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 MJO signal remains weak, with other modes, including a Kelvin wave over the East Pacific, and Rossby wave activity, including tropical cyclones, continuing to influence the pattern.

- Dynamical model MJO index forecasts have shifted considerably since last week, with no indications of a developing Maritime Continent event. In fact, both the GEFS and ECMWF depict enhancement over the East Pacific or Western Hemisphere during Week-2, which may reflect tropical cyclone activity and a gradual weakening of the Asian Monsoon.

- The low frequency signal weakened as higher frequency modes influenced the pattern, but the gradual transition towards El Niño conditions is anticipated to continue modulating the overall tropical convective field.

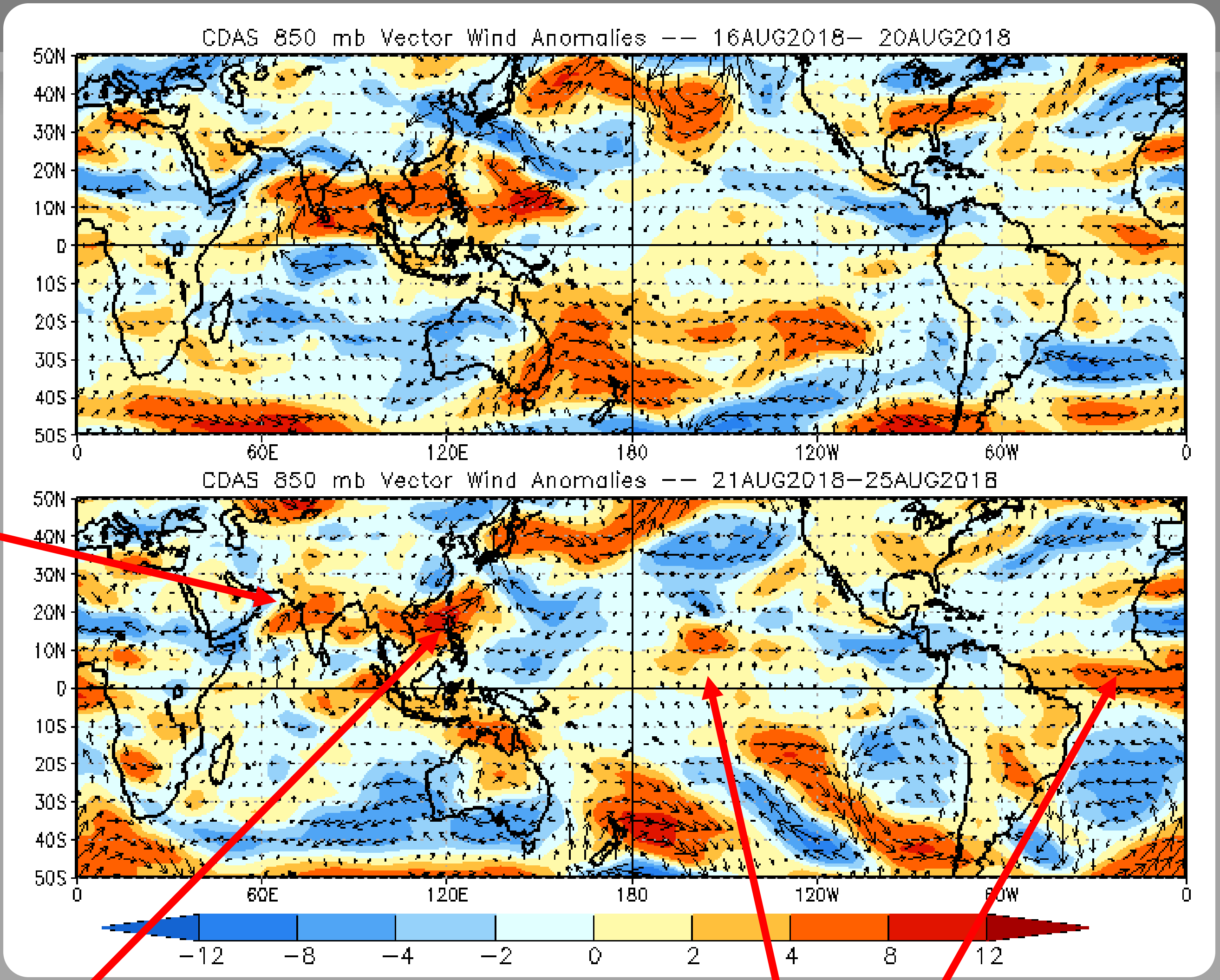
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Pronounced cross-equatorial flow persisted over the central Indian Ocean, as well as enhanced Monsoon activity over the northern half of South Asia.

Westerly anomalies associated with enhanced monsoon activity persisted over Southeast Asia

Zonal anomalies remained weak over the Pacific, other than the circulation of powerful Hurricane Lane, while westerly anomalies increased over the equatorial Atlantic basin.

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

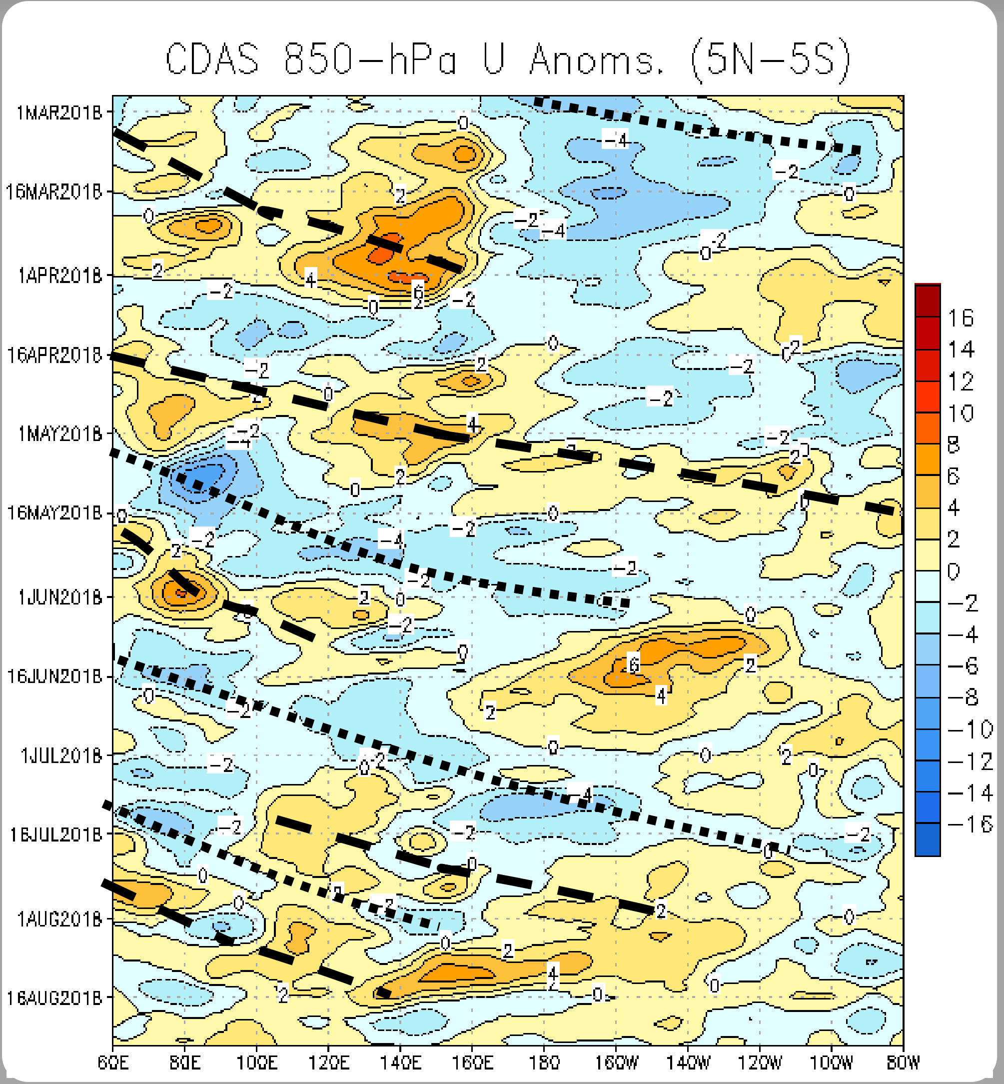
MJO activity was observed during March, but the signal rapidly broke down by early April.

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.



OLR Anomalies – Past 30 days

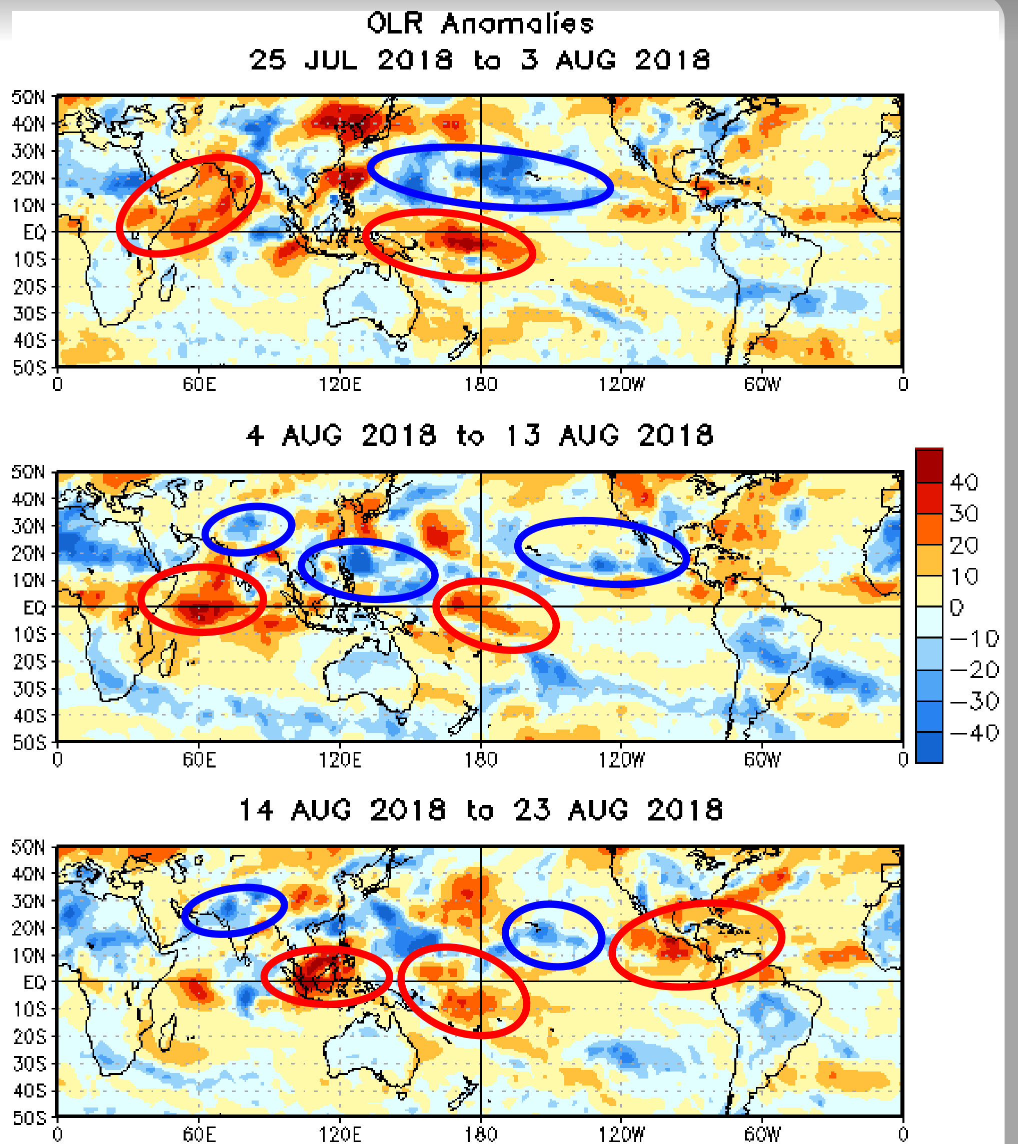
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late July and early August, broadly enhanced (suppressed) convection overspread much of the North Pacific (western Indian Ocean, South Asia, and the equatorial West Pacific).

The OLR field became more chaotic during the first part of August. Suppressed (enhanced) convection persisted over the western Indian Ocean (south-central Asia), while enhanced convection across the Pacific was primarily associated with tropical cyclones.

During mid-August, enhanced Monsoon activity was observed across northern parts of South Asia, while suppressed convection overspread the equatorial Maritime Continent, and persisted near the Date Line. Broad suppressed convection was observed across the East Pacific and Atlantic basins, while tropical cyclone activity (Hurricane Lane) began impacting Hawaii.



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

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

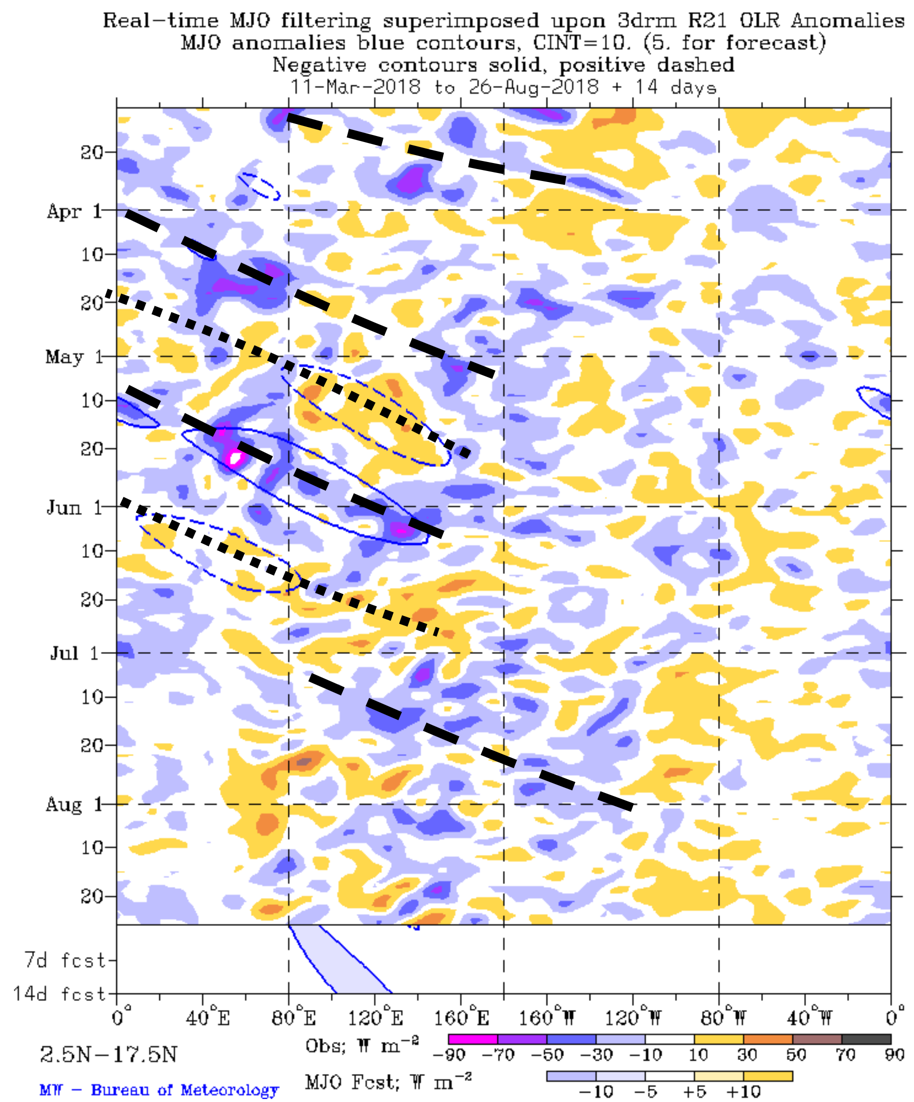
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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, as the intraseasonal signal remained fairly weak.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

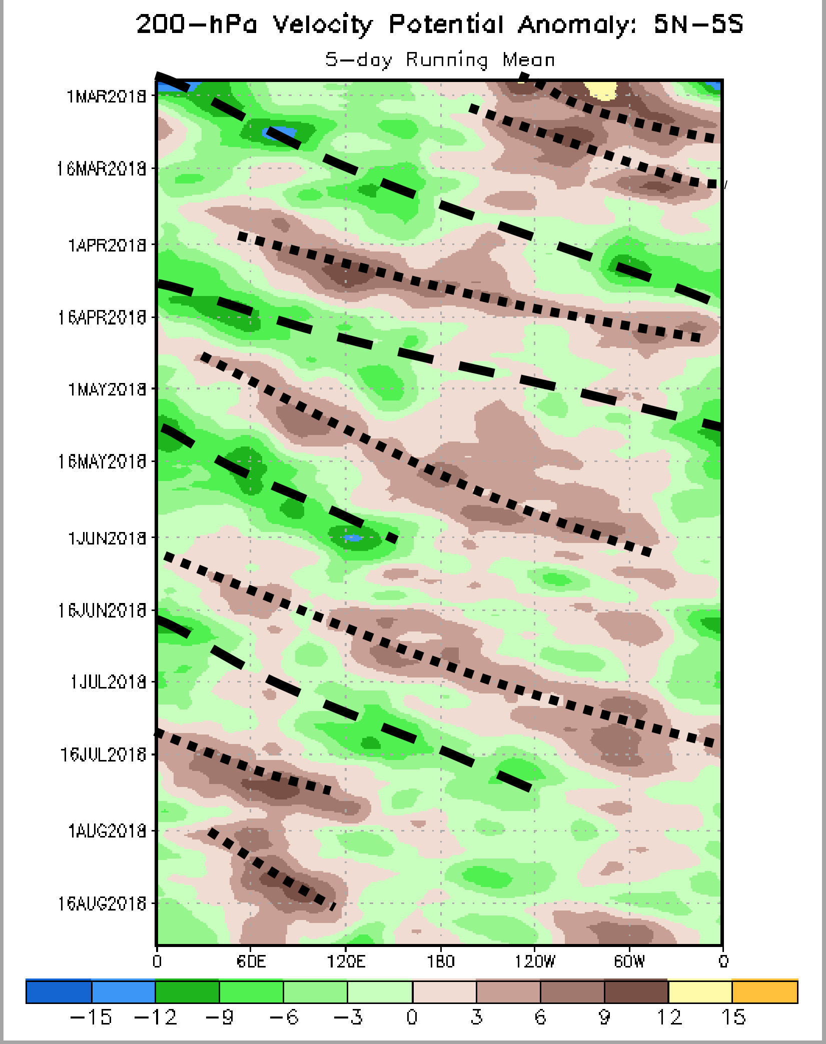
Negative anomalies (green shading) indicate favorable conditions for precipitation

Robust MJO activity was observed throughout the cold season despite the background La Niña state. Stationary upper-level divergence over the Maritime Continent associated with the base state began to wane by April.

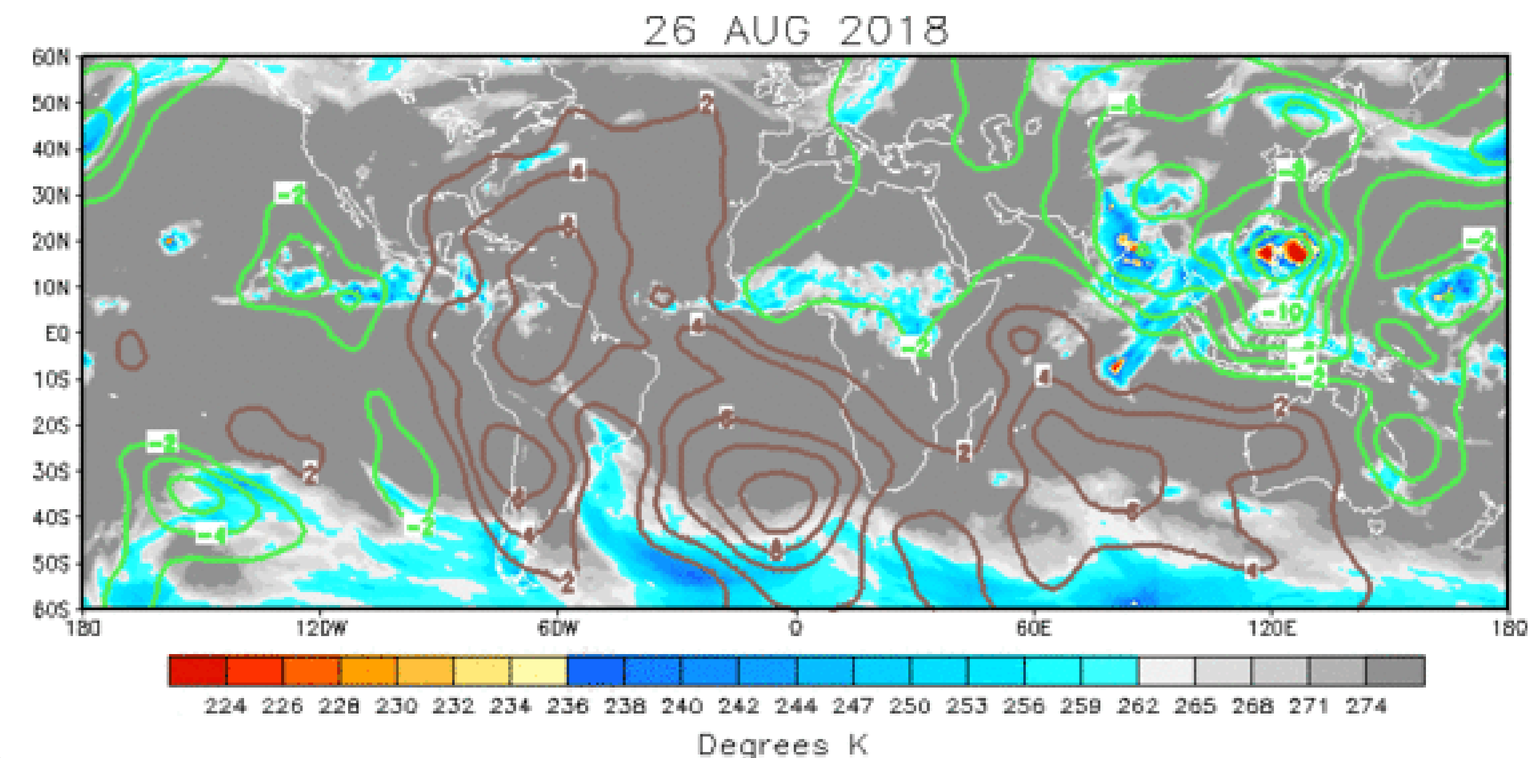
The enhanced phase of the MJO weakened east of the Date Line during June. Eastward propagation of broad suppressed convection continued into early July.

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



The upper-level velocity potential pattern remains largely disorganized, with enhanced South and Southeast Asia Monsoon activity yielding the strongest anomalies.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

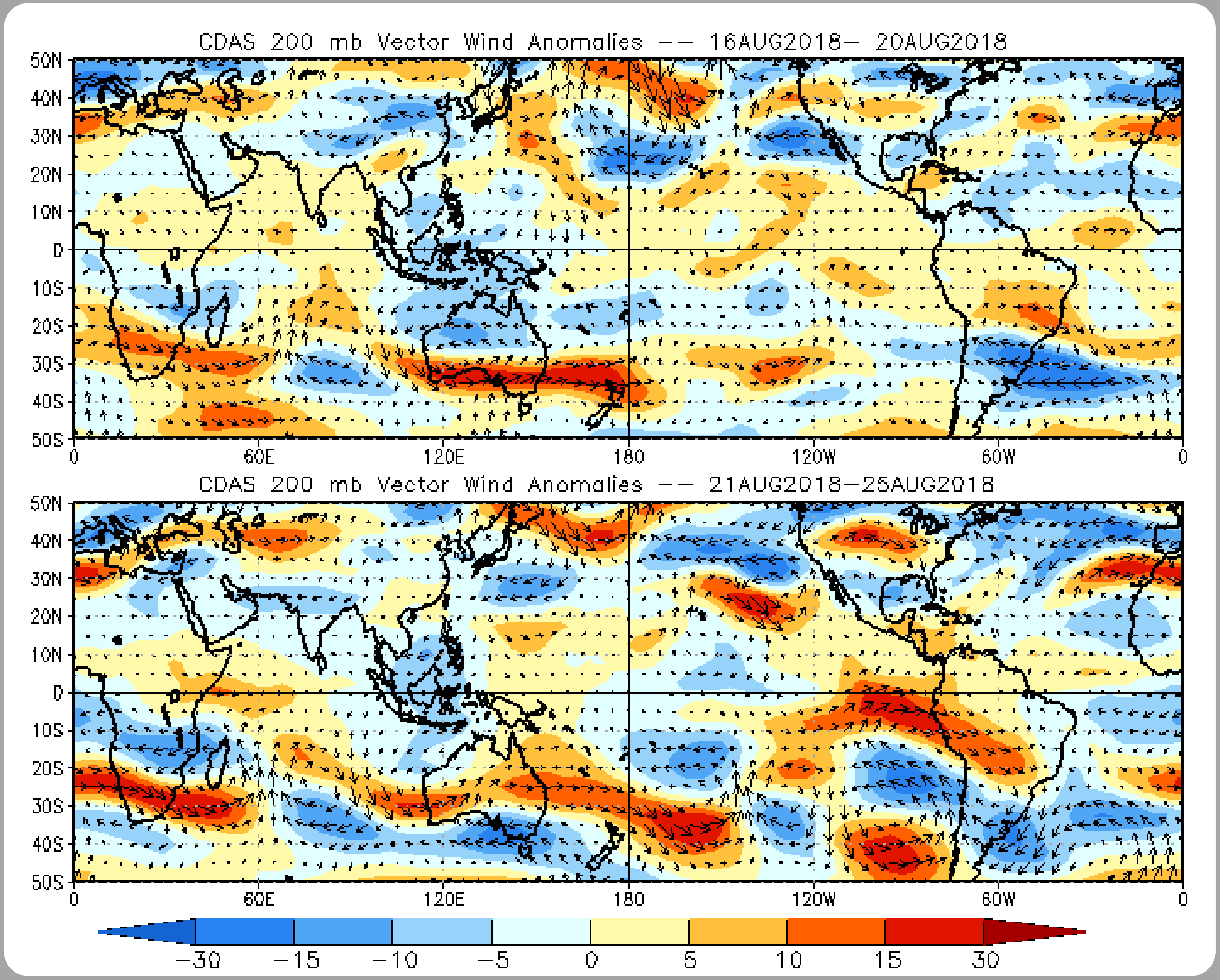
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Upper-level zonal wind anomalies are weak in the tropics, outside of strong westerlies over the East Pacific. Robust outflow from powerful Hurricane Lane is evident over the central Pacific.

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

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

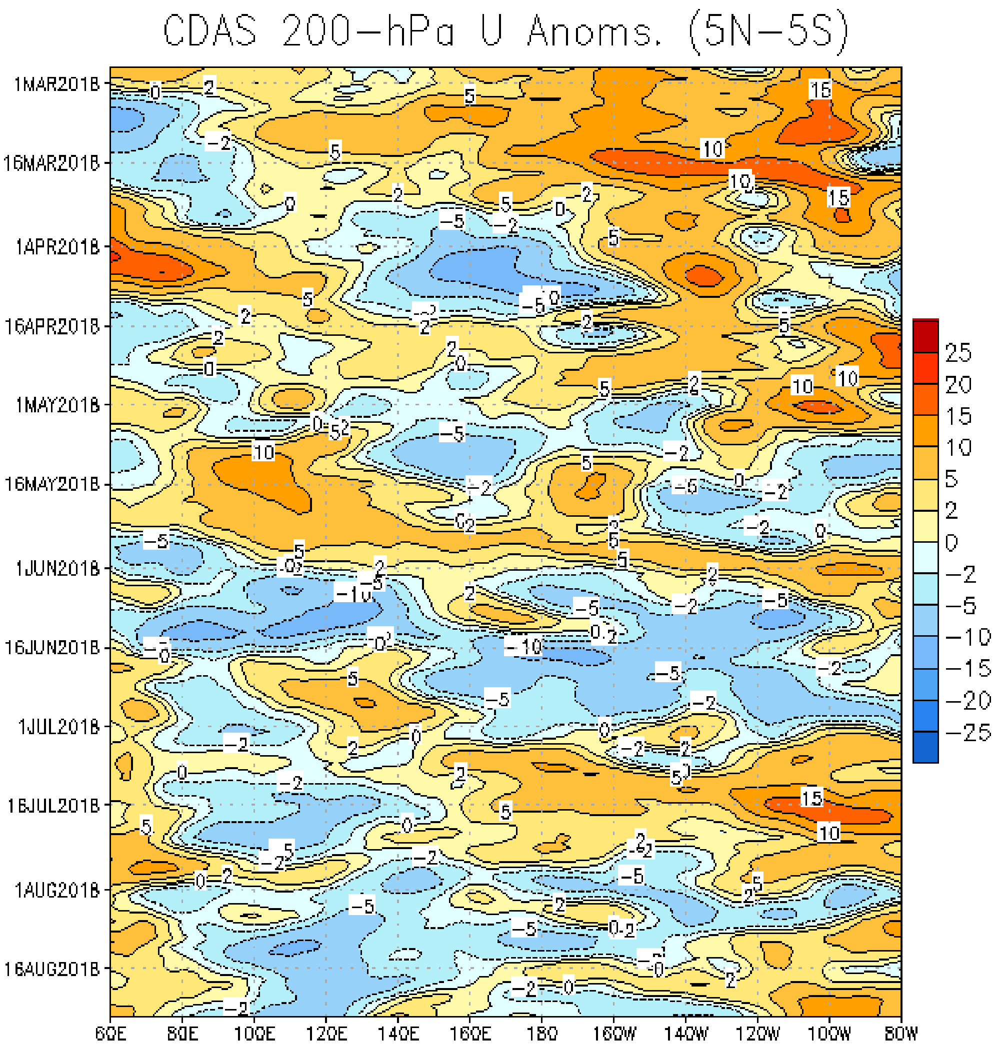
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

Since the beginning of May, weak westerly anomalies have continued to propagate eastward from the Indian Ocean to the Americas; this pattern broke down in early June.

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

During early August the intraseasonal pattern weakened, with Rossby wave activity influencing the West Pacific pattern. Persistent westerlies continue over the far East Pacific.



Weekly Heat Content Evolution in the Equatorial Pacific

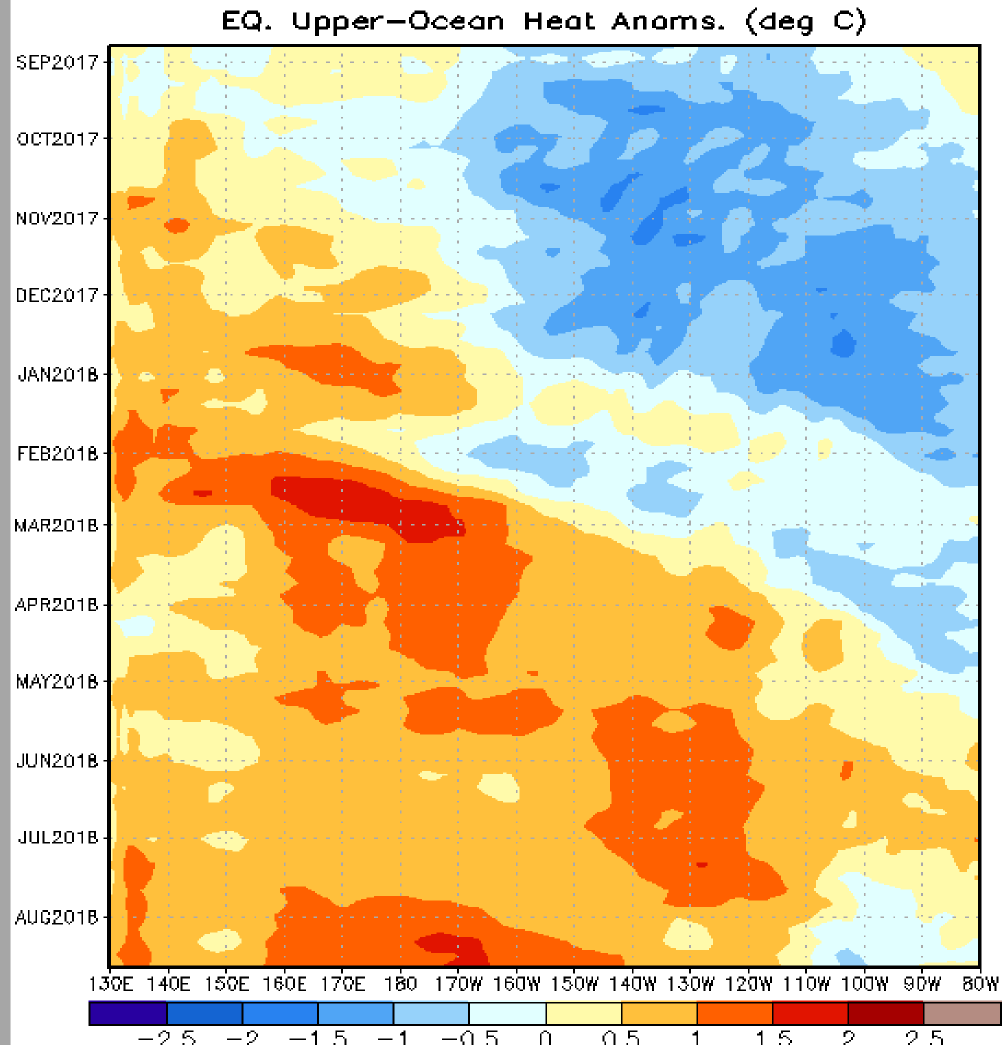
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

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

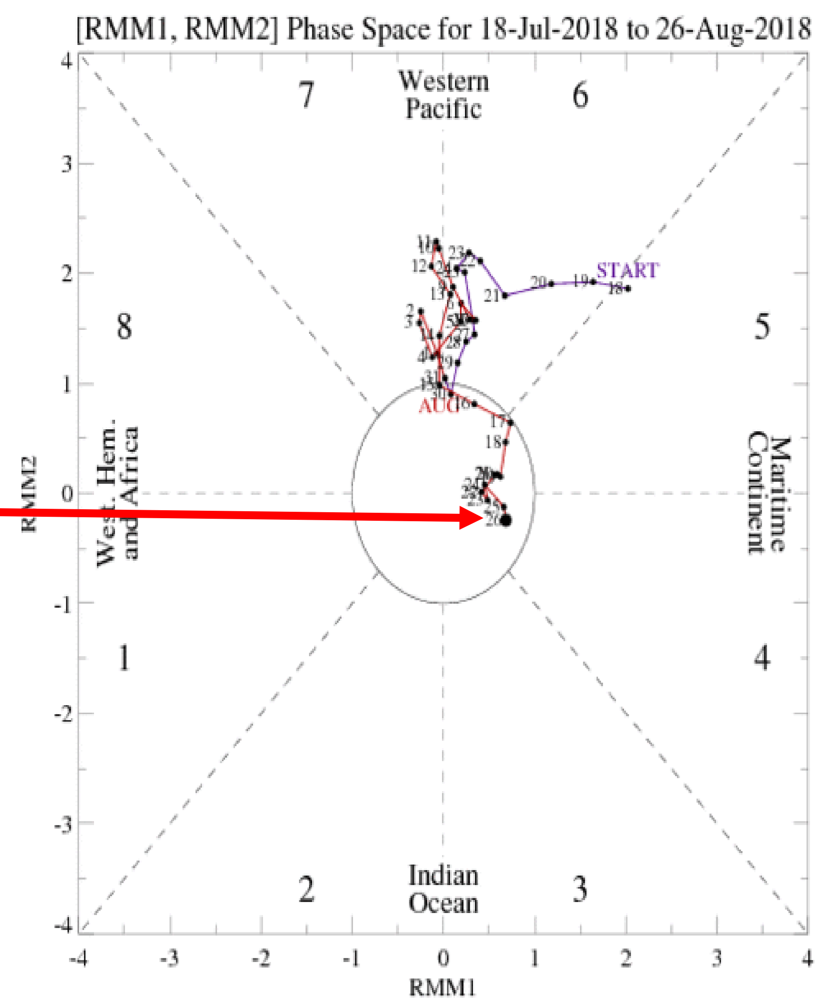
The triangular areas indicate the location of the enhanced phase of the MJO

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

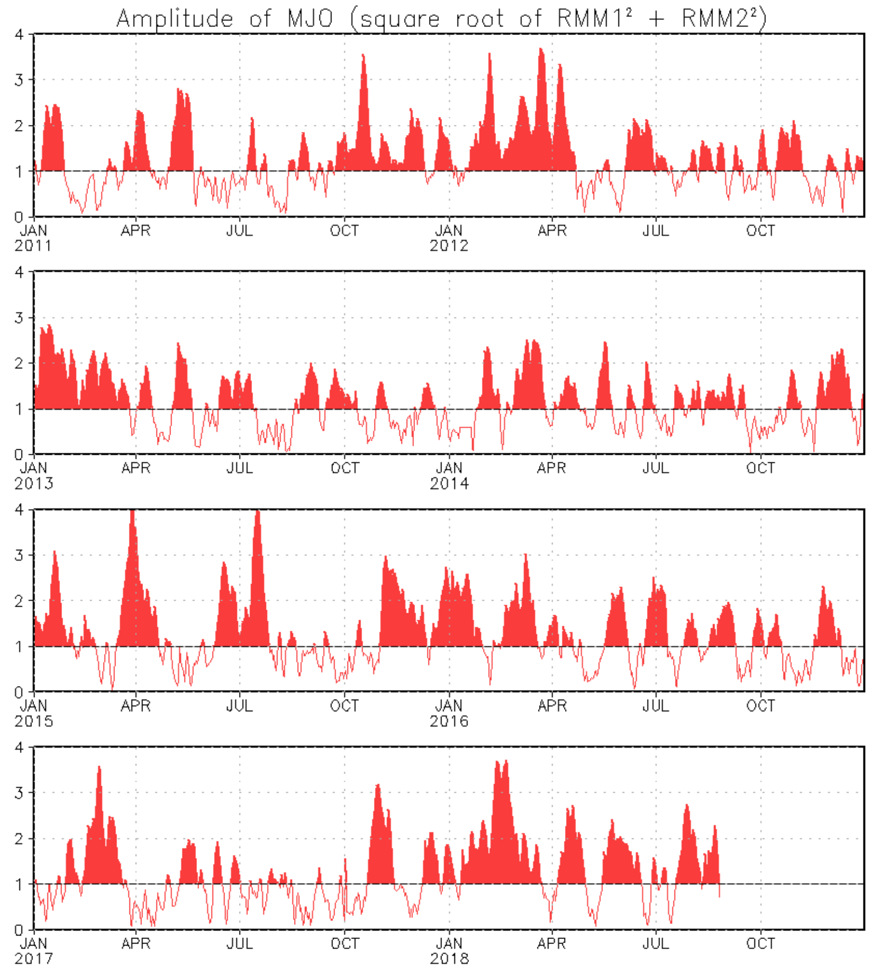
The RMM index continues to show a weak MJO.



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

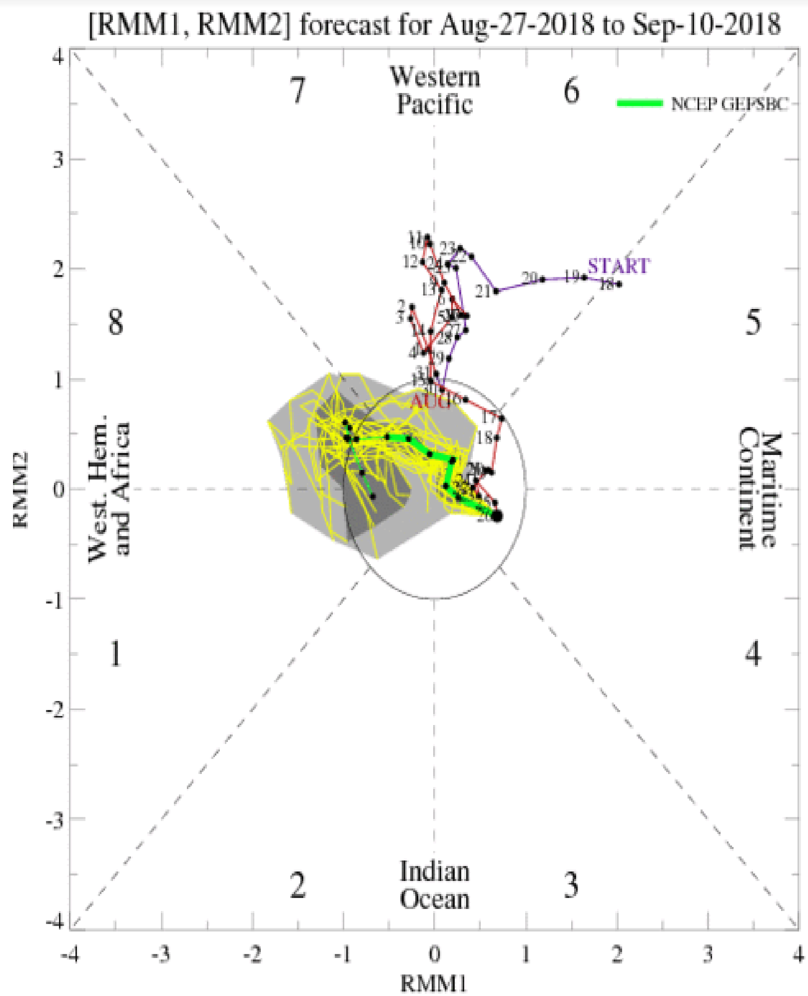
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

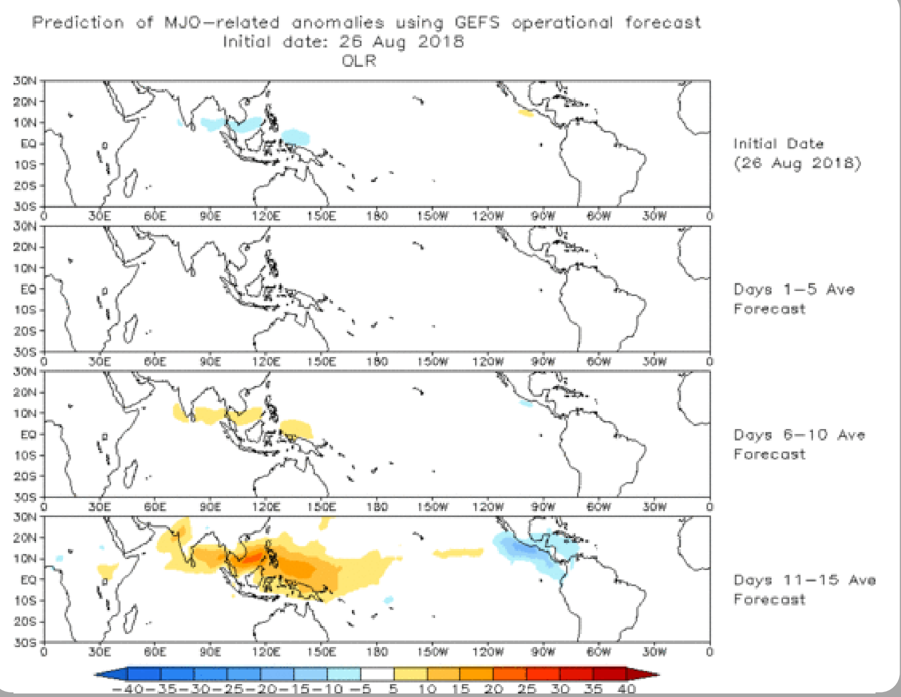
The GEFS maintains a fairly weak MJO signal throughout the forecast period. Multiple ensemble members depict an enhanced signal over the Western Hemisphere by Week-2, which may be reflective of increased tropical cyclone activity over both the East Pacific and Atlantic basins, and a break in Asian Monsoon activity.



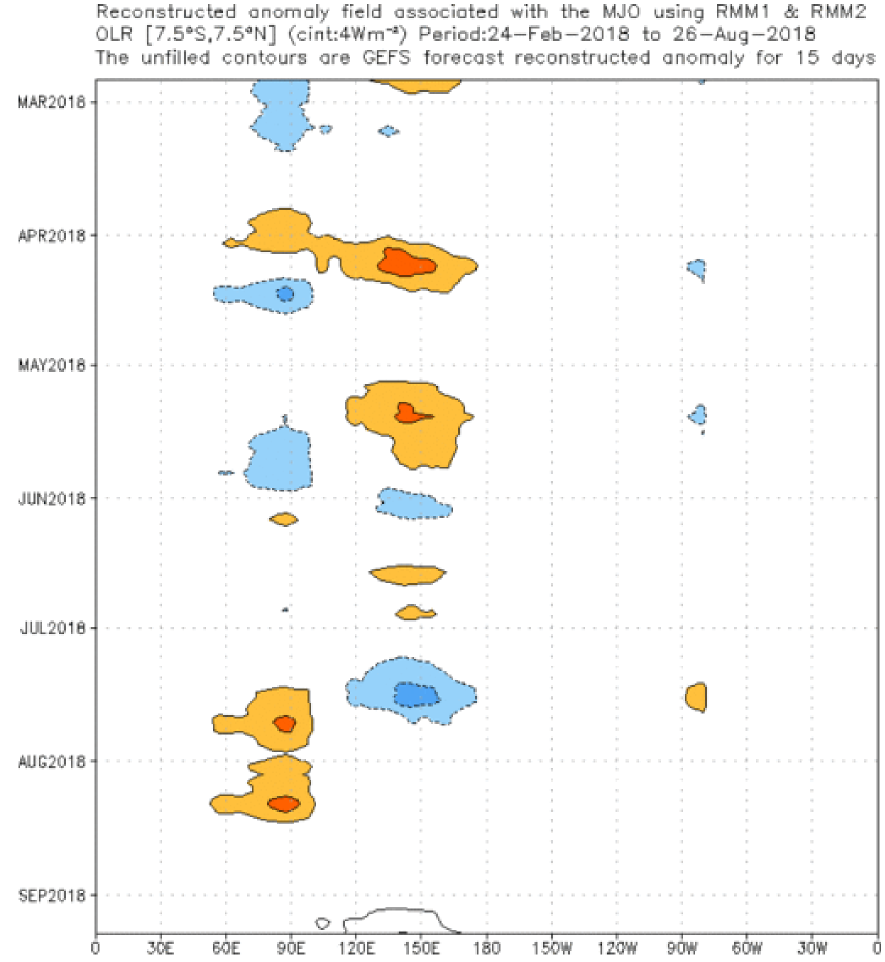
Ensemble GFS (GEFS) MJO Forecast

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

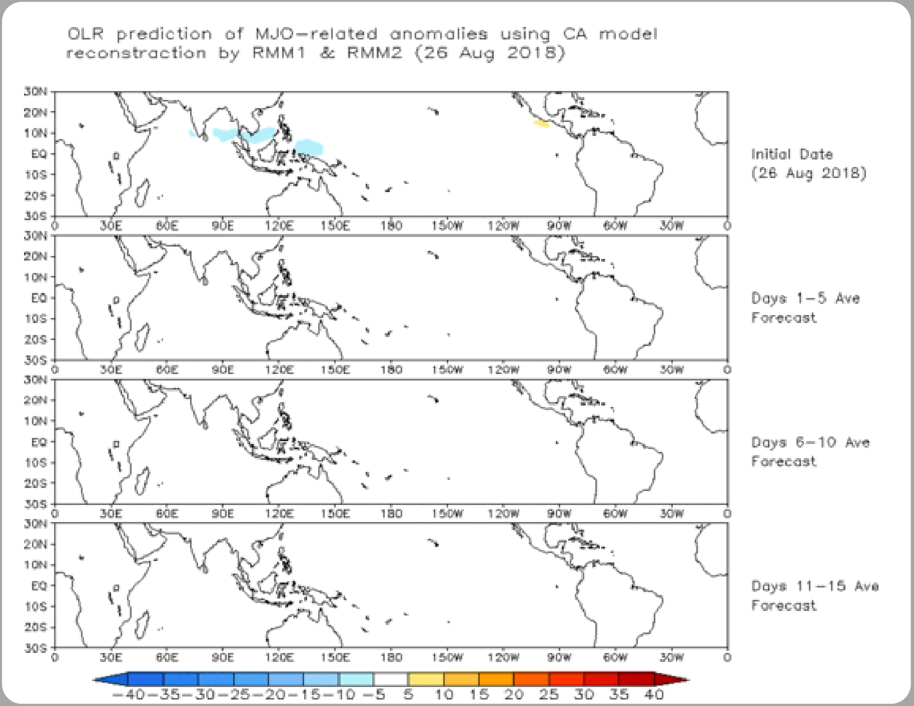


OLR anomalies based on the GEFS RMM-index forecast show a weak anomaly pattern, with some enhancement of an East Pacific signal during Week-2.

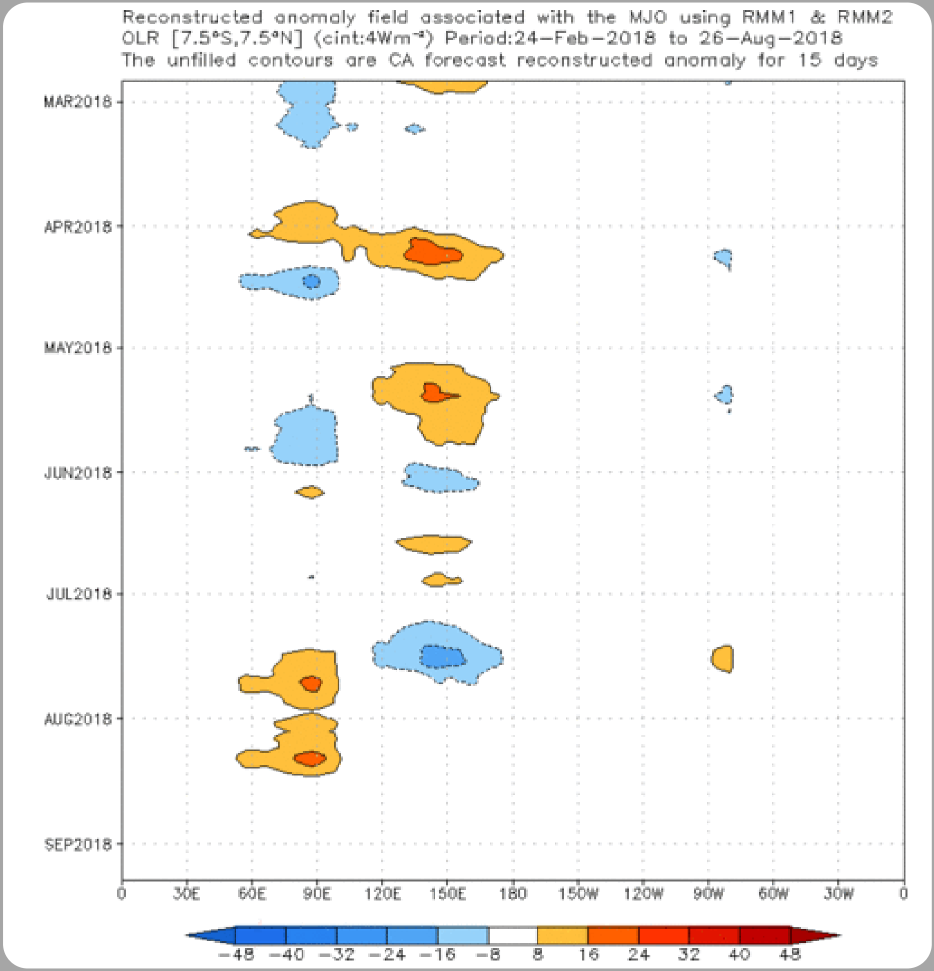
Constructed Analog (CA) MJO Forecast

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



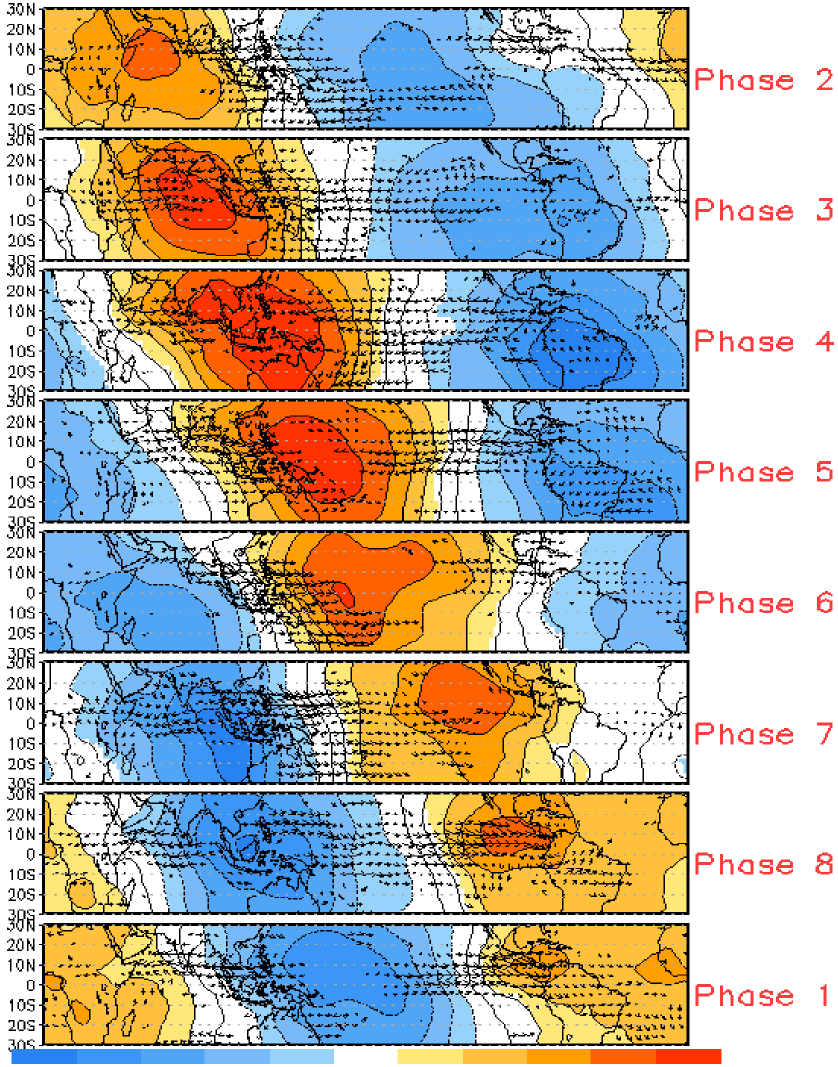
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



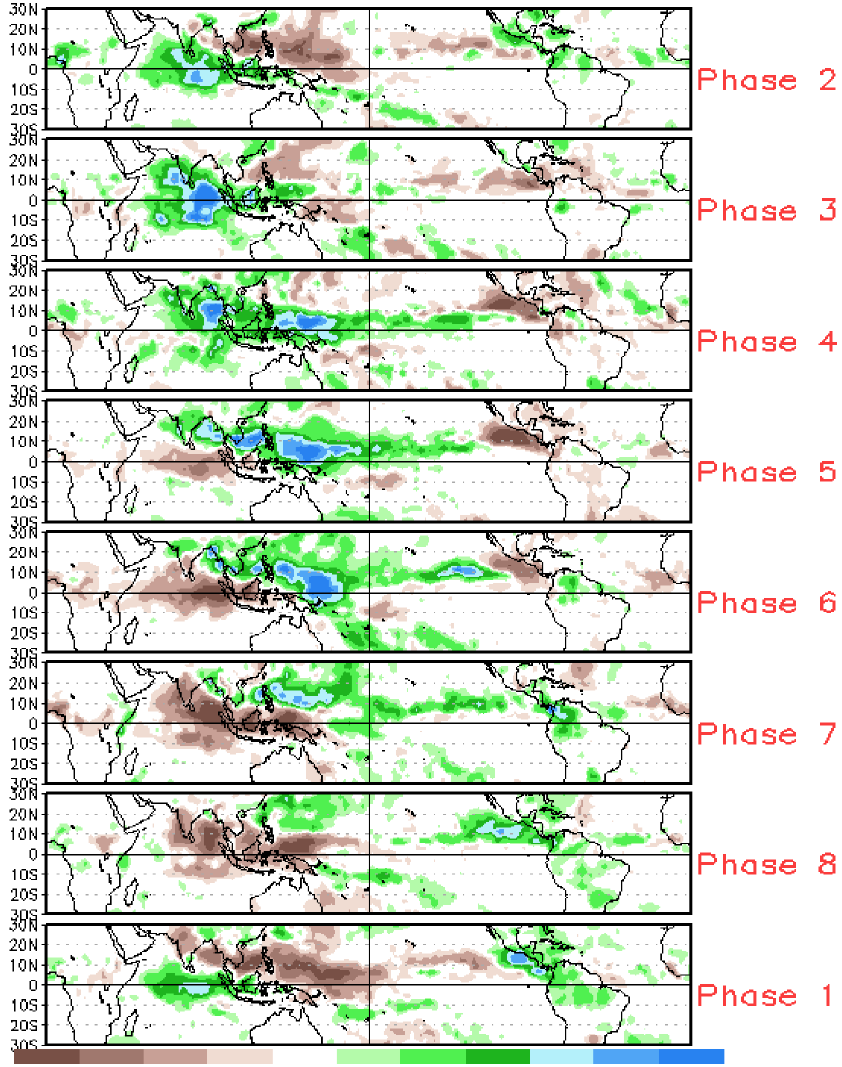
The constructed analog RMM-based OLR anomaly forecast depicts a very weak anomaly field.

MJO Composites - Global Tropics

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



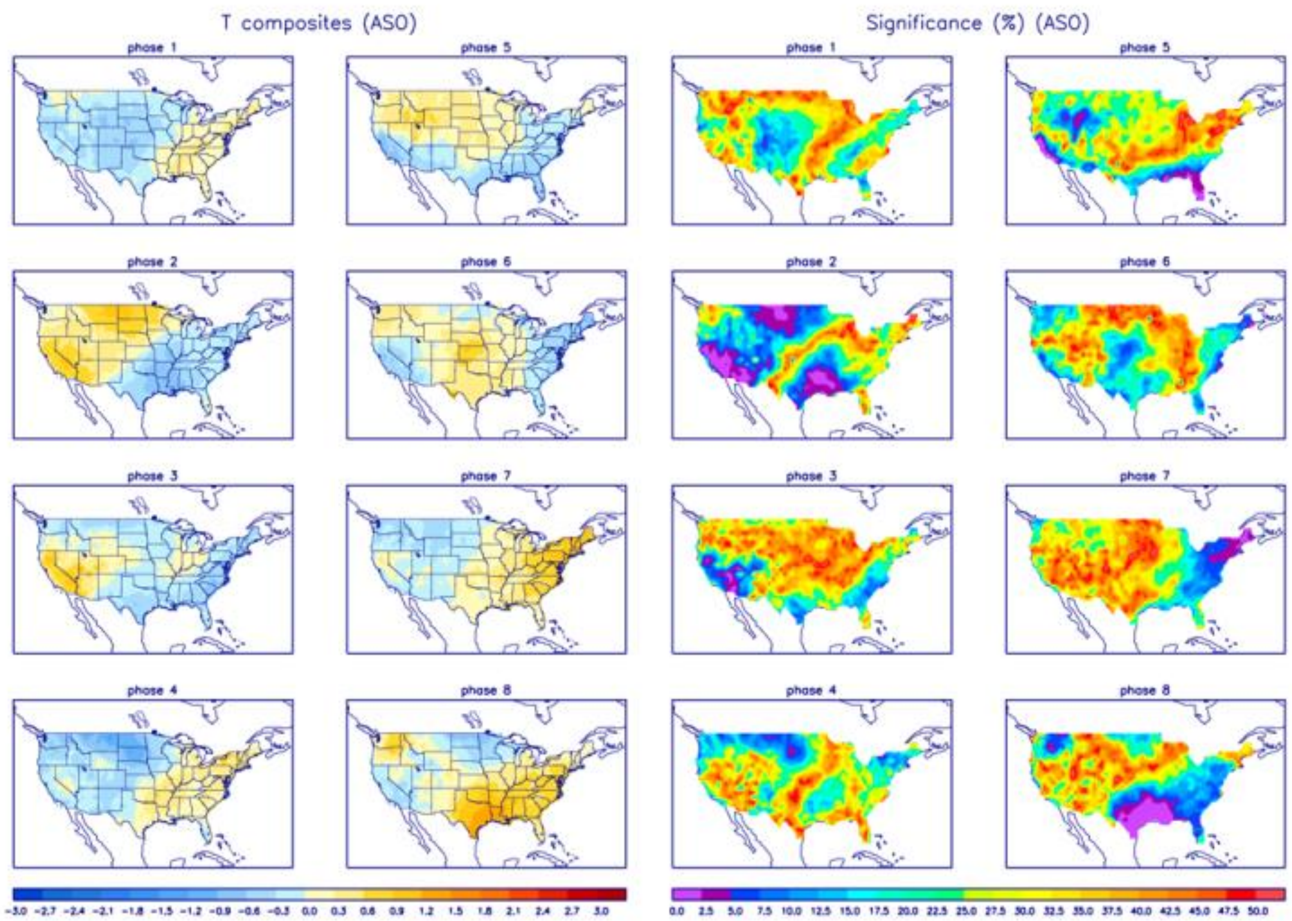
Precipitation Anomalies (May - Sep)



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.

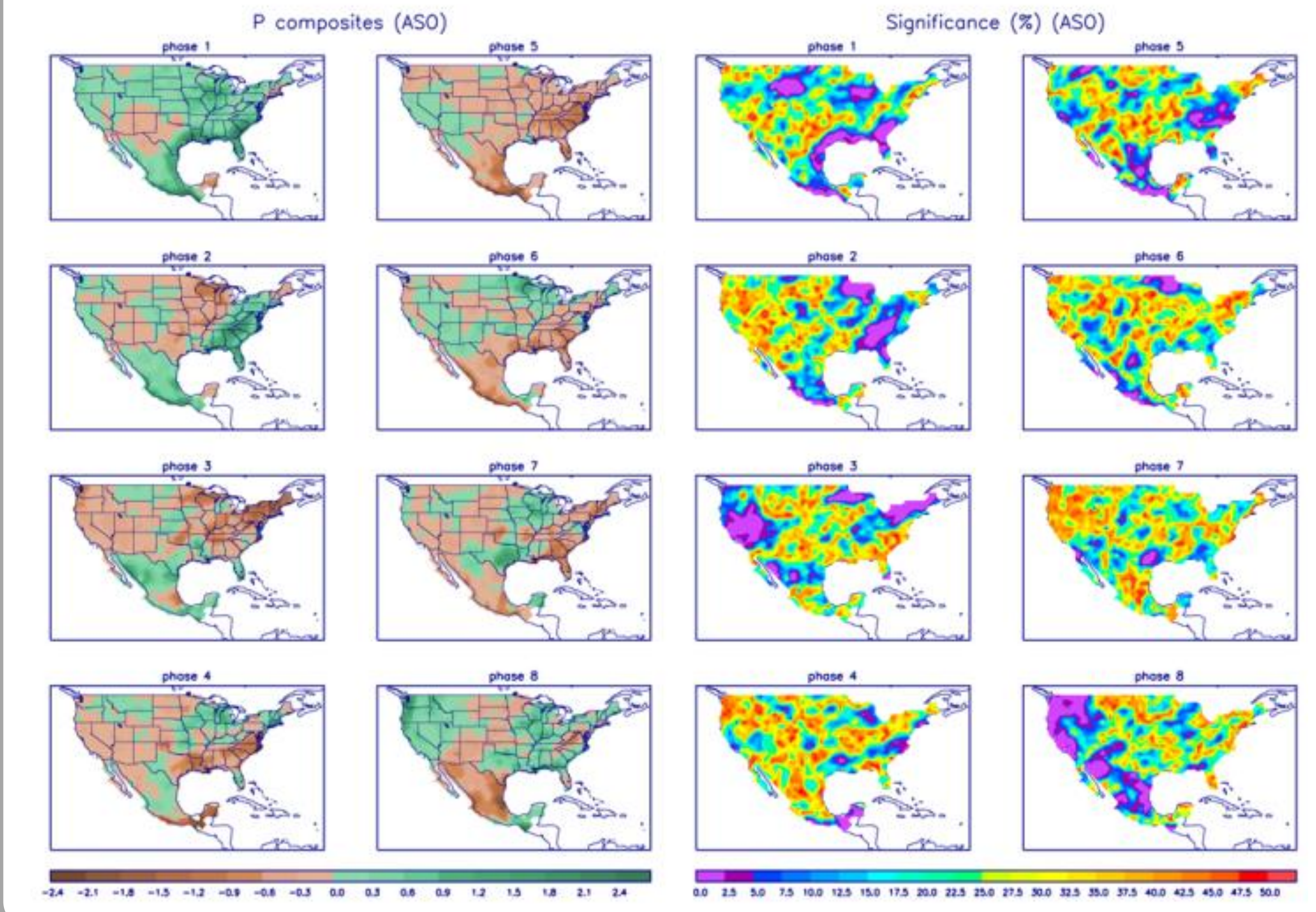
Right hand side plots show a measure of significance for the left hand side anomalies. Purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.



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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