

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



Update prepared by:
Climate Prediction Center / NCEP
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Overview

Although the MJO signal has recently weakened, convection associated with its remnant enhanced phase is shifting north across Southeast Asia and the northwest Pacific.

The MJO is expected to remain weak during the next two weeks.

Tropical cyclone formation is imminent across the Caribbean Sea. Elsewhere, tropical cyclone development is most likely over the east Pacific and higher latitudes of the northwest Pacific during the next two weeks.

Enhanced rainfall is likely to be mostly associated with tropical cyclones, while suppressed rainfall is expected over parts of the west and central Pacific.

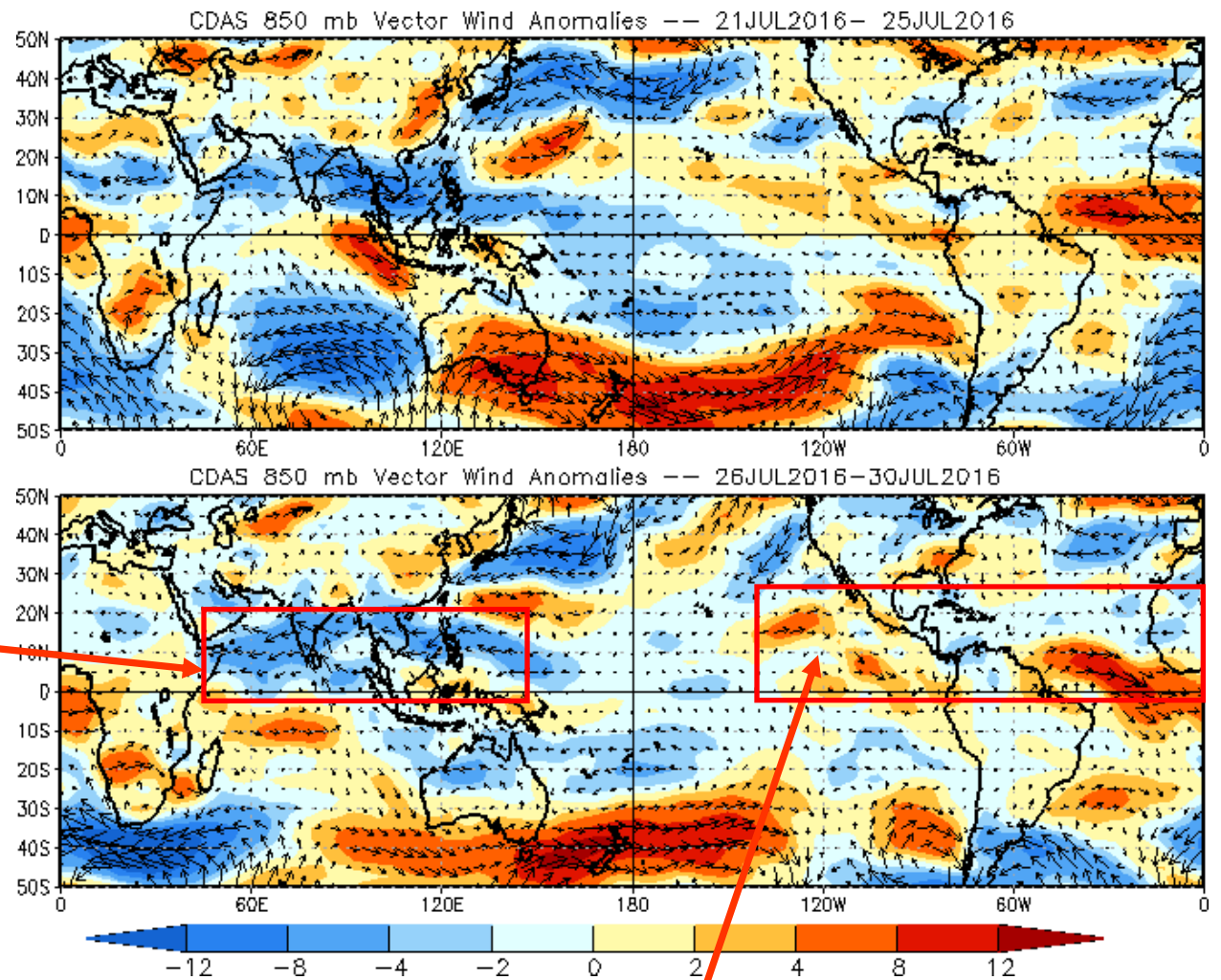
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php>

850-hPa Vector Wind Anomalies (m s⁻¹)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies persisted over the northern Indian Ocean, Southeast Asia, and the west Pacific.

Westerly anomalies become less coherent across the east Pacific during the past five days, while westerly anomalies persisted across the tropical Atlantic (10N to equator).

850-hPa Zonal Wind Anomalies (m s⁻¹)

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

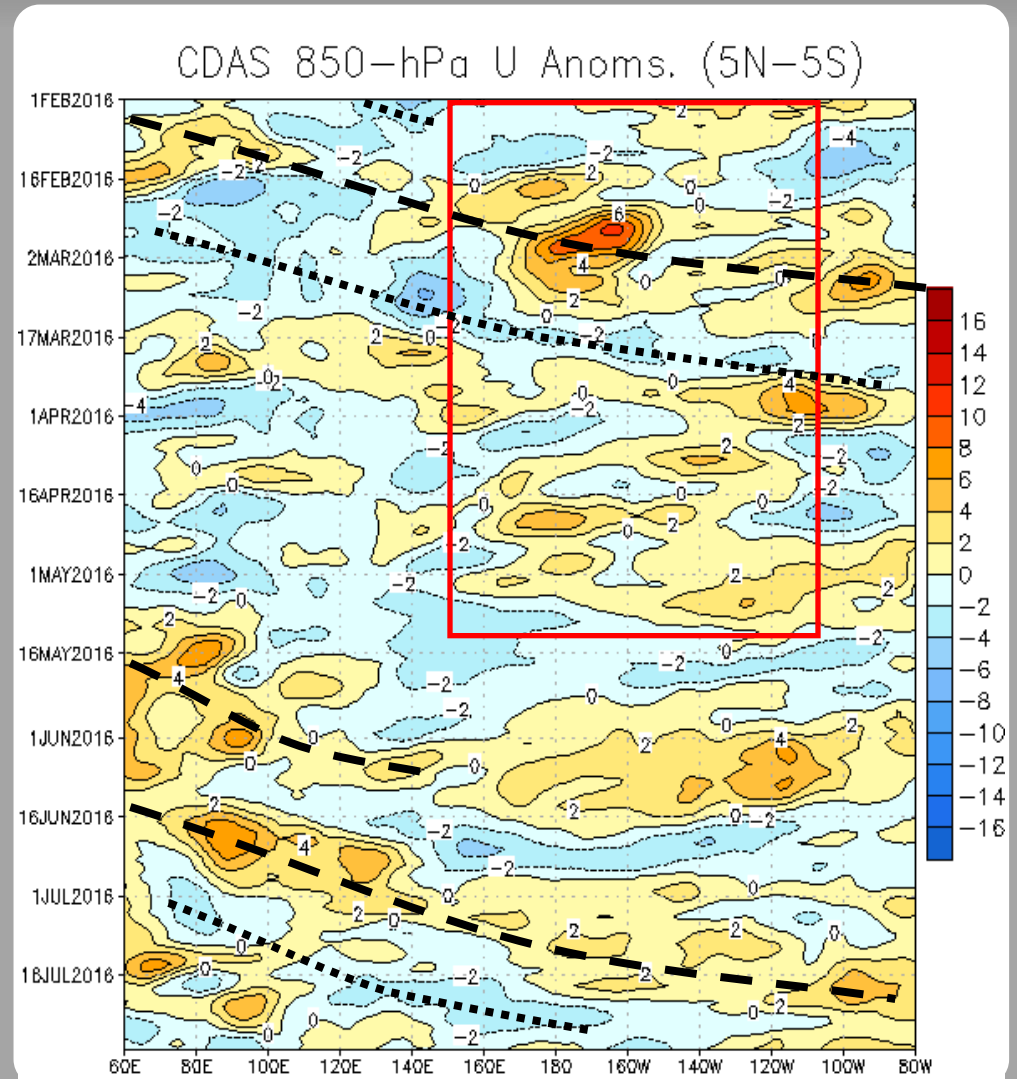
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

Fast-propagating intraseasonal events (long (short) dashed lines for the enhanced (suppressed) phase, modulated the El Niño base state.

During April, the wind field became less coherent as El Niño conditions weakened, while in early May, westerly anomalies move across the Indian Ocean. During June, westerly anomalies generally prevailed across the Indian Ocean and Pacific, with the exception of a brief transition in mid-month.

Recently, anomalies became more variable and decreased in magnitude due to competing higher frequency modes.



OLR Anomalies - Past 30 days

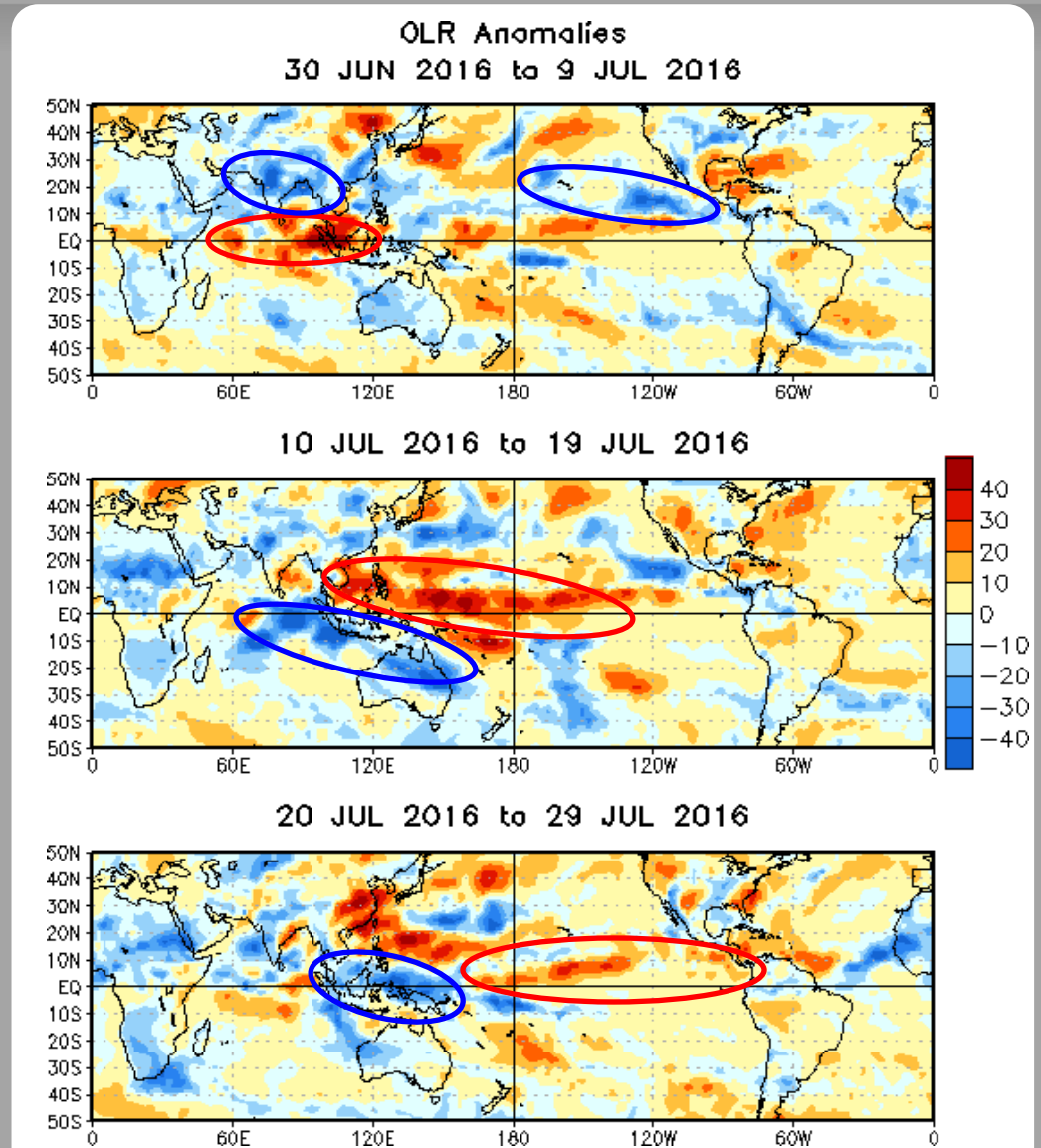
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

In early July, enhanced convection shifted northward over Southern Asia, while suppressed convection developed over the equatorial Indian Ocean. Off-equatorial, enhanced convection remained in place over the eastern Pacific as tropical cyclone activity picked up.

During mid-July, suppressed convection extended from the South China Sea eastward across the equatorial Pacific. Enhanced convection stretched from the Indian Ocean to the southern Maritime Continent and northern Australia.

Enhanced convection expanded north across the Maritime Continent during late July. Suppressed convection extended from the Date Line to the east Pacific.



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

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

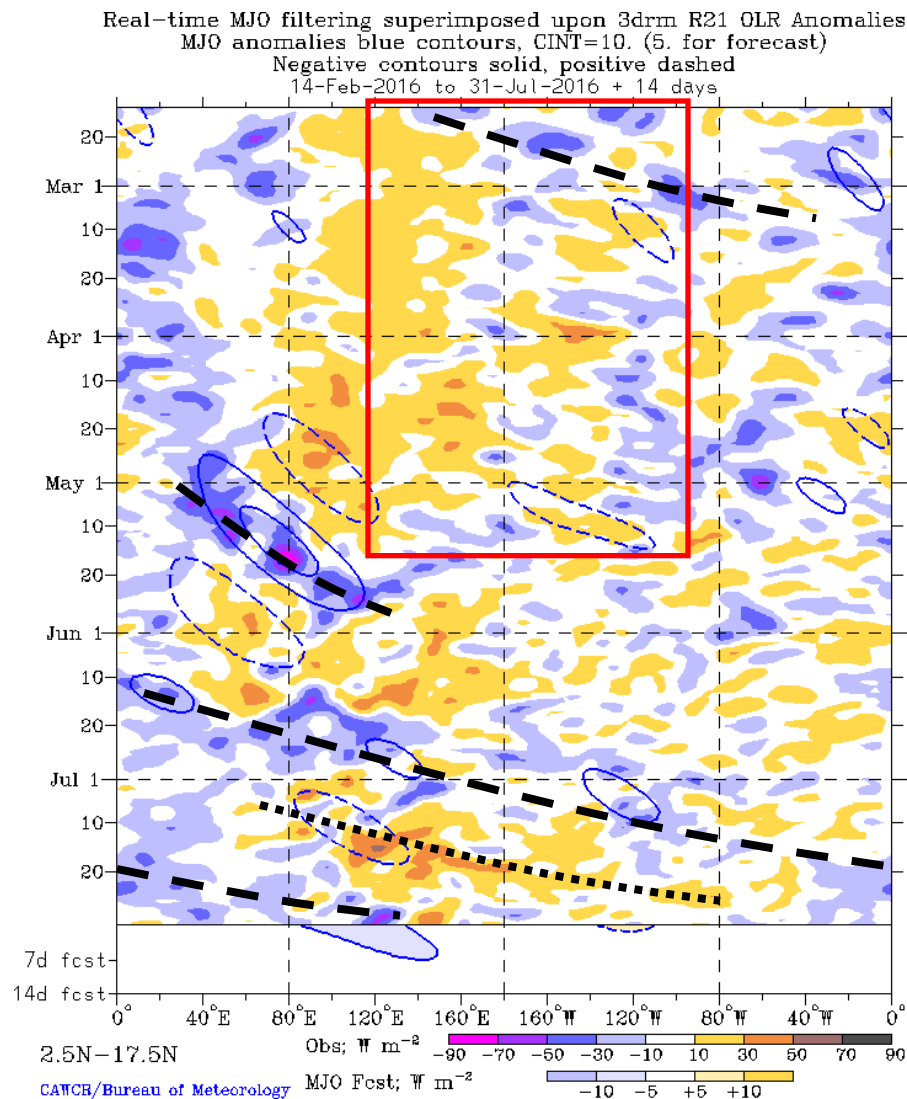
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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. During mid-June, some enhanced convection was evident over Maritime Continent.

Recently, signals have been mixed, with tropical cyclone activity evident in the patterns, especially over the eastern Pacific.



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

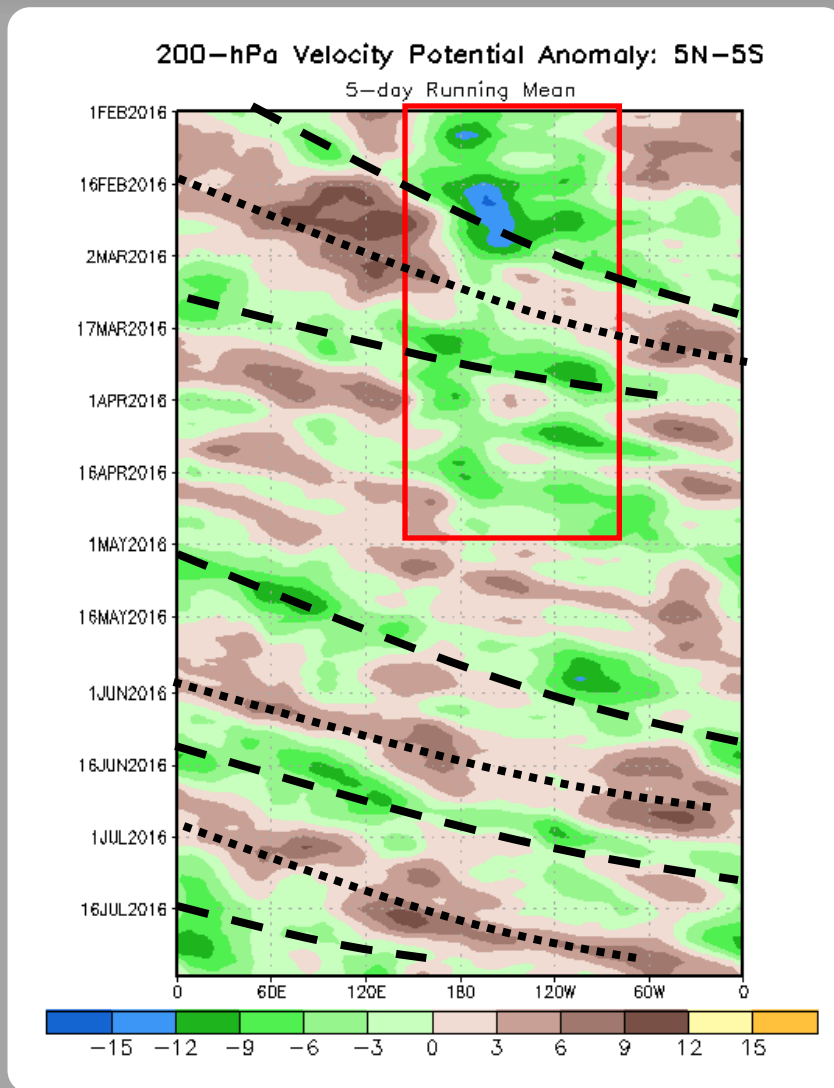
The 2015-16 El Niño background state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

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

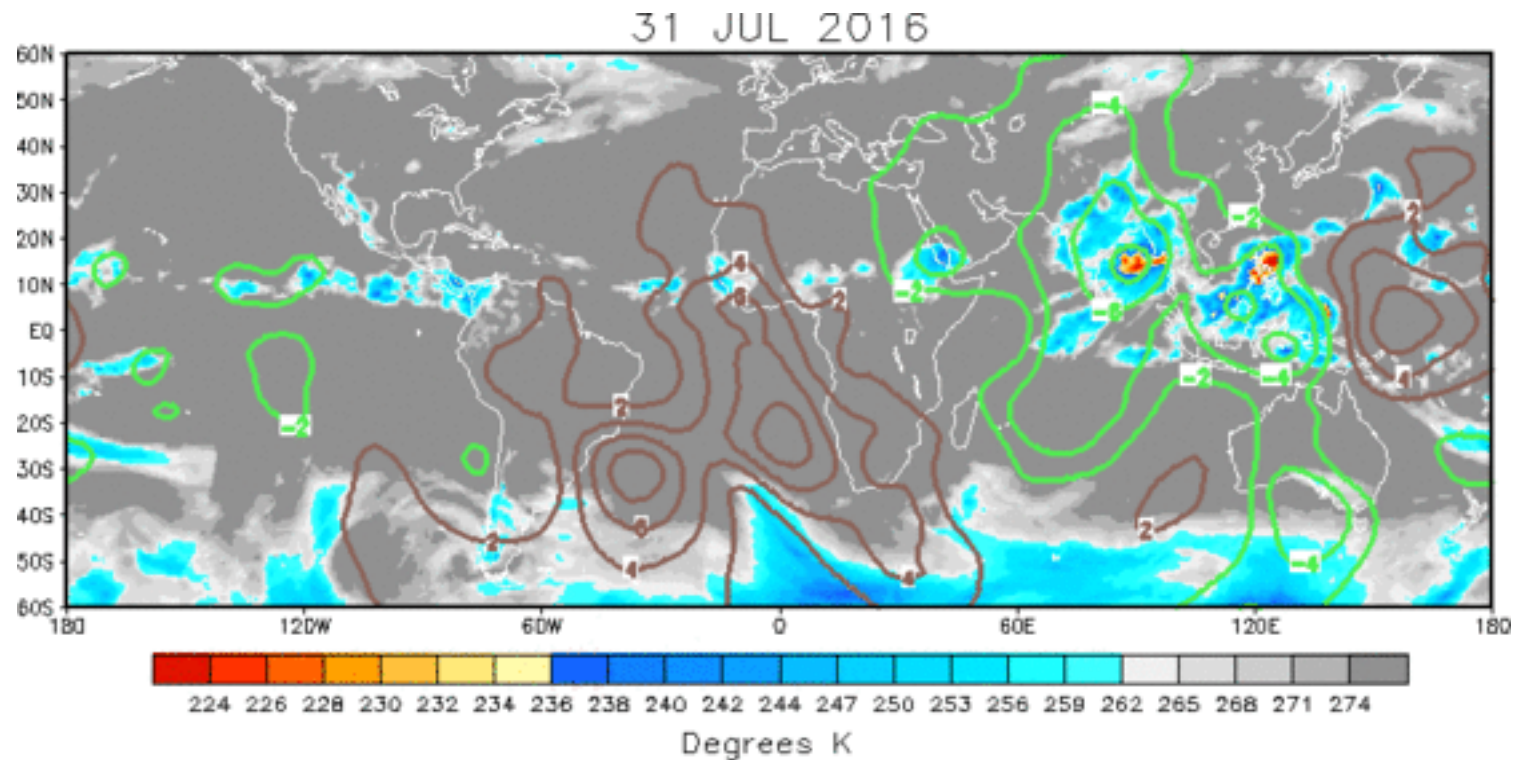
The upper-level velocity potential pattern became less coherent as the El Niño waned during April.

From May through the present time, an eastward propagating signal was evident in the upper-level velocity potential field. This signal was more coherent in time and space than the low-level MJO indicators.

Anomalous divergence developed over Africa, the Indian Ocean, and Maritime Continent during late July. Anomalous convergence shifted east across the Western Hemisphere.



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



The magnitude of upper-level velocity potential anomalies has decreased recently, especially over the Western Hemisphere.

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

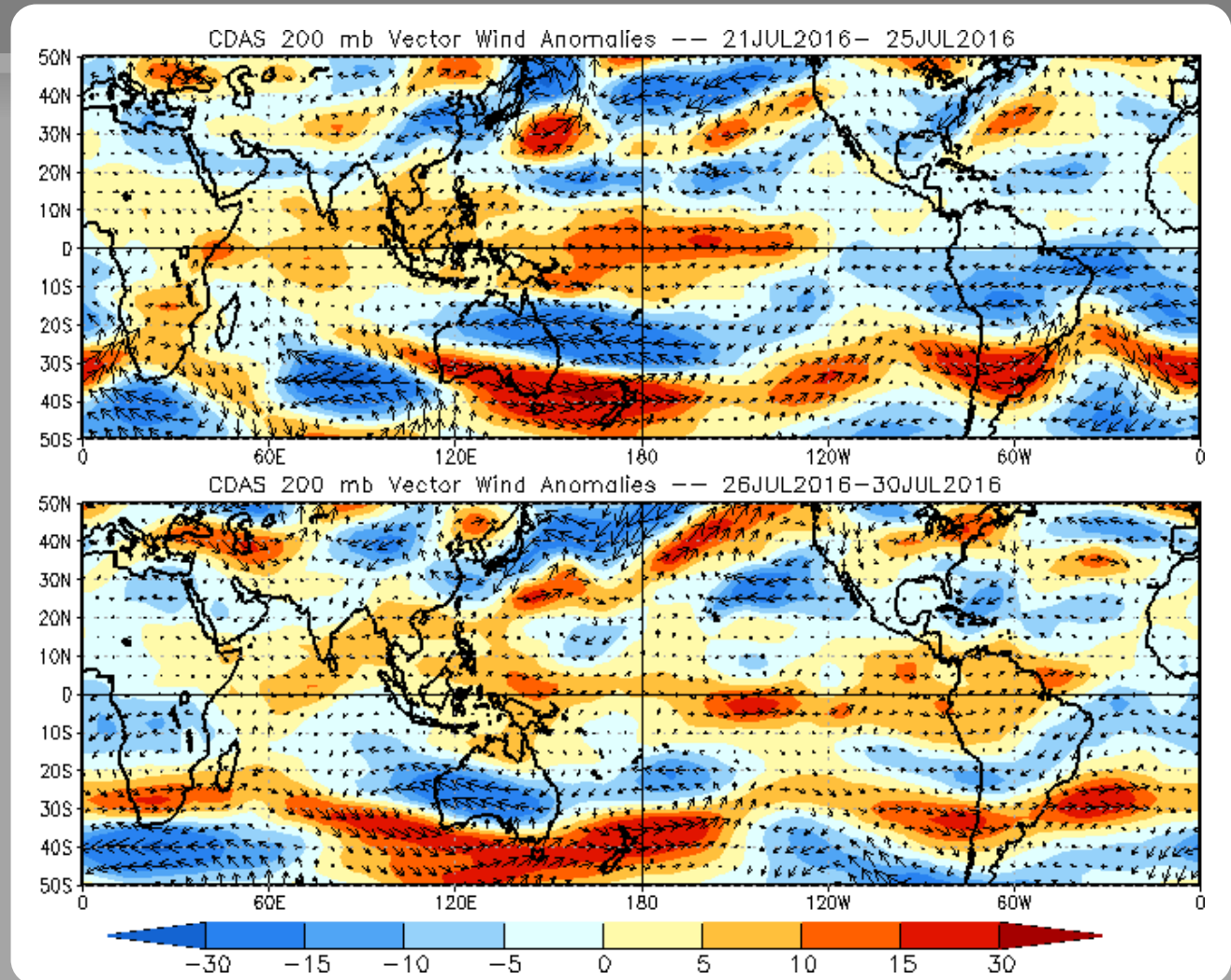
200-hPa Vector Wind Anomalies (m s⁻¹)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

During the final week of July, westerly anomalies extend across much of the global tropics.



200-hPa Zonal Wind Anomalies (m s⁻¹)

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

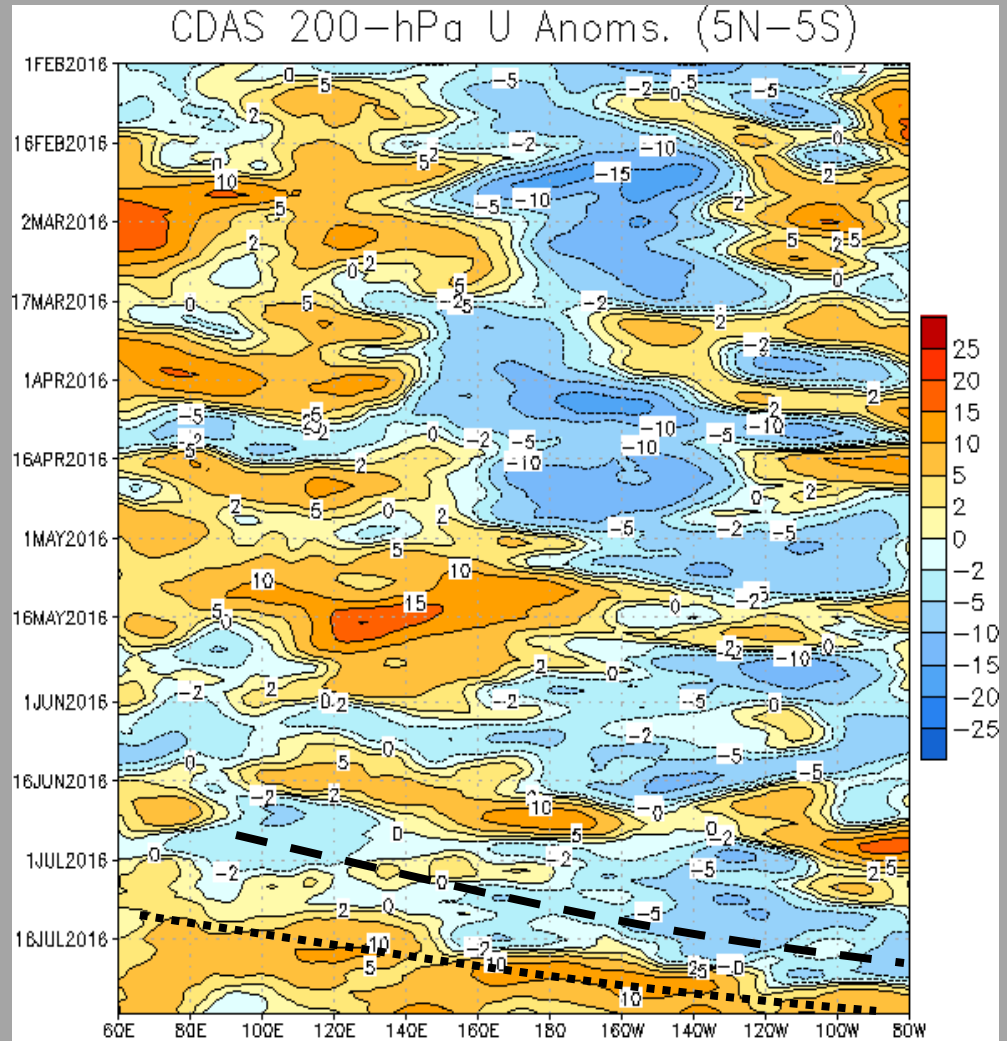
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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 zonal wind field became less coherent during late May and early June.

Most recently easterly/westerly anomalies have propagated eastward across the equatorial Tropics.



Weekly Heat Content Evolution in the Equatorial Pacific

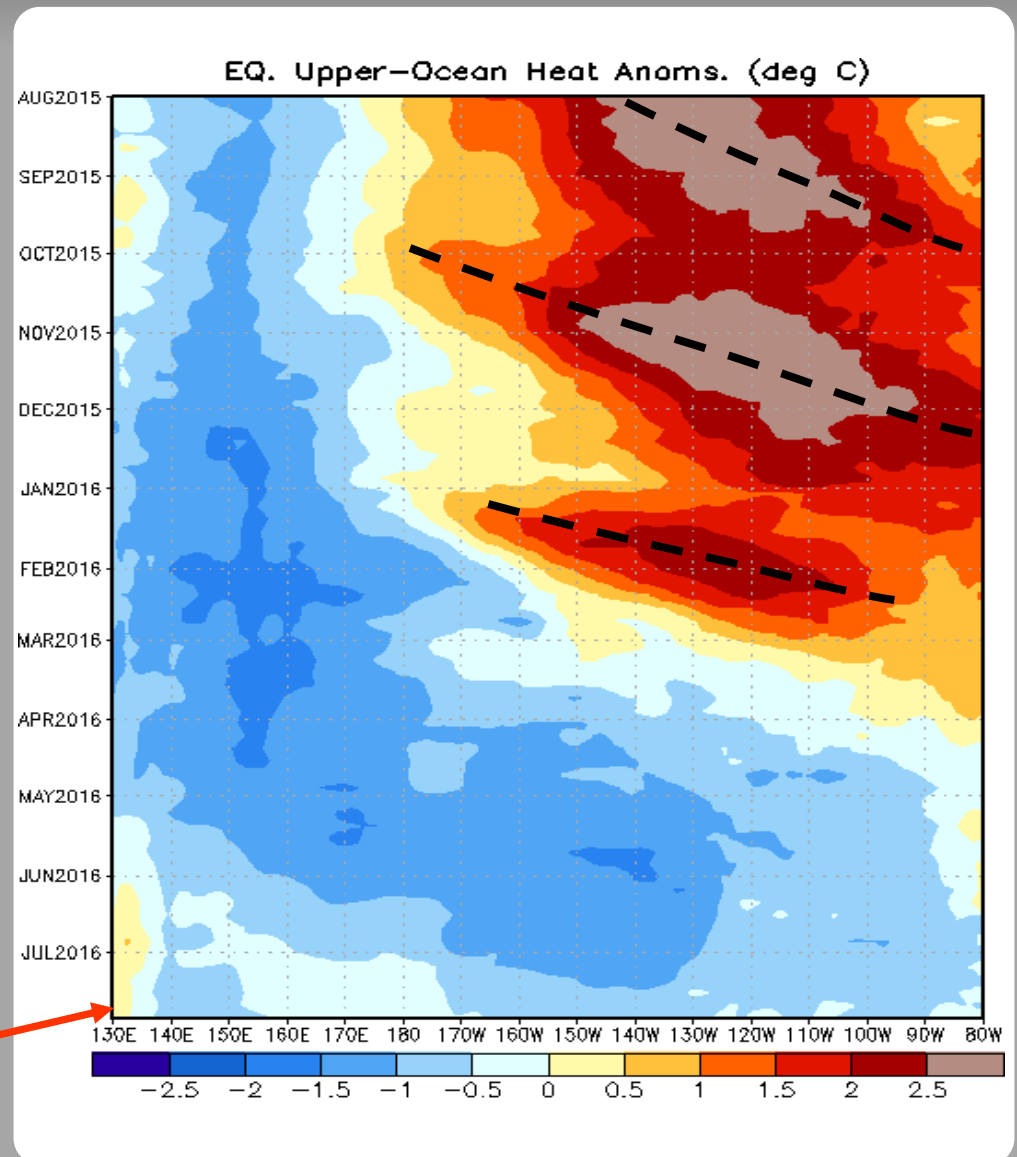
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

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 small area of positive SST anomalies is evident near 135E.



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

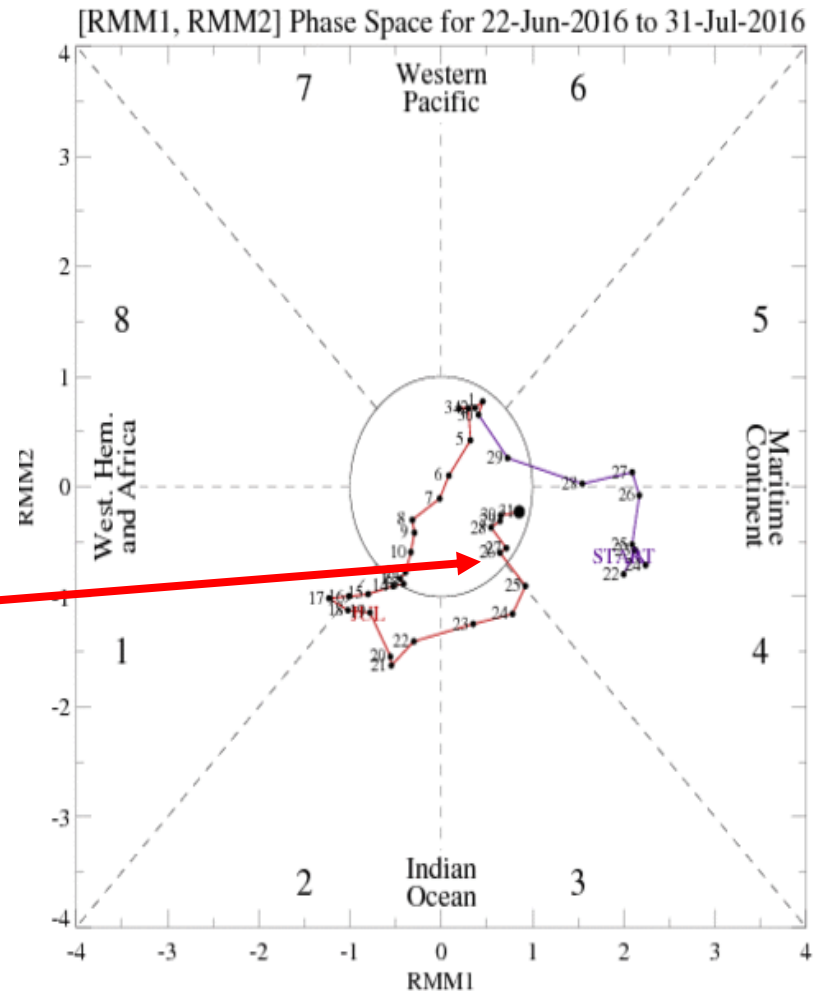
The triangular areas indicate the location of the enhanced phase of the MJO

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

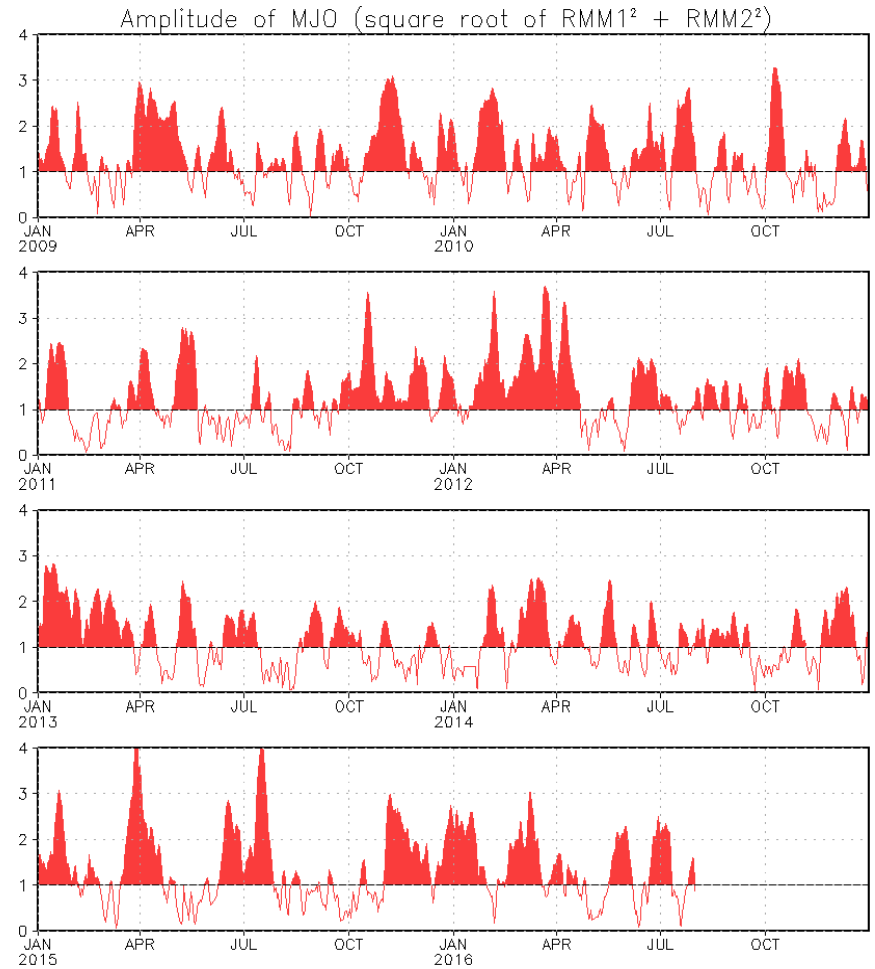
During the past week, the RMM index indicated a weakening of the MJO signal as its enhanced phase shifted east to the Maritime Continent.



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

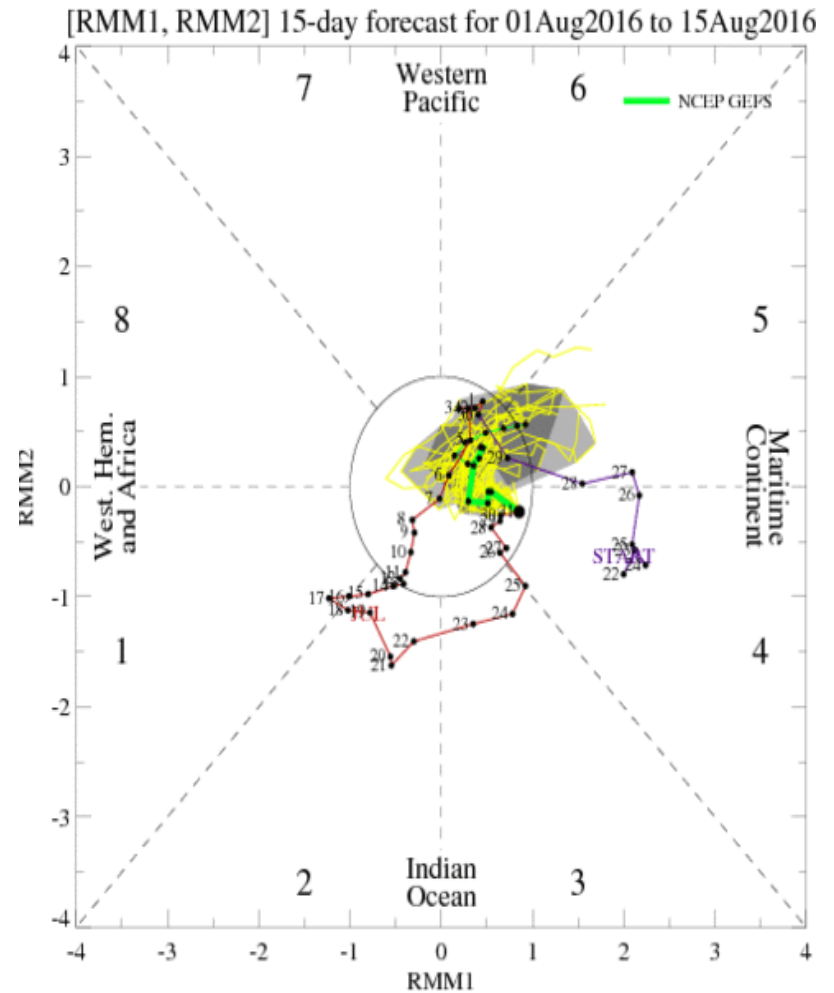
RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

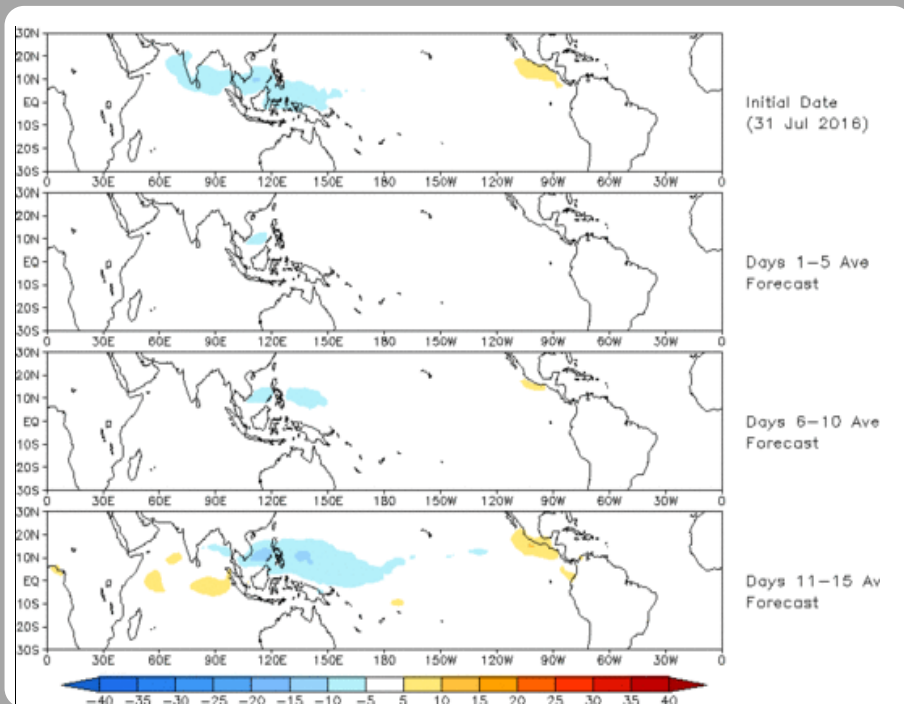
During the next two weeks, the GFS ensemble indicates a continued weak signal.

Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean



Ensemble GFS (GEFS) MJO Forecast

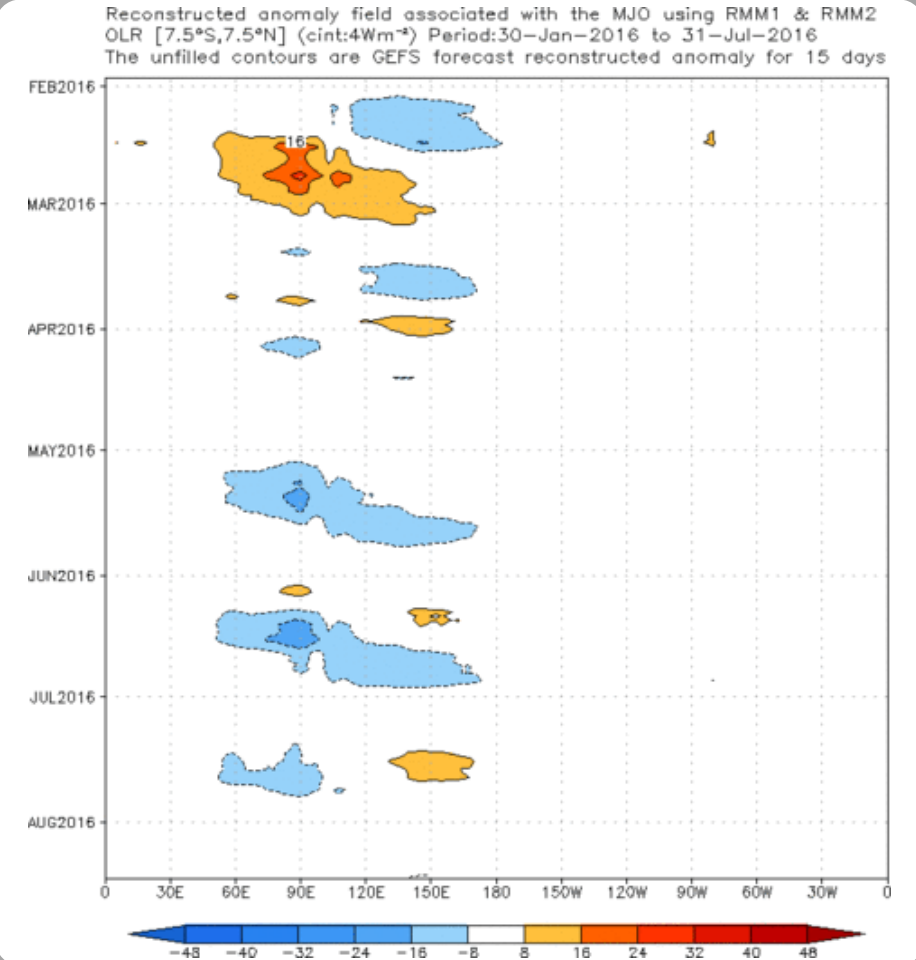
Spatial map of OLR anomalies for the next 15 days



The GEFS OLR forecast based on the GEFS forecast of the RMM Index depicts little to no anomalous convection.

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.)

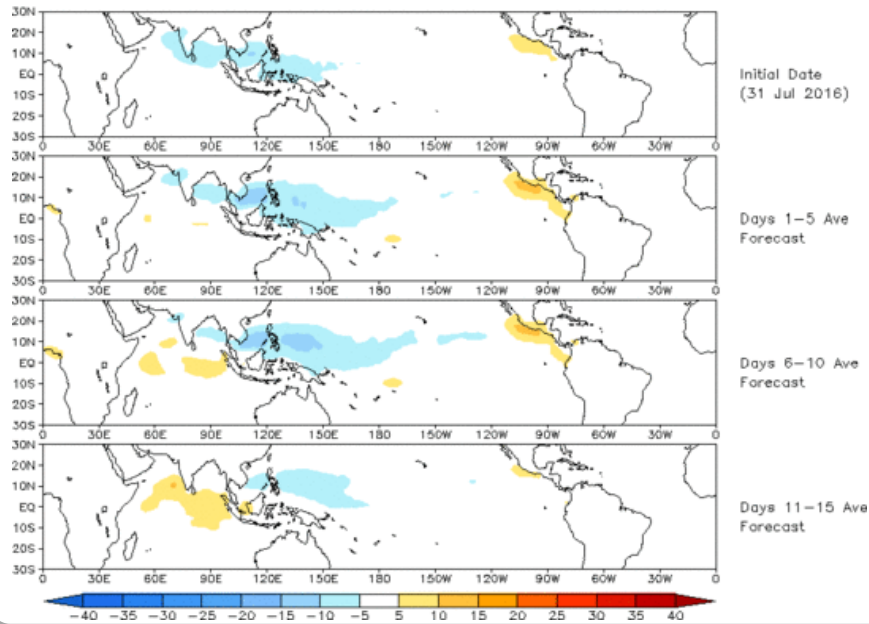
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



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 (31 Jul 2016)

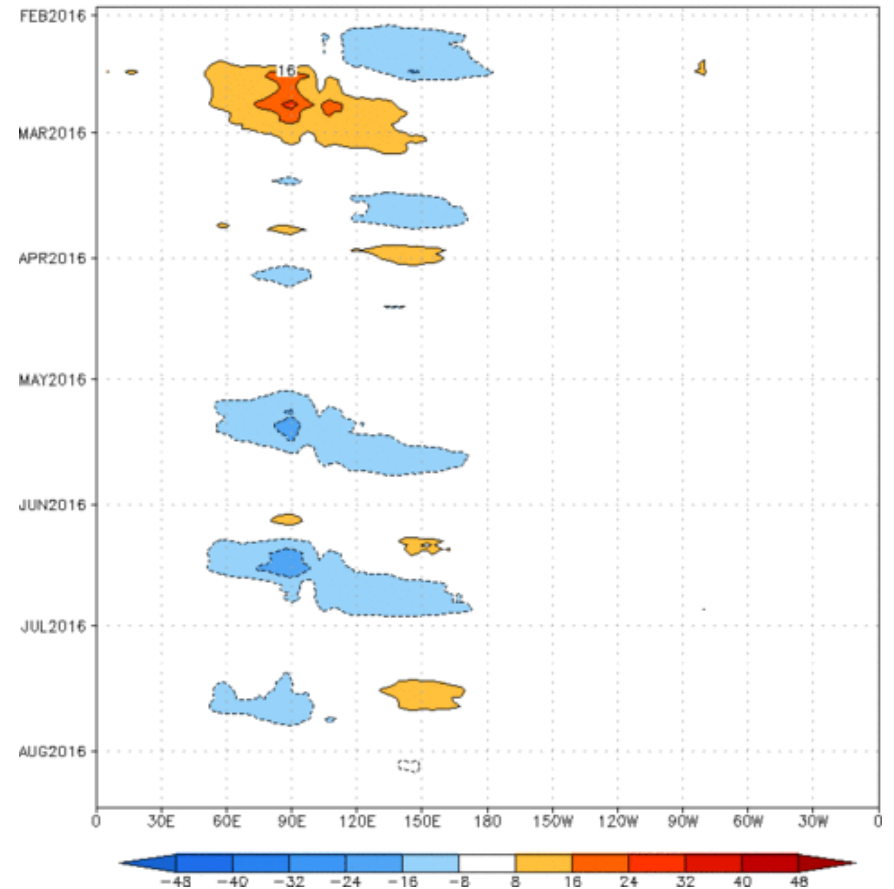


The Constructed Analog (CA) model predicts only small anomalies across the global tropics.

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

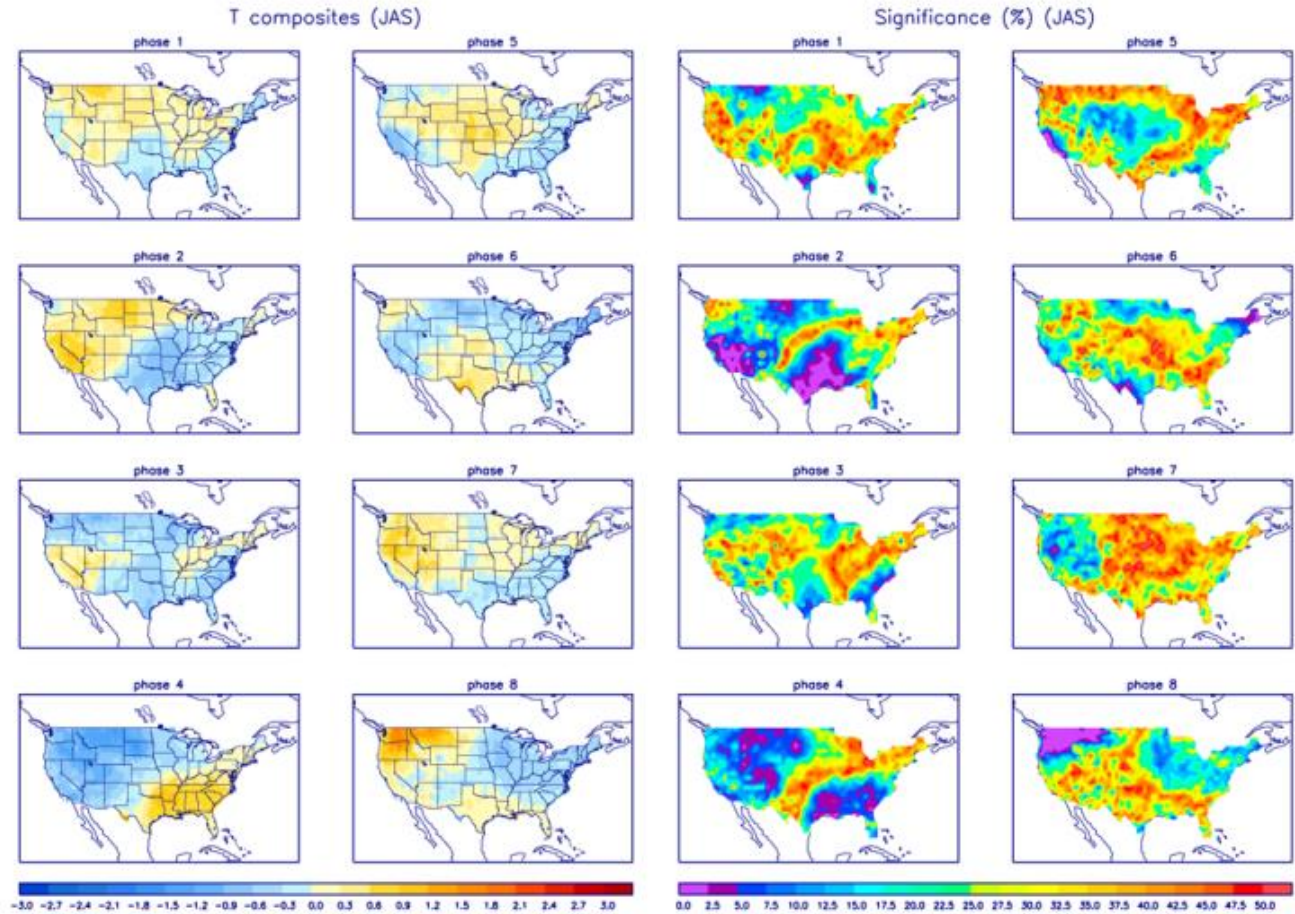
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [7.5°S,7.5°N] (cont:4Wm⁻²) Period:30-Jan-2016 to 31-Jul-2016
The unfilled contours are CA forecast reconstructed anomaly for 15 days



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.



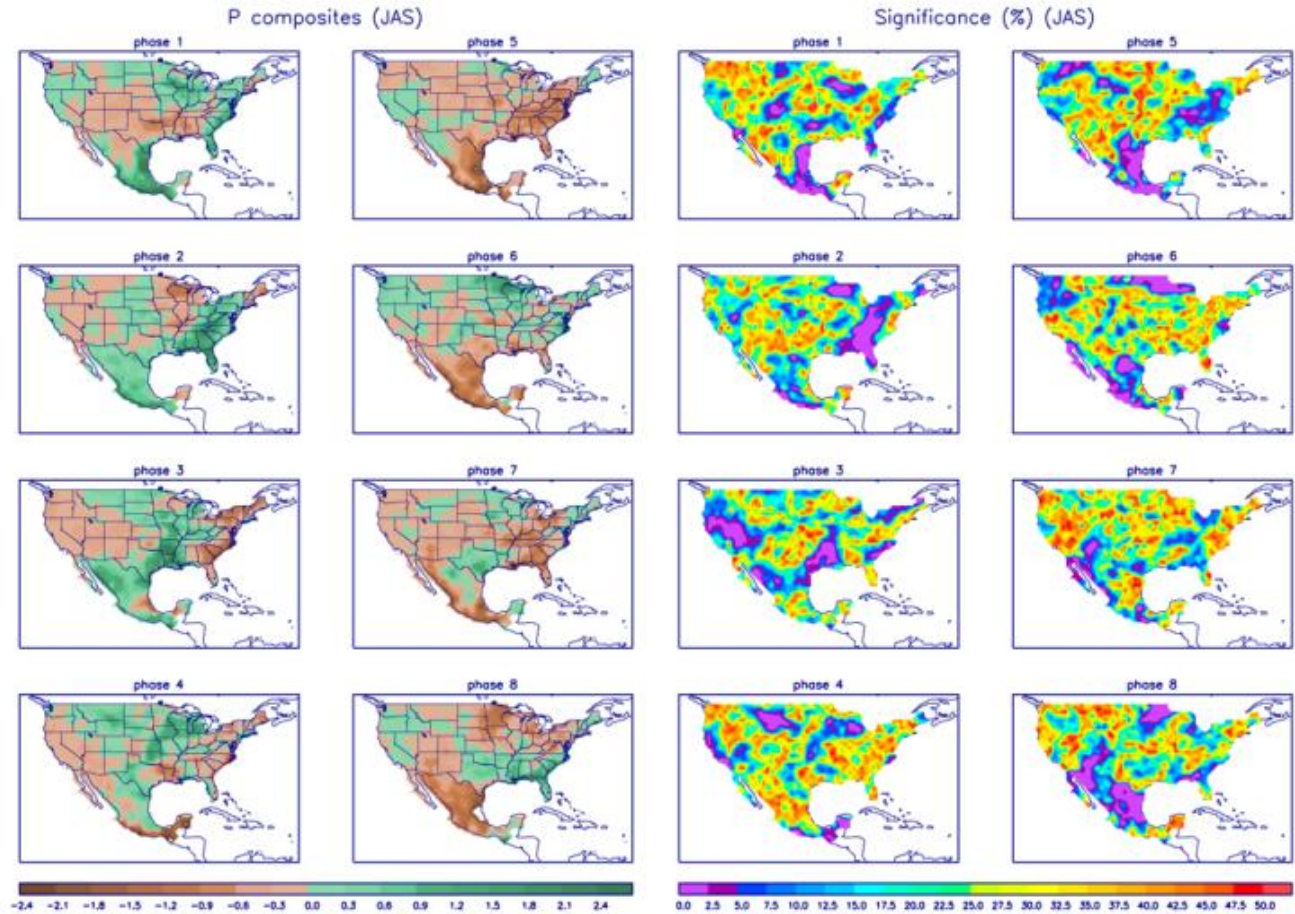
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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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