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.

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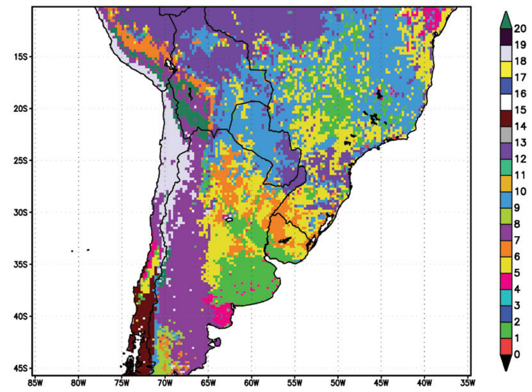

Figure 1: Model domain and land use categories (shaded). The box defines the region where land use was changed. Categories of land use from USGS: 1:Urban; 2: Dryland Crop. Past.; 3: Irrig. Crop. Past.; 4: Mix.Dry/Irrig. Crop. Past.; 5: Crop/Grassland Mosaic.; 6: Crop/Wood Mosaic; 7: Grassland; 8: Shrubland; 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.

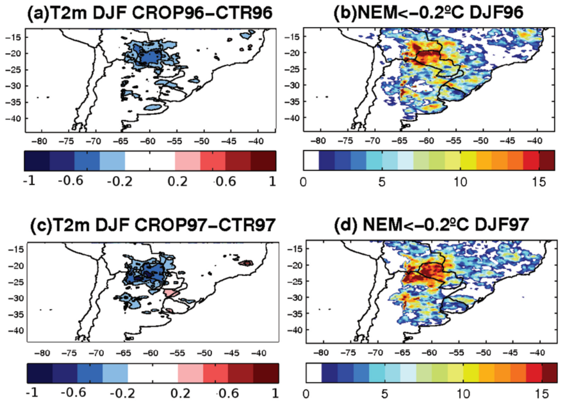

Figure 2: Differences between CROP and CTRL ensembles for T2m (ºC) for (a)DJF 1996-1997 and (c) DJF 1997-1998, (contour each 0.2ºC). NEM index for T2m for (b) DJF 1996-1997 and (d) DJF 1997-1998.

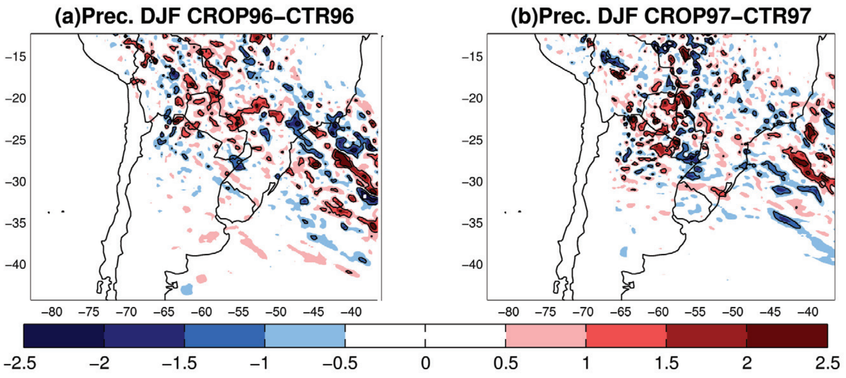

Figure 3: Differences between CROP and CTRL ensembles for precipitation (mm/day) for (a)DJF 1996-1997 and (b) DJF 1997-1998. Contour each 1mm/day.

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