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

Update prepared by: Kyle MacRitchie
Climate Prediction Center / NCEP
10 September 2018

Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The MJO signal as monitored by the RMM index has amplified over the Western Hemisphere of late. However, the velocity potential index better reveals a low-frequency pattern with enhanced upper-level divergence over the Pacific.

- Dynamical model MJO forecasts do not seem to sustain a physically meaningful MJO signal during the next two weeks.

- Enhanced convection over the equatorial Pacific should continue to slide slowly eastward as the gradual transition towards El Niño continues.

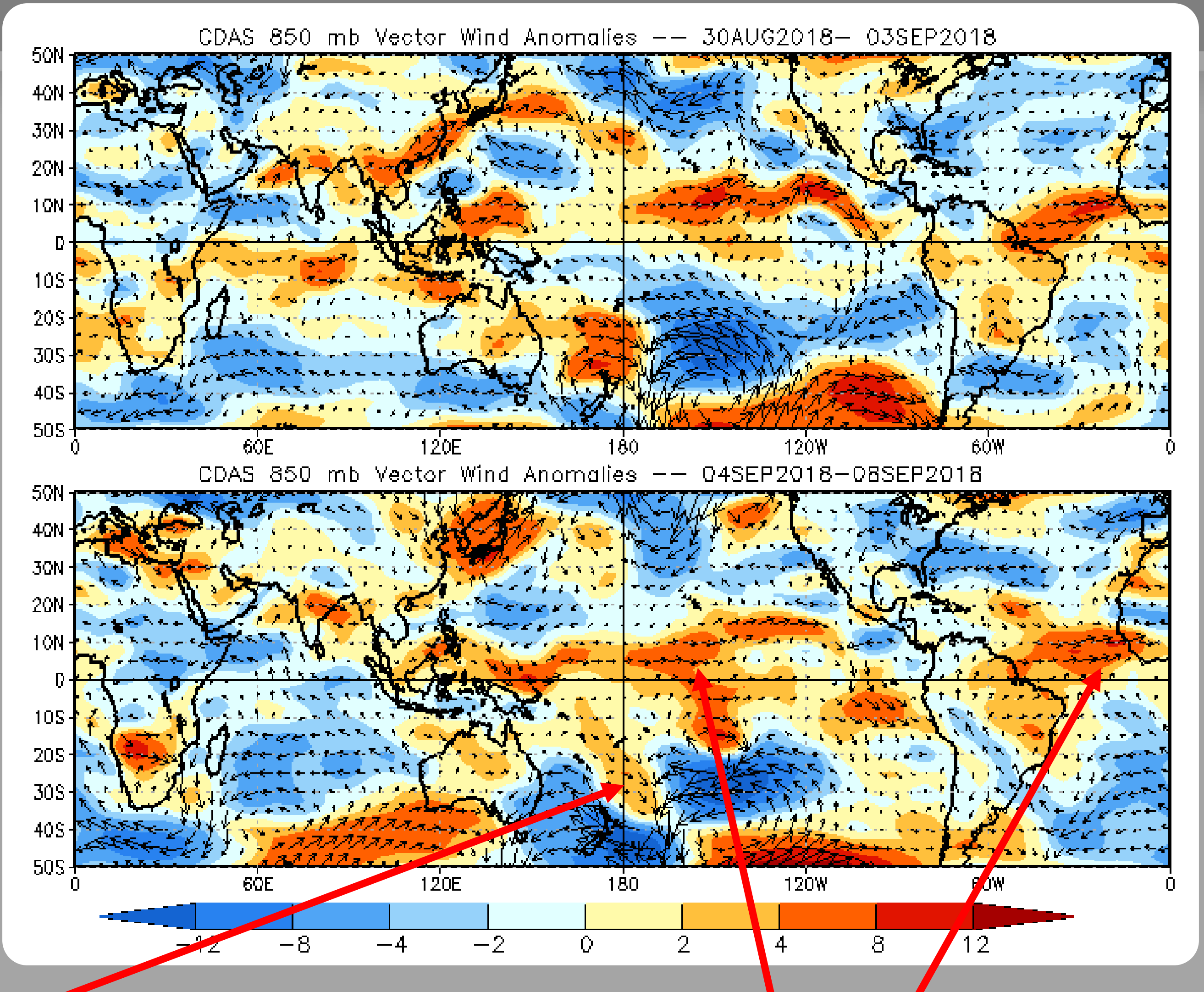
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



An extratropical Rossby wave trains is feeding into the southern Tropics.

Anomalous westerlies persisted over the Central Pacific and North Atlantic.

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

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

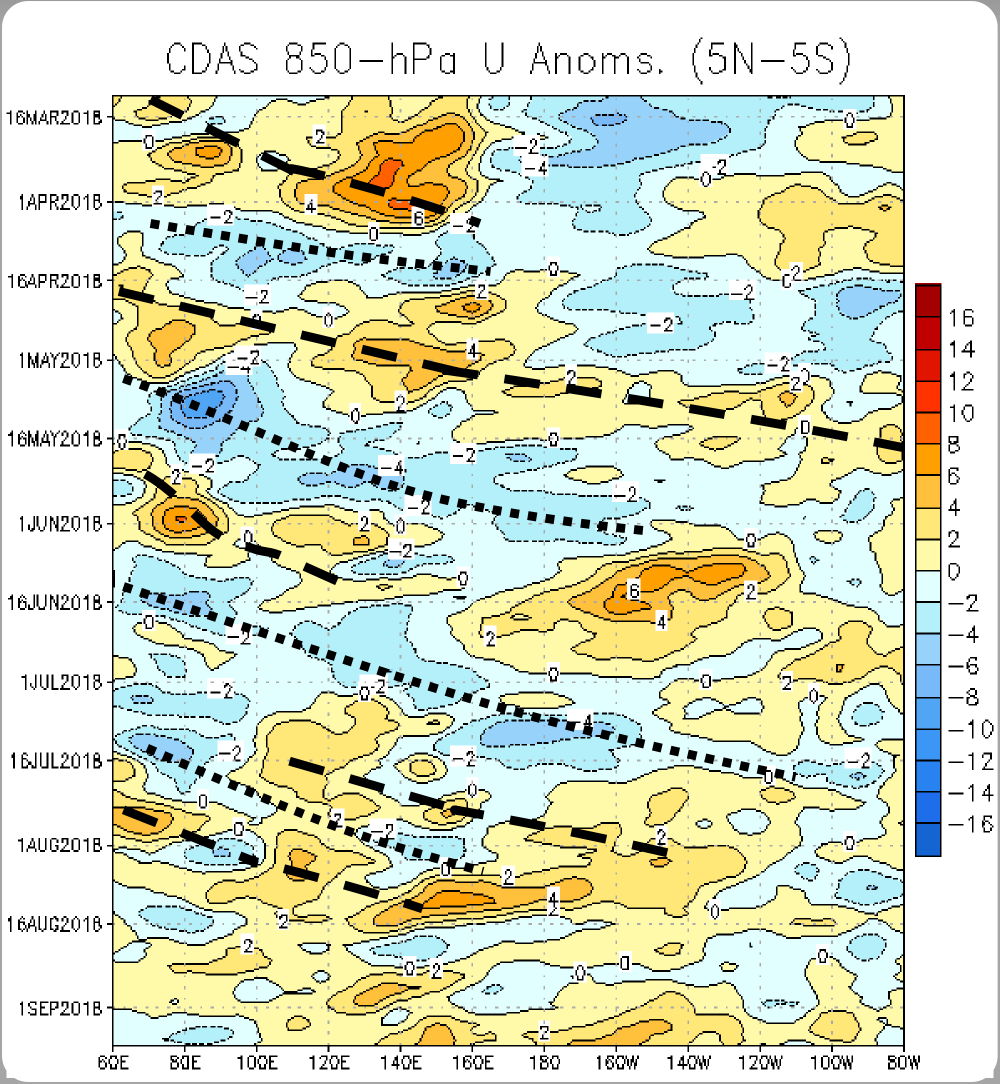
Easterly anomalies (blue shading) represent anomalous east-to-west flow

MJO activity was observed during March, but the signal rapidly broke down by early April.

The MJO was active again during late April and May. Westward moving variability, including TC activity over the Pacific and equatorial Rossby waves, weakened the signal during June.

A weak intraseasonal signal re-emerged during mid to late July. During August, the intraseasonal signal weakened, and other modes, including Rossby wave and tropical cyclone activity, influenced the pattern.

More recently, Rossby wave activity continues to dominate the Pacific, while westerly anomalies overspread the equatorial Maritime Continent and equatorial Pacific.



OLR Anomalies – Past 30 days

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

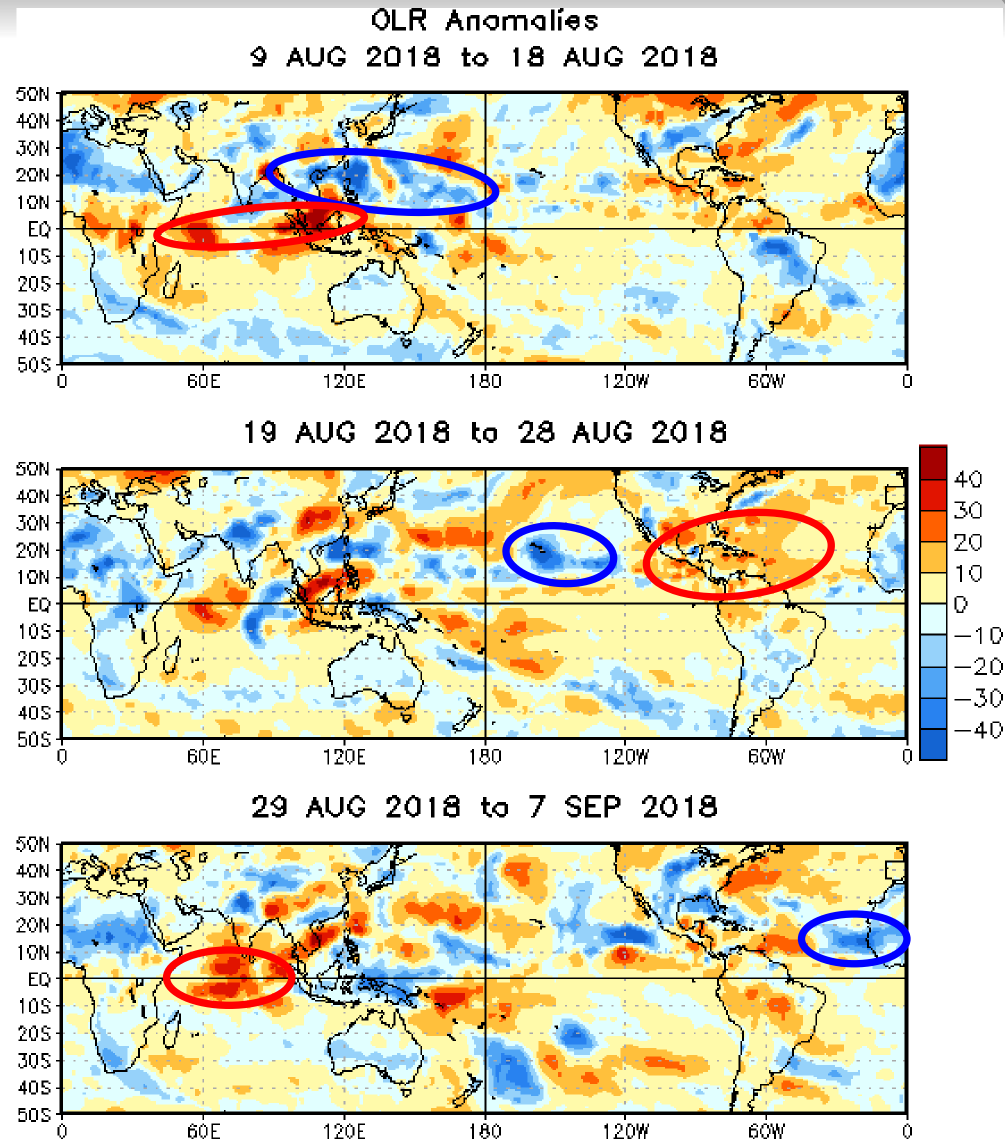
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During mid-August, enhanced (suppressed) convection was observed over the northwestern Pacific (equatorial Indian Ocean and Maritime Continent). Elsewhere patterns of anomalous convection were poorly defined.

The OLR field remained chaotic through late August. Negative anomalies associated with Hurricane Lane were evident near Hawaii, while generally dry conditions prevailed over the tropical North Atlantic.

During late August and early September, suppressed convection became more prominent over the Indian Ocean, while Tropical Storm Gordon is notable over the Gulf of Mexico and the central U.S.

Easterly waves increased recently across west Africa, which resulted in three tropical cyclones over the Atlantic.



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

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

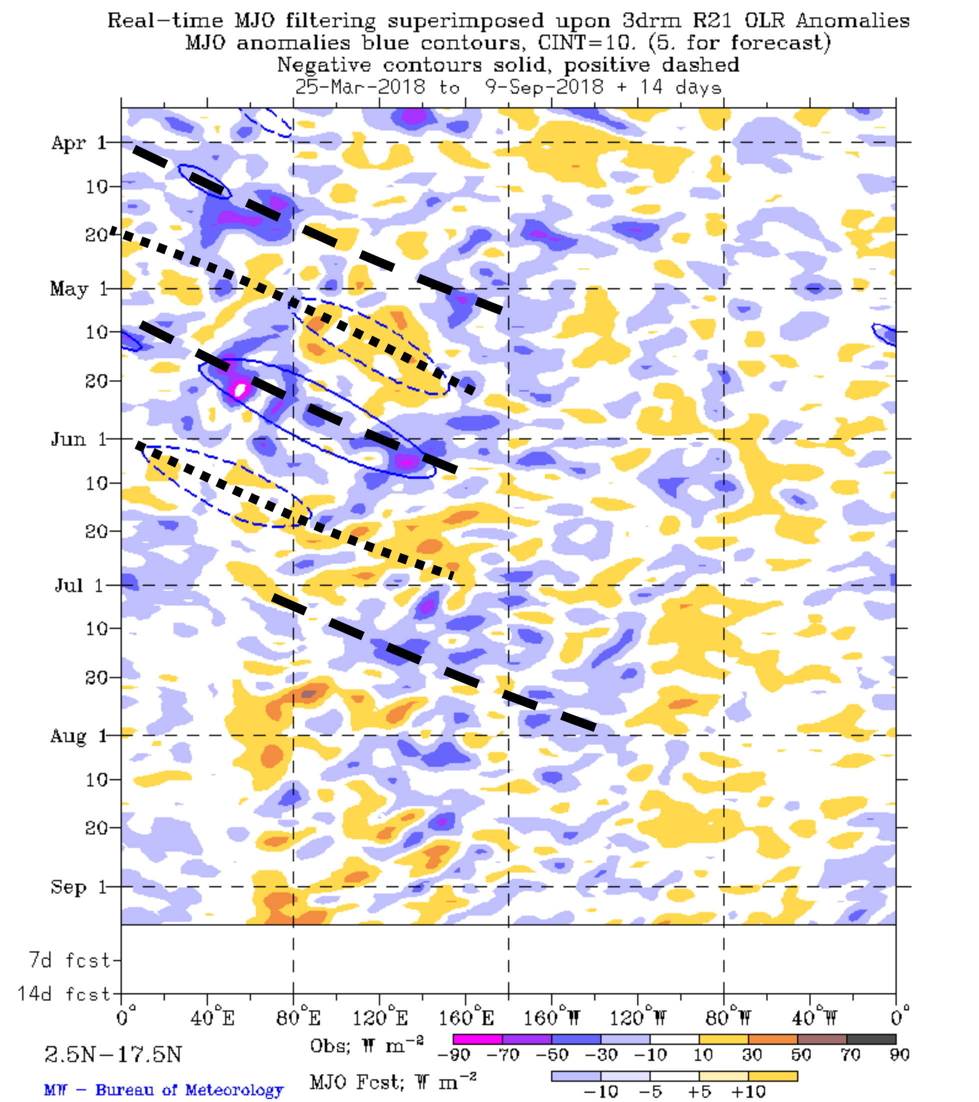
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

MJO activity during April weakened in early May as the suppressed phase destructively interfered with the low frequency La Niña base state. Stronger MJO activity emerged in late May, and weakened again during June coincident with pronounced Rossby wave activity.

The MJO remained weak during most of June.

During July, the intraseasonal signal re-emerged, with some eastward propagation evident in the OLR field.

Other modes, including Kelvin waves, Rossby waves, and tropical cyclones, dominated the pattern during August and early September, while the intraseasonal signal remained fairly weak.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

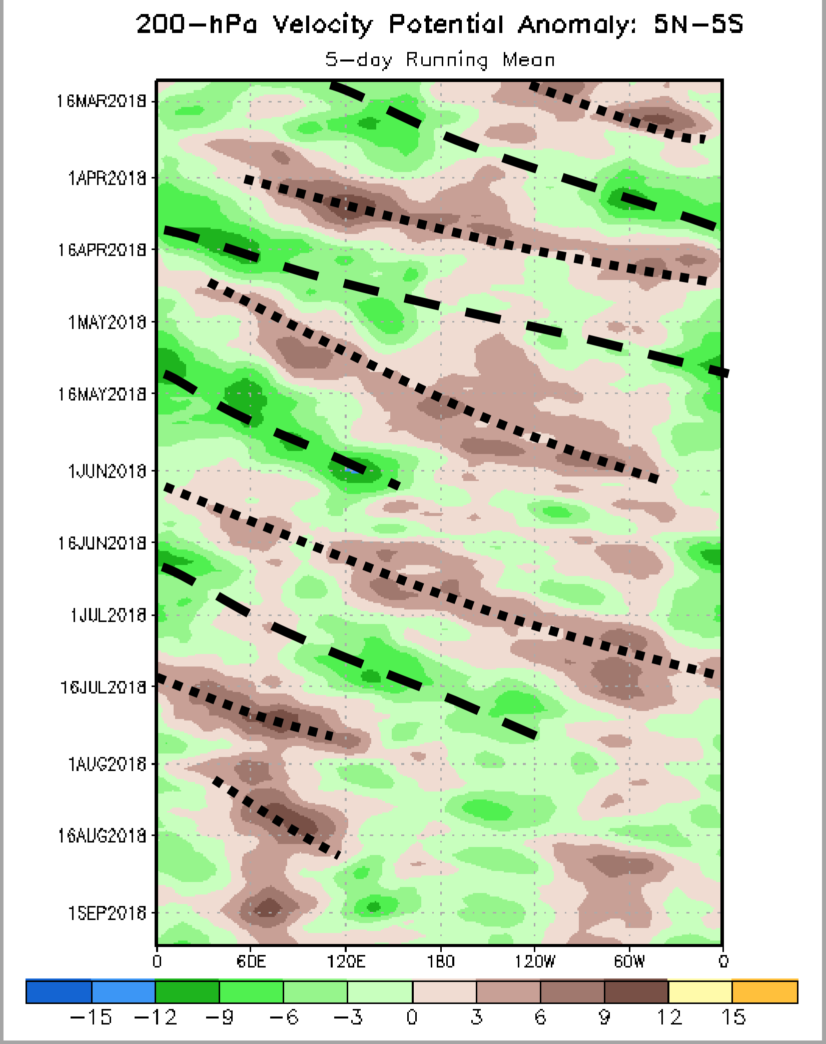
Negative anomalies (green shading) indicate favorable conditions for precipitation

Robust MJO activity through boreal spring along with the decay of La Niña conditions.

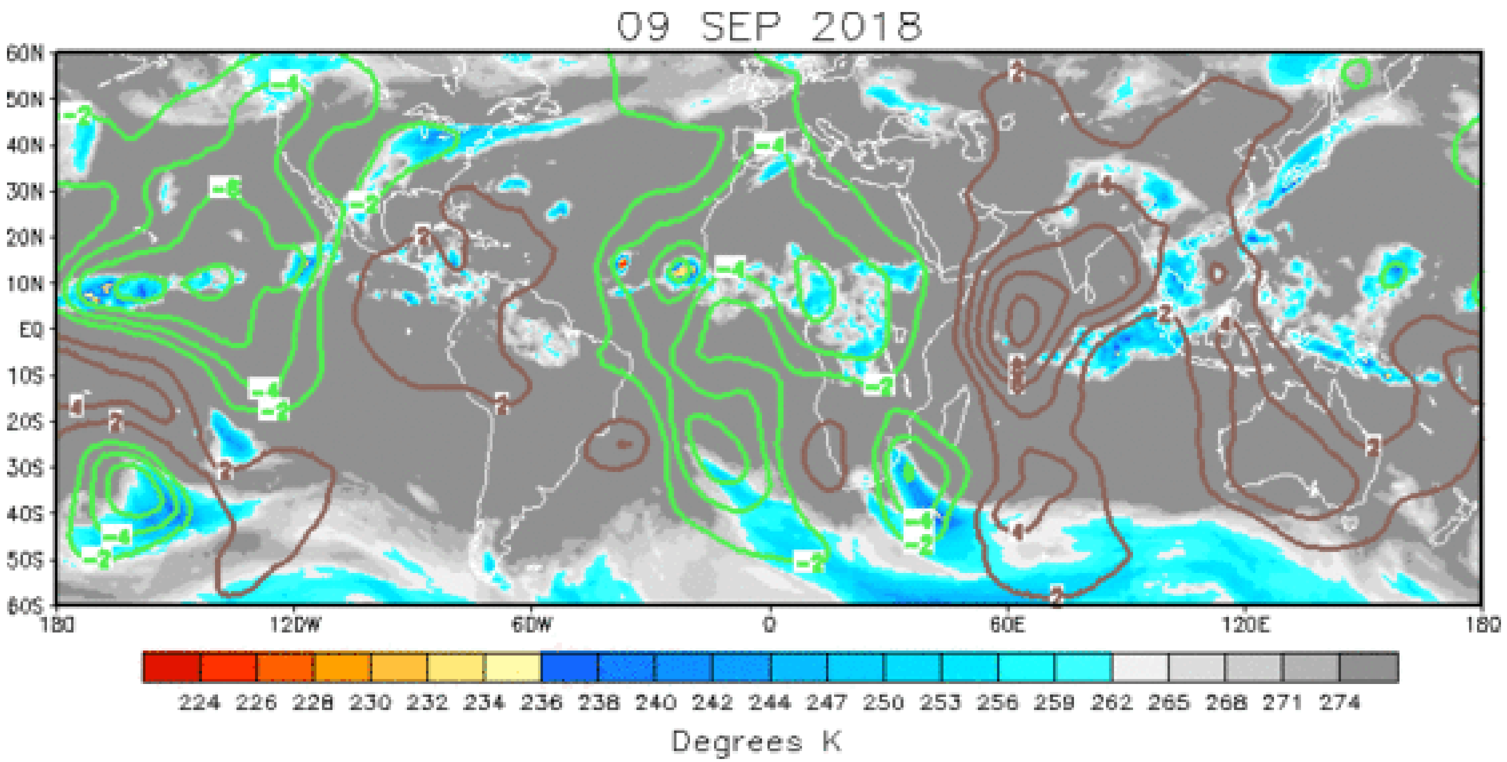
The enhanced phase of the MJO weakened east of the Date Line during June. Eastward propagation of broad suppressed convection continued into early July.

The upper-level footprint of the MJO re-emerged during mid-July, with a broad divergent signal propagating from the Maritime Continent to the central Pacific.

More recently, a somewhat stationary pattern of enhanced (suppressed) convection over the east-central Pacific (Indian Ocean) has emerged, associated with the transition towards El Niño conditions. Kelvin wave and Rossby wave (tropical cyclone) activity has modulated this slowly evolving base state.



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



A Wave-2 pattern is currently observed over the global Tropics, with enhanced (suppressed) convection observed over the central Pacific north of the equator and Africa (Central America and the Indian Ocean).

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

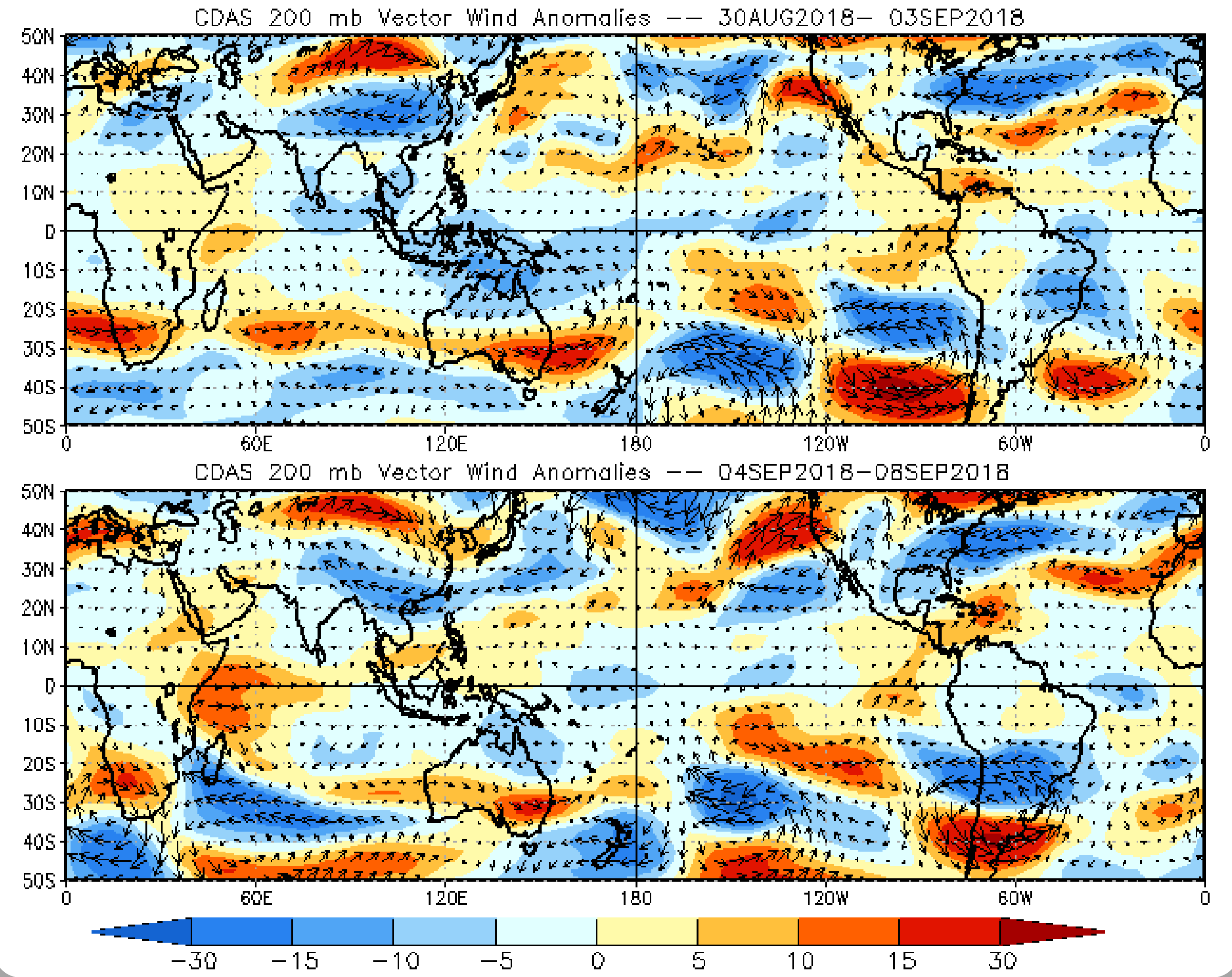
Negative anomalies (green contours) indicate favorable conditions for precipitation

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 wave train in the Southern Hemisphere appears to extend into the tropics, ending on the Equator just west of South America.

Low-amplitude easterly anomalies have persisted over the equatorial Pacific.

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

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

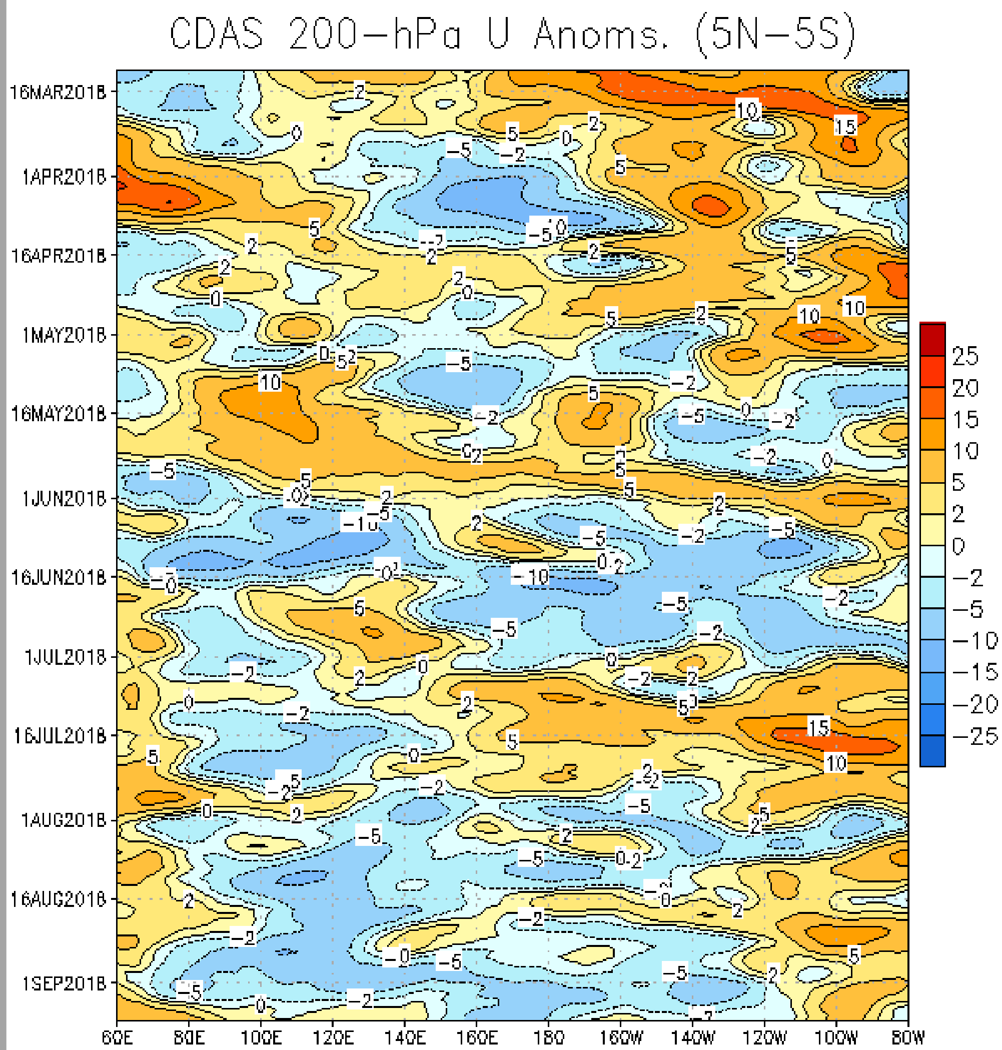
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Low-frequency anomalous westerlies remained in place east of 140E through late April 2018, with a few periods of brief interruptions.

Weak westerly anomalies propagated eastward from the Indian Ocean to the Americas in early May; this pattern broke down in early June.

Anomalous westerlies amplified over the Maritime Continent in mid-June and propagated eastward at MJO-like phase speeds.

During August the intraseasonal pattern weakened, with Rossby wave activity influencing the West Pacific pattern. Persistent westerlies continue over the far East Pacific, while easterly anomalies have been more prevalent over the central Pacific.



Weekly Heat Content Evolution in the Equatorial Pacific

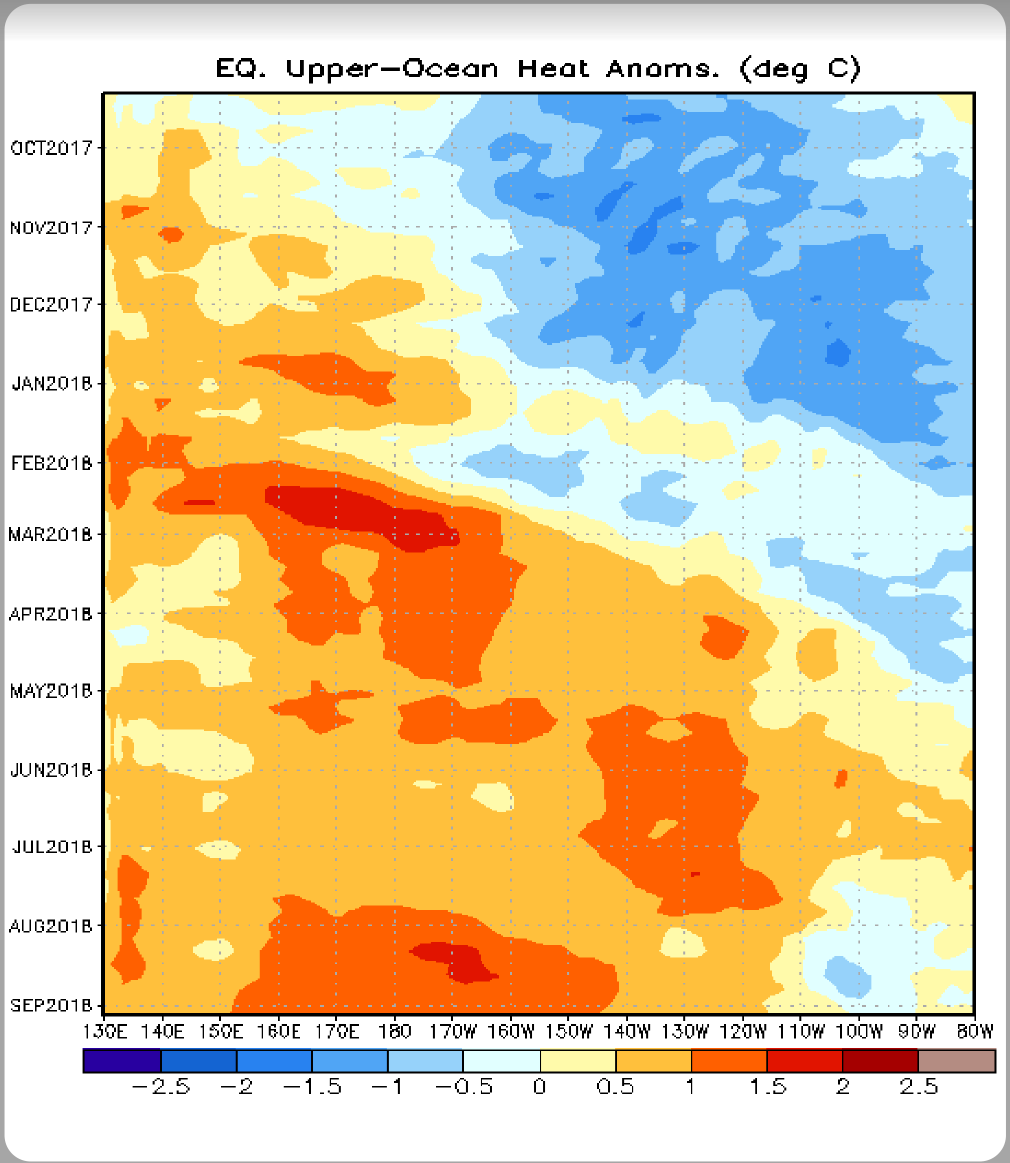
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

Negative upper-ocean heat content anomalies persisted in the central and eastern Pacific from August-December.

A downwelling Kelvin wave associated with the intraseasonal signal weakened the negative anomalies across the east-central Pacific during late January and early February.

Several downwelling oceanic Kelvin waves (associated with a relaxation of the trade winds) have contributed to the eastward expansion of relatively warm subsurface water (as much as 1.5-2.0°C above normal between 160E and 170W during February). Positive anomalies have now observed over most of the basin since April-May.

Another downwelling Kelvin wave event is evident near 140W.



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

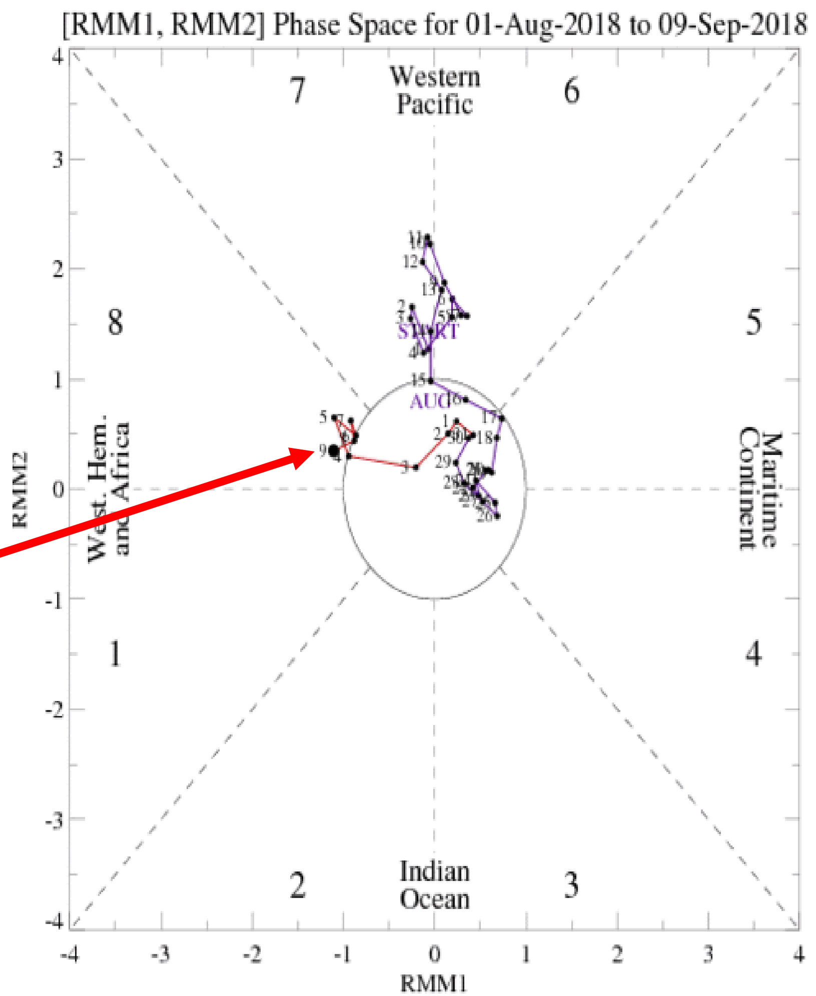
The triangular areas indicate the location of the enhanced phase of the MJO

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

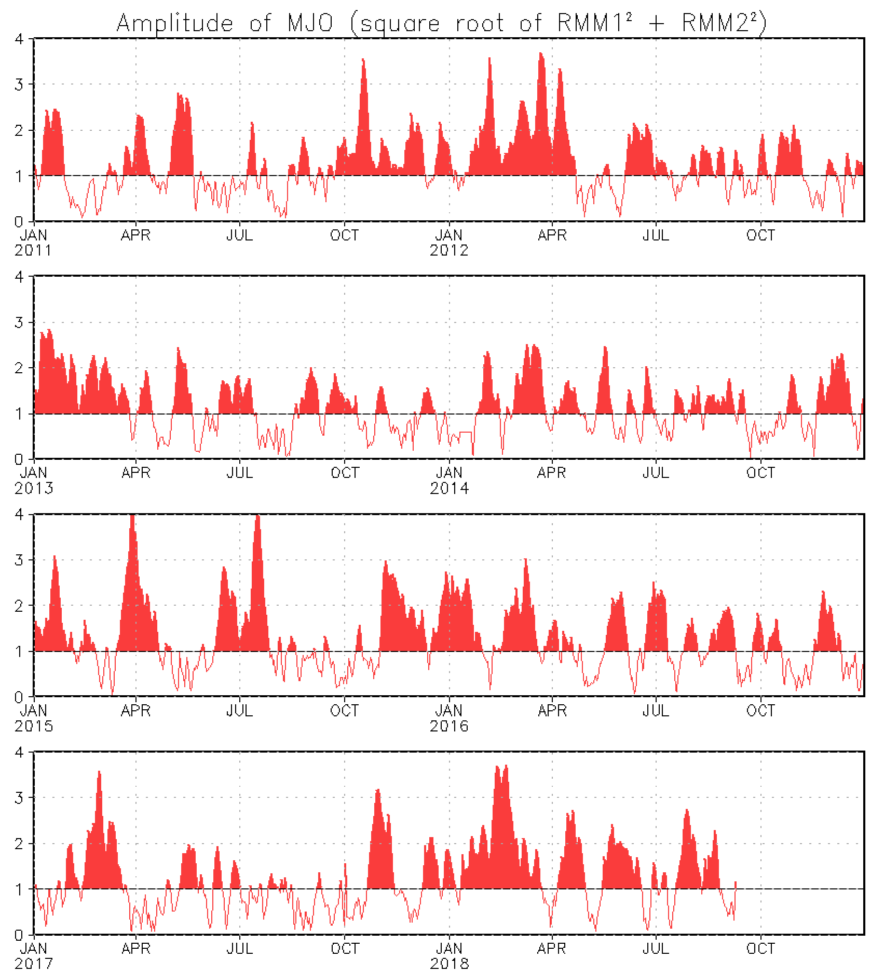
The RMM index has increased in amplitude over the past week, with the enhanced phase centered over Africa. This projection has been most heavily influenced by the low-level zonal wind anomalies.



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

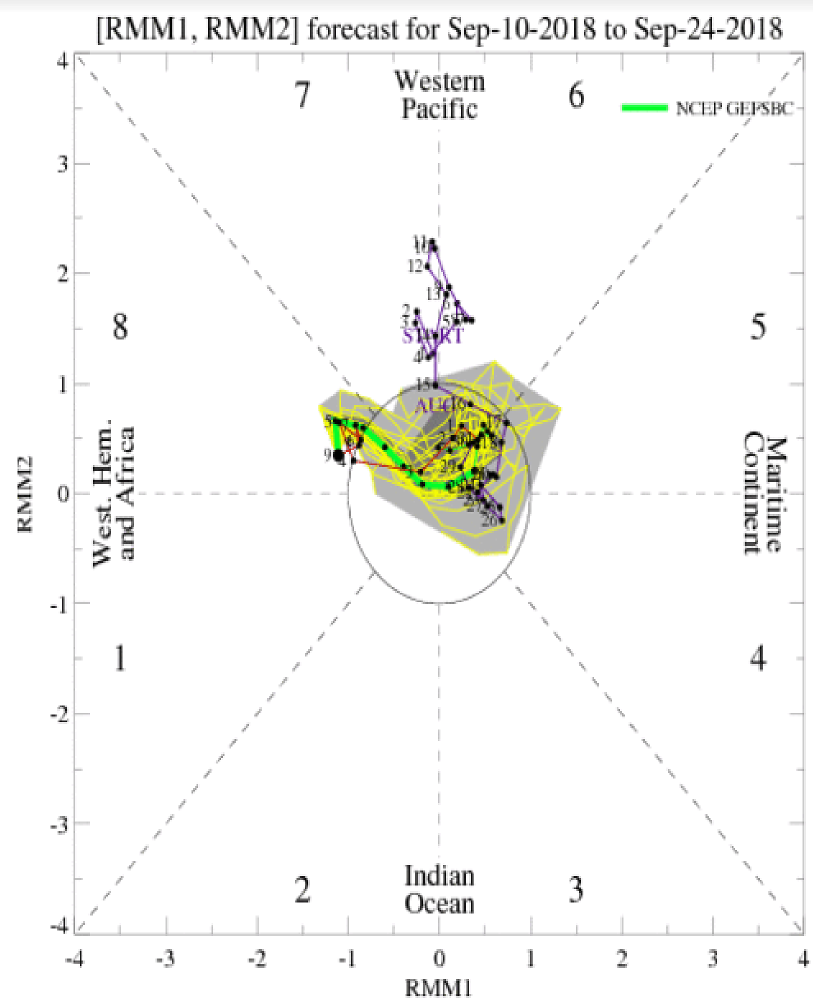
<u>Yellow Lines</u> - 20 Individual Members
<u>Green Line</u> - Ensemble Mean

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 forecasts a generally low-amplitude MJO signal during the next two weeks.

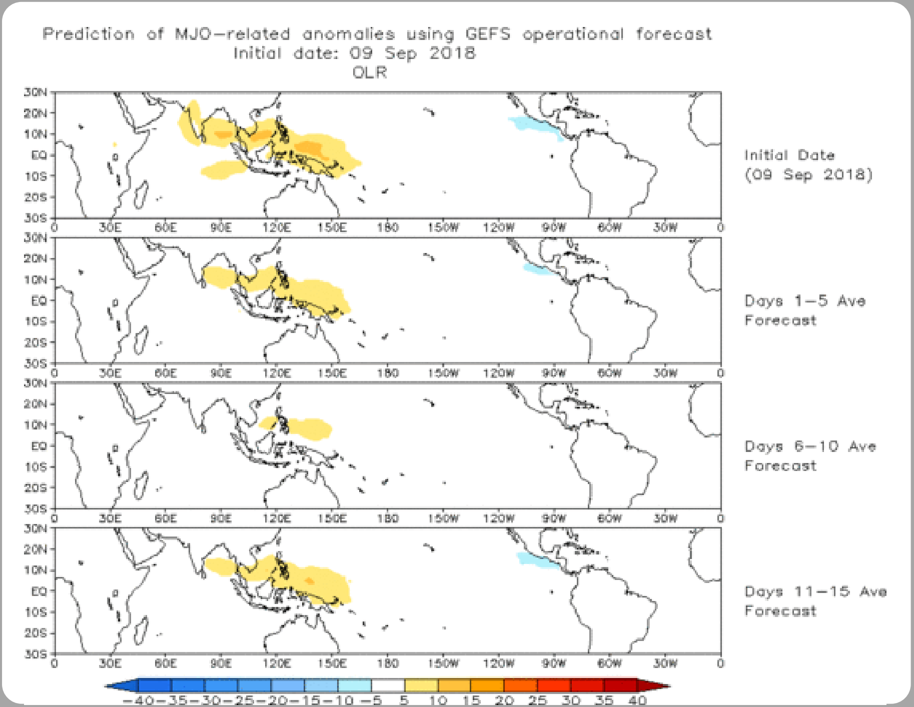


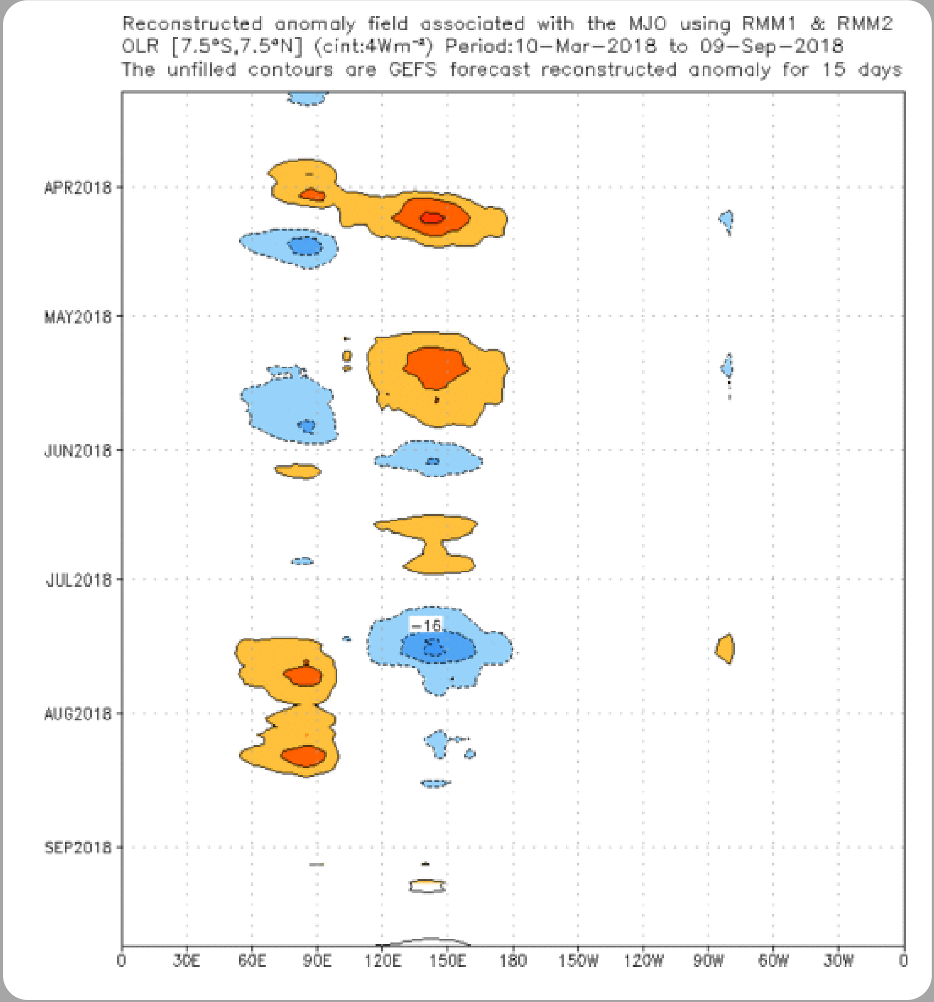
Ensemble GFS (GEFS) MJO Forecast

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



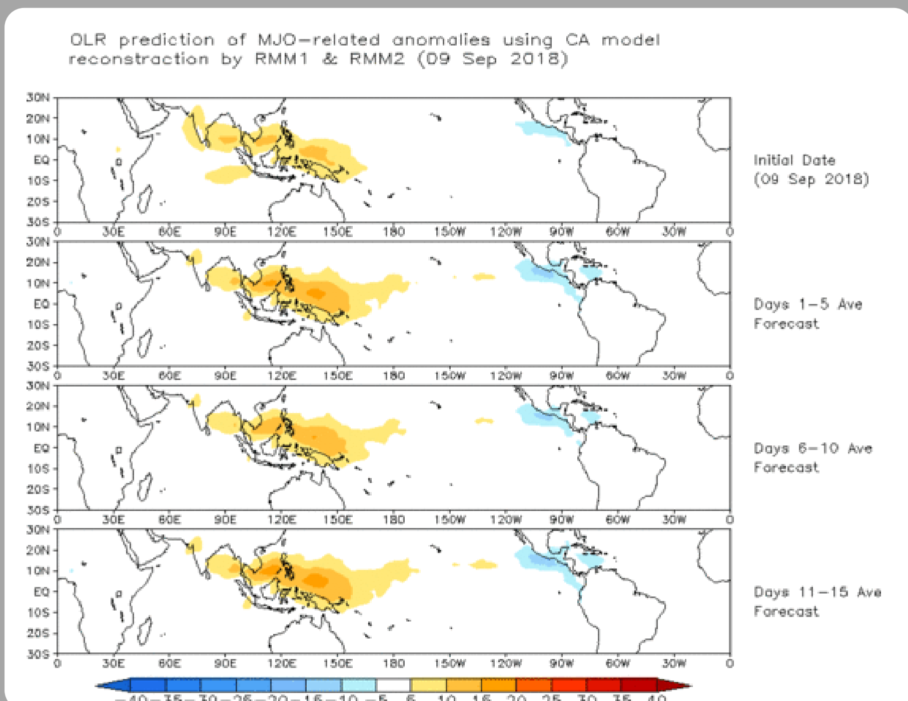


The GEFS spatial maps show only a low-frequency drying over Southeast Asia and the West Pacific.

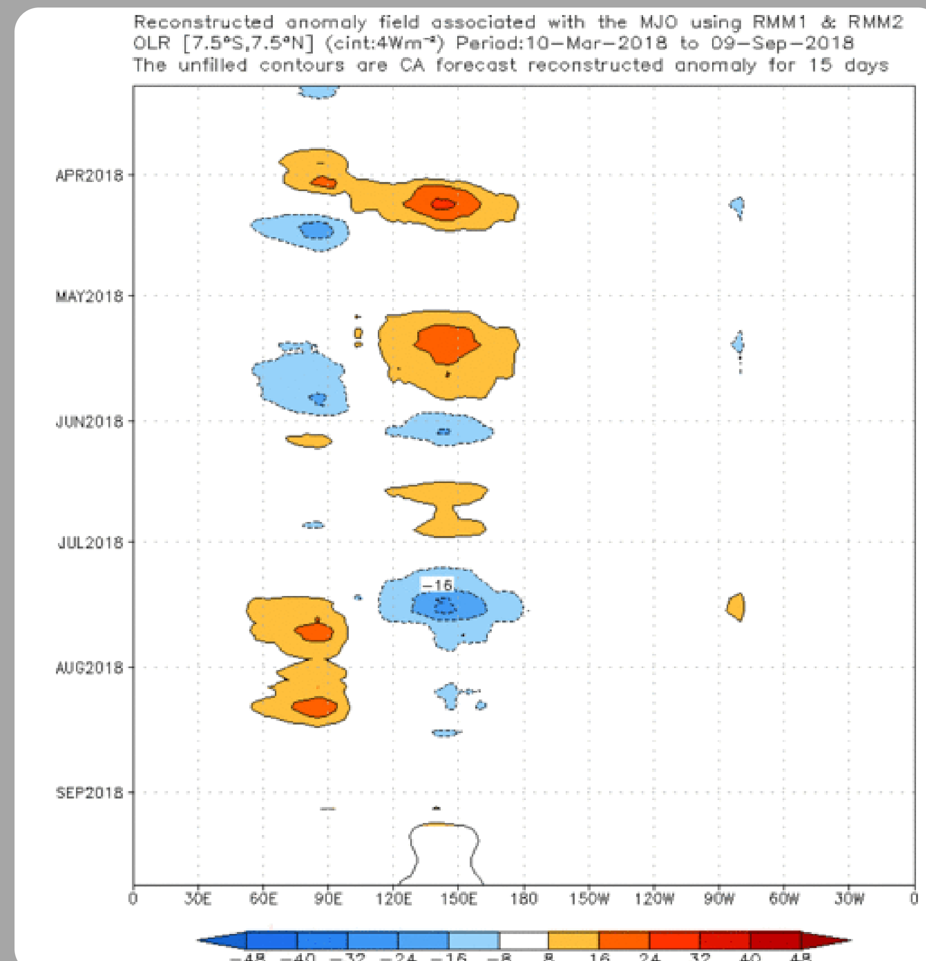
Constructed Analog (CA) MJO Forecast

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



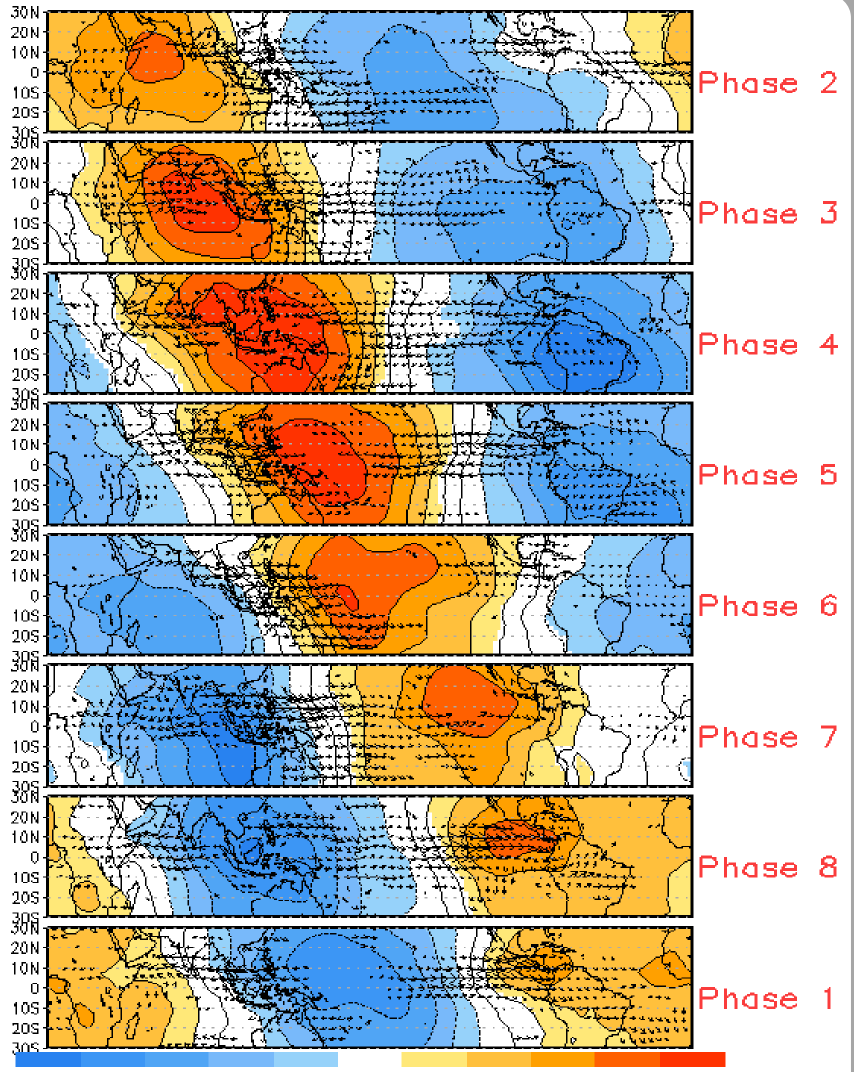
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



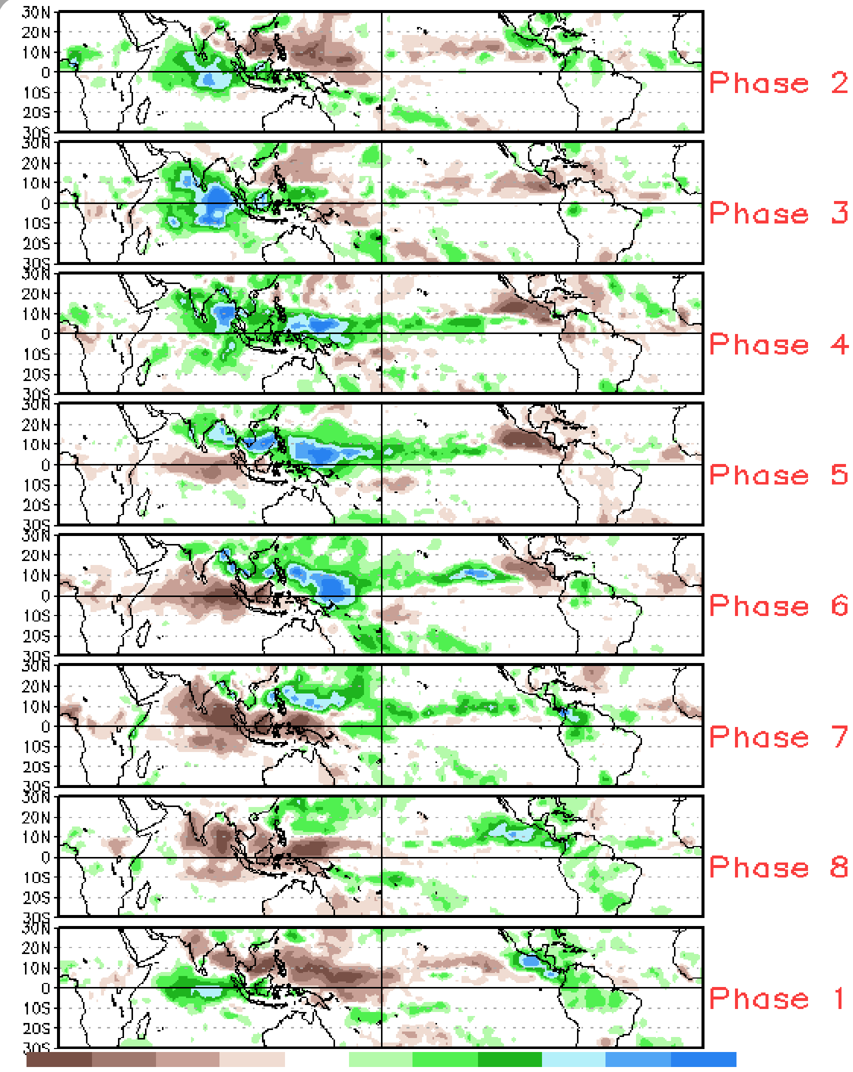
The constructed analog RMM-based OLR anomaly forecast is similar to the GEFS but at higher amplitude. Enhanced convection over the far eastern Pacific and Central America is more notable than in the GEFS-based reconstruction.

MJO Composites - Global Tropics

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



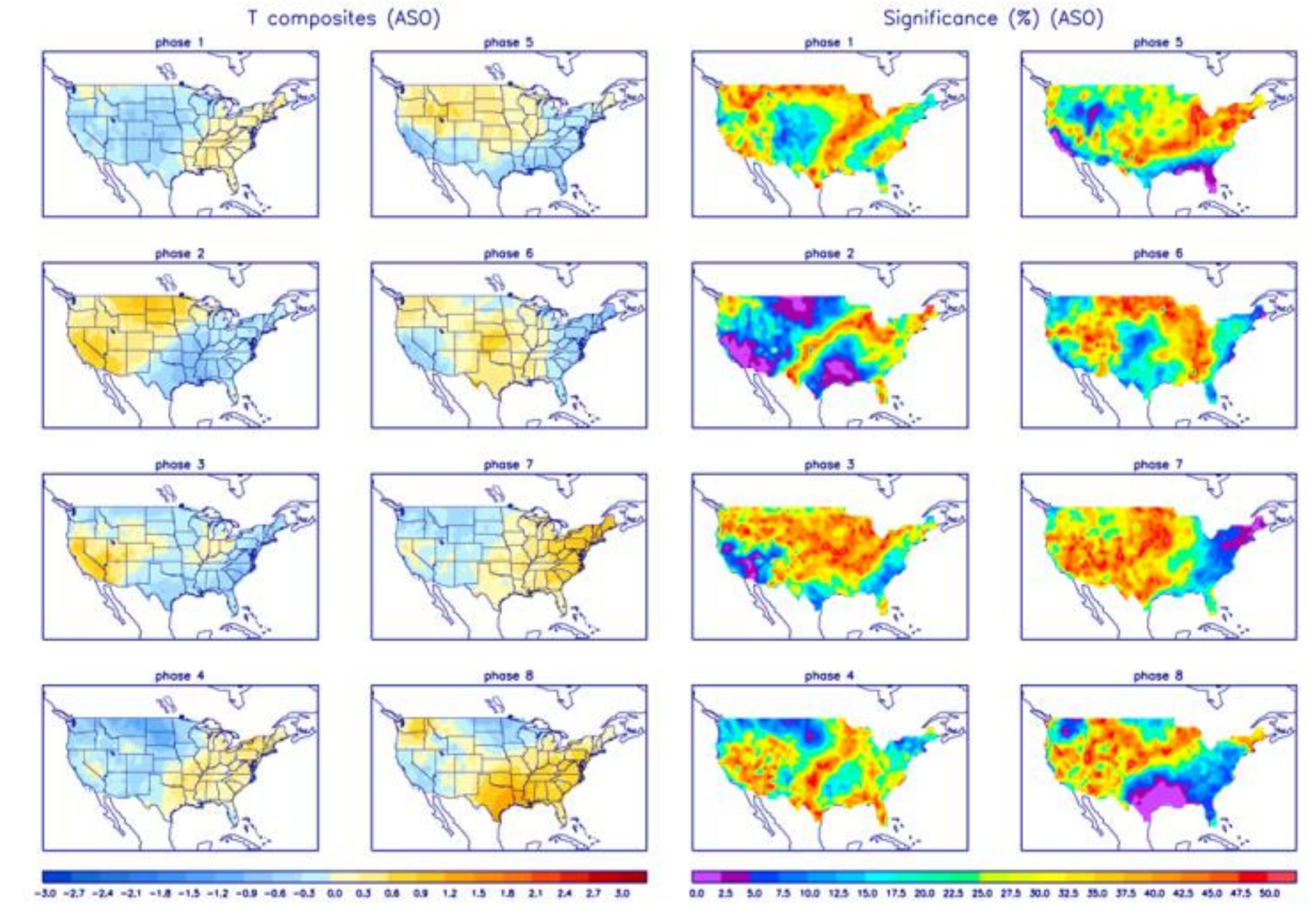
Precipitation Anomalies (May - Sep)



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.



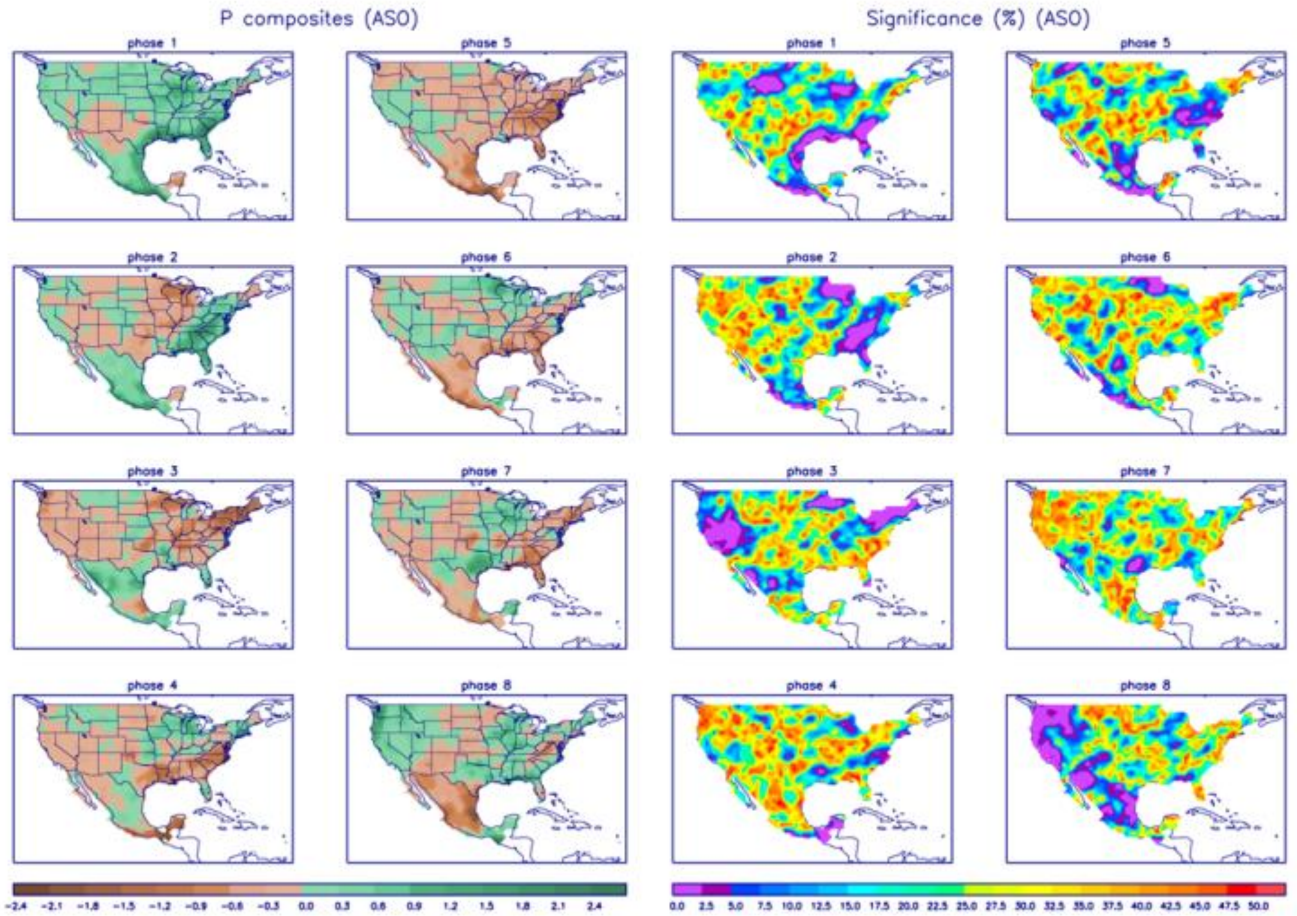
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml