



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

**Update prepared by  
Climate Prediction Center / NCEP  
September 16, 2013**



# Outline

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



# Overview

- **The MJO remained active over the past week with the enhanced convective phase now centered over the Maritime Continent.**
- **Dynamical model MJO index forecasts indicate a slowly propagating MJO signal into the western and central Pacific.**
- **Based on recent observations, statistical, and dynamical forecasts, the MJO is forecast to remain active and continue to impact anomalous tropical convection along with other types of subseasonal tropical variability.**
- **The MJO favors enhanced rainfall across much of the Western Pacific extending from Southeast Asia to the Date Line during the next two weeks. The MJO also favors suppressed convection in the wake of ongoing tropical cyclone (TC) activity across parts of the East Pacific and Central America over the next ten days.**
- **The MJO elevates odds for tropical cyclone (TC) formation across parts of the western Pacific, while reducing odds for TC formation across the East Pacific (Week-1) and Atlantic (Week-1 and Week-2).**

**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>**

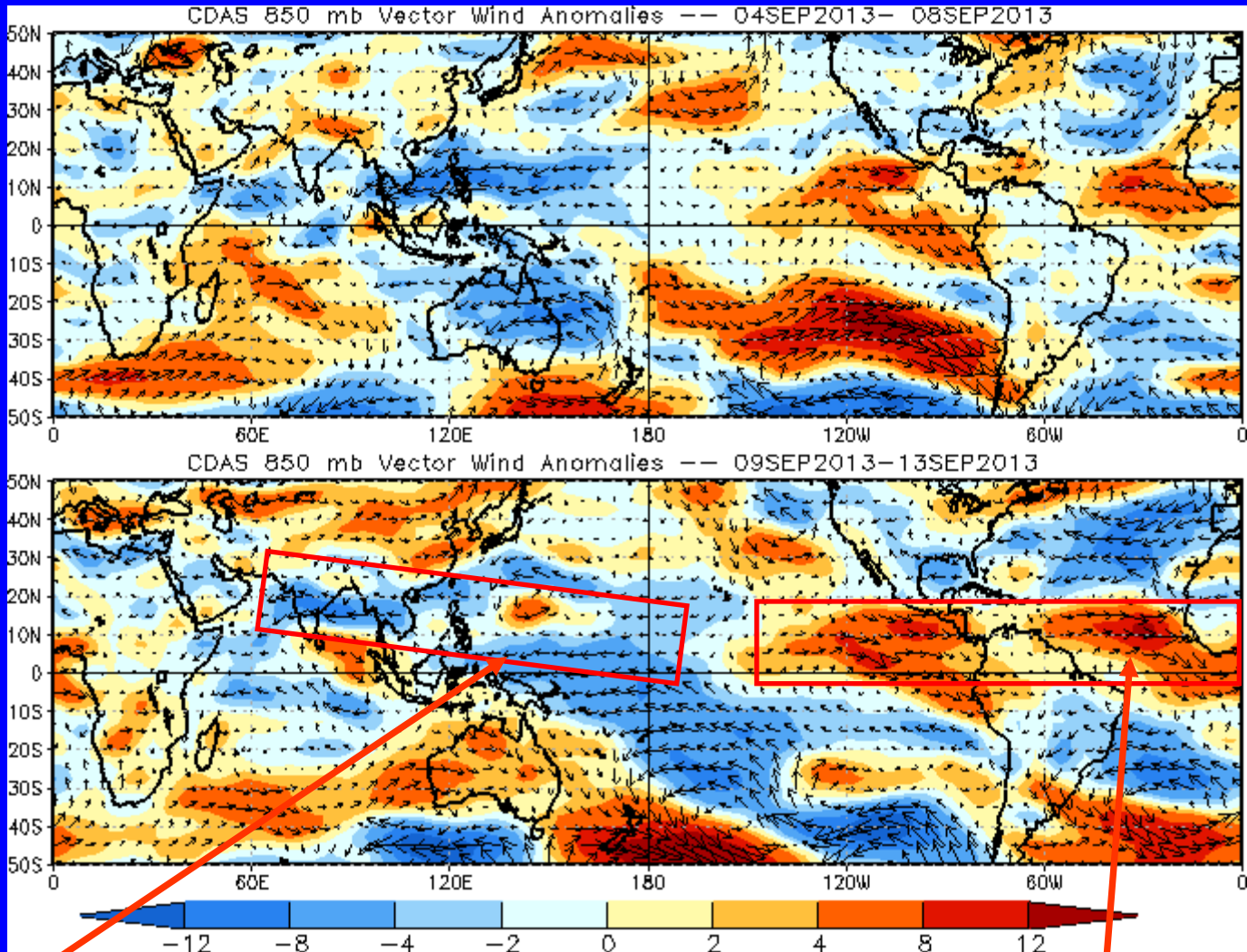


# 850-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies extended from India toward the Date Line, interrupted by westerly anomalies associated with tropical cyclone activity.

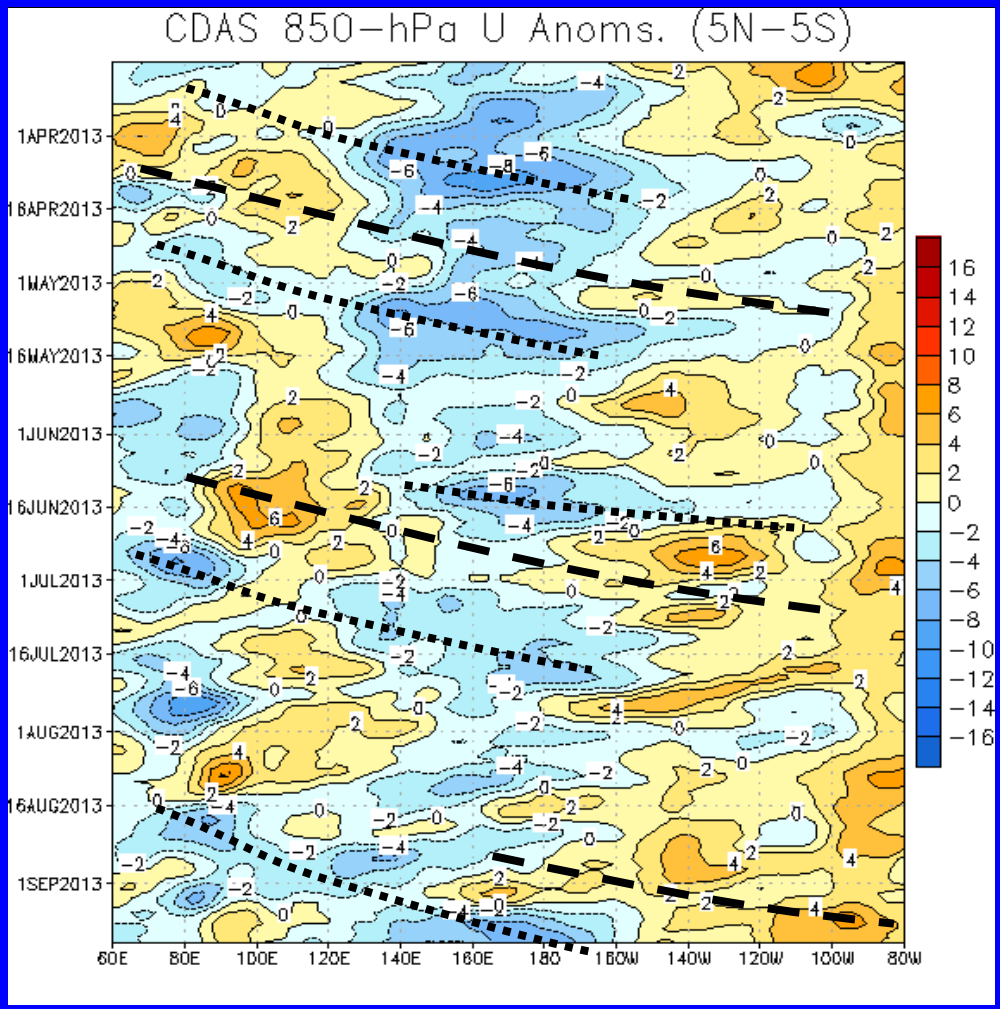
Westerly anomalies continued over the eastern Pacific and the Atlantic basins while increasing in amplitude.



# 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

The MJO was active from March into early May as indicated by alternating dotted (easterly anomalies) and dashed (westerly anomalies) lines.

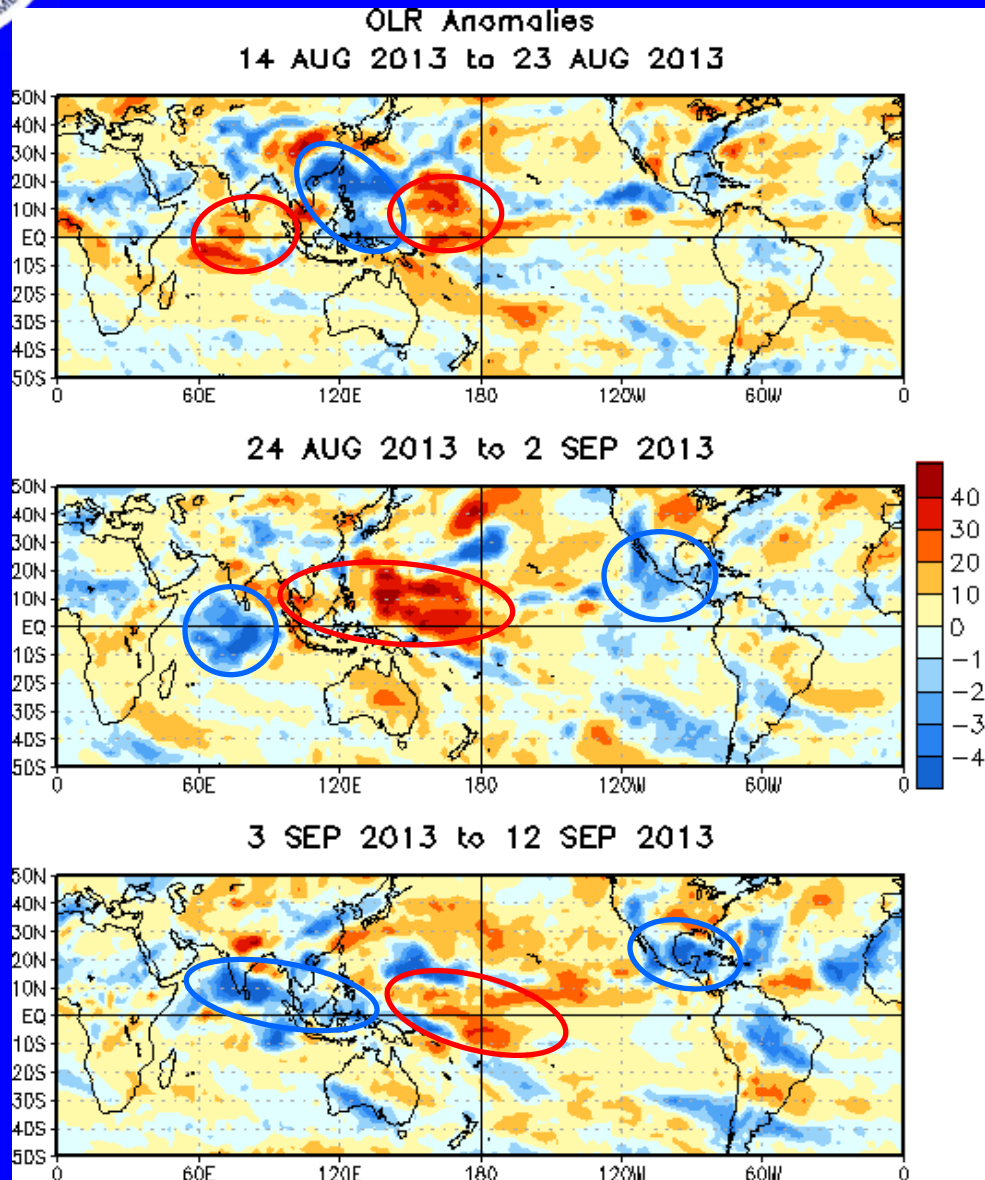
The MJO strengthened again in June and continued to mid-July with fast eastward propagation.

During late July through mid-August, other types of subseasonal variability strongly contributed to the observed anomalies. In late August and early September, westerly (easterly) anomalies increased over the eastern (western) Pacific in associated with renewed MJO activity.

Recently, there has been some eastward propagation toward the central 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)**

Although the MJO signal remained weak during the middle of August, enhanced convection persisted across parts of the Maritime Continent and western Pacific. Suppressed convection continued near the Date Line across parts of the Indian Ocean.

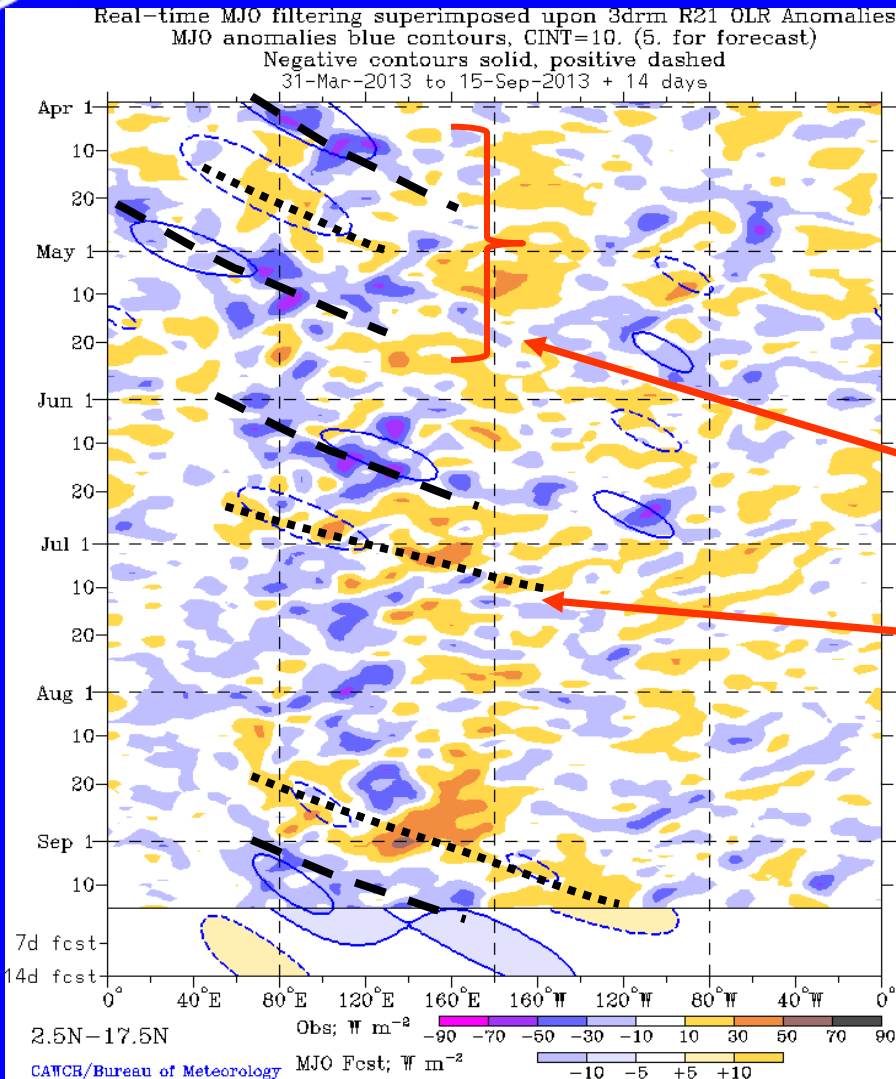
During late August and early September, subsidence increased near the Date Line while enhanced convection developed across the central Indian Ocean. Enhanced convection developed over the eastern Pacific and North American Monsoon regions.

In early to mid-September, suppressed convection dominated most of the central Pacific while enhanced convection propagated eastward across parts of the Maritime Continent. Enhanced convection continued across parts of Central and North America, partially due to TC activity.



# 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)

The MJO was active from early April into early May as shown by alternating dotted (suppressed convection) and dashed lines (enhanced convection).

The MJO strengthened once again during June and continued into July.

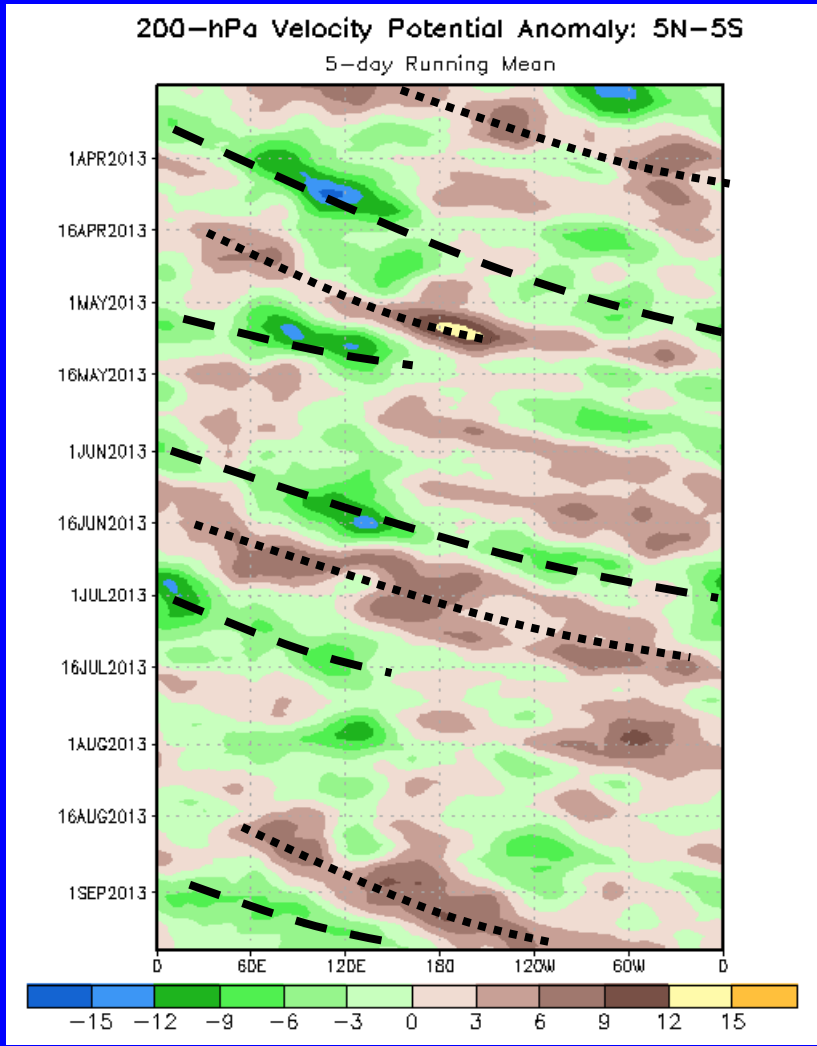
Recently, there has been a propagating MJO signal from the Western Hemisphere to the Indian Ocean and Maritime Continent.



# 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  
↓

Longitude

The MJO was active for much of the March to May 2013 period as shown by generally alternating positive (brown) and negative (green) anomalies with clear eastward propagation.

The MJO was less coherent during much of May.

The MJO strengthened once again during June and the first half of July before weakening by the end of the month.

The MJO was not active during much of August, although recently, the upper-level velocity potential anomalies have increased in magnitude along with some eastward propagation, indicating renewed MJO activity.

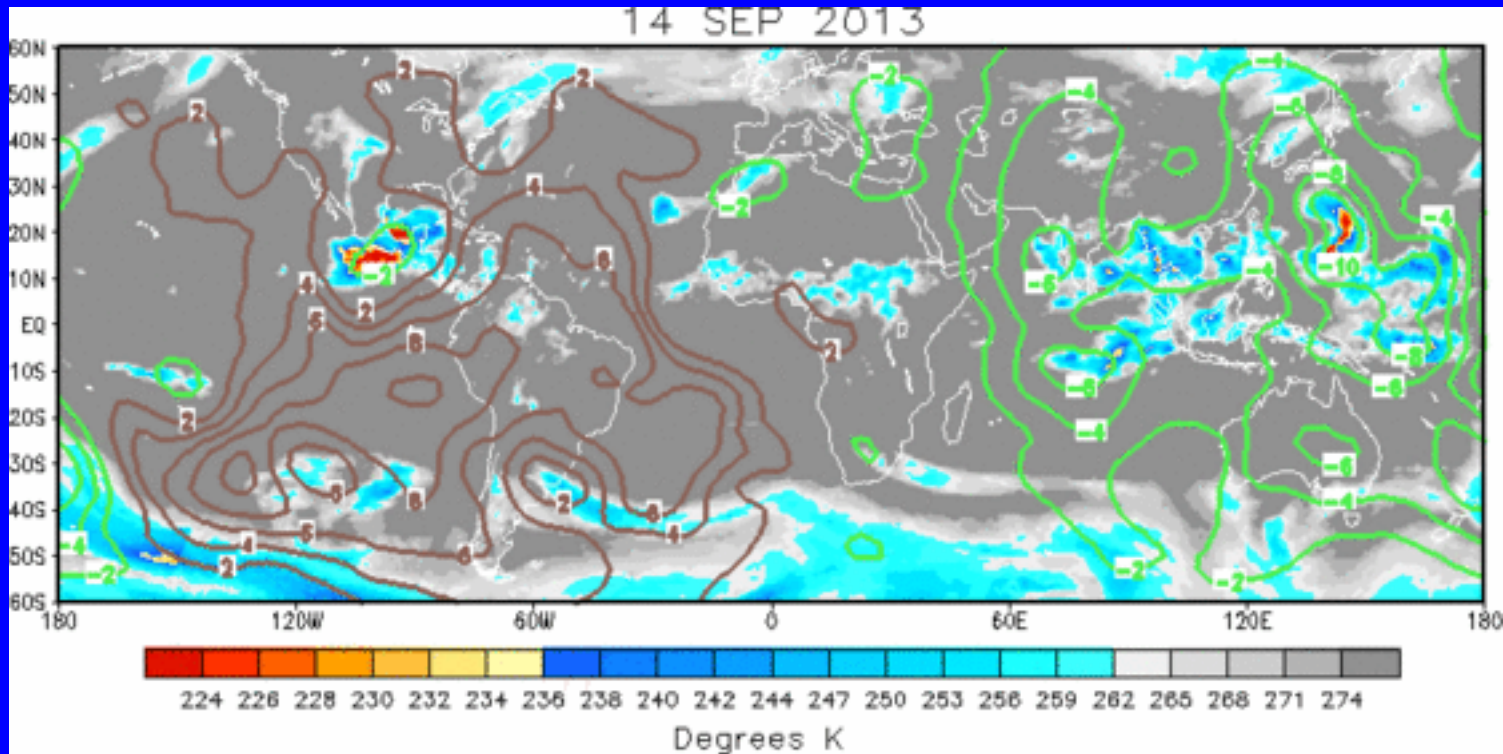




# IR Temperatures (K) / 200-hPa Velocity Potential Anomalies

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The velocity potential pattern remains coherent, nearly exhibiting the canonical wave-1 structure along the equator. Upper-level divergence is now centered over the Maritime Continent, while suppressed convection dominates most of the Western Hemisphere.

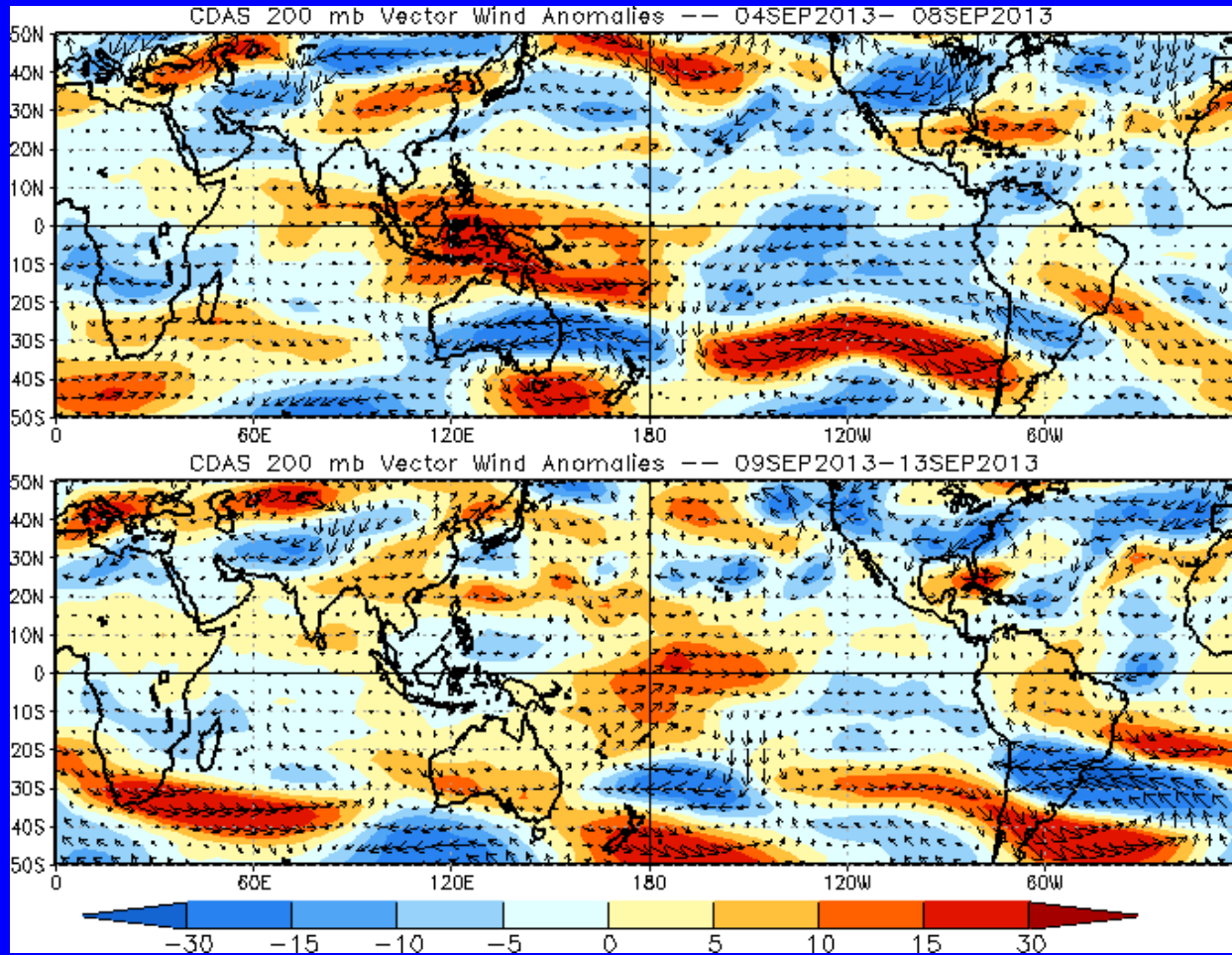


# 200-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



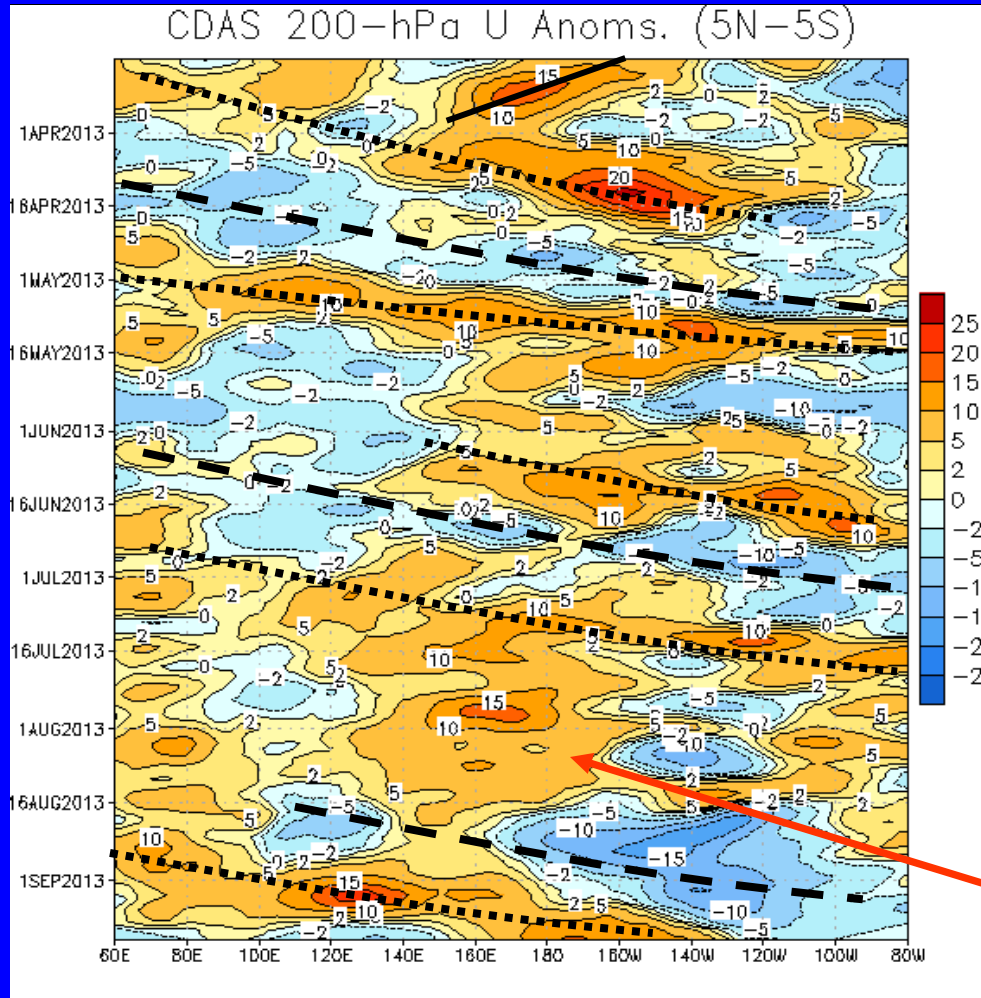
Westerly anomalies shifted eastward from the Maritime Continent to the central Pacific. Anomalies elsewhere in the Tropics are fairly weak.



# 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

Eastward propagation of wind anomalies associated with the MJO (dotted and dashed lines) continued into May 2013. During March and early April, anomalies were influenced by westward moving features (solid line) over the central and western Pacific.

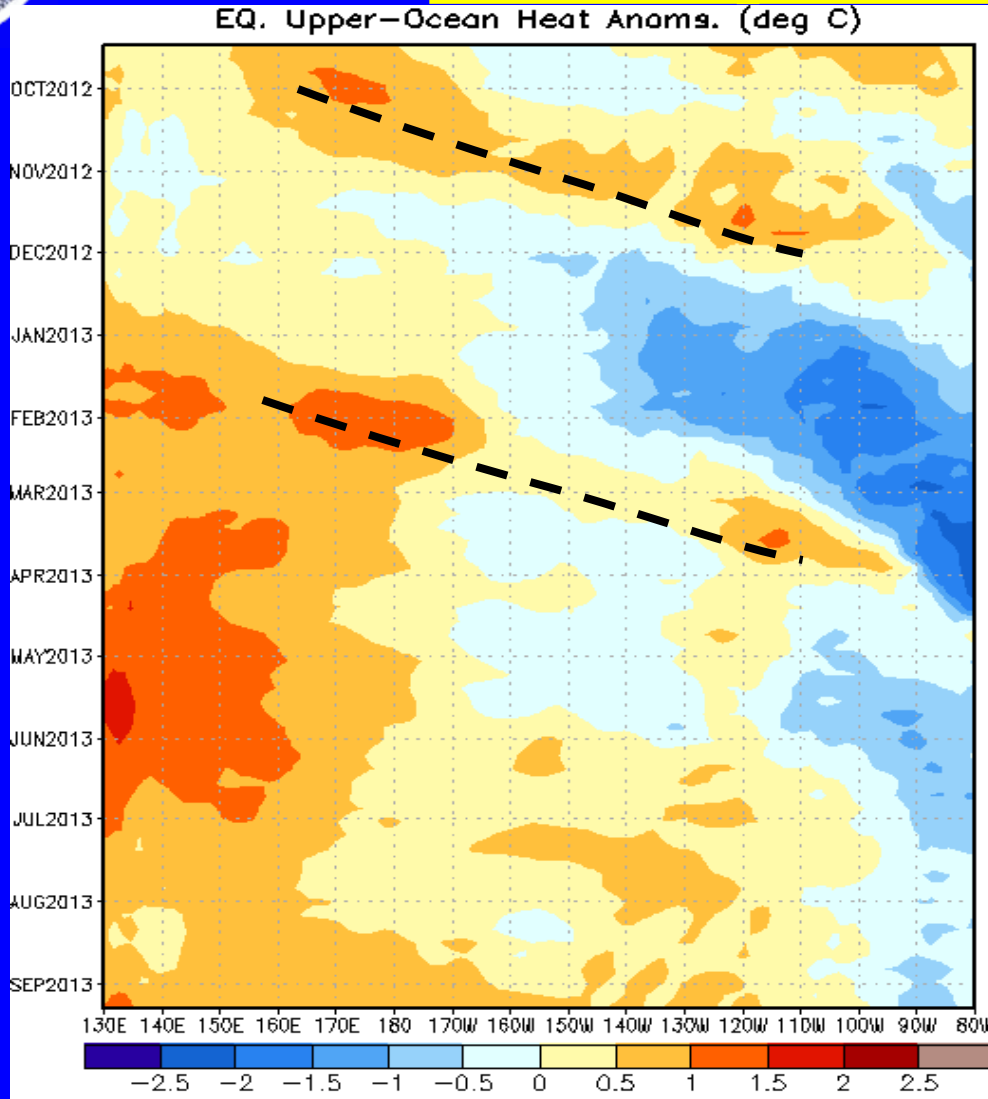
The MJO strengthened during June and continued to mid-July, as eastward propagation of wind anomalies associated with the MJO were again observed.

During August, westerly wind anomalies were generally persistent just west of the Date Line, recently strengthening over the Maritime Continent and shifting eastward. This is consistent with renewed MJO activity.



# Weekly Heat Content Evolution in the Equatorial Pacific

Time  
↓



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 developed in the western (eastern) Pacific during January 2013 and persisted into early March. The influence of a downwelling oceanic Kelvin wave can be seen during late February and March as anomalies became positive in the east-central Pacific.

Positive anomalies have persisted across most of the basin since June 2013.

Longitude



# 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.**

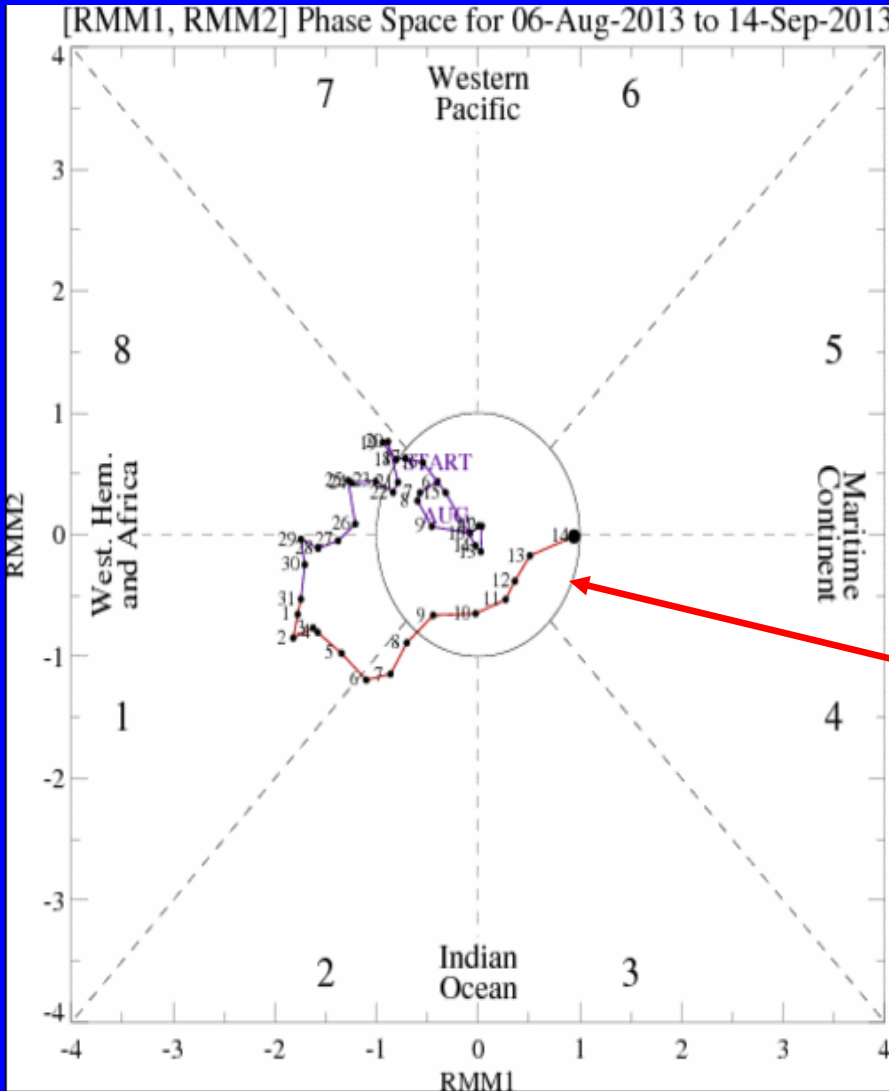
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

**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

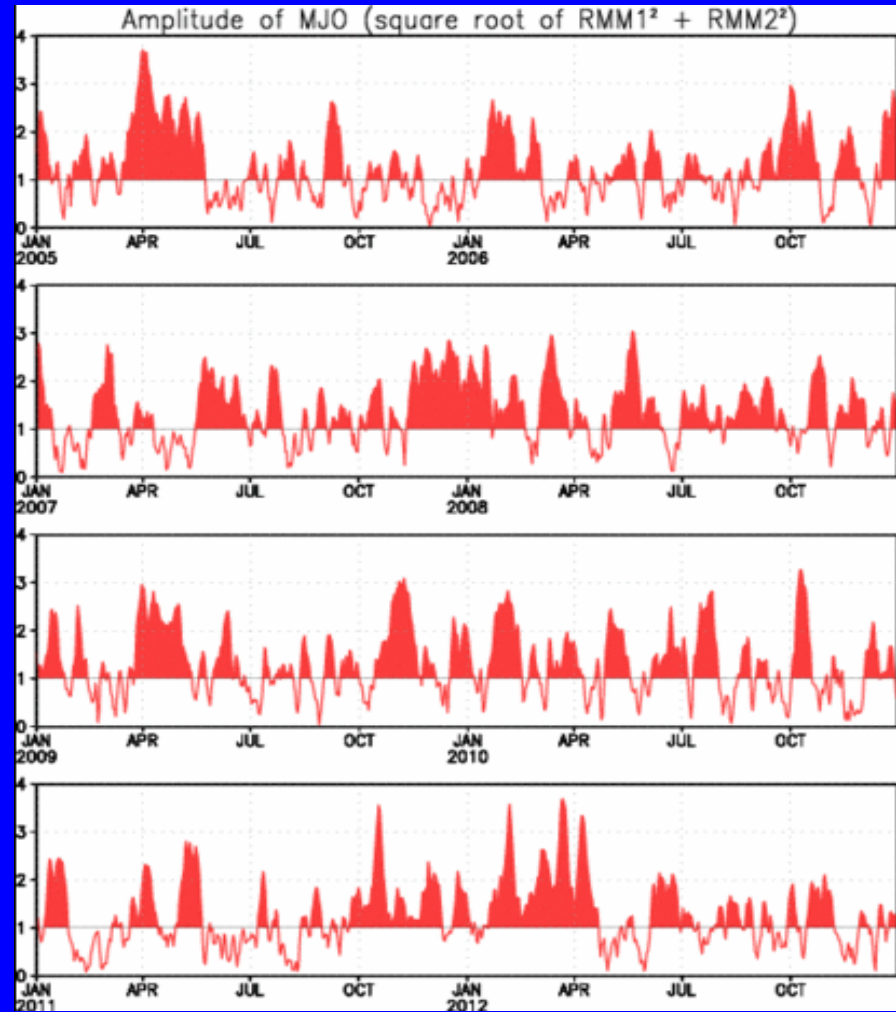
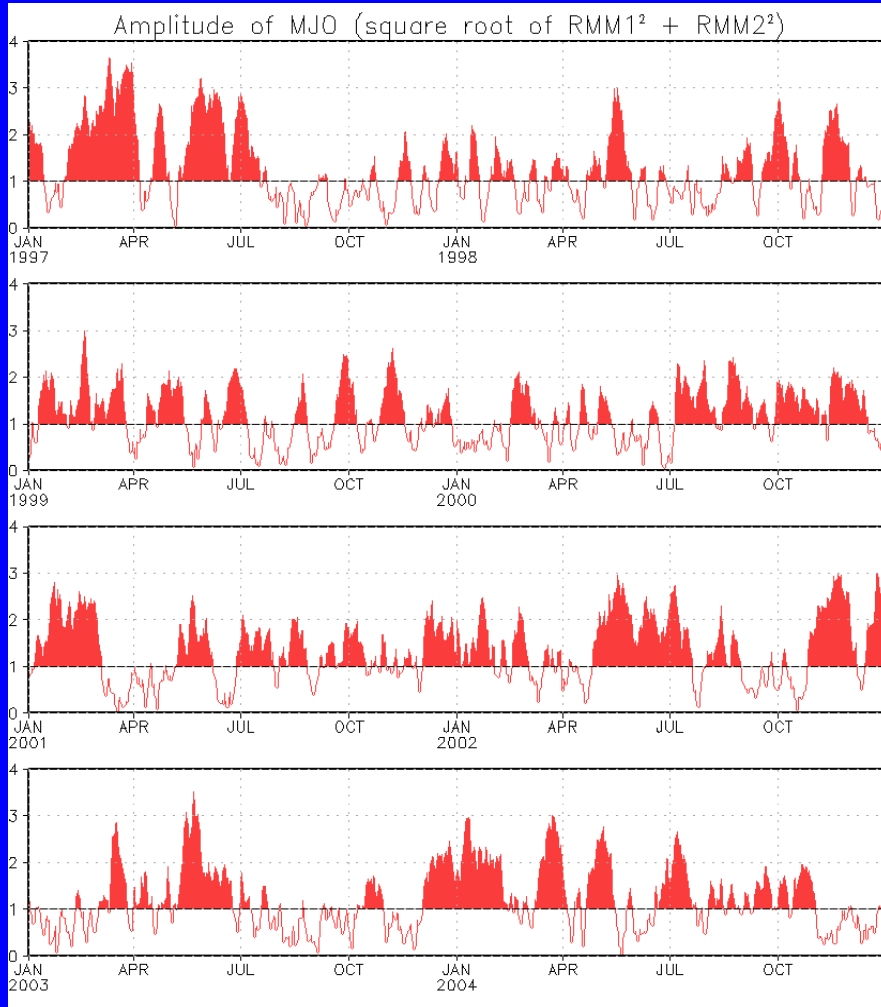


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

During the past two weeks, the MJO index exhibited both eastward propagation and decreasing amplitude. However, this is likely due to the influence of tropical cyclones and brief interference with other subseasonal variability.



# 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.



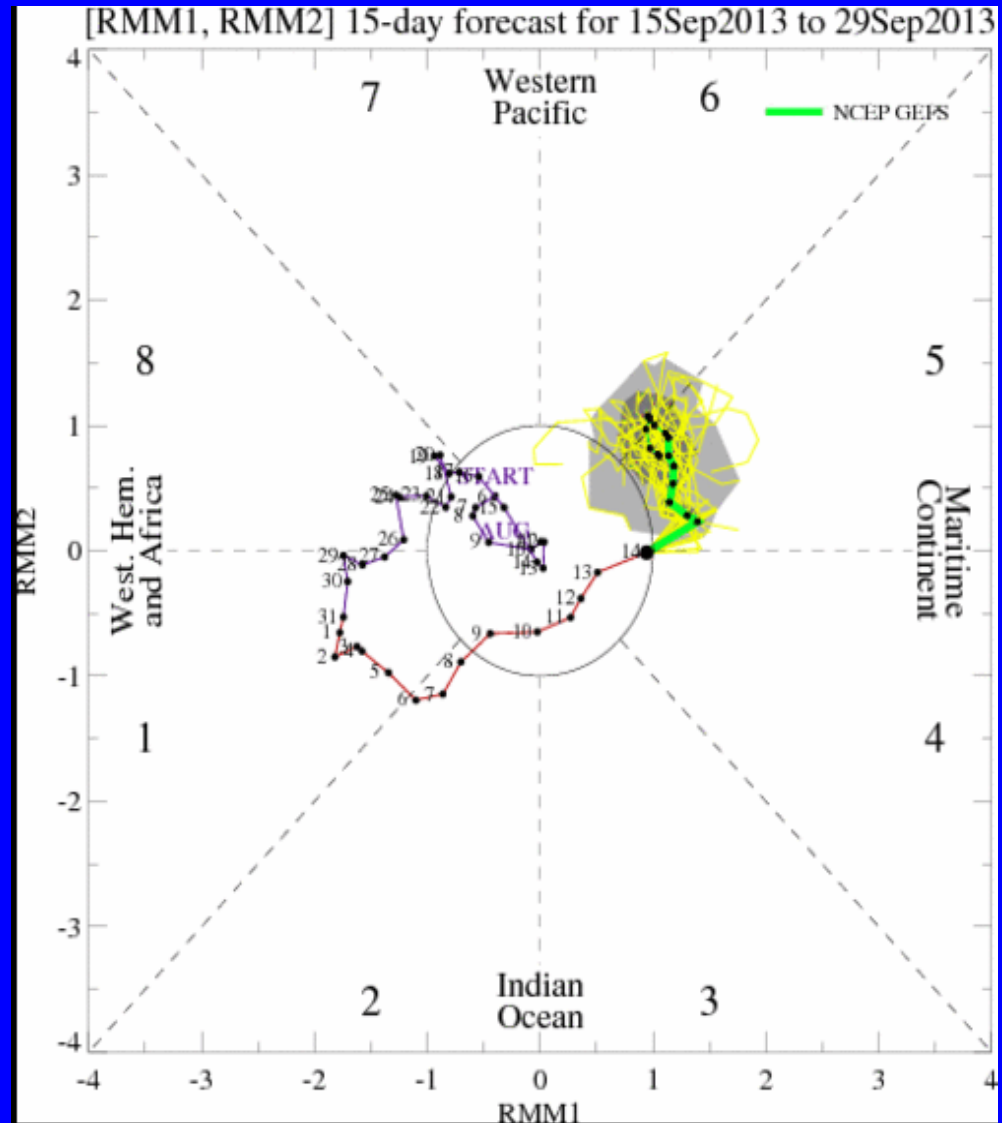
# Ensemble GFS (GEFS) MJO Forecast

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 ensemble GFS indicates an MJO signal generally propagating from Phase 5 to Phase 6 over the next two weeks.



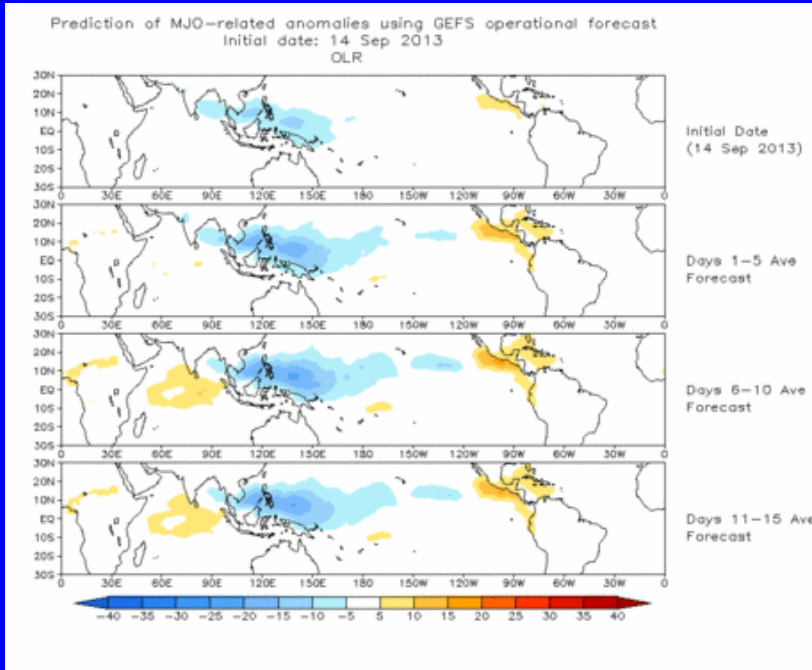




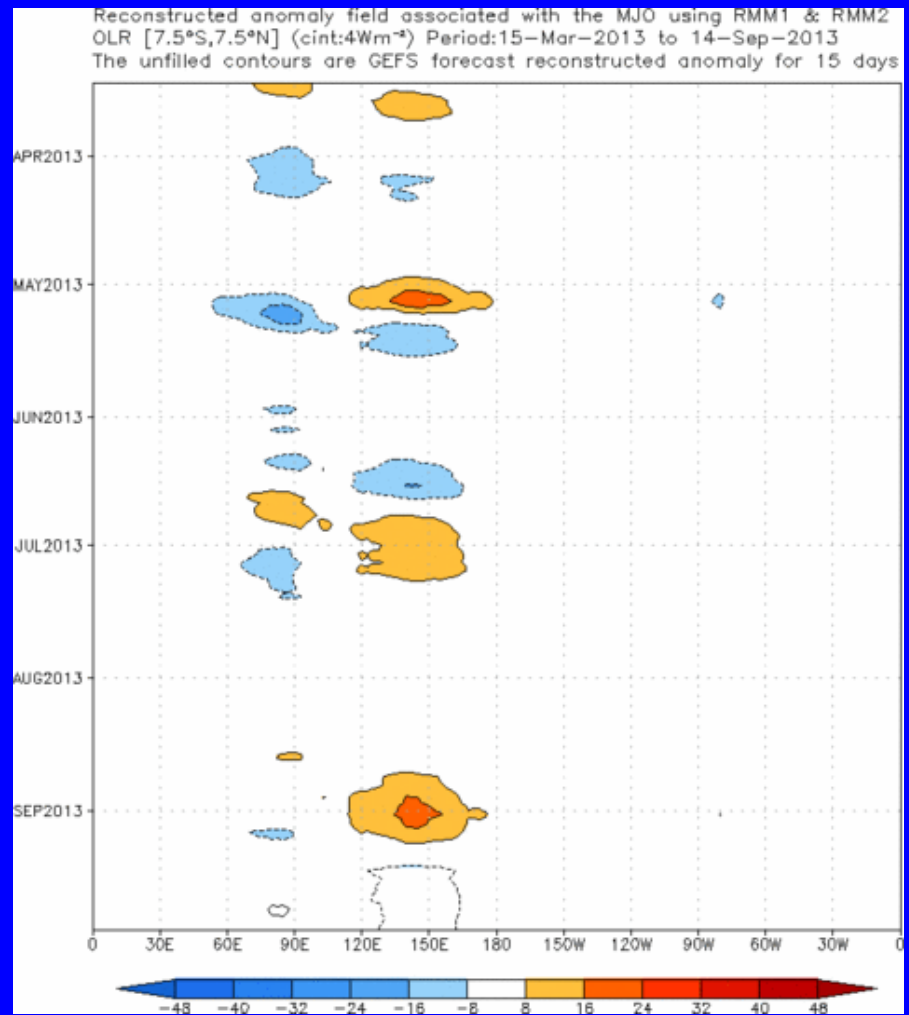
# Ensemble Mean GFS MJO Forecast

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 enhanced convection shifting subtly eastward toward the central Pacific. Suppressed convection is forecast to develop across Central America and later in the Indian Ocean.

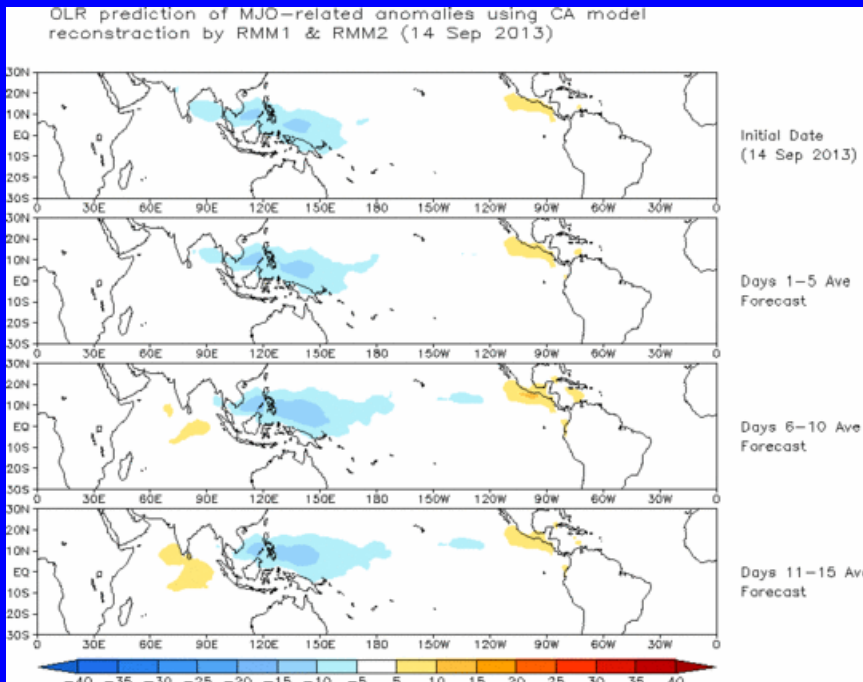


# Constructed Analog (CA) MJO Forecast

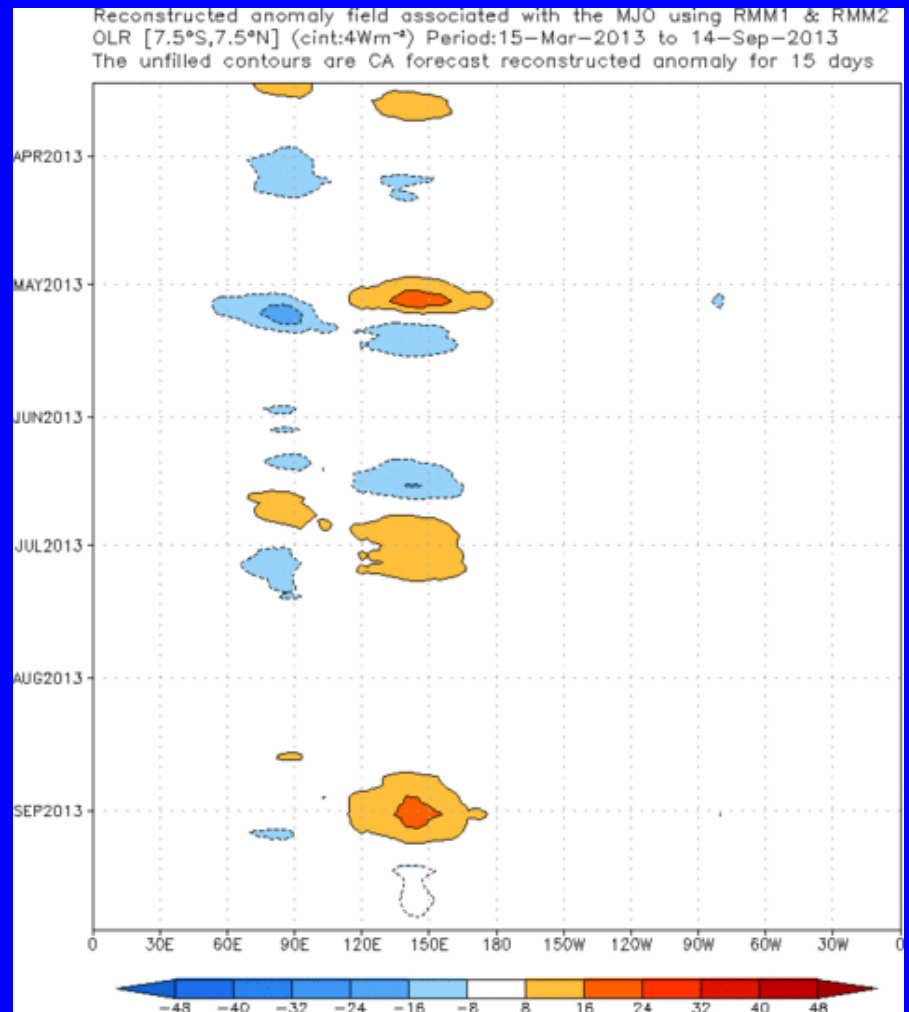
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

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 statistical forecast is similar to the GEFS forecast.

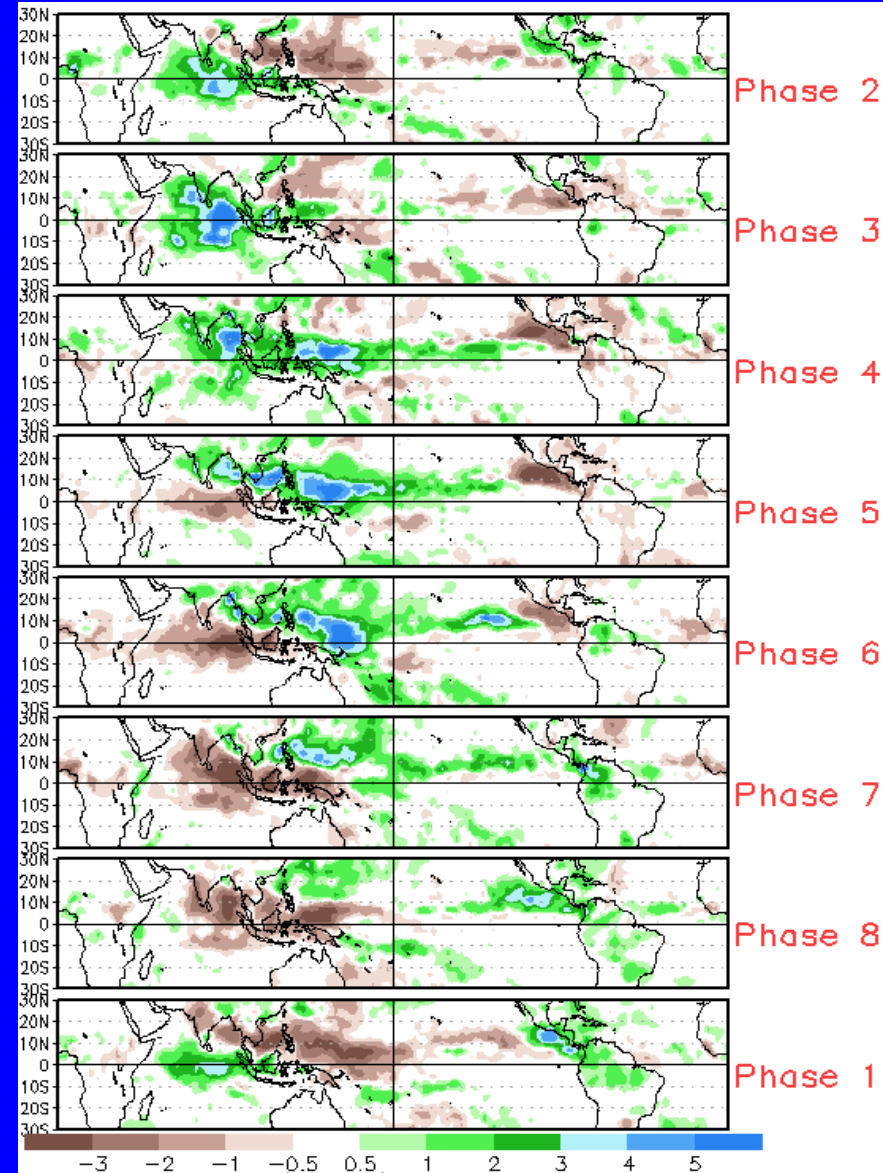
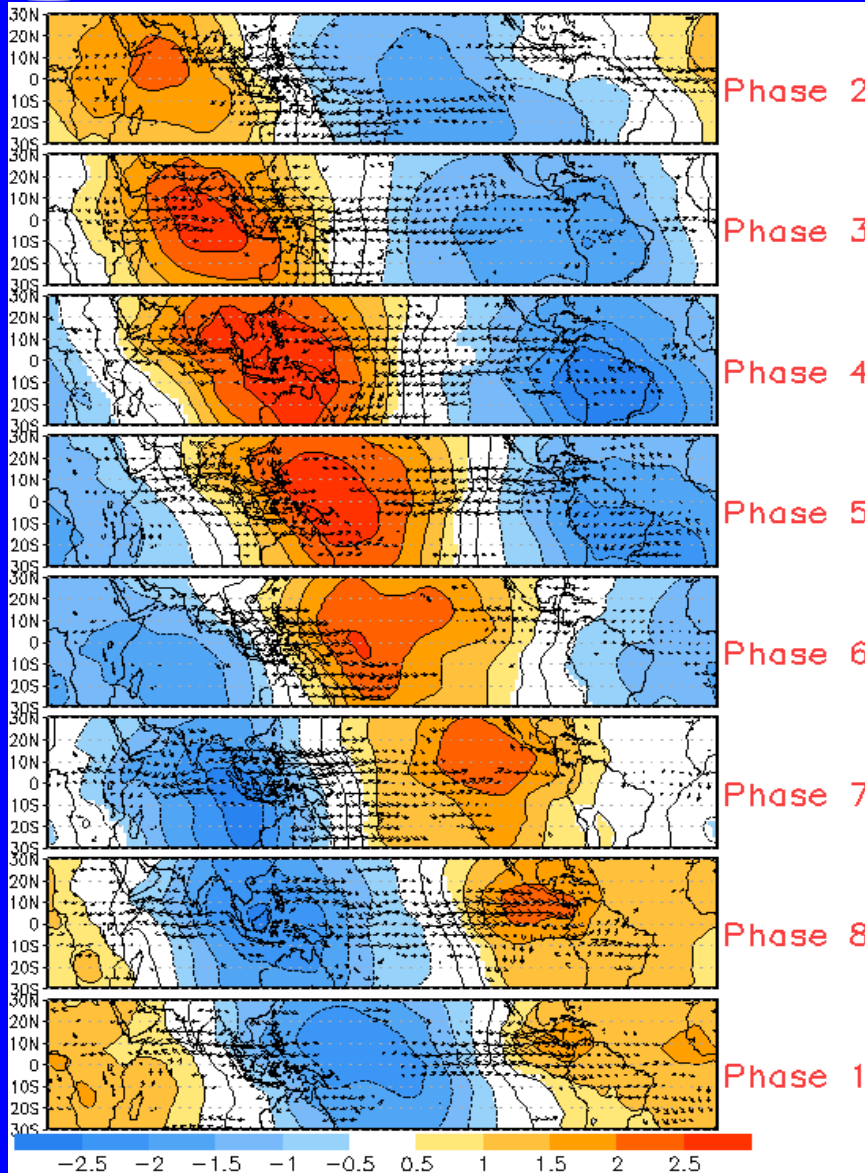




# MJO Composites – Global Tropics

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

Precipitation Anomalies (May-Sep)

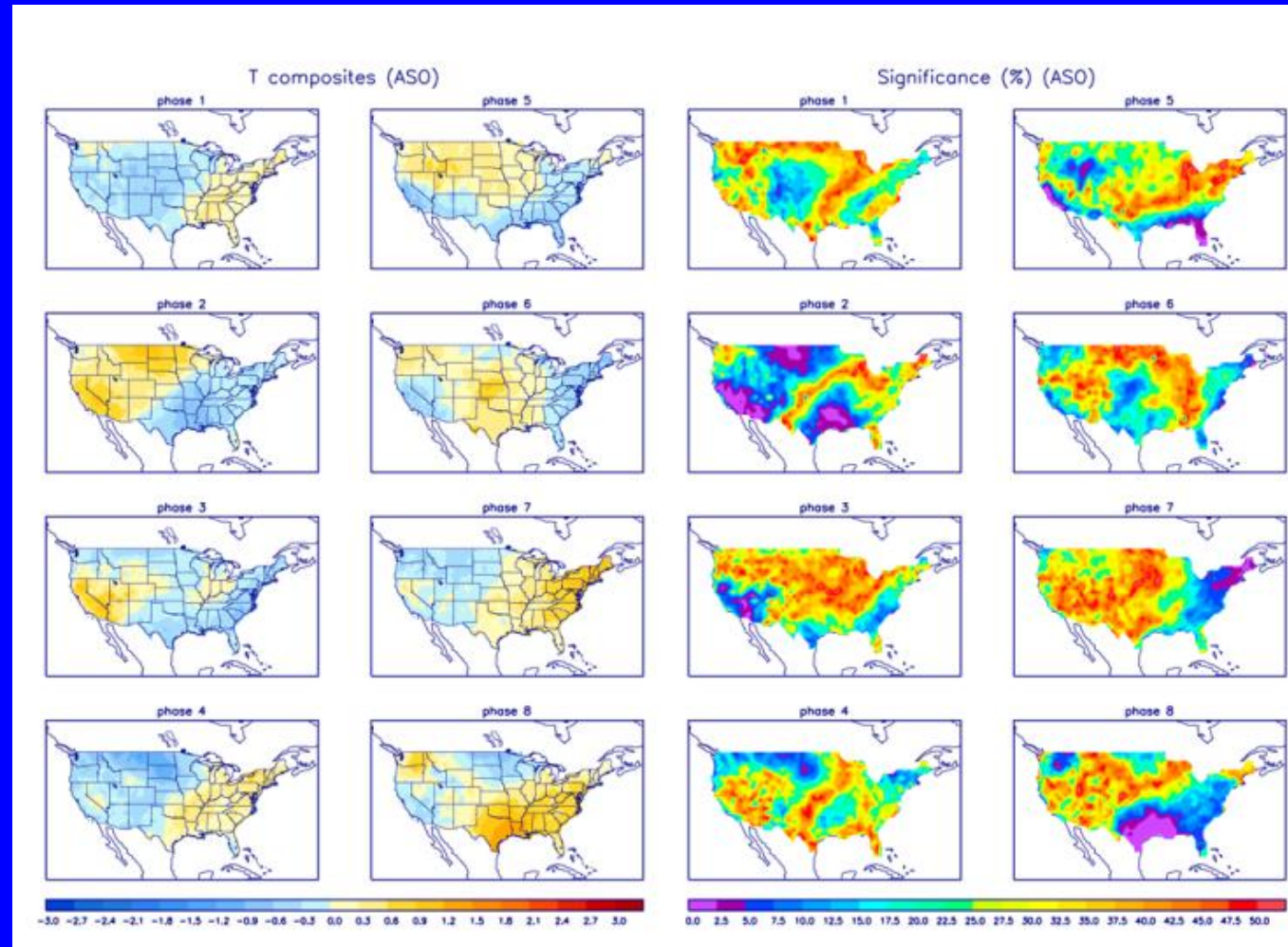




# U.S. MJO Composites – Temperature

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.



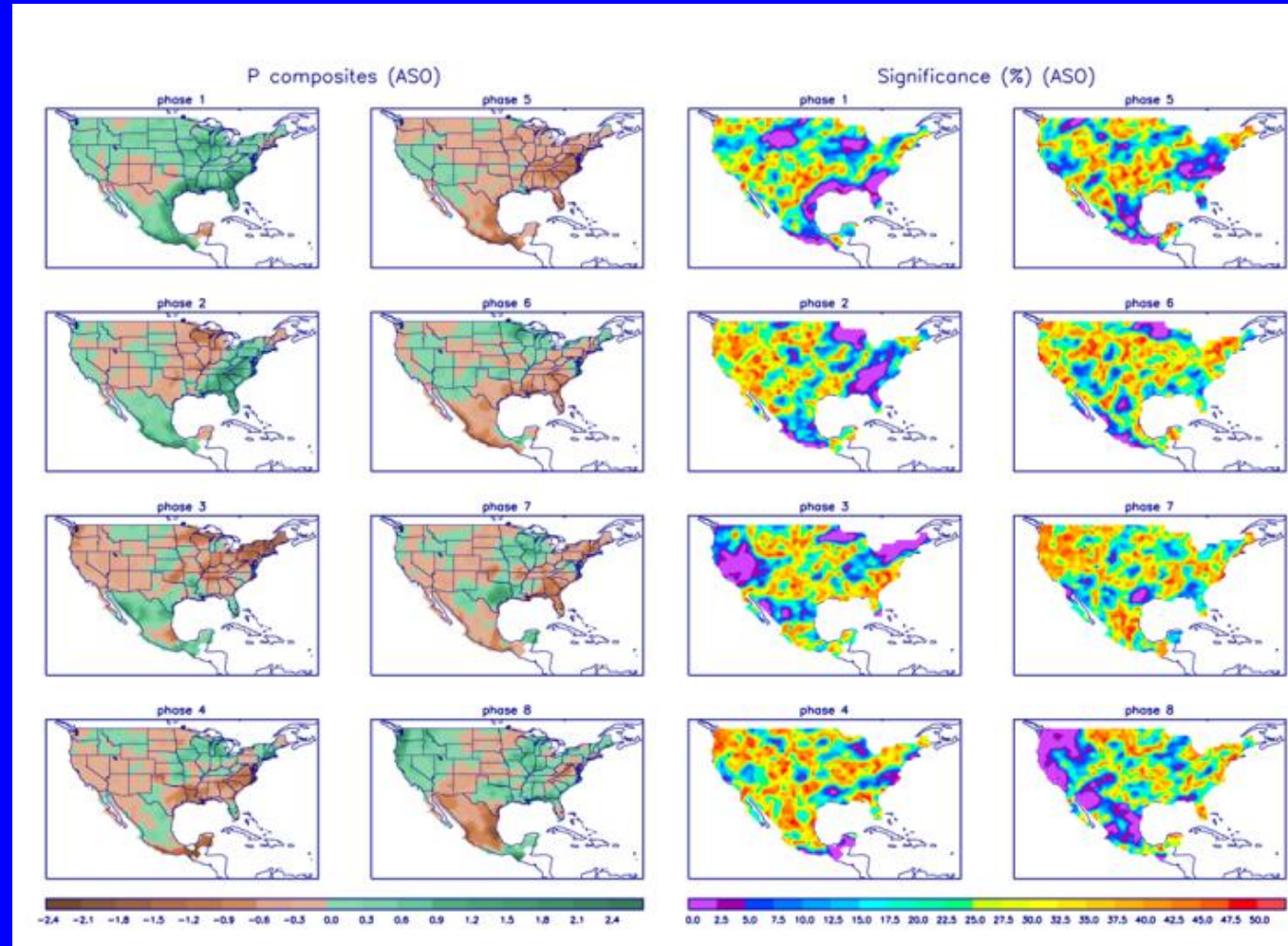
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>