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

Update prepared by

Climate Prediction Center / NCEP

March 25, 2013

Outline

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

Overview

- The MJO remained active with the enhanced phase now centered over the Atlantic Ocean, although the signal is less defined than the previous several weeks.

- Dynamical model MJO index forecasts generally support a weakening of the signal, with some eastward propagation. Statistical tools favor continued activity, with a slightly stronger signal than the dynamical models. All forecast tools indicate a less defined signal compared to recent MJO activity.

- Although the forecast tools indicate some weakening of the MJO, it is too early to determine if this is an end of the long-lived MJO activity seen over the last few months. Based on recent observations and model MJO forecasts, the less coherent MJO signal is forecast to propagate across the Indian Ocean by the end of Week-2. Other modes of subseasonal tropical variability are also resulting in less organization of large scale tropical convection.

- The MJO favors enhanced rainfall across portions of South America for Week 1 and elevated odds of suppressed rainfall across parts of the Maritime Continent for Weeks 1-2.

- Higher latitude variability, especially in the North Atlantic sector, is expected to be the primary driver across most of the U.S. over the next couple of weeks.

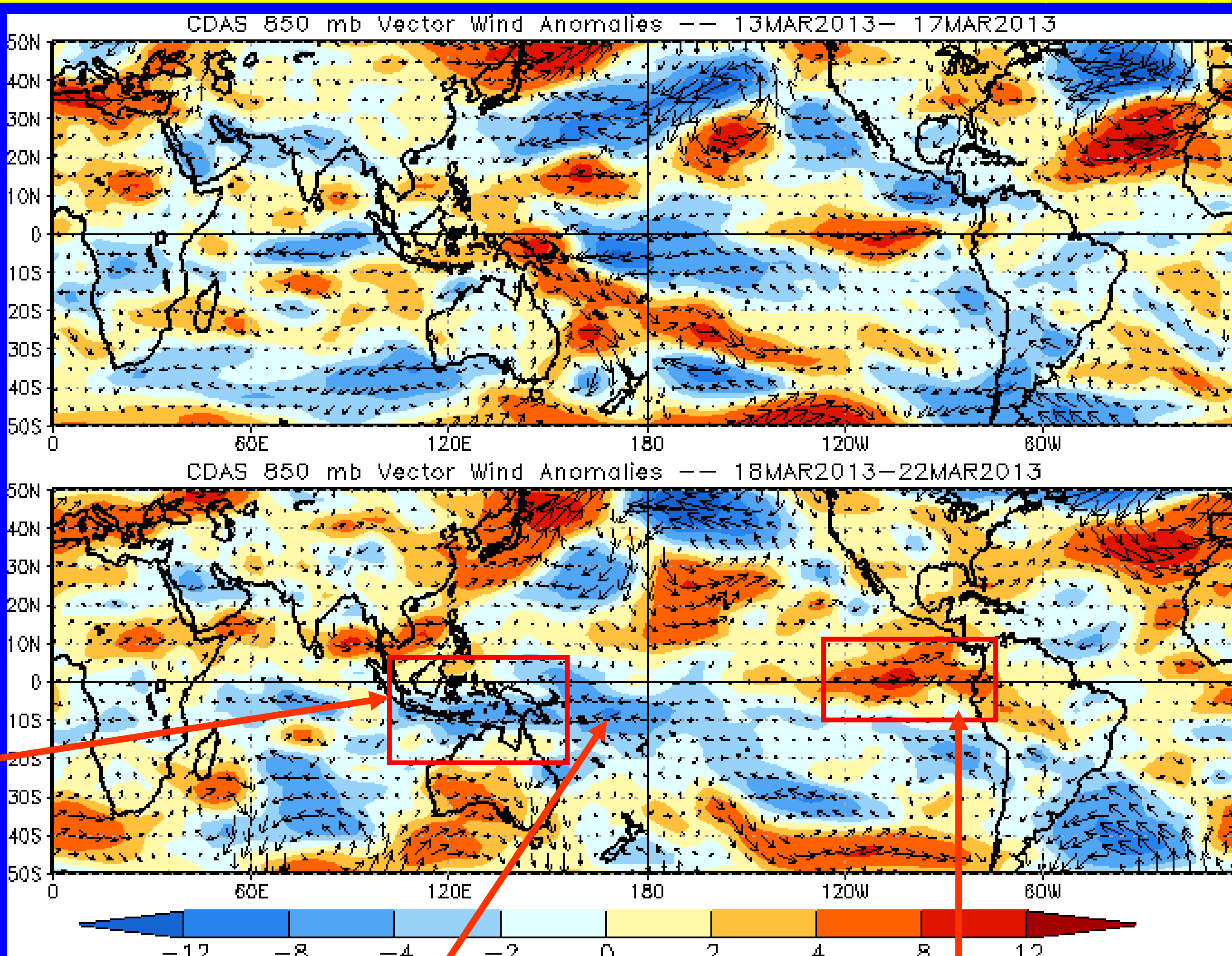
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 developed over the Maritime Continent and western Pacific, nearly a complete reversal from the previous period.

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

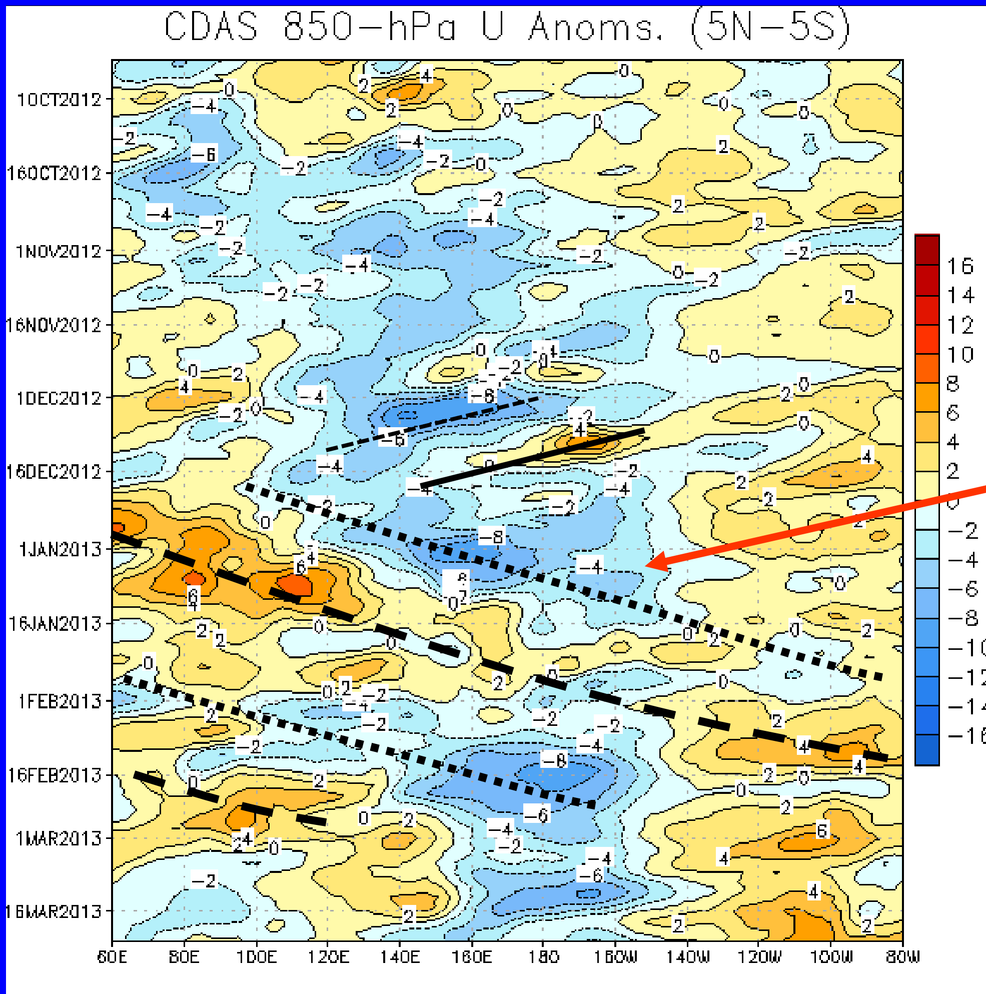
Westerly anomalies intensified and expanded in coverage during the past five days over the eastern Pacific.

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



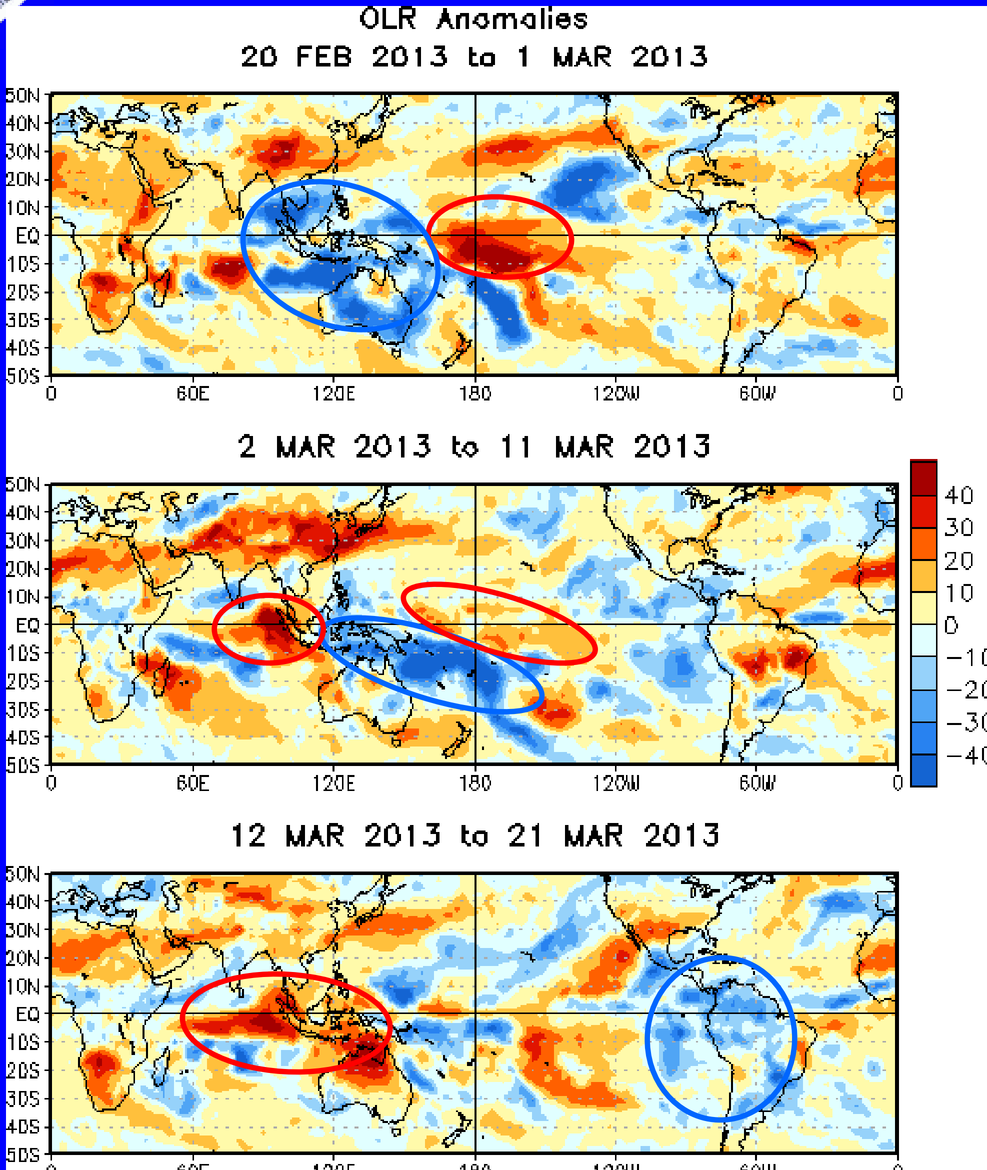
Longitude

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).

Most recently during March, anomalies are again showing signs of being impacted by Rossby wave activity (westward propagation), with less coherent eastward propagation associated with the MJO.

OLR Anomalies – Past 30 days



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

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

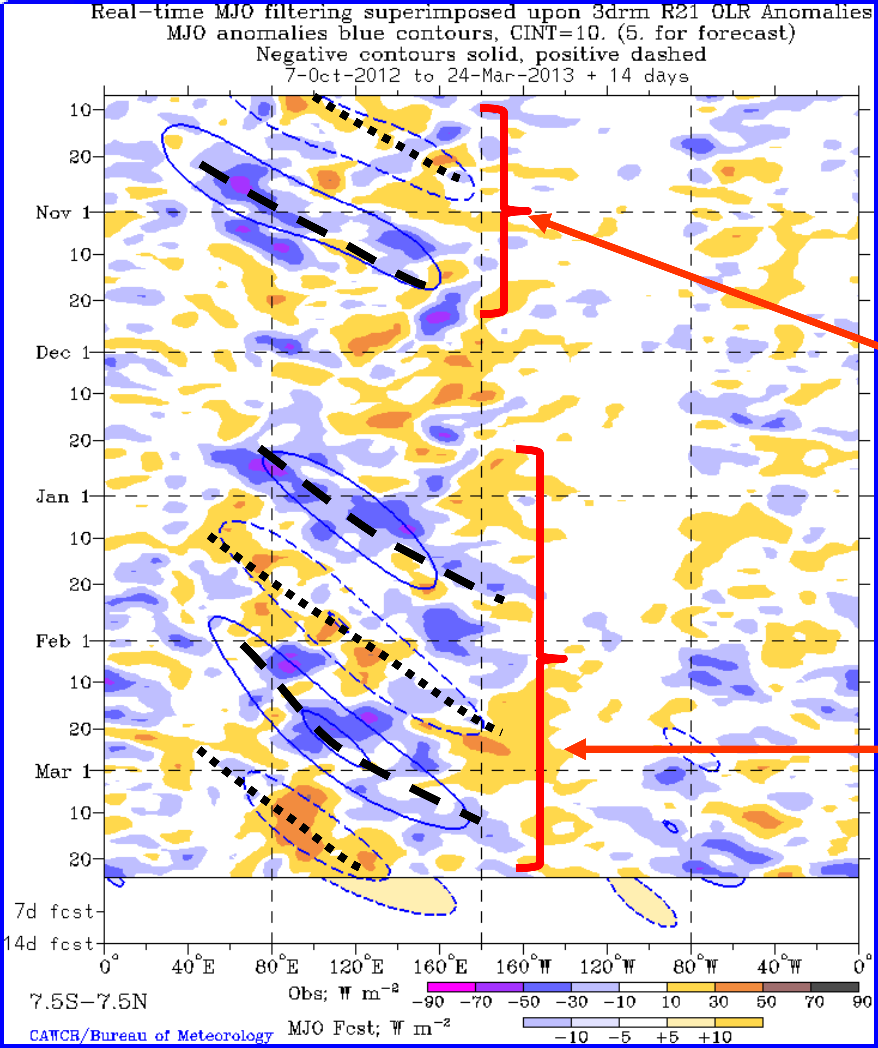
Enhanced (suppressed) convection stretched across the Maritime Continent (central, equatorial Pacific and Africa). The spatial arrangement of anomalies was consistent with the MJO.

By early- to 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-March, enhanced (suppressed) convection was located over South America (Indian Ocean and Maritime Continent).

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.

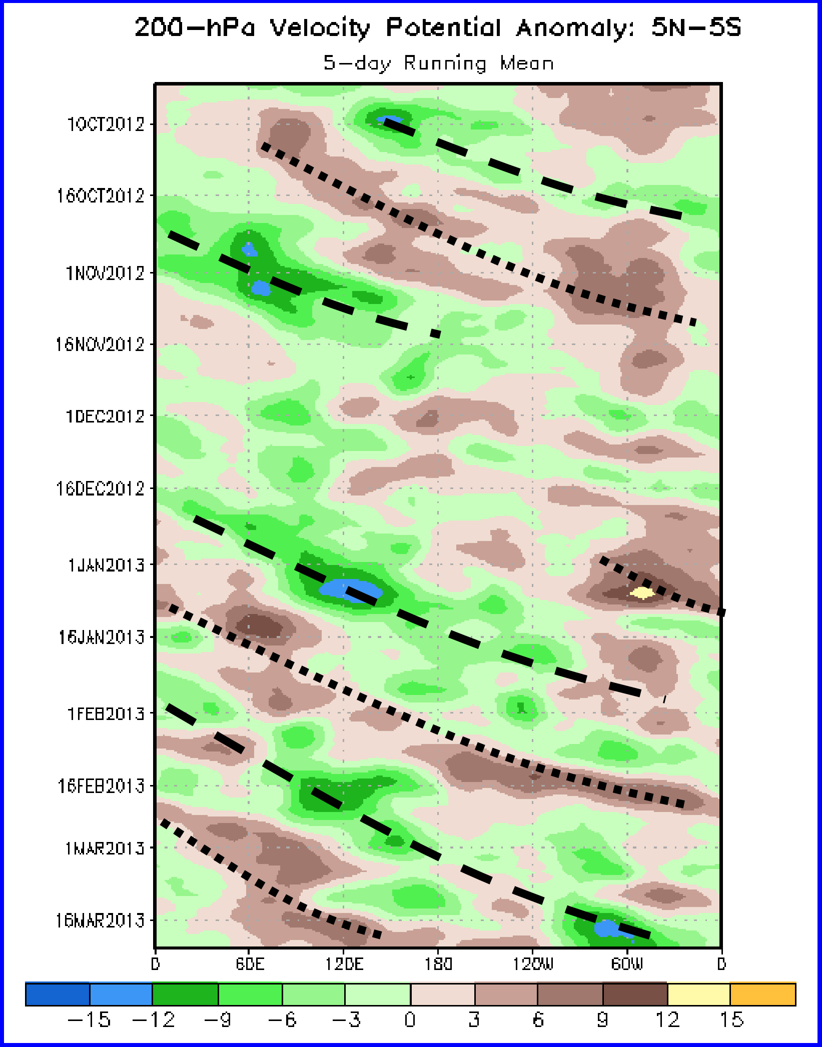
The MJO was again a dominant mode of variability across the Tropics from January into March as indicated by the alternating dashed and dotted lines.

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.

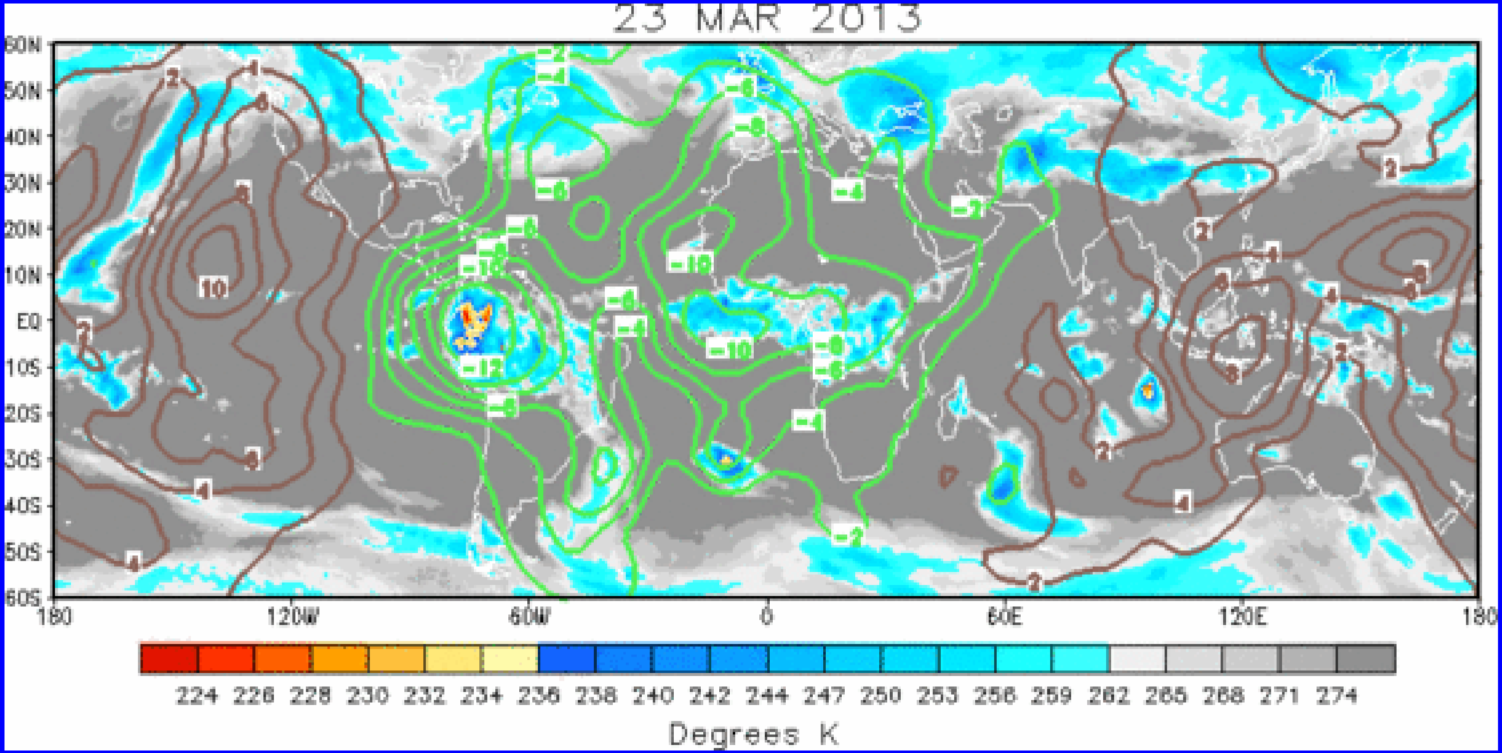
As the MJO strengthened in late December, anomalies increased in magnitude with more robust eastward propagation indicated during late 2012 and early 2013. Anomalies became less coherent during late January into early February, but reorganized in late February and early March.

Most recently, the strongest anomalies are located near 60W and 120E for the enhanced and suppressed MJO phases respectively.

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



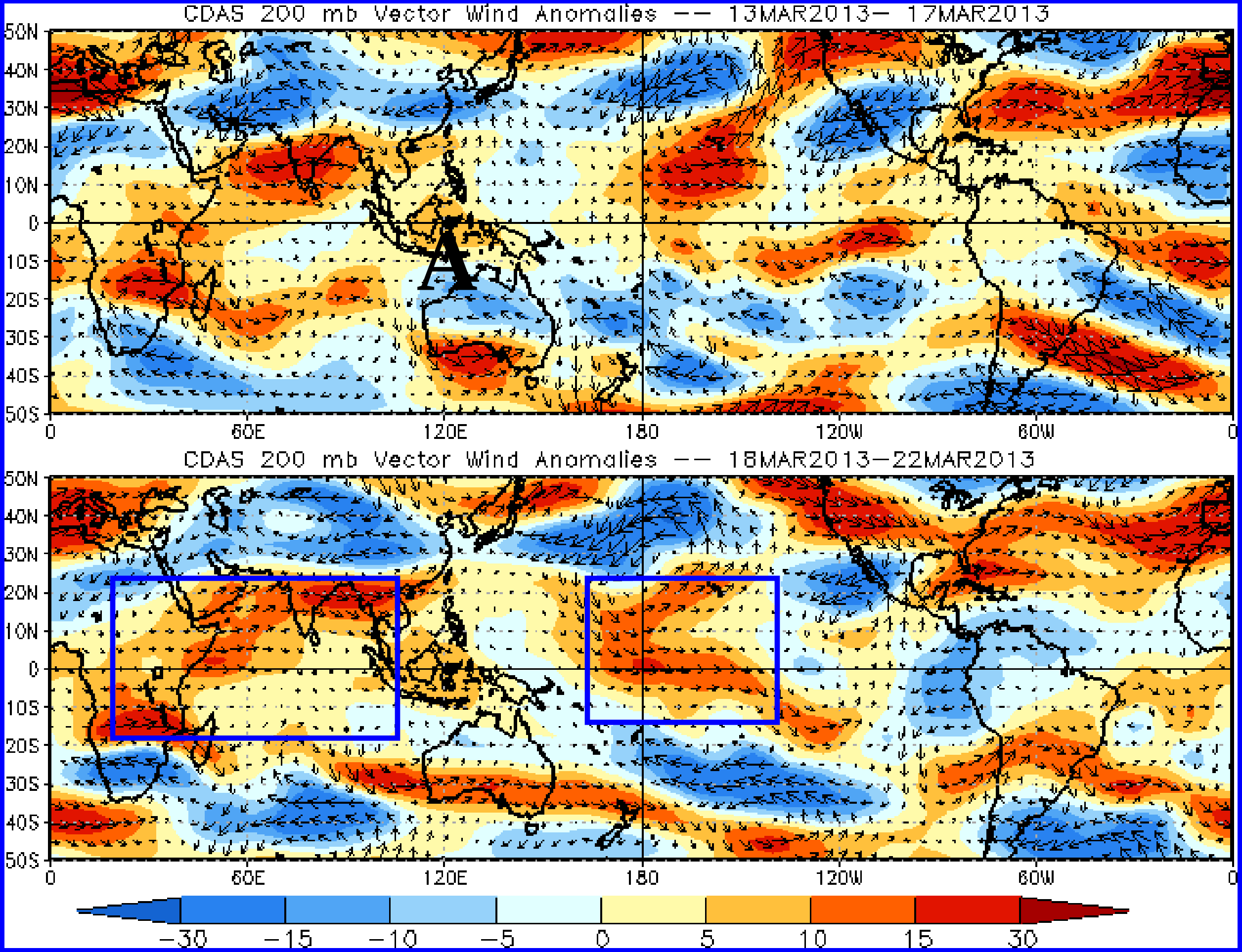
The velocity potential pattern shows strong upper-level divergence across South America and weaker divergence over central Africa. The strongest upper-level convergence is centered across the central Pacific, with weaker subsidence over the Maritime Continent. The pattern is consistent with the wave-1 structure associated with a robust MJO.

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



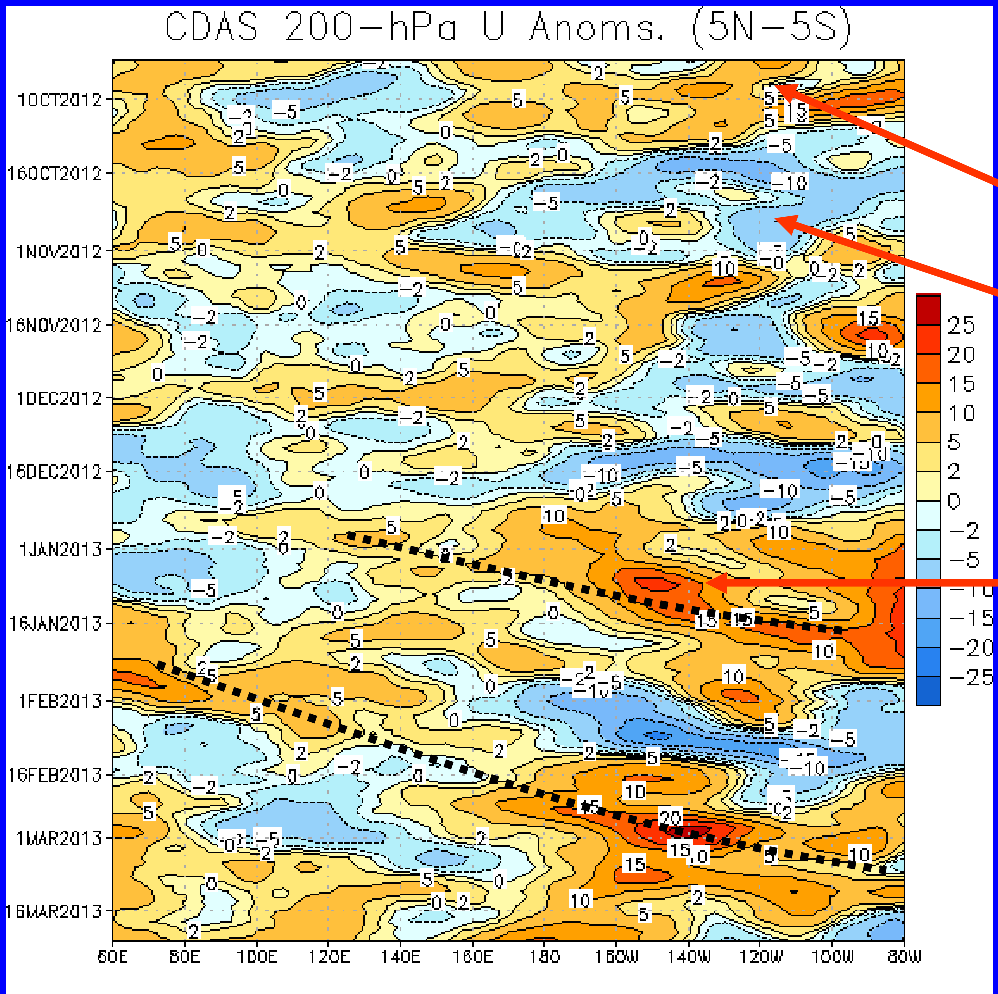
Westerly anomalies (blue boxes) remain across the central equatorial Pacific during the last five days and have continued over the western Indian Ocean and Africa.

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



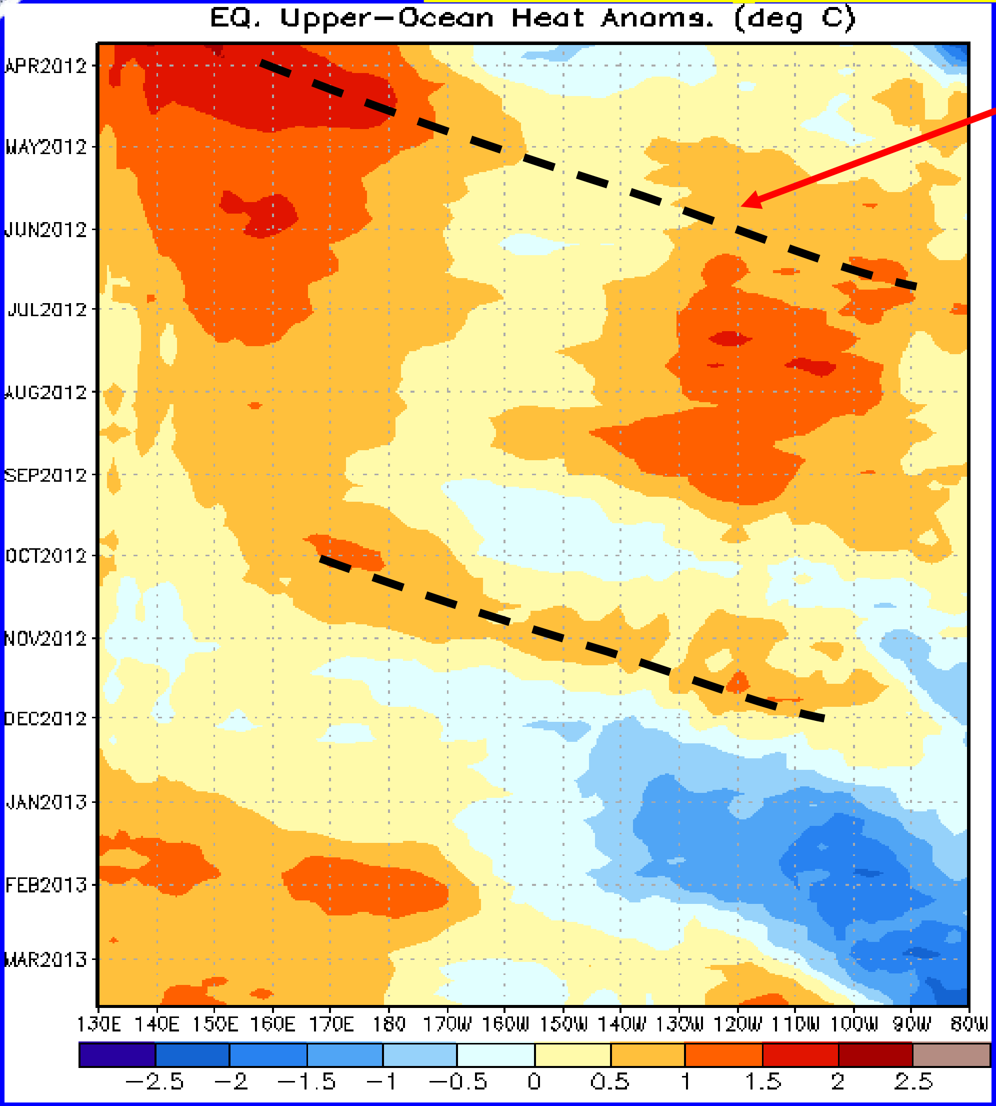
Longitude

Westerly anomalies prevailed across the eastern Pacific and Americas for much of September and October, but were replaced by easterly anomalies during mid-October.

Eastward propagation of westerly wind anomalies associated with the MJO is evident beginning in late December and continuing into March 2013. Propagation of easterly anomalies is also 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 respectively during January 2013 and have generally persisted through early March. There has been some indication of a weak downwelling Kelvin wave since early February.

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).

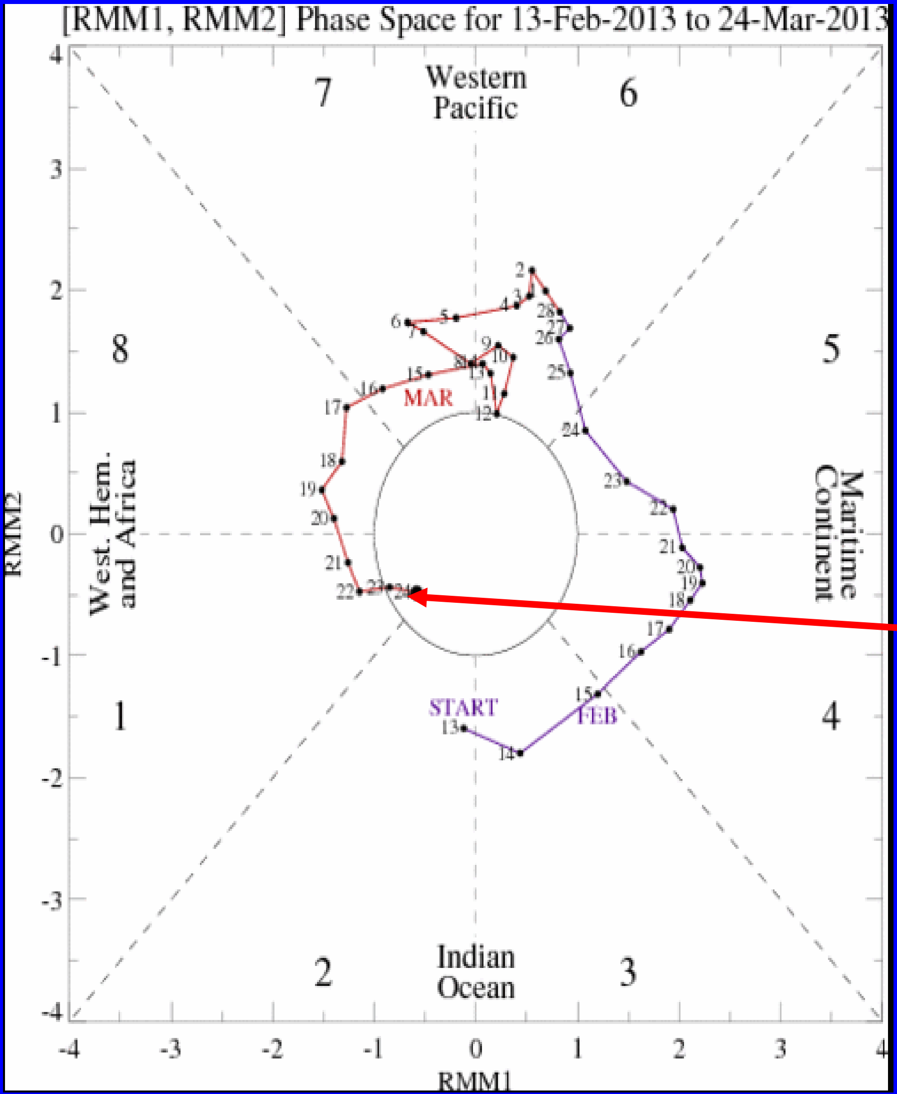
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

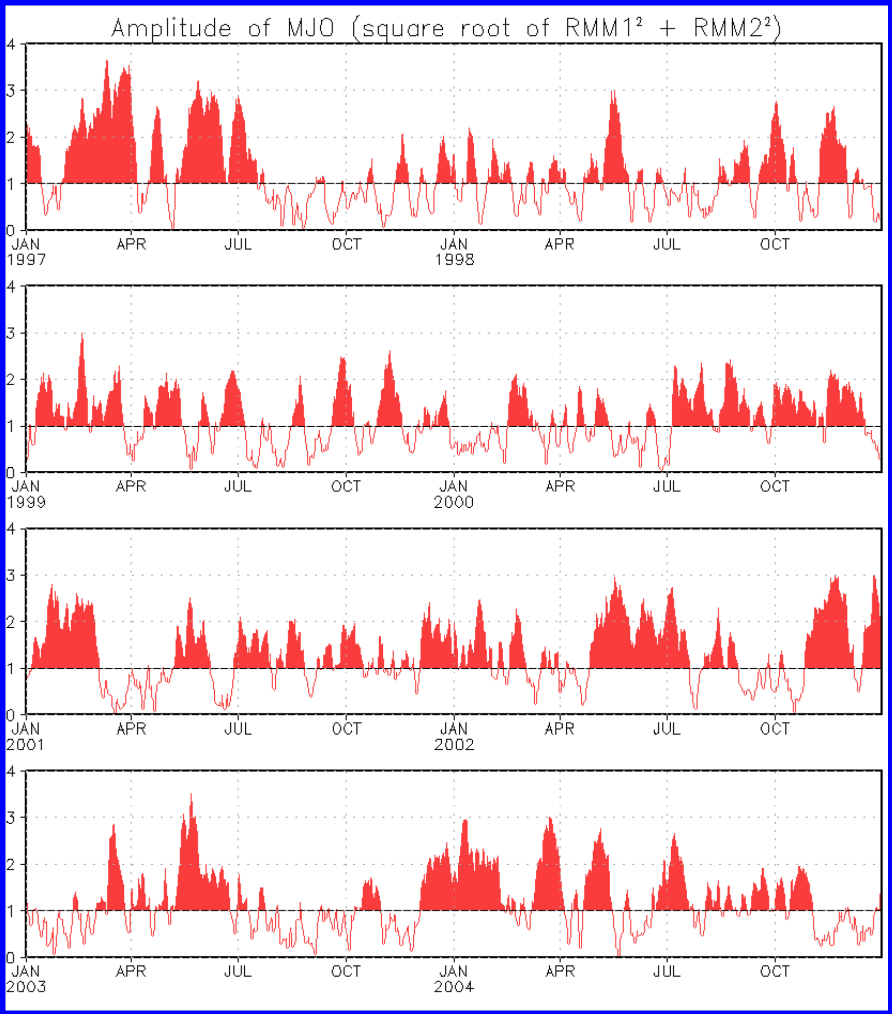
MJO Index -- Recent Evolution

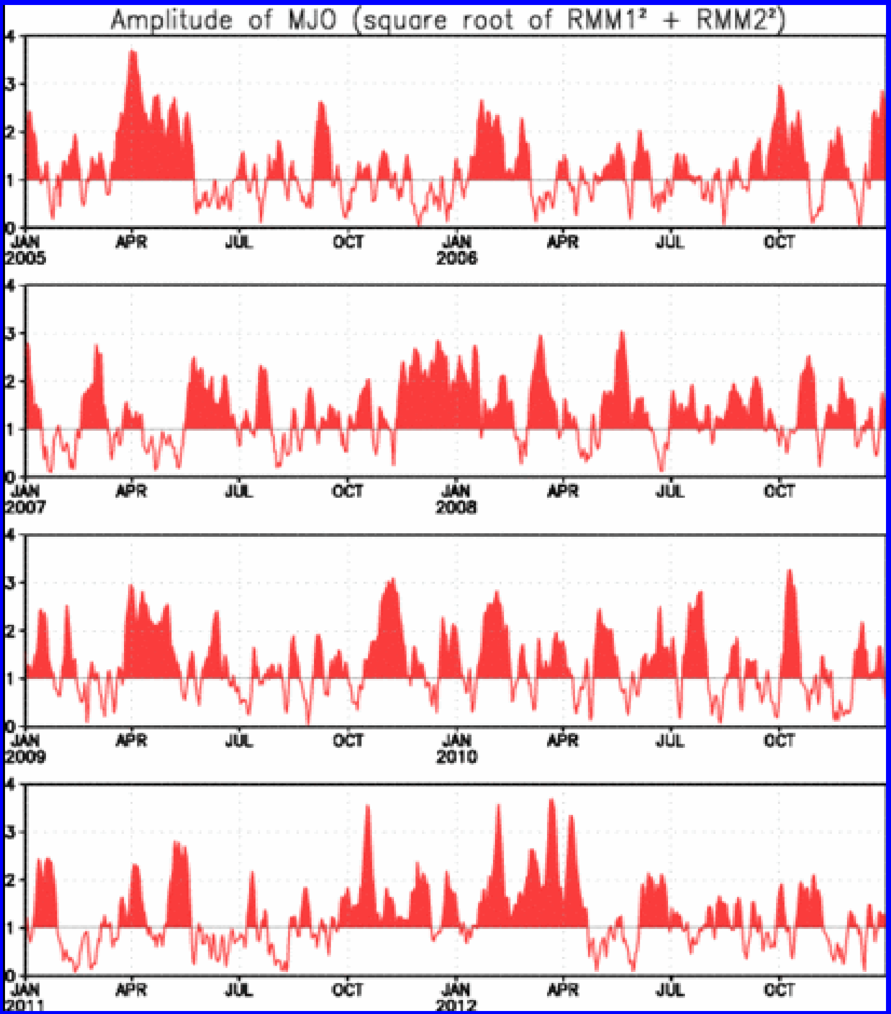


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates slow eastward propagation of the MJO over the past couple of weeks with the enhanced convective phase now entering Africa.

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.

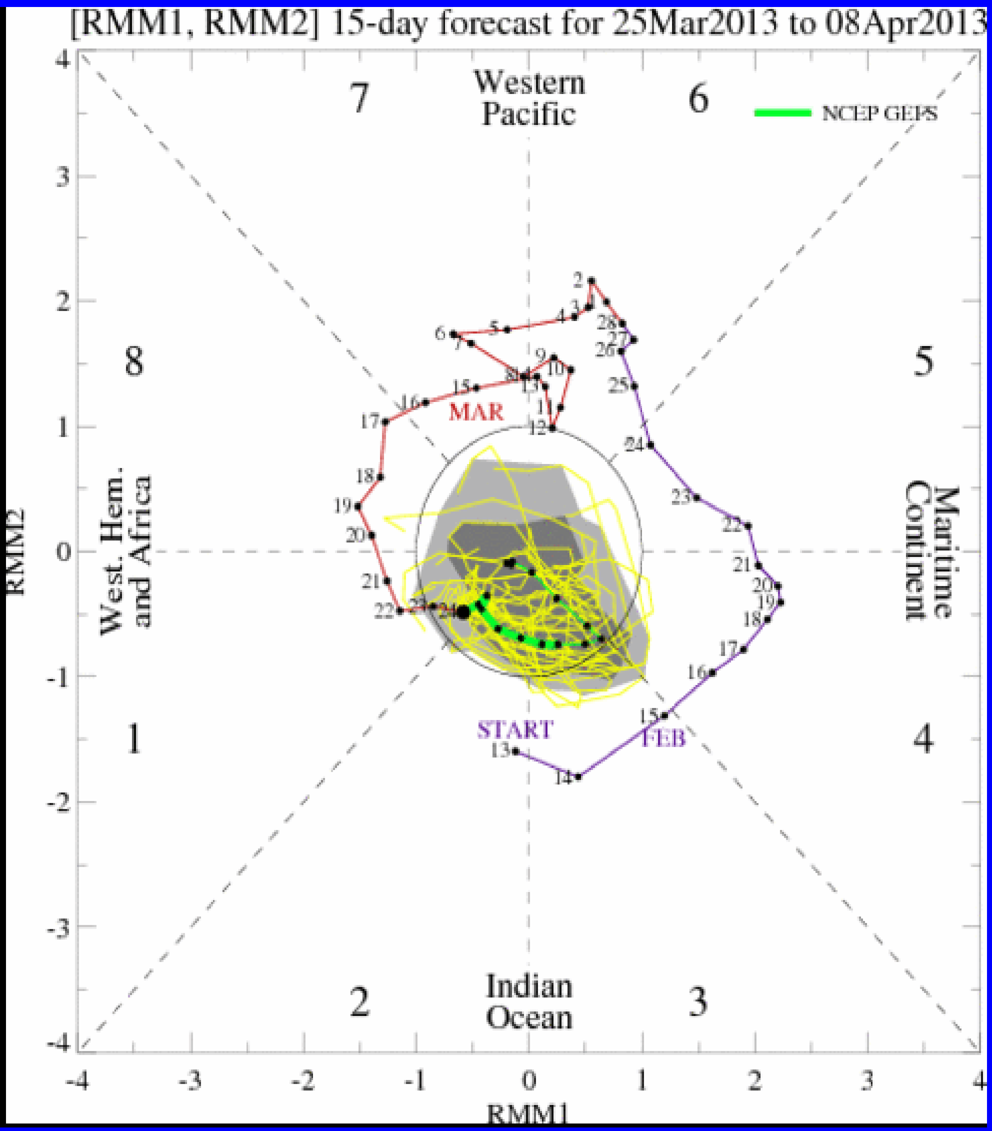
Ensemble GFS (GEFS) MJO Forecast

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

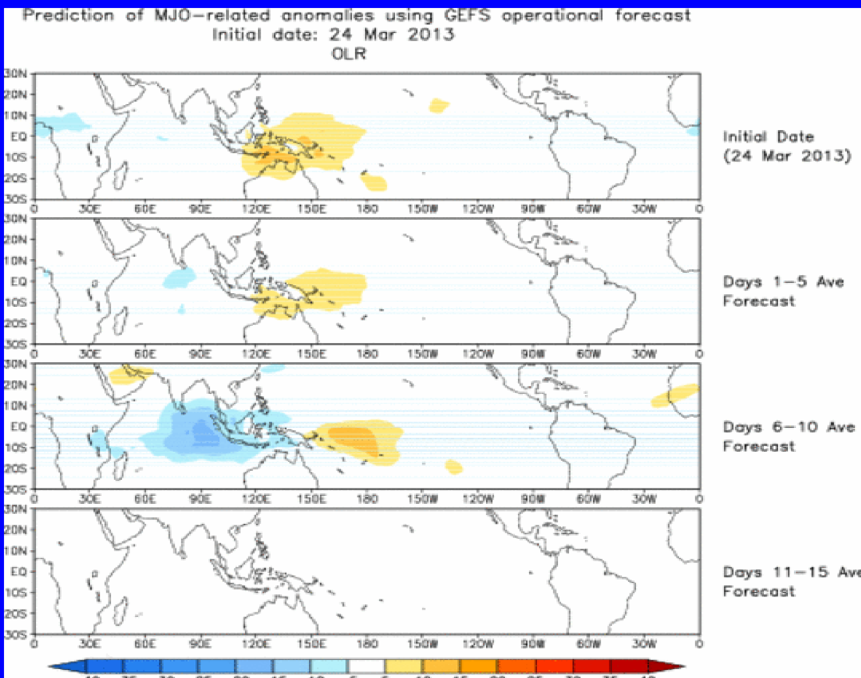
The bias-corrected ensemble GFS indicates a significant weakening of the signal during the period.



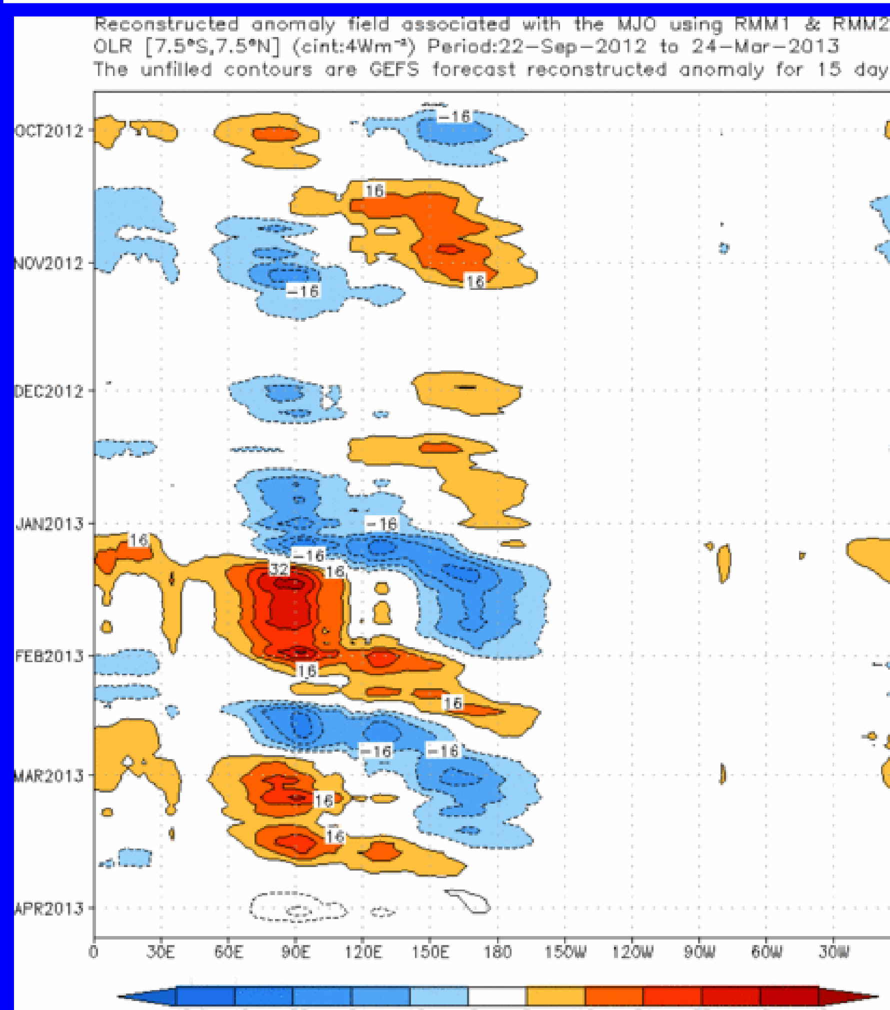
Ensemble Mean GFS MJO Forecast

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

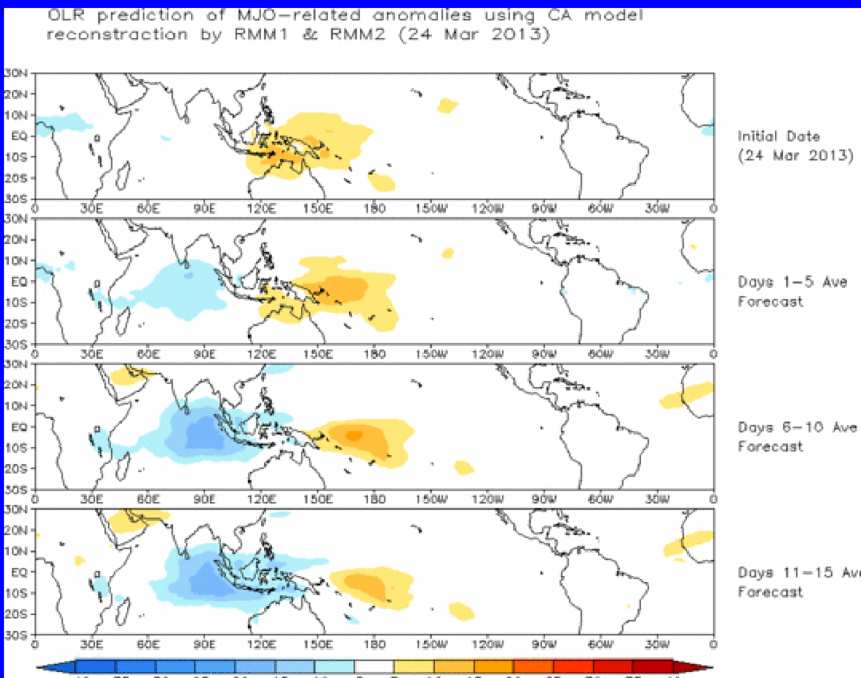


The ensemble mean GFS forecasts weak enhanced convection to propagate across Africa during Week-1 and emerge over the eastern Indian Ocean during Week-2. Suppressed convection is indicated over the Maritime Continent and western Pacific. Overall, the signal is weak.

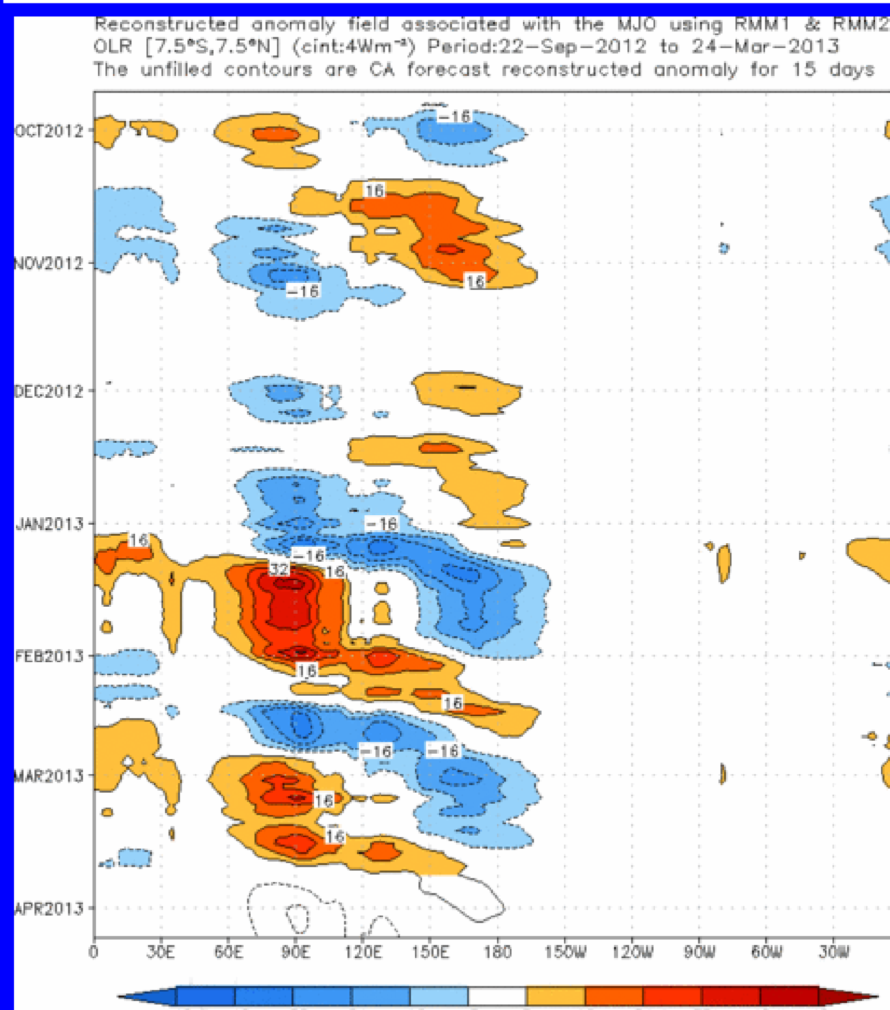
Constructed Analog (CA) MJO Forecast

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



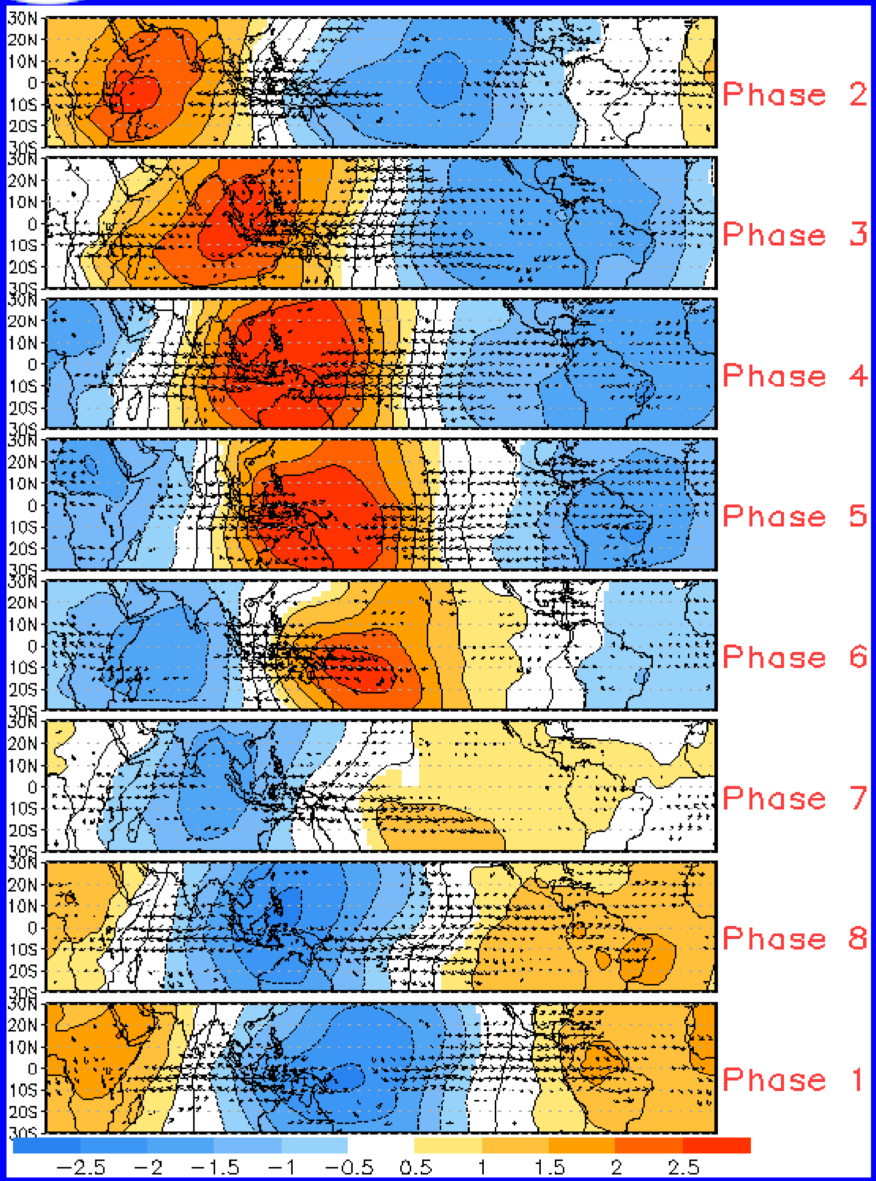
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



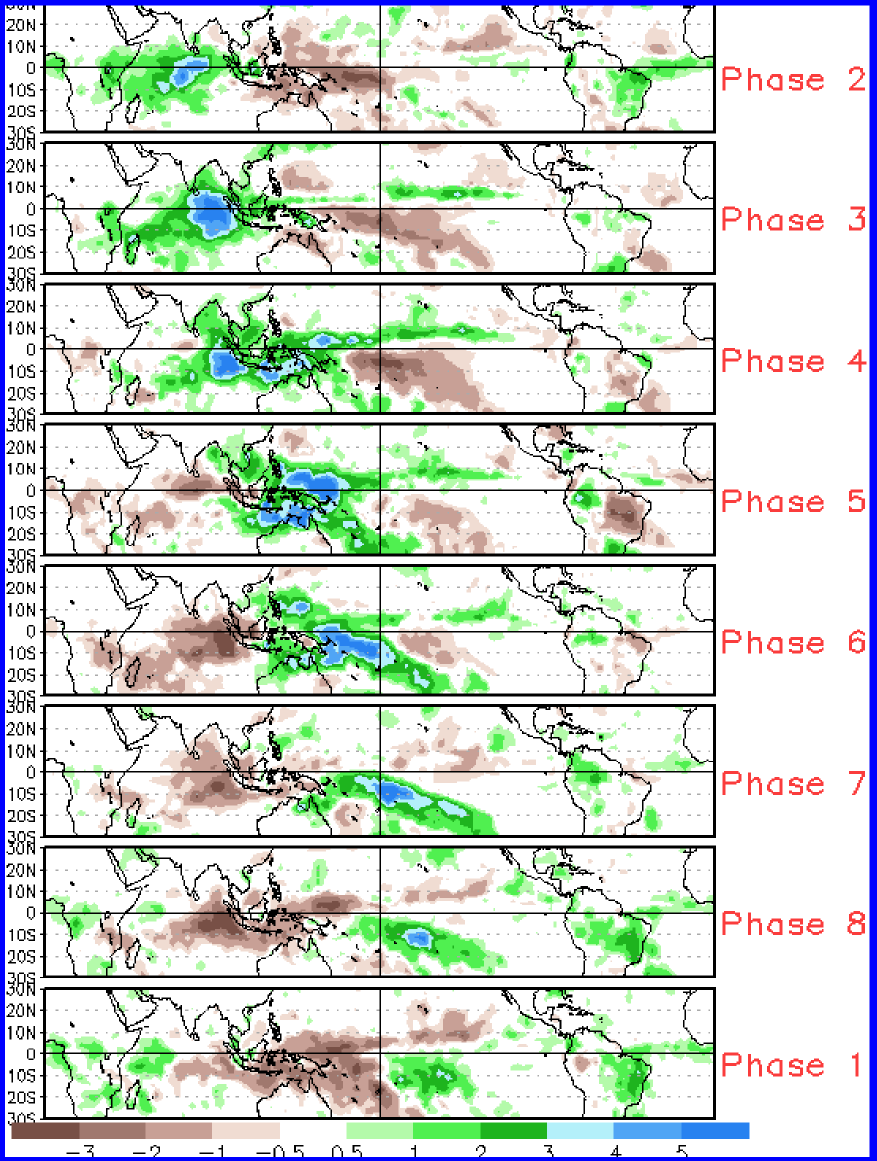
This forecast shows more clear eastward progression with enhanced convection shifting across Africa and the Indian Ocean. Suppressed convection is forecast to shift eastward across the Maritime Continent and into the western Pacific during Week-2. This signal is slightly stronger than the GFS forecast.

MJO Composites – Global Tropics

850-hPa Velocity Potential and Wind Anomalies (Nov-Mar)

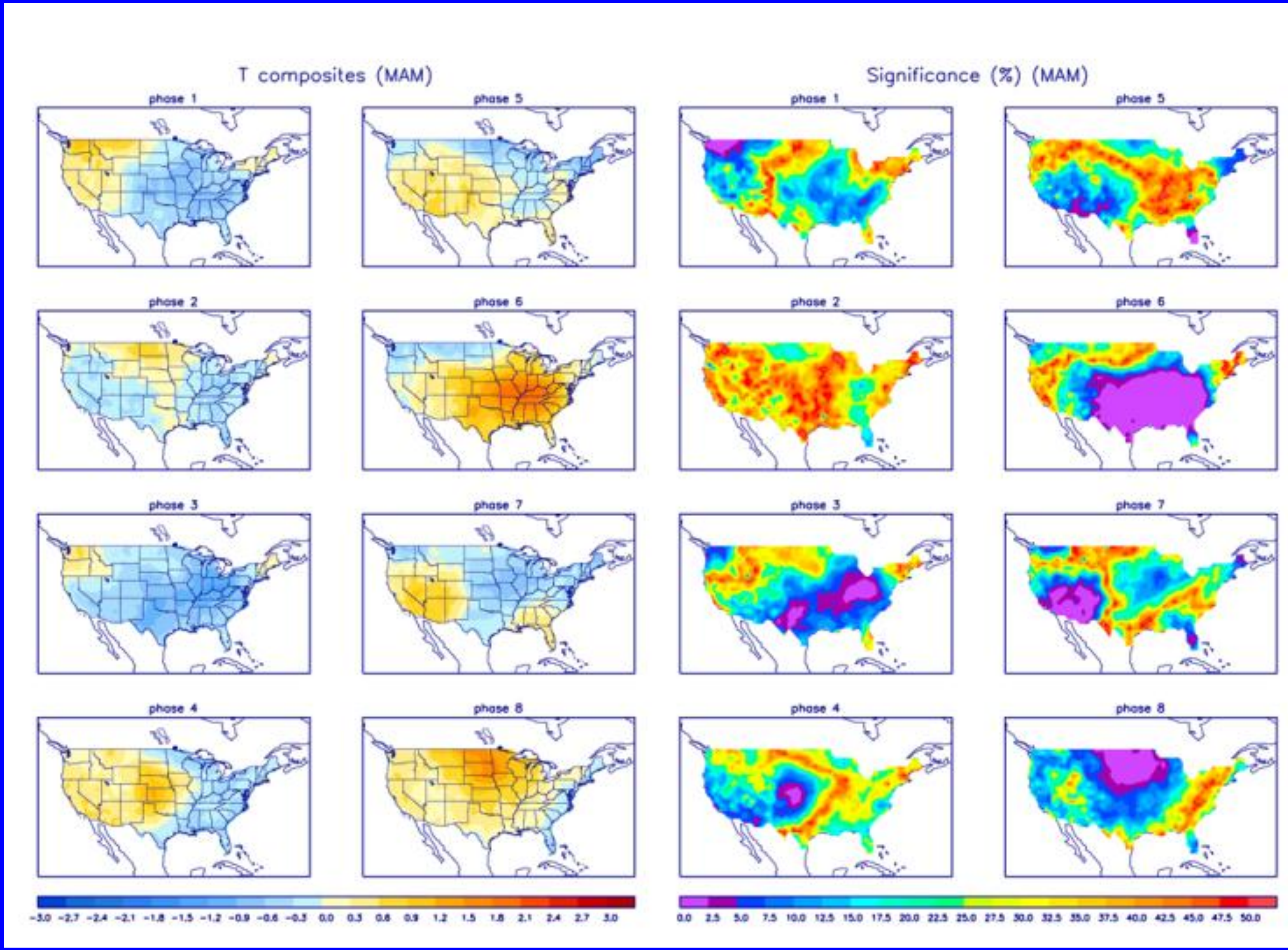


Precipitation Anomalies (Nov-Mar)



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.**

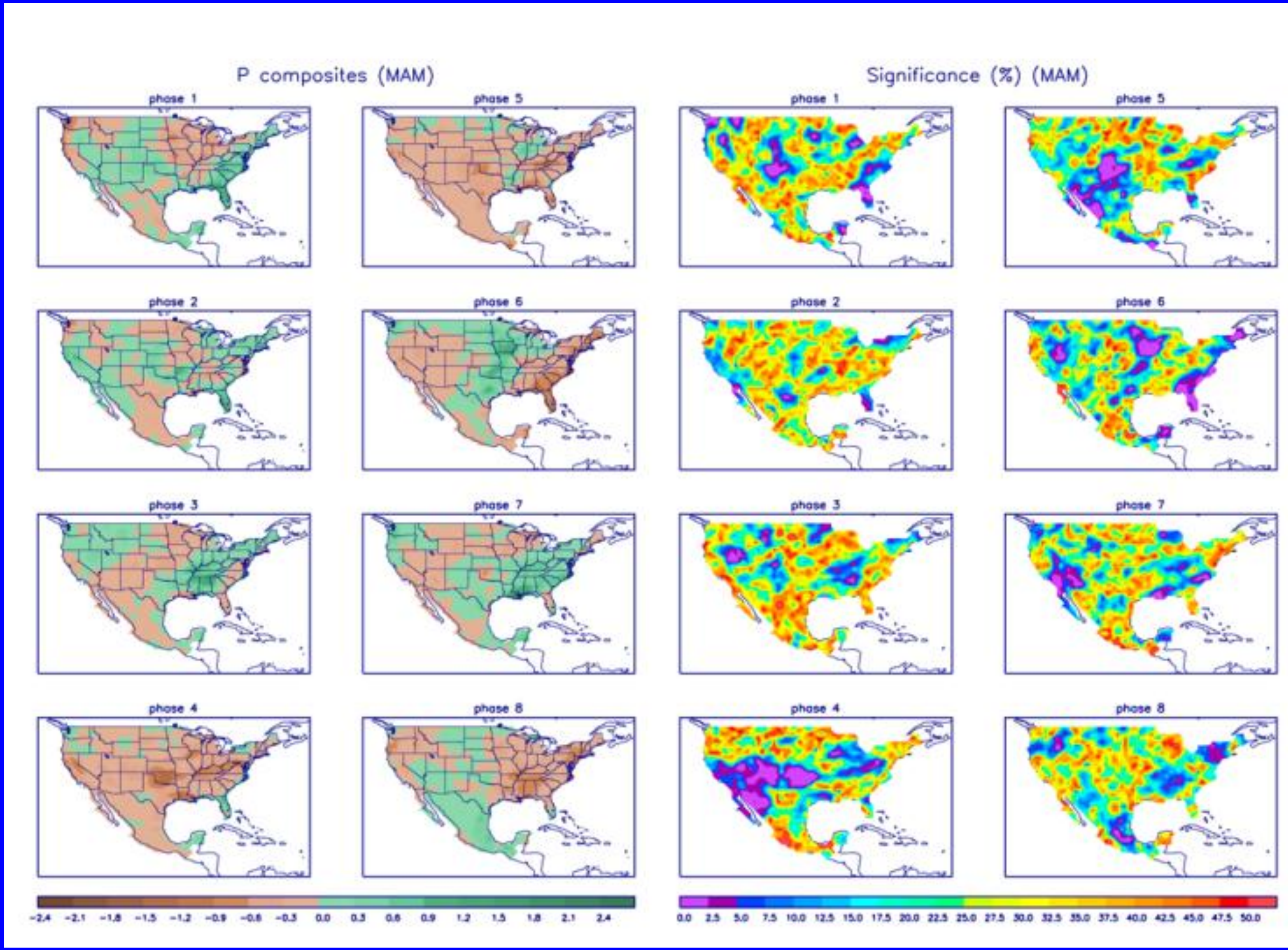


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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