MJO concept, eastward propagation, teleconnections, and South American rainfall

Fernando Hirata, Peter J. Webster, and Violeta Toma
School of Earth and Atmospheric Sciences, Georgia Institute of Technology

1. Introduction & Motivation

Recent in situ observations in the Indian Ocean (i.e. DYNAMO) led to a debate about the concept of an MJO event and our ability to describe it using indices or dynamic features. Operational forecasts use MJO indicators, such as the RMM index, as predictors of intraseasonal variability. However, not all winter MJO events are the same and potential MJO impacts on rainfall around the globe may also differ depending on particular characteristics of large-scale convection over the Eastern Hemisphere warm pools. Understanding event-to-event variations can improve extended-range forecasts in regions like South America, where MJO influence on convective activity seem to be significant.

2. MJO influence on South American intraseasonal convection

As MJO-related upper-level divergent anomalies overcome the Andes Mountains, positive precipitation anomalies are observed over Eastern Amazon and Northeast Brazil due to a combination of enhanced convective activity in the South Atlantic Convergence Zone (SACZ) and the Atlantic Intertropical Convergence Zone (ITCZ) [Ferranti et al. 1990; Souza and Ambrizzi 2006]. Convection over the SACZ is also modulated by extratropical wave activity on submonthly (10-30 days) and intraseasonal timescales (30-90 days) [Nógues-Paegle and Mo 1997; Liebmann et al. 1999]. Part of the intraseasonal modulation is linked to the MJO and very sensitive to convection to the east of the dateline [Grimm and Silva Dias 1995].

3. Data and analysis

ERA-Interim Reanalysis and NOAA OLR data from 1979 to 2011 are used to describe the evolution of large-scale convection over the Eastern Hemisphere tropics during winter (Oct-Mar), when the MJO is thought to be stronger. We adopt a statistical definition of the MJO that closely follows the one discussed by Kessler [2001]. EOF decomposition is applied to band-passed (20-90 days) OLR data meridionally averaged between 15ºN and 15ºS. To our advantage, the method is not excessively stringent, allowing the identification of events that do not fit the traditional definition of the MJO. For instance, Hendon et al. [1999] used a similar method and found that nearly half of Western Pacific intraseasonal variance is associated with the MJO. Our decomposition grants similar results. Furthermore, it allows us to inspect the evolution of somewhat different intraseasonal events and how these events influence atmospheric circulation and teleconnections to remote regions. Results of EOF are shown in Figures 1-3.

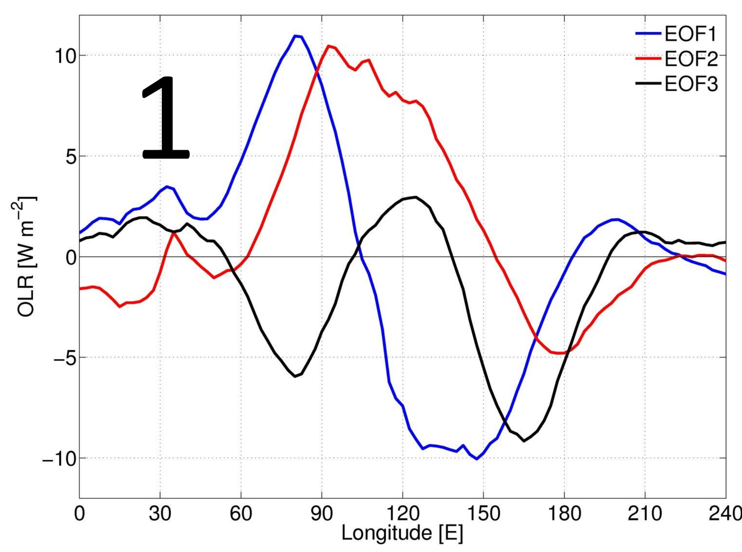
4. Intraseasonal events

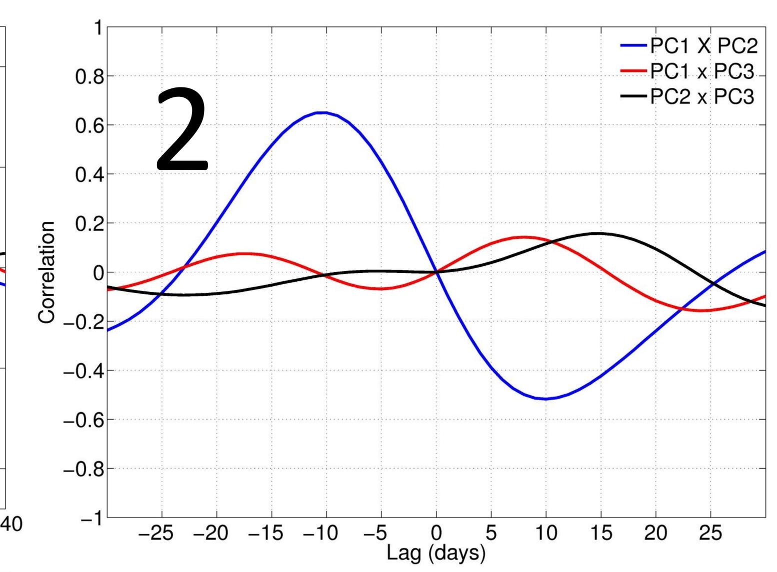
Three distinct classes of intraseasonal events are defined based on the EOF decomposition.

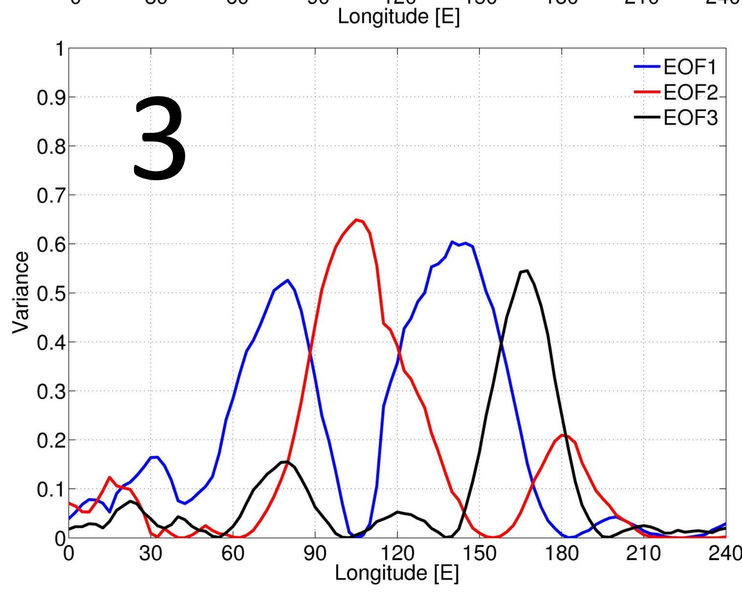
Canonical MJO: A PC1 minimum below -1 standard deviation is followed by a PC2 minimum below -1 standard deviation within 25 days. The period of 25 days is somewhat arbitrary but intends to exclude events with unusual long lags between PC1 and PC2.

Eastward decaying: PC1 minimum below -1 standard deviation is not followed by a PC2 minimum below -1 standard deviation.

Eastward intensifying: PC2 minimum below -1 standard deviation is not preceded by a PC1 minimum below -1 standard deviation.





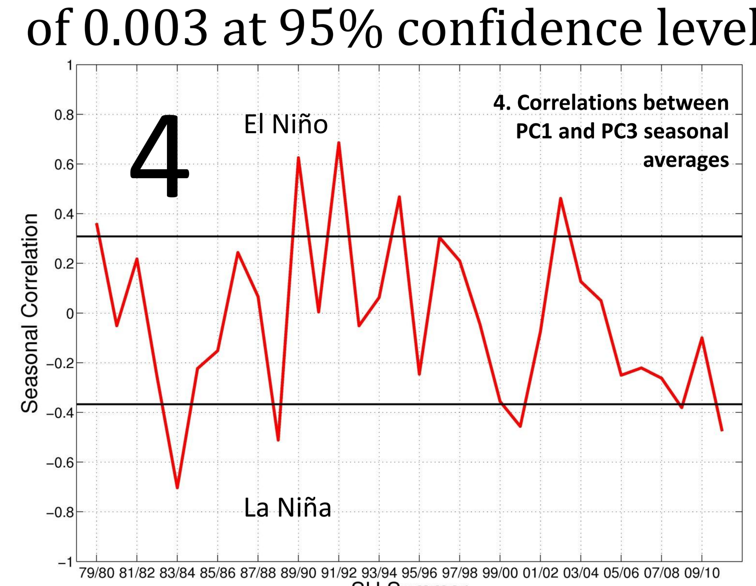


1. Classification of EOF-based intraseasonal events

Category	Number of events	Average lag (days)
Canonical MJO	52	10.8
Eastward decaying	25	-
Eastward intensifying	13	-
Others	5	35
TOTAL	95	-

Figure 1. EOF modes ; **Figure 2.** Principal components (PC) lag-correlation; **Figure 3.** Intraseasonal variance explained. **Table 1.** Results of EOF-based classification of intraseasonal events (EOF3 events not included).

The EOF decomposition also depicts a significant third mode. Kessler [2001] argued that EOF3 represents an eastward extension of MJO events associated with ENSO. Seasonal correlations between PC1 and PC3 (Figure 4) indicates that the correlations are slightly stronger during ENSO seasons. When these seasonal correlations are compared to a seasonally averaged SOI, a significant correlation of -0.5 is found (p-value of 0.003 at 95% confidence level).



PC3 presented 110 minima below -1 standard deviation. Moreover, EOF3 responds to an important fraction of intraseasonal variance near the dateline (Figure 3). Therefore, these events will be considered separately.

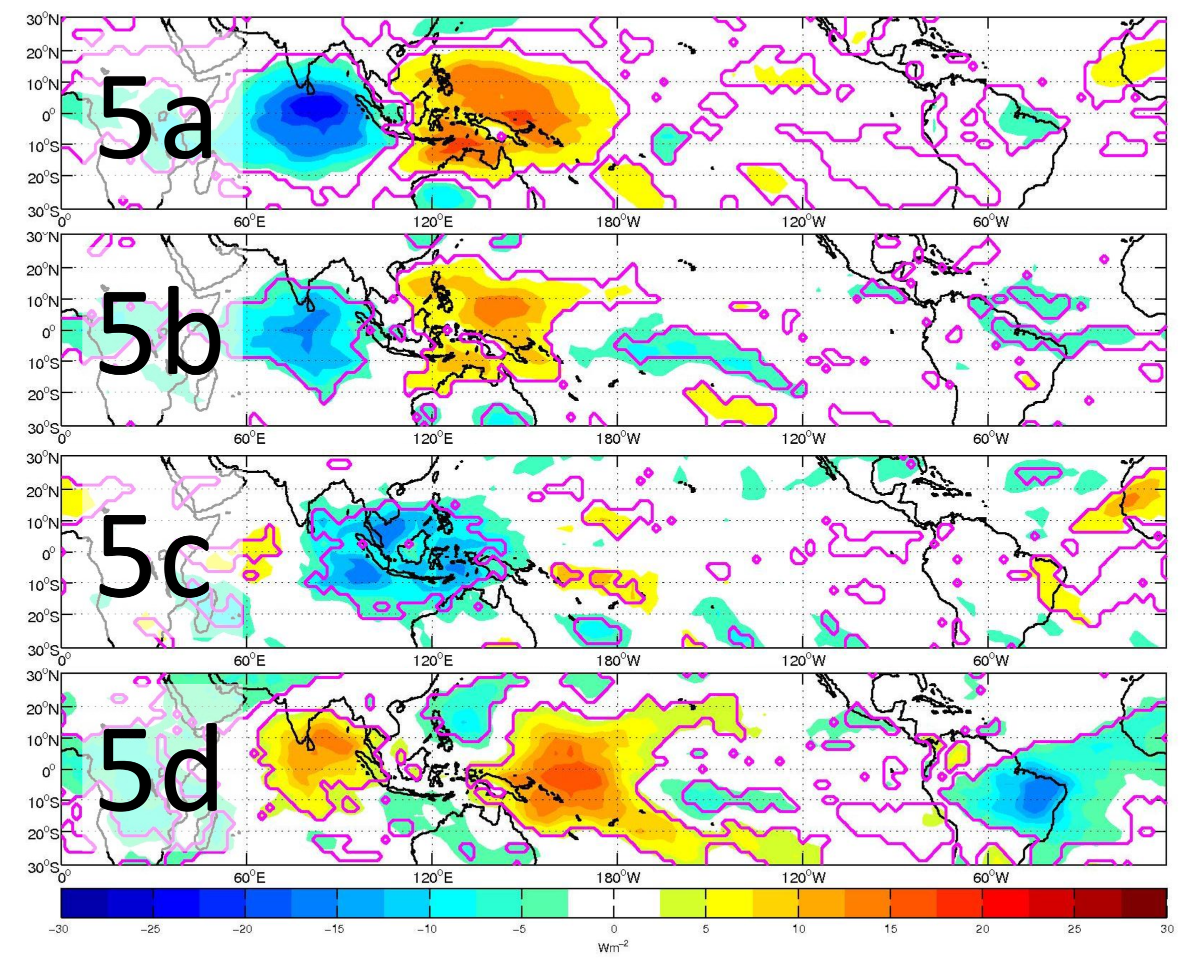


Figure 5. Composites (day zero) for a) canonical MJO ; b) eastward decaying; c) eastward intensifying; d) EOF3 events concurrent to South American convection (see text). Pink contours indicate 95% confidence level based on Monte Carlo simulations. [-30 to +30 Wm^{-2}]

5. EOF3 events

PC3 presents significant correlation with South American convection, especially over Northeast Brazil (-0.41 at zero lag). A comparison of PC3 and an area-averaged intraseasonal OLR over Northeast Brazil (0-20ºS, 30ºW-60ºW) reveals that 53% of PC3 minima below -1 standard deviation coincides with OLR minima below -1 standard deviation over Brazil. This relationship is not dependent on the behavior of PC1 (only 21 out of 53 concurrent PC3/Northeast Brazil events occurred around a PC1 minima below -1 standard deviation).

6. Concluding remarks

The composite life cycles of canonical MJO and eastward decaying events indicate that minimum OLR over South America is observed 7 (4) days before the MJO (eastward decaying) event (Figure 6). Both cycles suggest that suppressed convection across the Tropical Pacific (Figure 7) is instrumental for convection east of 60ºW. A fundamental distinction is the occurrence of an organized wave train in the extratropics during canonical MJO cycles (Figure 8). Note that negative OLR anomalies over Brazil exhibit a NW-SE diagonal orientation characteristic of a SACZ. This orientation and the organization of the wave train are not observed in the composites for different types of intraseasonal events.

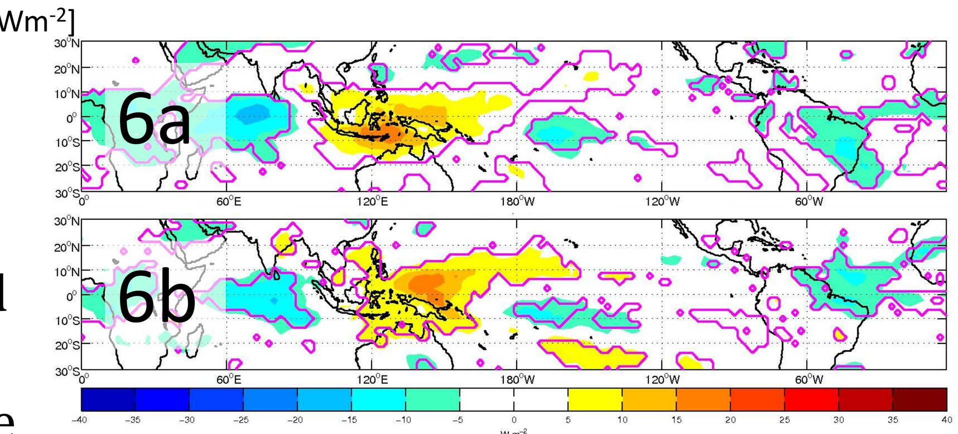


Figure 6. a) OLR composite day -7 for MJO; b) OLR composite day -4 for eastward decaying events. Pink contours indicate 95% confidence level based on Monte Carlo simulations. [-30 to +30 Wm^{-2}]

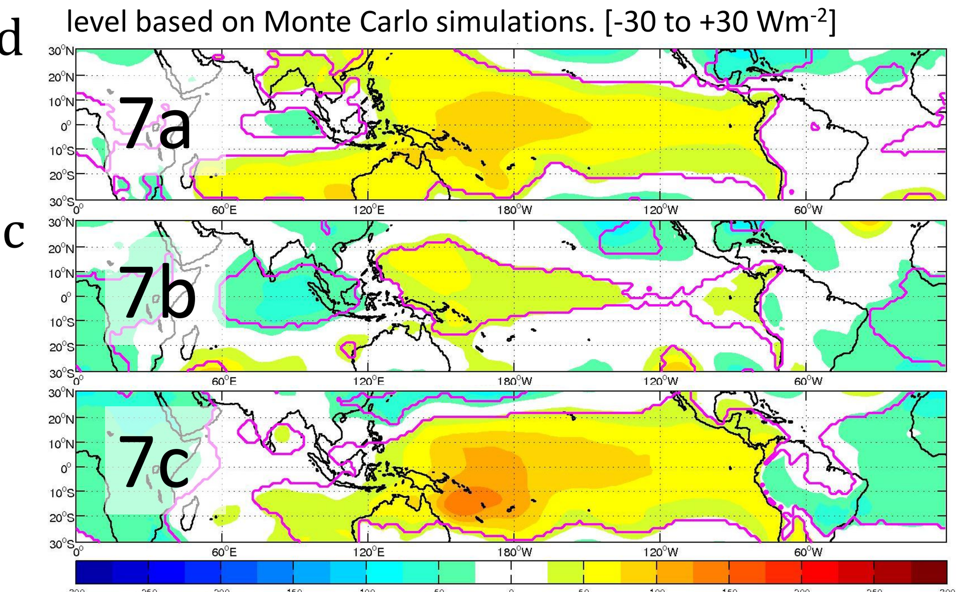


Figure 7. a) Surface pressure composite day -7 for MJO events; b) composite day -4 for eastward decaying events; c) composite day zero for EOF3 events. Pink contours indicate 95% confidence level based on Monte Carlo simulations. [-300 to +300 Pa]

7. Future work

A few questions are left unanswered and are the focus of current research.

- What causes the observed differences in eastward propagation?
- How is the extratropical wave train organized during canonical MJO events?
- What is the nature of EOF3?

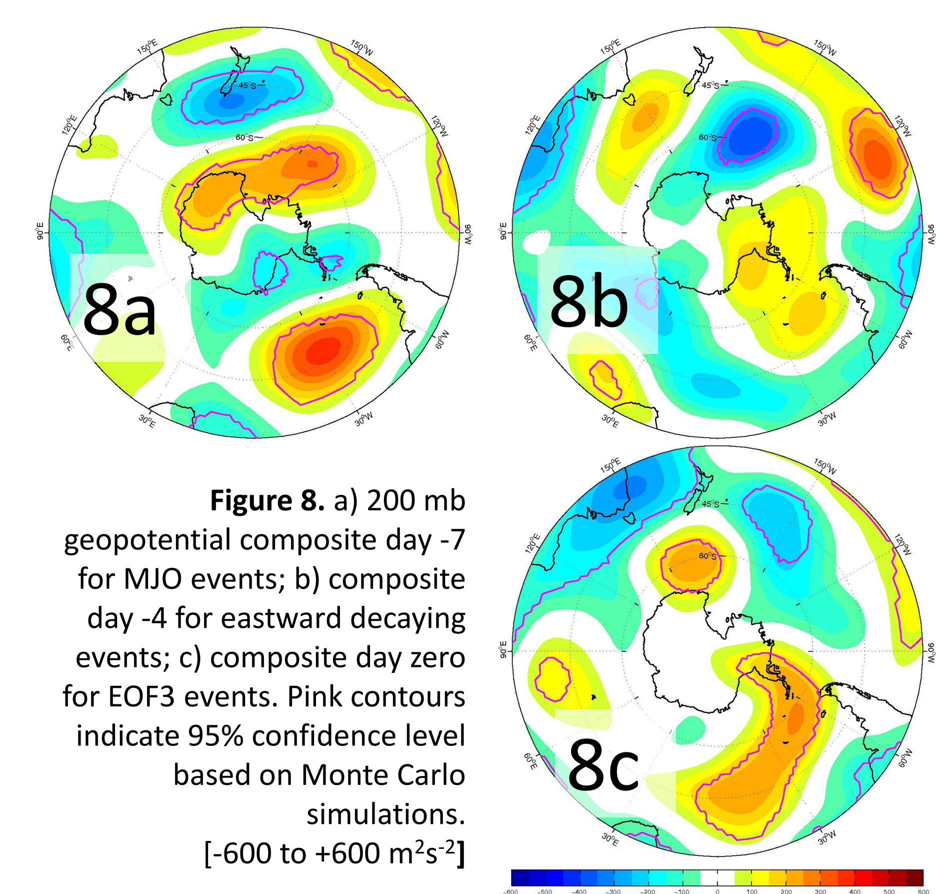


Figure 8. a) 200 mb geopotential composite day -7 for MJO events; b) composite day -4 for eastward decaying events; c) composite day zero for EOF3 events. Pink contours indicate 95% confidence level based on Monte Carlo simulations. [-600 to +600 m^{2}s^{-2}]

References

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