



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

**Update prepared by  
Climate Prediction Center / NCEP  
March 11, 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 western Pacific.**
- **Dynamical model MJO index forecasts generally support resumed eastward propagation after a brief pause due to interference from other subseasonal variability. The statistical tools also support continued MJO activity.**
- **Based on recent observations and consideration of both empirical and dynamical model MJO forecasts, the MJO is forecast to remain active during the next two weeks with eastward propagation of the enhanced phase into the Western Hemisphere by the end of Week-2.**
- **The MJO favors enhanced rainfall across the western and central Pacific (south of the Equator) with odds of suppressed rainfall elevated across the eastern Indian Ocean and Maritime Continent. The chances for tropical cyclogenesis remain elevated for the waters near northeast 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 has already contributed to an extension of the East Asian jet stream and is thus in phase with the current and predicted negative annular mode.**

**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>**

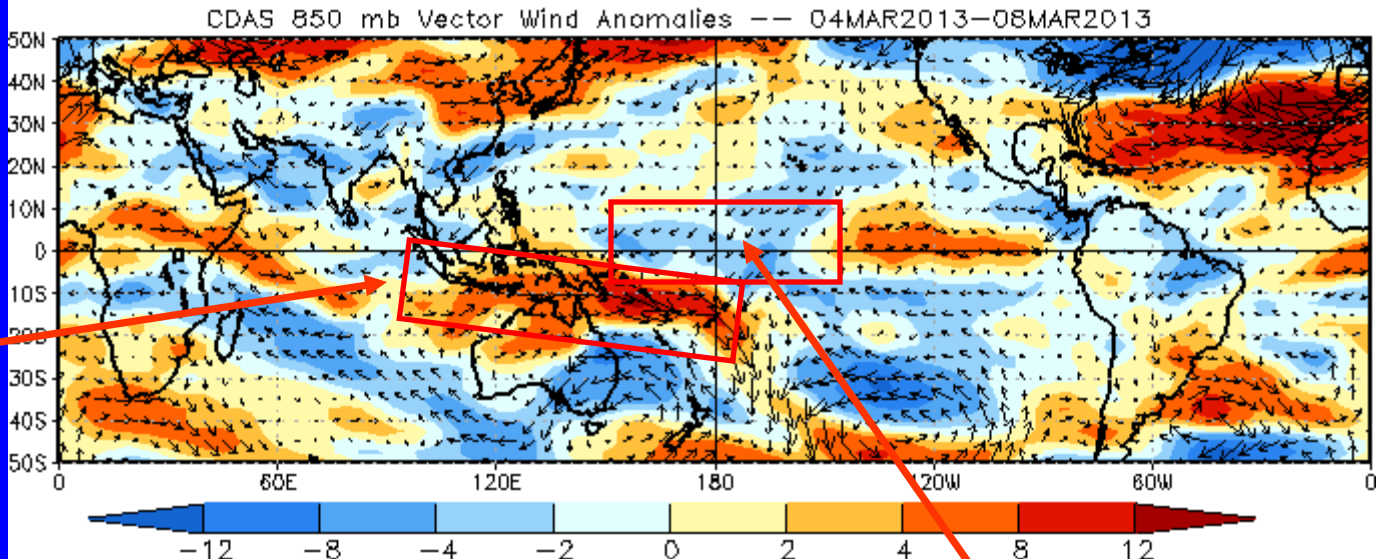
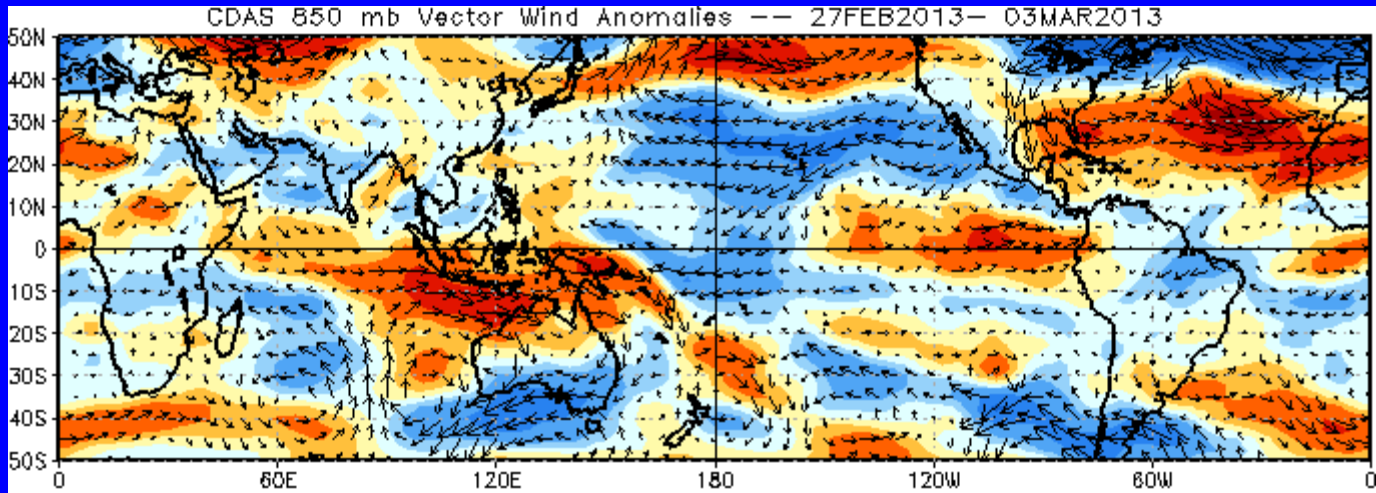


# 850-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



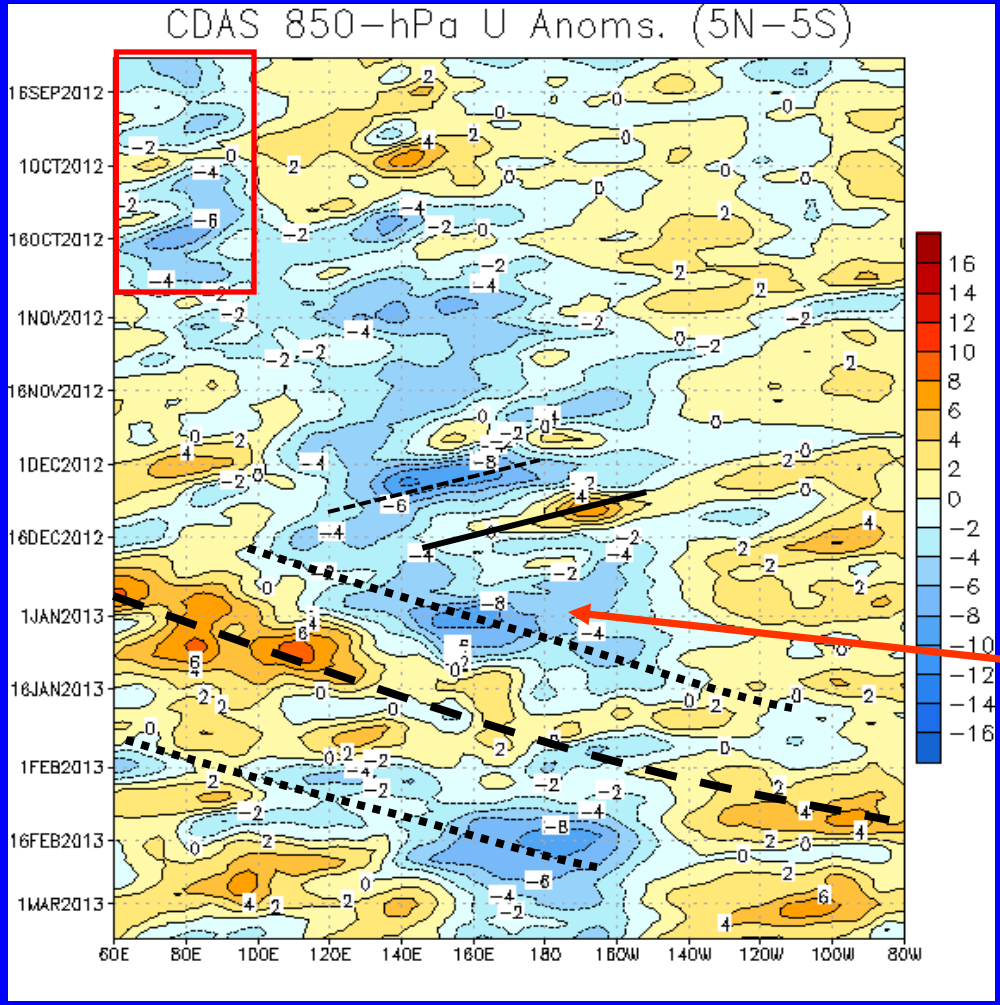
Westerly anomalies extended eastward across the Maritime Continent into the southwestern Pacific.

Easterly anomalies weakened and decreased in areal coverage over the western Pacific during the past five days.



# 850-hPa Zonal Wind Anomalies ( $\text{m s}^{-1}$ )

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



Time  
↓

Longitude

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

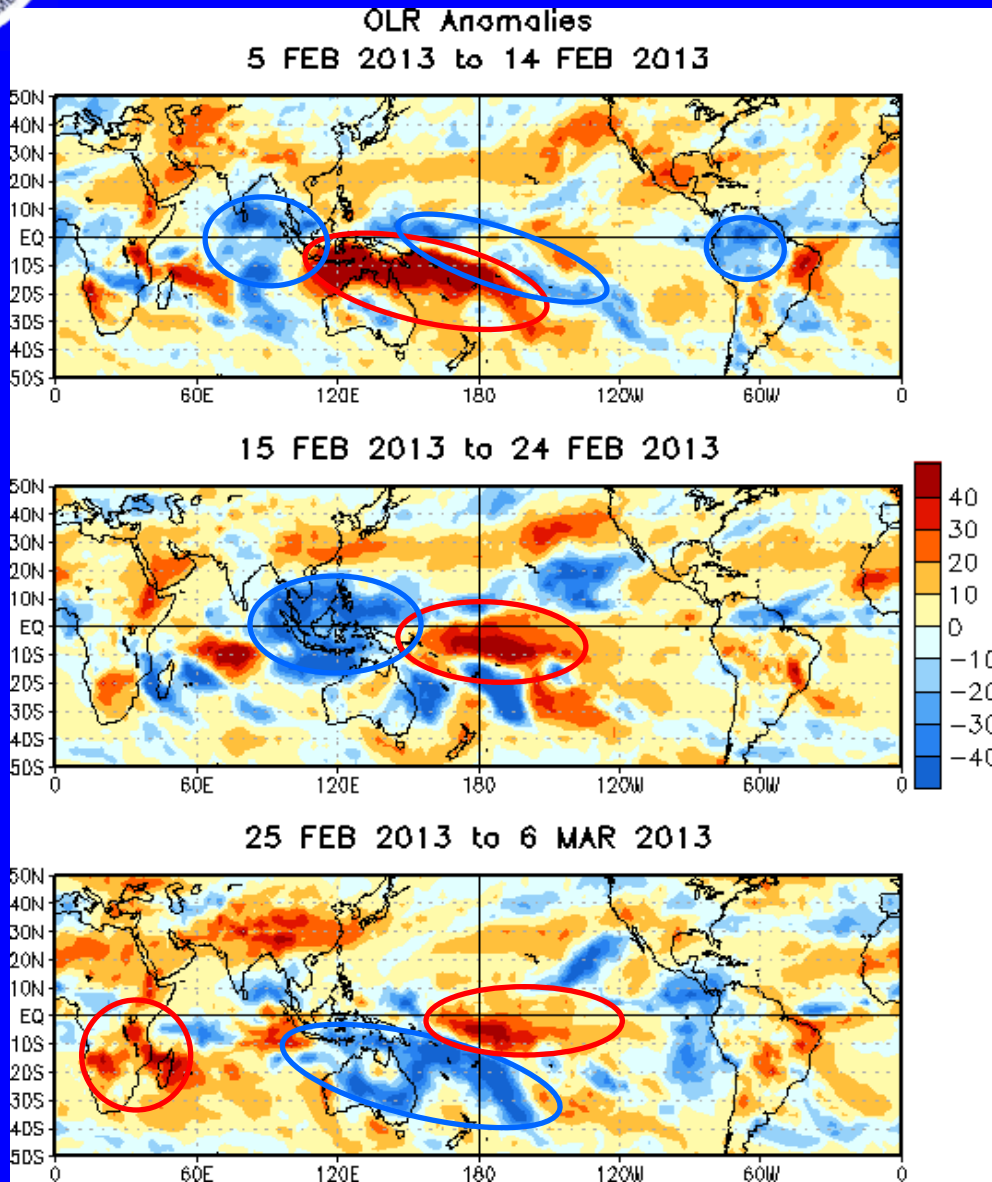
Westward propagation (dashed/solid lines sloping down and to the left) during much of November and early December are primarily due to equatorial Rossby wave activity as the MJO was generally weak throughout much of this period.

During late December the MJO strengthened as indicated by an increase in magnitude of anomalies along with eastward propagation (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.



# 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 convection lingered over the western and central Pacific while suppressed convection shifted slowly east across the Maritime Continent into the southwestern Pacific. Enhanced convection was noted over northern South America and the eastern Indian Ocean; the latter was likely initiated by modes other than MJO.

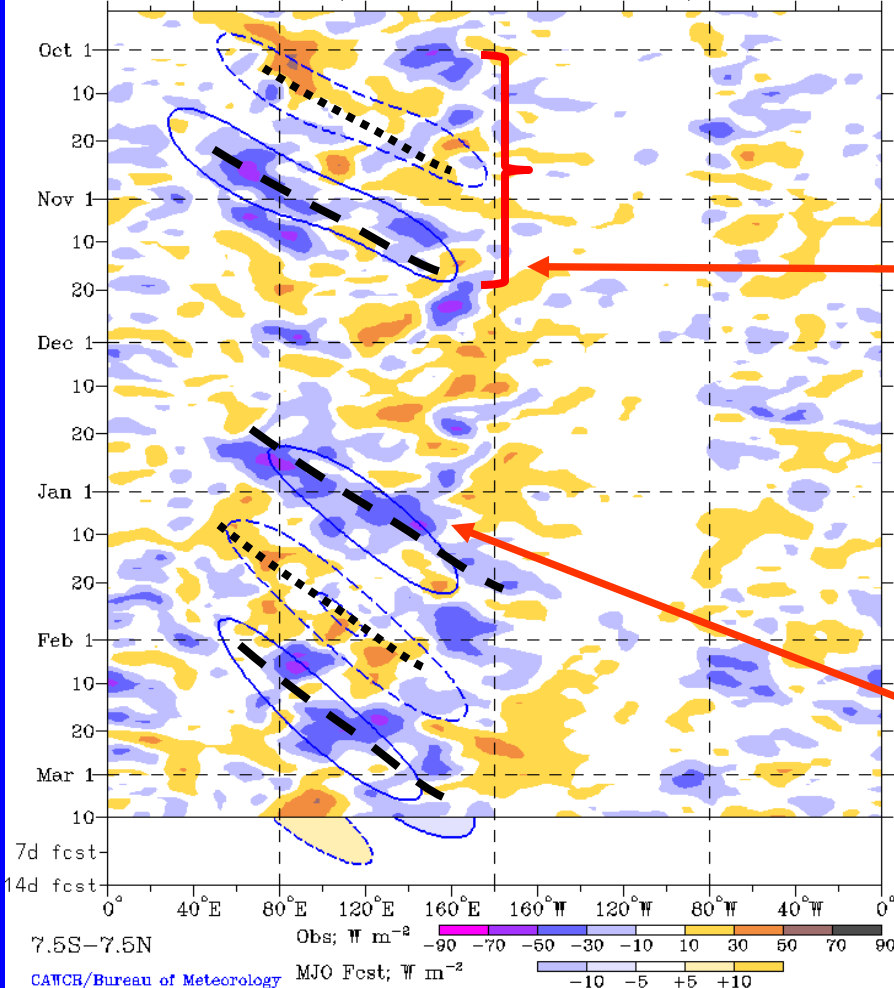
Suppressed convection shifted east in the Pacific during late February, mostly south of the Equator. Enhanced convection likewise shifted east across the Maritime Continent as the MJO became more organized.

By late February and early March, enhanced convection shifted into the southwestern Pacific, with suppressed convection to the east and west, near the Date Line and eastern Africa, respectively.



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

Real-time MJO filtering superimposed upon 3drmm R21 OLR Anomalies  
MJO anomalies blue contours, CINT=10. (5. for forecast)  
Negative contours solid, positive dashed  
23-Sep-2012 to 10-Mar-2013 + 14 days



**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 as the MJO strengthened.

Suppressed convection followed in the Indian Ocean during January and most recently during late February while strong enhanced convection redeveloped across the eastern Indian ocean and the Maritime continent, slowly shifting into the western Pacific during early March.

**Longitude**

**Time**



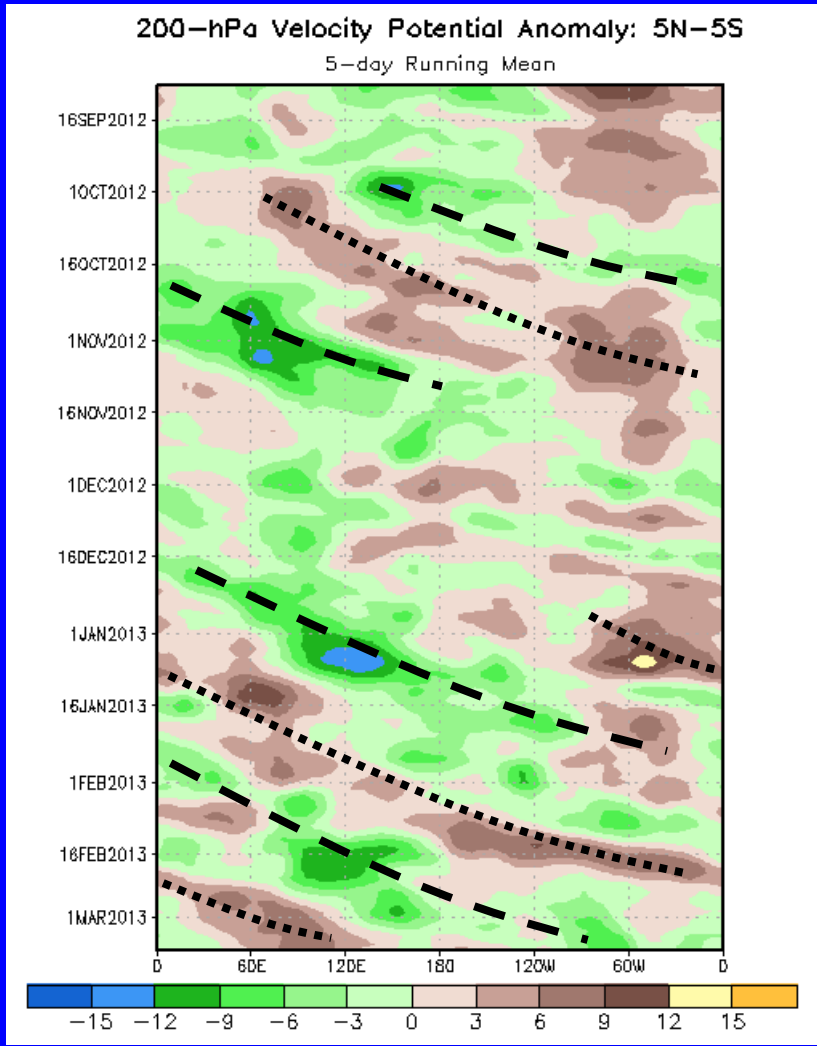


# 200-hPa Velocity Potential Anomalies (5°S-5°N)

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 December, anomalies were weak with less coherent eastward propagation. Other subseasonal variability was 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.

Longitude

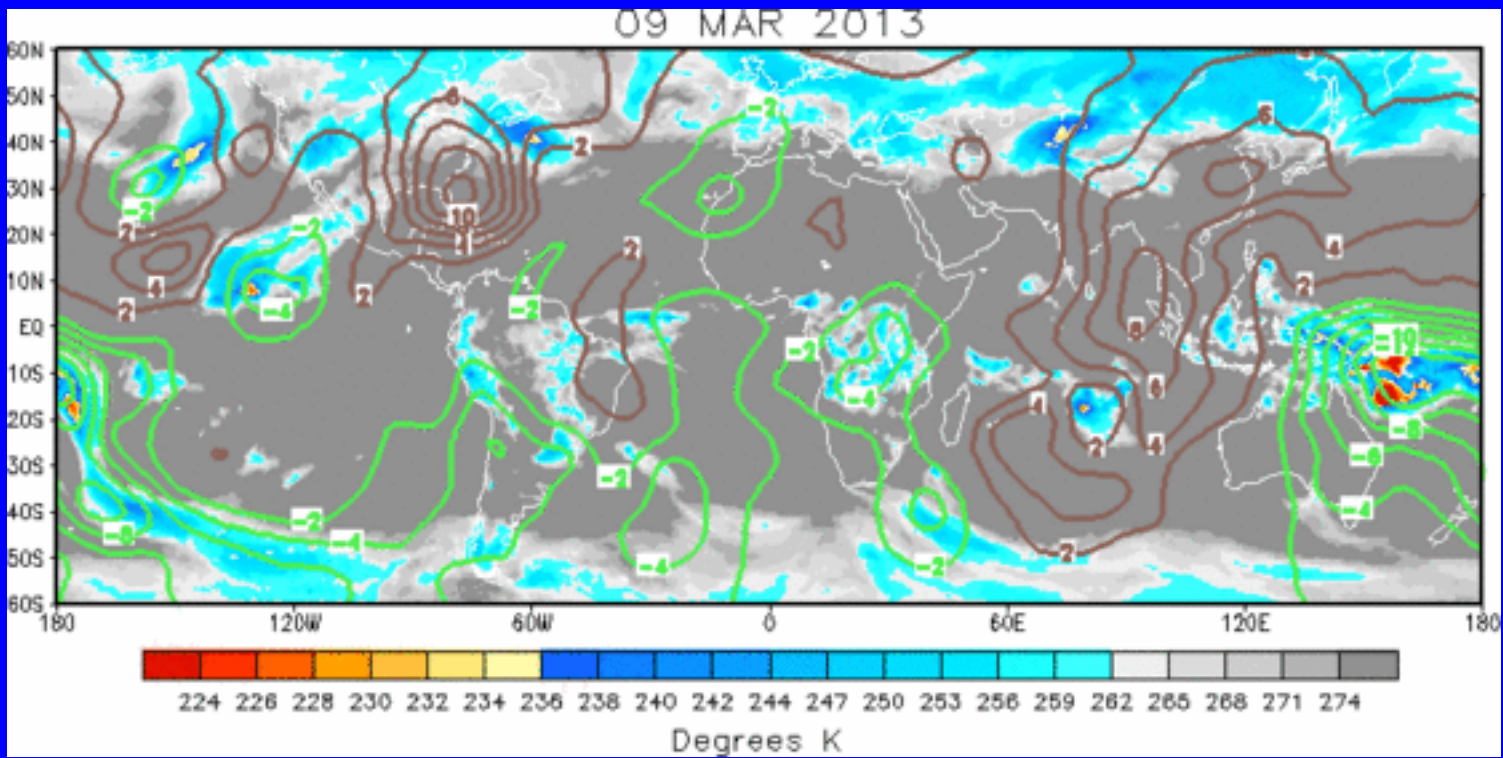




# IR Temperatures (K) / 200-hPa Velocity Potential Anomalies

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 extending into the western and central Pacific, south of the Equator. The strongest upper-level convergence is centered across the eastern Indian Ocean.

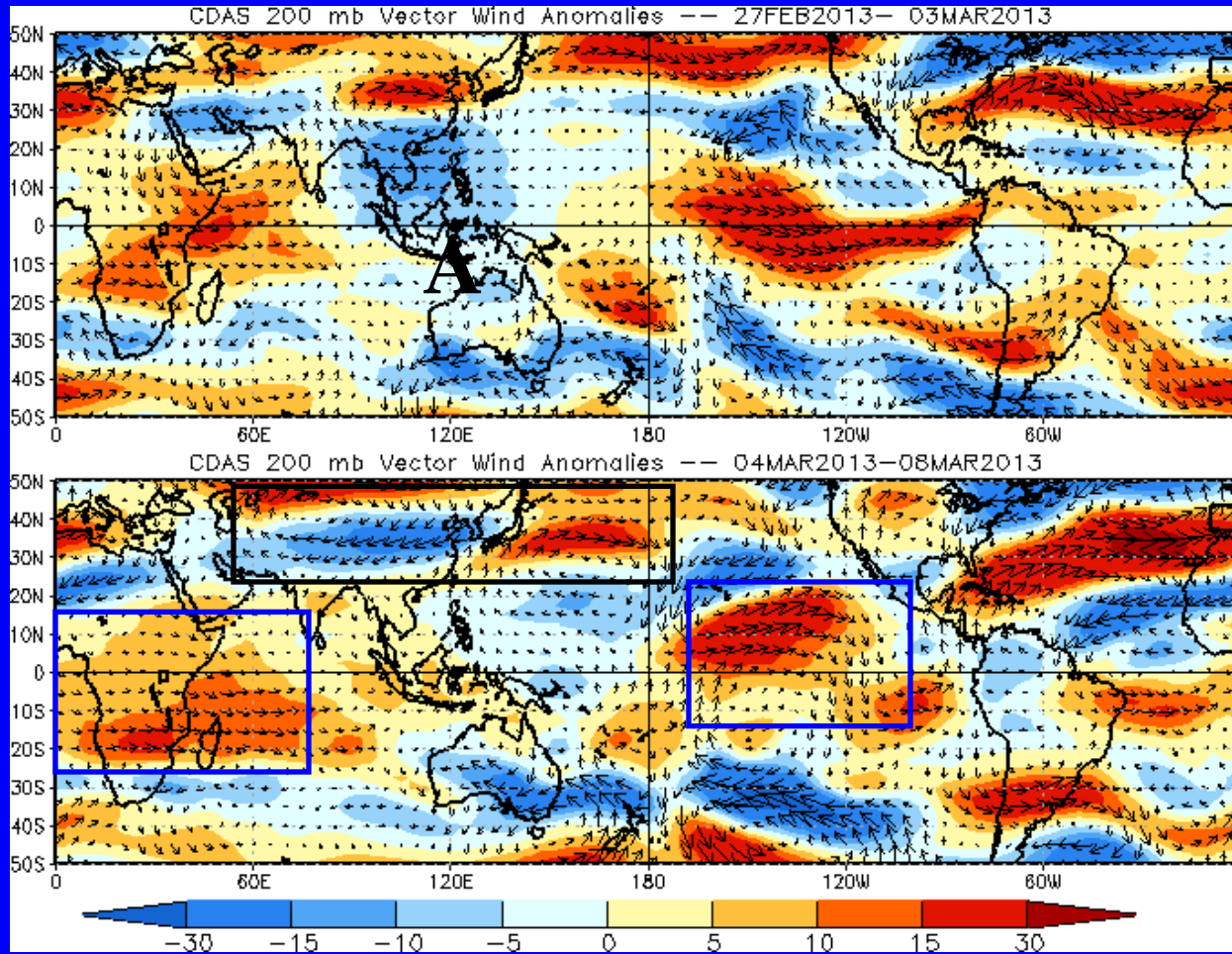


# 200-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



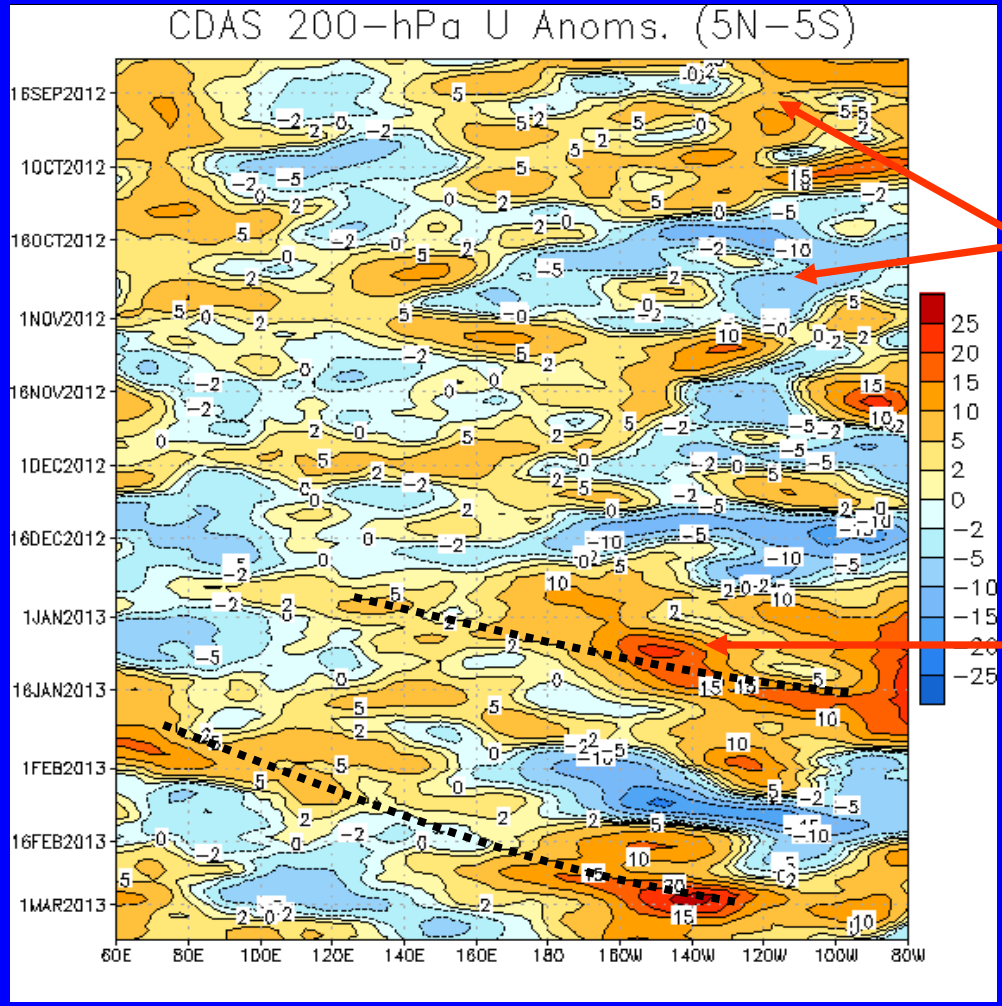
Westerly anomalies (blue boxes) remain across the central equatorial Pacific during the last five days and have continued over the western Indian Ocean and Africa.

The black box highlights an east-west couplet of zonal wind anomalies that indicates a jet extension consistent with recent MJO activity.



# 200-hPa Zonal Wind Anomalies ( $\text{m s}^{-1}$ )

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



Time  
↓

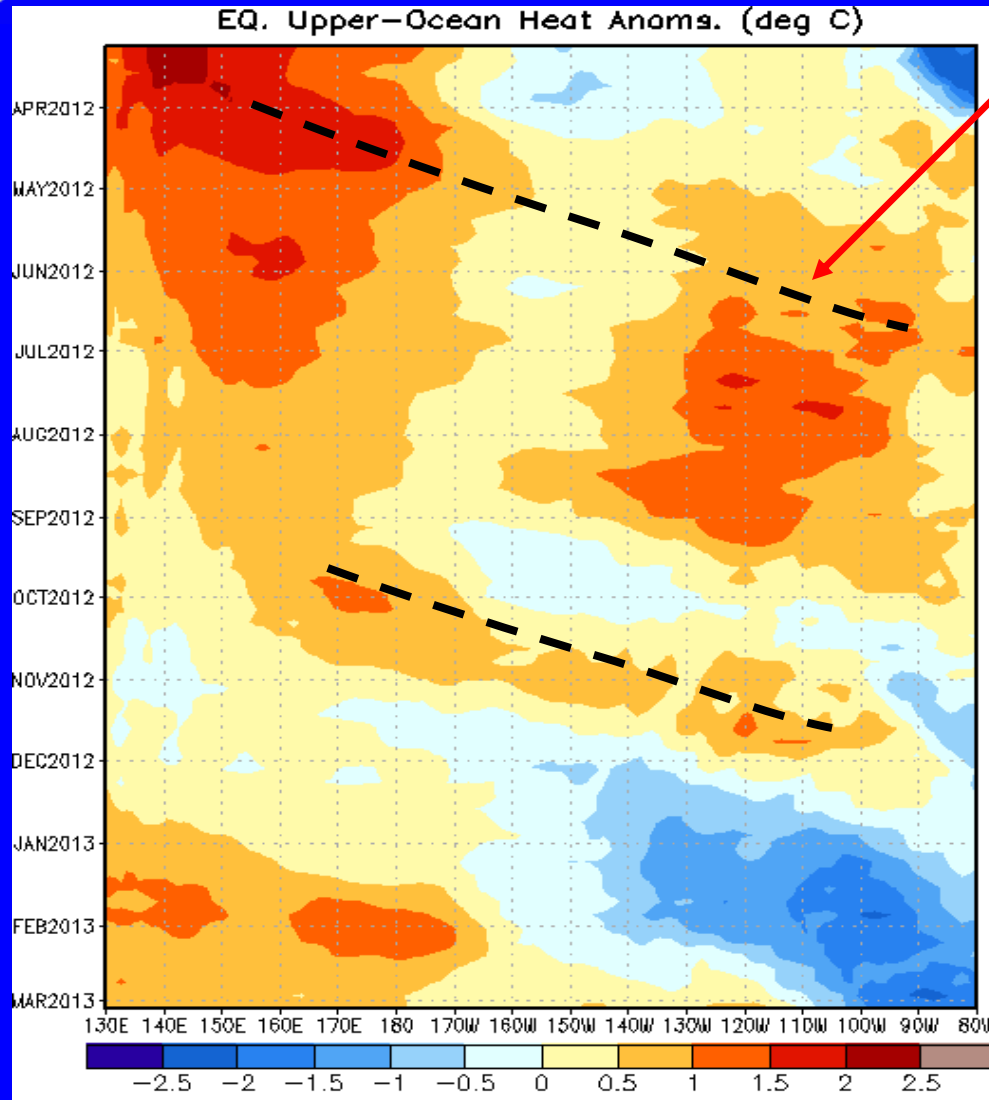
Longitude

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 February 2013. Some propagation of easterly anomalies is suggested of late as well.



# 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.**

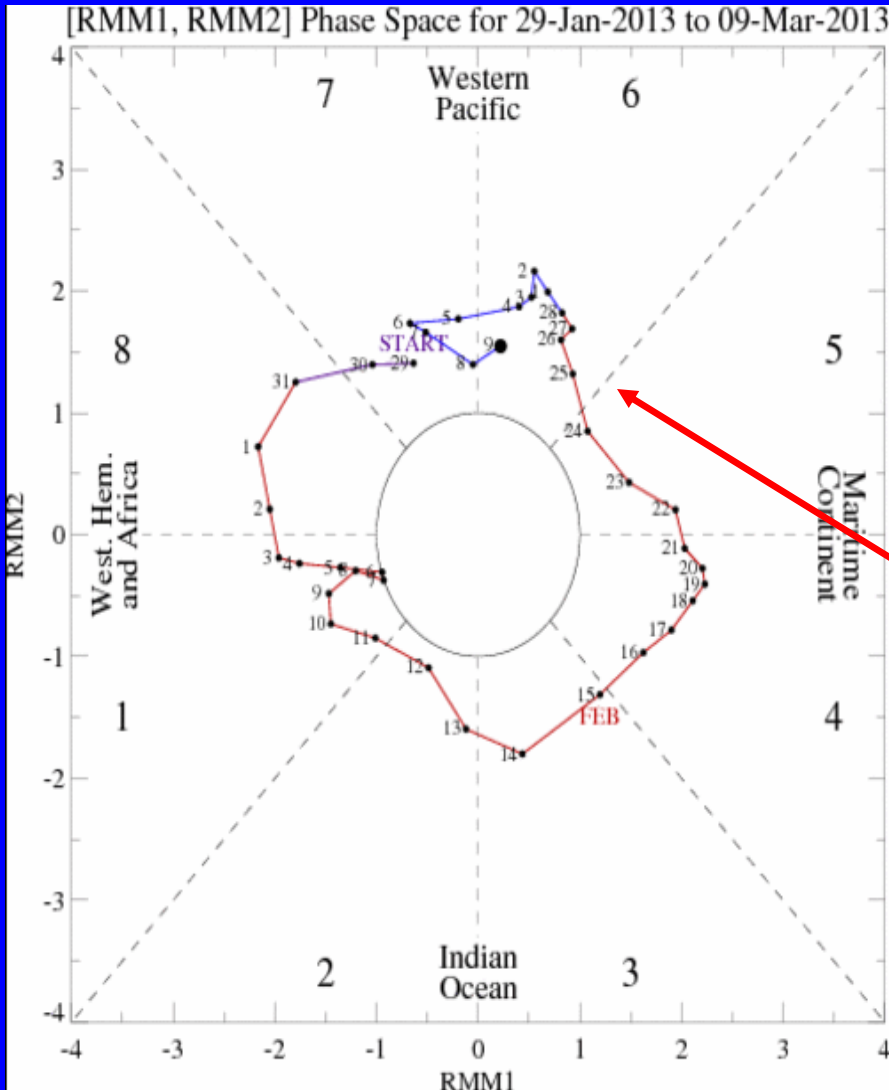
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

**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

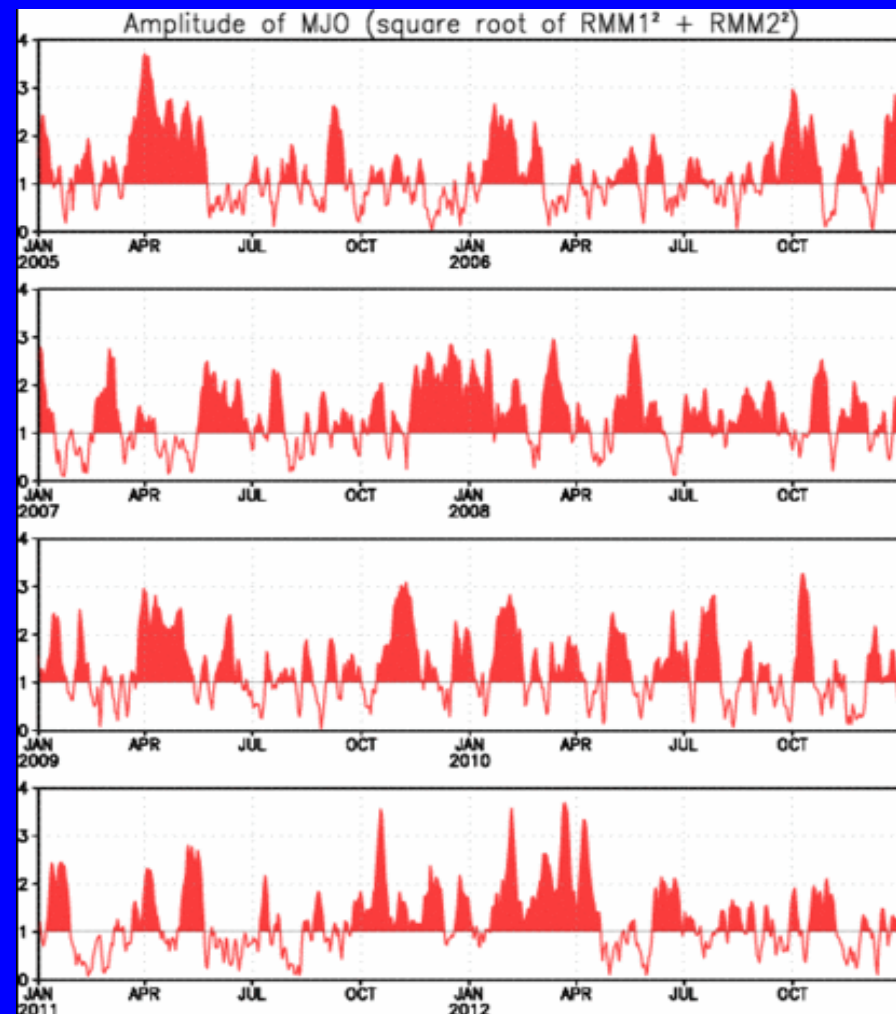
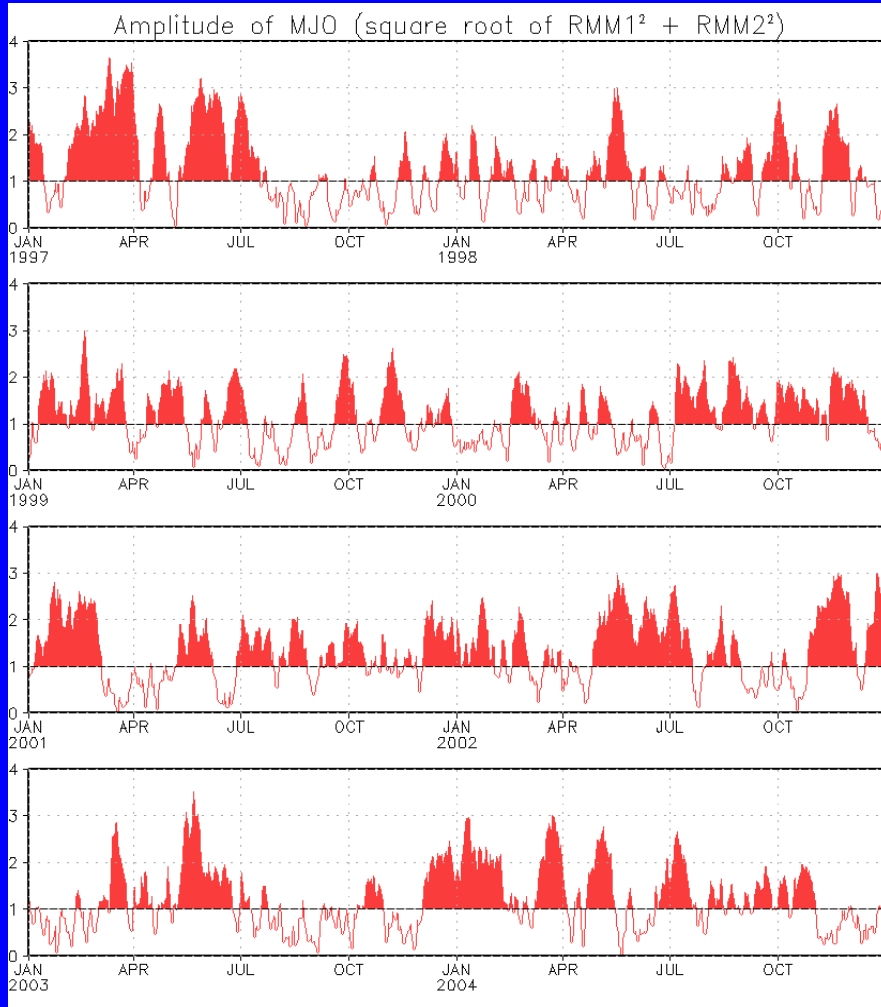


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the 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 crossing the Maritime continent and entering the western Pacific. The recent retrogression is likely due to interference from westward propagating equatorial Rossby waves.



# 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

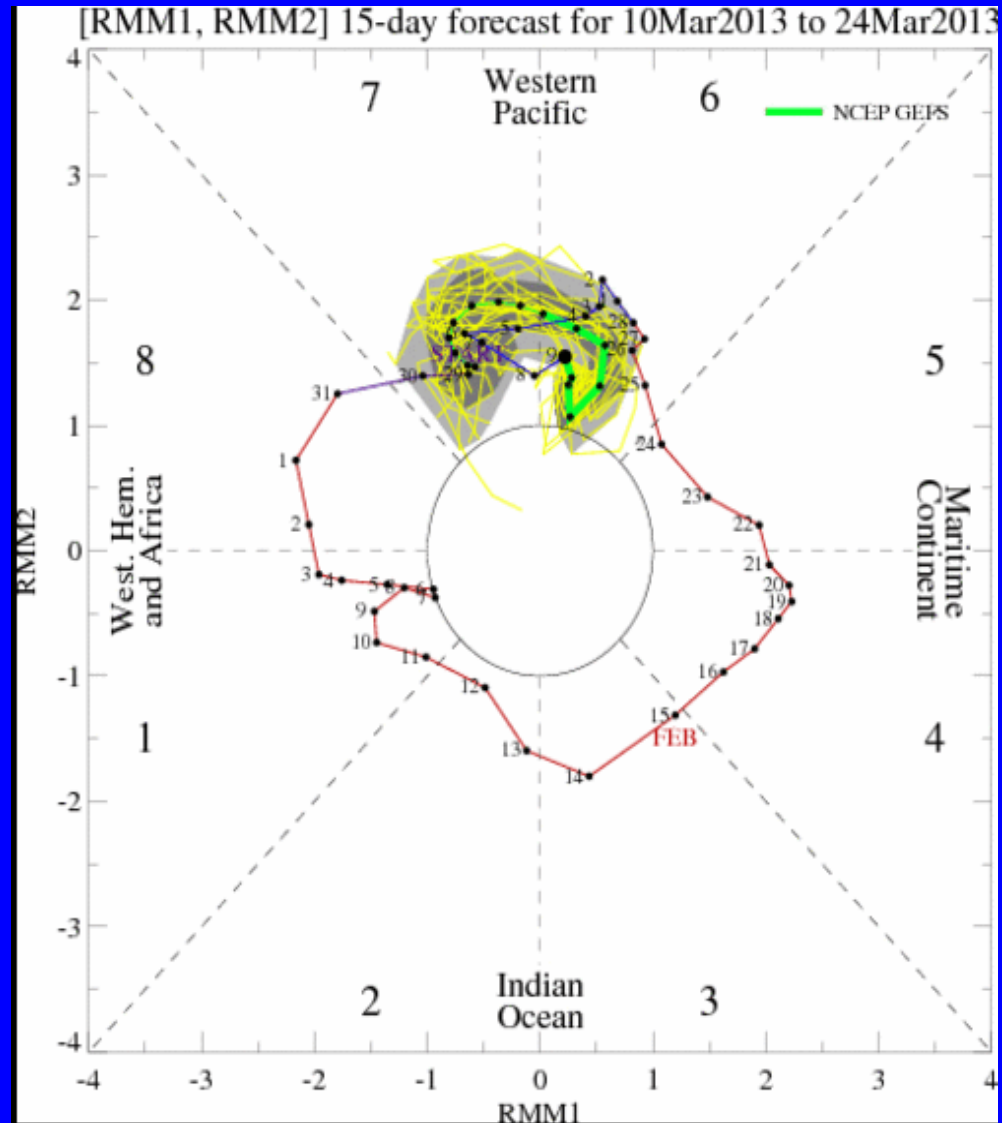
Yellow Lines – 20 Individual Members  
Green Line – Ensemble Mean

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 continues to be unable to propagate the MJO signal eastward at a reasonable phase speed. The forecast is likely being adversely impacted by other forms of sub-seasonal variability.

The MJO signal is favored to continue and resume eastward propagation.





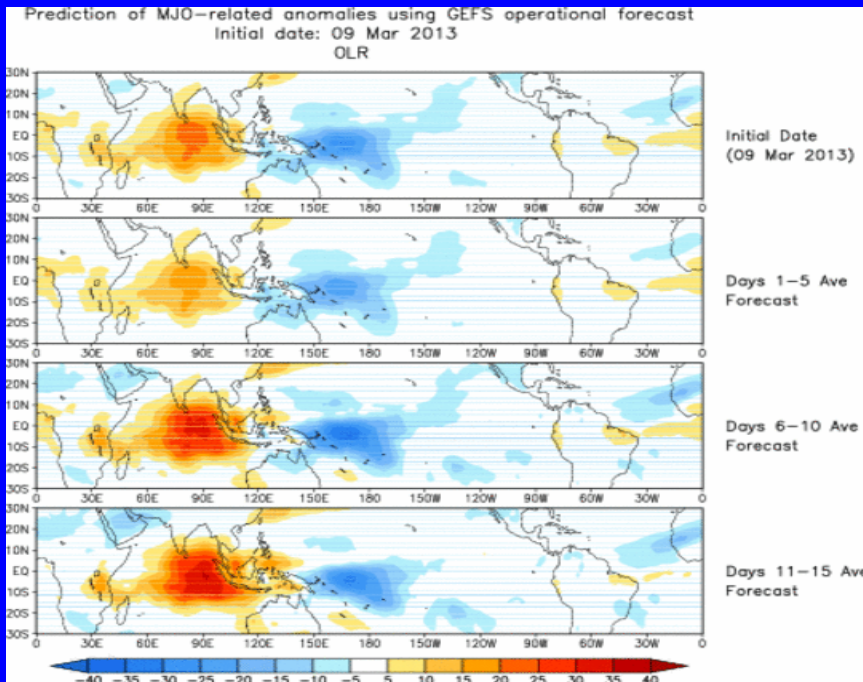


# Ensemble Mean GFS MJO Forecast

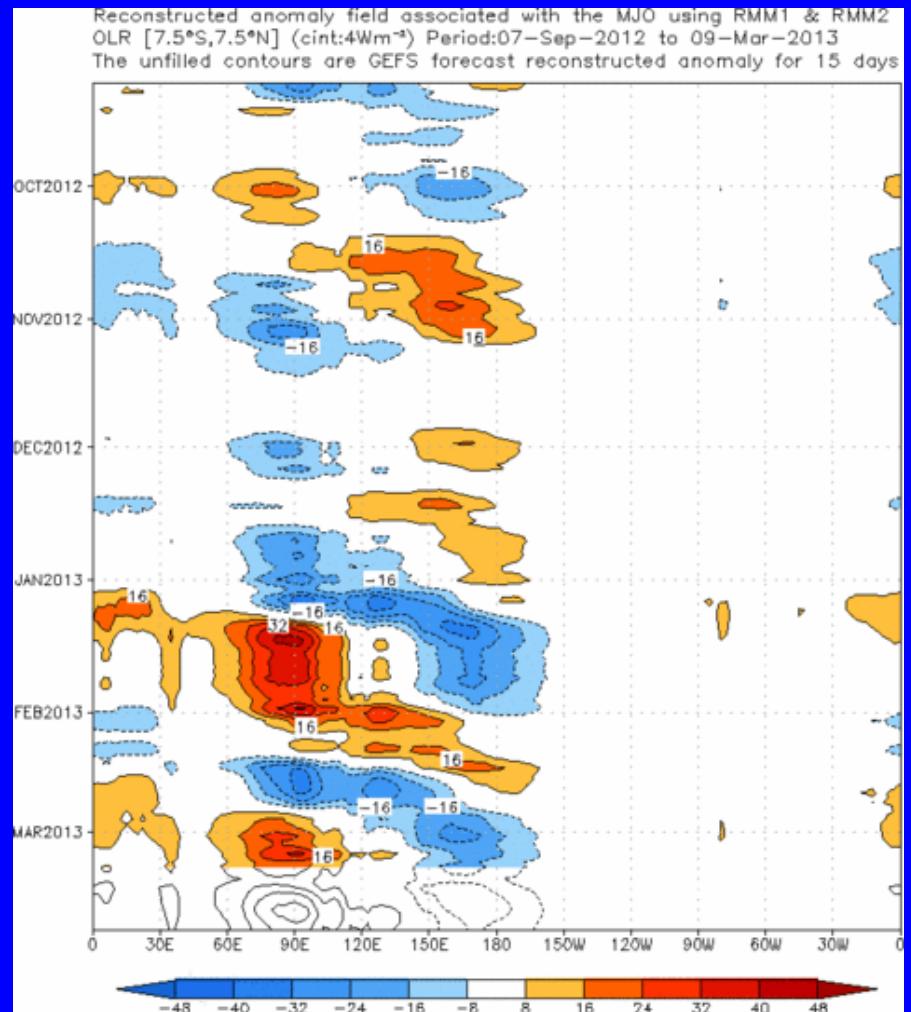
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

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 (suppressed) convection to persist across the western Pacific (Indian Ocean) during the period.



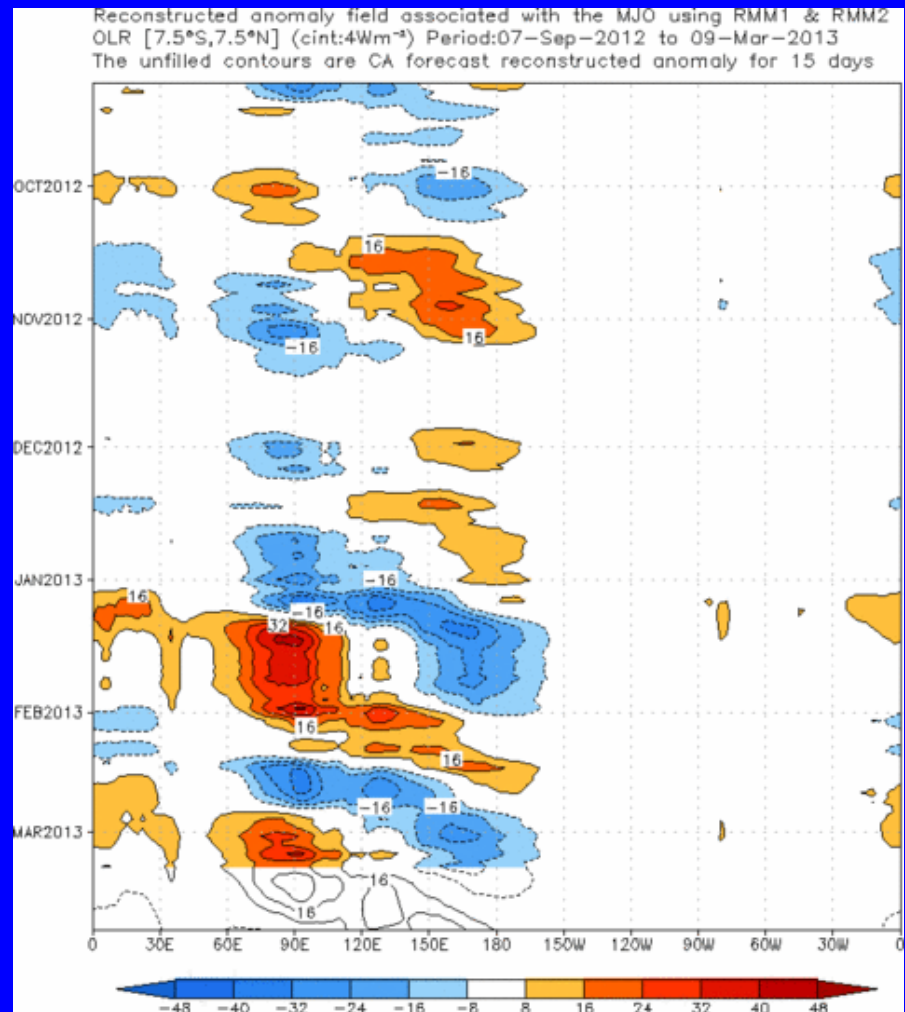
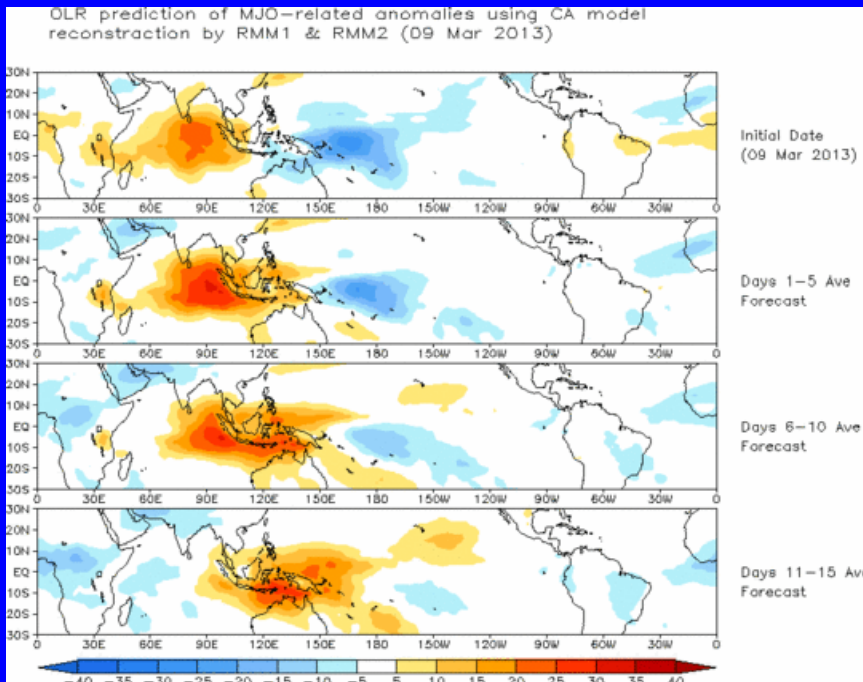


# Constructed Analog (CA) MJO Forecast

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



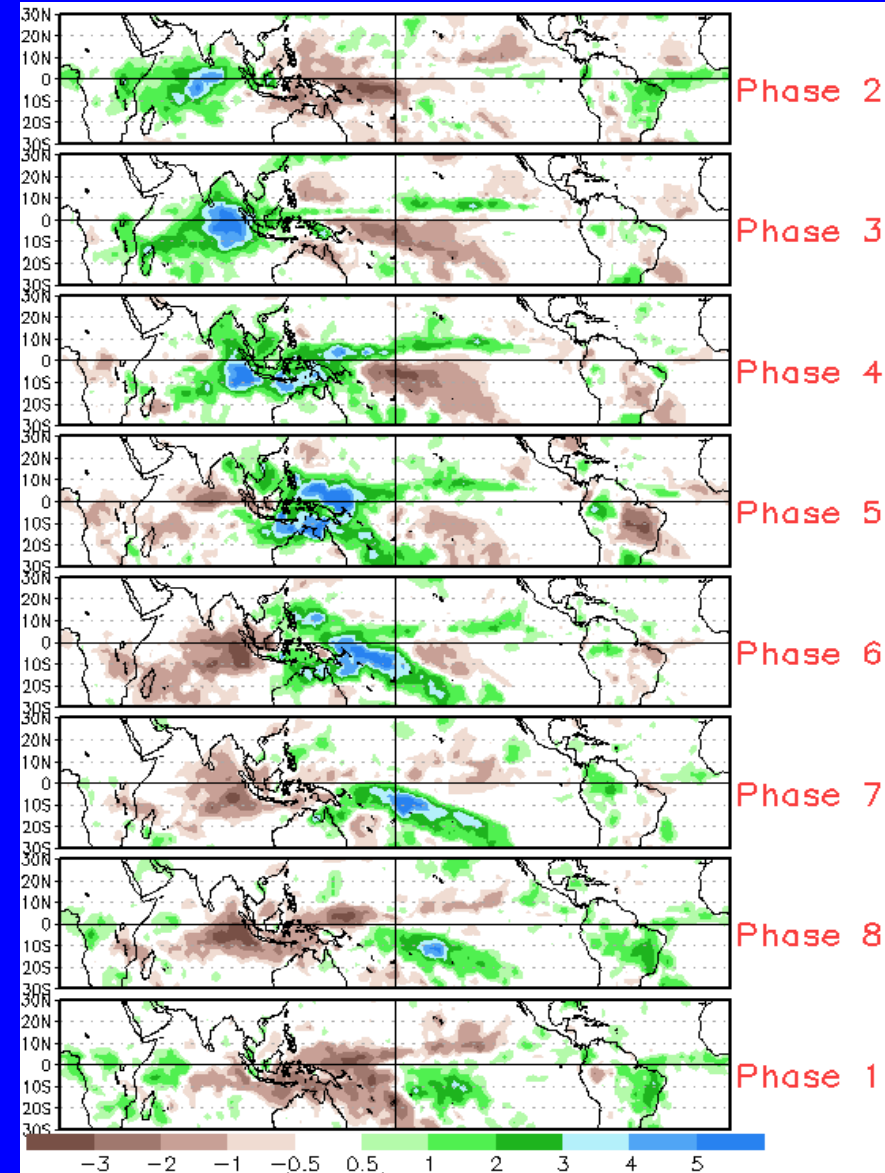
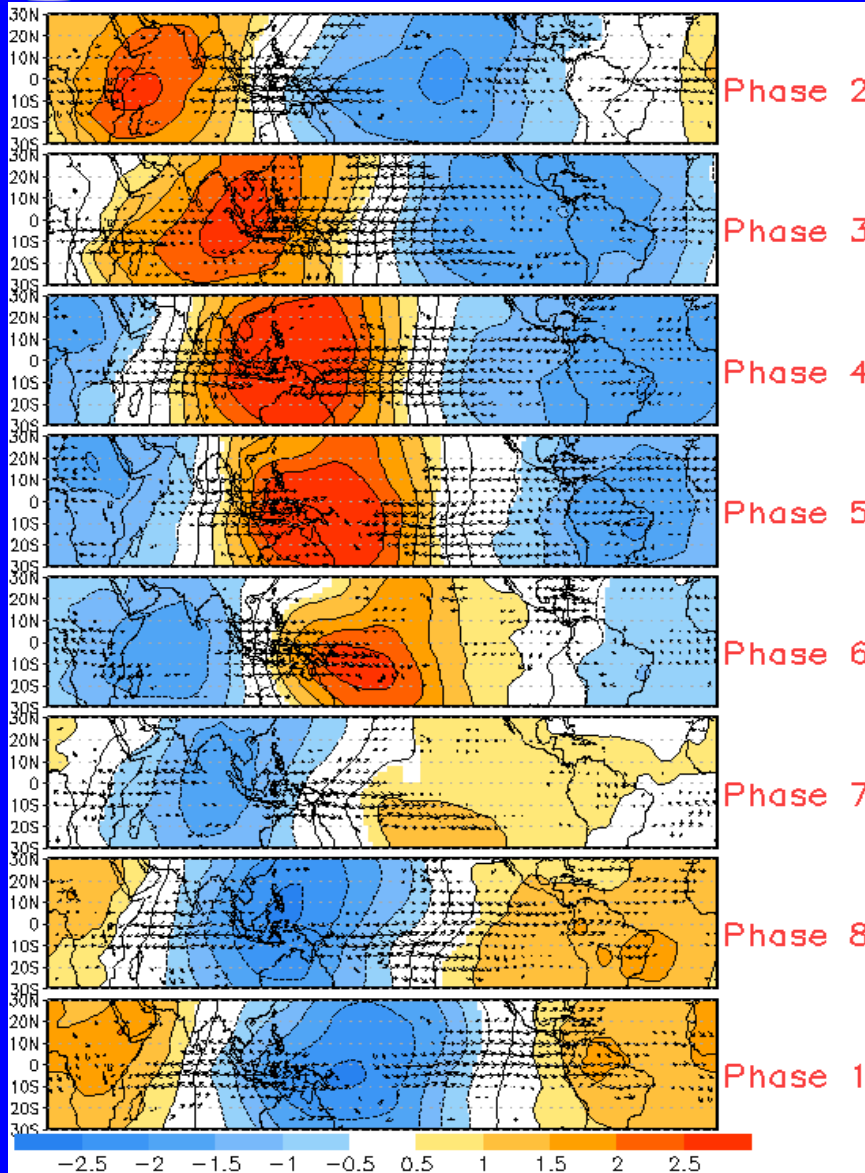
This forecast shows more clear eastward progression with enhanced convection shifting across the Pacific to South America and Africa. Suppressed convection is forecast to shift eastward across the Maritime Continent and into the western Pacific during Week-2.



# MJO Composites – Global Tropics

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

Precipitation Anomalies (Nov-Mar)

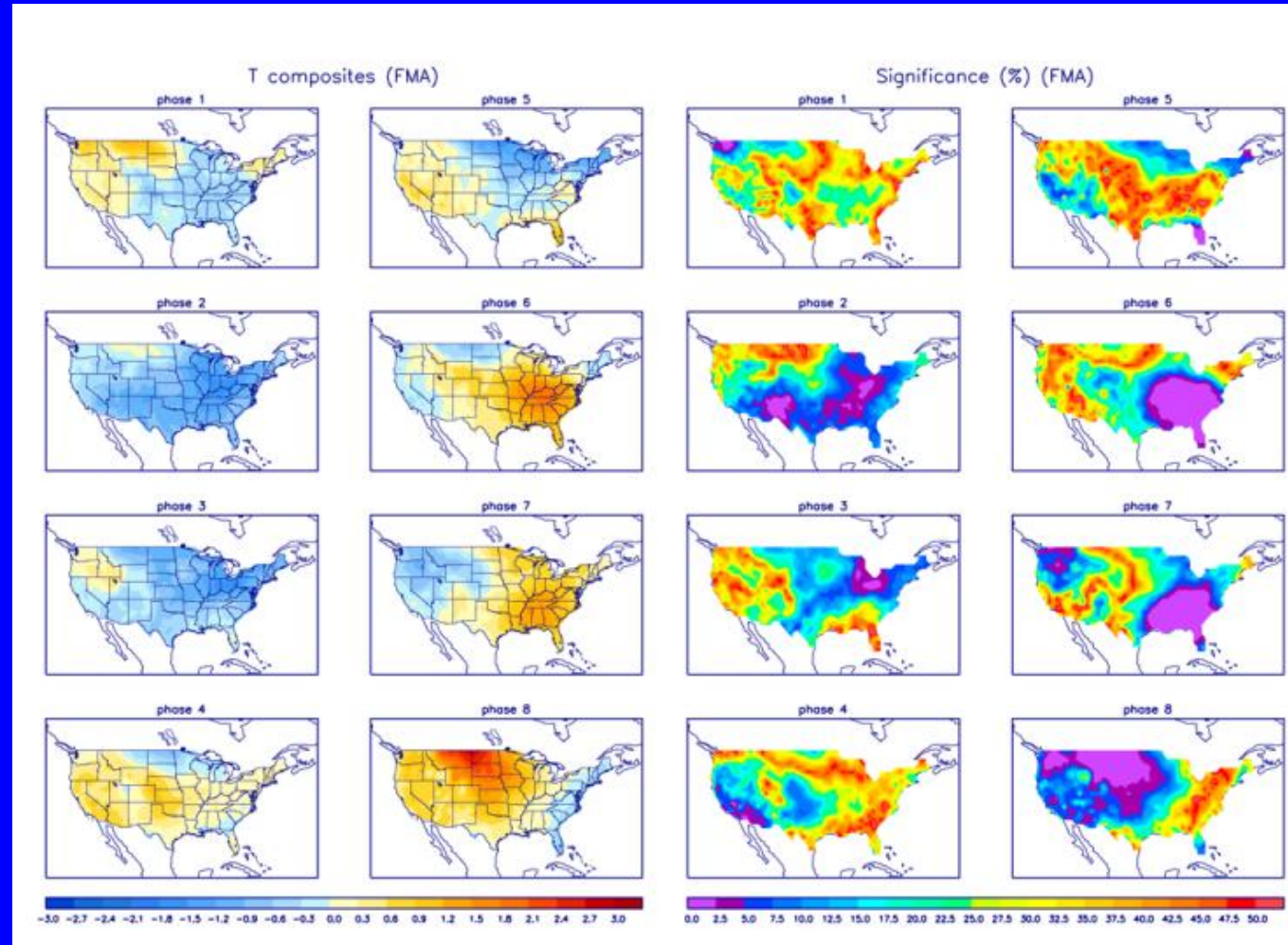




# U.S. MJO Composites – Temperature

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.



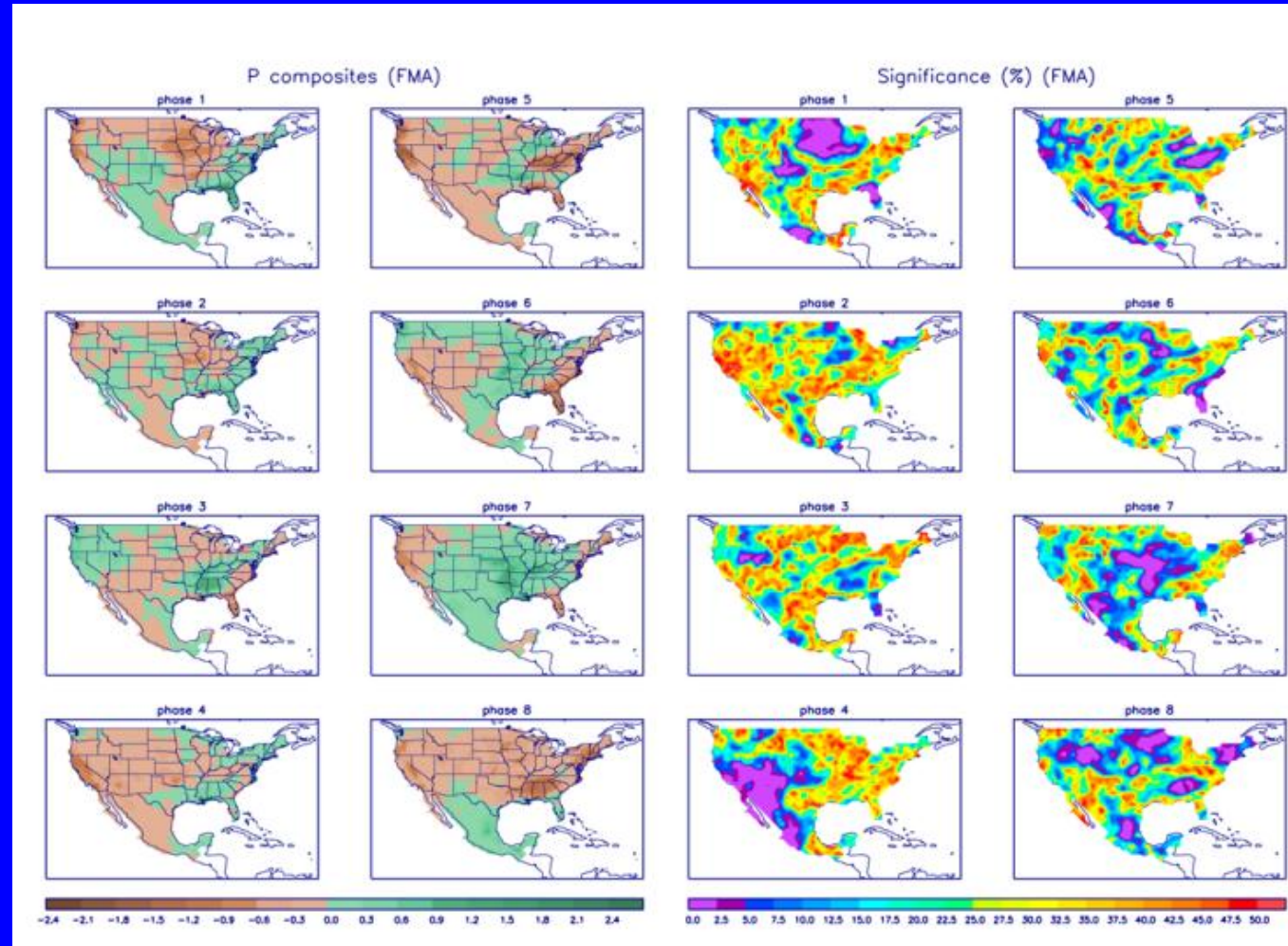
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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

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