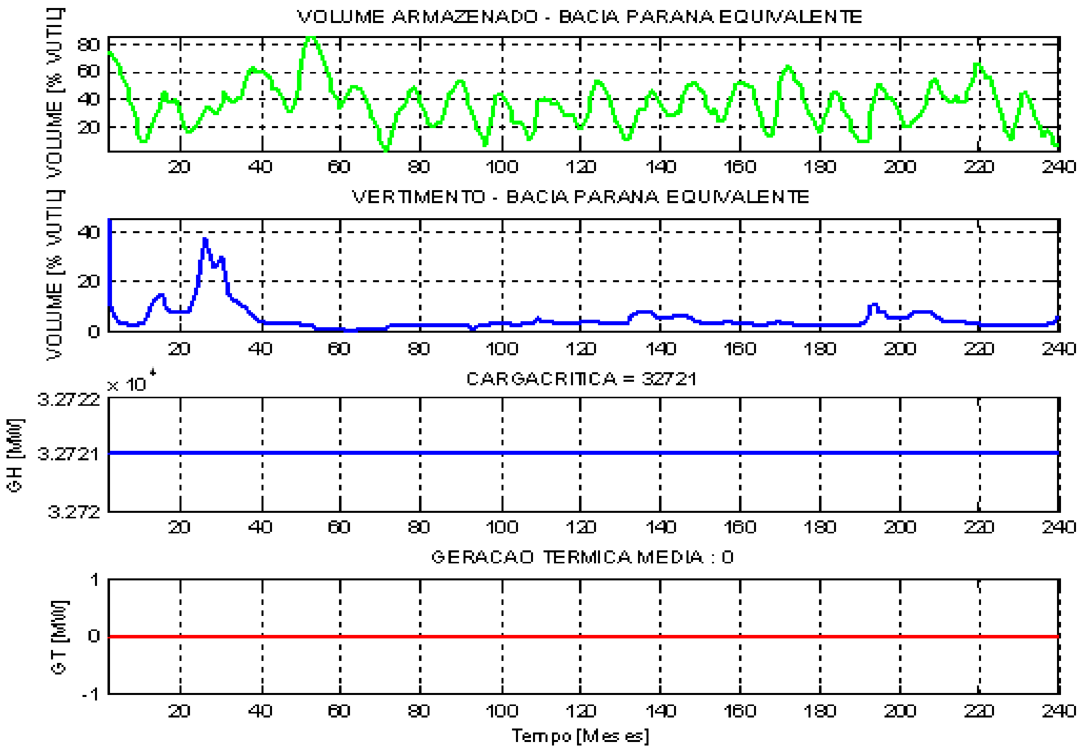


Figure 15 – Thermal Complementarity (1981-2001)

However, the thermal generation acting as a complementary mode is essential for the stability and reliability of the electrical system, in order that it is more and more observed the increment of dispatch of the National Interconnected System's thermoelectric plants, for energetic or electrical purposes (technical dispatches), since the thermoelectric plants' park becomes each time more representative.

This new scenario open the way for new criteria of hydroelectric power plants operation, since the change of these criteria allows the reduction of dispatch of the thermoelectric plants and a better utilization of the water existing in the reservoirs. It is presented, then, the operation of Furnas reservoir when it is aimed to maximize the energy generation, considering the productivity effect. What is verified, from figure 16 is the greater utilization of the reservoir's water, with its level being conserved as close as possible to its maximum cote. This operation causes a lower need of thermal generation and consequently, lower cost of generation for the concerned system.

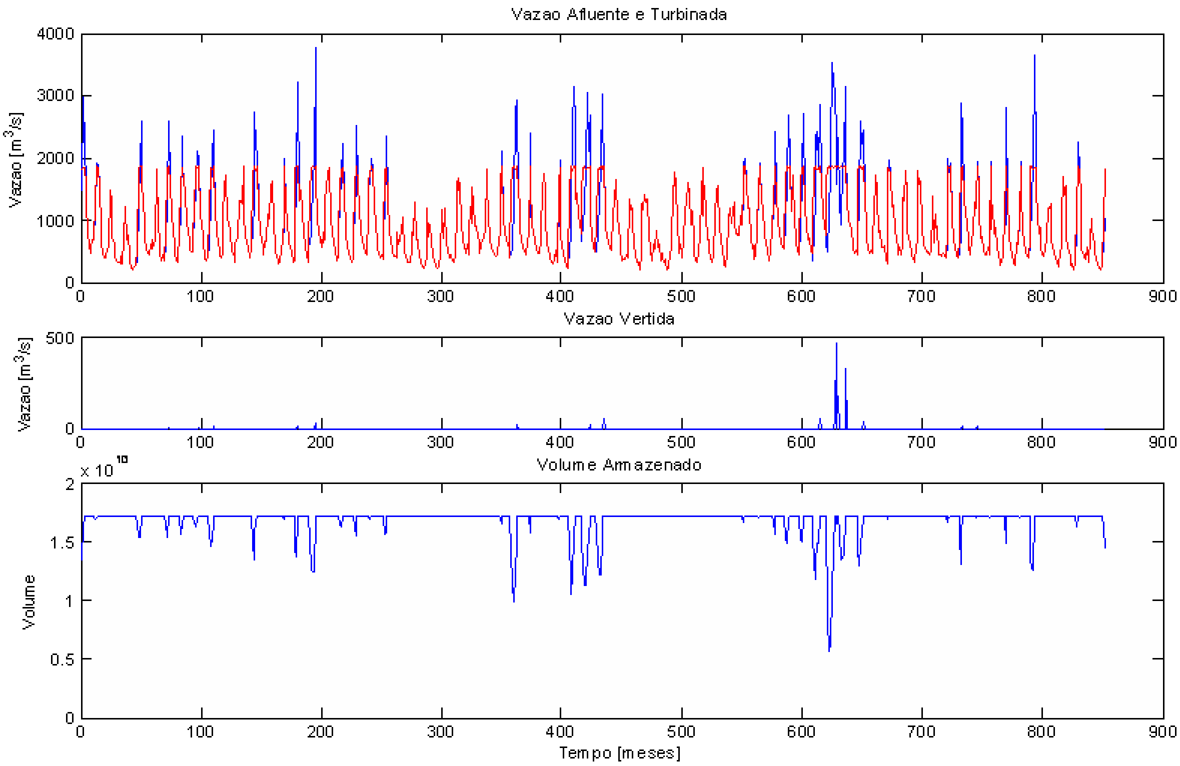


Figure 16 – Maximization of the Furnas Hydroelectric poer plant considering the productivity effect

The variability of inflows leads to a reduction of the firm energy and not an increase of it, as observed in Figure 17. A variation of 5% in the inflows causes a loss of 1.5% in the firm energy. In this way, it is verified that the increase of firm energy is due exclusively to the increase of the average inflows after 1971.

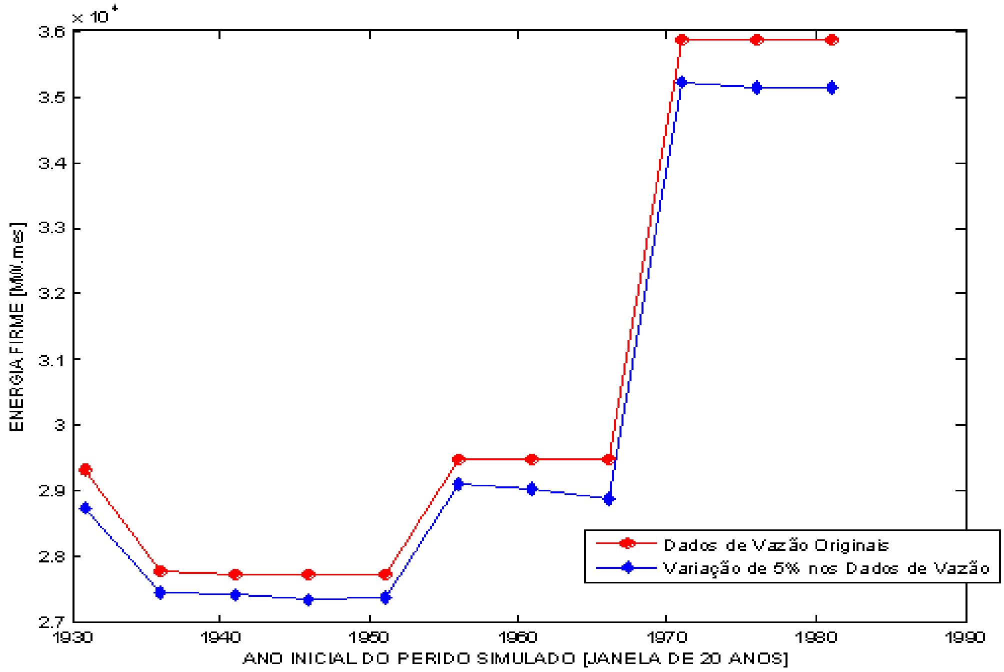


Figure 17 – Firm Energy for periods of 20 years

IMPACT IN THE MARKET

The NEWAVE model establishes a politics of medium-term operation (horizon of 5 years with monthly discretization) being composed by four computational modules: module of equivalent system calculation, which calculates the energy equivalent subsystems; module of outflow energies, which estimates the parameter of the stochastic model and generates synthetic series of outflow energies which are used in the calculation module of the hydrothermal operation politics, determining the most economical operation politics for the equivalent subsystems, and the module of operation simulation, which simulates the system operation along the planned period, for distinct scenarios.

The NEWAVE's fragility is clear when comparing the prices projected by the model and the prices realized by the market, in order that the model is shown appropriated only for very short term (up to 3 months) and indicative for short term (up to 1 year). The figure 18 shows the prices realized between months of September 2000 and December 2002. It presents also the prices projected in the following dates: September 2000, January 2001, and March 2001.

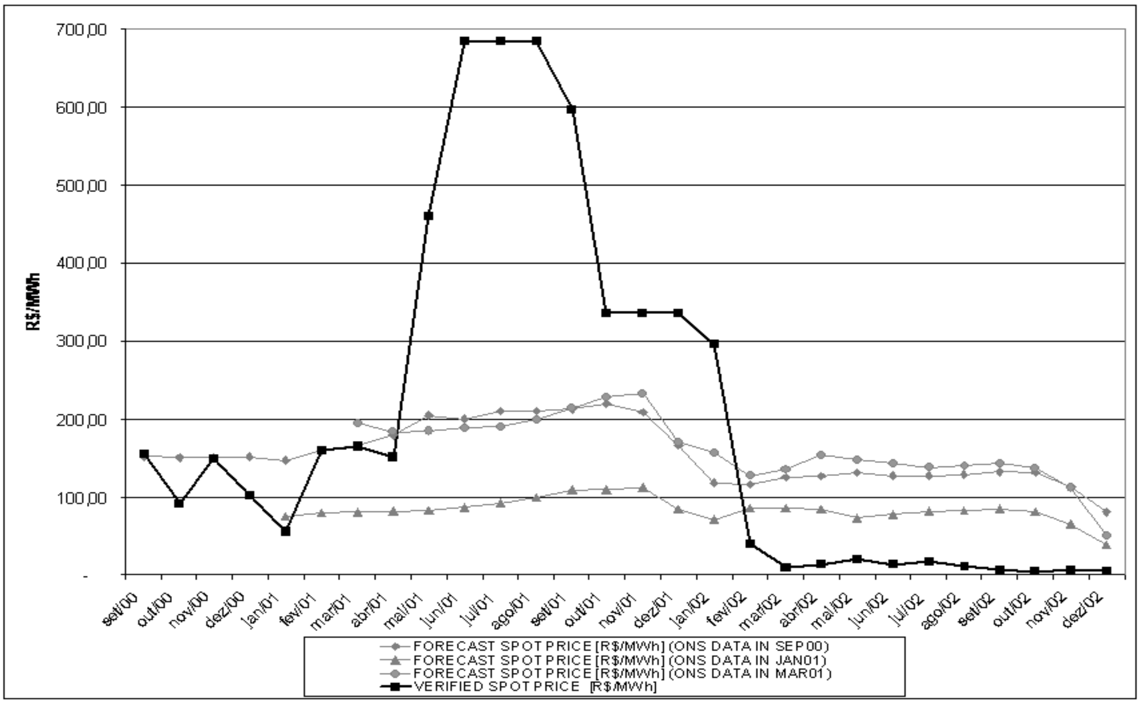


Figure 18 – Comparison between the Spot price projected and the Spot price verified.

CONCLUSION

The Industrial Revolution and the society development mark the begin of a process of progressive changes mainly in the environment. The causes and consequences of the climate global change are highly associated to these modifications.

However, some of these changes are manifesting of different ways, among which we can present a significant increase in the discharge of the Paraná River from the Seventies. Nevertheless, it is not possible to affirm that the origins of these changes arise from the climate changes, because this may be a cyclic effect of climate variability or of any significant change in the hydrographic basin.

According shown in this job, what is expected for next years is an increase in the demand of electric power, justifying the amplification of energetic efficiency programs, as the mitigator effect of an expansion of the generator park, which does not meet the requirements of the consumption's increase.

However, if these hydrologic changes are confirmed, it will be necessary to improve the current model which uses a stochastic model for forecast, being less sensible to these changes.

BIBLIOGRAPHIC REFERENCES

EPE – Empresa de Pesquisa Energética, As previsões da Demanda de Energia no Curto e Longo Prazo, presentation shown in the 3rd Conference about Free Market of Energy, promoted by International Business Communications, September 2005.

G. LAMBERT-TORRES et alli. – "Relatório Final do Projeto de Desenvolvimento de Aplicativo para Previsão de Cargas Elétricas da CEB", Centrais Elétricas de Brasília (CEB), 538 p., 2004.

IPCC (2001 b) Climate Change: Impacts, Adaptation and Vulnerability. A Report of Working Group II of Intergovernmental Panel on Climate Change, 2001.

LORA, E.S,"Prevenção e controle da poluição nos setores energético, industrial e de transporte"; Brasília, DF, ANEEL, 2000.

MARTINS, E.**,** Brasil e o Protocolo de Quioto - a situação do país na implementação do acordo. MME / CONPET, 05/09/2005.

NAE - Núcleo de Assuntos Estratégicos da Presidência da República – Mudanças do Clima. Nº3, Brasília, February 2005.

ONS, 2005. www.ons.org.br, 24/10/2005.

Projects: Estimativa das emissões de gases de efeito estufa derivados da queima de combustíveis fósseis no Brasil e Balanço de Carbono Executor. MCT/ Economia & Energia - ONG

SANTOS, A.H.M; Almeida, R.A; Pequenas Centrais Hidrelétricas, UNIFEI, CERNE, 2002

TUCCI, C.E. Impactos da variabilidde climática e uso do solo sobre os recursos hídricos. "*Estudo preparado como contribuição da ANA – Agência Nacional de Águas para a Câmara Temática sobre Recursos Hídricos do Fórum Brasileiro de Mudanças Climáticas*". May 2002

ENERGY CONTRIBUTION ON CLIMATE CHANGES

JOSÉ ROBERTO MOREIRA
Instituto de Eletrotécnica e Energia da USP
Centro Nacional de Referência em Biomassa (CENBIO)

1. Introduction

Climate change is being observed and attempts for its measurement are under way in the last 2 decades. Climate changes are being monitored through changes in global temperature, in rainfall frequency and amount, in ocean level changes, in occurrence of extreme weather events and other factors. Enough evidence exists to accept anthropogenic action as a major factor for such changes. Increase in Greenhouse Gases (GHGs) emissions is the major driver of climate change. Major GHGs are CO2, CH4, N2O and energy generation and use are the major origin of these gases. The contributions of these gases to the GHG effect, as well as other contributions are, shown in Figure 1.

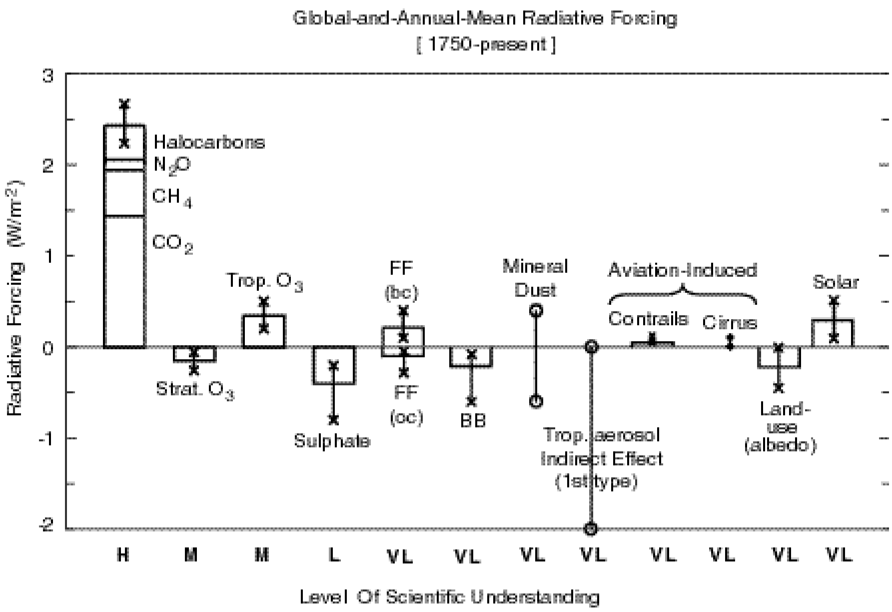


Figure 1

Note: H = High; M = Medium; L = Low; VL = Very Low

As noted, CO2 makes the largest contribution, followed by CH4. Next important driver of Climate Change are the use of halocarbons, presence of sulphates, presence of mineral dust, tropospheric aerosol presence, solar intensity variation and albedo due to land use changes, but large uncertainties are associated with their contribution to the GHG effect(see Figure 1). This means that these other drivers, when feasible must be mitigated, but impacts of such efforts in Climate Change mitigation can be small. On the other side CO2 and CH4 emissions are well understood and quantified, their sources are generally well established and efforts to mitigate them can yield assured results.

2. Anthropogenic Source of CO2 emissions

The sources of CO2 emissions in various sectors of the economy have been estimated by the IEA (2003). These are shown in Table 1 and power generation is the single largest source of emissions. Other sectors where emissions arise from a few large point sources are Other Energy Industries[1] and parts of the Manufacturing and Construction sector. Emissions from transport, which is the second largest sector (Table 1), have been growing faster than those from energy and industry in the last few decades (IPCC, 2001a); a key difference is that transport emissions are mainly from a multiplicity of small, distributed sources.

Table 1. Sources of CO2 emissions from fossil fuel combustion in 2001

	EMISSIONS			
	(Million tonnes CO_2/y)		**(Million tonnes C/y)**	
Public Electricity and Heat Production	8236		2250	
Unallocated Autoproducers	963		263	
Other Energy Industries	1228		336	
Manufacturing & Constructions	4294		1173	
Transport	5656		1545	
of which: Road		4208		1150
Other Sectors	3307		903	
of which : Residential		1902		520
TOTAL	23684		6470	

3. Other greenhouse gas emissions

Anthropogenic climate change is mainly driven by emissions of CO2 but other greenhouse gases (GHGs) also play a part[2]. Since some of the anthropogenic CO2 comes from industrial processes and some from land use changes (mainly deforestation), the contribution from fossil fuel combustion alone is about half of the total from all GHGs.

In terms of impact on radiative forcing, methane is the next most important anthropogenic greenhouse gas after CO2 (currently 20% of the total impact) (IPCC, 2001b). The energy sector is an important source of methane but agriculture and domestic waste disposal contribute more to the global total (IPCC, 2001c). Nitrous oxide contributes directly to climate change (currently 6% of the total impact of all GHGs), primarily from agriculture but also from industrial production of some chemicals; other oxides of nitrogen have an indirect effect. A number of other gases make significant contributions (IPCC 2001c).

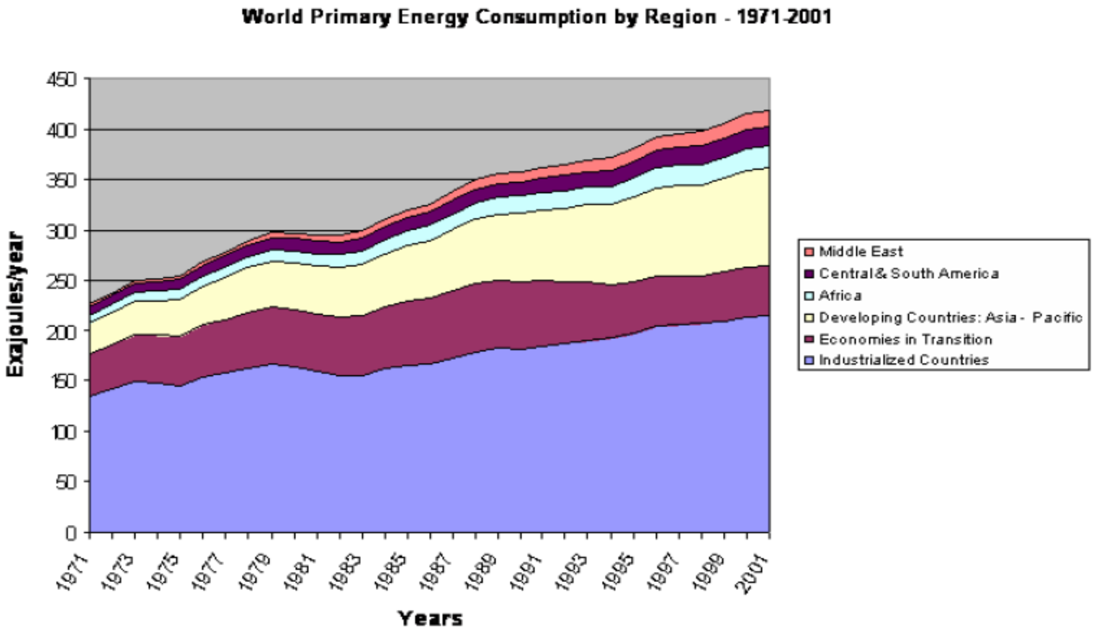
---

[1]There are differences in published estimates of CO2 emissions for many countries, as Marland et al. (1999) have shown using two ostensibly similar sources of energy statistics.

[2] Emissions from international bunkers were 780 Mt CO (213 MtC) in 2001 (IEA, 2003).

4. Energy consumption and CO2 emissions

Global consumption of energy and associated emission of CO2 continued an upward trend in the first years of the 21st century (Figures 2 and 3). Fossil fuels are the dominant form of energy utilized in the world (86%), and account for about 75% of current anthropogenic CO2 emissions (IPCC, 2001c). In 2002, 149 Exajoules (EJ) of oil, 91 EJ of natural gas, and 101 EJ of coal were consumed by the world's economies (IEA, 2004). Global primary energy consumption grew at an average rate of 1.4% annually between 1990 and 1995 (1.6% per year between 1995 and 2001) - the growth was 0.3 % per year (0.9%) in the industrial sector, 2.1% per year (2.2%) in the transportation sector, 2.7% per year (2.1%) in the buildings sector, and -2.4% per year (-0.8%) in the agricultural/other sector (IEA, 2003).

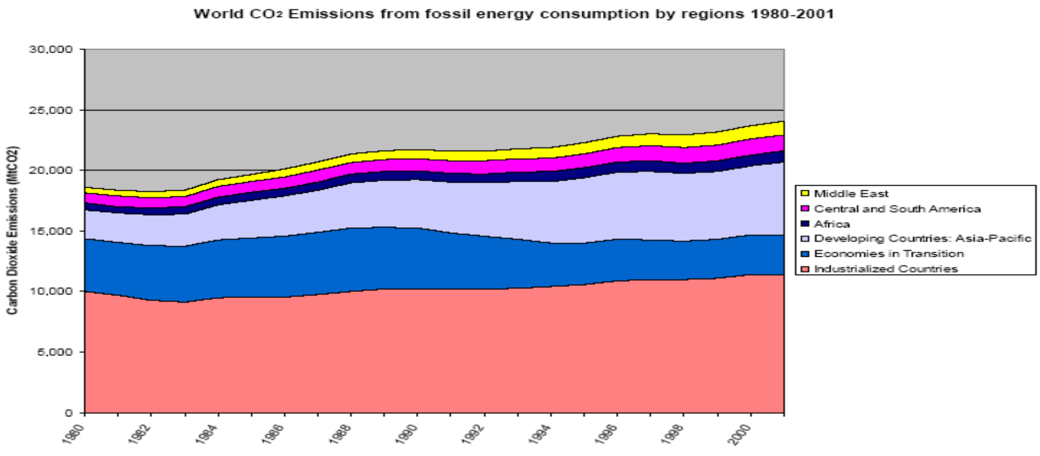


World primary energy use by region from 1971 to 2001 (IEA, 2003)

Figure 2

Average global CO2 emissions[3] grew at 1.0% per year between 1990 and 1995 (1.4% between 1995 and 2001), a rate slightly less than that of energy consumption in both periods. In individual sectors, there was no growth in emissions by industry between 1990 and 1995 (0.9% per year from 1995 to 2001), 1.7% per year (2.0%) in the transport sector, 2.3% per year (2.0%) in the buildings sector, and -2.8% per year (-1.0%) in the agricultural/other sector (IEA, 2003).

[3] Carbon Capture and Storage (CCS) involves a series of technologies to capture CO2 (mainly consequence of fuel combustion) avoiding its diffusion to the atmosphere. Once captured it has to be stored (mainly underground). If storage has a half life of hundreds to thousands of years, it is possible to control future GHG emission and try to stabilize CO2 concentration in the atmosphere.



World CO_2 emissions from fossil fuel use by region, 1980 to 2001 (US DOE, 2003).

Figure 3

Total emissions from fossil fuel consumption and flaring of natural gas were 24 Gt CO2/y (6.6 GtC/y) in 2001 - industrialized countries were responsible for 47% of energy-related CO2 emissions (not including international bunkers[4]). The Economies in Transition accounted for 13% of 2001 emissions; emissions from those countries have been declining at an annual rate of 3.3% per year since 1990. Developing countries in the Asia-Pacific region emitted 25% of the global total of CO2; the rest of the developing countries accounted for 13% of the total (see Figure 3)(IEA, 2003).

5. Scenarios of future emissions

Future emissions may be simulated using scenarios which are: "alternative images of how the future might unfold and are (...) tools (...) to analyze how driving forces may influence future emissions (....) and to assess the associated uncertainties." "The possibility that any single emissions path will occur as described in scenarios is highly uncertain" (IPCC, 2000a). In advance of the Third Assessment Report, IPCC made an effort to identify future GHG emission-pathways. Based on several assumptions, IPCC built a set of scenarios of what might happen to emissions up to the year 2100. Six groups of scenarios were published (IPCC, 2000a), the so-called SRES scenarios (Figure 4). None of these assume any specific climate policy initiatives, i.e. they are base-cases which can be used for considering the effects of mitigation options. An illustrative scenario was chosen for each of the groups. The 6 groups were organized into 4 "families" covering a wide range of key "future" characteristics such as demographic change, economic development, and technological change (IPCC, 2000a). Scenario families A1 and A2 emphasize economic development, whilst B1 and B2 emphasize global and local solutions, respectively, to economic, social and environmental sustainability. In addition, two scenarios, A1F1 and A1T, illustrate alternative energy technology developments in the A1 world (IPCC, 2001a). Given the major role played by fossil fuels in supplying energy to modern society, and the long time involved in making changes in energy systems (Marchetti and Nakicenovic, 1979), the continued use of fossil fuels is arguably a good base-case scenario.

[4] CO2 capture requires energy. This means that by capturing and storing CO2 it will be necessary to increase primary energy production while producing the same amount of final energy.

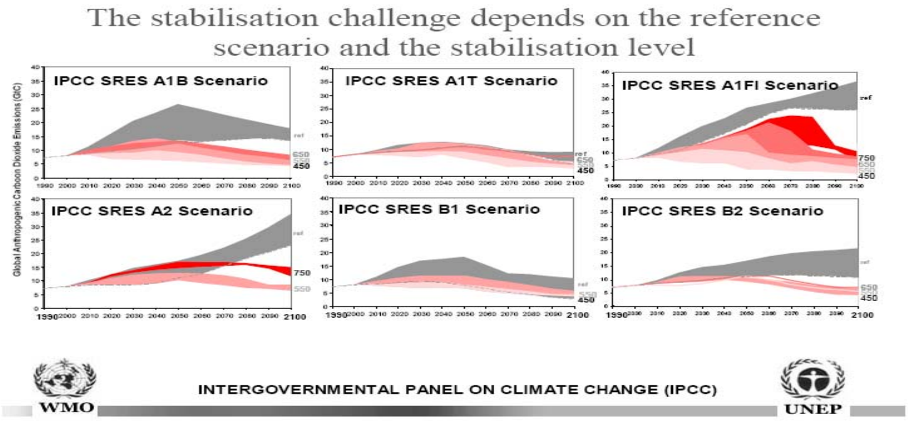


Figure 4

5.1 Fossil fuel availability

Fossil fuels are globally traded commodities that are available to all countries and potentially could be used for much of the 21st century although the balance amongst the different fuels may change.

Depletion rate and cost of use - Proven coal, oil and natural gas reserves are finite so consumption of these primary fuels can be expected to peak and then decline at some time in the future (IPCC, 2001a). However, predicting the pace at which use of fossil fuels will fall is far from simple because of the multiplicity of different influences.. Extracting fossil fuels from more difficult locations will increase the cost of supply, as will the use of feedstocks that require greater amounts of processing; the resultant increase in cost will also tend to reduce demand. Restrictions on emissions, whether by imposition of a cap or of a tax, would also increase the cost of using fossil fuels, as would application of Carbon Capture and Storage (CCS)[5]. At the same time, improved technology will reduce the cost of using them. All but the last of these factors will have the effect of extending the life of the reserves of fossil fuels, although application of CCS6 would tend to increase the demand for them

Reserves and resources of fossil fuels On top of the known reserves there are significant resources that, through technology advances and the willingness of society to pay more for them, may be converted into commercial fuels in the future. Furthermore, there are thought to be large amounts of non-conventional oil (e.g. heavy oil, tars sands, shales) and gas (e.g. methane hydrates). A quantification of these in the Third Assessment Report (IPCC, 2001a) showed that fully exploiting the known oil and natural gas resources (without any emission control) plus use of non-conventional resources would cause the atmospheric concentrations of CO2 to rise to a level above 750 ppmv

[5] Present global number of of sugarmills is 1,500 and the average capacity is very small. To process all sugarcane produced at global level (1,300Mt/yr) the average capacity is less than 1Mt/yr. Since some sugarcane is not processed in industrial plants the average capacity is even lower-something around 0.7Mt/yr. In Moreira(2005), it is assumed that the 4,000 sugar mills will process 20,000Mt of sugarcane some 30 years from now; thus, average capacity should be 5Mt/yr.

(see Figure 4 to compare some scenarios of atmospheric concentration of CO2 with expected CO2 emissions from the 6 different energy consumption scenarios). In addition, coal resources are even larger than those of oil and gas; consuming all of them would enable the global economy to emit 5 times as much CO2 as has been released since 1850 (5,200 GtCO2 or 1,500 GtC) (see chapter 3 in IPCC, 2001a) (Figure 5). A scenario for achieving significant reductions in emissions (Berk et al., 2001) demonstrates the extent to which a shift away from fossil fuels would be required to stabilize at 450 ppmv by 2100 but without the use of CCS. Thus, sufficient fossil fuels exist for decades more use so that the availability of fossil fuels does not put a limit on the potential application of CO2 capture and storage but CCS would provide a way of limiting the environmental impact of the continued use of fossil fuels.

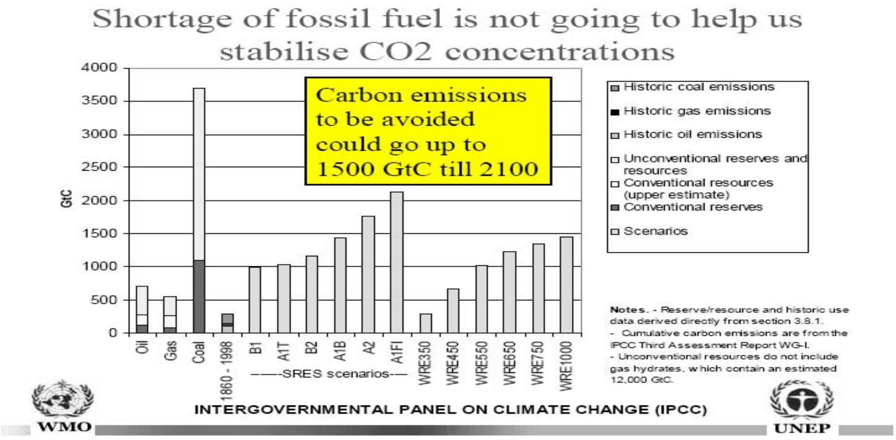


Figure 5

6. Options for mitigating climate change

A wide variety of technological options have potential for reducing net CO2 emissions and/or CO2 atmospheric concentrations, as will be discussed below, and there may be further options which are developed in future. The targets for emission reduction will influence the extent to which each technique is used. The extent of use will also depend on factors such as cost, capacity, environmental impact, the rate at which the technology can be introduced, and social factors such as public acceptance.

6.1. Improve energy efficiency

Reducing fossil fuel consumption can be achieved by improving efficiency of energy conversion, transportation and end-use, including enhancing less energy-intensive economic activities. Energy conversion efficiencies have been increased in the production of electricity, for example by improved turbines; combined heating, cooling and electric power generation systems reduce CO2 emissions further still. Technological improvements have achieved gains of factors of 2 to 4 in the energy consumption of vehicles, of lighting and many appliances since 1970 and further improvements and wider application are expected (IPCC, 2001a). Further significant gains in both demand-side and supply-side efficiency can be achieved in the near term and will continue to slow the growth in emissions into the future; however, on their own, efficiency gains are unlikely to be sufficient and economically feasible to achieve deep reductions in emissions of GHGs (IPCC, 2001a).

6.2. Switch to less carbon-intensive fossil fuels

Switching from high carbon to low carbon fuels can be cost-effective today where suitable supplies of natural gas are available. Typical emission reduction is 420 kg CO2/MWh for the change from coal to gas in electricity generation, i.e. about 50% (IPCC, 1996b). If coupled with the introduction of combined production of heat, cooling and electric power, the reduction in emissions would be even greater. This would make a substantial contribution to emissions reduction from a particular plant but is restricted to plant where supplies of lower carbon fuels would be available.

6.3. Increased use of low and near zero-carbon energy sources

Deep reductions in emissions from stationary sources could be achieved by widespread switching to renewable energy or nuclear power (IPCC, 2001a). The extent to which nuclear power could be applied and the speed at which its use might be increased will be determined by that industry's ability to address concerns about cost, safety, long term storage of nuclear wastes, proliferation and terrorism. Thus its role is likely to be determined more by the political process and public opinion than by technical factors (IPCC, 2001a).

There is a wide variety of renewable supplies potentially available - commercial ones include wind, solar, biomass, hydro, geothermal and tidal power, depending on geographic location. Many of them could make significant contributions to electricity generation, as well as to vehicle fuelling and space heating or cooling, thereby displacing fossil fuels (Table 2)(IPCC, 2001a). Some of the renewable sources face constraints related to cost, intermittency of supply, land-use and other environmental impacts. Nevertheless, it is possible to see significant penetration of some of them. Between 1992 and 2002, installed wind power generation capacity grew at a rate of circa 30% per year, reaching over 31 GWe by the end of 2002 (Gipe, 2004). Solar electricity generation has increased rapidly (c. 30% per year), achieving 1.1 GWe capacity in 2001, mainly in small-scale installations (World Energy Assessment, 2004). This has occurred because of falling costs as well as promotional policies in some countries. Liquid fuel derived from biomass has also expanded considerably and is attracting the attention of several countries, e.g. Brazil, due to its declining costs and co-benefits in creation of jobs for rural populations. Biomass used for electricity generation is growing at about 2.5% per annum; capacity had reached 40 GWe in 2001. Biomass used for heat was estimated to have capacity of 210 GWth in 2001. Geothermal energy used for electricity is also growing in both developed and developing countries, with capacity of 3 GWe in 2001 (World Energy Assessment, 2004). Thus, there are many options which could make deep reductions by substituting for fossil fuels, although the cost is significant for some and the potential varies from place to place (IPCC, 2001a).

Table 2

Long-term technical potential renewable and nuclear energy supply		
	Long-term Technical Potential (EJ/year)	
Hydro	>130	2100 Total Energy Demand for SRES scenario range: 526 – 2740EJ/yr
Geothermal	>20	
Wind	>130	
Ocean	>20	
Solar	>2600	
Biomass	>1300	
Total Renewable	>4200	
Nuclear total: 7700 – 462000EJ >>average 77 – 4620 EJ/yr over next 100 years		

Source: Nakicenovics et al. IPCC, 2000

6.3.1. Biomass Energy Use - Contribution of Sugar cane

Just to provide an example of how alternative sources of energy can contribute to energy supply and mitigate CO2 emissions let us examine the case of sugarcane as a source of energy. Table 3 shows the amount of energy that can be obtained from the installation of 4,000 sugar mills with the major purpose to generate alcohol and electricity. These industrial plants are assumed to use the best available technologies and will be installed, mainly, in some 10 to 20 tropical countries. To supply the processed amount of sugarcane an area of 143 million hectares will be necessary and the yield obtained should increase at a rate of 2% per year until reaches 140t/ha/yr (compared with present value of 80 t/ha/yr) (Moreira, 2005). The large number of mills (4,000) should be compared with present number which is over 1,5007. The extension of sugarcane plantation (140Mha) should be compared with present planted area of 23Mha.. The density of future mills, as shown in Table 3 (one unit each 6,200 km2 on all available agricultural area in the world) is lower than what is presently found in the state of Sao Paulo (one every 1,500 km2). Also, it is worthwhile to remember that global planted area for wheat is over 250Mha.

From such activity it should be possible to produce 164EJ of primary energy (current primary energy consumption in the globe is 440 EJ), but more important is that it is possible to produce almost 90 EJ of final energy (38 EJ of electricity and 70 EJ of liquid fuel).

Table 3 - Amount of energy produced from sugar/alcohol mills distributed over world agricultural land area at a density of 1 every 6,200km2 - BIG, Combined Cycle, and 40% more yield - Total number of renewable energy producing units is 4,000

FINAL ENERGY CATEGORY	PRIMARY ENERGY (EJ/yr)	FINAL ENERGY (EJ/yr)	TOTAL LAND AREA USED FOR CROPS
ELECTRICITY	94.1	37.9	
LIQUID FUEL	69.9	51.5	
TOTAL	163.9	89.5	1.43×10^6 km^2

Source: Moreira, 2005

To provide a metric to understand how big these numbers are Figure 6 shows that such amount of liquid fuel (alcohol) should be more than enough to cover all the increase in demand of liquid fuels in the globe in the period 2003-2033. Figure 7 shows that the electricity produced would be enough to fulfill all the increase in demand at global level in the same period.

Finally, it is important to understand how much CO2 mitigation would be achievable with this intensive sugarcane scenario. Figure 8 shows CO2 future emissions as calculated by one of the IPCC scenarios (see Figure 4, scenario B2) and the changes on emission expected if such huge contribution of sugarcane happens. Note that there are 2 different emission curves for sugarcane. The upper one consider only the CO2 abatement due displacement of fossil fuels by liquid fuels and electricity from sugarcane. The lower one consider that on top of the earlier contribution, CO2 emitted during juice fermentation, as well as CO2 emitted from biomass fed boilers are captured and stored underground, as is being proposed and made in experimental stage in oil weels.

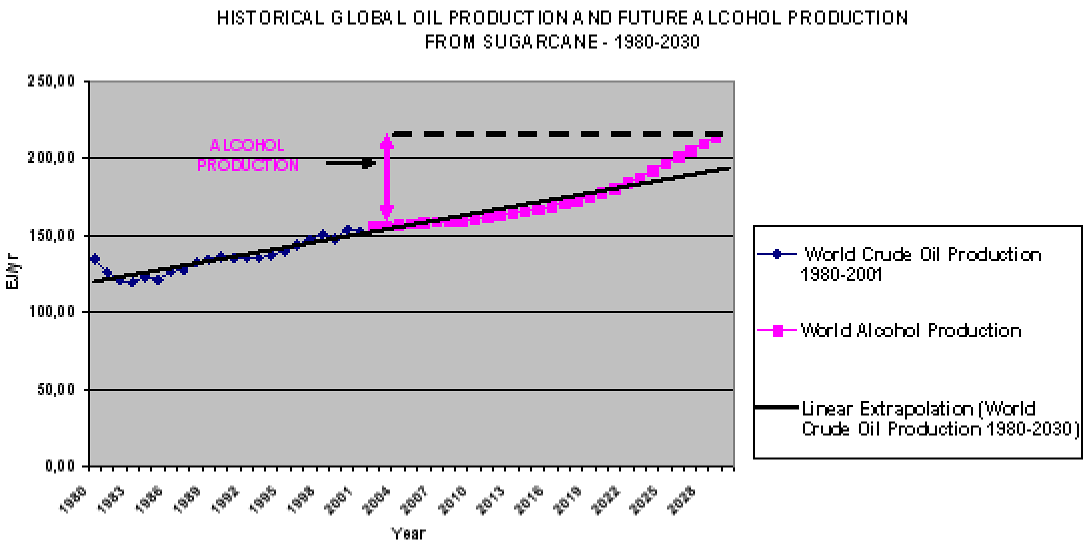


Figure 6

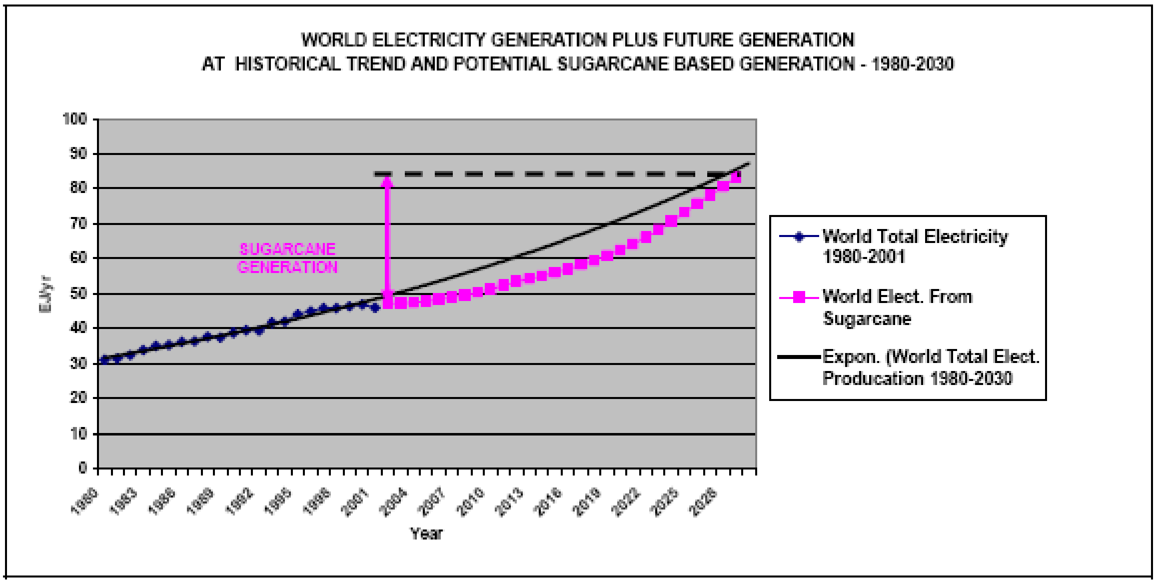


Figure 7

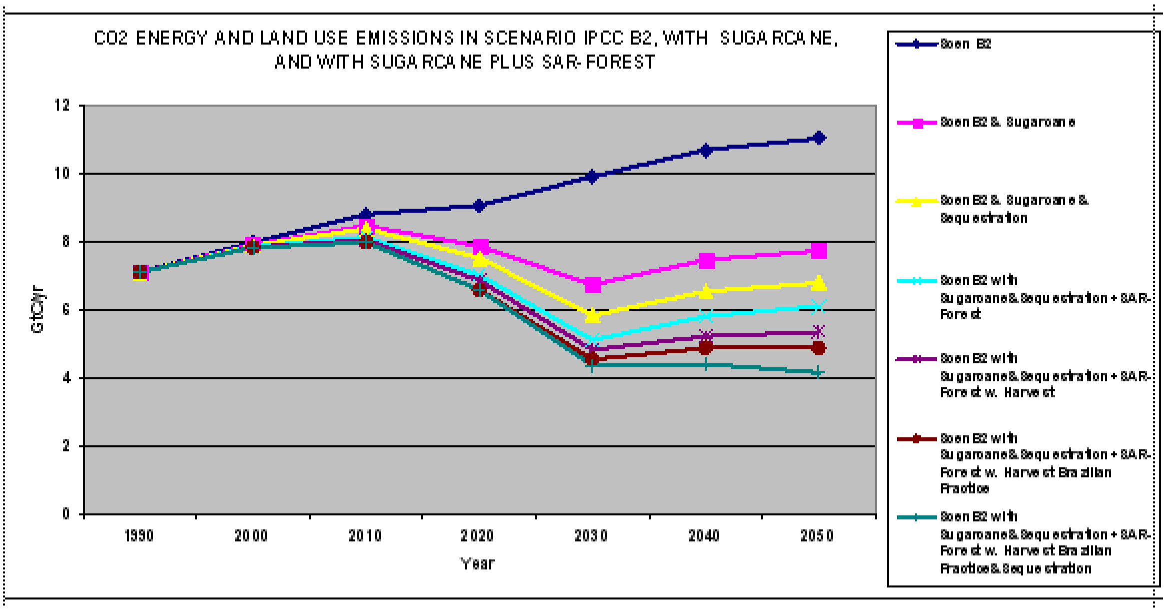


Figure 8

6.4. Sequester CO2 through the enhancement of natural, biological sinks

Natural sinks for CO2 already play a significant role in determining the concentration of CO2 in the atmosphere. They may be enhanced to take up carbon from the atmosphere. Examples of natural sinks that might be used for this purpose include forests and soils (IPCC, 2000b). Enhancing these sinks through agricultural and forestry practices could significantly improve their storage capacity but this may be limited by land-use practice, and social or environmental factors. Carbon stored biologically already includes large quantities of emitted CO2 but may not be permanent. Figure 8 shows the contribution for CO2 abatement that could be obtained by coupling the sugarcane scenario described in 6.3 with a reforestation/aforestation program covering some 300Mha at global level(Moreira, 2005). It is possible to draw four different curves. The higher one (see Figure 8) assumes planted forest will grow undisturbed to its highest level. The one below assumes the planted forest will be harvested for energy use and replanted. The next below the previous one assumes forest for energy productivity will be as effective as the ones planted in Brazil. And the lowest one assumes that CCS will also be practicized when consuming harvested biomass for energy production.

6.5 Capture and storage of CO2

As explained above, this approach involves the capture of CO2 from combustion of fuels, or released from industrial processes, and then storing it away from the atmosphere for a very long time. In the Third Assessment Report (IPCC, 2001a) this option was analyzed on the basis of a few, documented projects (e.g. the Sleipner Vest gas project in Norway, enhanced oil recovery practices in Canada and USA, enhanced recovery of coal bed methane in New Mexico and Canada). That analysis also discussed the large potential of fossil fuel reserves and resources, as well as the large capacity for CO2 storage in depleted oil and gas fields, deep saline formations, and in the ocean (Figure 9). It also pointed out that CO2 capture and storage is more appropriate for large sources, such as central power stations, refineries, ammonia, and iron and steel plants, than small, dispersed emission sources.

7. The Reverse Effect - Impacts of Climate Changes on Energy Production

Climate changes impacting future temperature and rainfall should produce some feedback on energy supply and use. Regarding energy use it is very ease to conclude that air conditioning demand, which is presently the major factor determining electricity peak load in summer season in developed countries, increases. Air conditioning demand has the perverse effect of being seasonal, strongly collaborating for significant increase in electricity generation costs since the installed capacity is poorly used during most of the year. There is also seasonal variation during the day acting perversely in the same way. Changes in amount of precipitation will impact water runoff and consequently water streams in rivers. Such changes must be properly considered when designing new hydroelectric plants, as well as when planning long term operation of the existent ones. Temperature and precipitation changes may have a synergetic impact in agriculture, including crops and biomass grown for energy production. The combination of temperature and precipitation is the major driver for biomass growth and it is possible to anticipate significant production impacts in the future.

Major difficulty when forecasting these issues is still related with knowledge limitations when carrying out regional evaluations of future consequences from climate change. Nevertheless, there are calculations, believed to be reliable, and Figure 10 shows forecast for world precipitation changes. It is interesting to note that changes are modest in Latin America, and, in particular in the Southeast of Brazil, it is expected some increase in precipitation.

Other sources of alternative energy can be also impacted, as is the case of wind, since its distribution and intensity also may change in the future.

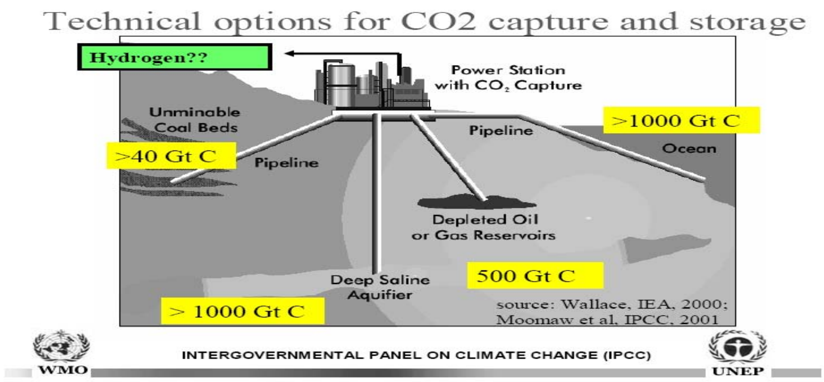


Figure 9

Regarding conventional energy sources the first impression is that they should be resilient to climate change due their underground origin. This is true when considering the primary energy supply, but it is to necessary to extract fossil fuel and is worthwhile to remember that most important for society is the final forms of energy. The conversion process from primary to final forms relies in refineries and electricity generation plants, which may be impacted by extreme weather events. Extreme weather events frequency shows correlation with climate change and is anticipated to increase.

8. Conclusions

The most obvious, well understood, and most effective way for reducing climate change is to reduce energy production from fossil fuels. Such reduction can be obtained through more efficient use of energy or reducing primary energy demand through more efficient conversion technologies. Alternative energy sources to fossil fuel are available and for some the economic barrier is significantly being overcome. The amount of alternative sources is enough to fulfill all energy demand up to the end of the century, if economic barriers are neglected (see Table 2). The necessity to add more renewable energy in the world energy portfolio is better explained by environmental impacts than by economic facts tied to reduction in fossil fuel availability. Presently, oil supply is seen as a serious constraint but it is still unclear if peak oil production, at global level, has been achieved. Even if this has occurred it is important to note that we are usually talking about conventional oil sources. And there are many other sources of unconventional oil, some of them already being explored in commercial basis. Even if only a small fraction of them could be extracted due economic and environmental issues, they may guarantee oil supply for one or two more decades. Regarding natural gas the scenario is roughly the same, since reserves are finite and transportation may pose limits in the use of a share of potentially identified resources. On the other hand coal reserves are huge and could supply all necessary fossil energy for more than a century. Nevertheless, it is clear that climate change effects would be enhanced and some actions must be taken before full use of all coal reserves (e.g. CCS).

Probably, the solution will be to use all available options to mitigate climate change and prioritize reduction on energy CO2 emission immediately. Different regions of the globe will select the best mitigation actions for themselves, but it is important to have global policies to provide necessary guidance to different countries and also reduce the cost of policies used in only a few countries. Essentially, what is being recommended is that initiatives like the Kyoto Protocol should continue for several decades.

Finally, it is necessary to remember that climate changes may be mitigated, but is impossible to be fully avoided, at this moment, due past human action. Due positive feedback climate change impacts energy supply and resilient energy expansion program must be pursued.

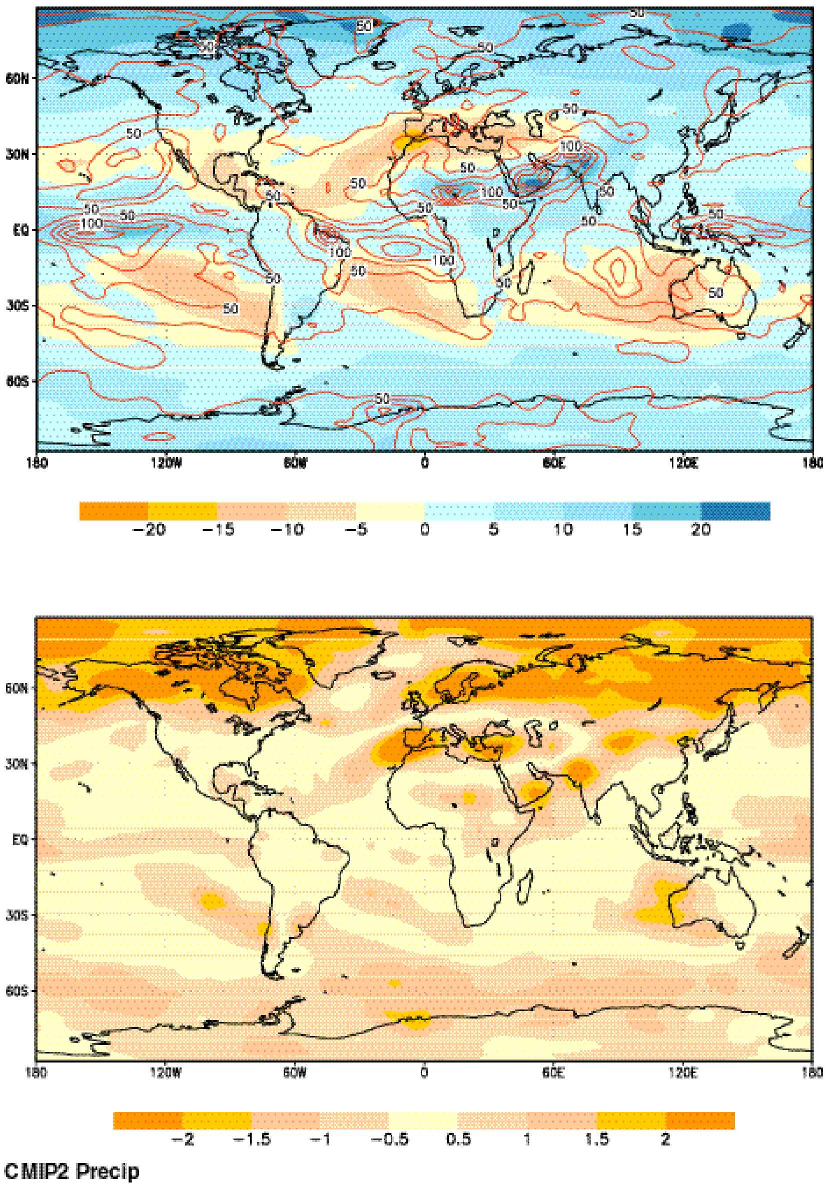


Figure 10

Source: (IPCC, 2001c)

The multi-model ensemble annual mean change of the precipitation (colour shading) and its range (isolines) [Unit: %] (upper panel) and multi-model mean change divided by the multi-model standard deviation of the mean change standard deviation] (lower panel) for the SRES scenario B2. Both SRES-scenarios show the period 2071-2100 relative to the period 1961-1990 and were performed by AOGCMs.

REFERENCES

Berk, M.M., J.G. van Minnen, B. Metz and W. Moomaw, 2001: Keeping Our Options Open, Climate Options for the Long Term (COOL) – Global Dialogue synthesis report, RIVM, NOP rapport nr. 410 200 118.

Gipe, P., 2004: Wind Power: Renewable Energy for Home, Farm, & Business. Chelsea Green Publishing Co., USA ISBN 1-931498-14-8

IEA, 2004, Energy Balances of Non-OECD Countries, 2001-2002. OECD/IEA, Paris

IEA, 2003, CO2 emissions from fuel combustion, 1971-2001, OECD/IEA, Paris

IPCC, 1996b. Technologies, Policies, and Measures for Mitigating Climate Change – IPCC Technical Paper I

IPCC, 2000a, Special Report on Emission Scenarios, Cambridge University Press, Cambridge, UK.

IPCC, 2000b: Land Use, Land-Use Change and Forestry. IPCC Special Report, R.T. Watson, I.R. Noble, B. Bolin, N.H. Ravindranath, D.J. Verardo, D.J., Dokken, (eds.). Cambridge University Press, Cambridge, UK.

IPCC, 2001a: Climate Change 2001 – Mitigation. The Third Assessment Report of the Intergovernmental Panel on Climate Change. B. Metz, O. Davidson, R. Swart, J. Pan (eds.). Cambridge University Press, Cambridge, UK

IPCC, 2001b: Climate Change 2001. The Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK

IPCC, 2001c: Climate Change 2001: the Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. J.T. Houghton, Y. Ding, D.J. Griggs, M. Nogouer, P.J. van der Linden, X. Dai, K. Maskell, C.A. Johnson, (eds.). Cambridge University Press, Cambridge, UK

IPCC, 2001d, Markandya, A., K. Halsnaes, A. Lanza, Y. Matsuoka, S. Maya, J. Pan, J. hogren, R Seroa de Motta, T. Zhang, Costing Methodologies. In Climate Change 2001: Mitigation. Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. B. Metz, O. Davidson, R. Swart, J. Pan (eds.). Cambridge University Press, Cambridge, UK

Marchetti, C. and N. Nakicenovic, 1979. The Dynamics of Energy Systems and the Logistic Substitution Model. RR-79-13. Laxenburg, Austria: International Institute for Applied Systems Analysis (IIASA). 17

Marland, G., A. Brenkert, O. Jos, 1999. CO2 from fossil fuel burning: a comparison of ORNL and EDGAR estimates of national emissions. Environmental Science & Policy 2: 265-273

Moreira, J. R., 2005: Global Biomass Potential, to be published in the Journal of Adaptation and Mitigation.

World Energy Assessment, 2004: Overview: 2004 Update. J. Goldemberg and T. B. Johansson (eds), United Nations Development Programme, New York.

URBAN FLOOD IN THE NEW CLIMATE CONTEXT: SOME CASES IN LATIN AMERICA

JUAN CARLOS BERTONI
Head Professor, Hydrology and Hydraulics Processes Chair Exacts, Physics
Natural Sciences Faculty Cordoba National University, Argentina

INTRODUCTION

Urbanization is one of the most meaningful manifestations of the human's activity. For the first time in the planet´s history the urban population percentage has reach the correspondent of the rural ones. Latin America is characterized by the permanent growth of its urban centers. In South America the urban concentration in the main cities has the highest growing rate in the world and it's also the highest in its history. The region has 77% of its population in urban areas, with an annual growth tax higher than 1,5 %. In this region, the problems related to urban floods have multiple effects. In many cases they lead to dramatic situations related to human lives lost, economical losses and serious social consequences. Latin America socio-economical problems do not contribute to the simple solution of this situation. In fact, there is a close relation between the disaster risk and a country development level. Generalized poverty increases the population's vulnerability due to its prevention and self-help reduced possibilities and also to its social and financial security lack.

The new world climate scenario forecasts global and regional changes in the climate variables, with consequences over the hydrology behavior of the basins. This is another input for the problem that would contribute to make the complexity of the urban flood problems in Latin America more evident. In fact, during the last years this region has registered catastrophic floods in urban areas associated with severe storms.

The flood occurred in Santa Fe city (400.000 inhabitants), Argentina, 2003, caused more than 20 deaths, important economical losses and serious social consequences. It was associated to an exceptional succession of rains occurred over the lower Salado river basin, with a previous scenery of strong wet conditions. The floods occurred in San Salvador city (2 million inhabitants), El Salvador, 2005, produced 65 deaths and a great injured number. It was associated to a succession of important rains produced by the tropical storm Stan that recently affected various Central America countries.

Beyond the climate severity, the real causes of many of the observed problems are associated to the non-controlled growth of impermeable surfaces, the exclusive use of the hydraulics conduction works, the occupation of naturally flooded areas and an inefficient planning and management of the pluvial drainage. In short, the analyse of these and others detach cases ocurred in Latin America countries shows essencially typical common causes for the urban floods problems.

This paper presents some detailed information referred to urban floods associated with the occurrence of severe storms. Two heavy floods occurred in Argentina (San Carlos Minas, 1993, and Santa Fe city, 2003) are initially presented. The floods ocurred in San Salvador city (El Salvador, 2005) are also presented. In the last part, the main cause's similarities of the urban floods problems are summarized. The work concludes with the idea that the inappropriate use of the urban space, the lack of a master plan referred to the water resources management (especially devoted to the urban drainage system) and a contingency plan lack are strong causes to the flood consequences. In this framework the climate global changes acts simply as a catalyser element of the problem.

THE URBANIZATION PROCESSES

The explosive urbanization of the world and the problems it brings about in the great urban conglomerates constitutes one of the most important subjects of our time. The urbanization's universalization is a recent phenomenon in the planet's history.

In 1800 only 1% of the population lived in cities. From middle XVIII Century, as a result of the industrial revolution, the urbanization has increased world wide with an accelerated rhythm. What has happened in the XX century is an example of it.

According to Guglielmo (1996), during the first half of the XX Century the world's total population increased in 49%, and the urban population in 240%. In the second half of the century, this evolution accelerated and the urban population went from 1.520 million inhabitants in 1974 to 1.970 million in 1982. The Table 1 illustrates the observed and the foreseen constant growth for the period 1955-2015. Nowadays the world population is approximately of 6.100 million and the urban population reaches 2.850 million, 46.7%. In a near future and for the first time in the history the quantity of cities inhabitants would have exceeded the rural areas ones.

Table 1 - The urban population's annual growth (period 1955-2015).

The urban population's annual growth				
Year	1955	1975	1995	2015
[%]	32	38	45	54

(Source: Fund of the UN to Population Attendance, 2000).

In our continent (Table 2), the main cities urban concentration has the highest increasing rate among the others of the world and the highest in its history, with a marked tendency of socioeconomic and administrative concentration in just a few important cities in each country (Figure 1). This metropolitan tendency is occurring within a frame of economical growth slow rate, and with an unequal income distribution structure, that leads to an urbanization process of the poverty.

According to Guglielmo (1996) in 1950 only 8 conglomerates reached or passed the 5 million inhabitants (New York, London, the Ruhr, Shangai, Paris, Buenos Aires and Moscu); they constituted around 7% of the urban world's population. According to UNESCO's estimates, in 2000 about 15% urban population was concentrated in metropolis of at least 10 million of inhabitants.

The urban process shows some differences between the developed countries, located mainly in the northern hemisphere and the underdevelopment countries of the southern hemisphere. During the pre-industrial era the great metropolis of Latin America grew in a steady rate as a result of the vast colonial trade. In the industrialization era an imbalance in the cities growth of this region and those in the developed countries was registered.

Table 2 - Distribution of the urban population in the World.

Distribution of the urban population in the World

Continent	South America	North America	Oceania	Europe	Central America	Africa	Asia
[%]	77	76	75	74	53	35	35

(Source: Fund of the UN to Population Attendance, 2000).

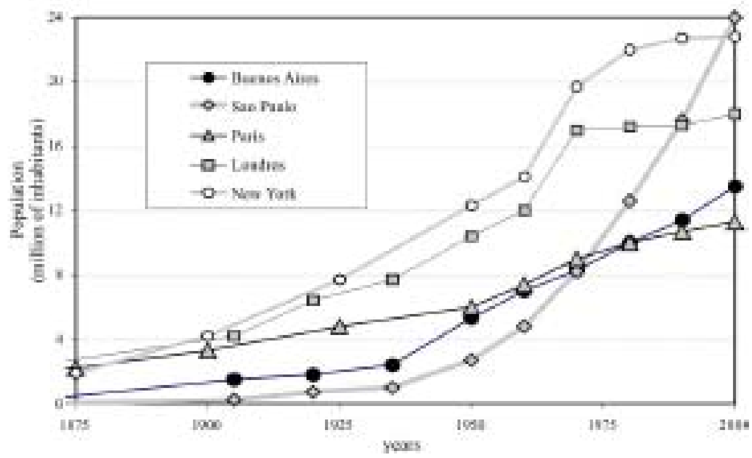


Figure 1 - Evolution of the population of big metropolis of Europe and America. (Source: Guglielmo, 1996; INDEC, 1999).

According Gugliermo (1996), in the second half of the XIX Century or in some cases, in the first half of the XX Century, the metropolis of the industrialized countries registered sudden acceleration in their demographic growth linked to the industrialization. On the other hand the industrial development of the fewer developed countries has been stronger during the second half of the XX Century. In fact, in 1950 six from the biggest metropolis in the world belonged to developed countries. According to the author, from the 37 cities of more than 5 million of inhabitants in 1990, only 12 belonged to the industrialized countries of the northern hemisphere. Also, among the most populated cities of the world, 4 were located in Latin America (San Pablo, Mexico City, Buenos Aires and Rio de Janeiro). Pelletier and Delfante (2000) remark these differences emphasizing that the cities of the third world have suffer, since the middle of the XX century an explosive growth. In this period the annual growth rate has been superior to 3% in almost every mayor metropolis of the third world, reaching in some cases 5 or 6%.

This growth rate has started to decrease since 1980. The Figure 2 shows the evolution of the urban population in several countries of South America.

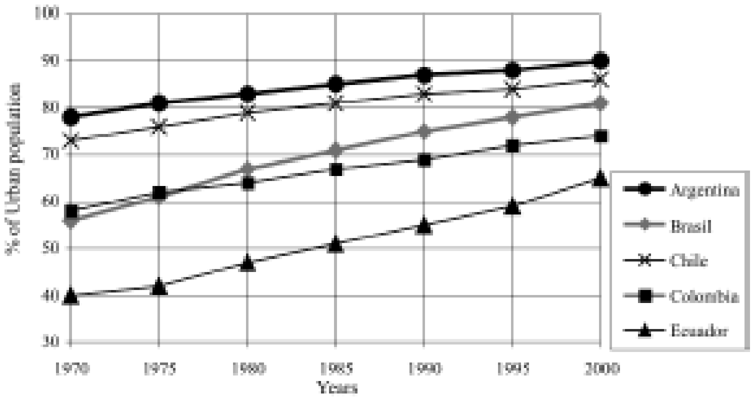


Figure 2 - Evolution of urban population in South America (period 1970-2000). (Source: World Development Indicators. World Bank, 1998).

URBAN FLOOD IN ARGENTINA

As indicated by the World Bank (2000), Argentina occupies the 14º position among the countries more affected by catastrophes related to urban and rural floods, reaching losses superior to 1,1% of the Gross National Product (GNP). The frequency of the flood occurrence with heavy consequences to the country is high and is reported as an important event that happens each ten years. The World Bank (2000) classified the argentinean flood in four basic types, depending on the region characteristics:

a) in the valley of the great rivers;

b) in the piedmont of the Cordillera;

c) in cities and rural areas associated to strong storm (flash flood);

d) in the plain bed areas, associated to inadequate management of natural resources, specially the soil and the vegetation.

The former is especially important by its duration and the degree of the affectation. In general this type of flood is related to the great rivers of the Del Plata basin. This region produces more than 76 % of the GNP and accommodates 70 % of the national population.

The catastrophic flooding of Santa Fe city, April-May 2003

The lower portion of the Salado river basin is integrally developed in the Santa Fe State, central region of Argentina. Its contribution area is about 55.950 km2. The predominant characteristic of the relief is to be plane, with an important sector rolling as a storage area (named “Bajos Submeridionales”). In many cases the limits of the sub-basins are diffused; they suffer constant modification by anthropologic actions, fundamentally by vial and hydraulics (channels) networks (Ferreira, 2005). The climate of the region shows a transition from sub humid (East) to semiarid

(West). The annual precipitation gradient for the period 1941/1970 varied from 1100 mm to 800 mm (East-West). During the three last decades (1971/2000) this gradient presented variations: 1200 mm to 900 mm (Paoli, 2004). The activities in the basin are typically rural, associated to agriculture (soybean/wheat) and cattle raising. In the basin are located some cities. Santa Fe city (400.000 inhabitants), the capital of Santa Fe State, is the most import. This city is located at the outlet of Salado River into Parana River system (Figure 3).

Figura 3 - Localization of Santa Fe city over the outlet of Salado river into Parana river system.

The flood occurred in April-May 2003 was originated by a succession of rains that occurred mainly between April 22 and April 24. Figure 4 illustrates the precipitation anomaly for April 2003. Due to important storms registered previously (in the period Dic/2002- Feb/2003) the soils of the basin were near saturation. Then, a substantial portion of these rains was transformed into runoff. Figure 5 shows the hydrogram characteristics.

Its rising limb presented a very important discharge gradient, been higher than others historic floods. A study based in the combined use of hydrologic historic marks and systematic information (Bertoni *et al*., no published) indicated that the recurrence of the 2003 peak discharge was 800 years.

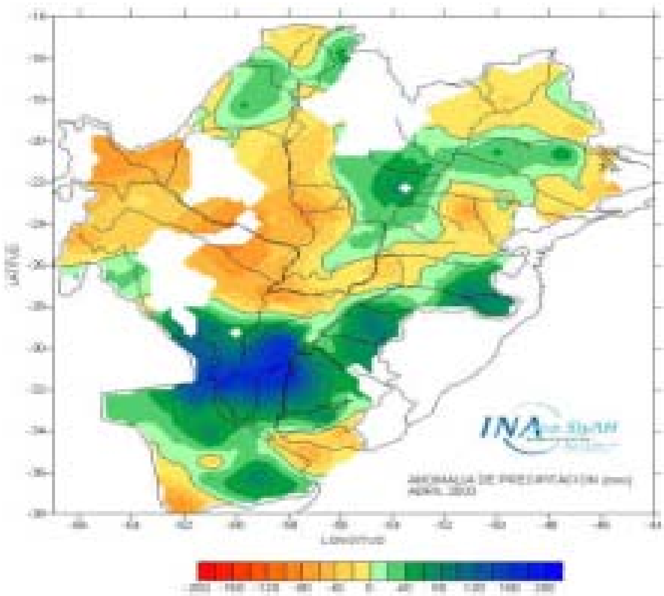


Figure 4 - Anomaly precipitation corresponding to April 2003 (Source: Paoli, 2004).

During ‘90 decade the Santa Fe Goverment State built various levees to protect Santa Fe city from floods especially from those associated to Parana River system. For the West margin of Salado River the protective levees (West levee) were though in three parts, but only two were realized (from downstream to upstream). Then, in 2003, at the moment of the rising water of the Salado River, the city showed a non-protected section from the end of second part to upstream. Due to the sector’s topographic characteristics, a section near the upstream extreme of the second part of West levee was the most critique (gap).

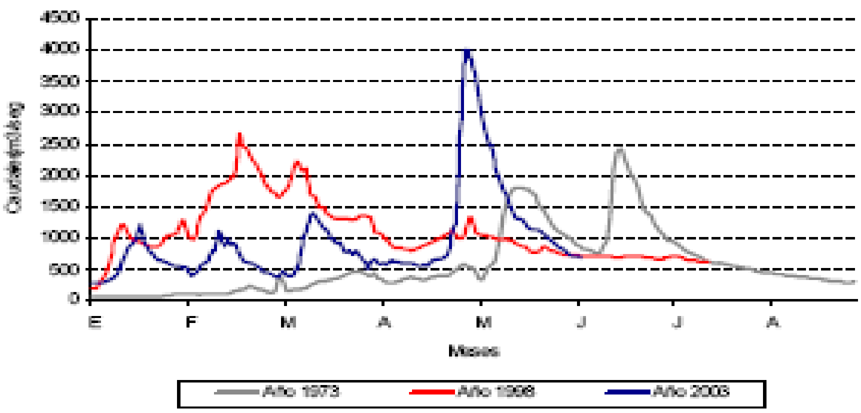


Figure 5 - Salado river hydrogram registered at RP 70 section for three historic floods (Source: Paoli, 2004)

To close the gap between the levee and higher lands nearby, a small non-engineered levee was tough to be built just before periods of high water levels (Figure 6). The situation associated with the evacuation of extraordinary floods was also complicated due to the existence of a bridge 1,5 km downstream. This work, associated to the AP01 Highway, was built in ’70 decade. It has an evacuate capacity very reduced and noncompatible with the flood magnitude.

During the 2003 event, the river spread its floodplain with unusual strength. The nonengineered levee was not built. The water entered to the city initially by the gap and some hours later the extreme North of the levee failed: the discharge to the city was about 700 m3/s. People living in west Santa Fe faced a sudden increase in water level of about 3,7 m in a few hours (Figure 7). The levee system hinders the exit of the water from the urban precinct rolling as the limit walls of a pool. The flooding took a heavy consequence, with 23 people death in the flood, and 43 reportedly death in the following weeks. One third of the city was under water at some point, including the new Children’s Hospital and middleand upper-class neighborhoods. One of the biggest problems during the emergency was associated to the control of diseases related to the stagnant water trapped inside the city. CEPAL (2003) reported 162 cases of hepatitis and 111 cases of leptospirosis occurred in the weeks following the catastrophe. Then, more than 200.000 people were direct or indirect affected by the disaster. The total loss attributed to the flood (rural and urban areas) was estimated on the order of 1,000 million dollars (CEPAL, 2003). This flood constitutes the worst environmental disaster in the Argentina’s recent history.

Figure 6 - Santa Fe city flooding sector. April-May 2003. (Source: El Litoral Journal, www.litoral.com.ar)

A detailed analysis of the phenomenon indicates that, despite of the severe climate conditions, the flood in Santa Fe city was maximized by:

a) The inadequate management of the emergency situation related to the lack ofa contingency plan.

b) Serious deficiencies in the hydraulic (levee) projects.

c) Inadequate drainage capacity of the bridge (AP01 Highway).

d) The occupation of vulnerable areas (areas threaten by floods) by the Santa Fe city urbanization processes.

e) Lack of a flood forecasting system.

Figure 7 - Flood in West portion of Santa Fe city, April-May 2003 (Source: Paoli, 2004).

The catastrophic flooding of San Carlos Minas, January 1992

San Carlos Minas (1.000 inhabitants) is located in Cordoba State, in the central region of Argentina. The town is developed into the margin of Noguinet Creek. Its basin, 260,4 km2, cover an area characterized by hill and strong declivities. In January 1992 the town was virtually devastated by a severe flood (Barbeito et al., 2004).

The convective storm precipitated 240 mm in 6 h into the upper basin, 140 mm in 7 h in the middle basin and 204 mm in 6 h in the lower basin. The average intensity of the rain was estimated in 180 mm/h. Nearly San Carlos Minas the water flood level activated an ancient stream system (Figure 8). The capacity of this course was suddenly surpassed.

As a result, the town was flooded in few minutes.

At the same time some big trees dragged by the flow were accumulated joint to a bridge located in the entrance of the town. The project capacity of the bridge was 800 m3/s but this value was drastically reduced by the trees. This originated a great backwater that a few minutes later produced a frontal wave, similar to a dam break wave. This huge wave devastated the town. Its peak discharge was estimated in 1.900 m3/s.

The consequences were 30 people death, 40 people disappeared and important material losses. Figure 9 illustrates the maximum level of the water at the upstream brigde section. Figure 10 shows some losses.

The geomorphologic studies confirmed that the town was located over a sector of the floodplain. These studies detected that the town was in the ancient path flow. In synthesis, the study of all the elements involved evidence the participation of natural factors as meteorologics, hydrologic and geologic-geomorphologics in the event. But to make these event a catastrophe the anthropologic factor was essential.

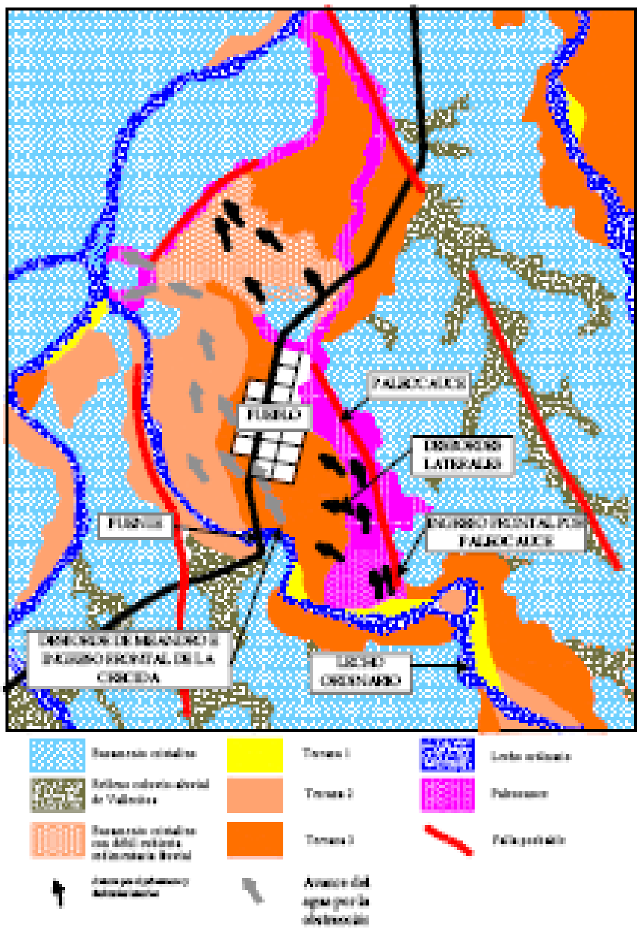


Figure 8 - Path flow into San Carlos Minas, in January 1992. (Source: Barbeito et al., 2004)

Figure 9 - Upstream bridge section, San Carlos Minas, Jan. 1992. (Source: Barbeito et al., 2004)

Figure 10 - Losses in a town developed with the loans of State, San Carlos Minas, Jan. 1992. (Source: Barbeito et al., 2004)

URBAN FLOOD ASSOCIATED TO TROPICAL STORM STAN – CENTRAL AMERICA

Floods in the Metropolitan Area of San Salvador, AMSS, El Salvador

El Salvador has 55,4 % of its population concentrated in urban areas. The Metropolitan Area of San Salvador (AMSS), El Salvador, has 2 million inhabitants. The 10 % of this population lives in conditions of extreme poverty and is located mainly in areas of high risk (areas threaten by floods, hillsides with high risk of detachment, etc.). The 75 % of the housing is served by sewer system, but less of 10 % of this total collected flow receives adequate treatment.

The AMSS is developed over the upper portion of two river basins: Acelhuate and Ilopango basins. The main part of the AMSS is located over the Acelhuate River basin.

This stream receives a sewer discharge equal to 5 m3/s from many point sources. In the AMSS the water supply system is insufficient for the demand of the new urbanizations, so the importance of the new water sources with adequate quality and quantity are always necessary. During many years the solutions for the pluvial drainage system were based in hydraulics conduction works as conduits, culverts, channels, etc.

The region has experimented also a non-controlled growth of the impermeable surfaces.

The tropical storm “Stan” recently affected various Central American countries (October 2005). This storm produced important rains during almost a week. For the AMSS area the total precipitation in the six days was superior to 500 mm (Figure 11). As a consequence, a succession of floods and the hillsides ocurred in all the 14 municipies than conform the AMSS.

It produced 65 deaths and a great number of injured. Figures 12 and 13 illustrate some the characteristics of the phenomenon in the urban sectors. Beyond the climate severity, the real causes of many of the observed problems are associated to lack of the urbanization processes planning. In fact, the non-controlled growth of impermeable surfaces, the exclusive use of the hydraulics conduction works, the occupation of naturally flooded areas and an inefficient planning and management of the pluvial drainage are some of the main causes for the recurrence flood suffered in the AMSS region.

As a result of its volcanic origins most of the AMSS soils have a high infiltration capacity.

Nevertheless, the use of infiltration devices as an efficient measure of control in the source is very little spreads yet.

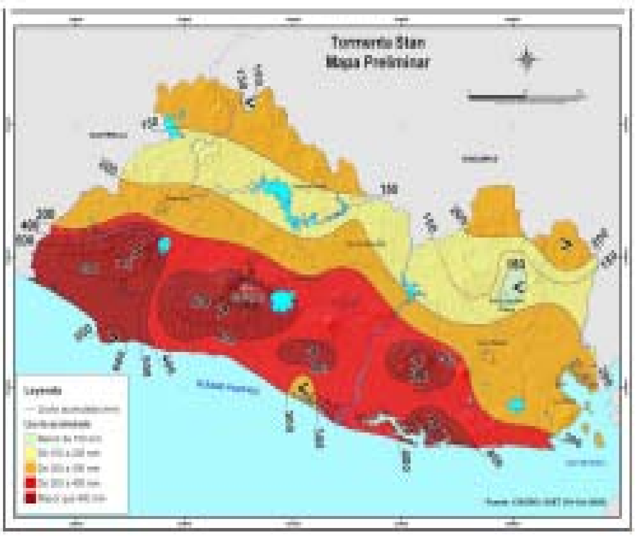


Figure 11 - Map of distribution of total rain over El Salvador (period 1-6 October). Stan Storm (Source: SNET, www.snet.gob.sv).

Figure 12 - Flood associated to the passage of Stan tropical storm. Bv. Venezuela, San Salvador. (Source: OPAMSS, 2005)

Figure 13 - Flood associated to the passage of Stan tropical storm. La Lechuza Creek, San Salvador. (Source: OPAMSS, 2005)

THE SIMILARITIES AMONG THE CASES ANALYZED: SOME SOLUTIONS

In the previous section were presented three cases of urban and semiurban flood associated to heavy storms. Tucci and Bertoni (2003) showed some other important cases in various countries of South America.

In general the geomorphologic, topographic, pedologic and climate factors are very different from one to other. Nevertheless the results are very similar.

A detailed analysis of the situation indicates that in most of the cases the main causes of the urban floods are related to the lack of planning associated to urbanization processes. In fact, to reach efficient solutions to the problems linked to the floods in urban areas, is necessary to act on the causes, covering all the relations among the different involved process. As the size of the cities increases the consequences of the lack of regulation and planning aggravates.

Among the typical reasons for the occupation of vulnerable areas is possible to point out:

i. Lack of restrictions in the parceling out of areas with high risk of flood.

ii. Sequence of relatively dry years that provoke the general "forget" of the authorities and the population.

iii. Lack of alternative for the population of low income.

iv. Lack of an Urban Drainage Master Plan.

The instrument that should contemplate this regulation is the Urban Drainage Master Plan of the city. The elaboration of this plan must consider the necessary concordance between the urban drainage system and the other systems of the urban environment. ASCE (1992) and Tucci (1994) enumerated diverse principles for the formulation of this plan. Among them there are three pointed out here:

a) The studies of the drainage urban may be analyzed in the integral context of the basins involved: it is necessary to eliminate the existent barriers among the study of the urban drainage problems (charged by the municipalities) and the analysis of the regional drainage (considered by the State or National level);

b) The near body's water areas, delineated by the natural floods, are part of the courses: all occupation that is carried out in these areas will originate the adoption of onerous compensatory measures later on.

c) The pluvial waters require space: once the rain water reaches the floor it runs downstream, existing (or not) an appropriate drainage system. The elimination of the natural storage needs compensatory measures. The lack of them, will implicate that the eliminated volume will be occupied in other place. In other words, the problem of urban drainage is, essentially, a problem of space assignment. That is why is indispensable to preserve areas or sectors for the handling of the waters.

CONCLUSIONS

Nowadays the popular current perception is that man's activities have disrupted most of the earth ecosystems. The hurricanes Mitch, Katrina and Stan, and the intense rainfall registered in many areas of Latin American countries are just few examples of that. In general this unexpected natural phenomenon has serious consequences for hundreds, or even thousands of people. In many cases the results are associated to urban or semi urban flood.

In Latin America the urbanization process is leading, among others, to the overexploitation of the natural resources, to the uncontrolled pollution, and to occupation of vulnerable areas. In most urban cases the concept of the basin as a unity for the water resources management is not considered. Then, the occupation of naturally flooded areas, the non-controlled growth of impermeable surfaces, and the lack of spaces for the efficient management of the pluvial waters create complex scenarios for the urban drainage. In this context the governments and the administrations of the underdevelopment countries do not have the human and economic resources and the legal frame required to reduce the risk of disasters through prevention and effective protection.

The urban flood associated to extreme climate event generally result in great disasters. But, as pointed out by Arnel (1996), from a scientific point of view it is difficult, however, to attribute those catastrophes to global warming.

Then the inappropriate use of the urban space, the lack of a master plan referred to the water resources management (especially devoted to the urban drainage system), and the lack of the contingency plan are strong causes of the flood consequences. In this framework the climate global changes acts maybe simply as a catalyser element of the problem.

REFERENCES

Arnel, N. (1996). *Global warming, rivers flood and water resources*. Wiley, Chichester.

ASCE, AMERICAN SOCIETY OF CIVIL ENGINEERS, (1992), *Design and Construction of Urban Stormwater Management Systems*, ASCE Manuals and Report of Eng. Practice Nº 77, WEF Manual of Practice FD-20. U.S.A.

Barbeito, O., Ambrosino, S., Bertoni, J.C. & Paoli, C.U. (2004), *Inundaciones Severas por Crecidas*

Extremas, Chapter 9, in: Bertoni, J.C. (org.), *Inundaciones Urbanas en Argentina*. Ed. Universitas. GWP-SAMTAC. CPCNA. SecyT/UNC, ARG-CapNet. Argentina.

Bertoni, J.C. (org.) (2004), *Inundaciones Urbanas en Argentina*. Ed. Universitas. GWP-SAMTAC. CPCNA. SecyT/UNC, ARG-CapNet. Argentina.

CEPAL. *Evaluación del Impacto de las Inundaciones y del Desbordamiento del Río Salado en la Provincia de Santa Fe, República Argentina, 2003*. NACIONES UNIDAS - COMISIÓN

ECONÓMICA PARA AMÉRICA LATINA Y EL CARIBE – CEPAL - LC/BUE/R.246. 20 de junio de 2003.

Collier, C.G. et Krzyzystofowicz, R. (2000). Quantitative precipitation forecasting. Journal of Hydrology. V. 239. 1-2.

Ferreira, G. (2005), Descripción de la crecida del río Salado e inundación de Santa Fe en 2003. XX Congreso Nacional del Agua, Mendoza, Argentina.

Guglielmo, R. (1996). *Les grandes métropoles du monde et leur crise*, Ed. A.Colin, Paris, 268 p.

NDEC (1999). *Anuario Estadístico*, Instituto Nacional de Estadística y Censos, Buenos Aires.

OPAMSS (2005), *Informaciones relativas a la tormenta tropical Stan*. Unidad Ambiental. San Salvador. No published.

Paoli, C.U. (2004), *Inundaciones Ribereñas en el Tramo del Paraná Medio*, Chapter 4, in: Bertoni, J.C. (org.), *Inundaciones Urbanas en Argentina*. Ed. Universitas. GWP-SAMTAC. CPCNA. SecyT/UNC, ARG-CapNet. Argentina.

Pelletier, J. & Delfante, Ch. (2000). *Villes et urbanisme dans le monde*, 4º édicion, Ed. A. Colin, Paris, 199 p.

Rosengaus, M. (2005). *Vulnerabilidad vs. Cambio Climático Global. Cuál Enfatizar en el Manejo de Riesgos?* Unidad del Servicio Meteorológico Nacional. Taller Regional Ibero Americano IMTA, CNA MMA España, RLOC y CDGIA. México DF.

Tucci, C.E.M. (1994). Enchentes Urbanas no Brasil, Revista da Associação Brasileira de Recursos Hídricos, Vol. 12/Nº 1, 117-136.

Tucci, C.E.M. & Bertoni, J.C. (edit.) (2003), Inundações Urbanas na América do Sul. Ed. ABRHGWP-SAMTAC. Brasil.

World Bank (1998). 1998 World Development Indicators, N.Y. USA.

Work Bank (2000). Argentina, Gestión de los recursos hídricos. Elementos de política para su desarrollo sustentable en el siglo XXI. Volume I-Informe Parcial. Informe Nº 20729-AR.

EMERGENCY AND DEVELOPMENT OF THE INTERNATIONAL REGIME OF THE CLIMATIC CHANGE (1990-2005)

EDUARDO VIOLA
Institute of International Relations of the
University of Brasilia

This article is organized in five parts. In the first part an introduction is given on the relation between the environment and the main lines of cleavage and alignment in the international system. In the second part a brief panorama is expressed on the emergency of the convention on climatic change. In the third part the differential realities of the main countries of the world are analyzed in reference to carbon emission and to the slow and troublesome process of negotiations that led to the Kyoto Protocol subscription, which started with its incomplete form in 1997 and was concluded in its definitive configuration in 2001. In the fourth part the specific role of Brazil in the world frame of carbon emission is analyzed - a country under no obligation in emission reduction, with an energetic matrix with low intensity of carbon and high emissions of carbon derived from the deforestation of the Amazon Region– and its attitude in the negotiations that led to its subscription to the Kyoto Protocol. In the fifth and last part there is an analysis of the changes in the international system that conducted to a relative decline (temporary?) of the Protocol in the first years of the XXI century.

ENVIRONMENT AND INTERNATIONAL RELATIONS

The global environmental problems, together with the information revolution and the economic globalization contributed to alter in a significant way the international relations in the last two decades. The environmental global problems emerged in the international agenda with the Stockholm Conference on Human Environment celebrated in 1972, but only gained a proper density when the hole in the ozone layer over Antarctica was discovered, which led to the subscription of the Vienna Convention For the Protection of the Ozone Layer in 1985 and of the Montreal Protocol in 1987. Soon after the ozone layer issue, at the end of the nineties, by initiative of the scientific community, the issue of global climatic change was put in the United Nations Agenda, originating a most complex, prolonged, relevant and fascinating international process of the environment issue. Four great international dimensions of cleavage (divisive line of conflict) and alignmenst are necessary to understand the complexity of global environmental problems and climatic change in particular: an interstate dimension, civilization, democracy versus non democracy and, within democracy, liberalism versus communitarism dimension.

Firstly, we have the classical cleavage among national states, which continues to be a fundamental origin of competition and cooperation, with a decrease on the relative importance of conflict and an increase on the relative importance of cooperation (when compared to the cold war period) due to the intensification of economic and technologic interdependence. In the interstate order, The USA occupies a position of superpower, considering that in the military sub-dimension they occupy a position of hyper-potency and in the economic sub-dimension they share the centrality with the European Union, Japan and China. Next come the regional potencies: Russia, India and Brazil. By their efficacy and efficiency in its govern-ability the states may be classified into developed, emergent, in debt and bankrupt. The interstate order continues to be fundamental in global environmental problems, in so far as the states are the contracting agents in the international regimes.

In a second dimension we have a differentiation among the great civilizations, such as: Western, Latin-American, Slavic, Japanese, Confucian or Chinese, Islamic, Hindu and African. The Western Civilization occupies definitely the vanguard position of the civilization process due to the combination of free market economy, individualism, state of law and representative democracy having produced a superior society in the dominance of nature and in the construction of a technosphere- the diverse technical structures that are the product of historically accumulated human effort, in counter-position to biosphere, which is the product of the history of life. The Japanese civilization has already totally converged towards the Western. The Latin-American presents nowadays a high heterogeneity, leaning from a convergence with the West, in the cases of Chile, Costa Rica, Uruguay, Brazil and Mexico, towards a significant distance in the cases of Cuba, Haiti, Nicaragua and Venezuela. The Slavic civilization initiates only in 1989 a process of approximation to the West, a process full of advances and retreats. The Confucian civilization is propelled towards a convergence with the West due to the technological vector, and urged to augment the distance from the West due to socio-psychological vectors. The Hindu civilization keeps a distance from the West while maintaining the chaste regime, though converging to the West whilst adopting political democracy and also due to technological vector. The Islamic civilization is currently in a process of confrontation with the West and, to a lesser degree with the Hindu, Slavic and Chinese. The African civilization, after being partially westernized during the colonial period from the midst of the XIX century to the midst of the XX century, is nowadays in a process of devastating regression. The Western Civilization was the birth of modern Environmentalism, in the 1960 decade. Beginning in the West, the concern with environmental problems expanded in the Japanese civilization in the seventies, in Latin America from 1980 onwards and progressively among the others in the decade of 1990.

In the third dimension we have the cleavage between the democratic world – strongly rooted in the Western and Japanese civilizations, almost consolidated in certain parts of Latin American civilizations, quite fragile in other parts of Latin America and in the Hindu and Slavic civilizations- and the non democratic world- most of the Chinese, Islamic and African civilizations. There is a high correlation between democracy and the expansion of the concern with environmental problems, with the only exception of Singapore (in this country prevails one of the highest levels of environmental quality in the world, subsisting a semi-democratic political regime which implies limitations to political competition).

In the fourth dimension, we had the cleavage between liberalism and communitarism within the democratic world. Liberalism is the dominant current all over the democratic world (except in Japan) and is based in the predominance of the individual over the groups, in the predominance of the market over politics, in meritocracy and political representation with sporadic participation of political parties. Communitarism is a secondary current within the democratic world (except in Japan , where it is predominant), having had periods of great impulse, as in the student's rebellion of 1968, in the utopia of govern-ability with a civil world society just after the end of the Cold War and in the anti-globalization movement institutionalized at the World Social Forum. Communitarism is based in the predominance of the group over the individual, the predominance of politics over the market (in one of its most extreme manifestations there is a rejection of the market) and in high political participation through multiple associative structures that can be more socially restrictive (due to gender or ethnics) or more based on individually construed options. Modern environmentalism was born within a communitarian angle of democracy, but in due course, an important part of it was converted to the liberal angle.

Since Stockholm-72, passing by Rio-92, until present time, the solution of scheduled environmental problems was always put in a context of global govern-ability. However, in these last decades there have been significant changes in relation to the role of different agents and to the characteristics of the regimes associated to many environmental problems. In the same way that in the 1970 decade a prominent role was intended to the states and in the years 1980 this same prominence was designed to civil society, in the nineties the axis of govern-ability was gradually transferred to the domain of the market and its agents. Global – govern-ability is certainly based in a mixed system of agents that functions in a polyarchic** manner (with a significant grade of inclusion and competition), but this does not presuppose that at each historic moment the responsibility of each agent may be always the same. Projecting the role that the states had in the seventies to the present or the civil society had in the eighties would be an anachronism. Global govern-ability presupposes a system of mixed agents that cannot be biased by ideological or utopian assumptions. Nor economic corporations, nor the states or non-governmental organizations can be excluded from the functioning of environmental regimes, but this does not mean that the so called regimes should be always subordinated to the concerns and motivations of one of these groups of agents. In this sense, what really interests is that a determined regime may respond to the solution of the environmental problem to which it is bounded and for this reason it is not important to know which is the more "righteous" of all alternatives, but which is more viable, the one that better contributes to a positive participation of the many involved agents. For this reason, what really interests in an environmental regime is the establishment of realistic norms of action which allow a progressive negotiation among the various agents in search of a common objective. In many occasions, when the regime does not function well, it appears that the agents have established rules that are under no obligation to the real dynamics of the contemporary world.

The govern-ability presupposes the existence of clear democratic and cosmopolitan rules so that the agents may negotiate their different interests, both as a realistic identification of which are the main interlocutors representing the group in this particular historical moment as in relation to the problem that summons them. Considering democracy in a utopian mode, as an instrument of equalization in the decision control of the various States, or as an equalization of the role of the agents from civil society and the market, the regime would be condemned to failure .A regime will only be effective when it is processed in a realistic way, correctly identifying the weigh of the engaged interests and giving to each agent the importance and hierarchy correspondent to each of them within the group. Thus, global govern-ability should be thought as a complex process, integrated by numerous processes which sometimes converge, or diverge, depending on the capacity of the involved agents to interact in a democratic, realistic and rational manner. This means, in other words, that the major or minor achievement of global govern ability, in a determined historical moment, will depend on the course the agents take towards a more cosmopolitan than national direction, more liberal than utopian and more realistic than formal.

There cannot be a global govern-ability in a context where the agents place their national interests above any other concern. From the historical point of view, the USA and the liberal democracies have been the most compromised with the maintenance of a pluralist based international system. Like it or not there is no other alternative to a realistic evolution towards cosmopolitan positions which does not have its origin in capitalist liberal democracies. There must not be any discussion on this. Global govern-ability demands from their agents a democratic and cosmopolitan vision of law and politics as well as a liberal vision of society and economy. Obviously, this does not imply that all countries and social groups of the world should accept the western vision of the world in all its details. However, it should imply that a basis to develop a system of agents with democratic and cosmopolitan orientation, capable to guarantee global govern-ability, will be found in the dynamics of the more advanced capitalist democracies of the West.

THE CONVENTION OF CLIMATIC CHANGE

If until the 1970 decade all important states, acting on their own interest, were capable of resolving most of their disputes with other states, be it through conciliation or coercion, without loss of their sovereignty, starting at the 1980 decade there occurred a differentiated loss of autonomy in most of them (with the only exception of the USA), and therefore a necessity of more international cooperation, which demands much flexibility in the negotiations. The collective benefit increasingly requires many procedures that affront the interests of each individual state. The constitution of international economic, security and environmental regimes began to impose a few restrictions to the sovereignty of most of the states. There was, simultaneously a certain transference of power from the state to supranational institutions and to transnational corporations, which developed new centers of authority.

The problems of climatic change are bounded to collective/common global goods. The atmosphere, for example, is a public global supply, since its utilization by an agent does not exclude the possibility of its utilization by another. It has, however, a limited capacity of absorbing pollution or greenhouse effect emission of gases with no changes on human health or on the climate. Considered these limitations, the international leaderships and conventions of the last decade attributed to atmosphere the "common concern of humanity", and the problems of its use were consensually linked to the construction of international regimes.

An international regime is a system of rules, made explicit in an international treaty, agreed among governments, which regulates the actions of many agents on a subject. The international regime of climatic change has as its fundamental parameters the Frame-Convention of the United Nations On Climatic Change, signed in Rio de Janeiro in 1992, and the Kyoto Protocol, signed in that Japanese city in 1997. The scientific community has a key-role in relation to these issues, as the great majority of scientists agrees to the diagnosis of a problem and is efficient in communicating it to the public and to decision makers, the so-called "epistemic community" being created. The constitution of the Intergovernmental Panel on Climate Change (IPCC) by initiative of the United Nations, in 1988, gave birth to the process of analysis and evaluation of the effects of climatic change that was politically translated in the constitution of the Intergovernmental Negotiating Committee for a Convention on Climate Change. During the 1990 decade, the IPCC furnished fundamental subsidies for the conduction of a negotiation in the domain of the Convention and has assumed a role of reference in the formation of public international opinion on the climatic change subject.

The scientific community of climatologists, which during the decade of 1980 formulated the theory of global warming is constituted of approximately two thirds of scientists who work in North American institutions. The United States, under the recently initiated presidency of Bush (father, 1989-1993) assumed a role of leadership in the negotiations that led to the formation of the IPCC and to the summit of the United Nations Conference on Environment and Development (CNUMAD/UNCED), in 1989. The leadership role of the United States began to decrease as the negotiations of the convention of climatic change in the years 1990-1992 advanced. The North American position was against the establishment of goals of reduction of greenhouse effect of gases emissions, with the argument that there were too many uncertainties on the subject and that it was necessary to have more scientific investigation; and more favorable to the promotion of carbon sequestration by means of massive forestation. Only two Scandinavian countries, Holland and Germany had a defined position in favor of establishing forceful goals for emissions reduction. The final text of The Convention on Climatic Change established a generic agreement for the countries that belonged to Annex I (developed countries of the Organization for Cooperation and Economic Development and industrialized ex-communist countries in transition to the economy of market): the basic year for emissions would be 1990, and in 2000 the emissions of these countries should not be superior to those of 1990. For the countries that did not pertain to Annex I (like Brazil), the convention established only an agreement for the elaboration of national inventories of carbon emissions.

During the electoral campaign of 1992, soon after the conference realized in Rio de Janeiro, Clinton and Gore criticized Bush and promised, taking advantage of the favorable impulse of the North American public opinion, a strong leadership action to confront the problem of global warming. At the I Conference of the Parties in the Convention of Climatic Change (Berlin, March of 1995), the Clinton government assumed a position of leadership in the sense of establishing mandatory goals of reduction for the developed countries and goals of reduction in the future rate of increasing emissions for developing countries. In this convention Brazil had an important role in arguing that, in a first phase, it would not be appropriate to establish obligatory agreements for developing countries; and during the discussion Brazil got the support of Japan and of the European Union, isolating the American position in relation to the issue. At the II Conference of the Parties (Geneva, 1996), the North American delegation newly asserted the urgency of negotiating obligatory goals of reduction of greenhouse effect gases emissions, introducing for the first time the idea of marketable quotas of carbon emission which would function as a flexible mechanism complementary to the reduction of emissions among the countries of Annex I. The idea was based in the experience with the marketable quotas in the emission of sulfur and particle materials of electrical plants according to aerial basins (the country is subdivided in units according to the regional atmospheric circulation), implemented in the USA four years ago, which had proved to be more effective than the classical mechanisms of command and control in the reduction of emissions. The American proposition was rejected in general terms for three reasons; first, due to lack of comprehension of the model, as no other country had experimented such mechanism; second, there was a principle attitude against the use of mechanisms of market for environmental protection; third, because the American proposition included commitments from developing countries in reducing the rates of rising emissions. Finally, the COP II agreed to immediately initiate the negotiations for the establishment of a protocol that would compel the reduction of emissions of countries of Annex I and would try to study ways of establishing complementary mechanisms.

THE KYOTO PROTOCOL

Between the II and the III Conference of the Parties (Geneva, June of 1996, and Kyoto, December 1997) there was a series of negotiations for the formulation of the Kyoto Protocol. The North American position followed three main lines: the establishment of low goals of emission (less than 5%) until 2010, having as 1990 as the year- base; the establishment of goals of reduction in the growth rate of emissions from emerging countries; and the establishment of market mechanisms that would flex the objectives, particularly the marketable quotas of emission among the Annex I countries. As to the first objective, The United States were successful in relation to the Europeans, who wanted more impressive agreements for reductions. As to the second, they were defeated, as they had already been in the Conferences of Berlin and Geneva. In relation to the third, they conditioned the signature of a new agreement to the flexing agreement, with the strong support of Canada, Australia, Russia and the countries of East Europe, members of the Annex I.

In July 1997, during the negotiation of the Kyoto Protocol, the USA Senate positioned itself unanimously contrary to the ratification of the Protocol, unless the emerging countries assume commitments to decrease their future rates in emission growth. In spite of this, the Clinton administration signed the Protocol, but did not send it to the Senate for ratification. It was the beginning, however, of a political articulation in the sense of obtaining commitments of reduction of emission growth from a few emerging key countries, among them Brazil and Argentina.

Every process of construction of an international regime demands always the presence of at least one agent to impulse the process, capable of leadership and maintenance of the regime. For its importance in the economy and in the global environment and the efficiency of its govern-ability, only the United States, the European Union and Japan presented this potential at first instance. On issues of environment international regimes, The European Union began to act as a group since the midst of the 1990 decade; thus, the supranational European State, in this case, had a much greater capacity of acting than the sum of its national states. Countries like China, India, Russia, Canada, Indonesia and Brazil have revealed themselves very important in all the processes of decision, in spite of not presenting a leadership potential. Finally, the participation of these eight countries and the European group is a basic condition for the functioning of the emissions control regime. The following frame presents important indicators of these countries and the European Union.

	World Population (1999)	World GDP (per buying power in 1999)	GDP per capita (per buying power in 1999)
United States	4,6%	21,3%	29.200 U$
European Union	6,3%	20,5%	24.000 U$
China	21,0%	10,2%	3.100 U$
Japan	2,1%	8,0%	23.600 U$
India	16,5%	5,4%	2.100 U$
Brazil	2,8%	2,9%	6.500 U$
Russia	2,4%	2,4%	6.200 U$
Canada	0,5%	2,3%	31.000 U$
Indonesia	3,5%	1,3%	2.400 U$

	World Carbon Emissions (1999) Anuual (1990-1998)	World Forest Area (1995)	Mean deforestation
United States	24,5%	6,0%	0,0%*
European Union	14,5%	2,0%	0,0%
China	13,5%	4,0%	0,1%
Japan	6,0%	0,7%	0,0%
India	4,5%	2,0%	0,05%
Brazil	3,5%	16,0%	0,5%
Russia	5,0%	22,0%	0,1%
Canada	2,5%	5,0%	0,0%
Indonesia	1,5%	3,0%	1,1%

*The north- Americans increase their forest area at the rate of 0,3% per year.

The conflict of interests among the developed, emerging and poor countries is one of the determining issues in the dynamics of negotiations of the process of establishing a climatic change regime. In the democracies there is a strong internal dispute of interests and values, configuring a situation that a certain country in a specific negotiation moment will result in a coalition that varies according to the definition of the country's policies in the international scenario. For this article's objective we shall call by pro-Kyoto the forces that are favorable to the regime of climatic change and anti-Kyoto forces the ones contrary to the climatic change regime. Alliances and groups were formed since the Rio de Janeiro Conference in 1992 as a result of vigorous disputes among the countries as well as cleavages and national alignments, international and transnational. The climatic change regime was led by the USA and by the European Union between 1989 and 1991; by the European Union between 1991 and 1995; by the USA, European Union and Japan, between 1995 and 1997; and since 1998, only by the European Union.

During the post Kyoto Conferences of the Parties (Buenos Aires, 1998; Bonn, 1999, and Hague, 2000) there were four chief negotiations coalitions: the European Union, the Umbrella Group, the G77/China e, finally The Alliance of Small Island States.

The European Union was (until 2004) formed by 15 countries, most of them with medium intensity of carbon per inhabitant and per unit of GDP. In the European Union there is a clear predominance of the Pro-Kyoto forces.

The Umbrella Group is constituted by three subgroups. First, there is the continental countries subgroup (USA, Canada and Australia) with high intensity of carbon per inhabitant and medium intensity per unit of GDP. Due to importance of long distance transportation, these countries have significant difficulties to reduce emissions. In these countries there is a profound division of forces between favorable and contrary to Kyoto. In second place, the subgroup of developed countries with medium intensity of carbon per inhabitant, which have difficulties in reducing its emissions, some of them because they had already significantly reduced before 1990 (Japan, New Zealand, Norway) or because they have a public opinion with low global responsibility (Switzerland, Iceland). In a third position, industrialized ex-communist countries which suffered a drastic reduction in emissions or carbon due to economy collapse (Russia, Ukraine, Belarus, Bulgaria, Romania) and, consequently have credits in the series of intrinsic commitments. In these societies predominate the forces favorable to Kyoto, due to expected benefits through implementation of quotas of emissions commerce; however there is no support for national public policies directed to decrease the intensity of carbon in their economies which are very high per unit of GDP.

The G77/China is constituted by more than a hundred countries, all in development, except the islands. All the countries of this group strongly support the Kyoto Protocol, due to the expectations of gains derived from the implementation of the Clean Development Mechanism. There are three sub-groups. First, large countries with a significant proportion of global emissions (Brazil, China, India, Indonesia, South Africa) from which the developed countries demand a commitment of reduction in the future emissions growth rate, the sooner the better. Of these five countries only Brazil shows predisposition to give some attention to the question, while the others are totally resistant. In second place, the countries of the Organization of Petroleum Exporters (Saudi Arabia, Kuwait, Iraq, Iran, United Arab Emirates, Libya, Algeria, Nigeria, Venezuela, Equator and Indonesia), which are in their great majority contrary to the regime of climatic change, though expressing this rejection in an indirect way. In third place, the countries strongly receptive to the establishment of a commitment towards the future reduction of emissions growth rate (South Korea, Singapore, Argentina, Uruguay, Chile and Costa Rica).

The Alliance of Small State Islands is constituted by two dozen small islands which are very vulnerable to climatic change and struggle for the intensification of the Kyoto protocol in the sense of augmenting the commitments in reducing the emissions of all countries.

During the Conferences of the Parties of Buenos Aires (1998, Bonn (1999) and Hague (2000) more controversial issues should have been negotiated. These issues had remained without definition at the Kyoto Conference, such as the limits to the role of the flexing mechanisms (the maximum proportion of the commitments of the Annex I that could be accomplished resorting to the Emissions Quota Commerce, to the Common Implementation and to the Clean Development Mechanism), the role of carbon sequestering and the role of technologies transference. The Umbrella Group supported the non-restriction role of the flexing mechanisms (Emission Quota Commerce – Joint Implementation among the Annex I countries- Clean Development Mechanism among all countries), against the position of the European Union. Brazil supported strongly the Clean Development Mechanism (this mechanism was based on a proposition of Brazil, in June 1997), aligning with the Umbrella Group, but tended to limit the action to the Emission Commerce and to Joint Implementation, getting closer to the position of the European Union. The Umbrella Group supported in an incisive manner the accountancy of carbon sequestration (forests, soil management, etc) as a deduction of the commitments for emissions reduction, against the European Union. Brazil supported the European Union but most of the Latin American countries aligned with the Umbrella Group.

The G77/China and the Alliance of Small Island States proposed a large package of free transference of clean technologies from the developed countries to the developing ones, against the Umbrella Group and the European Union, which supported only a more limited package. In this matter Brazil played a leading role. The petroleum exporter countries, led by Saudi Arabia, defended the possibility of a compensation for eventual decreases in exportation revenues, against the rest of the world.

The European Union proposed an ample sanction regime for those that did not accomplish their commitments, against the Umbrella Group, which presented a less radical regime. Brazil, in this case, supported the European Union.

The issue that precipitated the failure of the negotiations in Hague (2000) was the maximum value for the financial credit for carbon sequestration, as deductions from the Annex I emissions. There was no agreement on the maximum value: The European Union, contrary to the Umbrella Group, would only accept the sequestration with a very low value.

In January 2001 the third official report of the IPCC was approved in Shanghai, which alerted for the risks of climatic change and for the necessity of prompt action. This report caused great impact on the Economic Forum that occurred in Paris the next week. In this Forum, the globalization establishment appealed to president Bush (the son, 2001-2005) for him to assume a position of leadership (confronted with the new scientific certainty on climatic change) in the final negotiation for the ratification of the Kyoto Protocol. In March 2001, the Bush administration officially announced that it was withdrawing from the Kyoto Protocol negotiations, considering it inappropriate to deal with climatic change for two reasons: the lack of relevance credited to the mechanisms of the market and the non-establishment of commitments from the medium income countries with fast emission growth. The USA withdrawal caused a commotion in the international community. However, after a few weeks of disorientation, the European Union decided to carry on with the negotiations to complete and ratify the Protocol.

In July 2001, in Bonn, all countries, except the USA got to an agreement on most of the pending issues since the Conference of Hague, in 2000. To obtain the support of the Umbrella Group, The European Union had to accede in many points: a recognition of credits for apprehension of carbon through correct management of forests and soils, no restrictions to the use of flexing mechanisms and the acceptance of a reduced regime of sanctions. In these three spheres, the agreement was much under what had been proposed by the Clinton administration in Hague (2000) and which had been rejected by the European Union. In another front, to obtain the active support of countries outside Annex I, the European Union mobilized Canada, Norway, Japan and Switzerland in the sense of promising additional financing (circa half a billion dollars per year) for the development of institutional capacities and for transference of clean technologies, to begin in 2005.

After the withdrawal of the USA, the negotiating position of the European Union based on the principle that a minimum agreement would be better than the ending of the Kyoto Protocol. The arrogance of Bush’s retreat transformed the Protocol into a leading issue for the European Union foreign policy – it began to be operated by the Head of Governments and Foreign Ministers instead of being restricted to Environment Ministries. In general, countries started to consider the final approval as an emblem in favor of a govern-ability of the global ambiance based in the multilateral negotiation, in disagreement with the unilateral policy of the Bush administration. However, it was only in February 2005, that the Protocol came into force, due to Russia’s delay in ratifying it. Most of the analysts consider it of small effectiveness, unless the USA would adhere (through concessions) to the Protocol. In fact, beyond the role of rhetoric voluntarism, no international environmental regime (nor economic or of security) is viable without the presence of the USA. There is still the problem that, even with the presence of the USA, the Kyoto Protocol has a very limited impact on the growth of carbon emission. While the Intergovernmental Panel on Climatic Change estimates that a drastic reduction of emissions (approximately 40% or the l990 level) would be necessary to stop climatic change, the reality is that the implementation of the first period of commitments to the Kyoto Protocol would not engender a reduction in total emissions of more than 8% of the emissions of the developed countries, which would be lavishly counterweighed by the increase of the emissions in the developing countries.

All the most important countries of the world are being responsible for the difficulties in the construction of a regime that attenuates climatic change due to an excessive maximization of national interest. However a few countries have a greater responsibility for the apparent failure: firstly the USA (responsible for a quarter of the emissions, very high per capita emissions, with little disposition to reduce and without leadership vocation since 2000); Australia (which supports the USA and has the greatest per capita emission of the world); China and India (the giants, with, with great emissions per unit of GDP, whose emission rise fabulously, devouring the reductions of others and are not giving signs of a disposition to reduce the future curve of growth); and Saudi Arabia, Russia, Kuwait, Emirates, Iran, Venezuela, Nigeria and Algeria (all of them great exporters of petroleum and aware that they are the great losers in a world of renewable energies).

Confronted with the difficulties of cooperation for the mitigation of climatic change, the efforts of the countries should gradually be increased in the sense of adaptation to climatic change. Those that will suffer the most are the poorest and that is the reason for them to urgently but with many difficulties try to improve the efficiency of their economic and political systems. The most important aspect of adaptation to climatic change will derive from endogenous national efforts, and an international cooperation (even in the most optimistic scenario) will play a secondary role, even though relevant.

BRAZIL IN THE GLOBAL POLICY OF CARBON EMISSIONS

The Brazilian government position in the Rio-92 Conference was based on the following: the global environmental problems are very important and its resolution should be prioritized by the international community; the responsibility for global environmental problems has been differentiated among different countries along history, and this should have reflected on the policies to deal with them, the rich countries assuming the larger part of the costs. During the negotiations of UNCED (1990-92), the Brazilian government progressively retreated from its nationalism, a dominant characteristic of the years 1972-88, an adopted a global position: it took a leadership role in the elaboration of the Biodiversity Convention, facilitated the negotiations and the agreement in the convention on climatic change, and supported financial commitments in relation to the Agenda 21. In spite of this, nationalism had its brief reappearance when Brazil supported Malaysia in its opposition to sign a forest convention.

For a better comprehension of Brazilian participation in the negotiations of the Kyoto Protocol, it is necessary to take into consideration that, in what refers to emissions of CO2, the country has three great advantages and a principal disadvantage. The three advantages are: being a country of medium income (external to the obligatory commitments for CO2 gases reduction of the developed countries and the ex-communist industrialized countries); having an energetic matrix with great preponderance of the hydroelectric sector (more than 90% of the electricity is derived from hydroelectric plants), which reduces the emissions of greenhouse effect gases; and having, in its territory 16% of the forests in the world, with great importance in the global carbon cycle. The great disadvantage is having high rates of CO2 emissions, due to the use of slash and burn in the traditional agriculture and in deforestation in the Amazon Region. The Brazilian emissions of CO2 represent, approximately 3,5% of world emissions, 25% of these emissions being produced by modern economy and the other 75% produced by traditional agriculture, changes in the soil use at the agricultural frontier and by an inefficient timber industry. Consequently, the country has higher per capita emissions than the average of emerging countries, as well as a greater intensity of emissions per unit of GDP than the average of developed and emerging countries.

Due to the importance of the Amazon Region in Brazilian emissions of CO2 it is convenient to examine with more detail the federal government's policies in this sector. They have presented the following characteristics: incentives to large investments in mines, energy, timber, soybean and transportation; low punitive capacity to avoid illegal deforestation from timber industry, land-owners, invaders and settlers of the Movement of Landless Laborers (MST) and of traditional populations; low ability in the political articulation and incentives for the development of biodiversity/biotechnology complexes, which values the forest resources promoting the development of productive networks of aggregate value; low capacity in promoting national and international ecotourism; inability to control the expansion of organized crime derived specially from drug, weapon, gold and wild animals traffic; and priority to develop the SIVAM radar system, which became operational in 2002 and has been showing positive impacts in terms of controlling illegal activities. The rise in demand of timber in the rest of the country, the presence of vast contingents of inhabitants living in complete poorness with the consequent tendency to invade and burn public land, the frailty of the local IBAMA offices, and a short term development approach of the local elites, have been the fundamental causes of Amazonian deforestation. The rhythm of deforestation has been of more than 20 000 km² per year between 1985 and 1989, however, since 1990, a less predatory use of the forest puts the numbers between 15.000 and 20.000 km² per year with peaks superior to 20.000 only on years of strong economic growth (1994, 1995, 1996, 2000, 2003 and 2004). The small intent and limited capacity to restrict deforestation in the Amazonian Region by the Cardoso and Lula Governments (and by most of States governments) have been a limitation to the potentialities of Brazilian leadership in the Kyoto Protocol. The deforestation establishment, predominant in Amazonia and with great power in Congress, has conditioned the behavior of modern Central and Southern Regions.

The Brazilian performance in the process of negotiation/ratification of Kyoto(1996-2004) was guided by a definition of national interest based in five chief dimensions (which were much more committed with global govern-ability than at the time of the Stockholm Conference): 1- affirming the right to development as fundamental component of World Order, in continuity with one of the classical pillars of Brazilian Foreign Policy; 2- promoting a world vision of development associated to environmental sustainability, in correspondence with the strong growth of public conscience in respect to environment in Brazil and its translation in state and national policies; 3- promoting the financing from developed countries for climatic migration related projects in emerging countries; 4 – promoting a leadership role for Brazil in the world, in correspondence with the growth of the international prestige of the country during the Cardoso administration; and, 5 –obstructing international regulations to the use of forests with the objective of avoiding the risks or international questionings in relation to Amazonian deforestation. It is important to emphasize that the entrance of the forest issue in the world climatic regime was not noticed as a threat to its national sovereignty by a great part of the other country- holders of vast forests: USA, Canada, Russia, Australia, Chile, Argentina, Colombia, Peru, Costa Rica and Mexico. To the contrary, these countries promoted the international forest regulation.

In June 1997, Brazil made a new and original proposal, the Clean Development Fund, CDF, which would be defrayed by penalties paid by developed countries that did not fulfill their commitments in the reduction of CO2 emissions. This proposition had strong support from poor and emerging countries but confronted a firm opposition from developed countries.

In October 1997, there was a surprising event: the USA and Brazil articulated an altered version of the CDP, which would be called Clean Development Mechanism, CDM. The CDM had the objective to compel developed countries to finance non members of Annex I countries, which made a commitment to use less intensive in carbon types of energy. Without the penalizing character of the original Brazilian proposition, which established penalties for the Annex I countries that failed in reducing their emissions, almost all countries supported the CDM. This opened a possibility for developed countries to accomplish part of their promises of emission reduction through the financing of sustainable development projects in poor and developing countries. The CDM ended up by constituting one of the greatest innovations of the Kyoto Protocol, and through it Brazil accepted the concept of flexible market mechanisms to complement the commitments of reduction of the developed countries. Thus, Brazil broke up both the previous opposition to joint implementation (present in the Rio Convention of 1992), as with its opposition to the commerce of emission quotas among countries of the Annex I (which ended up by being introduced as a fundamental mechanism in the Kyoto Protocol).

The introduction of the CDM proposition implied in a moment of strong collaboration between the North American and Brazilian diplomacies a victory for both, since by means of such collaboration the poor and emerging countries started to accept flexible market mechanisms to complement the commitments of reduction from developed countries. The most interesting component of the Brazilian position in all the negotiations of the Protocol was the capacity to articulate with the American diplomacy, in October of 1997, transforming a non viable fund – the CDF – into a new and promising mechanism – the Clean Development Mechanism (CDM).

Between 1999 and 2001, Brazil led the countries that had proposed with success that the CDM should be the first of the three flexible mechanisms of market to be implemented and that its Directing Council should have a larger representation of poor and emerging countries than the Global Environment Facility. The Clean Development Mechanism was the most "green" position ever assumed by Brazilian diplomacy in the constitution of the Climatic Regime.

As to carbon sequestration, the Brazilian national interest was always defined in a defensive way: the Amazonian forest was perceived as an onus due to deforestation and was not considered as a trump card due to its world role in the absorption of CO2. The implicit assumption of Brazilian negotiators was that the country would not be able to prevent in an efficacious way the Amazonian deforestation. This led Brazil to oppose itself to the inclusion of all carbon cycle in the Protocol, fearing that in the future, when commitments were established for emerging countries, the country could be penalized due to high deforestation rates in Amazon Region. The final decision can be analyzed as an intermediary result for the Brazilian posture: from one angle, Brazil and the European Union were defeated because the issue or carbon sequestration was included in the Protocol, however, in relation to CDM, only re-forestation and forestation could be considered as carbon sequestration activities, remaining external to the CDM the avoided deforestation of primary forests (in this question, Brazil and the European Union would come out as winning parts). In the issue of not including the struggle against deforestation in the CDM, Brazil was in minority in a confrontation with the non members of Annex I countries, especially in Latin America.

In spite of being an emerging country with a clean energetic matrix, Brazil established a strong alliance with emerging countries which depended on fossil combustible (China, Indonesia, India and South Africa). The advantage of energetic matrix was always subordinated to the disadvantage of the Amazonian deforestation in the configuration of the Brazilian posture. Thus, the country aligned in general with the European Union against forest countries with competence to control its deforestation (USA, Canada, Australia, Russia, Japan , Chile, Argentina and Costa Rica) in the issue of inclusion or carbon sequestration in the accountancy of emissions. Consequently, did not duly evaluate the world benefit of forests as sequesters of carbon. An alternative positive vision in reference to the Amazon Region would have led Brazil to an inverse alliance, having influenced significantly in the final profile of the Protocol.

The Ministry of Foreign Relations in coordination with the Ministry of Science and Technology has been put in charge of the negotiations on climatic regime. Until 1999, The Presidency of the Republic did not consider Kyoto Protocol negotiation a sufficiently important issue to demand its interference. Also until 1999, there was a weak participation of non-governmental organizations in decision process in the Brazilian posture. A few big companies have begun to take interest on climatic change due to the influence of the Brazilian section of the World Business Council for Sustainable Development. There also has been a participation of a few scientists, responsible for the technical accessory to Brazilian diplomacy in multilateral debates. Parallel to this, there has always been an effort of national diplomacy to guarantee the participation of the country's scientists in the Inter Governmental Panel on Climatic Change. The Congress has a minimum participation in decision process on environmental regimes. Its function has been restricted to ratification of agreements endorsed by the Executive Power and occurs almost without any participation of civil society. The Brazilian foreign policy in relation to climatic changes has been internally consistent between 1996 and 1999 (after an open confrontation between sectors of the Environment and Foreign Relations of the government during the UNCED negotiations, between 1990 and 1992): a restrict number of agents, concentration of decisions on upper echelons of the national bureaucracy and a good articulation among the agencies within the bureaucratic structure.

From 2000 on, the arena for a definition of the Brazilian posture was increased by the inclusion of the Ministry of Environment, the Brazilian Business Council for Sustainable Development, a few Amazonian State governments and various NGOs. In June 2000, due to presidential initiative, the Brazilian Forum for Climatic Change was created, with an ample profile (multi-stakeholder), joining many governmental, economic, NGOs and academic agents. The forum was an innovation in international scale, external to developed countries, both in terms of constituting the arena for the establishment of a national posture, as in the potential in the internalization of the climatic regime in the country. From October 2000 on, the Ministry of Environment and Amazonian States governments started to look into the historical position of the country, at all times in opposition to the inclusion of all the carbon cycle in the Protocol (sequestration of carbon derived from forest an soil management). Many NGOs, especially those with great actuation in the Amazon Region have actively demanded that Brazil should support the inclusion of projects related to the protection of primary forests (making a great effort against deforestation) in the Clean Development Mechanism. However, the position of the Ministry of Science and Technology and the Ministry of Foreign Relations has prevailed.

Brazil always played a role of leadership in the G77, making a linkage with the developed countries, compared to India, China, Indonesia and Malaysia, countries that assumed positions of more confrontation. Brazil has maintained the position of attributing the responsibility for carbon emissions to developed countries and confronting the proposition of these countries for the establishment of future commitments of emissions reduction for the emerging countries. This leadership led Brazil to a confrontation with the developed countries (especially the USA) in many occasions and with Argentina in 1998/99. Brazil has assumed, since 1997 a position of principle in defending the doctrine that CO_2 emissions should be calculated in its historical accumulation since the end of the XVIII century, and not taking only 1990 as an year-base. In spite of this position counting with a strong support from most of the non-members of Annex I it was not seriously taken by the Annex I and, consequently, did not have an impact in the process of negotiation. The Brazilian proposition is technically robust, legitimate from a historical point of view and is molded by a theoretical approach base on universal rights of world population in the use of atmosphere as worldly public resource. It can be considered utopian for being quite far from the reality of world power at the beginning of the XXI century, but it is probable that it ends up contributing for the improvement of the bargaining power of emerging countries in future negotiations of the climatic regime, especially for the establishment of its commitments for reduction of the emissions curve from 2010 on, in case the Kyoto structure is continued.

Brazil always had a strong leadership in the issue of new financings from developed countries for the transference of clean technologies and capacity development in developing countries, and was victorious in this area at the Bonn Conference (2001). The Brazilian emphasis in promoting the transference of clean technologies was consistent with the objectives of foreign policy (during the Cardoso administration) in promoting the competitive integration of the country in a global economy.

The relation between Brazil and the USA became hard and difficult in 1999 due to a confrontation in many issues: the USA were favorable to the establishment of commitments of reduction of the future curve emissions growth of emerging countries in the first period (2010), while Brazil was totally against; Brazil was contrary to the inclusion of primary forests in the MCD and the USA were favorable; the USA were in favor of an implementation regime and weak sanctions , while Brazil approved the European Union in defense of a strong regime; Brazil, supporting the European Union, wanted to include limits for the accountancy of carbon sequestration from developed countries and the USA were against. From the withdrawal of the USA from the Protocol, in March 2001 to the conclusion of the negotiations, in November 2001, Brazil had a formidable performance, both in criticizing the American position as in the promotion of negotiations among the various blocks of countries. Brazil had a prominence in articulating the alliance among the European Union, Japan and the emerging countries, which allowed the success in the final negotiations of the Protocol. In many international discourses – before and after the eleventh of September- president Cardoso criticized incisively the Bush unilateral policy in relation to climatic change. Comparing the Brazilian and North American positions in relation to global environmental problems between 1989 and 2001, it can be said that there was an inversion of roles that shows the evolution occurred in Brazil, even with the limitations still persistent: in 1989, the Bush administration (the father), allied to other governments of developed countries, criticized the Sarney administration on the Brazilian contribution in relation to climatic change caused by the high Amazonian deforestation; in 2001, the Cardoso administration, allied to other developed countries, criticized the Bush administration for lacking a more responsible attitude towards world climate.

During the preparatory meetings to the Johannesburg Conference on Sustainable Development (2001-2002), Brazil led two important initiatives for the reduction of CO_2 emissions. The first initiative, in cooperation with the European Union, was to promote a sufficient number of ratifications to the Kyoto Protocol – The Brazilian Senate ratified it in quick time, in contrast to the usual rhythm of these type of proceedings in the country – with the objective of legalizing the signatures August 2002. The second was to obtain the support of all Latin America for the initiative of establishing as a world objective that at least 10% of its electricity should be produced through renewable sources until 2010. Brazil was defeated in both initiatives.

At the 7th Conference of the Parties of UNFCCC in New Deli , in October 2002, Brazil, which led the G77 confronted the European Union in its attempts to implement commitment of reduction for developing countries relative to the period 2010-2020. In this confront, the G77 got the support of the USA, revealing the other side of the profound arena of discussion of the climatic regime: the emerging countries were favorable to Kyoto only as long as this support did not imply in obligations for them; when the issue of reduction commitments was discussed new alignments appeared: one of them suggested the formation of an alliance among the countries of Annex I contrary to the Kyoto Protocol (USA and Australia) with the emerging countries; another alignment put together the European Union, Japan, Canada, Switzerland , Norway, New Zealand, and some emerging as South Korea and Costa Rica in a pro-Kyoto alliance.

The delay in the ratification of the Protocol brought disorientation in the domestic Brazilian arena. A profound division was established in the Lula administration, a relative common event in Brazil due to the complexities of is federative arrangements. The core of the current administration showed a rising lack of commitment with the Kyoto Protocol, although the Ministry of Environment has tried to show a commitment in fulfilling it. The long term viability of the climatic regime depends strongly on the involvement in some type of significant commitment for the improvement of the profile of its CO2 emissions by part of the main emitters, in the present and next decades: USA, European Union, Japan, Canada, Australia, Russia, China, India, Brazil, Mexico, Venezuela, Indonesia, Saudi Arabia, Iran, Iraq, Algeria, Nigeria and South Africa. The Brazilian position in this respect will possibly be of great importance, since the country finds itself in the best position among the emerging countries to assume commitments. To do this Brazil would have to reduce deforestation in Amazonia, an objective that would count with the immense majority of the population. Possibly, this reduction would have to be around 70% of the current year-rate (of approximately 0.40% of the Amazonian forest to 0,15%) so that it should be significant to the national balance of carbon emissions in spite of public opinion support in an open confront with the coalition of interests that support the deforestation. Due to peculiarities of the federal arrangement of the country, these interests are strongly represented in the National Congress. Consequently, a coalition for a more rational use of the Amazonian forest would have positive impacts not only inside the country, but also in the international scenario, bringing prestige to the country –soft power- and, in general, for an international multilateral cooperation.

THE CHANGES IN THE INTERNATIONAL SYSTEM AND THE RELATIVE DECLINE OF THE KYOTO PROTOCOL

The decline of the Kyoto Protocol in the last years has shocked the scientific community and the NGOs on global environmental changes since the majority of this community sub-estimated the importance of transformations in the world since the Summit of the Earth in 1992. In spite of optimistic predictions from many analysts at the time of the Berlin Wall Fall, issues of security and war continue to be crucial, as was demonstrated by the terrorist attacks of September 11 and by war against terrorism linked to Islamic radicalism, leaded by the USA after the attacks. The cooperation in the global arena have been much more difficult than it was supposed after the end of the Cold War, with much more world conflicts than what was generally anticipated. The possibilities of the creation of a prosperous, peaceful and sustainable world depend on the dissemination of economies of market and political democracies. However, the last fifteen years have showed that in many countries it is difficult to construct consistent economies of market and political democracies. Some examples of success are notable: Poland, Hungary, the Czechoslovakia, Republic, Slovenia, the Baltic States, Turkey, Chile, Brazil, Costa Rica, Mexico, South Korea and Thailand. However, the examples of failure are more numerous. The succession of failed economic reforms, bankrupt states, unsuccessful societies and civil wars, in the last years have been more the product of domestic historical obstacles than a consequence of globalization. However, the societies already integrated to world economy have not been taking a global responsible attitude in accordance with the Kantian suppositions of the final times of the Cold War- with the intent of supporting other societies in the construction of economies of market and political democracies. In synthesis, the failure in the dissemination of prosperous and democratic societies is the result of domestic obstacles in combination with a lack of responsible attitudes from the globalized societies.

Another important change since the Rio Summit has been the impact of the acceleration of the information technology revolution. The strong global wave of expansion of the environment movement (particularly from 1985 to 1995) is based in a reviewing process of the impact of economic prosperity and scientific and technological development on environmental quality. The environmentalism demanded a self-criticism from science and a decrease in the pace of technological and material progress, and a rising attention has been given to these demands by the main segments of society. This cultural atmosphere has changed since the beginning of the nineties. The acceleration of information revolution in the second half of the nineties promoted a rising trust in the capacity of technology to solve the problems created by technology itself, even when a technological abyss emerged between developed and poor societies. Furthermore, the ability to create technological environments – by generalized use or air conditioners, as well as of extremely fast transportation and communication- is producing a new post- environmentalist insensitivity in relation to the transformation of nature by man. The dramatic acceleration of technological innovation has disseminated in the developed countries the impression that people can protect themselves from the negative consequences of the world environment degradation. This phenomenon has undermined the idea of a common destiny in the confrontation with environment degradation-for all humanity, an idea that created a certain momentum at the time of the Rio Summit. However, the devastating impact of the cyclone season of 2005 (particularly the Katrina in New Orleans), has decreased the self confidence of the American society as well as of all developed countries, in the capacity of technology to solve the problems created by the impacts of economic growth.

The fast growth of world economy in the 2003-2005 period, the highest for a three year period since the decade of 1950 and with a perspective of continuing at the same pace for this year of 2006 has augmented dramatically the demand for fossil energy. Particularly the energetic demand of the demographic giants – China and India- has risen the consumption of petroleum surpassing the estimations of all analysts. As a consequence of this process the world emissions of carbon is alarmingly increasing in the last three years. The efforts of the European Union, Japan and Canada to reduce emissions are devoured by the emissions coming from the USA, Australia and the majority of the emerging countries.

The environmentalist movement has had great difficulties in understanding this new way of technological affirmation taken by the western societies and most of the emerging countries. Such difficulties have been inflated by the naïve vision on democracy that prevailed among environmentalists. The movement has contributed to the propagation of participative democracy, however, the increase of participation does not bring only incentives. The inflation of expectations generate fatigue and cynicism among the involved. A long term comparison of political systems demonstrates that, to guarantee good levels of govern-ability the institutional quality is much more important than the intensity of public participation.

At the beginning of 2006 the scientific evidences on global warming grew exponentially: the strongest coming from the rising retraction of polar caps and the mountain glaciers of the whole planet, from the disruptions in the vital cycles of many animal species and the devastating climatic extremes in multiple places. We find ourselves confronting a schizophrenic humanity: from one side the great majority of the scientific community, a cluster of long term oriented politicians and a minority segment of the general population clamming for the necessity of confronting the problem of climatic change; and, on the other, a vast majority of world population led by politicians – that continue oriented by electoral cycles of short term- demanding economic growth the highest and fastest possible and denying the problem of global warming or in the best of the hypothesis hoping that their worst effects will be felt at very long term. To continue at this pace there will be a bifurcation of the humanity: to one side the developed technological societies would continue to adapt incrementally to the climatic change, even implying in high costs, whose effects will be mitigated by the insurance companies, and, on the other the poor societies, particularly the most vulnerable in terms of sea level, who will go through a gigantic human suffering. In the middle will remain the heterogeneous societies of medium per capital income like Brazil with a combination of adaptation components similar to the developed societies and components of great human suffering as in poor societies.

ENVIRONMENTAL CHANGES AND THE PERCEPTION OF SOCIETY. THE CASE OF CLIMATE CHANGE

GUILLERMO FOLADORI
Universidad Autónoma de Zacatecas. México

SCIENCE AND TECHNOLOGY TAKE CONTROL OF THE ENVIRONMENTAL QUESTION

People first became aware of the modern environmental crisis in the late nineteen sixties and early nineteen seventies (Pierri, 2005). Until the late eighties, environmental movements and concerns covered a wide range of themes. In most cases were of local, regional or national concern, and involved contamination of water courses, or soil erosion, or air contamination in cities, or the destruction of ecosystems, or unchecked fishing and oyster fishing and other marine species, etcetera.

In the late eighties, environmental concerns and demands underwent a change. Global warming suddenly emerged as the unifying theme and quickly became the banner for many of the environmental movements and an encompassing theme in international debates concerning the environmental crisis. Environmental problems were now defined scientifically and science and technology (S&T) took on a central role in environmental debates (Sarewitz & Pielke, 2000; Lenoir, 1995).

The rising temperature caused by humanity is given as the main cause of climate change. According to some estimates, human beings have increased emissions of carbon dioxide – a greenhouse gas – into the atmosphere by around 30% because of the combustion of carbon and petroleum in the past one hundred and fifty years, consequently heating the earth's atmosphere. In recent years, the presence of carbon dioxide in the atmosphere seems to have increased, despite international efforts to reduce it. Over 1997 and 1998, atmospheric carbon dioxide increased by 2.9ppm per year, but in early 2004 it reached 3ppm over what it had been in 2003, according to the estimates of the Mauna Loa Observatory (Keeling & Whorf, 2004; Hanley, 2004; U.S. Department of Energy, 2003).

Global warming could make a significant impact on ecosystems, with mass extinction of species that could not adapt to the rapid change in climate, and could lead to migration in other cases. To humanity, there would be many consequences, but there are those that stand out above the others. The first is the rising ocean levels, which is supposed to be between 15 and 95 centimeters on average during this century. This would be catastrophic for people living near the coast. Myres (2005) estimates that rising ocean levels would lead to 200 million people having to relocate by 2050. The second is a change in the current crop farming zones which will be displaced to elsewhere. It is probably that this displacement to higher latitudes (poles) could be as much as 150 to 500 kilometers in a century. This will require geo-economic and geopolitical removal of crop production and associated industries. At the same time, areas that are currently humid and fertile could go through desertification. It is clear that these changes in the ecosystems are connected to the reserves of fresh water, which will be affected by the changes in rates of precipitation and evaporation. Furthermore, many tropical diseases will spread to other areas, for instance, malaria, yellow fever, dengue fever and others.

Throughout the sixties and seventies, little attention was paid to the possibility of global warming. In those days, many researchers believed that the world was cooling and that there was going to be another ice age. Some researchers were even of the opinion that warming could be good for mankind[1].

In 1984, a *New York Times* headline established the relation between anthropogenic emission of gases into the atmosphere and the greenhouse effect, and also with its global consequences. Finally, in 1985, the international scientific community made a U-turn on its positions. At the Villach Conference, supported by the World Meteorological Organization, the UNDP and the International Council of Scientific Unions, global warming, which had been considered positive, was viewed as catastrophic (Sarewitz & Pielke, 2000). From that time on, all the publicity, investigations and policies were centered on how to stop and reverse global warming. The following table, which put the blame for most environmental problems on global warming, highlight this change with selected indicators.

Table 1 - Some landmarks in the change in criteria concerning global warming

1972. B. Warde & R. Dubos write Only One Earth, the Care and Maintenance of a Small Planet, a report for the 1972 United Nations Conference on the Human Environment. They warn of the unpredictable and lasting effects that human actions could have on the climate.
1980. The U.S. State Department publishes The Global 2000 Report to the President in which it foresees cooling in the climate for the year 2000 and stating that global warming would be advantageous.
1985. The World Meteorological Organization and the United Nations Development Program, along with the International Council of Scientific Associations organize the Villach Conference. There a U-turn is made in the positions on global warming. Suddenly, what was once considered positive - warming - is now believed to be catastrophic.
1987. The Montreal Protocol. The progressive worldwide reduction of chlorofluorocarbons is agreed upon. From then on, halting global warming became the main environmentalist banner at the political, scientific and publicity levels.

Source: compiled from Lenoir (1995).

The second half of the 1980s may be considered the turning point in awareness of environmental matters. Firstly, because one element, climate change, became the common denominator for the whole environmental problem. Climate is linked to everything else. It affects biodiversity, it affects nd is affected by forests, it affects human production activities, and has to do with many contagious

[1] In 1980, the U.S. State Department commissioned the *The Global 2000 Report to the President,* which foresaw climate cooling for the year 200, and stating that the possibility of warming would be welcome.

a diseases. Climate change unifies the environment on a worldwide level. Climate change is a quintessential paragon of the idea of interrelationship of phenomena and life cycles that is so important in the ecology. Furthermore, nobody is immune to climate change. Reducing global warming became the goal of international environmental policy (Tommasino & Foladori, 2001).

Secondly, climate change became a concern to everyone. It ideologically unifies the human species. Climate change became a challenge to all human society. Environmental problems are no more unique to one group or to certain societies in certain places; rather they became general and global, affecting all people in all places. Most environmental and ecological organizations and groups accepted that global warming was the root of the environmental crisis (Lenoir, 1995).

Thirdly, science became the assessor of environmental problems and the spokesperson for their serious nature. Only a select group of scientists, with sophisticated technical equipment could accurately make measurements and monitor the atmosphere so as to alert us that the world is becoming warmer and what influence this is having on every region.

CLIMATE CHANGE AND HUMAN VULNERABILITY

Hurricane Mitch whipped the Central American coast in 1998, killing over ten thousand people with washouts and flooding, spreading cholera and destroying the economies of Honduras and Nicaragua. Several days later, the Fourth Conference of the Climate Change Convention was held in Buenos Aires. At the conference, Hurricane Mitch was declared as a presage of what would happen next if the greenhouse gas emissions that were destabilizing the earth's climate were not reduced immediately (IFRCRC, 1999).

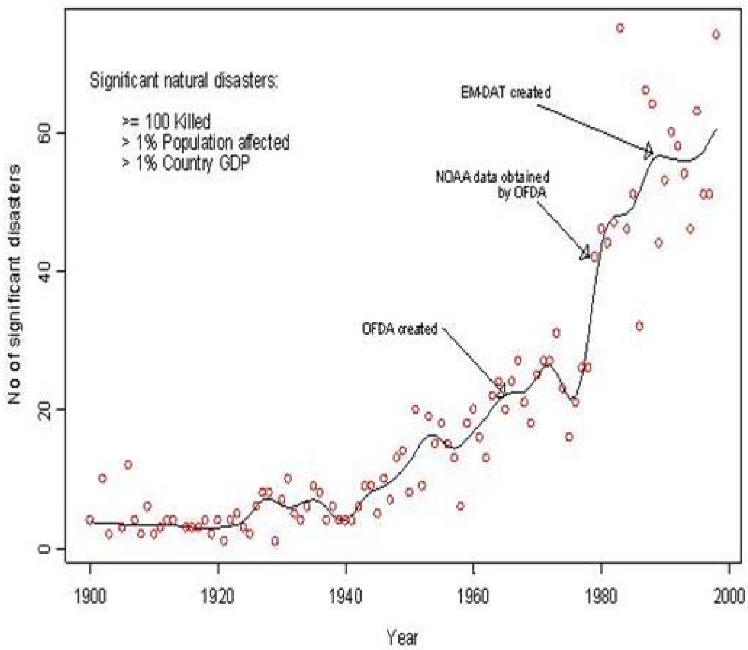
The same mechanical reasoning was publicly expressed days after the Tsunami in December, 2004 in Indonesia. In the following days, several mass media and personalities related the event to global warming caused by mankind. Here are some examples:

- *The Discovery Channel.* January 5, 2005. http://dsc.discovery.com/news/briefs/20050103/tsunamimaker.html Retrieved August 15, 2005.
- Sir David King, chief assessor of the British government. *The Guardian*, December 31, 2004.
- Farah Sofa, Friends of the Earth, *Agence France Presse* http://www.spacedaily.com/2004/041229011959.e796kzoh.html Retrieved August 15, 2005.
- *Reuters* news service environmental correspondent Alister Doyle, CNSNews.com, December 28, 2004. http://www.cnsnews.com/ViewNation.asp?Page=%5CNation%5Carchive%5C200412%5CNAT20041228a.html Retrieved August 15, 2005.

(Morano, 2005).

On 29 August, 2005, Hurricane Katrina, a level 5 hurricane on the Saffir-Simpson scale, hit New Orleans full force, causing devastation that could result in the most serious environmental catastrophe in the history of the United States. Three days after the first impact, the president of the Worldwatch Institute, Christopher Flavin (2005), issued a declaration in which he said that "If the world continues on its current course—massively altering the natural world and further increasing fossil fuel consumption—future generations may face a chain of disasters that make Katrina-scale catastrophes a common feature of life in the 21st century". Although he was careful to avoid saying that Katrina was a result of global warming, which is impossible to prove, his warning were clearly in that direction.

It is a fact that there has been an increase in serious disasters related to extreme natural events in the last few decades. Figure 1 outlines the tendency for these disasters to increase throughout the twentieth century.



Source: OFDA-CRED. International Disaster Data Base

Figure 1 - Trend of main disasters of the 20th century

We see the increase in disasters in the later decades of the twentieth century. Most of this increase is seen in poor countries. From 1960 to 1993, the less developed countries suffered around 97% of these catastrophes, and 99% of the deaths (Cutler, n/d). But, is this a consequence of the increase in the number and seriousness of disasters? Evidently, it is not. Human vulnerability to extreme events grows unequally; and not because of global warming, but rather as a consequence of increased populations, increased poverty, increased people living in risky places and the lack of defense mechanisms to counter these events.

Whether or not there are further investigations into climate change, or whether or not the mean world temperature can be accurately forecasted, or even whether carbon dioxide emissions can be reduced, this does not mean that extreme events can be avoided, nor can the settlement of millions of people in high risk areas in unhealthy conditions and precarious dwellings. Nevertheless, investigations into climate change remain outside this context. The clearest demonstration of the predominance of studies of the climate itself, instead of concern over how to reduce human vulnerability can be seen in public expenditure.

In 1989, the UN declared that the nineties would be the International Decade for Natural Disaster Reduction (IDNDR); the decade to reduce the loss of lives, to reduce damage to property, and other economic effects caused by natural disasters. The result was that throughout the nineties, twenty million dollars were poured into it. For their part, the United Nations Framework Convention on Climate Change, and the Intergovernmental Panel on Climate Change (UNFCCC) received, only in 1998-9, twenty-one million dollars. In other words, the budget to investigate climate change in those two years was larger than the money invested in reducing the effects of natural disasters in a decade (Pielke, *et al*, 2000). More recently, in 2003, public expenditure in the USA for scientific investigation for reducing losses caused by disasters was one hundred and twenty-seven million dollars, whereas funding for investigating climate change was one billion, eight hundred and fourteen million dollars (Rand Corp, quoted by Sarewitz & Pielke, 2005).

Let’s take the case of Katrina. Katrina has been eloquent. In 2002, almost four billion dollars had been approved to study what would happen if the rise in the water level were to reach twenty feet, and the outlook was that a level 3 hurricane would flood New Orleans (Dunne, 2002). The opinion was that there should be more investigation into the climate, more forecasts and more concern for improving the climate. But nothing was done to reduce the vulnerability of people, and this is the central issue, not global warming or weather forecasting. Katrina has been an eye-opener. New Orleans is a poor city. Over 28% of its people are poor, and over 68% are black. Craig E. Colten, professor of geography and anthropology at Louisiana State University, explained in a radio interview on 2 September (Coltlen, 2005), that the suburbs that are below the water level are populated mainly by poor people and African Americans. He also mentioned that in the early 21st century, New Orleans is considered to be much more segregated by class and color than it was in the 19th century. He also explained that in the fifties and sixties the rich and white people moved to higher neighborhoods and the city ended up segregated by wealth and by the waterline. When the authorities announced that people should evacuate the city, 24 hours before Katrina first hit, many of those living in the lower neighborhoods had no cars and no money to leave. The evacuation strategy depended mainly on private means of transport.

The study of climate change has prioritized analysis of the climate itself, without paying much attention to the context. The underlying question is whether knowledge of the climate helps to improve living conditions for most of the world’s people. It is evident that the effects of any measures to be taken to reduce global warming will only be felt within several decades or centuries. In the meantime, thousands or even millions of people will suffer a range of effects of climatic disasters, and this will not be the consequence of extreme climatic events, but of the lack of resources for reacting to these events in the high risk zones. Even reducing global warming to pre-industrial revolution levels, natural disasters will not be avoided. The case of studies into climate change is paradigmatic of the distance of S&T from social needs.

Furthermore, the policies that seek to change the standards of energy and reduce the carbon dioxide in the atmosphere depend on the more general tendencies of technology. Given the growing pace at which technological change takes place, it could be said that these could modify the energy standards and affect the climate – for better or worse – more profoundly, annulling the policies that are directly aimed at "correcting" the climate. Let us analyze the current case of the revolution in nanotechnologies.[2] Their expansion has been extremely rapid in the last five years. Scholars believe that the worldwide sale of nanoproducts will overtake the five-hundred-billion-dollar level in 2010. This is more than the total value of exports from Latin America and the Caribbean in 2004 (Baker & Aston, 2005). By 2015, around 15% of all merchandise will have some kind of nanotechnological content. However, one of the principal fields of nanotechnology is energy and cleaning the environment. Nanotechnology will allow us to generate solar energy at a very low cost, replacing fossil fuels and reducing emission of carbon dioxide. Nanorobots could be created to extract the three hundred billion of tons of excess CO_2 from the atmosphere, working with cheap solar energy.

The extracted carbon could be synthesized and used as raw material in a number of productive processes (Wang, n/d; Drexler, *et al*, 1991). Although much of this is speculation, there is no reason to consider its effects less probable than the policies to "correct" the climate.

In short, the policies aimed at "correcting" the climate and forecasting the climate are not enough, nor should they be the central theme of environmental problems. They are not enough because the causes of the disasters lie in greater human vulnerability rather than climatic events. They are not central because technological developments change much more quickly than the chance they have to affect the climate. It is true that the mechanical relationship between a natural disaster and social disasters is easy for the public to understand and attractive for the media to use, but it is the task of academics and scientists to deny this instead of encouraging it.

CLIMATE CHANGE, HURRICANES AND HUMAN VULNERABILITY

Like every year, the summer and autumn of 2004 were shaken by hurricanes in the Caribbean. In mid-September Hurricane Ivan arrived. It was the third in a month. Over one hundred people lost their lives, including thirty-eight in the United States, and there were millions of dollars in material losses (Infobae.com, 2004). On 15 September, a group of scientists informed The U.S. Senate Committee on Commerce that global warming could lead to intense hurricanes in the future, directly linking, one more time, the effects of Ivan to global warming. However, other scientists reacted to this by sending a letter to the head of the Committee, arguing that there was no scientific evidence linking hurricanes and other catastrophes to global warming. This shows how controversial this subject is, even among the scientists who study it (Doering, 2004).

The previous example teaches two things. The first is the impossibility to relate a certain hurricane or its intensity to climate change. There always have been and always will be hurricanes, with or without global warming. Table 2 outlines the presence of hurricanes on the U.S. coast during the twentieth century.

[2] Nanotechnology is the direct manipulation of atoms and molecules to manufacture products.

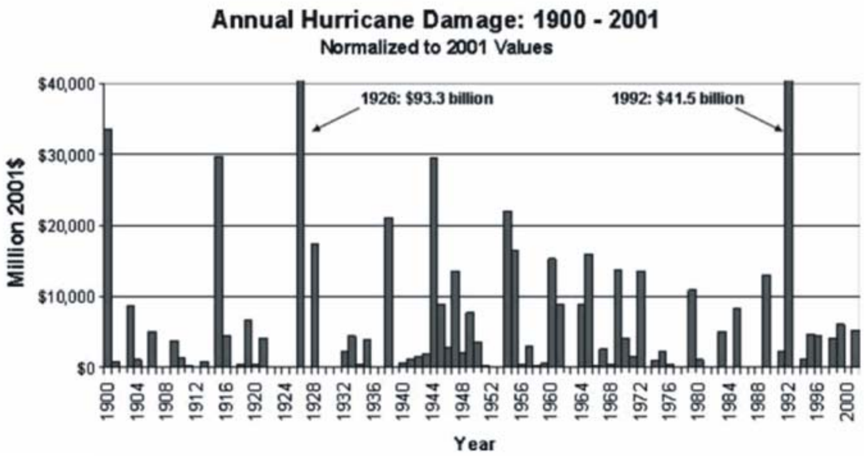
Table 2 - Number of hurricanes by category to strike the mainland U.S. each decade

DECADE	Saffir-Simpson[1] category					ALL 1-5	MAJOR 3-5
	1	2	3	4	5		
1900-1909	5	5	4	2	0	16	6
1910-1919	8	3	5	3	0	19	8
1920-1929	6	4	3	2	0	15	5
1930-1939	4	5	6	1	1	17	8
1940-1949	7	8	7	1	0	23	8
1950-1959	8	1	7	2	0	18	9
1960-1969	4	5	3	2	1	15	6
1970-1979	6	2	4	0	0	12	4
1980-1989	9	1	5	1	0	16	6
1990-1999	3	6	4	0	12	14	5
2000-2009	1	0	0	0	0	1	0

[1] Only those on the highest scale are included.

[2] Includes the re-categorization of Hurricane Andrew from 4 to 5 on the scale
Source: Jarrell, J.D., *et al*, 2001.

Pielke estimated the damage that previous hurricanes of the twentieth century would have caused in the present situation. The result was that the hurricane registered in Miami in 1926 would have caused 93 billion dollars in damage by 2001 standards; a great deal more than the largest hurricane at the end of the century, Andrew, which caused 41.5 billion dollars in damage (Pielke & Sarewitz, 2005).



Historical losses from hurricanes adjusted to 2001 values based on inflation, population, and wealth. The graph suggests the damage that would have occurred had storms of past years made landfall with the societal conditions of 2001.

Source: Pielke & Sarewitz, 2005.

Figure 2

The second lesson is that the degree of human vulnerability does not depend on the climate but on the socio-economic and political context. The example of Hurricane Ivan is demonstrative of this. Measured at category 4 to 5 on the Saffir-Simpson scale, it has been one of the most intense in recent years. The USA, despite having experience and forecasts, despite the forced evacuation of millions of people over a four-hundred-mile coastal area, despite all its wealth and raised level of awareness of this type of problem, still had to cope with thirty-eight deaths. The previous hurricane, Charley, had caused the loss of thirty lives in Florida.

On the other hand, Cuba mobilized its people and evacuated over a million people, but suffered no loss of lives from Ivan, and only four from Charley. The director of the Strategy for Disaster Reduction at the UN declared that Cuba was an example in the prevention of risks from hurricanes, and that this model should be used in other countries with similar economic conditions or even in a better situation (Rassí, 2004).

Another eloquent comparison is that of Hispaniola. Julia Taft of the UNDP commented that “In the Dominican Republic, which has invested in hurricane shelters and emergency evacuations networks, the death toll was fewer than ten, as compared to an estimated two thousand in Haiti…Haitians were a hundred times more likely to die in an equivalent storm than Dominicans” (quoted by Sarewitz & Pielke, 2005).

CONCLUSIONS

In the sixties and seventies, the main environmental problems were visible and perceptible to us. Air contamination in cities, the contamination of rivers and water courses, soil erosion, and deforestation were common examples. Public protests and demands were matters that mostly did not required scientific mediation.

In the mid-eighties, the collaboration of science and the media played a central role in the unification of the environmentalist movement under the banner of climate change. This meant a certain amount of elitism in environmental debate. It was no longer a matter if environmental impacts and their visible effects on humanity, but environmental impacts that could only be measured and assessed by a scientific elite, and with very dubious relations to concrete events. At this point, S&T took control of the environmental issue, concentrating resources on the investigation of phenomena whose greater knowledge could hardly have any immediate effects on most of the living conditions of the majority of people in the world, not even the reduction of the CO_2 in the atmosphere.

The example of extreme events such as hurricanes is typical of how far apart S&T is from social needs. 2004 was a devastating year with the passing of hurricanes through the Caribbean. Scientists and the media argued among themselves about whether the intensity and quantity of hurricanes in such a short time frame were a result of climate change. But deeper knowledge would not have avoided the floods in Haiti, which caused hundreds of deaths and the loss of many homes and the spread of contagious diseases, etc. For the vast majority of people, it is much more important to reduce their vulnerability to major disaster than to be concerned about the precision of the prognosis and the intensity of the events. The fact that the United States, the richest country in the world, suffered more deaths from hurricanes in 2004 than Cuba, one of the poorest, but better prepared for the risks of hurricanes, clearly demonstrates the possibility of reducing vulnerability albeit with limited material resources.

From an historical perspective it is a paradox and a calamity at the same time that the indubitable advances in S&T do not result in improvements in the situation of most people. Social sustainability is ignored because of the argument that it is better to improve knowledge of external nature. But it is clear that in order to reduce human vulnerability, it is not necessary to investigate climate change further. It is better to organize and mobilize people; local and regional policies and other more effective and less expensive measures than predictions of climate change could render higher human benefits.

REFERENCES

Baker, Stephen & Aston, Adam. (2005). The Business Of Nanotech. *Business Week*. February, 14.

Colten, Craig. E. (2005). *Race, poverty and Katrina* [radio interview by NPR (National Public Radio), September 02, 2005.]. http://www.npr.org/templates/story/story.php?storyId=4829446 Retrieved September 03, 2005.

Cutler, S. (n/d). Respuestas sociales a los riesgos ambientales. www.unesco.org/issj/rics150/cutter150.htm. Retrieved December 04, 2002.

Doering, Christopher. (2004). Will climate change spark fiercer storms? Lawmakers told that stronger hurricanes may arise. *MSNBC NEWS. Technology & Science*. 09/15/2004.

Drexler, Eric; Peterson, Chris y Pergamit, Gayle. (1991). *Unbounding the Future: the Nanotechnology Revolution*. New York: William Morrow and Co. http://www.foresight.org/UTF/Unbound_LBW/chapt_9.html Retrieved August 15, 2005

Dunne, Mike. (2002). Living with the threat of disaster. Study to seek ways of dealing with hurricane flooding in New Orleans. *April 21, 2002. The Advocate Science.* http://hurricane.lsu.edu/_in_the_news/april21_advocate.htm Retrieved September 03, 2005.

Flavin, Christopher. (2005). Unnatural Disaster: The Lessons of Katrina. Worldwatch projects catastrophe will be most costly weather-related disaster in history. *Worldwatch Institute News*, September 02. http://www.worldwatch.org/press/news/2005/09/02 Retrieved September 03, 2005.

Hanley, Charles J. (2004). Carbon Dioxide Reported at Record Levels. *Yahoo News*. http://www.thewe.cc/contents/more/archive2004/march/co2_record_high_levels_in_the_atmosphere.htm. Retrieved August 16, 2004.

IFRCRC (International Federation of Red Cross and Red Crescent Societies). (1999). *World Disasters Report 1999.*

Infobae.com. (2004). El huracán Iván ya mató a más de 100 personas. 21/09/2004.

Jarrell, J.D., Mayfield, M., Rappaport, N. & Landsea, C.W. (2001). The deadliest, costliest, and most intense United States hurricanes from 1900 to 2000 (and other frequently requested hurricane facts). *NOAA Technical Memorandum NWS TPC-1*. Miami: NOAA/NWS/ Tropical Prediction Center**,** NOAA/AOML/Hurricane Research Division. http://www.aoml.noaa.gov/hrd/Landsea/deadly/index.html Retrieved October 10, 2004.

Keeling, C.D. & Whorf, T.P. (2004). Atmospheric CO_2 records from sites in the SIO air sampling network. In Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge, Tenn., U.S.A.: Oak Ridge National Laboratory, U.S. Department of Energy.

Lenoir, Ives. (1995). *A verdade sobre o efeito de estufa. Dossier de uma manipulação planetária.* Lisboa: Caminho da Ciência.

Morano, Marc. (2005). Killer tsunami's "global warming" link branded "rubbish". *CNSNews.com* Reprinted *Eco-logic Powerhouse* January 15, 2005. http://www.eco.freedom.org/el/20050102/morano.shtml Retrieved August 15, 2005.

Myers, Norman. (2005). Environmental Refugees: An Emergent Security Issue. *13th. Economic Forum. Session III – Environment and Migration.* EF.NGO/4/05. Prague, 23-27 May. http://64.233.161.104/search?q=cache:-gQ7NH938BMJ:www.osce.org/item/14488.html+Myers+200+million+sea+level&hl=es&client=firefox-a Retrieved August 01, 2005.

OFDA-CRED. (s/f). *International Disaster Data Base.* http://www.cred.be/emdat/. Retrieved January 01, 2004.

Pielke Jr. Roger & Sarewitz, Daniel. (2005). Bringing Society Back into the Climate Debate. *Population and Environment*, 26(3), 255-268.

Pielke, Jr. R., Klein, R. & Sarewitz, D. (2000). Turning the Big Knob: An evaluation of the use of energy policy to modulate future climate impacts. *Energy and Environment*, 11(3), 255-276.

Pierri, N. (2005). Historia del concepto de *Desarrollo Sustentable.* In: Foladori, G., & Pierri, N. (editores). *Desacuerdos sobre el desarrollo sustentable*. México D. F.: Miguel Ángel Porrua/ UAZ.

Rassí, Reynold. (2004). Verdades irrefutables. Cuba ante los desastres naturales. *Granma*, 8(260), September 16, 2004.

Sarewitz, D., & Pielke, R. Jr. (2000). Breaking the global warming gridlock. *The Atlantic Montlhy* (July).

Sarewitz, D., & Pielke, R. Jr. (2005). Rising Tide: The Tsunami's Real Cause. *The New Republic*, January 17, 2005.

Tommasino, H., & Foladori, G. (2001). (In) certezas sobre la crisis ambiental. *Ambiente & Sociedade,* IV(8), São Paulo: Nepam/Unicamp.

U.S. Department of Energy. (2003). Mauna Loa CO_2 Measurements are the Longest Continuous Record in the World. *Oak Ridge, Tenn., U.S.A.: Oak Ridge National Laboratory, U.S. Department of Energy. 17* **Sept., 2003.** http://www.er.doe.gov/Science_News/feature_articles_2001/september/Maun_%20Loa/CDIAC-Mauna%20Loa.htm. Retrieved August16, 2004.

Wang, Sinclair. (n/d). Toward Total Environmental Sustainability Via Emerging Molecular Nanotechnology. Center for Responsible Nanotechnology. http://www.tainano.com/CCRN/TOWARD%20REAL%20SUSTAINABILITY%20BY%20NANOTECHNOLOGY.htm#12 Retrieved August 15, 2005.

SOCIAL VULNERABILITY, DISASTERS AND CLIMATE CHANGE IN LATIN AMERICA. THEMATIC, THEORETICAL AND METHODOLOGICAL APPROACHES

CLAUDIA E. NATENZON
Dr. in Geography PIRNA
Natural Resources and Environmental Research Program
University of Buenos Aires/FLACSO Argentina

"The estimations on poverty are very sensitive to the criteria adopted to consider each element involved in the indicators' elaboration, and therefore, it cannot be avowed that these convey an exclusively technical content. The information sources and the indicators' elaboration criteria influence the results." Lo Vuolo et al, 1999.

THE PROBLEM, THE CONTEXT

According to the Interamerican Development Bank (1998), Latin America is the region with the greatest inequity in the world. The sector richest made of its population concentrates the greatest part of the national income. The richest 5% of the population receives 25% of the national income. As for the richest 10%, the share they receive rises to 40% of the national income. At the other extreme, the poorest 30% receives 7.5% of the national income; and 40% of the LA population (200 million inhabitants) lay under the poverty line.

Things have not changed much since 1998 until now. In the "Social Panorama of LA" report on the countries of the region between 2001 and 2003 (CEPAL 2004), poverty is proved to have increased or, at best, stagnated.

Poverty's greatest incidence is found among extended and compounded families, and, within this category, mostly among single-parent families, especially in women-headed households.

On the other hand, during the current decade, up to the present, the GDP growth has not managed to reach a rate able to compensate the population growth. The incidence of poverty and destitution in rural areas of Latin America is still higher than in the urban ones.

The profound demographic transformations are reflected in the population's diminishing growth (from 2.7 % per year between 1950 and 1955, to 1.5 % nowadays), the increasing aging of the demographic structures, the accelerated decrease of fertility (since the 60's) and the mortality's reduction since the end of the first half of the 20th century (Magno de Carvalho 1999).

A well-known social scientist, Guillermo O'Donnell (1999, p.69) claimed: "The social situation in LA is a scandal". Even though poverty and inequity have always existed, they have taken on significance unknown decades ago: generalized poverty, increasing number of destitute people, deep inequity.

It is within this context that the social vulnerability issue should be thought-out.

There are two main geographic components involved in this matter: scale and territorial distribution. The first appears in the inter-scale determinations in localized, specific areas of social vulnerability: global or international, regional (LA as a whole, countries associations such as MERCOSUR and The Agreement of the Andean Countries), national, sub-regional (groups of provinces or states) and local (the particular places were all the other scales are locate and displayed on the territory.

Spatial distribution is an additional geographical problem in LA, where urban and rural areas differences are beginning to be not so distinguishable, different sorts of violence are increasing spatial segregation, and the territorial organization is merely driven by profit and gets permanently reshaped towards bigger economic benefits. Thus, the scenarios get homogeneous while –at the same time- they become increasingly fragmented.

SOCIAL VULNERABILITY MATTER

a) Social Vulnerability and Poverty
In a "normal" sense, it is possible to define poverty in terms of being an undesirable effect of the development process. From this viewpoint, the Latin American society can be analysed:

- through its contrasts or polarities: poverty and wealth, exclusion and inclusion, destitution and integration, formality and informality; or
- through its diverse and heterogeneous qualities: complexity, multiplicity, dynamism and change.

The firsts, contrasting categories, make it easy for poverty to be regarded as a "natural" phenomenon, synchronically set. In this sense, social vulnerability is a notion that allows us go beyond this schematic approach and thus, according to Minujin (1998, 1999), to analyse the dynamic complexity of poverty situations, mainly those stemming from the neo-liberal reform and structural adjustment programmes strongly applied during the 90's; and to identify a zone of significant gradients (or intermediate situations) between the "inclusion / exclusion" or "wealth/poverty" extremes.

b) Social Vulnerability and Disasters
When relating social vulnerability and disasters, we are talking about an "extraordinary" situation, the loss of the "normal" one. Disaster is an unexpected disruption in the development process. We can talk about disasters when there is population involved. It is a situation that causes tension and emphasizes the pre-existing characteristics of the socio-economic system.

From the point of view of natural sciences (IPCC 2001), vulnerability is the extent to which a system is susceptible to (or is not able to endure) the adverse effects of climate change, including the effects of climatic variability and extremes. Vulnerability is a function of the nature, size and proportion of climatic variation that a system is exposed to, its sensitivity and adaptation capacity.

As far as disasters are concerned, we can find other approaches. For instance, following Blaikie et al (1996), vulnerability -the social one- is a set of previous characteristics belonging to a person or group of people that determine their capacity to anticipate, survive, resist and recover from a hazard's impact. It is a relative and specific term that always implies certain vulnerability to a specific threat.

c) Social Vulnerability and Risk
The social theory of risk allows us to reveal the ordinary character of the extraordinary in modern societies, that is: social vulnerability as a risk dimension[1] amplifying poverty and disasters.

In what sense, risk? There is risk when it is possible to quantify uncertainty (according to Funtowicz and Ravetz, 1993). It is an intrinsic feature of modern society, which is based on scientific reliability. And it is also an unexpected result that rises as a consequence of our own activities or decisions, and not the result of some divine work, of fortune or fate (Giddens, 1990).

In general, common sense terms, vulnerability is the condition of those who may be hurt, injured or harmed. Social vulnerability, as a risk dimension, is each social group's possibility of being injured or harmed. It is part of the risk as long as the social groups are certain of which the risks they run. Otherwise, it is no longer risk, but uncertainty.

Taking all these considerations into account, we can re-define "disaster" as a updating of the risk becoming effective when the potentiality of what might happen take place, when it moves into action. The contribution of this approach lies in the dynamic, diachronic view of the problem that emphasises society's prevention capacity. Hence, we will now take a look at the way to make analysis viable from this perspective.

METHODOLOGICAL ISSUES

The studied universe's characteristics can be defined taking into account the following assumptions:

- The whole population is affectable.
- Some majority groups are poor, excluded, marginal, and operate within the informal sector.
- Some minority groups are rich, included, integrated, and institutionalised.

Within this framework, the question rises: Are they all vulnerable? And also: To which extent is each group at risk?

The most common techniques to measure poverty at a "normal" stage are the UBN (Unsatisfied Basic Needs) rate and the PL (Poverty Line) calculation. For the first one, the sources used are census data and the Household Permanent Survey. The UBN combines five indicators for each family: the dwelling's overcrowding rate, its sanity type and state, schooling, employment and education level of the household's head. It is used to identify the "structural poor" (those who have been poor all their lives).

The second technique, PL, finds its source in the cost of the basic foods. The PL is multiplied by the Engel coefficient and the resulting value indicates the necessary income to cover a wide range of basic needs: food, housing, clothes, education, health, transportation and leisure. It is related to the identification of the "new poor", i.e. those sectors mainly coming from the middle class, who have become poor as a consequence of the recent economic readjustment process, and their subsequent permanent loss of capital.

[1]We have already pointed out that the potential disasters' risk dimensions are hazardousness, vulnerability, exposure and uncertainty (Natenzon 1995; Natenzon et all 2003).

In order to measure social vulnerability - SV, Minujin (1998) proposed to combine the UBN and the PL rates. He identified three groups of different kinds: A. Excluded; B. Vulnerable; C. Included (see Table 1).

Table 1 – Proposal to measure SV by Minujin 1998

		Poor. Income < or = PL		Not Poor. Income = or > PL	
		Excluded	Poor but not excluded	Income 1 to 1,5	Income 1,5 and +
UBN	1 or +	A	A	A	= 0
	Only OCD*	A	B	B	B
SBN		A B	C	C	C

References: UBN – Unsatisfied Basic Need; SBN – Satisfied Basic Need; PL – Poverty Line; OCD – Overcrowded Dwellings = 3 people or + by room.

In order to measure the vulnerability in disaster situations, Downing (2001) accurately indicated that it is possible to find a multiplicity of rates, one per each particular case considered. The selection of indicators that configure a rate of this sort will be based on its suitability and its free-of-cost availability. Quantitative evaluations are complemented with qualitative analyses on diverse factors of the social vulnerability: socio-economic (development model, concepts of freedom and integration, capital behaviour), ideological-cultural (vulnerability perception, accumulated experience, process history), political-institutional (capacities and weaknesses of formal / informal systems in terms of democracy practice, sorts of social policies developed, negotiation methods, etc.), and communitarian (solidarity bonds, autonomy levels, representativeness and legitimacy of the organizations and their leaders, etc.).

A STUDY CASE[2]

We applied a series of techniques of this kind in order to investigate the social vulnerability associated to a probable increase in the average sea level on the Argentine coast of the La Plata River, and we studied three aspects:

- The structural situation (without any disaster involved) of the social vulnerability and its geographic distribution, through a social vulnerability index.
- The probable impacts on the population and the public assets of the studied area, through census and field data.
- The institutional aspects of the social vulnerability, through the analysis of local cases.

[2] The PIRNA researchers involved in these projects, led by Claudia E. Natenzon, are: Natalia Marlenko, Silvia G. González, Diego Ríos, Julieta Barrenechea, Ana Maria Murgida, Elvira Gentile, Sebastián Ludueña, Ana Paula Micou and María Cecilia Boudín (2002 -2004).

a) Social Vulnerability Index

A way to get the "x-ray" of the structural situation of the Buenos Aires Province and Federal Capital society in previous conditions to any disaster impact is using a social vulnerability index.

The *SVI - social vulnerability index* is a quantitative, statistical evaluation that allows us to *preliminarily* identify administrative units of the territorial distribution of different degrees of social vulnerability, through a given set of indicators chosen for this purpose. The administrative units with a greater degree of social vulnerability can be taken as study cases, to determine in depth, by means of qualitative techniques, what this social vulnerability consists of, and how it is constructed.

The scopes and limitations of the index are given by the very construction that will depend on the selection criteria of the indicators and the internal delimitations in each one on them that each researcher has made in each particular case, according to different purposes.

The utility of a index of this nature is to offer a first approach to the heterogeneities in the geographic distribution of the social vulnerability, helping to prioritise or choose the samples or the study cases in which to deepen the analysis.

The SVI is made up of a series of indicators that are grouped in three *sub index,* corresponding to specific subject groups: a *demographic* sub index, a *quality of life* one and, the last one, of *consumption* and *production.* This way it is possible to distinguish the importance acquired by the different aspects considered, identifying the one of greater significance in the conformation of the administrative units' social vulnerability.

The selected *indicators* came out of the relation between the representativeness of social, demographic and basic economic aspects, on the one hand, and the data's public availability, on the other. In this respect, we came across the difficulty that the data availability was not guaranteed for all the administrative units that were analysed, which forced us to diminish the amount of indicators.

Considering these limitations, we worked with the data of the entire Province of Buenos Aires in 1991, the last Census available at the moment of the study for most of the indicators and administrative units. Each indicator's situation in the study area was considered taking as analysis universe this provincial context (177 districts).

The study area is made up of all those administrative units that have all, or part of their surface, crossed by the 5 metres curve, which is the topographic available datum provided by the IGM. The areas of direct impact (permanent flood and incidental overflows) are located until the 4 metres, but, as the identification of this land curve has not been made yet, the maximum limit taken is the 5 metres one.

The study area is composed by the Autonomous City of Buenos Aires and a set of districts of the Province of Buenos Aires, located on the coast of the La Plata River and its tributaries. In the 1991 Census, those districts were 26: Tigre, San Fernando, San Isidro, Vicente López, San Martín, General Sarmiento, Tres de Febrero, Morón, La Matanza, Esteban Echeverría, Lomas de Zamora, Lanús, Avellaneda, Quilmes, Berazategui, La Plata, Berisso, Ensenada, Magdalena, General Lavalle, Maipú, Dolores, Castelli, Tordillo, Chascomús and La Costa. In the 2001 Census, the districts were 28, since the following jurisdiction changes had taken place: Morón was subdivided, and only the new district of Hurlingham remained within the study area. The same happened with General Sarmiento, having left only the new district of San Miguel in the study area. Finally, Esteban Echeverría and Magdalena subdivided, and incorporated two new districts: Ezeiza and Punta Indio, respectively.

The results (Table 2) show that Capital Federal, General Sarmiento and Vicente Lopez are the districts that present greater demographic vulnerability, with a dispersed distribution within the AMBA (Metropolitan Area of Buenos Aires); whereas the best situations are those of San Fernando, Tigre -both with a significant island surface- and General Sarmiento (the three of them in the AMBA), as well as those of Castelli, Tordillo, General Lavalle, Magdalena and the Coast district, all of them with a rural profile.

General Sarmiento, Castelli, San Fernando and Tigre have (unlike the previous situation) the worst life conditions, which increase social vulnerability. In turn, the units the lowest levels of vulnerability regarding this aspect are two urban areas -Capital Federal and Vicente Lopez-, and two rural ones: Magdalena and Tordillo.

There are only two districts that show high levels of vulnerability due to their labour, production and consumption conditions: General Sarmiento and La Costa. The first one is part of the AMBA and has a residential orientation. The second is a relatively new administrative unit, separate from General Lavalle in the 80's, the main economic activity of which is tourism. At the other extreme, we find Avellaneda, Capital Federal, General Lavalle, General San Martín, La Plata, San Isidro, Tres de Febrero and Vicente Lopez, with low levels in the percentage of 14-year-old, or older employees without provisional programmes, and a significant amount of car owners. All of them have an urban profile, except General Lavalle, which is a rural services centre.

Table 2 – Social Vulnerability Index and Sub-Index, 1991

Districts	Demographic Sub rate	Life Conditions Sub rate	Production Sub rate	Social Vulnerability Rate
General Sarmiento	4	4	4	4
Esteban Echeverría	3	3	3	4
Berazategui	3	3	3	3
Berisso	2	3	3	3
Castelli	1	4	2	3
Ensenada	2	3	3	3
General San Martín	3	3	1	3
La Costa	1	2	4	3
La Matanza	3	3	3	3
Lanas	3	3	2	3
Lomas de Zamora	4	3	2	3
Quilmes	4	3	3	3
San Fernando	1	4	3	3
Tigre	3	4	3	3
Avellaneda	3	3	1	2
Capital Federal	4	1	1	2
Chascomús	2	2	2	2
La Plata	3	3	1	2
Morón	3	2	2	2
San Isidro	3	2	1	2
Tres de Febrero	3	3	1	2
Dolores	1	3	2	2
Maipú	2	3	2	2
General Lavalle	1	2	1	1
Magdalena	1	1	2	1
Vicente López	4	1	1	1
Tordillo	1	1	2	1

References:

Category	Assigned Values	Demography	Life Cond.	Production	SVR
Very Low	1	7-8	6-9	6-10	24 - 29
Low	2	9	10-11	11-12	30 - 33
High	3	10-11	12-13	13-15	34 - 38
Very High	4	12-15	14-17	16-18	39 - 43

Each sub-index resulted from simply adding up the values assigned to four indicators on a 1 to 5 scale. The SVI resulted from the sum of the values assigned to the 12 indicators used. The delimitations and scales here included emerged as an application of ad hoc criteria, combining the natural delimitations offered by the SIG with particular aspects inherent to the indicator suitable for the studied problem.

Synthesising the three mentioned thematic axes, the SVR shows that Esteban Echeverria and General Sarmiento, districts of the AMBA, have the highest levels of social vulnerability. They are not coastal districts, but they do belong to the area that could be affected, under the 5 topographic metres, due to the tributaries of the La Plata River. On the other hand, General Lavalle, Magdalena and Tordillo, districts of a rural profile, present the lowest values of the SVR. The only urban district that can be found in this group is Vicente Lopez, a residential town with high-income population that belongs to the AMBA and neighbours the City of Buenos Aires.

b) Floods Probable Impacts

Floods can affect both population and assets. For that reason it was important to determine what population (in terms of the amount) and what assets (according to uses and location) would be exposed to floods in the case of an increase in the sea level as a result of climate change.

Calculating the amount of population exposed to future floods seems to be a simple task, but it is not. It is necessary to count on the localisation of the inhabitants of each municipality and to identify how many of them are in an area that can get to be flooded.

In order to obtain an approximate figure, two calculations were made using information provided by the INDEC (Surveys and Censuses National Institute) regarding the data of the1991 Population and Housing National Census. These data were divided in census zones (the smallest territorial unit of the Census data), for the administrative units belonging to the study area.

First, it was considered the topographic curve of 5 metres above the sea level, which had been identified by IGM (The Military Geographic Institute) and the population was calculated based on the census zones included in that area. The result can be seen below, in Table 3:

Table 3 – Affectable Population. First approach

Population and Housing National Census - 1991*			Population, Households and Housing National Census - 2001**		
Total Population (Inhab.)	Affectable Population		Total Population (Inhab.)	Affectable Population	
	Absolute Values	%		Absolute Values	%
10.357.411	1.705.117	16.5	9.636.231	1.872.845	19.4

References: * 26 districts and the City of Buenos Aires in 1991.

** 28 districts and the City of Buenos Aires in 2001.

In the next phase, a more precise calculation was made, as we could count on more updated topographic data of the elevations, provided by radar. That was necessary, because since the IGM reports those elevations have been modified by fillings and levelling of all sorts, in the town growth process. In this new calculation, the collected data indicate a population of 866,207 people who could be exposed within the studied area.

In order to calculate the exposed patrimonial assets, a research was carried out in the specific spheres acting in the study area, for each administrative unit: public offices and social security, health centres, buildings dedicated to education, security facilities, areas of transportation and circulation, industries and recreation areas. Again, in this investigation, we identified those assets located below the 5 meters level, and the result was the following town constructive patrimony that could be exposed to floods due to an increase in the average sea level:

Public Offices	125
Social Security	17
Health Centres	205
Education	928
Security	92
Circulation	41
Industries	1,046
Recreation Areas	306

The districts with the biggest percentage of exposed assets are Ensenada (88.3%) and Berisso (93.4%). However, the total figures of assets are not so relevant in this districts. If we consider the absolute amounts of assets registered below the 5 meters in the area, the administrative units with the biggest amount are: Capital Federal, San Fernando and Lanús, representing, altogether, a percentage closed to than 57% of assets distributed below 5 meters.

c) Social Vulnerability, Institutions and Culture

The analysis of the study cases of the La Boca district and the Avellaneda municipality allowed us to become aware of some qualitative aspects of social vulnerability: the institutional, political and cultural ones.

The La Boca District is one of the oldest in Buenos Aires City; it was born as a harbour, in a flooding area. In the urban imaginary, La Boca has always been considered a marginal area of the city, in spite of the urban renovation projects of that the Government of Buenos Aires City (GCBA) has been undertaking in the last years. Among other aspects that contribute to this negative imaginary, the floods (and the high degree of contamination associated to them) play a significant role. Indeed, the most important hazard La Boca faces is the flooding due to intense rain and "sudestadas" (strong, stormy winds coming from the south).

In 2001, this neighbourhood had 39,396 inhabitants on a surface of 3.3 km² (1.29 % of the Autonomous City of Buenos Aires) with a density of 11,938 inhab./km² (1.65% of the City).

The institutions of the GCBA that are in charge of the floods management in the different instances are:

- Prevention: the Social Emergencies and Civil Defence Office (DESyDC) and the Brigade for Emergencies in the Public Highway (CEVIP), from the Logistics and Emergencies Sub-secretariat; Hydraulics Office from the Infrastructure and Planning Secretariat.
- Response: the Social Emergencies and Civil Defence Office (DESyDC) and the Brigade for Emergencies in the Public Highway (CEVIP), from the Logistics and Emergencies Sub-secretariat; and the Emergency Medical Attention System (SAME).
- Rehabilitation: the Social Emergencies and Civil Defence Office (DESyDC) and the Brigade for Emergencies in the Public Highway (CEVIP), from the Logistics and Emergencies Sub-secretariat; the Health Department; and the Infrastructure and Planning Secretariat.

The analysis of public documents and the interviews taken have allowed us to ascertain that these institutions act inarticulately and often their interventions are superposed. In addition, there have been detected, attitudes of distrust between the public offices (the ones most related to decision-making) and the technical institutions that participate in the preparation for and response to disasters, such as the National Meteorological Service (which broadcasts the meteorological warning of severe storms) and the Naval Hydrology Service (that broadcasts the hydrologic warnings before sudestadas). The institutional misalignment is completed by the lack of communication channels between the institutions and the population.

Traditionally, the type of response developed by these government institutions has always been related to the engineering construction works, as a mitigation measure, usually without having contemplated non-structural measures, including instruments of urban planning for hazardous areas. We should point out that the flood management has always been separated from the urban planning, as if they were two instances with no relation between them.

The most important structural intervention of the last decade was the construction of a coastal defence to face the sudestadas, which also includes operative and tourist quaysides, but it was built without having contemplated the hypothesis the sea level rise. The purposes of this public work are related not only to floods mitigation, but also to the valuation of the neighbourhood, promoted by the GCBA. Nevertheless, from the point of view of risk construction, these processes install a false feeling of safety that debilitates the pre-existing cultural guidelines in the inhabitants of the neighbourhood (as for instance, informal warning networks operating among neighbours), hiding the risk of flooding.

Certain positive aspects that could be regarded as change potentialities somehow compensate all the problems hereby pointed out. We are talking about the recent changes in the organizational chart of the GCBA that have integrated within the same office the urban planning area and the one of public works. On the other hand, and also at a political decision level, recently some non-structural measures have been incorporated in the last floods prevention plans. Finally, and at another level, the strong participative tradition and knowledge that the neighbours of La Boca have regarding floods (how to prepare themselves, how to respond, how to help themselves) are important examples of how adaptive processes can tend to the reduction of their own vulnerability.

The Avellaneda Municipality, located in front of La Boca, just on the other side of Riachuelo, is one of the oldest population centres near Buenos Aires City. Sited on a floodable area, it has had an industrial profile from its origins. Since the 1940's, the municipality has high levels of urbanization (higher than 90%). The main hazards in Avellaneda are related to floods and contamination.

In 2001, its total population counted 328,980 inhabitants, in an area of 55 km². According to these data, the population density was of 5,993 inhabitantes/km².

As it is stated in the Civil Defence Law for all the Argentine municipalities, the main municipal institution in charge of the disasters management in Avellaneda is the Civil Defence Municipal Council (JMDC), integrated by:

- the Mayor (President);
- the Director of the Civil Defence Office (Secretary);
- the Municipal Secretaries - of Health, Social Action, etc. - (Members);

- the Voluntary Firemen Brigade (Member);
- the Naval Prefecture of Dock Sud (Member);
- the Red Cross - the office in Villa Domínico- (Member); and
- Leaders of Social Organizations such as the Boy Scouts (non permanent Members).

Some limitations found in the disasters management have been the result of the lack of continuity in the Civil Defence policies. In relation to it, the designation of the Director of Civil Defence, coordinator of the JMDC, is a political decision and it renews at least every four years, together with each change of municipal government, which affects the continuity of the policies of this institution negatively. On the other hand, the members and other representatives of the civil society are not efficient and continuous participants in the JMDC, and thus their points of view are not taken into account. Therefore, the decisions in this matter are only in the hands of the Civil Defence Director.

These deficiencies find their compensation in an intense coordination between some of the institutions in charge of emergency procedures: the Voluntary Firemen, the Red Cross and the Naval Prefecture, through the periodic emergency simulations. Another positive, although circumstantial aspect, was the designation, in 2003, of a new Civil Defence Director, that has a technical profile, and is capacitated for disasters management – a skill acquired in as Head of the Voluntary Firemen Federation of the Province of Buenos Aires. Finally, in the institutions of Avellaneda we found an important amount of people who are highly trained and experienced in the matter, who can be a significant base from where to put into practice and improve the disaster management policies.

Besides their own institutions, the municipalities can turn to provincial and national institutions that are directly related to the subject and work together with the local governments for the development and implementation of disaster management policies. At a national level, they are the Security Policies and Civil Protection State Office (DNPSyPC) and the Federal Emergency System (SIFEM). In the last decade, these institutions have undergone several changes of jurisdiction. The Security Policies and Civil Protection State Office, created at the end of the 1930's under the name of Argentine Army's Air Defence Commando, was transferred from the Defence State Department to the Internal Affairs Department by the second State reform, carried out in 1996. The SIFEM, created in 1999 within the Cabinet Headquarters, was transferred along with the Security Policies and Civil Protection State Office to the Presidential Office in February 2002. Five months later, both institutions were again transferred to the Justice and Human Rights Department. Finally, on 21st August 2004, was announced the transfer of the Internal Affairs Secretariat (within which the DNPSyPC and the SIFEM are located) to the Internal Affairs State Department. The assiduity of these changes does not respond, as it could be assumed, to fast processes of adaptation to new circumstances. On the contrary, they respond to other necessities, external to the disaster issue; this way they increase and aggravate social vulnerability, both at local and national level, hence manifesting the little relevance of the subject for the public agenda.

As a *conclusion*, it is possible to point out several characteristics evidenced by the institutions involved in disaster management:

- The flood management public measures are cut off from the global urban policies, when actually urban planning should tend to the reduction of risk through diverse decisions and actions (the so called "non structural measures").

- There are formal obstacles between institutions, such as: distrusts and rivalries, lack of communication (for example, unawareness of what the other institutions may offer), lack of coordination and articulation, among others.
- Some successful programs and projects have been discontinued with each government change, and even with each change of civil employee, which reveals the little importance given to disaster prevention as a considerable factor in decision making.
- The policy of these government institutions has been oriented from the beginning to the moment of the emergency, with particular emphasis on the "structural" type of solution (engineering works).
- There is not enough institutional communication on risks and disasters towards the affectable population.

This fragmentation of policies and actions increases the social vulnerability and generates high degrees of uncertainty that aggravate each disaster's damages. The institutions and their policies cannot be sustainable in time because of the kind of institutional management, typical to our culture that is not adequate to confront long term processes (social construction of the disaster risk). This can explain the fact that the mitigation plans and the small processes of communication to the public have not yet considered the changes implied by a potential sea level rise due to climate change.

Nevertheless, despite all these difficulties at an institutional level, the cultural aspects of social vulnerability can act as adaptive devices that play a positive role in the reduction of flood risk. The election of opportune constructive systems, the setting of solidarity and self-help networks (such as neighbour relations), the high sense of belongingness and identification with the place, the experiences with floods (both the personal ones and the stories transmitted from generation to generation), are some of the strategies established by sectors of the population in order to diminish the effect of the floods; at the same time, these strategies express people's awareness of their own social vulnerability.

The analysis of the potentialities related to the cultural aspects of the society reveals the practical knowledge regarding disasters that the population has constructed historically, which represents one more element to be taken into account in order to authorise it to actively participate (with its proposals, perceptions, ideologies, logics, etc.) in the decision making at the moment for planning or for offering solutions to this complex problem.

RISK, UNCERTAINTY AND ADAPTATIONS

It is necessary to stress the fact that, considering a particular location below the level of 5 meters above the sea level (for example, the location of a house, an industry or a store), it is not possible to know exactly whether and when it will be flooded or not. The precise location of each periodically or definitively flooded building will result from multiple present and future actions (the real estate value, the public works, the local protests to get these works done, the availability of funds, etc.) that are in the hands of a great amount of public and private decision makers, all of them with legitimate, but partial interests.

What it does seem possible to anticipate for certain areas is the chances there are it might happen, configuring different *scenarios* with different *recurrences*. Consequently, the decisions on how to prevent floods and diminish the impacts are not unique, but multiple, and the choice should result from a wide debate between all the involved actors, in which they should specify what risks (precise information) and what uncertainties (new data to construct) exist, what strategies can be carried out, whom they harm or benefit, and with what individual and/or State cost.

Is it possible to speak about adaptation? It is necessary to handle the "adaptation" notion with certain precaution. In natural sciences adaptation is synonymous of life, even under extreme conditions. In the analysis of social processes, however, adaptation can be used as preservation of the status quo, or as means to ground positions from which the model to be followed is the one of the poor. Certainly, the different practices of the different social sectors in extreme situations offer lessons to be taken profit in; but they should fit a development model where opportunities be more equitable for all, a model in which the right to know the risk one runs in his/ her place of residence be fully practised; a model within which all the possible measures to mitigate the impacts (including the responsibilities of the public institutions in the first place) be taken and in which one could freely choose whether to run that risk or not.

These studied cases offer lessons for future floods originated in a climatic change. The lessons of the UBA and AIACC LA26 Strategic Project show real situations of social vulnerability, impacts of floods disasters and processes that can be considered of positive social adaptation. They could be extended to similar cases of urban and rural settlements on bigger rivers and estuaries coasts.

ACKNOWLEDGMENTS

This work was funded by the UBA and AIACC - Project GEF implemented by UNEP and Co - executed by START and TWAS. I am grateful to Vicente Barros and Neil Leary for the opportunity to participate in these initiatives.

REFERENCES

Banco Interamericano de Desarrollo (1998). *América Latina frente a la desigualdad. Programa económico y social en América Latina*. Washington, BID, 318p.

Blaikie, Piers, Terry Cannon; Ian Davis and Ben Wisner (1998): *Vulnerabilidad. El entorno social, político y económico de los desastres*. Bogotá, LA RED/ITDG.

CEPAL (2004) *Panorama Social de América Latina*. In: www.eclac.cl or www.eclacwash.org.

Downing, T. E. et. al. (2001) *Vulnerability Indices, Climate Change, Impacts and Adaptation*. Nairobi, UNEP, 92p.

Funtowicz, Silvio and Jerome Ravetz (1993): "Riesgo global, incertidumbre e ignorancia". In: *Epistemología política. Ciencia con la gente*. Buenos Aires, CEAL; 11-42.

Giddens, Anthony (1990): *Consecuencias de la modernidad*. Madrid, Alianza Editorial.

IPCC (2001) *Climate change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report.* New York, Cambridge University Press.

Lo Vuolo, Rubén, Alberto Barbeito, Laura Pautassi and Corina Rodríguez (1999) *La pobreza... de la política contra la pobreza*. Buenos Aires-Madrid, Miño y Dávila. Colección Políticas Públicas, 350p.

Magno de Carvalho, José Alberto (1999) "La demografía de la pobreza y el bienestar en América Latina". In: Tokman y O'Donell –comp.- *Pobreza y desigualdad en América Latina. Temas y nuevos desafíos.* Avellaneda, Paidós; 55-67.

Minujín, Alberto (1998) "Vulnerabilidad y exclusión en América Latina". In: *Todos entran. Propuesta para sociedades incluyentes*. E. Bustello y A. Minujin, eds. Bogotá, 161-205.

Minujín, Alberto (1999) "¿La gran exclusión? Vulnerabilidad y exclusión en América Latina." In: *Los noventa. Política, sociedad y cultura en América Latina.* Daniel Filmus, comp. Buenos Aires, FLACSO/EUDEBA; 53-77.

Natenzon, Claudia (1995): *Catástrofes naturales, riesgo e incertidumbre.* Buenos Aires, FLACSO, Serie de Documentos e Informes de Investigación nº 197.

Natenzon, C E., N. Marlenko, S. González, D. Ríos, A. Murgida, G. Meconi and A. Calvo (2003) "Las dimensiones del riesgo en ámbitos urbanos. Catástrofes en el Area Metropolitana de Buenos Aires". In: *Procesos territoriales en Argentina y Brasil*. A. F. Alessandri Carlos and R. Bertoncello, comps. Universidad de Buenos Aires/ Universidad de San Pablo; 255-276.

O'Donnell, Guillermo (1999) "Pobreza y desigualdad en América latina. Algunas reflexiones políticas". Tokman y O'Donnell –comp.- *Pobreza y desigualdad en América Latina. Temas y nuevos desafíos.* Avellaneda, Paidós; 69-93.

ENVIRONMENTAL CHANGE AND SOCIAL CONSTRUCTIOIN OF URBAN RISK

HENRI ACSELRAD
IPPUR/UFRJ and Researcher of CNPq

The urban expansion carries with it different negative implications for the environment, such as contamination of water, air and soil, the reduction of biodiversity, the alteration of the climate, the reduction of river beds, erosion, the concentration of pollutants in the atmosphere, formation of islands of heat, etc.

It was by considering risk, including the risks associated to the pattern of energetic consumption, that the environmental issue has been gaining importance in the ambience of society. The way Global Climatic Changes and its social implications are considered depend on the historical circumstances over which the public debate is developing and the causal relations that are established from the scientific sphere, passing by the area of the media and the concrete experiences of the population. The "social perception" of climatic change, consequently, does not occur in a homogeneous way. That is why the damaging consequences that can be attributed to the phenomena of climatic change are experienced in various ways according to the income pattern of the different social groups. According to the vast literature on the "environmental injustice"[1] theme, the perception will necessarily be heterogeneous and the experience of the damage will usually fall in a more dramatic way over the poor, which, paradoxically, are the less heard by the great decision makers. The Tsunami episode and the Katrina cyclone which marked the debates on climatic change in the beginning of the 2000 years, left strong evidences of this unequal social distribution of the risks resulting from social processes in different production of vulnerabilities. Otherwise, Mike Davis[2] remembers, given the fact that most of the victims of the climatic events were of low income, the probability of a mobilization from the society towards the alteration of the urban pattern and the attempt to prevent new ones is very low.

In the Brazilian Case, it is observed that the presence of justifications related to climatic changes in the debate on urban politics is still very low. These policies do not seem to be integrating the political themes in which the issues of global climatic changes have been expressed. We may suppose that the mobilization of the urban elites for the introduction of the agenda of political urban concerns related to the theme of climatic changes, will tend to occur when the elites perceive that the impacts of global change may affect their projects, a sufficient motive for them to engage their capacity of making themselves heard in the public sphere. In the current text, we will make an evaluation of the recent debate on the urban environmental issue, in particular, in respect to the social conditions of adhesion to the discourse of "sustainable cities" and of a logical articulation between the urban risk and climatic changes.

---

[1] Gould, D.A. "Social Class, environmental justice and political conflict", in Acselrad, S. Herculano, J.A. Padua.

[2] Cf. M.Davis, Ecologia do Medo, Record , Rio de Janeiro, 2001.

SUSTAINABILITY AND URBAN REGULATION

In the last decades, the negativistic discourses on the cities exploded: cities in crisis, venues of crime, violence, landscape architectural degradation, infrastructure decadence, housing lack, decline of formal employment, mobility strangulation, and atmospheric pollution. In a parallel way discourses on the observed changes in the urban frame were also disseminated –new models of urban policies emerged, the city is simultaneously considered as the executor and the subject of a strategic action with a business scenario management, meant to attract investments in an inter-urban competition punctuated by the symbolic practices of marketing in the cities. Thus the urban gains a new scenario of "enunciation"[3] As a result some people accept a city identity crisis: "technologies of the spirit" are put in practice directed towards a re-composition of the urban subjectivities. The city is rediscovered as an area for "dramatic action"[4] were the "best practices" (the good ones, defended by the multilateral agencies) are the script for a passionate mobilization of the citizens (with the "indicators of urban sustainability" used to metaphorically adjust the movements of the actors in the theater of this drama). The identity of the cities thus progressively becomes an instrument for the legitimacy of the political operators who want to rescue it not as circumscribed to its current epoch, but as a reference to a past of glory and to a radiant future[5]. For some people a "change in the nature of the symbolic identity of the cities, marked by the rising competition among different places and by the greater importance that representation would be assuming in relation to the object it represents"[6] A degree of autonomy is thus given, in a questionable way, to the symbolic sphere which causes difficulties in the comprehension of its articulations with the sphere of urban spatial practices. We will suppose here, on the contrary, that between the game of representations and the practical reconfiguration of the object itself there is no important hierarchy. We shall try, before, to understand the nature of the relations that can nowadays explain, simultaneously, the sense of a symbolic reconstruction of the identity of the cities – a movement that involves the proposition itself of "sustainable cities", and the social and material processes which are underlying to them.[7]

In specialized literature, we find two types of treatment of the urban sustainability issue: a normative treatment, determined to delineate the profile of a "sustainable city" starting from principles of what is understood as a environmental urbanism: and an analytical treatment, that starts from a problematic

---

[3] Cf. A. Micoud, L'Écologie Urbaine: nouvelles scènes d'énonciation, in Ecologie et Politique, n.17, été 1996, pp. 31-43.

[4] Recupera-se aqui expressão inaugurada por Patrick Geddes.

[5] cf. M. Lussaut, Des Recits e des Lieux: le register identitaire dans l'actiion urbaine, in Annales de Geographic, 1997,p.522-530.

[6] cf. P. Peixoto, Gestão Estratégicca das Imagens das Cidades- analise das mensagens promocionais de estrategias de marketing urbano, in Revista Critica de Ciências Sociais n. 56, Liboa, fev. 2000, pg 99-122.

[7] The debate on sustainability is marked by a great diversity of approaching perspective.In the middle of an environmental issue progressively constructed along the last 30 years, the notion of sustainability is a discursive innovation, certainly lent to biological sciences. These sciences, had already formulated it under a strongly economics conception of the living systems, that is, under a analogy between biological processes and those of determined economies, more specifically of economies of surplus production. In this perspective, the notion of "sustainability " of Biology thought of living systems as composts of a "capital/stock" to reproduce and of a "surplus/flux" of biomass, liable do be appropriated for useful ends without committing the original mass of "capital. We can observe all trajectory of this concept of one scientific discipline to another until the appearance at the of the XX century as s relatively common notion in public debate. In this field, we will treat on a discursive construction that will position the ethic and political principles, utilitarian and others to orient the reproduction of the material basis of society. In doing so, this notion, in its multiple contents in discussion, presupposes a process of redistribution of legitimacy among the practices of the material basis disposition of the societies. Due to the type of definition which will prevail and be established as hegemonic, the social practices will be divided into more or less sustainable, among sustainable and unsustainable, taking away and attributing legitimacy to these different ways of appropriation.

process of socio-political conditions from which emerges the discourse on sustainability applied to cities. We shall try to discuss in the present paper that measures the investigated "norm"—In Ewald' terms, the principals of dimension "through which we intend to appreciate what is according to the rule, having as reference the medium in the game between the normal and the pathological"[8], integrate a more ample process of construction of a new mode of urban regulation appropriate to the new conditions of validity of the "machine-city of growth"[9] and of the "advanced marginality"[10] through which the flexible accumulation has dispersed in space.

THE CITY OF CONCRETE SOCIAL PROCESSES

The cities experimented in the last decades a process of an "opening of spaces to open relations"[11] in reference to flexing patterns of labor, transference of payments, technological and communicative formats. In a metropolis we now find movements of rearrangements of productive activities decomposed by the overcome 'fordism' and by the collapse of territorialism and industrialization of neo-liberal type.[12] The city is a place for egress and regulation through mobilization. An economy of speed and uncertainty justifies flexible business dynamics which tend to engender anti- structuring effects on installed and fixed capacities. Urbanism itself tends to be conceived "just in time", mostly commanded by the logics of real estate market[13]. The conditions of capital reproduction are less coordinated by the central State and the local power attributes to themselves a more proactive role in strategies of development. The economic processes catalyzed by the so called "urban entrepreneurialism," start to subordinate social policies, securing a fragmented and unequal supply of the collective means of consumption based on renewed criteria of economic performance.

What Harvey called "competitive reversion" is established where capital is not any longer in search of located advantages, however, the localities are competing among themselves, offering local returns to attract the capital[14]. The so called "urban governance", institutes a multiplicity of initiative and decision poles, involving non governmental, semi public and private players. A so called institutional flexing appeared, strongly favoring the business segments, through negotiation mechanisms of urbannorms, liberation in the control of land use, taxation renounce and private investment subsidies in exchange of infra structure, land, labor skills[15], etc.

[8] Cf. F. Ewald, Foucault and the norm, In F. Ewald, FOucaul, the norm and the law, Ed. Veja,Listoa, l993,p.81.

[9] Cf, O.B.F.Arantes, A Fatal Strategy – The culture of new urban management, in O.Arantes, C. Vainer,F.Maricato, The City of a Unique Thought – unraveling consensus, Ed. Vozes. Petropolis, 2000, p.27.

[10] Cf. Wacquant.l., The cities' condemned , ed. Revan ,Riio de Janeiro, 2001, p.188-194

[11] Cf. P. Healey Binding sustainable futures in small and médium sized cities in Europe, V. Mega O.Petreella, Utopias and Realities of Urban Sustainable Development – New Alliances between economies, environment andd democracy for small and medium sized cities, Conference proceedings, Turin-Barolo, 1996, pp. 79-88

[12] Cf. P.Veltz. Temps de l'Economie, Temps de la Ville; les dynamiques, in A. Obadia(org). Entreprendre laVille –Nouvelles Temporalites – Nouveaux Services. Ed. L'Aube, 1997, p.390-399: translated in Portuguese in H.Acselrad (org), The Duration of Cities , DP&A, Rio de Janeiro, 2001.

[13] dv. P. Veltz, ibidem

[14] D. Harvey, L'Accumulation Flexible par L'urbanization: Reflextions sur le "post-modernisme" dans la grande ville americaine, Furut Anterieur, 1995,p. 121-145.

[15] R. Compans da Silva, A Emergência doEmpreendorismo Publico Urbano na Cidade do Rio de Janeiro, Tese de Doutoramento, IPPUR/UFRJ,2001.

The emphasis on economical innovation and inter-urban competition, such as the subordination of the social programs to priorities of efficiency accentuated the divisions in society, pointing, in long term, towards eventual difficulties in economic stabilization itself. The new institutional forms began to call for connections amongst the distinct dimensions of local policies, as well as articulations amongst the different public, semi public, private and non governmental agencies[16]. In the absence of barriers to the dislocation of capitals, the private capital was free to blackmail the State with the phantoms of local crisis (in an analogy with the explanation given by Kalechi for the business opposition to employment policies in post-war)[17], demanding the "flexing" of environmental and urban rules. This new scenario that sets on the agenda a tension in cities between "the flux of the spaces" and the "flux of permanence"[18] can be interpreted as a new correlation of forces that opposes in the urban space the most mobile agents – the great corporations- to the least mobile agents – local powers, unions and popular organizations[19]. This new frame, which adds the loss of coordination mechanisms to gains in the mobility of business strengthened agents, puts in evidence the great difficulties in the management of local urban conflicts, also pointing, according to some authors, to the risks of social disintegration in long term[20]. We have here, by hypothesis, that these conflicts reflect the contradictions of this new way of regulation of cities in gestation, or the way of insertion of the cities in a regulation which is characteristic of capitalism in its flexible phases.

THE CITY OF REPRESENTATIONS

The environment is a unifying thematic which points towards a change of direction in urban planning in the context of a fragmented social order. The instability of contemporaneous urban sociability and the scenarios of the ecological crisis converge. An Ecology of the Risk tries to reconstruct what one feels is disappearing – species, tribes, sources of energy. The environmental urban planning tries to re-signify the space with reassuring comfortable gestures of security and control, giving visibility to the nature of the cities and exorcizing the fears of ecological destruction and instability of social order[21]. This environmentalist urban planning coincides, certainly, with the dismantle of public politics intended to put an end to socio-spatial inequalities. The idea of environment tends in this context to absorb the senses of the notion of well being in the city. The environment evoked by the plan- out discourse tries to reconstruct the unity of the cities, its social cohesion and political governing ability in confrontation with the dismantle of institutions and propositions of the Regulator-State, in opposition to the privatizing tendencies of life and to the fragmentation of social tissue. In parallel, therefore, to the dismantling of the public sector and privatizations, the thematic of sustainability has been evoked with frequency, allowing the passage of expectations of well being into the ambience of housing, health and social rights, strongly marked by unequal social access, towards a notion of environment construed as unique and common to all people.

---

[16] M.Mayer, Post-Fordist city politics, in A.Amin(ed), Post-fordism – a reader, Blackwell, Oxford, 1995, pp.316-137. 1994.

[17] M Kalechi,Political Aspects of Full Emplyment, in Political Quarterly, vol.14, l943, p.322-331, traduzido em M.Kalechi,Crescimento e Ciclo nas Economias Capitalistas, Ed.Hueitecc, SP,1983.

[18] m.Castells, The informational City. Information Technology, Economic Restructuring and the Urban regional Process. Osford, Blackwell, l989.

[19] Boltanski,L. Chiapello,E., LeNouvel Esprit du Capitalisme, Gallimard, Paris, 1999.

[20] Cf. M. Mayer, op.cit

[21] Cf. P. Brand, "The Environment and Postmodern Spatial Consciousness: A Sociology of Urban Environmental Agendas", in Journal of Environmental Planning and Management, 42 (1), 1999, p. 631-648.

The Environment, dressed in this universalistic clothing, is certainly in agreement with the propositions of a pre-construction of a social consensus designed for the reconstitution of the meaning, community, solidarity and common interest in a socially fragmented world, trying to accommodate the differences in a new interdependent totality.

In Urban planning, this kind of reference on environment has attributed legitimacy to political contested instances, mediating contacts amongst different urban groups and cultures, appreciating shared consumption spaces, focusing fluxing spaces such as rivers, corridors planted with trees and *waterfronts*, all of them converted into attractive places of the city through landscape architectural works and by the concentration of cultural events produced in these areas[22]. As Healey[23] observes, cities that intend to stay sustainable invest in the establishment of connections, through the dynamics of communication and cooperation, trying to integrate in space, society and ecosystems in present and future times. This is also the perception of Emelianoff[24], for whom the discourse of sustainability candidacy cities, have in common a logic of inclusion in space and temporal continuity: inclusion of peripheries (de-centralization), memory (recycling) and social agents (interaction) – including non living and absent generations: inclusion of the city in global ecosystem and in the local ecosystem of the city; inclusion of the city in the patrimony of future generations and local patrimony, inclusion of participative democracy in the city and the city in a "planetary democracy".

The intention of producing continuities is also visible among the agents of the enunciation of urban sustainability in Brazil, when they highlight "retro feeding" objectives, proper for "cyclic society fluxes"[25], manifesting the will to establish "positive interactions and interfaces", to "open doors and creating air or fauna corridors"[26], constructing "more connected" cities with a "pattern that links all things, with pertinence and permanence relations", which "spread synergies" through "strategic cooperatives"[27].

The inclusion of peripheries via de-centralization, of memory via restoration and of the social agents via interaction constitute, thus, discoursing proceeds in the symbolic expansion of the legitimizing basis of urban policies.

The search for an urban consensus thus amplified in temporal and space ways, legitimated on the propositions of biosphere equilibrium and on inter-managerial justice, is certainly explained by the necessity of preventing risks of socio-political rupture in cities with rising fragmentation due to processes of globalization and flexible accumulation.

---

[22] P. Brand, La Construcion Ambiental del bienestar urbano. Caso de Medellín, Colômbia, in Economia, Sociedad y Territorioi, vol III, n. 9,2001, p.1-24

[23] P.Healey, op.cit.

[24] C.Emelianoff, Lês Villes Durables^:l"emergence de nouvelles temporalities dans de veux espaaces urbains, Ecologie Politique, n.. 13, printemps l995,p.37-58

[25] R. Pesci, Um novo Humanismo e o planejamento ambiental" in R. Mengat. G.Almeida (orgs). Desenvolvimento Sustentavl E Gestão Ambiental nas Cidades, UFRJ Editora, Porto Alegre, 2004.p.103

[26] R.Pesci, La Construccion de la ciudad usstentable, proyectaciion y gestion. Urban 21, Conferencia Regional para Amarica Latina yel Caribe, Rio de Janeiro 24-26 abril 22) P. Brand, La Construcion Ambiental del bienestar urbano. Caso de Medellín, Colômbia, in Economia, Sociedad y Territorioi, vol III, n. 9,2001, p.1-24

[27] D.J.Silva. The transdisciplinarity of professional exercise in the sustainability of the cities, In Profesisional exercises an sustainable cities, referred texts, CONFEAS, São Luis, 30/11/2004, p.98

Therefore, the appeal to the notion of urban sustainability seems to increasingly integrate a statute of planning applied to strongly divided cities, the symbolic character of the actions associated to such notion – be it a unique and consensual environment through rhetoric representation – be it through the sense impressed on material operations “of connection” – such as corridors of trees, aquatic fluxes and other material icons of social integration, however, will not impose itself as sufficient to give stability to the mechanisms of urban reproduction. The notion of sustainability will seem thus to constitute only part of a more ample struggle to configure a new mode of urban regulation capable of a durable integration of the constitutive inequality of the cities in the reproductive dynamics where there is an advanced marginality and urban rental fees[28]. Therefore, to characterize the reconfiguration of the processes of regulation of the cities, it is time to advance in the investigation of the way how, through urban crisis, a city which is compatible with flexible accumulation is being reproduced.

SPACE CONTRADICTIONS AND URBAN SUSTAINABILITY

In the concept of Alain Lipietz, mode of regulation is the combination of rules, incorporated or explicit, of institutions, mechanisms of compensation, and devices of information (such as rules of salaries configuration, modalities of competition amongst companies and mechanisms of conception of money and credit) which permanently adjust the anticipations and individual behaviors to the combination logics of the accumulation regime[29]. In fordism, the alliance among great corporations, State and unions transformed the city into a space to carry out mass production of automobiles and real estate whose markets were detonated by rules of consumption through which the salaries, via collective negotiation, incorporated part of the productivity gains in a reasonably anticipated way. The city of so called fordist regulation was strongly marked by its compatibility with the production of automobiles and the capitalist housing sector.

In the emerging conditions of a so called flexible accumulation regime, a new mode of urban regulation was being generated by the fusion between the policies of location and the policies of production compatible with elevated levels of mobility of the capital promoted by the State – by some called Shumpeterian[30], in opposition to the previous Keynesian State—which integrates the dynamics of international competition, supporting socio-technical innovations that operate in open economies.

---

[28] Loic Wacquant calls “advanced marginality” the processes of production of social cotingents not integrated in contexts on which the salary paid work is a source of exclusion and not insertion. There is a functional disconnection originated from macroeconomic tendencies through which growth may not generate employment, there is fixation and territorial stigmatization, dissolution of identification places loss of the interior as for the excluded cities and symbolic fragmentation via de proletarization and weakening of the repertoires of collective representation.Wacquantm , The condemned of the cities, Ed. Revan, Rioio de Janeiro, 2001, p 188 194.

The urban rental fees would express the interests of elite coalisions centered on real estate properties, culturally valorizing spaces from which those of minor income are excluded. Cf. O.B.F.Arantes, A Fatal Strategy. Culture in new urban managements, in Ol. Arantes, C.Vainer, Maricato, The City of a Unique Thoufht; Unfolding consensus, ed. Vozes, Petropolis, 2000, p.28-29.

[29] A.Lipietz- D. Leborgne: Flexibilité Defensive ou Flexibilite Offensive: Lês Defis dês Nouvelles Technologies et de la Competition Mondiale, Conference Trends and Challenges of Urban Restructuring, Rio de Janeiro, Setembro 1988, mimeo, 35pp.

[30] B.Jessop, Recent Societal and Urban Change:principles of periodization and views on the current period. Paper of the Department of Sociology, Lancaster Univesity, 2003, 24pp.

The literature that has been committed to the study of the identification of the traces of what could be this new mode of regulation[31] signals that: 1) the conditions of reproduction of capital are less coordinated by the central state and the local powers assume a pro-active role in the strategies of economic development. The city is the link between local economy and the global fluxes, thus aspiring to be the object of international competitive pressures. The cities assert themselves as "machines of growth", promoters of international competition. Consequently an inter-urban competition is established to explore the competitive specific advantages and the "competitive reversion" – reduction of costs, subsidies, attraction of companies that need qualified human resources, better and more efficient economic infrastructure, proximity to centers of technology producers and consumption markets of high income, supply of tax favors, land, socio-political and environmental advantages, with the external restrictions favoring the adoption of socio-ecological dumping; 2) An interurban competition is developing through the supply of possibilities of local consumption, tourism attraction and cultural projects and events; 3) an interurban competition is developing in the capacity to control functions of financial and communication commands; 4) The economic processes are subordinating social politics and employment. The social policies are dismantled and substituted by "urban entrepreneurship" whose success depend on employment and income, leaving the problems of social marginalization to the dependence of the initiatives of the organizations of the society; 5) the new conditions of government of urban processes tend to involve also non governmental, private and semi private agents. The coordination of different fields of urban politics presupposes the insertion of new systems of bargaining, with the emergence of "partnerships" as mechanisms of support to the markets in substitution of pre- existent policies of market arrangement.

In a context of flexible accumulation, the intensification and temporal variability in the use of environmental resources threatens the stability of "urban metabolism". As Veltz underlines, the metropolis accelerates the division of labor and the continuous diversification of goods and services, constituting itself as a privileged place for the re-development of productive systems from now on ultra decayed. The economy of velocity and uncertainty associated to a less predictable demand, destroys and recreates the social territory. Given the high rates of interest that cause the elevation of land operation costs, the "just in time" market urbanization- the one performed by the companies- tends to be less regulatory and more commanded by the logics of the real estate capital[32]. Everything that pertains to the regulation of space ordainment in the city, including its ecological dimensions, disappears in the absence of coordination forces, which are eventually substituted by the auto-organization of "corporative governance", private-private partnership, that is, partly rising on account of the proper capital in competition.

This new urban regulation, compatible with the flexible accumulation moved by the high spatial mobility of capital, thus updates the city to "machines of growth"[33] for which coalitions of the elite centered on real estate business obey the rules of urban policies, giving free course to the proposition of expanding the local economy and augmenting wealth. The construction of a common sense promising labor policy becomes the model solution for a situation of permanent competitive mobilization

[31] See authors like J.Mayer, D.Harvey andB.Jessop, among others.

[32] Cf. P. Veltz, op. cit. p. 391.

[33] Cf. O. B. F.Arantes, Uma Estratégia Fatal – a cultura nas novas gestões urbanas, in O.B.F. Arantes, C. Vainer, E. Maricato, A Cidade do Pensamento Único – desmanchando consensos, ed. Vozes, Petrópolis, 2000, p. 27.

of the struggle between competing cities. The operation of these mechanisms implies in a transference of the wealth and new chances for the public well being in general, towards the profit groups having as corollary an unequal city where the "business setting" awards the participators of the growth coalition with amenities and assigns the social and environmental risks to the urban poor and the less organized laborers. The "machine city of growth" is therefore a city that imposes risks to the weak; it also constitutes a disorganizing machine for labor – fighting for employment at any cost – and the society in general – lacking resources for investment.

Trying to find the constitution of new models of urban regulation does not result in a solution without contradictions. In consonance with the imperatives of deregulation required by flexible accumulation, the institutional and social urban tissue has fragmented itself, both in a lower level fragmentation as in a higher one. The under fragmentation, as Jaglin[34] suggests, derives from a communitarian conception of solidarity, which promotes a distributive management of the poor neighborhoods, a physical discontinuity in the services net islands, producing competition amongst the communities and in their inner sectors in search of scarce resources. The higher fragmentation, by itself, joins all forms of disunion between rich and poor areas, of infra structural nets, fiscal and tariff sharing renounce, beyond performances of spatial auto segregation, via closed condominiums, fencing off, private security guard, etc.

To summarize, they are all mechanisms of weakening social cohesion and disintegration of collective sense institutions, all of them processes of which urban violence is only a spectacular symptom. However, there resides the ferment for the blossoming of an ideology of safety measures and punitive treatment of misery. As a result of the evidences of a crisis in sociability, a demand for order occupies the space of the censorial contestation of the State. Urban politics tend to be substituted by the city police. While transnational powers dominate world economy based in mega-cities, the role of social and police control over marginalized populations[35] is delivered to the State. To pacify the urban field, urban projects internalize the changeable security, seeking an ordainment of the ambience directed to the prevention of criminality in the so called "vulnerable, sensible or difficult" zones, "receiving a paraphernalia of vigilance technologies to be applied over the so called "populations of risk". To regulate urban tensions there is a tendency to "normalize those that transgress the norms of a social system that prevents them to lead a normal life"[36].

To pacify the market democracy, menaced by their own market deregulations, there is an insistent effort towards a reconstruction on local arrangement- in the communities – all that the global pact has been destroying at national level, that is, the "solidarity" and the "citizenship". The inequality of income, the unemployment and marginality are permanently feeding an urban instability that has only the security technologies as responses even if directed specifically to those that are not "capacitated for the consensus".

In this context, the efforts towards internalizing of segregation or of auto-segregation in the so called "fenced cities" – fenced residential real estate enterprises to which public access is restricted, frequently guarded by private security and internal TV system, usually characterized by legal

[34] S. Jaglin, La Gestion URbaine em Archipels em Afrique Australe, in Lês Annales de la Recherche Urbaine, n.80 -81, dec.1998, p.27-34

[35] J.Luzi, Dialectique de la Dependance, in Agone, n. 16, Paris, 1996.

[36] J.P.Garnier, Lê Nouvel Ordre Local- ouverner la violence, L'Harmattan, Paris, l999,p.18

agreements that link the residents to a common code of conduct- are experimented as elements of the new regulating institutions. A certain number of researches are developed to measure the functionality of auto-segregation. In this kind of research there is no question on what are the "fenced communities" as a social fact[37], but it is inquired if they could take part in the institutional body of the new mode of urban regulation, or else, if they resolve the "violence problem" without compromising the inequality dynamics of flexible accumulation.

The socio-spatial auto-segregation of the elites is thus presented as part of a spatial compatible contract with the low degree of social diversity desired for the housing areas, where the payment capacity is utilized to privatize services and limit the entrance of strangers and the passage of outside neighbors. The fenced community represents an artifact compatible with the new urban regulation, because it would provide conditions of closeness to the inequality of the "advanced marginality". The Shumpeterian State, reinforced through privatization of areas and public services, providing symbolic attributes of local promotion of image, favoring investment in conformity with great part or the researches results, would not contribute to social cohesion[38]. Thus, it would not resolve the main problem originated in the concreteness of social fracture.

A second kind of contradiction is found associated to the functional dualism of space- the process through which the social and environmental double pattern is institutionalized – business ambience versus degraded ambience. The social agents that find themselves "environmentally discriminated" denounce common sense, according to which the criteria of "not in my backyard" would come into force: according to them what really functions is the principle of " in the backyard of the most weak" of those spatially segregated. The changes introduced in the policies and strategies of locales, in a context of inter urban competition would multiply the conflicts of land use. As says Sabatini " the environmental conflicts in the cities which have multiplied in the last decades represent reactions in defense of the quality of life menaced by economic globalization[39]" and its implications in the imposition upon the weaker of "undesirable uses of land, congestion, contamination and insecurity"[40]. Such conflicts are primarily "resolved" by the allegation that the companies while threatening the conditions of housing, generate employment. The weaker communities (according to Gould[41], of "economic despair", incapable of attracting "clean" industries, would be satisfied with the lemma "to welcome filthy industry or no industry", or to accommodate the " environmental bomb –clock"[42]. So the location conflicts are thus redefined in terms of the differential of mobility among the agents.

Consequently, the resource to location blackmailing becomes an "argument" of force to impose certain manipulations over others: a) the helpless agents with no means to exert the power of

---

[37] Blandy,S. –Lister,D. –Atkinson, R. –Flint, J. Gated Communities: asystematic review of the research evidence, Center for Neighbourhood Research, paper 12 2003, University of Glasgow,60p.

[38] Blandy et alii,op.cit. It is verified that such expedient creates a protection barrier in relation to the other, who becomes a trap for himself;it is created, in the sense of Agamben,, a zone of indistinction, of which no one is free – prison for all. Dkiken, B. Lausten. C.B. Zones of indistinction –security, terror and bare life, dept. of Sociology, Lancaster University, jan. 2002

[39] F.Sabatini, Paricipacion ciudadanapara enfrentar conflictos amientales urbanos: una estrategia para los municipios , in Ambiente y Desarorollo, anl XV, n. 4, diciembre l999, p.27

[40] F. Sabatini, op. Cit. P.37.

[41] K.A.Gould, Classe Social, justiça ambiental e conflito politico,, H.Acelrad, S. Herculano, J.A.Padua (orgs), Justiça Ambiental e Cidadania. P. 69-80

[42] R.D.Bullard, ,Dumping in Dixie – Race, class and Environment Quality, Westview Press, Oxford, p.15-16

investment are expelled from territorial competition (ex. industries which succeed in approving their installation in areas of water springs due to "economic weakness" of environmentalists); b) the weaker laborers , belonging to most affected segments of unemployment are subjected to an argument leding to convince them that "all environmental regulation destroys employment": they are then pressed to accept any kind of employment even if precarious, unhealthy and environmentally risky; c) the less mobile residents, those that circulate only on risk segmented areas will have to be satisfied with the "use of socially undesirable lands" and victimized by a superposition of risks and needs. These processes of environmental imposition of risks on the weaker will not occur without resistance, due to struggles for democratization of space. They will also incorporate the demands for "location and environment justice". Such resistances to discriminatory decisions in the use of land are a relatively recent phenomenon associated to a re-significance of the environmental issue, now incorporating uncertainties on the impacts. In places of environment culture and lobby, such great efforts have implicated, in many countries and contexts, on street manifestations, *sit-ins*, mass manifests and boycotts. They have in common the denunciation of dual mechanisms, such as: 1) there would be a disconnection among the local decision makers, victims of undesirable aspects and the carriers of risk in these decisions (the political authority keeps pollution at a safe distance from the powerful); 2) while there are remaining areas of less resistance, every decision that may restrict the environmental damage of enterprises is followed by the transference of these damaging activities into urban poor areas. In Brazil, a certain number of episodes suggests that this kind of resistance to unequal imposition of environmental risks are multiplying – there already are cases of annulment of projects of localization of a thermo-electric plant in Itaguaí[43], Rio de Janeiro, the suspension of transference of chemical garbage deposits from Cubatao to Camaçari, by initiative of ACPO – Association to the Combat of Organic Persistent Pollutants, among others[44]. These are examples of social agents who "learned to say no"[45].

Such modalities of conflict –a more visible part of space contradictions in flexible accumulation_ tend to motivate the search for regulating institutions capable of stabilizing the ideal conditions of spatial implant of enterprises. The evidences point here to the perspective of privatization of location and environment conflicts, or to the establishment of a kind of "public-private-partnership" for the resolution of the conflicts through the participation of perpetrators themselves[46]. Campbell, for example, sustains that "the planner should contribute to the constitution of a new space pact that makes possible a "win-win" conflict solution with 'economy, ecology and justice', through a multi-language regulatory act[47]. The regulation would not result coherent, he proceeds, if there is a prevalence of one "language" over the other. The "sustainable city", would thus, in this perspective, be capable of negotiating hrough the p.p.p (public-private-partnership), having the planner as mediator of the "conflict or resources between economic growth and environment" as well as the "conflict of

[43] IaraFerraz, The en of the project of a thermoelectric plant using mineral coal of Itaguai, in II. Acselrad (org), Conflito Social e Meio Ambiente no Estado do Rio de Janeiro, Relume Dumara,Rio de Janeiro, 2004,p.239-250

[44] Julianna Mallerba, Environment, classe and labor in global capitalism: na analysis of new formsof resistance starting from the ACPO experience, in Encounter of the ANPPAS, mimeo, Indaiatuba,2004.

[45] Interview with the author, June 2003, Porto Seguro, Bahia.

[46] S.Cambell, Green Cities, Growing Cities, Just Cities? Urban Planning and the Contradictions of Sustainable Development, in Journal of the American Planning Association, Summeer, 1996. As indicated by O.Arantes, "the coalisions of'cituy-machines of growth, O.B.F.Arantes, A Fatal Strategy, in O.Arantes, C.Vainer. E. Maricato, The City of Uique Thought, ed. Vozes, Petropolis, 2000,p.27.

[47] S, Campbell, op.cit. p.5

development between environmental preservation and equity"[48]. The problem of the regulation would therefore be to make possible a compatibility of accumulation (labor and input) with legitimacy social adhesion t and political stabilization by neutralizing the conflicts), the planner assuming the role of promoter of "negotiable multilanguage process). To the State would remain the mediation of conflict which would not go through political sphere, being decided case by case, privatized. Sabatini suggests, according to a similar logic, that "the basic philosophy is that the best solution is to make possible the compatibility of interests, within the environmental and political limits fixed by law (environmental norms and citizen right)". Thus, he proceeds, " the planner could play an important role when a project of the municipality interest is rejected by powerful organizations of residents."[49] The planner could also "avoid the risk that an eventual accomplishment of an Environment Impact Study and the fulfillment of participation instances contemplated in legislation, should confirm the occurrence of an open environmental conflict"[50].

It would be the responsibility of the planner, therefore , in this sketch of regulating institution, to avoid the emergence of conflicts and improve their political stabilization . The fordist norm is now to provide flexibleness through the mechanisms of legalizing to which the planner – the State- is called to collaborate in. In this context, "more difficult to resolve" conflicts, according to Sabatini[51], will be exactly those related to the use of land, that is, locally undesirable land, because in those lands, the "local opposition tends to be total[52], excluding the necessary room of negotiation to overcome the conflict"[53].

The current urban crisis is, therefore, also a crisis in the constitution of a new mode of regulation for the cities – a mode that should be compatible with the dynamics of a flexible capitalism. This crisis has been provided by new space contradictions verified in the city, via infra-political processes (of the so called "urban violence"), or via political processes. The search for "sustainable" cities, inscribed in the "metabolism of fluxes and cycles of energy-matter, symbiotic and holistic", implies in the intention of promoting a gestation-connection to what really is a political fracture.

In each definition of "urban sustainability", we will certainly find the embryo of different future projects for the cities[54]. A pretension has been observed in the sense of the hegemonic agents to transform the discourse of sustainability into a means of establishing symbolic consensus trying to eliminate the ruptures of a social urban tissue increasingly crossed by the contradictions of globalization. From one angle the technical debate tries to frame the sustainability in the intentions of obtaining compact cities, economical in space, matter and energy; from another angle the consensus

---

[48] S.Campbell, p.506. Interrogated about the "hierarchic bilanguage" known by many societies, the historian Marc loch, cited by Depaule and Topalov, Affirms "… this opposition between two different languages, configures, in fact, only the limit case of common contrasts to all societies. Even in more unified nations, each small professional coactivity, each group characterized by culture or fortune possesses its particular system of expression. Effectively, complete Depaule and Topalov, in these cases" the languages should communicate and the solutions to this problem will be marked by an unequal negotiation among the talkers", df. Jean Charles Depaule et Chistian Topalov, La Ville à travers ses mots. MOST Clearing house Homepage, http://www.unesco.org/most/p2art.html.

[49] F.Sabatini, participacion ciudadana para enfrentar conflictos ambientales urbanos: una estrategia para losmunicipios, in Ambiente y Desarollo ano XV, n. 4, diciembre l999, p.32.

[50] F. Sabatini, op. Cit. P. 33.

[51] F.Sabatini,op.cot.p.34.

[52] F.Sabatini op;cit..34

[53] F. Sabatini. Op.cit.34-35

is fortified asa pre-condition for the construction of enduring cities, abdicating consequently from considering the cities as an excellent space for public debate and from the idea of constructing diverse and shared worlds. In this frame, the “urban sustainability” tends to reduce itself to a rational artifact to provide the cities of one more attribute to attract capital through the dynamics of inter urban competition, usually a predatory choice.

These investments in the construction of symbolic consensus - be it in a rhetoric plan of a “unique ambience”, or in the plan of the implementation of urban projects as carriers of the sense of “connection” of social fracture – integrate a more ample process in search of mechanisms and institutions through which one tries to constitute a new mode of urban regulation compatible with the requisites of flexible accumulation. The implantation of fenced communities and the diffusion of consensus technologies flexed towards the negotiated resolution of urban conflicts appear as strong elements of such a regulation which, in looking forward to the reproduction of cities through mechanisms of urban crisis, finds its main engine in the spatial contradictions of flexible accumulation.

URBAN FORM AND GLOBAL ENVIRONMENT

The urban expansion and the successive leveling that occurs reduces the river beds and with the erosion on the unprotected hillsides due to loss of vegetation, transform small fluxes into great torrents in the concentrated rainfall periods. Many of the river curves are eliminated by works of canalization which reduce the infiltration of water contributing to increase the speed of the flux[55]. The concentration of pollutant elements in the atmosphere together with the construction density of the cities lead to the formation of the so called islands of heat, responsible for the urban thermo discomfort[56]; the heat island associated to the impermeability of the surfaces due to asphalt and concrete concur to the phenomenon of floods; the thermo discomfort induced by heat islands stimulates the use of air conditioners, leading to a contrast between the internal microclimate of the buildings and the high external temperatures. The environment pollution and the thermo discomfort reach with more intensity the residential spaces of low income, where there simultaneously occurs a lack of trees as well as proximity to sources of pollution and the use of construction materials, all these causes emitting more heat[57].

Otherwise, the cities are recognized as great consumers of energy. In the countries of OCDE, the cities consume 60 to 80% of the energetic balance. According to current researches, the consumption of gasoline would be inversely proportional to urban density[58]. In Canada, USA and England, studies have shown that a duplication in the population and housing would be traduced by a reduction of 20

---

[54] H. Acselrad, Discurso da Sustetabilidade Urbana, in Acselrad H (org.). A Duração das Cidades-sustentabilidade e risco nas politicas urbanas. DP&A. Rio de Janeiro, 2001.

[55] A.M.P.Brandão, As alterações Climáticas na Área Metropolitana do Rio de Janeiro: uma provável influencia do crescimento urbano, in M.de A.Abreu (org), op.dit.,p.188.

[56] ”The bigger the city, more accentuated will be the effect thermo contrast between the city and rural áreas”,ccf. M. Lombardo, Ilha de Calor nas Metropolis- o exemplo de São Paulo, Hucitec, Sp,1985, p.39, apud C.Cabral, Clima e Morfologia Urbana em Belem, UFPA , Belem,1995,pg1.

[57] Marcelo Lopes de Souza, O Desafio metropolitano – Um estudo sobre a problematica sócio-espacial nas metrópoles brasileiras, ed. Bertrand Brasil, 1999, RJ, p.126

[58] UITP, Dês Villes a Vivre, Bruxelles, 1996, apud j. Bindé, Villes et Environnement au XXI Siecle, in vol I, lês Enjeux, GERMES, Paris, 1998.p.98

to 30% of the annual kilometers of dislocation of an automobile per person[59]. These data lead to a predominant tendency towards an effort to reduce consumption of energy by means of a more compact configuration of the cities. Furthermore, in spite of common sense suggesting that a better efficiency in traffic, via creation of express ways and the technical improvement of vehicles are efficacious means of reducing the level of urban pollution, researches made in New York and Perth, Australia, show that there is an inverse correlation between traffic combustible efficiency (that which flows at high speeds) and the cities efficient in combustible (which requires less dislocation)[60].

In spite of vehicles circulating in central denser areas spend more combustible per kilometer than the urban average, they, all the same, due to little circulation, would spend relatively less combustible. Inversely, vehicles that circulate in areas of low density, in spite of traveling less kilometers per liter of combustible than the urban average, they travel much more, finishing by utilizing more combustible.

According to other approaches, however, even implicating in a global decrease of consumption, the spatial concentration of residents and other activities bring a spatial concentration in the use of combustible and a consequent concentration of pollutants from mobile origin. In densely utilized spaces, there is a growth in the exposition of the population to the risks of atmospheric pollution. The consumption of energy linked to alternating migrations has little decrease with urban concentration, due to unchanging conditions in the structure of transportation. The most dominant source of combustible economy would be a change in the mode of transportation in dense areas, or else, the transference in favor of collective transport, which is less pollutant[61].

The emissions of CO2 in Brazil are basically due to deforestation, whose emitted volume is 7 times superior to emissions of energetic origin. The Brazilian energetic emissions of CO2 are highly inferior to those observed in other countries due the level of industrial production in the country and to the fact that the energetic matrix is concentrated on hydro electricity[62]. The role of urbanization in deforestation is considered of little importance. In a survey realized by researchers in the Department of Human Ecology at the University of Rutgers, among 825 articles discussing the causes of deforestation put the urbanization on l9th place among the 20 main causes[63]

The motorized vehicles are the main sources of atmospheric pollutants in Brazil. According to researches produced in the Metropolitan Region of São Paulo in 1990, they contributed with more than 90% of the cases of CO,HC,and NOx, 64%in SOx and 40% in the particles The quality of the air in urban centers is strongly associated to the system of collective transportation which generates great part of total emissions and stimulates individual transportation, favoring environmental losses and energetic inefficiency[64]. In large cities of industrialized countries, the positive correlation between

---

[59] J.Bindé, opo.cit.,p.98

[60] M>D.Lowe, Shaping Cities:The Environmental and Human Dimensions, Worldwatch Paper 105, Washington, October 1991,p.16

[61] P.Mathis. Consommation d'Energie etPollutions Liees a l'etalement des Densites, in J.P.Gaudemar (org) Environnement et Amenagement du Territoire, DATAR/La Documentation Française, 1996, Paris,p.106

[62] R.S. da Motta, Politica de Controle Ambiental e Competitividade, MCT/FINEP/PADCT. Estudo de Competitividade da Industria Brasileira, Campinas, 1993, p. 65

[63] T;K;Rude et Al, Tropical Deforestation Literature: Geographical and HistoricalPatterns, Forest Resources Assessment Program, Working Paper n.27 FAO apud D.S.Teixeira, Florestas Sociais- uma Resposta à Destruição das FlorestasTropicais?, Diss. Mestrado CPDA:UFRRJ,RJ,2001,p.39.

[64] R.S. da Motta, Indicadores Ambientais no Brasil – Aspectos Ecologicos, de Eficiencia e Distributivos, IPEA, Textos para a Discussão n. 403, RJ, l996,p.46.

population density and the proportion of traveling by public transport is strong[65]. Such correlation can only be observed, however, in cities where the collective system of transportation is the object of appropriate investments and policies.

The indicators of CO2 emission per inhabitant and per unit in energy consumption in Brazil are significantly low if compared with more developed countries, the first indicator expressing the low level of per capita income in the country and the second evidencing an efficiency in the use of renewable endogen resources[66]. Researches from COPPE/UFRJ show that between 1990 and 1998 the city of Rio de Janeiro, increased its methane gas emissions (CH4) in 57,7% probably due to improvement in garbage collecting and greater accumulation of residues in sanitary leveling. A small rise in the emission of CO2 was also verified due to an increase in the number of vehicles in circulation and the fall in the use of alcohol as combustible. In spite of tendencies towards a rise in emission of greenhouse gases occurred in Rio de Janeiro, the city of Berlin emitted in l990 almost four times more greenhouse gases than what was emitted in Rio in 1998[67].

If we observe the data on emission of greenhouse gases by sectors of final use of energy, the sector of transport responds for a considerable part (in estimates varying between 32,5% and 42%) of the total emissions of CO2 in Brazil[68]. However, in spite of an urban model that favors the use of automobiles, the relation inhabitant/vehicle is extremely high in Brazil if compared to those of other producer countries. Although the automobile industry having been implanted in Brazil for more than 40 years, and the country being the eleventh world producer of vehicles, its inhabitant/vehicle relation (10,3) in 1996 places it in the eighteenth position among the producing countries, behind Mexico, South Korea and Argentina.

The high investments accomplished in the automobile industry in Brazil in the last years, significantly augmented its established capacity, which is estimated approximately between 2,5 million unities/ year to 3,5 million of unities/years[69]. Data from the nineties show that the levels of increase in licensing new cars is very high in Brazil, if compared to other more developed countries[70], However, in 1998, only 1535 thousand unities were licensed , revealing that there is a very significant unoccupied capacity in the industry[71]. In spite of reduction, the Brazilian vehicle market varies strongly according

---

[65] E.A. Vasconcelos- I.M.O.Lima, Quantiricação das Deseconomias do Transporte Urbano: uma resenha da experiência internacional, IPEA, Texto para Discussão, nl. 586, RJ,l998, p.13.

[66] I.P.Rosa – M.R.T olmasquim, Na AAnalytical Model to Comapare Energy-efficincy Índices and CO2 Emissions in Developed and Developing Countries,L.P.Rosa et alii, Carbon Dioxide and Methane Emissions:a Developing Country Perspective, RJ. COPPE/ UFRJ, 1996, pp.30-32.

[67] D.Nogueira, Rio avalia os Gases do Efeito Estufa, in Jornal do Brasil, 13/08/2000, p.21.

[68] E.L.La Rovere, " A Sustentabilidade da Produção de Energia no Brasil, PNUD, mineo, oct. 1995,pg 17 e I.Klabin, O Mecanismo de Desenvolvimento Limpo e as Opportunidades Brasileiras, in Parcerias Estratégicas, outubro 2000,n. 9, Brasília, p 47. Ver também L.A>B. Uria, Emissão de Gases de Efeito Estufa no Setor de Transportes e seu Potencial de Aquecimento Indireto: o caos dos automóveis e veículos comerciais leves no Brasil, Diss. Mestrado COPPE/UFRJ, 1996, e A.G.Monteiro, Estratégia de Redução de emissões de Poluentesno Setor de transportes por Meio de Substituição Modal na Região Metropolitana de São Paulo,", Diss. Mestrado, COPOPE/UFRJ,1998

[69] Vigevani e Veiga, p.348; BNDES. AO2,GGSCA, Abril de 2000, Industria automobilística no Mercosul, p.5, apud F.Limoncic, Tempos de Reestruturação produtiva, Projeto Brasil Sustentável e Democrático, CadernosTematicos RJ,2001, pg.31.

[70] W. Meiners, Novo Ciclo de Investimentos da Industria Automobilística no Brasil e seus Desdobramentos Regionais, in Cadernos IPPUR/UFRJ, vol XIII, n. 1, jan. jul. 1999,p.199.

[71] Como afirmou Jack Smith ,chairman da General Motors: "\Temos muitas fabricas; precisamos agora vender carros"in Valor, 18/ 07/2000, apud F.Limoncic, op.dit. p.31.

to international crisis and economic conjunctures. In 1998, for example, due to the Russian crisis, 400 thousand less vehicles were produced than in the previous year.

Data from the industry show an elevated spatial concentration in the demand for cars, which points to the possibility of a permanent impact on Brazilian cities. The city of Sao Paulo, counts, nowadays, with the biggest national fleet, rising in an average of 6%/year. Every day, 1,5 thousand vehicles are incorporated. The average speed in the main traffic corridors has decreased systematically, having reached 20 km per hour in 1994. From another angle, environmentalist entities estimate that 300 children die per year due to pollution coming from exhaust pipes of cars[72]. These indicators express the environmental implications of the automobile option for Brazilian cities.

The massive entry of automobiles in the urban center of the cities was not accompanied by changes in the historic pattern of urban land occupation of the city. The urban investments, both in infra-structure as in renovation, in the period of expansion supply of cars in the country was concentrated in urban nucleuses. Thus, the urban conception that allowed in the USA the absorption of a rising number of cars in the cities, resulting in suburban areas with low population density and ample spaces for the circulation of vehicles, did not happen in Brazilian cities. On the contrary, the urban nucleuses had its population increased, mainly through an accelerated verticality. In some points of Rio de Janeiro ,as Copacabana, houses less than 30 years old were substituted by many storied buildings. With an area equivalent to 0,4% of the municipalities' territory, Copacabana shelters nowadays, 2,9% of its population[73].

In the beginning of the fifties , the construction of buildings for the middle class without garages was an indication that the automobile had not yet become an item in the consumption horizon of this class and that it would be incorporated in their style of life and as a project of social ascension after the installation of the industry in the country. The adjustment of the middle classes houses to the automobile became a reality at the end of the fifties, when a law enforced the new constructions to have a space reserved for car parking[74].

The sixties were characterized by an effort to adequate the urban space of the most important cities of Brazil to the requirements of the car, privileging therefore, the classes with greater acquisitive power. The emergency of this new family transport meant to these cities the destruction or degradation of public and residential areas, mainly the neighborhoods that were in the trajectory of the avenues that were being implanted. The road option also reflected the nearly exclusive transport by buses in the urban perimeter, with the suppression of street cars and the limited supply of subways[75].

In 1994, buses transported, in Rio de Janeiro, 1,3 billion passengers[76], which is nearly the number of passengers transported by subway in Paris.

---

[72] Greenpeace. Automóveis: saúde agredida e alterações no clima do planeta: 7.7.2000, apud F.Limoncic, op. Cit. P.35.

[73] Prefeitura da Cidade do Rio de Janeiro. IPLAN-RIO op.cit.apud F.Limoncic, op.cit

[74] M.Malin e I.Junqueira, Ivan.' Negrão de Lima'in Beloch, Israel e Abreu, Alzira Alves de. Dicionário, 1930-1984. Histórico Biográfico Brasileiro, Rio de Janeiro: Forense Universitária/FGV/CPDOC/Finep, 1984,p. 1851-1854, apud F.Limincic, op. Cit.

[75] F.Limoncic,op.cit.

[76] Prefeitura da Cidade do Rio de Janeiro, IPLAN-RIO. Anuário Estatístico da cidade do Rio de Janeiro 1993-1994, apud F. Limoncic, op.cit.

Brazilian metropolis did not follow the implant of a similar system to absorb automobiles as did the great American cities. Nonetheless, the ownership and use of this kind of transport played a similar role in the social distinction of the Brazilian middle class. In the seventies, a study from Fiat demonstrated that a Brazilian driver, traveled twice more than an Italian driver. The American pattern of consumption of cars was established in Brazil, without the corresponding change in the modes of land use that could contribute to avoid traffic jams and high levels of pollutant emissions. The type of use of urban land and the mobility pattern that characterized the Brazilian cities from the fifties onward was strongly associated to the more general pattern of spatial distribution of the activities conditioned by the specific dynamics assumed by the Brazilian modality of the so called "peripheral fordism".

FINAL CONSIDERATIONS

The researches related to climatic changes in the European Community only began to confront the relevant technological, social and economic aspects to support the formulation of policies, including the definition of the energetic efficiency focus, as a result of greenhouse effects in politics in 1986. To formulate the policies of prevention against climatic changes, this environmental effect had to be translated into terms of a politically "treatable" and "administrable" problem[77]. Thus, the procedures labeled by Hager as "closure of the problem" was configurated. According to the process, the discourses comprise the global environmental change as subject of politics, in a way that it might be presented as liable to a solution[78]. The transformation of climatic evidences in terms of a political plot thus passed through a selection of actions towards the search for energetic efficiency, which allowed the expectations for environmental benefits to be associated to a simultaneous achievement of economic benefits.

Buttel and Taylor maintain that after an initial period of "honeymoon", during the final eighties, the modeling of global climate, the estimates of biodiversity loss and other studies of the implications of environmental changes became the object of scientific disputes and, consequently, political disputes. According to them, however, there prevailed for some time, a "moral construction of the global environmental problems which emphasizes the common interest in the efforts for its confrontation, deviating the attention from political difficulties resulting from the diversity of social interests in the nations involved in this confrontation"[79]. But in 1988, the Swedish Perspective on Human Dimensions of Global Change report called attention to the processes of social construction of the scientific knowledge on global change, highlighting the role of history and culture in the definition of scientific and political themes. It is in this context of social construction of the problem that, in 1992, the report of the U.S. National Research Council on global environmental changes highlighted "the importance of Geography – for example, the distance among human settlements –and of Demography

[77] Liberatore, A., Facing Global Warming: the interaction between science and policy making in the European Community, in M.Redclift –T.Benton (eds.), SocialTheory and the Global Environment, Routledge, London, 1944, p.192

[78] M.Hajer, Politic sof Environmental Discourse:Ecological Modernization and the Policy Process, Oxford, 1995.

[79] F.Buttel-P.Taylor, How We Know We Have Global Environmental Problems? Science and the Globalization of Environmental Discours , in Geoforum v. 23, n.3,1992, p406.

– for example, the dispersion of populations in suburbs – in the determination of a pattern of energetic consumption”[80].

In analogy to what happened in the European experience, would it not be proper to ask on what would depend the construction of this “management capacity” of global environmental changes in Brazil? The presence of justifications related to climatic change in the Brazilian debate on urban policies seems relatively small. These policies do not seem to be integrating in a substantive way the political themes on which the issues on global climatic changes have been translated.

According to a research quoted by The Economist, the quality of the air starts to be a concern of public politics from the moment in which the GIP per inhabitant reaches 5000 dollars. We could infer by this that low indexes of development inhibit the struggle against pollution[81]. If we consider, hypothetically, that such correlation can be extended to less immediately visible problems such as global environmental changes, it would be expectant that the sociopolitical mobilization on such theme will increase in parallel way to the increase of per capita income. This association can be associated, as we have seen, to an eventual and particular involvement of urban elites which start to distinguish in the impacts of global change certain issues that could be of their interest, and which seem to affect substantially their projects, configuring sufficient reason to engage their capacity to make themselves heard by the public sphere. Nothing prevents, however, that representations of popular sectors, more than proportional victims of the risks associated to climatic events, to distinguish and put in evidence the global articulations of their local struggles – notably for secure housing, urban sanitation and appropriate collective transportation – developed by them in the urban ambience. The previous experience of Chico Mendes and of the global environmental articulations of the latex pickers of Amazonia seems to confirm it.

REFERENCES

Abreu, M. (org.), Natureza e Sociedade no Rio de Janeiro, Secretaria Municipal de Cultura, Turismo e Esporte, RJ, 1992

Acselrad. H. (org.), A Duração das Cidades – sustentabilidade e risco nas políticas urbanas, DP&A, Rio de Janeiro, 2001.

Arantes, O. B. F., “Uma Estratégia Fatal – a cultura nas novas gestões urbanas”, in O. Arantes, C. Vainer, E. Maricato, A Cidade do Pensamento Único – desmanchando consensos, ed. Vozes, Petrópolis, 2000.

Bindé, J. Villes et Environnement au XXI Siècle, in Environnement au XXI Siècle, vol I, les Enjeux, GERMES, Paris, 1998

[80] US: National Research Council, Committee on the Human Dimensions of fo Global Change, Global Envrironmental Change: Understanding the Human Dimension, Washington DC,National Academy, 1992.

[81] J;Bindé, Ville et Environnementau |XXI Siecle, vol 1 , Les Enjeux, GERMES, Paris, 1998, p.105

Blandy, S. – Lister, D. – Atkinson, R. – Flint, J. Gated Communities: a systematic review of the research evidence, Center for Neighbourhood Research, paper 12, 2003, University of Glasgow, 60p.

Blowers, A.”Environmental Policy: Ecological Modernization or the Risk Society”, in Urban Studies, vol. 34, n.5-6, p.845-871, 1997

Boltanski, L. - Chiapello, E., Le Nouvel Esprit du Capitalisme, Gallimard, Paris, 1999.

Brand, P. ,”The Environment and Postmodern Spatial Consciousness: A Sociology of Urban Environmental Agendas”, in Journal of Environmental Planning and Management, 42 (1), 1999, p. 631-648.

————— “La Construción Ambiental Del bienestar urbano. Caso de Medellín, Colombia”, in Economia, Sociedade y Territorio, vol. III, n. 9, 2001, p. 1-24.

Buttel, F. – Taylor, P. How We Know We Have Global Environmental Problems? Science and the Globalization of Environmental Discourse, in Geoforum v. 23, n.3, 1992,

Cabral, C. Clima e Morfologia Urbana em Belém, UFPA, Belém, 1995.

Campbell, S., “Green Cities, Growing Cities, Just Cities? Urban Planning and the Contradictions of Sustainable Development”, in Journal of the American Planning Association, Summer, 1996.

Castells, M., The Informational City. Information Technology, Economic Restructuring and the Urban-regional Process. Oxford:Blackwell, 1989.

Compans da Silva, R., A Emergência do Empreendedorismo Público Urbano na Cidade do Rio de Janeiro, Tese de Doutoramento, IPPUR/UFRJ, 2001.

Davis, M. Ecologia do medo, Record, Rio de Janeiro, 2001.

Depaule, J-C - Topalov, C. La ville à travers ses mots, MOST Clearing House Homepage, http://www.unesco.org/most/p2art.html acessado em jul.2004.

Diken, B. – Lausten, C.B. Zones of Indistinction – security, terror and bare life , Dept. of Sociology, Lancaster University, jan. 2002.

Emelianoff, C., “Les Villes Durables: l’émergence de nouvelles temporalités dans de vieux espaces urbains”, in Ecologie Politique, , n. 13, printemps 1995, p. 37-58.

Ewald, F. Foucault e a Norma, in F. Ewald, Foucault, a norma e o direito, Ed. Vega, Lisboa, 1993, p. 81.

Ferraz, I., O fim do projeto da usina termelétrica a carvão mineral de Itaguaí, in H. Acselrad (org.), Conflito Social e Meio Ambiente no Estado do Rio de Janeiro, Relume Dumará, Rio de Janeiro, 2004, p. 239-250.

Garnier, J.P. Le Nouvel Ordre Local - gouverner la violence, L´Harmattan, Paris, 1999, p.18.

Gould, K. A. “Classe Social, justiça ambiental e conflito político”, in H. Acselrad, S. Herculano, J. A. Pádua (orgs.), Justiça Ambiental e Cidadania, p. 69-80.

M. Hajer, Politics of Environmental Discourse: Ecological Modernization and the Policy Process, Oxford, 1995.

Harvey, D., “L’Accumulation Flexible par l’Urbanisation: Reflexions sur le “post-modernisme” dans la grande ville americaine”, in Futur Antérieur, 1995, p. 121-145

Healey, P., “Building sustainable futures in small and medium-sized cities in Europe”, in V.Mega-R.Petrella (eds.), Utopias and Realities of Urban Sustainable Development – new Alliances between economy, environment and democracy for small and medium-sized cities, Conference proceedings, Turin-Barolo, 1996, pp. 79-88.

Jaglin, S. “La Gestion Urbaine en Archipels en Afrique Australe”, in Les Annales de la Recherche Urbaine, n. 80-81, déc. 1998, p. 27-34.

Jessop, B., Recent Societal and Urban Change: principles of periodization and views on the current period, Paper do Department of Sociology, Lancaster University, 2003, 24p.

Kalecki, M., “Political Aspects of Full Employment”, in Political Quarterly, vol. 14, 1943, p. 322-331, traduzido em M.Kalecki, Crescimento e Ciclo nas Economias Capitalistas, Ed.Hucitec, SP, 1983.

Klabin, I. O Mecanismo de Desenvolvimento Limpo e as Oportunidades Brasileiras, in Parcerias Estratégicas, outubro 2000, n.9, Brasília.

La Rovere, E.L. “A Sustentabilidade da Produção de Energia no Brasil, PNUD, Rio de Janeiro, mimeo, out. 1995.

Liberatore, A., Facing Global Warming: the interaction between science and policy-making intje European Community, in M. Redclift – T, Benton (eds.), Social Theory and the Global Environment, Routledge, London, 1994.

Limoncic, F. A Insustentável civilização do automóvel – a indústria automotiva brasileira em tempos de reestruturação produtiva. Projeto Brasil Sustentável e Democrático, Cadernos Temáticos, Rio de Janeiro, 2001.

Lowe, M.D. Shaping Cities: the Environmental and Human Dimensions, Worldwatch Paper 105, Washington, october 1991

Lussault, M., “Des Récits et des Lieux: le registre identitaire dans l’action urbaine”, in Annales de Géographie, 1997, p. 522-530

Luzi, J., “Dialectique de la Dépendance”, in Agone n. 16, 1996.

Mallerba, J., Meio Ambiente, classe e trabalho no capitalismo global: uma análise das novas formas de resistência a partir da experiência da ACPO, in Encontro da ANPPAS, mimeo., Indaiatuba, 2004.

Mayer, M., “Post-fordist city politics”, A. Amin (ed.), Post-fordism – a reader, Blackwell, Oxford, 1995, pp. 316- 337.1994

Meiners, W. Novo Ciclo de Investimentos da Indústria Automobilística no Brasil e seus Desdobramentos regionais, in Cadernos IPPUR/UFRJ, vol. XIII, n.1, jan. jul. 1999.

Micoud, A. “L’Écologie Urbaine: nouvelles scènes d’énonciation”, in Ecologie et Politique, n.17, été 1996, pp. 31-43.

Monteiro, A. G. Estratégia de redução de emissões de poluentes no setor de transportes por meio de substituição modal na Região Metropolitana de São Paulo, Diss. Mestrado, COPPE/UFRJ, 1998.

Motta, R.S. Indicadores Ambientais no Brasil – Aspectos Ecológicos, de Eficiência e Distributivos, IPEA, Textos para a Discussão n. 403, RJ, 1996

Pesci, R. La construcción de la ciudad sustentable, proyectación y gestión, Urban 21, Conferencia Regional para America Latina y el Caribe, Rio de Janeiro, 24-26 abril 2000, mimeo, 19p.

—————— "Um novo humanismo e o planejamento ambiental", in R. Menegat – G. Almeida (orgs.), Desenvolvimento Sustentável e Gestão Ambiental nas Cidades, UFRGS Editora, Porto Alegre, 2004, p. 97-127.

Peixoto, P., "Gestão Estratégica das Imagens das Cidades – análise das mensagens promocionais e de estratégias de marketing urbano", in Revista Crítica de Ciências Sociais n. 56, fevereiro 2000, p. 99-122.

Rosa, L.P. et alii, Carbon Dioxide and Methane Emissions: a Developing Country Perspective, RJ, COPPE/UFRJ, 1996.

Sabatini, F. Participación ciudadana para enfrentar conflictos ambientales urbanos: una estrategia para los municipios, in Ambiente y Desarrollo, ano XV, n.4, diciembre 1999, p.26-35.

Silva, D.J. A transdisciplinariedade do exercício profissional na construção da sustentabilidade das cidades, in Exercício profissional e cidade sustentáveis, textos referenciais, CONFEA, São Luis, 30.11-4.12.2004, p.95-103.

Souza, M.L. O Desafio Metropolitano – um estudo sobre a problemática socio-espacial nas metrópoles brasileiras; ed. Bertrand Brasil, 1999, RJ

Teixeira, C.S. Florestas Sociais – uma Resposta à Destruição das Florestas Tropicais? , Diss. Mestrado CPDA/UFRRJ, RJ, 2001.

Uria, A. B. Emissão de Gases de Efeito Estufa no Setor de Transportes e seu Potencial de Aquecimento Indireto: o caso dos automóveis e veículos comerciais leves no Brasil, Diss. Mestrado COPPE/UFRJ, 1996

U. S. National Research Council, Committee on the Human Dimensions of Global Change, Global Environmental Change: Understanding the Human Dimension, Washington D.C., National Academy, 1992

Vasconcellos E. A. – Lima, I. M. O. Quantificação das Deseconomias do Transporte Urbano: uma resenha da experiência internacional, IPEA, Texto para a Discussão n. 586, RJ, 1998

Veltz, P., "Temps de l'Économie, Temps de la Ville: les dynamiques", in A.Obadia (org.), Entreprendre la Ville – Nouvelles Temporalités – Nouveaux Services, Ed. L'Aube, 1997, p. 389-399; tradução em português in H. Acselrad (org.), A Duração das Cidades, DP&A, Rio de Janeiro, 2001.

Wacquant, L., Os Condenados da cidade, Ed. Revan, Rio de Janeiro, 2001, p.188-194.

SOCIETY PERCEPTION AND GLOBAL CLIMATE CHANGE

MARIA DA GRAÇA BARROS SARTORI
Universidade Federal de Santa Maria

THE RELATION BETWEEN MAN, ENVIRONMENT AND PERCEPTION

For centuries, it was the originaly faith of perception that lead science and philosophy, as perception presents in all things a truth in itself, in which man can find the reason for the appearance of everything. For this reason, geographic analysis should always consider human experience, since knowledge is acquired through temporary, spatial and social human experiences. Thus, knowledge deriving from human experiences should not be forgotten because everyone is an individual before constituting a part of a certain social class, having a particular and real history to be observed (Nogueira, 1994: 63). Objective reality includes environmental perception as the result of lived experience, as the human body does not end at its physical limits, but extends itself to things and people which form its everyday surroundings.

When human experience and existence is observed, all studies about environmental perception must include reality and those who are living within it, analysing the sources of these phenomena with consideration the place where the data will be obtained as a starting point to create solid foundations of the investigation (Capel, 1973:80).

To refer to man and his interaction with the environment, Machado (1988: 2) assures us that "every man is unique, without precedents and unrepeatable meaning that each person perceives, feels and understands the same environment differently". To the above author, this human variability implies a variety of experiences that reinforces the "necessity for a thorough study of man and his environment and its most fundamental aspect: the interaction of both". In this relationship there is "a continuous exchange and mutual influence between external and internal world, […] always linked to the functioning of a human organism; they interact and evolve together.

The interactive process of man and the environment occurs through the senses, stimulating the sensations and, in this way, perception. Most people use the five senses to establish contact with the environment; these senses reinforce themselves mutually and constantly with the contribution of intelligence, defining and balancing the mental process as determined by a certain moment and place. The senses are like antennas that capture the outside world and receive not only external stimuli, but also more intimate ones from the individual. Without perception, man would be linked to the environment only physically and their experiences include the positive and pleasant as well as negative, repulsive and unpleasant ones.

This means that humans interpret, according to their individual optical perspective which depends on their personality, reflecting the nature, yearnings, experiences and desires of the perceiver.

Independent of the level of development of each society, interactions always have an intimate and permanent character, but it can be more or less intense depending on the cultural tradition, playing an important role in the behavior of people in relation to their environment. However, Lowenthal (1982) clarifies that "in every society, individuals with a similar cultural origin who speak the same language, can still interpret and understand the world differently ".

All information that is received from the environment can be inspired, determined and modified by feeling, and this, according to Machado (1988), explains the fact that personal concerns and interest are responsible for establishing differences between things, people, places or landscapes. The acts of to hear, feel, see and touch are stimuli of the senses, but perception is selective since it only really occur when we give meanings to the facts, objects or feelings.

In Tuan's opinion (1980), studies of topophilia, which include research on environmental perception, should consider three points: 1) "a person is a biological organism, social being and unique individual, so perception, attitude and values reflect these three levels"; 2) all human groups express and impose cultural standards that invigorate society, affecting in an intense way the perception, attitude and value of its components; 3) little is known about the "quality and variety of the experiences of human beings".

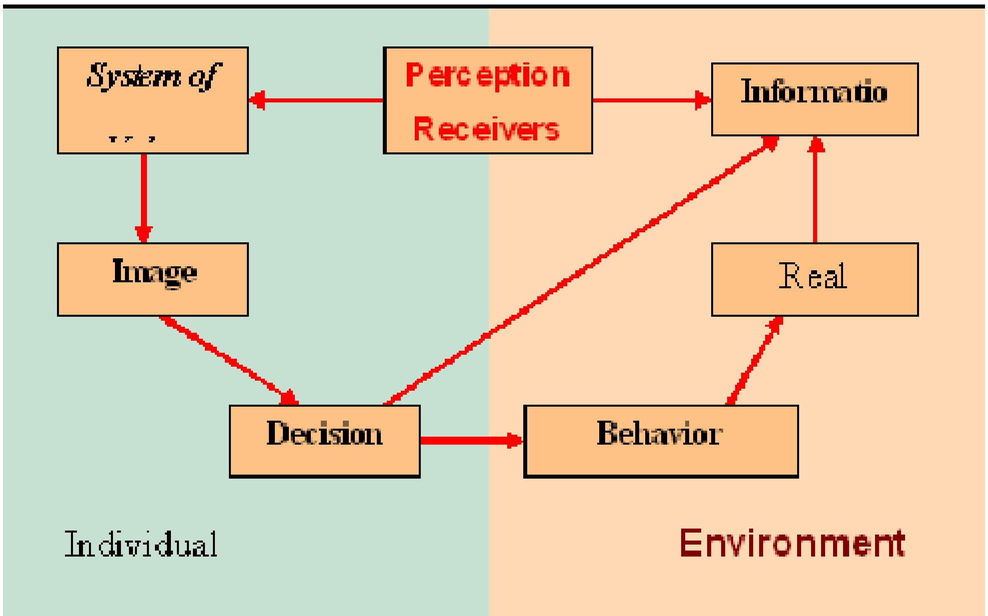
However, perception is a selective mental process in which man connects with the world, beginning with the sensations which are transmitted to the brain by the senses. Being selective, the mind is only conscious of part of these sensations, and among all, vision holds the most importance. Therefore, perception is like lens of a photographic machine that delimits, frames and prints part of the reality.

Today, our studies of perception must be considered as "ambient cognition", defined as a mental process to give meanings to the received information from reality and from the world, selecting and organising according to concerns and necessities. Personal objectives are determined by interests in the aesthetic, utilitarian, economic, ecological and affections which are, among others, very important in the characterisation of a perceived environment, as they can regulate different perceptions of atmosphere and resulting actions.

A conceptual diagram to the perception study was presented by Downs (1971: 84), which in a certain way summarises a highly complex situation of perception presented in Figure 1, where the boxes represent concepts and arrows indicate the linking and relations between these concepts.

For Tuan (1980), beyond the five senses (sight, sound, smell, taste and touch) human beings demonstrate other ways of responding to the world, as shown for example by the extreme sensitivity of some people to small changes in humidity and atmospheric pressure. All senses are used simultaneously in human perception of the world, thus the amount of available information is potentially vast from a given point of vision; in his daily life, man uses only a small part of this potential to experience, and which senses will be exercised more depends on each individual and his culture. Above all, among the five external senses, man uses vision more than the others, and so depends on this in his relationship with the world to interpret and organise his space.

In the first moment the human experience is developed from the senses and perception/cognition in a continuous act; interpretation by the brain of received stimuli. There are two phases of the impact produced by the stimulus in the human organism. In the first phase, the stimuli reach the organs of the senses and are resent to the centers of the brain through specific neural routes - this is the phase of sensation. In the second, the stimulus is interpreted on the basis of the experience and the appropriate reply is emitted - this is the phase of perception/cognition.



Fonte: DOWS (1971: 84).

Figure 1- Conceptual scheme for the study of perception of geographical space.

For normal adults, sensations never occur in a pure state, but they are always followed by perception that can be understood as the phenomenon of recognising what the stimulus is that produced a particular sensation within the individual; it is the interpretation of sensation as a signal of an external object. The perception hails the sensation, but it also includes knowledge of the noticed object (cognition), and the certainty of its existence. It is more than a complex sensation, as an identical sensory stimulation can produce distinctly varied perceptions, in the same way that different stimulations can produce the same perception.

During a lifetime or even a simple moment, an individual might acquire a finite and very small amount of information compared with what the environment can reveal. For this reason, the best vision of the world that the human mind is able to form consists at best in a partial world view and is always centered on man. This is what Lowenthal (1985:108-141) identified as the "anthropocentric character of the vision of the world".

The individual visions of the world are unique because each person lives in a different environment and each one chooses and reacts to their environment in different ways. It is the selective character of perception, that each person is unique, with sensory characteristics and abilities, intelligence, interests and temperamental qualities that altogether influence the entire activity of perception. Moreover, all information is inspired, edited and distorted by the feelings.

Even so, the idea that two people do not see the same thing in a natural situation surprises some people, because it shows that not all men have the same relation with the world around him. If these differences were not recognized, the process of the understanding of the perceived world of another individual might not happen or be possible. Certainly, the distance between perceptive worlds of two people of the same culture is lesser than that of two people of different cultures, but it still exists.

In regards variability of perception, Tuan (op.cit.: 52 -53) calls attention to "individual worlds" that are the result of "individual differences and preferences", since "human beings are extremely polymorphic" with a lot of physical variations existing between them, both external and internal, and organic contrasts can be so significant that they suggest difference in species. Therefore, human environmental attitudes reflect these physiological and biochemical variations, and it is necessary to know the human physiology, diversity of temperaments, age and sex of the individuals in order to understand these variations in attitude.

Hall (1989:71) argues that men and women live in completely different visual worlds and that these differences cannot be attributed to variations in the visual acuteness, for example, men and women "simply had learned to use the eyes in many diverse ways".

In relation to these differences, Tuan (op.cit.: 61-67) clarifies that physiological differences between men and women are not arbitrary, but clearly specified, affecting the way that they react to the world.

On the other hand, it must be considered that during life, differences of capacity occur within each age group, as rates of growth and ageing vary significantly of person for person.

Tuan (op.cit.: 68) explains that to understand the environmental preference of the individual it is necessary to examine biological heredity, education, profession and physical surroundings. The author says that "in the level of attitudes and preferences of the group, it is necessary to appreciate cultural history and the experience of the group in the context of their physical environment". There is significant evidence that people who grew up in different cultures live in distinctly varied perceptive worlds, and this can be identified, for instance, in the manner they relate to their environment and orientate themselves in space.

The personal vision of the world and therefore human perception deserves attention in the studies related to the environment, which are reinforced by the words of Merleau-Ponty (1996).

> "...tudo que sei do mundo, mesmo devido à ciência, o sei a partir de minha visão pessoal ou de uma experiência do mundo, sem o qual os símbolos da ciência nada significariam. Todo universo da ciência é construído sobre o mundo vivido e se quisermos pensar na ciência com rigor, apreciar exatamente seu sentido e seu alcance, convém despertarmos primeiramente para esta experiência do mundo da qual ela é a expressão segunda. A ciência não tem e não terá jamais o mesmo sentido de ser que o mundo percebido, pela simples razão de que é sua determinação e sua explicação".

CLIMATIC PERCEPTION

Throughout all history, man has used environmental perception, talent, effort and intelligence to obtain conditions more favourable for feeding and habitation, and to control adverse impacts of the environment. Humans have always been conscious of their dependence on nature, and consequently, of climate control in human life. Nature is an independent variable and lay down the ground rules for human space, a scene on which they arrived much later, becoming the dependent variable through the genetic adaptation during evolution, but mankind has always demonstrated an extraordinary capacity to adapt.

Climate, defined by the succession of types of weather, is the most important influence on the physical environment of human activities on land, sea and air. Urban man, like the country-dweller, is still subject to environmental influences in relation to his well-being and comfort, and in their power of decisions. Obviously, the urban man's actions are not completely determined by the environment, but urban man, more so than those of the country, has overwhelmed his natural environment making him increasingly detached from its more direct influences, mainly in the industrial and urbanised countries.

Thus, in the developed countries and also in most developing countries, man is adapted to average climate conditions and has dominated. However, he is still vulnerable to more unusual, extreme and sudden weather situations, these experiences often being highly catastrophic, such as the consequences caused by climatic paroxysms, phenomena which are widely documented in the media.

Human climate perception results from the environmental cognition that certain people develop, to a higher or lower degree, by the observations more or less accurate and true to the facts and phenomena which occur in the environment. As time goes by these observations become clues, or even evidence, of the behavior of the atmosphere, at least over shorter periods of time. Sensitivity to observation, which depends on many factors that change according to a person's original place, be it rural or urban, is fundamental to development of environmental and climatic perception and cognition.

Rural life demonstrates a deep attachment to the land and consequently to nature. Activities and life are directly linked to the cycles of nature, requiring attentive observation of the environmental more so than in any other situation (Tuan, 1980). As a result of this, popular proverbs for example, are often used by countrymen to project forthcoming atmospheric conditions, consisting of an empirical process of climate forecast encouraged by environmental perception.

The climate changes produced by urban infrastructures affect the well-being of the inhabitants of the cities. Moreover, the physical contact between man and the ambient is becoming more indirect and difficult what have been limited to special occasions of short duration. The bigger the city is, the greater the obstacles and difficulties to make this contact occur with the necessary frequency will be, so that individuals fail to notice climatic conditions, the very facts that form daily routine in the country, a tradition diminishing with each day.

Almost daily people express certain concerned conclusions about the atmospheric weather such as: "now it has not snowed so much as before; spring already does not exist; the weather is crazy; now it rains less; it used to be colder before or there is not winter anymore; today it is much hotter". Some statements or speculations can be considered correct, perhaps noticeably more so to people living in the cities, where many alterations in climatic attributes have already been proved. These alterations occurred during the last century due to the fast growth of the cities and the intensification of urban "heat islands". This change means many people are subjected to softer thermal conditions during the winter of the central latitudes, lighter and easier than for the people of smaller towns and the countryside who lived many years ago. Therefore, perception and reality differ from each other in many cases; when someone affirms that before it was colder, it perhaps means that it was more noticed before than now, perhaps because of thermal comfort and modern conditions of houses and clothes in general, which were inadequate in quality and amount years ago.

The climate perceived by people can differ from the real, resulting from objective analysis based on a systematic and homogeneous series of meteorological data, correctly registered. From the point of view of the climatologist, the human memory has relative value and is always selective. However, this is not truthful in the climatic reality in relation to human scale, because it comes from many fluctuations that, according to Vide (1990: 28) can represent a true climatic signal, which is always weak in this scale. Beyond this, the memory tends to make an irregular selection: it forgets or elaborates on certain past facts and it increases and details the most recent and relevant facts, according to the independent calendar of each individual.

There is not a safe and permanent factor of conversion that turn human memories into information of a climatologically based character, which should be homogeneous, continuous through time, registered systematically and, especially, objectively. This last point cannot be attributed to individual perception, neither the point of permanence or continuation in time, because the mental gaps are almost inevitably always bigger than those that exist in the meteorological archives. Besides this, it is relevant to consider that each individual has their own particular sensitivity in relation to experience before the atmospheric facts, doing a superficial observation of them and, in that way, making impracticable the numerical comparison between the remembered experiences by the various subjects.

To conclude, perception is a selective mental process through which man relates to the world, developing from the sensations transmitted to the brain from the senses. Since it is a selective process, the mind has awareness of only a part of reality, and among all the senses vision provides the greatest distinction. Therefore, the image is the most important aspect in media structure, its rules established and dictated by television, being nowadays, the main tool of leisure, enjoyment and information to a majority of the population, who embrace television as a principal source of culture.

STUDY OF CLIMATIC PERCEPTION

The region of Santa Maria, in the center of Rio Grande Do Sul, is where this specific study, which is about a climatic perception, takes place. Historical and environmental characteristics of this region make it possible for us to observe rural business of pastoral tradition in medium and big properties (on the top of Plateaus of Parana basin and in the Peripheral Depression Sul-Rio-Grandense), and colonial tradition in small properties (in the edge of the linked valleys of Plateaus). In addition, Santa Maria has more than 280,000 habitants.

This perception study tries to measure the variables that are initially present on the mind of one individual. This measure models usually do not relate to the measurable physical amounts, which demand measurement instruments.

In this research, some variables were considered to define rural and urban sample population, as:

- Personal experiences in the climatic conditions observations;
- Personal experiences in the nature observations, developing more sensitivity to the environmental and climatic perception, especially by the countryman;
- Place where the subject lived, if in rural or urban area;
- Time of residence in rural or urban area;
- Birthplace, Santa Maria or another region;
- Age group;
- Heterogeneity respecting the social situation, especially of people interviewed on the streets.

The fieldwork was realized in two moments: in the rural area of pastoral and colonial tradition and also in the urban area. To collect the data a printed questionnaire was used, set up in different parts with open and multiple choice questions.

The evaluative results between rural and urban area, on basis of similar questionnaires, permit a crossing comparative between the climatic and weather perception.

CLIMATIC PERCEPTION IN THE RURAL AREA

The objective of this search is to detect the weather and climate perception of the people who work with cattle breeding and agriculture. The questionnaire presented twenty one (21) questions; of which seven (7) are personal information and eleven (11) are about the weather and climate perception.

The interviews were realized with adults, from March to November, 1998, in rural properties of Santa Maria. The questionnaire was applied in a face to face way with owners and the rural workers, with experience and a relatively long time of residence (at least 30 years). A total of seventy seven (77) respondents completed the questionnaire.

The correct sequence of the answers allowed inferring that the countryman get to notice, with certain easiness, the habitual succession of the types of weather in the region where he lives, such as pre- frontal situation due to the North Wind, the frontal phase and the polar dominion. This is possible due to the familiarity with the nature and the necessity to understand these weather clues.

In relation to the nowadays climate perception, the results can be divided into four groups: 84.41% of the responders believed that nowadays the weather varies more than in the past, while the others 15, 58 % believe that does not happen.

For the question "Are winters nowadays more or less cold than a few years ago?", the answers also can be divided into four groups: 68,83 % of the responders believed that winters are less cold, while 18,18 % believed that this season has not changed, 9.09% affirm that the weather is more inconstant than in the last years, and only 3.89% believe that winters are colder.

The dialogue established during the interviews demonstrated that nowadays the countryman's quality of life is better than in the past, with more comfort and including more adequate clothes and shoes to the low temperatures, although it still is a simple way life. These aspects certainly intervene in the way of perception. To Vide (1990: 28), when he discusses about noticed and real climate, there is difference between climatic perception and climatic reality. When someone says that earlier it was colder, they mean that before it was more evident than now, due to the improvement on the quality of life of the population. It is common that the oldest people affirm that the climate is now milder than years ago. However, a lifetime is a very short period of time; this way is unlivable for someone to affirm that the weather is not the same anymore. It is necessary to have previous registers correctly collected to prove it.

As the human memory has a relative value, the perceptions must be measured, considering that the memory is irregular selective process. It is common for humans to forget or add some information about a past fact and detail or about a recent bigger fact, the most recent in their memory. According to Vide (op.cit.), "the mental gaps are almost always recurrent than the meteorological registers". Moreover, the author states that each individual has sensitivity and proper calendar in face to climatic facts. It makes each individual to observe a certain phenomena and register one of them in a more consistent way than the others.

CLIMATIC PERCEPTION IN THE URBAN AREA

In demographic terms, the urban place is bigger than in the rural area in Santa Maria. The questionnaire applied was set up in two parts with eighteen (18) questions each one. The first eight (8) questions refer to personal information and the others concern the register of the weather and climate perception, through open and multiple choice questions. The fieldwork occurred from March to November, 1998 and from March to September, 1999. A total of a hundred fifty four (154) respondents, women and men, completed the questionnaire. They were chosen randomly and according to their availability. Also, the responders were all adults with different professions. The search aims to check if the distinct experiences would determine different answers.

In the urban area of Santa Maria, 81,17 % of the people (125) recognize the North Wind pre-frontal, because it is “hot and strong”, while 18,83 % (29) do not identify it, although they are able to feel its effect. This result differs from the rural area, where all the respondents declared able to identify with easiness the North Wind, which means that a countryman has a climatic perception more developed than the urban. It was also proved with the reduction of the respondents’ percentage (88%) that affirms that “after the Wind North” there is rain.

The weather characteristics cited by rural and urban population do not differ only the highest percentages, they denote a climatic perception more developed in rural population.

In fact, urban population, although not living in direct and permanent contact with the natural environment, had a significant development on the perception of the habitual sequence of the weather types in Rio Grande Do Sul, and especially in the region where the study was realized. In part, this can be explained by the following reason: besides its climate, cities still keep relation to the Regional Atmospheric Circulation that preponderate and determines the succession of the atmospheric states.

URBAN CLIMATE PERCEPTION

Inadvertently, the human activity has modified the climates in urban areas, which implies potential changes of the environmental conditions and, consequently, its well-being aspect. Urban climates studies developed in Brazil and in the world show that the cities modify the Earth surface components, which absorbed and glowed energy. It creates new physical structure and provokes alterations of the local climate, accented according to the urban size.

Monteiro (1976: 126-133) argues that urban climates must involve, necessarily, the human perception. The author proposes that urban climate is an open system, with perceptive channels, which are “defined according to sensorial and behavior of the urban man”. Thus, the Urban System Climate (USC) is divided in three subsystems with the respective perceptive channels: Thermodynamic (thermal comfort), Physicist-chemistry (quality of air) and Hydro-meteoric (meteoric impact).

These phenomena act individually, and joined aim to produce a large variety of urban climates. Some determinants are capable to influence the sensations of well-being, discomfort of the population and in climatic perception.

“Urban canyon” interferes in the energy balance of temperature, wind and humidity, because of two environments that must be considered: the surfaces constructed and the air volume. These environments are different from each other according to the capacity of reflection, absorption, emission and storage of energy and water and also to aerodynamic function. These characteristics produced a lot of specific microclimates inside the city, along with the "urban canyons". There are relations between the height, density and spacing of the buildings, also the direction and speed of the wind.

When the wind, with relative intensity, penetrates in all the urban space redoubts, it modifies significantly the microclimatic effects that are generated by the energy balanced temperature. The urban behaviors in face to the regional and/ or local winds are complex and depend on geourban elements as plan, extension and broadness. Besides it is necessary consider density, vertical growth and also geological elements, especially the urban morphologic.

Noteworthy aspect is the "sky view factor" of Oke (1981) or the "sky configuration "of Sakamoto (1994) influence in the presence of solar energy inside the city (light and shade). Solar energy influences in the temperature, humidity and ventilation, and it is also important in the characterization of the urban climate, which depends on the amounts and fit of urban canyons.

Narrow streets, without vegetation, delimited by high buildings are hotter in the summer and beginning of autumn in temperate and subtropical regions. This happens due to the small angle of the sky, represented by the biggest ratio of built area. This season are uncomfortable to the population due to the heat, problems of ventilation and the streets, which are channels of circulation for the winds, speeding up the wind in the central part (lateral limits) and reaching more speed on the corners than the center, through the turbulence and whirlwinds, surprising many pedestrians. The broad, wooded and streets with low buildings present the highest temperatures in the winter and spring. It also presents great daily thermal amplitude, and, as a consequence, a larger angle of the visible sky and the lesser ratio of built area, what allows a greater insulation during the day and greater irradiation at night. In both cases, the orientation of the streets in relation to the apparent movement of the Sun is fundamental in the game of shade and light of urban environments, as well as the participation of the air masses.

For the perception human studies, the question of the "configuration of the sky or visible sky angle" is also important in the development of the climatic perception for the native urban man. Besides affecting the well-being due to different temperature fields, it is responsible for the visual blockage of the local horizon. The vision of the sky is restricted, limiting us to see only the top vision of the horizon. The consequence of this limited vision is that it does not allow the urban population to observe clearly the evolution of the weather. In spite of the countryman, whose activity depends on this perception, which is facilitated due to the absence of obstacles to its vision of the sky, in all directions that are possible.

A common climatic characteristic in the cities is the urban heat island, which provokes involuntary and substantial alterations in other atmospheric elements. It is important in the human climatic perception, such as: increase of the precipitation, more frequency of rains, storms and hails; reduction of the average relative humidity; increase of the cloudiness; reduction of the solar radiation; reduction in the wind speed ; reduction of snow storms free periods of longer frosts, especially in subtropical and tempered regions.

The population was defined according to four criteria:

1) homogeneity culture degree, to facilitate comprehension and communication of ideas; 2) residential time in the city, at least 30 years, so that the inhabitant could evaluate the noticed alterations in the urban climate; 3) superior age to 45 years, since children have little consciousness of the climatic facts; 4) availability and interest of the people in collaborating, not to harm the information.

To refer to perceptive content, the declarations evidenced that six subjects noticed the increase of the temperature in the last decades, through urban heat island in Santa Maria, than other similar site. While some subjects just pointed out that "the city is hotter" or "the heating has increased along the time". Other respondents complemented with associations between the increase of the temperature to the growth of population and constructions in the city. Besides this, some subjects compared the weather conditions in the rural area, in the winter and in the summer.

Three declarations presented the following statements: "winters are less cold or cold waves are shorter nowadays", what it is explained due to the urban heat island, mainly in the winter. Two subjects made reference to the "seasons are not so well definite anymore" and this perception also is associated with the fast heating of the city during the day, when compared with the rural area.

The Hydro-meteoric perceptive channel (Meteoric Impact) was presented in three declarations, when the respondents mentioned that "rains and hail are more frequent" in the city, with formation of "located clouds and torrents".

In another declaration, the subject demonstrates the perception in relation to the draining water of rain. He affirms that, "rivulets" have less volume of water than in the past and that "much water runs on the streets (tarred) and sidewalk when strong raining". These noticed facts are according to the effect of the waterproofing on the urban ground, what produces fast draining (great volume in superficial draining and reduced or absent infiltration). It does not supply groundwater, reducing the level of the water ways after rains and increasing of strong rains volume.

Street configuration and urban canyons in the centre area of the town were cited by the tenth subject who mentioned that the "North Wind was worse in the junctions of the streets corners where the winds spin". This is a correct perception and has relation with the effect of the wind canalization along the streets, where it increases its speed and creates whirlwinds on the corners. Specifically, Santa Maria and its more usual winds or bigger speed (E-SE and N-NW), the main streets of the center and its surroundings have general orientation ENE-WSW and SSE-NNW. It facilitates the canalization and the consequent turbulences and whirlwinds on the corners. This declaration also refers to "pollution" (physical-chemistral channel) as a conditional component in the atmosphere that increases the temperature and the formation of the heat island. These references show the high sensibility of the subject to observe his surrounding.

Independently of Aside from the climate perceptions disturbances, the subject that lives in a same city, with a great vertical and horizontal growth of the constructed area during a long period (more than 20 years), can develop a urban climate perception due to a particular sensitivity, capacity of comment, experience and attention to his space. This is variable from person to person because of the individuality of the human percipient worlds.

THE MEDIA AND THE PERCEPTION OF THE SOCIETY

The media has developed important and complex influence on the subject and/or collective climatic perception, especially, in last 25 years. Currently, when media exposes about increase of climate global changes to higher temperatures, the ordinary public assume it as truth and immediately "noticed" this supposed change. In fact, some lived experiences can have a similar character of the climatic change announced, strengthening that impression. However, on climatic perception studies it is necessary consider the "contamination" that can the suffer the subject by external information, which sometimes do not have a scientific fundamental.

The high level of living quality is result of both the best information net and more information freedom available.

Ramonet (1999), researcher of communication and manager of the French newspaper Le Monde, presents in his book “Tyranny of the Communication” an analysis of the media interference on the perception process. In this book, the cited author discusses about two parameters that determined the media activities in nowadays: mediatic mimetism and hyper emotion. Both factors are widely considered in the approach of the environmental news, especially of late. A small atmospheric event in a local scale climate view can represent a good visual material to be used by media, especially on weather broadcast on television programs.

According to Ramonet (1999), mimetism is defined as a “fever that suddenly domains the media [...] Impelling it in the most absolute urgency, to cover an event hastily [...] using as excuse that the other medias attribute a great importance to itself”. Uncontrollable imitation stimulates the media to do a report about an event with more journalists and during more time. Besides this, hyper emotion has always been explored by media; emphasize sensational and spectacular aspects of an event, which produce an emotional shock, although formerly he media was worried in maintaining a strict and serious character. This way, television is the most important vehicle of the media, mainly news programs which presents “allure for the spectacle of the event”, changing the media priorities from information to emotion. In addition, the Internet phenomenon has aggravated this change.

The author still explains that the veracity of the facts to the actual media are not so relevant as the possibility to divide this information in a lot of emotional segments. Furthermore, this parameters change was relevant from ethic and spatial/ social approaches, since climate phenomena are being analyzed in a planetary character.

In the globalize world, the television assumes the power to determine the news and its relevance. It obliged the printing press to follow the rules of the television, specially the classification, structure and hierarchic of the information. This power was imposed by technological advances reached via satellites, which allowed the transmission of live information and images from any part of the world at a speed of light.

Fascination of the television is improved by the importance of vision to the humans’ perception. It makes the image the most important element of the media, especially that ones that provokes some emotions caused by a destruction, suffering, affliction, indignation, revolt or death scene. All in all, the images are “addressed to heart and to emotions, instead of to intelligence and to reason” (Ramonet, 1999: 27). Consequently, media approach in relation to some events caused by climatic phenomena does not matter the local scale where they have occurred.

To guarantee the fascination of the news, the media needs to get live images, throughout the connections and correspondents in the place of the event where the event occurred. If these images actually do not exist, it is common to use images that are not related with the event in some old archived files of amateur cinematographer, or to produce images artificially, most of time, “truer than the true ones” (Ramonet, 1999: 29,31, 32, 91).

The attraction for live and strong images decreases the quality analyses about the phenomena, which prejudice the veracity of the fact. The reporters do not have much time to investigate, reflect and contextualize the news since the media, mainly the television, needs lots of news everyday.

The cultural, historic, socioeconomic and political are usually unknown by the correspondents. In the case of the natural accidents that cause some destruction or deaths is common to interview local inhabitants so that give information about the phenomenon, how it happen and if had already occurred a similar one. This media strategy aim to pay more attention of the audience than the concurrence. Many examples could be cited.

The Brazilian geographer Santos (1996: 22) regarding to the “terrorism of the media” referring to Kayser (1992), explains that certain mediatic ideas must be debated and exemplify with the Earth heating and the greenhouse effect. According to him “the continuous growth of the Co2 in the atmosphere did not only happen along to the century 20. The average to 1951 - 1980, in relation to the period of 1921 - 1950 shows a low of temperature (not significant) of -0,3°. In any way, the process of evolution is very slow. It is necessary a set of ten years so that a climatic change can be register “. The media pay attention of the audience and “sell” images through by sensational and fear feelings, prejudicing the individual and collective perception. It is possible because the television can do that millions of people attend live (or almost) climatologic events, real or reproduced by computer programs (simulation), presenting “a part of the Nature as if it was all”.

According to Santos (op.cit), “it is necessary to fight against pollution, degradation of the environment; in fact it must be making with opened eyes. However, based on scientific analyses and not limiting to alert: it is catching fire “. This researcher also alerts to the fact that fears and fantasy have important function for society. Fear always has been present during the humanity history. But, today, it is generalized and permanent by many reasons. Fantasy always provides the mind human; however when it is industrialized takes possession of all the places and moments of people live. It is “our model of life”, “servicing of the busyness and the power”.

Many headlines of television programs, newspapers and magazines discuss about ambient issues with exaggerate and sensationalism way, provoking panic and apprehension in the population. They used to associate climatic accidents with the probable global heating, intervening directly with the perception of the society.

For example, in a newspaper of national circulation (set. 2005) the headline was “As man increased the fury of hurricanes”. However, the arguments presented by the researches interviewed did not confirm what was announced in the title. The same situation has occurred in the South of Brazil with frontal or extra-tropical cyclones that are common in the Atlantic Ocean, but always are presented as an extraordinary event. Besides, is being associated with the global heating, mainly after the occurrence of the Catherine in March of 2004. It also happened in 90`s with the ozone layer, which, today, is practically forgotten for the media.

MANY DOUBTS BUT SOME CERTAINTY

Many climatic accidents result of the permanent variability of the climate, due to the atmospheric dynamics.

Global climatic changes are part of the Earth history, in geologic or historical weather scale. Many alterations in the atmosphere behavior do not represent climate change itself in relation to absolute values of its statistics from a year to another one. Considering the dynamicity of the atmosphere, the meteorological elements present different reaction between the seasons from a year to another one or from a decade to another one. In the geographic vision of the climate what is relevant is the rhythm of evolution of the weather states, including habitual alterations and extreme situation.

Climate can be understood as a complex process that presents alterations in a long or short period of time. Considering it, there are specific definitions for each climate variation, time spend and causes that are not discussed in this paper.

However, it is necessary consider the factors that can cause climatic changes and variations from the sea-level are multiple and complex. They have occurring gradually and naturally along the years and certainly, they will continue to happen.

The study of the atmosphere must analyze initially basic phenomena such as the processes of exchanges of energy between the Earth and the Sun, the process of solar energy transmission, the characteristics of the planet (shape and ground surface characteristics) and the movements and inclinations of the Earth's rotational axis (latitude effect). As Monteiro (2002) expose, only the linear causality of cause and effect can not be applied to explain the complex climatic phenomena.

In addition, solar radiation represents the primary energy source of any climatic system. The fluctuations of the solar activity affect directly the Earth surface, continental or oceanic, intervening in the climatic characteristics. Besides this, the atmosphere, especially the layer between the Earth surface and the space, has a decisive function in the balanced thermal and in the Earth climates. The solar activity is still a mysterious process as well as the probable reflects of solar radiation in the Earth climate.

In the local scale, there is the well-known "El Niño" which always is highlighted in almost all headlines of newspapers. The media always consider "El Niño" as the responsible to atmospheric disturbances or "occasional global climatic accidents "that usually followed it. Monteiro (2002:15) alerts to "El Niño" "instead of to be a direct cause" of all global climatic disturbs" is one of them, perhaps the heaviest one, in conjunction with any other manifestations" distributed by the Earth surface.

To this mentioned geographer probably the source of this thermal irregular phenomenon of the Equatorial Pacific is in the Sun. This way, grandiosity could be explained by two basic linked reasons: the equatorial position and the homogeneity of the immense liquid surface of the Pacific Ocean. The opposite phenomenon, "La Niña", may have the same causes, however with less significant effect.

In the local scale the approach of climatic problems must consider the "conjunctive causes". This requirement increases when the analysis spatial levels diversify and reduced themselves in extension, becoming more recurrent the quantity and variety of climatic factors that influence in the atmosphere condition.

Many are the quarrels and the doubts about global climatic changes. It is important to have doubts to search the truth and, thus, learning and knowledge. Doubts permit the growth in scientific discussions and it contributes to the well-being of the humanity.

CONCLUSIONS

This study realized in Santa Maria (RS) allowed inferring that more than 90% of the population got to notice, with certain easiness, the habitual succession of the types of weather according to the correct sequence answered by the respondents. It means, the pre-frontal situation caused by the North Wind, the frontal phase and the polar domain.

However, the actual knowledge about a climatic perception is paradoxical, because although most

of the population is able to identify the weather rhythm of evolution in Rio Grande Do Sul, they believe that these changes are a cumulative effect. This idea is due to the information divulged by the media that presents climatic accidents of many places, almost always emphasizing sporadic events (local or regional scales) that, in the most cases, already happened, but that they were not shown or divulged until time ago as gales, hails, heat waves, drought, and floods, among others. According to media, most of them can be associates to the global warming, what it is not truth.

Thus, according to geographical climatology there is not a real global climatic change, but a variability of some climatic elements according to evolution, which is the essence of the climatic phenomenon. It means that the atmospheric dynamic defines recurrent sequences of types of weather that are developing along the time on determined place. In certain domains the weather can happen as a more aggressive meteorological phenomenon, resultant of the conjunction between regional atmospheric cells and a lot of local and/or regional factors.

The behavior relative transitivity of the atmosphere is exposed in the words of Clyde Orr, Jr. (1966: 131):

> “O tempo é um drama em eterna representação, do qual somos o auditório fascinado. Com a atmosfera inferior como palco, o ar e a água como personagens principais, e as nuvens como indumentária, os atos do tempo são apresentados continuamente em algum lugar em redor do globo. O texto é escrito pelo Sol; a produção é dirigida pela rotação da Terra; e, como nenhuma cena de teatro é representada duas vezes da mesma maneira, cada episódio do tempo é interpretado com ligeira diferença, cada um assinalado por um traço de personalidade”.

This intrinsic dynamic of the atmosphere is not considered by the most of the global climatic changes researchers, that define the climate as the medium state of the atmosphere represented only for some of its elements, as temperature, for example. The succession of states or types of weather on a specific place, not depend of the scale considered, but they can change, provoking “accidents” that cannot be seen as exceptional. In fact, it is impossible admit a regular and mathematical behavior of the atmosphere meteorological elements during a year. This requirement is against to the essence of the climate and the types of weather.

As Ruskin exposed, apud Clyde Orr, Jr. (1966), the sky is “sometimes calm, sometimes capricious, and sometimes also terrible, but never the same at the same time; almost a human in its passions, almost spiritual in its tenderness, almost divine in its infinite “.

REFERENCES

CAPEL, H. Perception del medio y comportamiento geográfico. Barcelona, **Revista de Geografia**, Vol. VII, n.1 y 2, p.58-150, 1973.

DOWNS, R. Geographic space and perception: past approaches and future prospects. Cambridge, **Progress in Geograhy,** Vol. 2, p.67-103, 1971.

HALL, E.T. **A Dimensão Oculta**. 3ª edição. Trad. Sônia Coutinho. Rio de Janeiro: Ed. Francisco Alves, 1989. 200p.

LOWENTHAL, D. Geografia, Experiência e Imaginação: em direção a uma epistemologia.geográfica. In: CHRISTOFOLETTI, A. (Org.), **Perspectivas da Geografia**. São Paulo: Difel, 1982. p.193-141.

MONTEIRO, C.A.F. **Teoria e Clima Urbano**. São Paulo: Instituto de Geografia/USP, 1976. 181p.

MONTEIRO, C.A.F. O estudo geográfico do clima., **Cadernos Geográficos**, Ano I, n.1, Florianópolis; UFSC/Imprensa Universitária, 2002. 72p.

NOGUEIRA, A.R.B. **Mapa Mental: recurso didático no ensino de Geografia no 1°Grau**. Dissertação de Mestrado, Departamento de Geografia/FFLCH/USP, São Paulo, 1994:

OKE, T.R. Canyon geometry and the nocturnal urbans heat island: comparison of scale model and field observations. **Journal of Climatology.** 1981.

ORR J.R., Clyde. **Entre a Terra e o Espaço**. Trad. Antônio Lopes Pereira. Rio de Janeiro: Ao Livro Técnico, 1966. 247 p.

SAKAMOTO, L.L.S. **Relações entre temperatura do ar e a "configuração do céu" na área central da metrópole paulistana: análise de dois episódios diários.** Dissertação de Mestrado, Departamento de Geografia/FFLCH/USP. São Paulo, 1994. 200p.

SANTOS, M. **Técnica, Espaço, Tempo: Globalização e Meio Técnico-Científico-Internacional.** 2° ed. São Paulo:Hucitec, 1993. p.22-25.

SARTORI, M.G.B. **Clima e Percepção**. Tese de Doutorado, Departamento de Geografia/ FFLCH/USP. São Paulo, 2000. 488p.

TUAN, Yi-Fu. **Topofilia:um estudo da percepção de atitudes e valores do meio ambiente**. São Paulo:Difel, 1980. 288p.

VIDE, I.M. La perceptión del clima em lãs ciudades. Barcelona. **In: Revista de Geografia**. V.XXIV, 1990. p.27-33.

SOCIAL GOALS AND THE CLEAN DEVELOPMENT MECHANISM

CARLOS EDUARDO FRICKMANN YOUNG
Instituto de Economia
Univesidade Federal do Rio de Janeiro

INTRODUCTION

The ratification of the Kioto Protocol opened real perspectives for foreign resources that achieve sustainable development to be channeled to projects in Brazil, mainly those that contribute for the reduction of greenhouse effects through the Clean Development Mechanism (CDM). It is important to recover the initial idea of this story. Through the CDM, projects with certified reduction of greenhouse effect of gases emissions (GEE) will generate carbon credits that can be negotiated with the developed countries. However, according to Article 12 of the Kioto Protocol, these projects have to achieve sustainability, which means attending to economical, environmental and social criteria. Certainly the social criteria have been little explored. Is it really possible to combine economically viable projects with environmentally sustainable and socially fair ones?

There is no general theory of sustainable development, but only partial ideas which are concentrated in specific aspects. In the case of economic theory, two schools of thought emphasize different problems of the production – allocation circuit, with asymmetric results for sustainable development problems.

In the neoclassic theory, the concern is in the search for the better possible allocation of scarce results, which in an implicit or explicit way are considered as data. The emphasis is in the best use of means considered as scarce, and due to this fact it is assumed that the production factors are always fully occupied. For this reason, the neoclassic theory deals well with the issue of natural means since these are, by definition, finite – although its value is not, since the value is socially defined as derived from utilities and preferences. The largest the utility, the larger will be the intention of the individual to pay for it (utility-value) and, thus, there is no limit for the value of the means.

However, the neoclassic theory works badly with the production issue, as it ignores the problem of effective demand. The neoclassical models of growth consider that economy converges inexorably to full employment, ounce "faults of market" have been corrected. There is little concern with the possibility of abundance of means, as the full non-utilization of the factors of production violates the premises of optimality required for the best possible allocation of the means. In other words, as employment is considered a "fault" of market, which naturally should converge to full employment, the neoclassical models that deal with natural means simply ignore the problem. Effects of environmental policies on employment are never discussed.

In contrast, the keynesian theory puts all the emphasis on the concern with aggregated level of economic activity, but ignores the problem of the best social allocation of means. That is why the environmental issue is never approached, although this school has a better explanation for issues like unemployment, uncertainties and expectations. In the typical Keynesian model, the question is how to increase the level of activity, without incorporating the social externalities that may eventually be caused by this.

In a certain way, the CDM bears the same kind of problem: which should be its emphasis? Augment the economic activity, reduce environmental problems or contribute to the social development?

While we do not have a General Theory of Sustainable Development, we go tapping in the dark, elaborating *ad hoc* models that always have a bias for one of these sides.

The conventional answer is that we should search for solutions that simultaneously contribute for the three goals: economic, environmental and social. Great, when it is possible, but when there are conflicts among these objectives? That is, in general, the objective of this paper: to show that not always "win-win" solutions are possible and thus, in the field of CDM, the social side has been the most neglected of all. Therefore, more efforts in researches should be channeled to this proposition.

WHEN THE "WIN-WIN" IS NOT POSSIBLE

On of the most important themes for the effective implementation of environmental goals, such as reduction in the concentration of greenhouse effect gases, is to know how the competitiveness of the companies will be affected. It is very common to find, from one angle, business men complaining that the environmental controls make the production more expensive. From another angle, many specialists defend that an improvement in the environmental management reduces the costs of production. Who is right?

The basic premise of those that argument that environmental improvement of a company augments its competitiveness subsists in the idea that this practice ends up reducing waste and inefficiency in the consumption of energy and prime materials. The great advantage of clean technologies subsist in the possibility of reversing a cost into benefit. What was treated before as a problem, like additional expenses to avoid emissions or to pay compensations, in case the emission reduction is not technical or economically viable, crosses over to be an advantage, like gains in performance or productivity. Therefore, the gain of economic efficiency occurs simultaneously to the improvement in the conditions of life of the population.

However, if clean technology is always the most desirable, both for the company as for the population, why has it not been adopted in large scale? Why is it necessary a government action to control pollution?

There are many answers to this question. First, it is fundamental to observe that the productive structures are very heterogeneous, moreover in the case of late industrialization, like Brazil. This structural difference is the result of a technological inequality among the various sectors. We find an example of this in the striking contrast among activities of the manufacturing sector which demands high incorporation of technology, as the case of durable means of consumption and of capital which incorporate microelectronic innovations, with others in which the dynamism in the incorporation of technology is less present, such as in many traditional areas that utilize natural means as prime material. Furthermore, it is possible to observe the coexistence, in the same sector, of technologically high advanced companies, like those turned towards exportation, or transnational branches that try to accompany- despite out phased- the technical progress generated in developed countries, with backward technology, acting in areas where the quality of the product is not important to competition.

The opportunities to propagate clean technologies are numerous. In sector where this technological contrast among companies is very significant there is much space to advance simply through the improvement in out phased plants. In this case, the role of public politics is in assisting in the transference of these technologies, be it through diffusion or creating financing mechanisms and other incentives for technological improvement.

A still more complicated situation subsists when the sector in which the possibilities of "win-win" are very small, or else, in sectors where the adoption of clean technologies demand high investments on an installed industrial park which is not financially depreciated. The situation is more serious when the financing capacity of the company is minor, a typical condition of small and medium sized companies. Even if there is a knowledge of more efficient forms of productions, the restrictions of capital or scale impede its adoption, and the maximum achievement in terms of environmental management is the adoption of controls that simply avoid the emission to strike the ambience, the so called technologies of "end of the tube". This kind of technology represents only an increase on the production costs and, therefore, less competitiveness.

This limitation should be very clear in our reasoning. The improvement of environmental conditions is not always able to reduce the costs. And even in the cases in which it is possible to join the objectives of economic and environmental improvement, social aims may not be achieved. The circumstances that put clean technologies in practice are normally associated to industries of continuous process, where the reduction of effluents can represent a considerable economy of costs. However, these industries of continuous process tend to be less intensive in labor requirement. So, even if there are improvements in energetic efficiency of industrial sectors and most of the technologies for generation of renewable energy, both large fields forapplication of CDM , the social results may be of minor importance.

Therefore, there is no *a priori* reason to believe that CDM projects will always present an equilibrium among its financial, environmental and social aspects. As the more used parameters refer to the costs of the projects and avoided amounts of greenhouse effects of gases emissions, it is most probable that the social aspects be the less considered ones. Specific public policies should be necessary to treat with this issue and the mechanism of market should not be entirely responsible for the allocation of resources generated by the developed countries' non attendance of the goals established for their emissions.

FOR A SOCIAL CARBON

To what extent should the CDM projects with social content be stimulated? This is a very difficult question, however Brazil might be in a privileged situation to initiate this debate. Brazil has always played a detached role in the negotiations which resulted in the creation of CDM, and there are a few concrete options of projects that confer important social characteristics. An important example is the Project for Biogas Good Use in the Garbage Deposit of Adrianopolis, a pioneer in this mechanism that has as its objective the reduction of GEE emissions liberated in the decomposition of garbage, capturing the methane of the deposits (biogas) for the generation of electrical energy. In fact, the energetic good use of biogas is one of the most promising areas for CDM, and it is expected that a considerable number of similar projects be spread in Brazil for the next years.

Another area that has received much attention from the media is the use of biomass for the substitution of fossil combustible. Brazil has been a pioneer in the substitution of gasoline by sugar cane produced ethanol, and now there are great expectations circa the substitution of part of diesel oil by vegetal oils (biodiesel) from many cultures (being the mamona and the dende the most commented).

A third area, less quoted but not less important is the good use of degraded soils (abandoned or of low agricultural productivity) for reforestation projects. In this case, the acquisition of certified reductions of emissions occurs by the capture of carbon through forest restructure. Given its enormous forest vocation, Brazil offers many comparative advantages in this sector, although the volume of carbon credits thus generated has maximum limits established by the Kioto Protocol Regulation.

These three areas also present in common a high level of social importance. The management of solid residues is one of the great urban problems that are independent from the size of the municipality. Most of the residues are put in large unmanaged depositories in 64% of Brazilian cities (IBGE, 2000). This brings a series of environmental and social problems and finding an adequate destination, with the energetic good use of the garbage, would engender important positive externalities, further than the avoided emissions, both through the transformation of methane into carbon dioxide, of less influence on global warming, as by avoiding the burning of fossil combustible for the same destination. (Oliveira and Rosa, 2003, estimated in 50 TWh the energetic potential of solid residues in Brazil)

Programs of stimulation of small agriculture production units (small family farms), also have social positive effects, chiefly by mitigation of great unemployment in rural areas observed in Brazil in the last decades (Young 2004). In this sense, the stimulation towards small rural production, achievable both through biodiesel programs as forest culture, may have social positive impacts contributing to reduction of global warming.

However, these projects can also result in negative externalities. If badly managed, the burning of solid residues may generate atmospheric pollutants that affect the health of populations in the surrounding areas. Further, there is a contingent of people who find their subsistence in garbage selection – these elements should be considered in the evaluation.

The massive production of a combustible from an agricultural activity may bring serious social and environmental disturbance. There is always the risk of the biodiesel project to repeat the errors of the Pro-Alcohol, becoming a multiplier of land concentration, high mechanization and monoculture, which are elements that accentuate social exclusion on rural areas. There can also emerge an stimulus to deforestation, a particularly serious problem as the expansion of the culture of the main vegetal oil (soybean oil), produced in the country occurred to a great extent at the cost of the use of native areas of the "cerrado" and even of the Amazon forest, as shows the study done by the Work Group on Forests of the Brazilian Forum of NGOs and Social Movement for Environment and Development (FBOMS,2005). Although there is a certain controversy on the subject (Brandão et alli, 2005, argument the opposite), there is little doubt that a disorganized expansion of a monoculture will certainly cause serious pressures onto the conservation of native forests, damaging the biodiversity and even for global warming (if the conversion is carried out by forest slash and burn).

A similar problem may occur with the expansion of reforestation with the monoculture of exotic species, As shows Carpio and Ramirez (2001), in spite of the great potential of forests for CDM projects, little attention has been given do its indirect effects. One of these problems can be the increase of land concentration, due to scale economies of large plantations. Furthermore, there is the risk of loss in biodiversity, given the minor cycle of rotation in exotic species cultures (like the Pinus and Eucalyptus).

These issues, therefore, also deserve more profound studies. The technocratic vision tends to concentrate its efforts on technical and financial viability of the projects, but it cannot be assumed that other problems will find "natural" solutions. To measure the social aspects is as important as advancing in the analysis of technical and economical aspects of the considered projects.

CONCLUSION

It is necessary to highlight the comparative character of the benefits and economic costs, both environmental as social of the various options of CDM projects. Many sector studies have been made, separately analyzing each of these options and the bibliography is extensive. However the CDM tries to introduce market components in the search of more efficient solutions and few works have analyzed in a comparative manner the different possibilities that the investors will confront with. What lacks is to take a step forward and compare the returns expected from each project, avoiding to be restricted only by "traditional" aspects – amount of avoided emissions and necessity of financing – also considering its capacity of social inclusion.

The construction of indicators that are able to compare economic and social aspects is not necessary only for mitigation projects, but also to a more efficient allocation of the means for projects of adaptation to global warming. It is, therefore, a prior item for the future rounds of negotiation in the field of Climate Convention.

In the same way, other aspects related to sustainable development, like protecting biodiversity and opposing desertification should be taken into consideration in these negotiations. "Fragmented sustainability" cannot be considered if environmental themes (water, biodiversity, carbon, etc) are distinct manifestations of the common problem of inadequate use of natural means. Further, actions that accomplish more than one of the proposed objectives, as avoiding deforestation (which, simultaneously reduces carbon emissions and protects biodiversity and hydro-resources) should be prioritized. The allocation of the resources should not be based only on economic cost-effectiveness and in criteria of relative improvement. Further than mechanisms of flexing, mechanisms of direct transferences should be implemented, based on social and environmental criteria that go far beyond the least cost per unit of avoided carbon emission.

REFERENCES

Brandão, A. S. P., Rezende, G. C., Marques, R. W. C. *Crescimento agrícola no período1999-2004, explosão da área plantada com soja e meio ambiente no Brasil*. Rio de Janeiro, IPEA. (Texto para Discussão, n. 1062). 2005

Carpio, C. E., Ramírez O. A. Estudios económicos sobre el uso de los bosques latinoamericanos para mitigar el cambio climático. *Revista Asturiana de Economía – RAE*, v.21, p. 73-99, 2001.

FBOMS. Relação entre cultivo de soja e desmatamento: compreendendo a dinâmica. Grupo de Trabalho sobre Florestas. Fórum Brasileiro de Organizações Não Governamentais e Movimentos Sociais para o Meio Ambiente e o Desenvolvimento, São Paulo. 2005.

IBGE. *Pesquisa Nacional de Saneamento Básico, 2000*. Rio de Janeiro, 2002.

Oliveira, L. B. *Potencial de aproveitamento energético de lixo e de biodiesel de insumos residuais no Brasil*. Tese (D.Sc., Planejamento Energético) – Instituto Coppe, Universidade Federal do Rio de Janeiro, Rio de Janeiro. 2004.

Oliveira, L. B., Rosa L. P. Brazilian waste potential: energy, environmental, social and economic benefits. *Energy Policy*, v.31, p.1481–1491, 2003.

Seroa da Motta, R., Ferraz, C., Young, C. E. F., Austin, D., Faeth, P.
O mecanismo de desenvolvimento limpo e o financiamento do desenvolvimento sustentável no Brasil. Rio de Janeiro: IPEA (Texto para Discussão, n.761), 2000.

Young, C. E. F. Desenvolvimento e meio ambiente: uma falsa incompatibilidade. *Ciência Hoje*, v.211, p.30-34, 2004.

MITIGATION POLICIES AND ECONOMIC IMPACTS

RONALDO SEROA DA MOTTA
IPEA, Rio de Janeiro, Brazil

This text is fully based on Chapter 7 on Costing Methodologies and Chapter 8 on Global, Regional, and National Costs and Ancillary Benefits in Mitigation of the Report *Climate Change 2001: Mitigation*, Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Cambridge, 2001. Tables, Figures and Graphs will be presented according to their original numeration appearing in the supra- mentioned chapters. The text is, therefore, a summary of the most important issues related to economic impacts of mitigation climate policies that are closer associated with developing countries' perspectives. We first identify what are the potential impacts of mitigation policies. Next the most applied models to estimate these impacts are presented followed by the discussion of their results, including the ones related to developing economies. Additional issues, such as, trading effects, ancillary benefits, double dividend are also discussed within the modeling and estimation contexts. The CDM mechanism of Kyoto Protocol is next analyses in regard its size, structure and future functioning. Finally we point out some recommendations to promote the analysis and identification of economic impacts of mitigation policies in developing countries.

What are the economic impacts?

Emissions of greenhouse gases (GHG) and the resulting climate change impacts are external costs associated with past and current production and consumption patterns. Since impacts of climate change are associated with cumulative GHG emissions, developed countries contribution is still the major one. Developing countries' contribution will depend on their future growth path and rates.

Mitigation policies are options to reduce sources of GHG and so they need to be referred to baselines (see Figure 1).

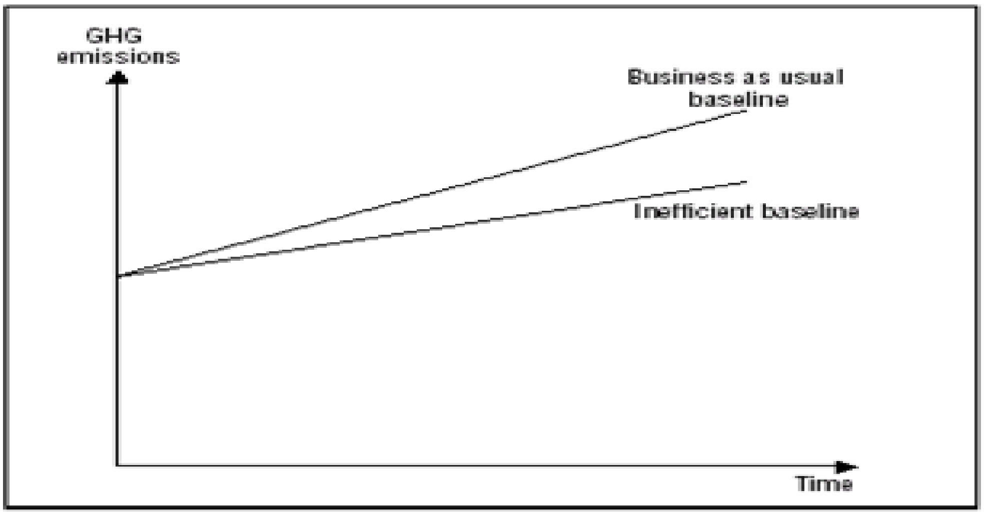


Figure 1 - Greenhouse Gas Emission Profiles of Different Baseline Case Approaches.

We can also identify three broad mitigation cost boundaries, namely, project (point specific), sector (partial equilibrium) and macroeconomic (general equilibrium) Mitigation costs can be, in turn, split into direct abatement costs (engineering and technological costs), implementation abatement costs (associated with information, institutions fiscal devices, etc) and indirect costs (macroeconomic effects and ancillary benefits and costs).

Apart from direct abatement and implementation costs, indirect macroeconomic effects need to be assessed such as those on:

· income and growth;

· competitiveness;

· structural adjustments;

· costs of public funds (tax distortions);

· inflation;

· capital scarcity;

· employment.

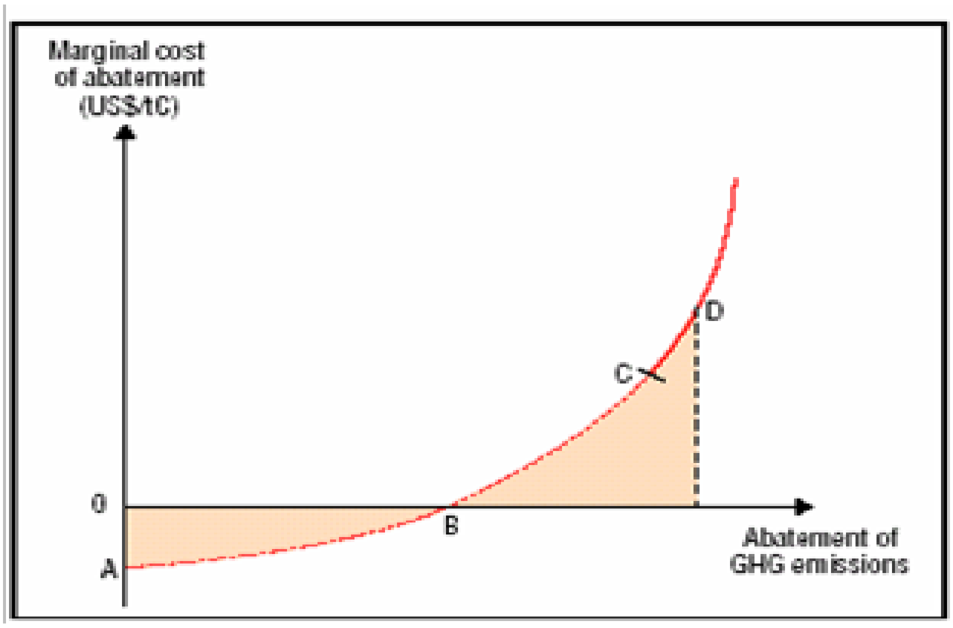


Figure 2 - A typical cost curve.

Costs tend to increase with levels of control, but removal of inefficiencies and positive spillover effects may allow for negative costs at certain range of control (see Figure 2).

So there may be "no regret options" that ameliorate most of these indirect costs since inefficiencies on information access, property rights assignments, perverse taxation and other, are corrected. As shown in Figure 3 below, an economy may move from a no efficient point (0) to an efficient point (O' and O") with net benefits. Along the curve all points lead to trade offs between output and emission control. No regret options must, however, be identified taking into account the resulting transaction costs of these inefficiency corrections.

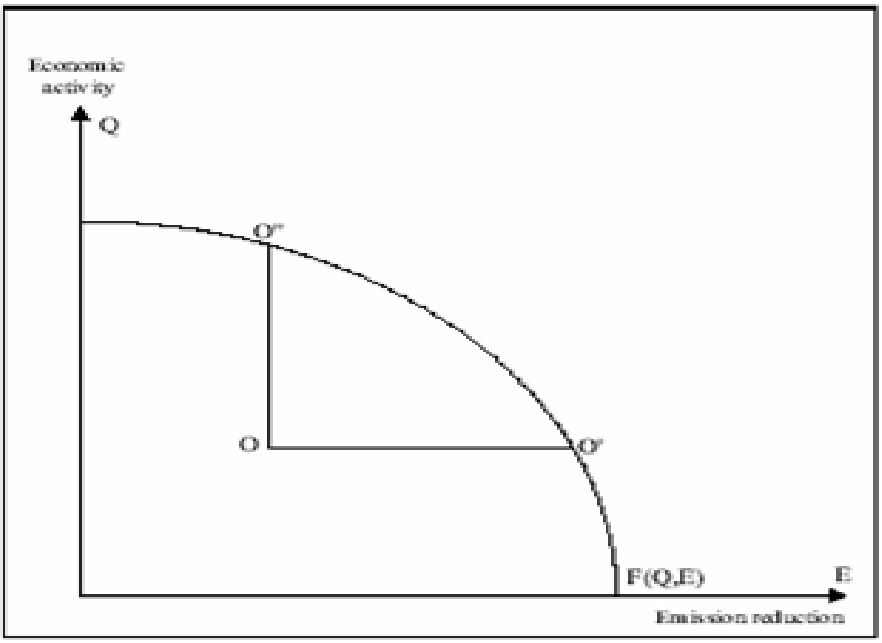


Figure 3 - Trade-off between emissions reduction and economic activity.

There can be also multiple baseline scenarios associated with uncertainty on the links between mitigation and adaptation effects[1], technology and consumption patterns, political and social changes Technological uncertainty is crucial and dependent on the future emission pathway that, in turn, may affect the impacts of autonomous improvement, learning by doing and R&D factors. So cost estimation using current observed prices, emission patterns and technological options must analyze the sensitivity of results to changes on these parameters.

Equity is, perhaps, the most relevant issue and difficult to account for with no ambiguous way. Discounting inter-generational cost and benefit flows is needed and can be done distinct weighting, from exponential to hyperbolic forms. Welfare weighting among contemporaries also requires some 'a priori" assumptions about people relative welfare's values.

Needs for rapid growth path and changes in consumption and production patterns also affect mitigation costs.

How can we measure these economic impacts?

Mitigation costs can be measured either from Bottom-Up Models or Top-down (T-D) models.

1 Options to adjust the economy to climate change impacts. See *Climate Change 2001: Impacts, Adaptation and Vulnerability*, Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Cambridge, 2001

Bottom-Up Models is disaggregated by sectors and technology and energy driven with the following features:

· Engineering costs with calculations independent by technology

· Integrated partial equilibrium models modeling supply and demand of the energy sector with price responses in least-cost optimization

· Simulation models includes other behavior pattern apart from least-cost optimization Top-Down (T-D) Models are aggregate with linkages to macroeconomic parameters and their structure can be:

· Input-Output matrixes (static and linear)

· Computable general equilibrium, CGE (price responses)

· Macroeconomic models (quantity responses)

How much are these costs?

B-U Models

Developed Countries

Summary of B-U models can be presented according to marginal abatement costs related to GHG emission variation from 1990 levels (see Figure 8.2).

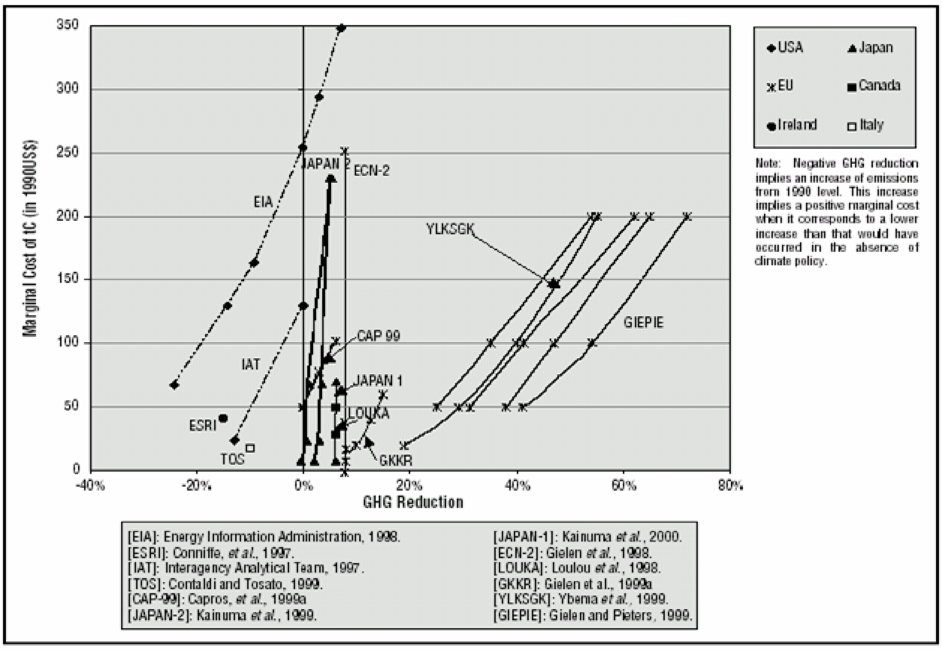


Figure 4 - Country results with battom-up studies using a crosscutting instrument.

Most models applying partial equilibrium models with no trade effects. And negative GHG reduction corresponds to a lower increase that would take place in the absence of climate policy. As can be seen in Figure 4, there are large discrepancies among countries and also for the same country. At

US$ 100/tCO2eq, Japan 1 and 2 (AIM studies) would reduce between 1 and 8% and Canada (MARKAL LOUKA) would decrease by 6%. At the same cost USA, Ireland (ESRI) and Italy (TOS) would increase. NEMS-EIA- USA saying than stabilization of 1990 levels in USA would cost at least US$ 250/tCO2eq and MARKAL – IAT –USA indicating about US$ 120. The latter is a simple least cost approach. EU studies would show wide range of reductions from small ones in PRIME – CAP-99 to large ones MARKAL types in GKKR, YLKSGK, GIEPIE. Models' results differ due to several reasons, such as: energy endowment and intensity; assumption on growth and policies. In addition to that some models may include demand feedbacks, transaction costs and some macroeconomic effects.

Developing countries and EIT

B-U studies for developing countries are available from UNEP (referring to 2030 levels) and ALGAS (referring to 2020 levels) models based on options in the energy, transportation, waste management and land-use sectors (see Table 1).

Table 1 - Emission reduction potentials achievable at or less than US$25/t CO_2 for developing countries and two economies in transition

Annual reduction relative to reference case		
Country	$MtCO_2$/yr	%
Argentina (UNEP, 1999a)	–	11.5
Botswana (UNEP, 1999c)	2.87	15.4
China (ALGAS, 1999c)	606	12.7
Ecuador (UNEP, 1999b)	12.7	21.3
Estonia (UNEP, 1999g)	9.6	58.3
Hungary (UNEP, 1999f)	7.3	7.6
Philippines (ALGAS, 1999h)	15	6.2
South Korea(ALGAS, 1999d)	5.3	5.7
Zambia (UNEP, 1999d)	6.09	17.5
Brazil (UNEP, 1994)	–	29
Egypt (UNEP, 1994)	–	52
Senegal (UNEP, 1994)	–	50
Thailand (UNEP, 1994)	–	29
Venezuela (UNEP, 1994)	–	24
Zimbabwe (UNEP, 1994)	–	34
Cumulative reduction relative to reference case		
Country	$MtCO_2$/yr	%
Myanmar (ALGAS, 1999e)	44	23
Pakistan (ALGAS, 1999f)	1120	23.7
Thailand (ALGAS, 1999g)	431	4.2
Vietnam (UNEP, 1999e)	1016	13.4

At US$ 25 /t CO2eq quite high annual reductions could be achieved in these economies; in some cases, over 50%, such as, in Estonia, Egypt and Senegal. Options in energy use efficiency are in general the most cost effective ones.

Partial equilibrium models are also available (see Table 2) with ETO type for China, India and Brazil, AIM for China and MARKAL for India, Nigeria and Indonesia.

Table 2 - Abatement costs for five large less-developed countries

Country	China	India	Brazil	China	India	Nigeria	Indonesia
Reference	Wu *et al.* (1994)	Mongia *et al.* (1994)	La Rovere *et al.*, (1994)	Jiang *et al.* (1998)	Shukla (1996)	Adegbulugbe *et al.* (1997)	Adi *et al.* (1997)
Span of study	1990–2020	1990–2025	1990–2025	1990–2010	1990–2020	1990–2030	1990–2020
Emissions in 1990 ($MtCO_2$)	2411	422	264				
Emissions in final year, baseline ($MtCO_2$)	6133	3523	1446				
% change	154%	735%	447%	130%	650%		
Emissions in final year, mitigation ($MtCO_2$)	4632	2393	495				
% change	92%	467%	88%	53%	520%		
% change: mitigation versus baseline, final year	**–40%**	**–36%**	**–80%**	**–59%**	**–20%**	**–20%**	**–20%**
Marginal cost in final year ($US\$/tCO_2$)	**32**	**–16**	**–7**	**28**	**28**	<30	
Average cost in final year ($US\$/tCO_2$)						<5	
Annual cost in final year (billion US$/yr)							**47**

China's results are quite similar but not the India's ones. India and Brazil in ETO studies are showing negative costs. In sum, developing countries can achieve high levels of mitigation at lower costs than those prevailing in developed economies. Such pattern will be dominant parameter in the design of international agreements on GHG control.

T-D Models

Energy Modelling Forum coordinated 13 T-D models for USA, Japan, OECD-Europe and CANZ (Canada, Australia and New Zeeland) analyzing costs (or carbon tax values) to achieve 2010 Kyoto targets (see Table 3).

Table 3 - Energy Modelling Forum main results; marginal abatement costs
(in 1990 US$tC; 2010 kyoto target)

Model	No trading				Annex I trading	Global trading
	USA	OECD-E	Japan	CANZ		
ABARE-GTEM	322	665	645	425	106	23
AIM	153	198	234	147	65	38
CETA	168				46	26
Fund					14	10
G-Cubed	76	227	97	157	53	20
GRAPE		204	304		70	44
MERGE3	264	218	500	250	135	86
MIT-EPPA	193	276	501	247	76	
MS-MRT	236	179	402	213	77	27
Oxford	410	966	1074		224	123
RICE	132	159	251	145	62	18
SGM	188	407	357	201	84	22
WorldScan	85	20	122	46	20	5
Administration	154				43	18
EIA	251				110	57
POLES	135.8	135.3	194.6	131.4	52.9	18.4

Source: cited in Weyant, 1999; Council of Economic Advisors, 1998; EIA (Energy Information Administration), 1998; Criqui *et al.*, 1999.

Again, as shown in Table 3, wide discrepancies in results, from US$85 to US$410 /tC in the USA, US$20 to US$966 for the OECD-Europe, US$122 to US$1074 for Japan, US$46 to US$423 for CANZ.

But results indicate that Japan's costs are the highest ones. CANZ and USA have similar costs and about 2/3 of the Europeans ones.

T-D models, including macroeconomic effects, can measure GDP losses (see Table 4).

Table 4 - Energy Modelling Forum main results; GDP loss in 2010
(in% of GDP; 2010 Kyoto target)

Model	No trading				Annex I trading				Global trading			
	USA	OECD-E	Japan	CANZ	USA	OECD-E	Japan	CANZ	USA	OECD-E	Japan	CANZ
ABARE-GTEM	1.96	0.94	0.72	1.96	0.47	0.13	0.05	0.23	0.09	0.03	0.01	0.04
AIM	0.45	0.31	0.25	0.59	0.31	0.17	0.13	0.36	0.20	0.08	0.01	0.35
CETA	1.93				0.67				0.43			
G-CUBED	0.42	1.50	0.57	1.83	0.24	0.61	0.45	0.72	0.06	0.26	0.14	0.32
GRAPE		0.81	0.19			0.81	0.10			0.54	0.05	
MERGE3	1.06	0.99	0.80	2.02	0.51	0.47	0.19	1.14	0.20	0.20	0.01	0.67
MS-MRT	1.88	0.63	1.20	1.83	0.91	0.13	0.22	0.88	0.29	0.03	0.02	0.32
Oxford	1.78	2.08	1.88		1.03	0.73	0.52		0.66	0.47	0.33	
RICE	0.94	0.55	0.78	0.96	0.56	0.28	0.30	0.54	0.19	0.09	0.09	0.19

According to Table 4, GDP losses vary from 0.45% to 1.96% for the USA, 0.31 to 2.08% for the EU and 0.25 to 1.88 for Japan. GDP ranking is different with CANZ and USA suffering the highest losses followed by Europe and Japan.

Except for China and Mexico, few comprehensive studies are available on climate policy T-D models for developing countries.

For China, Zhang (1997,1998, 2000), for 20-30% emission cut in 2010, reports GDP losses of 1.5% and 2.8%; Garbaccio *et al*. (1998 and 2000), instead, indicate that GDP losses would be fully net off by tax recycling and health effects.For Mexico, Viniegra and Boyd (2000) indicate that GDP losses, depending on assumptions on technological change rates and tax recycling, vary from 1.3 to 0.1%. In all cases, however, they observed progressive effects on welfare.

Trading Effects

Kyoto mechanisms allow for carbon permit and credit (CDM) trading that reduces climate policy costs. Table 8.7 also shows the effects of trading in marginal abatement costs in Annex 1 countries.[2]

Annex I trading could reduce by large abatement cost and GDP losses. Annex I permit prices would vary from US$ 14 to US$ 224 /t C and still lower, US$ 5-123, with CDM. GDP variation is also reduced to 0.09 from 0.66 in the USA, 0.03 to 0.54 in the OECDEurope, 0.01 to 0.33 in Japan and 0.04 to 0.67 in CANZ.

B-U models incorporating trading effects also indicate huge savings in Annex 1 countries. So trading may reduce drastically costs and losses, particularly with CDM as it will be later discussed. Example: a no-trading mitigation cost of 1% in the OECD countries would represent about US$ 250 billions. As trading could reduce GDP losses to a quarter resulting in savings of about US$ 187,5 billions.

Ancillary Benefits

Targeting of GHG emission control may raise additional or ancillary benefits (AB) such as those related to heath effects due to reduced air pollution concentration of associated local gases. Measures of AB can be given per ton of carbon reduced (see Figure 5).

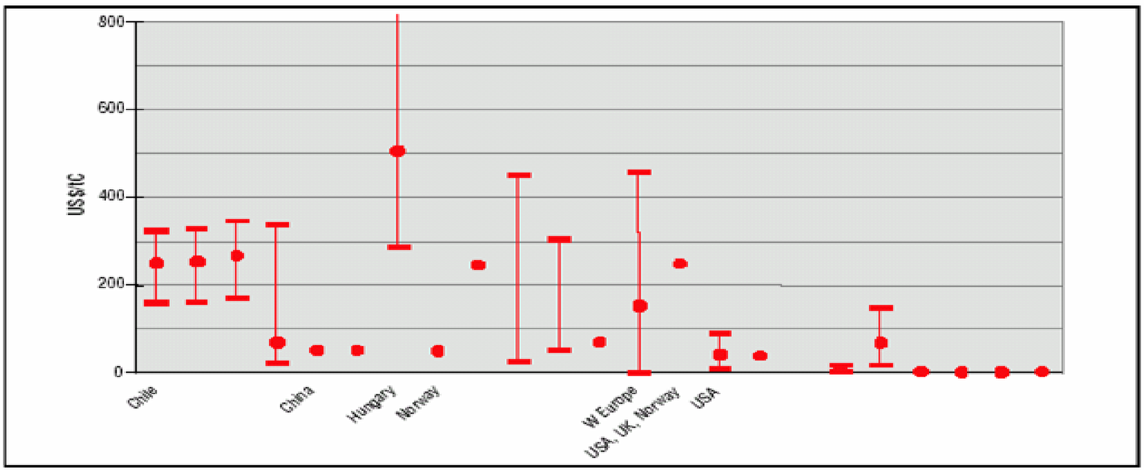


Figure 5 - Summary of ancillary benefits estimates in 1996 US$/tC.

2 Countries that have assigned cap emissions in the Kyoto Protocol.

As can be seen in Figure5, there are few estimates of AB and they vary from US$ 2 to 500 /tC among countries. There are also discrepancies in the same country. Mostly benefits are less than US$ 100 / tC and some quite low. USA with the lowest and Chile and Norway with the highest ones. Ancillary benefits contribution to mitigation policies may be very important but their dimension still requires further ana lysis.

Double Dividend

Domestic policies may also reduce climate policy costs using flexible economic mechanisms, such as, tax and tradable permits, which may generate revenues. They offer high cost-effectiveness when compared with control (no flexible) instruments. Generated revenues can also reduce tax burden elsewhere, so, apart from mitigation benefits, they may offer a double-dividend.

However, the interaction of these market mechanisms with the economy may generate welfare losses on consumers and producers (interaction effects). Cost savings can be again achieved if carbon tax or permit sales revenues are recycled in the economy against distortionary taxes (recycling effects). The higher the marginal cost of raising public funds the higher is the possibility of double dividend (see Figure 6).

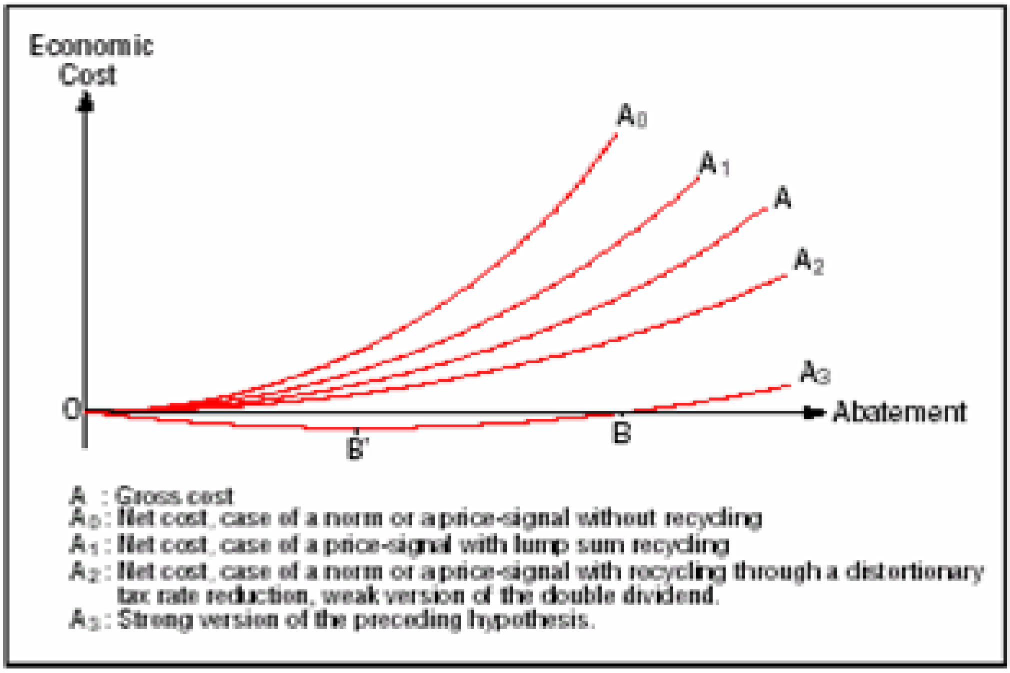


Figure 6 - Carbon taxes and the costs of environment policies.

CDM markets[3]

While, in the Kyoto Protocol, emission trading was only officially labeled as such for transactions among countries with caps, another similar instrument, called the "Clean Development Mechanism" (CDM), was set for emission trading between countries with caps and those with no caps. The estimates of the size of the CDM market also vary considerably from US$ 5 – 17 billions (see table below).

China's share is over 60% indicating that this country has an important role in the supply side of the market and CDM may be play a key role in the country's mitigation policy, A the lesser extent, that also holds for India that has the second highest share.

Estimates of the CDM Market

Model (author, year)	**OCDE** Van der Mensbrugghe (1998)	**G-Cubed** McKibbin *et alii* (1998)	**SGM** Edmonds *et alii* (1998)	**EPPA** Ellerman et alii (1998)	**UNCTAD** Zhang (2001)
Unit	MtC	MtC	MtC	MtC	MtC
Estimated total reduction in Annex I countries in 2010	1,201	1,049	1,053	1,312	620.6
Domestic reductions	539 (45%)	159 (15%)	193 (18%)	378 (29%)	172 (28%)
Annex I trading	265 (22%)	64 (6%)	110 (10%)	101 (8%)	52 (8%)
Hot Air		426 (41%)	247 (23%)	111 (8%)	105 (17%)
CDM	397 (33%)	400 (38%)	503 (48%)	723 (55%)	292 (47%)
Trading price (US$ /tC)	$19	$13	$26	$24	$10
CDM market size (US$ billions)	7.5	5.2	13	17.4	6.0
Country share					
China	57%	70%	68%	60%	60%
India	11%	– –	7%	14%	15%
Brazil	1%	– –	– –	0,3%	0,3%

Sources: Expanded from Austin, D., Faeth, P. *Financing Sustrinable Development with the Clean Development Mechanism*. Washington: World Resource Institute, 2000, Edmonds, J., C. MacCracken, R. Sands, S. Kim (1998), Unfinished Business: The Economics of the Kyoto Protocol, Pacific Northwest National Laboratory, Prepared for U.S. Department of Energy, September. ;McKibbin, W.J., Robert Shackleton, Peter J. Wilcoxen, 1998, "The Potential Effects of International Carbon Emissions Permit Trading Under the Kyoto Protocol," Draft Paper, September;Van der Mensbrugghe, Dominique (1998), "A (Preliminary) Analysis of the Kyoto Protocol: Using the OECD GREEN model", in Economic Modelling of Climate Change: OECD Workshop Report, OECD, Paris;Ellerman, A.D., H. Jacoby, A. Decaux (1998) "The Effects on Developing Countries of the Kyoto Protocol and CO2 Emissions Trading," Joint Program on the Science and Policy of Global Change, Massachusetts Institute of Technology, Draft, September;Zhang, Z.X. An Assessment of the EU Proposal for Ceilings on the Use of Kyoto Flexibility Mechanisms, *Ecological Economics*, 2001.

3 This section was not fully drawn from IPCC reports.

However, there are several aspects related to the Protocol application that may change the market size and structure, namely:

· USA defection of Kyoto Protocol and sinks eligibility to Annex 1 targets reduced largely the CDM markets by less than half. There will be a parallel USA carbon market[4]?

· Can CDM market capture sustainable development objectives in the seller countries[5]? There will be an ethical CDM market?

· How non-compliance liability rule will be placed? Seller or buyer dependent?

· How transaction costs will affect competitiveness among sellers?

· How is the optimum CDM transaction pathway taking into account a possible next commitment term?

How studies on economic impacts of mitigation in emerging economies could be improved?

First, we must promote the development of these studies with funding and, when it is needed, with technical collaboration of Research Centers that have already expertise on modeling and related issues.

Second, studies in developing countries may be even more complex than the ones applied in developed economies, not only in modeling aspects but also due to data availability.

In addition to that, the development stage of these economies requires that costing studies make all efforts to introduce:

· Alternative development pathways with different patterns of investment and their effects on GHG emission levels, international energy prices and technological change pattern.

· Also pathways of market transformation processes in the capital, labour, and energy markets, particularly in regard to their informal and traditional nature, and the respective costs of removing market barriers.

· The measurement of ancillary benefits, CDM and double dividend opportunities that may identify "no regret options" and low cost approaches.

· The estimation of these aggregate costs must be followed by the identification and measurement of the distributive pattern of these costs and benefits.

· Potential carbon related trade barriers that may arise due to domestic climate policies in Annex 1 countries.

4 Several initiatives are already in place in USA.

5 See Seroa da Motta, R. Social and economic aspects of CDM options in Brazil, in: Andrea Baranzini & Beat Buergenmeier (Guest Editors): Climate Change: Issues and Opportunities for Developing Countries, Special Issue, *International Journal of Global Environmental Issues*, 2 (3/4), 2002.

CONCLUSIONS AND RECOMMENDATIONS OF THE EVENT

1. It is accepted that all countries have common but differentiated responsibilities in relation to change of the climate. It is noticed that the developing countries, in spite of their lesser historical contribution in relative terms and considered their present expressive contribution in some cases, should assume in future protocols quantified compromises for limiting and reducing emissions in a voluntary or compulsory way.

2. The necessity of more detailed studies of the biogeosphere is observed, as well as the integration of human sciences to the existing analyses. Such studies should intensify the knowledge on the problem of global change, reduce the uncertainty inherent to this kind of focus, and reveal feasible recommendations on environmental and economic policies.

3. Furthermore, other studies should subsidize negotiation strategies for protocols and consider the requests of other developing countries as well as the industrialized countries and those in transition. To achieve this, specific lines of financing are needed to encourage the research on global change, specially climatic change counting on the support from national agencies for foment of research as well as international agencies.

4. It is necessary to produce more training in order to create other scenarios, considered the inherent uncertainty of the analyses in the area of global changes.

5. A better integration with other themes of sustainable development should be sought, particularly the biodiversity. Actions should be integrated. The many protocols should have compatible actions, avoiding conflicting compromises.

6. International technical cooperation is necessary, as well as the creation of human resources for research and interchange of researchers, both at the Latin-American level as well as at world level.

7. It is recommended that the LBA experience should inspire initiatives in other ecosystems.

8. The scientific publication of the main results of researches is recommended, using an appropriate language to reach the general public.

9. Social criteria should be taken into account in projects for the Mechanism of Clean Development, further than the dimensions normally considered, such as the economical and the environmental. In particular, cost-effectiveness ratio should not be the only indicator to subsidize the decisions. However, it is accepted that the projects will not generally have the same good performance in all the mentioned dimensions.

10. The possibility of the country to foment direct mechanisms of technology transference should be considered by means of adequate economic incentives.

11. It is necessary to recognize that mitigating actions on the consequences of global change should contemplate the socially less favored social groups, historically affected by a concentrated wealth distribution and poorness which will be affected in larger degree.

12. Studies should be elaborated with short term predictions, although it is recognized that the global heating phenomenon is a long-term one.

13. The effects of climatic change on the agricultural profile of each country should be anticipated, predicting its possible consequences on the sector composition of the product and the per capita income of each region. Measures should be taken for the necessary adaptation.

14. The consequences of climatic change on regional deceases that affect men and plagues that affect plants should be anticipated. In each case, solutions for the problems in potential should be anticipated, either by means of medication or through more resistant varieties of plants, or through other solutions not contemplated in this document.

INDEX OF AUTHORS

J

L

M

P

R

S

T

U

SPONSORS

GOVERNAMENTAL SPONSORS

CO - SPONSORS

COMERCIAL SUPPORT