Moisture cycle of the Madden-Julian oscillation, convectively-coupled Kelvin waves, and a subset of waves in between

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1. Introduction

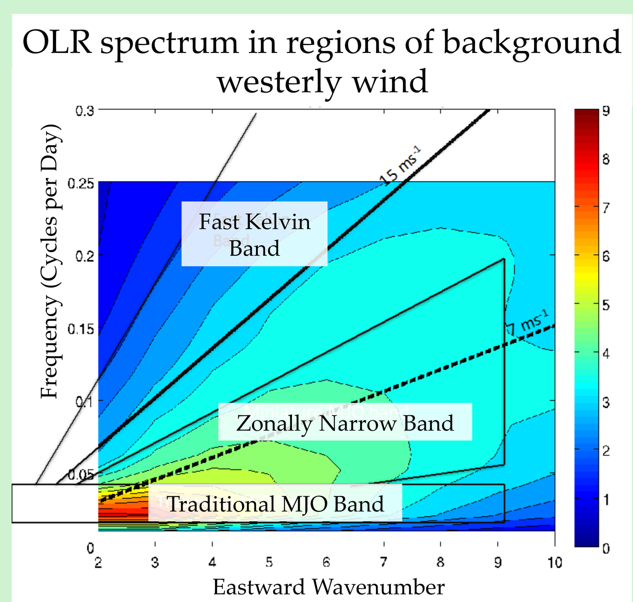


Figure 1: Adapted from Roundy, In Review

- In regions with lower level westerly wind background states, the Madden-Julian oscillation (MJO) and convectively-coupled Kelvin waves (CCKW) do not have distinguishable spectral peaks in OLR and their spatial structures occur as part of a continuum (Roundy 2012 a,b)
- Thus, further comparisons between the two modes would be beneficial

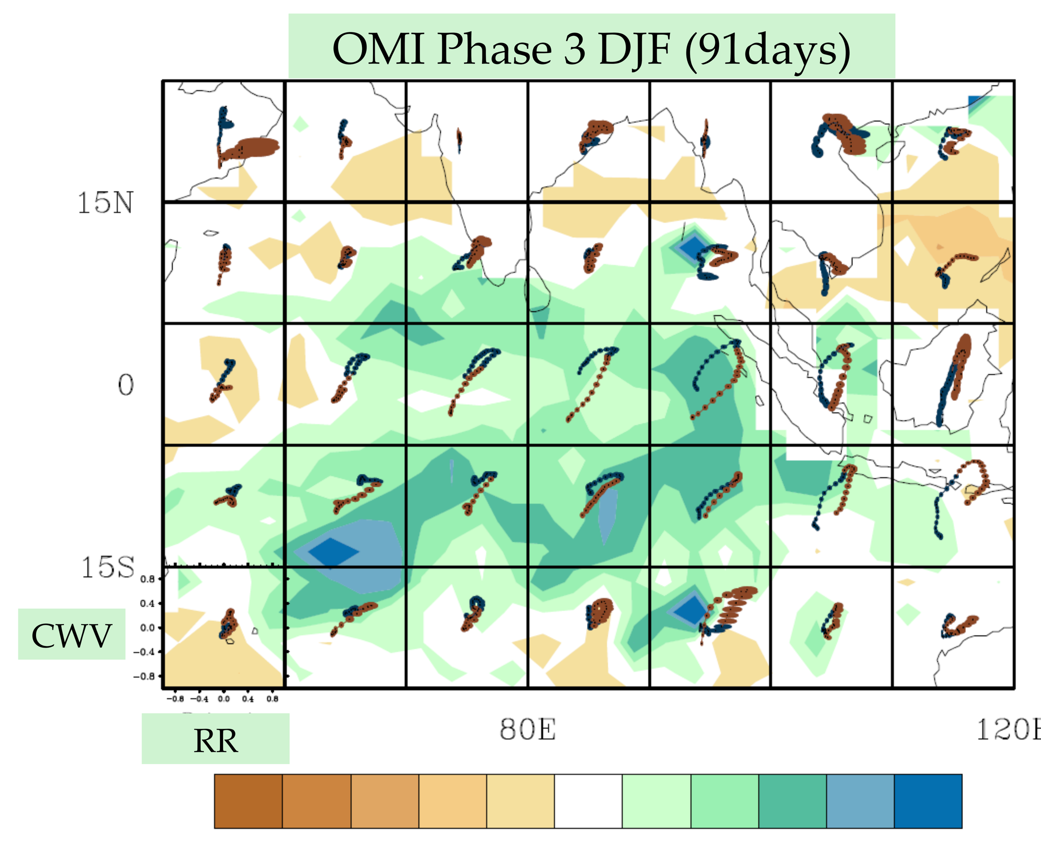
The **objective** of this work is to investigate how the relationship between water vapor and rain rate changes during the MJO, CCKW, and a subset of slow, zonally narrow, eastward-moving waves (ZN) with wavenumbers and frequencies in between.

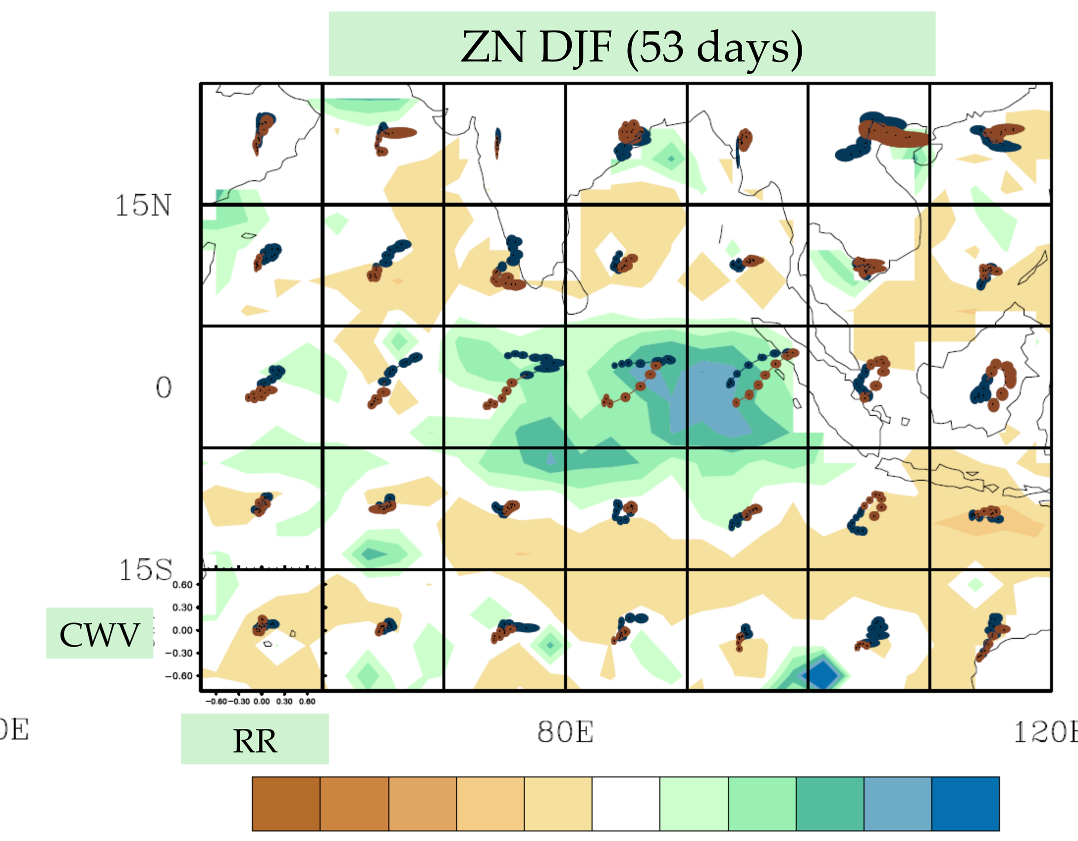
2. Data and methods

- Data:
  - Tropical Rainfall Measuring Mission (TRMM) Microwave Imager (TMI)
    - Columnar atmospheric water vapor (mm)
    - Derived radiometer rain rate (mm/hr)
    - 2.5 degree horizontal resolution
    - Daily resolution of three day averages
    - 1998-2010
  - ECMWF Interim 850 mb winds (m/s)
- Identification of Events:
  - OLR MJO Index (OMI) from Kiladis et al. (2014)
  - Indices for CCKW and ZN created by Roundy

3. Results

- "Moisture cycles" show the evolution of the relationship between rainfall (RR) and columnar water vapor (CWV)
- As enhanced convection builds up and dies down over a region, CWV and RR increase and decrease together

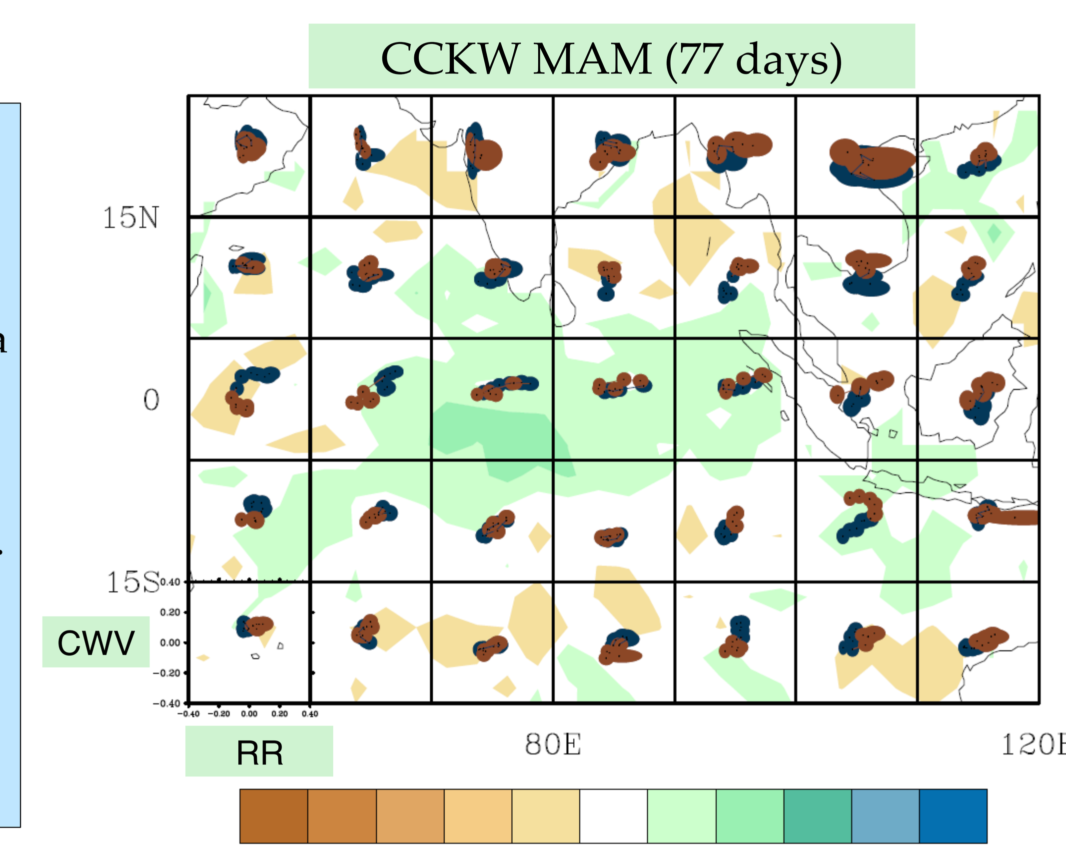




Days before lag 0

Days after lag 0

Figure 2 (top left): Standardized RR composite (contours) for phase 3 of OMI during DJF. Overlaid x-y plots show standardized RR (x-axis) versus CWV (y-axis) corresponding to the underlying area with axes set to one standard deviation (SD). Ellipses show 95% confidence intervals for each date in blue for days prior to phase 3, and orange for days after.
Figure 3 (top right): As in fig. 2 for a composite ZN phase. Axes set to 0.8 SD.
Figure 4 (bottom right): As in fig. 2 for a composite CCKW phase during MAM. Axes set to 0.4 SD.



- For the MJO, there is more CWV per amount of RR before the peak in convection as opposed to afterwards
- The ZN moisture cycle is comparable to the MJO with a smaller temporal and spatial scale
- During enhanced convection for CCKW, CWV and RR increase and decrease together, however results show no significant difference in their relationship between days before and after

4. Discussion

- The difference in pathway before and after lag 0 for the MJO and ZN is indicative of a hysteric relationship where sufficient moisture is necessary to reach a tipping point for convection to be triggered.
- This is consistent with the *Discharge-recharge theory* (Bladé and Hartmann 1993), which suggests that during the MJO, moisture builds up locally until it reaches a tipping point, and large-scale convection is able to be triggered. The convection then interacts with the atmospheric circulation to allow the air to dry through horizontal and vertical advection.

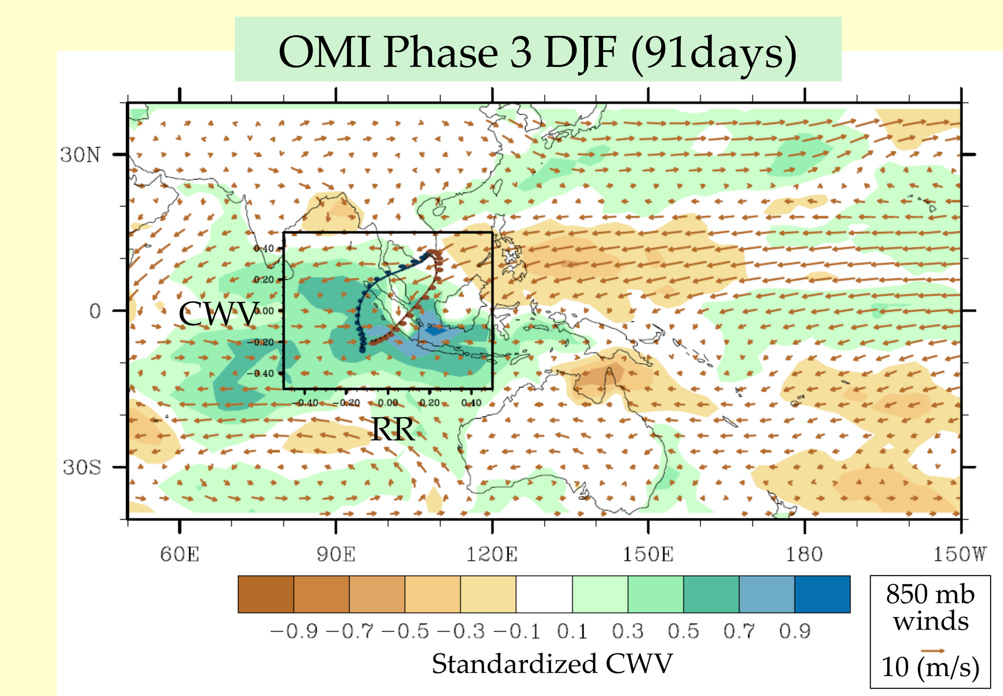


Figure 5 : Standardized CWV(contours) and 850 mb winds (vectors). Moisture cycle as in fig. 2, just composited over a larger area with axes set to 0.5 SD.

- The MJO is associated with a pair of cyclonic gyres in the lower troposphere characteristic of Rossby waves behind and to the west of the deepest convection
- This circulation advects dry air, which would reduce water vapor after the peak in convection
- This Rossby wave structure is not present in the CCKW, which may be part of the cause for the difference in moisture cycles

Literature cited

Bladé, Ileana, Dennis L. Hartmann, 1993: Tropical Intraseasonal Oscillations in a Simple Nonlinear Model. *J. Atmos. Sci.*, **50**, 2922–2939.

Kiladis G.N., J. Dias, K.H. Straub, M.C Wheeler, S.N. Tulich, K. Kikuchi, K.M. Weickmann, M.J. Ventrice. A comparison of OLR and circulation based indices for tracking the MJO. (in press, Monthly Weather Review, 2014) .

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Acknowledgments

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Further Information

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