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CLIVAR is an international research programme dealing with climate variability and predictability on time-sales from months to centuries. CLIVAR is a component of the World Climate Research Programme (WCRP). WCRP is sponsored by the World Meteorological Organization,the International Council for Science and the Intergovernmental Oceanographic Commission of UNESCO.

WCRP World Climate Research Programme

Editorial

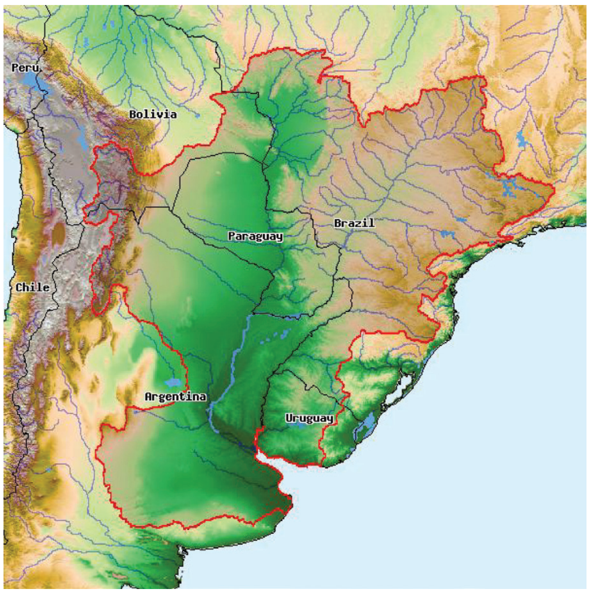
E. Hugo Berbery, Jean-Philippe Boulanger, Carlos Ereno

CLIVAR/VAMOS and GEWEX/GHP have recognized the La Plata Basin in southern South America as a system sensitive to climate variability and change, with potential consequences for water resources and agricultural activities of the region. Accordingly, both CLIVAR and GEWEX have endorsed the La Plata Basin Regional Hydroclimate Project (LPB) and its objectives of enhancing the scientific infrastructure in the basin, working with operational centers and communicating with producers and other users of climate information. We are pleased to present in this new issue of the CLIVAR Exchanges Newsletter a selection of articles focused on LPB research.

LPB objectives are being addressed through the development of international research networks that contribute to the goal of improving predictions of the climatic and hydrologic system, and designing adaptation strategies for land-use, agriculture, rural development, hydropower production, river transportation, water resources and ecological systems in wetlands, in La Plata Basin. Arguably, the main contributing project to LPB is CLARIS LPB, a Europe-South America Network for Climate Change Assessment and Impact Studies in La Plata Basin.

This issue of Exchanges presents a set of articles illustrating the diverse activities being carried out within the LPB framework, from basic science to applications in agriculture and hydrology, and with a strong component on capacity building.

We wish to express our gratitude to the European Commission, the Inter-American Institute for Global Change Research, the Global Environment Facility, and other Regional Agencies for their support to the climate research that we present herein.



Land cover changes and their effect on the climate of La Plata basin

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Introduction

Vast areas of the La Plata Basin (LPB) have experienced changes in land cover due to the expansion of agriculture replacing natural vegetation and also to changes in crop types. These changes affect the biophysical properties of the surface, including albedo, emissivity, surface roughness length and many other parameters. Modeling studies have shown that through the changes in those properties, the changes in vegetation types affect the overlying atmospheric states and the processes that modulate precipitation. Changes in land cover thus can affect near surface variables, the boundary layer, the atmosphere's convective instability, the low level moisture fluxes, and ultimately, their manifestation on precipitation. Changes in vegetation types (e.g., from forests to croplands) also involve changes in the root depth and thus in the deeper ground characteristics that affect the soil moisture content, the infiltration, subsurface and groundwater outflow, leading to changes in the volume, timing and quality of the water available at catchment scales.

The purpose of this study is to assess the range of changes that could be expected on the regional climate of LPB due to land cover changes. With this purpose two sets of idealized simulations for the period from September to November 2002 were prepared and contrasted against a control ensemble using the WRF (Weather Research and Forescasting Model)/Noah modeling system. The model configuration and performance in terms of precipitation and surface temperature biases are discussed in Lee and Berbery (2011). The first set assumes an extreme expansion of agricultural activity within LPB, where all natural vegetation is converted to dry croplands (this ensemble will be called CROP). The second set of simulations assumes a scenario with no croplands, akin to vegetation prevailing before colonial times (this set will be called NATR). All changes in land cover were restricted to the La Plata basin, although it is well known that land cover changes have been extensive over the Amazon basin and other nearby areas that may also affect the climate of LPB; these other factors will not be discussed here.

Results

Figure 1 presents the current land cover map, along with the land cover maps corresponding to the CROP and NATR experiments. The current map (Fig. 1a) shows that within the basin there are three types of natural vegetation: savanna, evergreen broadleaf forest and grasslands. Two additional categories representing agricultural activities are dry cropland and a cropland/woodland mosaic. In the CROP experiments

(Fig. 1b), the three natural vegetation types within La Plata Basin are replaced by dry croplands (rain fed agriculture). For the NATR experiments, current croplands were replaced by a pattern that resembles natural vegetation maps as those discussed in Matthews (1983), Ramankutty and Foley (1999) and Lapola et al. (2008). Fig. 1c presents the assumed changes for the NATR experiments: towards the north, dry cropland and woodland/cropland mosaic are replaced by savanna; in the central region, the cropland/woodland mosaic is replaced by grasslands; and towards the southern portion of the basin dry cropland is replaced by grasslands.

Table 1 presents the values of several surface physical parameters used in the experiments. It is clear then that the changes in vegetation induce changes in the land surface physical properties. While changes occur all over the basin, the most marked effects correspond to those regions in the CROP experiments where forest was replaced by croplands. Such regions are found mostly in the central part of the basin, and imply a decrease of the surface roughness length and an increase of the albedo. Towards the southern part of the basin, where grasslands are changed to croplands, surface roughness length is also reduced but to a lesser extent, while the albedo exhibits a slight decrease. Finally, regions toward the north covered by savanna exhibit slight decreases in surface roughness length and no changes in albedo.

Changes in albedo and emissivity affect the net radiation balance and the surface energy balance. Changes in the surface roughness length affect the low level winds, and the turbulent fluxes. More importantly, these processes are highly nonlinear and impact on the atmospheric vertical structure and affect the moisture fluxes, thus leading to local and nonlocal changes in near surface temperature and precipitation. As shown in Lee and Berbery (2011), due to the spatial differences in the physical parameters and consequently in the mechanisms that are excited, the impacts are not uniform in space.

The discussion focuses on the CROP-NATR differences, reflecting the range of changes that might occur from past natural vegetations to a future with the basin covered by croplands (as stated earlier, this is a hypothetical assumption and only for the purposes of understanding the possible changes in the basin's climate). The temperature differences CROP-NATR (Fig. 2a) show a generalized cooling in northern LPB (NLPB) and particularly over eastern Paraguay where the albedo has a large increase. A more localized warming is noticed in the western part of southern LPB (SLPB) where the albedo has decreased due to the change in land cover.

Figure 2b suggests that the NLPB would experience -in general- slight decreases of precipitation due to the expansion of cropland areas, while SLPB exhibits a larger increase, particularly over the Uruguay River, where the landscape has been changed significantly by agricultural practices. The increase in precipitation over the Uruguay basin agrees with observations showing an increase in precipitation during the second half of the past century (Barros et al. 2000; Haylock et al. 2006). While it is believed that the observed precipitation increases respond to changes in circulation due to a widening of the tropical belt (e.g., Fu et al. 2006; Hu and Fu, 2007; Seidel et al. 2008), the simulations show that land cover effects may have contributed as well.

Summary

Idealized numerical experiments were carried out to examine the potential changes in the regional climate of LPB due to land cover changes. The effects are region-dependent, and are the result of the diverse changes in the surface physical properties. The northern part of the basin, where forests and savanna were replaced by crops, experiences an overall increase in albedo that leads to a reduction of sensible heat flux and near surface temperature. A reduction of surface roughness length conducts to stronger low-level winds that, in turn, favor a larger amount of moisture being advected out of the region. The result is a reduction of the vertically integrated moisture flux convergence (VIMFC) and consequently in precipitation. In the southern part of the basin, changes from grasslands to crops reduce the albedo and thus increase the near surface temperature. The reduction in surface roughness length is not as large as in the northern sector, reducing the northerly moisture fluxes, and resulting in a net increase of VIMFC and, thus, in precipitation. Notably, advective processes modify the downstream circulation and precipitation patterns over the South Atlantic Ocean.

While the results are from idealized experiments, they are helpful to give a sense of the potential mechanisms that may be activated when changes in land surface occur within La Plata Basin, as well as the possible changes in the regional climate.

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Type of land cover	Surface albedo [%]	Surface roughness [cm]	Stomatal resistance [s m^{-1}]	Surface emissivity [%]
Savanna	20	15	70	92
Evergreen Broadleaf Forest	12	50	150	95
Grassland	23	10	40	92
Dry Cropland and Pasture	20	5	40	92

Table 1. Selected values of surface physical parameters adopted in the numerical model.

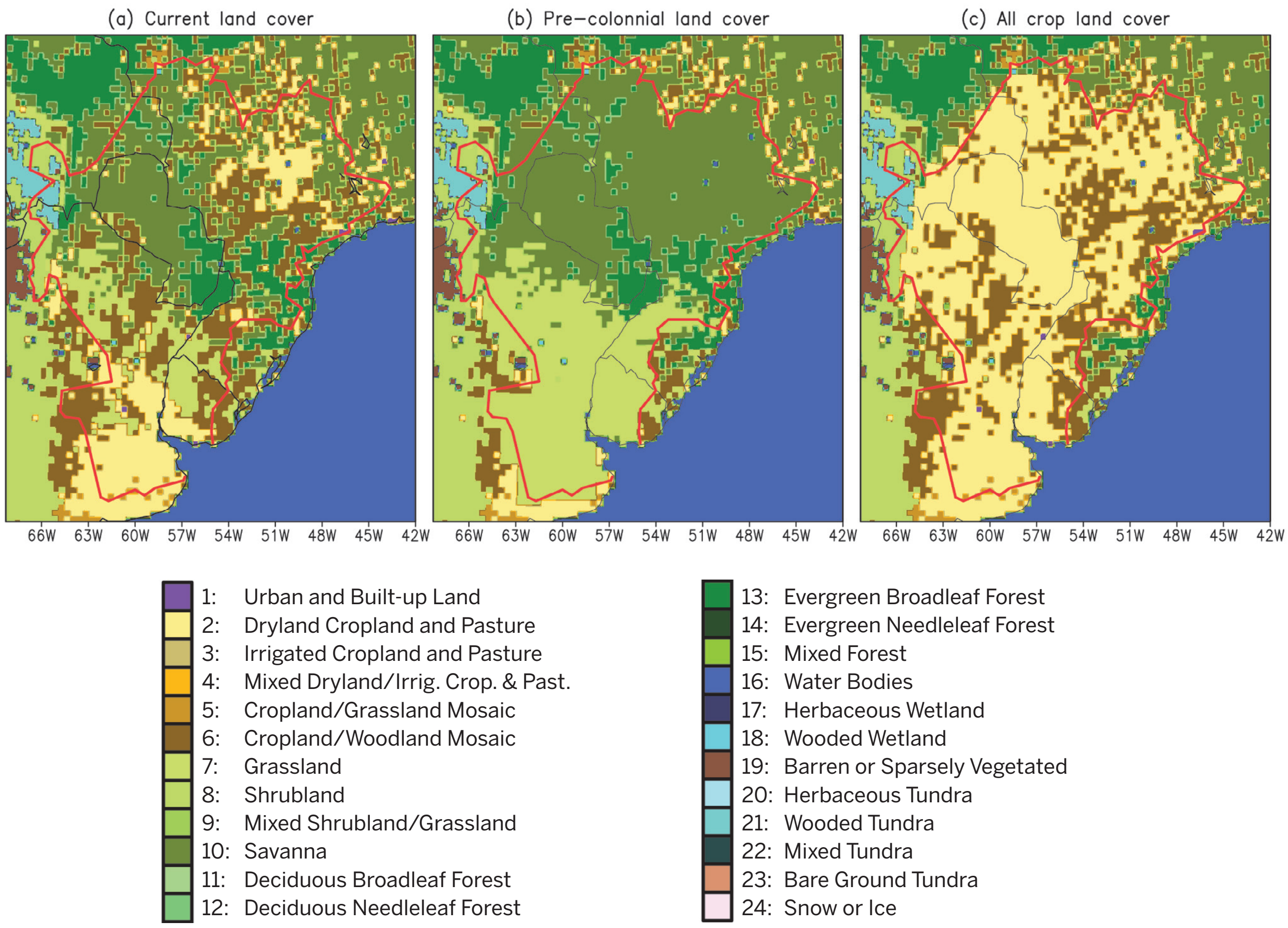

Fig. 1. (a) Land cover maps used for (a) the control experiments, (b) the NATR experiments, and (c) the CROP experiments. The land cover types are defined by the label bar below the figure

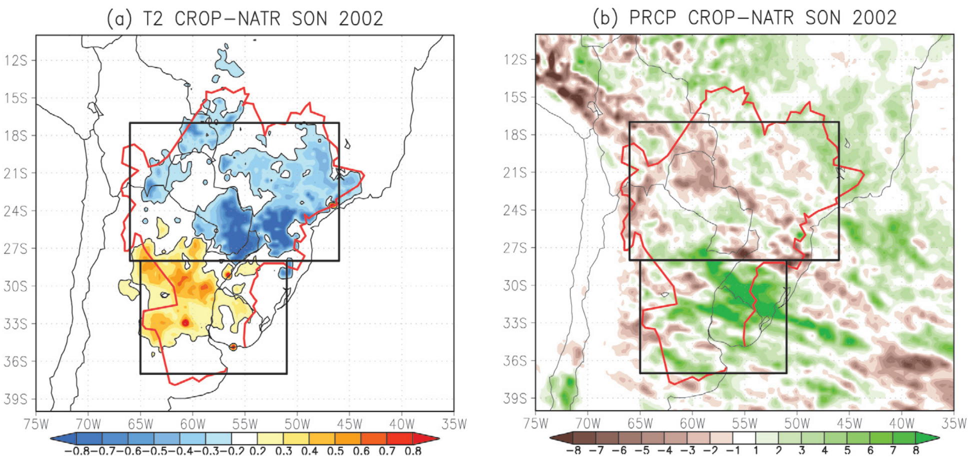

Fig. 2. (a) Two-meter temperature differences between CROP and NATR experiments; (b) precipitation differences between the CROP and NATR experiments. Contour intervals are given in the corresponding color bars.

THE INTERNATIONAL SUMMER SCHOOL ON LAND COVER CHANGE AND HYDROCLIMATE OF THE LA PLATA BASIN

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Introduction and motivation for the summer school

The La Plata Basin in southern South America has been subject to land cover and land use changes (LCLUCs) since colonial times, and with an accelerated rate in the last decades and over extensive areas. As well, over the last century much of the La Plata Basin has had a reported increase in precipitation and heavy rains, and these changes -along with an increase in population growth- have resulted in more adverse effects from flooding. To draw attention to these issues, during two weeks in November 2009 the International Summer School on Land Cover Change and Hydroclimate of the La Plata Basin was organized at the grounds of the Itaipú Hydropower Plant in Brazil.

The school was the result of the combination of interests between the La Plata Basin Regional Hydroclimate Project (LPB, endorsed by CLIVAR and GEWEX), the Inter-American Institute for Global Change Research (IAI), and the International Hydroinformatics Center (IHC) in Itaipú. LPB has made a priority to train young scientists and promote interdisciplinary collaborations in areas related to Climate, Hydrology, Ecology and Agriculture. The IAI, with a similar agenda, was a natural partner to develop this Summer School, which in turn benefited from Itaipu's interest in relating with the scientific community of neighboring countries.

The choice of location (Itaipú Technological Park) was made so that participants could relate research usually done at academic institutions to applications and operations at one of the largest hydropower plants in the world. The school was attended by 45 advanced graduate students and young scientists with different backgrounds from seven countries, including less-technically advanced ones in the region. Travel expenses of most students were covered by the Summer School, so that the student's selection (there were around 100 candidates) was primarily based on their scholarly merits.

Organization and contents of the school

The Summer School was organized within the activities of the Cooperative Research Network "The impact of Land Cover and Land use changes on the Hydroclimate of the La Plata Basin (CRN-2094)" funded by the IAI to investigate the role of land use in the hydroclimate of La Plata Basin. Classes were taught by investigators of the project and invited speakers from diverse academic and operational institutions. The school followed an interdisciplinary approach centered in three main themes: (a) Vegetation, Land Cover Changes, Ecosystems and Ecohydrology, (b) Remote Sensing with Applications to Data assimilation and Ecosystems, and (c) Mesoscale and Hydrological Modeling. Of particular interest was the analysis of ecosystem functioning, its relation to land cover/land use changes, and impacts on regional climate.

Students were presented with current methods to detect and measure vegetation and vegetation changes from space and methodologies to characterize terrestrial ecosystems. The surface water and energy budgets were examined and the possible impacts of land cover and land use changes were discussed. Regional Model and Hydrologic Model approaches including data assimilation of surface and atmospheric observations using satellite information were presented. Classes were complemented with laboratory exercises, two field trips and presentations by the students.

A computational laboratory was set up and lab assistants and technical support were provided by Itaipú and CPTEC/INPE. Given the diverse background of the students that came from different fields, the first week was dedicated to laboratory practices including hands-on exercises. The students were familiarized with computational environments and graphical tools applied in geophysics, such as Linux, GrADS and Matlab. The exercises aimed at developing simple scientific programming skills to work on hydroclimate diagnostics. During the second week, the students ran simple case studies using a regional mesoscale model, practiced land and atmospheric data assimilation techniques, and computed simple diagnostics of water and energy budgets estimated from output of a distributed hydrologic model.

Field trip and conservationism lessons

The international summer school was designed to provide the students with a valuable lesson beyond the classroom-related work. Itaipú is the second largest energy producing hydropower plant in the world opened in 1984 at the border of Brazil and Paraguay. Through two field trips, one to the Itaipú central facilities and the other to visit nontraditional farms, the students were presented with new technologies, conservationist practices and alternative ways of producing energy. The Itaipú Hydropower Plant has developed a program on renewable energy to promote and demonstrate the technical, environmental, and economical feasibility of renewable energy sources to replace current methods used by the farmers in the region. The environmental friendly programs are being carried out in a region with significant land cover changes due to intensive farming. The field trip emphasized those land use practices that are crucial for sustainable development from natural resources. In addition, Itaipú has created many programs to protect an area of approximately 100,000 hectares between Brazil and Paraguay. The activities include reforesting, conservation of the local biota, rivers and lakes by reintroducing native species including fishes, birds, animals and plants.

The Field Trip included a visit to several experimental farms where different approaches for energy production are being tested. The places visited were representative of many other farms in the region: (a) a large farm with an anaerobic biodigester that converts methane from livestock waste into clean electrical energy to sell it back to the grid; (b) a smaller farm that employs the energy generated by similar means but only for their own operations. The students had the opportunity to follow the whole process from the collection of dejects to details on the power generator functionalities.

The students were given time to make short presentations describing their research interests, which facilitated the exchange of ideas to learn to work in an interdisciplinary environment. The summer school turned out to be a practical channel to incorporate students to the CRN Project, as several expressed their explicit interest in getting involved in this research area. According to their background, students were invited to pursue postdoctoral studies with the research institutes and universities involved in the CRN. By agreement with the academic advisors and the Universities, graduate students were invited to perform research during short term visits at guest institutions. Those students that were selected were granted a scholarship with the support of the CRN.

Final remarks

The summer school attracted students from diverse backgrounds, like atmospheric sciences, environmental sciences, physics, agriculture, and geography. Despite this wide background, the students found that the course had helped them advance in their scientific development. The positive responses in the students' evaluations of the course suggest that it could be used as a model for training the next generation of scientists. In addition, the course attracted the attention of regional universities: the University of Buenos Aires gave credits to PhD students that participated in the summer school, and other Universities are in the process of following those steps. The authors of this note are providing support for the necessary administrative process.

In summary, the school gathered students from different disciplines and followed an interdisciplinary approach to study the hydroclimate of the La Plata basin. By economically supporting the students, a major difficulty was removed, and the students with most merits were accepted. The location of the Summer School at the Itaipú Hydropower Plant, and the possibility to experience the many activities carried out there, proved to be an enticing aspect of the School. Moreover, a channel to involve students in actual research was created. Though this first Summer School did not plan on credit recognition from regional universities, the action taken by the University of Buenos Aires was an unprecedented benefit. Future editions of this Summer School will seek credits of more Universities to further the students' interest.

This picture is offered to illustrate the note.

Acknowledgments

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CLARIS LPB WP1: Metamorphosis of the CLARIS LPB European project: from a mechanistic to a systemic approach

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Project history

The CLARIS LPB Project (A Europe-South America Network for Climate Change Assessment and Impact Studies in La Plata Basin; http://www.claris-eu.org) is funded by the European Commission 7th Framework Programme since October 2008 for a 4-year period. It is coordinated with the objectives of La Plata Basin (LBP) (http://www.eol.ucar.edu/projects/lpb/), an international Program on La Plata Basin (LPB), that has been endorsed by CLIVAR (http://www.clivar.org/) and GEWEX (http://www.gewex.org/) . The CLARIS LPB Project aims at predicting the regional climate change impacts on La Plata Basin in South America, and at designing adaptation strategies for land-use, agriculture, rural development, hydropower production, river transportation, water resources and ecological systems in wetlands.

The CLARIS LPB Project was built upon the CLARIS European Commission Project of the 6th Framework Programme (Boulanger et al., 2010), which climate studies were predominant and climate change impacts were designed as pilot studies. During the development stage of the CLARIS LPB, it was decided to create a large consortium open to social sciences as well, which allowed incorporating additional perspectives into the project enriching its objectives and approaches. However, the project still was built from the perspective of a very "linear" or vertical approach going from climate change and impacts to adaptation strategies.

The set up of the CLARIS LPB Project resulted in 4 Subprojects (SP):

Subproject 1: Management, dissemination and coordination activities

- WP1: Project management
- WP2: Project dissemination and coordination activities

Subproject 2: Past and future hydroclimate

- WP3: Improving our description of recent past climate variability in La Plata Basin
- WP4: Hydroclimate past and future low-frequency variability, trends and shifts
- WP5: Regional Climate Change assessments for La Plata Basin
- WP6: Processes and future evolution of extreme climate events in La Plata Basin

Subproject 3: Project interface

- WP7: An interface for improving prediction capability of climate change societal impacts

Subproject 4: Socio-economic scenarios and adaptation/prevention strategies

- WP8: Land use change, agriculture and socio-economic implications
- WP9: Water resources in La Plata Basin in the context of climate change

To guide the design of the project major emphasis was put on the importance of what has been called the cascade of uncertainty (Fig.1), as follows: global climate model analyses (including estimates of ranges in decadal variability) will be used to force regional models (dynamical or statistical), for which uncertainty in the land-atmosphere processes would be taken into account. The regional model outputs will force impact models (hydrological, crop, …) in order to evaluate the impact on each sector. The use of climate ensembles would lead to a statistical quantification of the uncertainty at each step of the process in order to provide to stakeholders probability distribution functions (PDFs), cost-benefits analysis of specific strategies and therefore a guidance to initiate the design of adaptation strategies.

Basically, we identified 11 specific studies:

- Impact of climate change on crop yields in Argentina, with possible extension to the whole La Plata Basin.
- Design of adaptation strategies for the agricultural sector with focus on three sites: Balcarce and Junin in Buenos Aires Province and San Justo in Santa Fe Province.
- Impact of climate change on pastures in Uruguay. Design of adaptation strategies for the agricultural sector.
- Adaptation strategies for agriculture in Brazil in very contrasted sites: Cotrijal cooperative (large producers) and Anchieta (small producers).
- Rural development and adaptation strategies in Argentina.
- Impact of climate change on fire risks.
- Impact of climate change on river floods.
- River sediment transportation, impact of climate change and adaptation strategies.
- Adaptation strategies of the hydroelectric sector in LPB under climate change conditions
- Adaptation strategies for the Ibera flooded ecosystems under climate change.

During a meeting of Subproject 4 in Curitiba at Month 9 of the project, a common framework called "Driver, Pressure, State, Impact, Response (DPSIR)" was adopted in order to allow comparisons in the learning process and progress in each specific study. The DPSIR conceptual framework was developed by the European Environmental Agency (EEA) in 1999 (Smeets and Weterings 1999). It was built on previous environmental frameworks like PSR (Pressure – State – Response) (OECD 2003) and the DSR (Driver – State – Response) framework by the UN Commission of Sustainable Development (1997). Initially these frameworks were developed to structure and organize individual socioeconomic and environmental indicators in a certain context (Holman et al. 2005).

Rethinking the design of adaptation strategies

Each of the impact groups (WP8 and WP9) described their own studies under the DPSIR framework. It became apparent that some groups needed climate projections to perform their studies, while others could work with qualitative storylines. At the time of the Curitiba meeting some groups were quite advanced in their interactions with stakeholders; others had not identified any.

This diversity was puzzling and actually led us to reflect on what each group meant by adaptation strategies. This reflection culminated during the 2nd meeting held in the following year . Indeed, each group had finalized most of its initial objectives and each "impact" study was supposed to enter in the phase of designing adaptation strategies.

Basically, the first conclusion was that not all the groups (whatever the definition used for the word adaptation) considered the adaptation process from a similar point of view. To make it simpler, we could classify the adaptation processes in two main groups regarding its features.

In the first group the adaptation process deals with organized institutions or countries (mainly developed countries, but not only, as developing countries have well-organized institutions, which can face similar challenges as the ones in developed countries). For them, basically, adaptation is a technical issue: to build infrastructures, to improve early-warning systems, and to develop financial incentives or insurance mechanisms to reduce vulnerability to climate change. Most of these "strategies" are mainly based on impact reports showing changes in climate variability, climate extremes, etc…

In the second group the adaptation process is related to vulnerability issues, to synergies between development and adaptation issues. They are more often associated to social challenges and to the need of a better development. In LPB countries, as in many developing countries, the adaptation challenges are more associated to development issues and the separation between development and adaptation is far from obvious.

The interesting process experienced in our project is the gradual change of focus from an impact perspective to a vulnerability perspective. Basically, this learning process is also a change from a "climate-science" perspective to a "social-science" perspective.

Indeed, the climate sciences often rationalize the problems through mathematical models. In CLARIS LPB, global models provide information to regional models, which provide forcing to climate impact models, which tell us the impact of climate change. This is the information that should be used to build adaptation strategies… This linear approach (serial or vertical, with climate being on the top…) is relatively well suited for the first kind of adaptation needs. Basically, a technical report describing the impact of climate change on a specific threat is sufficient for "stakeholders" to take decision and design adaptation strategies.

Unfortunately, the cascade of uncertainty in global-regional-impact models is such that the final ensemble of projections can lead to opposite scenarios and thus opposite adaptation strategies… Stakeholders can barely lead with such a large spectrum of possible futures and the final information is often of poor interest for final decision-making.

In our case, as actually done by some groups in the project, the first step was to work WITH the stakeholders in order to explain to them our objectives and most of all, to learn from them about their actual vulnerability to climate. And the sole exercise of asking people what their vulnerability to climate is leads to the fact that the causes of this vulnerability are hardly due to climate! Most of people's and society's vulnerabilities result from many other causes that actually must be understood before designing adaptation strategies.

In fact, technical solutions cannot always solve social problems. First, stakeholders must be aware of their vulnerability and of their non-climate causes before initiating the path (process) of adaptation to climate change. In that perspective, climate projections are useful as information about future threats in order to design climate-proof strategies and to avoid "maladaptation". But most of the adaptation is an interactive process with stakeholders where climate information is qualitative and often secondary. This process is basically requiring an understanding of the system under pressure (by climate) in all its components and complexities, which hardly can be modeled. A systemic approach (Ison, 2010) is therefore most appropriate to visualize, represent, and understand all the components of the system and their complex interactions and, therefore, is perfectly suited to the design of adaptation strategies.

Conclusions

The CLARIS LPB multidisciplinary project was born with a "climate-sciences" perspective where the climate change impact problem is simulated by a chain of models, where final outputs offer an ensemble of possible futures from which a decision making process can be derived to support the design of adaptation measures. Although models (global, regional and impact) are crucial to the understating of climate impacts and the projection of future threats, this approach is contrary to the basic fact that adaptation is a process and not a result based on any model simulations. Being a process, adaptation is in continuous evolution (and we hope progress/improvement) and is driven by complex human interests, which cannot be the subject of mathematical modeling approaches.

The design of adaptation strategies is therefore a human (social) issue, based on the current vulnerability of the system of interest, including all its components (social, economic, environmental). The adoption of a systems approach is paramount to deal with all the complexity in the process of developing adaptation strategies. The collaboration with stakeholders is key to understand the vulnerability of the system of interest, to show the climate change impacts and to reflect with them on the paths that could be taken in order to reduce its vulnerability and to initiate the adaptation process.

Therefore, after three years of research, interactions and discussions, we are able to distinguish in our list of 11 specific studies some that will deliver technical reports to be communicated to stakeholders for information, whereas others will build with stakeholders a clearer view of how to initiate the design of an adaptation process and finally, others more will build with the stakeholders possible adaptation strategies with the aim of reducing the vulnerability of the system/community to climate variability.

There exists no hierarchy between these studies. All are relevant to the challenges posed by climate change. But it is clear that the differences among them raise the question on what is relevant to climate research. This question is of great importance for the research system and the research institutions. Indeed, the technical reports are products whose delivery can be easily scheduled and that are often intended to satisfy research institutions (e.g. reports, and articles). However, the actual process of adapting to a changing climate (or reducing vulnerability to a changing climate) is a far less predictable output as it depends on human relationships (between the researchers and the stakeholders, between the stakeholders themselves) and can fail due to non-climate causes. However, who, especially in developing countries, will fund the design of adaptation strategies except a public entity? And who will be more capable of dedicating so much time in building confidence tights so crucial in the initiation of the adaptation process? Defining the roles of public and private research institutions proves to be essential given the challenges and needs of development on one hand and climate change on the other.

Acknowledgements

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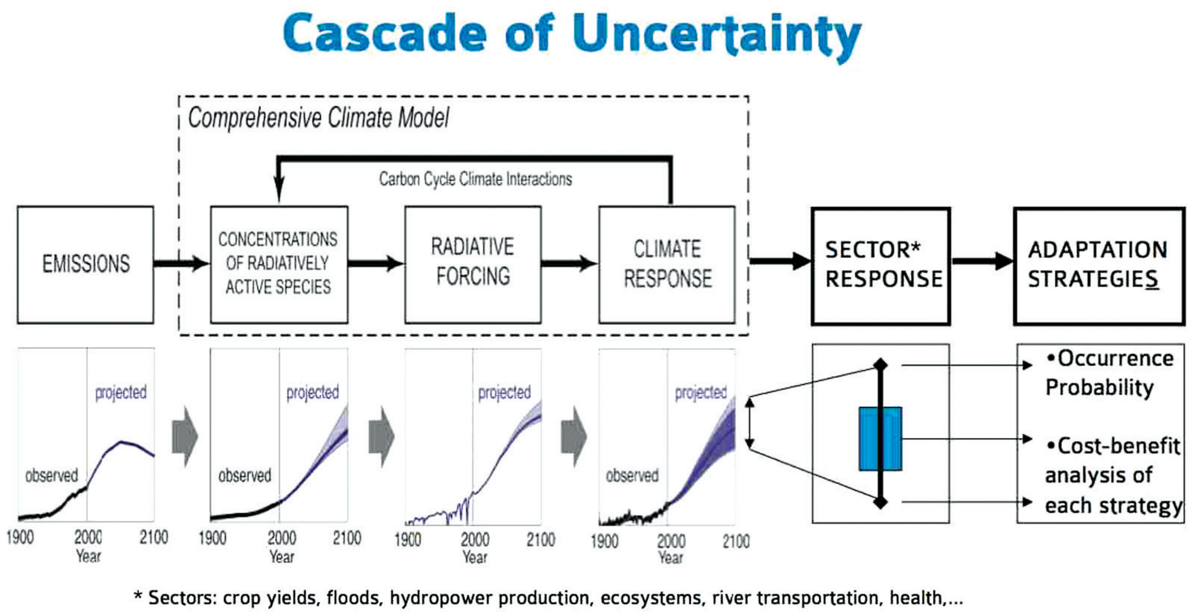

Figure 1: Cascade of uncertainty such as applied to the CLARIS LPB general construction in order to design adaptation strategies to climate change.

Partic. No.	Participant organisation name	Acronyms	Country
1 (CO)	Institut de Recherche pour le Développement	IRD	France
2	University of East Anglia	UEA	England
3	Leibniz-Zentrums für Agrarlandschaftsforschung	ZALF	Germany
4	Max-Planck Gesellschaft Institut	MPG	Germany
5	Euro Mediterranean Center on Climate Change	CMCC	Italy
6	Universidad de Bologna	UNIBO	Italy
7	Universidad de Castilla-La Mancha	UCLM	Spain
8	Swedish Meteorological and Hydrological Institute	SMHI	Sweden
9	Instituto Nacional de Pesquisas Espacias	INPE	Brazil
10	Universidad de Sao Paulo	USP	Brazil
11	Universidad Federal de Santa Catarina	UFSC	Brazil
12	Universidad Federal de Paraná	UFPR	Brazil
13	Consejo Nacional de Investigaciones Cientificas y Técnicas	CONICET	Argentine
14	Universidad de Buenos Aires	UBA	Argentine
15	Instituto Nacional de Tecnología Agropecuaria	INTA	Argentine
16	Instituto Nacional de Agua	INA	Argentine
17	Universidad de la Republica	UR	Uruguay
18	Centre National de la Recherche Scientifique	CNRS	France
19	RSE SpA	RSE	Italy
20	Université de Genève	UNIGE	Switzerland

Table 1: List of institutes in the CLARIS LPB consortium

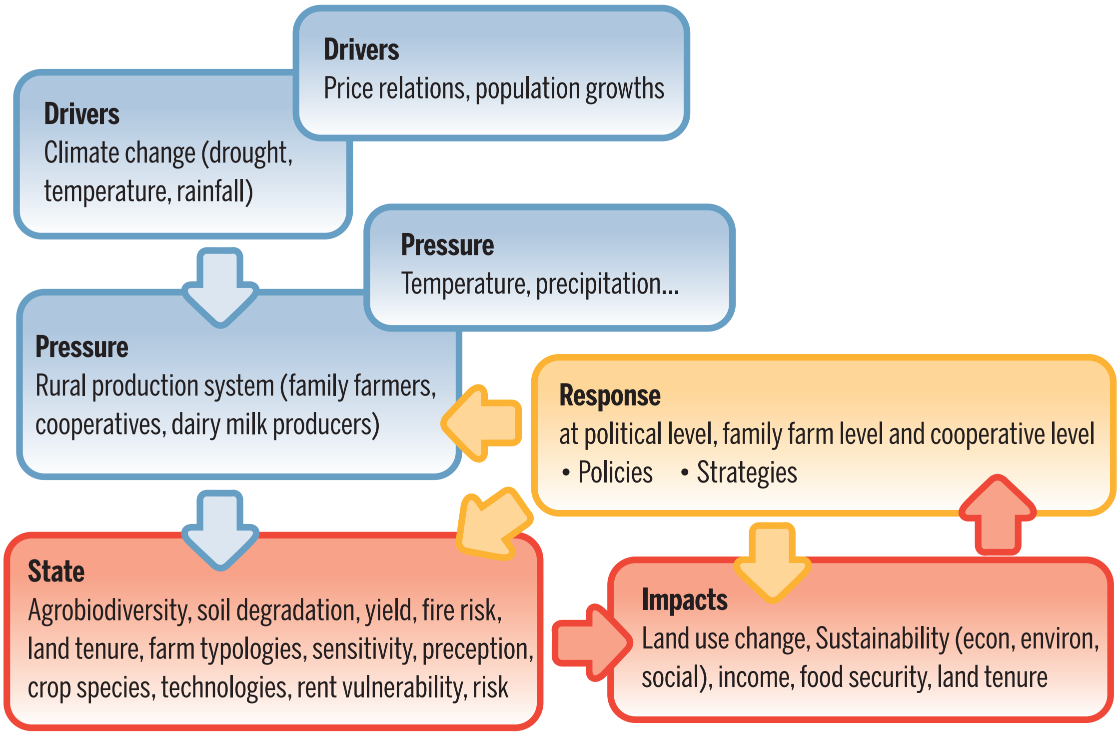

Figure 2: Example of a DPSIR structure for agriculture studies.

CLARIS LPB WP2: Project dissemination and coordination activities of CLARIS LPB

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The primary objective of the interdisciplinary research team of WP2 is to foster and coordinate dissemination activities of the CLARIS LPB initiatives and results at scientific, public, and stakeholder levels. This objective includes: to gain public support for national/regional efforts to address climate change, improve collective responses and promote the development of climate change action plans. In order to promote interaction between scientists and stakeholders, based on the three dimensions of the Project (intra WP, inter WP, trans-sectorial), WP2 objectives are:

To stimulate consortium communication with stakeholders
To produce outreach materials for the inter WPs, intraWP and transectorial dimensions (informative bulletin, web site, forum of young scientists, brochure, etc.).
To organize local workshops with stakeholders with the objective of installing the climate change problematic on the local social environment.
To coordinate the organization of CLARIS LPB/Stakeholders workshop at a regional level.
To communicate large-scale scenarios and uncertainties for the stakeholders' regions of interests.

Transectorial workshops and climate change perceptions

One of WP2´s main objectives is to promote the articulation of the multidisciplinary consortium with the needs and expectations of the social actors (stakeholders) from the agriculture, hydrological and political sectors. In this sense, WP2´s activities do not only aim at stimulating communication and exchange inside the researcher's network, but also to build the transectorial dimension. This aims to build collaborative relations "outside" the network in order to generate a real interaction between scientists and stakeholders.
Thus, WP2 organized local workshops with the stakeholders aimed at presenting and installing climate change issues in the local social and political agenda. To promote the interaction between scientists, stakeholders and public policy makers, we used the "participatory workshop" technique. This allowed us to create a space in which social actors can exchange experiences with CLARIS LPB researchers and work on climate change perception and the design of local adaptation strategies. We performed three transectorial workshops: the first one in the city of San Justo (Santa Fe Province, Argentina) in November 2009, the second in Junín (Buenos Aires Province, Argentina) in September 2010, and the third one in Junin in August 2011. In parallel, other Work Packages promoted specific interaction with their stakeholders in order to reach similar objectives and build specific adaptation strategies.

Outreach materials for the inter WPs, intra-WP and transectorial dimensions

In addition, to stimulate the transectorial dimension WP2 has produced dissemination material (regional brochures, informative bulletins and posters) and activities to discuss and inform at the local level on climate change issues.

In particular, we can mention CLARIS LPB presentations in agricultural events like Expodirecto in COTRIJAL (Santa Catarina State, Brazil), Expo Junín (Buenos Aires, Argentina) and a presentation at the Regional Workshop for "Latin America y the Caribbean" at Regional Dialogue Forum of policies for Latin America and the Caribbean, held in Mexico. Moreover, another CLARIS LPB dissemination result was the collaboration with the local media both in Brazil and Argentina (i.e. TV, radios, newspapers, websites).

Training for young South American students and scientists in European institutes through CLARIS LPB

Since the beginning of the project, we aimed at:

- promoting the presence of young scientists in the CLARIS LPB General and WP meetings
- favouring collaborations between the CLARIS LPB Researchers from different Institutes, and especially between Europe and South America
- creating multidisciplinary research, and dynamics

In order to reach these three objectives, WP2 managed specific calls with grants for:

- Young Scientists participation at project meeting
- Poster Prizes for young scientist posters: presented at project meetings based on scientific and multidisciplinary criteria
- Exchange grants for all scientists: based on scientific and multidisciplinary criteria
- Publication grants and in European Journals

In parallel, WP2 supported the organization of different training courses:

- CLARIS LPB Introductory Course on Systems Thinking, Systems Practice by Sandro Luis Schlindwein (WP8) during October and December 2009 in Buenos Aires;
- CLARIS LPB Training Course on APACH quality control web tool at the National Service of Meteorology and Hydrology (SENAMHI) in Lima, Perú on December 2009 by Ariel D'Onofrio and Jhan Carlo Espinoza.

Anthropological fieldwork on climate change scientific community

In order to encourage inter-work packages interactions, we have built a social communication field inside the network (CLARIS LPB as an ethnographic study field); and developed a metareflexive dimension about the epistemological implications of knowledge production in the frame of a "network of scientific-productive collaboration" on climate change and its social impacts. Our research combines different theoretical-methodological approaches: Qualitative Research (using traditional ethnographic method) and Social Network Analysis (SNA; this new methodological tool supposes a relational approach that allows combining qualitative data, and quantitative and graphical displays).

Acknowledgements

All WP leaders and scientists who contributed to WP2 activities!

CLARIS LPB Meeting, Florianópolis, Brazil, November 2010

CLARIS LPB WP3: Observational data and past climate variability across the La Plata Basin

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6 CICTERRA-CONICET, UNC, Argentina
7 IRD, France
8 CEREGE, France

The main objective of WP3 is to improve the description of past climate variability in the LPB in order to provide an observational basis for quantifying past climate variability (WP4 and WP6), evaluating climate scenarios (WP4, WP5 and WP6) and providing high-quality data to WP7 for impact model calibration (WP8 and WP9).

One of the specific objectives is to collect daily information originating from different institutions (governmental and non-governmental) to improve the EU FP6 CLARIS digitally-available records of daily weather data (maximum and minimum temperature, precipitation, surface radiation and vapour pressure) over La Plata Basin.

At present, the CLARIS daily database obtain information from the following instuments: 8163 raingauges, 861 temperature stations, 66 stations with measurements of solar irradiation or sunshine and 58 streamflow stations. CLARIS LPB database (http://wp32.at.fcen.uba.ar/) has the following information in the longest period (1959-2008) (Figure 1).

For Uruguay the construction of a daily precipitation database is starting. The observation practices in this network (part of the National Weather Service) has been to report only days when precipitation occurs creating a non sequential archive. This makes it difficult to determine whether no precipitation occurred or no reading was made.. These practices obviously affect for example studies of drought or of consecutive dry days. Trying to improve this, we select from a first list of 163 rain gauges which span the period 1960-2008 and develop a methodology to complete the database.

Another objective has been to create a gridded data set for use by the other WPs for Regional Climate Model validation and impacts modelling and also for the assessment of extremes. A southeastern South American gridded data set of daily minimum and maximum surface temperatures for 1961-2000 has been produced (Tencer et al., 2011). The data used for the gridding are observed daily data from meteorological stations in Argentina, Brazil, Paraguay and Uruguay from the EU FP6 CLARIS database, with some additional data series. This gridded data set is new for the region not just for its spatial and temporal extension, but also for its daily temporal resolution. The region for which the gridded dataset has been developed is 20º-40º S, 45º-70º W, with a resolution of 0.5º of latitude by 0.5º of longitude. Since the methodology used produces an estimation of gridbox averages, the developed data set is very useful for the validation of Regional Climate Models. The comparison of gridded and observed data provides an evaluation of the usefulness of the interpolated data. According to monthly mean values and daily variability, the methodology of interpolation developed during the EU FP6 ENSEMBLES for Europe (Haylock et al., 2008), is also suitable for southeastern South America. Root mean squared errors for the whole region are 1.77 degrees Celsius for minimum temperature and 1.13 for maximum temperature. These errors are comparable to values obtained for Europe with the same methodology.

The first version of this data set includes minimum and maximum daily temperature data interpolated to a 0.5º regular grid and it is freely available at the web site http://wp32.at.fcen.uba.ar/gridded in NetCDF format.

Two different but related procedures were developed both for the Error Detection problem and for the Inhomogeneity Detection problem of daily climatic measurements. Both procedures are semi-automatic in the sense that potential errors/inhomogeneities are highlighted but user intervention is needed in order to correct/homogenize the data. The Error Detection method is already available as a Web service on the APACH page and works at the moment with daily temperature data. The Inhomogeneity Detection method works with any continuous variable (temperature, precipitation intensity, sea level pressure, etc) and wil be available soon also as a Web service on the APACH page. In the procedureof the Error Detection Method a temperature observation Ti,d is considered suspicious (for a particular station i and for a particular day d) if that observation is far away from the expected behavior of Ti,d using information of that station as well as information of surrounding correlated stations. The notion of distance used is robust, meaning that outliers (those we want to detect) do not affect the results. Our methodology assumes that all stations could have erroneous information. Then, for every station i and day d, a robust distance D will be calculated taking into account the statistical relation existing among the temperatures of all involved stations. The error detection methodology comprises four main steps:

1. Calculating robust historical correlations between stations.
2. Defining the influence set of stations associated to each station.
3. Selecting optimal temporal bandwidths.
4. Calculating the robust Mahalanobis distances for daily observations.

The procedure outcome determines,for every observation,a continuous measure of suspicion (Mahalanobis distance), thus allowing the researcher to inspect first those data that are almost surely wrong.

The main aim of the Inhomogeneity Detection Method is to detect and characterize potential regime changes (inhomogeneities) in climatic data. We do not make a priori distinction between natural vs. artificial changes. We developed a methodology that warns of important distributional changes in the measurements and allows the researcher to decide, possibly using metadata, what to do with the potential change. The decision to correct climatic data must be based ona reliable metadata dataset. Otherwise the implemented corrections could seriously bias the original data. The method allows the researcher to analyze jointly several time series and also provides a criterion to estimate the proportional contribution of each time series in the detected potential inhomogeneity. We succeded in developing a method capable of detecting changes in mean, dispersion, skewness and kurtosis. The outcome of the method provides a time partition of the climate multivariate time series such that all the contiguous sequences of the partition are (statistically significant) different in distributional terms. The method is capable of detecting multiple inhomogeneities and of discriminating the station/variable responsible for such inhomogeneity.

The 20th century hydroclimatic variability that has taken place across the Argentinean Pampean plains was highlighted by conspicuous lake level fluctuations. The last 100 years includes contrasting hydroclimatic scenarios such as, a) long dry intervals and low lake-water levels during the first 70 years of the 20th Century, b) a wet phase and a widespread lake level increase after the 1970s and c) a hydrological reversal after the year 2003, underlined by lowerlake levels. The hydrological variability shown by pampean lakes (i.e., Laguna Mar Chiquita, 30°S; Laguna Melincué, 33°S; Lagunas Encadenadas del Oeste de Buenos Aires, 37°S) closely matches the hydrological variability shown by fluvial systems from La Plata Basin (e.g., Río Paraná; Río Paraguay). This close agreement highlights the value of Pampean Lake sedimentary records as climate archives for reconstructing the past activity of the South American Monsoon System (Piovano et al., 2009; Troin et al., 2010) (Figure 3).

Paleohydrological reconstructions indicate contrasting hydrological behaviour during the last 13,000 cal (calibrate) years BP (before present). In particular, the past two millennia were characterized by marked hydroclimatic variability. Extreme dry conditions dominated the beginning of the first millennia until comparatively wetter conditions around 1,500 cal years BP and around 1,060 cal years BP. This wet phase was synchronous with the Medieval Climatic Anomaly (MCA) and according to our paleohydrological reconstructions, the magnitude of lake level increase could be equivalent to that occurred during the 1970s. A return to severe droughts can be identified for the cold period ascribed to the Little Ice Age. Several proxies in the pampean lake records as well a high number of historical sources signify an intense drying probably due to a diminished meridional transport of moisture into the subtropics. Laguna Mar Chiquita, Laguna Melincué and Lagunas Encadenadas del Oeste de Buenos Aires when combined show extremely low water-levels after the wet phase corresponding to the Medieval Climatic Anomaly.

The regional analyses of paleoenvironmental reconstructions highlight the development of contrasting hydrological patterns between the Pampas and Patagonia. Numerous paleohydrological archives indicate dominant wet conditions during cold phases - such as those that occurred during the middle Holocene or the Little Ice Age - in Patagonia or even the Central Andes, with a dominant Pacific source of moisture. During the same time interval, contrasting dry conditions prevailed across the subtropical lowlands east and north of the Andean Divide with an Atlantic-dominated source of moisture. Conversely, extensive dryness across Patagonia and wet conditions in the Pampas can be inferred during warm climatic phases such as the Medieval Climatic Anomaly or the last part of the 20th century.

Paleohydrological reconstructions allowed historical analysis of regional hydroclimate behavior over longer timescales enabling the most recent hydrological changes (i.e., post-1970s) within a larger time-window (from hundreds to thousands of years) These results are critical for obtaining realistic regional reconstructions of past climate variability.

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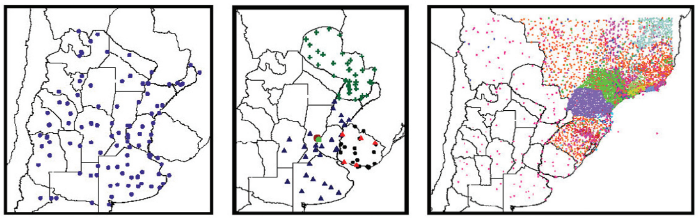

Figure 1: Location of the stations provided by National Weather Service of Argentina (left) and National Institute of Agricultural technology (blue triangles, right), University of Entre Rios (red dot, center) and El Pozo of University of Litoral (green dot, center) and stations in Brazil provided by 54 different institutions (right).

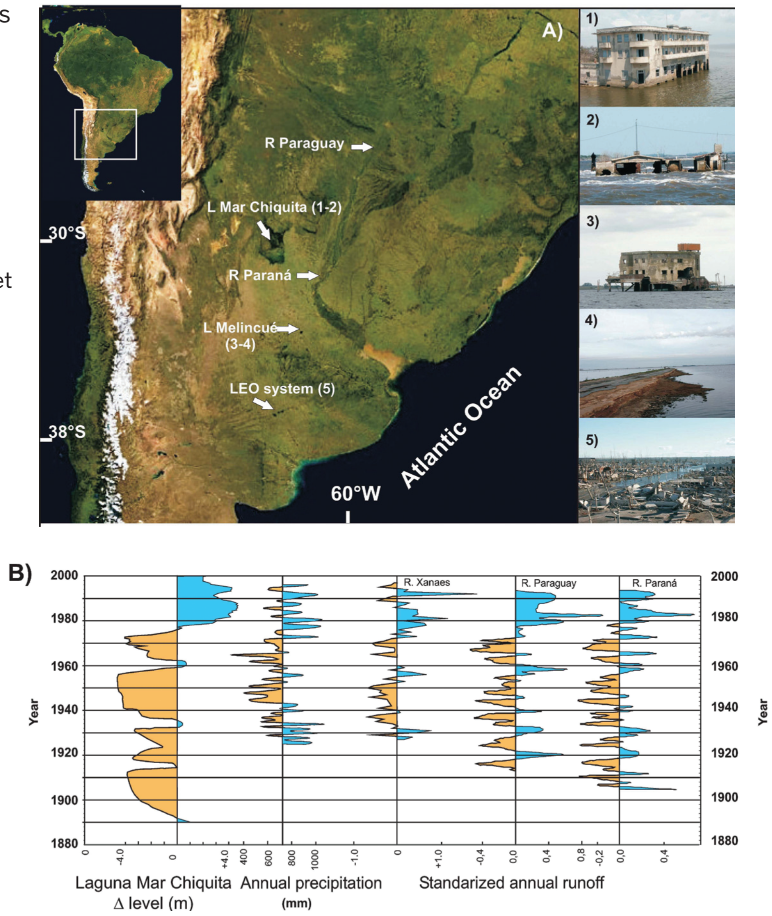

Figure 3: a) Satellite image of study area (composite image created by NASA, public domain). White arrows indicate locations of the Xanaes River, Paraguay River and Paraná River gauging stations used in graphs of (b), red arrows indicate locations of Pampas lakes (Mar Chiquita Lagoon, Melincué Lagoon and Lagunas Encadenadas del Oeste de Buenos Aires (LEO)). Photographs on right illustrate the consequences of water-level increases: 1-2) Laguna Mar Chiquita, 3) Laguna Melincué, 4-5) Lago Epecuén in the LEO system. b) Comparison of instrumental lake level for Laguna Mar Chiquita with an instrumental precipitation record and river runoff data. A lake level of 0 indicates an intermediate level that matches the AD 1977 shoreline (66.5 m asl). Positive values represent high stands (blue areas), and negative values indicate low stands (brownareas). Annual precipitation in the laguna Mar Chiquita basin covers AD 1925–96 interval. Values above average are in blue and below average in brown. Standardized runoff of Xanaes (within the Mar Chiquita lagoon basin), Paraguay, and Paraná Rivers with discharges above and below the mean annual runoff indicated in blue and brown, respectively (for further details see Piovano et al., 2004).

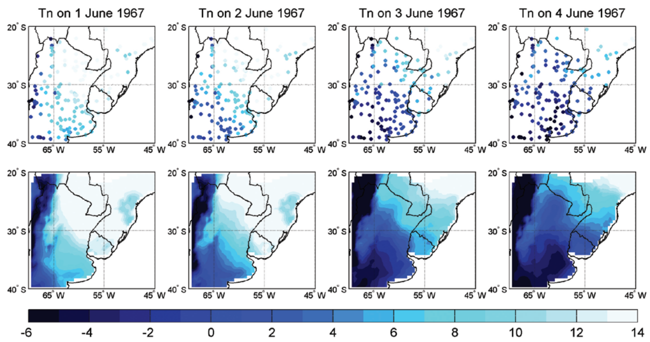

Figure 2. 4-day sequence of minimum temperature (ºC) shown on a 0.5º grid (lower panels) and at station points (upper panels). Color scale is the same for both datasets.

CLARIS LPB WP4: Hydroclimate past and future low-frequency variability, trends and shifts in La Plata Basin

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1. Introduction

Climate projections have three main sources of uncertainty: (1) uncertainty due to our incomplete understanding and representation of the physical/chemical/biological processes that govern climate; (2) uncertainty due to the emission scenario considered; and (3) uncertainty due to initial conditions, which on the time scales of interest are mainly related to the ocean state. On long lead times the main sources of uncertainty are those due to emission scenarios and model physics. WCRP-CMIP3 models are useful to learn about changes in climate statistics such as mean and variance (Meehl et al. 2007). The consolidated projection of all WCRP-CMIP3 models for the end of the XXI century indicates an overall warming of the South American continent including LPB, as well as a rainfall increase of about 20% in LPB, mainly concentrated in summertime (IPCC-AR4).

But, what will happen in the next 20-30 years? This is a time scale that is very relevant for policy makers and that presents a different challenge from the point of view of climate projections (Vera et al. 2010). On these time scales internal (as opposed to forced) climate variability plays a very important role. The problem can be exemplified using the annual mean rainfall over south Brazil and Uruguay (Figure 1). This time series shows variability on several time scales: interannual, decadal and a long term trend. Thus, if we were in 1945 and wanted to predict future changes we could use the overall long term trend as a first guess; the figure shows this would have overestimated the rainfall over the following 20 years. This is because even though the positive trend dominates over the 100 years, there are periods of 10-20 years when rainfall was above/below that trend.

This decade-to-decade variability is likely internal to the climate system, related to the ocean and thus potentially predictable. However, since WCRP-CMIP3 model projections were not initialized with the ocean state they cannot tell us about the phase of the decadal variability. Nevertheless, they can provide information about changes in the amplitude of the variability in the next decades under anthropogenic forcing. Thus, the research in the WP4 focused on the description and understanding of the large scale mechanisms that operate on interdecadal time scales and the evaluation of the WCRP-CMIP3 model's representation of the past climate of the LPB to assess the faithfulness of the projections.

Specifically, the WP4 had three main objectives:
Characterize the natural low frequency climate variability and trends over the past 150 years in the La Plata Basin using observations and global models.

Evaluate the skill of the models from the WCRP-CMIP3 (A1B SRES scenario) to asses the uncertainties in the projected hydroclimate changes on two time horizons: short term (2010-2040) and long range (2070-2100).

To elucidate the physical processes that govern the slow and rapid variations in the 20th century LPB hydroclimate and to determine how they may be linked to the South American Monsoon system and global ocean-atmosphere modes of variability.

Results presented here are not only important by themselves, but they are also crucial for the dynamical downscaling portion of the CLARIS-LPB Project developed to get more detailed information on regional scales.

2. Observed and simulated climate variability in LPB

We have analyzed the observed variability on intraseasonal, interanual and interdecadal time scales in order to have a basis for assessing the performance of models. Several techniques have been used, including EOF techniques, neural and complex networks (e.g. Grimm 2010, Espinoza et al. 2011, Barreiro et al. 2011). Interdecadal variability was diagnosed in observed and proxy longer term timeseries. Key findings include the occurrence of a "climate shift" in the mid-1970s in all the analyzed climatic quantities from local to continental scale and from extreme events to longer term cycles and trend. The occurrence of extreme events (drought, floods) increased over the La Plata region and precipitation decadal variability experienced a persistent phase reversal in response to tropical and extra tropical remote influences. In the following we summarize the main results.

a. Mean state

Overall, WCRP-CMIP3 models are able to reproduce the key elements of the regional atmospheric circulation such as the Bolivian High at upper levels and the continental scale gyre to the east of the Andes that promotes the moisture penetration from the tropical Atlantic into the continent. On the other hand, models tend to represent weaker moisture convergence and less precipitation than observed over LPB, which may be related to the bias that these models are not able to represent correctly the weather types that show a deflection of the low level winds by the Andes Cordillera (Espinoza et al. 2011).

Models are able to represent the main features of mean precipitation, although they exhibit large systematic errors or biases (Vera et al. 2006; Silvestri and Vera 2008, Grimm 2011). For example, the South Atlantic Convergence zone (SACZ), a key feature of summertime climate is incorrectly represented by most of the models. Particularly acute for LPB is the fact that while in the real world it rains over most of the basin the whole year round most models show significant precipitation only during summer and spring, but not in the fall and winter seasons. This is reflected in the maps of rainfall variability: overall, models show much smaller variability than observations in all seasons and particularly in fall and winter (Vera and Silvestri 2009).

b. Interannual-to-decadal variability

Most of WCRP-CMIP3 models show some kind of simulated El Niño that presents similarities with the observed phenomenon. Since the climate variability of LPB is strongly influenced by El Niño it is important that models reproduce the atmospheric links between the Pacific and southeastern South America. Models, however, have a hard time reproducing the atmospheric teleconnection processes during spring, the season of strongest El Niño signal on LPB: of 7 models considered only the MPI shows evidence of the extratropical wavetrain forced by the sea surface temperature anomalies associated with El Niño (Vera and Silvestri 2009).

It has been found that interannual variations in SST over the tropical South Atlantic play an important role in the total summer monsoon precipitation over South America. However, even though most WCRP-CMIP3 models are able to show realistic SST variability in this basin, they cannot capture this relationship (Bombardi and Carvalho 2010).

Most models are able to represent the annular-like structure characteristic of the Southern Annular Mode (SAM) in the Southern Hemisphere circulation, but they have serious deficiencies in representing the observed relationship between SAM and both precipitation and circulation anomalies in South America (Vera and Silvestri 2009; Cherchi et al. 2011, in preparation).

c. Interdecadal variability and trends

Most WCRP-CMIP3 models show weak interdecadal variability compared to observations. However, some models simulate patterns of variability that resemble the observed ones. For example, the coupled model HadCM3 has a Pacific Decadal Oscillation-like structure with a 16-20 years cycle that is also present in the real world. Moreover, the simulated precipitation changes in LPB associated with this pattern resemble those in observations (Talento et al. 2011, in preparation).

Given the model shortcomings the interdecadal rainfall variability in LPB was also investigated using AGCMs. For example, the LMDz shows modes of precipitation interdecadal variability similar to observed ones (Grimm and Khodri 2011, in preparation). Despite some differences, the simulated modes recover the 1970's climate and account for interdecadal changes in several regions, including Laguna Mar Chiquita, the largest saline lake in Argentina. Diagnostic studies (Grimm and Saboia 2011, in preparation) and hydrological modeling (Troin et al 2010a, 2010b) suggest that the lake level fluctuations in Mar Chiquita during the 1970's have a strong natural climate component. The same atmospheric model, however, misses important features such as the tendency for rainfall anomalies in spring and summer to have opposite anomalies in central-east South America, produced by local surface-atmosphere interactions (Grimm and Zilli 2009). Land-atmosphere interactions have been shown to be key to reproduce correctly the temperature and rainfall anomalies over all South America during El Niño events (Grimm et al. 2007, Barreiro and Diaz 2011).

The South American monsoon also shows a climate shift in the mid 1970s: the monsoon starts earlier and finishes later so that after the '70s the mean length has increased to about 195 days (vs. 170 days). Overall, WCRP-CMIP3 models can represent correctly the spatiotemporal characteristics of the annual cycle of precipitation in central and east Brazil, such as the correct phase of dry and wet seasons, onset dates, duration of rainy season and total accumulated precipitation during the summer monsoon. The models do not indicate significant changes in monsoon onset and demise under the A1B scenario (Carvalho et al. 2010; Bombardi and Carvalho 2009).

The observed daily circulation patterns in southern South America that are associated with rainfall conditions in the Pampas were identified. Also, after assessing the skill of the models in simulating these relationships in the XX century, the projected changes for the XXI century were calculated. WCRP-CMIP3 models are found to reproduce the full range of summer and winter circulation types found in NCEP Reanalysis. Moreover, models represent correctly the frequency of atmospheric situations that favor summer dry days in the present climate and under the A1B scenario show a trend in the reduction of circulation patterns associated with dry days and an increase in the frequency of patterns associated with rainfall (Penalba and Betolli 2011).

3. Physical processes

Despite the WCRP-CMIP3 models' biases in simulating precipitation over the LPB region, it has been possible to use them to understand the physical processes associated with the South American climate. Here we present a study for summertime, a season that is overall well simulated and the one in which models have projected a rainfall positive trend (e.g. Vera et al 2006). Figure 2 shows the projected changes in mean DJF precipitation for the end of the XXI century by a multi-model mean under A1B scenario. It shows a dipole-like structure with increased precipitation in LPB and decrease to the north of it. That rainfall change pattern has been related to an increase in the occurrence of the positive phase of the leading summertime pattern of interannual variability (Junquas et al. 2011). The behavior of this mode of variability is nonlinear though. There is a very small trend in rainfall anomalies before 2050 and only afterwards the trend becomes clear. These results then suggest that the behavior of the modes of variability under radiative forcing is not necessarily linear. According to these results internal variability would dominate during the first 50 years of the XXI century and the trend only overcomes natural variability in the second part of the century.

In addition, our research has also substantially contributed to the present understanding of how atmospheric teleconnections link the different ocean basins to LPB hydroclimate, including a review (Grimm and Ambrizi 2009) and the following results:

The continental scale modes of rainfall interdecadal variability have been determined and connected with global modes of SST, such as the Interdecadal Pacific Oscillation, the Atlantic Multidecadal Oscillation and regional SST modes. A tendency to inversion of SST anomalies has been detected on interdecadal time scales from spring to summer in parts of LPB, in spite of the persistence of SST anomalies. This indicates that, besides changing teleconnections from one season to the next, the interdecadal variability might undergo influence from surface-atmosphere interactions (Grimm and Saboia 2011, in preparation), as found on interannual time scales (Grimm et al. 2007).

A new index that describes daily intensity of extreme rainfall has been developed, and it has been found that rainfall extremes over Argentina during spring show interannual-to-interdecadal variations, and the associated atmospheric circulation anomalies are related to ENSO and the South Pacific Convergence Zone (Robledo et al. 2011, in preparation).

The impact of La Niña on summer precipitation in LPB changed in the mid1970s: it has a stronger impact after this time. Warmer SST conditions in the Indian Ocean during post 1979 La Niña events explain a large portion of the associated upper level atmospheric circulation differences (Cazes-Boezio and Talento 2011).

The impact of El Niño on precipitation in LPB depends on the “flavor” of the event, that is, on the location of the maximum SST anomaly in the equatorial Pacific. Different SST configurations induce different extratropical Rossby wavetrains and Gill-type responses that result in different rainfall anomalies in LPB region (Tedeschi et al. 2011; Zaninelli et al. 2011, in preparation; Zamboni et al. 2011, in preparation).

Interannual predictability of climate over LPB is strongly tied to ENSO showing high predictability during the seasons and periods when there is ENSO influence. This results in large inter-decadal changes: during 1949-1977 the surface temperature shows high predictability in late fall and early winter; during 1978-2006 the temperature shows low predictability only in winter, while the precipitation shows not only high predictability in spring but also in fall. Furthermore, it is found that the Atlantic can act as a moderator of the ENSO influence. During El Niño events the ocean off Brazil and Uruguay tends to warm up through changes in the atmospheric heat fluxes, altering the atmospheric anomalies and the predictability of climate over SESA. The main effect of the air-sea coupling is to strengthen the surface temperature anomalies over SESA; changes in precipitation are more subtle (Barreiro 2010).

4. Summary

Climate over LPB shows variability on several time scales, from subseasonal to interdecadal and longer. Moreover, the tropical oceans, particularly the tropical Pacific, play an important role on all time scales. Coupled models are able to simulate many of the main characteristics of LPB climate, though they tend to fail in reproducing some regional fundamental patterns like the SACZ, as well as the patterns of regional climate variability and associated atmospheric teleconnections on long time scales. The results presented here strongly suggest that climate projections for the next 20-30 years need to take into account the large inter-decadal variability. Decadal prediction experiments that are currently being carried out using the new generation of coupled models may help address this predictability issue.

To finish we mention other topics that need to be addressed in order to reduce the uncertainties of future climate projections over LPB: (1) new methods to determine the evolution of the rainfall pdf that weight models’s skill for the LPB, (2) role of the land-atmosphere coupling and land use in the regional climate, (3) role of the air-sea interaction in the southwestern Atlantic and its role in maintaining the SACZ, (4) role of the stratosphere and O3 recovery on SAM and the impact on LPB, (5) paleoclimate reconstructions that help determine the natural variability in LPB during the last thousand years and help test the models.

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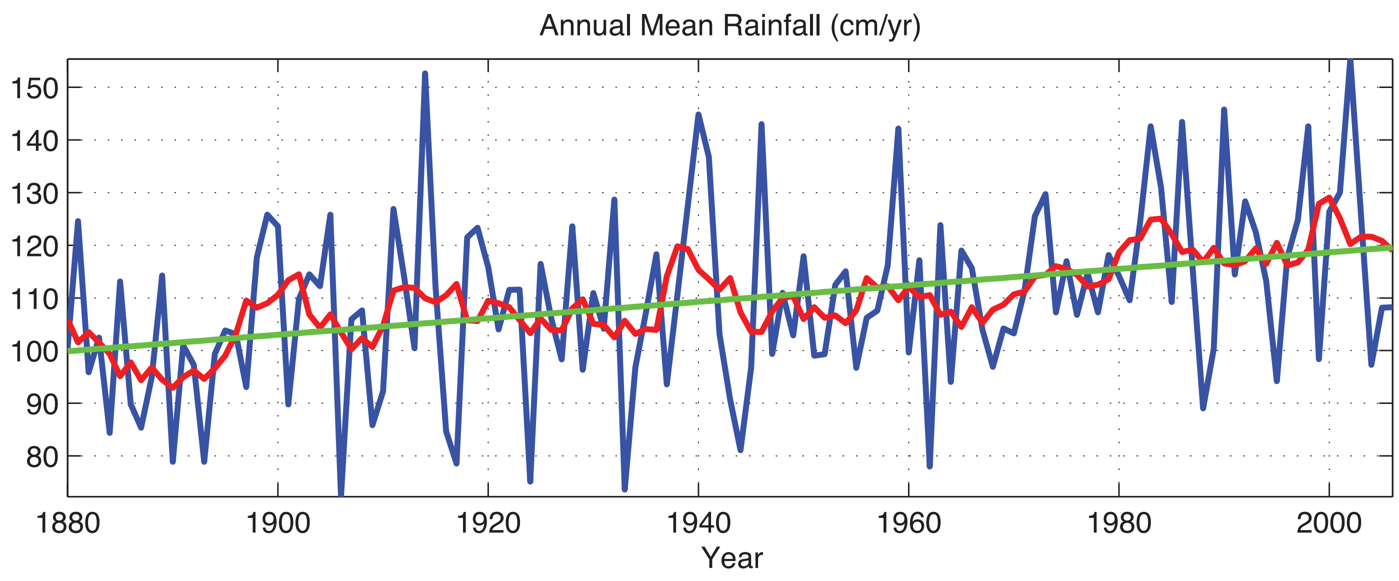

Figure 1 – Annual mean rainfall in the region defined by [60°W-48°W,24°S-35°S] from GHCNv2 (blue). The red curve is a smoothed version using a 7-year running mean that highlights the large interdecadal variability; the green curve is the trend over the whole period. The distribution of stations in time and space is very irregular over the region, and very few of them go back to the 1880s.

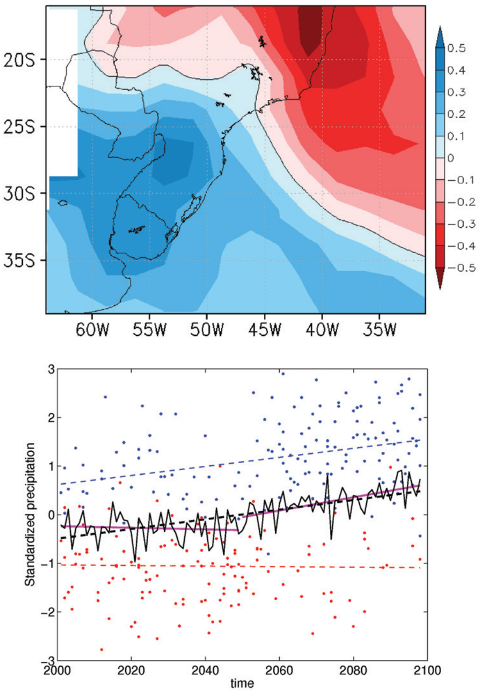

Figure 2 – (Upper panel) Differences of the mean DJF rainfall between 2050-2098 and 2001-2049 periods. The difference is standardized by the total number of years. Contour interval is 0.2 mm/day and black contour indicates the 0 level. (Lower panel) Temporal evolution of the standardized DJF rainfall in Southeastern South America from 9-model mean during the XXI century and its linear trend. The linear trends for the two halves of the XXI century are also shown. Blue (red) dots correspond to rainfall anomalies associated to each of the positive (negative) events of the first EOF of rainfall in the region for each of the models (modified from Junquas et al 2011).

CLARIS LPB WP5: Regional Climate Change assessments for La Plata Basin

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The CLARIS LPB Project aims at predicting the regional climate change impacts on La Plata Basin (LPB) in South America and at designing adaptation strategies for regional stakeholders. One of the main issues to achieve this objective relies on the development of ensembles of coordinated regional climate scenarios for dynamical downscaling over LPB. WP5 addresses two important components regarding the development of regional climate change scenarios for LPB: (a) performing an ensemble of coordinated regional scenarios; and (b) understanding the causes of uncertainties in regional model simulations. Results provided by WP5 represent the key input for other WPs, such as WP6 focused on evaluating extreme events, WP8 and WP9, focused on evaluating impacts on agriculture and hydrology.

The main objective of WP5 is to better understand the regional effects of climate change and variability on various components of the hydrologic cycle of LPB, with emphasis on land surface-atmosphere feedbacks. The first challenge was to design a coordinated experiment to produce ensembles of regional simulations over South America in order to evaluate the capability of the state-of-the-art regional climate models (RCMs) in reproducing the observed climate and investigating the associated uncertainty. The second challenge is to perform an ensemble of coordinated regional scenarios for LPB at two time horizons (2010-2040 and 2070-2100) in order to evaluate the uncertainties in the future regional scenarios.

In what follows some results of the simulations for the current climate are discussed. The aim of this work is twofold. First, to evaluate the capability of the RCM ensemble to represent observed climate over LPB, identifying the main strengths and shortcomings of the state-of-the-art dynamical downscaling tool for the region. This evaluation also serves as a basis for possible model improvement. Second, to characterize the uncertainty in simulating the LPB climate. The uncertainty is evaluated by comparing against observations and in terms of the spread among different RCMs, ascertaining their degree of agreement or disagreement and, therefore, giving a measure of the confidence level of the simulations of current South American climate. For this purpose seven regional climate models have been forced by ERAinterim reanalysis (1989-2008) (Simmons et al. 2006) to simulate the climate of all the South American continent at 50km horizontal resolution, with a special focus on the LPB. This domain is consistent with the one proposed in CORDEX (A COordinated Regional climate Downscaling Experiment; http://cordex.dmi.dk/). The Regional Models participating in this coordinated experiment are presented in the following table:

RCA	Rossby Centre, Swedish Meteorological and Hydrological Institute, Sweden	Samuelsson et al. 2006
REMO	Max-Planck-Institute for Meteorology, Hamburg, Germany	Jacob et al. 2001
PROMES	Grupo MOMAC, Area Física de la Tierra, Facultad Ciencias Medio Ambiente, Universidad Castilla-La Mancha, Spain	Sanchez et al, 2007
REGCM3	GrEC-USP, Departamento de Ciencias Atmosféricas, Universidade de Sao Paulo, Brazil	da Rocha et al. 2009
MM5	Centro de Investigaciones del Mar y la Atmósfera (CIMA)- Bs. As, Argentina	Solman and Pessacg, 2011
LMDZ	IPSL -Institute Pierre-Simon Laplace, France	Hourdin et al., 2006
ETA	Instituto Nacional de Pesquisas Espaciais -INPE, Brazil	Chou et al 2011

Figures 1 and 2 show results for each individual model together with observations for the annual mean temperature and precipitation, respectively. Every model is able to capture the spatial distribution of the annual mean temperature field, compared with the CRU (Climate Research Unit) dataset. However, several biases are evident and, what is more interesting, not all the models share the same biases. This behavior suggests that the ensemble mean is able to reproduce better the annual mean temperature field compared with any of the individual models. Over LPB the range of simulated temperatures for the different models agree with the observational dataset and the dispersion among models is smaller compared with tropical regions. The spatial structure of the simulated precipitation field also shows a general agreement with the observations, such as the maximum over western Amazonia, the wet tongue extending over the South Atlantic Convergence Zone (SACZ) and LPB, and the minimum over the Northeast of Brazil and central Argentina. However, there are some models that strongly overestimate or underestimate the annual precipitation almost all over the model domain, and some models are capable of reproducing better the annual precipitation for a certain region and their ability is lower for other regions. Over LPB all the models reproduce reasonably well (although with a slight tendency to underestimate) the annual amount of precipitation. As for temperature, the largest dispersion among models is located over the tropical areas of South America.

Focusing on LPB (see the contour of the region on top.left Figure 1), Figure 3 shows the annual cycle of temperature and precipitation as simulated by each individual model and the observations. The annual cycle of temperature is well reproduced by every individual model. The dispersion among models is around 2°C for almost every month, being slightly larger during late austral spring-early summer (from September to January). Moreover, during this period 4 out of 7 models overestimate the mean temperature. Overall, the ensemble mean captures the mean annual cycle of temperature very accurately, mainly because the ensemble mean compensates individual model biases. The annual cycle of precipitation is also well reproduced by every model though the major shortcoming shared by every model is the underestimation during austral winter months (June to August). It is evident that the largest uncertainty in simulating precipitation is found during austral late-spring and summer months (from October to March), compared with other periods within the year. It is worth to remark that during this particular period precipitation is mainly triggered by convective processes and the availability of humidity over the region is controlled by the low level jet east of the Andes. Consequently a proper simulation of the low level jet and its associated moisture flux convergence, together with an adequate activation of convective processes are expected to result in a good model performance. It is also remarkable that the biases of individual models have different signs and the ensemble mean reproduces quite well the amount of precipitation, does the negate model ensembles use for prediction?

This broad overview of the performance of individual models and of the ensemble mean in reproducing the observed climate over South America allows evaluating to what extent regional models are able to simulate South American climate but also allows identifying major shortcoming and uncertainties. However, climate change simulations are strongly conditioned by the quality of the lateral boundary conditions provided by the driving general circulation models (GCMs). Larger uncertainties are expected to be found for the set of RCMs and GCMs already performed by WP5 partners. The usage of this regional climate projections database is expected to serve as a reference tool for regional impact studies over the South America, in a similar way to PRUDENCE (Christensen and Christensen, 2007) and ENSEMBLES (van der Linden and Mitchell, 2009) projects over Europe.

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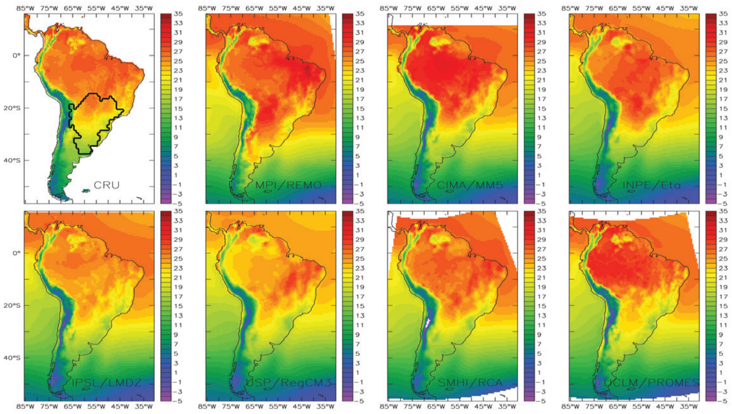

Figure 1: Annual mean temperature from CRU and simulated by individual Regional Climate Models (in °C).

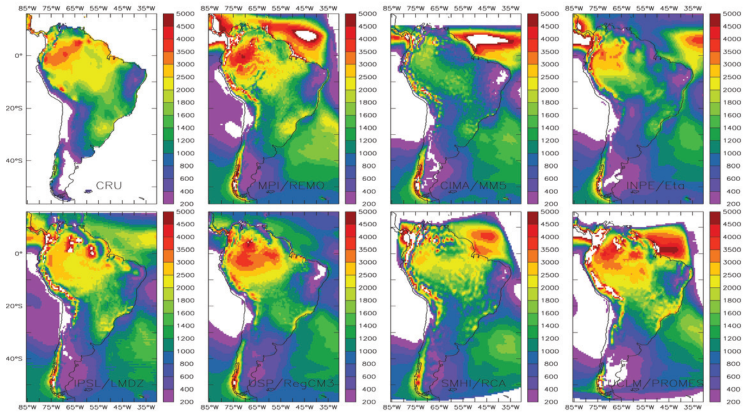

Figure 2: Same as Fig. 1 but for precipitation (in mm/month).

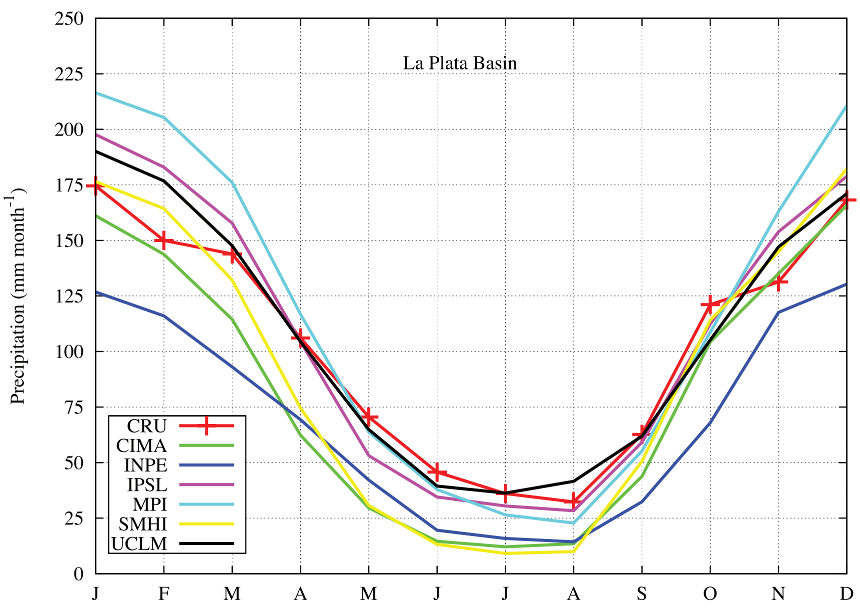

Figure 3: Annual cycle of precipitation (mm/month) as simulated from each individual model and from CRU observations.

CLARIS LPB WP6: Processes and Future Evolution of Extreme Climate Events in La Plata Basin

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1. Introduction

Extreme precipitation (wet or dry) over La Plata Basin (LPB) can cause intense damage in several sectors as agriculture and hydroelectricity, and also has an impact on urban areas due to flooding and landslides. Extreme temperatures (cold incursions or heat waves) have impact on agriculture and health. The frequency and intensity of extremes can vary in a warmer world, and there is a need to analyse the influence of climate change superimposed on natural climate variability. Therefore, the main objective of this working group is to elucidate the climate processes that are associated with extreme hydro-climate conditions over LPB region, considering both the role of the large scale forcing and the local interactions, and the way in which the frequency and intensity of such cases may change according to different projections of global climate change. The knowledge of extreme precipitation and extreme temperature frequency in the present climate and the projections for the future can provide useful information to the agriculture and hydrology sectors. The association of extremes with large-scale atmospheric and oceanic behaviour, as well as with synoptic and mesoscale conditions will improve the ability of monitoring them. In this article some of the results obtained during the project are presented.

2. Extremes in La Plata Basin Temperature.

Several datasets are commonly used for climate analyses purposes by the scientific community: analysis generated by the major forecasting centers, and gridded datasets developed by different groups of research. One of the objectives of this working group is to verify if the available gridded datasets of near surface temperature over southeast South America (SESA) give us confidence in detecting trends in daily extremes temperatures. While some groups focus on the diagnostics based on gridded data (Figure 1), others are using station data for extremes analysis. In particular, occurrence of extreme temperature events in Argentina is studied by fitting a GP (Geralized Pareto) distribution to four variables (HTx, HTn, LTx, LTn) that represent independent anomalies of the lowest (L) and highest (H) minimum (Tn) and maximum (Tx) temperature, based on the station series of daily data. The GP analysis has been performed in different sub-periods to analyze interdecadal variability in the frequency and intensity of temperature extreme events in some significant regions of Argentina. Preliminary results show that extreme events have changed both in intensity and frequency of occurrence, at both interannual and decadal timescales (Tencer, 2011a). The intensity of both, the HTx and the LTn, has decreased over the whole period, while with a lower magnitude- the intensity of HTn has increased. The warm extreme events have decreased in frequency from 1941-1960 to 1961-1980, and then have increased during the last 20 years of the twentieth century (1981-2000), except for the HTx at the Santa Rosa station where this increase is not seen. The cold extreme events in Tm have not homogeneously changed in all the stations considered for this study, and changes are of lower magnitude than those observed in warm extremes.

There is also evidence of multi-decadal changes in the relationship between extreme temperatures over Uruguay and the large scale circulation (Renom et al., 2011). Results suggest that in present climate, summertime (DJF) and wintertime (JJA) extreme temperature events are associated with a vortex circulation anomaly at upper levels that needs to be further studied. Moreover, the occurrence of extreme temperature events are correlated with changes in the ENSO evolution which occur around 1976. Since then the ENSO signal in extratropical South America seems to be weaker, with an increase of the influence of atmospheric internal variability, particularly during the winter season. Evidence of the influence of one of the principal modes of variability of the Southern Hemisphere, the Southern Annular Mode, was also found, particularly for the summer season before 1976. Nowadays, efforts to further study the potential links between the large scale conditions, the occurrence of extremes over South America and its potential inter-decadal modulation, focus on the analysis of sensitivity model experiments forced with idealized conditions.

Regarding model validation, on the one hand, there are some initiatives to validate the present climate over LPB as represented by a set of regional models (RCMs). Carril et al. (2011) have analyzed a set of four RCMs, integrated for the period 1991-2000, over a continental-scale domain, driven by ERA40 reanalysis. This initiative was conducted using a multi-model ensemble integrated in the framework of the previous EU-FP6 CLARIS project. (An updated analysis, based on the new RCMs ensemble, integrated in the framework of the present project, is in progress). Concerning temperature, metrics comparing the geographical patterns of daily max/min temperature for the individual models, the ensemble and the Tencer et al. (2011b) climatology (spatial standard deviation, correlation and root mean square difference) show relatively large spread between models in summer, but with offsetting errors in the ensemble. It is also noted that errors are generally larger at the tails of the probability distribution (e.g. P10, P25, P75 and P90) than in the mean field, especially in summer. On the other hand, annual indices extremes simulated by eight CGCMs from the IPCC AR4 project have been validated against observations from meteorological stations during the period 1961-2000 (Rusticucci et al., 2010). Results show that warm nights (WN) are better represented by CGCMs than frost days (FD). Both the mean fields and the interannual variability patterns are in good agreement with the observed values. For any specific extreme temperature index, minor differences appear in the spatial distribution of the changes across models in some regions, while substantial differences appear in some areas of tropical and subtropical South America. The differences are in the relative magnitude of the trends. Consensus and significance are less strong when regional patterns are considered, with the exception of the LPB, where observed and simulated trends in warm nights and extreme rainfall are evident.

Precipitation. The large scale conditions and synoptic patterns associated with LPB precipitation extremes analysed in this project have been related to variability of Sea Surface Temperature (SST) in the Atlantic and Pacific Ocean, El Nino-Southern Oscillation (ENSO), teleconnections, atmospheric blockings, cut off lows, Mesoscale Convective Systems (MCS) associated with the Low Level Jet, and specific synoptic configurations. The persistent development of organized MCS over LPB can lead to flooding in the region, as the case analysed in Cavalcanti (2011). In that case, the systems developed associated with the low level flow from the Amazon region and the subtropical jet at high level, are typical conditions of such developments. SST in different ocean regions were related with extreme precipitation in regions of Argentina: the tropical and subtropical Atlantic Ocean and the Indonesian Sea, in addition to areas of the Indian Ocean. Moreover, the temporal variability of each of these SST regions was detected and recognized as a possible large-scale, forcing of extreme rainfall variability over the Argentina region studied. Grimm and Tedeschi (2009) showed that ENSO-related changes at the frequency of extreme rainfall events are generally coherent with monthly (or seasonal) rainfall anomalies. Different types of ENSO events, with stronger SST anomalies in the central or in the eastern Pacific, are able to produce different impacts on rainfall over LPB (Tedeschi et al., 2011). There are also significant differences regarding the impact on the frequency of extreme events. The occurence of these events according to the maximum SST in the region Niño 4 or in the eastern sector of the region Niño 3 shows that this impact is greater in the middle LPB in the eastern Pacific category. The associated teleconnections explain the differences. Long term trends in the annual number of dry days in a station located at 29.73°S; 61.77°W tend towards a decrease in their values, meaning a trend to more humid conditions, but in other regions these trends have presented a reversal from the mid-1980s. This is in agreement with the occurrence of severe droughts during the years 1988/89, 1995/96, 2003 and 2008/09. Also the frequencies of extreme droughts have increased during the last 25 years.

Sensitivity experiments to assess the impact of soil moisture on precipitation were discussed in Sörensson and Menéndez (2011). They found that heavy rainfall in southern LPB may be partly related to land–atmosphere coupling. The coupling strength between soil moisture, evapotranspiration and precipitation was calculated for summer by analyzing ensembles of simulations performed with a Regional Circulation Model. The regional spatial patterns of extreme precipitation were well correlated with the regions of strong coupling between soil moisture and evapotranspiration over large areas of Southeastern South America. In addition, results suggest that extreme precipitation seems enhanced over regions of high soil moisture-precipitation coupling if the model includes a complete land surface-atmosphere interaction. Other sensitivity experiments were performed with the MM5 regional model, in which the natural cover was replaced by crop during different years in extreme phases of ENSO. The effects of land use/land cover changes (LULCC) over the climate were analysed in two important agricultural regions over southern South America, LPB and the Argentinean Pampas. In the last decade these regions have suffered a replacement of the natural cover, mainly by the expansion of the agricultural activity, associated with an increase in the soy production. In most of the cases the signal remained the same, but the strength of the signal changes with a strengthening of the wetter conditions and a weakening of the warming over north Argentina and west Paraguay during El Niño years.

Model evaluation in simulating and projecting extremes has been performed using Global and Regional models. In analysis of eight CMIP3 models, R95t, which relates the extreme precipitation to local climate, the best precipitation index that was represented by the models. The maximum of dryness observed over the central Argentinian Andes or the extensive dry season of the Amazon region could not be represented by any model. Analysis of precipitation extremes frequency using the Standardized Precipitation Index (SPI) in GPCP data, and results from CPTEC AGCM (six members) and HadCM3/CMIP3 shows that both models simulate more wet cases than dry cases, as in the observations and the frequency of cases are reasonable well simulated, mainly for the wet cases. Although there is large dispersion among CPTEC members, the ensemble reproduces the SPI variability in some periods. HADCM3 simulates intensities similar to observations, and for some periods it represents the interannual variability. CPTEC AGCM also reproduces the teleconnection patterns associated with extremes in the LPB and the opposition between the northern and southern LPB sectors. The skill of the GCMs in representing the circulation that causes or conditions the precipitation events has an important role in the evaluation of future climate projections. The evaluation of WCRP-CMIP3 and CMIP5 models in representing the daily circulation patterns and their relationship with daily rainfall in the Pampas region shows a reasonable consistency if the ensemble mean is compared to the NCEP/NCAR reanalyses. The projections for the 21th century show that the frequency of some patterns vary and some remain the same.

Carril et al. (2011) analyzed a set of four regional models which were integrated for the period 1991-2000, over a continental-scale domain, driven by ERA40 reanalysis. The range of variability of "strong" precipitation events was analyzed within different subregions of southern South America. These strong events were defined as days when precipitation is above the 75th percentile. In most cases individual models and the ensemble systematically underestimate the intensity of events derived from gauge data. The comparison of model-simulated precipitation extremes with station-based observations has two main sources of uncertainty. First one is mainly due to the sparseness of the observing network over most of South America. Second, models simulate grid box means whereas observations are point values. When models compare against satellite information up-scaled to the models resolution, the underestimation of P75 rainfall amounts is reduced, but errors remain large. Responses of precipitation seasonal means and extremes over South America in a downscaling of a climate change scenario were assessed by Sörensson et al. (2010) with the Rossby Centre Regional Atmospheric Model (RCA). The anthropogenic warming under the A1B scenario influences on the likelihood of occurrence of severe events like heavy precipitation and dry spells more than on the mean seasonal precipitation. The maximum amount of 5-days precipitation increases by up to 50 % in LPB, indicating risks of flooding. In the LPB, there is no clear pattern of change for the dry spell duration.

3. Ongoing and future analysis

Results from simulations of the present climate and projections for the future climate obtained in experiments performed in the project using several regional models are being analyzed. A comparison of regional model results with observations and the behavior of LPB temperature and precipitation extremes in future projections is expected. These results will be described to the groups leading the applications in Agriculture and Water resources within the project.

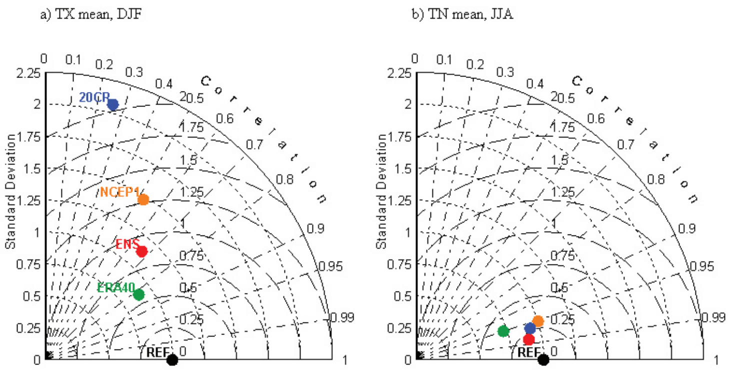

Figure 1: Normalized statistics displaying the spread of different gridded datasets (20CR is blue, NCEP1 is orange, ERA40 is green, ENSEMBLE is red), compared to Tencer et al. (2011b) black point, the reference climatology. Panel a (b) is for mean maximum (minimum) temperature in DJF (JJA). Domain is the Tencer domain (Southeastern South America).

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CLARIS LPB WP7: The CLARIS-LPB interface for improving prediction capability of climate change societal impacts

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1. Introduction

The objectives of the CLARISLPB project extend from observational and modelling studies of present-day and future climate in La Plata Basin (LPB), through to exploration of the socio-economic impacts of climate change focusing on key issues for regional stakeholders. Bridging the data and information needs of the different disciplines and the wide range of users within large inter-disciplinary projects is challenging. Thus central to CLARIS LPB is the WP7 Interface for improving the prediction capability of climate change societal impacts. As well as providing an interface between large-scale and regional climate models, and between regional models and hydroclimate studies, WP7 provides climate data access for the CLARIS LPB impact studies groups (covering land-use and socio-economic impacts and water resources) supported by user-friendly tools for data extraction and analysis. Finally, WP7 aims to ensure consistency of approach in terms of both observed and simulated climate and socio-economic scenario data used in CLARIS LPB.

The general objective of WP7, to facilitate climate data exchange and the further development and tailoring of knowledge between large-scale, regional-scale and impacts work, means that the activities are consistent with and highly relevant to current developments in the area of climate services (WMO, 2011). Thus an essential part of the WP7 work has been consultation on and evaluation of the needs of project partners for data and other resources. In part, this has happened through face-to-face discussion and feedback during CLARIS LPB meetings. These meetings have been organised and structured to maximise cross-WP interaction and with flexibility to respond to issues emerging during the meetings. Thus there is opportunity for agreeing on solutions and actions as well as identifying issues and needs.

2. Data dissemination: CLARIS LPB Data Archive Centre (CLDAC)

Following cross-WP discussions during the kick-off meeting, WP7 developed a questionnaire on needs for climate, biogeophysical and socio-economic data, as well as software tools. The questionnaire included the list of variables suggested to be archived from the WP5 regional models simulations and was circulated to partners working on impacts in advance of a meeting focused on the impacts work in June 2009. Assessment of the completed questionnaire indicated that it should be possible to meet all demands for climate scenario data either directly from the WP5 regional climate models or with additional downscaling and post-processing. Virtually all groups require time series data, either daily or monthly, for temperature and precipitation together with some additional variables such as soil moisture, radiation, evapotranspiration, wind speed, relative humidity and runoff. Users expressed a desire for a fully transparent user interface and made a number of suggestions about the kinds of data processing and analysis tools that they would like to be incorporated in the portal. The questionnaire results and broader discussion with partners also indicated a need for the provision of information and guidance on using climate scenario information, particularly with respect to the handling of uncertainty, including the treatment of model biases, and the potential use of probabilistic information. All these issues are reflected in subsequent and ongoing WP7 work which has focused on the creation and ongoing development of the Claris LPB Data Archive Centre (CLDAC).

The CLDAC is physically located at CIMA (Centro de Investigactiones del Mar y la Atmosfera; CONICET-UBA) and is accessible from the main CLARIS LPB web site (www.claris-eu.org). The web site also provides general public information about the project and access to the internal pages including the Dashboard project management tool. Both the internal pages and CLDAC are accessible to all project partners.

Two principle types of data are provided by the CLDAC - observed and simulated, together with associated metadata. The metadata encompass: data period, variables, type and geographical area; source; related publications, citation and contact details; data volume and format; and access (generally available to all consortium members). A url for access to the data themselves is also provided. The present-day observed climate data include reanalysis and CRU TS3.0 monthly gridded data together with data assembled as part of CLARIS-LPB by WP3. Daily temperature, precipitation, radiation and riverflow data are available, all searchable by latitude/longitude or station identification number and the data can also be filtered by time period before downloading. Interactive maps show the location of stations. The daily 0.5 degree gridded temperature data set developed by CLARIS-LPB (Tencer et al., 2011) is also accessible. Much of the geographic data and agro-data on land-use and soils are provided as ArcView shapefiles for GIS users, with the rest in Excel files. The agro-data also include information on crop yields, while currently available socioeconomic data covers land tenancy and land use.

The simulated model data currently available include global climate model data from the CMIP3 simulations underpinning the IPCC Fourth Assessment Report (searchable by various criteria including emissions scenario, model, data frequency and variable) and regional climate model (RCM) data from the WP5 CLARIS-LPB simulations. The latter are accessible via the linked RCM/WP5 data portal. As well as links for downloading RCM output files, a quick look analysis is provided. This currently includes maps of mean seasonal temperature and precipitation comparing reanalysis-forced simulations from the seven CLARIS-LPB RCMs with observed data. Supporting documentation and software utilities for checking the format compliance and plotting netCDF files are also provided. Simulated hydrological data from WP9 will be added in due course, together with agricultural impacts data from WP8.

3. Software tools

Two software tools developed within CLARIS-LPB are currently provided through the CLDAC. The first is APACH, an analysis and management platform for meteorological databases including an error detection/correction tool (Boulanger et al., 2010; Farall et al., in preparation). APACH uses third-party, open-source Java libraries and allows project members to work together to produce upgraded and reliable databases. The platform allows the user to:

- Upload and store meteorological databases
- Summarise and describe database information
- Download public databases useful for research actitivies
- Apply quality control procedures
- Error detection/correction tool
- Inhomogeneity detection/correction tool
- Generate new corrected databases from previous uploaded databases
- Modify, join and filter uploaded databases

The platform include a Procedure for Semi-automatic Quality Control and Homogenization of Weather Station Data, developed to quality control and homogenize historical daily temperature and precipitation data from meteorological stations (Figure 1). The platform is already able to store and handle all the CLARIS LPB databases – to which quality control procedures are now being applied. Future modifications of the platform will allow users to define their own quality control procedures to apply on the stored databases.

The second software tool is the CHAC weather pattern classification system for regional climate downscaling of daily precipitation (D'Onofrio et al., 2010). CHAC was originally developed as part of the earlier CLARIS project using MatLab toolboxes. Within CLARIS-LPB it has been further developed and enhanced to allow its use in a portable, concurrent processing, secure and private fashion through a statistical downscaling web portal. The main additional functionalities relate to:

- Access to more computational resources
- Portability and self-contained
- Session oriented
- Concurrent
- Privacy
- System usage

As in the earlier version of CHAC, three different downscaling/clustering methodologies are provided (k-means algorithm, self organizing map, and multi-layer perceptrons) together with tools for calculating and plotting various skill scores. Access is now provided through CHAC to ERA-40 reanalysis data.

CHAC and APACH are run through a software and server architecture which provides a general framework for hosting new web applications. The final goal is to allow every CLARIS LPB partner to run their own scripts on the hosting platform. It is also intended to incrementally support open source languages such as R and Octave. Many R scripts are freely available for the analysis of extreme weather and climate events, for example.

4. Guidance for users

Following presentation of the CLDAC to CLARIS LPB partners at the annual project meeting in November 2010, a number of enhancements were identified:

- Guidance on using datasets and handling the cascade of uncertainty
- More links to tools and software
- Observed data quality control and homogenisation
- Constructing indices of weather extremes
- Statistical downscaling (CHAC)
- Weather regime classification
- Handling and converting netCDF files
- Interpolation to common/standard grids
- Pulling together different data sets
- A summary of what's available for each variable from observations, reanalysis, models and links to relevant documents, papers, deliverables and presentations
- Hosting project outputs
- Metadata and/or data

A number of these enhancements have already been made, while others are ongoing. A general guide on working with regional climate projections and scenarios is close to completion. This encompasses issues such as: handling and quantifying uncertainty in global and regional climate model simulations; evaluating model performance and the added value of downscaling; and, techniques for bias correction of RCM data for input to impacts models. The guide draws on expert guidance [e.g., from the IPCC on assessing and combining multi model climate projections (Knutti et al., 2010) and the ETCCDI on analysis of extremes in a changing climate in support of informed decisions for adaptation (Klein-Tank et al., 2009)] and the recent peer-reviewed literature, together with the experience and activities of CLARIS LPB as well as the earlier EU ENSEMBLES project (van Linden and Mitchell, 2009). This general guide provides a broader framework and context for the more specific documentation and analyses of RCM uncertainty being produced by WP5.

5. Dealing with uncertainties in climate projections

As part of the WP7 work on uncertainties in climate projections, methods for the calibration and combination of multi-model ensemble simulations have been reviewed and recommendations made with respect to appropriate methods and datasets. Two methods [multiple linear regression (Greene et al., 2006) and fuzzy regression (Bisserier et al., 2010)] have been investigated using temperature projections from five of the CMIP3 (IPCC AR4) global climate simulations (a total of 27 ensemble members for the A1B emissions scenario). The analysis is for three homogeneous regions (northern, central, southern) of La Plata Basin identified using k-means cluster analysis. Combined and calibrated projections for the 21st century are shown in Figure 2. The uncertainty in the temperature projections is generally larger when estimated with fuzzy regression compared to when estimated with multiple linear regression, as indicated by the larger 90% confidence limits. Both approaches suggest an increase in temperature of the order of 1°C for the end of the 21st century in each of the regions (Figure 2).

In addition to this approach for calibrating temperature projections, the potential for spatial calibration of precipitation projections has been explored using the HadCM3 model. This model was selected because it is one of the CMIP3 models that best simulates El Niño-induced spatial patterns during the austral summer (DJF) in the 20th century. A forecast assimilation method based on a simple Bayesian approach and currently used in seasonal forecasting (Coelho et al., 2006) was used. The calibrated composite for El Niño years revealed much better agreement with the observations than the raw composite, including a more realistic pattern of precipitation relationships over South America (with wetter conditions over La Plata Basin during El Niño years).

The WP7 work on uncertainties in climate projections will help to put the WP5 RCM simulations (which sample seven RCMs, three global climate models and one emissions scenario - A1B) into the wider range of uncertainty space sampled by international climate modelling efforts. This is important both for project users and for the development of wider policy-relevant information and recommendations on adaptation strategies. Thus the WP7 activities contribute to and facilitate achievement of many of the CLARIS LPB objectives including the fostering of long-term collaboration between European and South American partners. The CLDAC will also provide a lasting legacy beyond the project lifetime.

Acknowledgements

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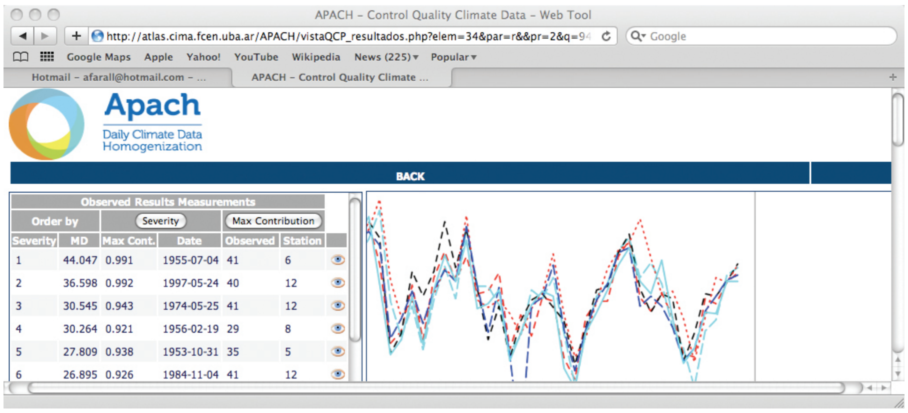

Figure 1: Screen snapshots of the APACH platform

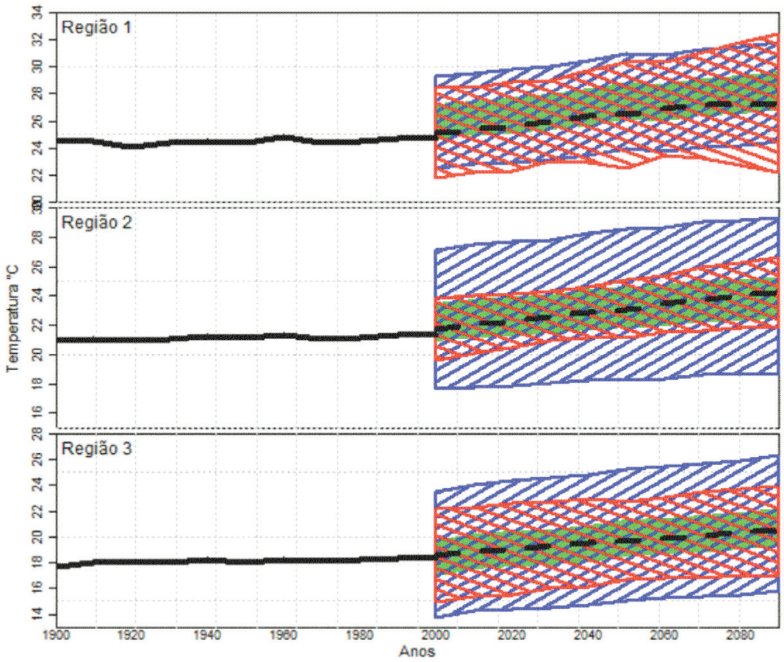

Figure 2: Observed decadal mean temperatures during the 20th century (solid thick line) for homogeneous region 1(top panel), 2 (middle panel) and 3 (bottom panel). Combined and calibrated decadal mean temperature projection for the 21st century with multiple linear regression (dashed thick line). The red hashed band is the 21st century projection 90% confidence interval for multiple linear regression. The blue hashed band is the 21st century projection 90% confidence interval for fuzzy regression. The green band is the 21st century projection 40% confidence interval for fuzzy regression.

CLARIS LPB WP8: Land use change, agriculture and socio-economic implications

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The primary objective of the interdisciplinary research team of WP8 is to reveal deep and comprehensive insights into the complex set of impacts and interdependencies of climate change and anthropogenic adaptation measures for land use, agriculture and deforestation. This has been accomplished by different case studies in Argentina, Brazil and Uruguay, which are taking political, social & organizational, environmental and economic aspects into account.

The identification of main land use sectors and changes in agricultural land use in Brazilian LPB are fundamental to recognize which areas of this part of the basin are more vulnerable to climate adversities. Since this region comprises 45% of the total basin area, which is dominated by cattle grazing and exporting monocultures, this characterization might be helpful in guiding the design of adaptation strategies to climate change. The data of areas used for temporary and permanent crops, forests and pastures and the area used for crops with major economical importance (coffee, maize, soybean, sugarcane, and wheat), as well as the most important sectors of animal production in the region were surveyed at the Brazilian Institute of Geography and Statistics platform for the period 1996 to 2008. Changes in land use/land cover were observed especially in relation to temporary crops and animal production that have increased in all Brazilian states within LPB. Economic drivers might have determined the verified dynamics of agricultural land use, which can be significantly altered by future climate change, influencing the geography of agricultural production in this region of the LPB.

Since 2009 studies were carried out in two sites (Anchieta and Guaraciaba) of the West part of Santa Catarina State, Brazil, focusing on the social perception about climate change, and the characterization of local agricultural production systems and adoption of decision support systems to face different management and climate scenarios. The employed methods to investigate these aspects were semi-structured interviews, surveys and field experiments. The region around these two sites is characterized by small family owned farms with a high level of diversification, and it is also known as a center of landraces of cultivated plants or traditional varieties. In cultural terms, the landraces are part of the local traditions, and some varieties are being cultivated by the same family for generations as a heritage; in environmental aspects, the landraces are more adapted to local conditions, require less inputs like fertilizers, are less affected by pests and diseases, sometimes resistant to drought, and usually perform well in intercropping systems; in economical terms, the seeds of traditional varieties are much less expensive than the industrial varieties, and in many cases they are obtained through an exchange system among the farmers. Farmers also reported that although yields are lower compared with hybrid varieties, the yields of landraces are more stable throughout the years, and the risk of agricultural losses due the threat of extreme climatic events is also reduced.

Furthermore, breeding programs were established by Universities and Research Institutions to improve the adaptation capacity of landraces to specific environments, different sowing dates and other purposes, like grain color or shape and taste among other characteristics. As part of the CLARIS LPB Project efforts, experiments were set up in Guaraciaba with two improved landraces of maize, one commercial open-pollinated and one hybrid. These maize varieties were characterized to be included in agricultural decision support systems (DSSAT), enabling decision makers (farmers, technicians) to evaluate these varieties in different environments (different soils, sites) under different management conditions, like different amounts of fertilizer, sowing date, soil management. Using this tool, farmers can decide which variety, sowing date and agronomic management is more efficient or more resilient for each situation. The same tool will be employed to simulate the influence of different climatic scenarios on agricultural systems. As was observed in the field experiments and similarly demonstrated by DSSAT, in current conditions the tested landraces obtained higher or similar yields when compared with commercial varieties in early sowing dates, although commercial varieties perform better in late sowing dates.

In one (Anchieta) of these two sites in the west part of Santa Catarina State, and in one site (Não-Me-Toque) in Rio Grande do Sul State, studies to evaluate the perceptions of climate change of farmers were also carried out. The aim of these studies was to investigate the influence of the context on the perception of climate change and how this might influence the design of adaptation strategies. In Anchieta, agricultural production has suffered severe pressure from adverse weather, specially the occurrence of droughts. The farmers' perceptions that climate has changed in recent years are probably associated with intensification of these droughts. Therefore, the local plant breeding program can be understood as part of an adaptation strategy to guarantee agricultural production in the region. In Rio Grande do Sul State the perception study was carried out in Não-Me-Toque with rural stakeholders associated to Cotrijal, a major and large Cooperative. The results show that also in this site the perception of climate change is strongly influenced by the context, determined most by the institutional arrangements provided by the Cooperative, and by the features of local agricultural production, mainly oriented to the production of commodities.

In Argentina, the interdisciplinary team integrated by researchers of INTA, IRD and UBA has conducted studies aiming at identifying stakeholders' perceptions of climate change and to investigate differences in management and production orientation of the farms present in three districts (Junin and Balcarce, in the Buenos Aires province, and San Justo in the Santa Fe province) within the Argentinean LPB. The overarching hypothesis is that different farm types will have varying capacities, or flexibilities, to adapt to climate change.

Heavily dependent on agriculture, Argentinean stakeholders must be ready to adapt to a different climate. A cognitive model of adaptation is used to analyze the perceptions of climate change of a cross section of stakeholders of the County of Balcarce, Argentina, and to assess their adaptive capacity. Most stakeholders note a warming process, more frequent droughts and a higher variability of water available for crops (i.e., more frequent droughts combined with more torrential rains). Local producers identify drought as the most threatening event. In order to adapt to such changes, stakeholders identify a series of adaptations appropriate to their productive systems. Stakeholders, across all backgrounds, suggest genetic-related adaptation strategies. This adaptation strategy includes using native species, developing genotypes with tolerance to specific events, and improving the match of genotypes with environments. Also, several stakeholders propose sustainable farming practices, and the implementation of land use planning to make agriculture more environmentally friendly.

Farms present in each of the study sites feature slight differences in size. The average farm size at Balcarce is 630 ha, while the average farm size at Junin and San Justo is 177 ha and 187 ha, respectively. Some common trends are identified at each of the districts. Results show an association between farm size, tenancy form, and production profile. Smaller plots are more frequently sown with annual crops by neighbors or local tenants, and in general do not carry cattle raising activities. Medium and large-size farms tend to produce crops and beef and to be operated by their owners. Large nation-wide sowing pools do not usually rent land in significant amounts in any of the study sites.

Also, at the three study sites a clear trend was verified to the increase in the area sown with annual crops, a decrease in the area used for livestock raising activities and an increase in the number of feed-lots facilities. These trends appear to be caused mainly by the relative economic yield of crops and of beef production activities. However, the increase in the area of annual crops, and especially of soybeans, is also supported by the good weather conditions experienced by the Pampas, in recent decades. Finally, domestic beef prices have exhibited an increasing trend during the last two years, which is contributing to slowing down the increase in the area sown with crops and helping to increase the national beef stock.

In one of these three CLARIS LPB pilot sites in Argentina (Junin, Buenos Aires), specific interviews with farmers identified drought as the major climate event affecting agriculture, as already mentioned. Focusing on this aspect, a decision-tree model based on a hydrological balance was developed. Basically, the model computes the risk of having very low yields, low yields or regular yields, and was found to predict quite well observed bad yields in years with droughts. The next step was to use this decision-tree to study the possible impacts of climate change scenarios on yields. It was found that the only way to compensate increasing temperatures is significantly increasing precipitation with respect to present climate (which seems to be improbable). Comparisons of simulated yields under regional climate change scenarios produced by CLARIS LPB are being investigated. Finally, all these results are presented to farmers in order to initiate a common reflection on possible adaptation strategies to future climates.

Fire is a major disturbance affecting worldwide ecosystems, and more particularly the tropics where drought and high temperature co-occur on highly flammable shrubs and grasslands. The LPB covers a wide range of "anthromes", a diversity of biomes (Pantanal, Atlantic Rainforest, Cerrado, Chaco and Pampas) transformed by a multiplicity of land uses, from urban areas and forest plantations to crop and livestock activities. The main objective is to investigate and disentangle the complex chain of biotic and abiotic factors that can lead to the different fire regimes in the anthromes of LPB and its potential risks under climate and socio economic changes in the future. The investigations being conducted are focused on analyzing recent fire history from remote sensing fire products, land use/land cover datasets, climate time series and social information.

The analysis of fire regime in LPB illustrate the high variability in both fire occurrence and fire seasonality, due to different climate conditions and related drought period, but also different fire practices and human pressure in the region. Fire is often said to be deeply rooted in the culture, society and traditions of most countries of South America. However our analysis pictured the fire embedded in agro-industrial landscapes and processes, responding to modern drivers rather than traditional uses. Multiple scale embedded factors appear to drive fire regimes across the LPB, from international commodity prices to national policies or

regional historical settings, such as struggles for land in Paraguay or colonization processes in Bolivia.

There are embedded policies and political discourses at different scales, in different regions inside the LPB, triggering fire uses, shaping fire patterns and trying to curb the "access" to fire. Studying the case of the three Brazilian states in LPB with most fire occurrence we found a very heterogeneous picture. In Mato Grosso do Sul, historical grounds of ranching, as well as political power of cattle ranchers, are likely to shape the vision of fire as a natural disturbance, in order to maintain a practice central to low cost extensive grazing. In São Paulo, heavy use of fire for pre-harvest burning of sugarcane has led to environmental laws to progressively phase out the burning by 2031. Unsatisfied by this distant deadline, municipalities have ceased the sugarcane sector and the state to diminish the deadline against what is pictured as a harmful practice, to health, nature and future generations. Firms prepared for mechanized harvests are pressuring the sector for reducing the terms, thereby demonstrating their sustainable visions of bio-ethanol markets, and eventually putting stress on the less adaptable concurrent producers. In Minas Gerais, were plantations of Pinus and Eucalyptus have been reshaping the landscape for over three decades, forest engineers have been charged with fire management, as elsewhere, their identity is sustained by their success in keeping trees alive. Therefore they tend to drive fire policies towards protection of Conservation Units were it is to be excluded. They double their success by training of firefighters and investment in equipment as well as burning permits to control the uses, a brilliant demonstration of their devotion to fire fighting.

Such diversified views on fire in just three neighboring regions inside LPB are likely to shape fire regimes in different ways in the forthcoming years, though the exact consequences remain poorly predictable. This intertwining of drivers that can be common across the basin with more local settings make more difficult the construction of a simple and/or general model to assess present and future fire risks on the basis of climate, land use, and ignitions. Simply because most human decisions related to ignition involve non-necessary and non-sufficient causal relations that are poorly captured by causal loops, which alternatively can describe efficiently physical relations such as combustion or evaporation. This mean that this study is a first step to understand the present fire use systems, and maybe to understand their link to climate drivers and other issues as changes in livestock or crop cultivation strategies and it can provide an image of fire patterns but perform poor for future projections, that is no more probable than any other alternative that could be imagined.

In Uruguay, the major climatic vulnerability of the cattle pasture production is associated with droughts. The more frequent and intense dry periods due to increased climate variability combined with the intensification of the production and the shift to more shallow soils due to the agriculture expansion has rendered the pasture system more vulnerable. This vulnerability is clearly manifested during severe droughts with large economic loss and social disruptions (job losses in all the production chain, indebtedness, bankruptcy and dislocation of producers, especially small ones), particularly in the dairy and cattle growers sectors.

For the whole agricultural sector, the Ministry of Agriculture estimated an economic loss of 450 million dollars due the drought during austral spring 2008 and summer 2009. The Rural Association of Uruguay doubled the estimate when considering the weight loss in the national cattle stock, and also reported a total of 12,800 jobs lost due to the impact of the drought.

Given this context, what is most commonly asked of climate change scenarios is the impact on climate risks associated with dry periods. In other words, it is expected that the scenarios would give an estimate of the frequency and intensity of droughts, especially multi-annual droughts which have historically generated the most devastating impacts. There are several ideas taking hold in the public sector to better prepare for the next drought. Currently, these strategies are being framed under the conceptual understanding that it is a manifestation of climate change. Large irrigation systems, drought emergency funds, insurance and other financial mechanisms are being explored by the public sector. One key and common element to all of these tools is a sound evaluation of the climate risk associated with droughts.

Apart from specific and problem-oriented cases, more general conceptual approaches are necessary to understand structure and design adaptation strategies to climate change. Therefore, a conceptual framework for the design of adaptation strategies to climate change is under development. The framework is based on a learning approach, and assumes that adaptation results from the reduction of the vulnerability of the system of interest. The framework has been built upon a range of assumptions and activities, as the delimitation of the problem situation and the feasible changes to be achieved, the identification of a set of traceable and easily available indicators, etc. In addition, the framework assumes that the engagement of stakeholders

is essential during the process of designing adaptation measures as well as when evaluating the effectiveness of their implementation in the considered system.

In complex "wicked situations", influenced by human-induced global warming and climate change, multiple causal factors are involved in determining the dynamics of land use change. Therefore, all the research teams of WP8 adopted the DPSIR framework to structure the research process, to create a common understanding of the research topics, as well as to facilitate communication and exchange of ideas. The adoption of this framework allowed the identification of some important factors affecting the vulnerability to climate change of the most important agricultural land use systems of LPB. This also allowed the understanding of how certain elements of the current situation being addressed are linked, and to which extent they might contribute in the design of adaptation strategies to climate change in agricultural land use for LPB.

Acknowledgements
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CLARIS LPB WP9: Water resources in La Plata Basin in the context of climate change

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Introduction

The WP9, Water resources in La Plata Basin (LPB) in the context of climate change, is part integrant of the Subproject 4, Socio-economic scenarios and adaptation/prevention strategies, that share with WP8, Land use change, agriculture and socio-economic implications, the technical, social and environmental responsibility to create tools to allow evaluate the impact of climate change scenarios at LPB.

In a more comprehensive approach, WP9 addresses issues of crucial importance for the region such as the flood risks, the river navigation (problems induced by sediment transport), the hydropower production and the ecological systems in wetlands. The economic implications and adaptation strategies will be suggested. Collaborations with stakeholders such as CIC (Comité Intergubernamental Coordinador de los Países de la Cuenca del Plata), hydropower dams (South Brazil), and national water resources ministries will ensure the dissemination of the results to local and regional actors.

Objectives

The primary objective of WP9 is to assess the impacts of Climate Change on the more sensitive aspects of the water resources of La Plata Basin to climate variations and to help to build the corresponding adaptation strategies. The horizon time will be 2010/2040 for adaptation strategies and 2070/2100 for assessment of long-range impacts. The WP9 component will focus on important climate change issues that are not currently addressed by other international projects on the Plata Basin. Specific objectives

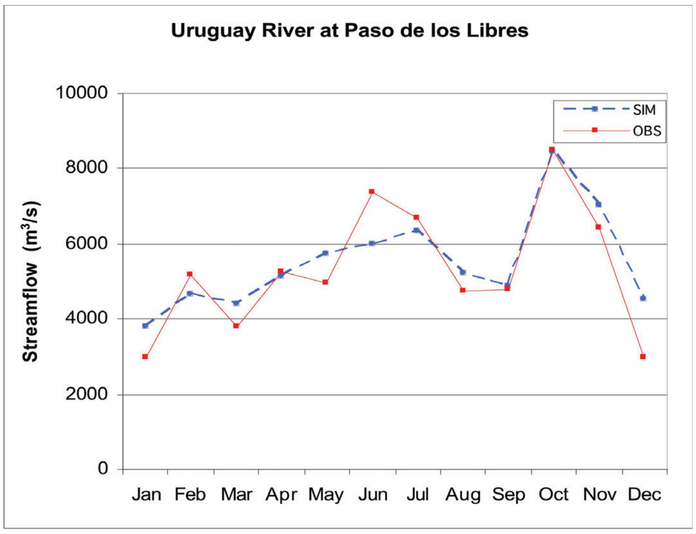
- To compute an ensemble of hydrological scenarios based on the HBV (SMHI) and VIC (CIMA) models forced by various 20th and 21st century large-scale and regional scale climate simulations provided by WP7 and based on models used in WP4 and WP5.
- To design statistical prediction schemes and hydrological scenarios forced by GHG increase and land use changes based on the knowledge of decadal variability of streamflow records in the region
- To suggest guidelines for the management of the Iberá wetlands ecosystems to stakeholders in order to preserve a region highly vulnerable to changes in the hydrological cycle.
- To recommend adaptation strategies (infrastructure) to face possible changes in the intensity and frequency of small regional floods of major impacts on society in the coming decades (2010-2040).
- To assess climate change effects on navigation and in the Paraná Delta front urbanization and recommend adaptation strategies
- To recommend operation strategy of the dams in the Brazilian South/South-East subsystem of LPB based on a set of future climate scenarios.
- To identify eventual vulnerabilities of the hydropower sector under climate change scenarios and quantify the possible need for other sources of energy

Main Results

Application of distributed models for La Plata Basin

Two hydrological distributed models were adjusted to the Plata basin, The Hype and the VIC models. The HYPE-model was set up for the LPB with an average sub-basin size of approximately 500 km^2. Simulation results show that the model generally captures the hydro-climatic features in the LPB. In the Uruguay River basin, which has the highest density of temperature and precipitation stations in the basin, the model captures the dynamics of the streamflow well. However, the simulated streamflow signal is too attenuated compared to the observations (Figure 1). This may be an effect of the reservoirs simulated in HYPE which may excessively smooth the streamflow signal. At Jupiá station at the Paraná River, the model simulates the seasonal cycle well, but not the interannual simulation of the summer peak. At Corrientes, downstream of the confluence of the Paraná and Paraguay rivers, the model results are worse. Streamflow is overestimated some years and underestimated others and the seasonal cycle simulation is also rather poor. The model

Figure 1: Simulated and observed streamflow, and monthly averages at the Paso the los Libres station at the Uruguay River.



has difficulties in capturing the streamflow dynamics of the Paraguay River, partly as a result of not capturing the effects of the large wetlands in this part of the basin. It may also be an effect of less accurate precipitation data in this part of the basin (the meteorological station network is rather sparse).

The VIC model is capable of reproducing the main hydrological features across LPB. The calibrations obtained at both the Paraná and the Uruguay Rivers are very good. The model results overestimate the summer streamflow by about 20-25%, but the autumn-winter-spring streamflow is very well represented by the model. In the case of the Uruguay River at Paso de los Libres, the VIC model is very accurate at representing the month-to-month variability. The hydrograph obtained with VIC is very similar to that derived from the observations, at both Paso de los Libres and Concordia.

The Paraguay River flow at the outlet of the big wetland of the Pantanal (Ladario), as in the case of the HYPE model, is not well represented by the VIC model. The amplitude of the streamflow wave is exaggerated with huge overestimations in autumn and slight underestimations during the dry season (from September to December).

Results obtained with VIC and HYPE models suggest that these models are good tools to simulate the water cycle of LPB, particularly in the Uruguay and Paraná rivers, but in the case of the Paraguay River their simulations are less accurate. Work is continuing to adjust these models for this River.

Analysis of available historical streamflow records and model-based hydrological reconstruction of the past and future climate scenarios

The objective is to analyze available historical streamflow records and model-based hydrological reconstructions of the past climate (comparing it to the observed records) and future climate scenarios with appropriate statistical tools (singular spectrum analysis – SSA). Based on this analysis, the final result will be the evaluation of models performance and of the influence of decadal variability on near-future scenarios. SSA allows the decomposition the original series in three kinds of additive components: oscillatory patterns (modulated in amplitude and phase), trends (not necessarily linear), and noise.

SSA was extensively applied to observed monthly streamflow series of Uruguay (Salto Grande), Negro (Rincón de Bonete) and Paraná (Posadas) rivers in LPB, both in annual and seasonal timescales. SSA was also used to analyse other global climate series (e.g. Niño 3.4 and Pacific Decadal Oscillation (PDO)) in order to determine signals with quasi-periods also present in LPB streamflows. Apart from SSA, other methods, like Maximum Entropy Method and Multi-Taper Method were applied to the time series.

The main results related to annual series indicates that Streamflow variability in LPB presents a strong link with ENSO, with pseudo-periods between 3 and 6 years approximately. In particular, there is a pervasive signal of 3.5 years both for annual and seasonal time series of the three rivers. Additionally, no quasi-periods above 10 years are obtained either for annual or seasonal time series, the exception being the time series of PDO, which exhibits a weak quasi-period of 23 years. For Uruguay and Paraná an increasing trend is evident beginning in the 60´s, with a weak decreasing tendency in the last few years of the record, while for Negro river there is a clear increase during the whole period, but it is less robust.

Assessment of the evolution of the Iberá wetland ecosystem

The main objective is to understand how Iberá wetlands will evolve with climate change by identifying the structural and functional components of Iberá Ecosystem most vulnerable (vegetation communities, vertebrate species, and other functional assemblies) and their tolerance/adaptation capacity to expected climate and ecosystem changes though scenario analyses. It will be used current approaches in animal species and vegetation geographic distribution modeling, combined with climate change and land cover/land use change scenarios to evaluate main trends and impacts on biodiversity distribution. These results will be used to assess current protected area conservation effectiveness, to propose areas and species with further conservation needs, and to suggest good land use practices to further reduce biodiversity threats. During this period, it was aimed to collate and preprocess spatially explicit environmental datasets and built a database of vertebrate species records from publish sources.

A GIS environmental database was built from different sources, subset to Corrientes province extent. An Elevation database at 400m cells was processed from a 90m SRTM digital elevation model by CIMA. So far, it was compiled distribution occurrences for a total of 420 nominal vertebrate species known for Esteros del Iberá (125 fish, 40 amphibian, 53 reptile, 135 bird, and 67 mammal species). Data sources include bibliographic references, on-line museum collection records and field data collected by the Project. Distribution information extends beyond the Iberá region in order to reduce bias, over fitting and have enough data for model calibration and validation.

Improve the understanding and modelling of local or small regional floods

The inventory of floods in the Argentine part of the Plata basin was carried out. 140 floods were identified within the period 1995 to 2008. Most of the floods persist for a few days, less than a week, but a 10% persists from 30 to 150 days. The first group are clearly associated to certain synoptic systems, while the second may result from persistent climatologic conditions. While short term floods may extend over a wide range of spatial dimensions (2 to 500 Km), most of the persistent floods have scales that are over 80 Km. Additionally, a mode was identified that consists of a trough with axis west of Chile and strong upper wind flow with cyclonic vorticity advection over the east of the subtropical South America. This mode shows a spectrum with two significant peaks at 40 and 70 days that indicates long periods with high positive rainfall anomaly over that part of the continent. Therefore, following these results and the characterization of floods in the Lower Paraná basin, a case study was started. During late summer/-early autumn of 2007 there was a period of 3 months with heavy rainfalls with centre in the provinces of Santa Fe and Entre Ríos that also impact part of Uruguay.

The soil moisture group of models CLASS U3M-1D was configured to simulate soil moisture conditions at Diamante Station in the province of Entre Rios. Soil layers and soil materials were obtained from Diamante soil map elaborated by INTA. Correlations between observations and modelled results indicate that the Brooks Corey model adequately represents soil moisture at surface and 20cm levels, with a better adjustment near surface. Correlations for the van Genuchten model are somewhat smaller near surface but indicate that this model probably is more representative of soil moisture behaviour at deeper levels.

Changes in the return periods of surpassing flow thresholds before and after 1976 were so important that certain important flows related to floods have a return period of an order of magnitude lower.

Description and simulation of the river-channel morphology of the lower Paraná

The main goal is the climate change impact assessment on Lower Paraná water way for oceanic boat navigation, on Buenos Aires urbanization beside the delta front, and on manmade structure near river banks. Climate change will impact those resources by affecting river hydro and morphodynamics. Therefore the first objective is to represent the main fluvial processes driven by climate change at different scale. Numerical models and underwater acoustic survey have been employed in order to achieve this objective. So far the work has been mainly focused on gathering Paraná morphological data, throughout scientific references, navigation stakeholders and on field surveys. Several numerical model implementations and calibrations are also being developed.

Concerning fluvial processes simulations, the expected final result is the prediction of future river morphology affecting economic resources such as navigation way or availability for urbanization areas. Therefore it will be possible to suggest adaptation strategies in order to minimize the negative socio economic impacts.

Regarding navigation routes it was studied the first survey (June-August 2009) was on the 20 km long Parana river reach near Rosario conducted in cooperation with the Centro de Estudio de Grande Rio of Università del Litoral, Santa Fe, (CIEGRI-UNL). As a result the bathymetry was obtained on a 20 km long reach near Rosario (Figure 2) that is the most important reach for inner navigation because of its many ports for oceanic boats, and also including 2 low depth area (Paso Borghi and Paso Bella Vista) that are critical for boat passage, and 2 bifurcation and 1 junction that are key features for long term morphodynamics. The 2D-H model, MIKE 21C of the Danish Hydraulic Institute, was applied to this area with the aim to simulate future development of banks, bifurcation and junction and therefore river channel divagation that strongly has been affecting navigation route in the last centuries.

The HEC-RAS 4.0, 1D model, with the final objective to predict very long term (100 year) river morphodynamics, was implemented. Finally a 2D hydrodynamic model of the area involving Paso Borghi and Paso Bella Vista was implemented. The goal of this model is the assessment of the angle of incidence of the current lines from the axis of the navigation channel in each of the reaches of interest. The bathymetry comes from a 2009 survey, and water levels from Prefecture Naval daily measurements. With the calibrated and validated model, the streamlines representing stream tubes of equal flux were calculated for each critical zone. The streamlines that enclose each critical zone are needed to define the geometry of the 2D-V model (discharge, width, velocity and angle between the flux direction and the navigation route).

Evaluation of the impact of climate change on energy production

The objective of this research project is to investigate how global climate changes will modify the guaranteed output of a system of interconnected hydropower plants. In particular it is proposed to analyze the performance of the hydropower plants system within the La Plata basin under a set of future climate scenarios. A Rainfall-Runoff Model based upon Artificial Neural Networks was developed.

Although there is other ANN methods in the literature, the ANN employed in this study uses the "Feed Forward Back Propagation" method. In this method, the connection of several neurons is distributed with layers. Within the ANN, the data flows in a single direction, feedforward, i.e., the input data are propagated through the ANN, layer by layer, in the forward direction.

The problem of training an ANN to solve a rainfall-runoff type problem is to fit a suitable function to a data sample. The rainfall-runoff process is non-linear, and the functional form for the fit is unknown. In this case, applying an ANN requires not only fitting the best weights and biases to the sample of data observed, but also to investigate, by varying the ANN architecture, which is the best functional form for the observed data.

In order to investigate the best functional form, 24 ANNs were created with variations in the number of inputs and the number of neurons in the middle layers. The output is always runoff. Each combination of inputs was called a model. Table 2 shows the input and output for each of these models. For each model 3, 5, 8 and 10 neurons were used in the middle layer, making up the total of 24 ANNs combinations. Varying both the number of neurons in the middle layer and the number of inputs, allows the evaluation of ANN sensitivity in terms of its architecture. During the training of the 24 ANNs, the following parameters were considered: length of data series, number of iterations called epochs and initialization of weights.

All the ANNs were trained with three different sets of data. From the 221 months available, sets of 60, 120 and 180 items were used for training, and 161, 101 and 41 items for validation, respectively. The combination, during the training, of the ANN architecture, the input sets, the number of initializations and the number of iterations generated a total of 1296 results for analysis. In order to evaluate the influence of all elements proposed in the ANN training, an algorithm was created in MATLAB software, that manipulates the data, trains, simulates, computes the statistics of the results and stores all responses in an output file. The statistics used at this time were the correlation coefficient and the percentage difference of the volumes.

Finally, with the rainfall- runoff model implemented the methodology to evaluate the impact of climate change on energy production will be explored based upon the Natural Energy method.

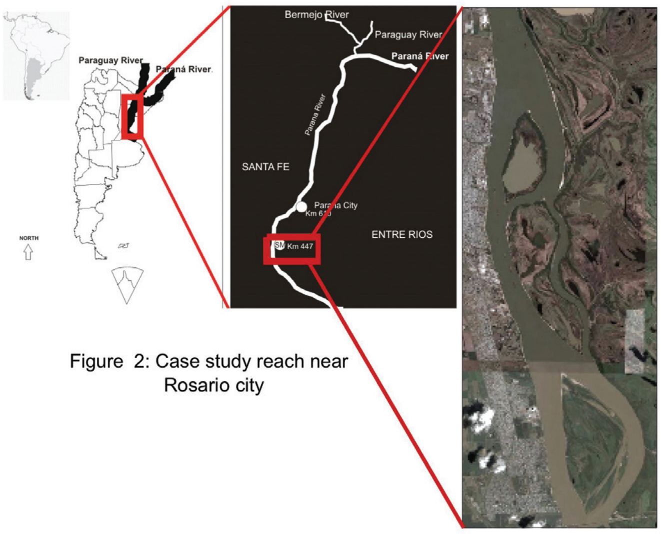


Figure 2: Case study reach near Rosario city

Assessment of the potential evolution of the hydroelectric production of the La Plata Basin

The specific objective is to identify eventual vulnerabilities of the hydropower sector under climate change scenarios and quantify the possible need for other sources of Energy. A GIS data base of the LPB has been elaborated, in which the river system, hydrological stations, hydropower reservoirs, etc. are represented. In addition, a homogenous Digital Elevation Model (DTM) of the full basin has been created. Finally, the VAPIDRO-ASTE numerical tool has been applied to evaluate the Maximum Potential Hydropower in several sub-basins of LPB. The final result will be the assessment of the potential evolution of the hydroelectric production of the LPB under an ensemble of climate change scenarios.

The data analyses conducted addresses the historical data base of hydrological data, such as rainfall and discharges, and the past hydropower production, population, economics production and energy demand in the LPB region. In particular we assessed the Maximum Potential Hydropower in the La Plata Basin, considering the present climate, using the VAPIDRO-ASTE numerical tool.

Final Comments

During the coming final year of CLARIS LPB, WP9 will focus its efforts in finalizing the analysis of the impacts of climate change on the topics described in this article. The results will help to build the corresponding strategies to mitigate potential impacts on the watershed.

Acknowledgements

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Impacts of land use changes over southern South American climate: a modeling study using the MM5 regional model

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1. Introduction

La Plata Basin (LPB) and the Argentinean Pampas are two of the most important agricultural regions in the world. In the last decades the areas devoted to agriculture over these regions have been extended at the expense of deforestation and replacement of natural pastures. Land use/land cover changes (hereafter LULCC) may modify the exchanges of energy and moisture between the land surface and the atmosphere due to the control that land surface exerts on the partitioning of available energy at the surface between sensible and latent heat fluxes and the available water between evaporation and runoff. Besides that, the surface heterogeneity not only determines the microclimate but also affects mesoscale atmospheric circulations (Hartmann, 1994; Weaver and Avissar, 2001; Yang, 2004; Sertel et al., 2010).

Over the LPB and Argentinean Pampas, there are some recent studies that suggest that the net warming and the strong reduction in diurnal temperature range could be associated with surface effects (Nuñez et al., 2008). Ferreira et al. 2006; Lee and Berbery 2009 and Blatter et al. 2010 showed evidence that the mechanisms associated with land use changes have an important impact on the local climate, particularly for temperature and precipitation and also for regional circulation patterns. Beltran-Przekurat et al. (2011) analyzed the impacts of LULCC over the LPB region and found that the shift from grass to agriculture led to cooler and wetter near-surface atmospheric conditions and warmer conditions resulted from the conversion of wooded grasslands or forest to agriculture.

Most of previous studies are based on the traditional experimental setup for this kind of sensitivity experiments that consist of a single model realization representing the control climate and a single model realization representing the regional response to a given forcing, which is forced through the boundary conditions (at the lateral boundaries or at surface). The difference between the two simulations is then evaluated as the response to the given forcing. Nevertheless, in recent years, several studies have shown that regional climate simulations are affected by several sources of uncertainties, among these internal variability (de Elia et al. 2008; Solman and Pessacg 2011), consequently those differences should be taken into account before drawing conclusions about the significance of the regional climate responses to the external forcings (O'Brien et al. 2008). Taking into account these previous results and with the goal of understanding how the LULCC may affect the regional climate over southern South America, ensembles of sensitivity experiments for an idealized land use scenario using the Fifth-generation Pennsylvania-State University-NCAR nonhydrostatic Mesoscale Model (MM5) (Grell et al., 1994) were performed with the aim of identifying the physical signal of the internal variability inherent to the system due to LULCC. This study is a contribution to one of the objectives of the CLARIS-LPB Project concerning assessing and quantifying the impact of land use change in climate change on the LPB.

2. Model, experiments and evaluation methods

The MM5 model version 3.7 was used in this study. The integration domain is from 10º S to 45º S and from 85º to 35º W with 155 points in the west-east direction and 190 points in the south-north direction (Fig.1). It was configured on a Mercator projection grid with a resolution of roughly 30 km. In the vertical, 23 sigma levels were used with the model top at 50hPa. The land-sea mask and topography have been derived from the US Navy 10-min resolution dataset. Vegetation and soil properties were obtained from USGS vegetation/land use data base. Surface processes are represented by the Noah Land Surface Model (Chen and Dudhia 2001). Initial and boundary conditions for the regional model and sea surface temperature were provided by the European Centre for Medium-range Weather and Forecasting reanalysis data set (ERAinterim) (Simmons et al. 2007) available at 1.5ºx1.5º resolution. Boundary conditions were updated each 6-hours.

Sensitivity experiments using idealized LULCC scenarios were performed with the MM5 regional climate model for two different periods, March 1996 to February 1997 and March 1997 to February1998. Results for the austral summer, December-January-February (DJF) are analyzed, allowing for nine months of model spin-up. The periods selected were chosen based on El Niño Southern Oscillation (ENSO) classification with the goal of capturing, on one hand the response associated with the local forcing and, on the other hand, the impacts of the local and the remote forcings together. Accordingly, DJF 1996-1997 corresponds to a non-ENSO period and DJF 1997-1998, to an extreme El Niño event.

The control (CTRL) simulations were carried out for each period in which the land use categories from USGS (Fig.1) were used. The sensitivity experiments were based on an idealized scenario of land use change in which the natural land cover was replaced over most of the LPB region and the Argentinean Pampas (black box in Fig.1) by dry land crop pasture (CROP experiment). This idealized scenario was estimated from transformed maps based on satellite observations corresponding to the years 2008 and 2000, respectively (http://www.proyungas.org.ar) and also from land use changes reported in the LechuSA Project (http://lechusa.unsl.edu.ar). The purpose of this highly idealized scenario is to evaluate what extent large changes in land use may impact on the climatic characteristics over the target region, before attempting more realistic scenarios. Four-member ensembles were performed for each experiment by changing the starting date of the simulations, from March 1st to March 4th. This methodology allows comparing the anomaly generated by the physical forcing with the internal variability. When the magnitude of the difference between the CTRL and CROP ensembles for a particular variable lies within the range of the internal variability it is difficult to separate the physical signal from the intrinsic noise of the system. For these cases, a measure of the robustness of the differences between ensembles is quantified by the number of times in which the ensemble members fulfils a certain threshold. This measure quantifies the number of times in which the following index is true in each grid point of the domain:

$$NEM(X)=\sum_{i=1}^{4}\sum_{j=1}^{4}[\![(Xmi-Xnj)>\mathrm{Y}]\!]$$

Where X is the variable, in our case precipitation and temperature, m and n represent two different ensembles, and i and j represent the members of each ensemble (in this case we have 4 members for each ensemble). Y is the threshold that is imposed as the condition for this index, in our case Y=-0.2ºC for temperature and Y=0.5mm/day for precipitation. Since each ensemble is built with four ensemble members, NEM can reach a maximum value of 16 considering all possible pairs of combinations for the difference between both ensemble members.

3. Results

The replacement of natural cover by crop causes to a cooling lesser than 1°C for the 2 meter temperature (T2m) over northern Argentina, Paraguay and part of Bolivia during DJF 1996-1997 (Fig. 2a). For DJF 1997-1998 a similar response is found, though the cooling is extended over central Argentina (Fig.2b). For both periods, the magnitude of the cooling lies within the range of internal variability, which reaches 1°C over the region (not shown). Consequently, it is difficult to detect the physical signal from the intrinsic noise of the system. However the NEM index (Figs.2b.d) showed that all of the possible ensemble members combinations for the temperature difference between CROP and CTRL are consistent among each other, consequently, even though differences should be carefully interpreted, the change in temperature associated with LULCC can be considered robust.

The cooling over northern Argentina, Paraguay and part of Bolivia due to LULCC during the El Niño year (DJF 1997-1998) tends to weaken the ENSO signal which, over this area, is characterized by a warm anomaly (not shown).

Over the region where the main changes in T2m were localized, there is a shift from savanna and cropland/woodland mosaic (in the CTRL ensemble) to dry land crop (in the CROP ensemble). This shift leads to a decrease of albedo and an increase of emissivity, which, in turn, leads to an increase of the latent heat flux and a decrease of the sensible heat flux (not shown), consequently, decreasing the Bowen ratio. Both mechanisms can explain the cooling in the CROP scenario with respect to the CTRL scenario. On one hand the increase in latent heat flux leads to an increase in the evaporative cooling and, on the other hand, the change in the energy partition that leads to a decrease of the Bowen ratio, indicate that more energy is used in transpiration and evaporation than in heating the atmosphere near to the surface. These mechanisms give a physical context to the change in temperature due to LULCC, that is the magnitude of these changes are smaller than the internal variability of the system, though statistically consistent.

This behavior is opposite to results shown by Beltran-Przekurat et al. (2011), who concluded that the shift from grass to agriculture over southern South America leads to cooler conditions and the shift from wooded grassland or forest to agriculture leads to warmer conditions, only over particular areas within the region. However the changes they found were limited to those regions where LULCC were imposed (center and east of Argentina), and large areas of forest in Paraguay and Bolivia that have been cleared due to agriculture expansion not considered in their work. Conversely, the cooling is consistent with previous results in other regions of the world; Bonan et al. (1999) showed a surface annual mean cooling of 0.6°-1°C (larger during summer) over central and eastern of United States in response to deforestation and replacement by crop; Hansen et al. (1998) found an annual cooling of 1°-2° also over United States, and Oleson etal. (2004) explained also a cooling over north-central of United States due to land use change.

For precipitation, through the differences between CROP and CTRL ensembles showed a noisy field (Fig.3), it is possible to detect during the austral summer for both periods that the shift from the natural cover to crop over northern Argentina, Paraguay and part of Bolivia led to wetter conditions due to the increase in the latent heat flux. The largest values of precipitation increase reached 1-2mm/day. Nevertheless, these changes are smaller than the internal variability and the NME index (not shown) indicates that the most but not all the ensemble members reproduced this precipitation increase , consequently it is difficult to explain this change to LULCC impacts without more extensive analysis that confirm this behaviour.

4. Summary and Conclusions

This study examines the effects of LULCC on climate over two important agricultural regions in southern South America, LPB and the Argentinean Pampas. In the last decade these regions have suffered a replacement of the natural cover, mainly by the expansion of the agricultural activity, associated with an increase in the soy production. Sensitivity experiments were performed with the MM5 regional model, in which the natural cover was replaced by crop category of land use. The experiments were analyzed for two particular periods DJF 1996-1997 and DJF 1997-1998, a non-ENSO year and extreme El Niño year, respectively. Experiments showed a decrease of temperature, smaller than 1°C, when crop replaces the natural cover. Though this value is close to the internal variability the signal is consistent for every pair of the ensemble members.

This cooling can be explained by a decrease of the net radiation budget, an increase of the latent heat flux and, consequently, a change in the partitioning of energy. This behavior is more intense over north Argentina, Paraguay and part of Bolivia.

On the other hand, the shift to crop led to a wetting, over north Argentina, part of Bolivia and Paraguay mainly due to the increase in latent head flux.

Acknowledgments

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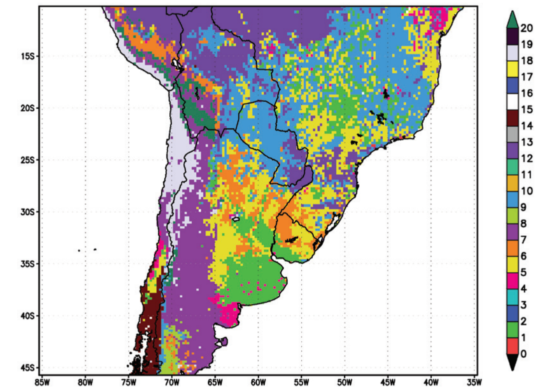

Figure 1: Model domain and land use categories (shaded). The box defines the region where land use was changed. Categories of land use from USGS: 1:Urban; 2: Dryland Crop. Past.; 3: Irrig. Crop. Past.; 4: Mix.Dry/Irrig. Crop. Past.; 5: Crop/Grassland Mosaic.; 6: Crop/Wood Mosaic; 7: Grassland; 8: Shrubland; 9: Mix. Shrub./Grass.; 10:Savanna; 11: Decids. Broadlf.; 12: Decids. Needlf; 13: Evergrn Broadlf; 14: Evergrn. Needlf.; 15: Mixed Forest; 16: Water Bodies; 17: Herb. Wetland; 18: Wooded Wetland; 19: Bar.Sparse Veg.; 20: Herb. Tundra.

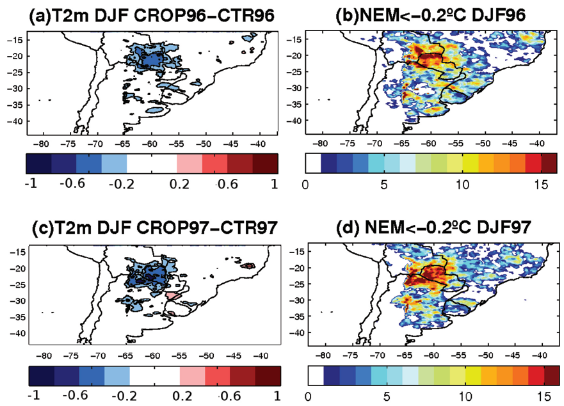

Figure 2: Differences between CROP and CTRL ensembles for T2m (ºC) for (a)DJF 1996-1997 and (c) DJF 1997-1998, (contour each 0.2ºC). NEM index for T2m for (b) DJF 1996-1997 and (d) DJF 1997-1998.

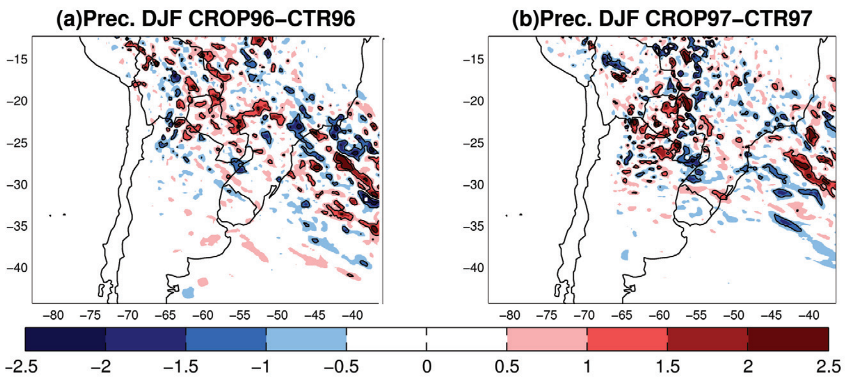

Figure 3: Differences between CROP and CTRL ensembles for precipitation (mm/day) for (a)DJF 1996-1997 and (b) DJF 1997-1998. Contour each 1mm/day.

Report from the workshop "Coupling Technologies for Earth System Modelling: Today and Tomorrow"

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On 15-17 December 2010, CERFACS (Centre Européen de Recherche et de Formation en Calcul Scientifique) and the Georgia Institute of Technology organized a workshop entitled "Coupling Technologies for Earth System Modelling: Today and Tomorrow". The workshop explored the trade-offs involved in the different approaches to coupling in use throughout the climate modeling community and laid out a vision for coupling Earth System Models (ESMs) in the year 2020.

45 people from different countries around the world attended the workshop. The first part of the workshop was devoted to detailed presentations of current coupling technologies: the Earth System Modeling framework (ESMF), the Community Earth System Model (CESM), the Model Coupling Toolkit (MCT), the PALM and OASIS couplers, the Flexible Modeling System (FMS), the Bespoke Framework Generator (BFG), OpenMI and the Object Oriented Framework for Coupling Data Assimilation Algorithms to Models (OOPS). The rest of

the workshop included presentations on coupled modeling perspectives at different centers, coupling related issues (e.g. data assimilation and education), future software and hardware challenges and roundtable discussions.

The main conclusions of the workshop are the following.

- Current coupling technologies can roughly be split into two main categories. The "multiple executable" approach, in which component models remain independent executables, is less flexible and can be less efficient but is straightforward to implement requiring minimal modification to individual models. The "integrated" mono-executable approach requires the original codes to be split into initialization, running and finalization units and supposes some standardization of the resulting component interfaces; however, because components can be run sequentially or concurrently, this approach offers additional optimization opportunities.

- For maximum coupling flexibility and efficiency, climate component models should be re-factored into initialization, run and finalization units. However, this refactoring may be not straightforward to apply for some legacy models and it may be difficult to achieve an agreement on the standard component interfaces required for integrated coupling. To satisfy all cases, an "ideal" coupling technology should therefore offer both approaches. Current research in Generative Programming explores ways to build such an "ideal" technology.

- Existing coupling technologies have been developed with different priorities and constraints. In the short term, parallel development of a small number of coupling technologies should continue, each one with a significant amount of resources. However coupler developers should interact more closely and share basic utilities when possible (e.g. regridding libraries). The development teams should include computing scientists interacting closely with climate modeling scientists. Best practices in coupling should also be discussed, identified, and promoted.

- As we approach the exascale era, increased parallelism with more concurrent components seems essential. Moreover, it will be crucial to limit the load of the associated data communication e.g. by carefully distributing the coupled components over available processes, overlaying communication and calculation, performing redundant calculations, etc. Future hardware platforms will likely require significant changes in programming structures. If sweeping changes to ESM software are required, the geoscience modeling community should seriously consider combining as much as possible available development resources and evaluate where infrastructure convergence is possible.

For more details on the workshop including the proceedings, see https://verc.enes.org/models/software-tools/oasis/general-information/events

The International CLIVAR Climate of the 20th Century Project: Report of the Fifth Workshop

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1. Introduction

The International CLIVAR Climate of the 20th Century Project (C20C; Folland et al., 2002) held its Fifth Workshop on 25-28 October 2010 at the Institute of Atmospheric Physics (IAP) of the Chinese Academy of Sciences, Beijing, China. The C20C project brings together climate modeling groups to study climate variations and changes over the last 140 years or less using observational data and atmospheric general circulation models (AGCMs) typically forced with observed values of atmospheric composition (concentrations of greenhouse gases and aerosols) and surface conditions (SST, sea ice, land surface vegetation, etc.). Some work with coupled models is also part of the project. Several major C20C papers have been published since the last Workshop in Exeter, UK, in 2007, particularly in Climate Dynamics.

The goal of the Fifth Workshop was to review new results on coordinated climate simulations and analyses, and to develop plans for new C20C projects. As in all previous C20C meetings, the forcing data sets used in coordinated model experiments, including ongoing development of the Hadley Centre's SST and sea-ice analysis (HadISST) were discussed (see Section 2). There was also discussion of how to coordinate C20C experiments with related international research programs, in particular the Intergovernmental Panel on Climate Change Fifth Assessment (see Section 3) and the LUCID – Land Use and Climate, IDentification of robust impacts – project (see Section 6).

The 45 workshop participants from 16 institutions representing 10 countries were welcomed by Dr. Huijin Wang, Director of IAP, and enjoyed wonderful hospitality from the host institution. The workshop included 28 presentations on various C20C results and a series of breakout sessions, including new core foci for the project. The workshop web site (http://www.lasg.ac.cn/c20c/) includes downloadable copies of the presentations and a fuller discussion of the Workshop. Summaries of the breakout discussions are available on the project web site (http://www.iges.org/c20c/).

Both "standard" C20C simulations (in which the SST and sea ice are specified from HadISST) and alternative strategies (e.g., regionally-coupled or "pacemaker" simulations) were presented. The presentations summarized new findings on:

- the variability in the north Atlantic, including the role of atmospheric noise and more detailed evaluation of the summer North Atlantic Oscillation (SNAO)
- the attribution of changes in variability and trends
- variability and trends in precipitation
- the effects and impacts of land surface variability and change
- the effects of spatial resolution on the simulation of the mean climate and its variability, including extreme event
- the east Asian climate, including the summer and winter monsoons
- modes of variability in the atmospheric circulation
- new model developments by various groups

The proposed new core projects are now described.

2. HadISST

The Hadley Centre continues to develop improved analyses of global SST and sea ice concentration so as to include more observations and attain greater accuracy and resolution. Key improvements of HadISST2 over HadISST1 are multiple realizations, better resolution in time, new bias corrections to SST right up to the present, inclusion of A(ATSR) satellite data and a considerably improved sea ice extent data set. HadISST2 will be fully available in summer 2011; a beta version is now available. Future versions will address the diurnal cycle through work planned under the European Space Agency (ESA) Climate Change Initiative SST project (see http://www.esa-sst-cci.org/). It is highly desirable to have a 0.5°-resolution daily version of HadISST, at least for the satellite era. In the short term new analyses such as the single realization Met Office OSTIA analysis, but without full bias correction, easily achieve this – see http://ghrsst-pp.metoffice.com/pages/latest_analysis/ostia.html

It is planned to integrate HadISST and OSTIA over the next few years. In the meantime, a small number of the approximately 100 realisations of HadISST2 will be adapted for the C20C project.

The use of AGCMs to detect and attribute trends, variations and extremes in the climate record of the past 140 years is a high priority for the C20C project and the Intergovernmental Panel on Climate Change Fifth Assessment. An international working group on detection and attribution has recommended a core project within C20C. Its primary purposes would be:

- to characterize historical trends and variability in the probabilities of damaging weather events, including the differences across climate models;
- to estimate the fraction of the historical, present, and future probabilities of damaging weather events that is attributable to anthropogenic emissions, and to characterize underlying uncertainties in these estimates.

This project is to a large extent an extension to the multimodel ensembles of Pall et al. (2011). It will comprise ensembles of simulations run under different scenarios of external radiative forcing, land use, SST and sea ice. Along with the base scenario of past observed changes in the boundary conditions, other scenarios will examine the effect of omitting changes in selected boundary conditions.

The main project will involve generating a standard C20C ensemble of historical simulations for 1950-2020 using HadISST2 (before 2011) and DePreSys (Smith et al., 2007; after 2010) for SST, and forced with historical changes in greenhouse gases, tropospheric aerosols, land surface conditions, volcanic aerosols, and solar luminosity. This ensemble will provide a basis for estimating changes in the probabilities of damaging events. A parallel ensemble will be generated in which anthropogenic contributions to the forcings are altered to pre-industrial conditions and the SST is altered accordingly. Comparison of these two ensembles will indicate the degree to which anthropogenic emissions have contributed to changes in the probability of selected weather events. The altered SST will be estimated using optimal fingerprinting regression analysis, a standard tool in detection and attribution studies.

Using the adjustment factors and linear combinations of the climate model response patterns, a spatio-temporal anthropogenic signal in SST will be estimated that will then be subtracted from HadISST2. Various methods for treating sea ice are being examined, with an option for no-change.

4. Weather Noise

Based on earlier work by Hasselmann, Schneider and Fan (2007) showed that some features of low frequency variability may result from stochastic variations in the atmosphere, sometimes called weather noise. Analyses of the output from existing C20C ensemble simulations will compare the properties of actual atmospheric weather noise implied by the various models. The weather noise would be computed by subtracting ensemble and monthly mean simulated fields from observational analyses. The potential uses for this product include:

- Model verification: By determining whether the weather noise inferred from a model satisfies the causality principle that the weather noise is unpredictable, the model's realism can be assessed. The predictable part of the weather noise should be included in the ensemble means of the simulations; hence, the residual should be unpredictable if the model is realistic. Predictability can be determined from simple lag regression analyses (e.g. does the North Atlantic tripole index predict future weather noise surface fluxes?).
- Studies of low frequency coupled climate variability:

The weather noise surface fluxes could be used to force simplified coupled models (such as versions of the Interactive Ensemble CGCM – Kirtman and Shukla, 2002) to analyze properties and mechanisms of the low frequency SST variability forced by weather noise.

5. Summer NAO

The Summer North Atlantic Oscillation (SNAO) can be defined as the first EOF of July-August or June-August extratropical North Atlantic pressure at mean sea level. It exerts a strong influence on European climate, e.g. rainfall, temperature and cloudiness, but is also associated with climate variability elsewhere, e.g. eastern North America, the Sahel region in Africa and eastern Asia (e.g. Folland et al. 2009) Moreover, modeling and observational results indicate that SNAO variations are partly related to the Atlantic Multidecadal Oscillation (AMO) on interdecadal time scales. This project will focus on the pattern and impacts of SNAO simulated by C20C models. Initial tests with coupled models show that models tend to produce different SNAO patterns, or sometimes not show a reasonable SNAO pattern. Thus, we need to separate those models that produce an SNAO pattern from those that don't. Composites of SNAO with surface air temperature, precipitation, and storm tracks from the different AGCMS and coupled models will be used to evaluate the impacts of SNAO on different regions (including East Asia). SST influences and the emerging issue of Arctic sea ice influences will also be investigated.

6. Links between LUCID and C20C

The LUCID project aims are to identify and quantify the robust biogeophysical impacts of land-use induced land-cover changes (LULCC) on the historical climate. To that end, a first set of snapshot ensemble simulations were carried out by 7 international modeling groups. The models were forced with 30 years (+ 1 year of spin-up) of observed SST and sea ice (1870-1900) for the pre-industrial era and for the present-day (1972-2002). Results show that the impacts of LULCC can be very large regionally, as large as (sometimes larger than) the impacts of the combined changes in atmospheric CO_2 , SST and sea ice (Pitman et al. 2009). LULCC should be accounted for whenever regional interpretations of past and future changes, and/or detection and attribution studies are carried out (see Section 3 above).

An interesting feature of LUCID results is that the dispersion among the models' responses to LULCC is substantially larger than that of their response to changes in SST and sea ice. This results from the different strategies applied to individual models to incorporate LULCC into their land-cover maps, and because land-surface parameterizations differ from one model to another. Thus it is very challenging to include LULCC in an identical way in model simulations. Two groups of experiments are proposed:

- Using observed SST and sea ice since 1870 as in standard longer C20C simulations;
- Using fully coupled atmosphere-ocean models, building on the CMIP5 experimental protocol.

The first set of C20C-style simulations will be ensembles done in two ways:

- constant land-cover throughout the period, prescribed to its pre-industrial state
- varying land-cover from year to year.

7. Precipitation over the 20th Century

A number of reconstructions of global precipitation for the past century or more have been developed. Most have focused on the satellite era, but some have inferred precipitation back to the beginning of the 20th century. Datasets to be used in the C20C project include modern global precipitation analyses such as the well-known Global Precipitation Climatology Project (GPCP) data set and the Climate Prediction Center Merged Analysis of Precipitation (CMAP) data set. Together with the new 20th Century reconstruction of precipitation (Smith et al. 2010). The spatial resolutions of the datasets are 2.5° latitude/longitude (GPCP and CMAP) and 5° (reconstruction); all offer monthly temporal resolution.

The project will focus on:

- Validation of precipitation simulations in C20C models;
- Improvement of observational datasets; and
- Enhanced understanding of climate variability and change during the 20th century.

Since existing models and observations are relatively limited in skill and accuracy, the effort will focus on large spatial and long time scales. Existing C20C model runs are adequate to create initial results. A critical challenge will be developing a standard set of metrics and protocols.

Particular diagnostics of interest will include:

- The simulated global mean and the long-term mean annual cycle of precipitation over large domains (global, hemispheric, land/ocean, continental) and changes over the century;
- the simulation of precipitation features associated with large-scale modes of climate variability such as ENSO, the NAO, the Pacific Decadal Oscillation/Interdecadal Pacific Oscillation and the AMO.
- the relationship of the features to be evaluated to observed atmospheric and SST variations.

Precipitation anomaly simulations from C20C runs will be compared against reconstructed precipitation anomalies over the full period from 1900-2000 or later. GPCP and CMAP will be used for more detailed examination of the mean annual cycle on a regional basis and for greater spatial detail.

8. Predictability Diagnostics

A novel mathematical diagnostic method to measure predictability that separates different spatial modes of variability, including a separation of the influence of external forcing from internal variability was developed by Zheng et al. (2008). It was first applied to C20C simulations by Zheng et al. (2009). The proposed project aims to apply this methodology in AGCM and coupled models to:

- Validate a climate model's simulation of the variability of tropical SST. Principal component analysis will be applied to the observed SST and simulated SST respectively. The derived EOFs will be compared each other. If they are similar, the corresponding principal components will be further compared each other.

- Validate the general circulation simulated by climate models. Here the seasonal mean is decomposed into components that arise from radiative forcing, from low frequency oscillations of the ocean and atmosphere, and from intraseasonal variability. Although each component cannot be separated a priori, their covariance matrices can be estimated (e.g. Zheng et al. 2009). Singular value decomposition of the covariance matrices of the simulated and observed component fields can be used to assess the validity of the simulation.

- Validate simulated temperature and precipitation. The above decomposition methodology can be applied to the cross-covariance matrices between temperature (or precipitation) and circulation. Then temperature (or precipitation) changes can be associated with the relevant component of the general circulation. Finally, partial least squares regression can be used to study associations between the daily variability of temperature and precipitation and the variability of the dominant circulation patterns of a given component.

9. Statistical Properties of Mid-latitude Atmospheric Variability

Theoretical and observational arguments suggest that the two main features of mid-latitude northern hemispheric winter variability can be almost unambiguously separated. First, synoptic phenomena can be associated with the release of available energy driven by conventional baroclinic conversion. Secondly, at lower frequencies (10-40 days), the planetary scale variability is related to non-linear orographic resonance processes. Moreover, non-linear wave self-interaction theories predict the existence of multiple equilibria of the mid-latitude planetary wave amplitude including switches from unimodal to multimodal regimes of the atmospheric circulation.

Focusing on December-February in the latitudinal belt where the bulk of the baroclinic and low frequency planetary waves are observed, daily averages of 500hPa height provide a one-dimensional longitudinal field representative of atmospheric variability in the mid-latitudes. Its variability can be described using a space-time Fourier decomposition introduced by Hayashi (1979). By computing the cross-spectra and the coherence of the signal, the eastward and westward wave propagating components can be discerned from the standing component.

Acknowledgments

Portions of this report were contributed by C20C participating scientists, including N. Rayner (Hadley Centre, UK; section 2), D. Stone (Univ. of Cape Town, South Africa; section 3), E. Schneider (George Mason Univ., USA; section 4), H. Linderholm (Univ. of Gothenburg, Sweden; section 5), N. de Noblet (Laboratoire des Sciences du Climat et de l'Environnement, France; section 6), P. Arkin (Univ. of Maryland, USA; section 7), X. Zheng (Beijing Normal Univ., section 8), and P. Ruti (ENEA, Italy; section 8).

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ANNOUNCEMENT

Replacement of EOS-80 with the International Thermodynamic Equation of Seawater – 2010 (TEOS-10)

The Intergovernmental Oceanographic Commission (IOC), with the endorsement of the Scientific Committee on Oceanic Research (SCOR) and the International Association for the Physical Sciences of the Oceans (IAPSO), has adopted the International Thermodynamic Equation Of Seawater - 2010 (TEOS-10) as the official description of seawater and ice properties in marine science. All oceanographers are now urged to use the new TEOS-10 algorithms and variables to report their work. The TEOS-10 computer software, the TEOS-10 Manual[1] and other documents may be obtained from www.TEOS-10.org.

A notable difference of TEOS-10 compared with EOS-80 is the adoption of Absolute Salinity to be used in scientific journals to describe the salinity of seawater and to be used as the salinity argument in the TEOS-10 algorithms that give the various thermodynamic properties of seawater. Note, however, that the salinity that is reported to national databases must remain Practical Salinity as determined on the Practical Salinity Scale of 1978. The practice of storing one type of salinity in national databases (Practical Salinity), but using a different type of salinity in publications (Absolute Salinity), is exactly analogous to our present practice with temperature; in situ temperature is stored in databases (since it is the measured quantity), but the temperature variable that is used in publications is a calculated quantity, being potential temperature to date under EOS-80, and from now, Conservative Temperature under TEOS-10.

To avoid confusion while the use of Practical Salinity in scientific publications is phased out, authors and editors are requested to ensure that salinity is specifically identified as being either Practical Salinity with the symbol S_P or Absolute Salinity with the symbol S_A. In addition, the method used to compute the location-dependent relationship between S_P and S_A should be explicitly stated.

The more prominent advantages of TEOS-10 compared with EOS-80 are

- For the first time the influence of the spatially varying composition of seawater is systematically taken into account through the use of Absolute Salinity. In the open ocean, this has a non-trivial effect on the horizontal density gradient, and thereby on the ocean velocities and transports calculated via the "thermal wind" relation.
- The new salinity variable, Absolute Salinity, is measured in SI units (e.g. g kg^{-1}).
- The Gibbs function approach of TEOS-10 allows the calculation of internal energy, entropy, enthalpy, potential enthalpy and the chemical potentials of seawater as well as the freezing temperature, and the latent heats of freezing and of evaporation. These quantities were not available from EOS-80 but are essential for the accurate accounting of "heat" in the ocean and for the consistent and accurate treatment of air-sea and ice-sea heat fluxes in coupled climate models.
- In particular, Conservative Temperature Q accurately represents the "heat content" per unit mass of seawater, and is to be used in place of potential temperature q in oceanography.
- The thermodynamic quantities available from TEOS-10 are totally consistent with each other; this was not the case with EOS-80.

A brief introduction to TEOS-10, "Getting started with TEOS-10 and the Gibbs Seawater (GSW) Oceanographic Toolbox", is available on the TEOS-10 web site (www.TEOS-10.org). This lists all the functions in the GSW computer software toolbox and also illustrates the differences associated with using Absolute Salinity and Conservative Temperature compared with using Practical Salinity and potential temperature.

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Prof. Dr. Wolfgang Fennel, President, Scientific Committee on Oceanic Research
Prof. Eugene G. Morozov, President, International Association for the Physical Sciences of the Oceans

[1]IOC, SCOR and IAPSO, 2010: The international thermodynamic equation of seawater – 2010: Calculation and use of thermodynamic properties. Intergovernmental Oceanographic Commission, Manuals and Guides No. 56, UNESCO (English), 196 pp.

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