# 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 places the MJO signal over the Maritime Continent, but the MJO convection and wind fields appear weak and disorganized by other metrics.
- Most models suggest that the MJO signal, which is primarily driven by the upper-level wind field, will decay over the next couple of weeks. There are some ensemble members that depict amplification of the MJO index during Week-2, but this seems unlikely given the current state of the Pacific.
- It is unlikely that the MJO will be a driving factor in the tropical circulation during the next week, but atmospheric Kelvin and equatorial Rossby wave activity is possible.

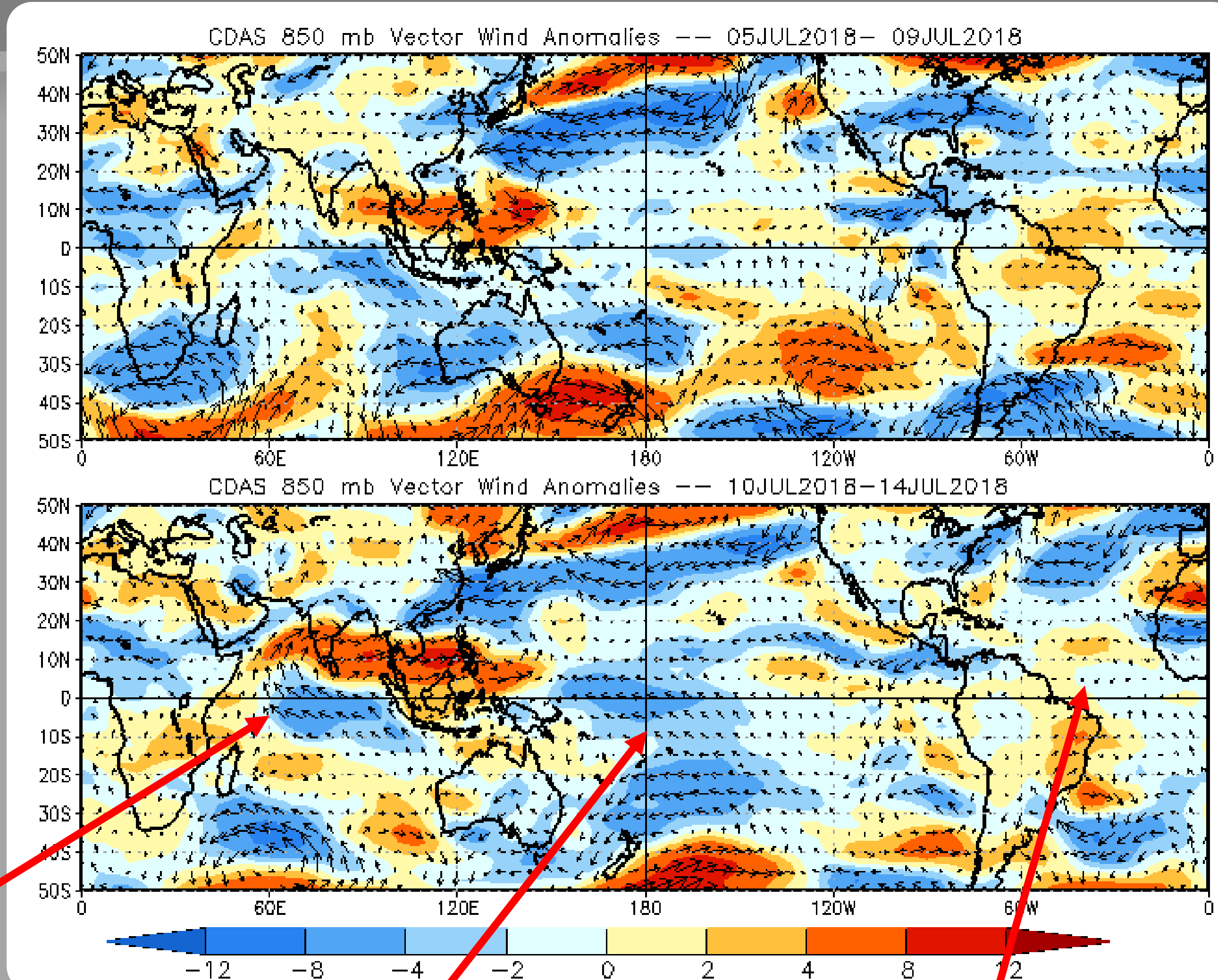
**Additional potential impacts across the global tropics and a discussion for the U.S. are available at:**
**http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php**

# 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 extend from the northern Indian Ocean to the Maritime Continent

Anomalous easterlies are found over the central Pacific.

Low-level winds are near climatology over the Atlantic Basin.

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

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

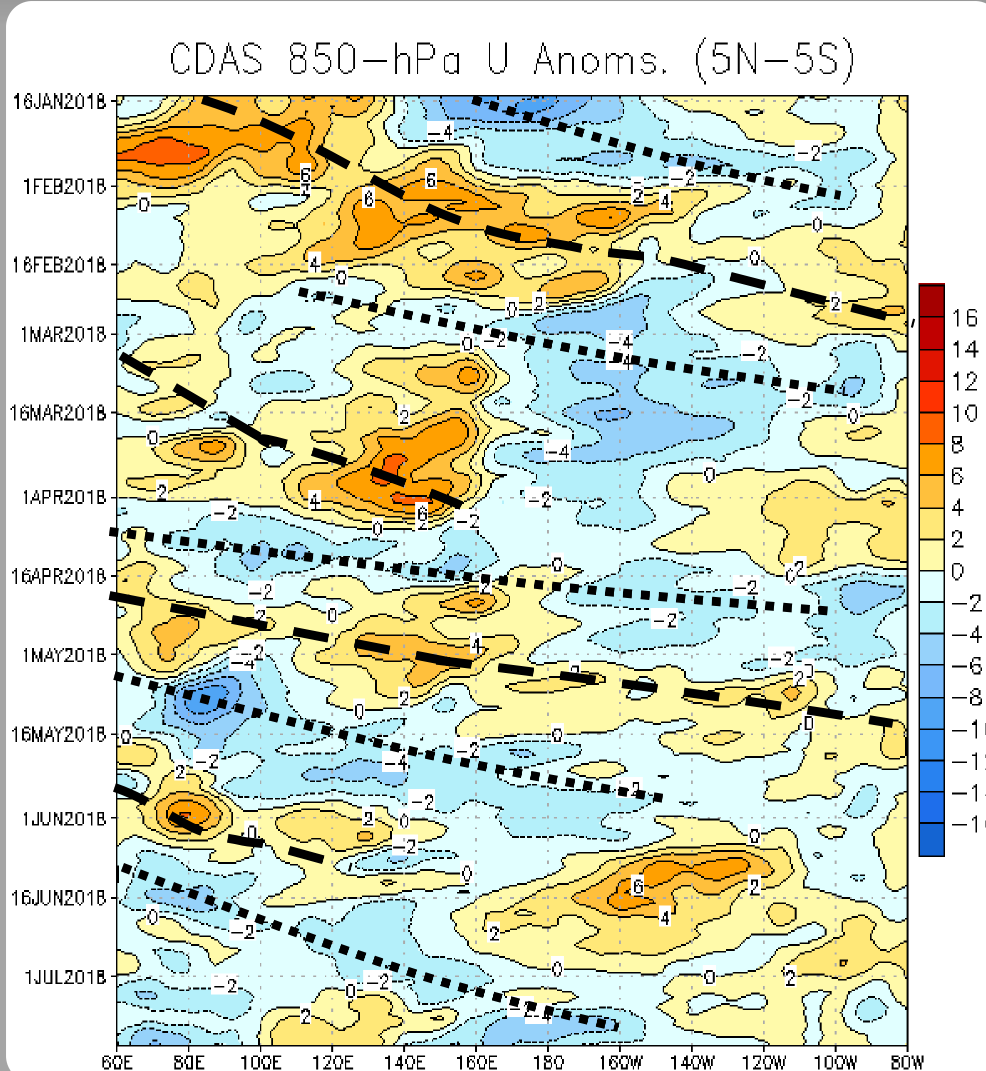
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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 April and 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 the first part of July.



# OLR Anomalies – Past 30 days

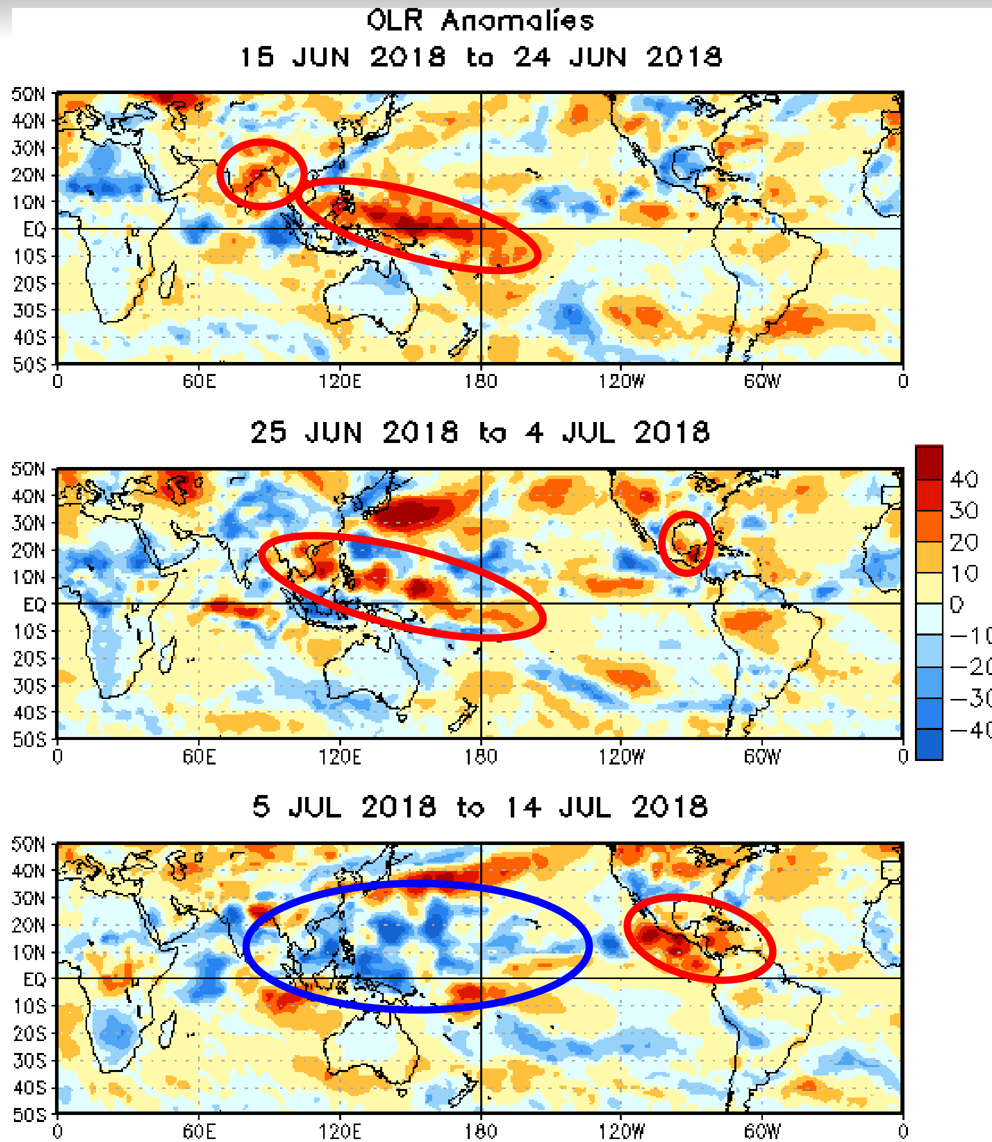
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

Suppressed convection overspread the West Pacific during mid-June, with no large-scale enhanced convective anomalies present. South Asia Monsoon activity waned and enhanced rainfall overspread parts of the U.S. Gulf Coast.

During late June and early July, enhanced convection was observed over Africa. The 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 part of July. Anomalously suppressed convection was found over the eastern Pacific during the same time.



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

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

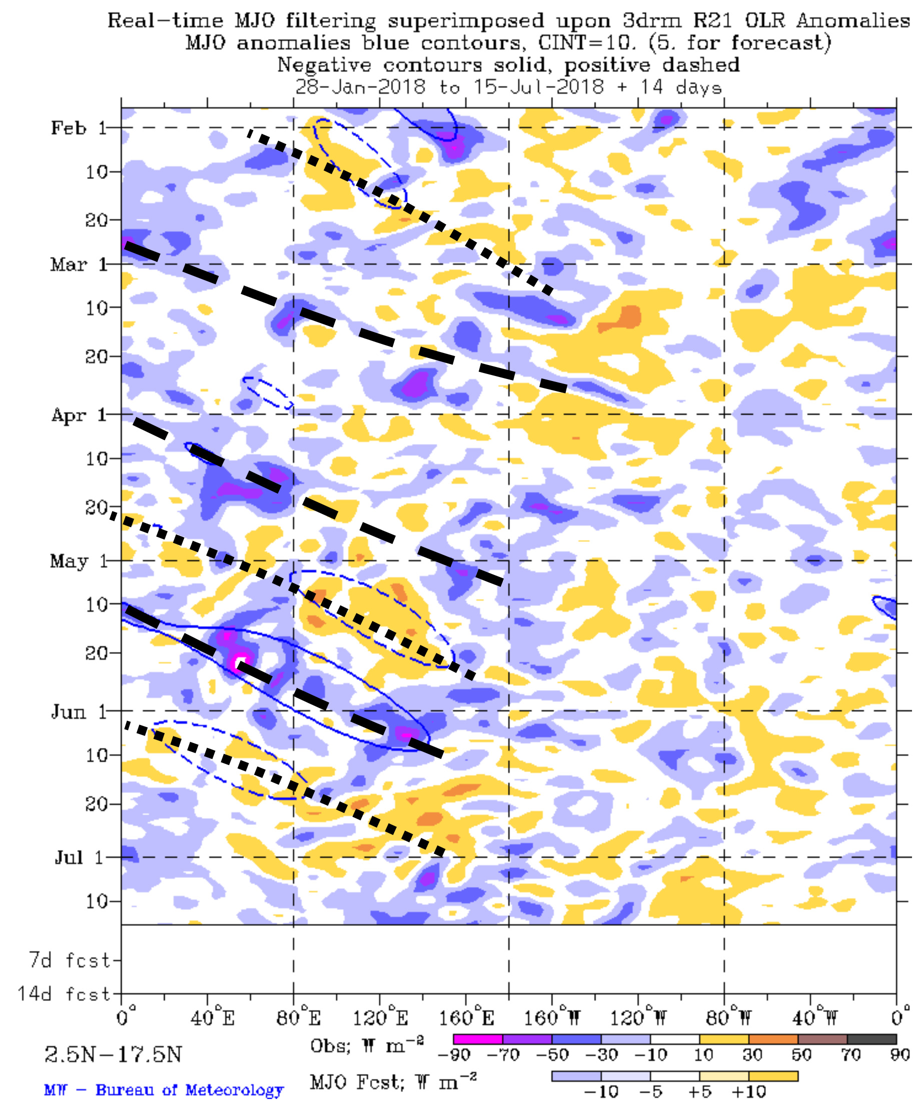
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During early 2018, La Niña activity was modulated by robust MJO activity.

An active MJO event propagated east from Africa to the Indian Ocean during early to mid-April.

During 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.

More recently, the OLR field has been dominated by higher frequency modes, including Kelvin waves and tropical cyclones.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

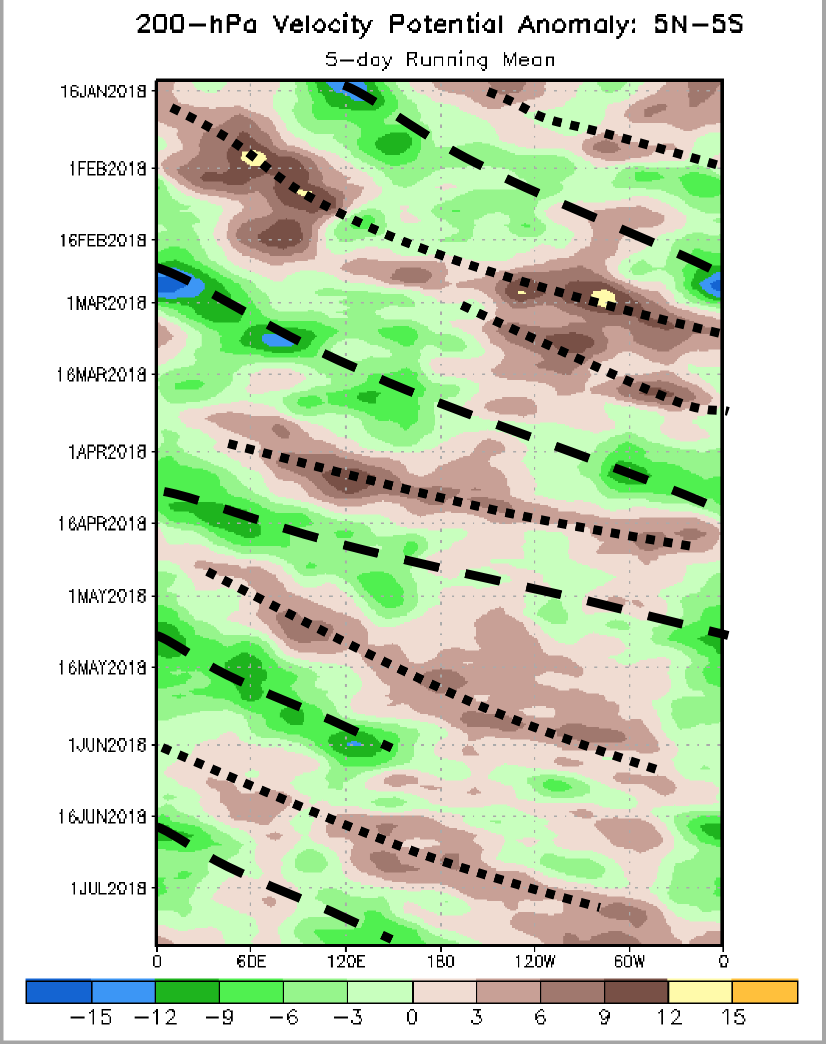
Negative anomalies (green shading) indicate favorable conditions for precipitation

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.

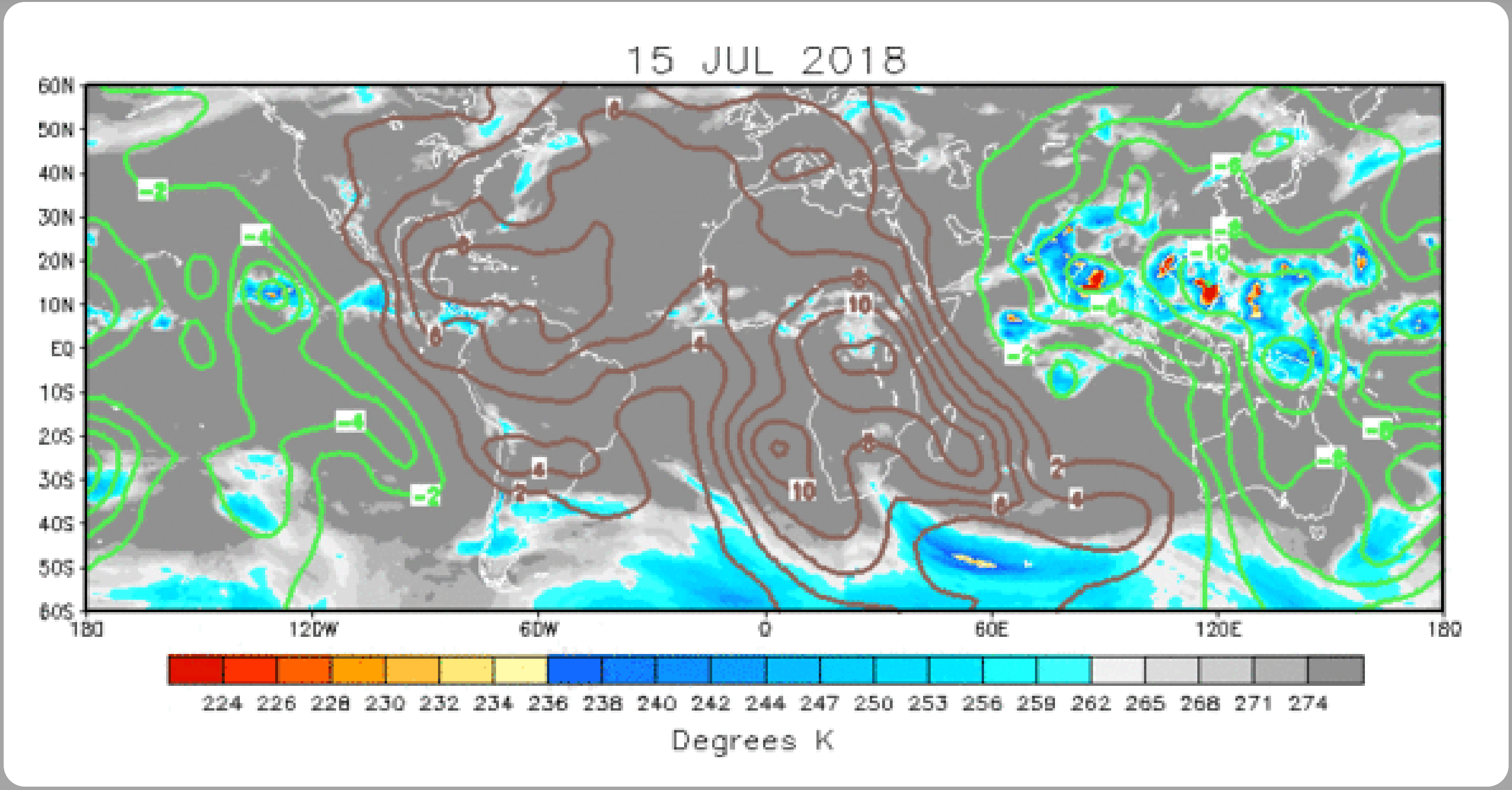
The large-scale region of suppressed convection along the Date Line associated with La Niña is less apparent in the velocity potential field than in the equatorial OLR field. This is primarily because velocity potential is a smoother field than OLR and is dominated by frequent MJO activity.

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, with a largely disorganized field elsewhere.



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




The Wave-1 signal is very similar to last week's, which is consistent with a slowly propagating active MJO.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

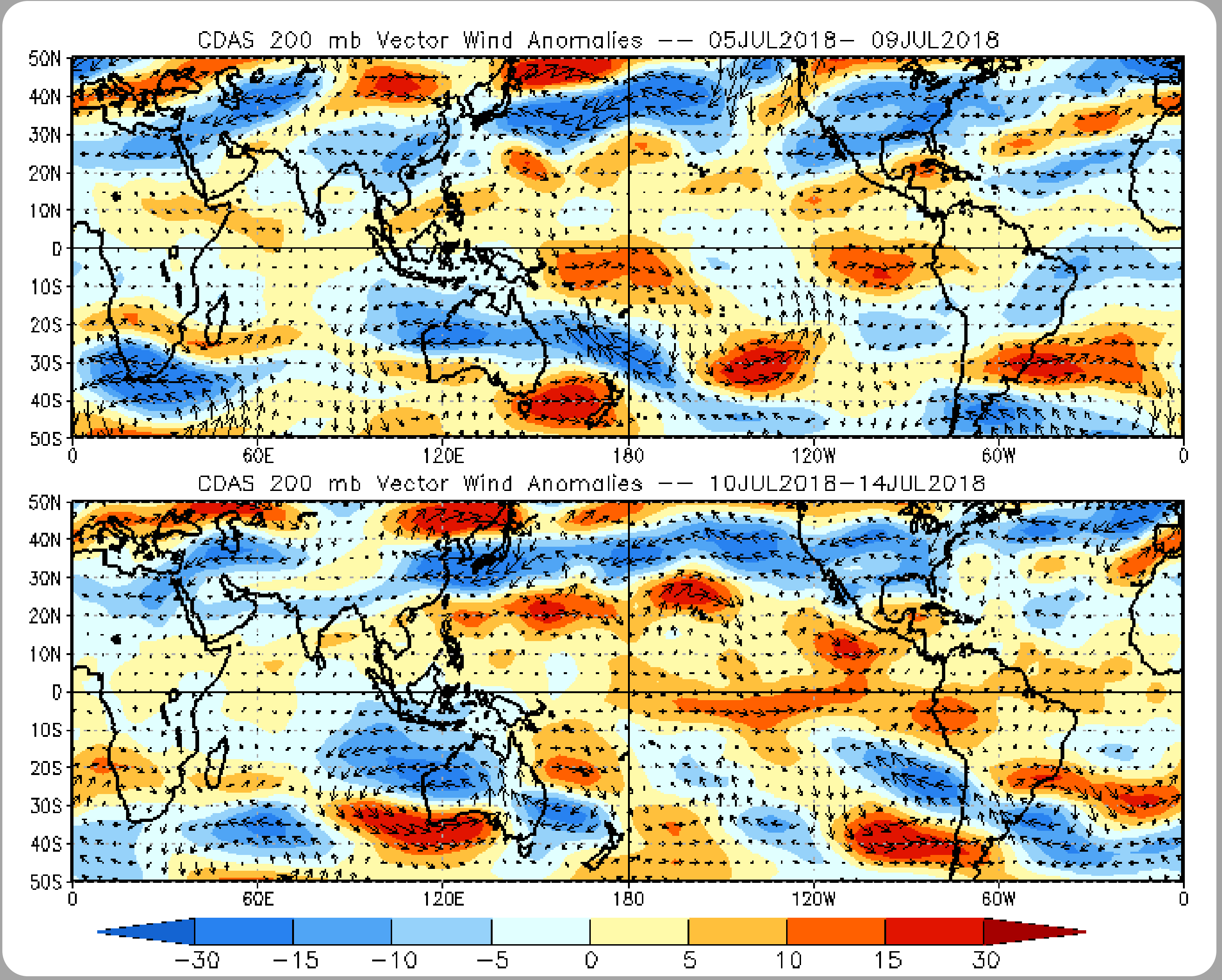
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies




Anomalous westerlies have increased over the equatorial Central Pacific. Extratropical waves in the Southern Hemisphere remain active.

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

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

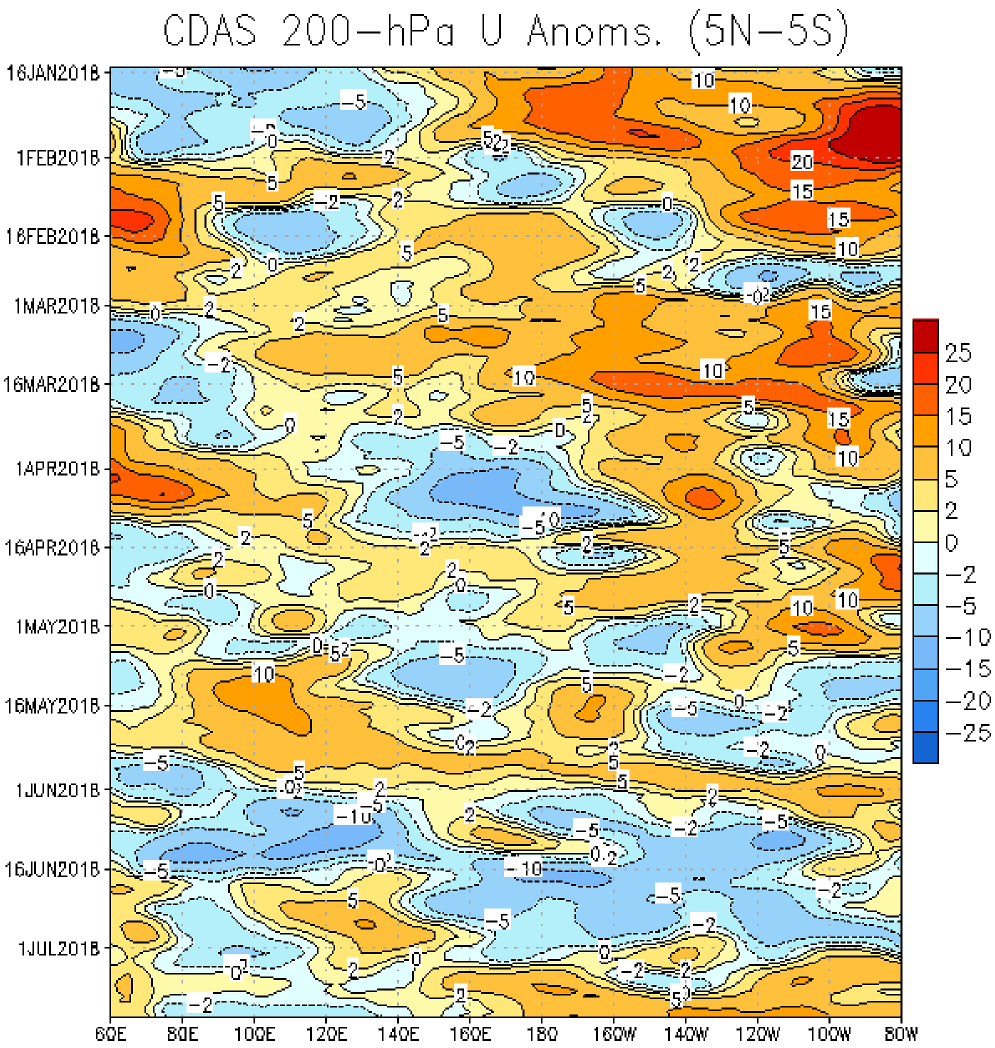
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.



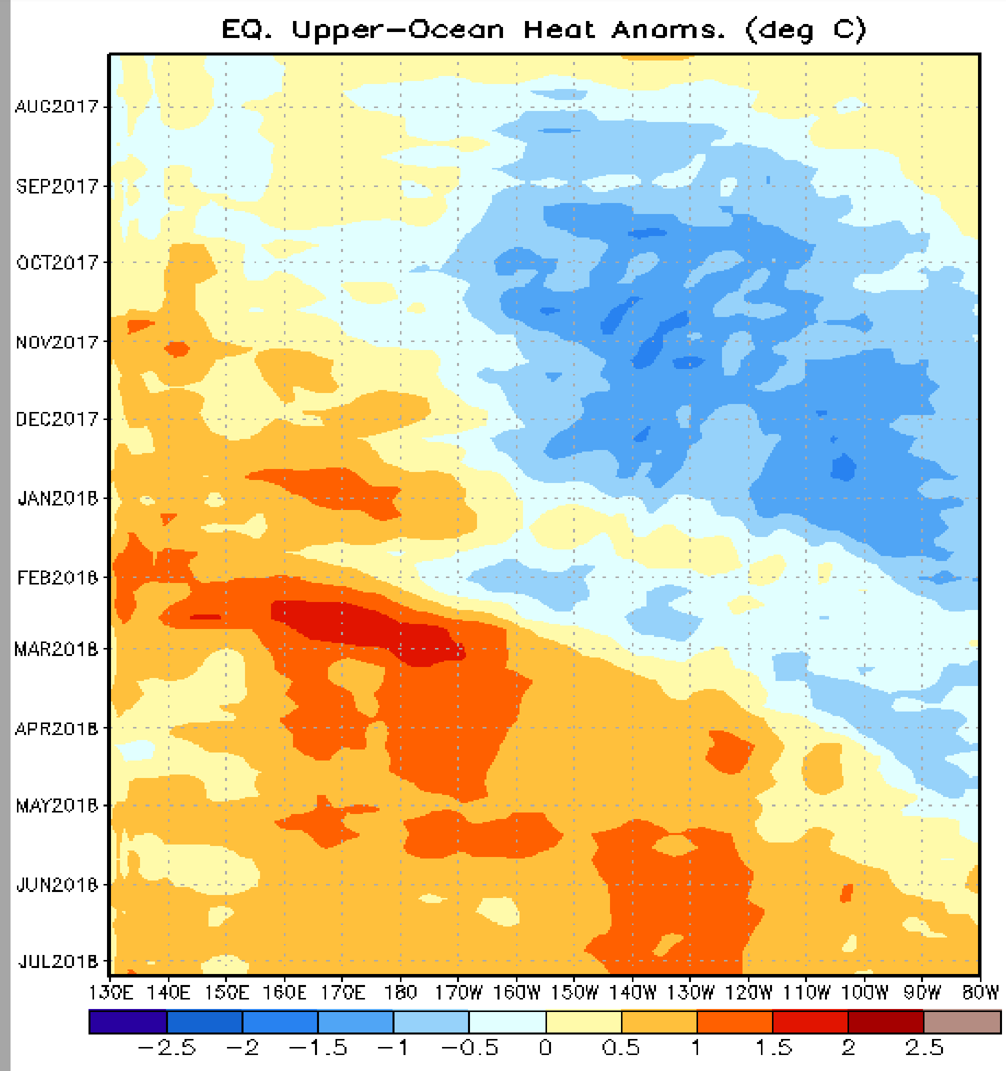
# Weekly Heat Content Evolution in the Equatorial Pacific

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**

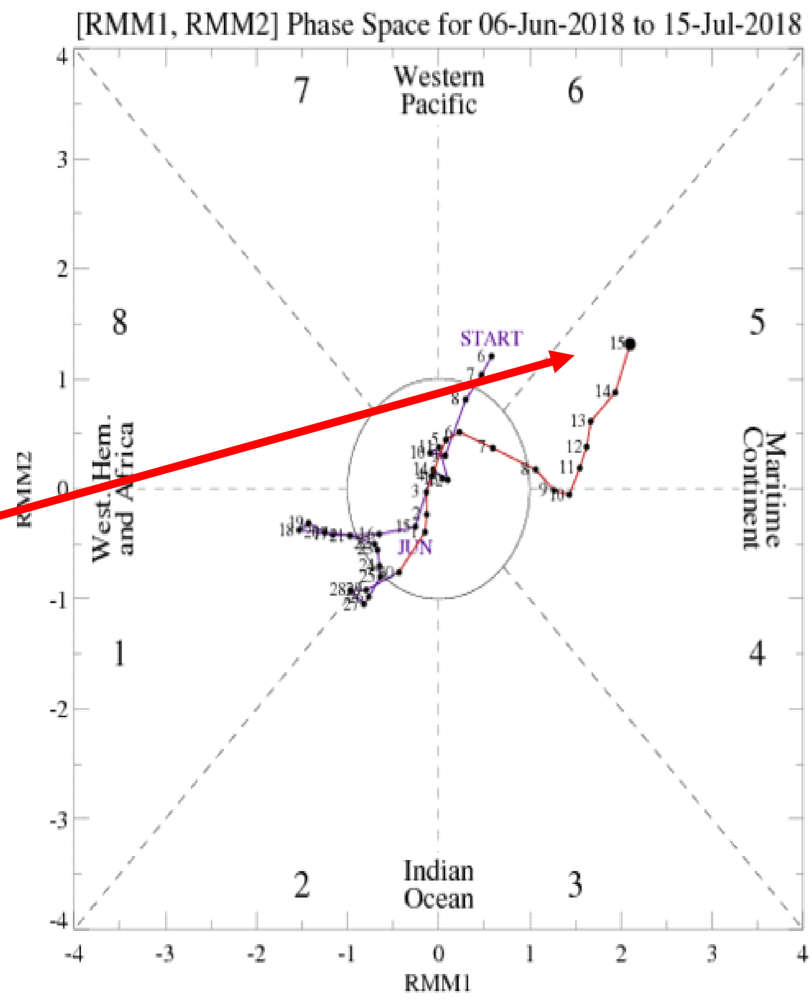
**The triangular areas indicate the location of the enhanced phase of the MJO**

**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**

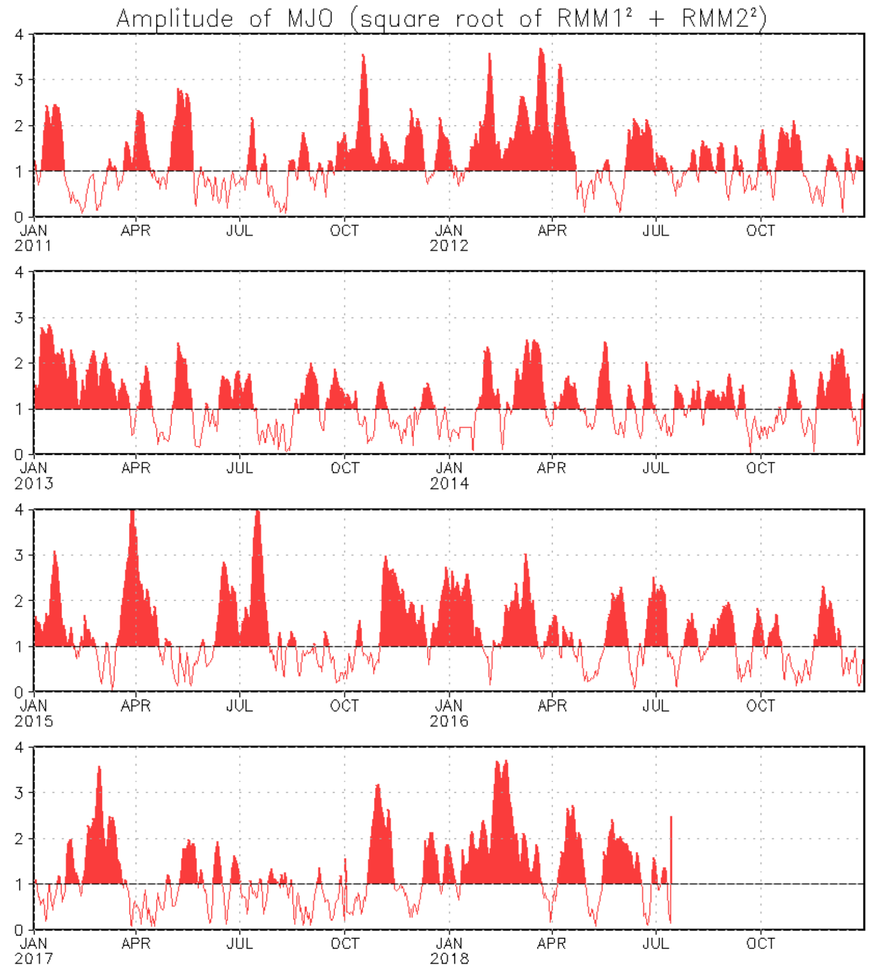
There is a modest projection onto the RMM index. This is driven mostly by the zonal wind fields; there is weak convective coupling.



# 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

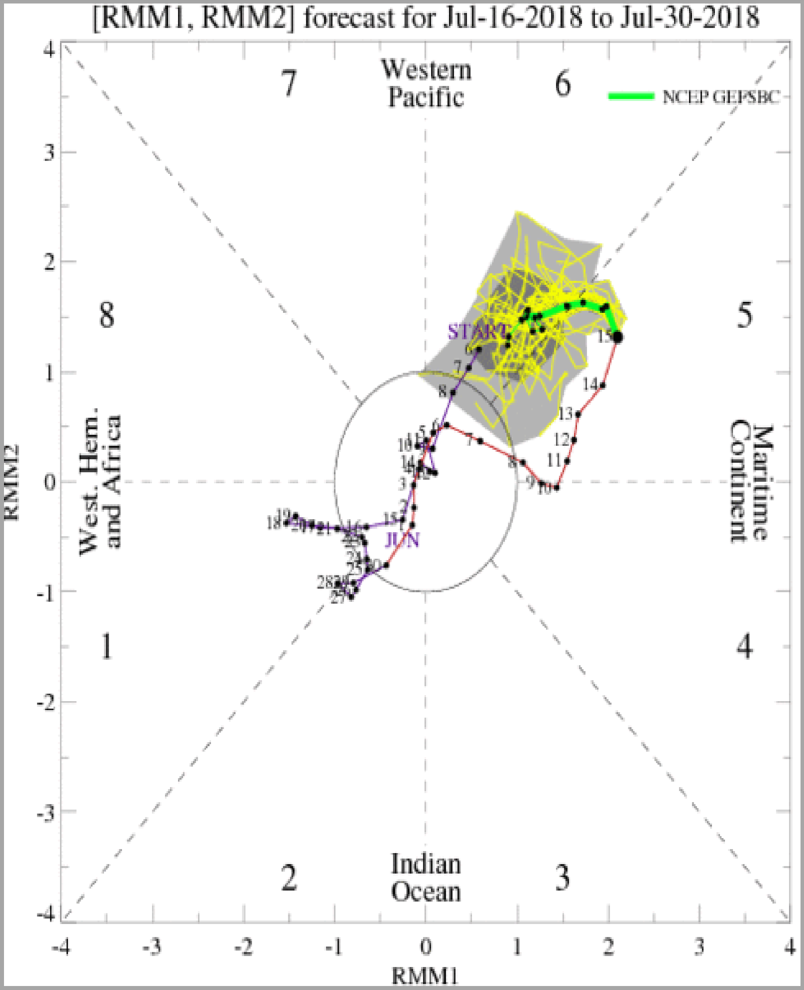
<u>Yellow Lines</u> - 20 Individual Members
<u>Green Line</u> - Ensemble Mean

**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 suggests that the MJO signal will weaken during the next week.

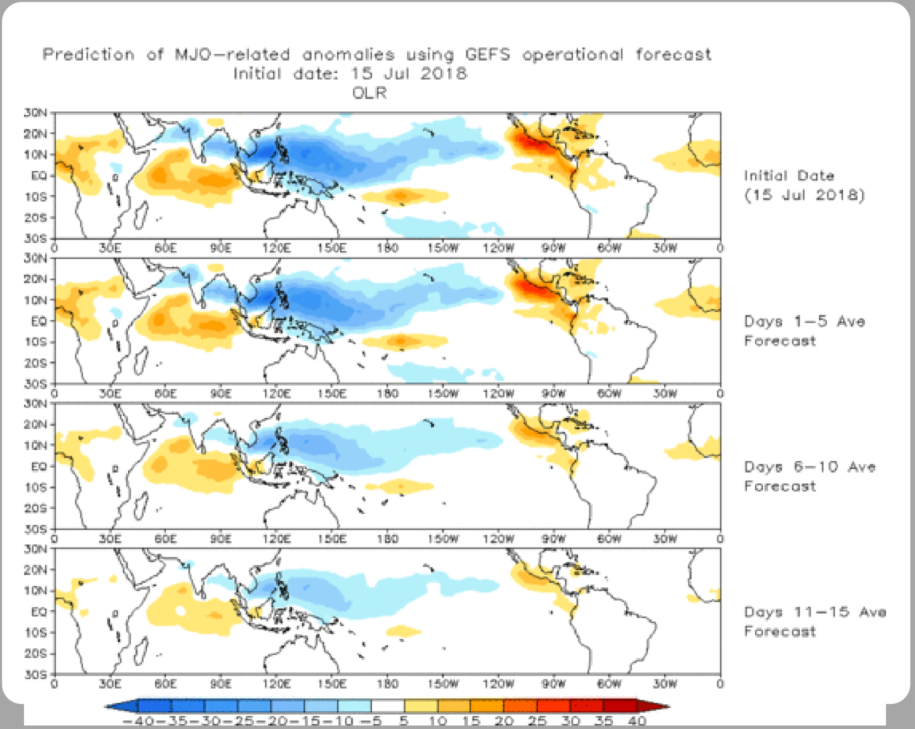


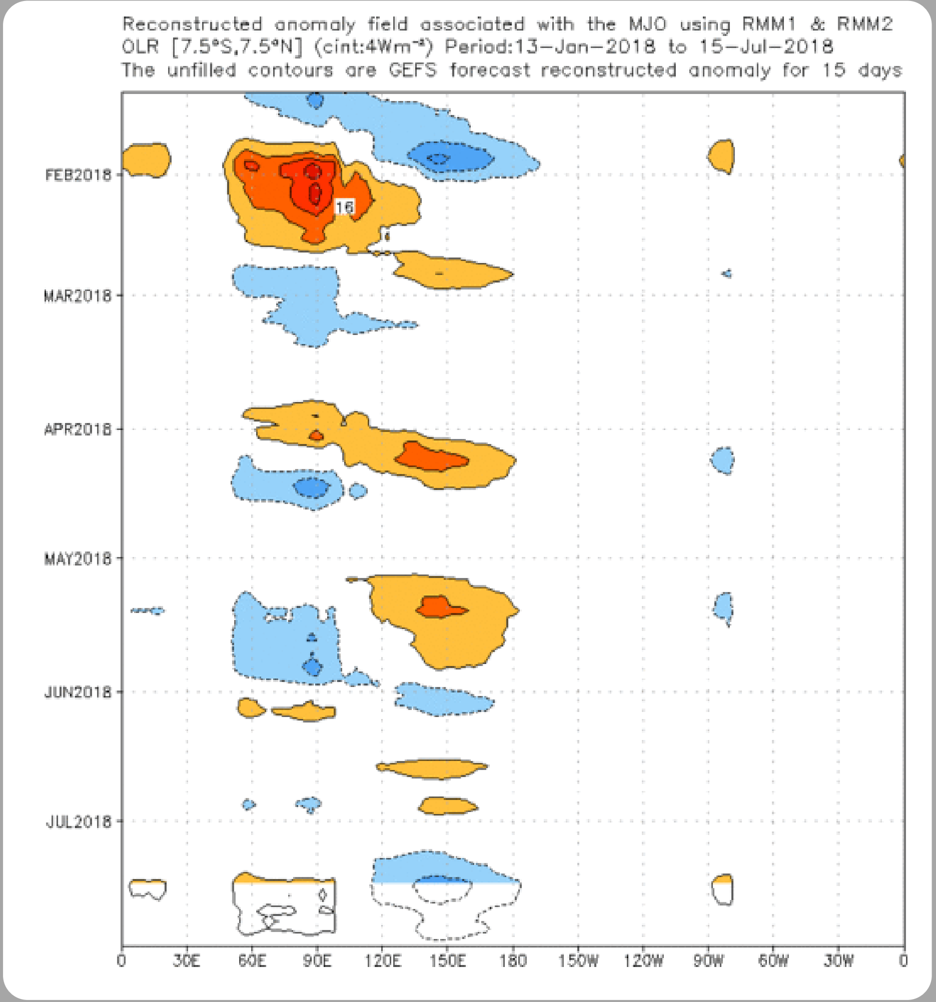
# Ensemble GFS (GEFS) MJO Forecast

**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



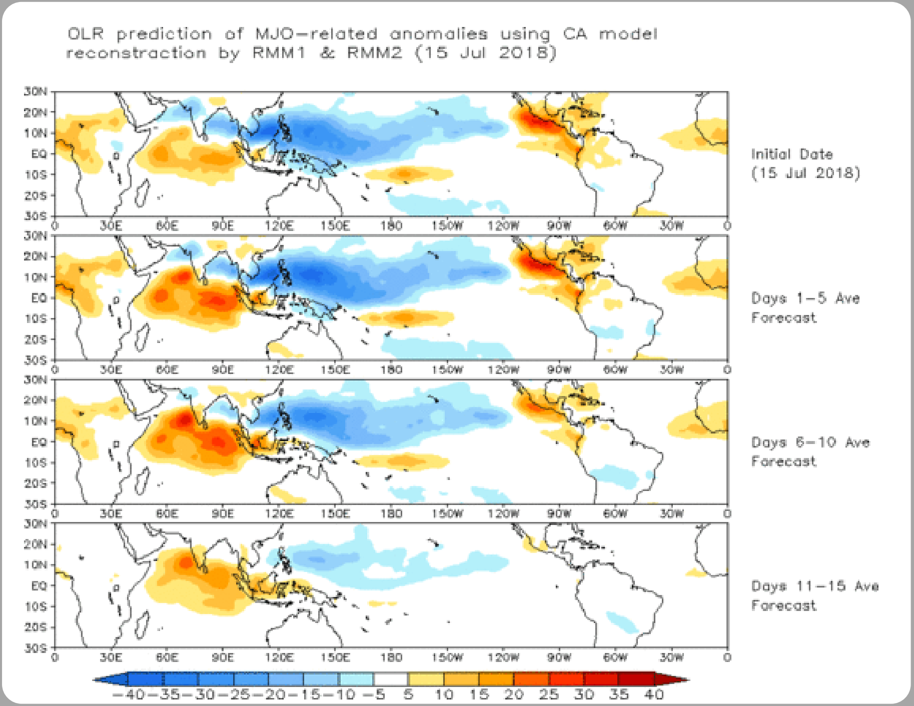




GEFS-based OLR anomalies depict a weakening MJO signal over the Maritime Continent.

# Constructed Analog (CA) MJO Forecast

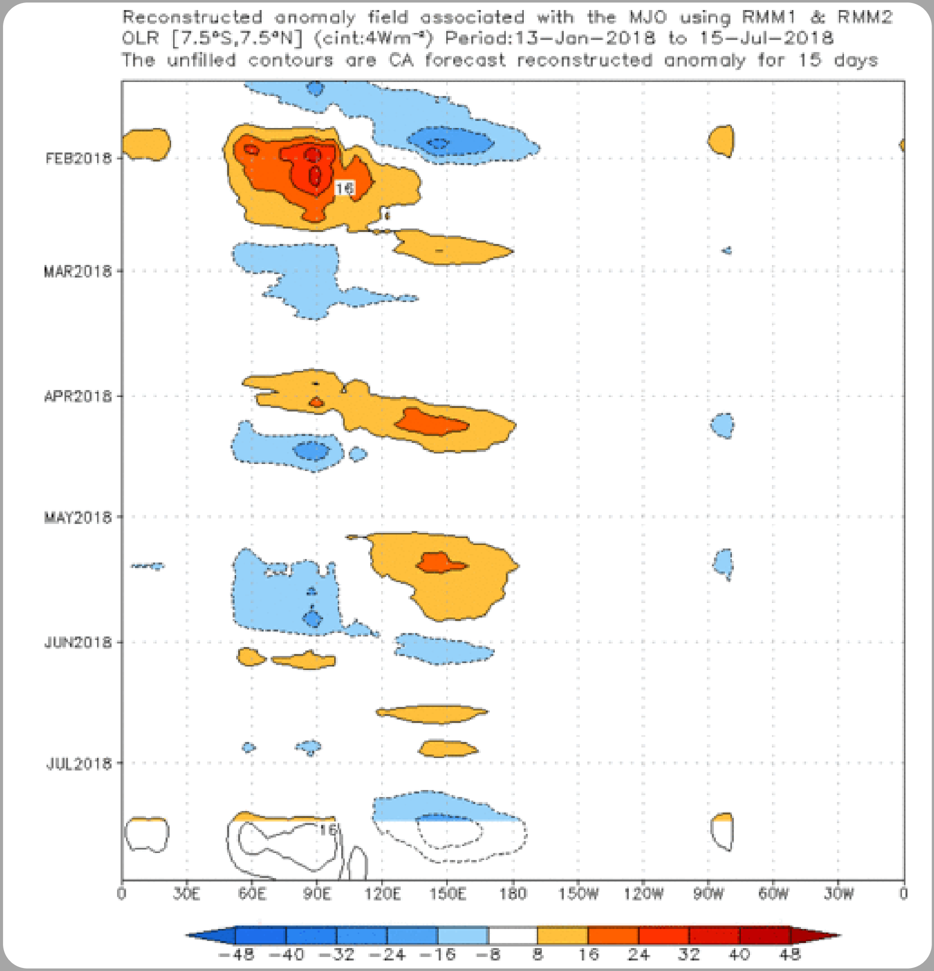
**Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)**

Spatial map of OLR anomalies for the next 15 days



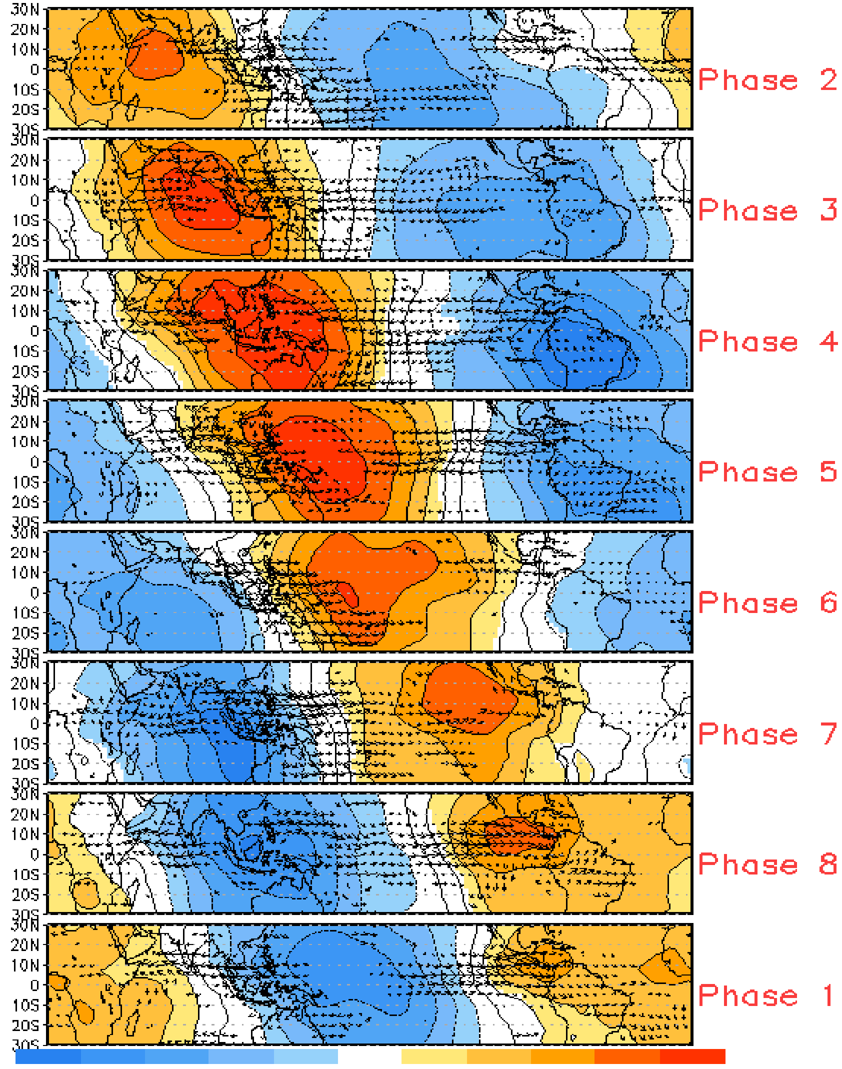

The constructed analog MJO forecast also weakens over time, consistent with the GEFS.

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

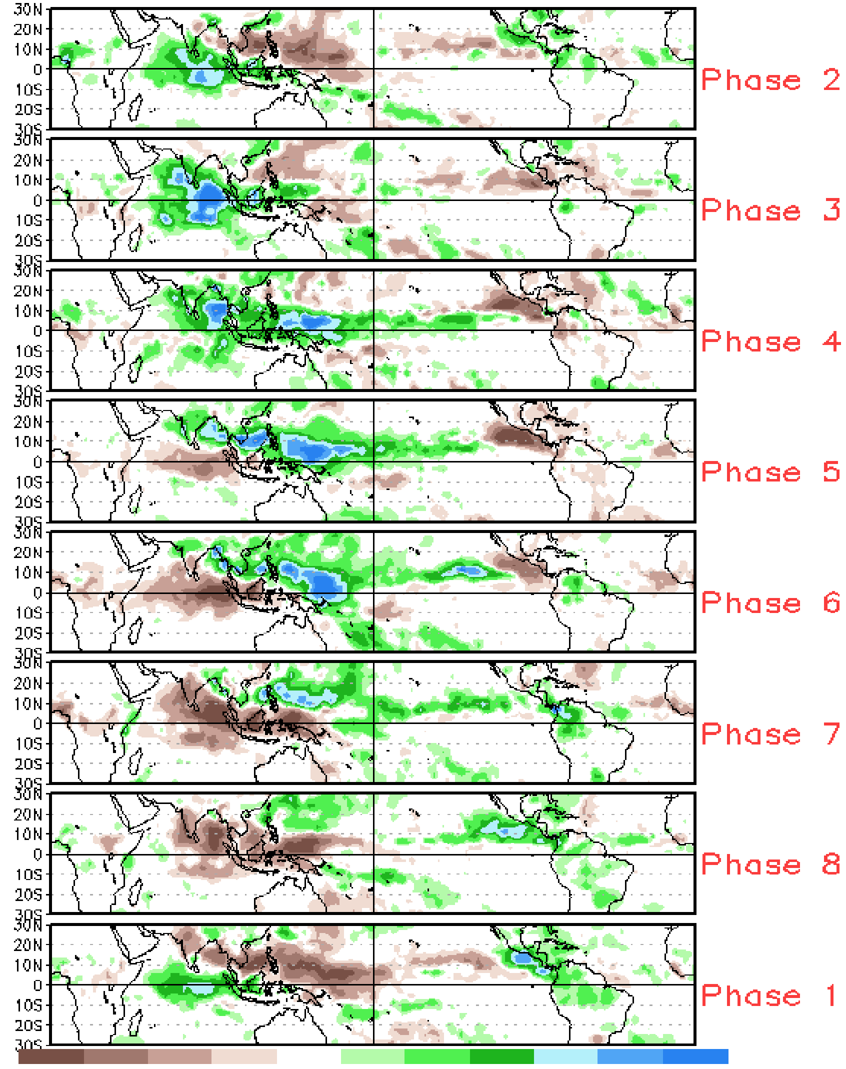


# MJO Composites - Global Tropics

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



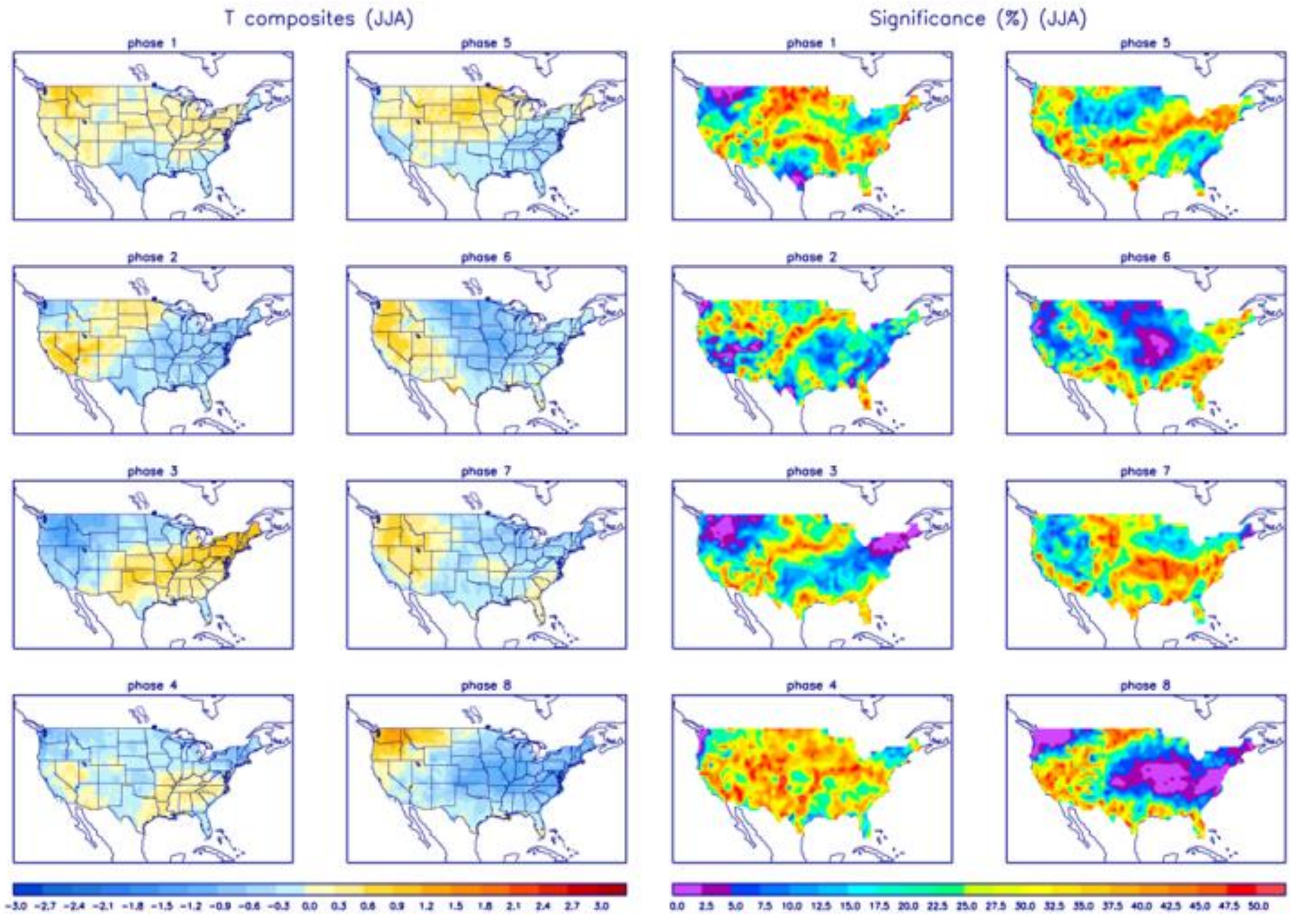

Precipitation Anomalies (May - Sep)



# 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.



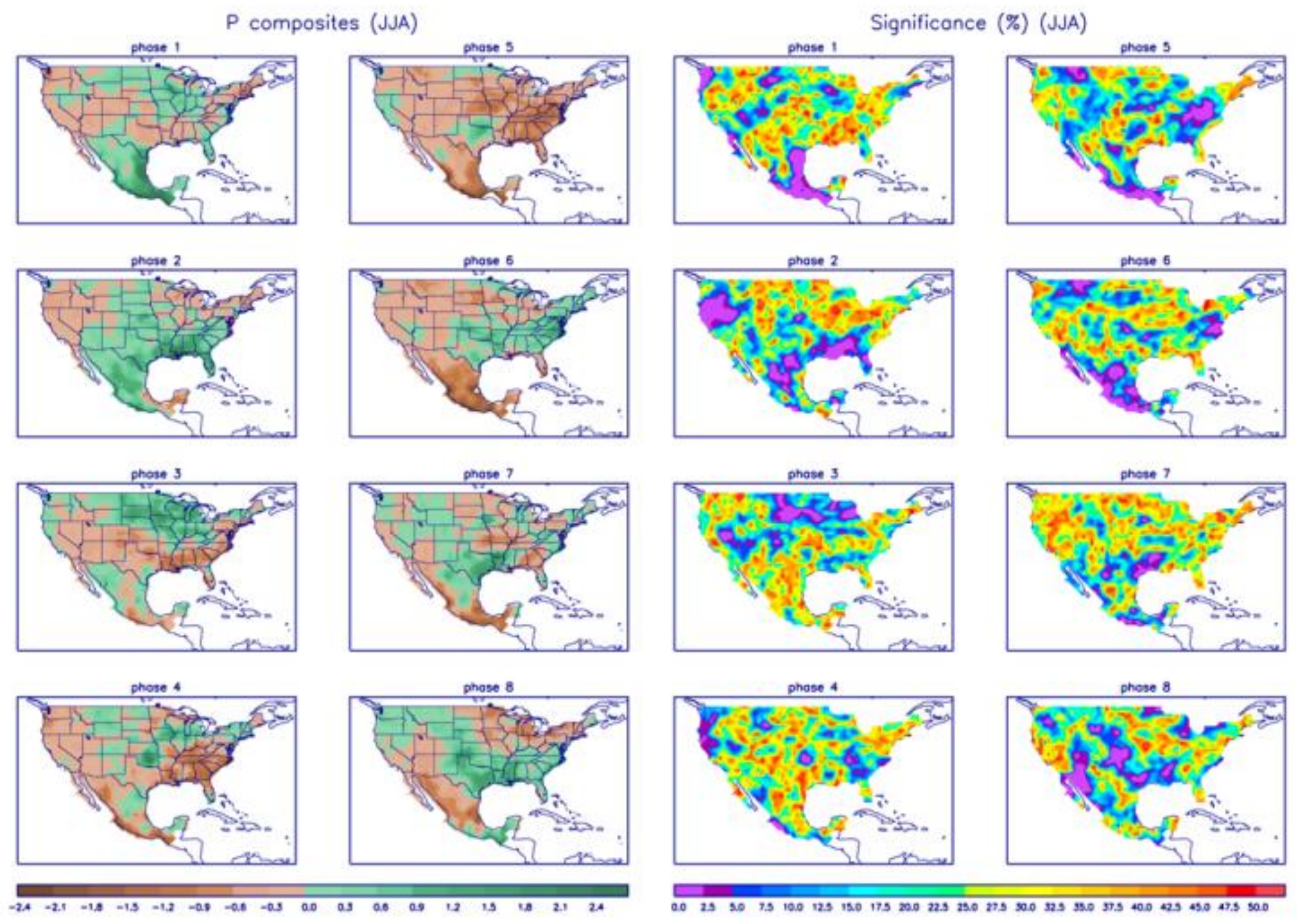

Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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.

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