

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



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Climate Prediction Center / NCEP  
21 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, remain the primary influences on the global tropical convective pattern.

The consensus among dynamical and statistical models is that the ongoing El Niño remains the major contributor to anomalous convection.

The MJO is not expected to play a major role in the pattern of tropical convection during the period.

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>

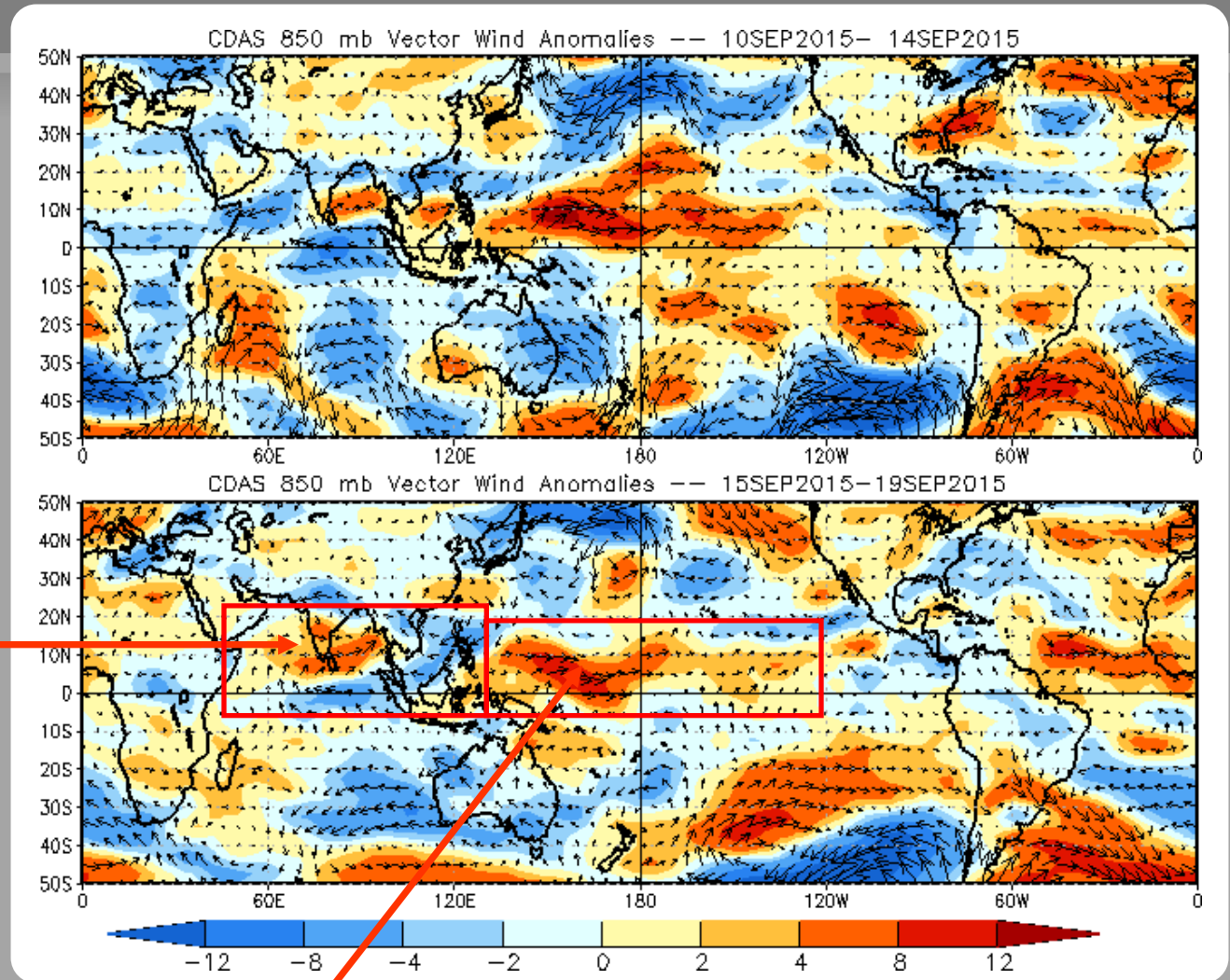
# 850-hPa Vector Wind Anomalies (m s<sup>-1</sup>)

Note that shading denotes the zonal wind anomaly

**Blue shades:** Easterly anomalies

**Red shades:** Westerly anomalies

Westerly anomalies developed over the Arabian Sea, while easterly anomalies persisted across the eastern Indian Ocean.



Westerly wind anomalies persisted over the western and central Pacific, although with a decrease in magnitude.

# 850-hPa Zonal Wind Anomalies (m s<sup>-1</sup>)

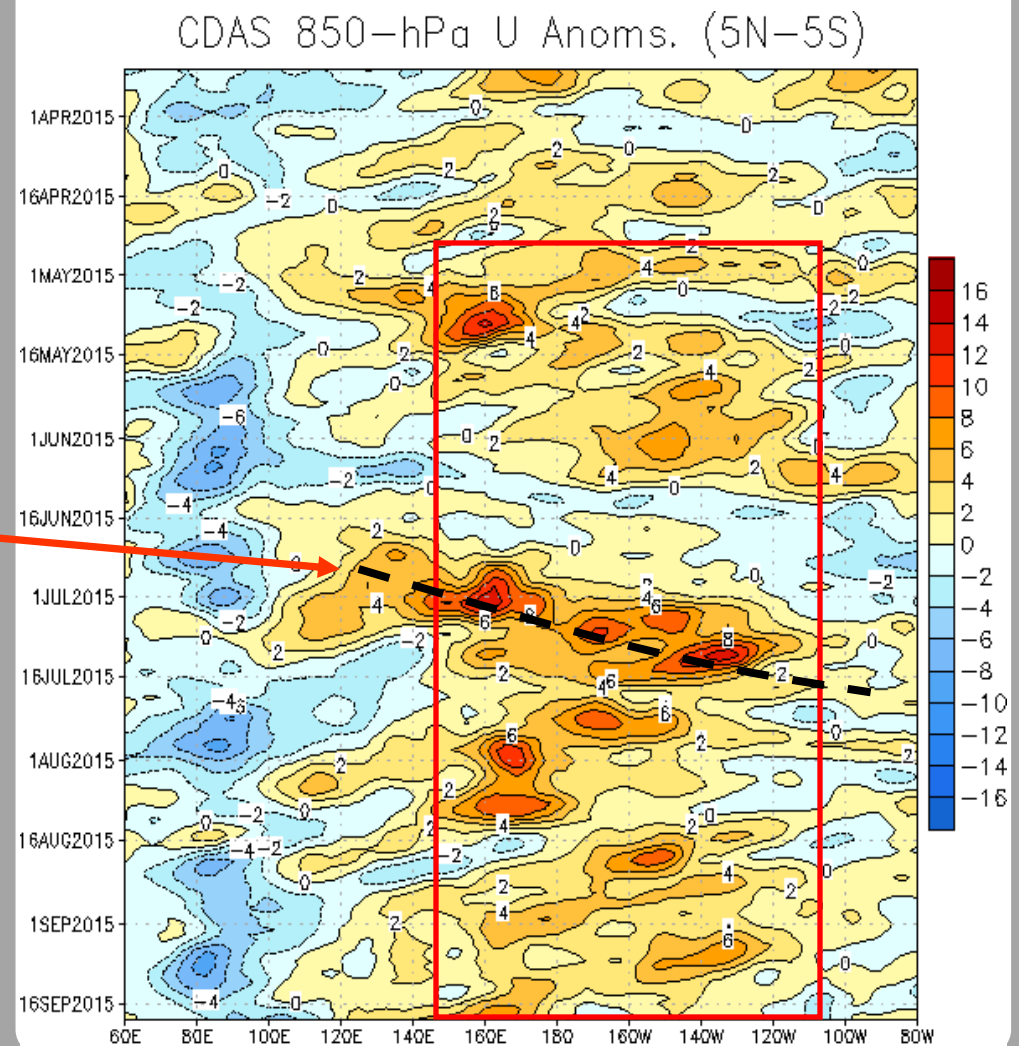
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

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.

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

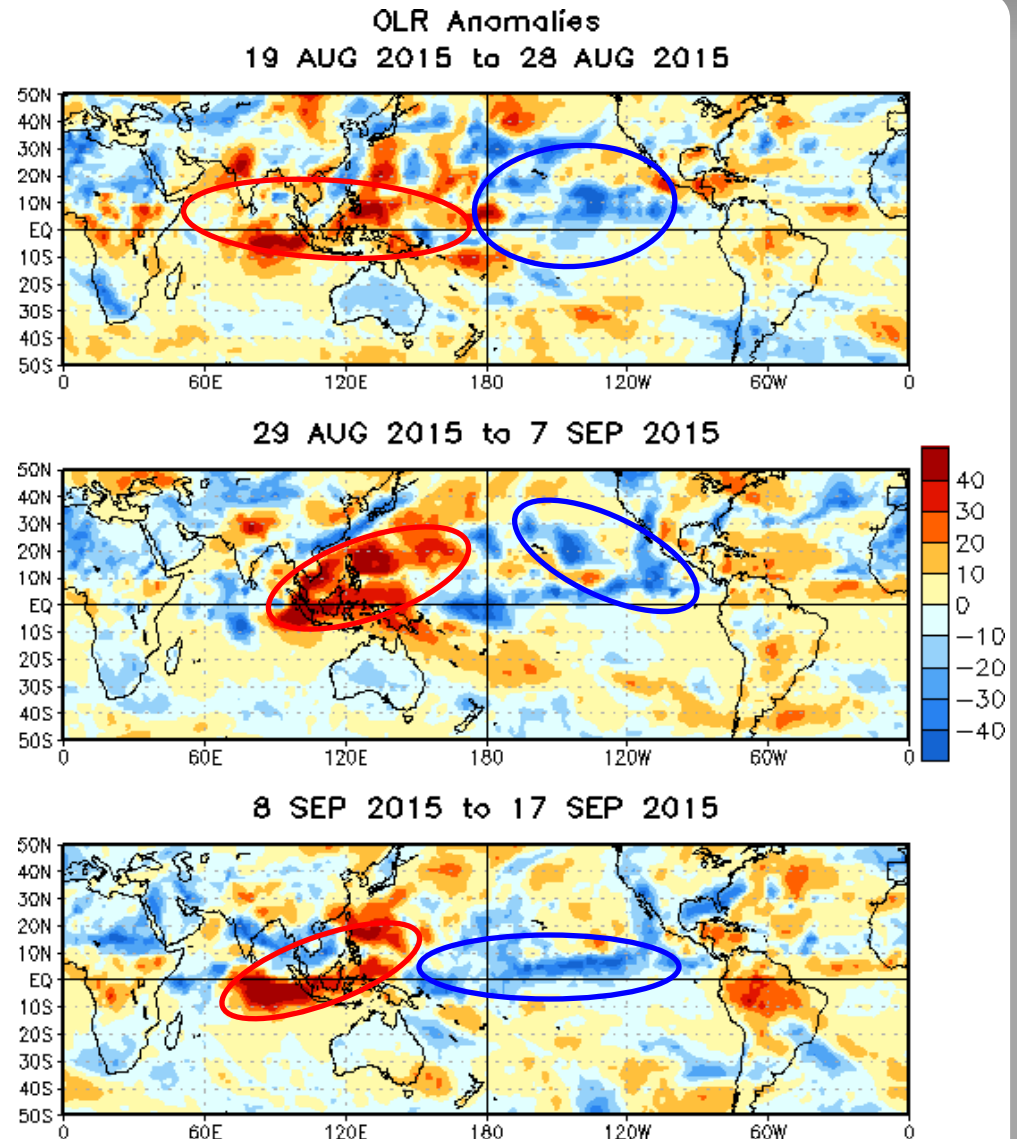
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late 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 early 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.

Convection waned near Hawaii during mid-September, but continued across the central and eastern Pacific. Suppressed convection persisted over the Maritime Continent.



# Outgoing Longwave Radiation (OLR) Anomalies (2.5°N-17.5°N)

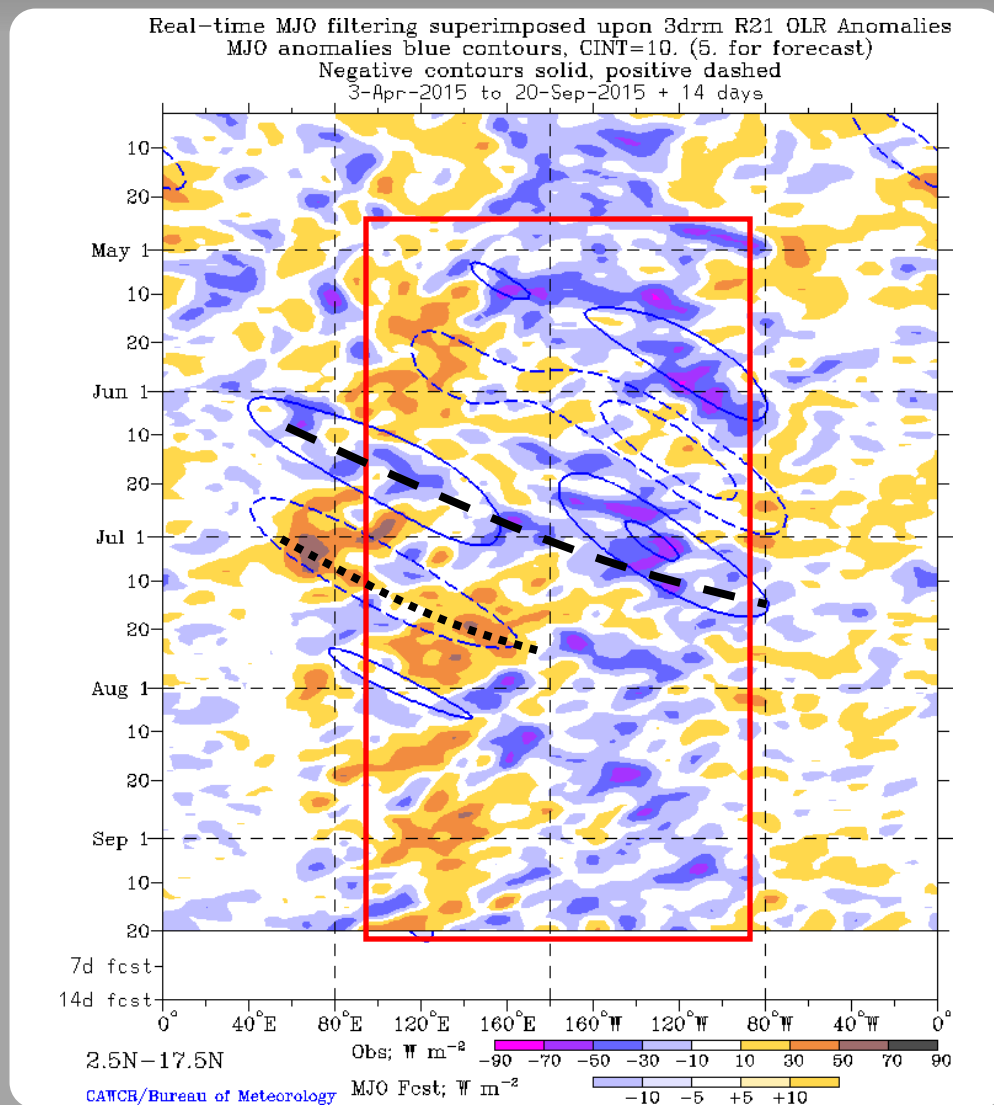
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

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.

Since July, the MJO has remained weak, with strong El Niño conditions and tropical cyclone activity dominating the pattern. During mid-August, some eastward propagation was evident in OLR, but the subsident phase and other dynamic variables did not follow suit.



# 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

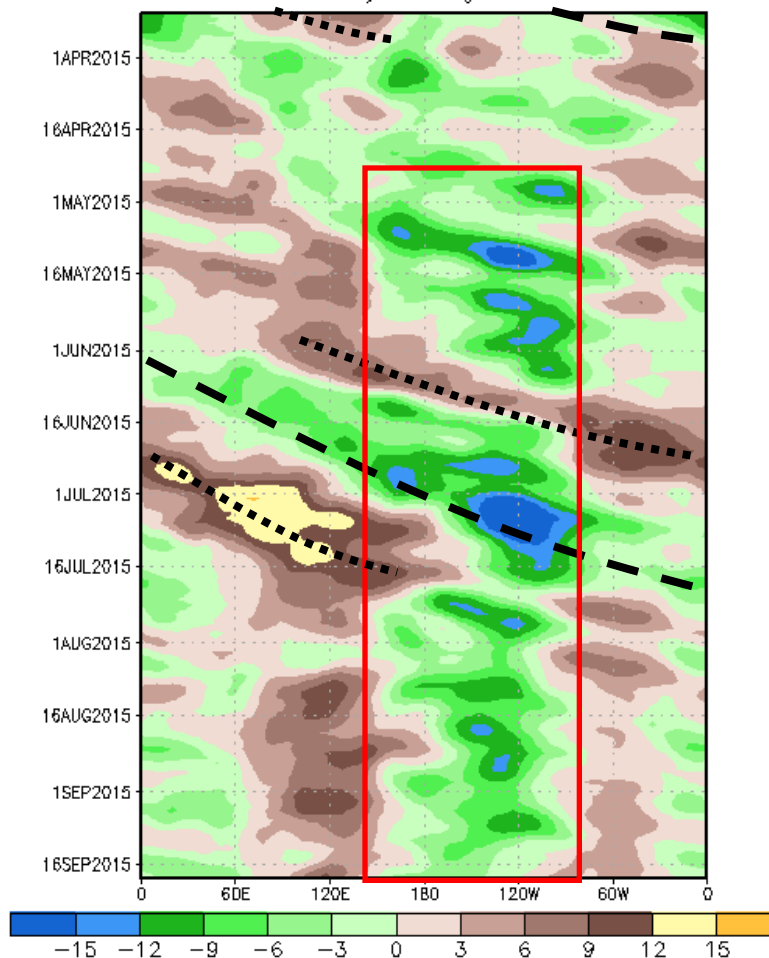
The MJO strengthened in March as seen in the upper-level velocity potential anomalies.

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.

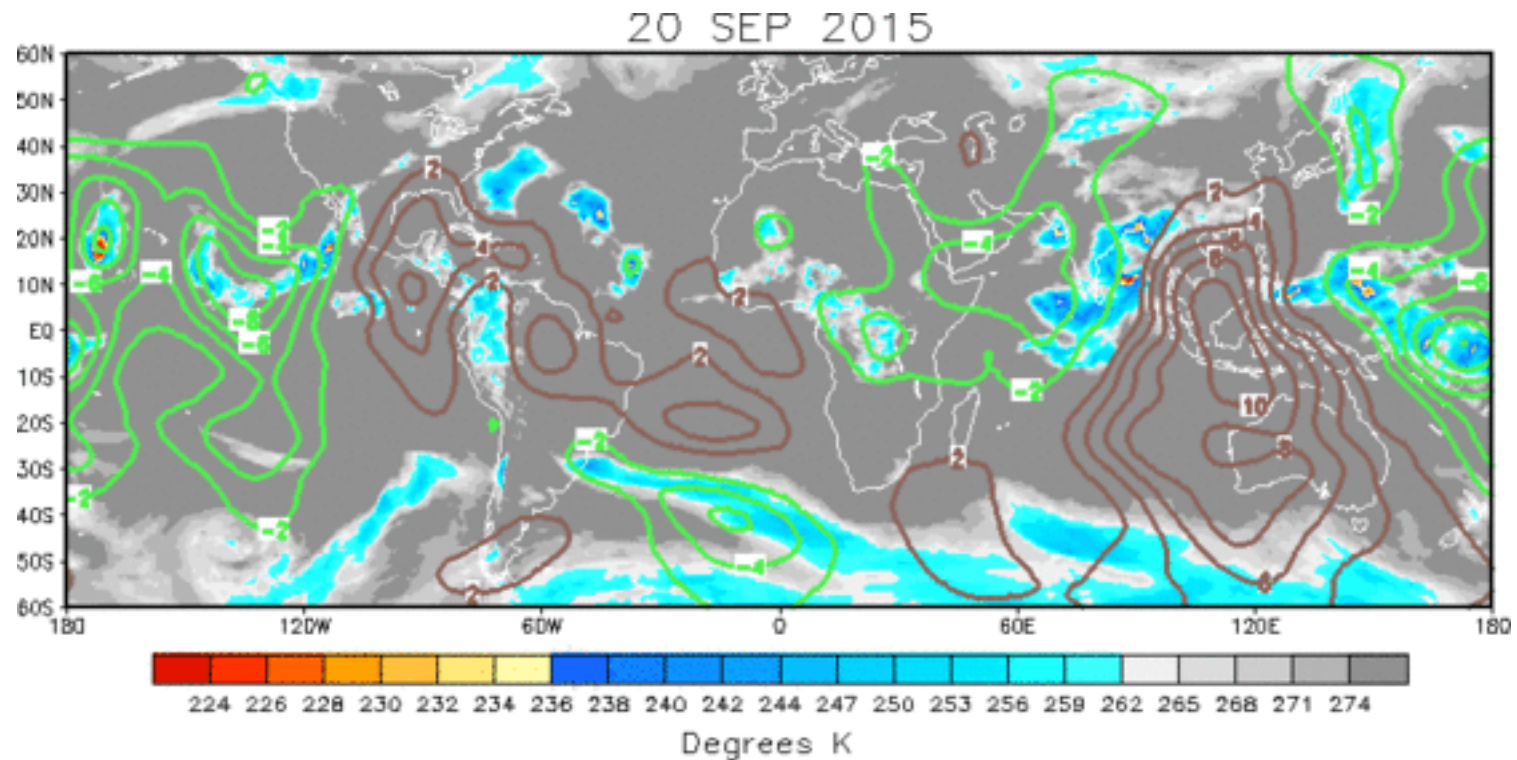
Since July, a generally stationary pattern, reflective of El Niño conditions, was observed.

200-hPa Velocity Potential Anomaly: 5N-5S  
5-day Running Mean





# 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 parts of the Maritime Continent.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation

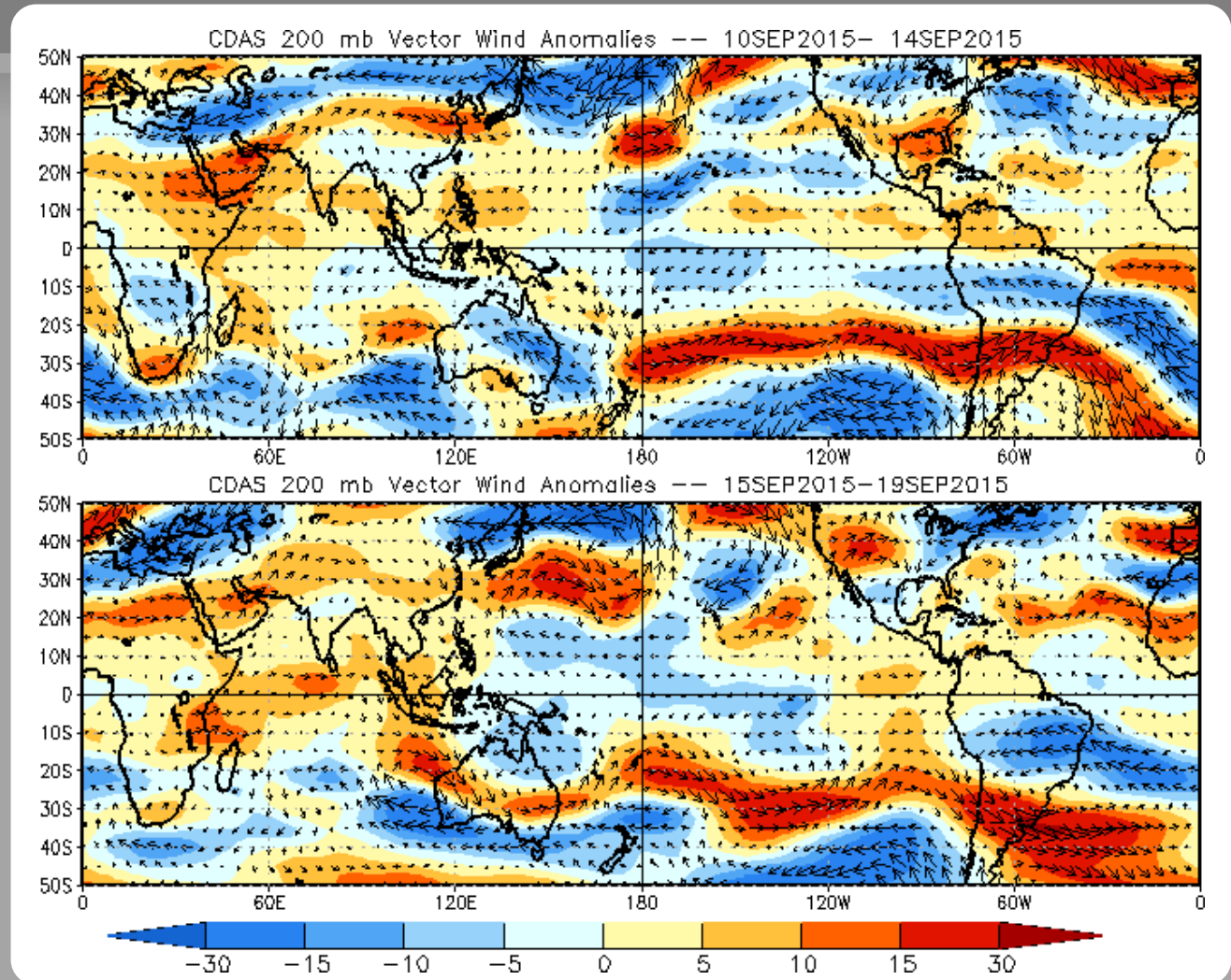
# 200-hPa Vector Wind Anomalies (m s<sup>-1</sup>)

Note that shading denotes the zonal wind anomaly

**Blue shades:** Easterly anomalies

**Red shades:** Westerly anomalies

Upper-level easterly (westerly) anomalies persisted over the Central Pacific (Indian Ocean).



# 200-hPa Zonal Wind Anomalies (m s<sup>-1</sup>)

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

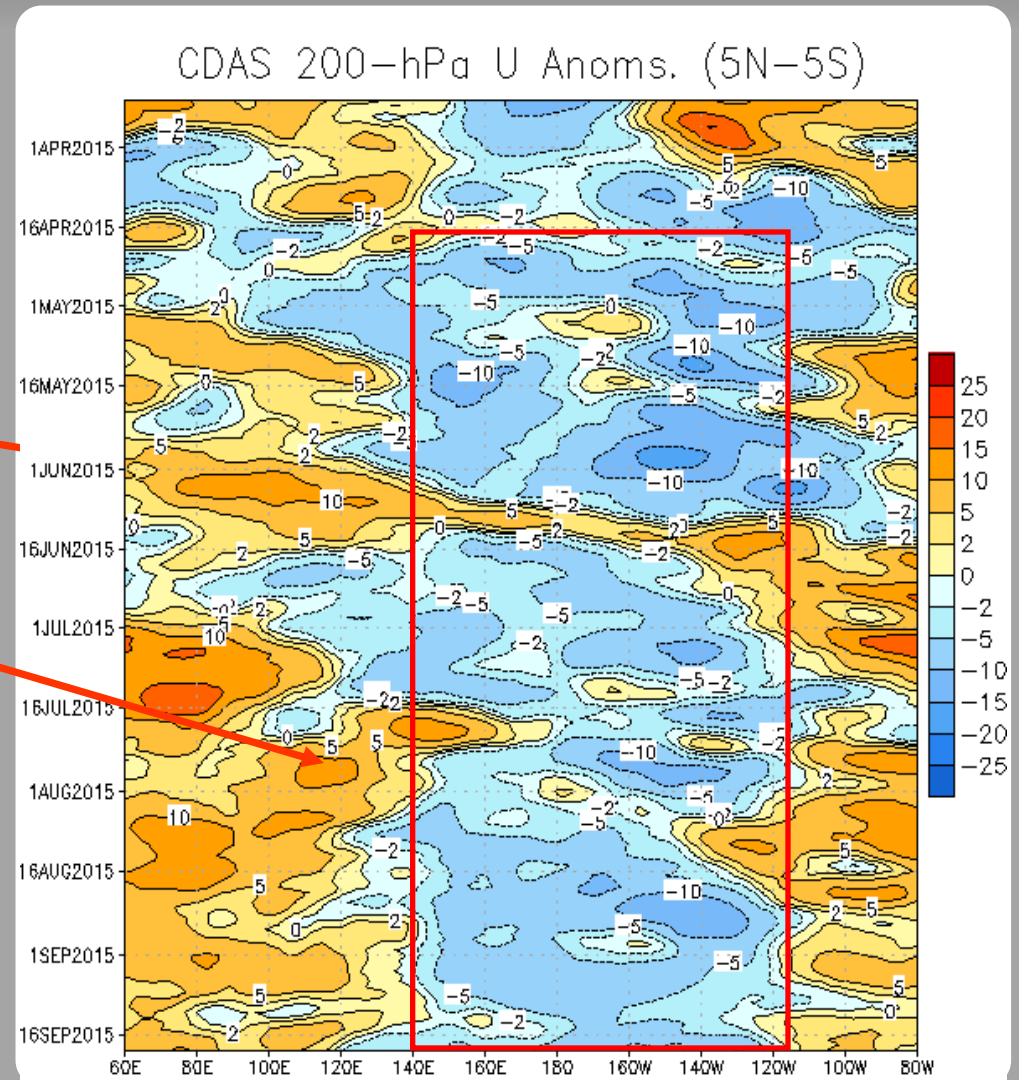
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.





# 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

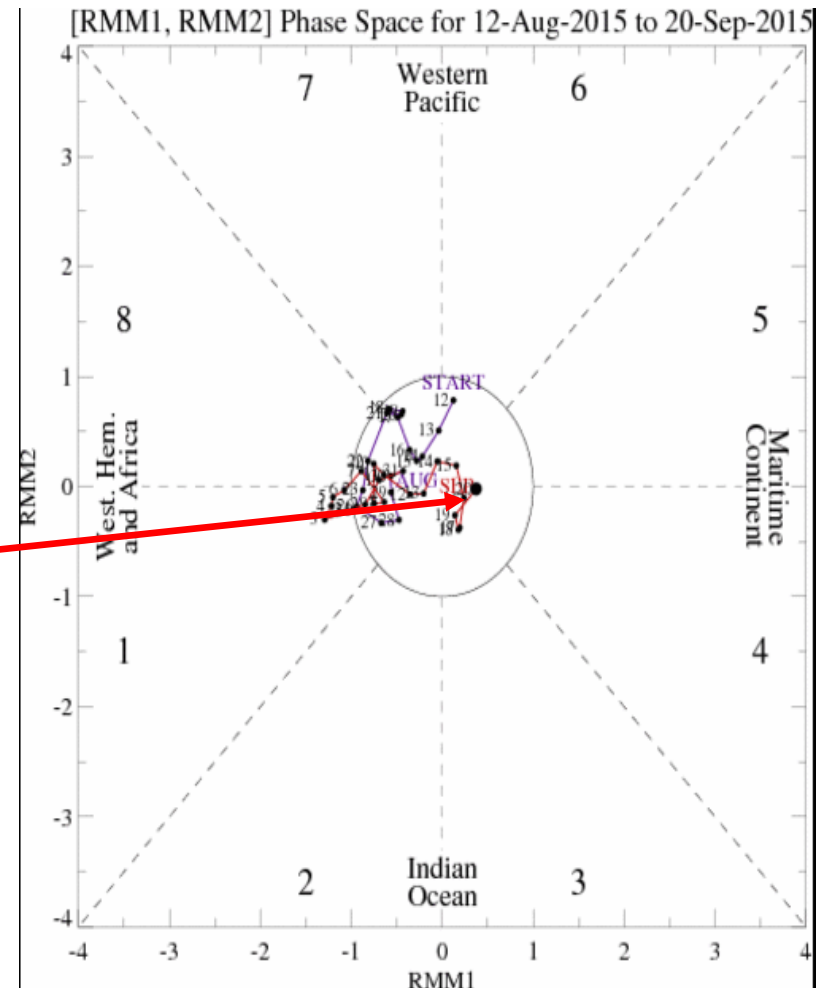
The triangular areas indicate the location of the enhanced phase of the MJO

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

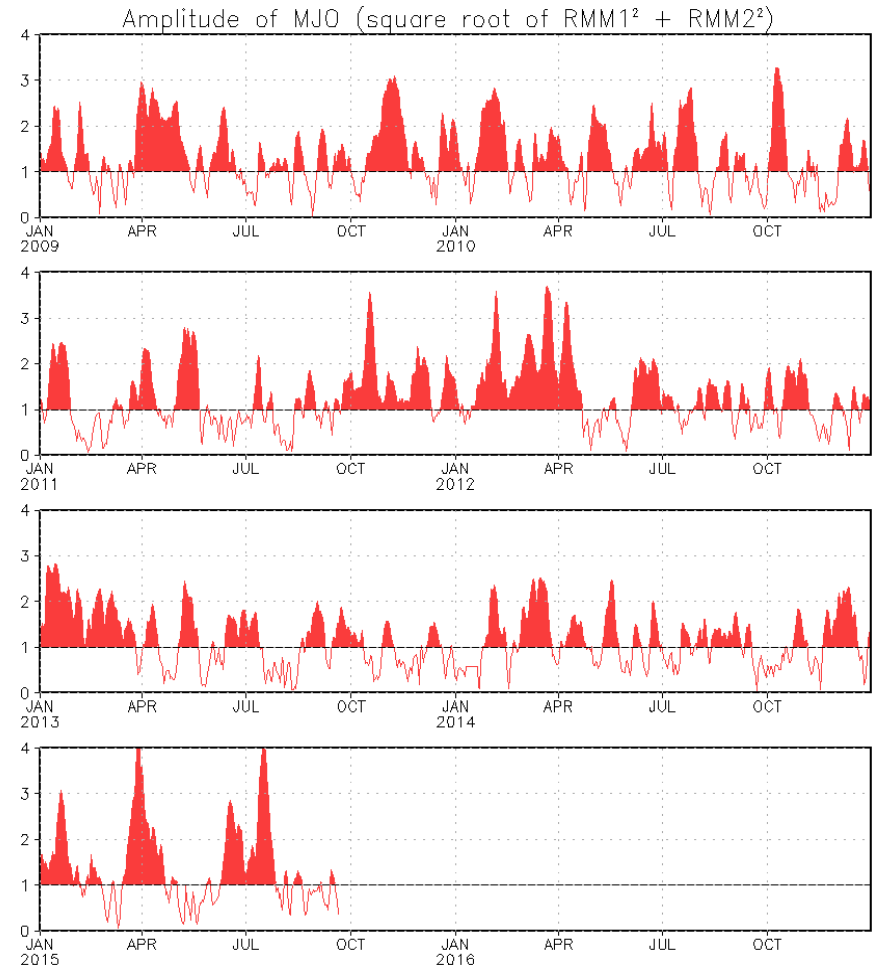
The MJO index indicated non-existent MJO activity during the past month.



# 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

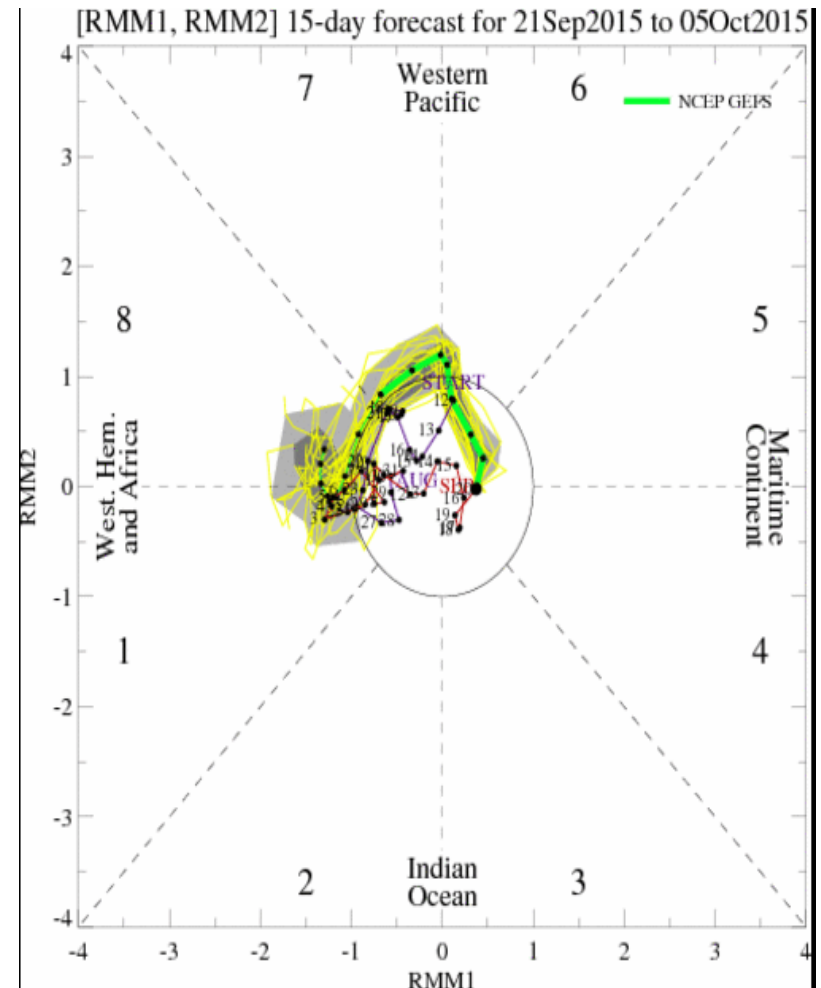
RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GFS ensemble MJO index forecast depicts an increase in amplitude during Week-1 with eastward propagation that is faster than typical MJO phase speeds during the next two weeks.

Yellow Lines - 20 Individual Members  
Green Line - Ensemble Mean





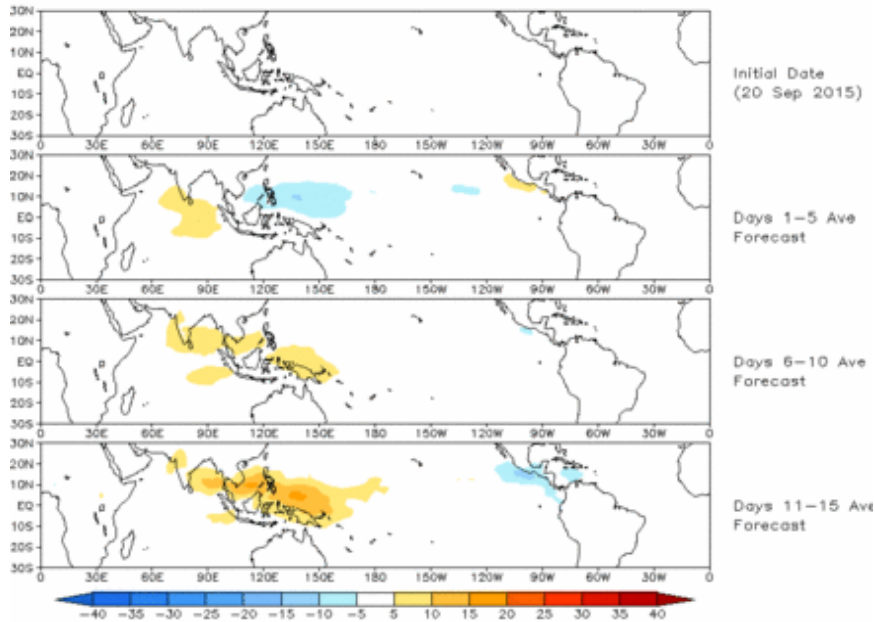
# Ensemble GFS (GEFS) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

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.)

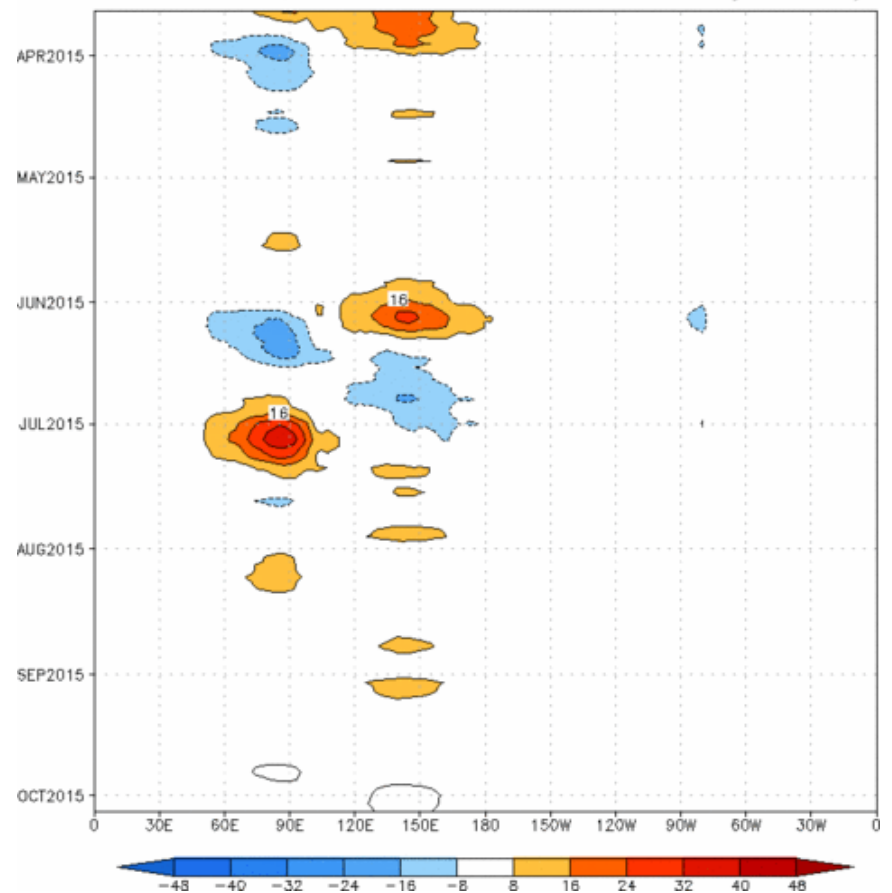
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days

Prediction of MJO-related anomalies using GEFS operational forecast  
Initial date: 20 Sep 2015  
OLR



The GEFS MJO index-based OLR forecast depicts expanding suppressed convection across the Maritime Continent and West Pacific, consistent with El Niño .

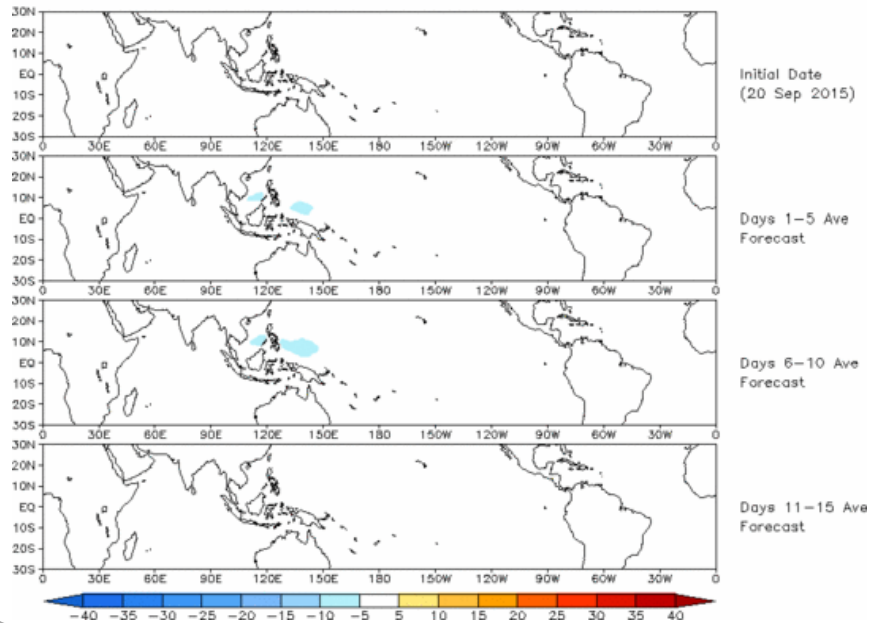
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2  
OLR [7.5°S,7.5°N] (cont:4Wm<sup>-2</sup>) Period:21-Mar-2015 to 20-Sep-2015  
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days



# Constructed Analog (CA) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

OLR prediction of MJO-related anomalies using CA model reconstruction by RMM1 & RMM2 (20 Sep 2015)

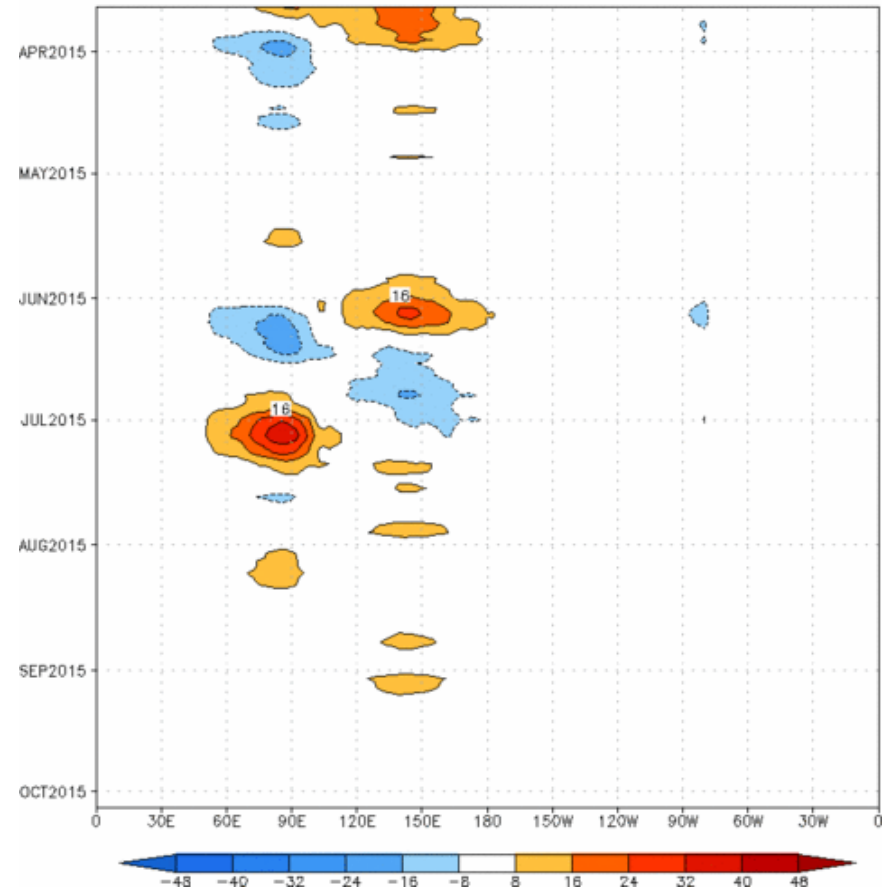


The constructed analog model depicts little to no anomalies.

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.)

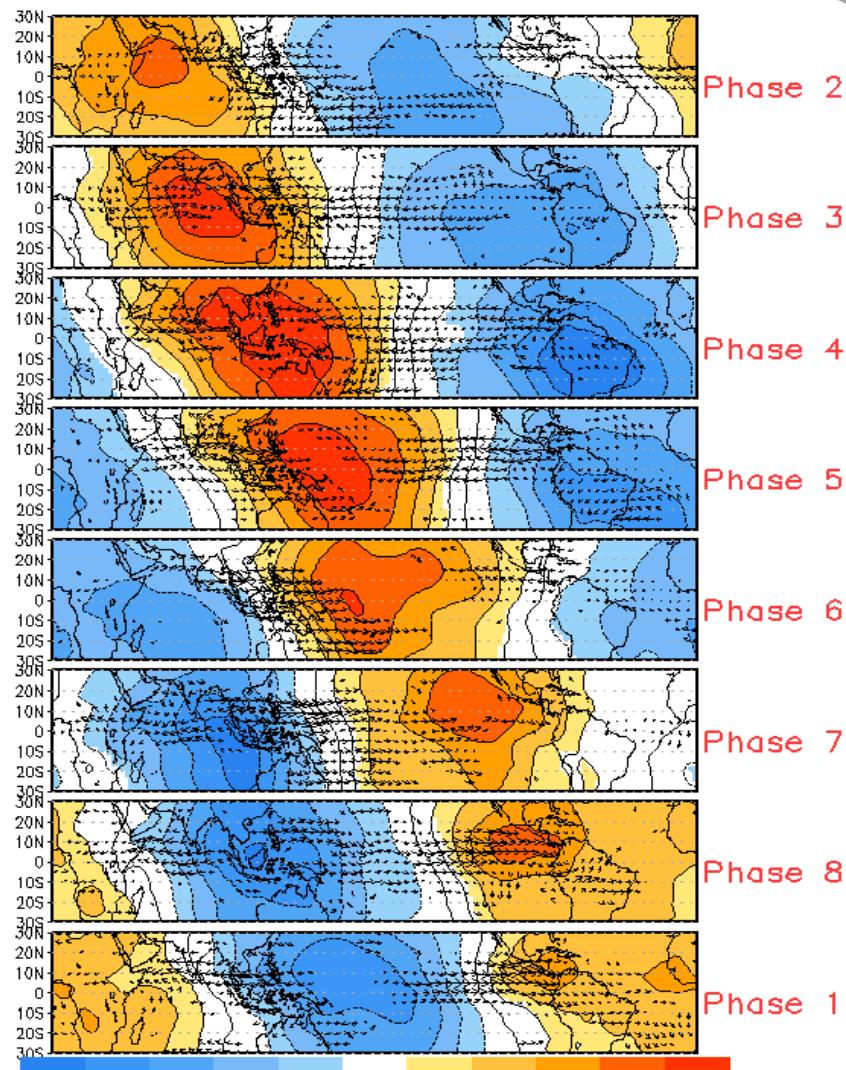
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [7.5°S,7.5°N] (cont:4Wm<sup>-2</sup>) Period:21-Mar-2015 to 20-Sep-2015  
The unfilled contours are CA forecast reconstructed anomaly for 15 days

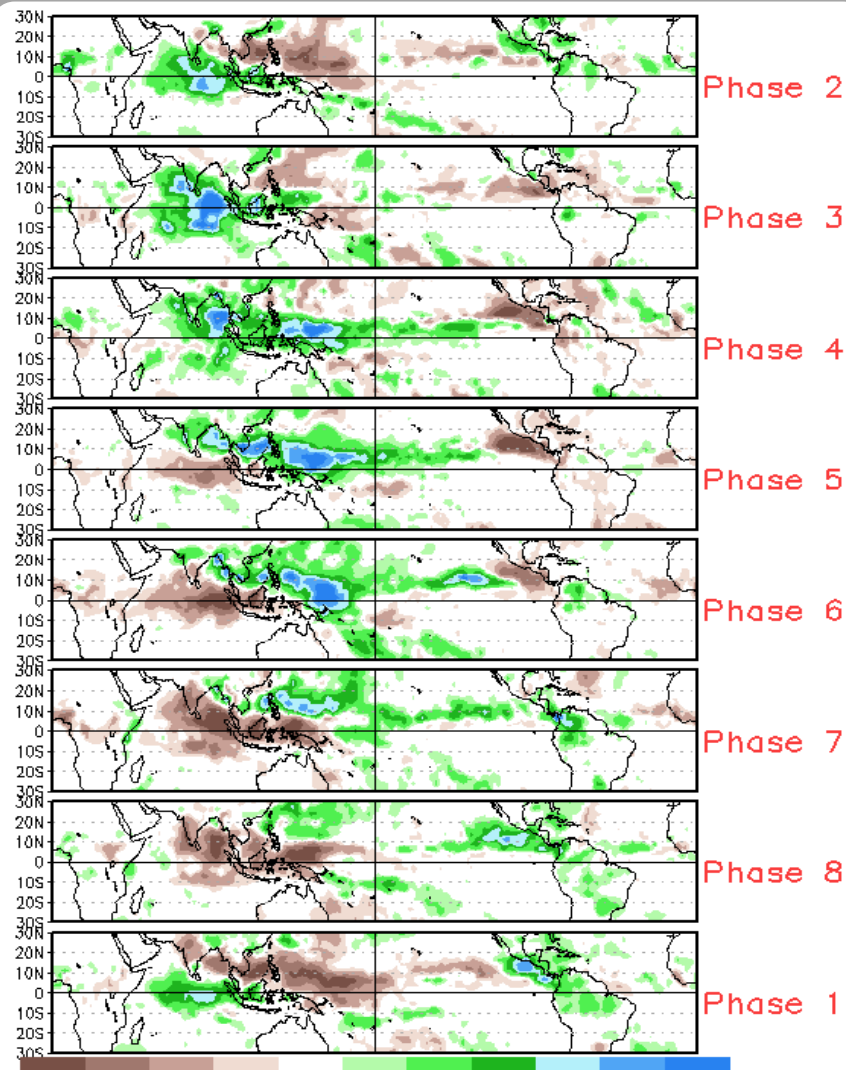


# MJO Composites - Global Tropics

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



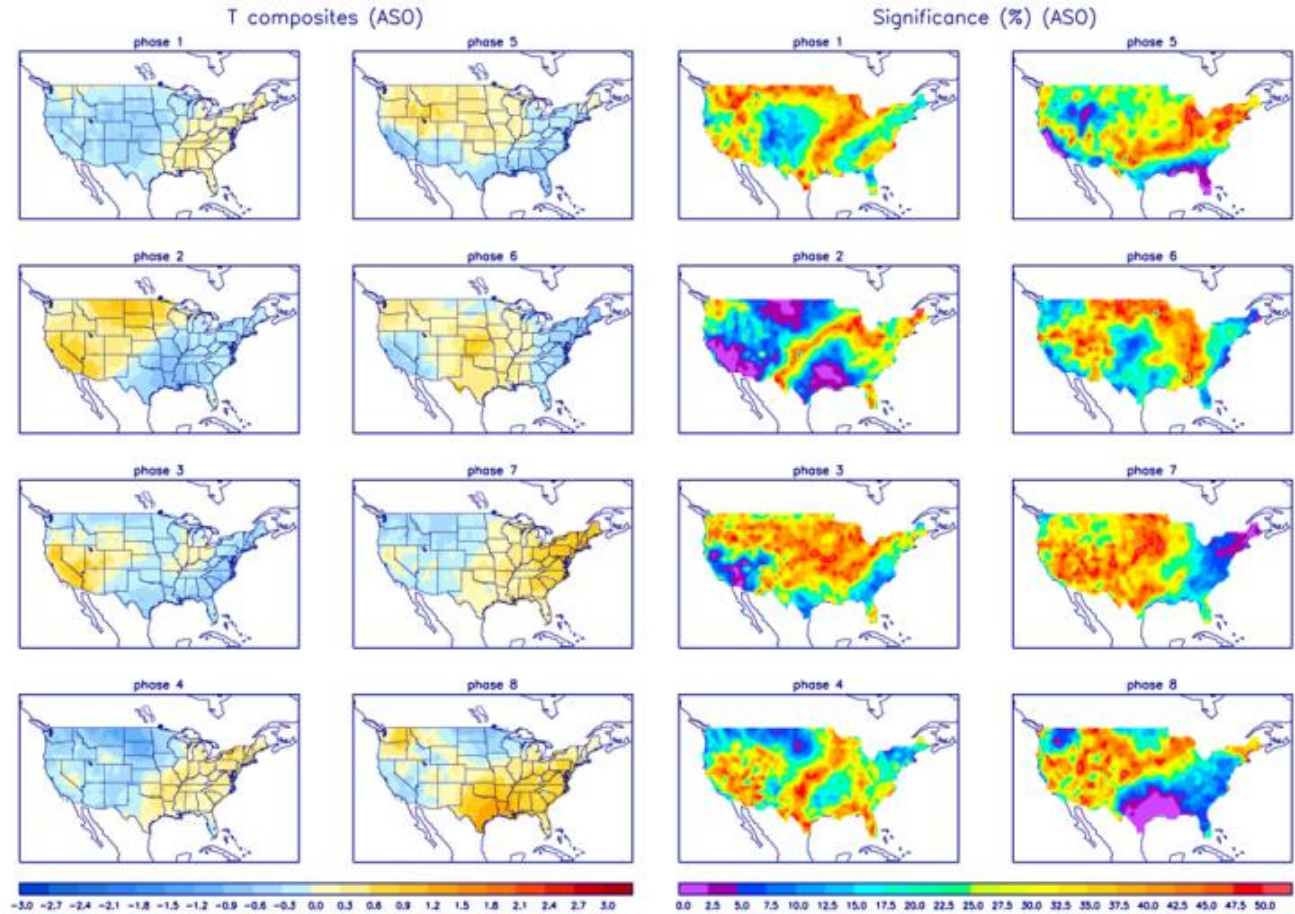
Precipitation Anomalies (May-Sep)



# 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.



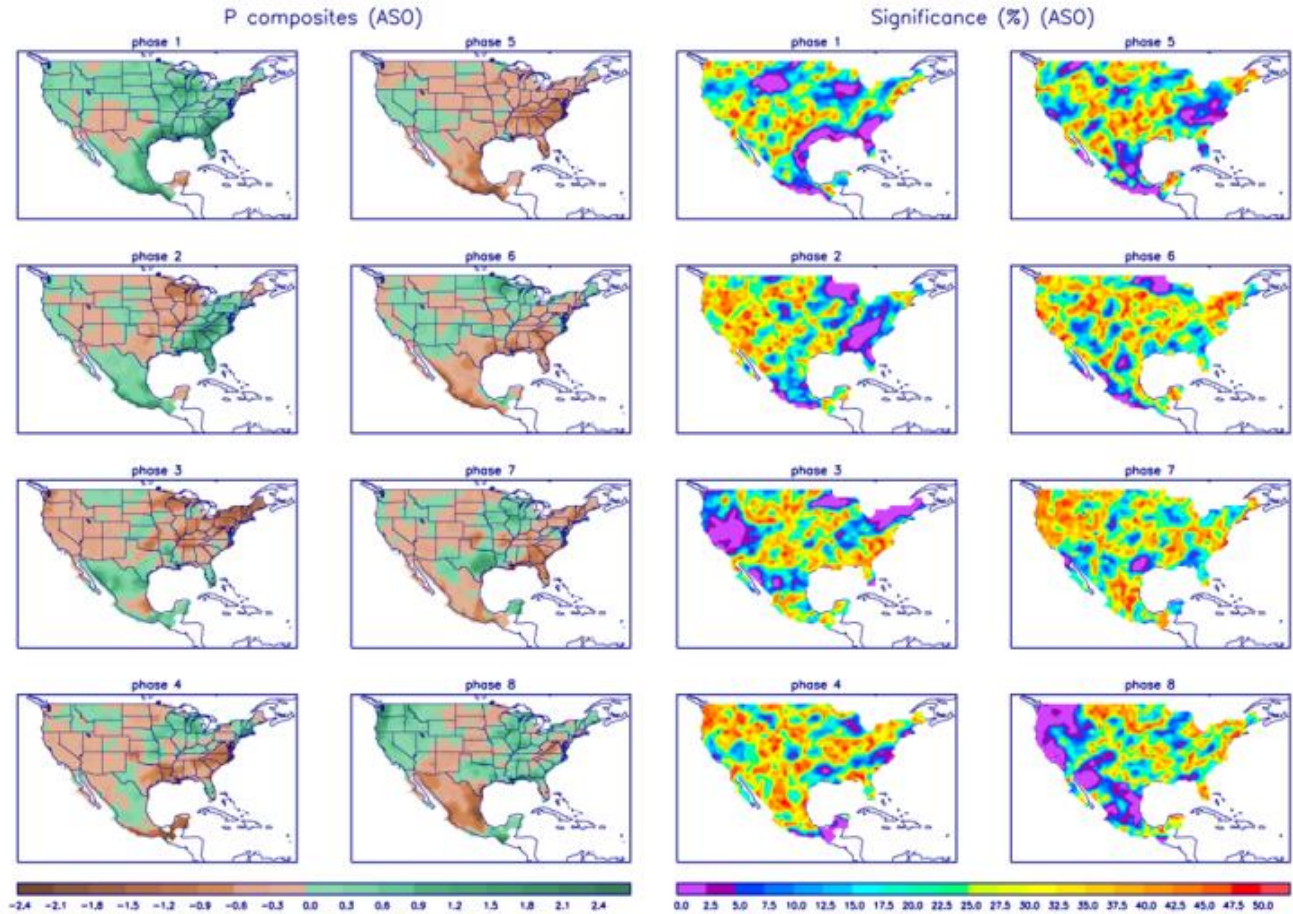
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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

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