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**CLARIS LPB**
**A Europe-South America Network for Climate Change Assessment and Impact Studies in La Plata Basin**

**DELIVERABLES**

# D5.6: Report on effects of soil moisture and land cover changes on hydroclimate of the region

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| Deliverable No | Deliverable title | WP | Lead beneficiary | Estimated indicative person-months (permanent staff) | Nature | Dissemination level | Delivery date |
|---|---|---|---|---|---|---|---|
| D5.6 | Report on effects of soil moisture and land cover changes on hydroclimate of the region | WP5 | | | R | PU | 30 |

This deliverable presents three independent studies on the effect of soil moisture / land use changes on the hydroclimate of the La Plata Basin. These three studies are summarized below. Publications and presentations at meetings are listed at the end of the document.

## Impact of soil moisture changes on South America low-level circulation and rainfall at subseasonal scales

Celeste Saulo, Juan Ruiz, Lorena Ferreira and Pablo Spennemann

The impact of changes in soil moisture in subtropical Argentina in rainfall distribution and low-level circulation was studied using a state-of-the-art regional model in a downscaling mode, with different scenarios of soil moisture for a 10-day period.
Four tests were conducted at 40-km horizontal resolution with 31 sigma levels, decreasing and increasing the soil moisture initial condition by 50% over the entire domain, and imposing a 50% reduction over northwest Argentina and 50% increase over southeast South America. A control run with NCEP/Global Data Assimilation System (GDAS) initial conditions was used to assess the impact of the different soil moisture configurations.
It was found that land surface interactions are stronger when soil moisture is decreased, with a coherent reduction of precipitation over southern South America. Enhanced northerly winds result from an increase in the zonal gradient of pressure at low levels. In contrast, when soil moisture is increased, smaller circulation changes are found, although there appears to be a local feedback effect between the land and precipitation.
The combined effects of changes in the circulation and in local stratification induced by soil wetness modifications, through variations in evaporation and Convective Available Potential Energy (CAPE), are in agreement with what has been found by other studies, resulting in coherent modifications of precipitation when variations of CAPE and moisture flux convergence mutually reinforce.

## The role of soil moisture gradients on extreme precipitation over Southeastern South America

Claudio Menendez, Anna Sörensson and Romina Ruscica

Soil moisture forces the atmosphere on different spatial and temporal scales and plays an important and complex role in the climate system. Its interaction with precipitation (couplings, positive/negative feedbacks) remains a subject of study connected to the hydrological cycle. The La Plata Basin in Southeastern South America has been identified as a region of strong coupling between soil moisture and evapotranspiration and precipitation during summer (see D5.5). Here, the possible connection between soil moisture horizontal heterogeneity and extreme precipitation over Southeastern South America (SESA, Fig.1), during the development of the South American Monsoon System 1992-93 is examined.

The Rossby Centre Atmospheric regional model RCA3-E was employed. The model domain covers the South American continent, and is based on a rotated grid system with a horizontal resolution of 0.5º and 24 unevenly spaced sigma levels in the vertical with the five lowest levels below 900 hPa. All initial and boundary conditions are from ECMWF Re-Analysis. An ensemble of ten four-months continuous simulations was created, starting from different initial dates. Each member extends from November 1 1992 to February 31 1993 (neutral ENSO conditions). The analysis is focused on the SESA region during

DJF, region and period in which RCA3-E has a good performance in the mean precipitation (Fig.1), as well as strong coupling strength

At each grid point the extreme precipitation events were defined as the percentile 95 of the ensemble daily precipitation, and the days in which rainfall equals or exceed the percentile 95 is called "day 0". A composite of the precipitation is calculated for day 0. Time-lag composite fields of the absolute value of the top soil moisture horizontal gradient for previous days (day -1) are computed. The relative anomalies (defined as the difference between the composite and the mean value, divided by the mean ensemble value) of precipitation for "day 0" and of soil moisture gradient for "day -1" are shown in Fig.2 and 3 respectively.

Over the region, rainfall extremes are associated with intense convective storms. We speculate that the surface soil moisture heterogeneities would favor the development of heavy precipitation events. In our experiment we find that, on the day before the extreme precipitation event, the spatial heterogeneity of soil moisture tends to be enhanced relative to that in the mean field ensemble. This is shown in Fig.3 where there are mostly positive relative anomalies of soil moisture gradient, with large surface contrasts on day -1 over parts of eastern Argentina, southern Brazil, Uruguay, and along the coasts (blue dots, values close to unity indicating that the horizontal contrast doubles the mean value). In general, these maxima are located in regions where precipitation anomalies are high (greater than 10 times the mean, Fig.2). As expected, the relative anomalies of soil moisture gradient in the "day 0" are mostly negative, because the heavy rainfalls tend to homogenize the soil moisture field.

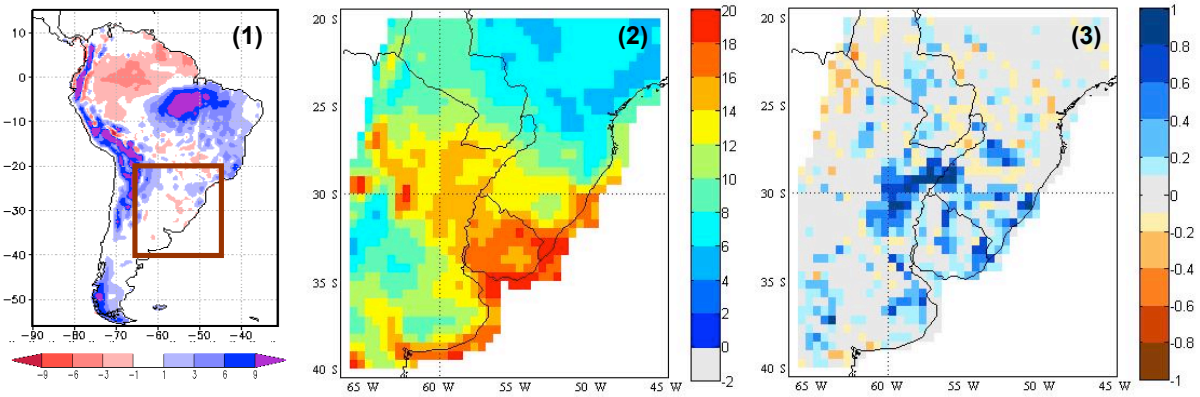



Fig (1): Mean Precipitation Bias (RCA3-E minus CRU) in DJF 1980-99 (mm/day) and studied SESA region inside box. Fig (2): Relative anomalies of precipitation, "day 0". Fig (3): Relative anomalies of absolute value of top soil moisture horizontal gradient, "day -1". Ocean and altitudes higher than 1200 m are masked.

## Impacts of land use changes in southern South America climate for extreme climatic periods

Natalia Pessacg and Silvina Solman

This study examines the effects of land use/land cover changes (LULCC) over the climate in two important agricultural regions over southern South America, La Plata Basin and the Argentinean Pampas. In the last decade these regions have been suffered a replacement of the natural cover, mainly by the

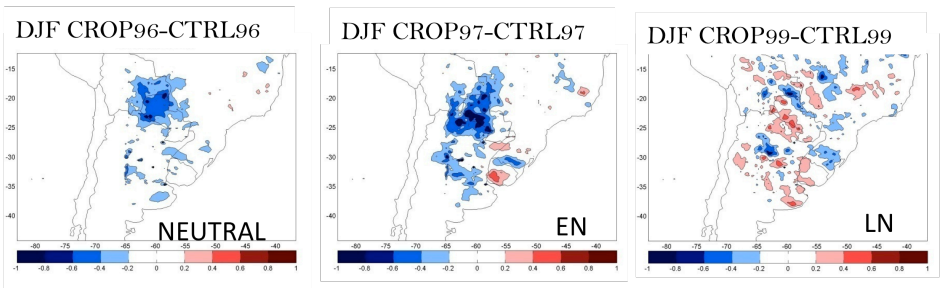
expansion of the agricultural activity, associated with an increase in the soy production. In this context and with the objective of analyze the impacts of LULCC in the southern South America climate, a series of sensitivity experiment were performed with the MM5 regional model, in which the natural cover was replaced by crop (CROP experiments) during different years related with extreme phases of the El Niño-Southern Oscillation (ENSO).

The experiments were analyzed for the austral summer during three particular periods 1996-1997, 1997-1998 and 1999-2000, a non-ENSO year and extremes El Niño (EN) and La Niña (LN) years, respectively.

Experiments showed a decrease of temperature, smaller than 1°C, when crop replaces the natural cover during the summer of the neutral and EN years over the north of Argentina and Paraguay (Fig.4). Though this value is close to the internal variability the signal is consistent for every pair of the ensemble members. For LN year the impacts of LULCC is quite different with regions of warming and cooling over the north and central Argentina, Paraguay and part of Bolivia.

Over the region where the main changes in 2meter temperature were localized (Fig.4), there is a shift from savanna and cropland/woodland mosaic to dryland crop. This shift leads to a decrease of albedo and an increase of emissivity, both driving to a decrease in the total radiation energy budget at surface, which, in turn, leads to an increase of the latent heat flux and a decrease of the sensible heat flux, consequently, decreasing the Bowen ratio. Both mechanisms can explain the cooling in the CROP scenario with respect to the control scenario during the neutral and EN years. 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 drives 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, being the magnitude of these changes smaller than the internal variability of the system, though statistically consistent.

Besides that, simulations allow us to determine the effect over the regional climate of the local and remote forcing together, and show that the interannual variability is important when assessing the strength of the impact. The cooling due to LULCC signal during El Niño year over north Argentina and Paraguay tends to weaken the strength of the interannual variability during the austral spring, which is characterized by a warm anomaly over this area. During summer, El Niño signal over the north of Argentina and Paraguay play in the same way as the LULCC signal, cooling the atmosphere near to the surface. Over the central and east of Argentina and Uruguay the interannual variability during summer presents a cold anomaly and the LULCC signal tend to enhance this effect and during La Niña there is a warming that is enhanced by the LULCC signal.




*Differences in T2m between CROP and CTR simulation for summer for a neutral year and for El Niño ( and La Niña year*

Fig. 4

## Publications:

Pessacg Natalia and Silvina Solman: Impacts of land use changes over southern South American climate: a modeling study using the MM5 regional model. Submitted to CLIVAR Exchanges

Pessacg Natalia and Silvina Solman, 2011: Impacts of land use/land cover change in southern South America climate. Submitted.

Ruscica R.C., A.A. Sörensson, C.G. Menéndez, 2011: Investigating the role of soil moisture gradients on extreme precipitation over Southeastern South America. 2011 WGNE Blue Book "Research Activities in Atmospheric and Oceanic Modelling" (A. Zadra, Editor), WGNE/WCRP-WMO, http://collaboration.cmc.ec.gc.ca/science/wgne/.

Saulo, Celeste, Lorena Ferreira, Julia Nogués-Paegle, Marcelo Seluchi, Juan Ruiz, 2010: Land–Atmosphere Interactions during a Northwestern Argentina Low Event. Mon. Wea. Rev., 138, 2481-2498. doi: 10.1175/2010MWR3227.1

## Presentations at meetings:

Ferreira, L, C. Saulo y J. Ruiz, 2010. Land-atmosphere interactions during a Northwestern Argentina Low event: impacts on precipitation fields. Third International Conference on Quantitative Precipitation Estimation (QPE) and Quantitative Precipitation Forecasting (QPF) and Hydrology. 18-22 Octubre 2010, Nanjing, China, 5 pp.

Menéndez C., A. Carril, A. Sörensson, R. Ruscica, P. Zaninelli, 2011: On the simulation of regional climate in South America with emphasis on extremes and surface processes, 2nd Meeting of IFAECI (UMI 3351), Buenos Aires, 25-27 April 2011.

Pessacg Natalia and Silvina Solman, 2010: Impact of land use change over southern South America climate.The Meeting of the Americas, Foz do Iguazu, 08-12 August 2010. Abstract