

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



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12 June 2017

# Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

# Overview

- Over the past week the RMM index suggested a weakness of the MJO, while the CPC velocity potential-based index tracked a signal across the Western Hemisphere tied to a Kelvin wave.
- Dynamical guidance, with the exception of the European ensemble that maintains a weak MJO, supports an emerging intraseasonal signal over Africa during Week-1 which enters the Indian Ocean by Week-2.
- Kelvin and Rossby wave activity are likely to drive the outlook over the coming two weeks, with the dynamical model forecasts suggesting emergence of the MJO being discounted due to signals apparently being tied to the ongoing Kelvin wave rather than an emerging MJO envelope.

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>

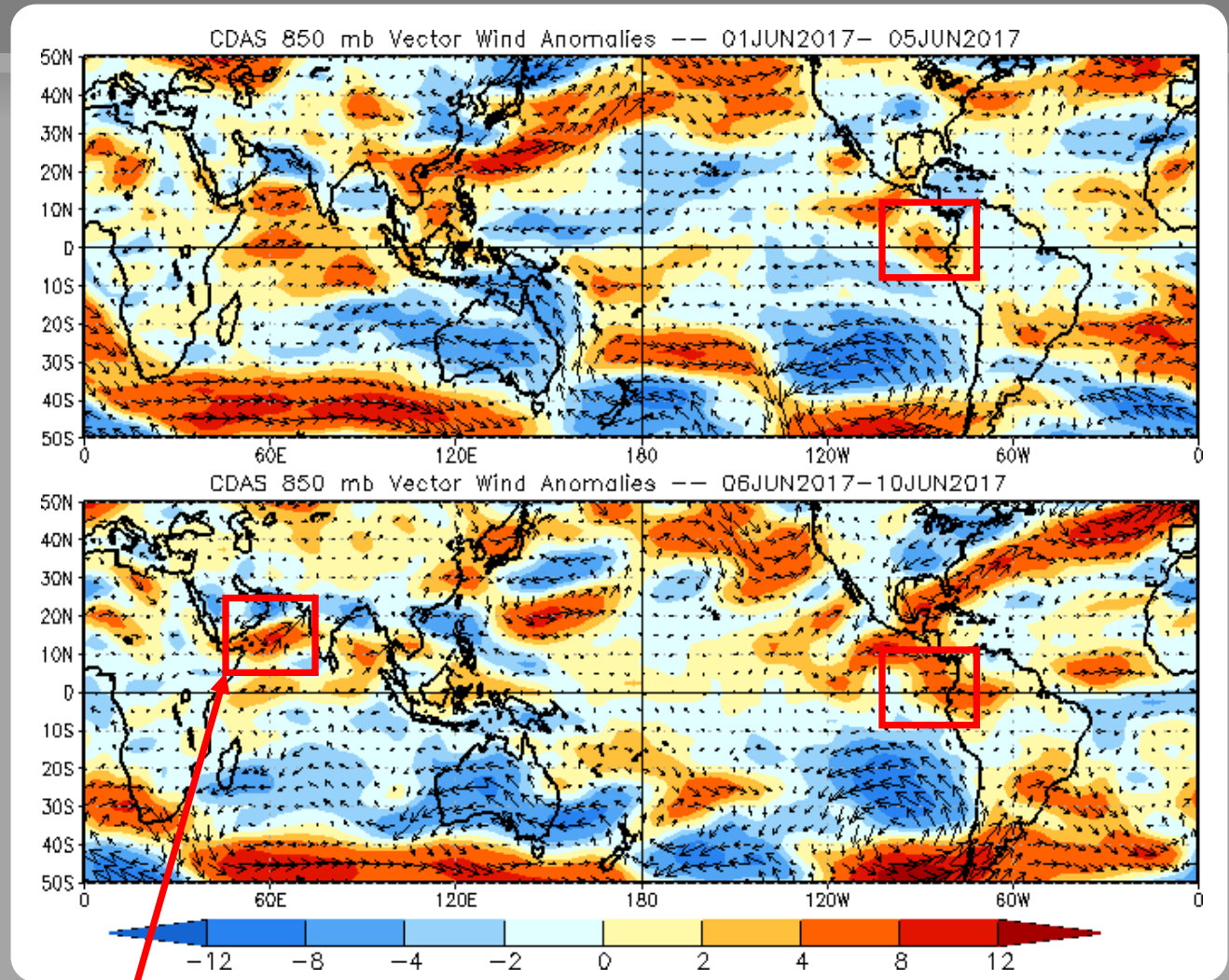
# 850-hPa Vector Wind Anomalies (m s<sup>-1</sup>)

Note that shading denotes the zonal wind anomaly

**Blue shades:** Easterly anomalies

**Red shades:** Westerly anomalies

Equatorial Pacific anomalies have been weak the prior 10 days, with highest values associated with westerlies in the East Pacific.



Westerlies continue to lift northward in the Arabian sea associated with the advancing southwest monsoon. Overall the monsoon has generally been slightly slower progressing this year relative to normal.

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

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

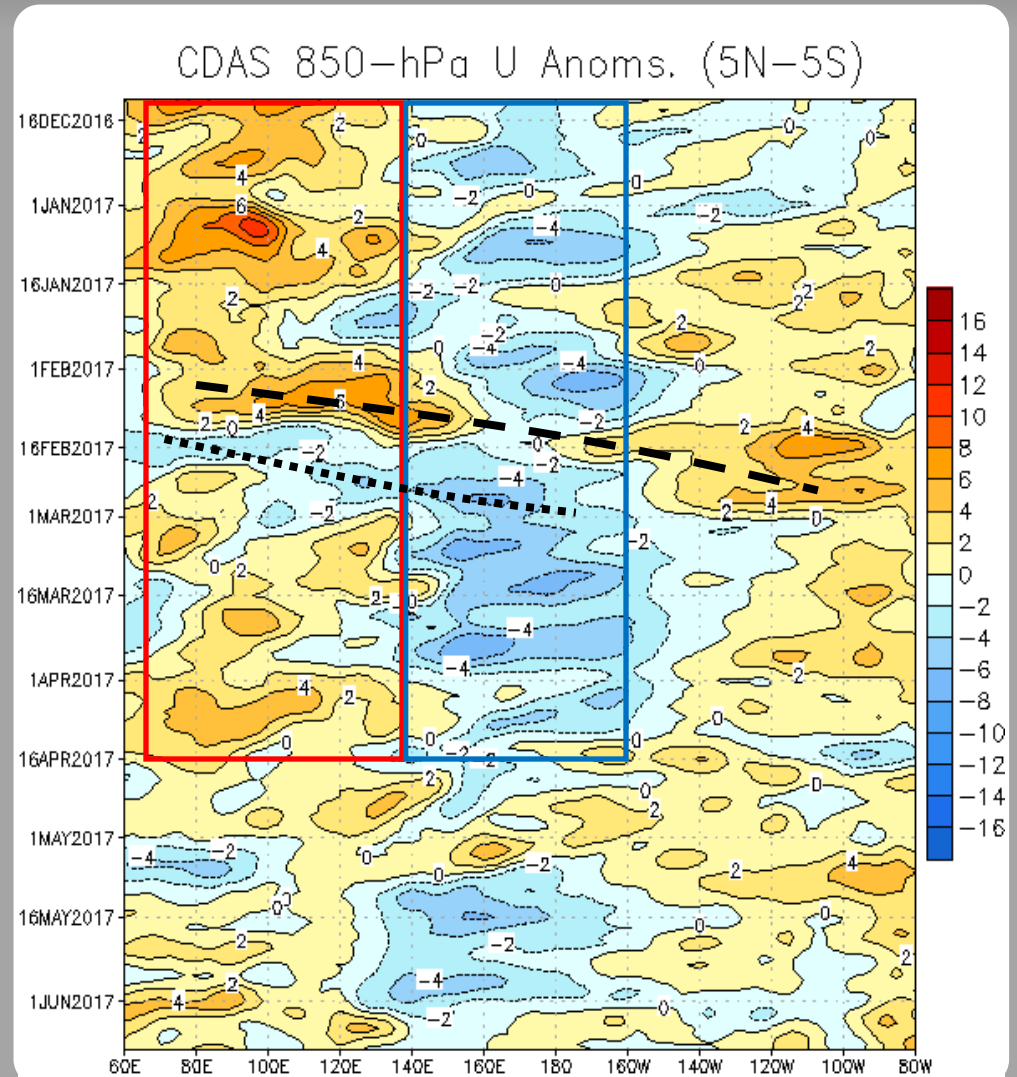
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

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

Most recently, equatorial anomalies have been weak, with some evidence of easterly anomalies drifting westward near 140E.



# OLR Anomalies - Past 30 days

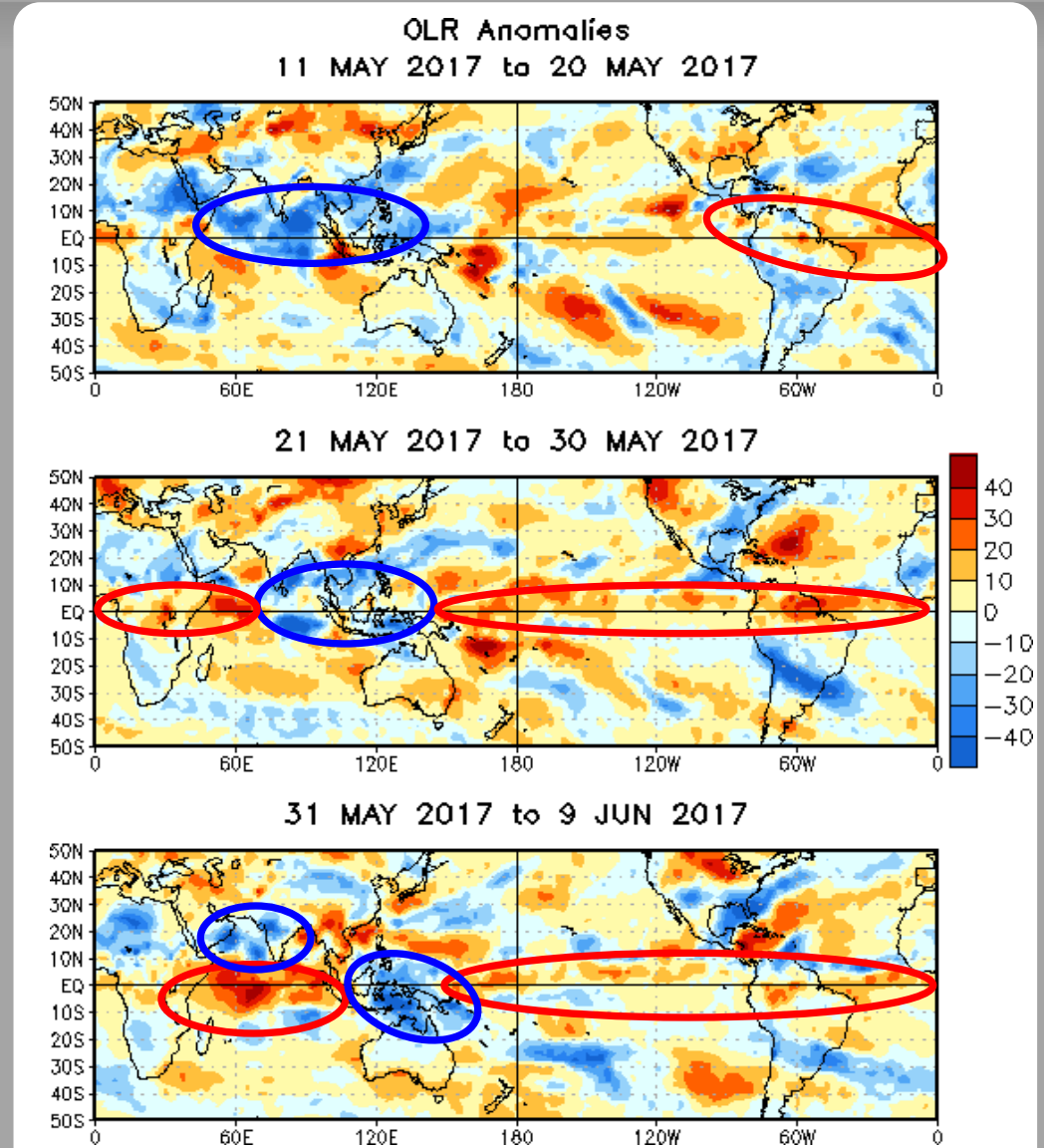
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

In mid-May, enhanced convection developed over the Americas and Atlantic Ocean, as well as over the Maritime Continent. Suppressed convection generally persisted over the Pacific along and north of the equator.

In late May, enhanced convection was noted across the eastern Indian Ocean and Maritime Continent region. Suppressed convection was noted over much of the remainder of the global tropics.

In late May/early June, enhanced convection was apparent over the eastern Maritime continent and Arabian Sea, with suppressed conditions over the Indian Ocean and equatorial Pacific.



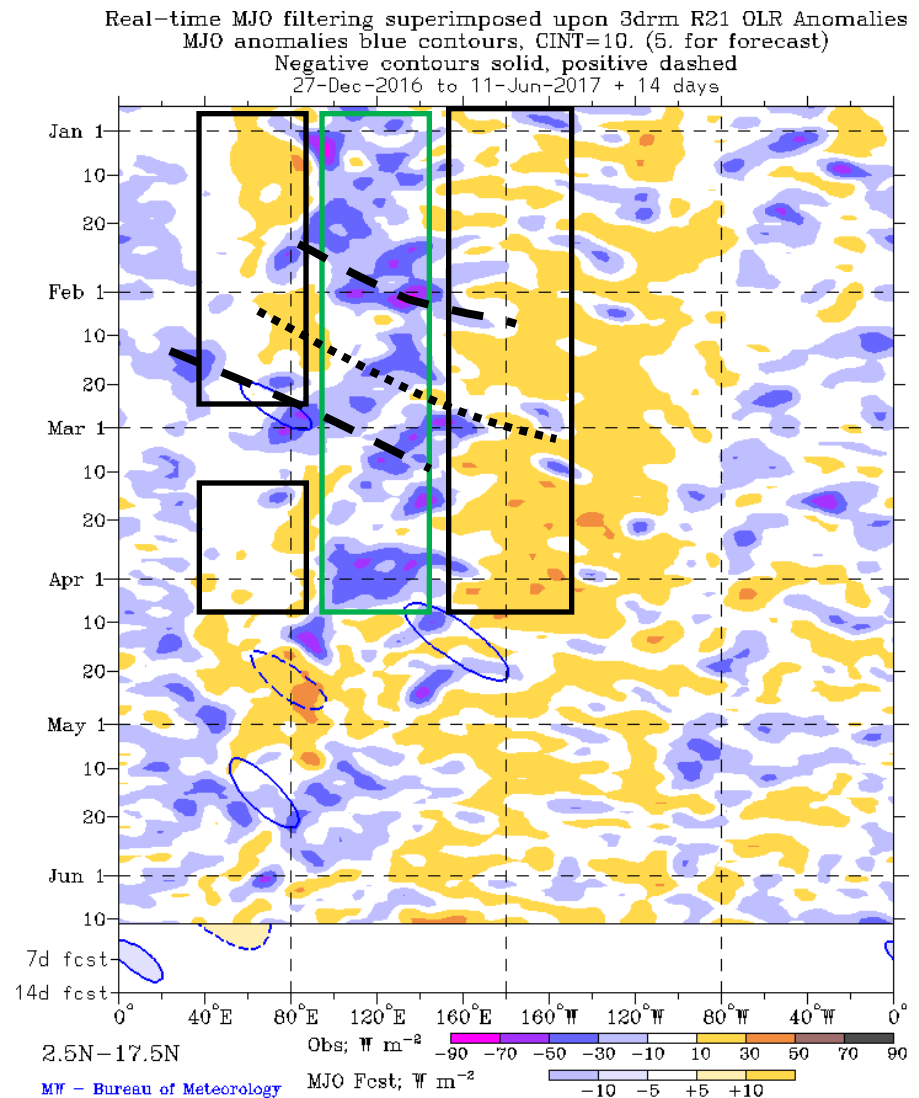
# Outgoing Longwave Radiation (OLR) Anomalies (2.5°N - 17.5°N)

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

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

A low frequency state favoring enhanced convection over the eastern IO and the Maritime Continent has been evident from July through early April (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 boxes), 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. The most recent pronounced signal is related to convective suppression between 140-160E.



# 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

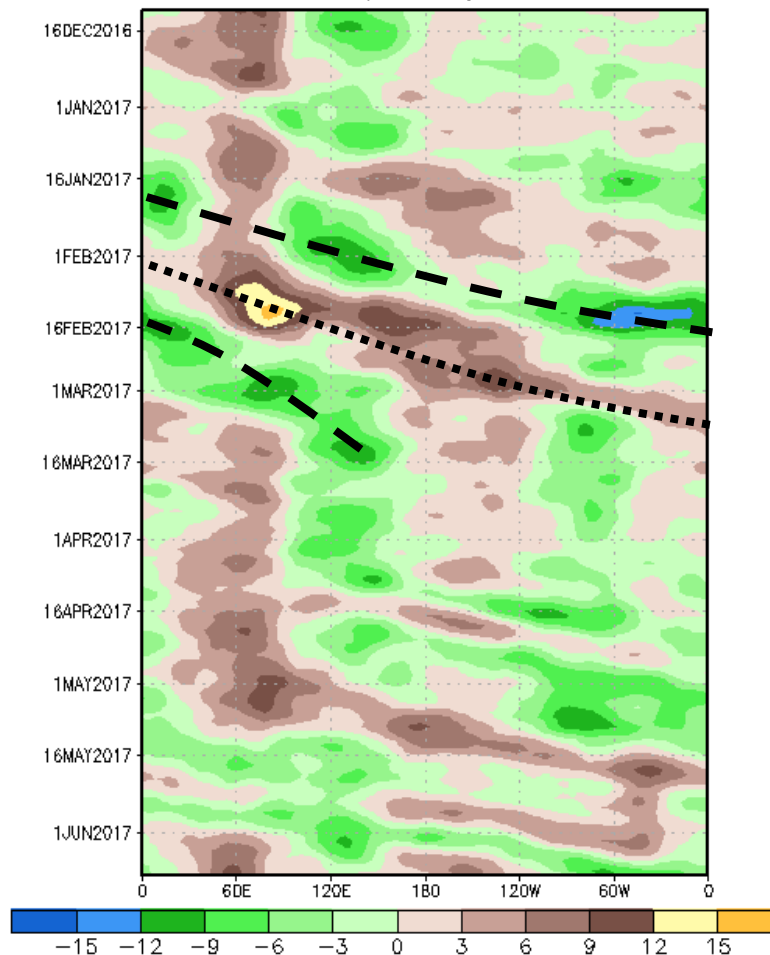
The pattern, during December and January, was more related to seasonal variability.

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.

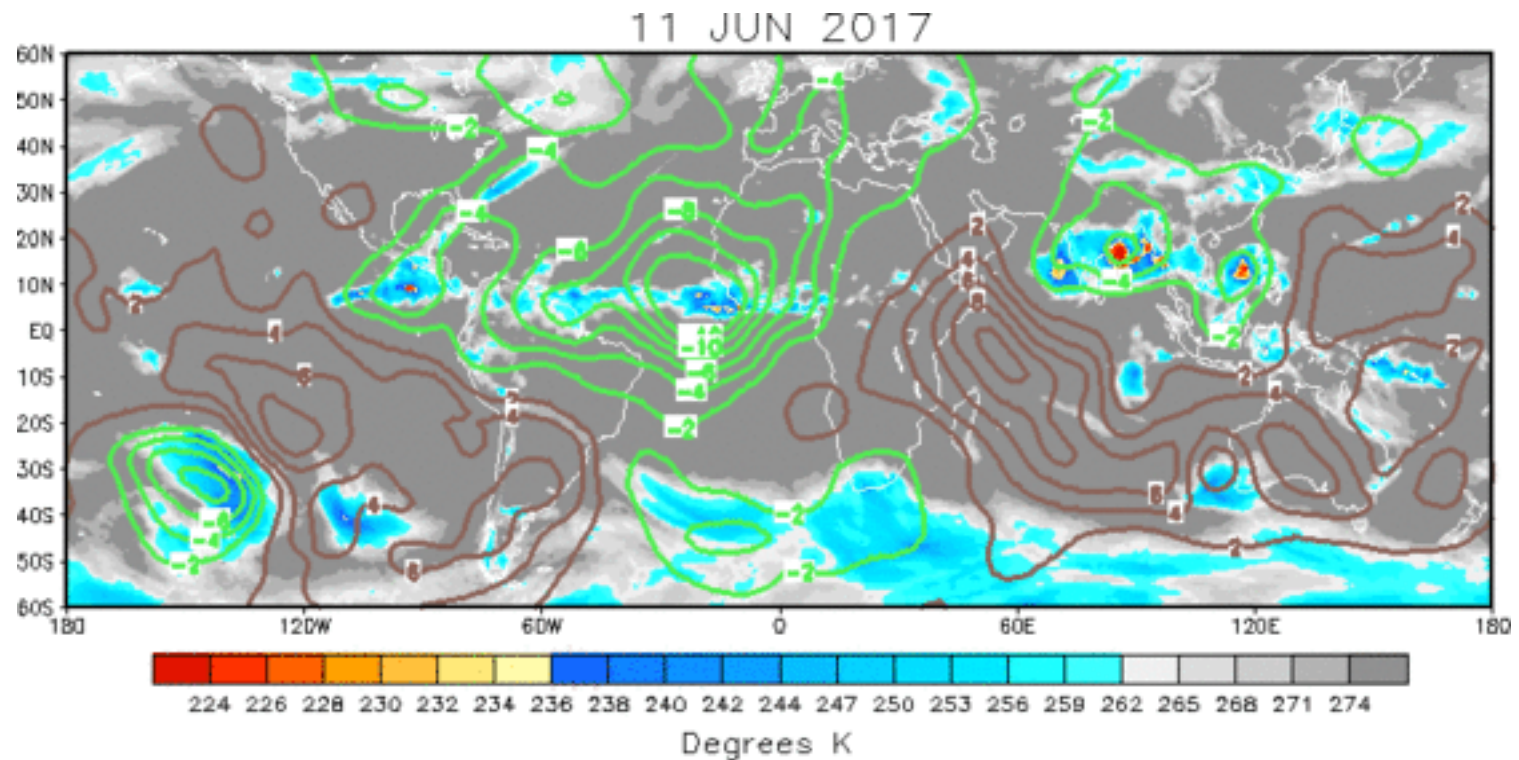
Kelvin wave activity has been apparent from April through the present, evident in the rapidly eastward propagating signals.

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





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



Enhanced convection exists most recently across the Americas and Atlantic, in addition to association with the advancing southwest monsoon across Asia. Suppressed conditions were apparent across most of the Pacific and the western Indian Ocean.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation

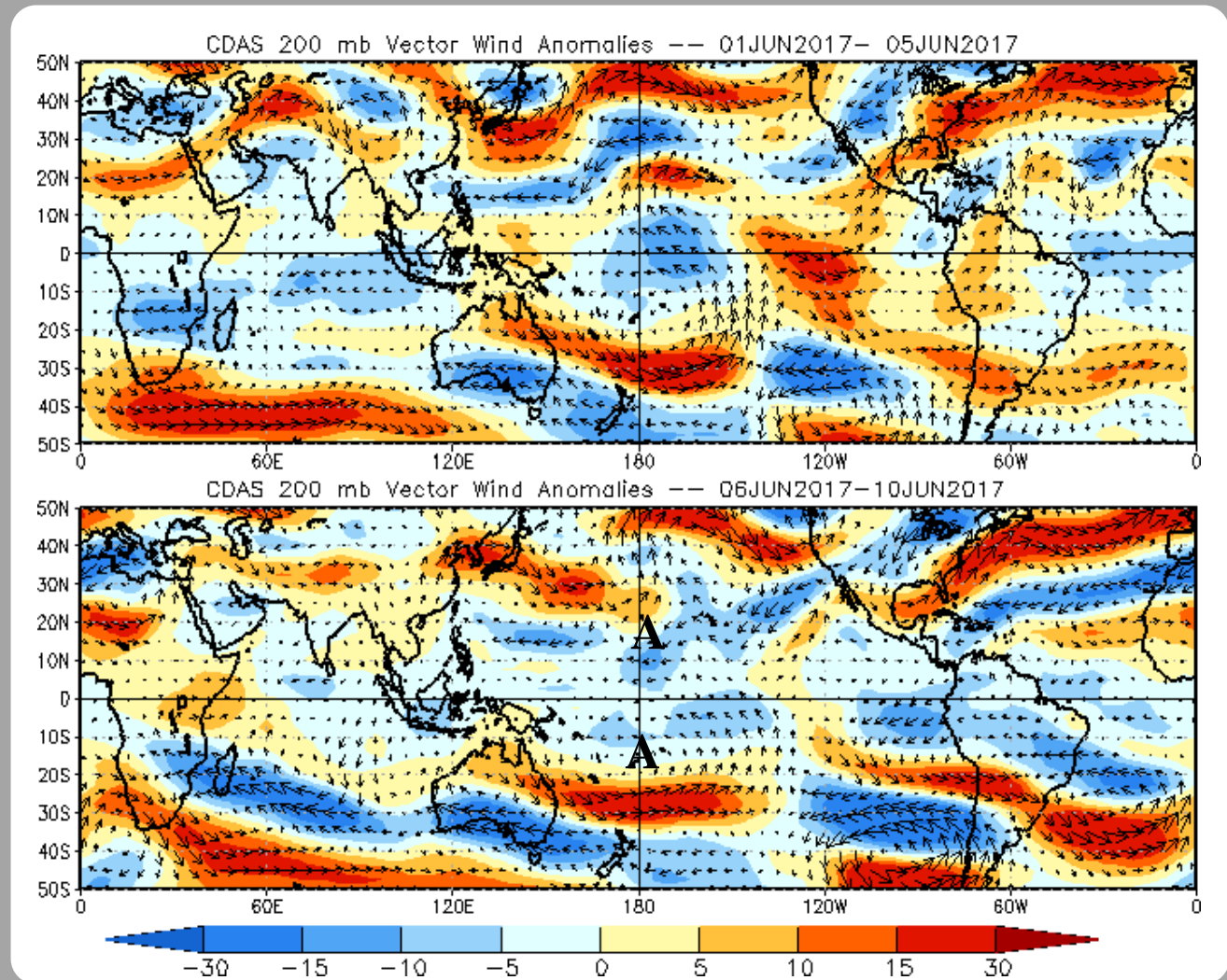
# 200-hPa Vector Wind Anomalies (m s<sup>-1</sup>)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

The top panel shows a largely incoherent structure over the global tropics.



Suppression of convection continues in the vicinity of the antimeridian associated with mass accumulation due to mid-latitude ridging.

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

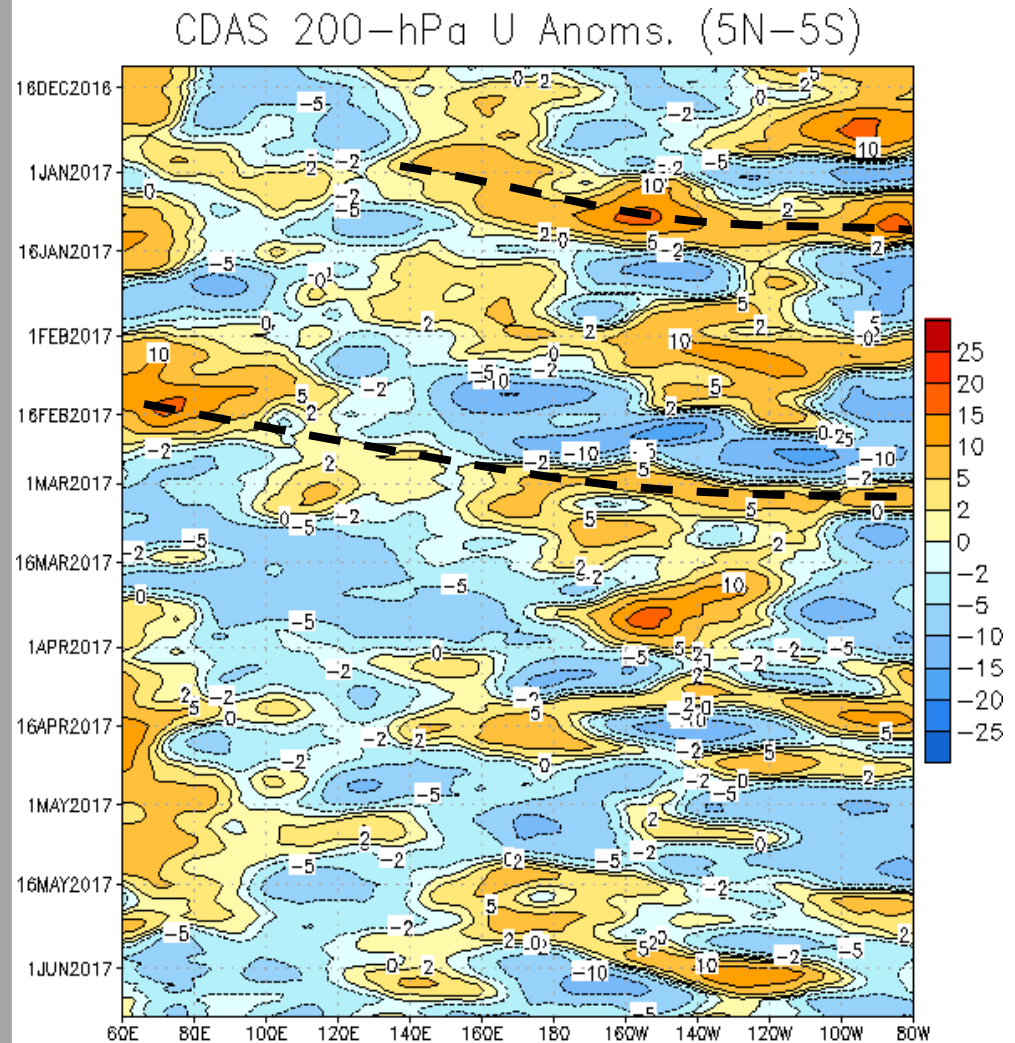
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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.

Over the last week anomalies tended to be weak and out of the east. Upper-level convergence acting to suppress convection is most pronounced near 140E in association with the mid-latitude influences on the prior slide.





# 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

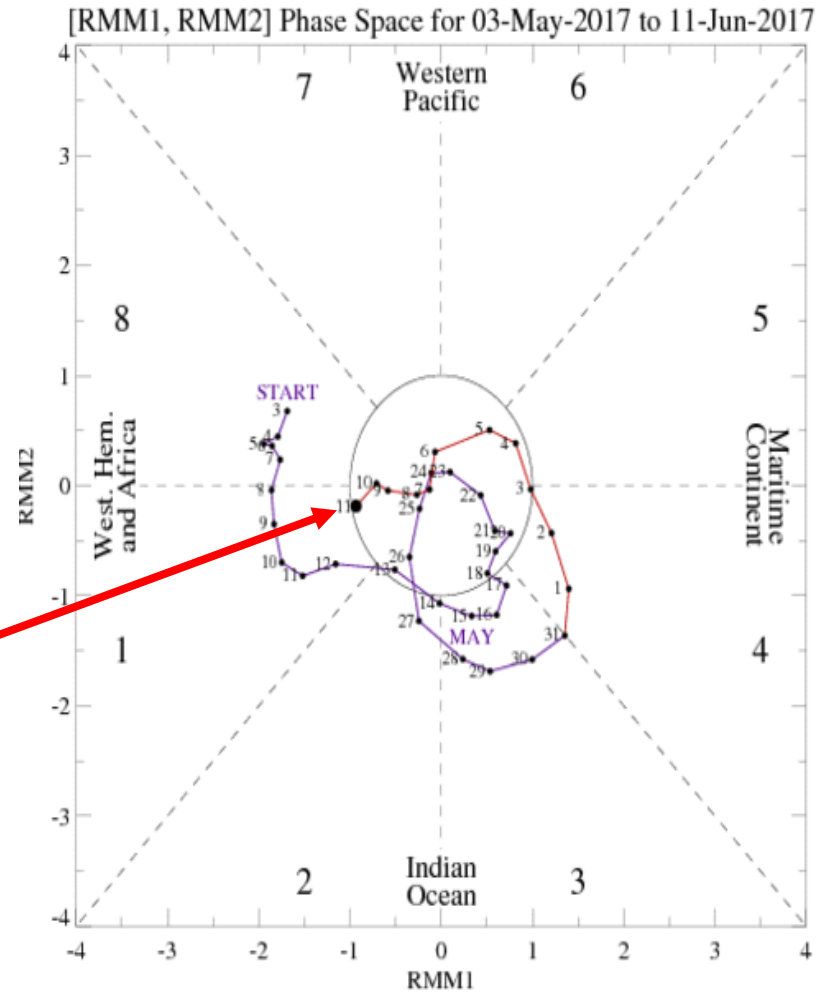
The triangular areas indicate the location of the enhanced phase of the MJO

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

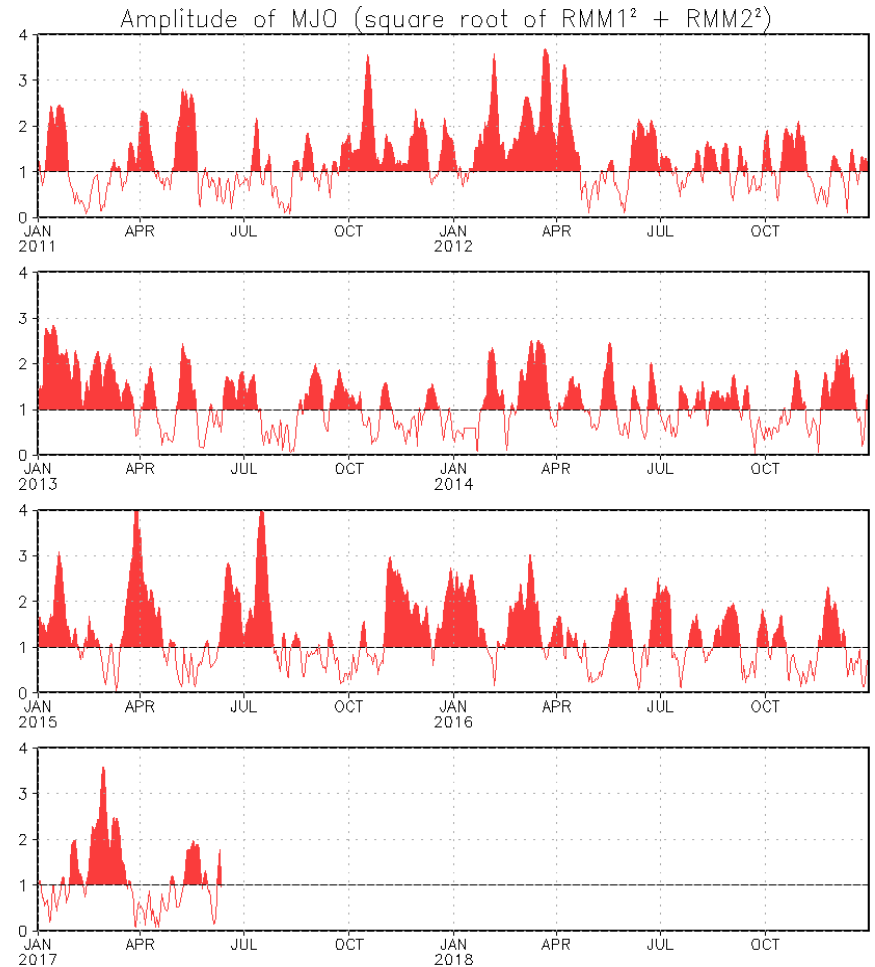
During the past week, the RMM index continued to lie within the unit circle, with progression towards a signal close to emerging over the Atlantic.



# 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

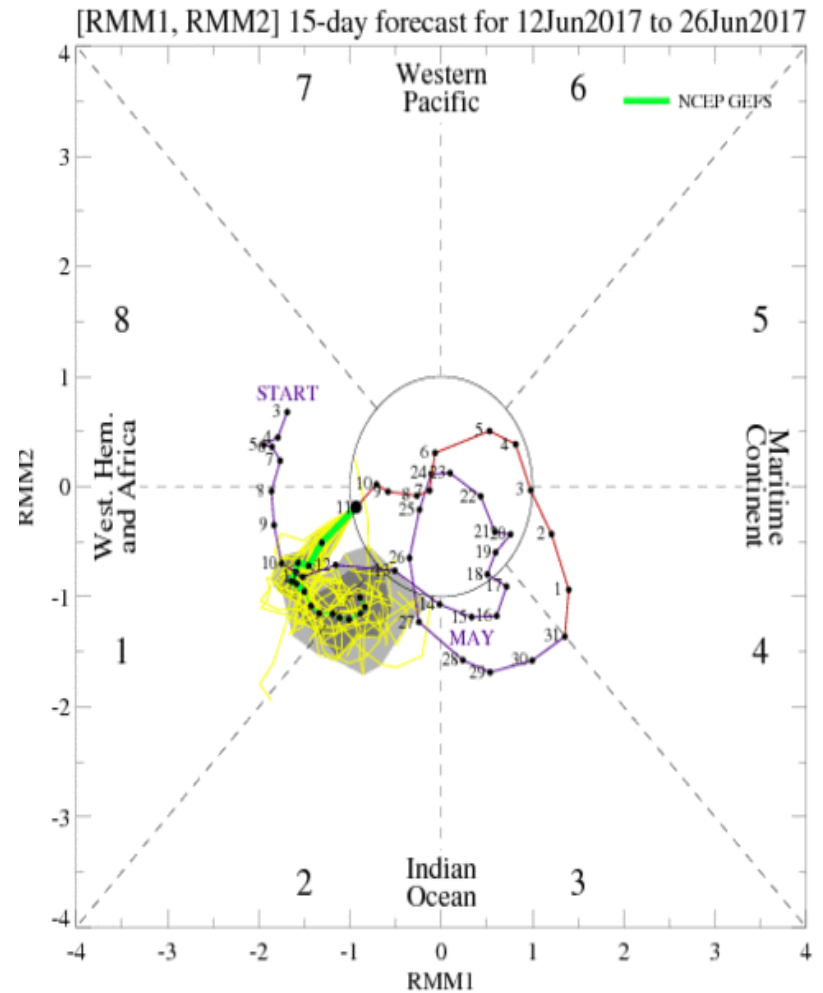
RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GEFS forecast predicts an emerging intraseasonal signal over Africa during Week-1, that advances eastward into the Indian Ocean during Week-2 before a turn to the west.

Yellow Lines - 20 Individual Members  
Green Line - Ensemble Mean

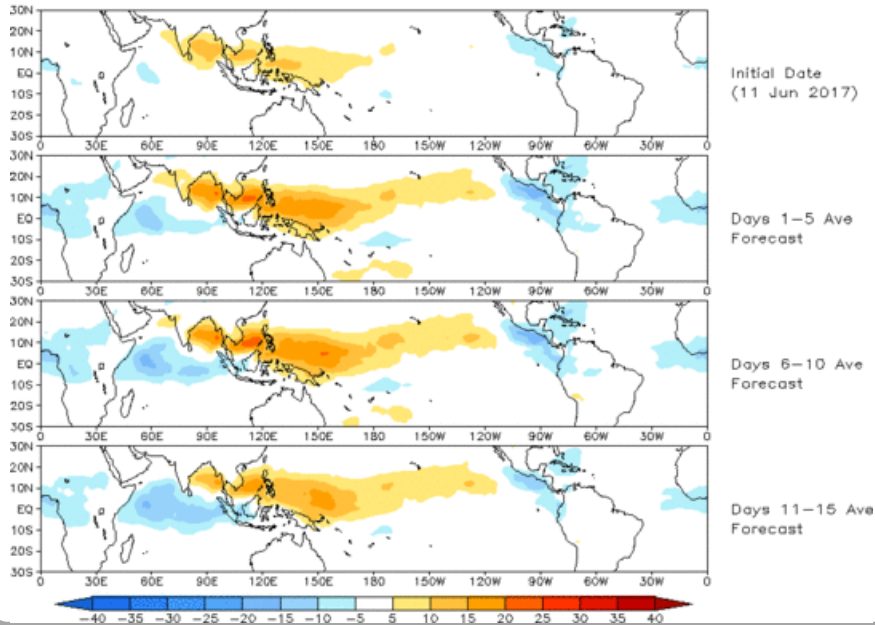




# Ensemble GFS (GEFS) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

Prediction of MJO-related anomalies using GEFS operational forecast  
Initial date: 11 Jun 2017  
OLR

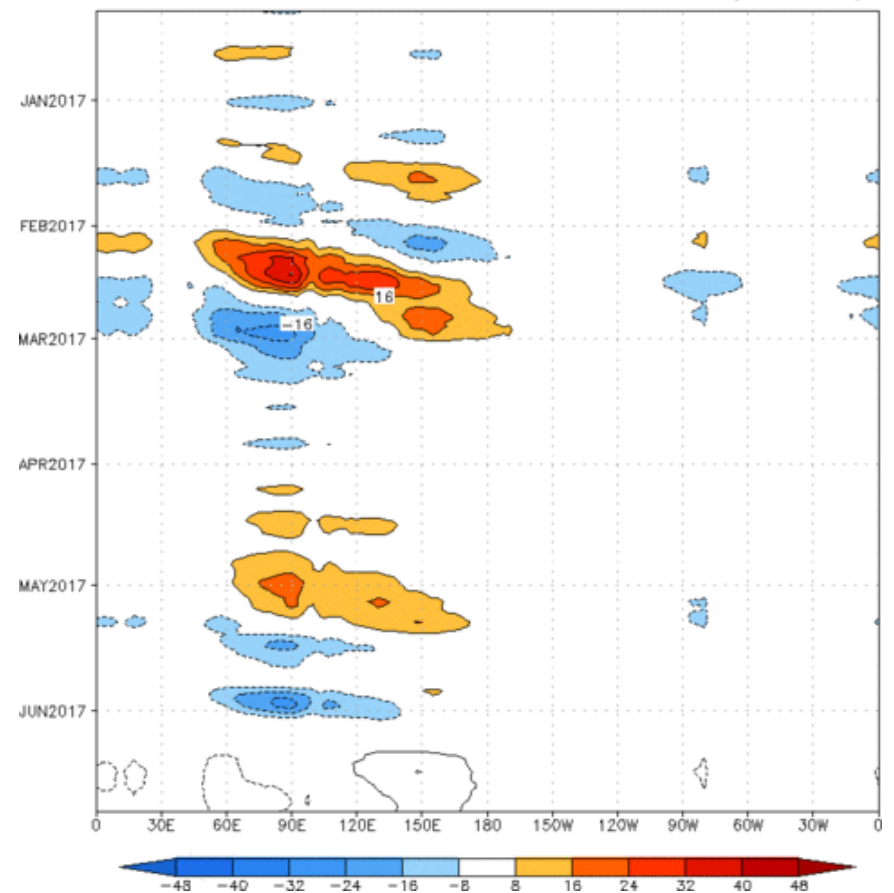


The GEFS RMM-based OLR anomaly forecasts convection building eastward across Africa and the Indian Ocean, while suppressed convection stretches from India through the North Pacific and drifts eastward with time.

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

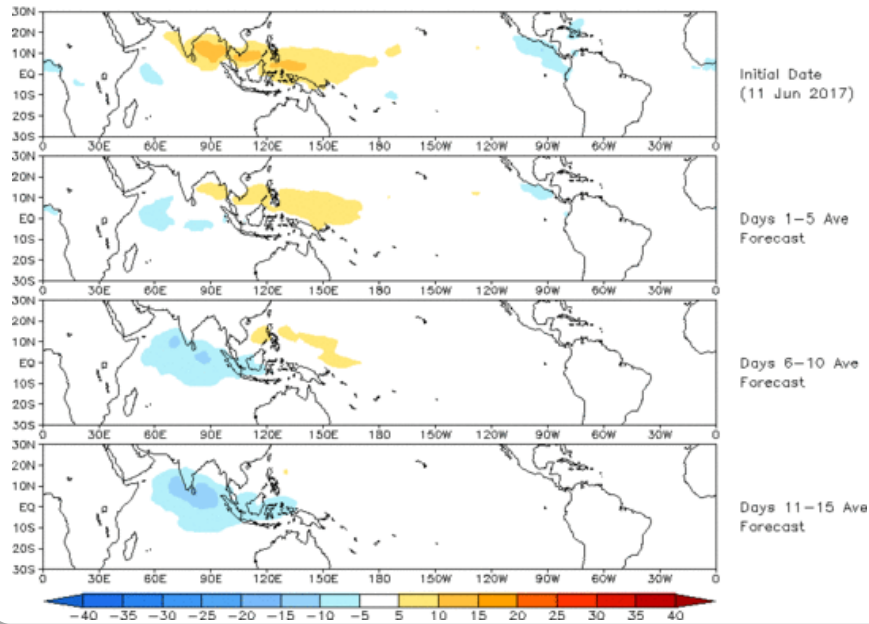
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2  
OLR [7.5°S,7.5°N] (cont:4Wm<sup>-2</sup>) Period:10-Dec-2016 to 11-Jun-2017  
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days



# 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 (11 Jun 2017)

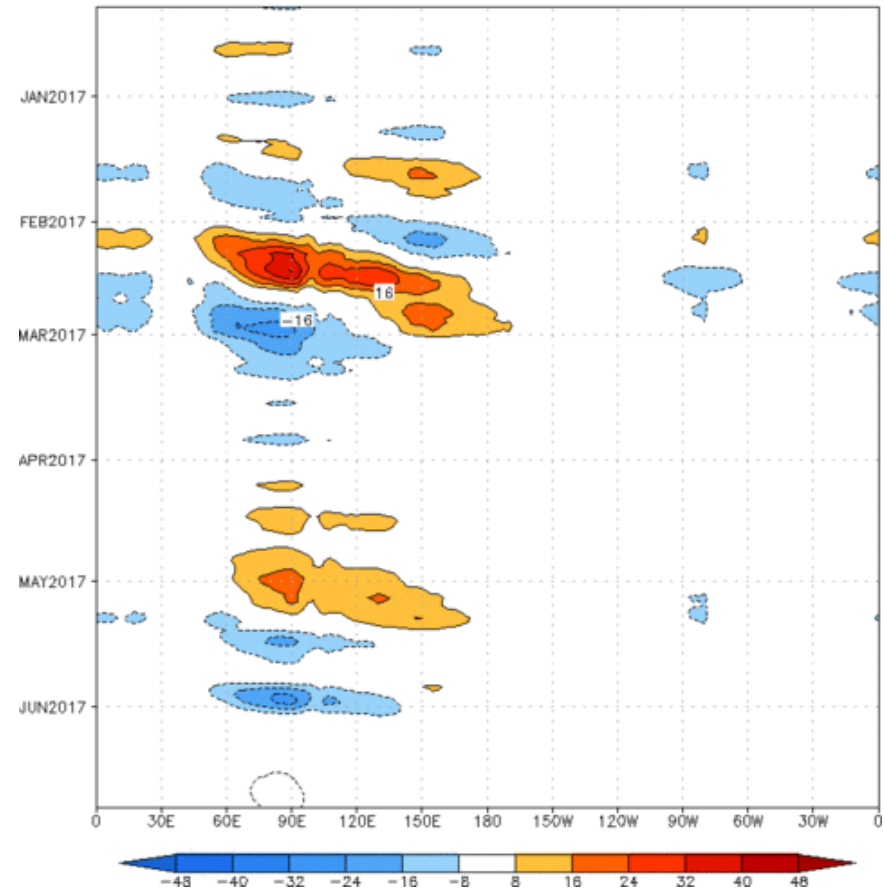


The constructed analog RMM-based OLR anomaly prediction indicates eastward propagation of enhanced convection across the Indian Ocean to the Maritime continent over the next two weeks, while suppressed conditions progressively decay in the Bay of Bengal and West Pacific.

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.)

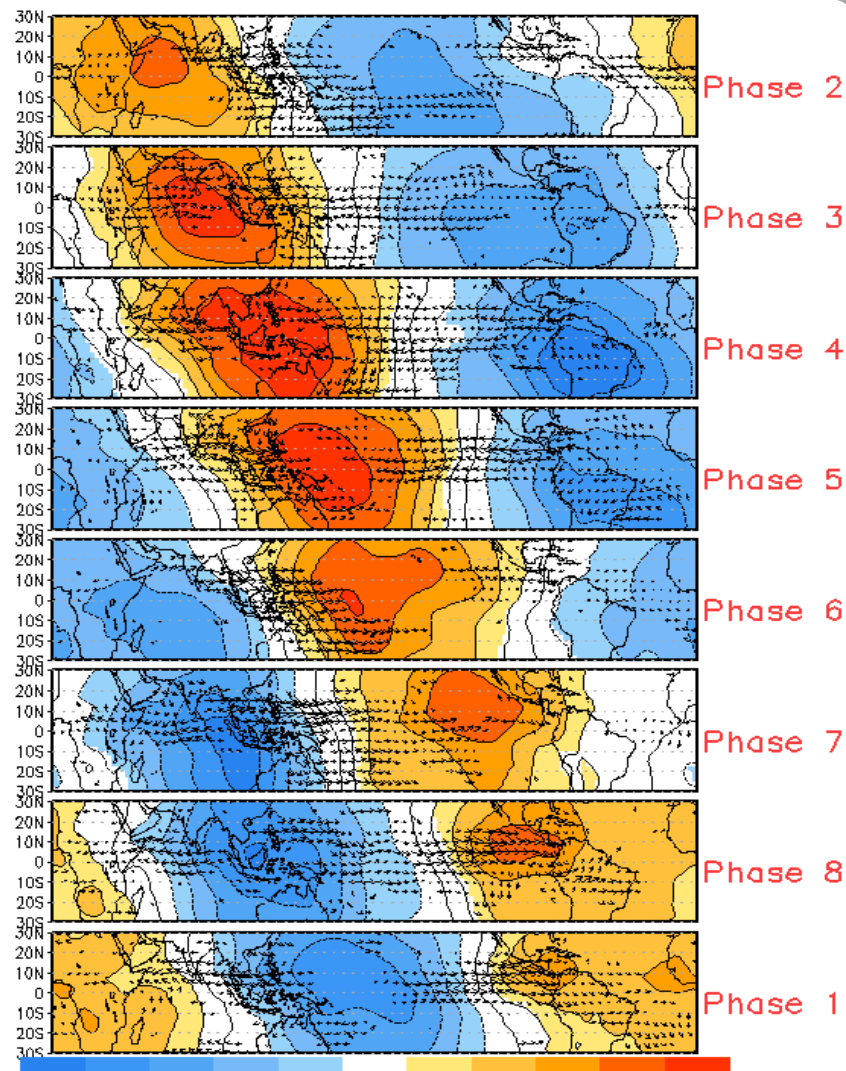
Time-longitude section of ( $7.5^{\circ}$  S- $7.5^{\circ}$  N) OLR anomalies - last 180 days and for the next 15 days

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [ $7.5^{\circ}$ S, $7.5^{\circ}$ N] (cont:  $4Wm^{-2}$ ) Period: 10-Dec-2016 to 11-Jun-2017  
The unfilled contours are CA forecast reconstructed anomaly for 15 days

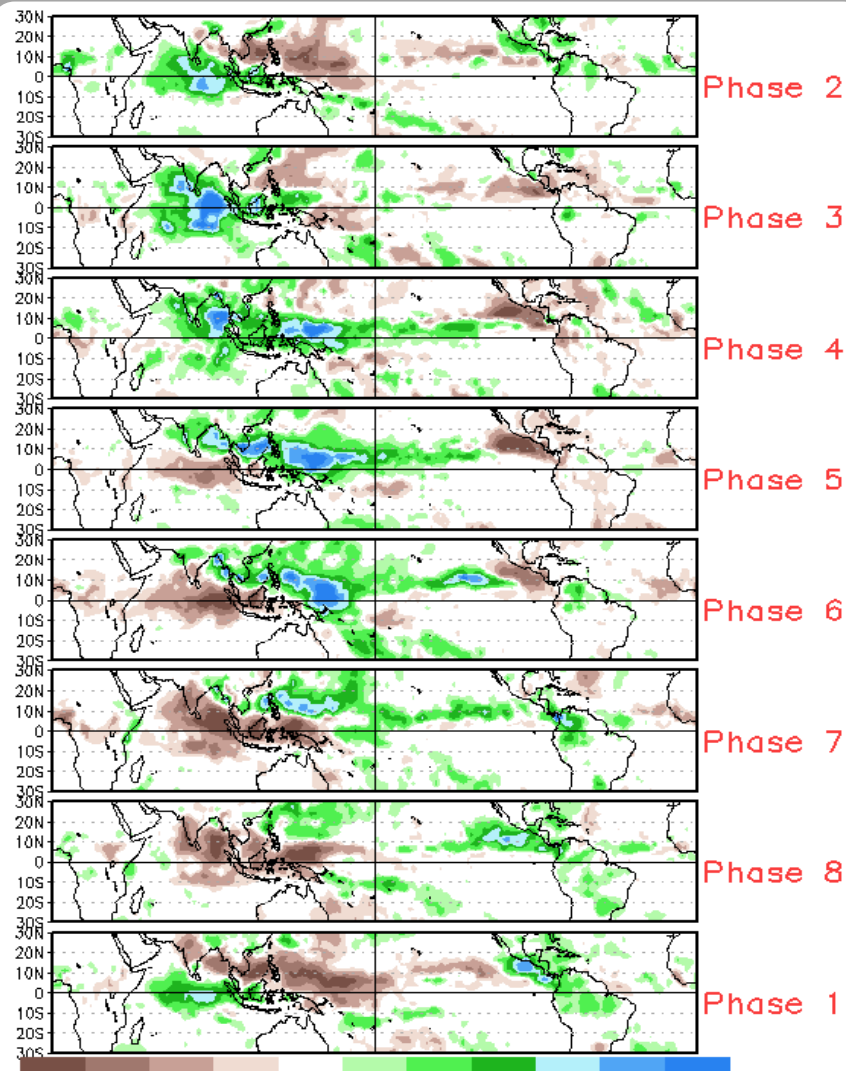


# MJO Composites - Global Tropics

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



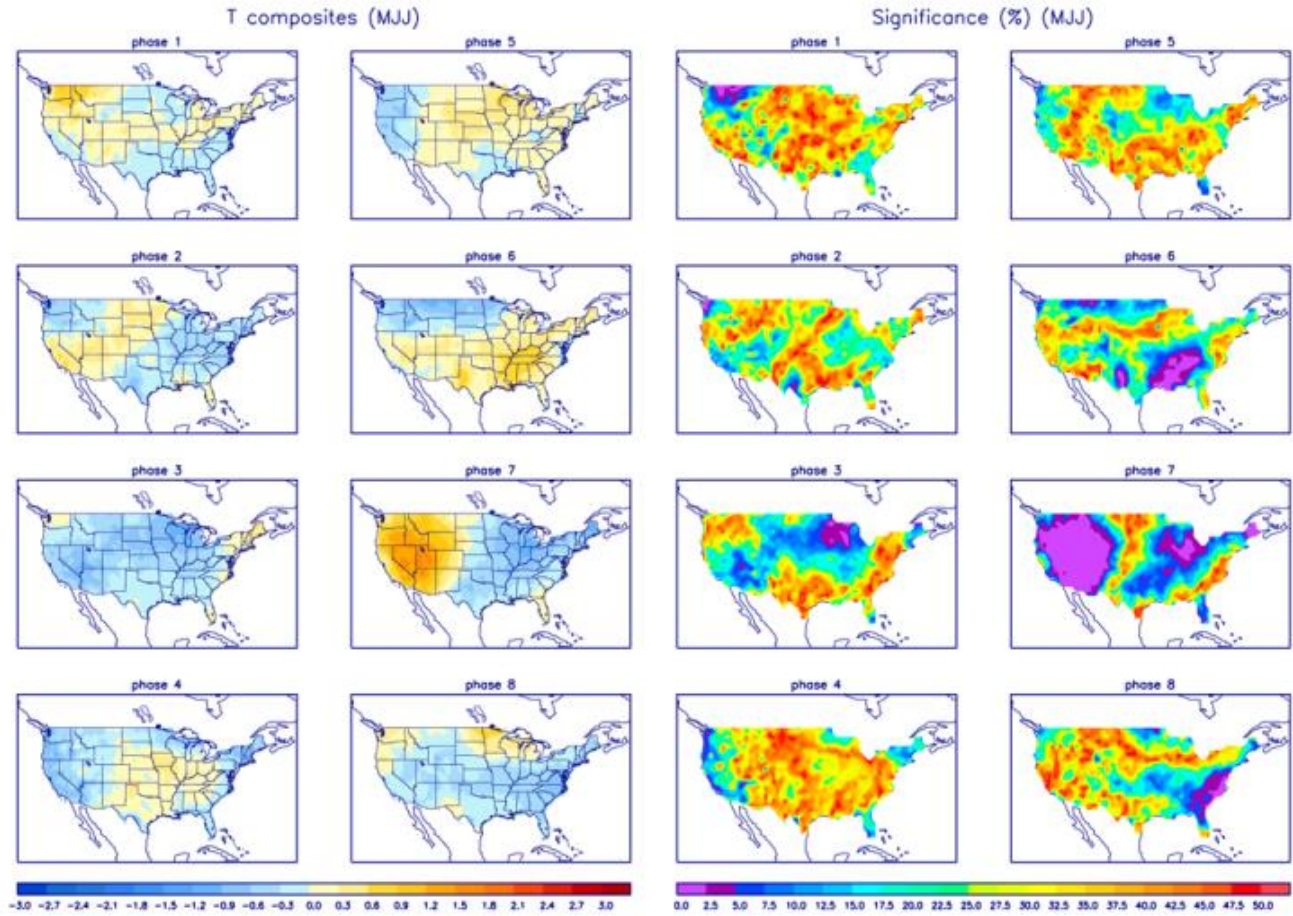
Precipitation Anomalies (May - Sep)



# 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.



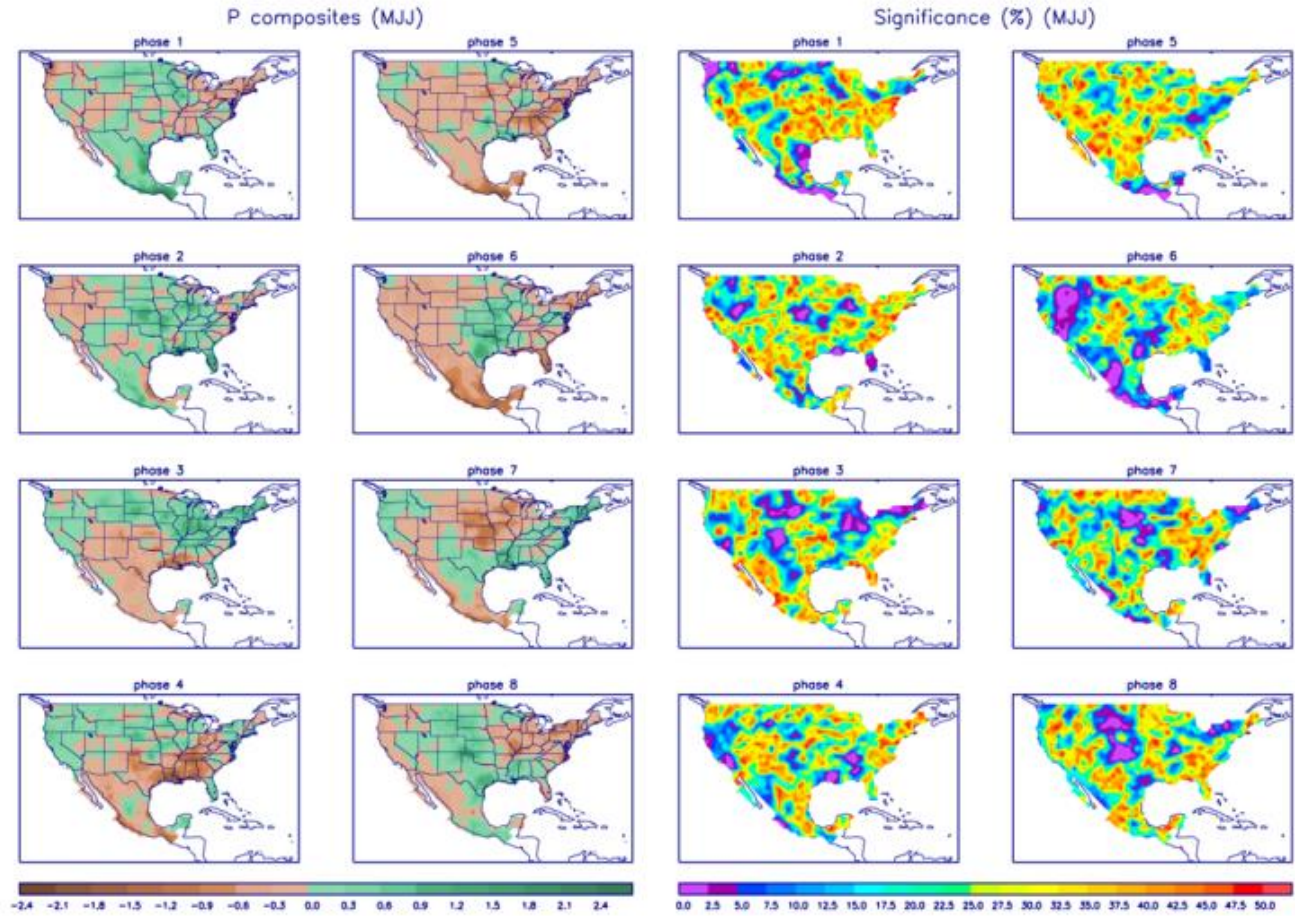
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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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