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

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Overview

The MJO is presently weak, with weakening of a signal over the western Pacific during the past week. This signal was not robustly tied to the MJO due to the lack of zonal propagation for several weeks, however, and was instead linked to the monsoon trough in the West Pacific.

Dynamical model RMM-based MJO Index forecasts generally depict the emergence of a weak MJO signal somewhere between the eastern Indian Ocean and the western Pacific during the next two weeks.

Continued weakness in the MJO is favored at this time, given lingering uncertainty in West Pacific monsoon trough influences that could be impacting the RMM index's capability to properly represent the intraseasonal signal. Tropical and mid-latitude influences are more likely to come from tropical cyclone activity and a slowly evolving low-frequency state. If an active MJO were to emerge over the Indian Ocean, favorable conditions for tropical cyclogenesis could be possible in both the East Pacific and Atlantic basins.

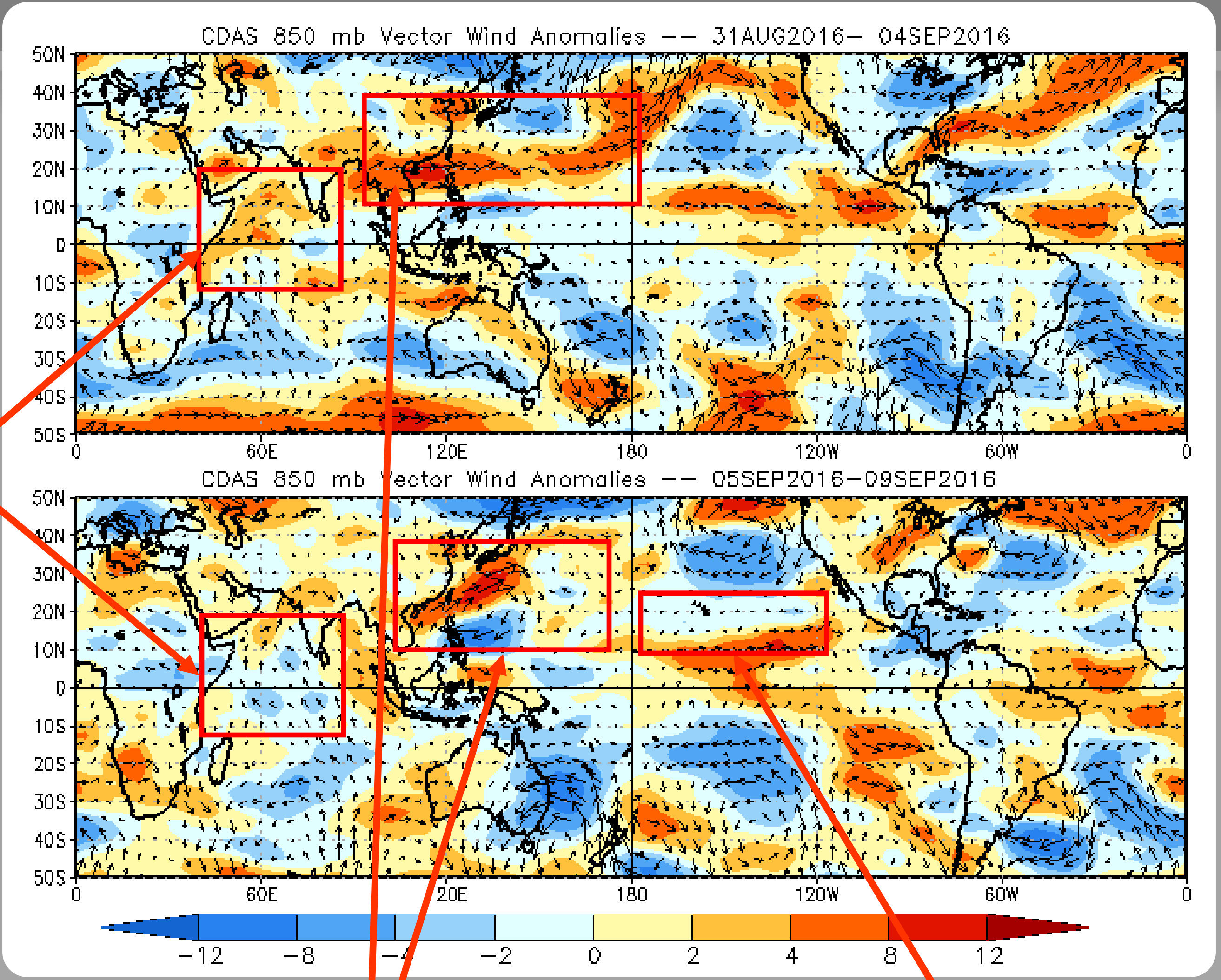
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Robust cross-equatorial flow returned to the western Indian Ocean and Arabian Sea, indicative of an uptick in the monsoon.

The western Pacific monsoon trough, displaced northward during the early period, assumed an anticyclonic rotation during the recent period.

Low-level winds weakened significantly during recent.

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

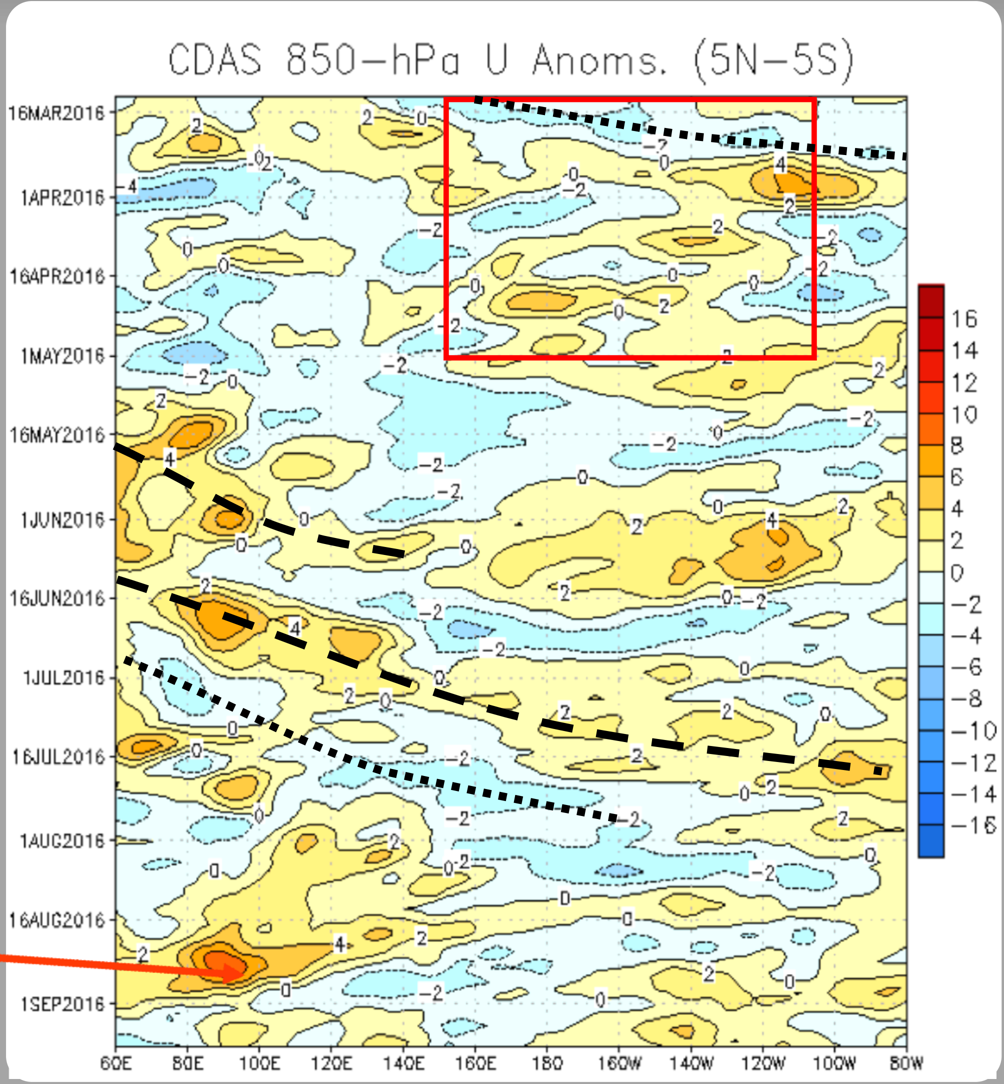
The red box highlights the persistent low-frequency westerly wind anomalies associated with the 2015-2016 El Niño background state.

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

During April, the wind field became less coherent as El Niño conditions weakened. During May and June, westerly anomalies were persistent over the Indian Ocean (IO), with higher frequency modes periodically propagating across the Pacific.

During late August, westerly anomalies were evident across the IO and western Pacific.

By early September, the anomaly pattern had weakened significantly.



OLR Anomalies – Past 30 days

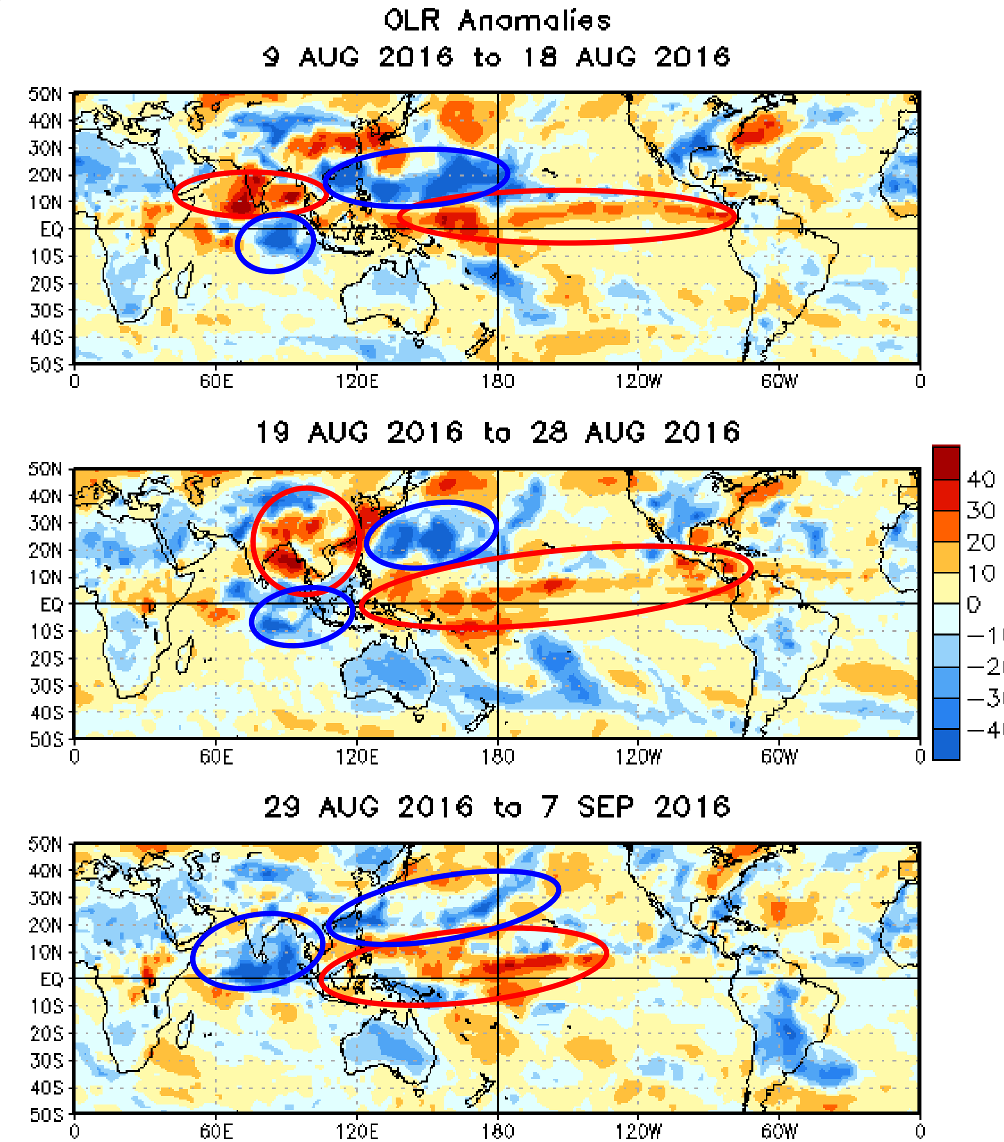
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

In early-mid August, suppressed convection existed across the northern IO, and just north of the equator in the Pacific. Enhanced convection was apparent over the eastern equatorial IO , and stretching east from the South China Sea with the monsoon trough.

In mid-late August, suppressed (enhanced) convection persisted over parts of south/southeast Asia (eastern Indian Ocean and western Maritime Continent), while enhanced convection, partially TC-driven, shifted northward over the northwest Pacific.

In late August and early September, convection associated with the monsoon trough weakened; suppressed convection was located from Borneo to the east-central Pacific. A return in monsoonal flow across the Arabian Sea brought enhanced convection back to much of India.



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

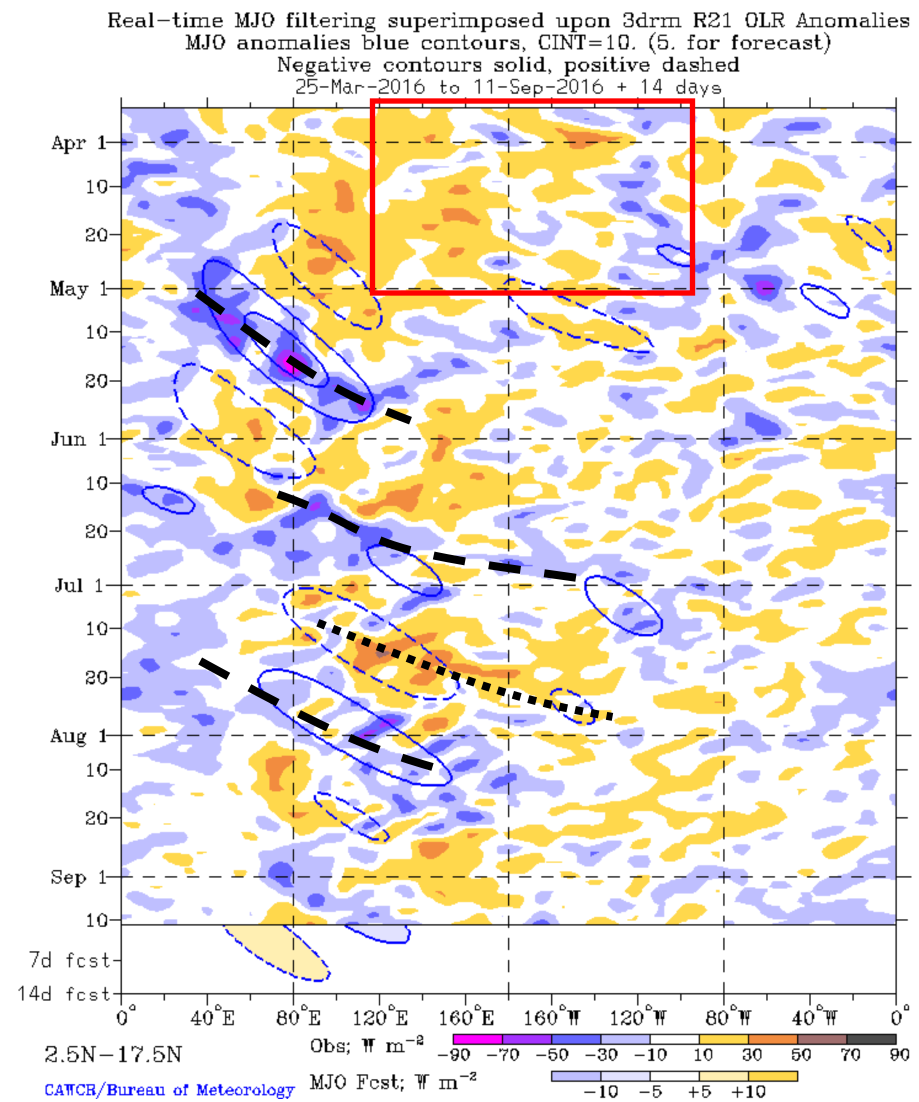
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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, another eastward propagating signal is evident. During July, the signal continued moving eastward, with interference from tropical cyclone activity.

During August, persistent suppressed convection over the Bay of Bengal and Maritime Continent is evident. Westward moving features (Rossby waves or TCs) embedded in the monsoon trough appear to be the dominant feature over the northwest Pacific.



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

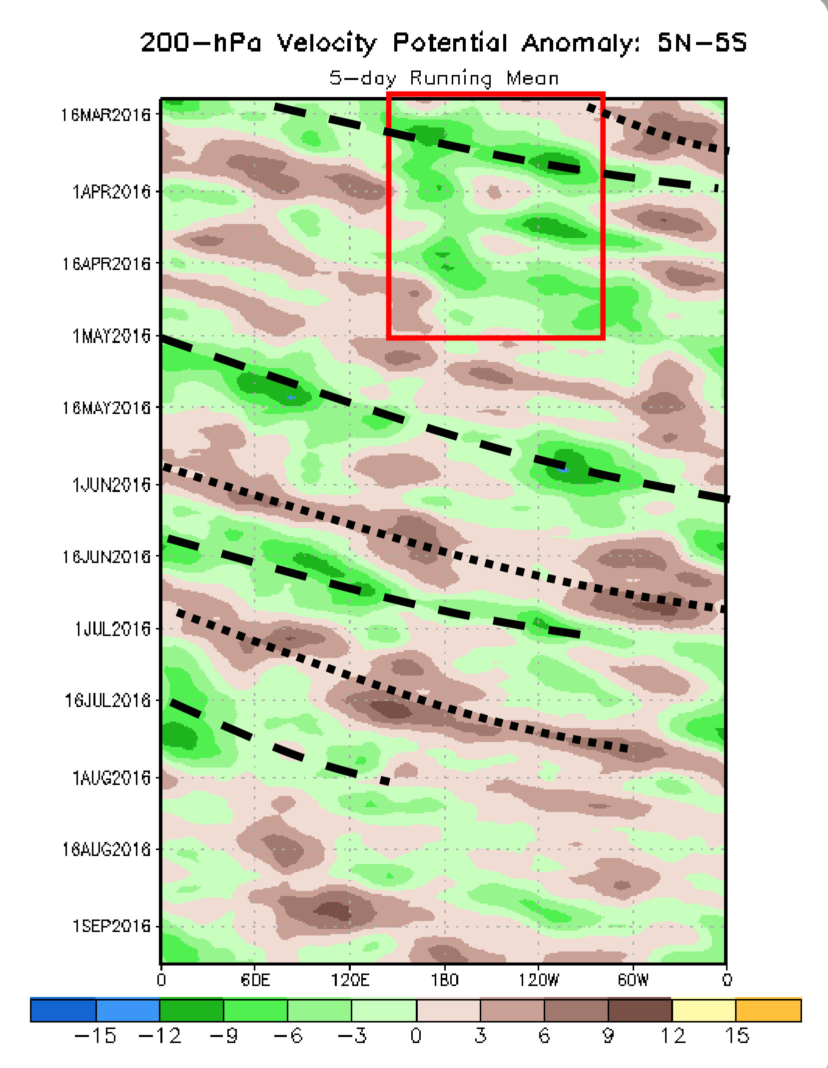
The 2015-16 El Niño background state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

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

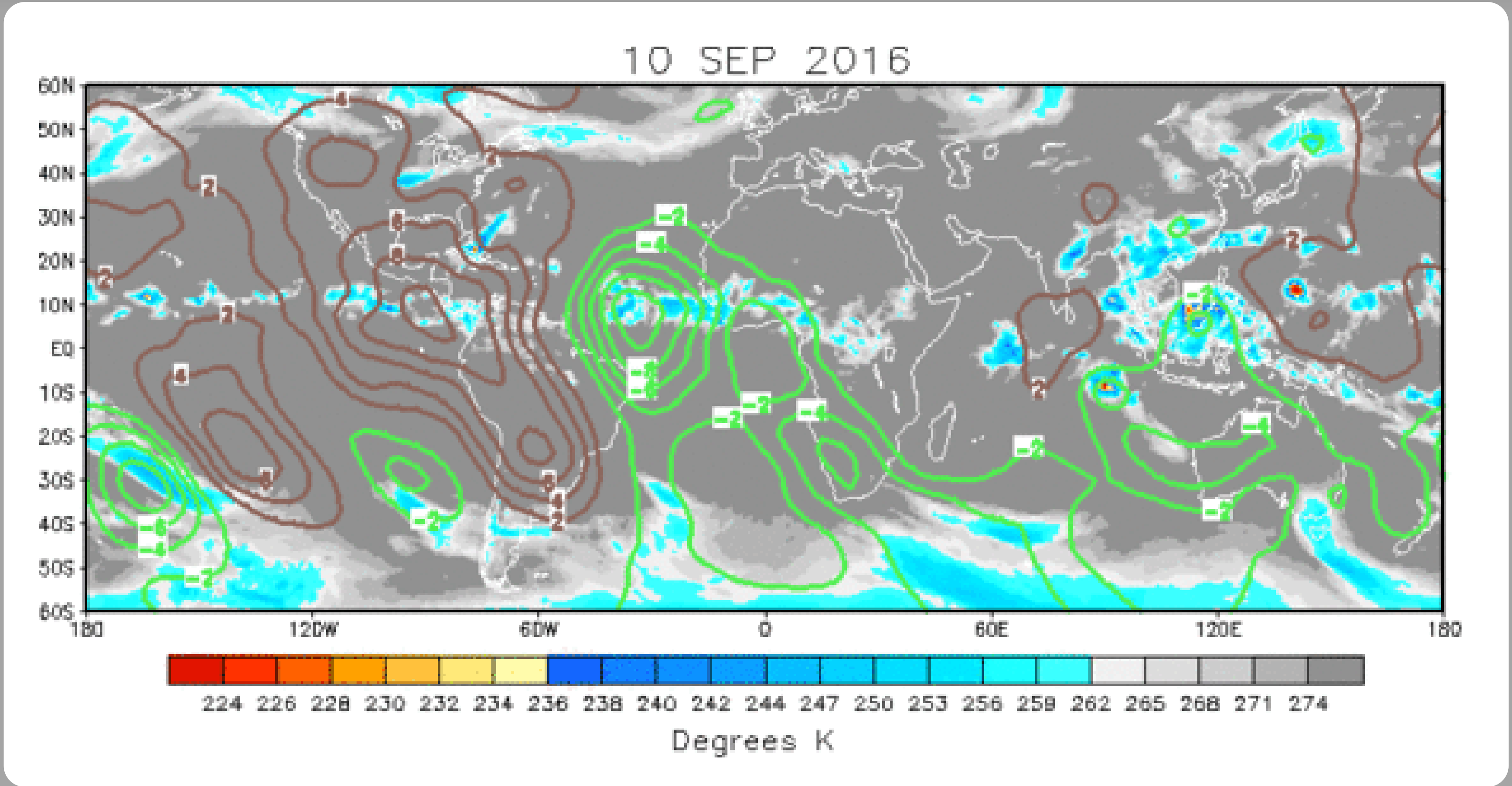
The upper-level velocity potential pattern became less coherent as El Niño waned during April.

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

During August, the intraseasonal signal became less coherent, with a weaker and somewhat more stationary anomaly field in place. By late August & early September, the intraseasonal signal depicts renewed propagation.



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



The upper-level velocity potential field is relatively weak and incoherent, with a slight tendency towards a Wave-1 pattern. Enhanced (suppressed) convection is generally favored across the eastern Atlantic and Maritime Continent (The Americas and much of the 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)

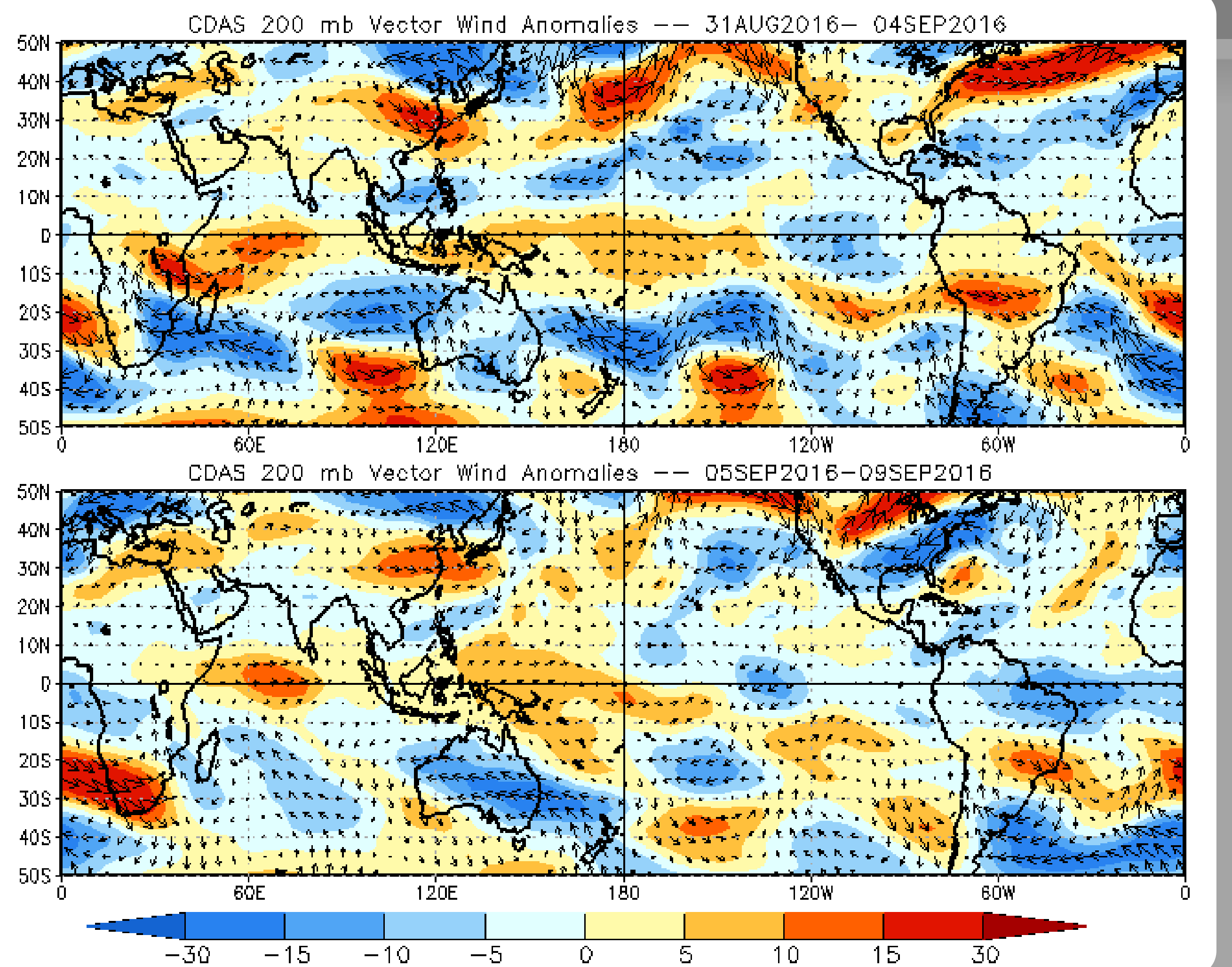
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

The continued poleward shift of the monsoon trough in the west Pacific was apparent over the last 10 days.

Westerlies built across the eastern Maritime Continent and western Pacific during the past 10 days.



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

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

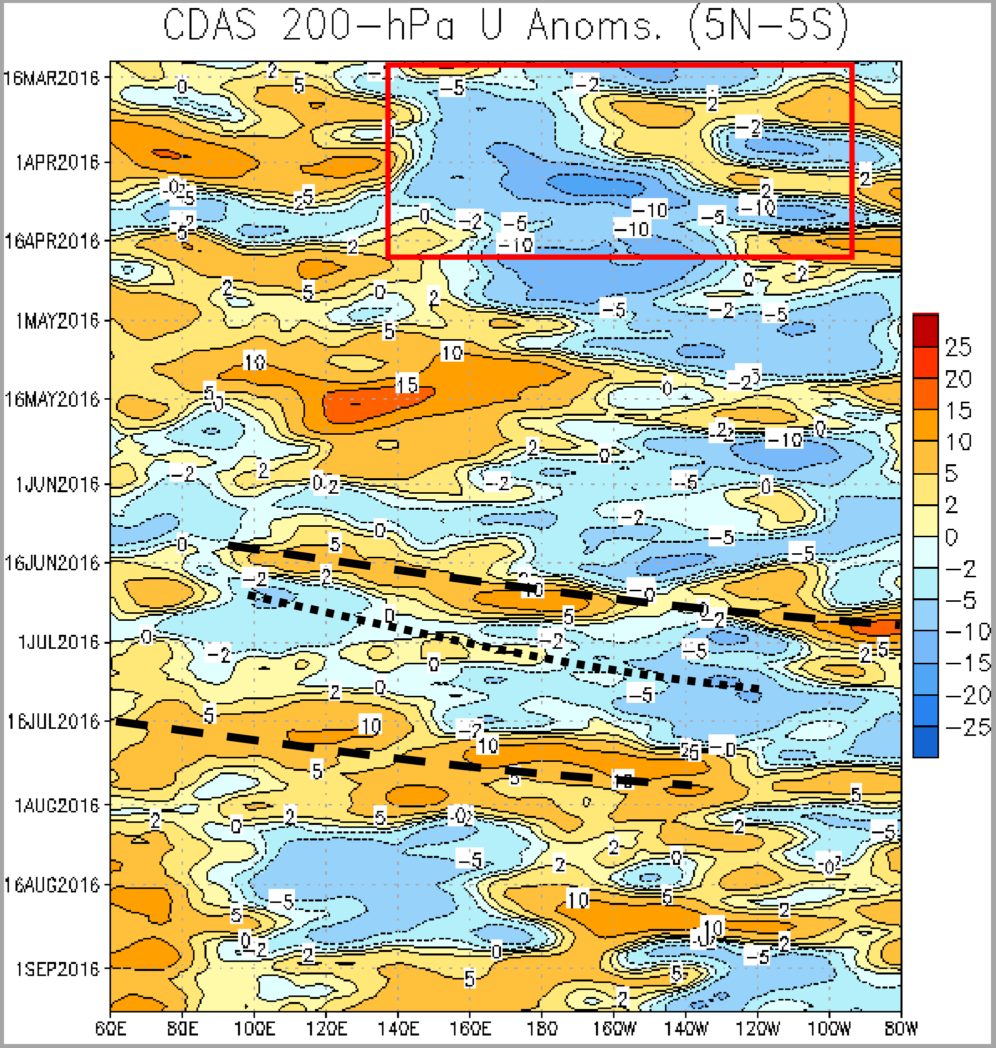
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Easterly anomalies 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. Faster modes were evident in the upper-level wind field.

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 and early September, the pattern has become relatively stationary, though a reversal in anomaly sign occurred about two weeks ago.



Weekly Heat Content Evolution in the Equatorial Pacific

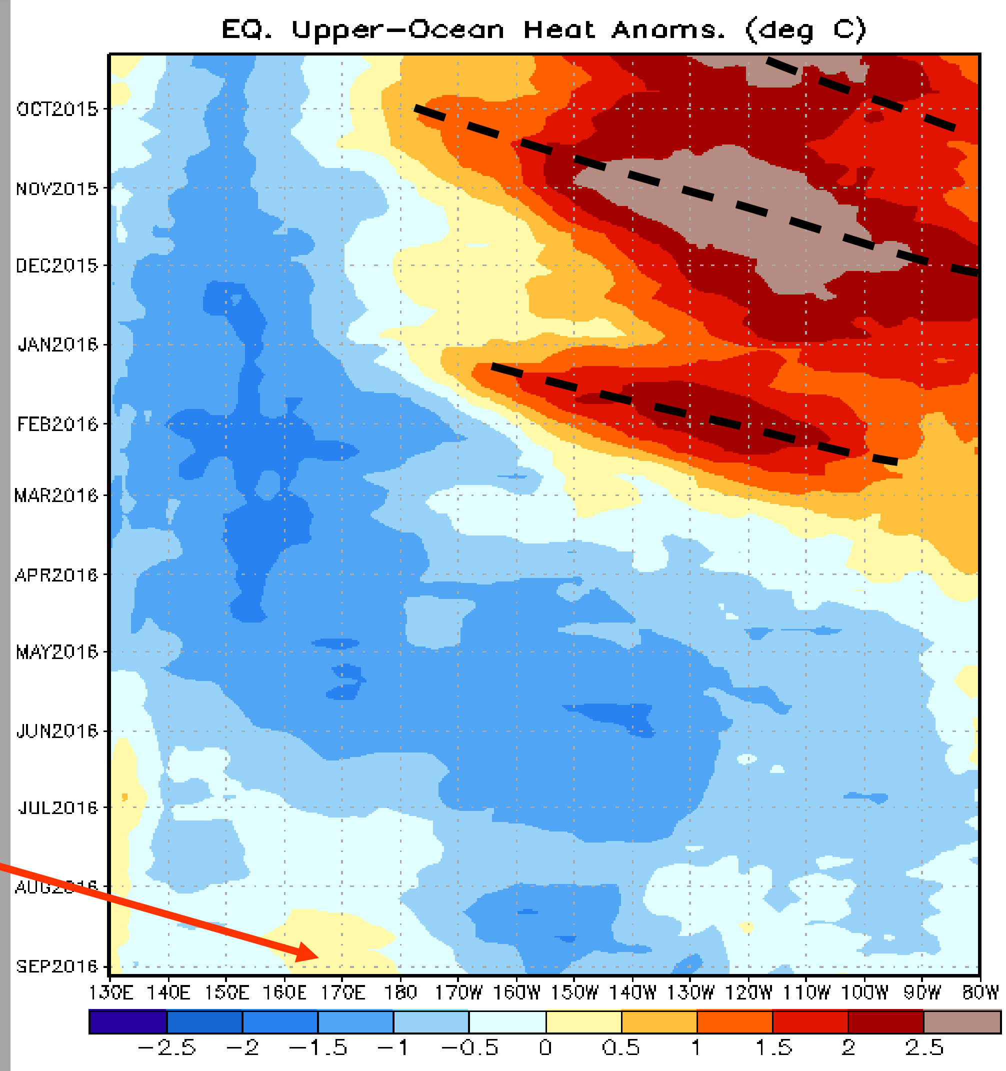
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

Reinforcing downwelling events were observed during late 2015, resulting in persistently above-normal heat content from the DL to 80W over that period.

An eastward expansion of below average heat content over the western Pacific is evident since January, with widespread negative anomalies building across the Pacific.

Strongest negative anomalies now persist over the east-central Pacific.

Some positive oceanic heat anomalies remain just west of the Date Line and in the vicinity of the Maritime Continent.



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

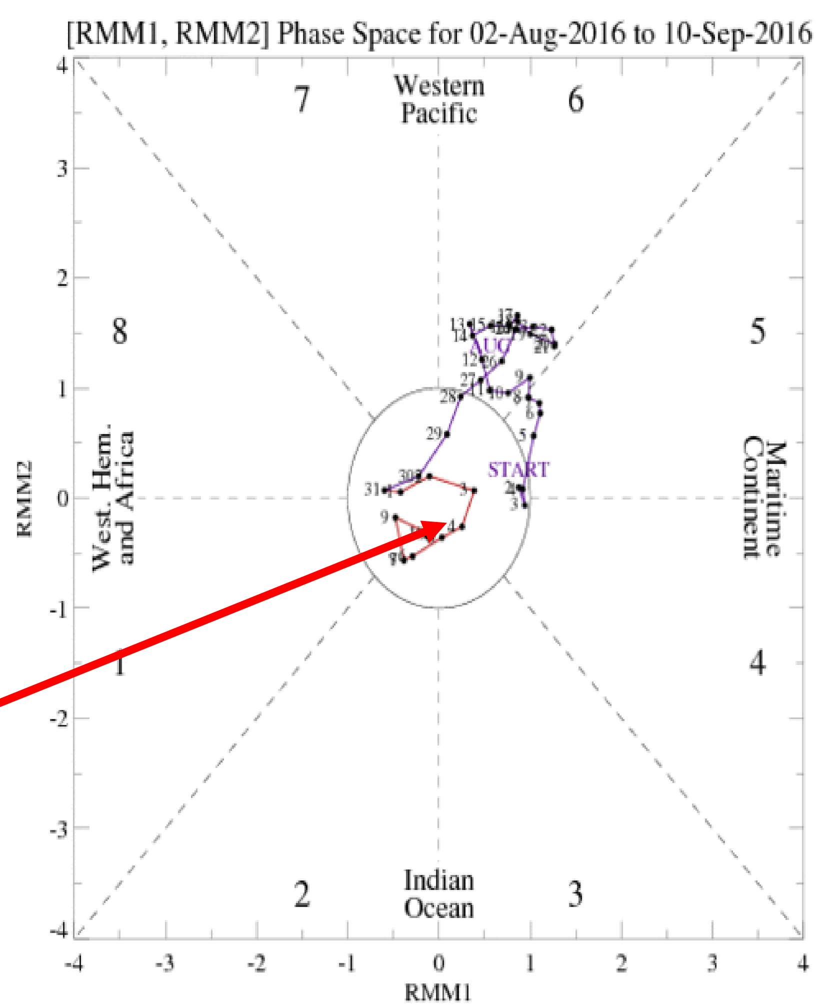
Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.

Distance from the origin is proportional to MJO strength

Line colors distinguish different months

During the past several weeks, the RMM Index indicated an enhanced signal over the western Pacific, with little eastward propagation. The MJO remained weak during the past two weeks.

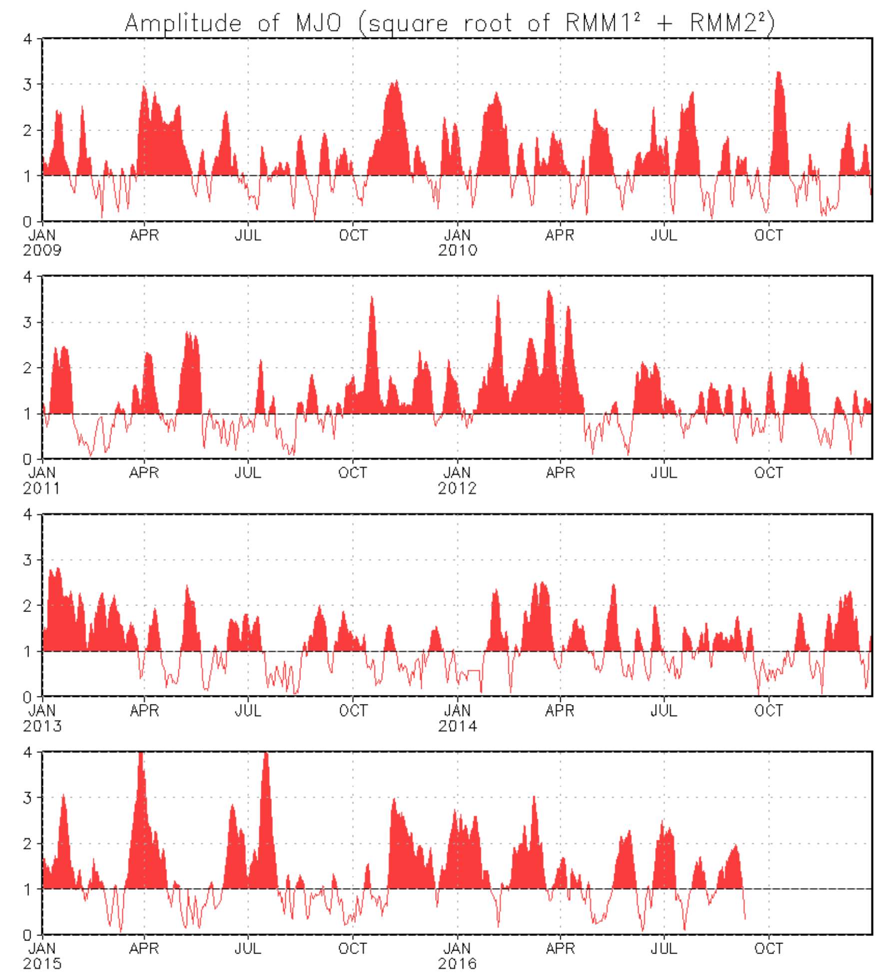
This quasi-stationary behavior may be tied to the influence of the monsoon trough and embedded TC activity, which may have now lifted far enough north to limit influence on the RMM framework.



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

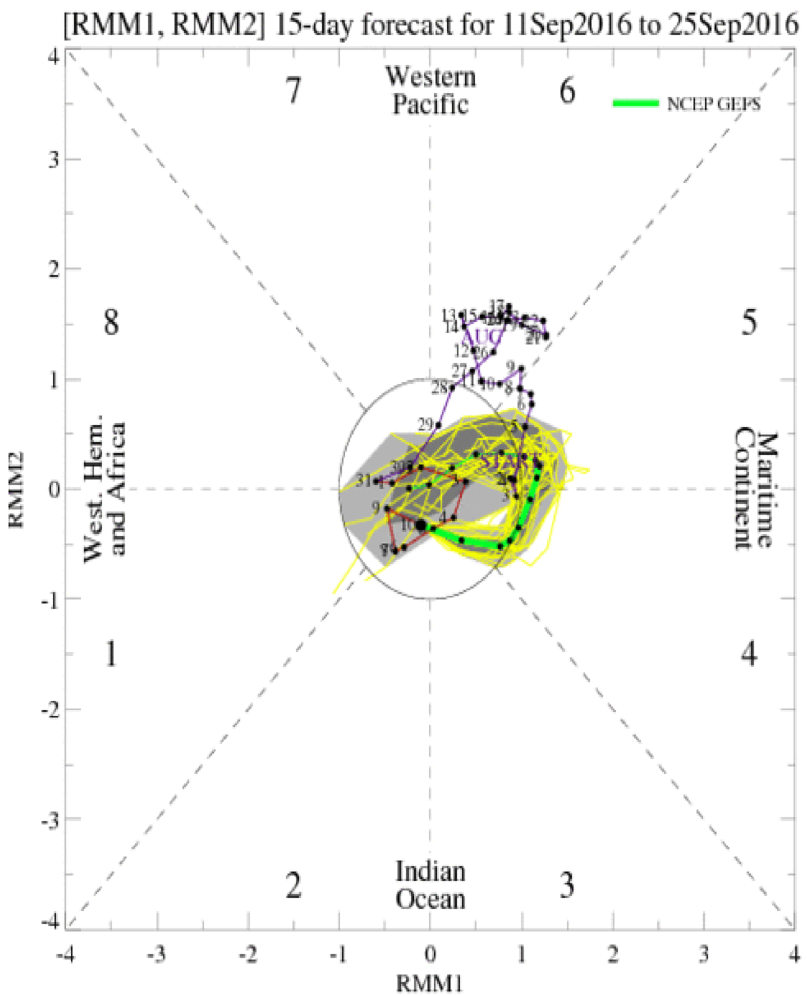
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

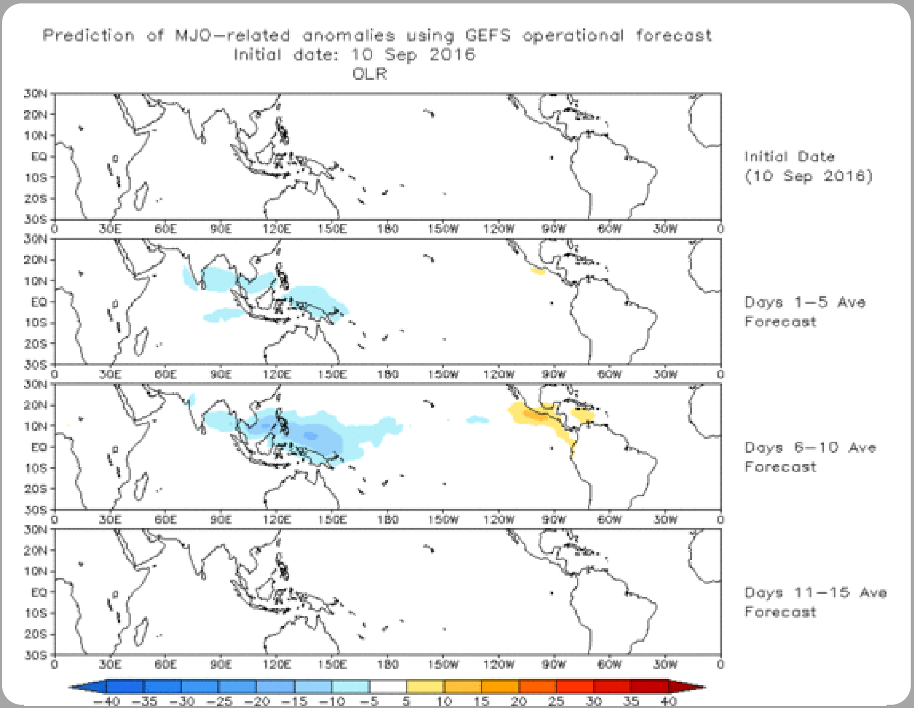
During the next two weeks, GFS ensemble RMM Index forecasts suggest the emergence of a weak MJO signal over the Maritime Continent.



Ensemble GFS (GEFS) MJO Forecast

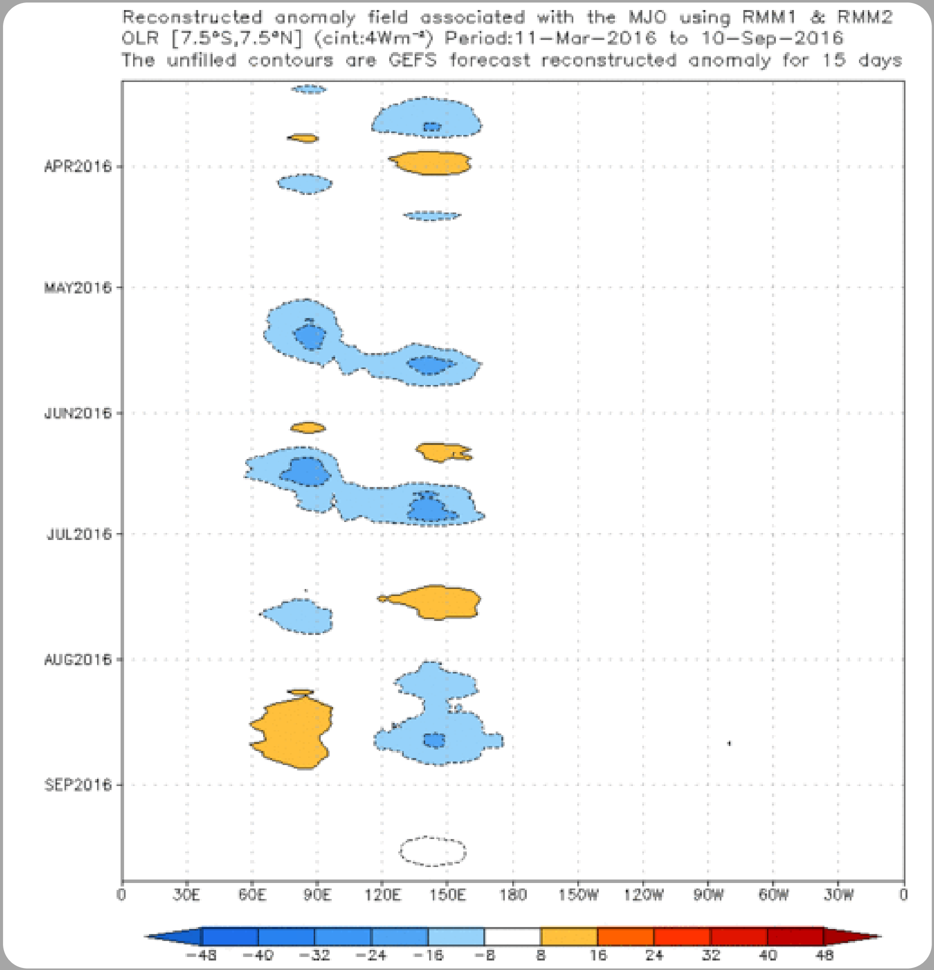
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS RMM Index forecast based OLR anomalies show an area of weakly enhanced convection emerging from the far eastern Indian Ocean to the western Pacific during the next 10 days.

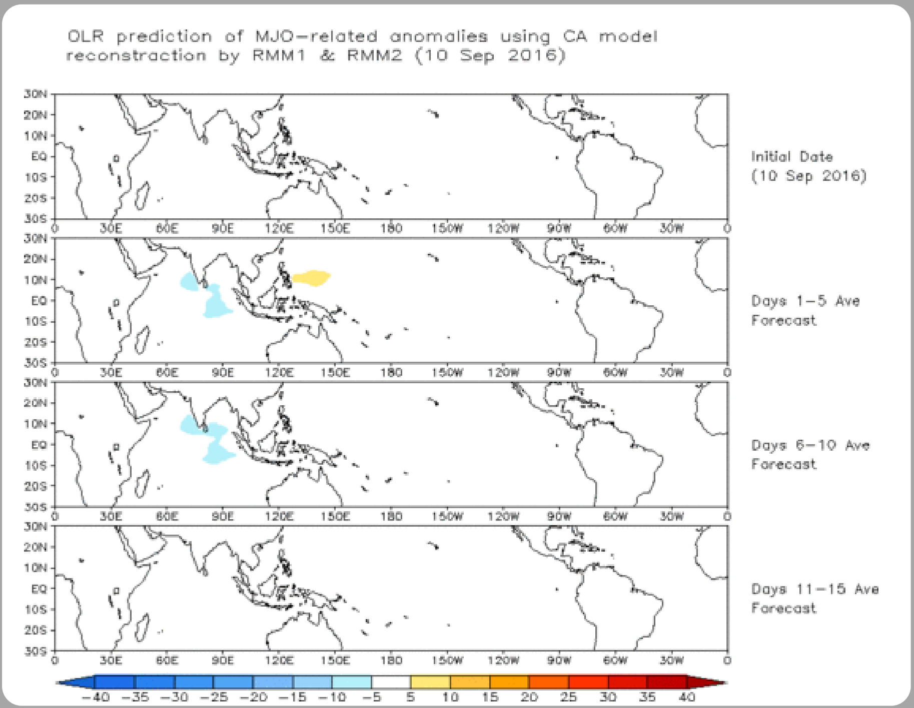
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

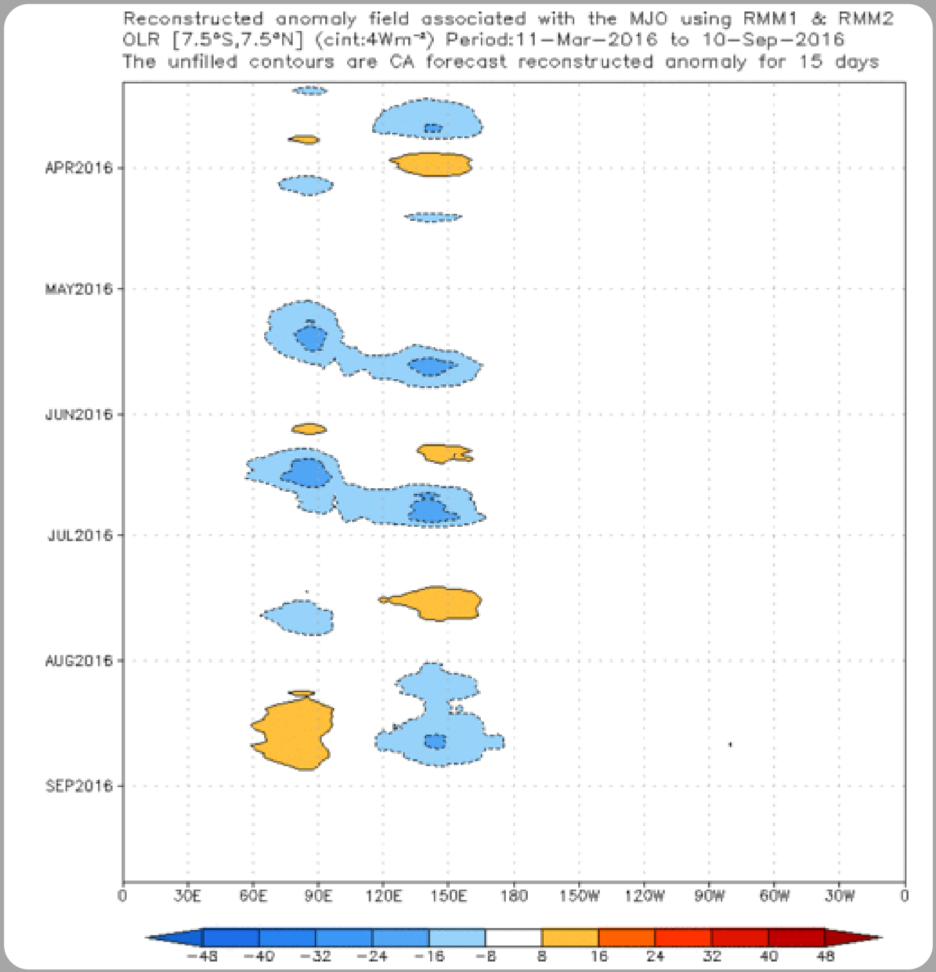
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



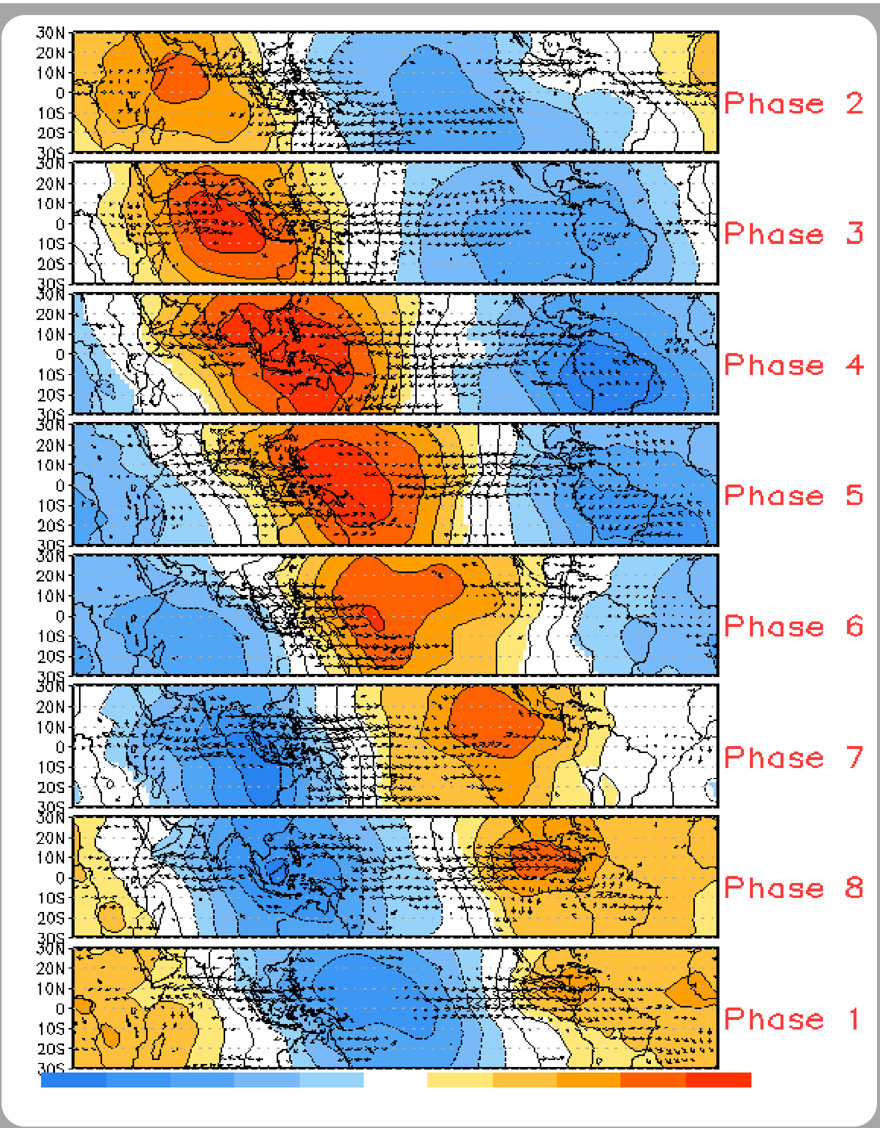
The Constructed Analog (CA) model predicts negligible convective anomalies over the next two weeks.

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

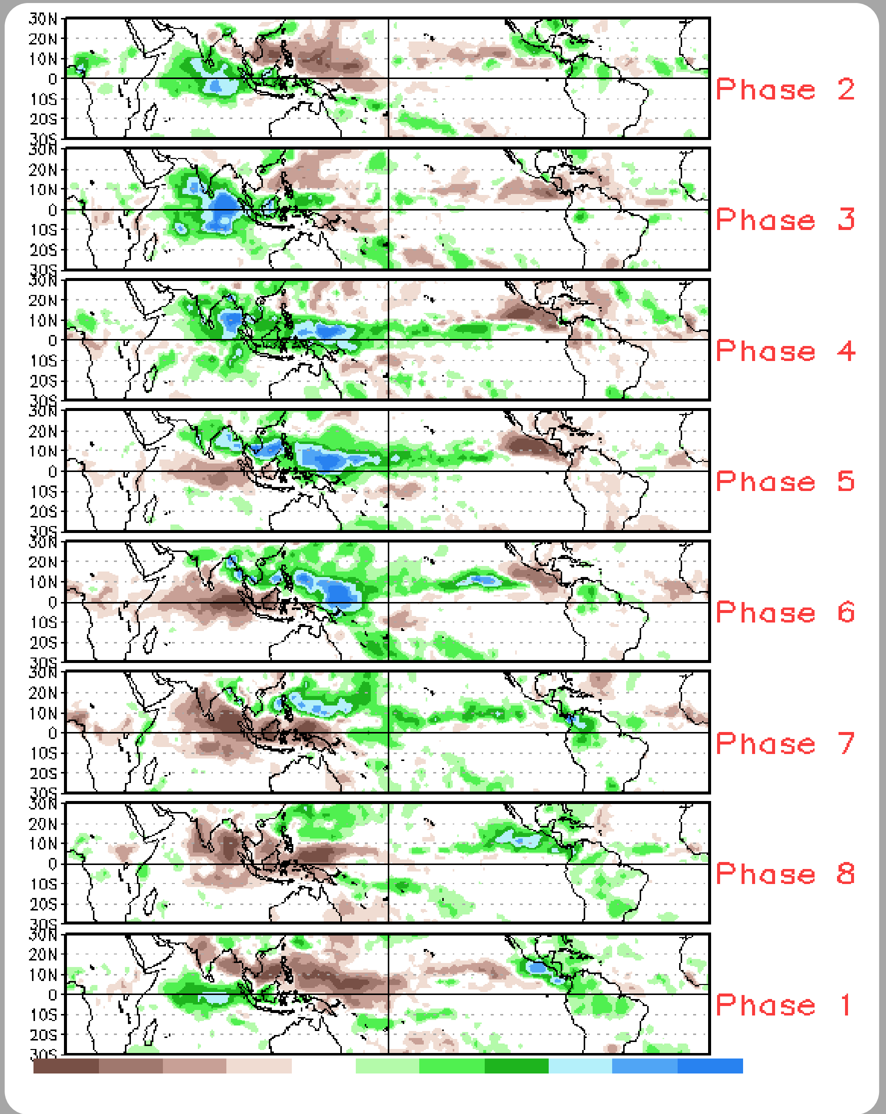


MJO Composites - Global Tropics

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



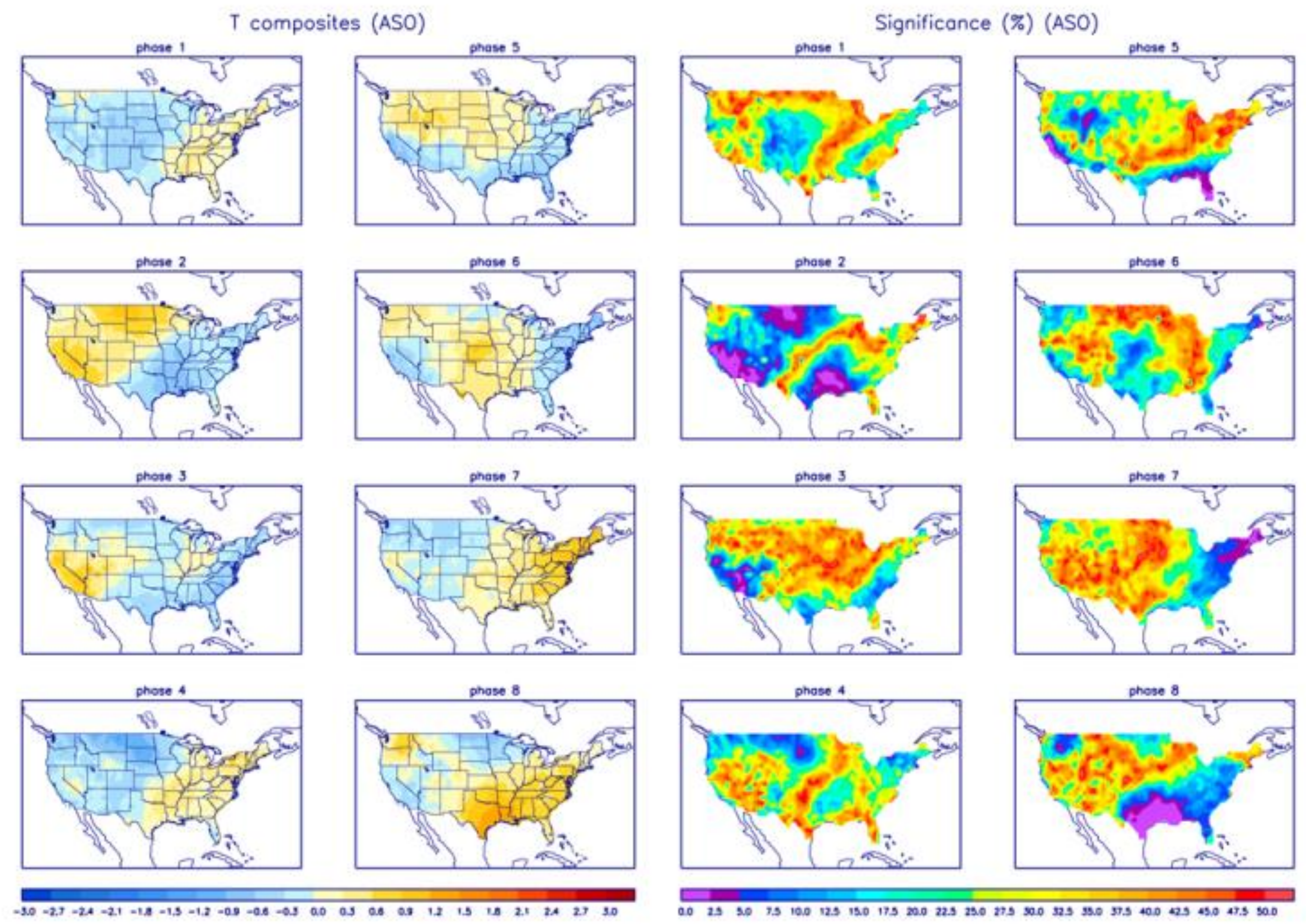
Precipitation Anomalies (May - Sep)



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.

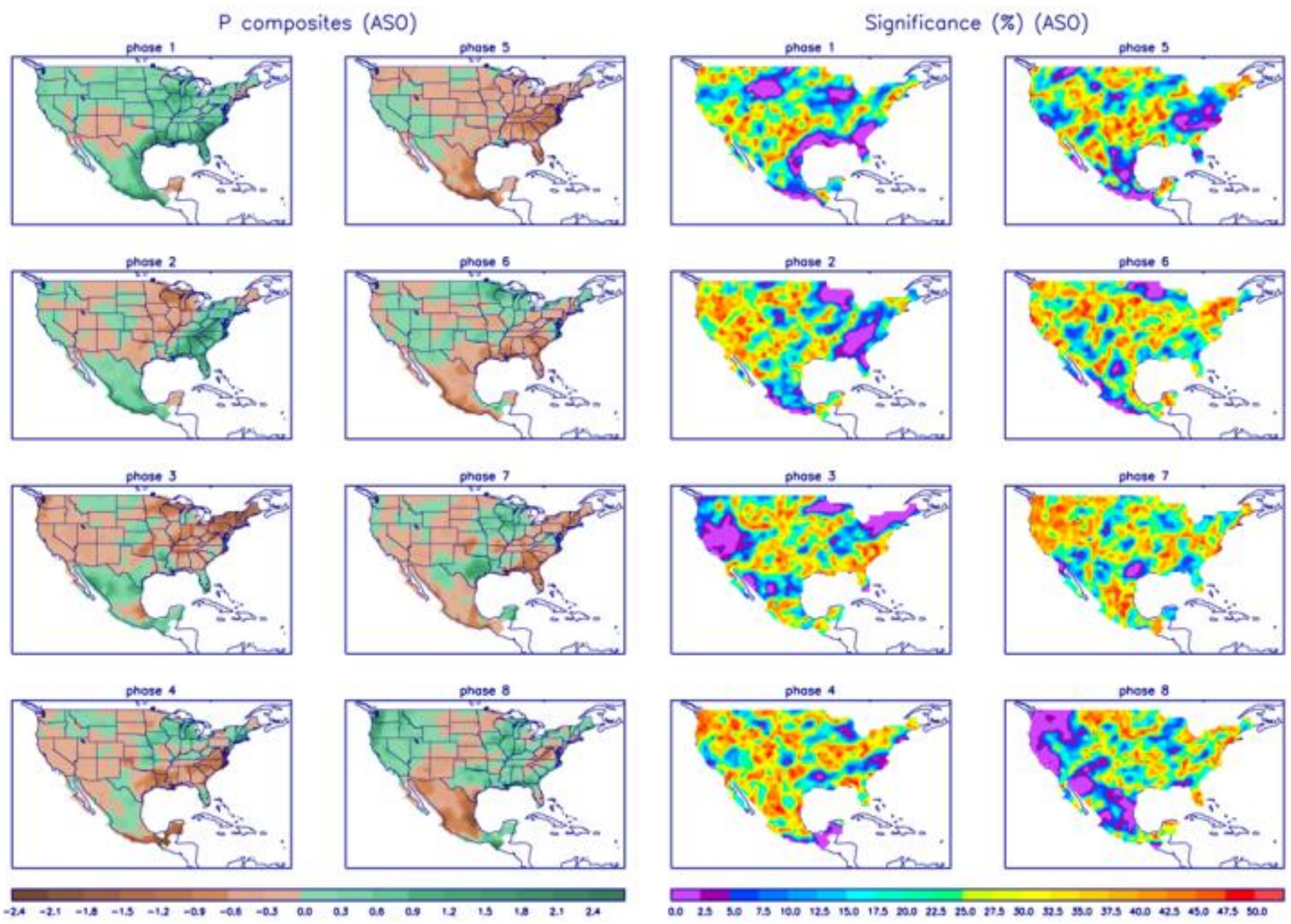
Right hand side plots show a measure of significance for the left hand side anomalies. Purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.



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.

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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