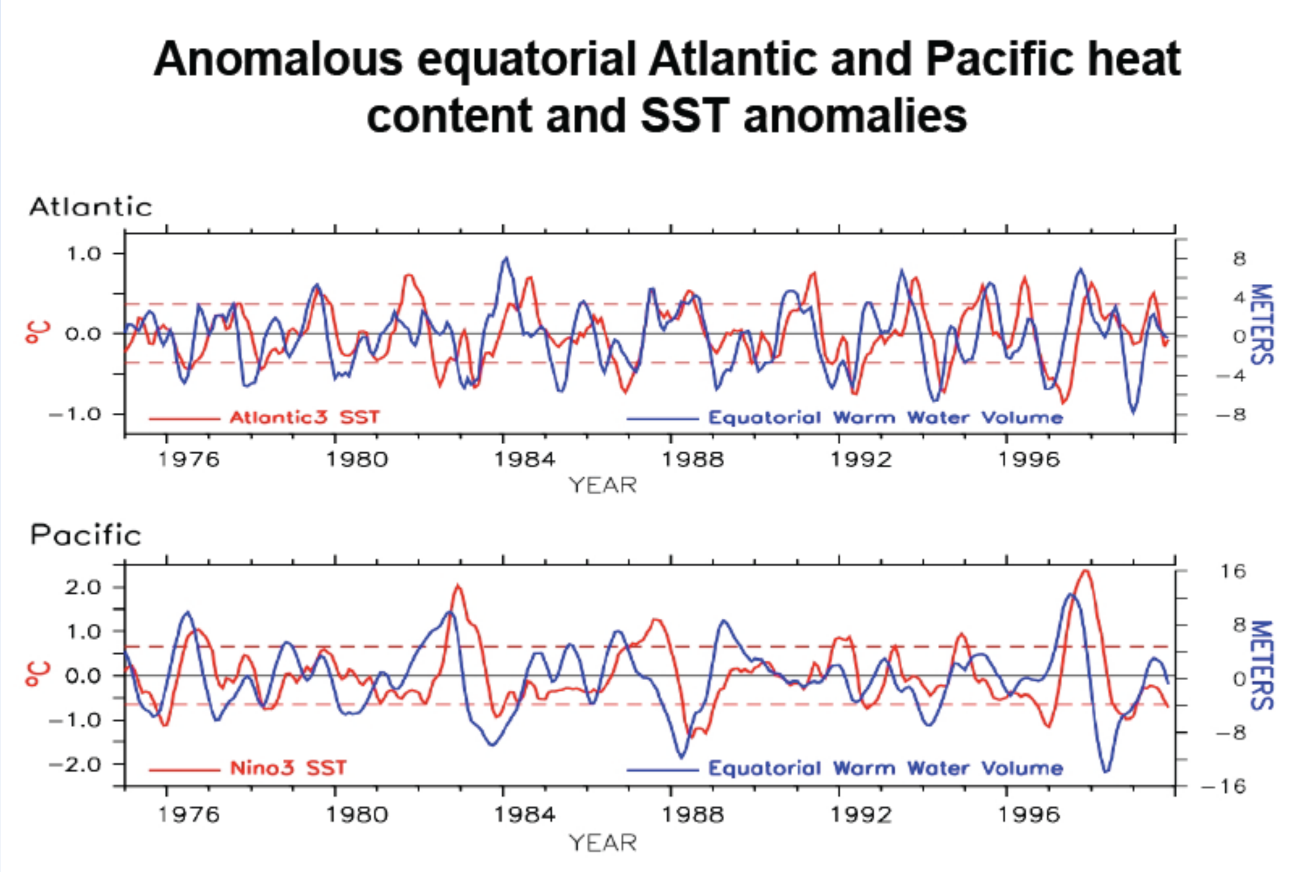
Equatorial Atlantic Variability: Dynamics, ENSO Impact, and Implications for Model Development

M. Latif[1], N. S. Keenlyside[2], and H. Ding[1]

[1]Leibniz Institute of Marine Sciences, Kiel University
[2]University of Bergen



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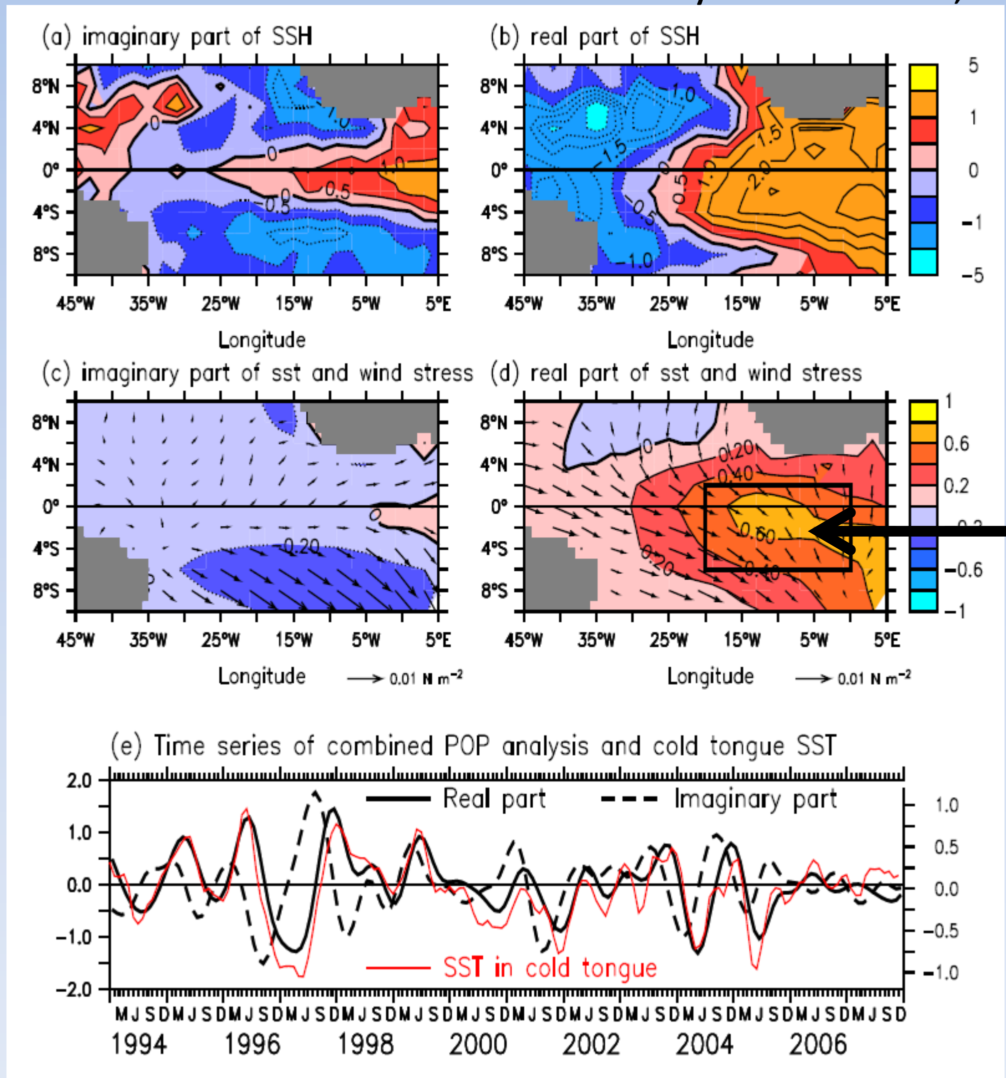
1. Equatorial Atlantic variability

Space-time structure of the zonal mode from POP analysis of observations, ≈20%

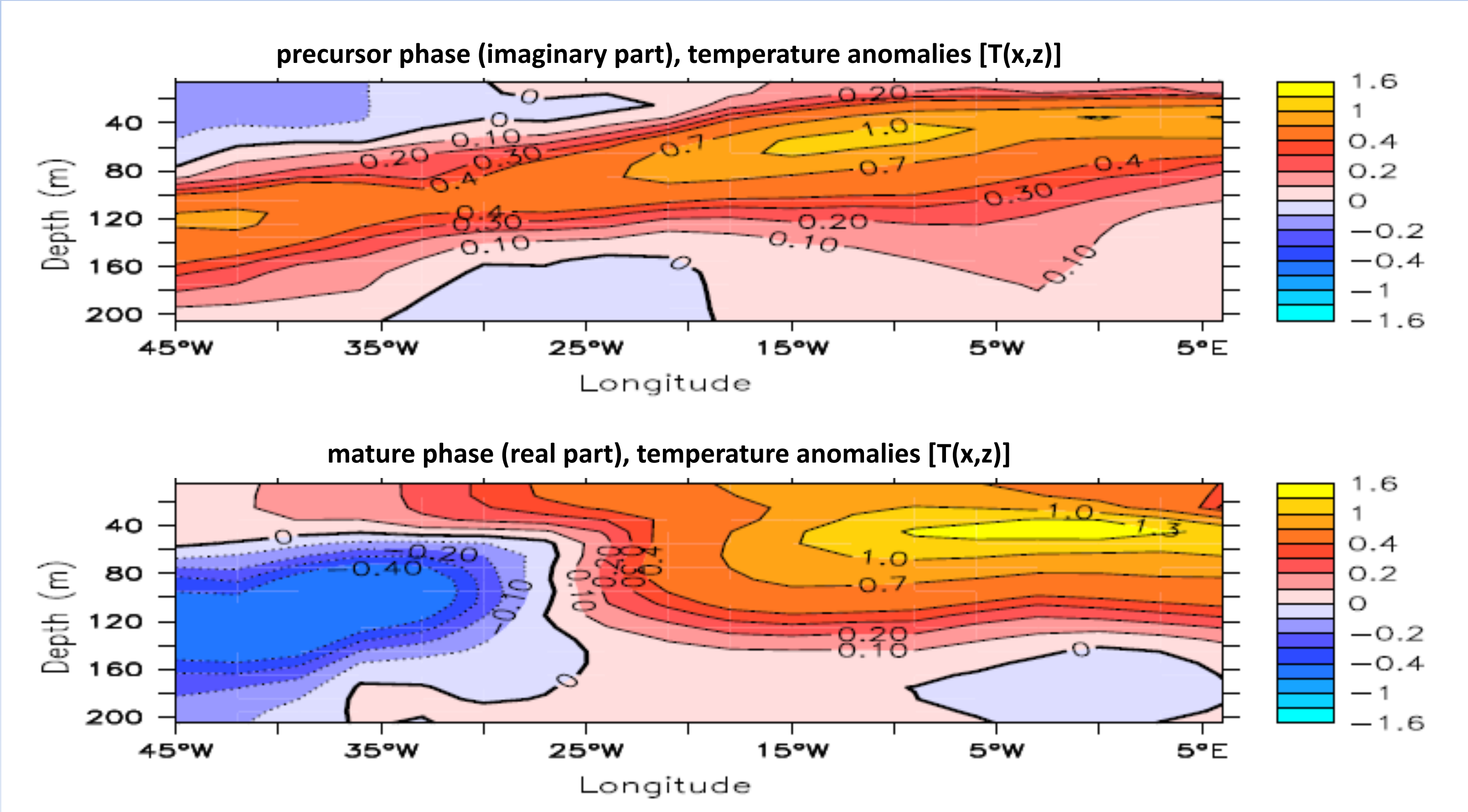


up to 70%

propagating heat content, stationary SST anomalies

Ding, H., N. S. Keenlyside, and M. Latif (2010), Climate Dynamics

Subsurface temperature anomalies (NCEP)



analysis supports the delayed action/recharge oscillator

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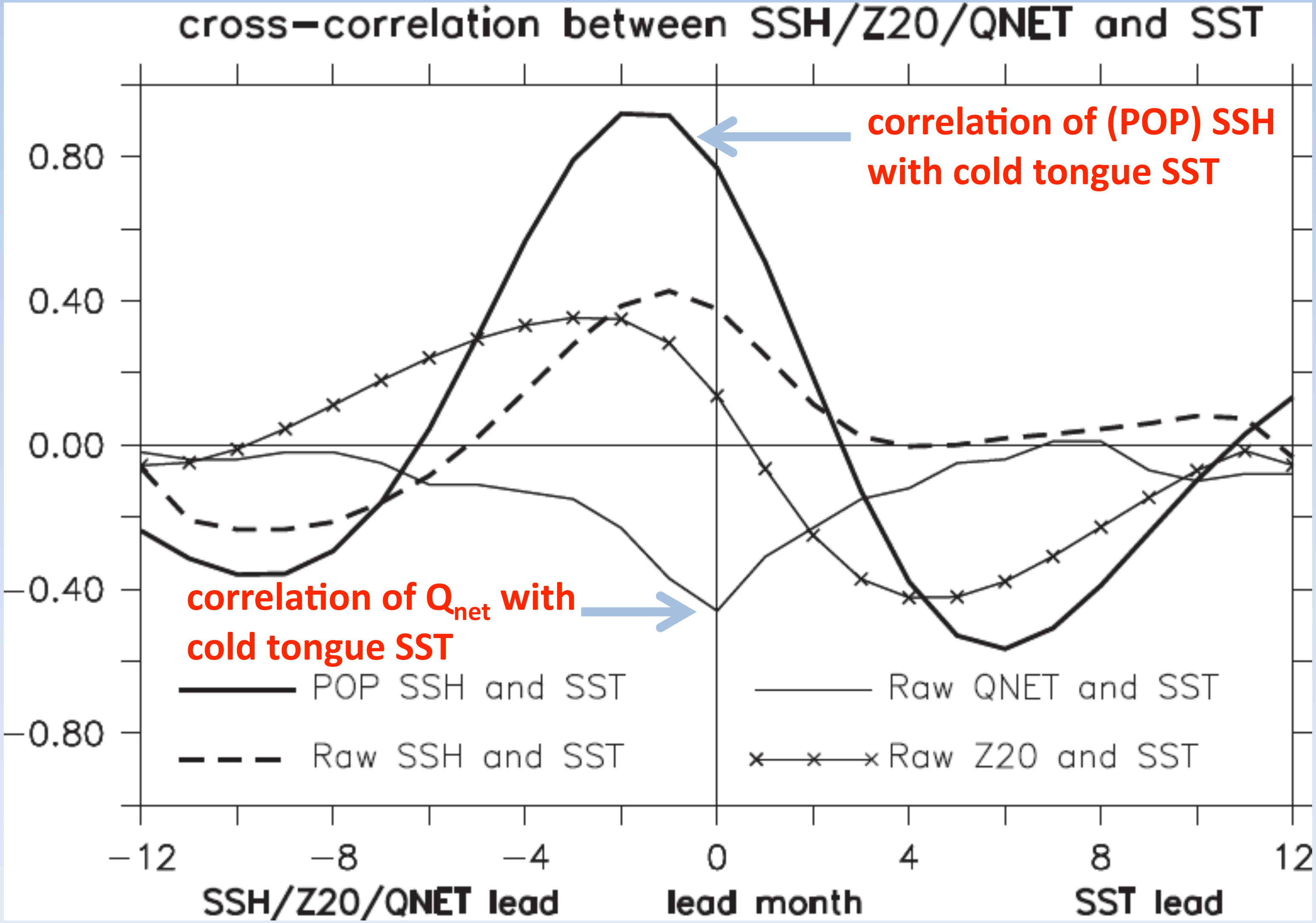
Heat content leads cold tongue SST, surface heat flux damps



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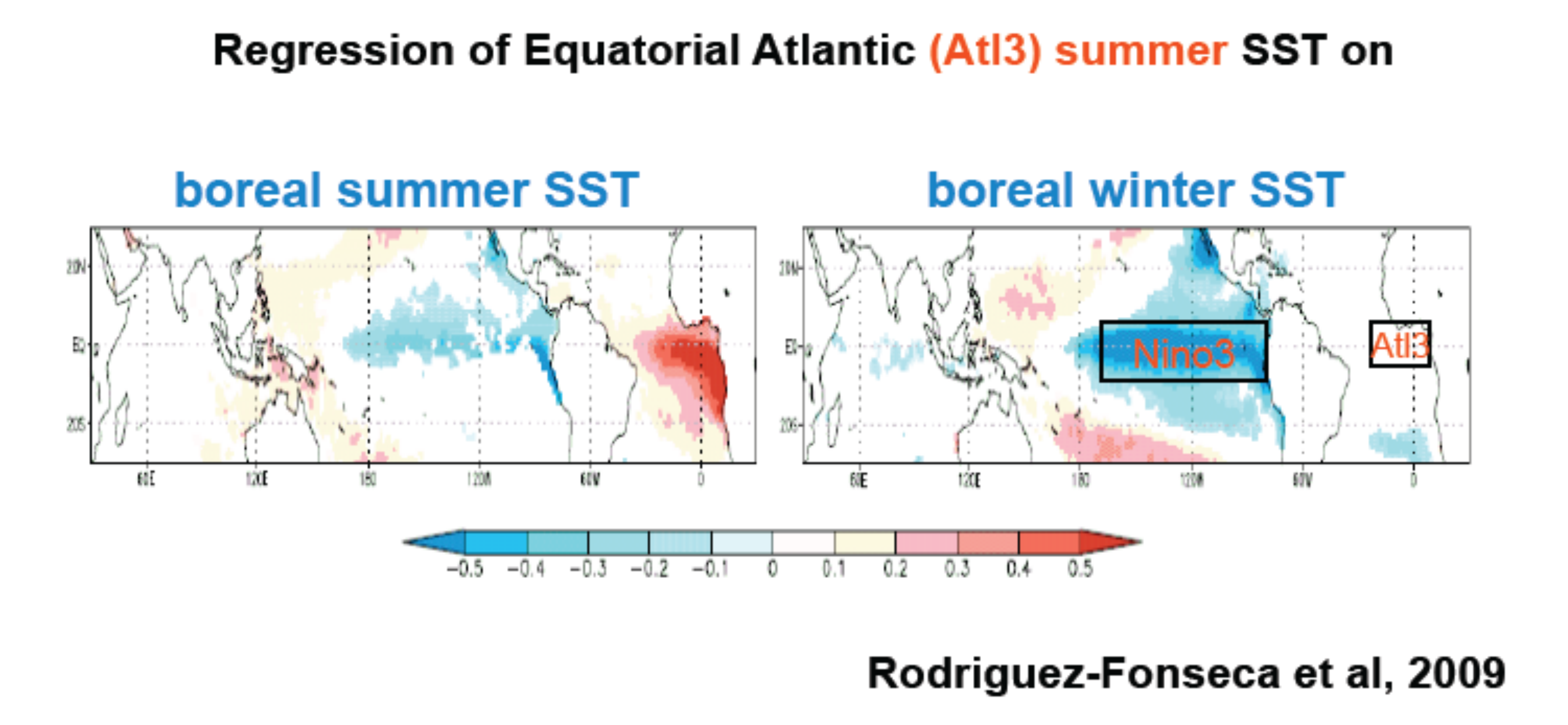
2. ENSO impact



Atmospheric teleconnections and the different seasonal cycles matter

Ding, H., N. S. Keenlyside, and M. Latif (2011), J. Climate (dynamics)
Keenlyside, N. S., H. Ding, and M. Latif (2011), to be submitted (ENSO hindcasts)

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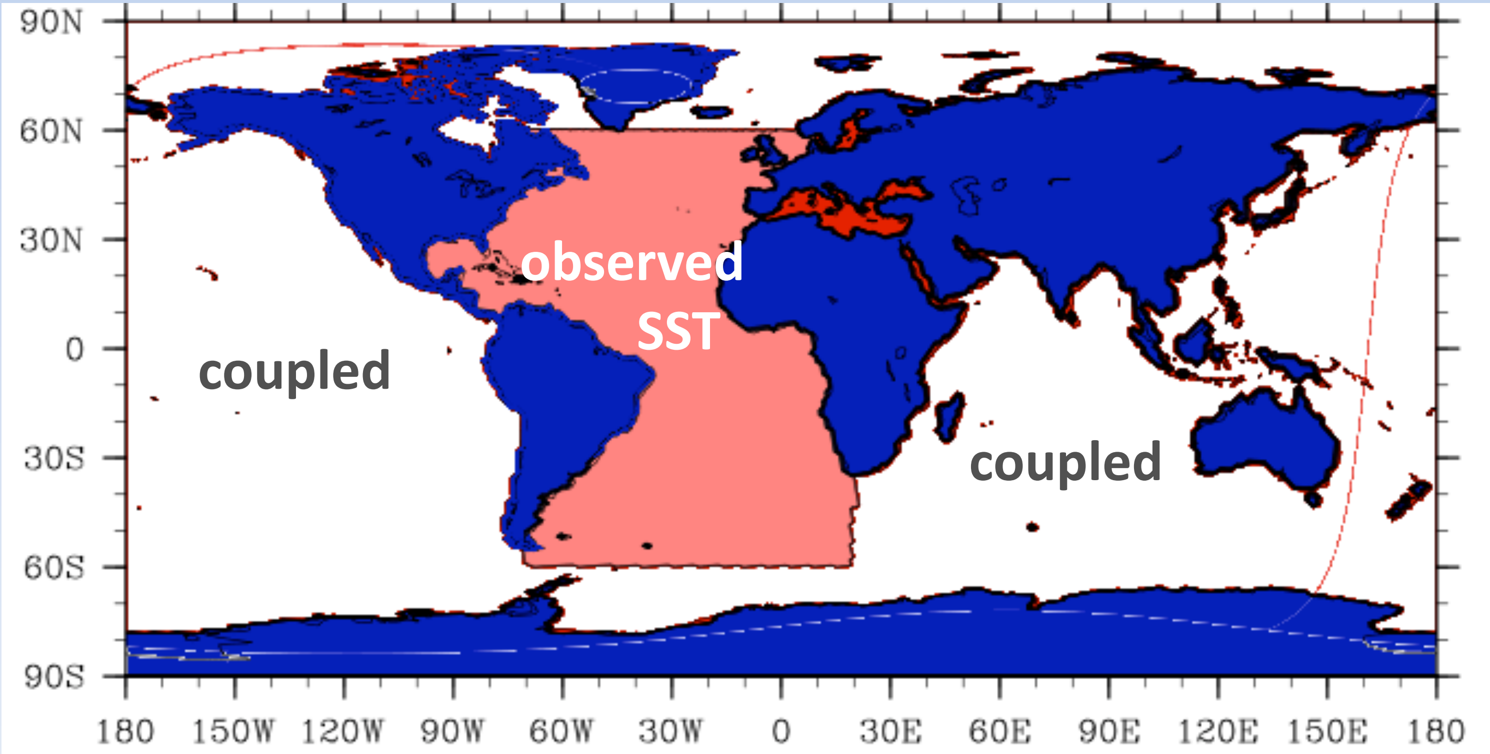
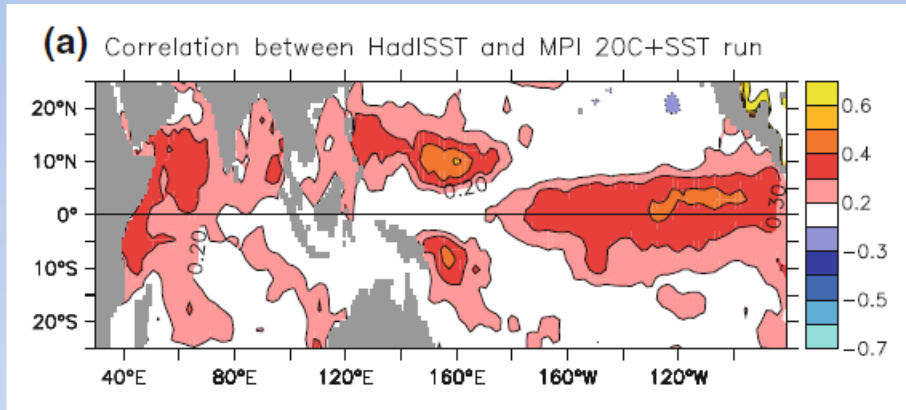
Coupled model forced by observed Atlantic SST

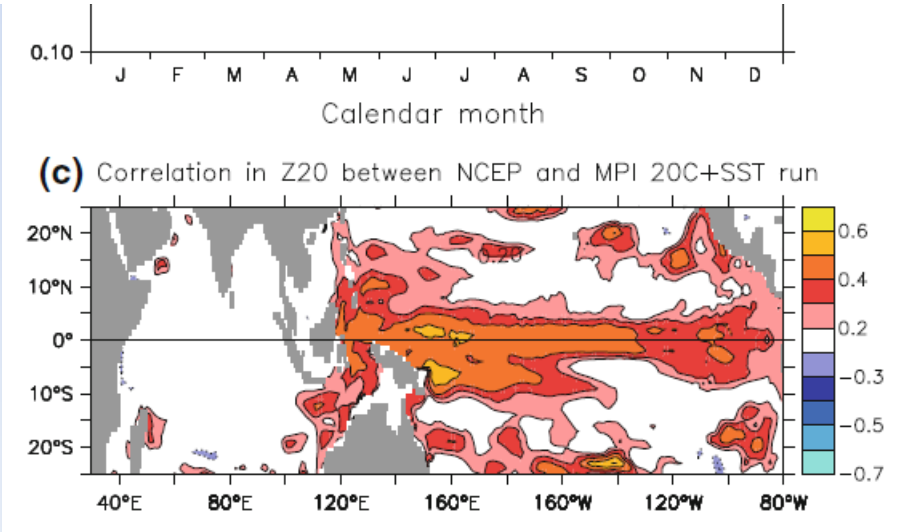
- MPI CGCM: ECHAM5 (T63, L31) coupled to MPI-OM (1.5°, L40)
- Tropical Atlantic - observed SST (1950-2005), elsewhere fully coupled
- Nine ensemble members, analysis of ensemble mean



Correlation with observations



knowledge of Atlantic SST could help to enhance ENSO forecasts



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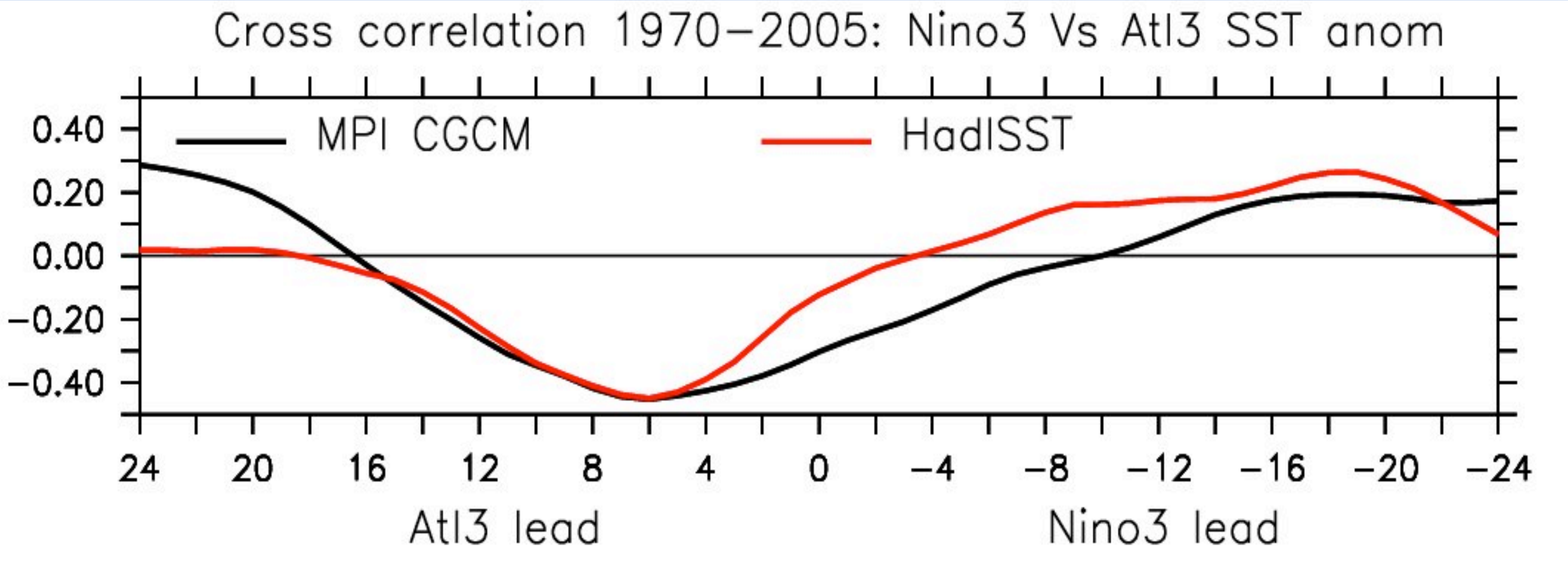
Cross correlation: Atl3 and Niño3 SST



The nudged (in the Atlantic only) coupled model reproduces the link with ENSO

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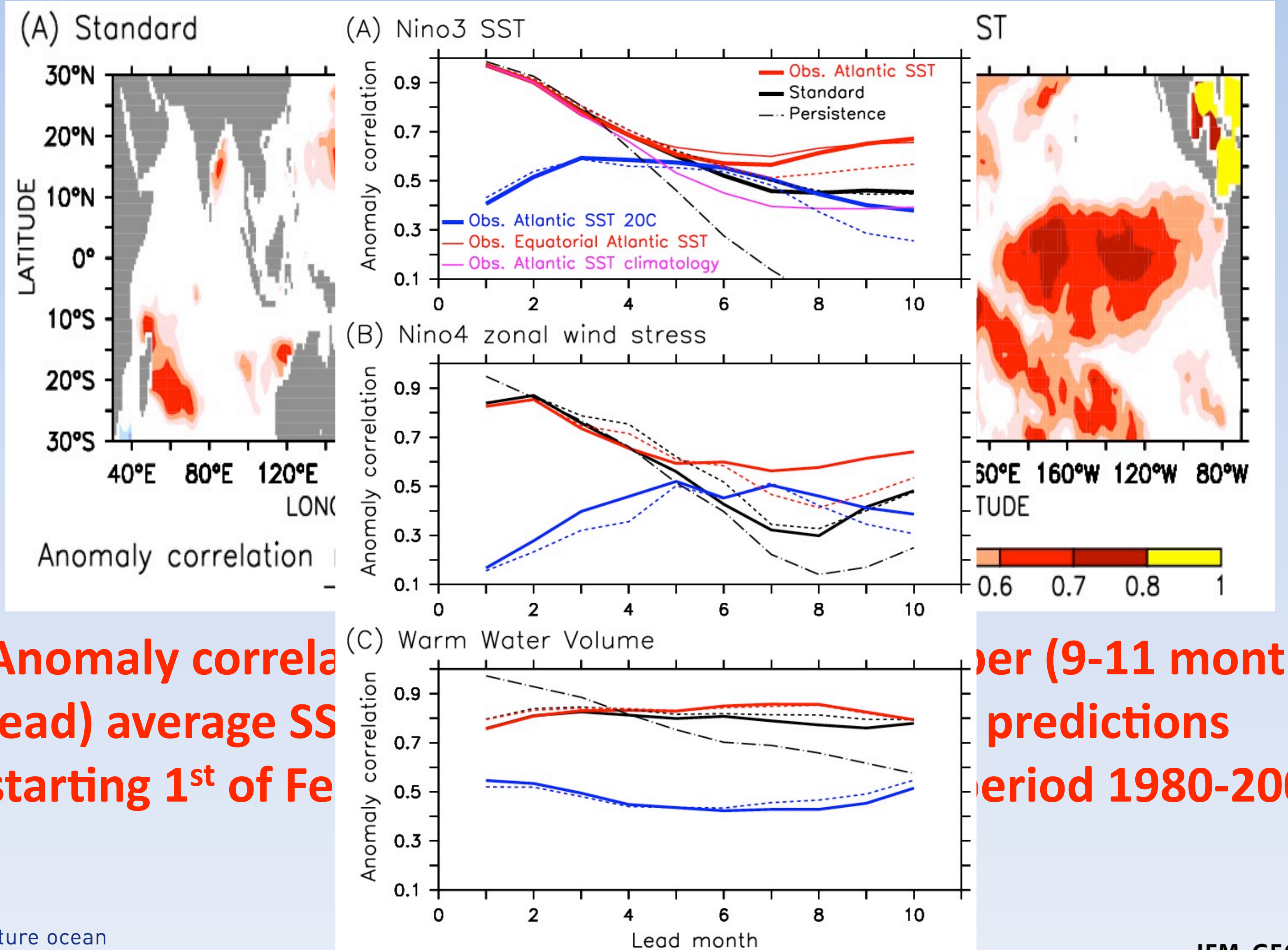
Hindcast of Indo-Pacific SST is much improved by specifying Atlantic SST



Anomaly correla… …ber (9-11 month lead) average SS… …predictions starting 1st of Fe… …eriod 1980-2005

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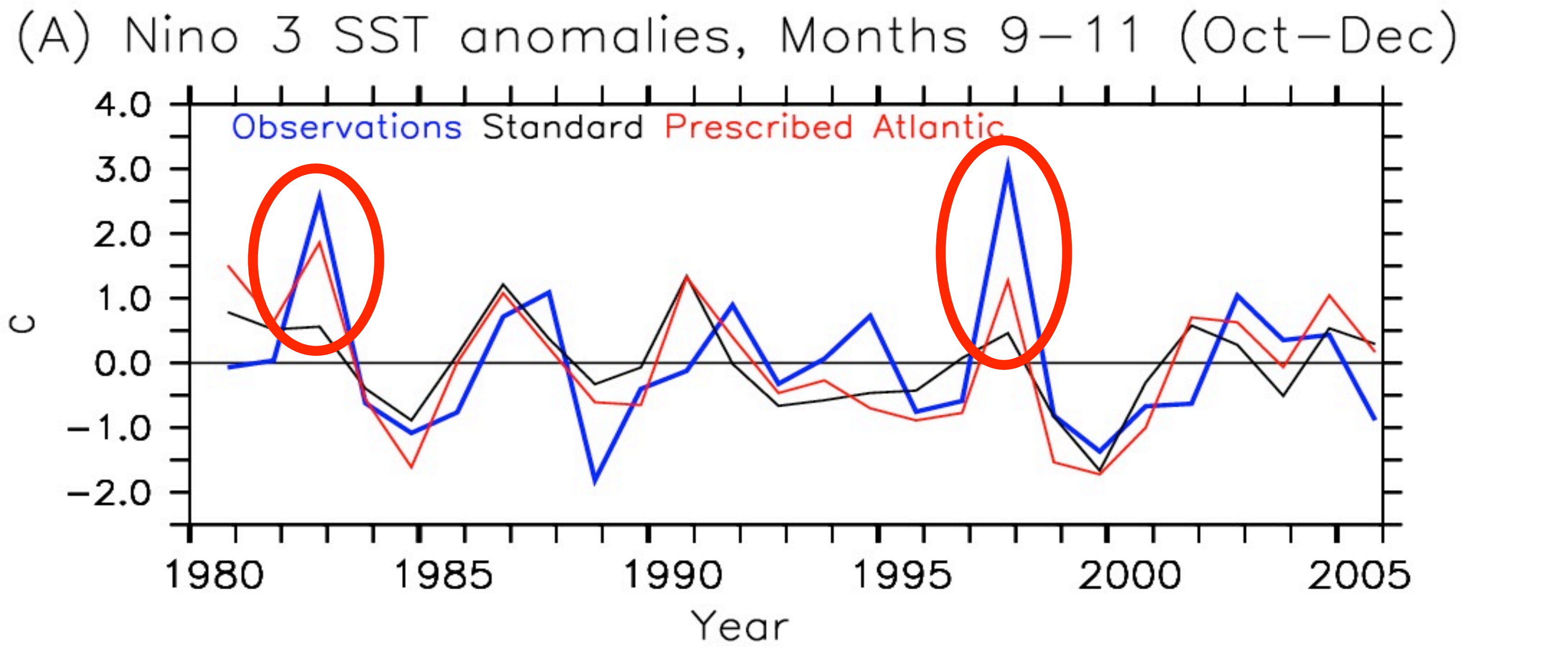
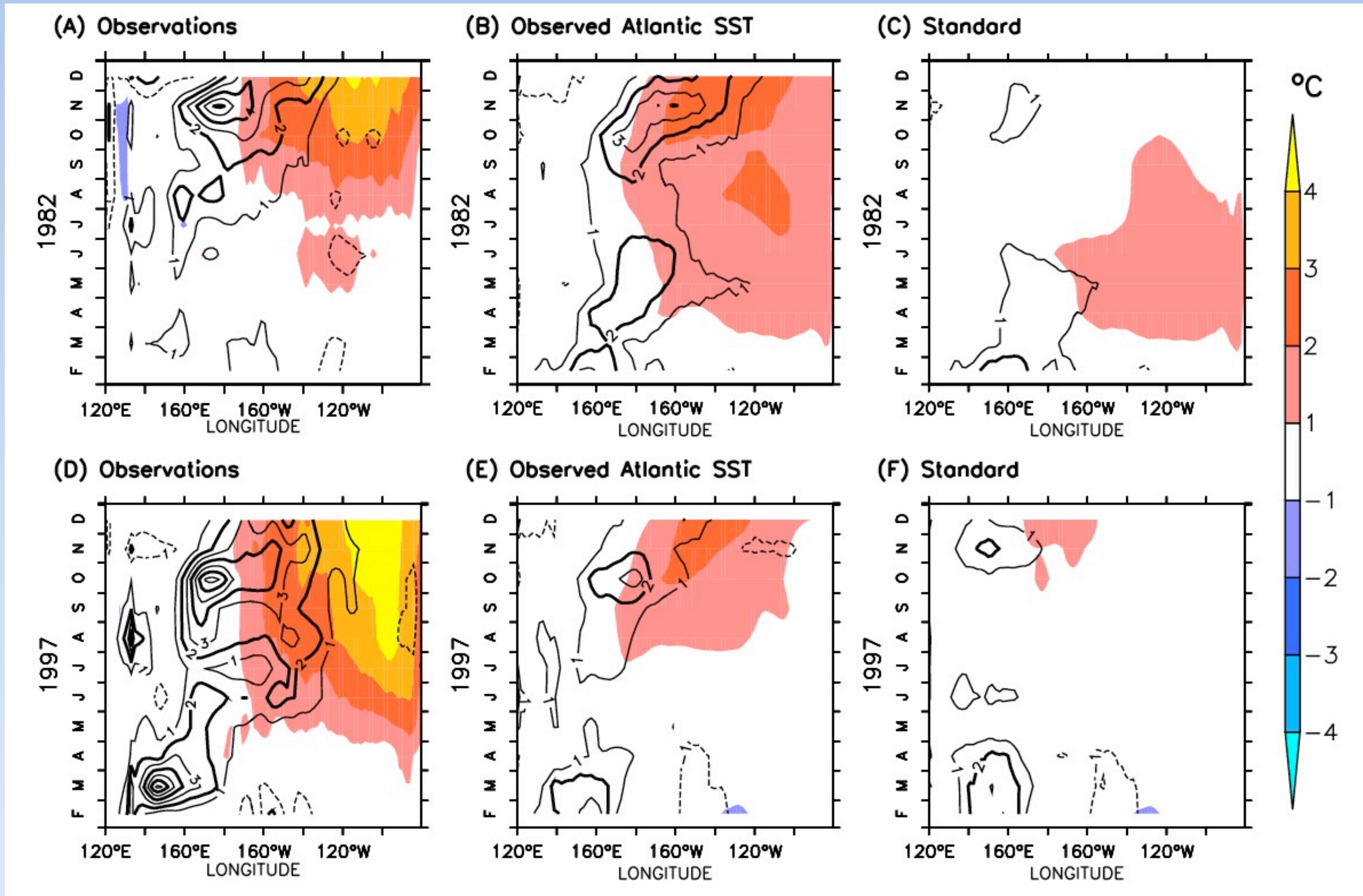
The skill enhancement in the Pacific stems mostly from the two big warm events



"While many of the models forecasted some degree of warming one to two seasons prior to the onset of the El Niño in boreal spring of 1997, none predicted its strength until the event was already becoming very strong in late spring." From Barnston et al. 1999 (BAMS)

Hindcasts of the 1982 and 1997 El Niños



Specification of equatorial Atlantic SST helps to predict the strong El Niño events

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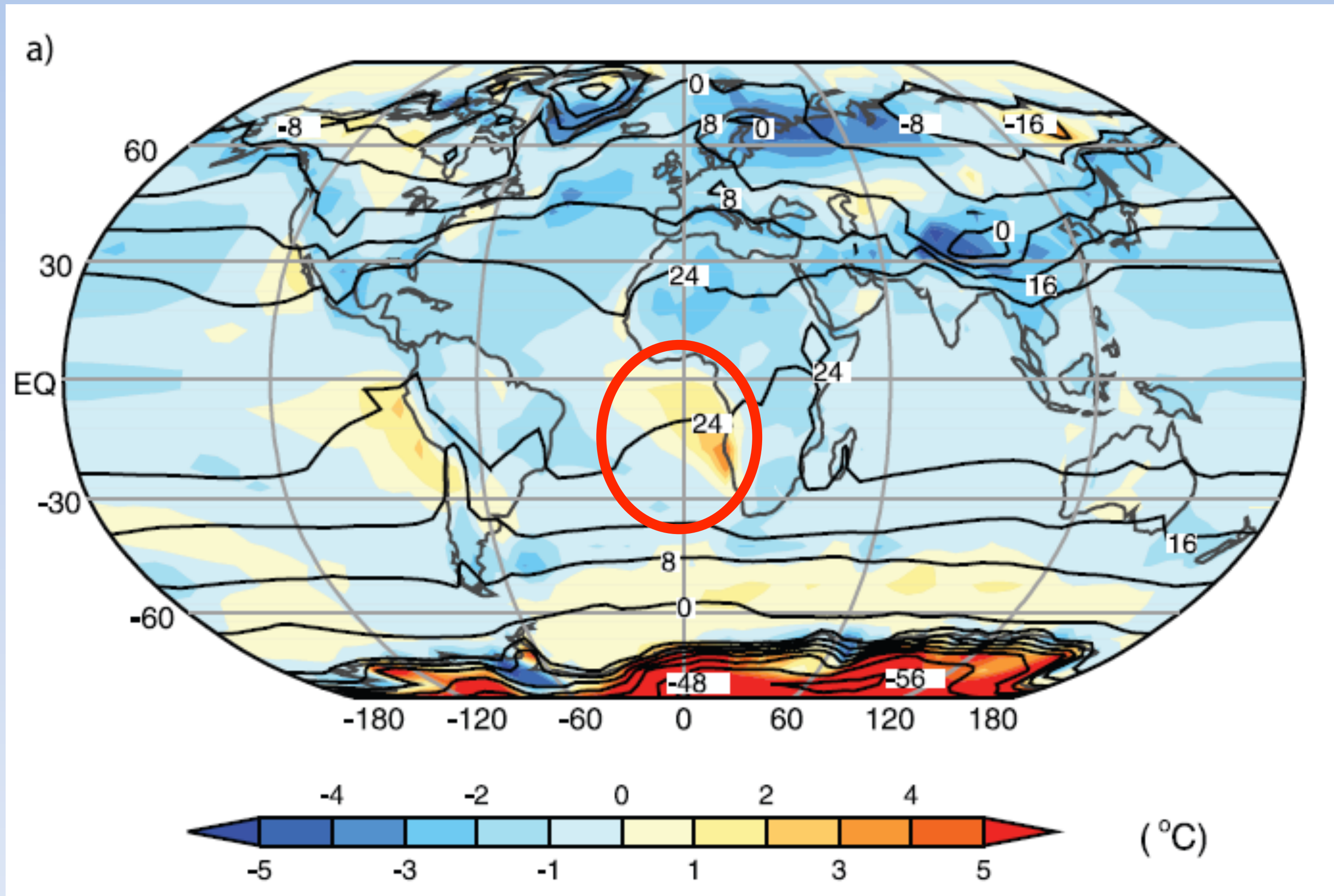
3. Implications for model development



The zonal SST gradient along the Atlantic Equator is reversed in many climate models

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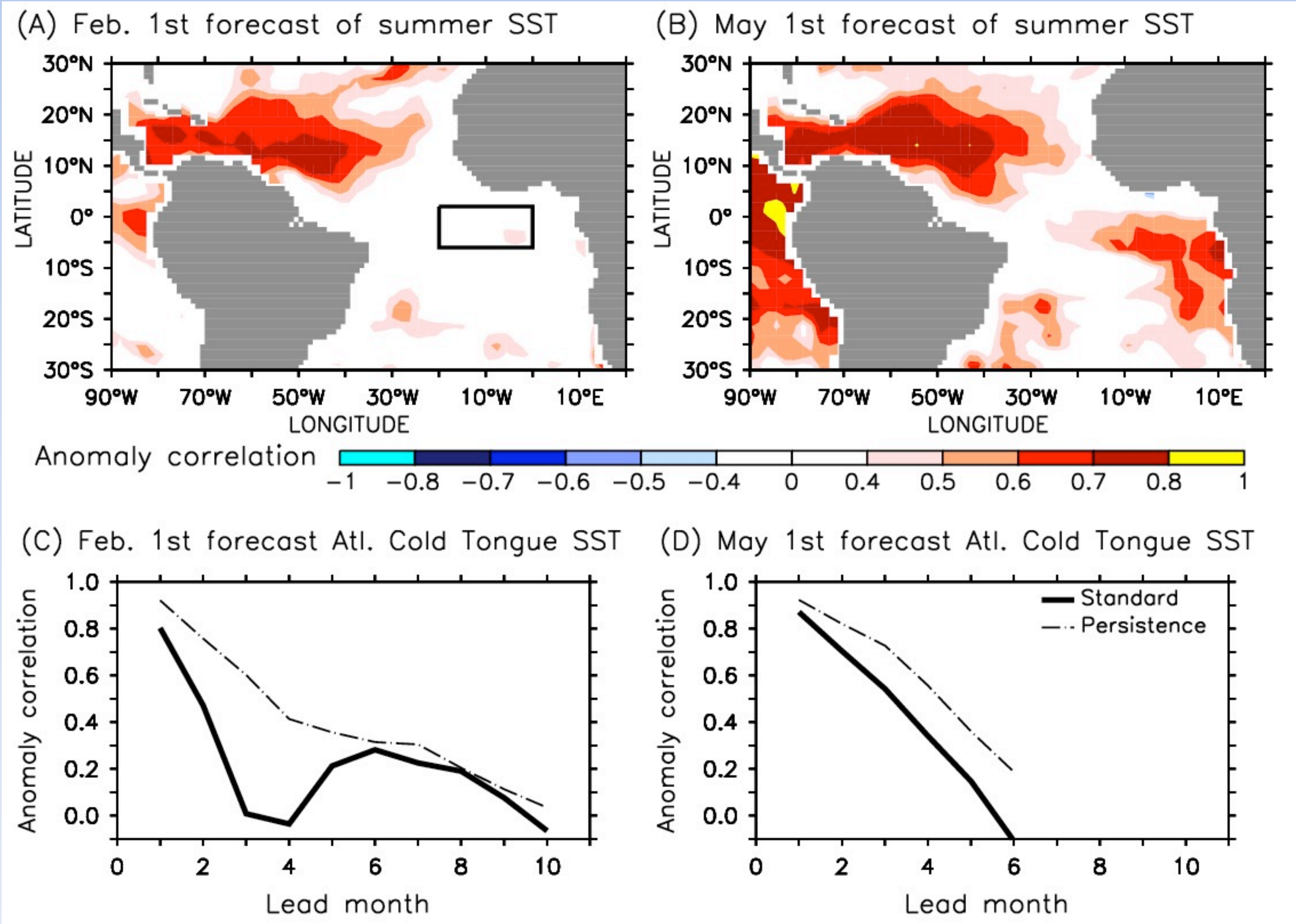
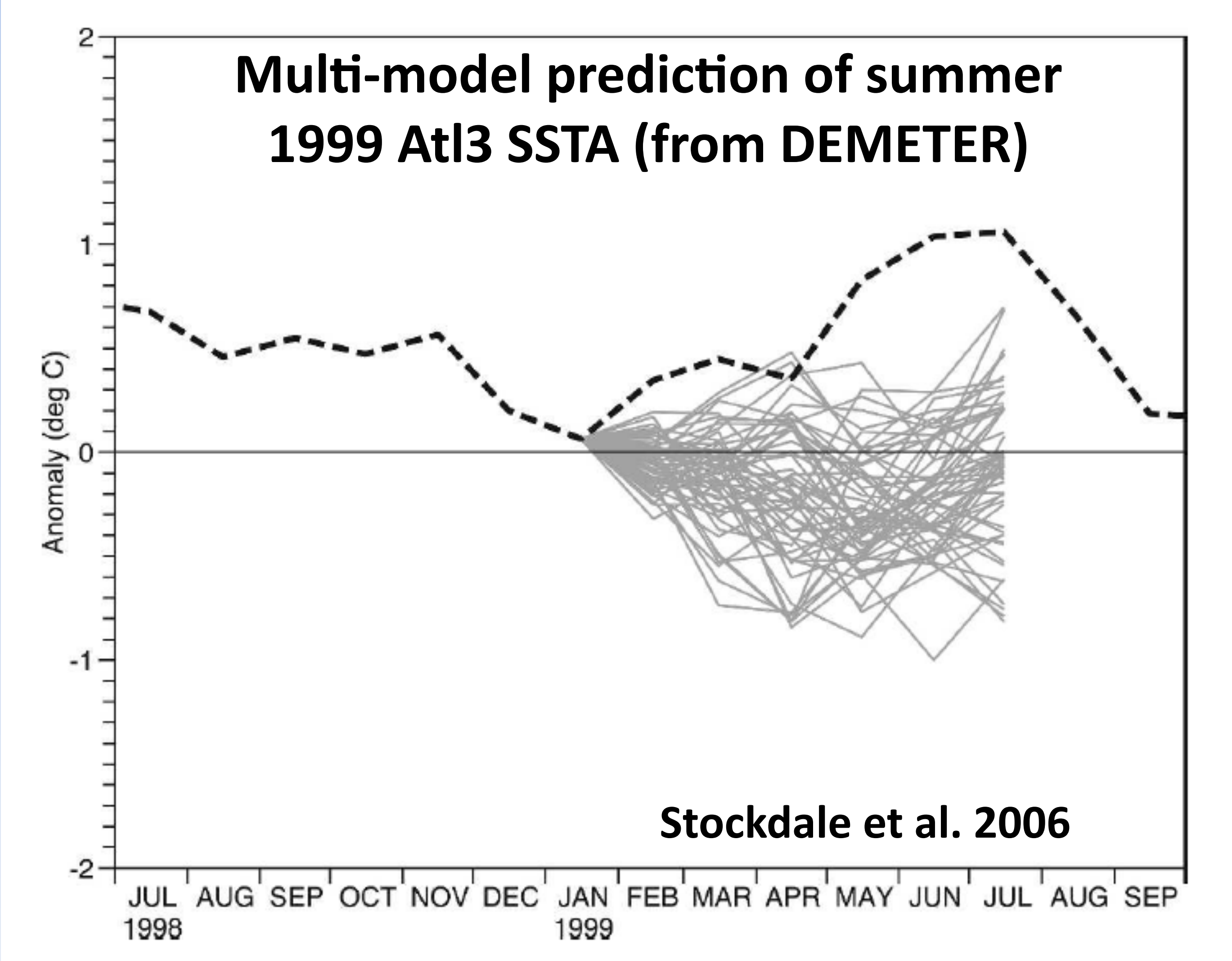
Not much skill in predicting equatorial Atlantic SST in our standard model



Not much skill in predicting equatorial Atlantic SST in other models too



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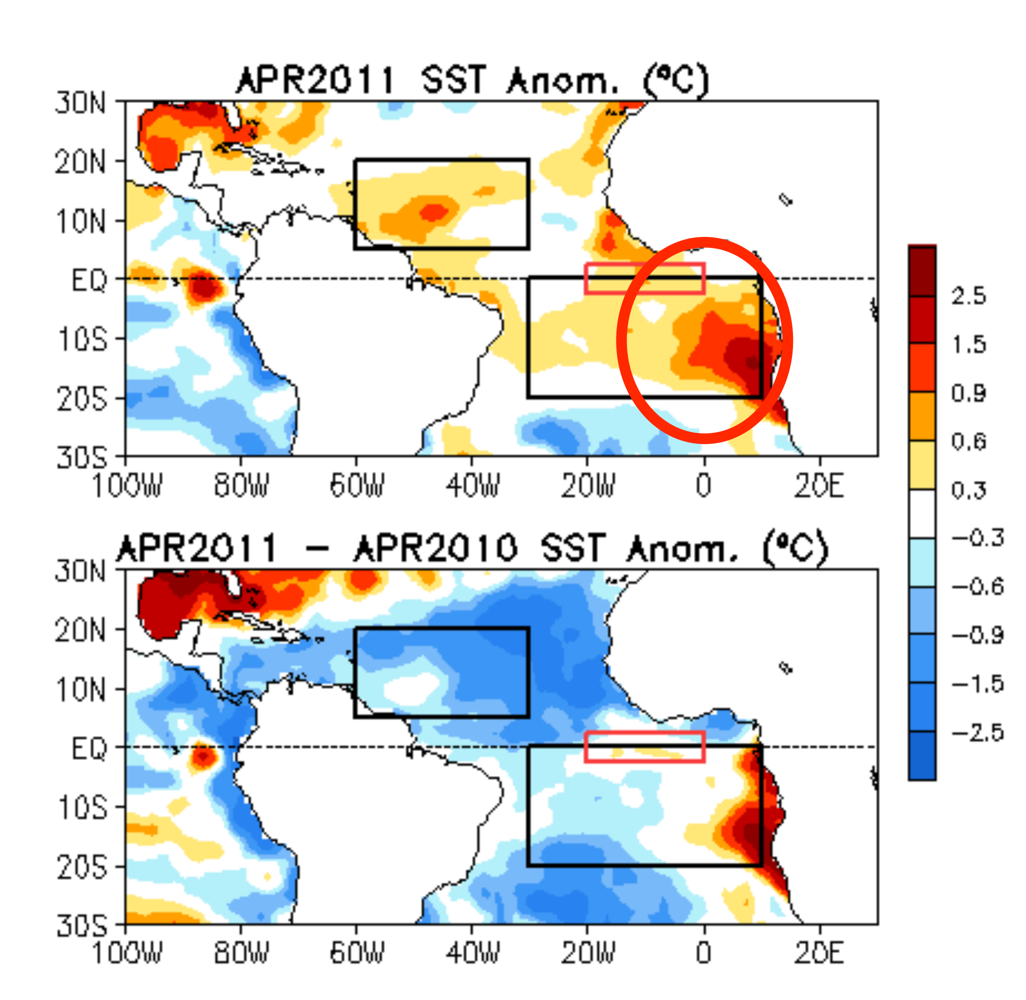
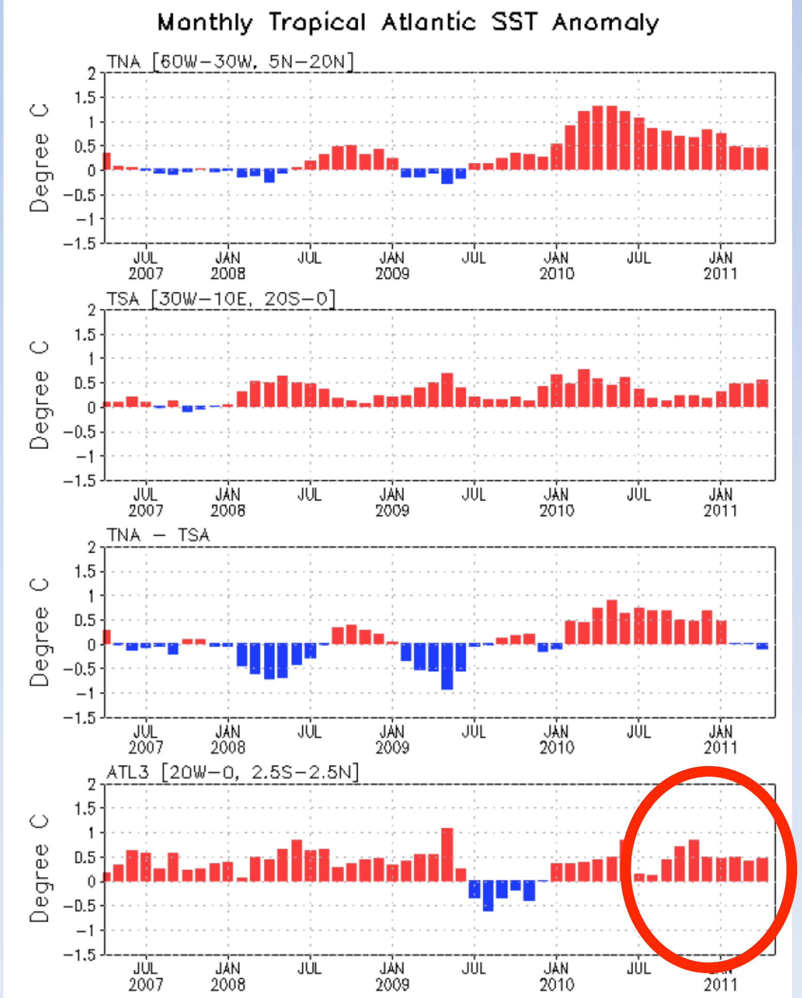
Did warm spring SST help to develop the current cold conditions in the Pacific?





Conclusions

1. There is a strong El Niño-like mode in the equatorial Atlantic that is referred to as Atlantic zonal mode
2. The Atlantic zonal mode explains a lot of variance near the Equator (locally up to 70% in SST)
3. The predictability of the Atlantic zonal mode arises from slow heat content variations (warm water volume, del. action/recharge osc.)
4. The Atlantic zonal mode influences ENSO through changes in the Walker Circulation
5. The seasonal cycle plays a crucial role, as the Atlantic affects the winds over the western Pacific during the development phase of ENSO
6. ENSO prediction can benefit from enhanced prediction of equatorial Atlantic SST
7. However, the equatorial Atlantic is a region of large model (SST and wind) bias
8. There is almost no skill in predicting equatorial Atlantic SST in current models
9. Model improvement (reduction of the tropical Atlantic SST bias) may thus not only enhance predictions in the Atlantic but also in the Pacific

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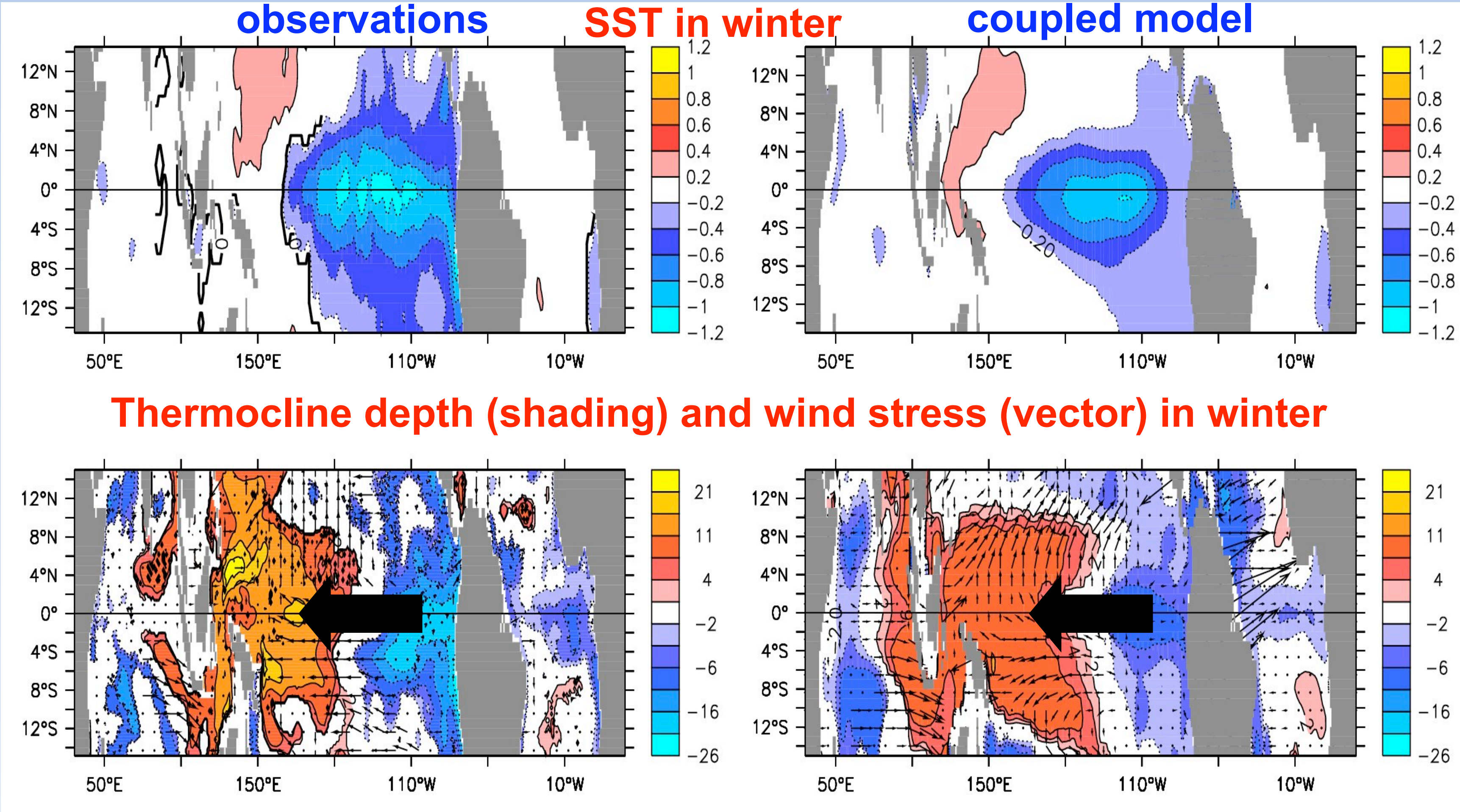
Link of Pacific quantities in winter with equatorial Atlantic SST in summer



The simulated links are consistent with observations

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