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

**Update prepared by:**
Climate Prediction Center / NCEP
7 September 2015

# Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

# Overview

The MJO remained weak during the past week.

Other types of variability, including the ongoing El Niño and tropical cyclone activity over the Atlantic and Pacific basins, remain the primary drivers of the global tropical convective pattern.

Some dynamical models indicate a potential for the development of an intraseasonal signal over the Maritime Continent that interferes with the ongoing El Niño pattern. Other models develop this signal over the far West Pacific.

The MJO is not expected to play a role in the pattern of tropical convection during Week-1, but a potentially developing signal during Week-2 may contribute to enhanced convection over the Bay of Bengal and South China Sea.

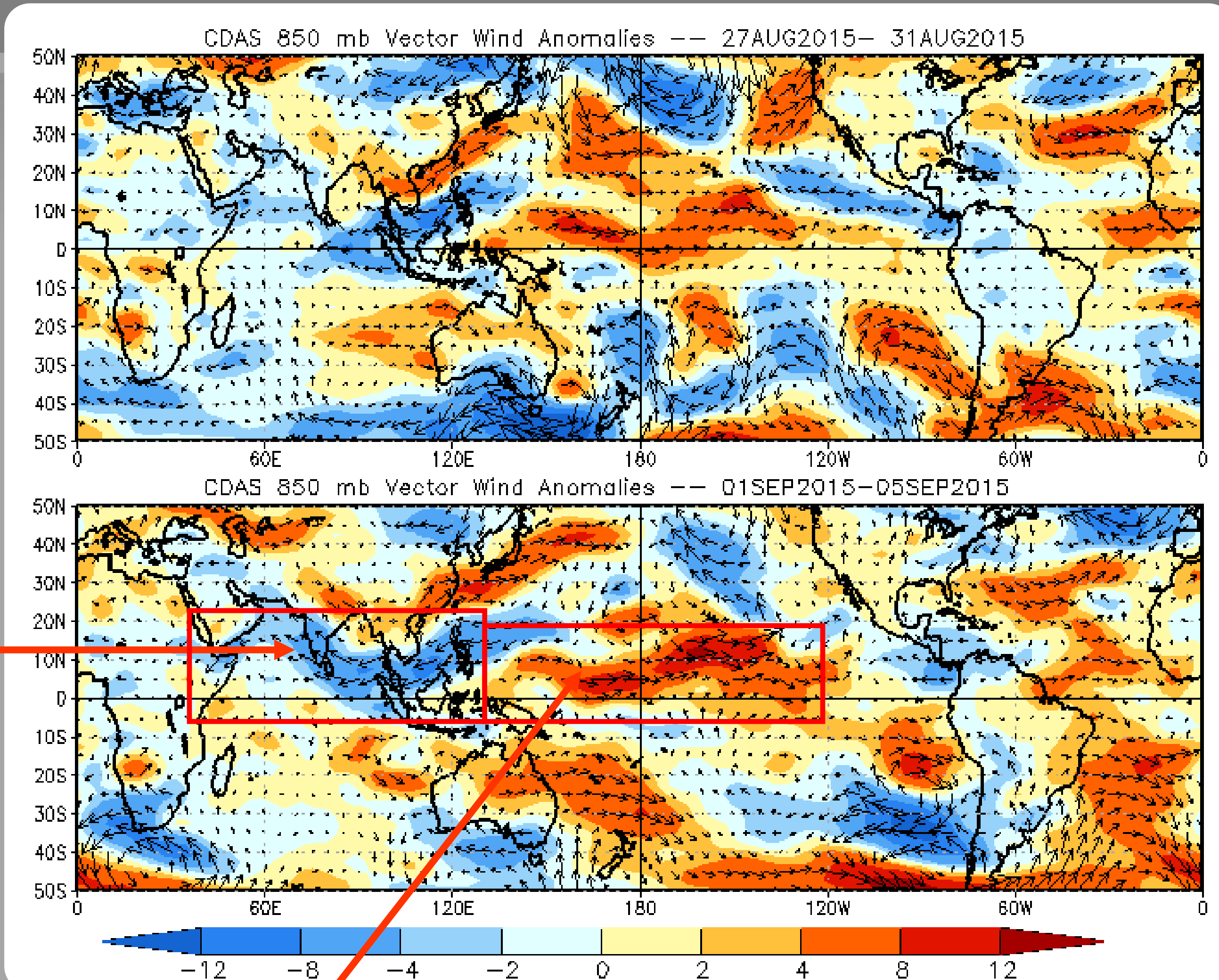
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

# 850-hPa Vector Wind Anomalies (m s-1)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies




Easterly anomalies intensified over South Asia and the northeastern Indian Ocean, and persisted over the northwestern Maritime Continent.

Westerly wind anomalies persisted and intensified over the central Pacific, consistent with the ongoing strong El Niño.

# 850-hPa Zonal Wind Anomalies (m s-1)

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

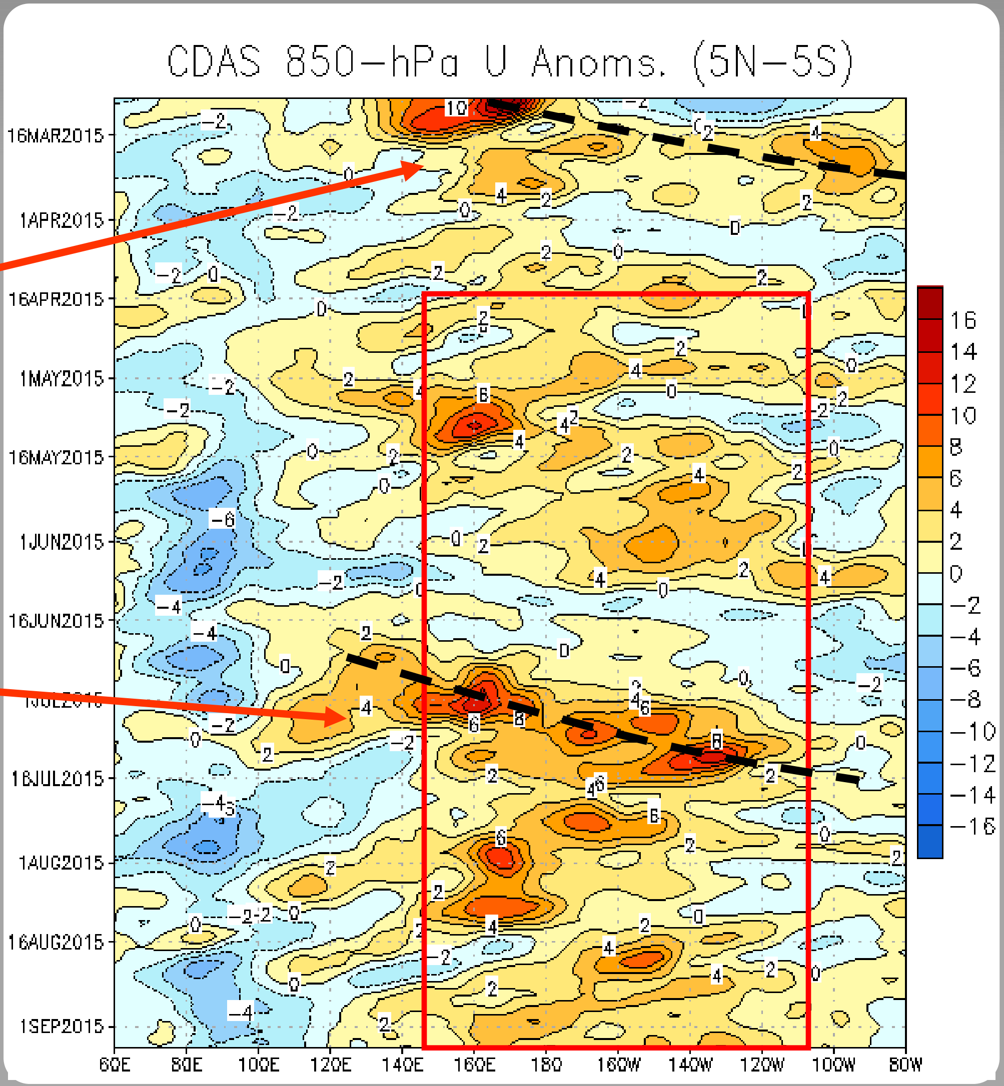
Easterly anomalies (blue shading) represent anomalous east-to-west flow

The MJO, Rossby wave activity, and El Niño conditions contributed to a strong westerly wind burst in early March.

The red box highlights the persistent low-frequency westerly wind anomalies associated with ENSO. Some transient variability is observed as well.

A robust MJO event was observed in late June through mid-July, constructively interfering with the background state.

Recently, the background ENSO remains the primary signal, but other modes, including tropical cyclone activity across much of the Pacific, continue to influence the pattern.



# OLR Anomalies – Past 30 days

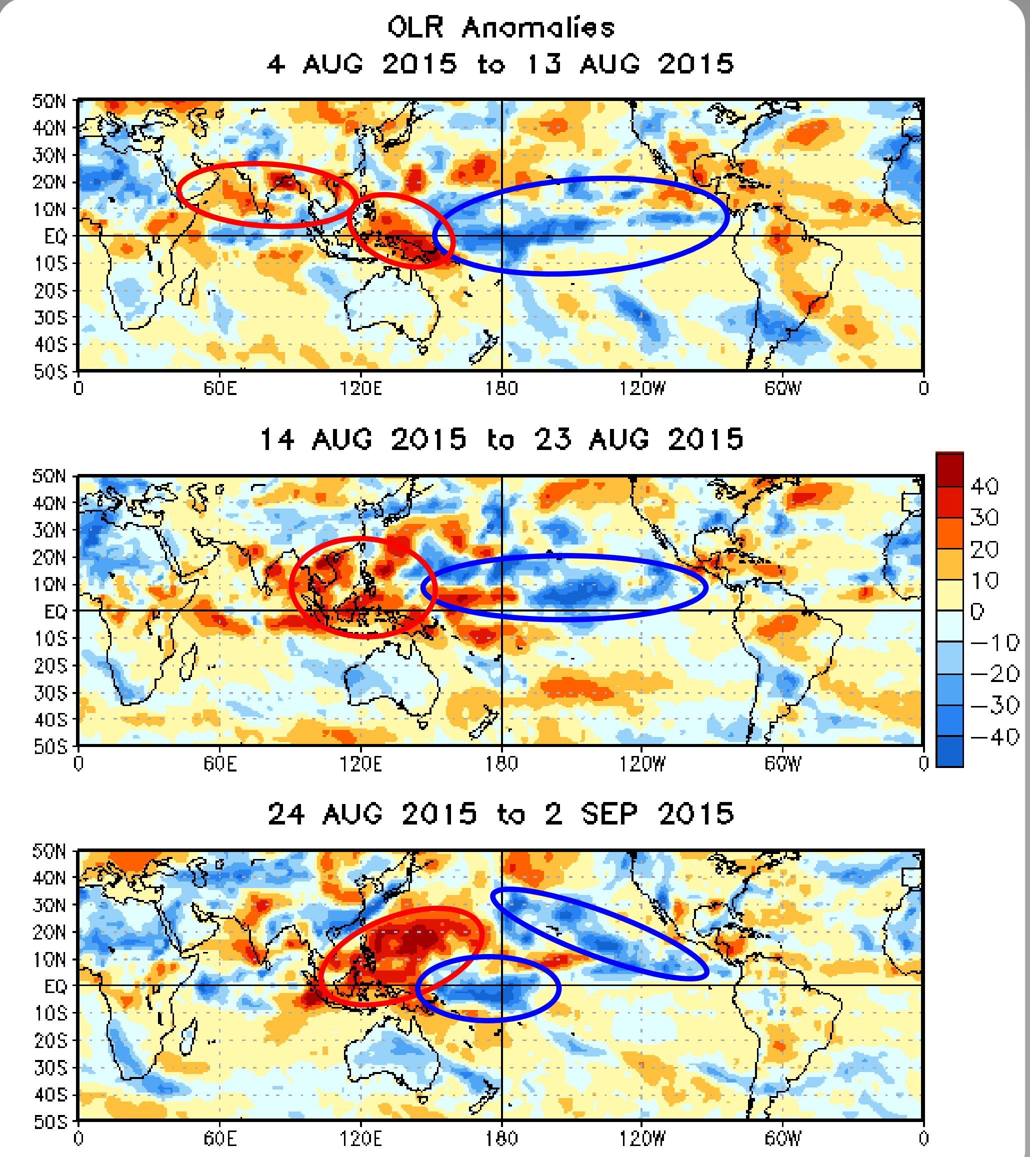
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During early August, the ENSO signal was dominant, with suppressed (enhanced) convection over South Asia and the eastern Maritime Continent (central and eastern Pacific).

During mid-August, the strongest enhanced convective signal shifted from near the Date Line to the east-central Pacific. TC activity was evident near Hawaii.

During late August and the beginning of September, the focus for enhanced convection shifted to the East Pacific, with continuing TC activity east, north, and west of Hawaii. Renewed convection developed near the Date Line, while suppressed convection persisted over the Maritime Continent and northwestern Pacific.



# Outgoing Longwave Radiation (OLR) Anomalies (2.5ºN-17.5ºN)

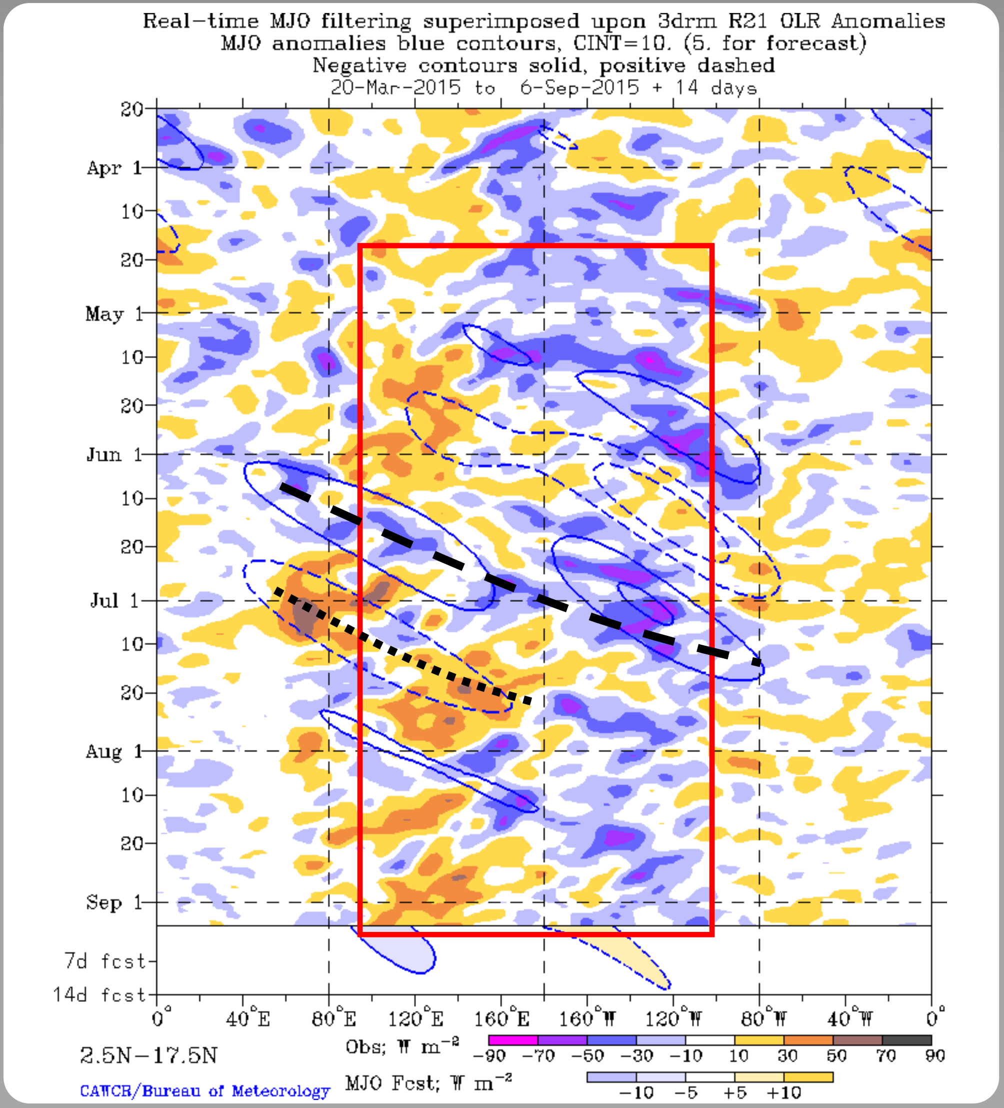
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

Wetter-than-normal conditions, negative OLR anomalies (blue shading)

Since April, the ongoing El Niño is observed (red box) as a tendency toward a dipole of anomalous convection extending from the Maritime Continent (suppressed) to the East Pacific (enhanced).

During June and early July, the MJO become active, interfering with the ENSO signal at times.

The MJO was weak during August, with strong El Niño conditions and tropical cyclone activity dominating the pattern. An eastward propagation of the strongest convective anomalies over the Pacific was observed, but there was no subsequent suppressed phase, and the signal was not apparent in other fields such as upper-level VP; therefore it was not MJO related.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

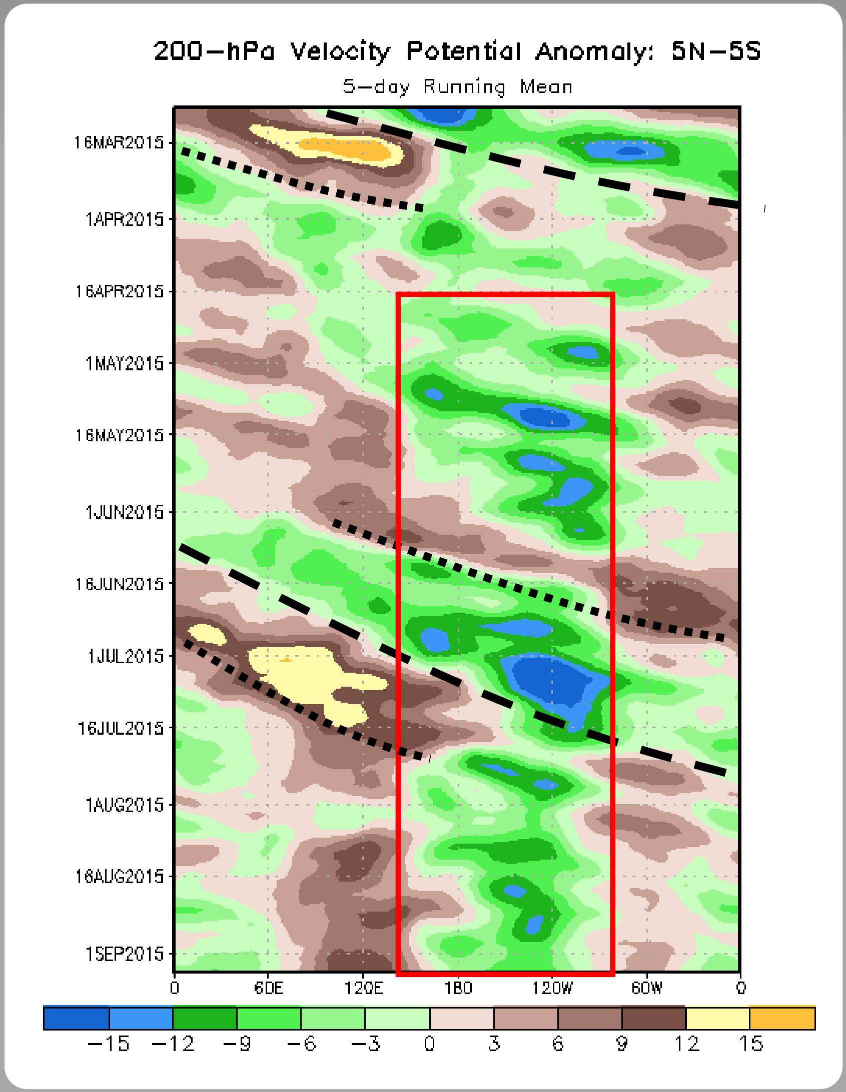
Negative anomalies (green shading) indicate favorable conditions for precipitation

The MJO strengthened in early March as seen in the upper-level velocity potential anomalies.

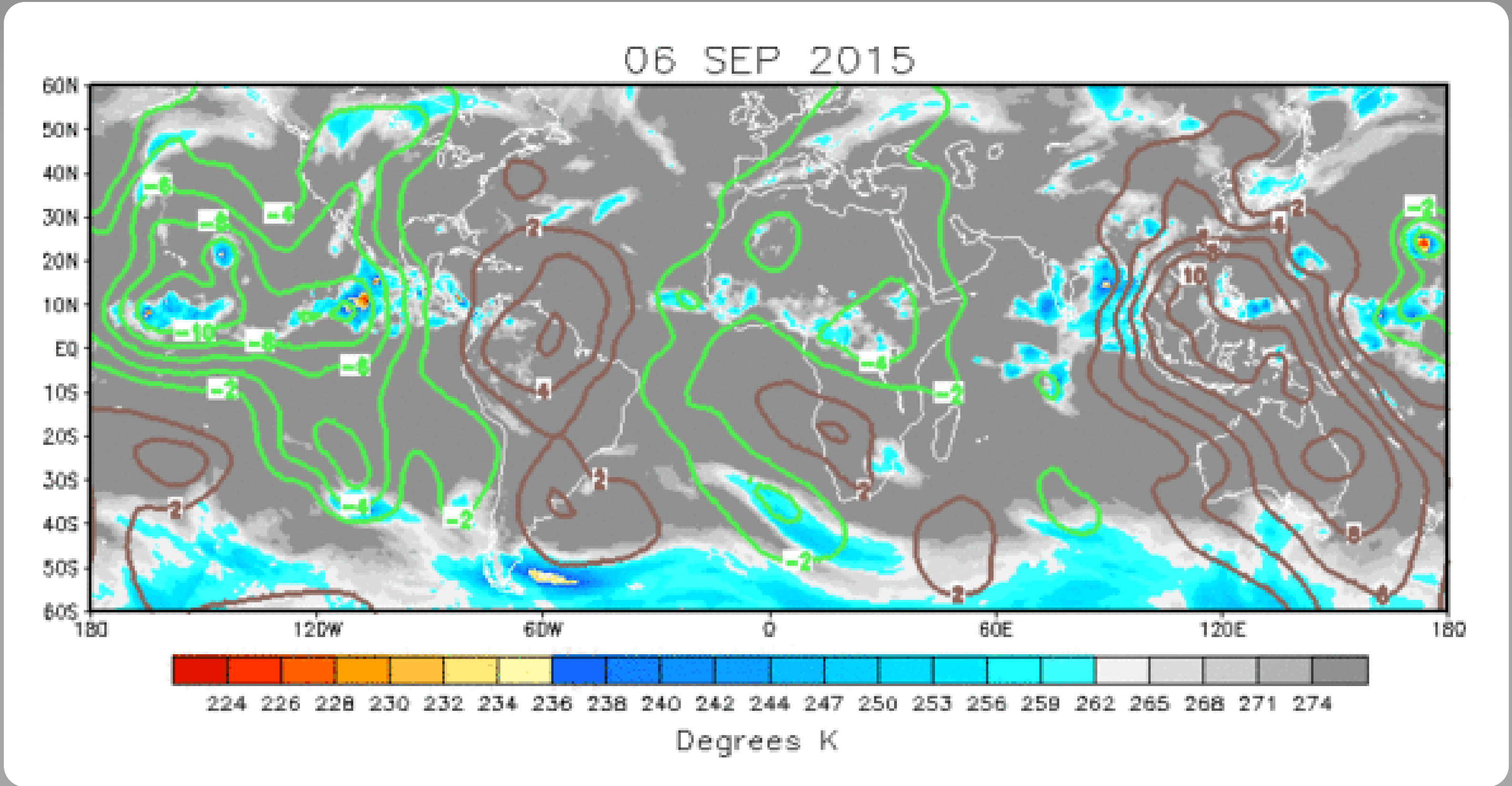
The developing ENSO state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific. This pattern has only been temporarily interrupted by strong Kelvin wave/MJO activity at times.

During June and early July, a high-amplitude MJO event was observed, constructively interfering with the El Niño signal in early July. By the end of July, the MJO weakened as the low-frequency state dominated the pattern of tropical variability.

More recently, a generally stationary pattern reflective of El Niño conditions was observed.



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




The upper-level velocity potential pattern continues to show anomalous upper-level divergence over the central and eastern Pacific with upper-level convergence over the Maritime Continent. Anomalous divergence over Africa and the far eastern Atlantic has contributed to more robust tropical wave activity and recent tropical cyclogenesis.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

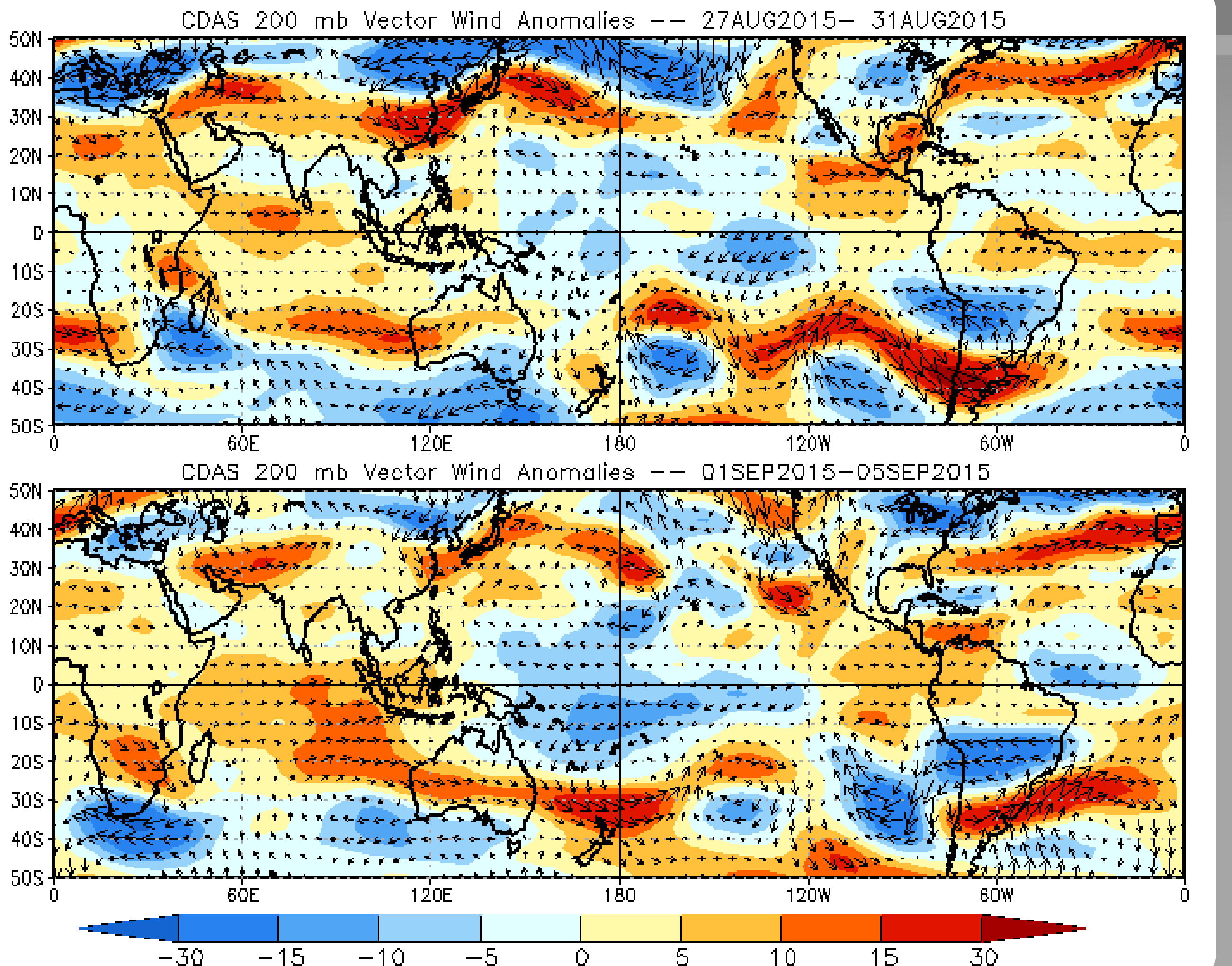
Negative anomalies (green contours) indicate favorable conditions for precipitation

# 200-hPa Vector Wind Anomalies (m s-1)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies




Upper-level easterly anomalies increased near the Date Line.

# 200-hPa Zonal Wind Anomalies (m s-1)

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

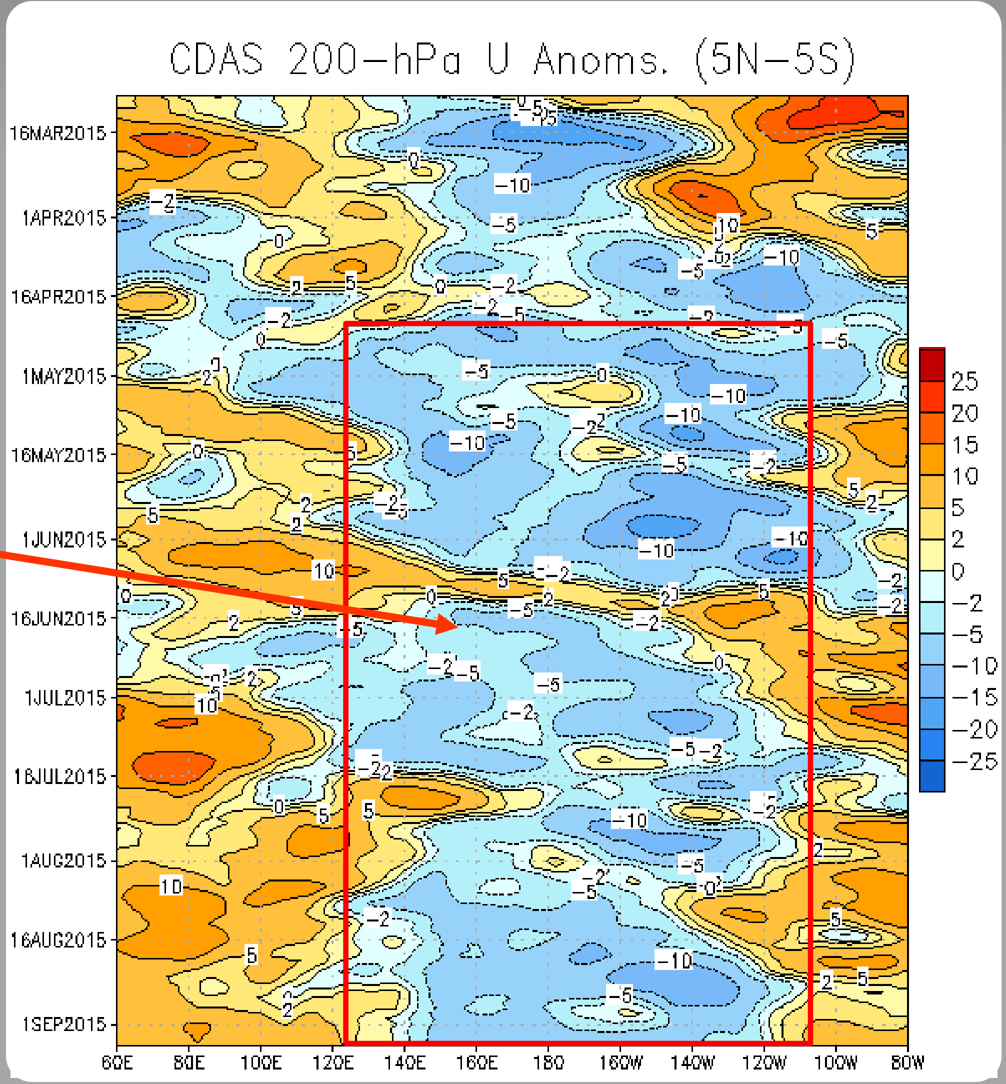
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Easterly anomalies have persisted over the central and eastern Pacific associated with El Niño since mid-April (red box).

During June, these easterly anomalies were interrupted by robust atmospheric Kelvin wave/MJO activity.

During August, some westward propagation of westerly anomalies from the Maritime Continent to the Indian Ocean was evident.

Recently, a generally stationary pattern was observed.



# Weekly Heat Content Evolution in the Equatorial Pacific

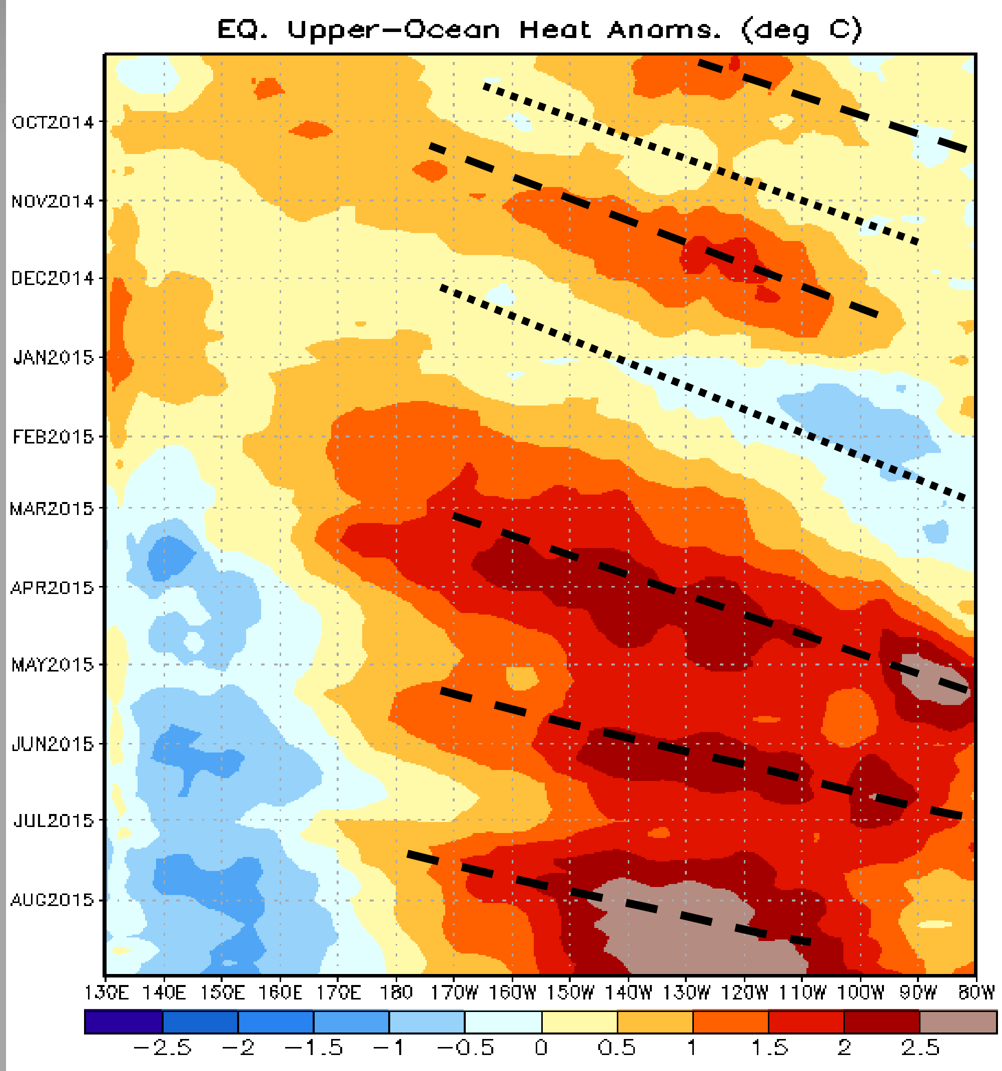
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

During October-November, positive subsurface temperature anomalies increased and shifted eastward in association with the downwelling phase of a Kelvin wave. During November - January, the upwelling phase of a Kelvin wave shifted eastward.

Following a strong westerly wind burst in March, another downwelling phase of a Kelvin wave propagated eastward, reaching the South American coast during May.

Reinforcing downwelling events have followed, resulting in persistently above-normal heat content from the Date Line to 90W.

Heat content anomalies greater than 2.5° C were observed over the east-central Pacific with the latest oceanic 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

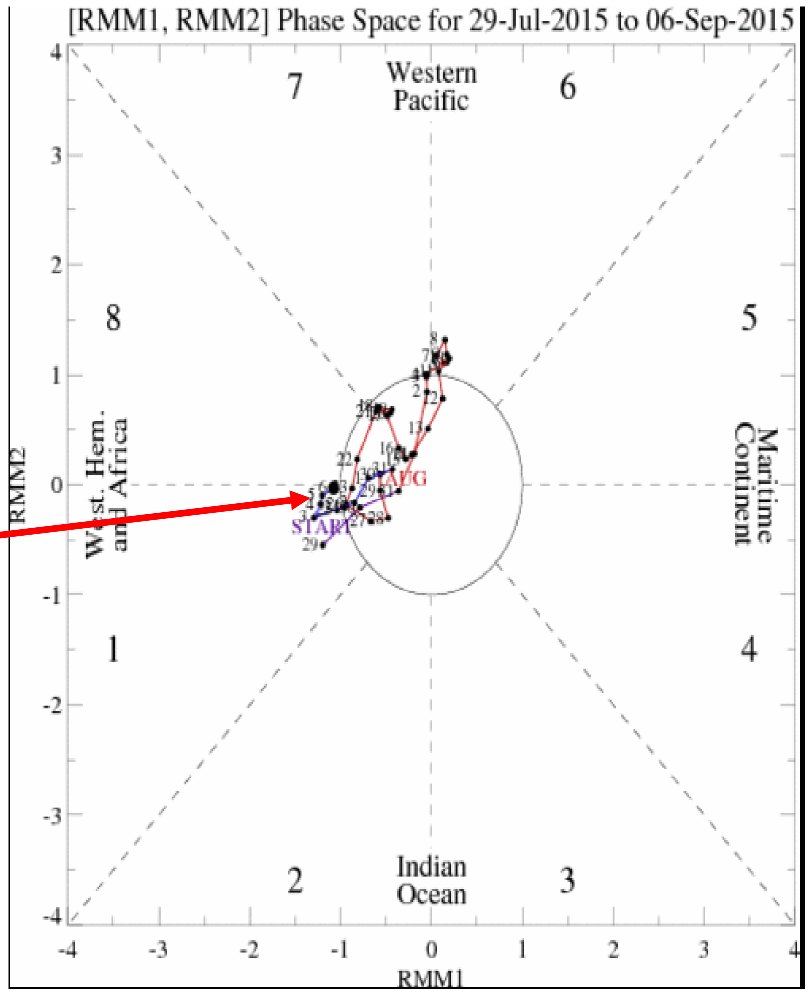
The triangular areas indicate the location of the enhanced phase of the MJO

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

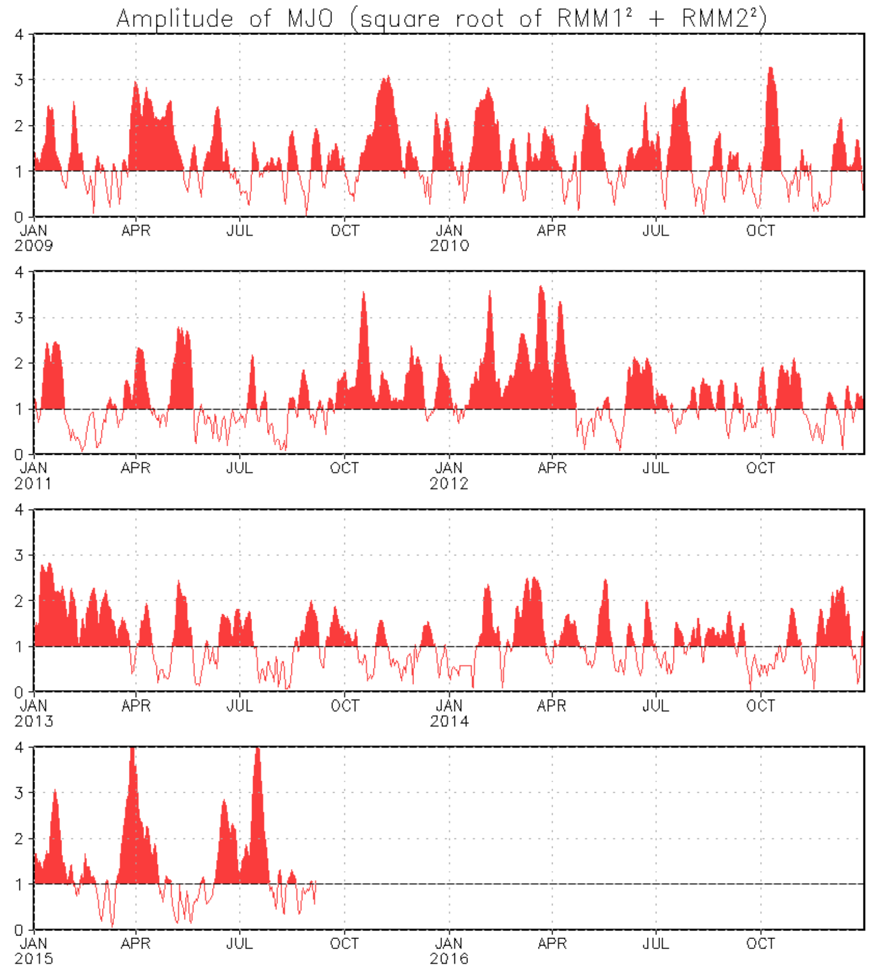
The MJO index indicated weak MJO activity during the past few weeks, with weak amplitude over the Western Hemisphere partly associated with tropical cyclone activity.



# MJO Index – Historical Daily Time Series

Time series of daily MJO index amplitude for the last few years.

Plot puts current MJO activity in recent historical context.



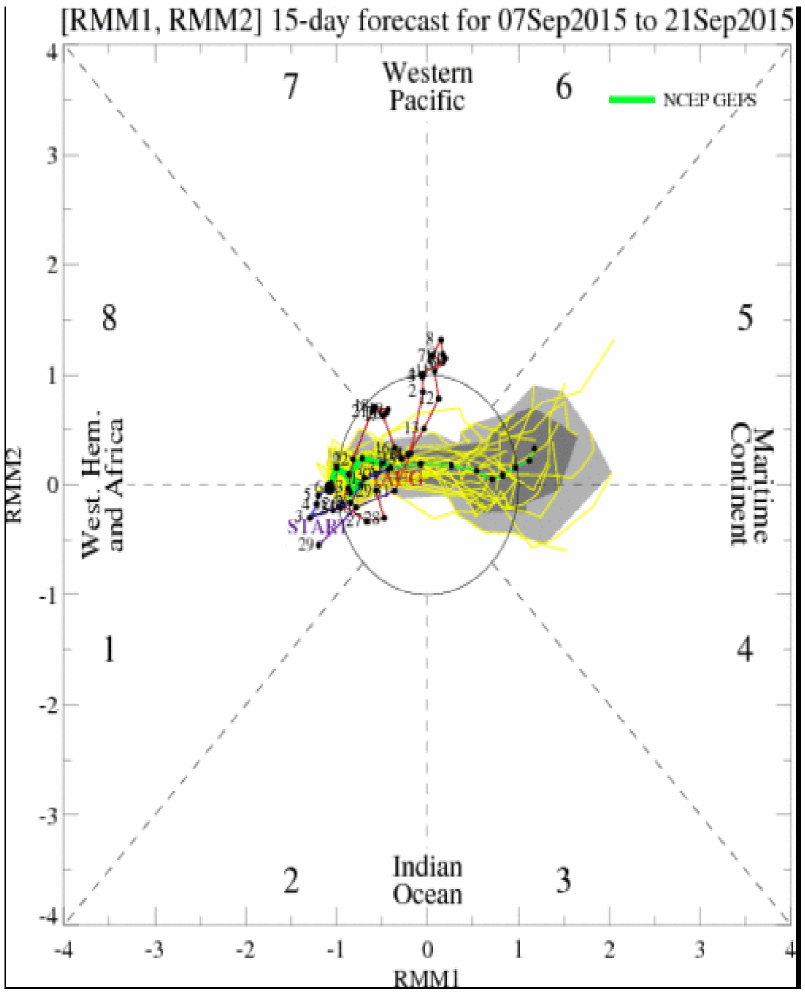
# Ensemble GFS (GEFS) MJO Forecast

<u>Yellow Lines</u> - 20 Individual Members
<u>Green Line</u> - 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

<u>light gray shading</u>: 90% of forecasts

<u>dark gray shading</u>: 50% of forecasts

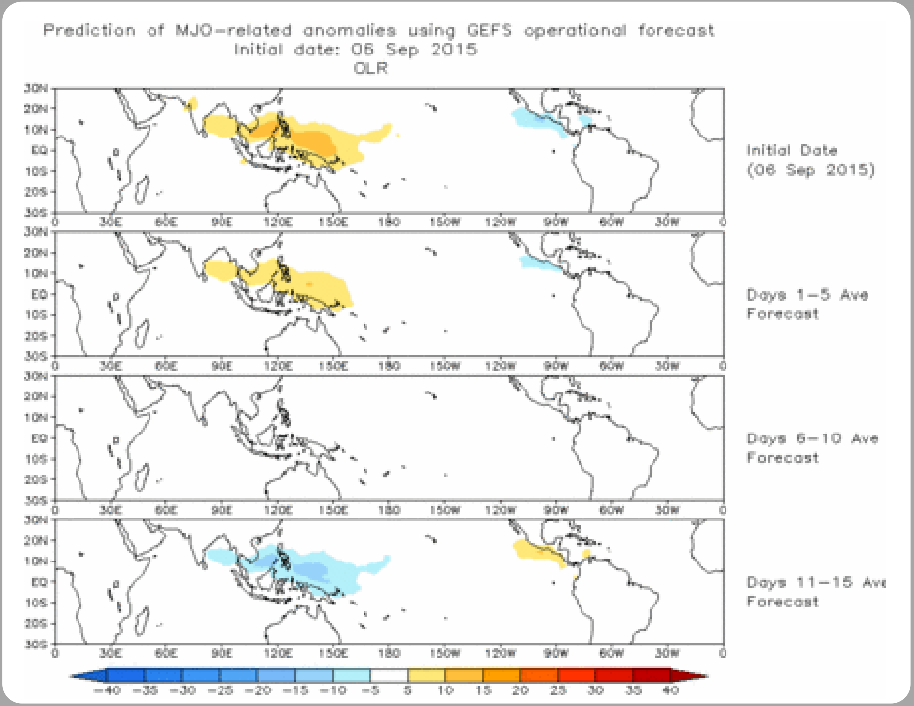



The GFS ensemble MJO index forecast depicts little signal during Week-1, with increasing amplitude over the Maritime Continent during Week-2.

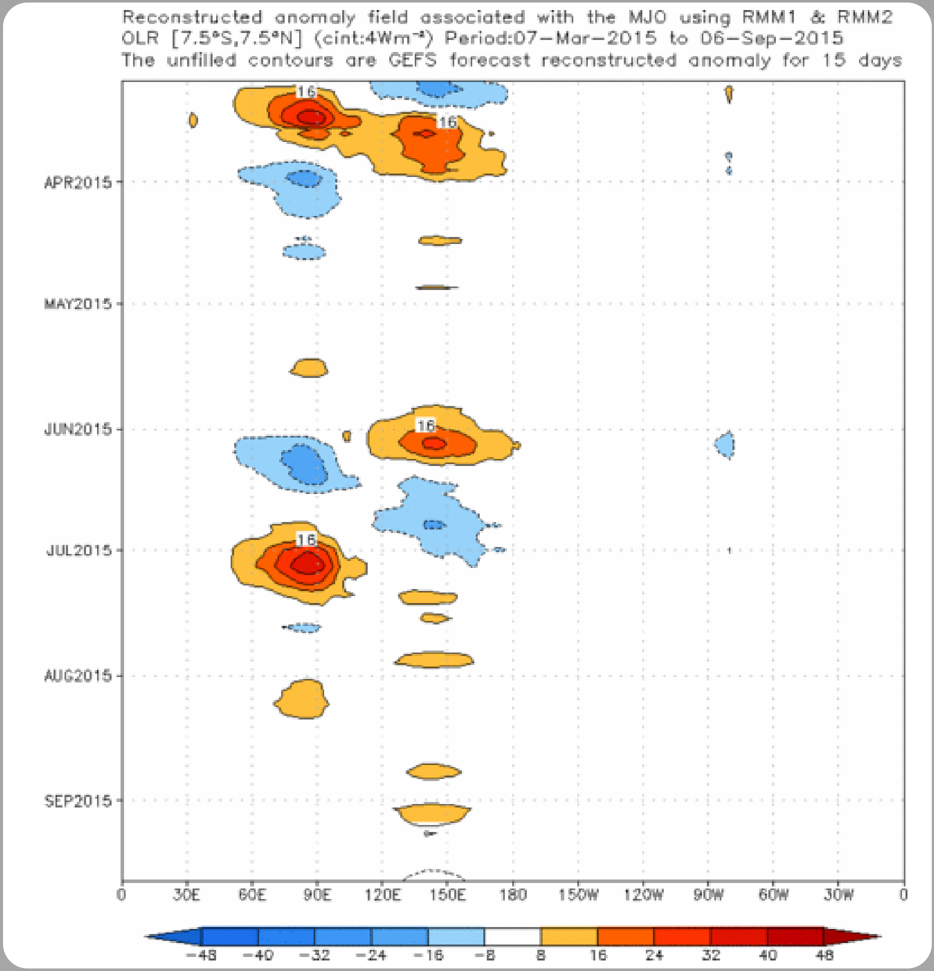
# Ensemble GFS (GEFS) MJO Forecast

**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 - last 180 days and for the next 15 days

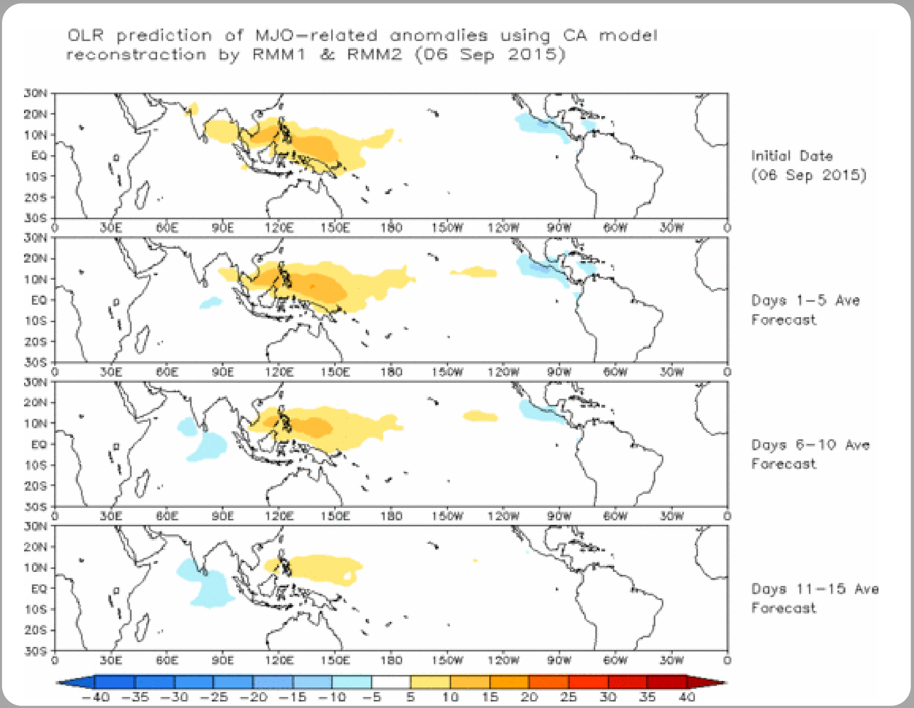



The GEFS MJO index-based OLR forecast depicts a reversal of the suppressed convection over the northern Maritime Continent by Week-2.

# Constructed Analog (CA) MJO Forecast

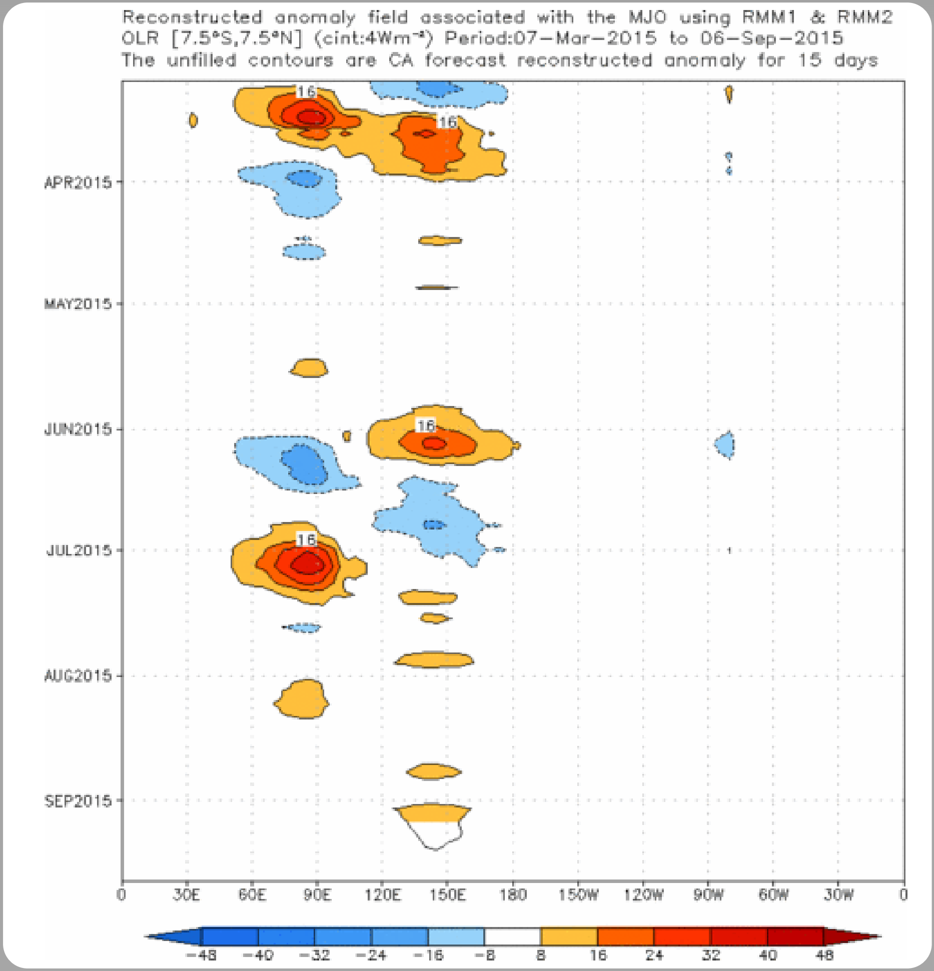
**Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)**

Spatial map of OLR anomalies for the next 15 days




The constructed analog model depicts a weakening stationary anomaly pattern.

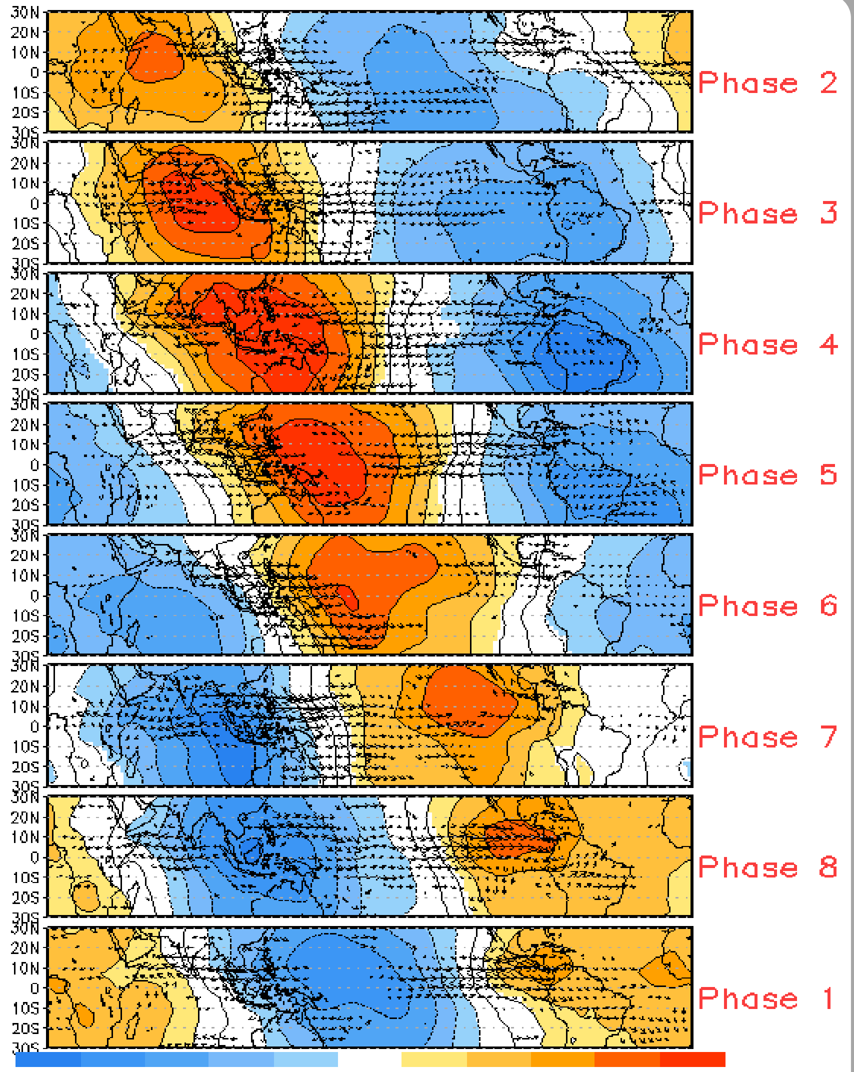
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



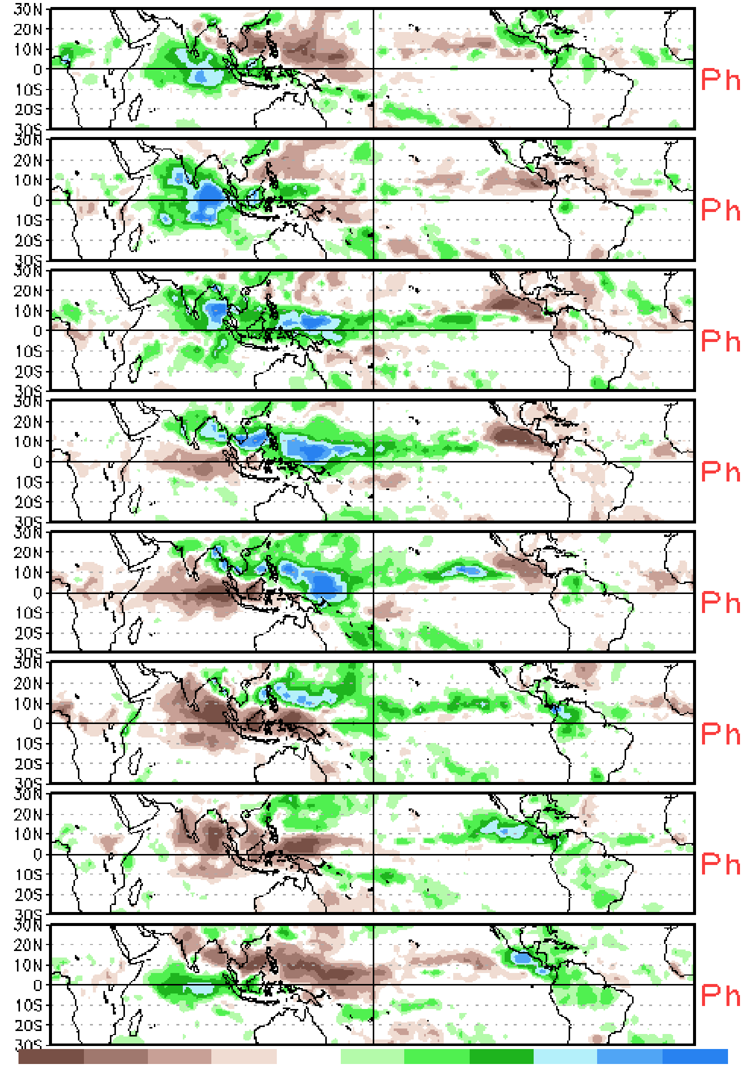
# MJO Composites - Global Tropics

850-hPa Velocity Potential and

Wind Anomalies (May-Sep)



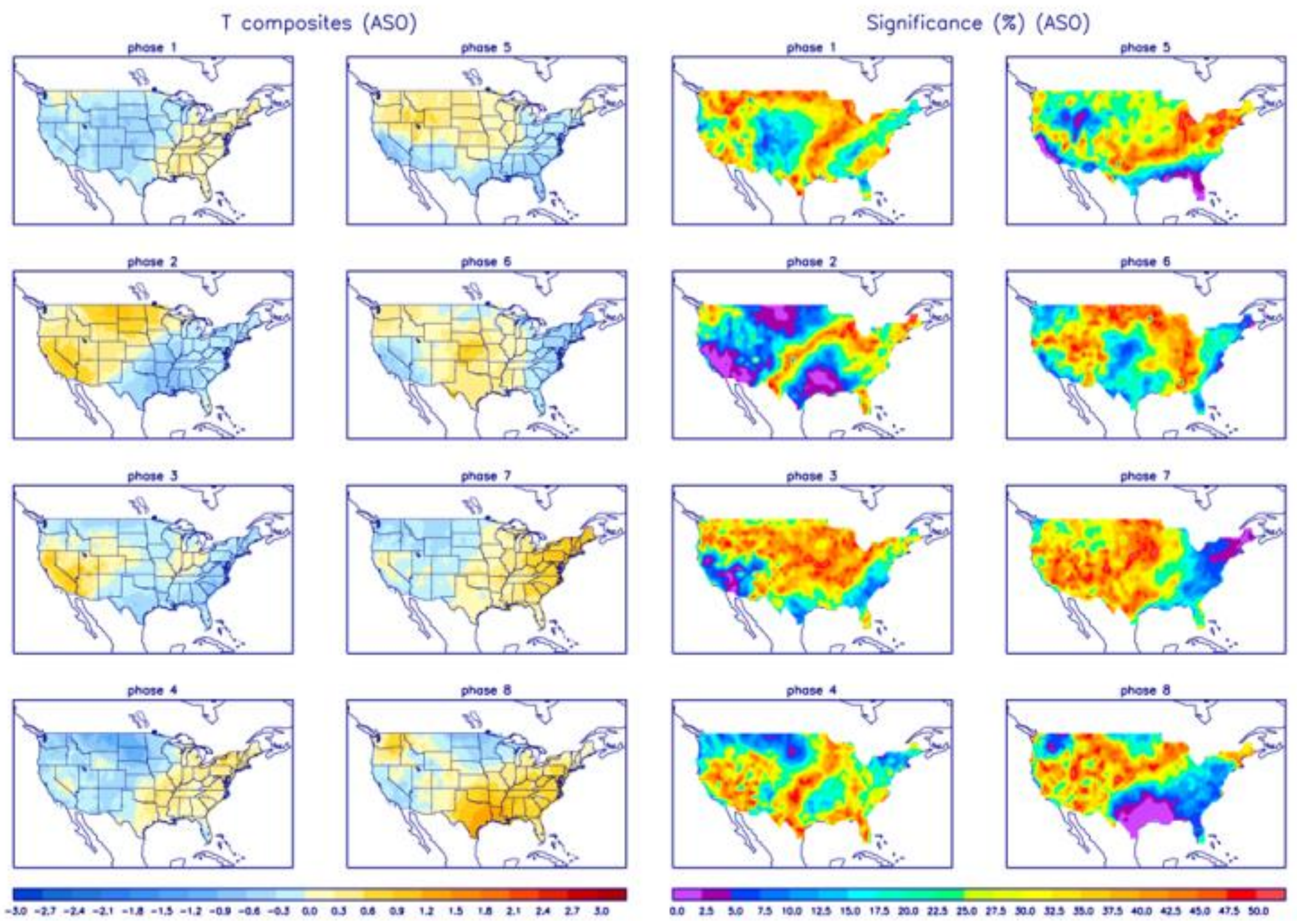

Precipitation Anomalies (May-Sep)



# 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.



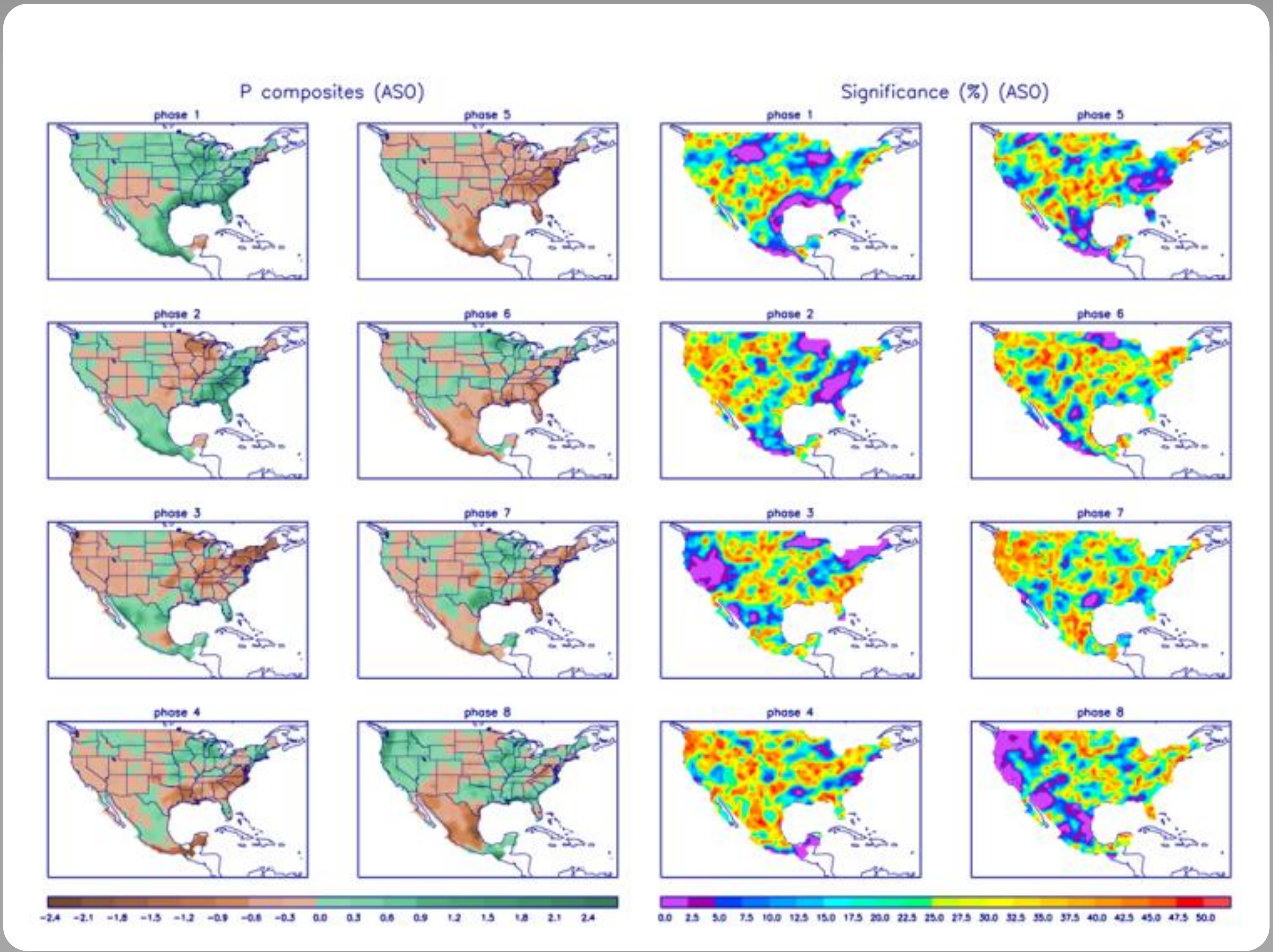

Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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