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Effects of Land Use Change on the Regional Climate of Paraguay

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Changes in land-cover and vegetation traits are capable of affecting the exchanges processes of momentum, heat, and moisture between the atmosphere and the underlying surface influencing climate over different ranges of spatial and temporal scales[1]. These effects directly affect the patterns of precipitation, temperature and air circulation processes, which can have significant consequences at local/regional scales[2)3)]. Regional effects of land-cover change, especially those related to deforestation, may be associated with reductions of evapotranspiration and moisture fluxes and, consequently, on precipitation by altering its intensity and spatial patterns. This study has the main objective of assessing the impacts of the actual land cover changes, produced in Paraguay between the years 1990 and 2000, on the climate of the country.

The methodology used in this study is based on the analysis of model simulations performed with the meso-scale numerical weather prediction model CReSiBUC[4)] which is capable of linking surface and atmosphere processes. The model was integrated over a domain centered at 23.5°S and 58.0°W. The horizontal grid consists of 240x144 with a grid spacing of 20km, while the vertical is composed of 50 levels and a grid resolution of 500m (Table 1). The experiment covered a 1-month period for two contrasting conditions, wet (November) and dry (July) from the year 2006 to 2012. The JRA (Japanese Re-Analysis) dataset from the Japanese Meteorological Agency (JMA) is used as the atmospheric boundary condition. Sea Surface Temperature from the NASA's Physical Oceanography Distributed Active Archive Center (PO.DAAC) of daily output and 0.05-degree resolution were used.

In order to isolate the effects of land-use change, two sets of simulations, called Present and Past respectively, were conducted for November and July 2006-2012. Each of these two sets used different vegetation scenarios and NDVI data, as it is detailed in Table 1. The land-use scenarios for the 1990s and 2000s were obtained by combining USGS' Global Land Cover Characterization data with the Paraguay Forest Change product (GLCF)[5)], and were aimed to represent actual land-use changes occurred in the period 1990-2000 in which all the deforested area were assumed to be transformed into farmlands.

Results are presented as the difference of the average of all years between the Present and Past sets of simulations for both wet and dry conditions.

Table 1. Simulation settings for each experiment

	November (wet)		**July (dry)**	
Simulation set	**Present**	**Past**	**Present**	**Past**
No. of Points *(xdim,ydim,zdi*	(240, 144, 50)		(240, 144, 50)	
Horizontal Res. *(m) (xres,yres)*	(20000, 20000)		(20000, 20000)	
Center *(lat, lon)*	(-23.5, -58.0)		(-23.5, -58.0)	
Atmospheric conditions	JRA (2006-2012)		JRA (2006-2012)	
Land use	2000	1990	2000	1990
NDVI	AVHRR (avg. 1991-2000)	AVHRR (avg. 1981-1990)	AVHRR (avg. 1991-2000)	AVHRR (avg. 1981-1990)

Land-cover change in Paraguay had somehow different impacts depending on the location or region where it was produced, the type of vegetation that was changed, and the season of the year that was considered. Simulations for November show that for Eastern Paraguay, where forest was shifted to farmland, the impacts included higher albedo, which can be correlated to the decrease observed in NDVI, that lead to a diminution of the latent heat and to an increment of the sensible heat flux (Figure 1a); higher root zone soil wetness, and lower temperature range. For Western Paraguay however, the impacts, in the area where grassland was changed to farmland, correspond to a reduction of the latent heat and thus an increment on the sensible heat fluxes (Figure 1b), higher surface soil wetness and root soil wetness. These changes in the energy balance could have driven changes in the pressure fields that in turn altered the magnitude and direction of wind, producing the changes in the precipitation patterns observed in Figure 2, which shows a displacement of the precipitation nucleus in Eastern Paraguay to the southeast direction, as well as modifications in the distribution of rainfall in the western part of the country.

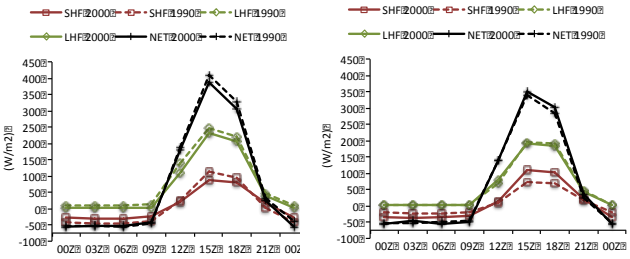

Figure 1. Averaged November Diurnal cycle of surface energy balance for a) Eastern Paraguay and b) Western Paraguay.

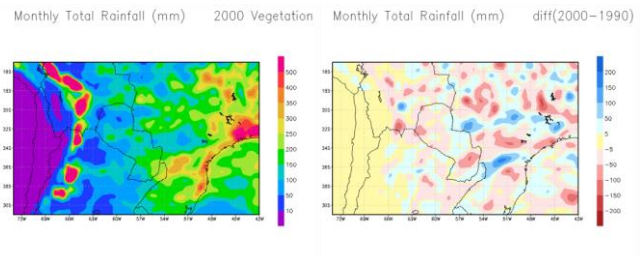

Figure 2. Simulated November rainfall, averaged over 2006-2012 for a) Present scenario, and b) the difference between Present and Past.

The effects of land-use change seem to be weaker under dry conditions (July) when they are compared to their counterparts of wet conditions. The mean diurnal cycle of the surface energy budget shows that the net radiation is smaller in Eastern and Western Paraguay, as well as the difference between the epochs 2000 and 1990, with the highest variance observed in the eastern part. However, the direction of the impacts in Western Paraguay is opposite to that observed under wet conditions. Impacts on rainfall are mostly observed in the east/east-south boundary of the country, a region known for its high levels of humidity during summer and drier settings over the austral winter. In contrast, Western Paraguay presented no identifiable impacts.

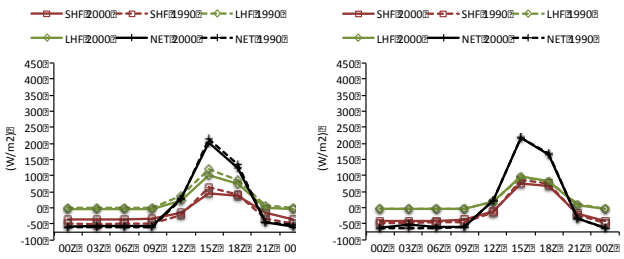

Figure 3. Averaged July Diurnal cycle of surface energy balance for a) Eastern Paraguay and b) Western Paraguay.

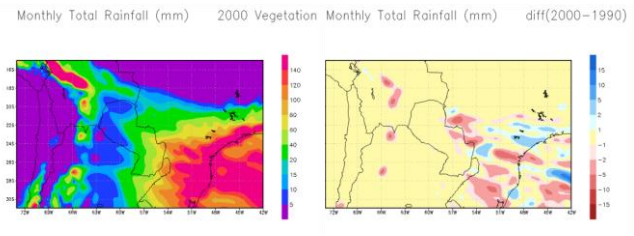

Figure 4. Simulated July rainfall, averaged over 2006-2012 for a) Present scenario, and b) the difference between Present and Past.

References

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