

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



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19 October 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 cyclones, remain the primary influences on the global tropical convective pattern.

The ongoing El Niño is likely to remain the major contributor to anomalous convection. Dynamical models differ on the evolution of the MJO during the next two weeks.

The MJO is expected to play only a minor 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>

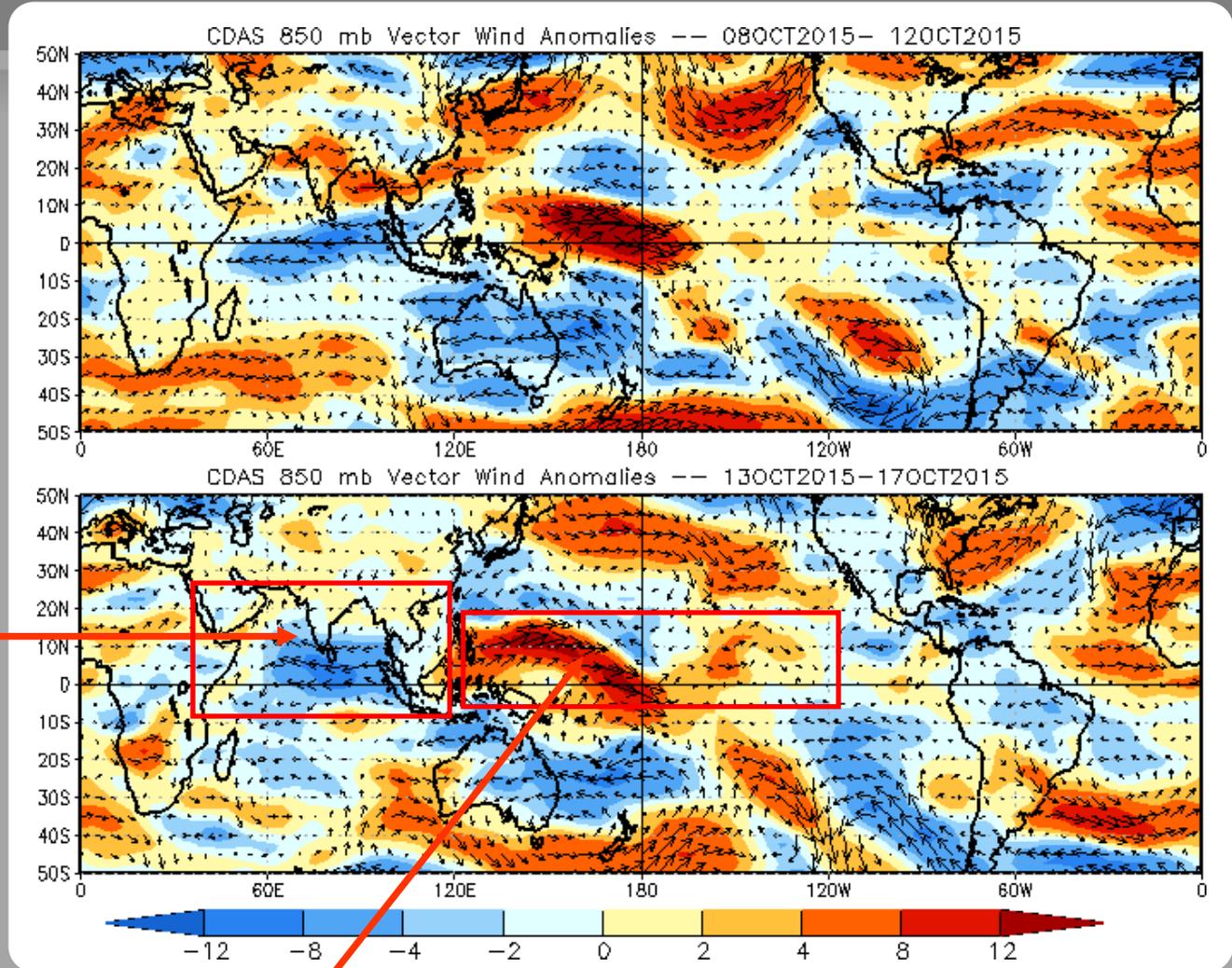
# 850-hPa Vector Wind Anomalies (m s<sup>-1</sup>)

Note that shading denotes the zonal wind anomaly

**Blue shades:** Easterly anomalies

**Red shades:** Westerly anomalies

Easterly anomalies persisted across the Indian Ocean.



Static pattern of anomalous low-level winds also continued across the Pacific Ocean.

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

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

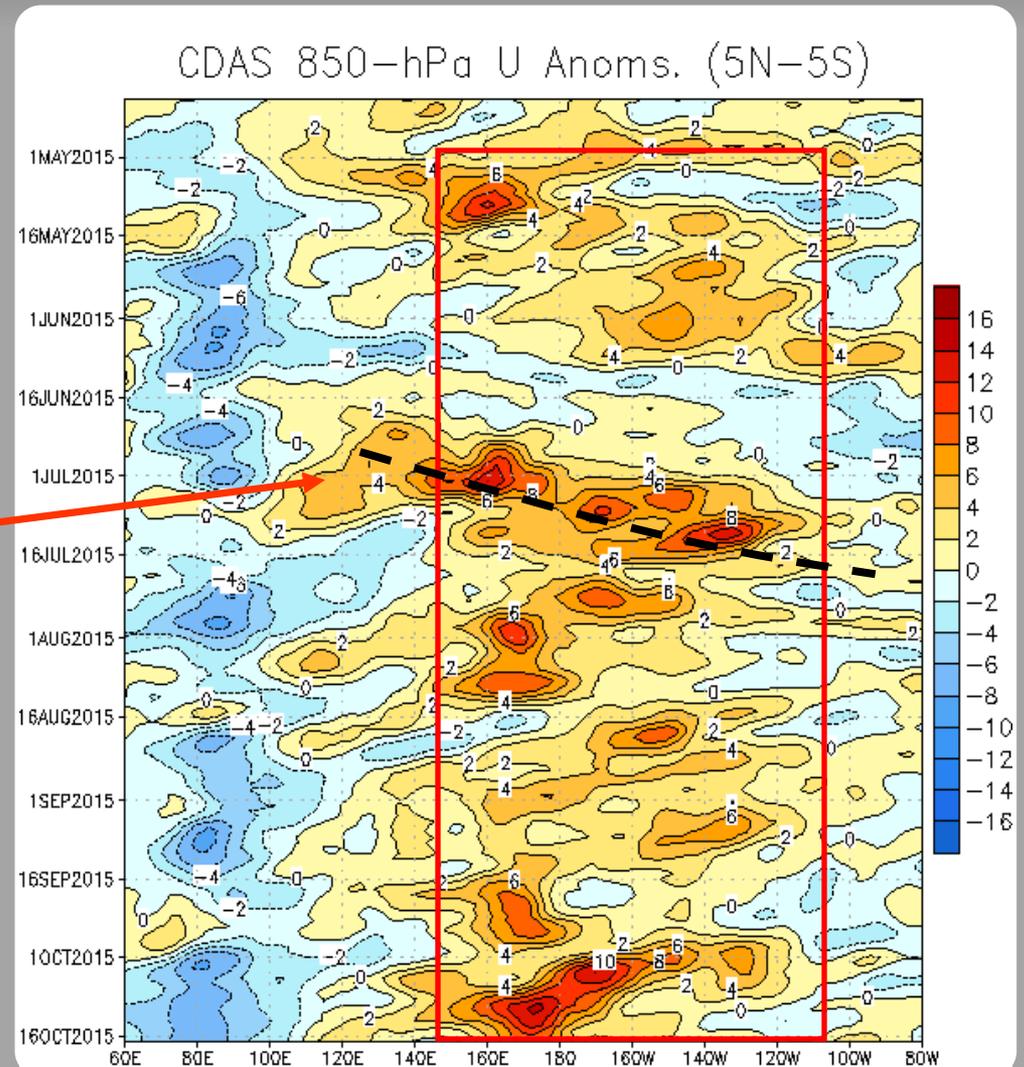
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

Strong westerly anomalies persisted near the Date Line, with a slight westward shift during early October.



# OLR Anomalies - Past 30 days

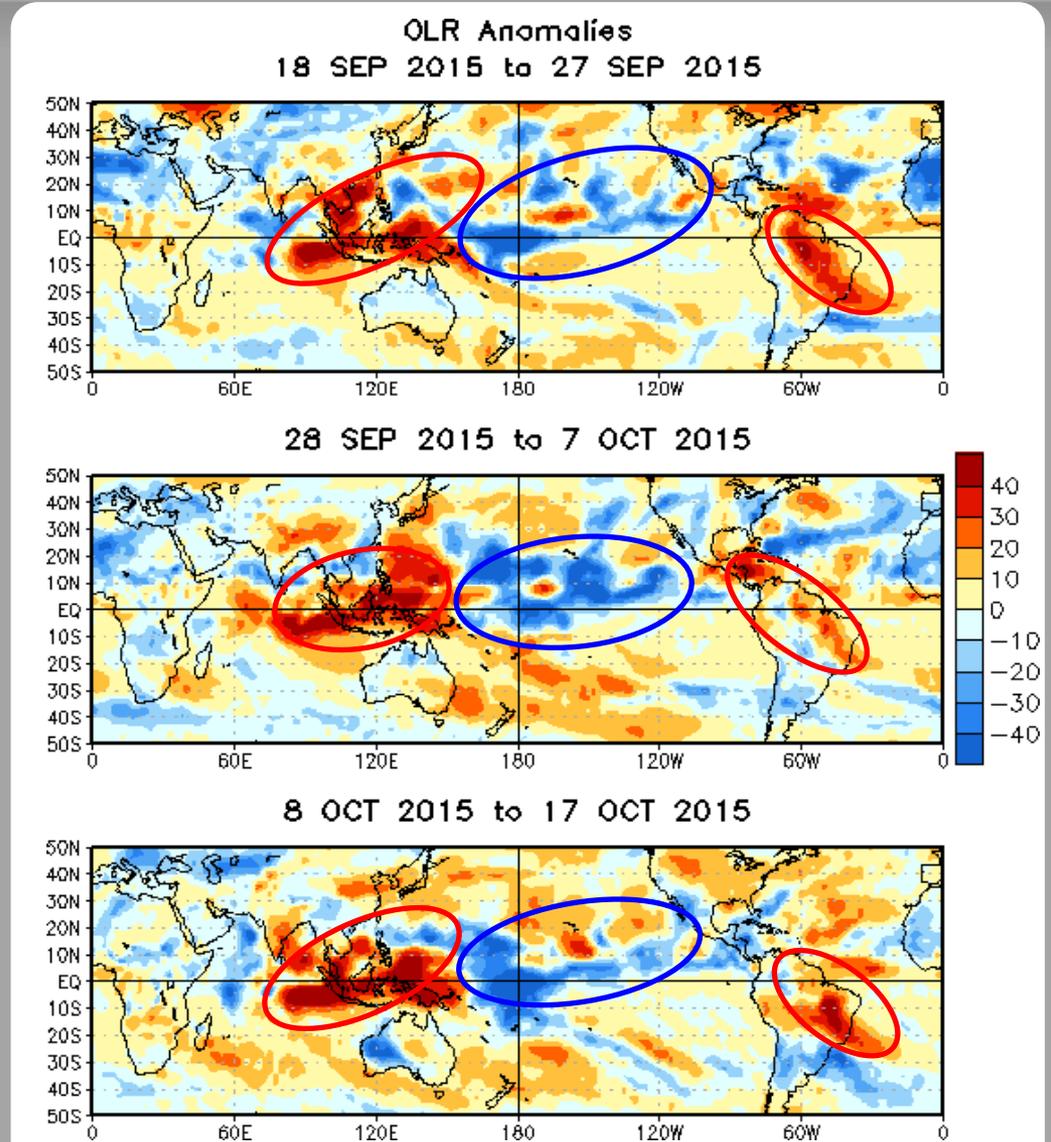
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid to late September, enhanced convection remained in place over the central and eastern Pacific, with suppressed convection over the Maritime Continent.

Enhanced convection continued across parts of the central and eastern Pacific, while suppressed convection remained centered on the Maritime Continent during late September.

El Niño continued to influence anomalous convection across the global tropics; suppressed convection has persisted over parts of the Caribbean, northern South America, and the Maritime Continent. Enhance convection spanned from 160E to the eastern Pacific.



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

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

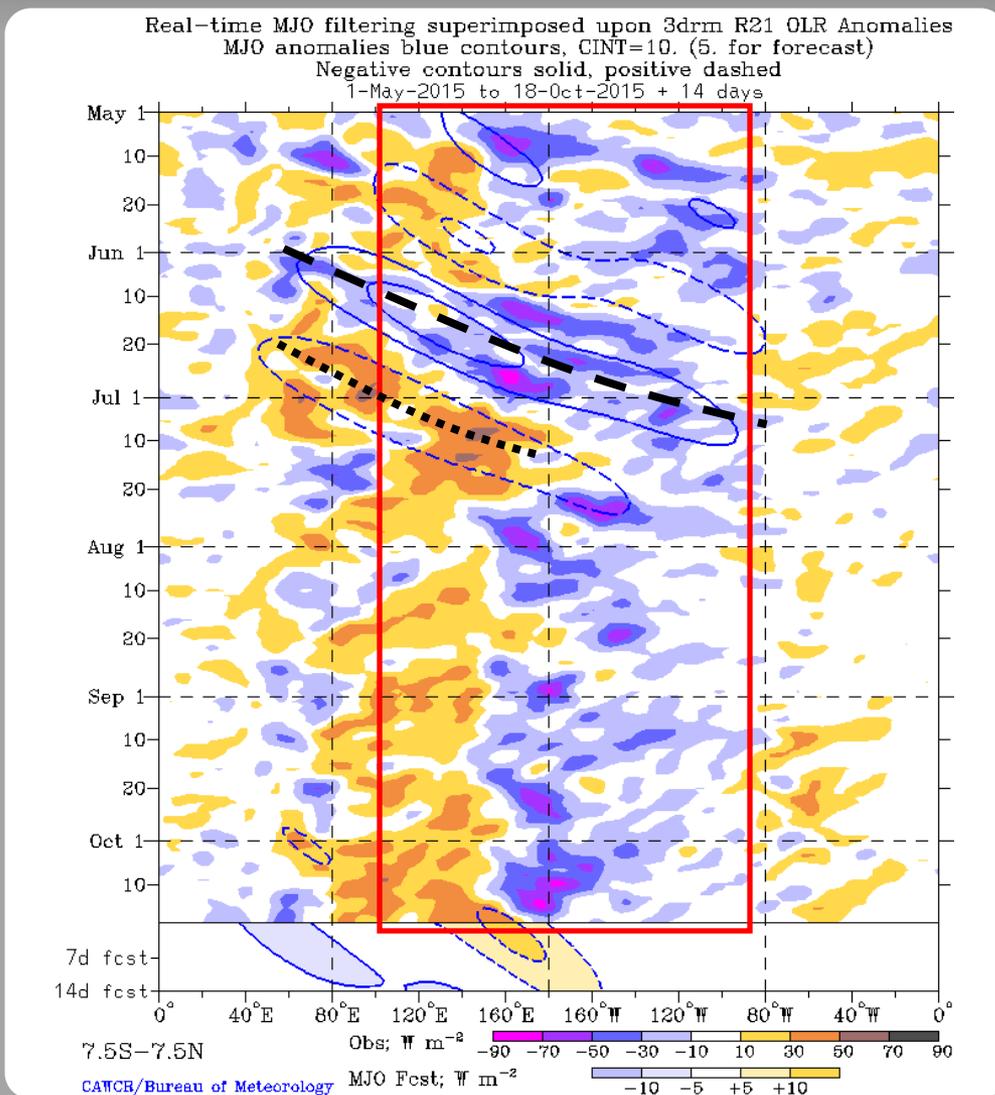
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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.

The diminishing enhanced convection near the Date Line recently is related to tropical cyclones lifting north.



# 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

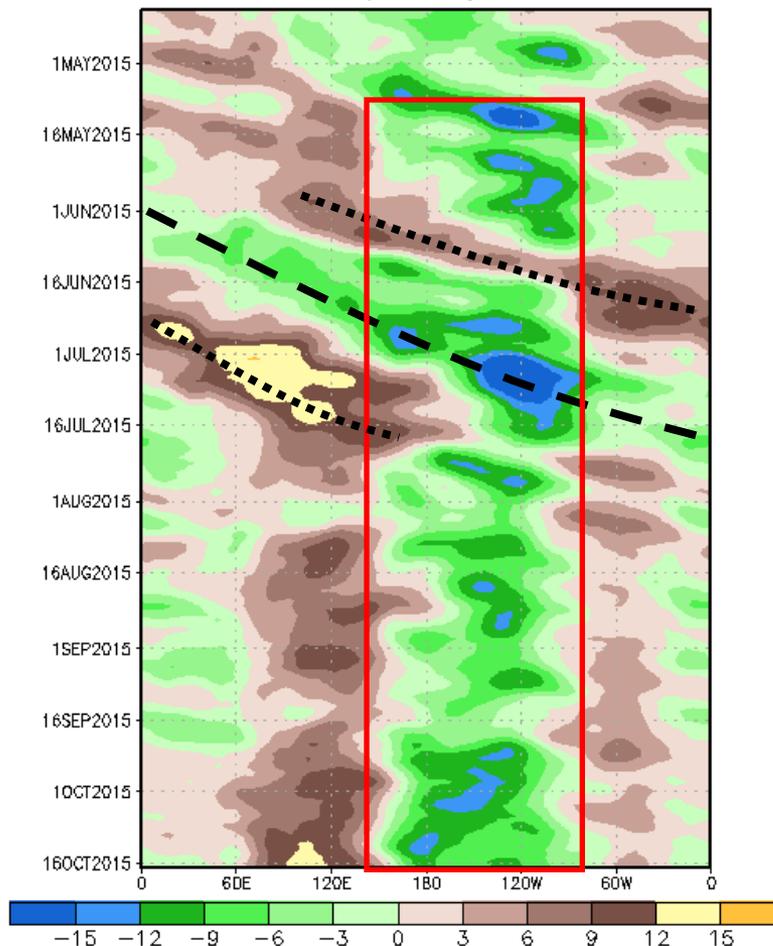
The MJO strengthened in March as seen in the upper-level velocity potential anomalies.

The ongoing 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.

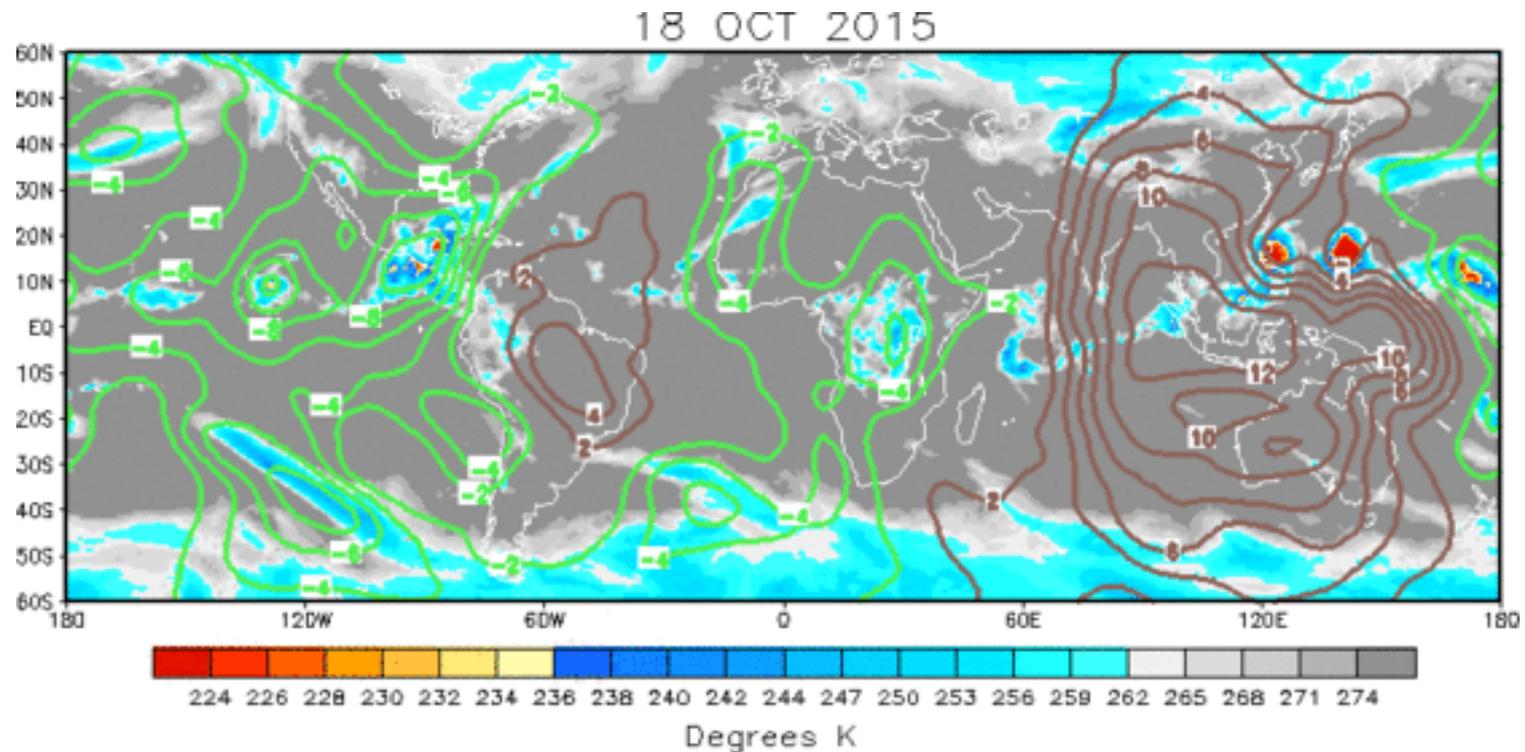
During June and early July, a high-amplitude MJO event was observed, constructively interfering with the El Niño signal in early July.

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 anomaly pattern indicates a coherent pattern of anomalous upper-level divergence (convergence) over the central and eastern Pacific (Indian Ocean and Maritime Continent). Upper-level divergence recently developed over Africa.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation

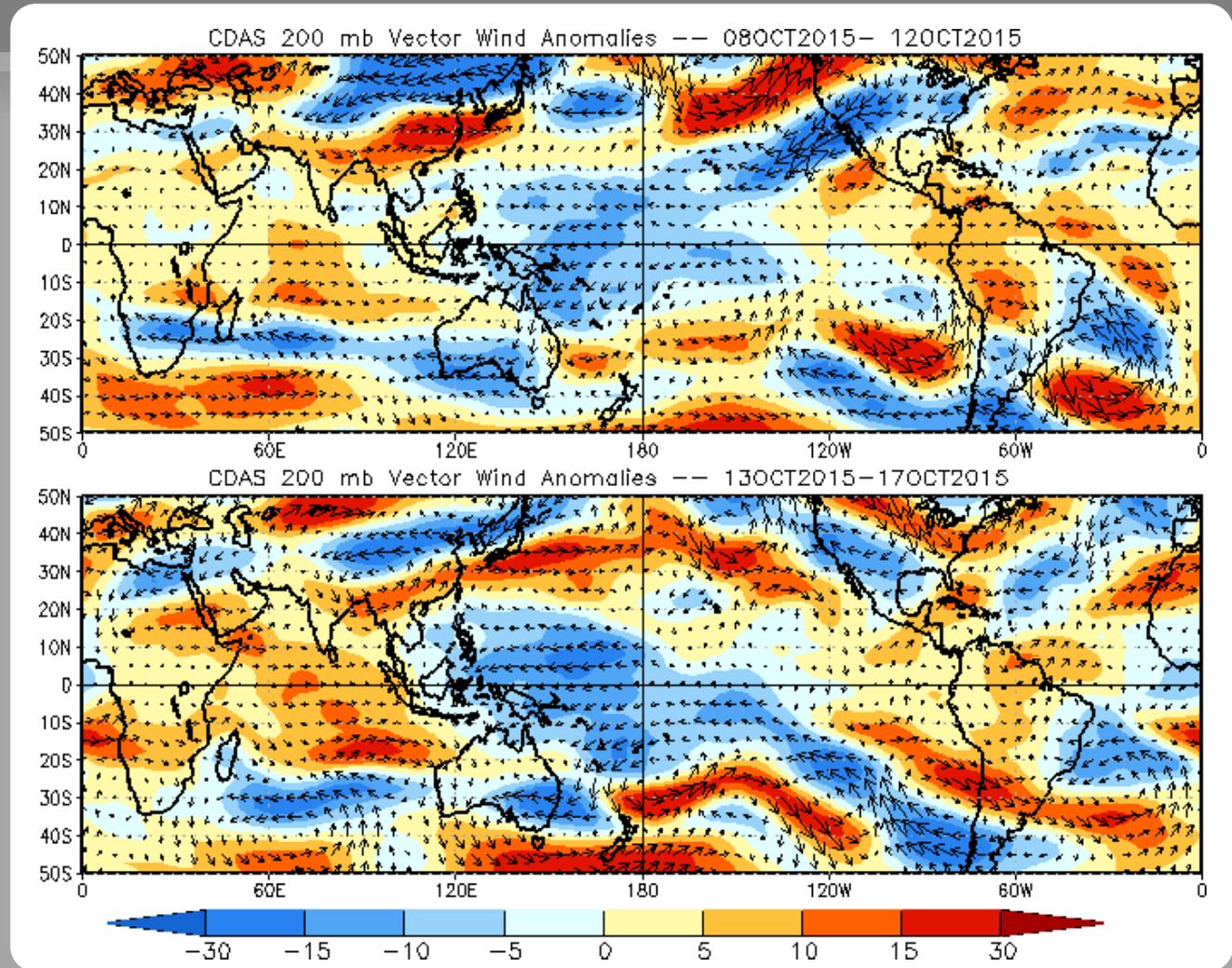
# 200-hPa Vector Wind Anomalies (m s<sup>-1</sup>)

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 and East Pacific/Caribbean).



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

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

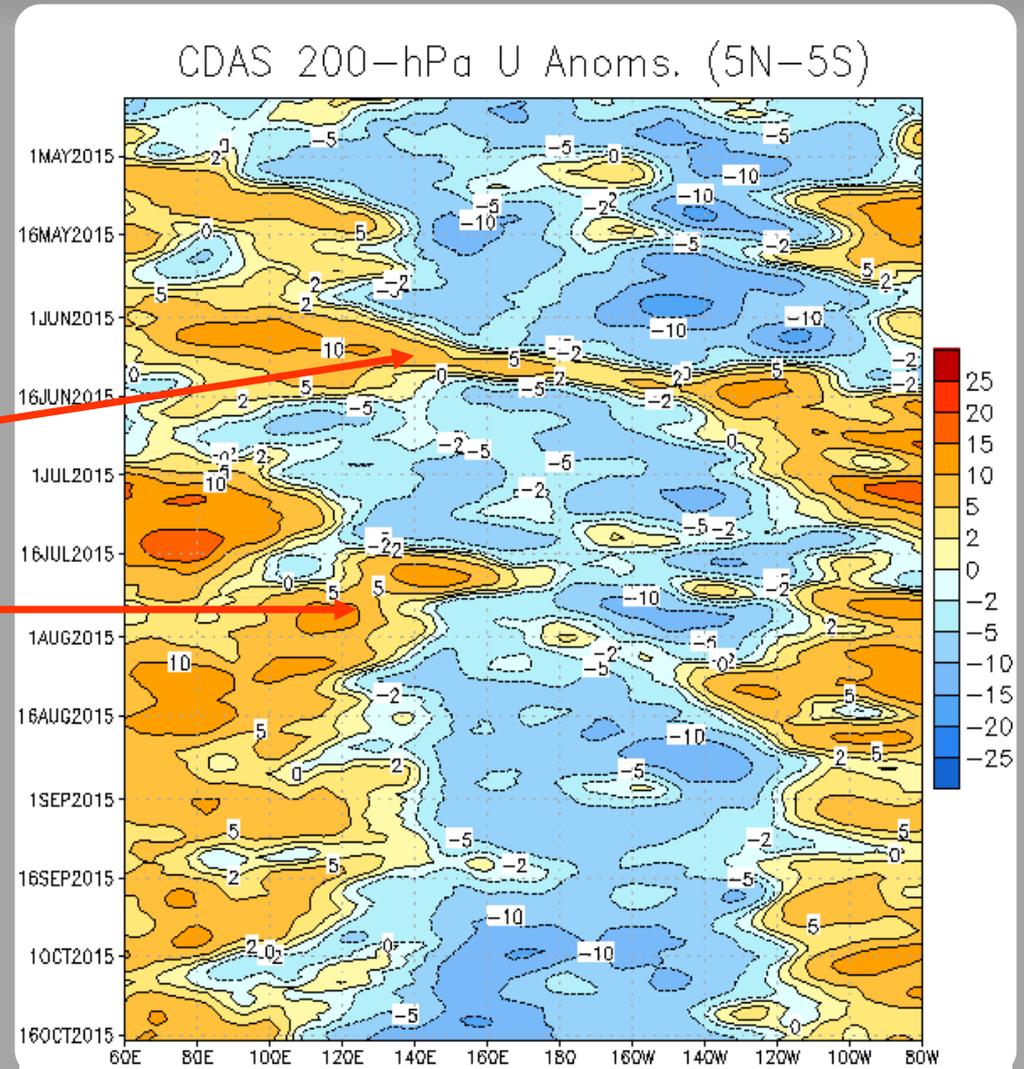
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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, easterly anomalies expanded westward to 20E while intensifying just west of the Date Line.



# Weekly Heat Content Evolution in the Equatorial Pacific

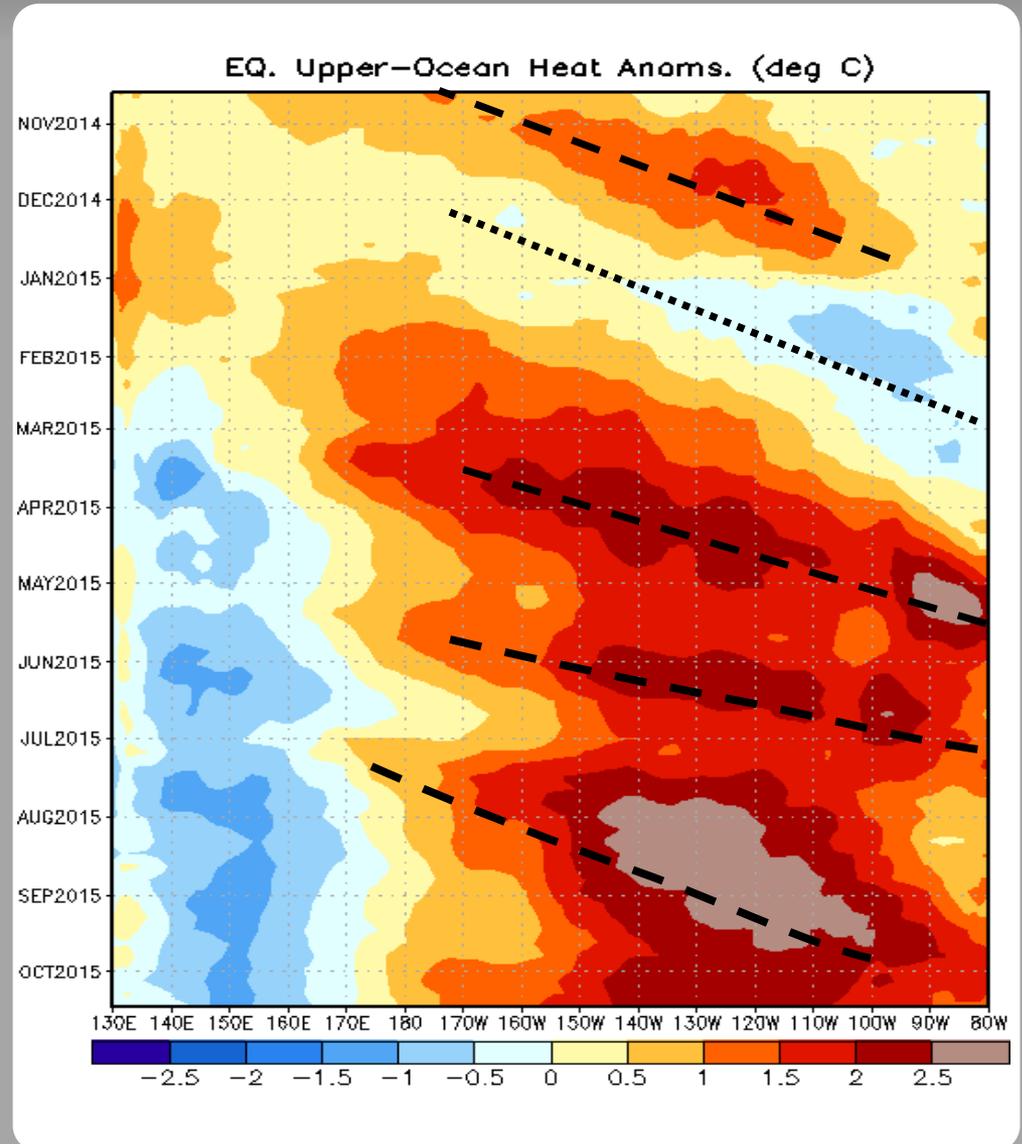
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

During 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.

Recently, another downwelling phase of a Kelvin wave developed in the Pacific Ocean associated with anomalous low-level westerlies.



# 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

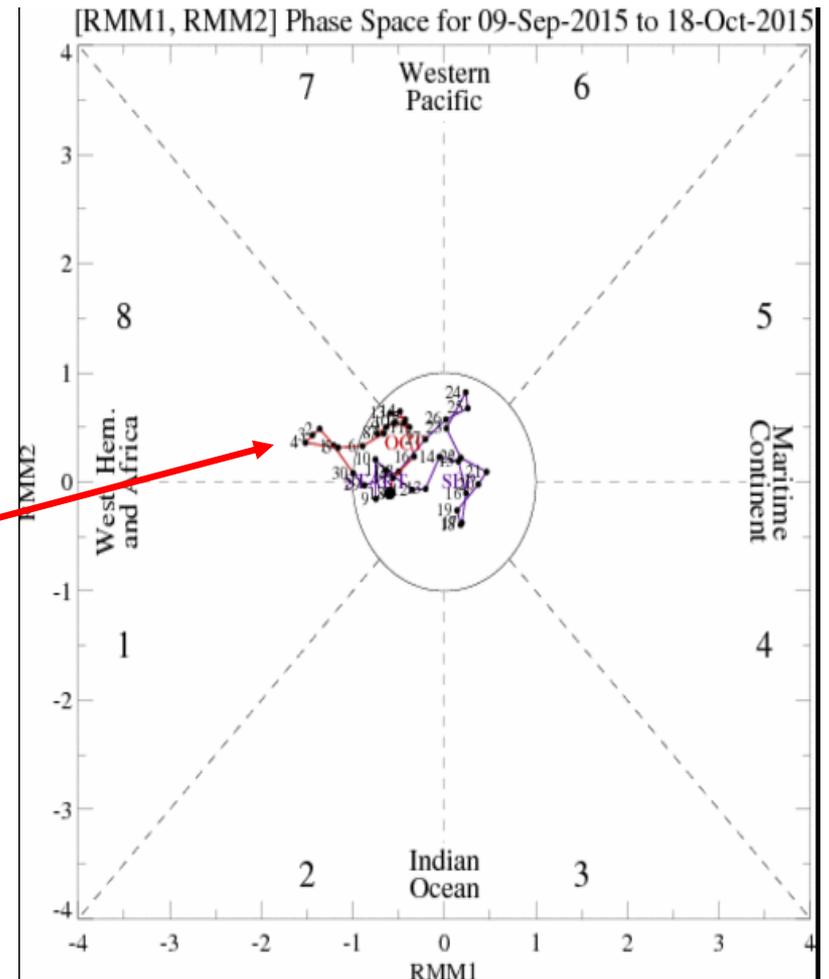
The triangular areas indicate the location of the enhanced phase of the MJO

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

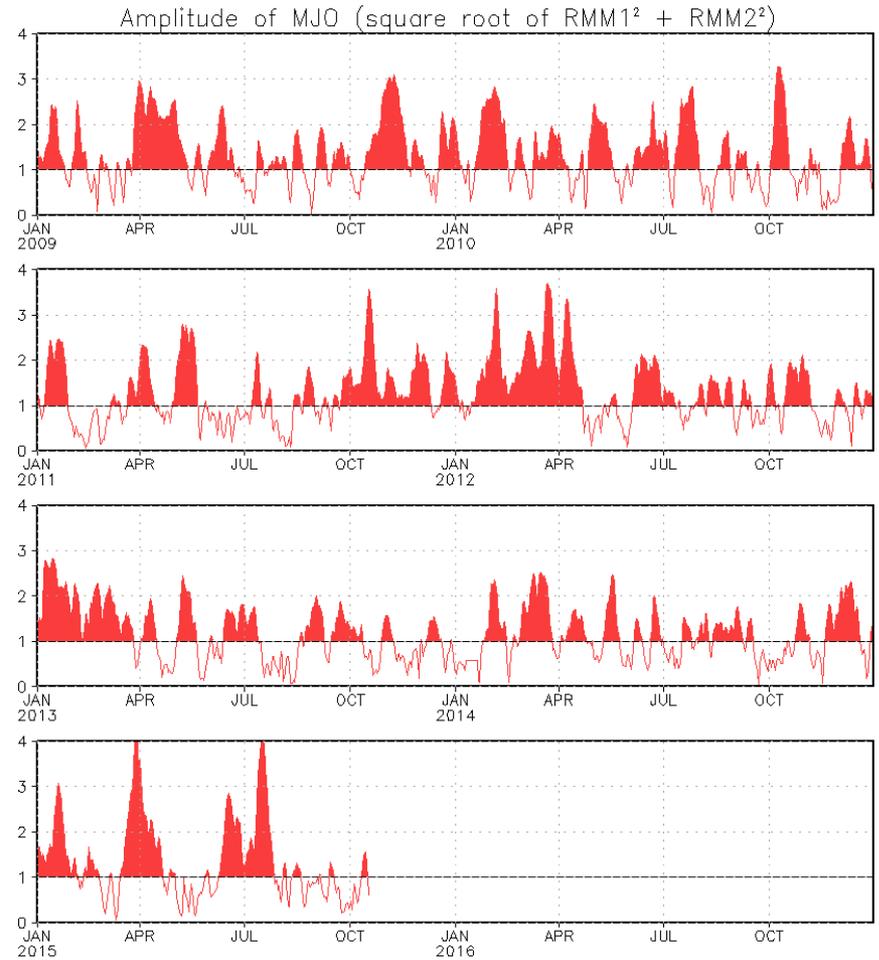
The MJO index indicated a continued weak signal.



# 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

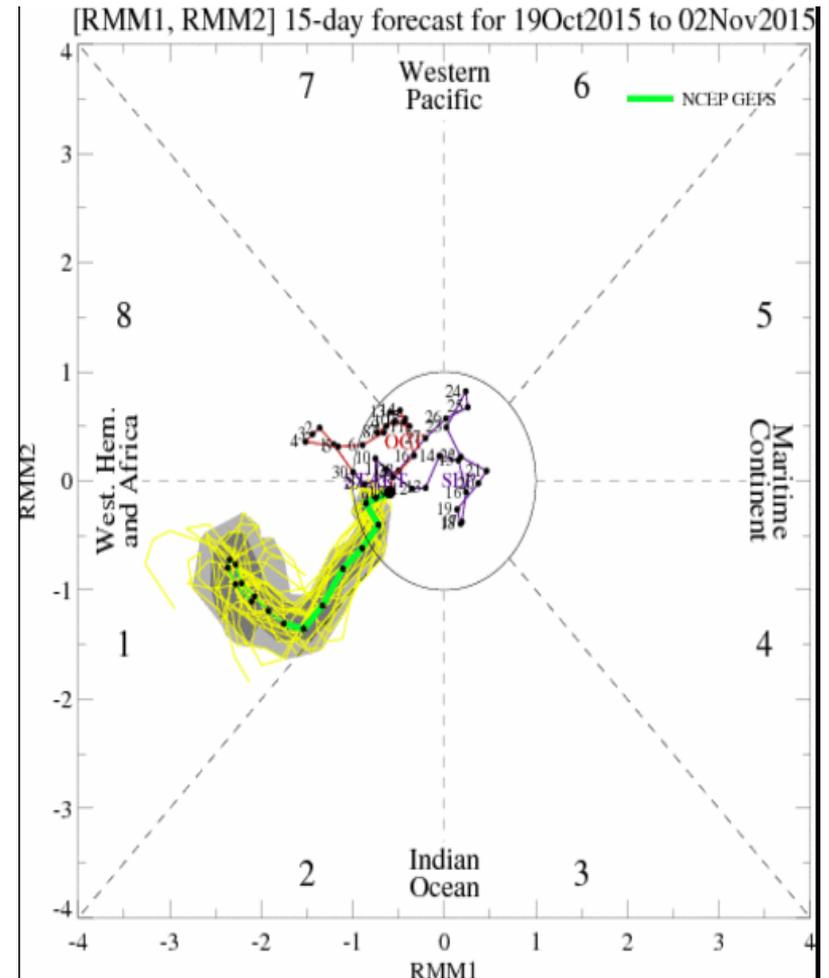
RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

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 but no eastward propagation.

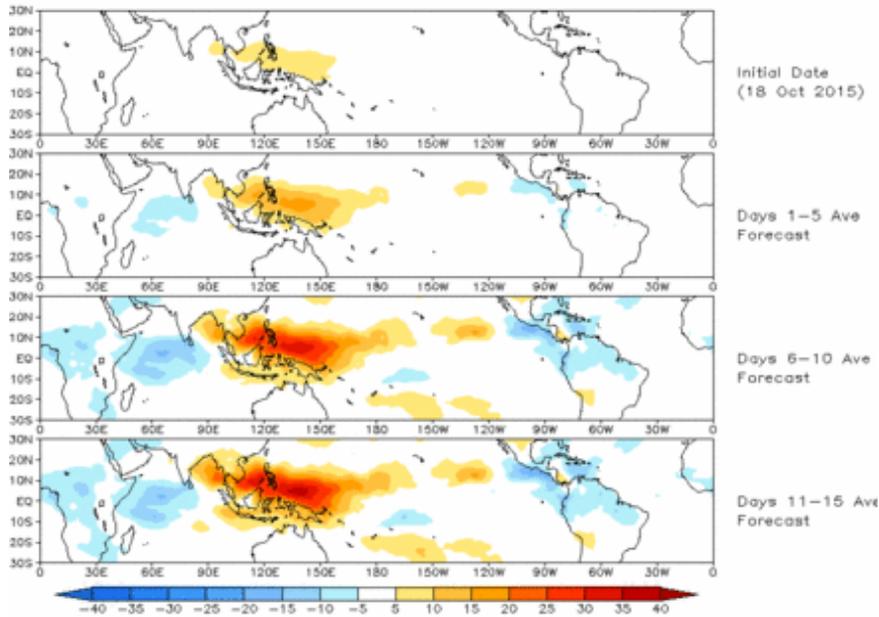
Yellow Lines - 20 Individual Members  
Green Line - Ensemble Mean



# Ensemble GFS (GEFS) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

Prediction of MJO-related anomalies using GEFS operational forecast  
Initial date: 18 Oct 2015  
OLR

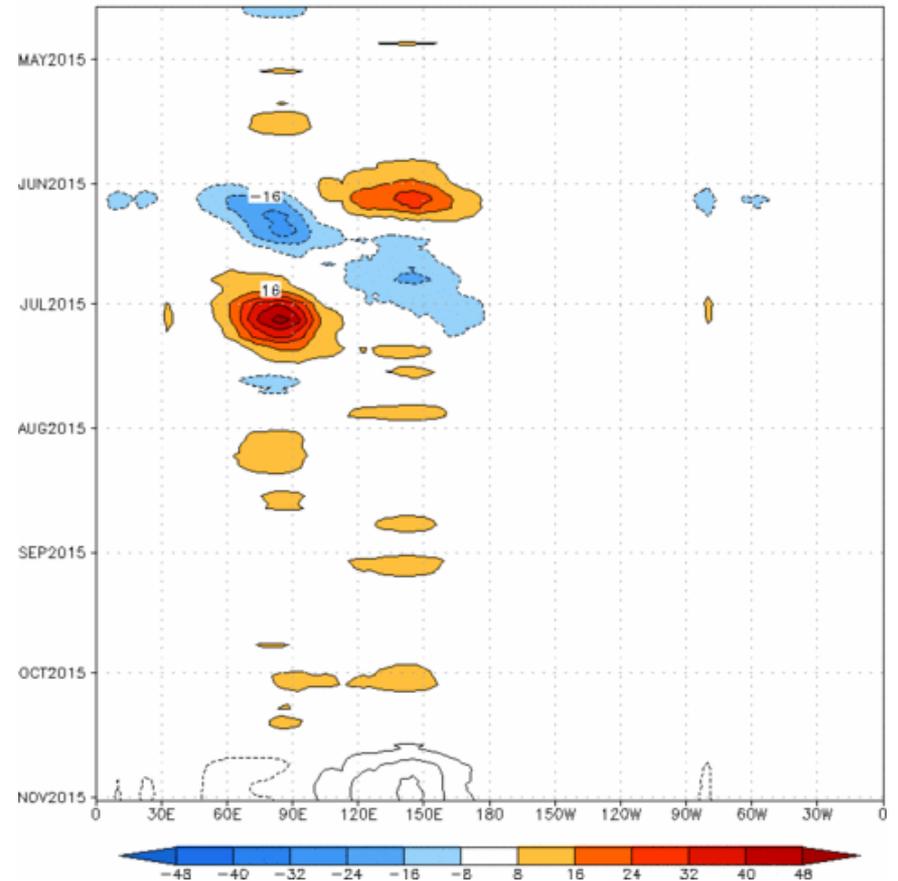


The GEFS MJO index-based OLR forecast depicts suppressed convection intensifying across the West Pacific with enhanced convection across the Americas, Africa, and western Indian Ocean.

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

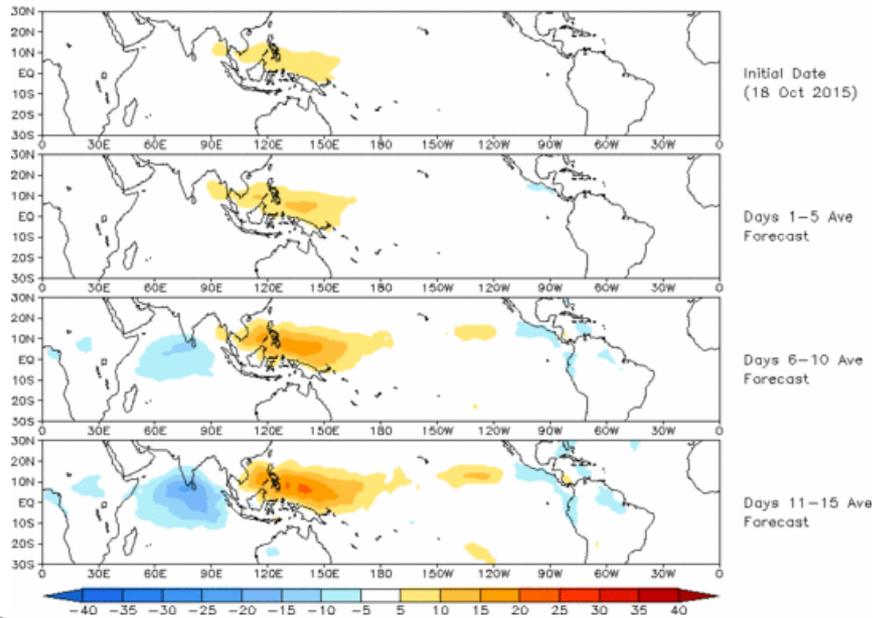
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2  
OLR [7.5°S,7.5°N] (cont:4Wm<sup>-2</sup>) Period:18-Apr-2015 to 18-Oct-2015  
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days



# 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 (18 Oct 2015)

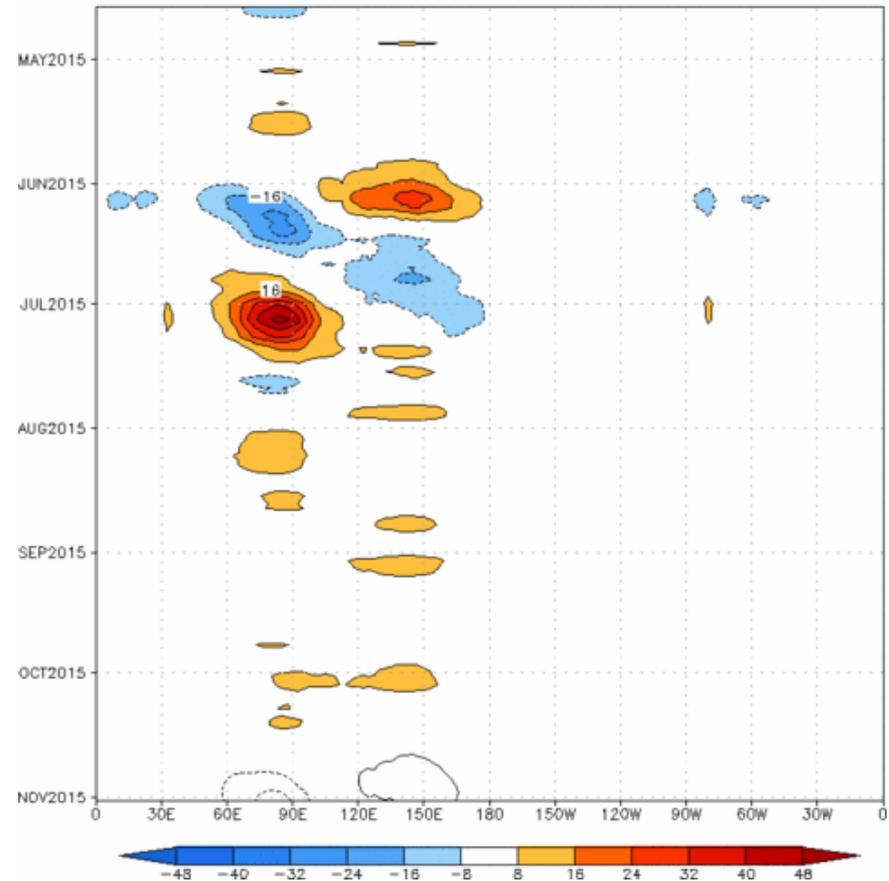


The constructed analog model depicts anomalies increasing in magnitude with suppressed (enhanced) convection across the West Pacific (Indian Ocean).

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.)

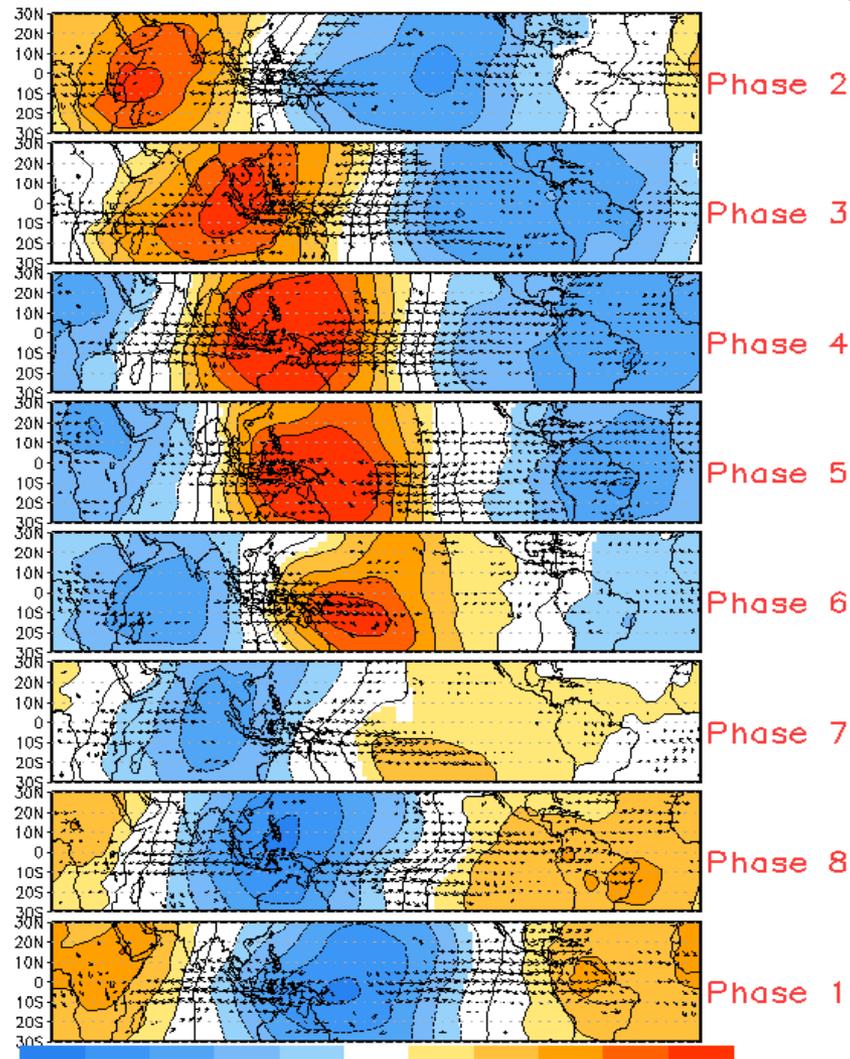
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [7.5°S,7.5°N] (cont:4Wm<sup>-2</sup>) Period:18-Apr-2015 to 18-Oct-2015  
The unfilled contours are CA forecast reconstructed anomaly for 15 days

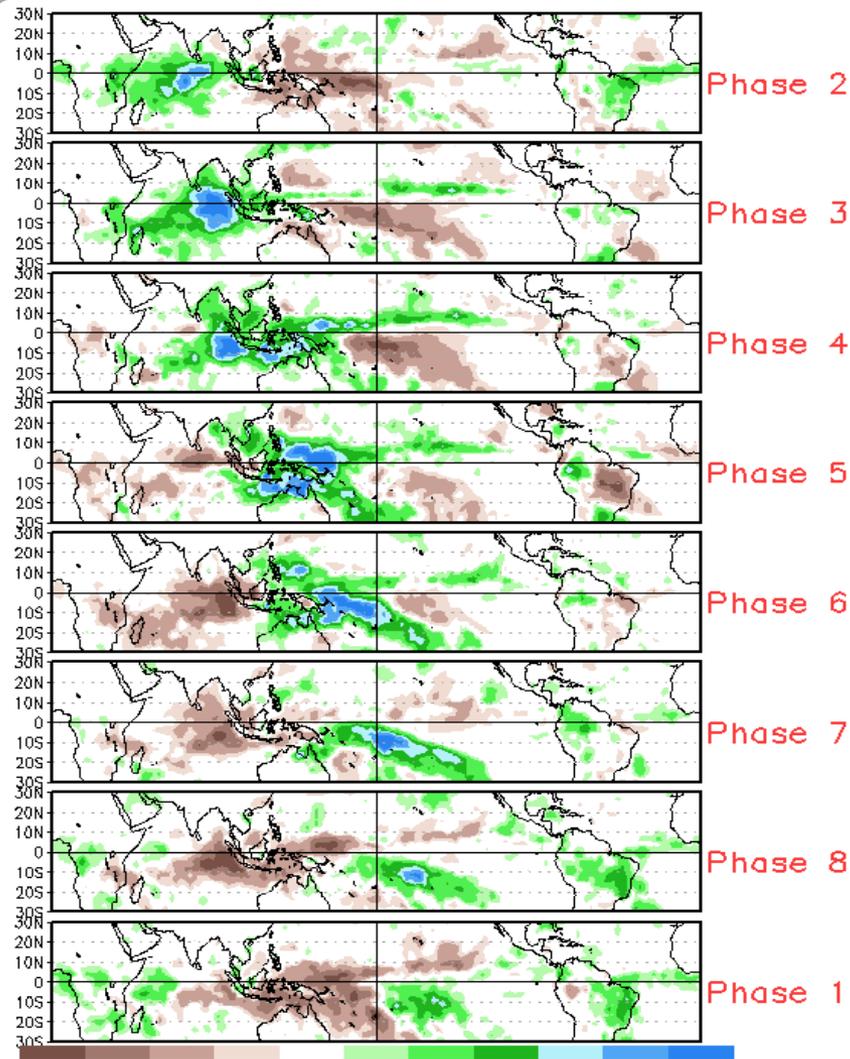


# MJO Composites - Global Tropics

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



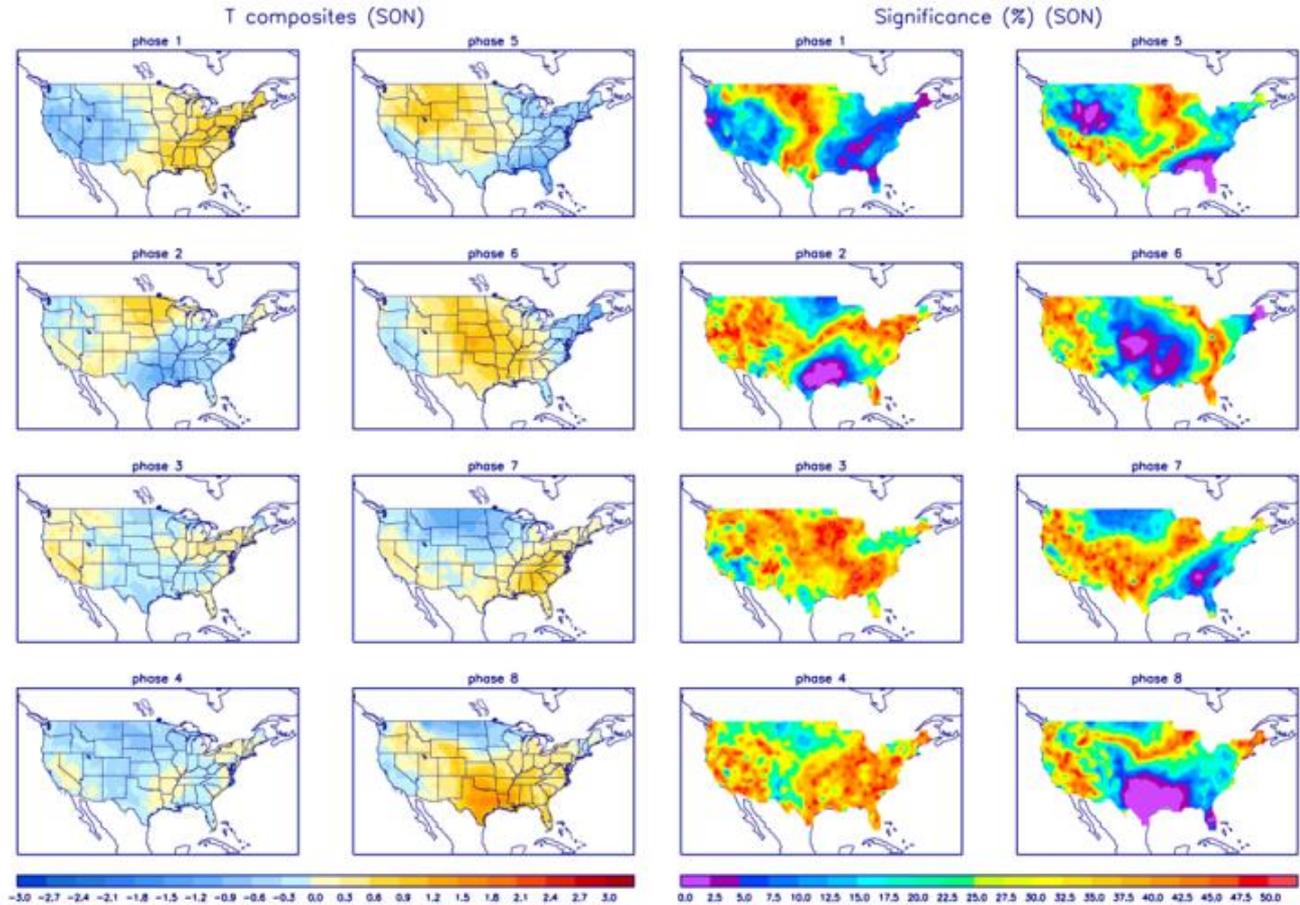
Precipitation Anomalies (May-Sep)



# 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.



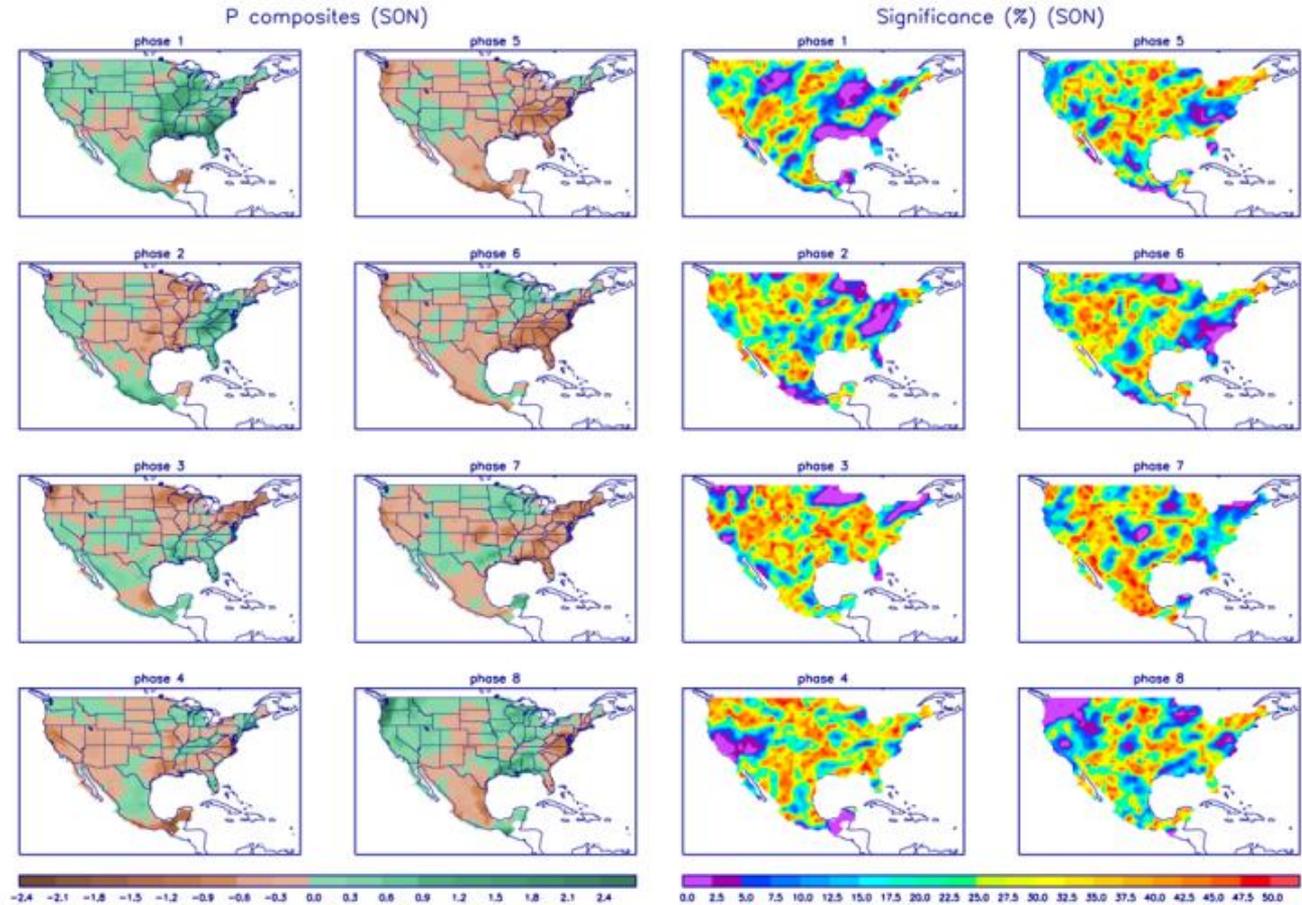
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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

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