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1934-15

Fourth ICTP Workshop on the Theory and Use of Regional Climate Models: Applying RCMs to Developing Nations in Support of Climate Change Assessment and Extended-Range Prediction

3 - 14 March 2008

Examples of regional climate modelling activities over South America

NOBRE Paulo

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MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Examples of Regional Climate Modeling Activities over South America

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D. F. Moncunill - FUNCEME
J. Guerra, F. Lacerda – LAMEPE
R. P. Rocha – USP

Outline

- **Regional Climate Change Scenarios**
  - **Eta and HadRM3 – CPTEC**
  - **RegCM3 – USP**
  - Argentina, Uruguay, Peru, Chile
- **Seasonal Climate Predictions:**
  - **Eta – CPTEC**
  - **RSM97 – FUNCEME**
  - **RSM CVS – LAMEPE**

Regional Climate Change Scenarios over South America

Project strategy summary

To provide high resolution future climate change scenarios in South America for development of studies that should lead to raising awareness among government and policy makers in assessing climate change impact, vulnerability and in designing adaptation measures.

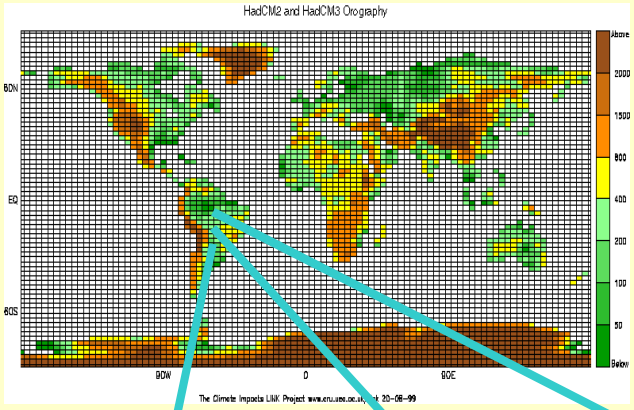
PI: José Marengo, INPE-CPTEC (marengo@cptec.inpe.br)

Thanks to C. Nobre, E. Salati, T Ambrizzi, I. Pisnitchenko, S. Quadra, R. da Rocha,

PROBIO-IPCC Global models used: IPCC TAR (HadCM3)-Version 1

Downscaling

IPCC Model: HadCM3

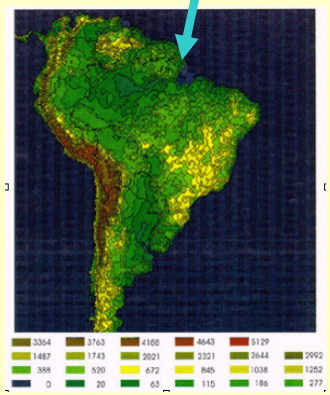


Climatology 1961-90

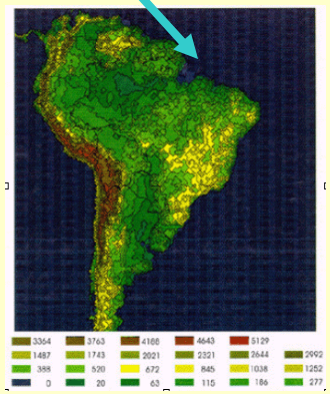
IPCC Scenarios A2, B2

Climate anomalies (future-present), from regional mulimodel ensemble Time slices 2071-2100, A2, B2

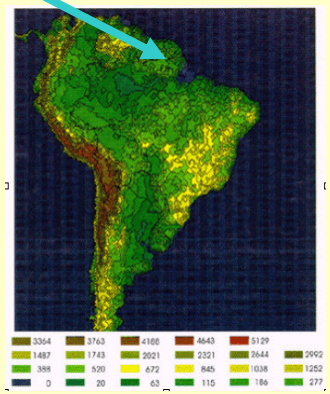
Regional models



RegCM3



HadRM3

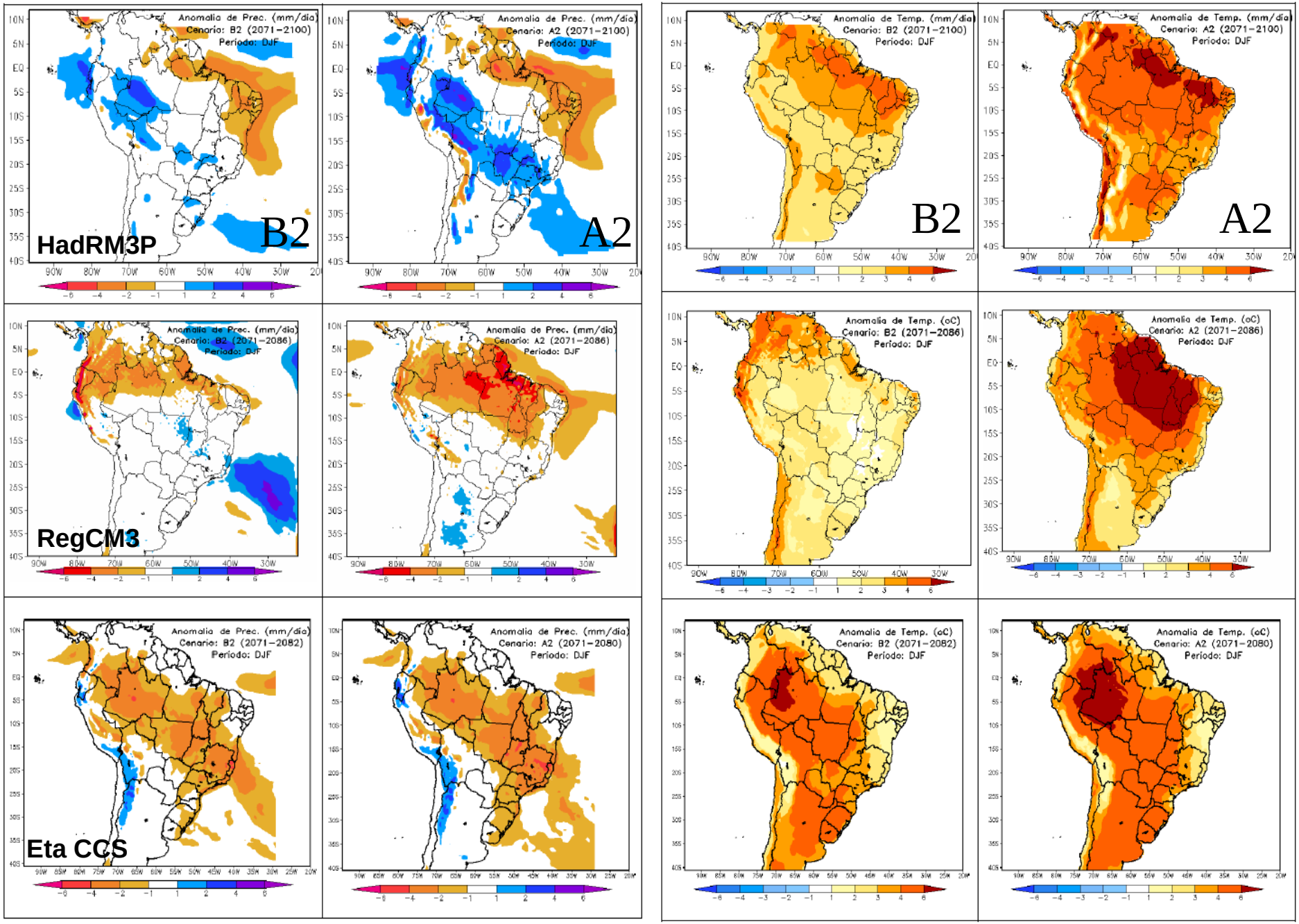


Eta CCS

Climatology regional model 1961-90

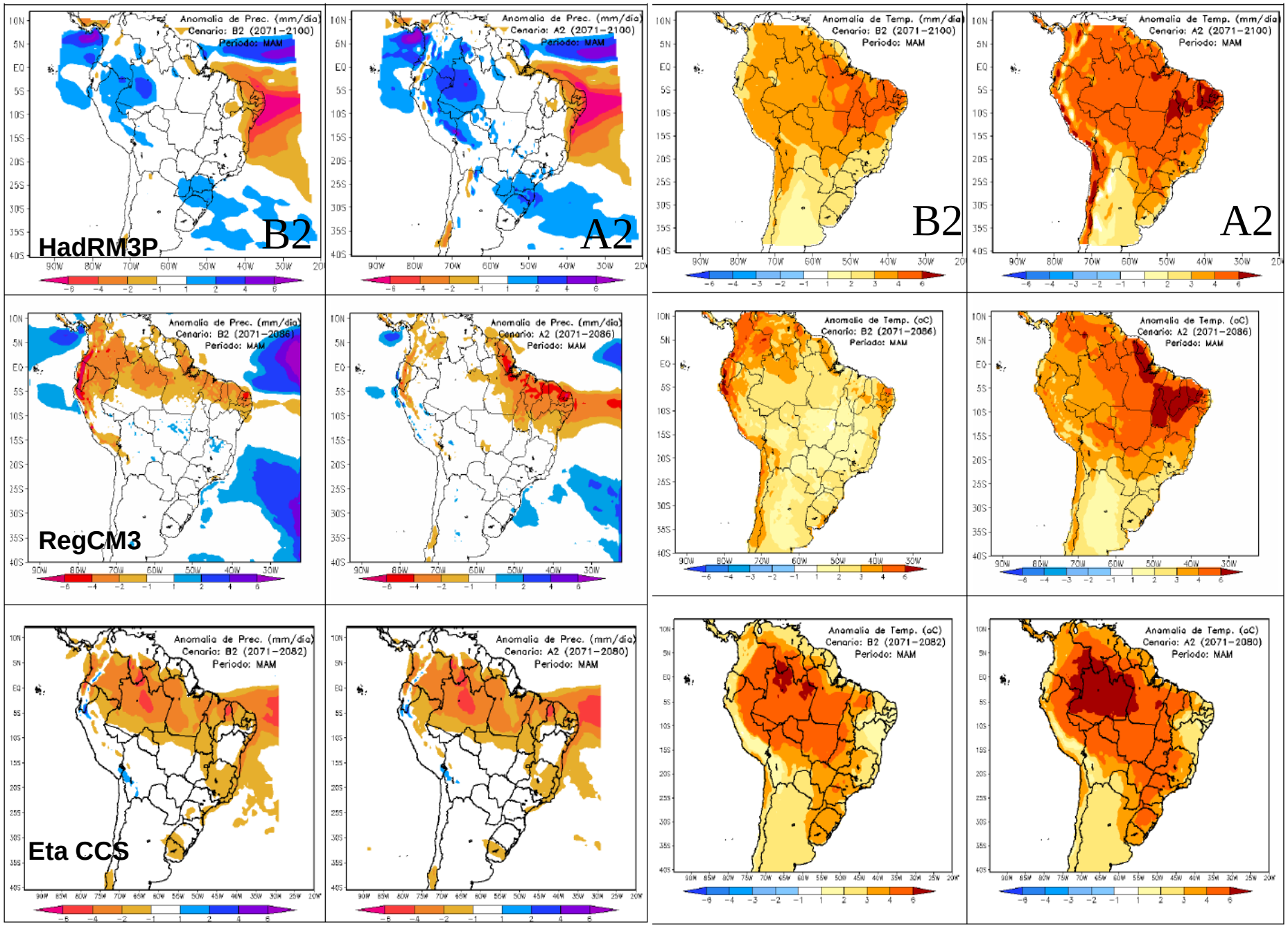
Maps of climate anomalies, and indices of extremes (Regional multimodel ensemble) 2071-2100, A2, B2

Regional climate change projections (DJF 2071-2100): Rainfall and temperature



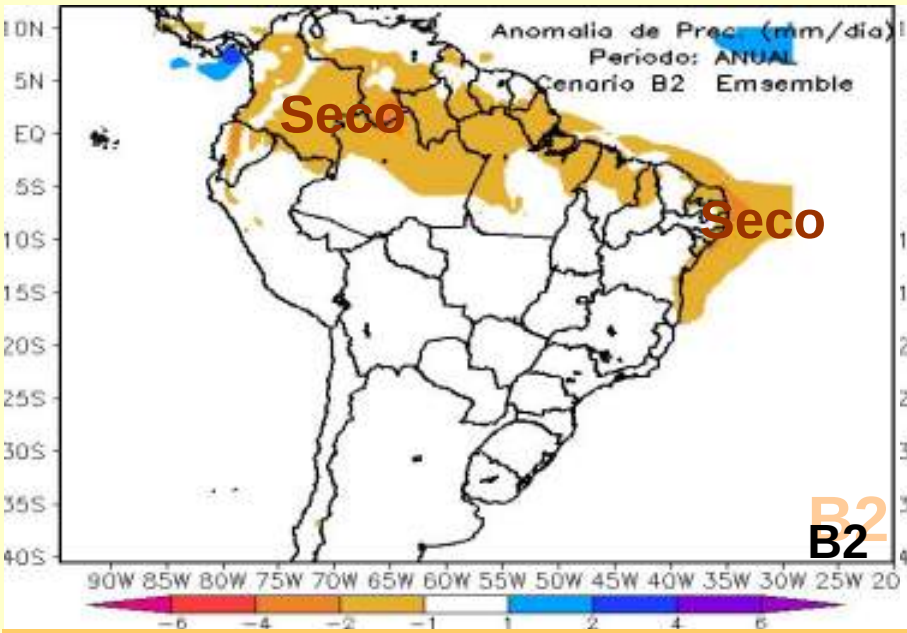
Ministério da Ciência e Tecnologia

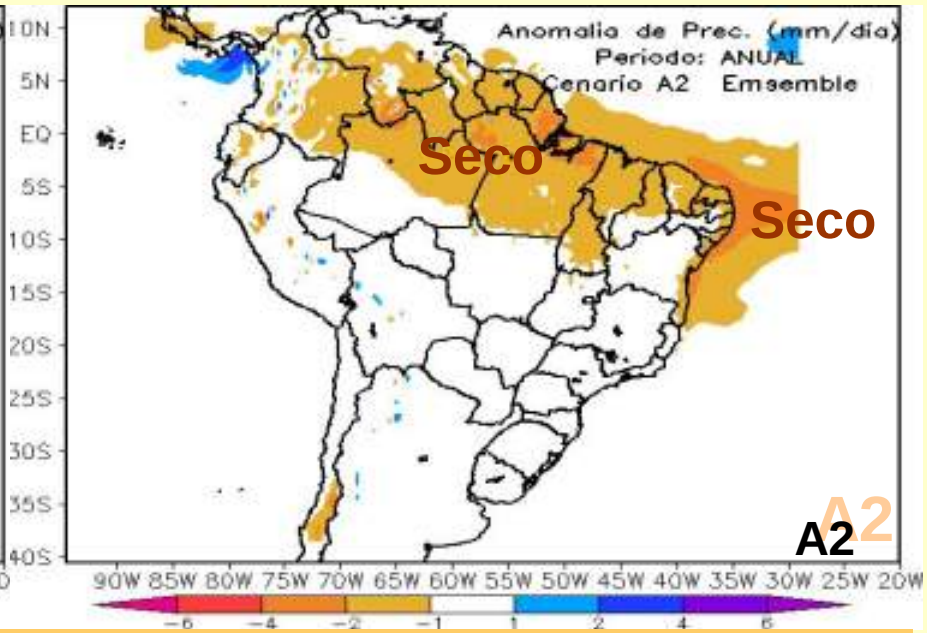
Regional climate change projections (MAM 2071-2100): Rainfall and temperature



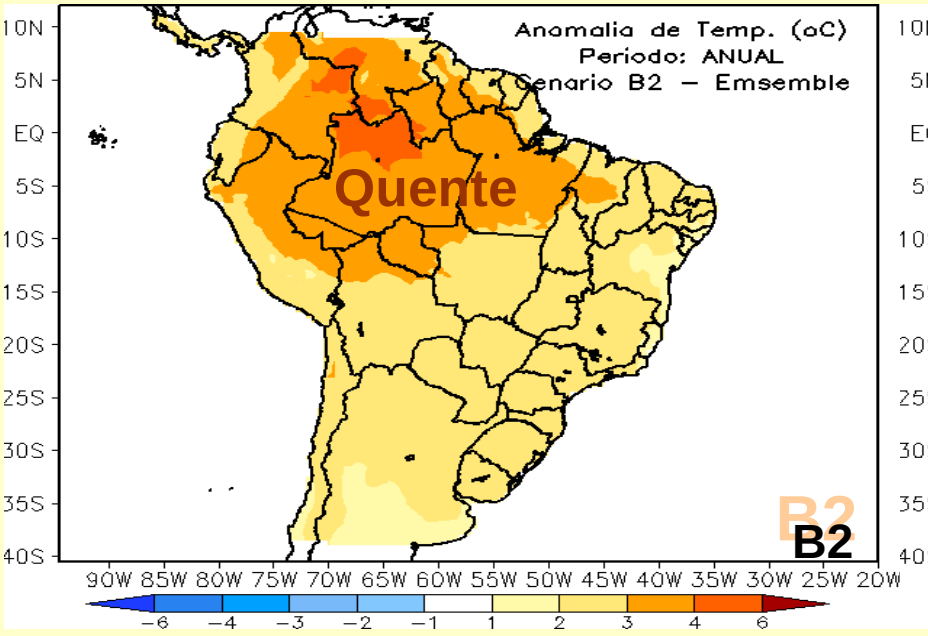
Ministério da Ciência e Tecnologia

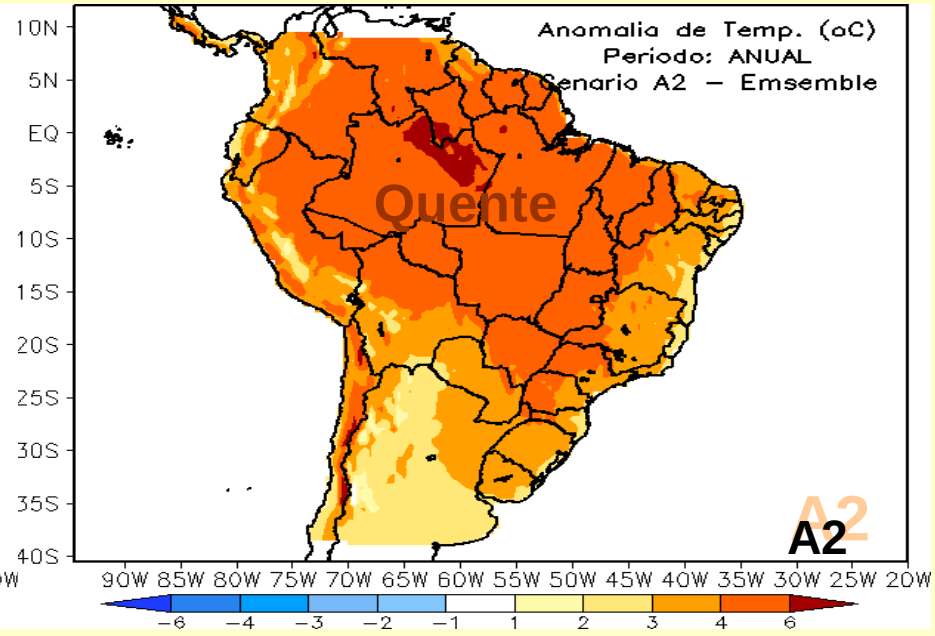
Rainfall anomalies (mm/day) (Annual) [(2071-2100)- (1961-90)]





Temperature anomalies (C) Annual [(2071-2100)- (1961-90)]

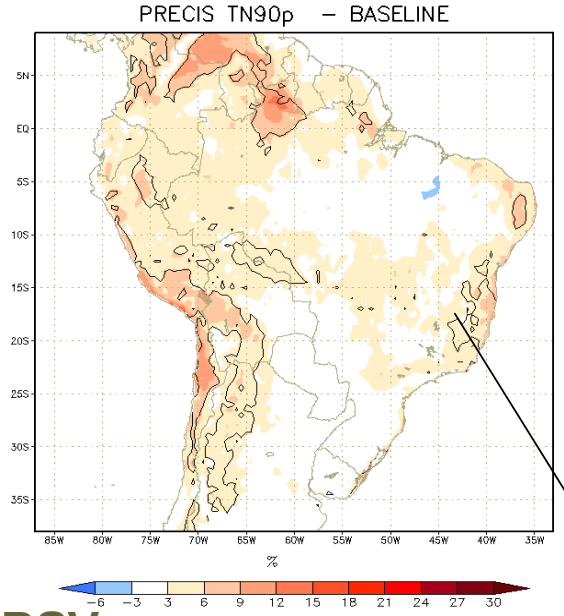




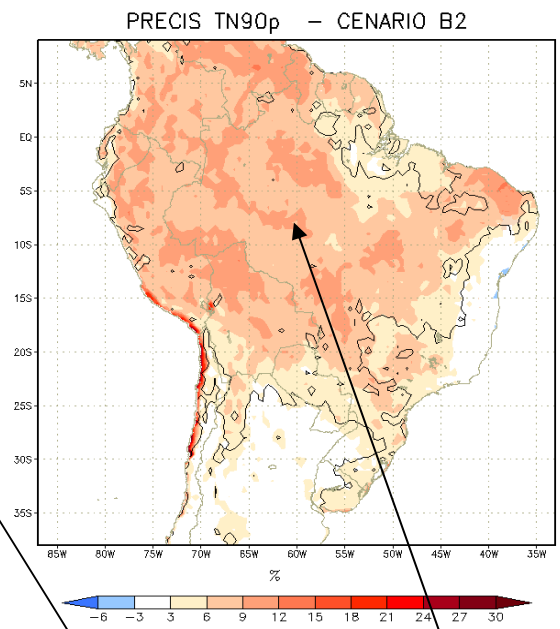
Ministério da Ciência e Tecnologia

Warm nights index (TN90) [(2071-2100)- (1961-90)]

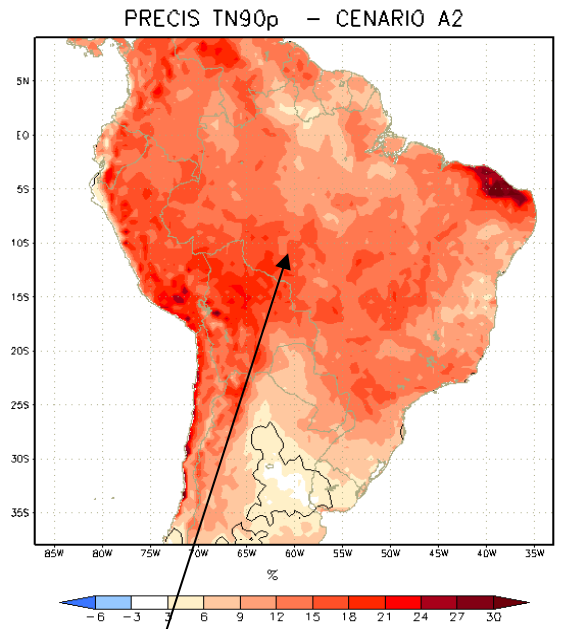
HadRM3 **1961-90**



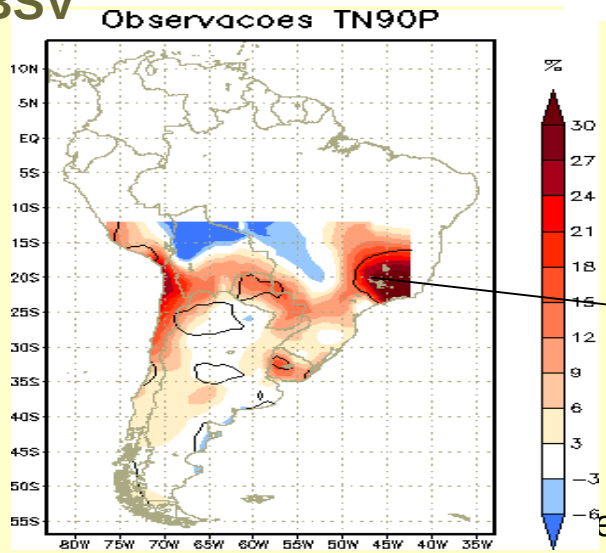
2071-2100, B2



2071-2100, A2



OBSV



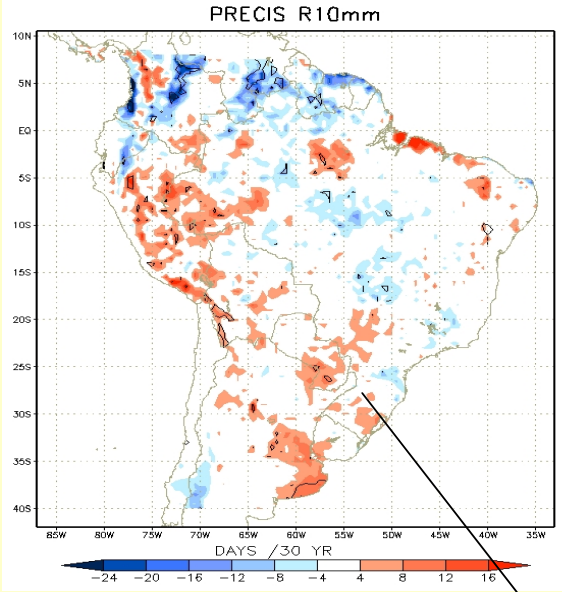
Increase in the frequency of warm nights until 2100

Increase in the frequency of warm nights during 1961-2000

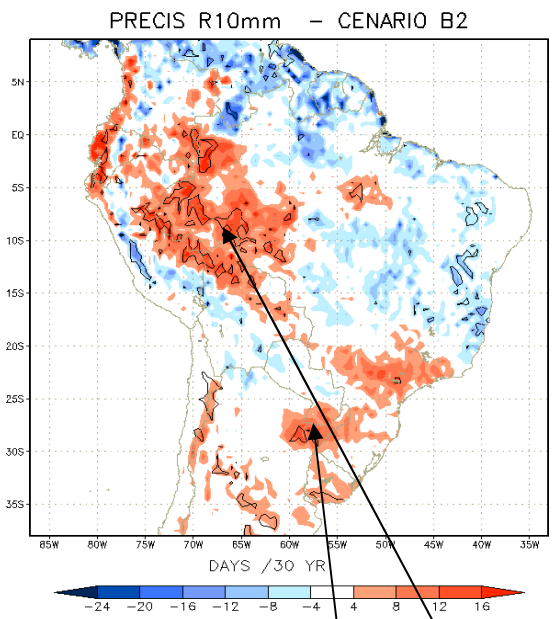
Intense rainfall index (R10) [(2071-2100)- (1961-90)]

HadRM3

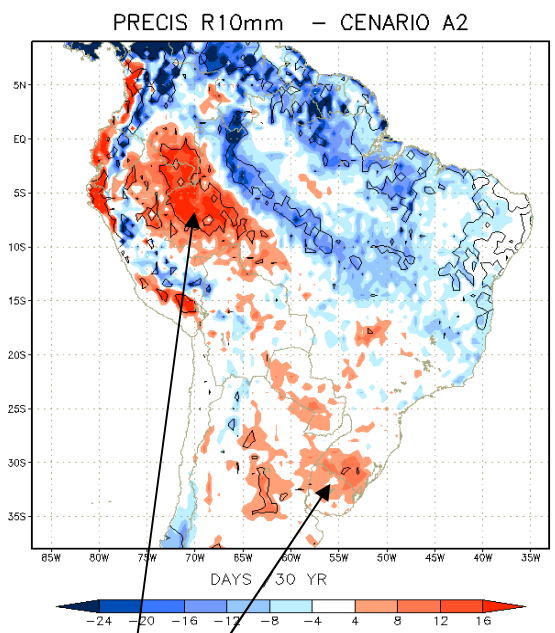
1961-90



2071-2100, B2



2071-2100, A2



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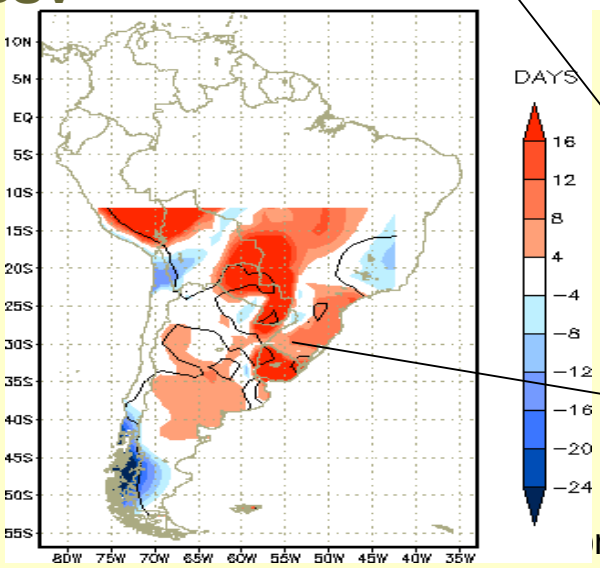


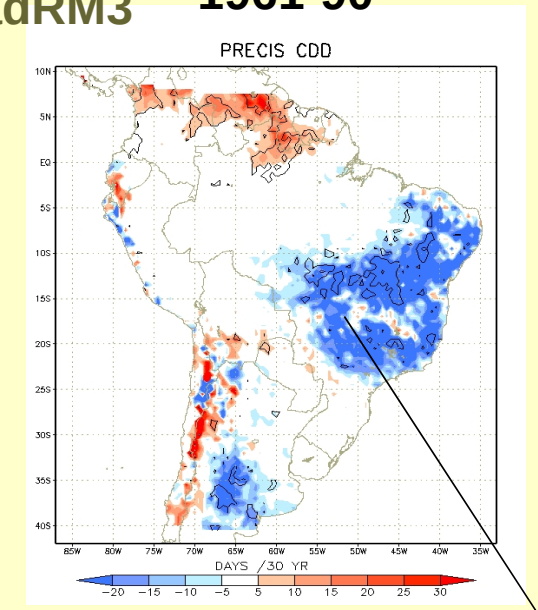
Increase in the frequency of intense rainfall events until 2100

Increase in the frequency of intense rainfall events during 1961-2000

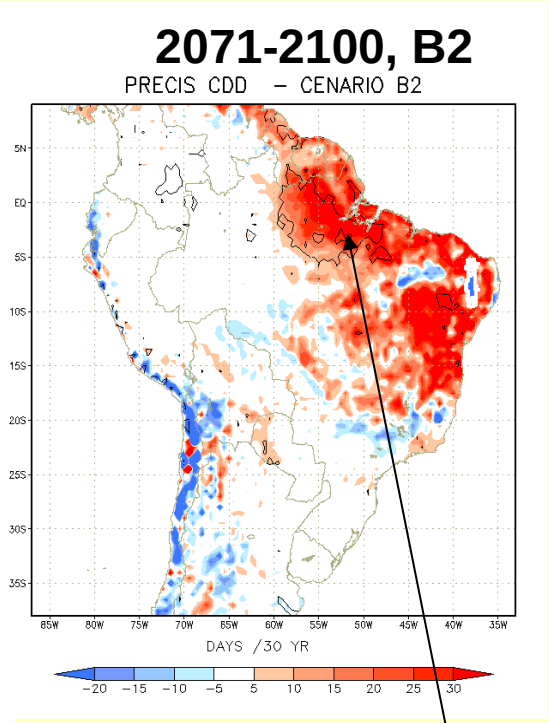
Consecutive dry days index (CDD) [(2071-2100)- (1961-90)]

HadRM3

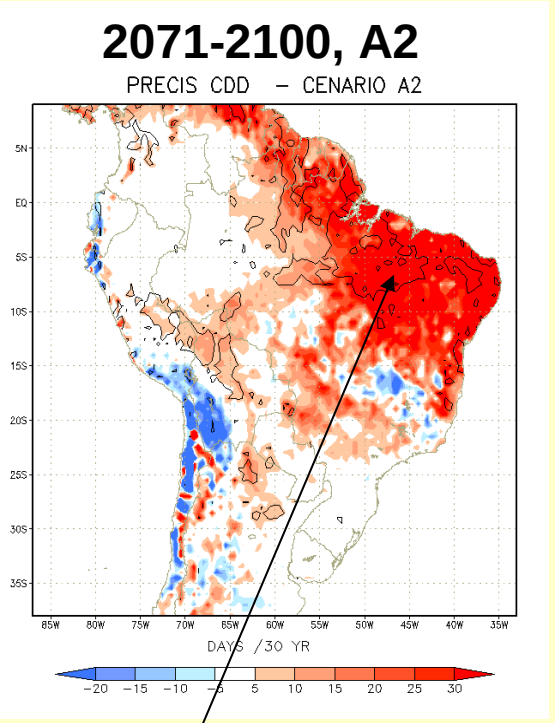
1961-90



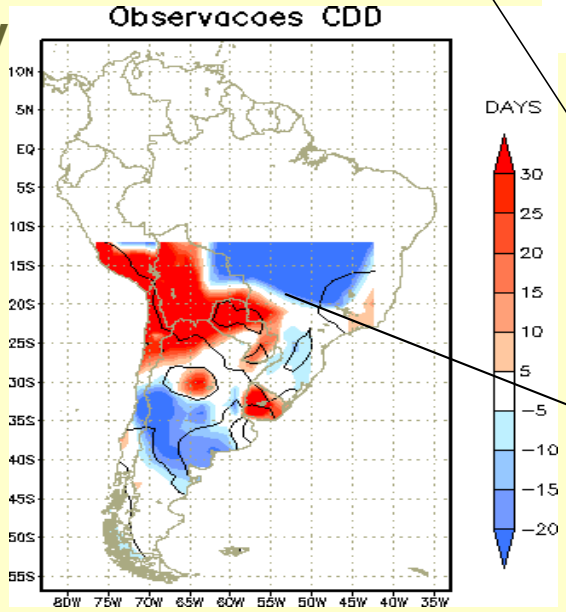
2071-2100, B2



2071-2100, A2



OBSV

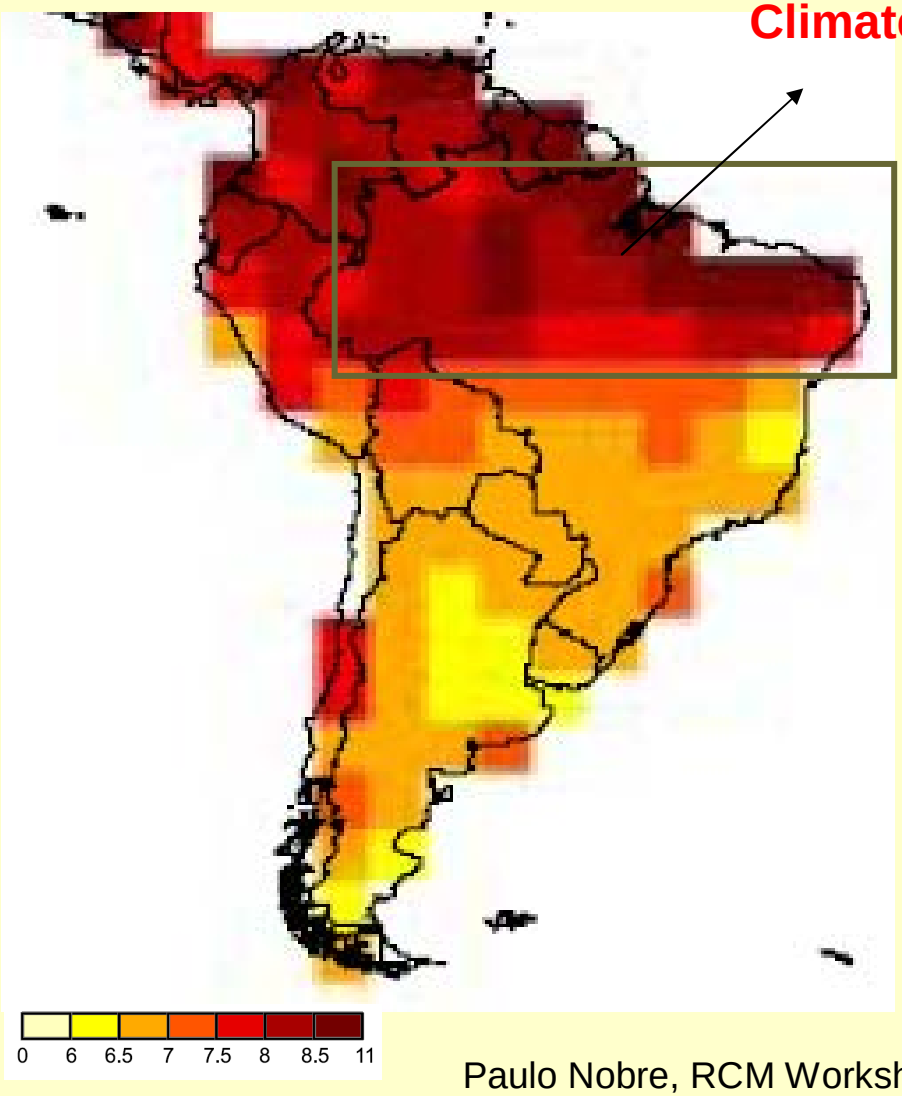


Increase in the frequency of consecutive dry days until 2100

Reduction in the frequency of consecutive dry days during 1961-2000

The aggregated CCI (Climate Change index) on a grid basis for South America, for the 2071-2100 period in relation to 1961-90. (Baettig et al. 2007).

Regions more vulnerable to Climate Change



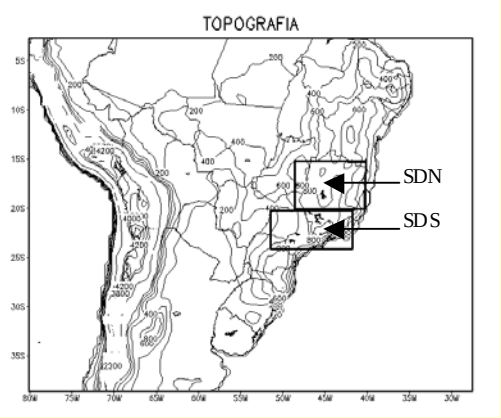
The CCI indicates that climate will change most strongly relative to today's natural variability in the tropics.
The high CCI-values in the tropics are caused by precipitation changes but also seasonal temperature events.
Concerning strong temperature changes, it has to be noted that in the tropics the hot temperature indicator responds more strongly to absolute changes in mean than elsewhere, because natural temperature variability is much smaller in the tropics than in higher latitudes.
According to the CCI, climate is expected to change more strongly relative to today's natural variability in these more vulnerable countries than in many countries with a high HDI and thus lower vulnerability.

USP/GrEC (**Climate Studies Group**) uses RegCM3 in various studies

- Simulate interannual and intraseasonal precip and circulation anomalies over Brazil
- Impact of SST on the seasonal simulations over southeastern South America during the summer
- Studying physical climate process (LLJ, ciclogenesis in the South Atlantic)
- Climate change scenarios (PROBIO project: RegCM3 nested in the HadAM3 global model)
- RegCM3 configured at horizontal resolutions (80 to 40 km) and vertical (14 to 23 levels) over several domains.

RegCM3 Interannual variability

Precipitation anomalies

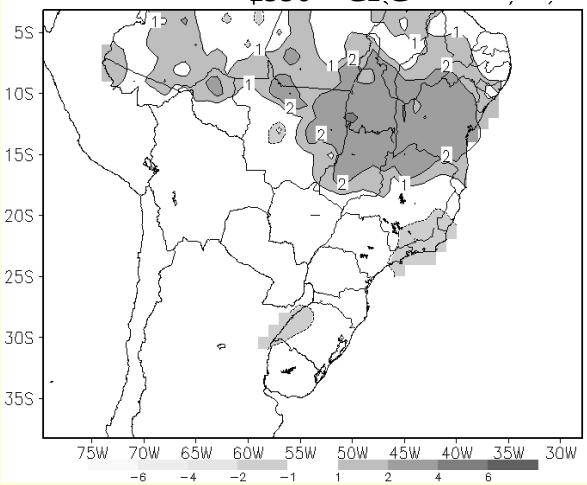


Two summers: 1990 and 1998

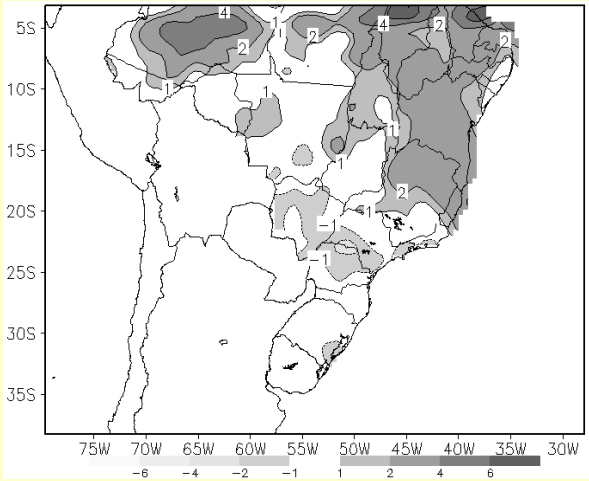
RegCM3 initial and boundary conditions from NCEP reanalysis

Daily precipitation data from CPC (Silva et al. 2007)

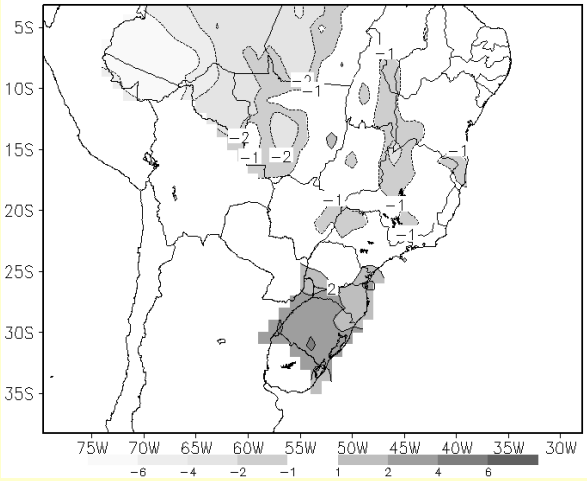
1990 – CPC



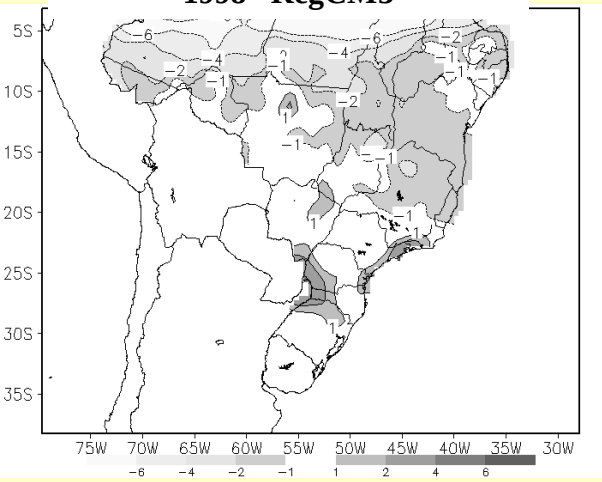
1990 – RegCM3



1998 – CPC

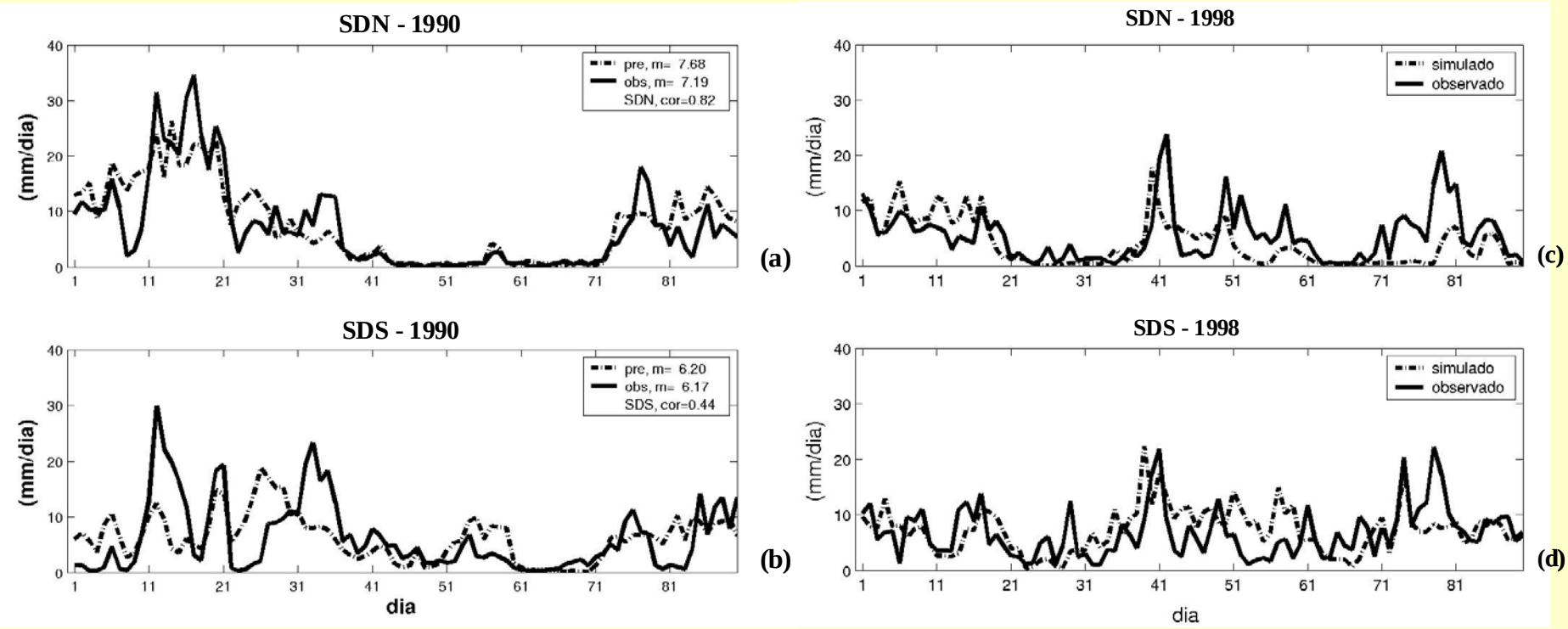


1998– RegCM3



Cuadra and Rocha (2005)

Daily precipitation (mm/day) observed (CPC) and simulated by RegCM3 in the subdomains (SDN and SDS)



summer	1990		1998	
	SDN	SDS	SDN	SDS
Precipitation (mm/day) – OBS	7.2	6.2	5.5	6.8
RegCM3	(7.7)	(6.2)	(4.0)	(7.2)
Relative bias (%)	7.0	0.0	-27.0	6.6
Correlation coefficient	0.82	0.44	0.46	0.39

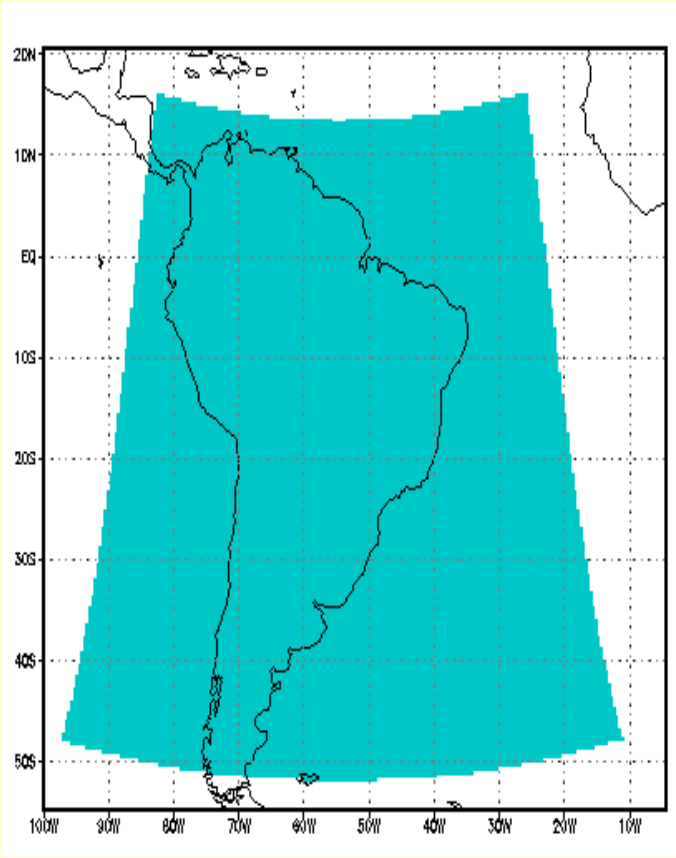
Seasonal Climate Predictions using Regional Climate Models

- CPTEC: Eta
  - 40 Km grid, 38 Eta levels,
  - Persisted SSTA OBC
  - CPTEC T062L28 AGCM LBC
- FUNCEME: RSM 97
  - 60 km Grid, 18 vertical sigma levels
  - Persisted SSTA OBC
  - ECHAM 4.5 T42L28 LBC
- LAMEPE: RSM CVS
  - 60 km grid, 18 vertial sigma levels
  - Persisted SSTA OBC
  - CPTEC T062L28 AGCM LBC

Eta Model configuration

Domain covers most part of South America

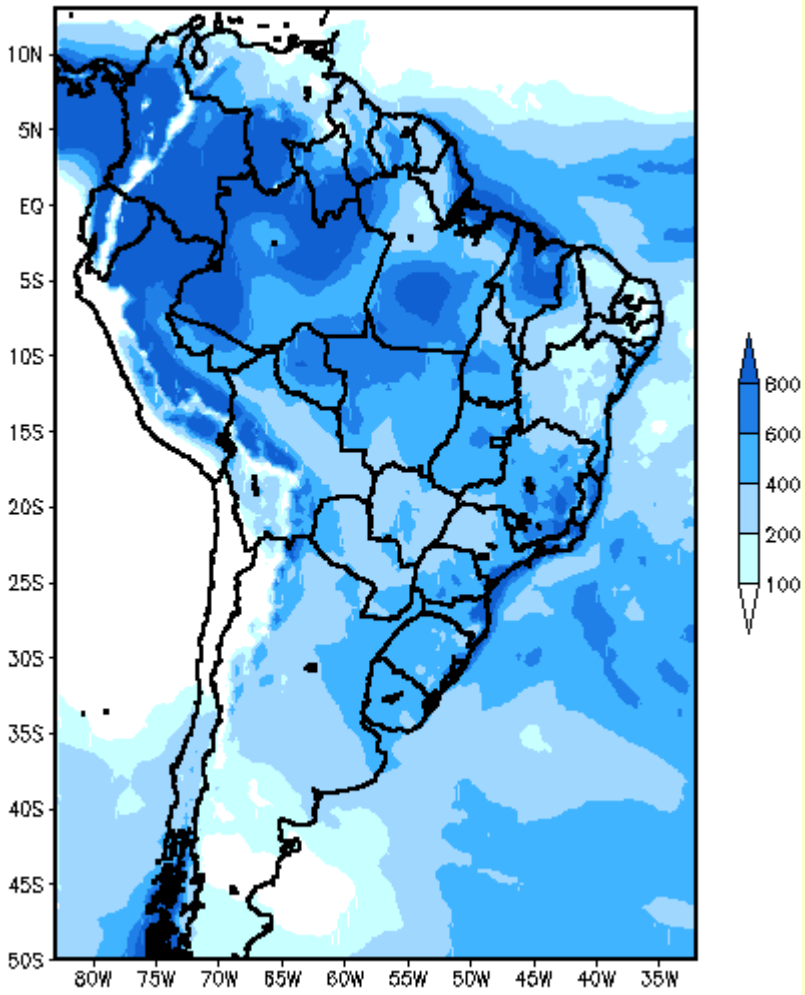
- ***Resolution*: 40 km**, 38 layers, dt = 96s
- Grid-point model (E-grid)
- Eta vertical coordinate (Mesinger, 1984)
- ***Model top***: 25 hPa
- ***Integration length:*** 4.5 months
- ***Prognostic variables***: T, q, u, v, p_s, TKE, cloud water/ice
- ***Convection***: Betts-Miller-Janjic scheme
- **Stratiform rain**: Zhao scheme
- ***Turbulence***: Mellor Yamada 2.5
- ***Radiation***: GFDL package, tendencies updated every hour
- ***Land surface scheme***: OSU scheme, 2 soil layers



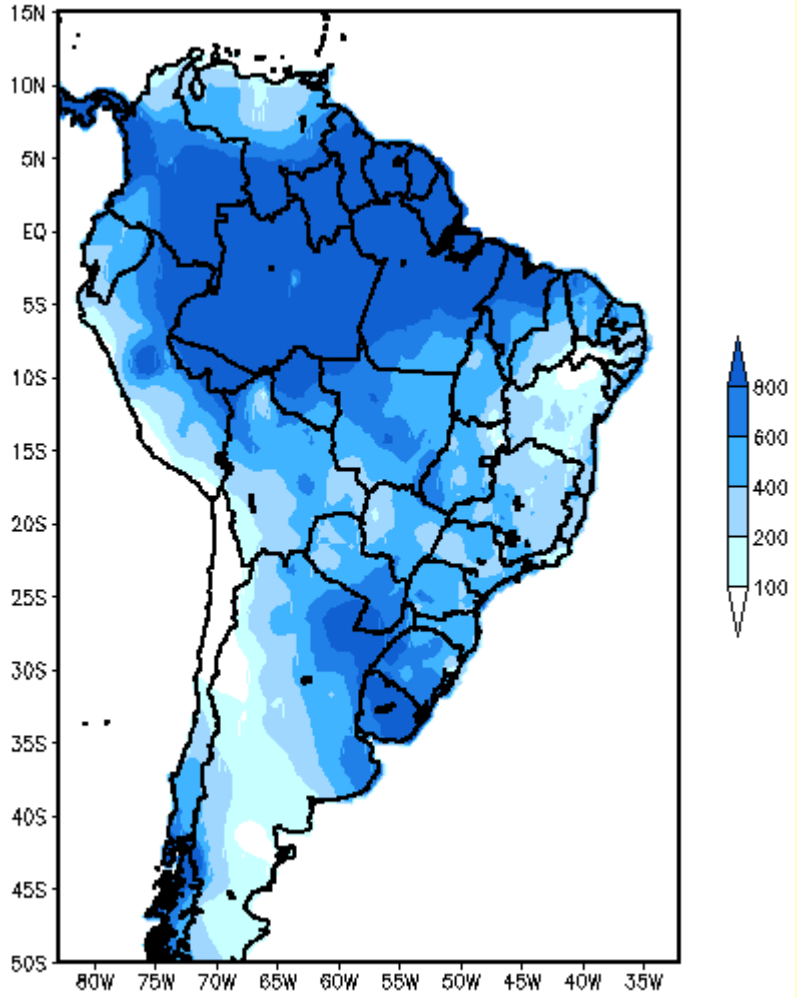
- ***LBC*** from CPTEC T62L28 GCM, updated every 6 h,
- Soil moisture: monthly climatology
- Albedo: seasonal climatology
- SST: persisted anomaly
- IC: NCEP analysesT62L28, on Day-15, mostly.

FMAM - 2002

Eta

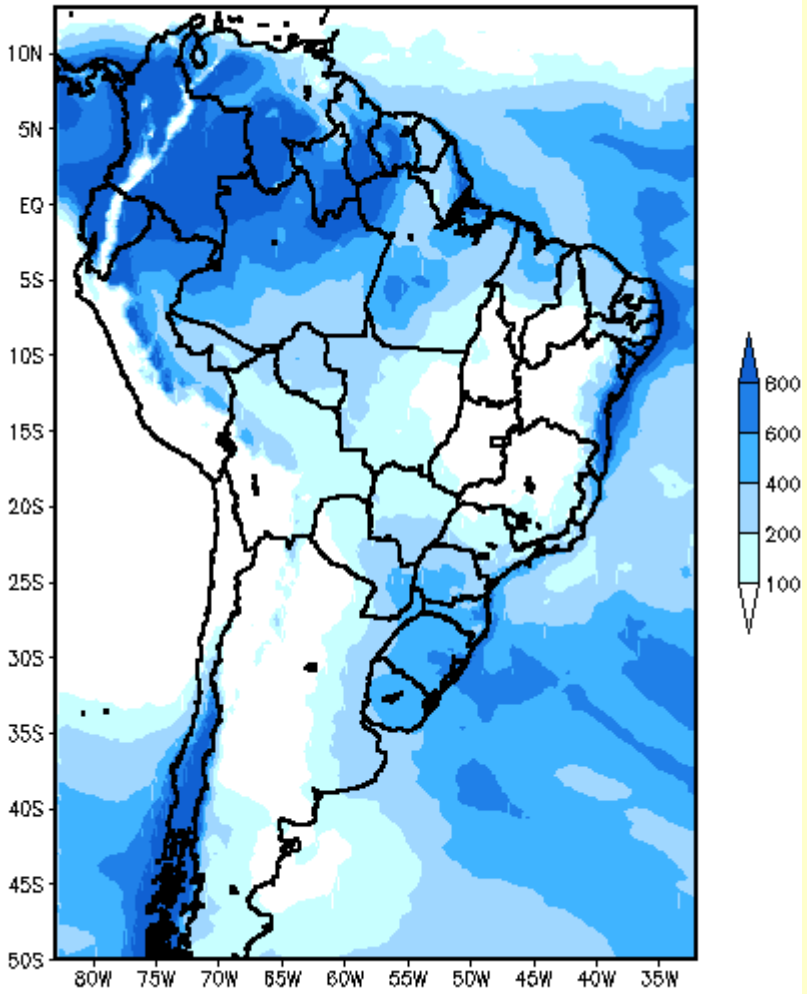


Obs

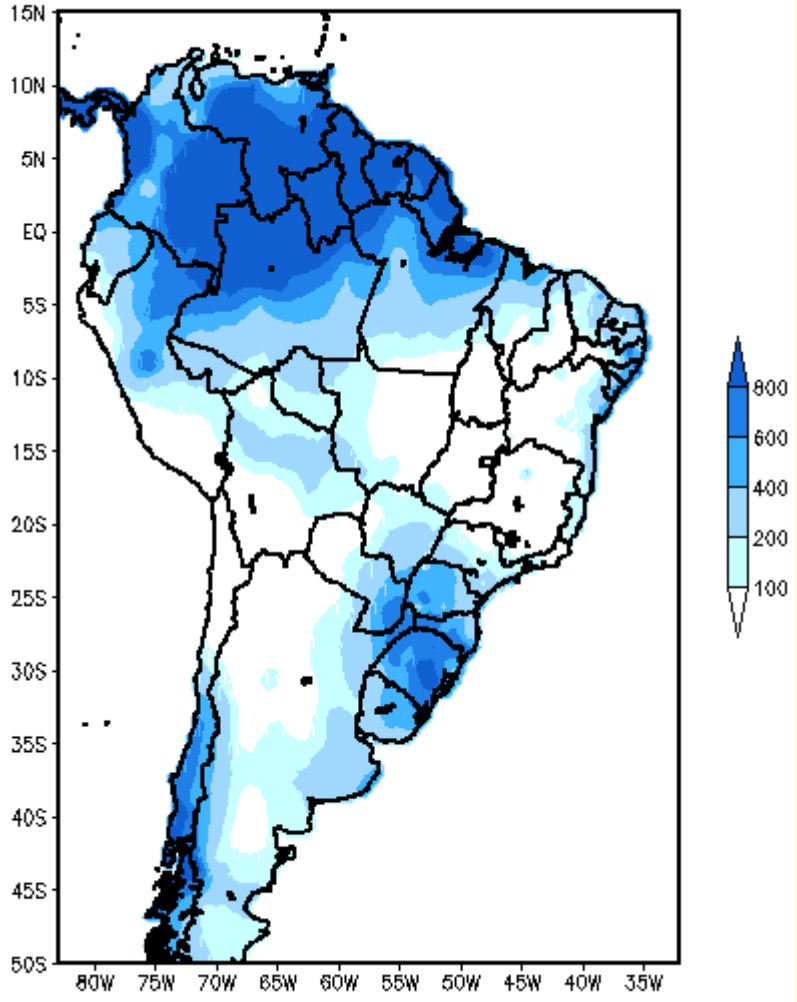


MJJA - 2002

Eta

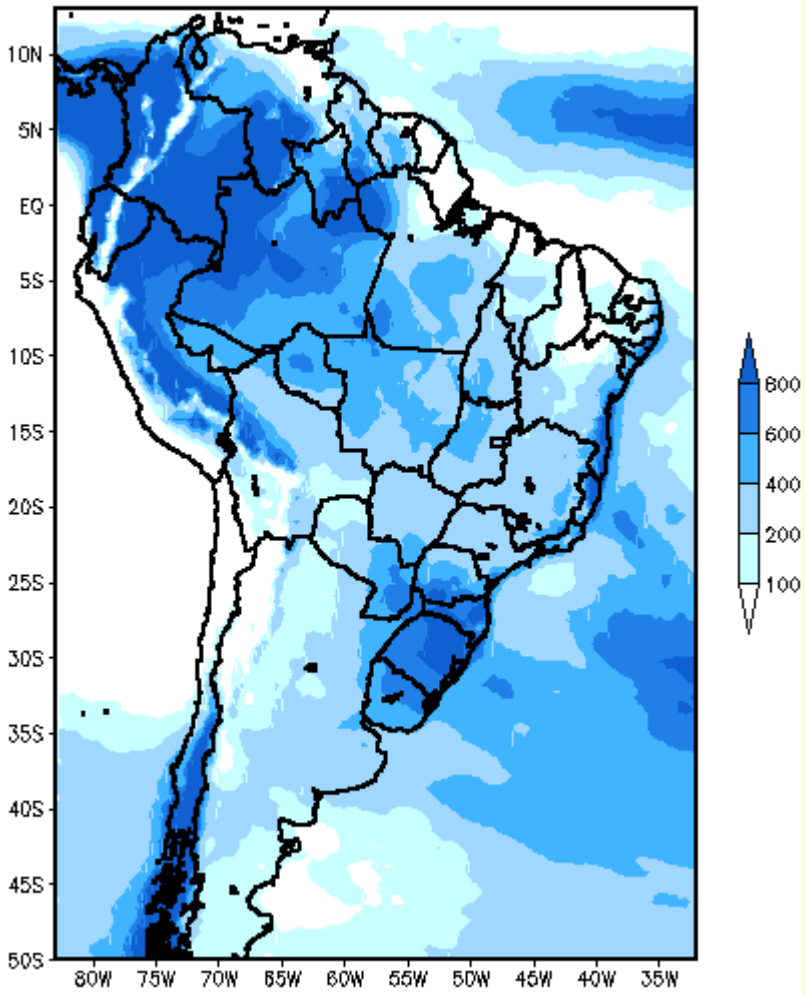


Obs

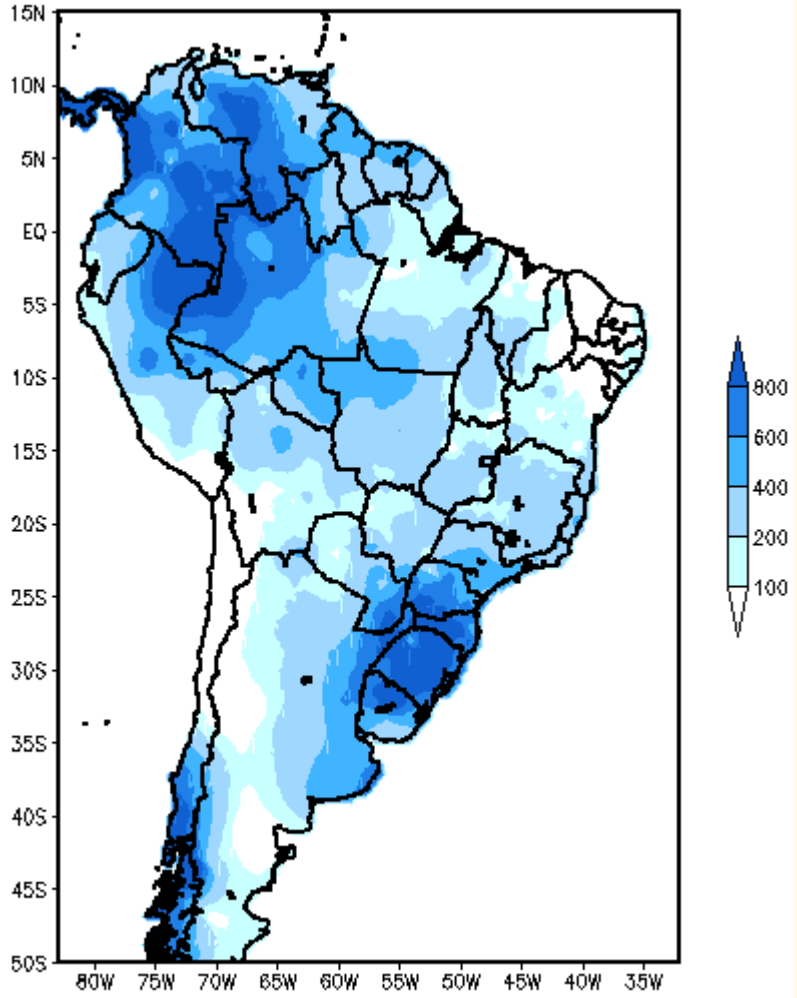


ASON - 2002

Eta

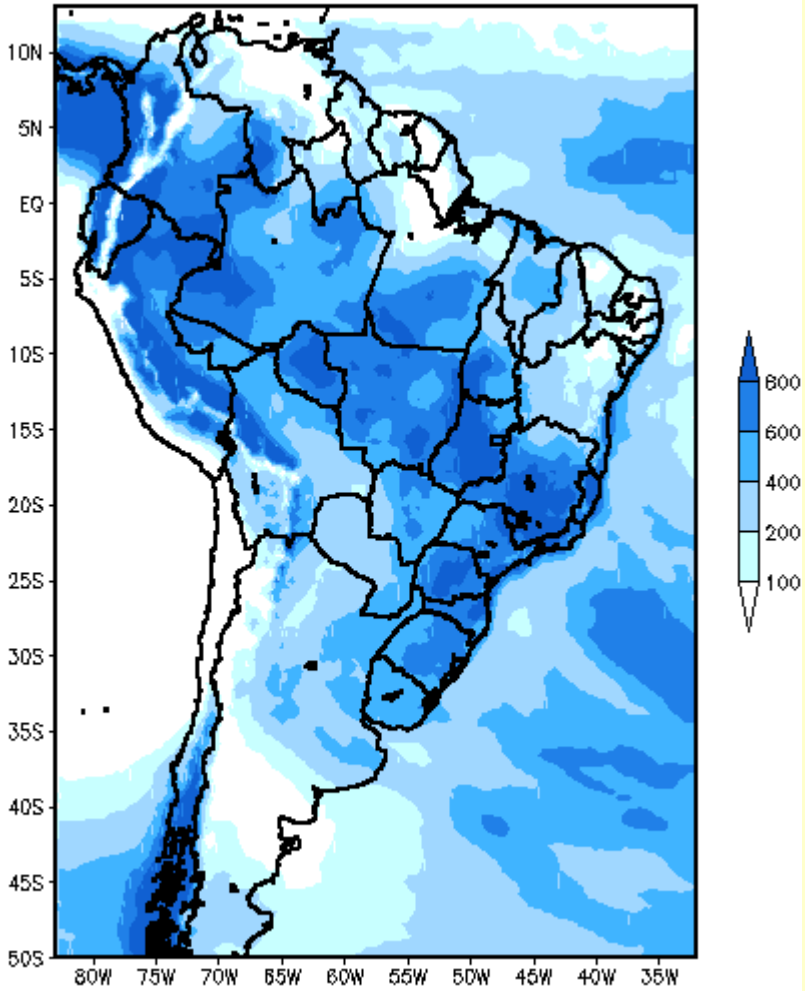


Obs



NDJF - 2002

Eta



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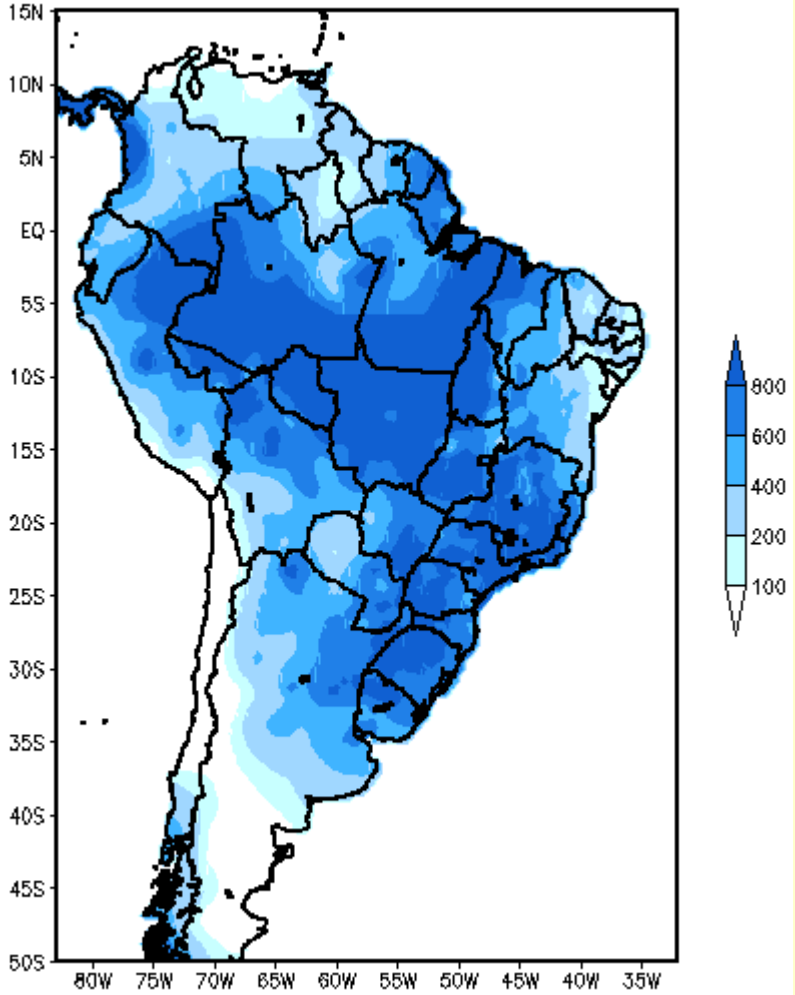


Equitable Threat Score

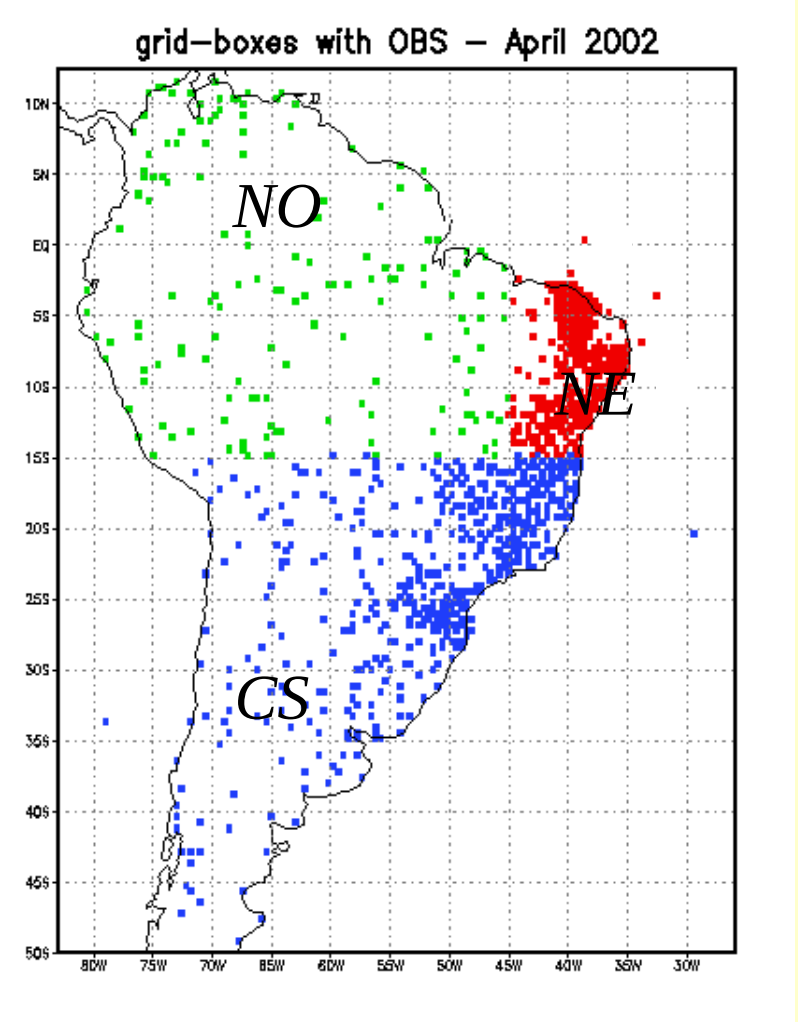
Two indices are calculated for precipitation evaluation.

$$ETS = \frac{H - CH}{F + O - H - CH}$$

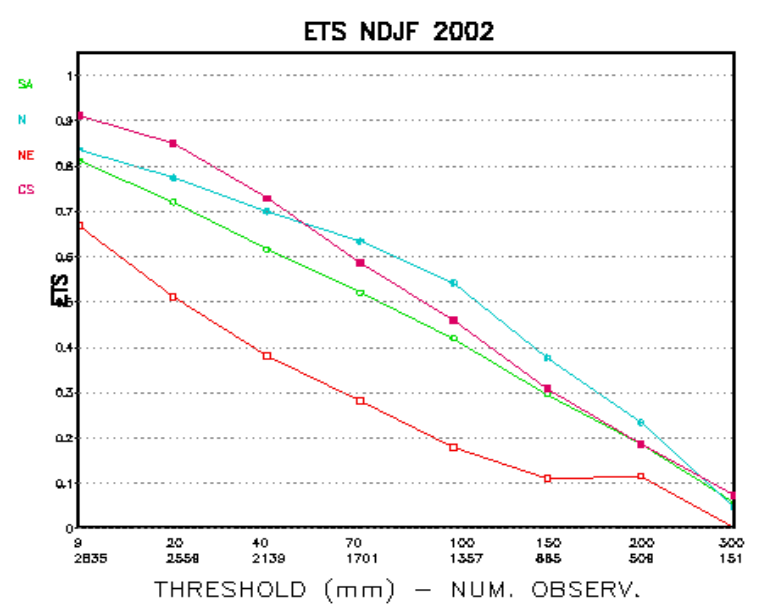
$$BIAS = \frac{F}{O}$$

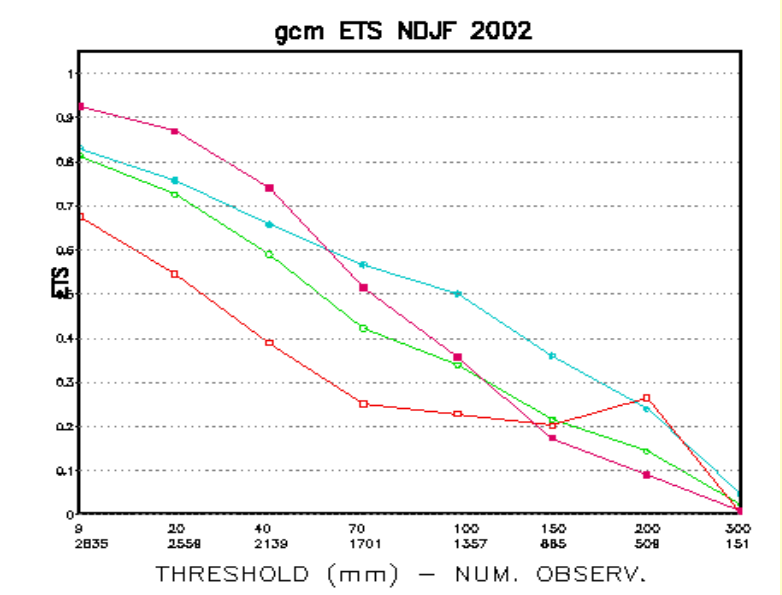
$$CH = \frac{F \times O}{N}$$

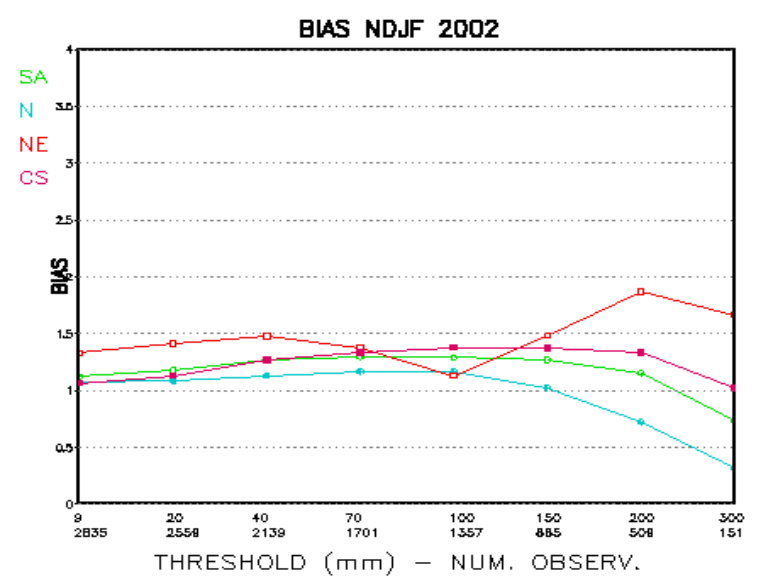
F = No. of forecast pts above a threshold
O = No. of observations pts above a threshold
H= No. of hits
CH = No. of points of random hits

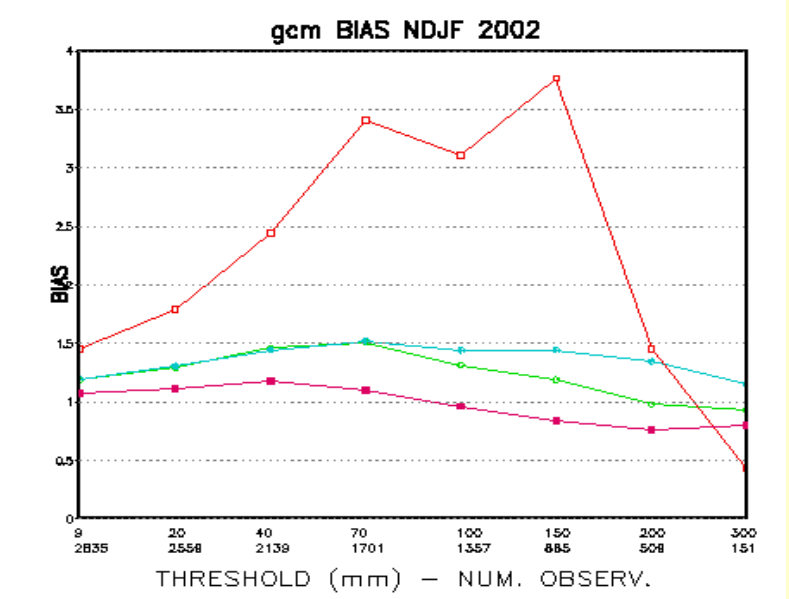


PRECIPITATION EVALUATION - NDJF

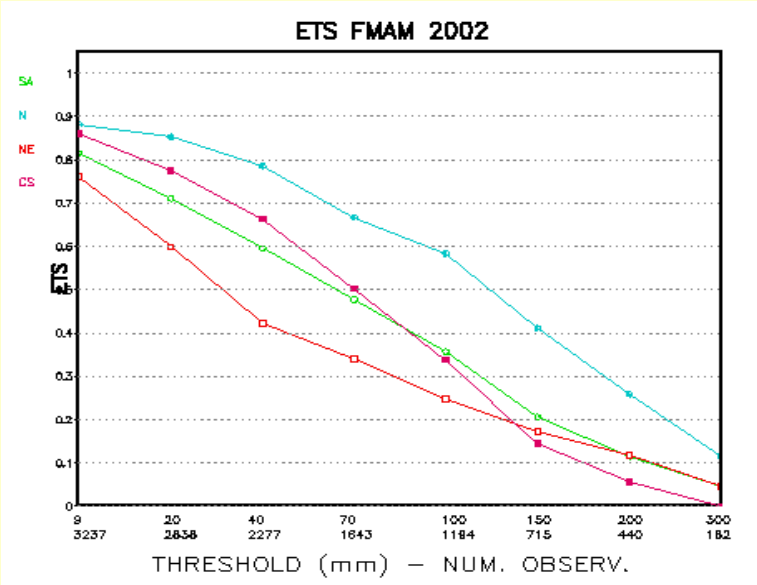


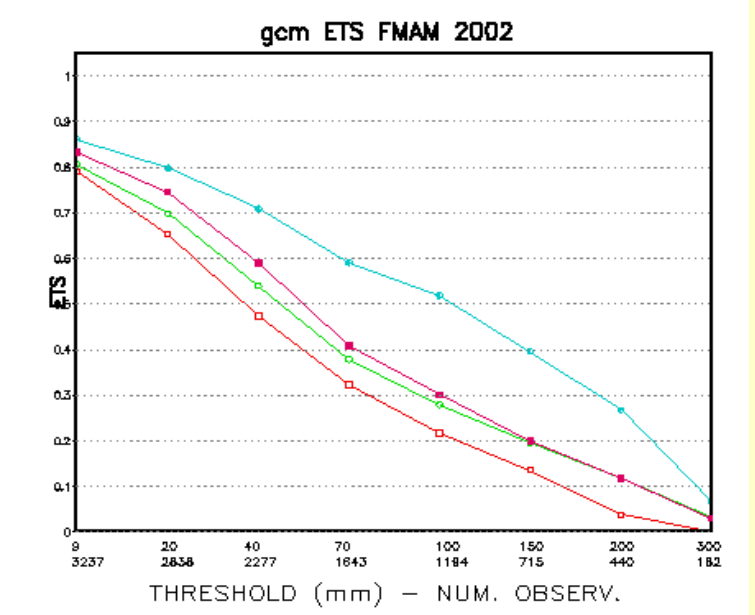


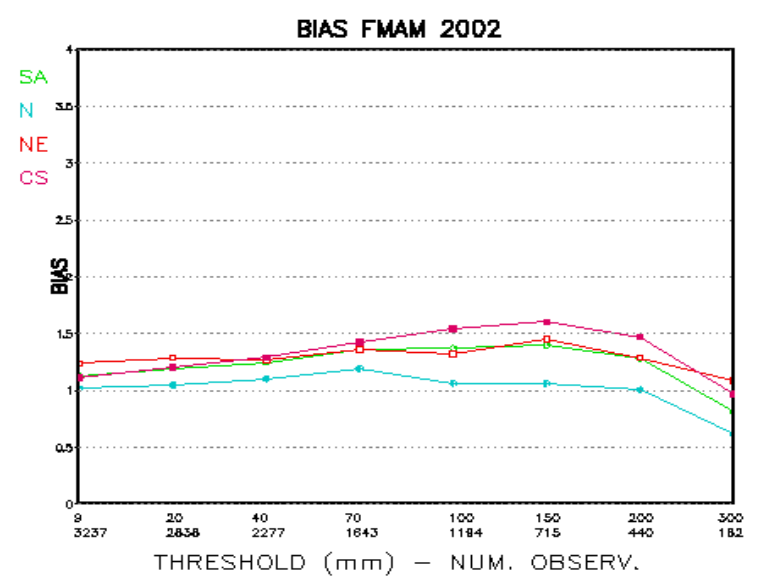


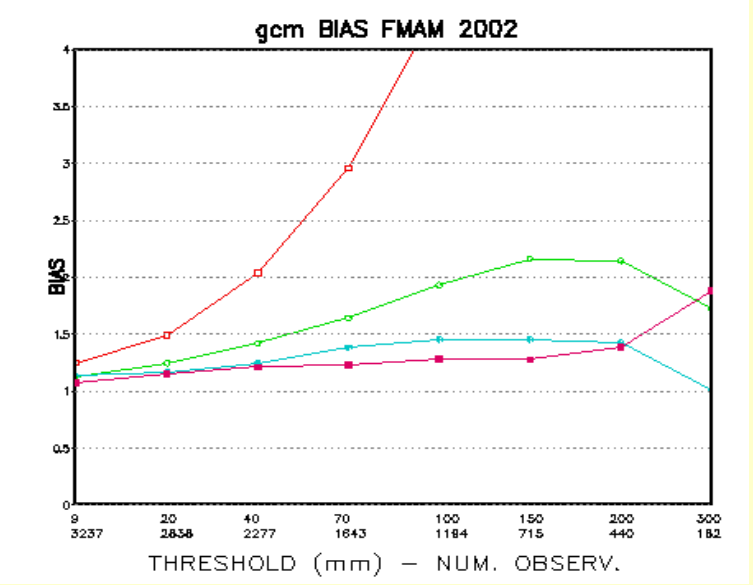


PRECIPITATION EVALUATION - FMAM







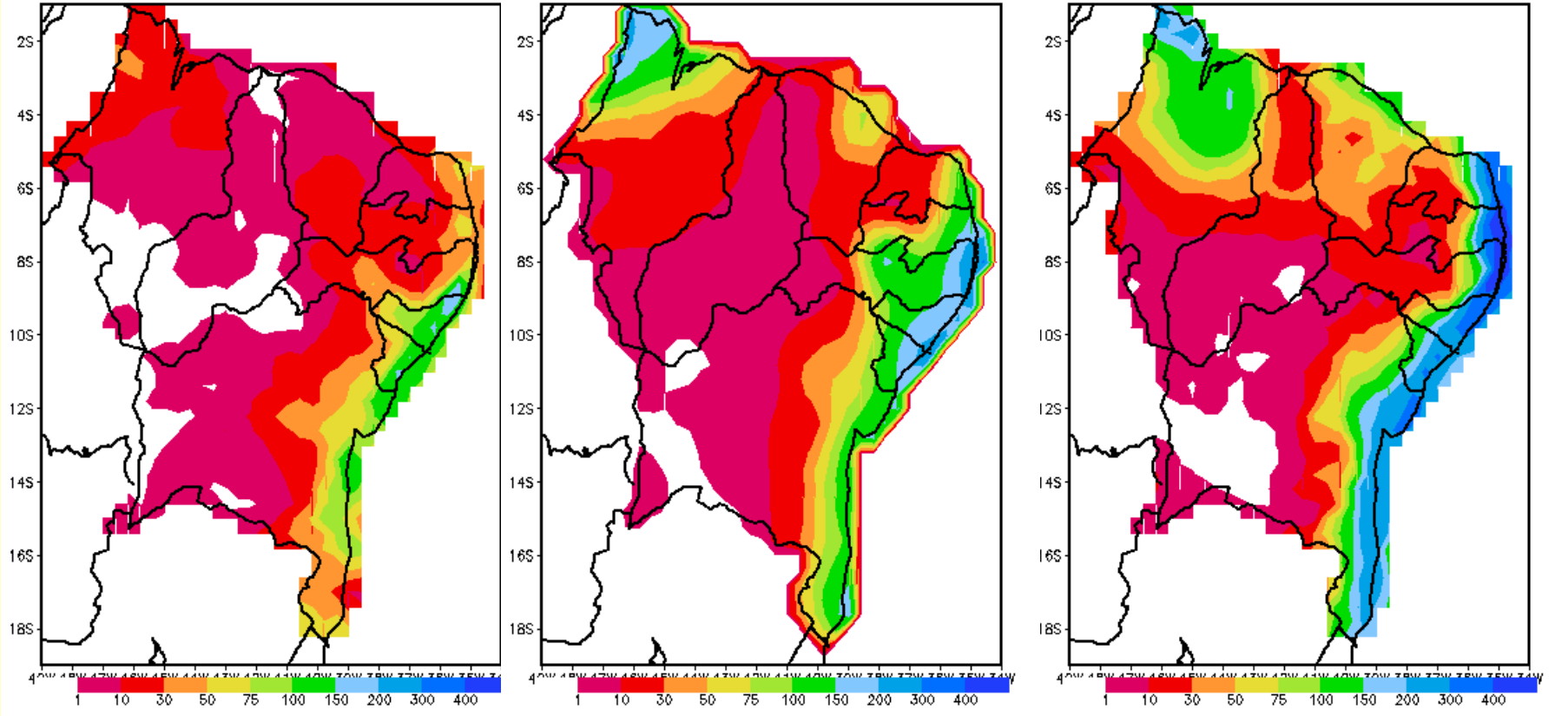


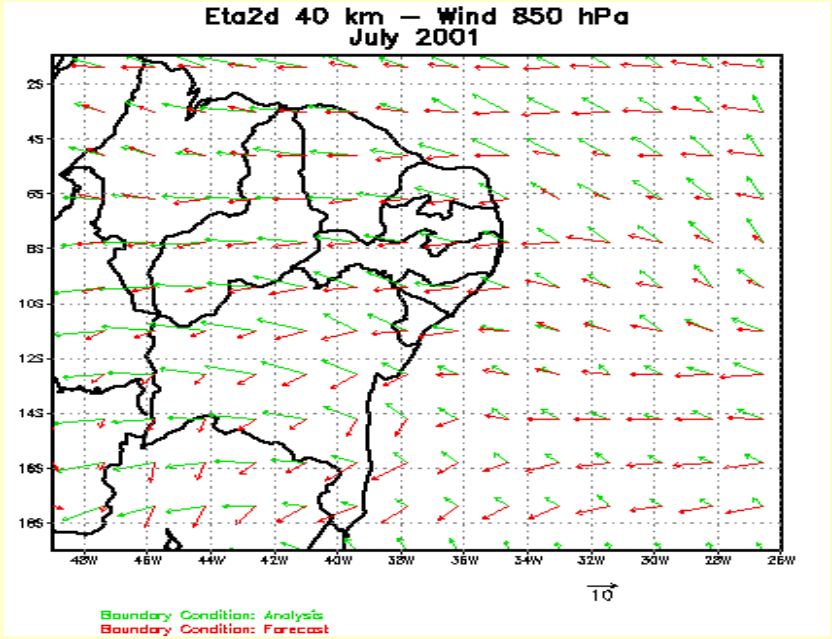
July 2001 Total Precipitation

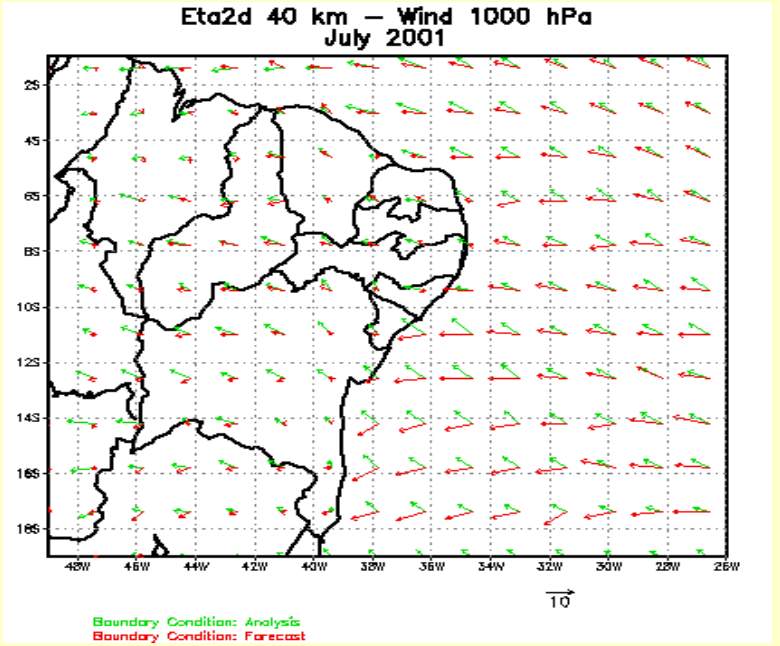
Simulated

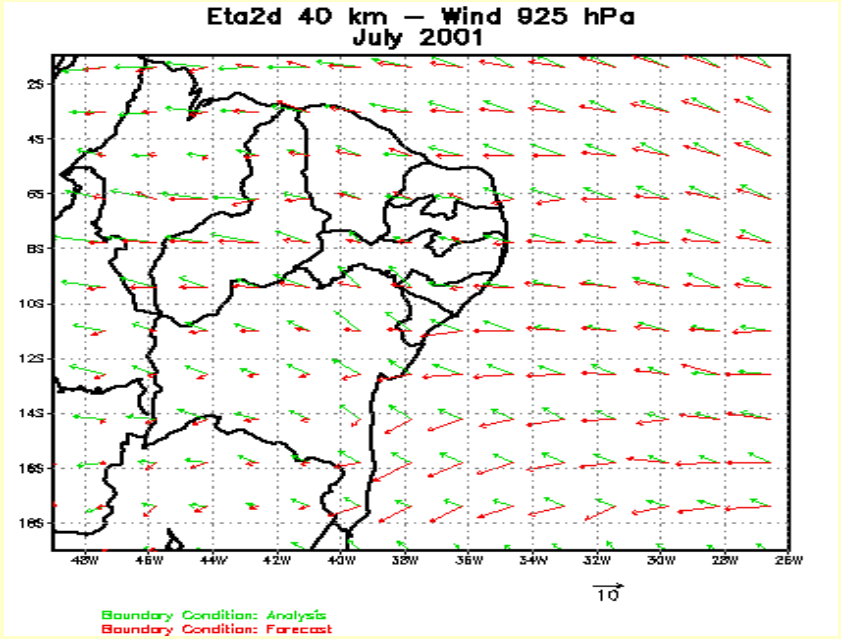
Observed

Eta forecast







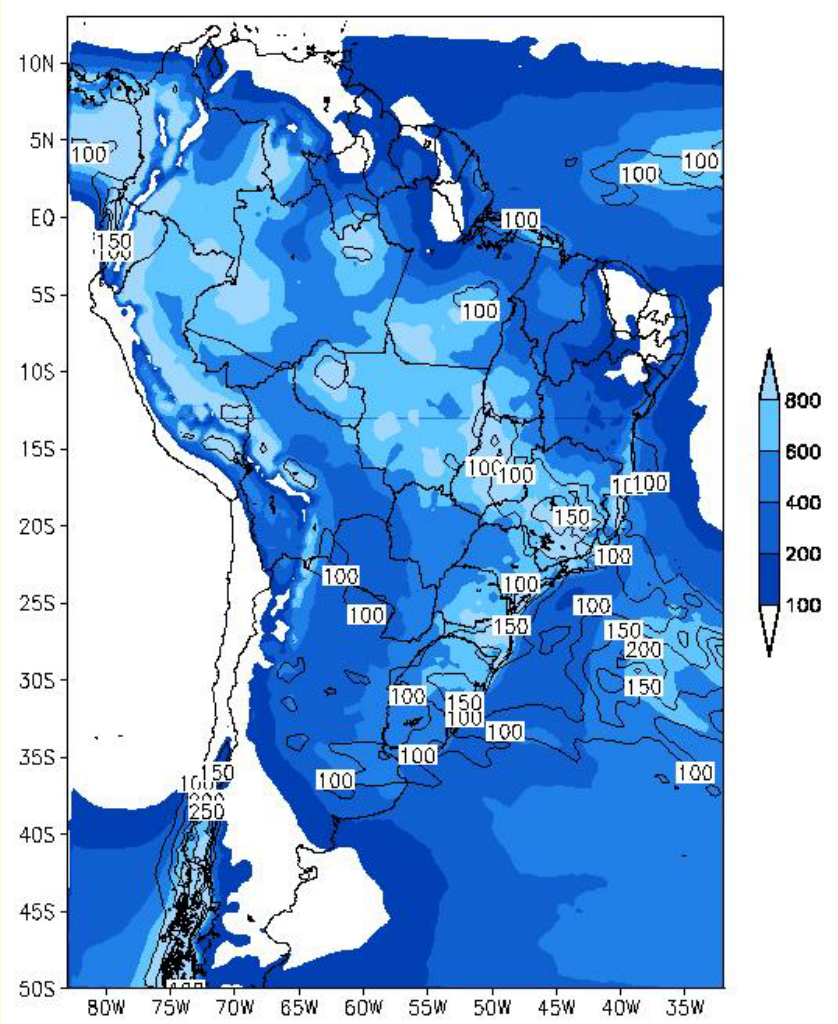


Analysis vs Forecast

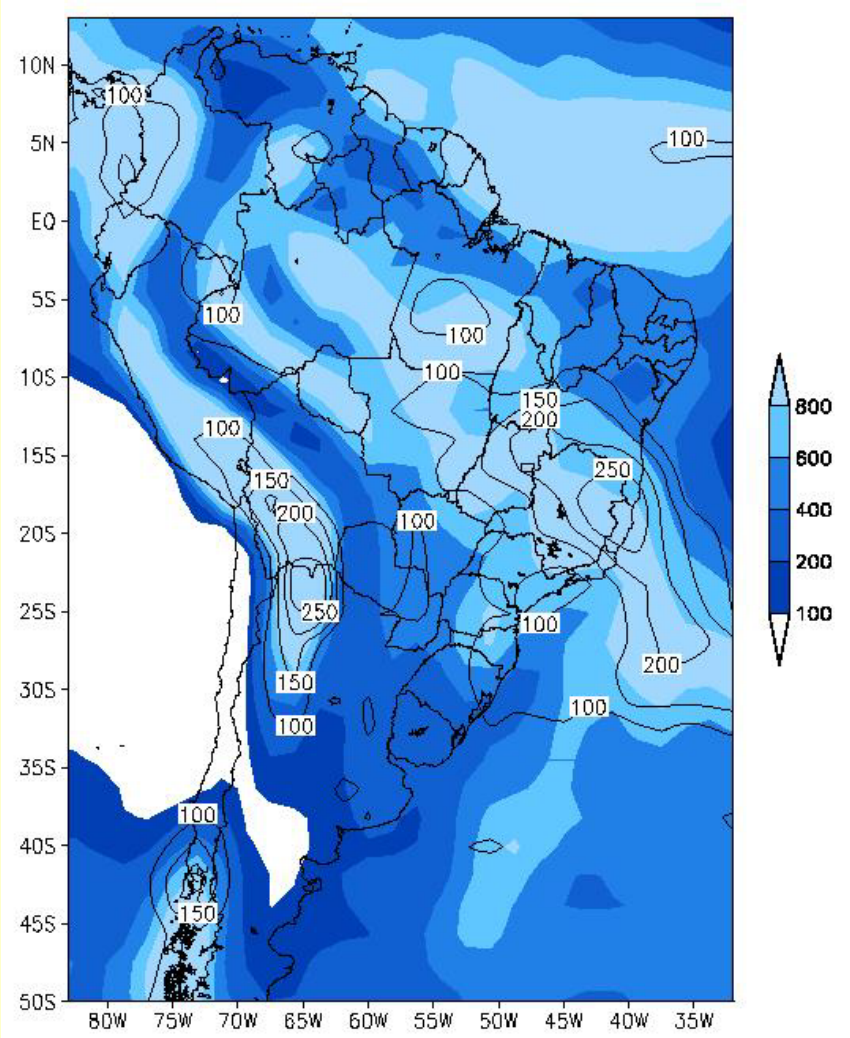
Wind Vetor

- ENSEMBLE Mean NDJF 2002-2003 total precipitation - shaded
- Spread of precipitation (4 months, mm) - lines
- 5 members

Eta



GCM



THE RUNS

5-year rainy seasons:

1998
1999 -- rainy year
2000 -- dry year
2001
2002

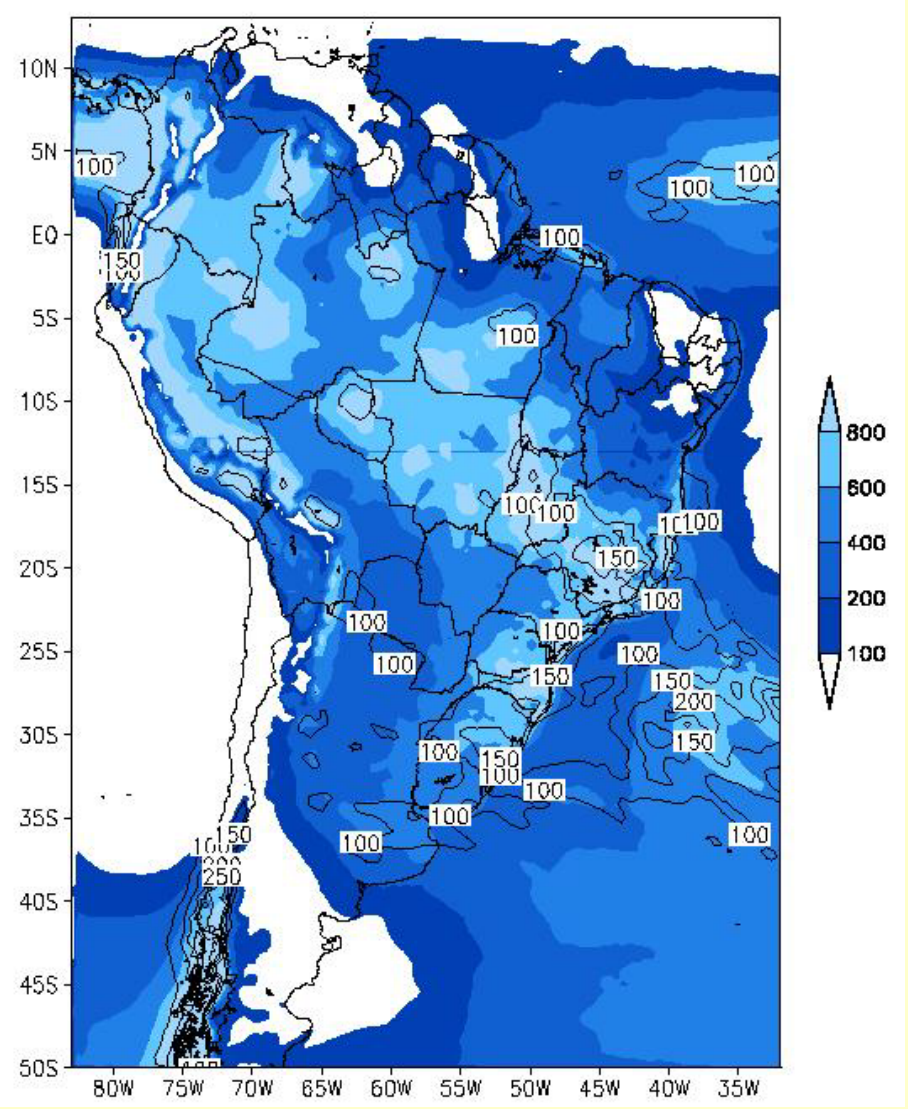
Runs	Integration Period
OND	Out-Nov-Dez-Jan-Fev-Mar-Abr
NDJ	Nov-Dez-Jan-Fev-Mar-Abr
DJF	Dez-Jan-Fev-Mar-Abr
JFM	Jan-Fev-Mar-Abr
FMA	Fev-Mar-Abr

Members	Description
1 Control	Initial conditions: DAY – 15
2	Increase convective rain through cloud eficiency
3	Continental convective activity equal to sea convective activity
4	Extend convective cloud life cycle
5	Earlier initial condition: DAY – 45

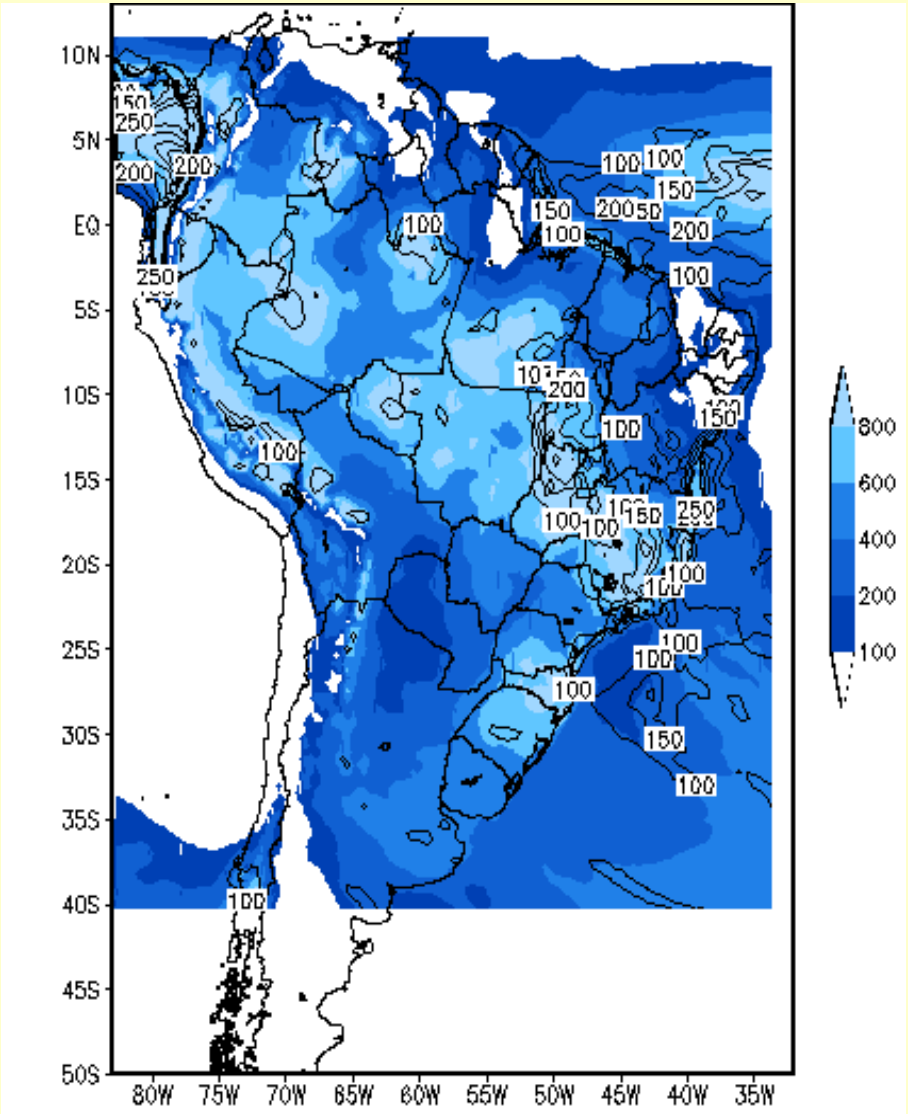
> Combination of ensemble generated by perturbation in the initial conditions and model physics

2002-2003 NDJF precip total & Spread

Initial Conditions

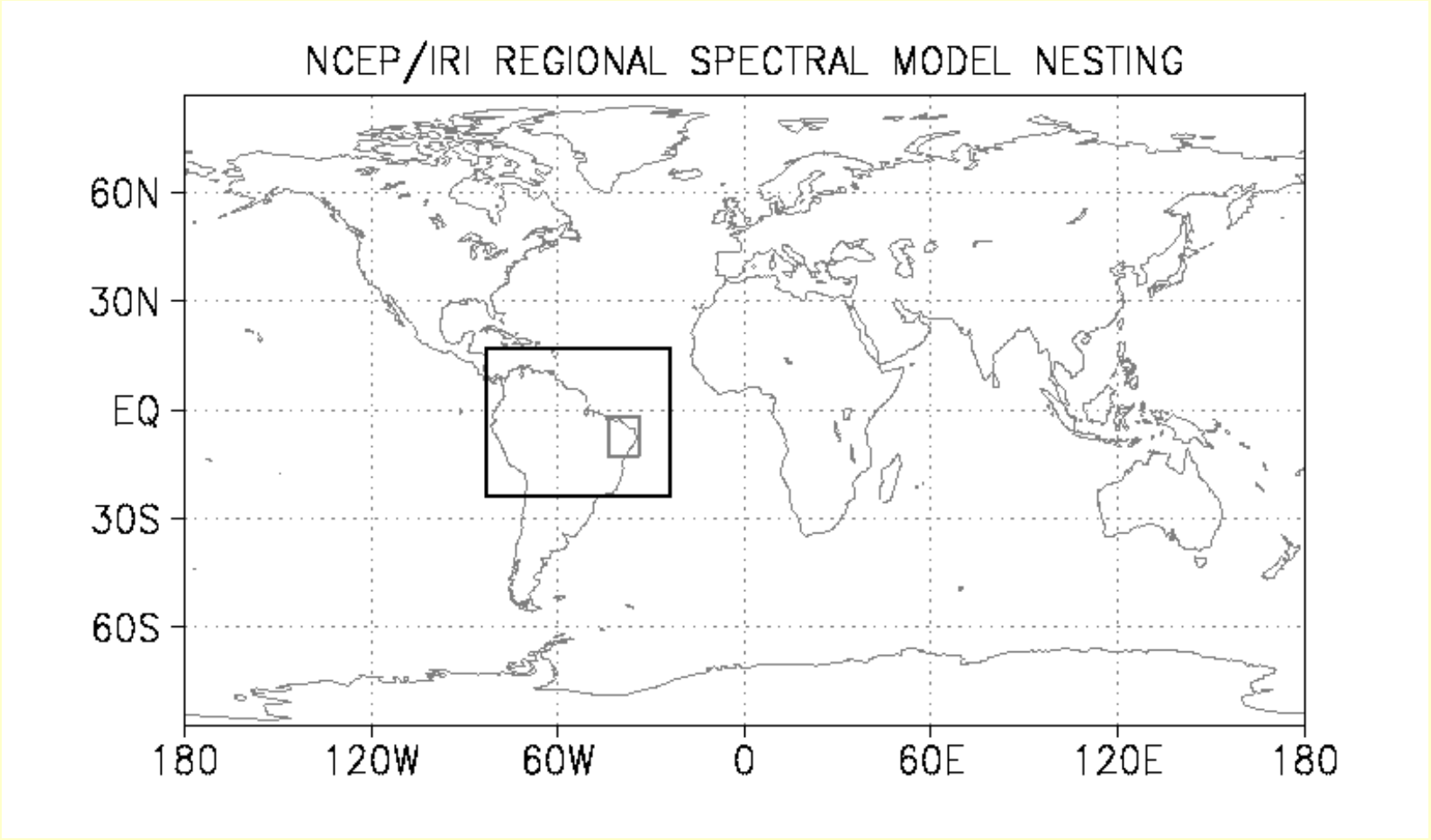


Physics



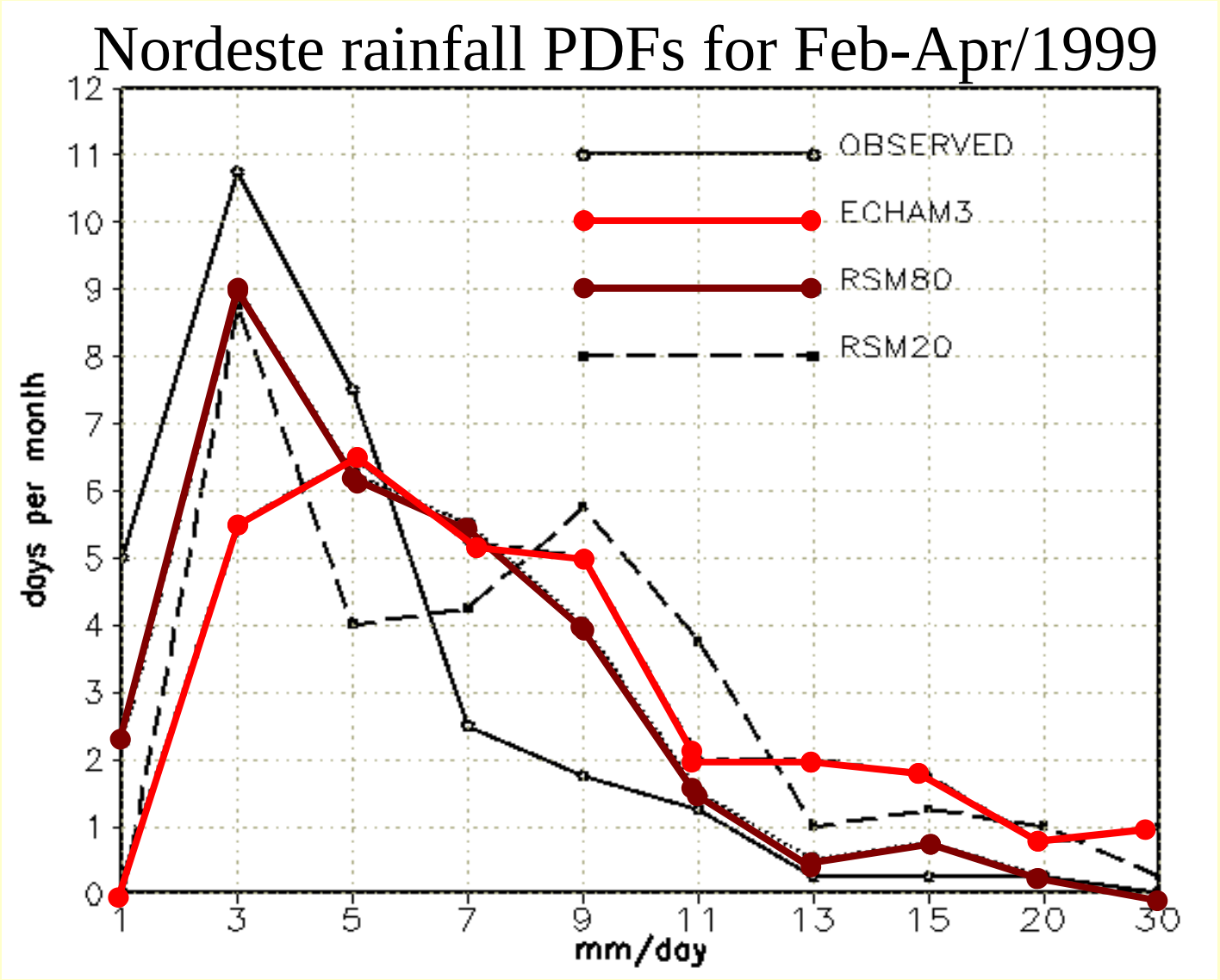
PRELIMINARY CONCLUSIONS:

- The ensemble runs generated from the physics perturbation show larger spread than the runs generated from perturbing the initial conditions;
- Spread from the physics prefer tropical areas, whereas spread from the initial conditions prefer higher latitudes;
- No clear improvement to forecast skill among the physics members.



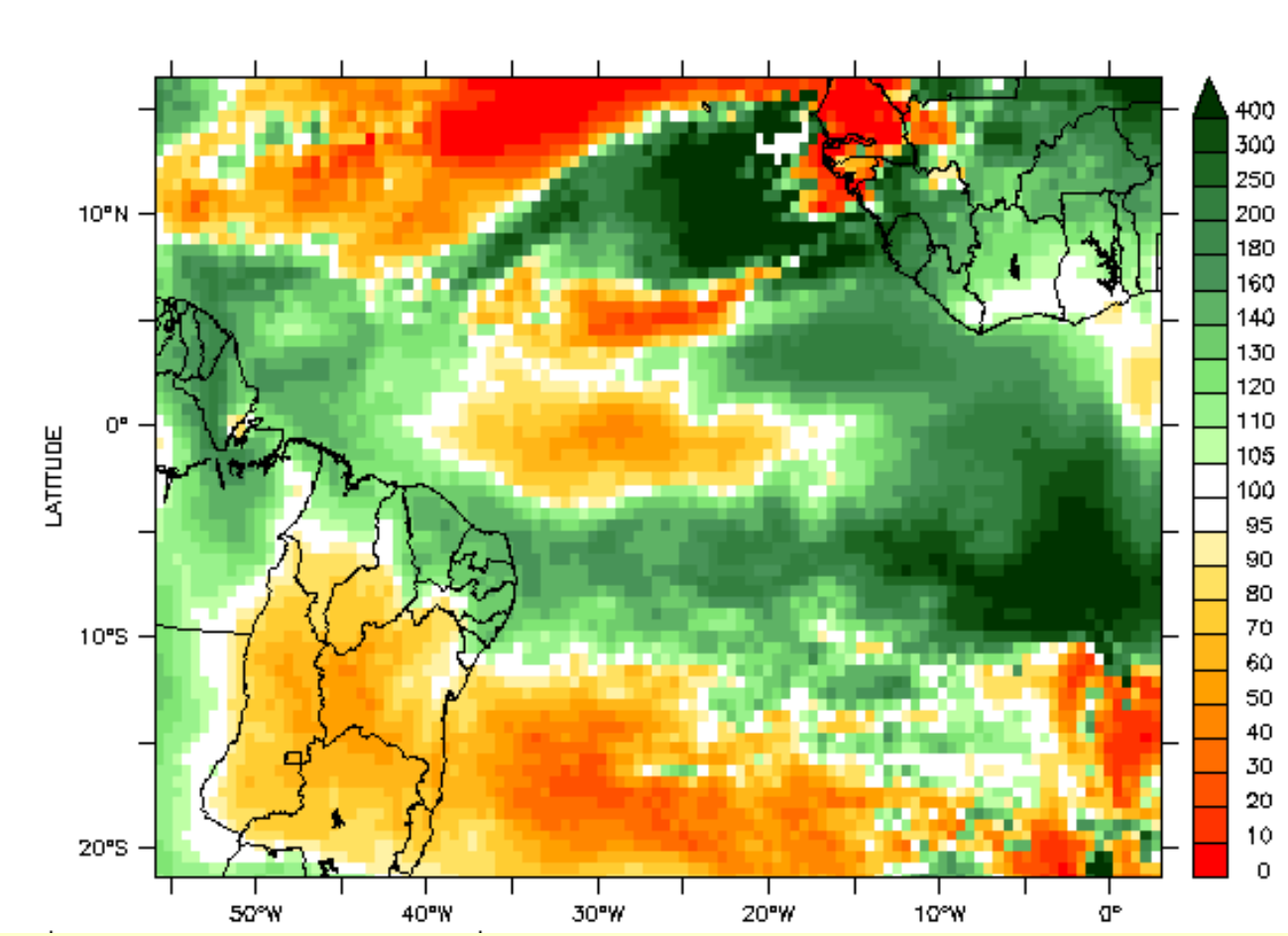
Nobre et al. (2001)

Regional Climate Prediction

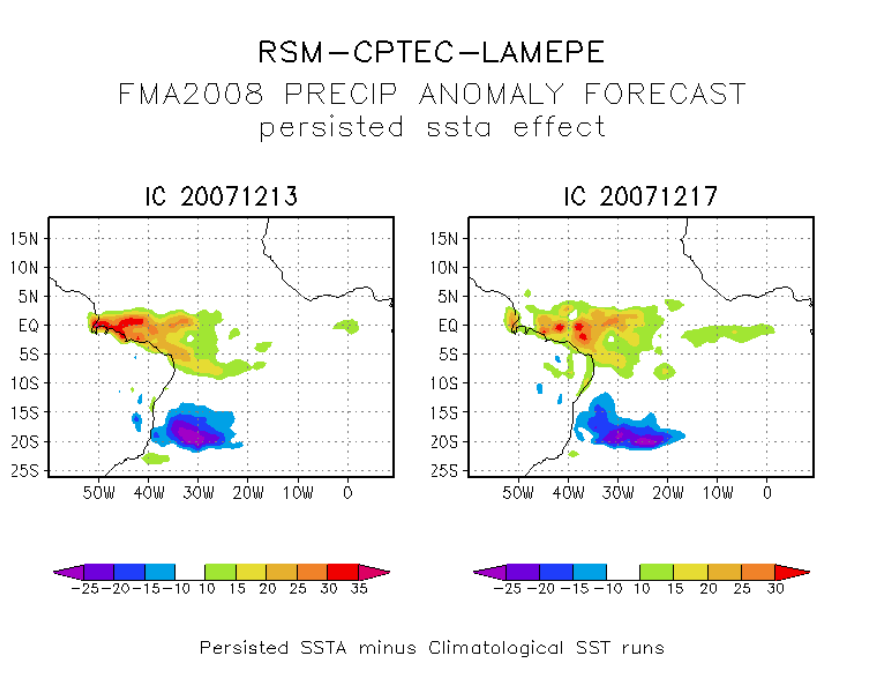


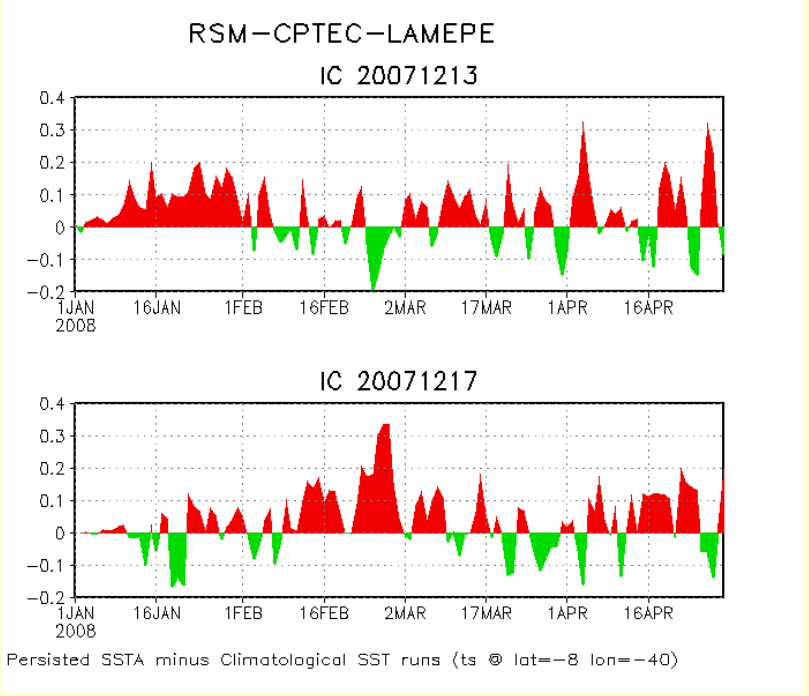
Nobre et al. (2001)

RSM 97 FUNCEME
RAINFALL FORECAST MAM 2008



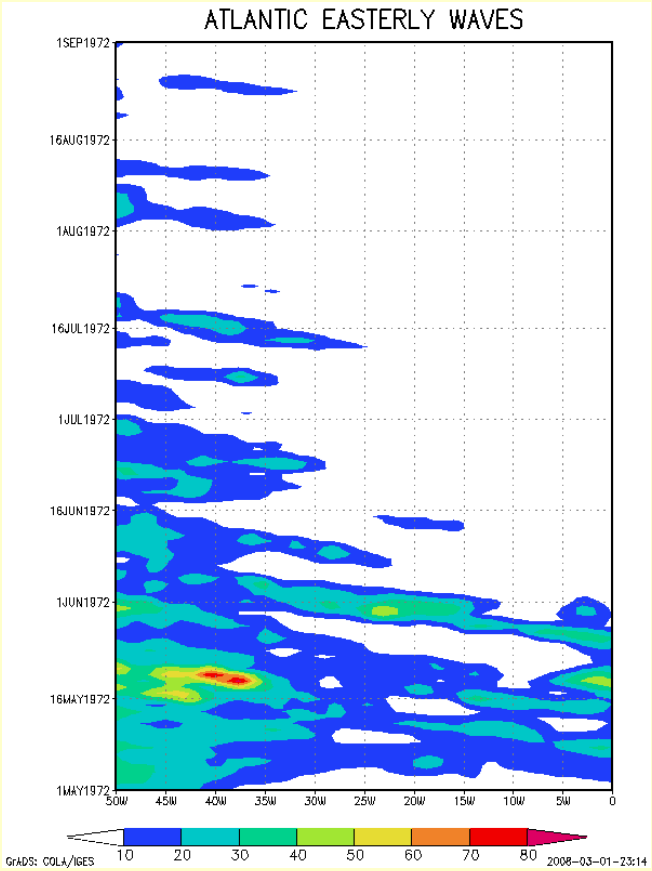
SST Impact on FMA/2008 precip forecast over Nordeste

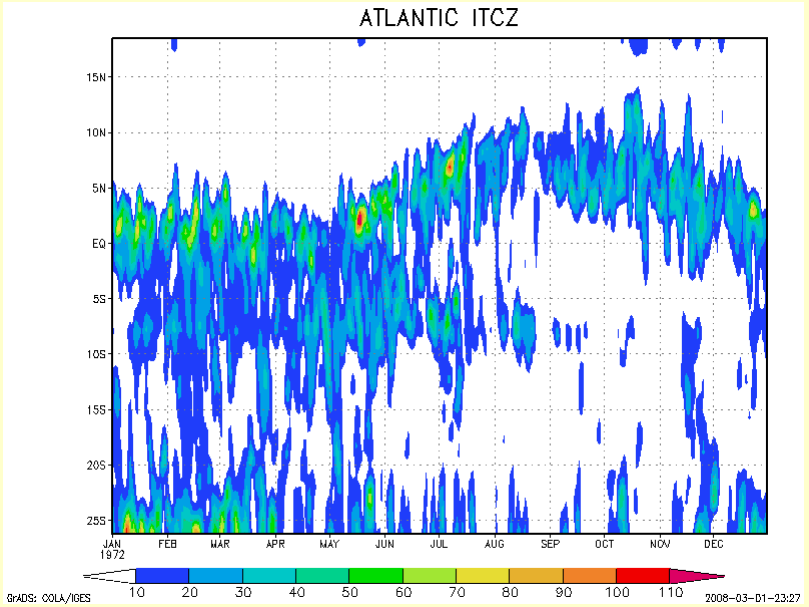




Nobre et al (in prep)

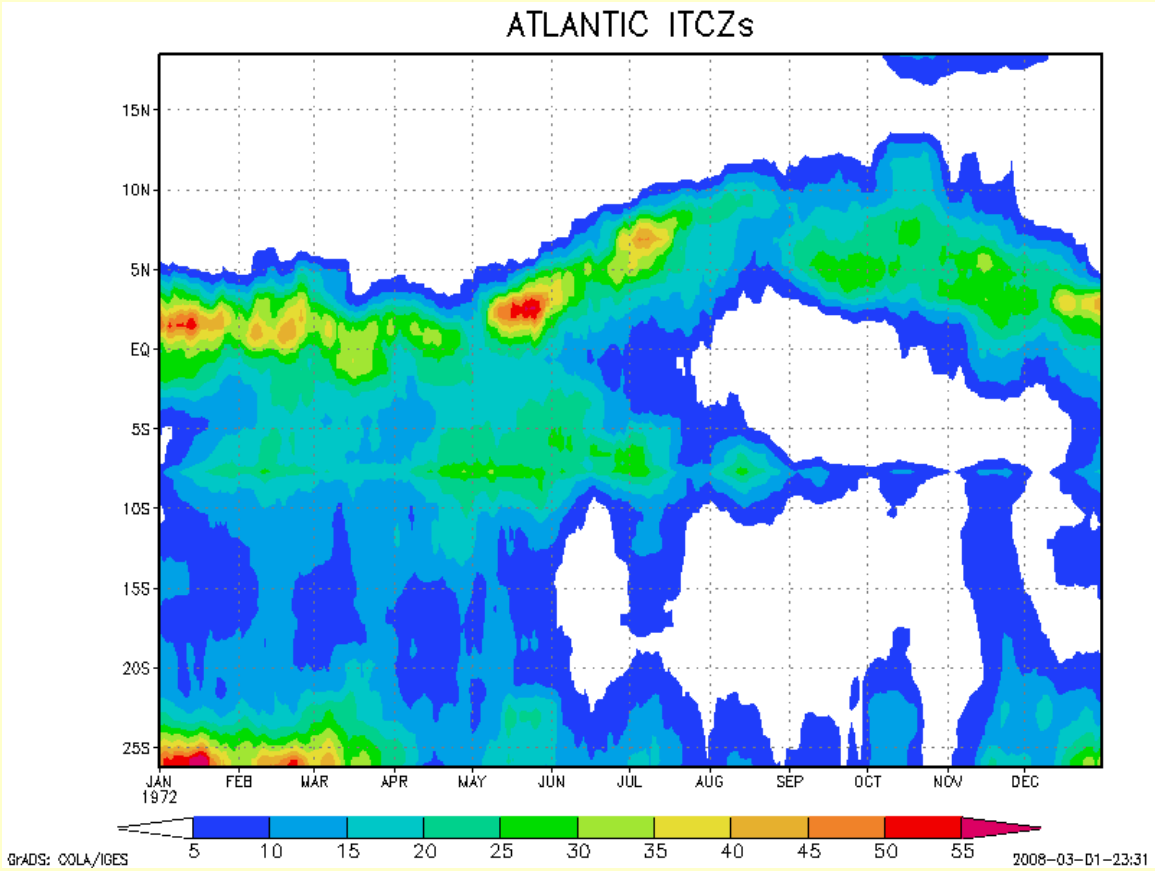
RSM-CPTEC-LAMEPE
Easterly Waves and ITCZ





Nobre et al (in prep)

RSM-CPTEC-LAMEPE
Intraseasonal Oscilations



Nobre et al (in prep)

SUMMARY

- Regional Climate Models have been widely used in South America for both, regional climate change scenarios and seasonal climate prediction activities.
- It is of less importance *how* RCM compare to GCM, but *what* RCM can do that GCM can not.
- “The problems are in the details.”

To be continued…

Thanks.