

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



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# Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

# Overview

- The MJO remains weak, but some signs of organization are apparent with enhanced convection centered over the eastern Indian Ocean.
- The large difference between the ECMWF ensemble system and the other dynamical guidance continues this week. The ECMWF continues to depict a more canonical MJO evolution while the GEFS shows no organized MJO activity over the next two weeks.
- The MJO is expected to remain fairly weak, though a weak signal could propagate eastward toward the West Pacific over the next two weeks, with some influence on the large-scale convective pattern.

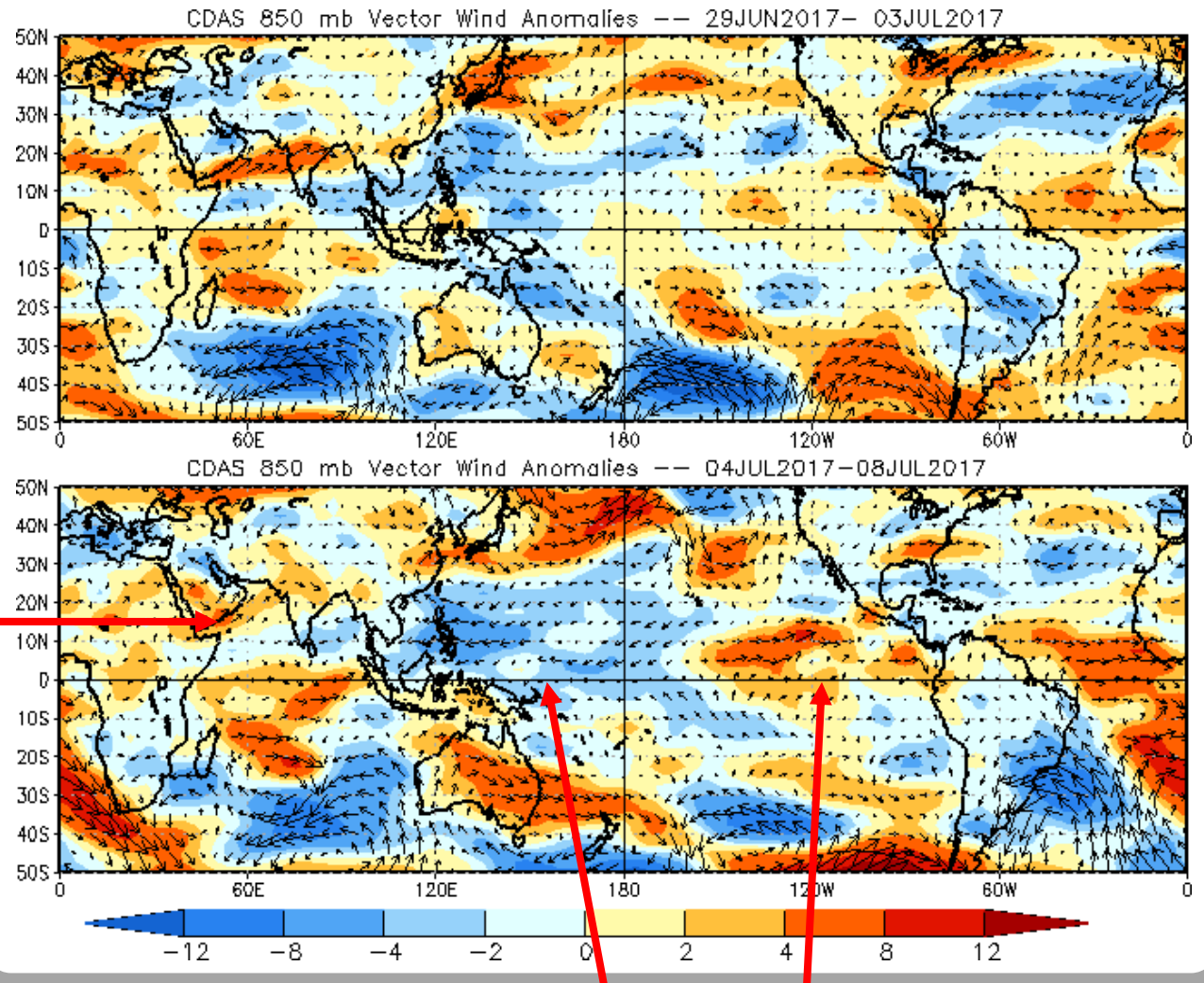
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:  
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php>

# 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 persisted across the Arabian Sea and India in association with the advancing southwest monsoon.

General easterly (westerly) anomalies persisted over the western (eastern) Pacific, with low-level divergence centered east of the antimeridian.

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

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

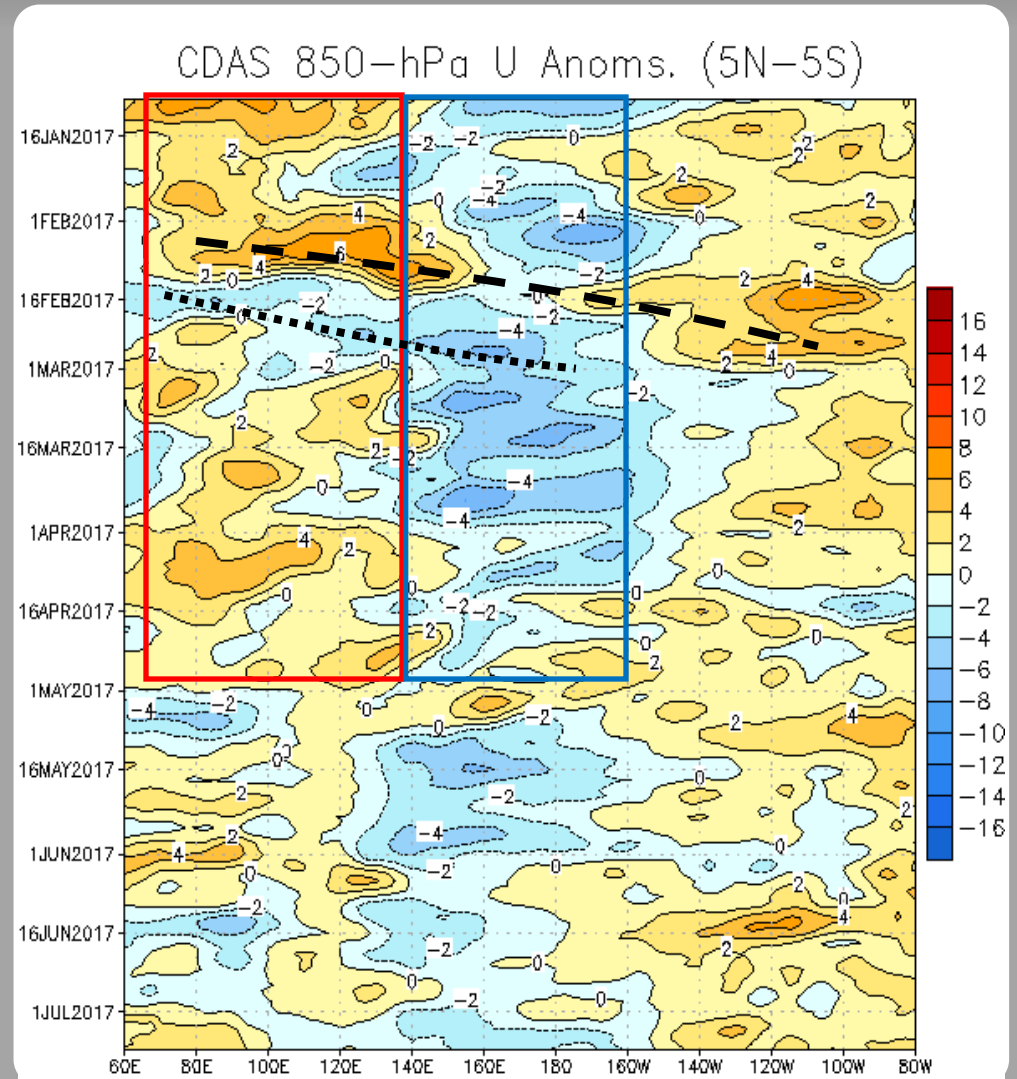
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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. Recently, however, a Wave-1 pattern has emerged.



# OLR Anomalies - Past 30 days

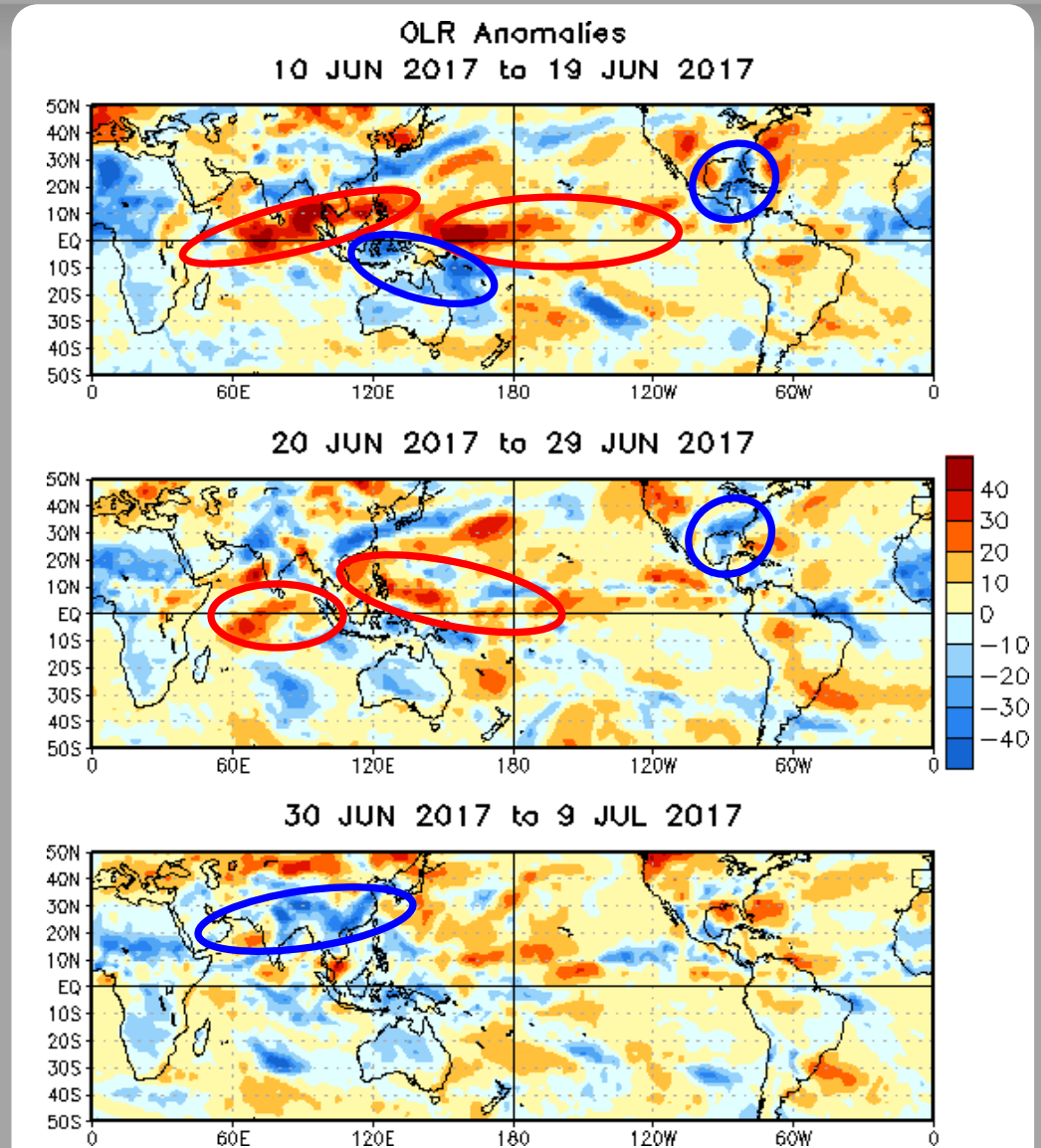
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid-June, enhanced convection was apparent over the eastern Maritime Continent and Southwest Pacific, with suppressed conditions observed over the Indian Ocean and central Pacific.

Convective signals were fairly weak in late June, with suppressed convection persisting over parts of the Indian Ocean and West-Central Pacific. The track of Tropical Storm Cindy is evident over the Gulf of Mexico and the southeastern U.S. A surge in southwesterly flow over the Arabian Sea helped advance the monsoon faster than climatology into southern Pakistan.

In early July convective signals were generally weak over the global tropics, with some enhanced convection noted over Southeast Asia.



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

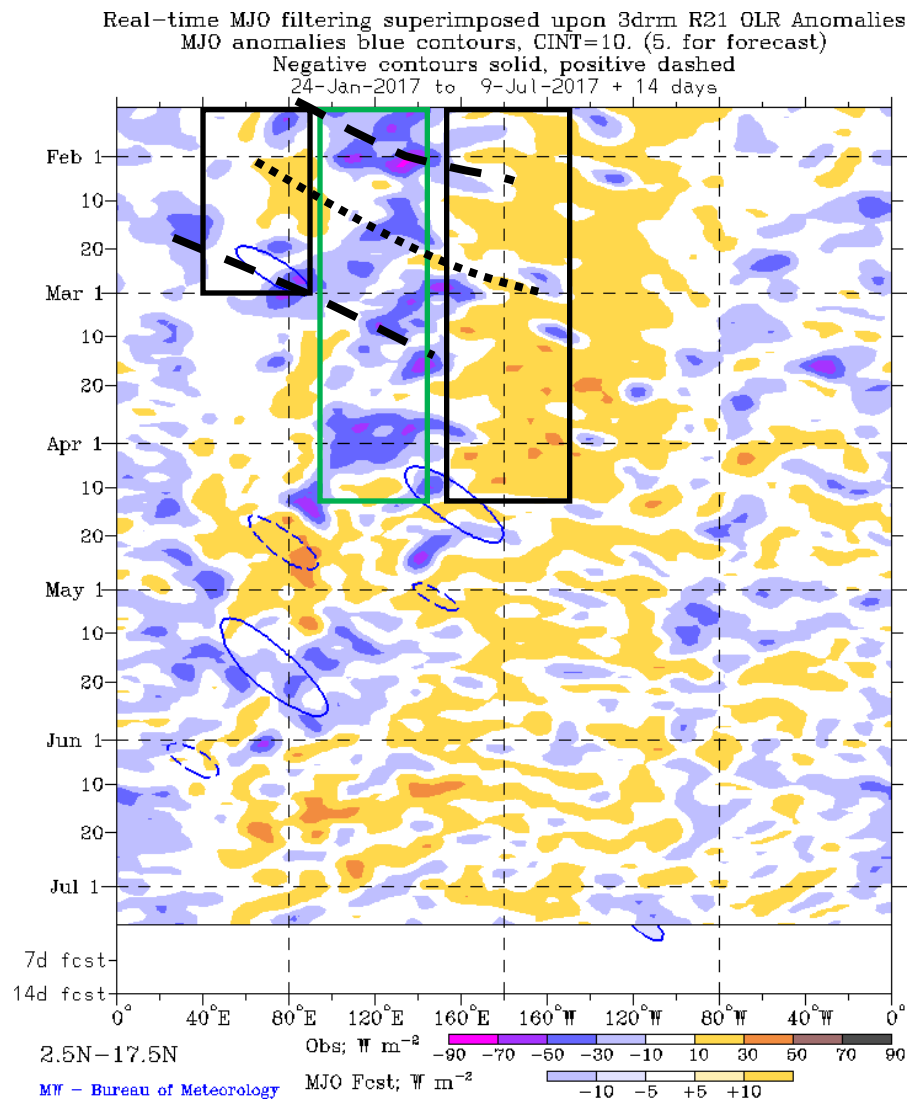
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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 some convection developing over the Indian Ocean associated with a westward-moving feature.



# 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

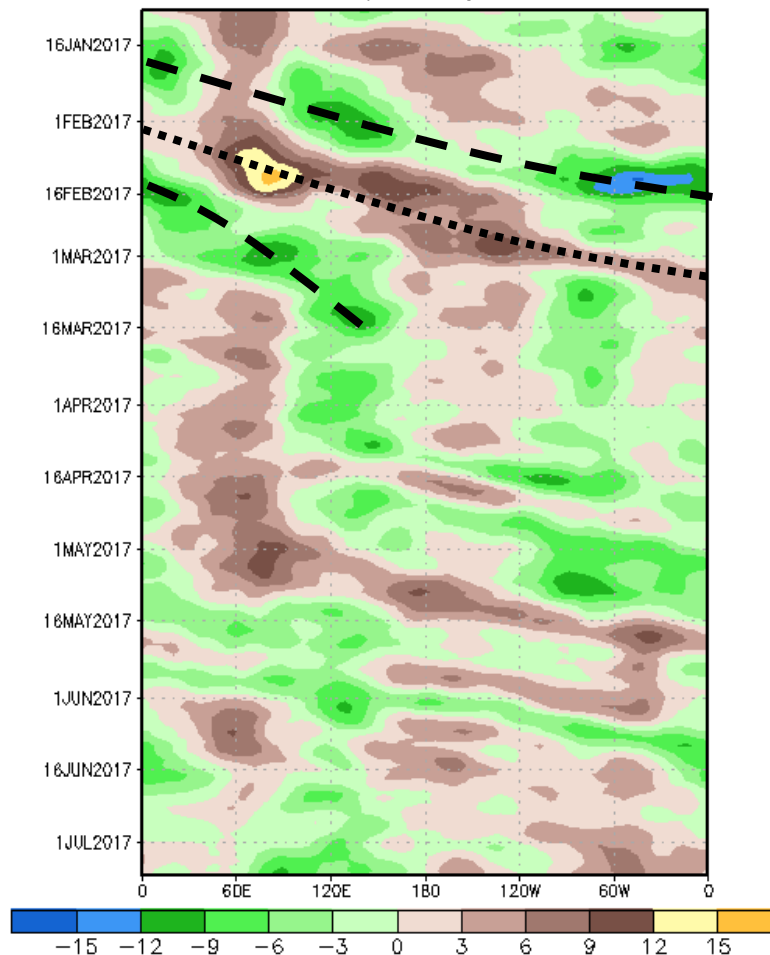
The pattern during December and January was more related to seasonal variability.

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 (East Pacific).

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





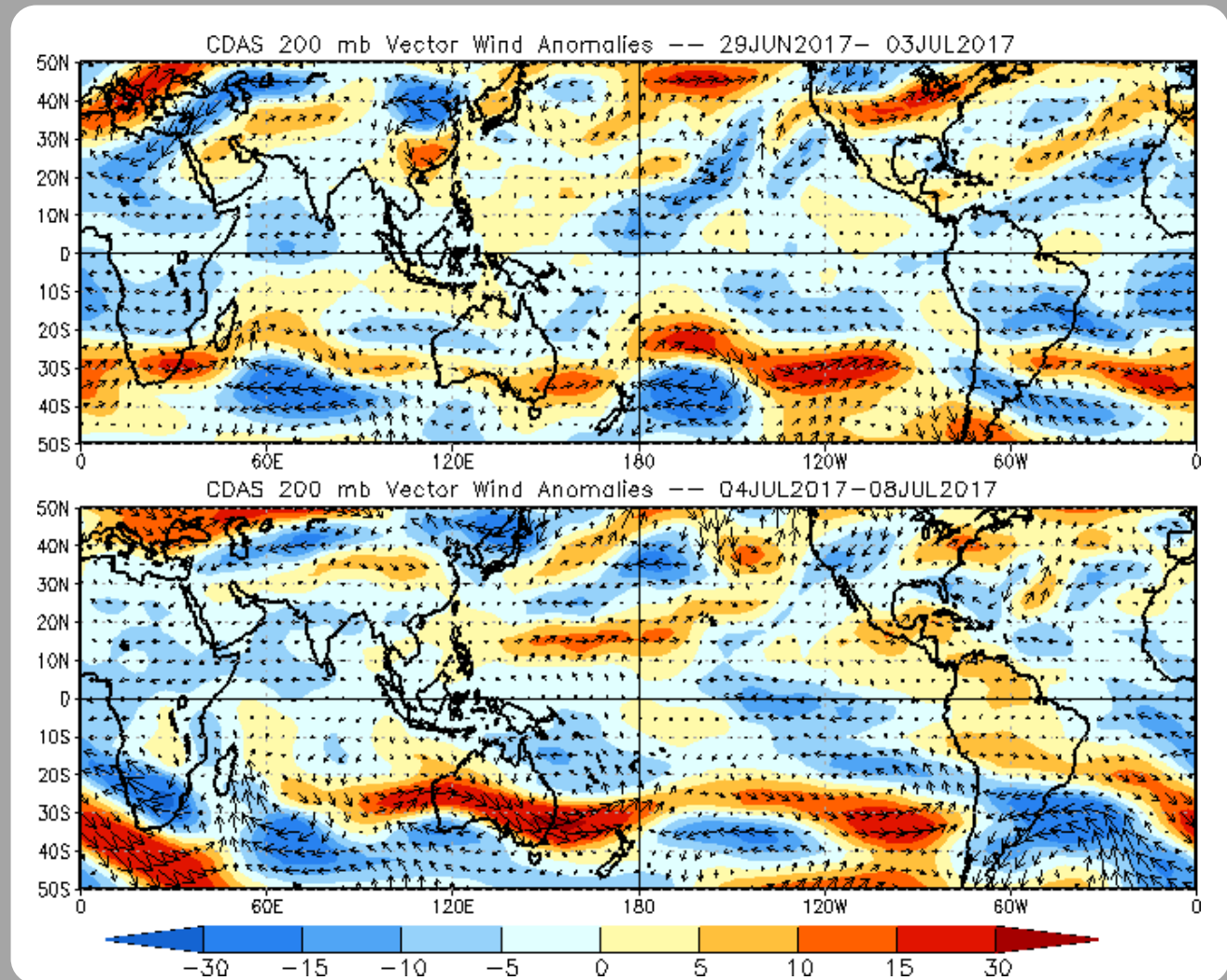
# 200-hPa Vector Wind Anomalies (m s<sup>-1</sup>)

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.



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

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

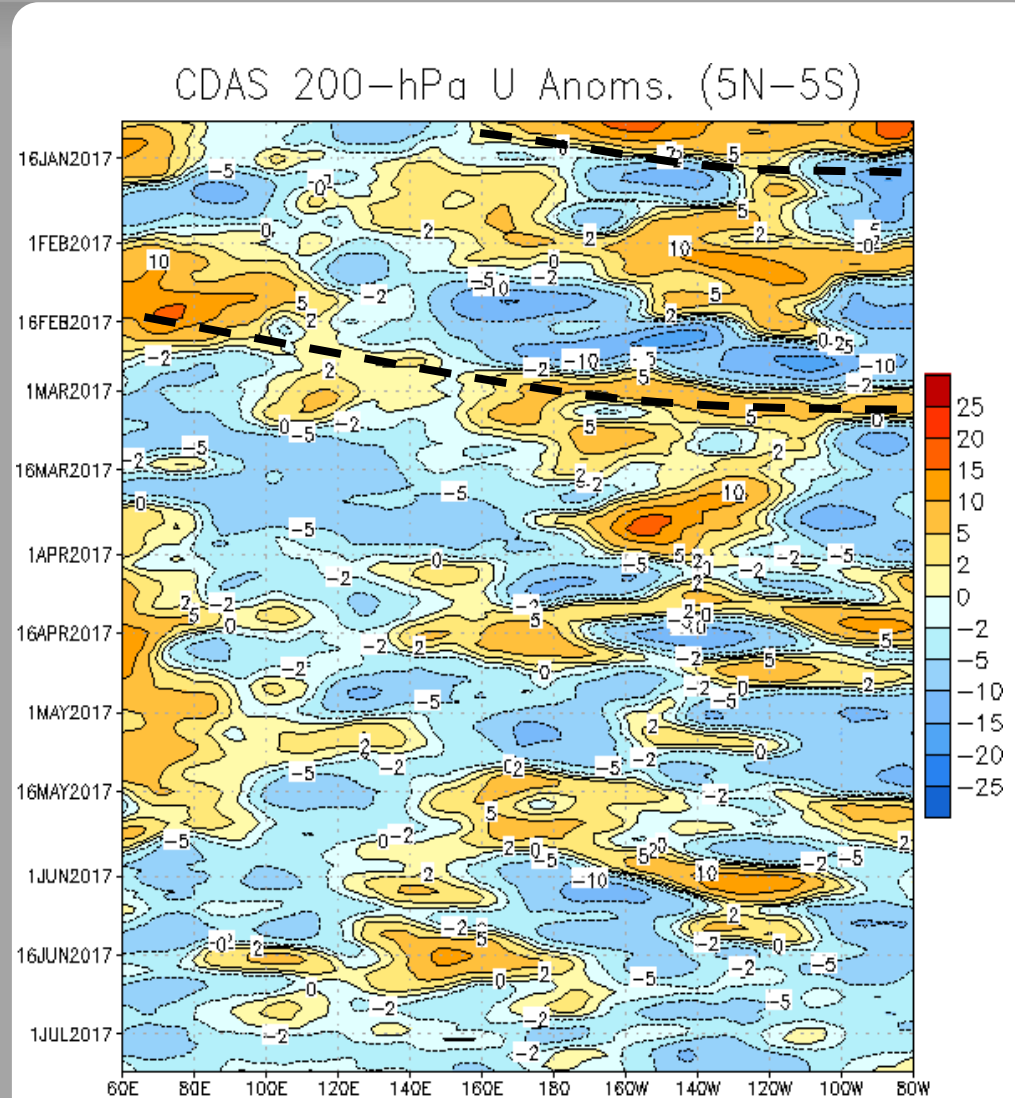
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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 easterly anomalies.





# 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

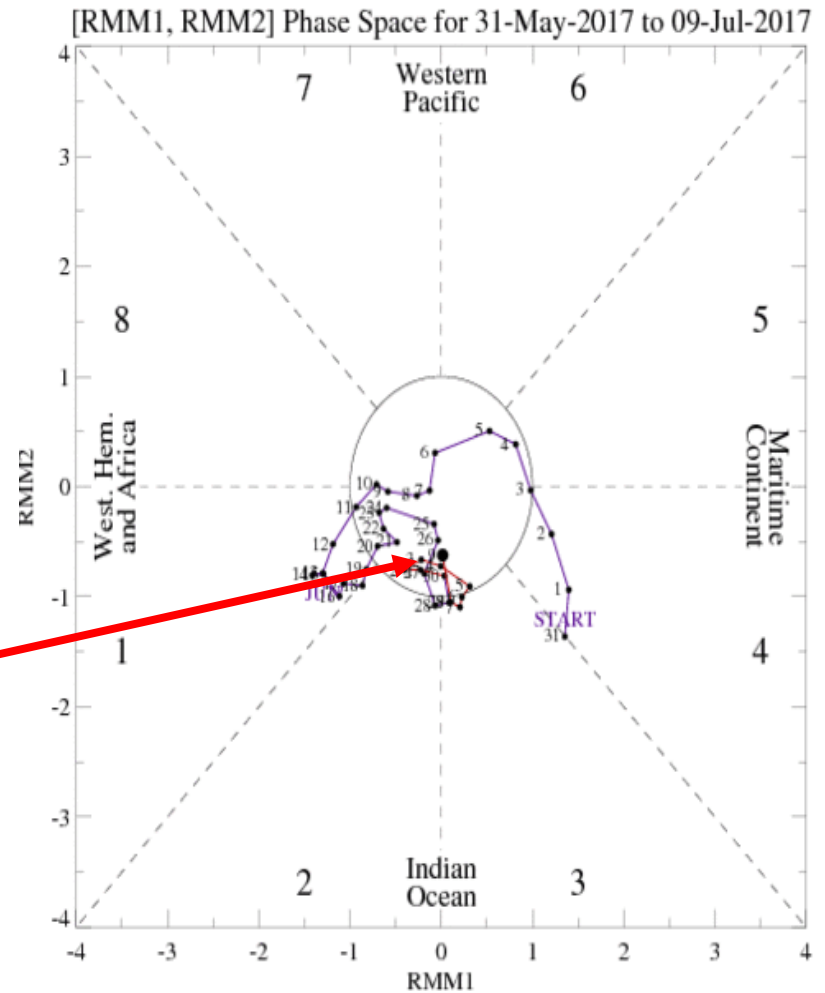
The triangular areas indicate the location of the enhanced phase of the MJO

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

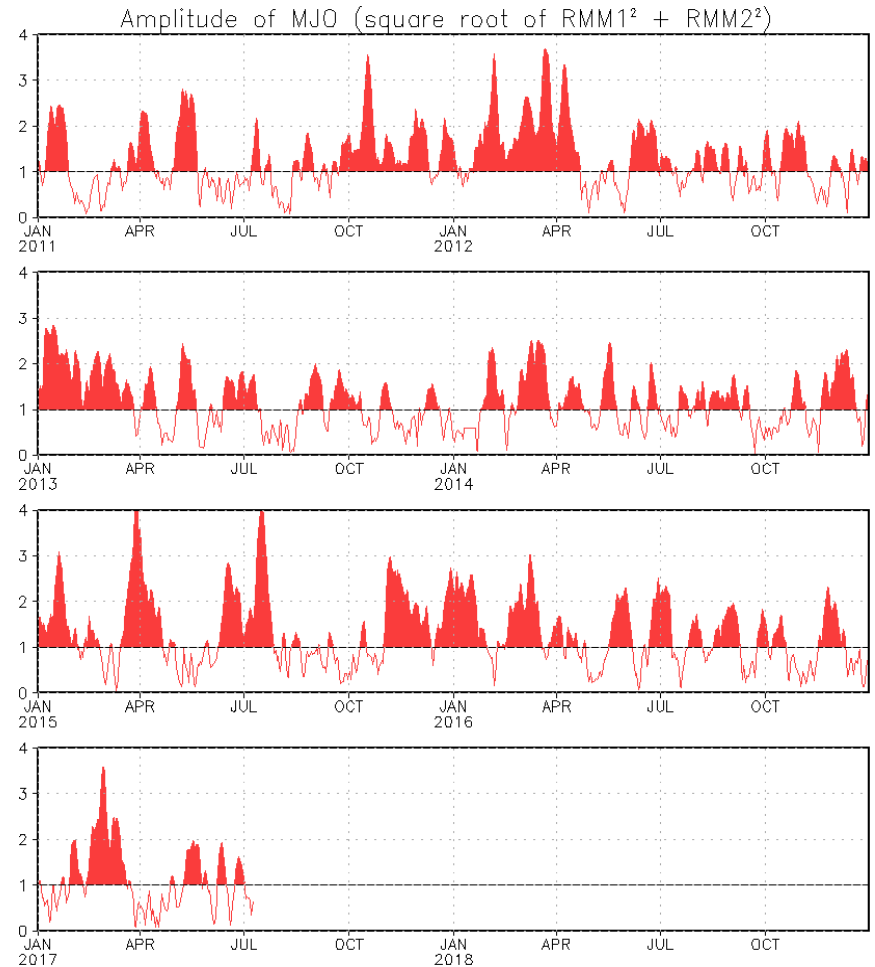
During the past week, the RMM index generally remained within the unit circle.



# 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.



# GFS Ensemble (GEFS) MJO Forecast

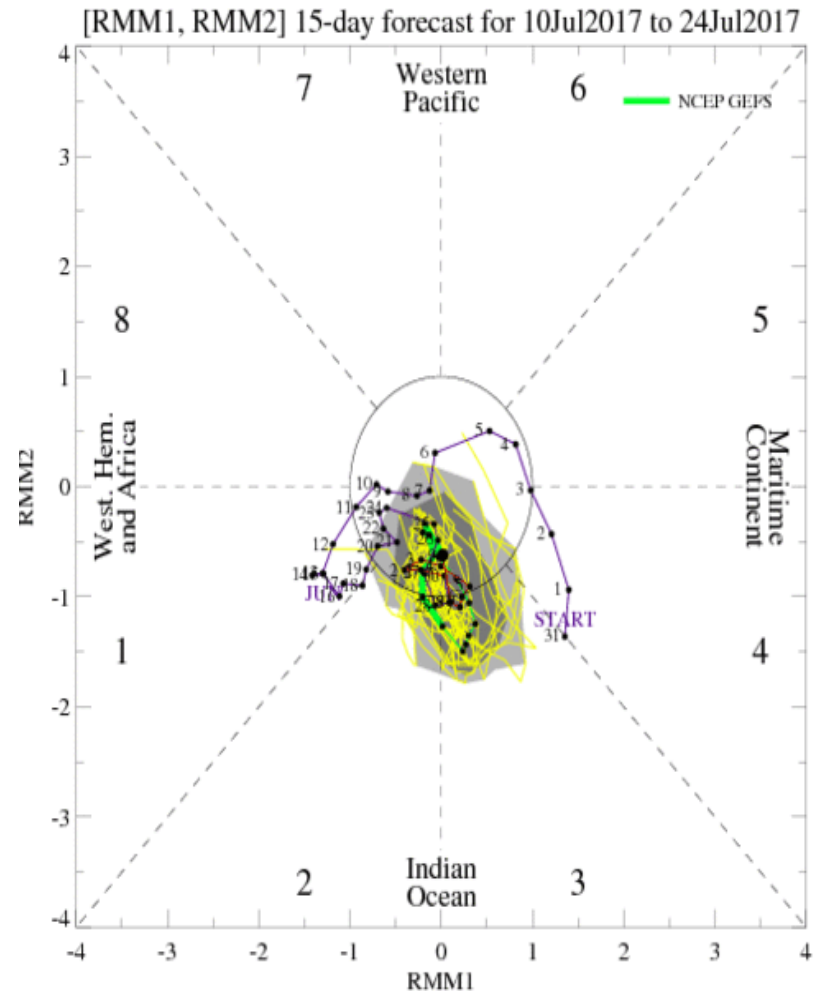
RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GEFS forecast predicts no coherent MJO signal during the next two weeks, despite a tendency for a signal to be shifted towards the Indian Ocean. The ECMWF forecast (not shown), however, depicts the development and propagation of a coherent MJO signal.

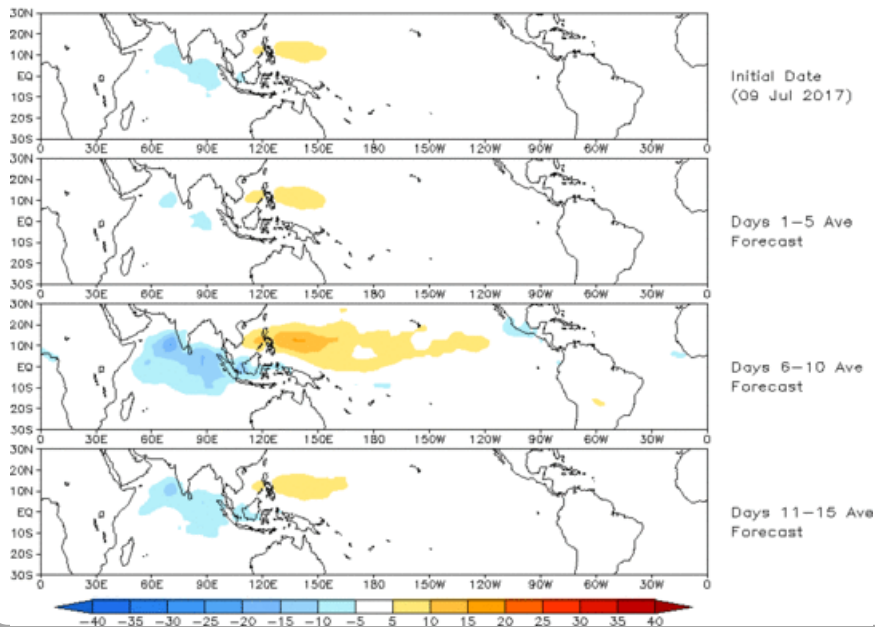
Yellow Lines - 20 Individual Members  
Green Line - Ensemble Mean



# 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: 09 Jul 2017  
OLR

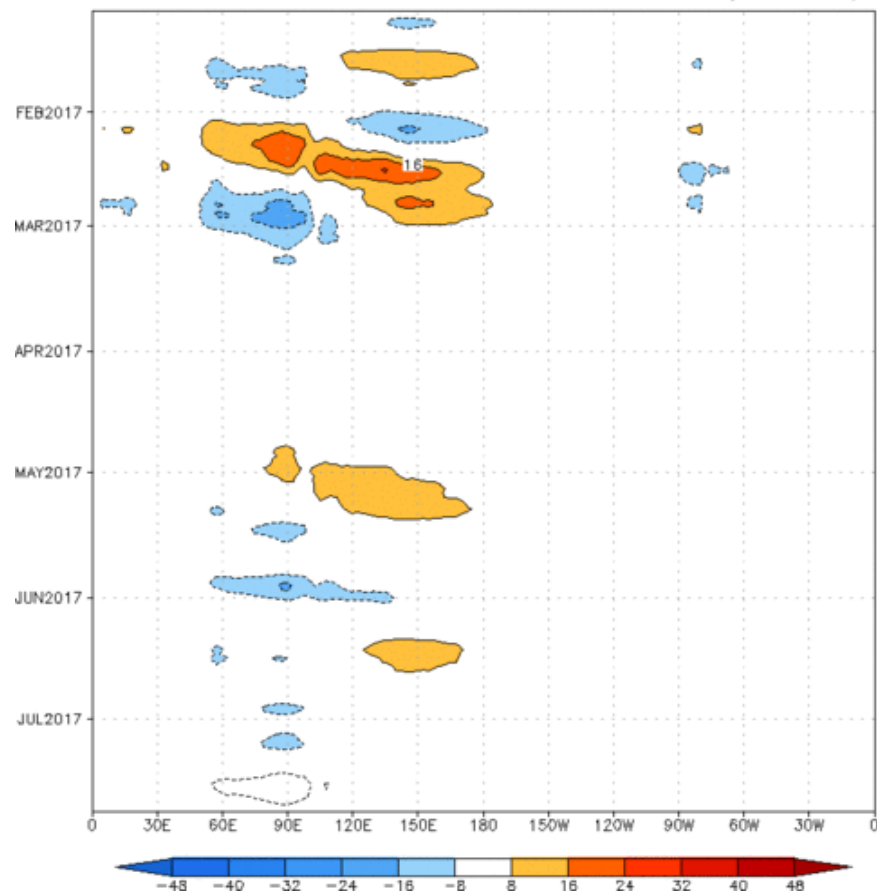


The GEFS RMM-based OLR anomaly forecasts a quasi-stationary enhanced (suppressed) convective signal over the Indian Ocean (West Pacific) throughout the next two weeks.

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:07-Jan-2017 to 09-Jul-2017  
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days

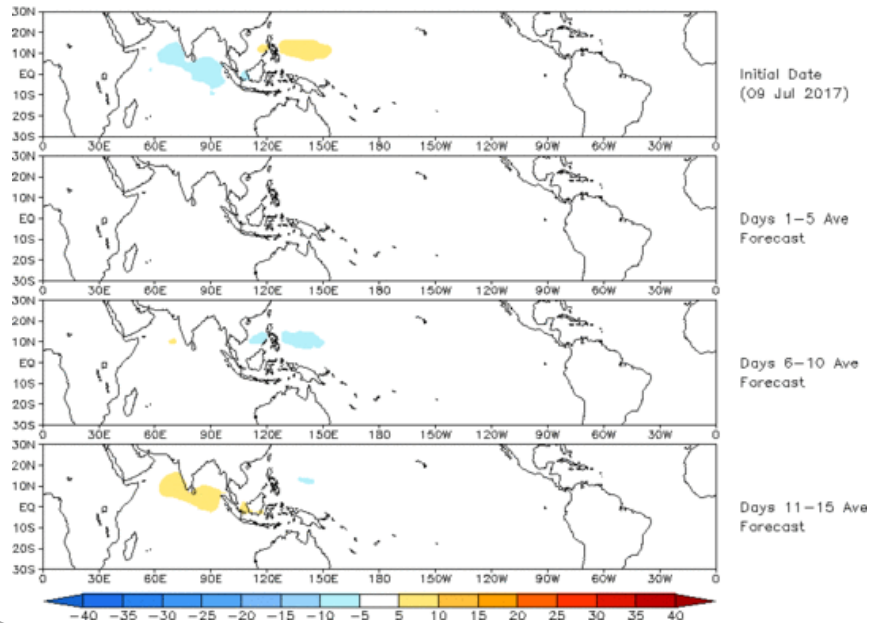




# Constructed Analog (CA) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

OLR prediction of MJO-related anomalies using CA model reconstruction by RMM1 & RMM2 (09 Jul 2017)

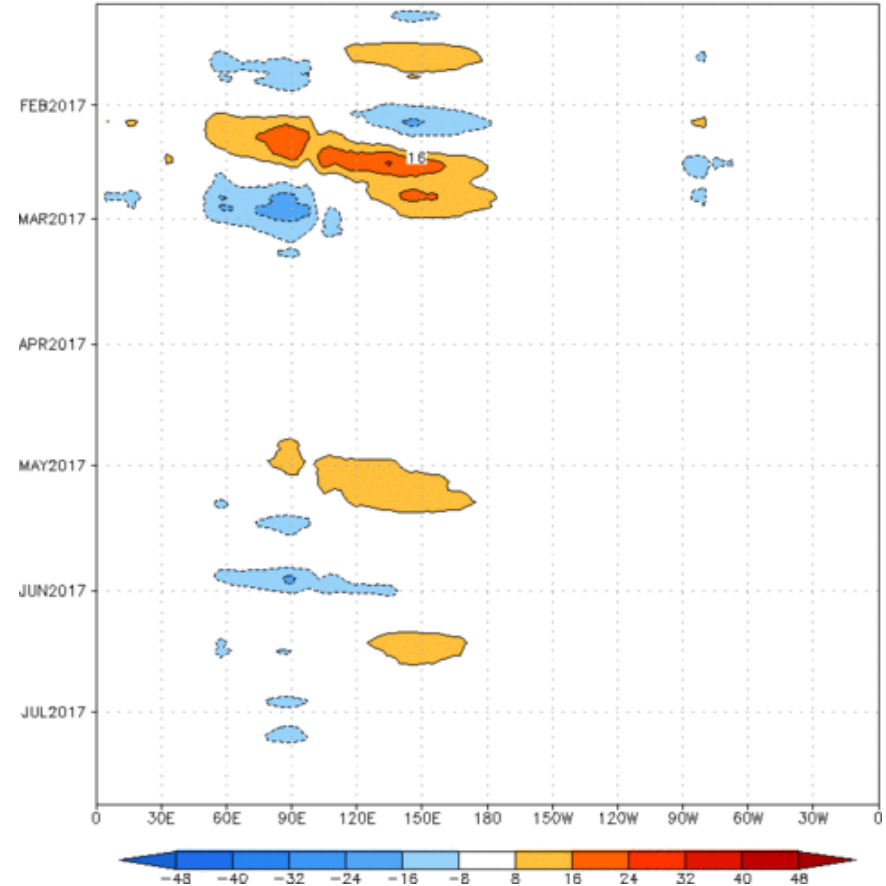


The constructed analog RMM-based OLR anomaly prediction indicates little to no propagation of a weak signal.

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.)

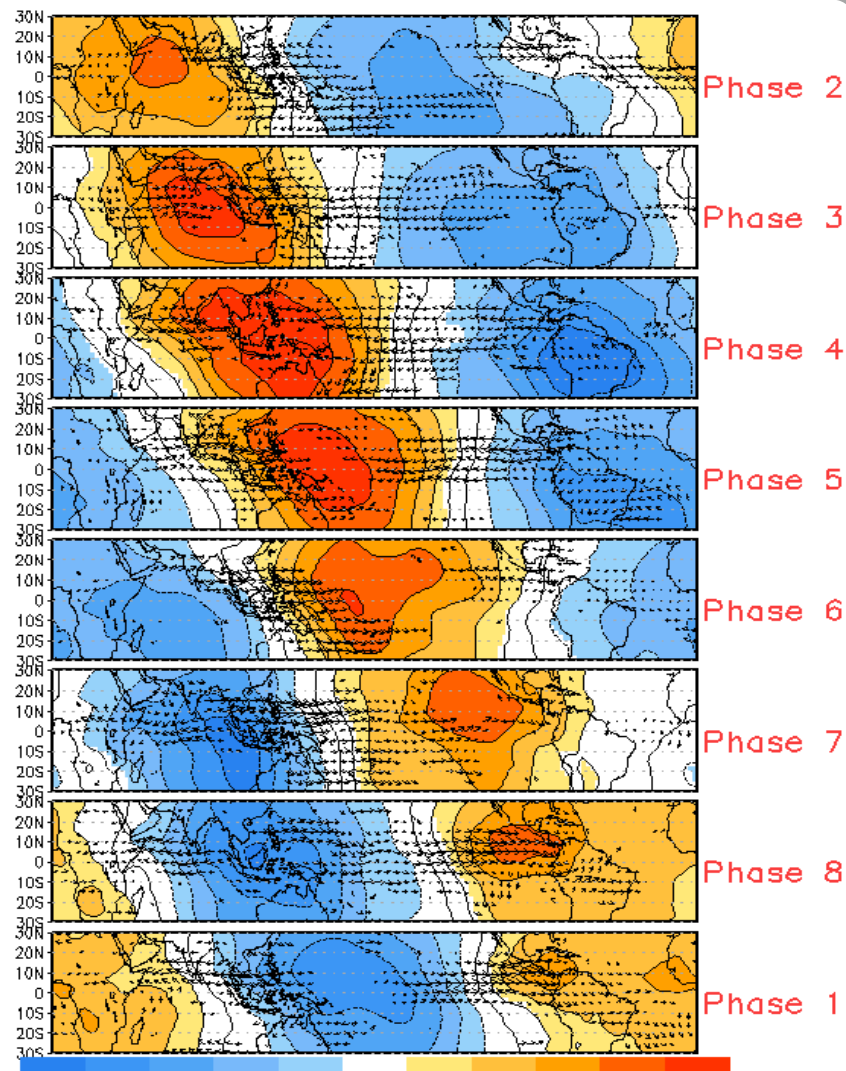
Time-longitude section of ( $7.5^{\circ}$  S- $7.5^{\circ}$  N) OLR anomalies - last 180 days and for the next 15 days

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [ $7.5^{\circ}$ S, $7.5^{\circ}$ N] (cont:4 $Wm^{-2}$ ) Period:07-Jan-2017 to 09-Jul-2017  
The unfilled contours are CA forecast reconstructed anomaly for 15 days

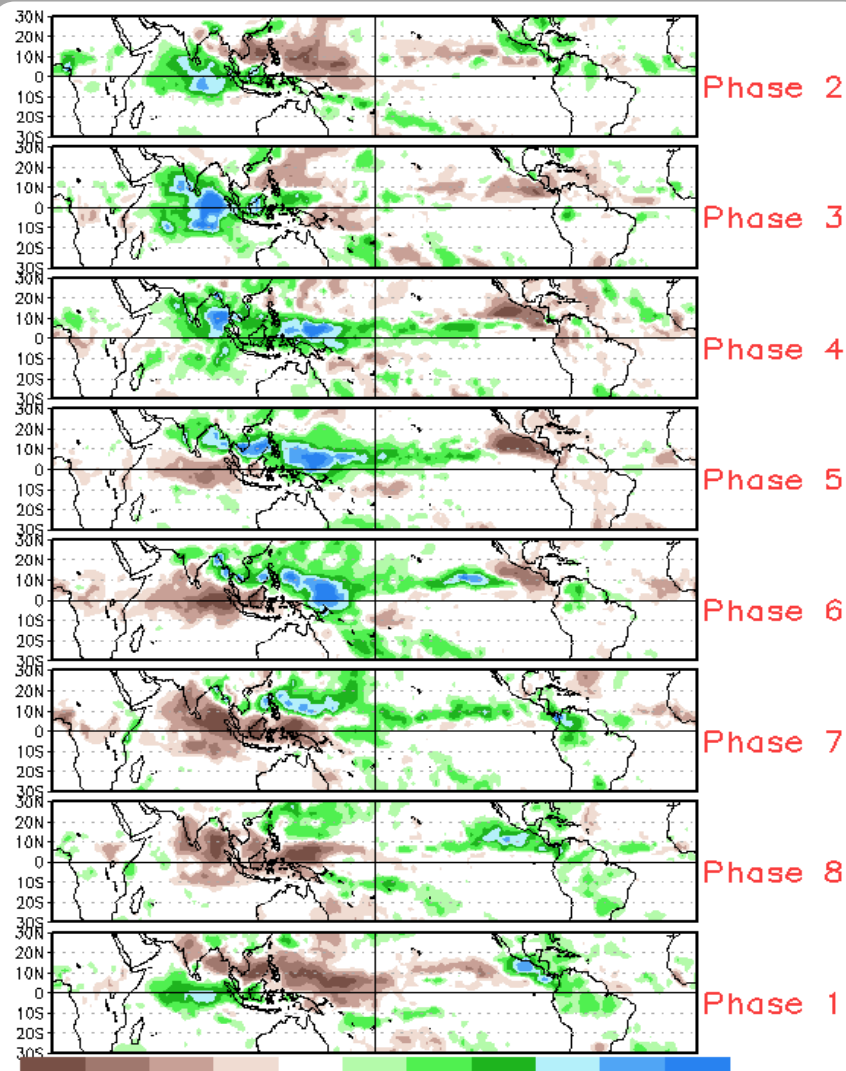


# MJO Composites - Global Tropics

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



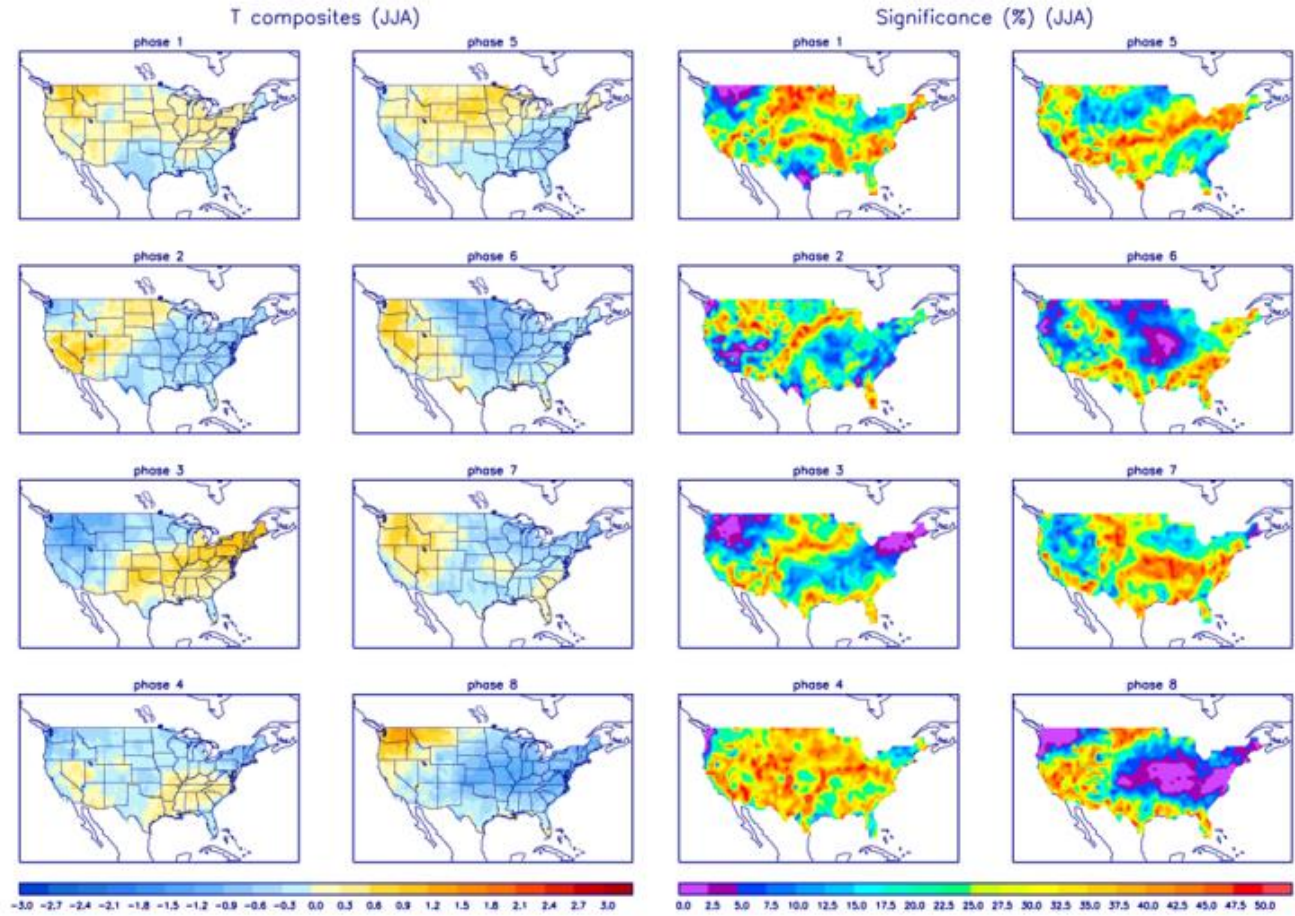
Precipitation Anomalies (May - Sep)



# 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.



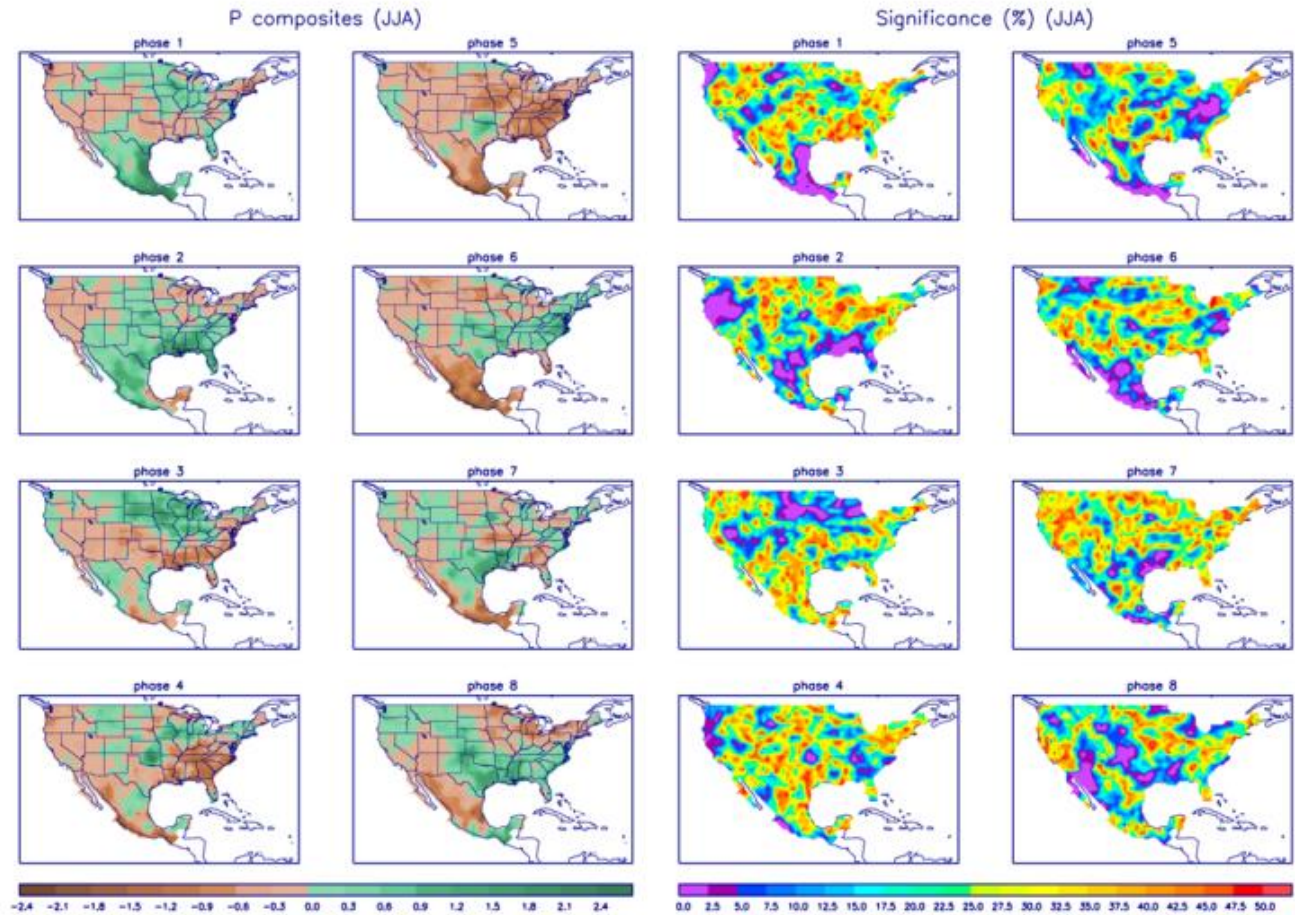
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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

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