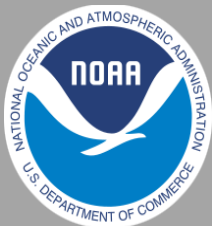


# Madden-Julian Oscillation: Recent Evolution, Current Status and Predictions



Update prepared by:  
Climate Prediction Center / NCEP  
3 July 2017

# Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

# Overview

- The MJO continues to exhibit weakness, with a brief signal emerging during the last 7-days over the Western Indian Ocean that failed to propagate eastward or maintain its amplitude.
- Dynamical model guidance continues to forecast the intraseasonal signal to be at low amplitudes over the next two weeks. ECMWF ensembles are the only model forecasting a signal that resembles an MJO event, although at a generally weak magnitude.
- The MJO is expected to continue to remain weak over the forecast period, with low-frequency signals and other intraseasonal modes instead driving the circulation in the global tropics.

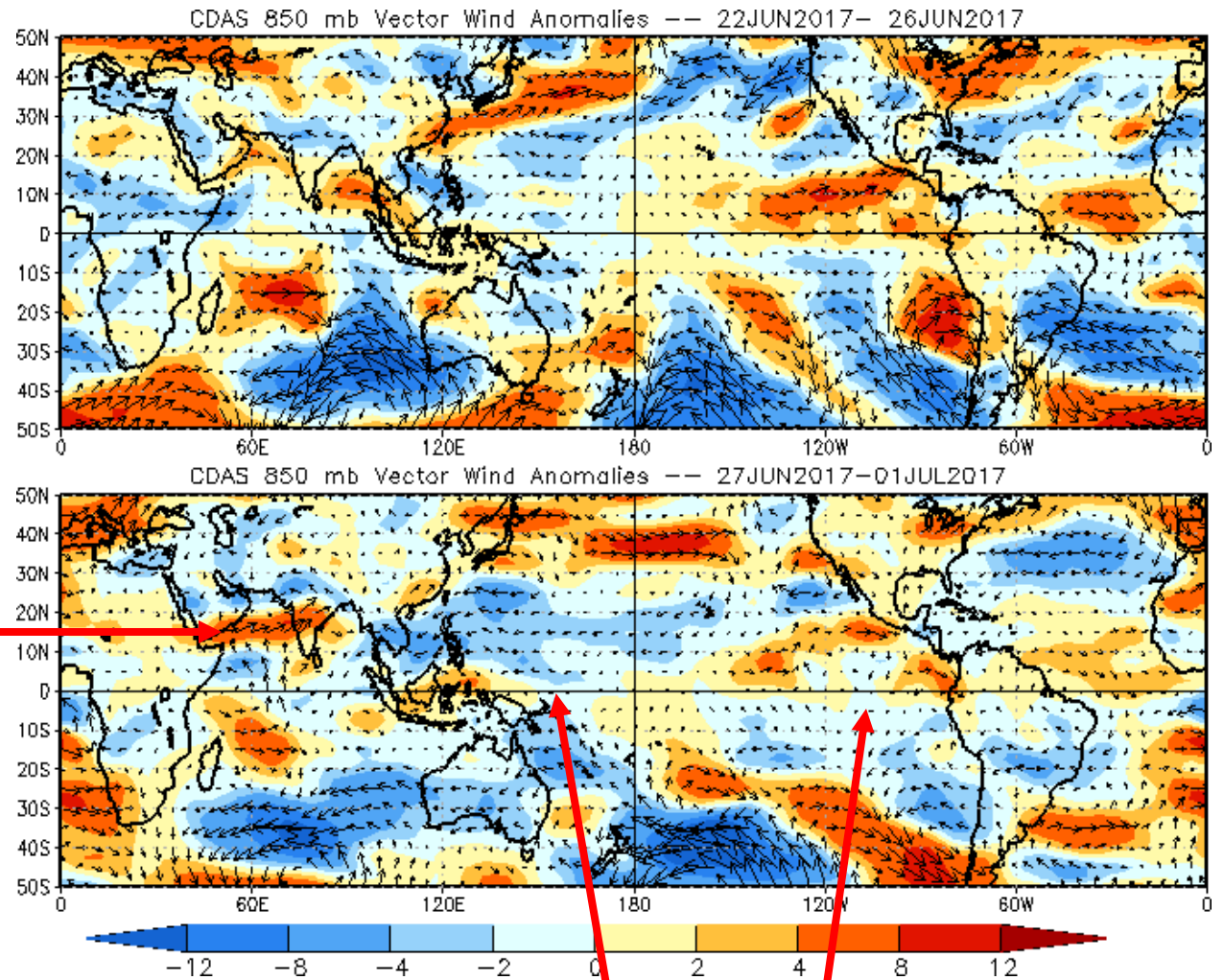
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:  
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php>

# 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



Southwesterly flow intensified across the Arabian Sea and India in association with the advancing southwest monsoon.

General easterly (westerly) anomalies persisted over the western (eastern) Pacific, with divergence focused just west of the antimeridian.

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

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

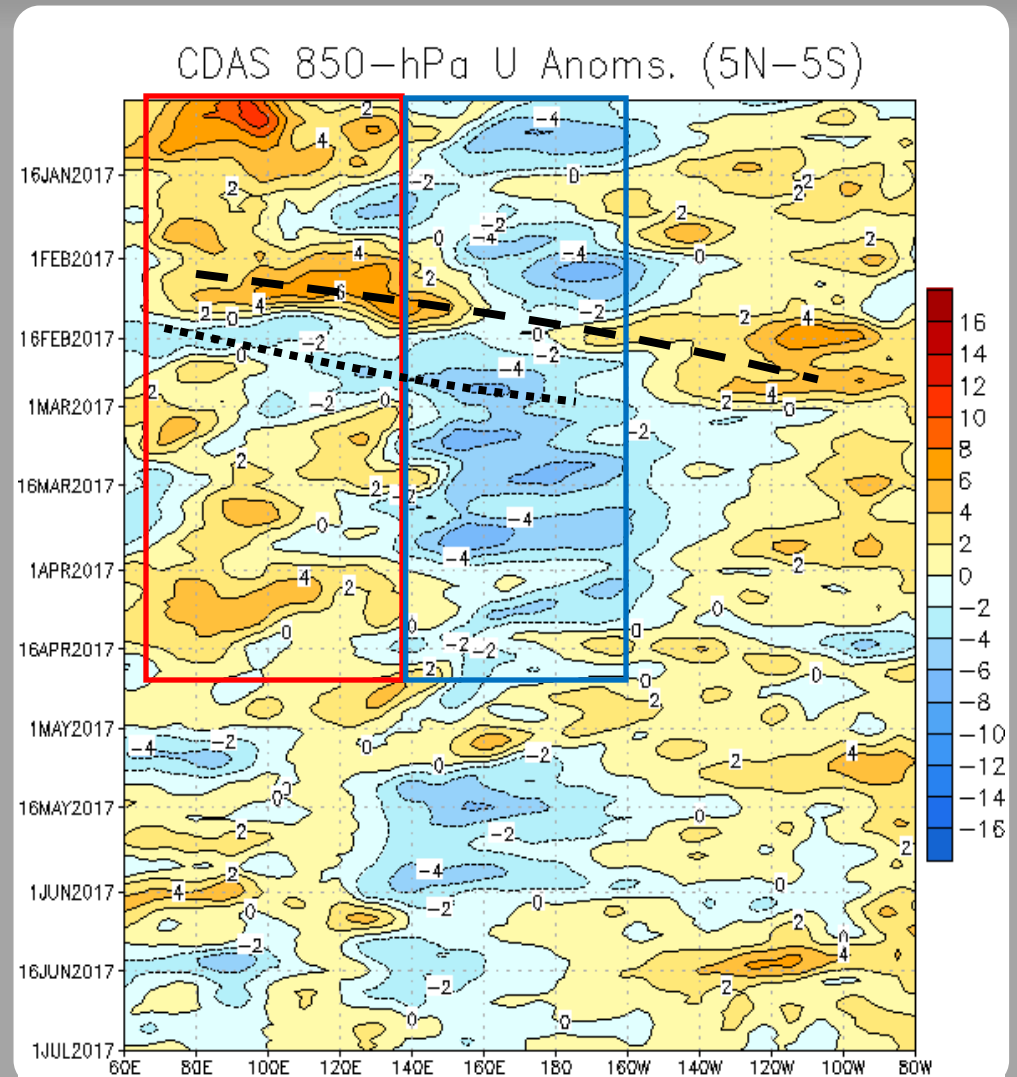
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Persistent westerly (easterly) anomalies, shown by the red (blue) box at right, were associated with the negative phase of the Indian Ocean Dipole (IOD), and later, La Niña.

During late January, Rossby wave activity was evident, with destructive interference on the base state evident through 100E.

In February, MJO activity also destructively interfered with the base state. During mid-March and early April, the low frequency state reemerged, with some intraseasonal variability evident in late March.

Equatorial flow was fairly weak throughout June, with easterlies favored between 120E and the Date Line and also emerging across the western Indian Ocean. Most recently, westerlies were generally favored throughout the global tropics.



# OLR Anomalies - Past 30 days

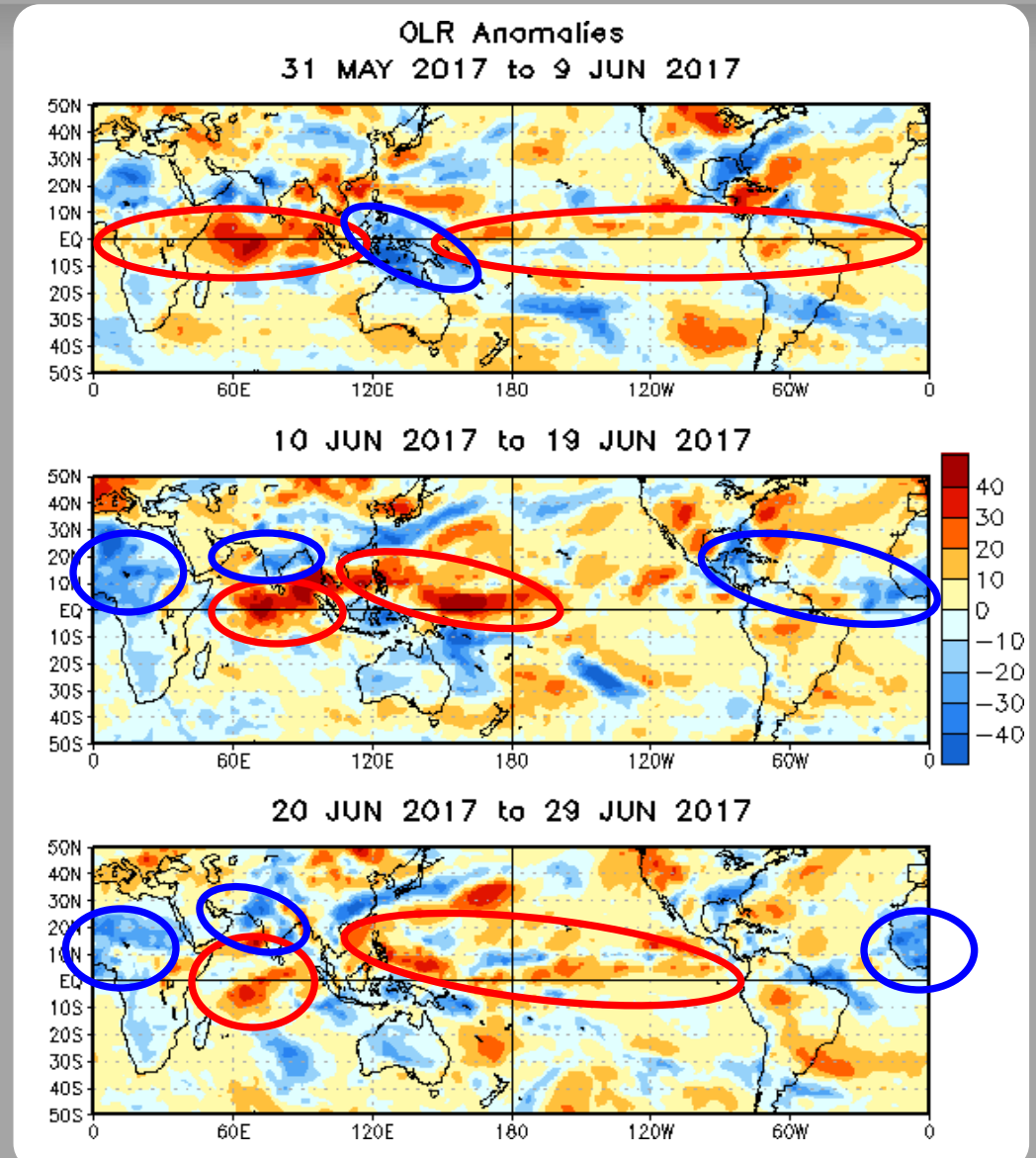
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late May and early June, enhanced convection was apparent over the eastern Maritime Continent, with suppressed conditions persisting over much of the remainder of the global tropics.

A robust Kelvin wave increased convection from Central America through Africa during mid-June.

Suppressed convection prevailed across the Pacific, with the exception of a strip near 10N associated with a Kelvin wave. A surge in southwesterly flow over the Arabian Sea helped advance the monsoon faster than climatology into southern Pakistan.



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

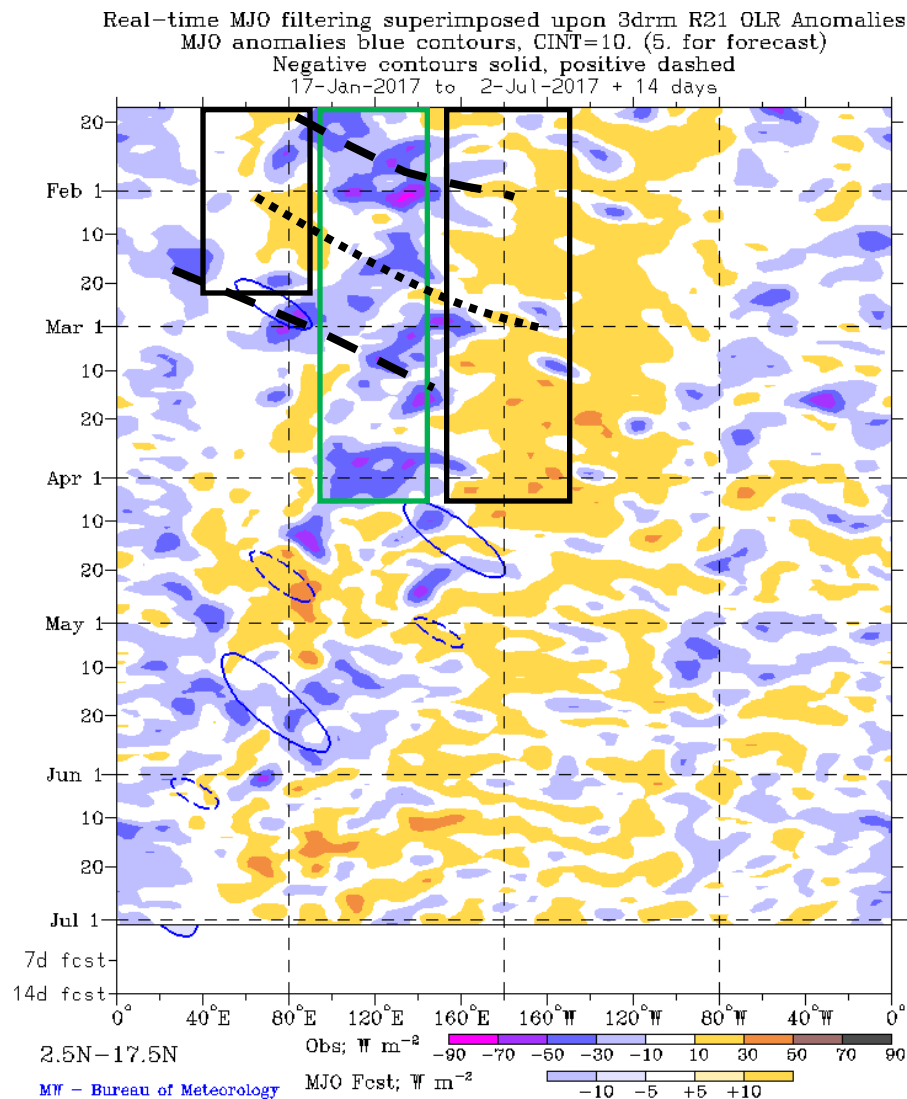
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

A low frequency state favoring enhanced convection over the eastern IO and the Maritime Continent was evident from July 2016 through early April 2017 (green box), with suppressed convection near the Date Line (right black box). The remainder of the IO generally had suppressed convection during this period (left black box), with the exception of an MJO-related wet period from mid-Feb to early March.

From mid-April through present, convective anomalies were generally weak. In mid-May, enhanced convection was noted over the Indian Ocean with some eastward propagation.

During the past week convective signals were weak and generally incoherent, with the most pronounced signal associated with suppressed convection over the eastern Indian Ocean.



# 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

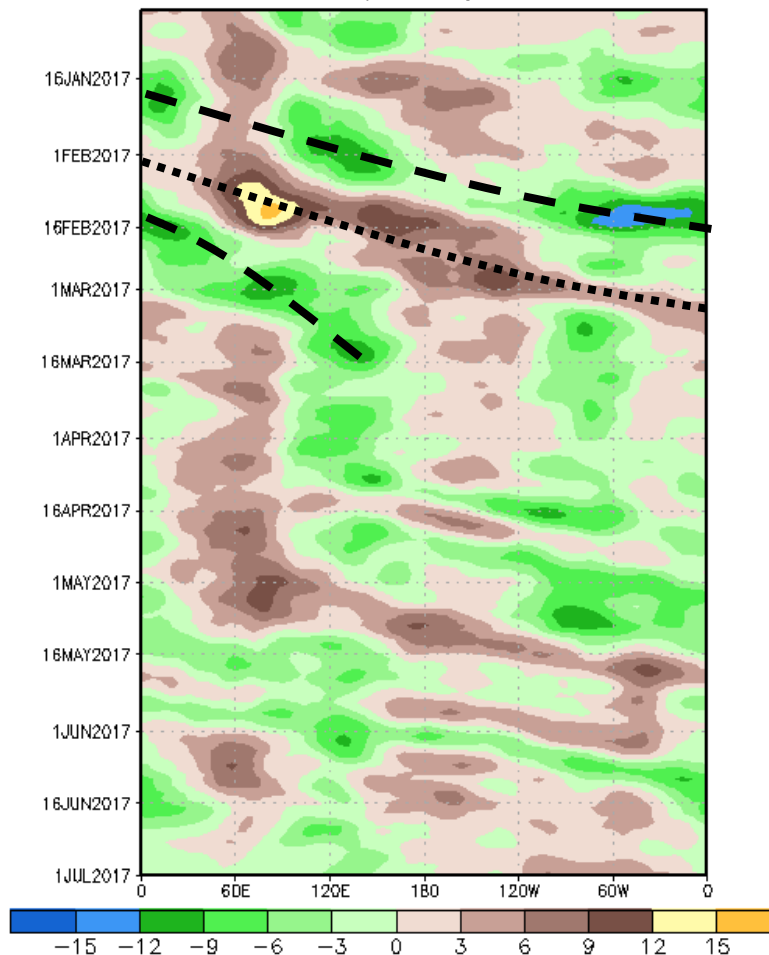
The pattern during December and January was more related to seasonal variability.

A signal emerged over the Maritime Continent and continued propagating through early March, creating alternating periods of constructive and destructive interference with the base state.

During March, a low frequency signal favoring enhanced (suppressed) convection over the Maritime Continent (Indian Ocean) once again became the primary component of the anomaly field.

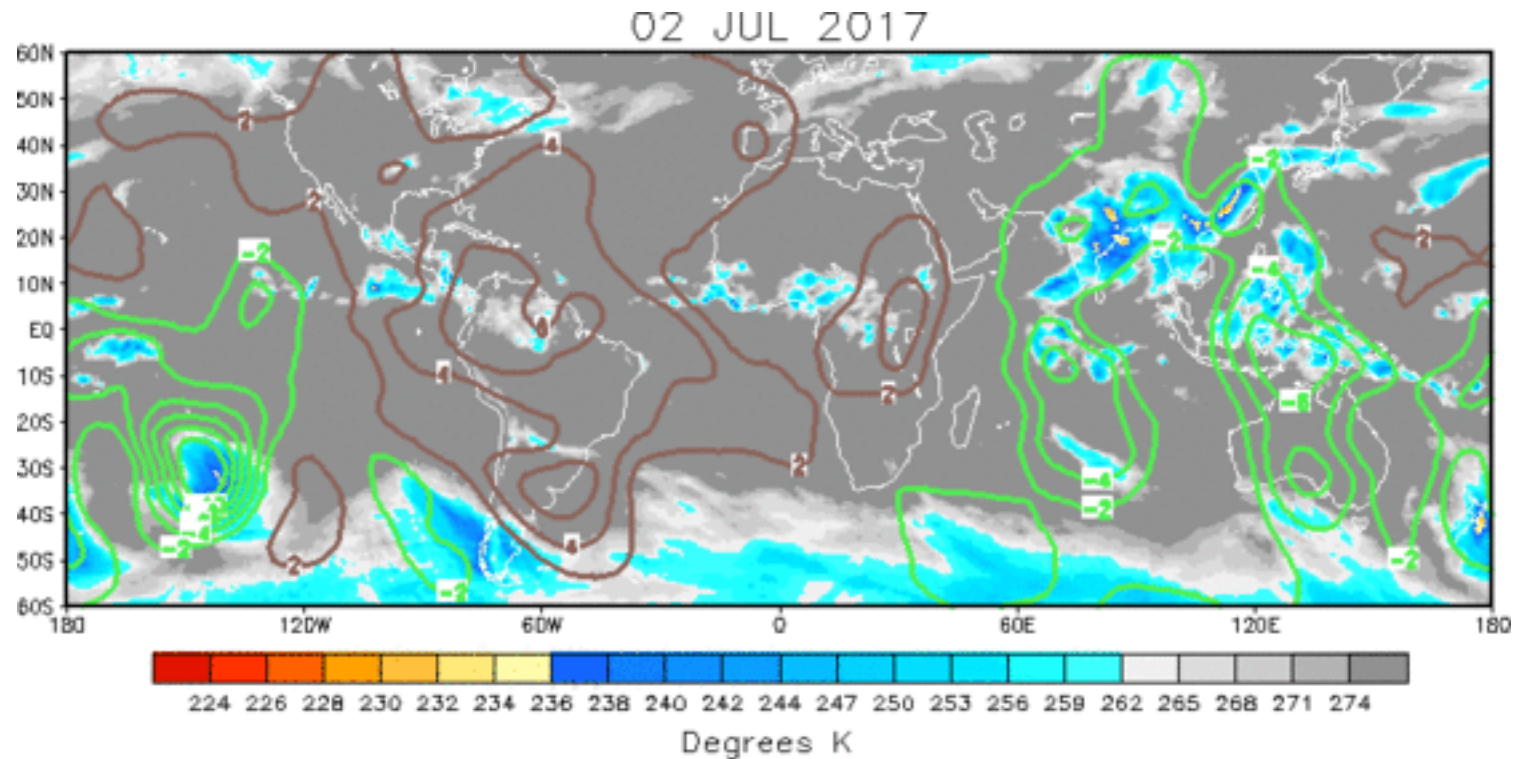
Kelvin wave activity has been apparent from April through early June, as seen in the rapidly propagating eastward signals. Over the past month anomalies have been somewhat stationary with enhanced (suppressed) convection over the Maritime Continent and West Pacific (East Pacific).

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





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



A broadly wave-1 pattern is present, but overall convective anomalies are weak and indicative of an absence of robust MJO activity.

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>)

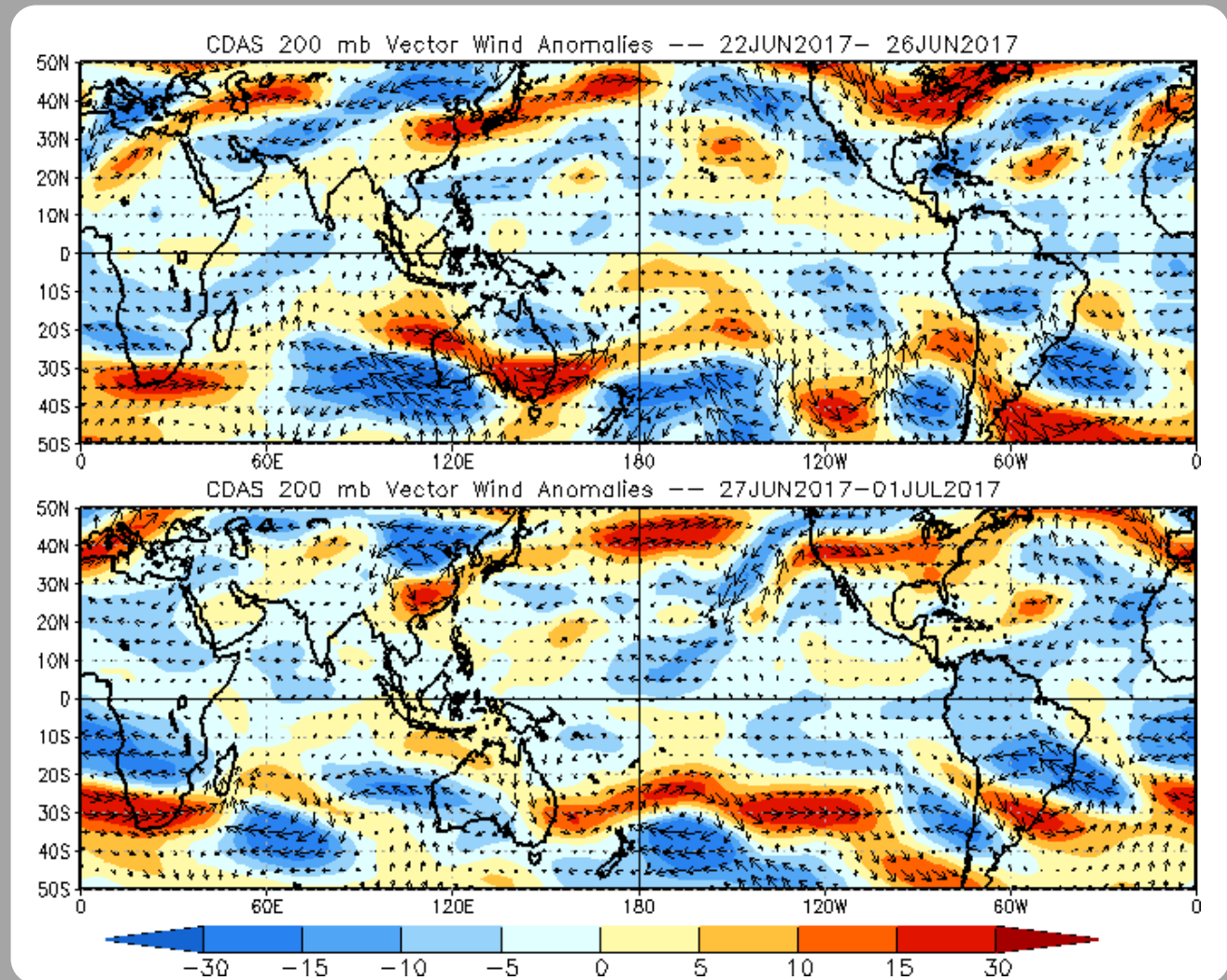
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Upper-level wind anomalies continue to be weak throughout the tropics.

Slight convergence is noted east of the Date Line over the past 5-day period that could impede the eastern edge of the low-frequency enhanced convection recently observed in the West Pacific.



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

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

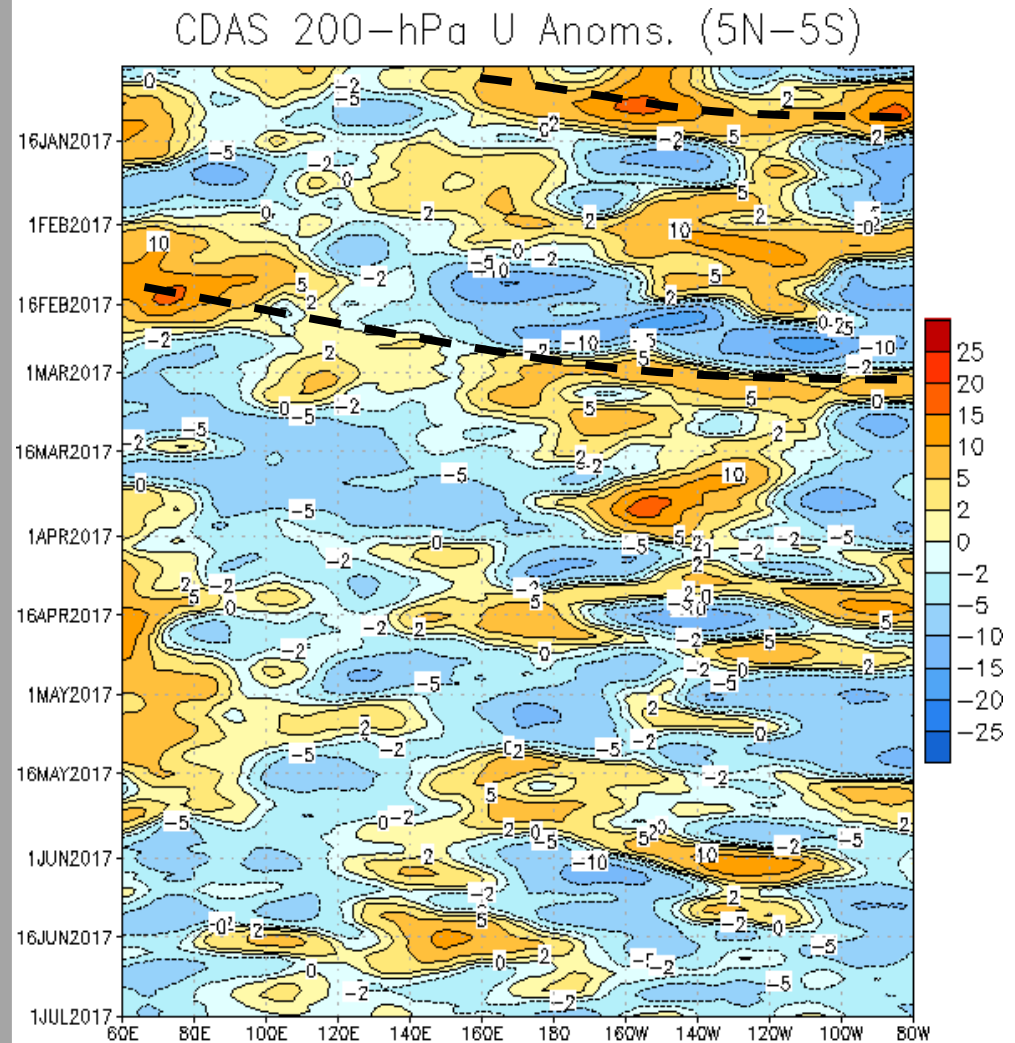
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Near the end of 2016 a period of westerlies disrupted the low frequency state between 80-130E and continued propagating eastward through the Western Hemisphere.

Easterly anomalies returned to the East Pacific during late April.

During early to mid-June, easterly anomalies were most prominent across the global tropics, in part due to mid-latitude influences.

Recently, anomalies along the equator are relatively weak, with a tendency for anomalies to be out of the east.

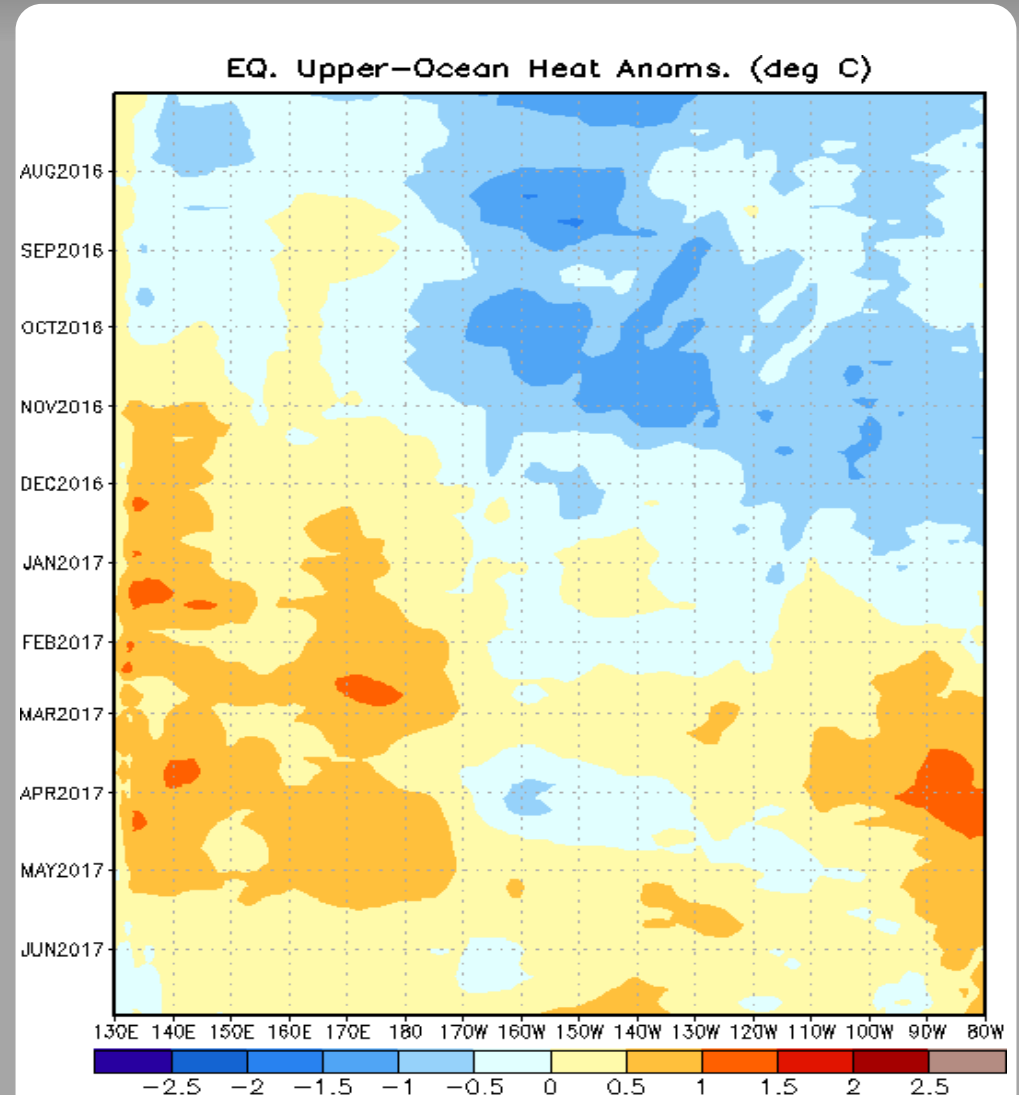


# Weekly Heat Content Evolution in the Equatorial Pacific

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.

An eastward expansion of below average heat content over the western Pacific is evident through June 2016, with negative upper-ocean heat content anomalies persisting through the end of 2016.

During the current year, positive anomalies have developed and generally persist over the entire basin. The anomalies are generally weak, though a small pocket of warmer than normal heat content has developed between 155-140W.



# 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

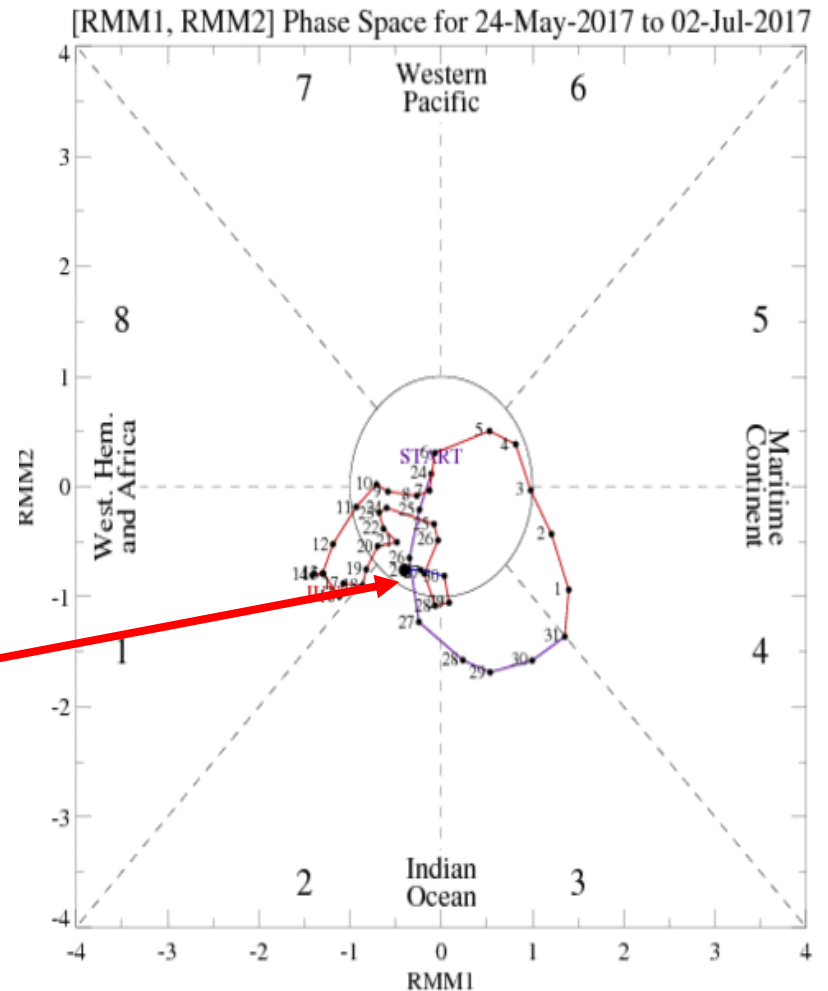
Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.

Distance from the origin is proportional to MJO strength

Line colors distinguish different months

During the past week, the RMM index strengthened and decayed slightly, generally remaining within the unit circle.

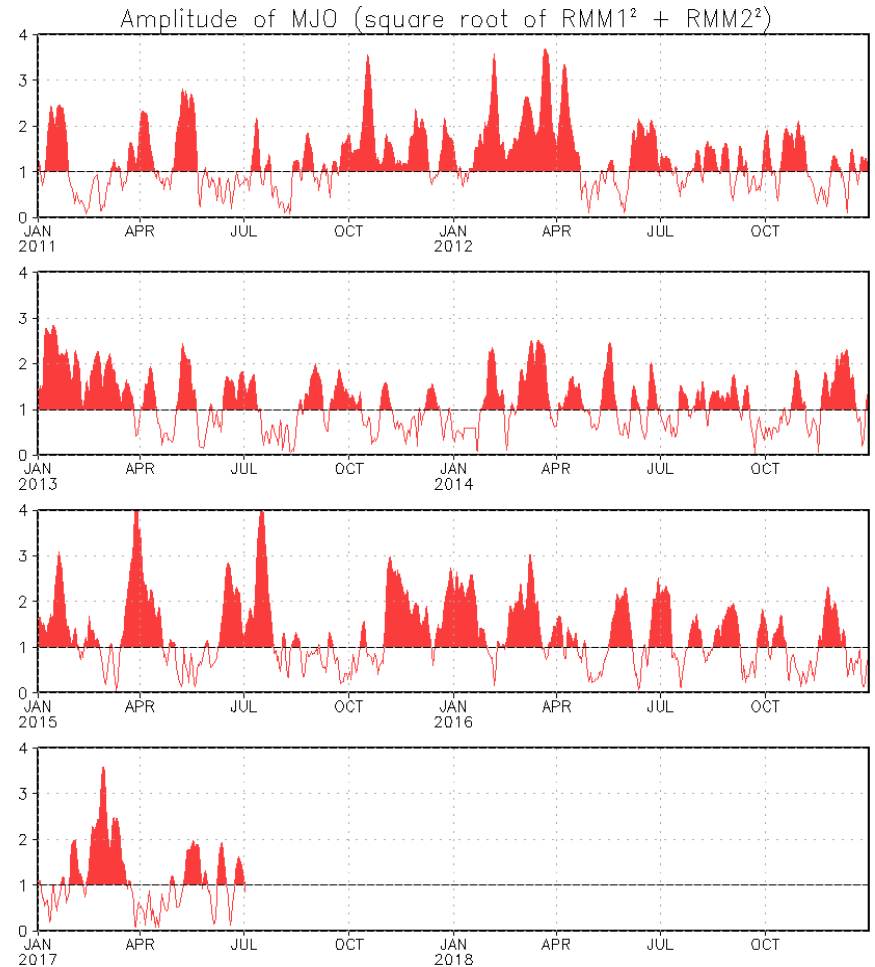
The emergence outside the unit circle appears to be tied to removal of an evolving long-term mean from this analysis, rather than intraseasonal activity at present.



# 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.



# GFS Ensemble (GEFS) MJO Forecast

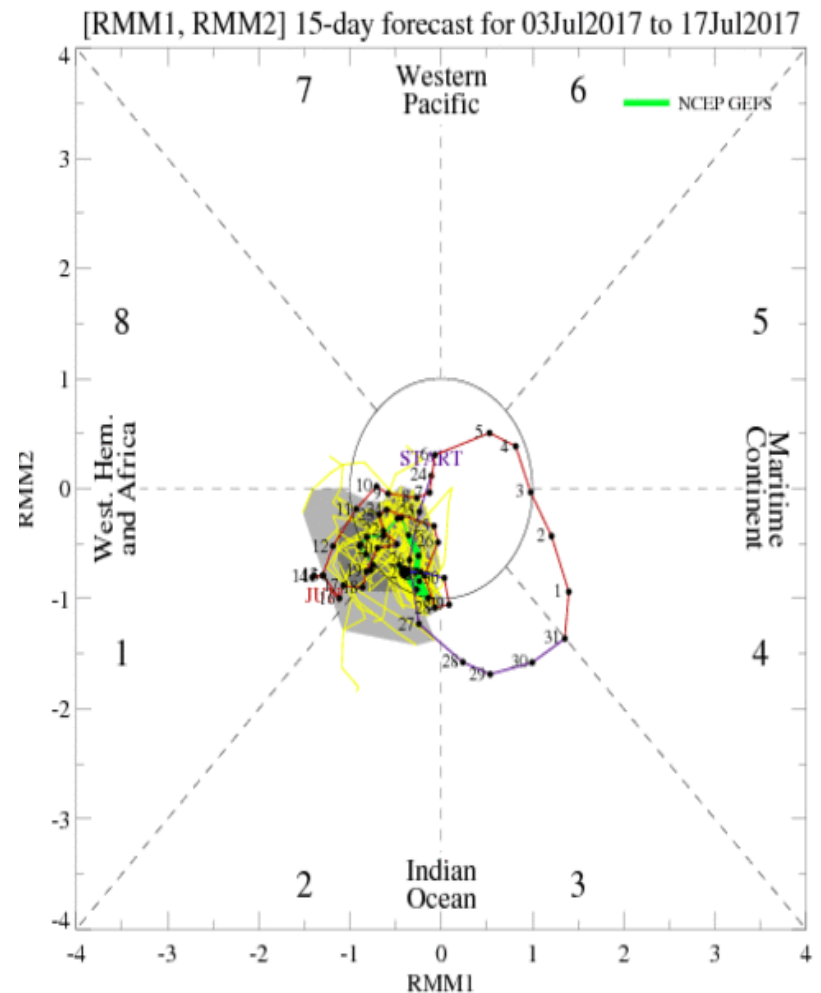
RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GEFS forecast predicts no coherent MJO signal during the next 2 weeks, despite a tendency for a signal to be shifted towards Africa or the western Indian Ocean.

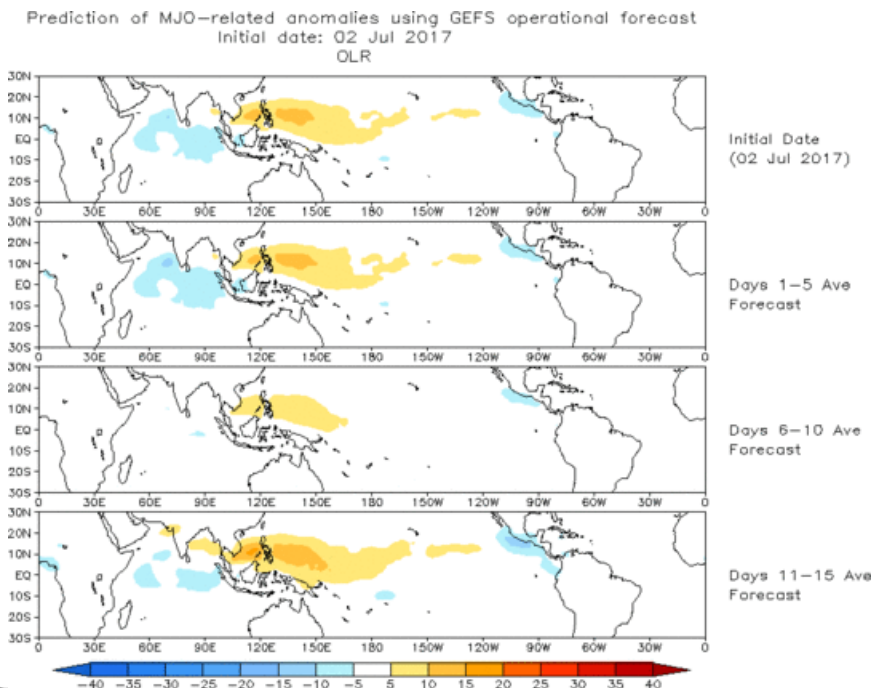
Yellow Lines - 20 Individual Members  
Green Line - Ensemble Mean





# Ensemble GFS (GEFS) MJO Forecast

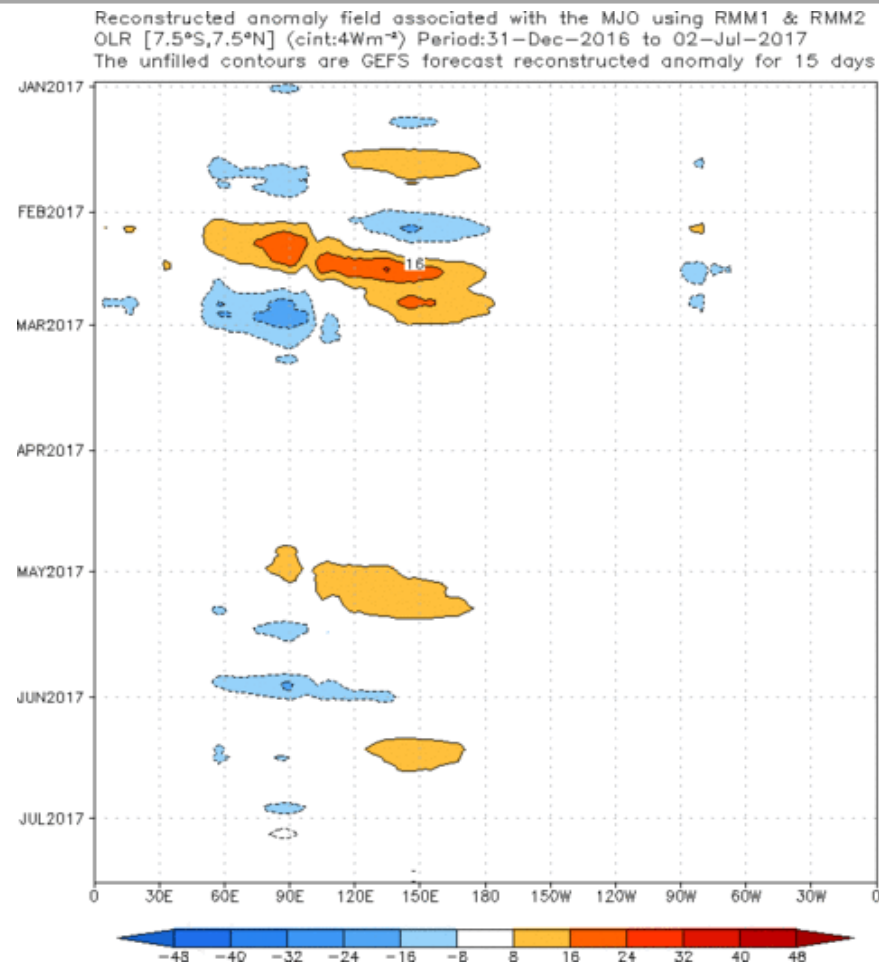
Spatial map of OLR anomalies for the next 15 days



The GEFS RMM-based OLR anomaly forecasts a quasi-stationary enhanced (suppressed) convective signal over the Indian Ocean (West Pacific) throughout the next two weeks that initially decays and subsequently reintensifies.

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.)

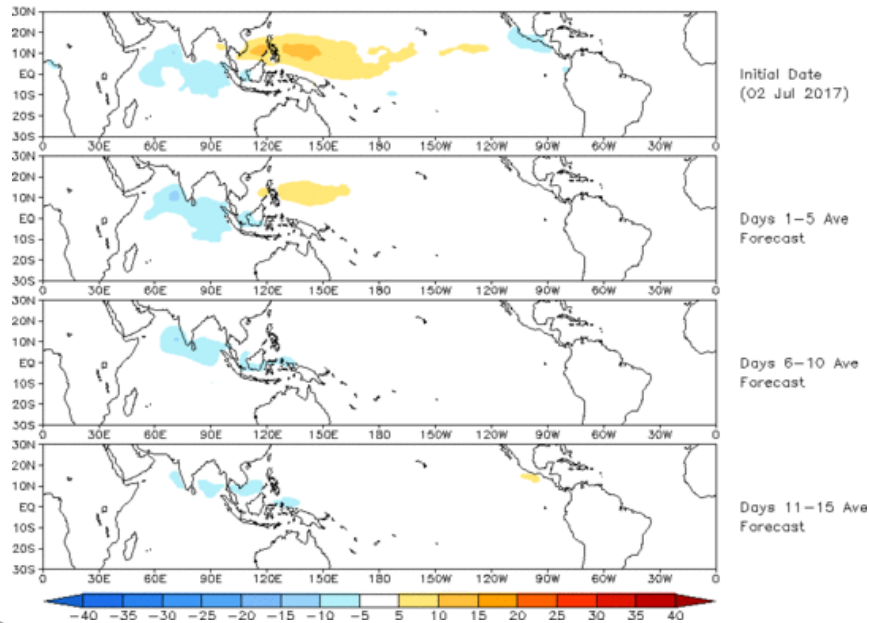
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



# 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 (02 Jul 2017)

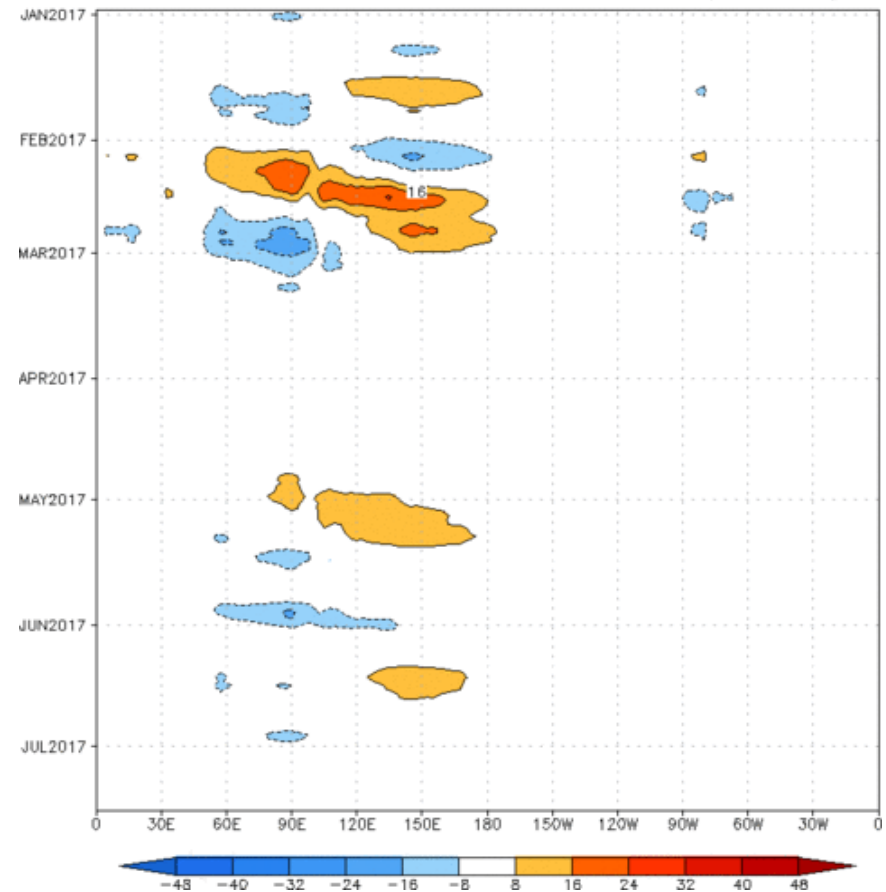


The constructed analog RMM-based OLR anomaly prediction indicates little to no propagation of a weak signal, with convection remaining over the Indian Ocean and weakening.

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.)

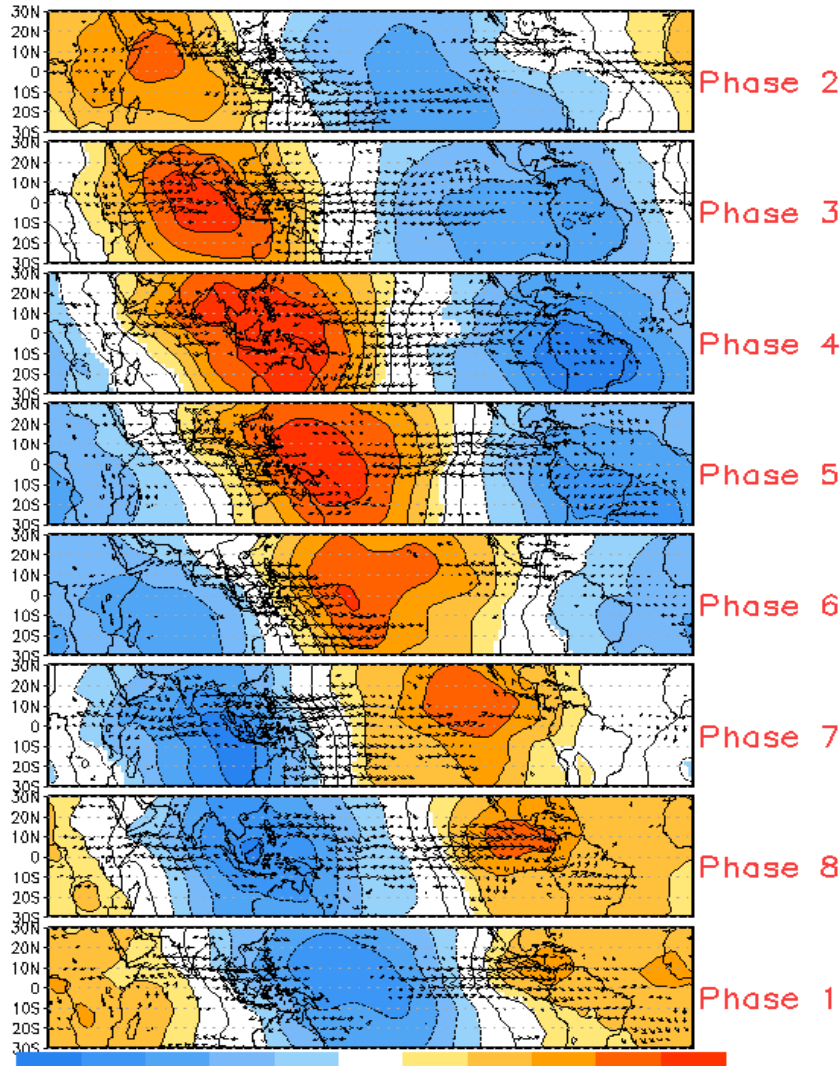
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [7.5°S,7.5°N] (cont:4Wm<sup>-2</sup>) Period:31-Dec-2016 to 02-Jul-2017 The unfilled contours are CA forecast reconstructed anomaly for 15 days

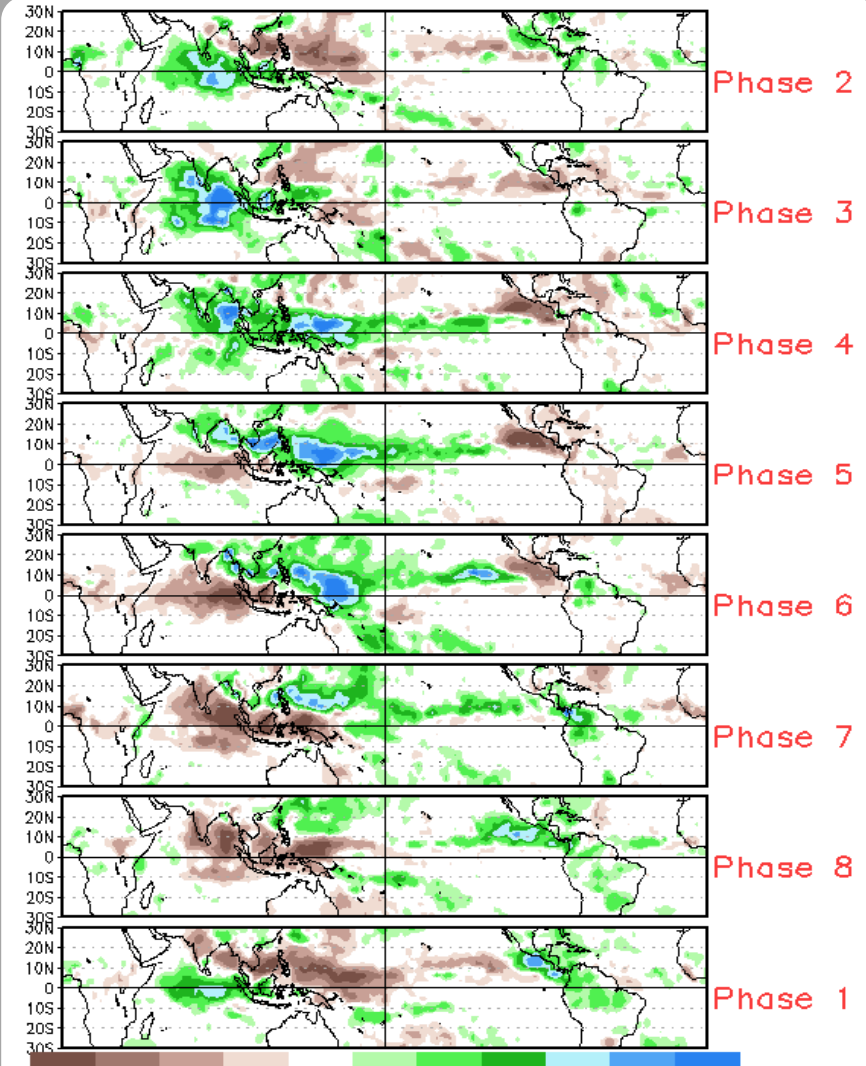


# MJO Composites - Global Tropics

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



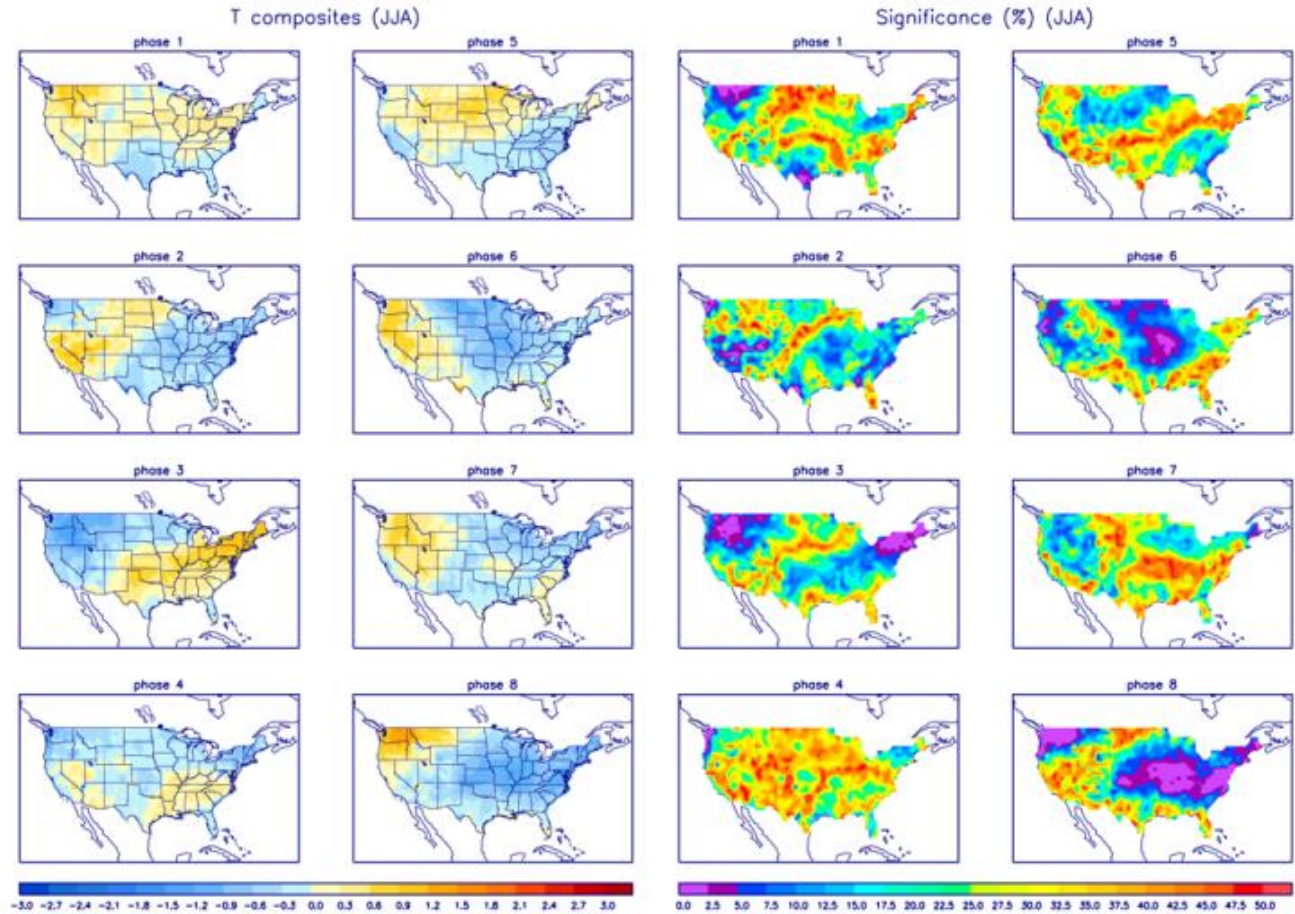
Precipitation Anomalies (May - Sep)



# 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.



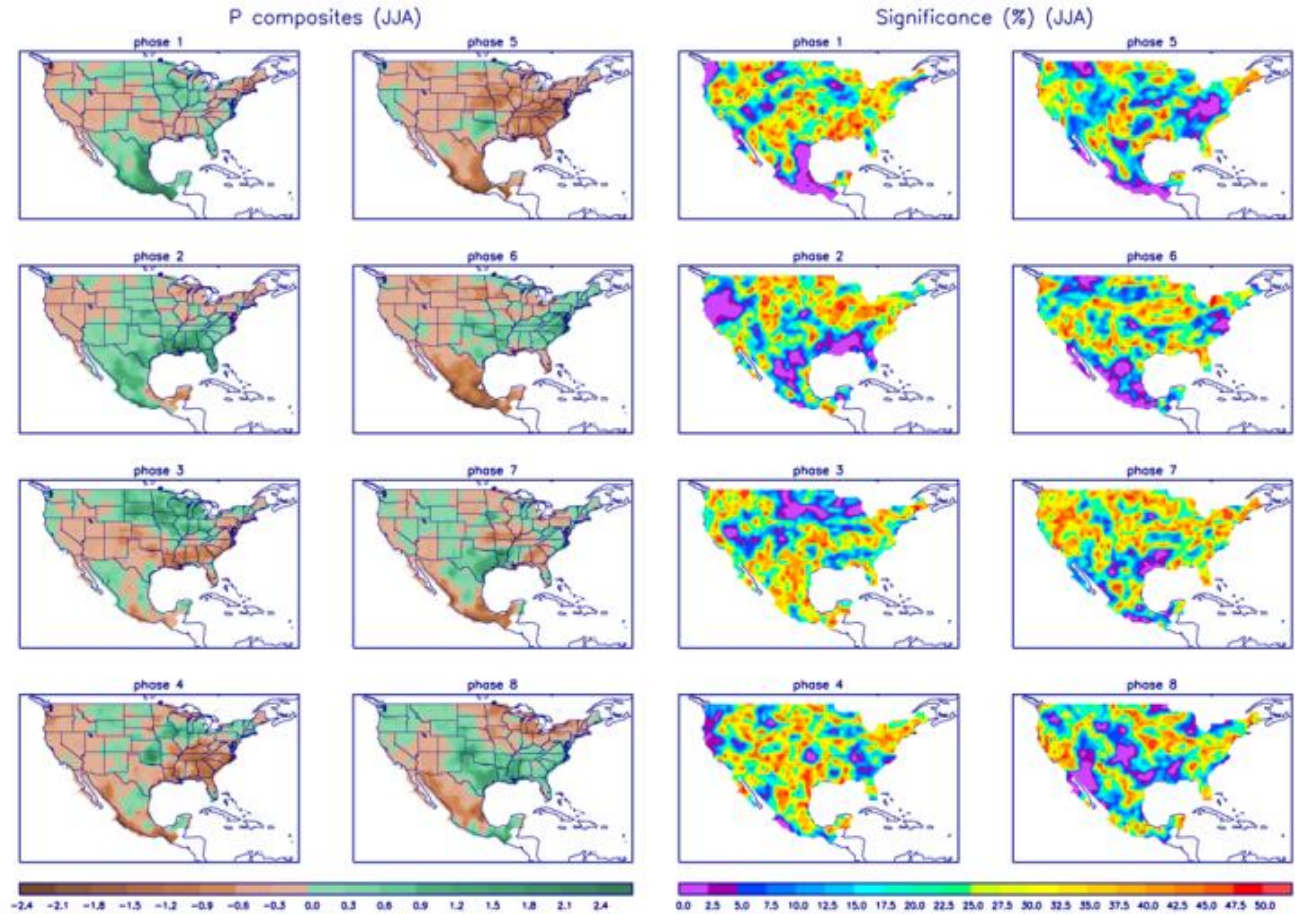
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>