Madden-Julian Oscillation: Recent Evolution, Current Status and Predictions

Update prepared by
Climate Prediction Center / NCEP
June 3, 2013

Outline

- Overview
- Recent Evolution and Current Conditions
- MJO Index Information
- MJO Index Forecasts
- MJO Composites

Overview

- The MJO has remained fairly weak over the past several days, with the enhanced phase centered across Africa and the western Indian Ocean.

- Dynamical model MJO index forecasts are in reasonable agreement for a generally weak MJO signal over the next one to two weeks, though with significant model spread. Some propagation of the enhanced phase across the Indian Ocean and Maritime Continent is suggested.

- Based on recent observations and model MJO forecasts, the MJO is forecast to remain fairly weak, becoming slightly better organized across the Indian Ocean and Maritime Continent over the next two weeks.

- Enhanced rainfall is favored during Week-1 across parts of the Indian Ocean and the Caribbean Sea. Suppressed rainfall is favored near the Date Line. Elevated odds for tropical cyclogenesis are forecast east of the Philippines while slight odds remain for TC formation in the southern Gulf of Mexico near the Yucatan Peninsula.

- During Week-2 the MJO favors enhanced convection across parts of the Indian Ocean and Maritime Continent.

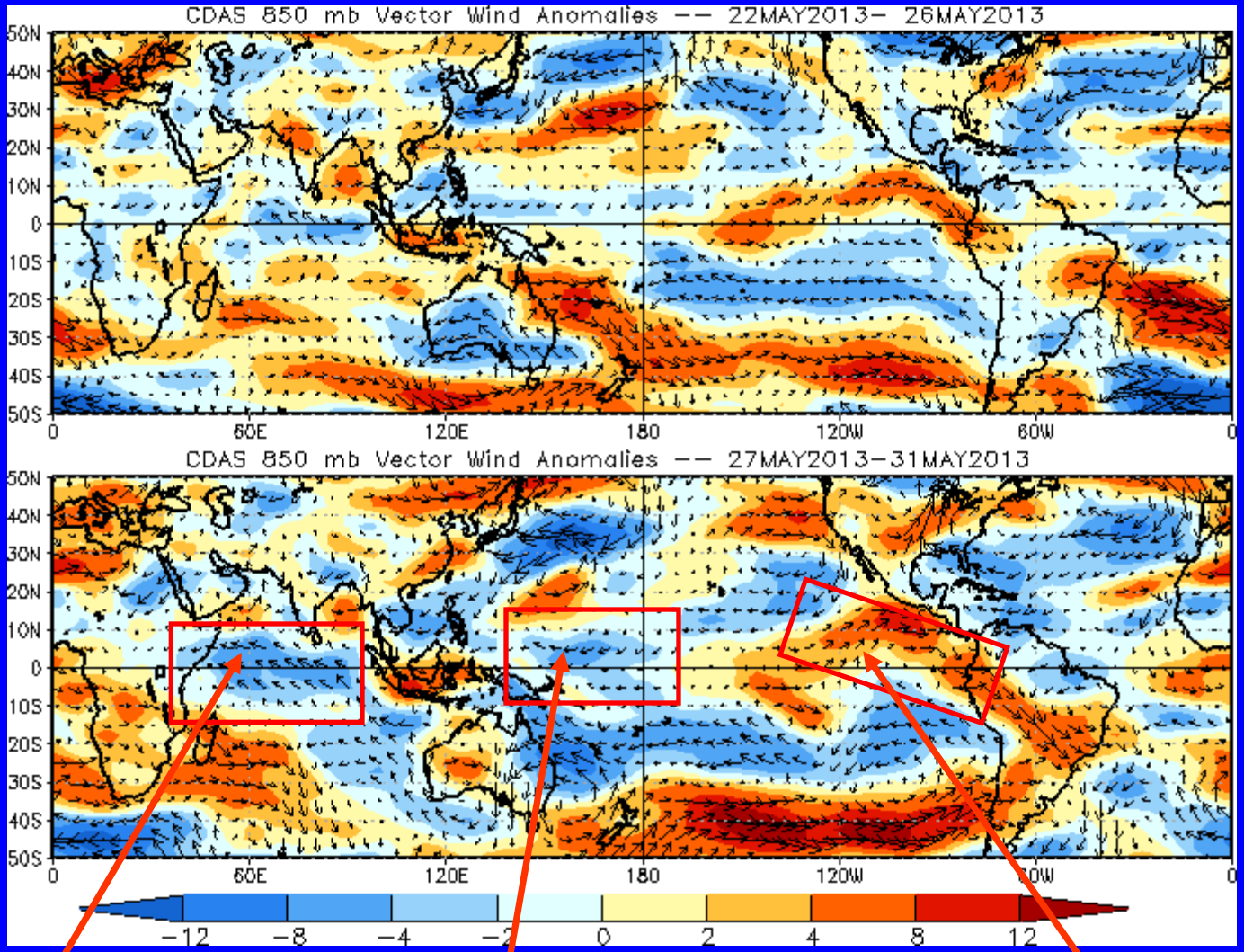
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies have become more organized over much of the equatorial Indian Ocean.

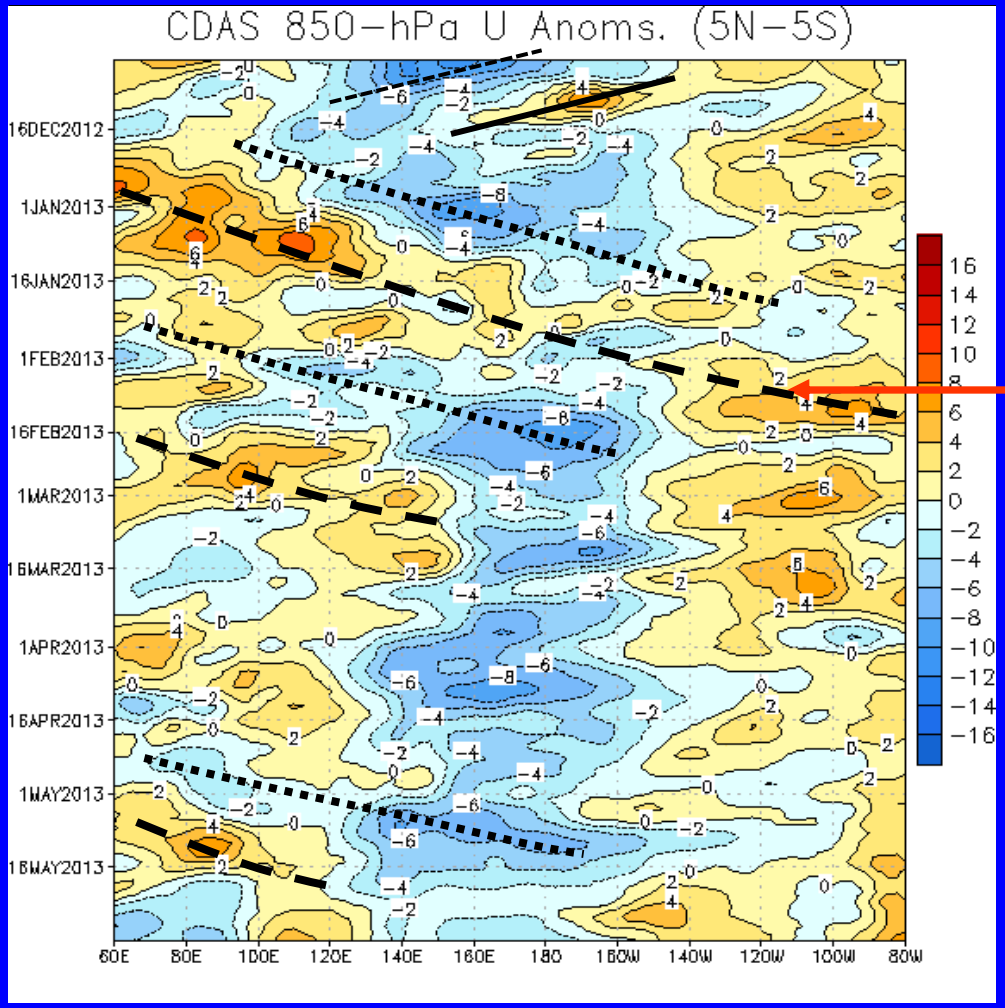
Easterly anomalies strengthened over a small area of the western Pacific.

Westerly anomalies continued over the East Pacific during the past five days.

850-hPa Zonal Wind Anomalies (m s^{-1})

Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

Easterly anomalies (blue shading) represent anomalous east-to-west flow



Time

Longitude

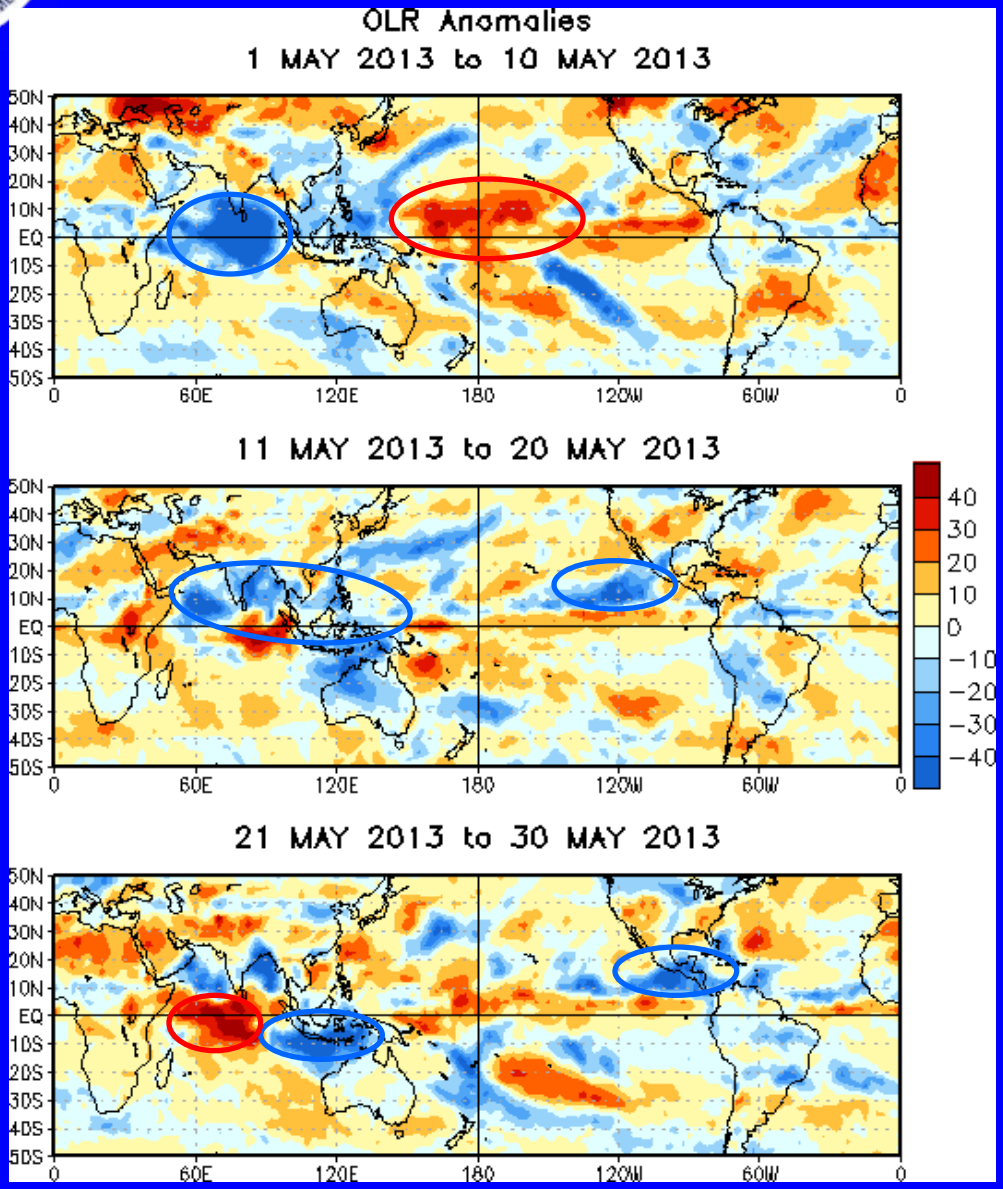
Westward propagation (dashed/solid lines sloping down and to the left) of anomalies during early December were primarily due to equatorial Rossby wave activity as the MJO was then generally weak.

During late December the MJO strengthened (alternating dotted/dashed lines).

During March and early April, anomalies indicate signs of being influenced by equatorial Rossby wave activity with less eastward propagation evident.

The MJO strengthened during early May with eastward propagation of low-level wind anomalies noted. A weaker MJO combined with interference from other sub-seasonal modes has limited eastward propagation recently.

OLR Anomalies – Past 30 days



Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

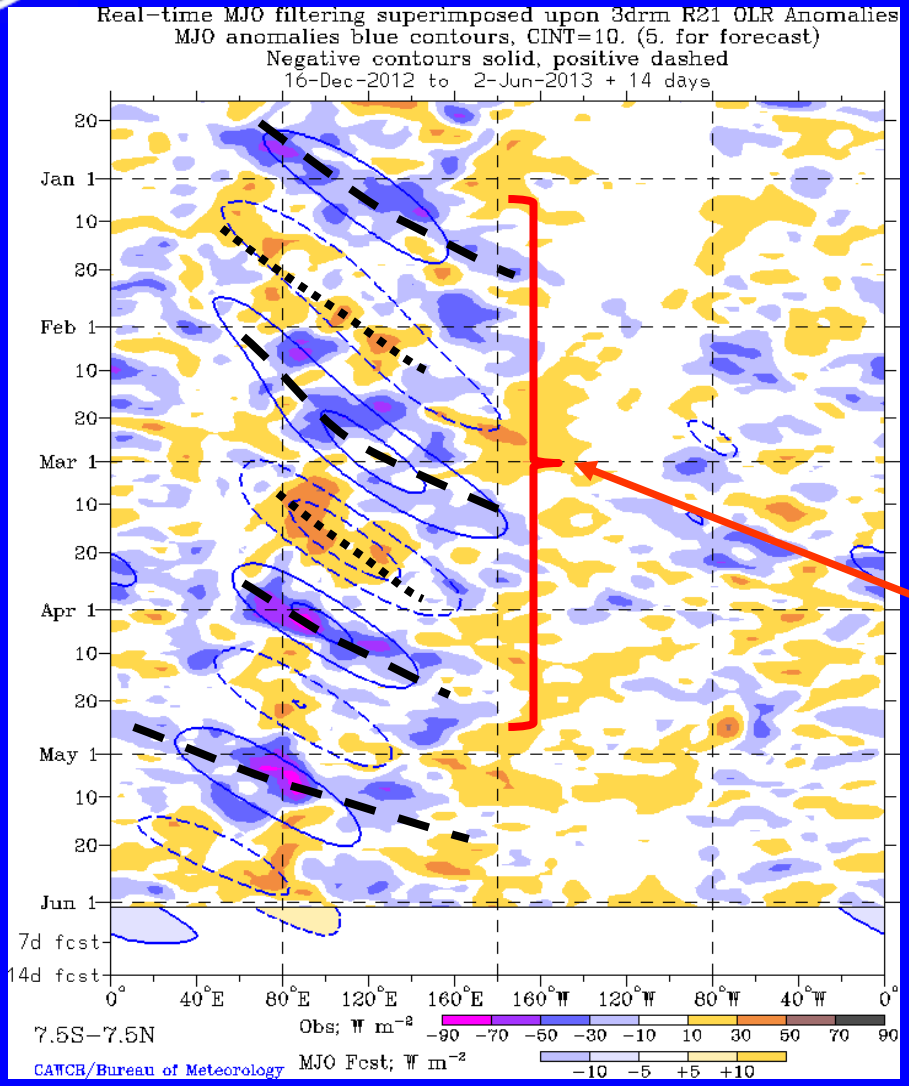
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During early May, convection rapidly developed across the Indian Ocean, while the west-central Pacific experienced suppressed convection.

During mid-May, the OLR field became less coherent with generally enhanced convection north of the Equator across the Indian Ocean and Maritime Continent. Convection also increased in parts of the East Pacific due to a northward displaced ITCZ

Most recently in late May, the OLR field has remained incoherent with respect to the MJO. A convective dipole across the Indian Ocean and anomalous convection across Central America appear to be the dominant features.

Outgoing Longwave Radiation (OLR) Anomalies (7.5°S-7.5°N)



Time

Longitude

Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

Wetter-than-normal conditions, negative OLR anomalies (blue shading)

(Courtesy of CAWCR Australia Bureau of Meteorology)

The MJO was a dominant mode of variability across the Tropics from January into March as indicated by the alternating dashed and dotted lines.

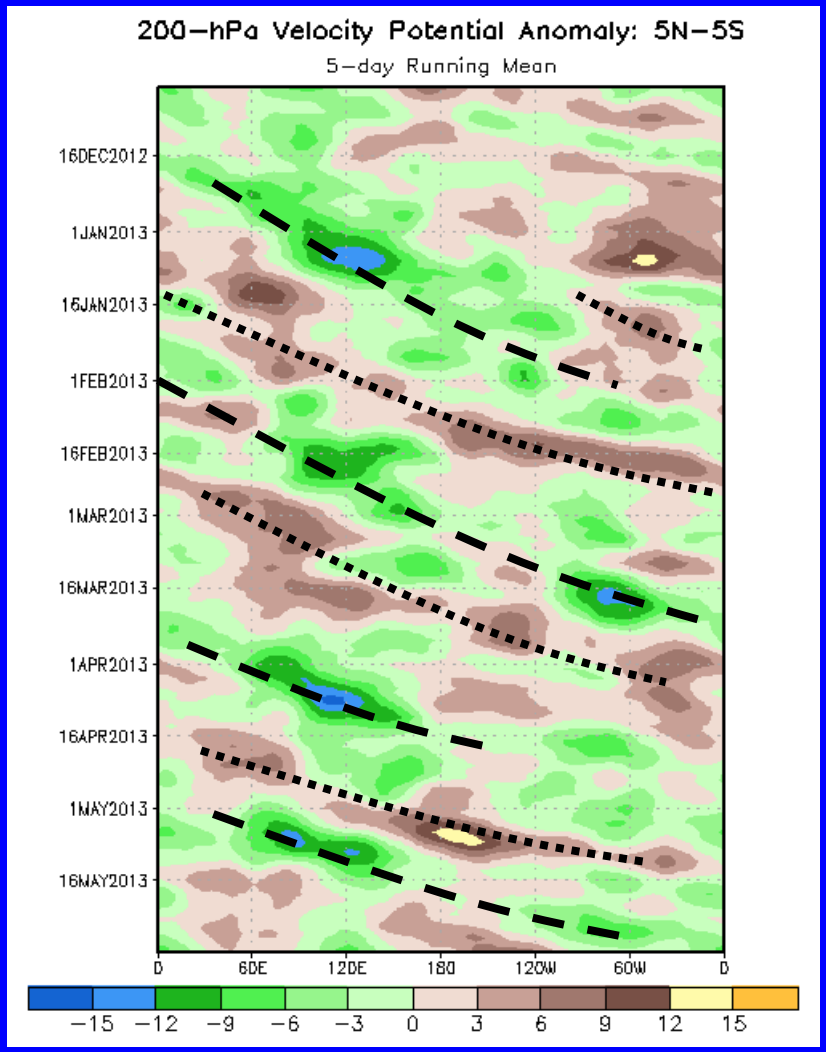
Near the end of March, the anomalies show signs of influence from other modes of tropical variability. However, MJO activity reemerged in early April across the Indian Ocean.

During early May, anomalous OLR increased significantly across the Indian Ocean. The MJO signal broke down during the middle of the month and remains fairly weak.

200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation



Time

Longitude

Other modes of subseasonal variability were more prevalent than MJO during much of December.

As the MJO strengthened in late December, (alternating dashed and dotted lines), anomalies increased in magnitude with more robust eastward propagation indicated during late 2012 to April 2013.

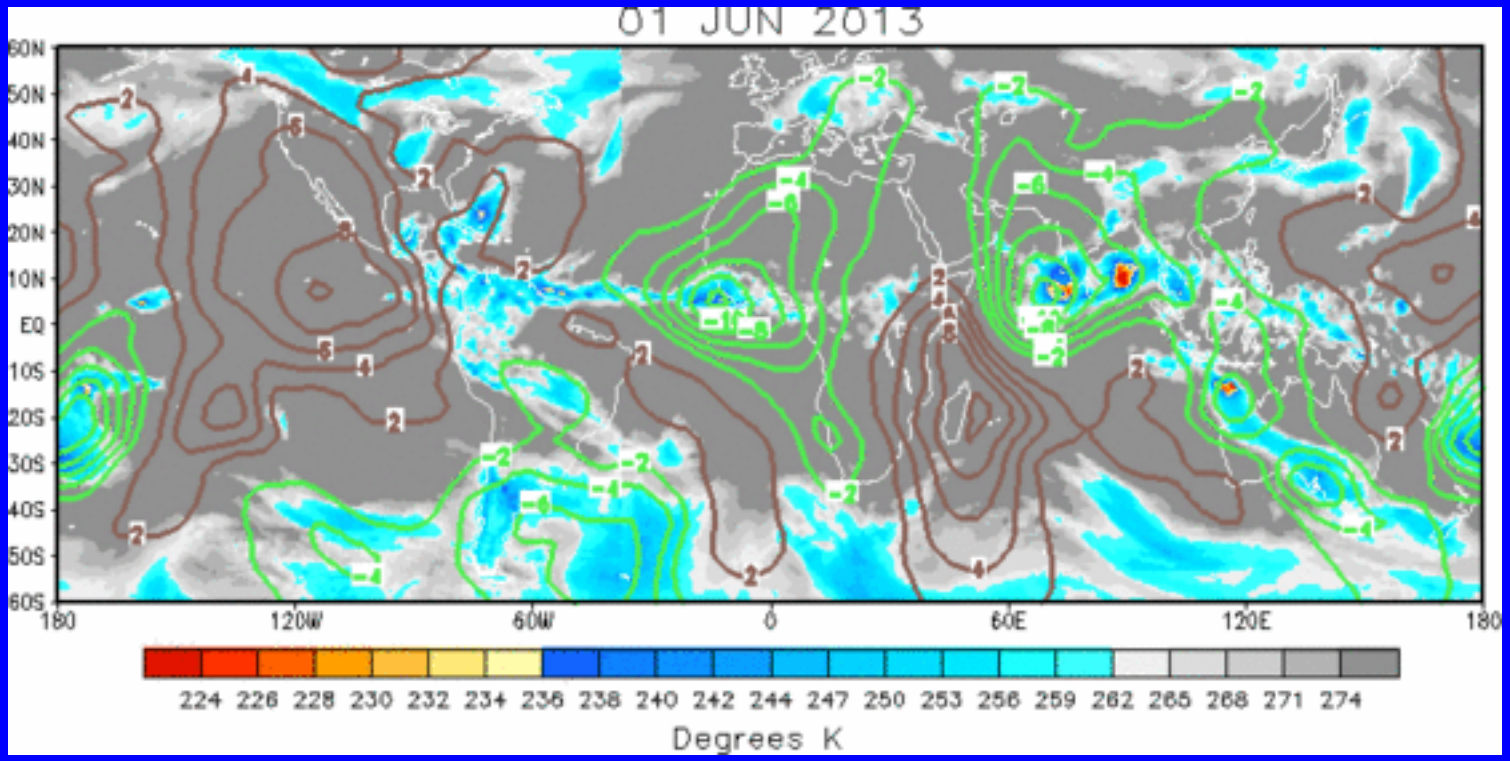
Anomalies became less coherent at times during this period as the influence from other modes of variability are evident in the depicted anomalies, namely during late January into early February, before reorganizing in late February and early March.

The velocity potential anomalies were more coherent only briefly during early and mid-May and have since broken down.

IR Temperatures (K) / 200-hPa Velocity Potential Anomalies

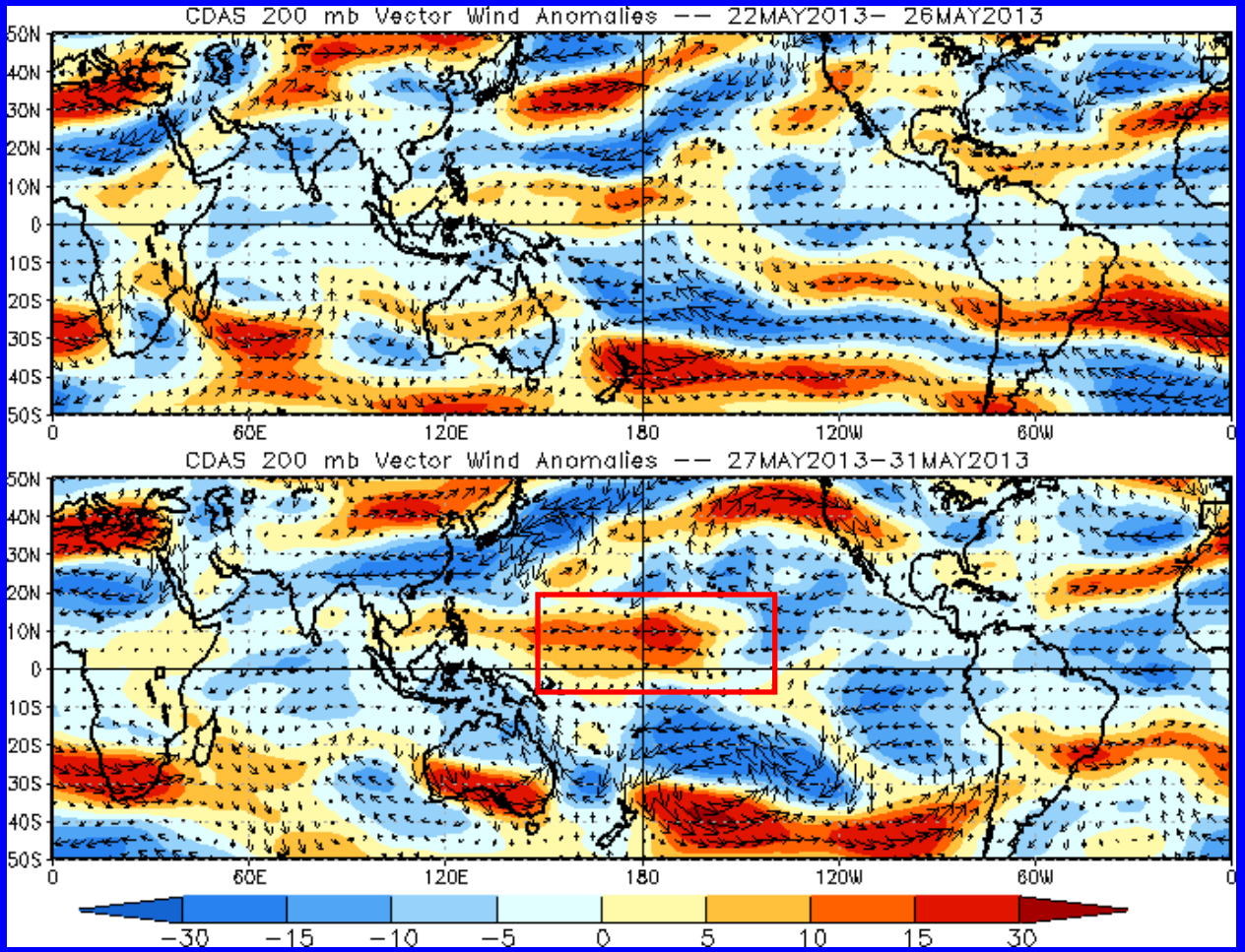
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The velocity potential pattern suggests some modest reorganization of the MJO across Africa and the Indian Ocean. However, other modes remain important as the MJO signal is weak.

200-hPa Vector Wind Anomalies (m s^{-1})



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

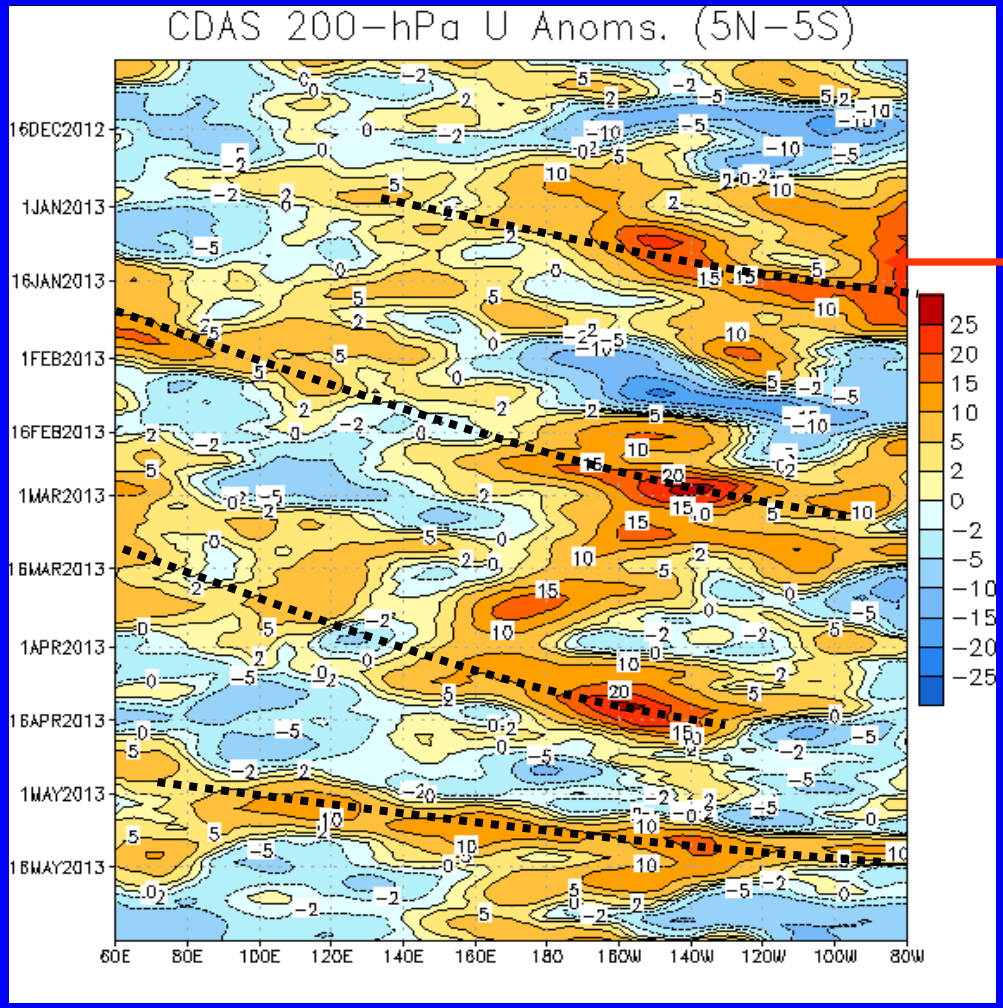
Red shades: Westerly anomalies

Large-scale tropical anomalies remain fairly weak, though westerly anomalies have strengthened just north of the Equator at the Date Line.

200-hPa Zonal Wind Anomalies (m s^{-1})

Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

Easterly anomalies (blue shading) represent anomalous east-to-west flow



Time

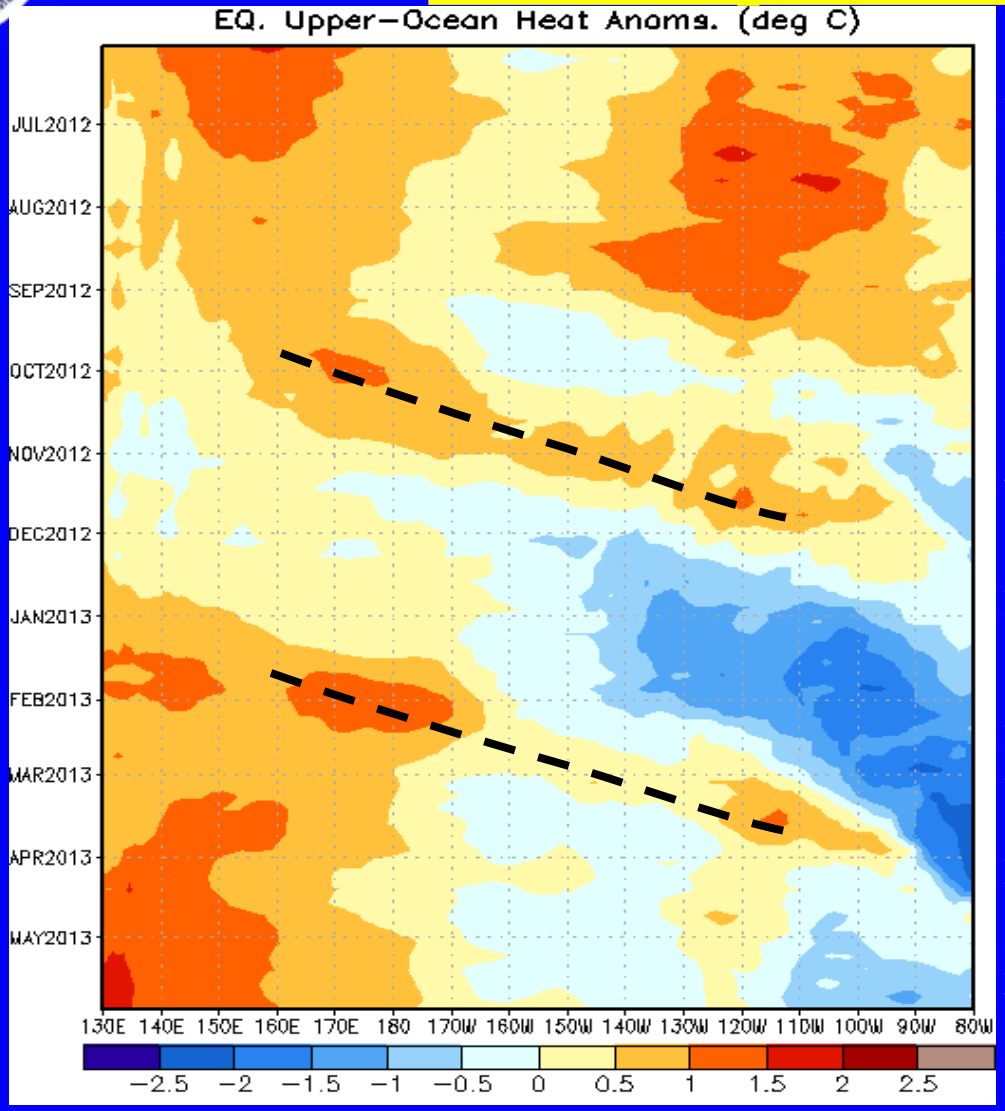
Longitude

Eastward propagation of westerly wind anomalies associated with the MJO is evident beginning in late December and continuing into April 2013. Some propagation of easterly anomalies is evident during late January and early February.

During March and early April, anomalies were influenced by westward moving features over the central and western Pacific.

Westerly anomalies shifted east of the Date Line during early May. The rapid phase speed suggests the influence of a higher-frequency Kelvin wave. Easterly anomalies have reemerged in the western Indian Ocean, consistent with weak MJO activity.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

From March into August 2012, heat content anomalies became positive and increased in magnitude across the eastern equatorial Pacific, partly in association with a downwelling Kelvin wave.

An oceanic Kelvin wave was initiated at the end of September and increased heat content across the central and eastern Pacific during October and November.

Positive (negative) anomalies developed in the western (eastern) Pacific during January 2013 and persisted into early March. The influence of a downwelling oceanic Kelvin wave can be seen during late February and March as anomalies became positive in the east-central Pacific.

MJO Index -- Information

• The MJO index illustrated on the next several slides is the CPC version of the Wheeler and Hendon index (2004, hereafter WH2004).

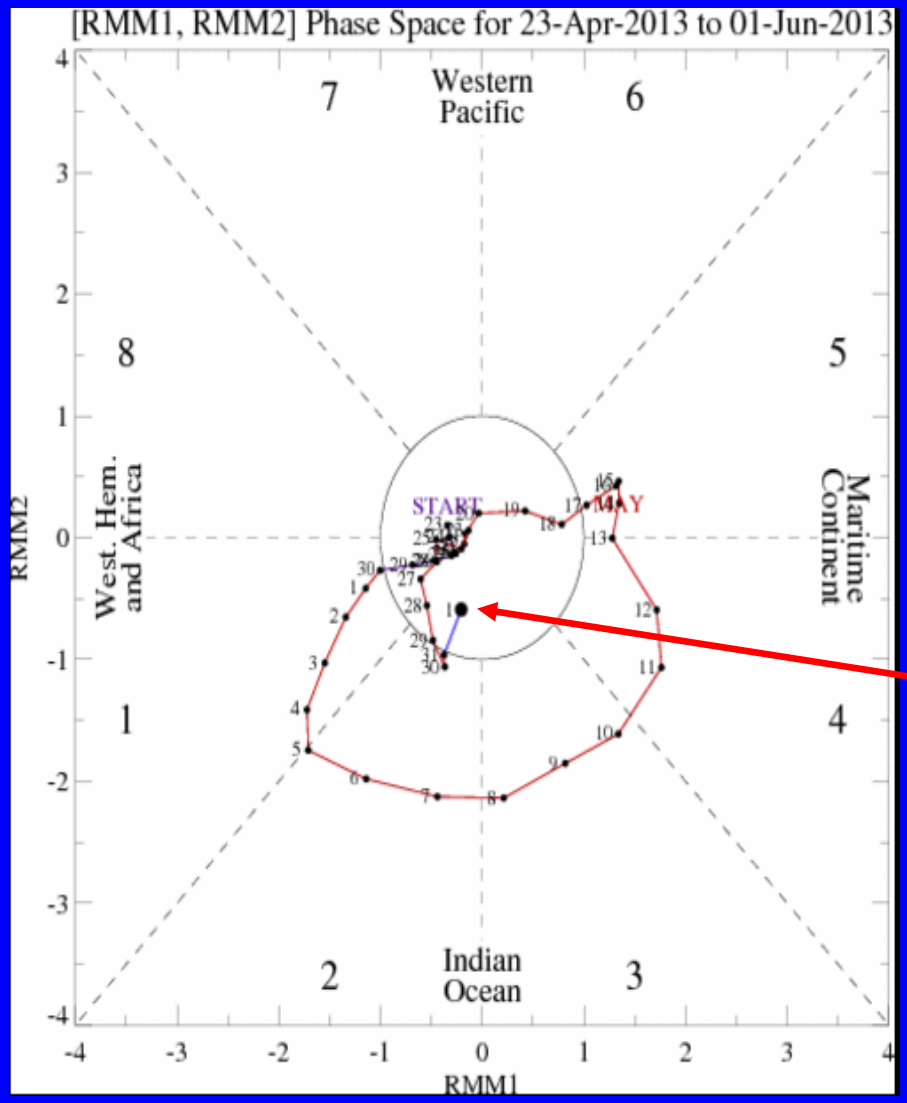
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

Gottschalck et al. 2010: A Framework for Assessing Operational Madden-Julian Oscillation Forecasts: A CLIVAR MJO Working Group Project, *Bull. Amer. Met. Soc.*, 91, 1247-1258.

• The index is based on a combined Empirical Orthogonal Function (EOF) analysis using fields of near-equatorially-averaged 850-hPa and 200-hPa zonal wind and outgoing longwave radiation (OLR).

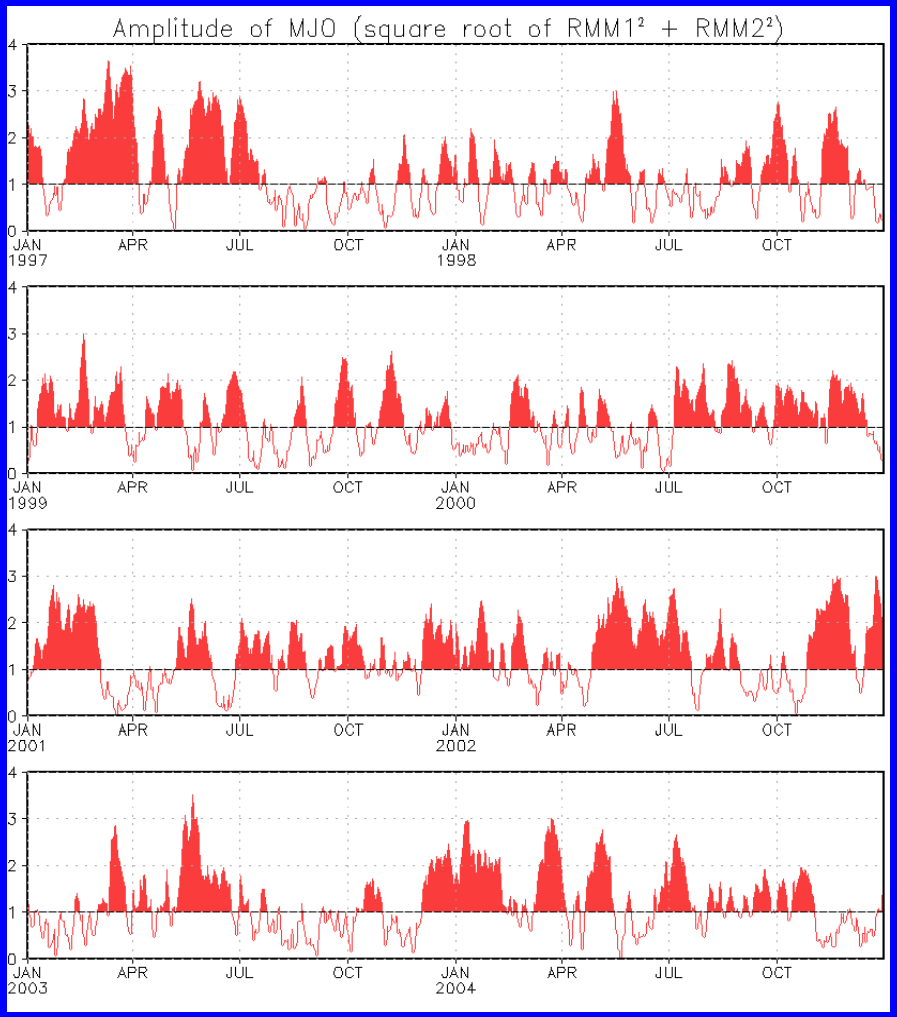
MJO Index -- Recent Evolution

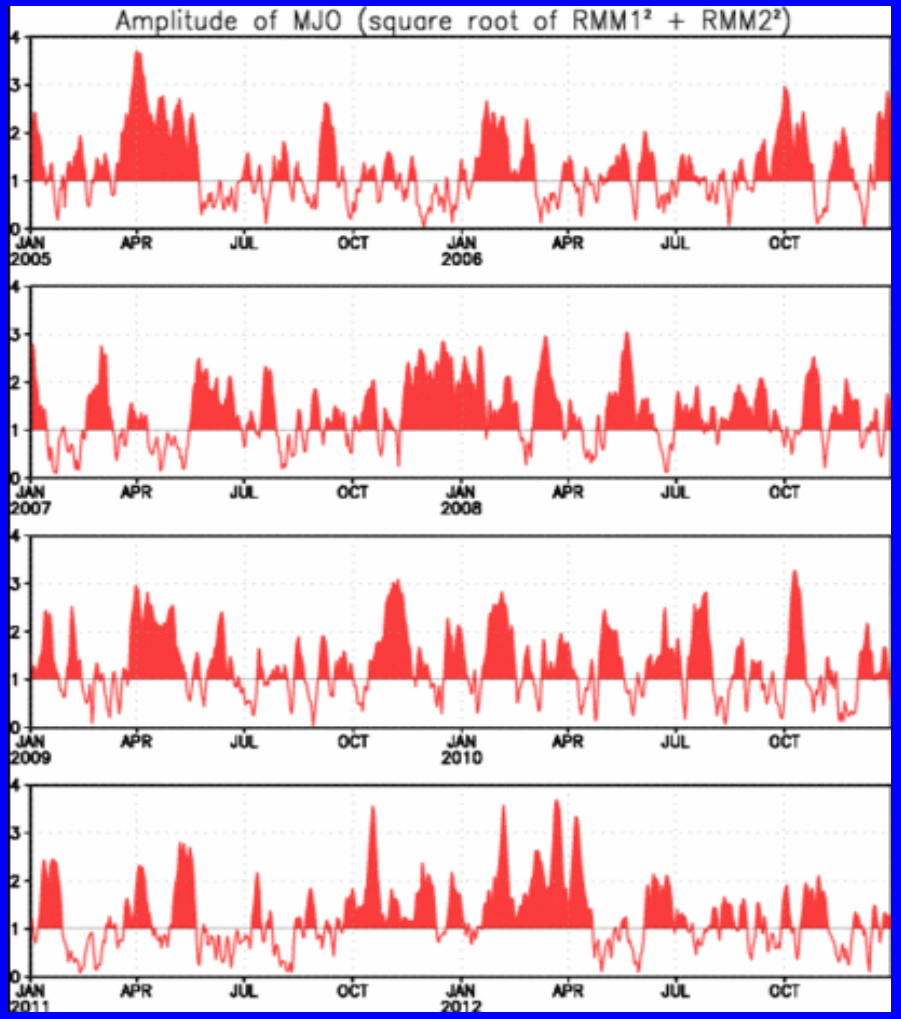


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the origin is proportional to MJO strength
- Line colors distinguish different months

The MJO index indicates some strengthening of the MJO signal in phase 2 over the past several days. However, the MJO remains fairly weak.

MJO Index – Historical Daily Time Series





Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

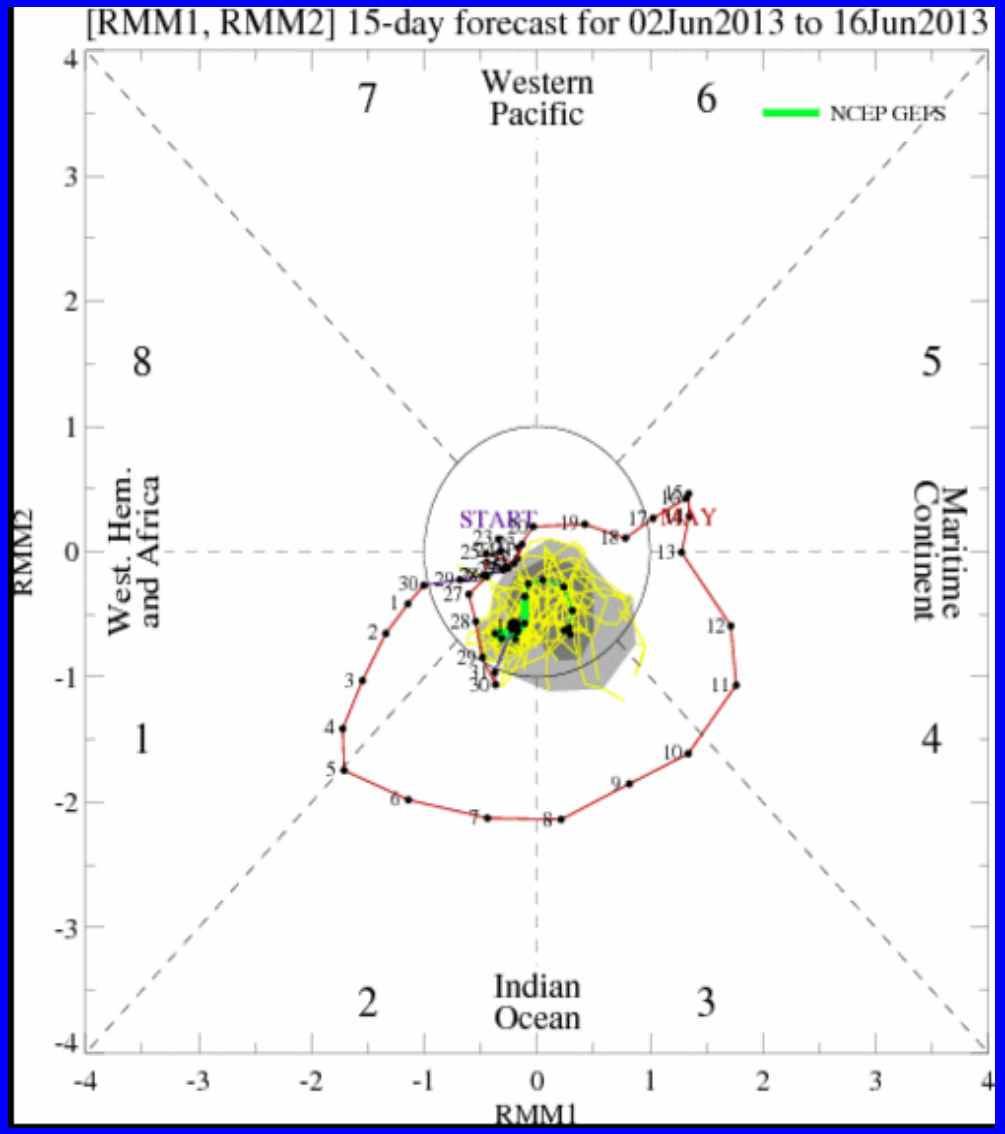
Ensemble GFS (GEFS) MJO Forecast

Yellow Lines – 20 Individual Members
Green Line – Ensemble Mean

RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

light gray shading: 90% of forecasts
dark gray shading: 50% of forecasts

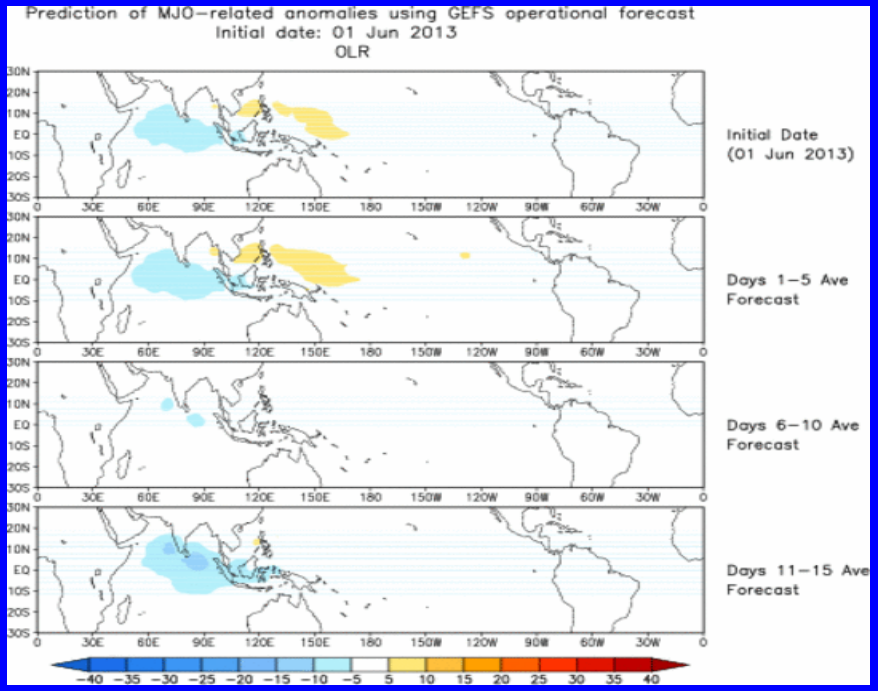
The bias-corrected ensemble GFS indicates a weak MJO signal, with some propagation toward Phases 3 and 4 suggested.



Ensemble Mean GFS MJO Forecast

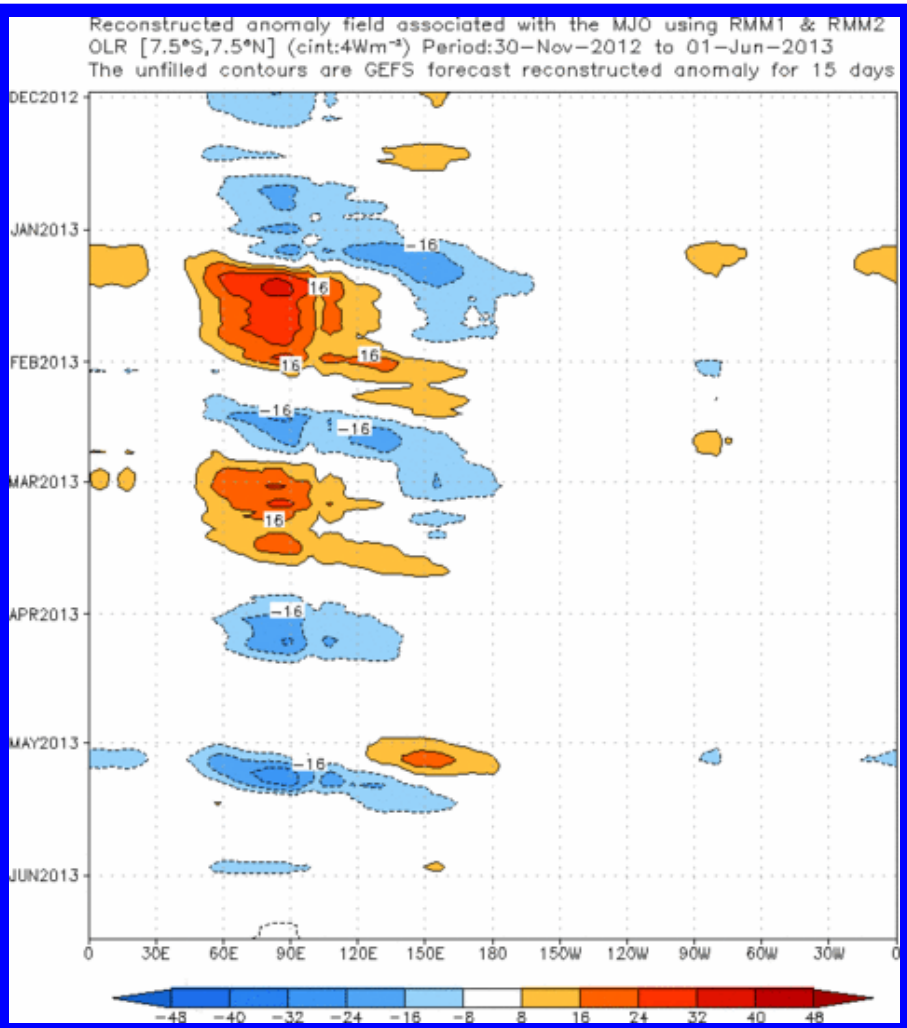
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecasts weakly enhanced convection across the Indian Ocean with some suppressed convection across the West Pacific.

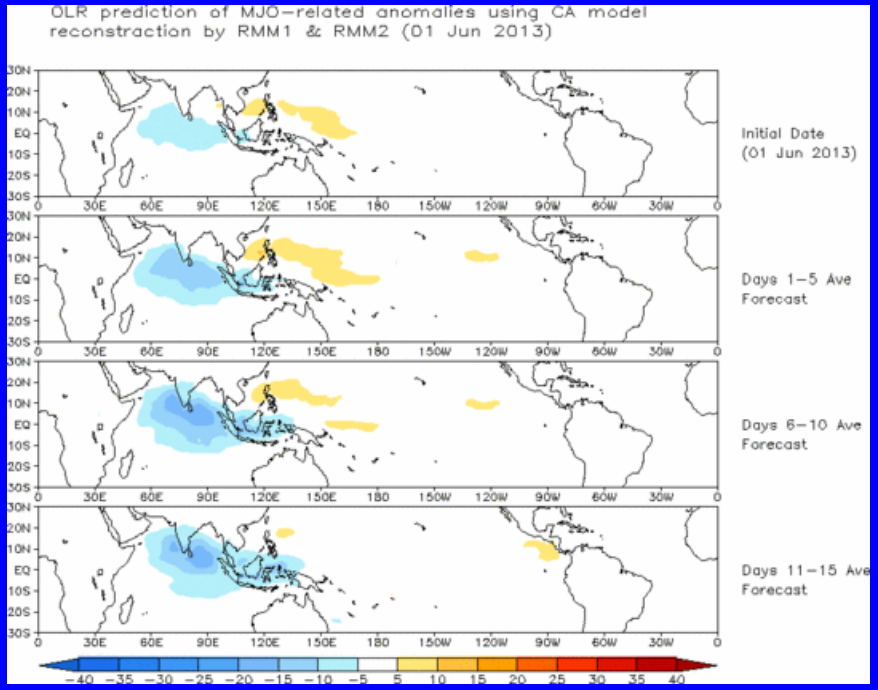
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

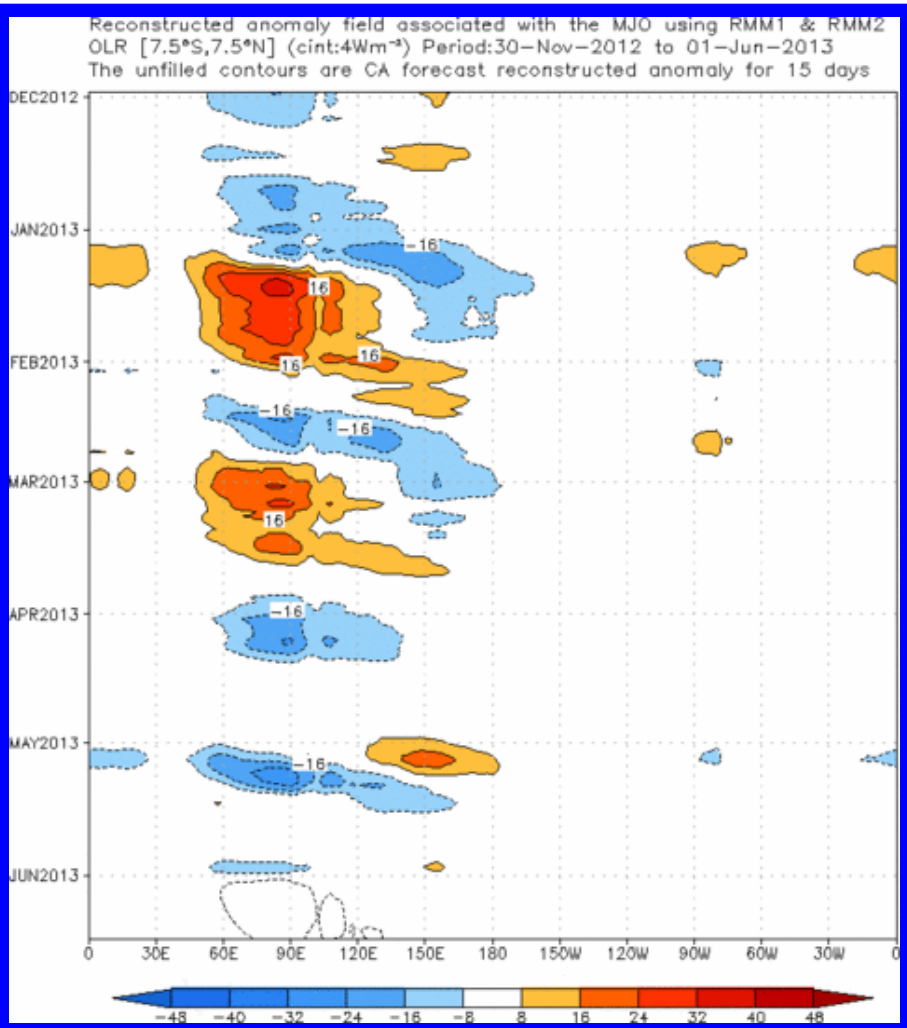
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



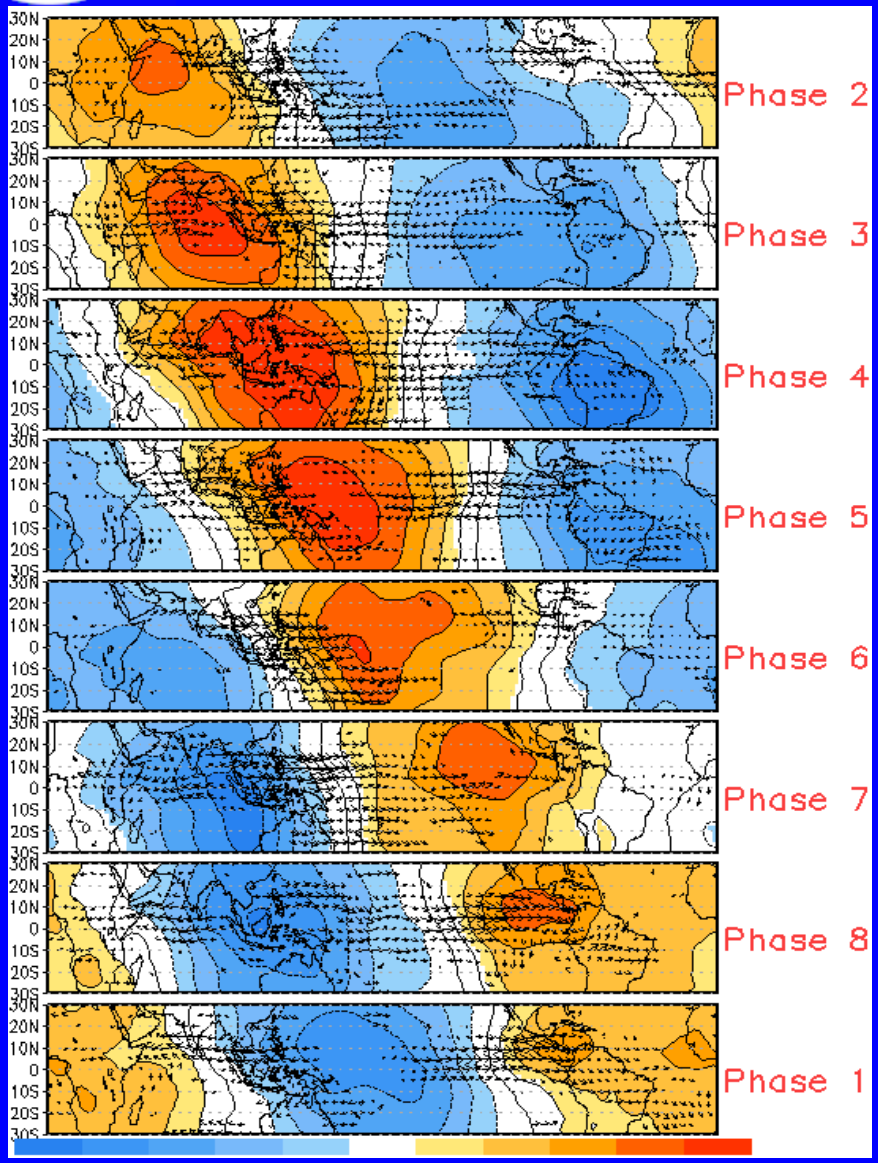
This statistical forecast indicates a more pronounced MJO signal in Phase 3 with stronger convection in the Indian Ocean and little eastward propagation.

Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days

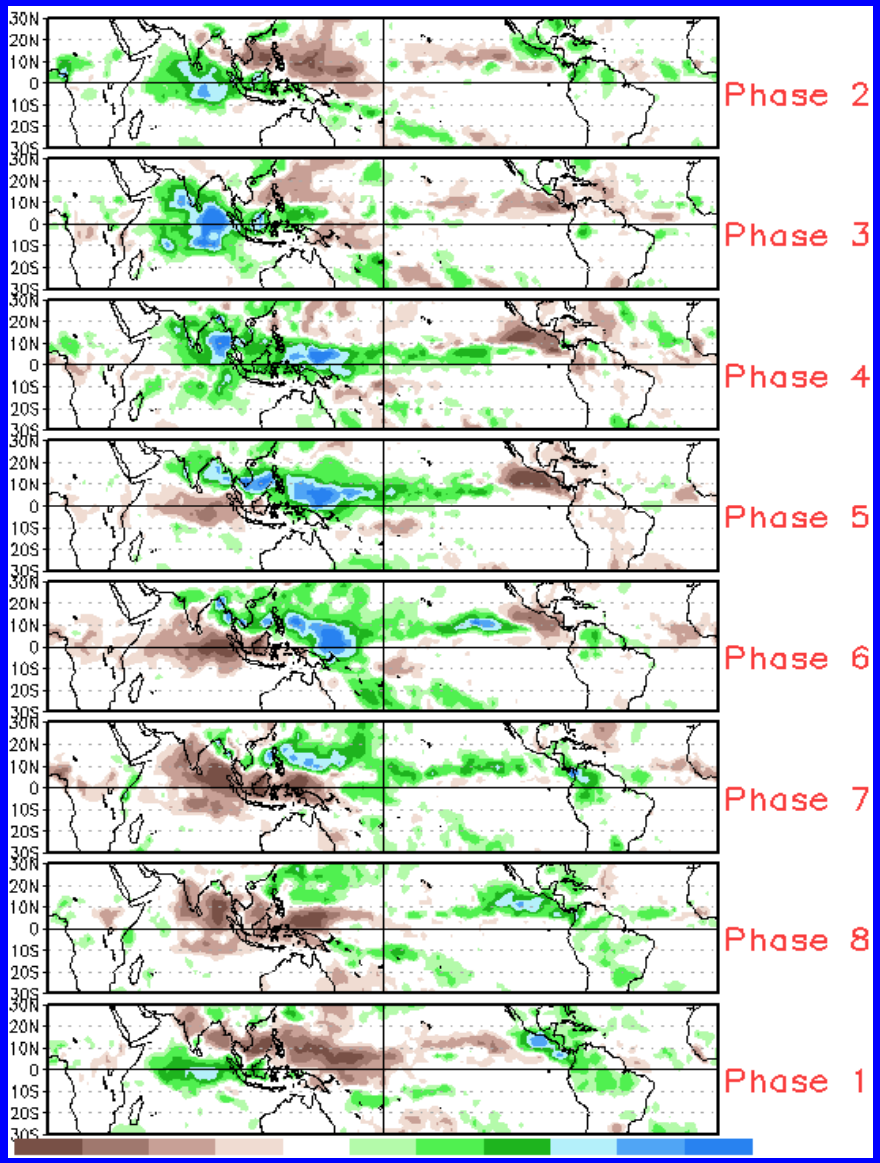


MJO Composites – Global Tropics

850-hPa Velocity Potential and Wind Anomalies (May-Sep)

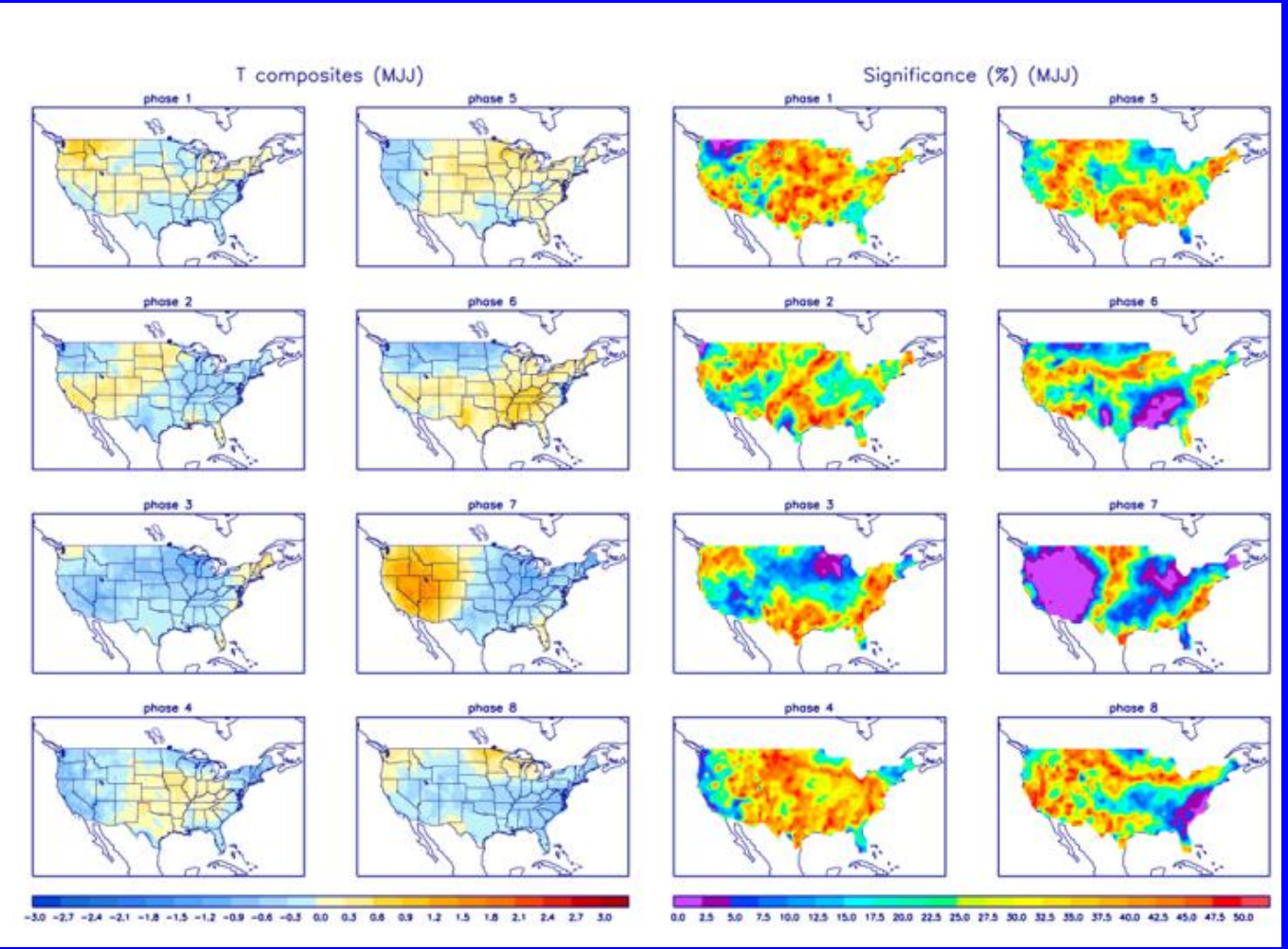


Precipitation Anomalies (May-Sep)



U.S. MJO Composites – Temperature

- **Left hand side plots show temperature anomalies by MJO phase for MJO events that have occurred over the three month period in the historical record. Blue (orange) shades show negative (positive) anomalies respectively.**
- **Right hand side plots show a measure of significance for the left hand side anomalies. Purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.**

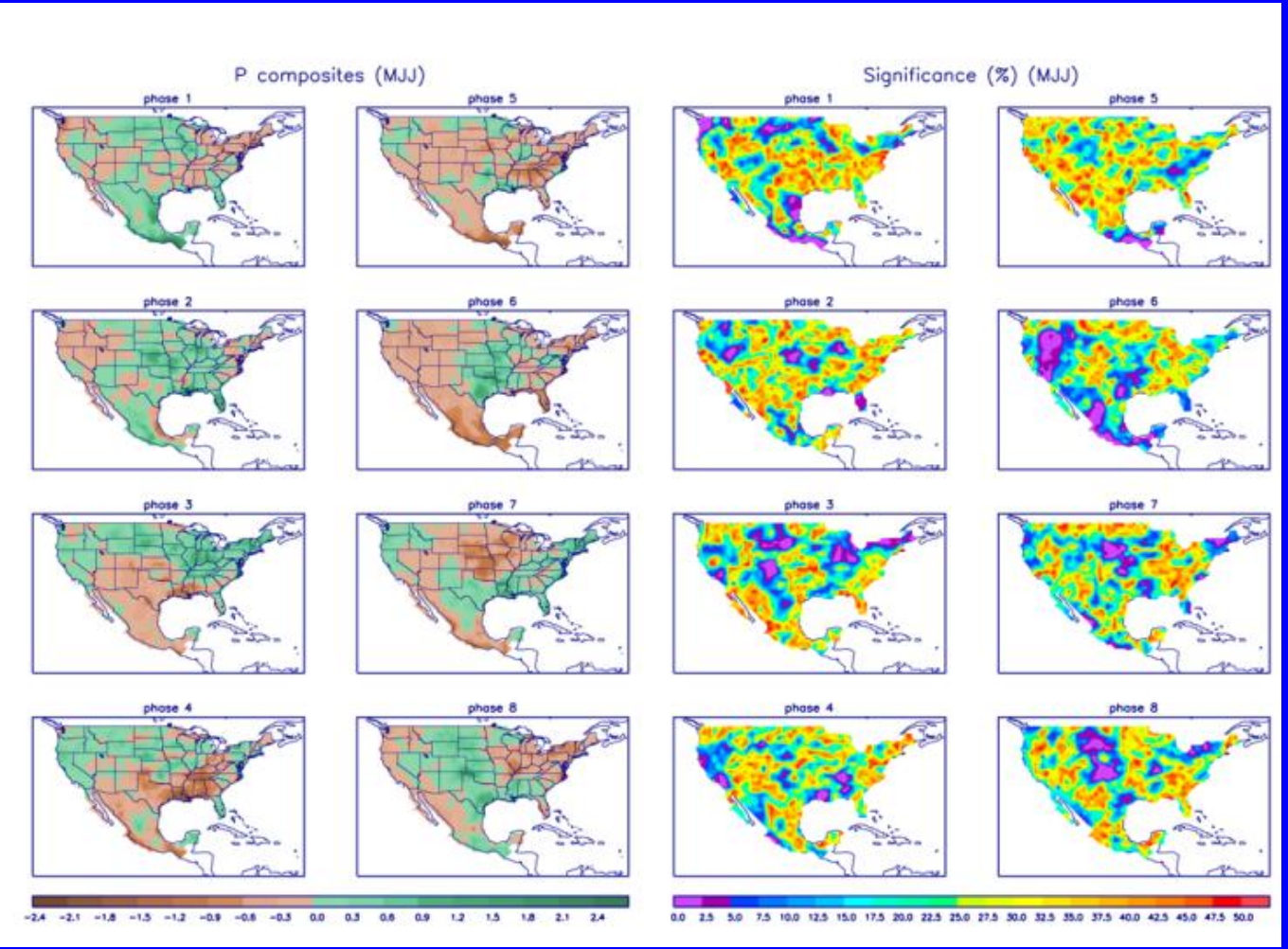


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml

U.S. MJO Composites – Precipitation

- **Left hand side plots show precipitation anomalies by MJO phase for MJO events that have occurred over the three month period in the historical record. Brown (green) shades show negative (positive) anomalies respectively.**
- **Right hand side plots show a measure of significance for the left hand side anomalies. Purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.**



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