Barrier Layers of the Atlantic warmpool : Formation and influence on climate

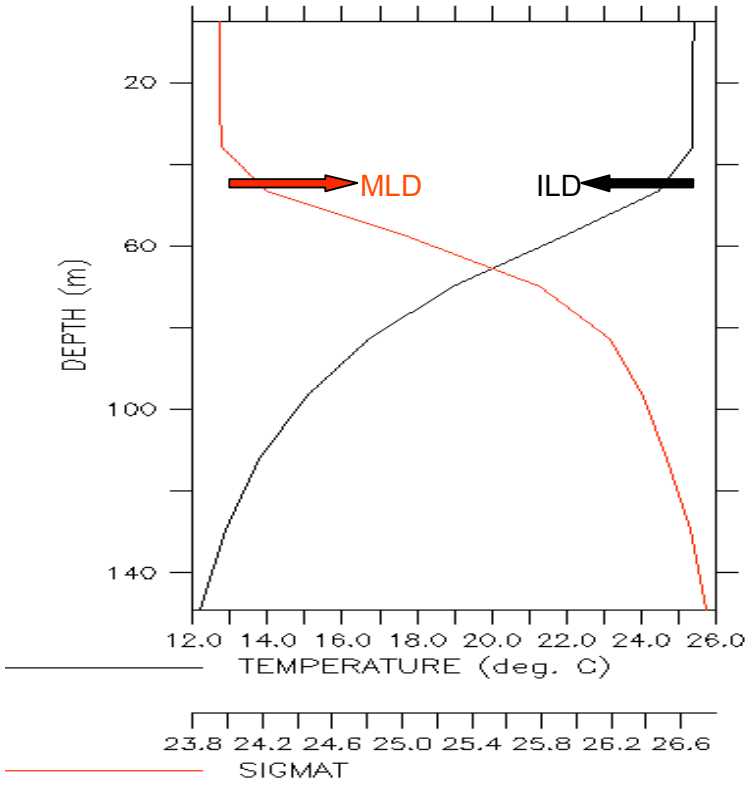
Karthik Balaguru

Ping Chang

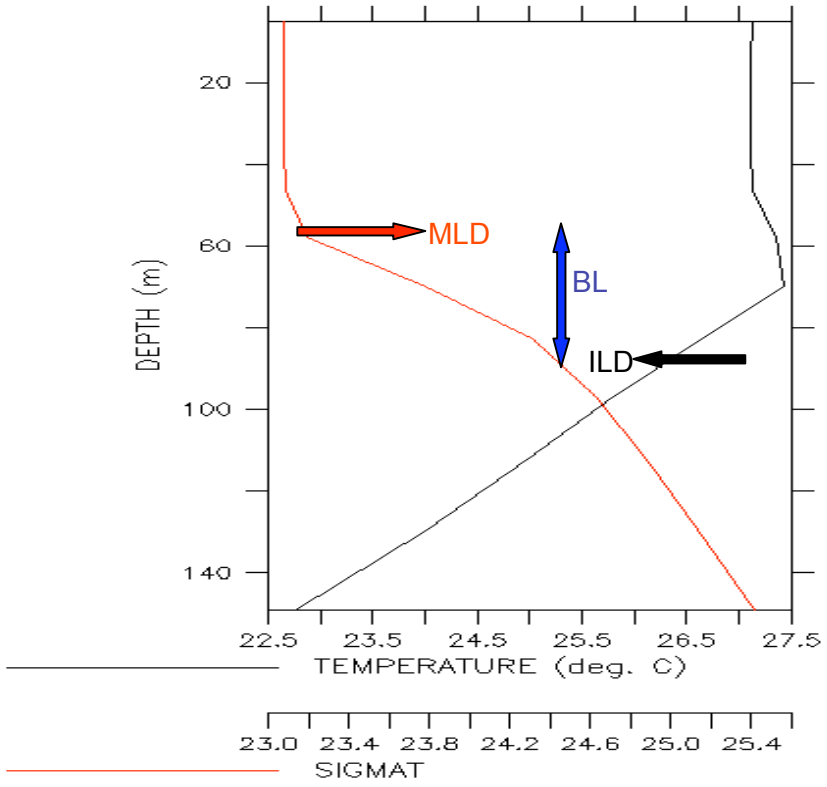
R. Saravanan

Upper ocean stratification

Traditional viewpoint



Upper ocean with a Barrier Layer (BL)



$$BLT = D_{T-0.2} - D_{\sigma}$$

$$\Delta_{\sigma} = \sigma_{\theta}(T_{10} - 0.2, S_{10}, P_0) - \sigma_{\theta}(T_{10}, S_{10}, P_0)$$

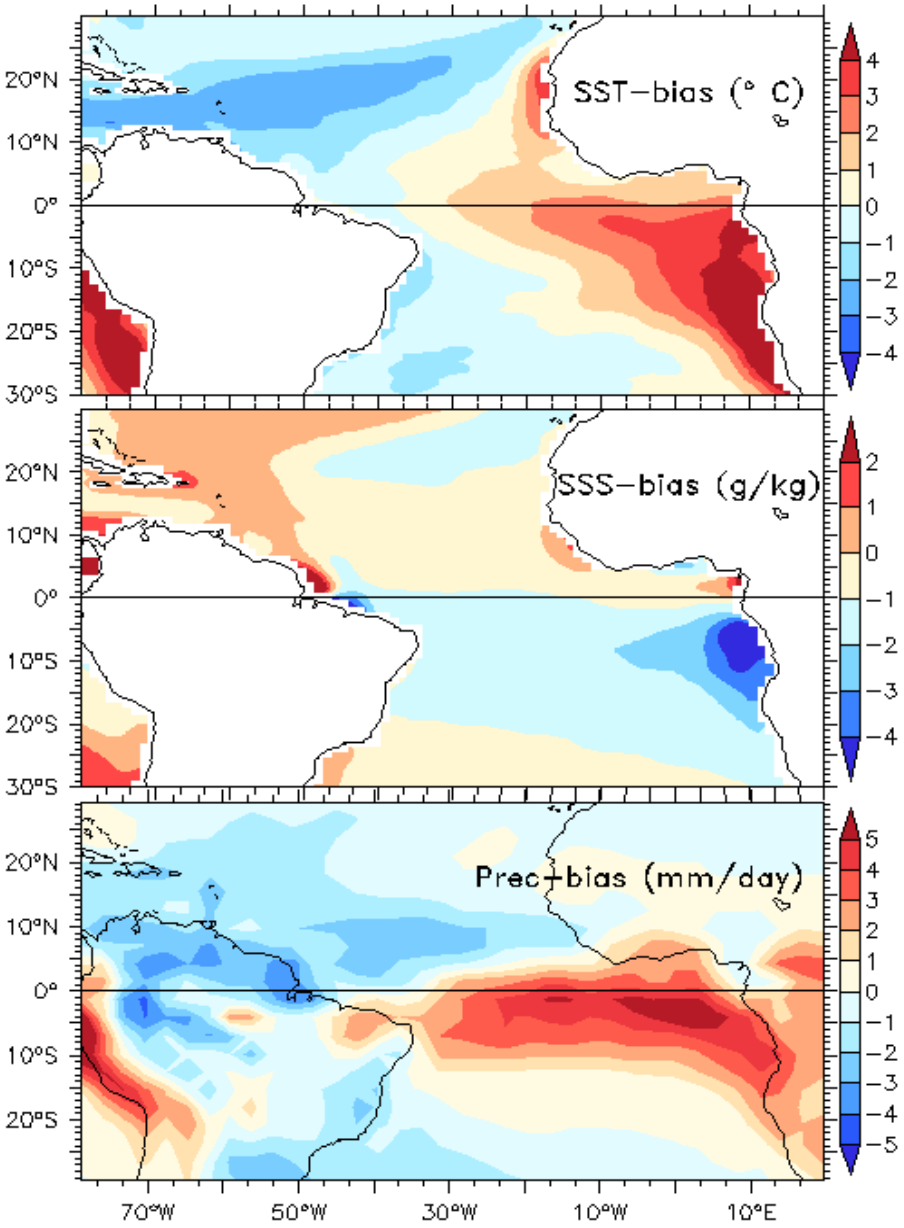
Profiles from SODA

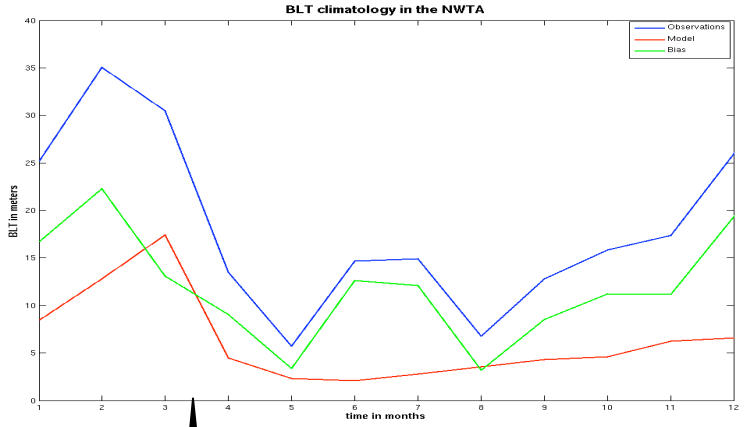
Some climatic phenomena in which BLs could play a role

1) ENSO
2) Monsoon
3) BL-SST-ITCZ
4) Tropical cyclones

The Tropical Atlantic bias problem

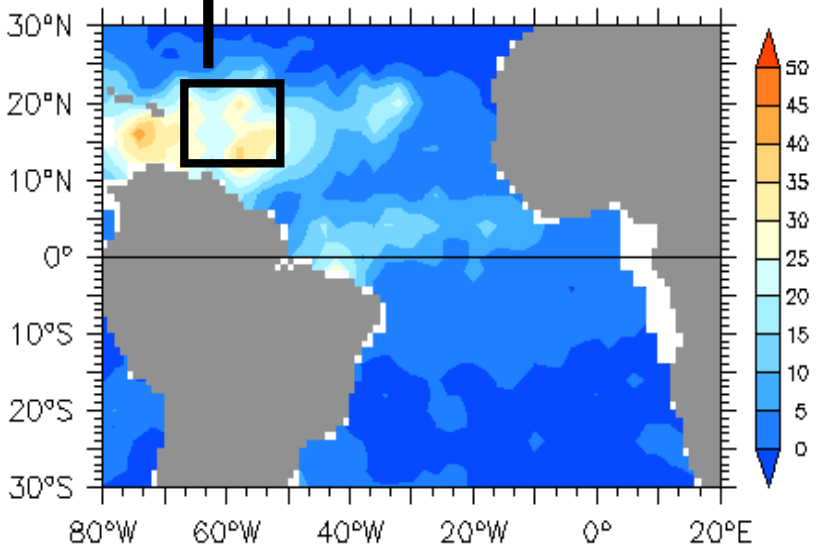
CCSM 3.0 (NCAR)



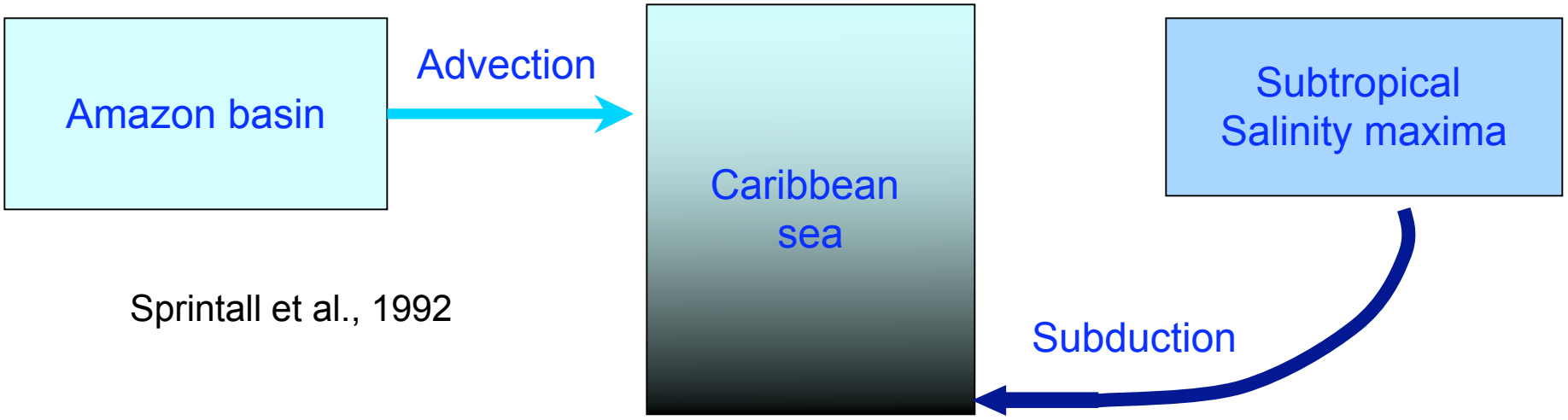


BL-SST-ITCZ feedback ?

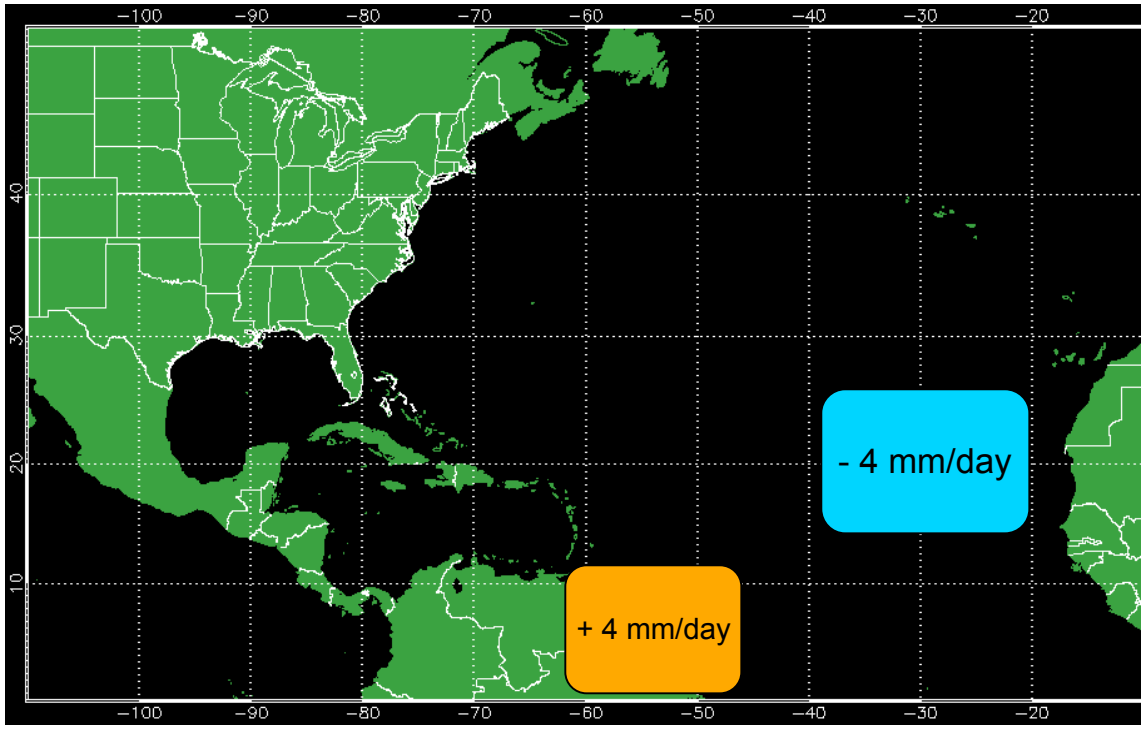
- Breugem et al. (2008)



The Method



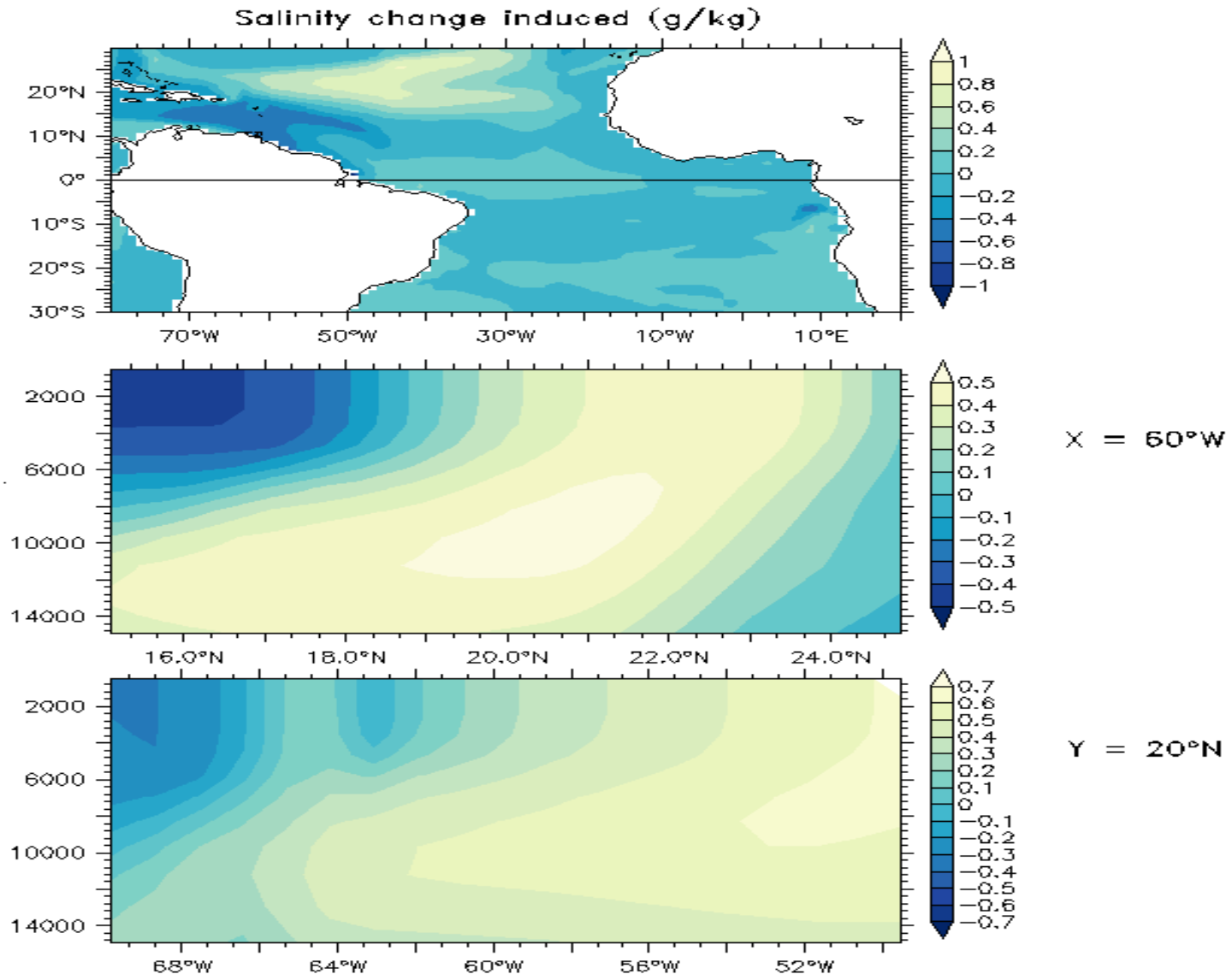
Sprintall et al., 1992



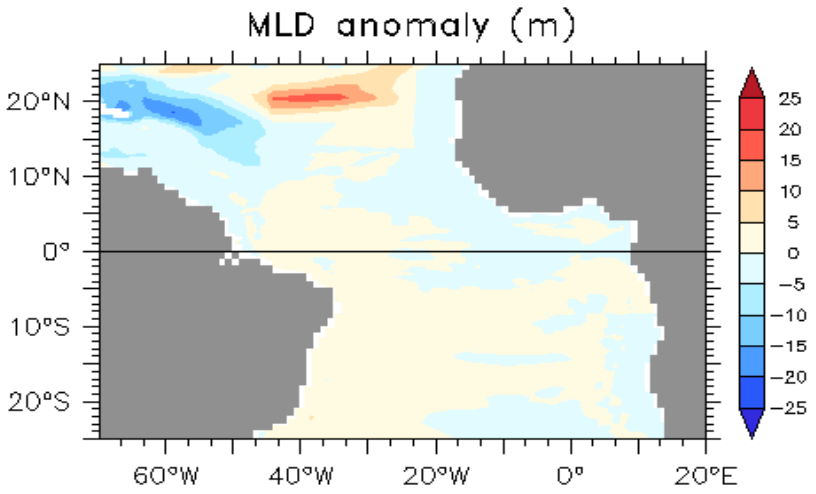
Modeling tool used :
CCSM 3.0 (NCAR)

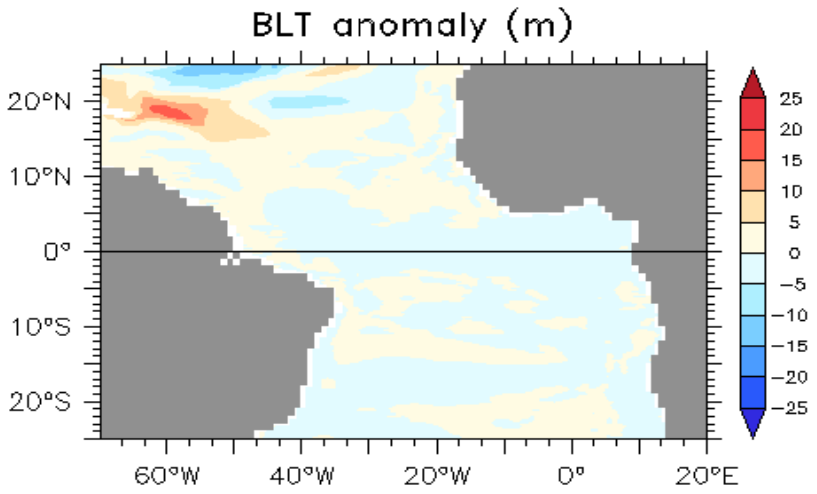
- 5 member ensemble
- (P-E) forcing as shown

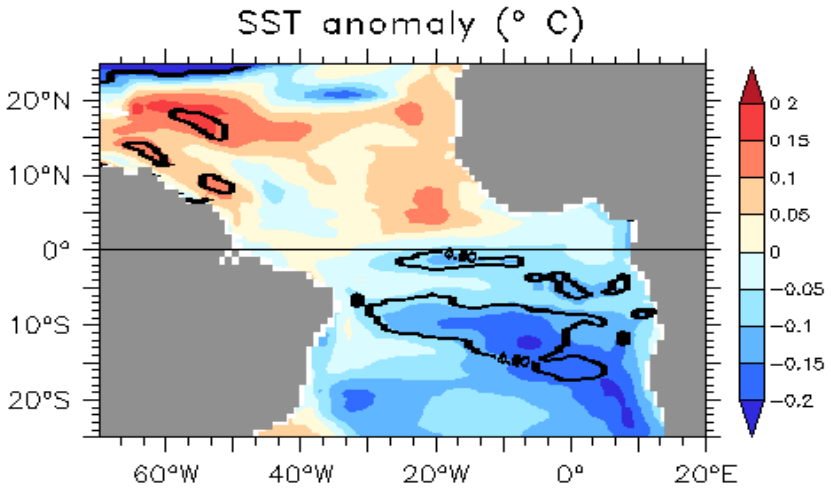
Surface and sub-surface salinity response to the (P-E) forcing

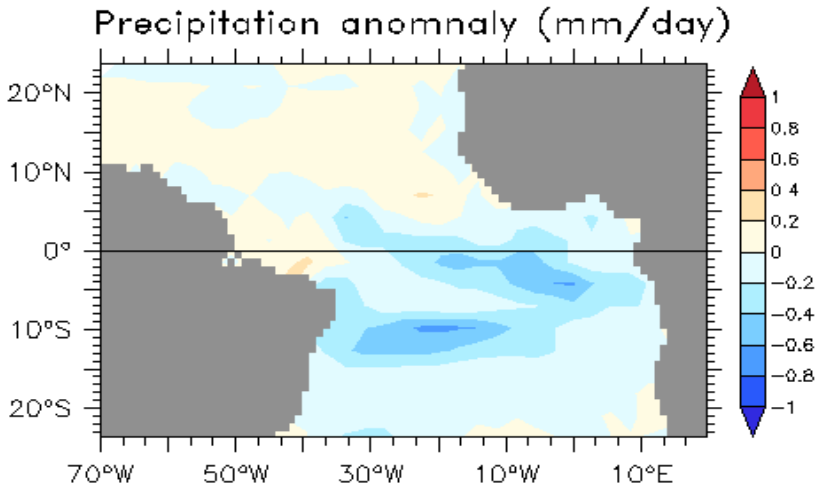


Response of the coupled system to the (P-E) forcing

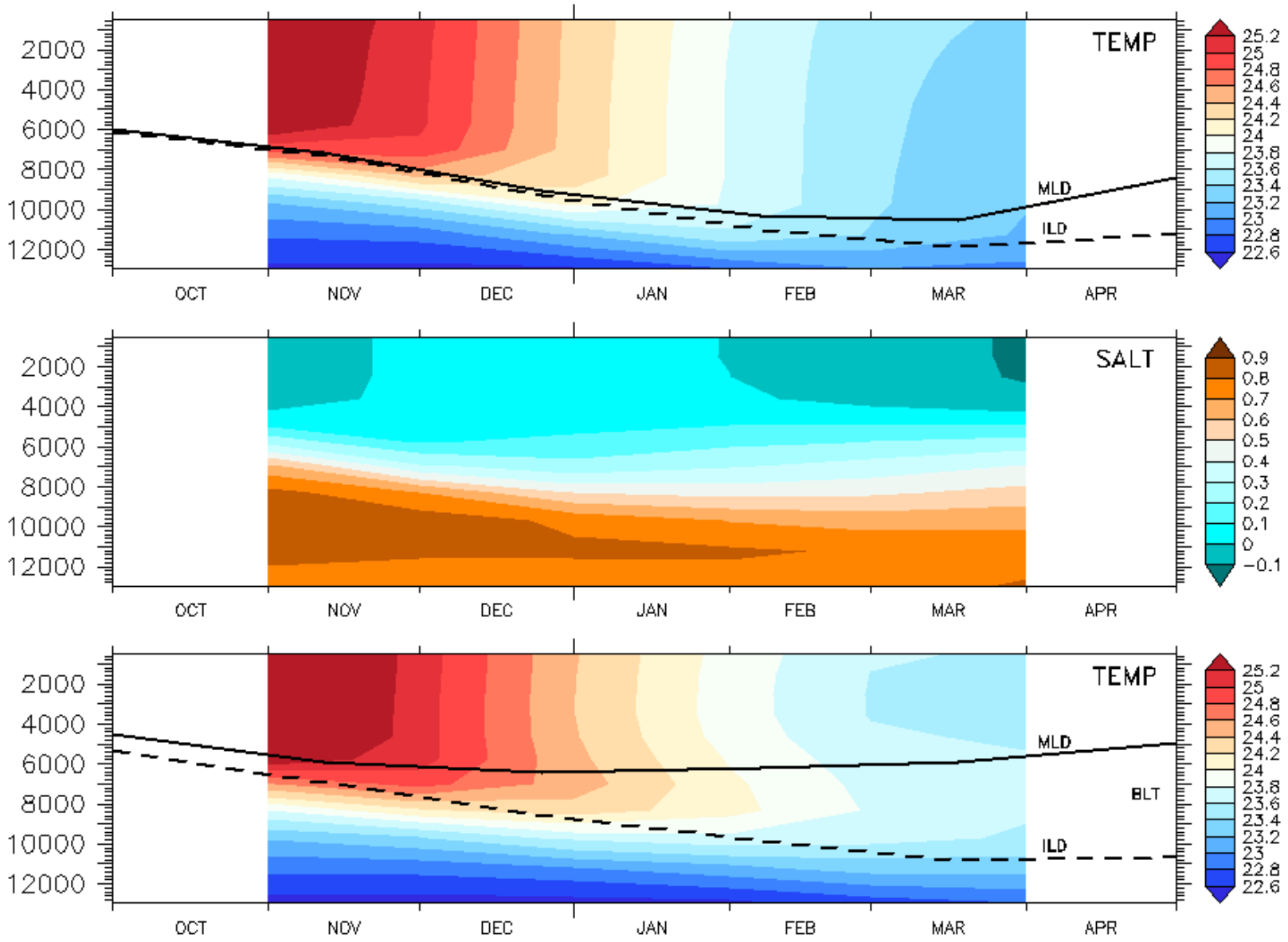








Temperature Inversions in the NWTA



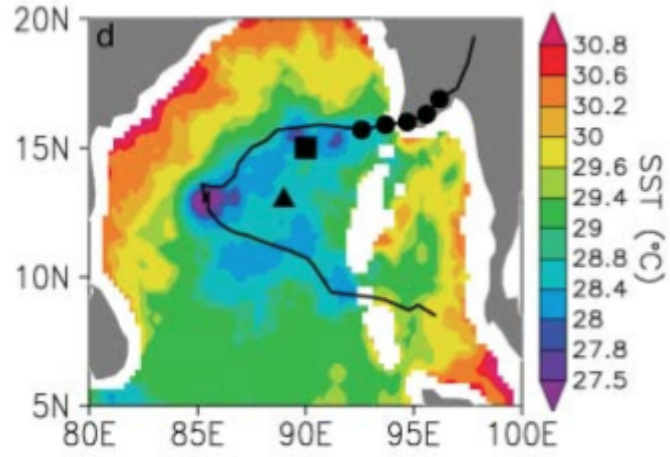
Control run

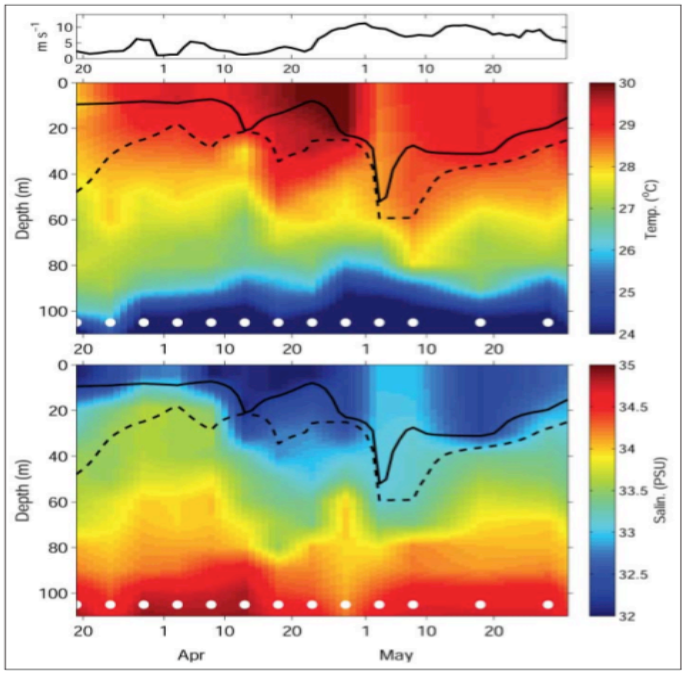
Anomaly in the forcing run

Forcing run

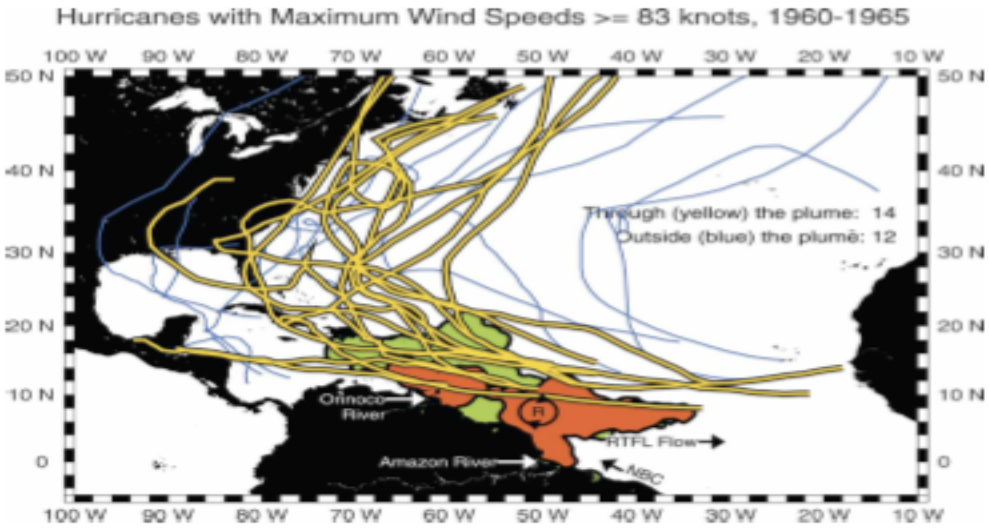
Modulation of upper ocean response to tropical cyclones by BLs

Barrier Layers and tropical cyclones





McPhaden et al., 2009



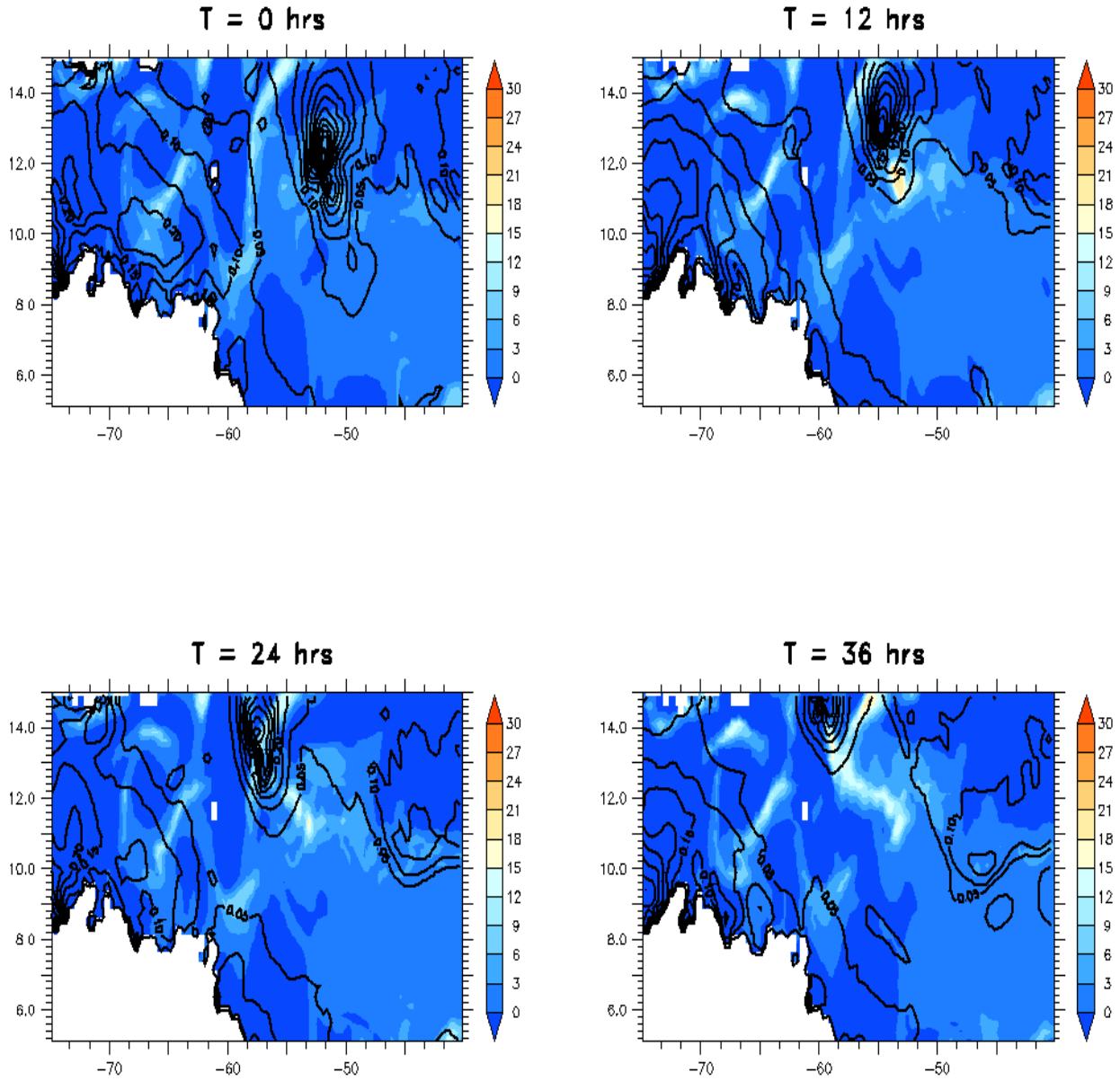
Ffield., 2006

$$V_{max} = \sqrt{\frac{C_k}{C_d}\frac{(T_s - T_o)}{T_o}(K_s - K_d)}$$

Emanuel, 1986

Surface SST cooling : Negative feedback factor

BL formation in the wake of tropical cyclones



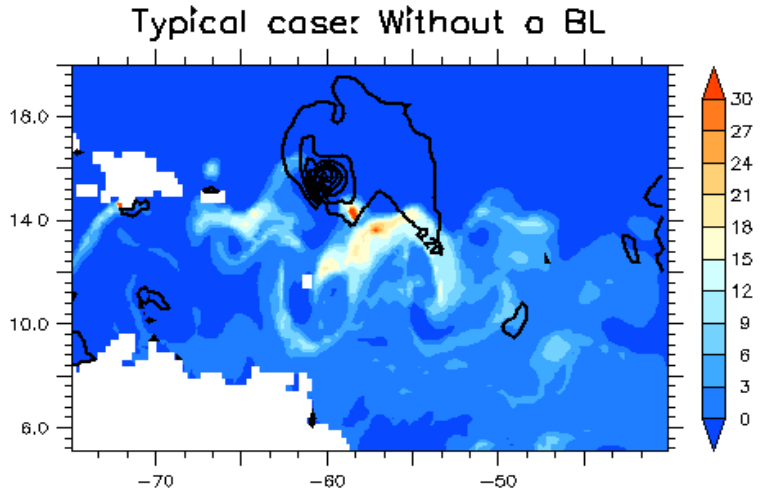
Framework of study

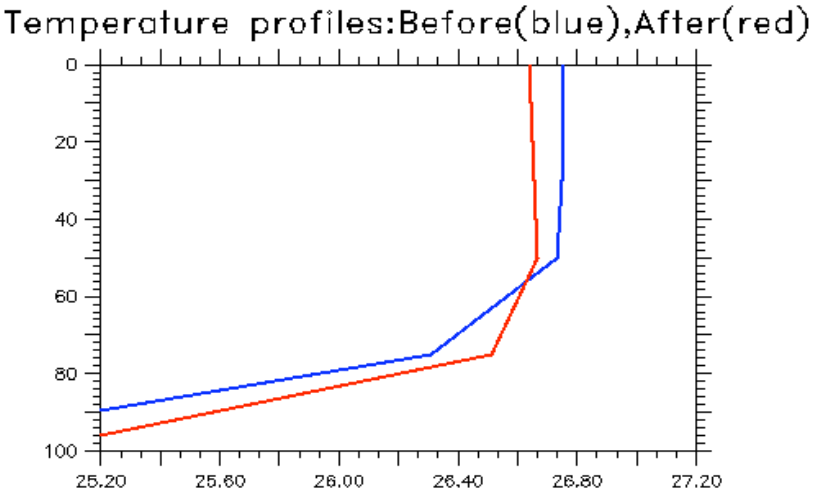
Regional Coupled Model (RCM)

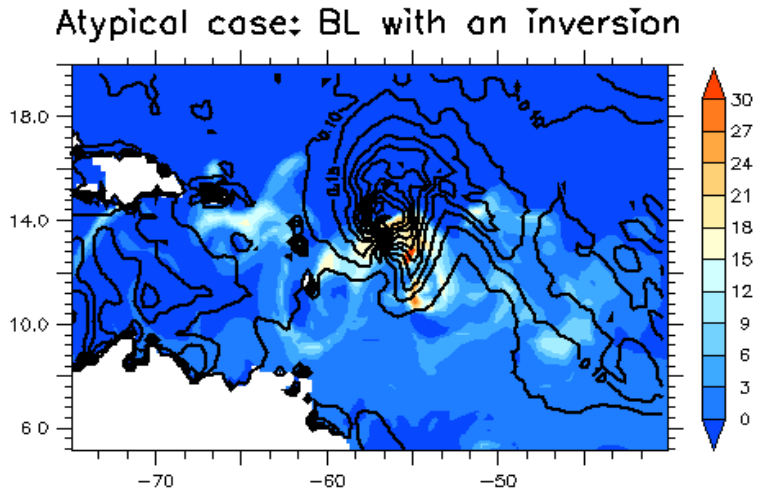
ROMS(27 km) - WRF (30 km)

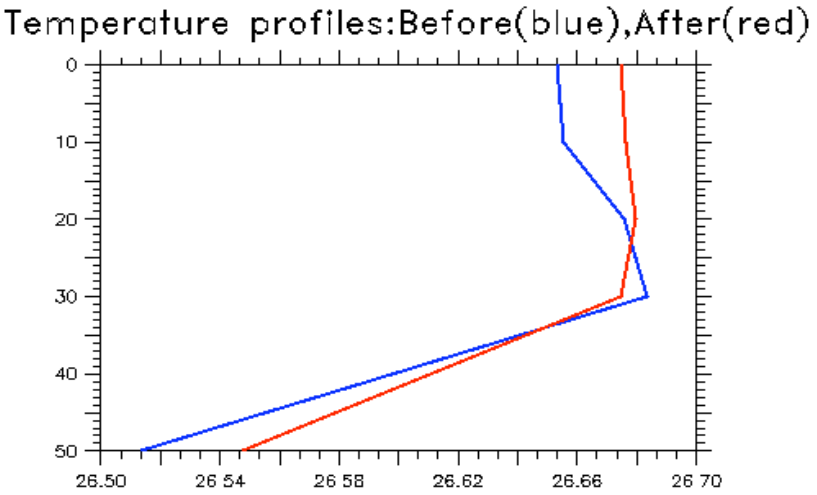
Initial and boundary conditions derived from NCEP re-analysis and Levitus data

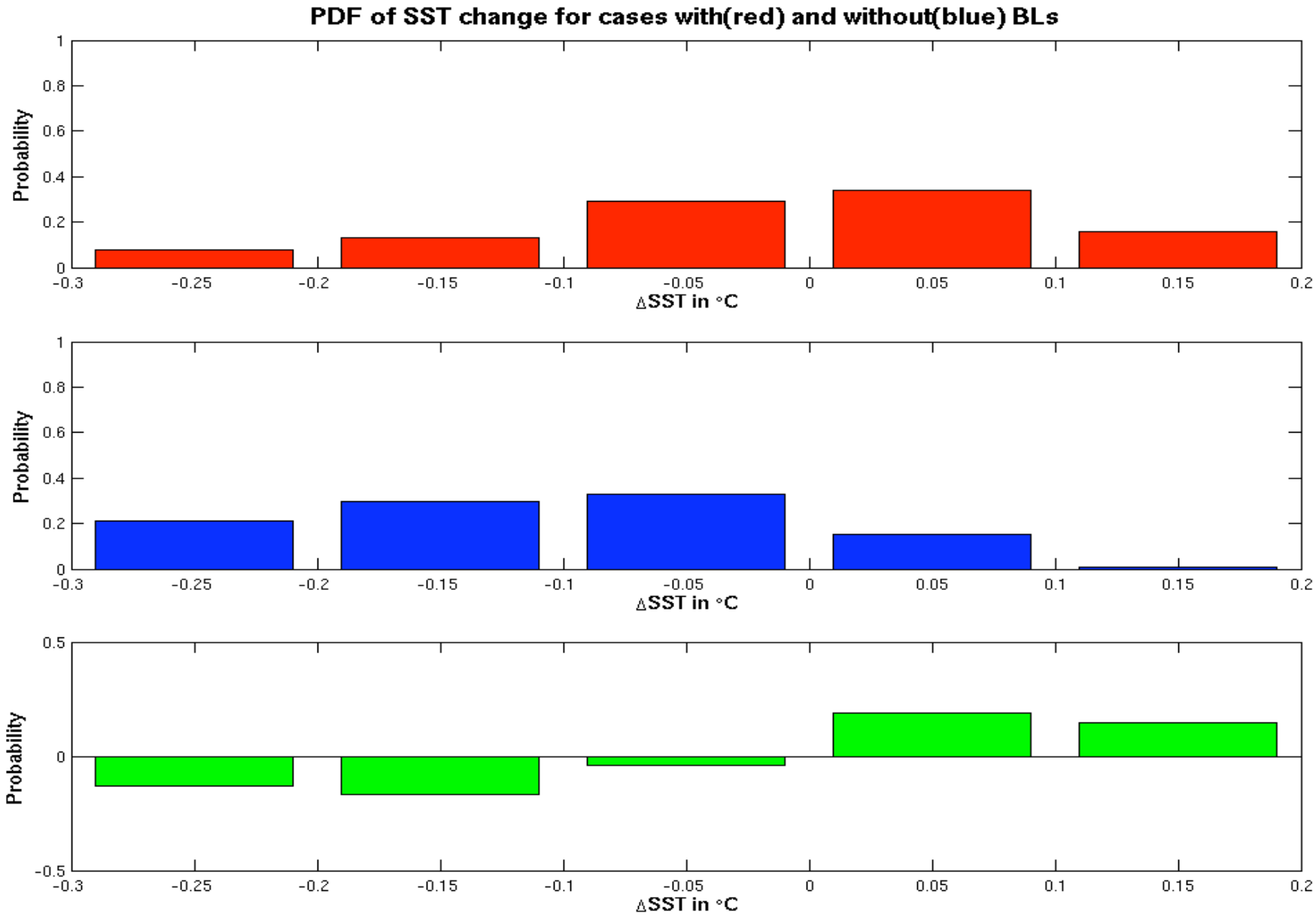
Comparison of SST response for cases with and without a BL





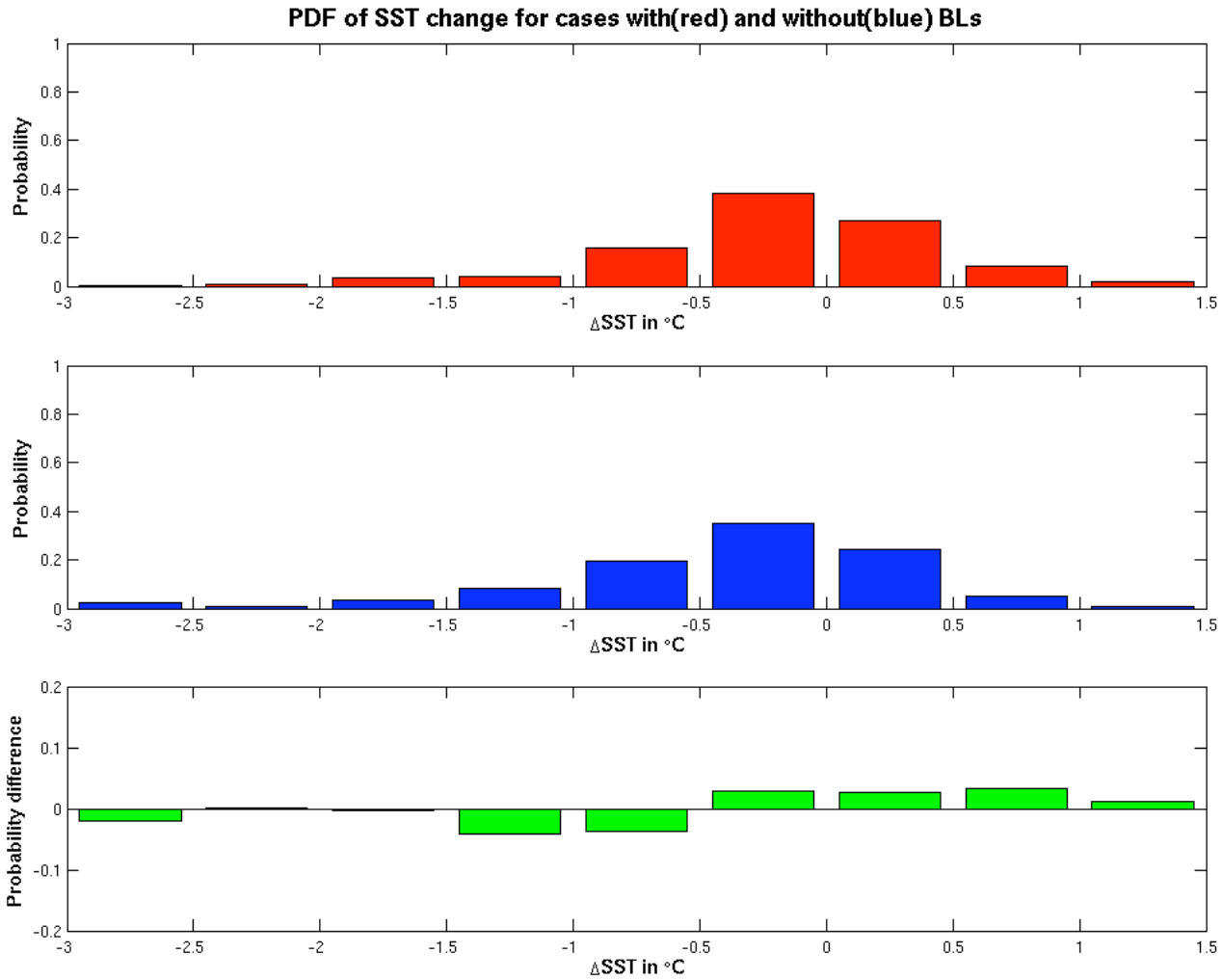






mean ΔSST_{BL} = 22% of mean ΔSST

Observational analysis



SST data (1998 - 2007): TRMM

Hurricane tracks: NOAA-AOML

Monthly maps of BLT : SODA 2.0.4

mean ΔSST_{BL} = 51% of mean ΔSST

Conclusions

- Numerical experiments with a coupled GCM indicate that the BL of the Atlantic warmpool is sensitive to upper ocean salinity stratification.

- SST warming and formation of temperature inversions in the region of BL increase offer support to the BL mechanism to be at work.

- At a basin scale, even though the SST and precipitation response is in the right direction, the improvement is less than 10% of the mean bias and thus not very significant.

- Results from a RCM simulation and observational analysis show that BLs considerably reduce the upper ocean SST cooling due to passage of tropical cyclones.

- In cases with a temperature inversion, mixing due to tropical cyclones could even cause an SST increase. This can have potentially important implications for tropical cyclone intensity.

Thanks!

"We need a PIRATA station in the Atlantic warmpool"