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

Update prepared by:
Climate Prediction Center / NCEP
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Overview

The MJO signal is weak and incoherent. The recent uptick in tropical storm activity this past week over the western North Pacific has aliased into the MJO band.

Dynamical model guidance generally suggests a westward shift in the tropical convection from the western North Pacific towards the Maritime Continent.

Tropical cyclone formation and above-normal rainfall likelihood are enhanced over the western North Pacific throughout the forecast period. Tropical cyclone activity is also enhanced across the central, tropical North Atlantic, but any systems which may form are expected to weaken as they track westward into the Caribbean Sea or far western Atlantic.

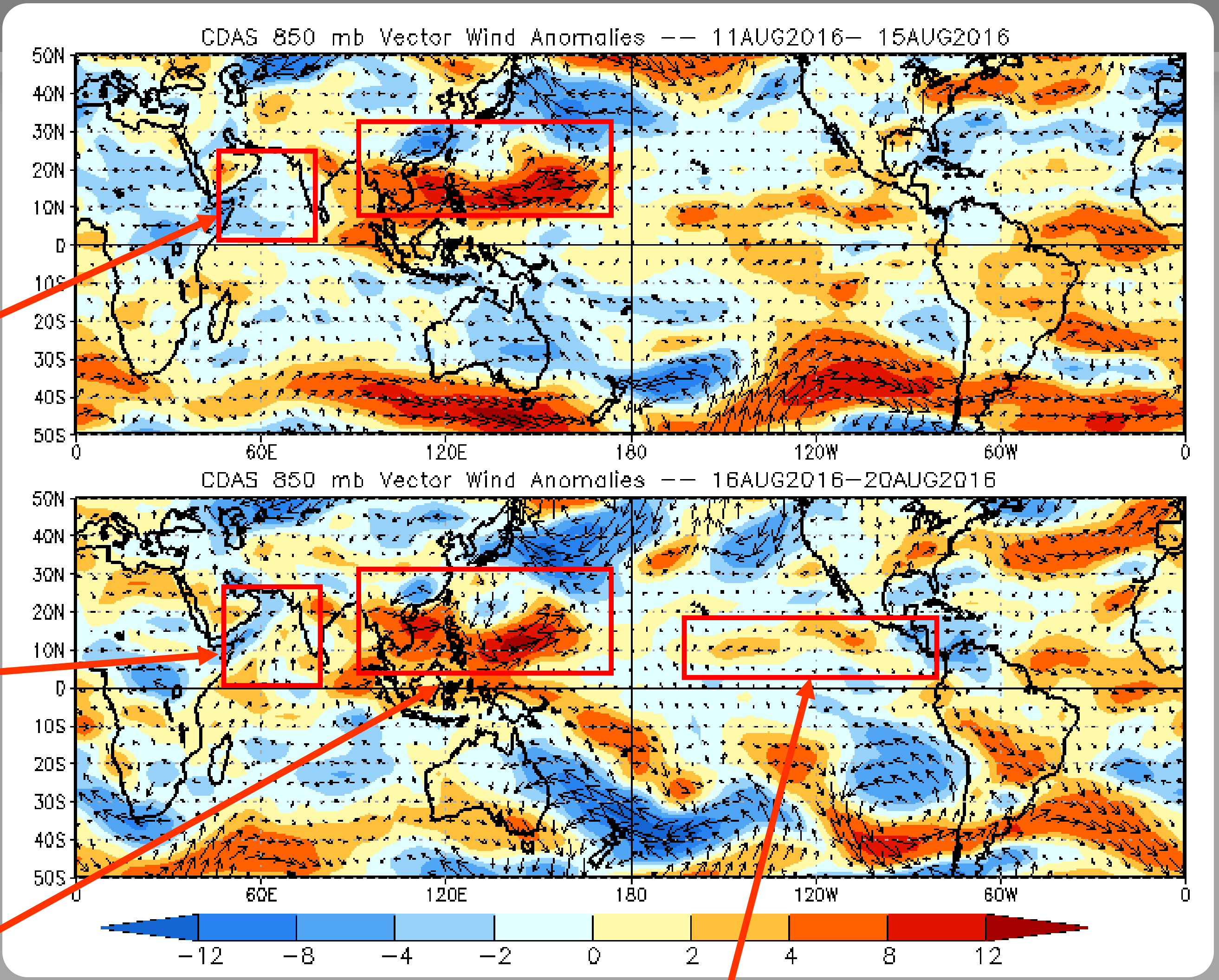
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Wind anomalies over the Arabian Sea changed from easterly last week to southerly this week, which suggests conditions are again becoming more favorable for the monsoon.

In the past week, westerly wind anomalies strengthened a bit in parts of the monsoon trough region.

Westerly anomalies weakened a bit over the eastern Pacific relative to the prior week.

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

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

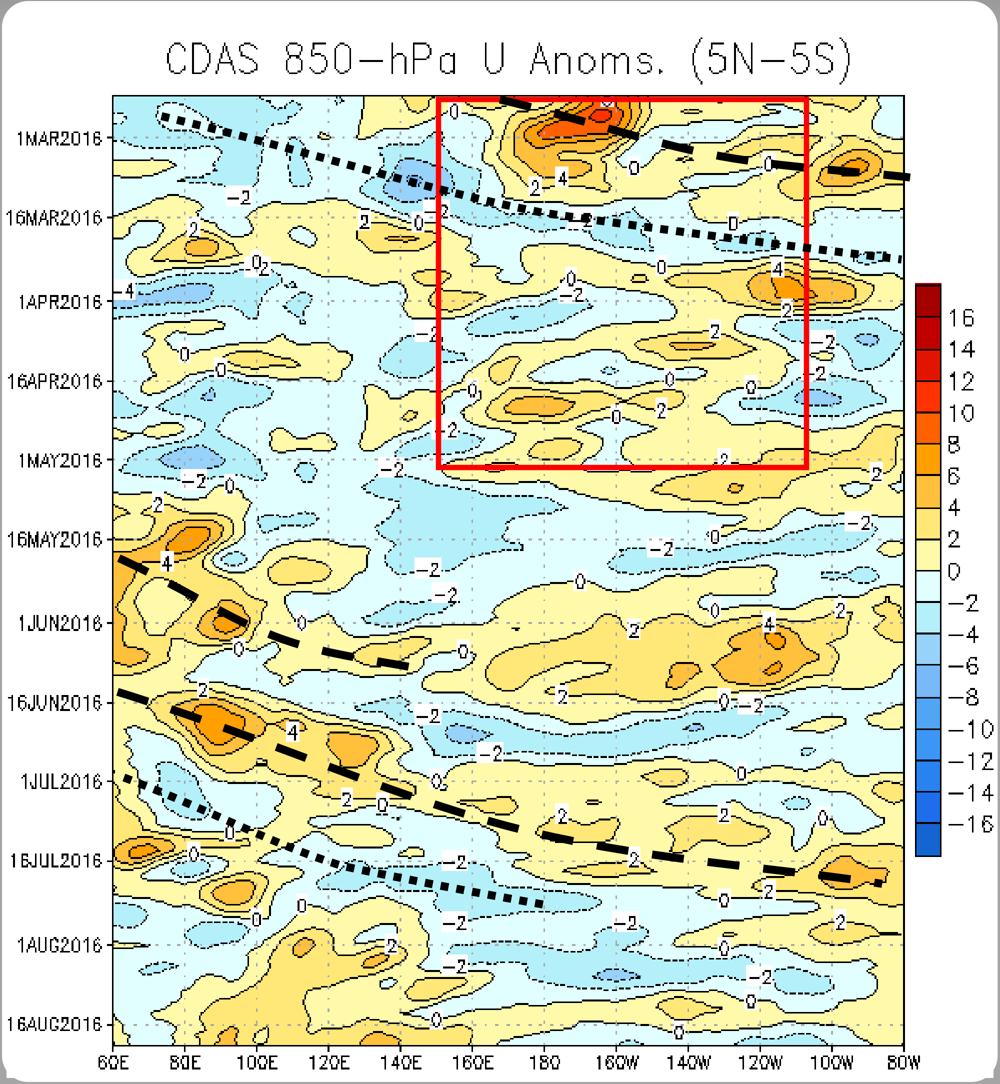
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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. 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.

The coherent signal propagated to the near the Maritime Continent during late July, then became stagnant, indicating the end of that MJO event.

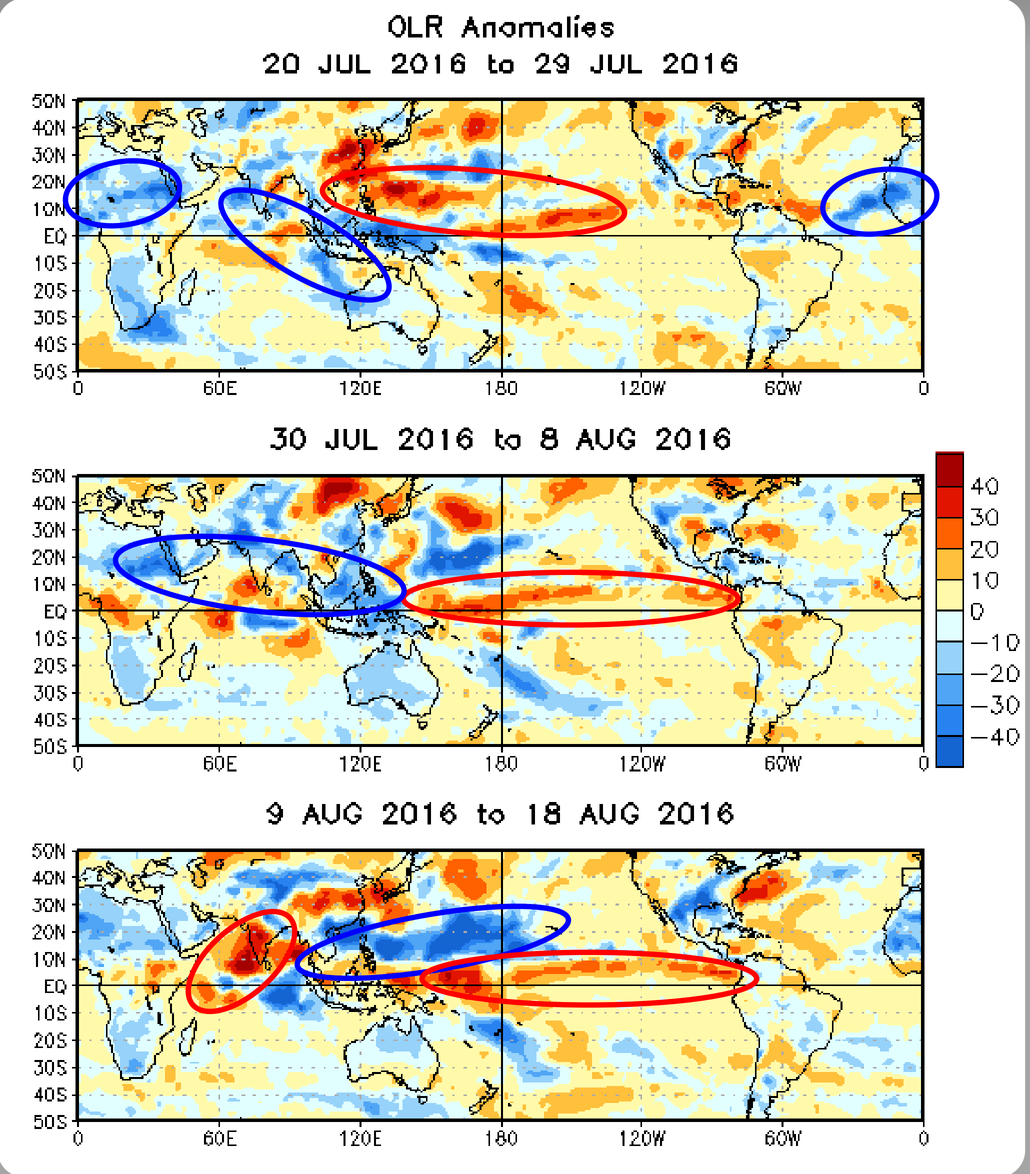


OLR Anomalies – Past 30 days

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

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

From mid-late July into early August, convection remained enhanced from Africa to the Maritime Continent, while suppressed convection was noted across the tropical Pacific. However, in early August, an area of suppressed convection emerges near the southwest coast of India, and adjacent parts of the western tropical Indian Ocean.



In early/mid-August, suppressed convection built across the western Indian Ocean and Indian subcontinent while remaining across the tropical Pacific. Enhanced convection was apparent between 10N-25N in the western and central Pacific associated with the presence of the monsoon trough.

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

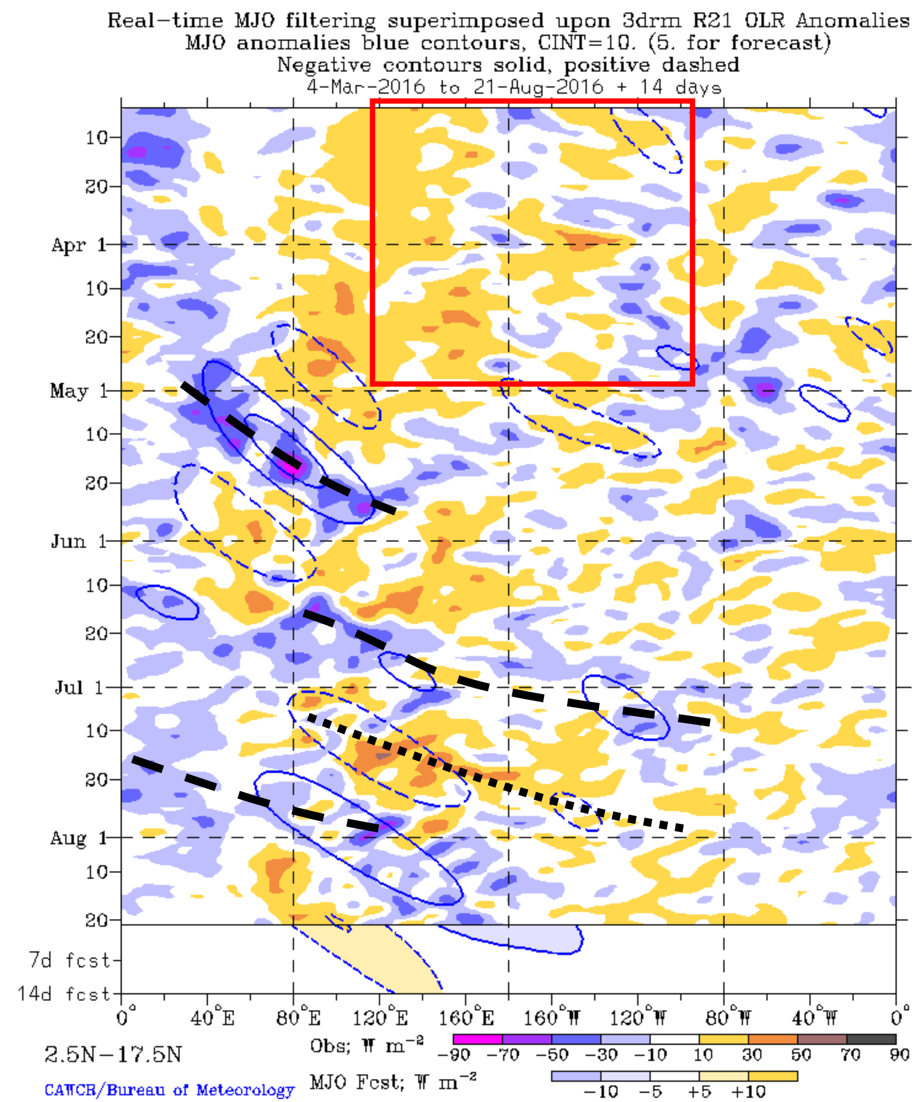
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

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.

During early May, an eastward-propagating convective envelope associated with the MJO developed east of the Prime Meridian. During the latter half of June, an eastward propagating signal is evident. During July, the signal continued moving eastward, with interference from tropical cyclone activity.

The enhanced convection over the western and central tropical Pacific is apparently related to the presence of the monsoon trough, while suppressed convection is evident over the eastern Indian Ocean. Some eastward propagation of these OLR anomalies is forecast.



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

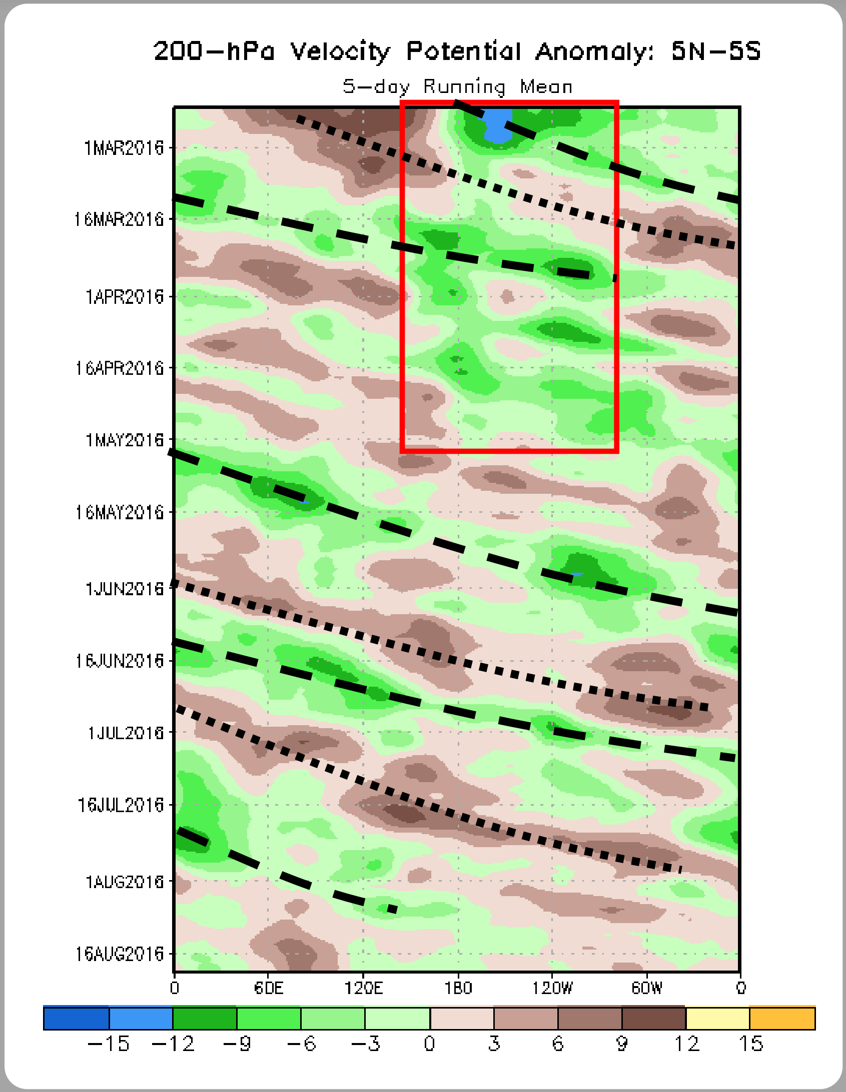
The 2015-16 El Niño background state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

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

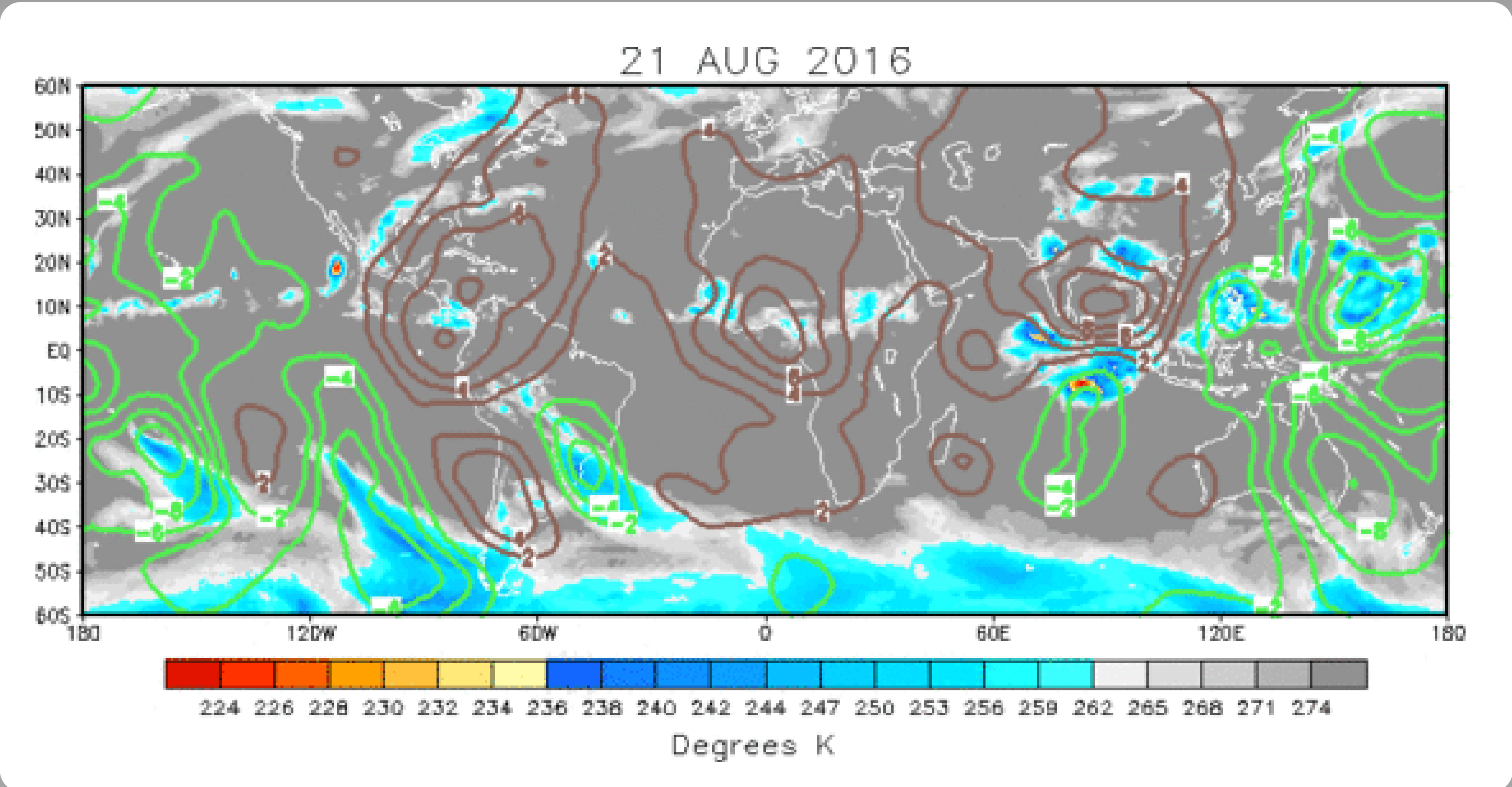
The upper-level velocity potential pattern became less coherent as El Niño waned during April.

From May through early August, a propagating signal was evident, with multiple periods of variability apparent.

Recently, the intraseasonal signal has weakened. An area of enhanced convergence is evident over the eastern Indian Ocean, while areas of modestly enhanced divergence are indicated over Africa, and from the Maritime Continent eastward across most of the tropical Pacific.



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



The upper-level velocity potential anomalies exhibit somewhat of a weak wavenumber-1 pattern with generally enhanced (suppressed) convection from the Maritime Continent to the eastern Pacific (90W through Africa and the Indian Ocean).

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

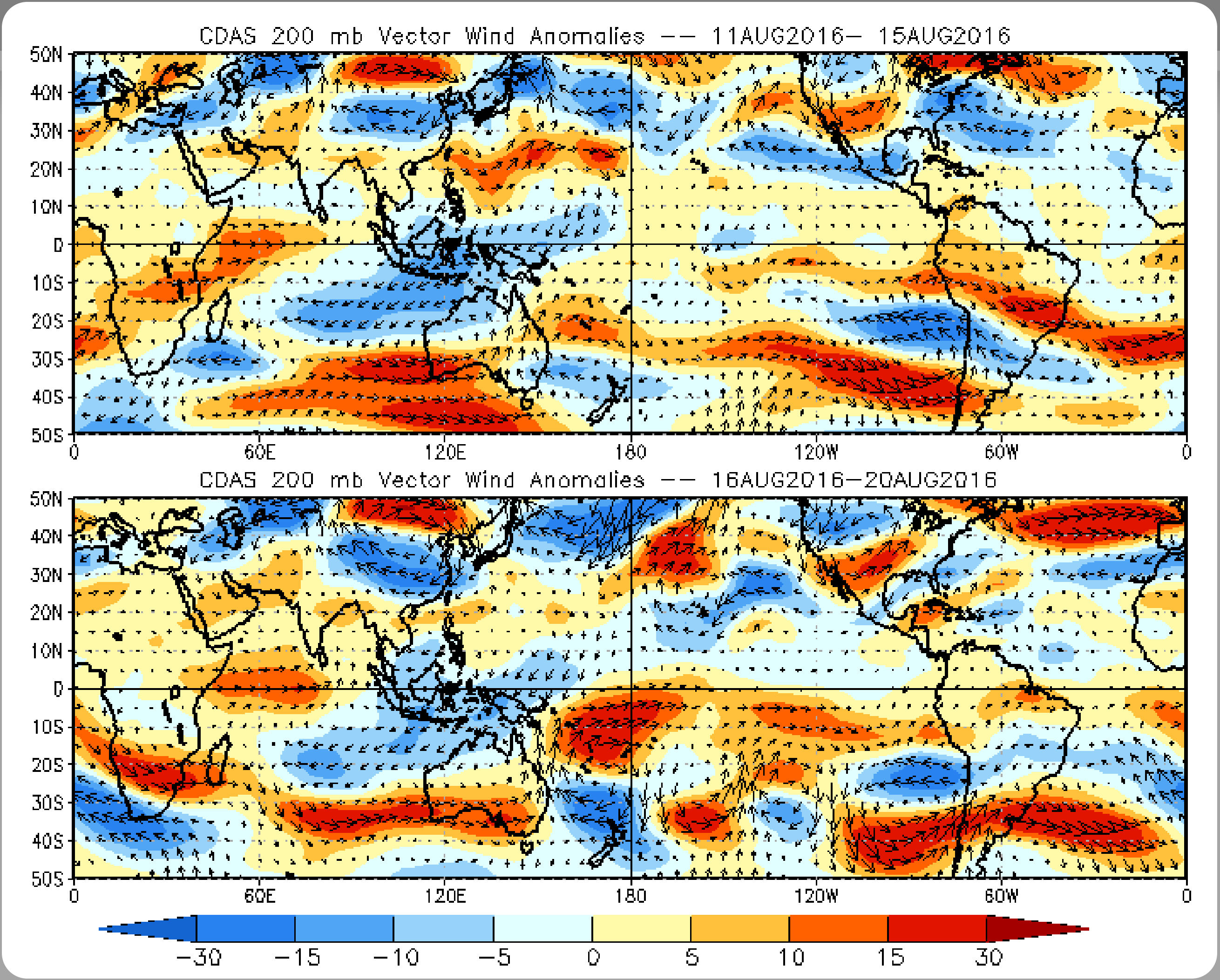
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



The anomalous anticyclone originally near 140E weakened over the past two weeks. Anomalous wave responses are apparent to the north of this feature and continuing eastward across the Pacific.

Some strengthening in easterly wind anomalies is evident across the low latitude eastern Pacific and northwestern CONUS in the past week.

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

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

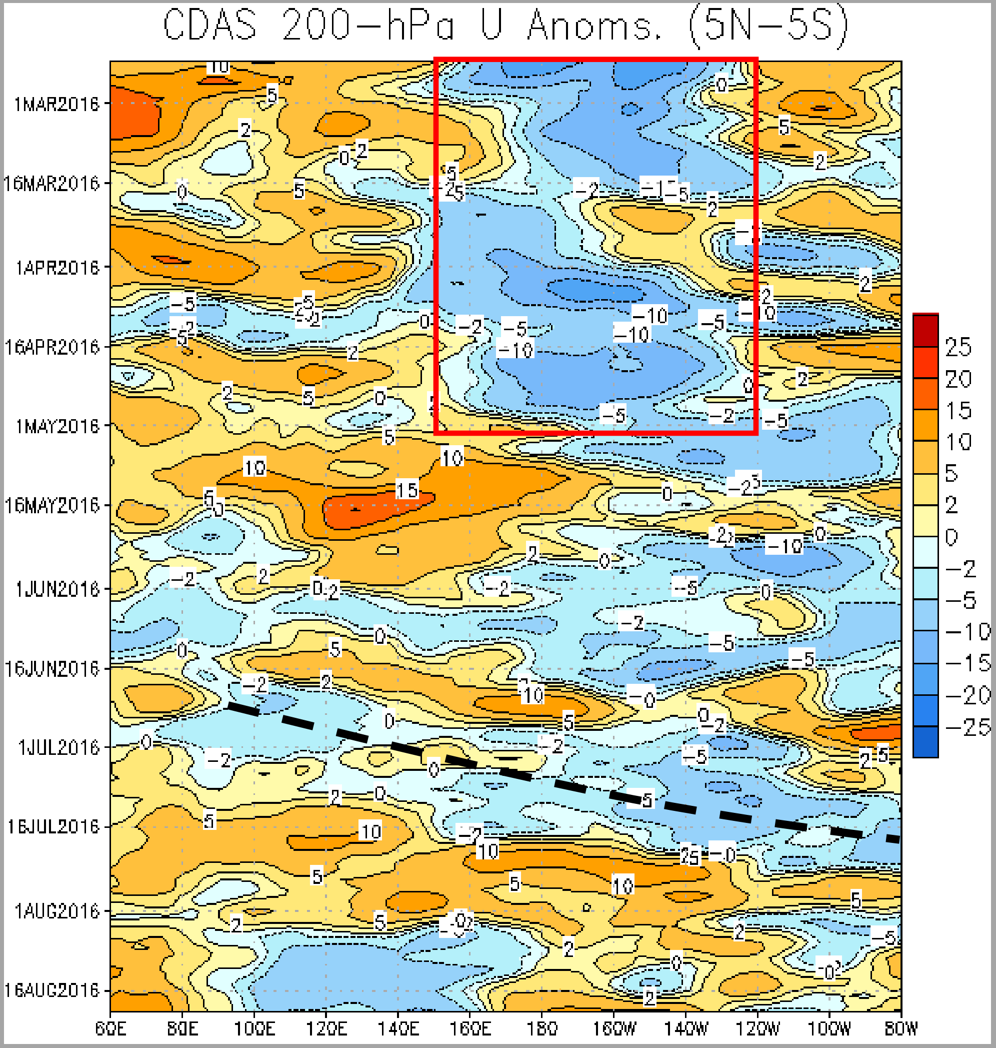
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

During July, some eastward propagation in large scale anomalies are evident, although the spatial consistency implies higher frequency variability than expected with MJO activity. During August the pattern has become relatively stationary.



Weekly Heat Content Evolution in the Equatorial Pacific

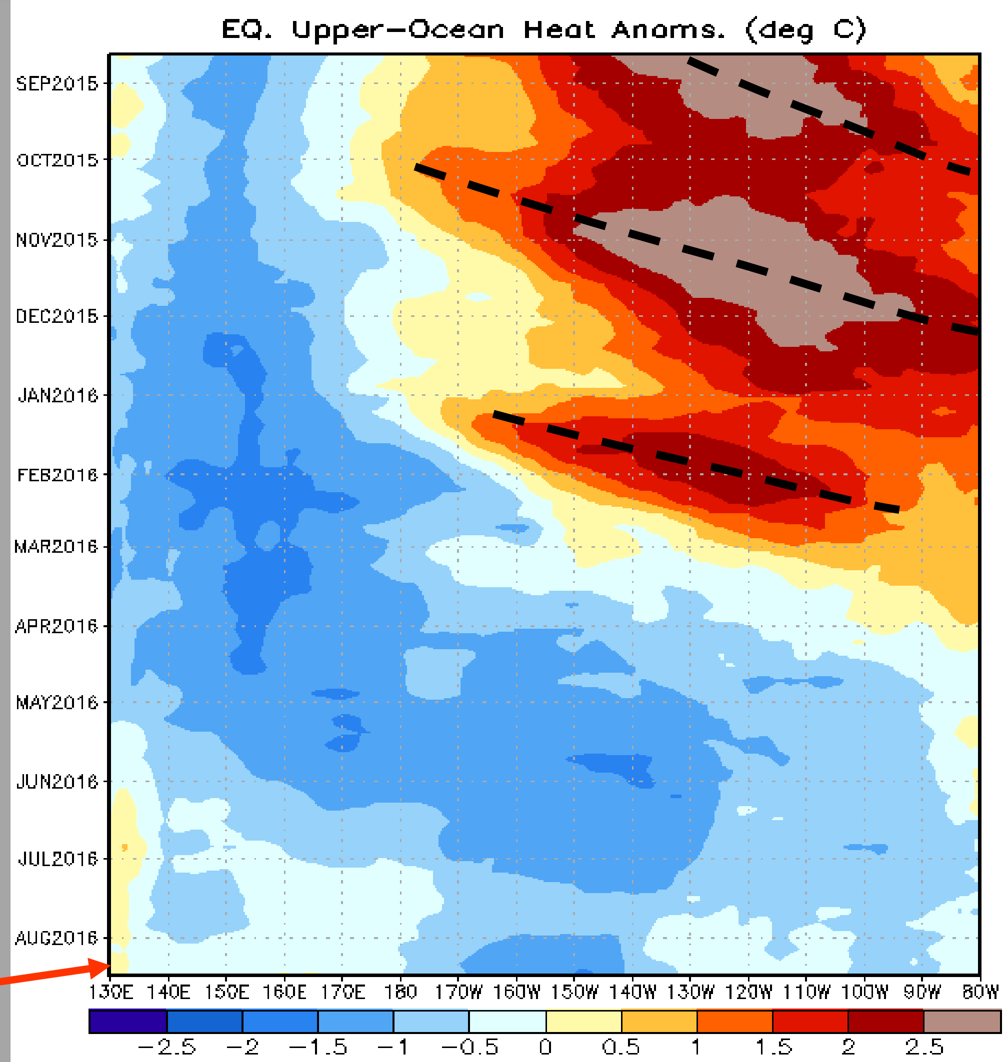
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

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 heat content anomalies is evident near 135E. Upper-Ocean Heat Content is lowest from 170W-140W in the east-central equatorial Pacific.



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

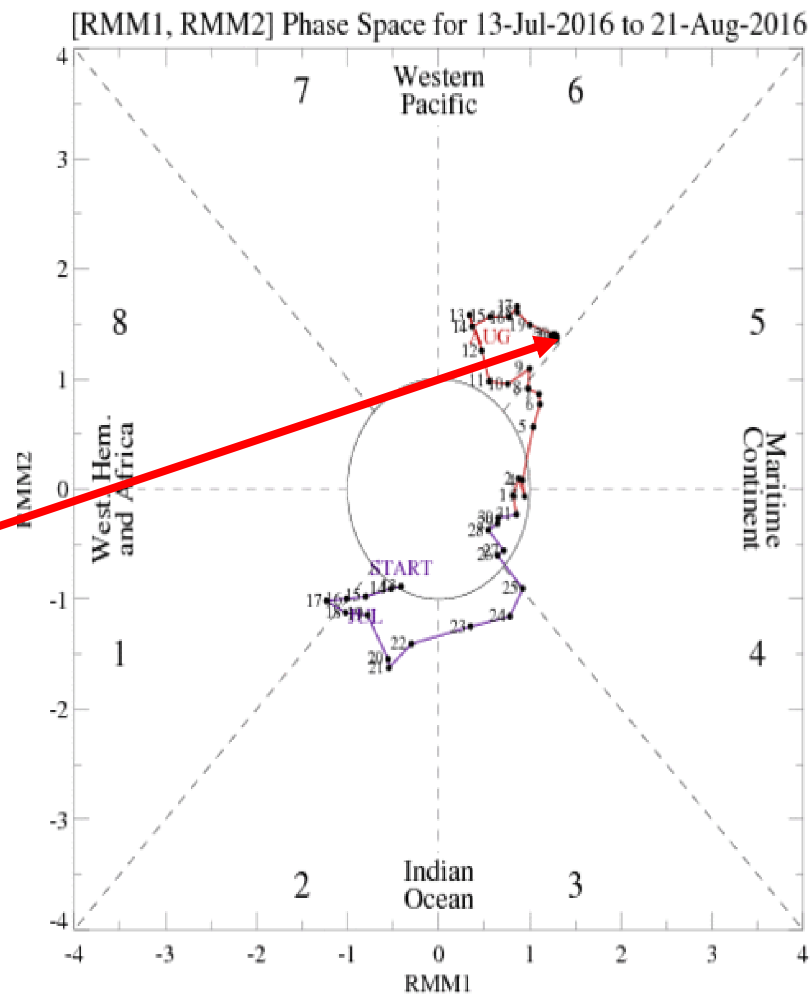
The triangular areas indicate the location of the enhanced phase of the MJO

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

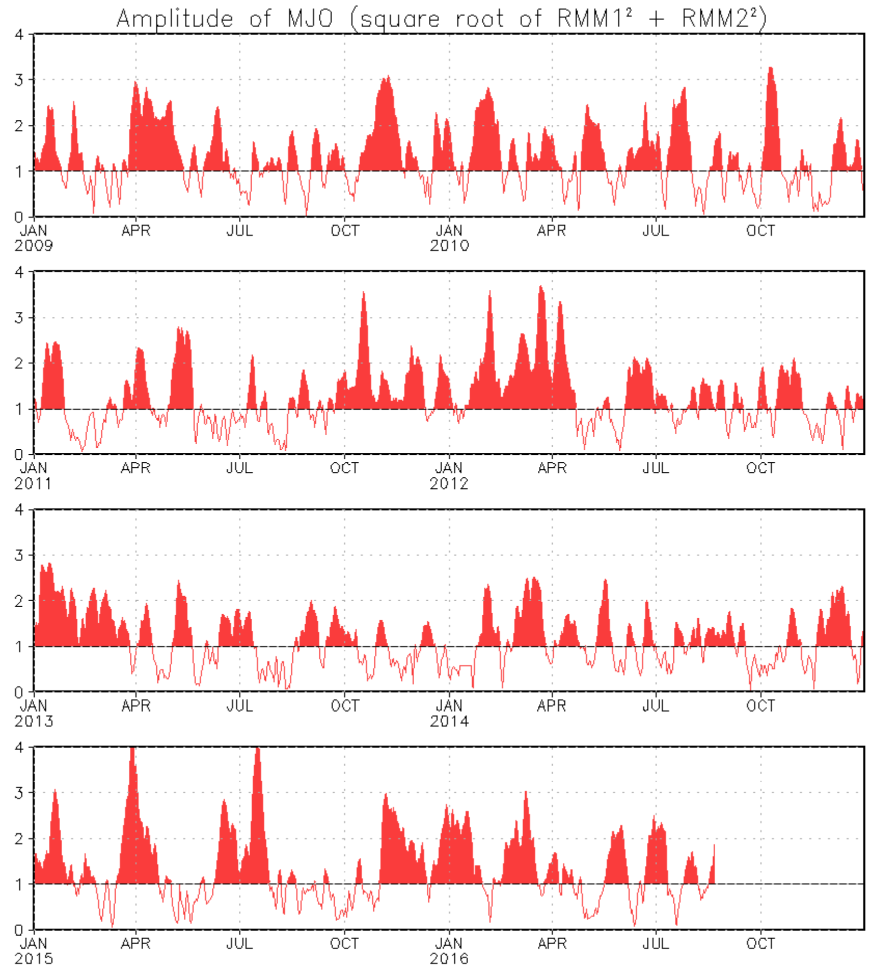
During the past week, the RMM index indicated westward motion of an existing signal across the western Pacific.



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.



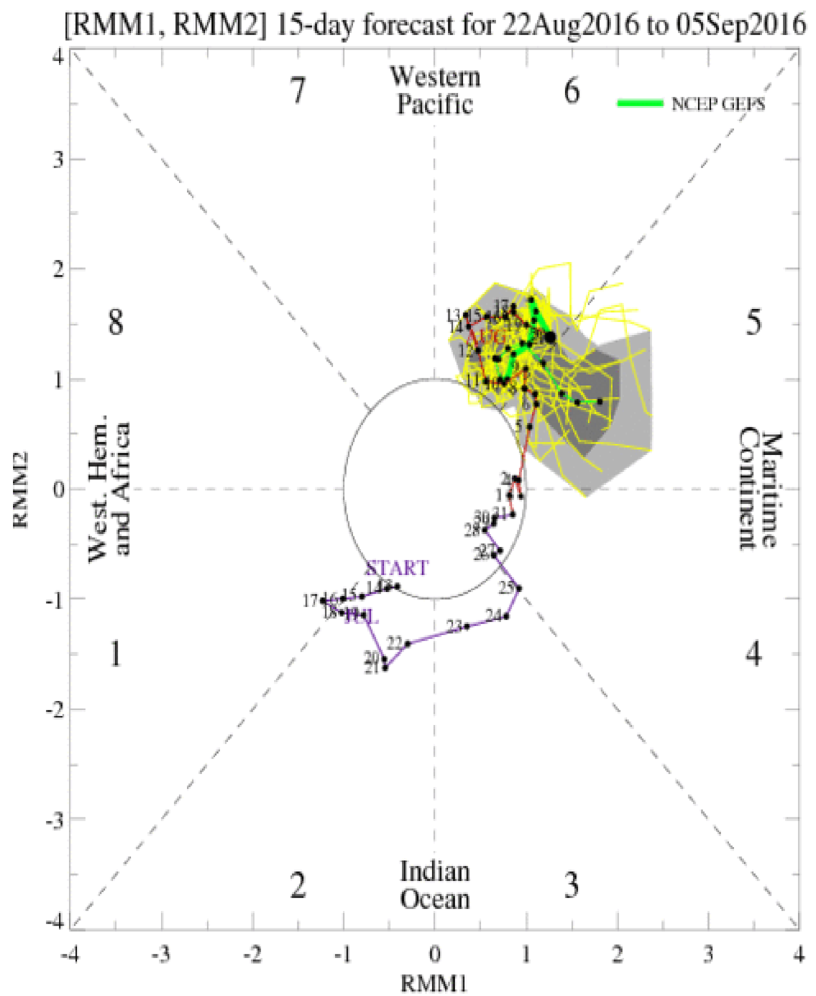
Ensemble GFS (GEFS) MJO Forecast

__Yellow Lines__ - 20 Individual Members
__Green Line__ - Ensemble Mean

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



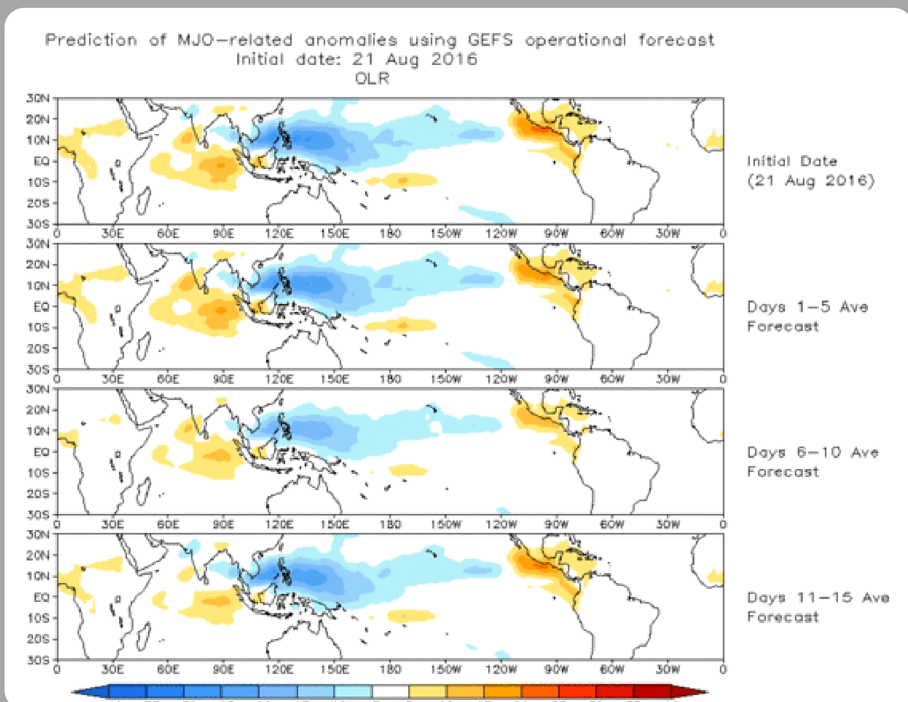
During the next two weeks, the GFS ensemble predicts the signal will either remain fairly stationary over the western Pacific, or shift westward towards the Maritime Continent.

This westward shift may be tied to the monsoon trough and any embedded tropical cyclone activity within it.

Ensemble GFS (GEFS) MJO Forecast

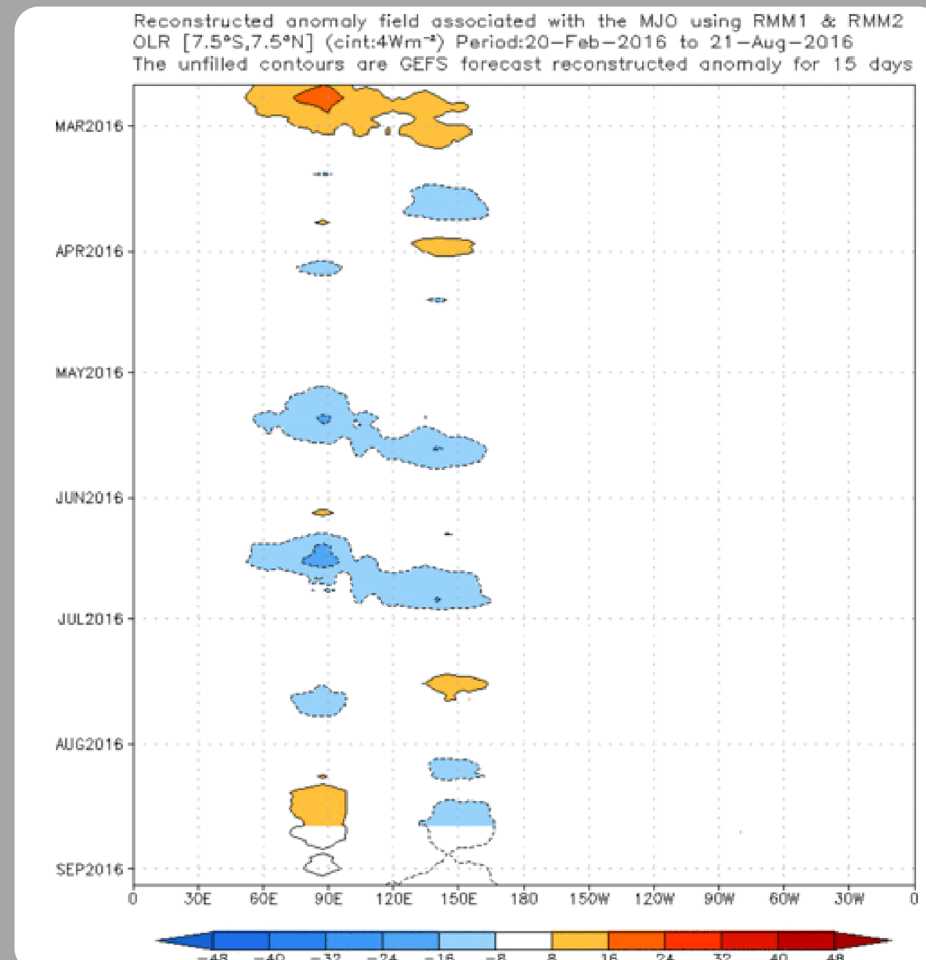
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The OLR from the GEFS keyed to the RMM Index depicts a stationary, but moderately strong signal with enhanced (suppressed) convection centered over the western Pacific/Maritime Continent (Indian Ocean and near Mexico).

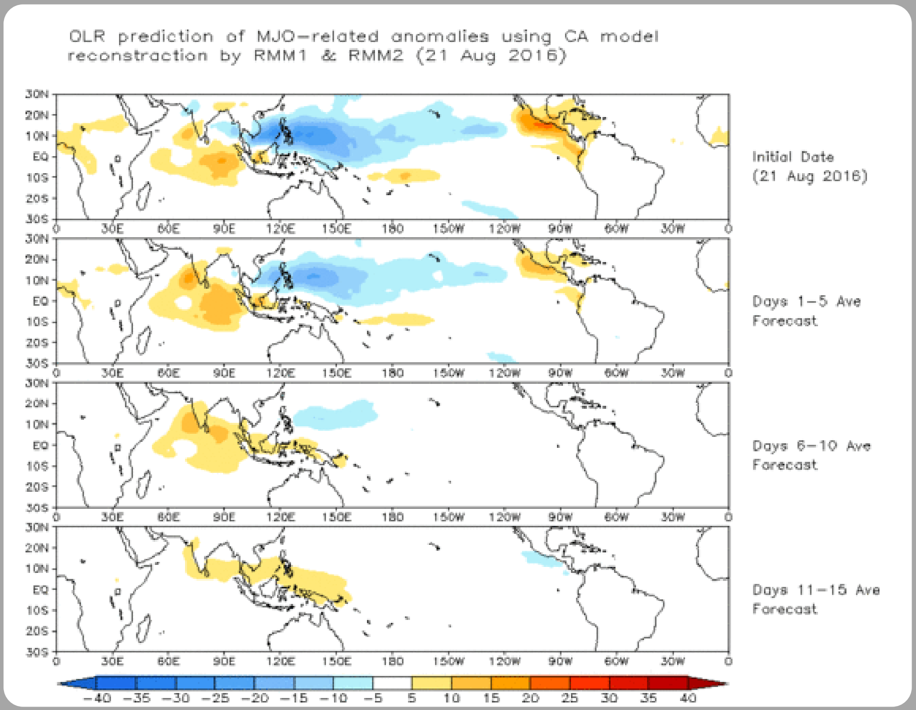
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



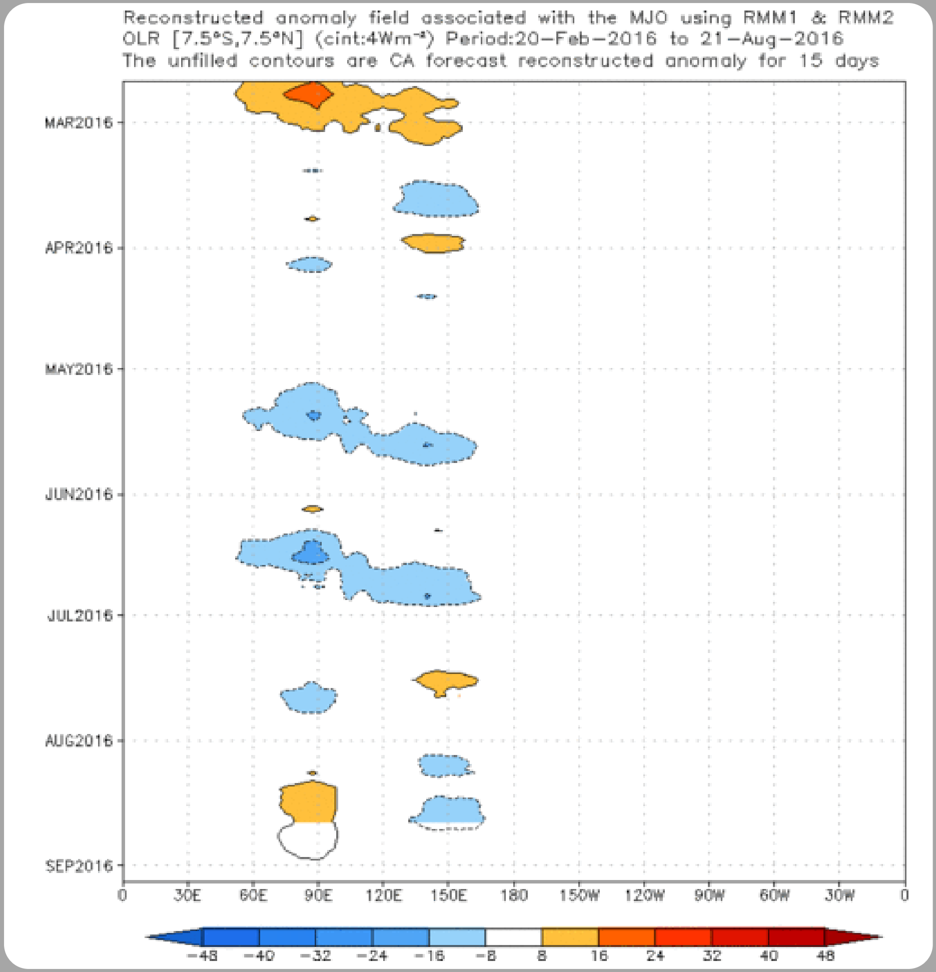
Constructed Analog (CA) MJO Forecast

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



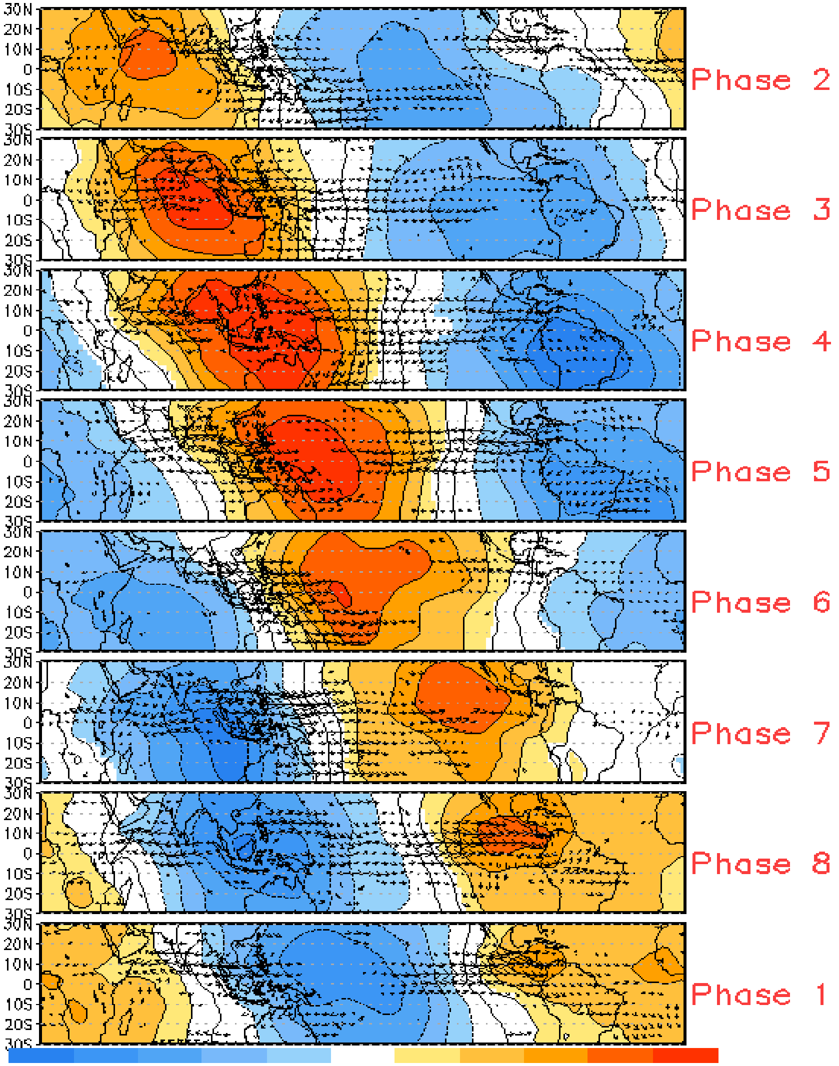
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



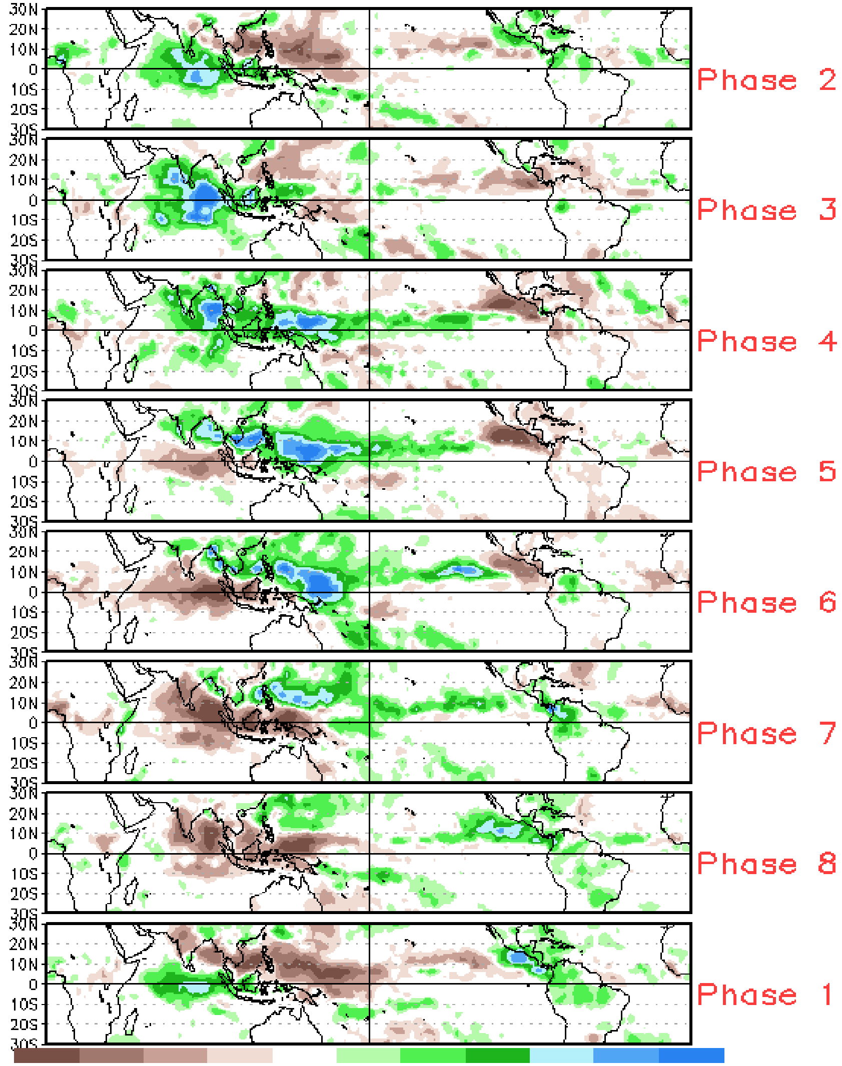
The Constructed Analog (CA) model predicts a weakening signal, with slow propagation of suppressed convection from the Indian Ocean to the Maritime Continent.

MJO Composites - Global Tropics

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



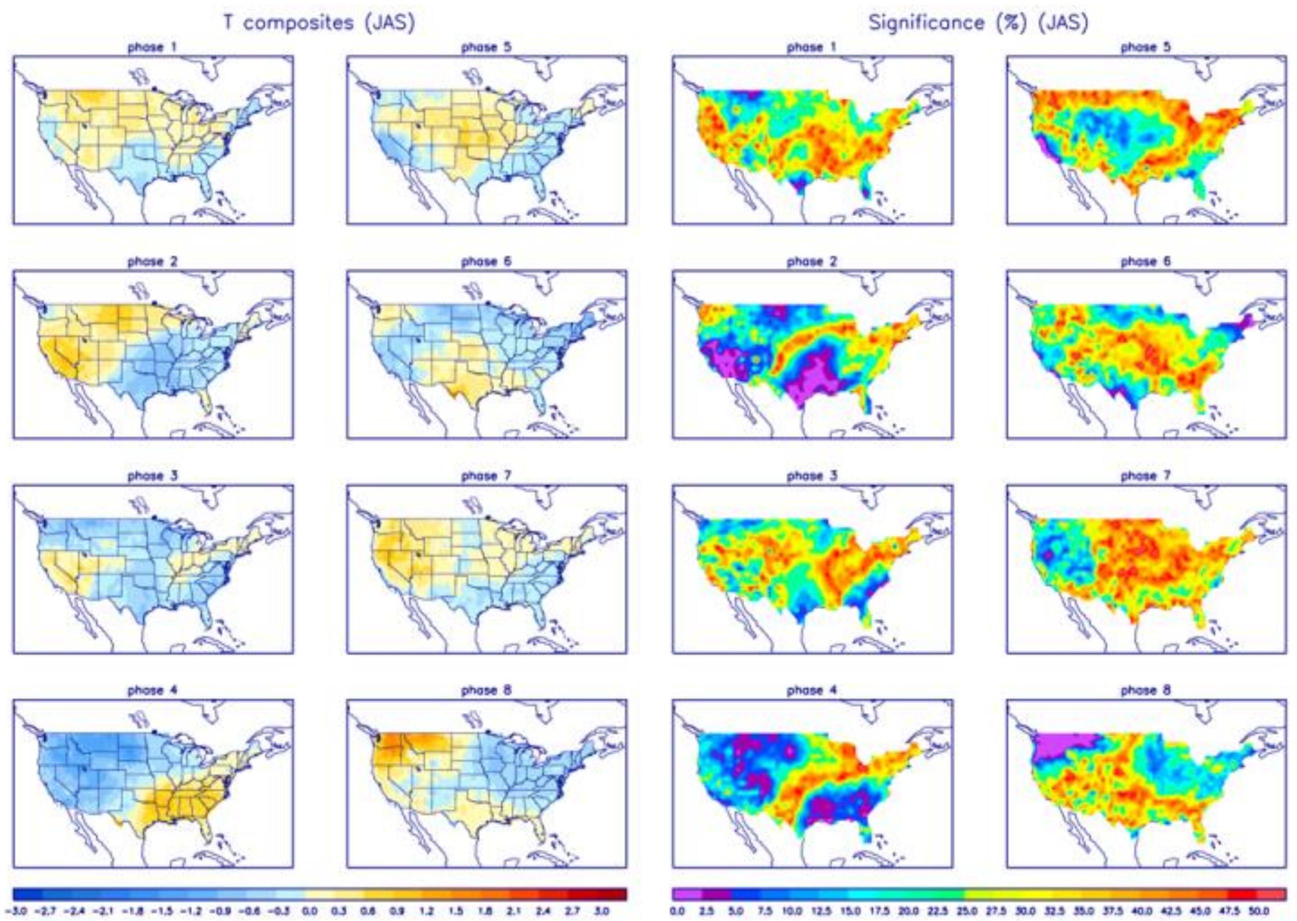
Precipitation Anomalies (May - Sep)



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.



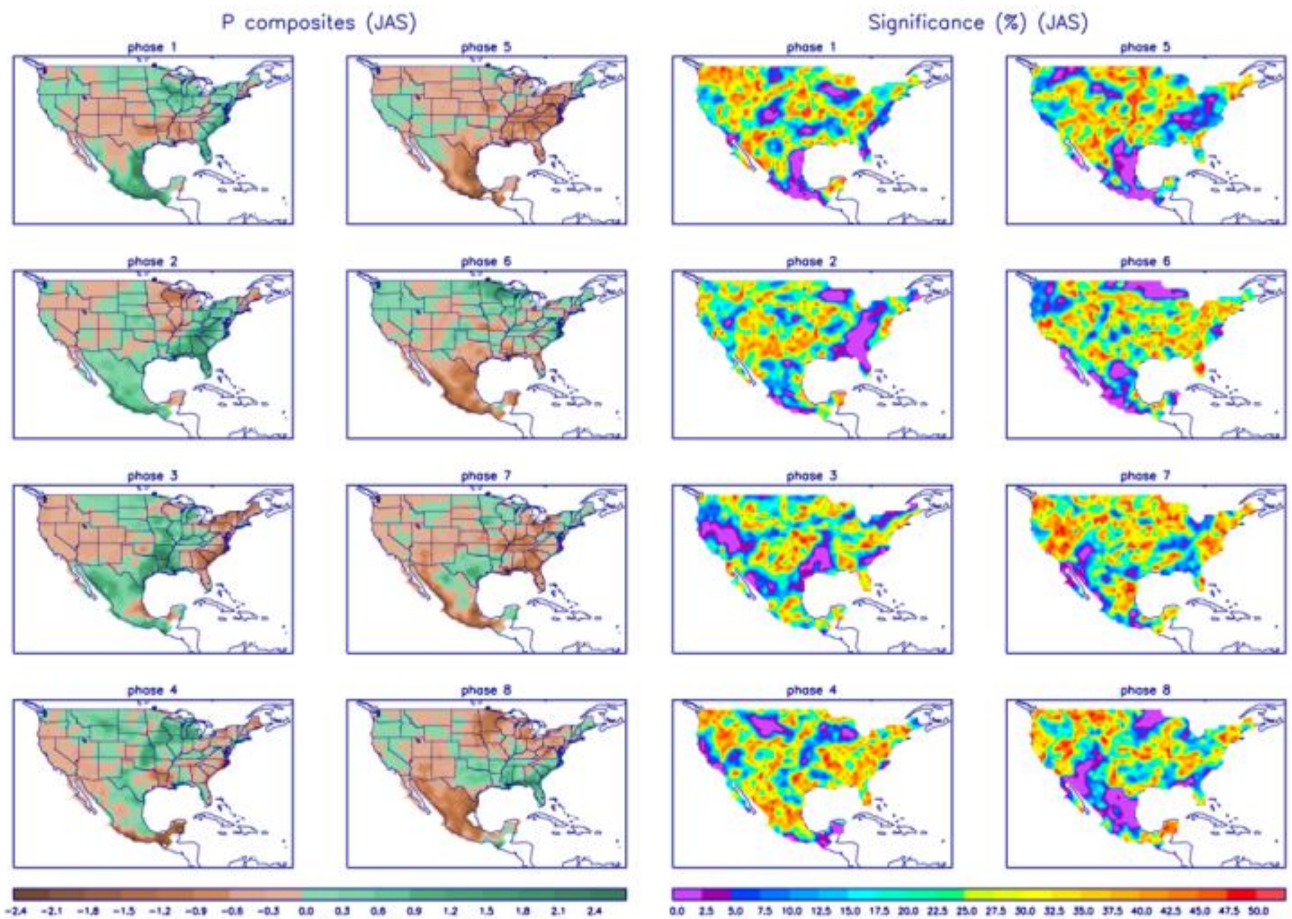
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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