



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

**Update prepared by  
Climate Prediction Center / NCEP  
September 8, 2014**



# Outline

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



# Overview

- **The MJO became increasingly coherent during the past several weeks, with MJO indices indicating the enhanced (suppressed) phase propagating over the Maritime Continent (Western Hemisphere).**
- **Other types of subseasonal variability, including tropical cyclones and Kelvin Waves, continue to play a large role in determining the pattern of anomalous tropical convection.**
- **Dynamical and statistical models do not support the continued evolution of a robust MJO signal during the upcoming two weeks.**
- **Based on recent observations and model guidance, the MJO, although subject to considerable interference from other modes, may contribute to enhanced convection over southeastern Asia and the northwestern Pacific.**

**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>**

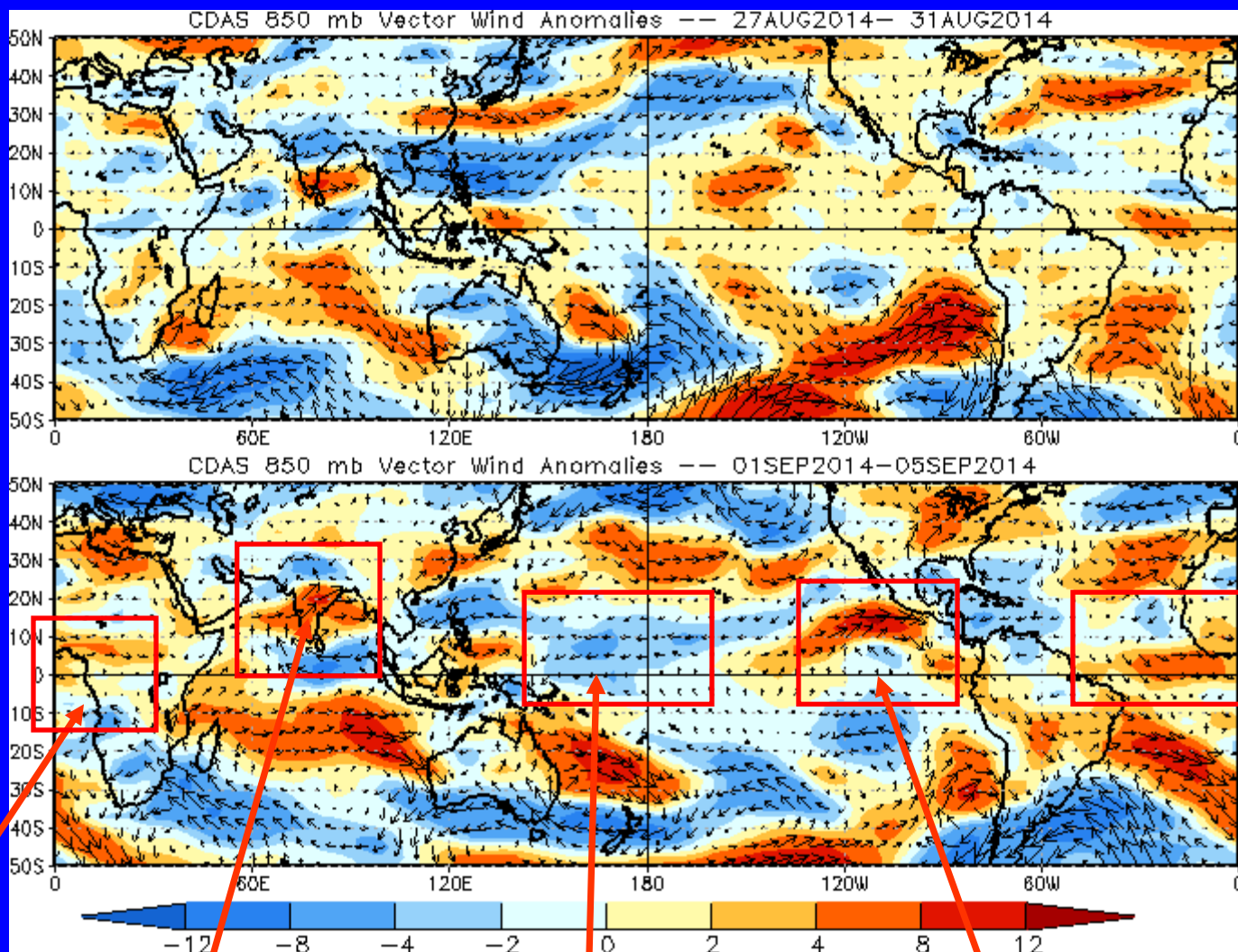


# 850-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies increased over Africa and persisted over the tropical Atlantic.

Monsoon flow increased over South Asia.

Weak easterly anomalies spread across the west-central Pacific.

Westerly anomalies increased north of the equator over the eastern Pacific, with weak anomalies on the equator.

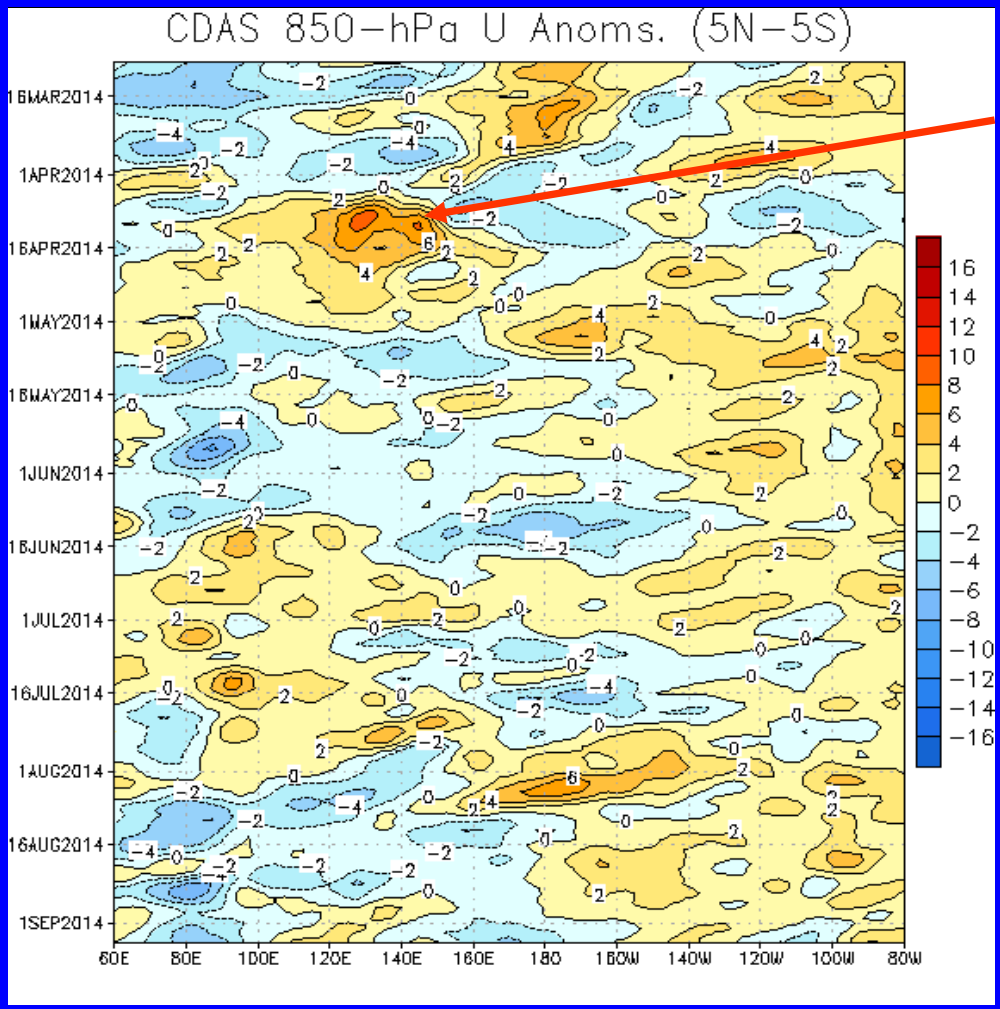


# 850-hPa Zonal Wind Anomalies ( $\text{m s}^{-1}$ )

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

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

Time  
↓



Longitude

A westerly wind burst was observed across the western Pacific in mid-April.

During April, westerly anomalies were generally persistent across the Maritime continent and far western Pacific.

During much of May and June, westerly anomalies were observed over the eastern Pacific. Westerly anomalies associated with an enhanced Southeast Asian monsoon circulation are evident from 80E to 120E during much of June and July.

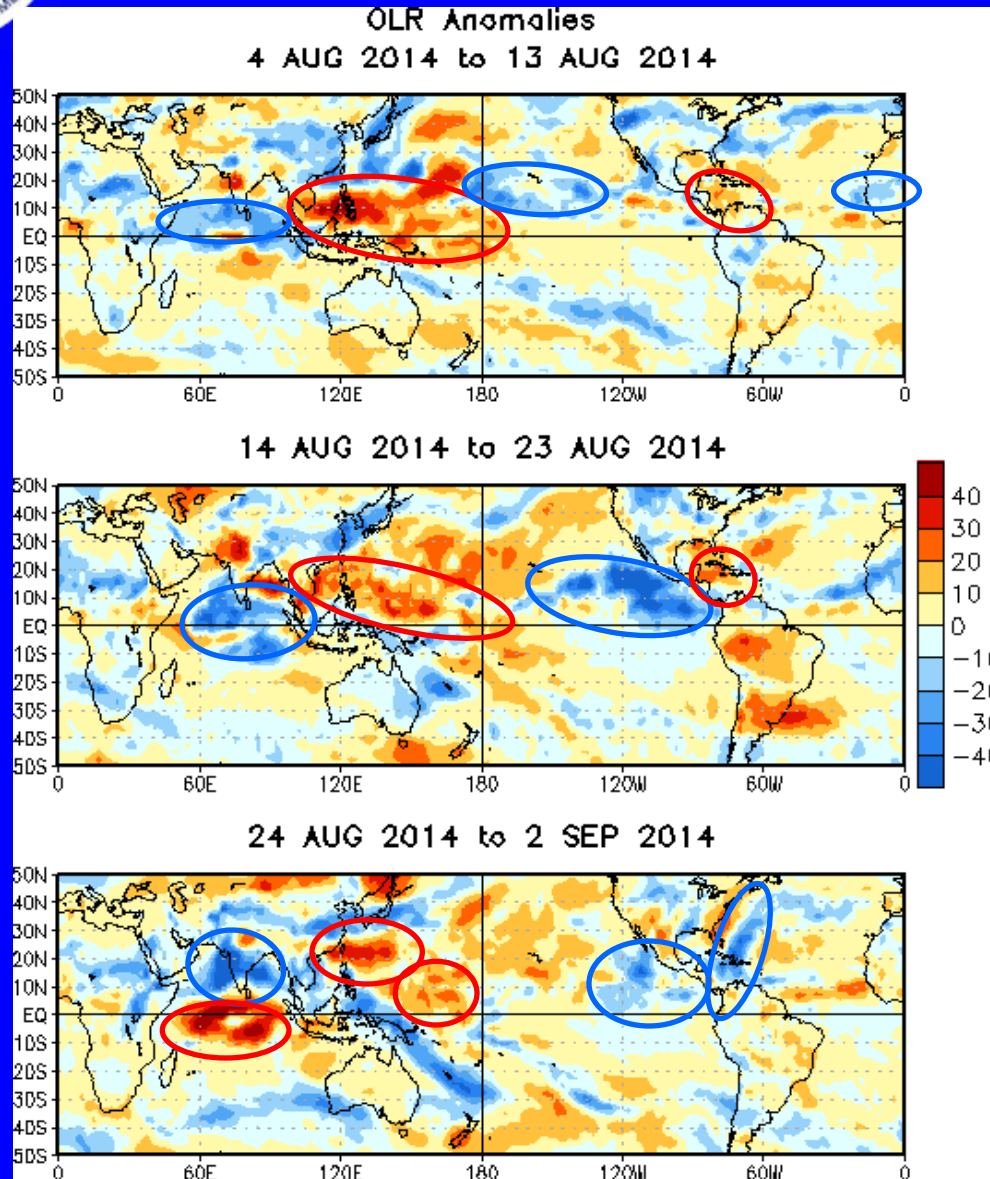
Beginning in late July into August, westerly (easterly) anomalies shifted westward over the eastern and central Pacific (western Pacific, Maritime Continent, and Indian Ocean). Recently, anomalies west of the Date Line have remained incoherent, with generally westerly anomalies persistent over the eastern Pacific.



# 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 August, enhanced (suppressed) convection was observed over the northern Indian Ocean (northwestern and west-central Pacific). Tropical cyclone activity was evident over the central Pacific.

During mid to late August, enhanced (suppressed) convection persisted over the central Indian Ocean (northwestern Pacific). Enhanced convection partly associated with tropical cyclone activity increased over the eastern Pacific, while suppressed convection persisted over the western Caribbean.

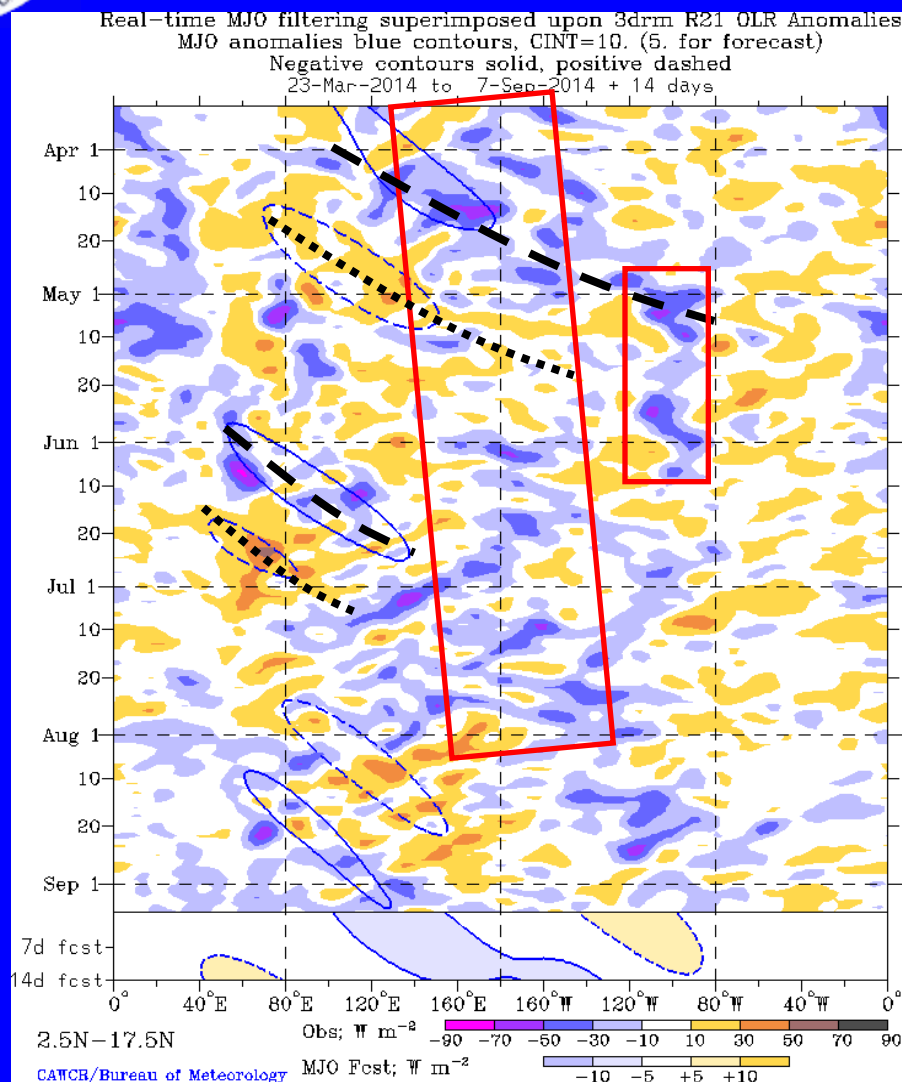
During late August and early September, enhanced convection propagated northward over South Asia, with suppressed convection overspreading the equatorial Indian Ocean. Convective anomalies weakened across the Pacific, with tropical cyclone activity evident over the western Atlantic and eastern Pacific.





# Outgoing Longwave Radiation (OLR)

## Anomalies (2.5°N-17.5°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)

Since March, enhanced convection has propagated slowly eastward from the Maritime Continent to the central Pacific (red box).

The MJO became more coherent during April, with the subseasonal envelopes of enhanced and suppressed convection modulating the strength of the low frequency signal. The anomalous tropical convection pattern became largely incoherent during mid-May, with enhanced convection centered over the eastern Pacific (red box).

During June, the MJO became more organized, primarily over the Indian Ocean, but during July and into early August the pattern became less coherent with respect to canonical MJO activity.

There is evidence of westward-moving subseasonal variability during the middle and latter parts of August, as well as an eastward-moving envelope of suppressed convection.

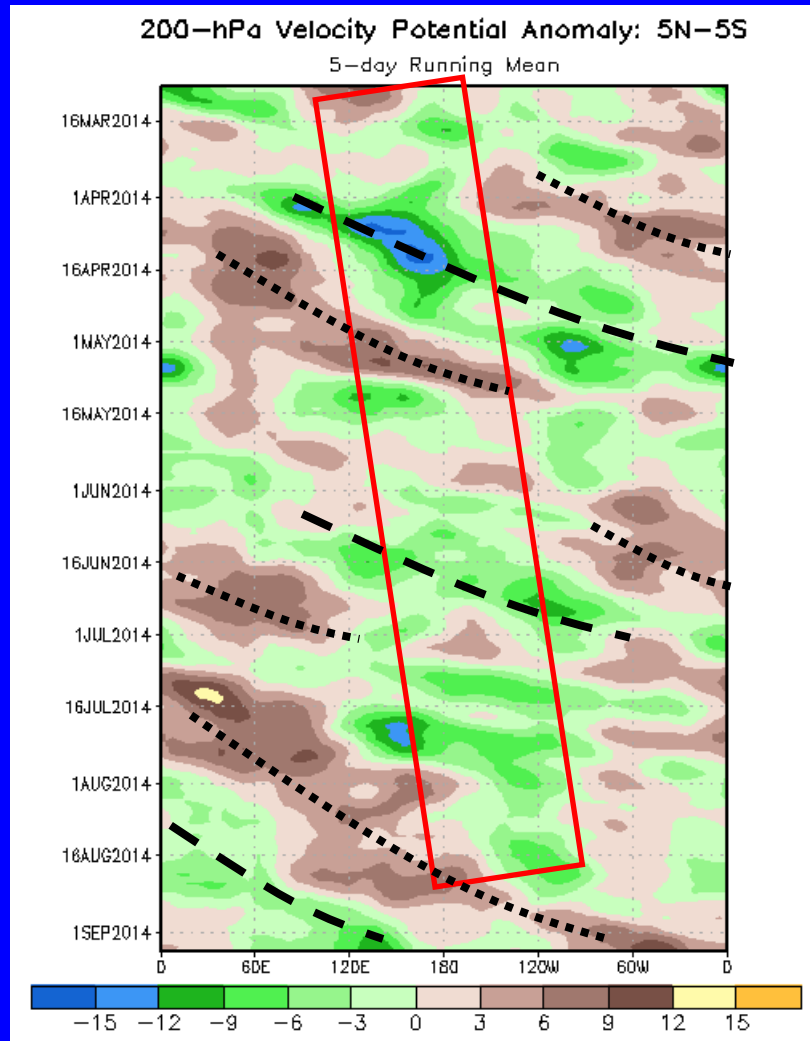


# 200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time



A slow eastward progression of negative anomalies was observed from January to present across the Indo-Pacific warm pool and central Pacific (red box).

During February through April, anomalies propagated eastward with time associated with the MJO before weakening for much of May.

The pattern became more organized during June with a more coherent wave-1 MJO-like structure with eastward propagation.

The pattern became less coherent during July and August as other modes of subseasonal tropical variability, e.g., equatorial Rossby and Kelvin wave activity, became the more dominant signals.

More recently, the signal strengthened with some eastward propagation.

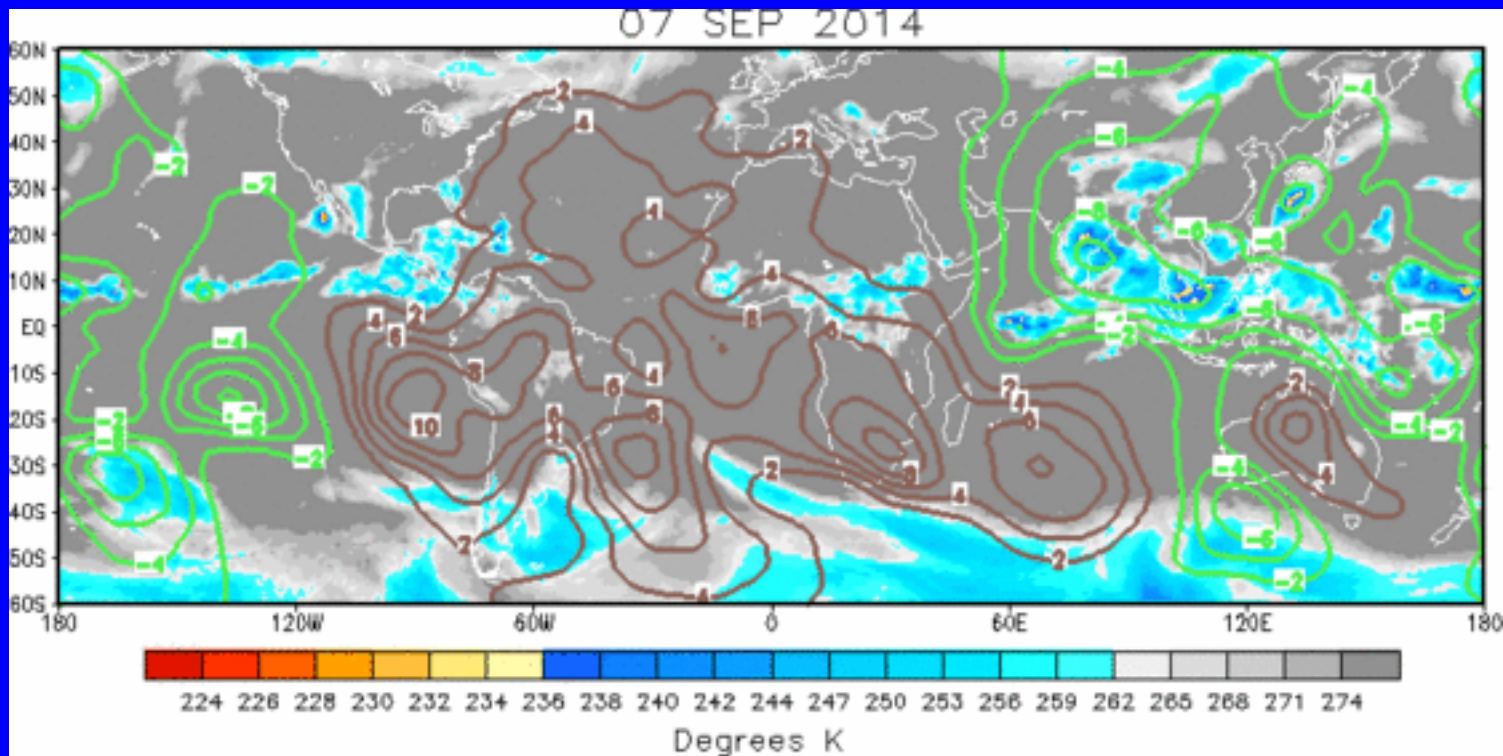




# IR Temperatures (K) / 200-hPa Velocity Potential Anomalies

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The upper-level anomalous velocity potential spatial pattern has become increasingly coherent, with large scale negative (positive) VP anomalies associated with anomalous ascent (descent) over the northern Indian Ocean, Maritime Continent, and western Pacific (the Atlantic and Africa). The pattern is weaker over the Pacific.

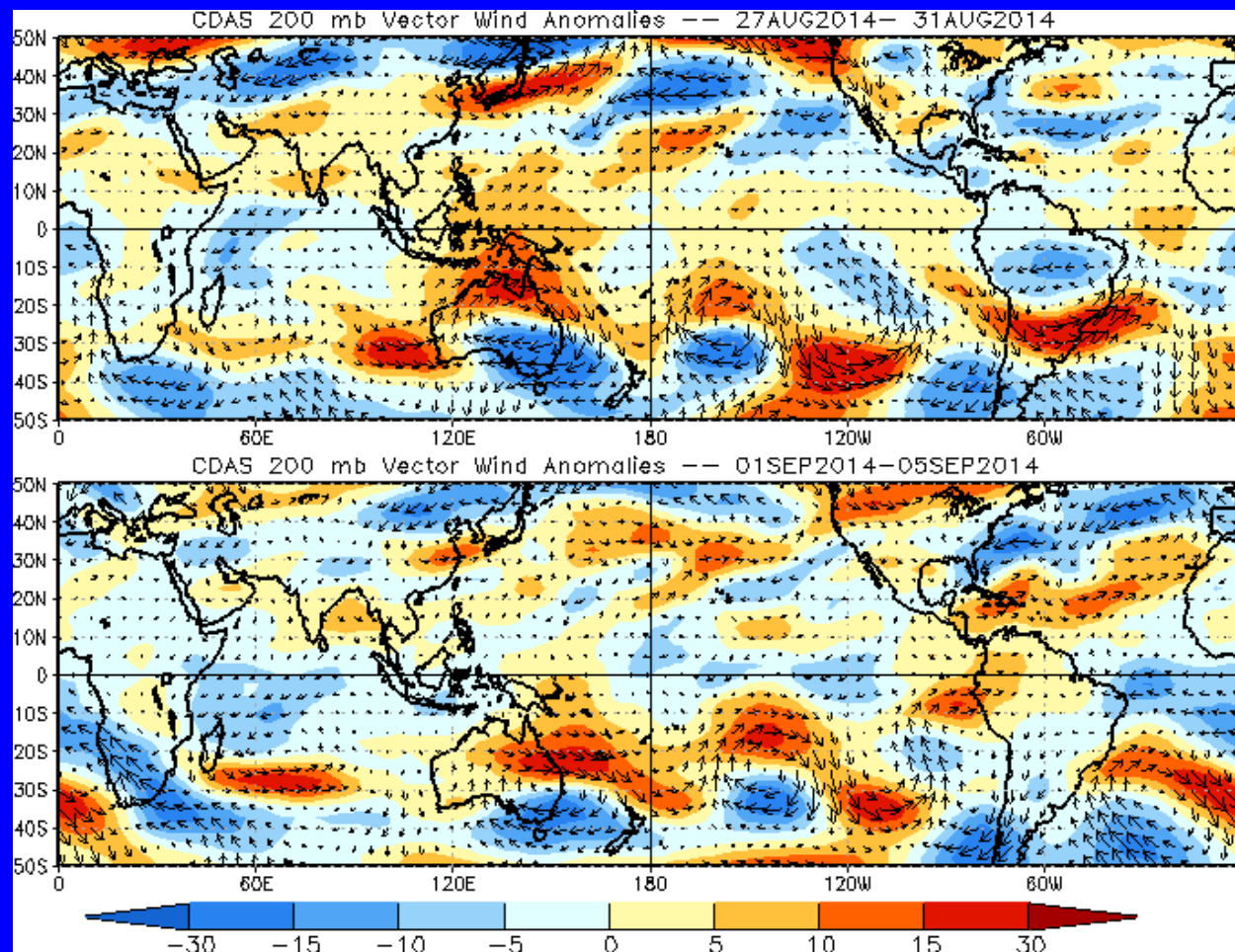


# 200-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



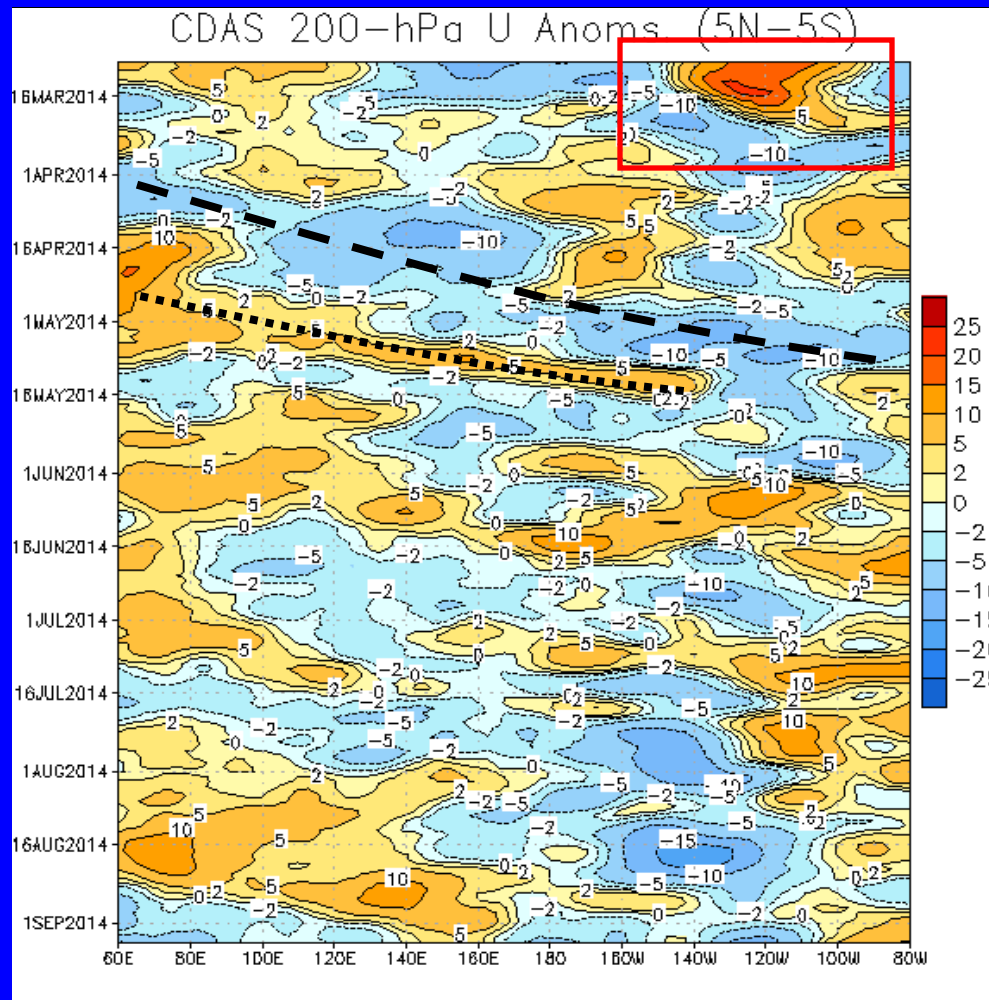
The upper level zonal wind anomaly pattern weakened during early September, with weak easterly anomalies over the Indian Ocean.



# 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



In March, westerly anomalies were most prevalent across the western Hemisphere (red box).

MJO activity is evident in the eastward propagation of both easterly and westerly anomalies during April and early May. This signal weakened during late May.

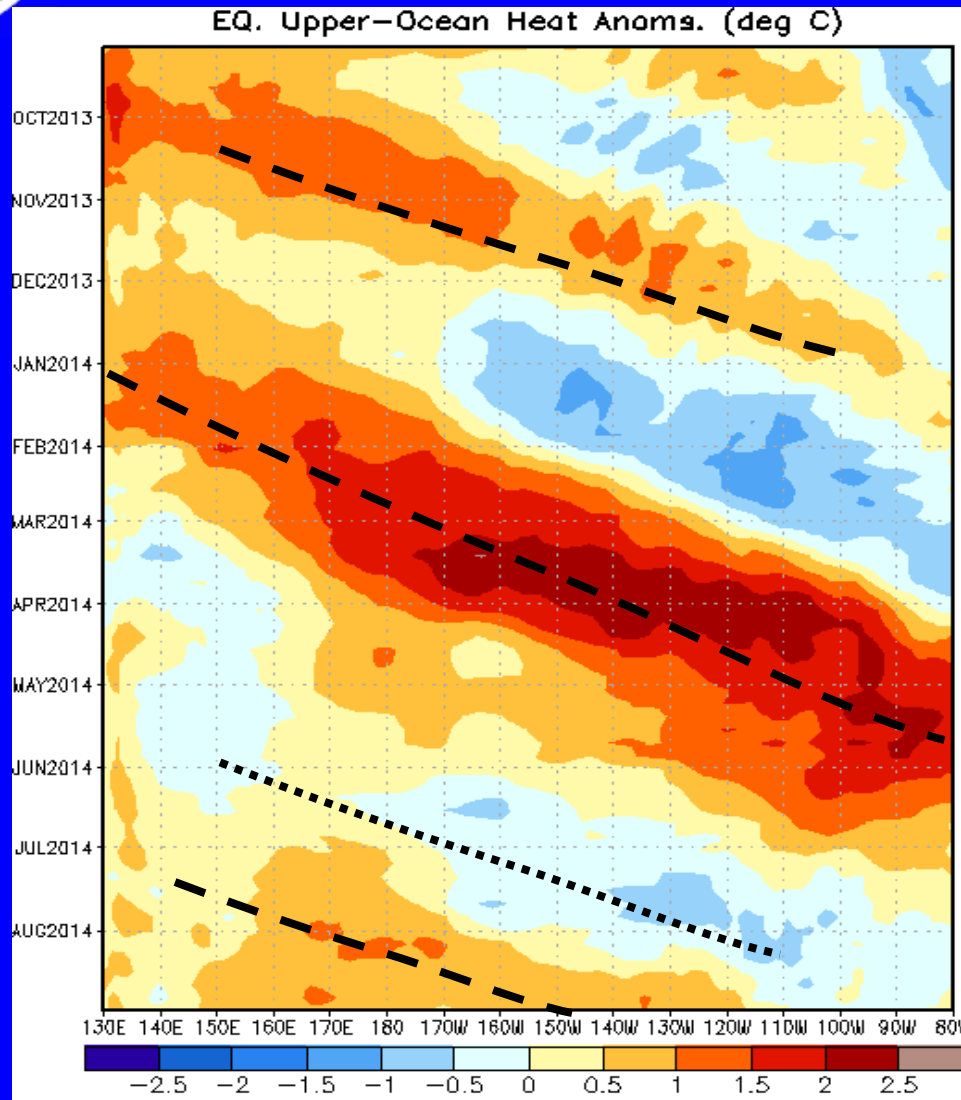
Westward propagation of westerly anomalies is evident over the east-central Pacific during June. In July, easterly anomalies intensified over the central and eastern Pacific.

Westward propagation of westerly anomalies was present over the western Pacific and Maritime Continent during early August.

Recently, fairly coherent eastward propagation of a wave-1 signal is evident.



# Weekly Heat Content Evolution in the Equatorial Pacific



Oceanic downwelling Kelvin wave activity is evident in late August 2013 and once again during October through early December 2013.

A considerably stronger downwelling event began in January 2014 and propagated across the Pacific.

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

Warm anomalies are again evident across much of the Pacific due to another downwelling Kelvin wave.





# **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.

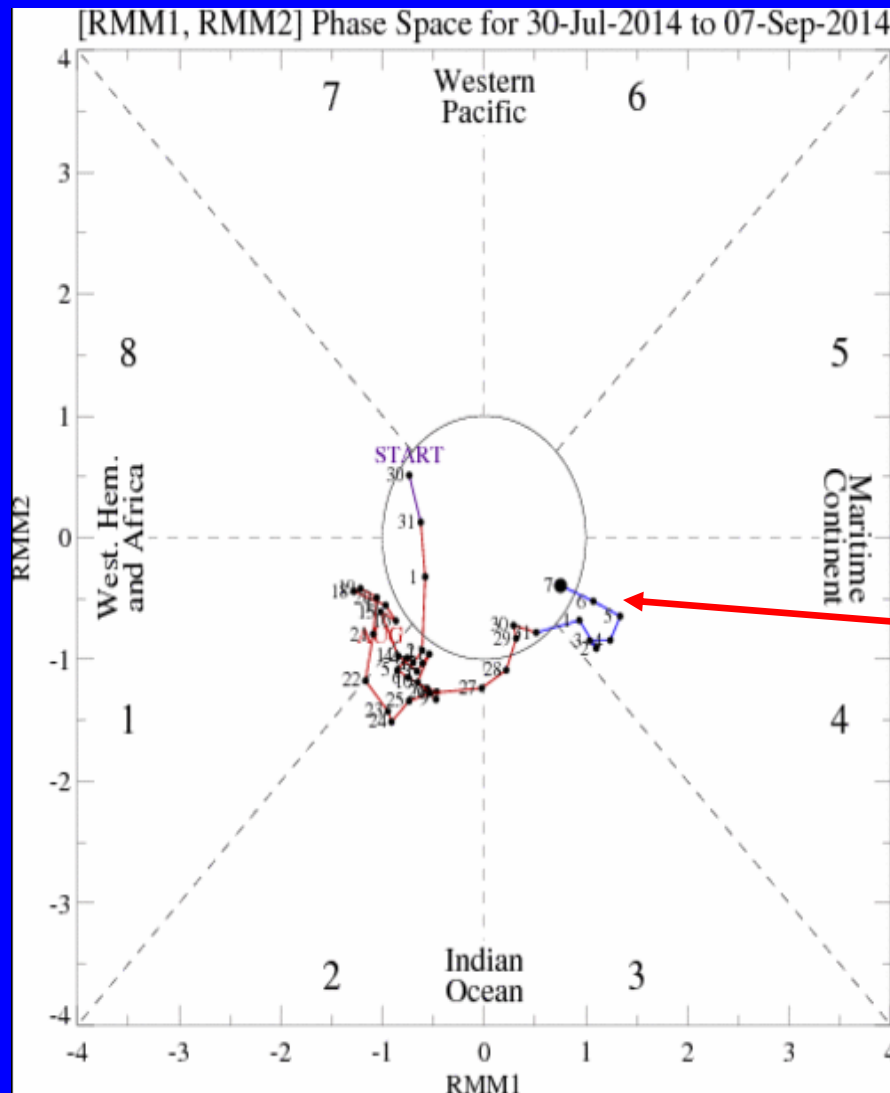
**Gottschalck et al. 2010: A Framework for Assessing Operational Madden-Julian Oscillation Forecasts: A CLIVAR MJO Working Group Project, *Bull. Amer. Met. Soc.*, 91, 1247-1258.**

- 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

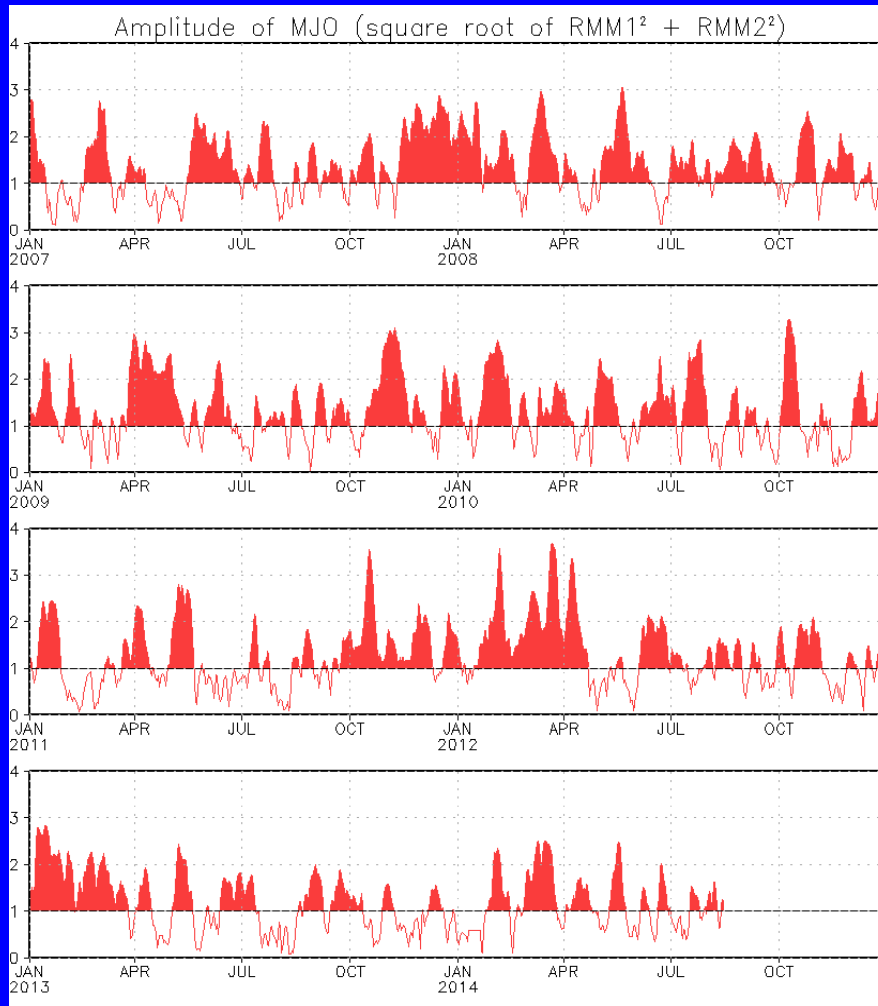


The RMM MJO index indicates the presence of a subseasonal signal propagating from the Indian Ocean to the Maritime Continent during the past two weeks, although the amplitude of the index decreased during the past two days.





# 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

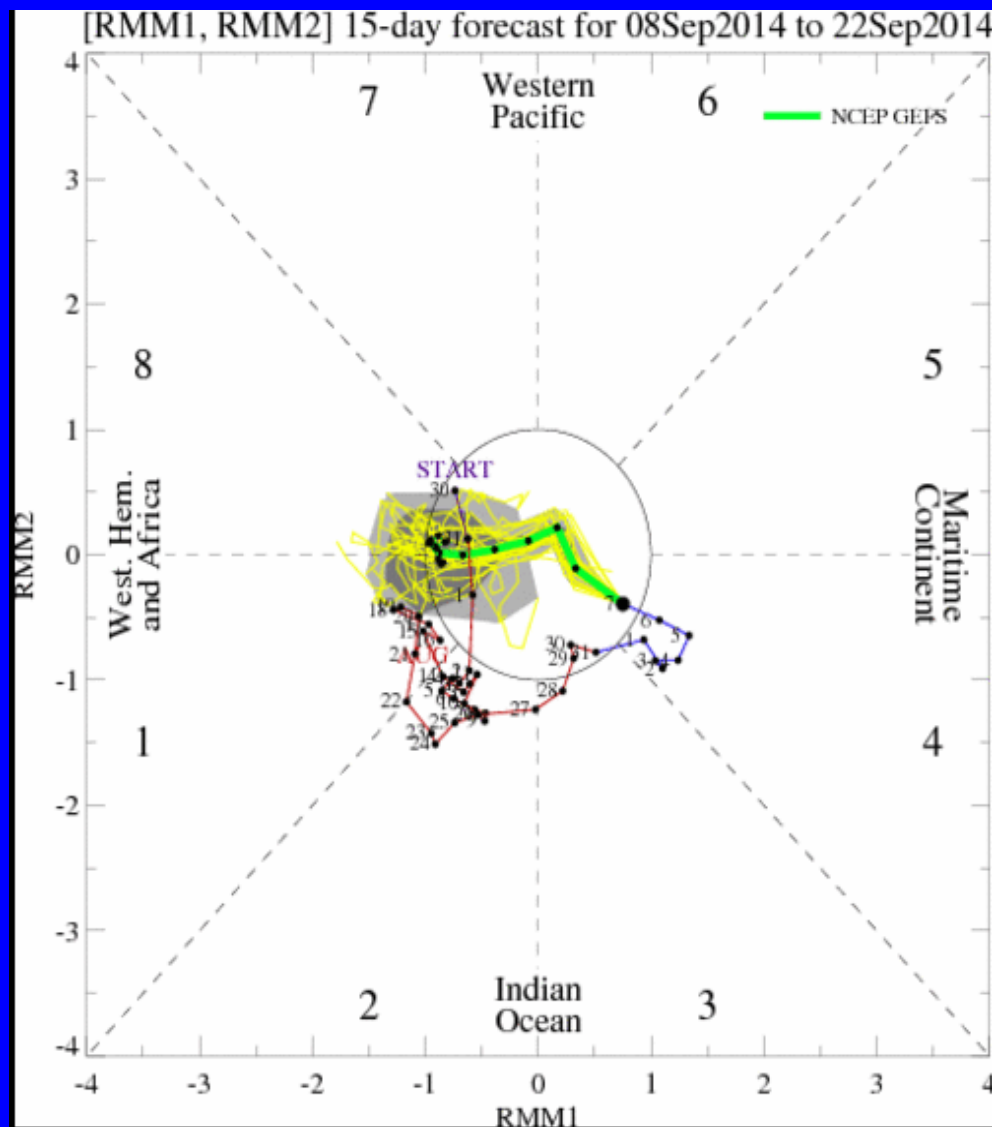
Green Line – Ensemble Mean

**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 ensemble GFS forecast indicates a weak MJO signal during the upcoming two weeks.

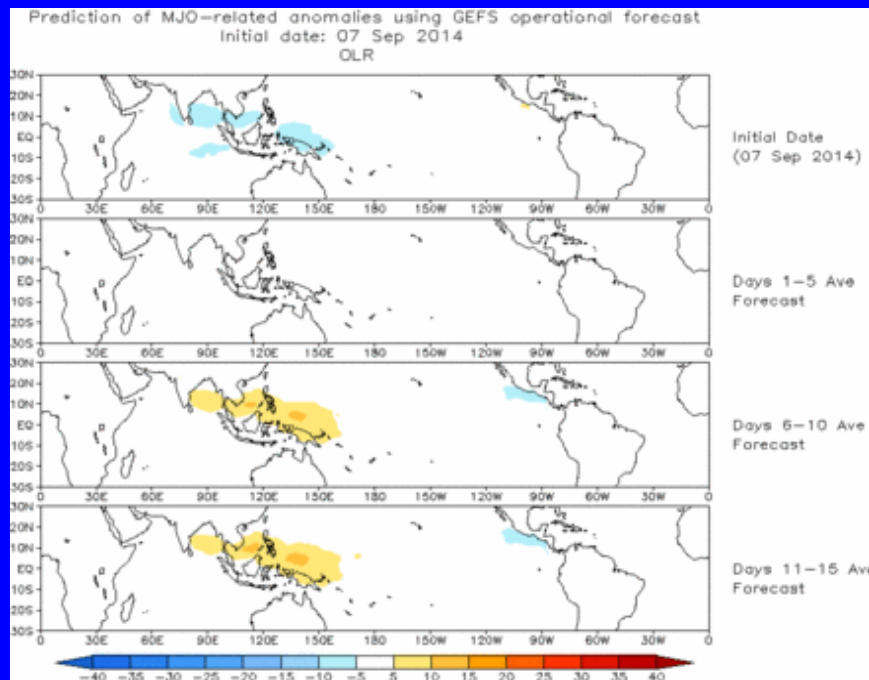




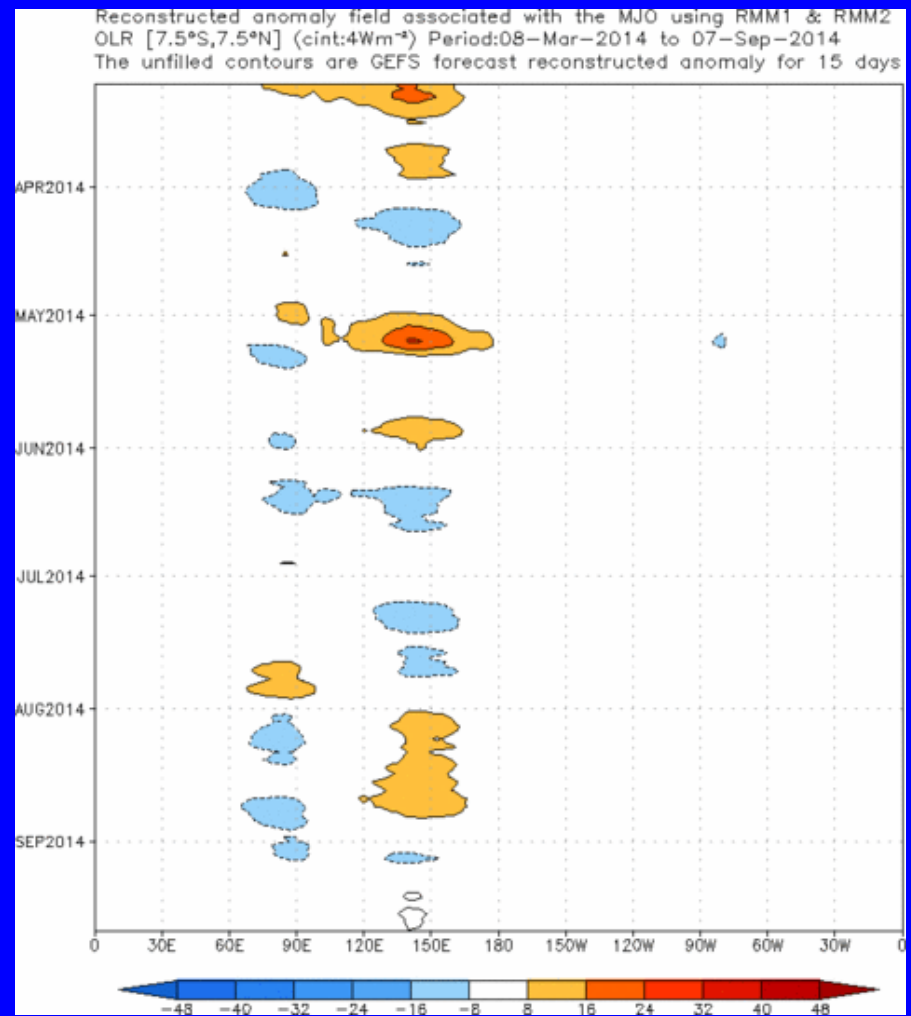
# Ensemble Mean GFS MJO Forecast

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



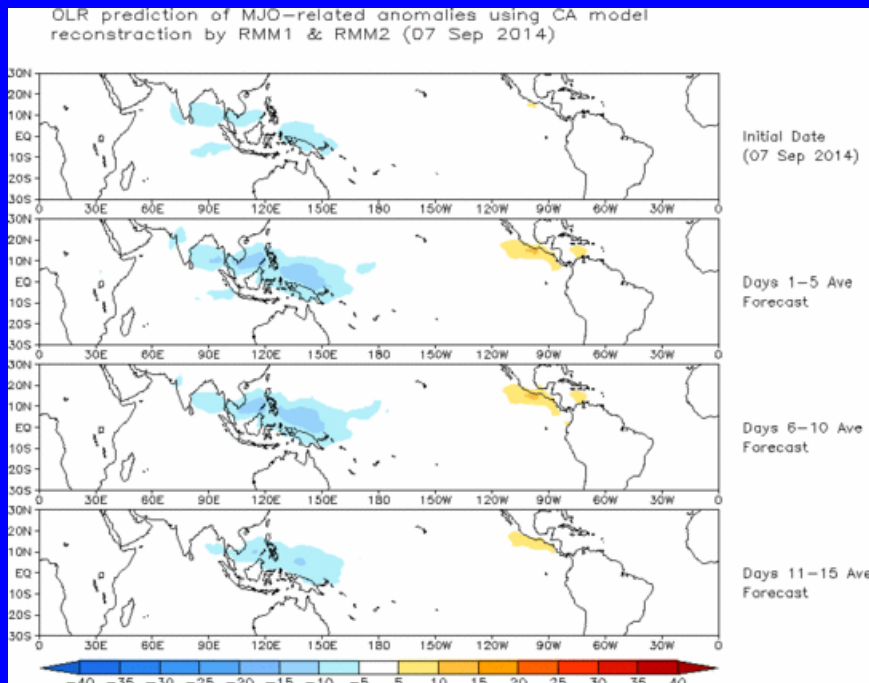
The ensemble mean GFS forecasts a weak anomaly pattern during the upcoming two weeks.



# Constructed Analog (CA) MJO Forecast

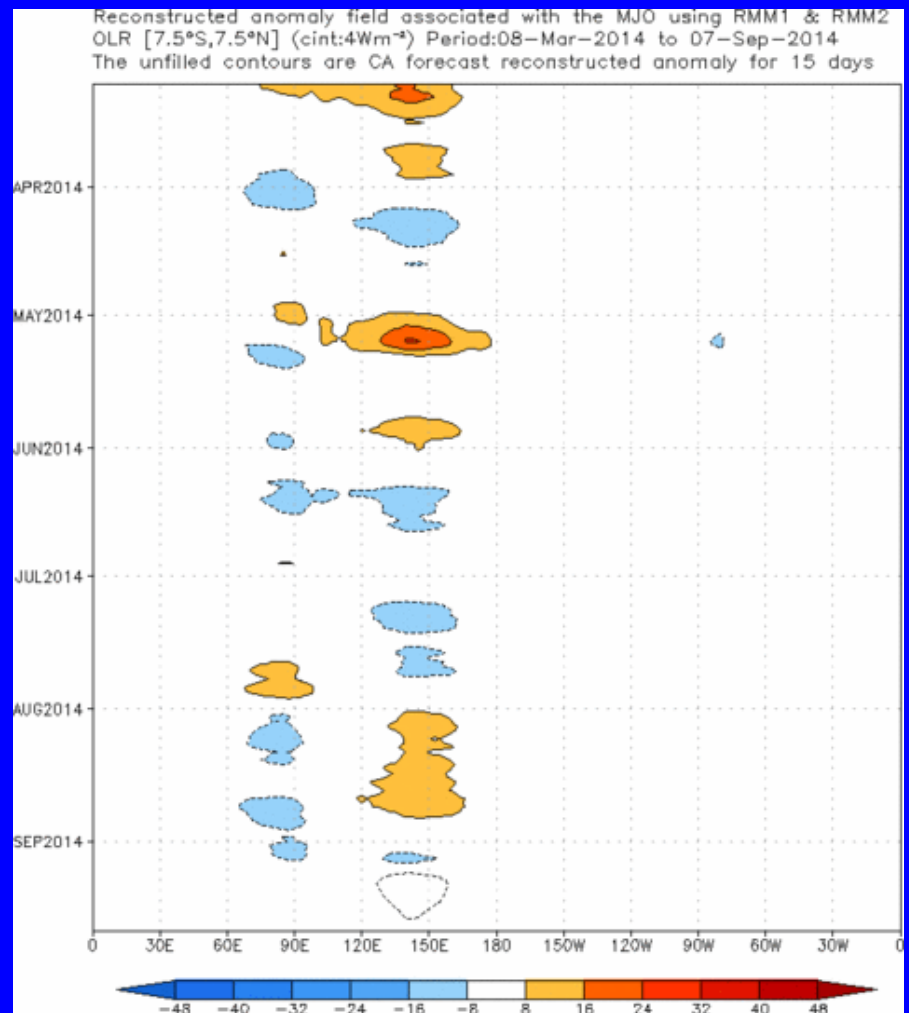
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

## Spatial map of OLR anomalies for the next 15 days



The constructed analog forecast depicts a fairly stationary pattern, with enhanced (suppressed) convection over the western Pacific (eastern Pacific and Caribbean).

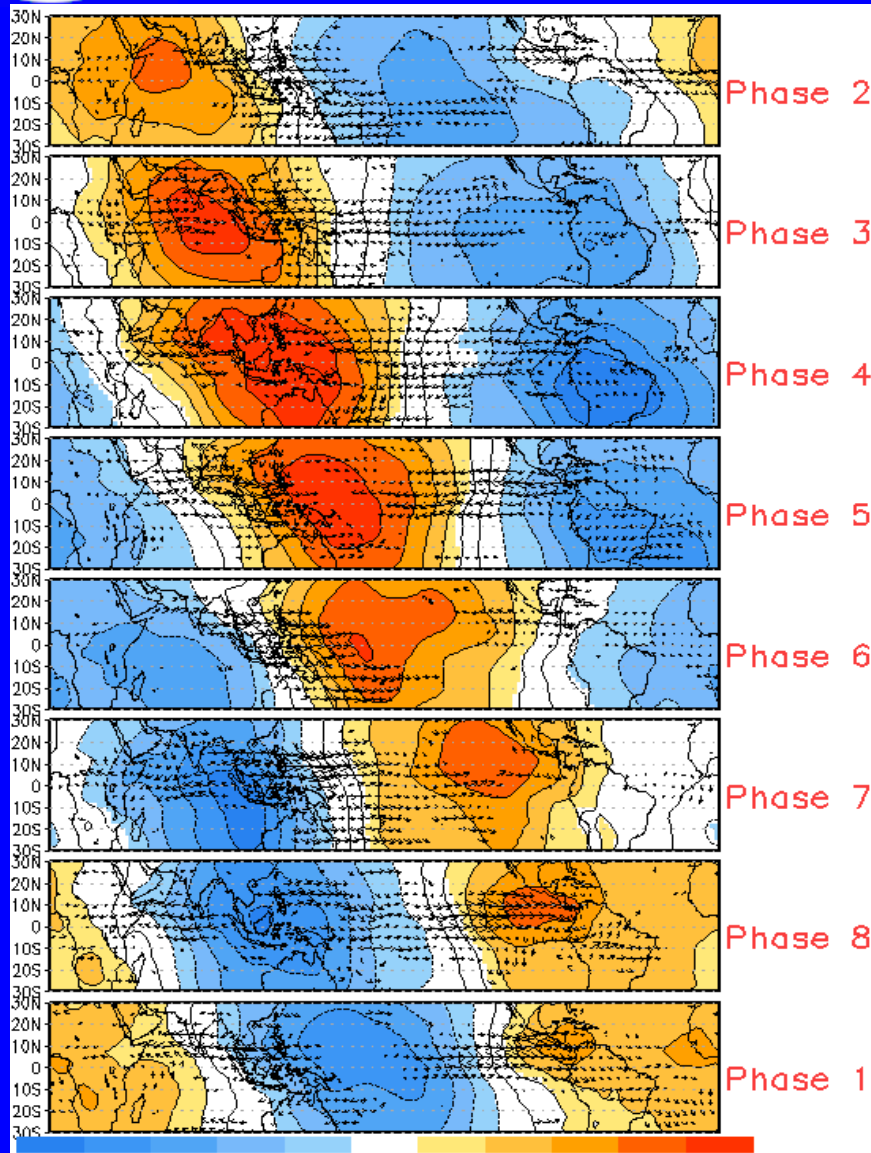
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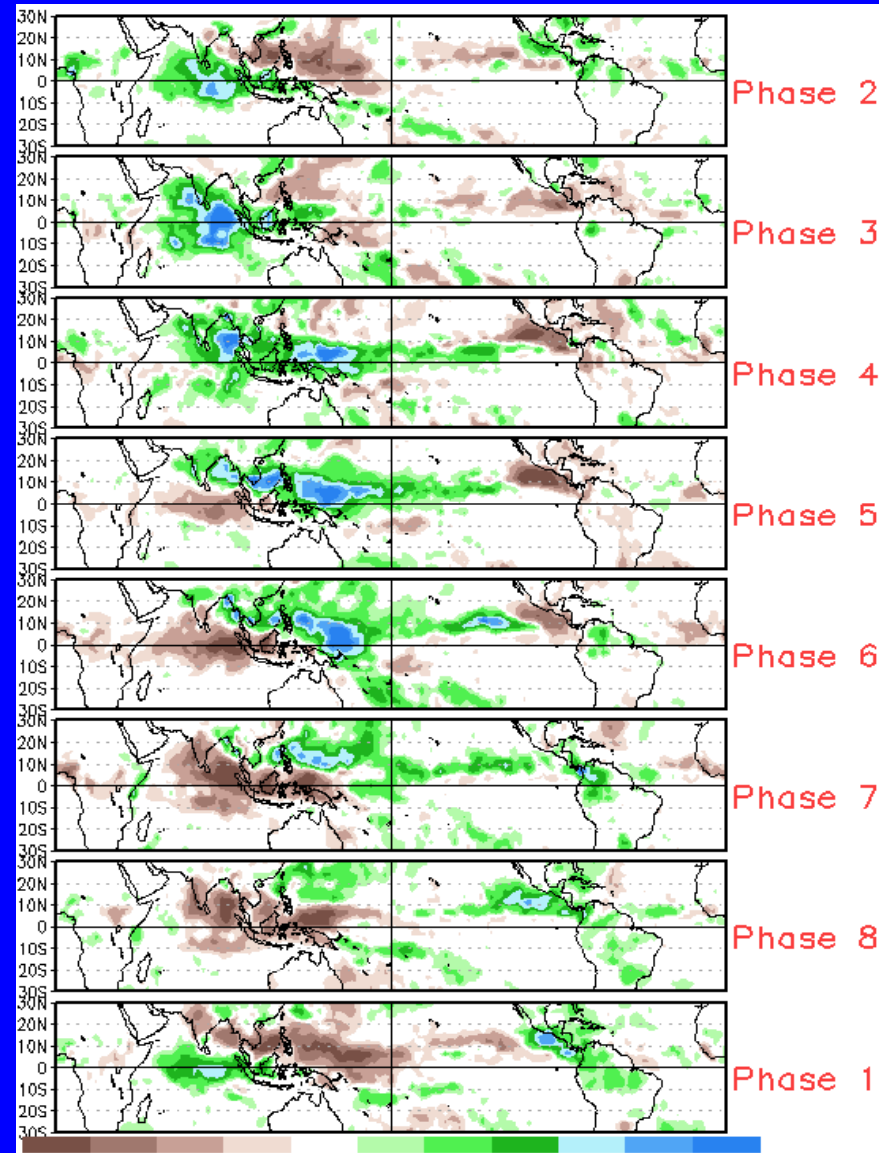


# MJO Composites – Global Tropics

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



Precipitation Anomalies (May-Sep)



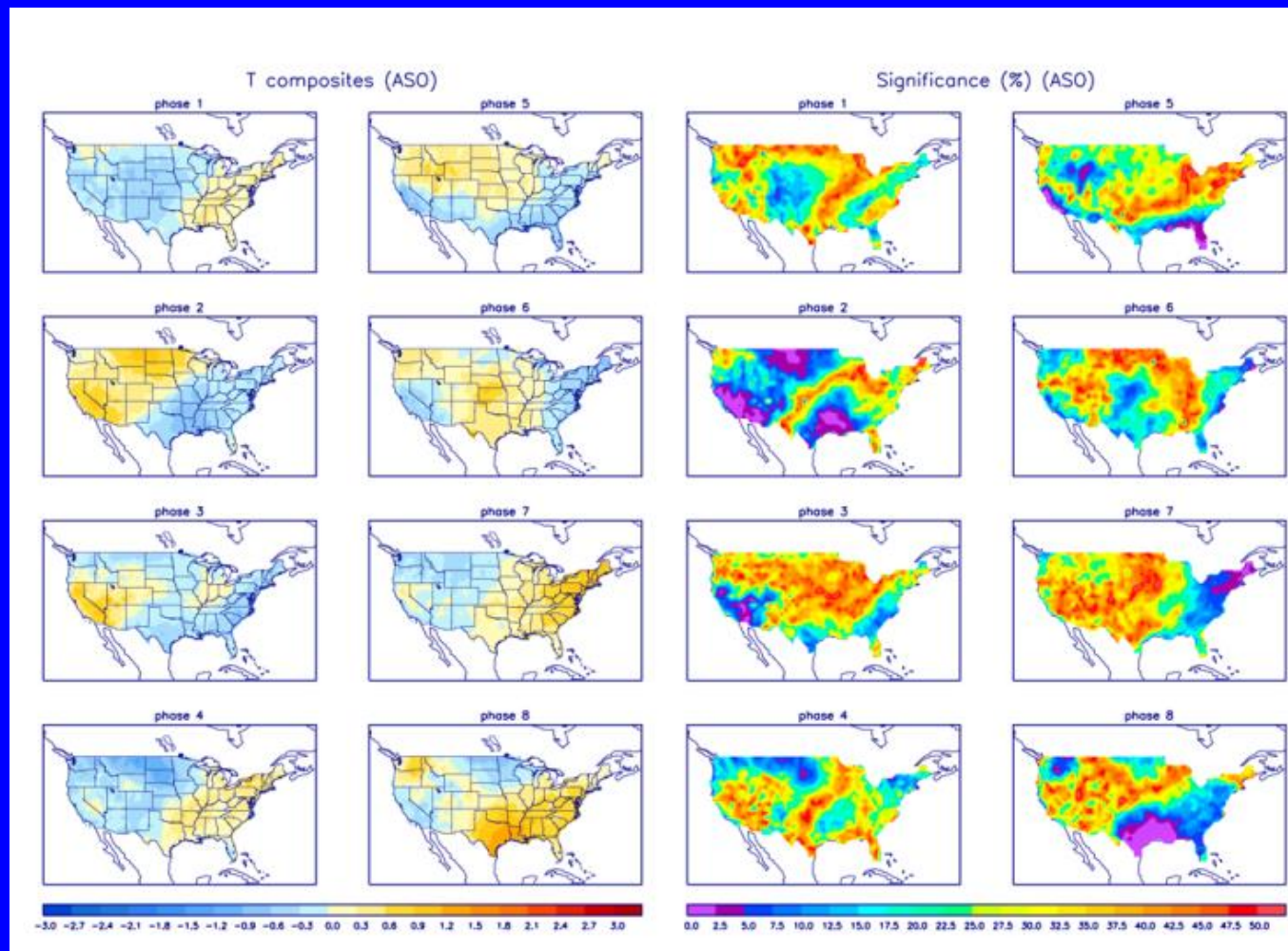




# U.S. MJO Composites – Temperature

- 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

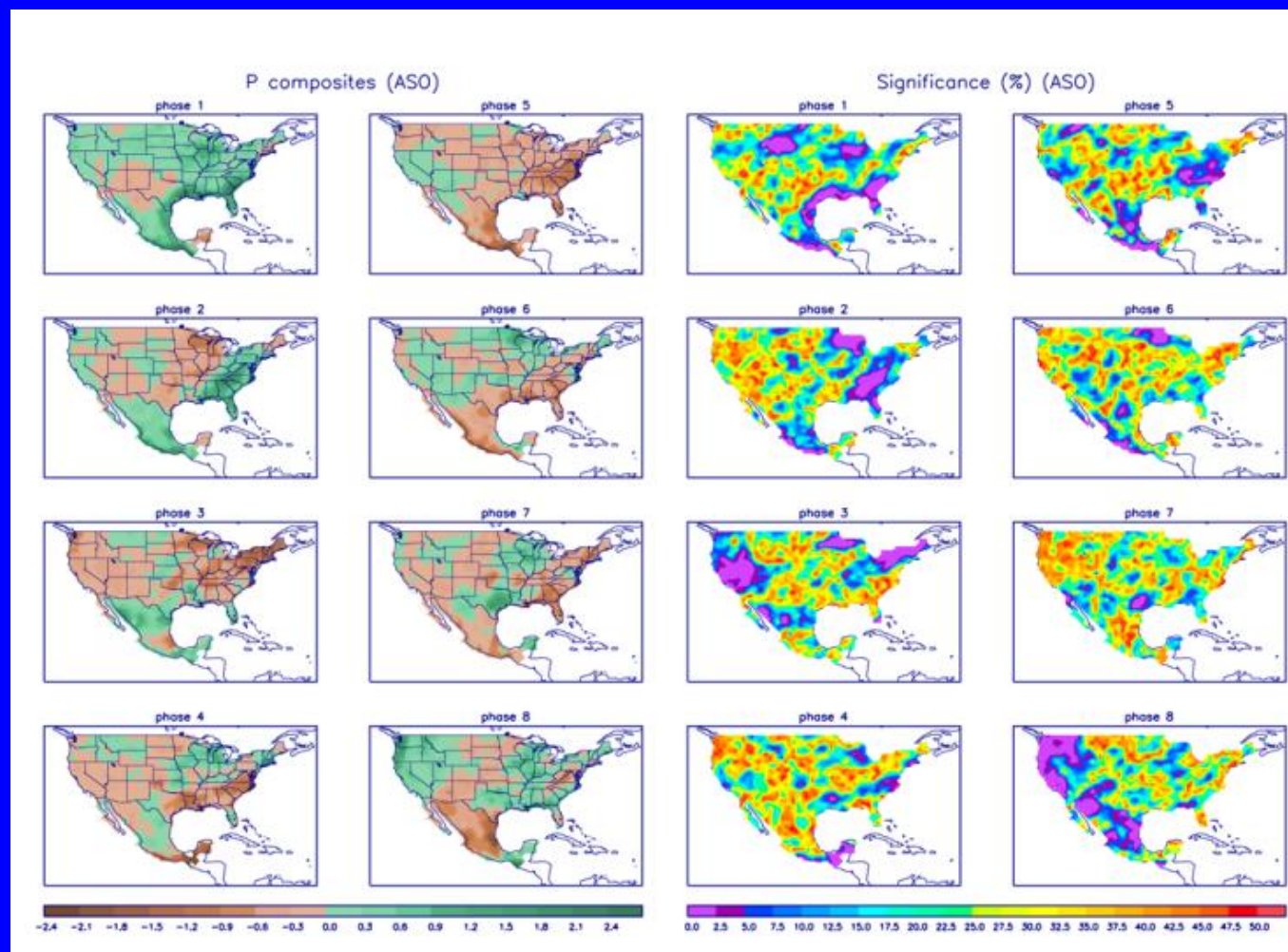
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml>





# 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.



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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