About SACZ simulations in present and future climate by global climate models

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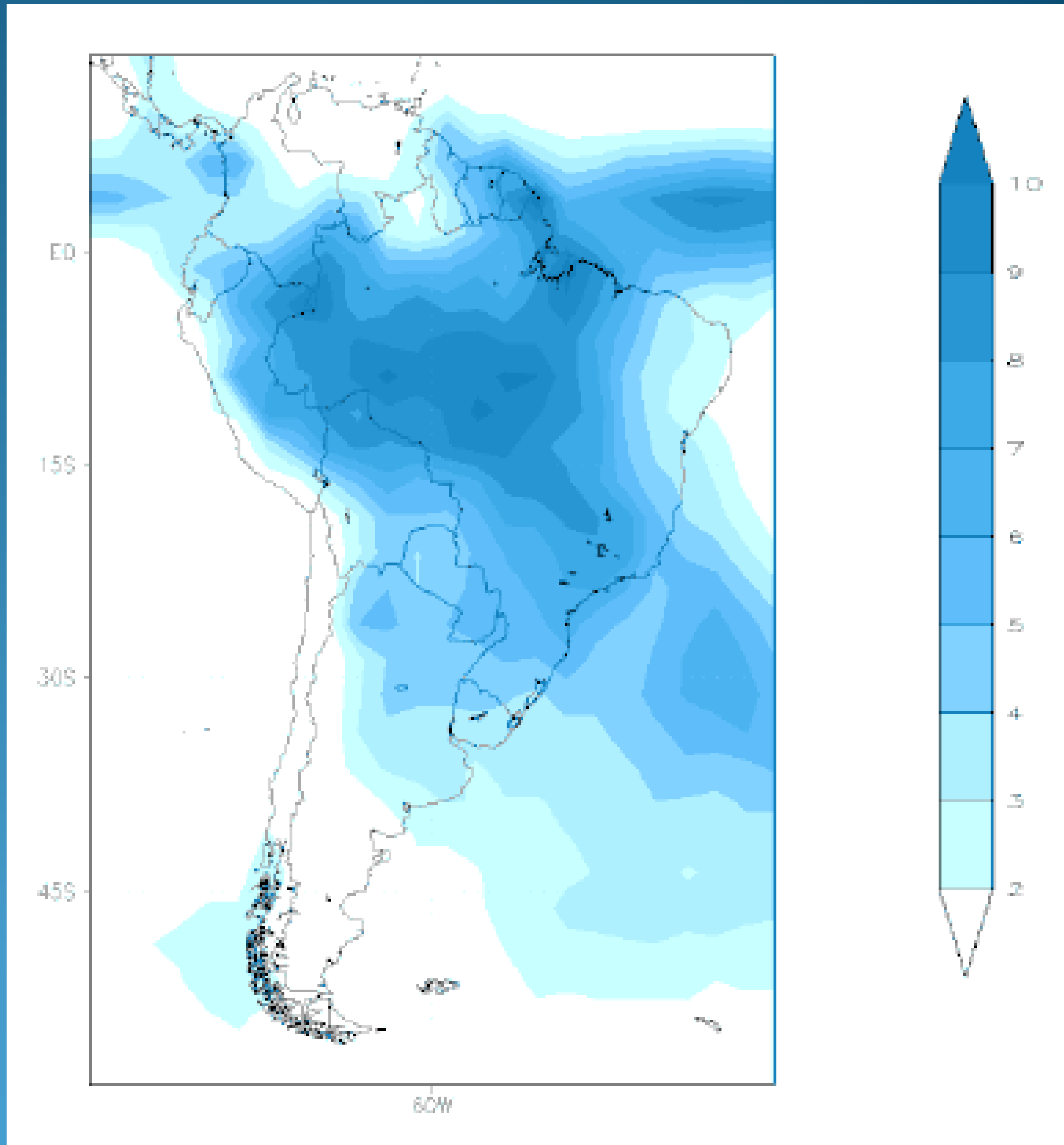
UMI-IFAECI (3351)

- The SACZ activity modulates summer climate at southeastern South America (SESA) on many time scales ranging from intraseasonal to interannual and longer time scales

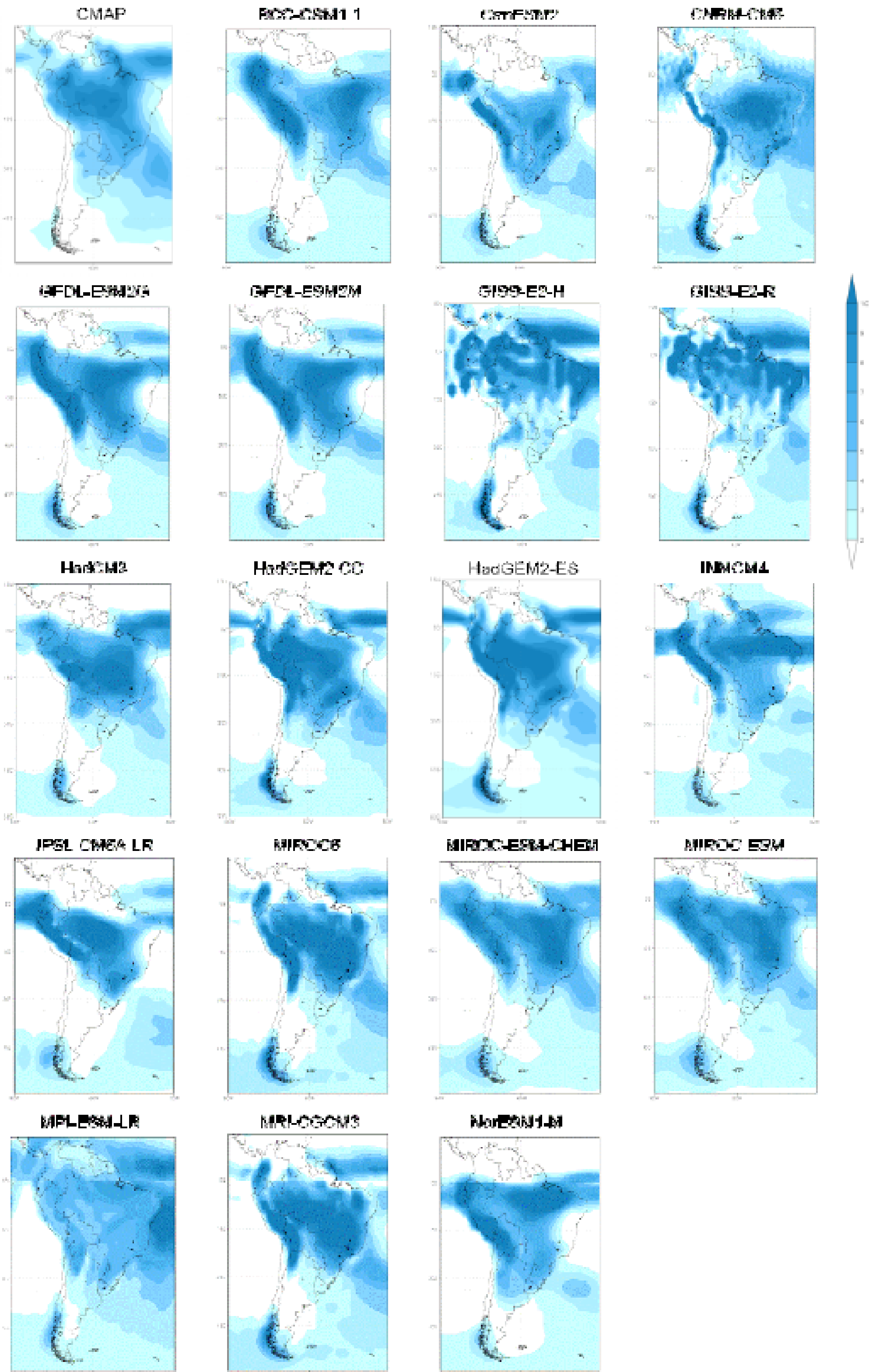
- SACZ simulation is still challenging for climate models and indirectly can affect the climate simulation over SESA

DJF Climatological mean precipitation CMAP (1979-2005)



DJF climatological mean precipitation for CMAP and for 18 WCRP/CMIP5 models

(1979-2005)

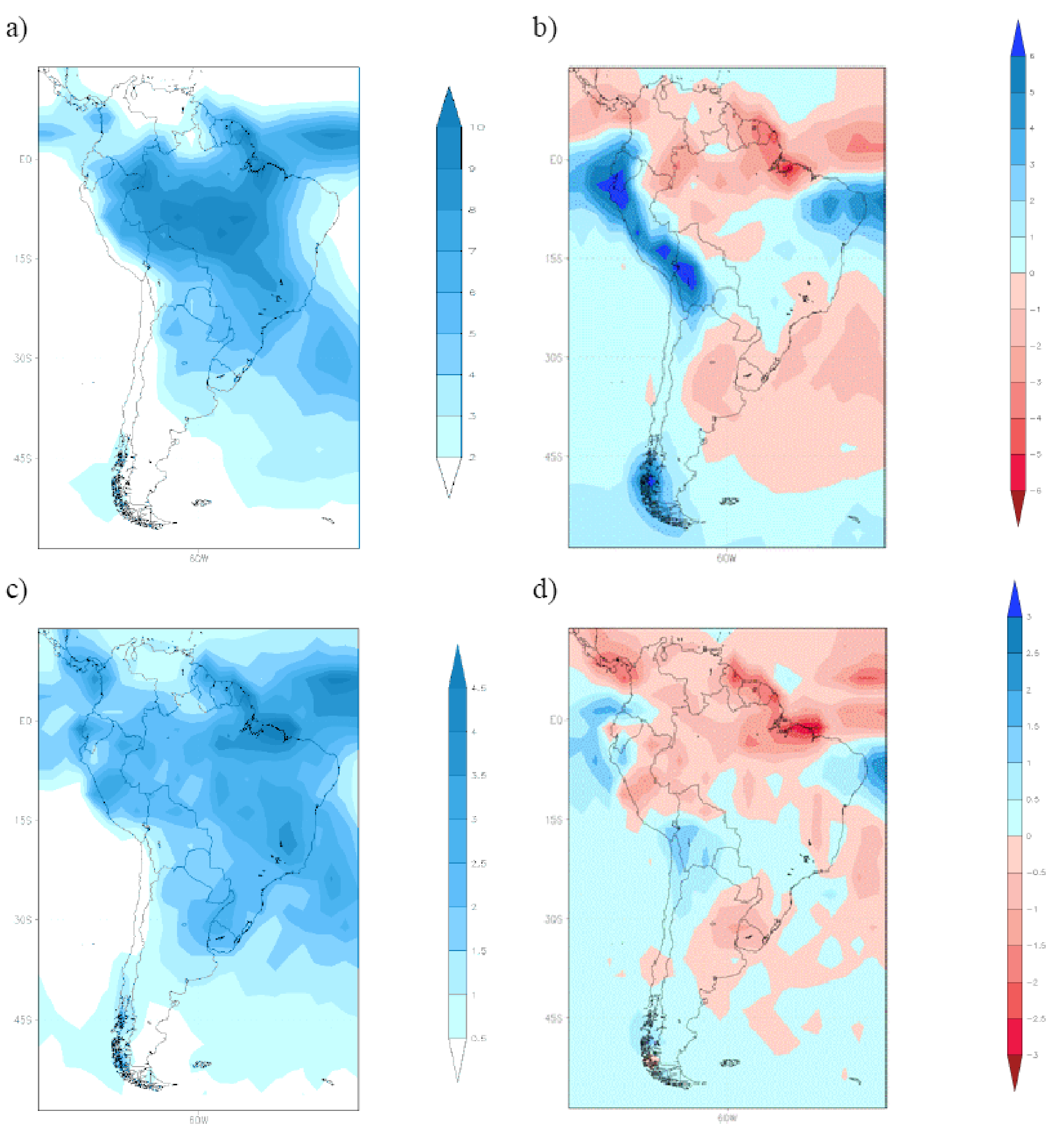


Vera et al. (2012)

DJF Climatological mean precipitation

CMAP (1979-2005)

DJF precipitation standard deviation

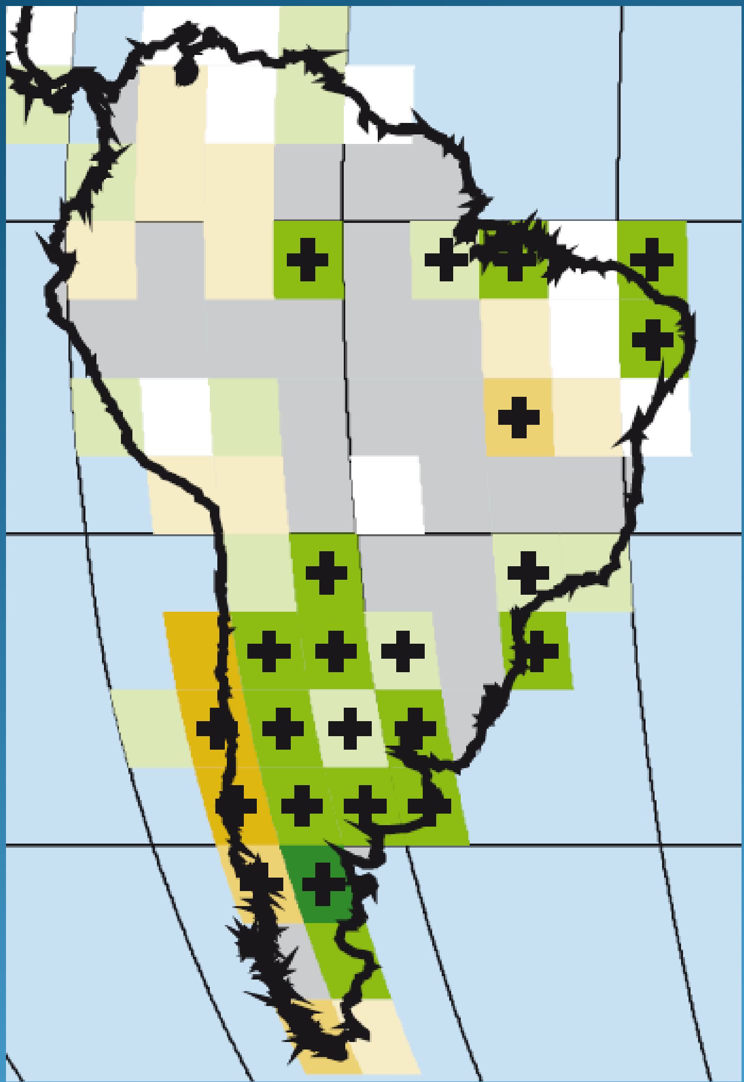


Bias of CMIP5 MME (18 models) for DJF mean precipitation

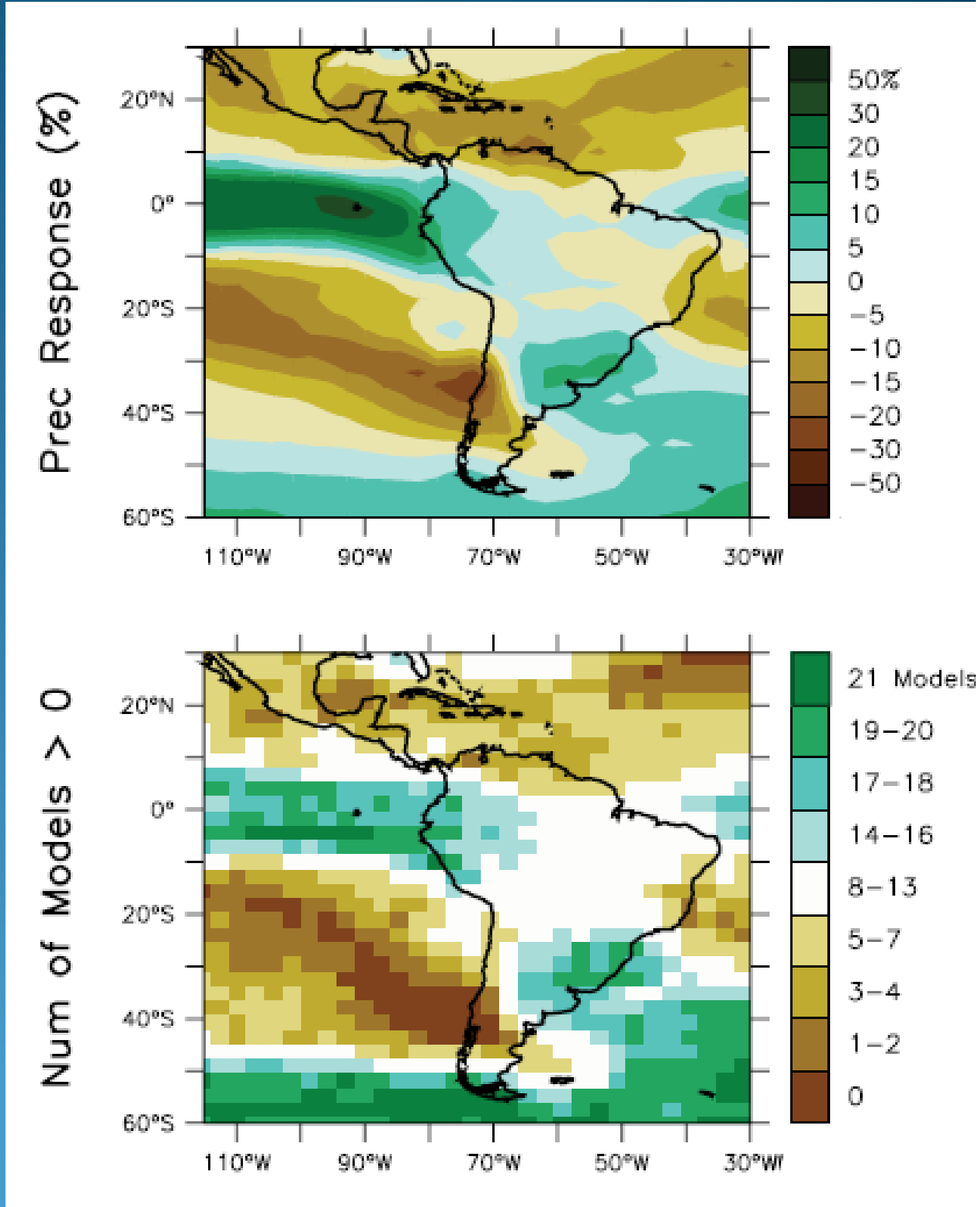
Bias of CMIP5 MME (18 models) for DJF precipitation standard deviation

Vera et al. (2012)

MOTIVATION



Annual mean precipitation trends (1901-2005) (IPCC, 2007)



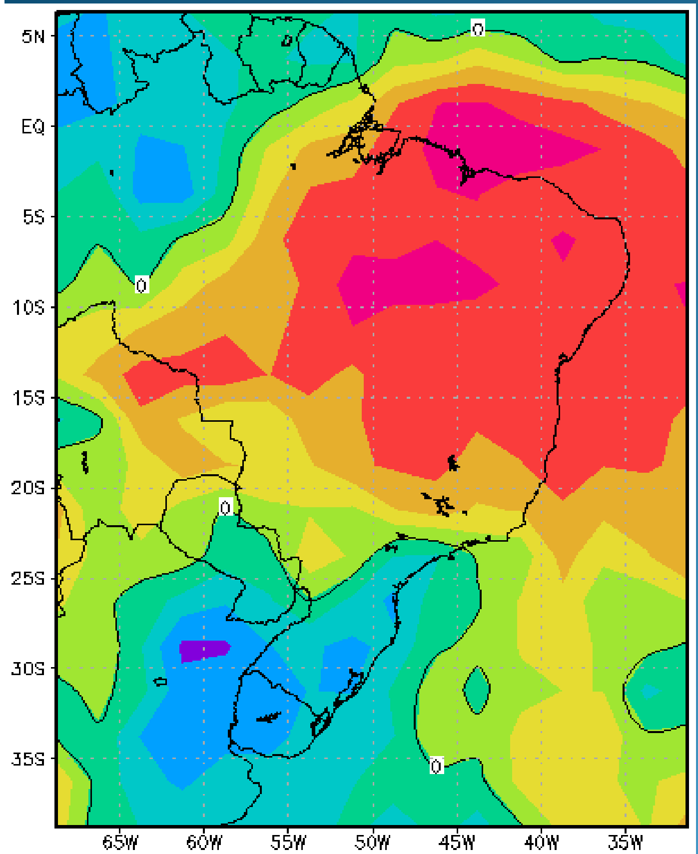
Precipitation changes as depicted by the WCRP/CMIP3 multi-model ensemble (SRESA1B) (2080-2099)-(1980-1999) (IPCC, 2007)

Which are the physical mechanisms explaining an increase of summer precipitation in southeastern South America (SESA) under GHG increment scenario?

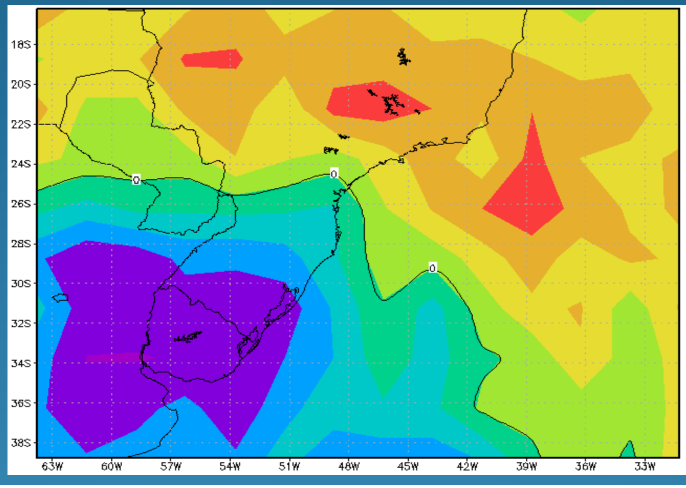
- Junquas et al. (2012a, ClimDyn) showed that precipitation increase in SESA projected for the XXI century is largely related to changes in the activity of the leading pattern of summer precipitation variability (EOF1) with centers of action over SACZ region and SESA respectively.

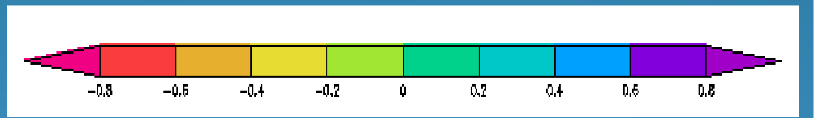
Leading pattern of year-to-year variability of DJF precipitation anomalies (CMAP)

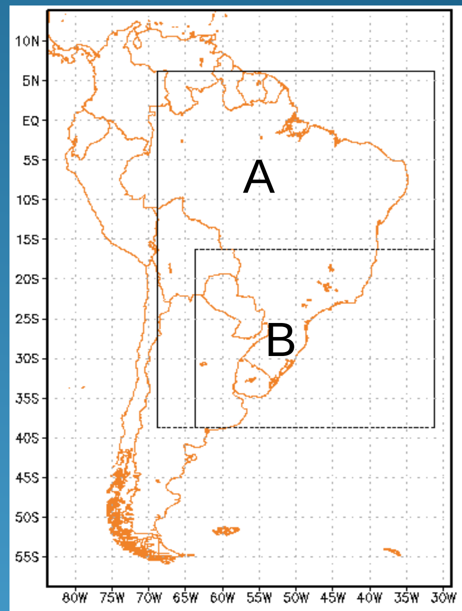
EOF1 - domain A

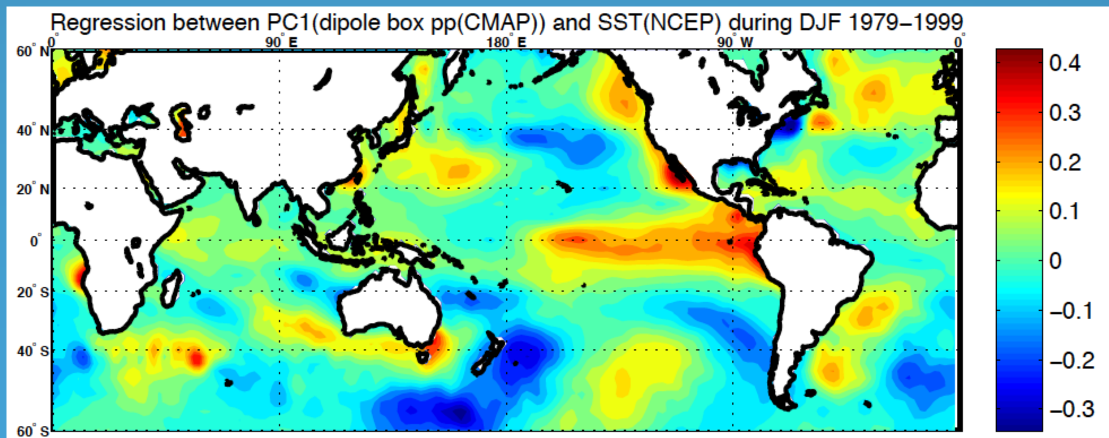


EOF1 - domain B









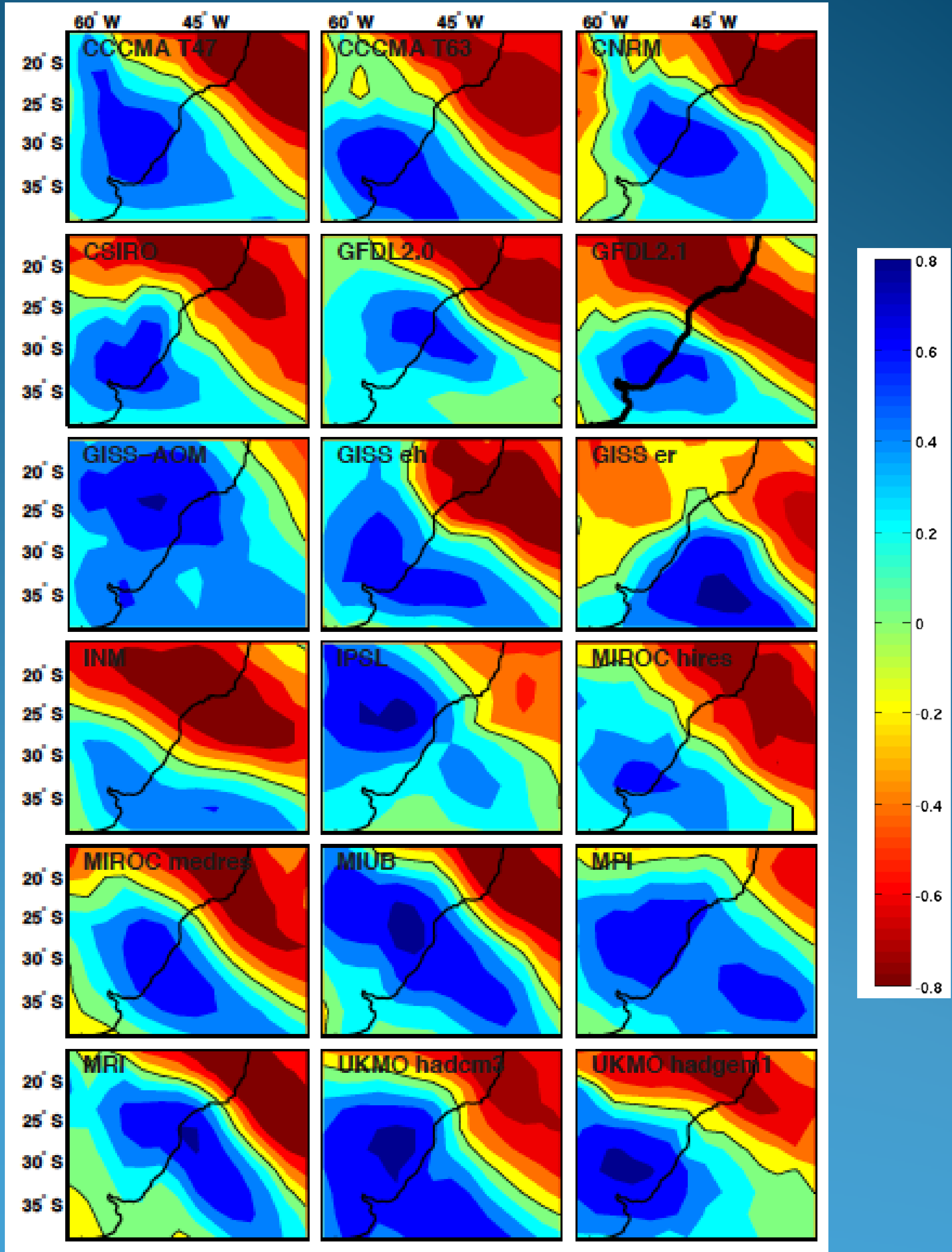
Junquas et al. (2012a)

Leading pattern (EOF1) of DJF rainfall anomaly variability

from the 18 models

Period: 2001-2099

Scenario: SRESA1B

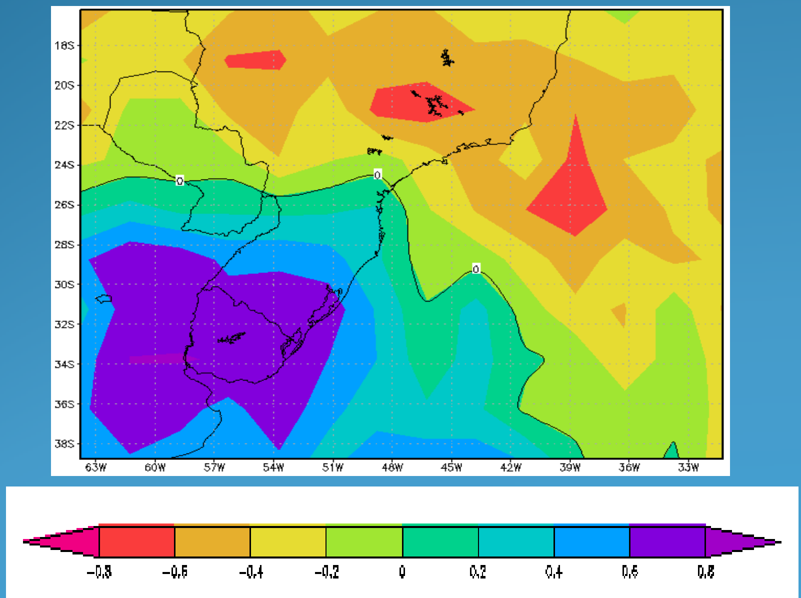


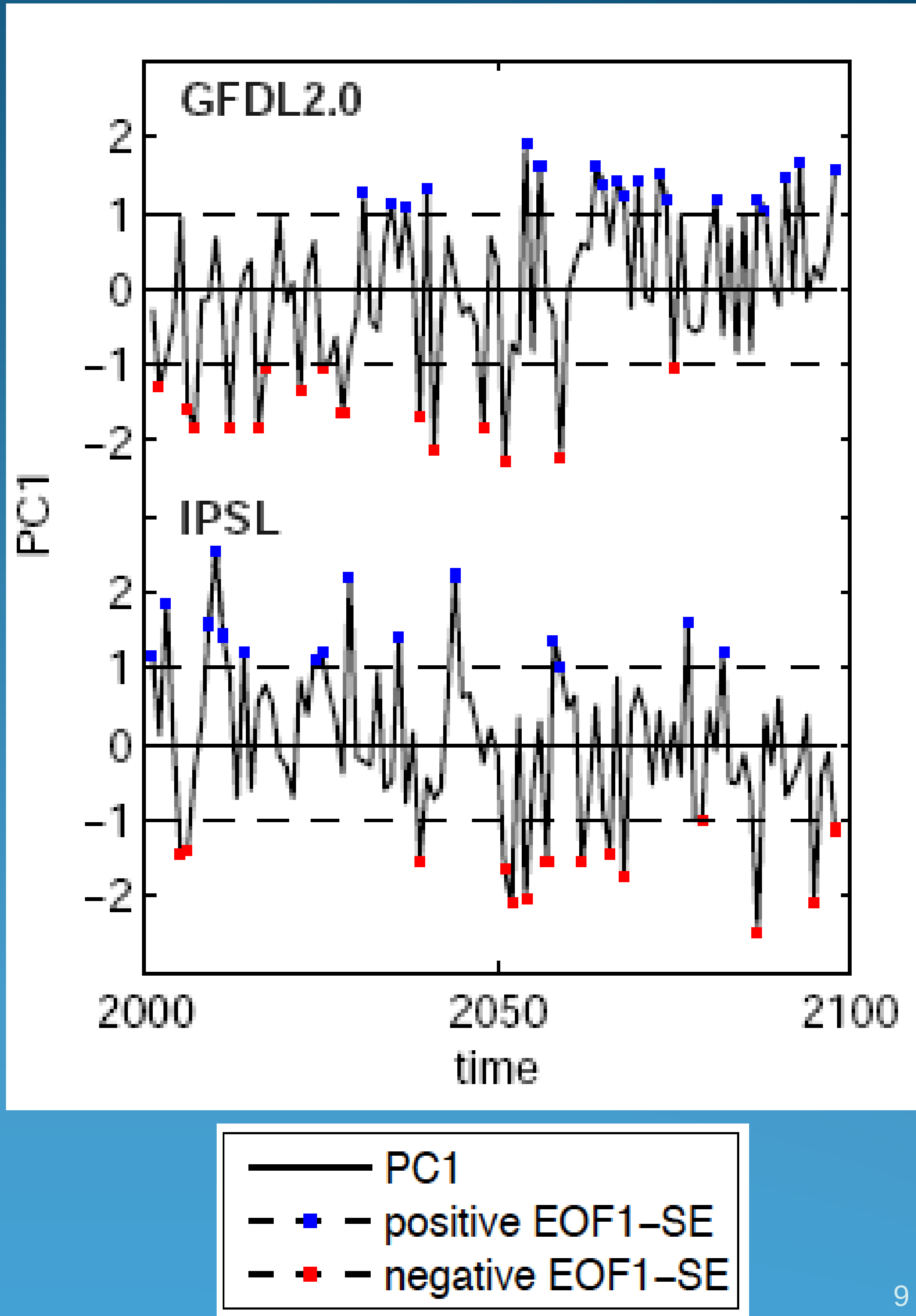
Junquas et al. (2012a)

Principal Components (PC1) of EOF1 from two of the models

- Blue (red) : PC1 larger (smaller) than 1 (-1) standard deviation →Positive(Negative) EOF1-SE.

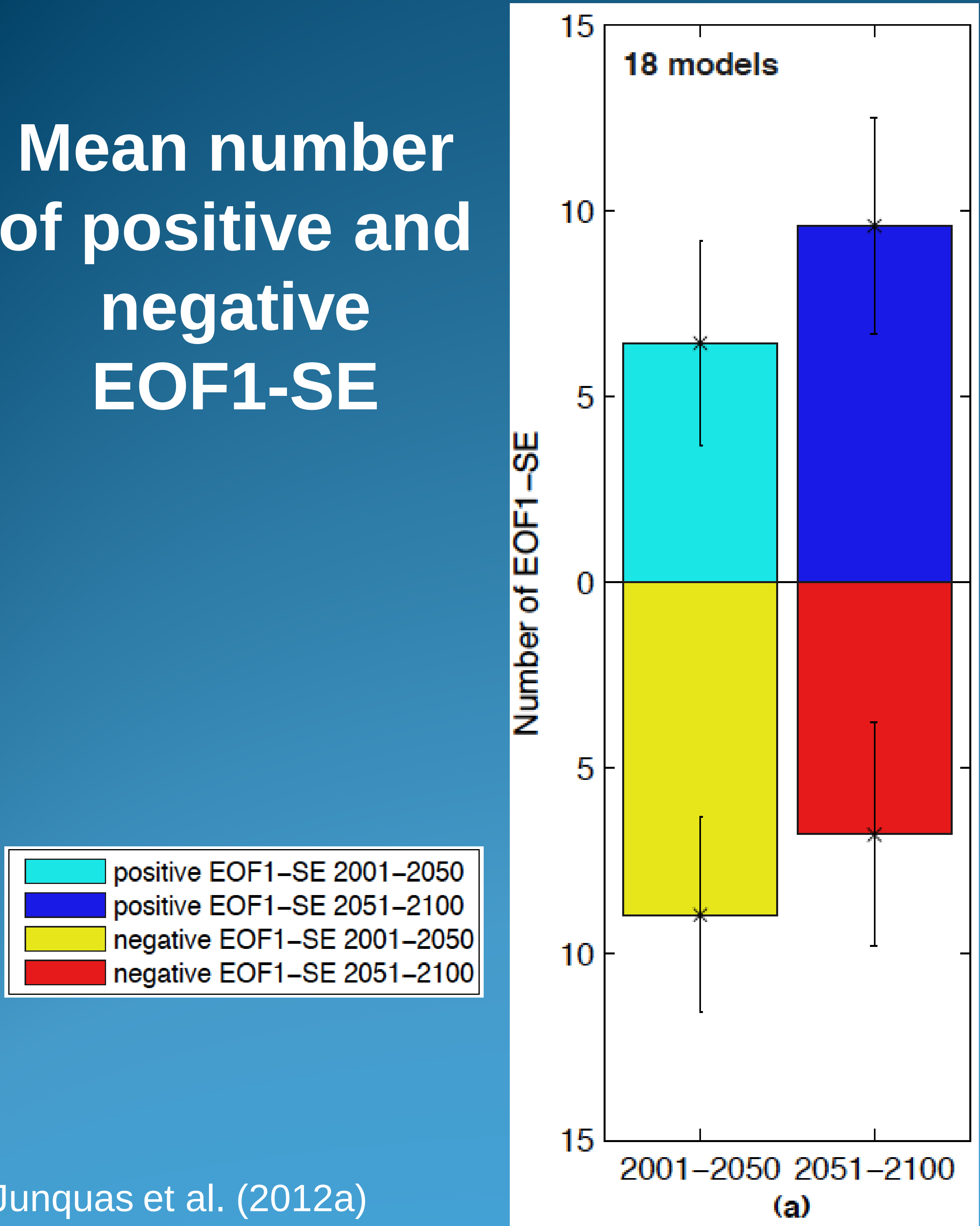
- Positive (negative) EOF1-SE are associated with positive (negative) precipitation anomalies in LPB





Junquas et al. (2012a)

Mean number of positive and negative EOF1-SE



Increment of wetter than normal DJFs in the la Plata Basin and drier than normal DJFs in the SACZ region

Decrease of dryier than normal DJFs in the la Plata Basin and wetter than normal DJFs in the SACZ region

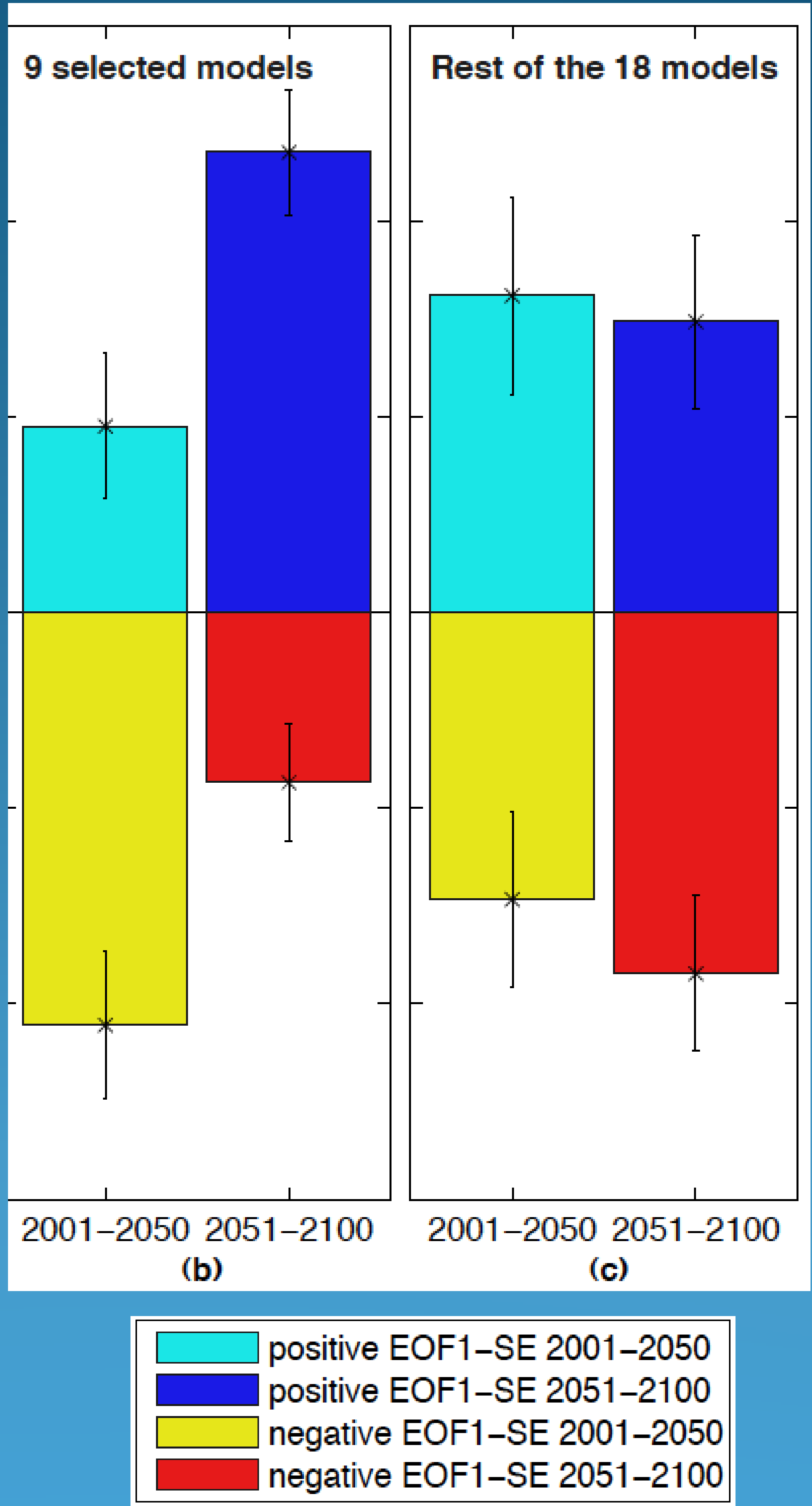
Junquas et al. (2012a)

9 models were selected that show:

i) a realistic representation of the dipole-like structure associated to EOF1 events in the present as in the future

ii) an increase of the projected summer rainfall in LPB by the end of the 21st century .

iii) an increase of the frequency of positive EOF1 events and a decrease of negative EOF1 events during the 21st century

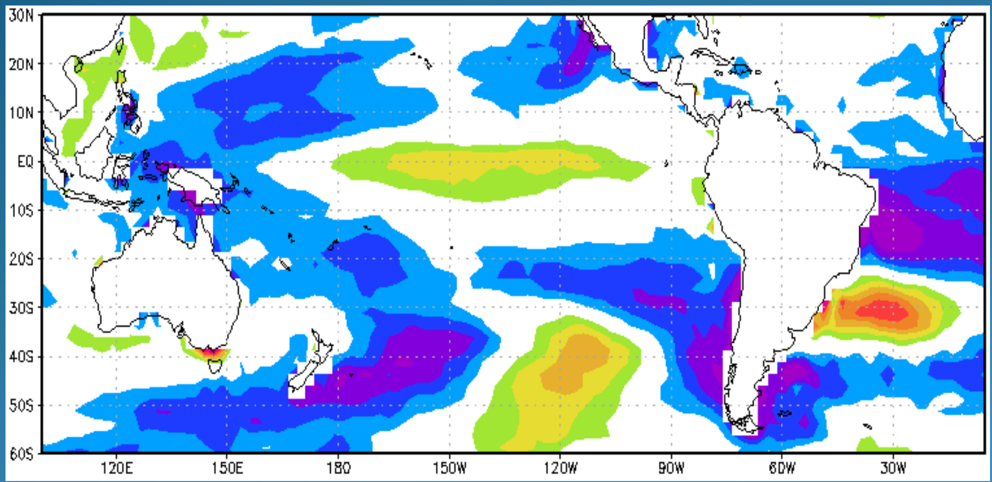


Mean number of positive and negative EOF1-SE

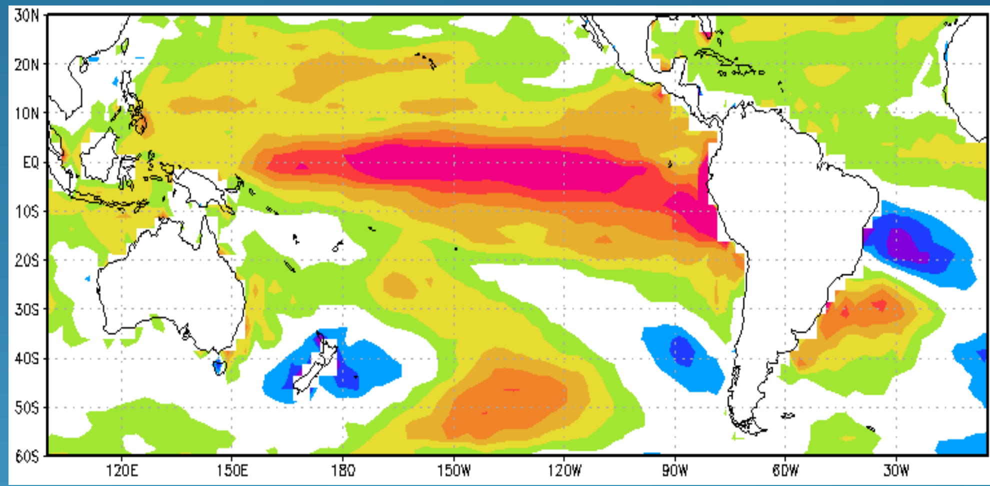
Junquas et al. (2012a)

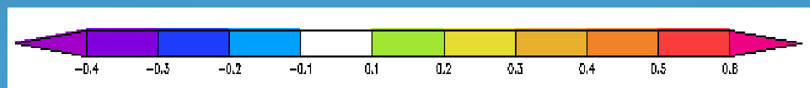
Composite differences of mean DJF SST anomalies between positive and negative EOF1 events from the 9-model ensemble mean

(A) 2001-2049



(B) 2050-2099



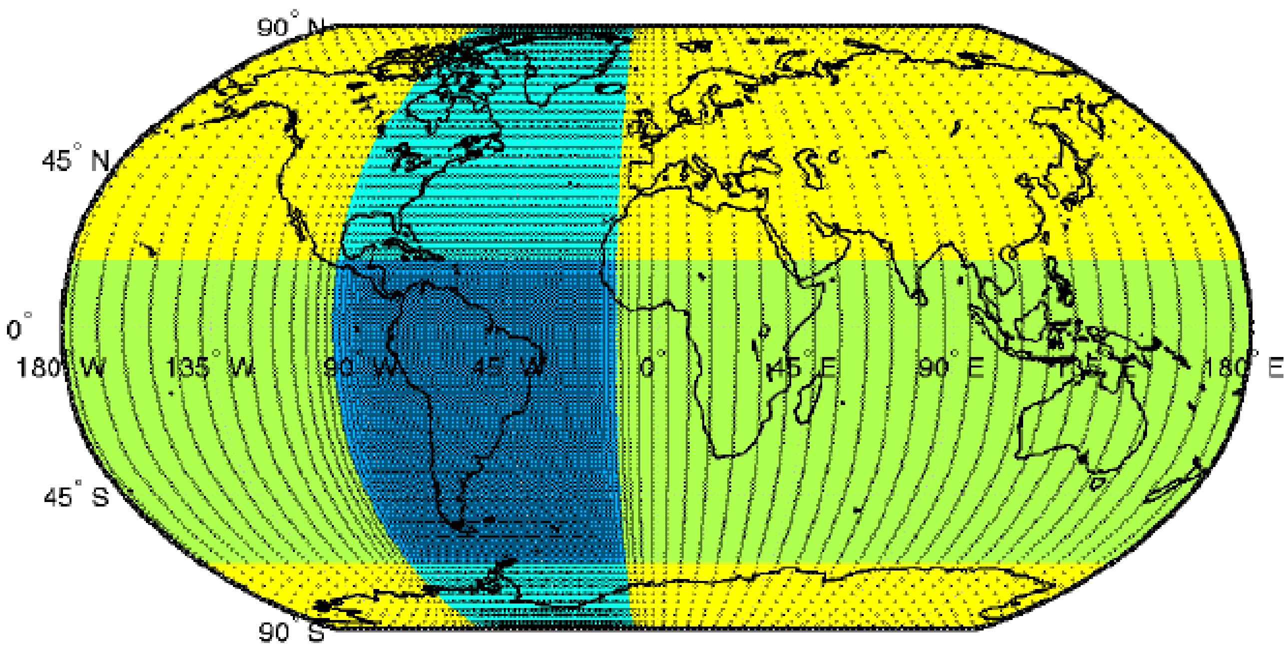


Junquas et al. (2012a)

Specific simulations have been set up to further study the underlying atmospheric mechanisms relevant to South America summer climate

Description of the model

The LMDZ atmospheric model configured in "two-way nesting" (TWN).



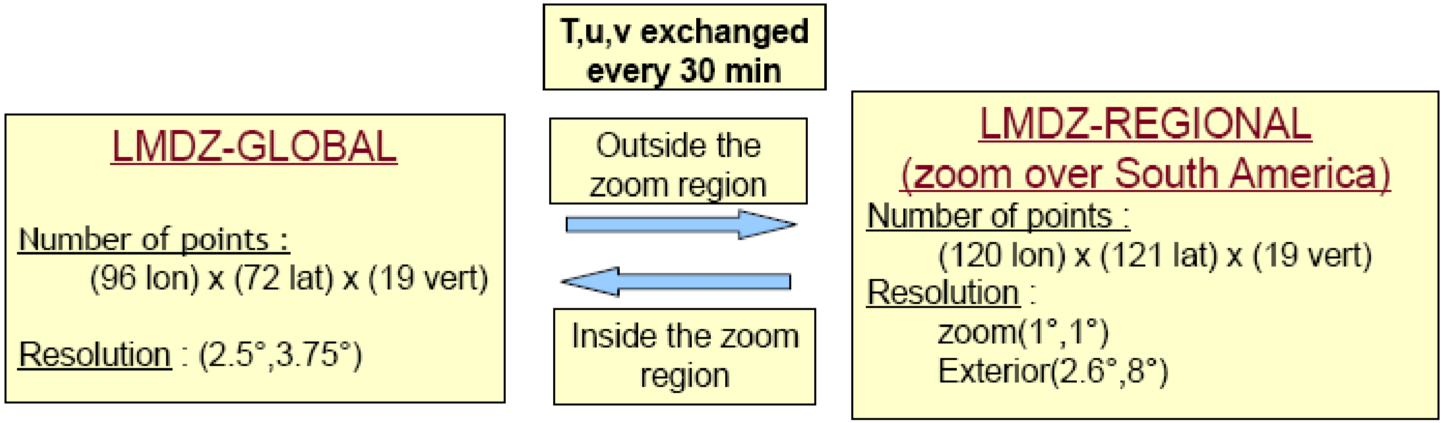
LMDZ-regional, zoom over South America

- The grid of LMDZ is able to be streched or "zoomed" over a particular region. Here the zoom is over South America.
- The "two-way nesting" system is able to improve the interactions between global and regional processus. For example with this method the influence of a particular regional change over the large-scale atmospheric circulation is improved (Lorenz et Jacob, 2005).

Junquas et al. (2012b)

Description of the model

The LMDZ atmospheric model configured in "two-way nesting" (TWN).



- LMDZ-regional zoomed over South America is run in parallel with LMDZ-global (regular grid). Temperature, wind and humidity variables are exchanged every 2h.

Junquas et al. (2012b)

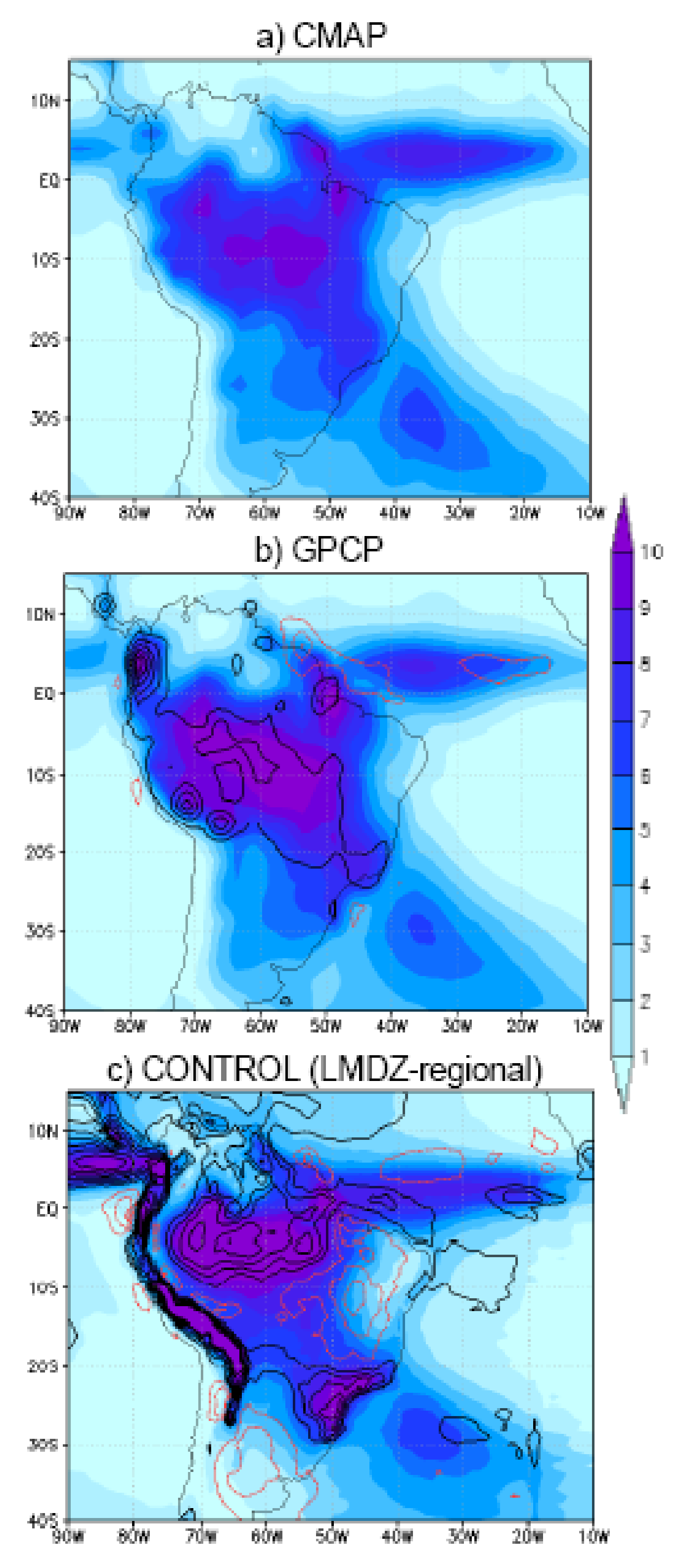
CONTROL simulation

- 30-Member ensemble of DJF simulations forced by climatological daily mean SST from AMIP dataset (1979-1999).

- Each DJF ensemble member simulation is generated by a random sampling of the initial atmospheric conditions (Li ,2006).

Junquas et al. (2012b)

REGIONAL VALIDATION

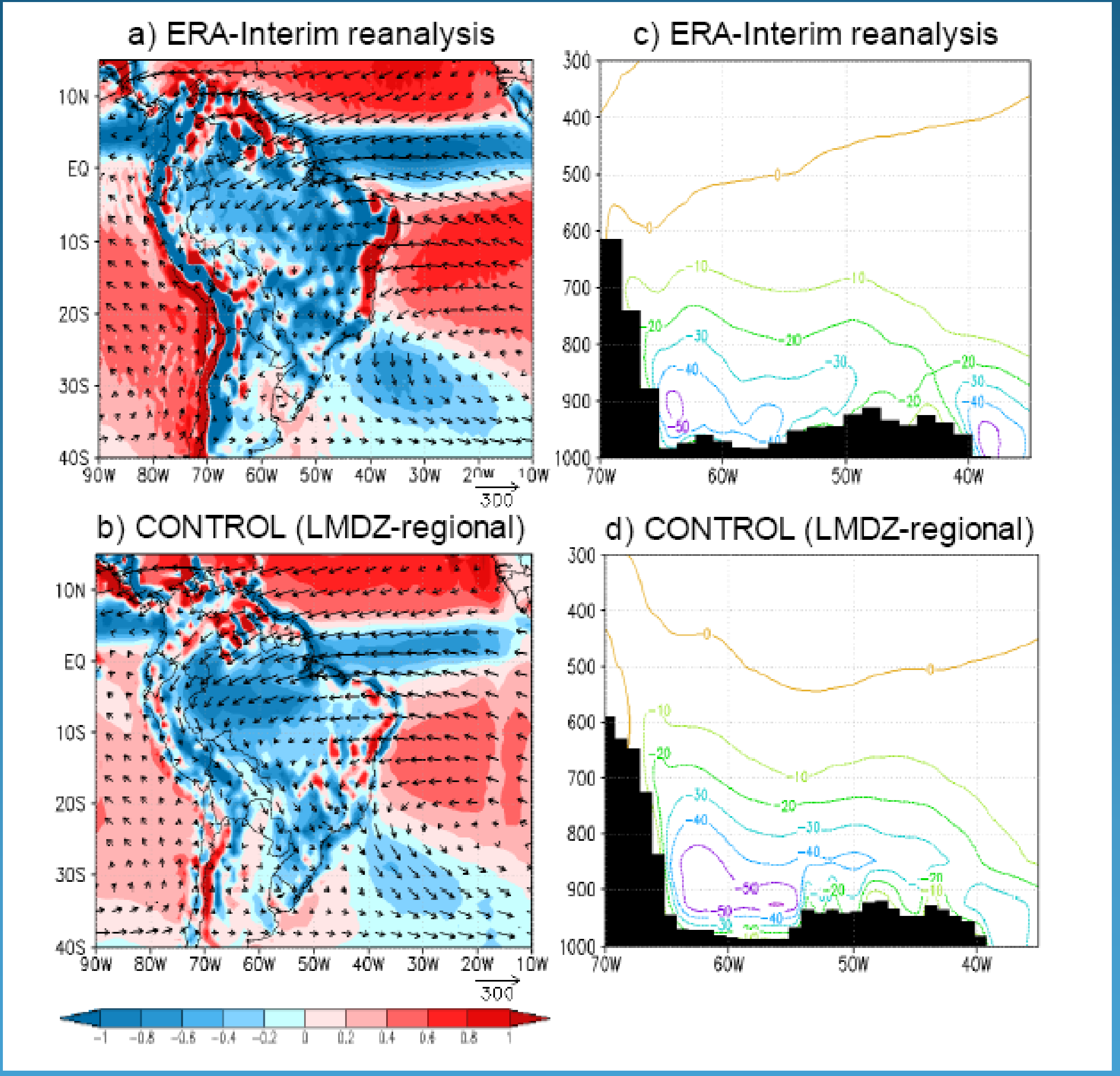


RAINFALL (mm/day)

Junquas et al. (2012b)

REGIONAL VALIDATION

Humidity flux vertically integrated between 1000 and 300 hPa



Junquas et al. (2012b)

Specific simulations have been set up to further study the underlying atmospheric mechanisms relevant to South America summer climate

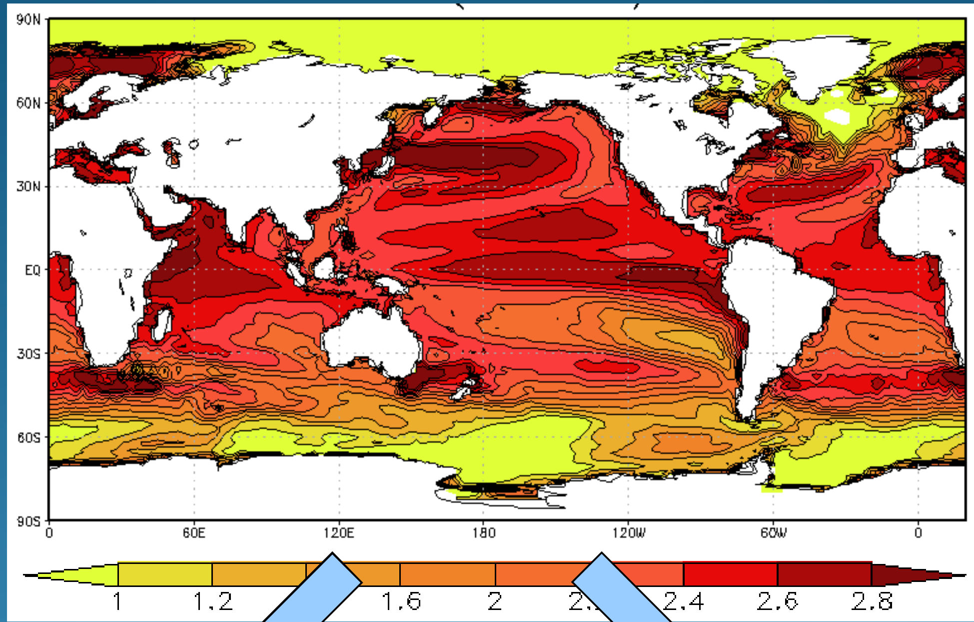
- Experiments of South America climate sensitivity to:

  - SST changes in the tropical Oceans and South America

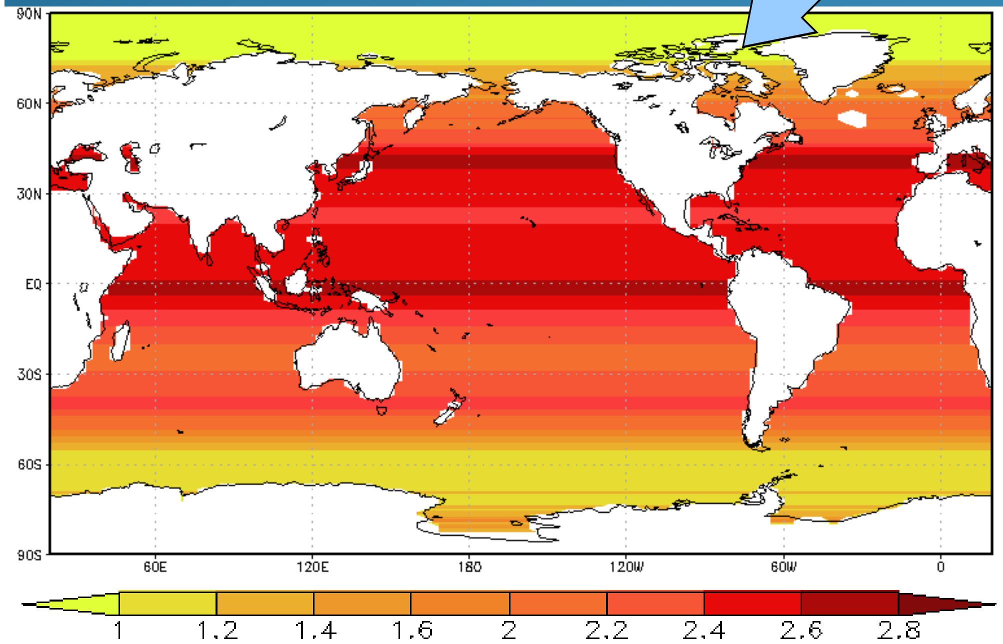
  - Orography (Andes and/or Brazil Planalto)

Full future SST change **(from WCRP/CMIP3 models)**

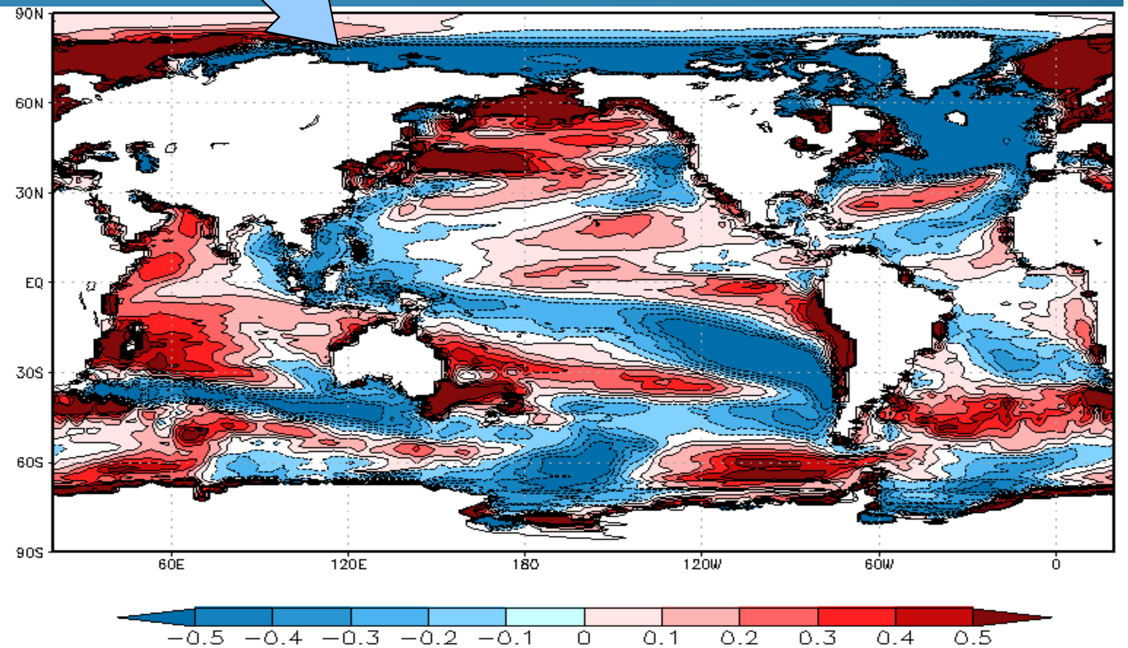
Experiments of 30-member ensemble of DJF simulations forced by climatological AMIP daily mean SST + SST CHANGE in the XXI century



SST change Zonal Mean



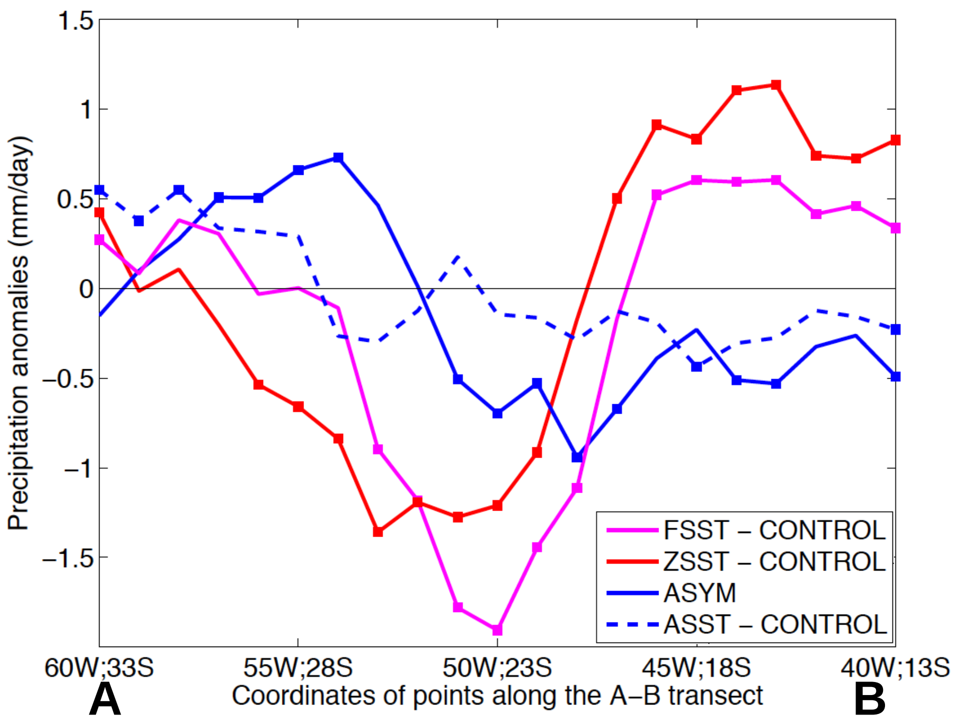
Full - Zonal Mean SST change

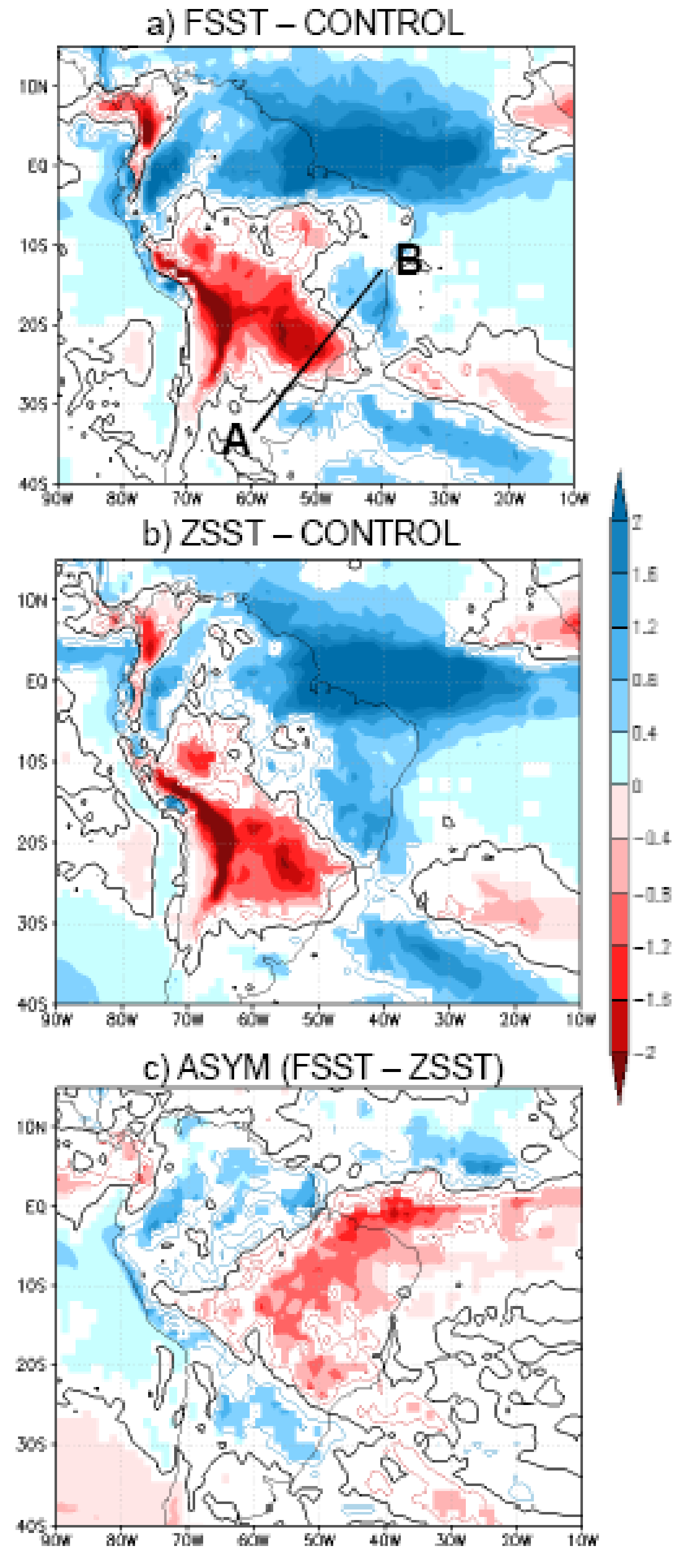


→ **Asymmetric signal**

Junquas et al. (2012b)

RAINFALL CHANGE IN SOUTH AMERICA (mm/day)

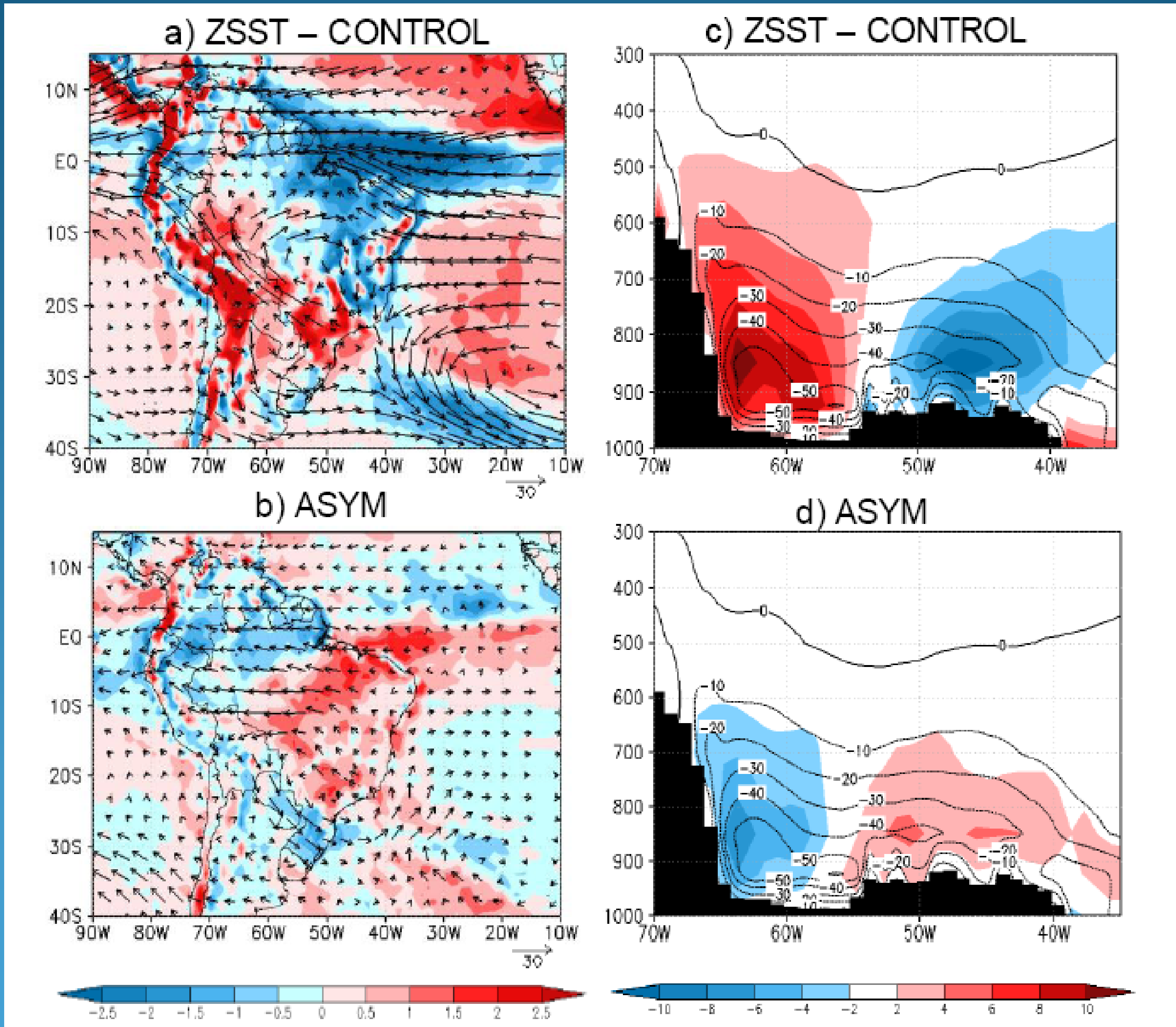




Junquas et al. (2012b)

Humidity flux vertically integrated between 1000 and 300 hPa

Vertical section of the humidity flux at 22°S



Junquas et al. (2012b)

Experiments of South America climate sensitivity to: SST changes in the tropical Oceans and South America

- Rainfall changes in South America can be explained as:

  - the response of the rainfall dipole structure to the zonally-asymmetric (or longitudinal) component of the SST change associated to a precipitation increase at the subtropical regions and a decrease over the SACZ region and further north

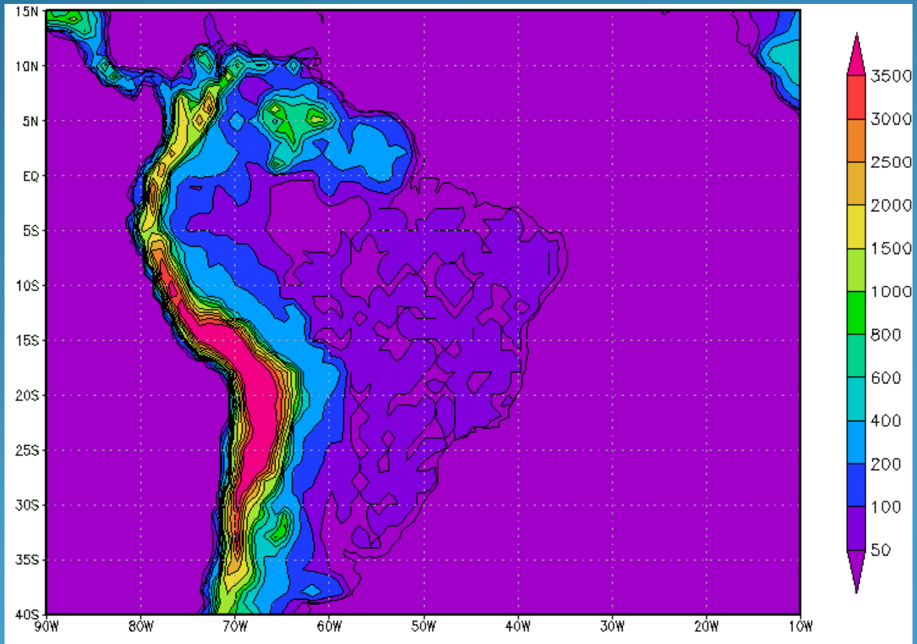
  - while the response to zonal-mean (or latitudinal) SST changes (including the global warming signal itself) shows an opposite contribution.

Experiments of South America climate sensitivity to Orography

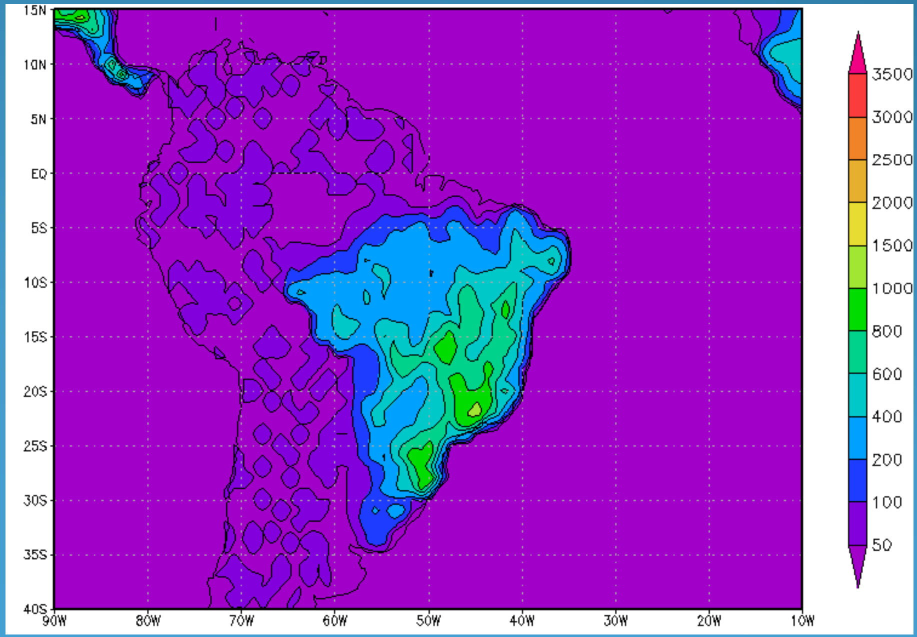
- 30-member of DJF simulations were performed with the LMDZ two-way nesting system:

1. with the brasilian plateau (BP) reduced to 50m (Andes-NoBP)
2. with the Andes moutains reduced to 50m (BP-NoAndes)

Andes-NoBP



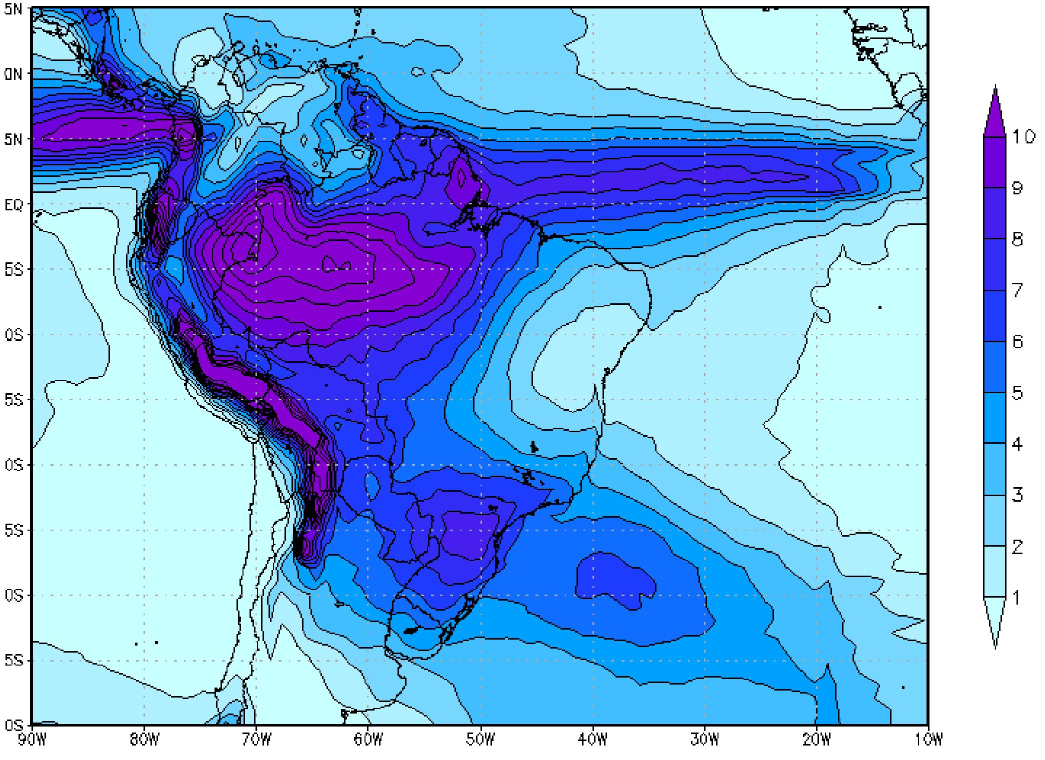
BP-NoAndes



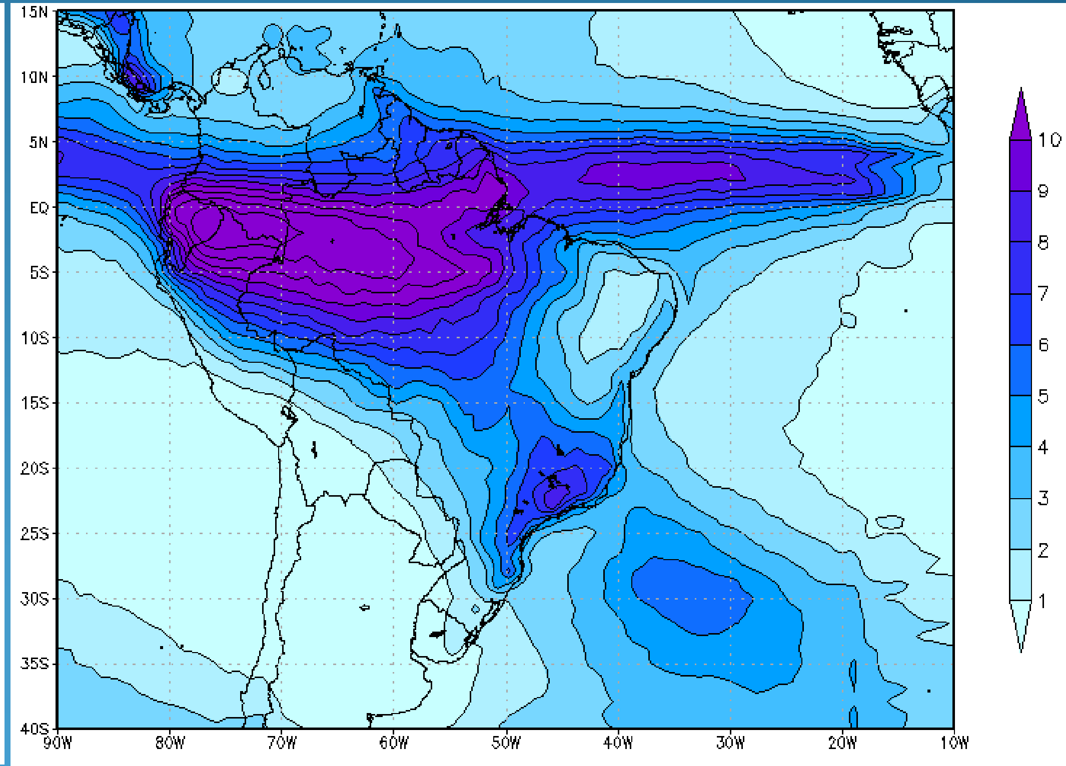
Junquas et al. (2012c)

Precipitation
(mm/day)

Andes-NoBP



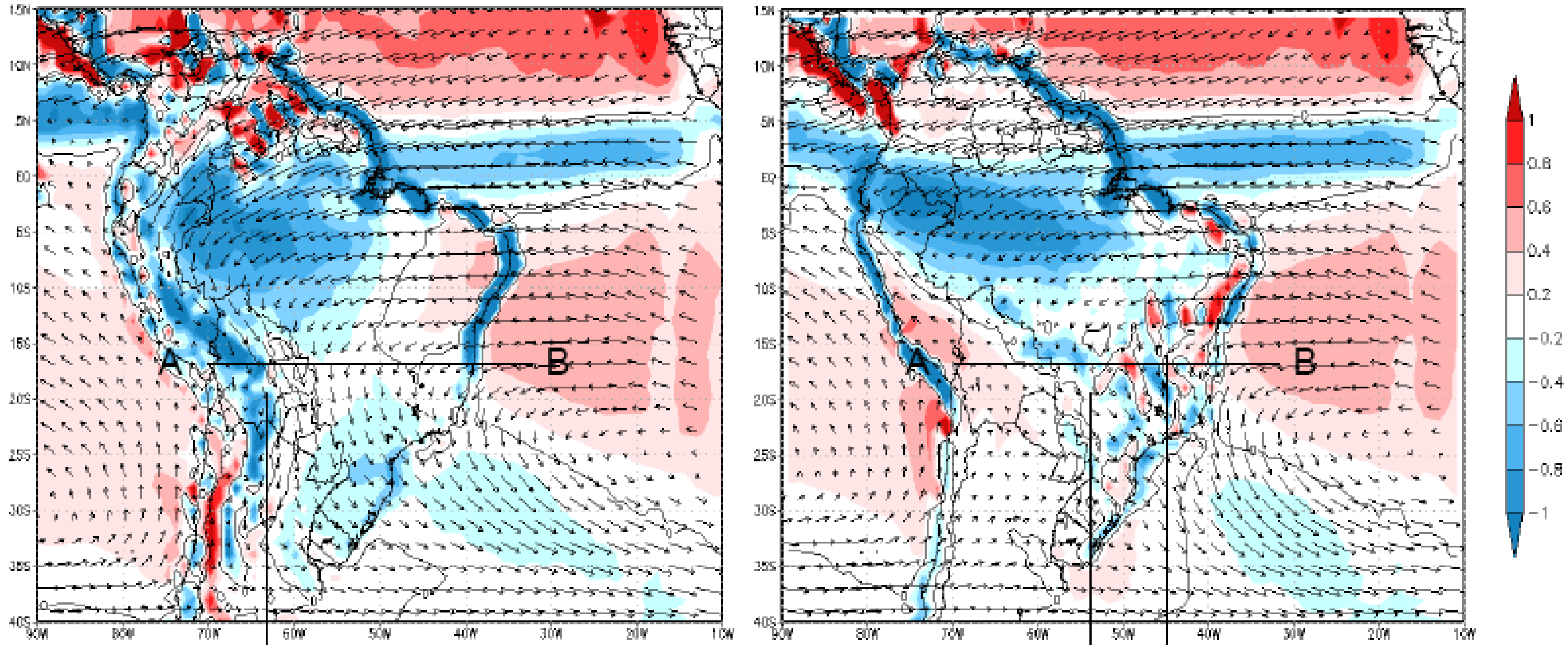
BP-NoAndes

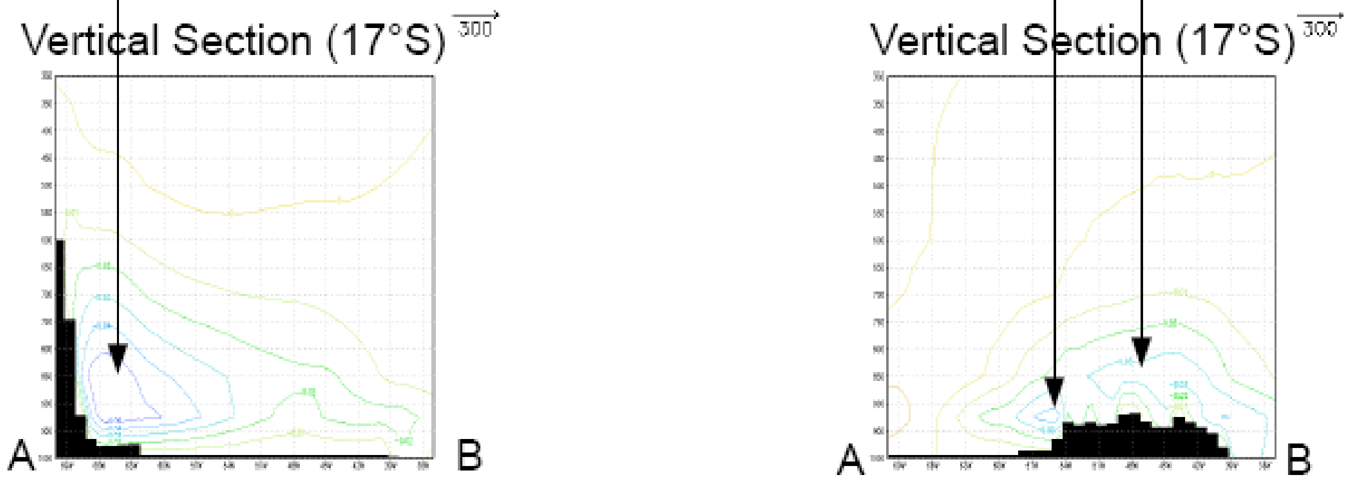


Junquas et al. (2012c)

Vertically integrated humidity flux and divergence
(blue=convergence,red=divergence)

Andes-NoBP **BP-NoAndes**





Junquas et al. (2012c)

Experiments of South America climate sensitivity to Orography

- Simulations show that the presence of BP without Andes, promotes moisture transport from tropical regions towards the continental SACZ region where precipitation is enhanced, while it decreases over SESA.

- The presence of the Andes without BP, induces a strong southward moisture transport into the subtropics so the continental SACZ maximum is shifted southward.

- The DJF precipitation associated to the oceanic SACZ component did not show significant differences in its location and structure, between the two simulations, although it seems to be more intensity in Andes-NoBP simulation.

FUTURE CHALLENGES

o A-O Coupled model simulations

o Better description of the full range of variability associated to SACZ (diurnal, synoptic, intraseasonal)