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 RMM index indicates the MJO signal has strengthened to a moderate amplitude across the western Pacific over the past week.

Uncertainty exists in regards to the subsequent behavior of the intraseasonal signal across the western Pacific during the forecast period as the MJO interacts with the monsoon trough. Dynamical model guidance generally suggests a westward shift in the intraseasonal signal, however, some of this may be in response to expected tropical cyclone development across the region.

Tropical cyclone formation and above-normal rainfall likelihood are enhanced over the western North Pacific throughout the forecast period. Climatological expectations from an active MJO over the West Pacific or Maritime Continent would support suppressed tropical cyclone activity in the eastern Pacific and Atlantic, however tropical cyclogenesis possibilities are non-zero for both regions in weeks 1 and 2.

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

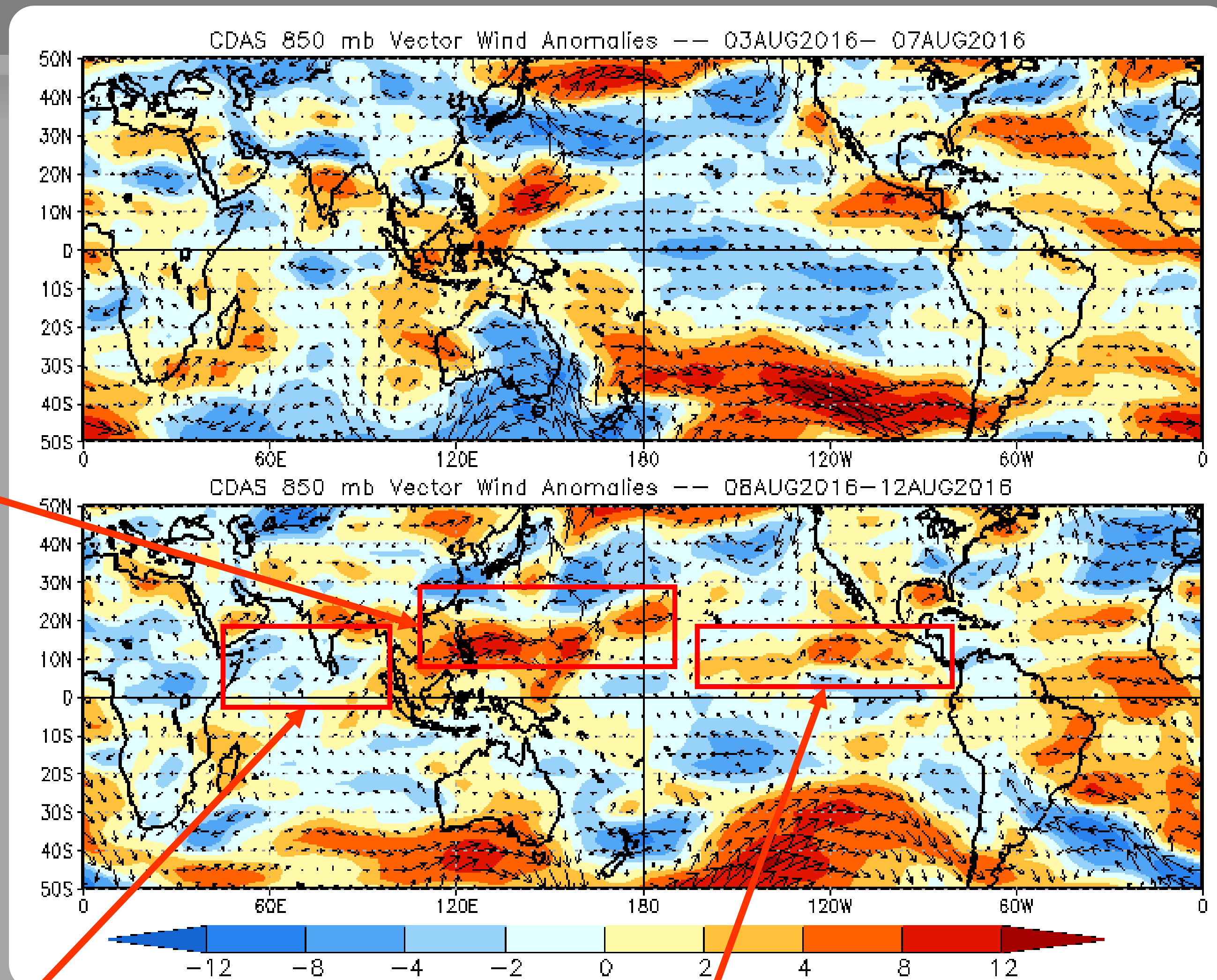
850-hPa Vector Wind Anomalies (m s-1)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

The monsoon trough became increasingly apparent near 20N.



Weak easterly anomalies spread across the northern Indian Ocean indicative of a break in the monsoon.

Westerly anomalies spread westward across 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

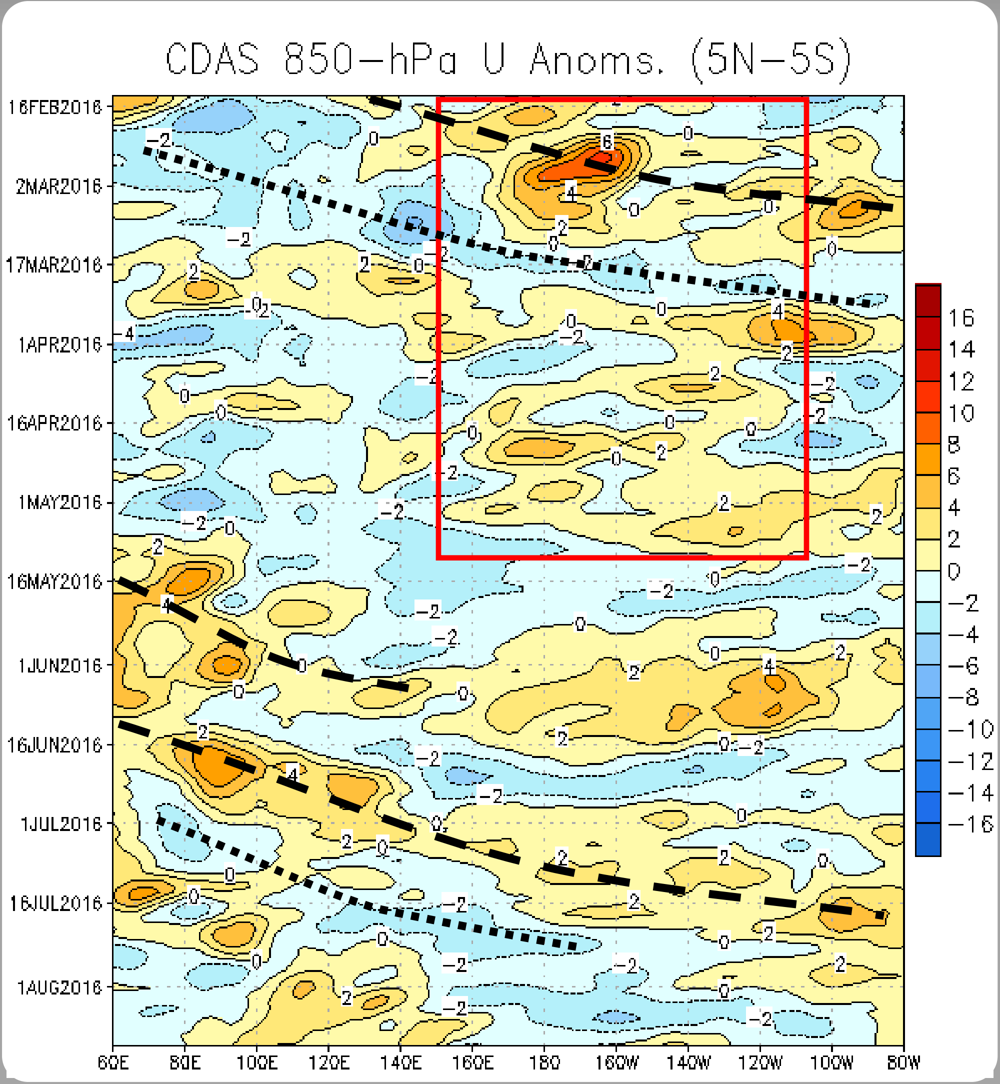
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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 faded during mid July.

Recently, a signal has emerged over the Maritime Continent, although continued coherent propagation is unclear.



OLR Anomalies – Past 30 days

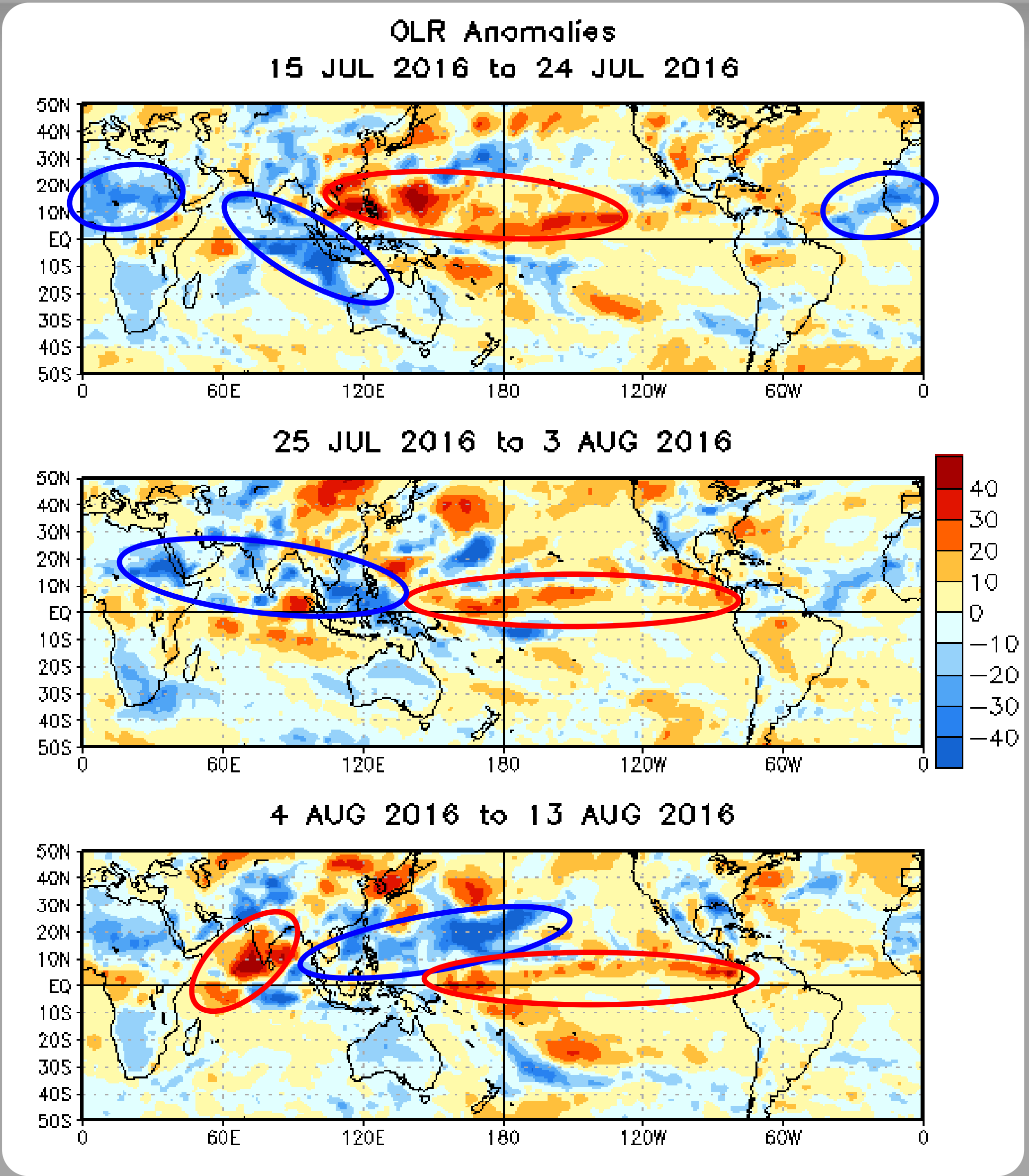
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid-July, suppressed (enhanced) convection remained over the western and central Pacific (Indian Ocean), but intensified over Africa and South Asia. The intensification was consistent with an intraseasonal signal.

Enhanced convection remained over the area from Africa to the Maritime Continent, while the suppressed convection shifted slightly eastward, both consistent with an eastward shift of an intraseasonal signal in the MJO time band.

In early/mid-August, suppressed convection built across the western Indian Ocean and Indian subcontinent while remaining across the eastern Pacific. Enhanced convection was apparent between 10-20N in the western Pacific associated with presence of the monsoon trough.



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

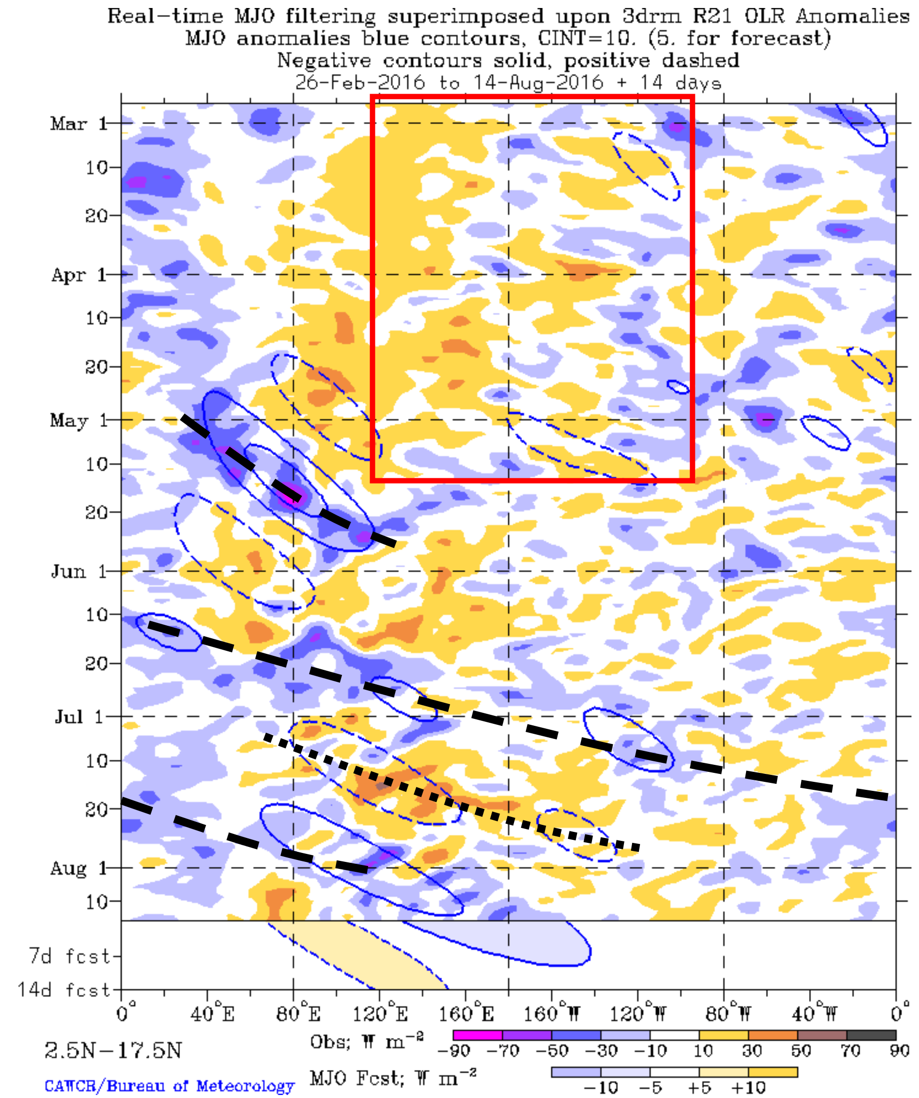
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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.

Some of the OLR reductions in the western Pacific may be tied to the MJO presence, with enhancement via the monsoon trough presence.



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

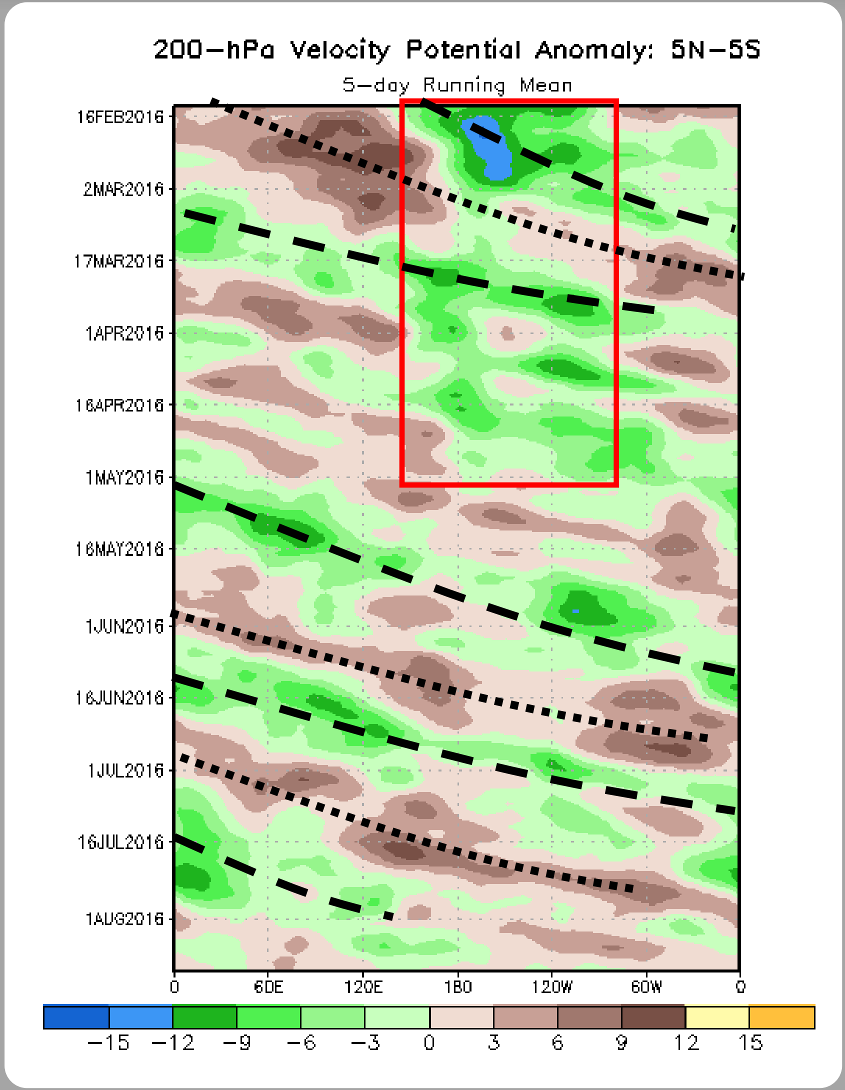
The 2015-16 El Niño background state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

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

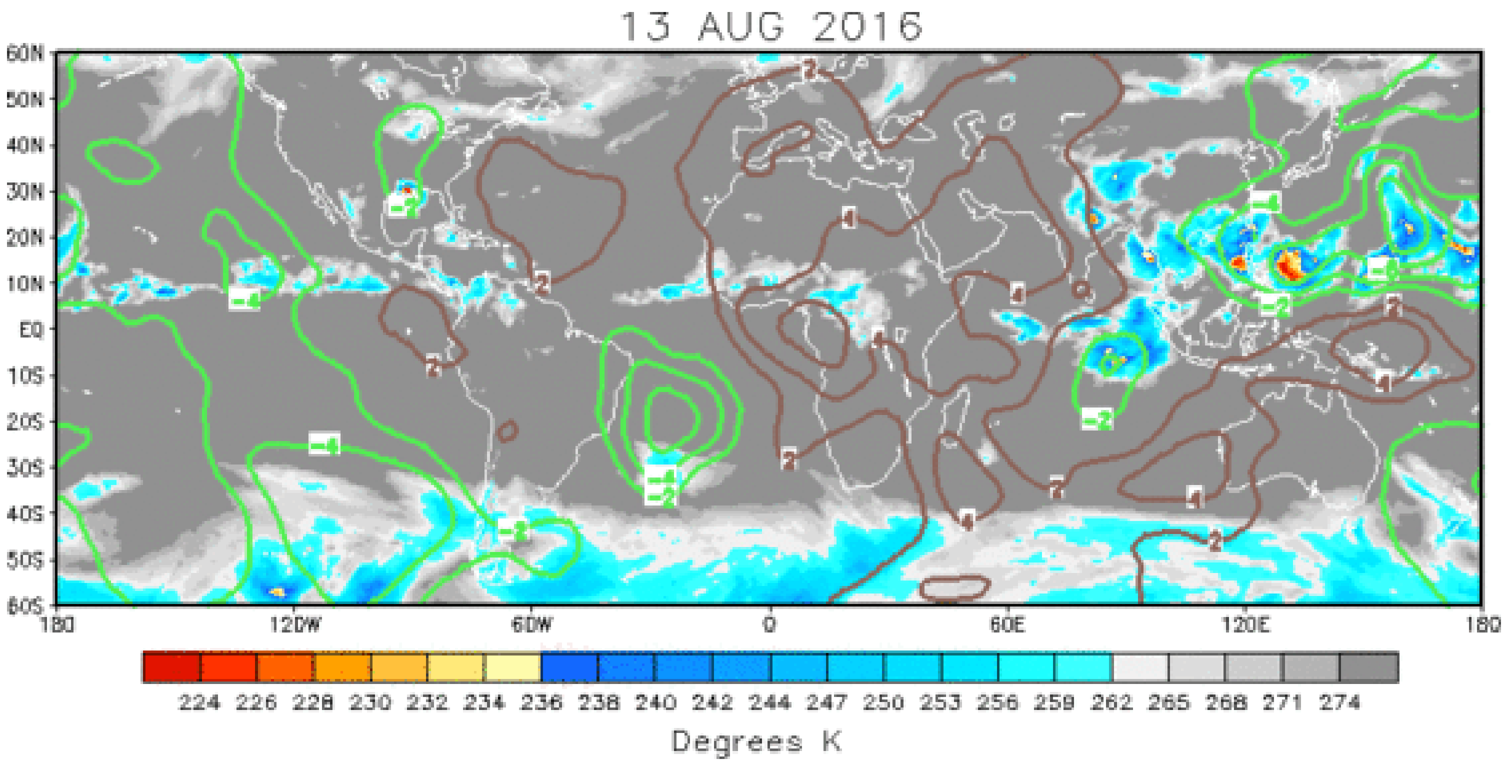
The upper-level velocity potential pattern became less coherent as El Niño waned during April.

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

Recently, the intraseasonal signal has weakened. A more stationary pattern is apparent with enhanced divergence (convergence) across the Maritime Continent (eastern 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 across the eastern Indian Ocean through eastern Pacific (Americas through Africa).

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

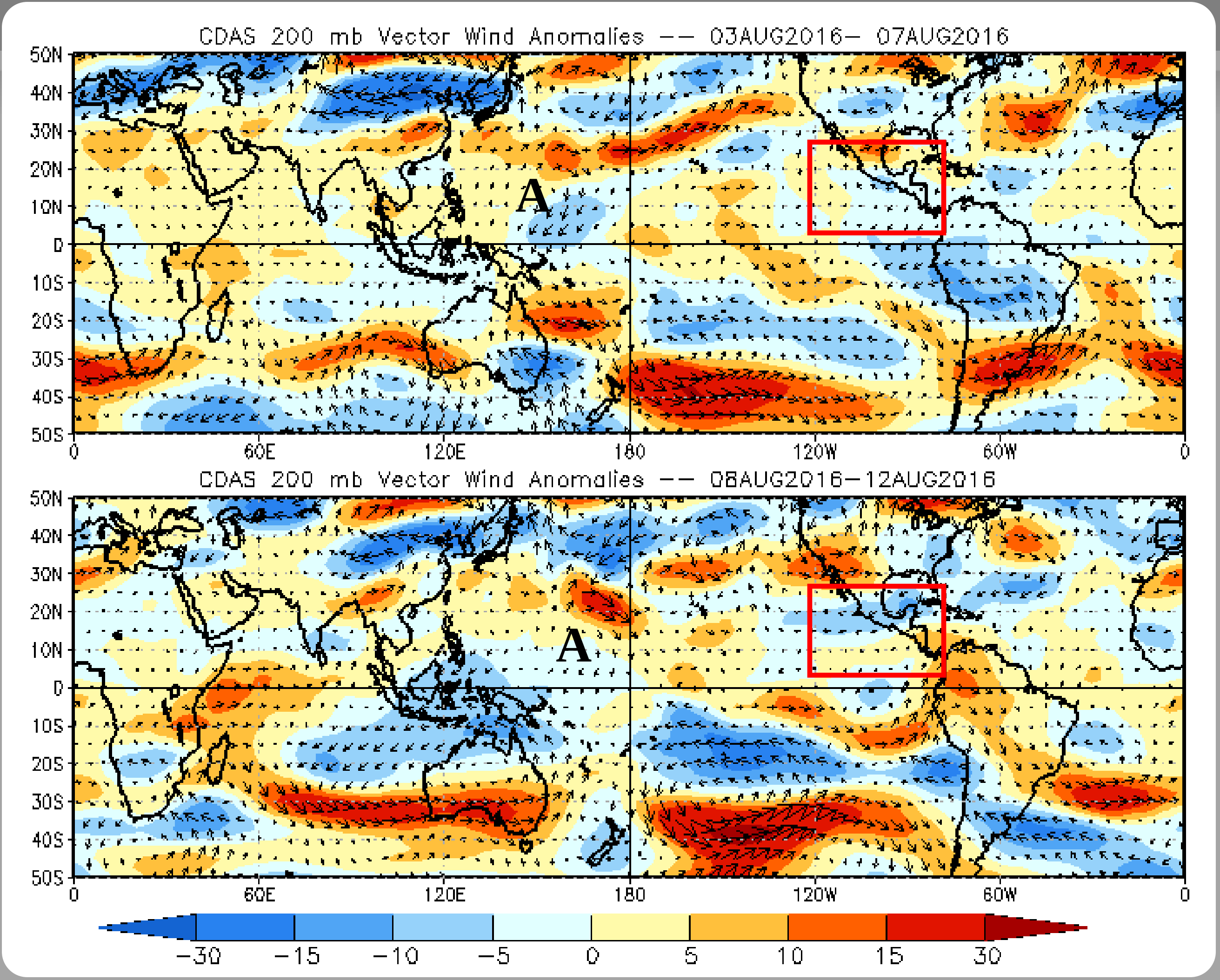
Negative anomalies (green contours) indicate favorable conditions for precipitation

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 shifted eastward and weakened over the past week. Anomalous wave responses are apparent to the north of this feature and continuing eastward across the Pacific.

Flow reversed across the eastern Pacific with easterly anomalies poleward of westerly anomalies over the most recent period.

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

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

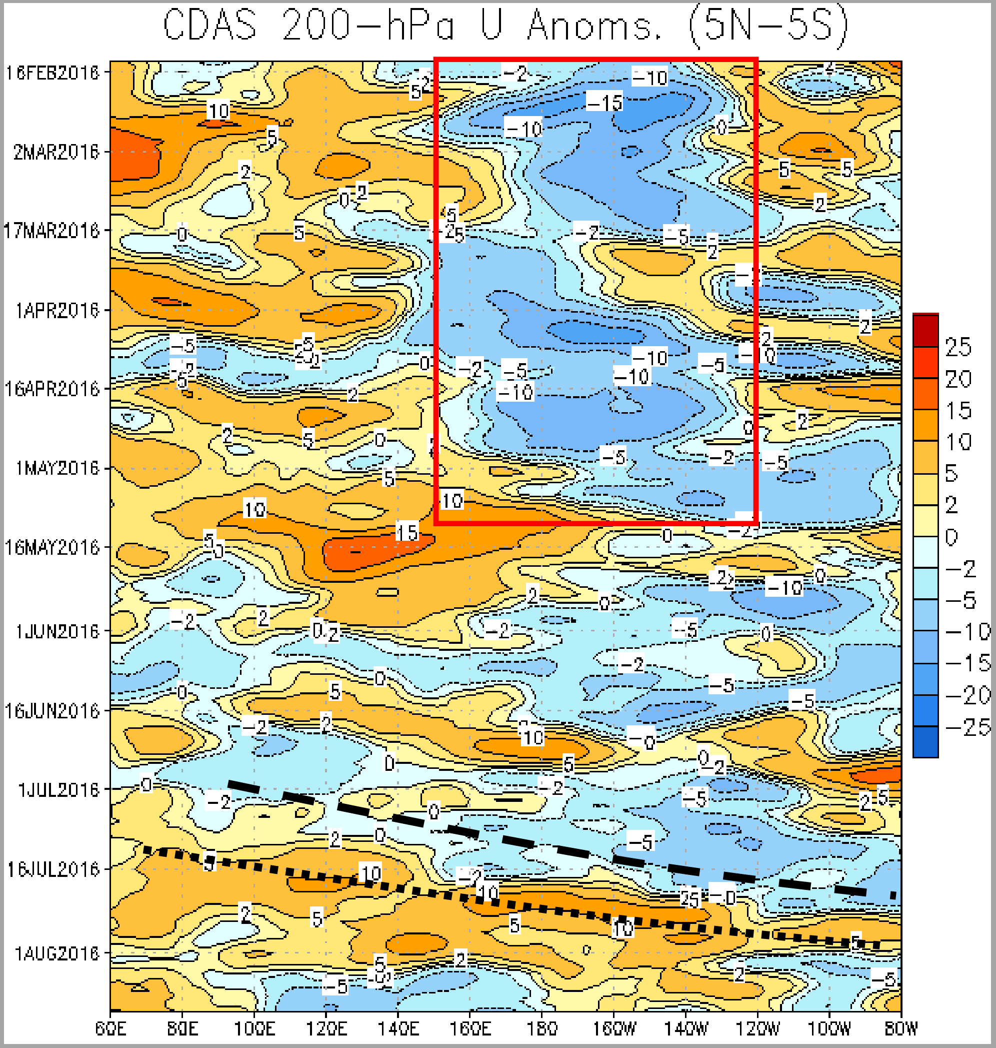
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

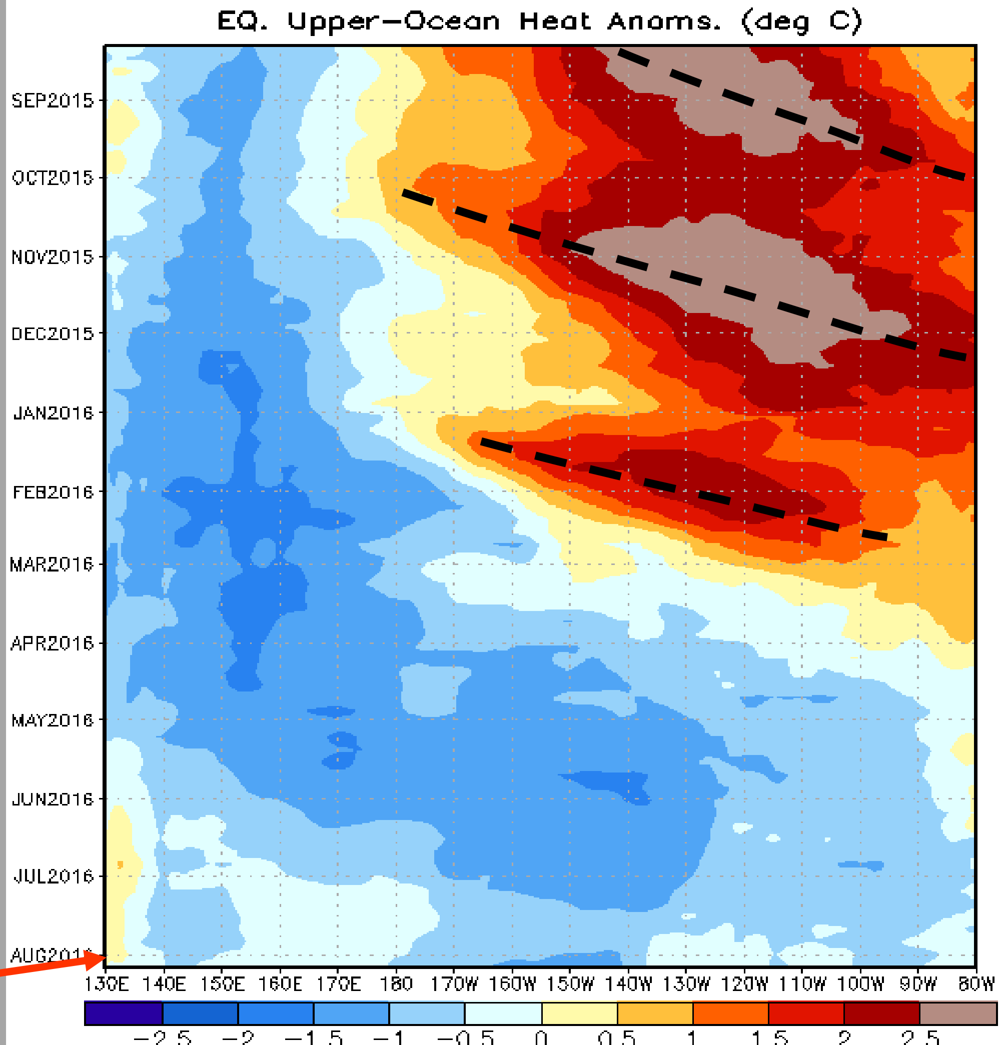
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

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.



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

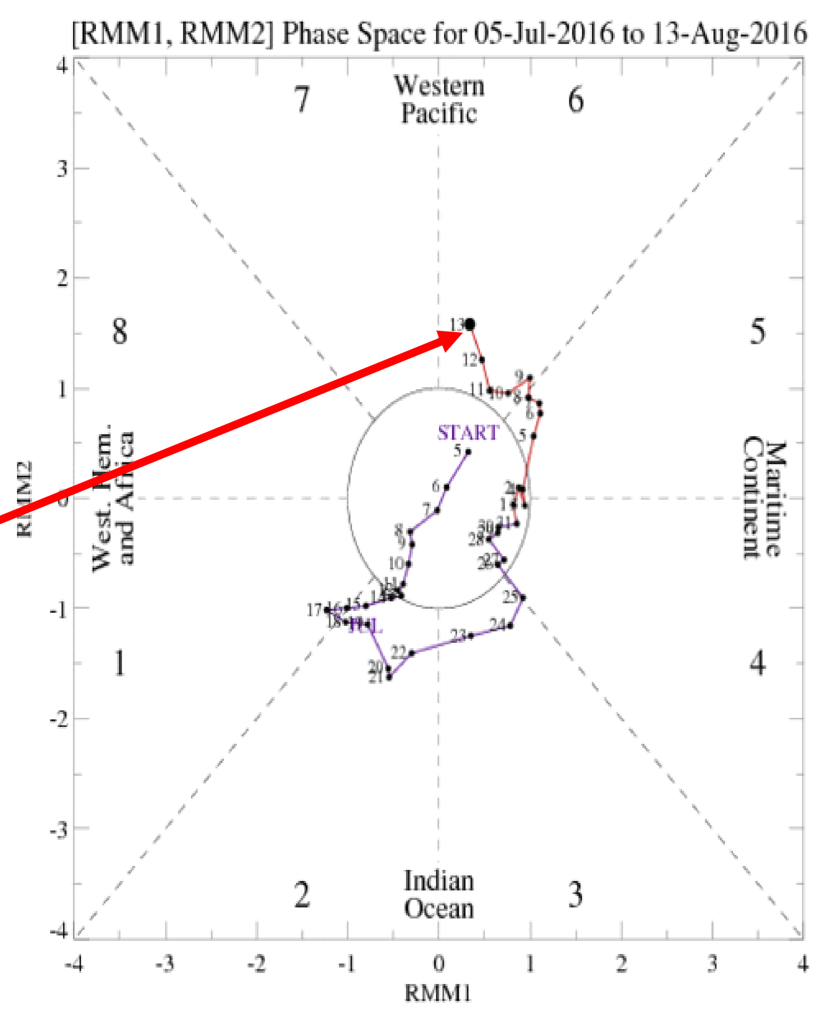
The triangular areas indicate the location of the enhanced phase of the MJO

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

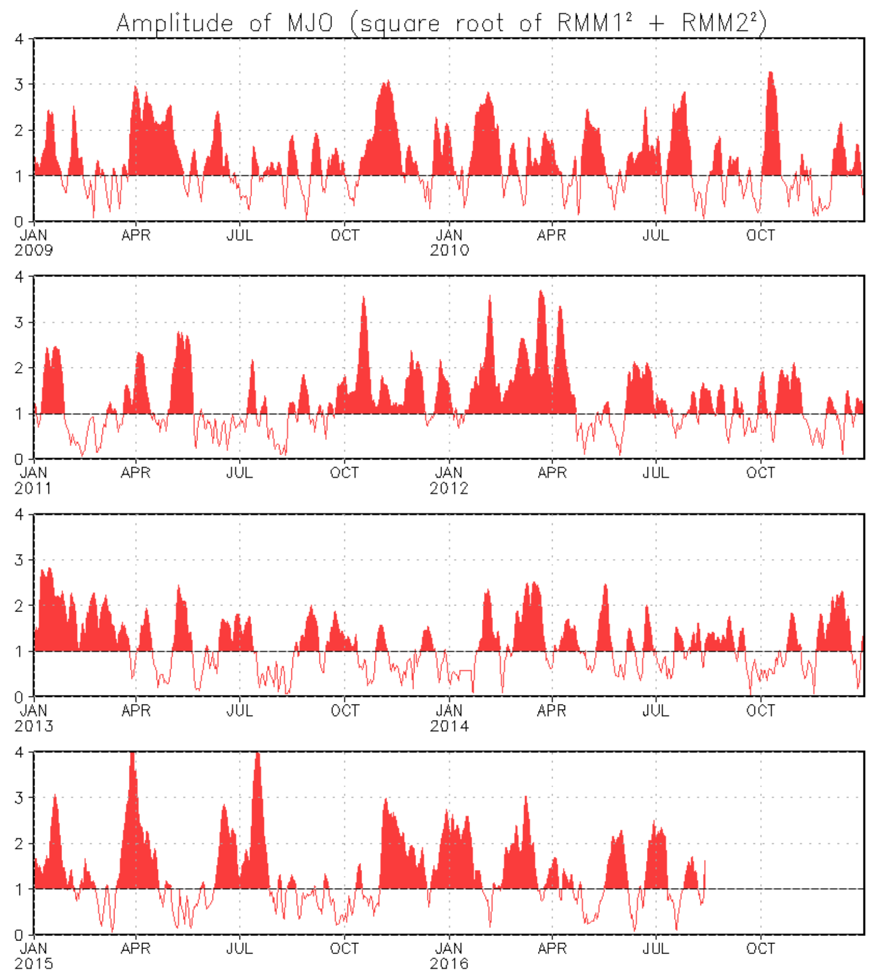
During the past week, the RMM index indicated a slight strengthening across the western Pacific of an existing signal.



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.



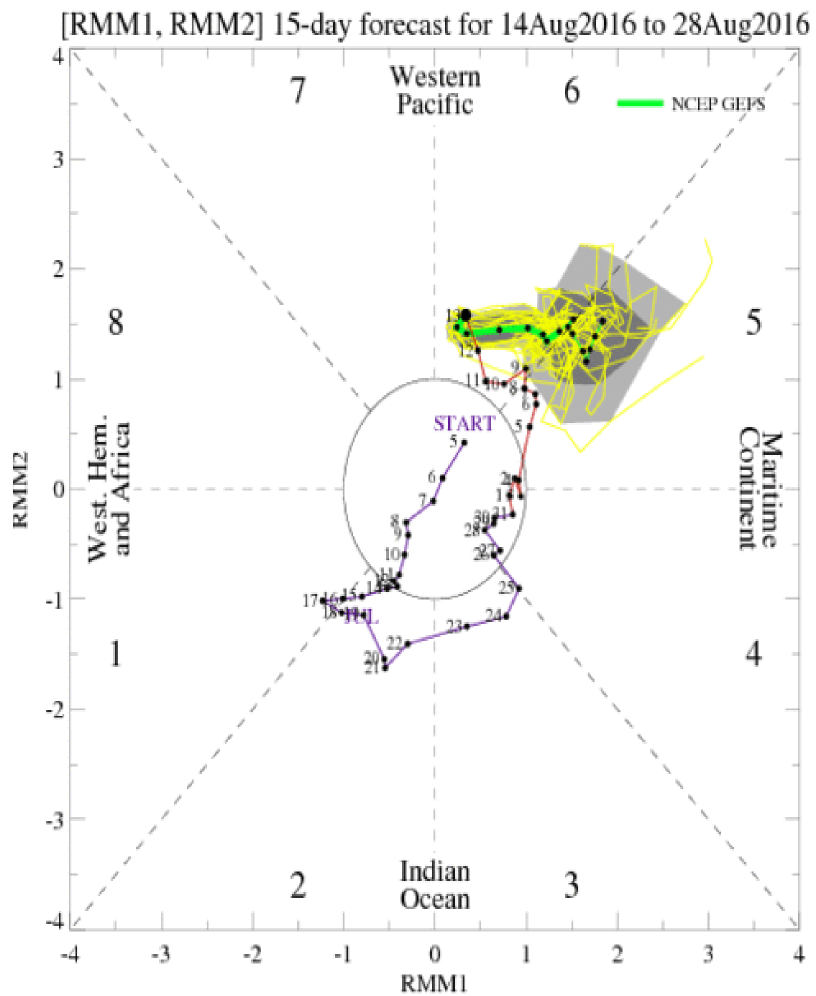
Ensemble GFS (GEFS) MJO Forecast

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



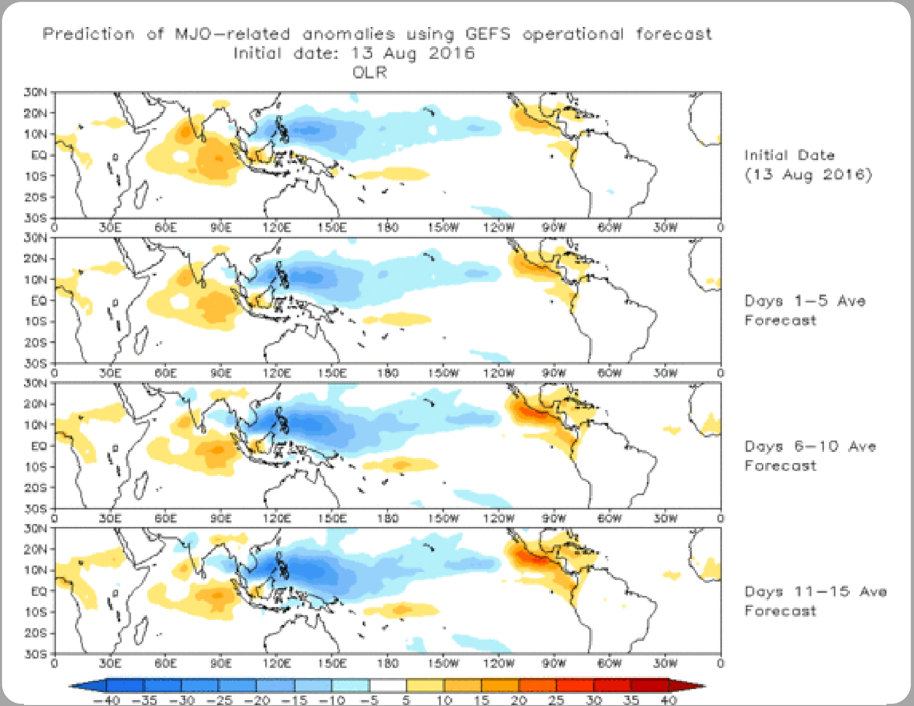
During the next two weeks, the GFS ensemble indicates the MJO signal to shift from the western Pacific towards the Maritime Continent.

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

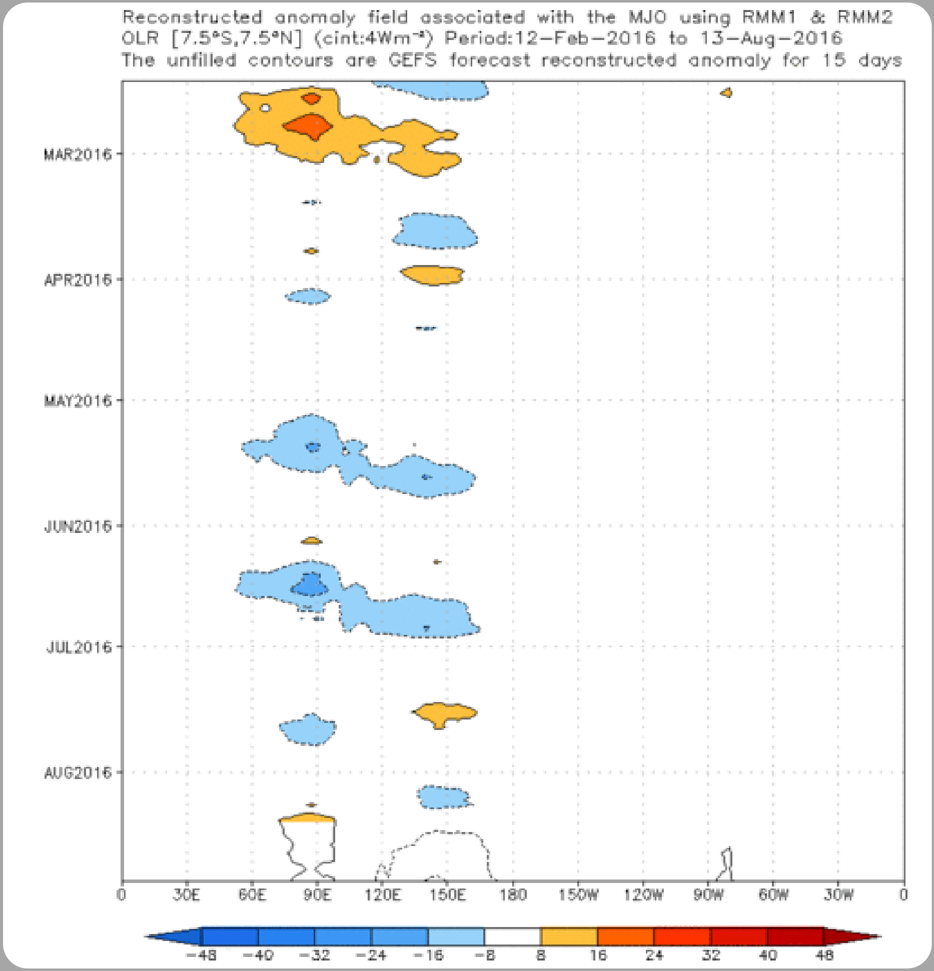
Ensemble GFS (GEFS) MJO Forecast

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



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

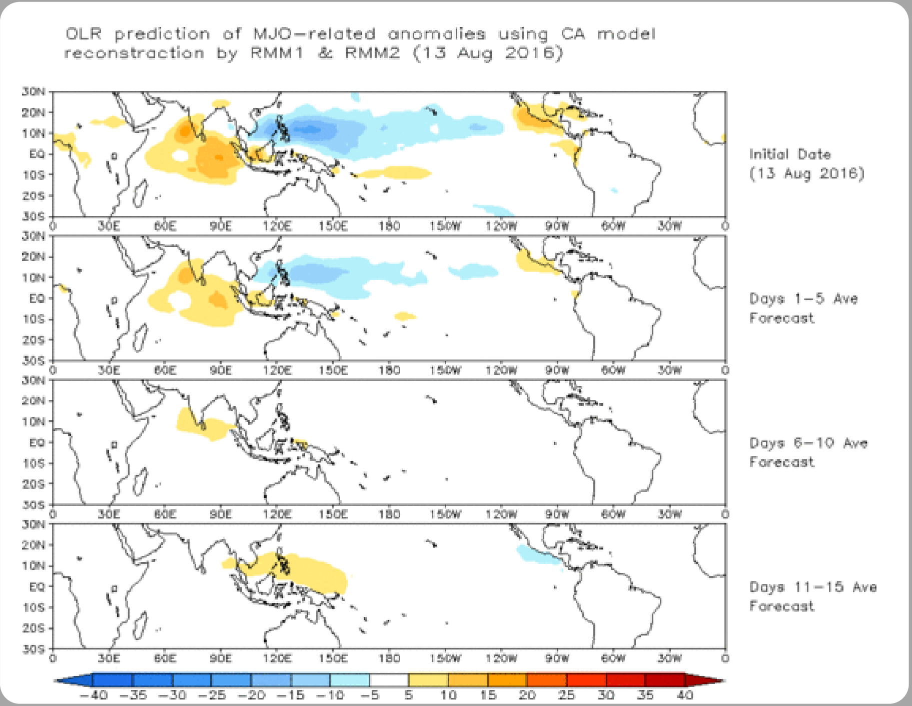


The GEFS OLR forecast based on the GEFS forecast of the RMM Index depicts an amplifying but spatially stagnant signal.

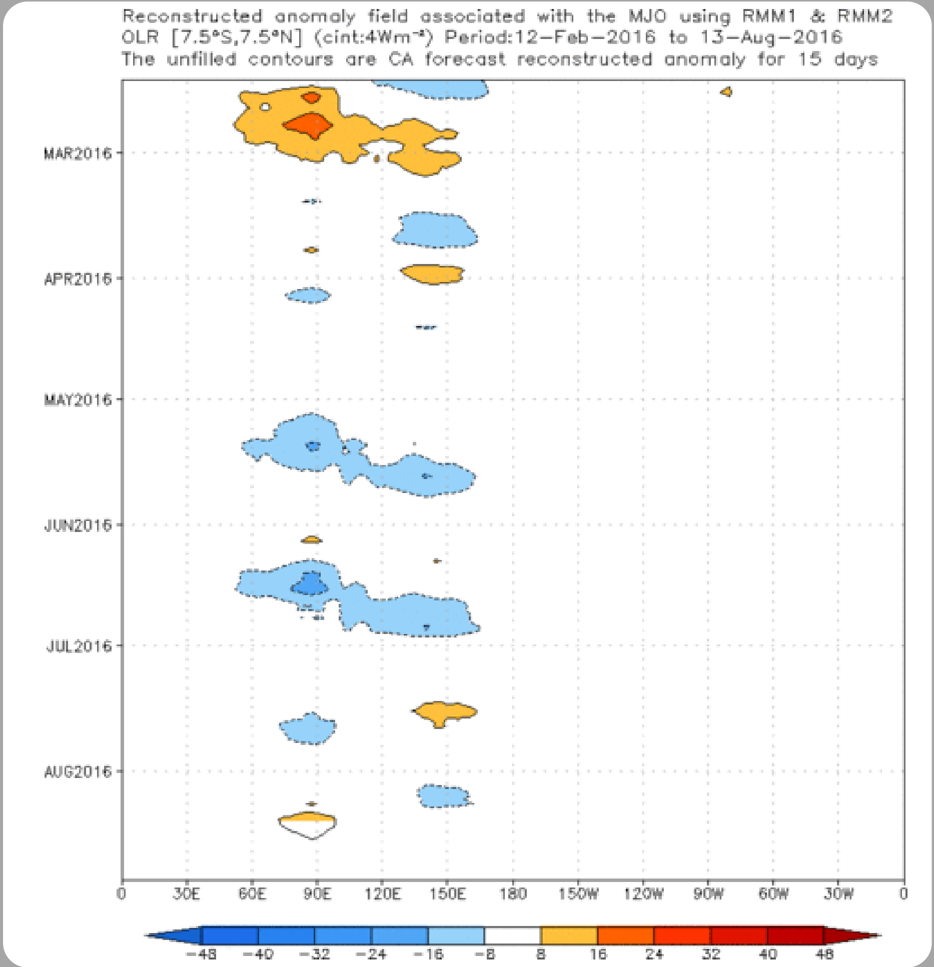
Constructed Analog (CA) MJO Forecast

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



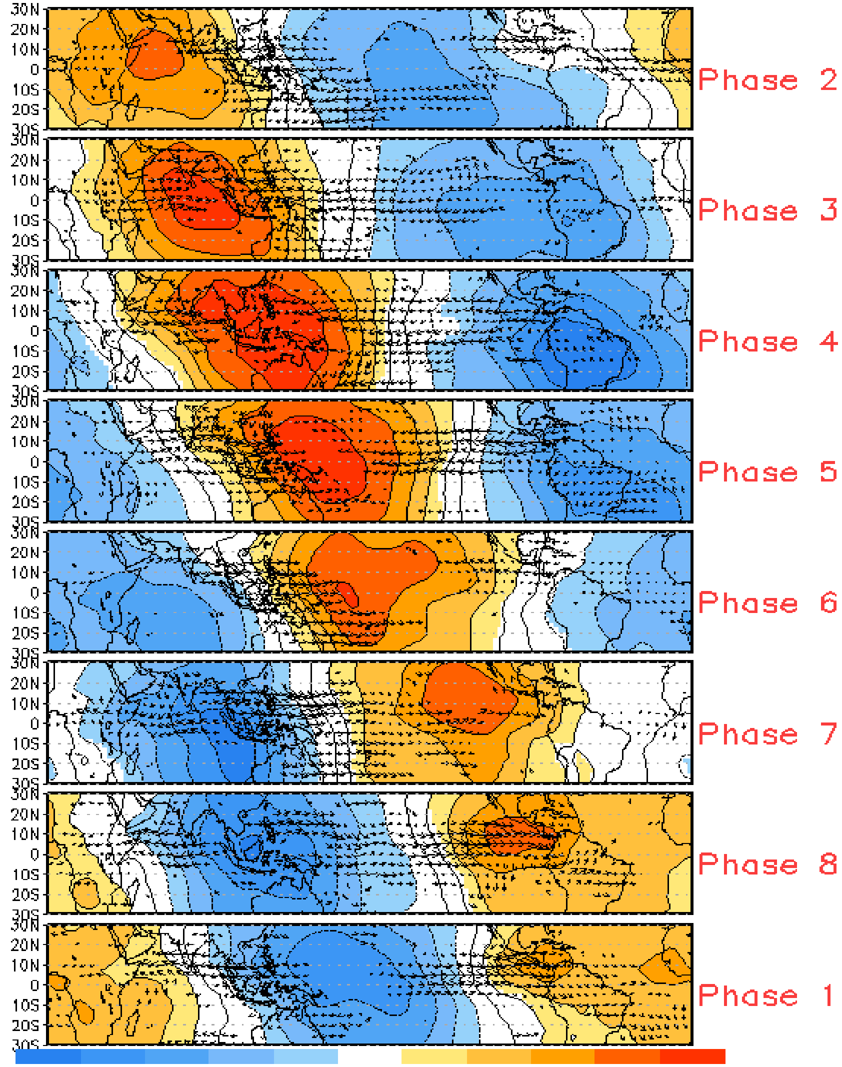
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



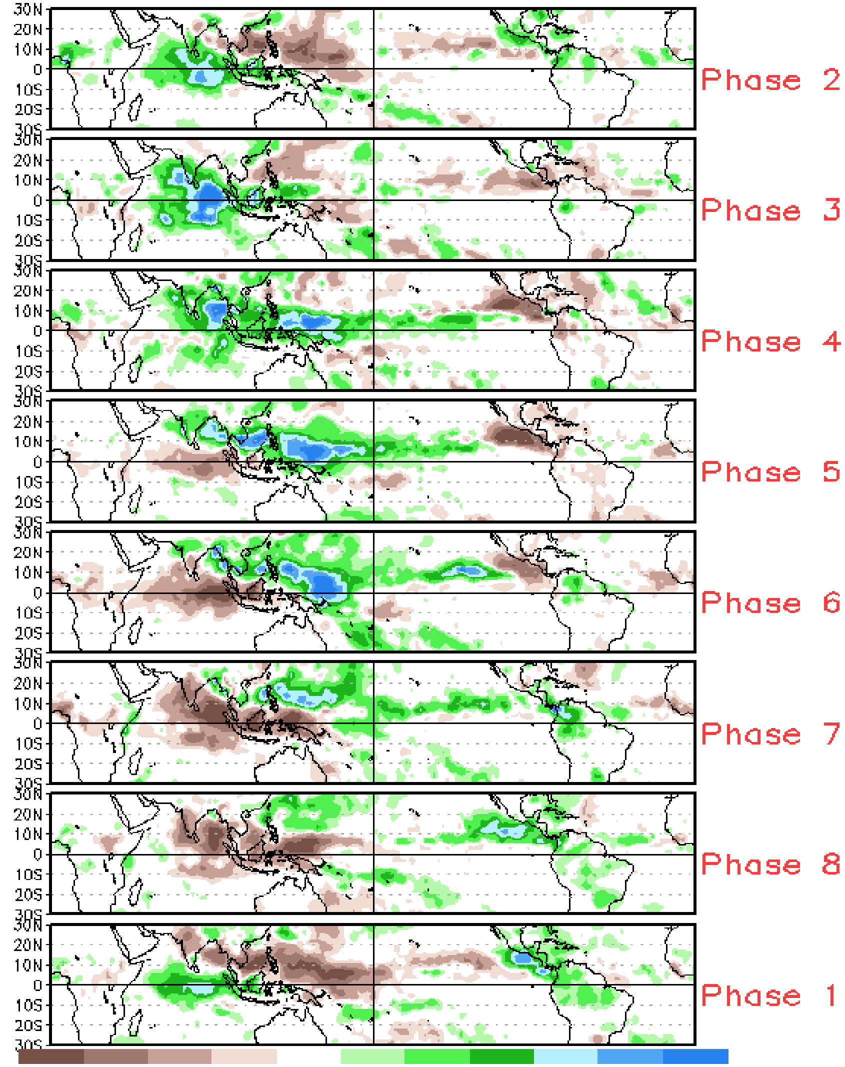
The Constructed Analog (CA) model predicts a rapidly weakening signal, with slow propagation of suppressed convection from the Indian Ocean to the Maritime Continent.

MJO Composites - Global Tropics

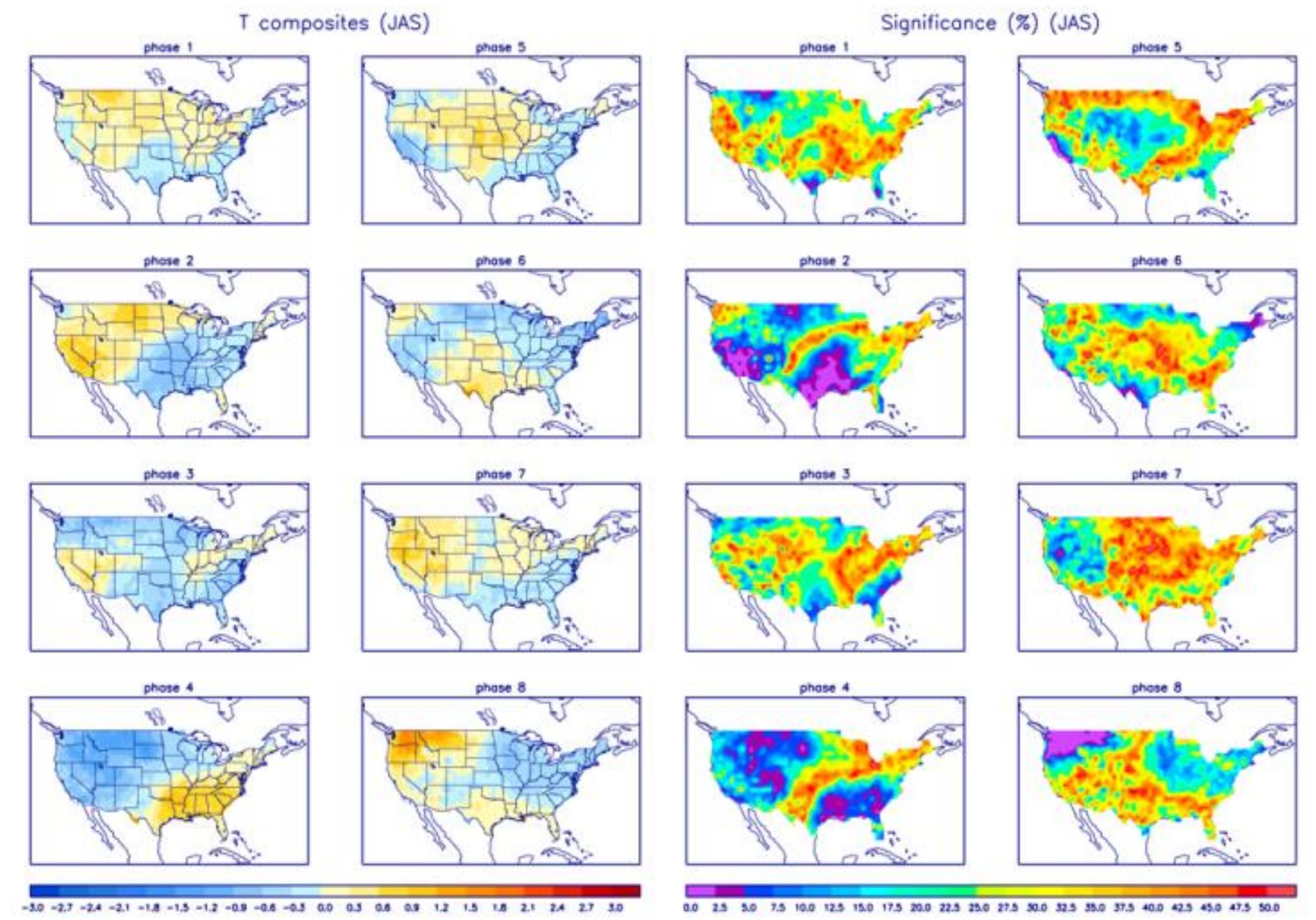
850-hPa Velocity Potential and Wind Anomalies (May - Sep)



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.

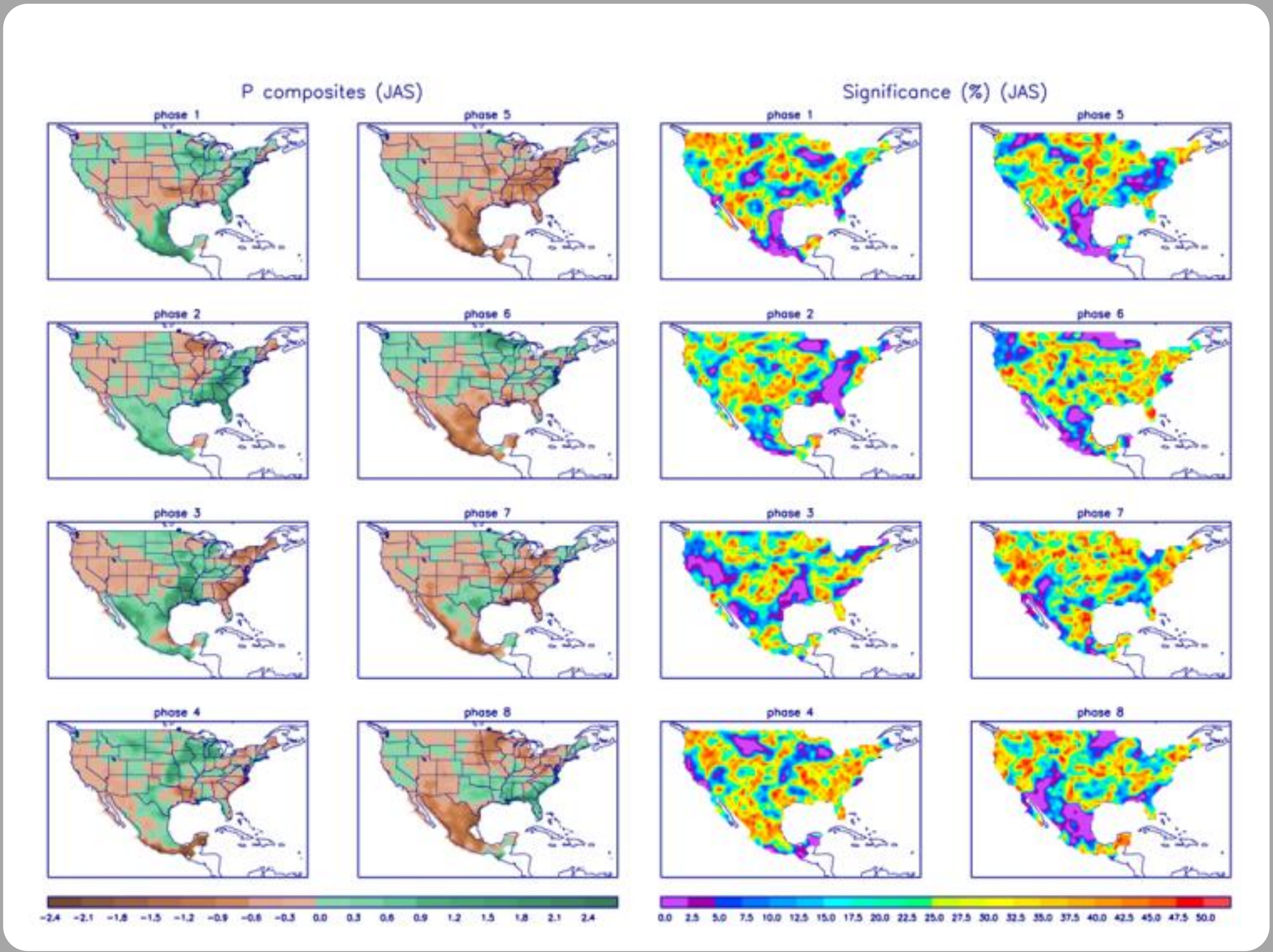
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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