Effect of Atlantic Meridional Overturning Circulation on Tropical Atlantic Variability: A Regional Coupled Model Study

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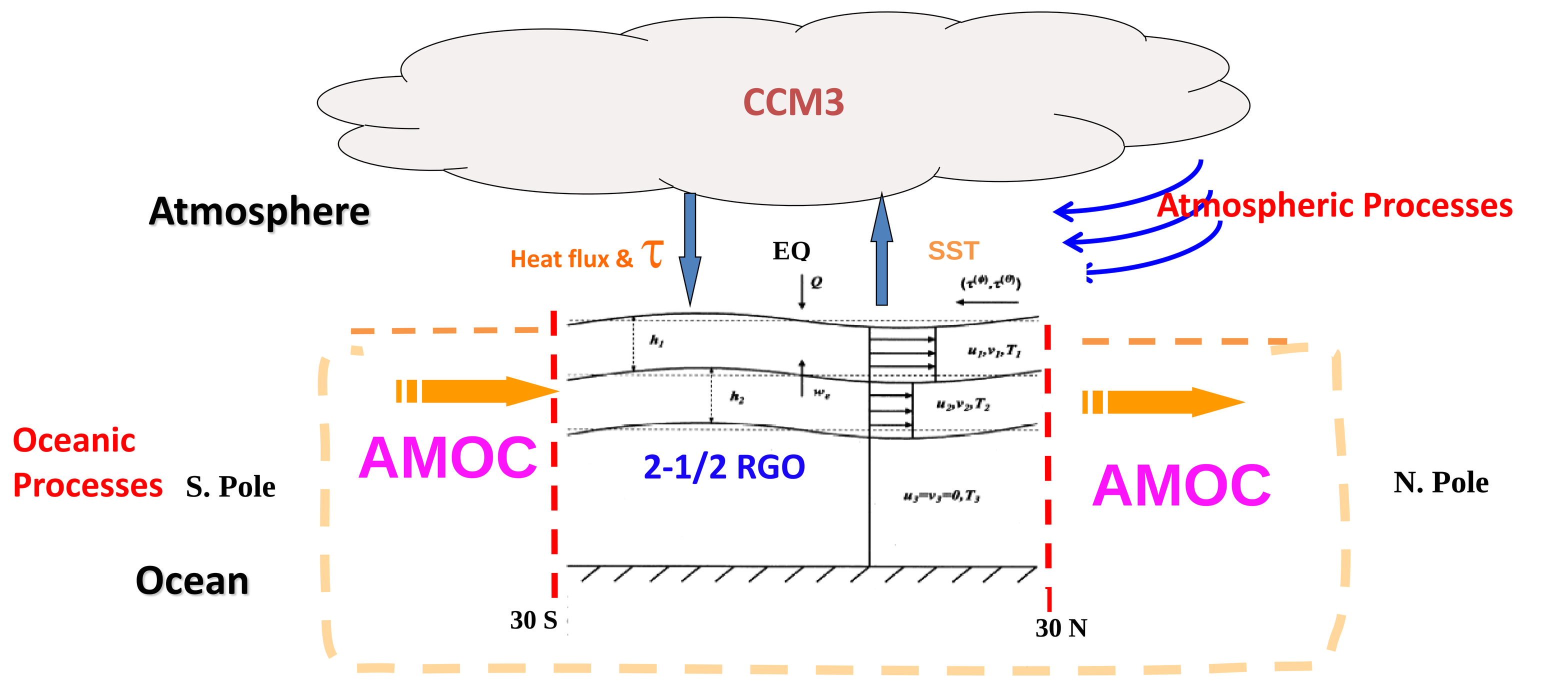
Introduction:

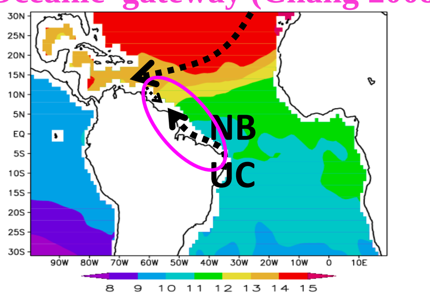
The pronounced dipole like SST pattern and the southward shift of ITCZ are robust climate response to a slow-down of AMOC, coming from both coupled climate model simulations and paleoclimate studies. However, the detailed mechanisms by which the AMOC exerts its influence on TAV remain to be elucidated. The goal of this study is to advance our understanding of the role of AMOC on abrupt climate change, and explore the impact of AMOC on TAV and predictability. Specifically, *objectives of this study are (1) identify the relative contribution of the oceanic and atmospheric processes to the response of tropical Atlantic to AMOC changes; (2)explore the impact of AMOC changes on the annual cycle of the Atlantic cold tongue/ITCZ complex; (3) assess the sensitivity of the tropical Atlantic coupled system to changes in AMOC strength.*

Regional Coupled Model Structure and Experiments

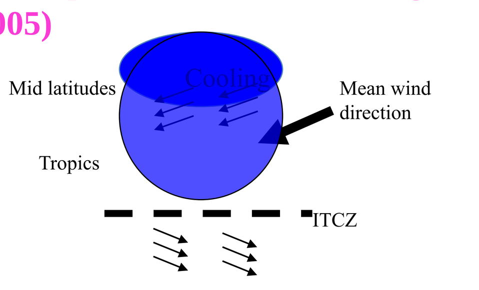


Schematic structure of a simplified Regional Coupled Model used in this study. A unique feature of this model is the strength of AMOC can be modulated by the prescribed mass transport at the northern and southern boundaries of the ocean model.

Oceanic gateway (Chang 2008)



Atmospheric Processes(Chiang 2005)



(Mechanisms to be examined)

Experiments:

- *To elucidate the relative role of oceanic and atmospheric processes*

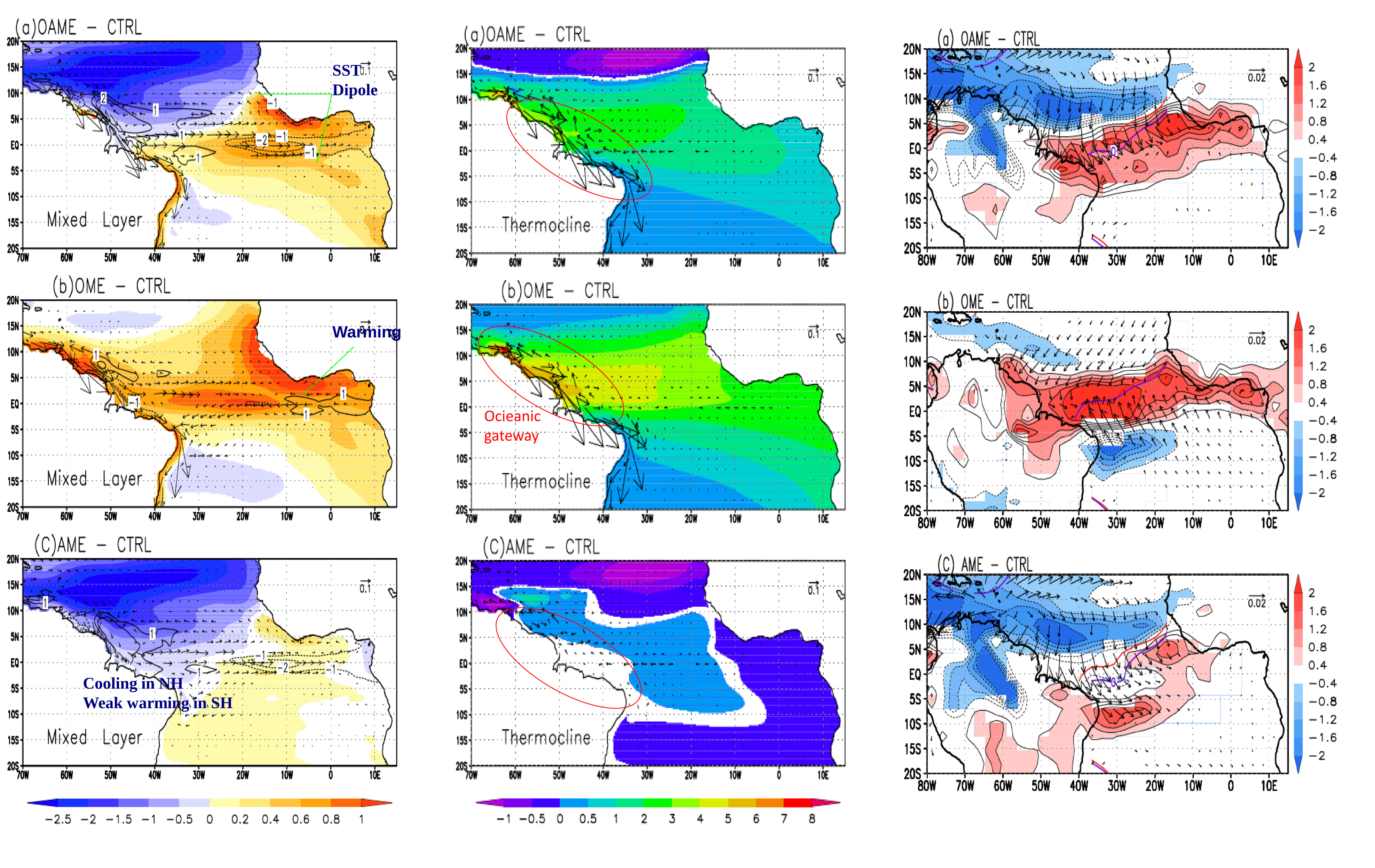
	OAME	OME	AME
Oceanic Processes: (Mass transport set to 0Sv)	X	X	
Atmospheric Processes (heat flux anomalies applied between 10N-30N)	X		X

- *To assess the sensitivity of TAV to changes in AMOC strength*
  --imposed northward mass transport is decreased systematically from 14Sv to 0Sv

Impact of AMOC changes on TAV

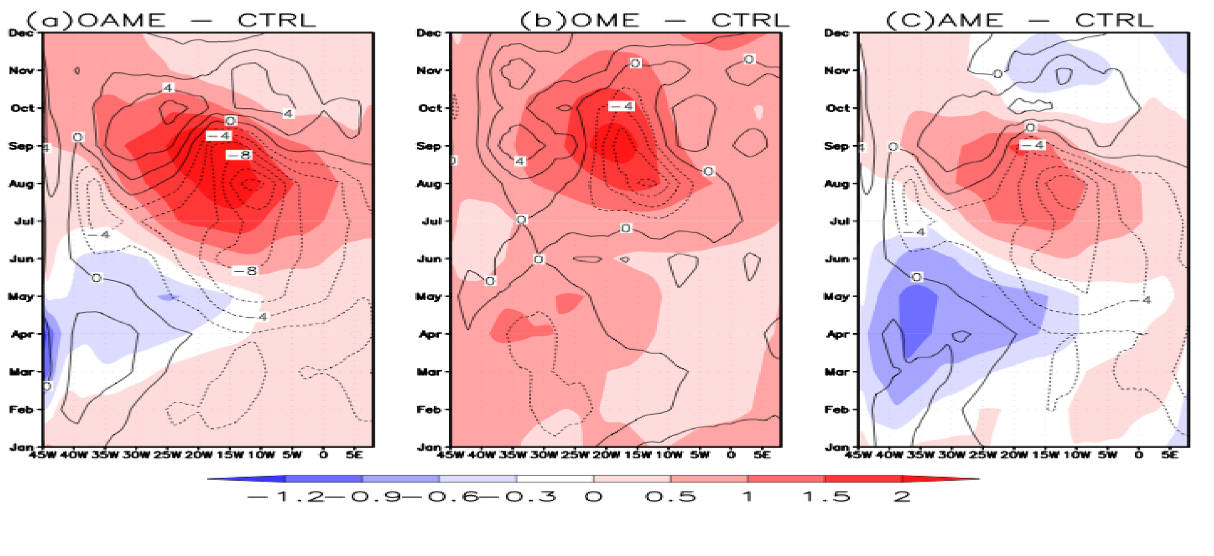
Annual mean response

Temp & Current   Precipitation & Windstress

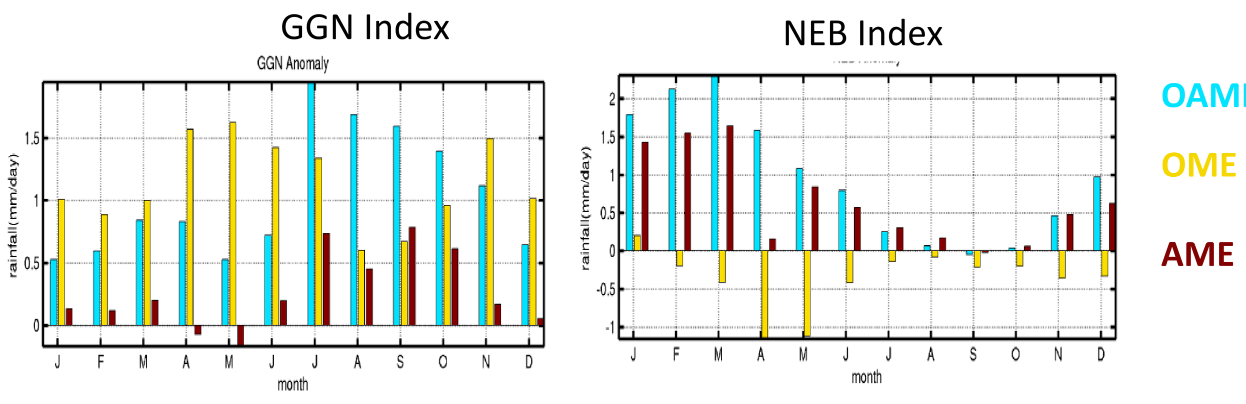


Seasonality of response

SST(shaded) and Entrainment(contour) response along EQ

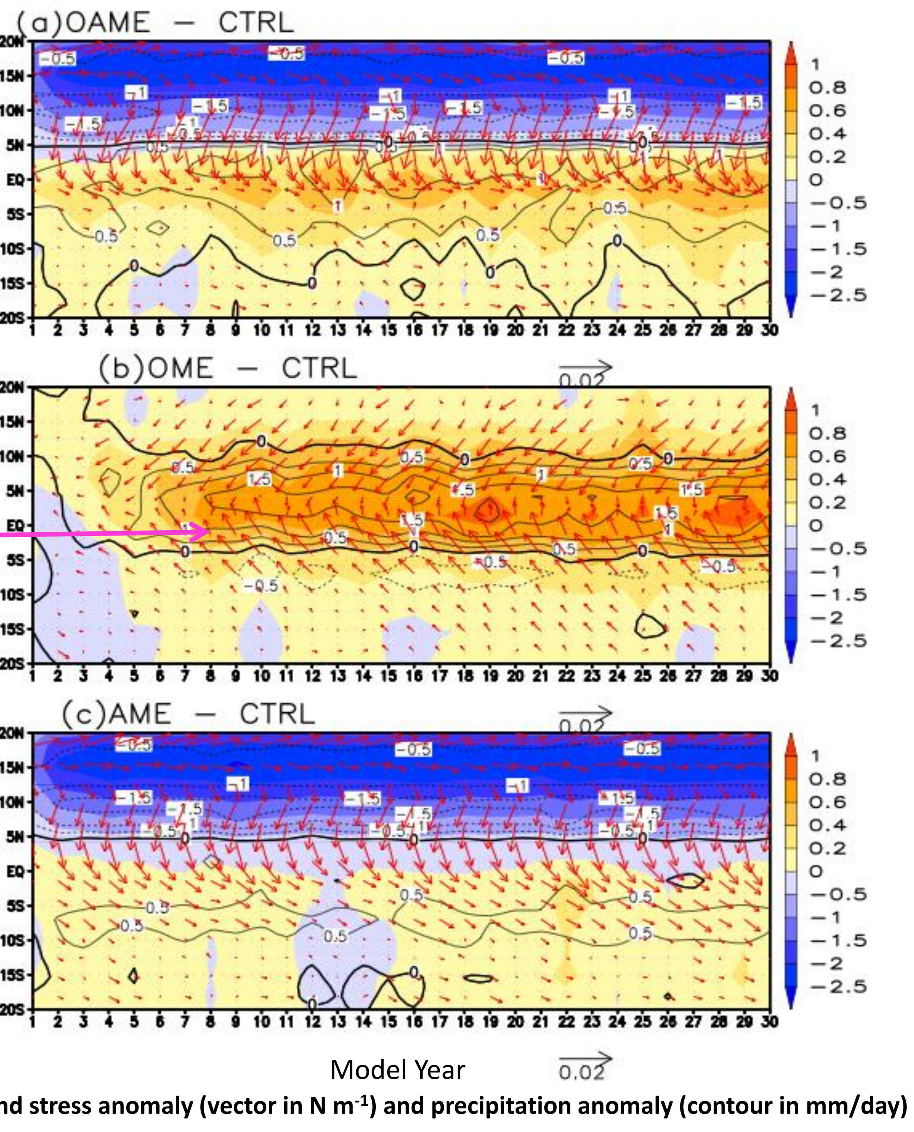


Precipitation reponse



GGN: Precipitation anomaly averaged over Gulf of Guinea (10°W-10°E, 0°-7°N)
NEB: Precipitation anomaly averaged over Northeast Brazil (42°W-35°W, 12°S-4°S)

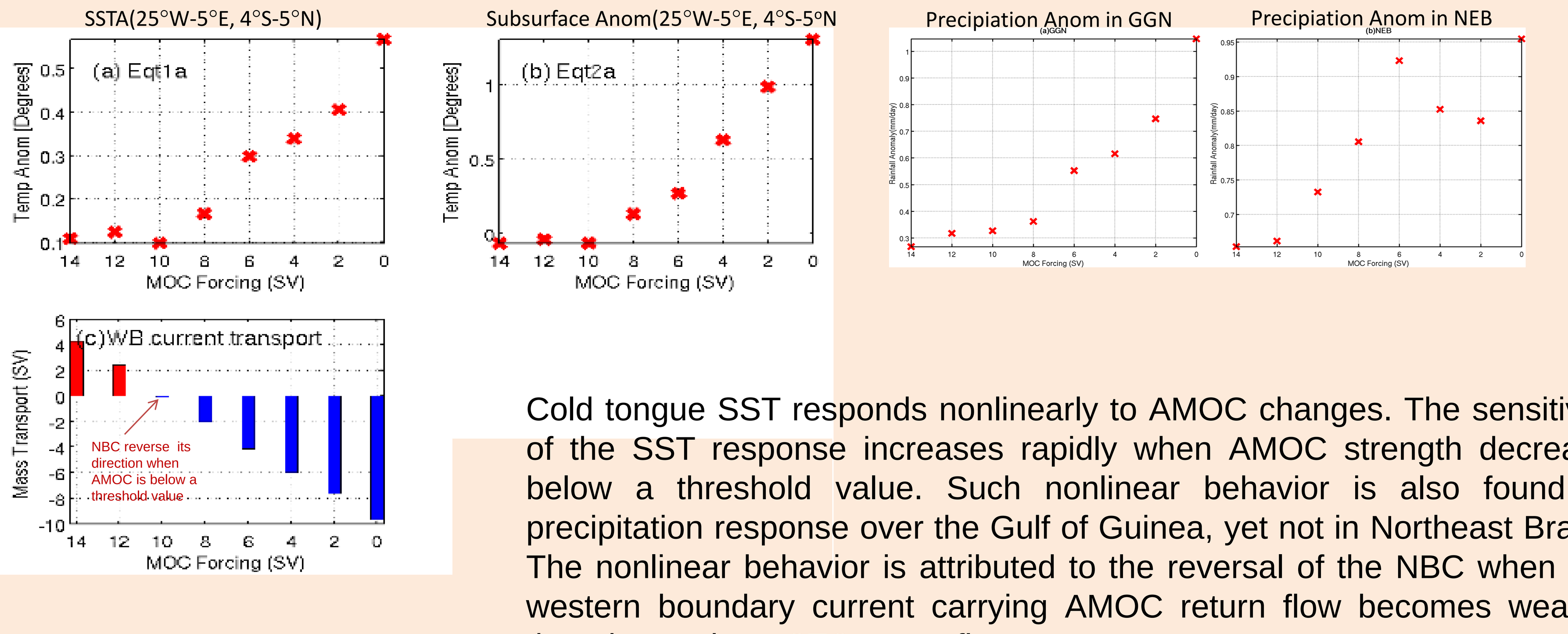
Evolutions of Zonally Averaged Response



SSTa(color), wind stress anomaly (vector in N m^{-1}) and precipitation anomaly (contour in mm/day)

Oceanic processes causes the equatorial warming to lag the AMOC changes by 8yr. ***This may give rise to certain predictability at decadal time scales.***

Sensitivity of TAV to changes in AMOC strength



Cold tongue SST responds nonlinearly to AMOC changes. The sensitivity of the SST response increases rapidly when AMOC strength decrease below a threshold value. Such nonlinear behavior is also found in precipitation response over the Gulf of Guinea, yet not in Northeast Brazil. The nonlinear behavior is attributed to the reversal of the NBC when the western boundary current carrying AMOC return flow becomes weaker than the northern STC return flow.

Conclusions:

1. Oceanic processes are a primary factor contributing the warming at and south of the equator and the precipitation increase over the Gulf of Guinea, while atmospheric processes are responsible for the surface cooling of the tropical north Atlantic and southward displacement of ITCZ.
2. The response of tropical Atlantic to AMOC changes exhibits a pronounce seasonality. The atmospheric processes and the oceanic processes interact in a complex manner.
3. Equatorial warming lags the AMOC change by about 8 years. This delayed response may give rise to certain predictability of equatorial SST in response to AMOC changes at decadal time scales.
4. SST over the cold tongue region responds nonlinearly to AMOC changes. Similar behavior is also found in precipitation response over the Gulf of Guinea. These nonlinear behaviors are attributed to the oceanic gateway mechanism.

Reference:
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