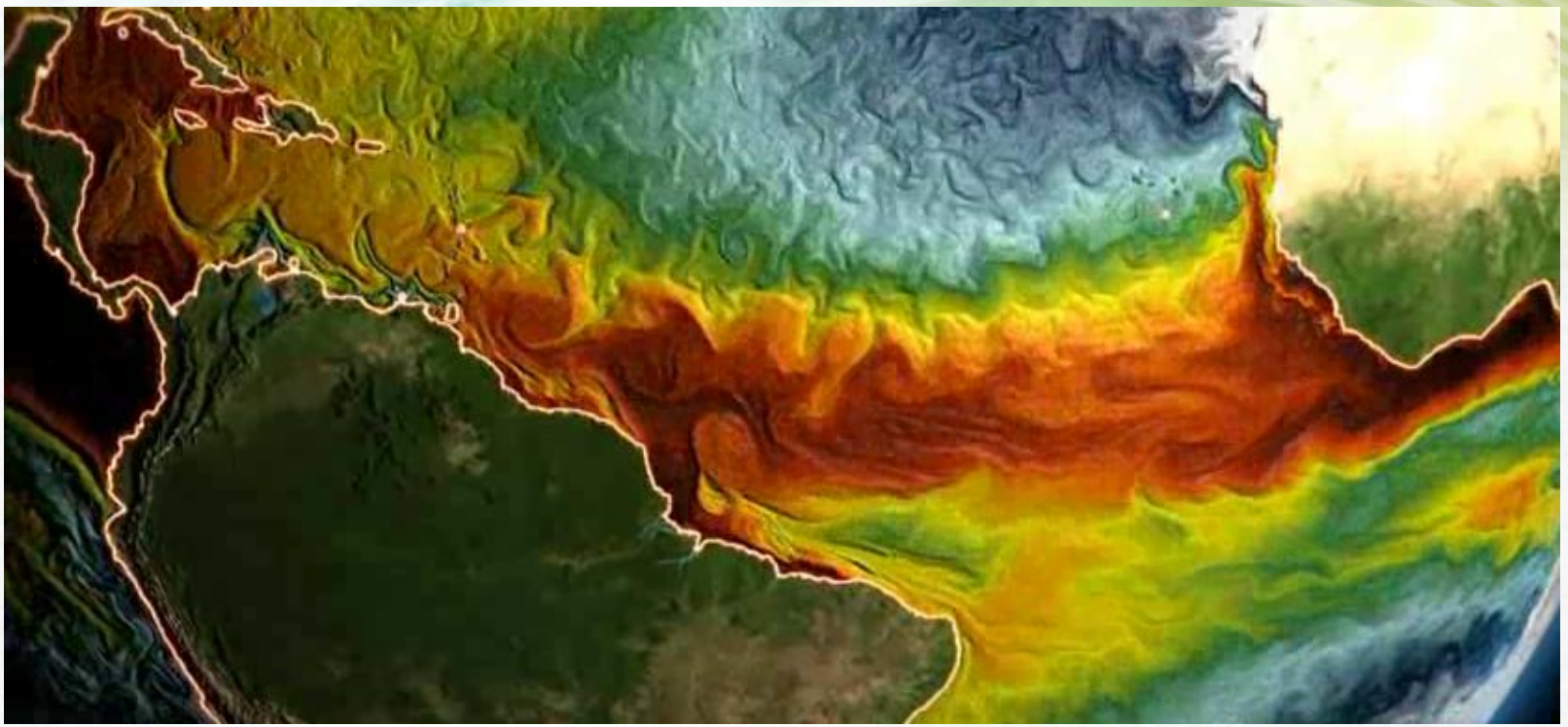
BESM Ocean Model

BESM
BRAZILIAN EARTH SYSTEM MODEL



From GFDL High Resolution climate model (10X10km) using MOM4 as the oceanic code base.

Léo Siqueira

Ph.D. Meteorology and Physical Oceanography

BESM Ocean model

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- Modular Ocean Model (Griffies 2009) from GFDL version MOM4p1:
- Includes the Sea Ice Simulator (SIS) built-in ice model (Winton 2000).
- Includes TOPAZ built-in Global physical-biogeochemical model.

BESM Ocean model

BESM
BRAZILIAN EARTH SYSTEM MODEL

- Background vertical diffusivity and horizontal diffusivity need to vary both meridionally and vertically for different grids.

- Atmospheric boundary layer stability and gustness also affect the ocean model kinetic energy and amplitude of sea surface temperature anomalies.

- Needs precise adjustment of key factors depending on the grid setup and parameterization adjustment.

- Main goal is to simulate annual cycle correctly and SST anomalies for different time-scales.

BESM Ocean model

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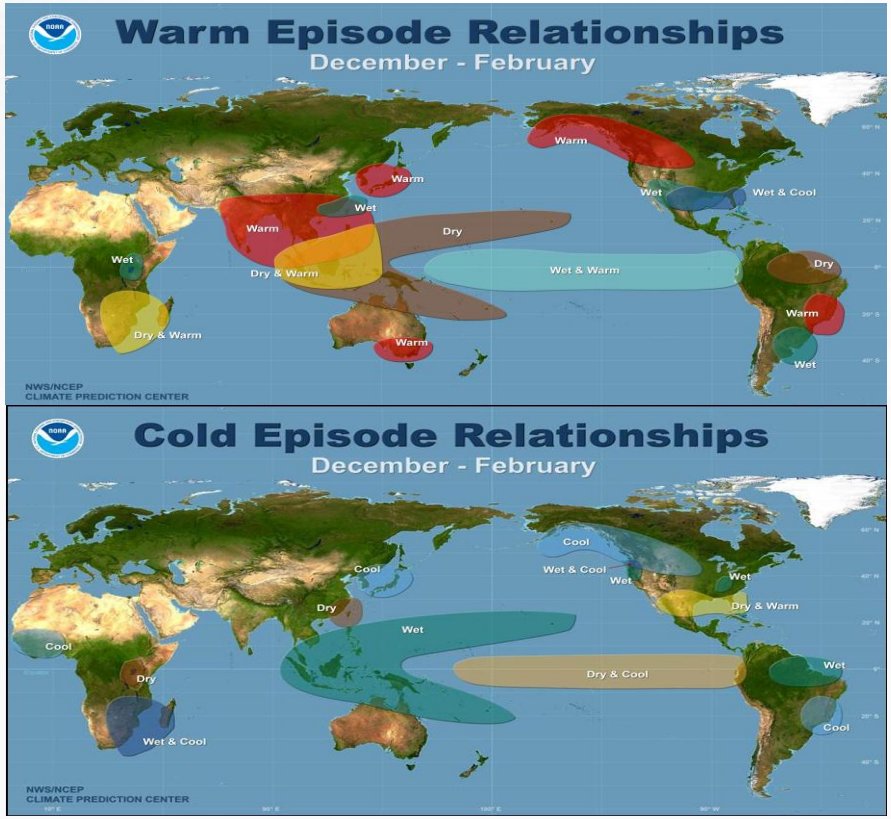
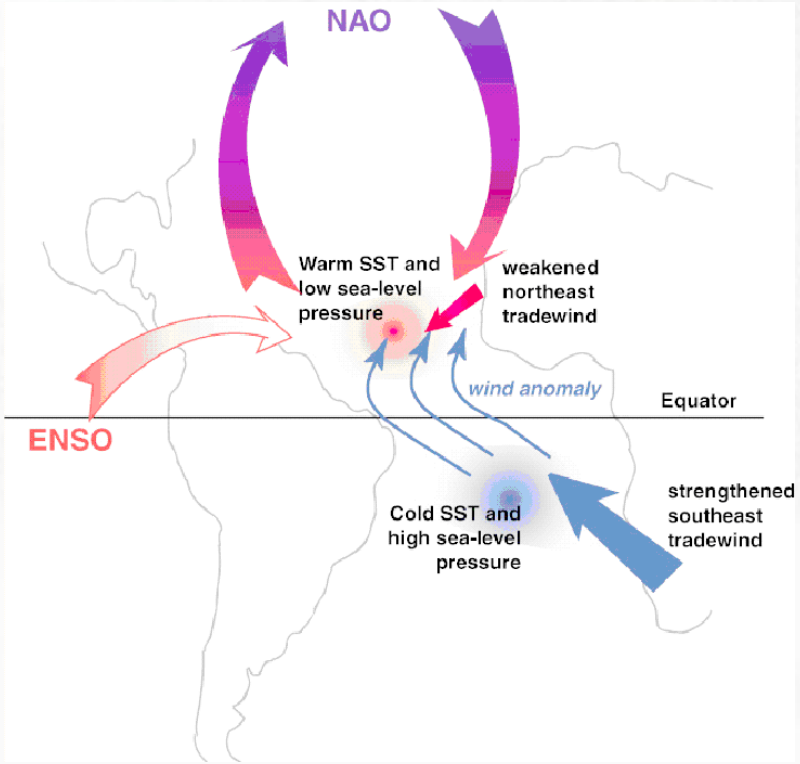
BRAZILIAN EARTH SYSTEM MODEL

- Strong link between rainfall anomalies over Brazil and sea surface temperature anomalies in the tropics .

ENSO Impacts



Tropical Atlantic Variability



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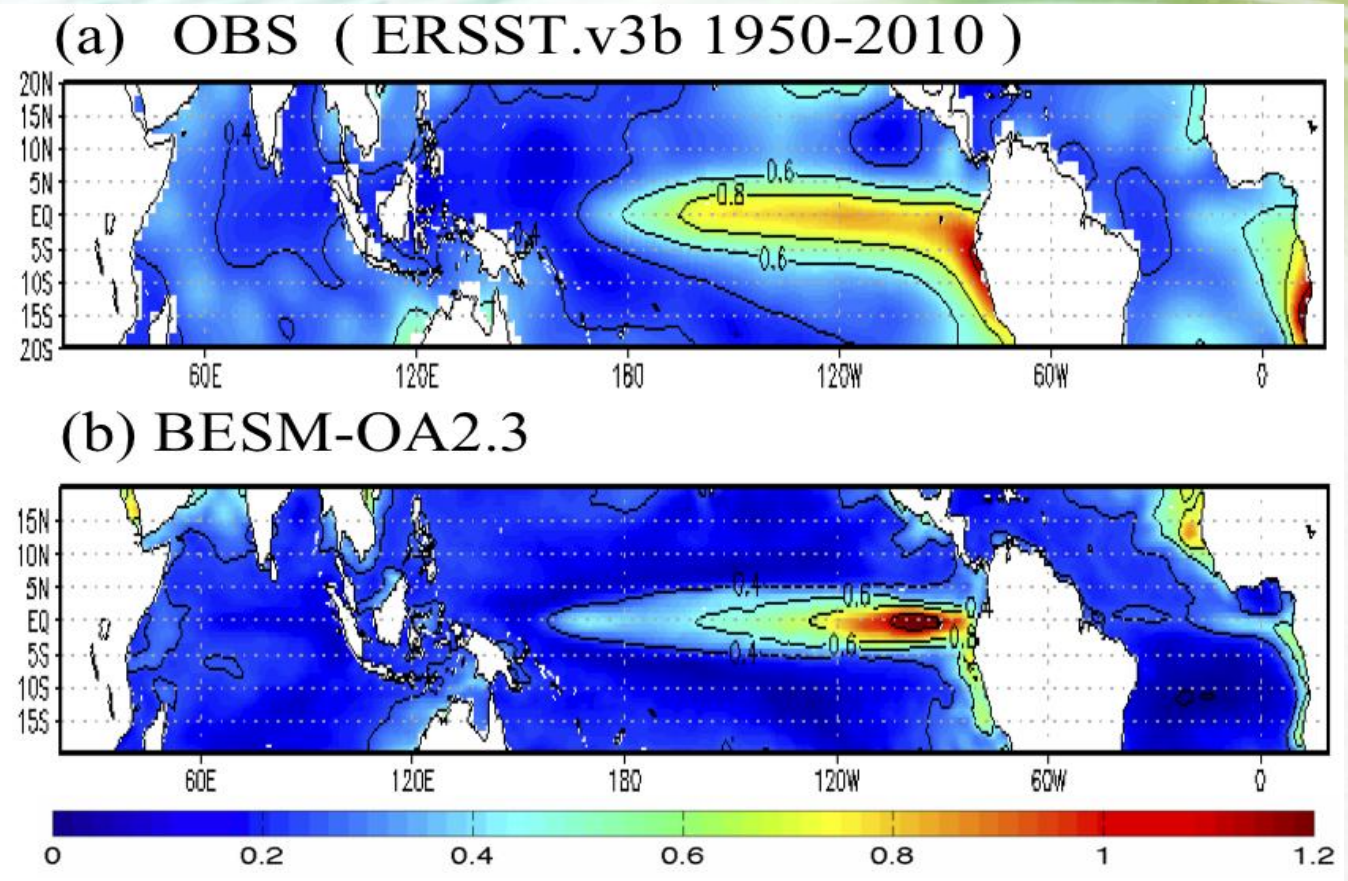

- Interannual climate variability: BESM shows a robust ENSO signal over the equatorial Pacific Ocean, with peak energy in the 3 to 5 year range, in agreement with observations.

BESM Ocean model

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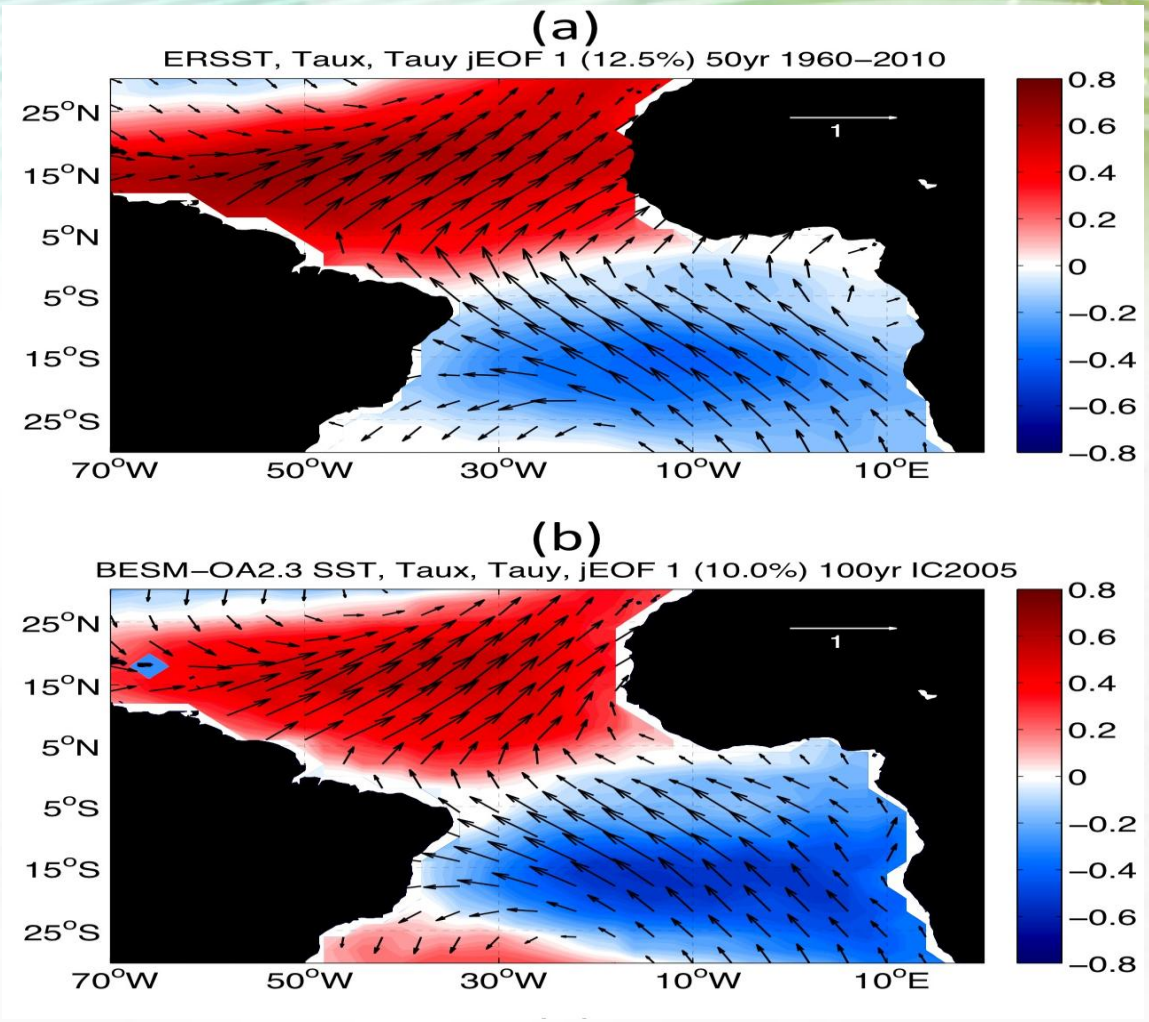
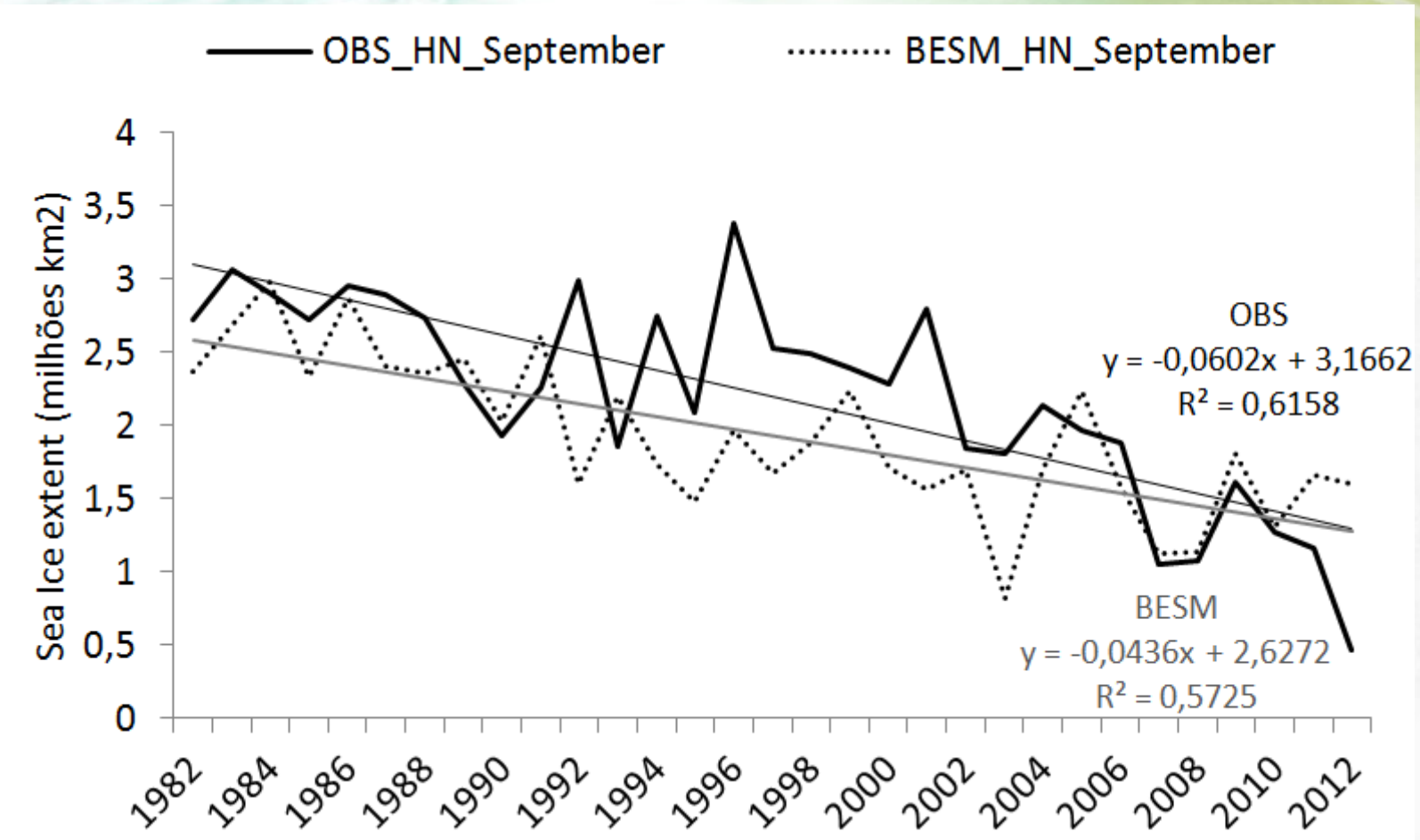


- BESM shows a dipole-like pattern of SST and surface winds with peak energy on the decadal scale in the Atlantic Ocean, in agreement with observations.

Nobre et al (2013) J.Climate Submitted

BESM-OA2.3
Ice Extent

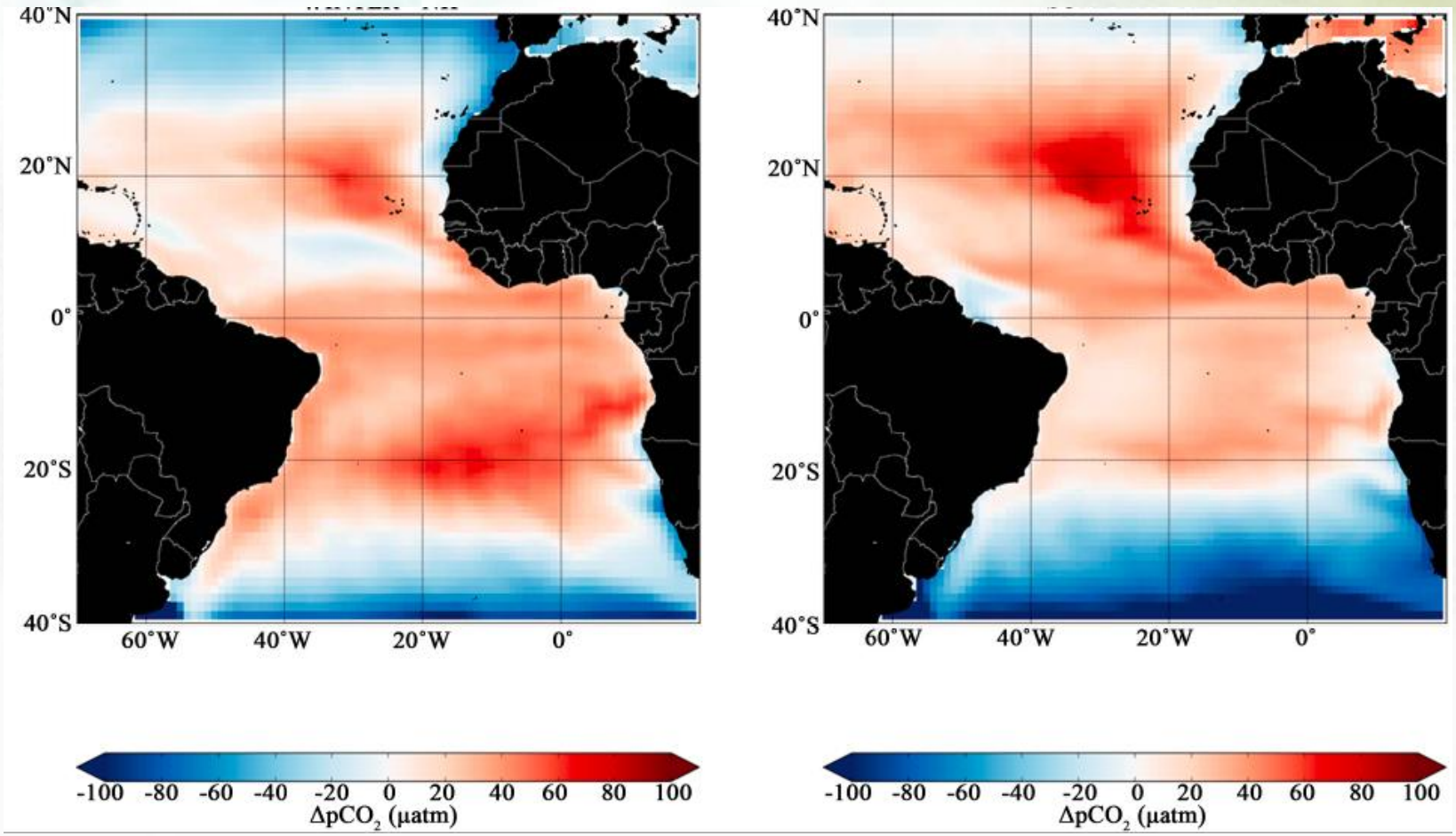


F.Casagrande (2013) Ph.D. Research

BESM
BRAZILIAN EARTH SYSTEM MODEL

BESM-OA2.3_Topaz pCO2

DJF JJA



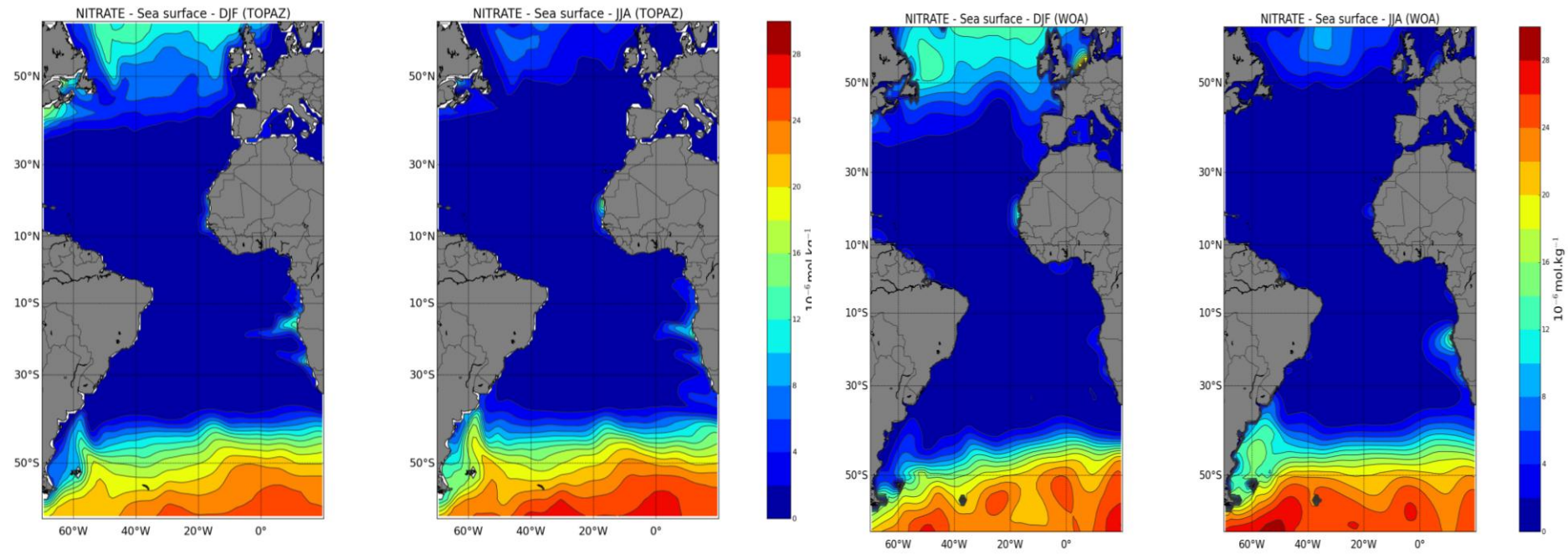
De Farias et al (2012)

BESM-OA2.3_Topaz
Ocean Nitrate

BESM
BRAZILIAN EARTH SYSTEM MODEL

TOPAZ

OBSERVATION



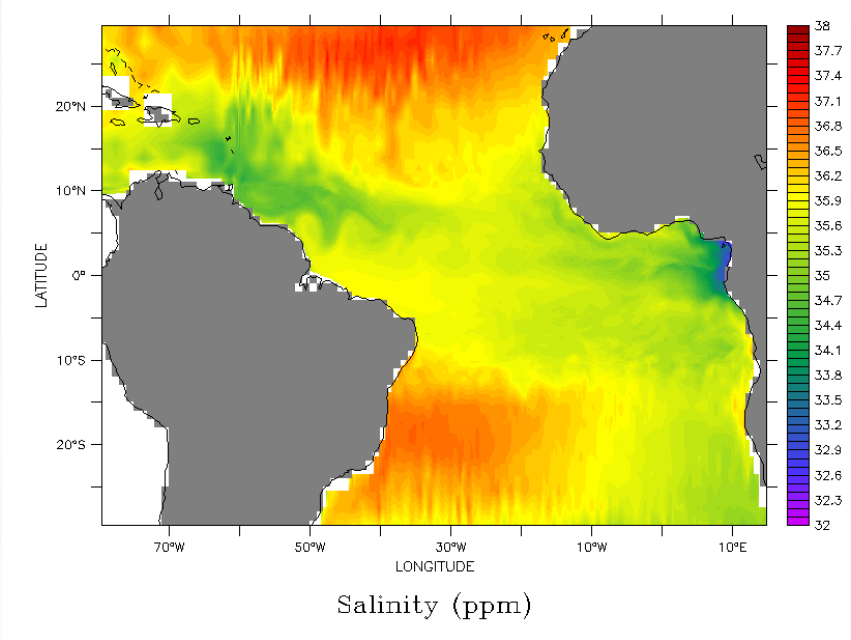
De Farias et al (2012)

Land-Ocean coupling: River inflow effects on ocean circulation and salinity

BESM
BRAZILIAN EARTH SYSTEM MODEL

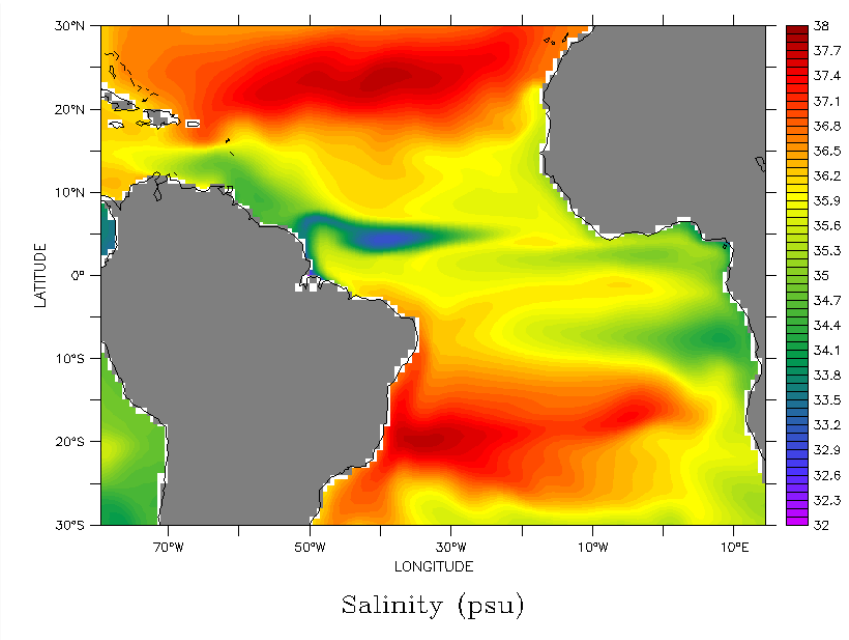
MOM3

w/o river discharge



MOM4

with river discharge



Source: P. Nobre (personal comm.)

BESM Ocean model
Climate Change

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- Ocean Heat content and Atmospheric CO2 concentration .

- The essential balance in the Earth System is between total OHC (the primary heat storage term) and FTOA (the total energy flux entering or leaving the system).

BESM Ocean model

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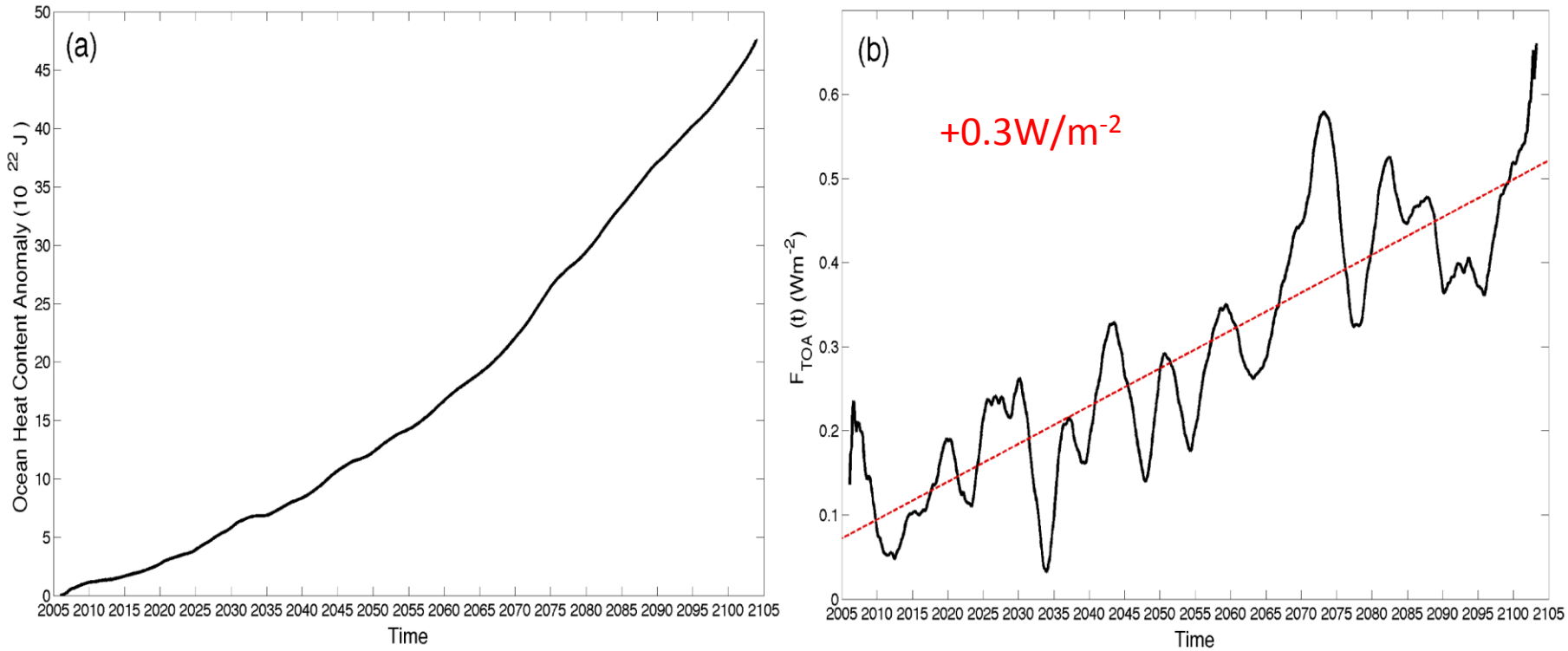
BRAZILIAN EARTH SYSTEM MODEL



- 100yr trend in:

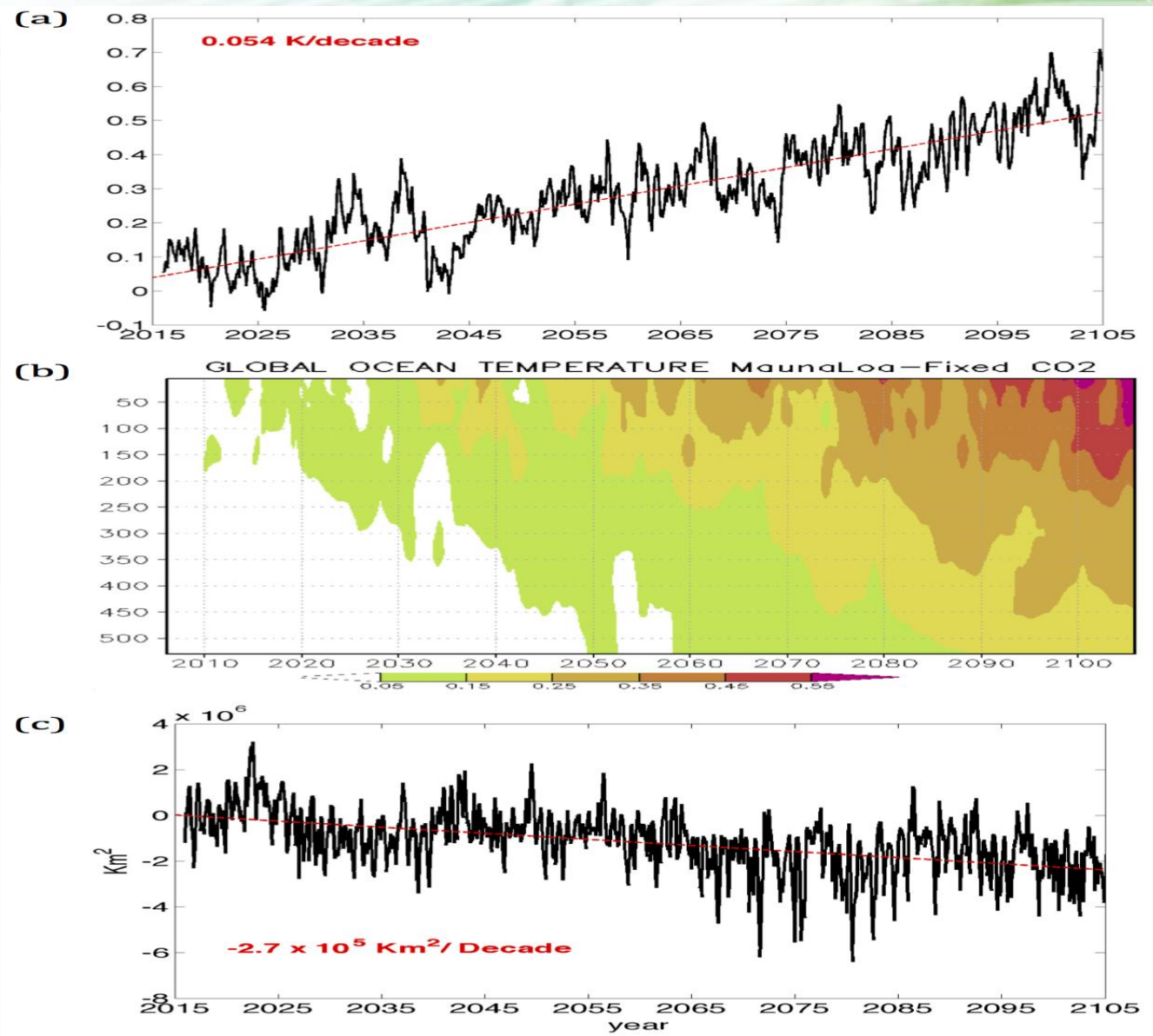
(a) full depth Ocean Heat Content Anomaly

(b) top-of-atmosphere radiation flux imbalance

Nobre et al (2013) J.Climate Submitted

BESM Ocean model

BESM
BRAZILIAN EARTH SYSTEM MODEL



- Global SST increase.
- Time-depth profile of ocean temp.
- Sea ice extent reduction.

Nobre et al (2013) J.Climate Submitted

BESM Ocean model

BESM
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SYSTEM MODEL

Future Challenges:

- It is recognized that interactions across time and space scales are fundamental to the climate system itself.
- “Low resolution” climate simulations do not capture these interactions.
- The large-scale climate determines the environment for microscale (order 1 km) and mesoscale (order 10 km) variability which then feeds back onto the large-scale climate.

BESM Ocean model

BESM
BRAZILIAN EARTH SYSTEM MODEL

Future Challenges:

- In typical climate models these variations occur on unresolved scales, and the micro and mesoscale processes are parameterized in terms of the resolved variables.

Moving towards high resolution simulations
(10km ocean – 50km atmos)

- Needs adequacy of ocean model towards 10km grid and atmospheric model towards 50km grid.

BESM Ocean model

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Future Challenges:

Resolution often portrayed as the solution to everything -> untrue and new problems arise, for example:

- Increase in heat transport due to eddies and changes in the mean circulation makes high-resolution simulations ubiquitously warmer than the low-resolution simulations.

- The largest differences are in the Arctic with notable losses of sea-ice and in regions of relatively large ocean eddy activity (i.e., Southern Ocean and western boundary currents).

- Warming involves an ice-albedo feedback in the polar latitudes, changes in cloud cover in the western boundary current regions and global water vapor in the tropics and sub-tropics.

THANK **YOU!**

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INPE

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