Comparison of Mean States and MJO Events during MISMO and DYNAMO Field Campaigns

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1. Background & Motivation

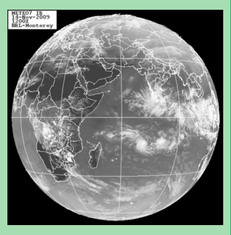
The background conditions of wind, moisture, shear, and sea-surface temperatures (SSTs) are associated with changes to the Madden-Julian Oscillation[1,2]. Emerging research demonstrates that the frequency and intensity of MJO disturbances may be dependent on the background states of low-level zonal wind and SST[3,4].

This study serves as a very preliminary investigation into the roles that the background atmospheric and oceanic states play in modulating MJO disturbances during two recent field measurement campaigns [***M**irai* **I**ndian Ocean Cruise for the **S**tudy of **MJO**-Convective **O**nset (MISMO[5]) and Dynamics of the Madden-Julian Oscillation (DYNAMO[6])]. The MJO is most active over the open Indian and West Pacific Ocean basins, where collecting *in situ* measurements is difficult. These field campaigns offer the opportunity to examine a comprehensive suite of data, including radiosondes of exceptionally high temporal resolution and quality.

One focus of our ongoing research is on the Indian Ocean Dipole (IOD[7]), a shift in SST anomalies and associated changes in wind and moisture within the equatorial Indian Ocean region. The IOD is captured by the Dipole Mode Index (DMI), which was found to be very positive during MISMO but near neutral during DYNAMO[4]. We investigate the resulting changes to the background states during these two periods and explore how such changes might impact MJO intensity and structure.

2. Key Questions

This study seeks to address the following questions:

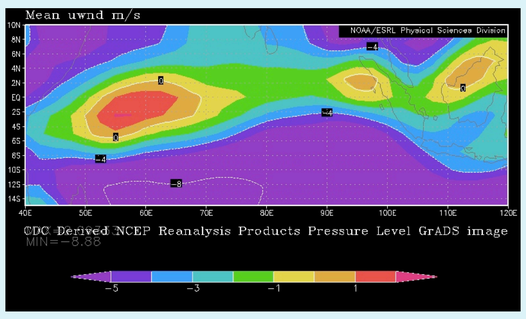


(1) What do the background thermodynamic and dynamic fields look like during MISMO and DYNAMO, and how do they compare to long-term climatology?

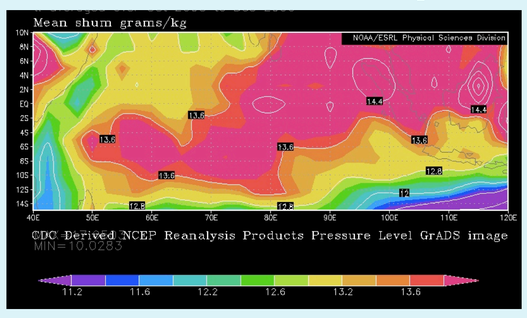
(2) Based on possible differences in the background states, how might we expect MJO intensity and structure to change?

3. Mean Fields

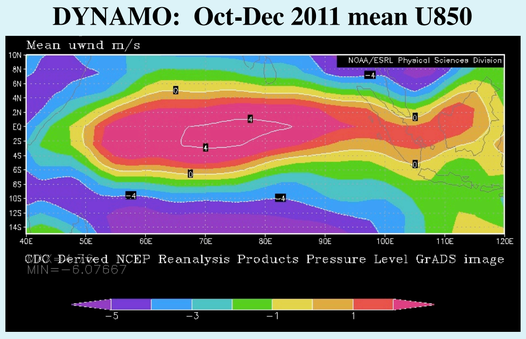
MISMO: Oct-Dec 2006 mean U850



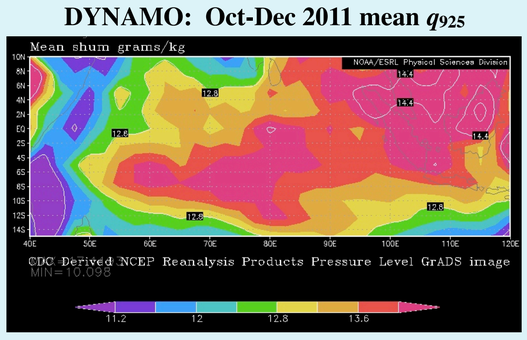
MISMO: Oct-Dec 2006 mean q_{925}



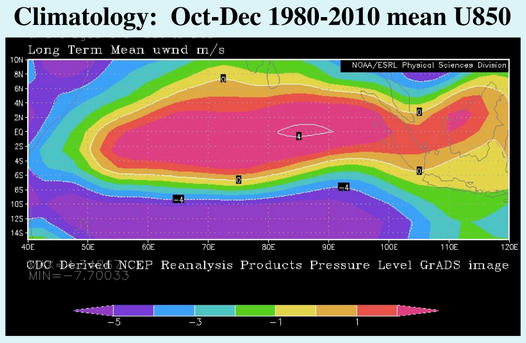
DYNAMO: Oct-Dec 2011 mean U850



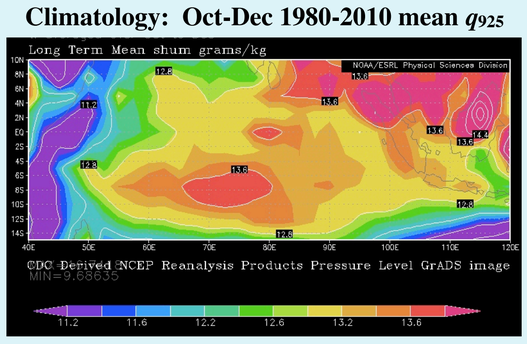
DYNAMO: Oct-Dec 2011 mean q_{925}



Climatology: Oct-Dec 1980-2010 mean U850

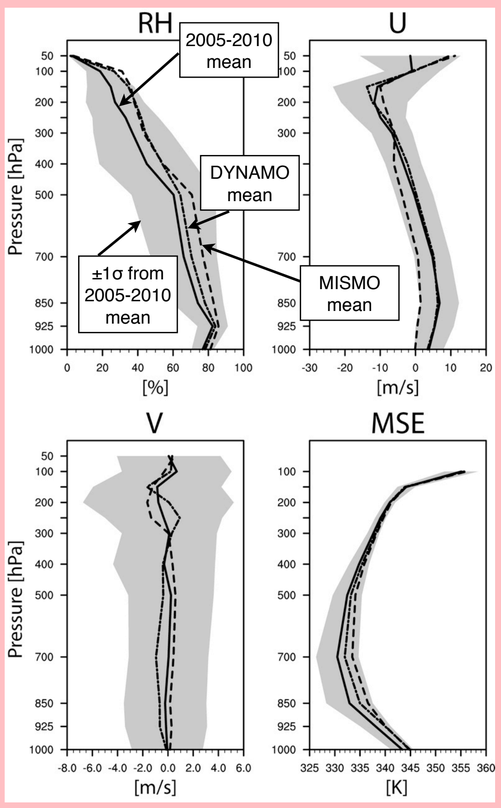


Climatology: Oct-Dec 1980-2010 mean q_{925}



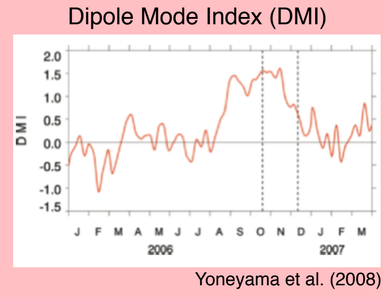
Background 850hPa winds (left) and 925 hPa specific humidity (right) were strikingly different from climatology during MISMO. Conditions during DYNAMO were closer to their expected climatological values. In several GCMs, weakened U850 westerlies over the Indian Ocean are associated with a weakening of intraseasonal variability and MJO disturbances.

4. Selected Results

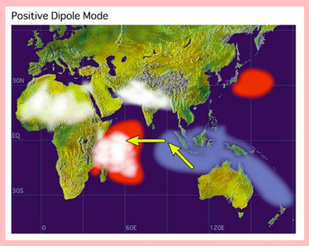


(*Left*) At Gan Island (1°S, 73°E), background humidity and moist static energy were higher than climatology (solid) during MISMO (dashed), and low-level westerlies and tropospheric shear were strongly reduced. Background states closer to climatology were observed during DYNAMO (dot-dashed).

Dipole Mode Index (DMI)



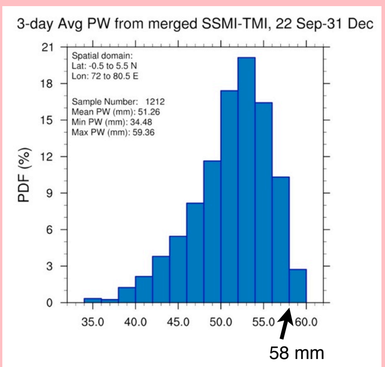
Yoneyama et al. (2008)



Source: JAMSTEC

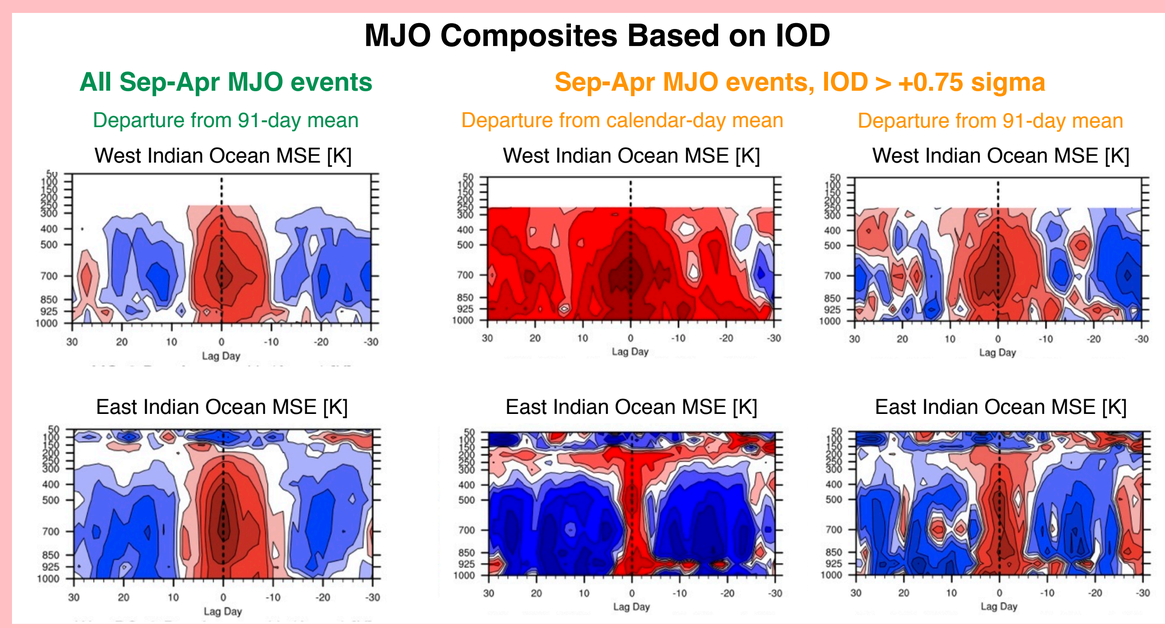
(*Above*) The DMI was very positive during MISMO but near neutral during DYNAMO (not shown).

(*Right*) A histogram of climatological precipitable water (PW) near the MISMO and DYNAMO focus domains. Mean PW during MISMO was in the 97th percentile (58 mm). Mean PW during DYNAMO was 54 mm.



(*Below*) Positive phases of the IOD are linked with longitude-dependent modulation of MJO events. During IOD+, the west Indian Ocean is anomalously moist (top center) and MJO events involve a strong, gradual build-up of low-level MSE that subsequently deepens (top right). East Indian Ocean sites are anomalously dry (bottom center), and the build-up of MSE is weak (bottom right). It is likely that some combination of background wind and moisture gradients conspire to modulate the MJO during IOD+.

MJO Composites Based on IOD



5. Summary

Our analyses indicate that:

(1) MISMO exhibited a background state that was moister and had reduced U850 westerlies and vertical wind shear, compared to climatology. Conditions during DYNAMO were close to the expected climatology.

(2) Large and persistent moist anomalies were observed during MISMO, but development of deep convection was delayed/suppressed.

- ***Disorganized MIMSO convection linked to positive Indian Ocean Dipole event***

(3) The Indian Ocean Dipole (IOD) strongly modulated the MJO during MISMO but not DYNAMO. IOD-related changes to the background state were associated with a weakening of MJO events as they crossed the Indian Ocean during MISMO. Future work will focus on the role that wind shear and moisture distribution played in modifying MJO events during MISMO.

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