Outstanding Issues in MJO Simulation and Initiation (NCAR CAM)

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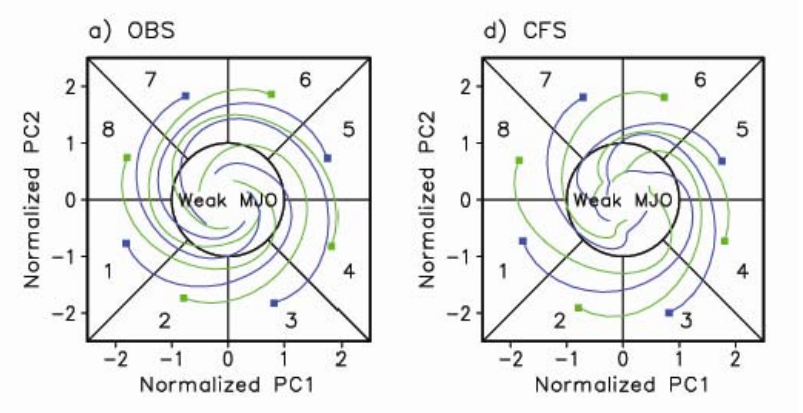
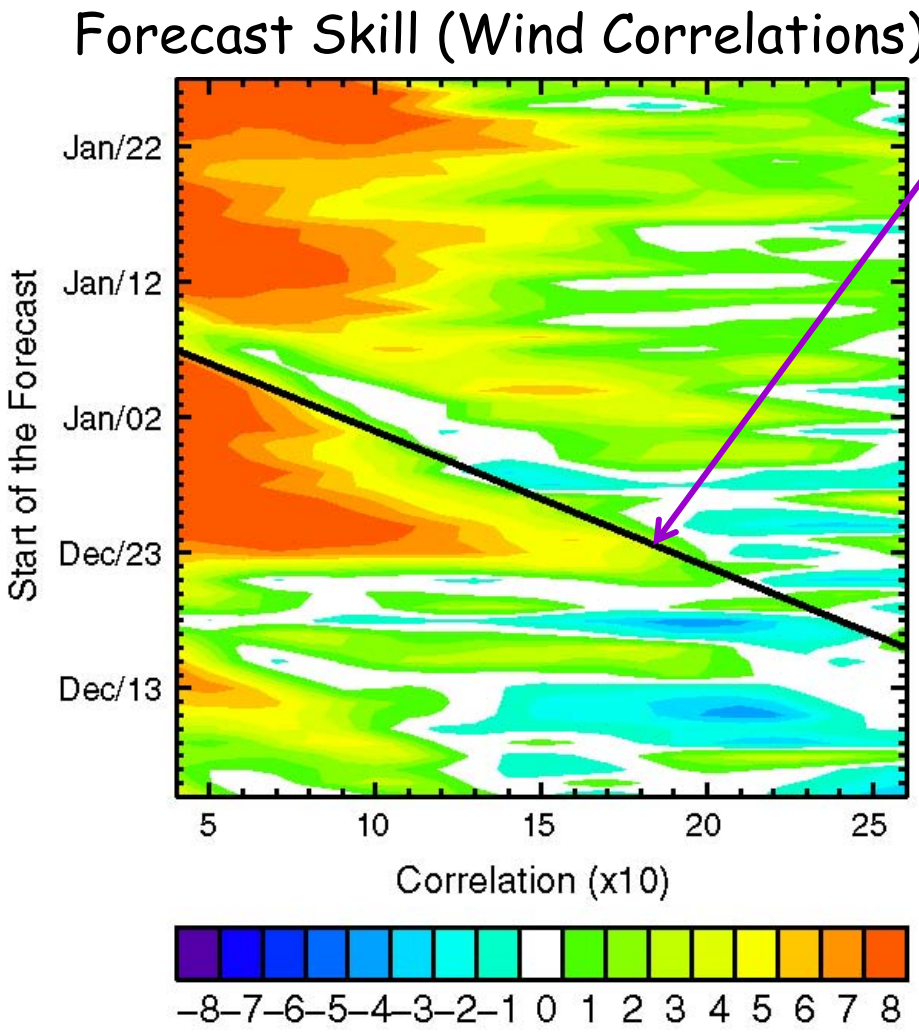
Common Comment from the Literature…..

Comments like the following are common:

"This model was found unable to sustain the eastward propagating, convectively coupled tropical circulation anomalies produced by the MJO when initialized at times the MJO is active. This particular model furthermore is unable to develop an active MJO when initialized prior to such observed development." (Hendon et al. 2000).



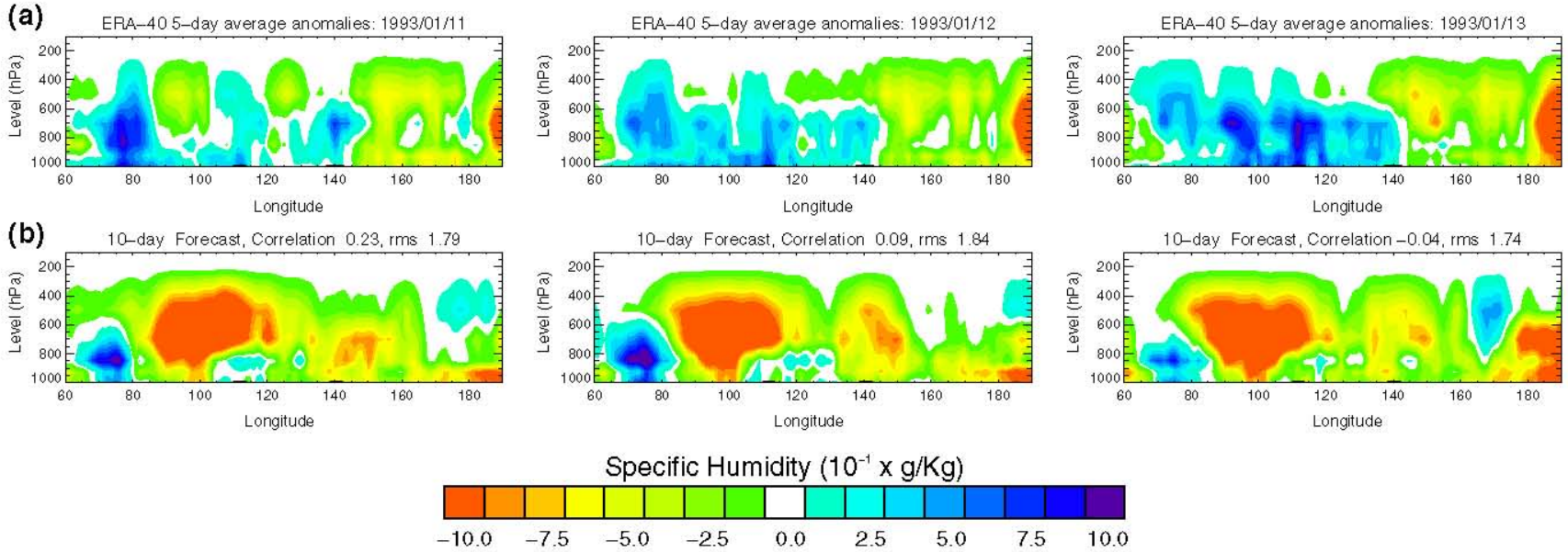
Initiation of MJO Convection in the Indian Ocean Presents a Prediction Barrier



- Hindcast experiments with ECMWF forecast model
- Lack of skill at forecasting Indian Ocean convective initiation provides a barrier to MJO prediction.

Agudelo et al. 2007

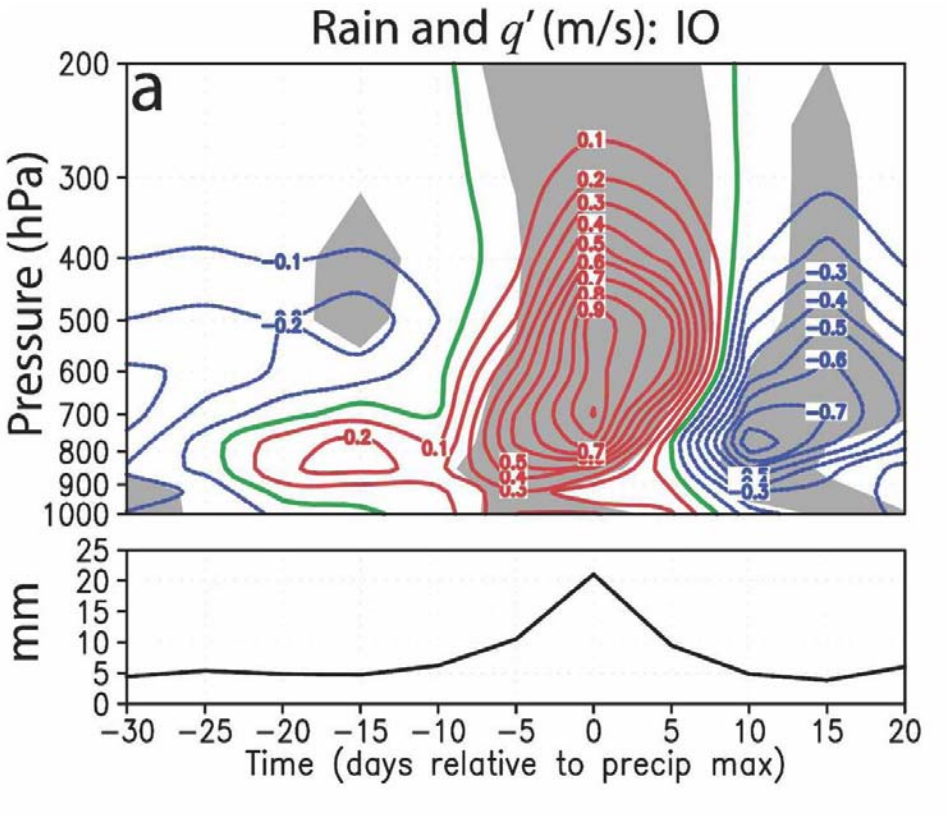
The Preconditioning of the Indian Ocean Troposphere in Advance of MJO Convection is Not Well Simulated



- Tropospheric humidity anomalies in this model do not build to same extent as in observations in advance of MJO initiation, and the strong convective event is missed

Agudelo et al. 2007

Observations Generally Indicate a Notable Preconditioning of the Indian Ocean Atmosphere in Advance of Convection



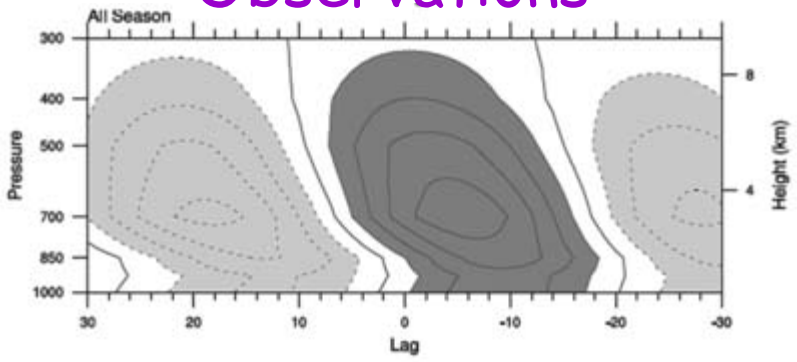
- The troposphere gradually moistens in advance of MJO convection
- Plot is generated from reanalysis data, and humidity field is constrained by the model

Benedict and Randall 2007

Increasing Sensitivity of Convection to Free Troposphere Humidity Improves Representation of MJO in A Climate Model (CAM3/RAS)

- Top model's convection very strongly tied to CAPE

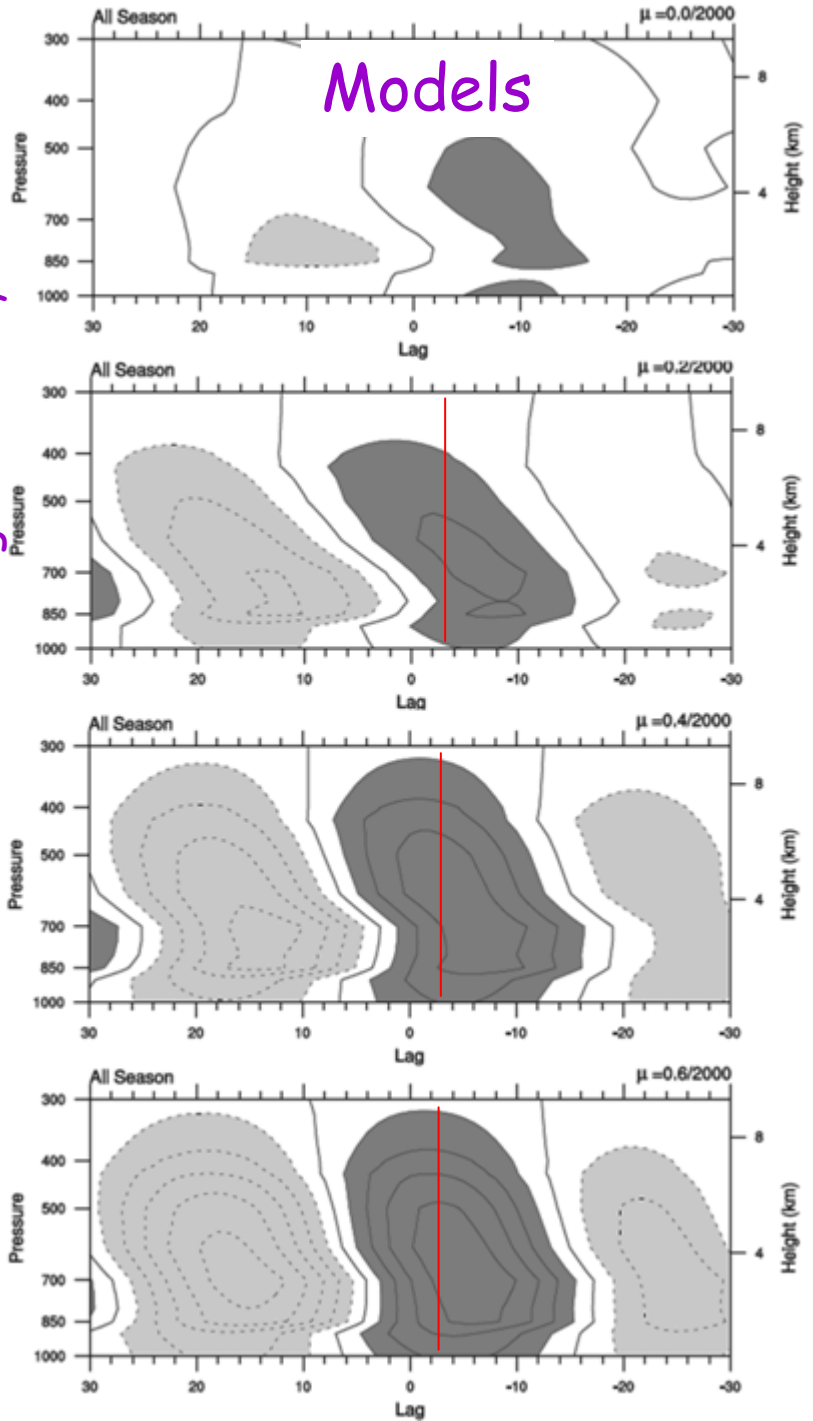
Observations



Hannah and Maloney (2009?)

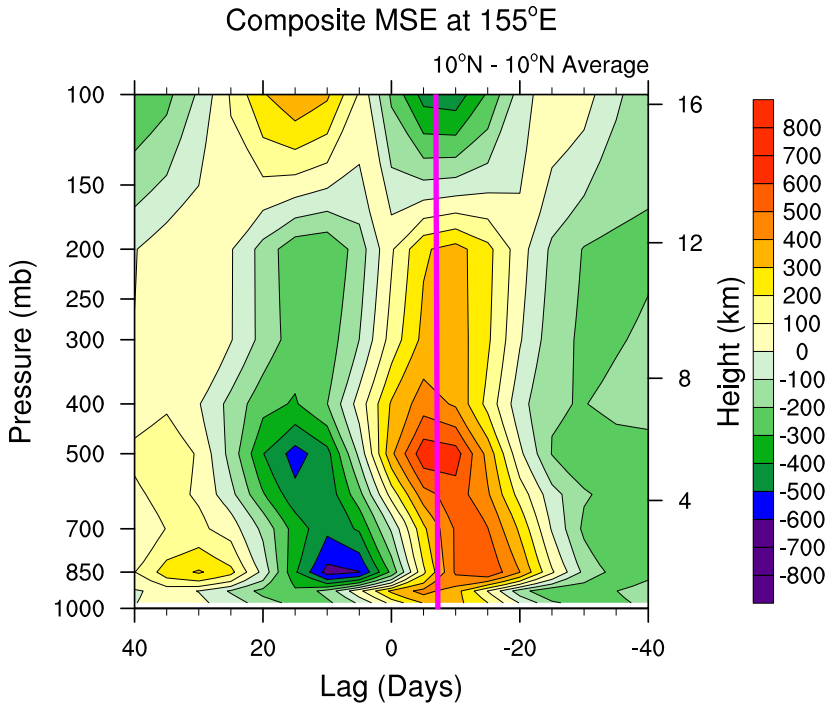
Models

Increasing sensitivity

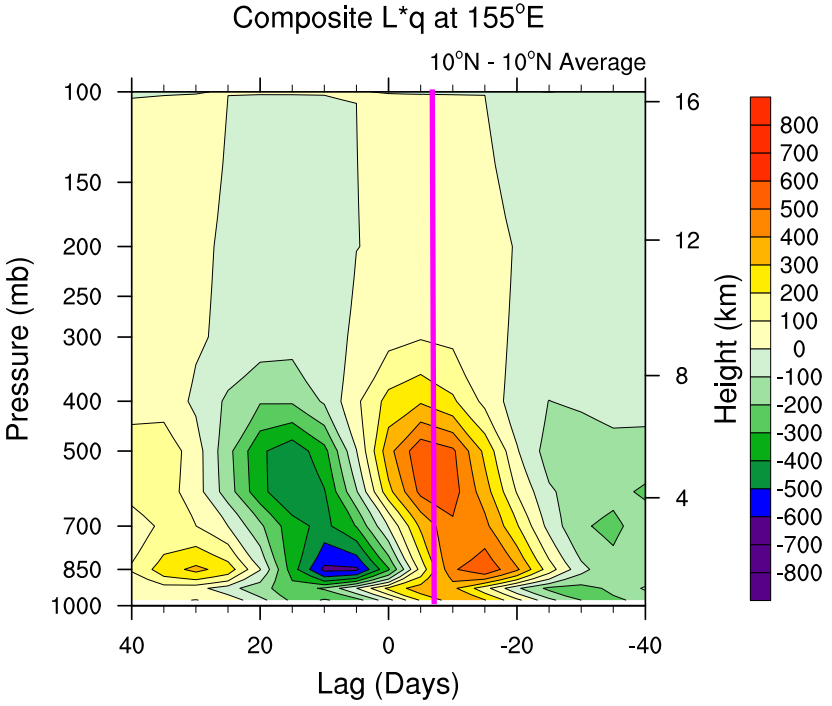


Moist Static Energy Anomalies, Vertical Structure

Moist Static Energy



Humidity Portion



Units: J kg^{-1}

$$m = c_p T + gz + Lq$$

What Contributes to Model Preconditioning? (Moist Static Energy Budget)

Vertical Integral

$$\left\langle \frac{\partial m}{\partial t} \right\rangle_{ISO} = -\left\langle \omega \frac{\partial m}{\partial p} \right\rangle_{ISO} - \langle \vec{v} \cdot \nabla m \rangle_{ISO} + LH_{ISO} + SH_{ISO} + \Delta SW_{ISO} + \Delta LW_{ISO}$$

30-90 Day Anom.

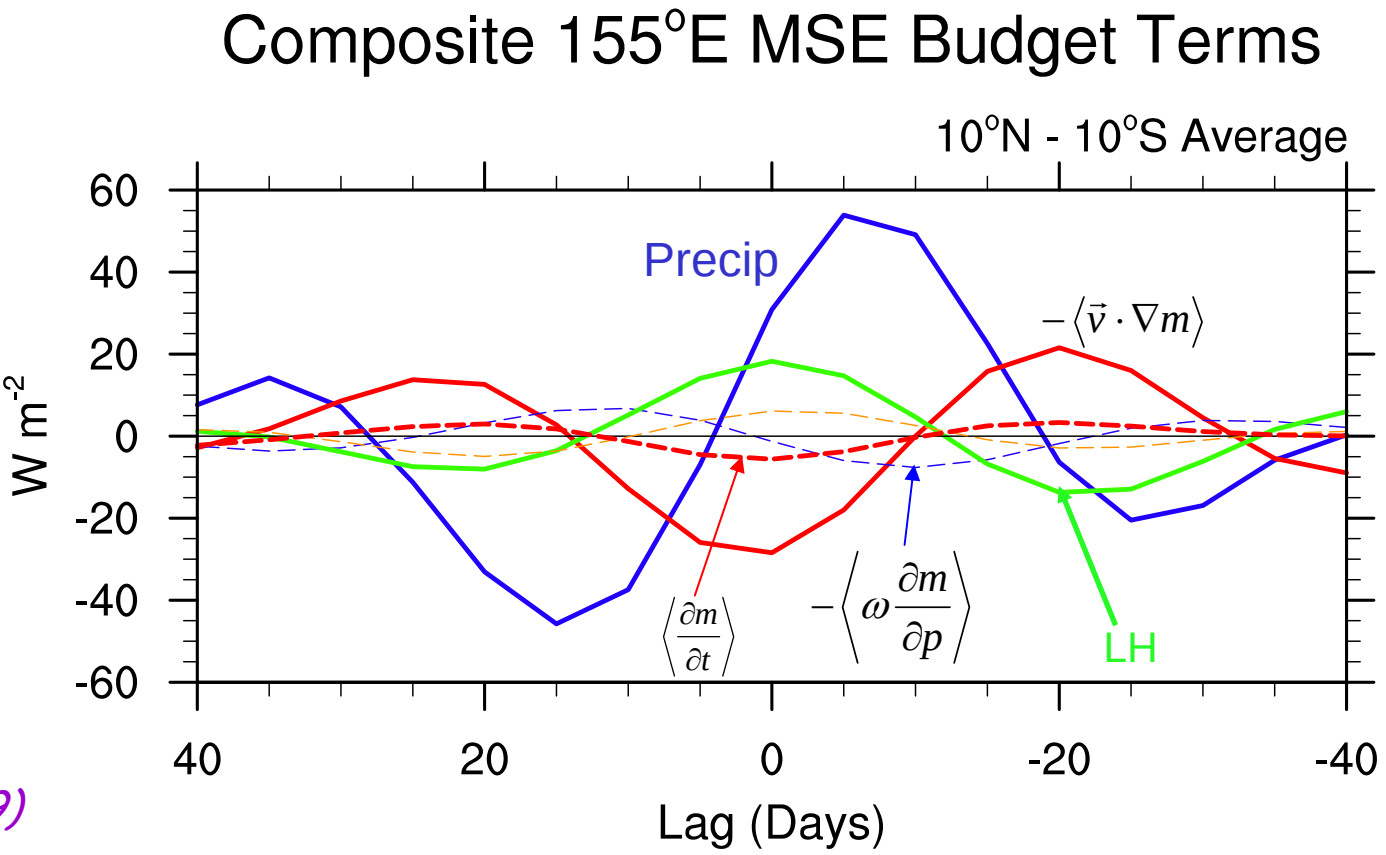
Vertical advection

Horizontal advection

Surface Latent and Sensible Heat Flux

Shortwave Flux Convergence

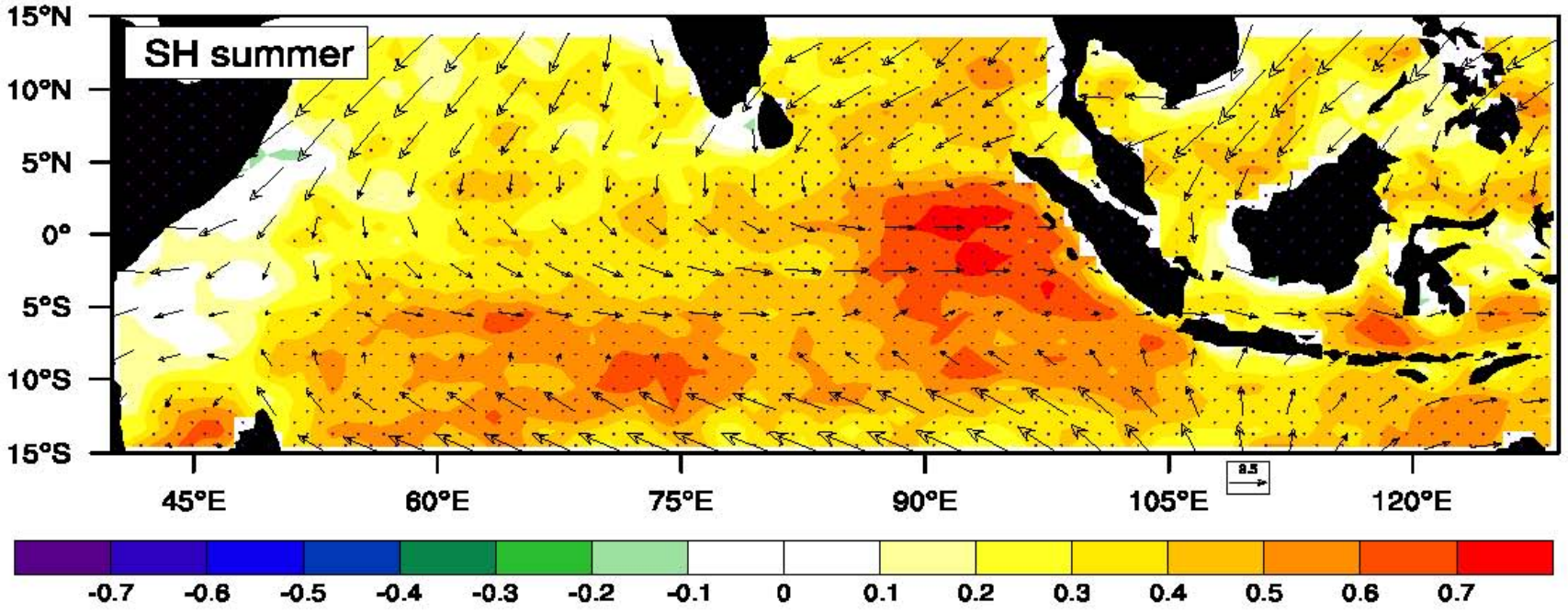
Longwave Flux Convergence



Maloney (2009)

Intraseasonal Wind Speed (QuikSCAT) vs. Precipitation (TRMM) Correlation

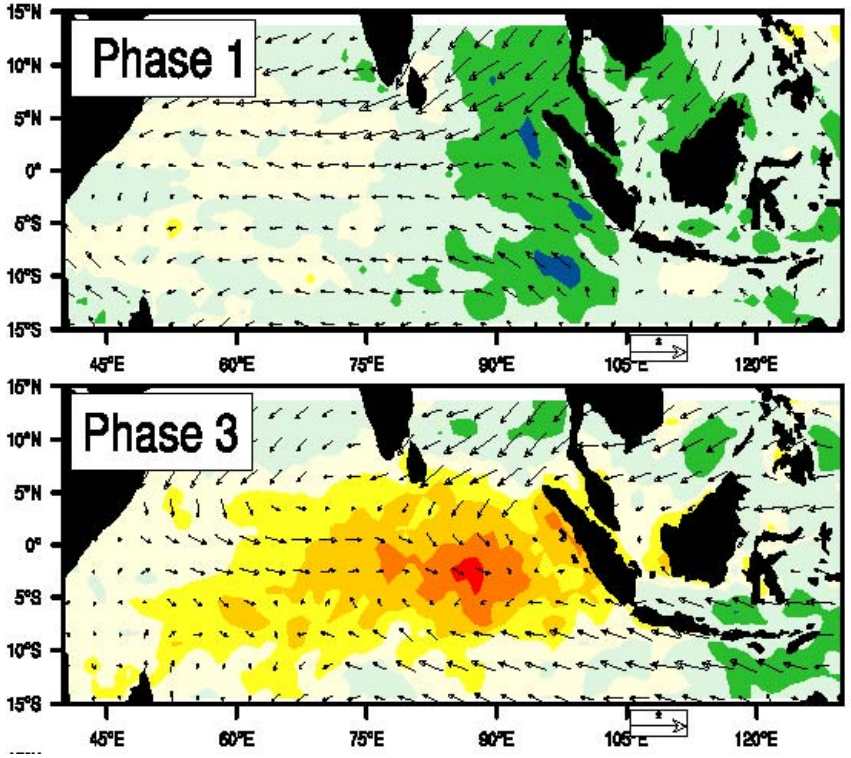
Correlation (with Mean Boreal Winter Winds)



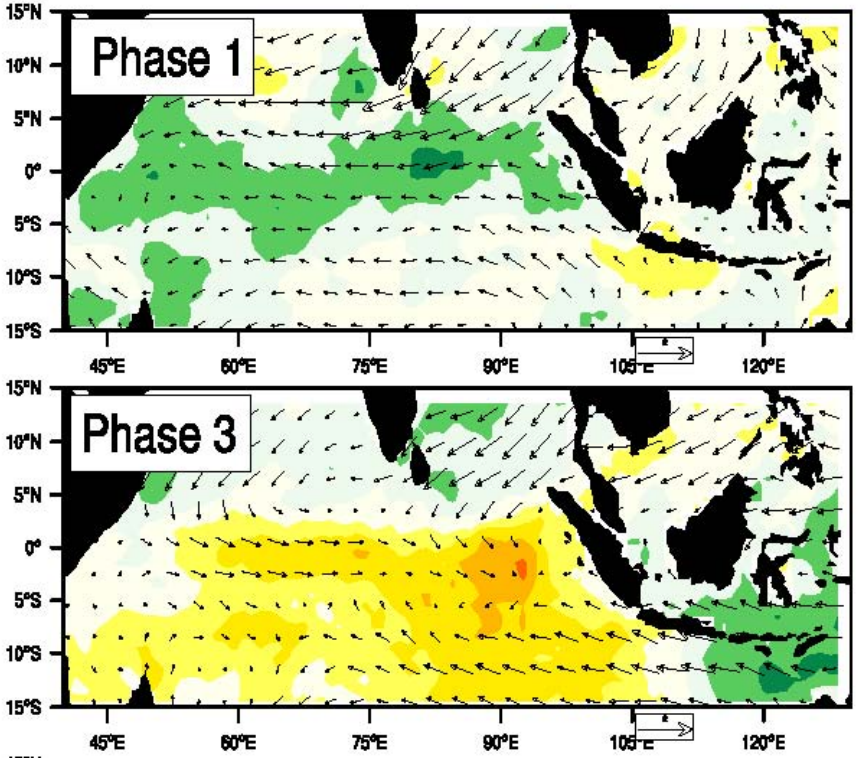
Araligidad (2007)

Suppressed Wind Speed Precedes Initiation of MJO in Indian Ocean

Precipitation/Wind



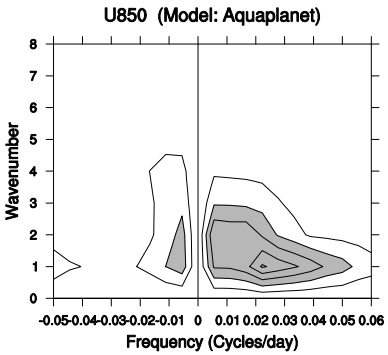
Wind Speed/Wind



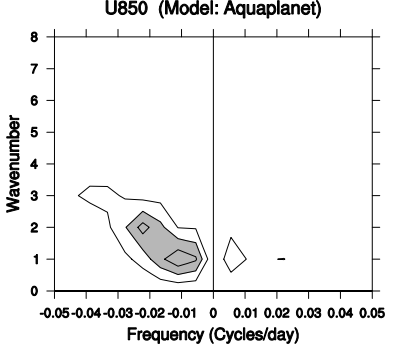
Araligidad (2007)

Changing the Basic State the Surface Fluxes Feel Can Change MJO Propagation Speed

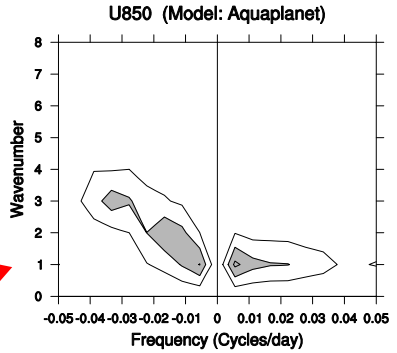
Realistic SST Distribution



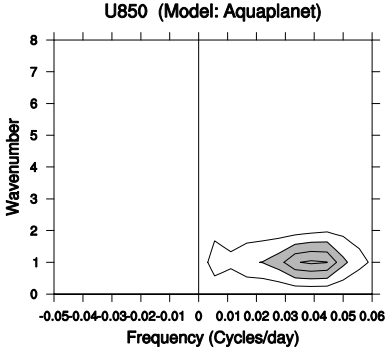
1) Strong westerly basic state perturbation (~6 m/s):



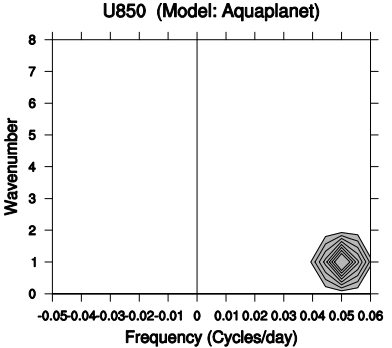
2) Feel a weaker westerly basic state perturbation (~3 m/s):



3) Aquaplanet easterly



4) Strong easterly basic state correction (~-4 m/s)



Key Questions on MJO Initiation That DYNAMO Might Be Able to Answer

- What combination of processes contribute to this buildup (or slow the buildup) of column moist static energy/humidity in advance of the initiation of MJO convection?
  - Vertical advection (e.g. shallow convection)
  - Horizontal advection
  - Surface Heat Fluxes
  - Contributing buildup of upper ocean heat content
- Why is the preconditioning timescale longer for the MJO than other convectively coupled disturbances?
- DYNAMO can aid development of convection parameterizations, which presently extinguish convective instability too early, and damp existing MJO events too quickly