Moisture Sensitivity Parameters and the MJO

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Motivation

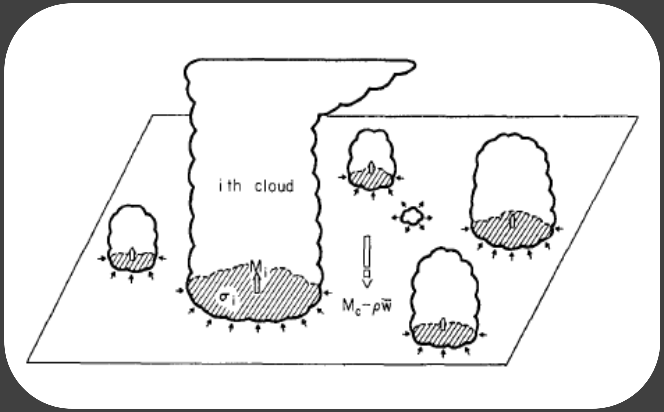
- Modifying a convection scheme so that moisture has a larger influence on convection tends to produce a stronger MJO in a GCM

  Tokioka et al. (1988) Wang and Schlesinger (1999);, Grabowski and Moncrieff (2004), Lin et al et al. (2008), Maloney (2009)

- Can comparing how various modifications affect a model reveal a common result that explains why they all produce a stronger MJO?

Relaxed Arakawa-Schubert

- Cloud heights are determined by their fractional entrainment rate
- Zero entrainment is allowed



Taken from Arakawa and Schubert (1974)

Sensitivity Parameters

- Minimum Entrainment Rate (Tokioka et al., 1988)
  - Cloud which require less entrainment than the minimum in order to exist are suppressed
  - The min. entrainment is constant throughout each simulation

$$\boxed{\mu = \frac{\alpha}{D}}$$

- Rain Evaporation Fraction (Sud and Molod, 1988)
  - This allows a set fraction of precipitation to be exposed to environment outside the cloud and evaporate depending on the conditions

Model Setup

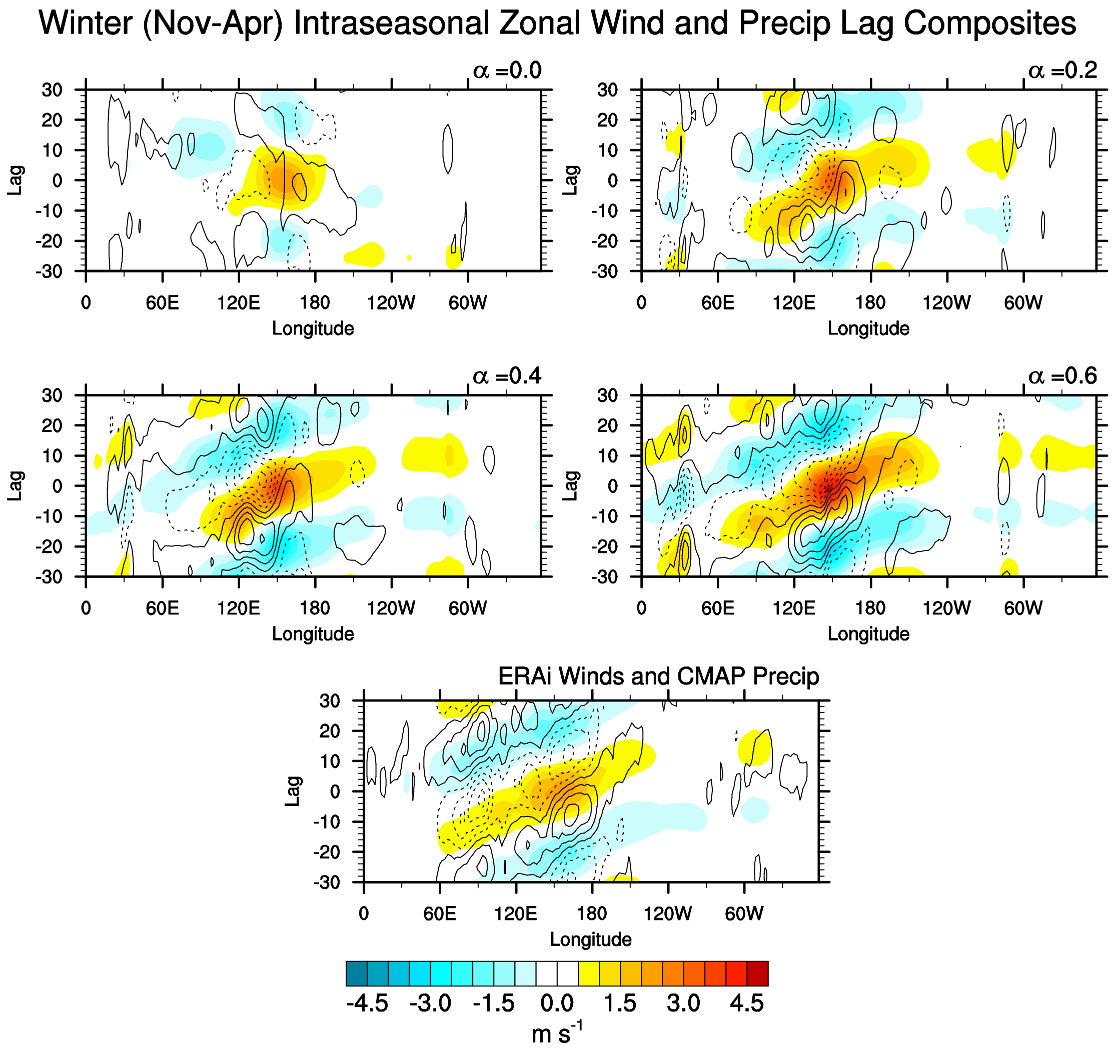
- NCAR CAM 3.1 with Relaxed Arakawa-Schubert (RAS) convection

- 4 separate 16 year simulations with various min. entrainment and a constant rain evaporation fraction of $\varepsilon = 0.3$
  - $\alpha = 0.0$
  - $\alpha = 0.2$
  - $\alpha = 0.4$
  - $\alpha = 0.6$

$$\boxed{\mu = \frac{\alpha}{D}}$$

- 2 additional simulations with varying rain evaporation fraction and constant minimum entrainment with $\alpha = 0.2$
  - $\varepsilon = 0.05$
  - $\varepsilon = 0.6$

Horizontal Structure

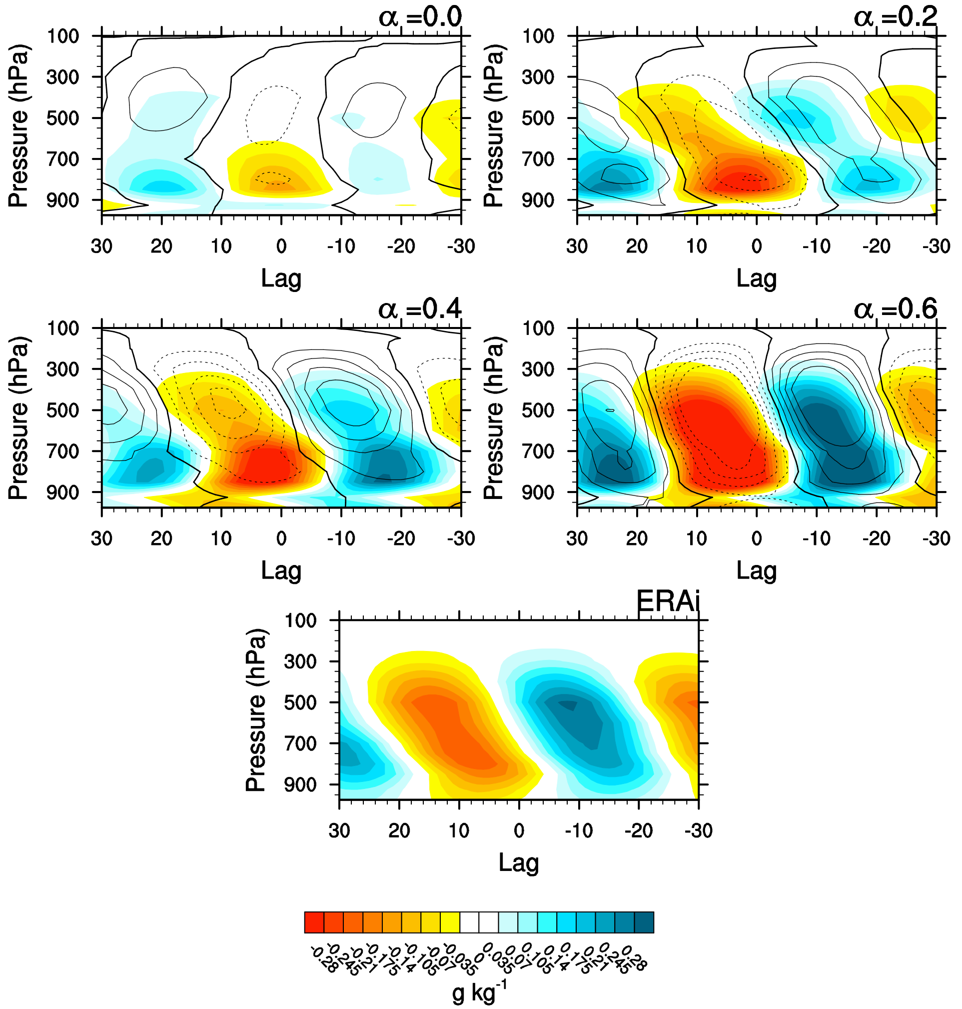


Winter (Nov-Apr) Intraseasonal Zonal Wind and Precip Lag Composites

ERAi Winds and CMAP Precip

Vertical Structure

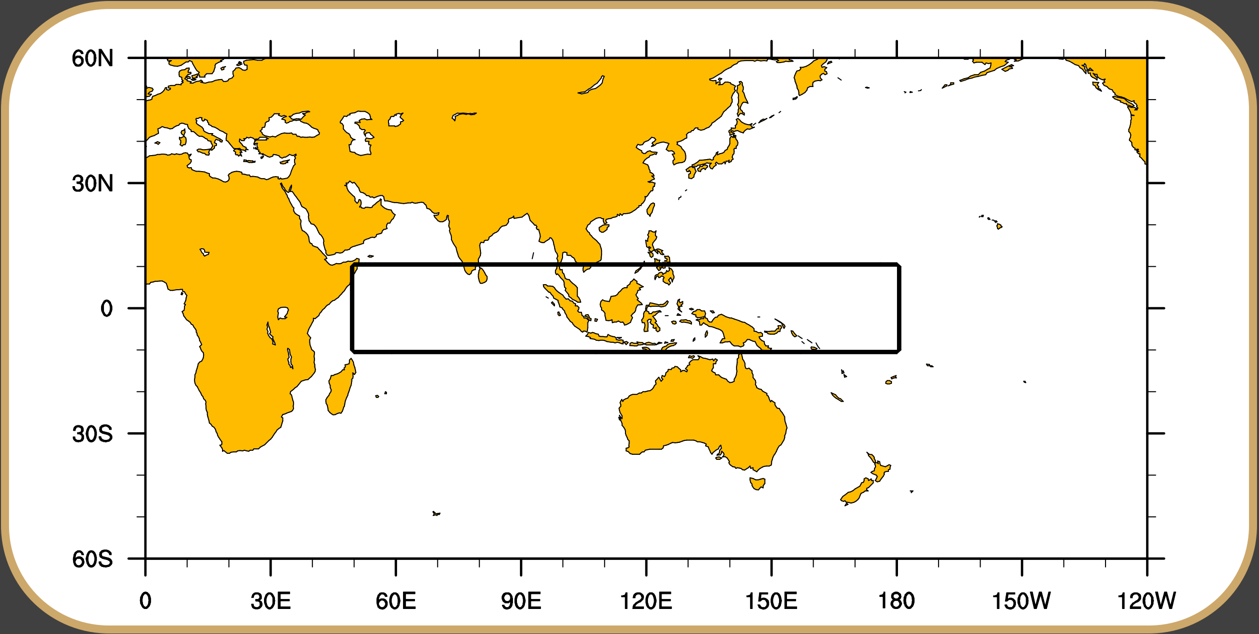
Winter (Nov-Apr) Filtered Specific Humidity and Diabatic Heating Lag Composite



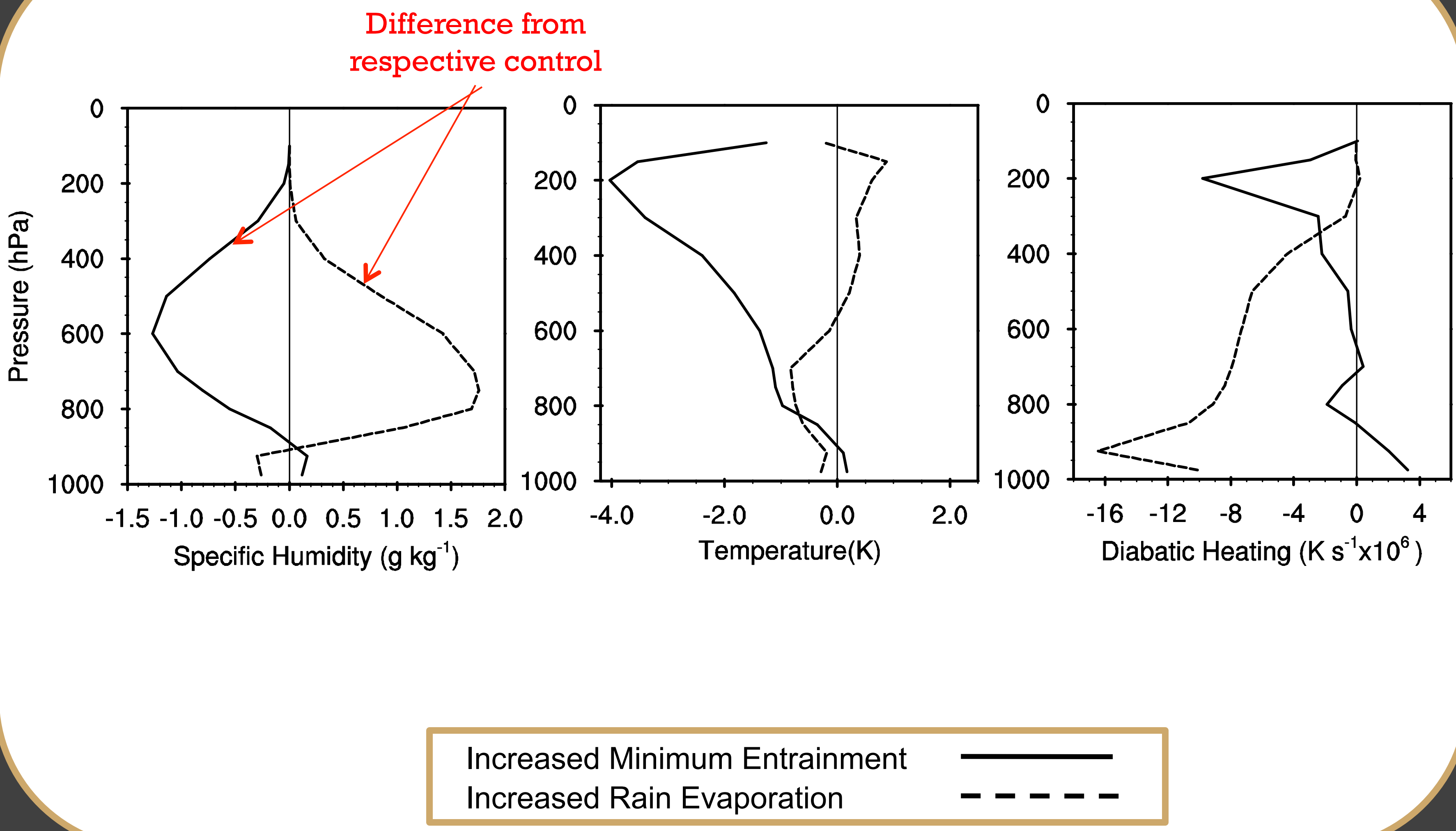
Process Oriented Diagnostics

- The following figures aim to uncover the main mechanism by which the moisture sensitivity parameters lead to increased intraseasonal variance and a more coherent MJO

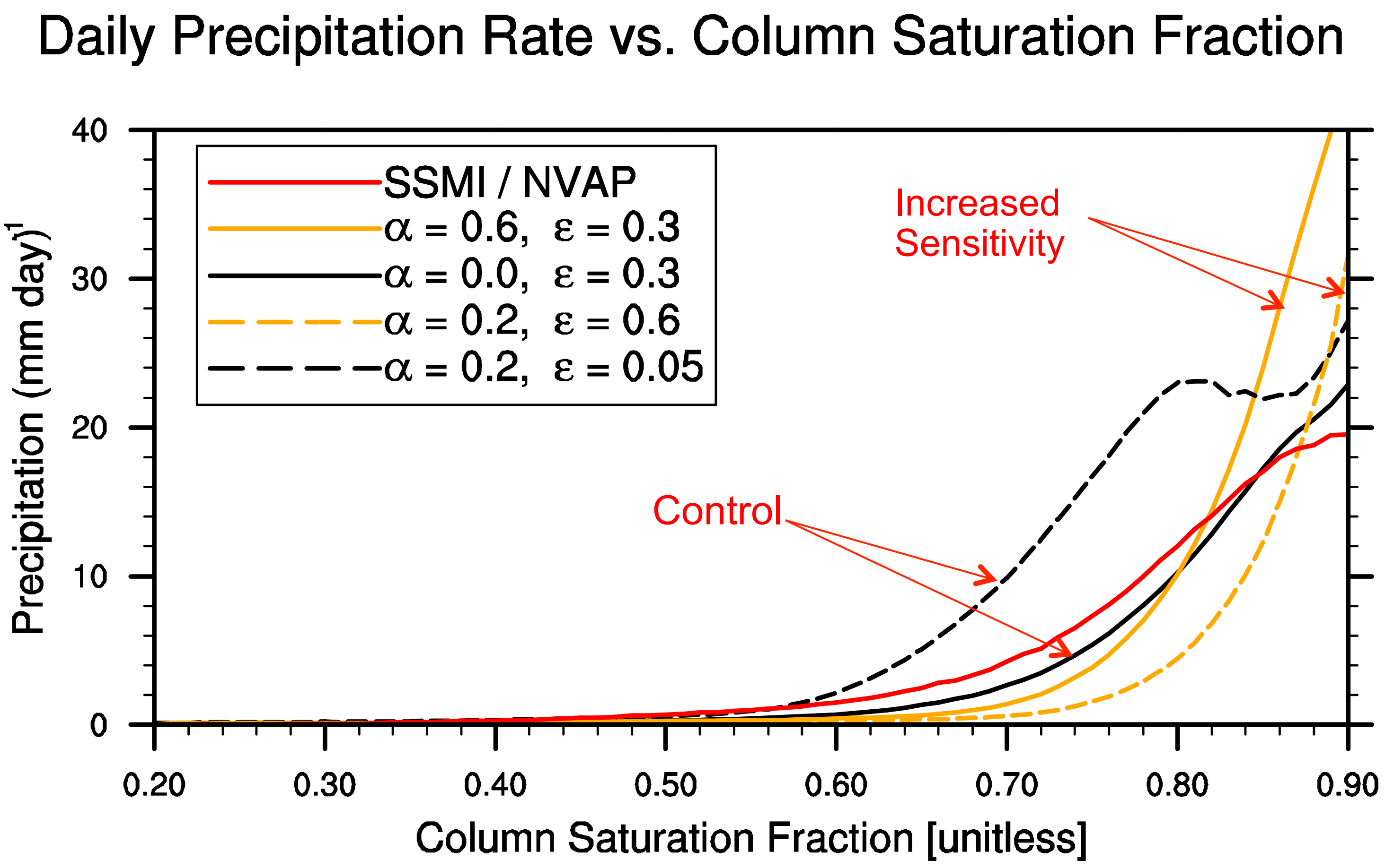
- Figures were generated using data for the Indo-Pacific warm pool region (10N - 10S and 50 - 180E)



Changes to the Mean State


Difference from respective control

Rain Rate vs. SF



MSE Export

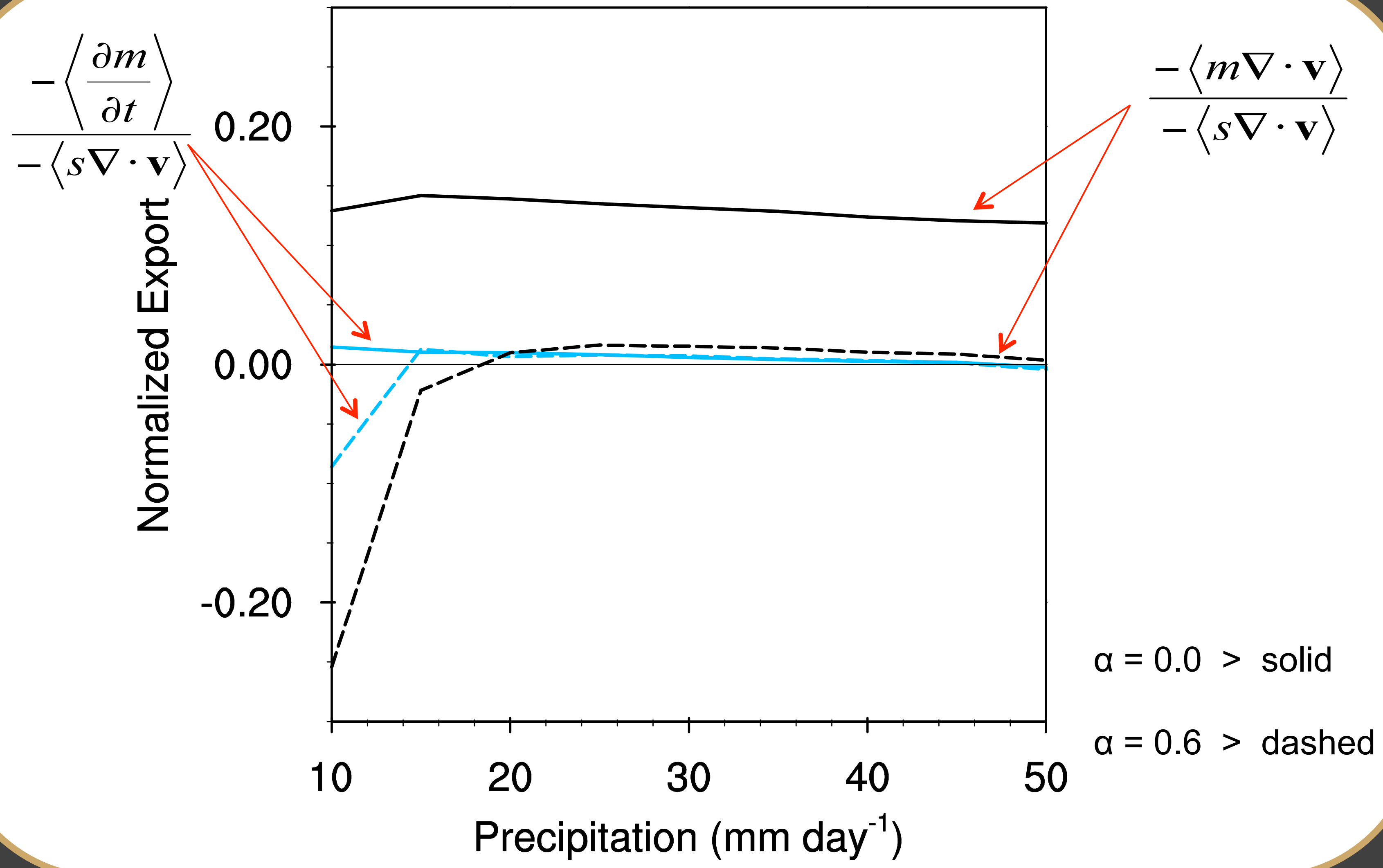
- The vertically integrated MSE budget

$$\left\langle \frac{\partial m}{\partial t} \right\rangle = -\langle m\nabla\cdot\mathbf{v}\rangle - \langle \mathbf{v}\cdot\nabla m\rangle + LH + SH + \langle LW\rangle + \langle SW\rangle$$

- Terms are normalized by the Dry Static Energy (DSE) export by vertical motions to give dimensionless quantities which are relevant to theories of precipitation

$$-\langle s\nabla\cdot\mathbf{v}\rangle$$

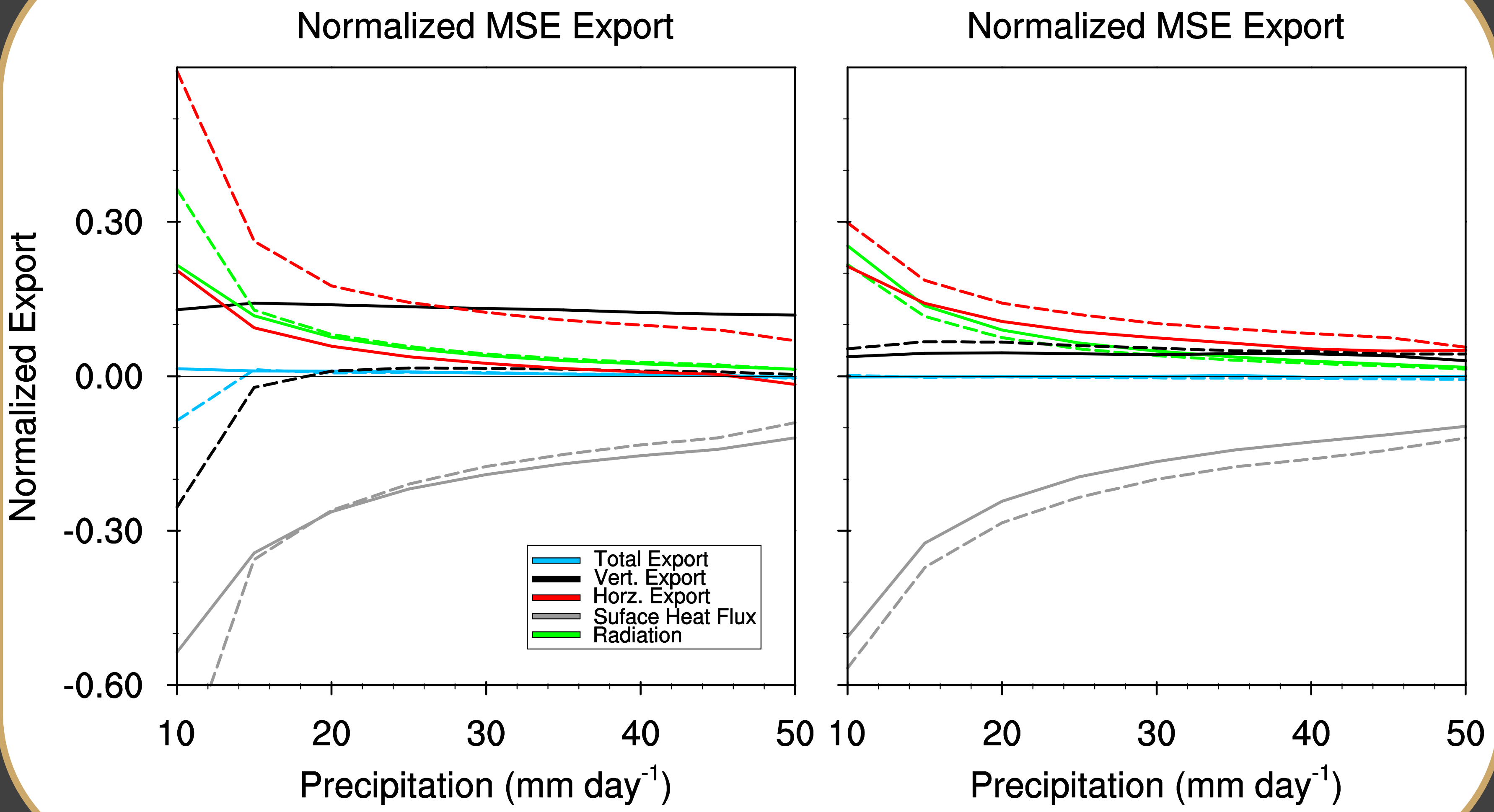
MSE Export



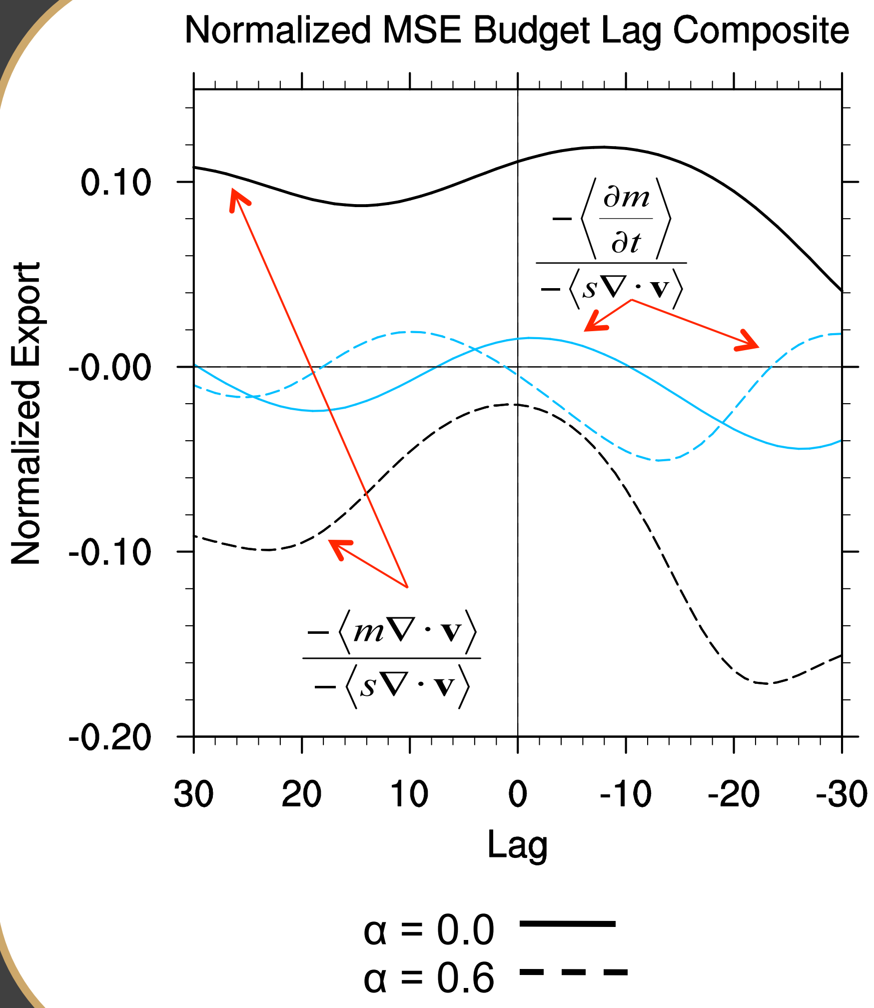
α = 0.0 > solid

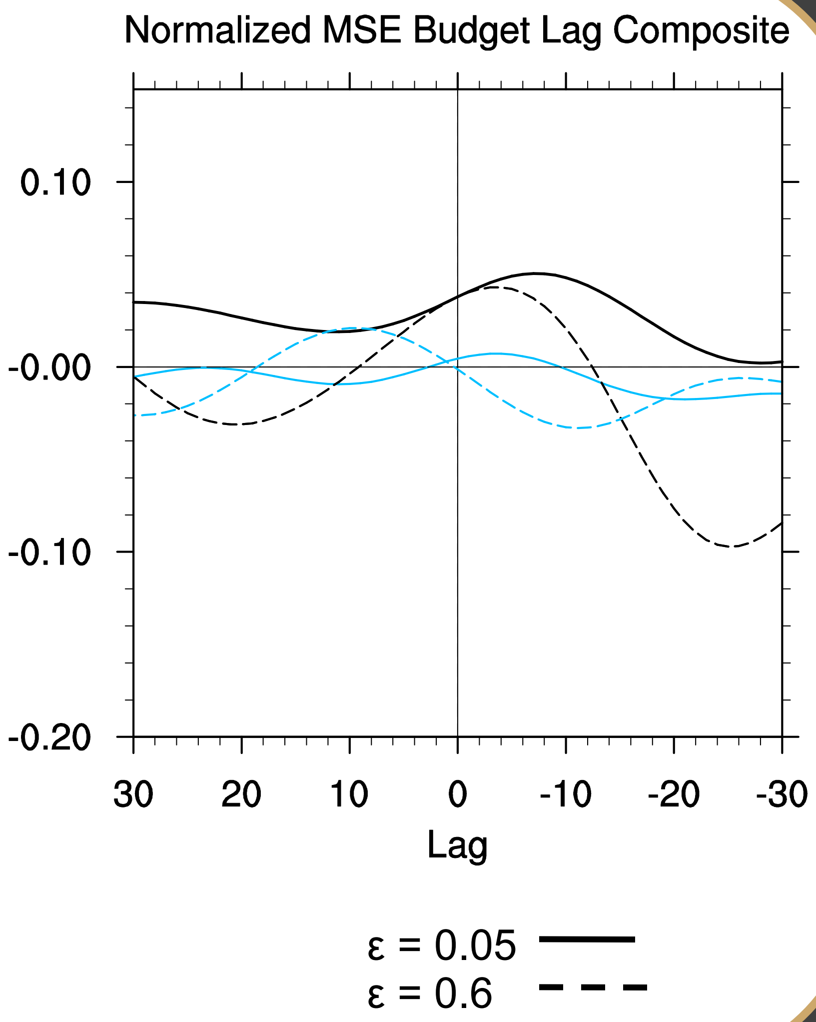
α = 0.6 > dashed

MSE Export


Normalized MSE Export
Normalized MSE Export
Normalized Export
0.30
0.00
-0.30
-0.60
10
20
30
40
50
Precipitation (mm day^{-1})
Total Export
Vert. Export
Horz. Export
Suface Heat Flux
Radiation

MSE Export


Normalized MSE Budget Lag Composite


Normalized MSE Budget Lag Composite

Conclusions

- The mean humidity may not be as crucial to the MJO as some studies suggest given that both parameters result in an enhanced MJO signal and different mean states

- The ability to achieve negative GMS seems to be a good diagnostic as to whether a model can produce an MJO (Raymond et al., 2009), but the fluctuations of GMS appear more useful than the mean