



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

**Update prepared by  
Climate Prediction Center / NCEP  
April 6, 2015**



# Outline

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



# Overview

- **Recent observations indicate that the MJO remains active, with the enhanced phase currently over the eastern Indian Ocean and Maritime Continent.**
- **Other modes of tropical convective variability, including Equatorial Rossby Wave activity and an El Niño background state, continue to influence the pattern, now destructively interfering with the MJO signal.**
- **Dynamical model MJO index forecasts indicate little propagation, with a rapidly weakening signal during Week-1 as the El Niño background state continues to destructively interfere with the pattern. Statistical models continue slow eastward propagation.**
- **The MJO is expected to become less important over the next one to two weeks as the pattern of tropical variability is likely to be driven more by the low-frequency state.**

**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>**

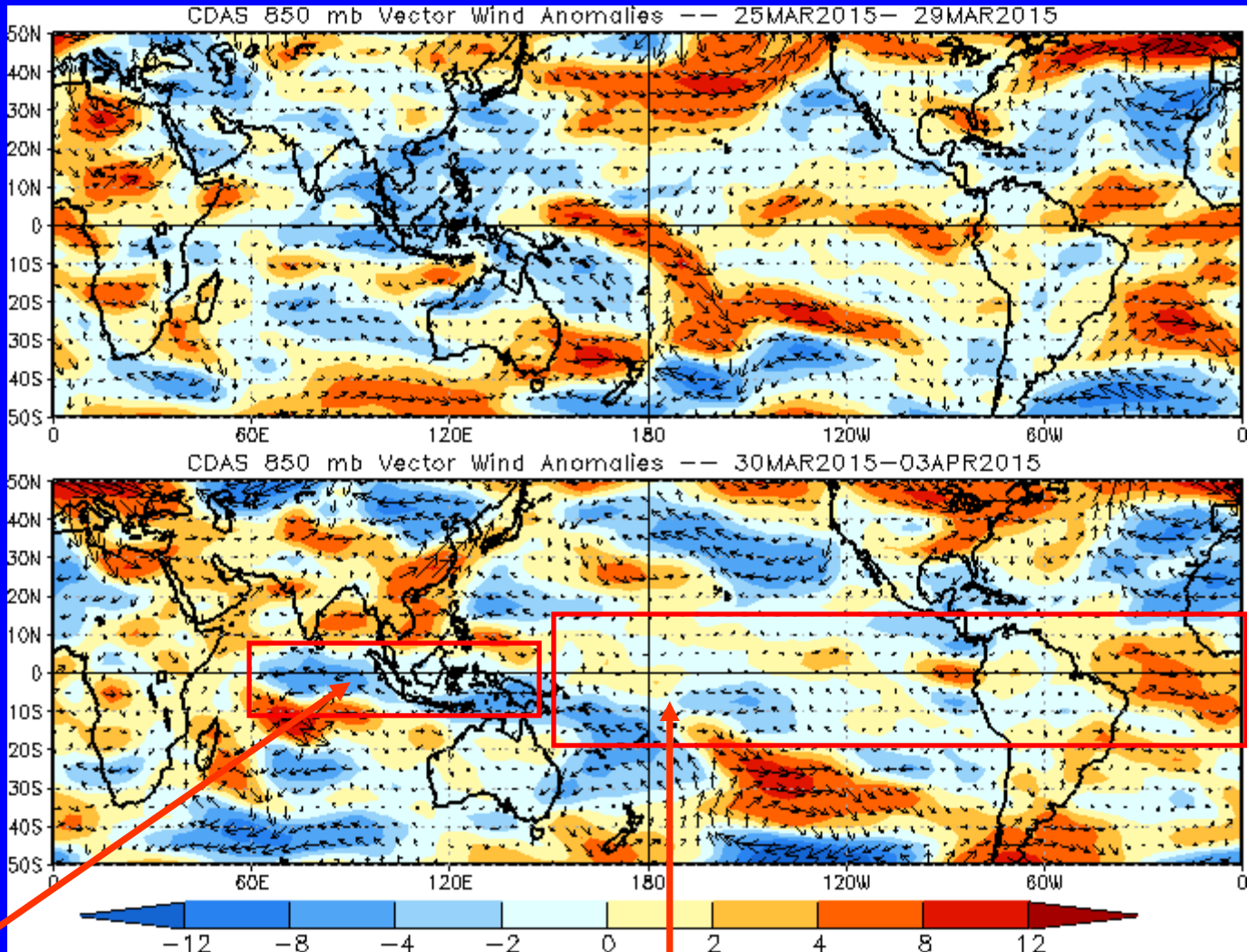


# 850-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Generally, easterly anomalies persisted across the equatorial Indian Ocean and Maritime Continent.

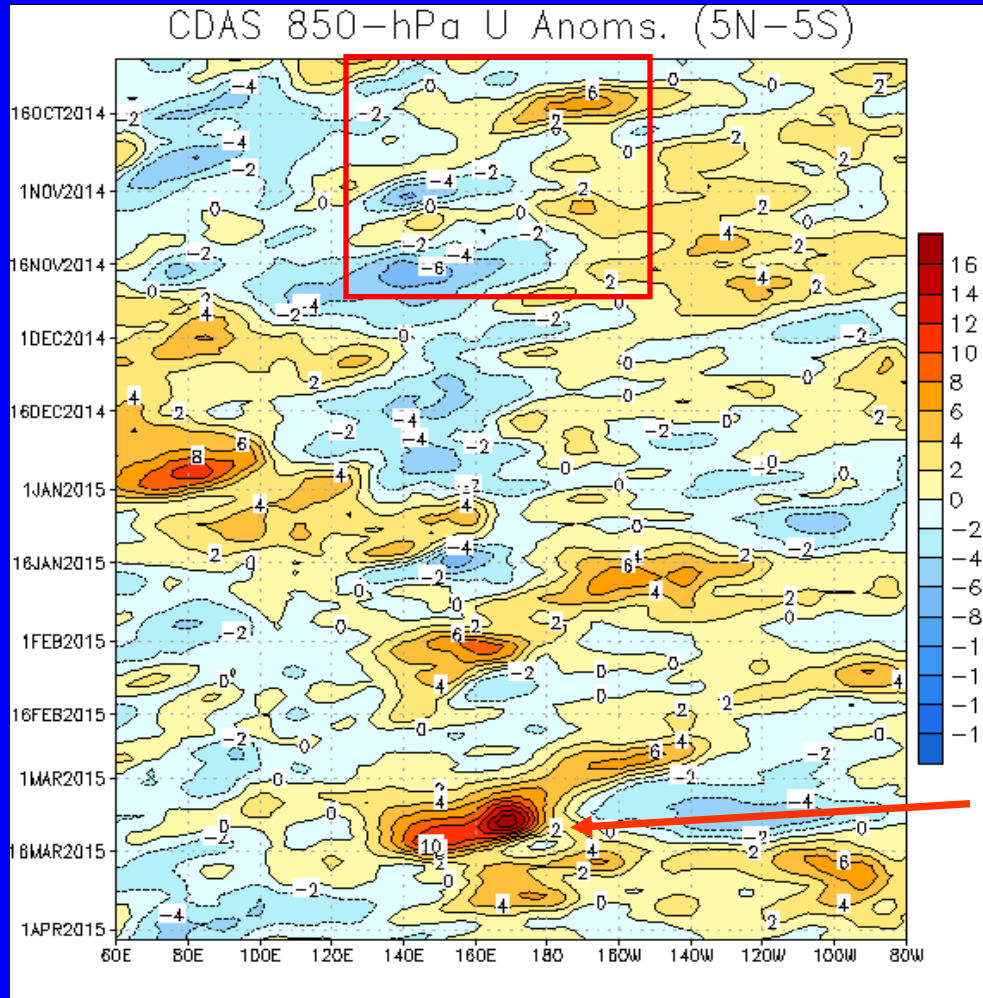
Westerly anomalies weakened substantially over the Western Hemisphere.



# 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



During October and into November, equatorial Rossby wave activity was strong from 160E to 100E as westward movement features are evident (red box). MJO activity was less coherent during this period.

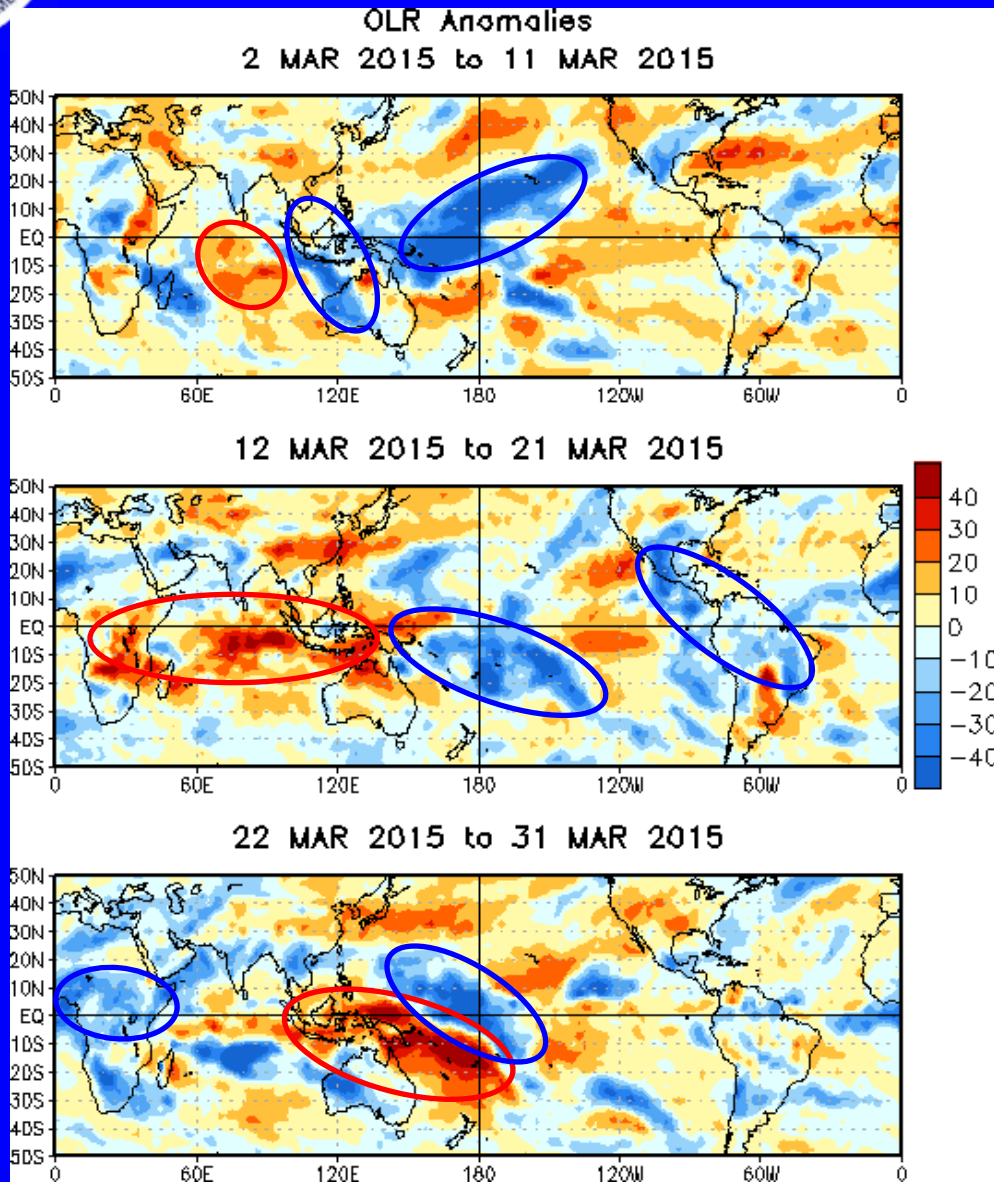
During November and December, easterly anomalies were persistent from 120E to near the Date Line. Westerly anomalies replace those easterly anomalies during January. Easterly anomalies disrupted the signal during early February. Westerly anomalies returned to the Western Pacific during late January.

Westerly anomalies associated with an ERW propagated west of the Date Line during early March. A strong westerly wind burst is evident just west of the Date Line, likely due to constructive interference among several modes of variability.



# 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 March, enhanced (suppressed) convection was observed over parts of the Maritime Continent and the West Pacific (Indian Ocean).

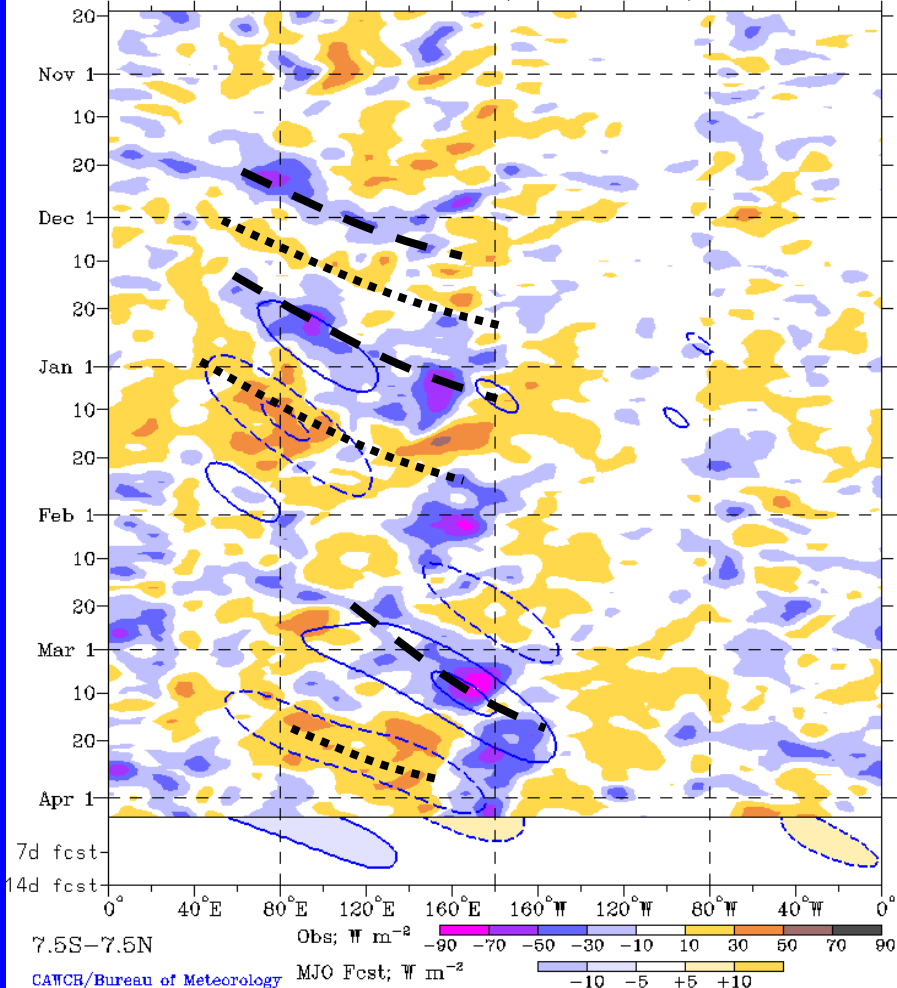
During mid-March, widespread enhanced convection was observed over the West and Central Pacific, while suppressed convection developed over Africa and the Indian Ocean. Enhanced convection was also observed over parts of Central and South America.

Suppressed convection propagated eastward across the Maritime Continent into the southwestern Pacific during late March, while enhanced convection lingered near the Date Line over the tropical Pacific. Enhanced convection developed over parts of Africa.



# 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  
19-Oct-2014 to 5-Apr-2015 + 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 strengthened in late November with alternating areas of enhanced/suppressed convection moving from the Indian Ocean to the Date Line through January. During early February the MJO signal broke down.

Convective anomalies were generally small during February as the MJO signal remained incoherent.

The MJO became active again during March, with eastward propagation of enhanced (suppressed) anomalies evident across the Pacific (Indian Ocean and Maritime Continent). More recently, enhanced convection persisted near the Date Line.

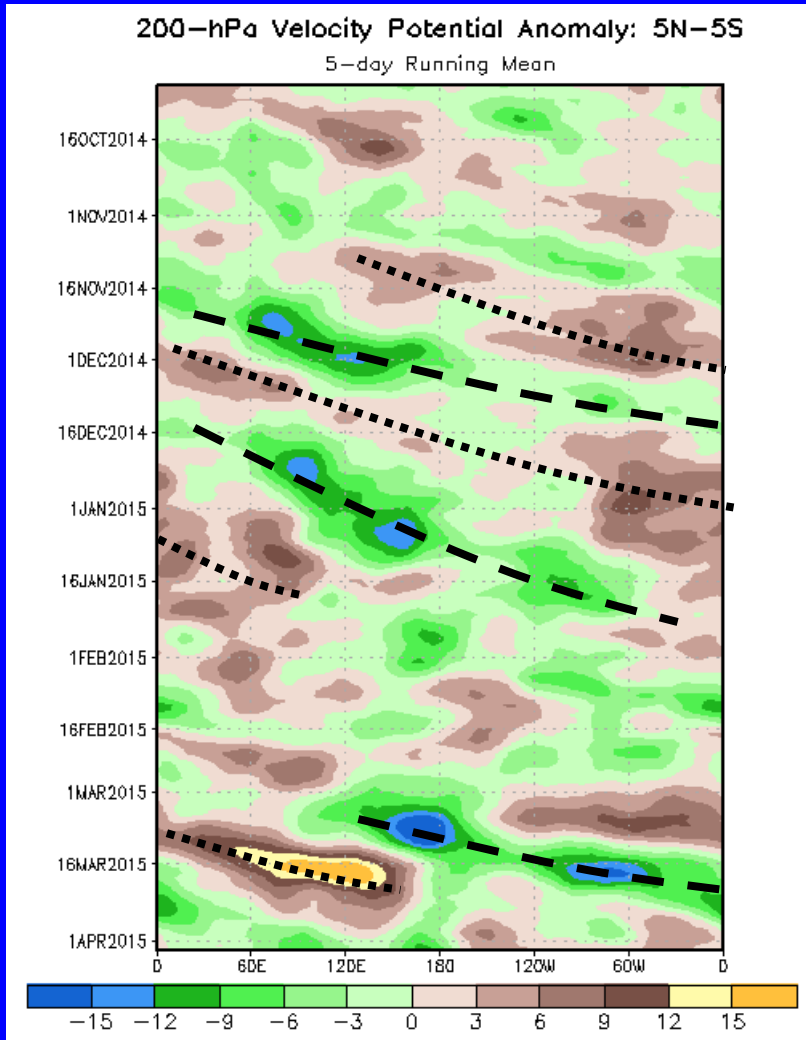
**Longitude**



# 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



The MJO was incoherent from mid-September through October.

Beginning in November the MJO strengthened as indicated by eastward propagation of alternating anomalies into January 2015. At times, the signal was dominated by faster-moving variability on the Kelvin Wave time scale, but from late December through mid-January the signal was more consistent with canonical MJO activity.

Beginning in mid-January, the signal broke down, with other modes of variability dominating the upper-level velocity potential anomaly pattern.

More recently, eastward propagation of a strong anomaly couplet was observed, with negative (positive) anomalies propagating over the Western Hemisphere (Maritime Continent and far West Pacific). Negative anomalies persisted near the Date Line.

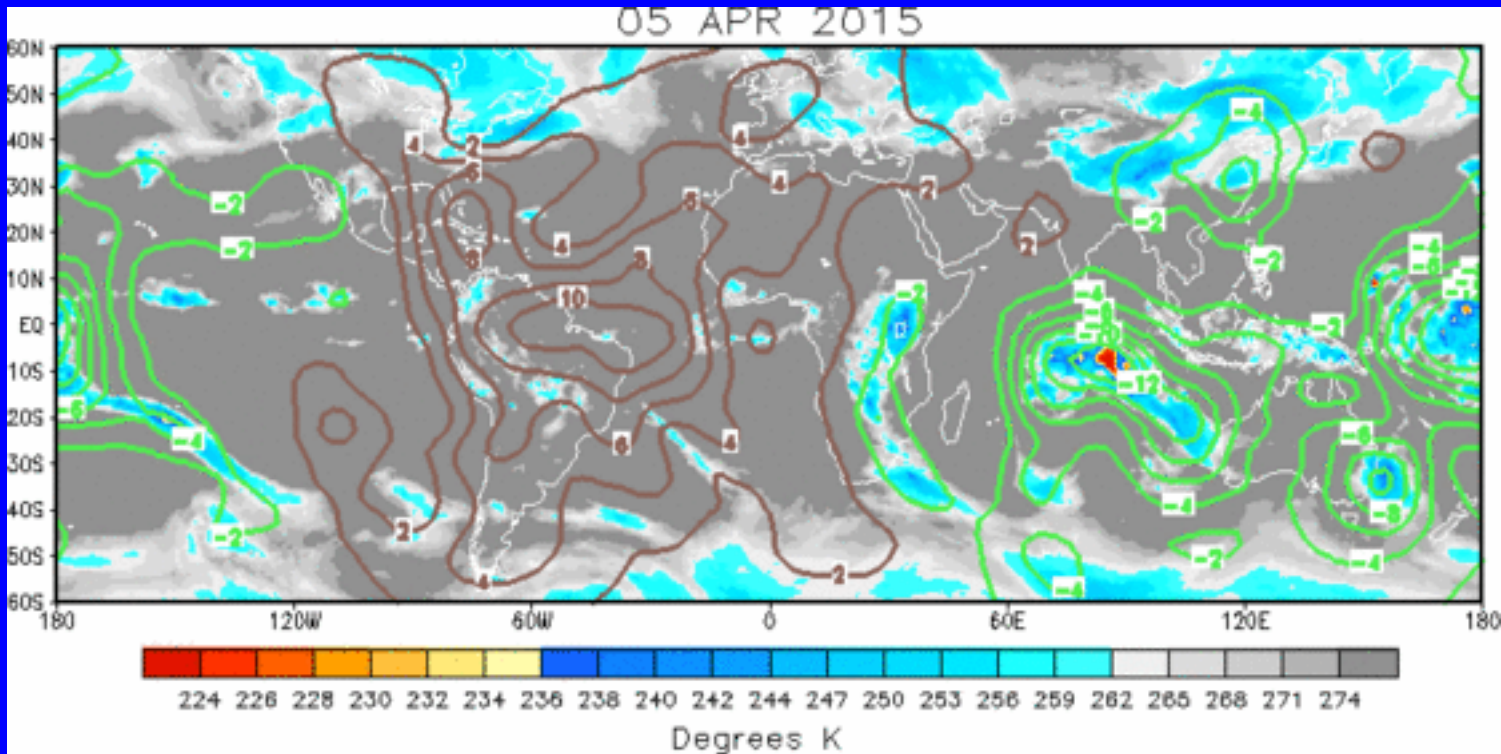




# IR Temperatures (K) / 200-hPa Velocity Potential Anomalies

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The spatial pattern has regained its Wave-1 structure, with upper-level divergence extending from the Indian Ocean to the central Pacific. Upper-level convergence is centered over the Atlantic.

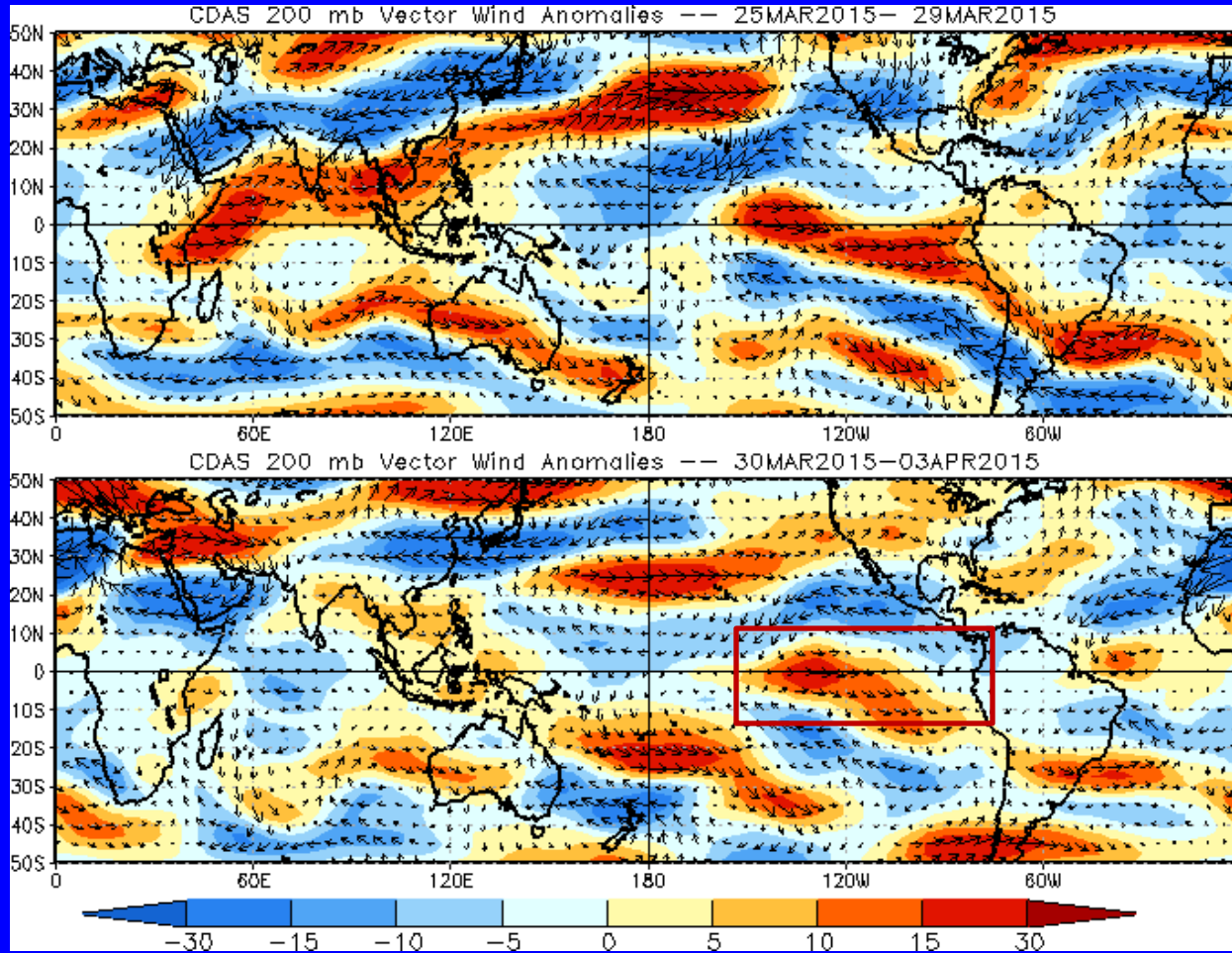


# 200-hPa Vector Wind Anomalies ( $m s^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



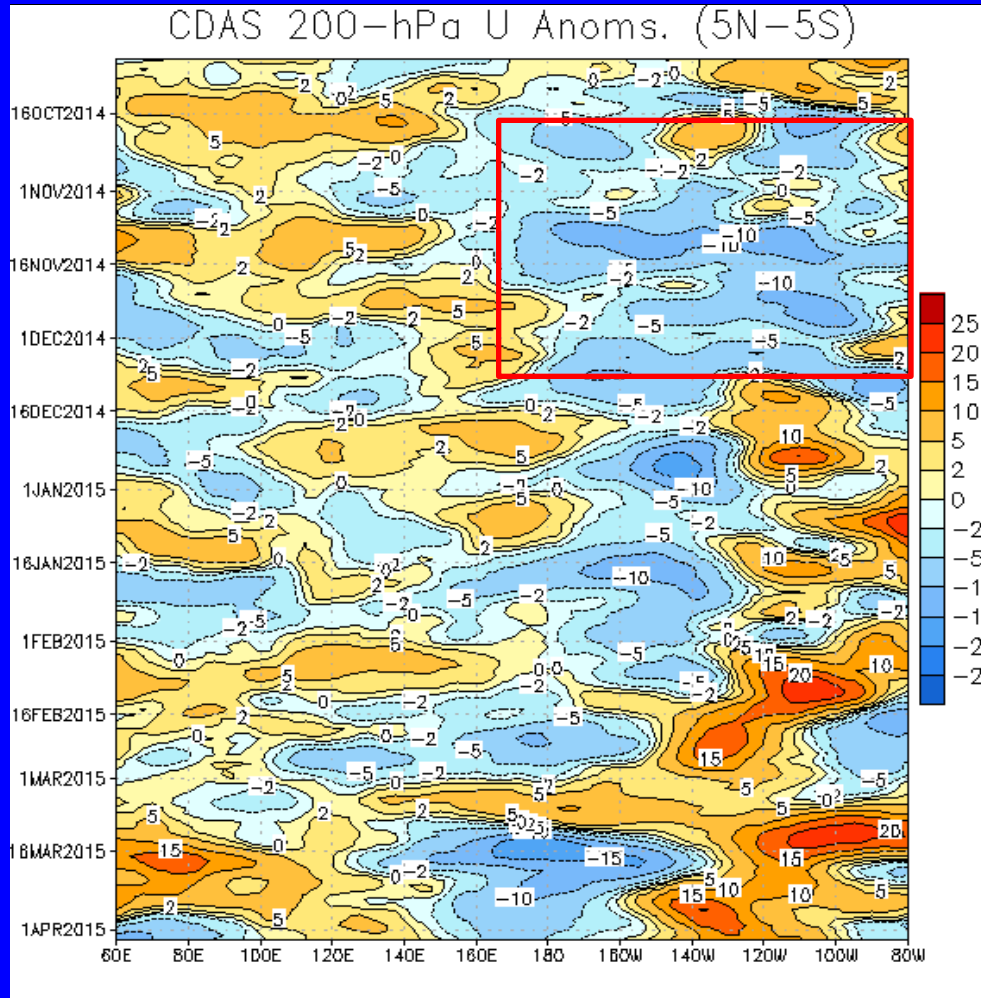
Westerly anomalies persisted across the eastern Pacific.



# 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



Easterly wind anomalies persisted east of the Date Line from late October through early December (red box).

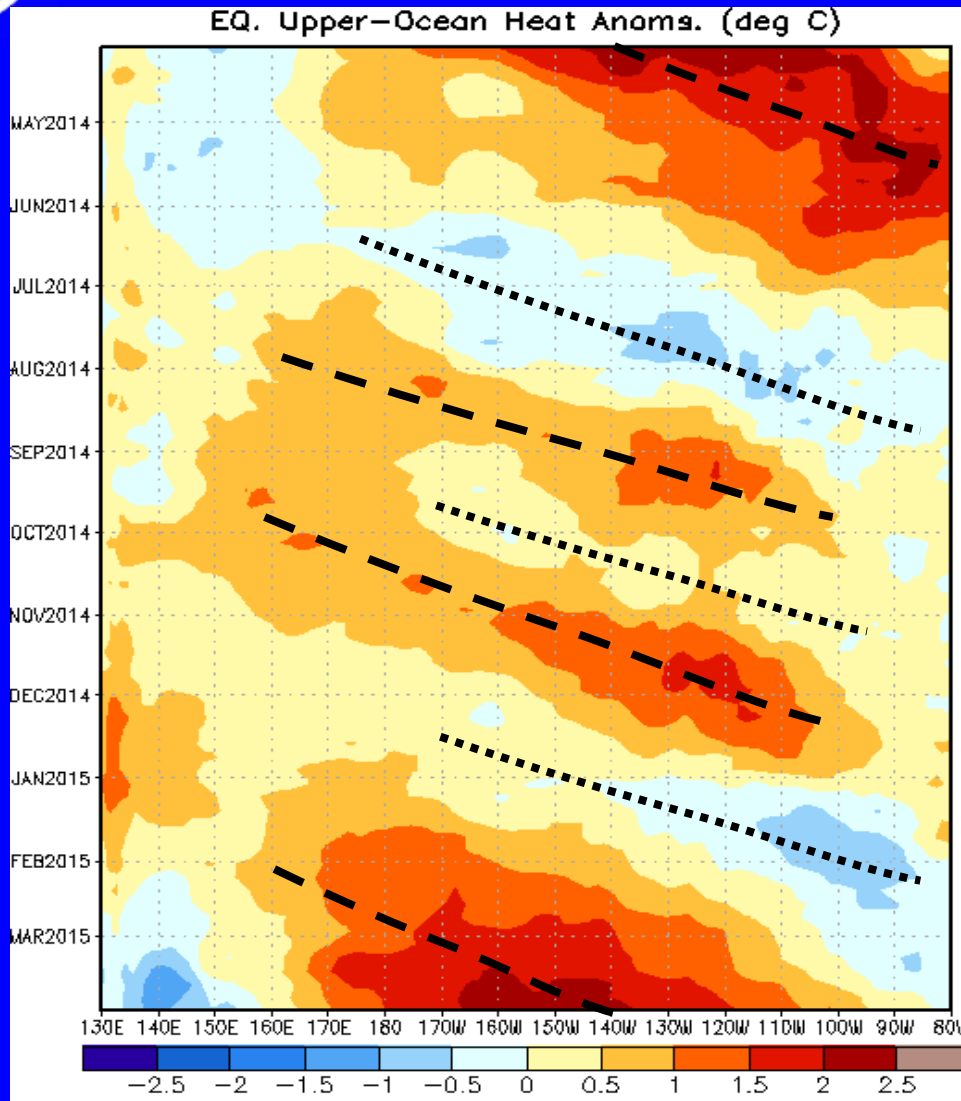
During late December through the present, westerly anomalies increased in coverage and intensity from 120W to 80W, similar to September and October 2014. Westerly anomalies also became more persistent over the Indian Ocean.

Westward propagation of westerly anomalies was evident over the eastern Pacific during late February.

Recently, easterly anomalies have developed over the Central Pacific, with westerly anomalies over much of the rest of the Tropics.



# Weekly Heat Content Evolution in the Equatorial Pacific



A strong downwelling event began in January 2014 and propagated across the Pacific, reaching the South American coast by May 2014.

Warm anomalies persisted over much of the Pacific during April and May, though basin-averaged anomalies decreased during June and July associated with an upwelling Kelvin wave (dotted line).

Warm anomalies increased across much of the Pacific basin due to another moderate downwelling Kelvin wave traversing the Pacific during October and November 2014. The upwelling phase was evident in the central and eastern Pacific during January.

Warm anomalies associated with another downwelling Kelvin Wave are evident over the central Pacific, with warm anomalies persistent near the Date Line.



# 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.**

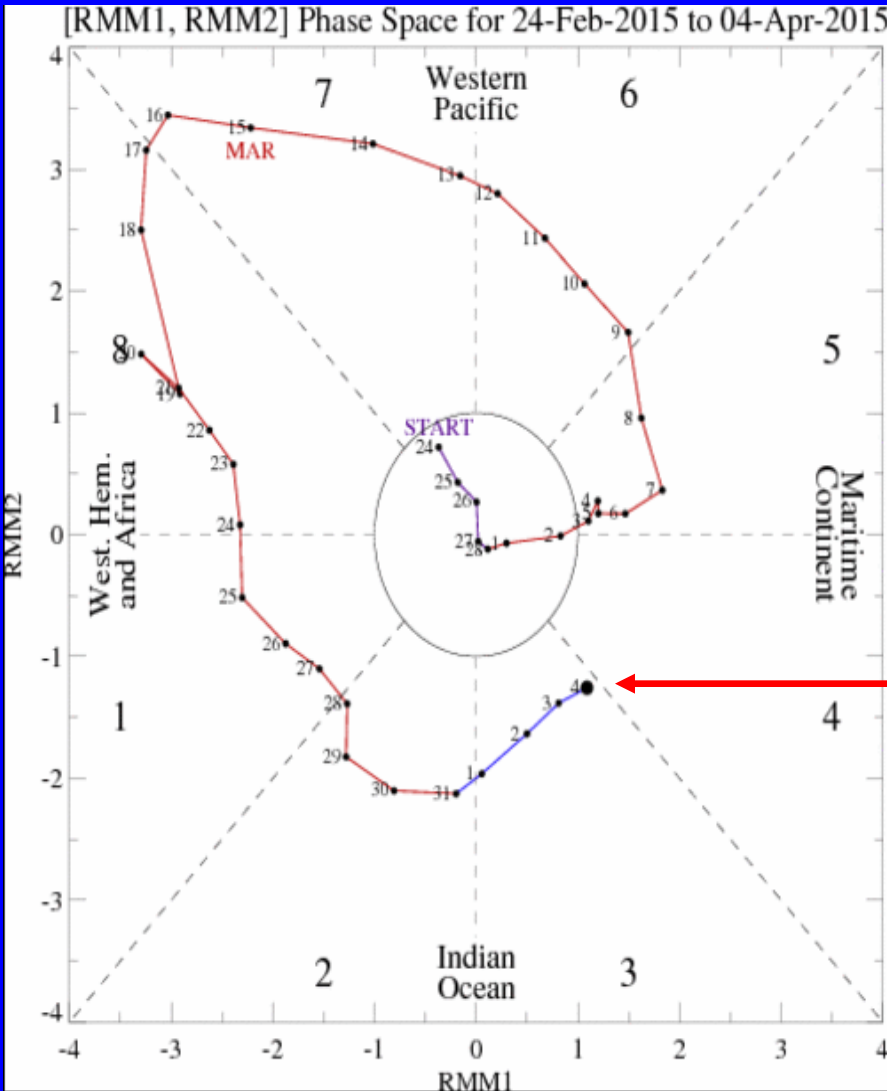
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

**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

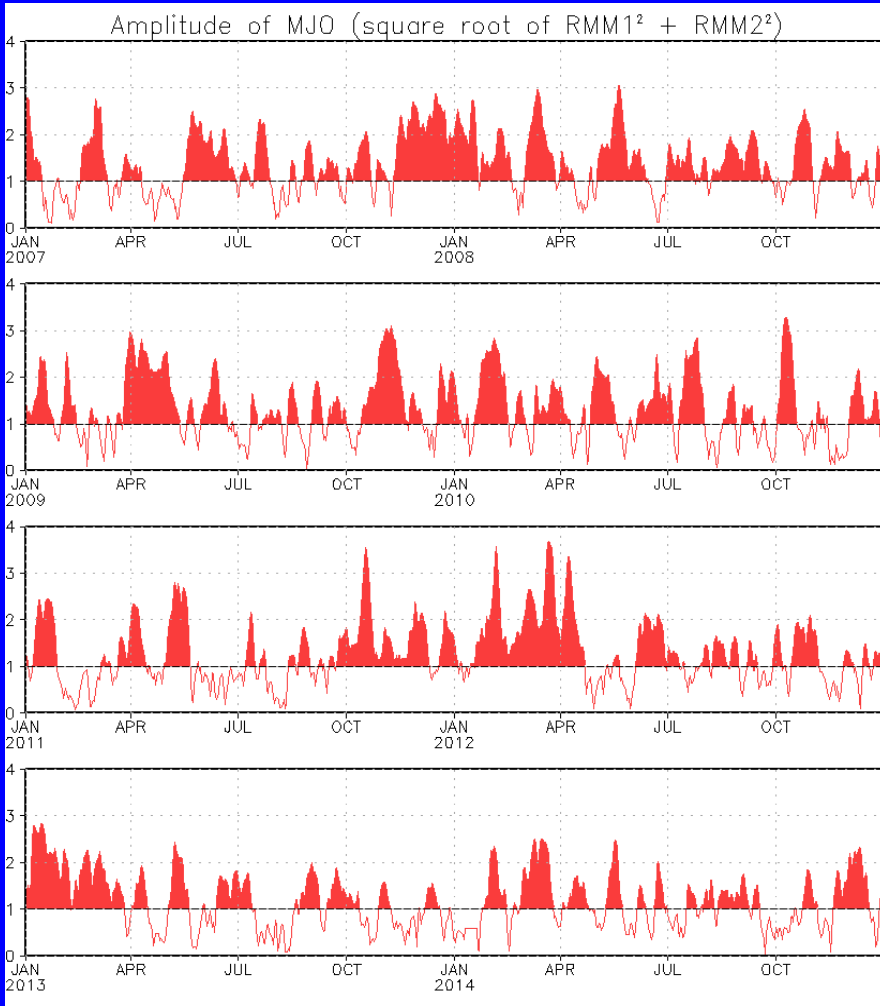


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The RMM MJO index indicated fairly rapid propagation across the Indian Ocean during the past week.



# MJO Index – Historical Daily Time Series



Time series of daily MJO index amplitude from 2007 to present.

Plot puts current MJO activity in recent historical context.



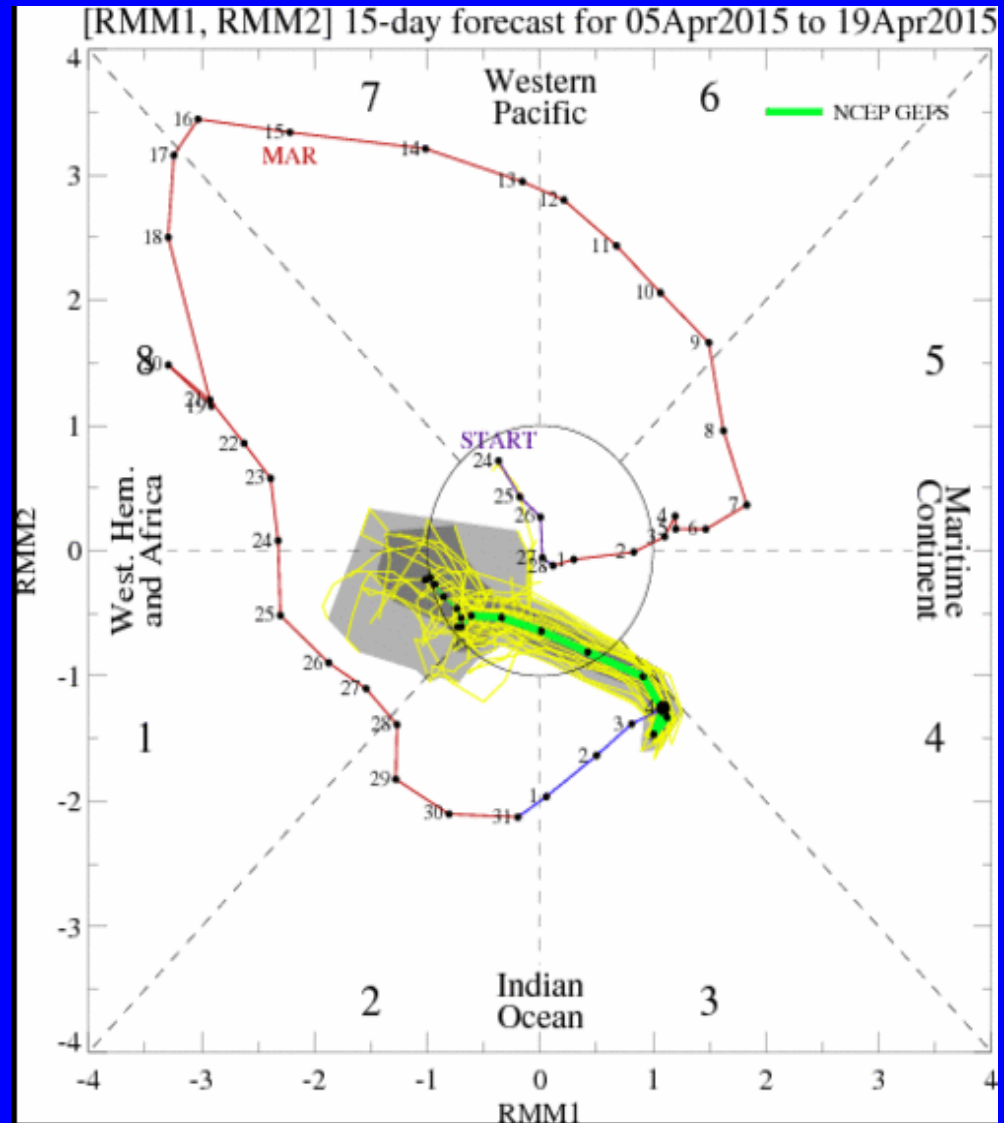
# Ensemble GFS (GEFS) MJO Forecast

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 GFS ensemble RMM Index forecasts depict a weakening of the signal over the next week, as destructive interference grows between the ENSO signal and the subseasonal variability.



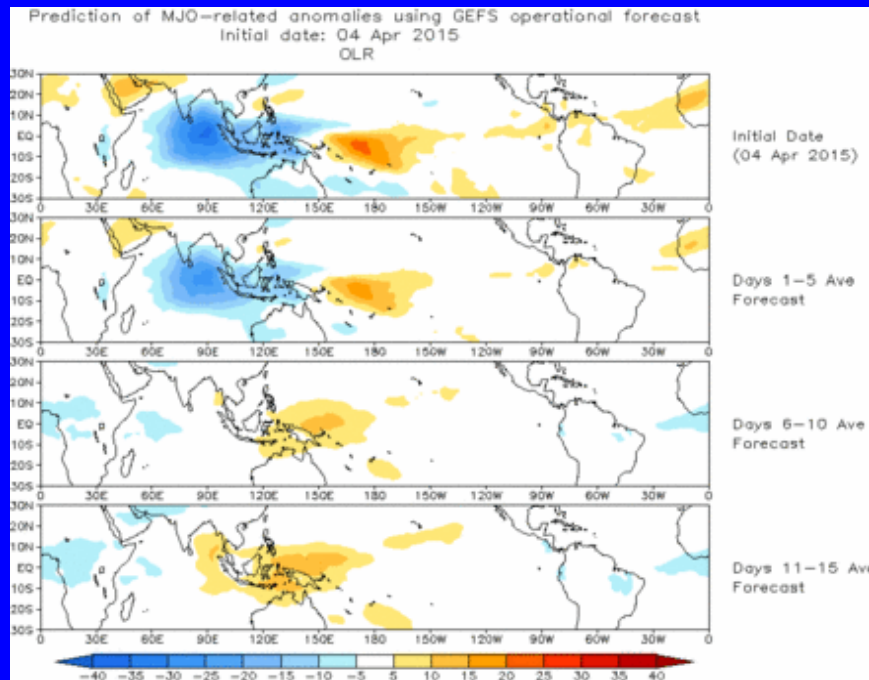




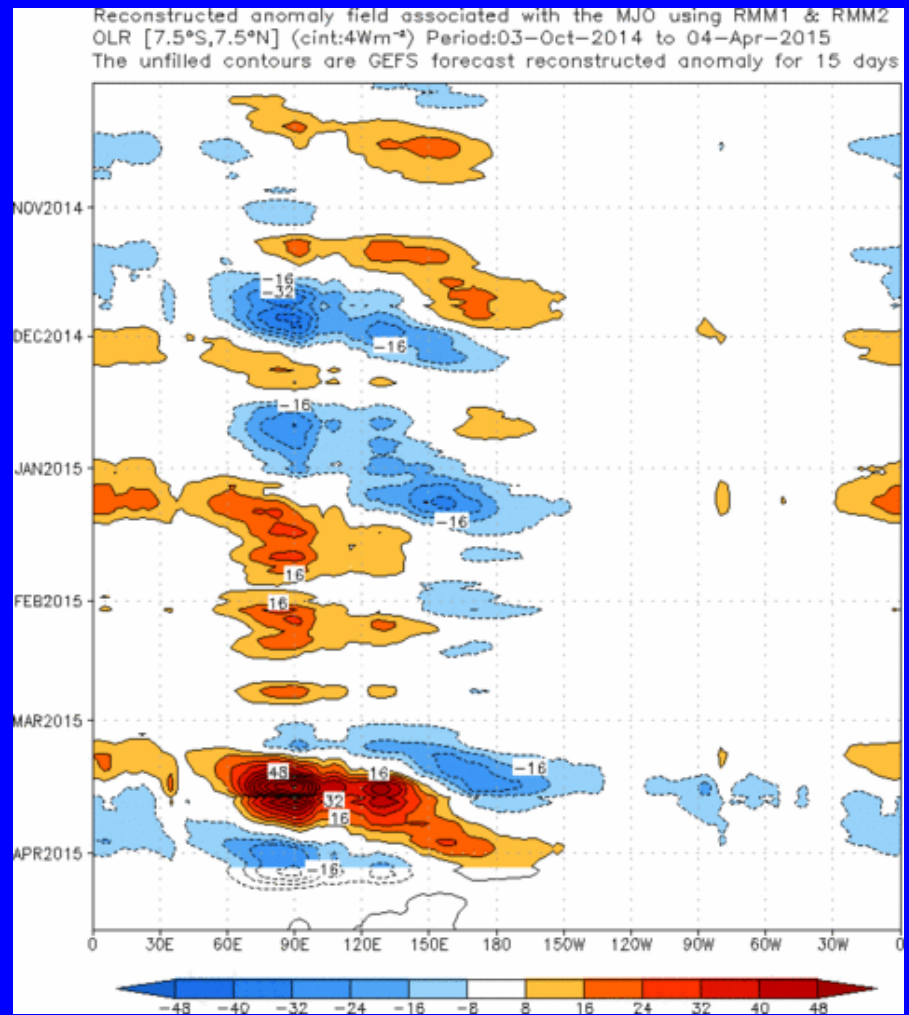
# Ensemble Mean GFS MJO Forecast

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



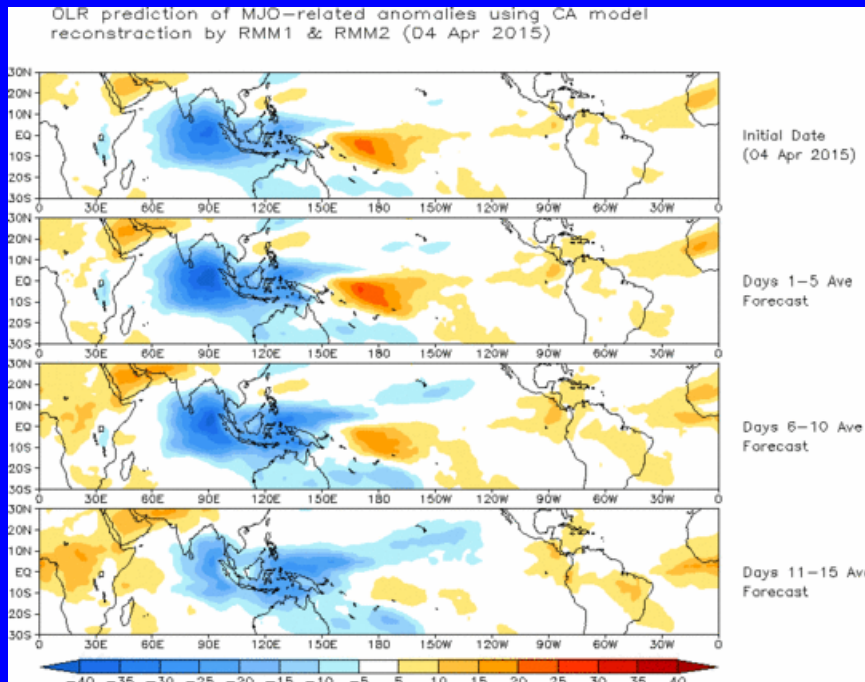
The GFS RMM Index based OLR anomalies forecast depicts a weakening signal with no eastward propagation.



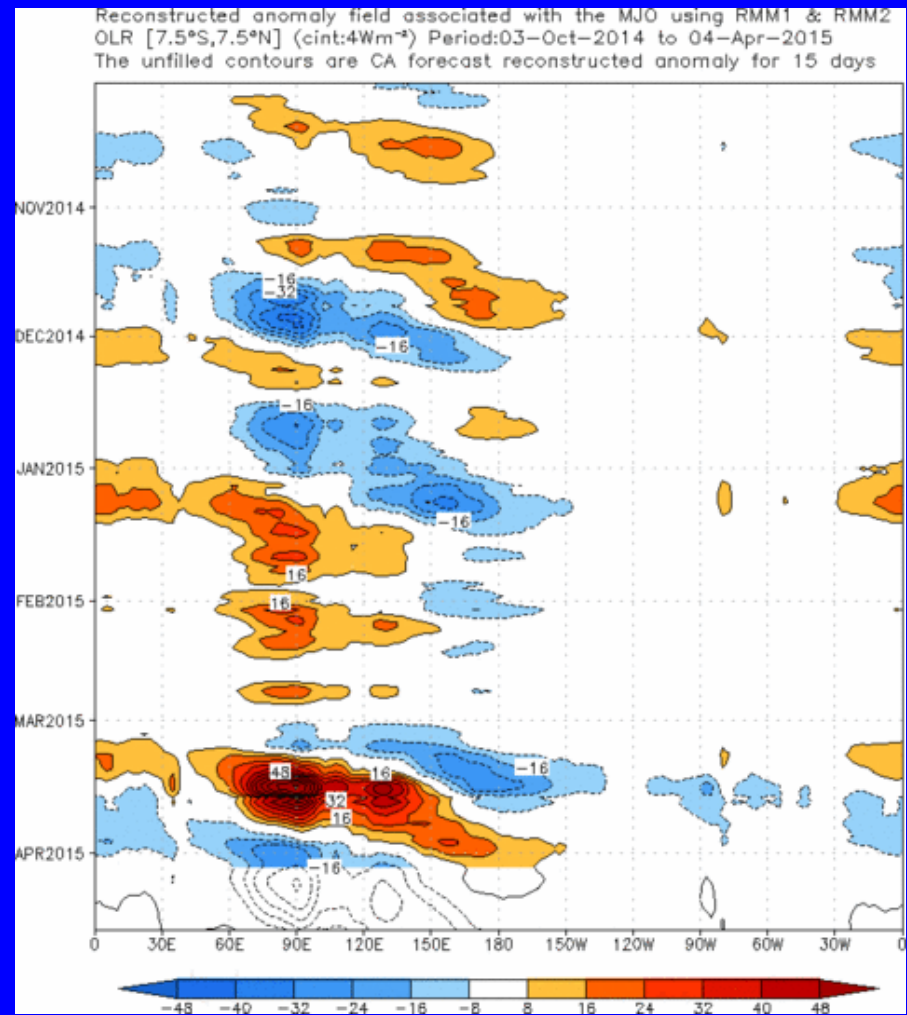
# Constructed Analog (CA) MJO Forecast

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



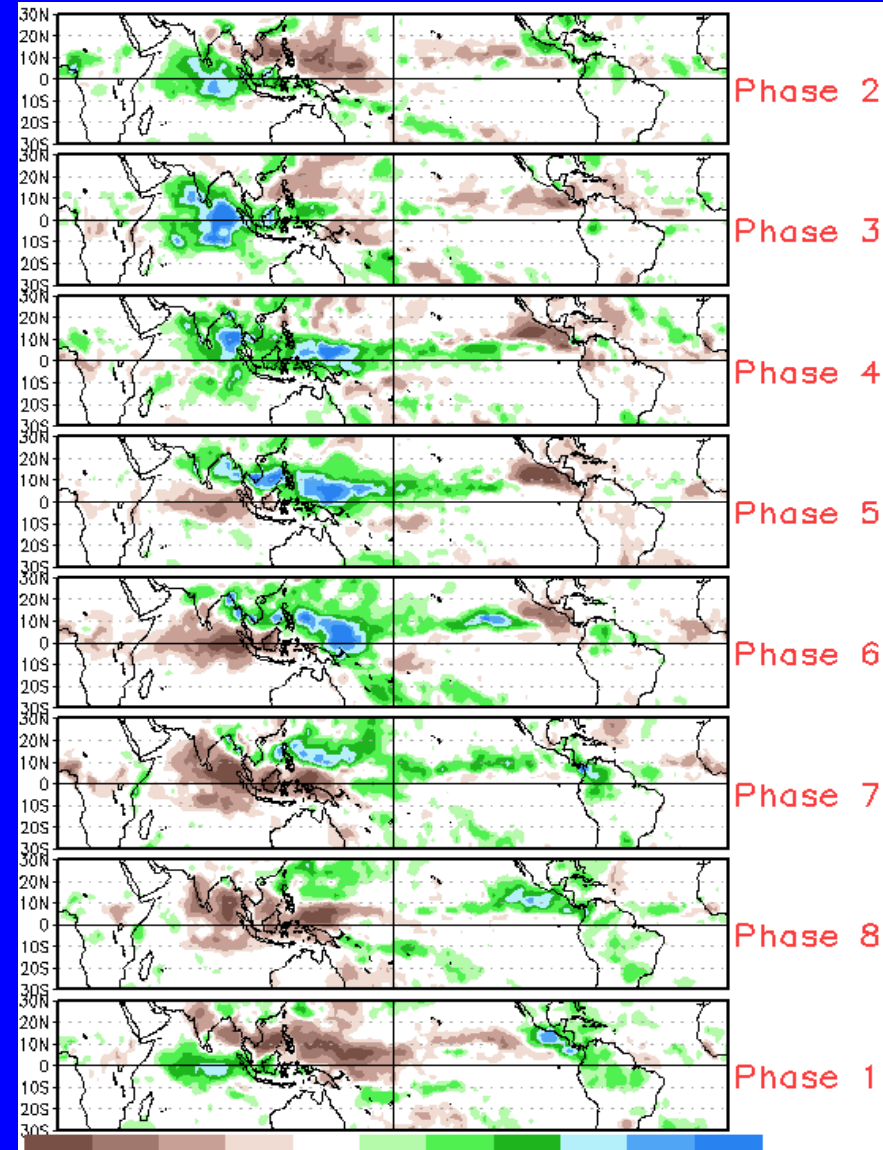
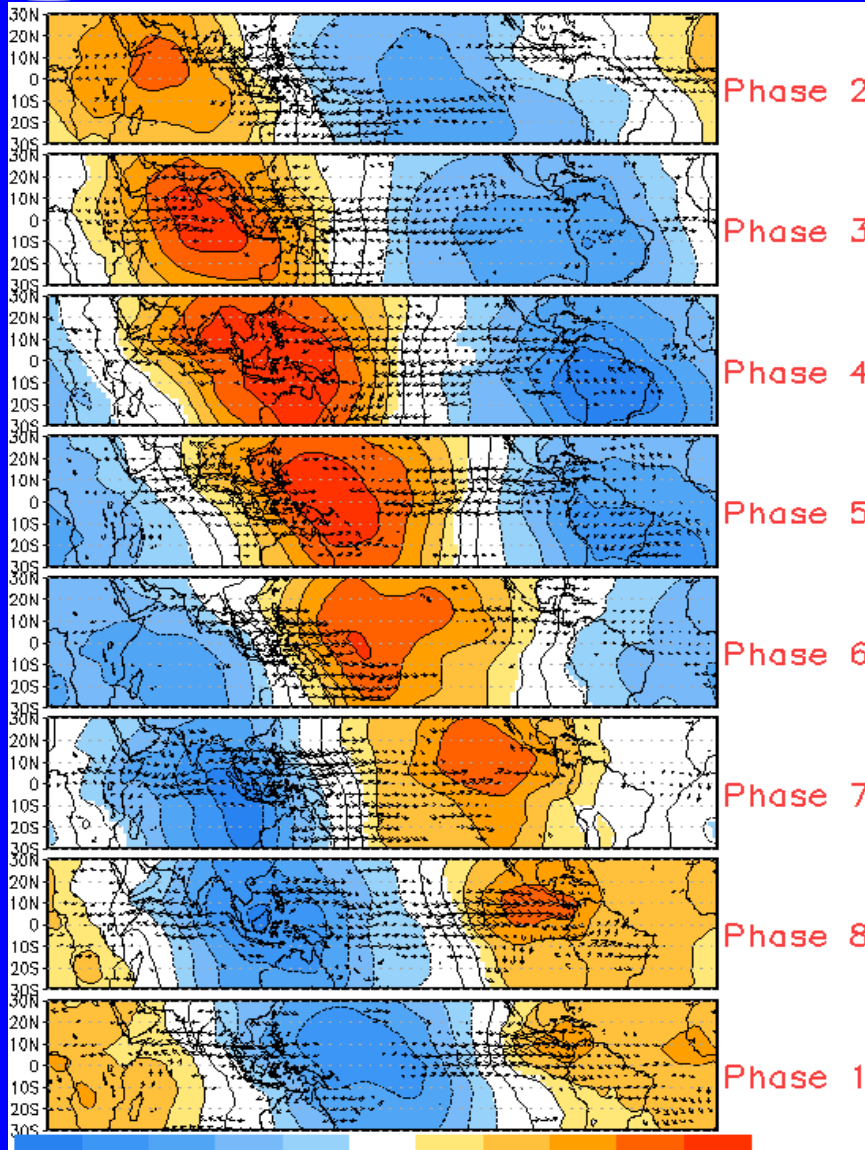
The statistical forecast depicts very slow eastward propagation of a robust MJO signal over the next two weeks.



# MJO Composites – Global Tropics

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

Precipitation Anomalies (Nov-Mar)

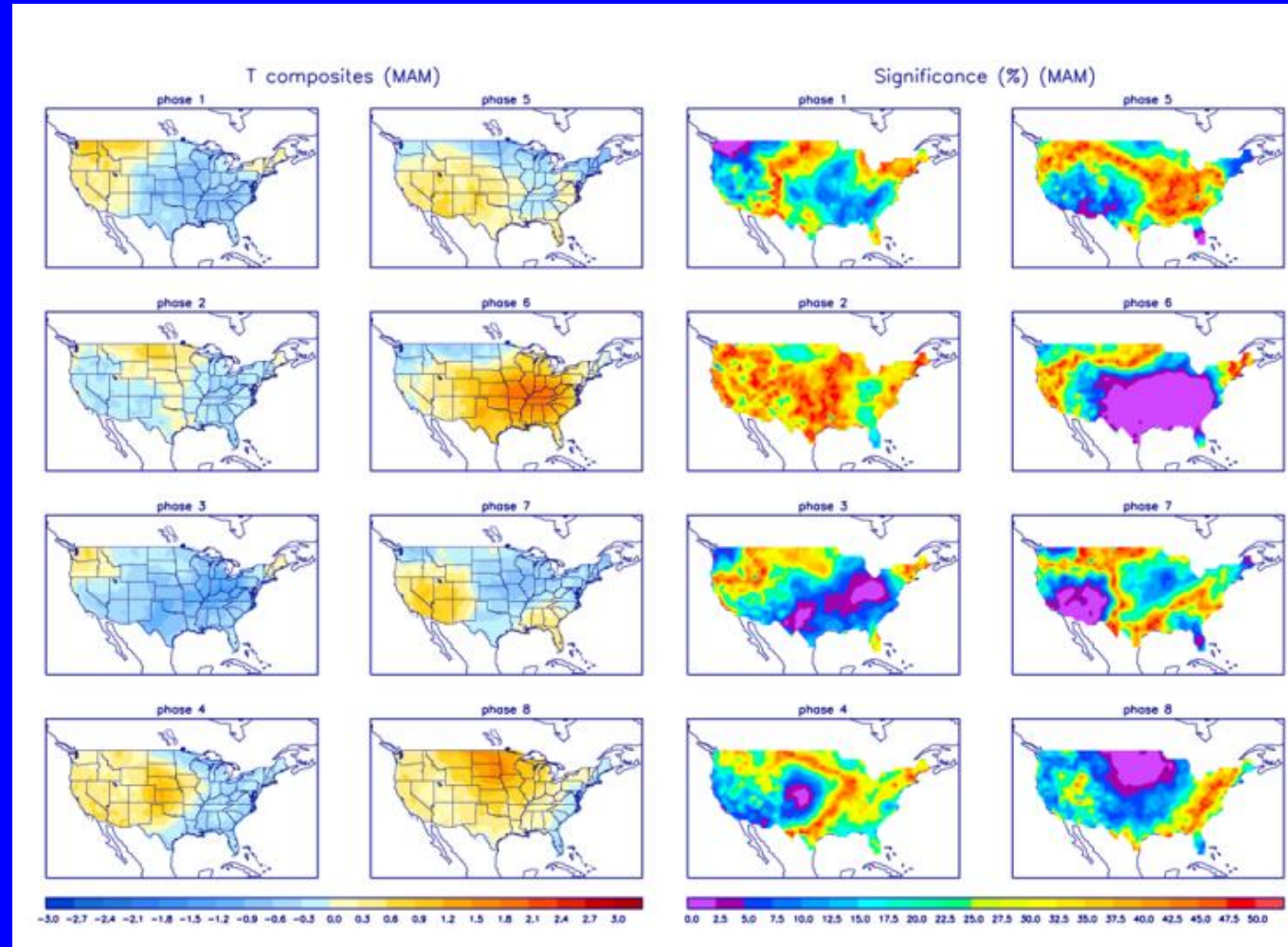




# U.S. MJO Composites – Temperature

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.



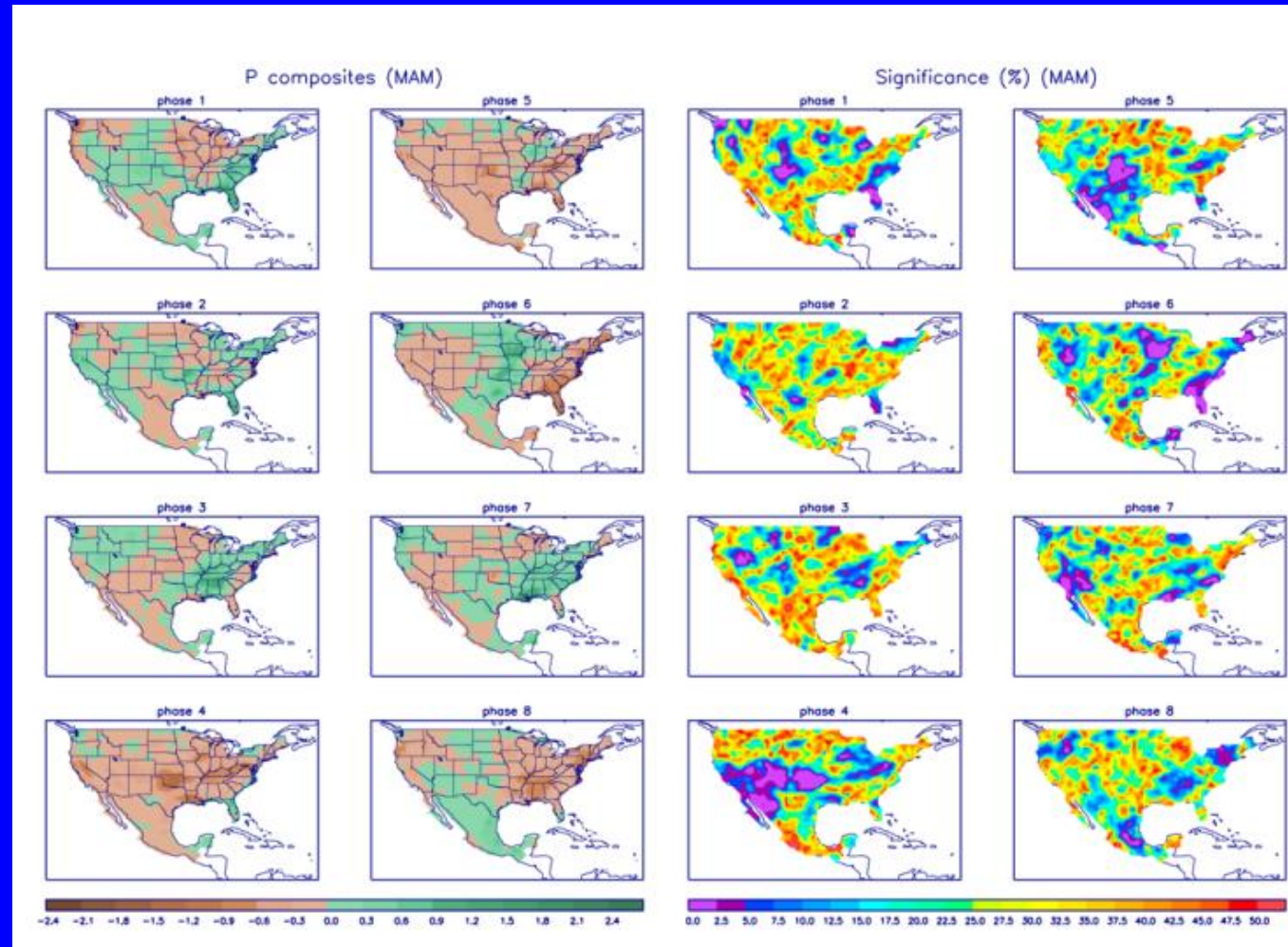
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>