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 2008

The Drought of Amazonia in 2005: Numerical Experiments with a RegCM3

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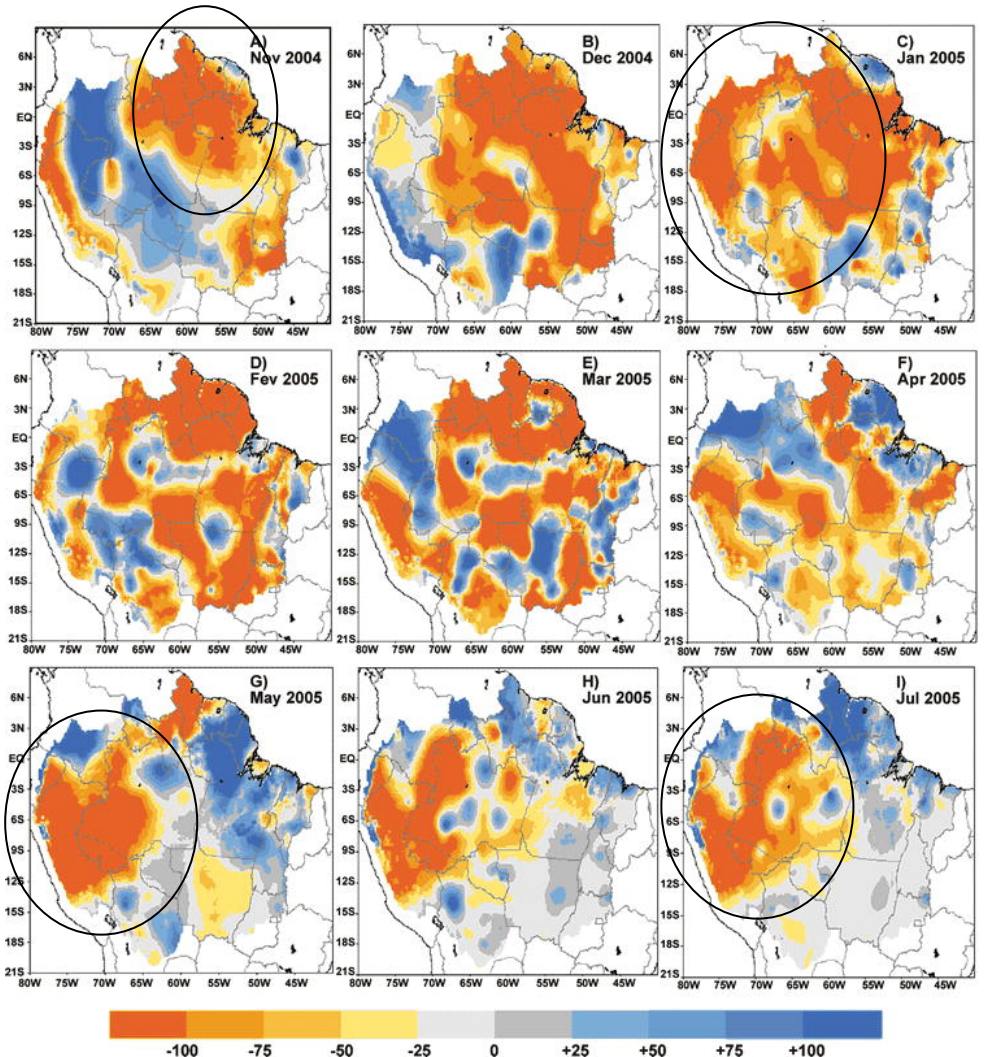
Background

- Drought characteristics: localized and not continuous in the space and time

Observed monthly rainfall anomalies

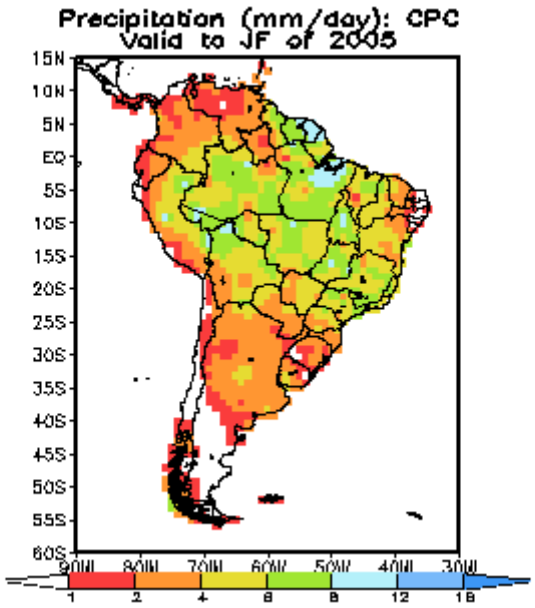
From Nov/2004 to Jul/2005

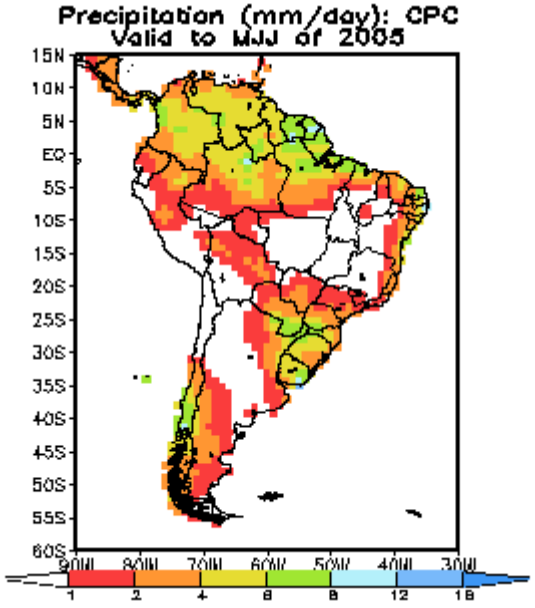


Marengo et al. 2008

J. Climate

CPC rainfall analysis for JF and MJJ 2005



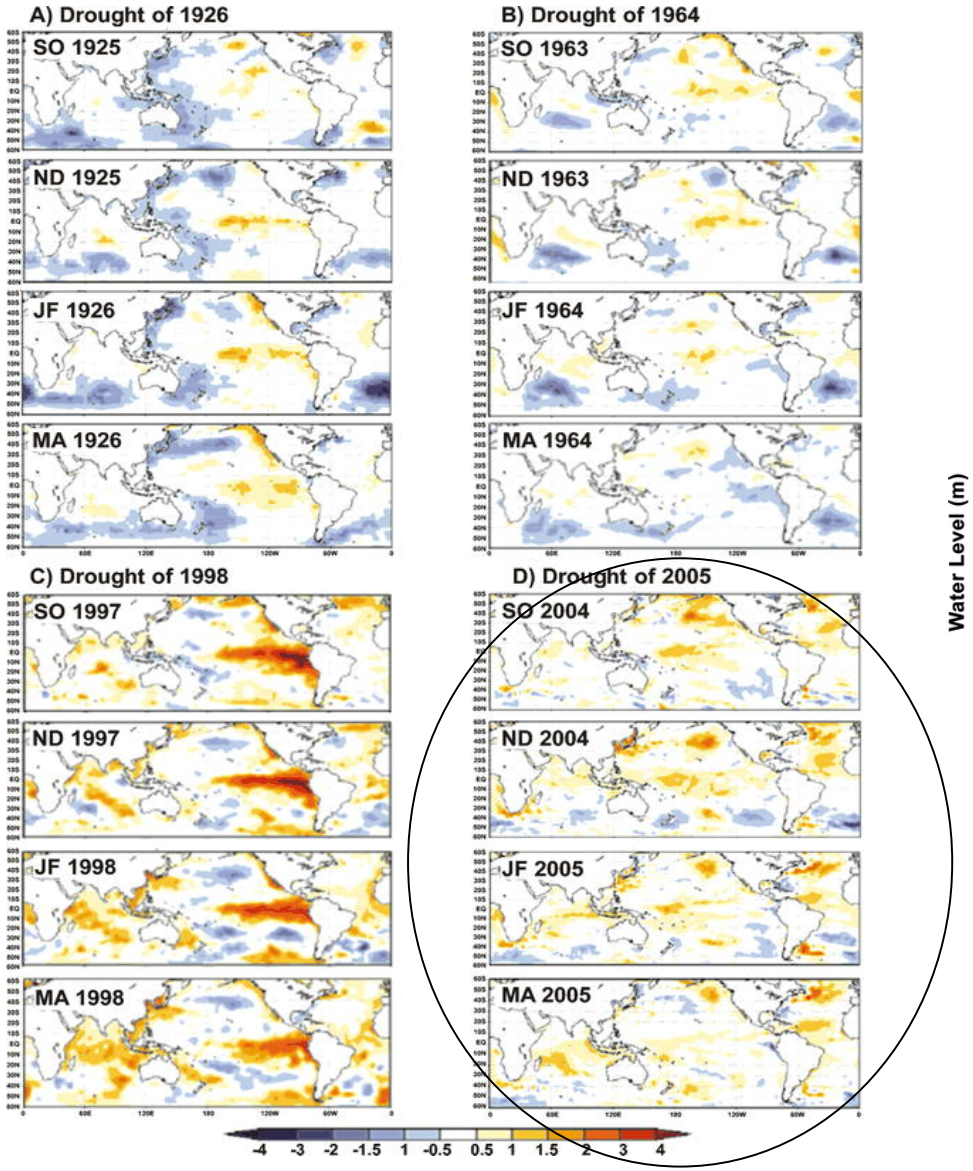


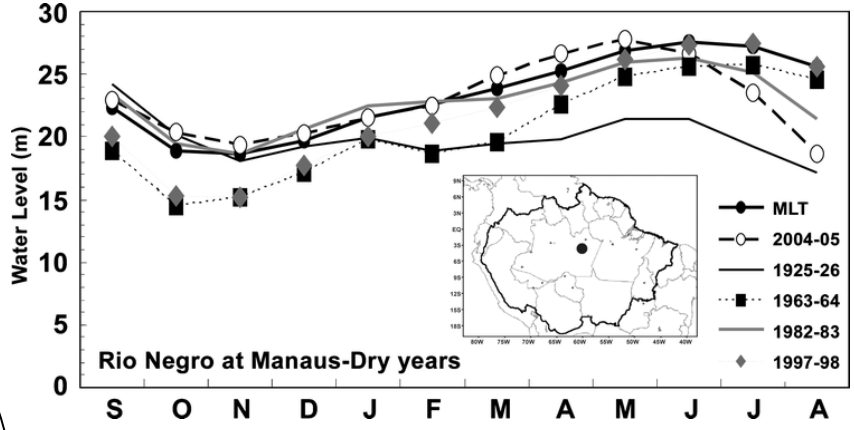
Motivation

- Scientific and social aspects (impact in the water resources-agriculture, fishery, boat transportation, economy)

• *Hypotheses*

- There is no relationship between the 2005 drought and the El Nino (Marengo et al. 2008)
- Tropical North Atlantic SST: warm anomalies *(weaker trade winds ➔ reduction of the moisture fluxes to the Amazon basin ➔ less precipitation) (Marengo et al. 2008)
- Soil moisture anomalies **(local forcing: reduces the evapotranspiration ➔ less precipitation);





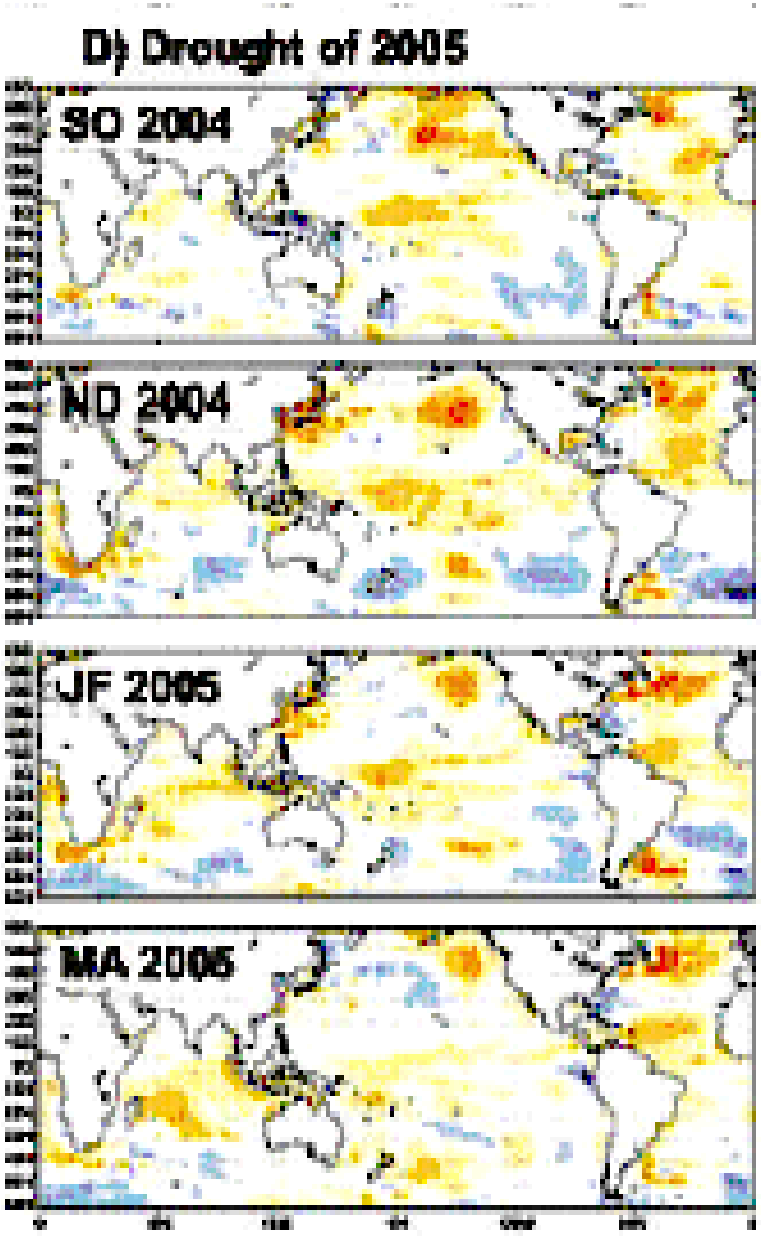
Marengo et al., 2008

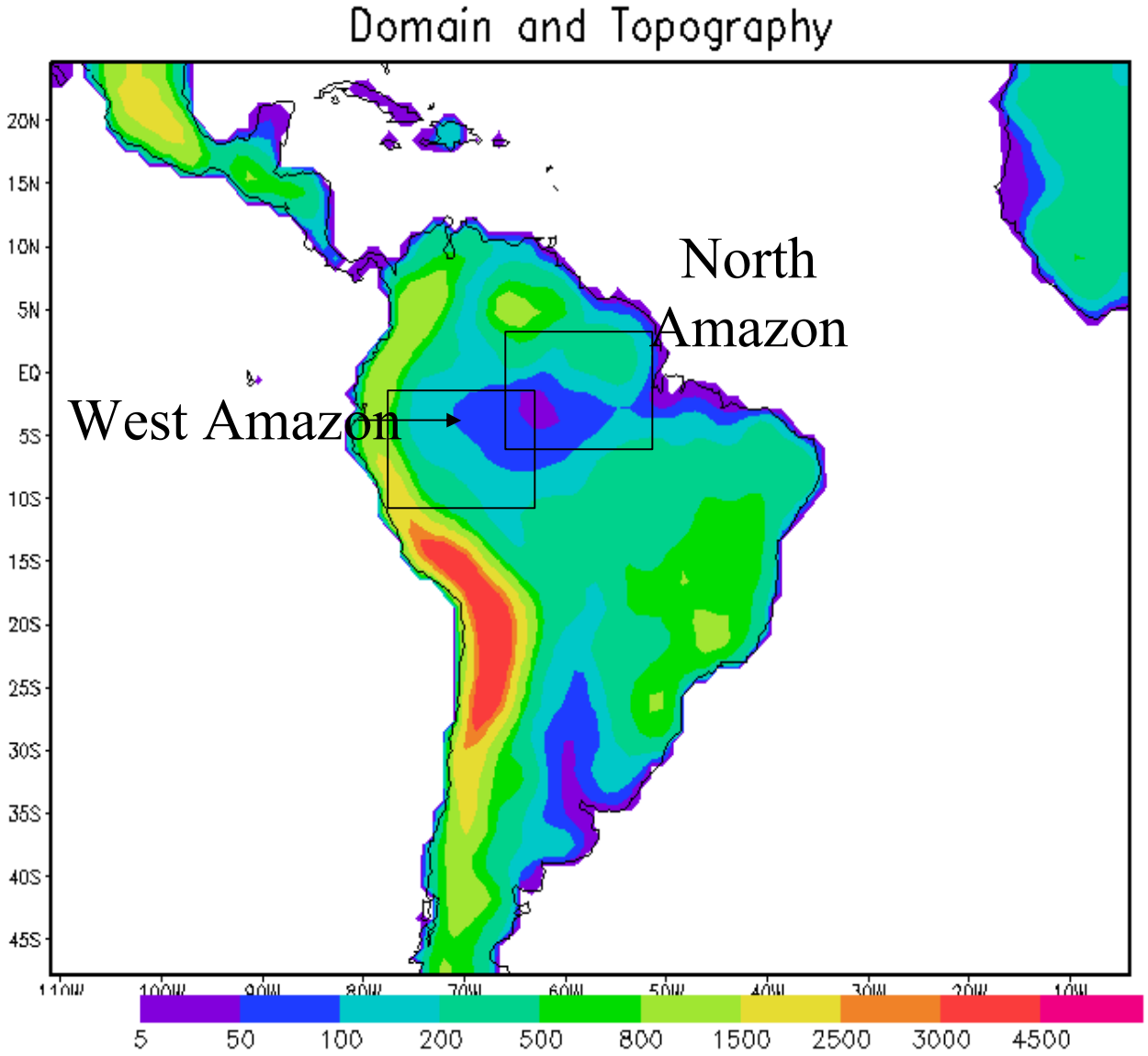
Objectives

- Understand the physical process(es) associated to the drought of Amazonia in 2005 using a RegCM3 for sensitivity experiments:
  - Tropical North Atlantic SST anomalies (remote)
  - soil moisture initial condition; (local)
  - Aerosols impact; (local)
  - Impact of cumulus convection parameterization

Numerical design

- Integrated the RegCM3 over South America domain
- Coarse resolution 120 km (computational resources)
- IC and BC from NCEP/DOE reanalysis II and monthly mean SST from Reynolds
- Period: from 00Z01 Nov 2004 till 00Z01 Dec 2005 (or less)
- Physical parametrizations: Emanuel or Grell-FC (cumulus convection) and Zeng (surface fluxes over the ocean)

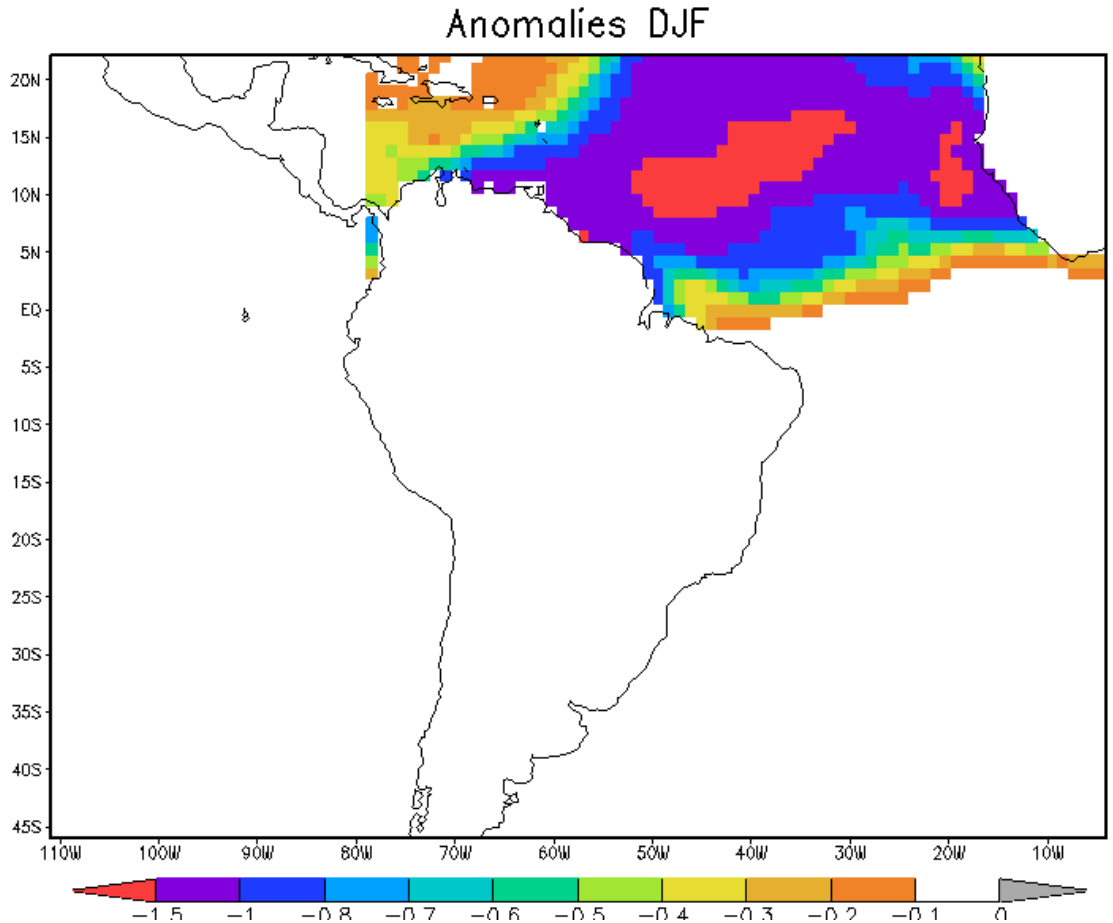

D) Drought of 2005
SO 2004
ND 2004
JF 2005
MA 2005


Domain and Topography
North Amazon
West Amazon
20N
15N
10N
5N
EQ
5S
10S
15S
20S
25S
30S
35S
40S
45S
110W
100W
90W
80W
70W
60W
50W
40W
30W
20W
10W
5
50
100
200
500
800
1500
2500
3000
4500

Experiments: 5

- CRTL, control: uses the convective Emanuel scheme
- SST: removed the positive SST anomalies only in the North Atlantic ocean
- MOIST: reduces initial soil moisture by -40% in all domain
- AER: aerosol with feedback (10 types – [B + dust]) and another one without feedback
- GFC – is like the CTRL, but uses the Grell with FC closure

SST Perturbation

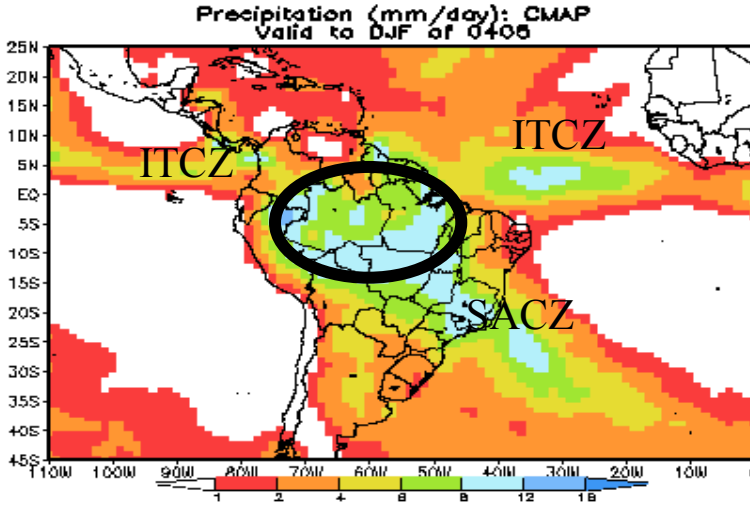


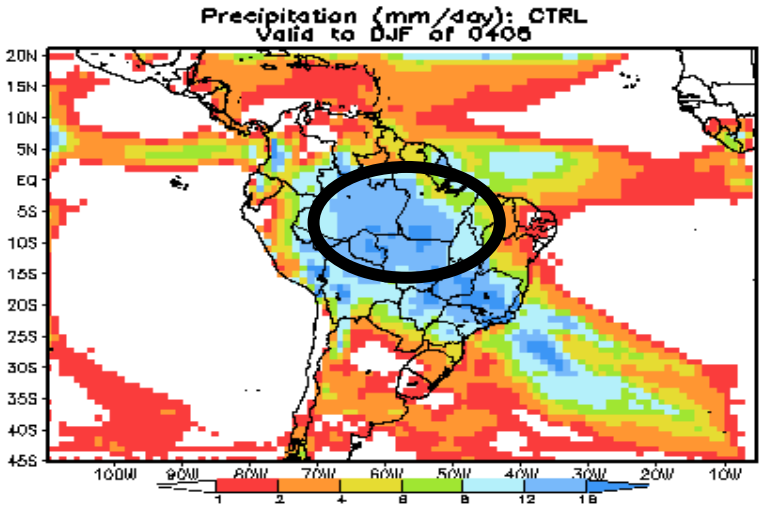
Comparisons

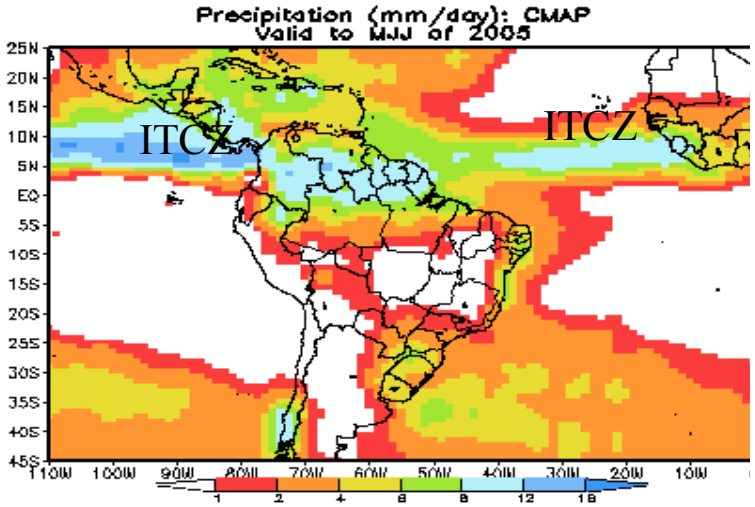
- DJF/2004:2005 and MJJ/2005
- GPCP and CMAP for precipitation
- CRU for air temperature (not available for period)

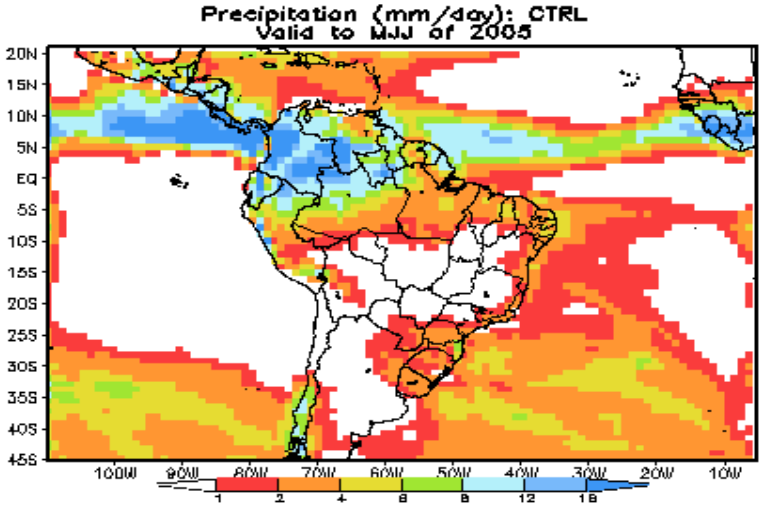
Results

The CTRL experiment and the observations: DJF/2004:2005









CMAP CTRL

CTRL simulated very well the observed rainfall pattern as the:

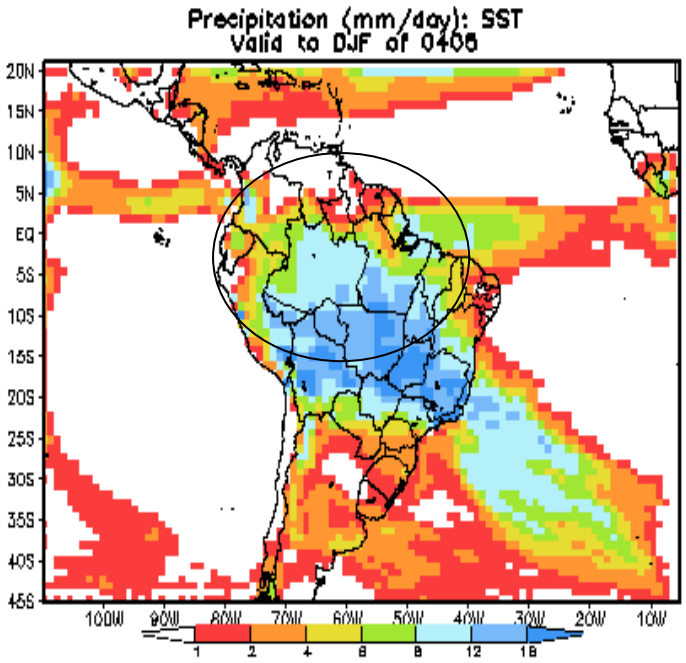
ITCZ position and north-south displacement (in both Pacific and Atlantic Oceans)

SACZ during the summer

Precipitation in the south of Brazil associated to the mid latitude systems.

Problem: the simulated rain is more intense and it is not possible to identify directly the drought during the DJF of 2005.

DJF



SST Experiment

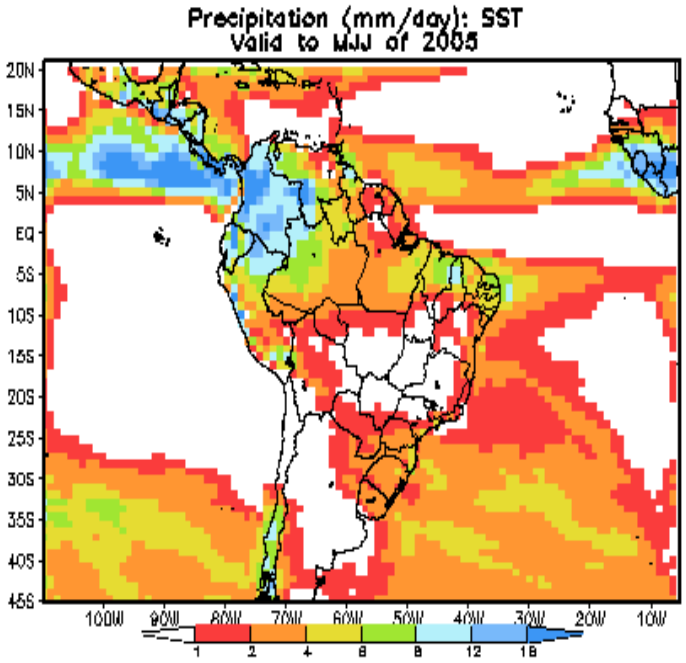
The spatial pattern is similar to the CTRL experiment:

ITCZ

SACZ: less precipitation in the ocean

Mid latitude systems

MJJ



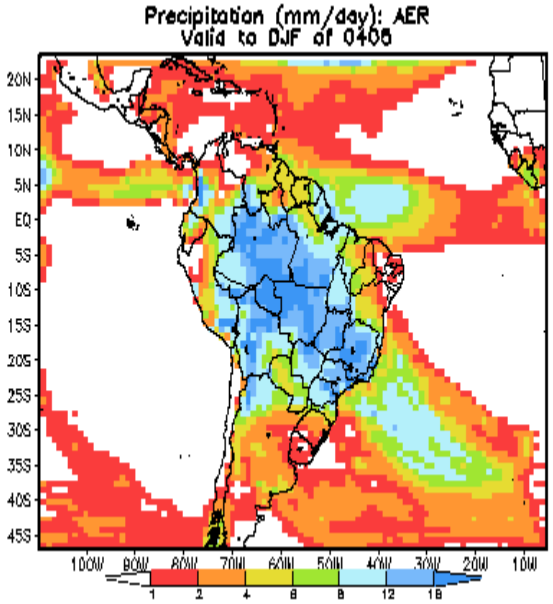
SST

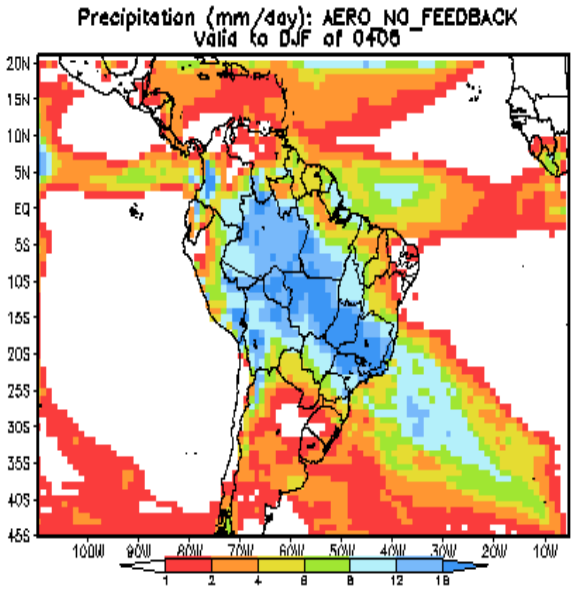
Aerosol Experiment

with feedback

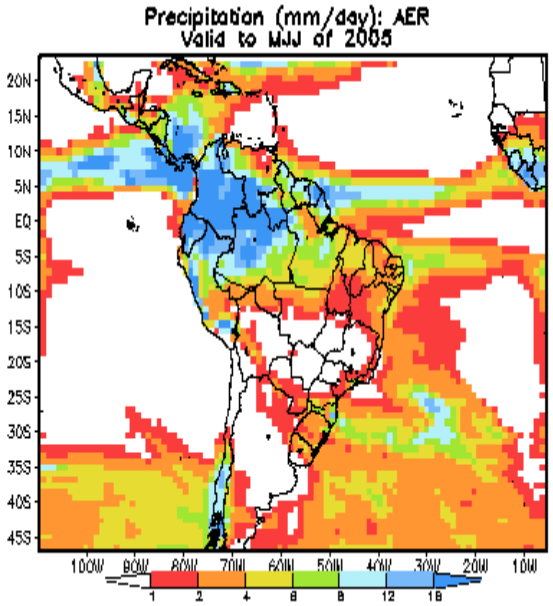
without

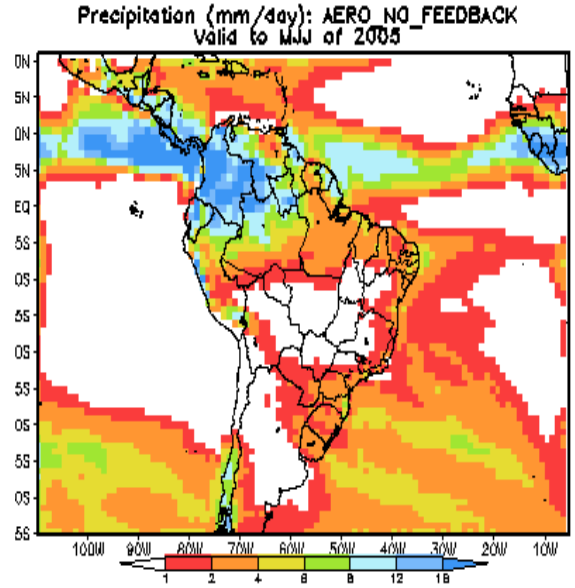
DJF





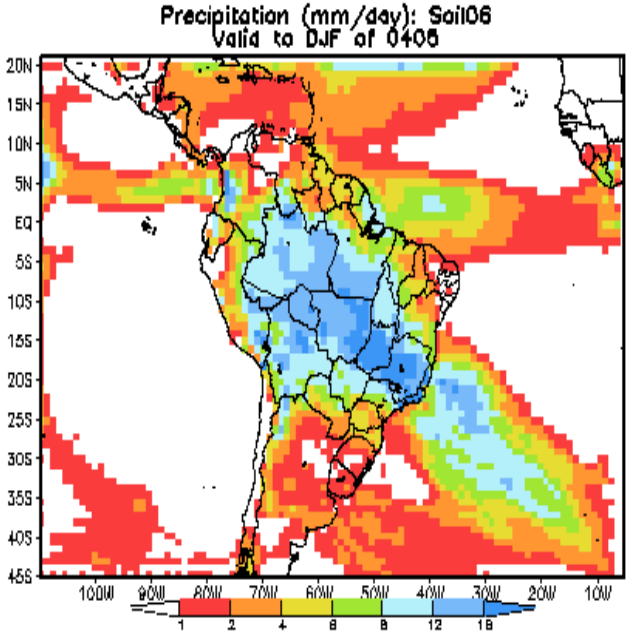
MJJ

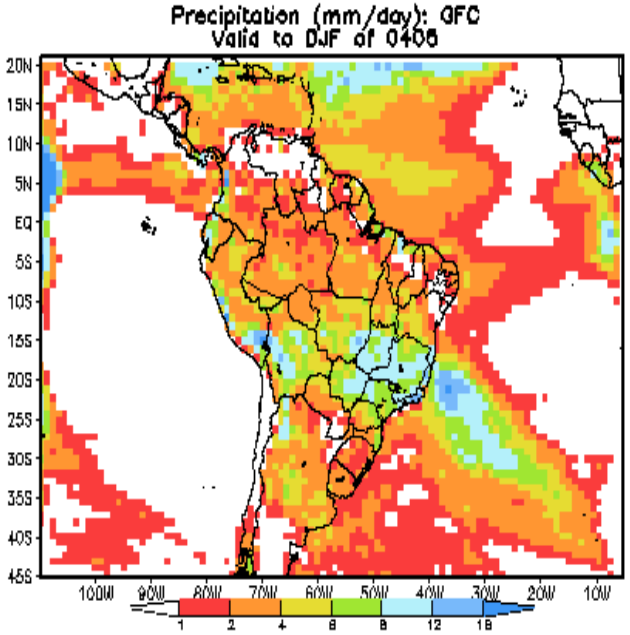




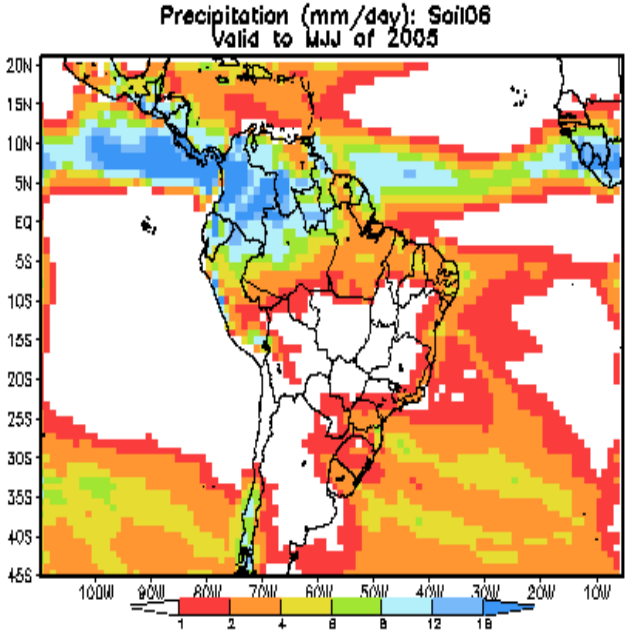
Aerosols experiments show similar spatial pattern of the CTRL, but in the case without feedback the precipitation is less intense

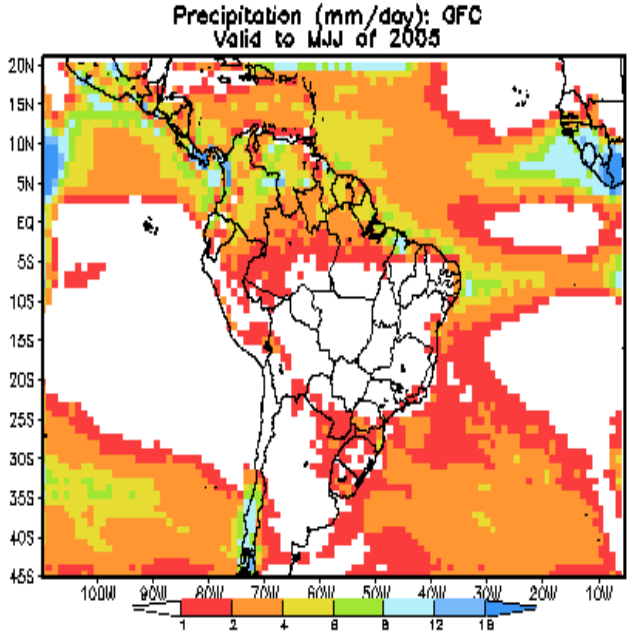
DJF





MJJ





SOIL

GFC

Soil Moisture and Grell-FC Experiments

MOIST: reduce the precipitation in the north part of Amazon (in the drought area).

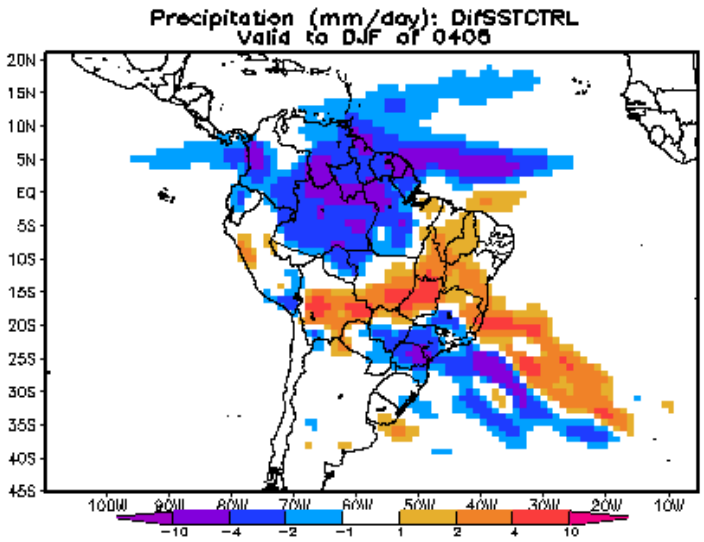
GFC: is drier in the Amazon and can indicate some signal of the drought. However, the ITCZ is not well simulated.

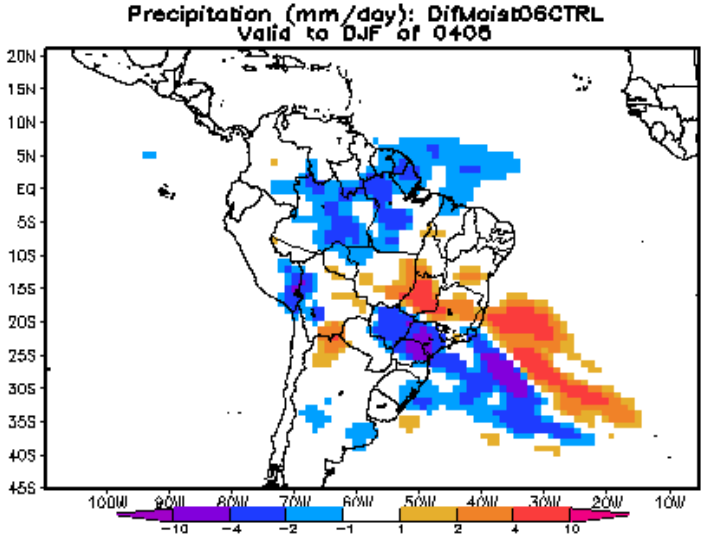
Differences

CTRL-SST

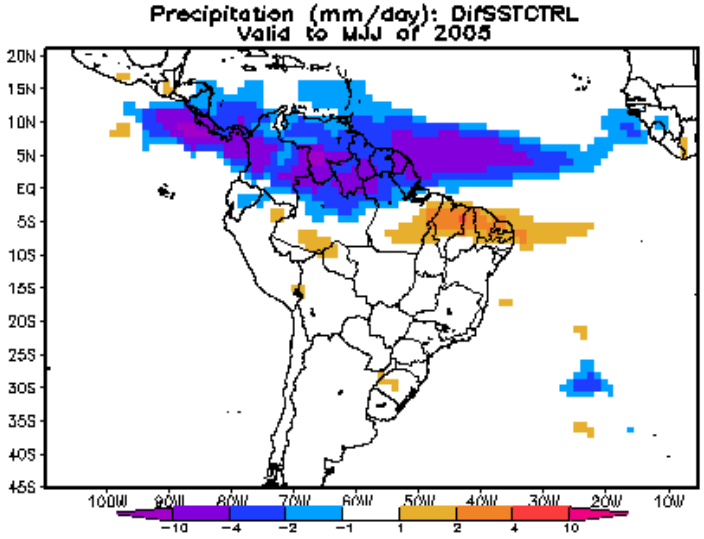
CTRL-MOIST

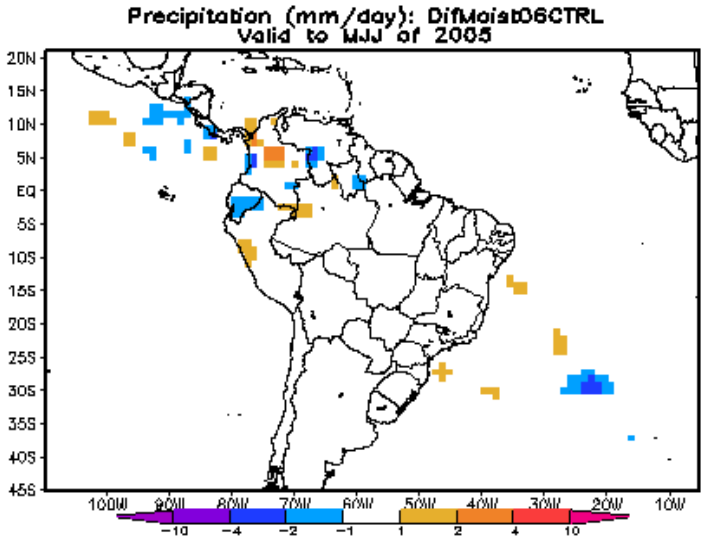
DJF





MJJ





Both experiments have less precipitation in the Amazon during DJF.

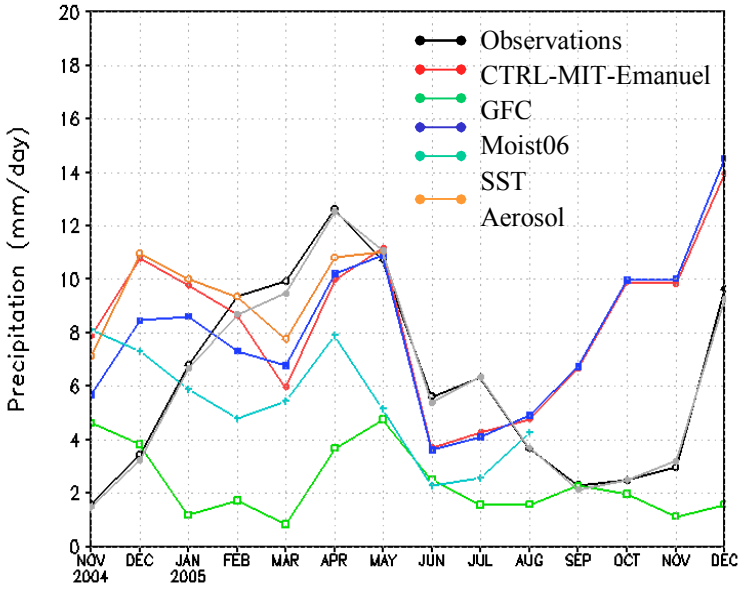
MOIST: the reduction of the rainfall during DJF can be due to the “spin-up” of hydrologic cycle.

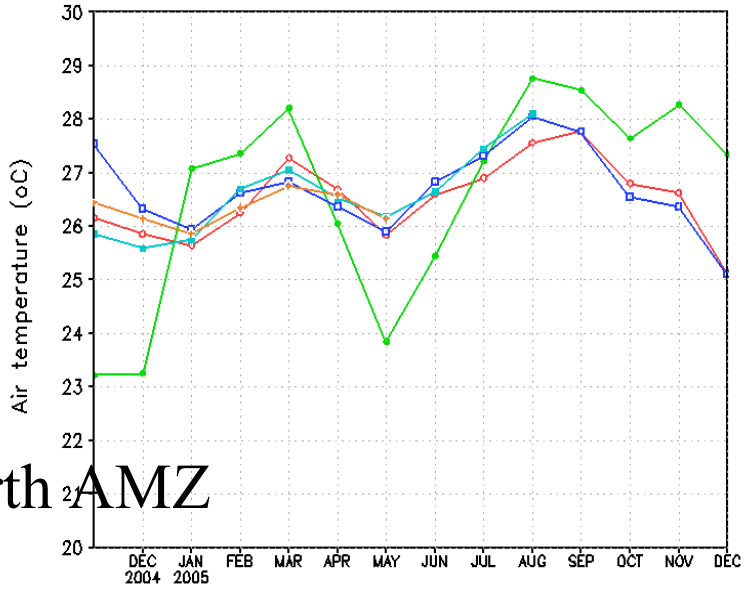
SST: results is in opposition to a hypothesis.

Times series

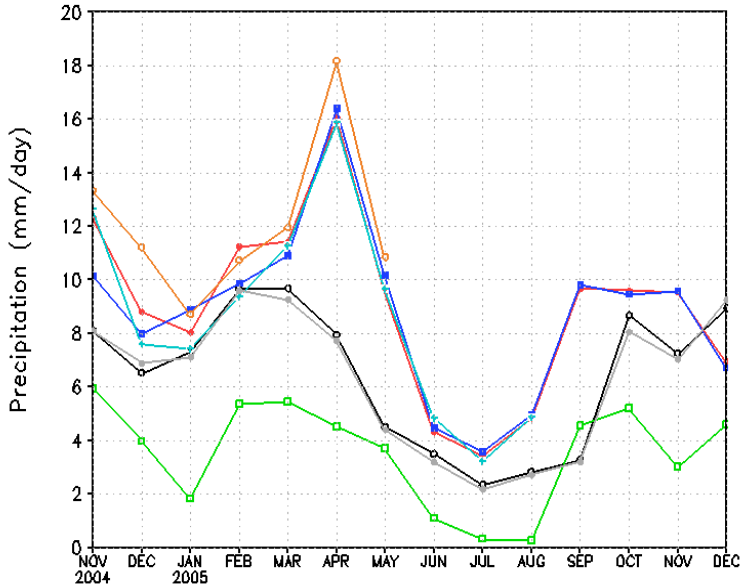
Rainfall

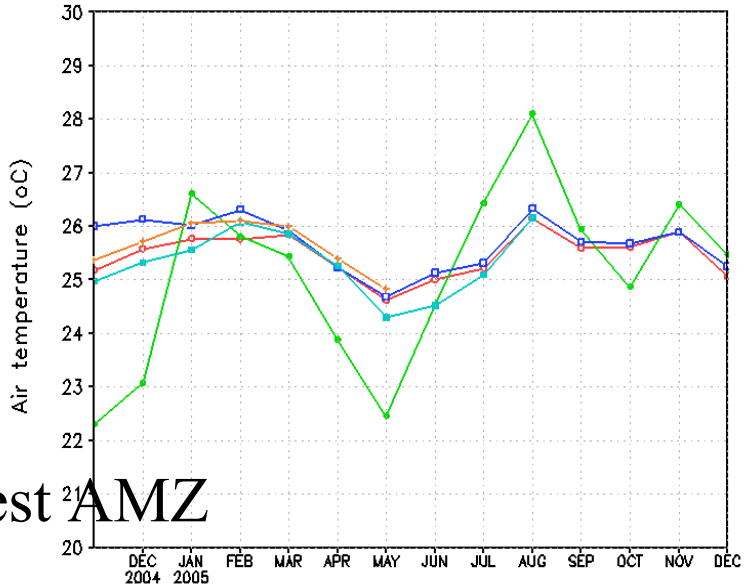
air temperature





North AMZ





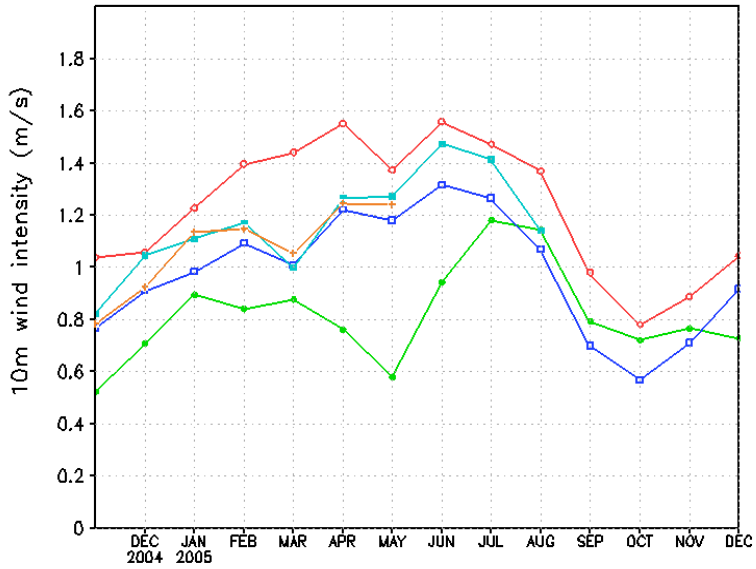
West AMZ

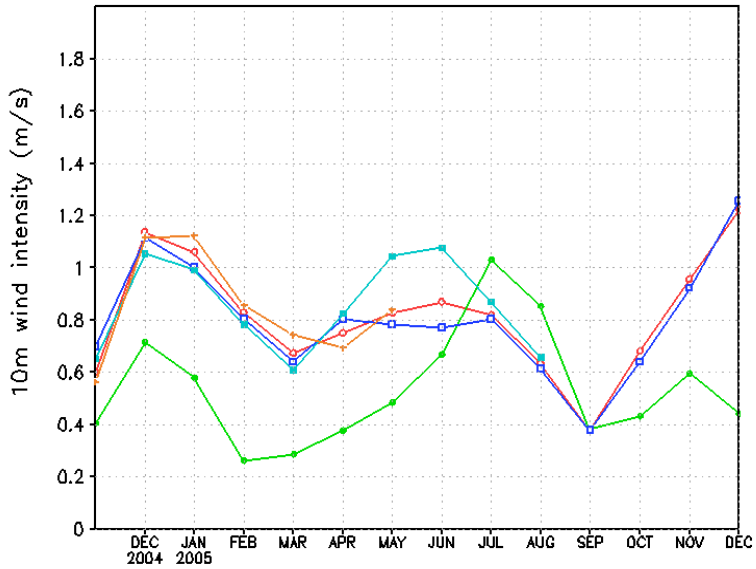
Strong signal of the "spin-up" in the first 1-3 months of simulations;

GFC under-prediction is large;

Emanuel: in the North of AMZ the overestimation is large during the rainy season. In the dry season the bias is small.

GFC: annual cycle of air temperature shows higher amplitude than is possible to find in the observations.


10m wind intensity (m/s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
DEC 2004
JAN 2005
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC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DEC 2004
JAN 2005
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Summary

- CTRL experiment simulates the precipitation pattern (ITCZ, SACZ, and mid latitude systems). However, the rain is more intense than observed and drought is not obvious during DJF in the north part of AMZ (when it was observed).
- The reduction of precipitation associated to the initial soil moisture is a transient factor in the first months of the simulation;
- Aerosol experiments: after 2-3 months of simulations they do not show much differences when compared to the CTRL experiment;
- The big impact is found in the SST experiment: that presents a similar pattern of the observed drought;

SST experiment:

Using the climatology (SST cool than observed) over the NA we obtained two impacts:

(1) A local reduction of the precipitation → cool air over ocean → reduces atmospheric instability and precipitation

(2) A remote impact: reduction in the precipitation in the central-northern of Amazon. This is in opposition to the hypothesis for the drought (Marengo et al. 2008).

Question:

Is the proposed experiment correct to investigate this drought?

Future work

- We need analyse in more details the results of the experiments;
- Experiments shows that to understand better this drought we need initiated the model some months before: the spin-up of hydrologic cycle is in course in the drought period.
- High resolution RCM simulation ---> Amazon
- AOGCM ---> SST --> Climate Change?

References

- Giorgi, F., and L.O. Mearns, 1999: Introduction to special section: Regional climate modeling revisited. ***J. Geophys. Res.***, 104, 6335–6352.
- Marengo, J.A., et al. 2008: The Drought of Amazonia in 2005. ***J. Climate***, 21: 495-516.
- Pal, J., et al. 2007: Regional climate modeling for the developing world: The ICTP RegCM3 and RegCNET, ***Bull. Amer. Meteor. Soc.***, 88(9), 1395-1409.