



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

**Update prepared by
Climate Prediction Center / NCEP
March 18, 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 central Pacific.
- Dynamical model MJO index forecasts generally support continued eastward propagation with some influence from other modes of subseasonal variability. The statistical tools also support continued MJO activity.
- Based on recent observations and model MJO forecasts, the MJO is forecast to remain active during the next two weeks, propagating across the Americas to Africa by the end of Week-2.
- The MJO favors enhanced rainfall across the central Pacific (south of the Equator) and portions of South America, with elevated odds of suppressed rainfall across the eastern Indian Ocean and Maritime Continent. The chances for tropical cyclogenesis remain elevated for the waters near Australia during Week-1.
- 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. The MJO may exhibit some influence on precipitation over the southern US.

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>



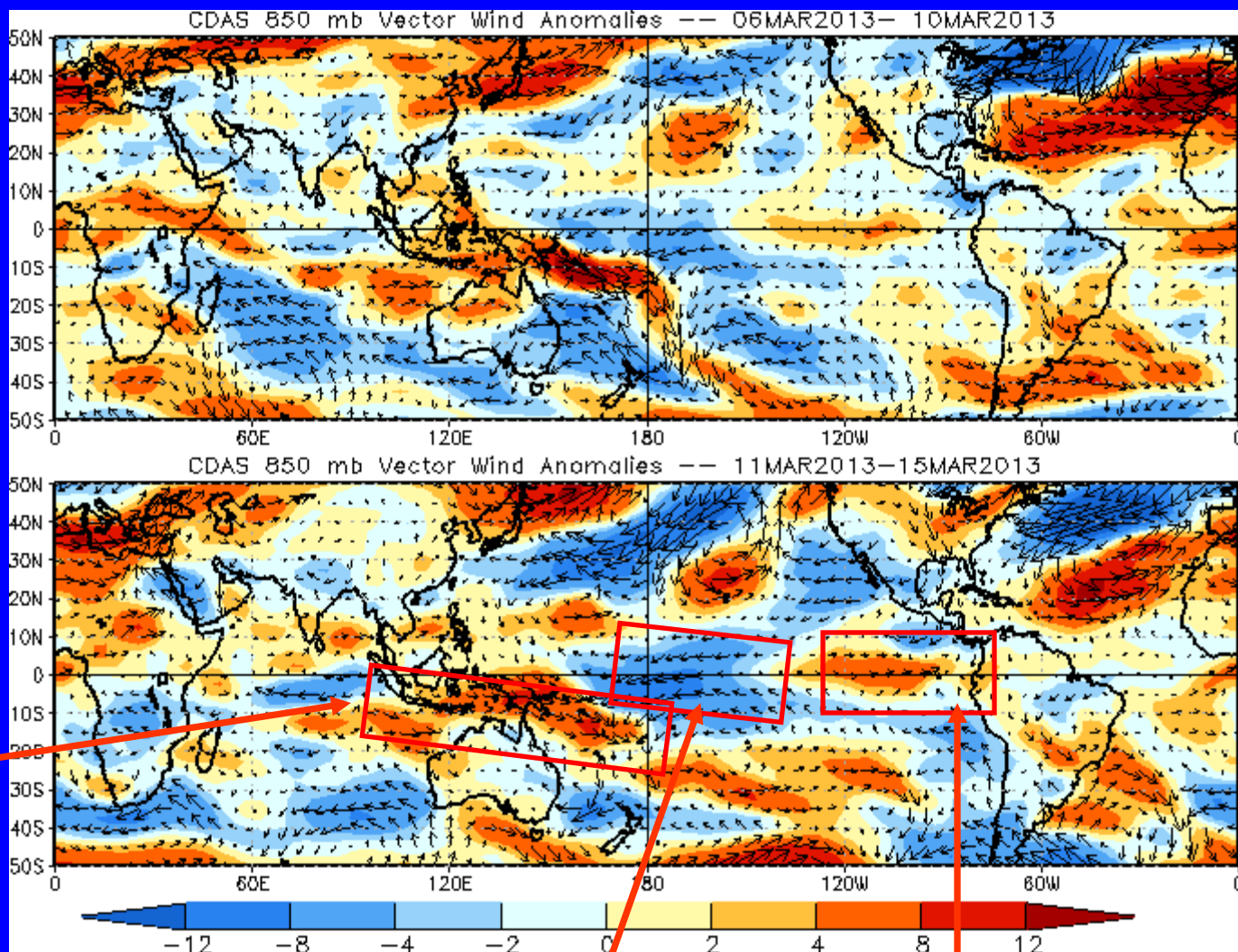
850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Westerly anomalies extended eastward across southwestern Pacific but weakened slightly.



Easterly anomalies intensified and expanded slightly over the western Pacific during the past five days.

Westerly anomalies intensified slightly during the past five days over the eastern Pacific.

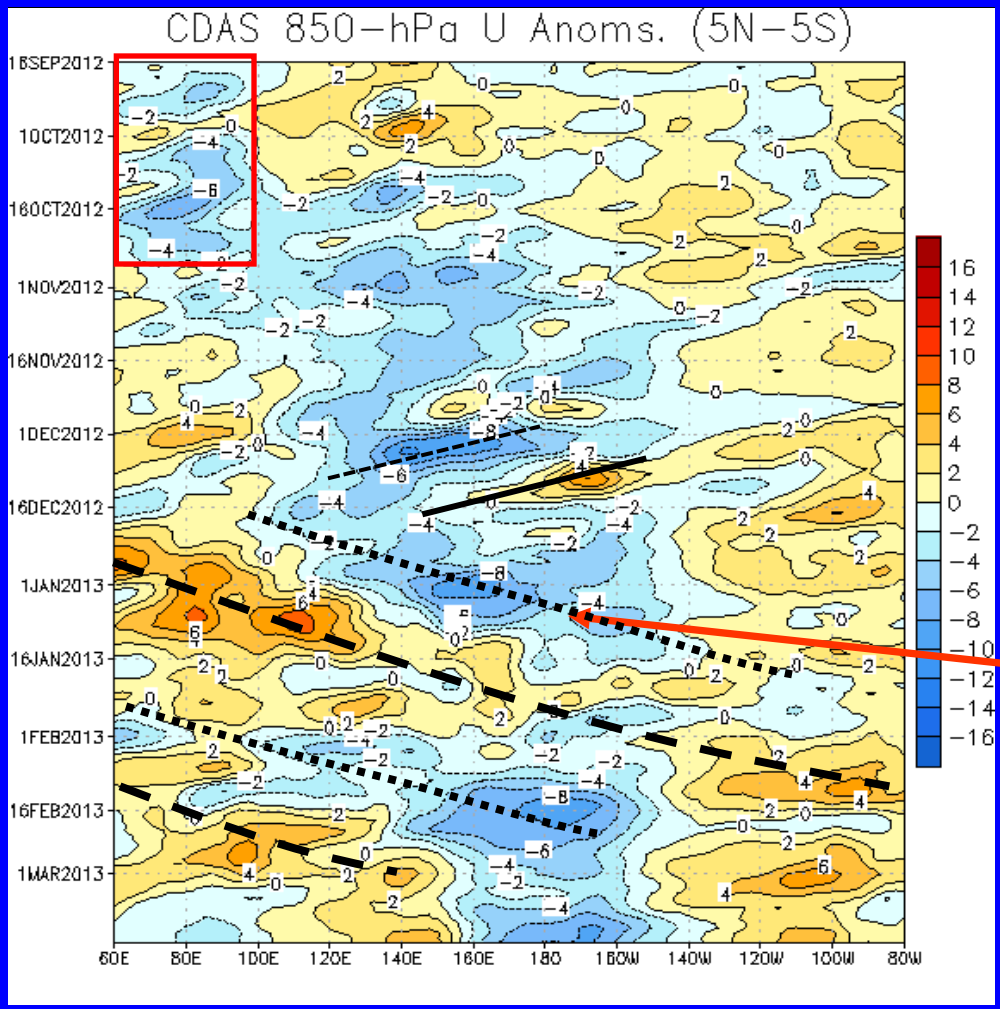


850-hPa Zonal Wind Anomalies (m s^{-1})

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

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

Time
↓



Easterly anomalies persisted near 80E for much of September to October (red box).

Westward propagation (dashed/solid lines sloping down and to the left) during much of November and early December are primarily due to equatorial Rossby wave activity as the MJO was generally weak throughout much of this period.

During late December the MJO strengthened (alternating dotted/dashed lines). The MJO has remained active through February, although the signal was less clear at times due to interference from other modes, such as westward propagating equatorial Rossby waves.

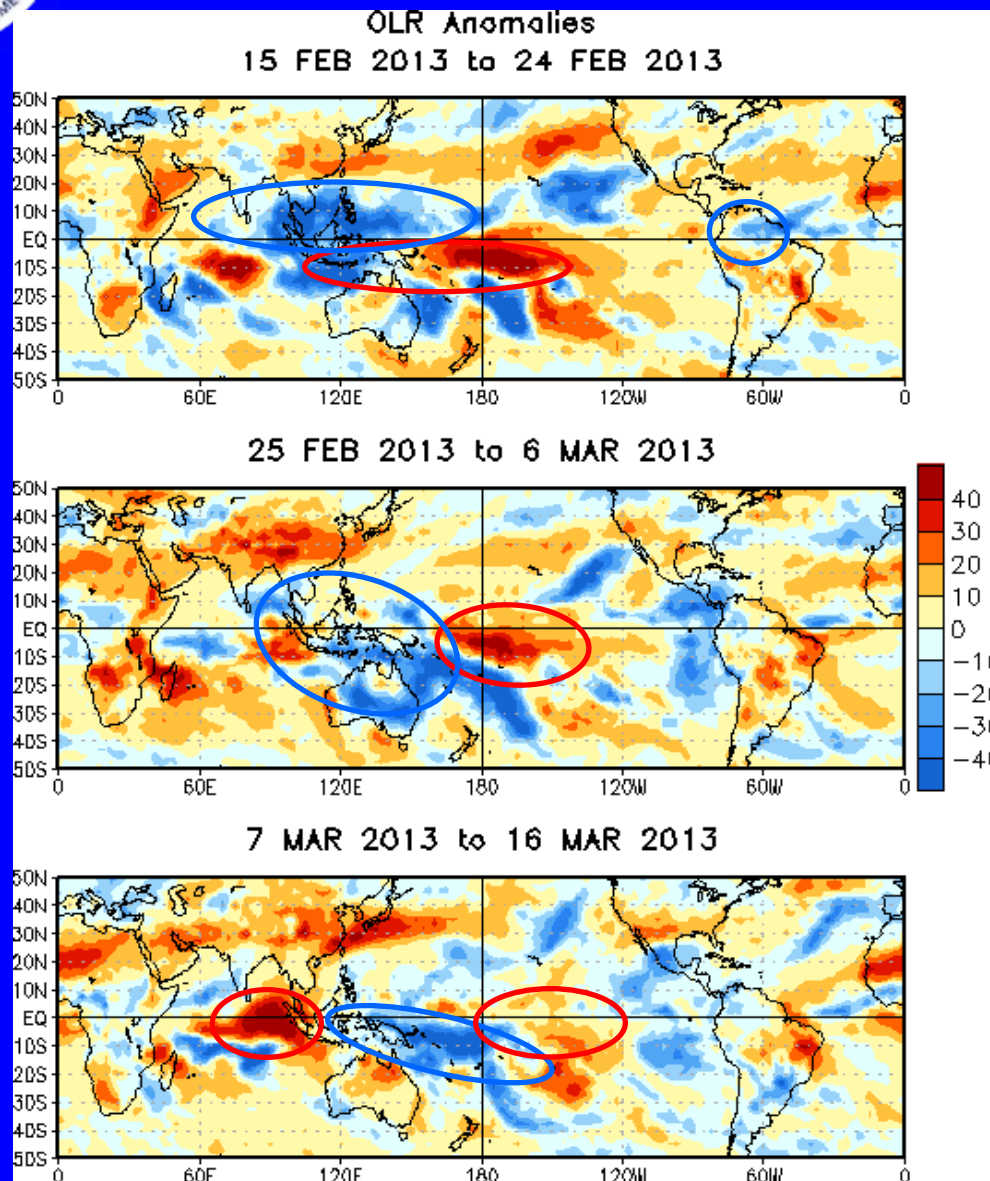
Recently, the wind anomalies have become more stationary.

Longitude



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 from the Indian Ocean to the western North Pacific (Maritime Continent to southwest Pacific). The elongated nature of the anomalies indicates other modes of variability played a significant role during this time.

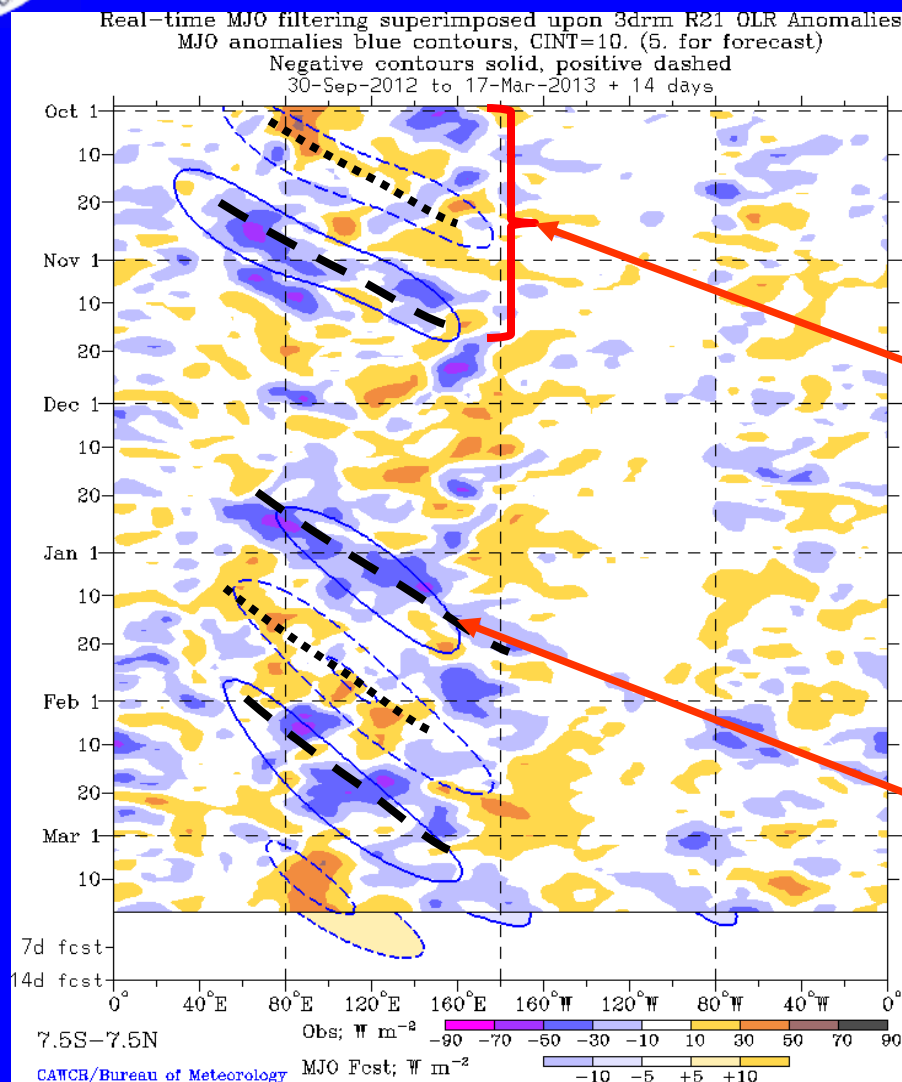
Suppressed convection shifted east and intensified near the Date Line. Enhanced convection expanded meridionally across the Maritime Continent, and over the southwest Pacific.

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).



Outgoing Longwave Radiation (OLR)

Anomalies (7.5°S-7.5°N)



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.

Enhanced convection developed across the Indian Ocean in late December and shifted eastward into January 2013. Suppressed convection followed in the Indian Ocean during January.

Most recently, enhanced convection is slowly propagating across the southwest Pacific, while suppressed convection is intensifying over the Indian Ocean.

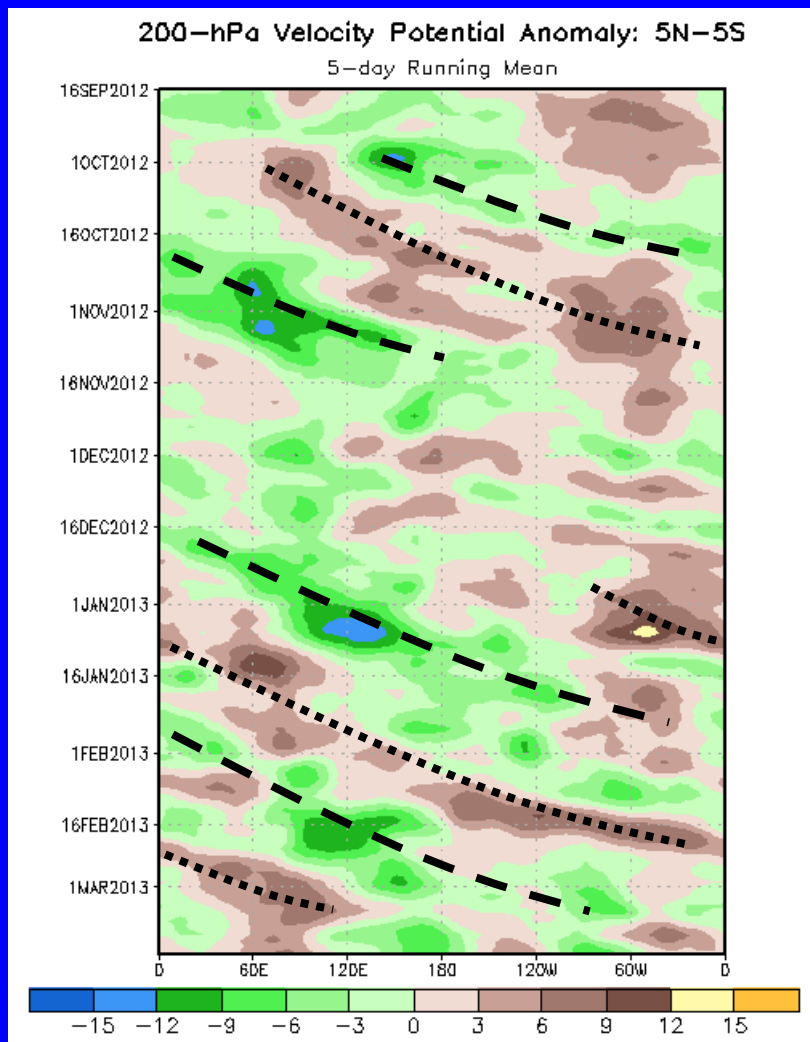


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time



In mid-September, anomalies were small with little eastward propagation as the MJO was weak.

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.

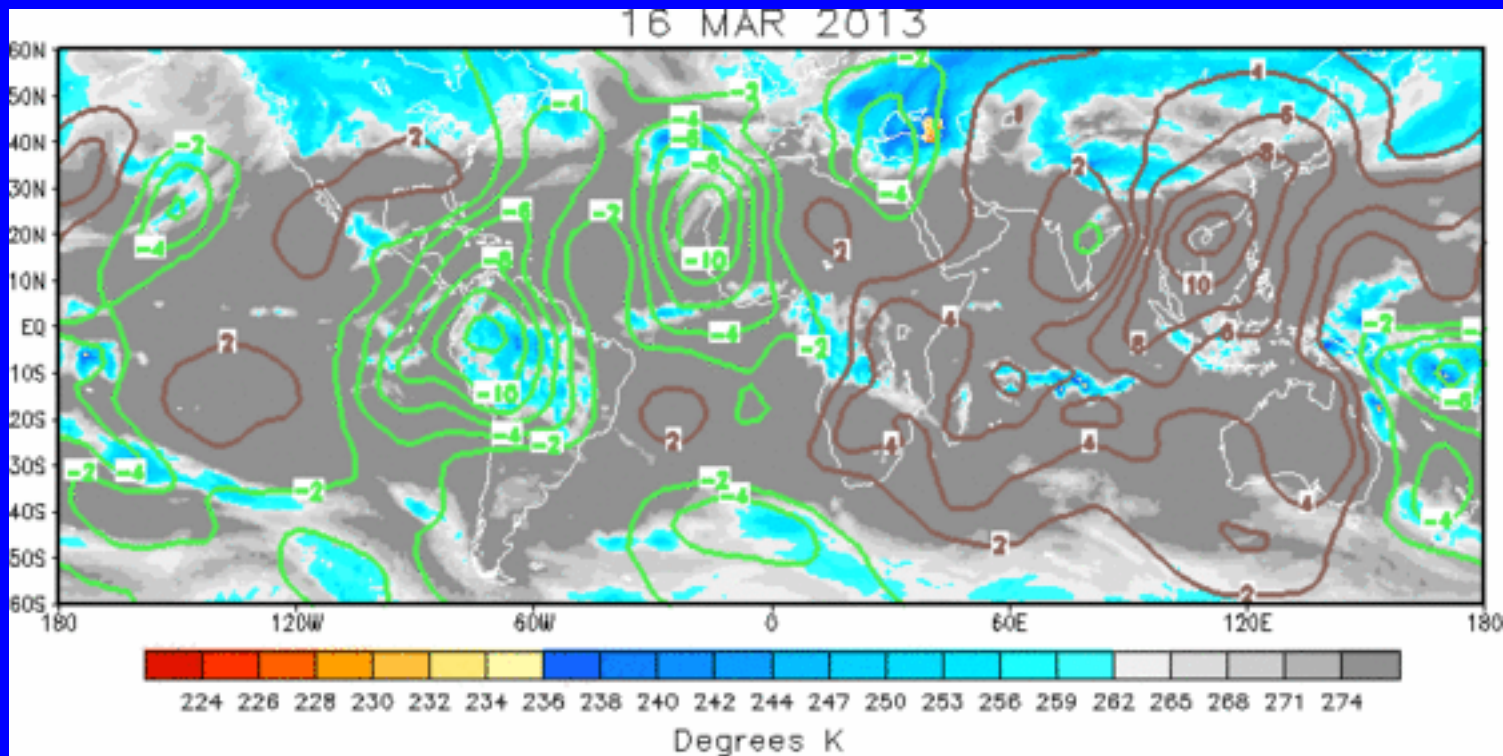
Recently, the anomalies indicate a stagnation of the signal over the Indian Ocean.



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 far eastern Maritime Continent and across South America. The strongest upper-level convergence is centered across the eastern Indian Ocean and Southeast Asia. Generally, divergence is indicated from the Date Line to the Prime Meridian, with convergence east of the Prime Meridian.

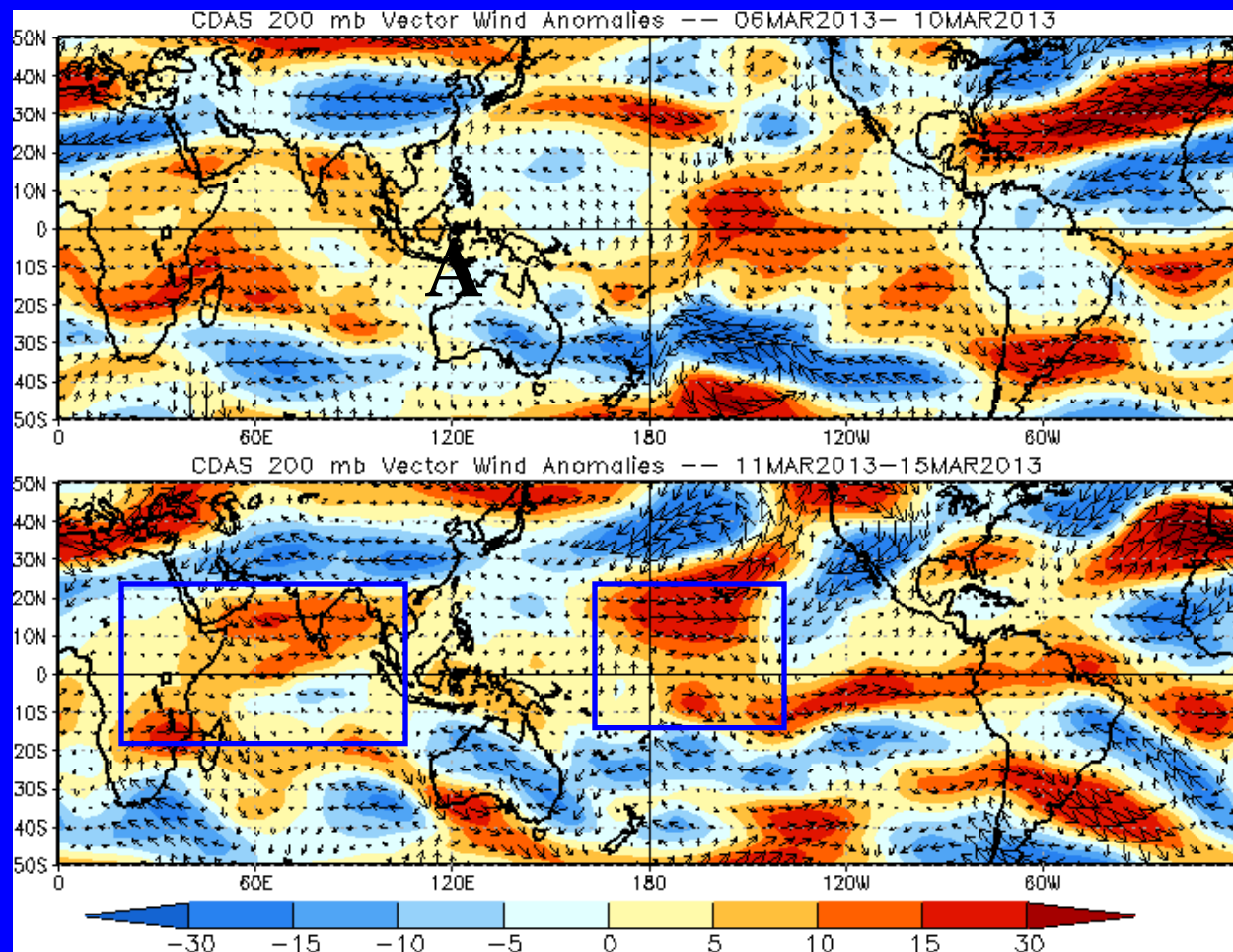


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



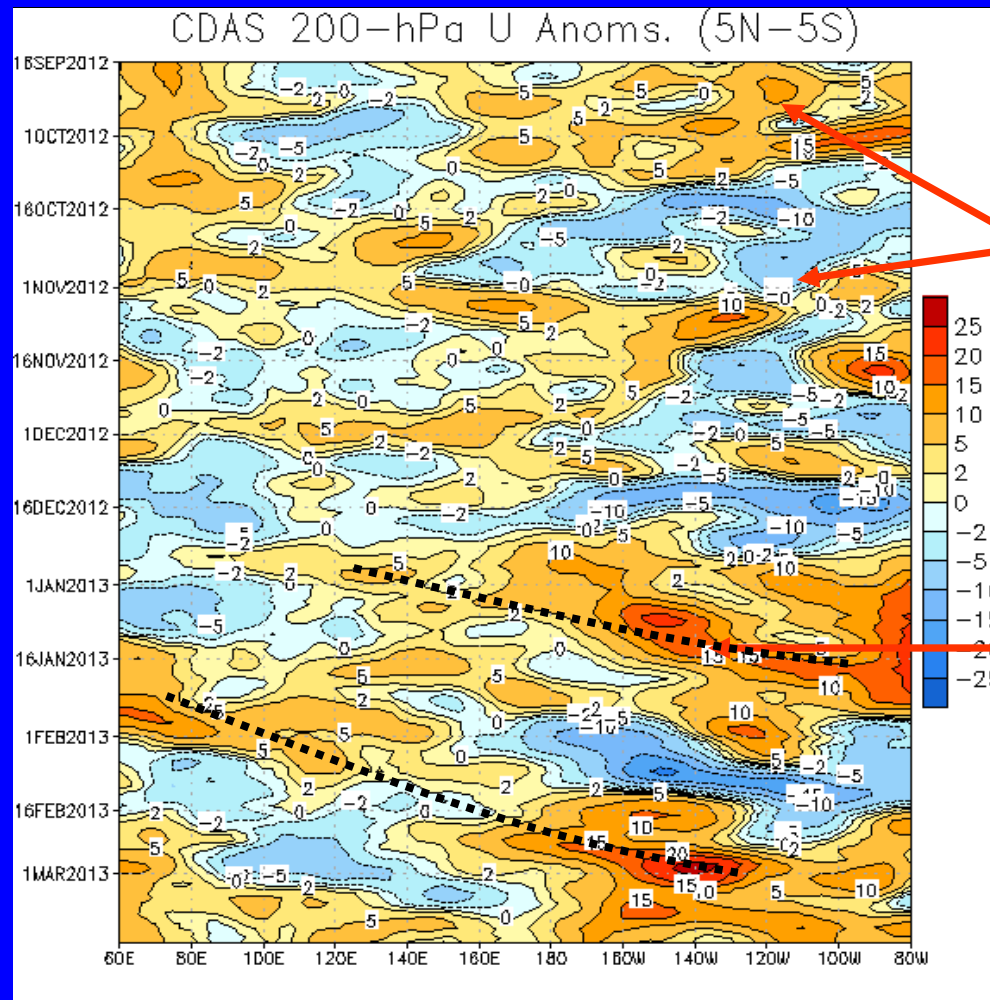
Westerly anomalies (blue boxes) remain across the central equatorial Pacific during the last five days and have continued over the western Indian Ocean and Africa.



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



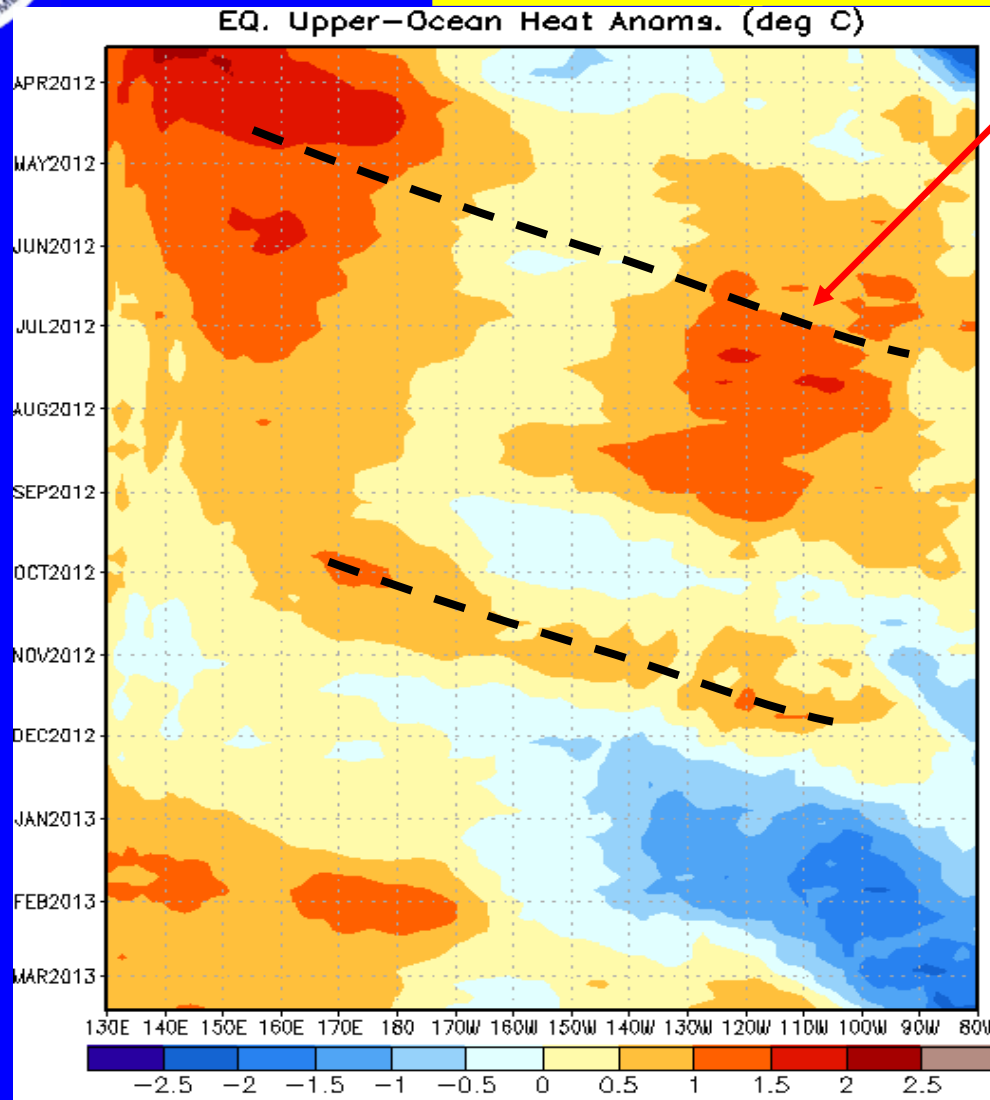
Westerly anomalies prevailed across the eastern Pacific and Americas for much of September and October, but were replaced by easterly anomalies during mid-October.

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

Most recently, propagation has slowed.



Weekly Heat Content Evolution in the Equatorial Pacific



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.

Positive anomalies decreased across the eastern Pacific during late August and September.

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 have 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.

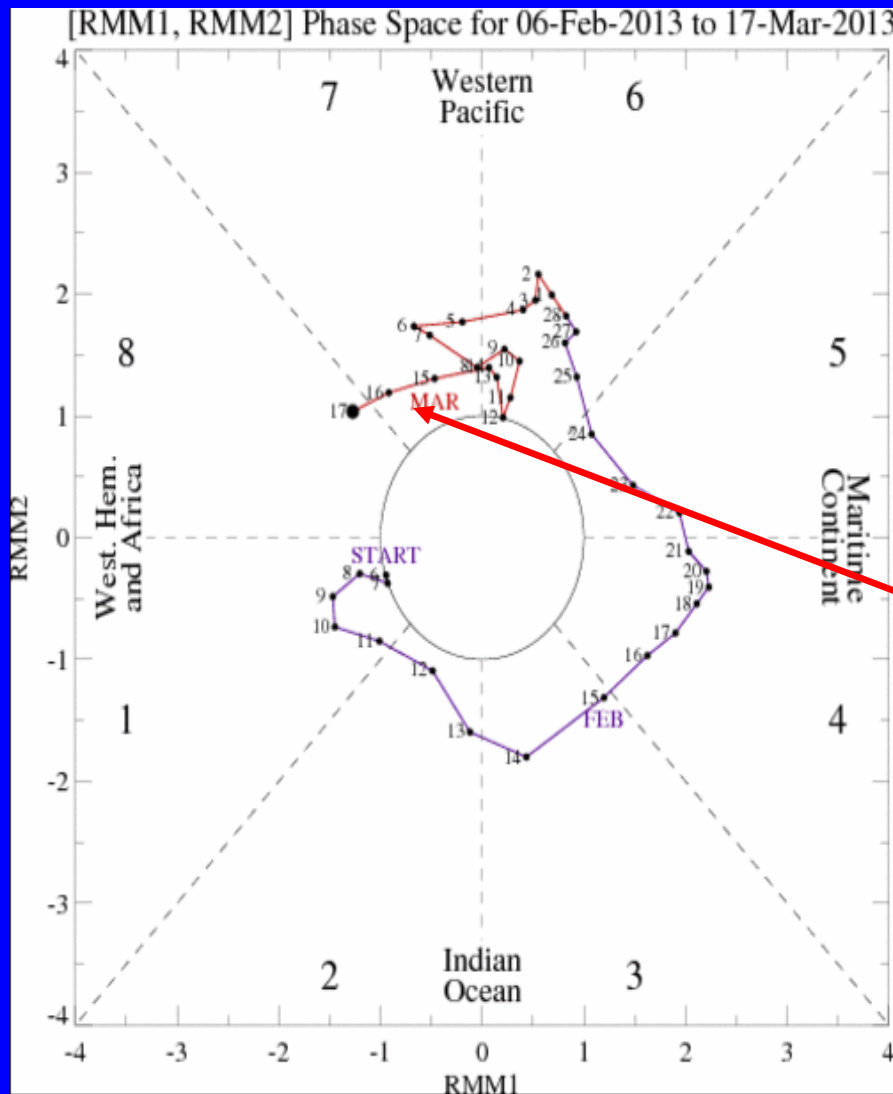
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

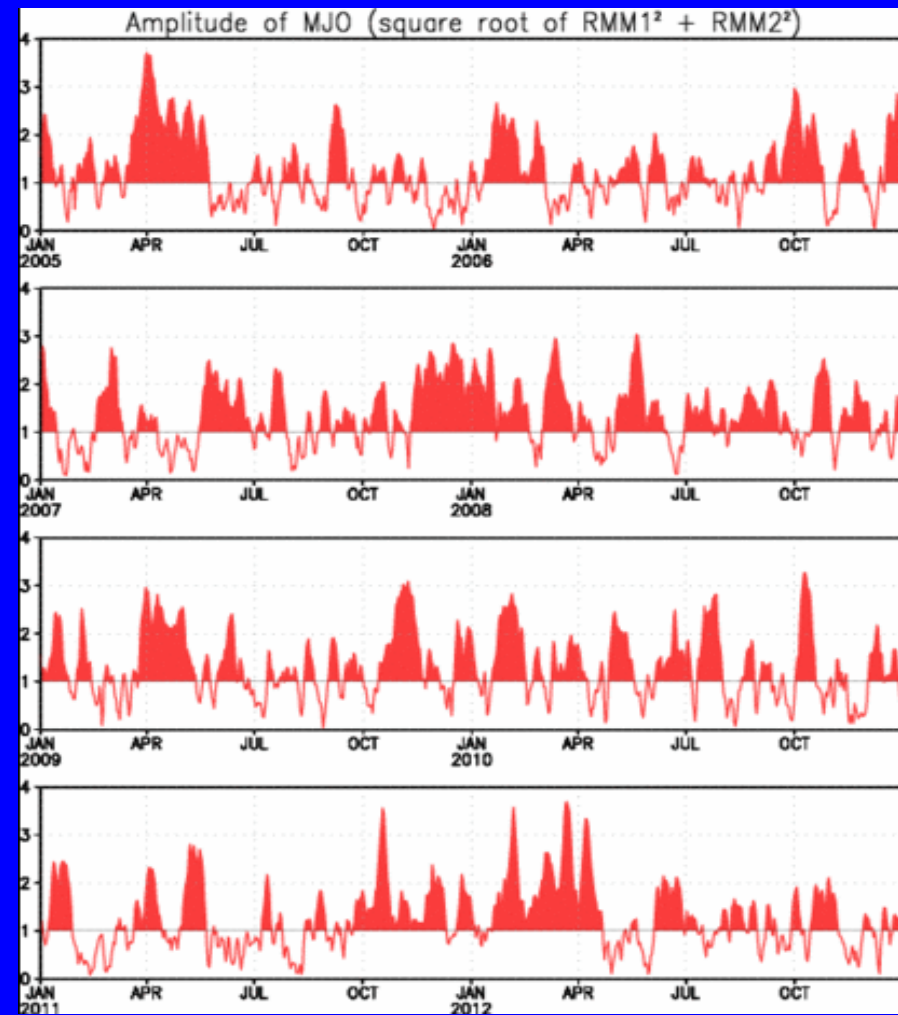
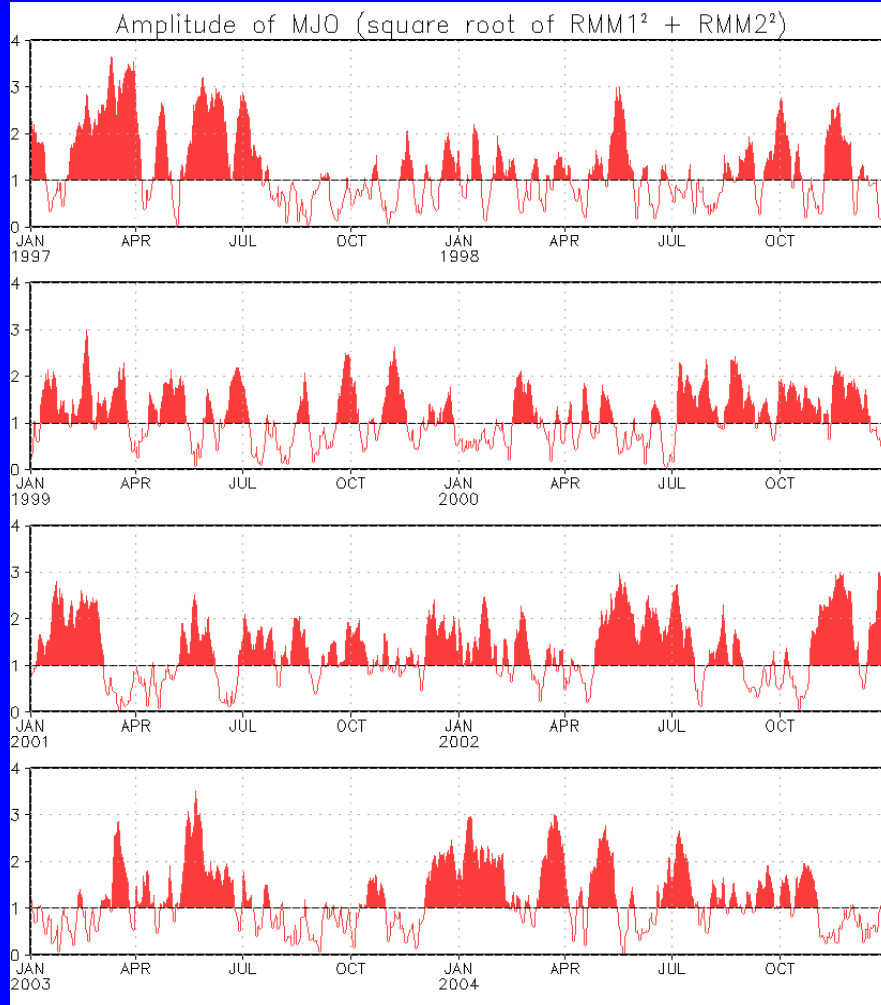


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the 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 the central Pacific.



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

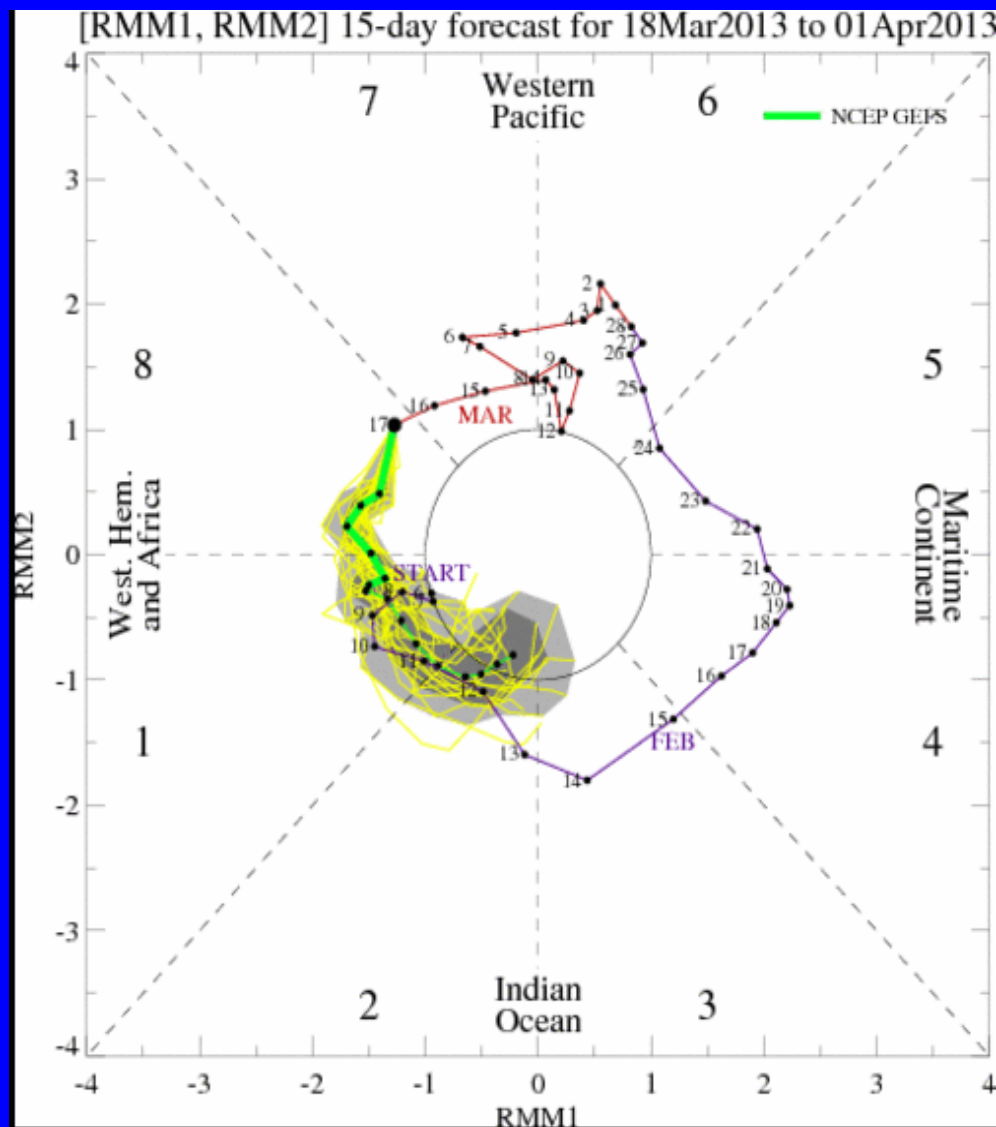
Green Line – Ensemble Mean

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 propagation of the signal across the Pacific to the Americas during Week-1, and to Africa by Week-2.

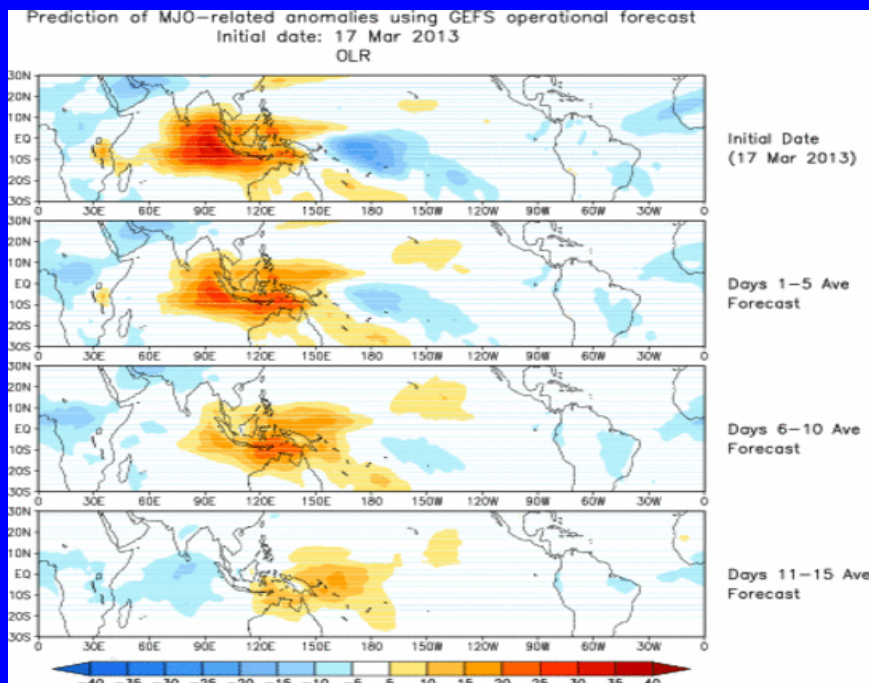




Ensemble Mean GFS MJO Forecast

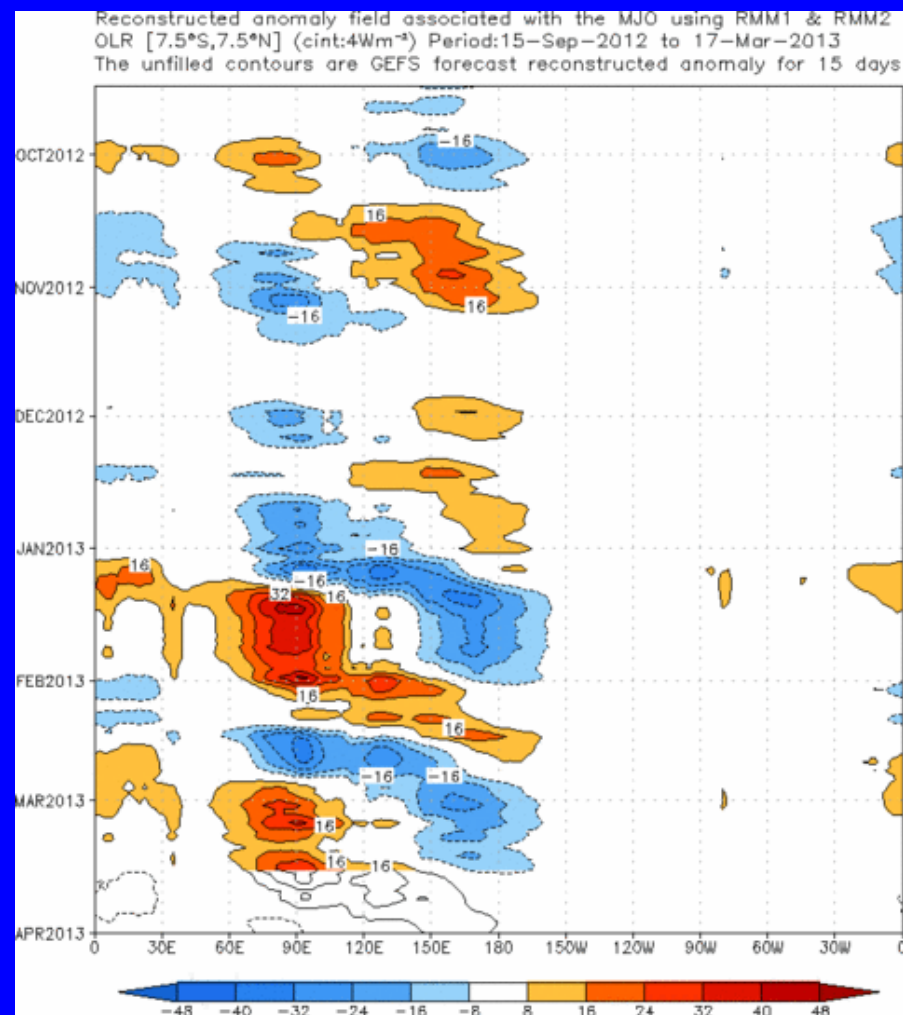
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecasts enhanced convection to persist across the central Pacific, before moving to the Americas and Africa. Suppressed convection is indicated across the Indian Ocean and the Maritime Continent.

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

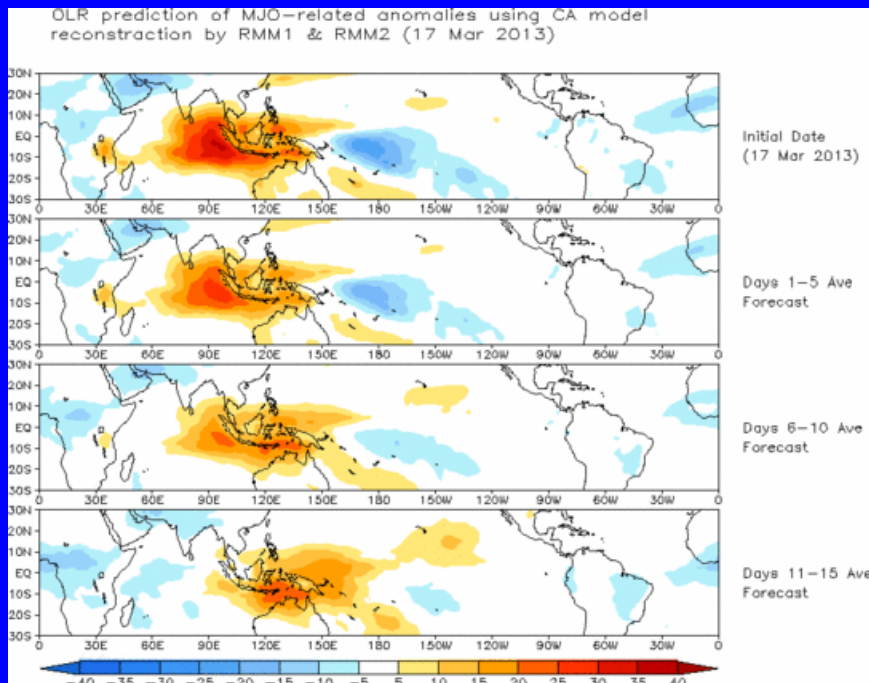




Constructed Analog (CA) MJO Forecast

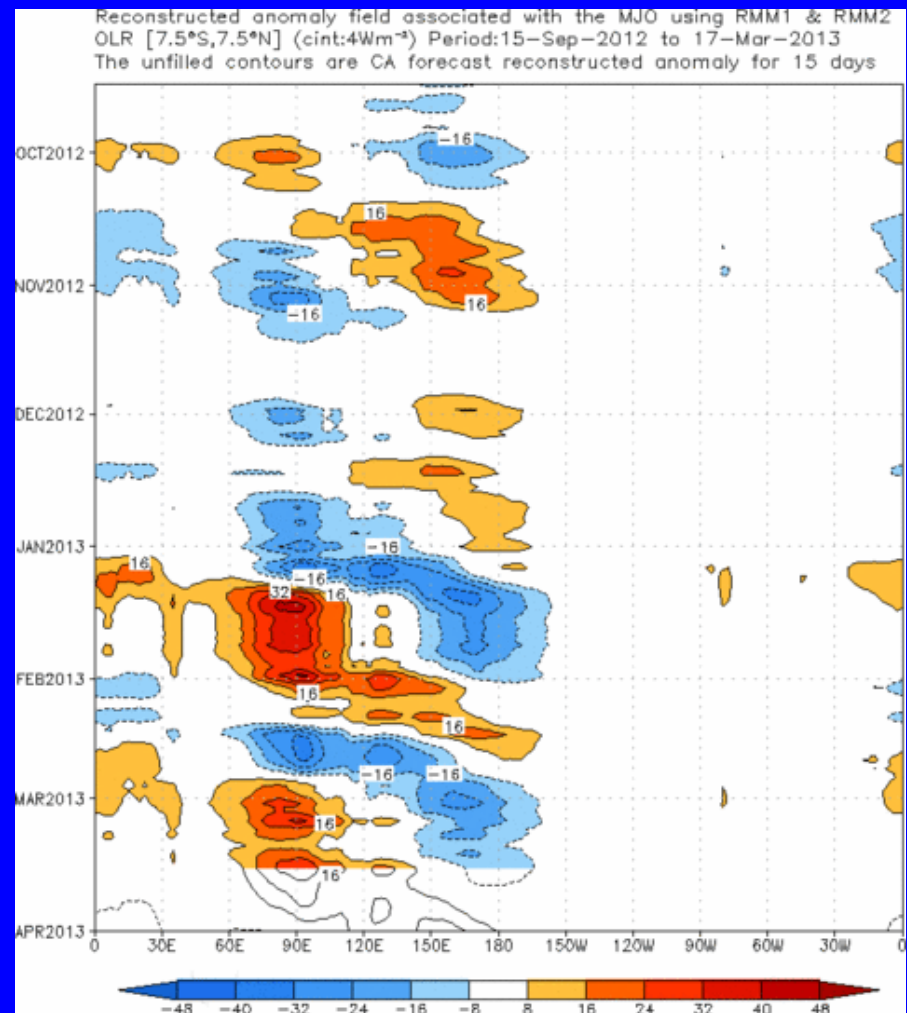
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



This forecast shows more clear eastward progression with enhanced convection shifting across the Pacific to South America and Africa. Suppressed convection is forecast to shift eastward across the Maritime Continent and into the western Pacific during Week-2.

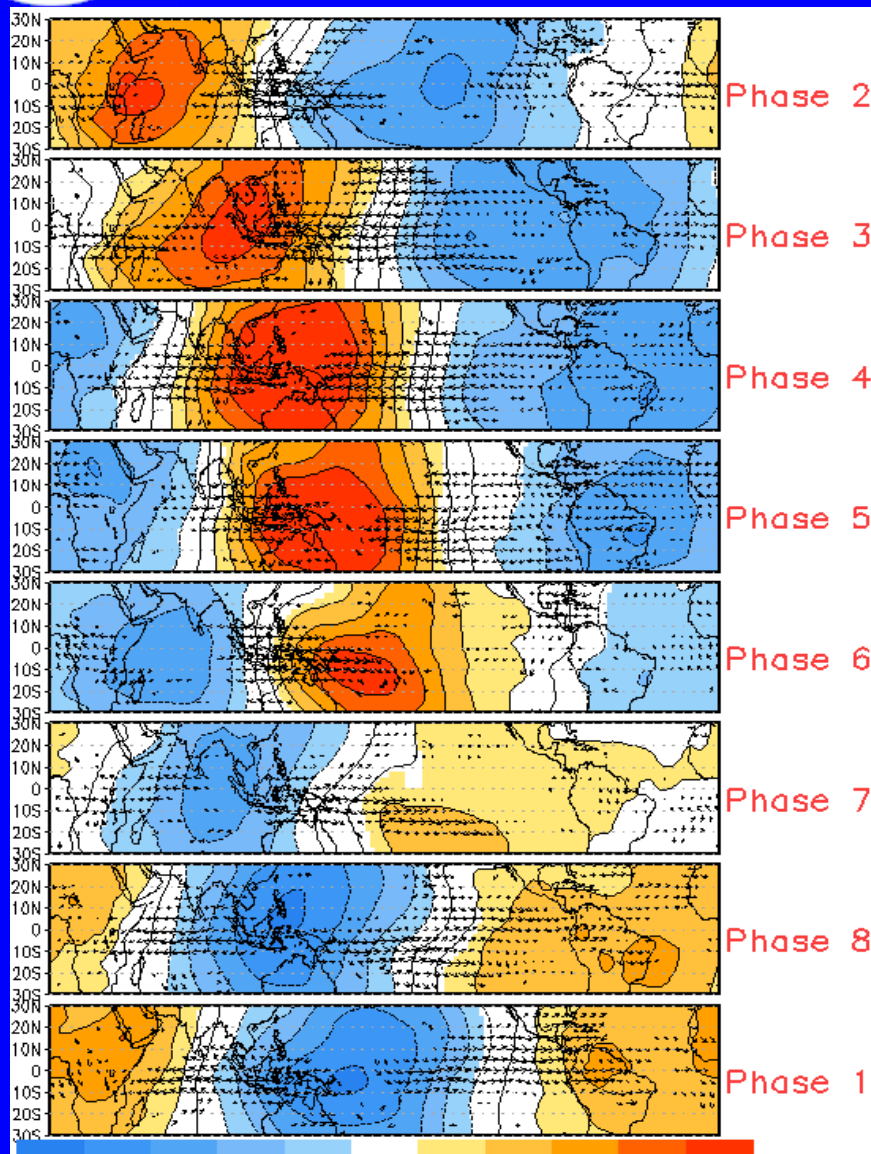
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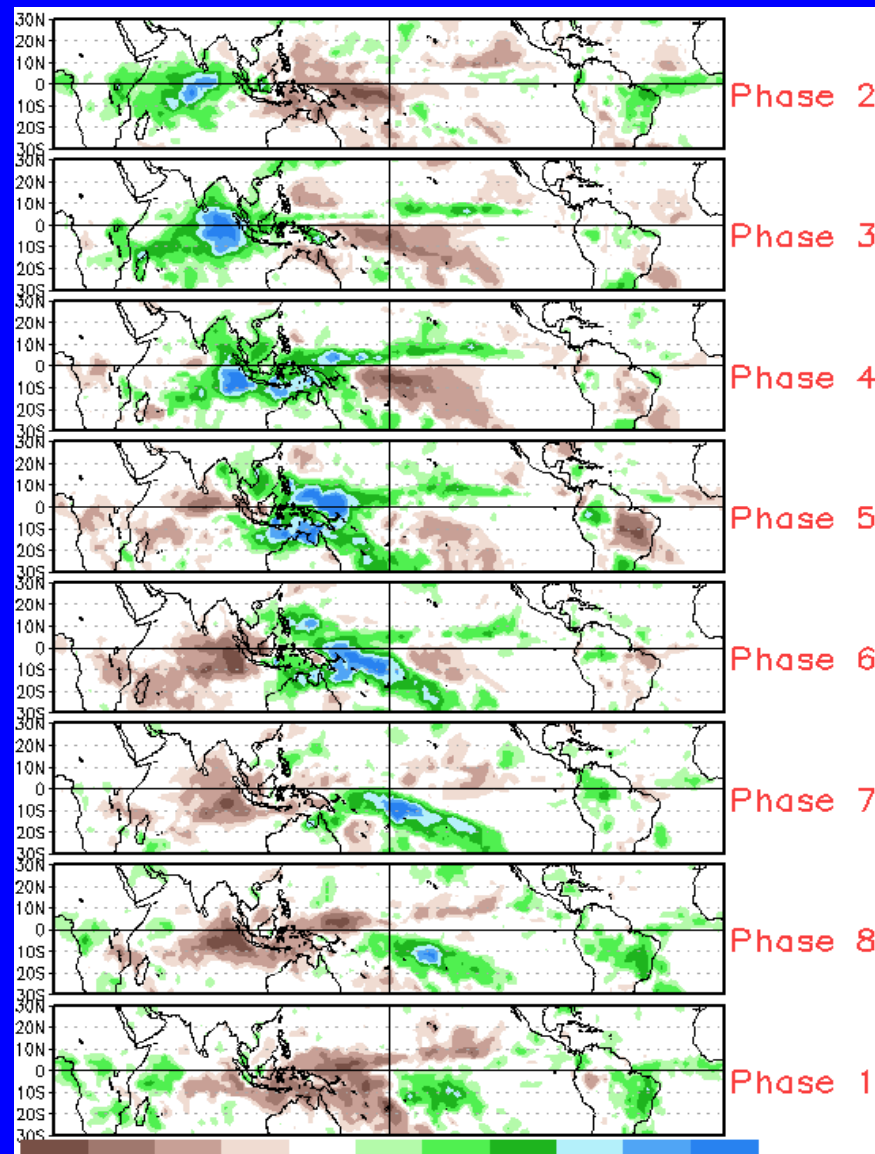


MJO Composites – Global Tropics

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



Precipitation Anomalies (Nov-Mar)

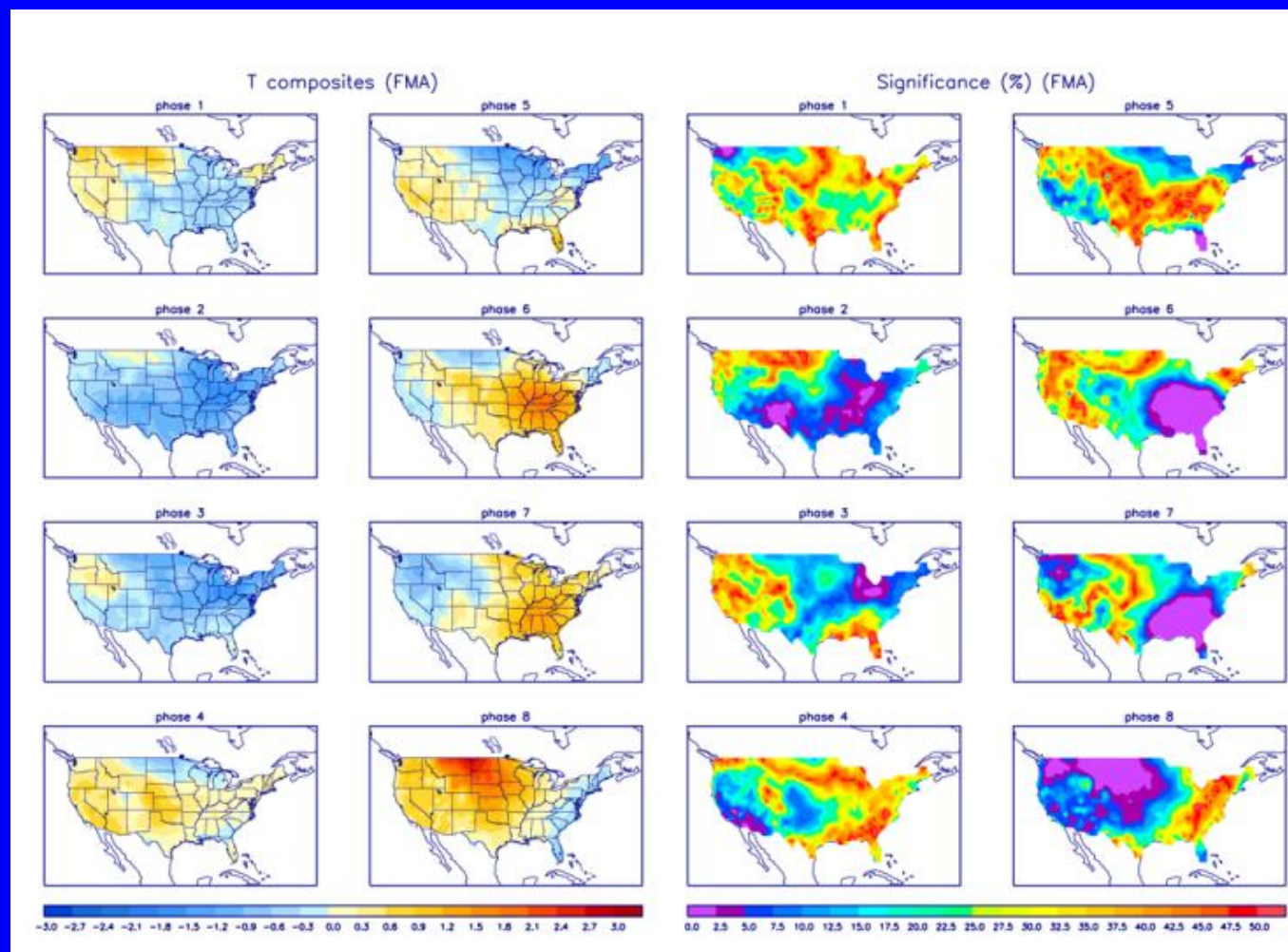




U.S. MJO Composites – Temperature

- 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.



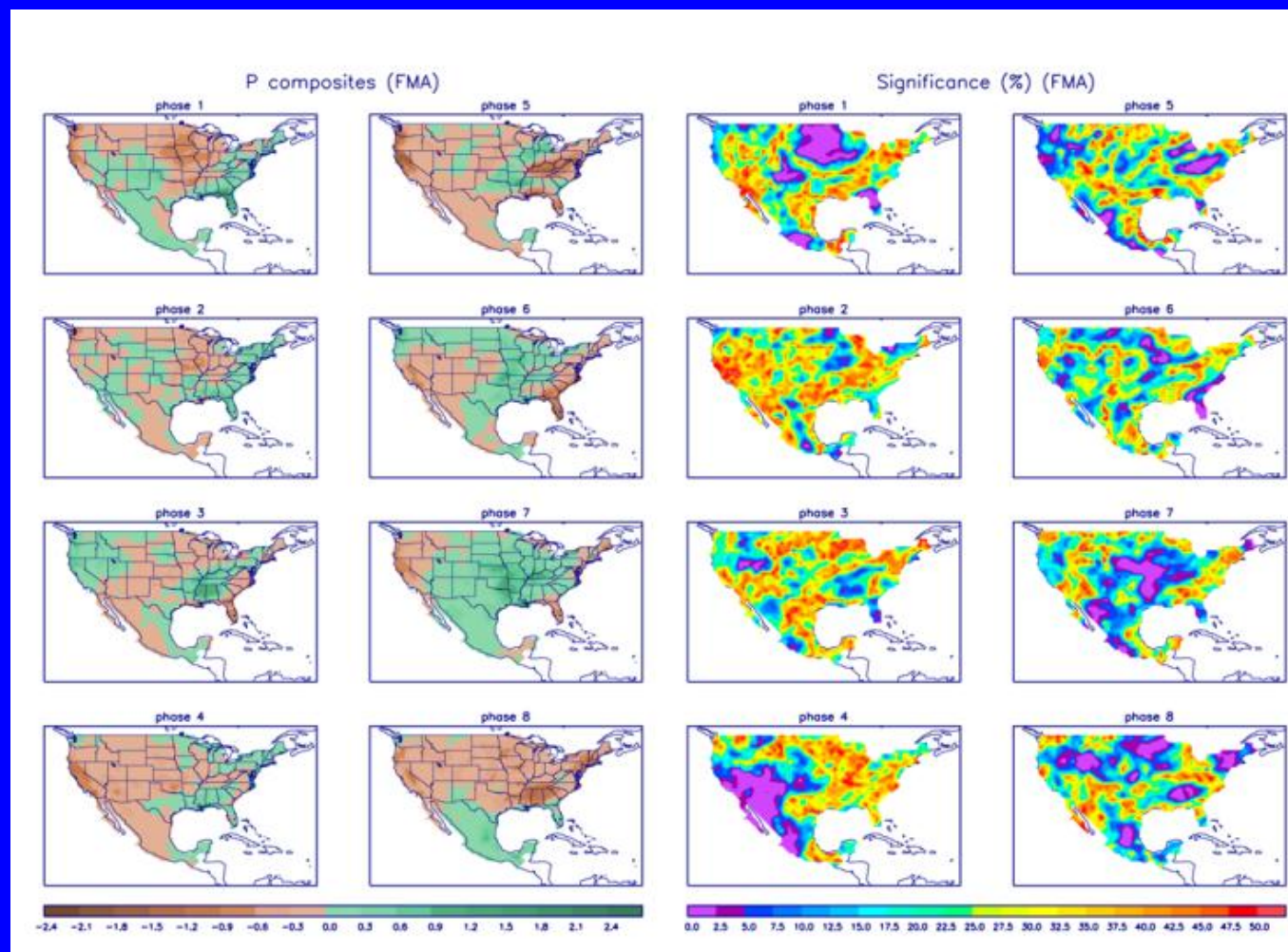
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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.



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

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