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# PERFORMANCE OF GCMs AND CLIMATE FUTURE SCENARIOS FOR SOUTHEASTERN SOUTH AMERICA

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## 1. INTRODUCTION

There are not many studies concerning model evaluation and climate scenarios in South America and more specifically in Southeastern South America (Nuñez 1990, Hoftadter 1997, Carril et al 1997, Bidegain 2005). All these studies are experiments comparing sea level pressure, surface air temperature and precipitation from the models against observed climate fields, trying to estimate regional performance of the control simulations (baseline climate scenarios). We assume that the models that better simulate the current regional climate in their control experiments are likely to be more reliable in their simulations of regional climate under changes of greenhouse gases concentrations. The present study is a component of two regional projects of Assessments of Impacts and Adaptations to Climate Change (AIACC), funded by GEF (Global Environmental Facility) in South America (LA32 and LA26), and describes the results of an intercomparison experiment in a region of Southeastern South America defined by the latitudes 20°S to 40°S and the longitudes 45W° to 65°W (see figure 1), for six different GCMs. In order to evaluate the differences between the observed climate (sea-level pressure, temperature and precipitation) and the climate simulations, we selected six available runs using the IPCC SRES-A2 socioeconomic forcing scenarios. These runs are available in the Modelle and Daten (MOD) web page of IPCC.

The sea level pressure observed data considered for the evaluation of the GCMs outputs are the monthly averaged gridded reanalysis from the NCEP-NCAR (Kalnay et al. 1996). The monthly rainfall and temperature series were taken from a data set assembled by Willmott and Matsura (2001) from University of Delaware.

| Model | Institution |
|---|---|
| HadCM3 | Hadley Centre for Climate Prediction and Research |
| CSIRO-mk2 | Australia's Commonwealth Scientific and Industrial Research Organization |
| ECHAM4/OPYC3 | Max Planck Institute für Meteorologie |
| GFDL-R30 | Geophysical Fluid Dynamics Laboratory |
| NCAR-PCM | National Centre for Atmospheric Research |
| CGCM2 | Canadian Center for Climate Modelling and Analysis |

Table 1. GCMs considered in the performance experiment over Southeasten Southamerica

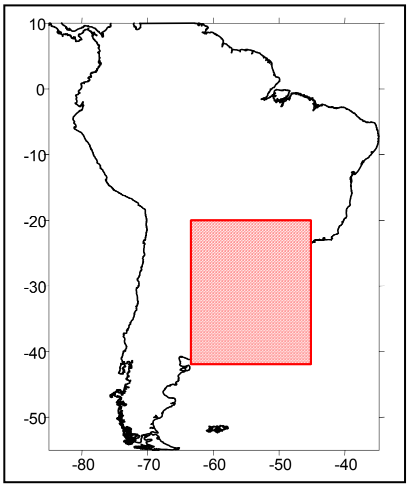


Figure 1 Domain of the GCMs intercomparison experiment

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## 2. INTERCOMPARISON EXPERIMENT

### 2.1 Sea level pressure.

The comparison between the monthly and annual SLP fields shows that only four models: HADCM3, CSIRO-mk2, ECHAM4 and GFDL-R30, have an acceptable agreement with the observed SLP field and are able to represent the position and intensity of the pressure systems and the annual cycle.

This agreement is a little poor in the austral winter months (July to September) and show good correlation with observed values during the austral summer (December to March).

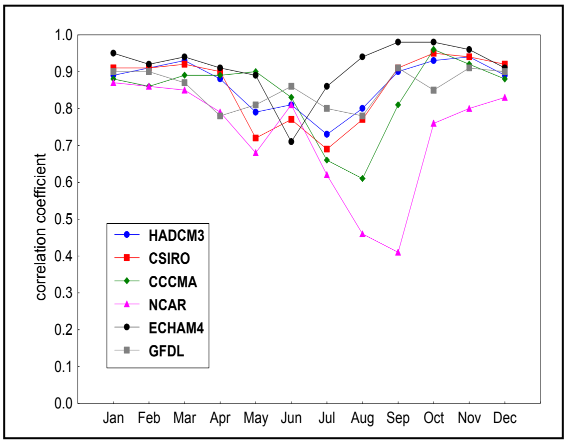


Figure 2. Monthly spatial correlation coefficients between SLP GCMs data and the NCEP reanalysis.

### 2.2 Precipitation.

Differences between the annual mean precipitation fields, over the South American region defined by the latitudes 20°S to 47°S and the longitudes 45W° to 67°W, were computed between each GCM data and the University of Delaware database. Was selected the period 1961-1999 in the case of HADCM3, GFDL-R30, CSIRO-mk2, and 1990-1999 for ECHAM4. Comparison was performed for the four models with best agreement in the SLP fields: HADCM3, ECHAM4/OPYC3, CSIRO-mk2 and GFDL-R30. In all cases, precipitation is largely underestimated in the Río de la Plata basin. (See figure 3).

In general the results are improved from prior studies over the same region Carril (1997), Hoftadter (1997). The annual precipitation rate field calculated with the HADCM3 is adequate with maximum and minimum well located but underestimated amounts in the entire region. The results obtained with the CSIRO-mk2 and GFDL-R30 models are not quite good, as the models does not reflect the observed maximum in northeastern Argentina and southern Brazil, and also precipitation rate values are strongly underestimated.

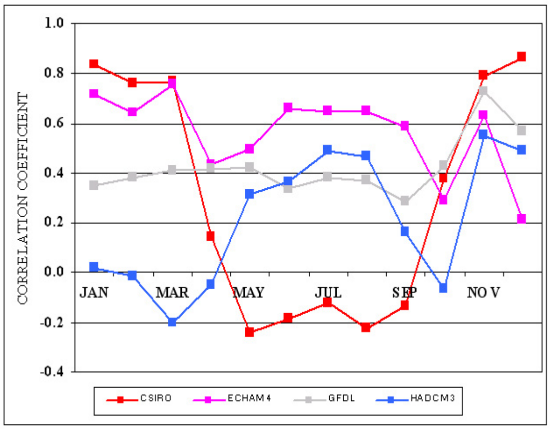


Figure 3. Monthly spatial correlation coefficients between precipitation from GCMs data and the Univ. of Delaware database.

Results show that most models (the only exception is the ECHAM4/OPYC3 model) have a poor correlation. In the case of CSIRO model show a very poor correlation during the cold austral season months (May to September) and high correlation values during the warm austral season (October to March). In the opposite case is the HADCM3 because show a best correlation during the austral winter months.

### 2.3 Temperature.

Differences between the annual mean surface temperature over the South American study region, were computed between four GCMs data and the University of Delaware reanalysis for the different periods available. Surface temperature was selected as indicator of the observed surface energy balance and used to evaluate the goodness of each GCM to reproduce these features. The comparison over region between the annual surface temperature and University of Delaware climatology shows that only HADCM3 have an acceptable agreement with the observed fields (see figure 4). The ECHAM4 model have a strong dipole over Argentina from overestimation in the east (+6°C) to underestimation in the west (-8°C). The CSIRO-mk2 model tend to underestimate (from +0 to -4°C) surface temperature in the region, especially over Chaco (western Paraguay and southern Bolivia). The GFDL-R30 model has a systematic underestimation over the whole region and have a coincidence with CSIRO model in the Chaco region but with more intense underestimation.

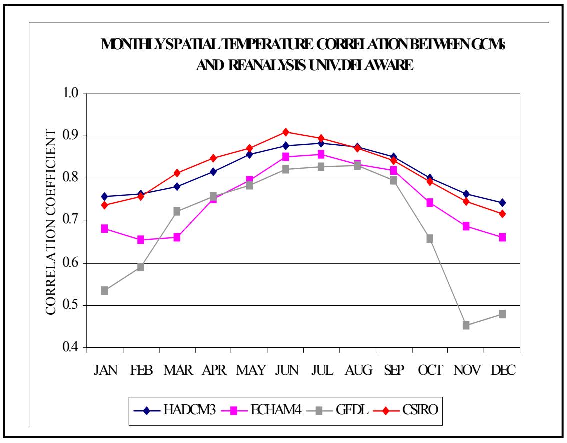


Figure 4. Monthly spatial correlation coefficients between temperature from GCMs and the Univ. of Delaware database.

## 3. FUTURE CLIMATE SCENARIOS FOR SOUTHEASTERN SOUTH AMERICA.

Future changes in mean temperature (°C) and precipitation (%), over region, respect to period 1961-1990, were assessed in this study based upon four GCMs: HADCM3, ECHAM4, CSIROmk2 and GFDL R30. The models were run with the IPCC A2 and B2 SRES socioeconomic scenarios. Were used the maximum common spatial resolution of four models: 2.8° of latitude and 3.75° of longitude.

### 3.1 Future temperature scenarios

Annual temperature across the region may rise by 2020s +0.2 to 1.0°C and 1.0°C to 2.0°C by the 2050s according to GCMs composition, for the high emissions scenario (A2) (see figure 5). For the low emissions scenario (B2) may by rise +0.2 to 0.9°C by 2020s and 1.0°C to 1.6°C by the 2050s (see figure 6) according to GCMs composition.

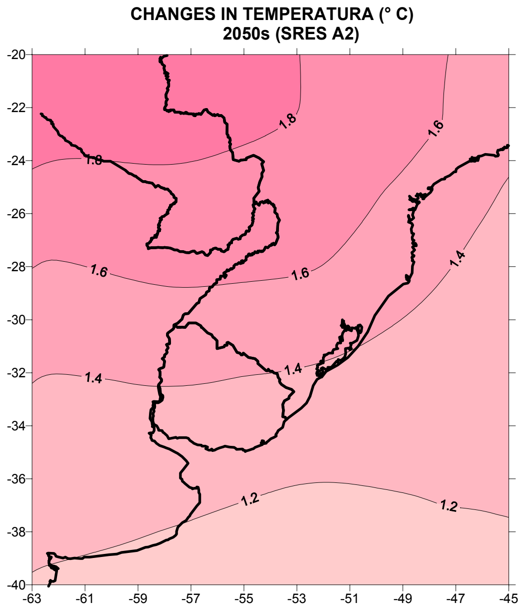


Figure 5. Future annual temperature change (°C) from the GCMs for 2050s (SRES A2).

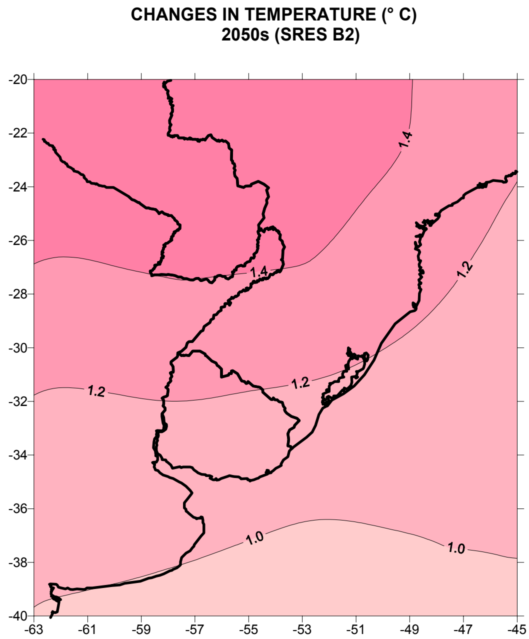


Figure 6. Future temperature change from the GCMs for 2050s (SRES B2).

### 3.2 Future precipitation scenarios

Changes in annual precipitation across the region may vary between +0% to 4% by 2020s and +0% to +6% by the 2050s according to GCMs composition, for the high emissions scenario (A2) (see figure 7). In the case of the low emissions scenario (B2) may vary between 0% to 2% by 2020s and 0% to 5% by the 2050s (see figure 8) according to GCMs composition.

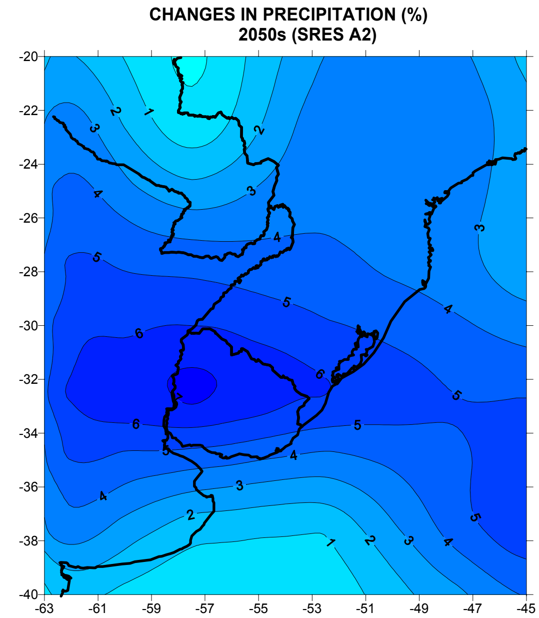


Figure 7. Future precipitation changes from the GCMs composition for 2050s (SRES A2).

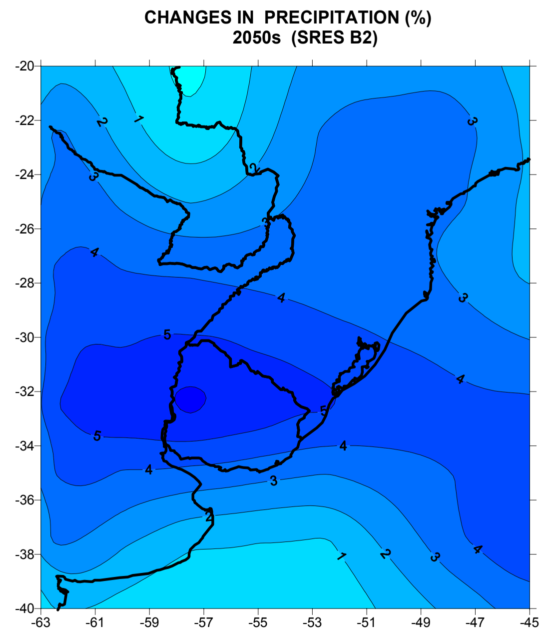


Figure 8. Future precipitation changes from the GCMs composition for 2050s (SRES B2).

## 4. CONCLUSIONS

The models have common errors in reproducing the precipitation field over Southeastern South America. They underestimate the precipitation rate over eastern Argentina, Uruguay and southern Brazil, simulating a precipitation field that is about 50% or less of the observed one**.** The best-simulated field is produced by the Hadley Centre Model Version 3 (HADCM3) which in the area simulates an annual rainfall only 75% of the observed. Other common feature of the four models is that they overestimate precipitation in northwestern Argentina and southern Bolivia.

It is likely that SSA will warm slightly less rapidly in the future than the global average temperature. However, the north of the region will warm considerably more rapidly than the south. For example, in the A2-high scenario the southern region warms at a rate of about 0.3º/decade, whereas the north of region warms at the rate of about 0.4ºC/decade.

The southern states of Brazil, northeastern Argentina and Uruguay become wetter in the future, and the area of maximum wetting is the southern state of Rio Grande and Uruguay (about 7 per cent wetter for 2050s). The lower Rio de la Plata River Basin will experiences increased annual precipitation.

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