The role of ocean-atmosphere coupling in simulations of the Asian summer monsoon

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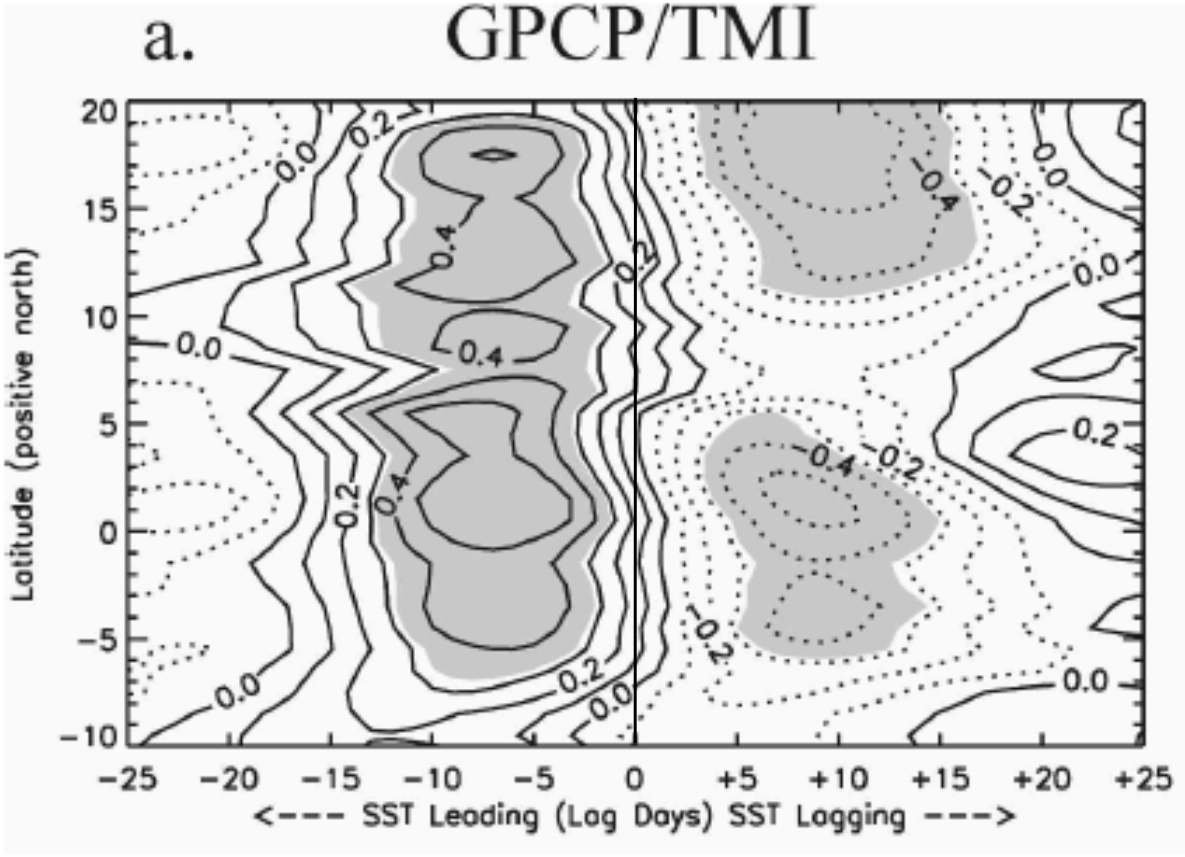
Air-Sea Interaction

- Mean state impacts on intraseasonal variability
- Air-sea interaction on intraseasonal timescales

Rainfall-SST lag correlation vs. latitude



SST leads precipitation in observations and CGCMs

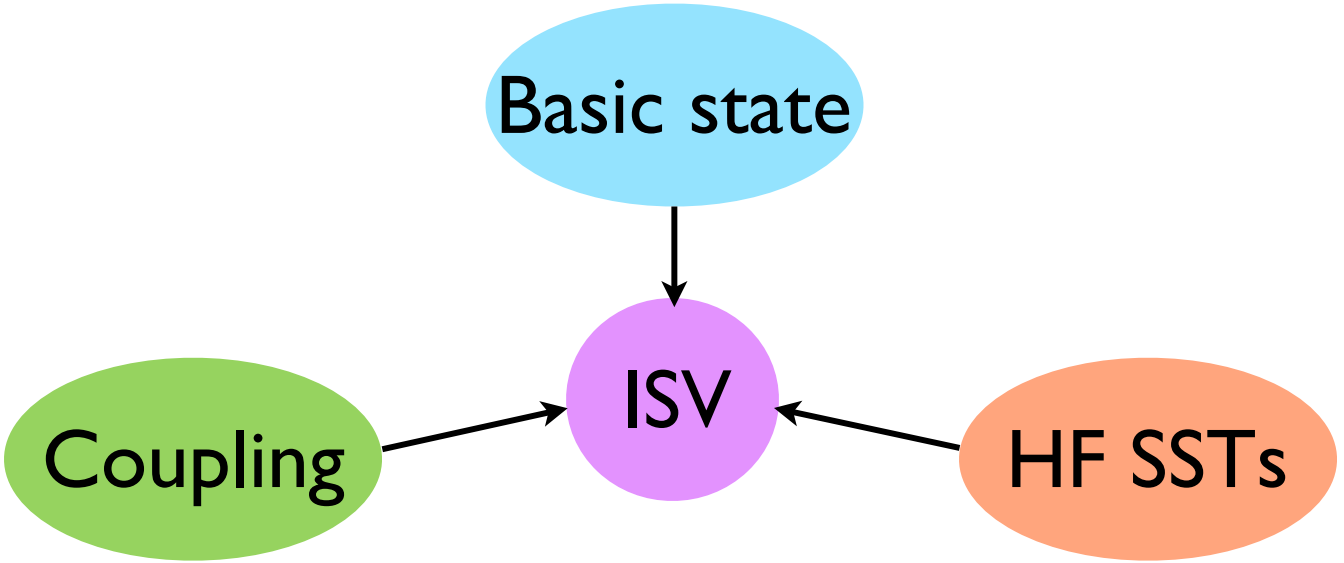
Klingaman et al. 2008

Air-sea interactions in coupled simulations

- Coupled models generally simulate improved intraseasonal variability (ISV) compared to their atmosphere-only counterparts using monthly mean SSTs.
- To what extent is coupling necessary for simulating ISV?
- What processes are responsible for improved ISV?

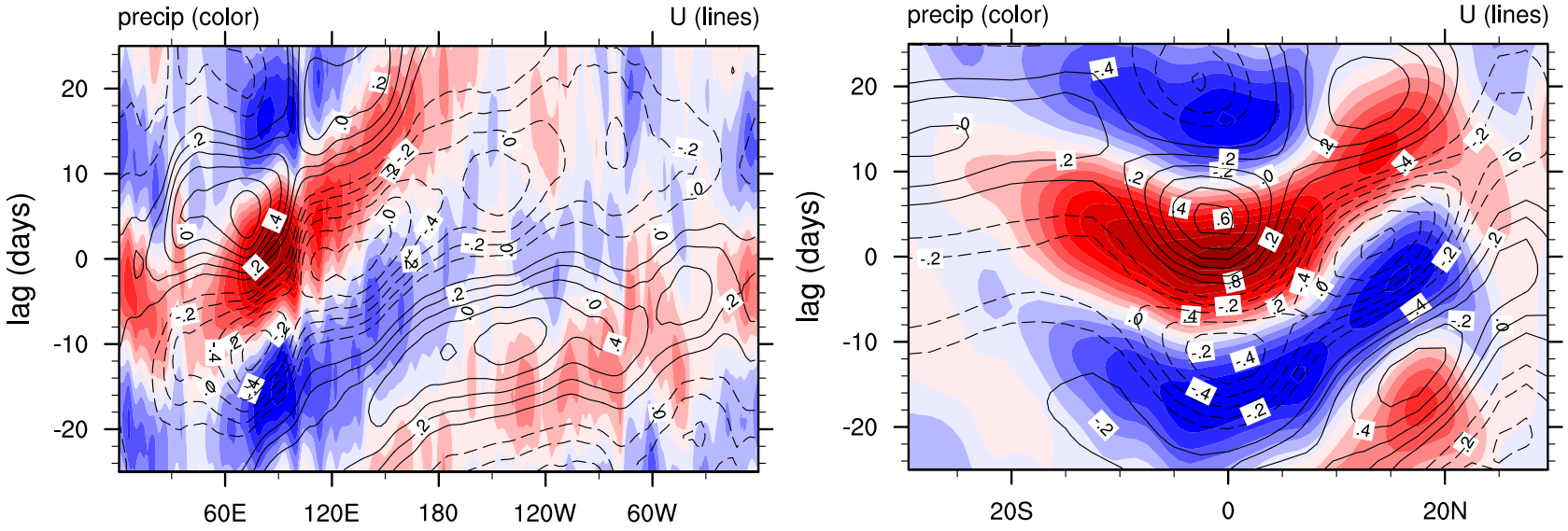
Coupling vs. high-frequency SST variability

- Are ocean-atmosphere feedbacks responsible for improved ISV?
- Is high-frequency SST variability responsible for improved ISV?
- What role does the mean state of the coupled model play in ISV?

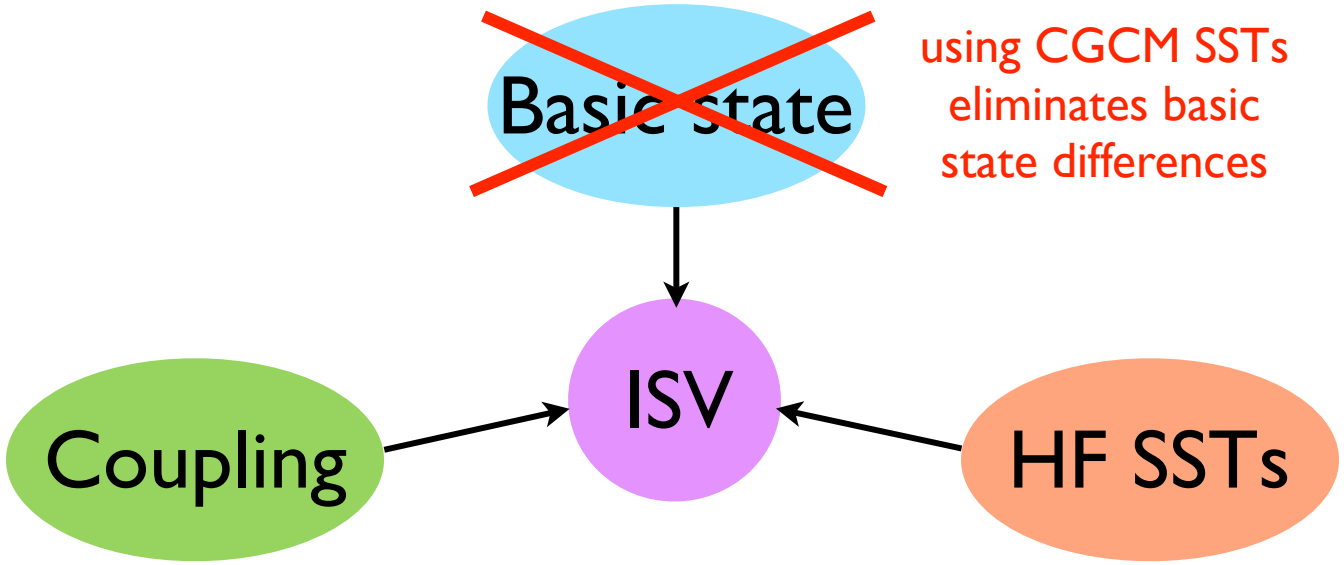


Modeling approach to understanding coupling vs. high-frequency SST variability

- Use SSTs from coupled run as boundary condition for atmosphere-only run.
  - monthly-mean SSTs (AMIP-like)
  - daily SSTs with 5-day running mean filter applied
- Analyze eastward & northward propagation



Coupling vs. high-frequency SST variability



in our case, "HF" refers to daily SSTs with a 5-day running mean applied

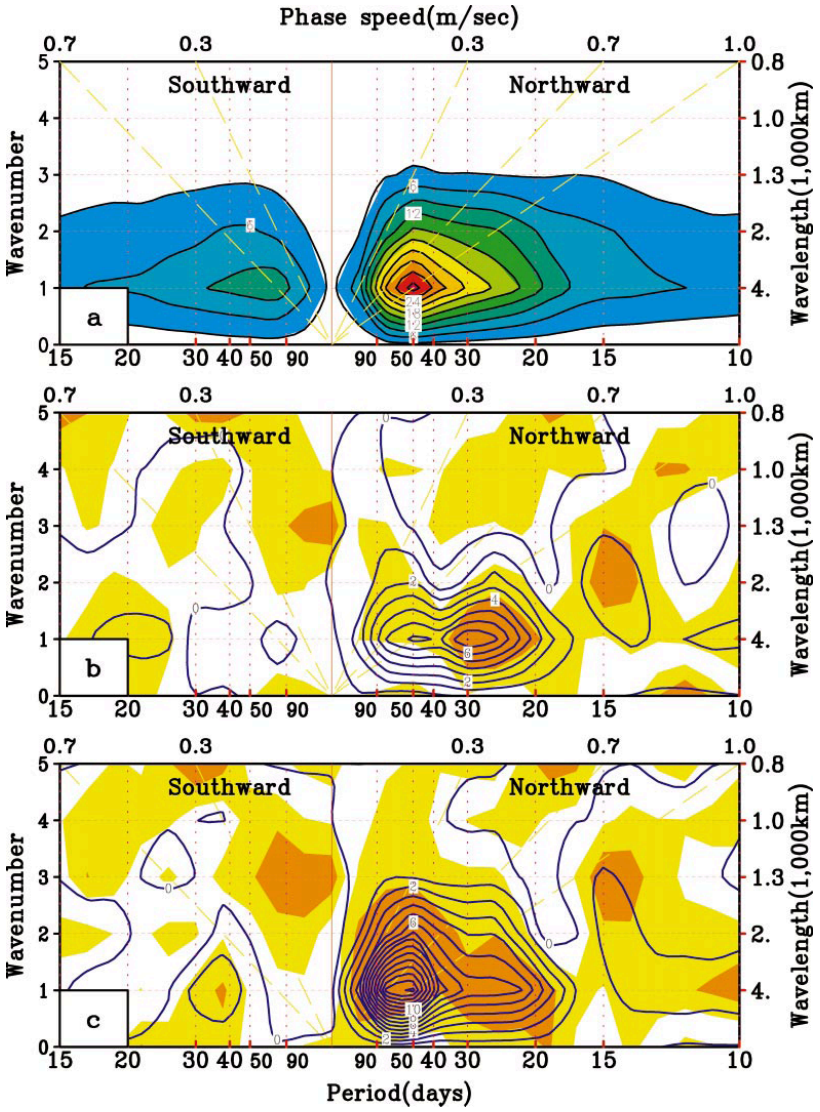
Some examples from other studies

ECHAM4

coupled

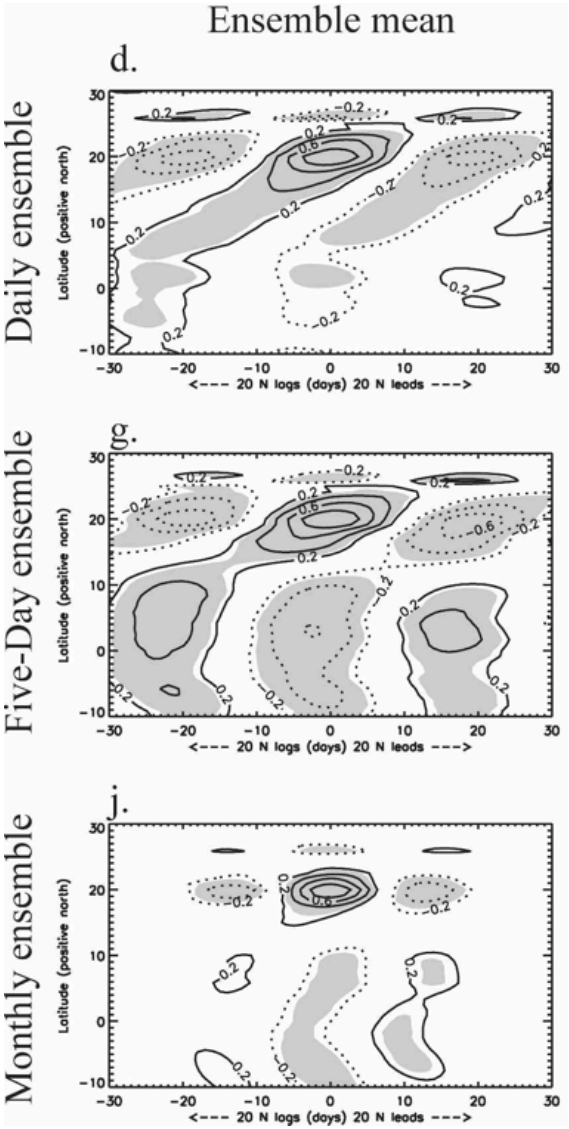
coupled-daily

coupled-monthly



Fu et al. 2003

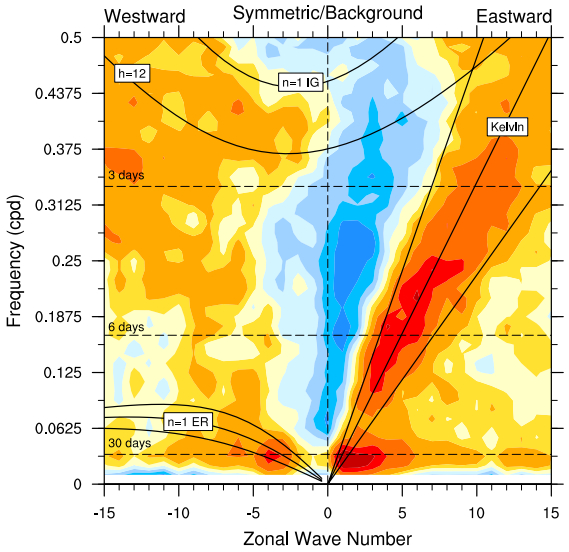
HadAM3



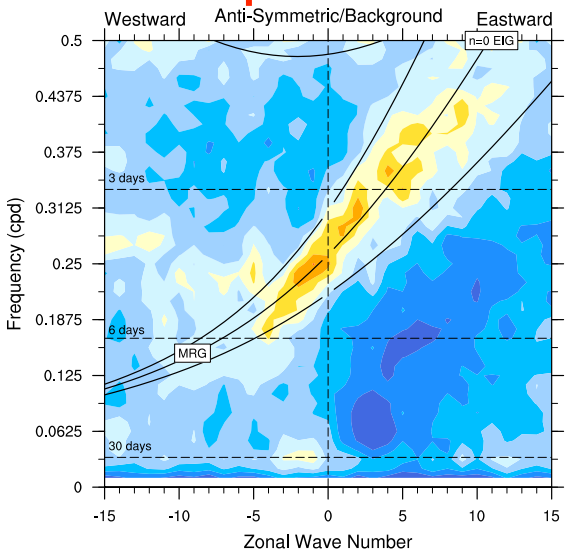
Klingaman et al. 2008

OLR spectra

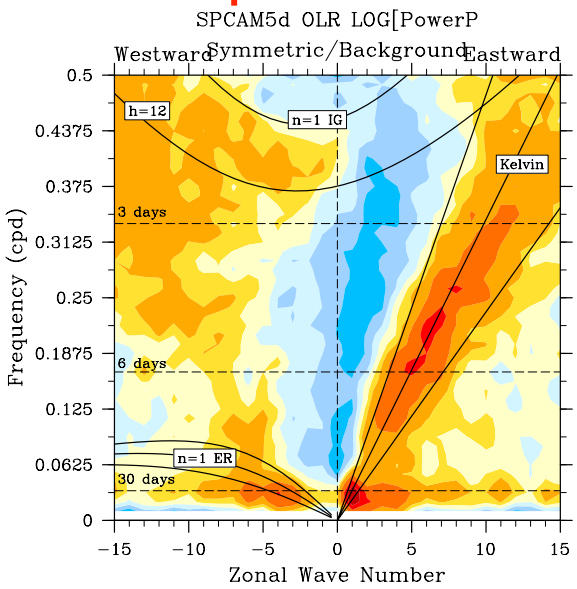
SpCCSM



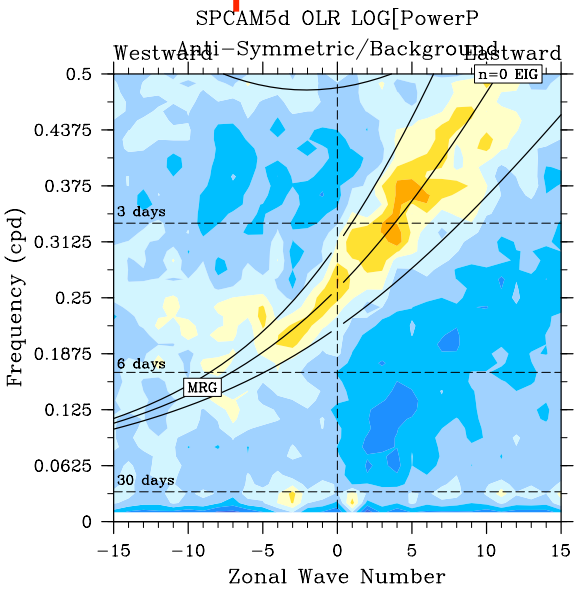
SpCCSM



SpCAM5d



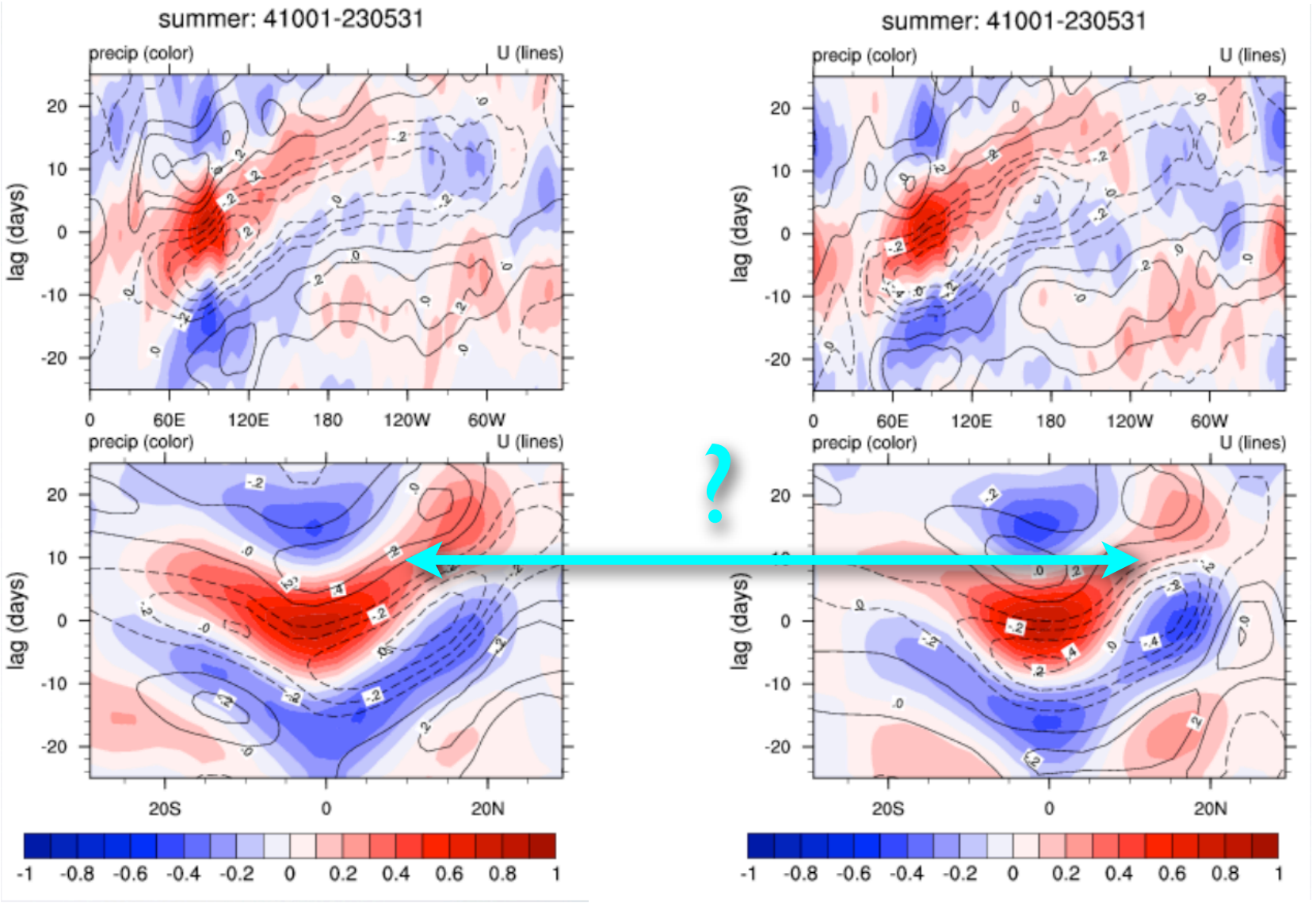
SpCAM5d



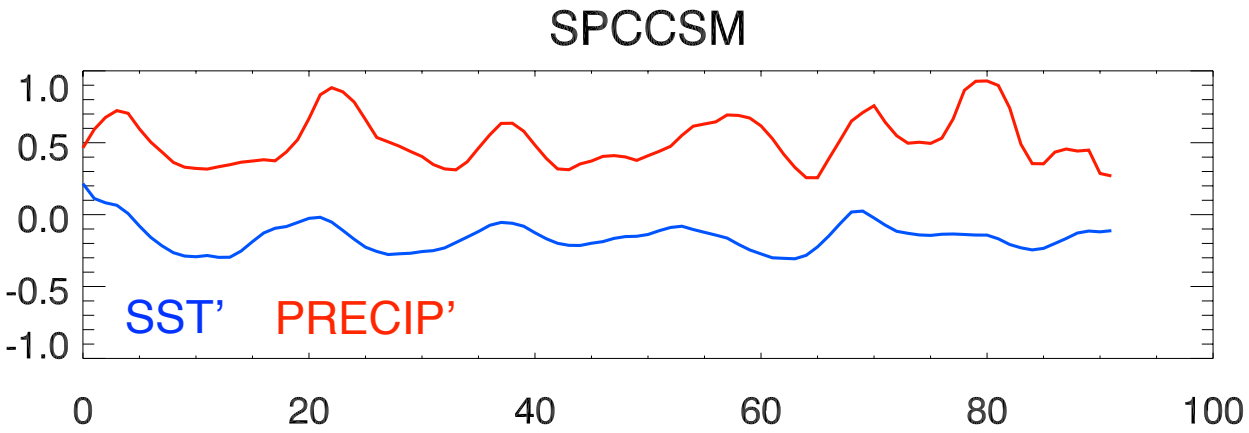
SP-CCSM vs SP-CAM5d

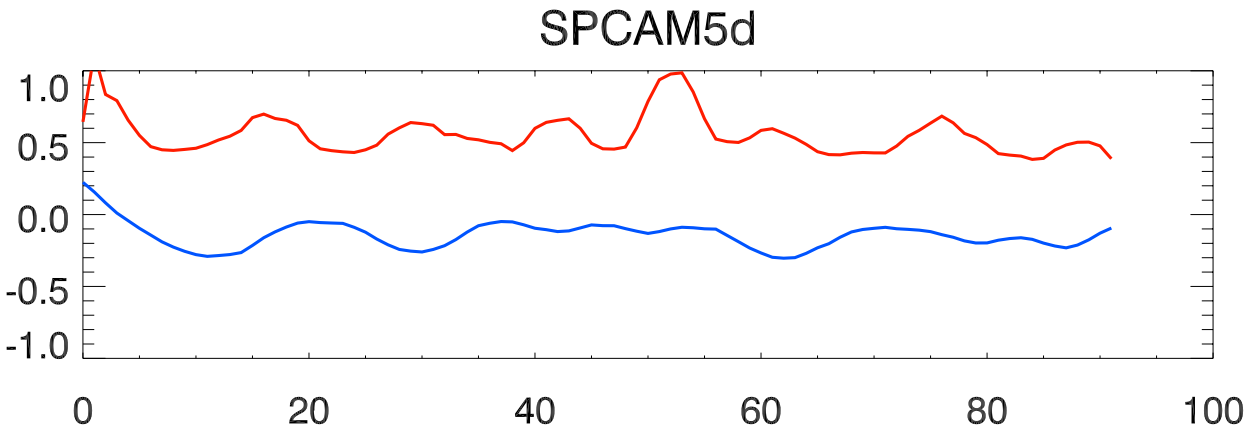
SP-CCSM

SP-CAM5d



Does this mean that HF SST variability (< 5 days) is critical for the MJO and the monsoon?





scaled SST and precipitation anomalies for one JJA season in the Bay of Bengal

r = 0.98 r = 0.11

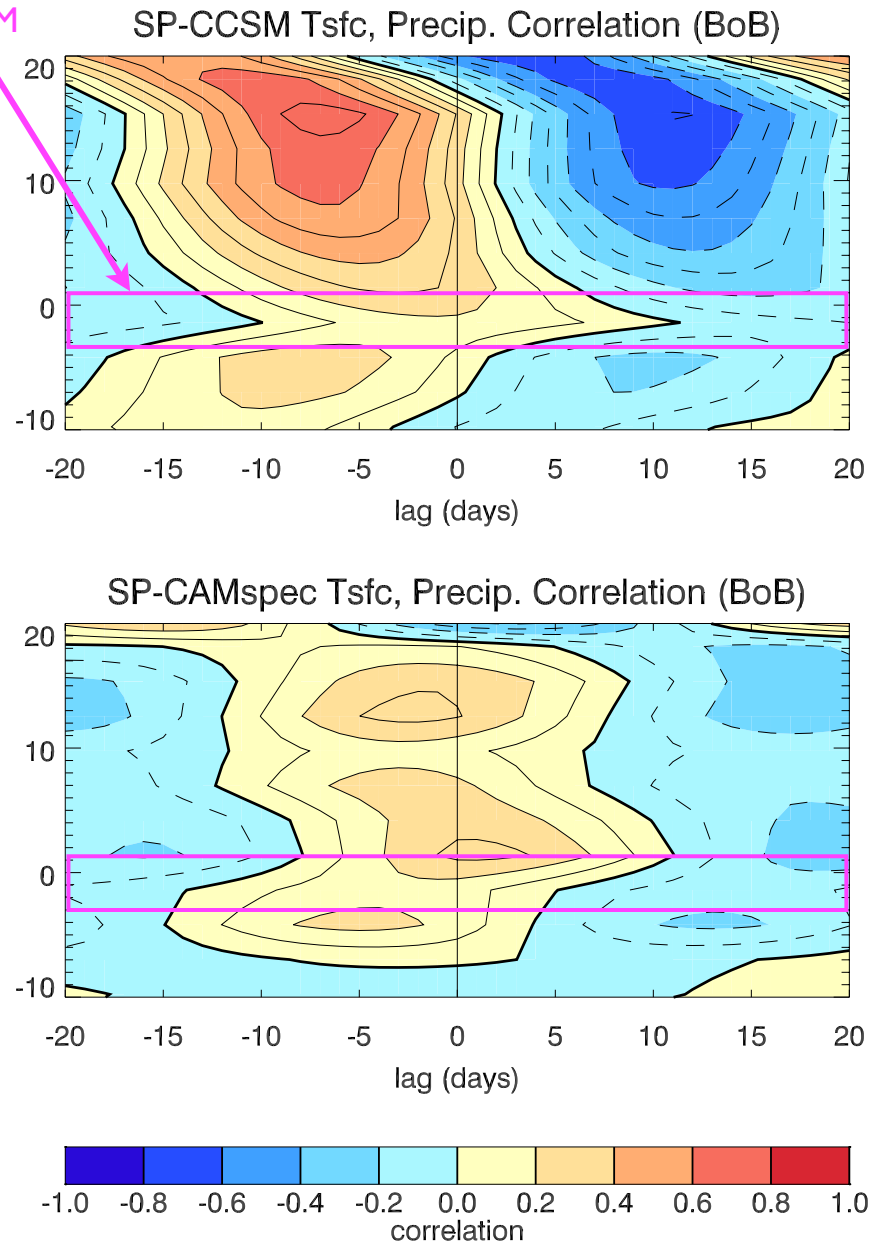
Tsfc, Precip lead-lag relationship, (85E-95E)

(30-50 day filtering applied to SST, Precip)

odd Tsfc-Precip phase relationship south of Equator in SP-CCSM

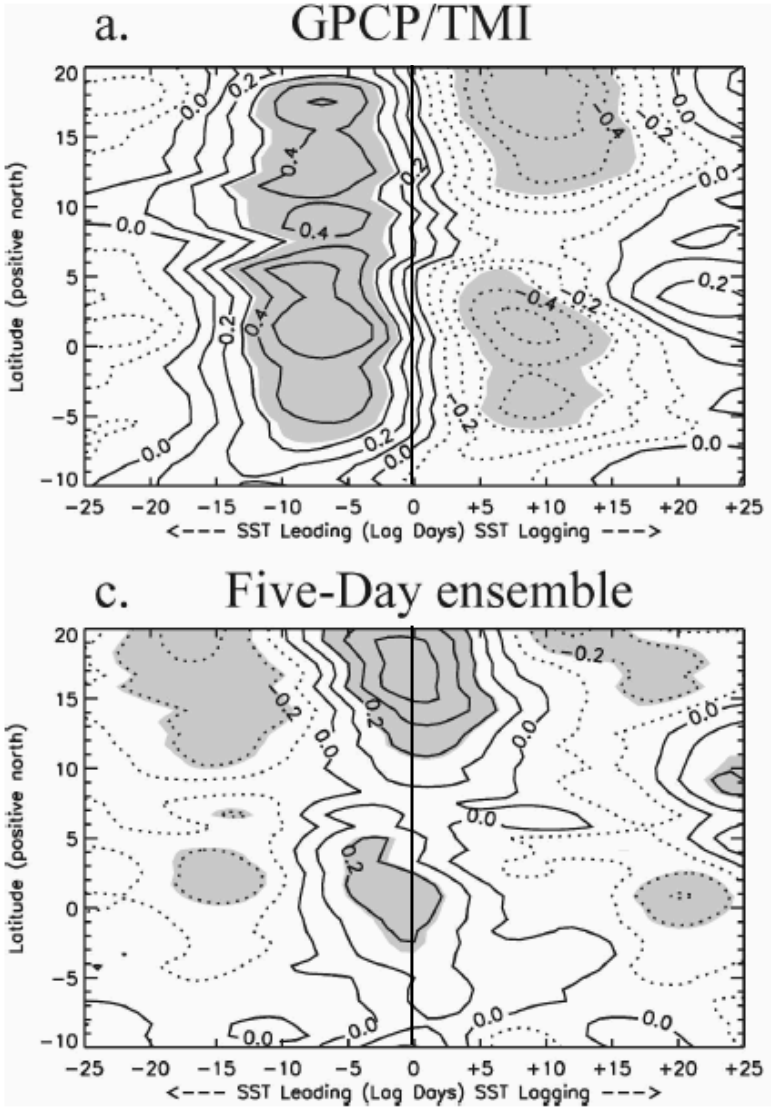
coupled

HF SSTs



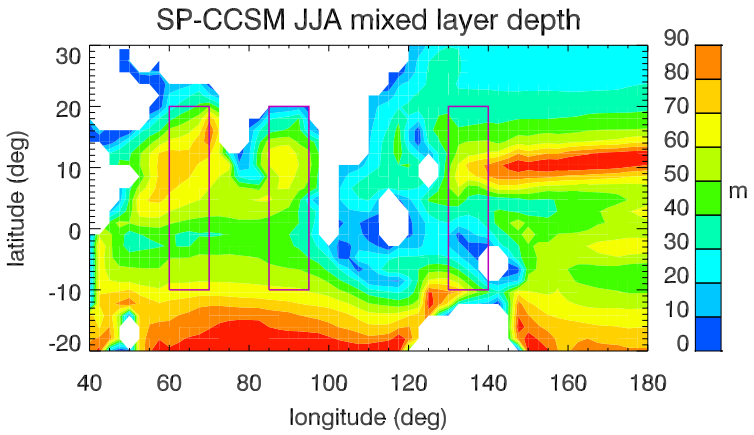
observations

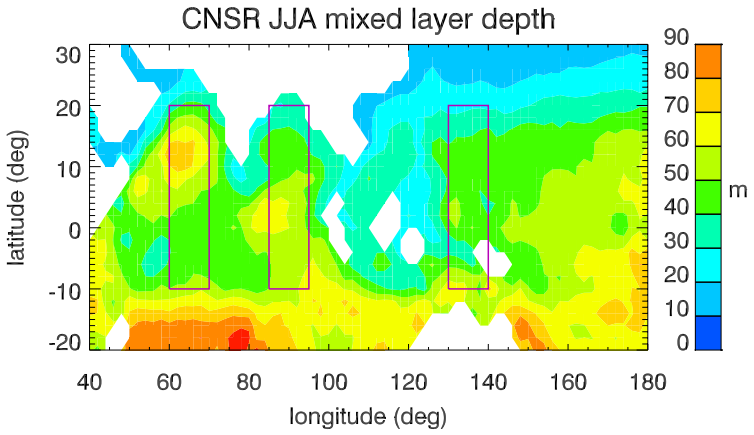
HF SSTs

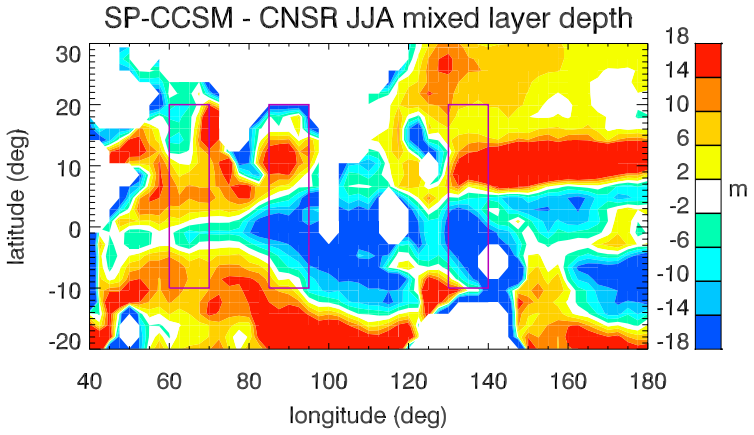


HadAM3 (Klingaman et al. 2008)

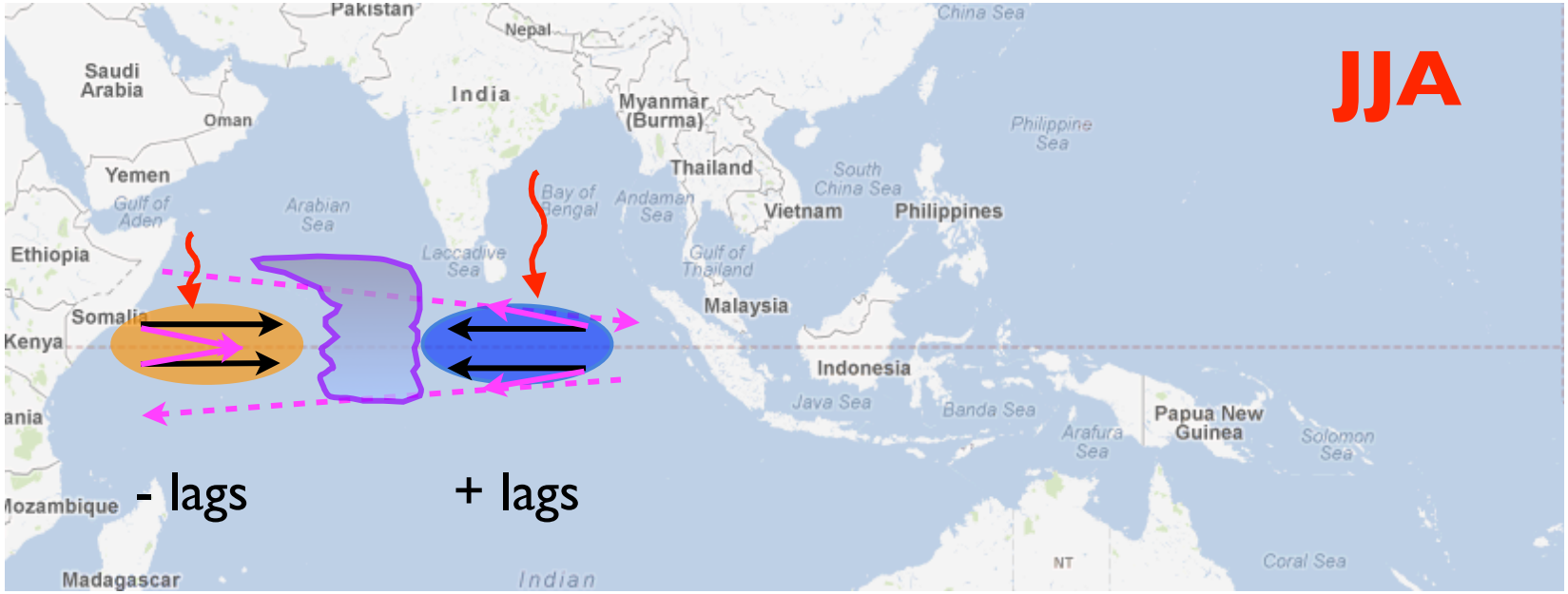
JJA Ocean Mixed Layer







Thoughts on SP-CCSM equatorial SST-Precip relationship



low-level wind anomaly

oceanic Ekman response to wind anomalies

oceanic Ekman response to mean winds

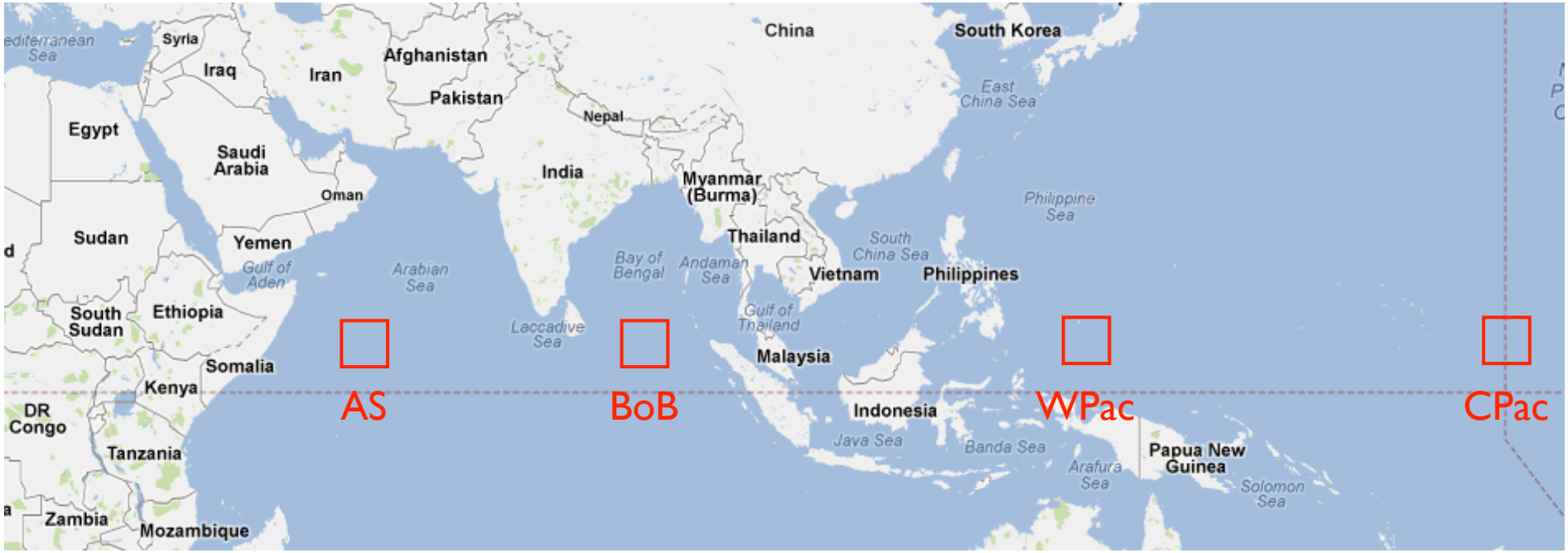
solar heating

Ekman-induced upwelling (by wind anomaly)

Ekman-induced downwelling (by wind anomaly)

Could a shallower-than-observed mixed layer combined with stronger-than-observed winds lead to a spatial/temporal shift in SST heating as a function of MJO phase?
Does upwelling east of convection offset some of the solar heating?

How does air-sea interaction vary with location?



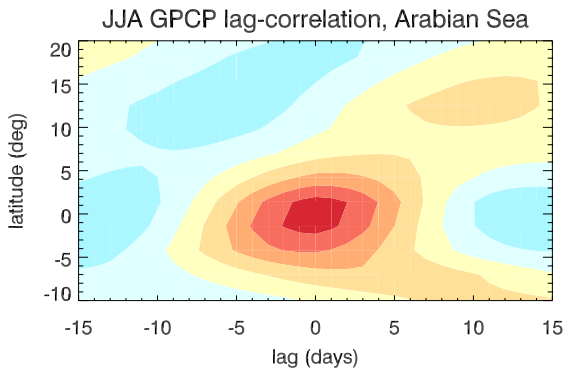
JJA NPISO in Precipitation

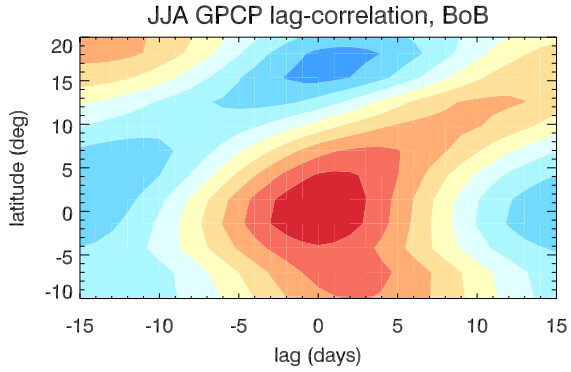
Arabian Sea

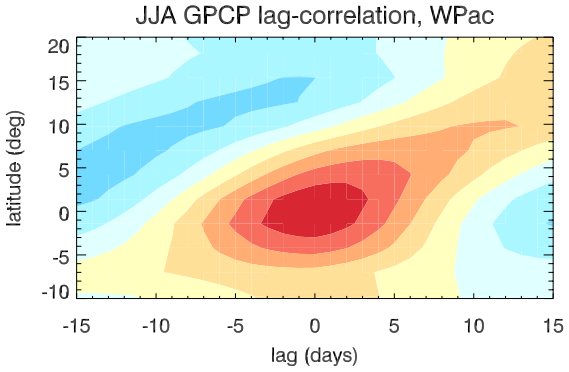
BoB

Western Pacific

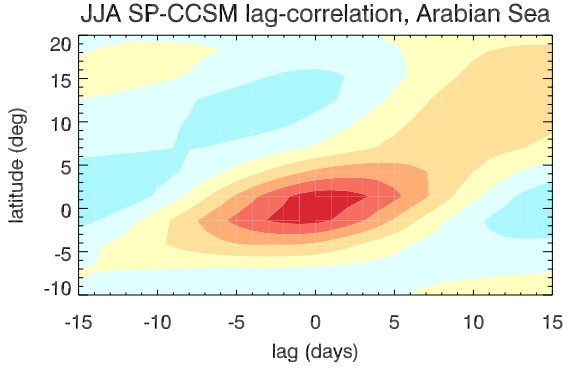
GPCP

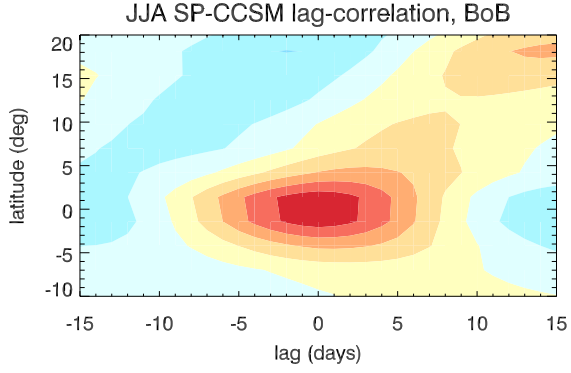


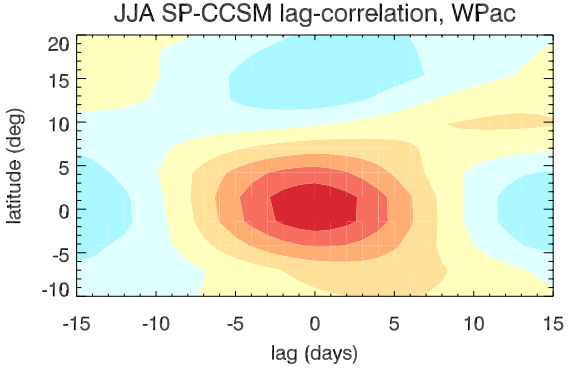




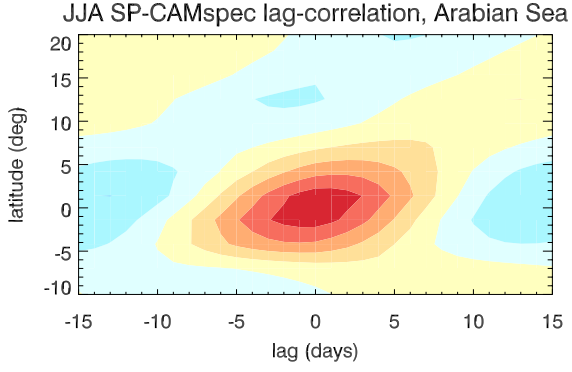
SP-CCSM

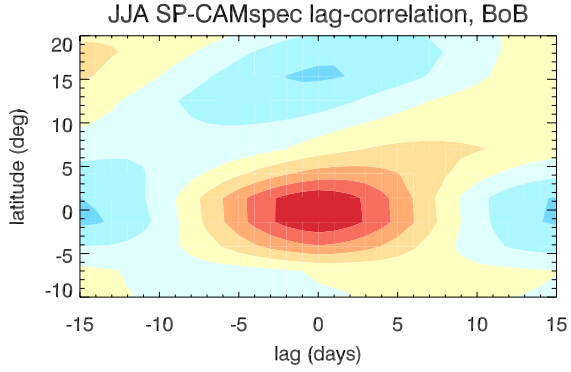


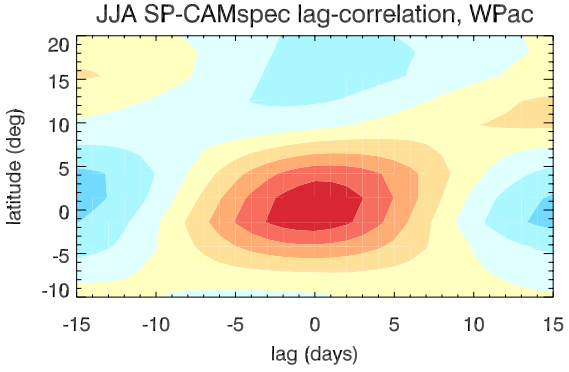




SP-CAM5d





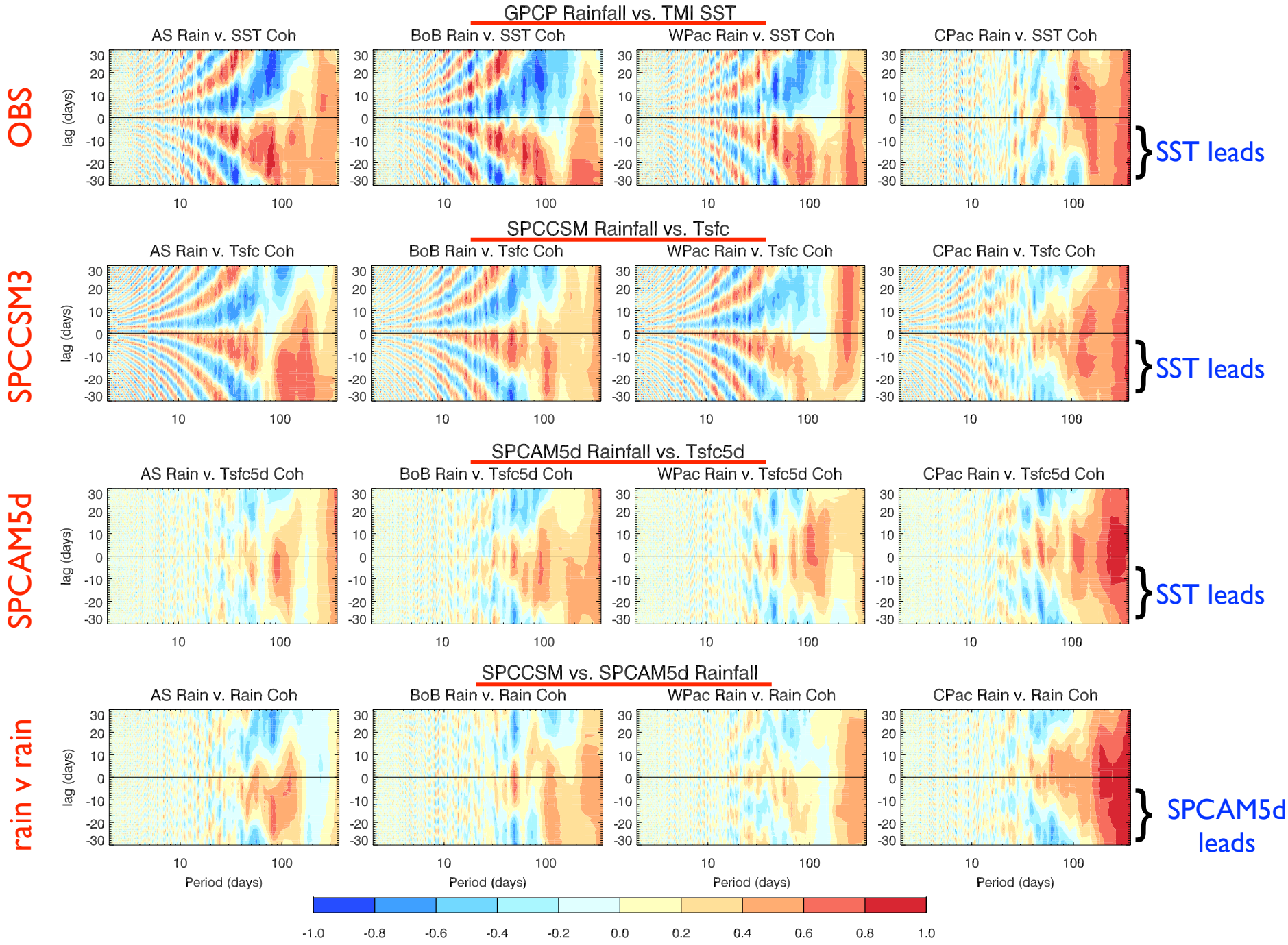


Timescale of air-sea interaction

Does the atmosphere drive the ocean, or does the ocean drive the atmosphere?

- Intraseasonal timescales: atmosphere drives ocean SSTs
- ENSO timescales: SSTs influence precipitation anomalies

Signed coherence of rainfall and SST/Tsfc



Summary

- Understanding the roles of coupling, high-frequency SSTs, and cumulus parameterization on ISV is a complex exercise.
- SP-CAM5d retains variability and monsoon behavior, but that variability is somewhat weaker than in SP-CCSM.
- Phase mis-match between precipitation and SST anomalies in SP-CAM5d complicates interpretation.
- Biases in ocean model further complicate the issue.