Accessing Climate Change Impacts On Moisture Flux Over South America During the Rainy Season

Henrique M J Barbosa – IF/USP – Brazil
Josefina M Arraut – CCST/INPE – Brazil

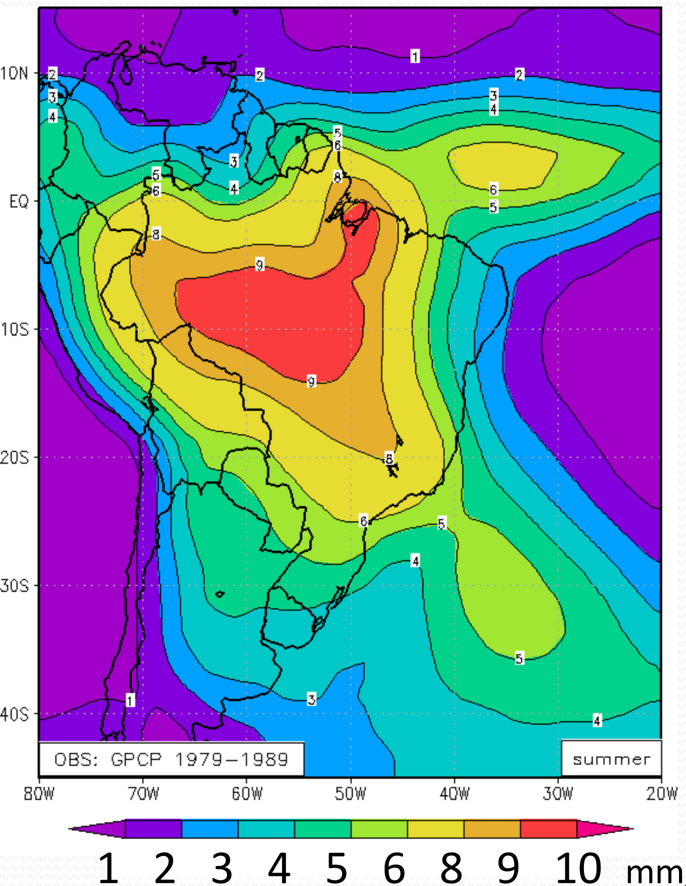
Session: Global Environmental Change (Room C2)

Monday , 10:45-11:00 - GC12A-02

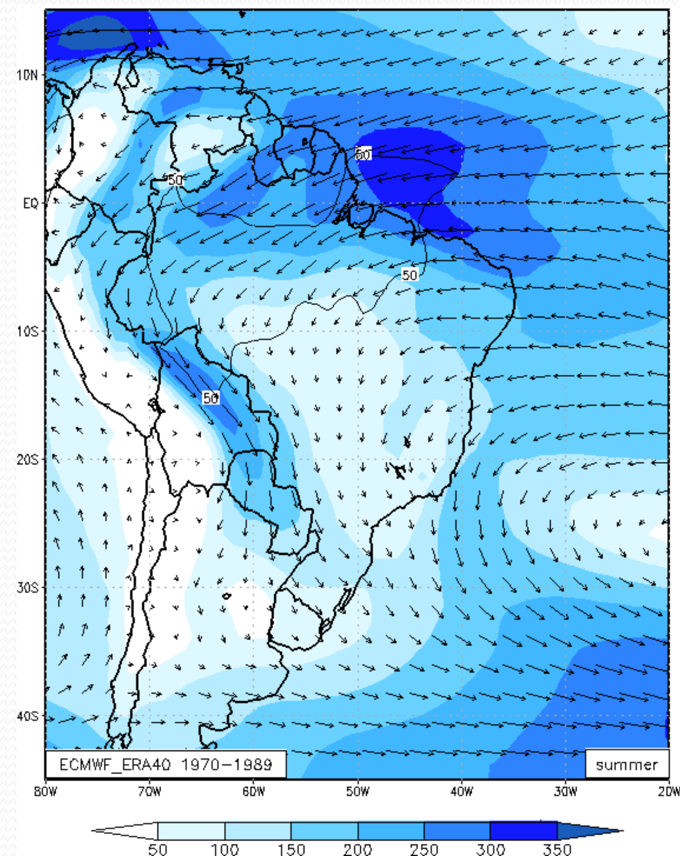
CNPq INSTITUTO DE FÍSICA USP CPTEC CST Centro de Ciência do Sistema Terrestre INPE

Motivation

- There has been an interesting scientific debate about the **importance of the Amazon forest to the precipitation** in regions further south, such as **southern Brazil and northern Argentina**.



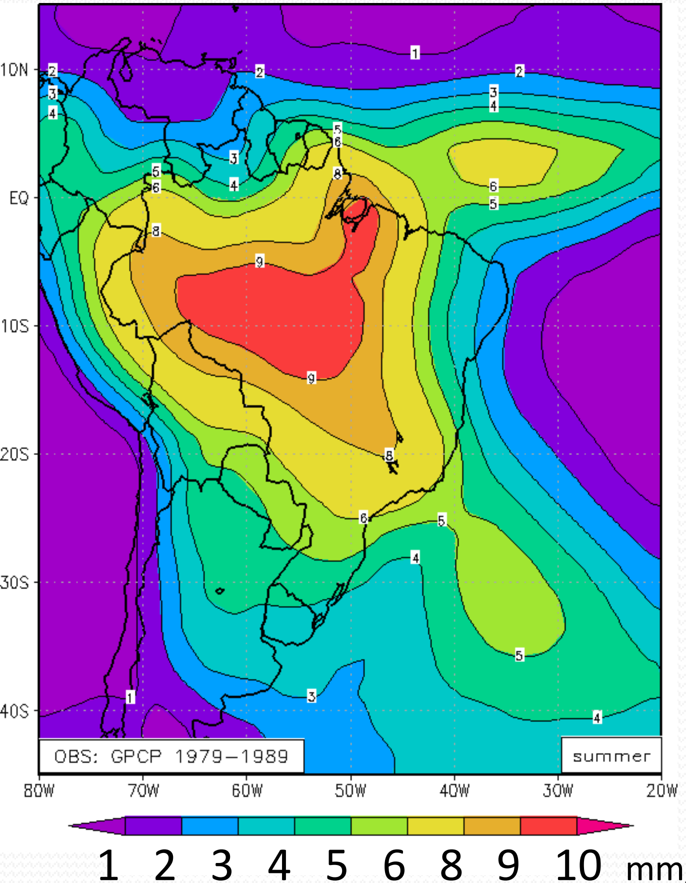
Observed precipitation from GPCP, Dec-Feb 1970-90 averaged.



Moisture flux from ECMWF ERA40, Dec-Feb 1970-90 averaged.

Motivation

- The South American Monsoon System (SAMS) plays an important role as it **influences the water balance** in the tropics and subtropics by **modulating** the Tropical Atlantic Ocean's **moisture flux** as it enters South America at its northern coast and as it is **deviated southwardly by the Andes** to end up contributing to subtropical precipitation.



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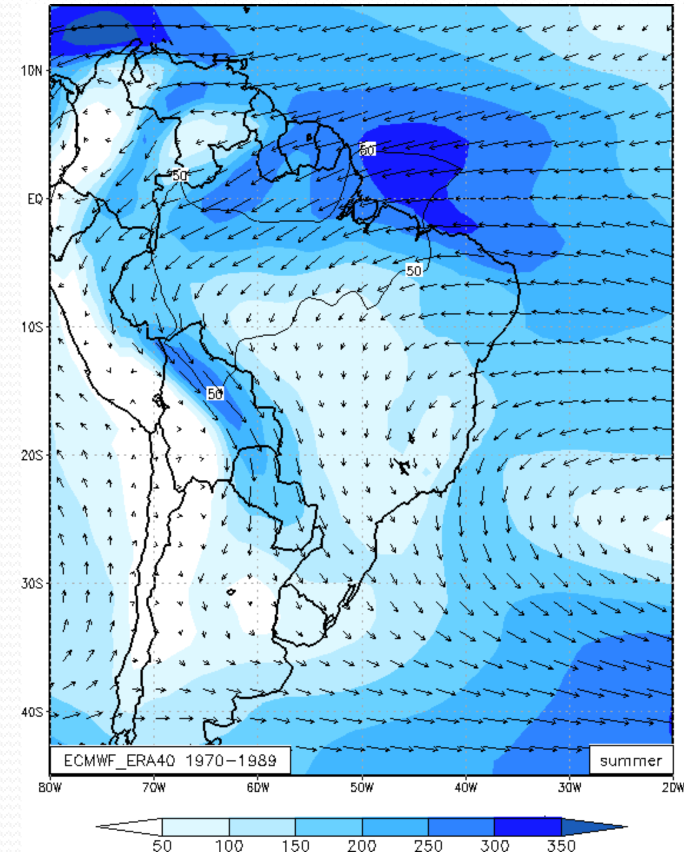
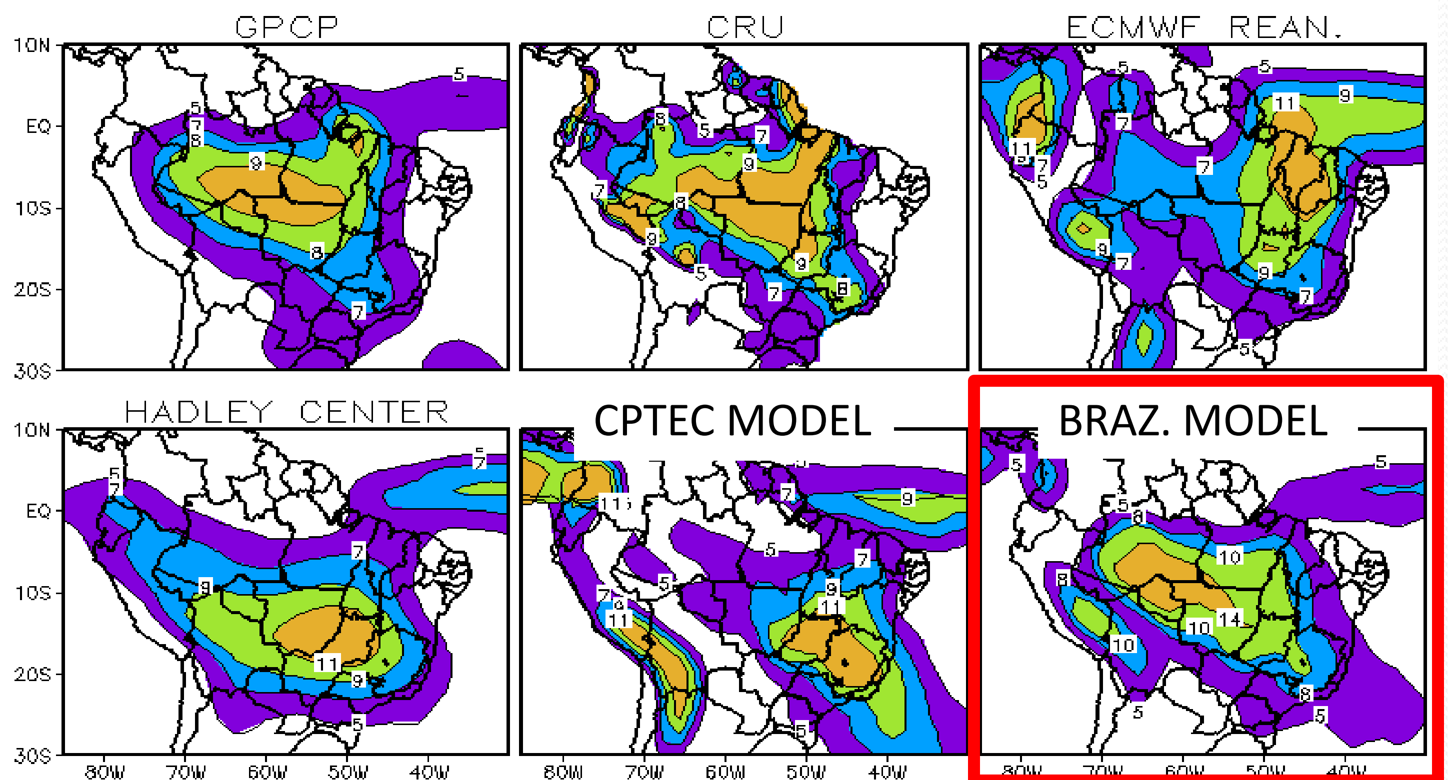


Motivation

An yet open question is *how this picture might be changed under the upcoming anthropogenic climate changes*? In order to answer this question **one needs a model that reproduces** well the **South American Monsoon**.



Modeled and observed 20th century **summer** precipitation

Figueroa et. al, 2006 – 8th Int. Conf. Southern Hem. Meteo. Oc.

Figueroa et. al, 2010 – THIS MEETING, Wednesday, 16h30 A34B-07

Model Used

Brazilian Model of the Global Climate System (BMGCS)

- Community model being developed by the Brazilian scientific community for its climate change studies.
  - Atmosphere: based on CPTEC-AGCM (Cavalcanti et al 2002)
    - Spectral with Eulerian and Semi-Lagrangean cores
  - Ocean: based on CPTEC-AGCM
  - Surface: based on Ibis
  - Chemistry: based on CATT-BRAMS

Atmospheric component:

- <u>Radiation:</u> **Edwards & Slingo (96)**, Clirad, . . .
- <u>Convection:</u> **Grell ensemble (02)** , Kuo, . . .
- <u>PBL:</u> **Mellor-Yamada (82)**, . . .
- <u>Biosphere:</u> Ibis, **SSib (Xue et al 91)**, CLM, . . .

Work outline

- We had an **atmospheric** model able to reproduce the South American Monsoon
  - Brazilian Model of the Global Climate System (BMGCS)

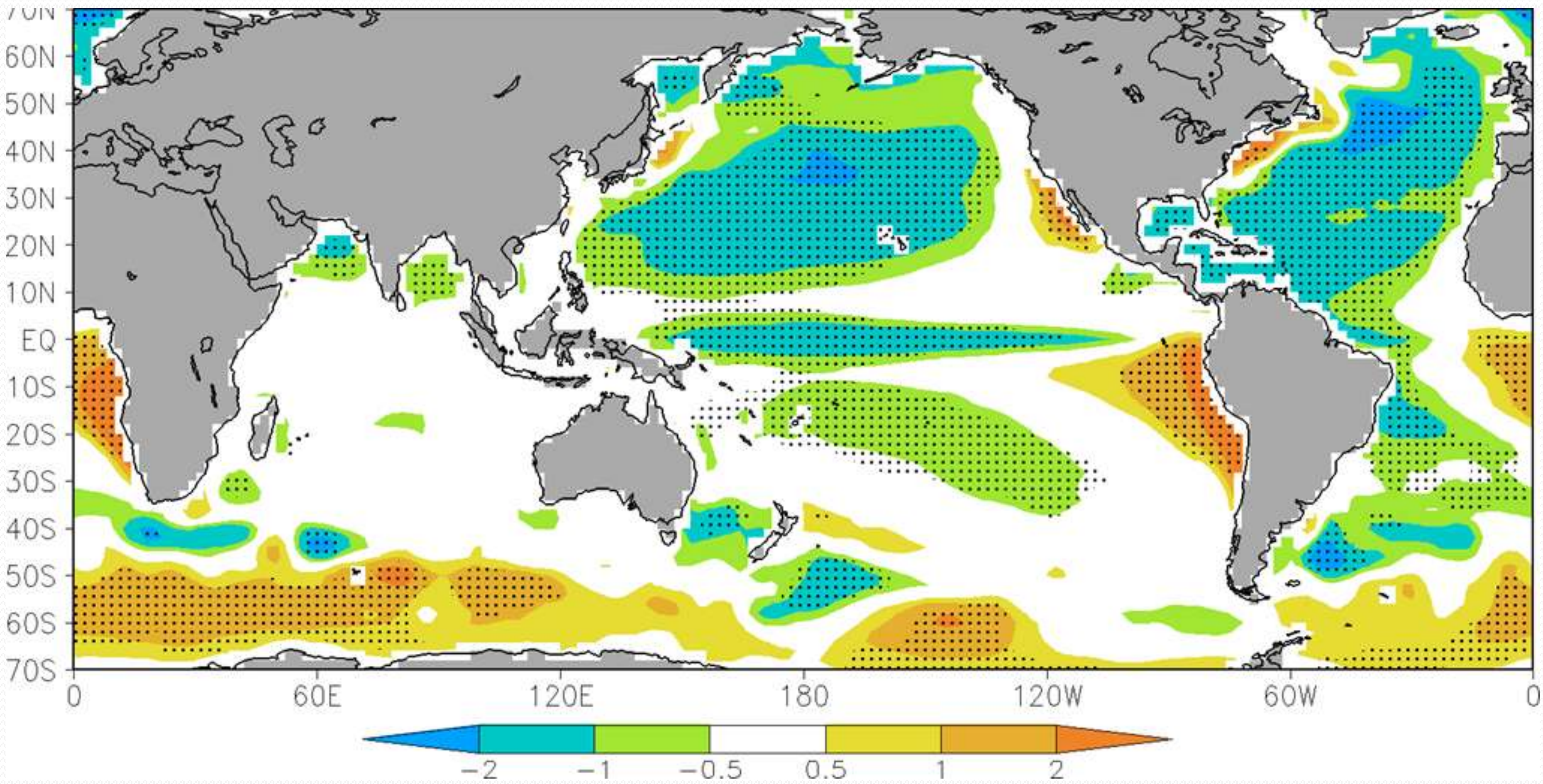
BMGCS has an oceanic component but we did not used it

- We **forced** that model with **prescribed** sea surface temp. (SST) and **SRES Scenarios: A2 and B1**
  - Observed for 20th century
  - Simulated IPCC-AR4 runs : 20C3M, A2 and B1
    - Hadley Center-HadCM3, GFDL-CM2.1 and MPI-ECHAM5

Using a higher spatial resolution than original IPCC-AR4 runs

- We **compared modeled moisture fluxes** for 20C3M, A2 and B1 to access climate change impacts on moisture flow over South America

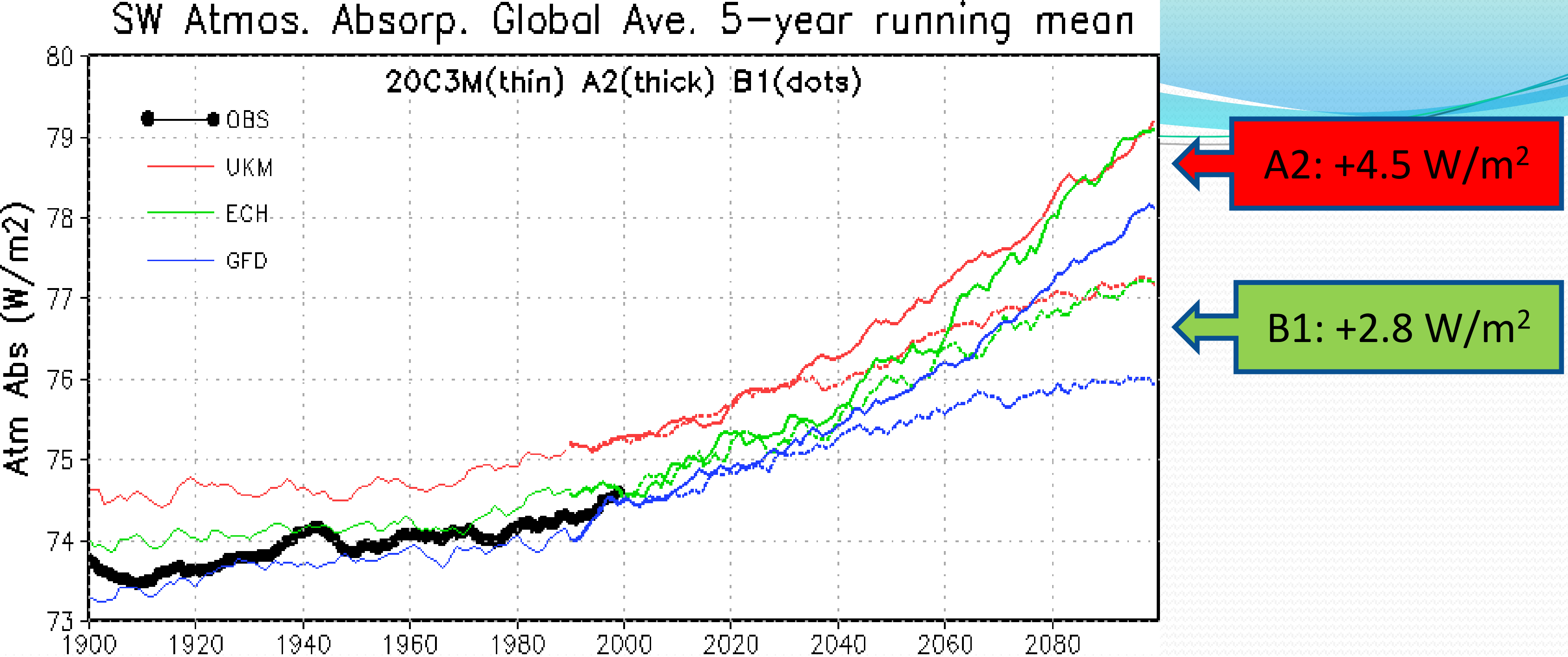
SST @ IPCC AR4 – Bias in 20C3M runs



Average (1930-2000) bias in Sea Surface Temperature (degrees) from 22 IPCC-AR4 models. Hatched regions indicate where more than 70% of models "agree".

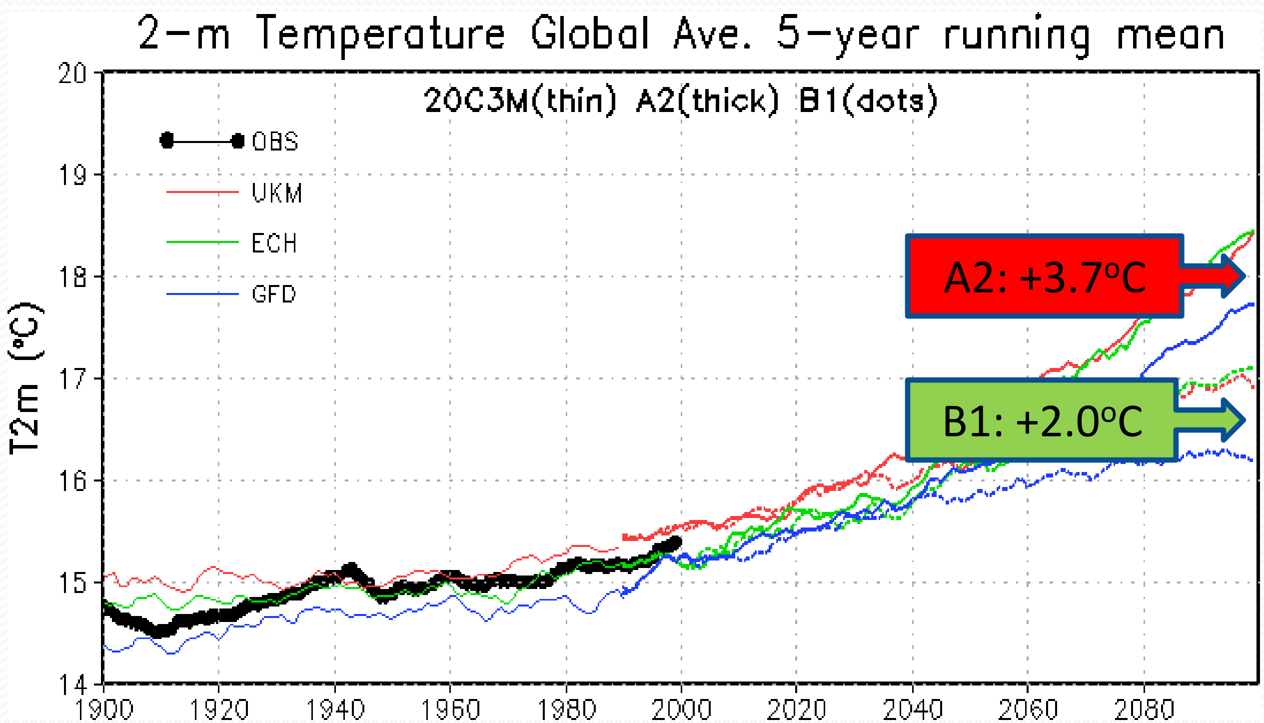
Climate Change Simulations

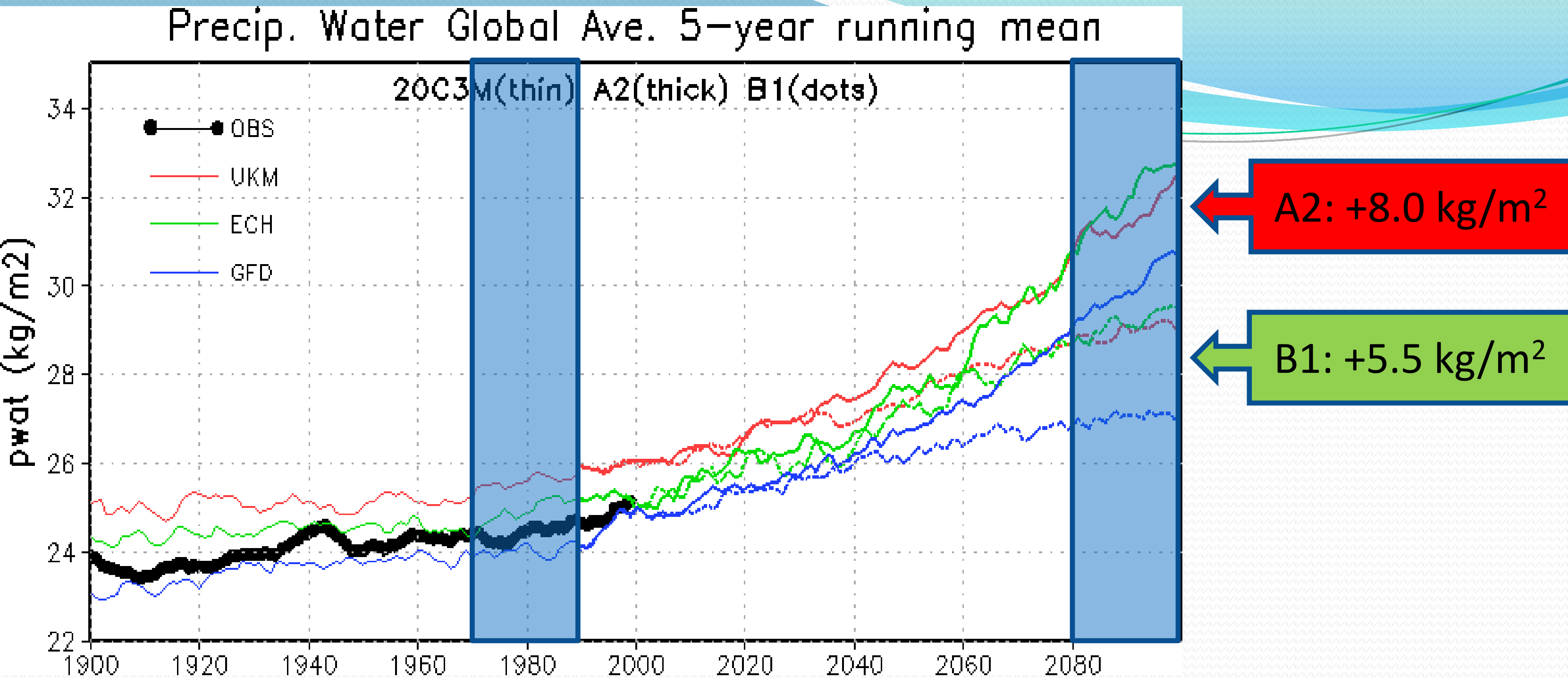
- Forcings:
  - Gases - Johns et al Clim. Dyn. (2003)
  - TSM – **ECHAM5, HadCM3, GFDL**
    - **20C3M, A2 e B1**
- First run:
  - Low resolution (2.5 degrees), 18 levels
  - Period: 1870-2100
  - Scenarios 20C3M, A2 and B1
- Second run: (GFDL only)
  - Higher resolution (1.8 degrees), 28 levels
  - Period: 1960-1990 and 2070-2100
  - Scenarios 20C3M, A2 and B1



Global averages

BMGCS forced with **OBS**, **UKM**, **ECH** and **GFD** SST fields.





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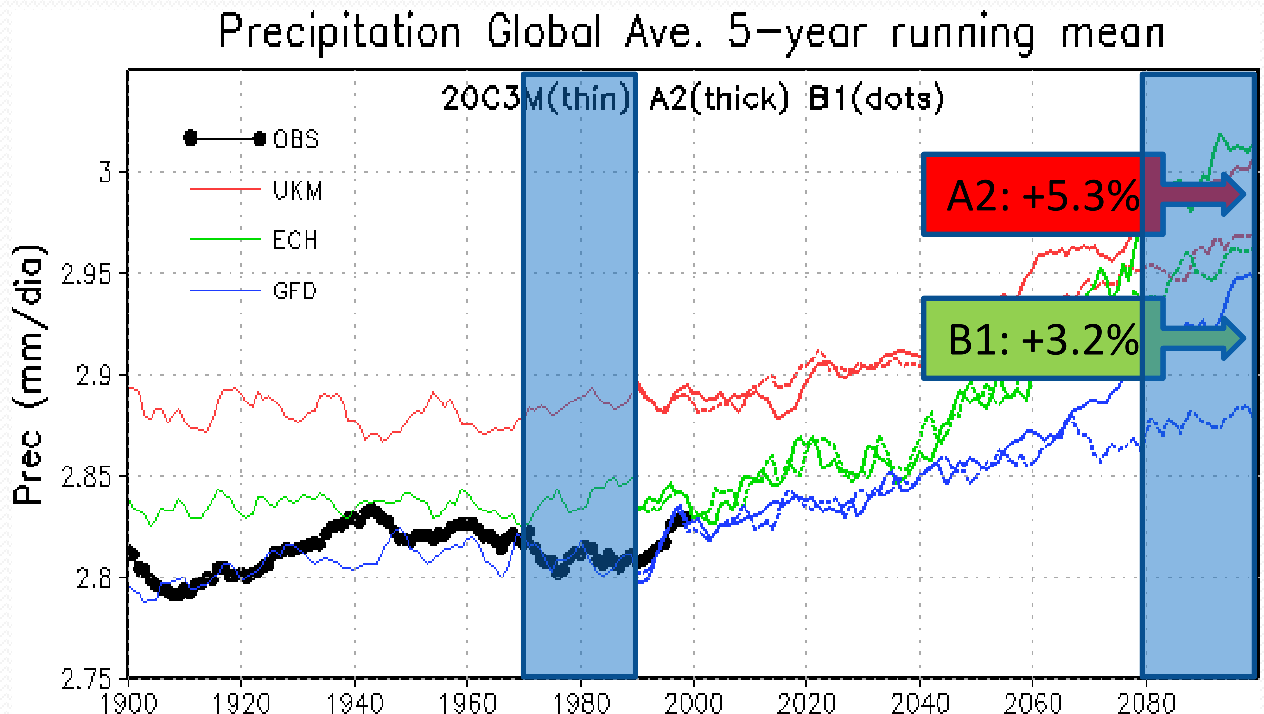
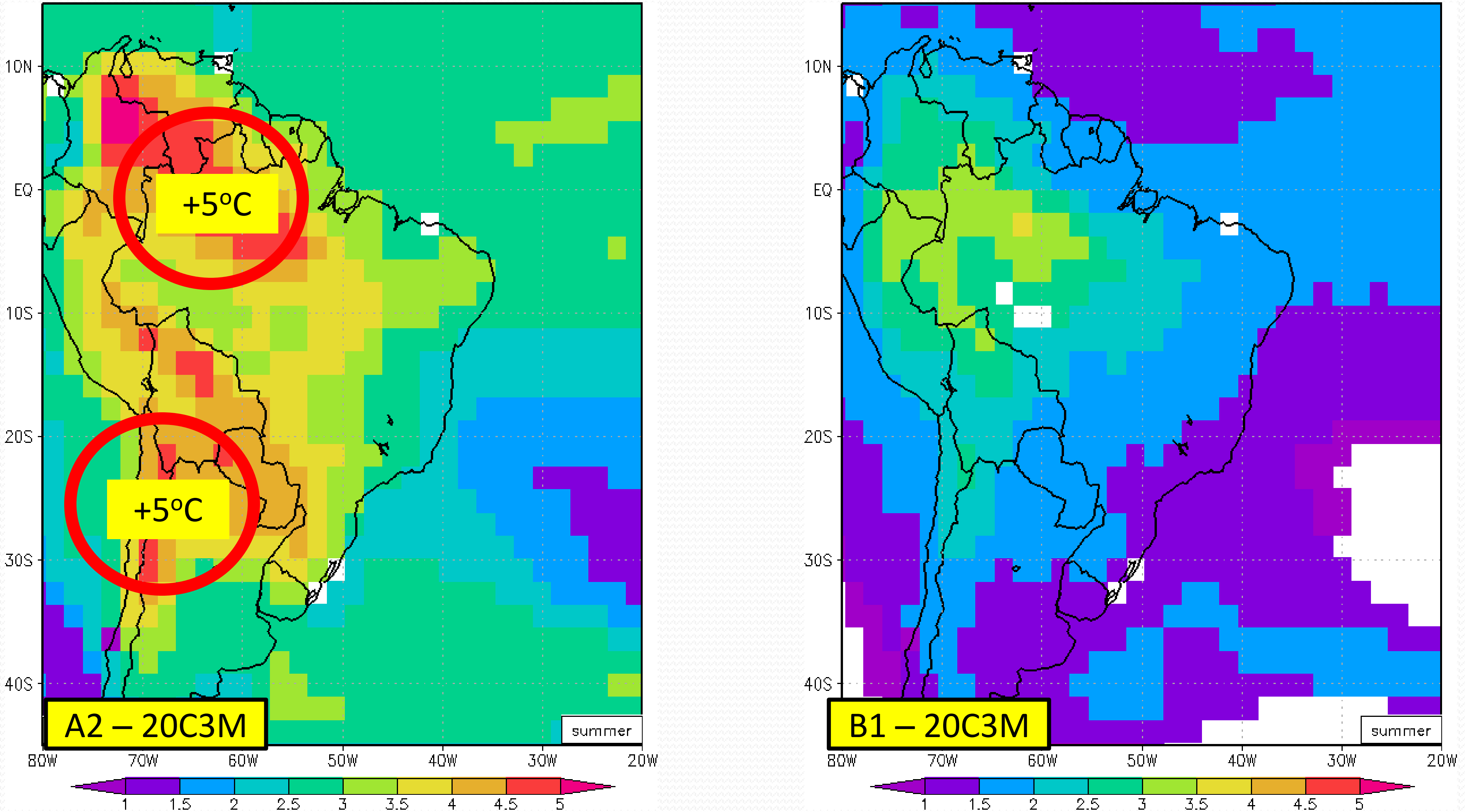


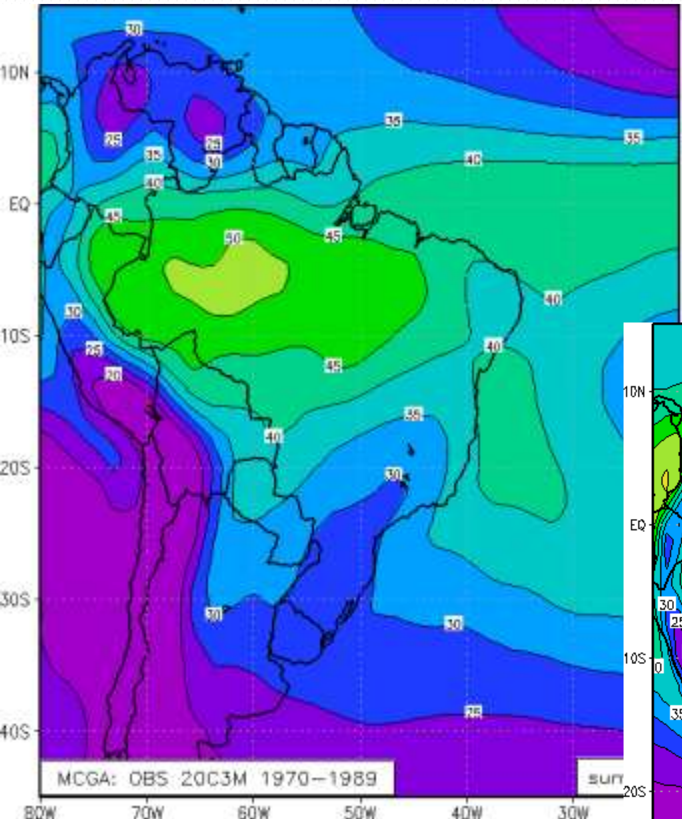
DJF 2m-Temperature (ºC) – Climate Change

BMGCS, forced by GFDL – Anomaly: 2100-80 – 1990-70

Statistical significance >95%

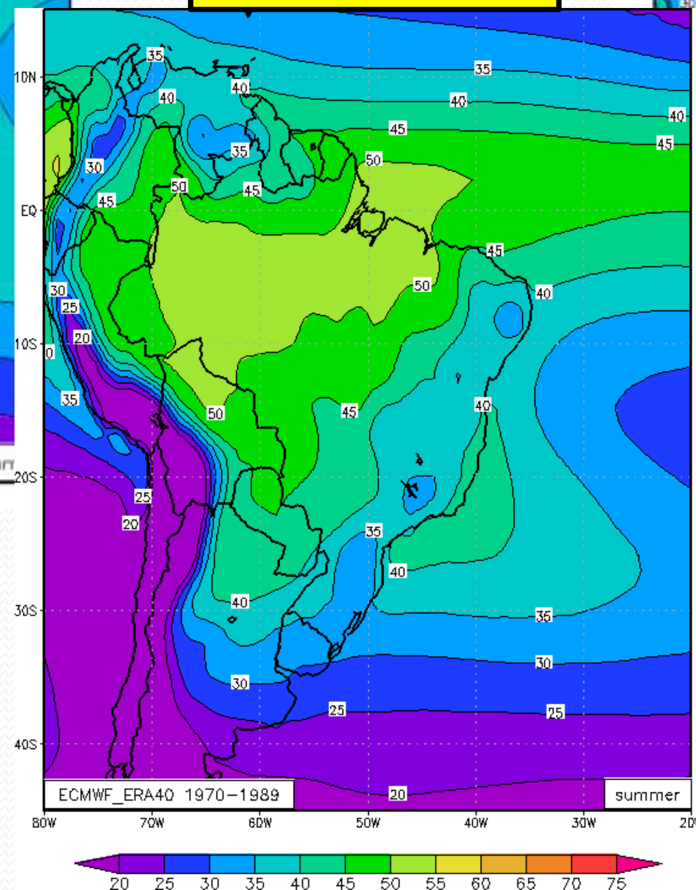


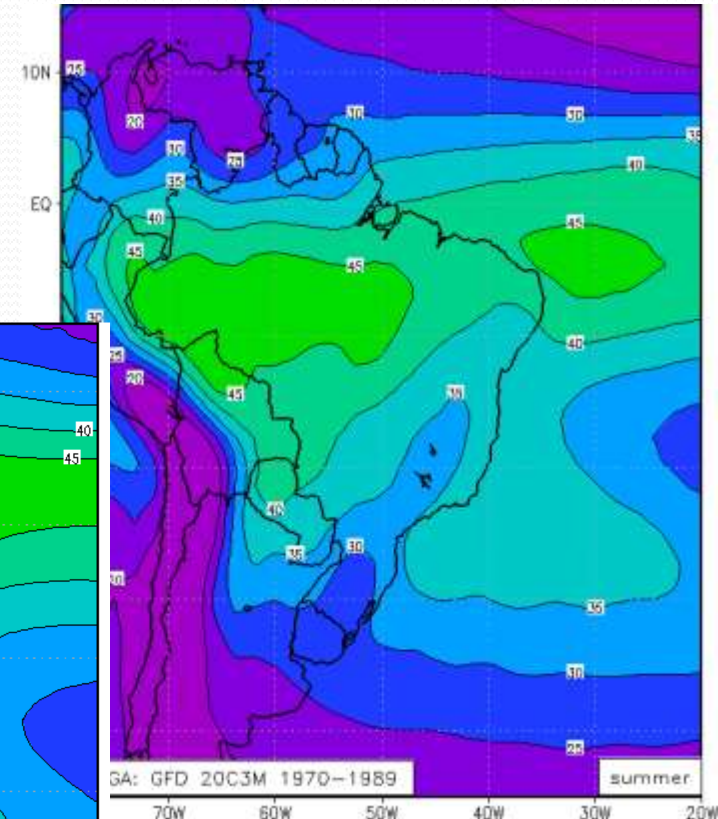
DJF Prec. Water – 1970-90



Model: BMGCS
Forcing: OBS

ECMWF – ERA40
Reanalysis



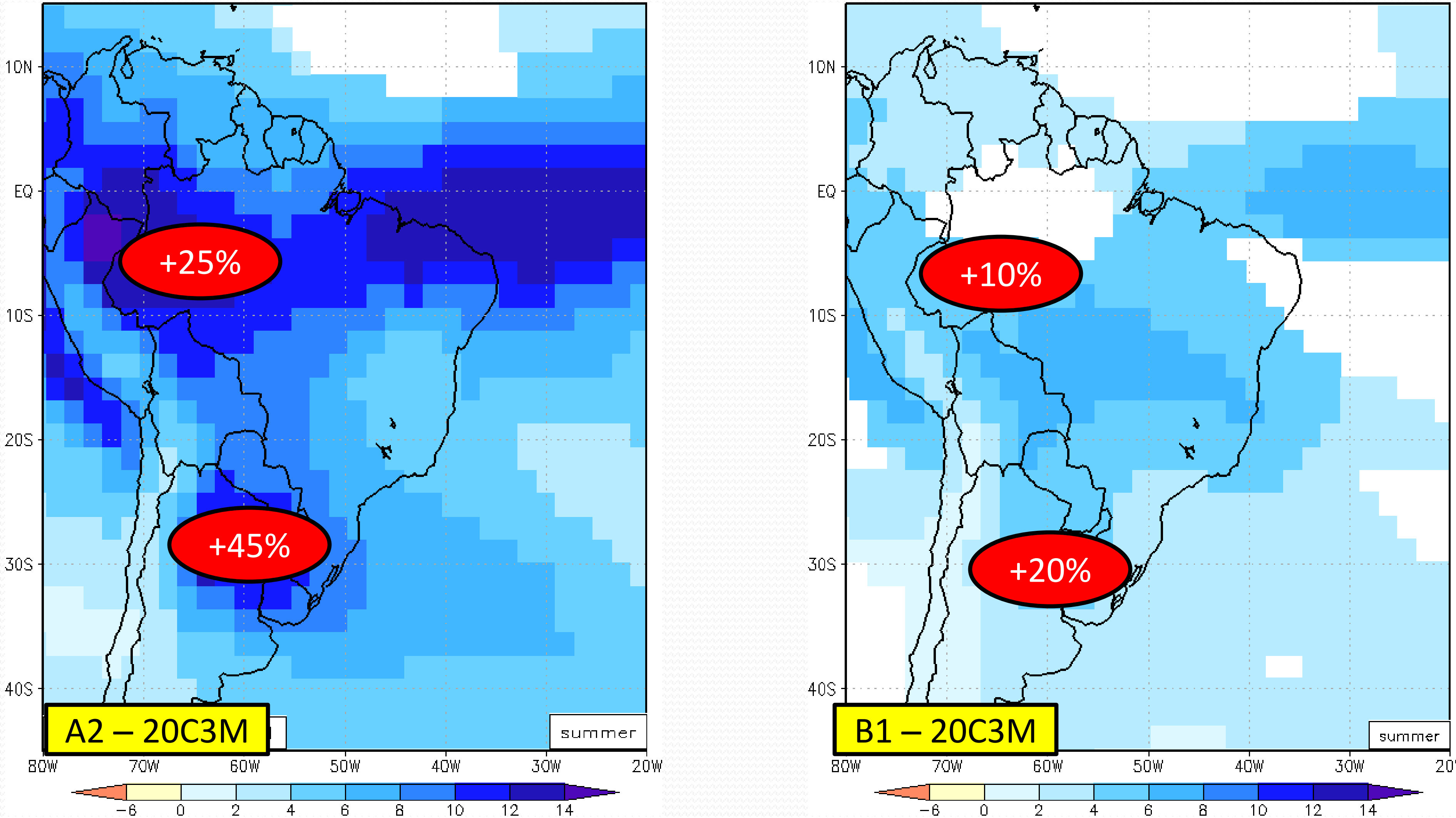


Model: BMGCS
Forcing: GFDL/20C3M

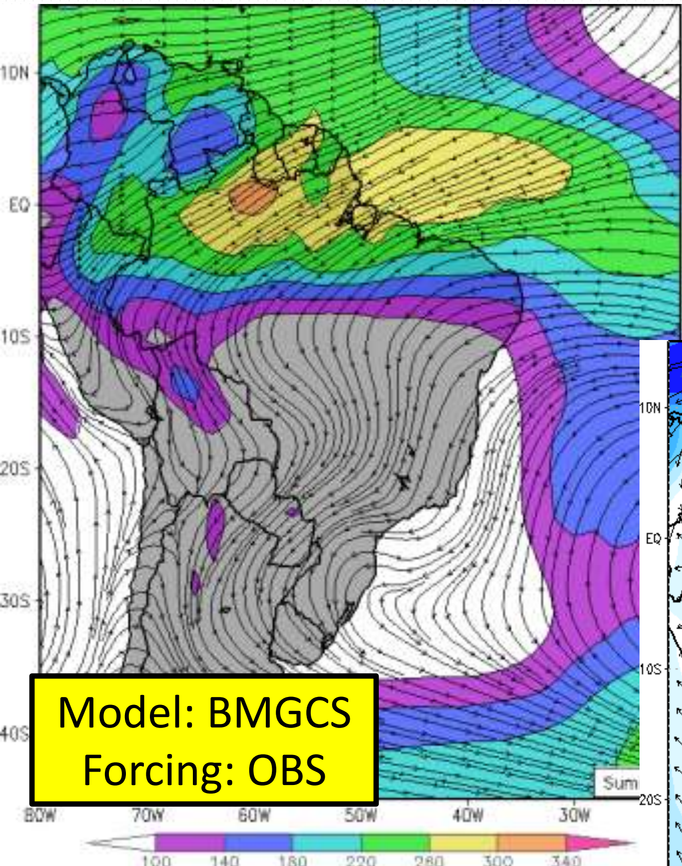
DJF Prec. Water (kg/m^2) – Climate Change

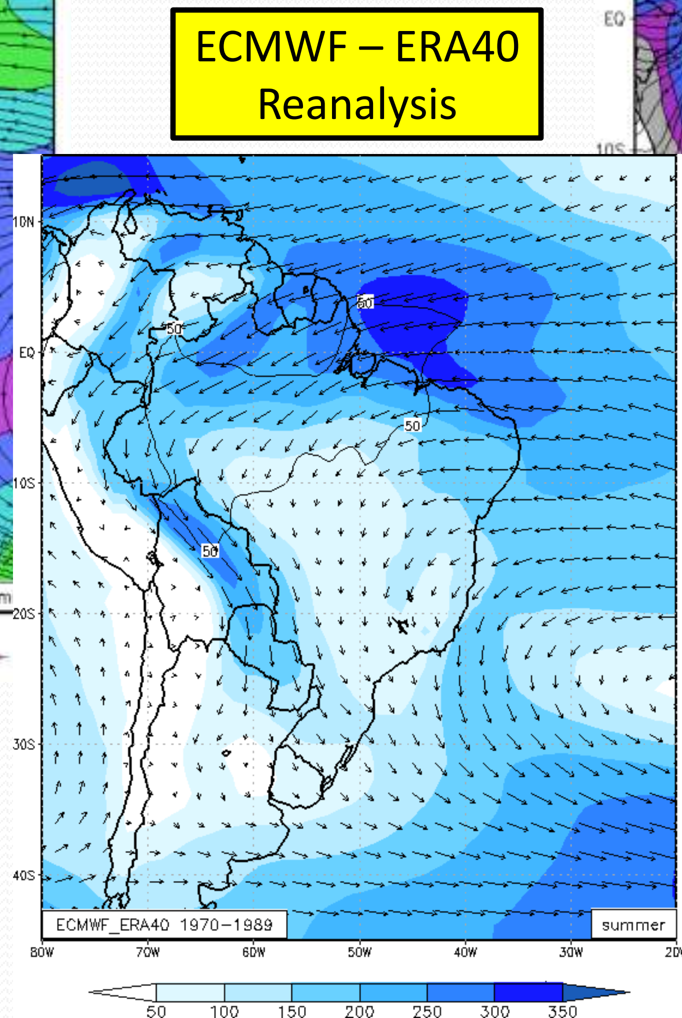
BMGCS, forced by GFDL – Anomaly: 2100-80 – 1990-70

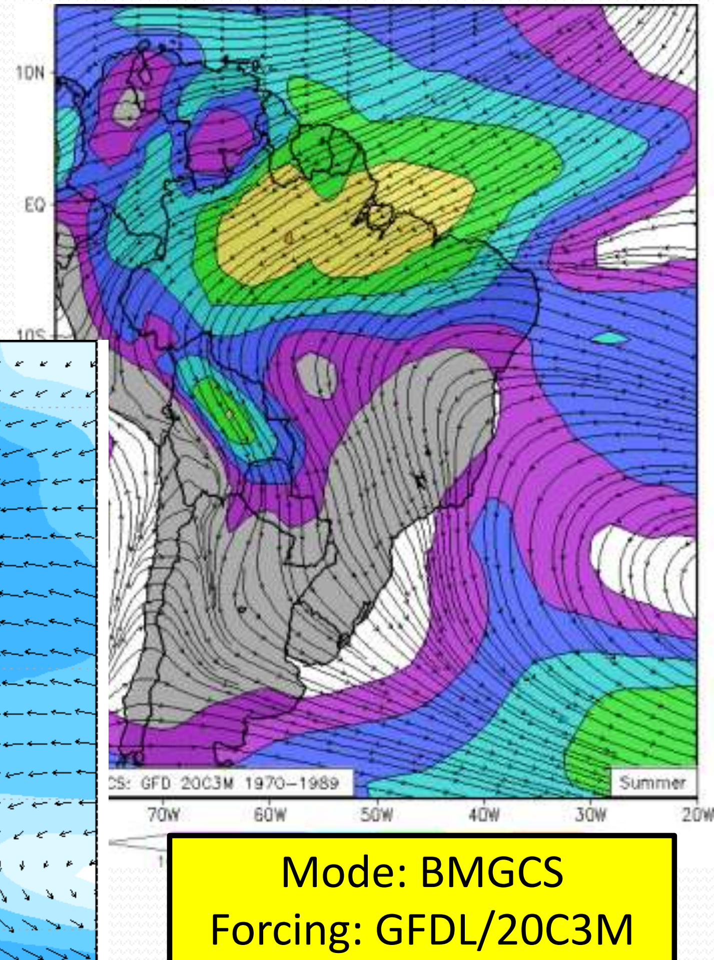
Statistical significance >95%



DJF Vertically Integrated Humidity Transport – 1970-90



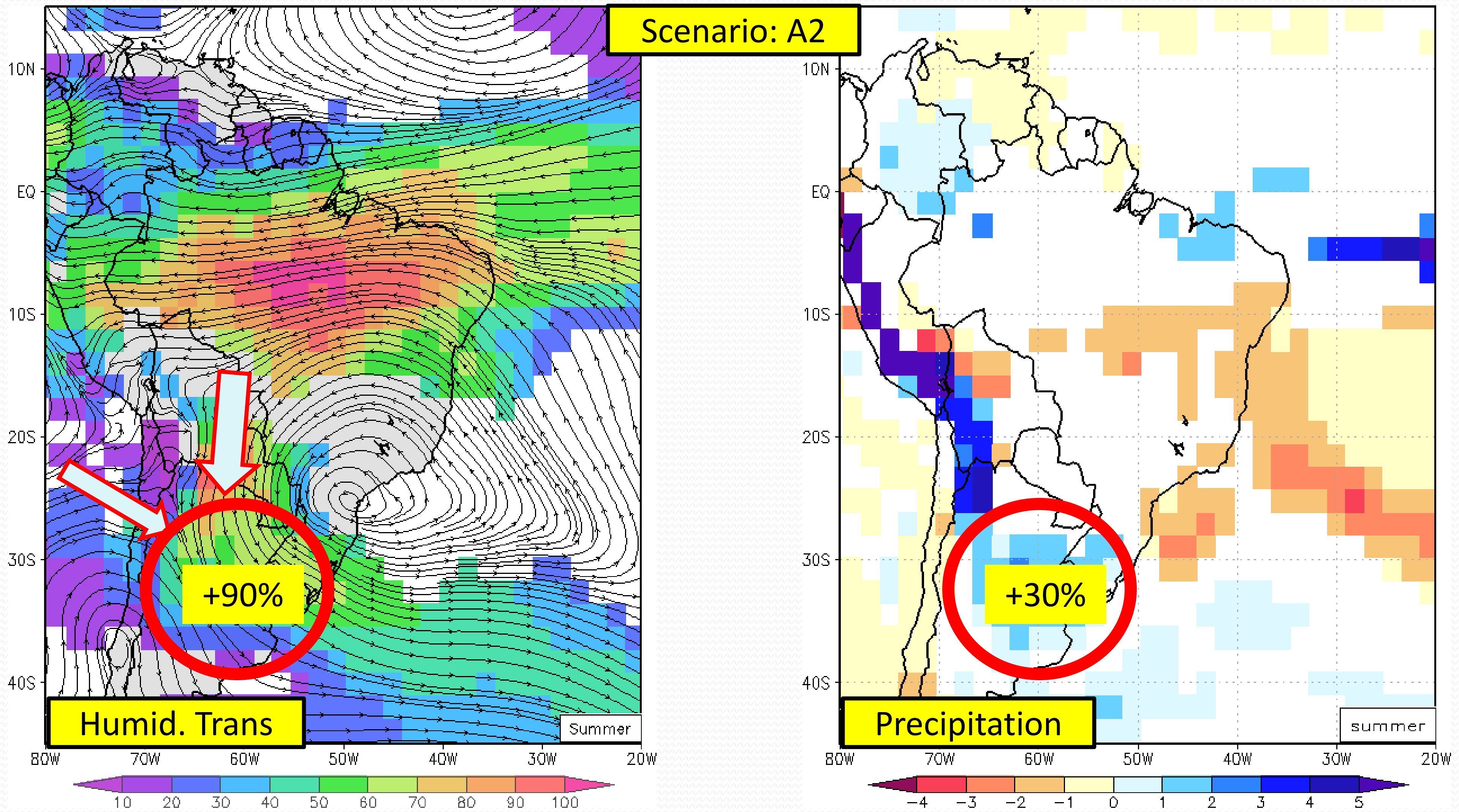




DJF Humidity Transport Anomaly (kg/m/s)
DJF Precipitation Anomaly (mm/day)

BMGCS, forced by GFDL – Anomaly: 2100-80 – 1990-70

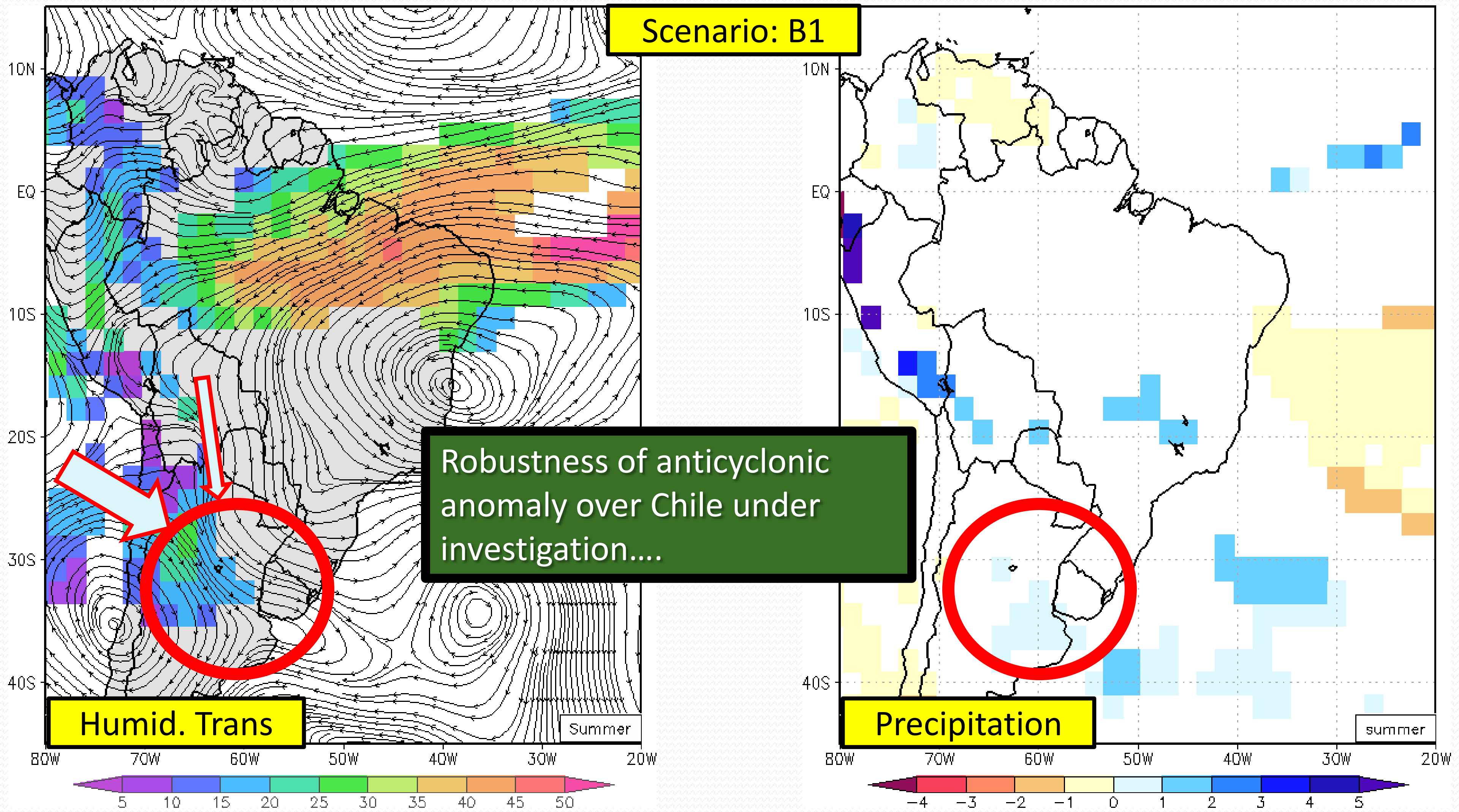
Statistical significance >95%



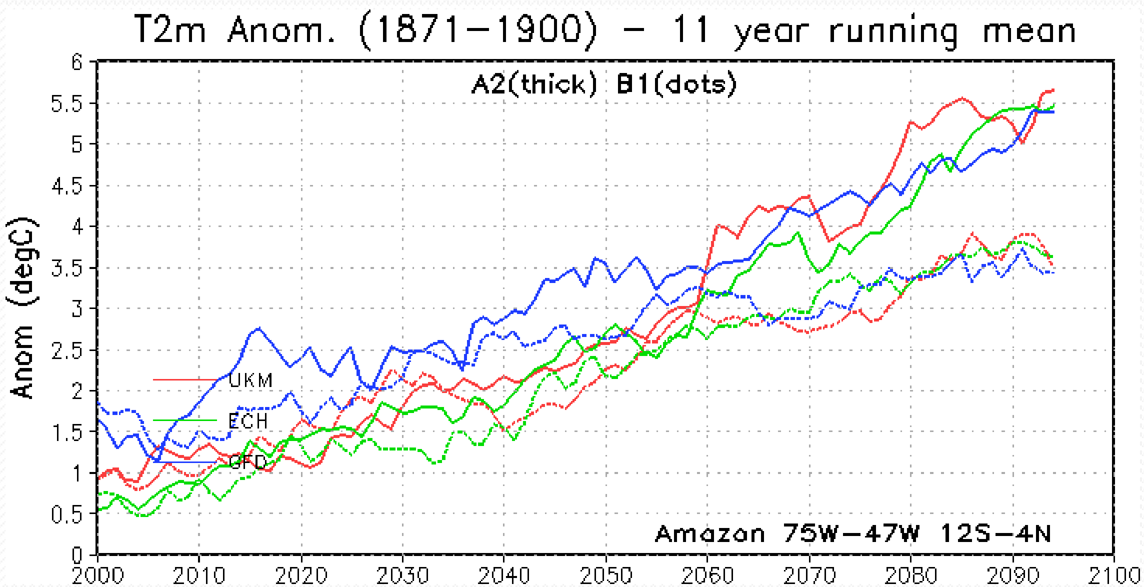
DJF Precipitation (mm/day) – Climate Change

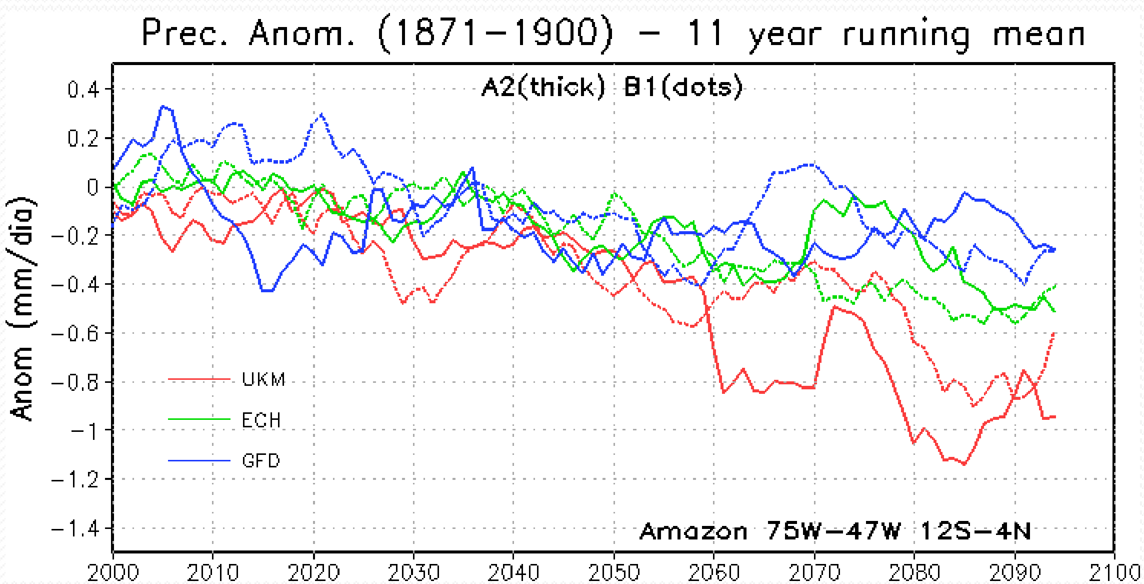
BMGCS, forced by GFDL – Anomaly: 2100-70 – 1990-70

Statistical significance >95%



Anom. Amazônia (75-47W 12S-4N)





Em 2100

Hadley Centre – A2

- -2.9 mm/day
- +9.2°C

BMGCS/UKM – A2

- -1.0 mm/day
- +5.5°C

Final Remarks

Comparing 1970-90 (20C3M) with 2080-99 (A2 and B1)

	Amazon	Subtropical South Am.
Temperature	+5ºC (A2) to +3ºC (B1)	+5ºC (A2) to +2ºC
Prec. Water	+25% (A2) to 10% (B1)	+45% (A2) to +25% (B1)
Moist. Flux	+50% (A2) to +25% (B1)	+90% (A2) to +30% (B1)
Precipitation	Not statistically significant	+30% (A2) to +10% (B1)

- Increase in temperature → increase in water content → → moisture transport → increase in precipitation

Remarks / Future work

- The increase in temperature allows for an increase in precipitable water and both for a more unstable atmosphere in the subtropics.
- Our simulations shows and anticyclonic anomaly over the Andes which contributes with at least part of the moisture necessary to the extra subtropical precipitation (the rest comes from the Amazon).
- We are still investigating whether:
  - Anticyclone anomaly is reliable?
  - Will there be more C.C.M. and extreme events?
  - How would this picture change if we considered deforestation as well?

Want to know more?

- Research project: Role of Amazon forest on moisture flux over South America. **C. Nobre**, J. Marengo , J. Arraut, H. Barbosa, C. Chan, G. Obregon, G. Sampaio, W. Soares - CST/INPE and IF/USP

- **Arraut, JM et al**: Poster A33C-12, *Southward Moisture Transport from Amazonia and Rainfall in SE South America*
- **Barbosa, HMJ et al:** Poster A33C-14, *Contribution of Amazon's evapotranspiration to the moisture flux over South America*

Posters, Wednesday, 2pm, Room Expocenter II-III

EDWARDS & SLINGO (96)

Same parameterizations used by Hadley Centre models

<u>Short wave</u>:

- 5 spectral intervals**,** solar spectrum from Kurucz (1995).
- *Absorption*: $\mathbf{H_2O}$, $\mathbf{O_3}$, $\mathbf{O_2}$ e $\mathbf{CO_2}$; **HITRAN2000** and **Zhong et al.** (2001).
- *Water vapor Continuum*: **CKD 2.4** (**Clough et al**. 89).

<u>Long wave</u>:

- 6 spectral intervals
- *Absorption*: $\mathbf{H_2O}$**,** $\mathbf{O_3}$ **e** $\mathbf{CO_2}$,N_2O, CH_4, CFC11, CFC12, CFC113, HCFC22, HFC125, HFC134a.