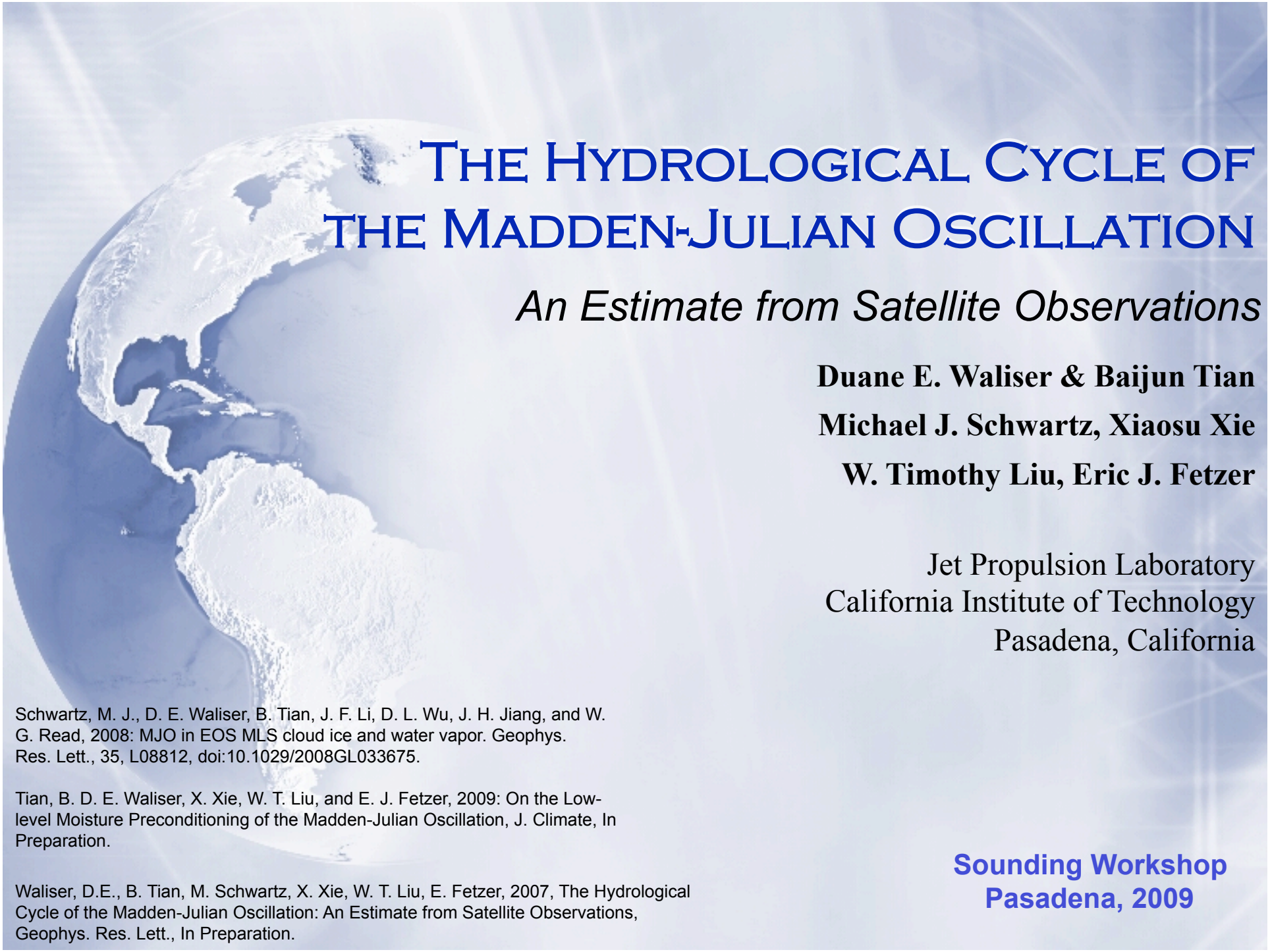

The Hydrological Cycle of the Madden-Julian Oscillation

An Estimate from Satellite Observations

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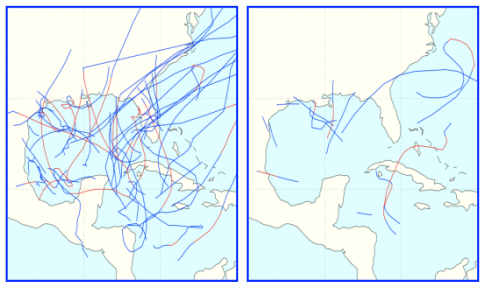
Schwartz, M. J., D. E. Waliser, B. Tian, J. F. Li, D. L. Wu, J. H. Jiang, and W. G. Read, 2008: MJO in EOS MLS cloud ice and water vapor. Geophys. Res. Lett., 35, L08812, doi:10.1029/2008GL033675.

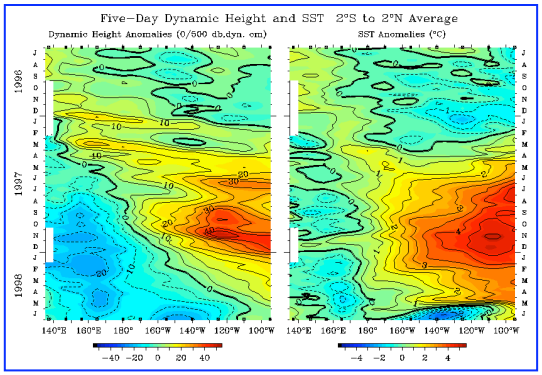
Tian, B. D. E. Waliser, X. Xie, W. T. Liu, and E. J. Fetzer, 2009: On the Low-level Moisture Preconditioning of the Madden-Julian Oscillation, J. Climate, In Preparation.

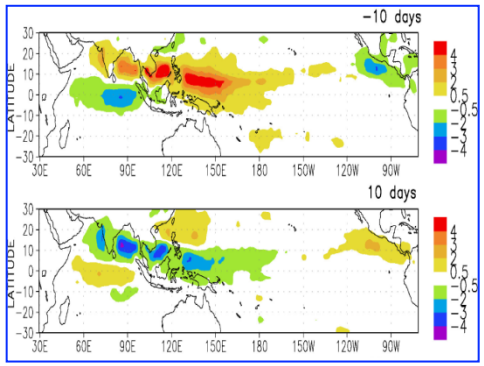
Waliser, D.E., B. Tian, M. Schwartz, X. Xie, W. T. Liu, E. Fetzer, 2007, The Hydrological Cycle of the Madden-Julian Oscillation: An Estimate from Satellite Observations, Geophys. Res. Lett., In Preparation.

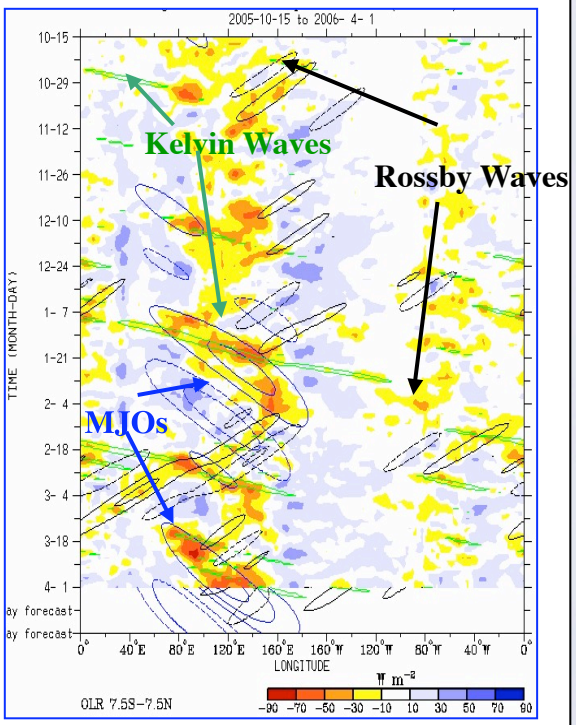
Sounding Workshop
Pasadena, 2009

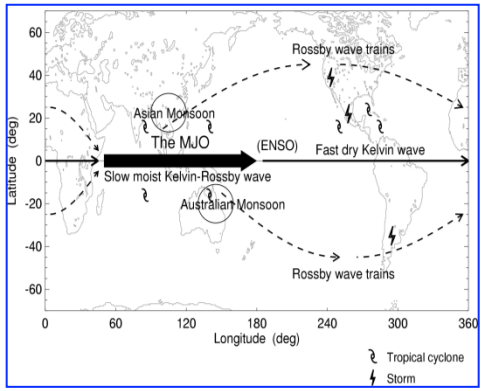
Motivation











- The MJO is the dominant form of intraseasonal variability in the Tropics, with impacts a wide range of phenomena.
- Our weather & climate models have a relatively poor representation
- Most studies have focused on dynamics or components of the energy and water cycle.
- Space-based observations now make it possible to document and examine the complete hydrological cycle of the MJO.

Figures: E. Maloney, PMEL/TAO, M. Wheeler, J. Lin, D. Waliser

Question?

Using space-based observations only, what can be said about the hydrological cycle of the MJO?

Data

- **CMAP Rainfall :**
  global, 2.5°x2.5° lat-long, pentad, 01/01/1979-02/22/2007. Xie and Arkin (1997)
- **TRMM 3B42 Rainfall:**
  40S-40N, 0.25° x 0.25°, 3-hourly, 01/01/1998-06/30/2007. Huffman et al. (2007)
- **AIRS H2OVapMMR & TotH2OVap**
  V4, L3, global, 1.0° x 1.0°, 2Xdaily, 09/01/2002-04/30/2007. Chahine et al. (2006)
- **QuikSCAT & TMI Moisture Transport**
  40S-40N, 0.25° x 0.25°, 2Xdaily, 08/1999-12/31/2005. Liu and Tang (2005)
- **OAFlux Evaporation**
  65S-65N, 1.0° x 1.0°, daily, 01/01/1981-12/31/2002. Yu and Weller (2007)
- **SSMI Total Column H2O Vapor & Total Cloud Liquid H2O**
  V6, DMSP F13, global, 0.25° x 0.25°, 2Xdaily, 01/01/1996-06/30/2007.
  Wentz (1997), Wentz and Spencer (1998)
- **MLS Ice Water Content**
  80S-80N, 4° x 8° lat-long, 2Xdaily, 08/26/2004-02/22/2007. Wu et al. (2006)

HYDROLOGIC BALANCE

$$\frac{\partial W}{\partial t} + \nabla \bullet \Theta = E - P$$

$$\Theta = \frac{1}{g}\int_0^{p0} qU\,dp$$

$$W = \frac{1}{g}\int_0^{p0} q\,dp$$

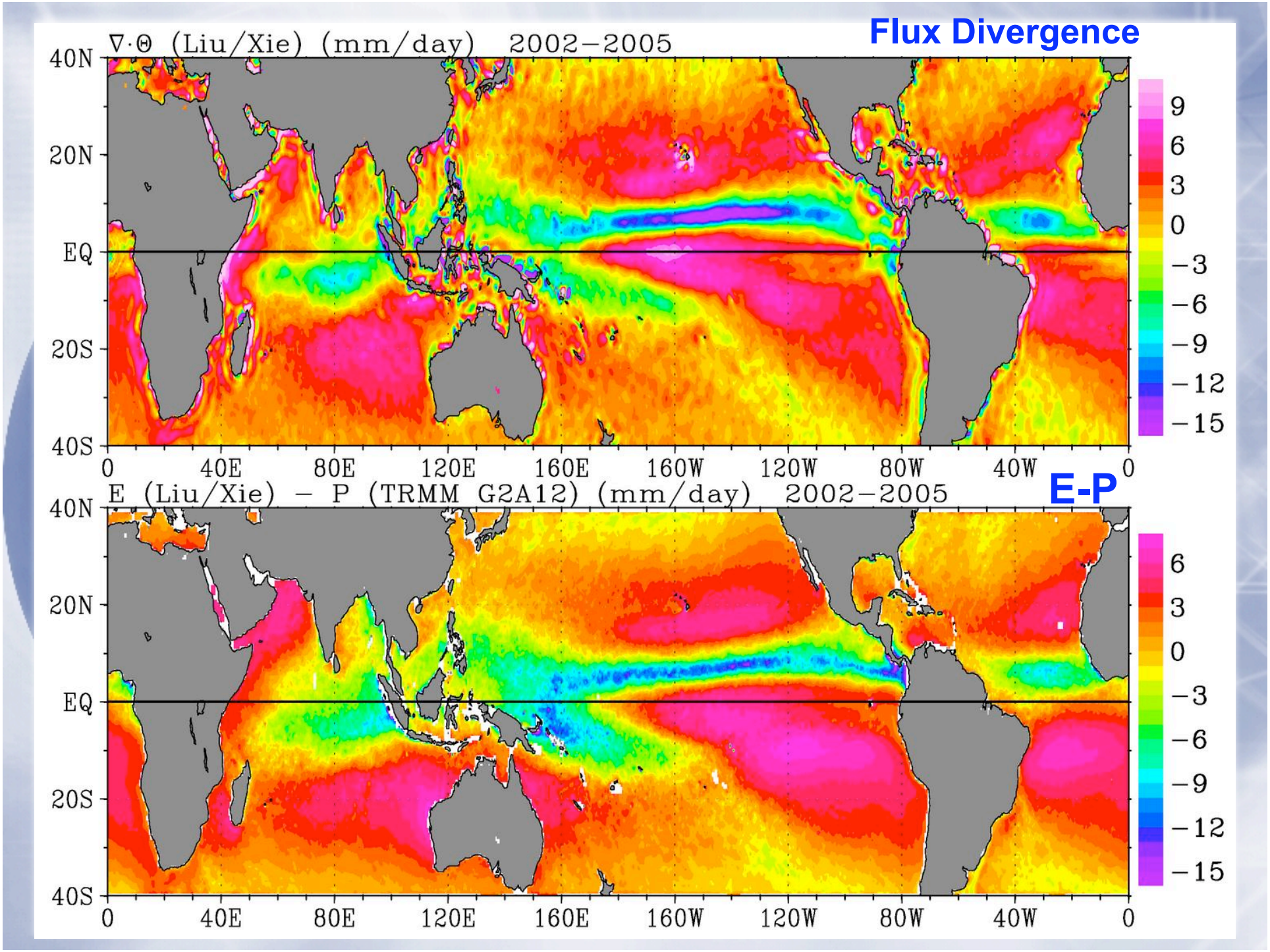
$$\Theta = Ue\ W$$

Ue=f(Us) **Liu (1993)-polynomial**

Liu & Tang (2005) - Neural Network

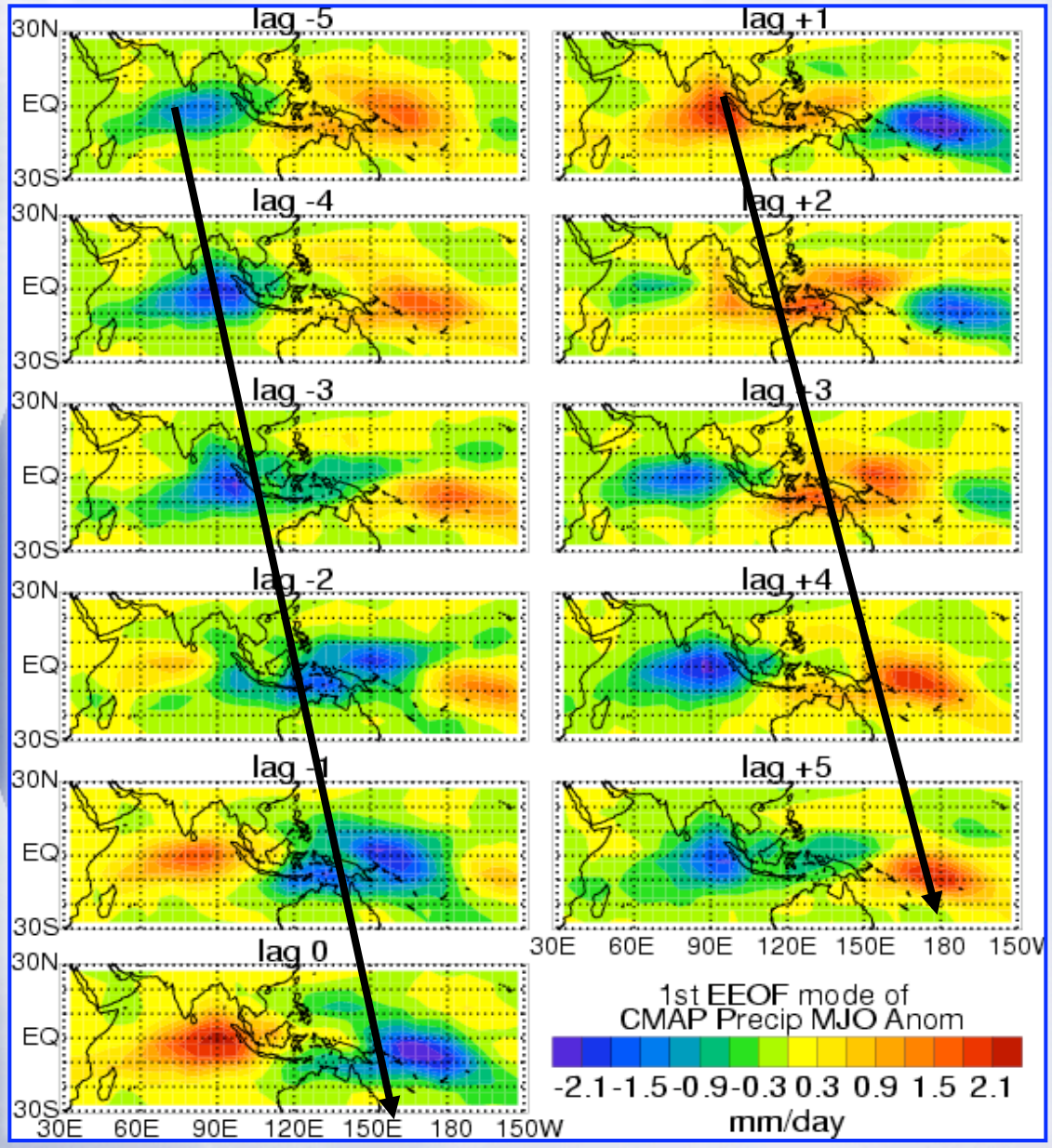
Ue = U_{850mb} **Heta & Mitsuta (1993)**

Both Us & U_{850mb} **Xie et al. (2007) - SVR**


∇·Θ (Liu/Xie) (mm/day) 2002–2005
Flux Divergence
40N
20N
EQ
20S
40S
0
40E
80E
120E
160E
160W
120W
80W
40W
9
6
3
0
−3
−6
−9
−12
−15
E (Liu/Xie) − P (TRMM G2A12) (mm/day) 2002–2005
E-P
6
3
0
−3
−6
−9
−12
−15

Methods

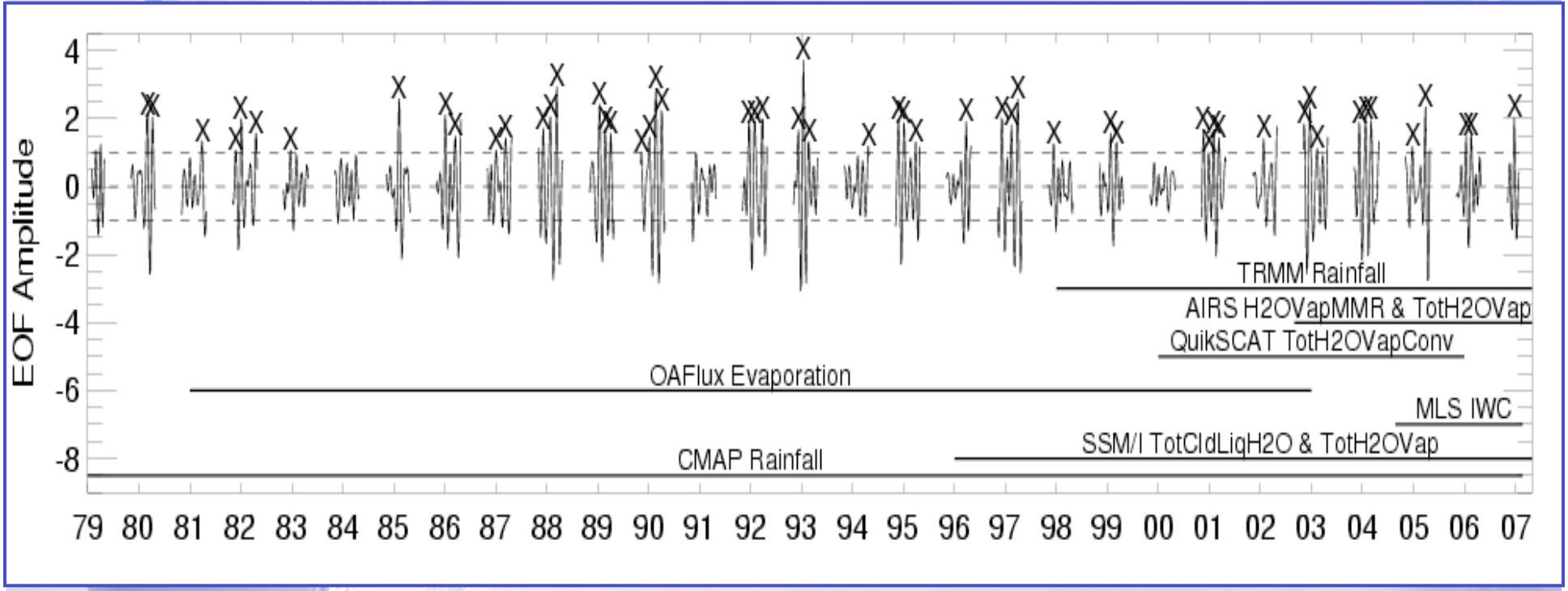
MJO Event Selection



Spatial-temporal Pattern of the 1ST EEOF Mode of Rainfall Anomaly

MJO Events in Hydrological Time Series

Principal Component Time Series of 1st EEOF Mode of Rainfall Anomaly



TRMM: 18

CMAP: 57

AIRS:11

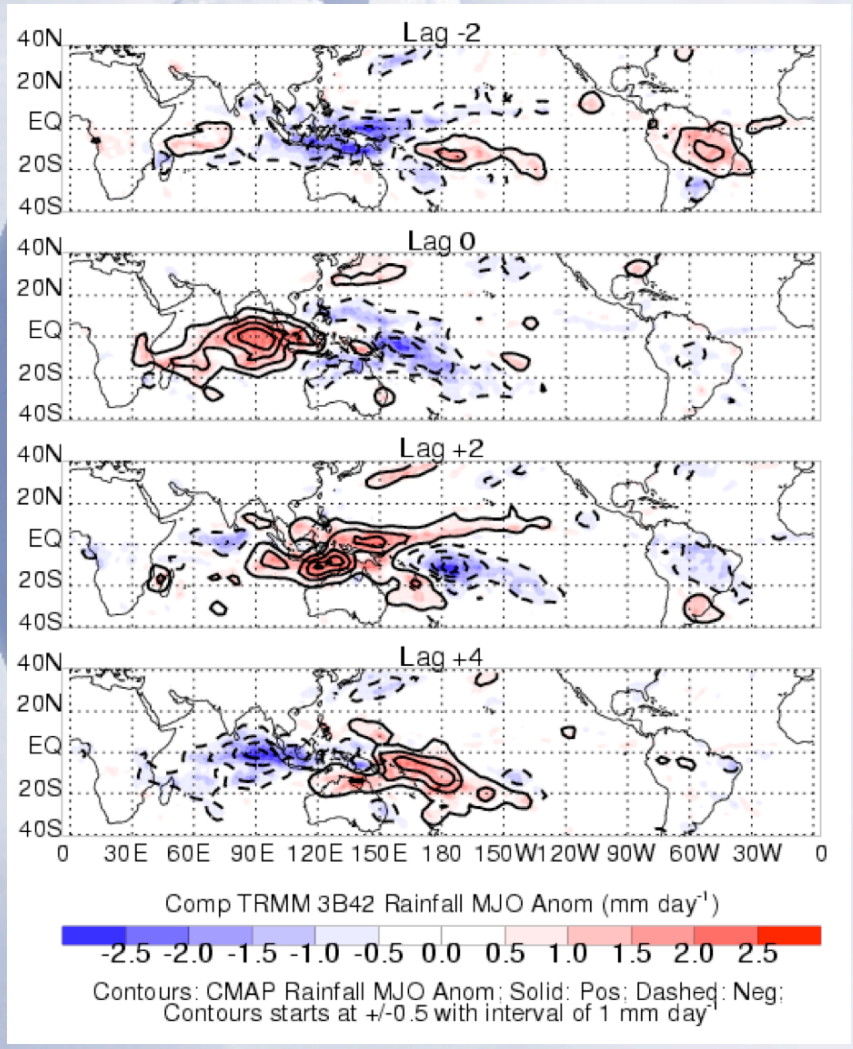
QuikSCAT&TMI: 13

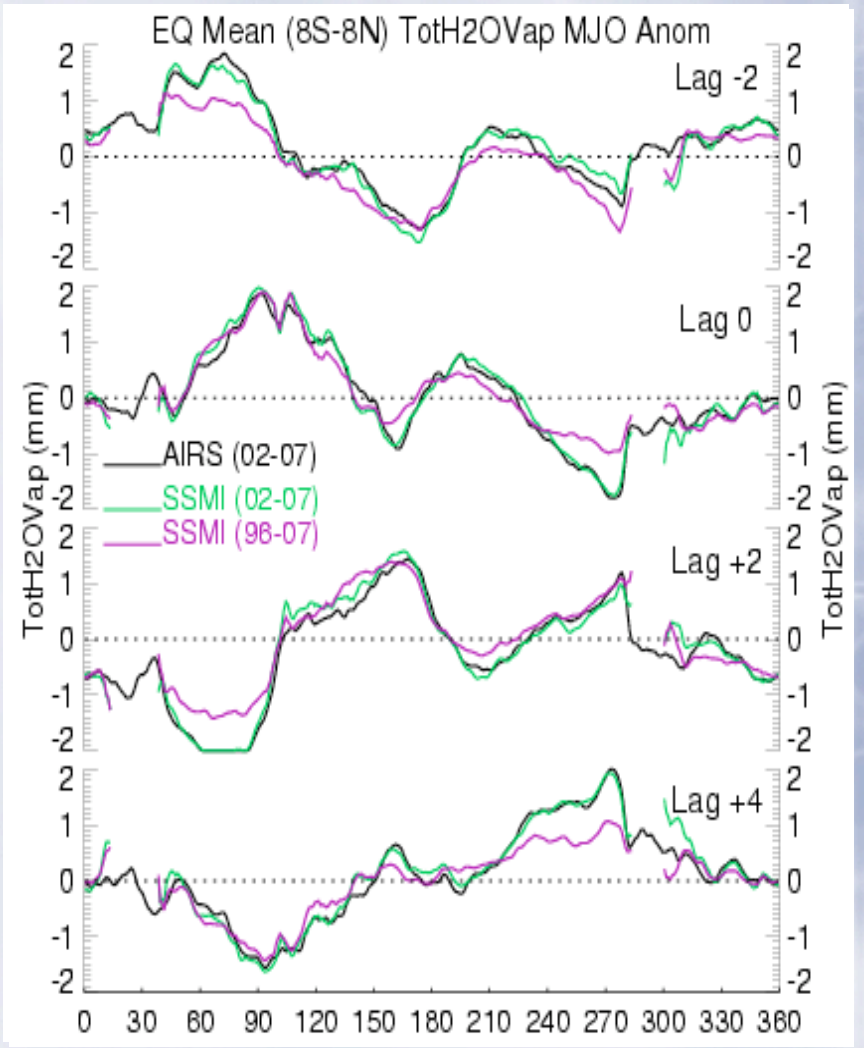
OAFlux: 44

SSMI: 23

MLS: 5

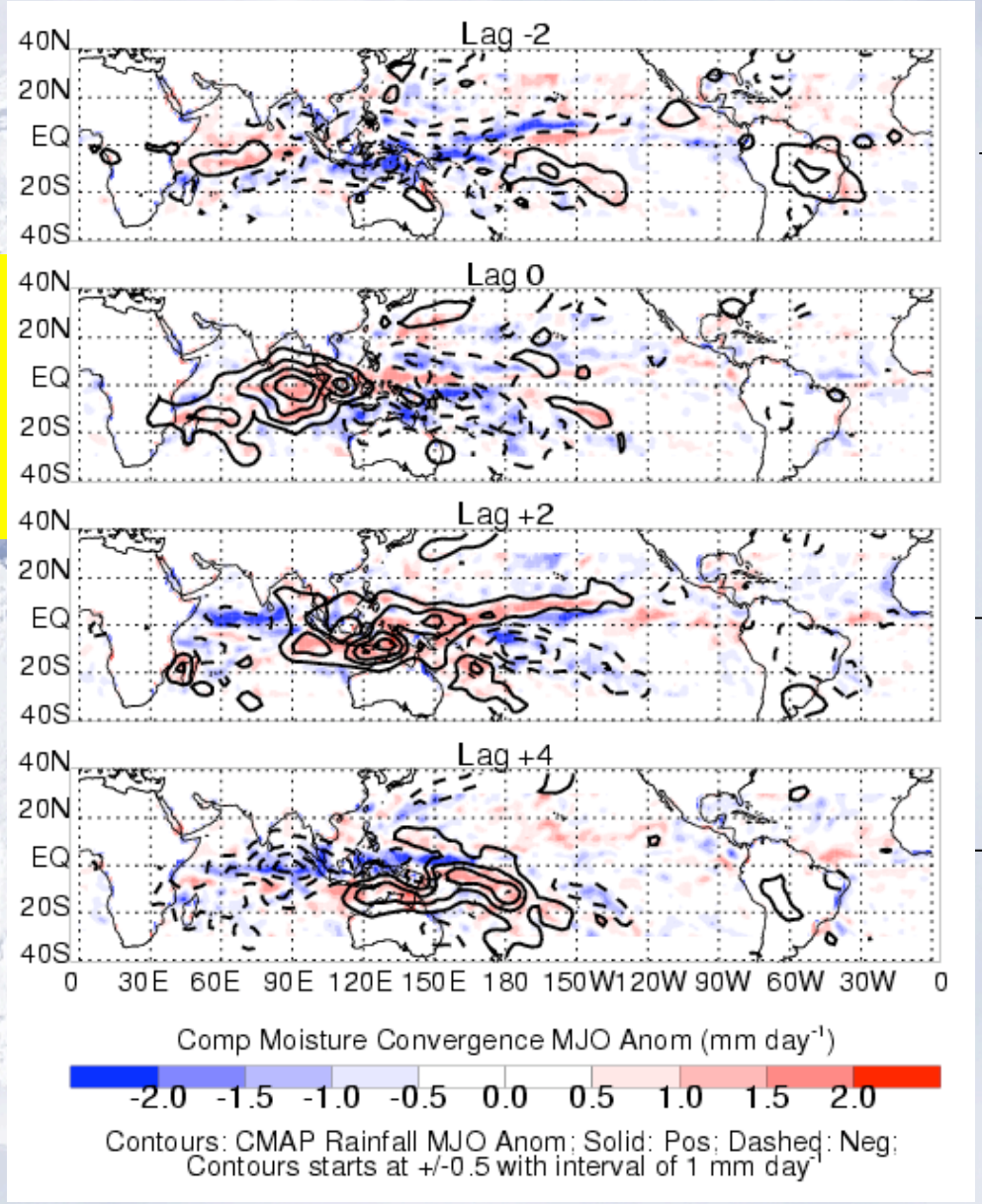
Rainfall Pattern & Data Sensitivity





Rainfall & Moisture Convergence

Rainfall and Total Column Moisture Convergence tend to be Correlated throughout Tropics - except maybe over S. America



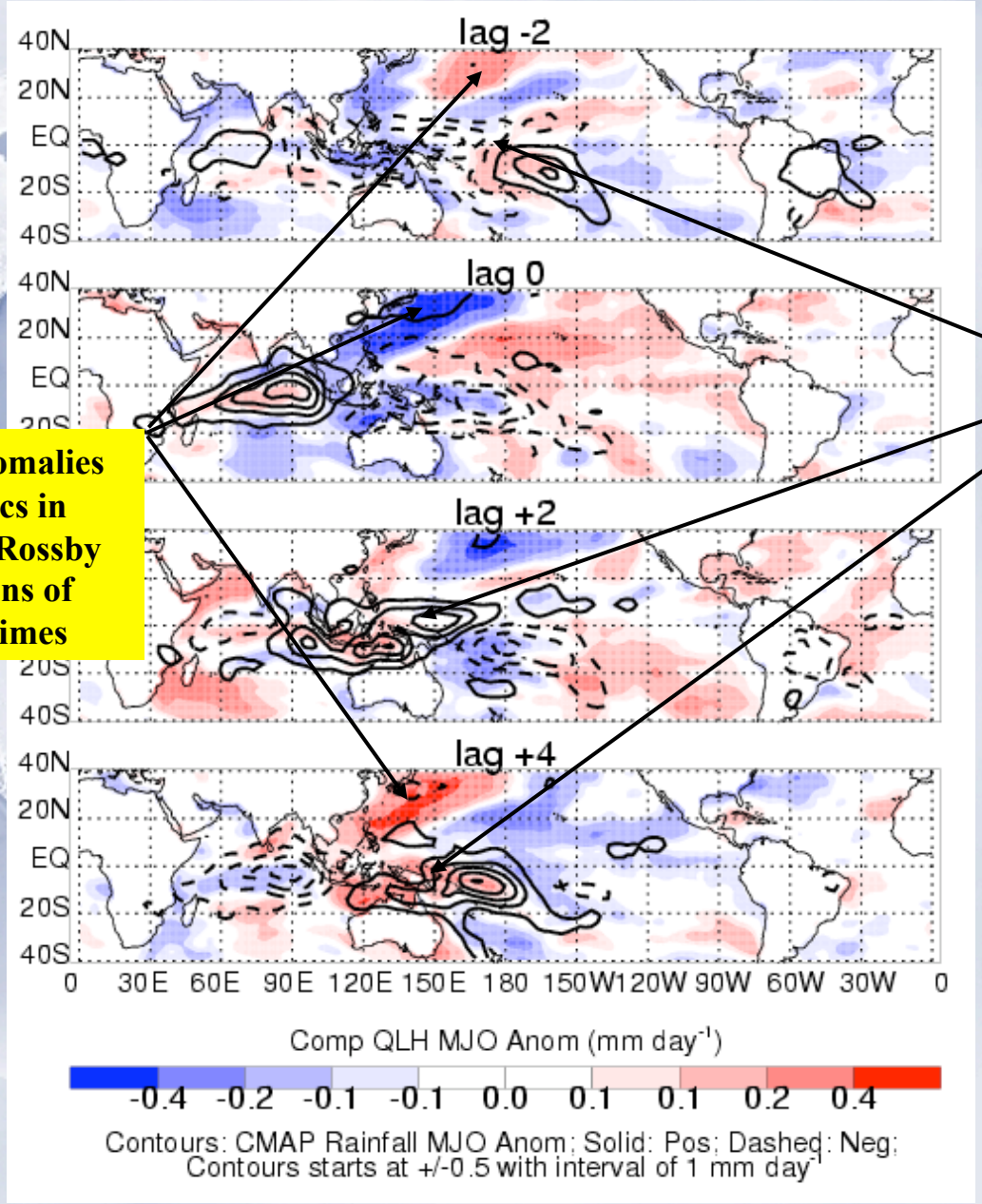
-10 Days

0 Days

+10 Days

+20 Days

Rainfall & Surface Evaporation



-10 Days

0 Da

+10 Days

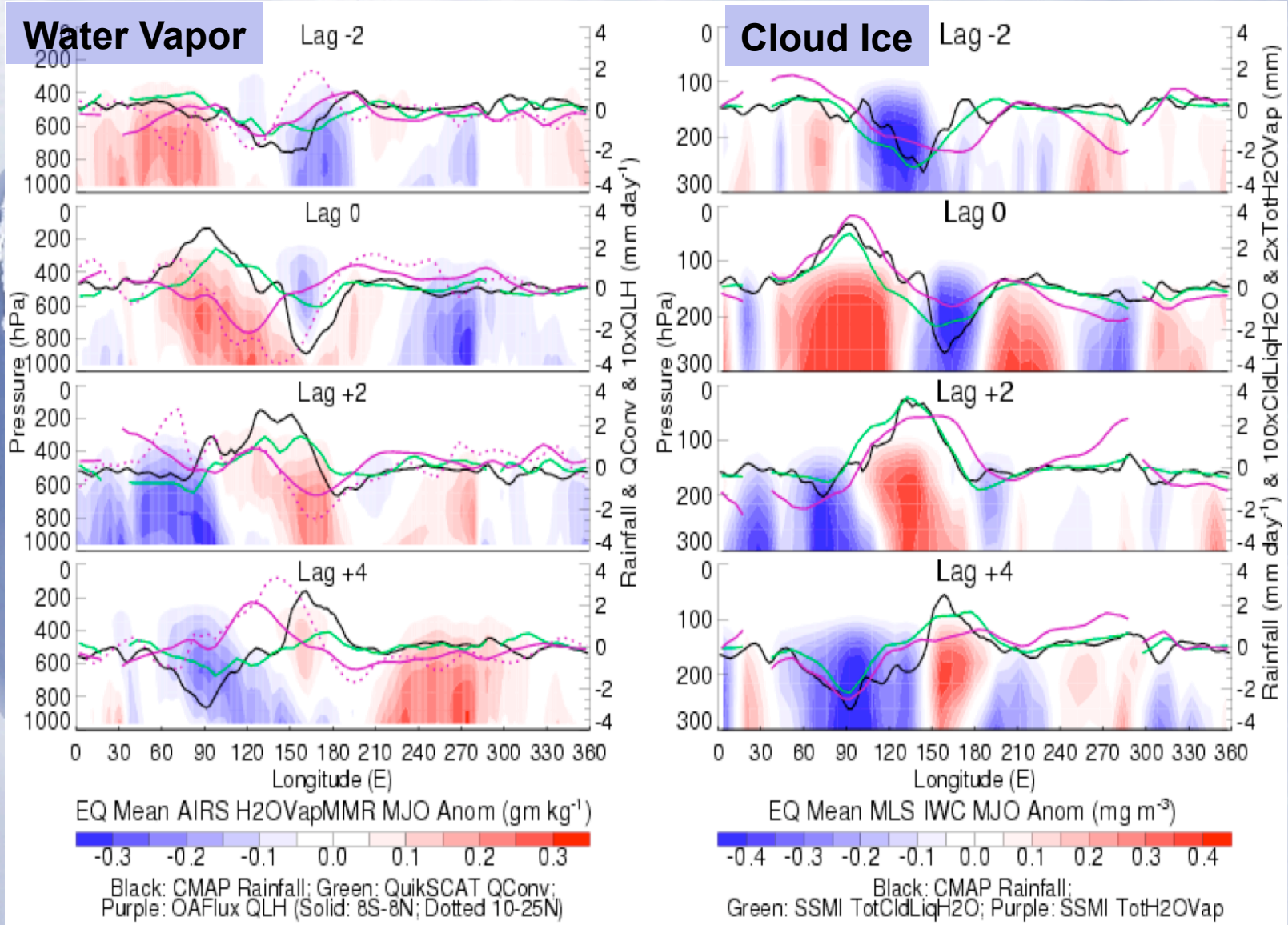
+20 Days

Largest Evap anomalies in the subtropics in association with Rossby grye modulations of tradewind regimes

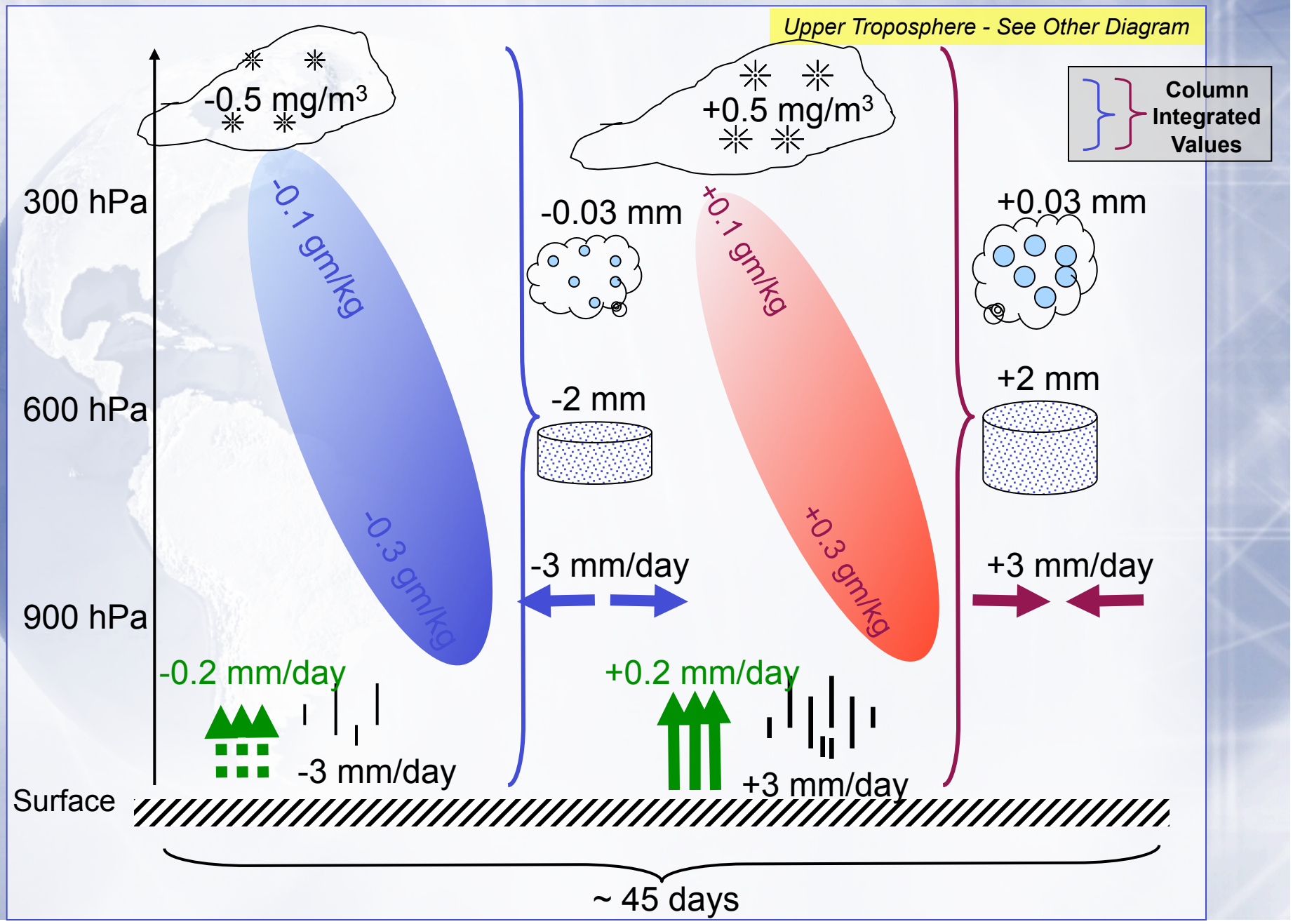
Near-equatorial Evap anomalies tend to lag precipitation anomalies

Composite Hydrological Cycle

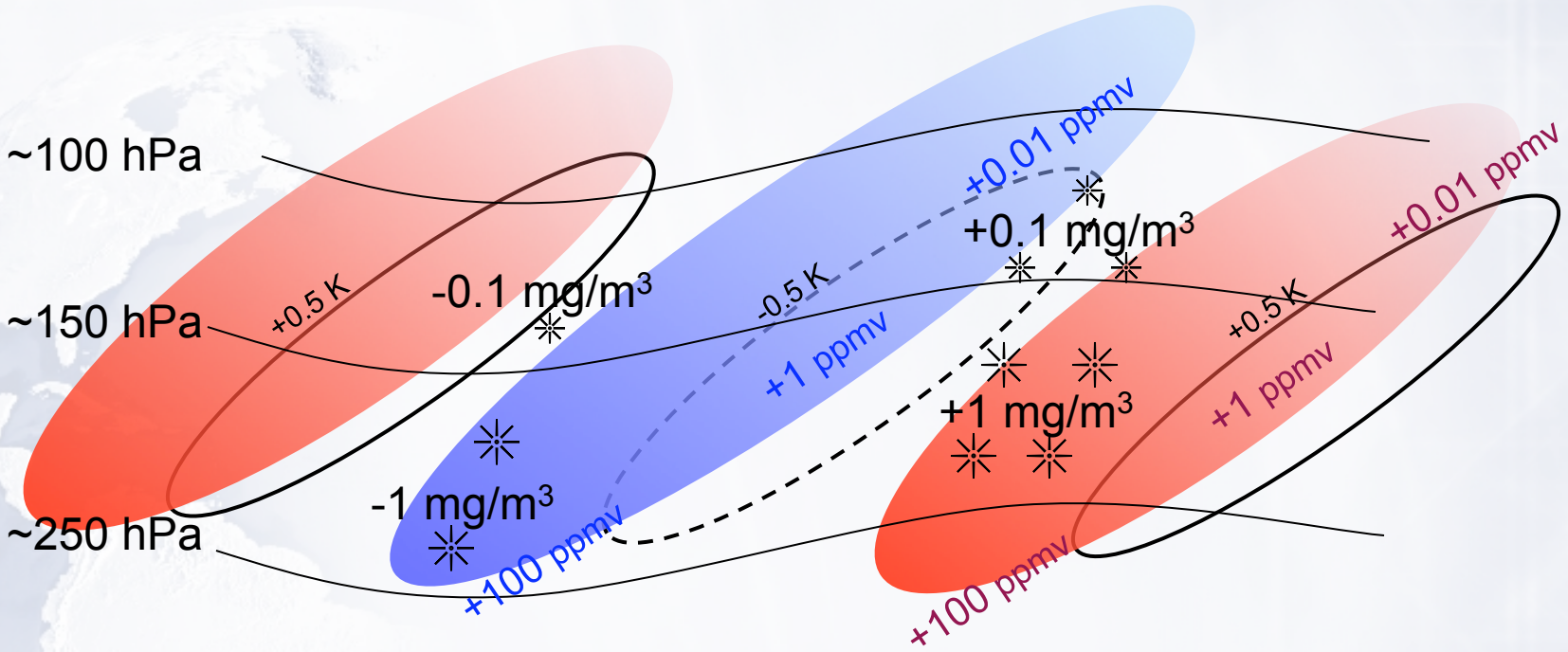
Vertical Structure



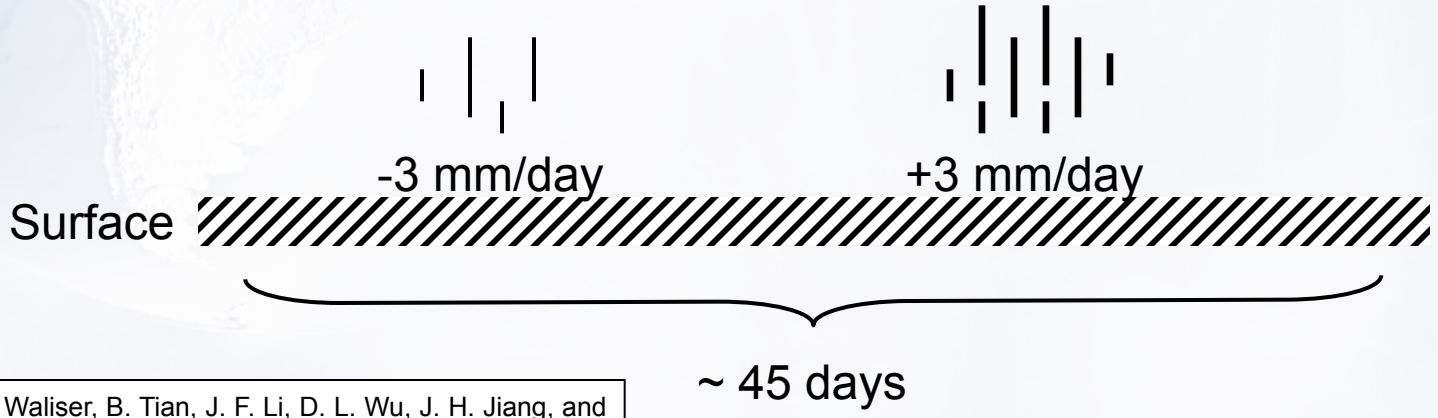
MJO Hydrological Cycle - Troposphere



MJO Hydrological Cycle - UTLS



Lower-Middle Troposphere - See Other Diagram



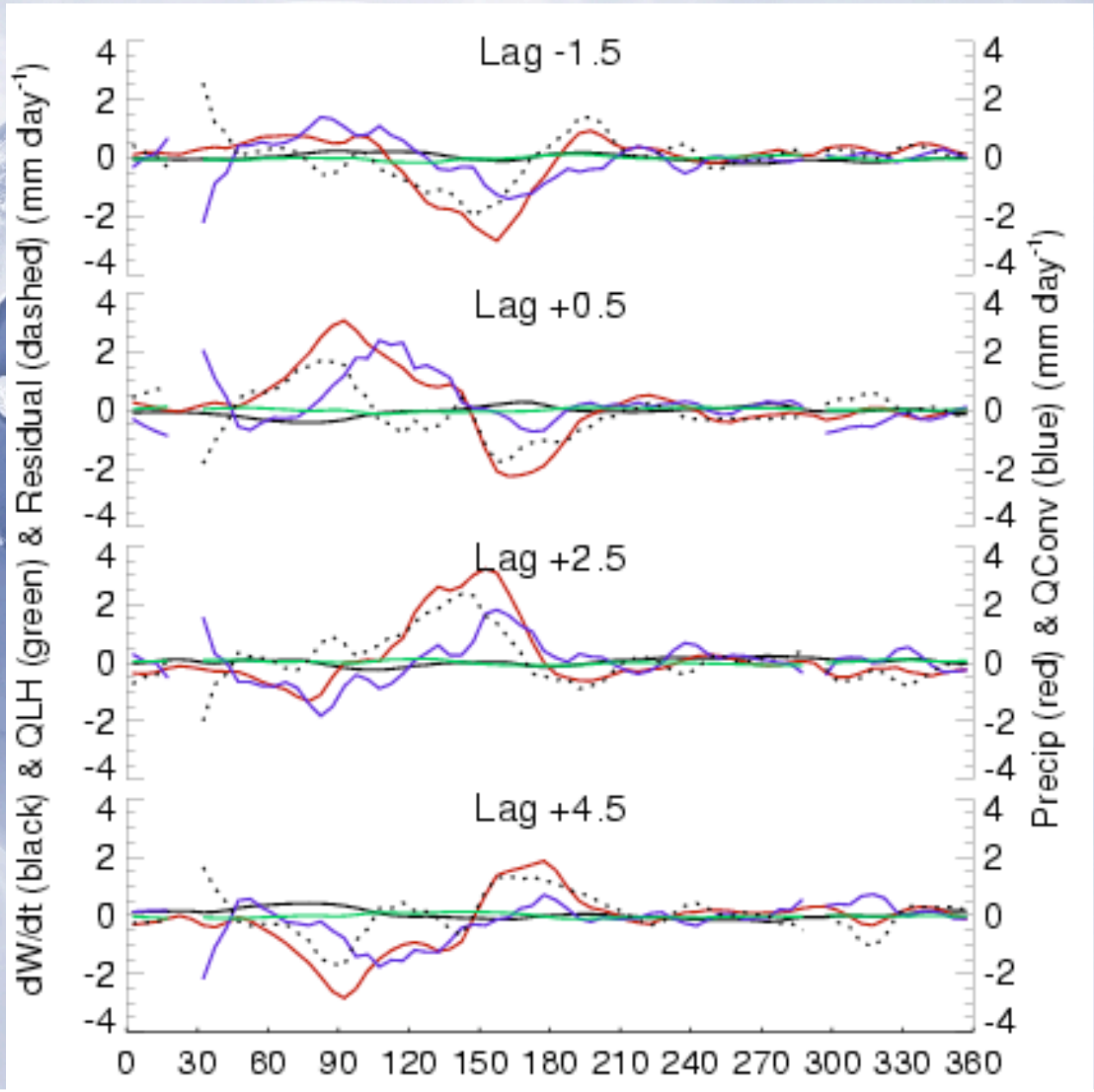
Schwartz, M. J., D. E. Waliser, B. Tian, J. F. Li, D. L. Wu, J. H. Jiang, and W. G. Read, 2008: MJO in EOS MLS cloud ice and water vapor. GRL.

Total-column Moisture Budget

$$\partial W / \partial t = -P + MC + E$$

Total column Moisture change Moistening (>0) Drying (<0)	Surface Rainfall	Moisture Convergence due to large-scale moisture transport	Surface Evaporation

$$\partial W / \partial t + P - MC - E = residual$$



Residuals are nearly order one quantities

Summary

- Satellite Observations are now able to provide an estimate of the chief components of the Hydrological Cycle Associated with the MJO, in some cases with vertical structure information.
- However, calcululations of the Residual Term of the column-integrated values indicates closing the budget with current generation of satellite retrievals is difficult.
- It is all but certain that robust moisture convergence estimates will necessarily be derived from a numerical analysis system but having co-located wind and moisture sounding information from the same platform would be ideal for making such estimates via assimilation.
- Within the levels of uncertainty, Future plans involve applying the observed Hydrological Cycle of the MJO as a means to diagnose, evaluate and validate GCM simulations of the MJO or Evaluate Theoretical considerations.