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

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Climate Prediction Center / NCEP
21 August 2017

Outline

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Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The MJO remained weak over the past several days, with limited signs of coherent intraseasonal tropical variability apparent throughout the globe.

- Dynamical model guidance is mixed, with models generally forecasting an eastward moving signal from the Indian Ocean through West Pacific over the next two weeks, with differences in amplitude ranging from a nearly negligible signal to a modest MJO event.

- Kelvin wave activity is more likely to impact weather throughout the global tropics and extratropics, via locally increasing/decreasing tropical cyclone formation chances, than any impacts from the MJO over the next two weeks.

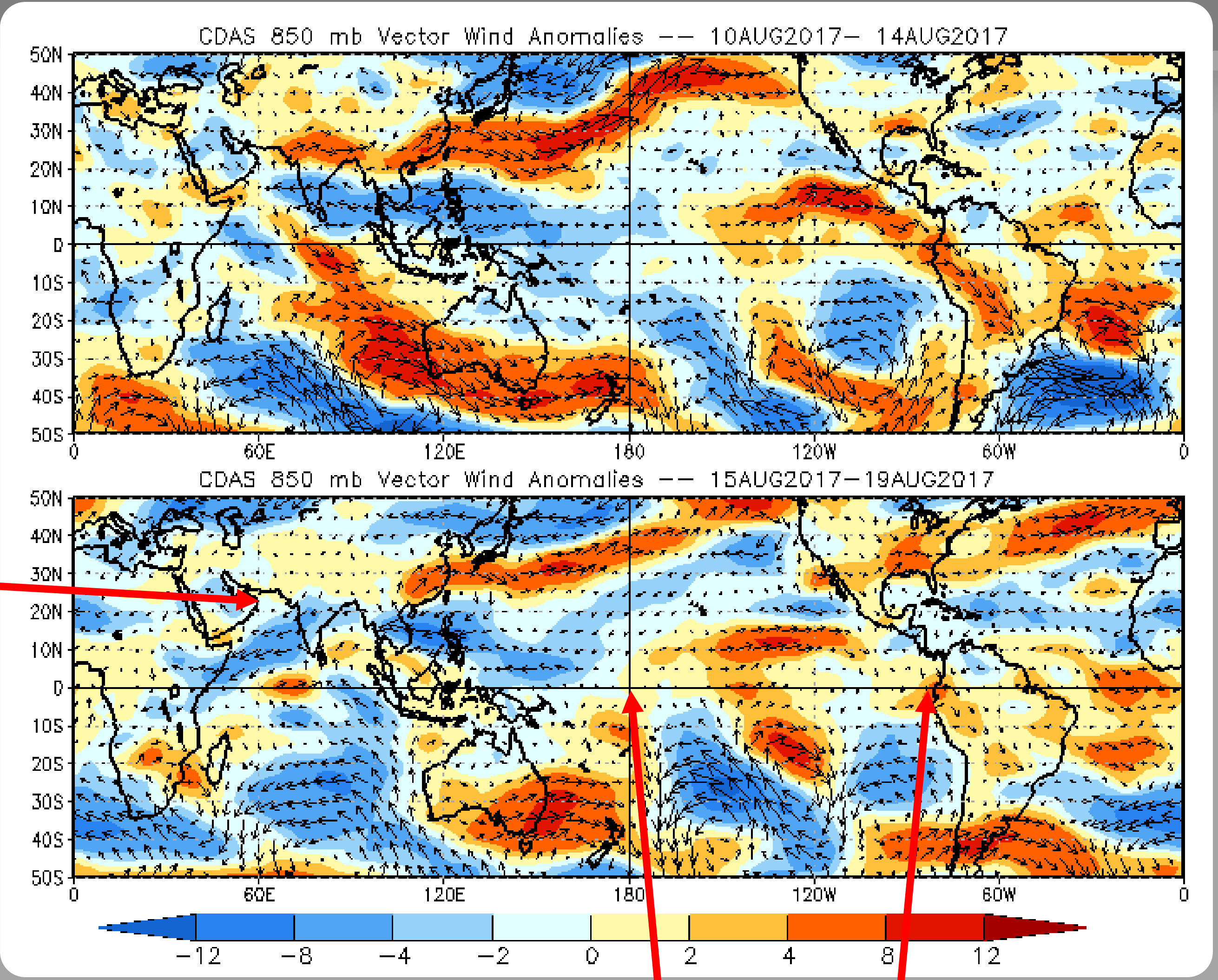
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Monsoon inflow weakened over the Arabian Sea, with easterly anomalies across most of India.

Westerlies were prevalent in the equatorial region from the Date Line through Central Africa.

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

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

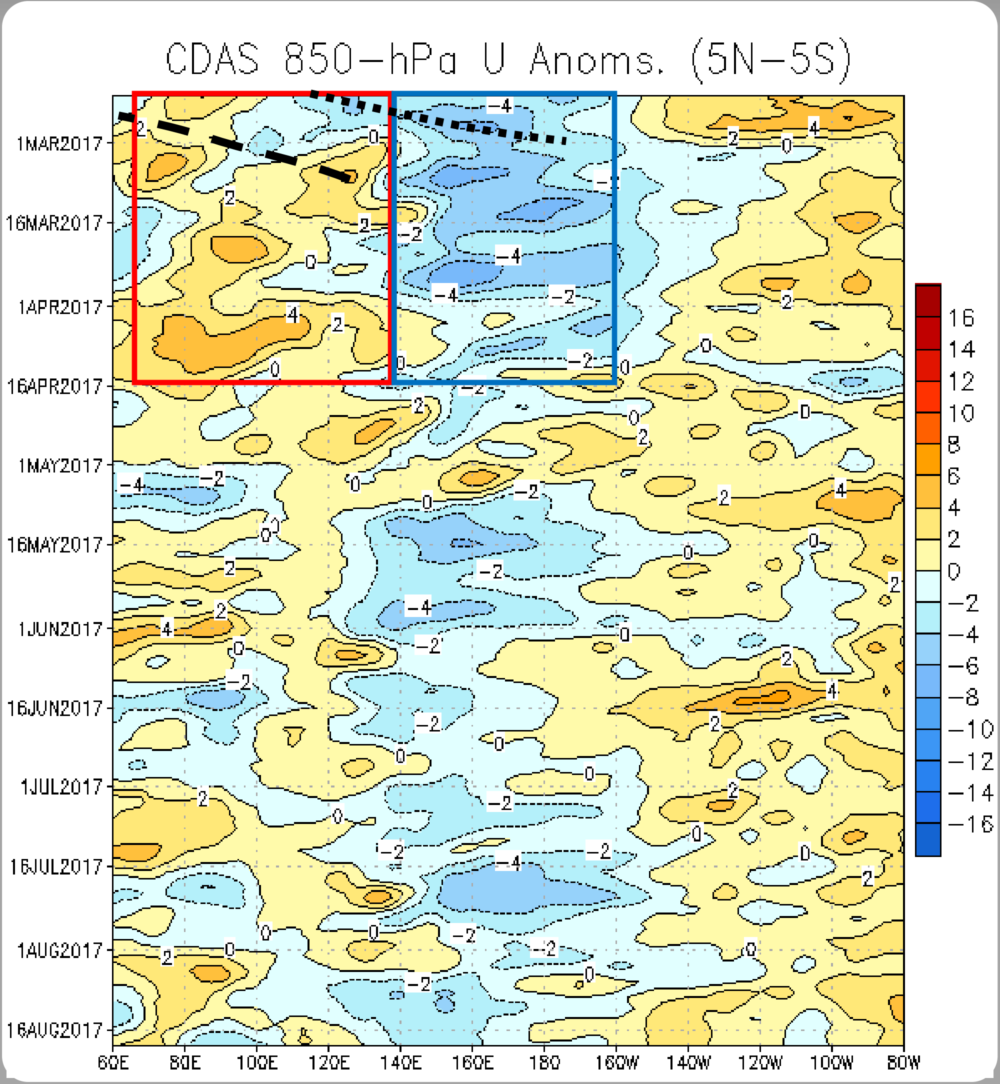
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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 La Niña.

In February, MJO activity 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 close to climatology during June. During July, the low-frequency pattern shifted eastward, with easterly anomalies over the central Pacific. Intraseasonal variability shifted the pattern in late July.

Recently, easterly anomalies have developed over the Maritime Continent, with westerly anomalies over the East Pacific and Atlantic.



OLR Anomalies – Past 30 days

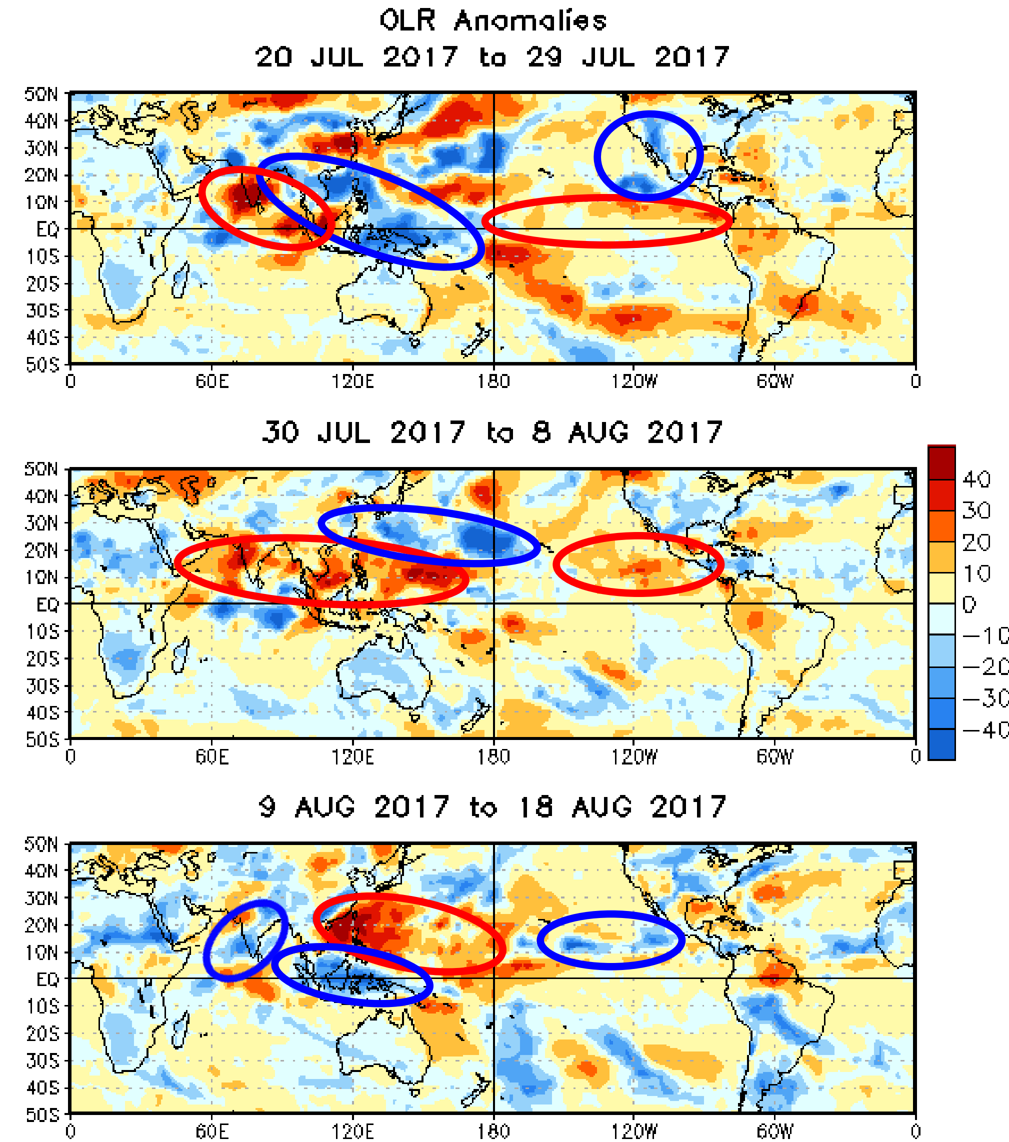
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late July a dipole of suppressed (enhanced) convection existed over India (southeast Asia and the Maritime Continent). Tropical cyclone (TC) activity and a surge in the North American Monsoon were obvious in the East Pacific.

During late July and early August, anomalous dryness was observed from the Arabian Sea through West Pacific, while wet conditions further north were associated with Typhoon Noru. TC activity in the East Pacific experienced a lull.

TC activity resumed in the East Pacific with Jova and Kenneth, while anomalous dryness extended from the South China Sea through Date Line. Anomalously wet conditions returned to India and the Maritime Continent.



Outgoing Longwave Radiation (OLR) Anomalies (2.5ºN - 17.5ºN)

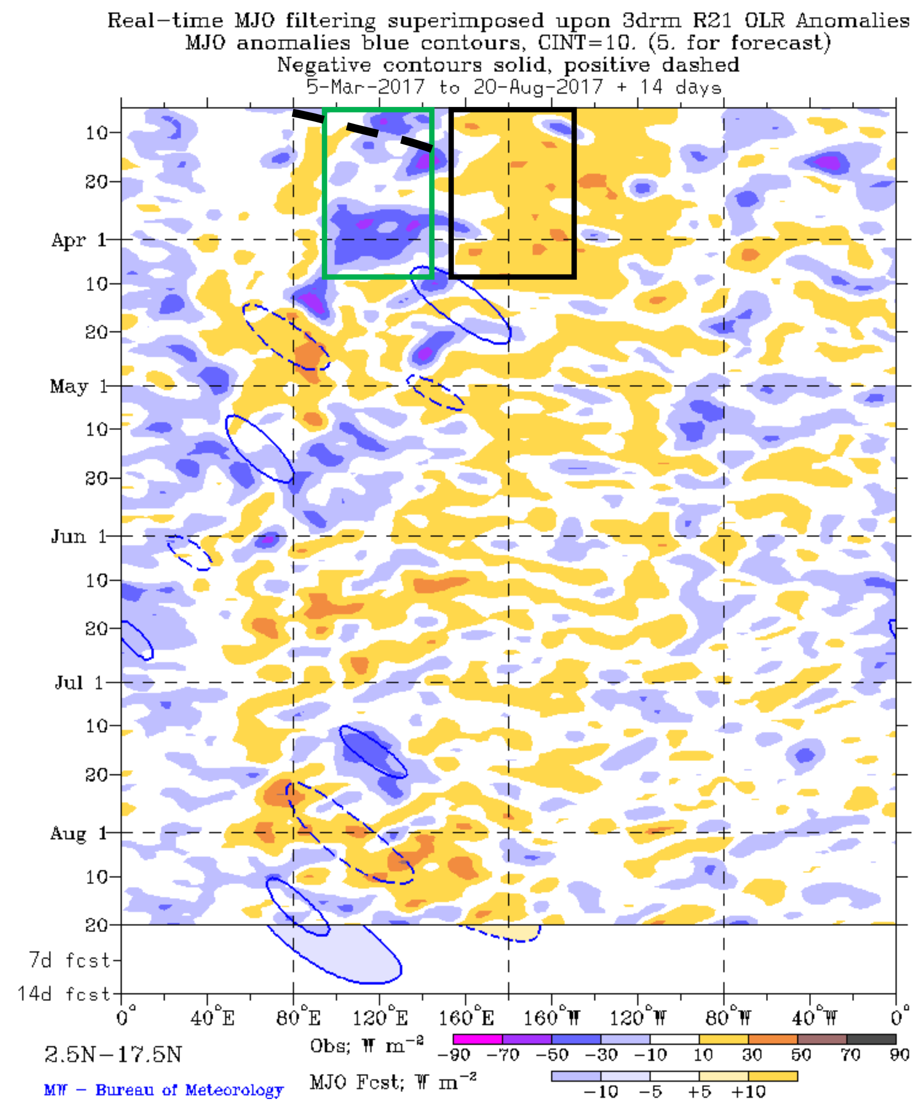
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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 (black box).

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 mid-July, there was a burst of enhanced convection over the Maritime Continent, due to interactions between a potential intraseasonal signal and the low-frequency state. More recently, another enhanced intraseasonal envelope appears to be crossing from the eastern Indian Ocean towards the Maritime Continent.



200-hPa Velocity Potential Anomalies (5ºS - 5ºN)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

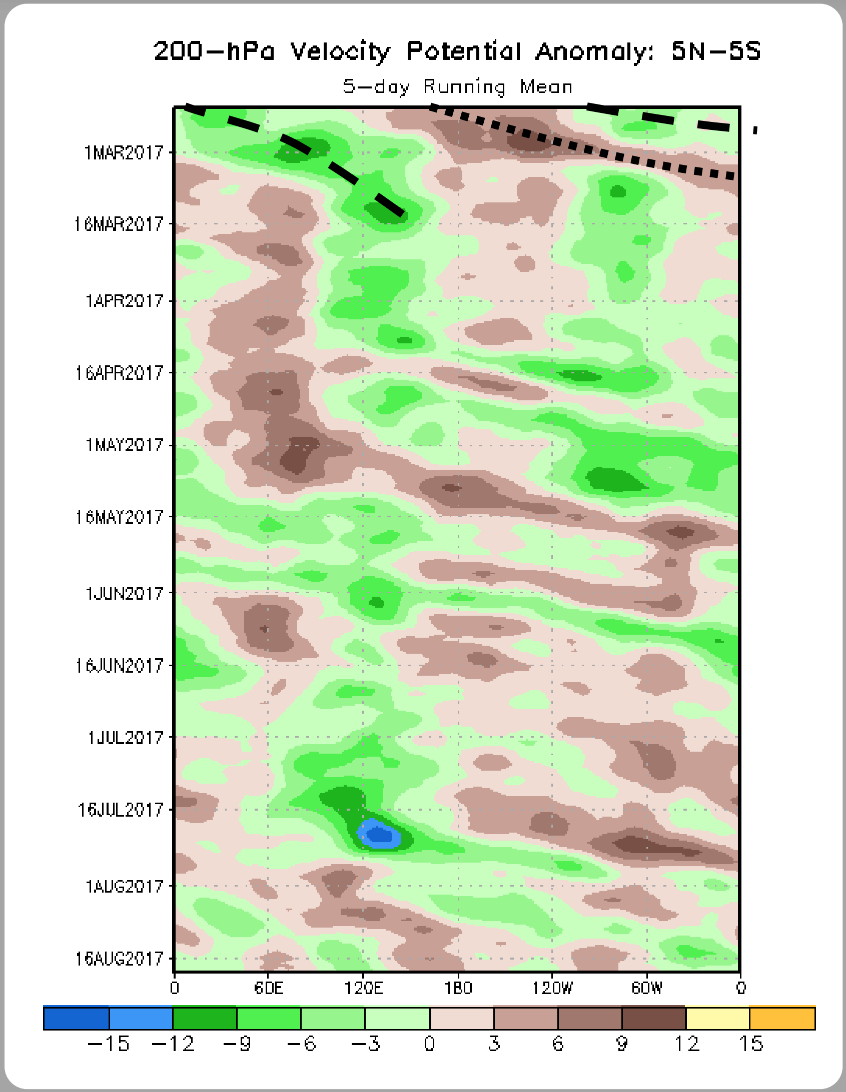
Negative anomalies (green shading) indicate favorable conditions for precipitation

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.

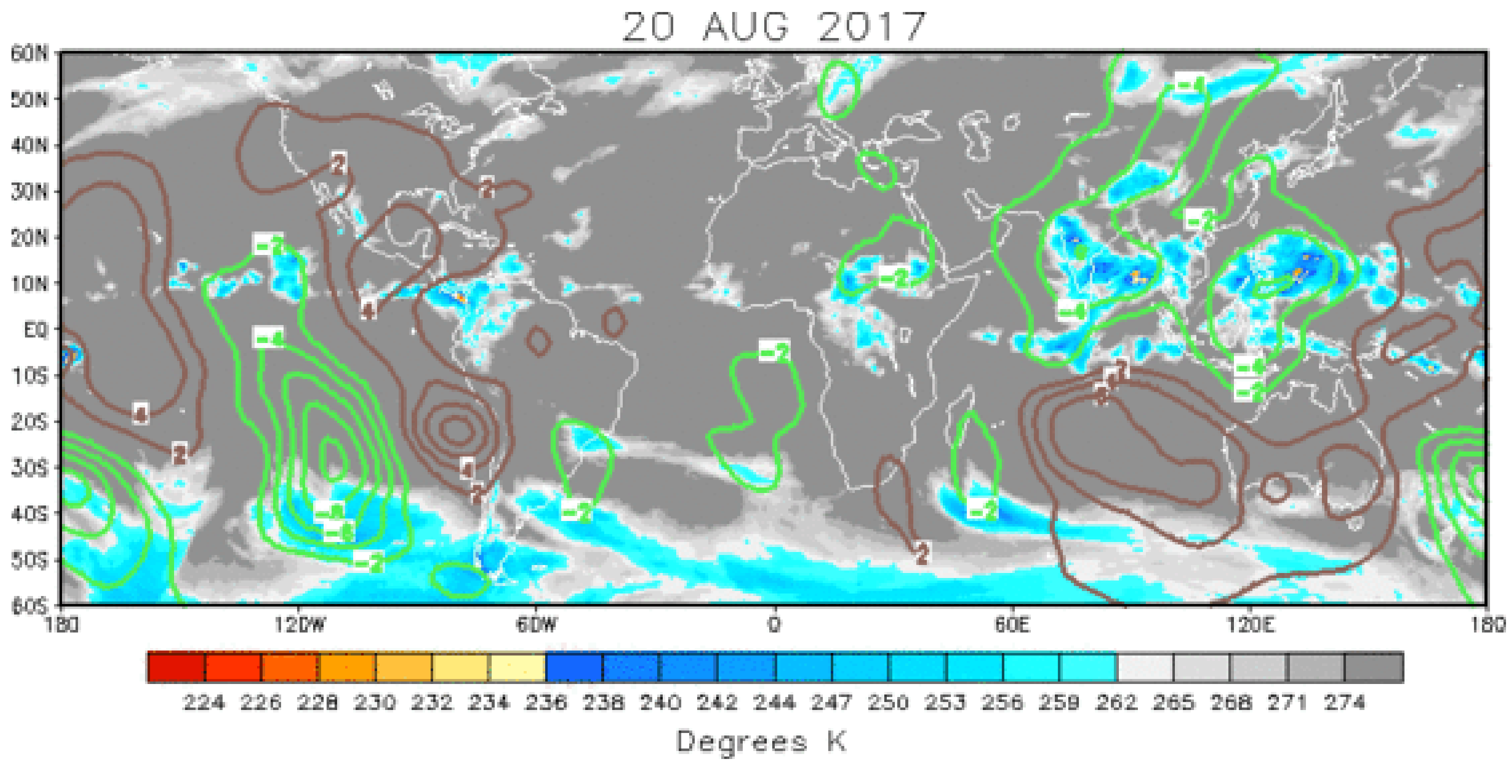
During March, a low frequency signal favoring enhanced (suppressed) convection over the Maritime Continent (Indian Ocean) became the primary component of the anomaly field.

Kelvin wave activity was apparent from April through early June, as seen in the rapidly propagating eastward signals. During July, enhanced convection strengthened over the Maritime Continent as the low-frequency signal constructively interfered with an easterly propagating signal.

Recently, suppressed convection overspread the West Pacific, with weakly enhanced convection (Kelvin wave-related) now over the Maritime Continent and Africa.



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



No clear ties to coherent intraseasonal variability are apparent. A convective dipole exists across the equator in the Indian Ocean and West Pacific while tropical cyclone activity is associated with a break in suppressed convection over the Central and East Pacific.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

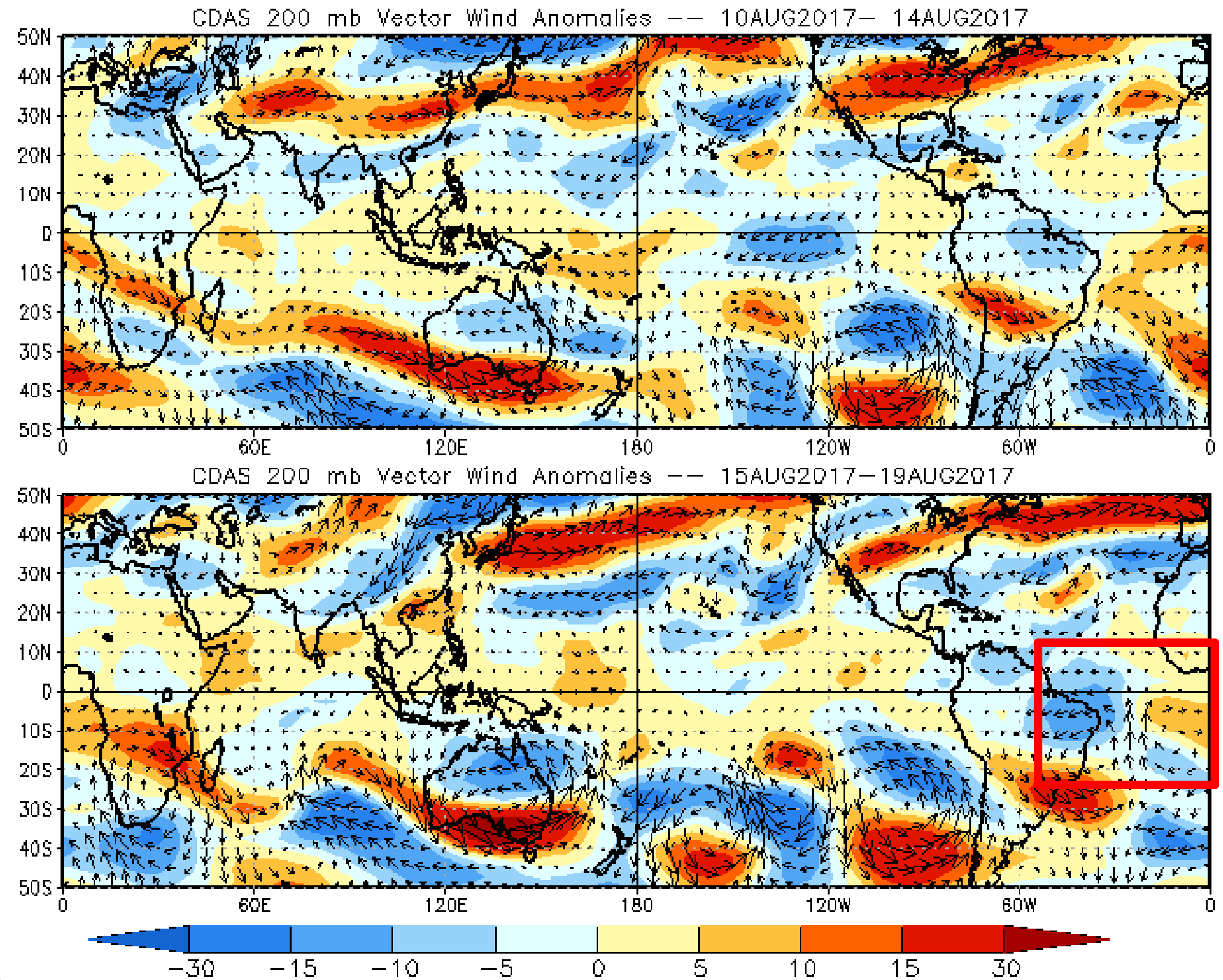
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



In the extratropics, anomalous flow in the Northern Hemisphere remained fairly zonal, while Southern Hemisphere was more amplified but had little tropical impact outside of the Atlantic.

Elsewhere, flow in the tropics was fairly weak and generally westerly.

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

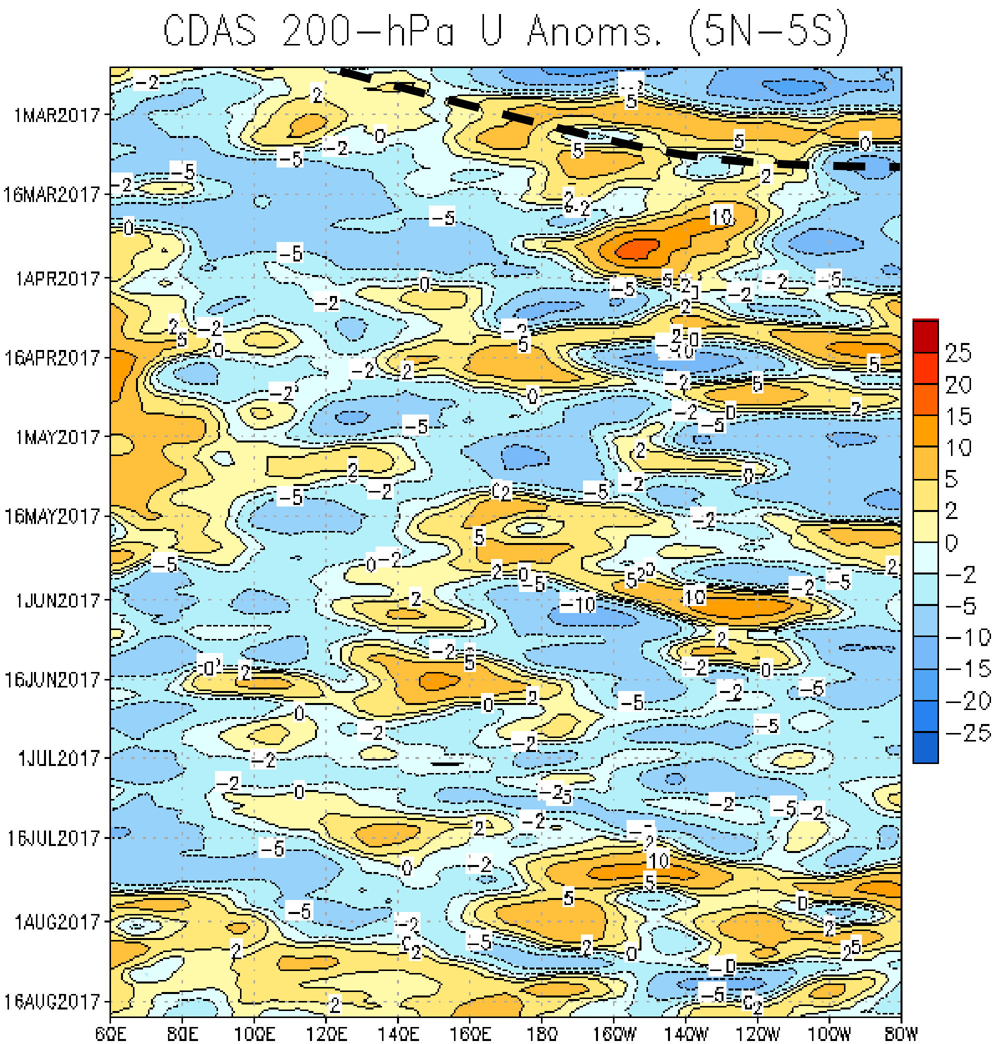
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

Easterly anomalies returned to the East Pacific during late April and persisted with some period of high-frequency interference.

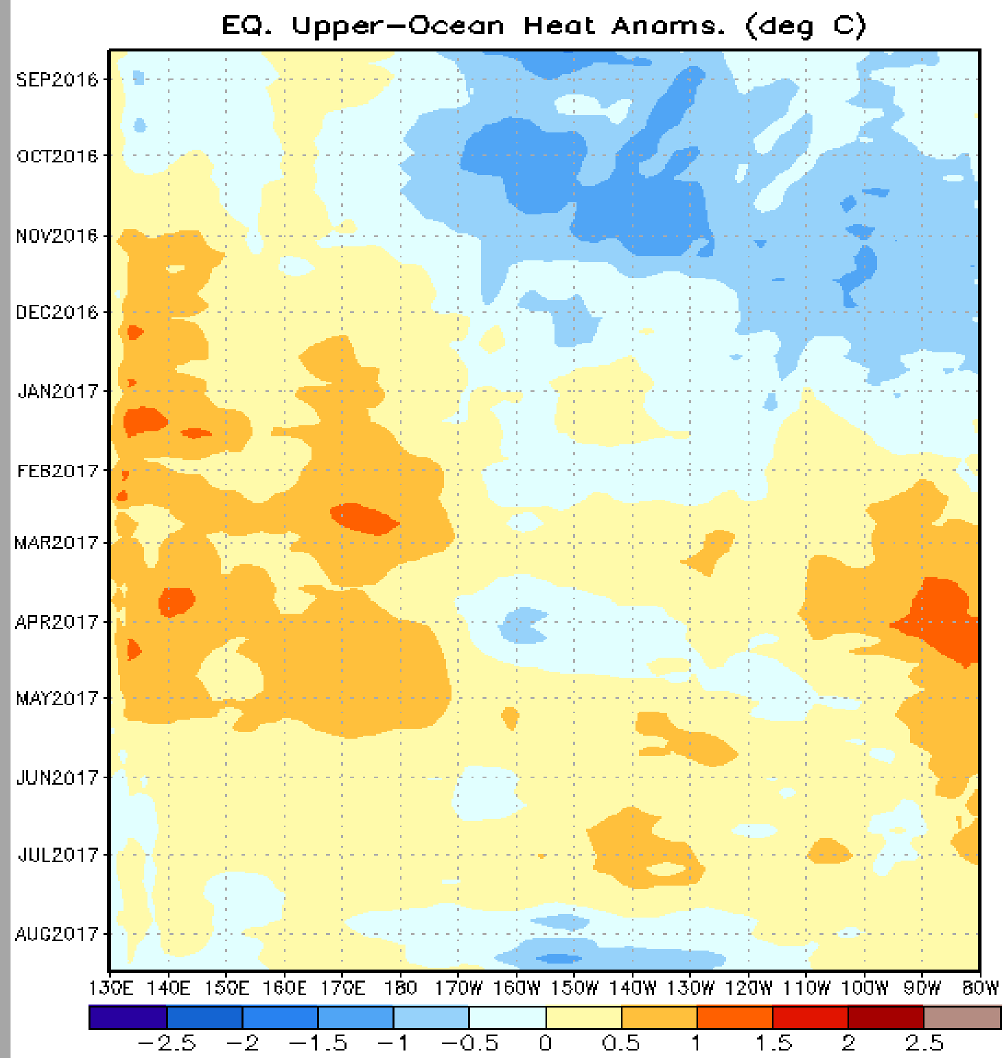
During early to mid-June, easterly anomalies were most prominent across the global tropics, in part due to mid-latitude influences.

Starting in July, the anomaly patterns have been continually moving eastward. Now westerly (easterly) anomalies are over the Maritime Continent (Central Pacific). Smaller spatial scale anomalies (associated with higher-frequency variability) are also evident.



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.



Upper-ocean heat content values continued to drop in the central Pacific as trade winds were near to above average during early August while temperature anomalies 50-200 meters below the surface continued to cool.

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

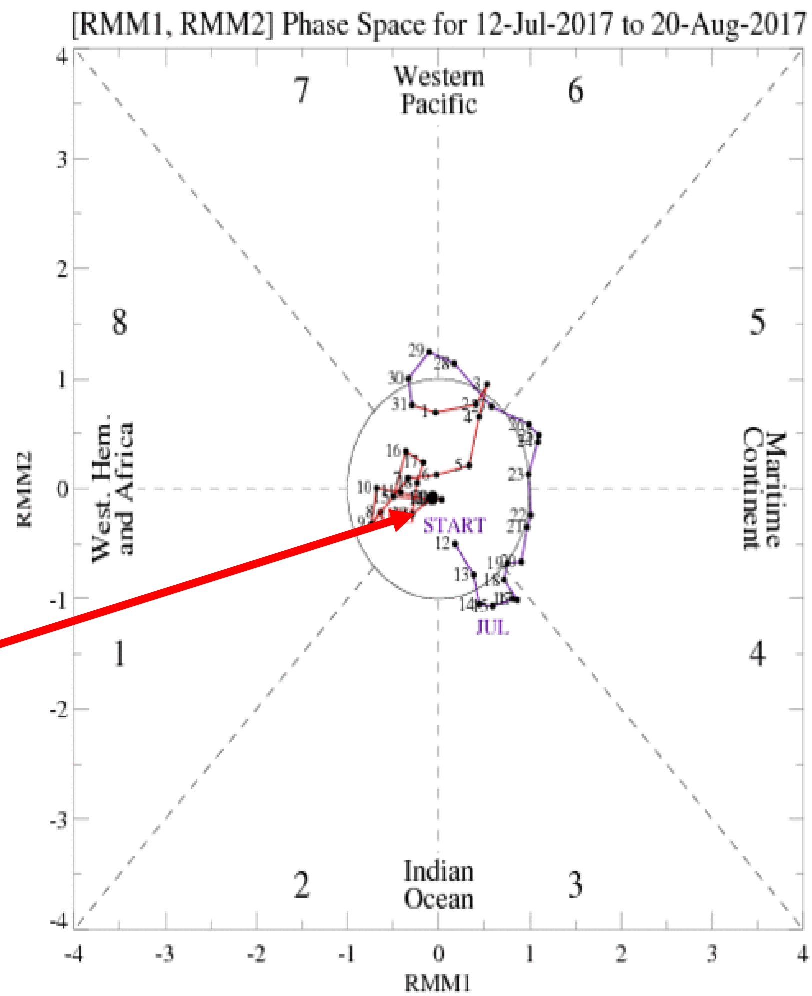
The triangular areas indicate the location of the enhanced phase of the MJO

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

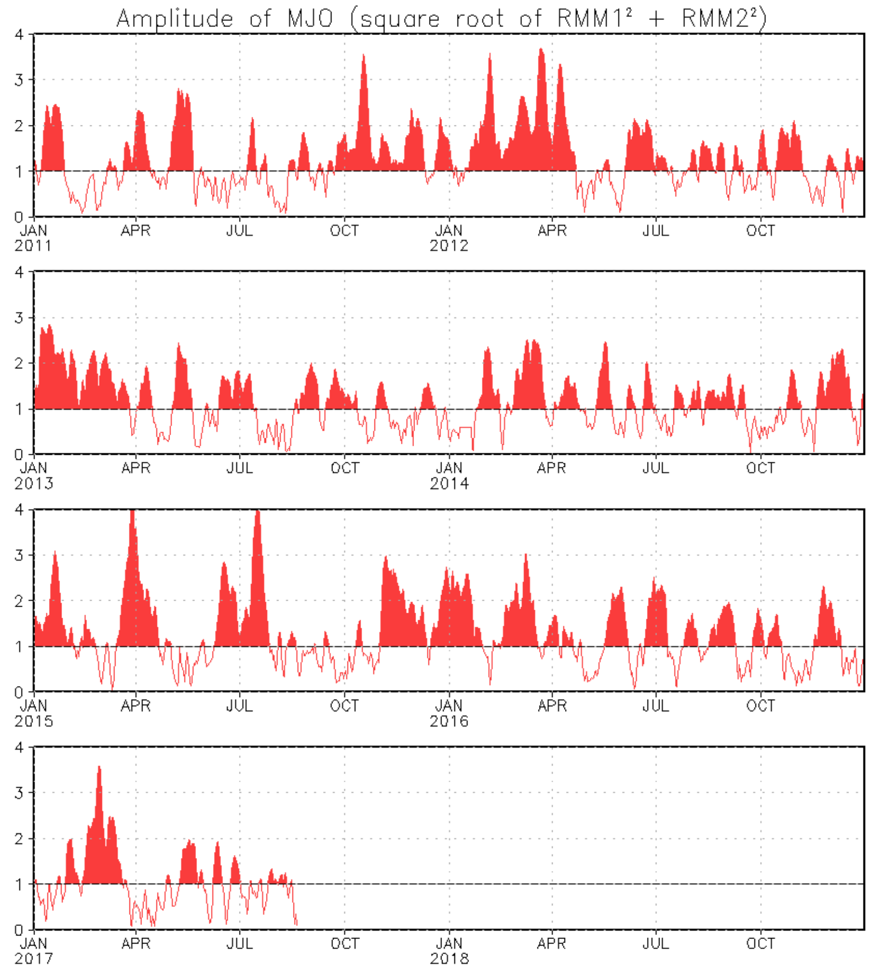
The MJO signal remained weak during the past 7 days.



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

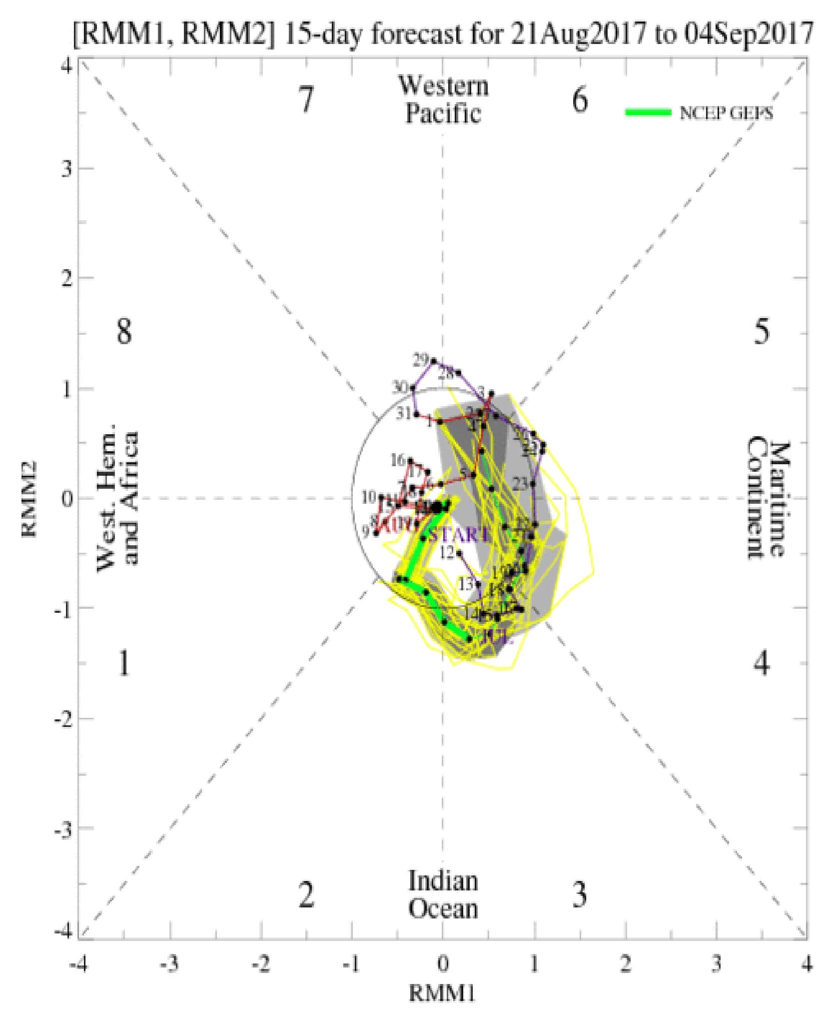
<u>Yellow Lines</u> - 20 Individual Members
<u>Green Line</u> - Ensemble Mean

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

<u>light gray shading</u>: 90% of forecasts

<u>dark gray shading</u>: 50% of forecasts

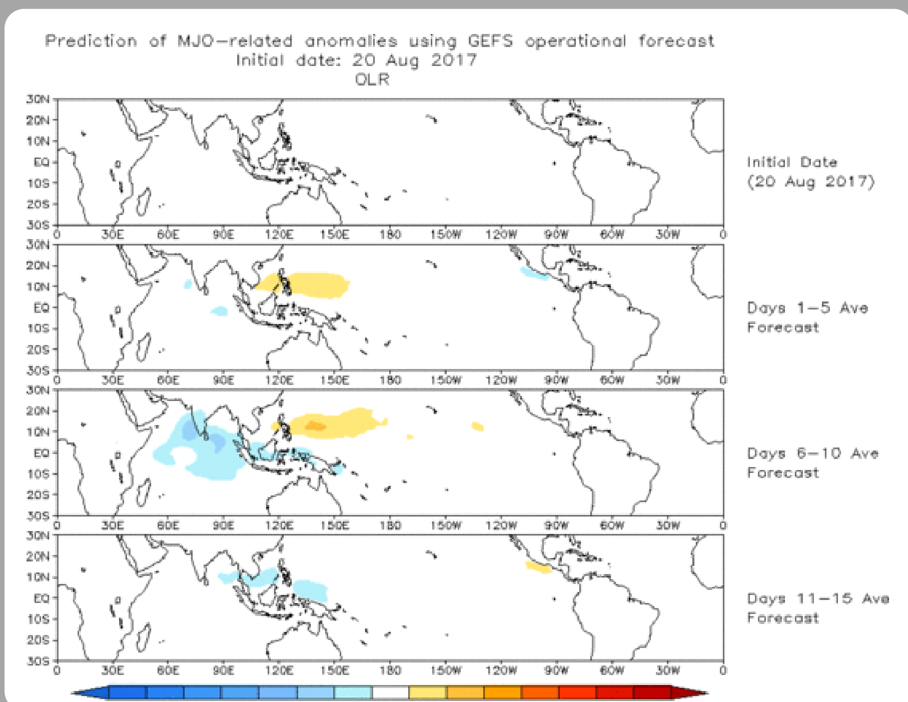
The GEFS ensembles consistently depict an emerging intraseasonal signal over the Indian Ocean late in Week-1 that decays over the Maritime Continent in Week-2.



Ensemble GFS (GEFS) MJO Forecast

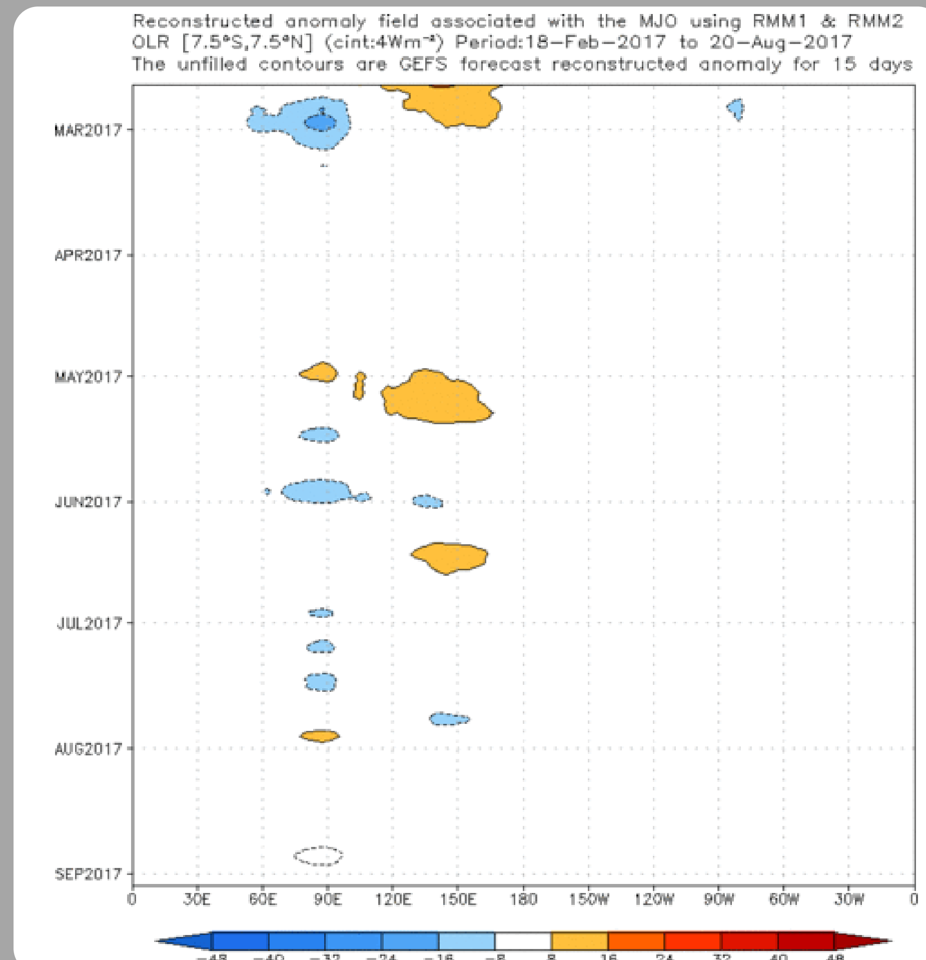
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS RMM-based OLR anomaly forecast shows a weak signal emerging in 6-10 days, that then propagates eastward and weakens.

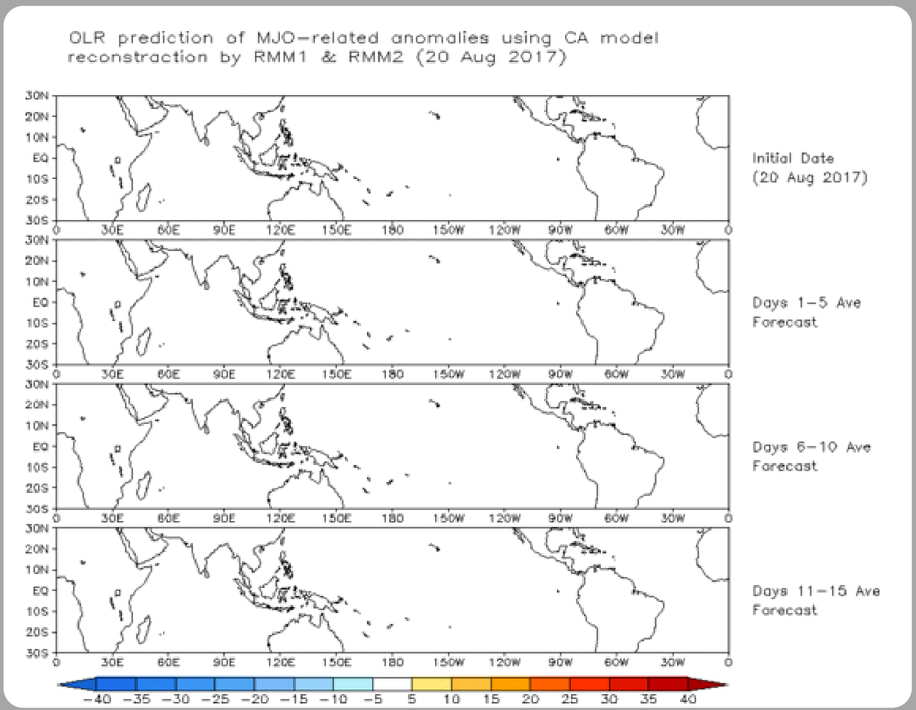
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

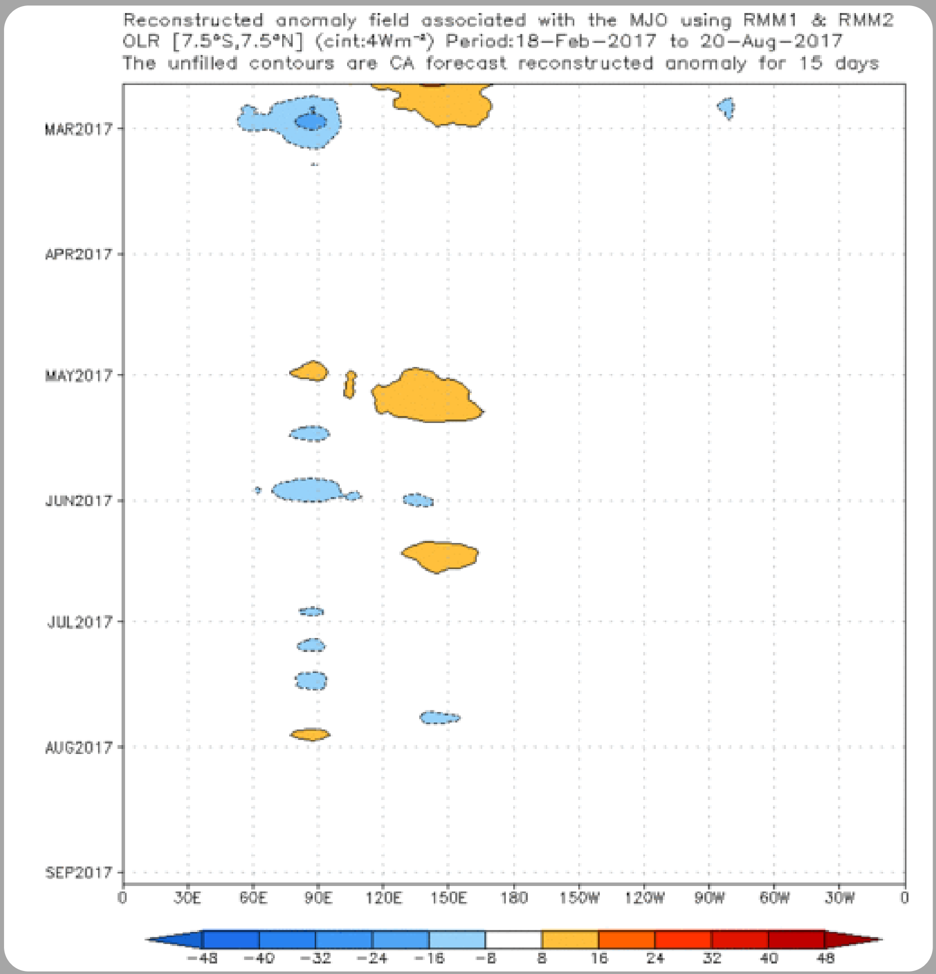
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The constructed analog depicts no MJO-based signal.

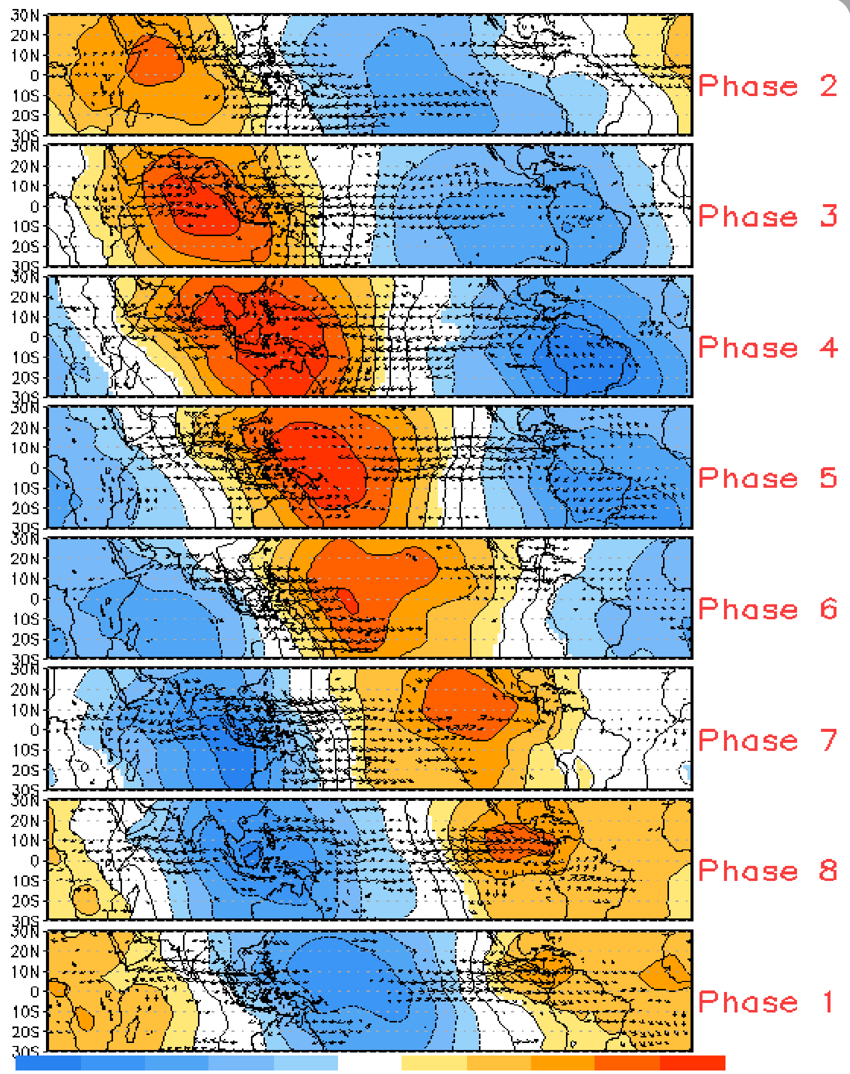
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



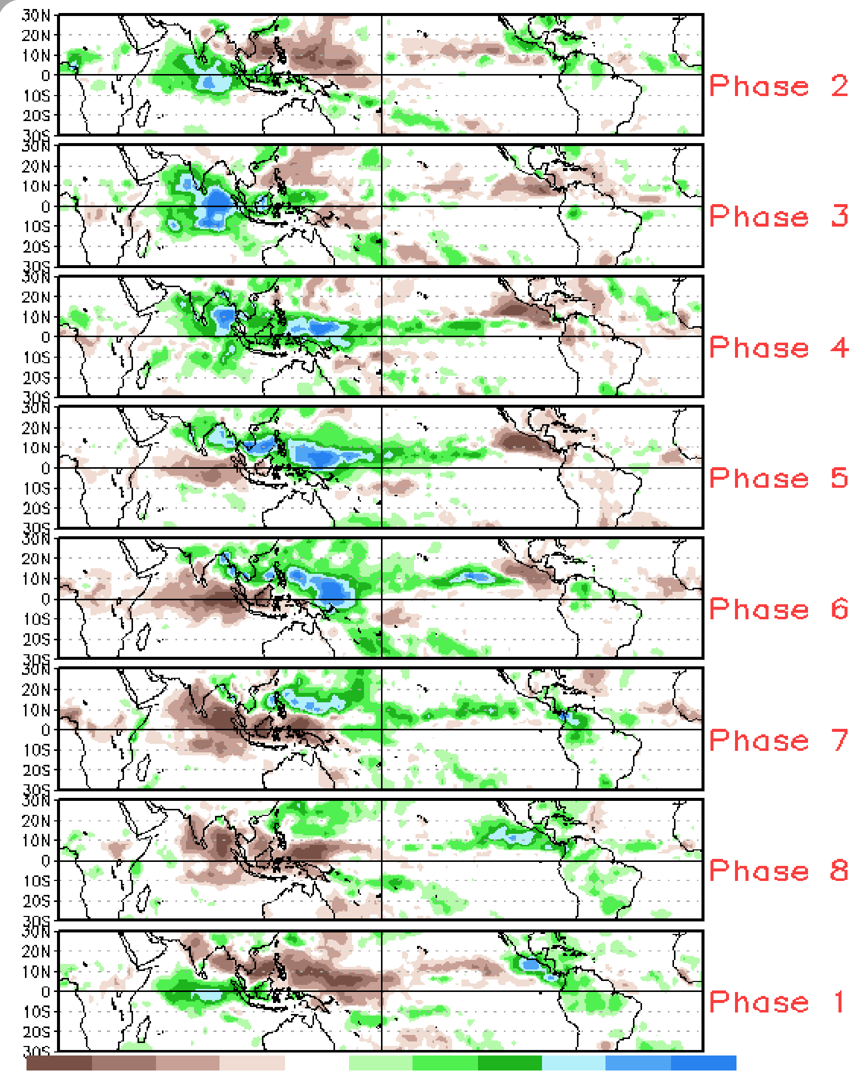
MJO Composites - Global Tropics

850-hPa Velocity Potential and

Wind Anomalies (May - Sep)



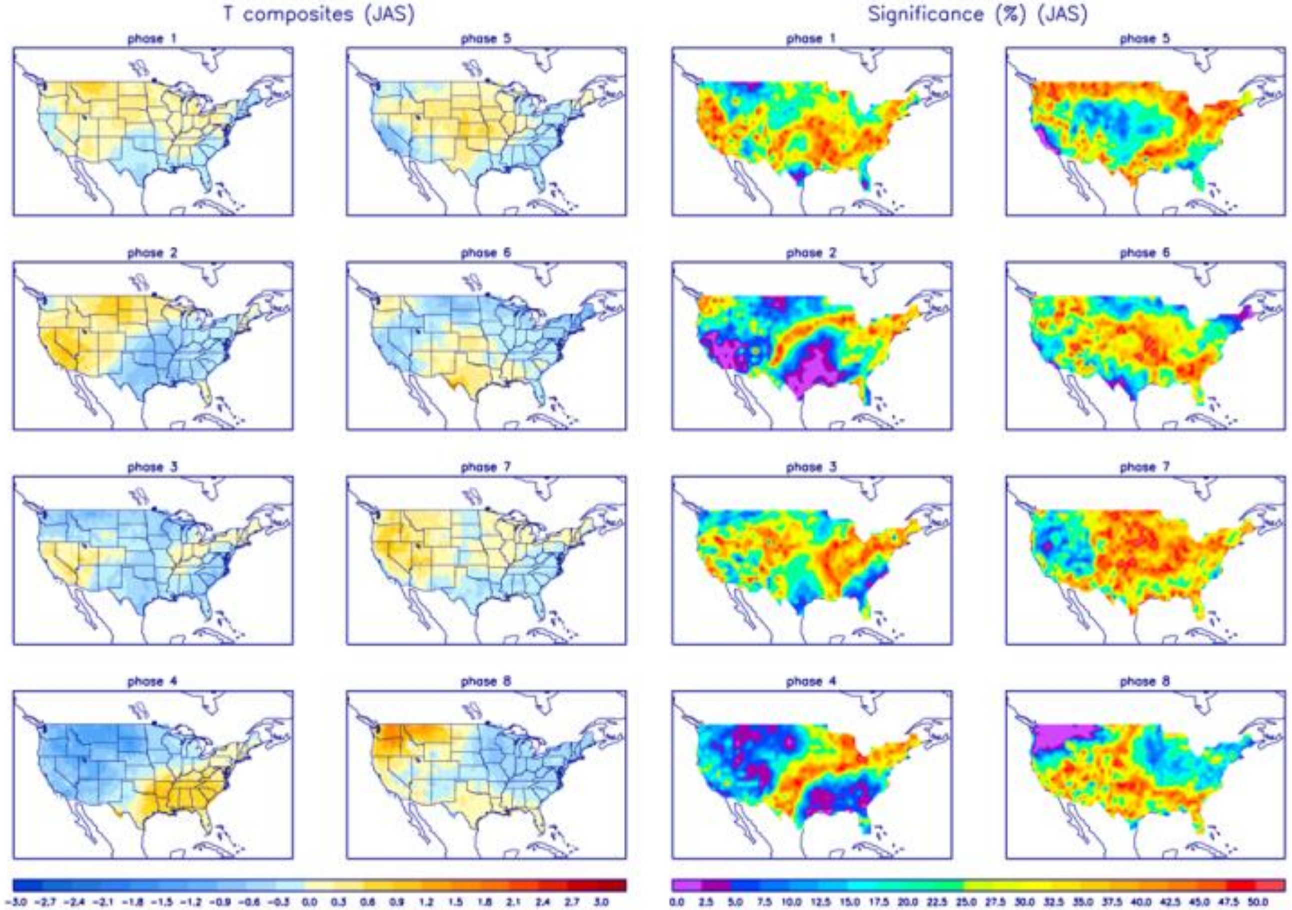
Precipitation Anomalies (May - Sep)



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.



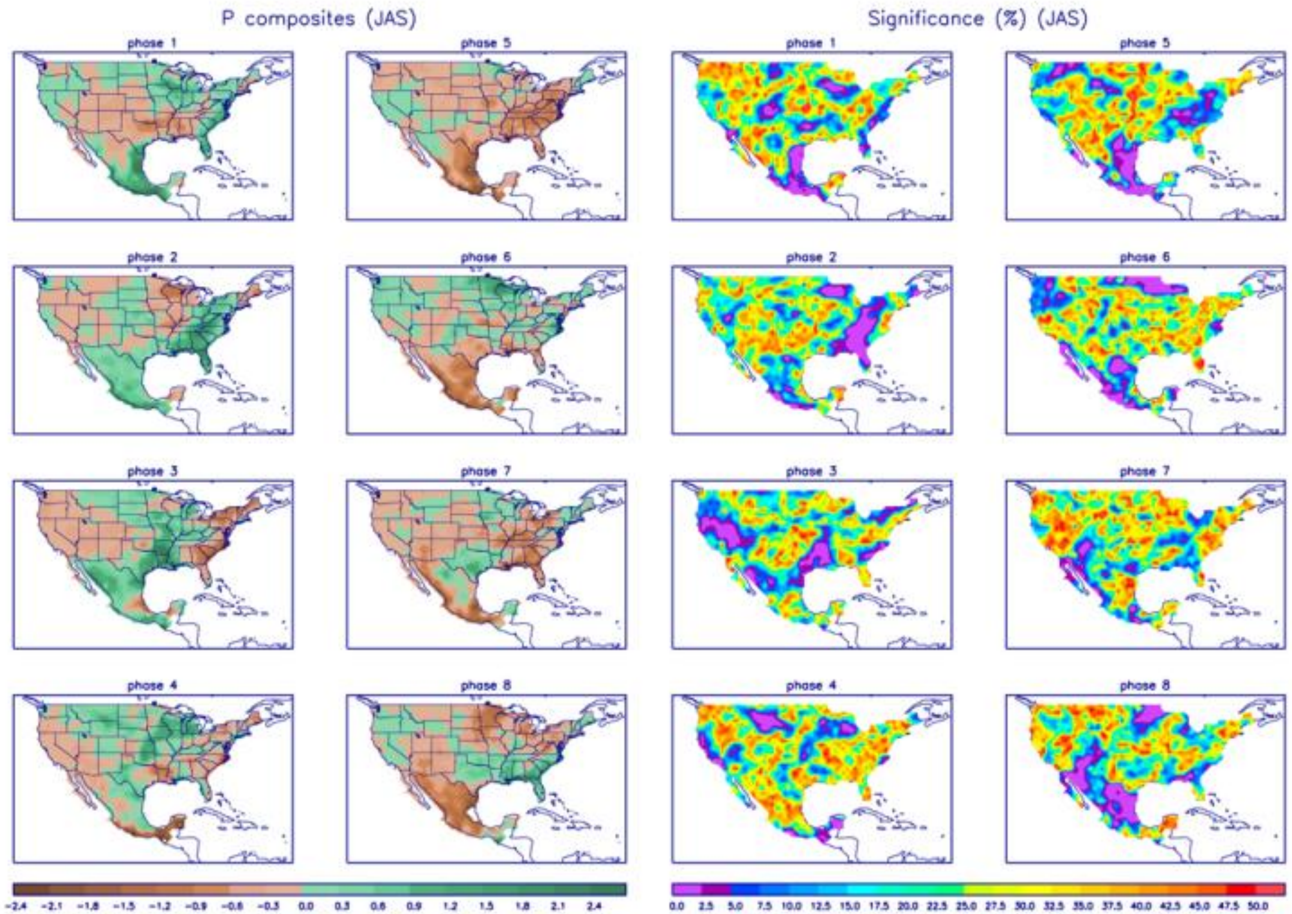
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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.



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