

**Diversity of the MJO since 1974
compared to events during
CINDY/DYNAMO**

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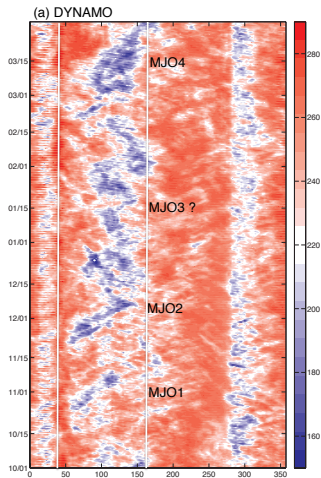
with George Kiladis and Kazu Kikuchi

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What type of diversity?

- ▶ Statistical behavior of higher frequency variability within the MJO
- ▶ Higher frequency variability during CINDY/DYNAMO.

HFV \Rightarrow CCEWs



Why are we interested in the relationship between MJO and CCEWs?

The broad question we are interested in is:

Does successful simulation and prediction of tropical low-frequency variability depends critically on properly resolving higher-frequency modes of variability?

a strong systematic relationship between the MJO and CCEWs would imply that properly resolving CCEWs is critical to the MJO proper simulation..

Moreover...

- ▶ Some theoretical MJO studies suggest that particular phases and scales of CCEWs and MSCs are not essential to simulating the evolution of the MJO (Majda and Stechmann [2009]; Sobel and Maloney [2013]); Others state that CCEWs are they essential? (Yang and Ingersoll [2011, 2012], Liu and Wang [2012]).

Back to today's talk...

1. Methodology

1.1 Detecting the MJO convective envelope

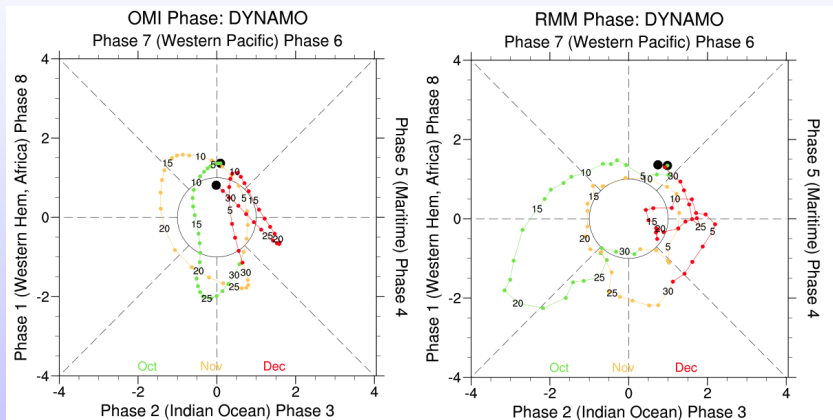
1.2 Identifying CCEWs within the MJO convective envelope

2. Examples

2.1 CCEWs during MJO vs climatology

2.2 CCEWs variability across events

How to identify MJO events?



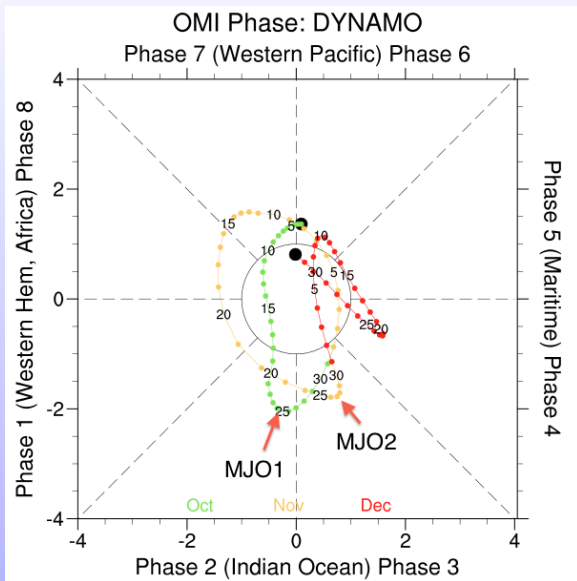
Note: OMI is similar to the bimodal index from *Kikuchi et al. 2012*, and is based of EOFs of 30-96 eastward OLR data (no circulation!). *Details in Kiladis et al., 2014 (MWR)*

More on OMI...

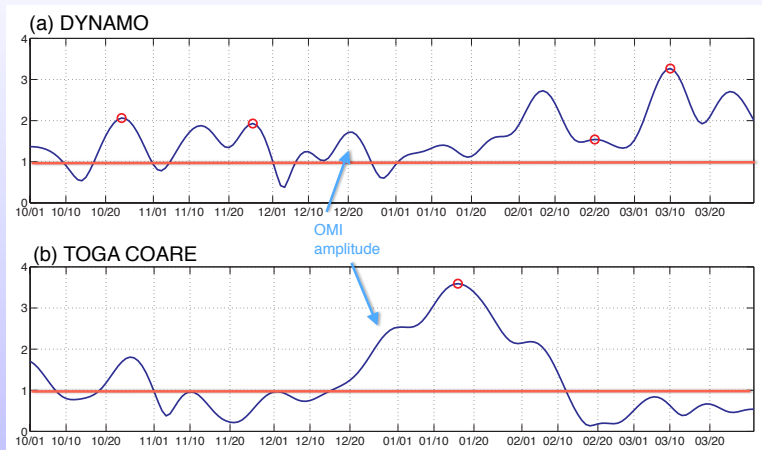
Similarly to RMM, the first 2 EOFs are form a propagating pair, and the OMI index is defined as projection of 20-96 days filtered OLR onto the patterns above.

<http://www.esrl.noaa.gov/psd/mjo/mjoindex/>

How to define MJO events?



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Example:

18-Nov-1979

31-Dec-1980

30-Oct-1982

19-Oct-1983

28-Feb-1980

20-Mar-1981

24-Dec-1982

07-Nov-1983

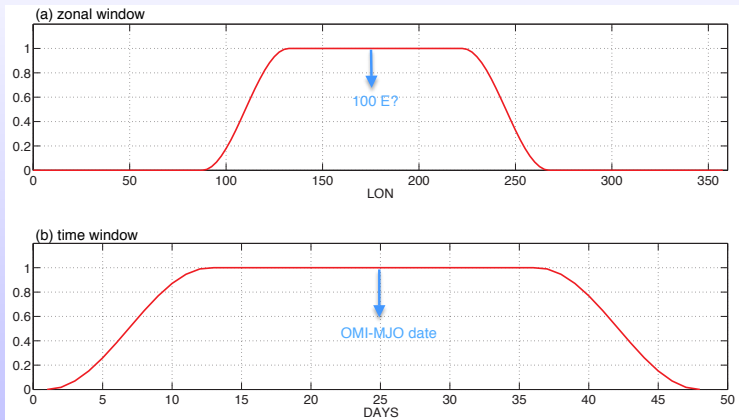
11-Oct-1980

26-Oct-1981

13-Feb-1983

20-Dec-1983

How to assess the local behavior of CCEWs?



our approach is based on **computing localized space-time power spectrum** (either using FFT or wavelets)

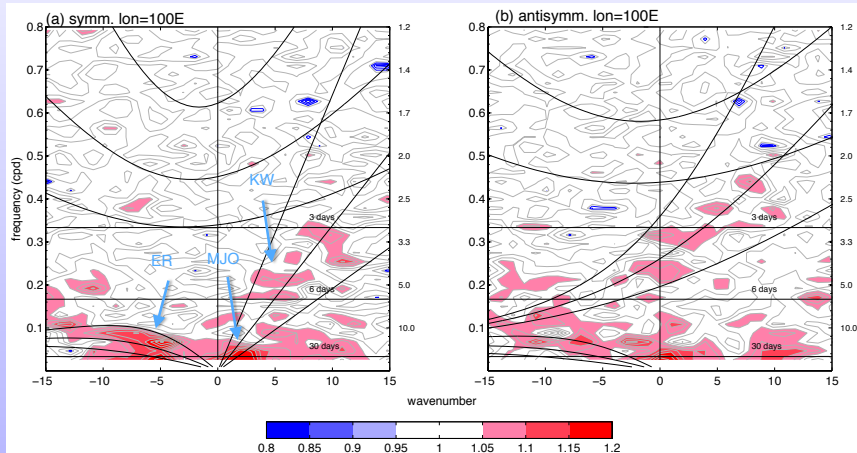
Example 1: CCEWs during Indian Ocean active MJOs compared to climatology

Comparison between MJO dates and climatology

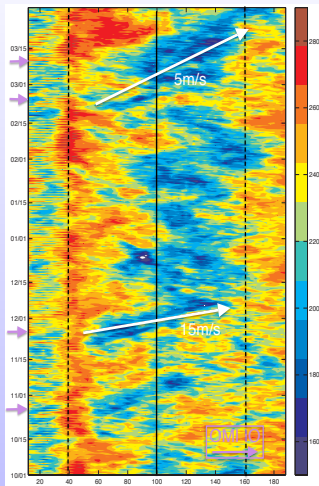
For any period from 1979-2013 the local PS can be compared to the daily climatology (shown below).

Comparison between MJO dates and climatology

$$\bar{R} = \frac{\sum_N \frac{E_{mjo_j}}{E_{cal_j}}}{N}$$

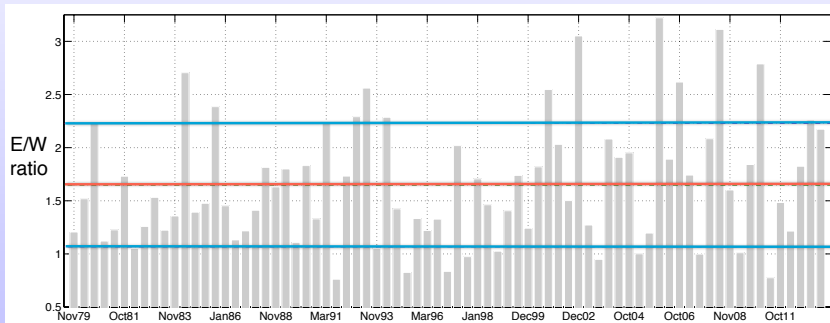


How about CCKWs during DYNAMO?



Example 2: MJO diversity across events

CCKWs variability during MJO events (over the Indian Ocean)

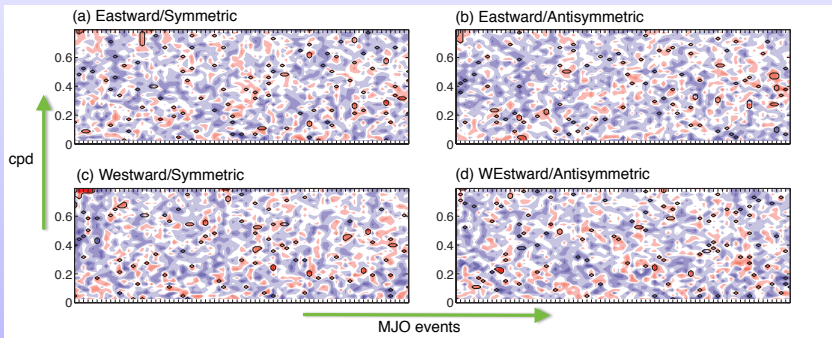


There is substantial variability in the East/West ratio for wavenumbers 1-3 and at the lowest freq...

CCKWs variability during MJO events (over the Indian Ocean)

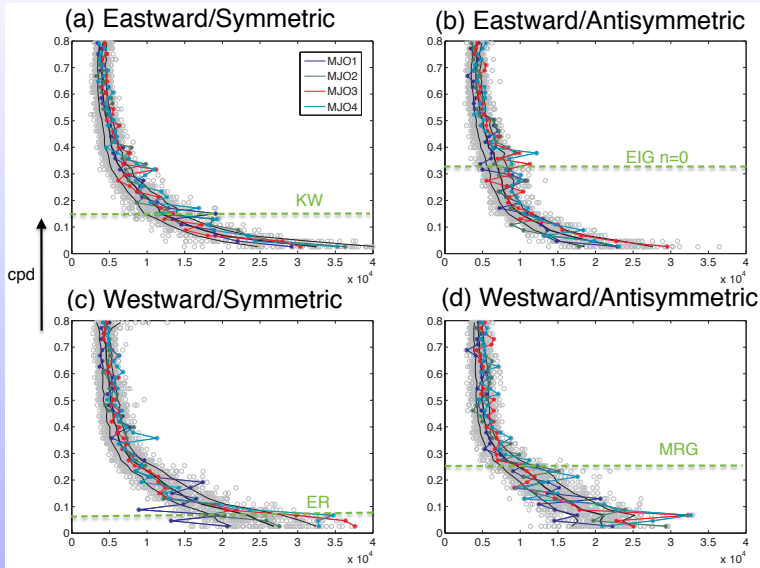
Power spectrum anomalies are defined as:

$$PS_{anom}^j(k, \omega) = PS^j(k, \omega) - \overline{PS^j(k, \omega)}^{j=1:N}$$



Note: 'j' are all the MJO events from 1979-2012 obtained using OMI

How about CCEWs during DYNAMO?



Summary

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One implication is that this result supports large-scale cumulus parametrizations in simulating the MJO? That is, it may not be necessary to resolve CCEWs in order to properly simulate the MJO (*more in Dias et al, 2013 GRL*).

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One implication is that this result supports large-scale cumulus parametrizations in simulating the MJO? That is, it may not be necessary to resolve CCEWs in order to properly simulate the MJO (*more in Dias et al, 2013 GRL*).
- ▶ On the other hand, visually, and quantitatively, it is clear that there are a number of cases of MJOs that exhibit a stronger Kelvin Wave component. Why is that?

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- ▶ Composites on MJO “types” based on types of enhanced CCEWs (vertical structure, moisture budgets, etc);
- ▶ Tracking CCEWs using an object approach (*see Dias et al 2011, JAS*). Does the MJO modulate the path and propagation of CCEWs?

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- ▶ Model inter-comparison in terms of the their MJO/CCEWs relationship.