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

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Outline

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Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

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Overview

- Strength of the MJO signal has rapidly weakened over the past week in the RMM index. Most models forecast that the MJO signal will continue to decay over the next couple of weeks. Some models and statistical tools indicate that the signal could continue to weakly propagate eastward over the next week, but most do not indicate a re-intensification of the signal.

- Previous organization in the upper-levels has broken down over the past week, which was carrying most of the strength in this MJO signal. Rossby and Kelvin wave activity has weakened the signal in these fields and continued activity will likely destructively interfere with the remaining signal.

- Tropical cyclone formation odds are likely to continue to be enhanced over the Eastern Pacific during the next two weeks.

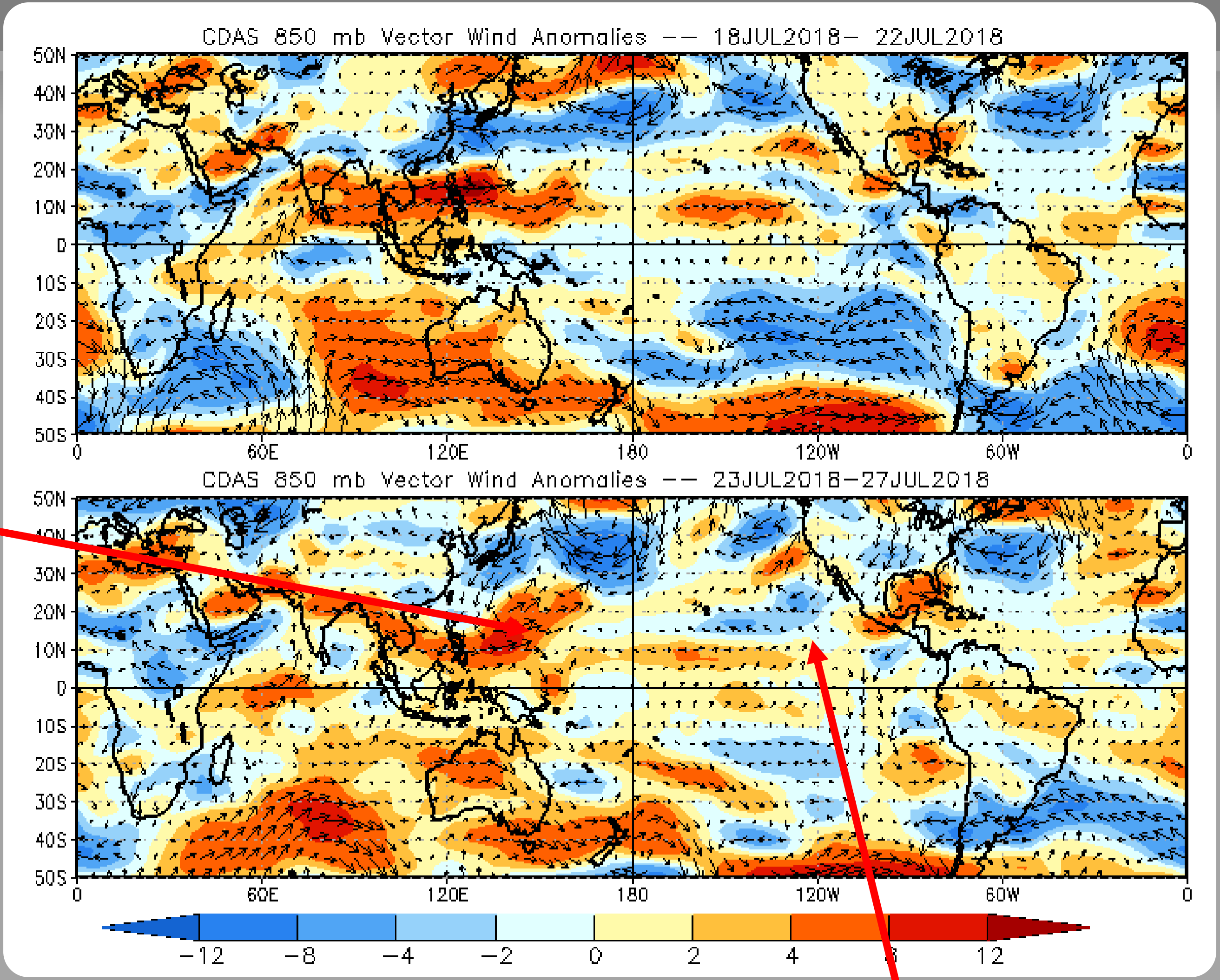
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Anomalous westerlies over the Maritime Continent and western Pacific have weakened, coincident with Rossby wave activity.

Anomalous easterlies increased over the eastern Pacific, while anomalous westerlies have weakened along 10 N.

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

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

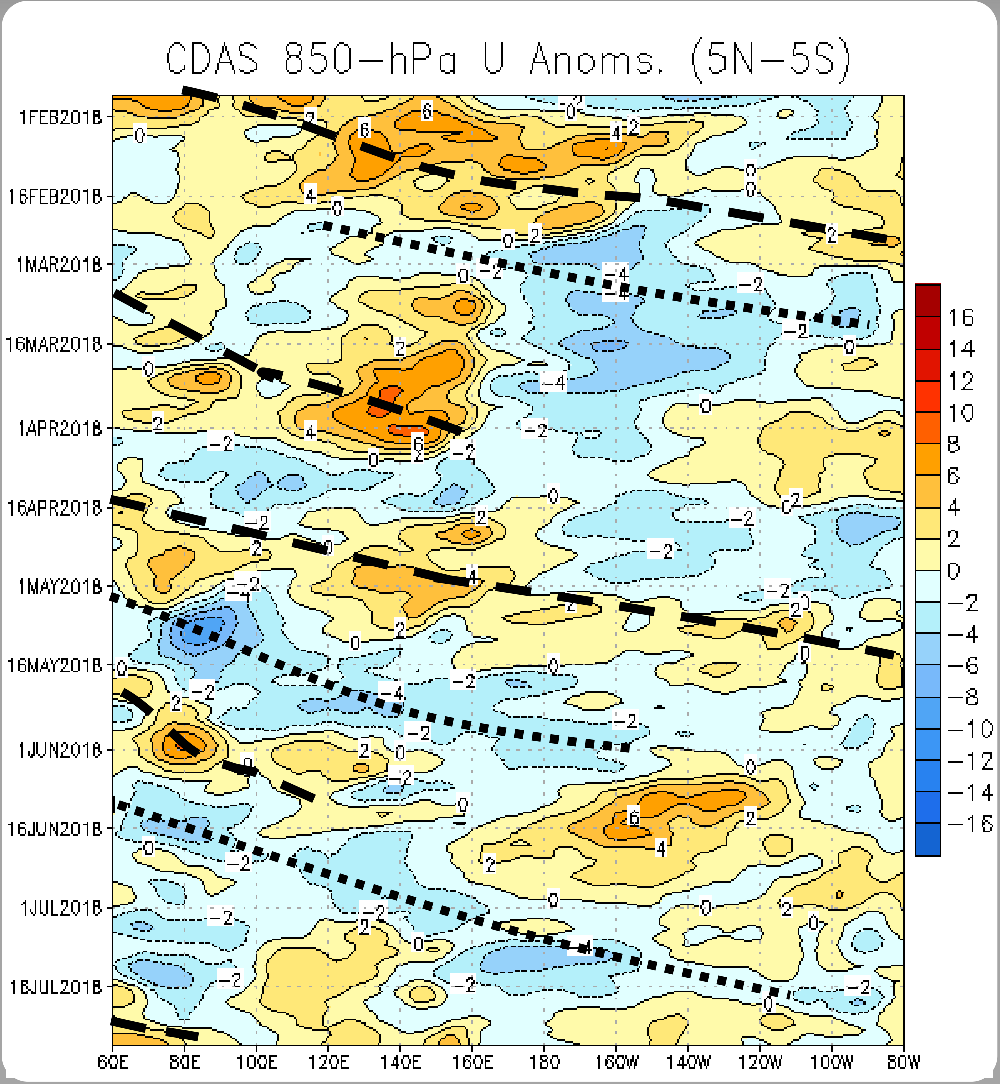
Easterly anomalies (blue shading) represent anomalous east-to-west flow

A strong MJO circumnavigated the globe twice through January and mid-February.

During mid to late March, anomalous westerlies shifted east from the Indian Ocean to the Maritime Continent as the MJO signal re-emerged. These westerlies were associated with the envelope of active MJO convection. This signal broke down during April.

The MJO was active during late April to May. During June, eastward propagation was obscured by westward moving variability, including TC activity over the Pacific and equatorial Rossby waves.

The low-level wind pattern has been broadly disorganized during most of July. There is evidence of some strengthening of an MJO signal toward the end of the month.



OLR Anomalies – Past 30 days

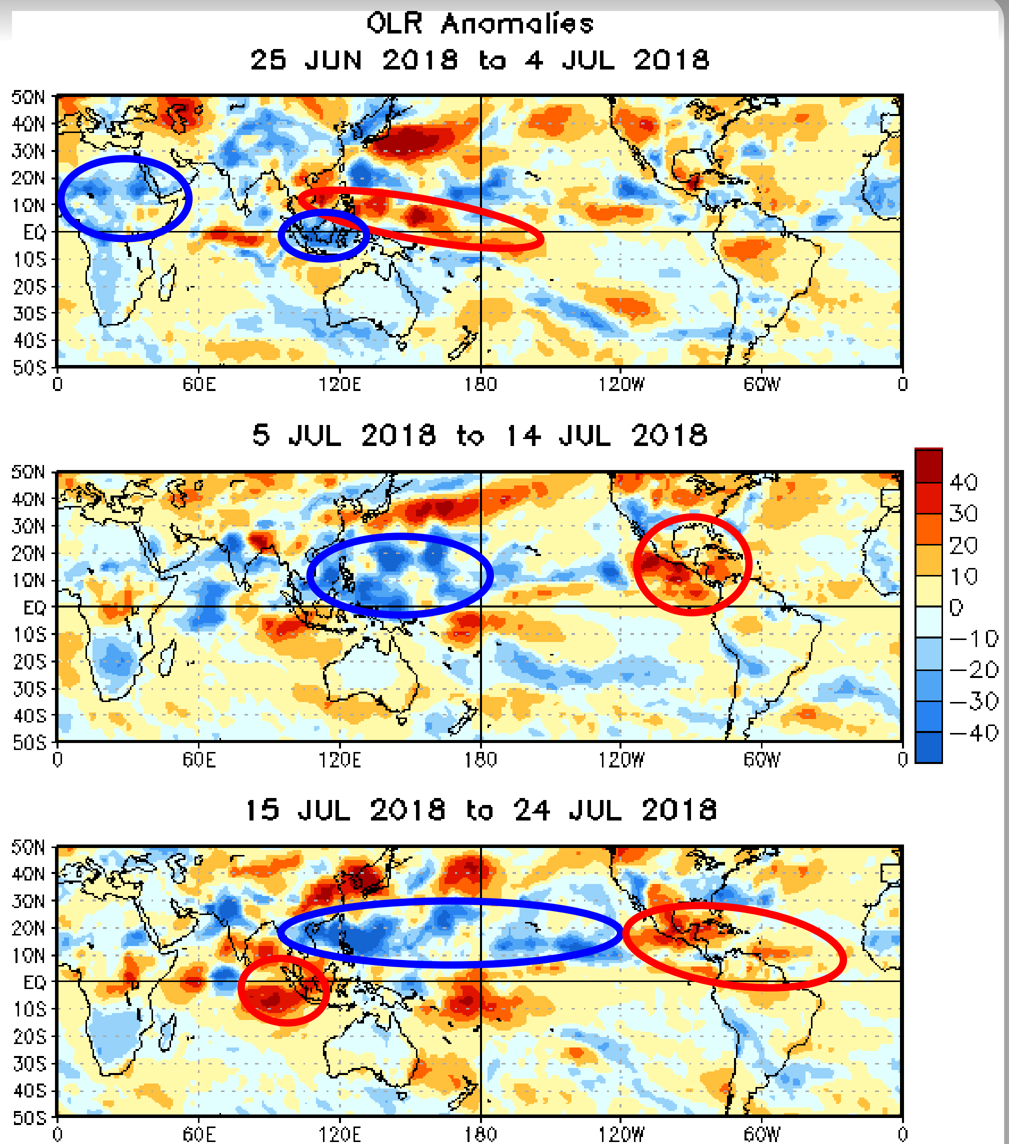
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late June, enhanced convection was observed over Africa. A band of suppressed convection lifted northward over the West Pacific and Southeast Asia, with tropical cyclone activity initiating to the north of this band and over the East Pacific.

A broad area of anomalous convection stretched from the Maritime Continent to the central Pacific during the first half of July. Anomalously suppressed convection was found over the eastern Pacific during the same time.

Enhanced convection has expanded over much of the North Pacific, with suppression over the Western Maritime Continent, consistent with an evolving MJO signal. Suppressed convection over the eastern Pacific has weakened and intensified in the Gulf of Mexico.



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

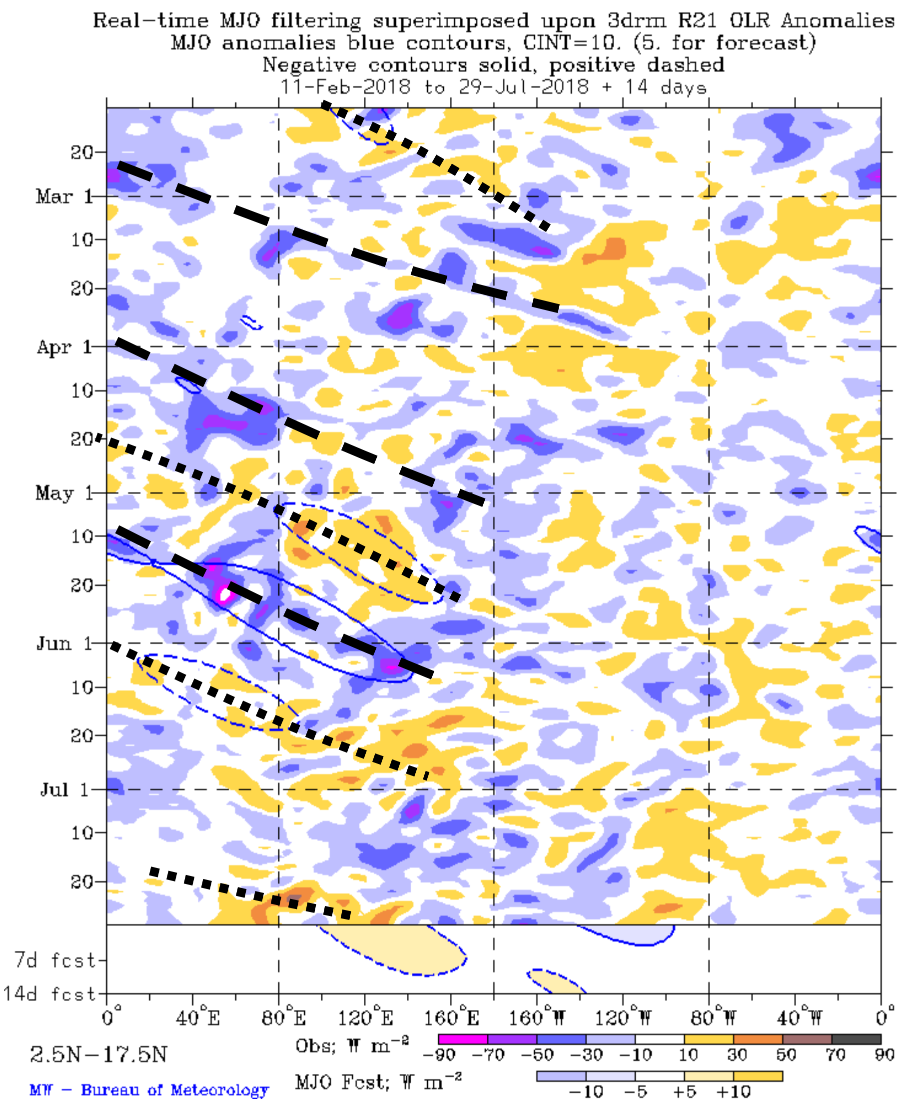
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

After a period of stronger MJO activity, during April into early May, the OLR signature of the MJO weakened as the signal crossed the Maritime Continent and eventually destructively interfered with the weakening La Niña footprint.

During early June, the enhanced phase of the MJO shifted eastward from the Indian Ocean to the Maritime Continent before constructively interfering with westward-moving variability.

Recently, higher frequency modes influenced the OLR field, including Kelvin waves and tropical cyclones. A larger area of enhanced convection is evident near the western Pacific mid-month, while an area of suppressed convection has moved from Indian Ocean to the western Maritime Continent in the latter half of July.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

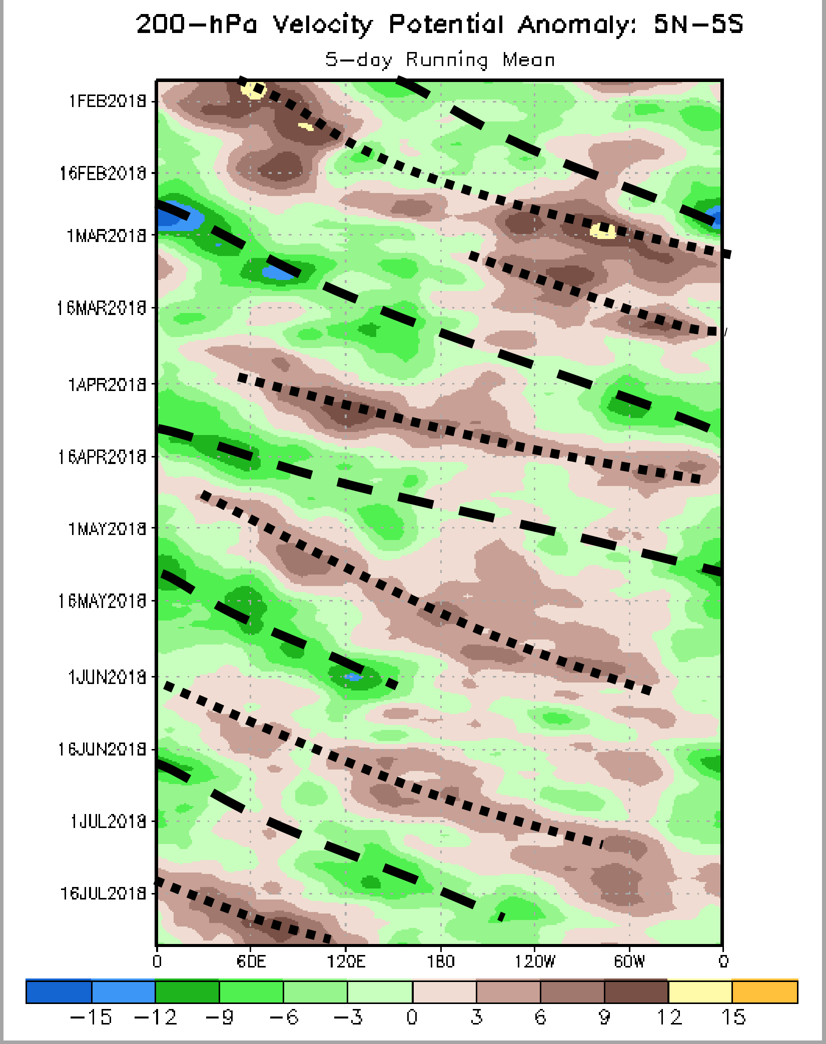
Negative anomalies (green shading) indicate favorable conditions for precipitation

MJO activity can be seen during January and February. Additionally, there are indications of atmospheric an Kelvin wave east of the Date Line during late February and early March.

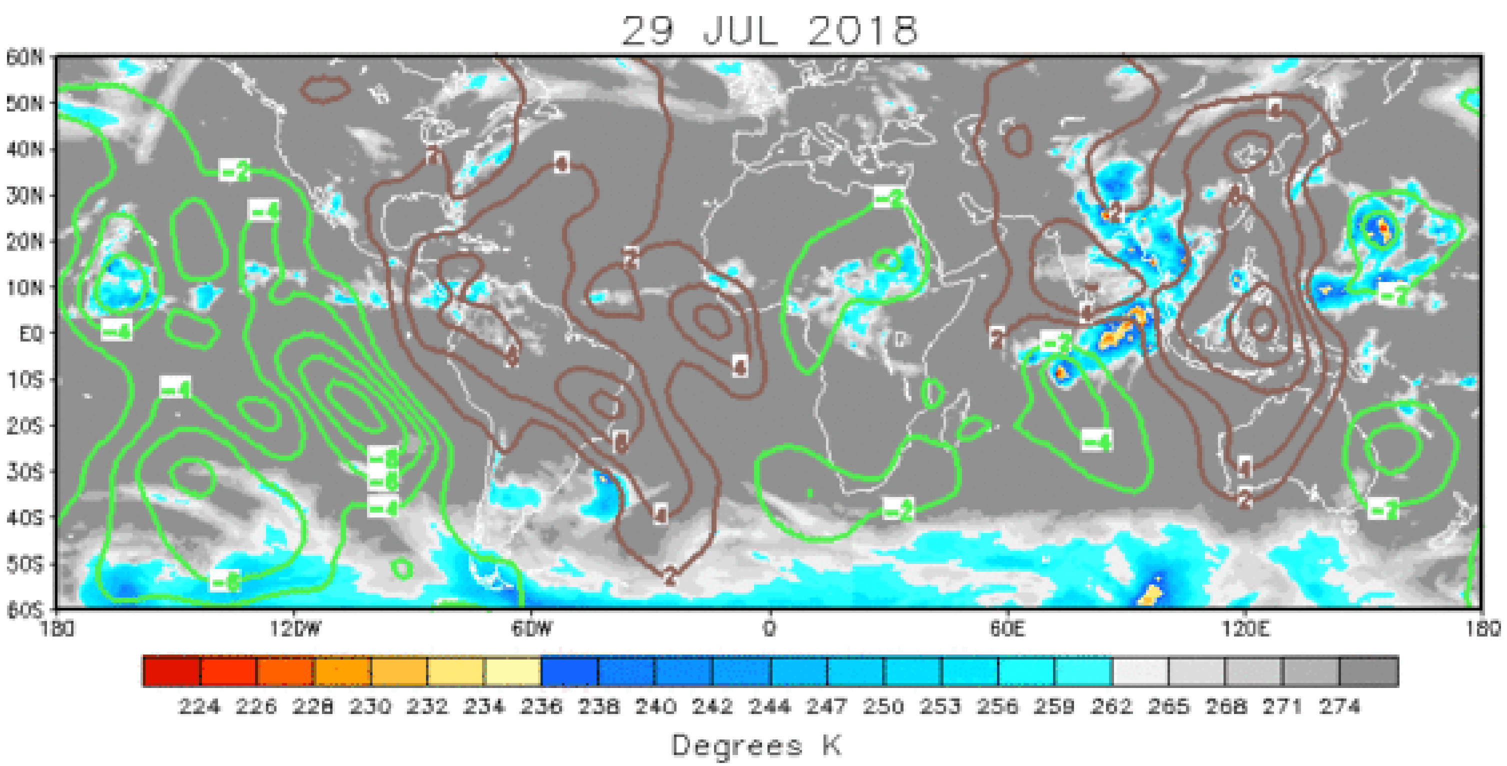
The large-scale region of suppressed convection along the Date Line associated with La Niña is became less dominant as La Nina waned during the spring.

During the month of May, the MJO signal strengthened as measured by the velocity potential. MJO propagation from Africa to the Maritime Continent was observed before the signal weakened during mid-June.

Since mid-June, the suppressed signal has maintained some cohesiveness. During July, a robust active signal in the velocity potential is evident and moved from the Indian Ocean to the Pacific. Suppressed convection is also evident over the Indian Ocean, propagating eastward over the Maritime Continent.



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



The upper-level velocity potential now shows a Wave-2 pattern, unlike the past few weeks. Kelvin and Rossby wave activity over Africa has led to upper-level divergence, breaking down the Wave-1 pattern. Upper-level divergence continues over the Central and East Pacific. Convergence over the Indian Ocean has shifted eastward over the western Maritime Continent, consistent with an active MJO.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

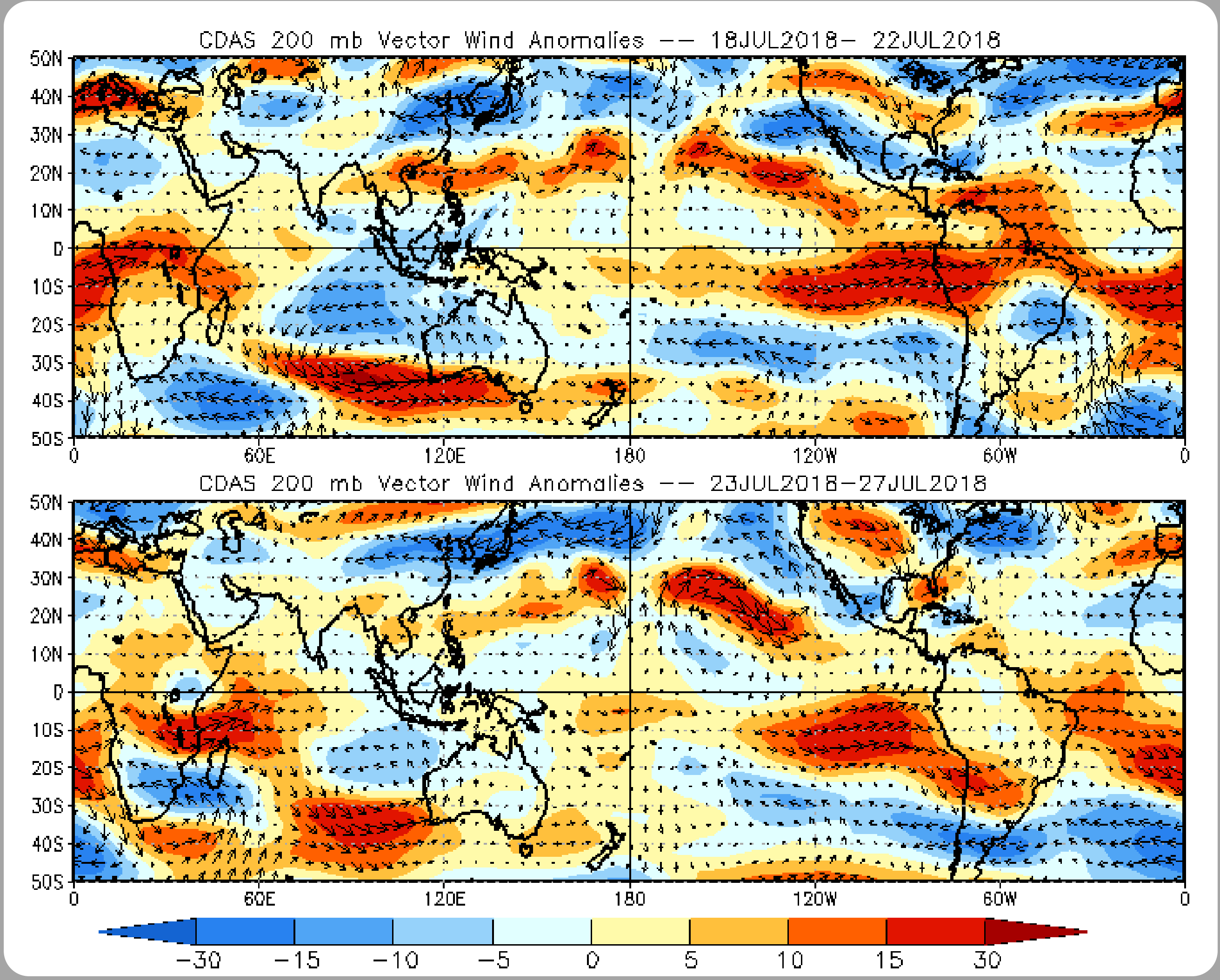
Negative anomalies (green contours) indicate favorable conditions for precipitation

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 upper-level wind anomalies have overall weakened along the tropics. Anomalous westerlies have increased near Hawaii and remain in the eastern Pacific. Anomalous easterlies in the eastern Indian Ocean have drastically weakened.

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

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

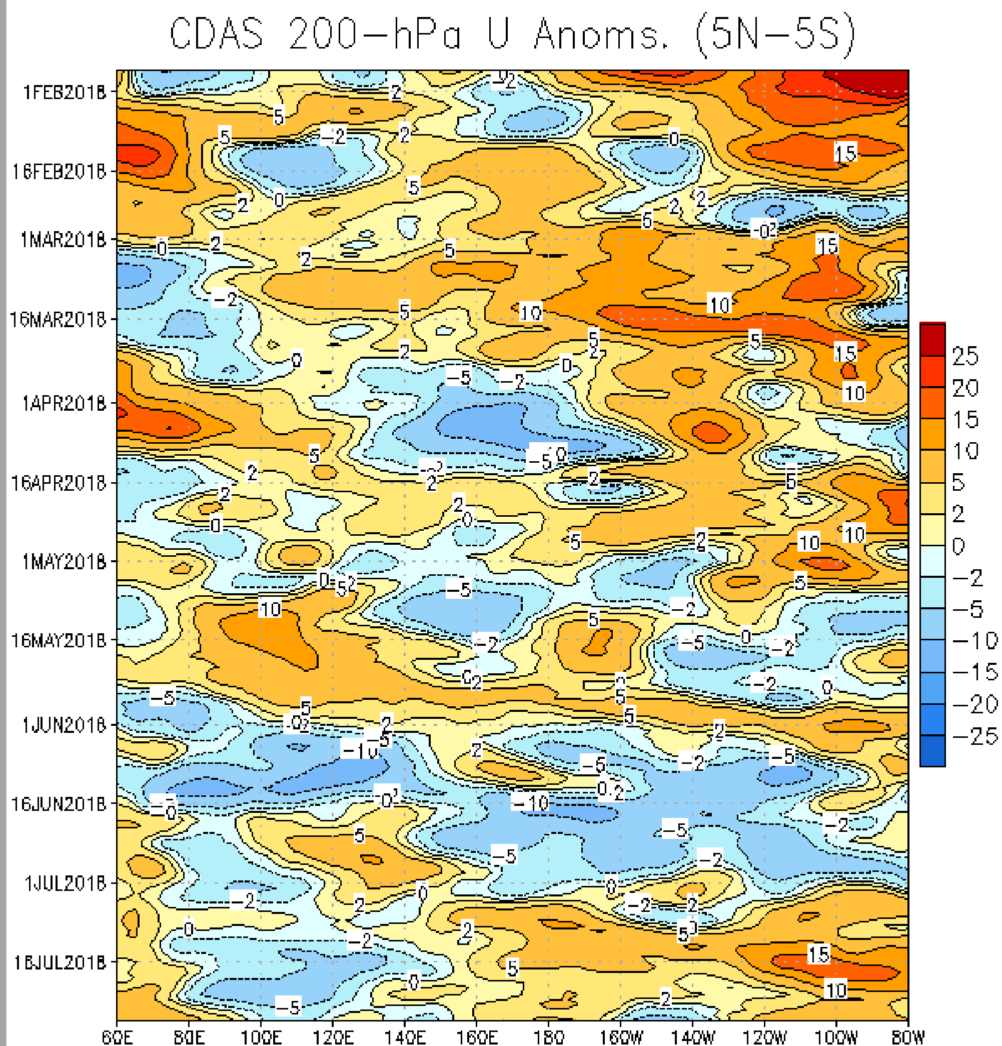
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Strong anomalous westerlies that formed in early January just west of the Date Line propagated eastward, consistent with a strong MJO event during this period.

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.



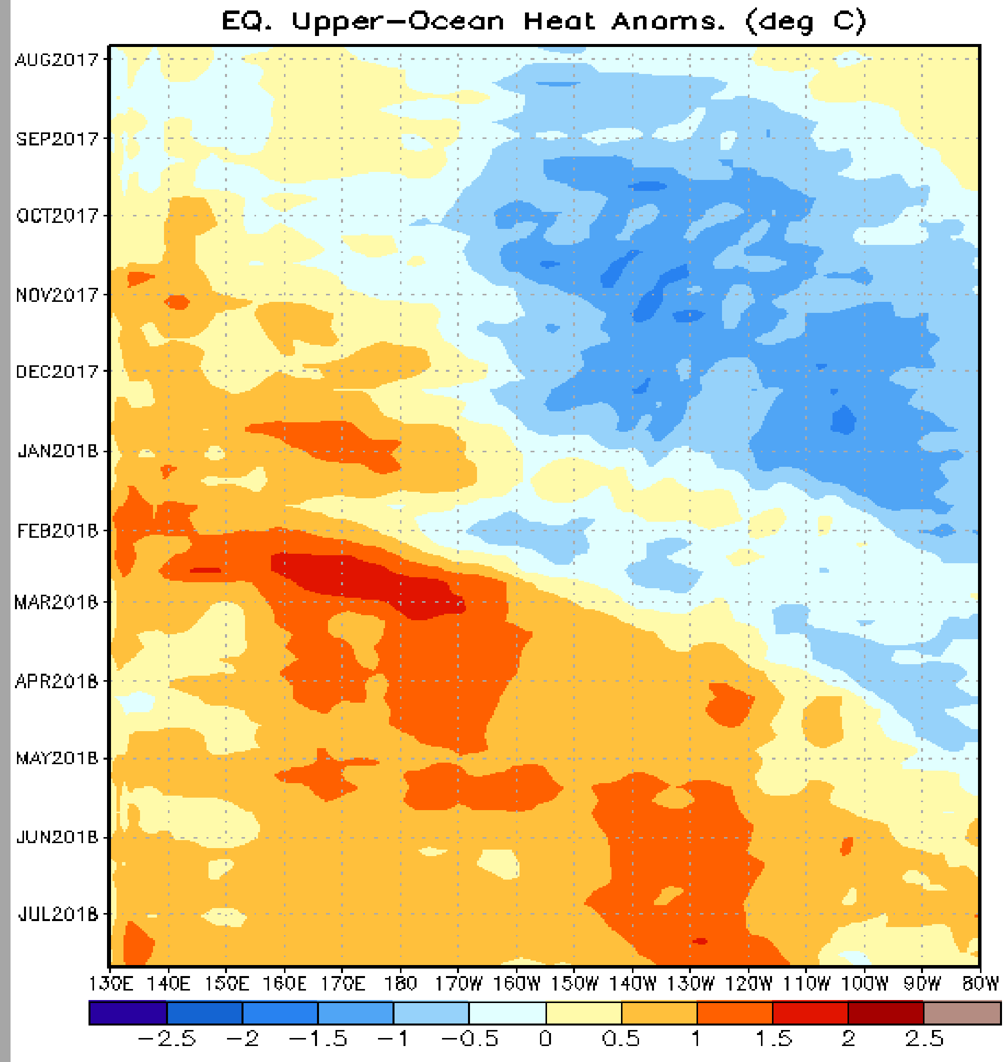
Weekly Heat Content Evolution in the Equatorial Pacific

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 are now observed over the entire basin.



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

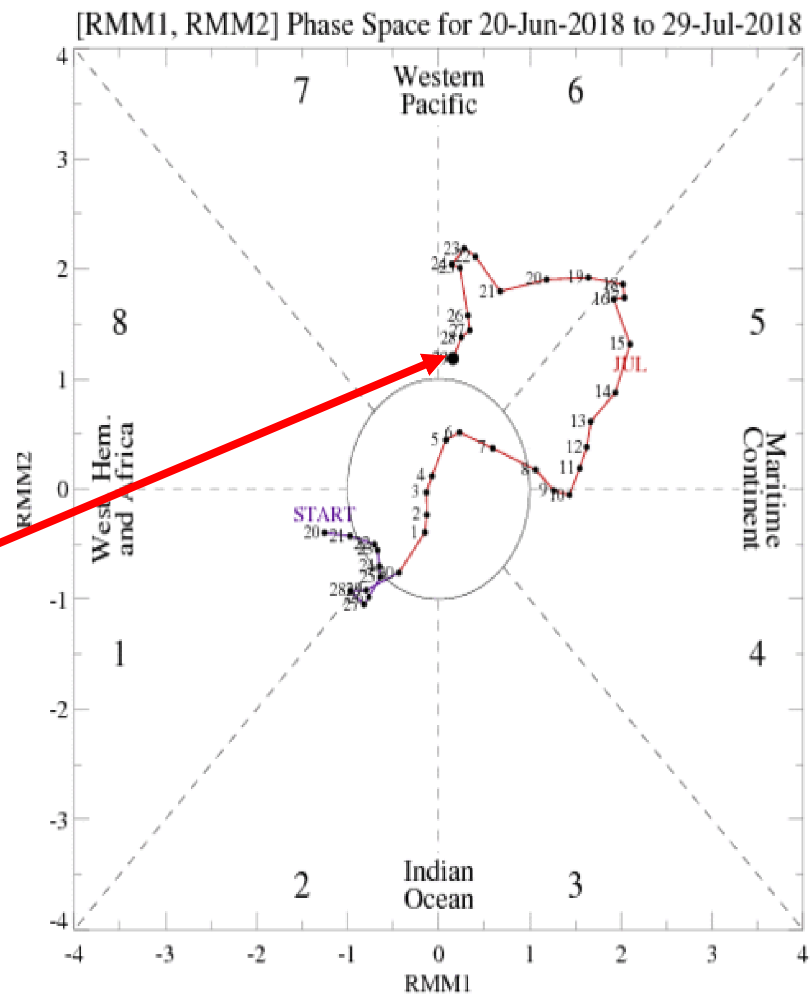
The triangular areas indicate the location of the enhanced phase of the MJO

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

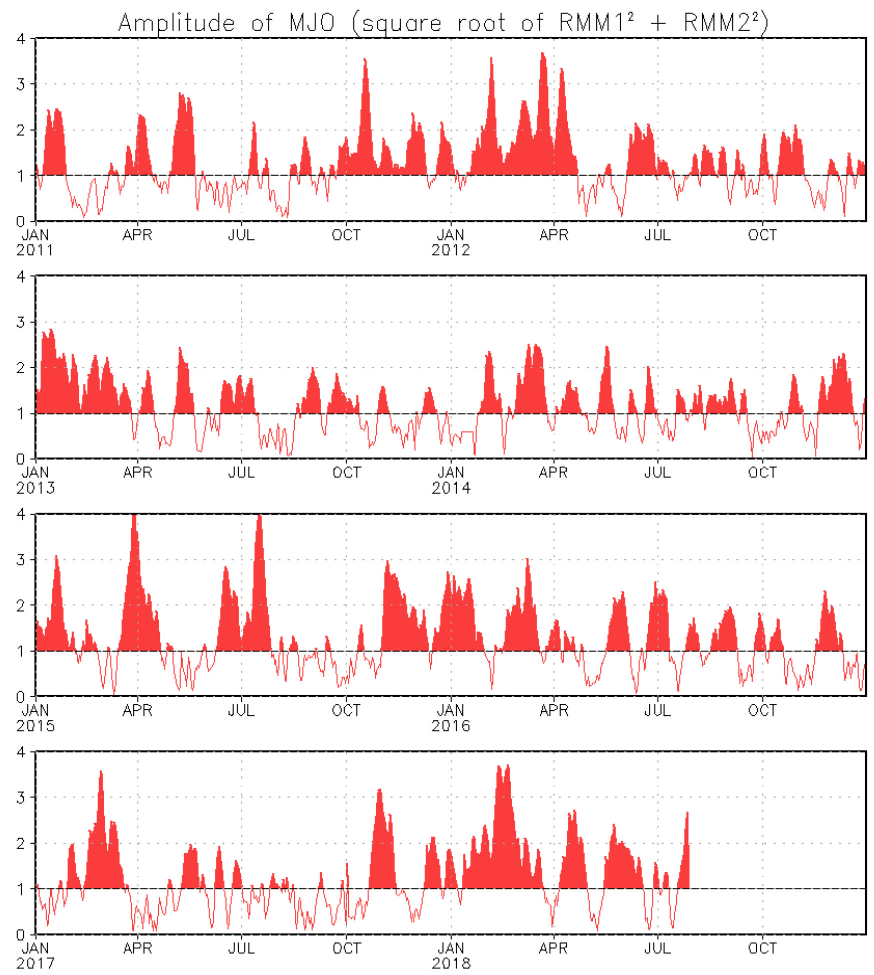
The MJO signal projection on the RMM index has weakened over the past week. This is driven mostly by the weakening of the signal in upper-level fields, where the signal was previously the most robust.



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

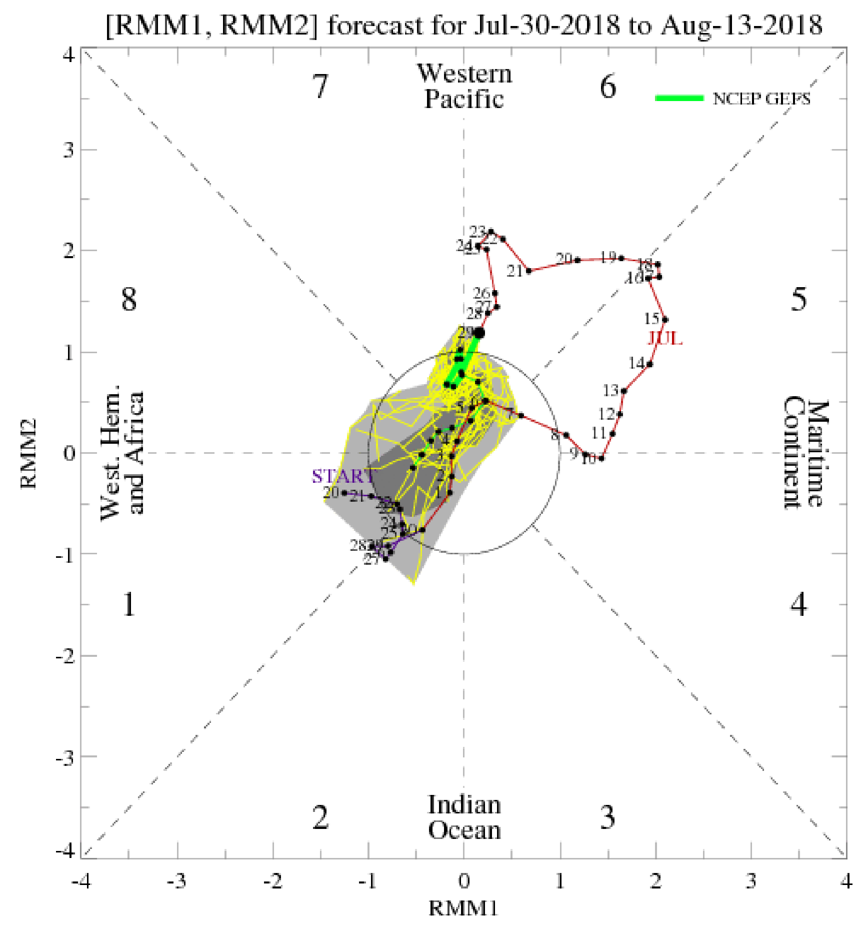
<u>Yellow Lines</u> - 20 Individual Members
<u>Green Line</u> - Ensemble Mean

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

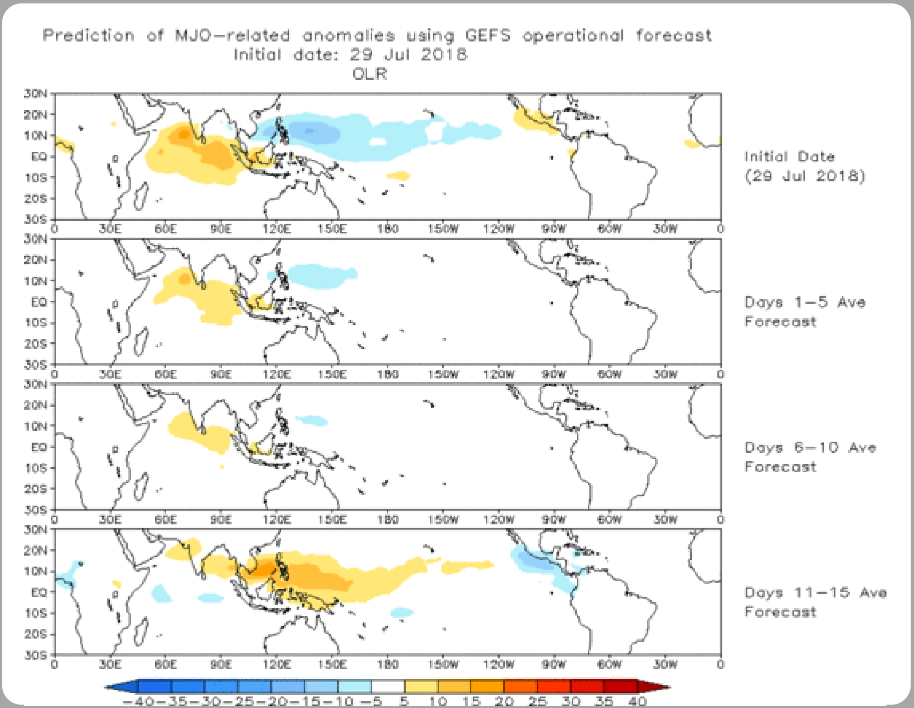
The GEFS RMM index forecast continues to weakly propagate the MJO signal into Phase 7, but the signal falls back inside the unit circle in Week 1.



Ensemble GFS (GEFS) MJO Forecast

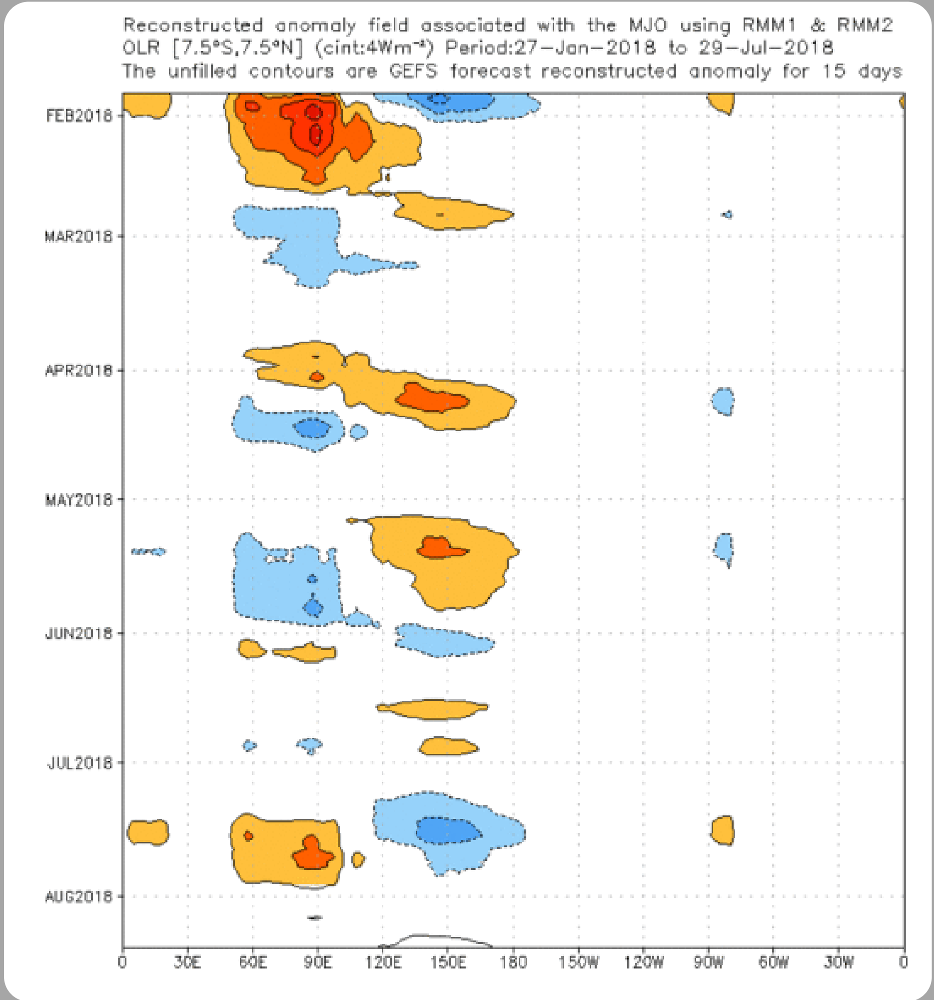
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



GEFS-based OLR anomalies depict a weak propagation of MJO signal over the Pacific.

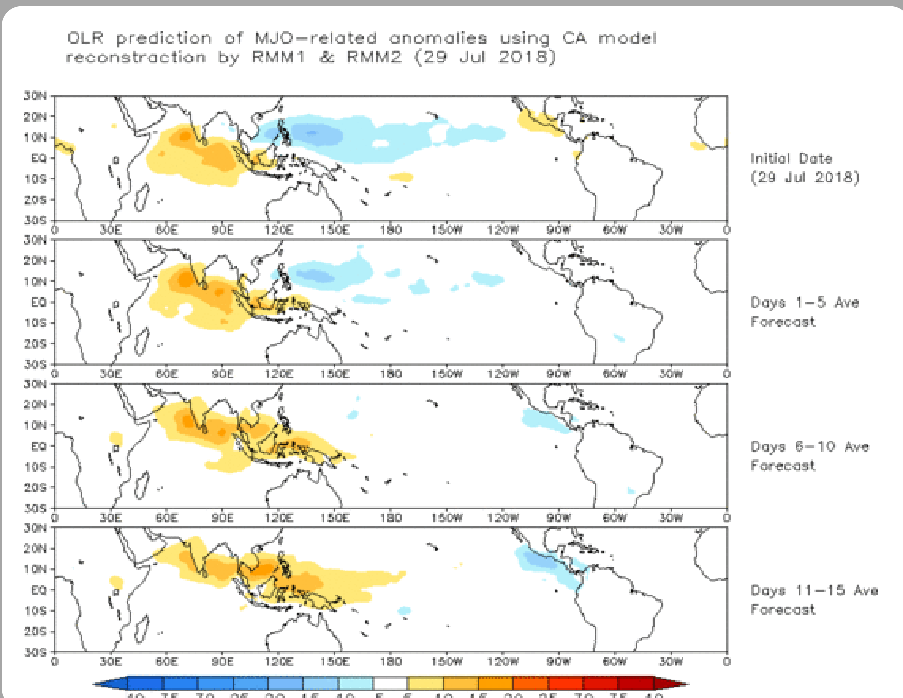
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



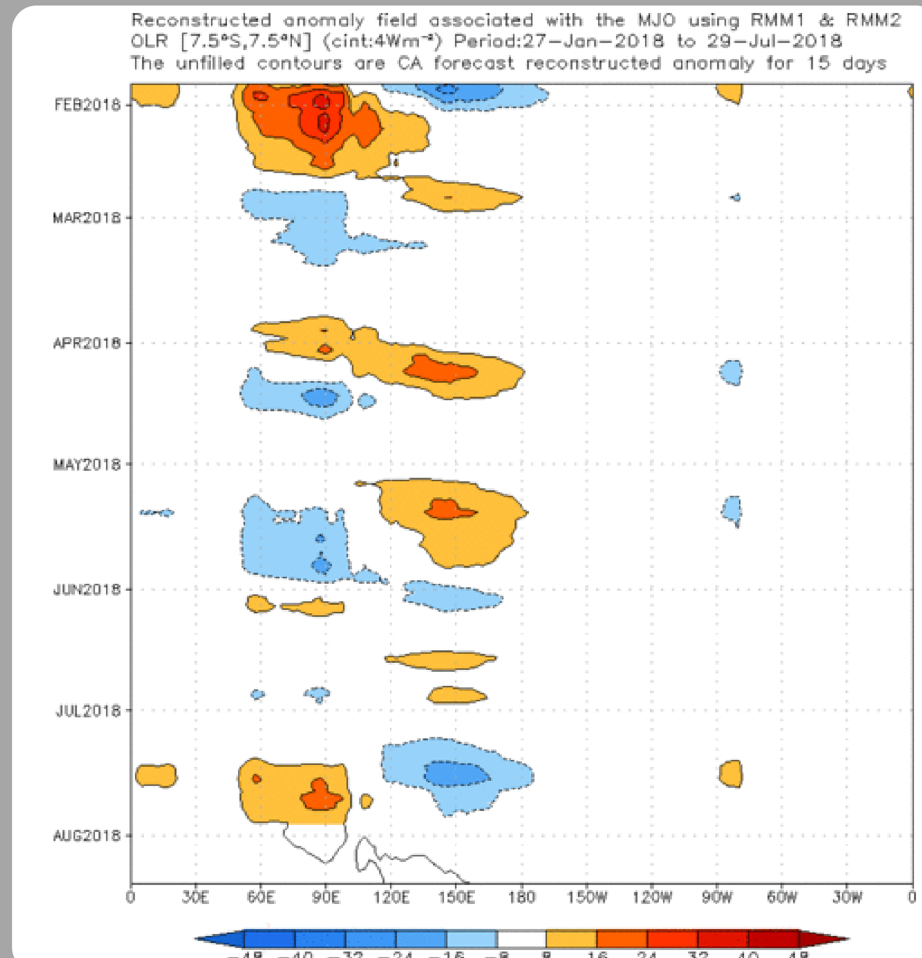
Constructed Analog (CA) MJO Forecast

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



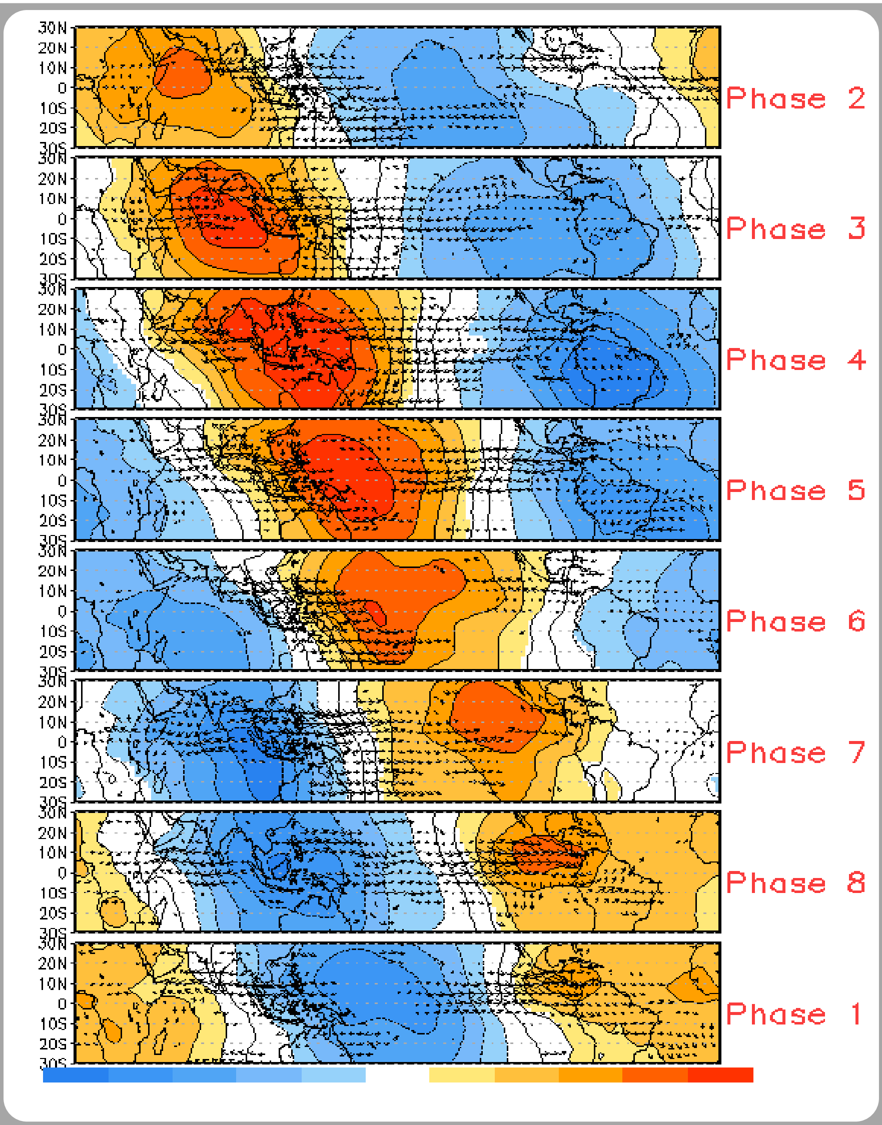
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



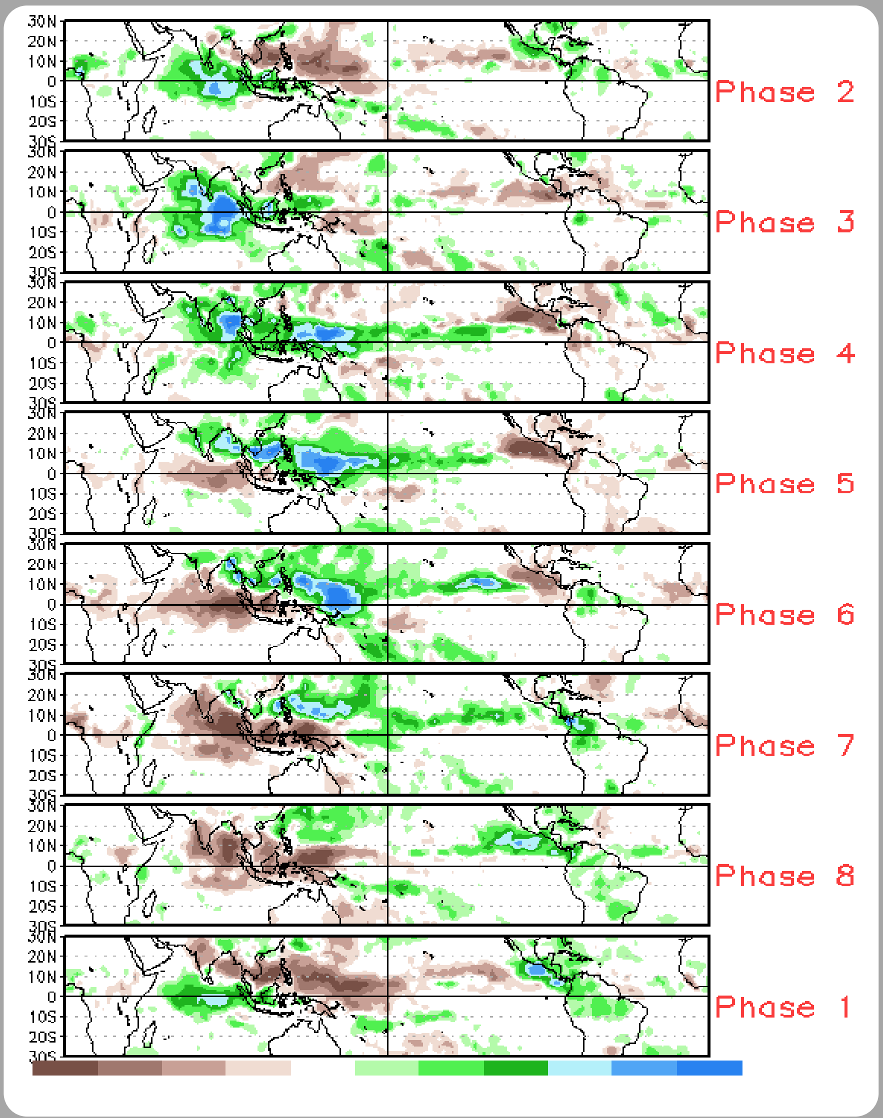
The constructed analog MJO forecast propagates the enhanced phase of the MJO signal across the Pacific.

MJO Composites - Global Tropics

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



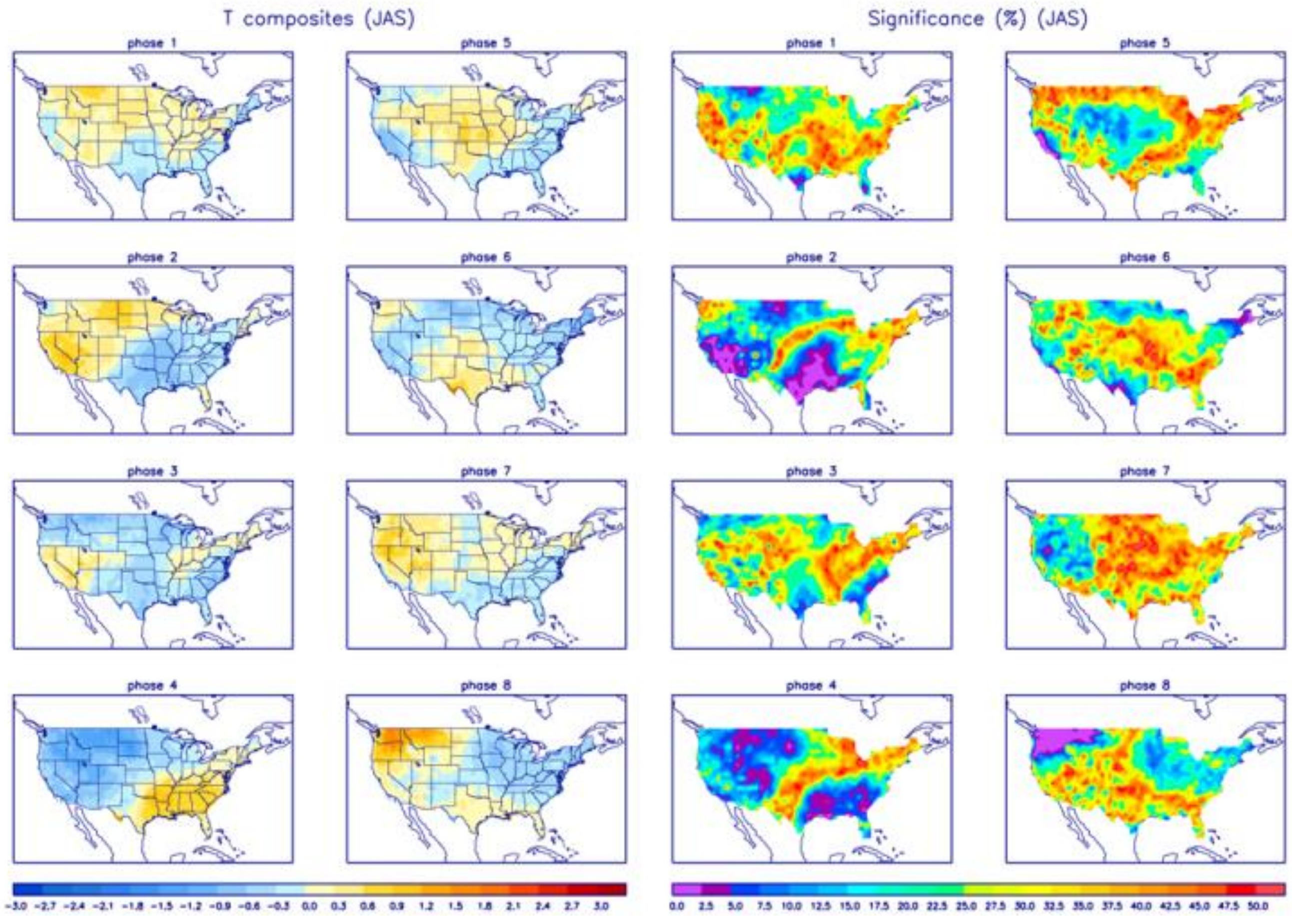
Precipitation Anomalies (May - Sep)



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.



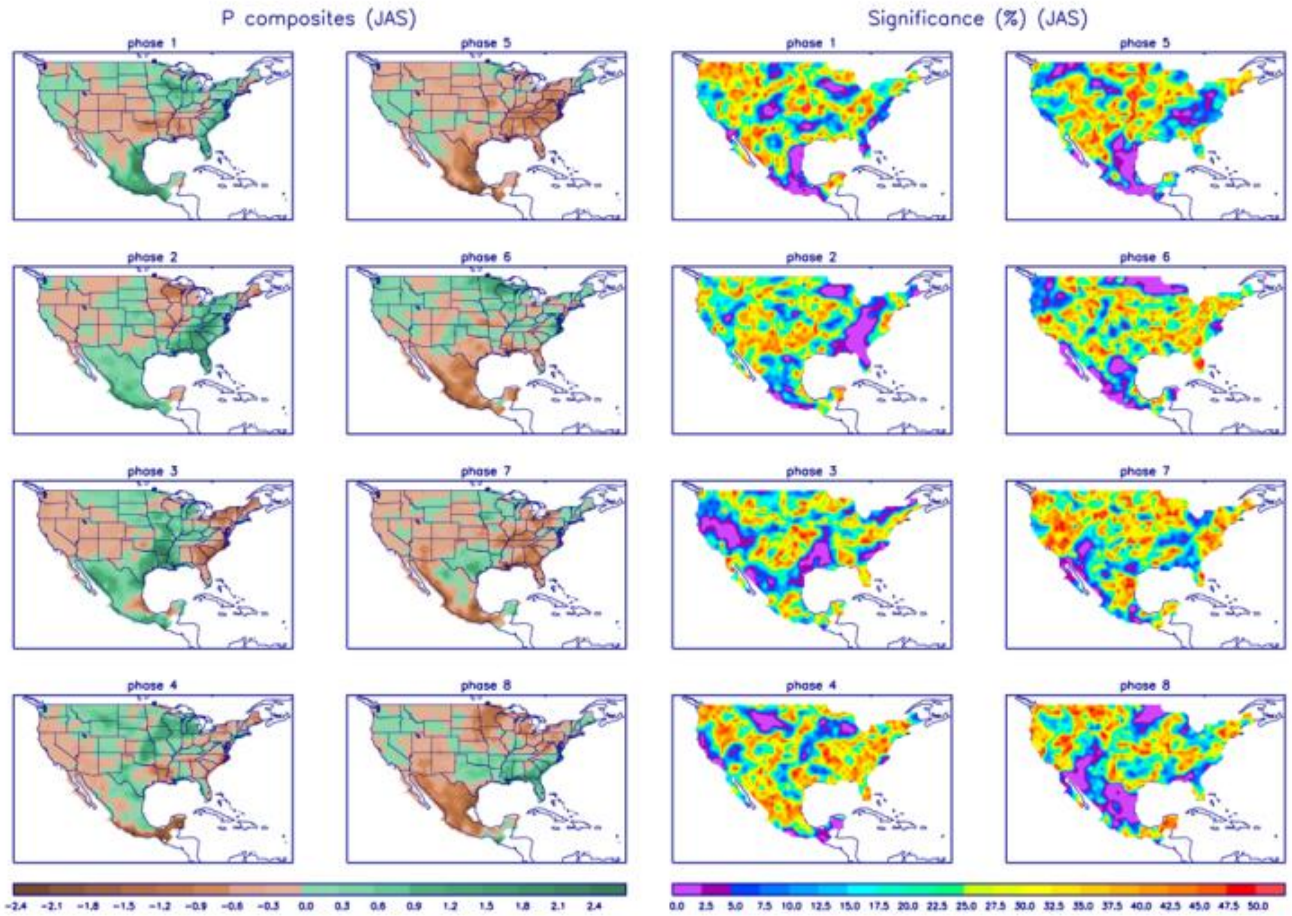
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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