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INCT FOR CLIMATE CHANGE 2009.2010 ACTIVITY REPORT

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INCT for Climate Change

2009.2010 | ACTIVITY REPORT

Welcome

Dear Colleague,

We are proud to present the First Activity Report of the National Institute of Science and Technology (INCT) for Climate Change (hereinafter referred to as 'INCT for Climate Change'). This report summarizes the goals, objectives and organization of the INCT, presents scientific highlights from its first 18 months of existence, and describes succinctly its 26 research projects.

The National Institutes of Science and Technology were created in 2008 by the Ministry of Science and Technology of Brazil (MCT). They are funded by MCT's National Council for Scientific and Technological Development (CNPq), by the Ministry of Education's Coordination for Post-Graduate Programs (CAPES) and by State-level Science Foundations - for INCTs located in the State of São Paulo, by the São Paulo State Research Funding Agency (FAPESP). Currently, there are 123 INCTs in operation, covering most areas of science and technology. More information on INCTs can be found at www.cnpq.br/programas/inct/_apresentacao/.

The INCT for Climate Change brings together the largest and most far-reaching interdisciplinary network of environmental research institutions in Brazil, involving over 90 research groups from 65 institutions and universities from Brazil and abroad, with over 400 participants. It is an ambitious scientific undertaking created to provide high quality and relevant information to help Brazil meet the goals of its National Climate Change Plan.

In order to inform scientists, policy-makers, the media and the general public, the INCT for Climate Change will publish annual reports with highlights of its scientific and capacity-building achievements and results. Detailed information on the INCT for Climate Change can be found at http://www.ccst.inpe.br/inct.

We invite your comments, suggestions, questions and criticisms on any part of this first activity report. Your input will most certainly help us in meeting our goals and objectives, ensuring that INCT for Climate Change outputs not only meet the highest scientific standards, but are also readily understandable to the public and decision-makers. Your feedback will also provide us with valuable guidance for refining our research strategy.

With my best regards,

Carlos A. Nobre
Scientific Coordinator of the
INCT for Climate Change
December 2010

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Introduction

Scientific and Societal Contexts

One of the most important and compelling intellectual challenges facing humankind today is the comprehensive and predictive understanding of the structure, dynamics and functioning of the Earth System. Recent progress in the understanding of the atmosphere, oceans and land surface together with a rapid expansion of our ability to observe our Planet, offers the scientific community new and expanded opportunities to advance our understanding of the Earth as a complex system.

The IPCC's Fourth Assessment Report (IPCC AR4) concluded that "warming of the climate system is unequivocal…", and attributed it to human activities: "Most of the observed increase in global average temperature since the mid-20th century is very likely - identified with more than 90% certainty - due to the observed increase in anthropogenic greenhouse gas concentrations".

This suggests beyond a reasonable doubt that the observed surface warming of the last five decades is mainly due to anthropogenic emissions of greenhouse gases (GHG). Due to the long lifetime of some GHG in the atmosphere and to the large thermal inertia of the oceans, there is already a substantial chance of future significant change over the next 30-40 years, and the rate of change may accelerate over the rest of the 21st century, and continue beyond.

What are the risks of rapid climate change? Even a 1°C warming presents the risk that some marine ecosystems, such as coral reefs, may suffer irreversible change because of ocean warming and acidification resulting from the increased flux of atmospheric carbon dioxide into the ocean. If the warming reaches 3°C or more, the melting of the Greenland and Western Antarctica ice sheets may accelerate, posing a very serious risk of significant sea level rise. With a 3-4°C warming, there is a risk of significant loss of the Amazon tropical forest. Globally, few ecosystems can adapt to rapid climate change; life-supporting systems are therefore at risk, with serious implications for global food security. Greater–though still undetermined–warming could increase the risk of reaching other tipping points, such as vast releases of methane from undersea stores of methane hydrates and from the permafrost in cold regions of the Planet, both of which could greatly exacerbate global warming.

The IPCC AR4 indicated with confidence that global warming will result in an increase of the occurrence of extreme weather and climate phenomena such as droughts, heat waves, intense rainfall episodes, storms and tropical cyclones, floods, storm

surges, and others. Exacerbation of current climate variability already poses substantial challenges to society, and further changes in climate are now unavoidable, even assuming effective implementation of ambitious mitigation policies. This makes the development of adaptation strategies imperative, and also demands that attention be given to issues of ethics and justice, since the people most likely to bear the brunt of global climate change impacts are those who have contributed least to it. The impacts of this unavoidable climate change would most severely affect the poor, making them the most vulnerable. This calls for unprecedented international collaboration, to create far-reaching and effective adaptation programs worldwide, in which increased adaptive capacity goes hand-in-hand with increased knowledge and scientific and technological development in the developing world.

Sustainable development in Brazil is strongly linked to the capacity to respond to the challenges and opportunities associated with climate change. Brazil is vulnerable to present-day climate variability and change and will be profoundly impacted by projected climate change in the future. The Brazilian economy is strongly based on climate-dependent natural resources. Our renewable energy sources, agriculture and biodiversity are highly vulnerable to climate change, and social and regional inequalities mean that large portions of the population are also vulnerable.

Recently, Brazil established a National Climate Change Plan and an advanced Climate Change Act (Law Number 12,187 of 29 December 2009 and Executive Order Number 7,390 of 9 December 2010). This Act sets ambitious targets for GHG emissions cuts by 2020, placing Brazil on the forefront of countries effectively committed to climate change mitigation. Furthermore, the Climate Change Act established a National Climate Change Fund as a mechanism for implementation of mitigation and adaptation policies and for funding the generation of new knowledge.

In this context, the INCT for Climate Change was created to generate high-quality and relevant scientific knowledge, in order to 1) understand the risks posed to society by current climate variability and change, 2) predict the long-term impacts of climate change in Brazil, and 3) help decision-makers and society at large to choose sustainable pathways for our future, so that effective adaptation measures are designed and adopted and mitigation policies are successfully implemented.

Premises and Historical Scientific Context

An opinion poll (*see illustration on this page*), with the aim of detecting the interests of the Brazilian population regarding science, was carried out and the results were presented during the 4th National Conference on Science, Technology and Innovation. Surprisingly, it positioned climate change in third place, next only to agriculture, which came in second, and drugs and medical technologies, which came in first. This is consistent with previous polls about climate change, which positioned Brazilians as one of the most interested and concerned people in the world concerning this theme.

Thus, it is natural that the Brazilian scientific community has been increasingly and rapidly involved with climate change. Between 2002 and 2007, Brazil contributed approximately 1.5% of the world's scientific articles concerning climate change in indexed journals. This is, however, still below the country's average contribution to the world's total scientific production, which was of 2% in 2007. Nevertheless, the 2002-2007 index of Brazilian production in climate change science reflects considerable progress when compared to its 0.5% contribution in the previous 5-year period (1997-2001).

In reality, these numbers reflect the relatively new development of global change science in the country. The great international interest in the Amazon has directed a large part of the research efforts since the 1980's to that region. Until the end of the 1990's, research initiatives usually began by foreign research groups, such as the micrometeorological, atmospheric chemistry and biosphere-atmosphere interaction experiments that were carried out in cooperation with Great Britain, Germany and the USA. These experiments were carried out throughout the 1990's and constituted an important experience and an opportunity to conduct cutting-edge environmental research held to international standards. This laid the foundations for a great leap forward that came about with the Brazilian leadership and planning of the Large-scale Biosphere-Atmosphere Experiment in the Amazon (LBA). It started in 1998 and runs through the present, and it is considered the largest research undertaking carried out in the tropics. It resulted in the conclusion of more than 250 Brazilian MSc's and PhD's. LBA created an effective network of national and international collaborations.

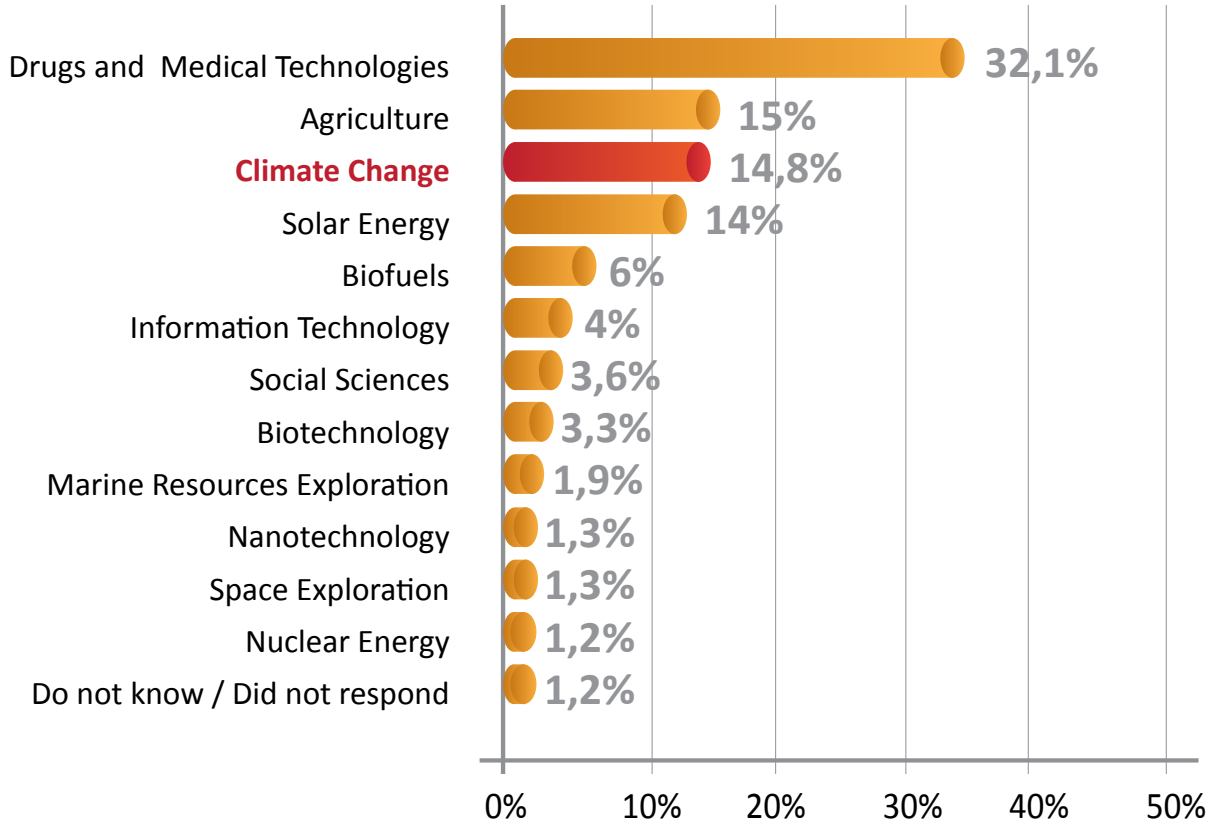
In the following decade, the interest in developing applied research that could inform public policies aiming at the sustainable development of the Amazon resulted in the creation of a new research network, called the Thematic Network in Environmental Modeling of the Amazon (GEOMA), constituted of Brazilian researches and in close collaboration with LBA. At the same time, a research network directed at biodiversity studies in the state of São Paulo, the BIOTA-FAPESP Program, was under development. In the last three years of the decade

the density of climate change research programs achieved a new level, with the creation of the Brazilian Research Network on Climate Change (*Rede* CLIMA), the FAPESP Research Program on Global Climate Change (PFPMCG) and of State-level research programs in Amazonas, Pernambuco, Rio de Janeiro and Rio Grande do Sul.

The previous research networks formed the foundations for the INCT for Climate Change. It furthers the goals of those programs, and collaborates directly with the present ones such as *Rede* CLIMA and the PFPMCG, in addition to encompassing a relevant effort for the continuity of LBA. Thus, the generation of knowledge carried out in this INCT should be seen as well as the follow-up of previous projects mentioned above, by means of a larger interdisciplinary integration of scientific results.

Public Perception of Science in Brazil

Most important areas of development in Brazil – 2010



Source: Ministério da Ciência e Tecnologia

Vision

To provide high-quality scientific information to guide mitigation of and adaptation to future climate change relevant to Brazil.

Objectives and Structure

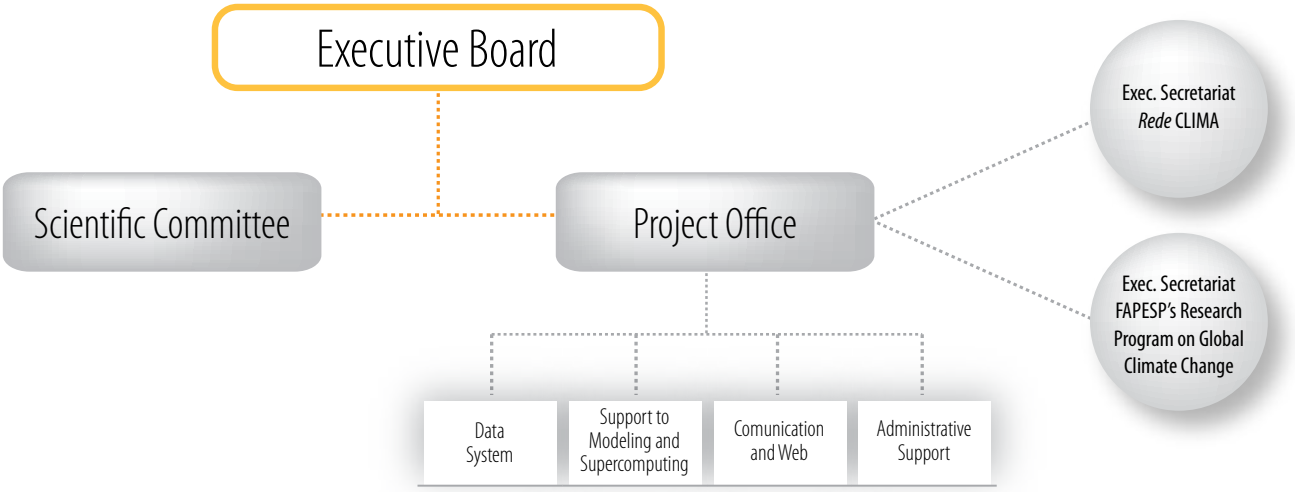
The main goal of the INCT for Climate Change is to provide high-quality and relevant scientific information needed to a) understand climate functioning, variability and change and b) inform adaptation and mitigation policies at local, national and international levels.

To achieve this goal, the scientific objectives of this INCT are to: **(i)** detect environmental change over Brazil and South America, and attribute causes to the observed changes (e.g., global warming, land use and land cover change, urbanization); **(ii)** develop a global climate system model required to generate scenarios of future global and regional environmental change (especially high-resolution scenarios of climate and land use/land cover change); **(iii)** study impacts of changes and identify vulnerabilities to climate change on key sectors and systems (ecosystems and biodiversity, agriculture, water resources, human health, cities, coastal zones, renewable energy, economy); and **(iv)** develop techniques and methodologies needed for climate change mitigation.
Along with the Brazilian Research Network on Climate Change (*Rede* CLIMA; see next section), the INCT for Climate Change is one of the twin research and development pillars of the Brazilian National Climate Change Plan. Ultimately, the INCT aims to advance the understanding of the complex dynamics of interacting natural and social systems to provide information for Earth System governance of relevance to regional and national development.

The INCT for Climate Change research program is structured along four axes: three scientific and one technological (Figure 1):

- the scientific basis of global environmental change;
- research on impacts, adaptation and vulnerability;
- mitigation;
- technological developments and products.

Organizational and Functional Structure



Scientific and Technological Research Projects

The Scientific Basis

1 2 3 4 5 6 7 8

Projects

1 Detection and Attribution of Climate Change and Natural Variability

2 The Amazon

3 Changes in Land Use

4 Global Biogeochemical Cycles

5 Oceans

6 Greenhouse Gases

7 Biosphere-Atmosphere Interactions

8 Reduction of Uncertainties in Models and Climate Change Scenarios

Impacts, Adaptation and Vulnerability Studies

9 10 11 12 13 14 15 16 17 18

Projects

9 Climate Change Scenarios for the 21st Century

10 Agriculture

11 Water Resources

12 Renewable Energy

13 Biodiversity

14 Human Health

15 Coastal Zones

16 Urbanization and Mega-cities

17 The Economy of Climate Change

18 Science, Technology and Policy Studies

Mitigation

19 20 21

Projects

19 Emissions from Lakes and Reservoirs

20 Combustion Processes

21 Reducing Emissions from Deforestation and Forest Degradation (REDD)

Tecnological Products (Models, Geo-Sensors, Natural Disasters Risks)

22 23 24 25 26

Projects

22 Global Climate Change Modeling: the Brazilian Model of the Global Climate System (MBSCG)

23 CPTEC's Atmospheric Global Circulation Model

24 Multi-scale modeling: a Challenge for Future Modeling Efforts

25 Observational Technologies for Climate Change

26 Early Warning System in Support of Natural Disaster Risk Reduction

Rede Clima

Brazilian Research Network on Climate Change

Scientific partner of the INCT FOR CLIMATE CHANGE

In response to the urgency that the challenge of global climate change imposes on society, and the critical need for high quality and relevant scientific knowledge to inform the public policy process on this, the Federal Government of Brazil, through its Ministry of Science and Technology (MCT), established the Brazilian Research Network on Climate Change (*Rede* CLIMA), with the following goals:

1. Provide high-quality scientific information to support international negotiations under the UN environmental conventions (United Nations Framework Convention on Climate Change-UNFCCC, Convention on Biological Diversity-CBD and Convention to Combat Desertification-CCD).

2. Implement studies on detection and attribution of causes and impacts of global and regional climate change in Brazil, emphasizing the identification of vulnerabilities to climate change.

3. Study adaptation strategies of social, natural and economic systems to climate change.

4. Assess the contribution of natural and socio-economic systems to GHG emissions and

propose alternative mitigation pathways.

5. Contribute to policy formulation on climate and environmental change of relevance to Brazil.

6. Promote technological developments for the reduction of GHG emissions.

7. Increase public awareness of environmental and climate change and their impacts in Brazil.

Rede CLIMA is closely linked to the INCT for Climate Change. The former, through existing and planned funding mechanisms, provides additional resources for the successful implementation of the INCT, while the latter provides *Rede* CLIMA with articulation, integration, cohesiveness and networking. Currently, *Rede* CLIMA is organized in ten thematic areas (Agriculture, Biodiversity and Ecosystems, Cities and Urbanization, Regional Development, Economy, Renewable Energies, Water Resources, Health, Coastal Zones, and Climate Modeling) which primarily cover the scientific areas of impacts, adaptation and vulnerability. Three new themes are being added to *Rede* CLIMA in 2011: natural disasters, oceans and ecosystems services.

Science

Highlights

After 18 months of existence, the INCT for Climate Change has made important scientific advances. A brief and non-exhaustive description of such advances is presented here to illustrate the interdisciplinary breadth of research carried out. More detailed results, main publications, and other relevant information can be found in the next four chapters, each of which presenting one of the INCT for Climate Change's four main themes: the Scientific Basis; Impacts, Adaptation and Vulnerability; Mitigation; and Technological Products. Within each theme, several research projects (hereinafter referred to as subprojects) are found, each one covering a particular science or technology theme. In the fifth chapter a list of selected publications is presented. Overall, a significant number of peer-reviewed scientific papers in journals with international circulation, as well as books and book chapters, have been produced through December 2010.

During its first 18 months, the INCT for Climate Change focused on development of research infrastructure and organization. Thus, a great deal of effort was devoted to further establishing collaborations within and outside the INCT, organizing subproject meetings, assembling databases, making bibliographical revisions, setting up field experiments and laboratories, and building the necessary support for their activities.

Key scientific results are summarized in this section.

Climate variability and change, and future climate scenarios. New climate scenarios for South America for the 21st century under different greenhouse gas concentrations suggest that climate change and its related impacts have regional variability: northern areas of the continent are projected to experience rainfall deficiency, while in southeastern South America rainfall is projected to increase. Projections also indicate widespread increase of intense precipitation events and extreme droughts for some regions. One study developed a coherent model to describe how intra-seasonal climatic phenomena interact with the annual and inter-annual (2-7 years) scales leading to decadal/multi-decadal climate variability.

Oceans. Researchers are focusing on understanding projected future changes in extra-tropical cyclones generated over the South Atlantic Ocean, and on understanding projected changes in atmospheric blocking patterns over the sub-tropics and mid-latitudes, which are associated with droughts in Brazilian agricultural regions. In this context, and in order to increase our understanding of the role of the oceans in the present and future climate, some studies are dedicated to investigating the increase in the amount of warm, salty waters that originate from the South Indian Ocean subtropical gyre (the Agulhas current) and enter the South West Atlantic (the Agulhas leakage). Based on preliminary studies suggesting that this increase might be causing changes to the regional climate, researchers are now focusing on detecting and understanding the mechanisms behind such changes.

The Amazon. Important advances have been made in understanding the role that the Amazon region plays in the climate system, including emissions, and the influence of climate, fire activity and deforestation on the equilibrium of tropical forest ecosystems. One study has quantified the effects of fires from biomass burning on the radiation balance of the Amazon forest near Manaus and Porto Velho. Recent measurements showed that up to 30% of solar radiation is being absorbed by aerosols emitted by these fires. They are now investigating the effects of high aerosol concentrations on the health of local populations. Another fire study has refined the calculation of emission factors for the main gases that originate from Amazon biomass burning, thus contributing to a better quantification of their effect on the greenhouse warming of the atmosphere. Another group of researchers developed a method to measure the combined influence of deforestation, global climate change and fire activity on the future spatial distribution of major biomes in the region. Their results indicate that the predicted changes in local climate (generally warmer and drier) from these combined drivers of environmental change can lead to transitions to biomes where the vegetation is relatively sparse, such as transitions from tropical forest to savanna, from savanna to dry shrubland, or from dry shrubland to semi-desert. However, they note that plant fertilization effects from higher CO_2 concentrations could minimize or even compensate for climate change effects on biome distributions. Yet another promising modeling result showed that in the absence of natural fires caused by lightning strikes, the forest-cerrado boundary would penetrate about 200-250 km into the present position of the Cerrado in central Brazil. Finally, some interesting advances have been made in terms of actions directed toward emission reductions via REDD (Reducing Emissions from Deforestation and Forest Degradation) mechanisms. This group has studied a stock-flow approach to the allocation of REDD benefits in Brazil, which could provide a formal mechanism by which Amazon states with low rates of deforestation could participate actively in the process.

Urbanization and Mega-cities. With respect to Brazil's large urban areas, studies detected that extreme rainfall events (greater than 50 mm/day) in the city of São Paulo have become more frequent and intense since 1960, and that this increase can be attributed more to urbanization the so-called urban heat island effect than to climate change caused by global warming. Parallel to these investigations, this research group generated maps of vulnerabilities to climate change for the São Paulo Metropolitan Region and a preliminary map for the city of Rio de Janeiro for floods, landslides and health impacts. In sum, the locally induced climate change in the megacity of São Paulo over the last 50 years has drastically changed environmental conditions and partly explains the increasing number of natural disasters. This research group will undertake a deep analysis of the social, economic and policy responses of the city to current climate change in order to understand determining factors for adaptation.

Economy, health and social issues. From the Brazilian economy point of view, preliminary results suggest that climate change will have adverse effects on the country's growth and welfare, though some sectors and regions may be positively affected. Moreover, an issue to be taken very seriously is that climate change will reinforce Brazil's regional economic inequalities, i.e., the poor will suffer more drastically. This is even more worrisome when looked at from the context of studies on the influence of climate in the transmission of diseases and other human health issues. Studies suggest that climate change needs to be looked at in conjunction with globalization (increase in the connectivity between people, trade and information), environmental changes (ecosystem degradation, biodiversity reduction and the accumulation of toxic substances in the environment), and the undermining of governance systems (via reduced

investments in health, increased dependency on markets and increased social inequalities), since all these factors interact closely and in complex ways. An important advance was made with consequences for the security of human populations that live in areas at risk of natural disasters: the second version of the "Information System for Risk Reduction of Natural Disasters (SISMADEN)", already available on the web, was released. This system provides improved monitoring of natural disasters and risk assessments due to weather and climate extremes in the present, and could be easily applicable for future risks.

New technologies. On the application side of the INCT, and regarding research on mitigation of greenhouse gas emissions, a promising technological initiative involves the replacement of O_2 from air with that from metallic oxides (O_2 carriers) in order to provide hydrogen, instead of CO_2, as a final product in general combustion processes. In the experiments, nickel oxide had the best performance via CLC (chemical-looping combustion; a novel combustion technology with inherent separation of greenhouse CO_2) and CLR (chemical-looping reforming; a novel chemical looping technique to produce synthesis gas and hydrogen). Another group investigating new materials has shown that organic oxidation and nitrate reduction, including surface treatment by micro/nanocrystals of boron or nitrogen-doped films (BDDN), show a huge potential for environmental applications.

Model development. INPE is leading a multi-institutional project to develop the Brazilian Model of the Global Climate System, which incorporates component models of vegetation and land processes, atmospheric chemistry and aerosols, marine ice, biogeochemistry, and river discharge, into INPE's coupled ocean-atmosphere General Circulation Model (GCM). The project is the result of a partnership among more than 50 scientists from several institutions in Brazil and abroad. Global climate change research modeling efforts in Brazil also include a scientific collaboration with the UK Met Office's Hadley Center for Climate Prediction. The hot plume rise algorithm, created at INPE, has been implemented within the HadGEM2-ES (Hadley Centre Global Environmental Model version 2 - Earth System) model, arguably among the world's most sophisticated climate system models. A joint project to develop and implement a forest fire model within HadGEM2-ES has been completed with the participation of INPE researchers who are members of the INCT for Climate Change. The new version of the model was named HadGEM2-ES/INPE. The development of HadGEM2-ES/INPE has moved through the phases of planning, implementation of the hot plume model, and development and validation of the fire model, and is now in the phase of operational suite implementation on the new supercomputer (Cray machine), ranked with the most powerful supercomputers in the world. The scenarios generated by the HadGEM2-ES/INPE model will be important for our understanding of future climate and will consolidate Brazil's participation in the IPCC Fifth Assessment Report (IPCC AR5).

Facilities and Capacity Building

The interaction and integration of the INCT for Climate Change research subprojects depends strongly on the efficiency of the project's organizational structure and the provision of services to facilitate communication. The large size of the INCT, involving over 90 research groups from 65 institutions, and over 400 participants, poses considerable organizational and management challenges. Fortunately, the synergies between the INCT and the MCT's *Rede* CLIMA allow for the sharing of facilities and procedures. In particular, a Project Office (PO) has been established to serve both the INCT and *Rede* CLIMA.

The INCT for Climate Change has the following organizational structure: an Executive Board overseeing overall program implementation; a Project Office at the headquarters of the INCT at INPE, staffed with a Science Officer and administrative personnel, four coordination units dealing with data and intellectual property, communication, relationship to public policies and modeling; and a Scientific Committee, which oversees the scientific implementation of the program by coordinating and promoting communication between research projects.

The Project Office provides participants with the following services and benefits:
a) access to INCT database and information, including access to projections of climate scenarios available in the database; **b)** access to supercomputer facilities, installed at INPE, with the possibility of using numerical climate models or models designed for the study of climate change impacts on sectors and systems;
c) logistical support for the organization of workshops, seminars, technical and scientific meetings;
d) organization of activities for capacity building in the use of computational systems and numerical models; **e)** establishment of a website; **f)** dissemination and communication of research results; **g)** communication and connection with the relevant governmental entities for policy-relevant issues.
In addition to the facilities mentioned above, the partnership with *Rede* CLIMA has allowed the INCT for Climate Change to increase considerably the number of scholarships for students and young researchers. After 18 months of existence, these two projects funded a total of BRL 3.321 million for human capacity building, being BRL 2.6 million through *Rede* CLIMA and BRL 721 thousand through the INCT for Climate Change.

In order to guarantee the material conditions necessary to carry out research, *Rede* CLIMA has provided desks, chairs and cabinets to 28 institutions throughout the country. It is now in the process of delivering 15 servers, 180 desktop computers, 70 laptops, 20 laser printers and 10 UPC units to these institutions. Most of these research institutions are part of the INCT for Climate Change. Finally, through its financial and scientific support, the INCT for Climate Change is helping several of its research projects to build laboratories and field equipment (see research project reports) that will become available to researchers and students from many different regions and fields of research.

The New Supercomputing Facility. Additionally, INPE will be providing full support to researchers from *Rede* CLIMA, the FAPESP Research Program on Global Climate Change and INCT for Climate Change to use the new INPE-*Rede* CLIMA-FAPESP Research Program on Global Climate Change supercomputing facility, inaugurated in December 2010. This facility consists of a state-of-the-art Cray supercomputer that will lead the way to a new era of research advances using complex numerical models of the Earth and climate systems. This supercomputing facility– the largest of its kind in Latin America and in the Southern Hemisphere and one of the most powerful in the world for climate change research–will allow competitive research in climate science and the production of global climate scenarios. It will also allow collaboration with international centers of excellence in climate modeling. INPE will maintain a staff of researchers and computer experts to facilitate the use of climate models on the new supercomputer.

Supercomputing Facility

29th largest computer in the world; 8th largest computer in climate science

TUPÃ = "God of Thunder"

TECHNICAL SPECIFICATIONS	
CPUs	1272 nodes, each with two 2GHz Opteron 12 core and 192 GFlops/s maximum speed, 32 GB of network SeaStar2 memory, totaling 30528 cores
Performance	Maximum of 244 TFlops/s, Effective 15.8 TFlops/s
Primary Disk	Archive system with 866 net TB, accessible at 320 Gbs
Secondary storing	3.84 Petabytes in SATA disks, tape library with 8.000 slots with 8.000 LTO4 tapes, 6 PB of tapes
Ancilliary processing	20 nodes, each with 4 Opteron 4 core of 2.7 GHz, 128 GB of memory with 3760 SPCE aggregate performance
Interactive acces	13 nodes, each with with 4 Opteron 4 core of 2.7 GHz, 128 GB of memory with 2444 SPCE aggregate performance
Physical space, energy and refrigeration	occupies 100m², requires 639 Kw of energy and air refrigeration with 550.000 Kcal/h maximum dissipation

Facts and Figures

CAPACITY BUILDING		
	Current	**Concluded***
MSc's	**39**	**19**
PhD's	**58**	**10**
Post-Doctoral Fellows	**21**	**-**
Undergraduate Students	**23**	**-**
Technical Level	**03**	**-**
Research Scholarships granted by ***Rede*** CLIMA, CAPES and INCT for Climate Change in 2008-2010	**100**	**82**
Doctoral Program on Earth System Science created at INPE	**01**	**-**

* Most of the thesis concluded relate to research projects initiated prior to the creation of the INCT for Climate Change, but which were fully incorporated into it.

PUBLICATIONS*	
Peer reviewed scientific papers in international journals	**112**
Peer reviewed scientific papers in Brazilian journals	**32**
Books	**06**
Book chapters	**25**

*List of publications starts on page 83

KNOWLEDGE AND TECHNOLOGY TRANSFER	
Patent deposited	**01**
Project with industry	**01**
Open Softwares	**02**
Interactions with other INCTs	**05**

OUTREACH ACTIVITIES	
Short Courses	**03**
Events (workshops, seminars etc.)	**45**
Educational Materials (Interactive CD-ROM, e-book for children, illustrated books for Elementary School and High School	**06**
Climate Change related news for TV Broadcasts and Magazines (2009-2010)	**225**

This ferry was transporting trucks to Caapiranga (Amazonas, Brazil) and got stranded in Lake Manacapurú by the receding waters of the extreme drought of 2010 in Amazonia.

Photo: Eduardo Arraut/INPE

Innovative Science

THE SCIENTIFIC BASIS

IMPACTS, ADAPTATION AND VULNERABILITY STUDIES

MITIGATION

TECHNOLOGICAL PRODUCTS

In what follows, the 26 research projects of the INCT for Climate Change are introduced and their main accomplishments in 2009-2010 are presented. The current status of each project is indicated at the top left of the page. Projects that are building equipment, carrying out meetings to establish main goals, and carrying out other activities prior to data collection are classified as in IMPLEMENTATION phase. Projects that are collecting data are classified as in the DEVELOPMENT phase. Eventually, by the time of project finalization, projects that will be carrying out the final data analyses, discussing results and elaborating reports will be classified as in the SYNTHESIS phase.

HIGHLIGHT

Three regional climate models (Eta CCS, RegCM3 and HadRM3P) nested within the HadAM3P global model showed warming of up to 6-8°C for the IPCC A2 high emission scenario for the period 2071–2100. Warming is predicted to be more intense in the 5°N-15°S band. In Southern South America, projections are that warming in summer will vary from 2-4°C, and from 3-5°C in winter. Projected rainfall changes suggest increase in the Northwest coast of Peru-Ecuador, and Southeastern South America, and a decrease in the Eastern Amazon and Northeastern Brazil. Regarding the observational studies, it was detected that, in the city of São Paulo, extreme rainfall events above 50 mm/day have become more frequent and intense since 1960, due more to urbanization effects than to natural climate change.

KEY RESEARCH QUESTIONS

What are the main observed changes in rainfall extremes in large Brazilian cities during the last 60 years? Do climate models project trends in rainfall extremes until the end of the twenty first century that are consistent with the observed tendencies? Would these observed and projected changes be due to human activities (urbanization) or to natural climate variability?

DEVELOPMENT

KEYWORDS

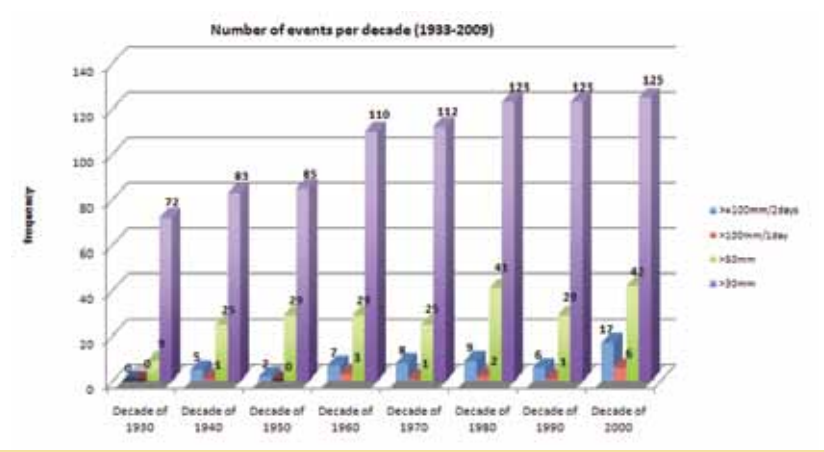
Extra tropical cyclones, megacities, extreme climate events, regional climate models, lightning discharge data, rainfall extremes.

Detection and Attribution of Climate Change and Natural Variability

The Intergovernmental Panel on Climate Change (IPCC), established in its Fourth Assessment report (AR4), disclosed in 2007, that global warming is unequivocal and that human activities have contributed significantly to the warming observed during the last 50 years. This project explores the issues of detecting such changes and attributing its causes.

Detection of climate change is the process of demonstrating that climate has changed in some defined statistical sense, without providing a reason for that change. *Attribution* of causes of climate change is the process of establishing the most likely causes for the detected change, with some defined level of confidence. Detection and attribution depend directly on observational data, climate projections and/or simulations.

Climate varies continually in all time scales. Thus, this research project is contributing to a better understanding of weather and climate variability and change in Brazil over several different time scales. It is important to know if the observed changes can be explained by natural climate variability, or human induced changes in the form of land use for urbanization and/or increase in the greenhouse gases GHG concentration.



Intense rainfall events (days with rainfall > 30, 50 and 100mm) in the city of São Paulo (Água Funda Meteorological Station – IAG/USP) per decade (1933-2009). (Source: Julia Reid, CCST/INPE).

COORDINATORS

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CAPACITY BUILDING

Three PhD and four MSc students are working on issues referring to long-term climate variability and change in South America, considering detection of observed change based on long-term observations and climate change projections, from both IPCC AR4 global models and regional climate model projections.

FACILITIES

A computer cluster and data storage environment was acquired by the Climate Studies Group (GeEC) of the USP-Department of Atmospheric Sciences to help with the simulations of present and short-term future climate using a variety of regional models.

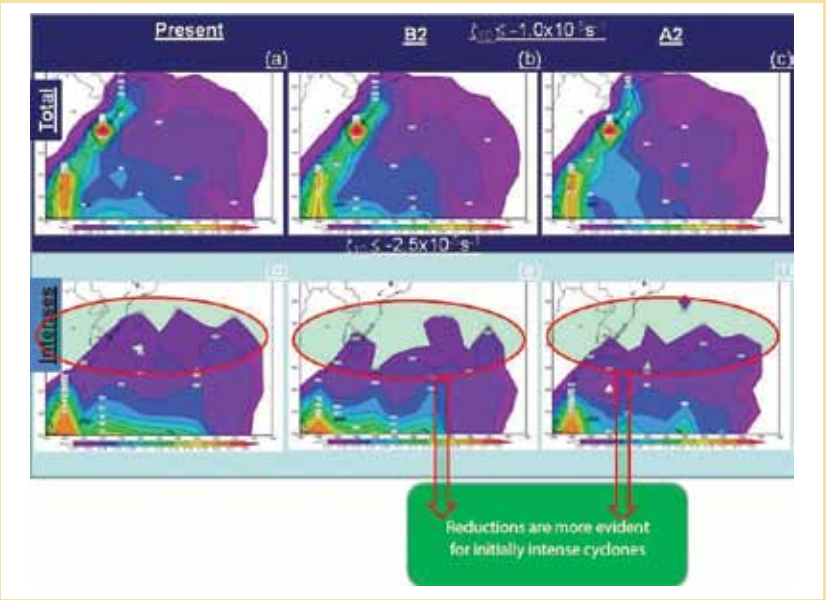
KEY EVENTS

A general meeting with all members of this project was held in order to organize tasks and responsibilities and to establish the research agenda. Presentations of results of this project have been made at scientific events such as the XVI Congress of the Brazilian Meteorological Society, in Belém, Pará and at the American Geophysical Union Annual Meeting in Iguassu Falls, Paraná.

Science Highlights

Three regional climate models (Eta CCS, RegCM3 and HadRM3P) were nested within the HadAM3P global model. Simulations covered a 30-year period representing the present climate (1961–1990) and a future scenario was defined for the IPCC A2 high emission scenario for the period 2071–2100. The focus was on changes in the mean circulation and surface variables, particularly surface air temperature and precipitation. The three models showed warming of up to 6-8°C, more intense in the tropical region, especially in the 5°N-15°S band. In Southern South America, warming in summer varied between 2-4°C, while the projected variation for the same region in winter was between 3-5°C. Projected rainfall changes suggest rainfall increase for the Northwest coast of Peru- Ecuador, and Southeastern South America, and rainfall decrease in the Eastern Amazon and Northeastern Brazil.

As for observational studies, it was detected that extreme rainfall events above 50 mm/day have become more frequent and intense since 1960 in the city of São Paulo, due more to urbanization effects than to natural climate change.



Mean annual cyclone density in the present climate (1975-1989) and A2 and B2 (2071-2085) scenarios simulated by the RegCM3. (Source: Luis F. Kruger 2009 IAG/USP).

SCIENCE-POLICY INTERFACE

Results are being used for an INPE-UNICAMP-USP-IPT-UNESP study on Vulnerability of the City of São Paulo to Climate Change, and on impacts analyses and vulnerability assessments for various sectors for the 2nd National Communication of Brazil to the UNFCCC, as well as for providing information to the Brazilian Panel on Climate Change on observed tendencies and projected climate change scenarios in Brazil and South America.

SELECTED PUBLICATIONS

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Reboita MS, Da Rocha RP, Ambrizzi T & Sugahara S. South Atlantic Ocean cyclogenesis climatology simulated by regional climate model (RegCM3). Climate Dynamics. DOI: 10.1007/s00382-009-0668-7. (Published online: 23.09.2009).

HIGHLIGHT

Measurements of the impact of emissions from biomass burning showed that up to 30% of the solar radiation is absorbed by aerosols emitted by such burning.

KEY RESEARCH QUESTION

How does the Amazon currently function as a regional entity and how will changes in land use and climate affect the biological, chemical and physical functions of the Amazon, including the sustainability of development in the region and its influence on global climate (LBA overarching questions)?

DEVELOPMENT

KEYWORDS

Amazon, deforestation, climate, aerosols, health, biogeochemistry cycles, LBA.

The Amazon

A. C. Ribeiro

Implementation of a monitoring system in Manaus. A fully equipped container with aerosol instruments has been installed in a pristine tropical forest area. This station is located close to a 60 meter-high micrometeorological tower at INPA´s Reserva ZF2, and situated in a small basin (Cueiras River) 65 km from the city of Manaus. The instruments measure the properties of aerosols and correlate them with atmospheric characteristics.

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The main research topic of this project is to understand the integrated functioning of the Amazon ecosystem through the understanding of the integrated dynamics of several of its components (physical climate, human health, hydrology, atmospheric chemistry, and others). The research is being conducted as part of the LBA Experiment and is an interdisciplinary initiative involving organizations from SE Brazil (IF/USP, IAE/CTA, INPE, FIOCRUZ, CENA/USP) and Amazonian Universities (UFPA, UEA, UNIR, etc.). The aim is to study the natural physical-chemical-biological processes that regulate the functioning of the Amazonian ecosystem, as well as the changes caused by anthropogenic influences, such as changes in land use and cover and global climate change. The main focus is the analysis of data, some of which have already been collected (LBA RACCI 2002, AMAZE 2008, etc.). Moreover, environmental modeling is also being conducted.

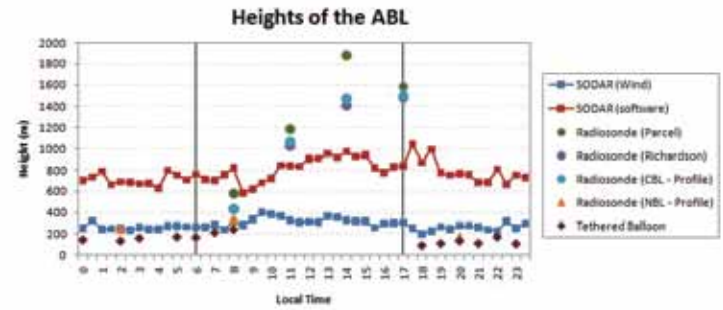
CAPACITY BUILDING

During this initial phase of the project, eight students at MSc and PhD levels that used data collected in previous experiments (within the LBA framework) finished their postgraduate programs. There are three post-doctoral fellows, six PhD students, five MSc students and four undergraduate students working on this project.

Science Highlights

Two permanent monitoring stations were installed and are in continuous operation in the Amazon, in Manaus (one in a pristine area and the other in an undisturbed area) and Porto Velho (one in a disturbed area). They measure the impact of emissions produced by biomass burning on regional climate, particularly on the radiation budget and on cloud microphysics. Changes in the radiation balance are very pronounced, with up to 30% of the solar radiation being absorbed by aerosols emitted by biomass burning. Studies of health impacts are being correlated with these measurements. The boundary layer over forest and pasture is very important for the GHG gases (mainly carbon dioxide) because it couples the processes at the surface and the lower atmosphere. The boundary layer over pasture is deeper and more energetic, and thus can trigger convection during the onset of the rainy season.

The carbon content in streams was also measured for pasture and forest sites in the Amazon, as well as transition to Cerrado, and presented high values of carbon loss due to evasive CO_2 fluxes.



The time evolution of the atmospheric boundary layer growth over pasture area in southwestern Amazon (Rondonia) derived by several different methods.

SCIENCE-POLICY INTERFACE

The influence of aerosols due to deforestation (biomass burning) on human health (rate of mortality and number of hospital admissions) is being investigated. Future results will determine actions to be taken in order to preserve society's well-being.

SELECTED PUBLICATIONS

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IMPLEMENTATION

HIGHLIGHT

Fieldwork and scenario workshops were carried out in one of the study sites (Santarém region) with the aim of identifying institutional arrangements that shape land use dynamics in the region.

KEY RESEARCH QUESTIONS

How interrelated are the trajectories of land systems and the evolution of institutional arrangements in the Amazon?

How can such co-evolution of land use systems and institutional arrangements be represented in computational models and scenarios of land use change?

KEYWORDS

Land use change, institutional arrangements, remote sensing, computational models, Amazon, deforestation, agriculture.

Changes in Land Use

Cuiabá (MT), 22/12/2003

The emission of CO_2 related to changes in land use and land cover is one of the major factors associated with climate change. In Brazil, deforestation of the Amazon is the main reason why the country is the world's 4th or 5th largest emitter of carbon to the atmosphere. The Brazilian Amazon occupies an area of about 5 million km² and, to date, about 17% of the forest has been removed.

In this project, the understanding of the dynamics of land use in the Amazon at different scales is being improved, and subsidies are being generated for the construction of environmental models that analyze the bidirectional relations between deforestation and climate change. In order to achieve this, a set of integrated themes and questions has been defined: (1) Monitoring of changes, on the basis of remote sensing data; (2) Analysis of the socioeconomic dynamics and of the vulnerability of city systems to these changes; (3) Modeling of changes, with focus on the interactions between social and environmental systems and on scenario building.

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CAPACITY BUILDING

One MSc student is finishing his thesis about institutional arrangements and scenarios in the Santarém region, and two other MSc students are concluding their theses on Land Use and Cover Change (LUCC) modeling. Six PhD and two MSc theses on modeling, remote sensing and land-use dynamics are being developed in the context of the project.

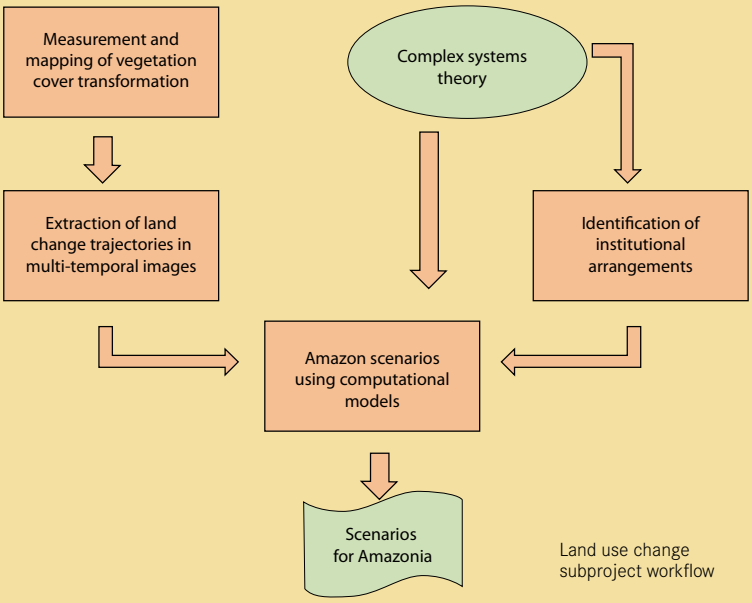
KEY EVENTS

A general meeting with all members of this project was held in order to organize tasks and responsibilities.

Science Highlights

Research is being carried out through comparative case studies, combining methods from social analysis of institutional arrangements (focusing on land tenure and planning, market arrangements, and measures for controlling deforestation), remote sensing, landscape ecology and dynamic modeling. The first case study is in the Santarém region. There, fieldwork and scenario workshops were held during the first year of the project, aiming at identifying the institutional arrangements that shape land use dynamics in the region.

Simultaneous lines of research are being worked on with a two-fold goal: besides the understanding of the institutional arrangements and the construction of scenarios, the project aims at improving remote sensing, landscape analysis and dynamic modeling methodologies. These lines of research contribute to the overall project research question through the case studies. For instance, the main results of the modeling subgroup were the establishment of a LUCC modeling framework in the TerraME modeling environment, including support for top- down/allocation models, agent-based models and dynamic coupling of multi-scale models.



Land use change subproject workflow

SCIENCE-POLICY INTERFACE

This project has close links with public policies in that it aims at understanding those institutional arrangements that shape land use in the Amazon. Such knowledge will be made available to society through reports and participatory scenario construction processes, which can be expected to support policy planning at different scales..

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Moreira E, Costa S, Aguiar AP, Câmara G, Carneiro T. Dynamical coupling of multiscale land change models. Landscape Ecology, vol 24(9): 1183-1194, November 2009 (DOI: 10.1007/s10980-009-9397-x).

IMPLEMENTATION

HIGHLIGHT

The successful mobilization of key scientists to produce documents synthesizing current Brazilian knowledge of biogeochemical cycles, and the production of datasets on stocks and fluxes of carbon, nitrogen and phosphorus in a variety of ecosystems in Brazil.

KEY RESEARCH QUESTIONS

How will the climate change scenarios projected for this century affect the structure and functioning of the main Brazilian biomes?

How will changes in the structure and functioning of the main Brazilian biomes affect aquatic ecosystems, coastal waters and the Atlantic Ocean?

KEYWORDS

Biogeochemical processes, climate change, ecosystem functioning, Brazilian biomes.

Global Biogeochemical Cycles

COORDINATORS

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Methane bubbles emitted by floodplain lake during the low-water season in the Amazon region.

Biogeochemical cycles connect the atmosphere to the biota, soil, groundwater, surface water and the oceans. The carbon and nitrogen cycles are mediated by biological reactions performed by plants, animals and microorganisms, which in turn are dependent on the temperature of the environment in which they live and the amount of water available. Because global changes potentially alter planetary temperature and rainfall distribution, these changes could modify the functionality and distribution of organisms on the Earth and, therefore, change the biogeochemical cycles.

Such changes could exceed the capacity of ecosystems to provide environmental services essential to the survival of our species. It is thus important to understand how ecosystems operate the C and N cycles, to allow for the prediction of possible changes and the adoption of mitigation and adaptation actions. Due to the close relationship between energy and matter fluxes in ecosystems and biodiversity, this project is developed in cooperation with the Biodiversity sub-project of the INCT for Climate Change.

CAPACITY BUILDING

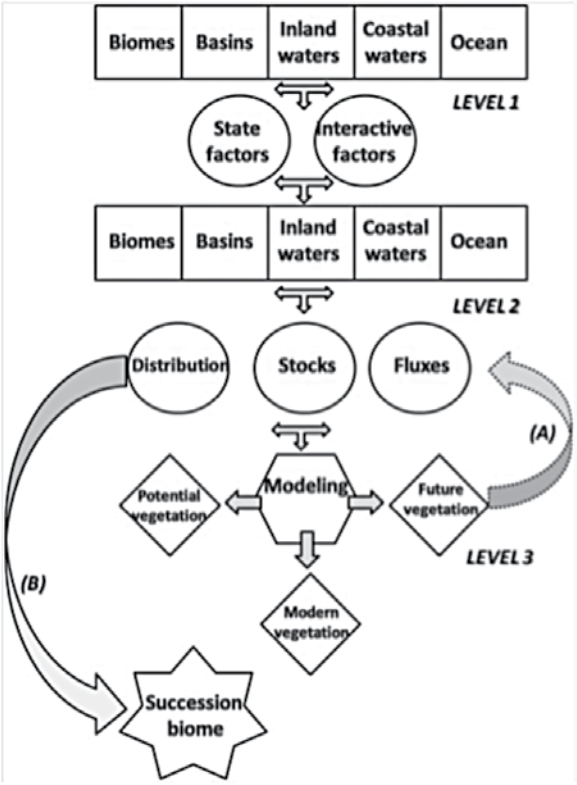
There is one post-doctoral fellow allocated at the University of Brasilia.

KEY EVENT

The Workshop Brazilian Biomes and Climatic Change: An Ecosystem Ecology Approach, held November 8-13, 2010, to which biogeochemists specialized in different Brazilian biomes and watersheds, inland waters, coastal waters and oceans were invited.

Science Highlights

Two major activities are being developed: 1) The construction, through literature search, of a database containing information about carbon, nitrogen and phosphorus fluxes and stocks in different ecosystem compartments. This information will be important to help understand regional problems related to, for example, land use. Furthermore, they will enable the prediction of future impacts caused by climate change and their effects on biogeochemical cycles. This database could be used as reference by several of the INCT for Climate Change projects. 2) Production of a special issue of the Brazilian Journal of Biology with current knowledge on biogeochemical cycles in the Brazilian biomes and watersheds, connecting the terrestrial environment with the estuaries and inland waters. These outreach articles will help disseminate the new scientific knowledge to the broader public.



Framework of the entire operation plan of the workshop and themes for the white-papers.

SCIENCE-POLICY INTERFACE

The understanding of the processes that lead to the maintenance of the global biogeochemical cycles, as well as those related to biodiversity and land-use change, is an important pre- requisite for the production of the basic knowledge necessary for environmental conservation at local and global scales.

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Della Coletta L, Nardoto GB, Latansio-Aidar SR, Rocha HR, Aidar MPM, Ometto JPHB. An isotopic view of vegetation and carbon and nitrogen cycles in a Cerrado ecosystem, southern Brazil. Scientia Agricola, v. 66, p. 467-475. 2009.

Ometto JPHB and Martinelli LA. Ciclos Biogeoquímicos. In: Marcos Buckeridge (ed) Biologia e Mudanças Climáticas no Brasil. Rima Editora. 2009.

HIGHLIGHT

Preliminary experiments with the Hybrid Coordinate Model HYCOM showed that, in accordance to some other studies in the region, the export of Indian Ocean waters into the SW Atlantic might be causing some changes in the latter that could impact the regional climate.

KEY RESEARCH QUESTION

What are the impacts and consequences of the increase in export of Indian Ocean waters into the SW Atlantic's subtropical gyre (a phenomenon called the "Agulhas Leakage")?

IMPLEMENTATION

KEYWORDS

Atlas Buoy, Southwestern South Atlantic, ocean-atmospheric interactions, Agulhas Leakage, South Atlantic Convergence Zone, Equatorial Atlantic thermocline depth simulation.

Oceans

COORDINATORS

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This subproject is a contribution to the understanding of ocean-atmosphere properties, and their interactions in the SW Atlantic, that are relevant to the climate in South America. The research is being conducted combining fieldwork and numerical modeling and it benefits from the cooperation between several institutions from Brazil and abroad.

The observational framework is based on the construction and deployment of a Brazilian prototype of the Atlas buoy, similar to the PIRATA and TAO Arrays. This buoy, known as "Atlas-B", will be moored in the vicinity of 28°S/42°W, off Southeastern Brazil. In order to moor and service the buoy, at least one oceanographic cruise will be carried out per year, with the conduct of a repeat hydrographic survey across the Brazil Current.

The numerical modeling component is based on the implementation of an Eddy-Resolving Ocean General Circulation Model (OGCM) to study the circulation forced with observed wind products, and a coupled ocean-atmospheric model to investigate the impact of changes in the SW Atlantic on the climate over the adjacent continental region.

CAPACITY BUILDING

In 2009, one student started his MSc program at IOUSP with the objective of analyzing numerical simulations to investigate the impacts of changes in the wind stress on the Agulhas Leakage.

FACILITIES

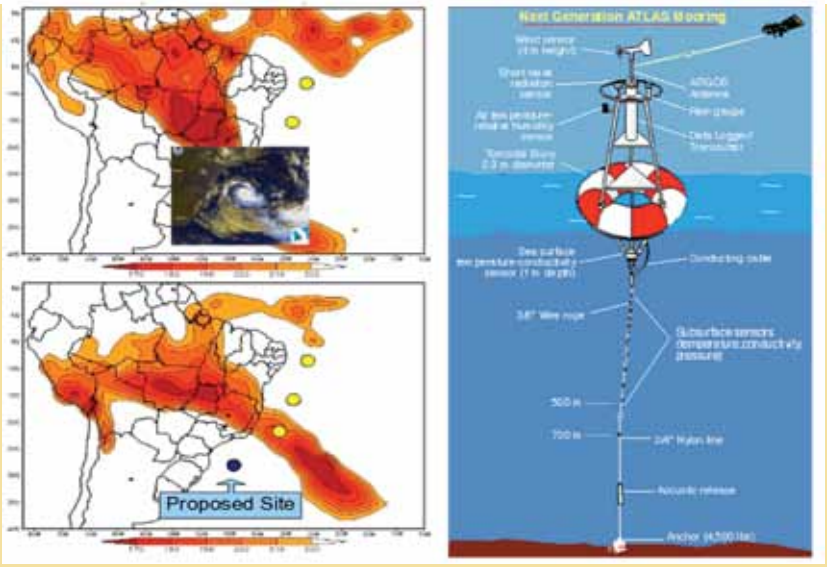
With additional funding granted by CNPq, this project is enhancing the instrument calibration capability of the Ocean Instrumentation Laboratory at IOUSP.

KEY EVENTS

The ocean-modeling workshop at INPE, held in October 2009, had the participation of the major ocean modeling groups in Brazil. These discussed, amongst other things, the development of the Brazilian Model of the Global Climate System. The 1st Annual Workshop, immediately following the SAMOC3 meeting, was held in Niteroi, RJ, in May 2010.

Science Highlights

With the additional funding provided by the Brazilian National Research Council (CNPq), this project is starting to construct, and will later deploy, the Brazilian version of the Atlas Buoy ("Atlas-B"). The construction and deployment of the ATLAS-B system at 28°S/40°W, during 2011, will allow for the collection of oceanographic data time-series to be used in the creation of e a coupled ocean-atmosphere model of the South Atlantic Convergence Zone-SACZ. This model will be used in tandem with the ocean-atmosphere data being collected by the southwestern extension of the PIRATA buoys array over the SW Tropical Atlantic. With data collected by the Brazilian Satellite (SCD), built and operated by the National Institute for Space Research (INPE), and with the deployment of the ATLAS-B buoy by the Brazilian Directorate of Hydrography and Navigation (DHN) in the South Atlantic, this project will become the first fully Brazilian sustained oceanographic monitoring system with a deep sea moored buoy.



The Oceanographic subproject of the INCT for Climate Change is based on observations and modeling of ocean-atmosphere interactions in the Western South Atlantic. The dark blue circle in the lower-left panel indicates the location planned for the deployment of the "Atlas-B" buoy (right panel). The yellow circles are the PIRATA-WE buoys. In place, the "Atlas-B" buoy will provide invaluable datasets for studying the SACZ variability and for enhancing our capability to predict extreme events such as the Catarina Hurricane, shown in the upper-left panel.

SCIENCE-POLICY INTERFACE

The data collected by the "Atlas-B" buoy will help detect cyclones in the South Atlantic when they are still being formed, prior to their arrival at the Brazilian coast. This will be important for the prevention of disasters such as the Catarina Hurricane that wreak havoc on coastal cities of the states of Santa Catarina and Rio Grande do Sul, in March 2004.

SELECTED PUBLICATIONS

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HIGHLIGHT

The collaboration of this research group with the Observational Technologies for Climate Change project has resulted in the implementation of a laboratory to study atmospheric aerosols and water quality.

KEY RESEARCH QUESTION

How will absolute and relative concentrations of greenhouse gases be modified by alterations in cropping land, biomass burning and fossil fuel uses in Brazil?

IMPLEMENTATION

KEYWORDS

Greenhouse gases, time-series data, gas emissions.

Greenhouse Gases

Pantanal do Miranda, Mato Grosso, Brazil

There is presently an understanding that the increase in greenhouse gases (GHGs) in the atmosphere constitutes a strong component of climate change due to its influence on the energy balance of the Earth system, resulting in a positive feedback (warming), mainly in the past five decades. To evaluate and mitigate the effects of growing GHGs concentrations in the climate system, and especially the effects in Brazil, it is necessary to improve the understanding of the processes related to the emission, chemistry and transport of these gases into the atmosphere, as well as their interaction with the biosphere.

The main objective of this project is to obtain historical data to build a time-series of greenhouse gases, focusing on CO_2, CH_4 and N_2O, by implementing monitoring stations in two sites: Maxaranguape/RN and Pantanal/MS. Such data will be used to track the changes in gas concentrations in the atmosphere, as well as in models where they will help evaluate the climatic impacts of variations in the gas concentrations in local, regional and global scales.

COORDINATOR

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FACILITIES

The group has a laboratory that is prepared to carry out gas chromatography and is, thus, useful for the identification of the main greenhouse gases (CO_2, CH_4, N_2O).

Science Highlights

Few studies are discussing the emissions of methane from the wetlands in the Pantanal region, though they have become very important because of their relevance to the global methane budget. Pantanal is subject to annual flooding from November to March/April, and this produces the environmental conditions that result in methane emissions increase. The emissions obtained in the experiments (global average of 117mgCH_4 m-2 day-1) showed marked seasonal variation, with annual averages similar to those observed for the Amazon.

The Experimental Station at the Maxaranguape site (5°29'22"S, 35°15'39"W) is located close to the Atlantic Ocean, on the northeastern cost of Brazil. It is used to make greenhouse gases sampling and ozonosonde launching. The site is about 70 km from the INPE regional center at Natal, RN.

SCIENCE-POLICY INTERFACE

Knowledge of the processes related to the increase in the concentrations of GHGs in the atmosphere is one of the main grounds for discussions regarding impacts, attribution and mitigation.

SELECTED PUBLICATIONS

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HIGHLIGHT

A model of the combined influences of deforestation, global climate change, and fire activity on the future spatial distribution of major biomes in South America indicates that the predicted warmer and drier local climate will cause biomes to change to forms with sparser, less-biomass vegetation. Fertilization from higher CO_2 concentrations, however, could minimize or even compensate for climate change effects on the biomes' distribution.

KEY RESEARCH QUESTIONS

What is the present state (spatial and seasonal) of vegetation and land use in South America?

Taking into account the bidirectional interactions between the atmosphere and the vegetation cover, will possible impacts of climate change on ecosystems in South America be amplified or counter-balanced?

DEVELOPMENT

KEYWORDS

Biosphere-atmosphere models, vegetation dynamics, land cover and land use maps.

Biosphere-Atmosphere Interactions

This project started in 2009 with the goal of producing new environmental analyses that could take into account the bidirectional influences that connect the biosphere to the atmosphere, focusing on South America. To this end, research activities have concentrated on the use of computer models to simulate the dynamics of the terrestrial ecosystems in the region, supposing different land use and climate scenarios. Major progress was made by structuring and determining the main tools for the research. Currently, focus is on the process of implementing and testing models and building human capacity. There is substantial exchange of research experiences with other related projects planned to strengthen the research agenda. This includes contributions to the development of the new Brazilian Model of the Global Climate System, to the Brazilian Research Network on Climate Change (*Rede* CLIMA) and to the FAPESP Research Program on Global Climate Change.

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CAPACITY BUILDING

There are five undergraduates, one student with a Technical Development grant, two PhD students and one postdoctoral fellow working on this project. A short course on the scientific basis of climate change was also given to the Institute of the Environment of the State of Bahia Government.

KEY EVENTS

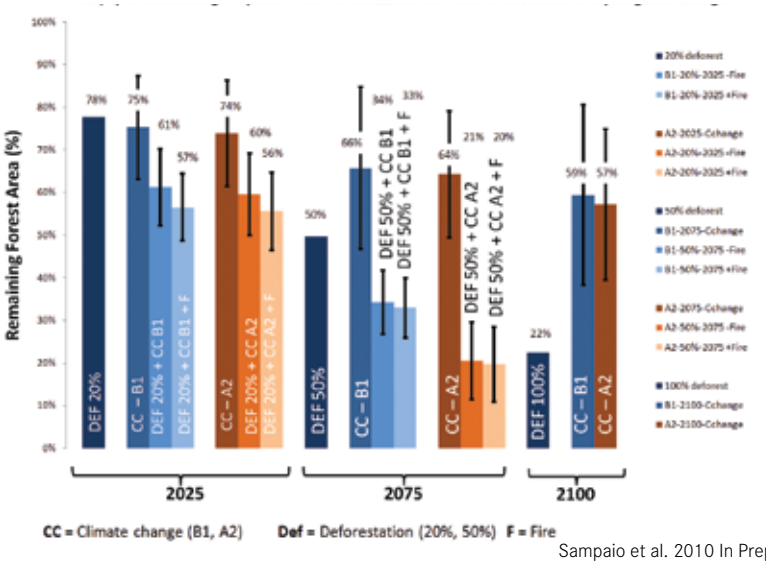
The "Workshop of the Brazilian Model of the Global Climate System/ Land surface Component", on July 27-31, 2009 in Cachoeira Paulista, SP, Brazil.

Science Highlights

(i) At large scales, different levels of fire occurrences and deforestation can be explained by broad patterns of atmospheric wetness and soil-moisture seasonality in the region. (ii) A study of the impacts of changes in the rainfall regime to the vegetation's carbon balance using a dynamic vegetation model showed that an increase of interannual variability of precipitation may cause changes in the ecosystem. This indicates that the rainforest is stable for a realistic range of current variations, but a sequence of below-average dry years may cause a collapse of the rainforest. (iii) A method developed to combine the influences of deforestation, global climate change, and fire activity on the future spatial distribution of major biomes in the region indicated that the changes in local climate (generally warmer and dryer) from these combined processes can support transitions to biomes where the vegetation is relatively sparse, such as transitions from tropical forest to savanna. Fertilization from higher CO_2 concentrations, however, could minimize or even compensate for climate change effects on the biomes' distribution.

(iv) Modeling results show that in the absence of natural fires caused by lightning strikes, the forest-Cerrado boundary would penetrate about 200-250 km into the present position of the Cerrado of Central Brazil.

Area (%) of Remaining Tropical Forest in the Amazon for Various Scenarios of Synergistic Change



Sampaio et al. 2010 In Prep.

SCIENCE-POLICY INTERFACE

The maps produced will help policy makers decide which regions and biomes are more vulnerable to climate change, so that conservation policies and investments can be more effective at local and regional scales.

SELECTED PUBLICATIONS

Bustamante Becerra J. A, Shimabukuro Y. E., Alvalá R. C. S. Relação do padrão sazonal da vegetação com a precipitação na região de cerrado da Amazônia Legal, usando índices espectrais de vegetação. Revista Brasileira de Meteorologia, v.24, n.2, 125-134, 2009.

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Hirota, M., Nobre C., Oyama M. D., Bustamante M. M. The climatic sensitivity of the forest, savanna and forest–savanna transition in tropical South America. New Phytologist, 187, 707–719. 2010.

Salazar LF & Nobre CA. Climate change and thresholds of biome shifts in Amazonia. Geophysical Research Letters, v. 37, L17706, 5 pp. 2010.

Zanchi FB, Waterloo MJ, Aguiar LJG, Von Randow C, Kruijt B, Cardoso FL & Manzi AO. Estimativa do índice de área Foliar (IAF) e Biomassa em pastagem no estado de Rondônia, Brasil. Acta Amazonica, 39(2): 335-348.10.1590/S0044-59672009000200012. 2009.

DEVELOPMENT

HIGHLIGHT

Analysis of uncertainties were made for the global projections from the IPCC AR4 global models and for the regional projections derived from the Eta CPTEC regional model for South America. A field campaign took place in March 2010 in Alcantara-Maranhão, Northeastern Brazil, (Projeto CHUVA). It had the objective of estimating uncertainties in model rainfall simulations using *in situ* field campaigns; this data was later assimilated in the CPTEC global and regional models.

KEY RESEARCH QUESTIONS

How can the uncertainties in the projections of future climate generated by global and regional models be estimated?

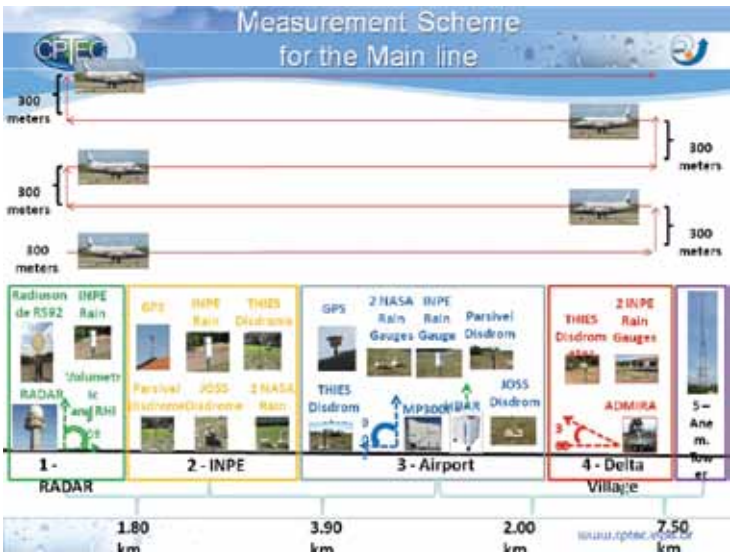
How can uncertainties in important processes such as simulation/projection of rainfall be reduced?

KEYWORDS

Climate change projections, uncertainty analysis, field campaign, regional climate models, global climate models, cloud microphysics.

Reduction of Uncertainties in Models and Climate Change Scenarios

Two approaches for uncertainty analysis are being carried out: (1) The first involves the estimation of uncertainties in ensembles of projections of the UK Met Office Hadley Centre HadCM3 global model, for the A1B emission scenario. By using the Perturbed Physics Ensemble (PPE) method, four members of the HadCM3 model have been used as boundary conditions for the Eta-CPTEC regional model, and projections for 2010-2100 were derived from this downscaling. First, the PPE method is applied to assess uncertainties at the river basin level (São Francisco, Amazon and Paraná), and then it is applied to each grid point throughout South America. (2) The second approach considers uncertainty analyses of rainfall observations; these are used to assess long-term trends, as well as uncertainties in the simulation of rainfall from global and regional climate models. The introduction of cloud physics processes in the modeling process reduces errors in the simulations of rainfall in the climate models. Improved global precipitation retrievals from satellite allows for the study of possible changes in rainfall regimes with greater accuracy. In order to achieve this, in situ rainfall measurements from the Projeto CHUVA field experiment will help understand cloud processes and thus improve rainfall calibration, while permitting a better microphysical description in cloud resolving models, and, consequently, generate more realistic future rainfall projections.



Measurement strategy of the CHUVA field campaign

COORDINATORS

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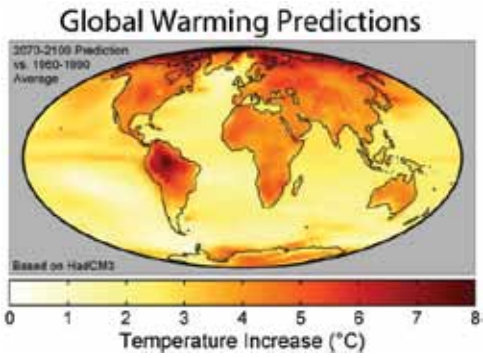
CAPACITY BUILDING

Eight PhD students are involved with the field campaigns and several post-doctoral positions are being established to work on the field campaign data analysis of the CHUVA campaign. Two PhD students are working in collaboration with UK Met Office researchers in the implementation of the PPE method for climate change projections.

KEY EVENTS

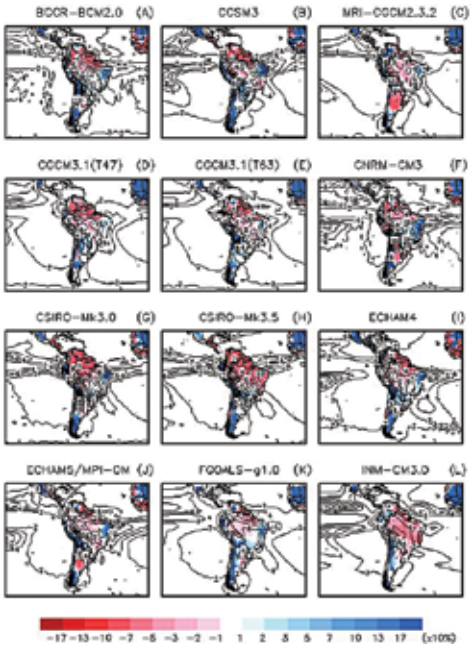
A general meeting involving all INCT for Climate Change, CPTEC and INPE's Earth System Science Center (CCST-INPE) members was organized in December 2009. Special Sessions were held at the American Geophysical Union Annual Meeting in Iguassu Falls, Paraná, and at the Second International Conference of Climate and Sustainable Development in Semiarid Regions, which took place in Fortaleza, Ceará, in 2010.



Science Highlights

The new regional climate scenarios are already being used by various groups of the INCT for Climate Change, *Rede* CLIMA and other research groups from universities and federal institutes, mainly involved with impact analyses and vulnerability assessments. These activities are part of the efforts to prepare the 2nd National Communication of Brazil to the United National Framework Convention on Climate Change Convention (UNFCCC). The project works with the development of an improved version of the Eta CPTEC regional models that include changing GHG concentration and dynamic vegetation scheme (resolution 20 or 40 km) forced with various global climate models and for various emission scenarios until 2100. This shows synergies with the Brazilian Model of the Global Climate System (MBSCG) sub-project, which is generating climate change scenarios for Brazil and Latin America. The Eta CPTEC regional model will also run with the global projections from the MBSCG as boundary conditions.

The second component will carry out field experiments at seven sites to investigate the different precipitation regimes in Brazil. It intends to further the knowledge of cloud processes in order to reduce uncertainties in precipitation estimation, mainly from warm clouds, and consequently improve knowledge of the water and energy budget.



Austral summer climatology (December-February) simulated by 12 IPCC AR4 global models for 1901-1998. Contours (every 2 mm/day) represent the actual rainfall and colors represent the bias (simulates minus observed, x10%).

SCIENCE-POLICY INTERFACE

The work using future climate change scenarios to estimate the impacts and vulnerabilities of climate change includes various sectors, such as agriculture, water resources, biodiversity, human health, semiarid regions, tourism and coastal zones. The climate change scenarios for Brazil and Latin America will be depicted in the form of national or regional reports and thematic georeferenced maps, so that the adverse effects of climate change in the short, medium and long term can be identified and governments can decide on adaptation options and measures.

SELECTED PUBLICATIONS

Diedhiou A, Machado LAT, Laurent H. Mean Kinematic Characteristics of Synoptic Easterly Disturbances over the Atlantic. Advances in Atmospheric Sciences, v. 27, p. 1-17, 2010.

Marengo JA, Chou SC, Kay G, Alves LM, Pesquero JF, Soares WR, Santos DC, Lyra AA, Sueiro G, Betts R, Chagas DJ, Gomes JL, Bustamante JF & Tavares PD. Development of regional future climate change scenarios in South America using the Eta CPTEC/HadCM3 climate change projections: Climatology and regional analyses for the Amazon, São Francisco and the Parana River Basins. Accepted, Climate Dynamics.

HIGHLIGHT

Regional climate change projections until the end of the 21st century have been derived from the downscaling of the global HadCM3 model using the Eta-CPTEC regional climate models. These have been generated for South America, at a resolution of 40 km latitude-longitude, and are being used for impact studies and analyses of climate extremes in various key sectors, with the aim of designing adaptation measures. Examples of the application of such new future climate scenarios are the vulnerability assessments of the Metropolitan Region of São Paulo and other large Brazilian cities to projected climate extremes.

KEY RESEARCH QUESTION

What will be the changes in patterns of regional rainfall, air temperature and winds, as well as rainfall and temperature extremes in South America, during the 21st century?

DEVELOPMENT

KEYWORDS

Climate modeling, climate change scenarios, uncertainty assessments, downscaling.

Climate Change Scenarios for the 21st Century

This project investigates regional climate change using projections derived from the Eta CPTEC regional model nested in the UK HadCM3 global model. Focus is on the generation of detailed high resolution scenarios of future climate change in South America needed for impact studies and vulnerability analyses. Projections of climate extremes (dry spells, intense rainfall events, heat and cold waves) are also being generated. All of these projections were generated up to 2100, at a resolution of 40 km of the Eta-CPTEC regional model. The projections include the period 2010-2100 and the present 1961-90, with a horizontal resolution of 40 km (latitude-longitude) for the IPCC A1B emission of greenhouse gases (intermediate level).

Some important studies already using these regional climate change scenarios include analyses of extremes and risk assessments related to desertification in the semiarid region of Northeastern Brazil, and impacts of climate change and extremes in Brazilian megacities, particularly São Paulo and Rio de Janeiro.

COORDINATORS

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Flood in Santa Catarina (SC), November 2008

CAPACITY BUILDING

A PhD student at INPE´s Meteorology post-graduate program is analyzing regional and global patterns of climate change from IPCC AR4's global climate models and the upcoming IPCC AR5 runs, as well as from the current Eta-CPTEC regional climate change scenarios being generated in this project. Moreover, there is activity directed at capacity building of post-graduate students, post-doctoral fellows and researchers from other institutions in Brazil and other South American countries.

KEY EVENTS

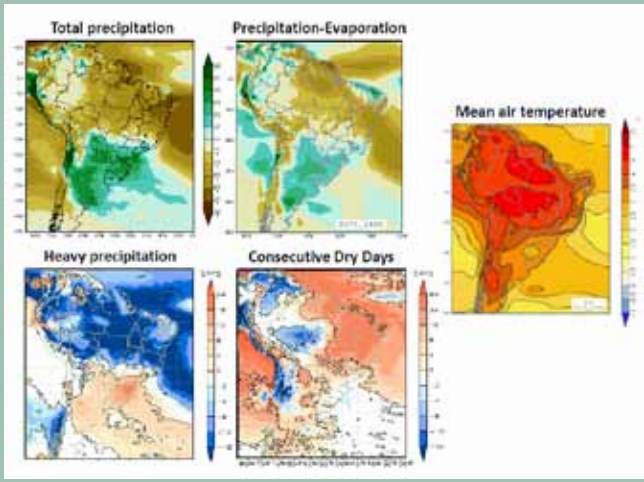
Special sessions on this topic were organized at the International Symposium of Climatology in Canela, Rio Grande do Sul, and at the annual meeting of the American Geophysical Union in Iguassu Falls, Paraná, Brazil.

Science Highlights

New future climate scenarios derived from the downscaling of the HadCM3 global model using the Eta-CPTEC for South America, under the A1B emission scenario, suggest that climate change and its related impacts have regional variability. By the end of the 21st century, strong warming (4-6°C) of continental South America increases the temperature gradient between continental South America and the South Atlantic. This leads to stronger SLP gradients between continent and oceans and to changes in moisture transport and rainfall from the tropical Atlantic into tropical South America. The northern areas of the continent, which include the Amazon and Northeastern Brazil, are projected to experience rainfall deficiency (reaching up to 40% reductions), while in southeastern South America, including the Parana La Plata River basin, rainfall is projected to increase by about 30%.

The Precipitation-Evaporation (P-E) difference in the A1B downscaled scenario shows that for northern South America a scenario where P<E, suggesting water deficits and river runoff reductions in the eastern Amazon and São Francisco River Basin, making these regions susceptible to drier conditions and droughts in the future. In the case of Northeastern Brazil, the risk of desertification may increase in the future.

Climate projections also indicate widespread increase of heavy precipitation mainly in southeastern South America, as well as more frequent consecutive dry days and droughts in the Amazon and Northeastern Brazil. The changes will become more intense by the middle of the century.



Projected changes in total annual precipitation (%), precipitation minus evaporation (%), heavy precipitation (days), consecutive dry days (days) and mean annual temperature (°C), derived from the Eta-CPTEC 40 km regional model for 2071-2100 relative to 1961-90 for the A1B emission scenario.

SCIENCE-POLICY INTERFACE

The climate scenarios generated in this subproject were used in vulnerability and impact assessments relevant to the 2nd National Communication of Brazil to UNFCCC, and to establish public policies for adaptation to climate change in the region. Several studies regarding megacities in Brazil have been developed (São Paulo), or are now being prepared (Rio de Janeiro), showing an integration of the scientific community and decision makers at the federal, state or city levels. There is an expectation that all projects from the INCT for Climate Change and from *Rede* CLIMA will use these new regional climate change scenarios.

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IMPLEMENTATION

HIGHLIGHT

Up to now the main activity has been the preparation of the experimental field and the purchasing of the equipment, as well as the development and testing of the open-top chambers. The experiments carried out in 2009 aimed at testing the operation of the open-top chambers in an environment with increased CO_2 concentration. Both tests were performed with successive growth of a C_3 crop (beans, *Phaseolus vulgaris*), and a C_4 crop, (maize, *Zea mays*).

KEY RESEARCH QUESTIONS

What is the level of dependence of C_3 and C_4 crops to rising CO_2?

How far does the photosynthetic acclimation for rising CO_2 go?

KEYWORDS

Surface temperature, climate change, CO_2 fertilization, C_3 e C_4 yields, open top chambers.

Agriculture

The last century has been characterized by a substantial increase in world population, which has brought the need for food supply to the fore of global issues. In general, to increase food production, the planted area can be increased, crop productivity can be maximized to reach values close to potential productivity or new crop varieties can be developed. This project aims at investigating the impact of increased atmospheric CO_2 concentration on agriculture. The focus is on the effect of increased CO_2 concentration on the phenological stage, the physiological response and the yield for both C_3 and C_4 crops, as a proxy of climate change studies. The proposed evaluation is crucial because crop phenological cycles, and therefore worldwide crop yields, are very closely linked to environmental conditions. For instance, studies have found that wheat and maize productivity presents a marked negative response to increased temperatures. Nevertheless, the response of crops to CO_2 changes is controversial. In order to investigate this issue, open top chambers have been used to simulate an atmosphere enriched with distinct levels of CO_2 resembling the IPCC emission scenarios (B2 and A2).

COORDINATOR

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Detail of bean (*Phaseolus vulgaris*) growing inside an open-top chamber in a CO_2 enriched environment.

CAPACITY BUILDING

At present there are two MSc, two PhD and four undergraduate students involved in this project.

FACILITIES

New equipment to collect data on CO_2 emissions from plants and monitor the condition of the soil were acquired. In addition, the experimental area located at the university, which is available for other research groups, was improved.

KEY EVENTS

International Workshop on Addressing the Livelihood Crisis of Farmers: Weather and Climate Services, held in Belo Horizonte, 12-14 July 2010.

Science Highlights

Based on the experiments described in the Introduction, several variables will be measured. These will include estimates of parameters associated with plant phenology and physiology. These quantities are extremely important for crop modeling studies in order to calibrate the models as well as to be used as initial conditions. Estimates of the climate change impact on crop yield, and therefore on food security, are primarily done using the experimental-modeling approach. In this sense, we argued that our expected findings are extremely useful to alert decision-makers of possible issues to be faced in the future regarding increased pressure on the need for food supply.

Open-top chambers used to simulate an atmosphere enriched by distinct levels of CO_2 resembling the IPCC emission scenarios (B2 and A2)

SCIENCE-POLICY INTERFACE

The thematic maps of the climate change impacts on agricultural productivity and of the productivity evolution of several cultures under different climate change scenarios will be fundamental for national and regional strategic planning and for food security.

SELECTED PUBLICATIONS

Costa LC, Justino F, Oliveira LJC, Sediyama GC, Ferreira WPM & Lemos CF. Potential forcing of CO_2, technology and climate change in maize (*Zea mays*) and bean (*Phaseolus vulgaris*) yield in Southeastern Brazil. Environmental Research Letters. DOI: 10.1088/1748-9326/4/1/014013. 2009.

HIGHLIGHTS

Two scientific papers explored the differences between the hydrological droughts of 1997 and 2005 in the Amazon, which have been included as the most severe in the last 100 years in the Amazon Basin and became study cases for understanding the effect of future climate extremes on Amazon resilience.

KEY RESEARCH QUESTIONS

What are the potential impacts of climate change on water resources in Brazil?

Taking into account the climate change scenarios, how can the project contribute to the management of Brazil's water resources?

IMPLEMENTATION

KEYWORDS

Water resources, hydrology, Brazilian semiarid, digital elevation model.

Water Resources

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The main efforts of this subproject are devoted to modeling catchments in all Brazilian regions. Activities include the development of: a database of existing meteorological and hydrological data in a format suitable for climate change studies; software tools to support modeling efforts, particularly to facilitate the preparation of numerical hydrological experiments; improvements in hydrological model routines; observational and numerical studies in representative catchments in the humid and semi-arid tropics of Brazil; modeling studies for assessing the impacts on water resources' availability and hydropower in key Brazilian catchments under different climate change scenarios; and the effects of climate change on aquifers of the Brazilian semiarid region.

KEY EVENTS

There have been two meetings for this subproject. The first was in May 2009, in the city of Campina Grande, Paraíba, Brazil, and the second in November, in Campo Grande, Mato Grosso do Sul, Brazil. In both meetings the discussions focused on how the research activities are to be developed and performed.

Science Highlights

Climate inter-decadal variability, which has a strong impact on water resources management, poses a serious challenge to plans that consider both current climate conditions and future climate change scenarios. Research in the water resources group tries to address how those fluctuations can be explicitly incorporated into water resources management plans in the semiarid regions of Northeastern Brazil. Most of the modeling efforts have been devoted to checking the ability of atmospheric models to represent current hydrological scenarios. This effort is usually focused on the period between 1970 and 1990, for which hydrological data is available. Bias correction of atmospheric model outputs has been identified as an unresolved issue, and has been recognized as one of the main obstacles for using climate change scenarios in hydrological simulations. Another source of uncertainties is related to the dispersion of climate change scenarios in regions of Brazil where climate predictability is usually low. The effect of the contribution time of Amazon tributaries to the definition of the hydrological main stem response during the 1997-98 and 2005 droughts was explained (Tomasella et al., 2010a). A second paper (Tomasella et al., 2010b) focuses on the impacts of both droughts on the water levels of floodplain lakes, showing that during the drought of 2005 local meteorological conditions produced higher evaporation rates and water temperatures, which favored rapid lake depletion and were probably associated with higher fish mortality rates.

Wetland in the lower Purus River region during the extreme 2010 low-water season. The degree of lake isolation during low-water depends on how low a level the waters reach during the drought season. Extreme droughts cause increased loss of lake connectivity and diminish the quality of the water for human consumption. During high-water this whole area becomes flooded.

SELECTED PUBLICATIONS

Rodriguez DA, Tomasella J & Linhares CA. Is the forest conversion to pasture affecting the hydrological response of the Amazonian catchments? Signals in the Ji-Paraná Basin. Hydrological Processes, v. 24, p. 1254-1269, 2010.

Trancoso R, Carneiro Filho A, Tomasella J, Schietti J, Forsberg BR & Miller RP. Deforestation and conservation in major watersheds of the Brazilian Amazon. Environmental Conservation , v. 36, p. 277-288, 2010.

DEVELOPMENT

HIGHLIGHTS

The key highlights are related to the development and application of radiative transfer models for solar energy assessment, the study of climate change impacts on wind-power resources and the dissemination of environmental data acquired from the SONDA network.

KEYWORDS

Renewable energy, wind, solar, climate change, energy, development.

KEY RESEARCH QUESTIONS

What is the impact of global climate change on solar and wind energy resources in Brazil? What is the need for reassessments of solar and wind energy resources in Brazil? How can the ground data network be expanded to provide relevant information for the energy sector? How can the synergy between national and international research groups concerned with technology exchange required for the development of renewable technologies be increased?

Renewable Energy

The relationship between energy, environment and socioeconomic development is unambiguous. How should society make use of its energy resources causing lower environmental impact while allowing robust sustainable development necessary to provide services and goods to the ever-growing world population? This is a crucial question in most developed economies, as well as in developing countries. This challenge calls for worldwide action to increase the insertion of renewable energy sources into energy matrixes.

Brazil is developing its own domestic policies to promote renewable energy for electricity generation and transport. Both are part of a strategic objective of enhancing energy security and meeting the IPCC call for reducing greenhouse gas emissions. This project intends to increase Brazilian expertise in the area and promote collaborative efforts from the Brazilian scientific community to boost R&D activities regarding renewable energy resource assessment.

COORDINATOR

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CAPACITY BUILDING

There are two PhD students involved in this project. One is working on the influence of biomass burning aerosols on solar energy resources in order to improve numerical models for solar energy assessment. The other is studying the impacts of climate change on the wind regime in Brazil.

FACILITIES

The creation of a network of ground data acquisition and information dissemination to be used by the energy and environmental sectors (SONDA network - www.sonda.cptec.inpe.br)

KEY EVENT

A general meeting with all members of this project was held in order to organize tasks and responsibilities.

Science Highlights

Wind power scenarios for the next 100 years for the A1B climate scenario show significant increase of wind power in Brazil, particularly in the Northeast. Solar energy shows potential applications in Brazil, particularly across a large area that stretches from the Northeast to the Southwest. The potential usage of hybrid diesel-PV systems for mini-grids in the Amazon region is estimated to be hundreds of MWp (Megawatt peak). The payback time for water heating for a compact low-cost system designed to replace electric showers in low-income households can be less than 3 years in most regions of the South-Southeast. A survey sent out to a number of companies, universities, research centers, governmental and non-governmental organizations and civil society associations, has shown that the most important points for the development of solar and wind energy in Brazil are: 1) Adoption of renewable solar-power and wind-power to be encouraged by government fiscal policies and increase public awareness of the environmental benefits. 2) Improvement of government regulations for electricity generation with intermittent sources (solar and wind). 3) Better incentives and actions to stimulate domestic markets for solar and wind technologies on an industrial scale.

SCIENCE-POLICY INTERFACE

One of the outputs of the project is to provide reliable information on energy assessment. This has been partially achieved by a feedback survey employing questionnaires and personal interviews with key stakeholders covering key issues concerning the insertion of solar and wind power in the Brazilian energy matrix. The results pointed to some of the main obstacles for effectively promoting government policies and actions for investments in the renewable energy market in Brazil.

SELECTED PUBLICATIONS

Martins FR & Pereira EB. Enhancing Information for Solar and Wind Energy Technology Deployment in Brazil. Submitted to Energy Policy.

Viana TS, Ruther R, Martins FR & Pereira EB. Assessing the Potential of Concentrating Solar Photovoltaic Generation in Brazil with Satellite Derived Normal Irradiation. Submitted to Solar Energy Journal.

Guarnieri RA, Martins FR & Pereira EB. Solar Radiation Forecast Using Artificial Neural Networks. Submitted to Solar Energy Journal.

Fernando Weberich / stock.xchng

IMPLEMENTATION

HIGHLIGHT

The web-based GIS database that was assembled possesses extensive MODIS products time- series (2000-2009) for the Cerrado and Atlantic Forest biomes, as well as a wide variety of vector layers containing data on environmental variables.

KEY RESEARCH QUESTION

How will climate change affect the distribution and the composition of biodiversity in the Cerrado and Atlantic Forest?

KEYWORDS

Phenology, Cerrado, Atlantic Forest, functional biodiversity

Biodiversity: Composition, Structure and Function of Ecosystems in the Cerrado and Atlantic Forest Biomes: Responses to Climate Change

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The Brazilian Cerrado and the Atlantic Forest biomes are hotspots of biodiversity - areas of high species richness and levels of endemism, subjected to a rapid and extensive loss of habitats. Our main motivation is assessing the potential impacts of climate change on the distribution of functional groups and changes in ecosystem functioning in these natural ecosystems. Through the compilation of information from permanent plots and ancillary data, as well as satellite imagery, an extensive database is being built.

This database will ultimately allow the modeling and spatial discrimination of functional groups defined with respect to the mechanisms of the vegetation's response to climate change. As it is important to associate changes in biodiversity (specific and functional) with the biogeochemistry and hydrological functioning of these systems, this project is working in close collaboration with the Biogeochemistry sub-project of the INCT for Climate Change.

CAPACITY BUILDING

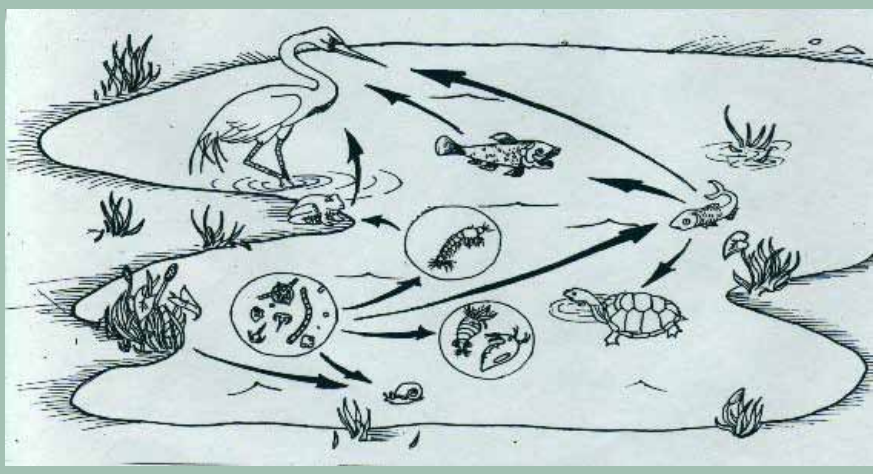
Three post-doctoral fellows (PD Junior-CNPq and PNPD-CAPES), one DTI assistant (funded by the INCT for Climate Change) and two undergraduate students (ITI-INCT for Climate Change and IC-volunteer) are involved in this project.

KEY EVENTS

The first Workshop held between the Biodiversity and the Biogeochemistry sub-projects established the official collaboration. As a result of this meeting, the structure of the database concerning plant traits and the phenology of the Cerrado and Atlantic Forest ecosystems were also delineated.

Science Highlights

We defined the conceptual and logic structure and the deployment (based on an open-source platform) of the project database in order to facilitate management and data accessibility. All MODIS images, as well as a variety of maps in vector format, are available at LAPIG - Federal University of Goiás website (www.lapig. iesa.ufg.br). A query (a GIS algorithm) was developed in order to allow the user to consult the entire spatial database, with the possibility of choosing the biome of interest (Cerrado or Atlantic Forest), the available products (e.g. MOD11, MOD13, and MOD15), the year of analysis(e.g. 2000), amongst other options. With the continuous development of the project activities, new data will be entered into the database. The entire database is readily available to scientists and the public in general.



Foodweb (Figure by USP). A foodweb shows the trophical relationships between species in an ecosystem. A foodweb is part of the structure of an ecosystem, and thus influences the ecosystem's energy balance, population and species dynamics, and other ecosystem characteristics, several of which are related to its response to changes in climatic conditions.

SCIENCE-POLICY INTERFACE

This project will provide scientific knowledge regarding the conservation of the Cerrado and of what little is left of the Atlantic Forest. Such information is relevant to Brazil's decision-makers, because informed biodiversity and ecosystem management is a necessity in a world subject to climate change and where ecosystems are being destroyed at alarming rates.

SELECTED PUBLICATIONS

Muñoz MES, Giovanni R, Siqueira MF, Sutton T, Brewer P, Pereira RS, Canhos DAL & Canhos VP. OpenModeller: a generic approach to species potential distribution modelling. Geoinformatica (Dordrecht). In press.

Carvalho FMV, De Marco P& Ferreira Jr. LG. The Cerrado into-pieces: Habitat fragmentation as a function of landscape use in the savannas of central Brazil. Biological Conservation, v. 142, p. 1392-1403, 2009.

DEVELOPMENT

HIGHLIGHT

Studies developed under this project show the influence of climatic factors on the transmission of waterborne diseases, respiratory diseases associated to air pollution and vector-borne diseases.

KEY RESEARCH QUESTIONS

What is the present spatial distribution and variability of climate-sensitive diseases?

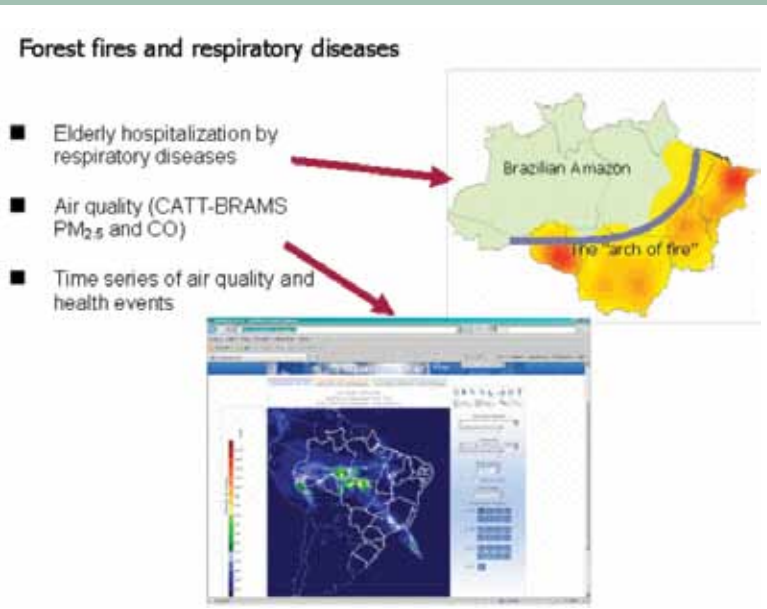
To what extent do environmental factors affect their distribution?

KEYWORDS

Waterborne diseases, air pollution, natural disasters, vector-borne diseases, extreme events.

Human Health

The project's main objective is to make available data and information on climate and human health through the Brazilian Climate and Health Observatory (Observatorium). This initiative aims at monitoring and predicting the effects of global climate change on human health, integrating environmental, climatic, epidemiological, socio-economic and public health information. The Observatorium integrates databases from institutions such as the National Institute for Space Research (INPE), the Brazilian Institute for Geography and Statistics (IBGE), and the Information Systems Department (which was defined to support the Unified Health System (DATASUS)), as well as primary data collected by universities. It aims at fostering studies and developing technological innovations in the areas of climate and health. It enables accessing, querying and sharing information. In the current phase of the project, an inventory climate and health data has been produced and constitutes the basis for shared data.



COORDINATORS

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CAPACITY BUILDING

There are four PhD and seven MSc students working on this project. The Observatory has generated large amounts of data, which have been used by students from Fiocruz, INPE, UNIR, UFRN, USP, amongst other research institutions.

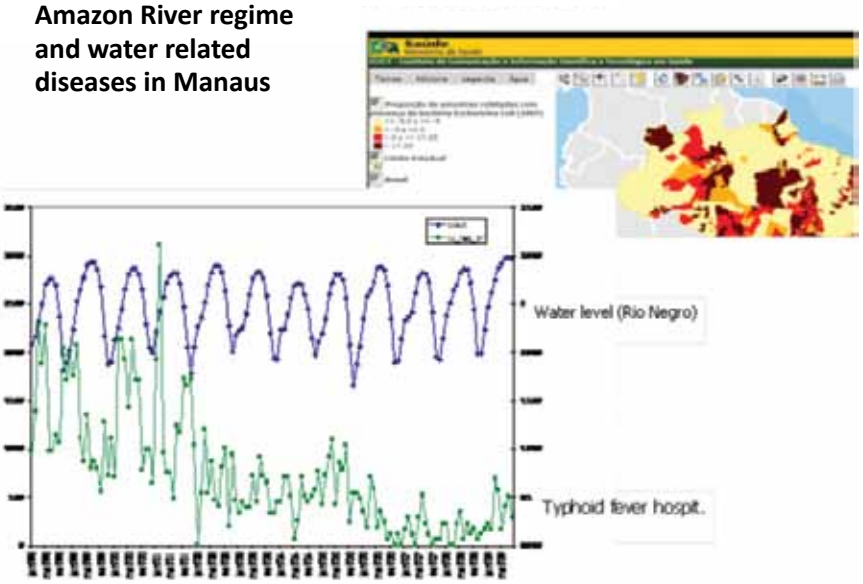
KEY EVENTS

The beginning of activities for this research group was marked by a workshop, held in May 2009, during which objectives and inter-institutional relationships were established. Other workshops were organized to discuss more specific topics, such as waterborne diseases, respiratory diseases linked to air pollution and vector-borne diseases.

Science Highlights

In the sentinel sites - those of particular interest for in-depth studies, either because conditions are more critical, or because there is better data, or other -, studies are being conducted to evaluate temporal variations of climatic variables and diseases. Priority is being given to leptospirosis, respiratory and cardiovascular diseases, and dengue. The project presents its results in two different scales and approaches: the health impact of large environmental and climatic changes and case studies developed in sentinel areas. Such areas were selected according to biomes and prevailing diseases: studies of respiratory diseases in certain regions of Mato Grosso, Acre and Rondônia; studies of leptospirosis incidence associated to floods in Salvador; studies of waterborne diseases in Manaus; and studies of dengue fever incidence in Rio de Janeiro. In Manaus, a GIS platform was used to gather and analyze health, environmental, and socio-demographic data to assess the risks of climate change affecting malaria incidence along the urban fringe. Deforestation, the presence of creeks, and recent settlement explain the high incidence of malaria in this area. The pace of deforestation and the extent of floodable creeks can increase considerably during the next decades due to river water level variation and land use pressures.

Amazon River regime and water related diseases in Manaus



SCIENCE-POLICY INTERFACE

This project is being conducted under the supervision of Brazil's Ministry of Health and the Pan-American Health Organization, both of which will use the results in a climate change adaptation plan. In addition, meetings with civil society organizations and the Brazilian Forum on Climate Change are being held. These aim at increasing public and political awareness on the threats that climate change imposes on human health.

SELECTED PUBLICATIONS

Barcellos C, Monteiro AMV, Corvalan C, Gurgel HC, Carvalho, MS, Artaxo P, Hacon S & Ragoni V. Mudanças climáticas e ambientais e as doenças infecciosas: cenários e incertezas para o Brasil. Epidemiologia e Serviços de Saúde. , v.18, p.285 - 304, 2009.

Ignotti E, Valente JG, Longo KM, Freitas SR, Hacon S & Netto PA. Impact on human health of particulate matter emitted from burnings in the Brazilian Amazon region. Rev. Saúde Pública. 44(1): 121-30. 2010.

Reis I, Honorio NA, Codeco C, Magalhães MAFM, Lourenço de Oliveira R & Barcellos C. Relevance of differentiating between residential and non-residential premises for surveillance and control of Aedes aegypti in Rio de Janeiro, Brazil. Acta Tropica. 114(1): 37-43. 2010.

DEVELOPMENT

HIGHLIGHT

The conclusion of the first inter-institutional meeting was that, for the study of Brazilian coastal zones, it is imperative that observational systems be improved so that systematic monitoring programs of physical, biological and social parameters can be carried out. Another conclusion was that experimental approaches could help climate change science and management, but only after a better choice of questions and hypotheses with relevance at regional scales.

KEY RESEARCH QUESTION

What are the vulnerabilities of coastal ecosystems and what is their resilience to the climatic driving forces that are projected to change over the next decades?

KEYWORDS

Coastal zone, vulnerability to climate change, historical analyses, preliminary evaluation, observational systems.

Coastal Zones

The long Brazilian coastal zone is too complex to be addressed by a single research project, or investigated under the perspective of a single research question. At the land-sea-air interface, and occupied by dense human populations and structures, coastal zones are composed of a mosaic of different and interconnected ecosystems that are being exposed to natural and anthropogenic impacts and are highly vulnerable to most climate change effects. Within this context, a major effort was made to establish a multidisciplinary research team, under a coordinated approach, comprising both regional and institutional representativeness, aiming at achieving national and international scientific impact. During the elaboration of the proposal it was decided that that current knowledge about Brazilian coastal zones is insufficient to come up with hypotheses regarding the influence of climate change on these environments. Thus, priority goals for this sub-project and its collaborators are to: 1) evaluate the state of knowledge; 2) identify gaps of knowledge; 3) recommend future studies; and 4) coordinate/ integrate projects that investigate the effects of climate change throughout Brazilian coastal regions and ecosystems.

COORDINATORS

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The INCT for Climate Change Coastal Zone Network is composed of several research groups and institutions distributed throughout Brazil's Coastal zone. About 15 studies are approaching issues regarding impacts and vulnerabilities to climate change of the regions. In 2009, the main topics covered were: sea level rise, extreme events, coastal erosion, estuarine hydrology, phytoplankton, coral reefs, benthic flora and fauna, mangroves, fishery ecology and economics and limnology.

CAPACITY BUILDING

There are five undergraduate students under a technical training (ITI) scholarship, three MSc's, one PhD, and three postdoctoral fellows collaborating in this project.

FACILITIES

The "Laboratory for Ocean and Climate Studies" was created at FURG.

KEY EVENTS

This research project organized the 1st Brazilian Workshop on Climate Change and Coastal Zones and the Workshop "Climate Change, Oceanographic Variability and the Artisanal Fisheries in the SW Atlantic: a Human Dimension Program".

Science Highlights

The First Brazilian Workshop on Climate Change in Coastal Zones (http://mudancasclimaticas.zonascosteiras.com.br/workshop), hosted by the Federal University of Rio Grande and sponsored by INCT for Climate Change and another CNPq Scientific Event Grant, aimed at disseminating Coastal Zone preliminary results, consolidating the research group, stimulating the integration of its members and discussing methodological protocols and future research. The event was attended by 200 people, including scientists and students, from several national institutions. The Workshop successfully achieved its goals, and its results were highlighted by the national scientific community and by the media and society in general. By bringing together different research areas and institutions, new collaborations were established. Open to the general scientific community and students, the project has begun contributing to new knowledge on climate change related problems. Another highlight has been the production of the Special Issue "Climate Changes in Brazilian Coastal Zones", published by the Pan-American Journal of Aquatic Sciences (PANAMJAS), with full research articles and workshop recommendations.

Participants of the I Brazilian Workshop on Climate Change on Coastal Zones, held at the Federal University of Rio Grande (FURG) and mainly sponsored by the INCT for Climate Change, on September 13-14, 2009.

SCIENCE-POLICY INTERFACE

A direct attempt to influence policy and society was made throughout the release of the Rio Grande Declaration (http://mudancasclimaticas.zonascosteiras.com.br/declaracao-de-riogrande/898), an open letter signed by Coastal Zone members and Workshop participants. The letter, sent to the main national media groups, warns about climate change problems, particularly those affecting the coast, and demands action from political and civil society.

SELECTED PUBLICATIONS

Mudanças Climáticas e Zonas Costeiras: Avaliação Preliminar do Estado do Conhecimento. 2009. http://mudancasclimaticas.zonascosteiras.com.br/temas

Climate Changes and Coastal Zones. 2010.

Pan-American Journal of Aquatic Sciences. (Special Issue). In press. (Containing 14 full articles and documents related to I Brazilian Workshop on Climate Changes and Coastal Zones).

DEVELOPMENT

HIGHLIGHT

Climate change may negatively impact the infrastructure and worsen access to basic urban services, decreasing life-quality in cities. The poor - slum dwellers in megacities – will probably be the most affected.

KEY RESEARCH QUESTIONS

What are the main vulnerabilities of the cities of São Paulo and Rio de Janeiro to climate change?

How will the impacts of climate change (e.g. sea level rise and extreme events) affect these cities?

Which population groups are most vulnerable to climate change in São Paulo and Rio de Janeiro?

KEYWORDS

Social vulnerability, urbanization, climate change, adaptation, flooding, landslides.

Urbanization and Mega-cities

Traffic in São Paulo, Brazil

The aim of this research project is, on the one hand, to understand how climate change will affect urban areas, specifically the megacities of São Paulo (21 million inhabitants) and Rio de Janeiro (11 million inhabitants), and how this new situation will impact the population in terms of the increase of social vulnerability to these new climate risks. On the other hand, the goal is to identify and propose public policies aiming at contributing to climate change adaptation. The research methodology is composed of two approaches: 1) social vulnerability is discussed using secondary data (census data) and 2) panels of experts are established to identify the areas more vulnerable to climate change related risks. During the first year, two panels of experts on "Mega-cities and Climate Change: São Paulo and Rio de Janeiro" were set up in order to discuss and build awareness on the paramount roles that cities and local governments have regarding climate change impacts. In the second year, the group will identify the most vulnerable population groups in São Paulo by assembling information about environmental risks and socioeconomic characteristics.

COORDINATOR

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CAPACITY BUILDING

There is one post-doctoral fellow, three PhD students, two MSc students and one undergraduate student working on the project; they are from UNICAMP, UFMG and USP.

FACILITIES

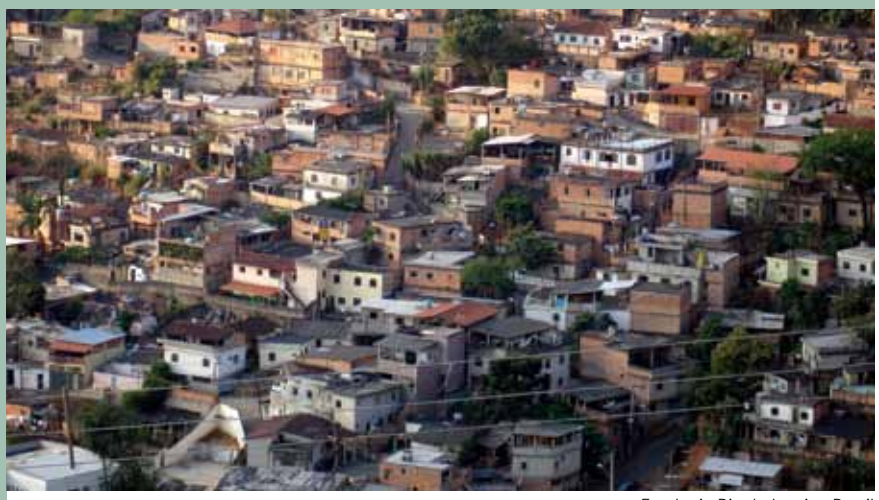
The project brought improvements to the computational facilities at the Population Studies Center of the University of Campinas (NEPO/ UNICAMP). The NEPO is a multidisciplinary research center that has been tackling population, urbanization and environmental issues in Brazil for more than 20 years, and has a team of researchers with demographers, sociologists, geographers, urban planners, among others.

KEY EVENTS

In 2010, the event "Vulnerabilidade das Megacidades Brasileiras às Mudanças Climáticas: Região Metropolitana de São Paulo" was organized. The objective was to present the executive summary of the São Paulo Metropolitan Region study. Another similar event took place in Rio de Janeiro.

Science Highlights

The publication organized by Hogan and Marandola Jr. (2009) makes some important contributions to the theoretical and conceptual discussions on population and development issues, as well as on urbanization and climate change. It should be noted that the analyses of human dimensions of climate change are at an initial phase. There is the need to develop more accurate definitions for concepts like risk, vulnerability, mitigation and adaptation. The understanding of the relationships between these concepts is central to building policy proposals. With the aim of drawing attention to the risks of sea level rise, Carmo and Silva (2009) presented estimates of the population living in coastal zones of Brazil. The book organized by Carmo and Cabrera Trimiño (2009) brought together themes related to population and environment in Latin America within a wide perspective, covering issues such as urbanization processes and the impacts of climate change. This publication is a synthesis of six years of discussions within the "Red Población y Medio Ambiente", from the "Asociación Latino Americana de Población" (ALAP). The workshops show that, despite existing knowledge on the impacts of rapid urban growth and environmental changes, decision-makers in São Paulo and Rio de Janeiro still lack the capabilities to deal with and implement climate change policies. Regarding this gap, the project organized two short courses and one conference session to spread the state-of-art of this field; from then on, several contacts have been made among researchers and policy makers. Results from the São Paulo case show that climate change will affect urban planning and past economic and political processes have created most of the challenges. Poorest people with no access to formal urban settlement will be the most affected by climate changes due to their most vulnerable situation.



Favelas in Rio de Janeiro, Brazil

SCIENCE-POLICY INTERFACE

The information provided by the reports about the mega-cities' populations vulnerable to climate change will contribute to the formulation of local Action Plans and the National Climate Change Plan.

SELECTED PUBLICATIONS

Hogan DJ & Marandola Jr. E (Orgs.). População e Mudança Climática: Dimensões Humanas das Mudanças Ambientais Globais. Campinas: Núcleo de Estudos de População – epo/Unicamp; Brasília: UNFPA, p. 137-158. ISBN 978-85-88258-12-9. 2009.

Carmo RL & Cabrera-Trimiño GJ (Orgs.). Población y medio ambiente en Latinoamérica y El Caribe Cuestiones recientes y desafios para el futuro. Serie Investigaciones Nº 6. ALAP Editor. Rio de Janeiro. 2009.

Carmo RL, Silva CM. População em zonas costeiras e mudanças climáticas: redistribuição espacial e riscos. In. HOGAN, D. J. (Org.); MARANDOLA JR., E. (Org.). População e Mudança Climática: dimensões humanas das mudanças ambientais globais. 1. ed. Campinas: Nepo/UNFPA, v. 1. 290 p. 2009.

Nobre C, Young A, Saldiva P, Marengo J, Nobre A, Alves Jr. S, G. Costa MS, Lombardo M, 2010: Vulnerabilidade das Megacidades Brasileiras as Mudanças Climáticas: Região Metropolitana de São Paulo. Sumario Executivo. São Paulo, 31 pp (www.inpe.br/noticias/arquivos/pdf/megacidades.pdf).

DEVELOPMENT

HIGHLIGHTS

Preliminary results suggest that climate change will have adverse effects on growth and welfare in Brazil. Moreover, it will reinforce regional inequality in the country. On the other hand, some sectors and regions may be positively affected.

KEY RESEARCH QUESTION

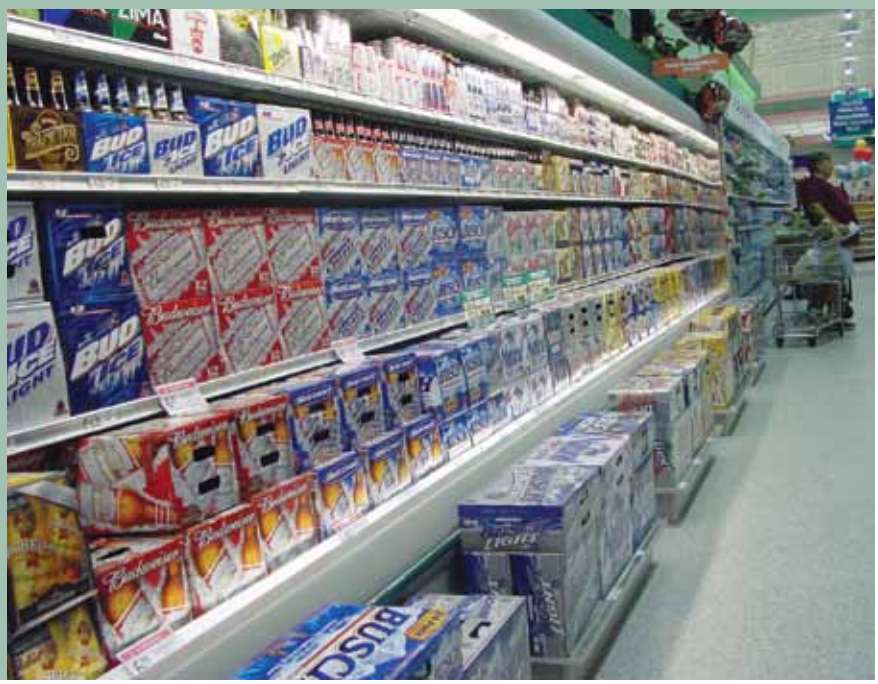
How, and to what extent, will climate change impact Brazil's development agenda?

KEYWORDS

Impact analysis, modeling integration, computable general equilibrium models, economics of climate change, spatial economic analysis, regional science.

The Economy of Climate Change

The main goal of this project is to develop an integrated methodology to simulate the potential economic impacts of climate change on Brazil's economy, considering its various sectors and spatial dimensions. The project aims at integrating the climate change scenarios provided by projects that form the scientific basis of the INCT for Climate Change into socioeconomic models. Such integration involves direct relationships with other sub-projects of the INCT for Climate Change, such as Renewable Energy and Agriculture, which will provide the main transmission mechanisms for the economic models. Still in its development stage, the implementation of the project relies on a research network of experts from different academic institutions of the country and on the exchange of experiences with international research groups.



COORDINATORS

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CAPACITY BUILDING

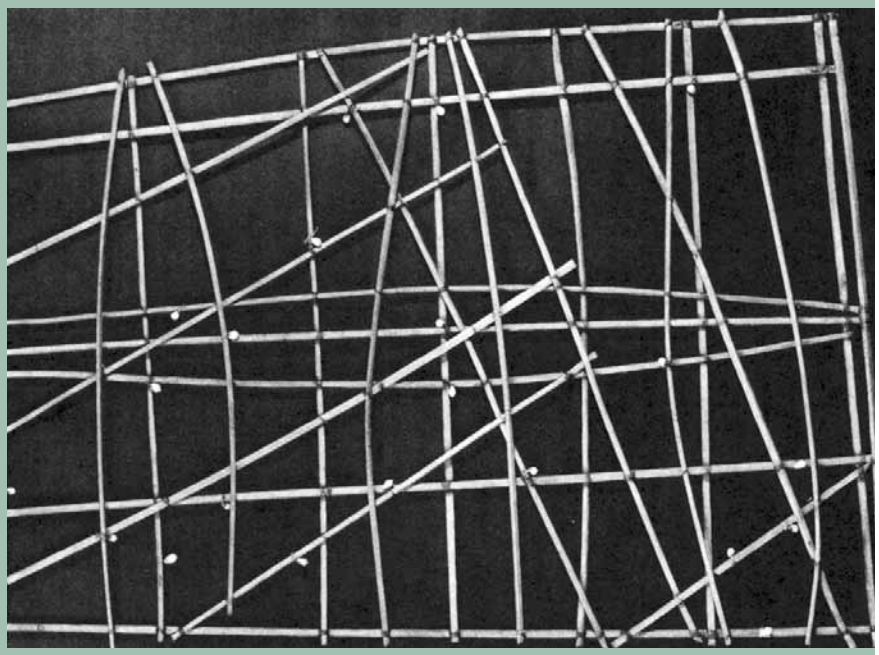
There are currently six graduate students directly linked to this project, all of which are developing projects on topics related to the modeling of the economic impacts of climate change.

KEY EVENTS

"Workshop FEA/IEA de Economia do Clima", March 17, 2010, at FEA-USP, co-organized by FEA-USP and IEA-USP.
"International Workshop on CGE Modeling and Climate Change", June 14, 2010, at FEA-USP.

Science Highlights

If costs of global climate change in Brazil until 2050 were anticipated to the present, at a reduction rate of 1%, the costs in terms of the 2008 GDP would be approximately between BRL 719 billion and BRL 3.655 billion, representing between 25% and 125% of the 2008 national Gross Domestic Product (GDP). This result comes from the "Economics of Climate Change in Brazil" study, which involved the main researchers from INCT for Climate Change and served as the basis for the creation of this sub-project. This was the first time that an estimate for the economic costs of climate change was made within an integrated framework of the Brazilian economy. Using the accumulated experience in this modeling effort, the project is now in the process of further progressing in the development of the modeling framework. Recently, an international workshop on "CGE Modeling and Climate Change" took place at FEA-USP, as part of INCT for Climate Change and *Rede* CLIMA activities, bringing together both national and international experts on the topic, and contributing to the strengthening of the collaboration between Brazilian and Australian institutions.



This curious nautical chart, made of vegetable fiber strips, represents the Marshall Islands area in the Pacific Ocean, Northeast of Australia. Some islands are represented by shells attached to the strips.

SCIENCE-POLICY INTERFACE

We expect that the results from our project will contribute to the design of policies, providing the necessary economic rationale for their ex ante assessment.

SELECTED PUBLICATIONS

Azzoni CR, Haddad EA & Kanczuk F. Climate Change and Energy Use in the Long-Run Growth in Brazil. In: Amann E, Baer W, Coes D. (Org.). Energy, Bio Fuels and Development: Comparing Brazil and the United States. Florence, Kentucky, USA: Routledge Taylor & Francis Group, 2010.

Barbieri AF, Domingues EP, Queiroz BL, Ruiz RM, Rigotti JI, Carvalho JAM, &Resende MFC. Climate change and population migration in Brazil's Northeast: scenarios for 2025–2050. Population and Environment. v.31, p.344 - 370, 2010.

IMPLEMENTATION

HIGHLIGHT

Interviews confirmed a continued but diminishing insularity that marks top Brazilian climate decision-making, limiting receptivity to the participation of civil society and to national scientists' pronouncements related to climate change and deforestation.

KEY RESEARCH QUESTIONS

What is the role of a diverse set of actors in the formation of Brazilian climate policy and politics?

What are the key obstacles to effective, forward-looking climate policy and what are promising, future pathways?

KEYWORDS

Policy, social science, human dimensions, science-policy interface

Science, Technology and Policy Studies

This research examines the climate science-policy interface in Brazil. Using survey methods, interviews and media analysis, the project identifies and analyzes networks of actors in science, government, industry and politically engaged parts of civil society. In particular, it focuses at how the configurations and the dynamics of the interactions among these heterogeneous actors shape Brazilian climate policy and politics, especially the emergence and shape of the National Climate Change Plan. The goal is to improve understanding of the socio-cultural, political and economic factors that cause greenhouse gas emissions in Brazil and that shape the inclination and capacity of Brazilian society to avoid, resist and adapt to the impacts of human-induced climate change. The research fills a gap in current research, as little research to date has probed the role of social networks, culture, interests, and scientific information about climate change in the formation of climate policy, especially outside the US, Europe, and the richest and "Northern" parts of the world, in general.

COORDINATOR

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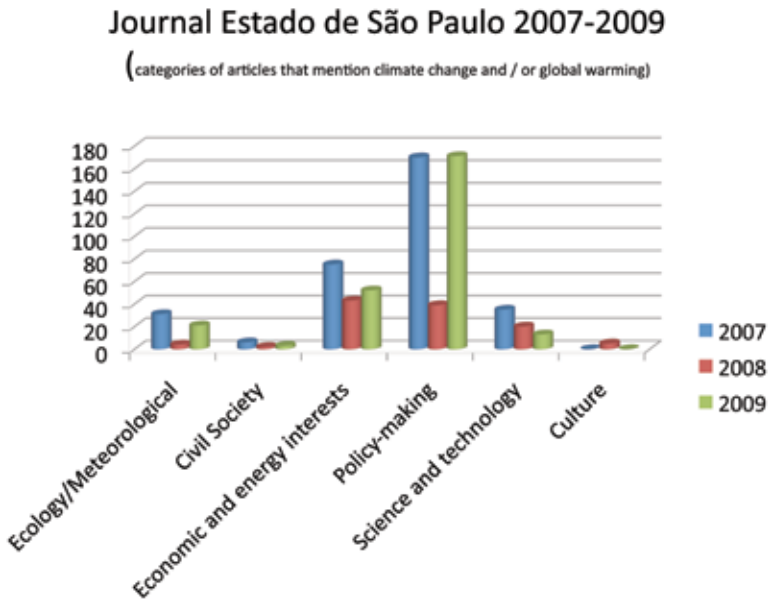
CAPACITY BUILDING

The Coordinator participated in the 2009 ANPOCS (*Associação Brasileira de Pós-Graduação e Pesquisa em Ciências Sociais*) meeting as part of the effort to overcome the lack of social science engagement with global environmental problems in Brazil. In 2010 a post-doctoral fellow became involved in the research being carried out at INPE.

Science Highlights

During 2009, activities were concentrated on the development of the data collection and analysis instruments and methodologies to be used by all 15 teams (all from different countries) collaborating under Compon (Comparing Climate Change Policy Networks). Detailed research protocols defining each step of these processes of data collection and analysis were developed in conjunction with the coordinator of the Compon study and the leaders of each of the participating national research teams. It has been decided that each participating national team needs to build a database with newspaper articles focused on climate change from three major national newspapers for the years 2007-2009, undertake in-depth interviews with at least 15 experts and leaders of organizations, and carry out a quantitative survey among representatives of organizations engaged with climate change issues. The objective is to collect data from between 50 and 100 actors per country. In Brazil, Lahsen gathered over half the required media articles and conducted preliminary interviews.



SCIENCE-POLICY INTERACTION

The study summarizes the existence of interpretive differences on the part of key Brazilian scientists and decision-makers in regard to the national interest in the international climate regime, as well as long-standing but weakening tendencies towards insular decision-making.

SELECTED PUBLICATIONS

Lahsen M. "A Science-Policy Interface in the Global South: The Politics of Carbon Sinks and Science in Brazil", Climatic Change, Vol. 97, Issue 3, 339-372 (DOI 10.1007/s10584-009-9610-6). 2009.

Lahsen M. "The Social Status of Climate Change Knowledge," WIREs Climate Change, Volume 1, issue 2, pp. 162 - 171. (DOI: 10.1002/wcc.27). Accessible at: http://wires.wiley.com/WileyCDA/WiresArticle/wisId-WCC27.html . 2010.

IMPLEMENTATION

HIGHLIGHT

Remote sensing and telemetric technology are proving to be important tools in evaluating the influence of meteorological forcing on water properties.

KEY RESEARCH QUESTION

What is the contribution of Brazilian lakes and reservoirs to CO_2 emissions into the atmosphere?

KEYWORDS

Remote Sensing, heat balance, bio-optical properties, emissions from lakes and reservoirs.

Emissions from Lakes and Reservoirs

The management and sustainable use of water resources relies heavily on water quality data and on how this quality is changing over time. In the case of reservoirs, their lentic characteristic is an additional problem because it acts as a potential triggering mechanism of phenomena such as eutrophication and salinization. These systems are also under the influence of natural forcings associated with meteorological and climatological conditions. Such factors play an important role in the emissions of greenhouse gases from lakes and reservoirs. The hydroelectric reservoirs are recognized by the IPCC (Intergovernmental Panel on Climate Change) as important sources of greenhouse gases to the atmosphere (by diffusion and bubbling). The study of the relative importance of physical processes (e.g., wave climatology) in influencing the greenhouse emissions is a scientific hotspot. In Brazil, there are approximately 31 hydroelectric reservoirs that add-up to a volume of more than 1 billion m^3, a fact that increases our attention and justifies this research.

Telemetric Monitoring System (SIMA) deployed at the Itumbiara Reservoir, Goiás, Central Brazil.

COORDINATORS

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CAPACITY BUILDING

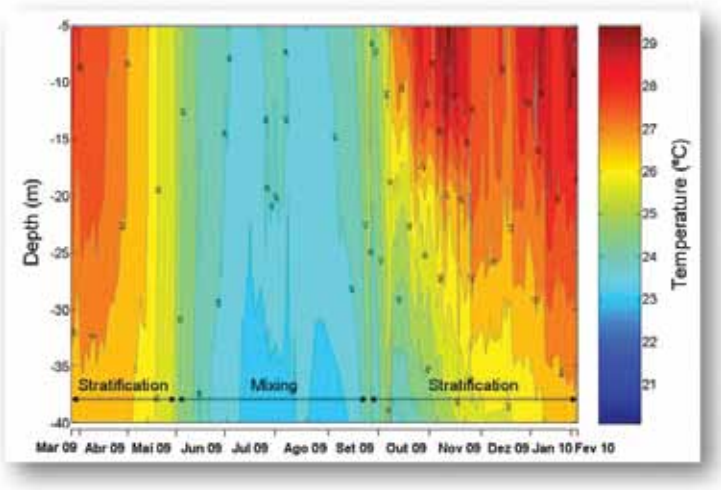
There is one PhD and one MSc student at INPE's Remote Sensing post-graduate program. The former is studying remote sensing of temperature and heat flux on the water surface of the Itumbiara Reservoir, Goiás, Brazil, while the latter is focusing on carrying out a bio-optical characterization of this same reservoir.

KEY EVENTS

Special sessions at the International Symposium of Climatology in Canela, RS, Brazil, in September 2009, and at the AGU-Conference of the Americas in August 2010, in Iguassu Falls, Brazil.

Science Highlights

Long-term environmental time series are fundamental to identify and classify the fast disturbances that occur in aquatic systems - particularly regarding the variability of greenhouse gas emissions -, as well as comparing different systems. To solve this problem, a telemetric monitoring system (a buoy called SIMA) was built and deployed at the Itumbiara hydroelectric reservoir, in Goiás, Central Brazil. This system collects meteorological (air temperature, humidity, shortwave radiation, air pressure, wind intensity and direction) and limnological (water temperature, pH, chlorophyll-a concentration, turbidity, electric conductivity and dissolved oxygen) data at pre-programmed time intervals and transmits them by satellite in quasi-real time to any user within a range of 2500 km from the acquisition point. The selection of the environmental parameters measured by SIMA took into account aspects such as adequacy to be used as an environmental index (i.e., the variables that respond consistently to alterations in the functioning of the aquatic system), importance to the greenhouse gas emission process in aquatic systems, and technical suitability for data acquisition and transmission from automatic platforms. All data acquired operationally by SIMA go through a quality control processes and are stored in a numerical database.



Water thermal structure at Itumbiara Reservoir derived from the Telemetric Monitoring System (SIMA).

SCIENCE-POLICY INTERFACE

Establishing the contribution of lakes and reservoirs to CO_2 emissions is fundamental to several aspects of the climate change debate, adding substance to mitigation and to Brazil's development plans.

SELECTED PUBLICATIONS

Alcântara E, Novo EMLM, Stech JL, Assireu AT, Nascimento R, Lorenzzetti JA & Souza A. Integrating historical topographic maps and SRTM data to derive the bathymetry of a tropical reservoir. Journal of Hydrology (Amsterdam), v. 389, p. 311-316, 2010.

Alcântara EH, Stech JL, Lorenzzetti, JÁ, Bonnet MP, Casamitjana X, Assireu AT & Novo EMLM. Remote sensing of water surface temperature and heat flux over a tropical hydroelectric reservoir. Remote Sensing of Environment, p. 2651-2665, 2010.

Santos MA, Rosa LP, Matvienko B, Santos EO, Almeida CHE, Sikar E, Silva MB & Bentes Jr. AP. Estimate of degassing greenhouse gas emissions of the turbined water at tropical hydroelectric reservoirs. Verhandlungen – Internationale Vereinigung fur Theoretischeund Angewandte Limnologie / Proceedings of the International Association of Theoretical and Applied Limnology, v. 30, p. 834-837, 2009.

DEVELOPMENT

HIGHLIGHTS

In evaluating reactivity with different oxides, nickel oxide had the best performance via CLC and CLR. Emission factors were obtained for the main gases from Amazon biomass burning.

KEY RESEARCH QUESTIONS

What are the emission factors from biomass burning?

What are the emissions from the different kinds of Amazon vegetation?

Which oxygen carriers are more efficient for CLC and CLR processes?

KEYWORDS

CO_2 capture, oxygen carriers, CLR, CLC, emission factors, soot.

Combustion Processes

Greenhouse gas emissions from fossil fuel and biomass burning processes are the main causes of recent climate change. This sub-project of the INCT for Climate Change deals with several facets of combustion processes and is further divided into 3 sub-sub-projects. (1) Because more than 80% of energy comes from fossil fuel combustion, which generates pollutants, one alternative is to replace O_2 from air with oxygen from metallic oxides (O_2 carriers) in general combustion processes (CLC), via CO_2 capture and storage. The objective is to develop the oxides and catalysts that provide hydrogen as a final product (CLR). This research is in the R&D phase for new materials, which started in 2008. (2) Calculate emission factors, combustion efficiency, thermal degradation, coal formation, and characterize biomass burning in the field and in the lab, as well as quantify biomass regeneration. (3) Implement computer models to verify soot formation and the structure of multi-component fuel flames.

COORDINATORS

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Inauguration of the laboratory facilities, in September 2009, built with funding from Petrobras, for the development of new combustion technologies aiming at mitigating greenhouse gas emissions.

CAPACITY BUILDING

One undergraduate student and one PhD student have begun working on this project. The latter is participating in the determination of the emission factors from biomass burning.

FACILITIES

Laboratory for the development of new combustion technologies aiming at mitigating greenhouse gas emissions, in September 2009, built with funding from Petrobras.

Evaluation unit of oxygen carrier in fixed-bed reactor coupled with gas chromatography and mass spectrometry.

Science Highlights

Biomass consumption and emission factors for the gases CO_2, CO, and main hydrocarbons (C_2 and C_3) were determined, resulting from the burning of 1 hectare of Amazonian Forest near the city of Alta Floresta, state of Mato Grosso, Brazil (at the heart of the deforestation arch). It was found that burning released about 117 thousand kg of CO_2; 8,1 thousand kg of CO; 675 kg of CH_4; 407 kg of Non-Methane Hydrocarbon (NMHC); and 354 kg of Particle Pollution 2.5 (PM2.5). Moreover, members of this project participated in the 3rd International Annual Meeting 2009 – Catalysis for Environment: Depollution, Renewable Energy and Clean Fuels, held September 9-12, 2009, in Zakopane, Poland. As a result, contacts were made in Poland, France and Vietnam, all of which may contribute to the interpretation of reaction kinetics (redox reactions) and the study of parameters to evaluate more efficient oxygen carriers.

Thermogravimetric analysis of an oxygen carrier in the combustion reaction.

SCIENCE-POLICY INTERFACE

Knowledge about combustion processes is fundamental for all climate change discussions since it has implications for the economy, the environment, and public policies, at all scales.

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HIGHLIGHT

The debates on REDD promoted by the INCT for Climate Change and *Rede* CLIMA have made it possible to achieve the 2020 targets expressed in the National Climate Change Plan, including an 80% reduction of deforestation in the Amazon by 2020.

KEY RESEARCH QUESTION

How can the National Climate Change Policy be consolidated in Brazil, reducing deforestation in the Amazon to nearly zero over the next 10 years, in support of a nationwide low emission development model?

DEVELOPMENT

KEYWORDS

REDD, deforestation, Brazilian Amazon, climate change, low-emission development.

Reducing Emissions from Deforestation and Forest Degradation (REDD)

COORDINATOR

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There is now consensus in the international community that in order to avoid "dangerous interference" in the global climate system, tropical deforestation should be greatly reduced. Reducing deforestation could offer a viable, cost-effective means of reducing GHG that could be used to bring financial benefits to developing countries and preserve planetary biological diversity. Brazil could make a substantial contribution to climate change mitigation by reducing deforestation, as it has been doing successfully over the last five years. Through the mechanism adopted by UNFCCC entitled "Reduction Emission from Deforestation and Forest Degradation" (REDD), developing countries that make an effort to reduce deforestation in their territories could be compensated. The Brazilian government has already made progress by proposing its own mechanisms to reduce deforestation (Amazon Fund and National Climate Change Plan). By implementing a national REDD strategy, however, Brazil could create the basis for a low-emission development and implement the National Climate Change Plan, which has been recently approved by the National Congress.

KEY EVENTS

1. Side Event at COP15: Making REDD a Reality at Multiple Scales, December 14, 2009.

2. REDD Workshop in São Paulo, September 2009. Debate on the REDD strategy for the Amazon and Brazil.

Science Highlights

Last December, at COP 15 of UNFCCC, Brazil announced its official goal of reducing between 36% and 39% its GHG emissions by 2020 (with respect to Business as Usual emissions scenarios for 2010), including goals for reducing deforestation in the Amazon – the major source of Brazilian emissions. During the conference, researchers from this sub-project contributed with presentations about the potential pathways for Brazil to reach the officially announced goals, with emphasis on reducing deforestation in the Amazon. The research group also presented the "Stock-Flow Approach" to the allocation of REDD benefits that could bring significant financial incentives for Amazon forest conservation. Moreover, during the COP 15, the research group presented two reports outlining the fundamentals for a REDD strategy in Brazil that could help the implementation of the National Climate Change Plan that was recently approved by the Brazilian Congress. The results of these reports were published in the journal Science. In addition, the coordinating institution of this sub-project (IPAM) worked at state and regional levels in the Brazilian Amazon promoting debates on the design of REDD programs, supporting participation of indigenous groups in UNFCCC negotiations and harnessing the market in its efforts to exclude deforesters from the soya and beef supply chains.

SCIENCE-POLICY INTERFACE

Brazil is at a critical point in the implementation of its national low-emissions development policy, due to the implementation of the National Climate Change Plan recently approved by the National Congress. The INCT for Climate Change is collaborating in the consolidation of such policies so that the demands of the national strategy for a low-emission development can be met.

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DEVELOPMENT

HIGHLIGHT

Important aspects of the development of the Brazilian Model of the Global Climate System were discussed at the workshop held in Brazil, in 2009, in which senior and young scientists took part.

KEY RESEARCH QUESTIONS

What are the effects of forest fires on clouds?

What is the impact of river discharge on ocean circulation and biogeochemistry?

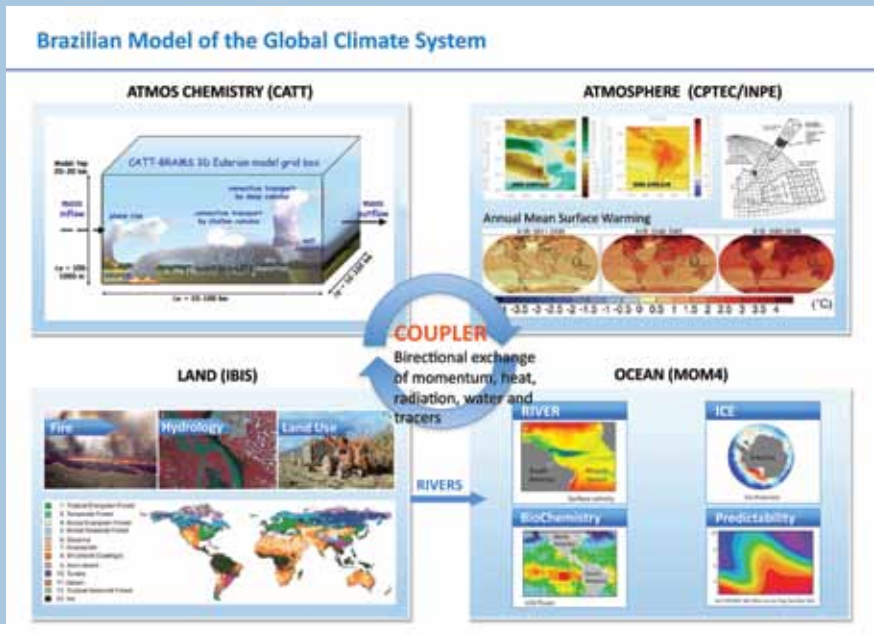
How to up-scale very high-resolution surface fluxes from both continental and ocean sub-grid processes to the atmospheric grid?

KEYWORDS

Global climate modeling, Amazon forest, forest fires, surface hydrology, ocean circulation, biogeochemistry, Earth System modeling, Brazilian Model of the Global Climate System.

Global Climate Change Modeling: the Brazilian Model of the Global Climate System (MBSCG)

Due to the high degree of non-linearity of the Earth system (e.g. moist processes, biogeochemical processes, ocean and atmosphere circulation, cryosphere dynamics and carbon cycles in marine environments) it is only possible to estimate the most probable scenarios of the Earth´s climate through the creation of a model that consistently incorporates the interactions between the relevant hydro-bio-physical-chemical processes of the global climate system. The main goal of this subproject is to bring together the Brazilian scientific community to model the different components of the climate system, such as the atmosphere, the biosphere, the oceans, the cryosphere, the aerosols and the land surface processes, as well as to develop the computational methods necessary for the creation of such a complex model. In this context, two main products are being developed: (1) Global climate change scenarios that will constitute Brazil's contribution to the IPCC AR5, and (2) the Brazilian Model of the Global Climate System (MBSCG), which is an original contribution from Brazil to the international efforts to model and project global climate change.



COORDINATORS

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CAPACITY BUILDING

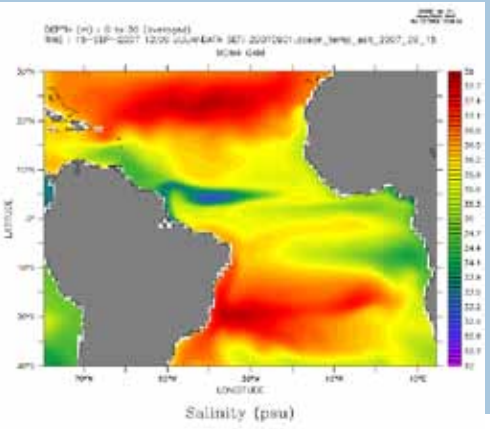
Two MSc students are studying the effects of the ocean-atmosphere coupling on continental hydrology and surface fluxes using a nested regional model. Four PhD students and two MSc students are being trained in various aspects of development, testing and calibration of the component surface-processes sub-model.

KEY EVENTS

A number of diagnostic workshops took place regarding the modeling of the Earth System. These workshops occurred in collaboration with the climate modeling project of *Rede* CLIMA. These workshops evaluated the state-of-the-art on the topic and made specific recommendations regarding the best ways to develop the MBSCG. Special emphasis was given to the processes that affect South America's climate.

Science Highlights

One of the most important aspects for the development of the Brazilian Model of the Global Climate System was the multinational cooperation involving leading research institutions from Brazil, the United States, India, South Africa, Argentina, Chile, and Uruguay. Senior researchers and young scientists from these nations participated in at least one of the four workshops organized by the MBSCG project, hosted in Brazil, in 2009. This interest will bring much needed scientific expertise on topics covering all components of the global climate model under development in Brazil, from forest fire to surface hydrology, effects of river discharge on the ocean, marine biogeochemistry and ice, and advanced topics on atmospheric convection and rainfall. The development of the associated datasets needed for the model runs were discussed. Furthermore, the first scientific paper on the impacts of Amazon deforestation on climate using the coupled ocean-atmosphere global model was published. This coupled model forms the backbone of the MBSCG development, showing the interconnection between rainfall over the Amazon, the general circulation of the atmosphere and the oceans.



The modeling of river discharges on the global oceans integrates continental hydrology with ocean circulation and biogeochemistry, which in turn impact atmospheric circulation and CO_2 cycles. This figure shows the effect of the Amazon River discharge on equatorial Atlantic sea surface salinity, as simulated by the coupled ocean-atmosphere version of the MBSCG

SCIENCE-POLICY INTERFACE

The MBSCG is a necessary scientific infrastructure for Brazil to deal with climate change because it will allow for the production of climatic scenarios for South America with greater reliability than those that are presently available. This will help Brazil and the other South American countries to take the necessary actions to adapt and mitigate climate change.

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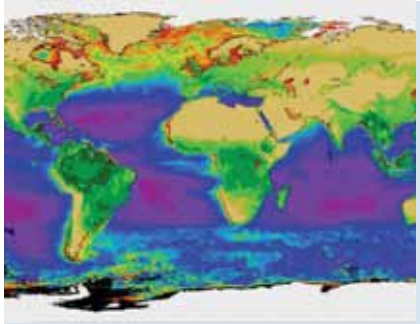


IMPLEMENTATION

HIGHLIGHT

The web-based GIS database comprising an extensive array of MODIS products was assembled. The code of the AGCM/CPTEC was optimized and massive parallelism (MPI ove OpenMP) was introduced to hundreds of processors.

KEY RESEARCH QUESTION

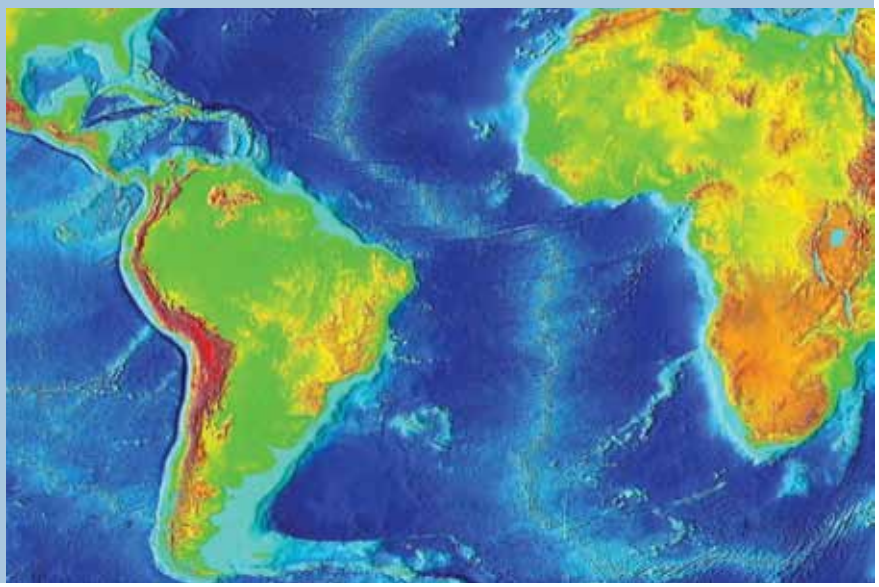
What is the capacity of the AGCM/CPTEC to reproduce atmospheric teleconnection, extremes of precipitation and temperature, and the patterns and the variability of the main trace gases and aerosols?

KEYWORDS

Global Atmospheric Model, global changes, Brazilian Model of the Global Climate System.

CPTEC's Atmospheric Global Circulation Model

The main objective of this sub-project is the development of a Brazilian Model of the Global Climate System, which will allow Brazil to generate climate change scenarios. The understanding of the interactions between the different components of the Earth system, such as the ocean, the atmosphere, the cryosphere and the biosphere, and the capability to simulate part of their dynamics using numerical models, is fundamental to be able to project the impacts of the increase in greenhouse gases and aerosols in the atmosphere, as well as to understand changes in the land use patterns on the Earth's climate. This project has proposed the development of global climate model capacity in two steps: 1) using a state-of-the-art model of international reputation for the generation of Brazil's climate change simulations, which will be the country's contribution to the IPCC AR5, and 2) develop the Brazilian Model of the Global Climate System (MBSCG). Research in this sub-project focuses on creating the atmospheric sub-model of the MBSCG.



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FACILITIES

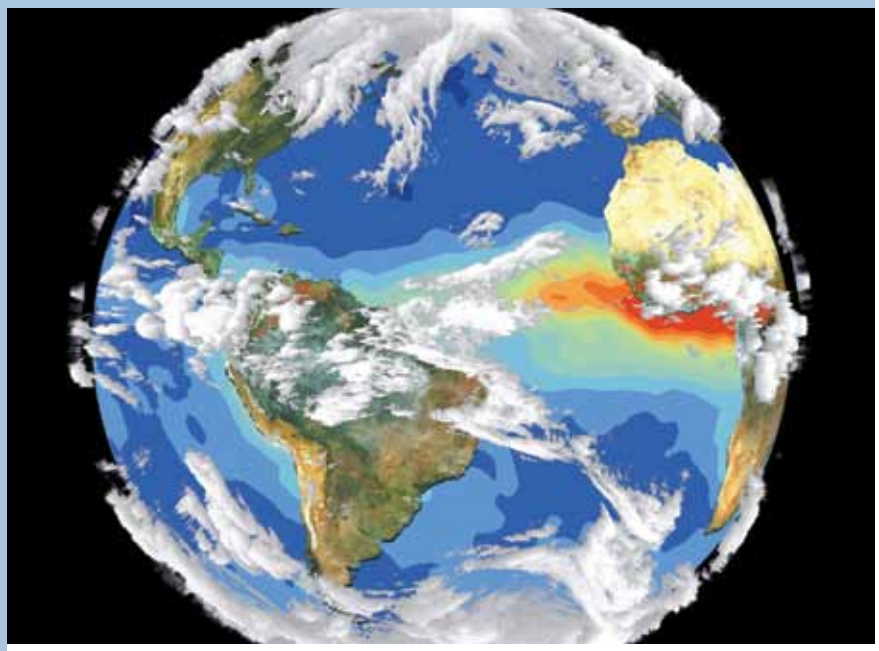
The Brazilian Atmospheric Global Circulation Model will be freely available to researchers with expertise in the area so that they can carry out climate change simulations.

KEY EVENTS

The First Workshop on the CPTEC's Atmospheric Global Circulation Model was held. The main conclusion was that there is a need to include chemical reactivity of the atmosphere in the model.

Science Highlights

The main results involve the improvement of the AGCM/CPTEC model, with the aim of integrating it with the MBSCG. As part of this objective, tests of model performance to simulate atmospheric processes important to climate variability over South America and adjacent oceans will be carried out using time scales of hours, days, seasons and longer periods. The following processes will be included: chemical reactivity of the atmosphere, including natural emissions and anthropogenic aerosols and trace gases, their impacts on air quality and interaction with the atmosphere; assimilation of environmental data, including aerosols and trace gases; parameterization of convection with stochastic approach and coupling microphysics of clouds and radiation; improvements in simulation of planetary boundary layer and the process of continent-atmosphere interaction; parameterization of radiation and its interaction with aerosols and gases; effects of aerosols on the hydrological cycle represented by convective parameterizations; and evaluation of the impacts of land use change and surface coverage in the production of atmospheric aerosols.



SCIENCE-POLICY INTERFACE

The results will help decision-makers from the Brazilian government to make strategic plans and adopt mitigation and adaptation procedures associated with climate change.

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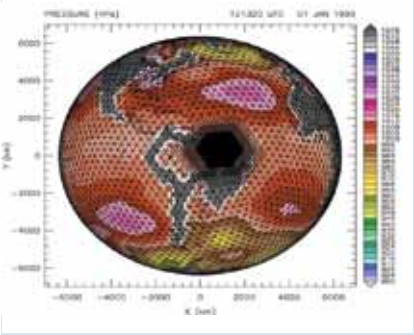

Global hycosaedral grid with refinement over the eastern Amazon for studying scale interaction associated with coastal circulations.

DEVELOPMENT

HIGHLIGHT

A coherent model was developed to describe how intra-seasonal climatic phenomena interact with the annual and the inter-annual (2-7 years) scales leading to decadal/multidecadal climate variability.

KEY RESEARCH QUESTION

Is climate variability in the decadal/multidecadal scales effectively connected to the intra-seasonal variability through multiscaling processes?

KEYWORDS

Multiscaling in climate, ENSO, multidecadal variability, variable resolution modeling, parallel efficiency.

Multiscale Modeling: a Challenge for Future Modeling Efforts

Climate is a clear example of multiscale phenomena. It has been hypothesized that better climate forecasts in the seasonal time scale can be accomplished with models that perform better in weather forecasting. The so-called "seamless prediction" constitutes the current trend in climate modeling. The project focuses on the challenges by exploring (over 5-10 years) the production of future versions of climate models. In particular, the modeling of the multiscale nature of atmospheric processes and their interactions will be the main focus. The work is mainly carried out with computer simulations and theoretical development of analysis tools based on concepts of nonlinear energy exchange among different scales of climate systems. This sub-project has substantial interaction with the INCT for Mathematics. This sub-project has already achieved a better understanding of the physics of slow climate variability (period of the order of decades), of the role of the diurnal variation acting as a trigger for climate variability in the 20-60 day scale, and an improvement of the parallelization of a possible dynamical core for future climate models based on numerical techniques that allow coherent multiscaling modeling.

COORDINATOR

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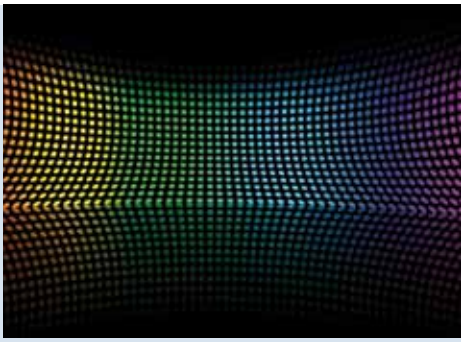
CAPACITY BUILDING

There are two MSc students working on numerical aspects of multiscaling climate modeling and one PhD student working on the development of theoretical models for climate multiscaling. There is also one post-doctoral fellow developing numerical techniques.

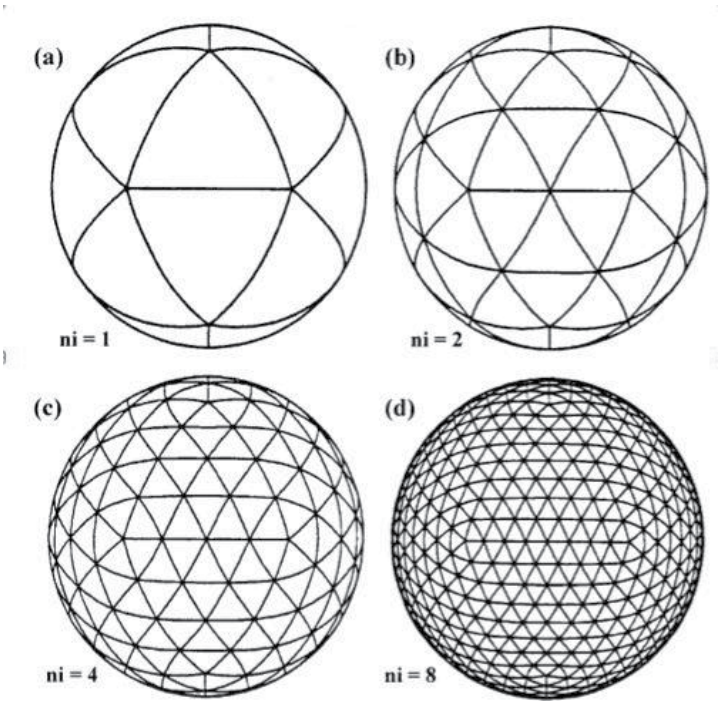
KEY EVENTS

A joint workshop between INCT for Climate Change and INCT for Mathematics was held at IMPA, Rio de Janeiro, Brazil, on January 23-24, 2009.



Science Highlights

The issue related to the role of multiscaling processes in the atmosphere leading to the interaction between the diurnal variability and the intra-seasonal time scale is the focus of the papers by Raupp and Silva Dias (2009, 2010). The dynamical explanation for the energy transfer is the major contribution of these papers. The practical implication is that climate models must be able to properly reproduce the diurnal variability in order to correctly simulate the slow climate variability. The Ramirez Gutierrez et al. (2009) paper is a contribution to the understanding of the monsoon precipitation regime in South America. It focuses on scale interaction that leads to the summer rainfall regime in tropical South America. The Barros and Peixoto (2009) paper contributes to the development of numerical techniques that properly simulate the multiscaling processes in climate models.



Construction of a global geodesic grid with triangular mesh cells for the finite volume discretization of the governing equations of the atmospheric motion.

SCIENCE-POLICY INTERFACE

This project will provide the theoretical basis for the development of better climate models, which, in turn, serve as the basis for more reliable climate change scenarios.

SELECTED PUBLICATIONS

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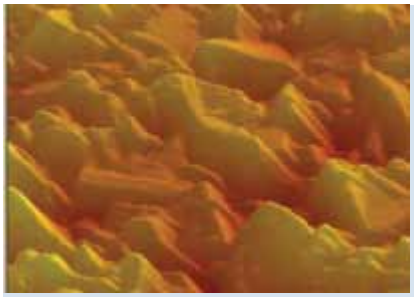

Atomic Force Microscopy (AFM) image of a boron-dopped diamond (BDD) film with Cu

DEVELOPMENT

HIGHLIGHT

Studies concerning organic oxidation and nitrate reduction including surface treatment by micro/nanocrystals of boron or nitrogen-doped films (BDDN) show a huge potential for environmental applications.

KEY RESEARCH QUESTIONS

Can stable, reliable and low cost devices for the detection of nitrate and organic compounds be developed?

Is it possible to build efficient and low cost reactors for effluent treatment?

KEYWORDS

Boron-doped diamond, nitrate, organic compounds, sensor, moisture, carbonaceous, ceramic.

Observational Technologies for Climate Change

Analytical chemistry facilities at INPE - São José dos Campos (partial view).

This research and technological project was created to allow technological development, validation and operation of sensor devices based on carbonaceous and ceramic materials. The development of carbonaceous materials aims at detecting chemical species (organic and inorganic), as well as at developing reactors for effluent treatment. The development of ceramic materials seeks devices for continuous measurement of atmospheric and soil moisture. This is a multidisciplinary initiative that combines technological research for applications on water quality monitoring and effluent treatment. To reach these targets, specific sensor/reactors will be tested on a workbench, first with synthetic chemicals, then with real environmental or effluent solutions. Provided that the objectives are reached, the use of sensor devices based on carbonaceous materials will allow tertiary treatment of effluent to eliminate nitrate and organic compounds (main target), which will represent an improvement in sanitation while lowering its costs.

COORDINATOR

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CAPACITY BUILDING

There are four graduate students and three post-doctoral fellows involved in the production and characterization of diamond and carbonaceous materials applied to nitrate reduction and the advanced oxidative process for waste water treatment.

FACILITIES

A chemical laboratory for sample preparation and analysis, covering a large spectrum of analytics, using liquid ion chromatography, total carbon and nitrogen analyzer, amongst others, was implemented at INPE, São José dos Campos, SP, Brazil.

Science Highlights

The results for oxalic acid oxidation showed the superiority of the BDDN (micro/nanocrystals of boron- or nitrogen-doped films) electrodes treated with hydrogen plasma in comparison with other treatments and films without doping. These results confirm the importance of surface terminations control in the electrochemistry response of BDDN electrodes, and the possibility of applying them in the oxidation of other molecules, which has already begun with the study of phenol oxidation in the cleaning of effluents. A workbench-developed electrochemical cell is being used in tests of dye degradation. BDD films have been modified from metallic nanoparticles' electrodepositing with the objective of improving the electro-catalytic properties of boron-doped diamond, which can then be used to analyze nitrate in water. Five papers were published in indexed scientific journals and 18 presentations in International and National scientific conferences were made. Also, one patent was deposited: Solicitation at IPI on 15/Apr/2009 PI 0901543-4.

Sample preparation and sensor characterization facilities at INPE - São José dos Campos (partial view).

SCIENCE-POLICY INTERFACE

Our results have applications in areas spanning from public sanitation to the collection of better data for climate modeling.

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Angra dos Reis (RJ), Brazil, January, 2010

DEVELOPMENT

HIGHLIGHT

The release of the second version of SISMADEN (the information system for natural disasters risk reduction).

KEY RESEARCH QUESTION

How to develop, implement, test and validate semi-automatic environmental, hydrological and meteorological information systems to support the management of natural disasters caused by extreme hydro-meteorological conditions in Brazil?

KEYWORDS

Natural disasters, early warning system, landslides,floods, vulnerabilities, risk areas.

Early Warning System in Support of Natural Disaster Risk Reduction

Natural disasters cause great loss of life and property all over the world, and their increasing risk, caused by global warming, is an issue of global concern that demands fast and globally coordinated actions to reduce the vulnerability of human populations. In Brazil, few studies deal with the impacts of extreme climatic events on natural ecosystems, agro-ecosystems, coastal zones, renewable energies, water resources, mega-cities and human health; though, without a doubt, Brazil will not be left untouched by climate change. Frequently, due to lack of predictions, governmental actions are taken only after the occurrence of the extreme event that causes natural disaster, which means that they can only try to remedy the losses. In response to this inadequate situation, this sub-project is developing, implementing, testing and validating a semiautomatic environmental and hydro-meteorological information system to support the management of natural disaster risks caused by extreme hydro-meteorological and climatic conditions.

COORDINATOR

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Rio de Janeiro (RJ), Brazil, April, 2010

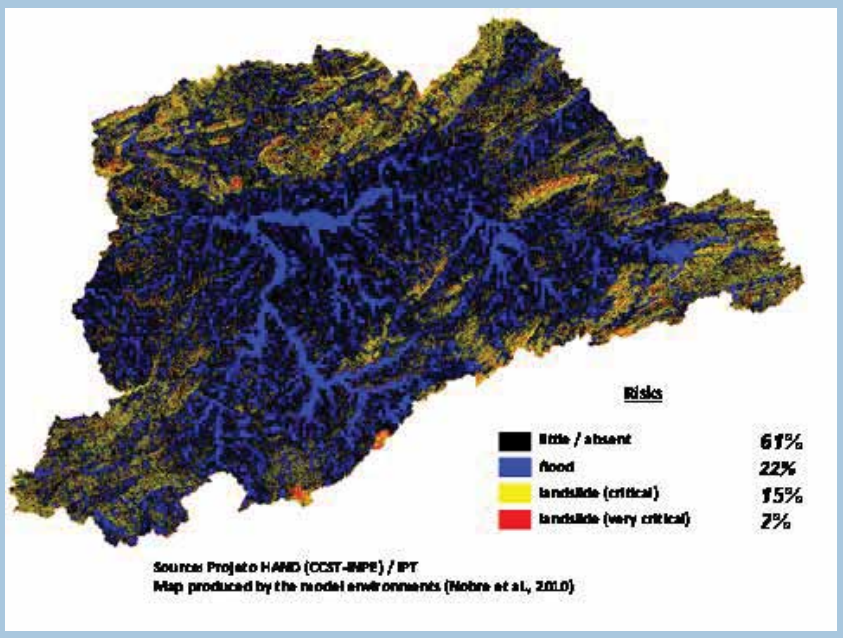
CAPACITY BUILDING

One PhD student, enrolled in the Earth System Science doctoral program at INPE, is carrying out research in this sub-project. Moreover, presentations to research institutions located in regions susceptible to landslides are being carried out with the purpose of improving the modeling and alert system.

Flood in Jacuípe, Mundaú river, Alagoas, Brazil, in 26 June 2010.

Science Highlights

(1) An improved version of the Information System for Risk Reduction of Natural Disasters (SISMADEN), Version 2, was released (www.dpi. inpe.br/ sismaden). (2) The system was installed at the Institute for Technological Research (IPT) and the Geological Institute of the State of São Paulo (IGSP). Tests conducted with the system indicate that it may be used operationally. The availability of meteorological data and the increasing number of extreme events with consequent floods and landslides indicate that sectors of society/potential users could be previously notified (e.g. Civil Defense). (3) Divulgation and presentation of the developed system took place at research institutions located in metropolitan areas susceptible to landslides, with the purpose of exchanging the necessary knowledge to improve it. (4) Documentation and training materials to transfer the system were compiled and made available to state and federal agencies, as well as to developing countries with similar vulnerabilities to natural disasters.



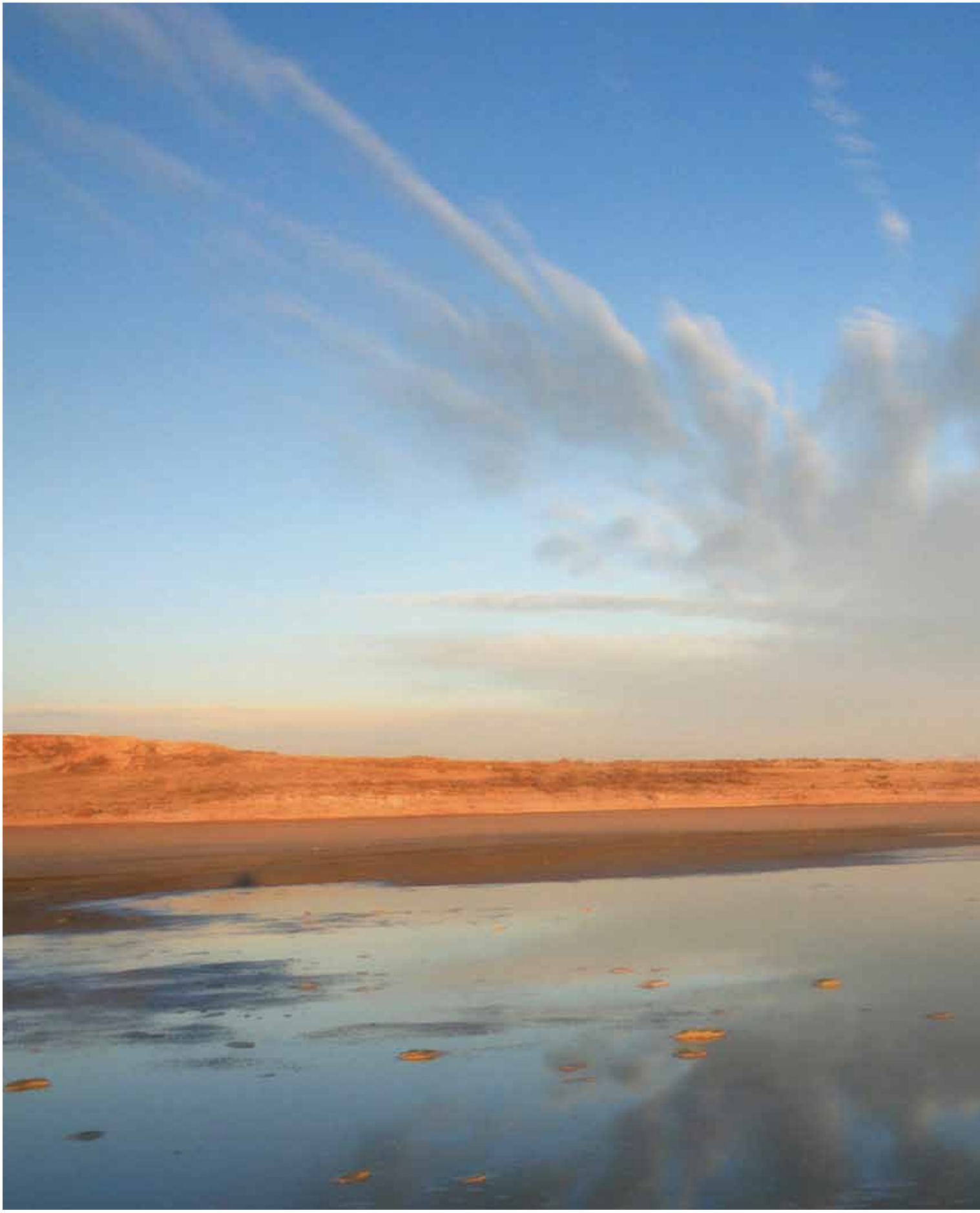
Risk-areas in São Paulo's Metropolitan Area.

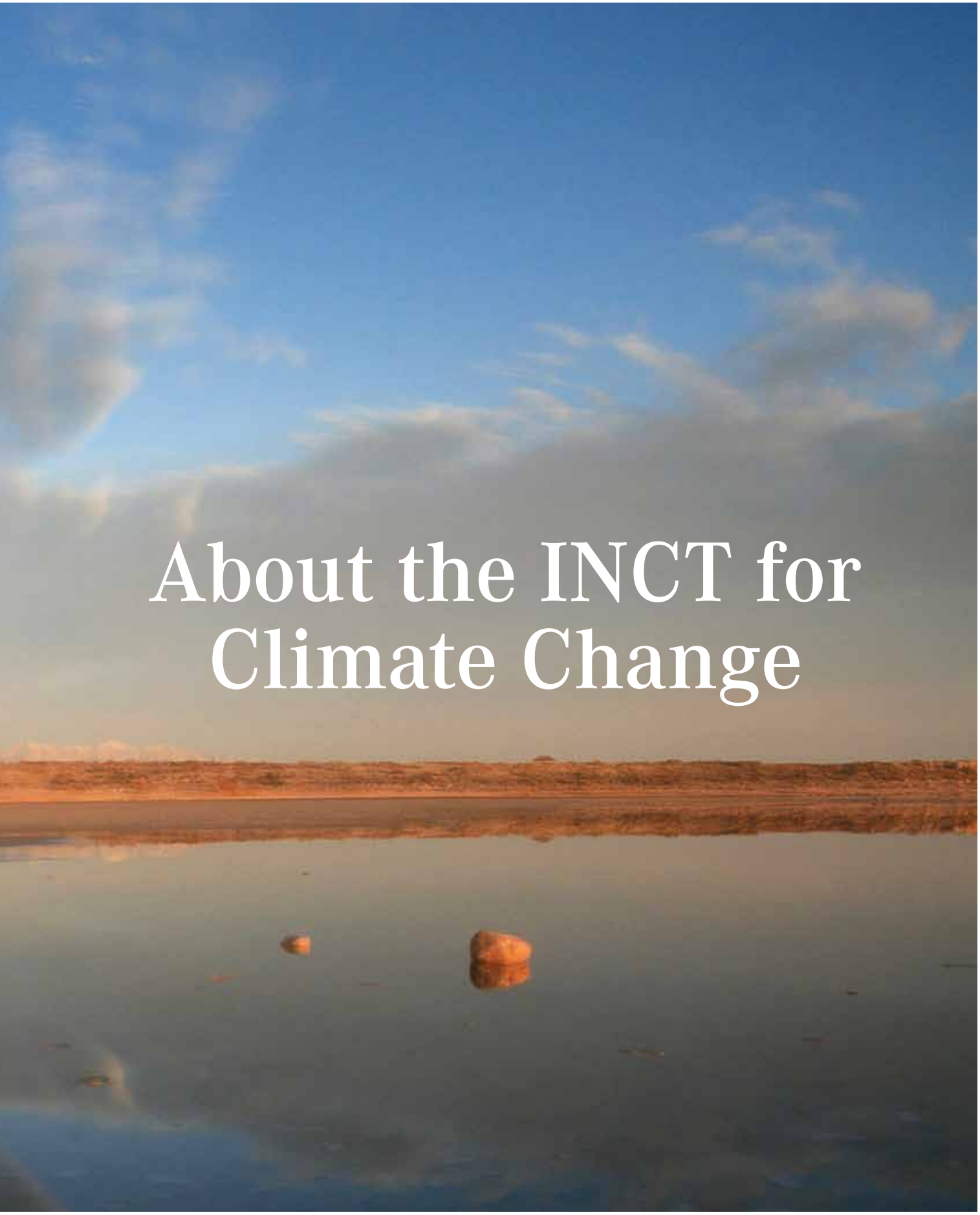
SCIENCE-POLICY INTERFACE

SISMADEM will facilitate issuing warnings about the risks of natural disasters to governmental authorities at all levels. This will allow actions to be taken earlier and, thus, probably more lives will be saved.

SELECTED PUBLICATIONS

Updated tutorials and training scripts are available at www.dpi.inpe.br/sismaden/documentos/php.



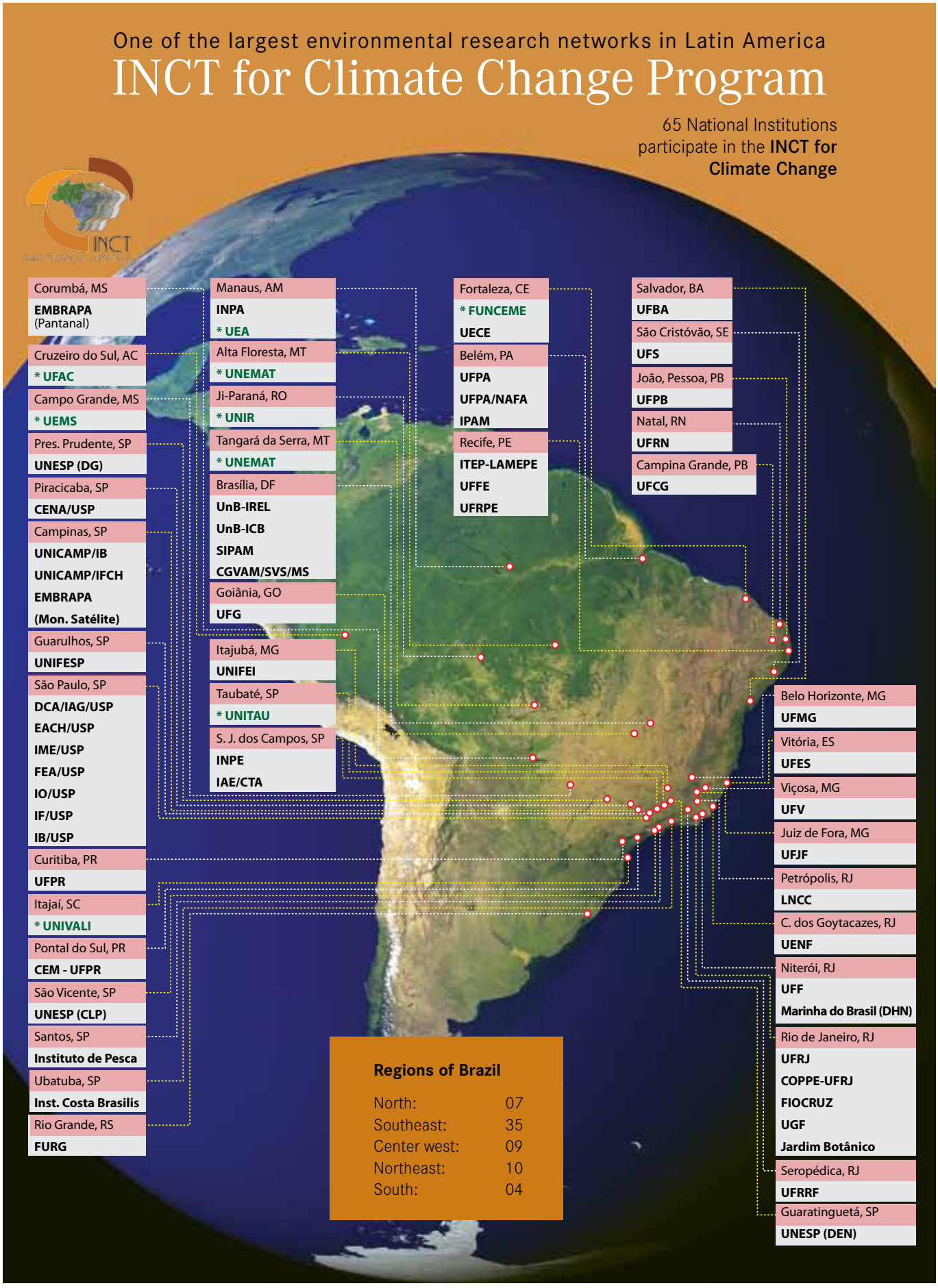


About the INCT for Climate Change

One of the largest environmental research networks in Latin America

INCT for Climate Change Program

65 National Institutions participate in the **INCT for Climate Change**

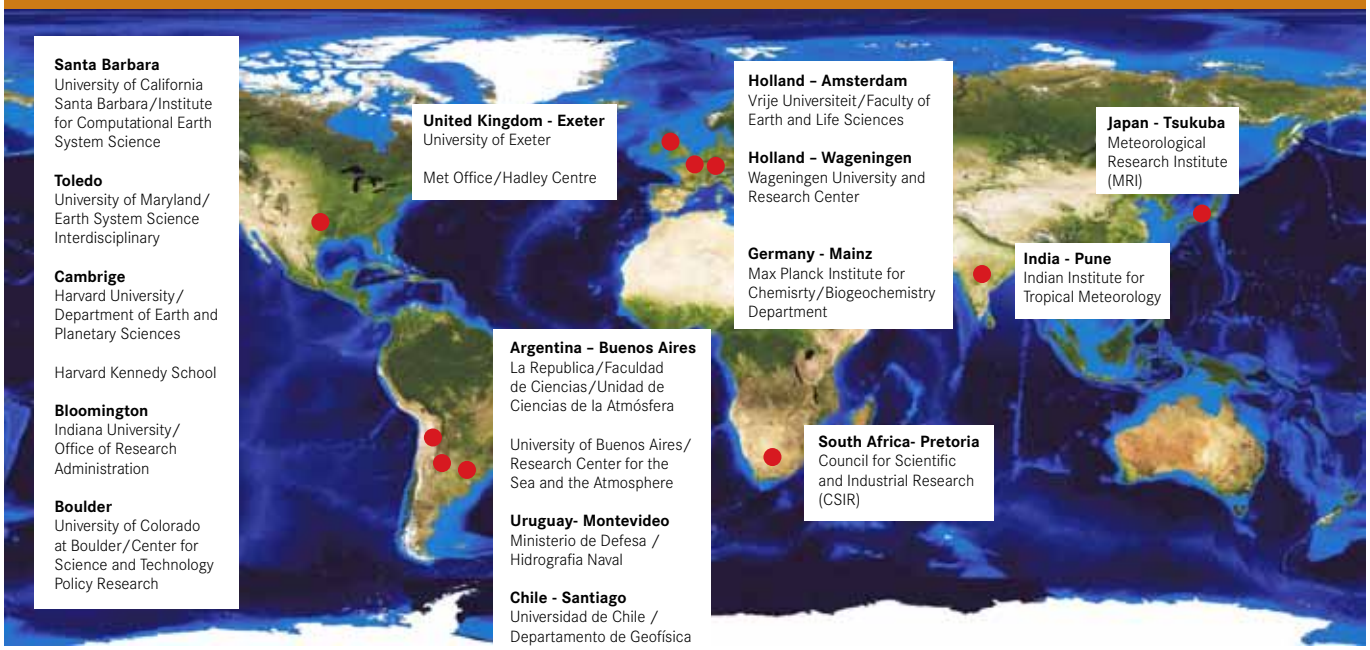


Regions of Brazil

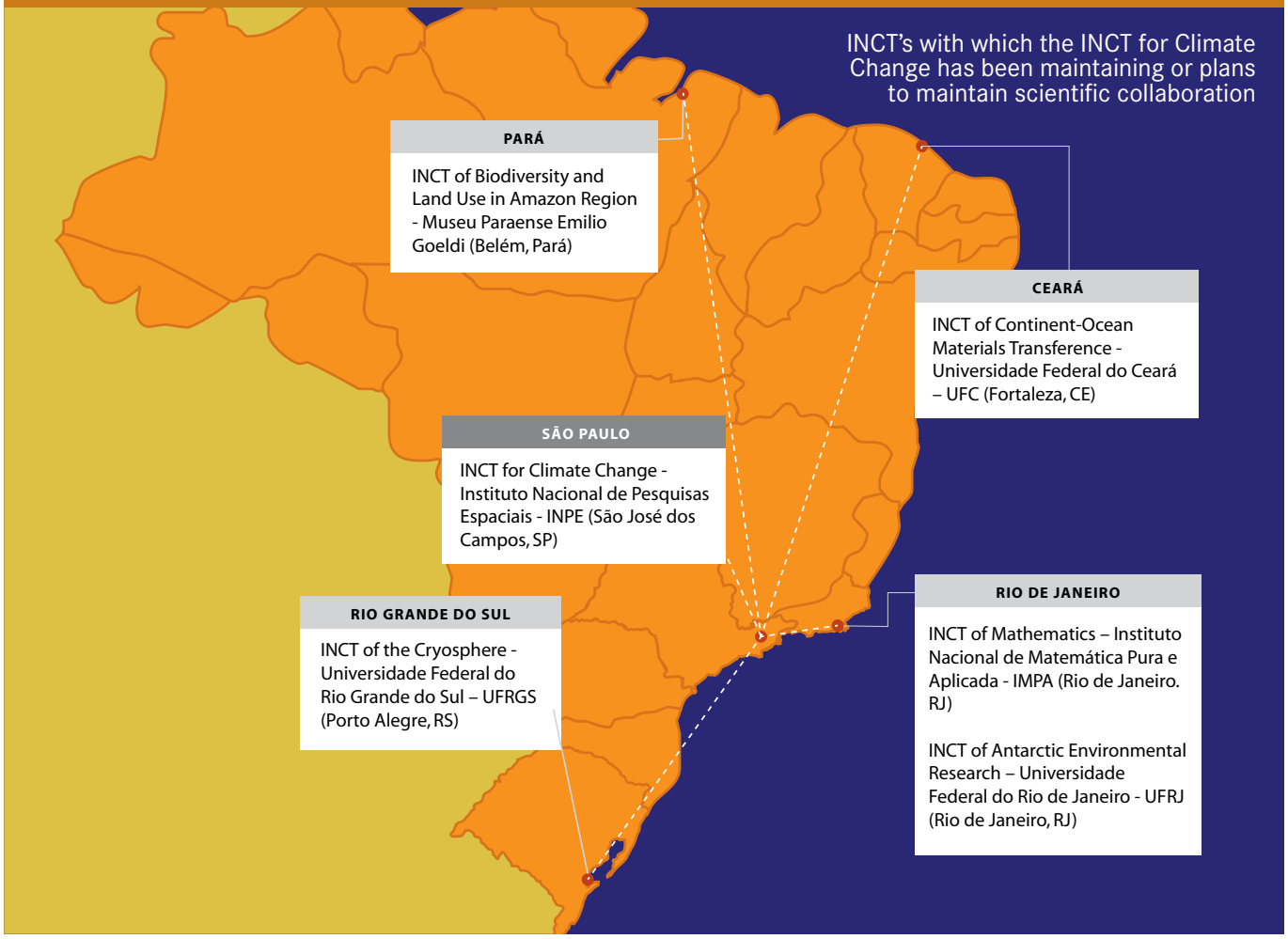
North:	07
Southeast:	35
Center west:	09
Northeast:	10
South:	04

Research Groups from Institutions abroad
Argentina, Chile, Uruguay, USA, Germany, Holland, South Africa, India and Japan.

Apart from the collaborations with Brazilian institutions, the INCT for Climate Change also collaborates with 17 institutions from 10 other countries.



Network of INCT's



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(Brazilian Model of the Global Climate System)

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(Observational Technologies for Climate Change)

M. Lahsen, INPE
(Studies of Science, Technology and Policy)

P. Alvala, INPE
(Greenhouse Gases)

P. Artaxo, USP
(The Amazon)

P. Moutinho, IPAM
(Reduction of Emissions from Deforestation and Degradation - REDD)

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(Brazilian Model of the Global Climate System; Oceans)

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(Multiscale Modeling)

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LIST OF SCIENTIFIC PUBLICATIONS | 2009.2010

The INCT for Climate Change had its path set by previous research networks (LBA, GEOMA, Biota-FAPESP, etc.); it further the goals of the previous programs and encompasses a relevant effort for the continuity of LBA. It also collaborates directly with other, more recent, projects, such as *Rede* CLIMA and the FAPESP Research Program on Global Climate Change (PFPMCG). Thus, knowledge generated by the INCT for Climate Change must be seen to some extent as the follow-up of studies began previous research programs. In addition to that, there are many new research lines initiated by this INCT.

For this reason, in this first report we present a list of the publications produced by the INCT for Climate Change organized by subprojects, but that also includes publications that are the result of studies initiated prior to thecreation of the INCT for Climate Change, but which were incorporated fully into the current program. This helps to better set the scientific historical context in which the INCT for Climate Change was created.

The Scientific Basis

Detection and Attribution of Climate Change and Natural Variability

Papers published in International journals

Marengo J, Ambrizzi T; Rocha RP, Alves LM, Cuadra SV, Valverde MC, Ferraz SET, Torres RR & Santos DC. Future change of climate in South America in the late 21st century: Intercomparison of scenarios from three regional climate models, **Climate Dynamics** 35(6): 1073-1097, 2009. DOI: 10.1007/s00382-009-0721-6.

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The Amazon

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Ahlm L, Nilsson ED, Krejci R, Martensson EM, Vogt M & Artaxo P. Aerosol number fluxes over the Amazon rain forest during the wet season. **Atmospheric Chemistry and Physics** (Print) 9:9381-9400, 2009.

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Araújo MS, Bolnick DI, Martinelli LA, Giaretta AA & Reis SF. Individual level diet variation in four species of Brazilian frogs. **Journal of Animal Ecology** (Print) 78:848-856, 2009.

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LA, Tsamakis E, Hedges JI & Keil RG. Lignin phenols used to infer organic matter sources to Sepetiba Bay RJ, Brasil. Estuarine, **Coastal and Shelf Science** (Print) 87:479-486, 2010.

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Saad SI, Rocha HR, Dias MAFS & Rosolem R. Can the Deforestation Breeze Change the Rainfall in Amazonia? A Case Study for the BR-163 Highway Region. **Earth Interactions** 14:1-25, 2010.

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