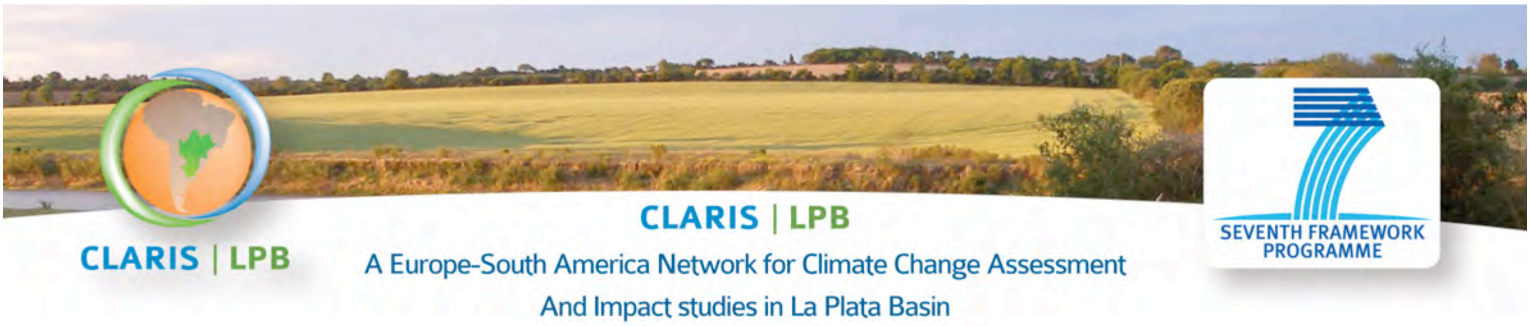

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Deliverables

Instrument: **SP1 Cooperation**

Thematic Priority: **Priority Area 1.1.6.3 "Global Change and Ecosystems"**

FP7 Collaborative Project – Grant Agreement 212492

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

DELIVERABLES

D4.4: Inter comparison reports/papers on multi-model (IPCC) skills in simulating important characteristics of past decadal variability of the LPB hydroclimate (such as for example the 1940 or 1970 climate shifts) and teleconnections to main modes of variability

Due date of deliverable: Month 21

Start date of project: **01/10/2008** Duration: 4 **years**

Organisation name of lead contractor for this deliverable: P1-IRD

Deliverable No	Deliverable title	WP	Lead beneficiary	Estimated indicative person-months (permanent staff)	Nature	Dissemination level	Delivery date
D4.4	Inter comparison reports/papers on multi-model (IPCC) skills in simulating important characteristics of past decadal variability of the LPB hydroclimate (such as for example the 1940 or 1970 climate shifts) and teleconnections to main modes of variability.	4	PI-IRD	27.1	R	PU	21

Publications

Authors: Bombardi, R. and L. M. V. Carvalho, 2010
Institutions: Universidade de Sao Paulo, University of California Santa Barbara
Title: The South Atlantic dipole and variations in the characteristics of the South American Monsoon in the WCRP-CMIP3 multimodel simulations.
Journal: *Climate Dynamics* (DOI 10.1007/s00382-010-0836-9)

Authors: Bombardi, R. and L. M. V. Carvalho, 2009
Institutions: Universidade de Sao Paulo, University of California Santa Barbara
Title: IPCC Global coupled climate model simulations of the South America Monsoon System.
Journal: *Climate Dynamics,* 33, 893-916

Authors: Grimm, A. M., 2010
Institutions: Universidade Federal do Paraná
Title: Interannual climate variability in South America: impacts on seasonal precipitation, extreme events and possible effects of climate change.
Journal: *Stochastic Environmental Research and Risk Assessment*

Authors: Grimm, A. M. and T. Ambrizzi, 2009
Institutions: Universidade Federal do Paraná, Universidad de San Pablo
Title: Teleconnections into South America from the Tropics and Extratropics on Interannual and Intraseasonal Timescales.
Journal: *Past Climate Variability in South America and Surrounding Regions: From the Last Glacial Maximum to the Holocene*. Vimeux, F., F. Sylvestre, and M. Khodri, Eds., Springer Chapter 7, pp 159-193.

Authors: Vera C., and G. Silvestri, 2009
Institutions: Centro de Investigaciones del Mar y la Atmosfera/CONICET-UBA (CIMA), and DCAO/FCEyN, Universidad de Buenos Aires, Buenos Aires, Argentina.
Work Package: WP4
Title: Precipitation interannual variability in South America from the WCRP-CMIP3 multi-model dataset.
Journal: *Climate Dynamics, doi: 10.1007/s00382-009-0534-7*.

Summary of work

Precipitation Year-To-Year Variability over Southeastern South America in the Context of Climate Change

Clementine Junquas[123], C. S. Vera[1], H. Letreut[3], L. Li[3]
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[2]Ecole Polytechnique, France
[3]Institute Pierre Simon Laplace (IPSL)/LMD, Paris, France.

Previous studies have shown that precipitation variability at both tropical and subtropical regions of South America exhibits considerably level of co-variability at a wide range of timescales ranging from synoptic, intraseasonal, interannual to decadal. Positive precipitation anomalies over the subtropical plains of La Plata Basin (LPB) region tend to occur in association with negative anomalies over the South Atlantic Convergence Zone (SACZ) region and vice versa. In addition, long-term future climate simulations project, overall, positive trends in summer precipitation over LPB. The objective of this work is to assess the ability of the WCRP-CMIP3 models (developed for the IPCC-AR4) in representing such leading patterns of year-to-year variability in precipitation over South America and to explore changes of those patterns in the context of a climate change induced by GHG increase. In particular, the work focuses in exploring how much of those changes account for the trends projected for the LPB mean summer precipitation.

Austral summer rainfall mean and variability conditions in South America has been diagnosed for 18 coupled general circulation models (CGCMs) from the WCRP/CMIP3 dataset, for both present climate and SRESA1B climate change scenario simulations.

The leading patterns of precipitation year-to-year variability were identified by an EOF analysis applied to austral summer rainfall anomalies of CMAP dataset for the period 1979-1999. The leading pattern (EOF1) is characterized by a dipole-like structure with centers of action of opposite sign over the LPB and the SACZ regions, respectively (Figure 1). Model assessment shows that most of the models are able to represent the EOF1 dipole structure (Figure 2). However, overall, models tend to locate the SACZ-related center further northeastward than observed.

EOF1 was also identified for the climate change scenario over the period 2001-2100 and the corresponding EOF1 time series was used to determine wet and dry active events in southeastern South America. It was found that an increase of the frequency of EOF1 positive events, which means an increase (decrease) of the frequency of wet events in LPB (SACZ) region, is in average projected for the second half of the XXI century by the multi-model ensemble. Such projected change is significantly larger than the inter-model variability for a subset of 9 models that also project positive precipitation trends in the mean summer precipitation conditions in the LPB.

Wet events in the LPB associated to EOF1 activity seems to be promoted in present climate by a differential warming of the equatorial Pacific surface oceanic conditions compared to that in the Atlantic

Ocean. The analysis of the projections resulted from the multi-model ensemble show that such conditions seem to intensify in the context of climate change.

It is then concluded that the positive trend of austral summer precipitation in LPB projected for the end of the XXI century by most of the CGCMs, and already discussed in previous publications like the IPCC-AR4, seems to be associated with an increase in the frequency of events associated with the leading pattern of year-to-year variability.

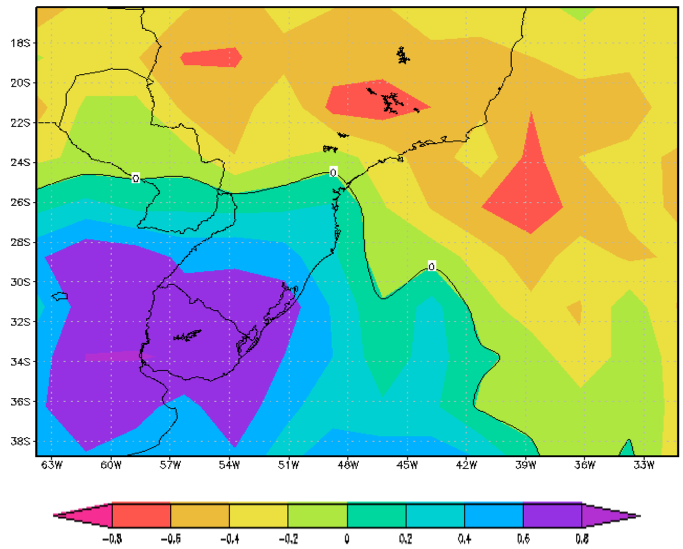


Figure 1 - Leading patterns of year-to-year variability of DJF precipitation anomalies obtained from CMAP dataset for the period 1979-1999.

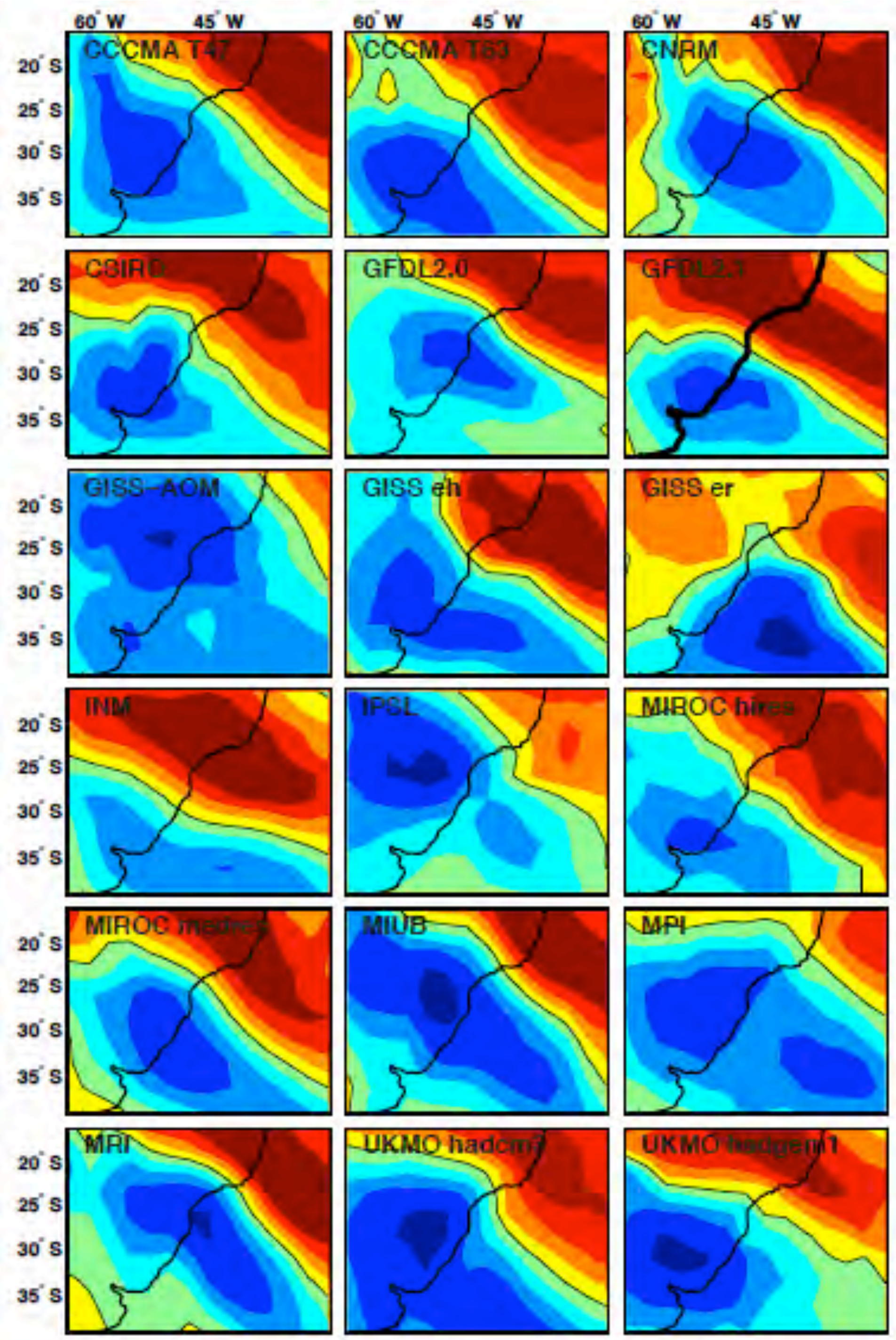


Figure 2 - Leading pattern (EOF1) of DJF rainfall anomaly variability obtained from the SRESA1B simulations of 18 WCRP-CMIP3 models for the period 2001-2099.

Performance of models on interannual and inter-decadal time scales

Alice Marlene Grimm and João Paulo J. Saboia
Universidad Federal do Parana, Brasil.

We evaluated the performance of models in reproducing the climatology and the most important aspects of the interannual and interdecadal variability of precipitation. In the interannual time scales, we focused on ENSO-related variability, which is the most significant in the La Plata Basin. In the interdecadal time scales, we focused on the 20^{th} century decadal/interdecadal variability of the SAMS-related precipitation, although we also extended the analysis to other seasons.

i) Models skill in simulating the South American climatology and interannual variability

A first assessment of the performance of some models regarding precipitation over South America was done by looking at the way they reproduced the precipitation climatology for different seasons. On the average, the best performance of the IPCC AR-4 models in the La Plata Basin was shown by ECHAM5-OM (Grimm 2010). The observed and simulated annual cycles of precipitation in Fig. 3 show that the model has a reasonably good performance over the La Plata basin. The main discrepancies occur in the northern part of the continent. For instance, in northwestern Brazil the model shows a bimodal regime, while the observed annual cycles display only one peak in the austral autumn. In view of the good performance in simulating precipitation climatology in the LPB, further studies of the models' ability in reproducing ENSO-related variability used the output of ECHAM5-OM.

First, the ability of the model in reproducing the interannual variability of precipitation over South America during the monsoon season was reviewed. The first mode of spring produced by the model is associated with ENSO, as in the observations, and reproduces the observed north-south dipole, but the northern center is shifted northwestward, and does not show the observed components over central-east South America. The components of this simulated first spring mode over southeastern South America (SESA) are weaker than the observed ones, indicating that the model represents a weaker impact of ENSO than the observed in SESA. The first mode of summer in the model, also associated with ENSO, corresponds to the second observed mode. There is no indication that the first modes of spring and summer tend to have an inverse relationship as that in the observed modes (Grimm and Zilli 2009). This might be ascribed to the poor simulation of the variability in central-east South America in spring.

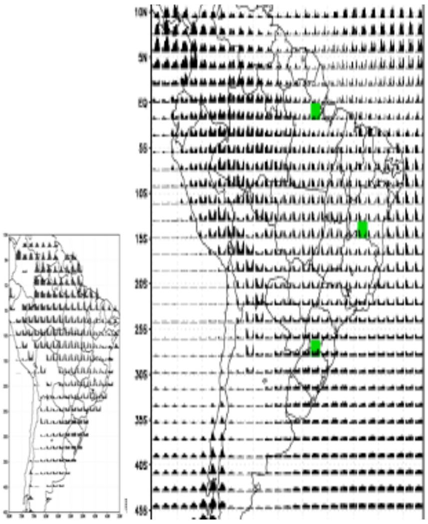


Figure 3 - Annual cycles of precipitation in areas of 2.5° x 2.5° latitude–longitude, calculated with (left) at least 25 years of observed data for the period 1950–2005 (Grimm, 2010), and (right) with the precipitation output of ECHAM5-OM.

Further studies on the model representation of the ENSO direct impact on South America precipitation were carried out, and the underestimation of this impact on SESA was again confirmed by other methods. For this analysis, the ENSO mode and ENSO events were determined for the model ECHAM5-OM, which shows a well-defined ENSO mode. Figure 4 shows the observed expected precipitation percentiles during November (0) of La Niña events (left) and the expected percentiles calculated from the model simulation for the same period (1960-2000). The dryness expected in SESA is clearly underestimated in the model. Similar underestimation occurs for the wet conditions expected during November (0) of El Niño events. This might be ascribed to deficient teleconnections.

Figure 4 - Expected precipitation percentiles during November (0) of La Niña events from (left) observations, and (right) ECHAM5-OM simulation for the same period (1960-2000).

ii) Models skill in simulating the South American interdecadal variability

This is a joint work of UFPR (Alice M. Grimm and João Paulo J. Saboia) with IRD (Myriam Khodri). The analyzed model is the LMDz atmospheric model, with resolution 2.5° X 3.75°, and 19 vertical levels, forced by HadISST sea surface temperatures. The analysis was carried out with the ensemble mean of 10 members (1951-2005). The climatology was also analyzed with a higher resolution run.

The model output was submitted to the same analysis applied to the observed precipitation data, described above. Some analysis was also performed on the observed (Reanalysis) and simulated circulation fields associated with the modes of interdecadal precipitation variability.

The model reproduces well the precipitation climatology for all seasons. The simulation is even better with higher resolution (zoom on South America), especially over the La Plata Basin in austral autumn, winter and spring (Fig. 5).

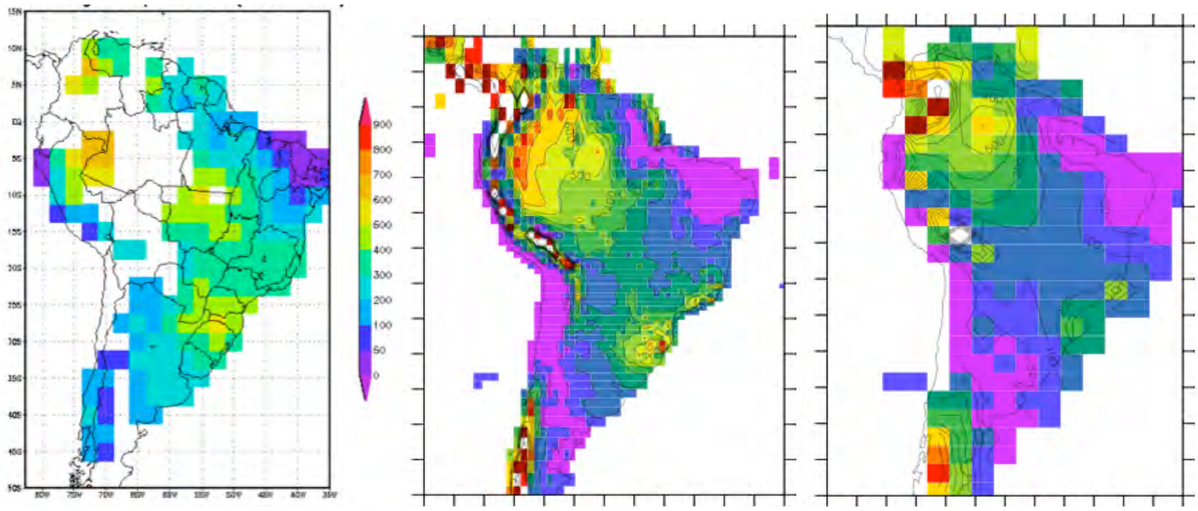


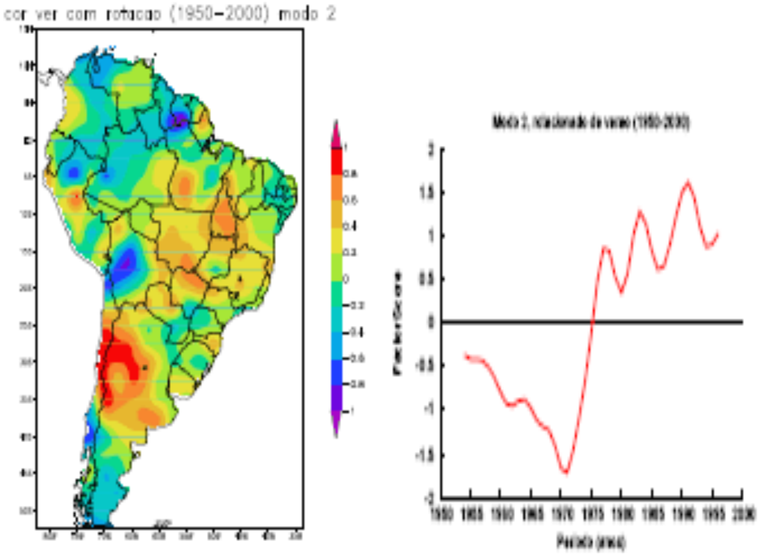
Figure 5 - Spring precipitation climatology (left) observed; (middle) LMDz atmospheric model with zoom over South America, and (right) LMDz atmospheric model without zoom.

The model shows modes of variability that account for the interdecadal variability in several regions, for instance the Laguna Mar Chiquita basin in Argentina, although not all the features in the model modes correspond to the features in the corresponding observed modes. The best correspondence between the model and the observed variability happens in the first spring mode. The mid 1970's climatic shift corresponds to a change of phase in the interdecadal variability both observed and simulated. For instance, the second observed summer mode (Fig. 6a) and the corresponding first summer mode obtained from the model (Fig. 6b) both show a change of phase in the mid 1970's, with strong components in the Laguna Mar Chiquita basin, although there are differences in the components of this mode over other regions.

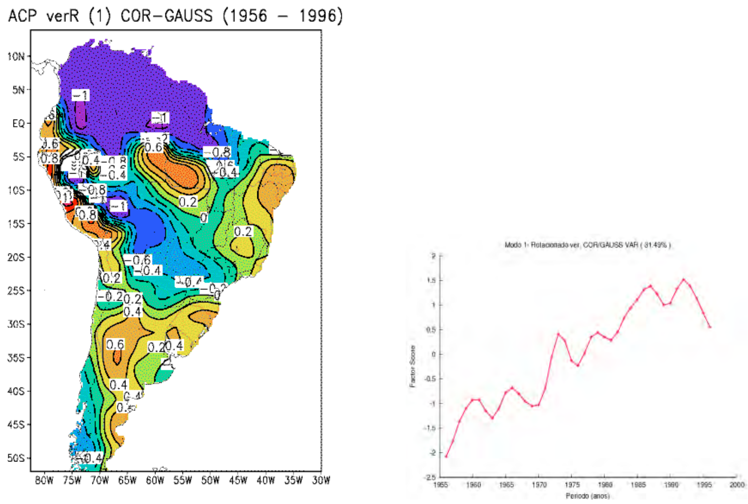
There is generally good correspondence between the SST anomalies associated with the observed and the corresponding model modes of variability. However, as not all the features in the model and observed modes are the same, it is not expected that the circulation anomalies are the same.

In summary, the model is able to simulate important characteristics of past decadal variability of the LPB hydroclimate (such as the mid 1970's climate shift) and teleconnections to important modes of SST variability. However, there are important features that are not simulated, such as the tendency to opposite anomalies in spring and summer in central-east South America, produced by local surface atmosphere interactions. This produces a first mode of summer variability with very different temporal evolution than the observed one.

A paper on the model performance in reproducing the observed interdecadal variability will be prepared.



(a)



(b)

Figure 6- (a) Second mode of interdecadal variability of observed summer precipitation. (b) First mode of interdecadal variability of summer precipitation from the model.

Study of the inter-decadal variability in the HadCM3 model

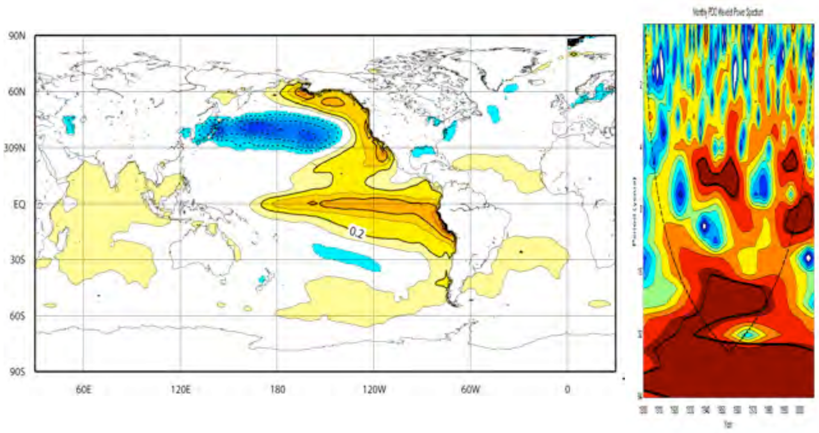
Stefanie Talento, Gabriel Cazes-Boezio, Marcelo Barreiro
Universidad de la Republica, Uruguay

We study the ability of the HadCM3 general coupled model to simulate climate processes relevant to the Río de la Plata basin, with emphasis on the interdecadal variability. We used an IPCC AR4 simulation representative of the XX century, in order of being able to validate it with observed data. We consider the only available run.

First we performed a principal component analysis of the interannual anomalies of the atmospheric circulation at 200 hPa and 850 hPa in a region around the basin, and a similar analysis of rainfall in South America. These analysis were done for each trimester (a total of 12 moving trimesters trhough the year). We find patterns of circulation and precipitation variability comparable with documented observed modes, and we also find that the relantionship between the anomalies of atmospheric circulation, precipitation ans SST are realistic.

Besides this, we also studied the low level frequency variability of the patterns found (considering the variability of their temporal amplitudes with periods larger than 10 years). We found that the interdecadal variability in the region is associated with SST anomalies in the Pacific basin presenting similarities with the PDO pattern of the observed SST. The PDO index is defined as the first PC of the monthly variability of the Pacific ocean SST at latitudes higher than 20ºN. (Mantua et al. 1997). Applying this methodology to the simulated SST fields we defined a simulated PDO index. Figures 1a and 1b show the EOFs associated to the PDO and the simulated PDO indexes, computed for the interanual SST anomalies of all the months of the Reynolds analysis between 1948 and 2009 (7a) and of the XX century simulation (7b). The simulated pattern shows important similarities with the observed one: in the positive phase of the indexes, cold anomalies in the northwestern Pacific and warm anomalies in the equatorial Pacific. However, the simulated pattern extends this equatorial anomaly further to the west than the observed one and shows a second maximum at subtropical latitudes of the North Pacific. Morevoer the simulated warm anomalies close to South America are weaker than the simulated ones. Figures 7c and 7d show the wavelet analysis for the PDO (10c) and simulated PDO(10d) indexes. In both cases the wavelet function used was Morlet. It is found that both in observations and in simulations there is an important variability at frequencies between 16 and 20 years. The observed PDO index also shows maximums at interanual variabilities (between 6 and 8 years) and at frequencies larger than 30 years, not shown by the simulated PDO.

a) c)



b) d)

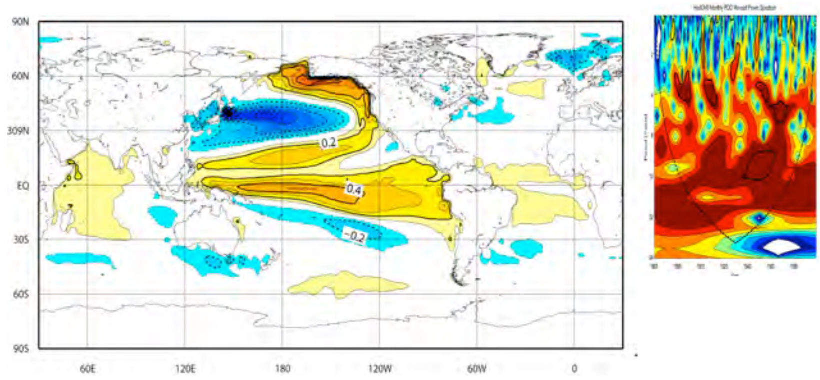


Figure 7 - (a) First-order linear regression coeficcient between PDO index and observed SST in the 1948-2009 period. Contour interval: 0,1ºC. (b) Idem (a) for the simulated-PDO index and simulated SST in the hole simulated period. (c) Wavelet power spectrum for the PDO index. The thick contour encloses regions of greater than 95% confidence for a red-noise process with lag-1 corresponding to the lag-1 of the time series considered. The dotted line indicates the influence cone, where edge effects become important. (d) Idem (c) for the simulated-PDO index.

We studied the relationship between the PDO and the simulated PDO indexes and the observed and simulated precipitation at the Rio de la Plata basin, computing the correlation coefficient between the indexes and the respective precipitation fields. It is found that both in the observed and in the simulated data the association is stronger during the austral summer trimester (DJF). In Fig. 8 we show the regression coefficient between the standardized DJF PDO index and the simultaneous precipitations in South America, for the observations (8a) and simulations (8b). We considered the PREC-L data set for observed precipitations. In the observations we find a maximum at southern Brazil and Uruguay, which extends to a large part of the west of Rio de la Plata Basin. The simulations show a maximum weaker that only covers parts of the basin (to the west and the north).

In summary, this preliminar study of the HadCM3 XX century simulation shows that this model has some kind of interdecadal variability, particularly with frequencies between 16 and 20 years. The model shows a PDO-like oscillation with similar aspects of the observed one, and with capacity to impact on the precipitation of the Rio de la Plata basin, particularly during summer. In the following stages of this work we will analyze the regression between the PDO and the regional precipitations in the

16-20 years band, for both observations and HadCM3 simulations, and the relationship between PDO and atmospheric circulation at different levels.

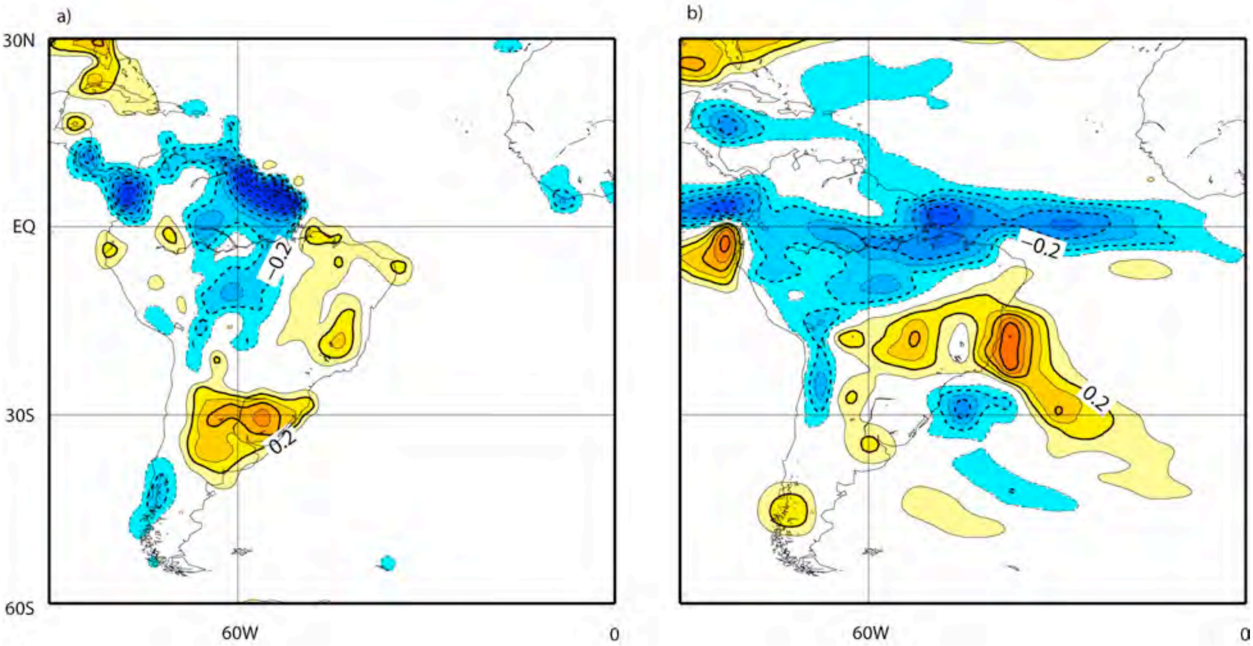


Figure 8 - (a) First-order linear regression coeficcient between the PDO index and observed precipitation (prec-L data set) in DJF for the period 1948-2009. Contour interval: 0,1 mm/day. (b) Idem (a) for the simulated-PDO index and simulated precipitation in the hole simulated period.

The South Atlantic dipole and variations in the characteristics of the South American Monsoon in the WCRP-CMIP3 multi-model simulations

Rodrigo J. Bombardi, and Leila M. V. Carvalho
Department of Atmospheric Sciences, Universidade de São Paulo, Brasil

This study investigates relationships between Atlantic sea surface temperature (SST) and the variability of the characteristics of the South American Monsoon System (SAMS), such as the onset dates and total precipitation over central eastern Brazil. The observed onset and total summer monsoon precipitation are estimated for the period 1979–2007. SST patterns are obtained from the Empirical Orthogonal Function. It is shown that variations in SST on interannual timescales over the South Atlantic Ocean play an important role in the total summer monsoon precipitation. Negative (positive) SST anomalies over the tropical South Atlantic along with positive (negative) SST anomalies over the extratropical South Atlantic are associated with early (late) onsets and wet (dry) summers over southeastern Brazil and late (early) onset and dry (wet) summers over northeastern Brazil. Simulations from Phase 3 of the World Climate Research Programme Coupled Model Intercomparison Project (CMIP-3) are assessed for the 20th century climate scenario (1971–2000). Most CMIP3 coupled models reproduce the main modes of variability of the South Atlantic Ocean (Fig. 9). GFDL2.0 and MIROC-M are the models that best represent the SST variability over the South Atlantic. On the other hand, these models do not succeed in representing the relationship between SST and SAMS variability.

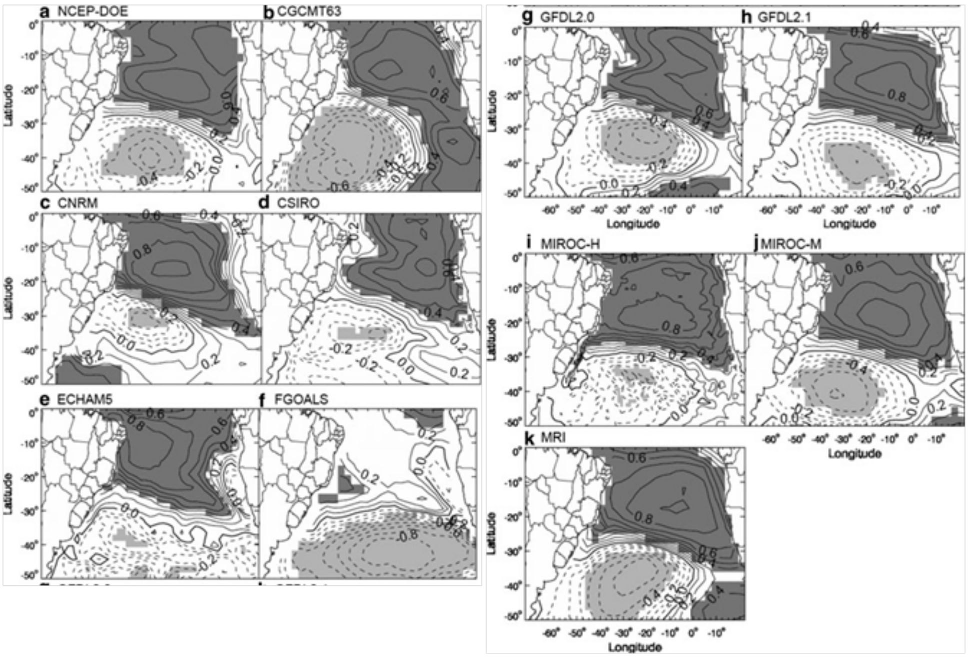


Figure 9 - Correlation between the time coefficient of the first mode of the EOF of SST and SST over the South Atlantic Ocean

IPCC Global coupled climate model simulations of the South America Monsoon System

Rodrigo J. Bombardi, and Leila M. V. Carvalho
Department of Atmospheric Sciences, Universidade de São Paulo, Brasil

This study examines the variability of the South America monsoon system (SAMS) over tropical South America (SA). The onset, end, and total rainfall during the summer monsoon are investigated using precipitation pentad estimates from the global precipitation climatology project (GPCP) 1979–2006. Likewise, the variability of SAMS characteristics is examined in ten Intergovernmental Panel on Climate Change (IPCC) global coupled climate models in the twentieth century (1981–2000) and in a future scenario of global change (A1B) (2081–2100). It is shown that most IPCC models misrepresent the intertropical convergence zone and therefore do not capture the actual annual cycle of precipitation over the Amazon and northwest SA. Most models can correctly represent the spatiotemporal variability of the annual cycle of precipitation in central and eastern Brazil such as the correct phase of dry and wet seasons, onset dates, duration of rainy season and total accumulated recipitation during the summer monsoon for the twentieth century runs. Nevertheless, poor representation of the total monsoonal precipitation over the Amazon and northeast Brazil is observed in a large majority of the models. Overall, MIROC3.2-hires, MIROC3.2-medres and MRI-CGCM3.2.3 show the most realistic representation of SAMS's characteristics such as onset, duration, total monsoonal precipitation, and its interannual variability. On the other hand, ECHAM5, GFDL-CM2.0 and FDL- M2.1 have the least realistic representation of the same characteristics. For the A1B scenario the most coherent feature observed in the IPCC models is a reduction in precipitation over central-eastern Brazil during the summer monsoon, comparatively with the present climate. The IPCC models do not indicate statistically significant changes in SAMS onset and demise dates for the same scenario.