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# NewsLetter of the project *GOF-UK-CPTEC*

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## Editorial

The production of climate change scenarios from regional models in South America is a hard and complicated task, and CPTEC/INPE has taken it as part of the activities of the Ministry of Science and Technology MCT Brazilian National Climate Change Program. The implementation of these future climate scenarios, as consequence of the increase of greenhouse gases concentration is made at almost continental level. These activities has made quite a progress, thanks to funding from the UK Global Opportunities Fund - Climate Change and Energy Programme from United Kingdom (GOF-UK-CPTEC), the PROBIO Project from the Ministry of Environment MMA and the Climate Change Modeling Activity from the Ministry of Science and Technology and currently developed at CPTEC/INPE. We anticipate that the construction of regionalized future climate change scenarios will be of great utility in generating impact and vulnerability assessments and design public policies for the decision making processes regarding mitigation and adaptation by the different sectors of society.

"In Search of Lost Time", UPME, 2000

Despite of the proven usefulness of the climate change scenarios as strategy tools, it is common to find arguments of disagreement, where it says that the processing of scenarios is a very time and money consuming process a very little benefit for decision making, besides of the uncertainties associated to the climate models that generate the climate projections of the future. However, it is important to remember that the function of the future climate scenarios is to show to the decision makers all the possible future scenarios in which climate could change and how these changes can affect the society. Therefore, the problem of the climate change is no longer scientific, and climate change should force the governments to question their positions related to the environment and reorganize their maps of reality, in such case, the problem is not on the scenarios, but also on the process of making decisions knowing what could happen with the climate in the future.

The objectives of the *GOF-UK-CPTEC* Project are the generation of future regional climate change scenarios for the three most populated and the most economically important basins of South America (Sao Francisco, Amazon and Parana - La Plata), intending to define a group of possible qualitative and quantitative climate futures for these basins, in such a way that they can serve to the development of multidisciplinary studies which have the purpose to call the attention of the governments and the policy makers, about the climate impact, the analysis of the vulnerability and the measures of adaptation. As the scenarios are learning tools, the importance of them will be in activating the reevaluation, discussion and new learning for the stakeholders and interested governments. Indices of vulnerability are going to be implemented in the region, with emphasis on the three case studies.

Activities of *GOF-UK-CPTEC* Project started on July 1st of 2005, after almost eight months of activities and during this first step of the project, simulations of the regional climate models are being made, and we anticipate that by May 2006 we will begin the construction of the future climate change scenarios, that will be the fundamental piece of information for decision makers, stakeholders and policy makers. The first Newsletter was published in middle 2005, the project was presented in several scientific and governmental meetings in Brazil and in other countries. At the moment a database and a website about the topic of climate change relevant to the project are being implemented at CPTEC/INPE.

It is with great satisfaction that we deliver this Newsletter second edition of the project *GOF-UK-CPTEC.* On this issue, Dr. Walter Baethgen, Coordinator of Latin American activities at the *International Research Institute for Climate and Society IRI* reveals his plans for collaboration with our project and he remarks the importance of climate change in decision making. We also discuss some preliminary results of possible effects of climate change on agriculture in Brazil, as well as an assessment about the impacts of climate change on hydrological regimes on the three basins of the project with emphasis on the Sao Francisco River basin, as well as the uncertainties associated with differences among model projections.

This discussion is important, because currently it is being discussed in Brazil the controversial Project of Diversion of the Sao Francisco River waters to irrigate large regions of the interior semi-arid region of Northeast Brazil, that is one of the poorest regions of Brazil and the most vulnerable to climate change. The project would benefit millions of people, but its implementation does not consider how the hydrological regimes in this basin would change in the future, and having contrasting results among the various future climate and hydrology projections from modeling scientific teams from US Geological Survey and from Hadley Centre for Climate Prediction and Research of Met Office from the United Kingdom adds even more uncertainty. This is a large project and need some debate, and we realize that the scenarios of future climate generated by *GOF-UK-CPTEC* project can also contribute to this debate.

Again, we reiterate our interest in making available all the results generated by the project to the entire scientific and decision making community, with the purpose of offering a forum for discussion about climate change and its impacts, as well as for vulnerability analysis and the implementation of adaptation measurements on the three basins focus of thus *GOF-UK-CPTEC* Project.

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### In this edition

# The Climate Change Into Decision-Making

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Decision makers (including those who develop policies) working in the public and private sectors of developing countries, typically confront the pressure to act in response to problems that require immediate action. Moreover, the effect of such actions must be evident during the usually short terms in which those decision makers operate. Consequently, they assign relatively low priority to issues that are viewed as problems of a distant future as is often the case of "Climate Change". At the International Research Institute for Climate and Society (IRI) we propose that "Climate Change" must be introduced in the agendas of decision makers (including policy makers) as an issue of the present, directly linked to socioeconomic sustainable development.

Some of the most important expected impacts of climate change on societies are the ones caused by possible increases in climate variability, including more frequent and more damaging extreme events. Consequently, at the IRI we propose that an effective manner for assisting societies to be prepared and adapt to any possible climate change scenarios is by helping them to cope better with current climate variability. This requires the establishment of climate risk assessment and risk management strategies (as opposed to crisis management), including the identification of policies and practices that help to reduce the socioeconomic vulnerability to adverse climate conditions including extreme events and that take advantage of the favorable climate conditions. Climate risk management strategies also include actions for transferring risks associated to climate variability for example through the establishment of adequate insurance programs. A clear advantage of this approach is that it provides immediate assistance to the public and private sector: while it helps stakeholders to confront possible future climate scenarios, it assists them to manage the existing climate variability that is currently affecting societies. Furthermore, the impacts of the taken actions are also evident and verifiable in the immediate term making them more attractive to policy makers and decision makers.

IRI's approach for adaptation to climate change based on climate risk management is well attuned with the research activities of the GOF project in Brazil. Establishing collaborative activities between the scientific GOF team and the LAC Regional Program of the IRI will result in improved and effective communications with the stakeholder community of the region. On the other hand, the IRI is currently engaged in several research projects in southeastern South America and in the Brazilian Nordeste. This work is being developed in close coordination with decision makers of the public and private agricultural and water resource sectors, and these activities will be greatly enhanced by the collaboration with the GOF project.

We propose that "Climate Change" must be introduced in the agendas of decision makers as an issue of the present, directly linked to socioeconomic sustainable development.

# Hydrological Impacts of Climate Change in Three Large Basins in Brazil: Amazonia, Parana - La Plata and Sao Francisco

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In Brazil, the Sao Francisco, Amazon and Parana-La Plata Rivers are largely important for their contributions to the agricultural, transport and hydroelectric potential in Brazil, as well as for their ecological and social implications. The vulnerability of the Amazon ecosystem and biodiversity, of the population in the semiarid Northeast Brazil, and of the agriculture and production hydroelectric power of the Parana-La Plata basins to climate change, already suggest strong impacts of climate change in the economy of Brazil. Great projects as the *Diversion of the Sao Francisco River* water could have a different social impact if the hydrological regime in this river basin changes in the future.

Two studies recently published have suggested that there is evidence of change in the hydrological regime and river flux all around the world, due to an increase in the concentration of greenhouse gases in the atmosphere and the consequent global warming.

The first study has been prepared by a team of scientists of the US Geological Survey, and it was published by Nature in November 2005 (Milly et al. 2005). This paper assesses the impacts of climate change in global river flow in future warmer climates. An ensemble of twelve IPCC climate models [CCSM3, CGCM3.1(T63), ECHAM5/MPI-OM, ECHO-G, FGOALS-g1.0, GFDL-CM2.0, GFDL-CM2.1, GISS-AOM, MIROC3.2(hires), MRI-CGCM2.3.2, UKMO-HadCM3 and UKMO-HadGEM1] showed qualitative and highly significant quantitative skill in identifying the regional runoff trends indicated by stream flow measurements at 165 long-term stream gages in present climate. In integrations for the XXI Century, the same set of models robustly projects regions of increasing runoff and regions of decreasing runoff in each of North America, South America, Africa, and Eurasia.

Figure 1 shows XXI Century percentage changes in runoff estimated by the model ensemble. The ensemble-average change in runoff by the period 2041-2060 shows a pattern generally consistent with that of XX Century change, though amplified and with important qualitative differences. In general, areas of increased runoff shrink while areas of decreased runoff grow in XXI Century related to XX Century. Initially increasing trends of runoff in the XX Century are projected to reverse in the XXI Century in eastern Africa, the western central plains of North America, and much of Australia. Modeled drying of the Mediterranean region extends farther north into Europe in the XXI Century.

Almost all model runs agree on the direction of XX Century trends in certain regions (Figure 1) for the future scenario A1B. These agreements include positive trends in the high latitudes of North America and Eurasia, in the La Plata Basin of South America, in eastern equatorial Africa, and in some major islands of the equatorial eastern Pacific Ocean.

Prominent regions that show agreement on negative trends in the runoff include southern Europe, the Middle East, mid-latitude western North America, southern Africa, eastern Amazonia and Northeast Brazil. The runoff increase or decrease is related to changes in rainfall amount or distribution, and most of the models simulated reductions in rainfall in Amazonia and Northeast Brazil (some uncertainty is present since the HadCM3 and the GFDL models shows more and less rainfall related to the present climate, respectively), while for the Parana-La Plata basin all models project increase in rainfall. Temperatures in all these regions have increased by 2100 by 2 to 8 ºC in the three regions for the high emission scenario A2, and by 1.5 to 6 °C in the low emission scenarios B2 (with the warmest in Amazonia). The model projections for the XXI Century on Milly et al. (2005) paper are dependent upon various assumptions, e.g., concerning future greenhouse-gas emissions, volcanic activity, and solar variability.

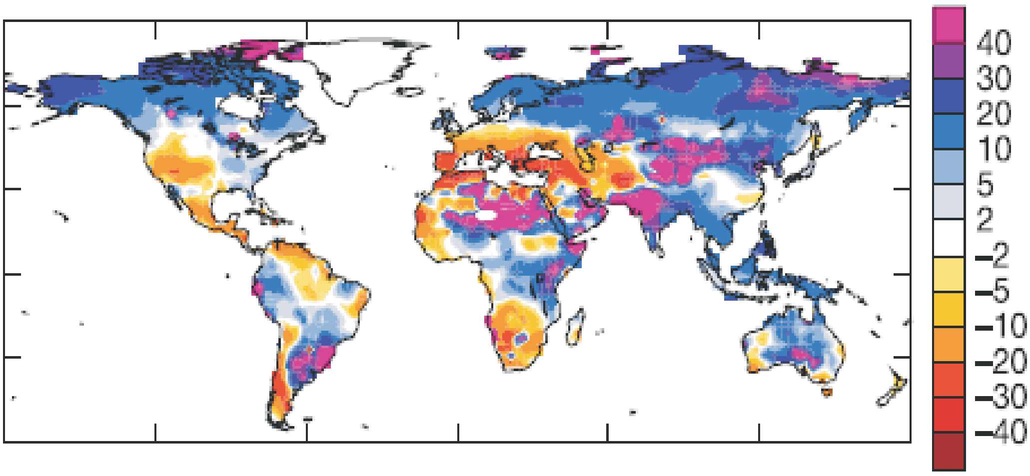


Figure 1. Ensemble (arithmetic) mean of relative change (percentage) in runoff for the period 2041-60, computed as 100 times the difference between 2041-60 runoff in the SRESA1B experiments and 1900-70 runoff in the 20C3M (XX Century) experiments, divided by 1900-70 runoff. (Milly et al. 2005)

The second paper is a Report of the Hadley Centre for Climate Prediction and Research, from the UK Met Office (UK Met Office 2005). This report shows the first predictions of the XXI Century climate from the new Hadley Centre climate model, HadGEM1 (the UK Met Office global environmental model), with predicted changes in river flow from this model. Different that the work from Milly et al., these simulations include the two most important processes: the direct effect of climate change and the effect of $CO_2$ on plants that were not included on the HadCM3 projections. They made two future predictions for the XXI Century. When the direct $CO_2$ effect on plants is omitted, the global average river flow is predicted to increase in 2% between the 2000-2020 and 2080-2100 periods. When the direct $CO_2$ effect is included, the predicted increase rises to 7%. Thus, the direct effect of $CO_2$ is predicted to be dominant on a global scale. Predictions have been made with the HadGEM1 for the SRES A1B and A2 scenarios. In both cases, global total river flow is predicted to decrease slightly until the middle of the XXI Century, and then increase until 2100 (Figure 2).

**The new environmental global model of the Hadley Centre "HadGEM1" includes the direct influence of $CO_2$ in the plants, this adds realism to the simulation of the climatic system.**

The total XXI Century increase in river flow is 4% and 8% for the A1B (moderate) and high emission scenarios A2 cases (pessimist) cases, respectively. In South America, the river flux in XXI Century in the semiarid Northeast Brazil will increase between 50% and 200%. In the Amazon region the river flow will decrease between 25% e 50% and in Parana-La Plata will increase in 50% in the lower and middle basins together with a 25% in the Upper basin and in the Pantanal region. There is a great difference (opposite tendencies) between the projections of discharge in the Sao Francisco River basin when is included and omitted the direct influence of $CO_2$, while in the other regions the differences are small but of the same direction.

The difference is on tendency in the Sao Francisco River streamflow, and the contrasting projections could add uncertainty of these trends. In present climates, the experience in seasonal climatic prediction at CPTEC show that the river basin of the Sao Francisco exhibits lower seasonal climate predictability and models do not show good skill on the medium and upper basins. If we assume that predictability would remind the same, then projections for future climate will have a large degree of uncertainty. On the other hand, the inclusion of the effects of plant behavior on future climate projection would add reality to the simulation of the climate system. For one side, if this is not done, there is a risk that fluvial flood risk will be underestimated while droughts may be overestimated in some areas. It also highlights the need to consider the climate system behavior as a whole, including both physical and biological aspects.

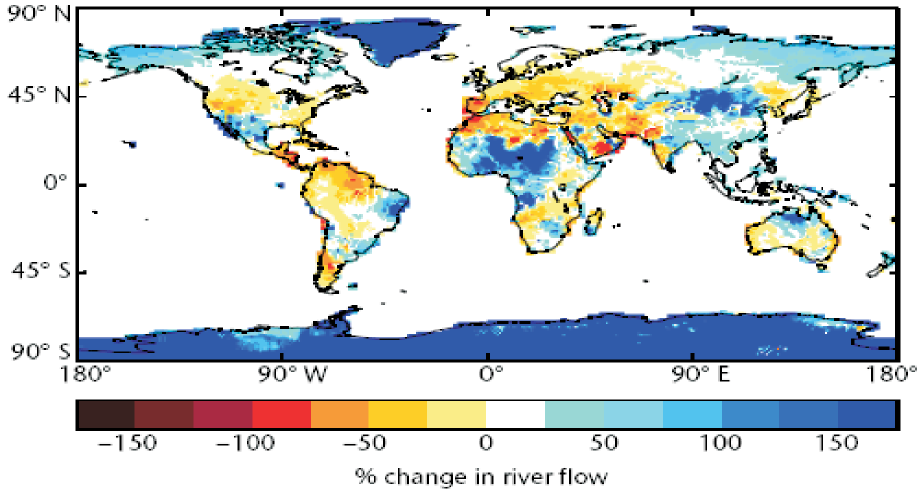


Figure 2. Predicted change in global river (%) flow between present day and the late XXI Century for SRES emission scenarios A1B from the new Hadley Centre climate model, HadGEM1 (UK Met Office 2005).

On the other hand, the positive trends in the Sao Francisco streamflow projected for the end of the century are simulated for one model only, and more experiments and the use of other models would reduce the uncertainties.

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# Global Climate Changes and its Effects on Brazilian Agriculture

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## Introduction

According to Marengo (2001), since 1980 there are scientific evidences about possible global climate change. In 1988 the United Nations Program for Environment and World Meteorological Organization founded IPCC (Intergovernmental Pannel on Climate Change), a research effort to assess our real knowledge and understanding about climatic changes and its connections with anthropogenic activities. The IPCC results show a global increase of greenhouse gases (GHG) with an enhancement of global warming. Several studies show that increasing of carbon dioxide ($Co_2$), $CH_4$ (methane), carbon dioxide (CO), nitrous oxide ($N_2O$), nitrogen oxide (NOx) and ozone ($O_3$), partially due to human activities, has caused an increase in surface temperature and variabilities in precipitation. An increase of 0,65ºC in global mean temperature in the XX Century was observed, and the higher increase was verified in the last decade. However, these increases also could be caused for natural causes. Therefore, global concerning will demand global actions, mainly about decreases in GHG's emissions and implementing new adaptative strategies. Under any scenario, however, in the future we expect likely, extreme events like droughts, floods, hot waves, etc, with intensive impacts on biosphere-atmosphere systems.

## 2. Biophysical relationships between climate and agriculture

There are strong cause-effect connections between climate and agricultural systems, in developed and in underdeveloped countries; instead advances in management and technological strategies like irrigation, genetic engineering, etc. However, subtropical and tropical countries have a higher vulnerability.

The vulnerability of a country or a region could be seen as damage extensions due to climatic changes in any sector or production system. These damages will be as more intense as higher their sensibility and capacity of adaptation before these changes.

Weather and climate can affect agricultural systems in some ways, in crop production and yields, in pests and diseases and field management. The climate elements and factors will impact the crop geographic distribution and also with impacts in socio-economic issues. Therefore the agricultural climatic impacts will be new challenges for development with security food and abatement poverty.

## 3. Impacts on Brazilian agriculture. What should we do, wait or adapt?

Brazil has continental dimensions and a great set of soils, landscapes and climates and will be experienced a lot of consequences of global warming. Under an agricultural point of view, real zoning regions will be change, with modifications in crop productions, dates of seeding/planting/harvest, etc. As higher change ranges lower the adaptation possibilities. The tolerance of crops to higher temperatures will be a good indicator while other crops can be displaced to other regions for planting. Before uncertain future climate scenarios the science can propose some adaptative strategies to minimize negative impacts of climatic change. For agricultural systems these strategies include changes in planting dates and harvest, the select of better crops suited to regional climates, the adoption of best management practices and the respect to agro climatic zoning.

There are few studies about global warming and its impacts on agricultural production for Latin America and Brazil in particular. Some works for Brazilian conditions [Siqueira et al. (2000) and Siqueira et al. (2001)] have shown decreases in maize and wheat production, and increases for soybean.

Another one is Assad et al. (2004) about temperature impacts (increases of 1ºC, 3ºC and 5,8ºC) and precipitation (increases of 15%) in present-day coffee distribution in some regions for mid-west, south and south-east. The results have shown progressive increase on unsuitable areas for coffee, by end of century, making the cultivation more suitable at south and more elevated areas.

### 4. The use of regional climate models at CPTEC/INPE

Some results related to regional climate models show significant increases in means, maximum and minimum temperatures beyond this century for the major Brazilian grain production regions, like mid-west, southeast and southern. A Brazilian research study group on climate change impacts is at CPTEC/INPE, located at Cachoeira Paulista city, state of São Paulo. One of its efforts is related to agricultural impacts of global warming in south, southeast and mid-west Brazilian regions. These regions contribute by. 63%, 82% and 97% on national grain production of maize, soybean and wheat, respectively.

### 5. Partial results obtained

The following Figures 1 and 2 show anomalies in annual mean temperatures and precipitation. These scenarios likely will be great negative impacts on the crops cultivation, mainly maize, wheat, soybean, rice and common bean, all of significative importance for food security and exportation.

However, we know that some crops are cultivated in winter (wheat) and others in summer, but we also need to investigate seasonal analyses. In the following Figures 3 to 8 there are seasonal anomalies graphs for temperature (ºC) and precipitation (mm) for December to February (summer), June to August (winter) and March to May. We include this last period because in some southern states there is second maize planting named "safrinha", occurring before winter grains.

Regarding summer precipitation (Figure 3), it can be observed an increase up to 100 mm in mid west region (specially in southern Mato Grosso do Sul (MS) state and northern/mid Mato Grosso (MT)) and increases at eastern Minas Gerais (MG) and northern Sao Paulo (SP) state. In the other regions there are increases up to 20 mm. However, winter precipitation (Figure 4) shows decreases at least 20 mm for southern on east Sao Paulo state; almost whole Parana (PR) and southern Mato Grosso do Sul (MS). By last, "pre-winter" precipitation increases at least 20 mm to mid/north Rio Grande do Sul (RS) and the following states: Sao Paulo, Mato Grosso do Sul and Mato Grosso and also mid-Goias (GO).

In seasonal temperatures is present some warming signals, mainly in summer with positive variabilities (4,0ºC) in western Rio Grande do Sul, Santa Catarina (SC) and Parana states, and almost whole Mato Grosso do Sul and Goiás territories. Mato Grosso anomalies will be up to 5,0ºC. In winter pattern is the same: up to 3,5ºC in north of Rio Grande do Sul, east and north Santa Catarina and whole Parana and Mato Grosso do Sul states. From east Parana to Sao Paulo state mid-east and north, positive anomalies go up to 4,0ºC. In north Mato Grosso do Sul, whole Mato Grosso, eastern Goiás and mid-south Tocantins (TO) state increases will be up 5,0ºC. The temperature anomaly standards for March-May are similar to June-August.

Therefore, the most affect crops will be, likely, those with lower tolerances to higher temperatures during the growing season and these effects could promote a crop "displacement" from current agricultural zoning to other regions with different and suitable conditions. On the other ones, the $CO_2$ fertilization effects merged with increase temperatures must be better understood. Our next step in our modeling efforts is running crop models under those scenarios and two management file conditions: current conditions and future adaptative process.

It is also noticed, that studies about climatic change and its possible effects on the agricultural systems surely have significant connections with food security, adaptation strategies, public and private policies, and with the micro and macroeconomic behavior, that would have represent, in fact, preoccupation for the local administration, regional and national governments.

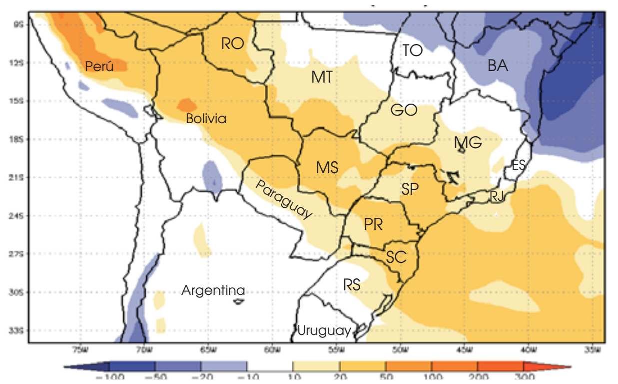


Figure 1. Anomalies (scenarios A2 and climatology), waited on the annual medium precipitation (mm), between 2070-2100 for some Brazilian regions.

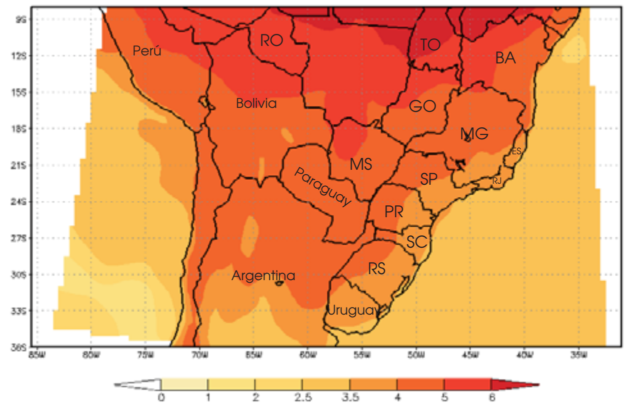


Figure 2. Anomalies (scenarios A2 and climatology), waited on the annual medium precipitation (ºC), between 2070-2100 for some Brazilian regions.

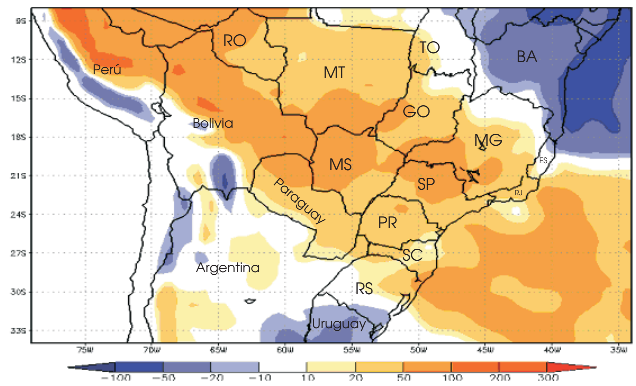


Figure 3. Anomalies (scenarios A2 and climatology), waited on the annual medium precipitation (December-February), between 2070-2100 for some Brazilian regions.

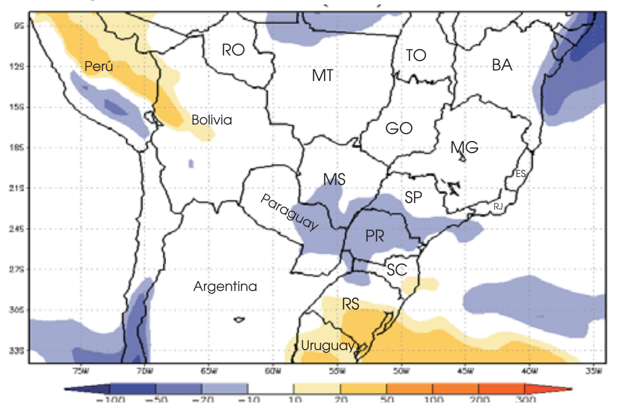


Figure 4. Anomalies (scenarios A2 and climatology), waited on the annual medium precipitation (June-August), between 2070-2100 for some Brazilian regions.

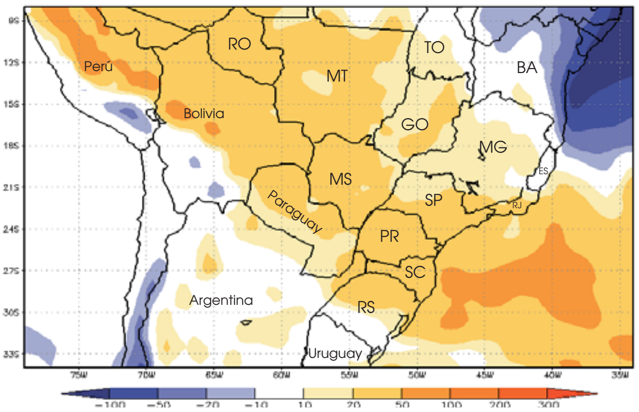


Figure 5. Anomalies (scenarios A2 and climatology), waited on the annual medium precipitation (March-May), between 2070-2100 for some Brazilian regions.

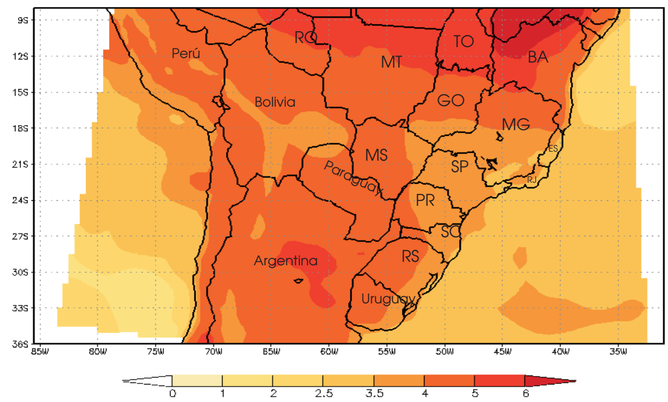


Figure 6. Anomalies (scenarios A2 and climatology), waited on the annual medium temperature (December-February), between 2070-2100 for some Brazilian regions.

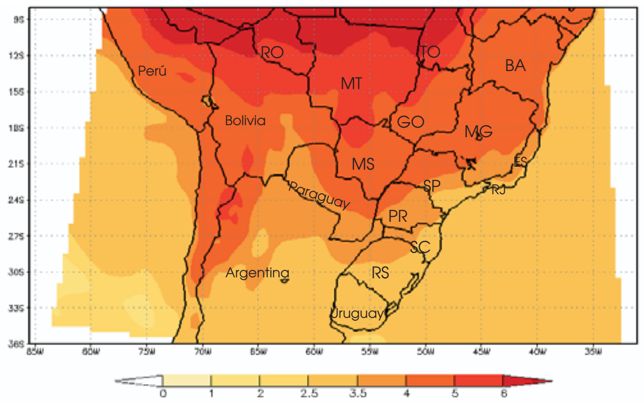


Figure 7. Anomalies (scenarios A2 and climatology), waited on the annual medium temperature (June-August), between 2070-2100 for some Brazilian regions.

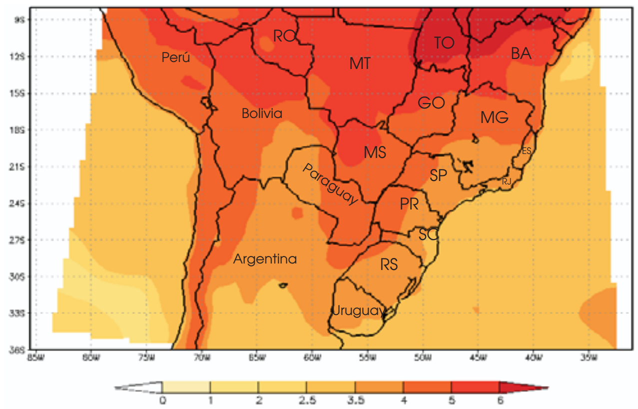


Figure 8. Anomalies (scenarios A2 and climatology), waited on the annual medium temperature (March-May), between 2070-2100 for some Brazilian regions.

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Project "Using Regional Climate Change Scenarios for Studies on Vulnerability and Adaptation in Brazil and South America (GOF-UK-CPTEC)"


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The Figure of the editorial was taken from the book "Futures for one Energia Sustainable in Colombia", Unidad de Planeamiento Minero Energética-UPME-, 2000.