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

Update prepared by
Climate Prediction Center / NCEP
April 8, 2013

Outline

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

Overview

- The MJO remained active over the past week, with some observational indicators less coherent than in previous weeks, as other subseasonal modes of variability are playing a role in the tropical convection pattern. The MJO enhanced phase is centered over the eastern Indian Ocean.

- Dynamical model MJO index forecasts generally support continued eastward propagation with most tools indicating a weakening signal, likely the result of interference from other modes of variability. The statistical tools also support continued MJO activity, with a stronger signal, as they are keyed solely to the MJO.

- Based on recent observations and model MJO forecasts, the MJO is forecast to remain active during the next two weeks, propagating across the Maritime Continent by the end of the period.

- The MJO favors enhanced (suppressed) rainfall across the eastern Indian Ocean / Maritime Continent (parts of the Americas and Africa) during the period. Tropical cyclogenesis remains favored across the Indian Ocean.

- The extended range forecast for the U.S. aligns well with the typical circulation patterns based on the current and forecast phases of the MJO. These include a trend towards above-normal temperatures across the southern U.S. and a more active precipitation across the north-central U.S.

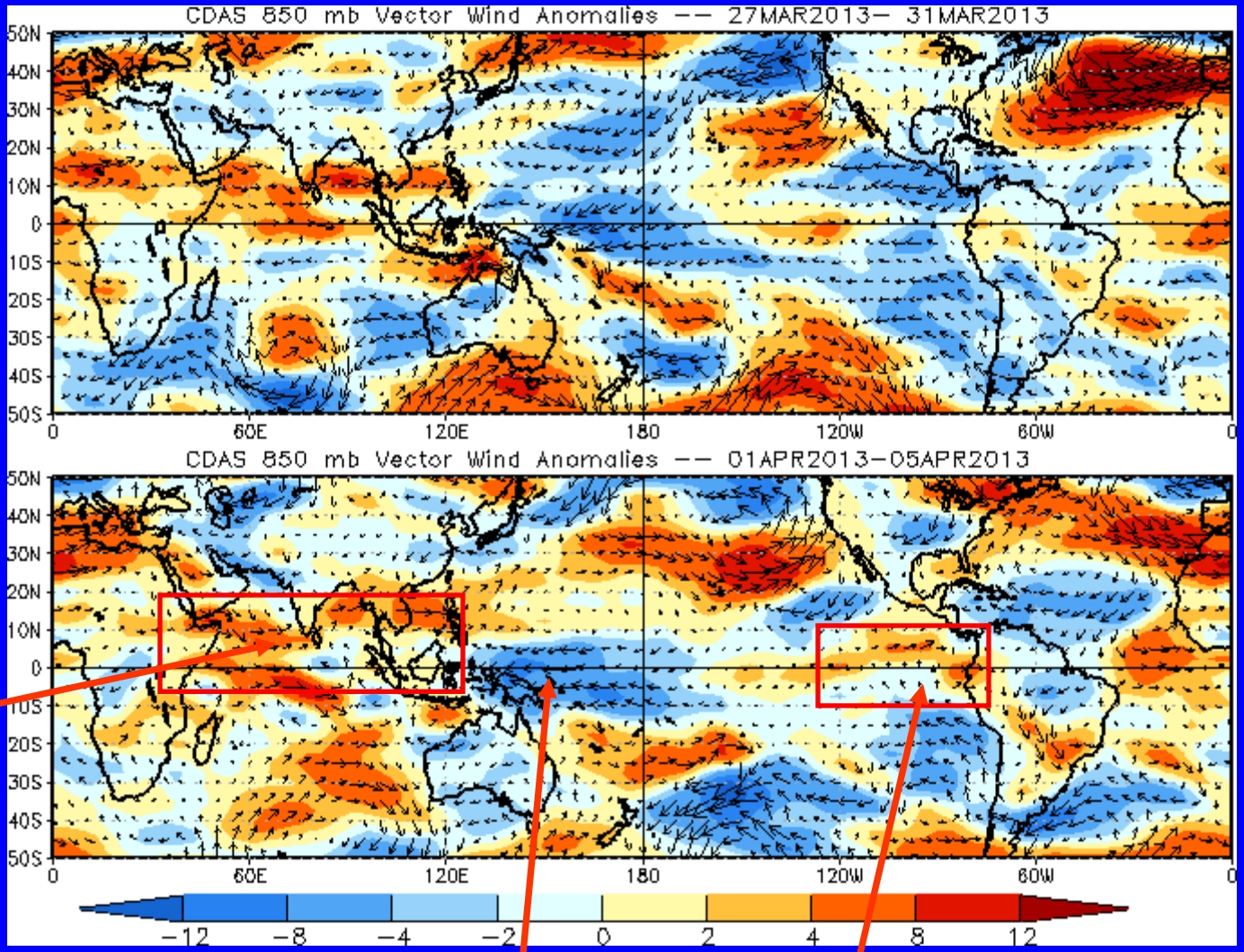
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies persisted over the Indian Ocean.

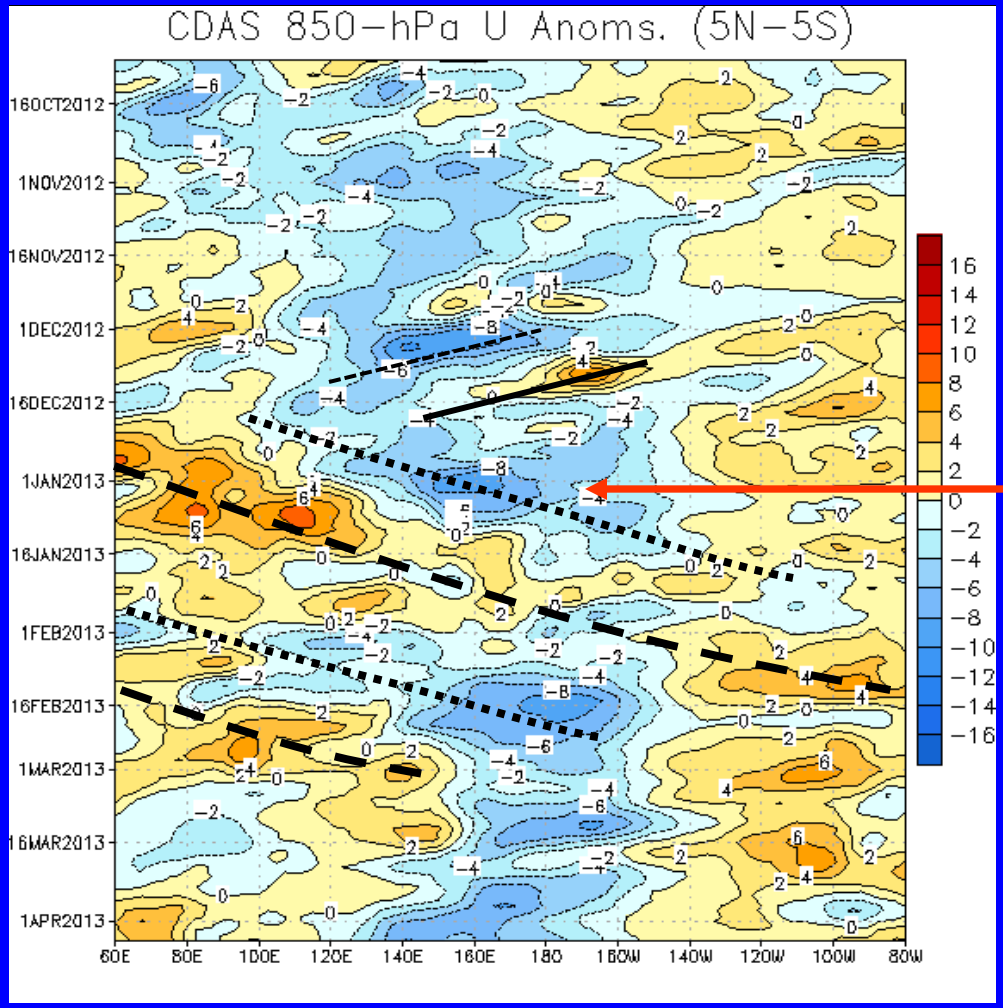
Easterly anomalies persisted and intensified over the equatorial, western Pacific during the past five days.

Westerly anomalies returned to the eastern 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

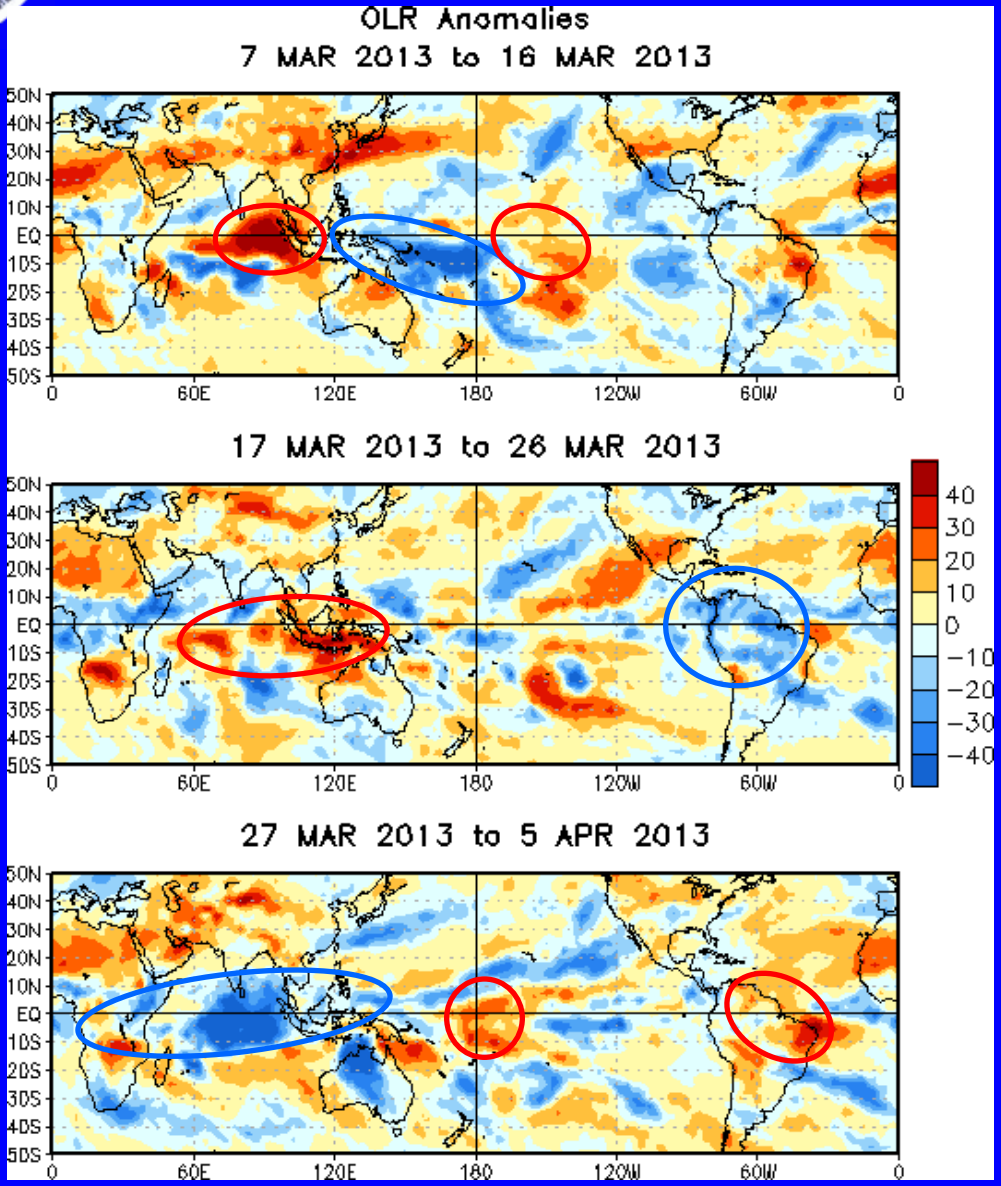
Longitude

Westward propagation (dashed/solid lines sloping down and to the left) of anomalies during much of November and 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, anomalies indicate signs of being influenced by equatorial Rossby wave activity with less eastward propagation evident.

OLR Anomalies – Past 30 days



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

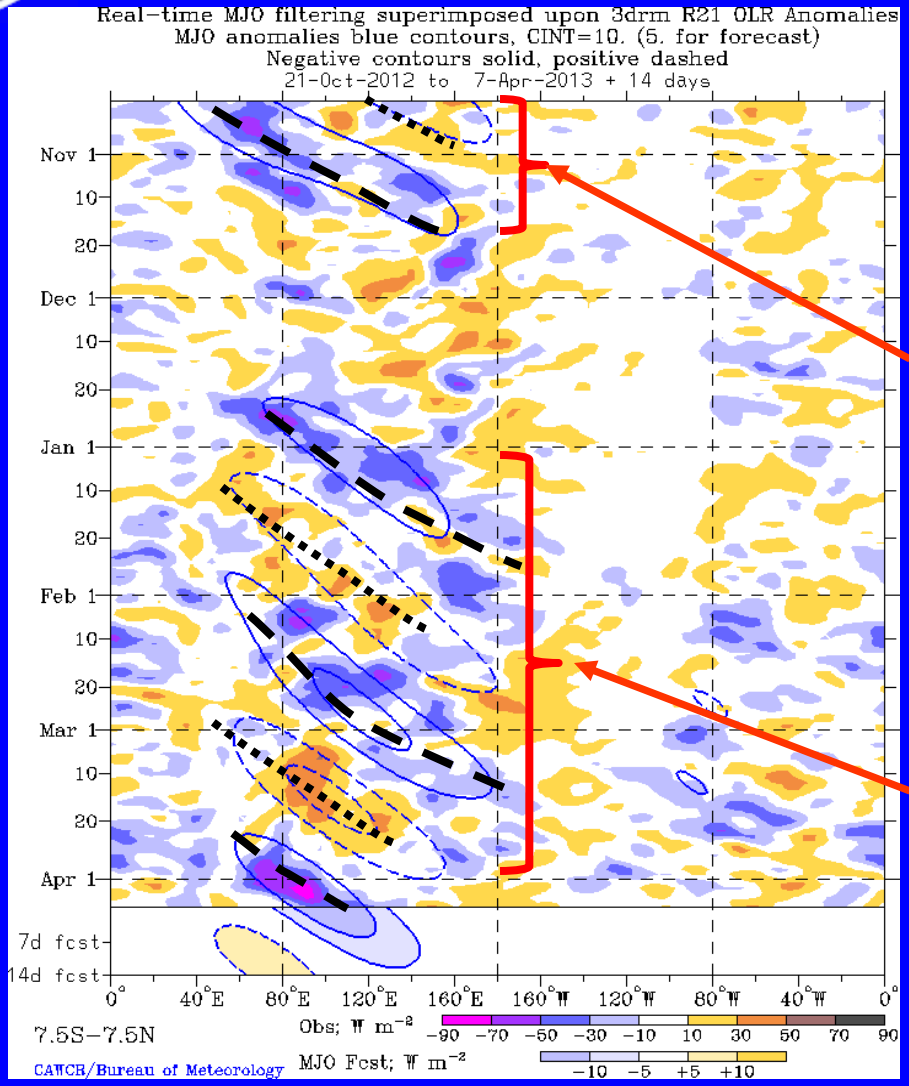
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During mid-March, enhanced convection moved predominantly to the southwest Pacific, while suppressed convection increased (decreased) over the Indian Ocean and South America (Central Pacific).

During mid to late March, enhanced convection was decreased over the southwest Pacific and developed over South America and Africa, while suppressed convection increased across the Maritime Continent.

From late March to early April, enhanced convection continued across Africa and expanded to cover most of the Indian Ocean. Suppressed convection returned to the central Pacific and northern South America.

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 (alternating dashed and dotted lines) was active during October into November with enhanced convection developing over Africa during mid-October and shifting eastward to the western Pacific by mid-November.

During late November and much of December, convective anomalies were disorganized.

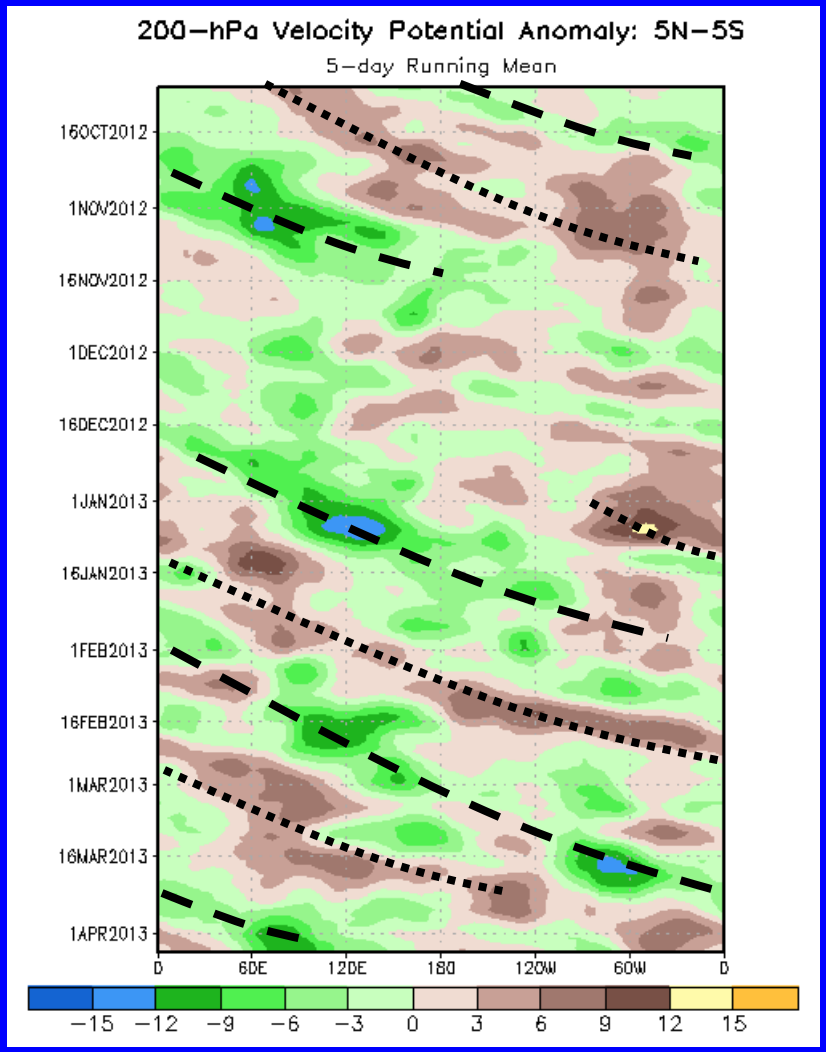
The MJO was again a dominant mode of variability across the Tropics from January into March as indicated by the alternating dashed and dotted lines.

Near the end of March, the anomalies show signs of influence from other modes of tropical variability.

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

In early October, upper-level divergence (convergence) increased over the Pacific (Indian Ocean) and shifted eastward until mid November (alternating dashed and dotted lines).

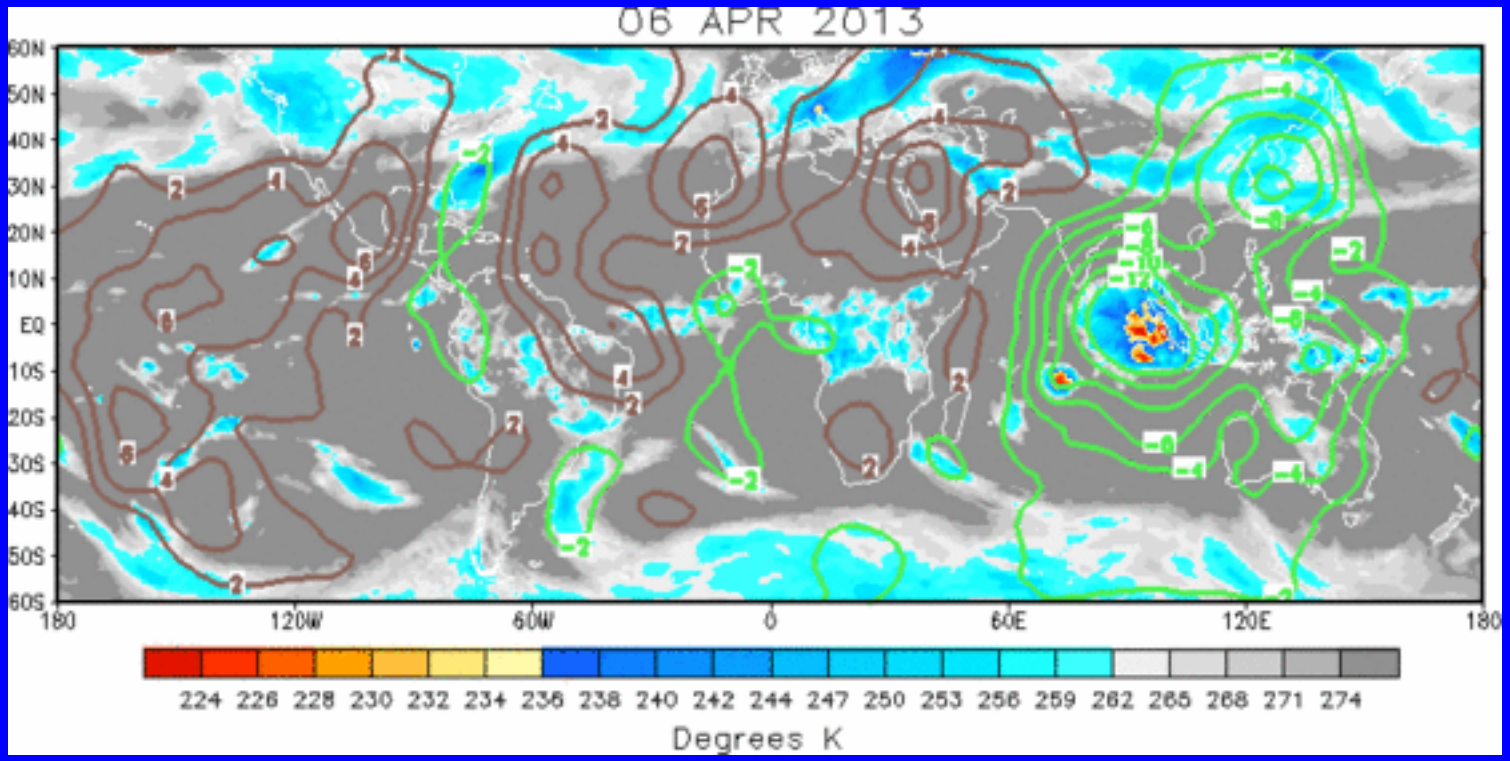
During most of November and December, anomalies were weak with less coherent eastward propagation. Other modes of subseasonal variability were more prevalent during this period.

As the MJO strengthened in late December, anomalies increased in magnitude with more robust eastward propagation indicated during late 2012 and early 2013. Anomalies became less coherent during late January into early February, but reorganized in late February and early March. Influence from other modes of variability are evident in the anomaly field.

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

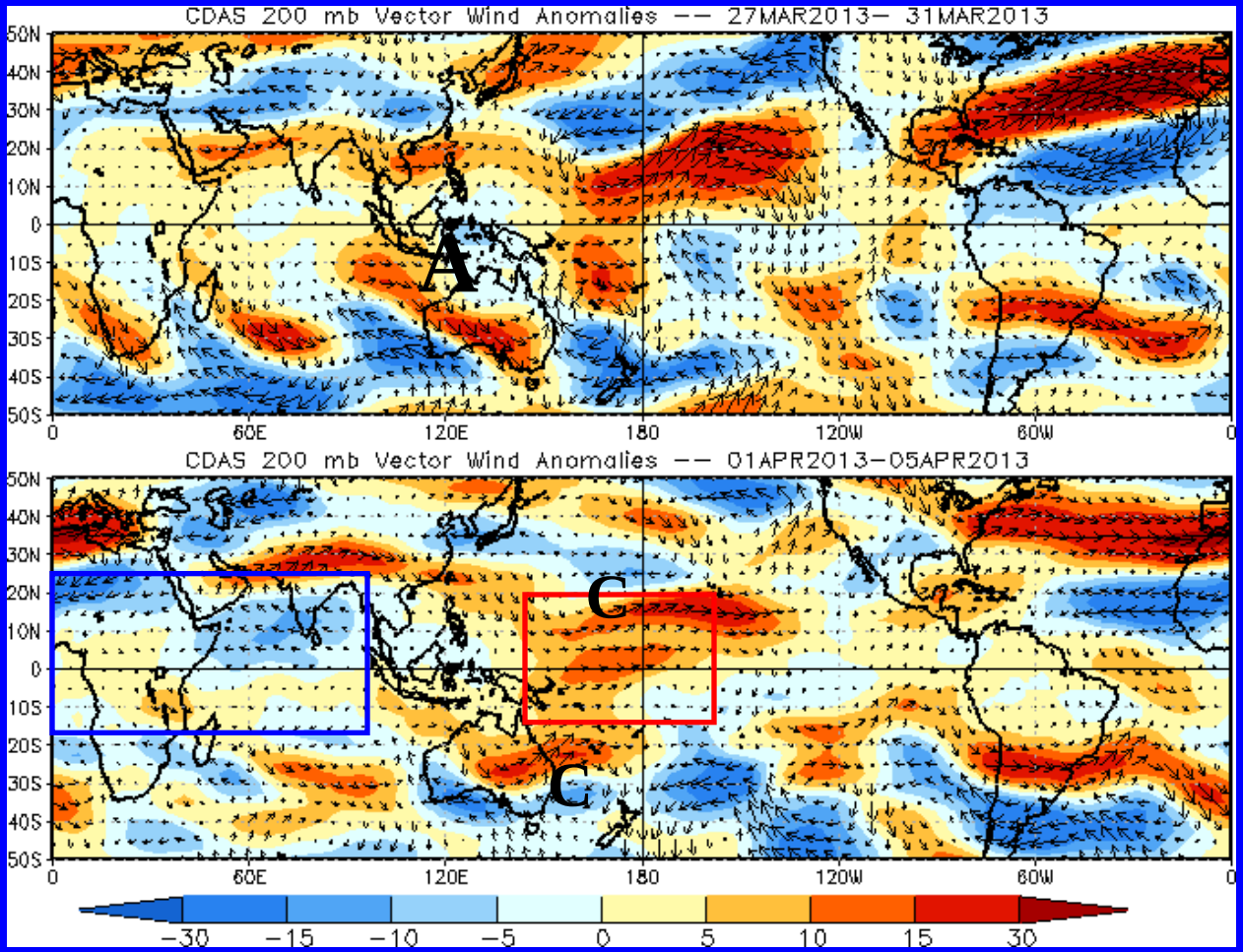
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The velocity potential pattern shows strong upper-level divergence across the Indian Ocean and the Maritime Continent. The strongest upper-level convergence is centered across the central Pacific. Influence from higher frequency modes of variability can be seen.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Westerly anomalies (red box) remain across the central equatorial Pacific during the last five days, while easterly anomalies developed over the Indian Ocean and Africa.

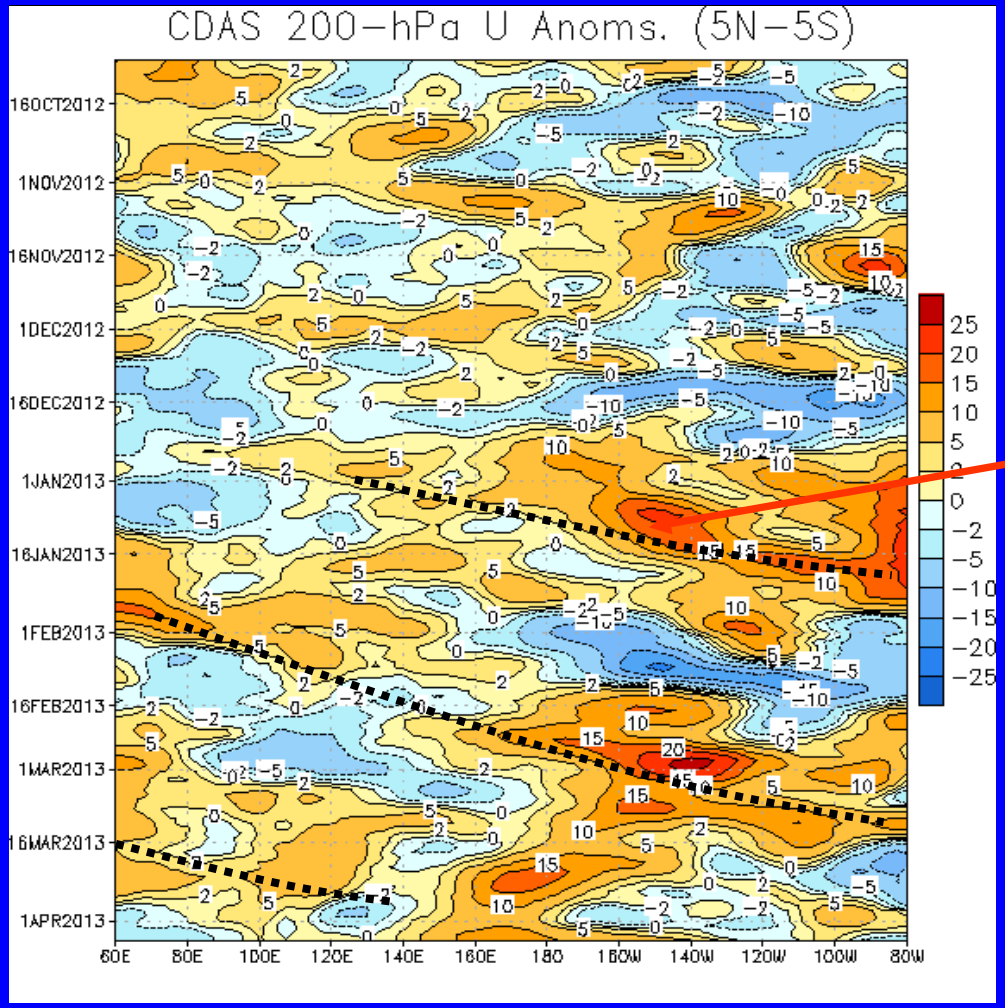
Two cyclonic circulation centers (indicated by 'C') are also evident over the central Pacific. These circulations have weakened during the past five days.

Mid-latitude influence can be seen over the eastern Pacific and South America.

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



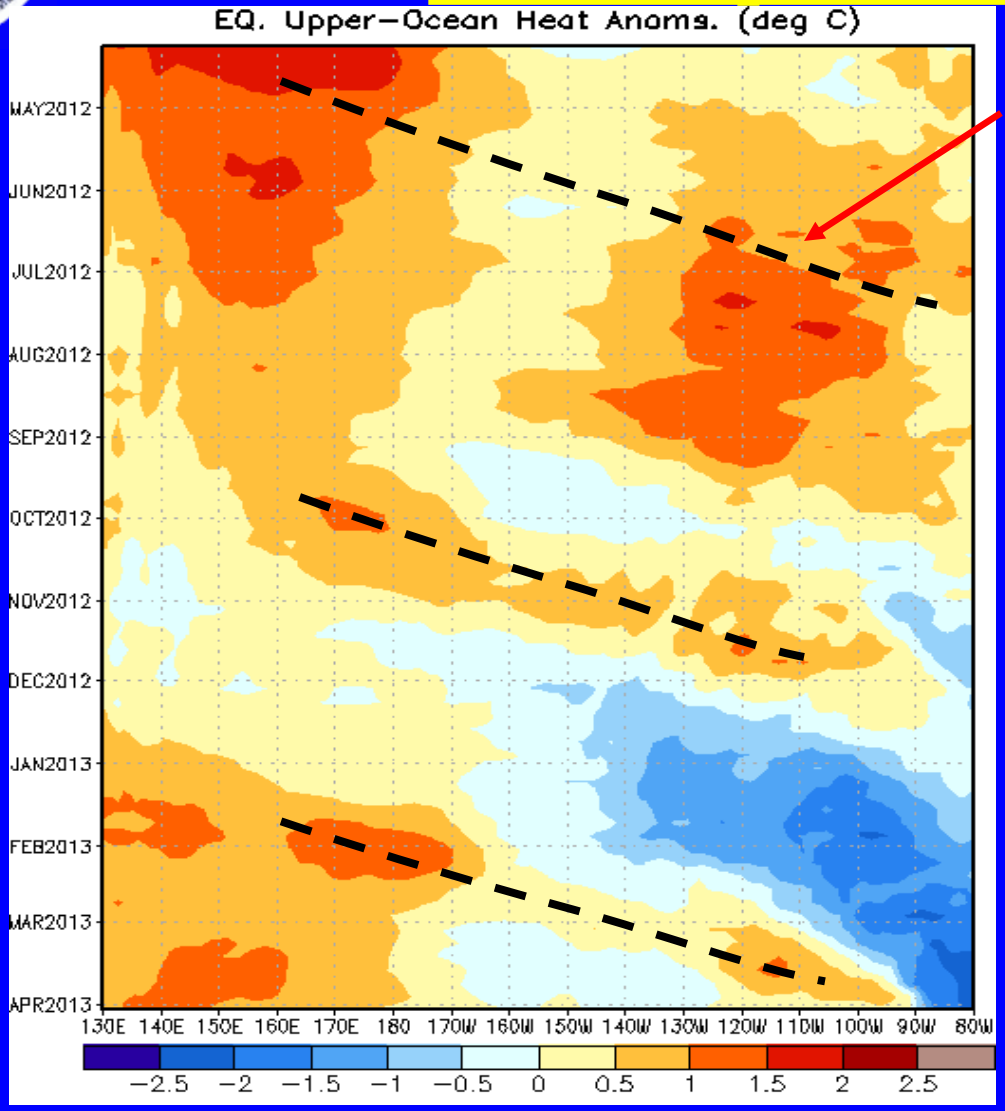
Time

Longitude

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

Most recently, propagation has slowed, with some signs of influence of westward moving features, especially over the western and central Pacific.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

From March into July 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 have generally persisted through 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).

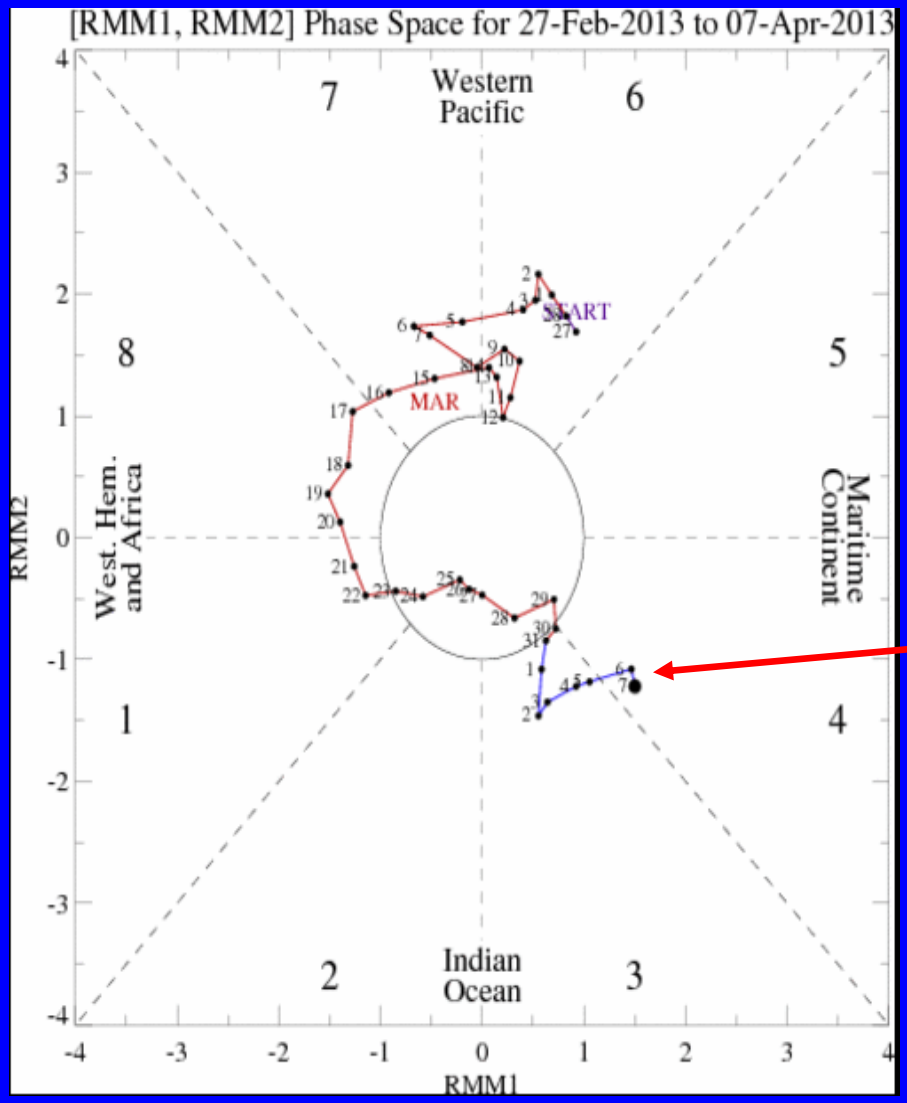
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

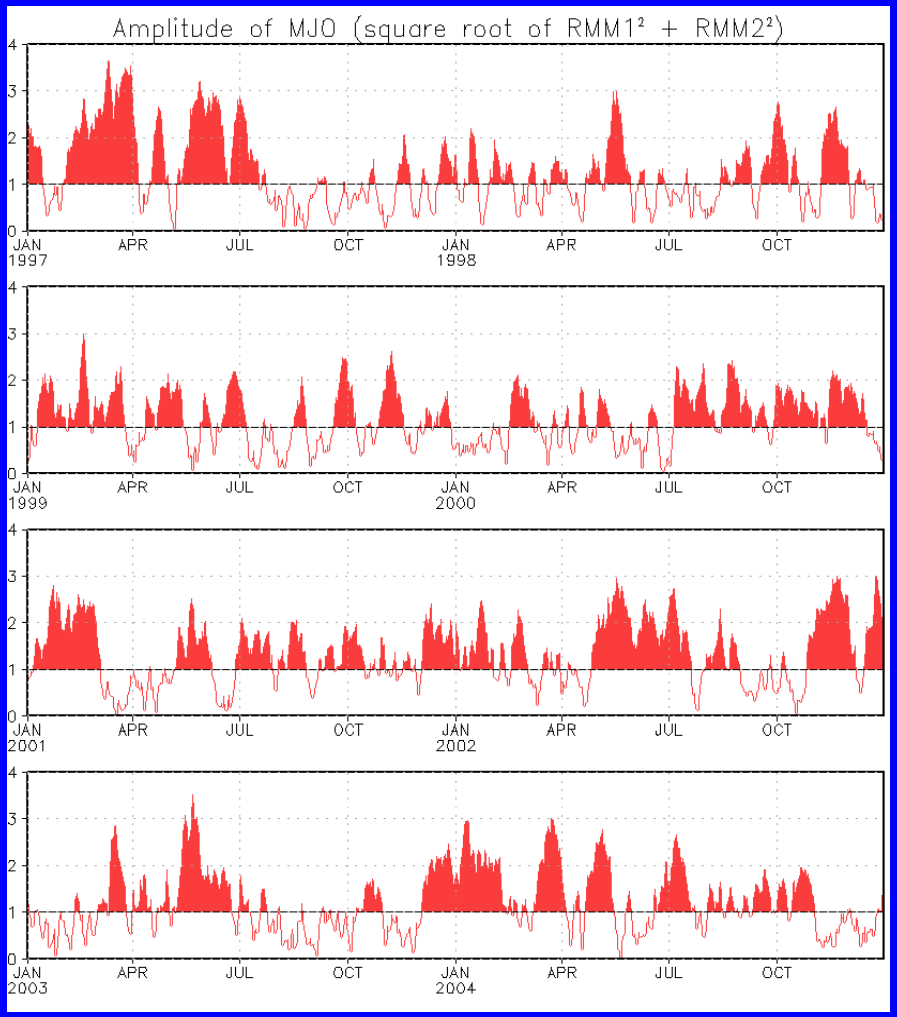
MJO Index -- Recent Evolution

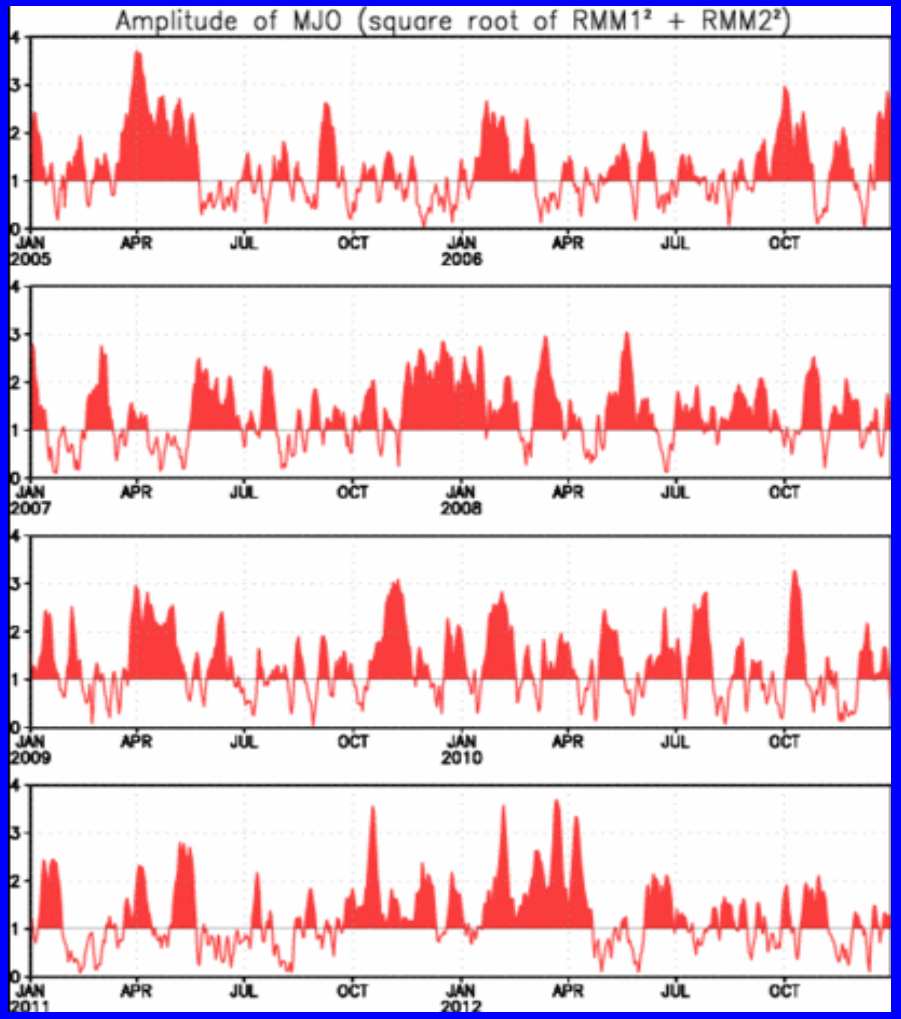


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates slow eastward propagation of the MJO signal during the past week, now centered over the western Maritime Continent.

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.

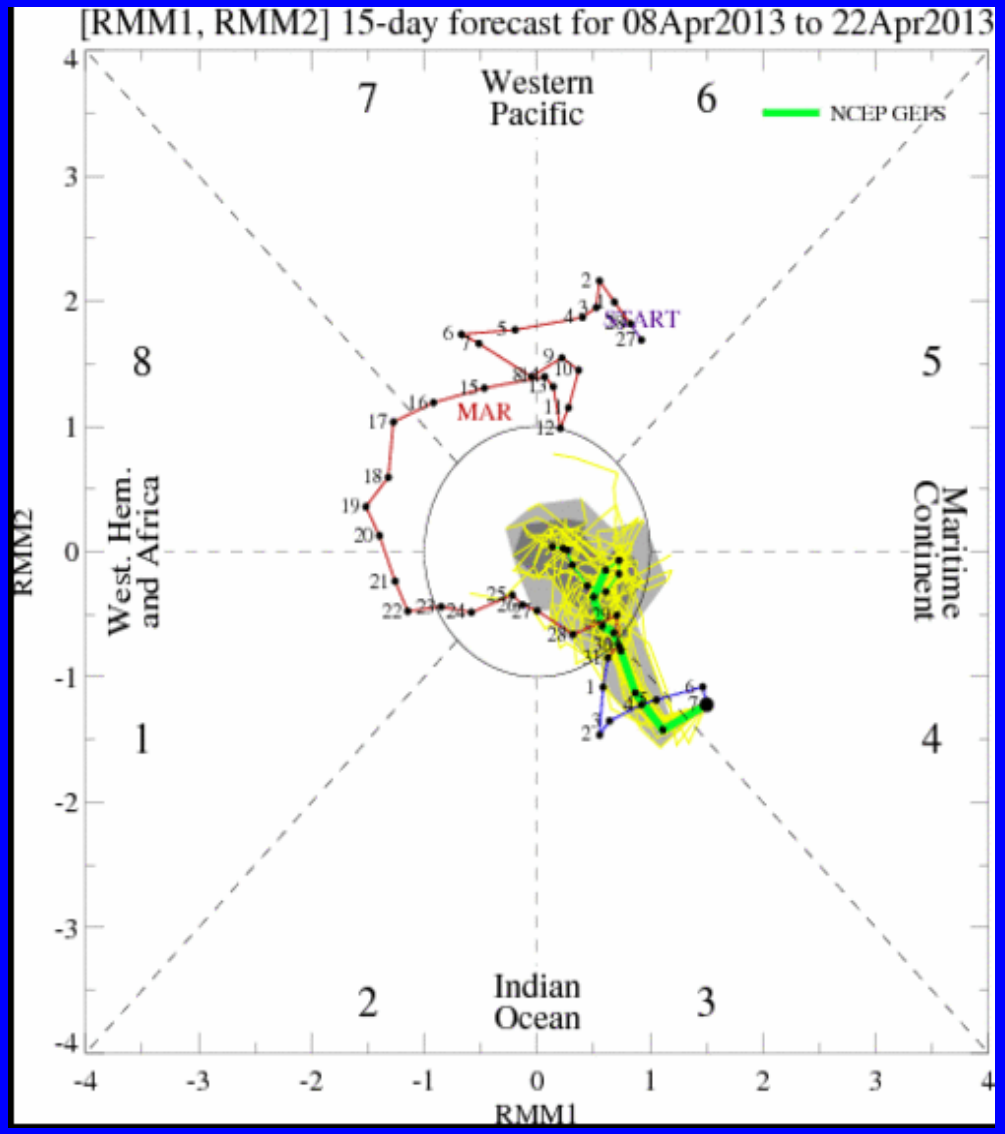
Ensemble GFS (GEFS) MJO Forecast

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

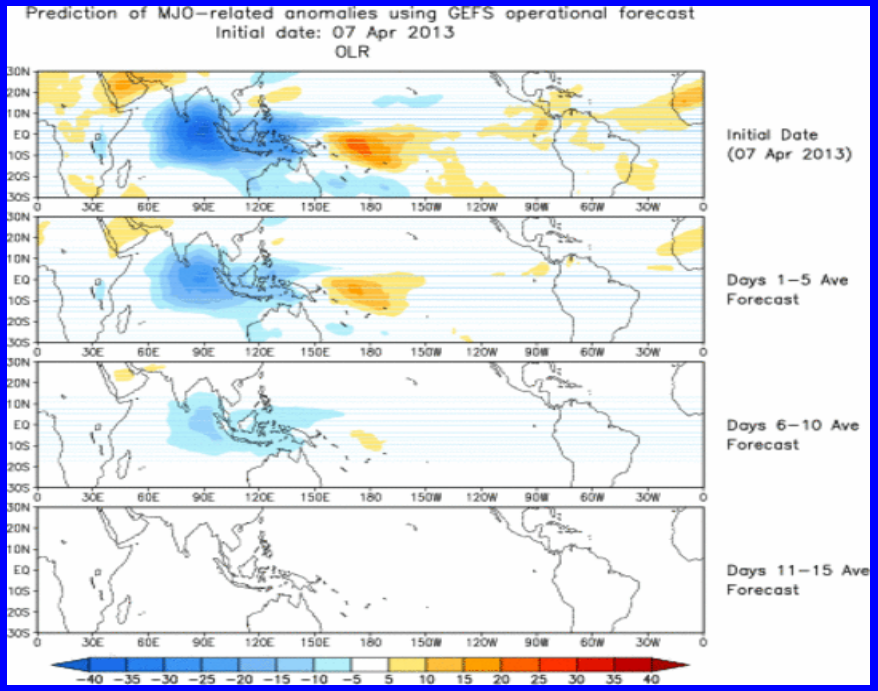
The bias-corrected ensemble GFS indicates a some eastward propagation during week-1, with a weakening signal during week-2. The forecast index indicates influence from other modes of variability.



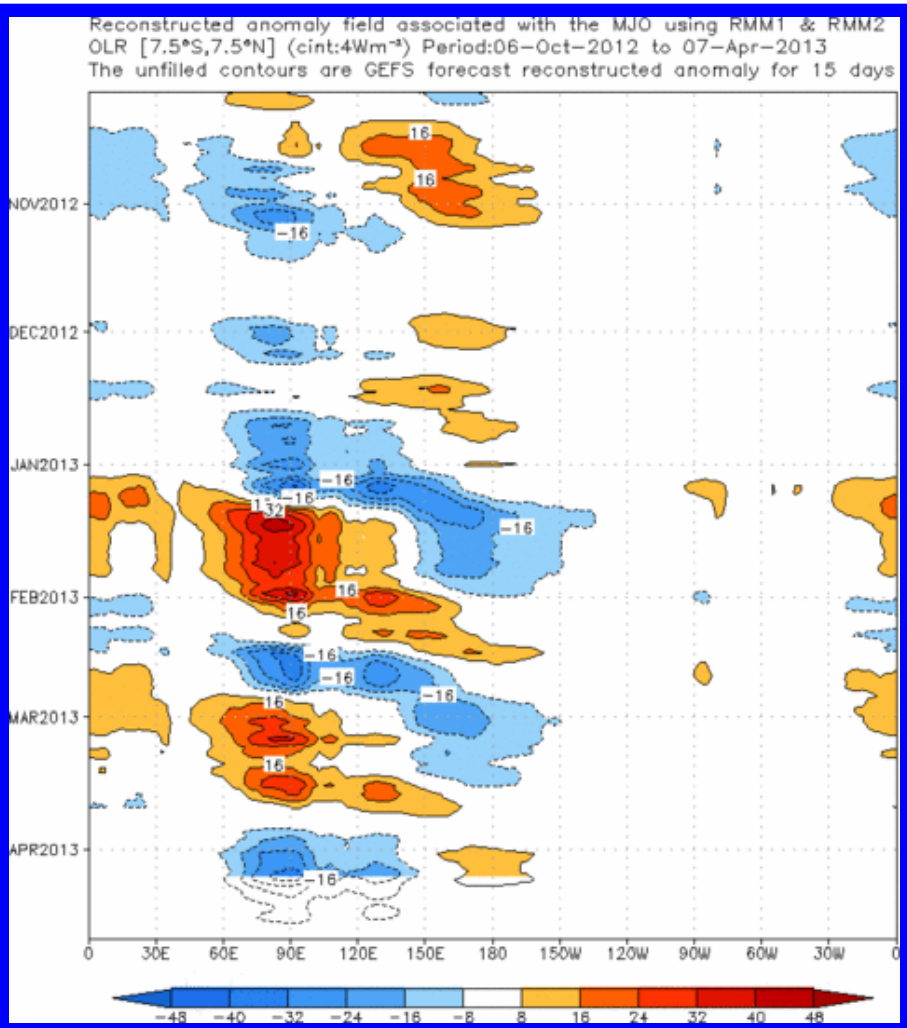
Ensemble Mean GFS MJO Forecast

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



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

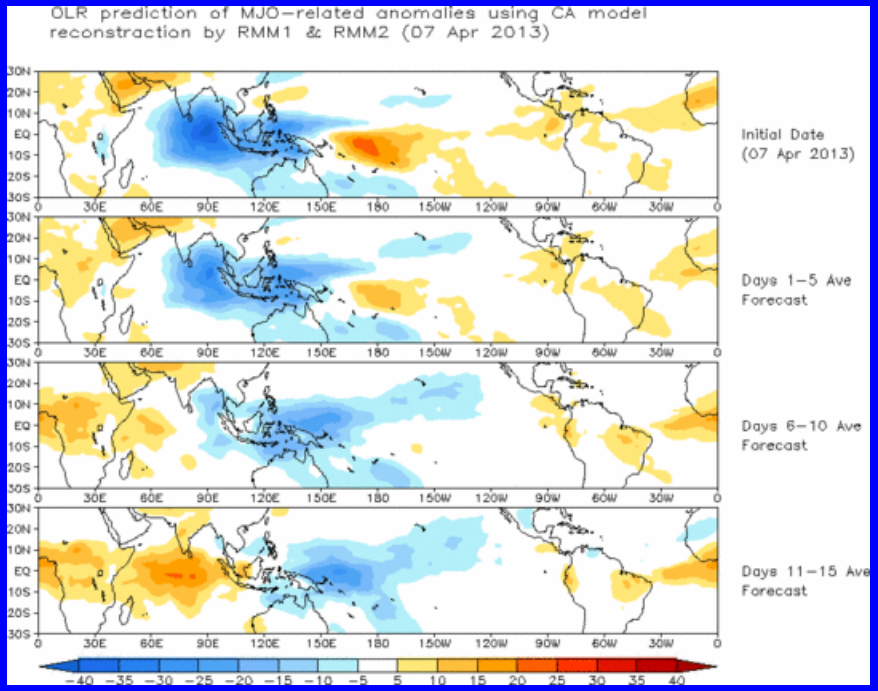


The ensemble mean GFS forecasts enhanced convection across the Indian Ocean and Maritime Continent for Week-1, with some eastward propagation, followed by weakening during Week-2. Suppressed convection is indicated over the central Pacific, with some propagation and a weakening of this part of the signal.

Constructed Analog (CA) MJO Forecast

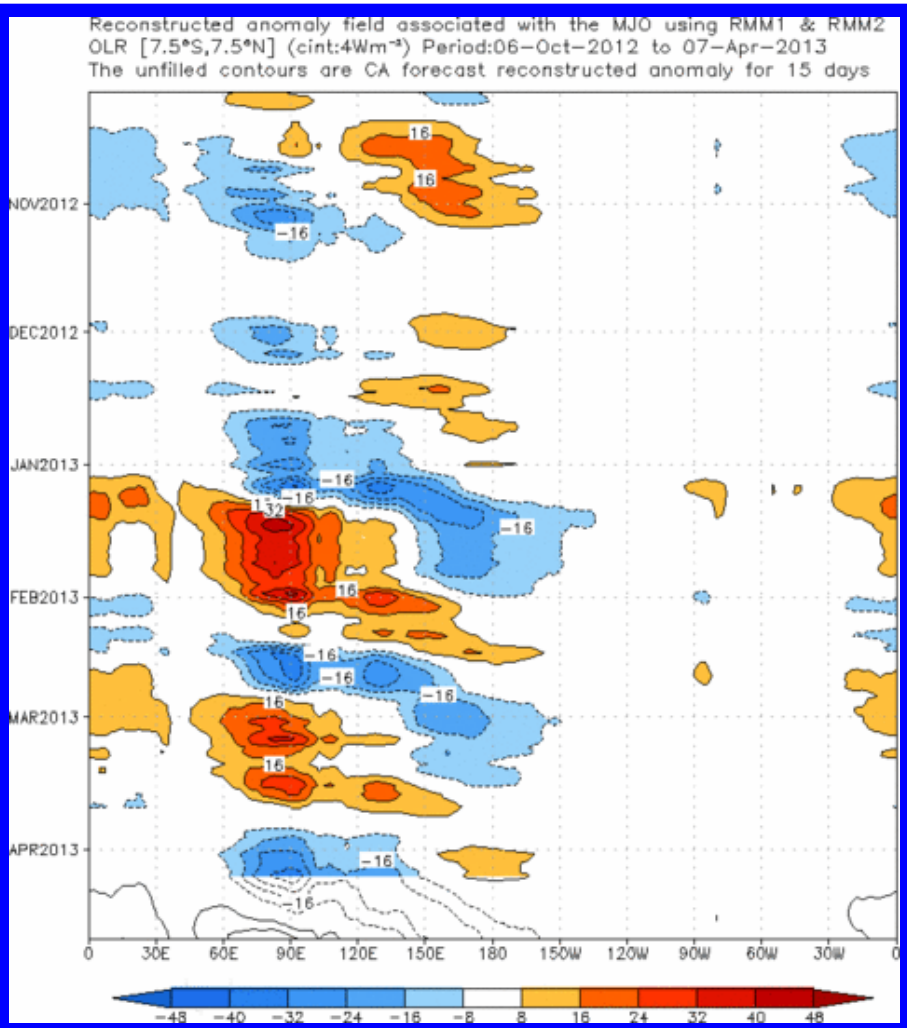
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



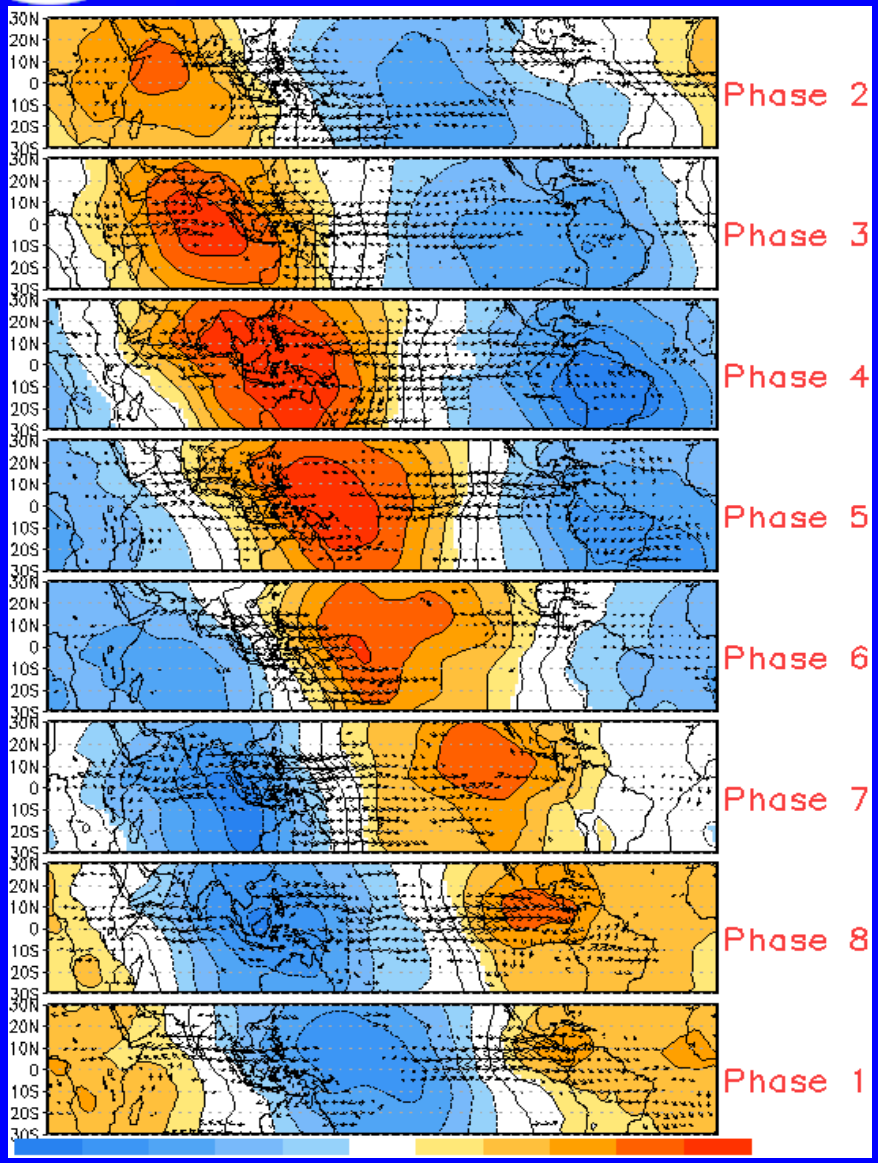
This forecast shows more clear eastward progression and a stronger signal with enhanced convection shifting across the Maritime Continent. Suppressed convection is forecast to develop over Africa during week-2.

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

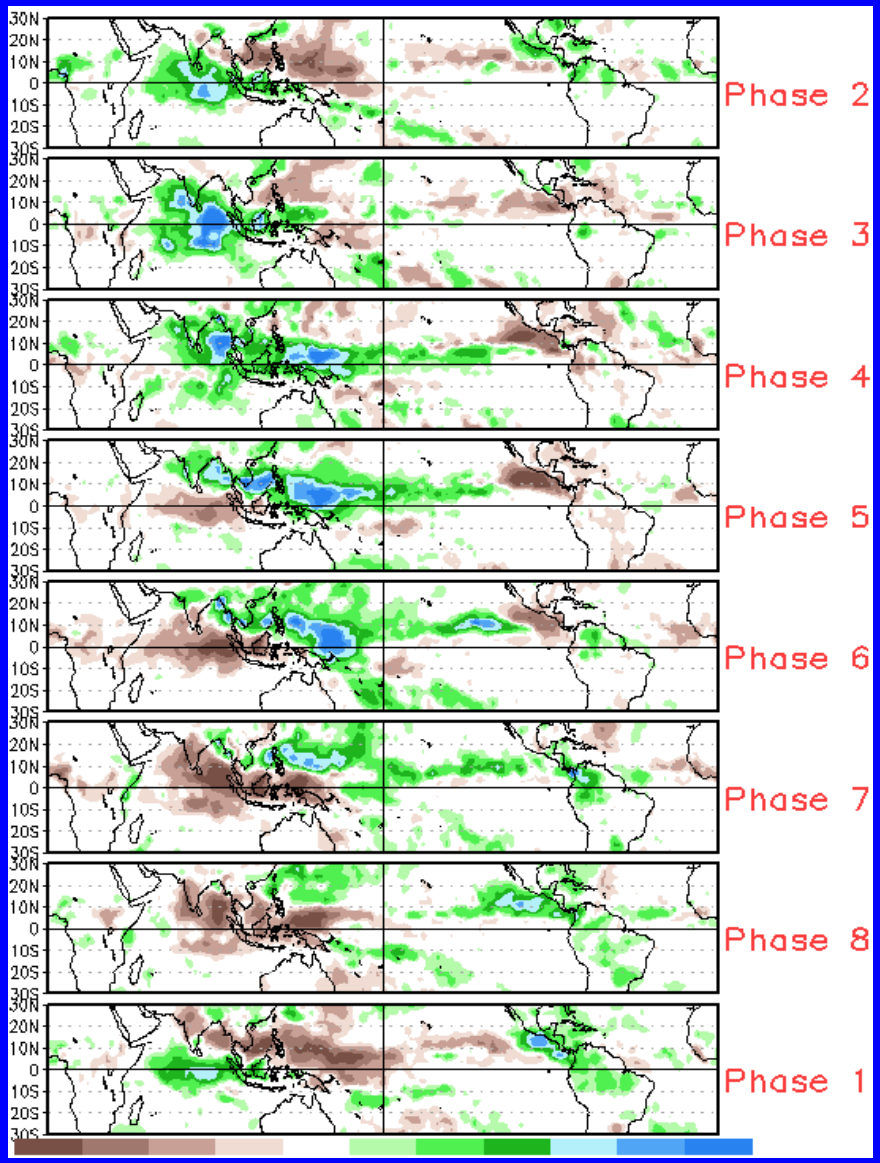


MJO Composites – Global Tropics

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

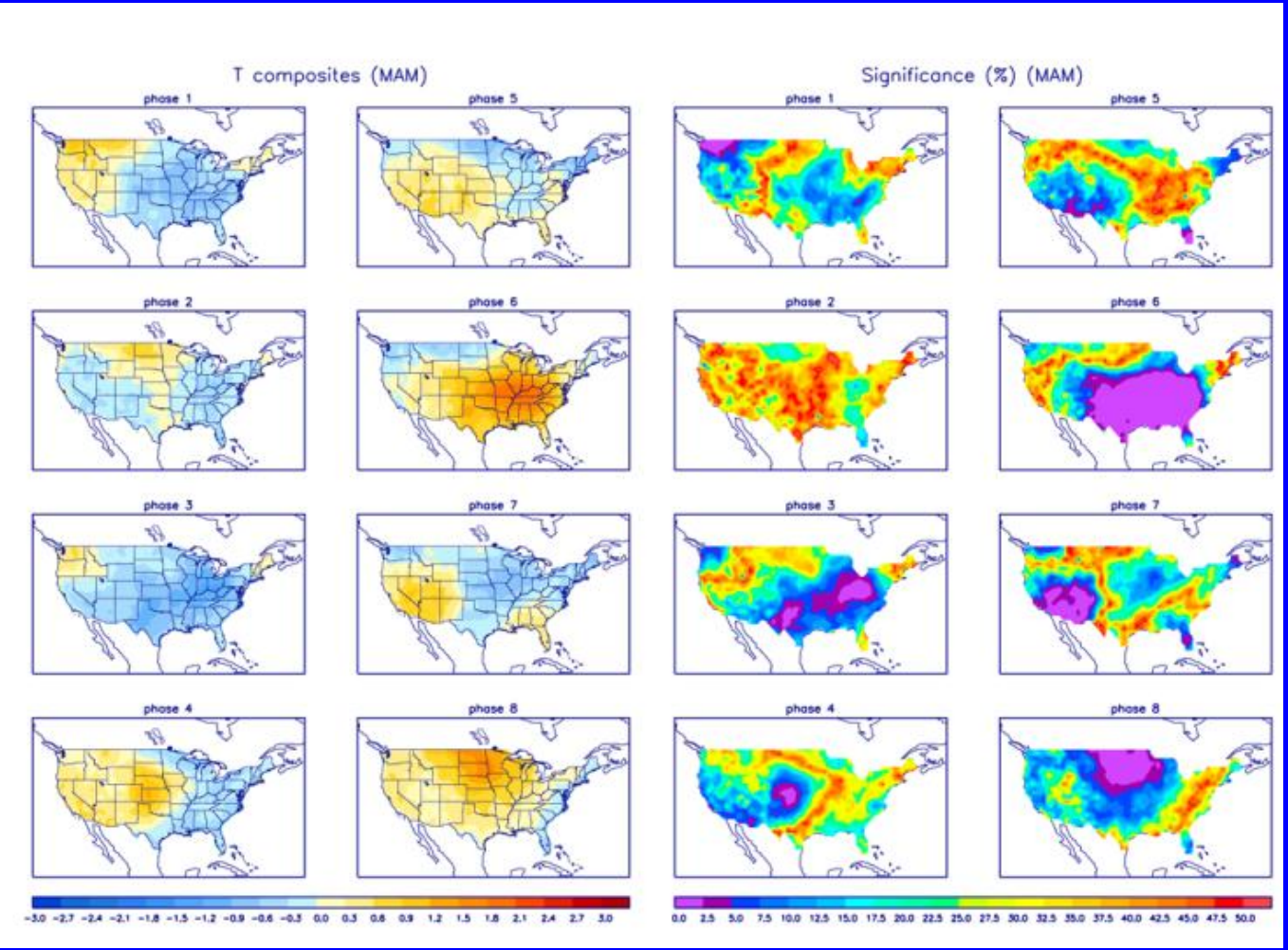


Precipitation Anomalies (May-Sep)



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.**

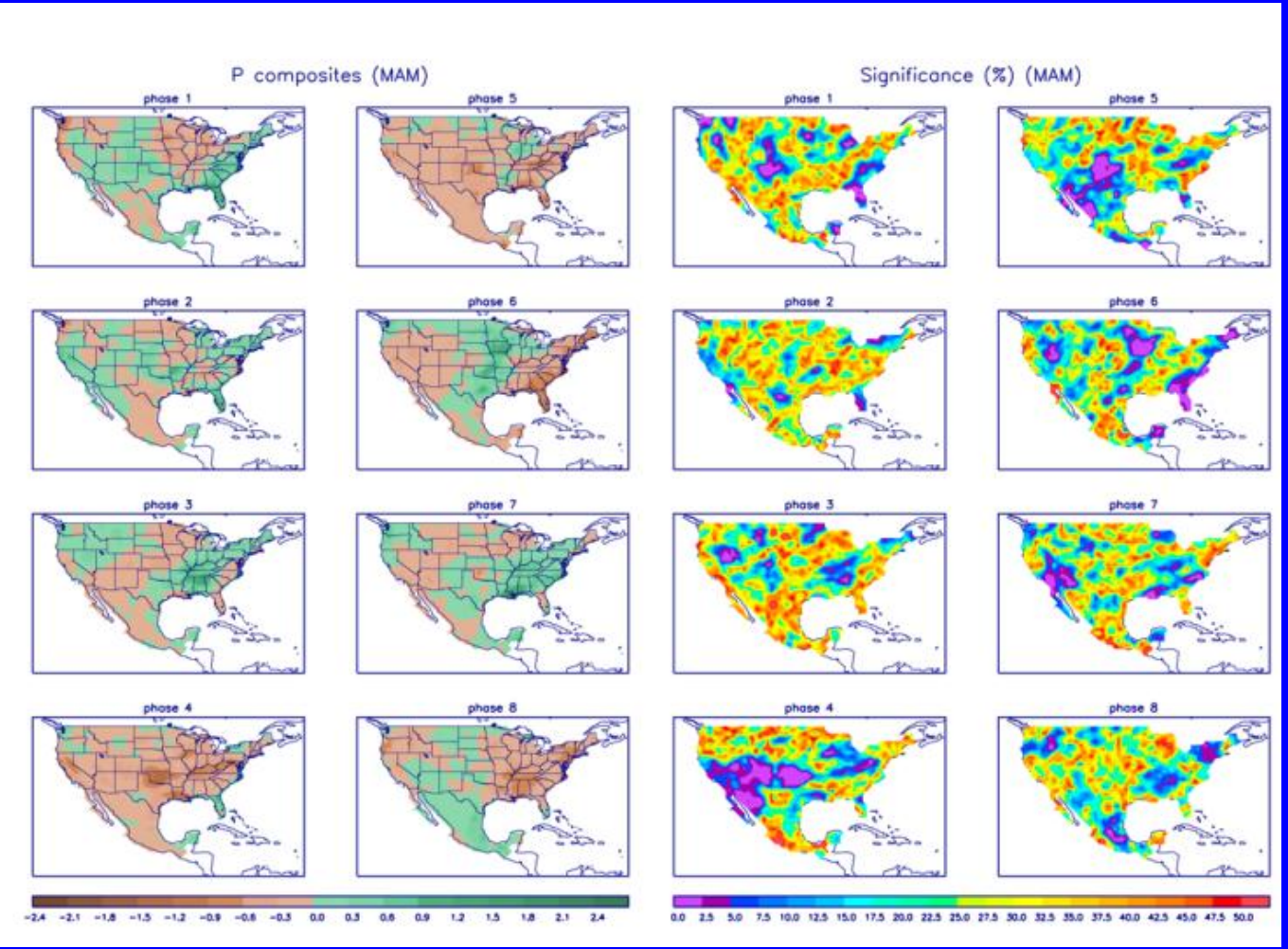


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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