Confiabilidad e incertezas de los resultados del IPCC 2007 en Sudamérica

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The uncertainty of Climate Change

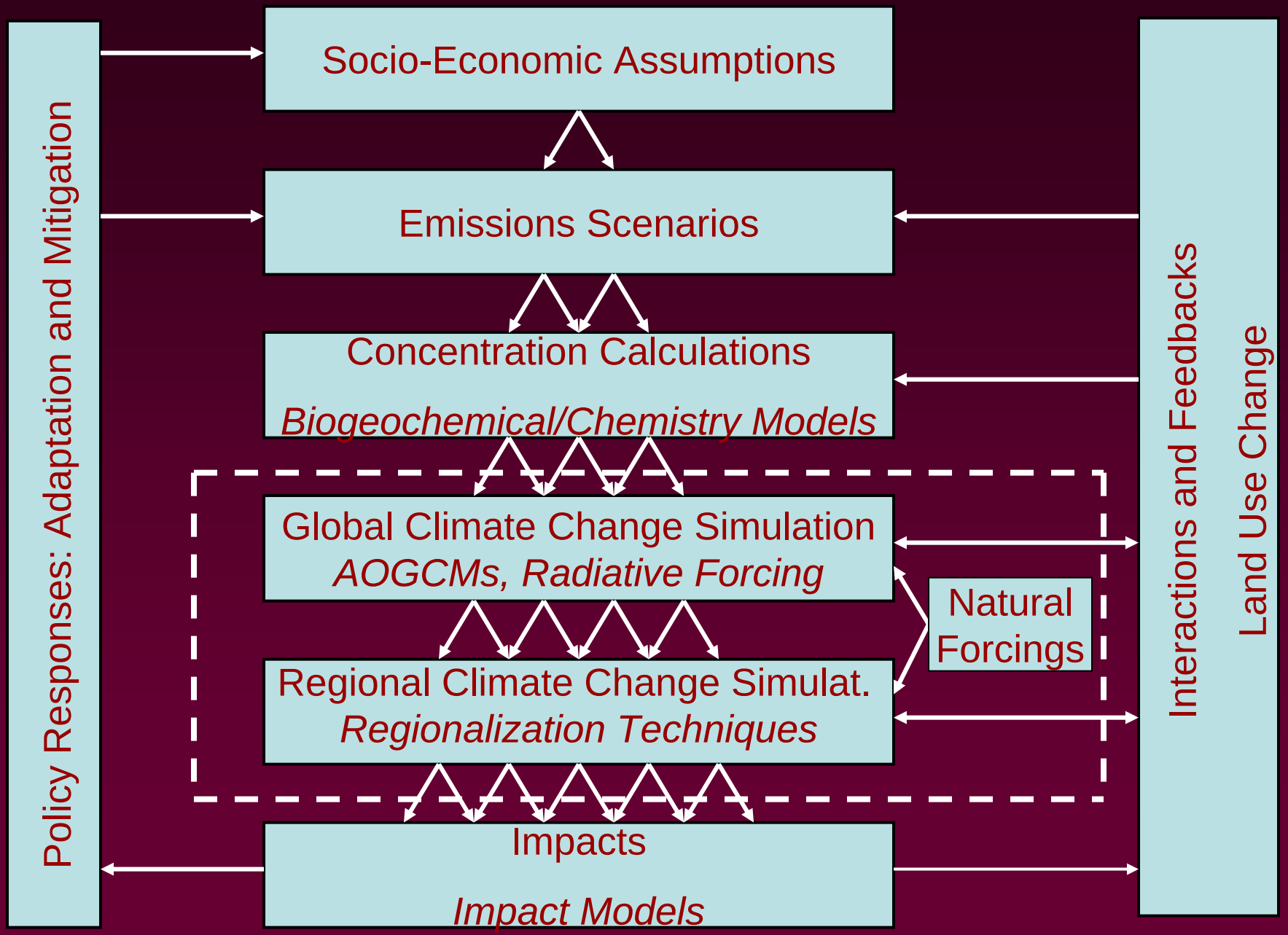
Because of:

- the internal variability and non-linearity of the climate system,
- the random component of the external natural and anthropogenic forcing,

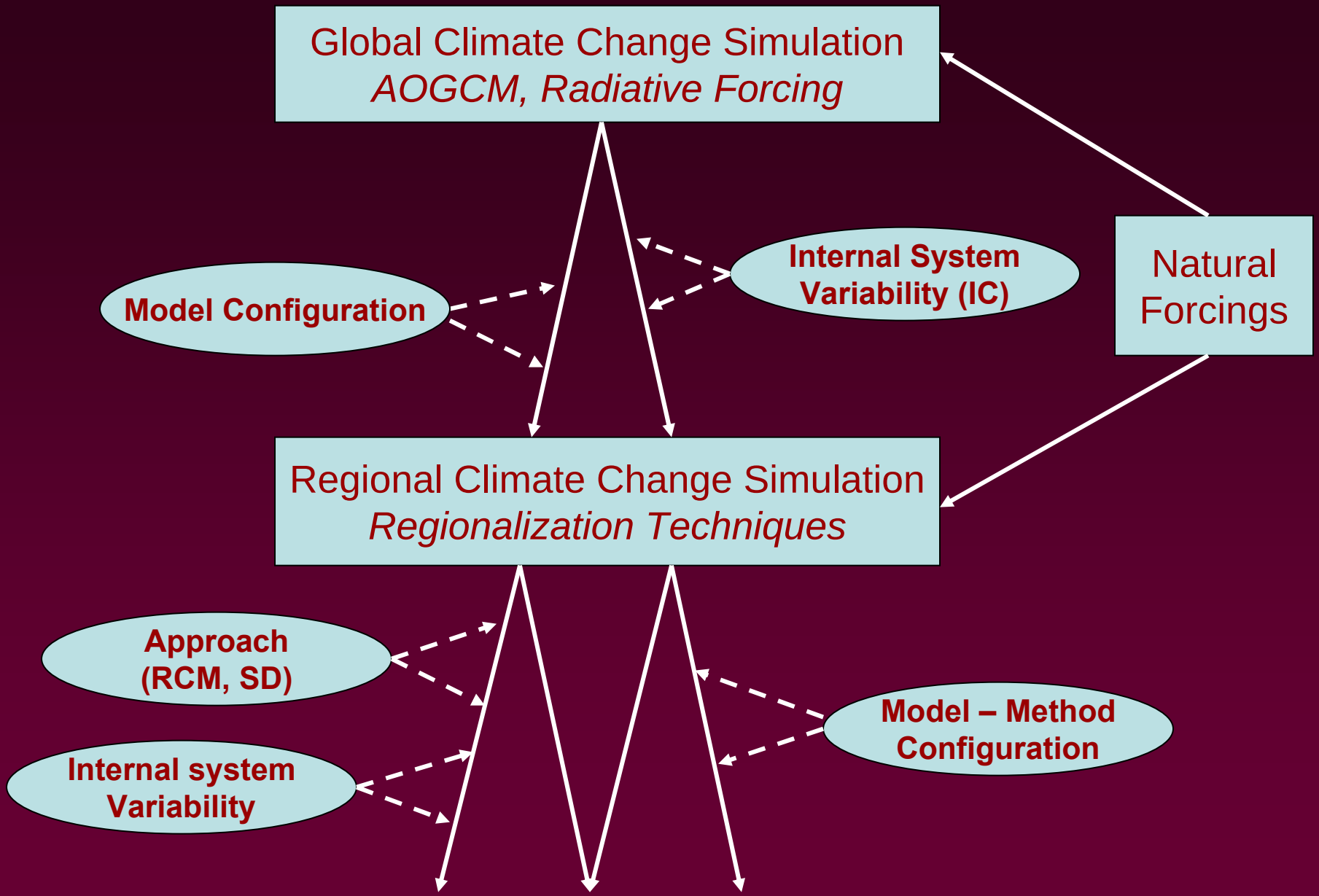
many future climate states are possible, each with a certain likelihood to occur.

Therefore, future climate change is characterized by an intrinsic level of uncertainty

Cascade of uncertainty in climate change prediction



Climate Simulation Segment of the Uncertainty Cascade



Global climate change simulations (1/3)

Global climate models (GCMs) are numerical representations of the fundamental equations that describe the behavior of the climate system and the interactions among its components (Atmosphere-Ocean-Cryosphere-Biosphere).

Global climate change simulations (2/3)

There is substantial uncertainty across models in the simulation of climate change, therefore a climate change prediction needs to be based on the compounded information from different models and methods and large ensembles of model simulations to cover the space of possible climate change pathways (scenarios, models/methods, initial conditions) .

Global climate change simulations (3/3)

For most of the countries the computation of an ensemble of global climate simulations is beyond the national computing capacities

International collaborations are essential!

The WCRP CMIP3 multi-model dataset: A new era in climate change research

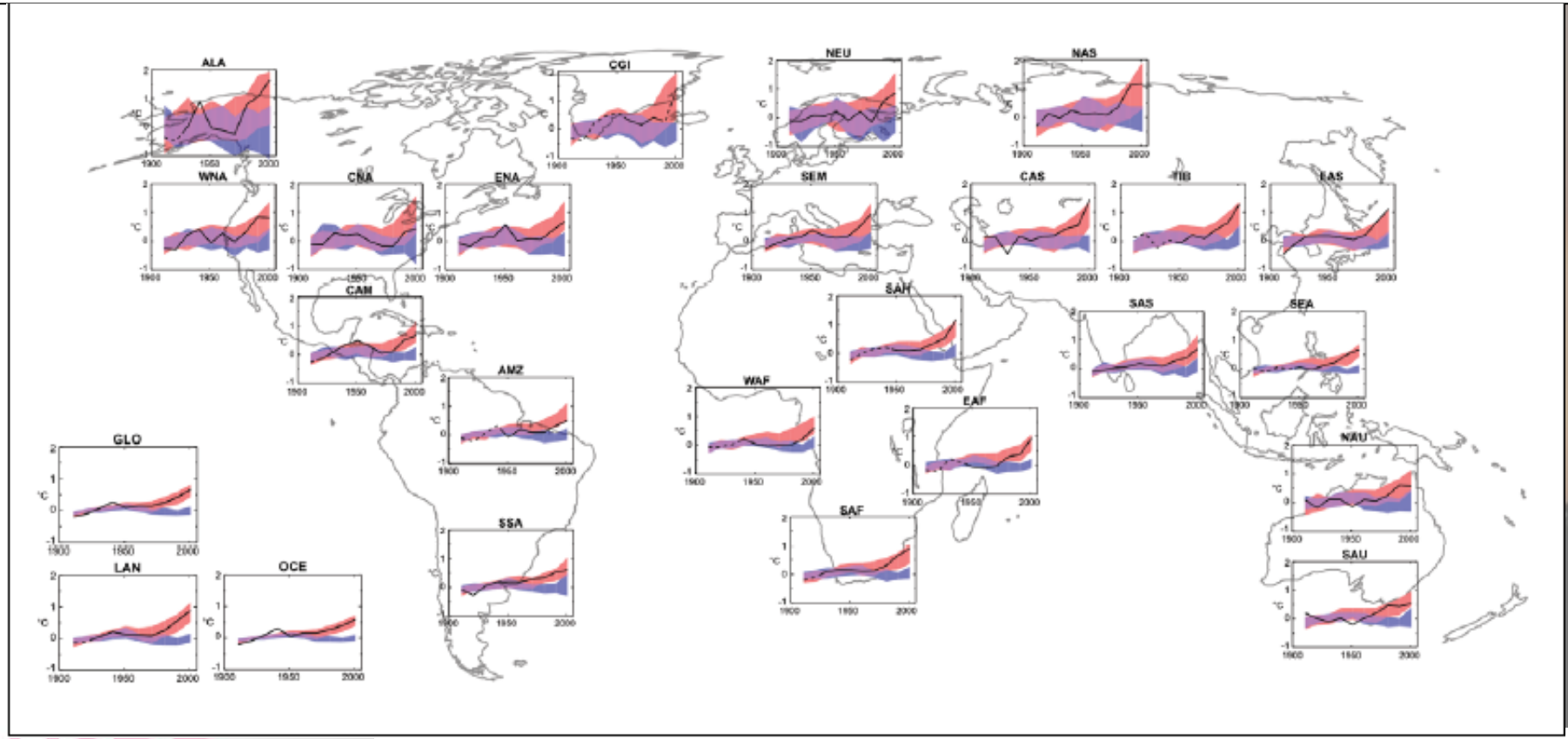
- International effort coordinated by the World Climate Research Program (**WCRP**) for the IPCC Fourth Assessment Report
- **24 Global Coupled Models** (Australia, Canada, China, France, Germany, Japan, Norway, Russia, UK, and USA)
- **Open and free usage for the global community**:
  - < 200 publications
  - < 1000 users
  - < 170 Tbytes downloaded
- It represents the **largest and most comprehensive international global coupled climate model experiment and multi-model analysis effort** ever attempted!

WCRP World Climate Research Programme

WMO IOC ICSU International Council for Science

IPCC-AR4: Climate change attribution

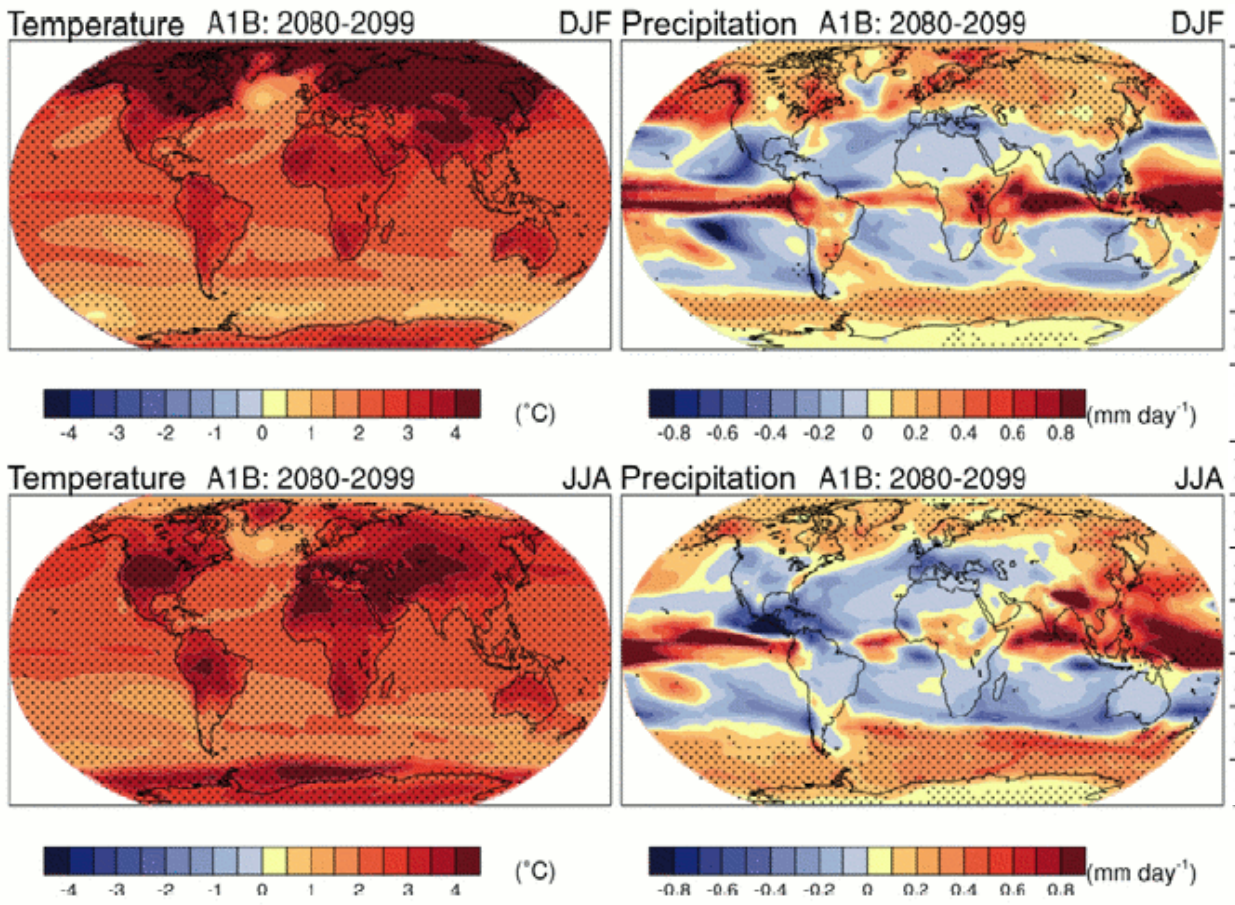
CGCM ability to simulate temperature evolution on continental scales and the detection of anthropogenic effects on each of six continents provides stronger evidence of human influence on the global climate than was available at the time of the TAR.

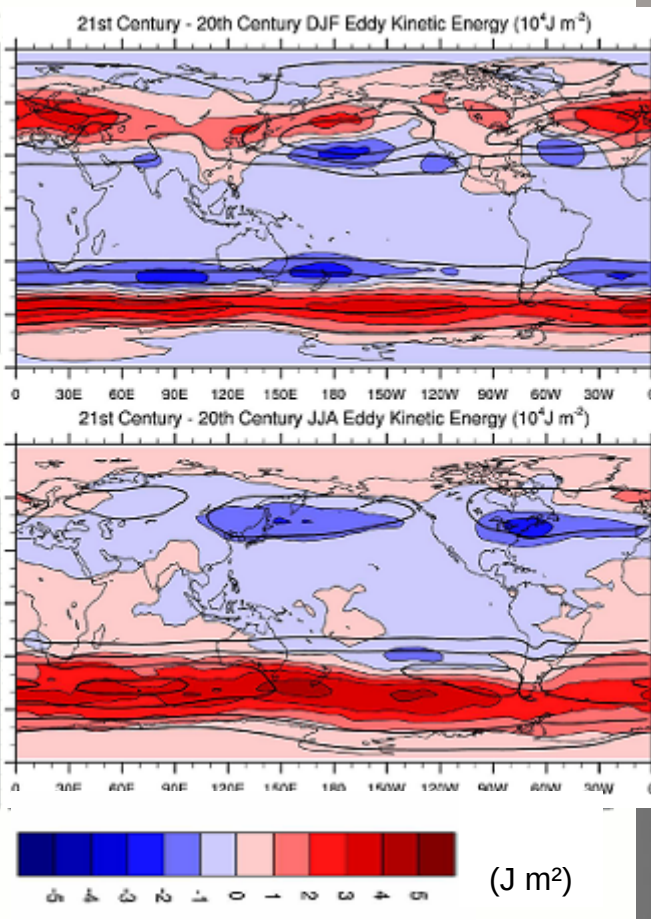


WCRP World Climate Research Programme

Black: Observations, Blue: 19 simulations from five climate models using only the natural forcings due to solar activity and volcanoes. Red: 58 simulations from 14 climate models using both natural and anthropogenic forcings.

IPCC-AR4 Projections of Climate Change





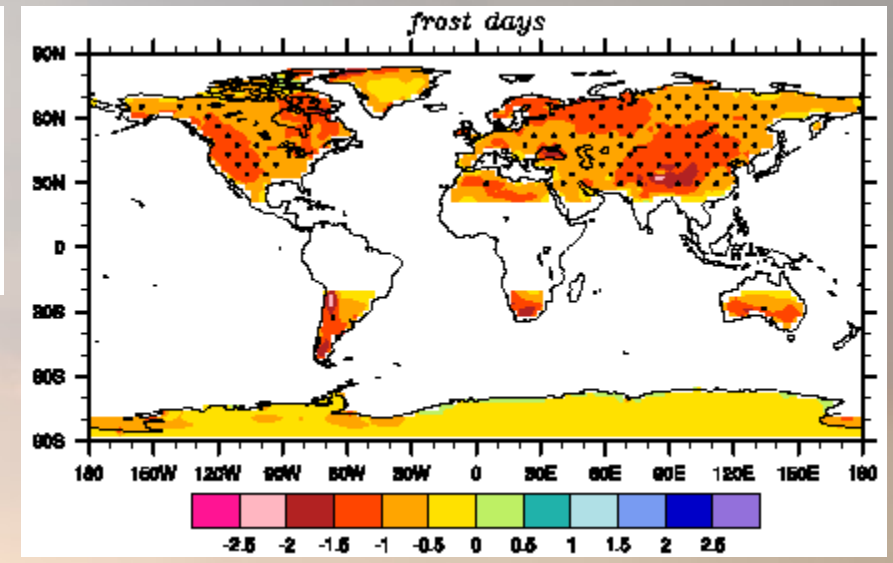
WCRP World Climate Research Programme

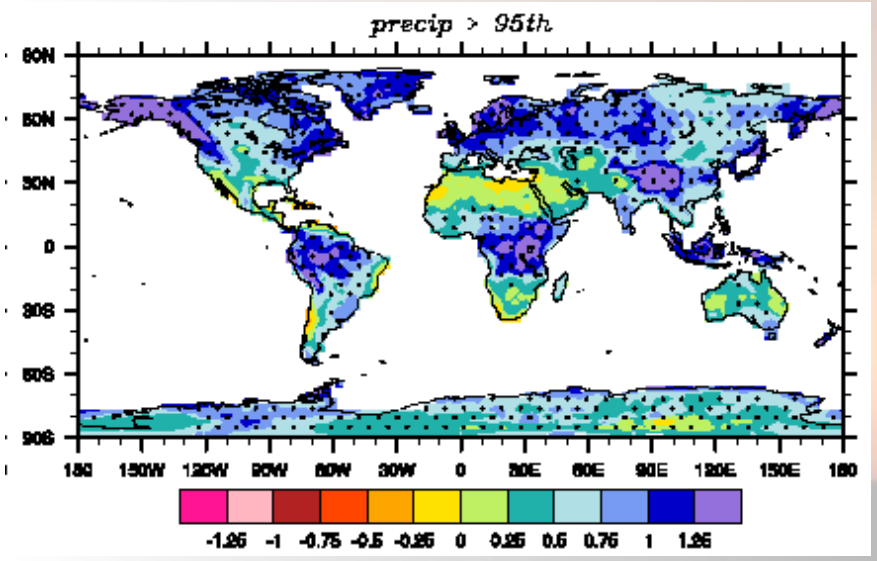
Relative changes in temperature, precipitation and storm tracks for the period 2080-2099 relative to 1980-1999 based on SRESA1B scenario

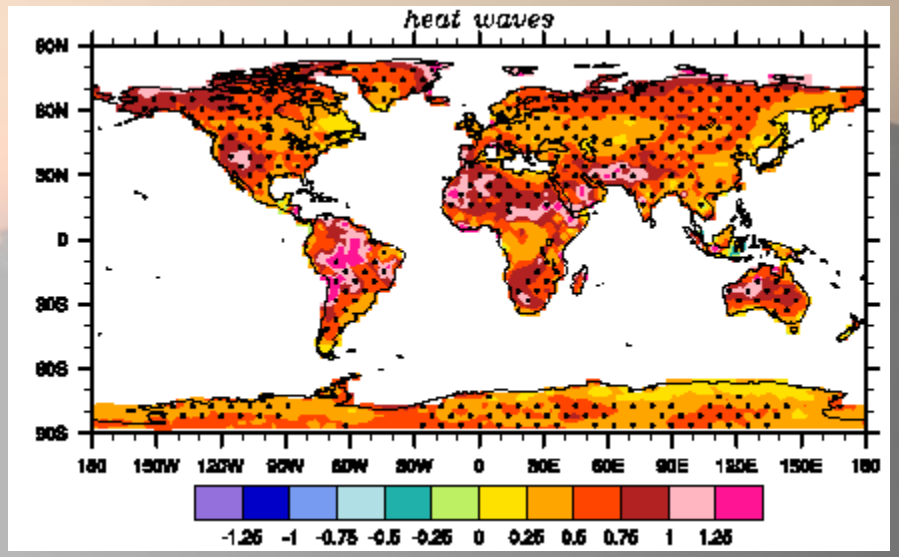
IPCC-AR4 Climate change projections of extremes

Multi-model averages of spatial patterns of change under A1B. Shown is the difference between two twenty-year averages (2080–2099 minus 1980–1999).

Stippled regions correspond to areas where at least 5 of 9 models concur in determining that the change is statistically significant.





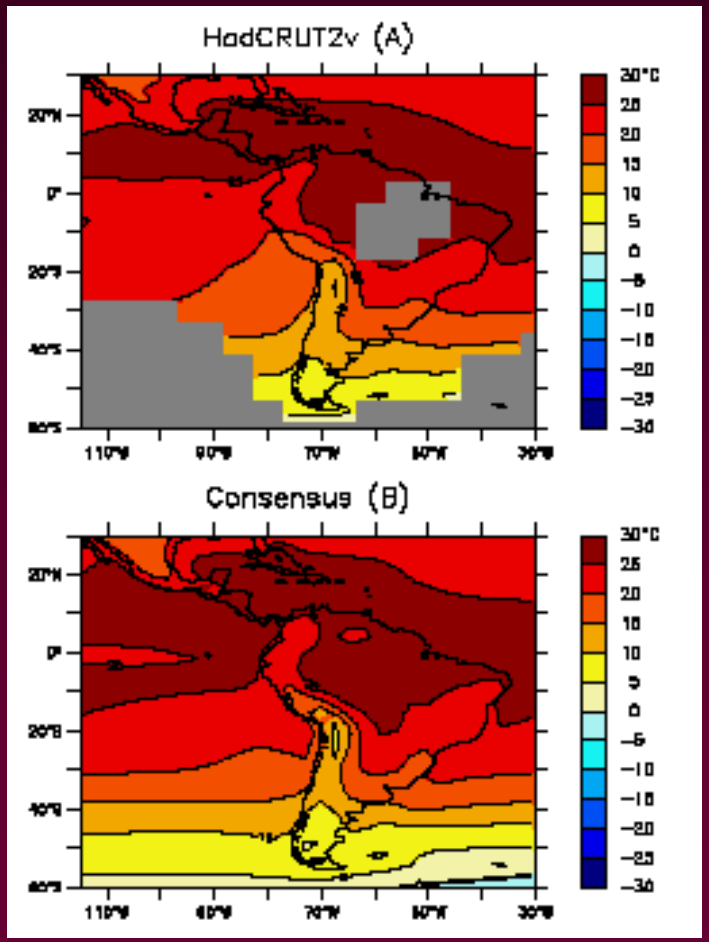


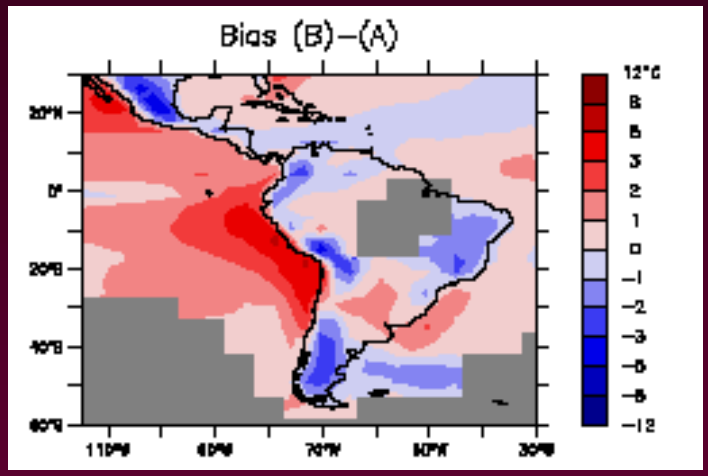
Tebaldi et al. 2006, IJCL

WCRP
World Climate Research Programme

Climate simulations in South America from IPCC-AR4 Models

Annual mean surface temperature





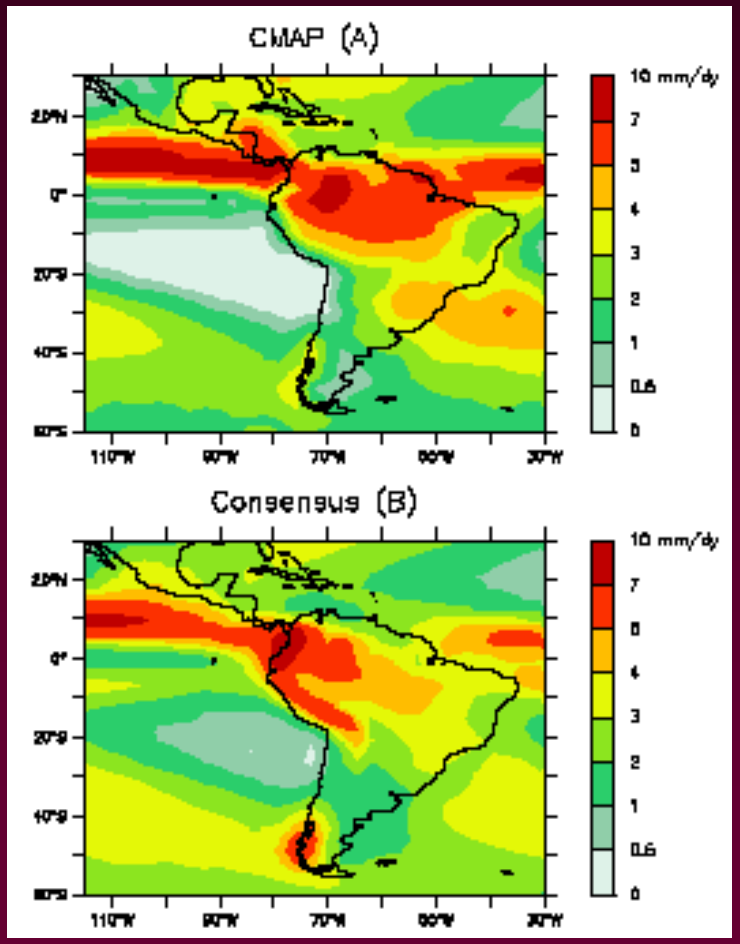
(A) Observations from HadCRUT2v (Jones et al., 2001)

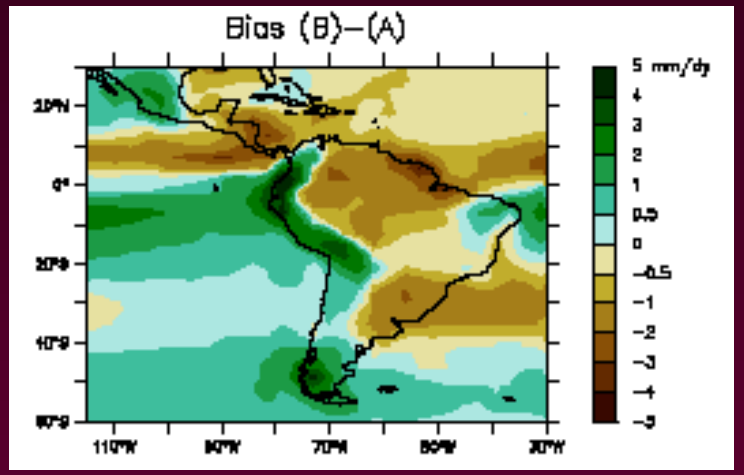
(B) Multi-model ensemble mean (21 Models)

Units °C.

Climate simulations in South America from IPCC-AR4 Models

Mean annual precipitation



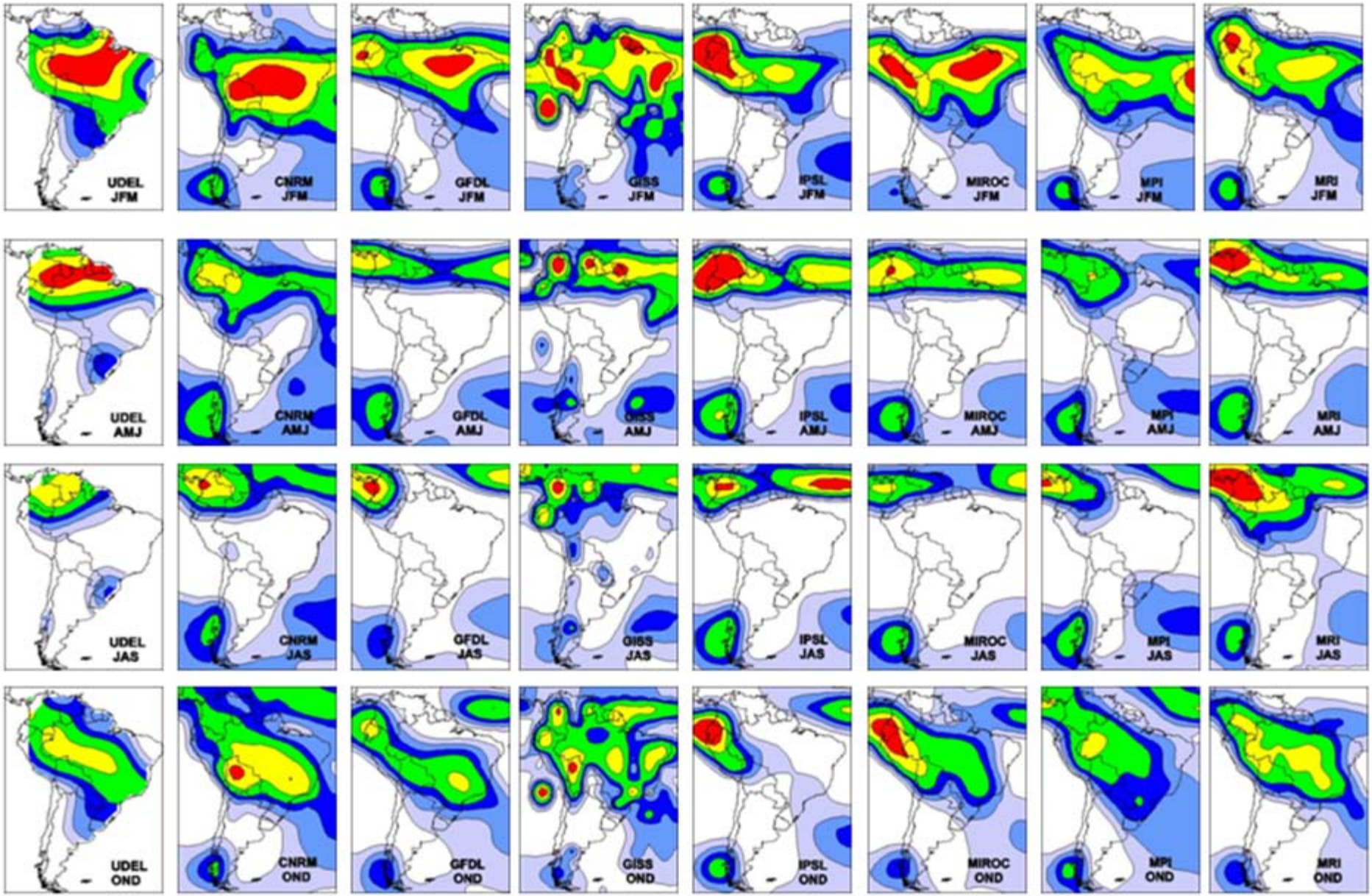


(A) Observations from CMAP (Xie and Arkin 1997)

(B) Multi-model ensemble mean (21 Models)

Units mm/day

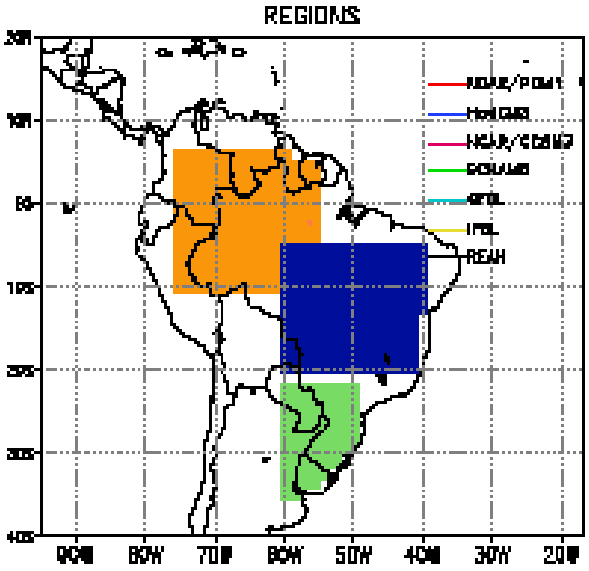
Climatological mean seasonal cycle of precipitation (Observations and IPCC-AR4 models)

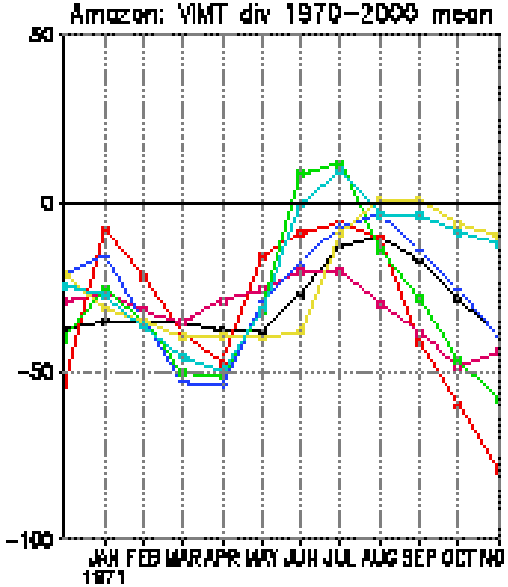


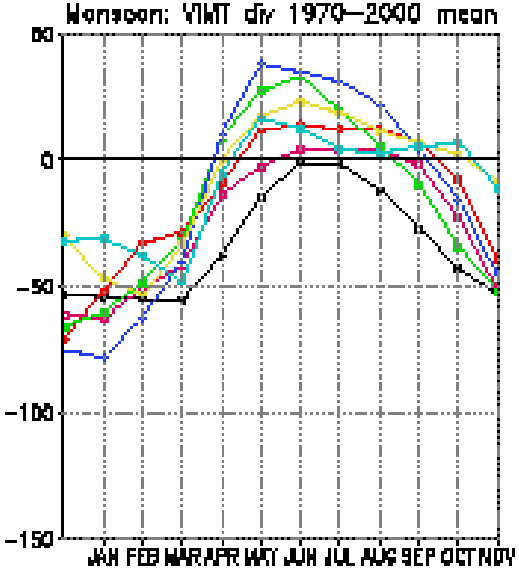
(1970-1999 period)

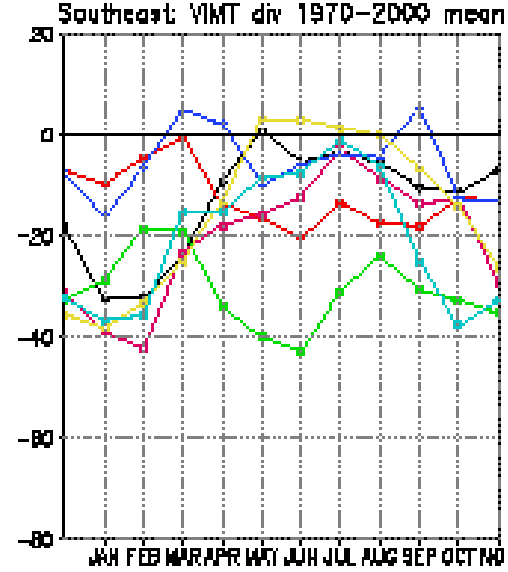
(Vera et al., 2006, GRL)

Convergence of vertically integrated moisture fluxes (Observations and IPCC-AR4 models)



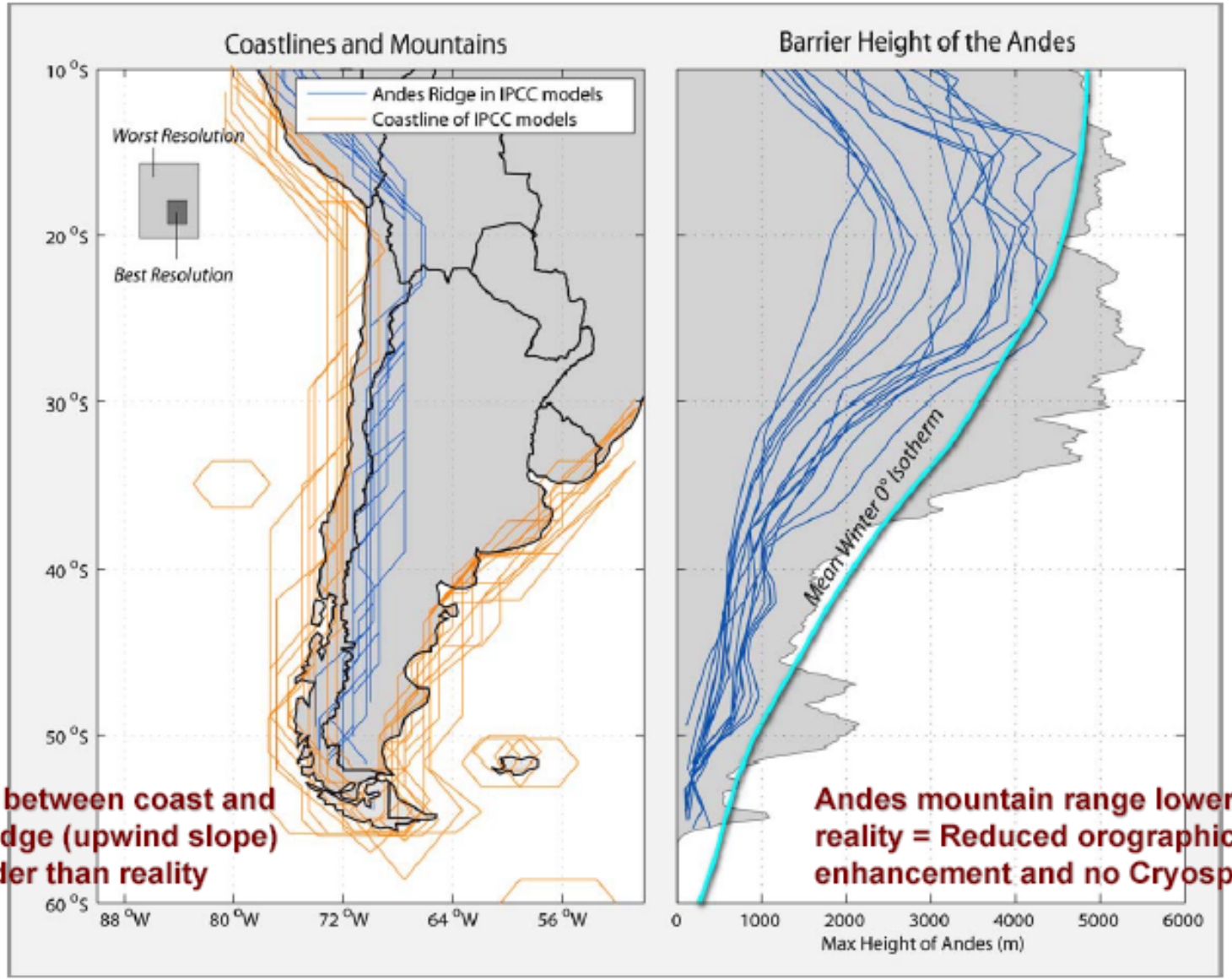






Rojas et al (2007)

Representation of terrain features

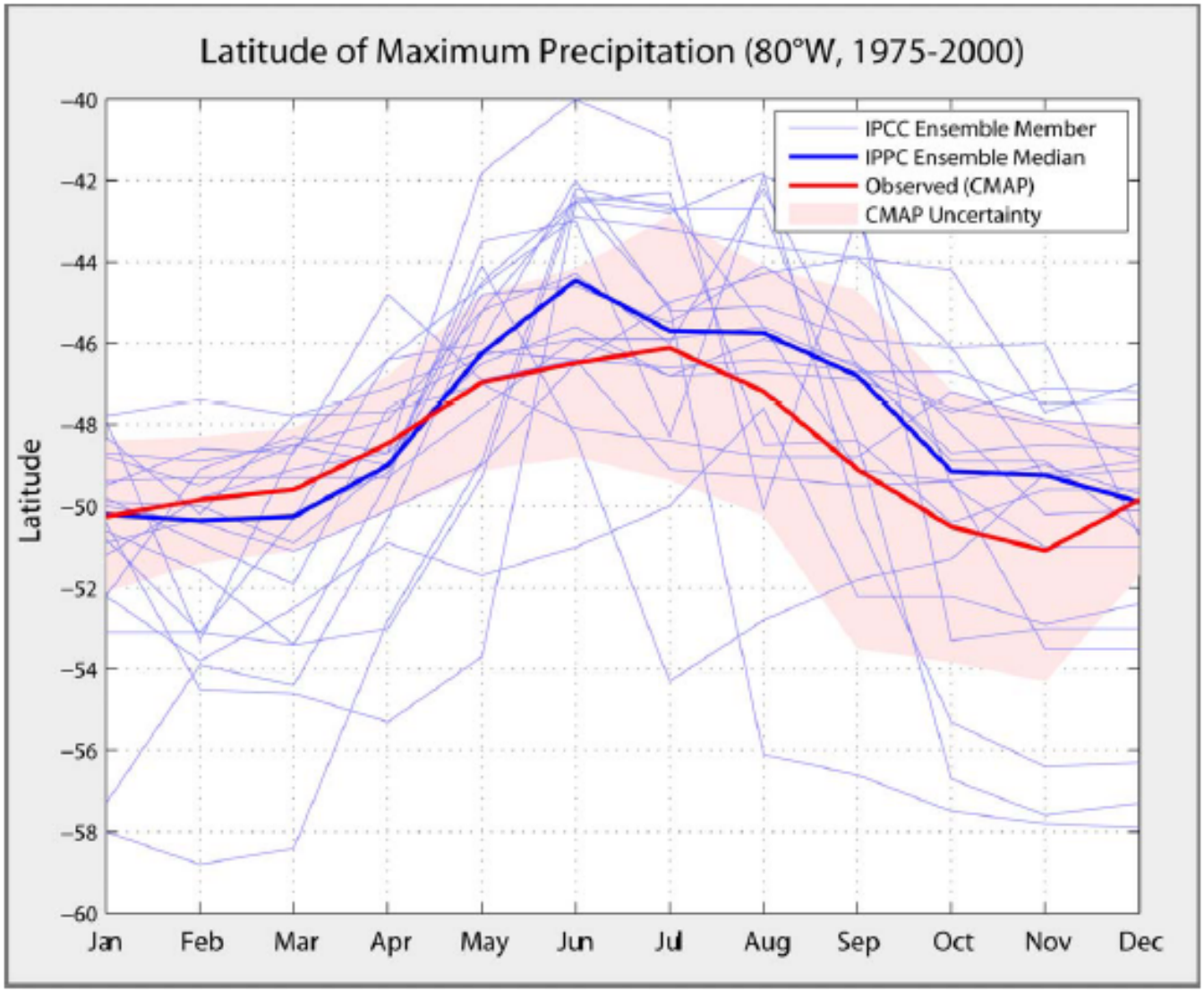


Distance between coast and Andes Ridge (upwind slope) much wider than reality

Andes mountain range lower than reality = Reduced orographic enhancement and no Cryosphere

Falvey et al (2007)

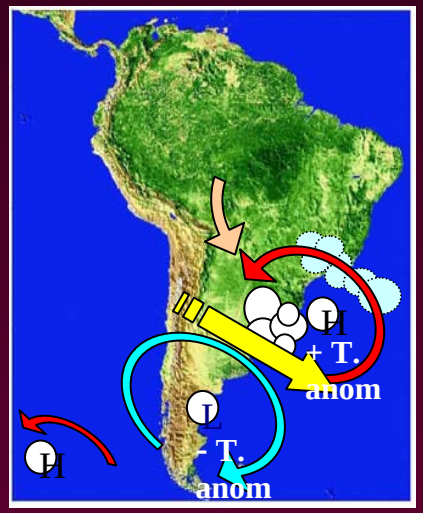
Seasonal variations of “Storm-tracks” at the extratropics

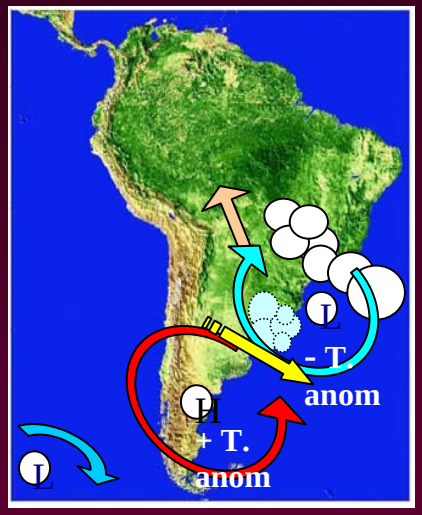


Falvey et al (2007)

Intraseasonal variability (20-70 days)

Typical circulation features of the SAMS accompany wet and dry conditions over Southeastern South America (e.g.Nogues-Paegle and Mo 1997, Diaz and Aceituno 2003)

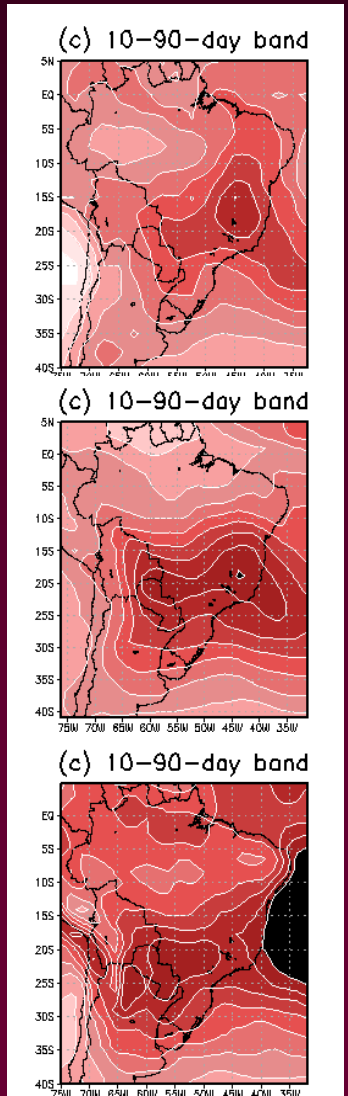




González, Vera, Carril (2007)

Standard Deviation of daily (10-90 days) Filtered OLR

Nov-Mar (1979-1999)



OBS

GFDL

MPI

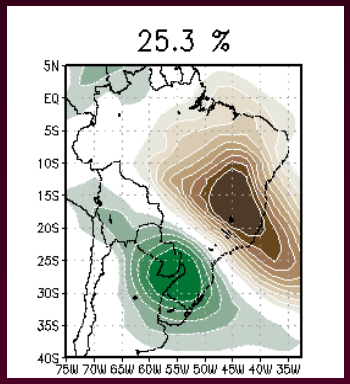
Intraseasonal variability (20-70 days)

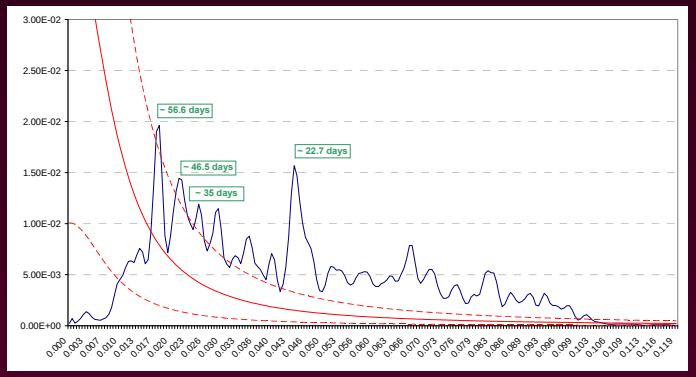
EOF-1 (10-90 days) Filtered OLR

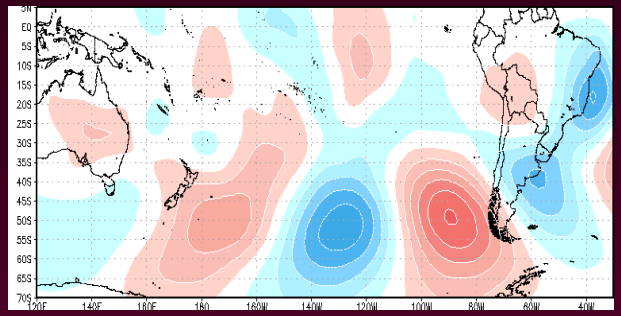
EOF-1 Spectral Density

Regressions EOF-1 & 200-hPa v´

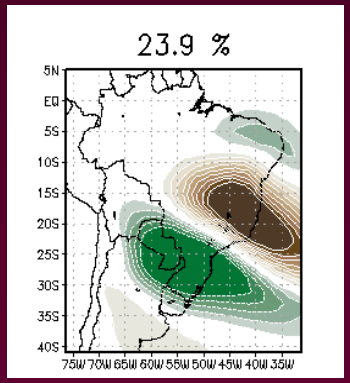
OBS

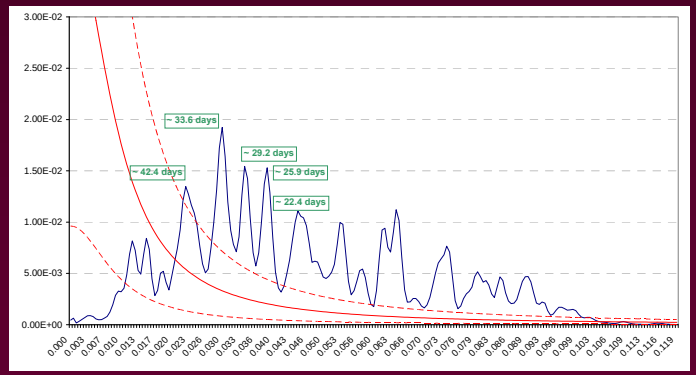


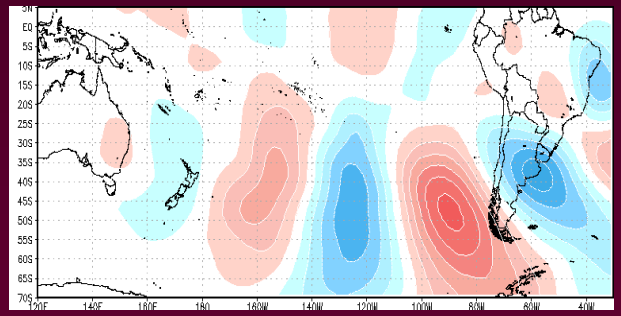




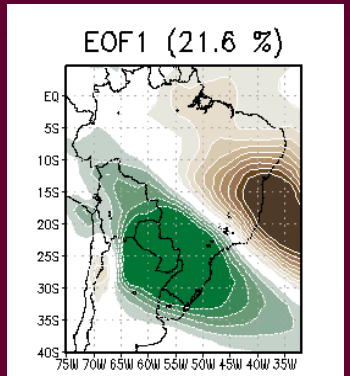
GFDL

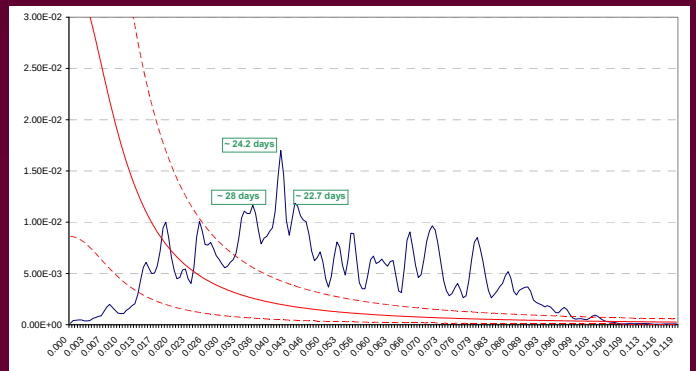


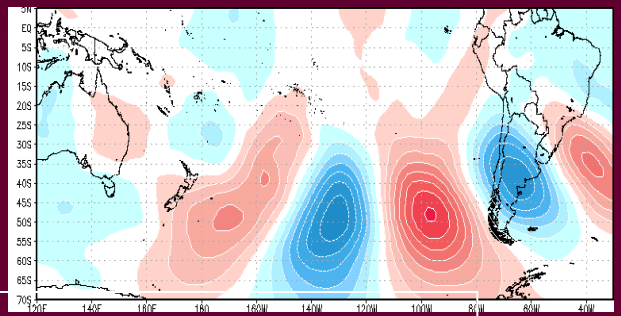




MPI







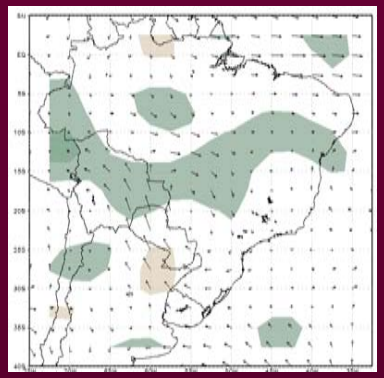
González, Vera, Carril (2007)

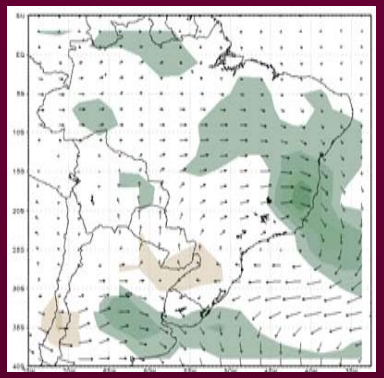
NCEP/NCAR

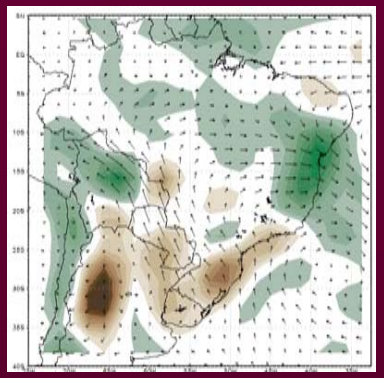
GFDL

MPI

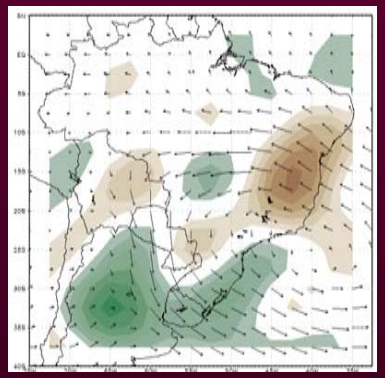
Day -10

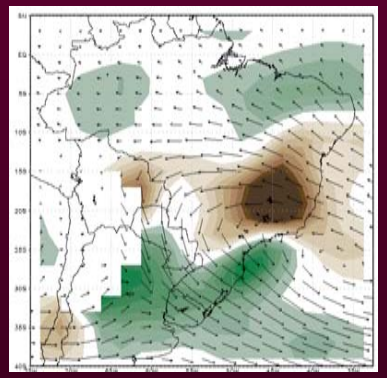


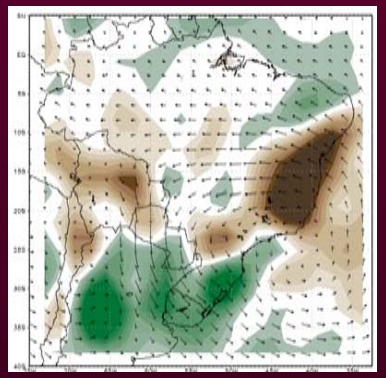




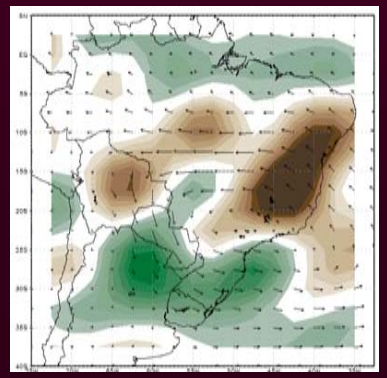
Day -5

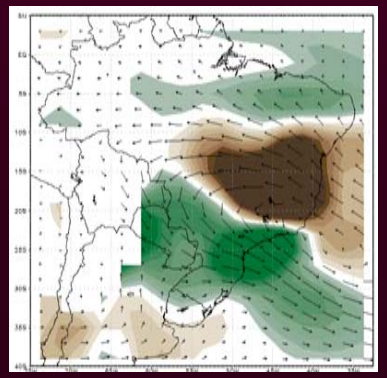


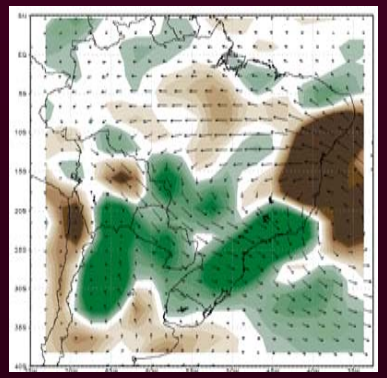




Day 0







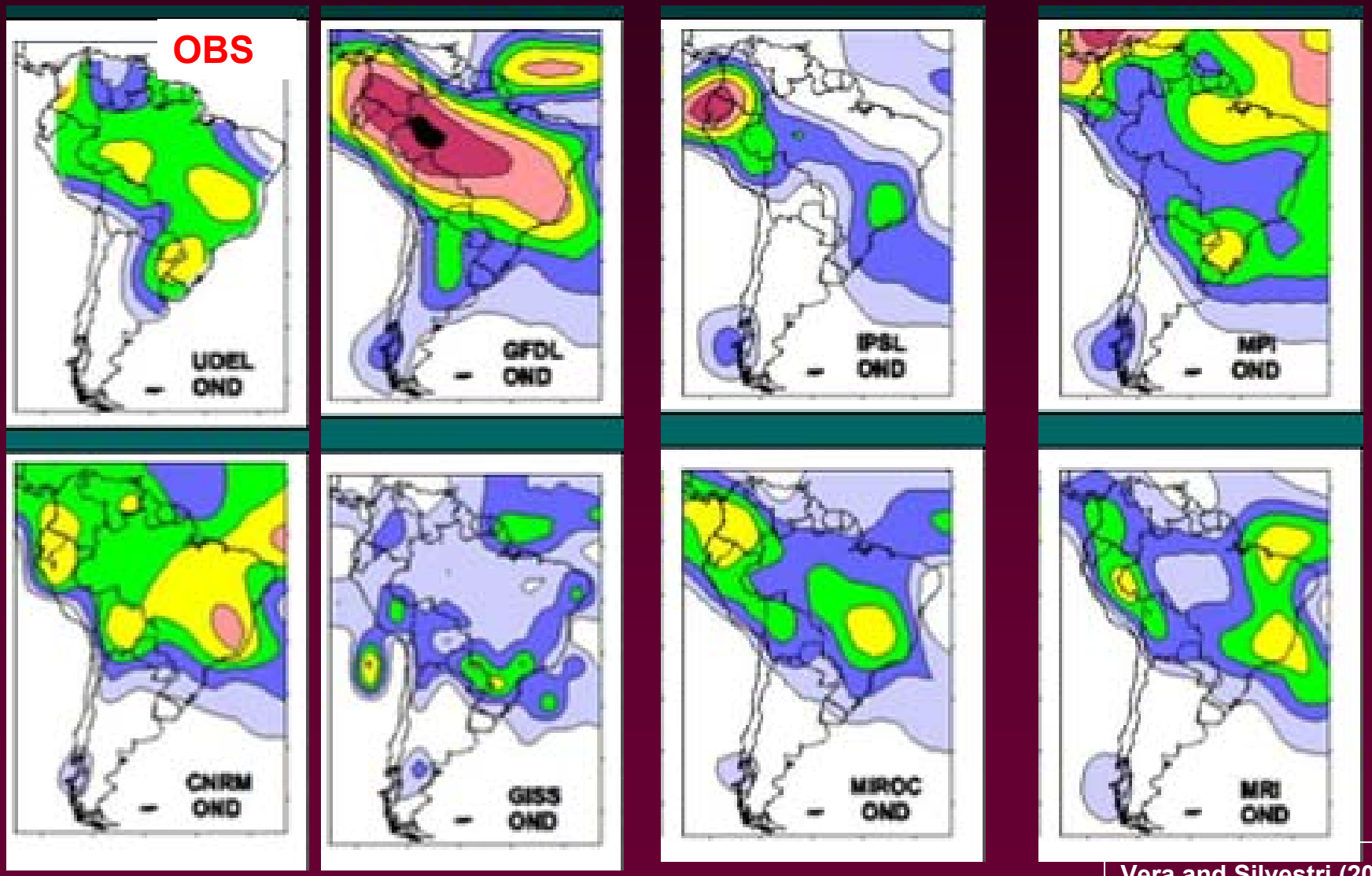
Regressions
EOF-1 & 850-hPa v´

(Divergence shaded)

González, Vera, Carril (2007)

Precipitation Interannual Variability

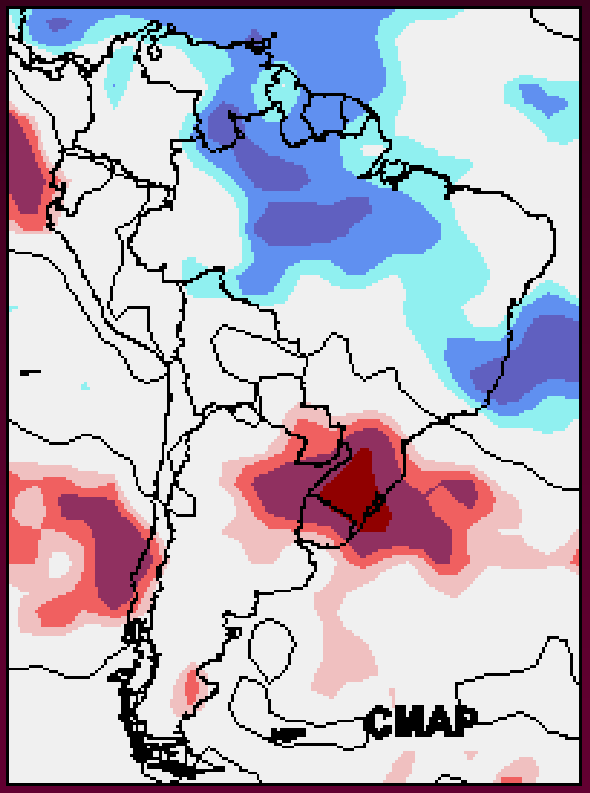
Oct-Nov-Dic (1970-1999)

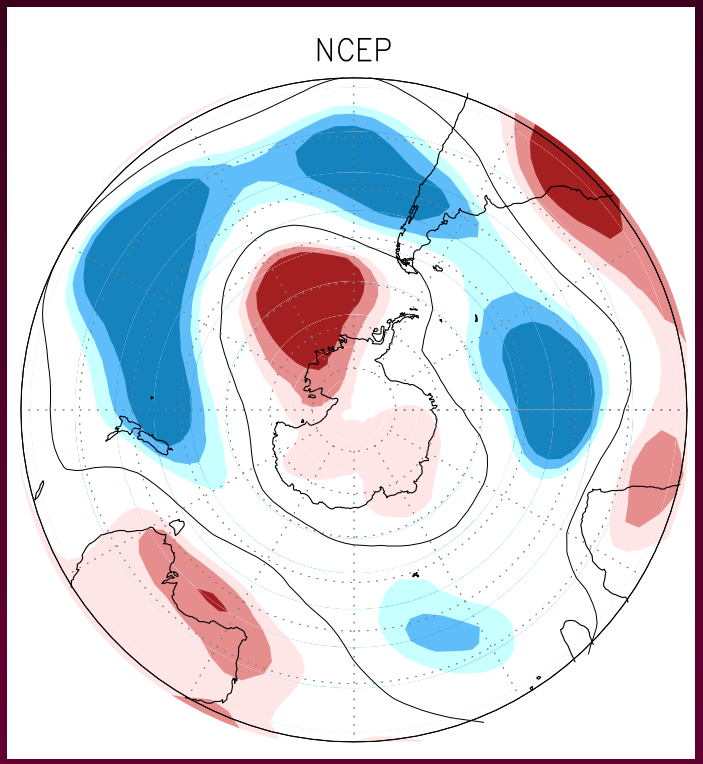


Vera and Silvestri (2007)

Observed ENSO signature

OND (1979-1999)

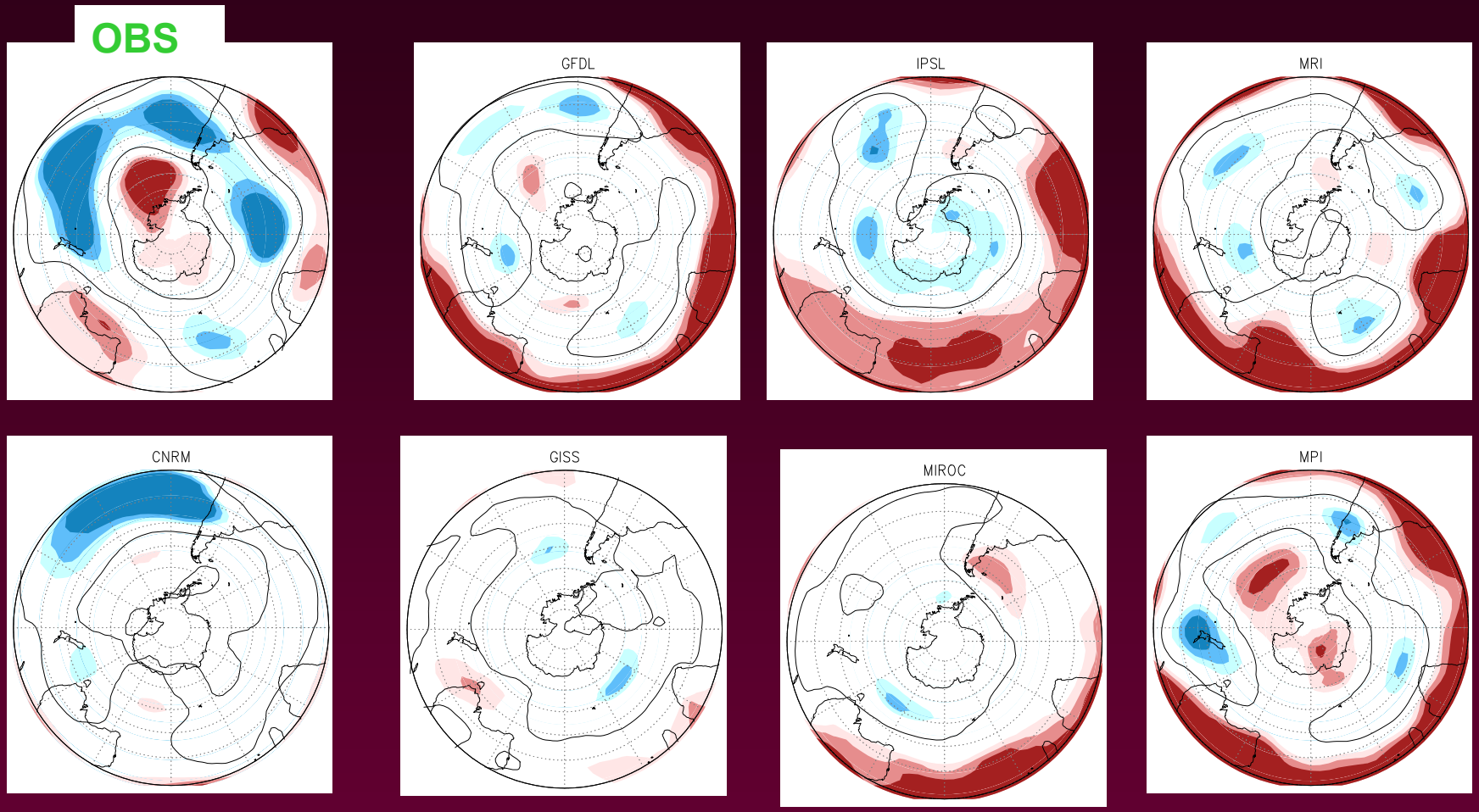




Correlations between ElNino3.4 SST anomalies and (left) precipitation and (right) 500-hPa geopotential height anomalies. Significant values at 90, 95 and 99% are shaded. NCEP reanalysis data.

(Vera and Silvestri 2007)

ENSO signal in SH Circulation anomalies from IPCC-AR4 models

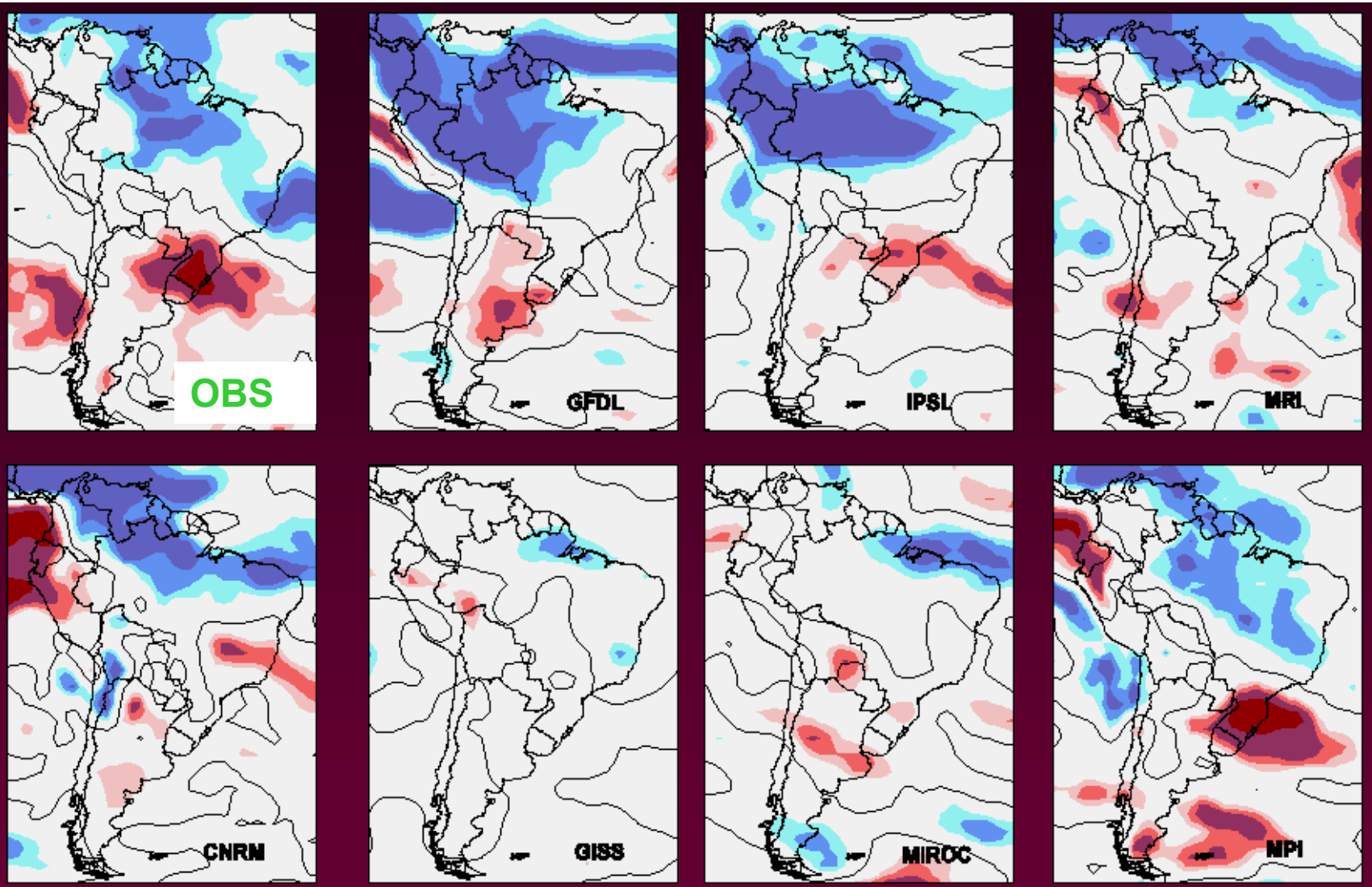


OND (1970-1999)

Correlations between ENSO index and 500-hPa geopotential height anomalies. Significant values at 90, 95 and 99% are shaded.

(Vera and Silvestri 2007)

ENSO signal in South America precipitation anomalies from IPCC models

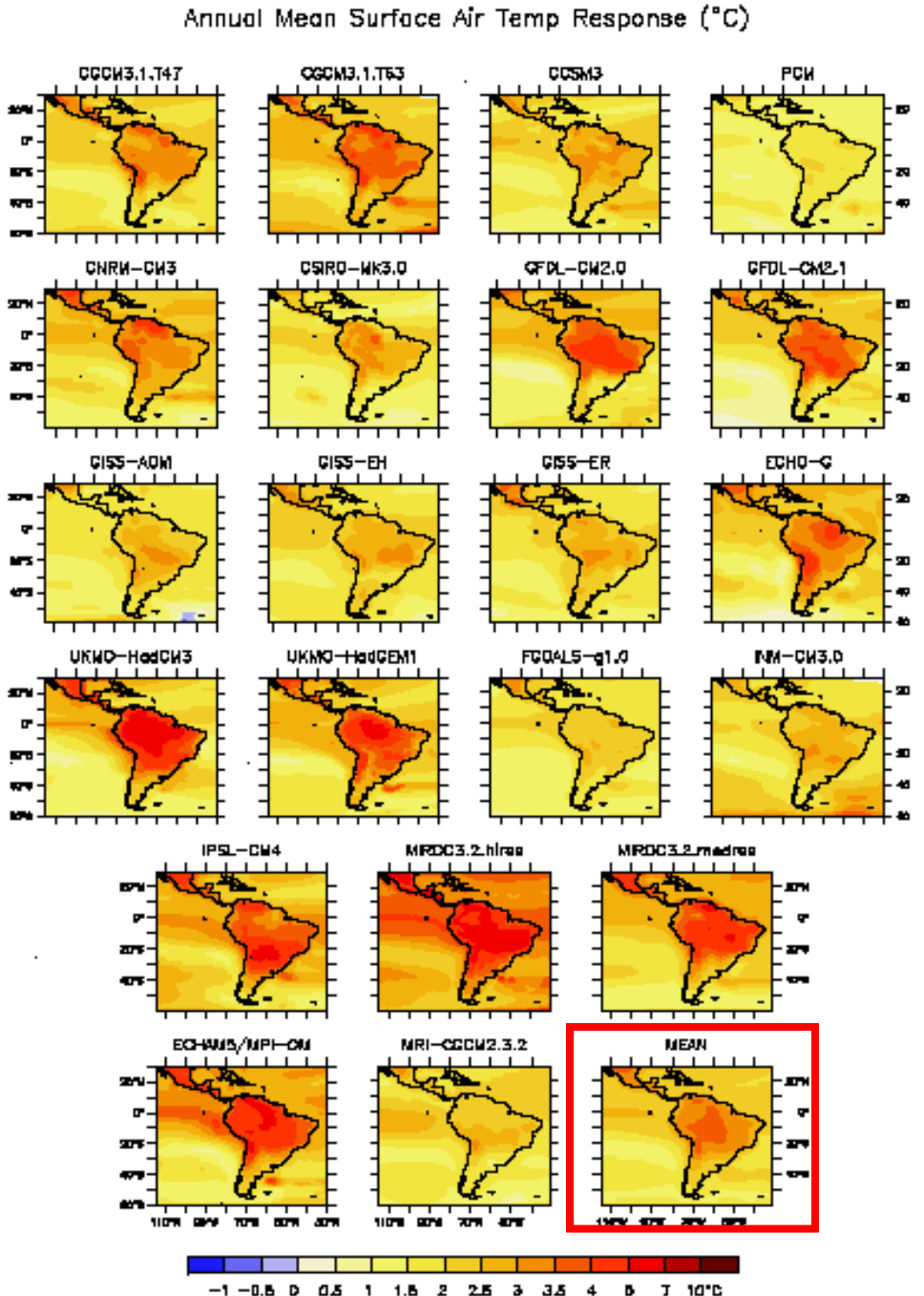


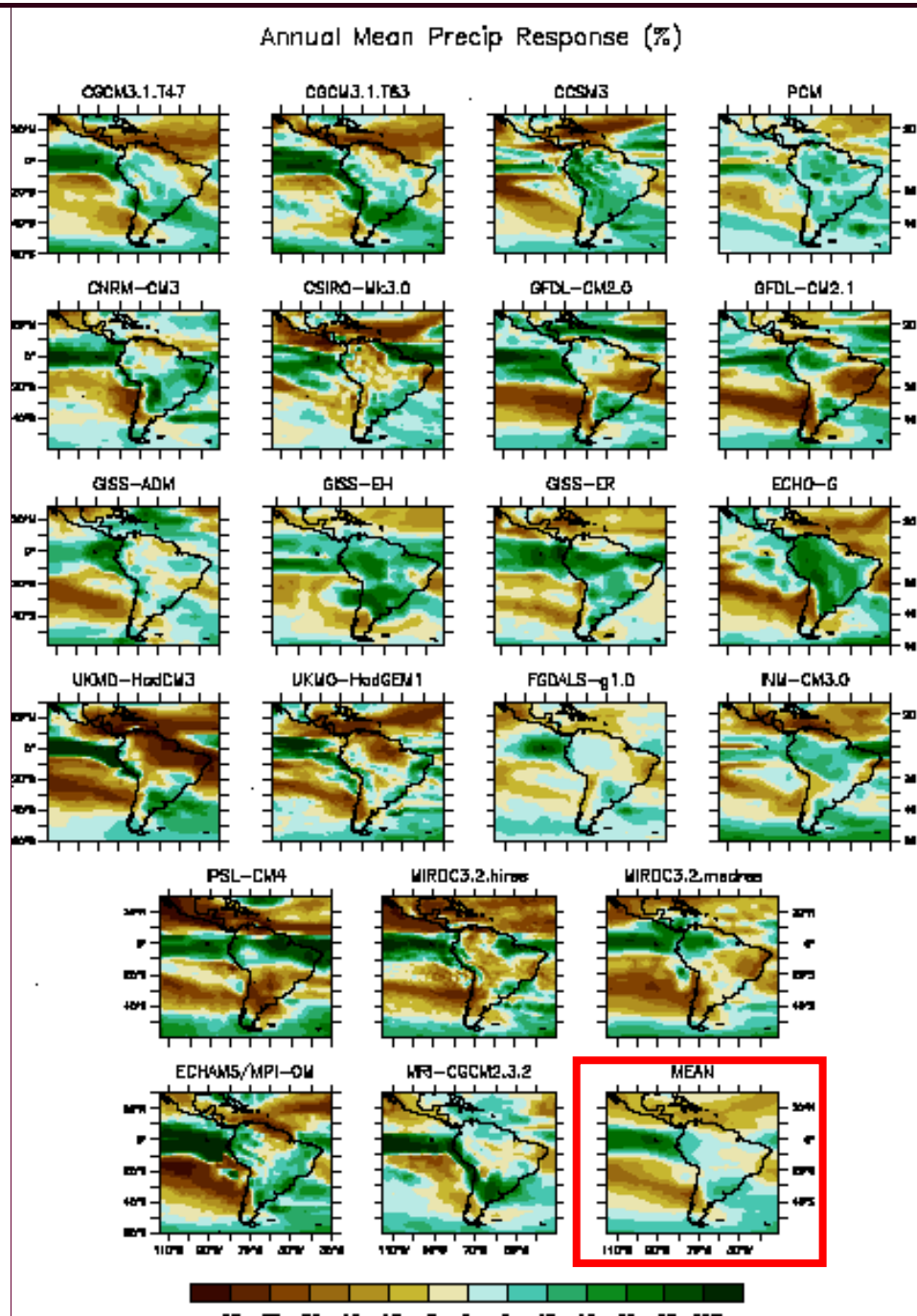
OND (1970-1999)

Correlations between ENSO index and precipitation anomalies. Significant values at 90, 95 and 99% are shaded.

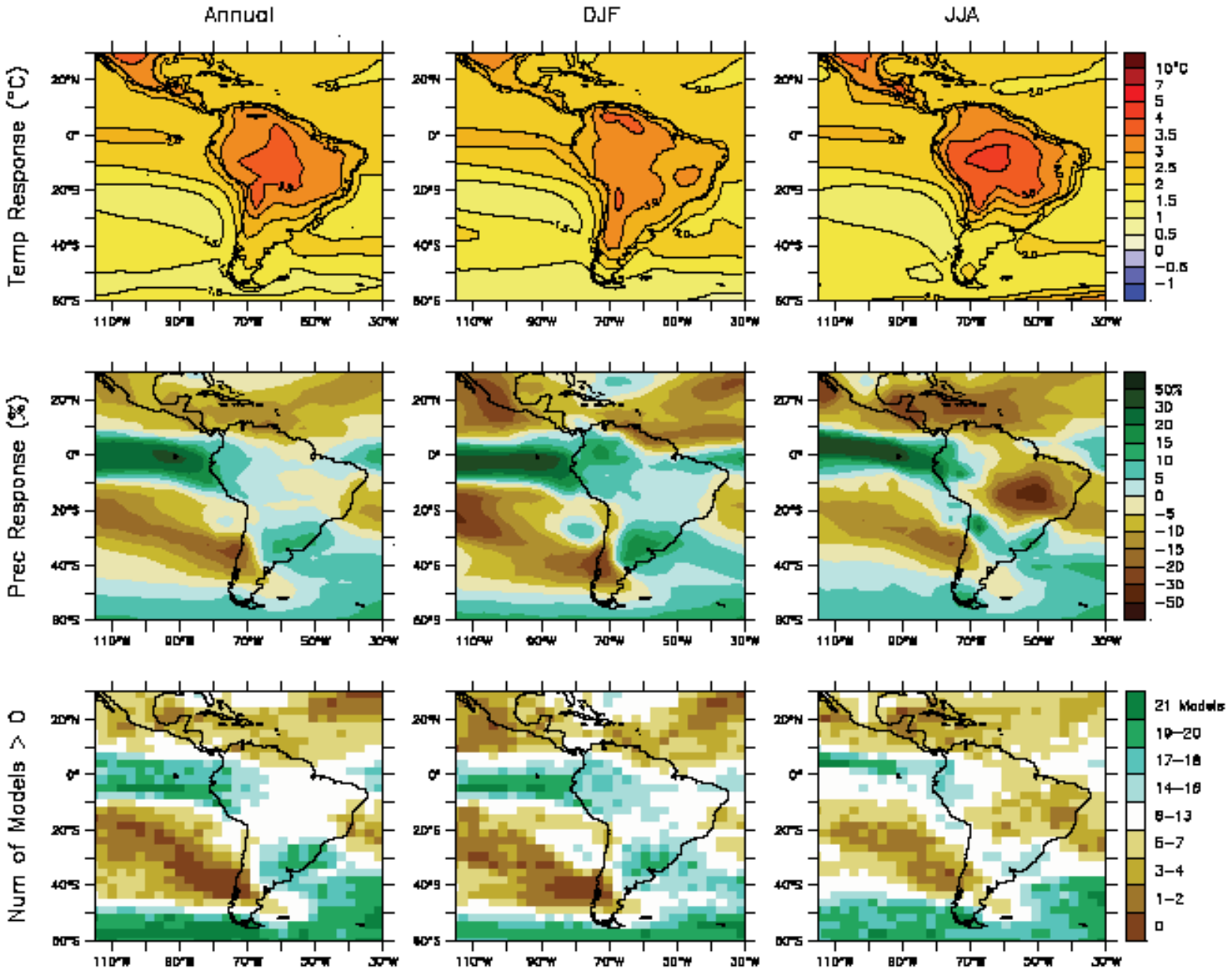
(Vera and Silvestri, 2007)

Temperature and precipitation changes (2080-2099)-(1980-1999). SRES A1B



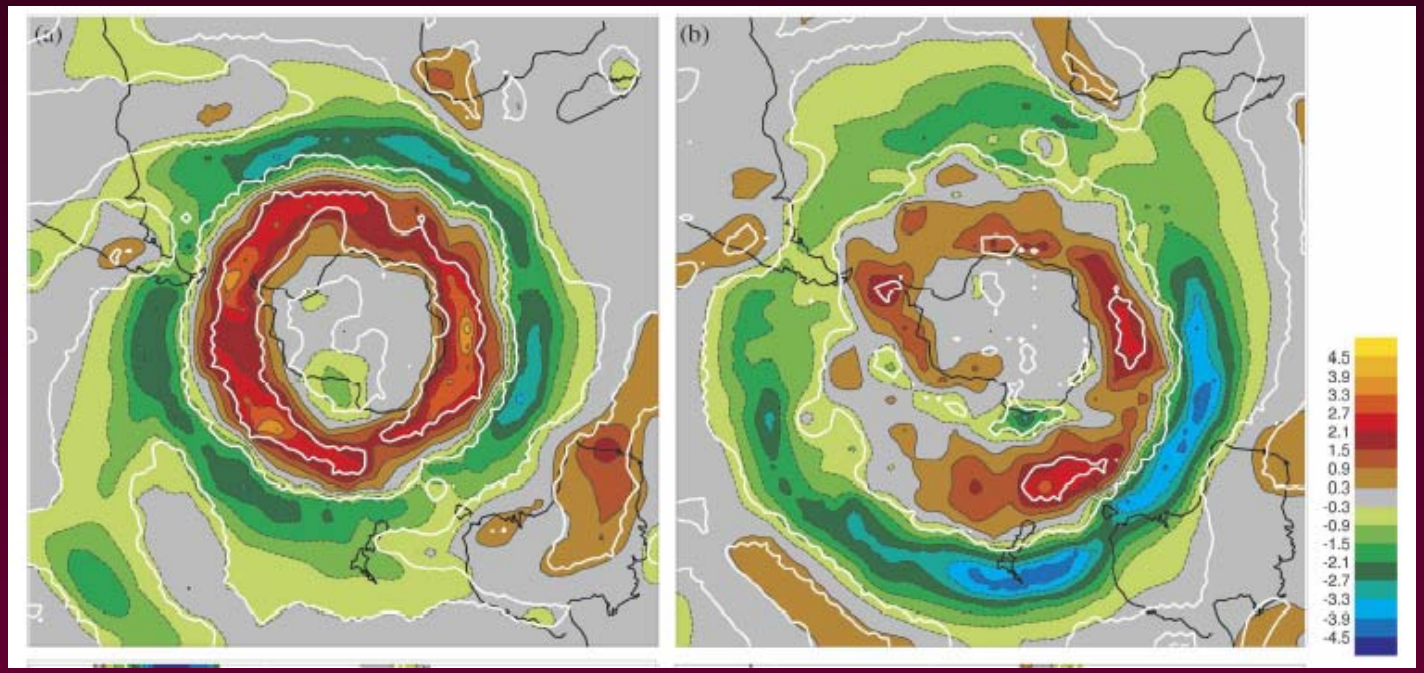


Temperature and precipitation changes from Multi-model ensemble simulations (2080-2099)-(1980-1999). SRES A1B



REDUCTION OF PRECIPITATION IN THE SOUTHERN ANDES:

Poleward shift of the storm tracks



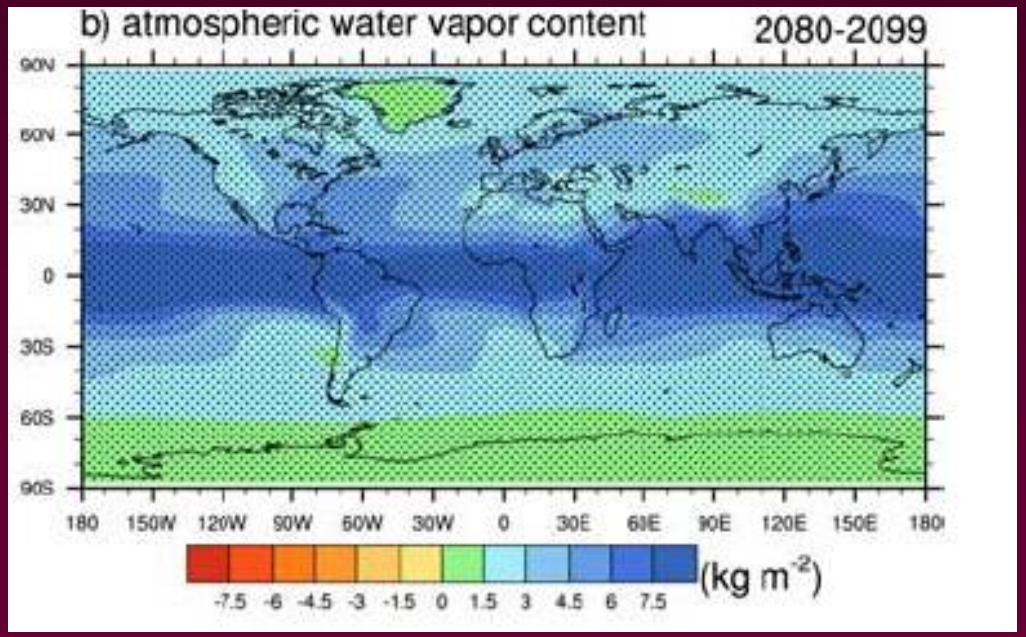
Difference in SH cyclone tracks between the 21C and 20C model simulation (left) DJF track density, (right) JJA track density (Bengtsson et al. 2006)

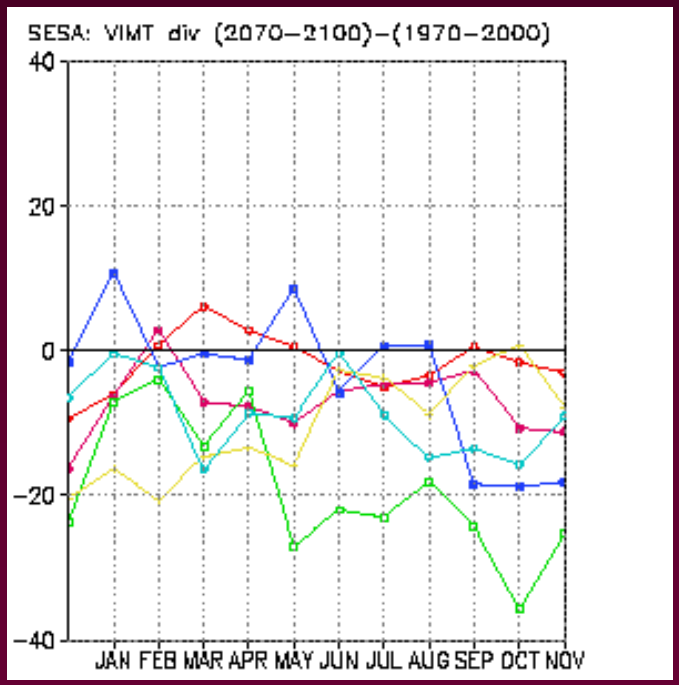
PRECIPITATION INCREASE IN THE LA PLATA BASIN

Increased tropical SST anomalies → increased water vapor at tropical continental regions

→

Advective effects (associated with circulation changes) → increased moisture convergence



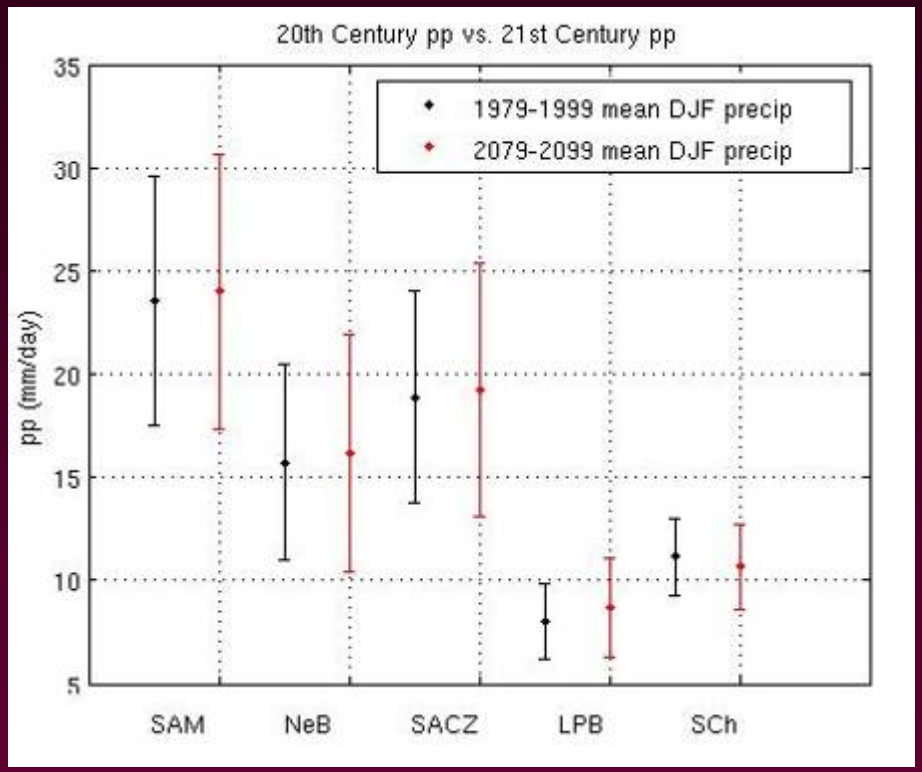


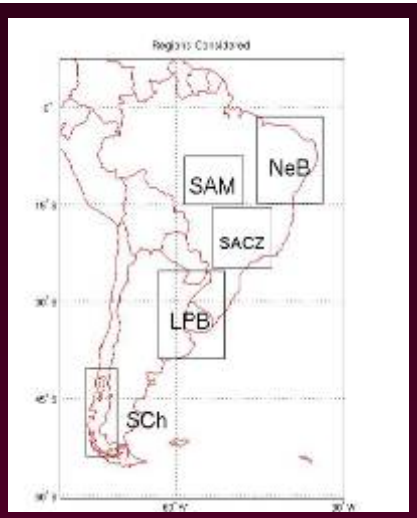
Meehl et al. (2005)

Rojas et al. (2006).

Uncertainties in the DJF precipitation changes from the multi-model ensemble (2080-2099)-(1980-1999). SRES A1B

20 Model simulations

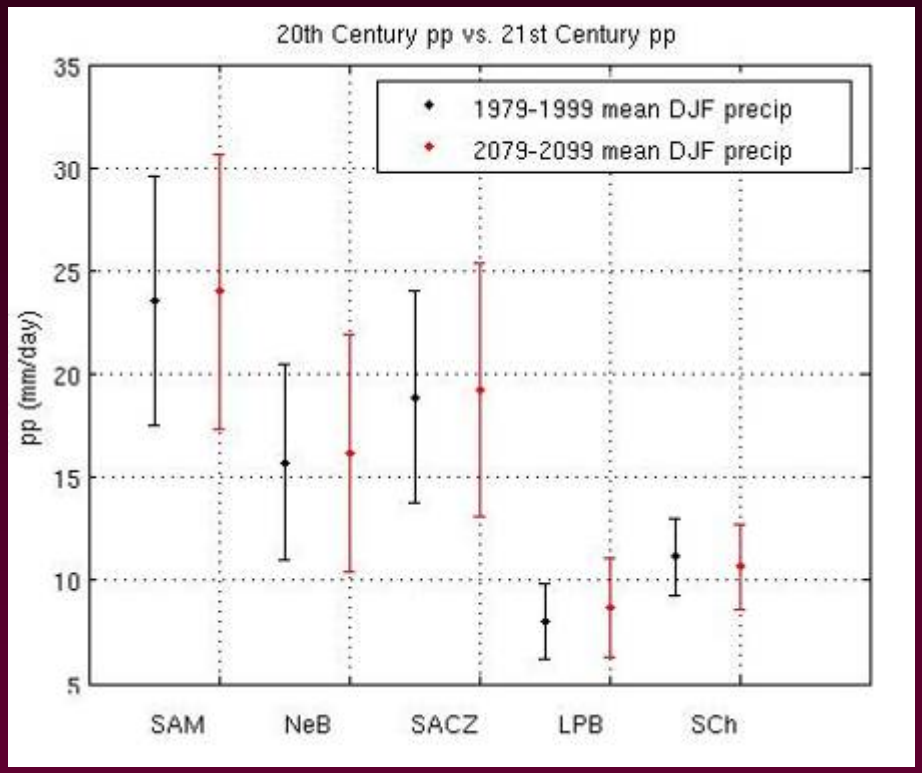


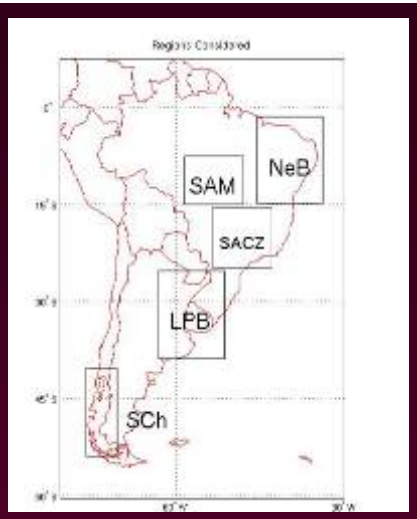


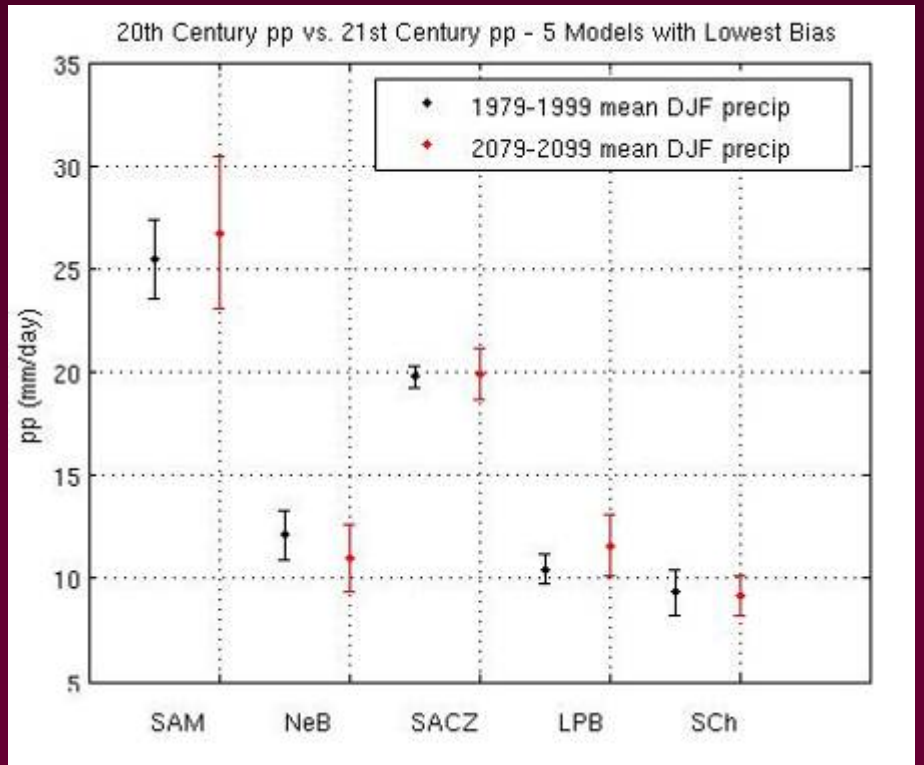
González and Vera (2007)

Uncertainties in the DJF precipitation changes from the multi-model ensemble (2080-2099)-(1980-1999). SRES A1B

20 Model simulations







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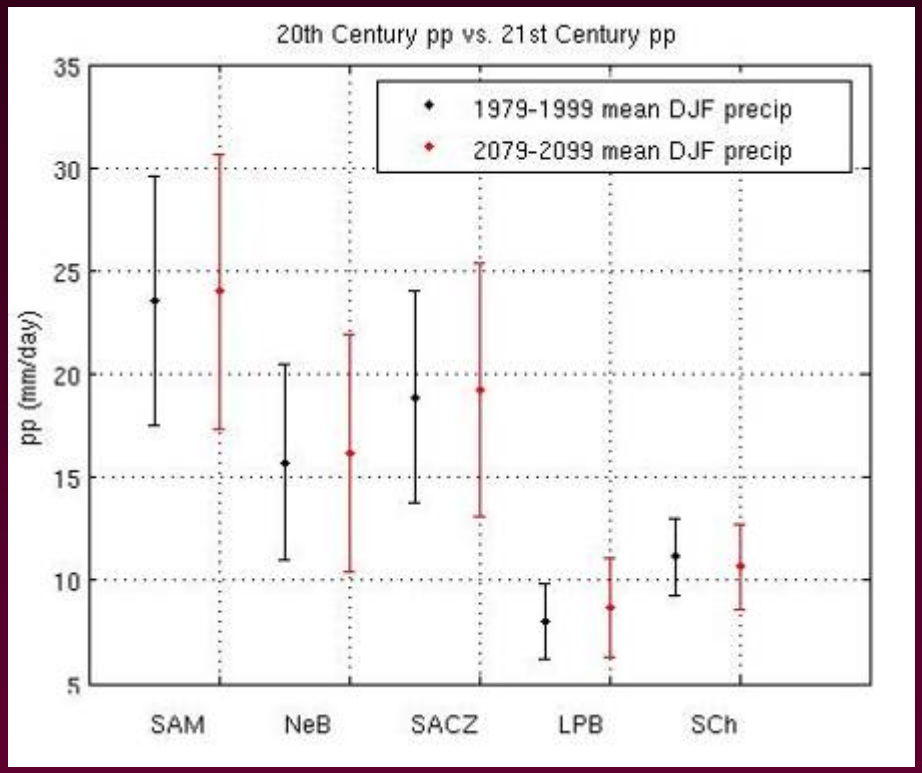
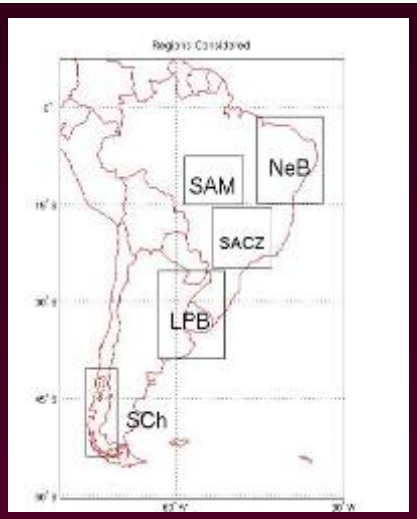
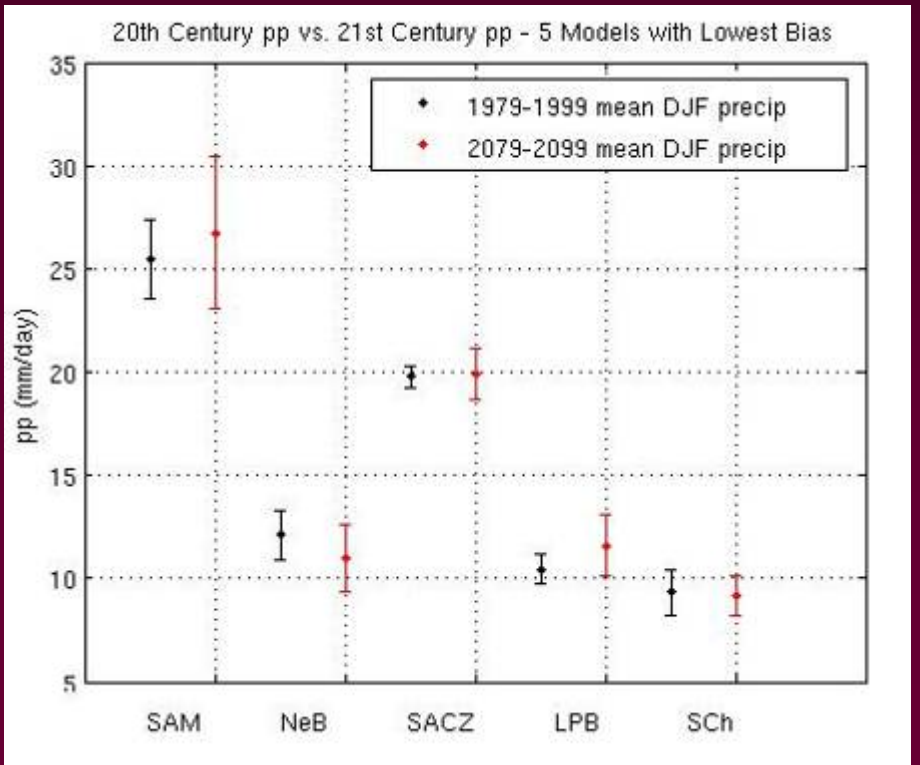


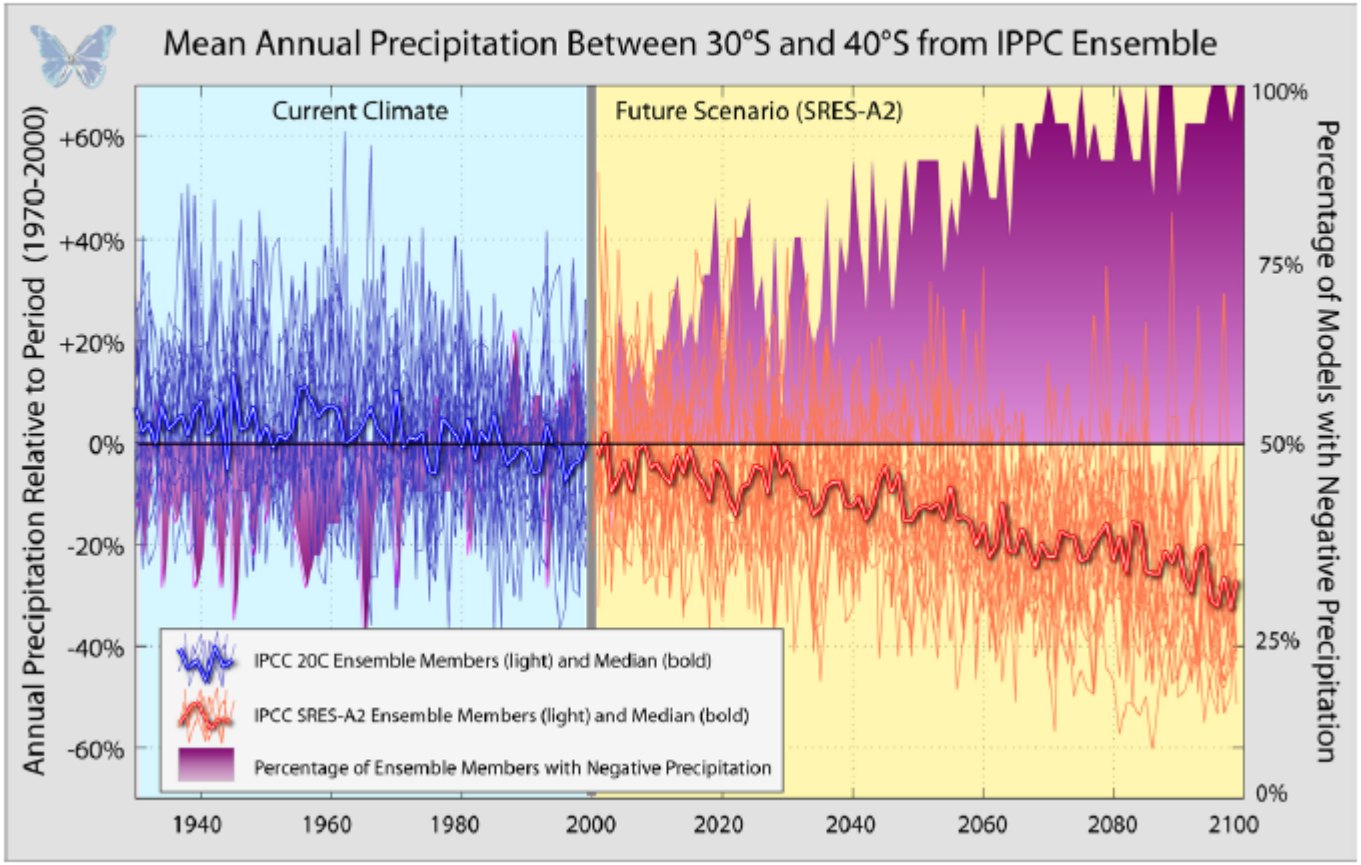




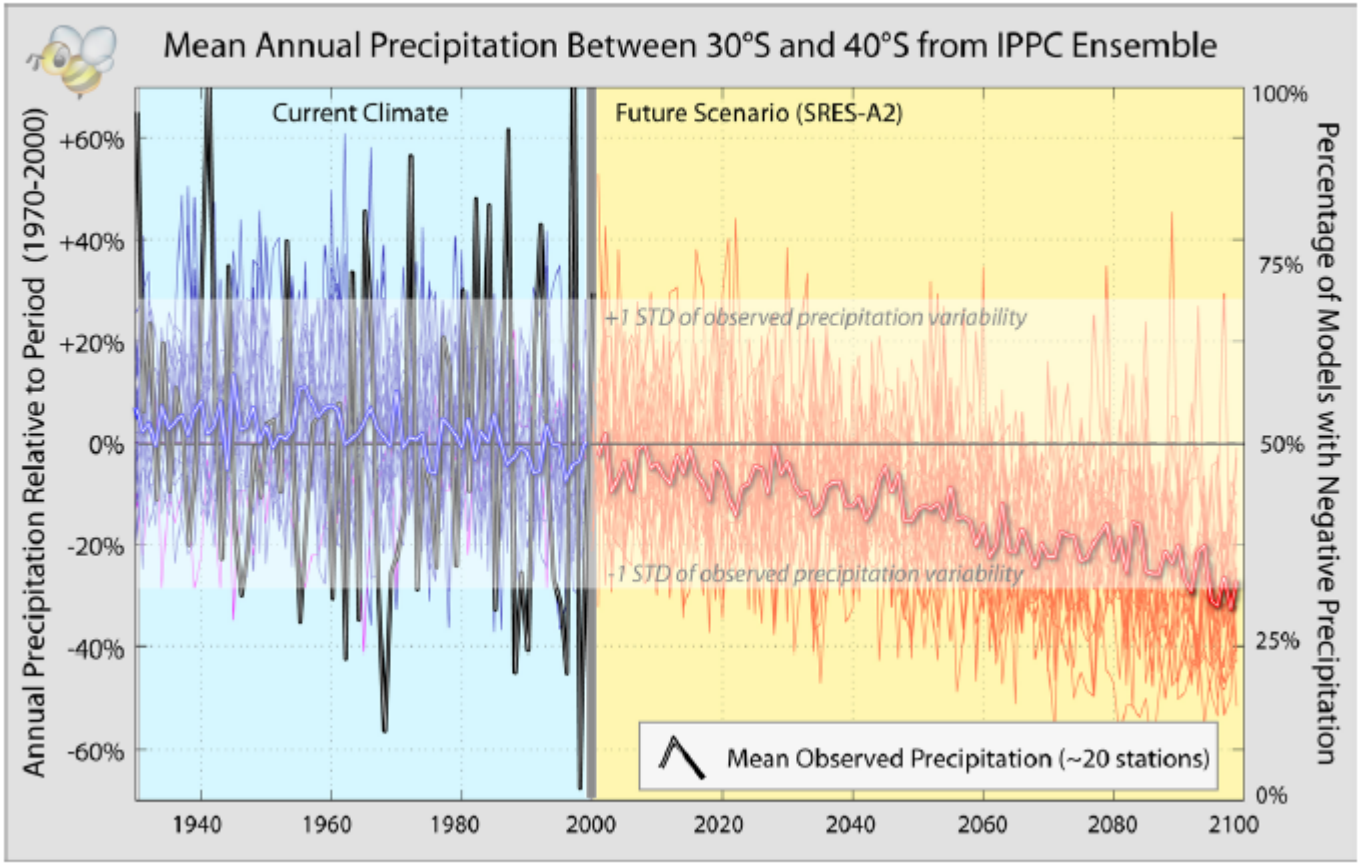
5 Models with lowest Bias

González and Vera (2007)

IPCC Models indicate that drying in Central Chile will occur steadily over this century.



However, the natural variability in Central Chile is of the same order of magnitude as the projected changes…



It may be some time before anthropogenic impact on precipitation can be clearly detected…

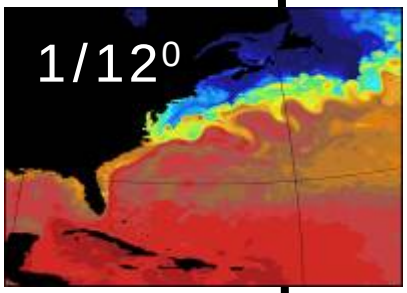
Climate model progresses and limitations:

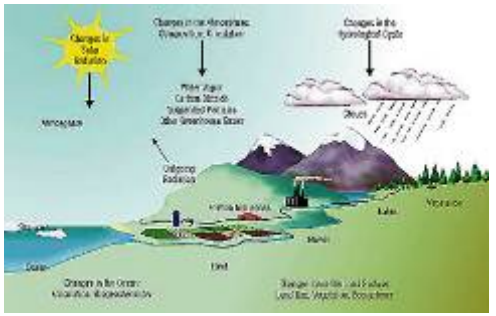
- Current AOGCMs have demonstrated to reproduce observed features of observed climate changes.
- There is considerable confidence that AOGCMs provide credible quantitative estimates of future climate change, particularly at continental and larger scales. Confidence in these estimates is higher for some climate variables (e.g., temperature) than for others (e.g., precipitation).
- Current AOGCMs still have limitations in simulating the space-time structure of the current climate (rainfall in the tropical forests, ITCZ, monsoons, dryness over deserts etc), and the activity of transient variability
- Climate model projections still exhibit a large range of uncertainties at regional scales that limit their use for many impact assessment studies.

More reliable climate change projections require:

- Improving and sustaining global climate observations
- Improving the modeling of the climate system
- Increasing the spatial resolution of the AOGCMs
- Enlarging the size of the ensembles and the duration of the simulations

Competing demands to improve climate simulations: resolution, complexity and ensemble size



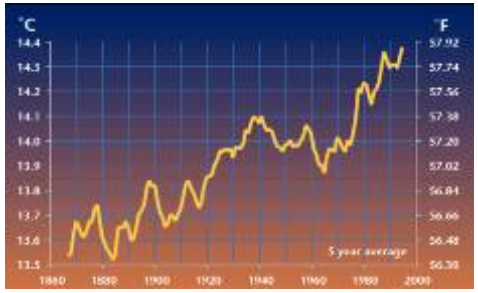


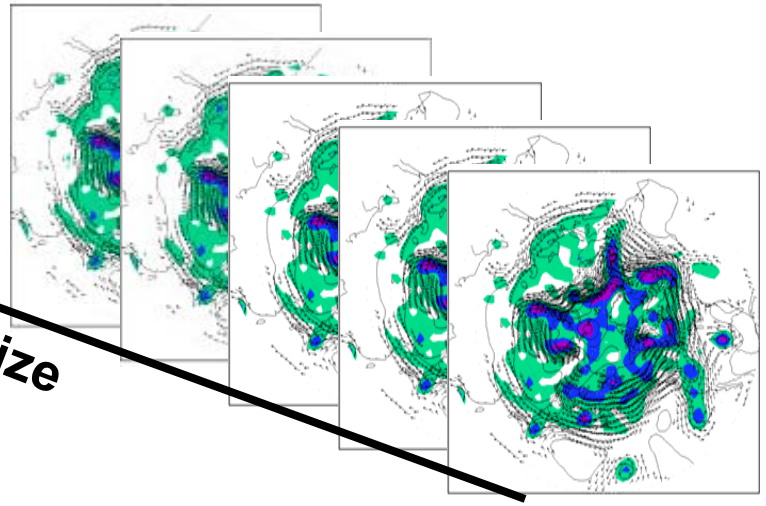
Resolution

Computing Resources

Complexity

Duration and/or Ensemble size





Giorgi 2007

Some of the relevant processes to South America climate that need to be better understood and simulated:

- Dynamics over complex terrain like the Andes and the Brazilian plateau

- Land-Atmosphere interaction (Land use changes)
- Air-Sea interaction in the surrounding oceans

- Diurnal cycle of precipitation
  - Diurnal evolution of the PBL
  - Diurnal cycle of the LLJ

- Feedbacks within the physical climate system (climate & biogeochemical cycles)

- Cloud related processes and associated phenomena (including aerosol-cloud interactions)

Further international collaboration is needed to:

Implement multi-national plans for providing regional climate change projections with reliable confidence limits at the scale necessary for local risk analysis and for adaptation purposes:

- Further analyze AOGCM outputs in the region
- Define common model validation metrics at regional scales
- Determine strategies for regionalization of global climate simulations
- Build multi model datasets at regional scales
- Develop probabilistic tools to treat regional uncertainties
- Strengthen collaborative efforts in improving climate models

Further information

- **The WCRP CMIP3 Multimodel dataset is available at:**

www-pcmdi.llnl.gov

Reference:

"The WCRP CMIP3 multi-model dataset: A new era in climate change research", G. Meehl et. al, 2007, (accepted in BAMS)

About WCRP:

wcrp.wmo.int

WCRP World Climate Research Programme

WMO IOC ICSU International Council for Science

Interannual Variability in the La Plata Basin (LPB)

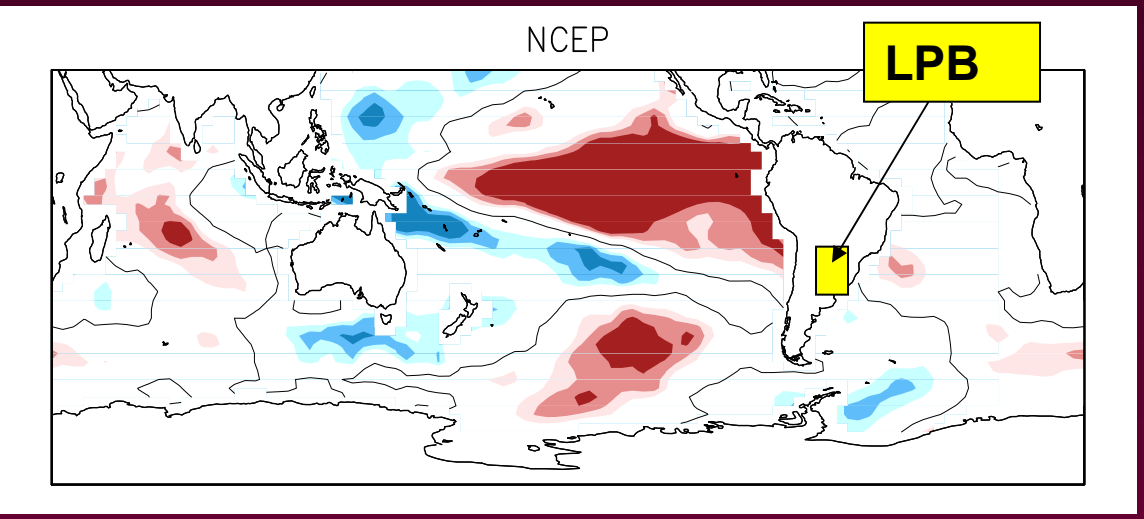
-ENSO warm events

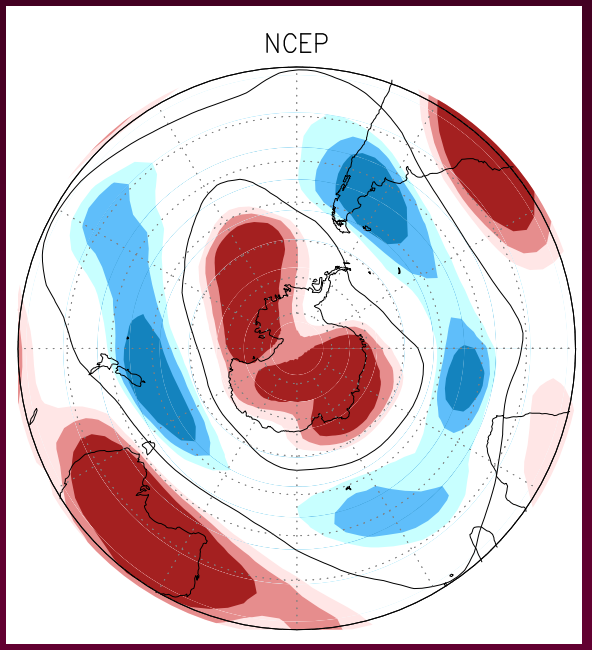
-AAO negative phase

→

Positive OND precipitation anomalies

(1970-1999)





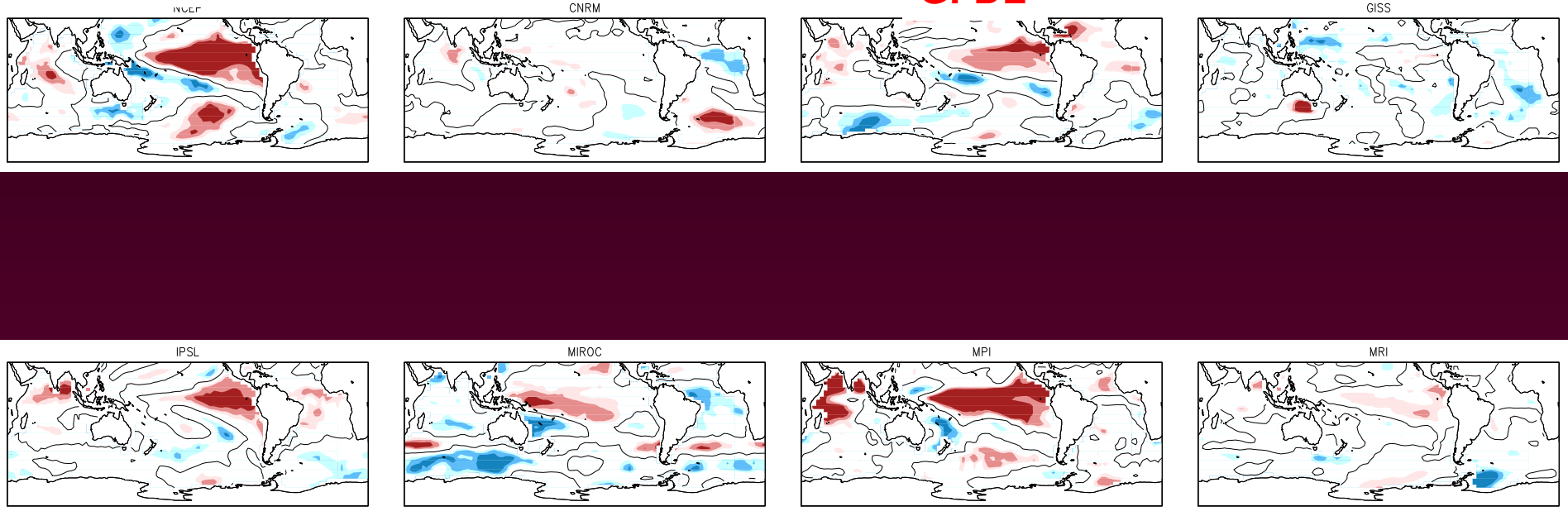
Correlations between precipitation anomalies in LPB and (left) SST anomalies and (right) 500-hPa geopotential height anomalies. Significant values at 90, 95 and 99% are shaded. NCEP reanalysis data.

(Vera et al. 2007)

Correlations between OND precipitation anomalies in LPB and SST anomalies from IPCC-AR4 models

OBS

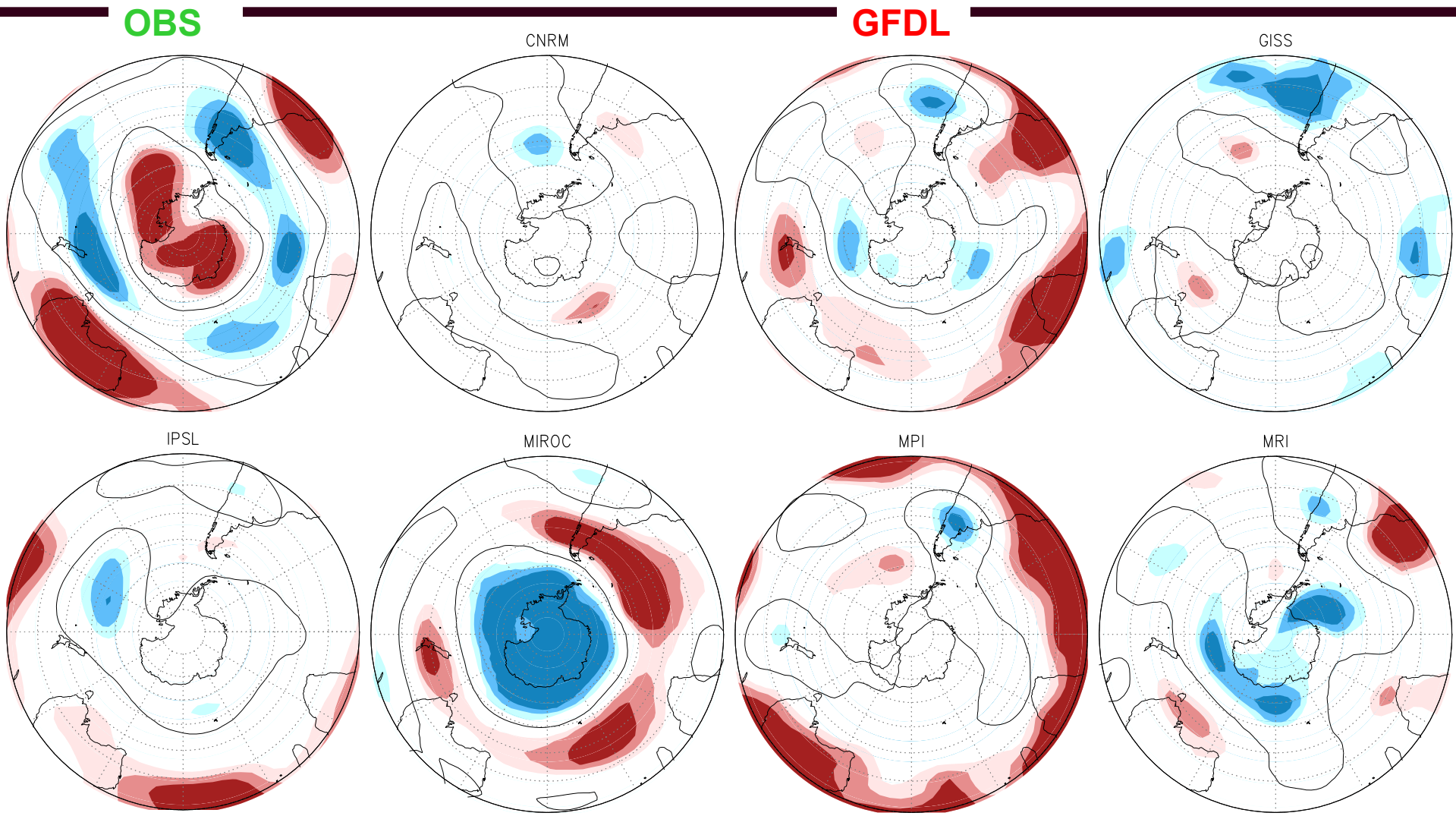
GFDL



Significant values at 90, 95 and 99% are shaded.

(Vera et al. 2007)

Correlations between precipitation anomalies in LPB and 500-hPa geopotential height anomalies from IPCC-AR4 models



Significant values at 90, 95 and 99% are shaded.

(Vera et al. 2007)

Mejoras en los modelos climaticos del IPCC-AR4 comparados con IPCC-TAR

- Mejoras en la ***resolución, métodos computacionales, parametrizaciones, y procesos adicionales*** (e.g. aerosoles interactivos) han sido incluidos en la mayoría de los modelos. La mayoría no utiliza ya ajuste de flujos.

- El **ensemble** de modelos está permitiendo determinar **métricas** para los modelos basadas en observaciones para **condicionar las proyecciones** de clima futuro.

- Algunos pocos modelos ya cuentan con tratamientos explícitos del **ciclo de carbón** necesarios para explorar la importancia potencial de los feedbacks del ciclo en el sistema climatico.

- AOGCM **reproducen** las patrones observados de cambio climático y proporcionan **estimaciones cuantitativas creíbles de futuros cambios climáticos** en **escalas grandes** y para algunas variables como la **temperatura.**

- **Progresó** la simulación de modos principales de variabilidad como el **ENSO**. Mejor representación de **ciclones extratropicales**. Algunos modelos pueden simular bien la frecuencia observada y distribución de los ciclones tropicales.

- Mejoró la habilidad simular eventos extremos, especialmente **olas de calor y de frío.**