YOTC MJO Task Force

Official name:

WCRP/WWRP-THORPEX YOTC MJO Task Force

Overall goal:

Facilitate improvements in the representation of the MJO in weather and climate models in order increase the predictive skill of the MJO and related weather and climate phenomena.

Members:

Duane Waliser (co-chair)	Matt Wheeler (co-chair)
Ken Sperber	Harry Hendon
Eric Maloney	Xiouhua Fu
John Gottschalck	Richard Neale
Chidong Zhang	Daehyun Kim
Augustin Vintzileos	Frederick Vitart
Dave Raymond	Masaki Satoh
Hai Lin	

Task Force Activities

1. Further development and promotion of process-oriented diagnostics/metrics that improve insight into the physical mechanisms for robust simulation/prediction of the MJO and that facilitate improvements in convective and other physical parameterizations relevant to the MJO.

2. Develop, coordinate, and promote analyses of the multi-scale interactions that are a critical component of the MJO, both in observations and by exploiting recent advances in high-resolution modeling frameworks, with particular emphasis on vertical structure and diabatic processes.

Task Force Activities

3. Promote the ongoing evaluation of real-time MJO forecasts. Expand efforts to develop and implement MJO forecast metrics under operational conditions, including a boreal summer focus and multi-model ensemble development.

4. Develop an experimental modeling framework (e.g.,hindcast experiment/dataset) to assess MJO predictability as well as forecast skill of the MJO and closely related phenomena from contemporary/operational models.

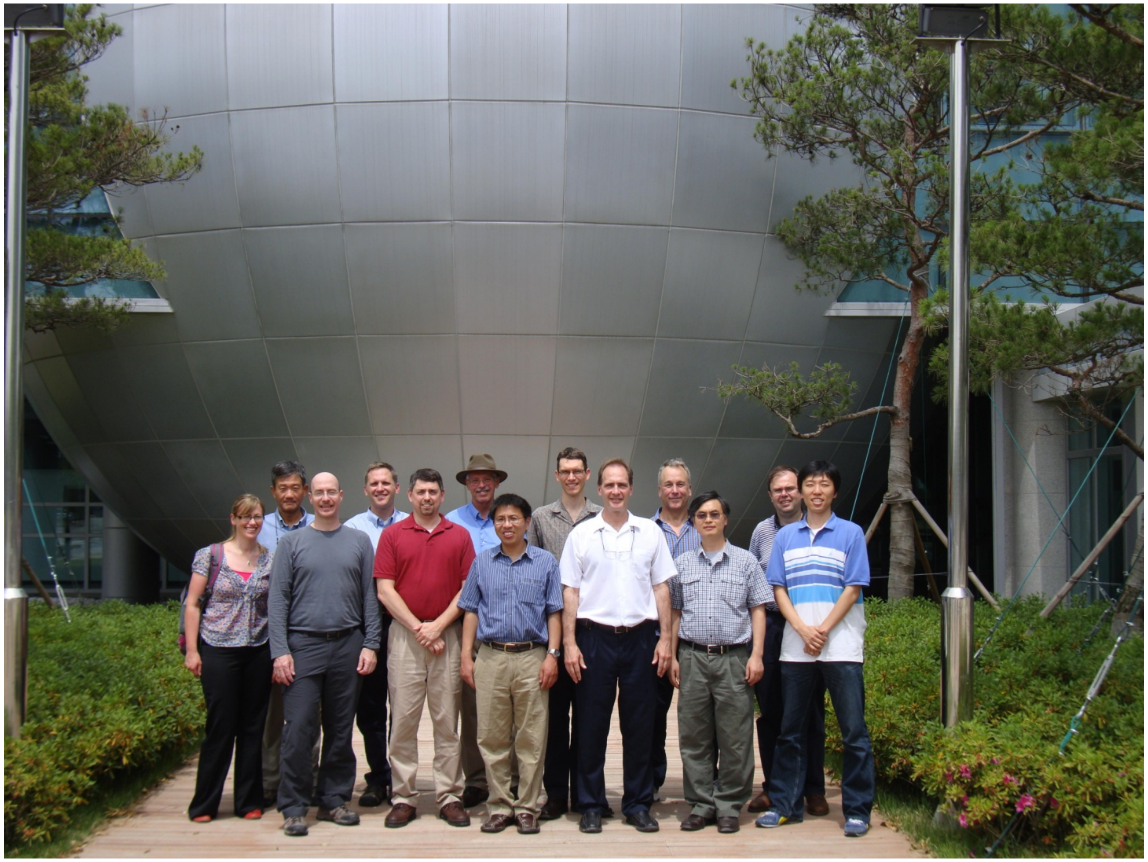
Task Force Activities

5. Interact with the proposed activity to simulate monsoon ISOs under the WCRP monsoon cross cut activity, including application of MJO diagnostics to outputs and integration of these simulations with the overall MJO experimental modeling framework.

6. Organize workshops and meetings of opportunity to further the work of the Task Force

First Meeting: Monsoon Intraseasonal Variability Modeling Workshop June 14-18, 2010 in Busan Korea

- Organized by CLIVAR AAMP and YOTC MJO Task Force
- APEC Climate Center



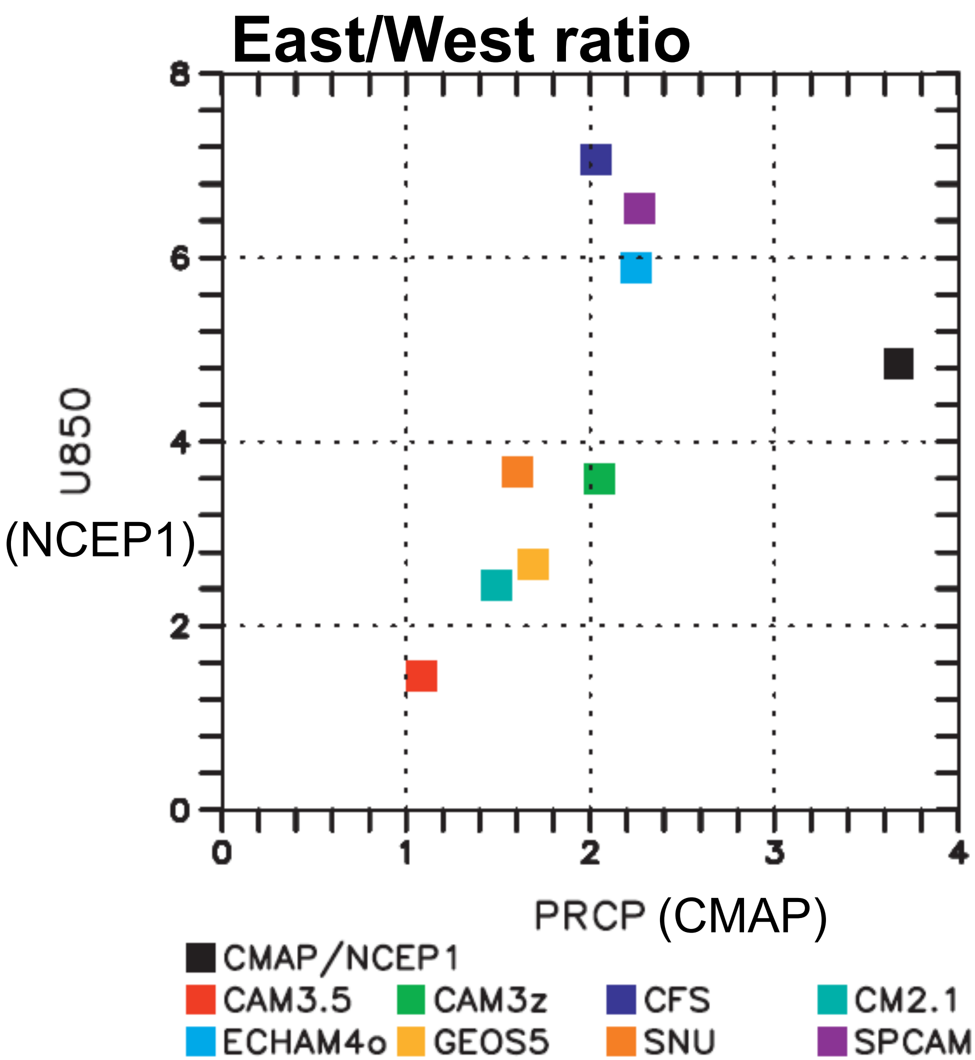
First Meeting: Monsoon Intraseasonal Variability Modeling Workshop June 14-18, 2010 in Busan Korea

Development of process-oriented diagnostics for GCM simulation of the MJO

Process-oriented diagnostics sub-group of MJO TF

Harry Hendon, Daehyun Kim, Eric Maloney, Richard Neale,
David Raymond, Duane Waliser, Chidong Zhang

Legacy of CLIVAR MJO Working Group: MJO Diagnostics



Kim et al. (2009)

- Does a model produce a good MJO or not?
- However, what determines difference between models?

Motivations

- CLIVAR MJO WG developed diagnostics that makes it possible to diagnose the MJO in order to assess simulation and track improvements (e.g. amplitude):
- We can say confidently whether one model simulates the MJO and another doesn't but we need diagnostics that provide insight as to why
- Need to develop diagnostics that focus on physical processes of relevance to the MJO so as to deepen understanding of simulation and promote improved simulation
- Provide physical insight and ideas of how parameterization should be improved for better MJO in a climate model

Initial diagnostics

- **Precipitation vs. Saturation fraction** (originally Bretherton et al 2004; Zhu et al. 2009; Maloney et al. 2010) bin rainfall into sat frac bins

- **Composite/bin based on precipitation or some other measure of convection** (Thayer-Calder and Randall 2009, Kim et al. 2009, Zhu et al. 2009)
  - relative humidity, temperature, specific humidity, diabatic heating, moistening, cloud liquid/ice water, convergence, changes in PW, MSE export.

- **Composite based on MJO index** (doesn't work if no MJO; Maloney et al. 2010, Tian et al. 2010, Jiang et al. 2010, Ling and Zhang 2010)
  - Maloney et al.: moist static energy budget : horizontal/vertical advection, surface flux, radiative heating
  - Tian et al.: temperature and specific humidity anomaly
  - Jiang et al.: cloud liquid/ice water
  - Ling and Zhang : diabatic heating
  - Momentum budget

complexity

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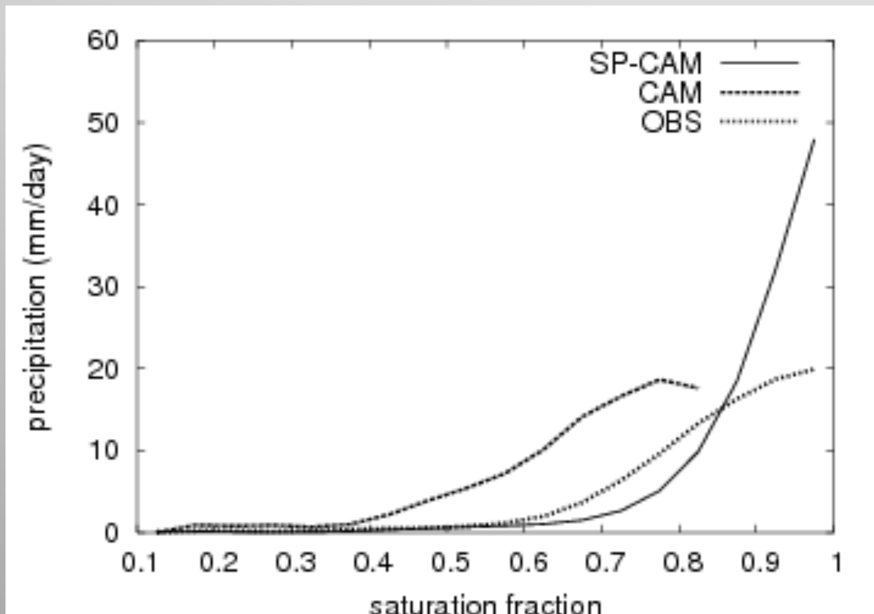
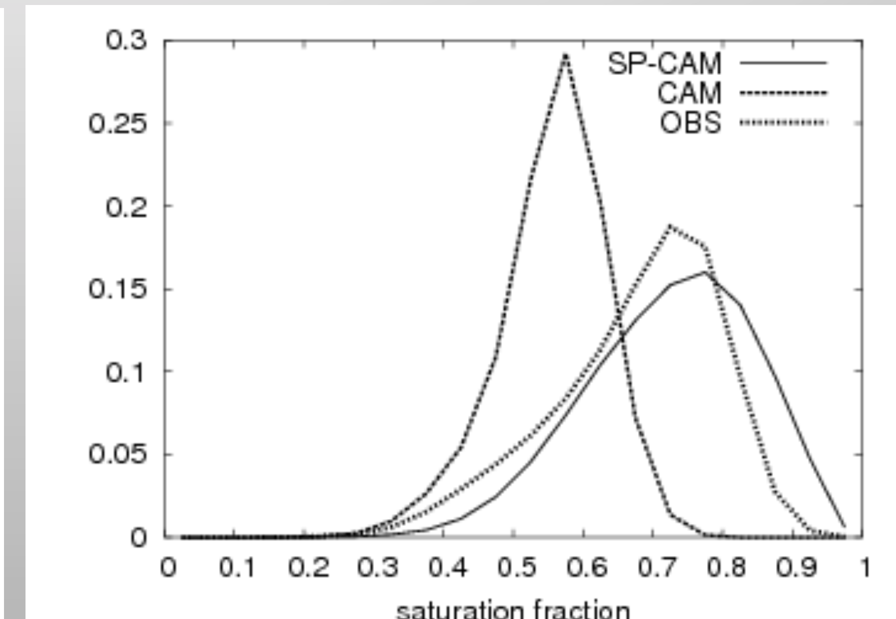
Precipitation vs. Saturation fraction



PDF of saturation fraction



CAM vs. SPCAM
(Zhu et al. 2009)

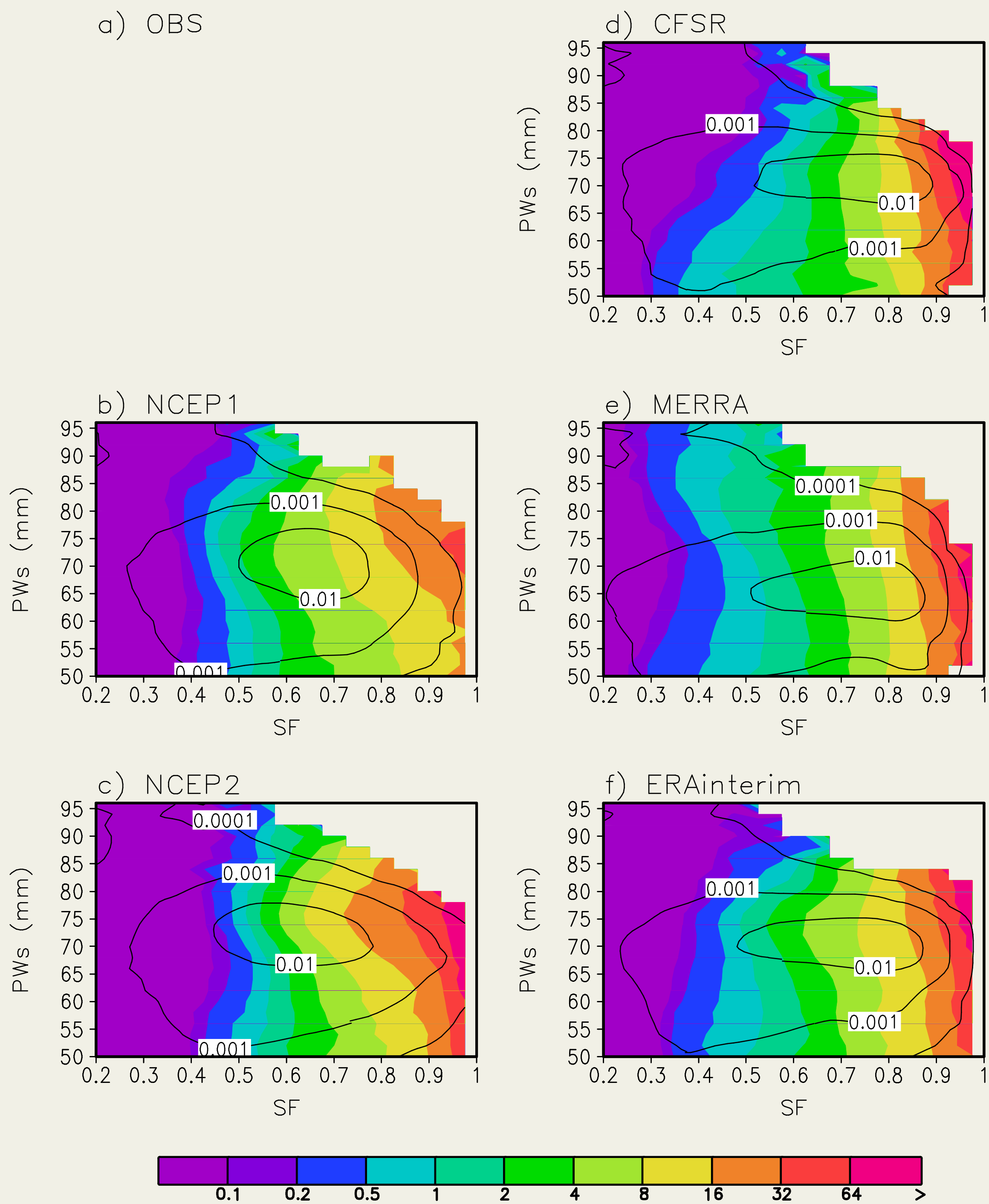


Figure. Composite precipitation (mm day^{-1}, shaded) based on saturation fraction and saturation precipitable water, and joint probability density function (unitless, contoured) of saturation fraction and saturation precipitable water. a) observation, b) NCEP1, c) NCEP2, d) CFSR, e) MERRA, and f) ERAinterim. The data is analyzed over 40-180^{o}E, 20^{o}S-20^{o}N.

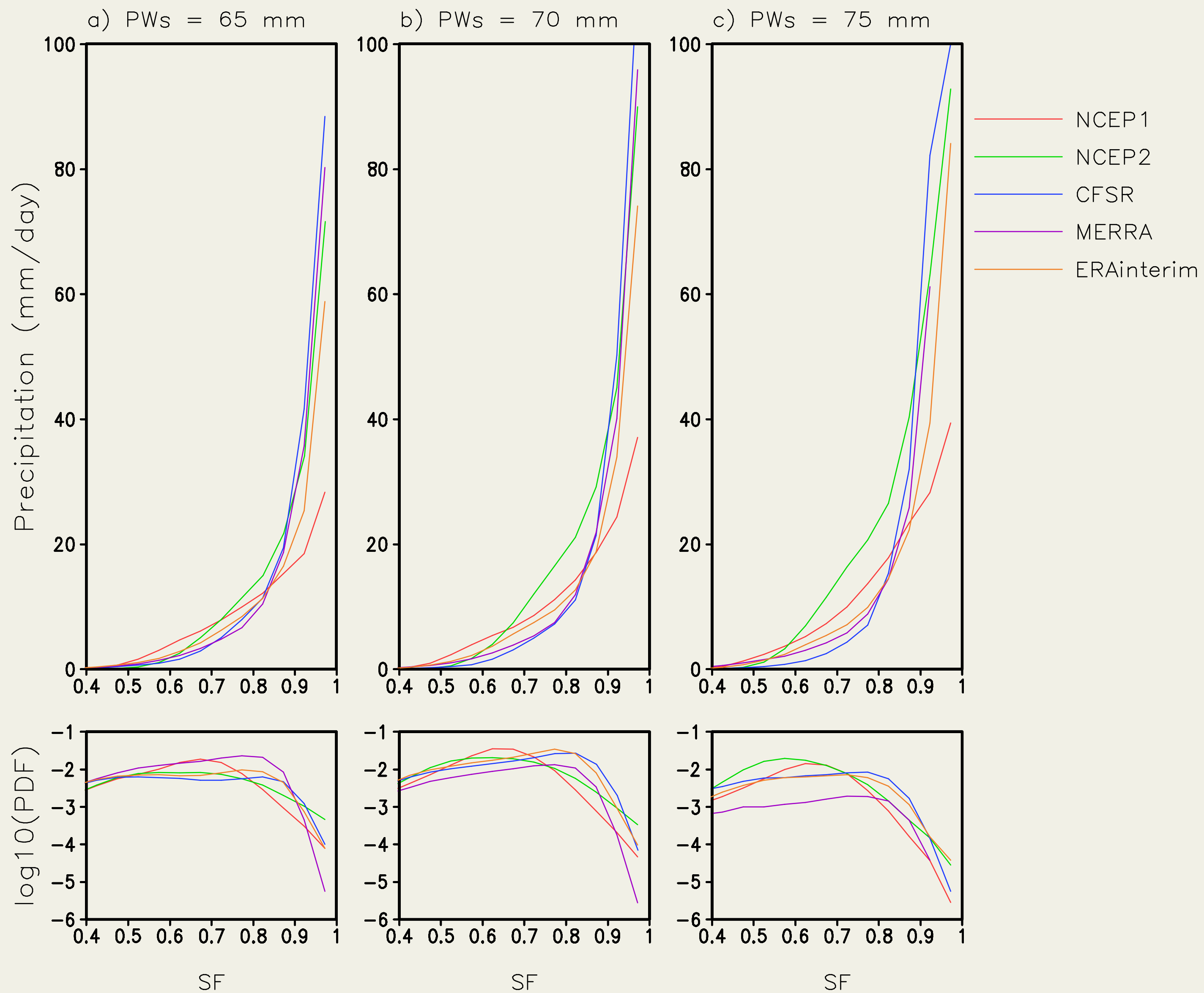


Figure. Composite precipitation (mm day^{-1}, upper) based on saturation fraction (SF) for different regime of sa turation precipitable water (PWs), and joint PDF (unitless, lower) of SF and PWs. a) PWs=65mm, b) PWs=70 mm, and c) PWs=75mm. The data is analyzed over 40-180^{o}E, 20^{o}S-20^{o}N.♪

Initial diagnostics

- **Precipitation vs. Saturation fraction** (Zhu et al. 2009, Maloney et al. 2010)

- **Composite/bin based on precipitation or some other measure of convection** (Thayer-Calder and Randall 2009, Kim et al. 2009, Zhu et al. 2009,)
  - relative humidity, temperature, specific humidity, diabatic heating, moistening, cloud liquid/ice water, convergence, changes in PW, etc.

- **Composite based on MJO index** (Maloney et al. 2010, Tian et al. 2010, Jiang et al. 2010 , Ling and Zhang 2010)
  - Maloney et al.: moist static energy budget : horizontal/vertical advection, surface flux, radiative heating
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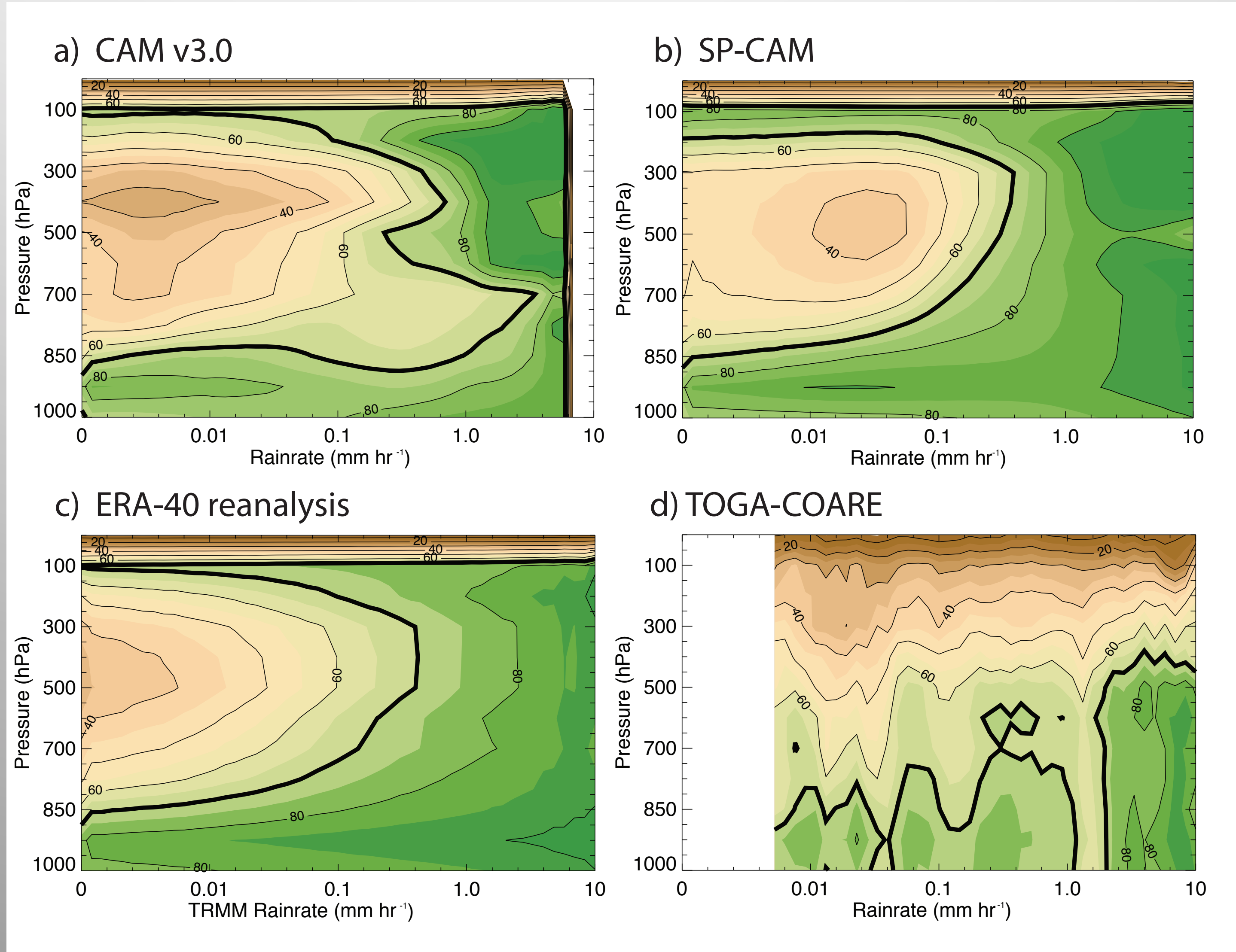
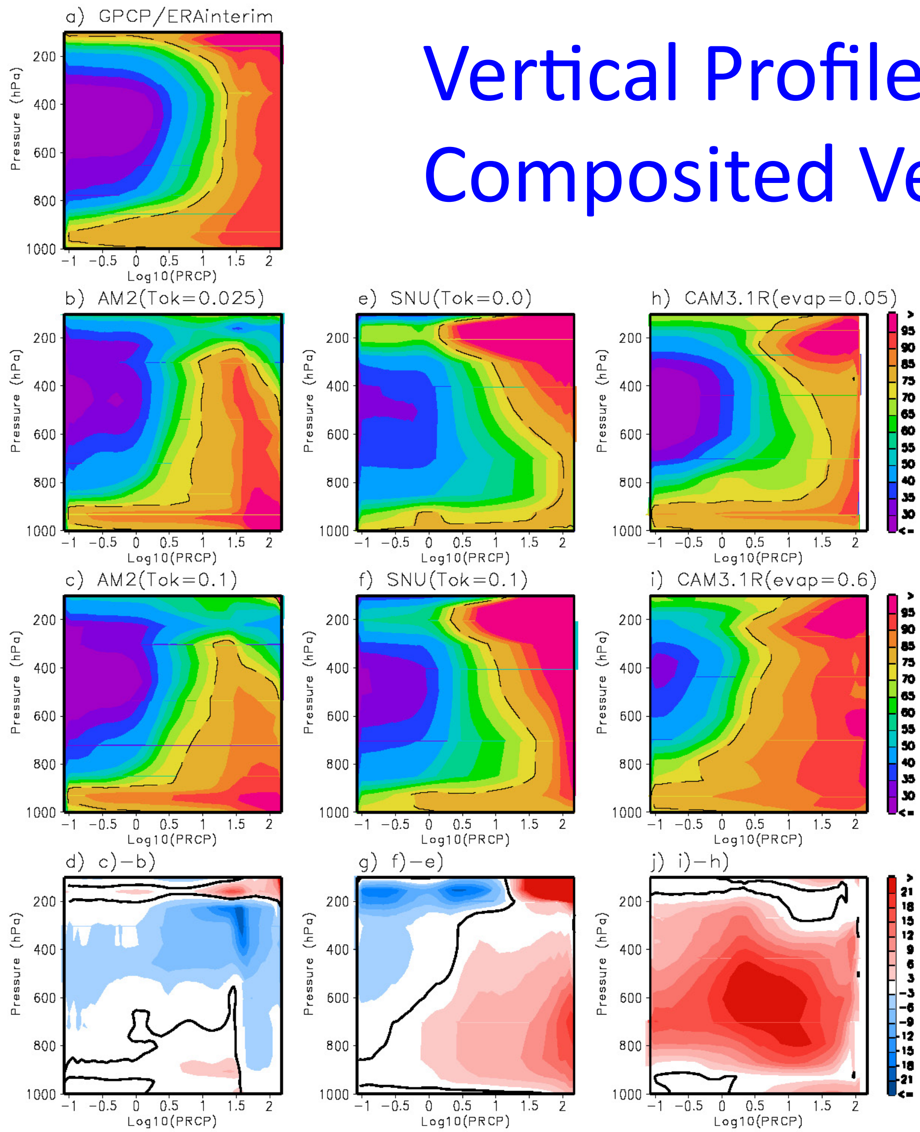
Relative Humidity Profiles



CAM vs. SPCAM
(Thayer-Calder and Randall 2009)

Vertical Profile of Relative Humidity Composited Versus Precipitation



Weak ISV Models

Strong ISV Models

Figure 11. Composite vertical profile of relative humidity based on precipitation rate a) GPCP/ERAinterim, b) AM2 (Tok=0.025), c) AM2 (Tok=0.1), e) SNU (Tok=0.0), f) SNU (Tok=0.1), h) CAM3.1R (evap=0.05), and i) CAM3.1R (evap=0.6). Difference between strong- and weak-ISV models are shown in d) AM2, g) SNU, and j) CAM3.1R. The precipitation rate is plotted on a log scale with the relative humidity averaged for each bin shown on the x-axis. The data is analyzed over 40-180°E, 20°S.-20°N.

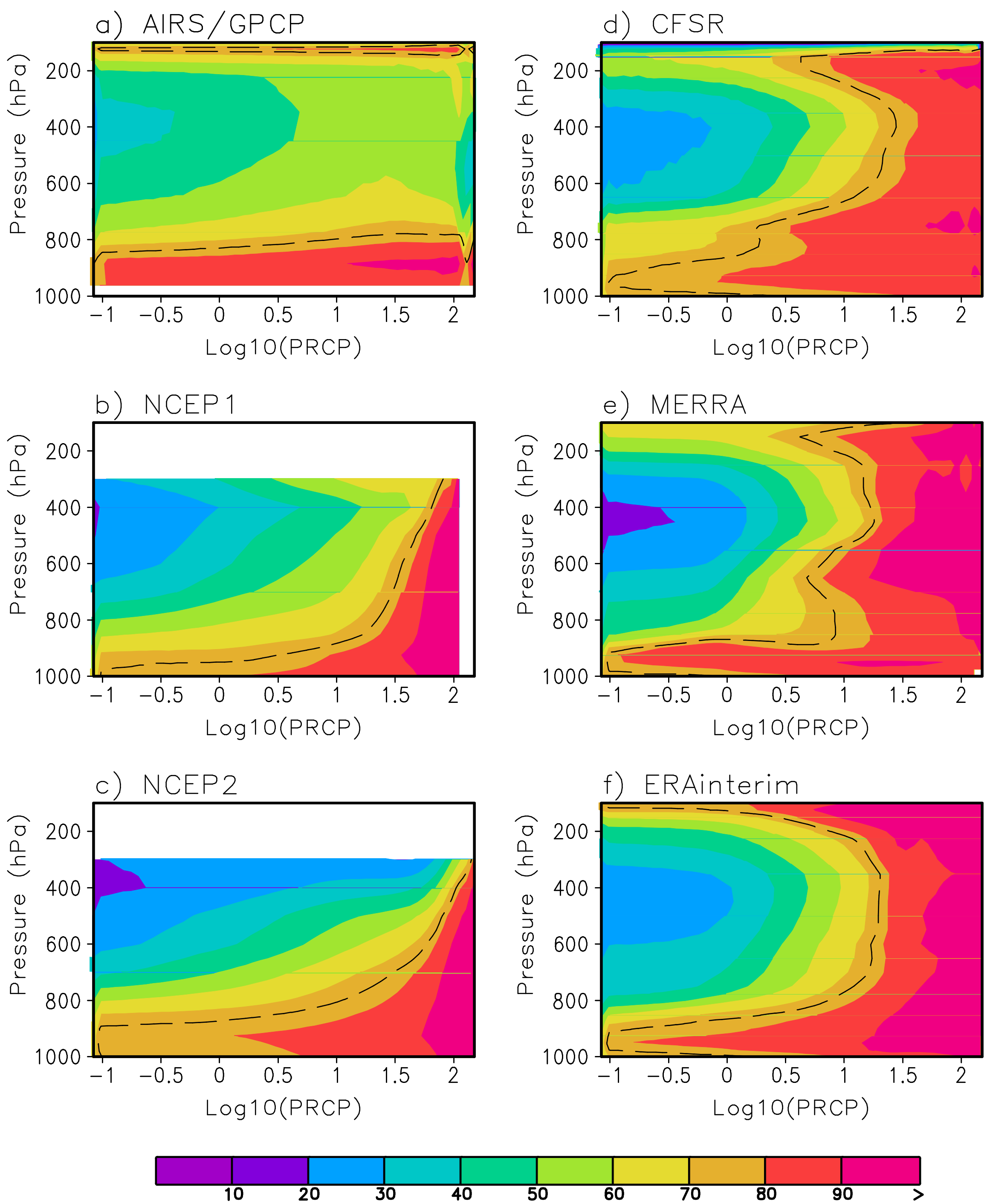


Figure. Composite vertical profile of relative humidity based on precipitation rate a) AIRS/GPCP, b) NCEP1, c) NCEP2, d) CFSR, e) MERRA, and f) ERAinterim. The precipitation rate is plotted on a log scale with the relative humidity averaged for each bin shown on the x-axis. The data is analyzed over 40-180°E, 20°S-20°N.

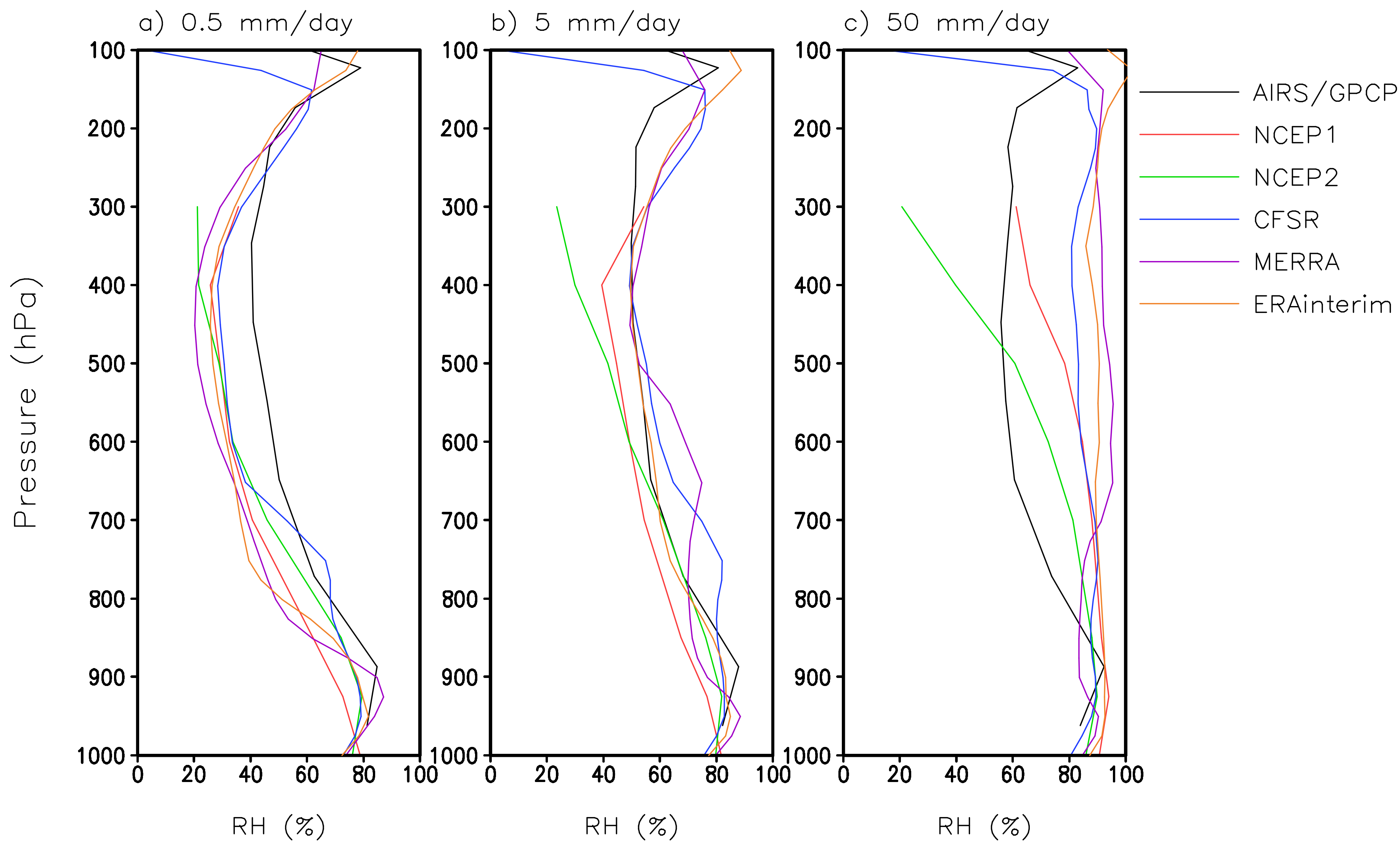


Figure. Averaged vertical profile of relative humidity when precipitation rate is near a) 0.5, b) 5, and c) 50 m m/day. The data is analyzed over 40-180°E, 20°S-20°N.

Column-Integrated Moist Static Energy Advection Binned by Some Measure of Convective Activity

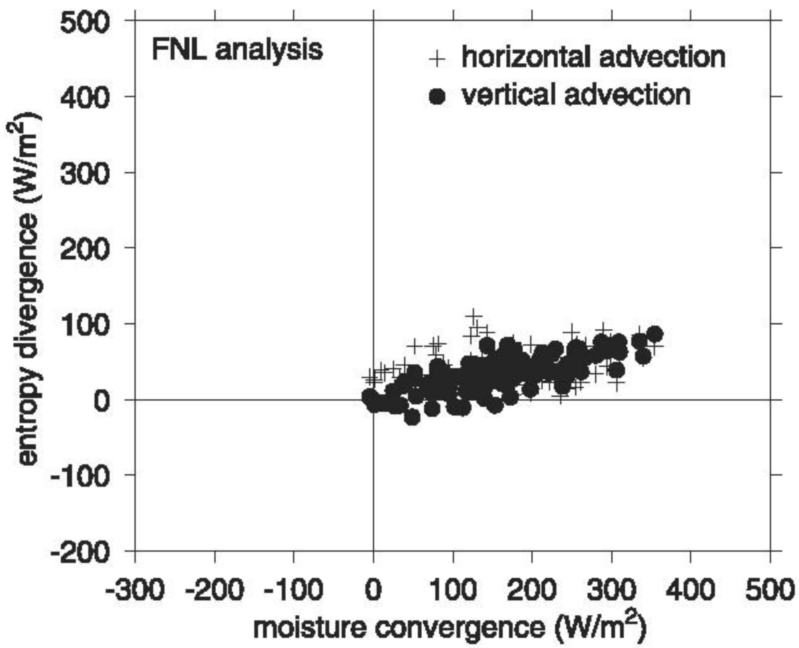
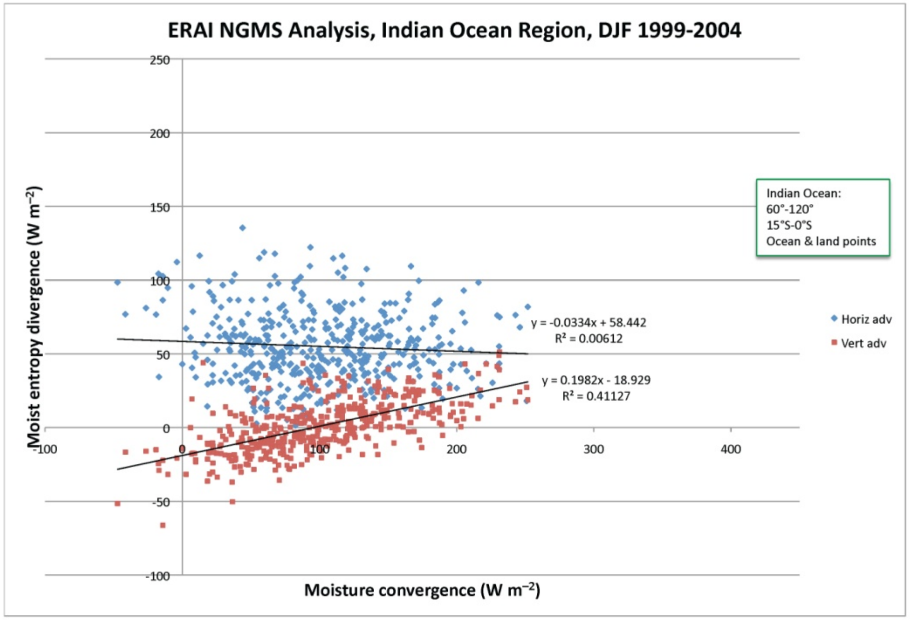


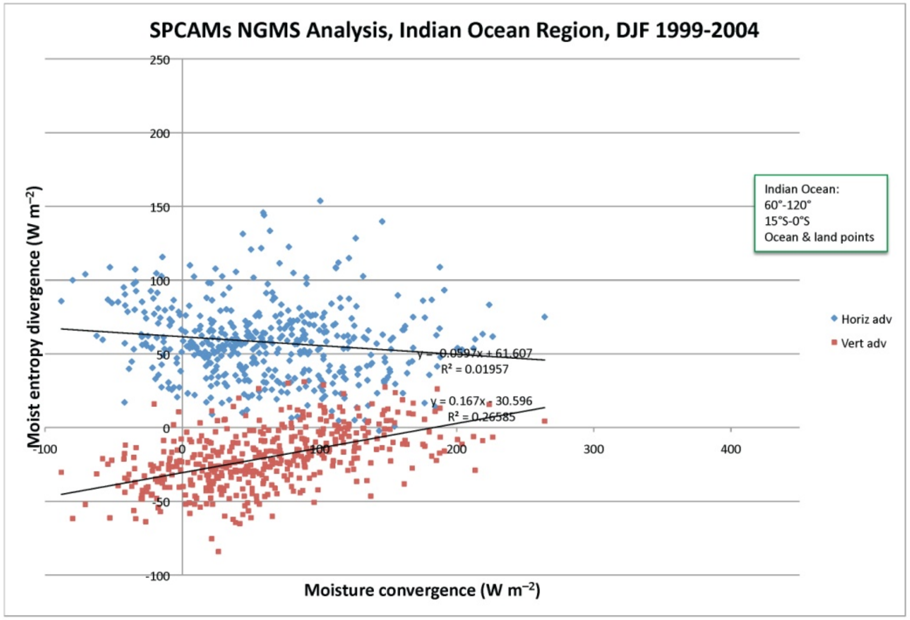
FIG. 12. As in Fig. 9, except for the FNL.

Raymond and Fuchs (2009)

- Analysis from NCEP FNL analysis
- For positive column-integrated moisture convergence, vertical MSE advection is positive even for periods of modest convergence
- Raymond and Fuchs (2009) argue that negative gross moist stability may be needed for successful MJO simulation

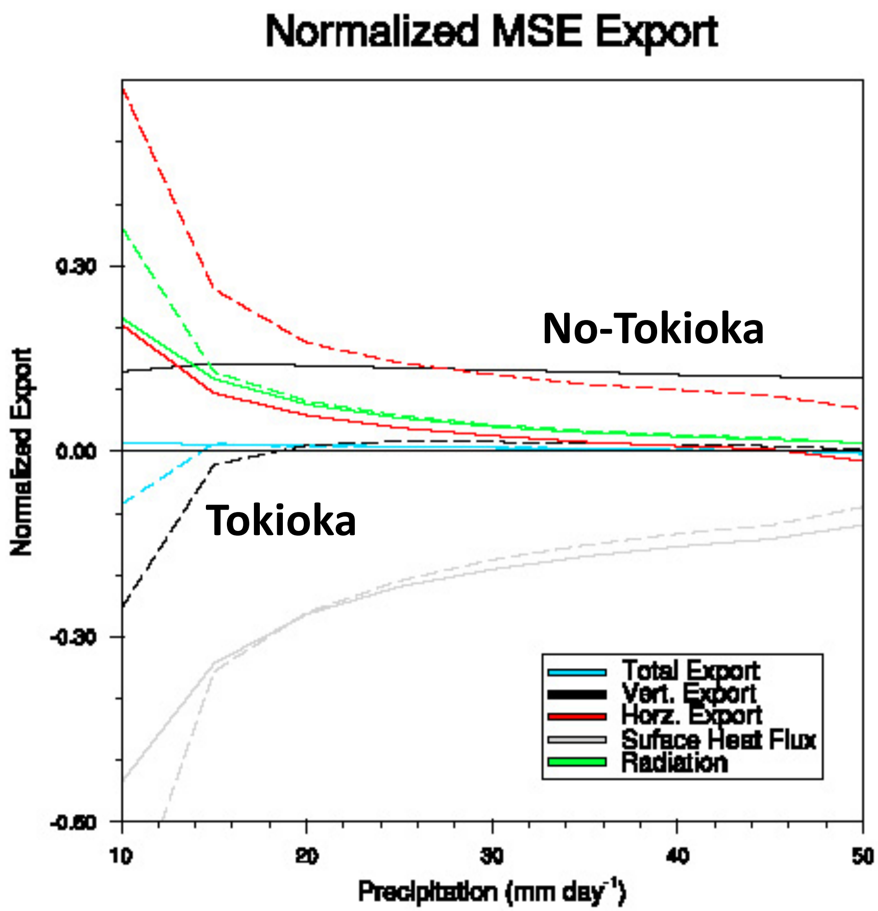


MSE Advection Analysis for ERA-I and SP-CAM (with SOM)



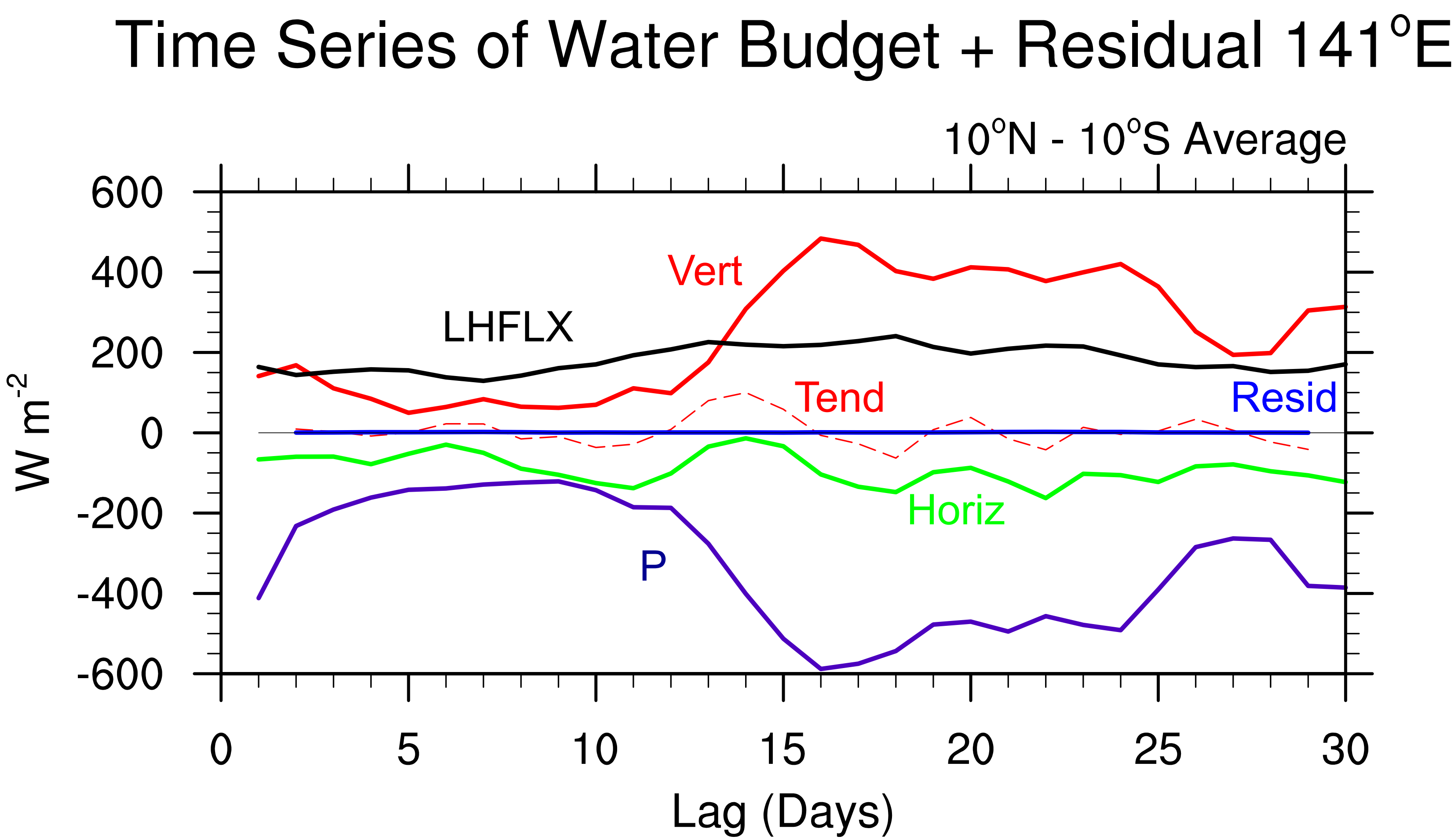
From Jim Benedict

Effect of Tokioka Parameter on Vertically-Integrated MSE Export

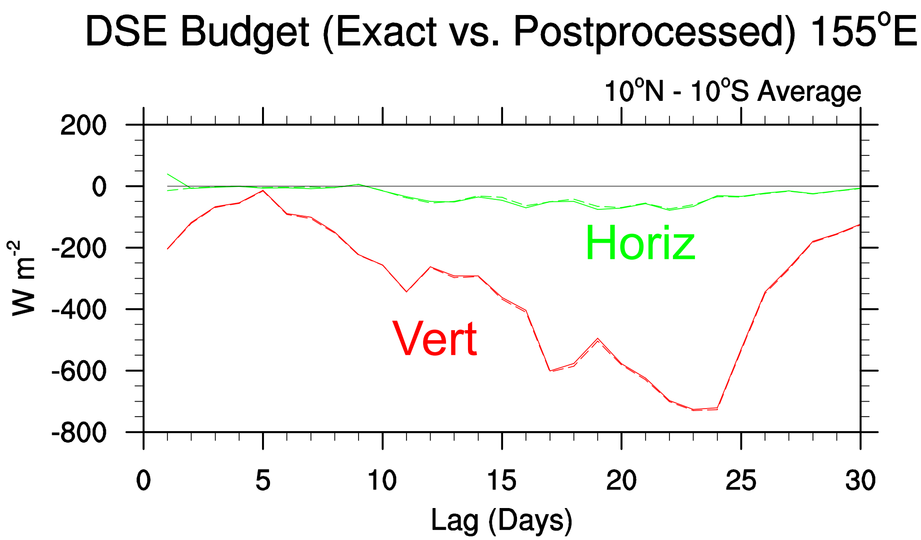


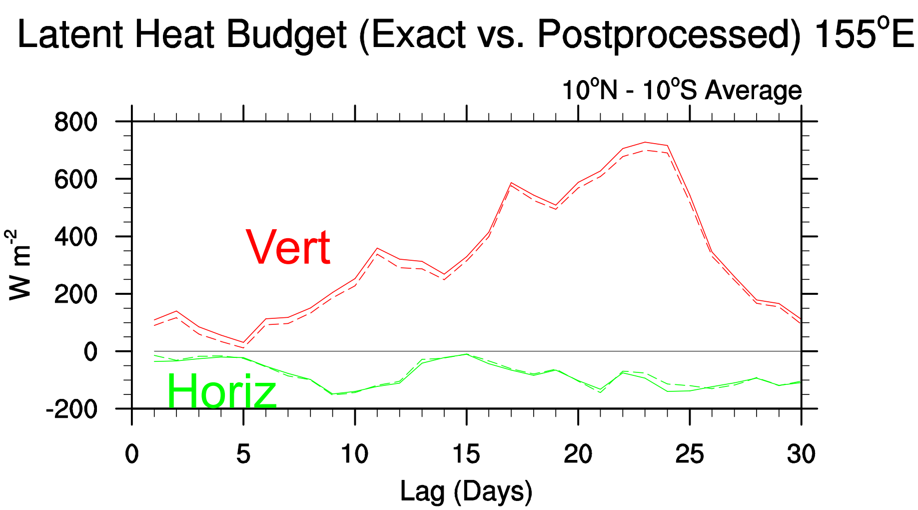
Hannah and Maloney (2011)

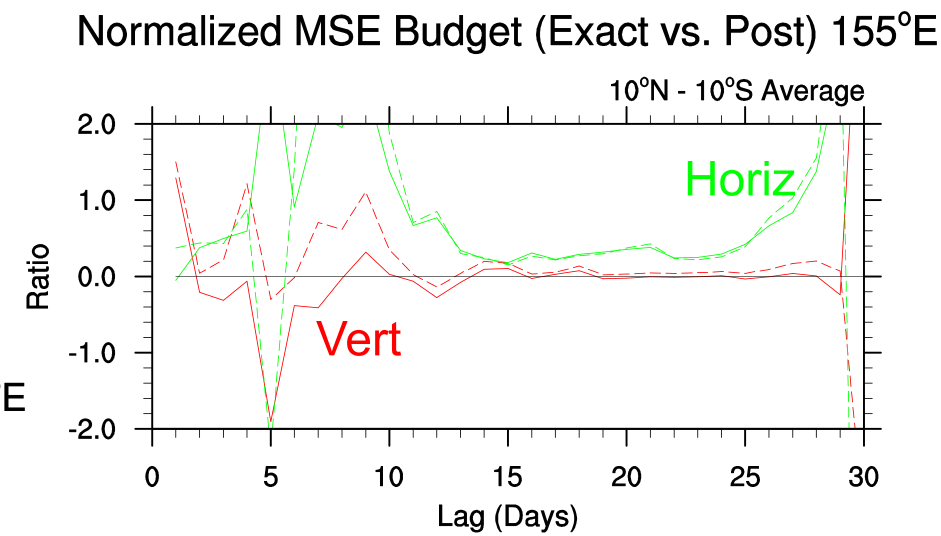
CAM3/RAS Vertically-Integrated Total Water Budget



How Well Can Advection Terms Be Computed From Standard Model Output Variables?







Initial diagnostics

- **Precipitation vs. Saturation fraction** (Zhu et al. 2009, Maloney et al. 2010)
- **Composite based on precipitation** (Thayer-Calder and Randall 2009, Kim et al. 2009, Zhu et al. 2009, Neale ??)
  - relative humidity, temperature, specific humidity, diabatic heating, moistening, cloud liquid/ice water, convergence, changes in PW
- **Composite based on MJO index** (doesn't work if no MJO; Maloney et al. 2010, Tian et al. 2010, Jiang et al. 2010, Ling and Zhang 2010)
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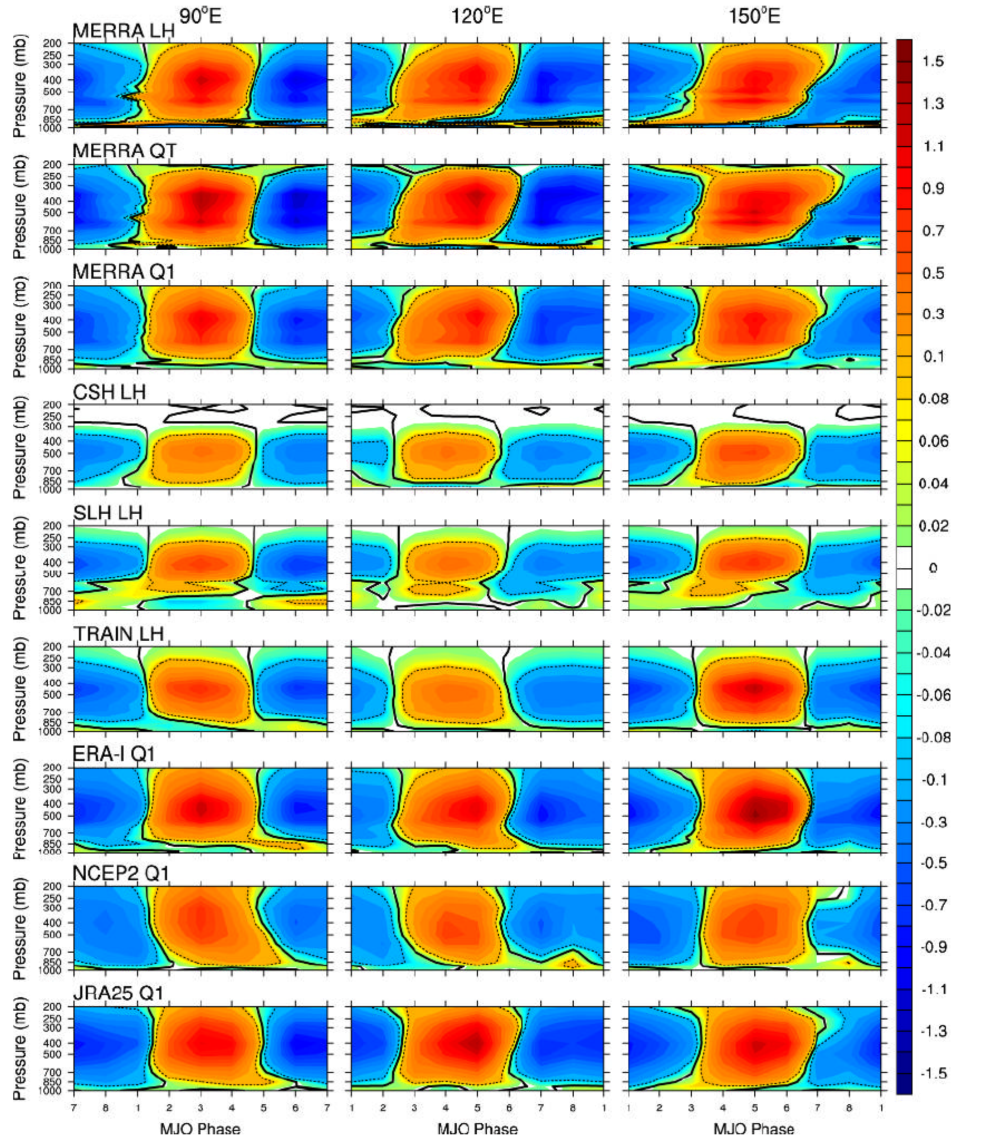
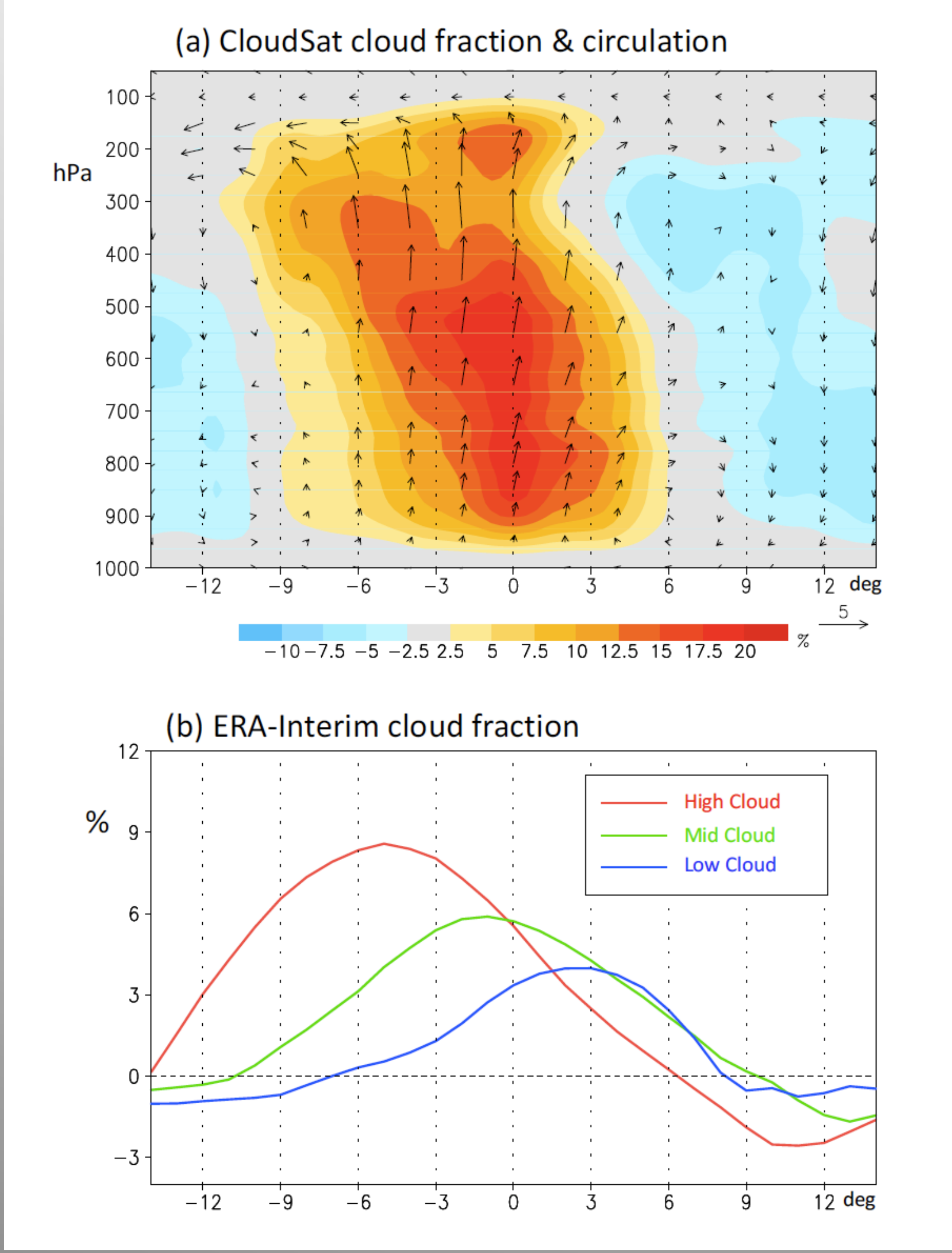
Diabatic Heating Anomaly vs. MJO Phase



(From Ling and Zhang 2010)

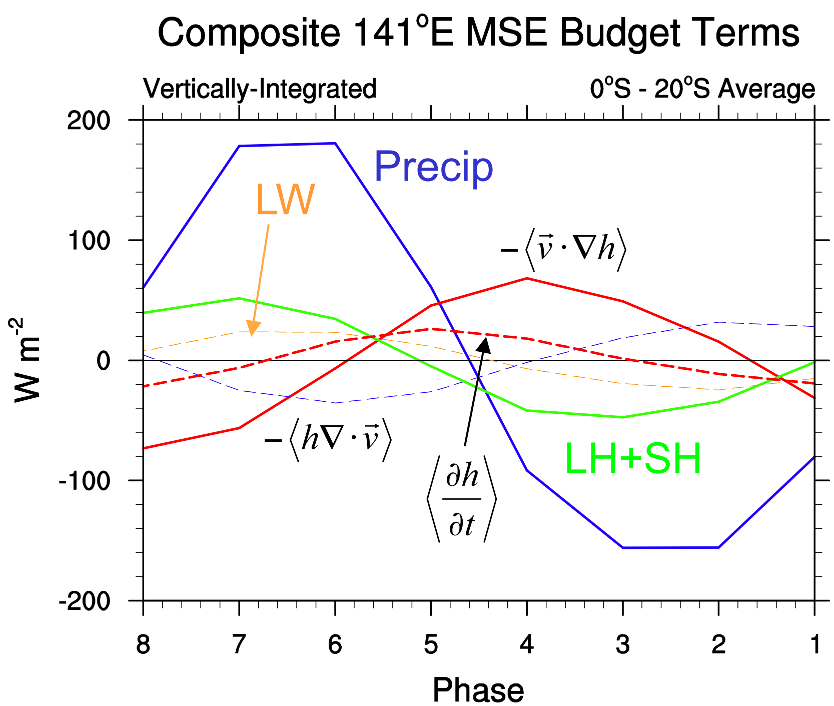
- Needed is a comprehensive model intercomparison of latent and radiative heating structures
- How best to do this, given that we are interested in comparing models with good MJO versus those without?
- Some consternation at how different diabatic heating anomalies are between observed products.



(a) Composite anomalous cloud fractional coverage based on CloudSat (shading) and meridional-vertical wind vectors (see scale at lower rhs with units of m s^{-1} for v and 100 Pa s^{-1} for w) derived from ERA-Interim;
(b) Composite anomalous cloud coverage of low (blue), middle (green), and high (red) level clouds from ERA-Interim reanalysis.
X-axis in each panel is the meridional distance (degrees of latitude) relative to the BSISV convection center. The positive (negative) values mean to the north (south). All variables are averaged over 80-95^{o}E.

Jiang et al 2008, Climate Dynamics

Intraseasonal Vertically-Integrated MSE Budget



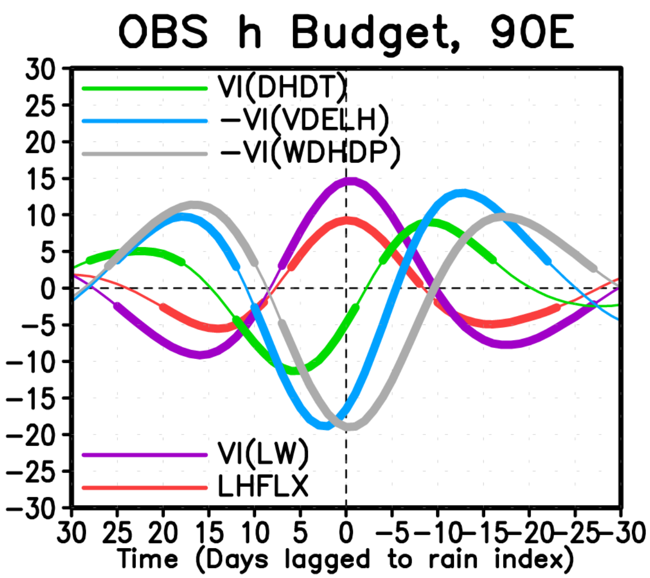
$$\left\langle \frac{\partial h}{\partial t}\right\rangle = -\langle h\nabla\cdot\vec{v}\rangle - \langle \vec{v}\cdot\nabla h\rangle + LH + SH + \langle LW\rangle + \langle SW\rangle$$

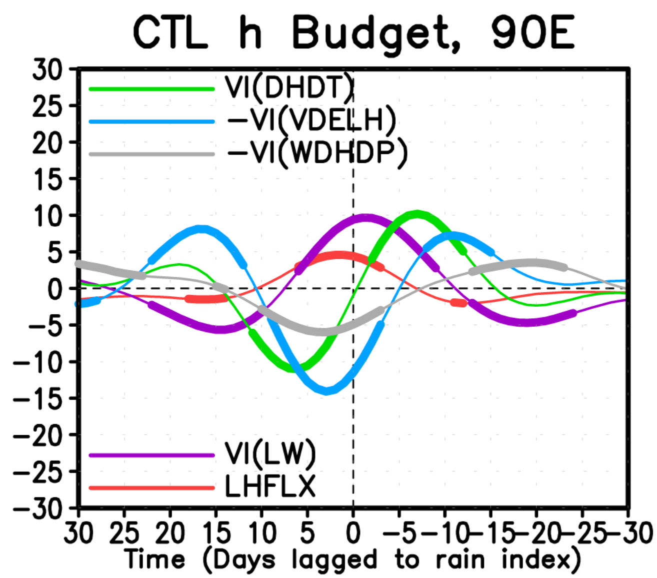
e.g. Neelin and Held (1987)

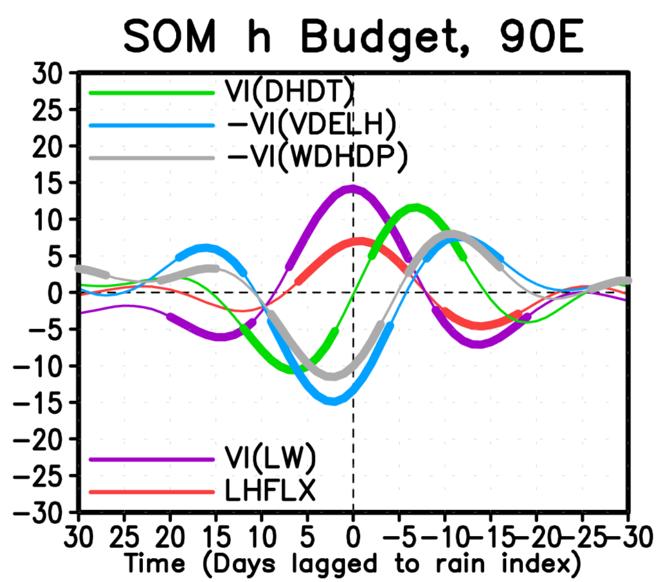
- Horizontal advection is the leading t erm and is (nearly) in quadrature wi th PW and precipitation in the intra seasonal MSE budget
- Latent heat flux slightly lags precipit ation, and has a positive covariance with precipitation
- 80-90% of MSE tendency due to lat ent heat component
- Vertical advection causes anomalou s MSE export during enhanced preci pitation, although is overcompensat ed by LH and LW anomalies

CAM3.1 aqua planet (Maloney et al. 2010)

Intraseasonal Vertically-Integrated MSE Budget (ERA-I vs. SP-CAM)







courtesy of Jim Benedict

Intraseasonal MSE Budget in Zonally-Symmetric SP-CAM

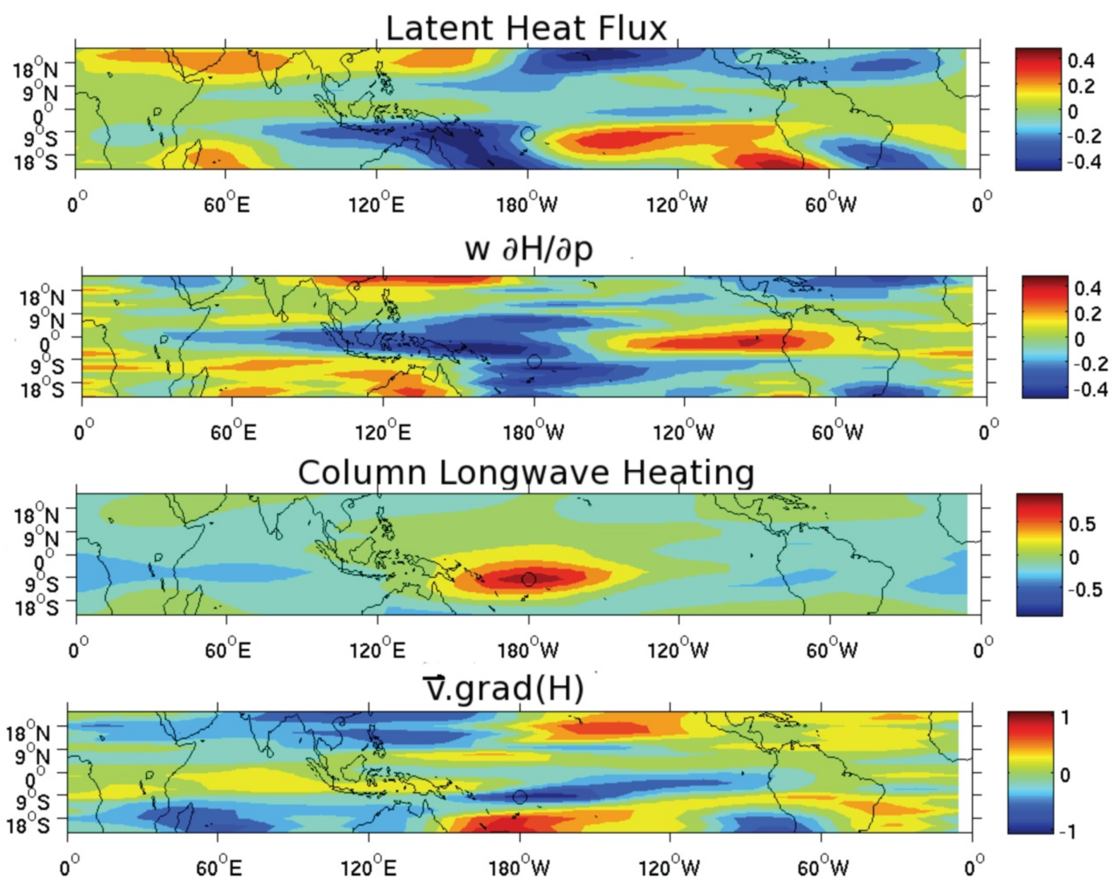


Figure 5 – Dominant "MJO" MSE budget terms.

SP-CAM aqua planet
(Andersen and Kuang 2010)

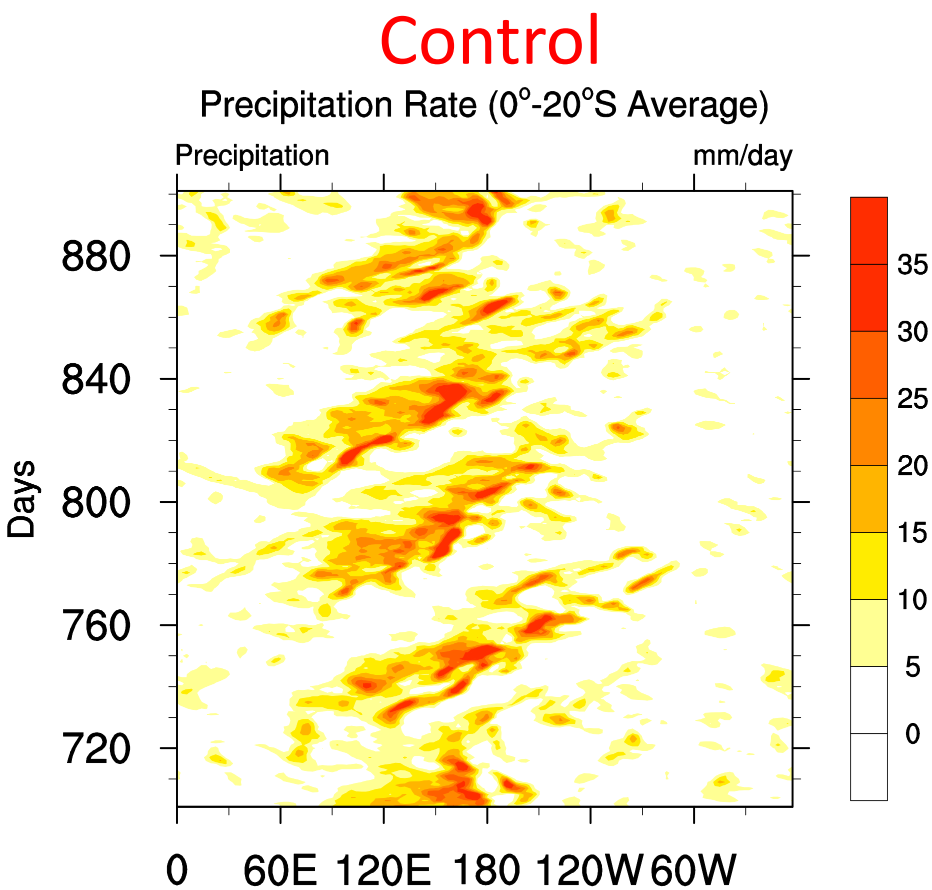
- Latent heat flux anomalies contribute to eastward propagation and horizontal advection contributes to poleward propagation
- Longwave radiative feedbacks are the dominant instability mechanism

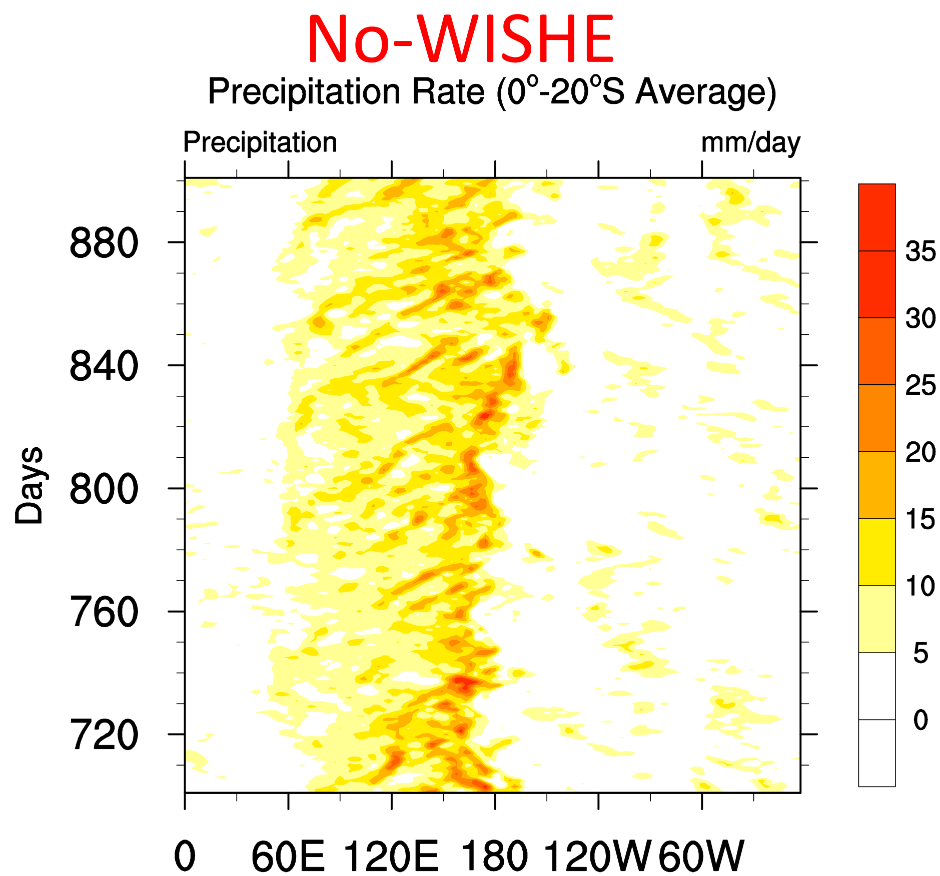
Outstanding Issues

1. Process-oriented diagnostics for multi-scale interaction (e.g. as they affect momentum, moisture budgets)
2. Reconciling differences in diagnostics among observational datasets
3. Suggestions for diagnostics?
4. CMMAP might be suited to take the lead in some diagnostic development
5. Comments?

Extra Slides

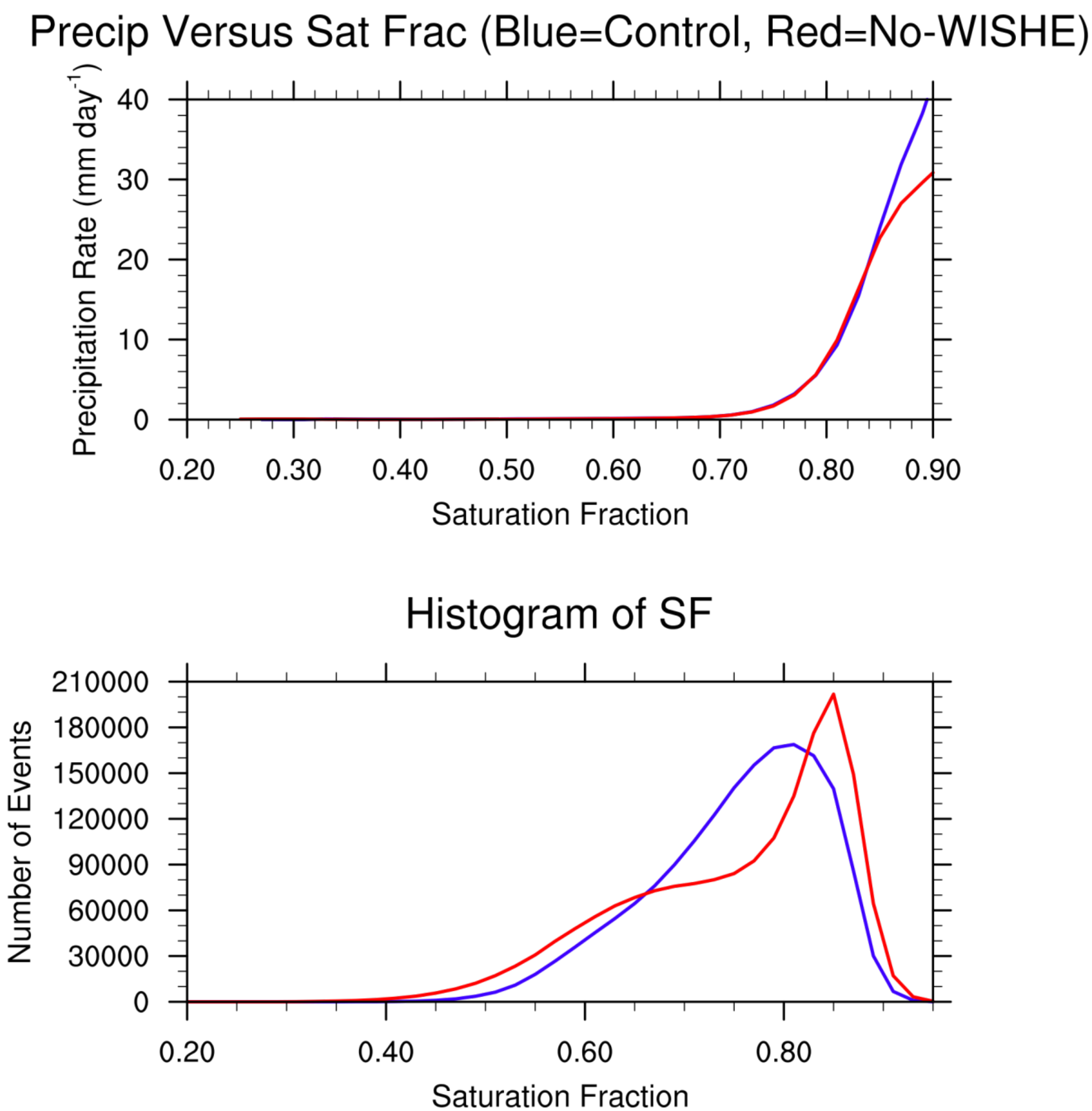
Unfiltered Precipitation vs. Longitude, Control Versus No-WISHE





- WISHE appears to destabilize the MJO in the model. 30-90 day, zonal wavenumber 1-3 variance decreases dramatically without WISHE active
- Small spatial scale precipitation variability that moves slowly east is still apparent in the model

Precip vs. Saturation Fraction



No WISHE vs. WISHE (aqua CAM3.1, Eric)