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

Update prepared by:
Climate Prediction Center / NCEP
4 July 2016

# Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

# Overview

The MJO weakened and failed to cross the Maritime Continent as per the RMM index and low-level observations. Upper-level fields suggest continued presence of the MJO envelope, placing it across the East Pacific.

Forecast models suggest continued weakness of the MJO for the next two weeks, however parallels are drawn with the recent decay and re-emergence of the MJO over the Western Indian Ocean in May that appears similar to the current event where the upper-level signal remained despite decay of the corresponding low-level signature.

The apparent upper-level MJO presence and a Kelvin wave in the East Pacific have helped spawn two tropical cyclones (TCs) in the East Pacific (Agatha, Blas) and one in the West Pacific (Nepartak). The eastward progression of the upper-level MJO signature may continue to aid TC development over the East Pacific during the next two weeks. Given the time of year, any MJO-related teleconnection impacts to the mid-latitudes are anticipated to be exclusively TC-related.

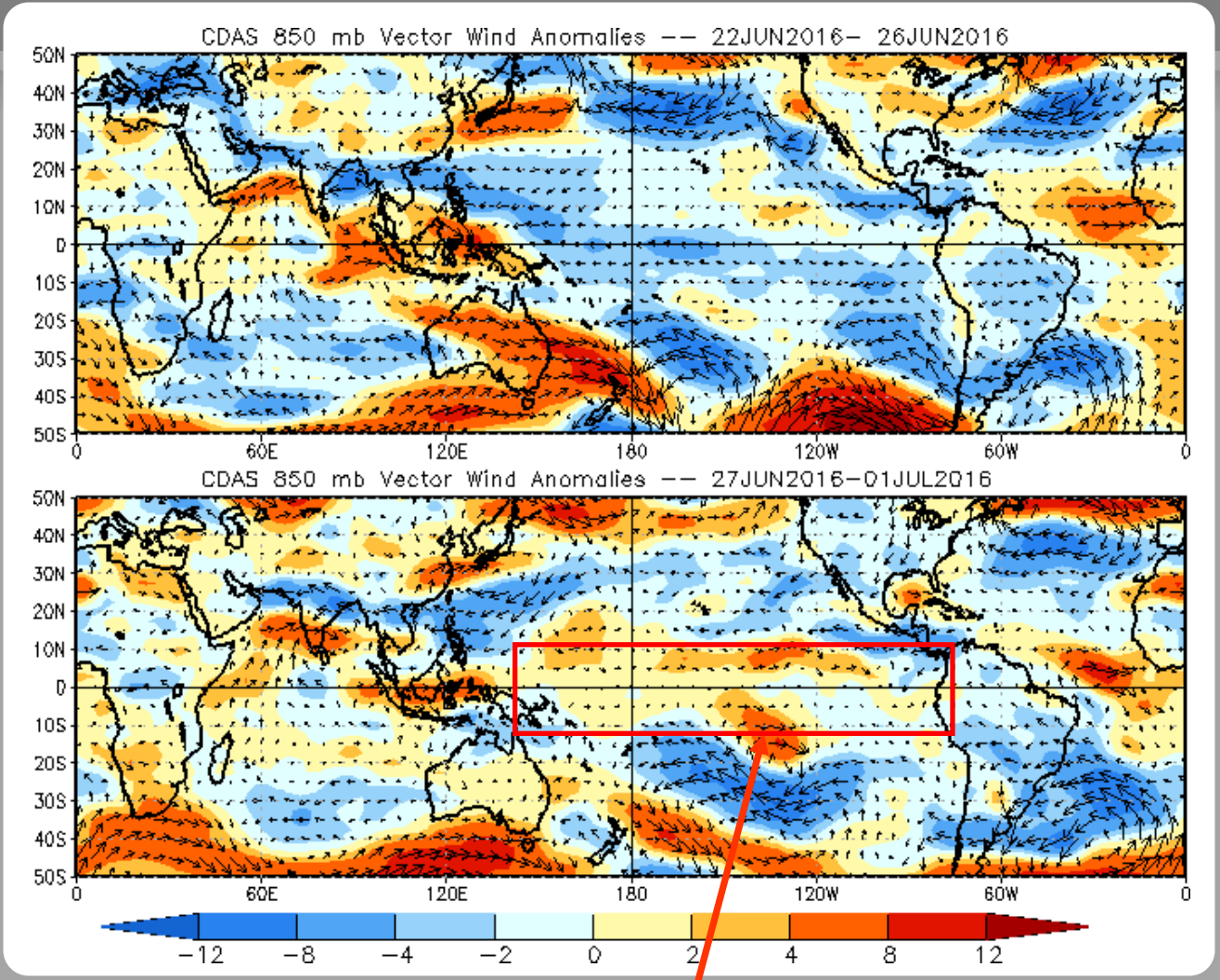
**Additional potential impacts across the global tropics and a discussion for the U.S. are available at:**
**http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php**

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies




Recently, anomalous low-level flow reversed across the equatorial Pacific, from easterlies to westerlies.

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

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

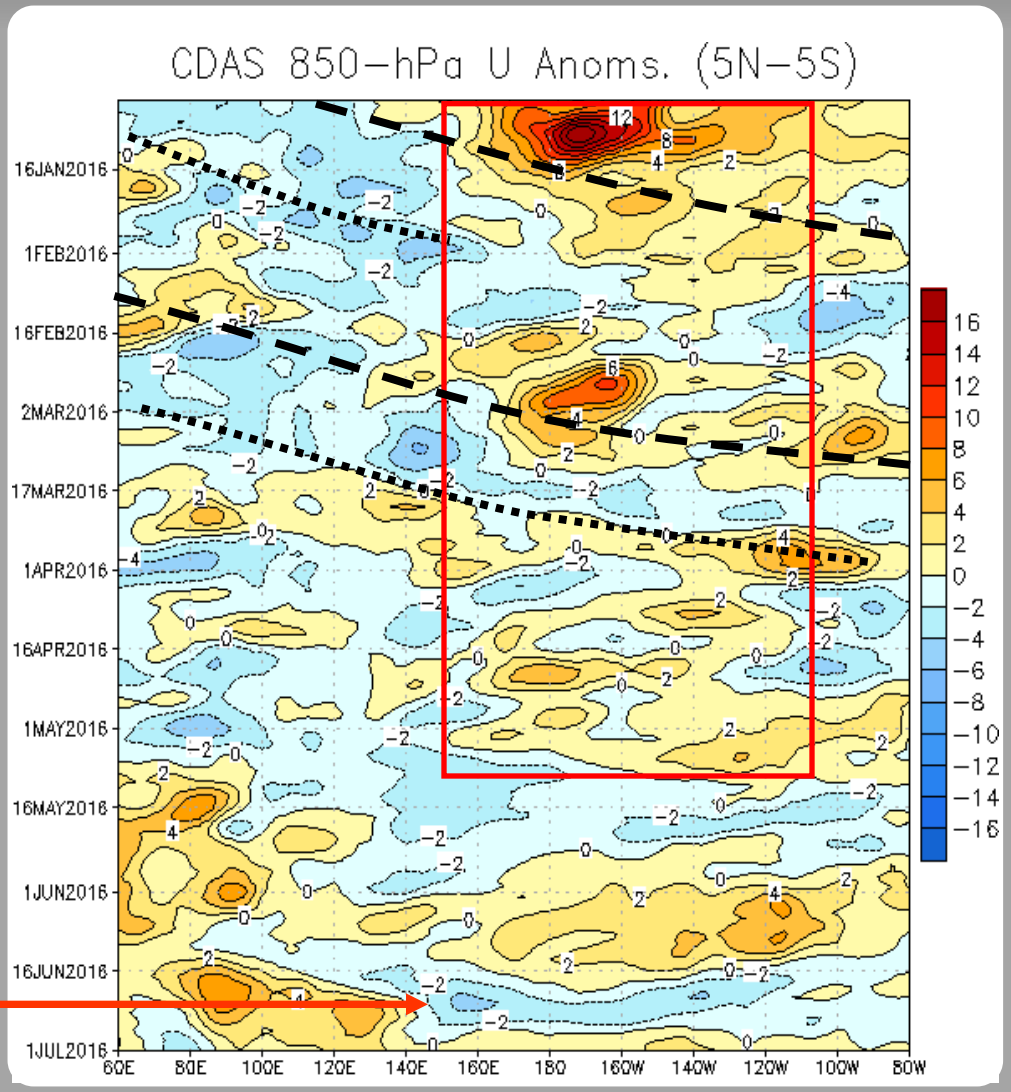
**Easterly anomalies (blue shading) represent anomalous east-to-west flow**

The red box highlights the persistent low-frequency westerly wind anomalies associated with the 2015-2016 El Niño background state.

Several fast-propagating intraseasonal events modulated the El Niño base state, and are marked using long (short) dashed lines for the enhanced (suppressed) phase of the intraseasonal signal.

During April, the wind field became less coherent as El Niño conditions weakened. Westerly anomalies strengthened over the Indian Ocean in late May, with some eastward propagation.

During June, westerly anomalies generally prevailed across the Indian Ocean and Pacific, with the exception of a brief transition to easterlies beginning mid-month.



# OLR Anomalies – Past 30 days

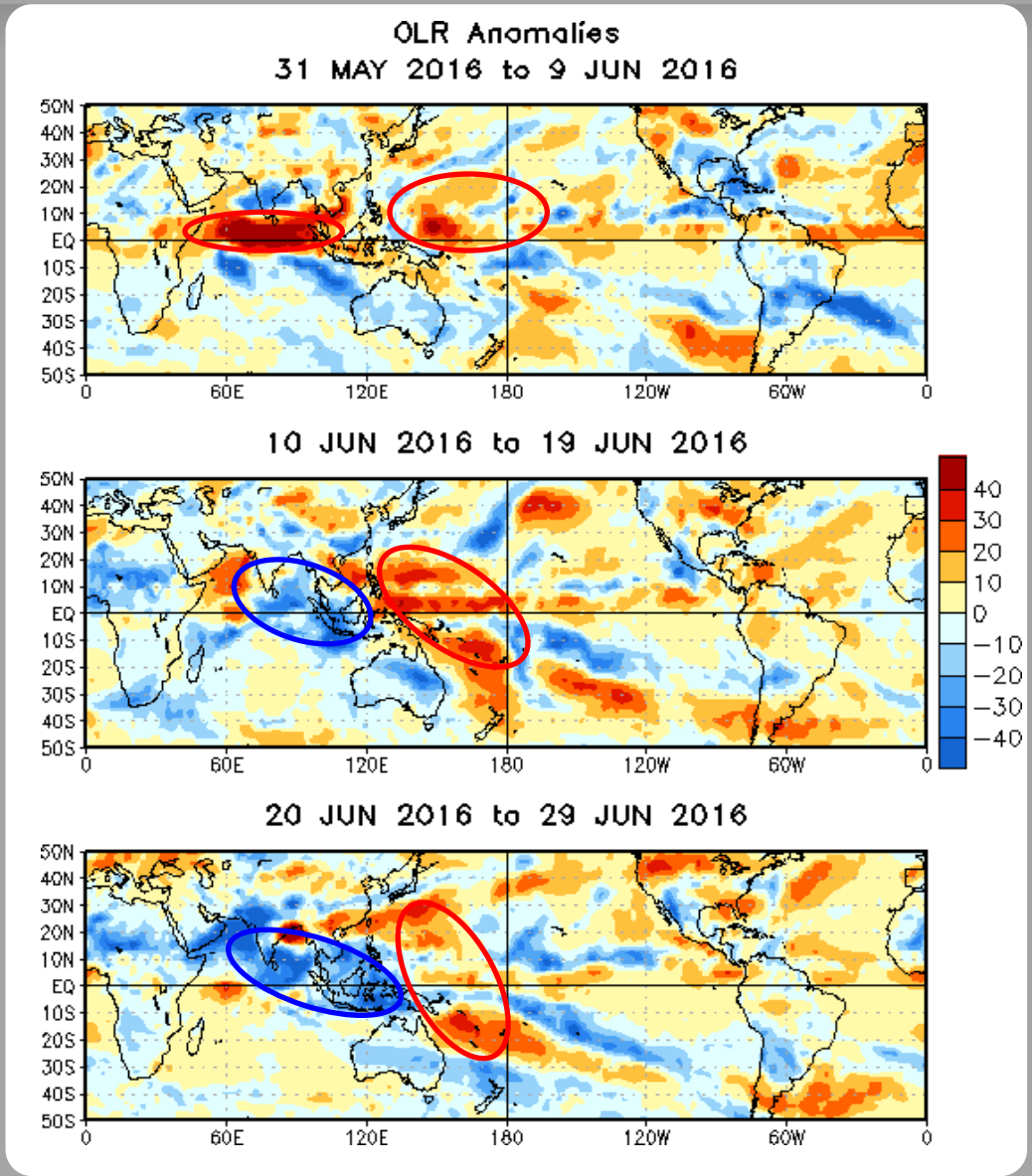
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During early June, suppressed convection encompassed the equatorial Indian Ocean and region between the Maritime Continent and DL.

Enhanced convection returned to the eastern Indian Ocean and western Maritime Continent during mid June, while suppressed convection persisted over the western equatorial Pacific.

In late June, enhanced convection remained across the eastern Indian Ocean and pushed into the Maritime Continent. Convection remained suppressed further east to the DL, but to less so relative to earlier in June.



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

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

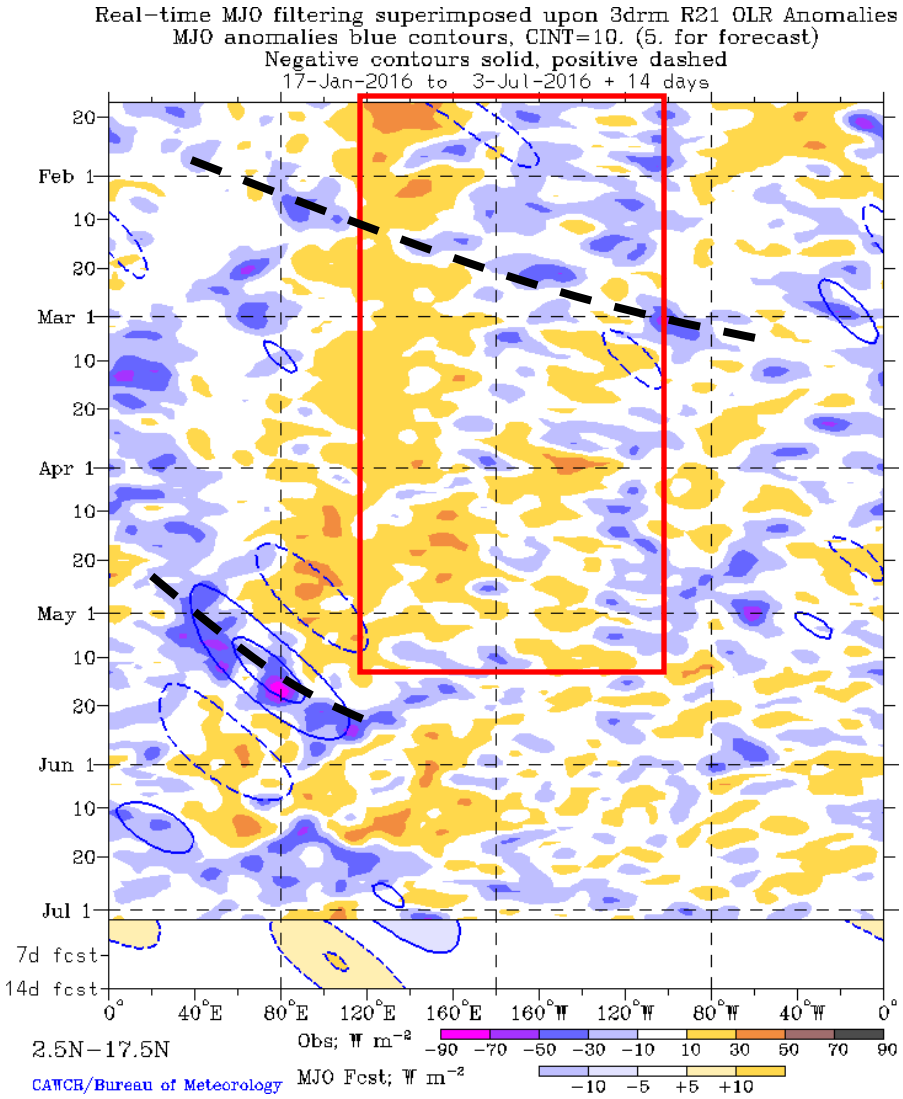
**Wetter-than-normal conditions, negative OLR anomalies (blue shading)**

The 2015-2016 El Niño background state is observed (red box) as a dipole of anomalous convection extending from the Maritime Continent to the East Pacific. The signal weakened steadily through boreal Spring.

Alternating periods of constructive and destructive interference with El Niño are evident. A fast eastward propagating signal raced across the Pacific during February.

During early May, an eastward-propagating convective envelope associated with the MJO developed east of the Prime Meridian. This OLR signal weakened over the Pacific.

Recently, hints of anomalously low OLR have begun to manifest across the eastern Indian Ocean, apparently tied to the suppressed phase of the MJO.



# 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**

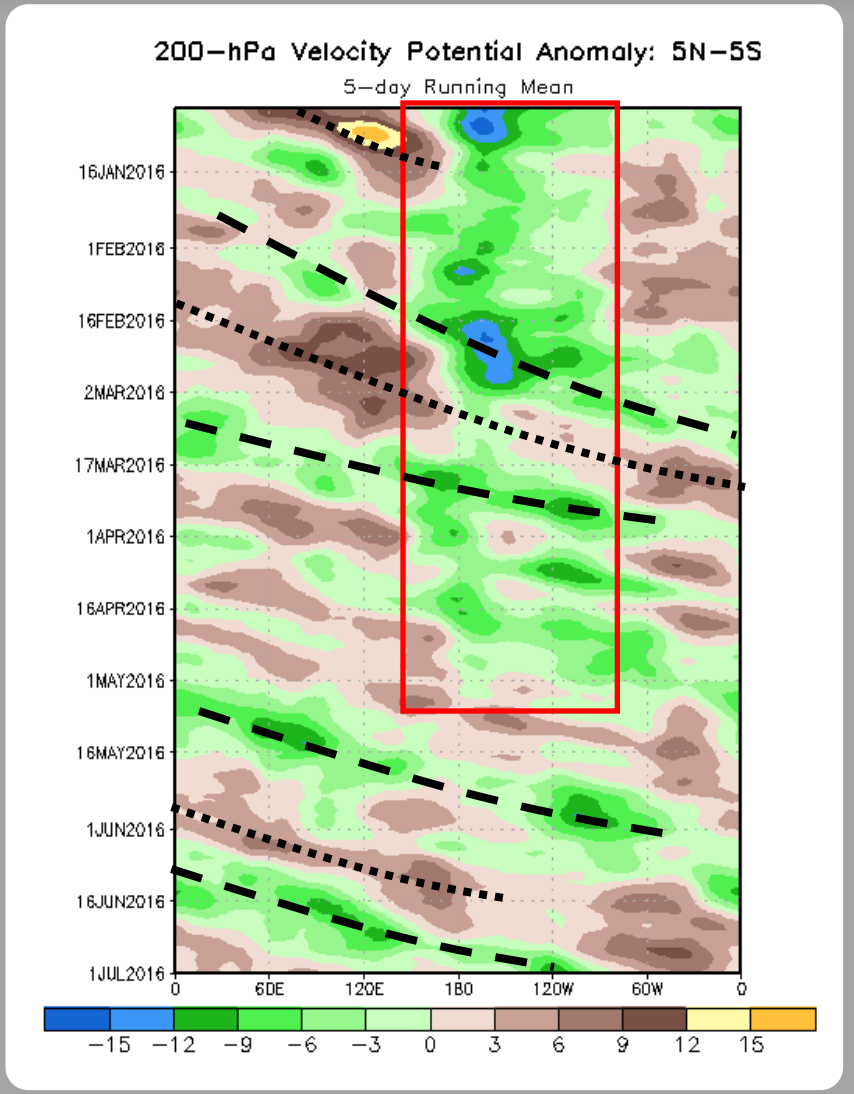
The 2015-16 El Niño background state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

MJO activity was evident in February and March, alternatively constructively and destructively interfering with the ENSO background state.

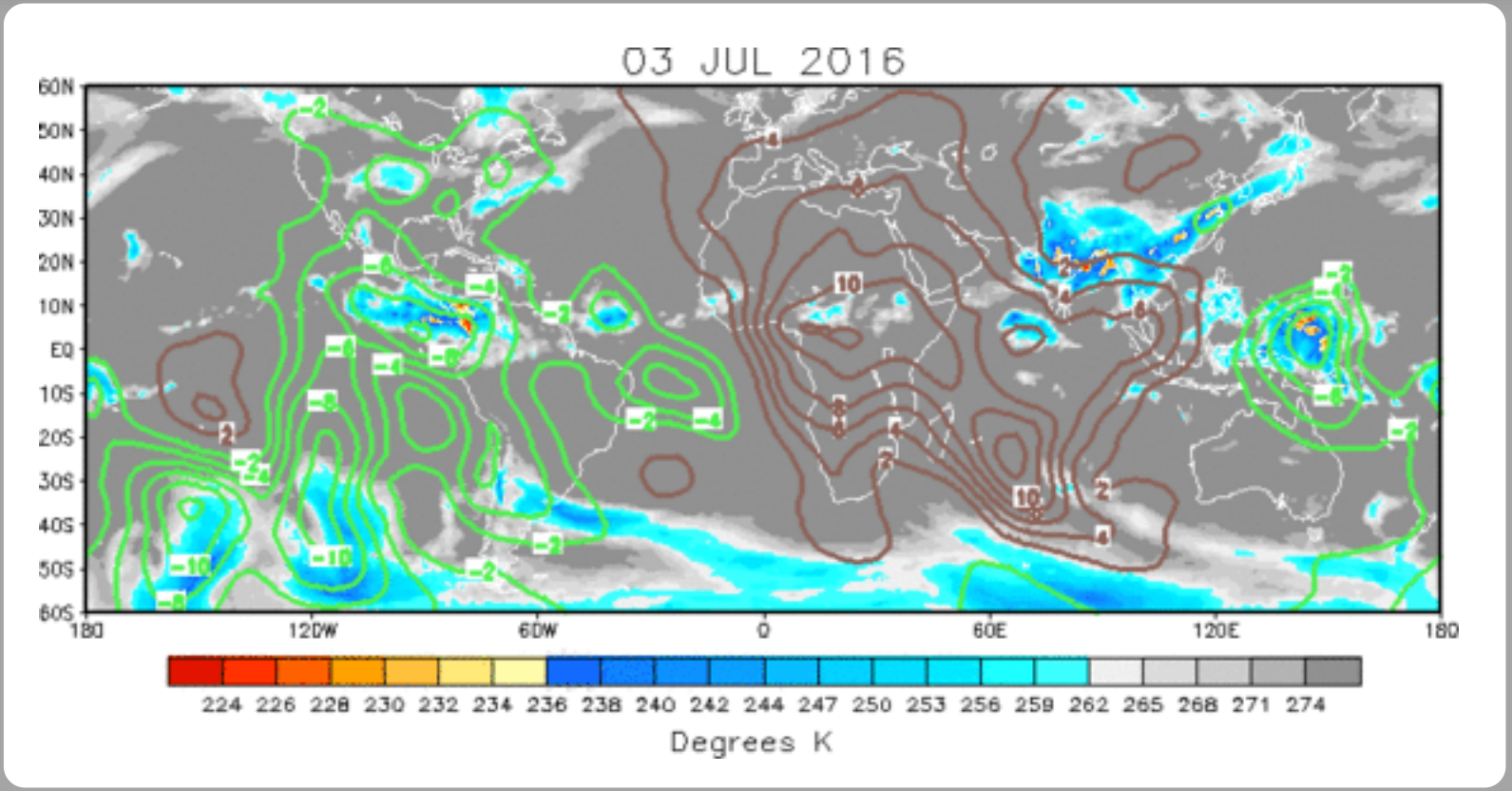
The upper-level velocity potential pattern became less coherent as the El Niño waned during April.

During May and June, an eastward propagating signal was evident in the upper-level velocity potential field. This signal was more coherent than the low-level MJO indicators.

As July begins the aforementioned anomalous divergence envelope is centered over the East Pacific and continues to manifest most clearly aloft.



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




The large scale upper-level velocity potential anomaly pattern is a coherent Wave-1 field with positive (negative) anomalies over Africa and the Indian Ocean (Eastern Maritime Continent, Pacific, Americas, and Atlantic).

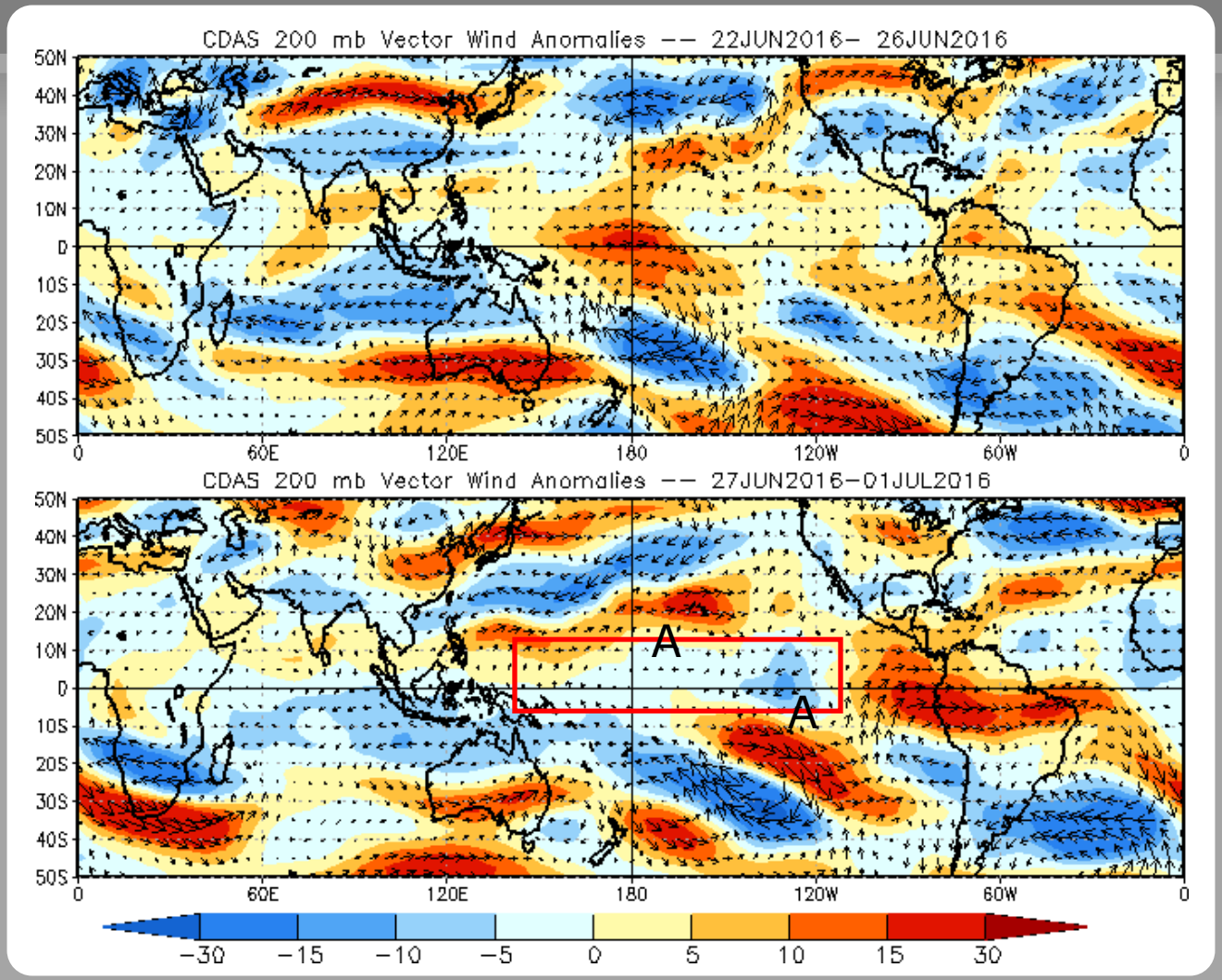
| |
|---|
| Positive anomalies (brown contours) indicate unfavorable conditions for precipitation |
| Negative anomalies (green contours) indicate favorable conditions for precipitation |

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies




Easterlies came to dominate the tropical Pacific over the past 5 days.

Anomalous anticyclones are apparent over the Pacific, but not well-aligned across the equator.

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

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

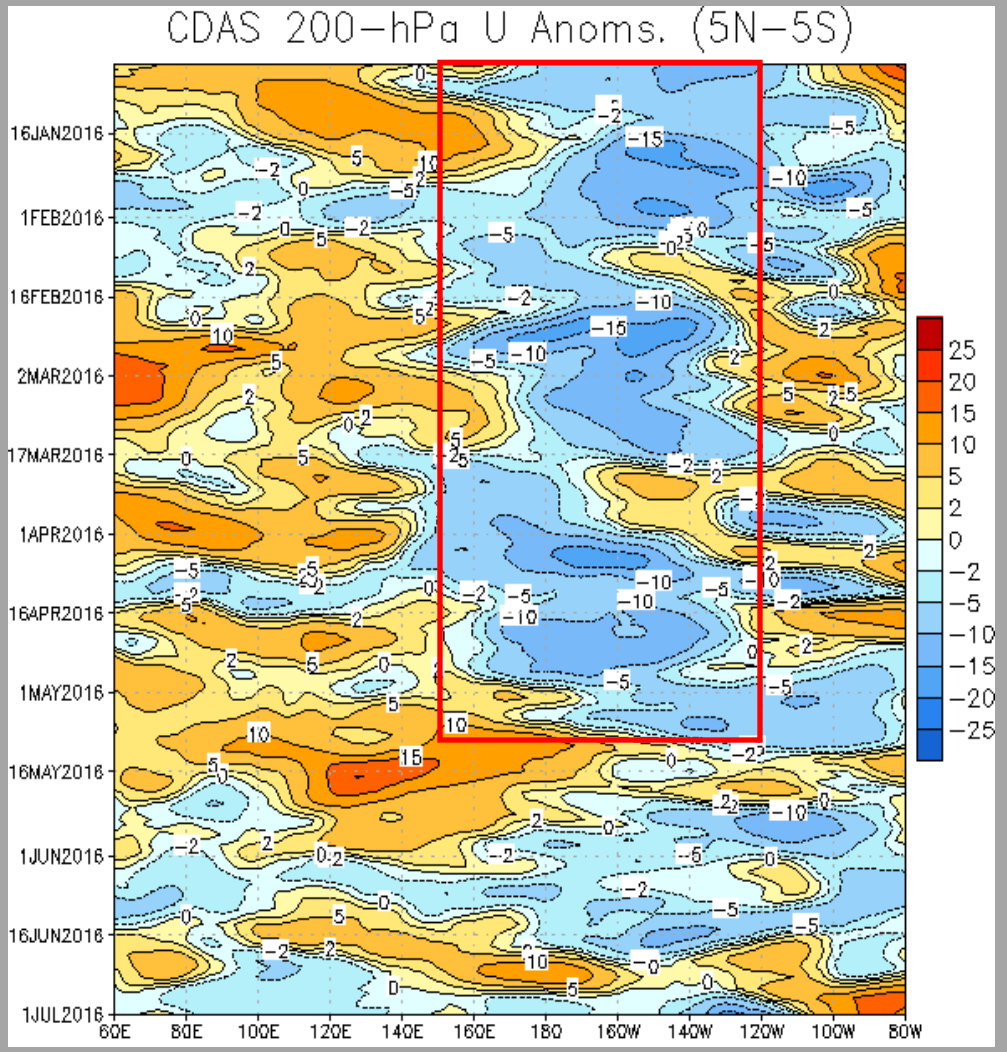
**Easterly anomalies (blue shading) represent anomalous east-to-west flow**

Easterly anomalies have persisted over the central and eastern Pacific from June 2015 to May 2016 associated with El Niño (red box). Corresponding westerly anomalies persisted over the Maritime Continent.

During May, westerly anomalies expanded eastward to the Date Line as El Niño weakened. Faster propagating modes were evident in the upper-level wind field.

The upper-level wind field became less coherent during late May and early June.

Most recently westerly anomalies are focused across the East Pacific with easterly anomalies to its west, revealing the anomalous divergence from the MJO-envelope's presence here.



# Weekly Heat Content Evolution in the Equatorial Pacific

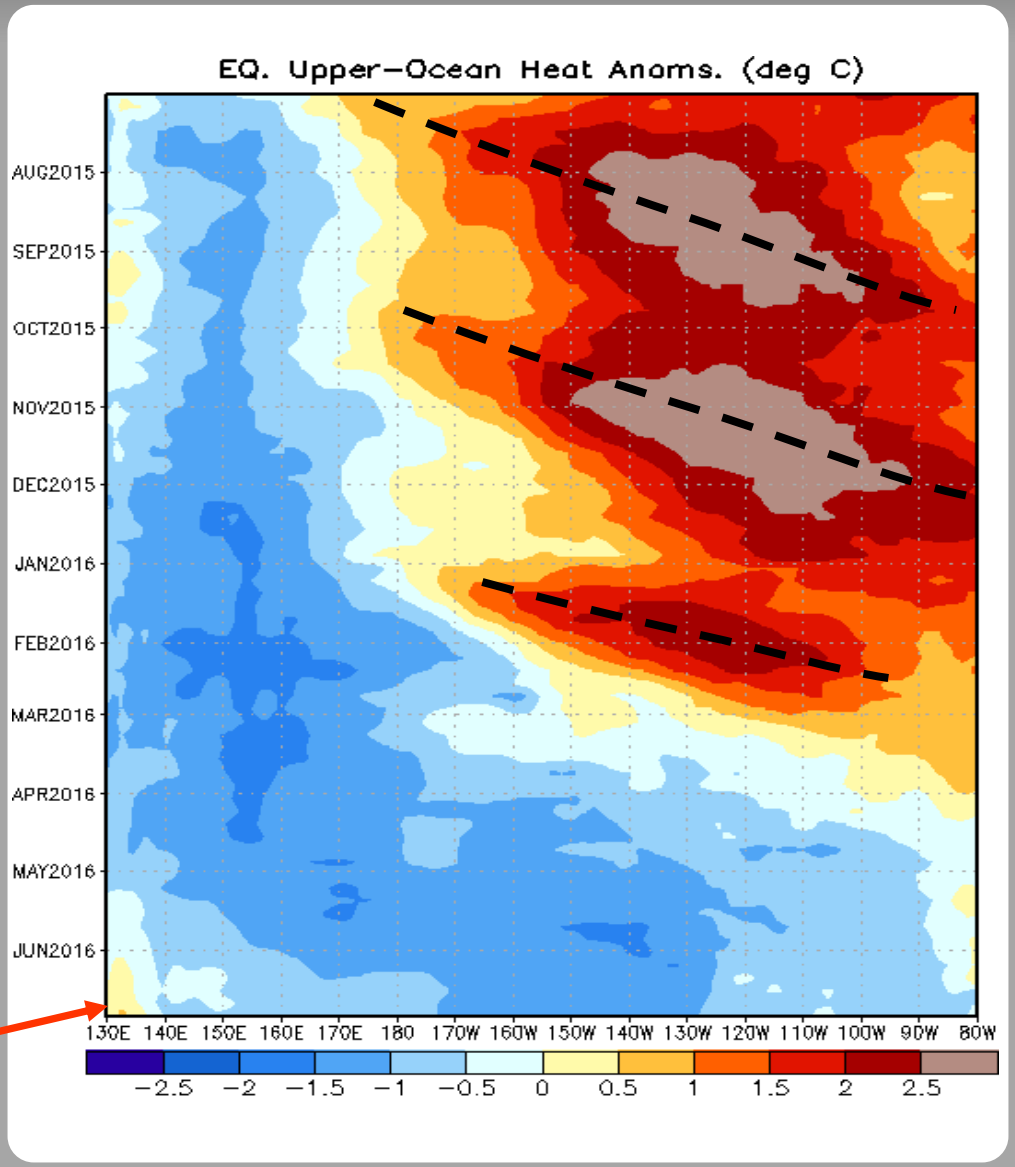
**Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.**

Reinforcing downwelling events were observed during the second half of 2015, resulting in persistently above-normal heat content from the DL to 80W throughout the period.

An eastward expansion of below average heat content over the western Pacific is evident since January, with negative anomalies beginning to spread east of the Date Line.

In the last three months, there has been a rapid eastward expansion of below-average oceanic heat content across the central and eastern Pacific. Negative anomalies now extend across the equatorial Pacific.

A hint of anomalously warming SSTs is apparent west of 140E.



# 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**

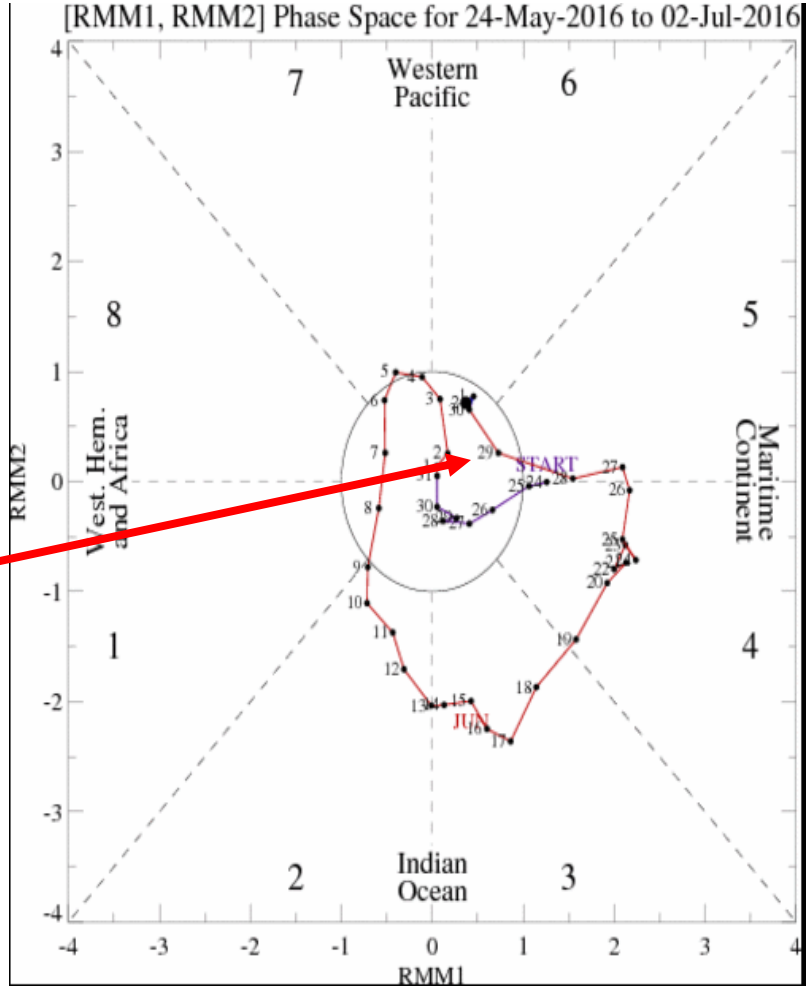
**The triangular areas indicate the location of the enhanced phase of the MJO**

**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**

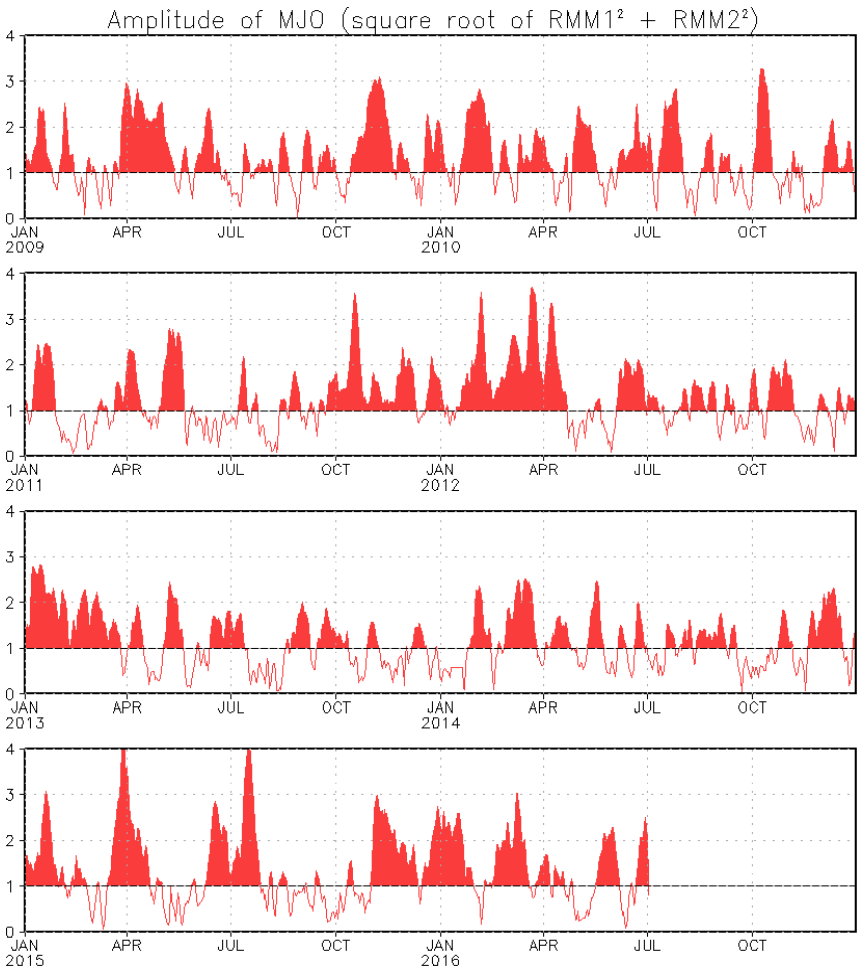
During the past week, the RMM index indicated weakening of the MJO event, with amplitudes returning to within the unit circle.



# 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.**



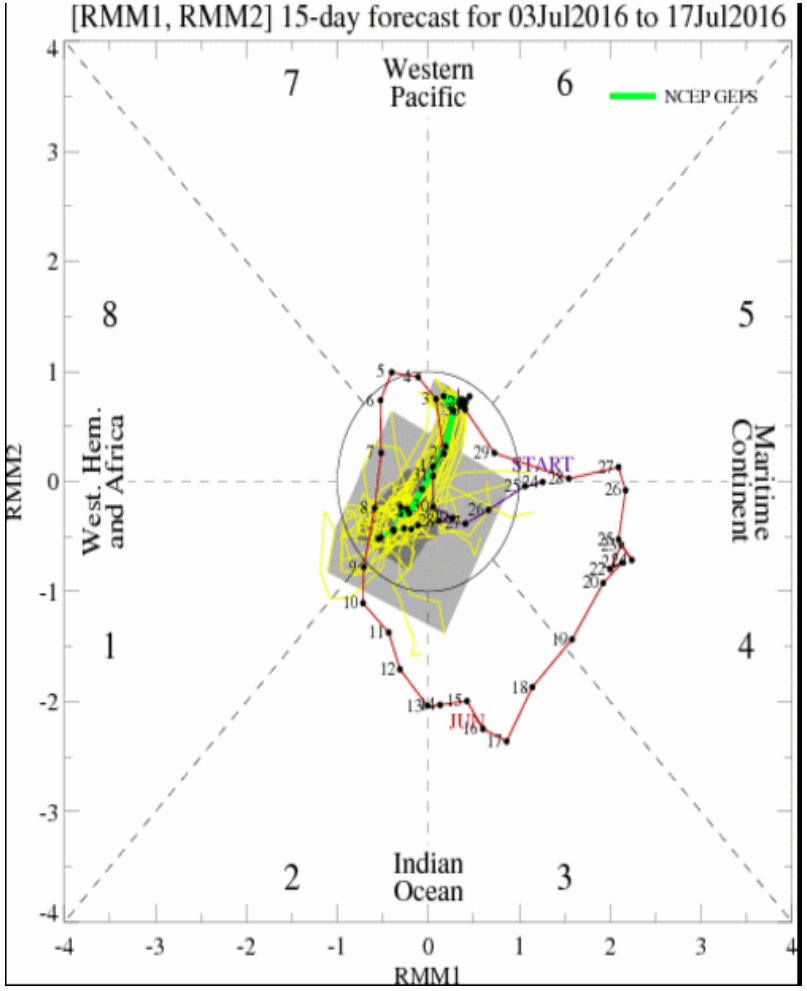
# Ensemble GFS (GEFS) MJO Forecast

**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**



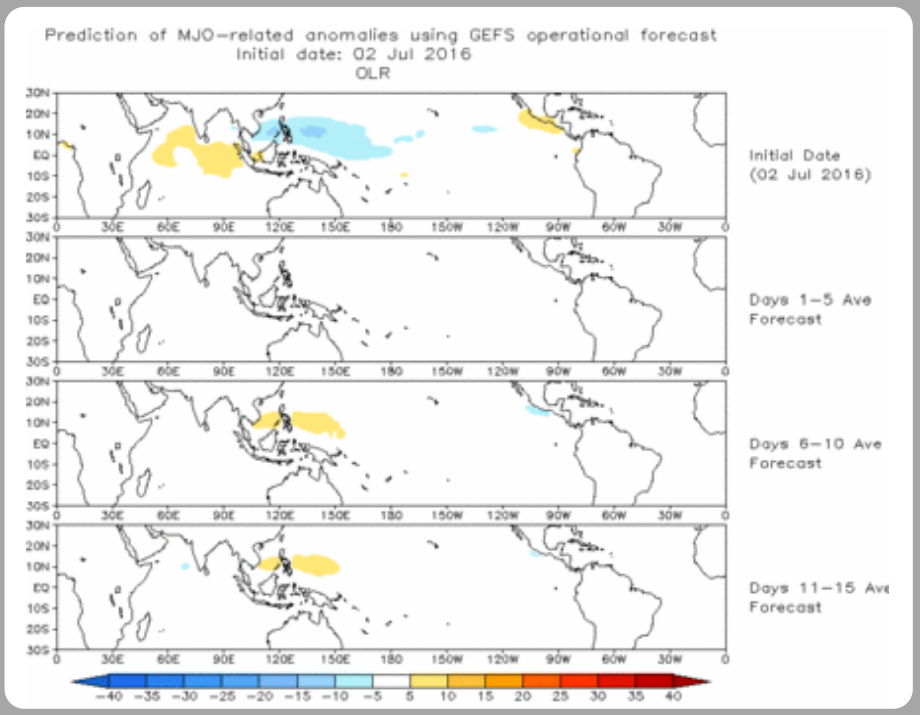

During the next two weeks, the GFS ensemble indicates continued weakness of the MJO.

This forecast pattern is similar to the observed MJO activity in early May that saw eventual re-emergence of the MJO signal across the Indian Ocean in the RMM framework. This possible outcome would be currently forecast to be slower than was observed during May, but the low mean phase speed may be interference from ensemble differences in the MJO envelope's phase speed being averaged together.

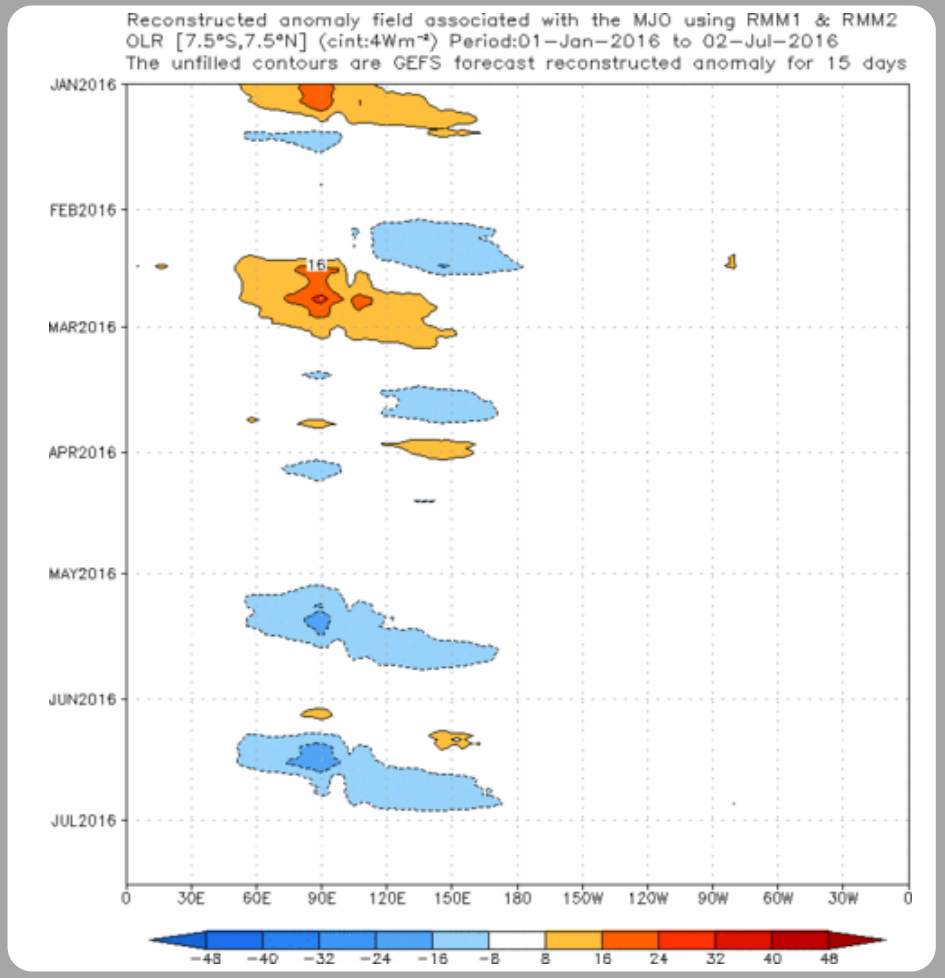
# Ensemble GFS (GEFS) MJO Forecast

**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**

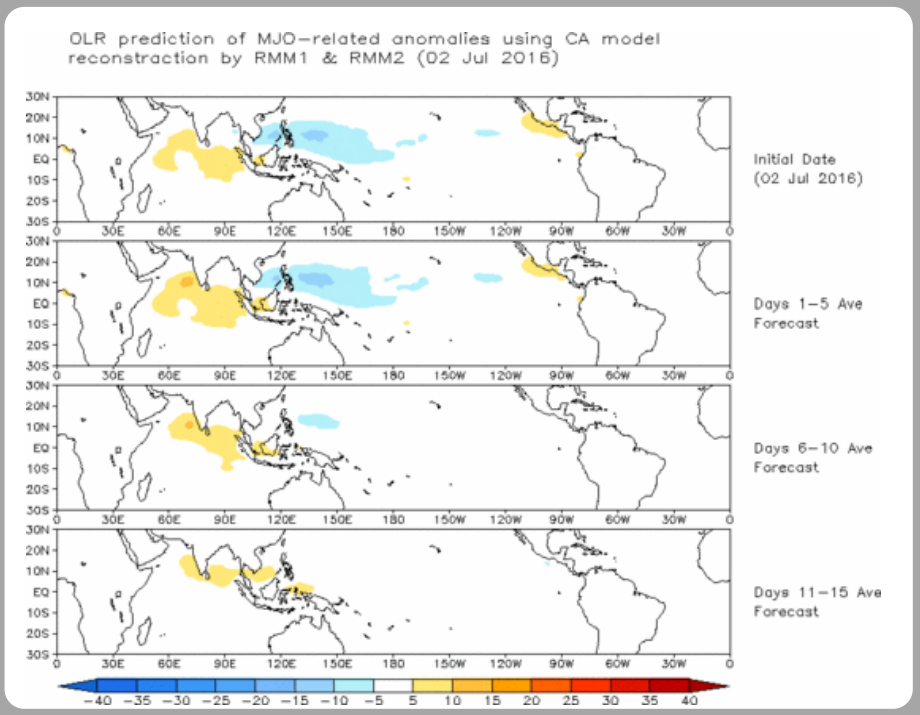



The GEFS OLR forecast based on the RMM Index depicts rapid weakening of robust convective anomalies during the next week, with suppressed convection North of the Maritime Continent in week-2.

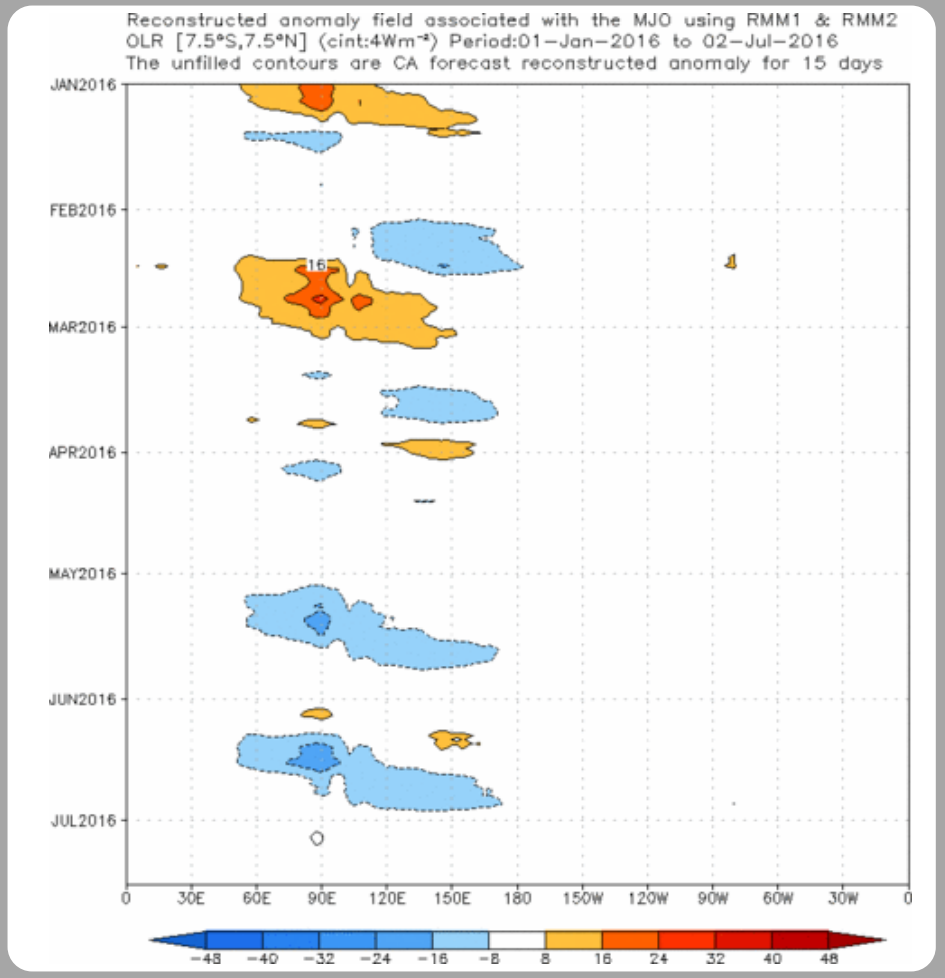
# Constructed Analog (CA) MJO Forecast

**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**



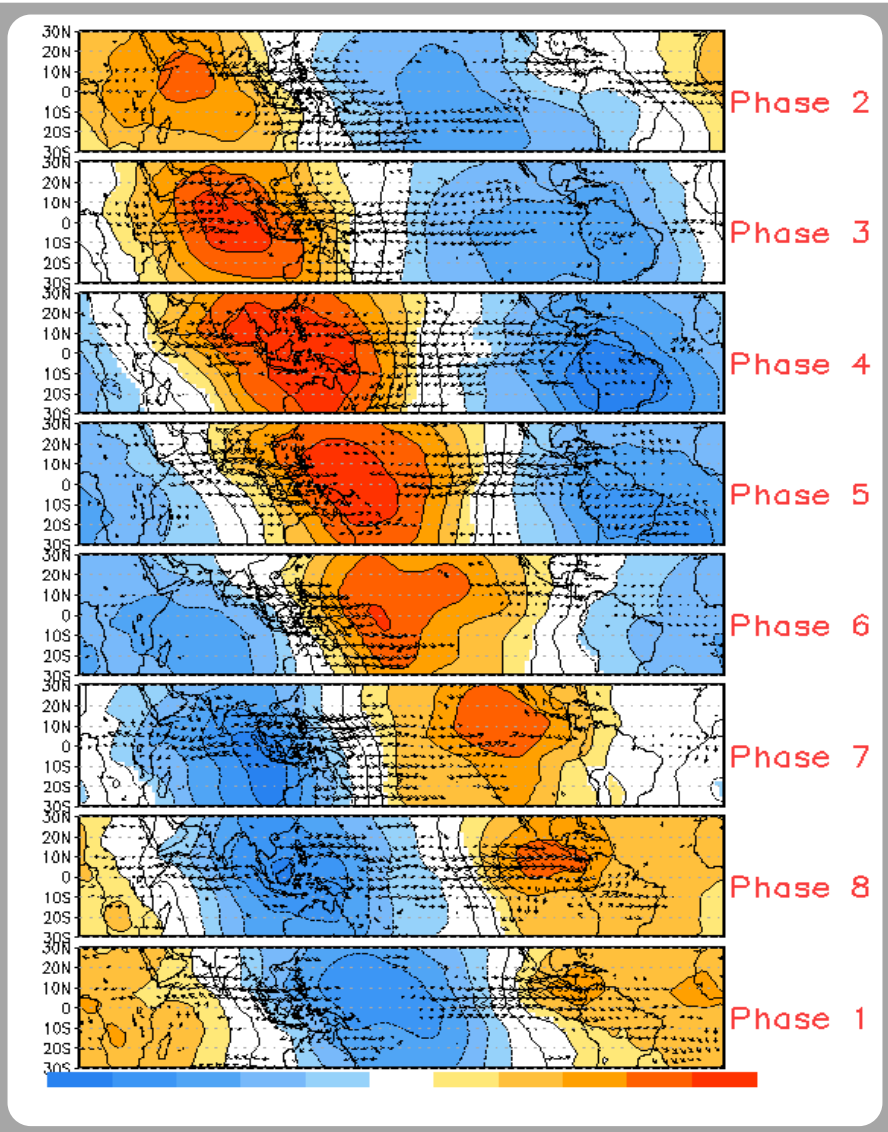

**Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days**



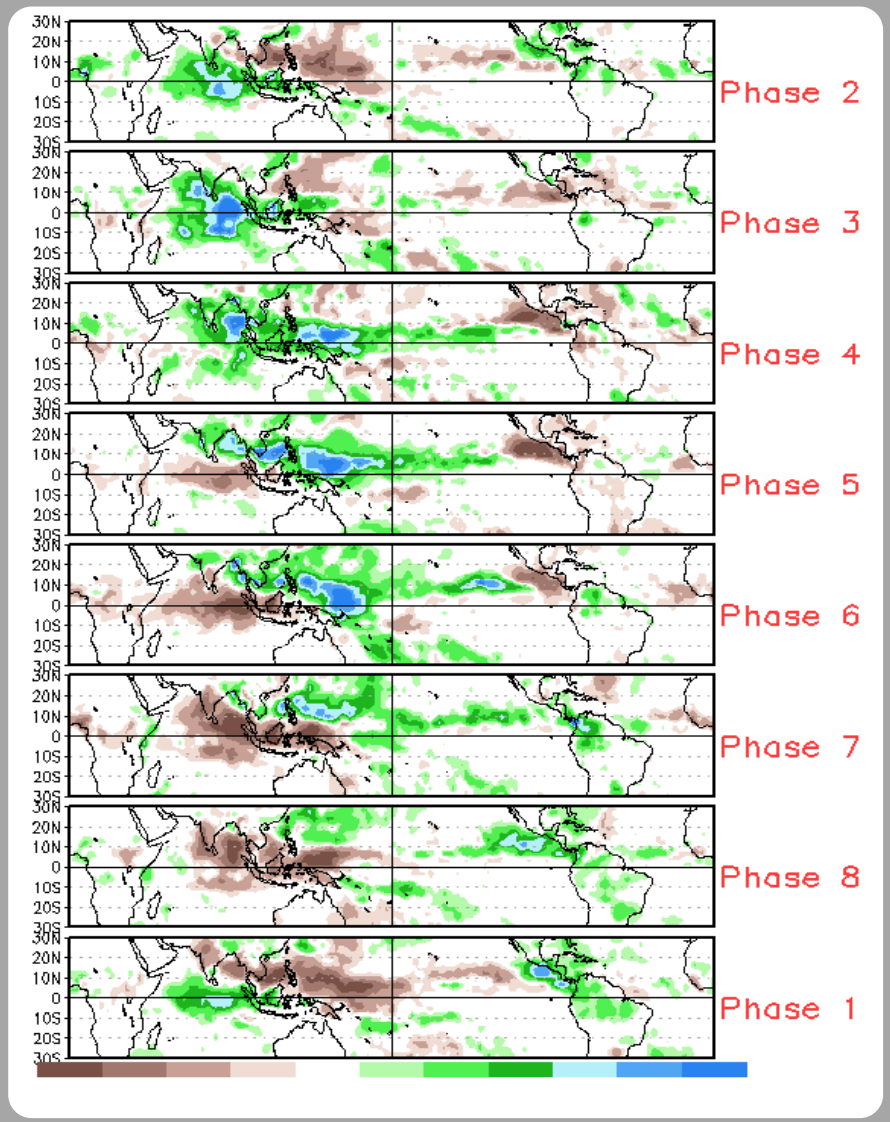

The Constructed Analog (CA) model predicts a stationary and weakening MJO-signal during the next two weeks.

# MJO Composites - Global Tropics

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



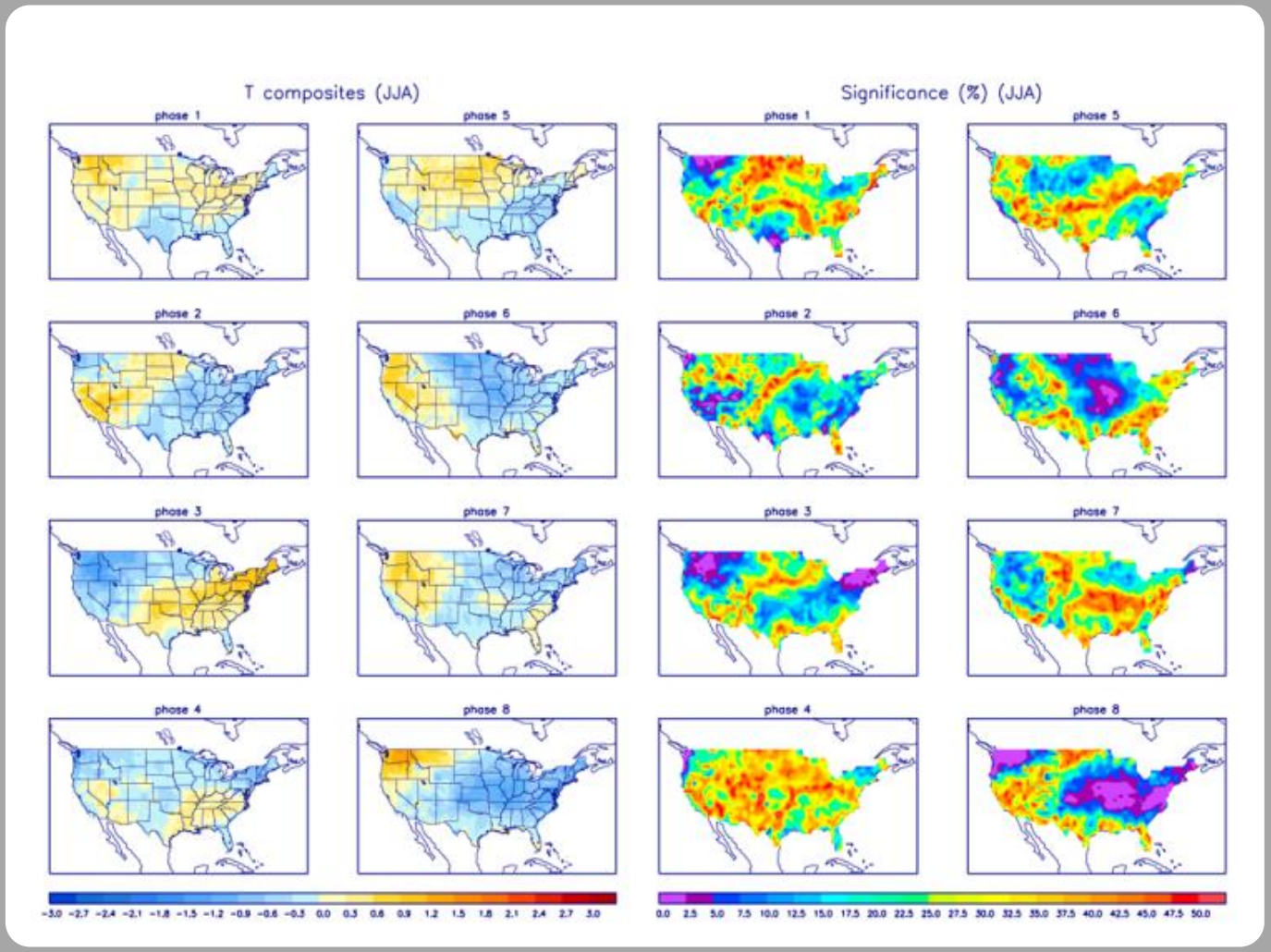

**Precipitation Anomalies (May - Sep)**



# 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.**



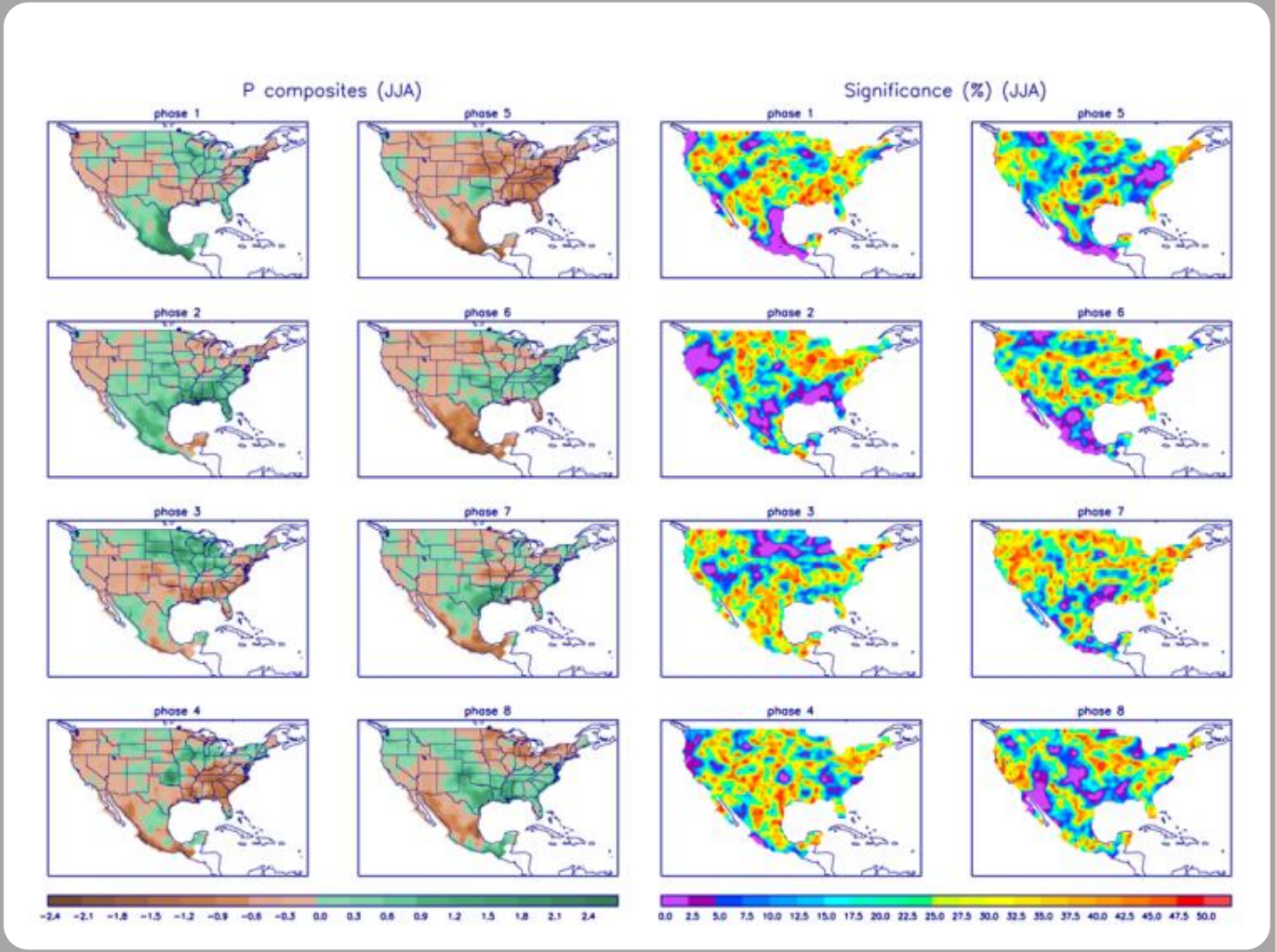

Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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