



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

**Update prepared by  
Climate Prediction Center / NCEP  
October 20, 2014**



# Outline

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



# Overview

- **The MJO became more coherent during the past week with the enhanced phase currently centered over Africa.**
- **Other types of subseasonal variability, including tropical cyclones, continue to play a large role in determining the pattern of anomalous tropical convection.**
- **Dynamical models indicate varying MJO outcomes, while statistical tools favor a nearly stationary pattern of anomalous convection.**
- **Based on recent observations and model guidance, the MJO is not expected to be a major contributor to anomalous convection across the global tropics.**

**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>**

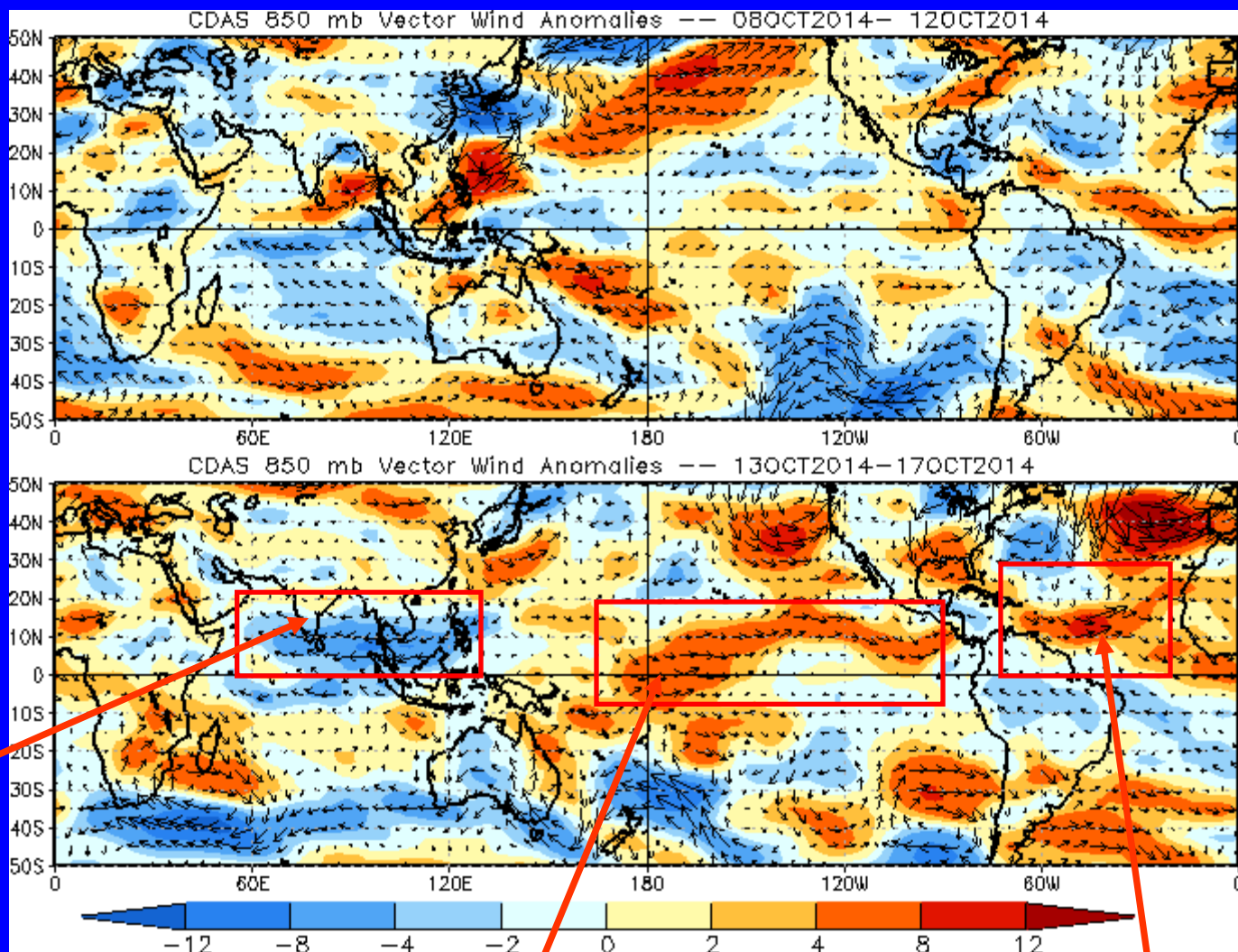


# 850-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies returned to India and expanded east to the Philippines.

Westerly anomalies strengthened across the central and eastern Pacific during the past 5 days.

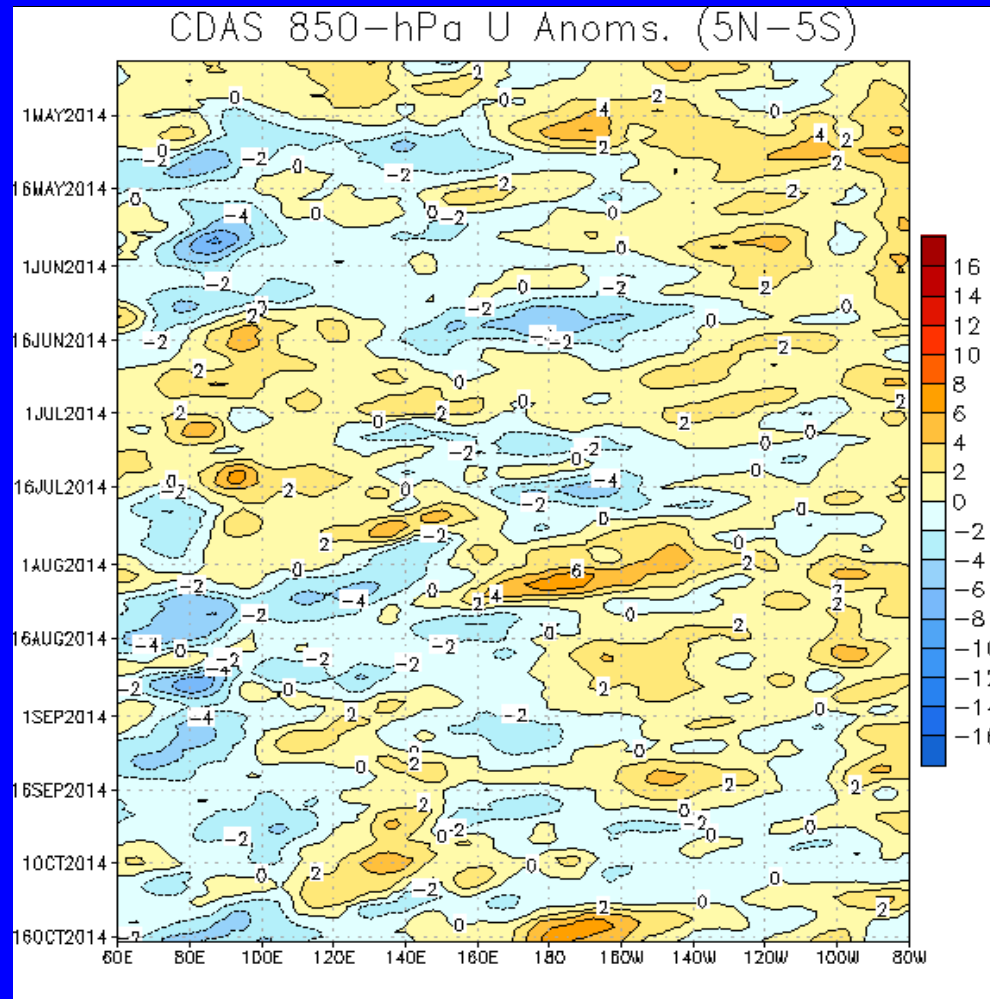
Westerly anomalies over the Atlantic also strengthened.



# 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 much of May and June, westerly anomalies were observed over the eastern Pacific. An enhanced South Asian monsoon circulation developed during much of June and July.

From late July to August, westerly (easterly) anomalies shifted westward over the eastern and central Pacific (western Pacific, Maritime Continent, and Indian Ocean).

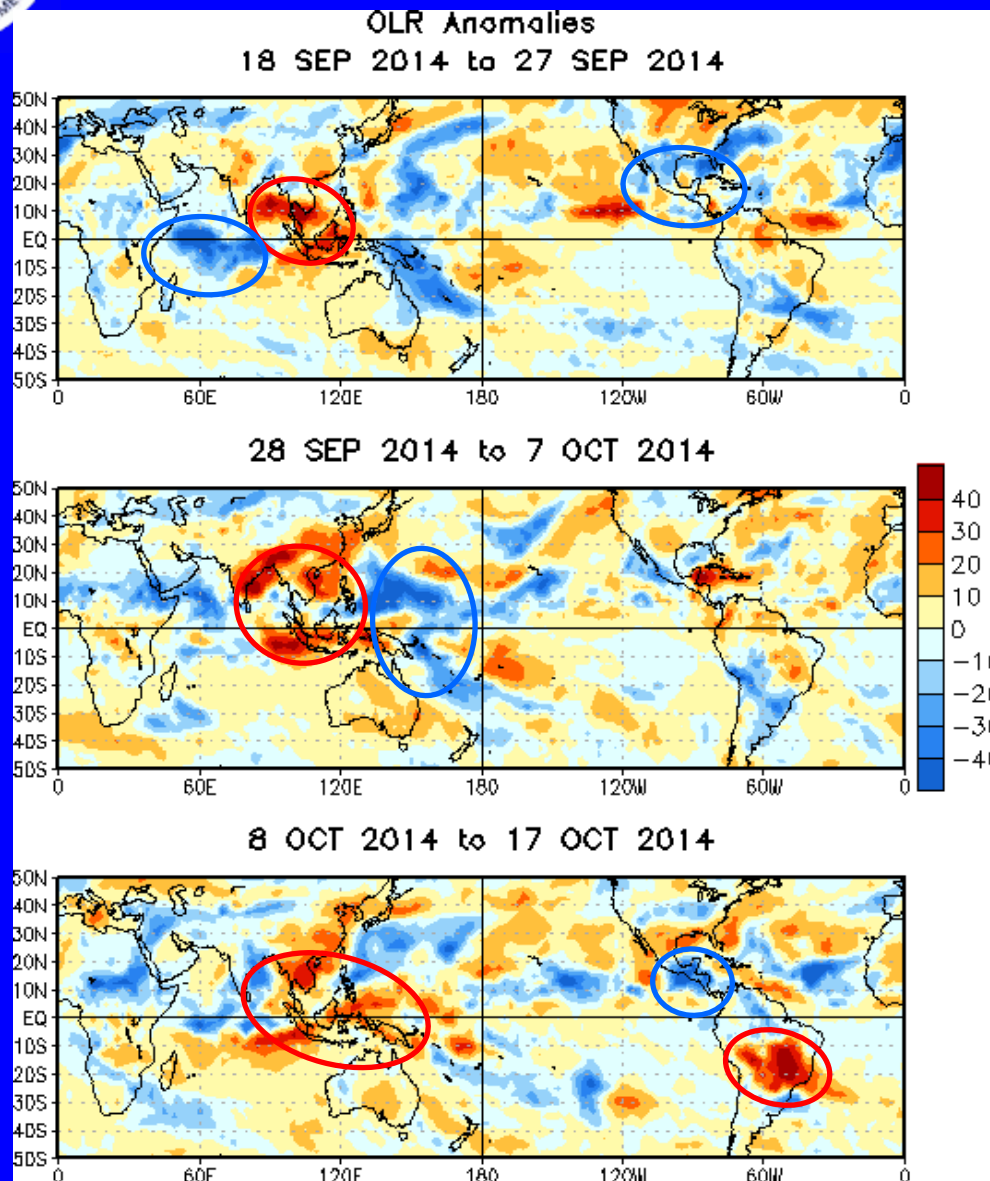
Westerly anomalies strengthened near the Date Line during mid-October.



# 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 late September, suppressed (enhanced) convection was observed over Southeast Asia (parts of North America). Suppressed convection remained over Northern South America, while enhanced convection developed across the Indian Ocean.

From late September to early October, suppressed convection became entrenched over Southeast Asia and the Maritime Continent, while tropical cyclone activity contributed to enhanced convection over the West Pacific.

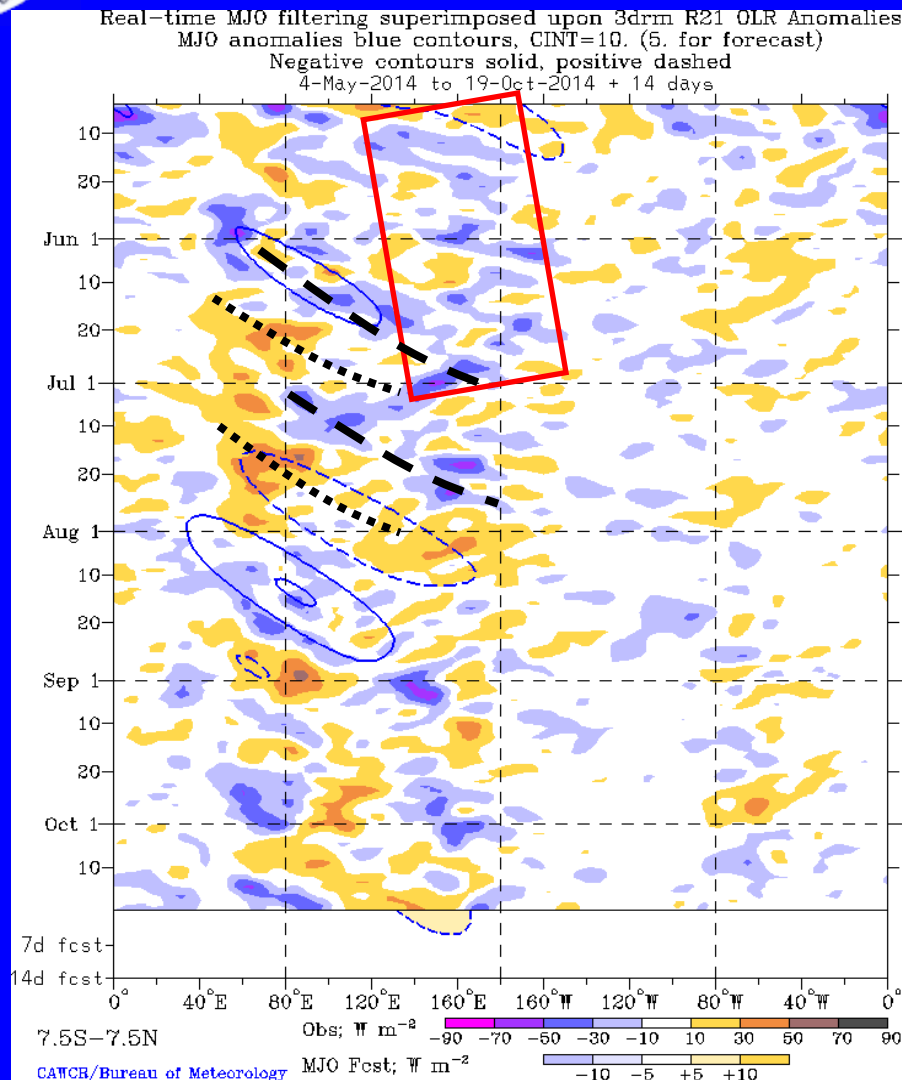
Suppressed convection persisted over the Maritime Continent during early to mid-October. Enhanced convection was observed across Central America with suppressed convection across southern Brazil.





# 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)**

**During May and June, enhanced convection propagated slowly eastward from the Maritime Continent to the central Pacific (red box).**

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

**There is evidence of westward-moving subseasonal variability from mid-August and later. Some evidence of faster, eastward moving waves is also evident recently, although nothing appears consistent with robust MJO activity on a broad scale.**

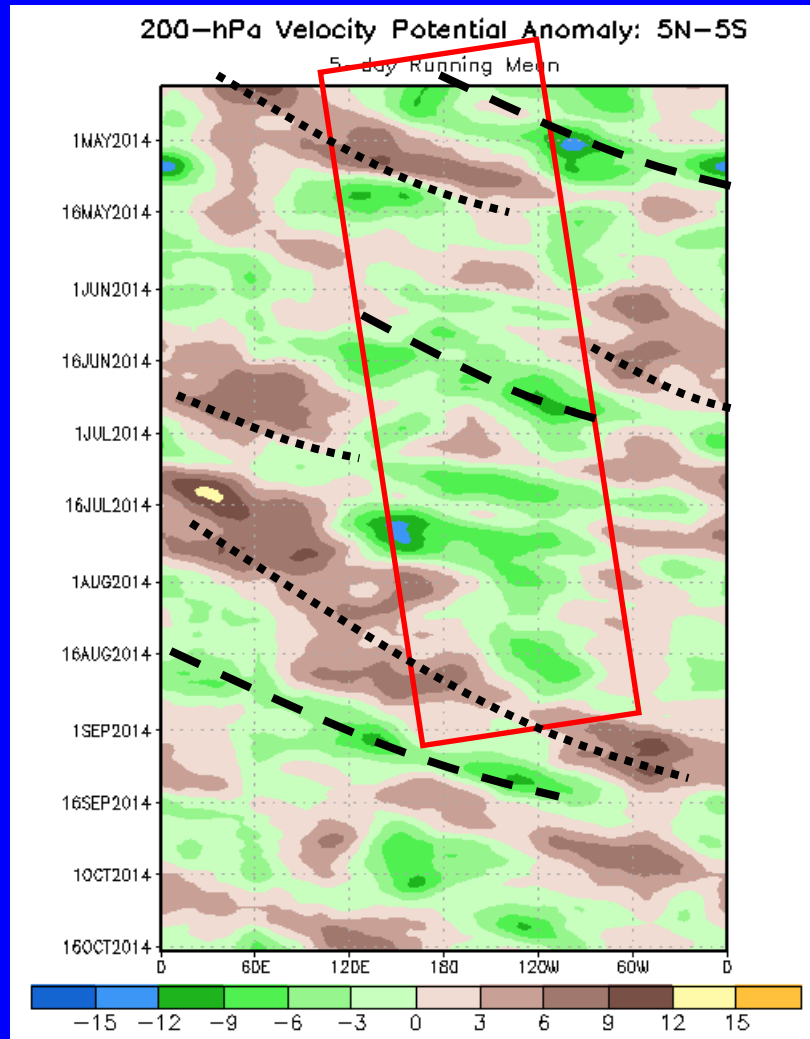


# 200-hPa Velocity Potential Anomalies (5°S-5°N)

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 during the late spring and summer across the Indo-Pacific warm pool and central Pacific (red box).

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 early July, but then organized again in late July and August, with a wide area of suppressed convection moving around the planet.

During early September, anomalies were consistent with rapid eastward propagation, before becoming stationary for the second half of the month.

During October, some eastward propagation is evident over Africa, with a wave-1 structure developing.

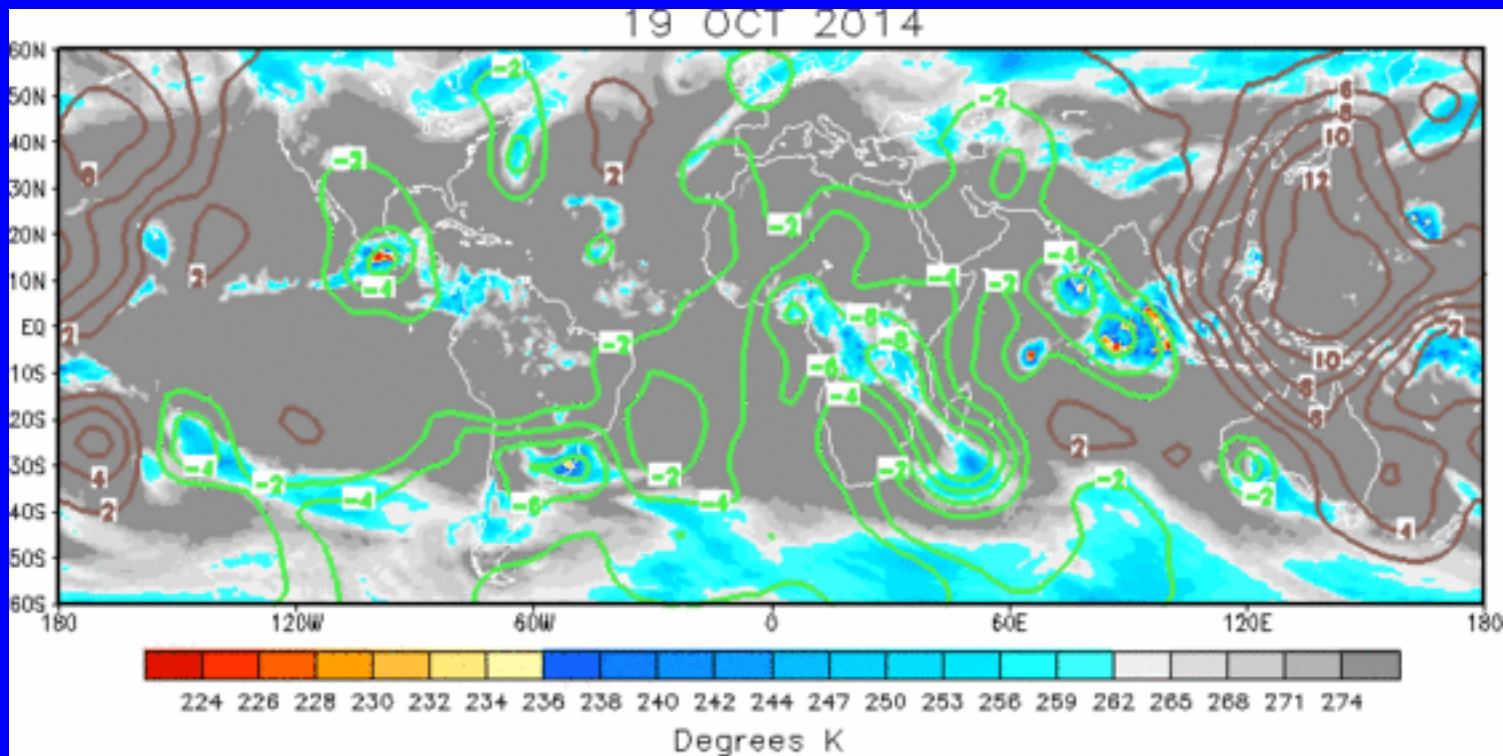




# IR Temperatures (K) / 200-hPa Velocity Potential Anomalies

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 indicates a more coherent pattern, with enhanced (suppressed) convection from the East Pacific to Africa (Maritime Continent and West Pacific).

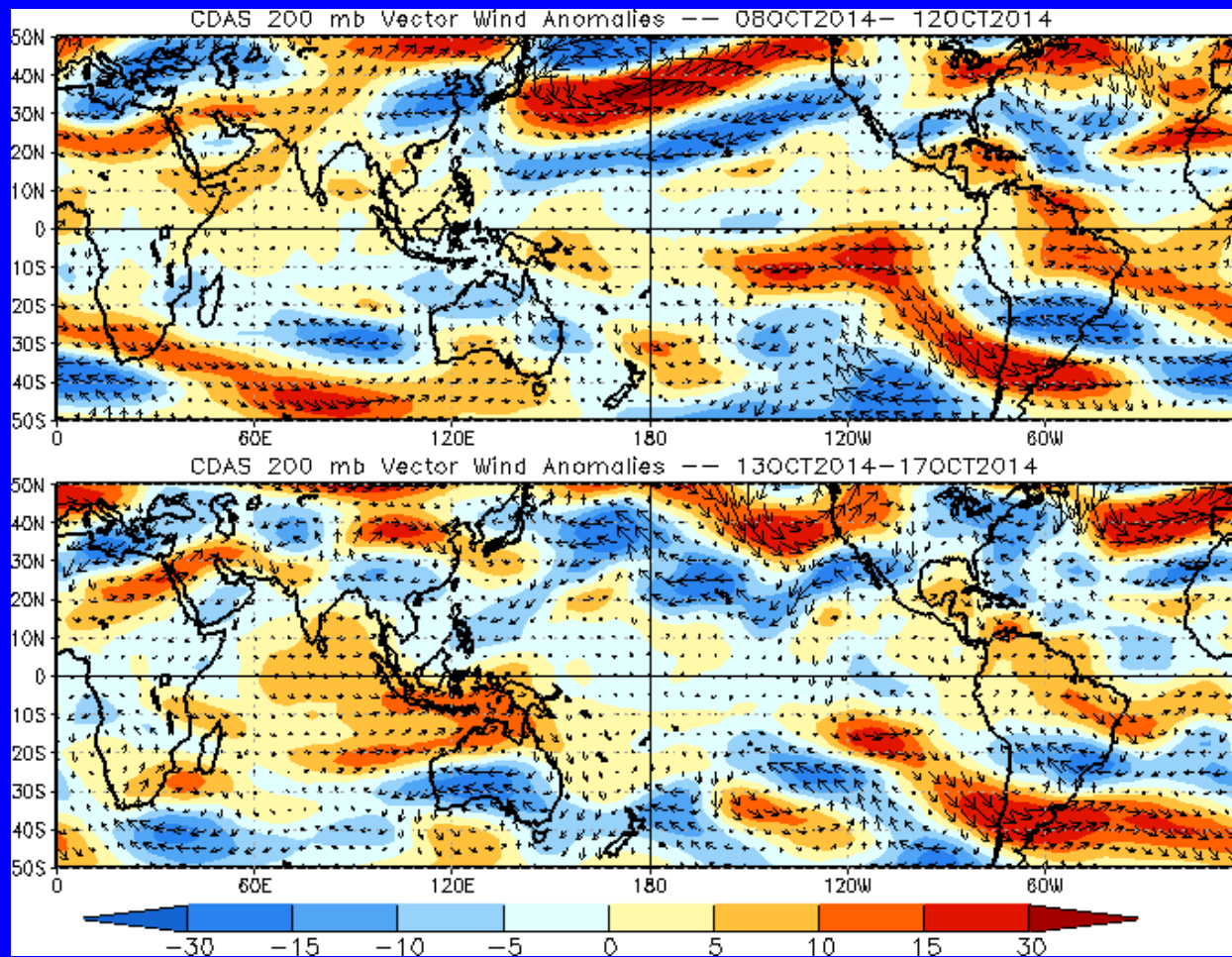


# 200-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



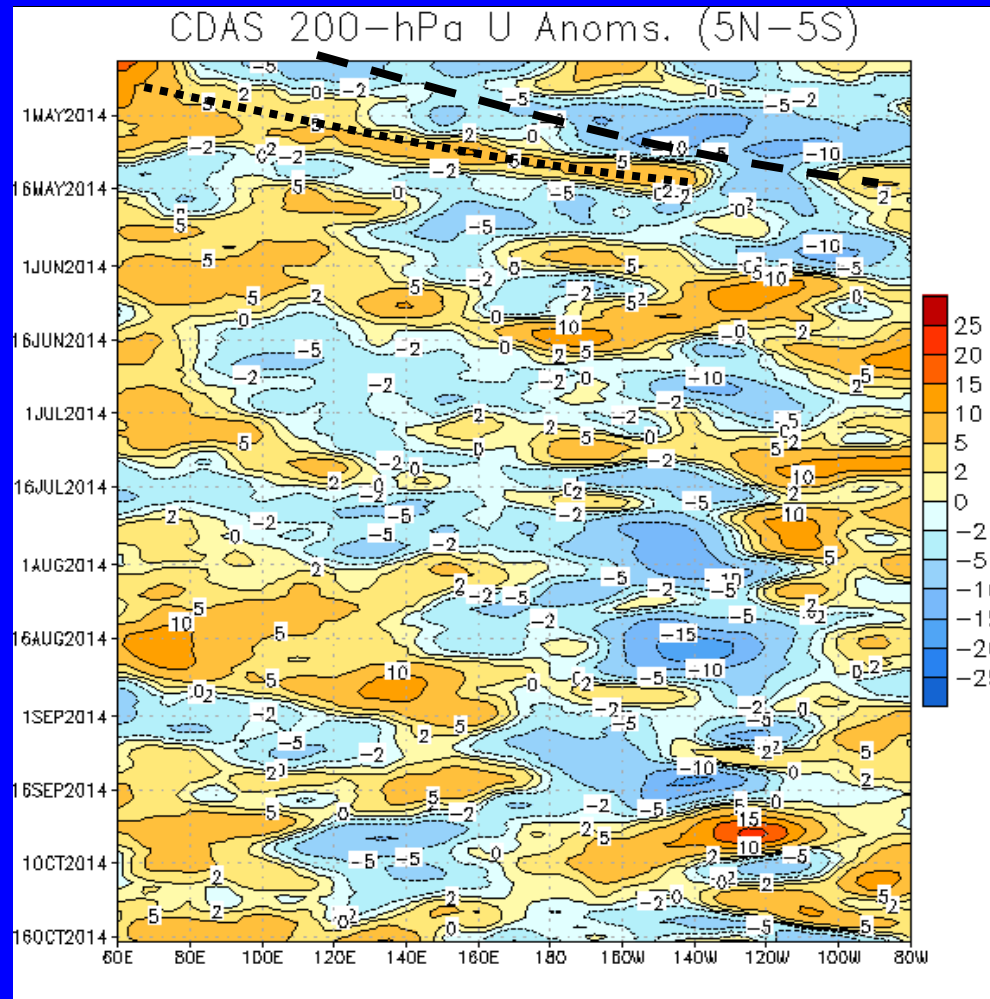
Westerly wind anomalies increased across the eastern Indian Ocean, Maritime Continent, and northern Australia during mid-October.



# 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



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.

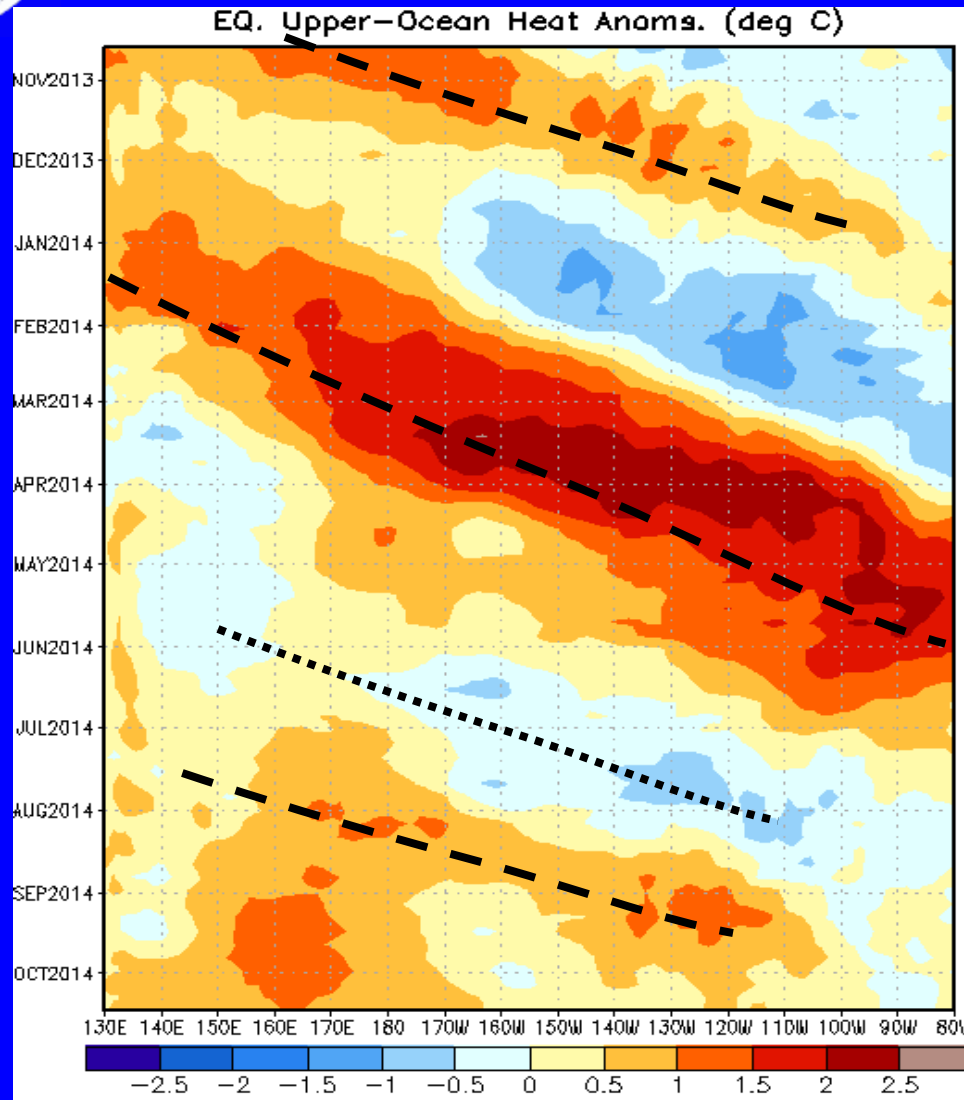
Westward propagation of westerly anomalies is evident over the east-central Pacific during June. In July, easterly anomalies intensified over the central and eastern Pacific.

A slow, eastward progression of westerly anomalies is evident over the Maritime Continent and western Pacific during August.

More recently, westerly anomalies expanded east from the Indian Ocean to the Maritime Continent.



# Weekly Heat Content Evolution in the Equatorial Pacific



Oceanic downwelling Kelvin wave activity is evident 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.

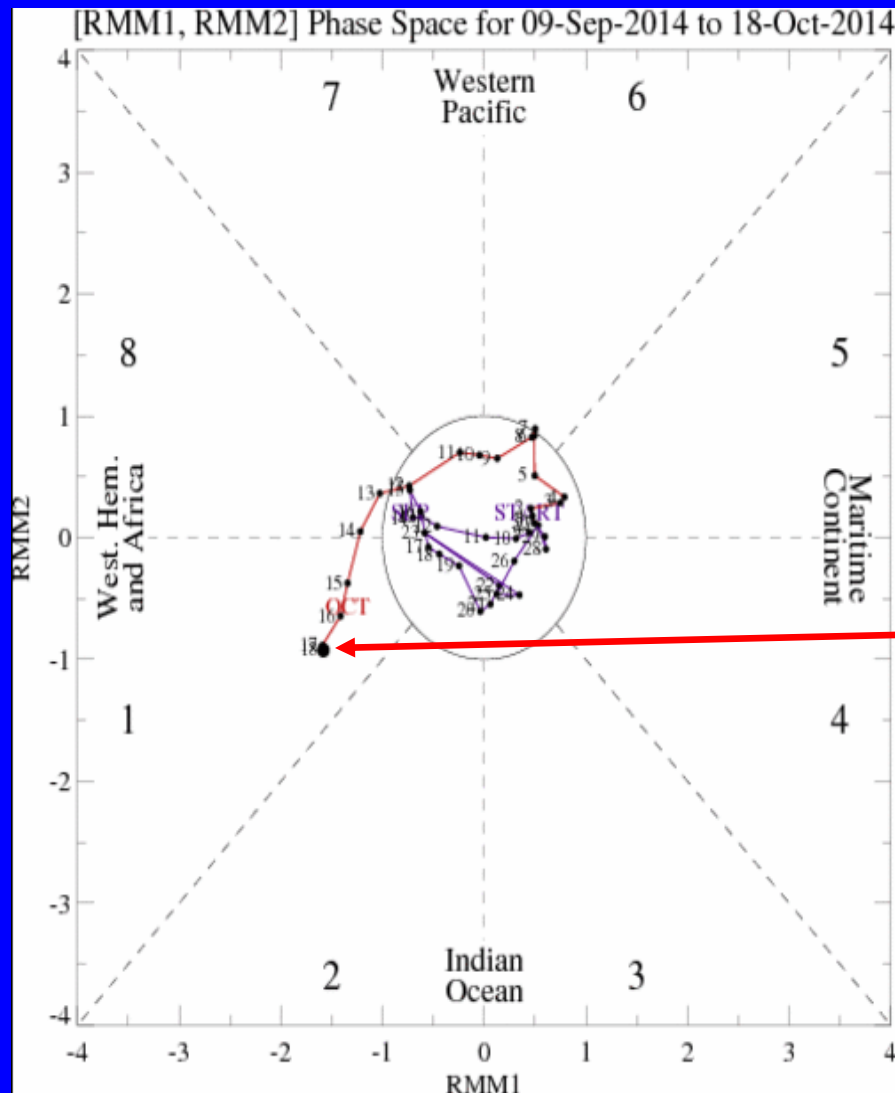
**Gottschalck et al. 2010: A Framework for Assessing Operational Madden-Julian Oscillation Forecasts: A CLIVAR MJO Working Group Project, *Bull. Amer. Met. Soc.*, 91, 1247-1258.**

- 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

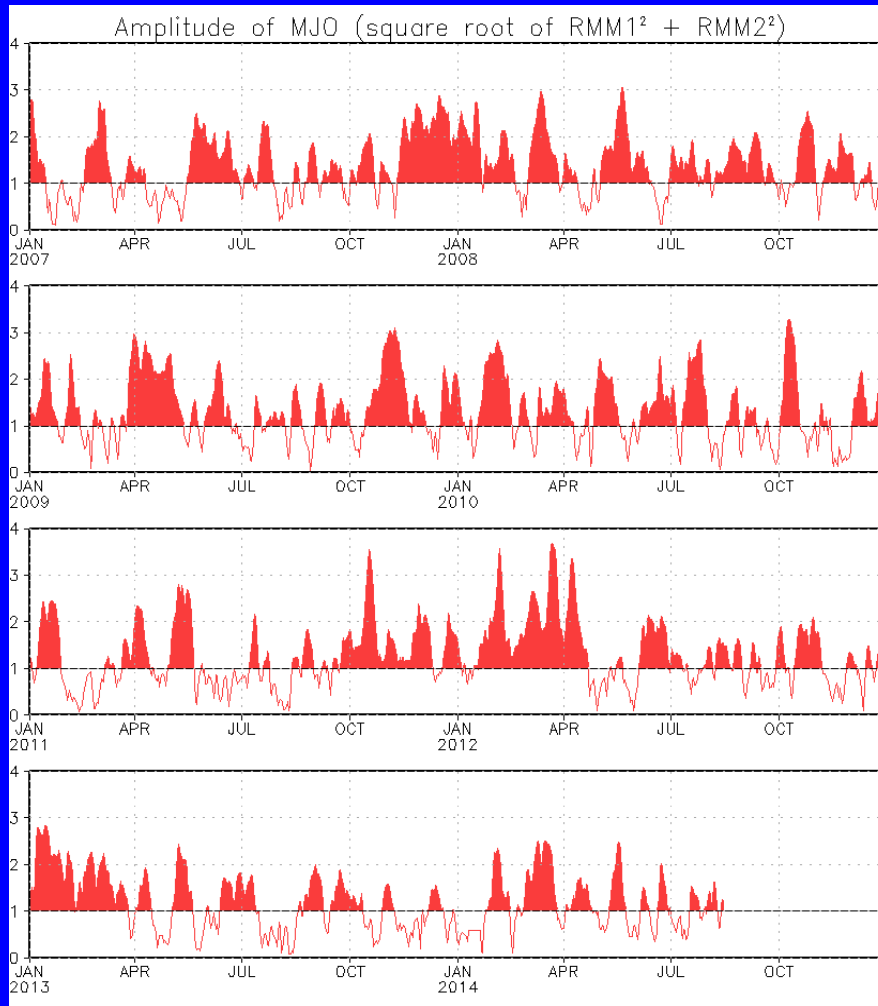


The RMM MJO index indicates eastward propagation with increasing amplitude across the Western Hemisphere.





# 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

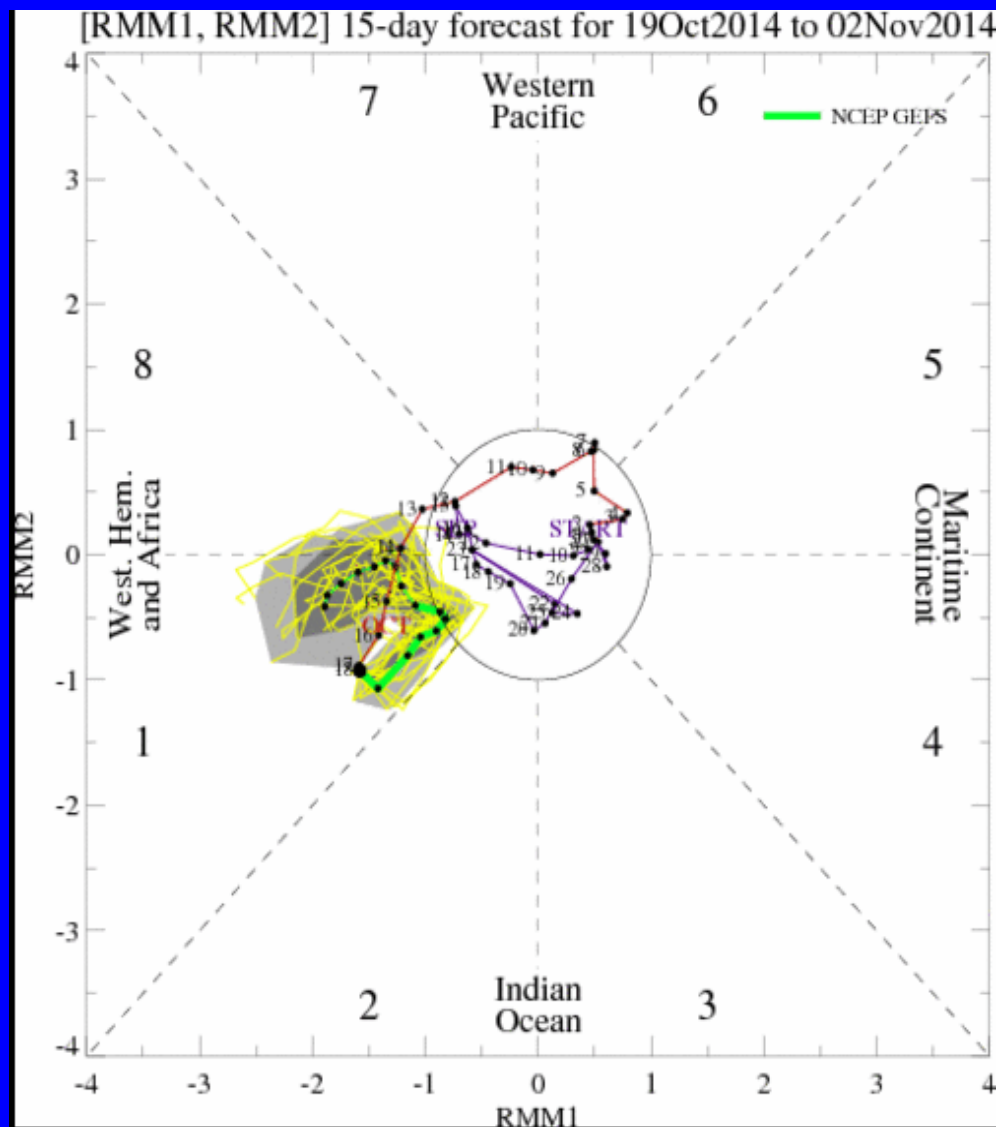
Green Line – Ensemble Mean

**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 stationary pattern in Phase-1 during the next two weeks.

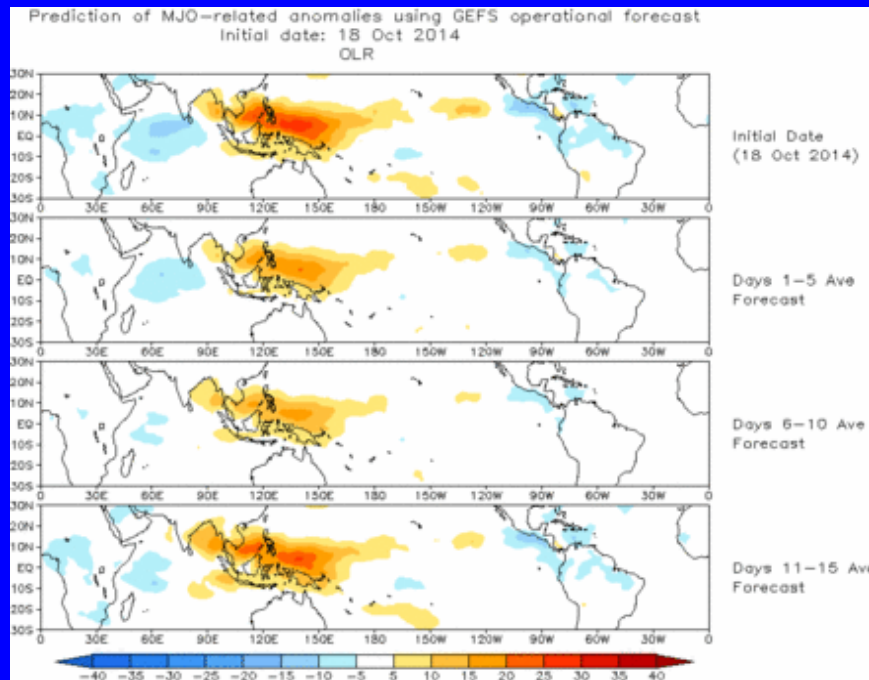




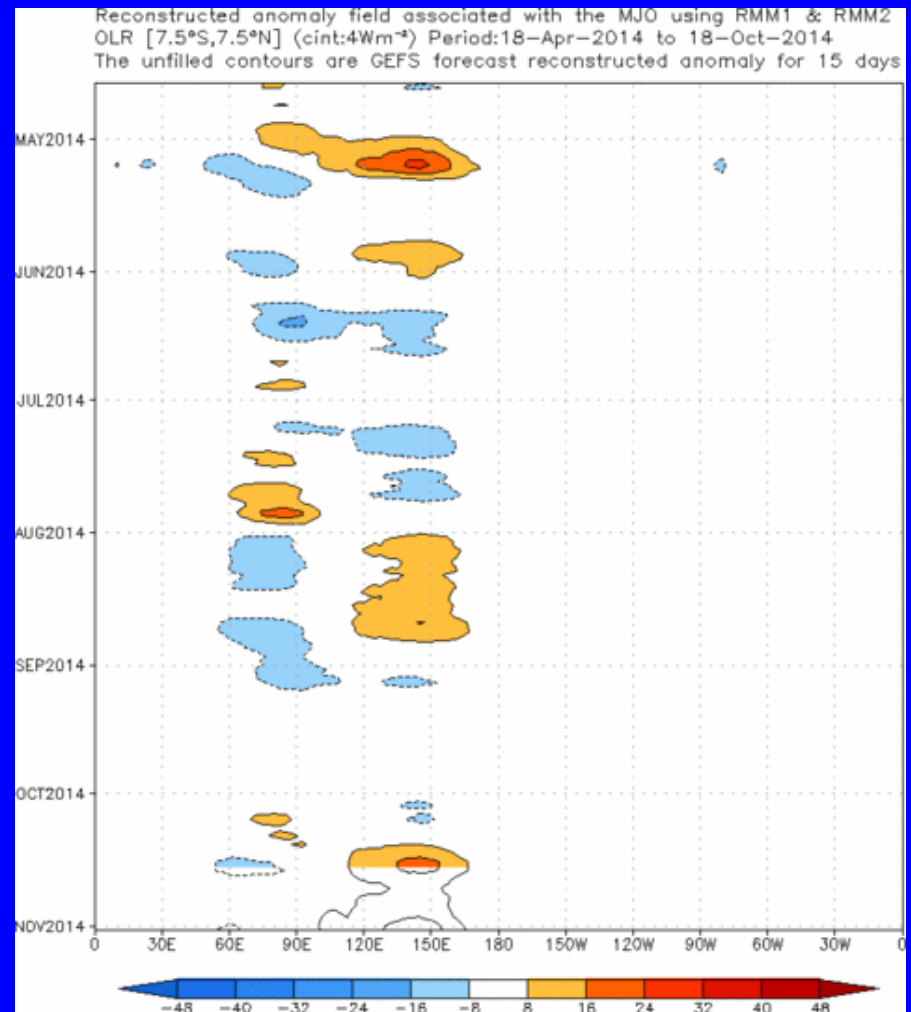
# Ensemble Mean GFS MJO Forecast

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



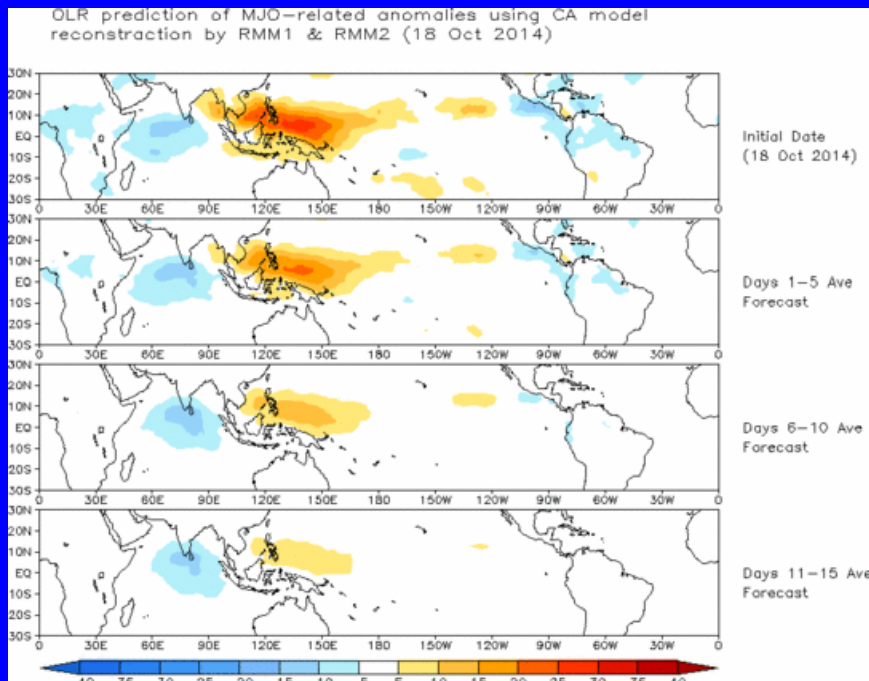
The ensemble mean GFS forecasts a stationary pattern of suppressed (enhanced) convection across the Maritime Continent (Western Hemisphere and western Indian Ocean) during the next two weeks.



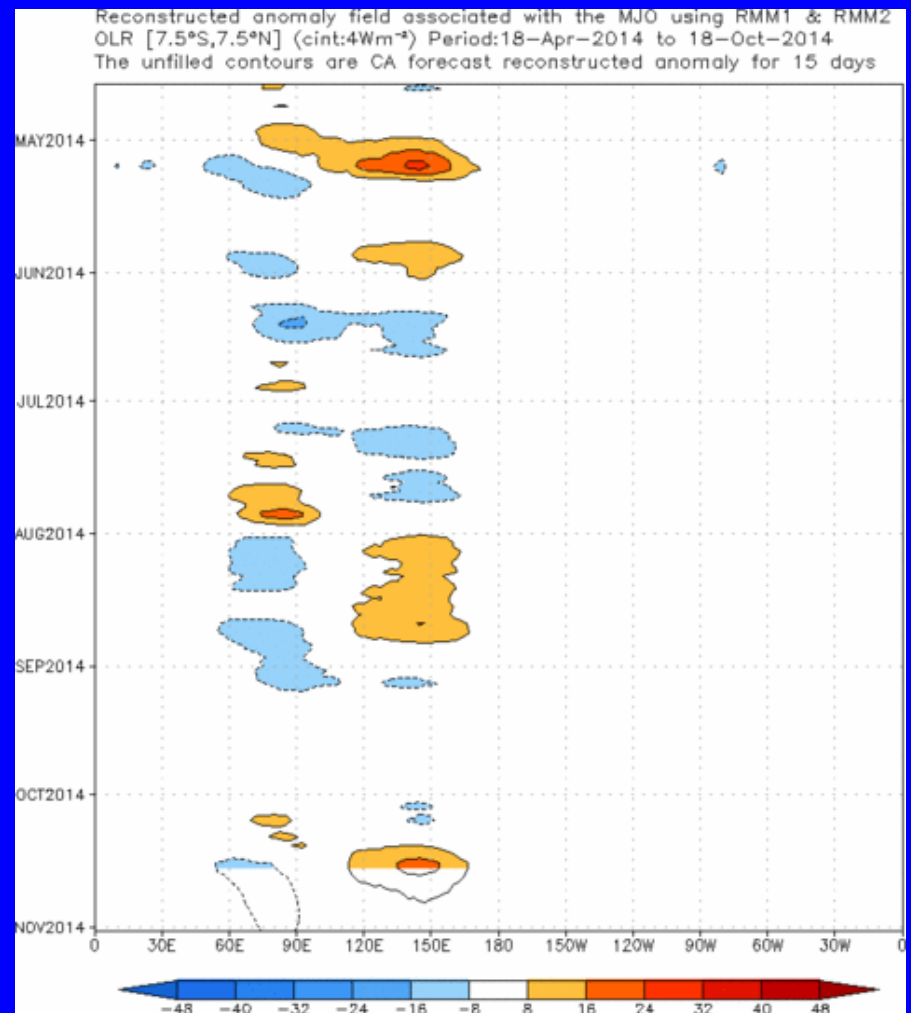
# Constructed Analog (CA) MJO Forecast

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**



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



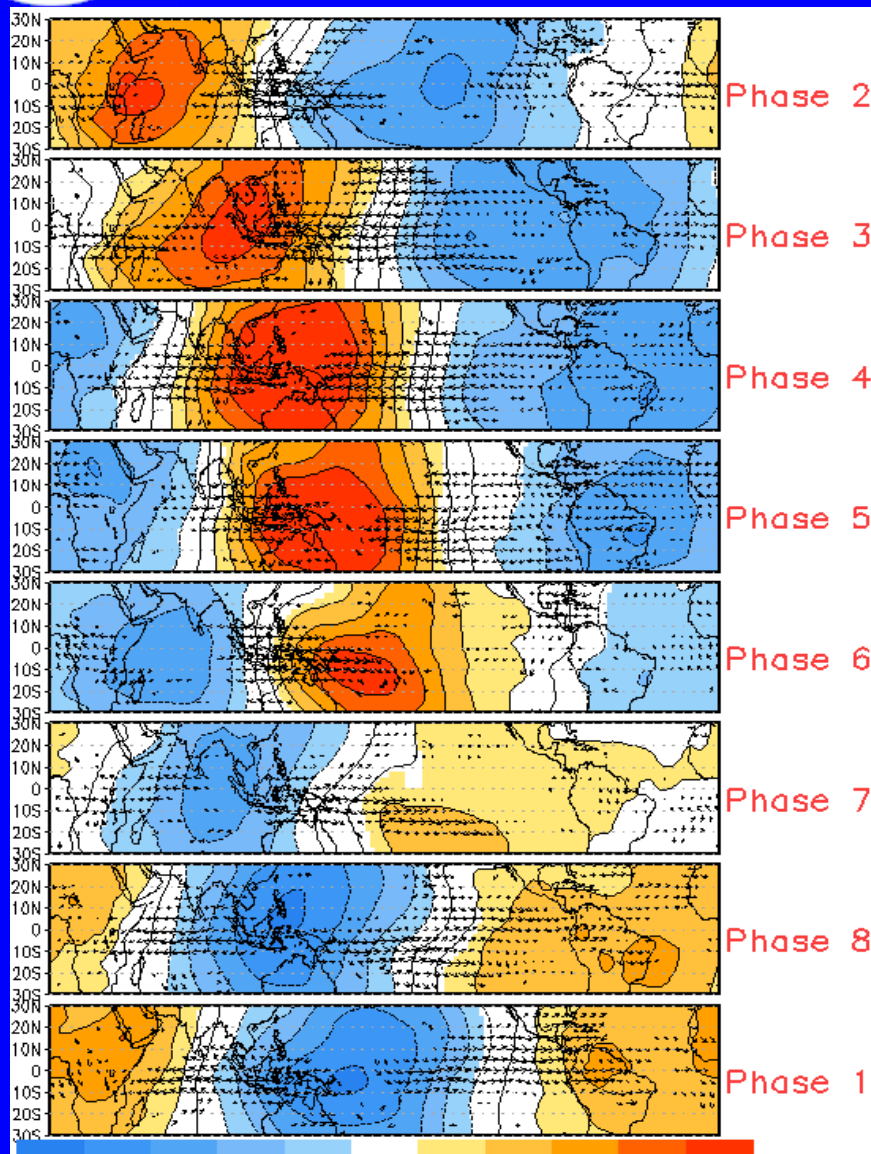
The constructed analog forecast also depicts a nearly stationary pattern with suppressed (enhanced) convection across the Maritime Continent (Americas and Indian Ocean).



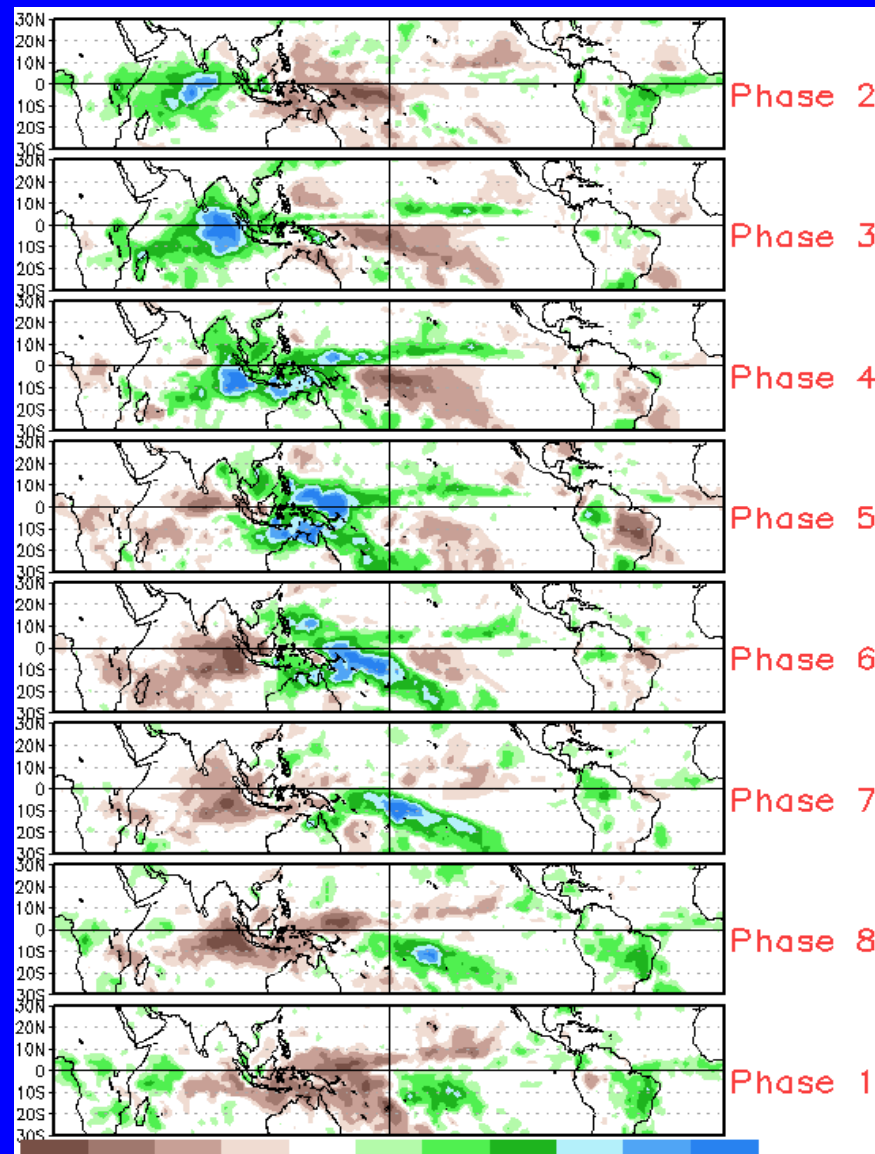


# MJO Composites – Global Tropics

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



Precipitation Anomalies (May-Sep)

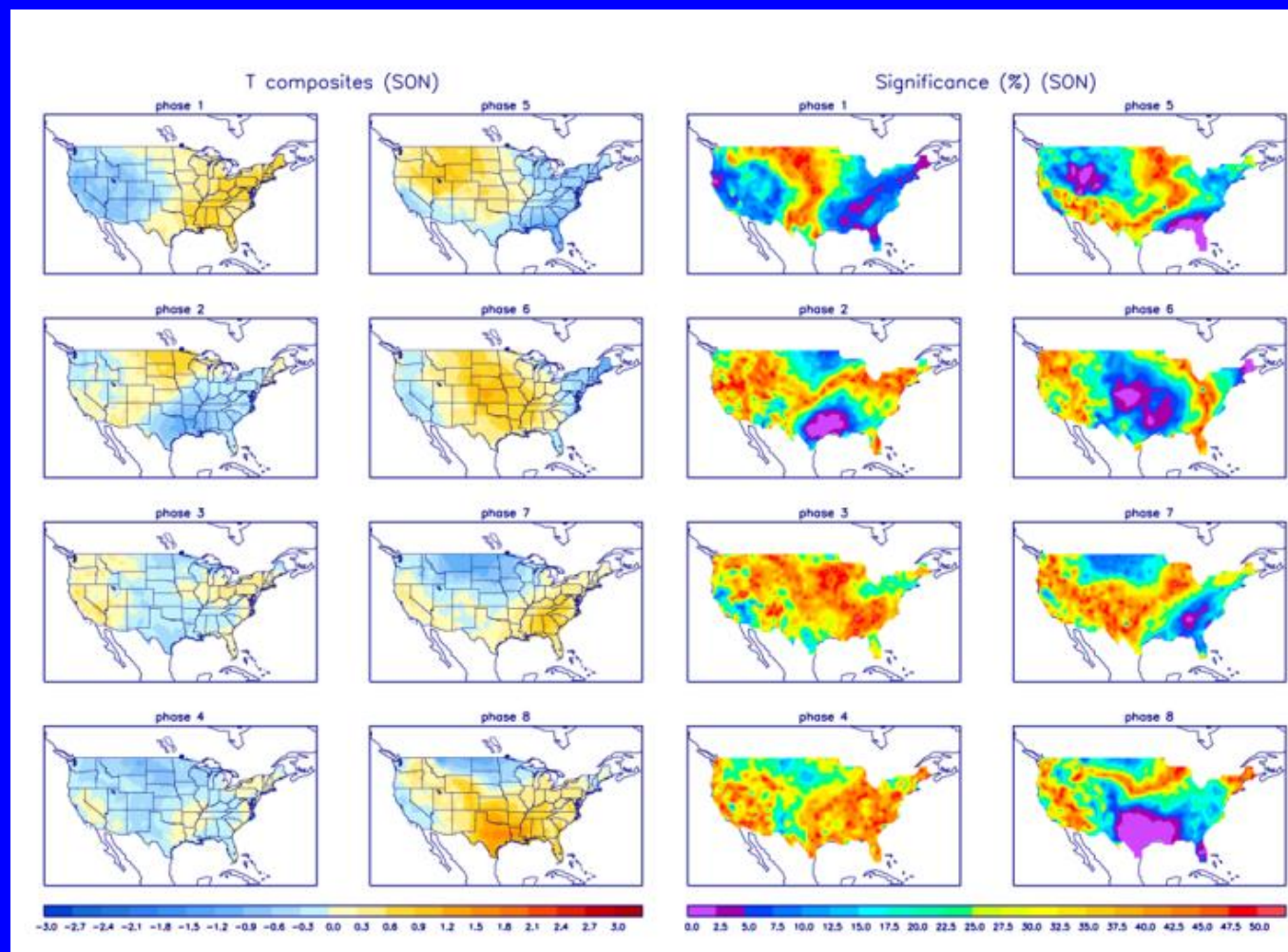




# U.S. MJO Composites – Temperature

- 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

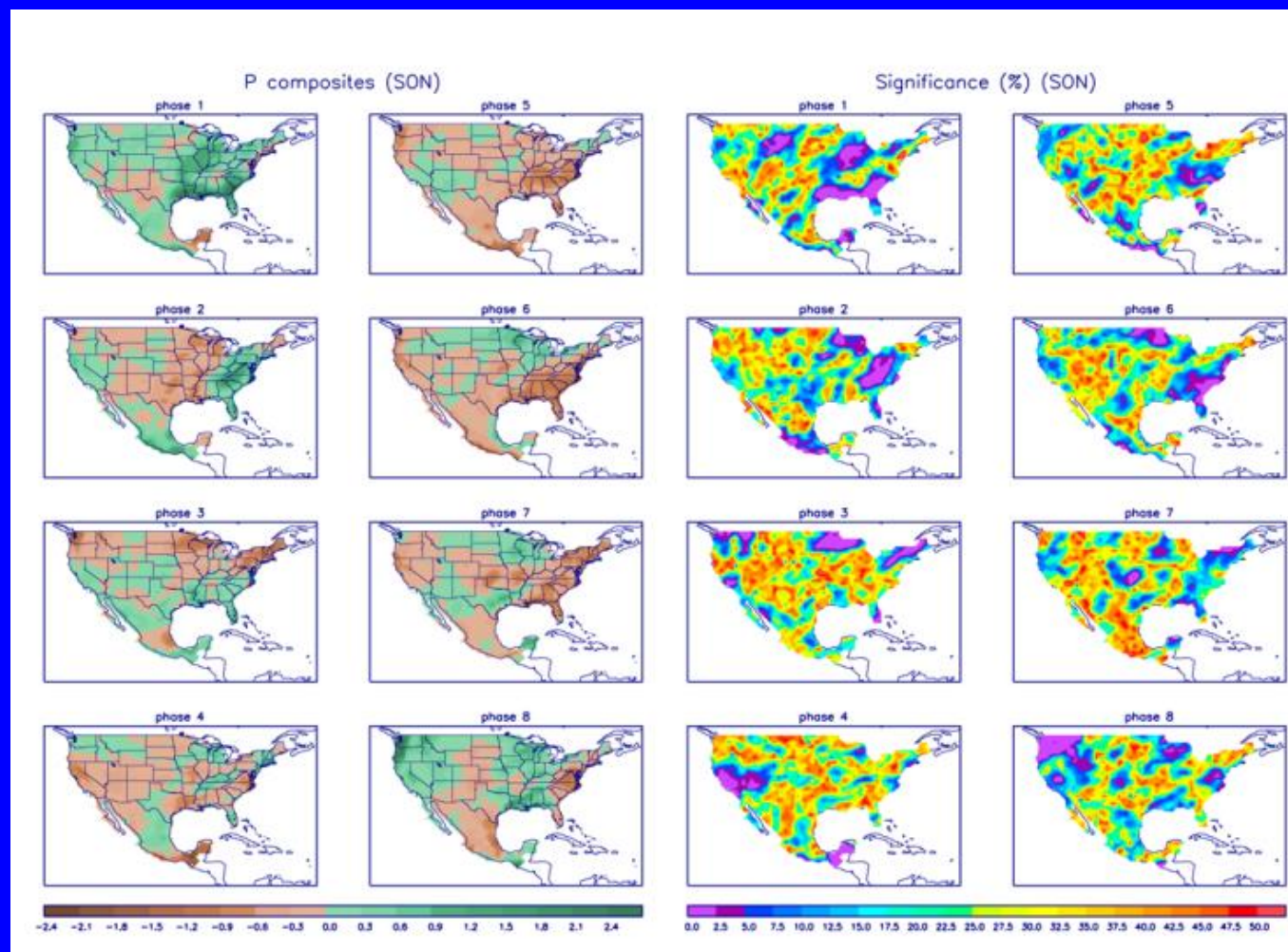
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml>





# 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

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