The South Atlantic Convergence Zone and the paradigm of SST-driven climate variations

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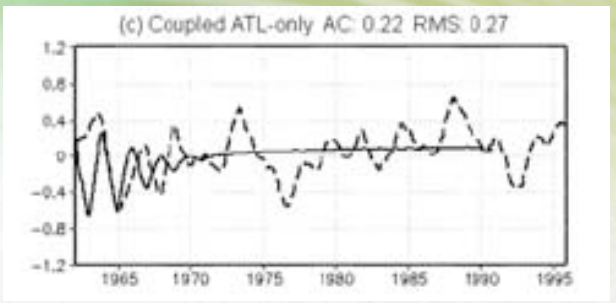
TAV in review

Damped Equatorial mode, e.g. Atlantic Niño:

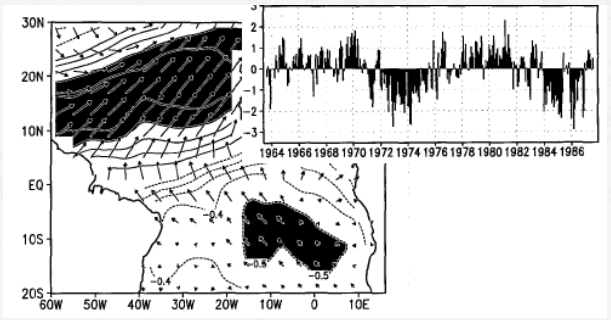
Zebiak (1993)
Chang et al (2000)
Nobre et al (2003)



(Nobre, Zebiak & Kirtman, 2003)

Thermally direct meridional mode, e.g. ITCZ:

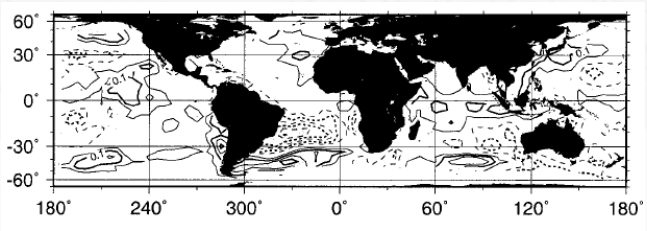
Moura and Shukla (1981)
Nobre and Shukla (1996)
Giannini et al (2001)



(Nobre and Shukla, 1996)

Thermally indirect, e.g. SACZ:

Robertson and Mechoso (2000)
Chaves and Nobre (2004)
De Almeida et al (2007)
Nobre et al (2012)



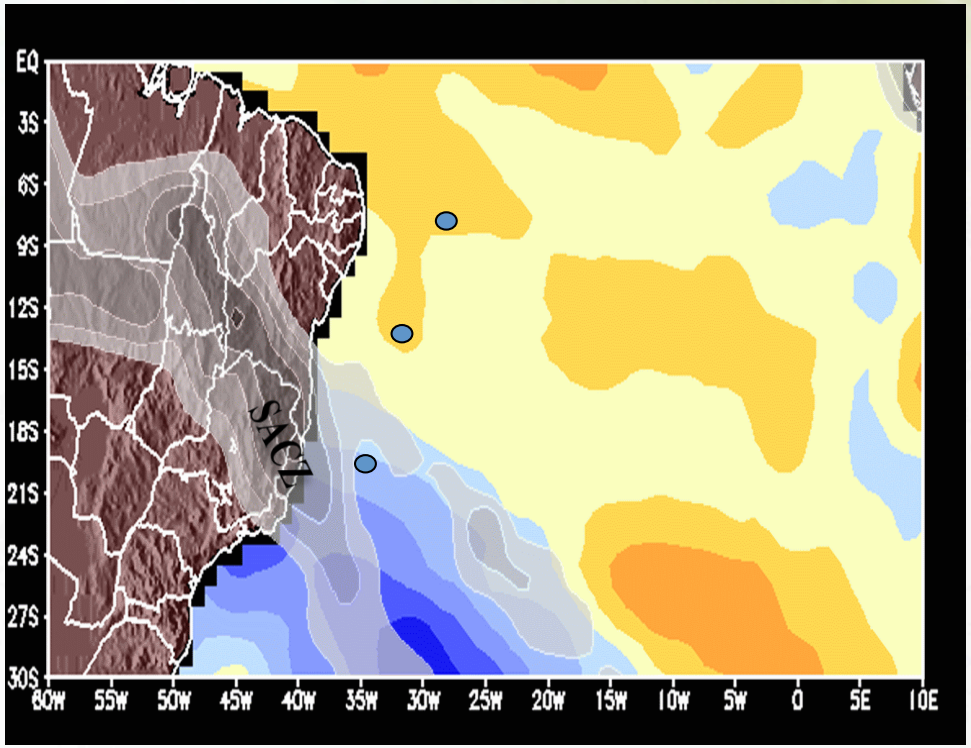
(Robertson and Mechoso, 2000)

Continental convection and Cupled O-A Model bias

SACZ: Continental Rainfall & Cold SST

Atmospheric forcing of underlying SST?

- Kodama et al (1992)
  - Description
- Figueroa et al (1995), Kodama et al (2012)
  - Continental rainfall
- Robertson and Mechoso (2000)
  - Summer monsoon
- Robertson et al (2003), Barreiro et al (2002, 2005)
  - AGCM simulations
- Chaves and Nobre (2004)
  - SST-Cloud-SWR feedback
- Nobre et al (2005)
  - First CGCM evidences neg. feedback
- De Almeida et al (2007)
  - Stochastic SST-SWR negative feedback
- Nobre et al (2012)
  - Fully coupled GCM thermally indirect cell: increased rain, ascending motion over cooler waters



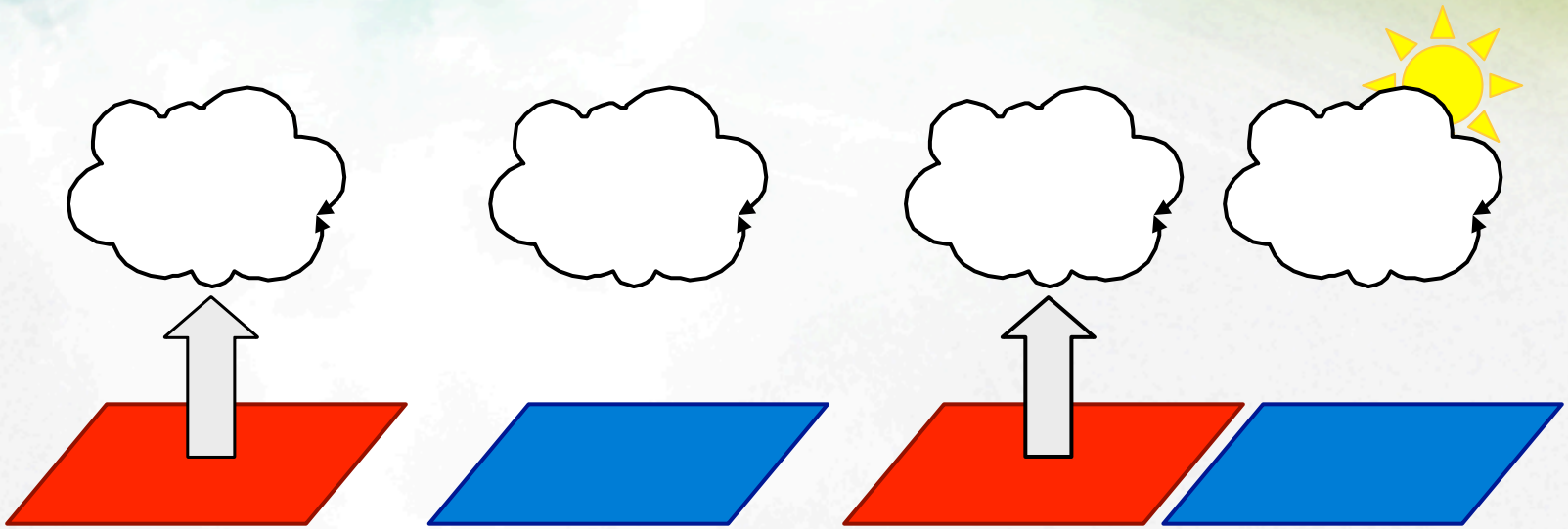
OLR SSTA

OBS: 17-25 NOVEMBER 1999

PIRATA SWE

Courtesy: P. Nobre

The SACZ Cartoon



Continental Rainfall
Figueroa et al (1995)
Kodama et al (2012)

SA Summer Monsoon
Robertson & Mechoso (2000)

Ocean-Atmosphere Feedback
Chaves and Nobre (2004)
De Almeida & al (2007)
Nobre et al. (2012)

Courtesy: R.A.F. Almeida (2007)

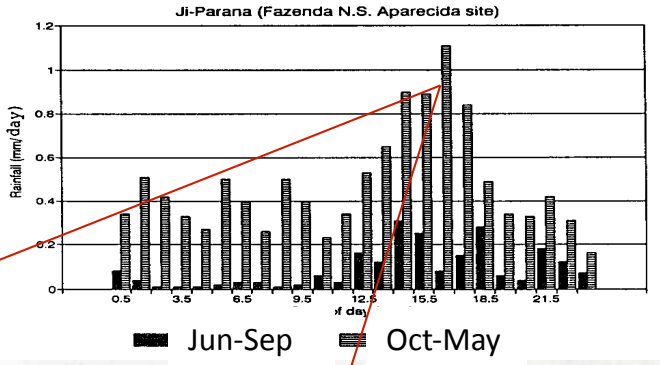
On the SACZ Origin...

1) **Amazon convection**
   - diurnal cycle
   - max diabatic heating at 500 hPa.

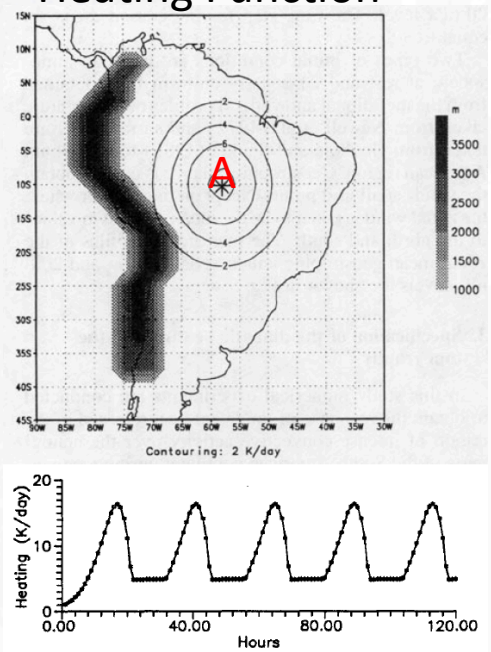
2) **Large-scale zonal flow**

Interaction between (1) and (2) → SACZ

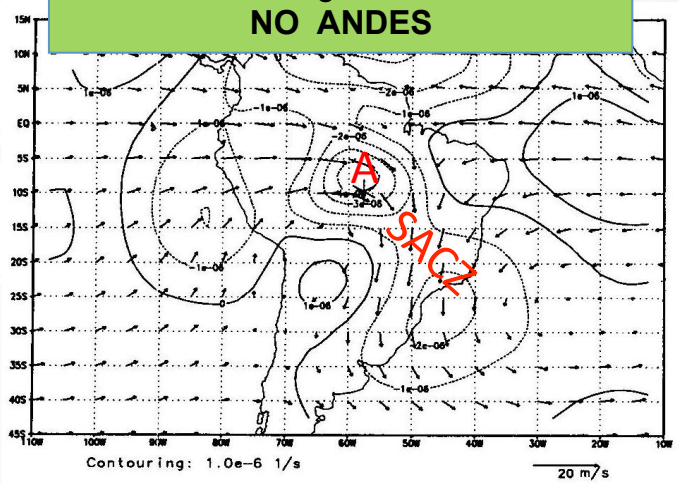
Amazon rainfall diurnal cycle



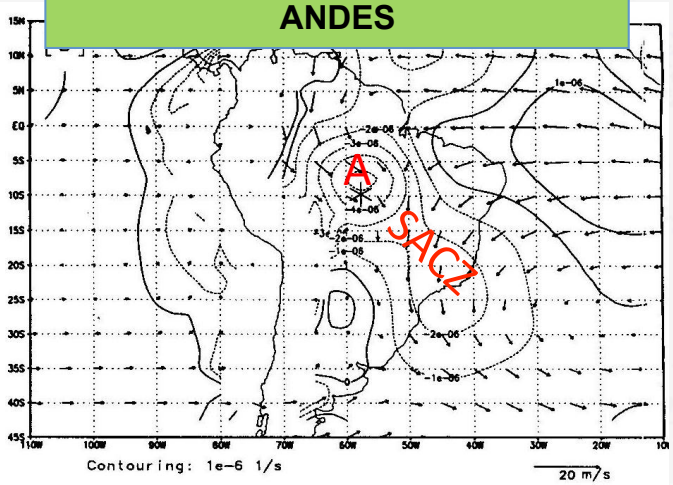
Heating Function



Wind and divergence at 850 hPa.
NO ANDES



Wind and divergence at 850 hPa.
ANDES

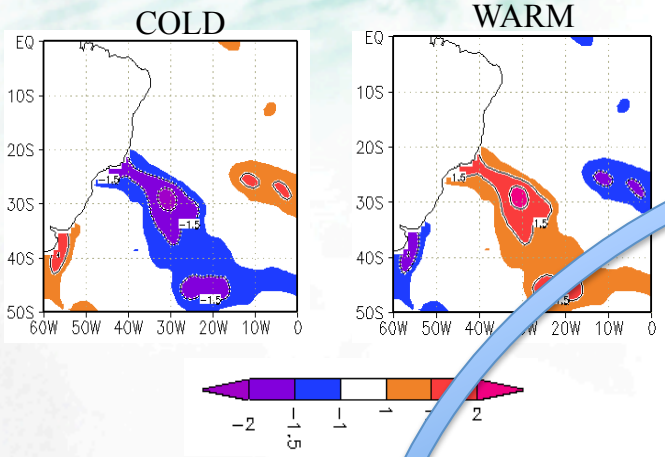


- Andes mountain range intensifies SACZ
- Weak SACZ over the ocean: model insensitivity to SST

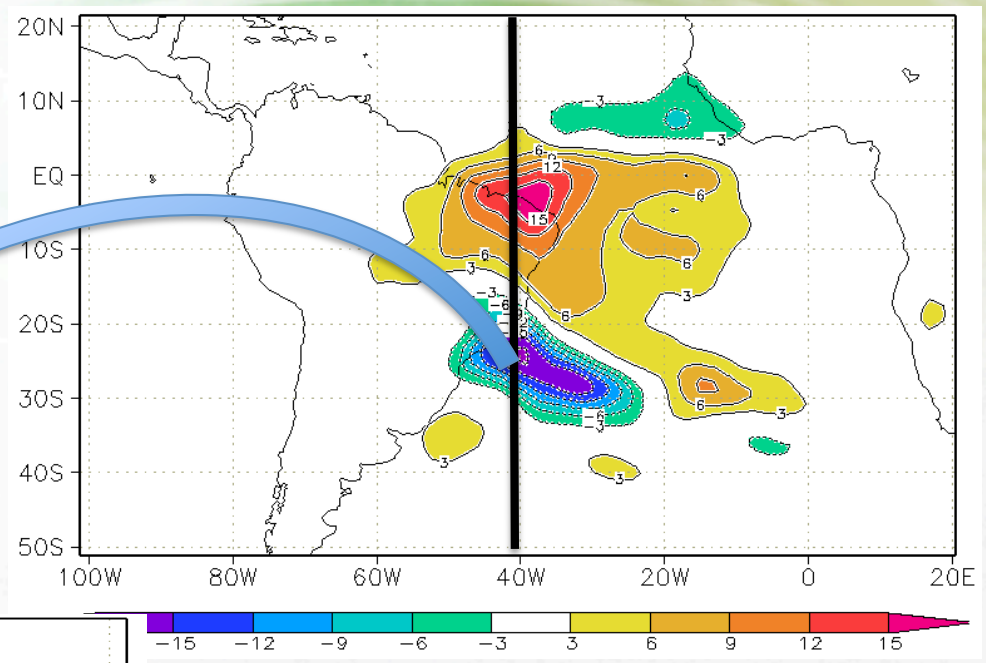
Figueroa et al. (1995)

SST driven SACZ Experiment: forced AGCM

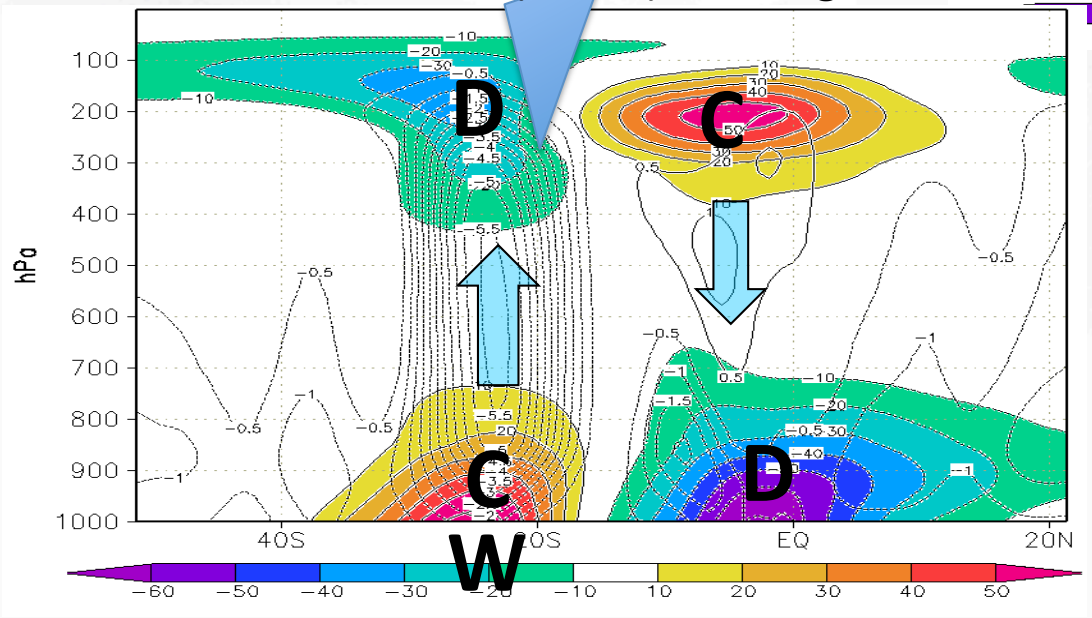
SST FORCING



Warm-Cold OLR ensemble diff (W/m2)



V.Potential (shade) & Omega

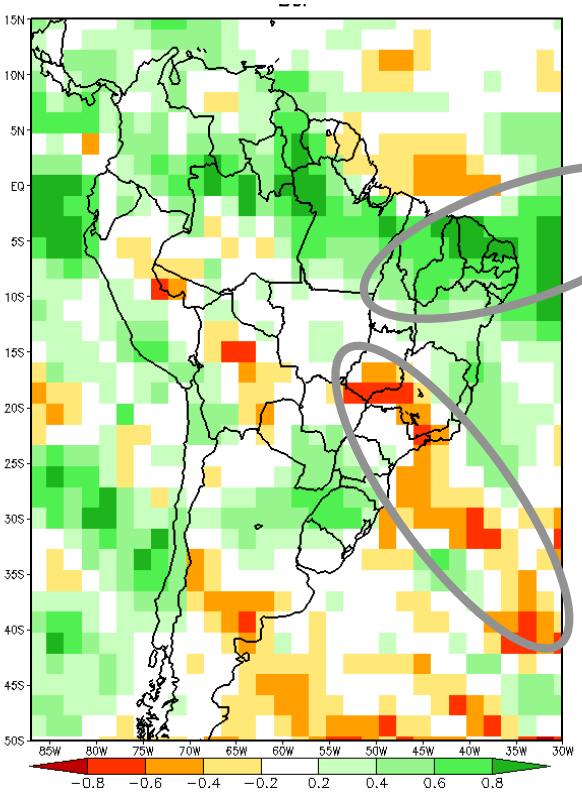


Hydrostatic Response:
Ascending motion, enhanced cloudiness & rainfall, reduced SWR over warmer SST

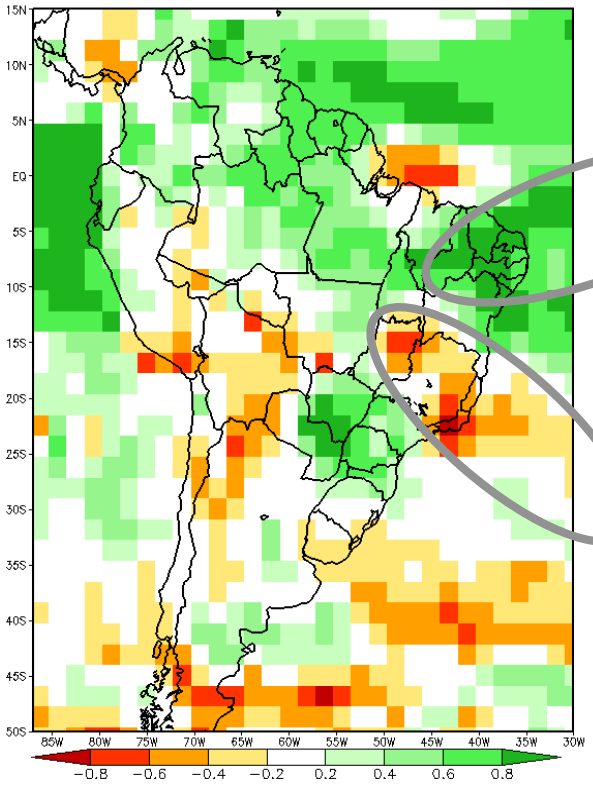
Nobre et al. (2002)

The SACZ 2-tier Quest

DJF



MAM



CPTEC AGCM, 50 years, 10 Member Ensemble, Kuo, T062L28, Obs SST

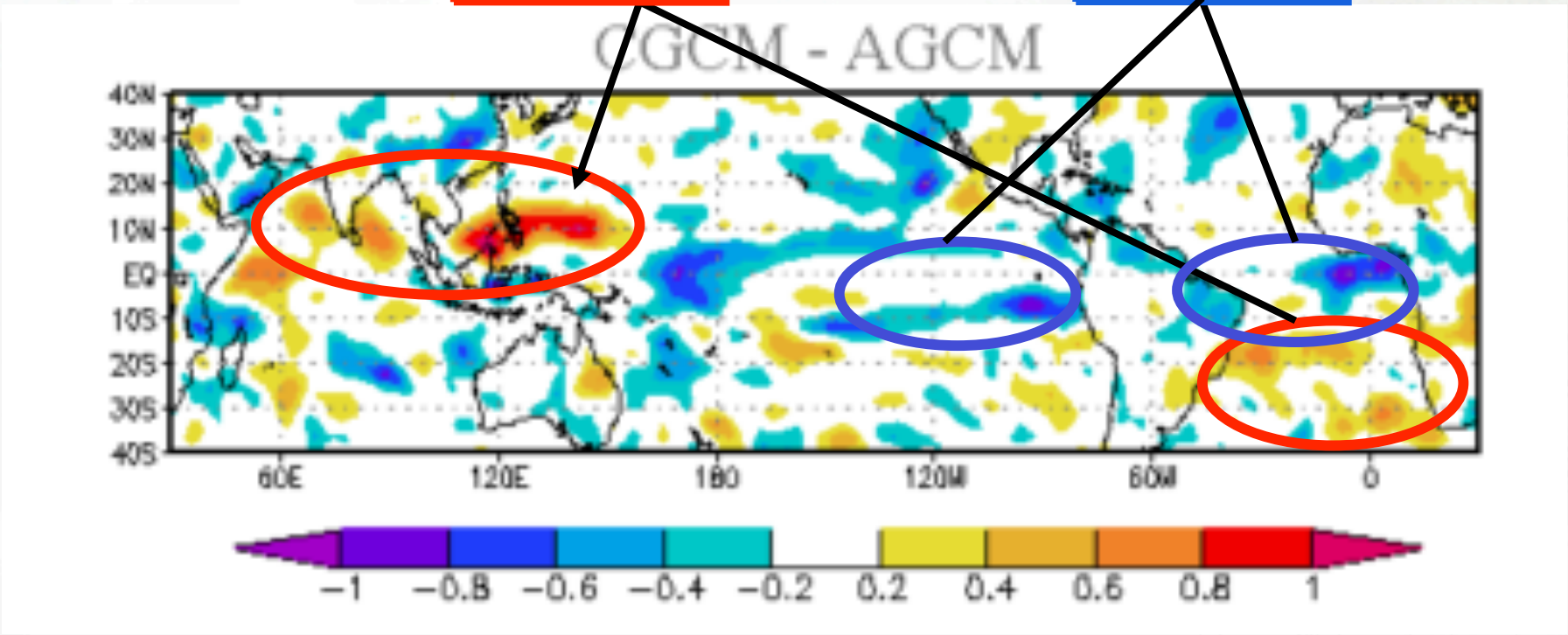
Marengo et al. (2002)

Coupled Ocean-Atmosphere processes at play

DJF Precipitation Forecasts anomaly correlations

Increased
Coupled Model
Forecast Skill

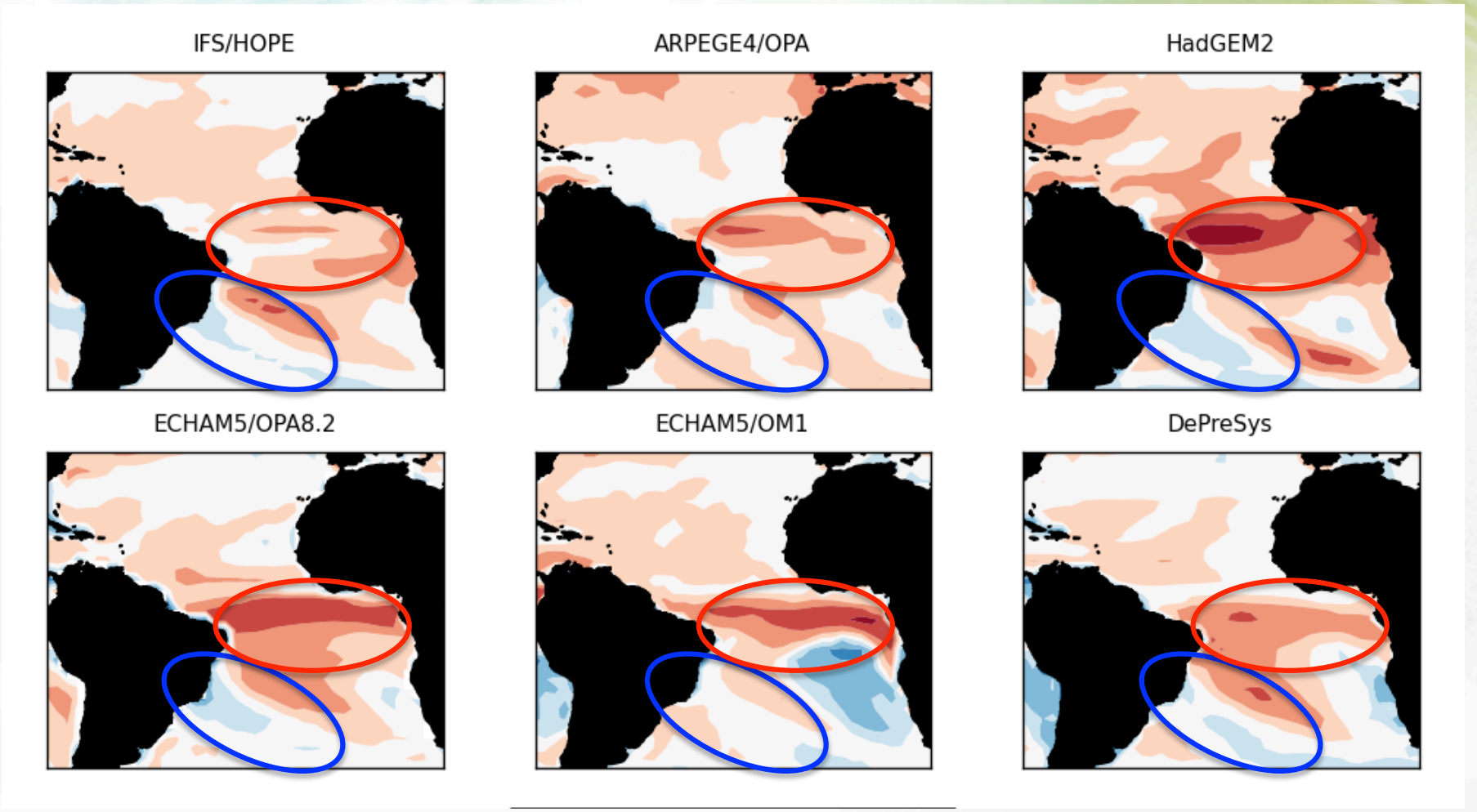
Decreased
Coupled Model
Forecast Skill



20 years, 10 member ensemble CGCM & tween AGCM runs

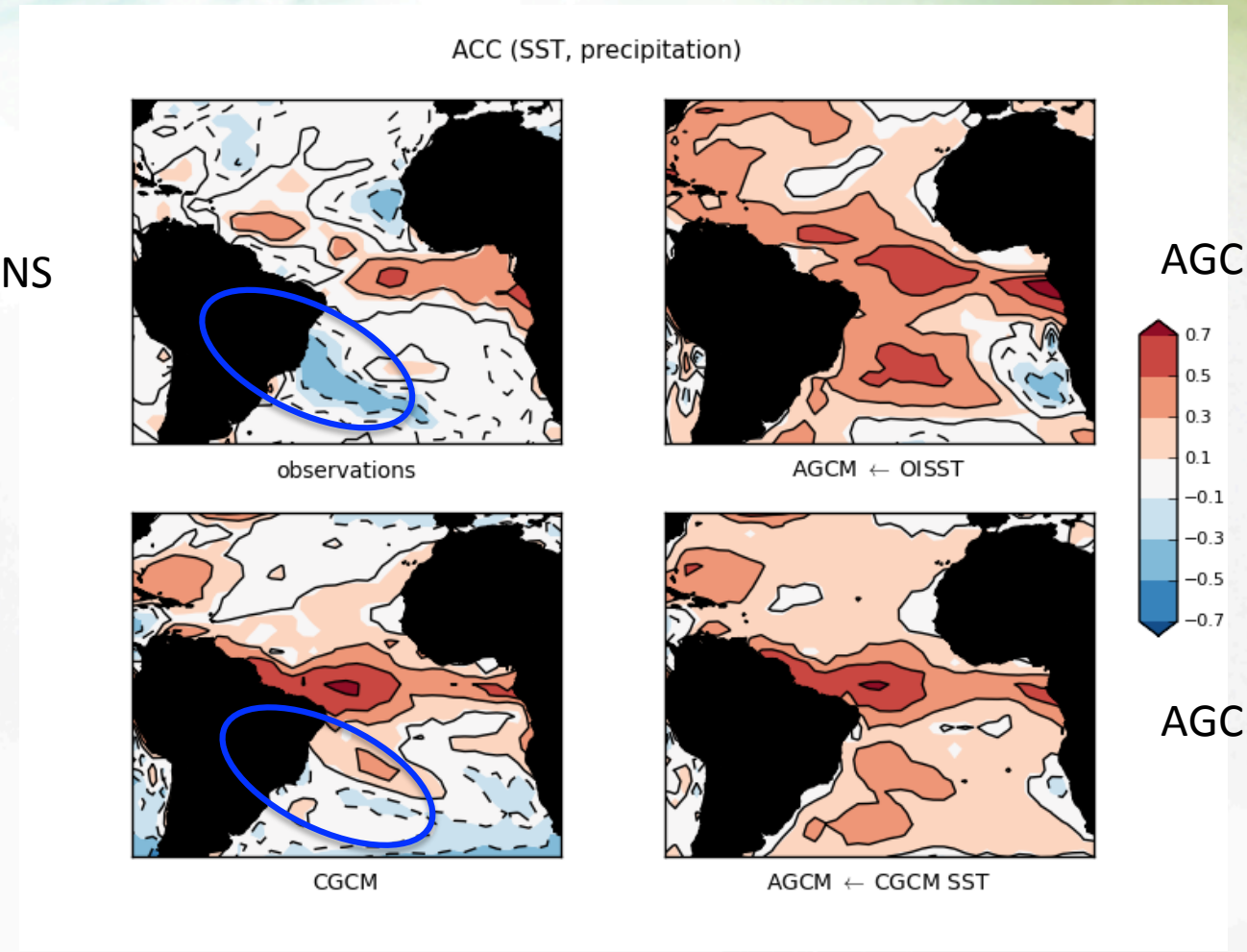
Nobre et al. (2005)

Ensembles Coupled Forecasts
SST-Rainfall Anomaly Correlations



Nobre et al. (2012)

SACZ Signature
Increased Rainfall over Cold Waters

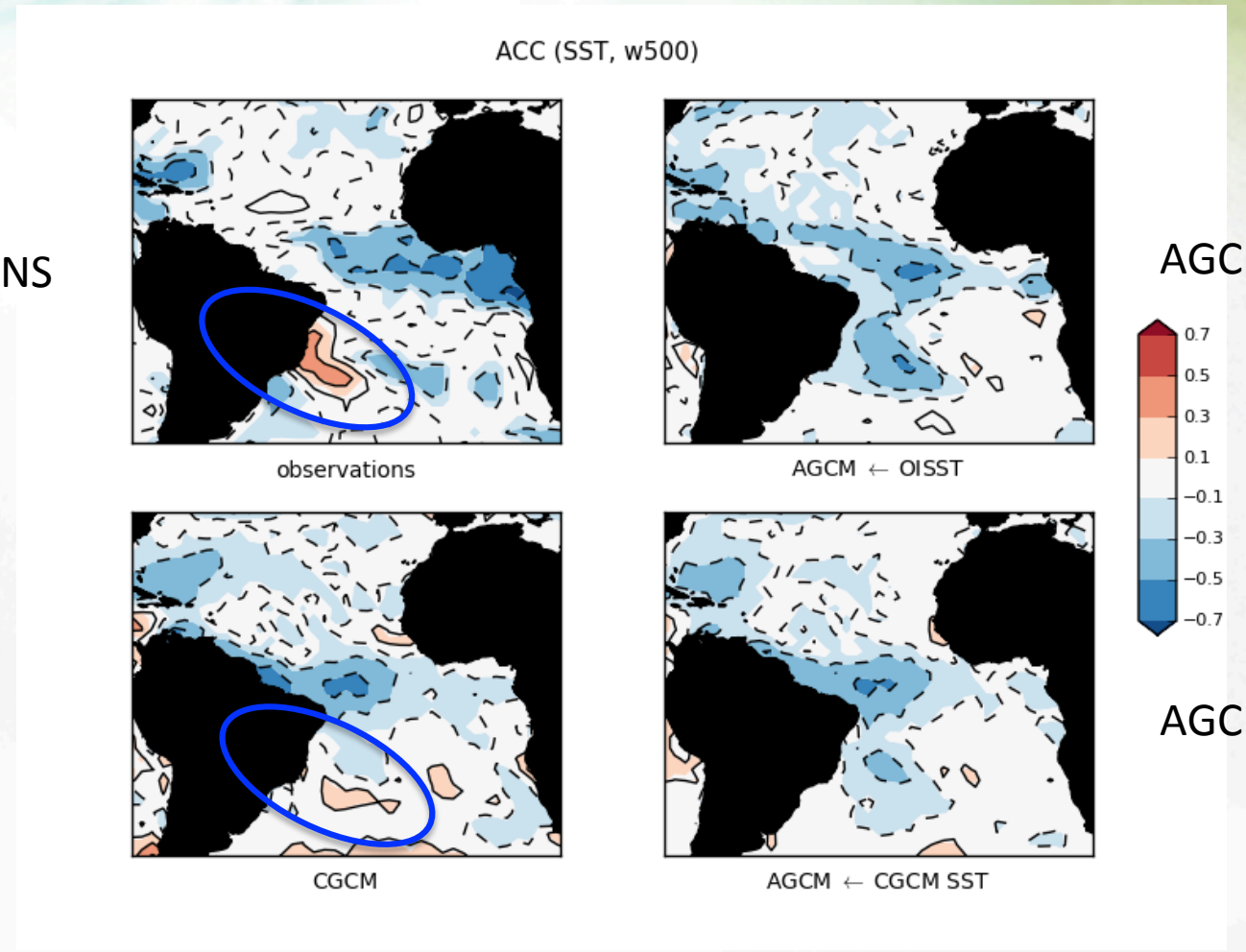


Nobre et al. (2012)

SACZ Signature:
Ascending motion over cold water

OBSERVATIONS

BESM-OA2.3



AGCM, Obs SST

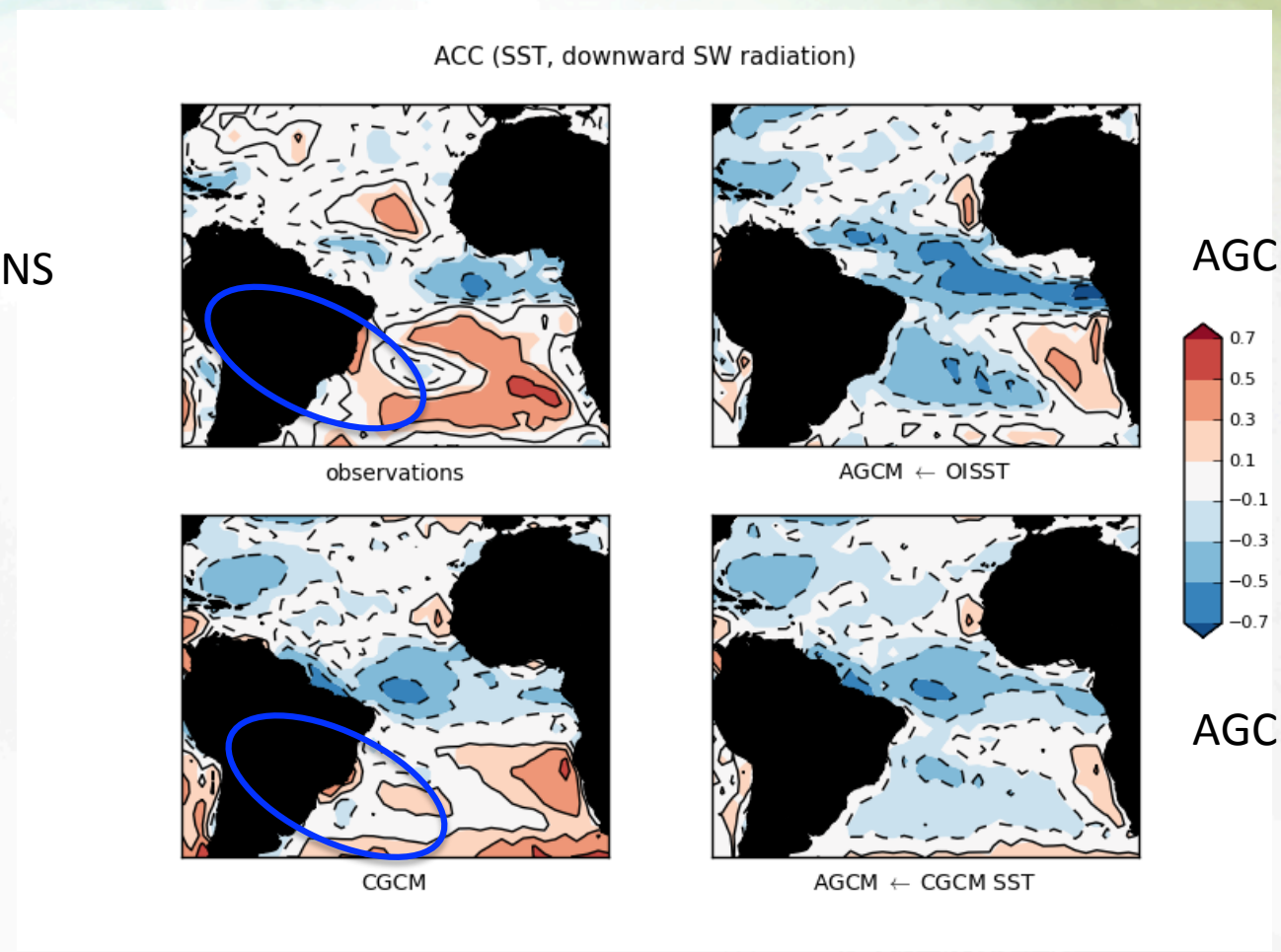
AGCM, BESM SST

Nobre et al. (2012)

Increased downward SW radiation over cold water

OBSERVATIONS

BESM-OA2.3



AGCM, Obs SST

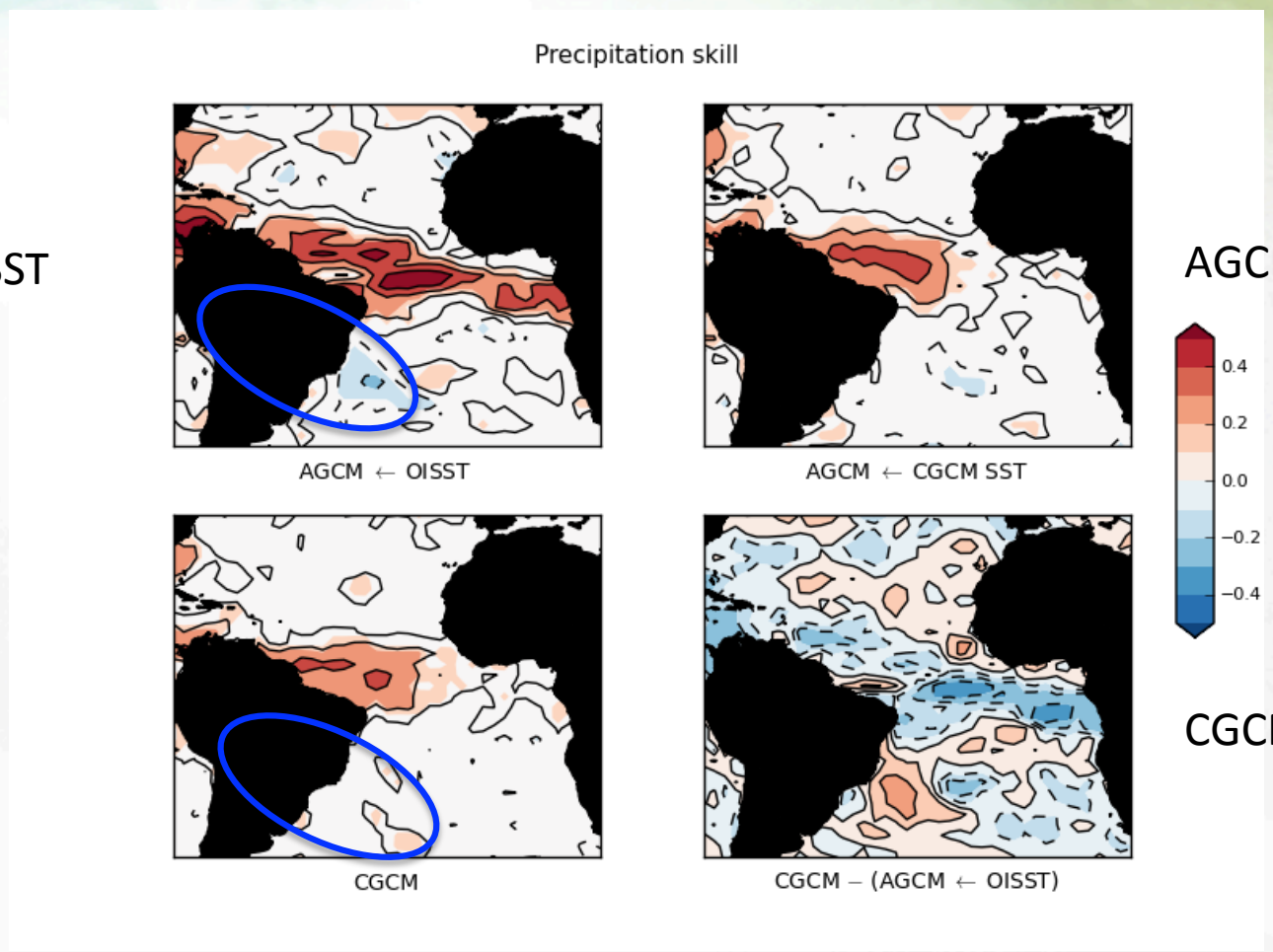
AGCM, BESM SST

Nobre et al. (2012)

2-tier x 1-tier
Rainfall Predictability

AGCM, Obs SST

AGCM, BESM SST



BESM-OA2.3

CGCM-AGCM

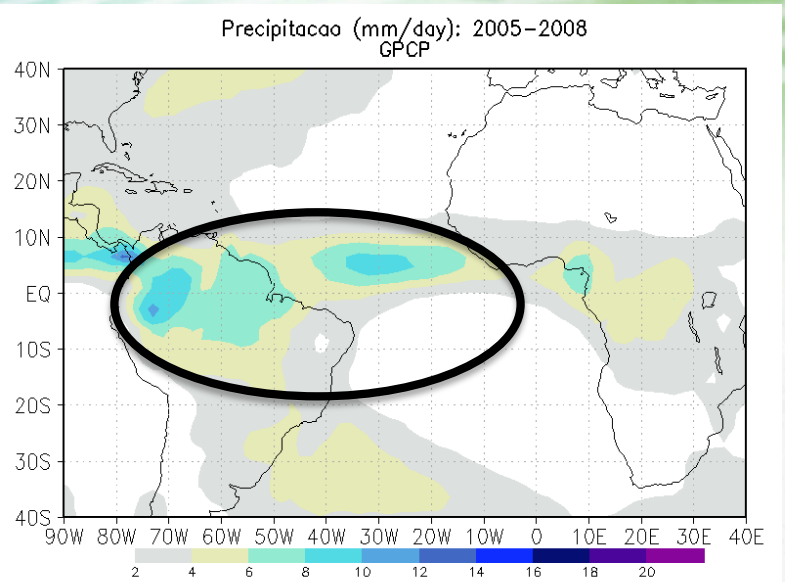
Nobre et al. (2012)

Next Steps…

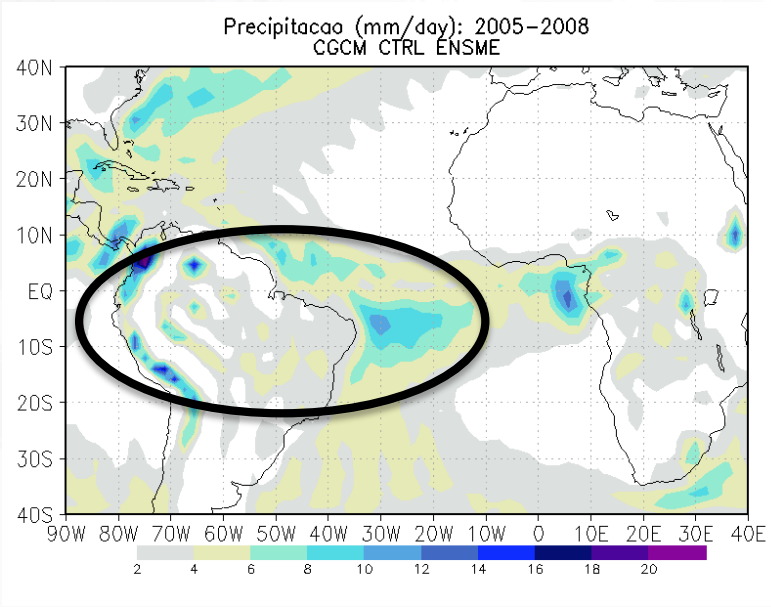
- Development of the Brazilian Earth System Model
  - CPTEC AGCM
  - GFDL MOM4p1 OGCM, ISI, TOPAZ & FMS coupler
  - CCST INLAND Surface model (based on NCAR IBIS)
  - MPI/NCAR HAMMOZ Aerosol-Chemistry model
- Bettering the representation of tropical rainfall, srfc processes, river discharge on the Atlantic Ocean, and its effects on global climate:
  - Contributing to solve Atlantic SST bias, ITCZ and SACZ variability and change issues.

BESM AMAZON RAINFALL REPRESENTATION

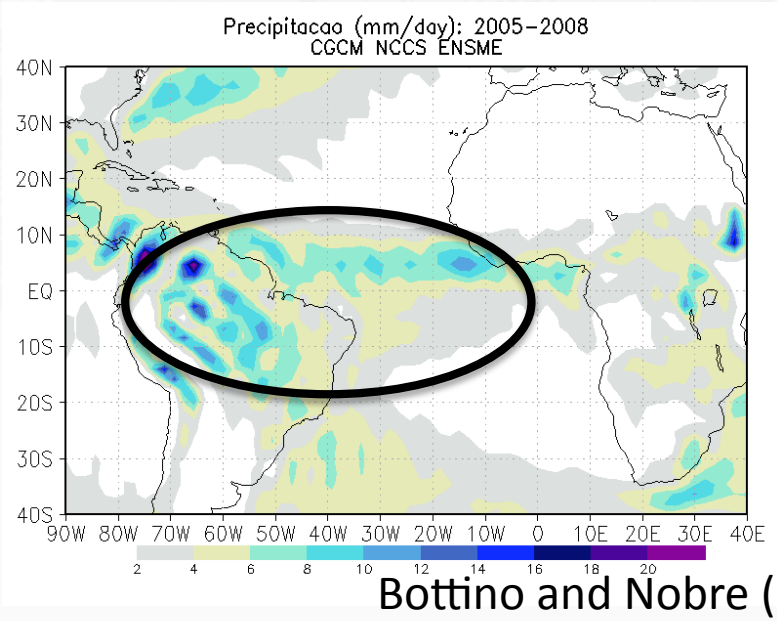
GPCP



BESM 2.3



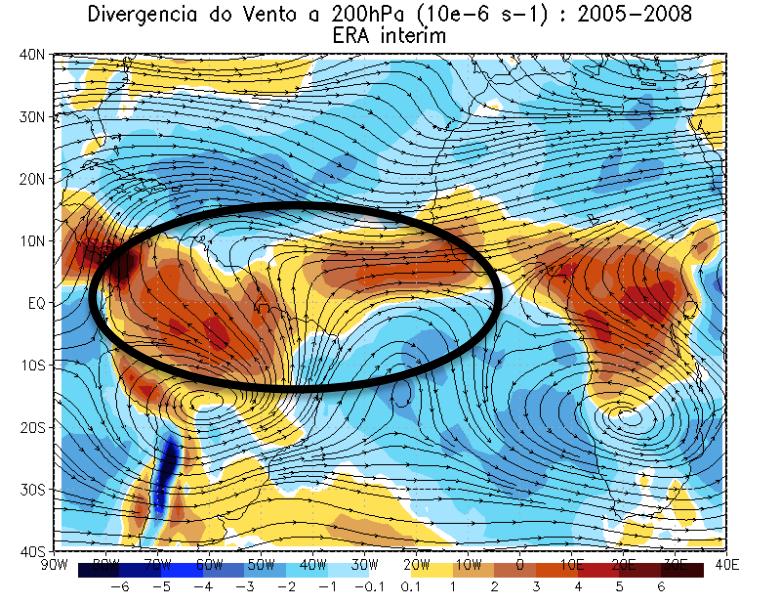
BESM 2.3.1



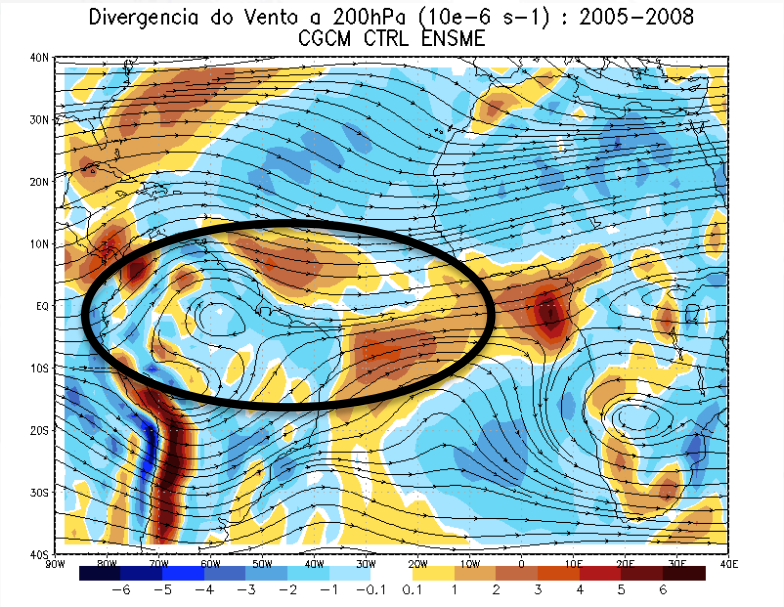
Bottino and Nobre (2013)

BESM UPPER LEVEL FLOW REPRESENTATION

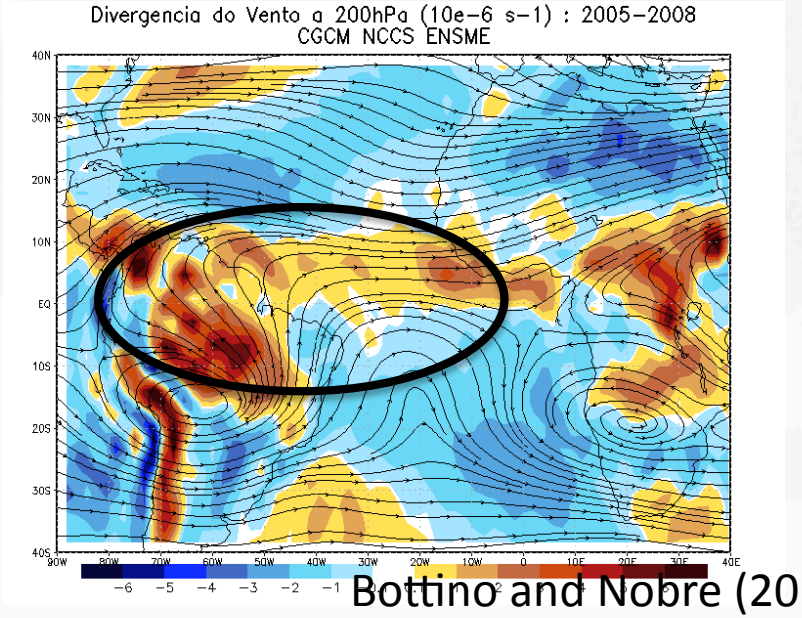
ERA interim REANALISYS



BESM 2.3



BESM 2.3.1

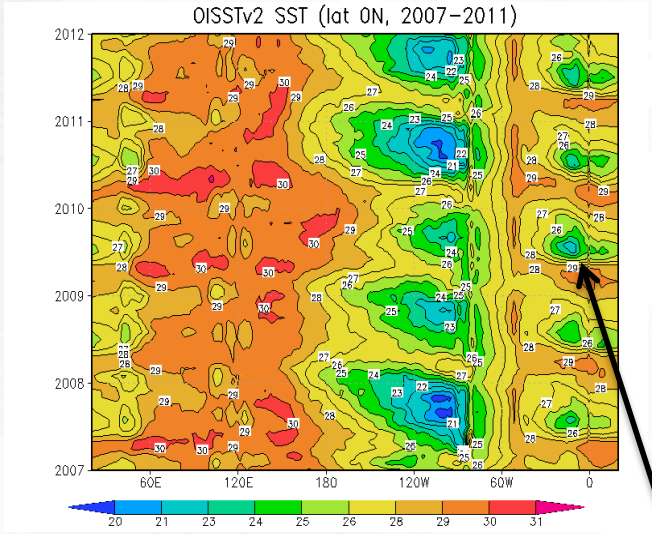


Bottino and Nobre (2013)

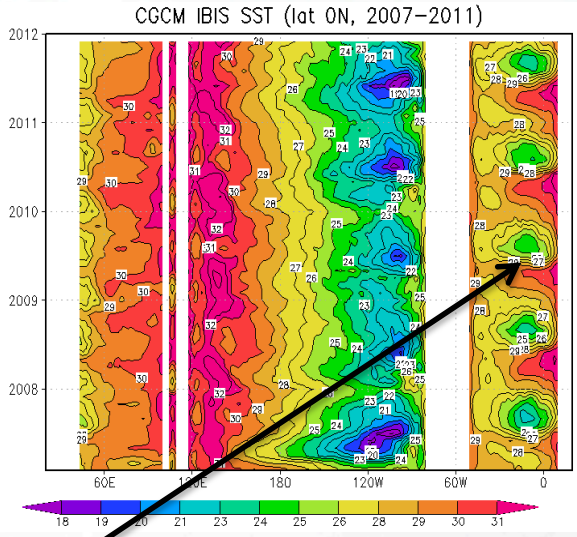
BESM-Ibis2.4

Equatorial Atlantic Cold Tong Simulation

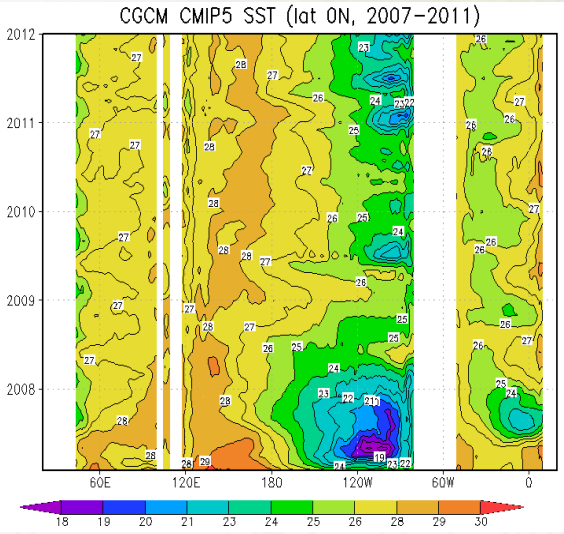
OISSTv2



BESM-IBIS2.4



BESM-OA2.3 (CMIP5)



Interannual representation of the Equatorial Atlantic Cold Tong formation

Courtesy: Marta Malagutti

Concluding Remarks

- Hydrostatic, thermally driven circulation (ascending motion over warm waters), does not explain SACZ formation.
- Coupled ocean-atmosphere interactions are fundamental to explain SACZ formation and variability.
- Improved representation of continental diabatic heat source is needed to predict SACZ formation.
- Work's being done in Brazil, with international cooperation, to develop BESM to a fully interactive ESM.