Changes in precipitation variability over South America from both CMIP3 and CMIP5 Models

C. Vera[2*], Junquas C. [1,2], Le Treut H.[1] , Li L.[1]

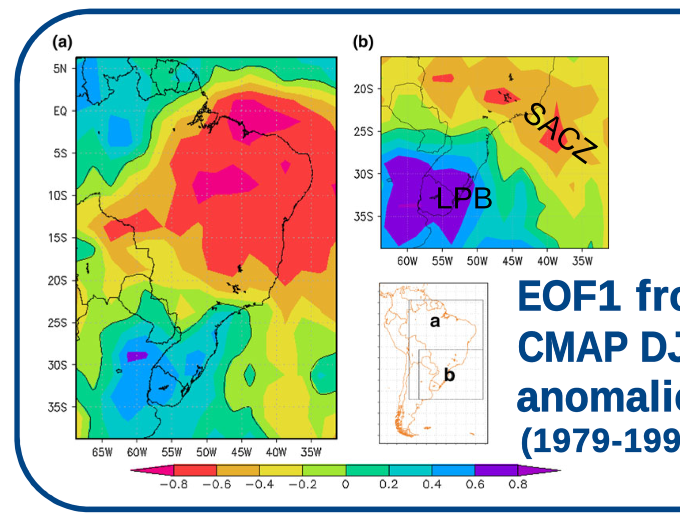
(1) LMD/IPSL, Paris, France (2) CIMA/CONICET-UBA, UMI-IFAECI/CNRS, Buenos Aires, Argentina ([*]carolina@cima.fcen.uba.ar)

MOTIVATIONS AND GOAL

Precipitation anomalies at both tropical and subtropical regions of South America exhibits considerably co-variability at interannual timescales. Positive precipitation anomalies over the subtropical plains of La Plata Basin (LPB) tend to occur in association with negative anomalies over the South Atlantic Convergence Zone (SACZ) and vice versa. Also, long-term future climate simulations project positive trends in summer precipitation over LPB. The objective of this work is therefore to explore changes in the leading pattern of precipitation in South America in the context of a climate change induced by GHG increment, and to explore how much of those changes account for the trends projected for the LPB mean summer precipitation.

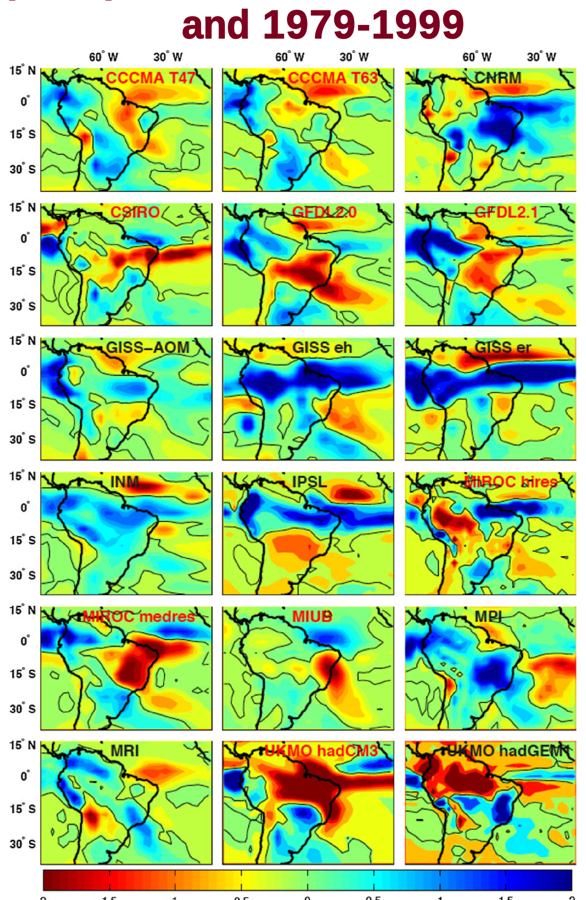
DATA

- **Monthly means of rainfall, SST and a few tropospheric variables were obtained from the set of simulations of 18 coupled general circulation of the WCRP/CMIP3 multi-model dataset**
- **(CMAP) dataset (Xie and Arkin 1997) are used to describe the mean and variability conditions observed in the rainfall between 1979 and 1999 (Figure 1a).**
- **Monthly means of rainfall of historical runs available from the WCRP/CMIP5 multi-model dataset were also used.**
- **Monthly means of rainfall from the set of historical runs of 5 models of the WCRP/CMIP5 multi-model dataset.**



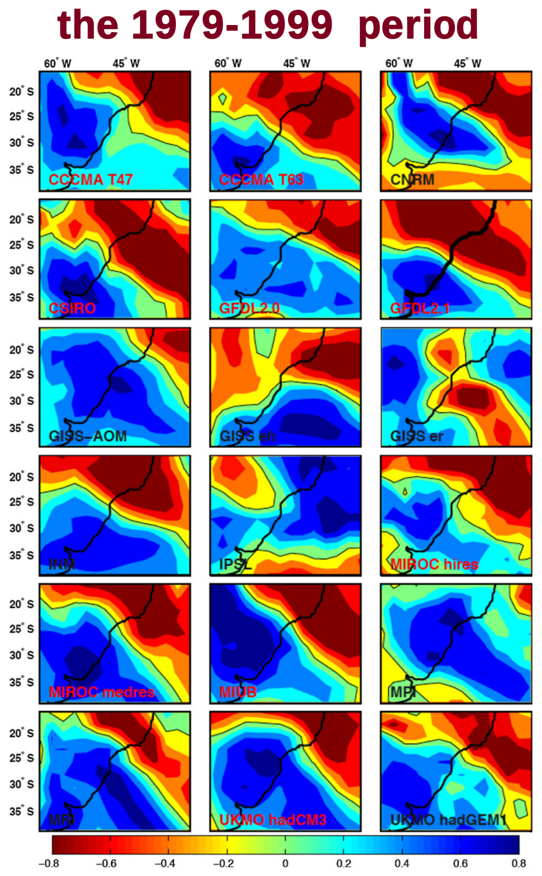
EOF1 from CMAP DJF anomalies (1979-1999)

Differences of DJF mean precipitation between 2079-2999 and 1979-1999



(red labels) 9 CMIP3 models project precipitation increase in LPB and decrease in the SACZ region

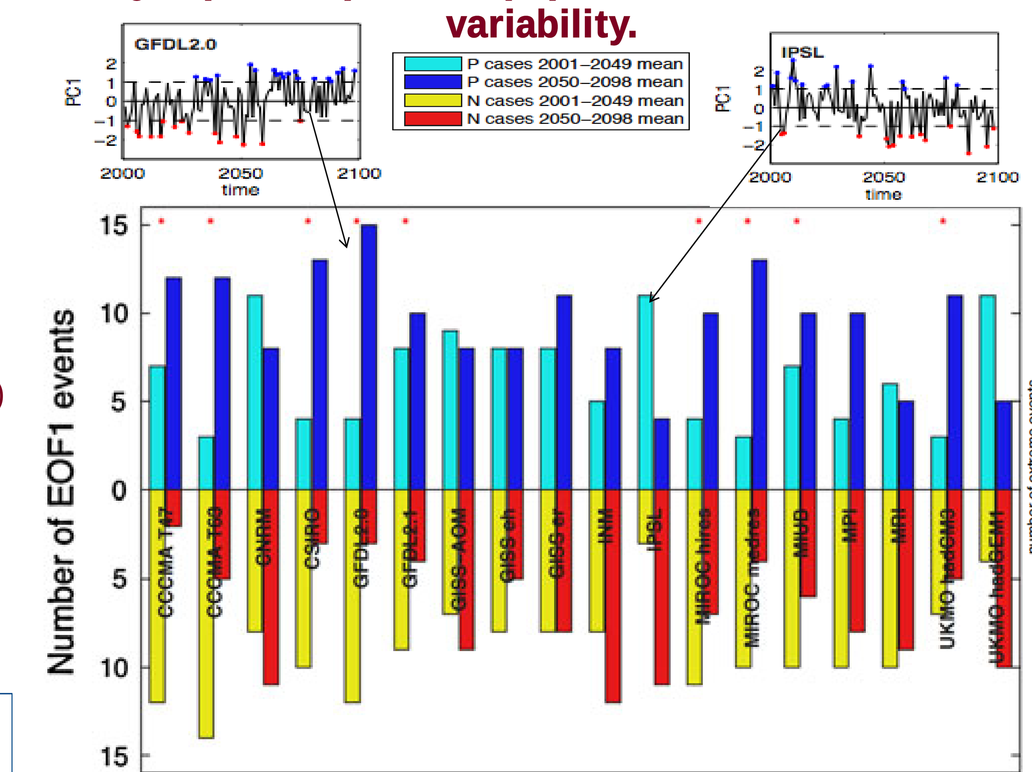
EOF1 of DJF rainfall for the 1979-1999 period



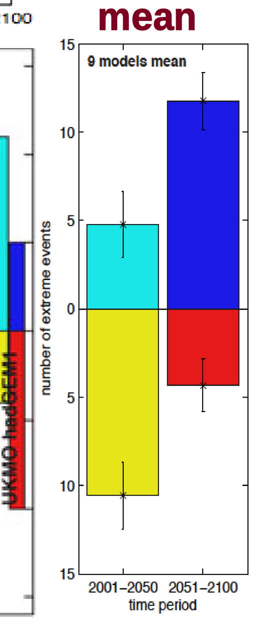
14 CMIP3 models are able to represent the EOF1 pattern. However, models in general tend to locate the SACZ-related center further northeastward than observed

Positive (negative) EOF1 events were identified for each model as those years when PC1 is larger (smaller) than 1 (-1) standard deviation of its interannual variability.

- Positive events (P) Wetter conditions in LPB and dryer in the SACZ.
- Negative events (N) Dryer conditions in LPB and a wetter in the SACZ.

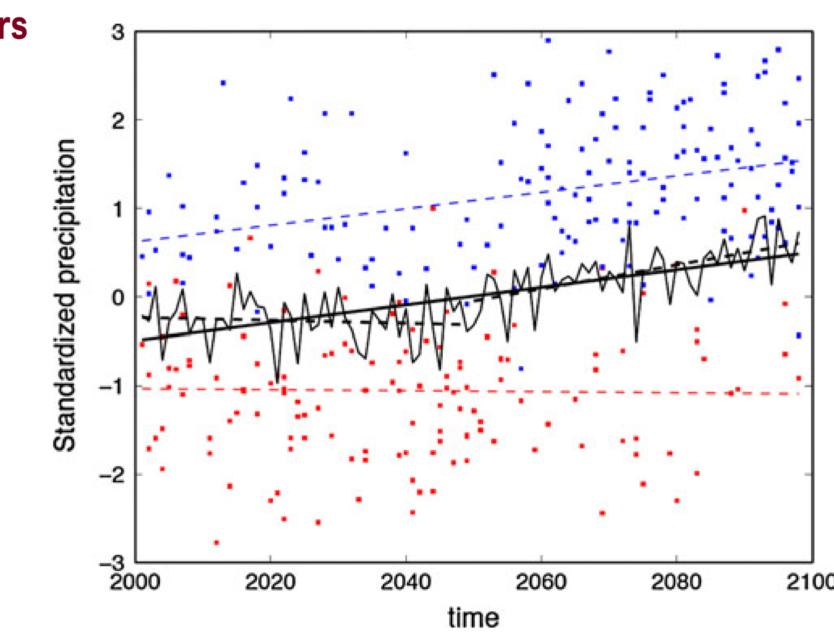


9-model mean



CHANGES IN EOF1 ACTIVITY ALONG XXI CENTURY

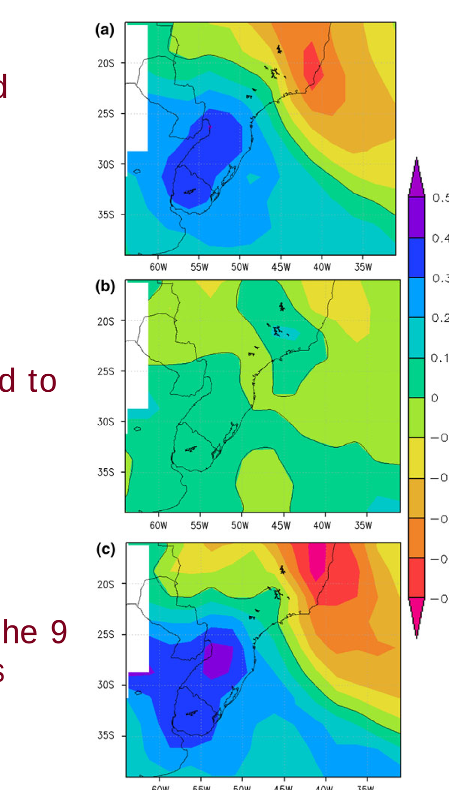
(red stars) 9 models were selected that show (1) a realistic representation of EOF1 spatial structure, (2) an increase of the projected DJF rainfall in LPB by the end of the XXI century and a decrease in the SACZ region, and (3) an increase of the frequency of P EOF1 events and a decrease of N EOF1 events during the XXI century.



Temporal evolution of the standardized DJF rainfall in SESA (38°S-26°S,64°-50°W) from the 9-model mean during the 21st century (black thin line) and its linear trend (black thick line). The rainfall linear trends for both the first and the second parts of the 21st century are represented by the two dashed black dashed thick lines. Blue (red) dots correspond to the rainfall anomalies associated to each of the positive (negative) EOF1 events identified for each of the models (the corresponding linear trends are depicted in dashed lines)

EOF1 & PRECIP TRENDS

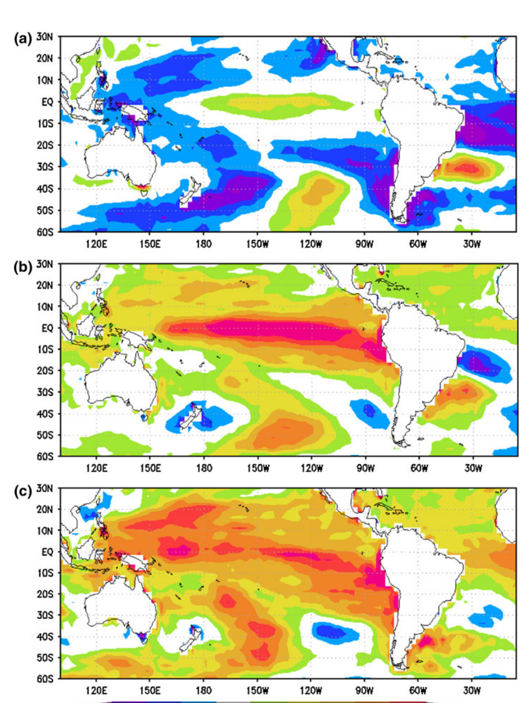
Differences of mean DJF rainfall computed between 2050-2098 and 2001-2049 periods considering



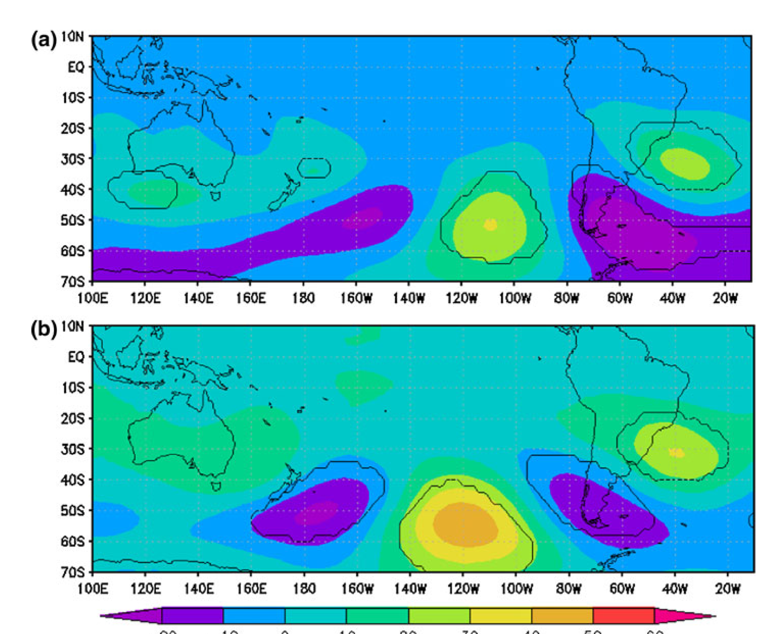
- Years associated to positive and negative EOF1 events
- Years not related to EOF1 activity
- All years from the 9 selected models

→ more than 70% of the summer precipitation changes in LPB are explained by those summers associated to an active dipole EOF1

Dynamics associated to EOF1 changes (CMIP3)



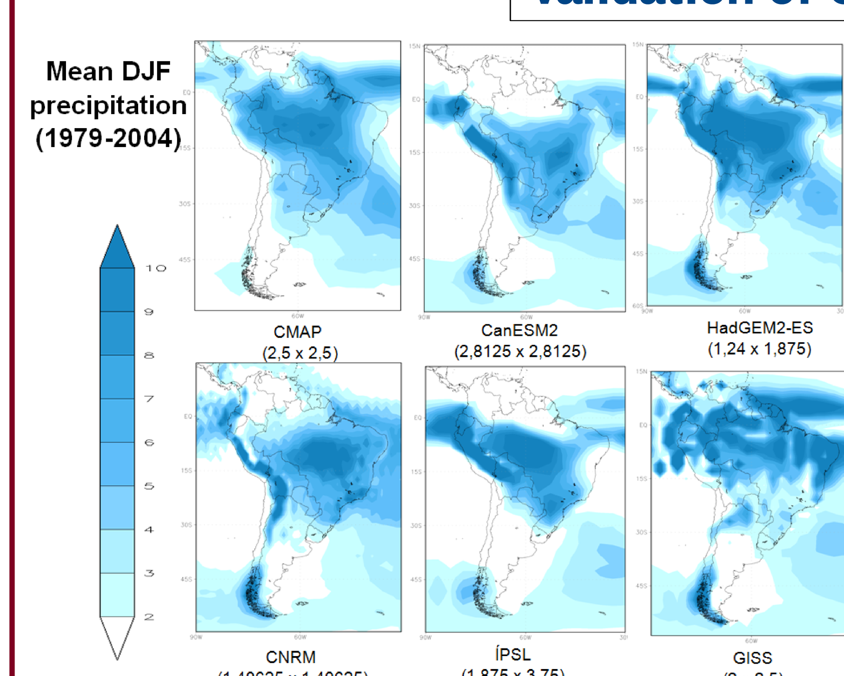
Composite differences of mean DJF SST anomalies between P and N EOF1 events for a) (2001-2049), and b) (2050-2098) from the 9-model ensemble mean. C) Difference between b and a.



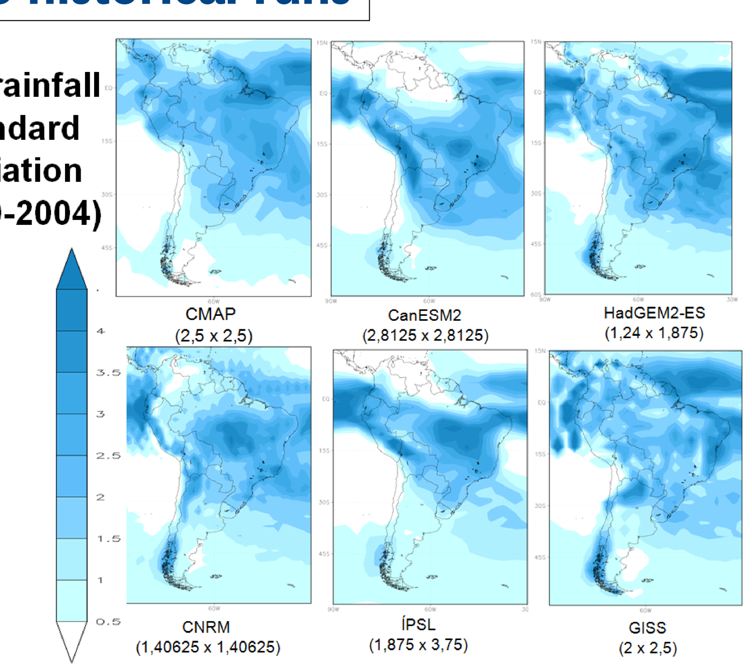
Composite differences of DJF geopotential height anomalies at 500 hPa between positive and negative EOF1 events for a (2001-2049), and b (2050-2098) periods, computed from the model ensemble mean. Areas where values are statistically significant at the 90% of the Student test are inside a black contour

Validation of CMIP5 historical runs

Mean DJF precipitation (1979-2004)



DJF rainfall standard deviation (1979-2004)



CONCLUSIONS

Results obtained from the CMIP3 multi-model ensemble show that future rainfall variability in LPB has a strong projection on the changes of seasonal dipole pattern activity, associated with an increase of the frequency of the positive phase.

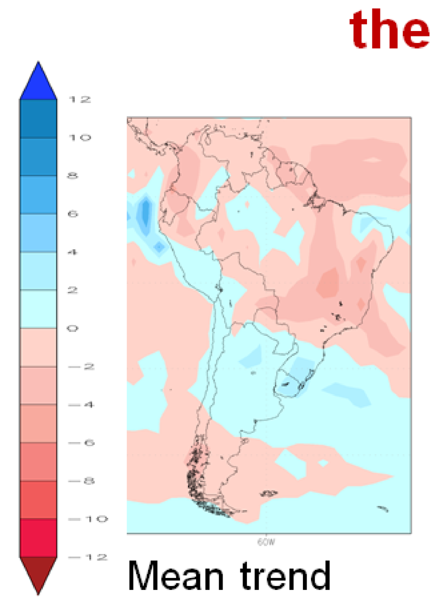
The frequency increase of positive dipole phase in the twenty first century seems to be associated with an increase of both frequency and intensity of positive SST anomalies in the equatorial Pacific, and with a Rossby wave train-like anomaly pattern linking that ocean basin to South America.

How much of the signal depicted by the CMIP3 climate change projections for the summer precipitation in LPB is related to the ability of current climate models in correctly reproducing both the tropical Indian-Pacific ocean dynamics and the associated teleconnection patterns, is not clear yet .

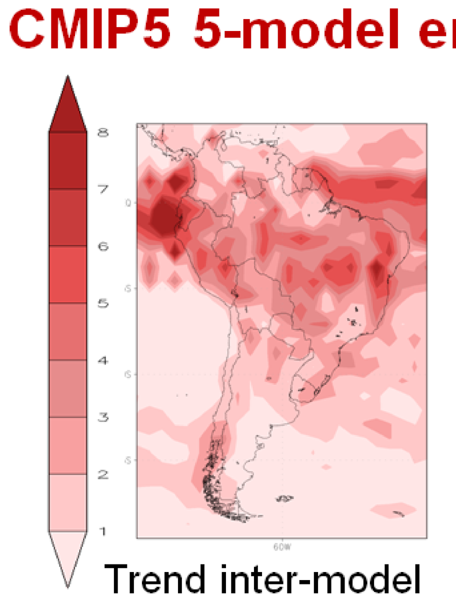
Preliminary analysis of the historical runs for XX century from 5 CMIP5 models show some improvement of the representation of the DJF climate in South America than that done by CMIP3 models.

CMIP5 models are able to reproduce in some extent the positive DJF rainfall trend observed in LPB along the XX century. Moreover, the changes in the EOF1 activity described by 5 CMIP5 models show an increase (decrease) of the number of positive (negative) EOF1 events along the XX century. It is expected to increase the number of CMIP5 simulations considered in order to reduce the uncertainty levels that results currently exhibit.

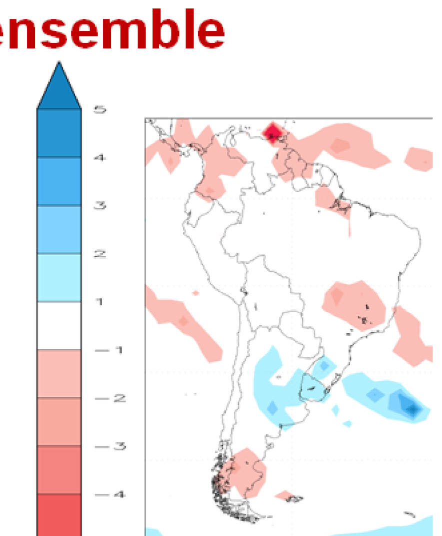
DJF rainfall Linear trend (1859-2004) from the CMIP5 5-model ensemble



Mean trend (mm/summer/decade)

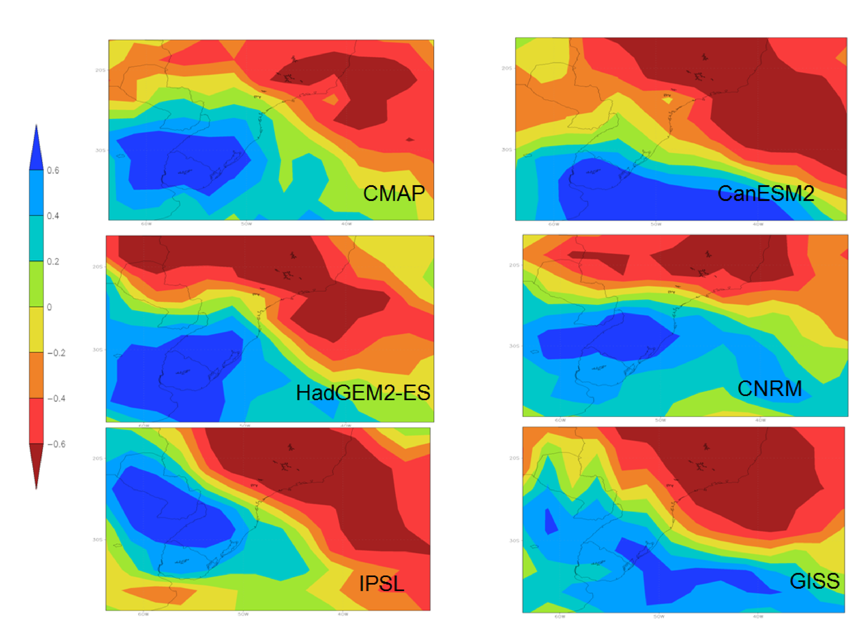


Trend inter-model dispersion (mm/summer/decade)

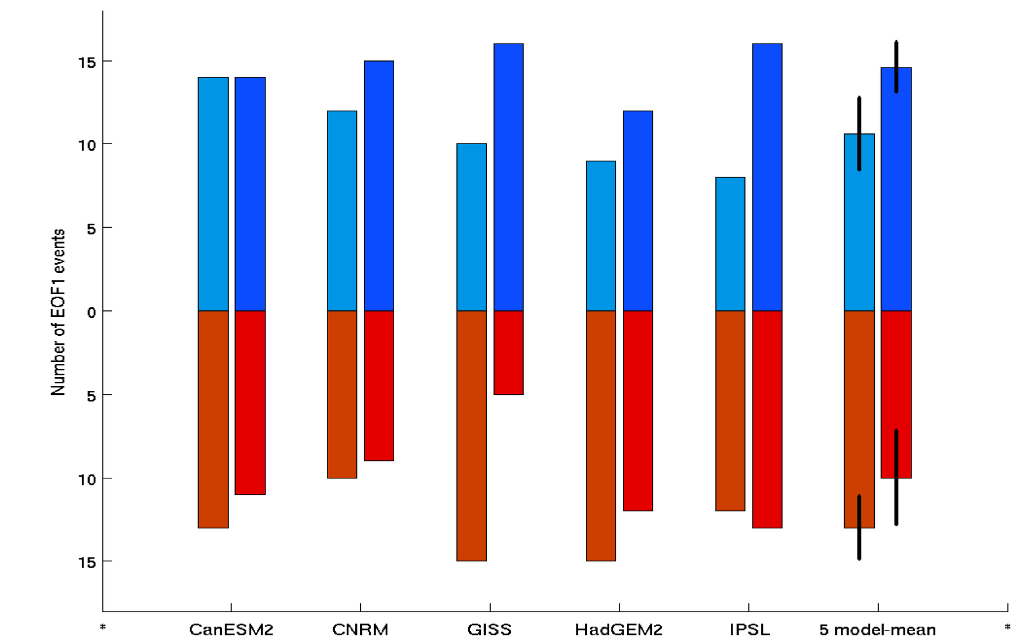


Mean Trend/Trend inter-model dispersion

CHANGES IN EOF1 ACTIVITY DURING XX CENTURY AS DEPICTED BY CMIP5 MODEL HISTORICAL RUNS



EOF 1 of DJF rainfall interannual variability, according to CMIP5 models and CMAP data (1979-2004)



Number of positive and negative EOF1 events on 1861-1932 and 1933-2004

REFERENCES

Junquas C, Vera C, Li L, Le Treut H, 2011: Summer precipitation variability over southeastern South America in a global warming scenario. Clim Dyn, in press