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

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Climate Prediction Center / NCEP
2 July 2018

Outline

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Overview

- There are indicators of an active intraseasonal signal in the observation fields, with large-scale enhanced upper-level divergence (convergence) over Africa and the Indian Ocean (the Pacific). Despite the favorable background state, limited enhanced convection is yet to be observed.

- Most dynamical model MJO forecasts support an initially weak intraseasonal signal emerging in the vicinity of the Maritime Continent near mid-July. Tropical cyclone activity in the East Pacific during the past week may have helped interfere with the primary intraseasonal signal, resulting in a weak RMM projection despite the active MJO presence. Statistical guidance depicts a very weak and incoherent signal during the next two weeks.

- Given the weak teleconnections this time of year between the tropics and extratropics, limited mid-latitude impacts from the MJO are anticipated during the next two weeks. Tropical cyclone formation chances begin to wane in the East Pacific as the intraseasonal signal approaches the Maritime Continent.

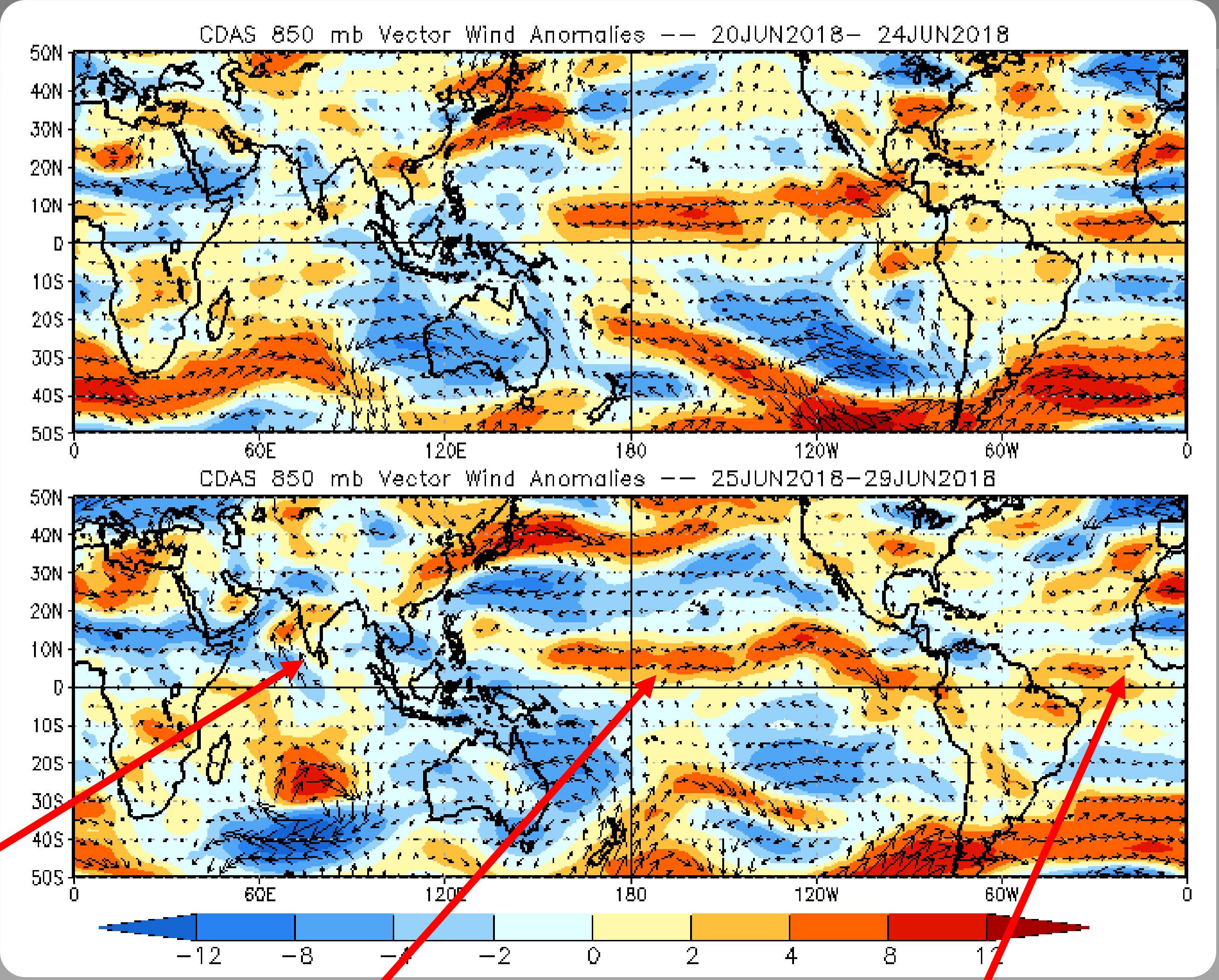
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Monsoon flow strengthened in the vicinity of the Indian subcontinent.

Westerly anomalies persisted over the central and eastern Pacific.

Westerly anomalies weakened over the Atlantic basin.

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

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

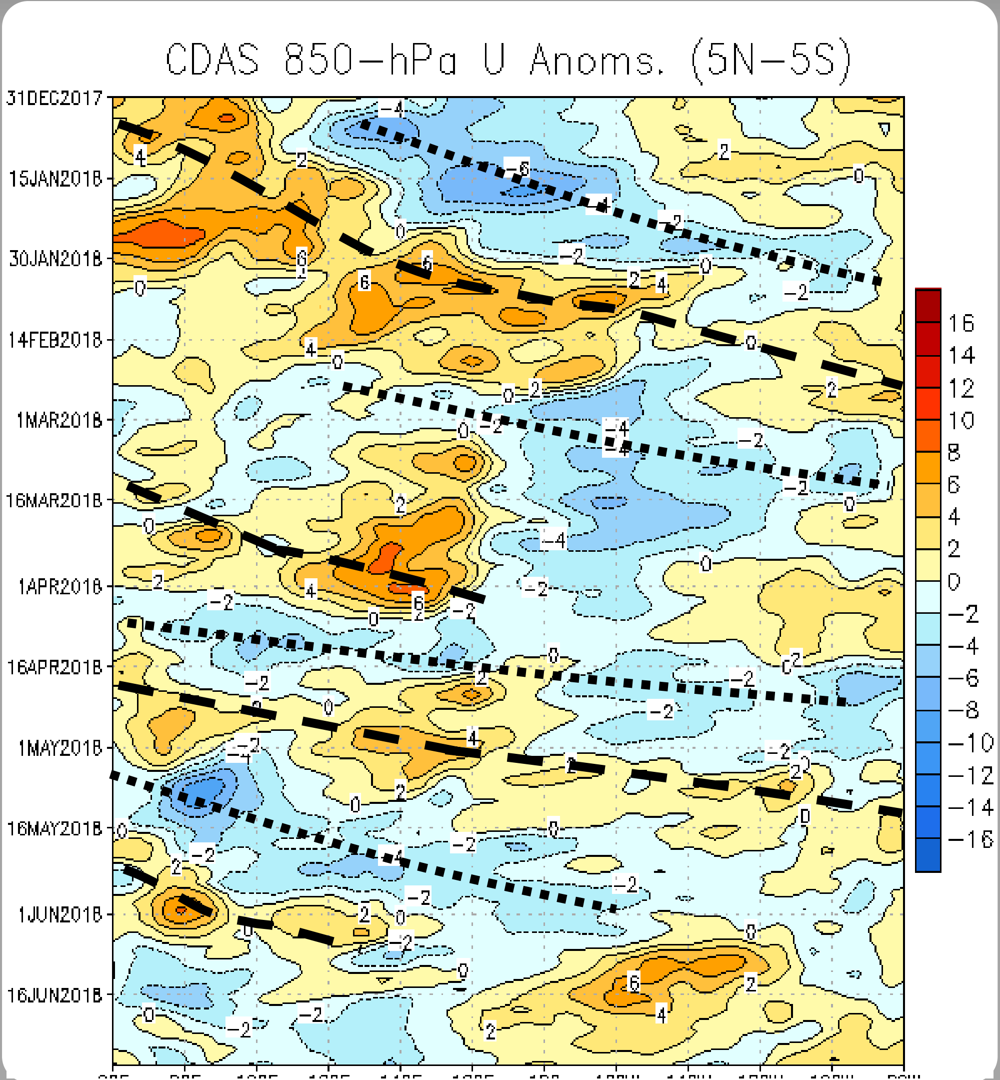
Easterly anomalies (blue shading) represent anomalous east-to-west flow

A strong MJO event formed in early December and 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 began to break down during April.

The MJO has been active over the past several weeks, with a period near 30-40 days. Recently eastward propagation became obscured by westward moving variability, including TC activity over the Pacific and equatorial Rossby waves.

More recently, a Wave-1 asymmetry has become more established.



OLR Anomalies – Past 30 days

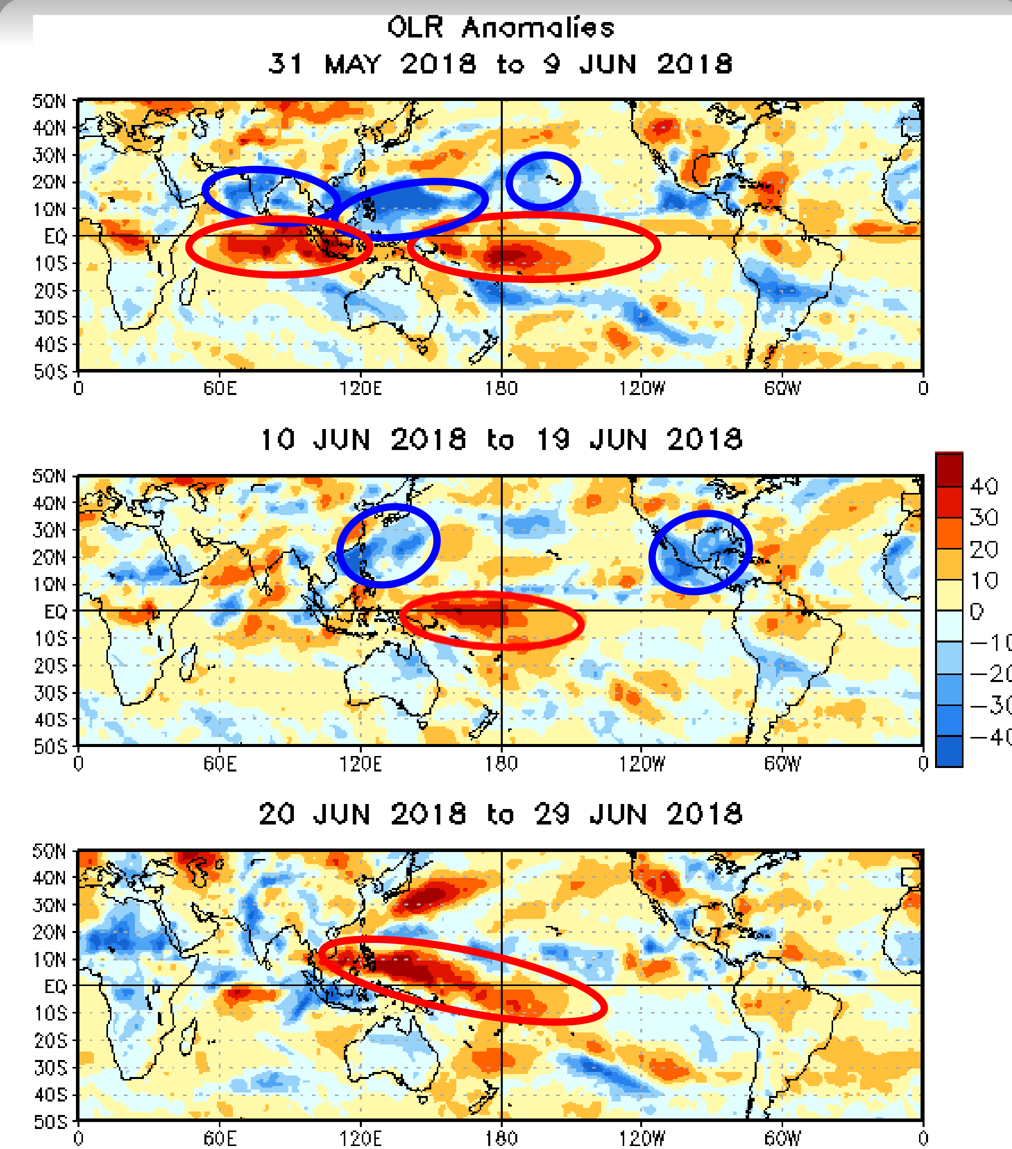
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

Enhanced convection related to the MJO and monsoon activity was observed primarily north of the equator over the Indian Ocean, Maritime Continent, and West Pacific; with suppressed convection on or south of the equator.

As the MJO enhanced phase weakened in mid-June, little enhanced convection was seen along the equator. Enhanced convection was noted over the far western Pacific (off the China coast), as well as the East Pacific, Gulf of Mexico and Caribbean.

During mid- to late-June, the OLR field was weak and fairly noisy. Suppressed convection extending across the West Pacific may be related to interactions between the remnant MJO suppressed phase and the suppressed phase of a Rossby wave.



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

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

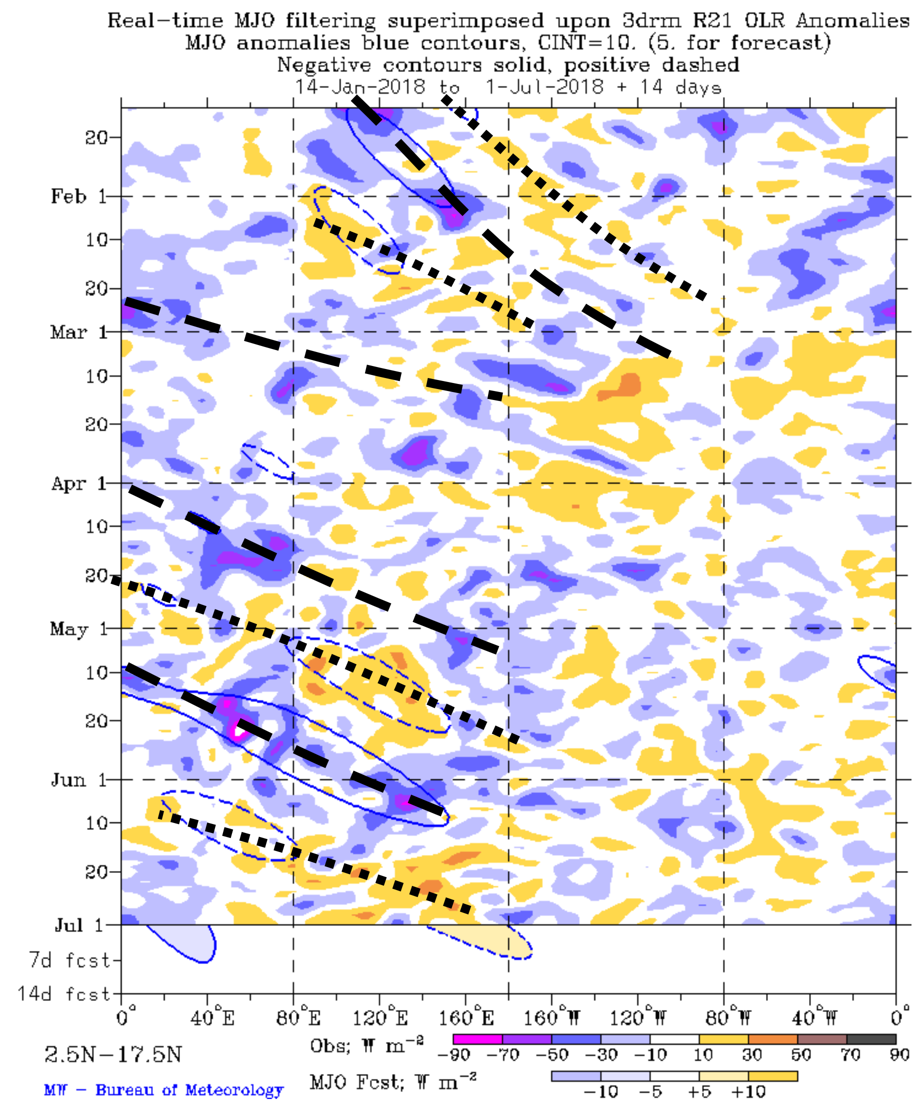
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During early 2018, La Niña 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, suppressed convection overspread the West Pacific near and west of the Date Line.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

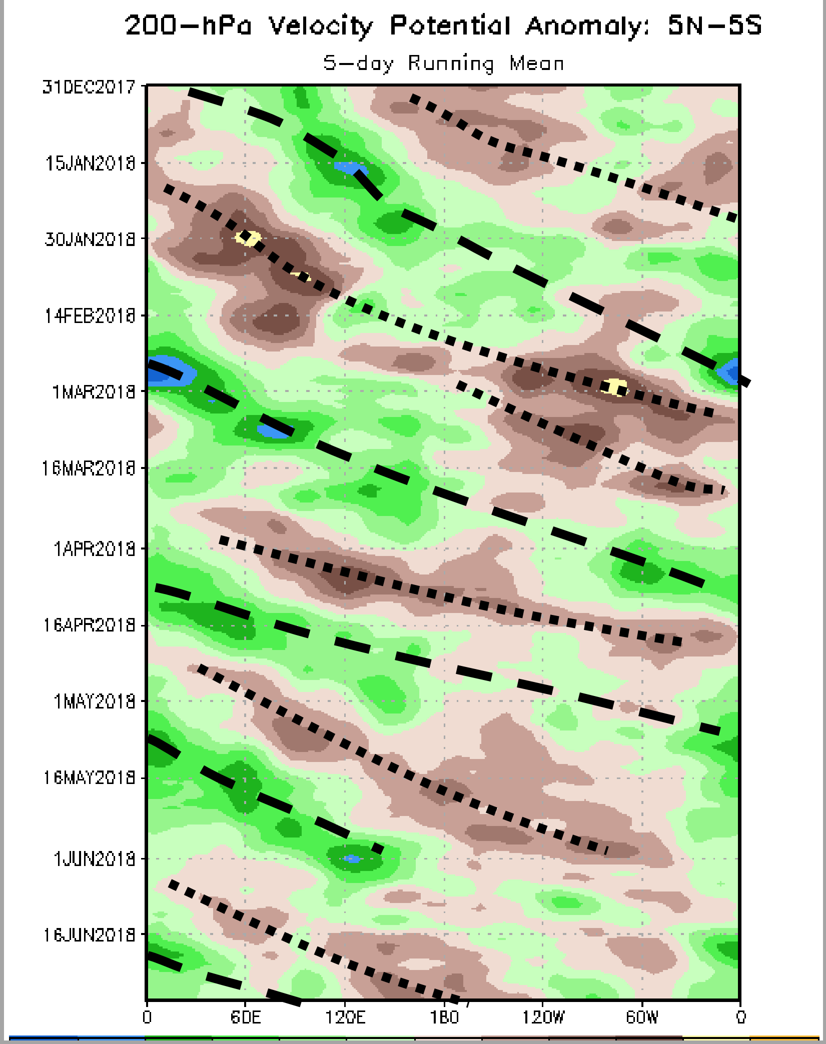
Negative anomalies (green shading) indicate favorable conditions for precipitation

Consistent MJO activity can be seen in the upper level velocity potential field since the start of this year. Additionally, there are indications of an atmospheric Kelvin wave east of the Date Line during late February and early March.

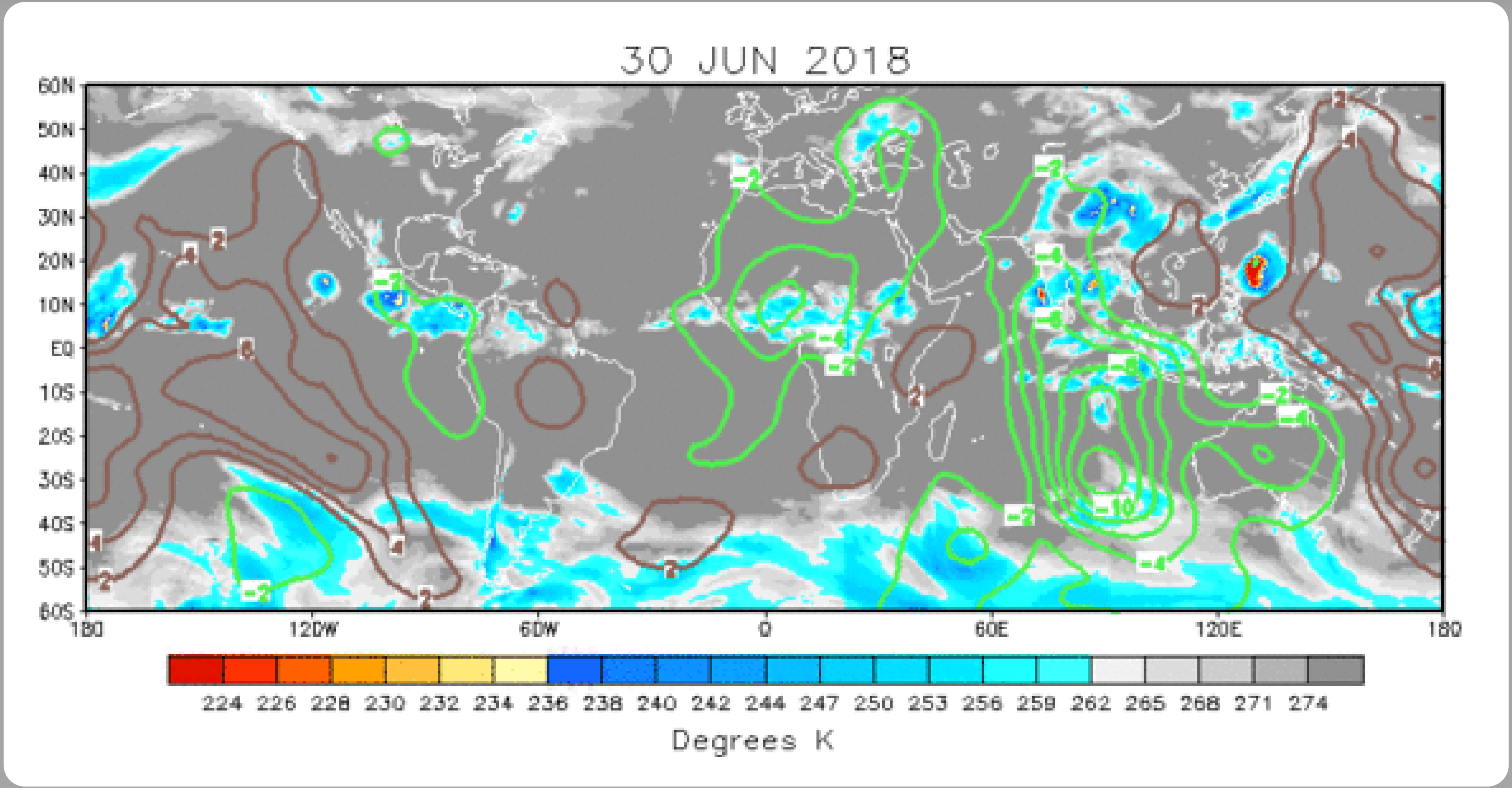
The large-scale region of suppressed convection along the Date Line associated with La Niña is less apparent in the velocity potential field than in the equatorial OLR field. This is primarily because velocity potential is a smoother field than OLR and is dominated by frequent MJO activity.

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.

There is currently a weak enhanced (suppressed) signal over Africa and the Indian Ocean (the Pacific).



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



Compared to last week, the upper-level velocity potential field is less organized, with broad enhanced (suppressed) divergence over Africa and the Indian Ocean (Pacific) despite multiple breaks in the pattern from convective modes other than the 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)

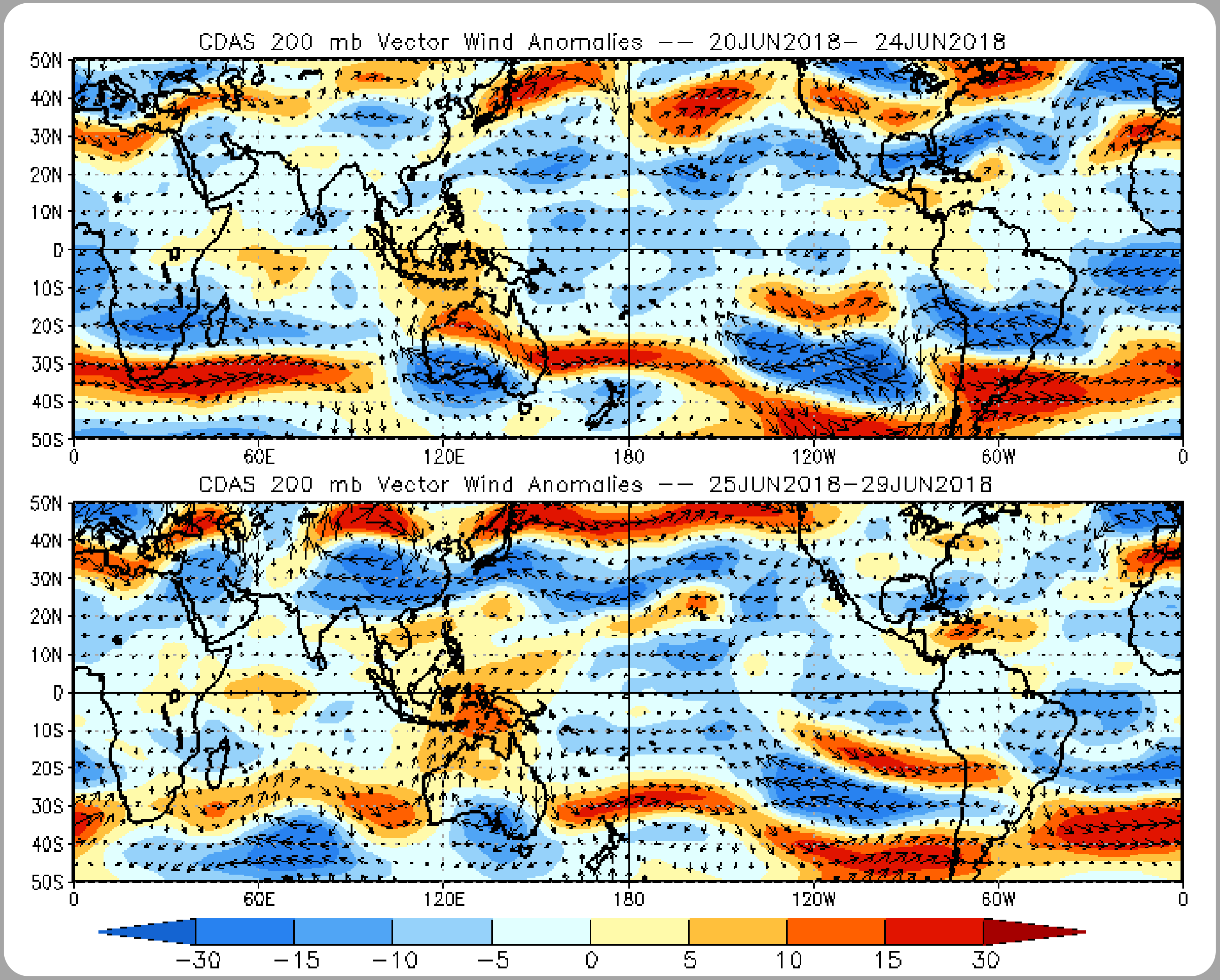
Note that shading denotes the zonal wind anomaly

<u>Blue shades</u>: Easterly anomalies

<u>Red shades</u>: Westerly anomalies

Anomalous easterlies persisted over much of the Pacific basin.

The latest 200-hPa anomalous flow pattern weakened significantly over the U.S. compared to the previous 5-day period.



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

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

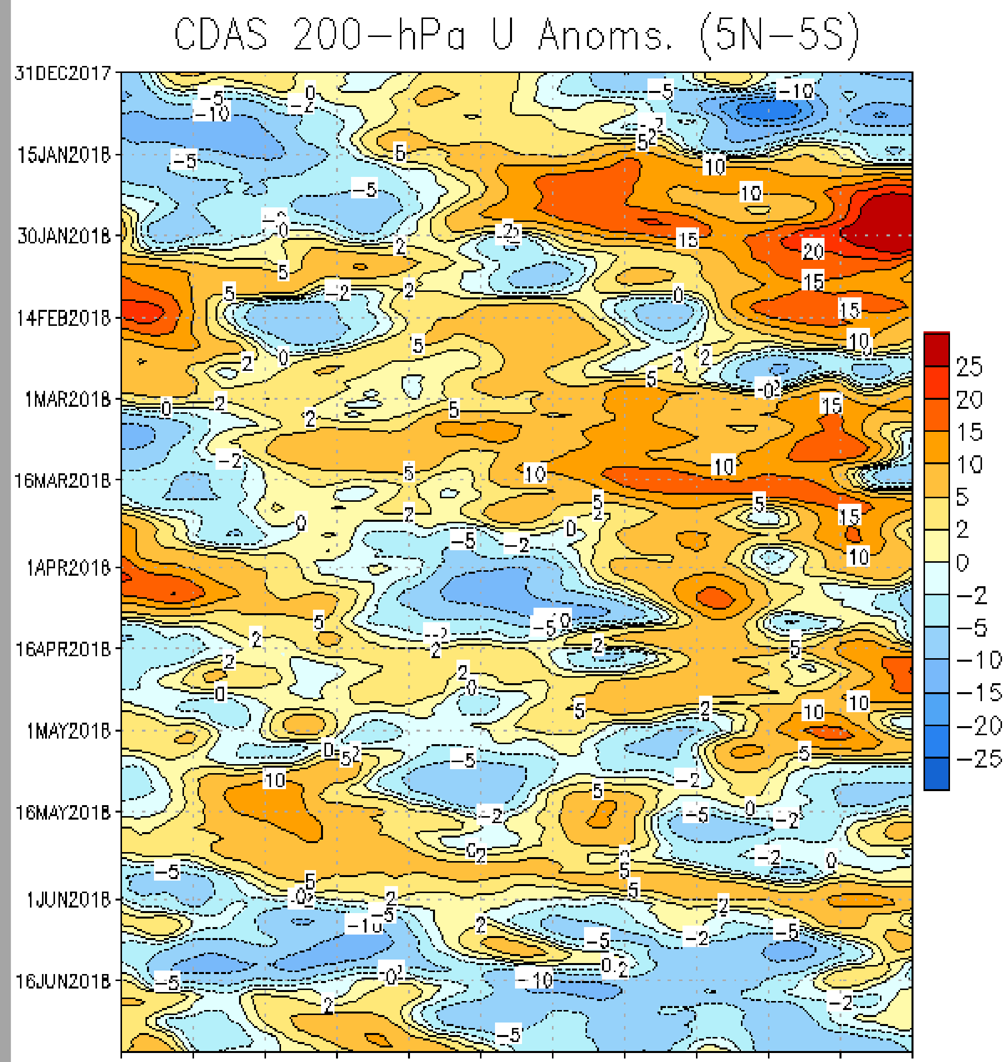
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Low-frequency anomalous westerlies remained in place east of 140E starting in October 2017 through late April 2018, with a few periods of brief interruptions.

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.

Since the beginning of May, weak westerly anomalies have continued to propagate east from the Indian Ocean to the Americas. During early June this pattern broke down due to competing modes of variability.

More recently, westerly anomalies redeveloped over the far eastern Indian Ocean and Maritime Continent to the western Pacific.



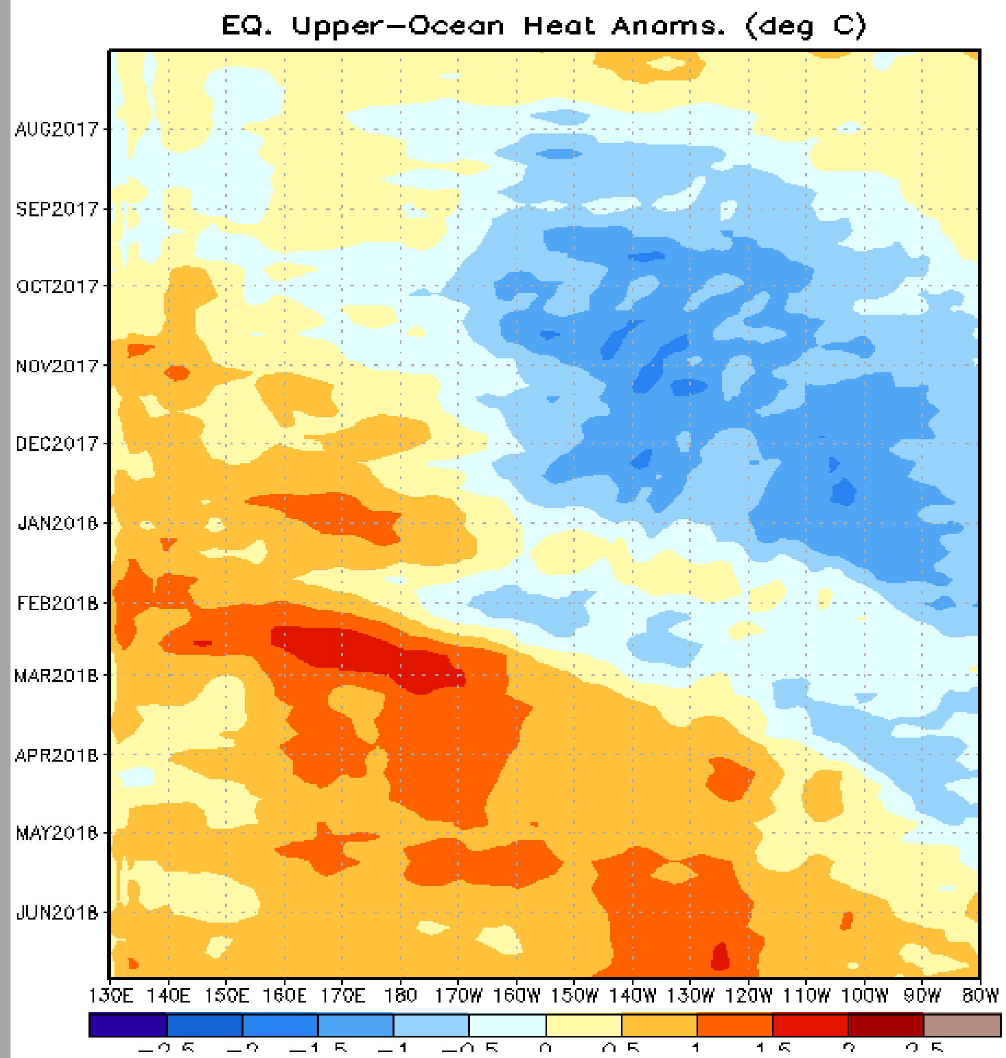
Weekly Heat Content Evolution in the Equatorial Pacific

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 are now observed over nearly 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

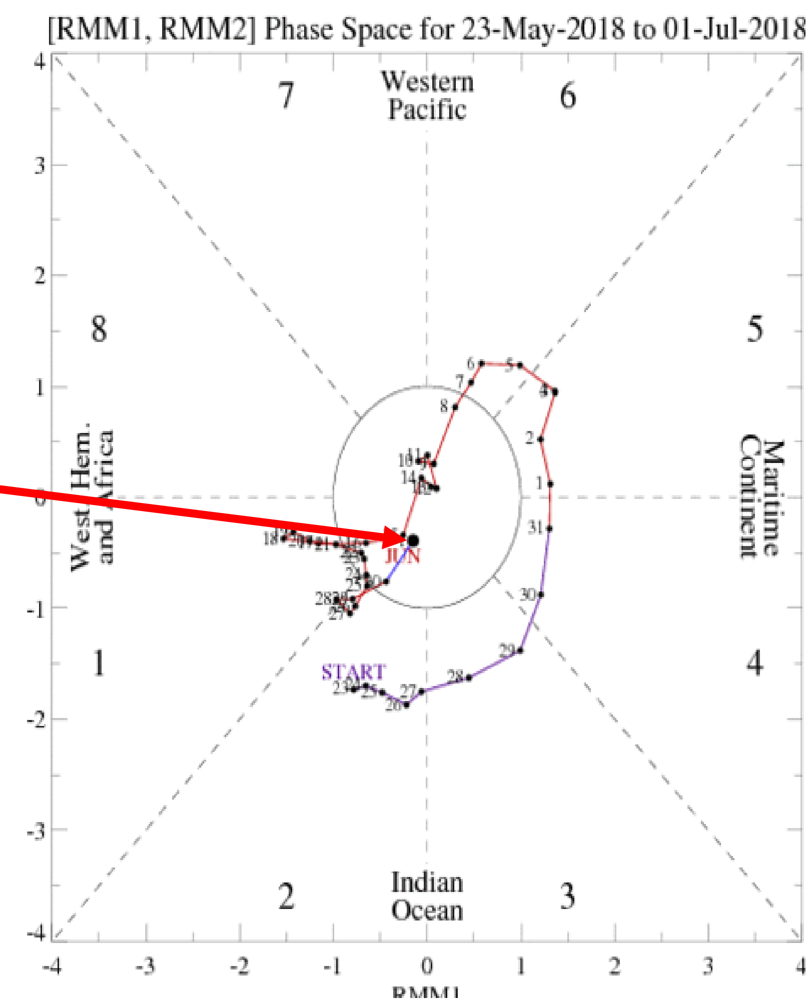
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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



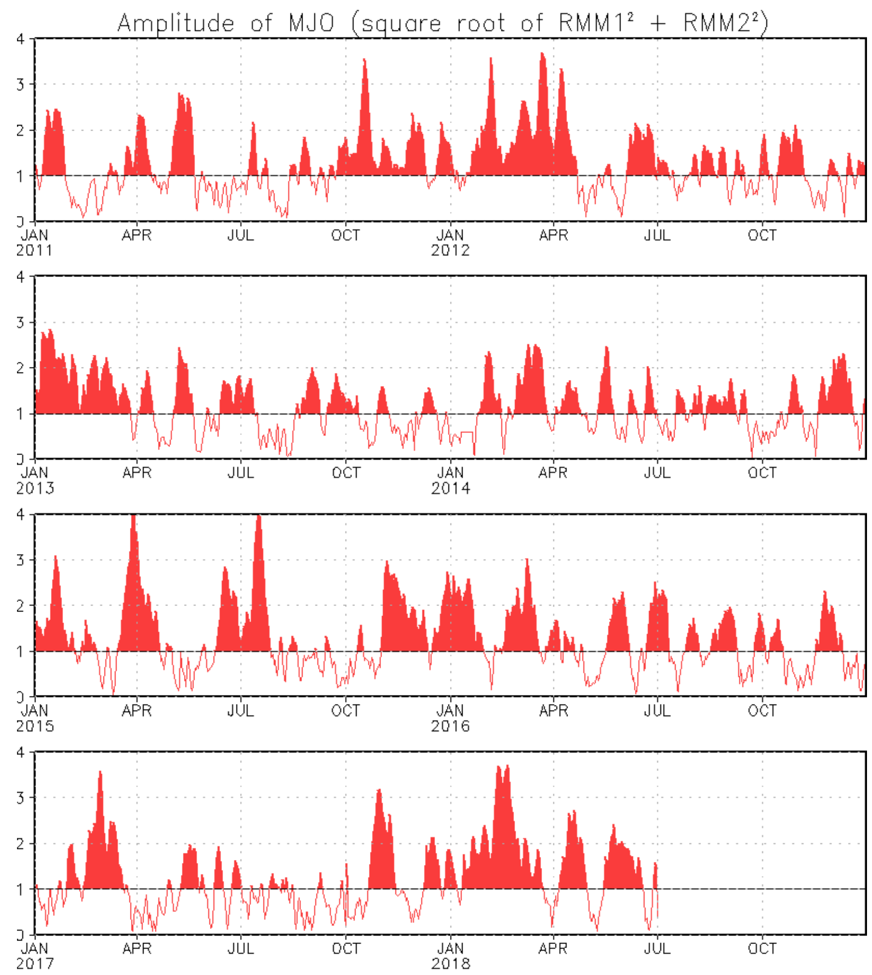
The MJO signal remains weak from the perspective of the RMM MJO Index, with a value near 0.

This amplitude appears to be a result of competing signals that are roughly 180-degrees out of phase, from tropical cyclone activity in the East Pacific and intraseasonal activity over the Indian Ocean, that are destructively interfering with the RMM indices.

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

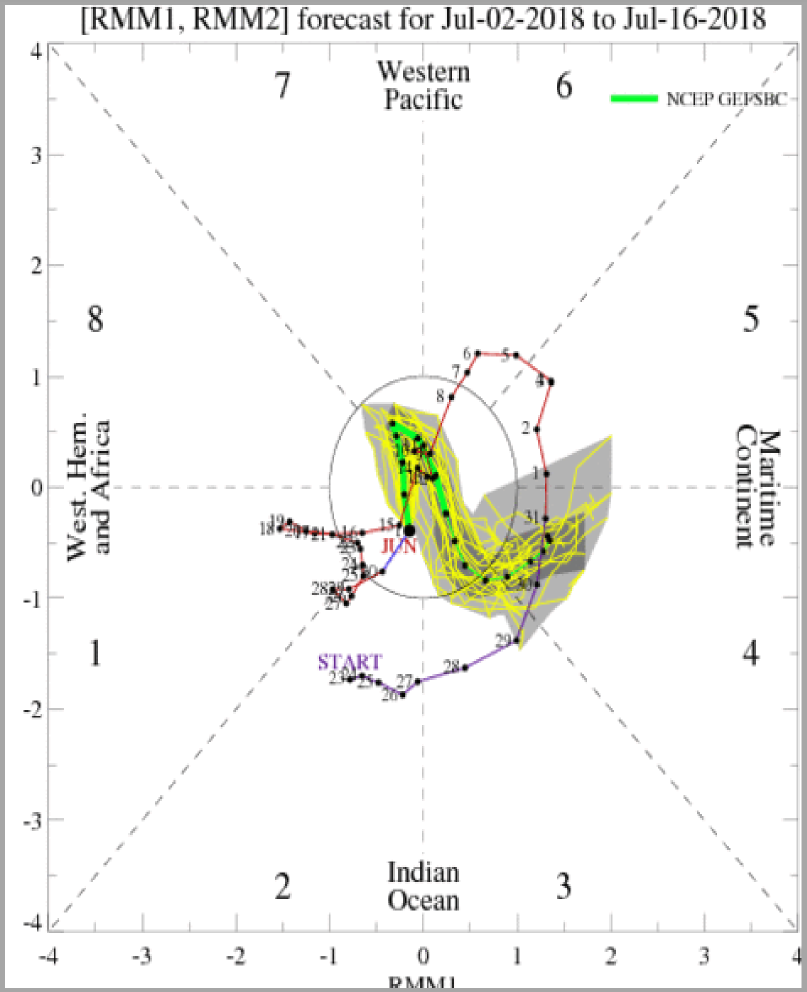
RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

<u>light gray shading</u>: 90% of forecasts

<u>dark gray shading</u>: 50% of forecasts

The GEFS depicts limited eastward propagation of the MJO signal during the next week; followed by more substantial eastward propagation from phase 3 into phase 4 during the second week.

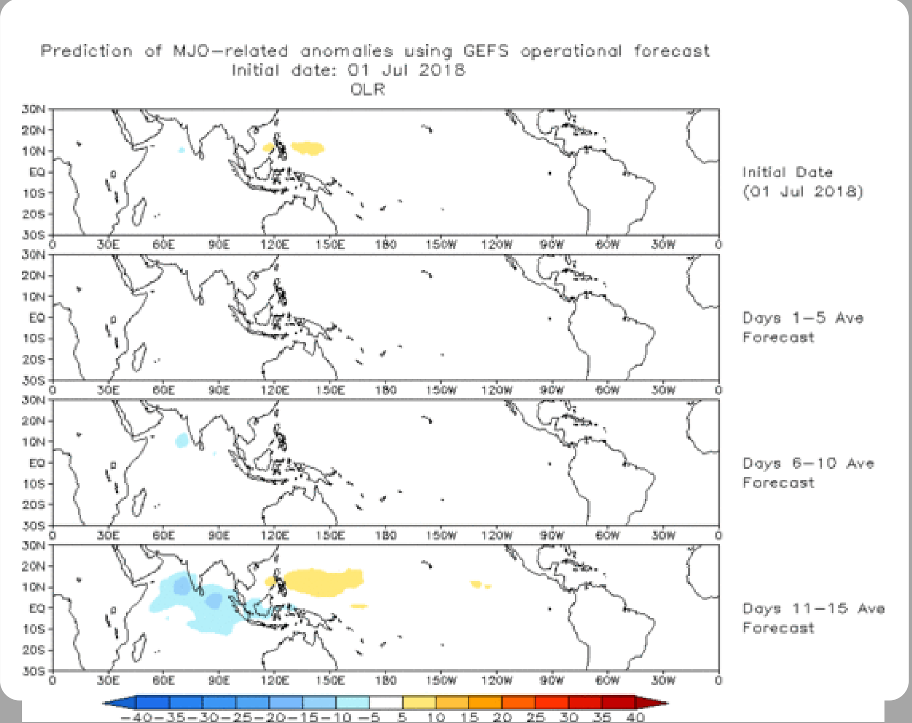
This lack of a signal in the GEFS (especially early on) may be due to the model tendency to overplay westward moving features coupled with tropical cyclone activity anticipated in the Pacific.



Ensemble GFS (GEFS) MJO Forecast

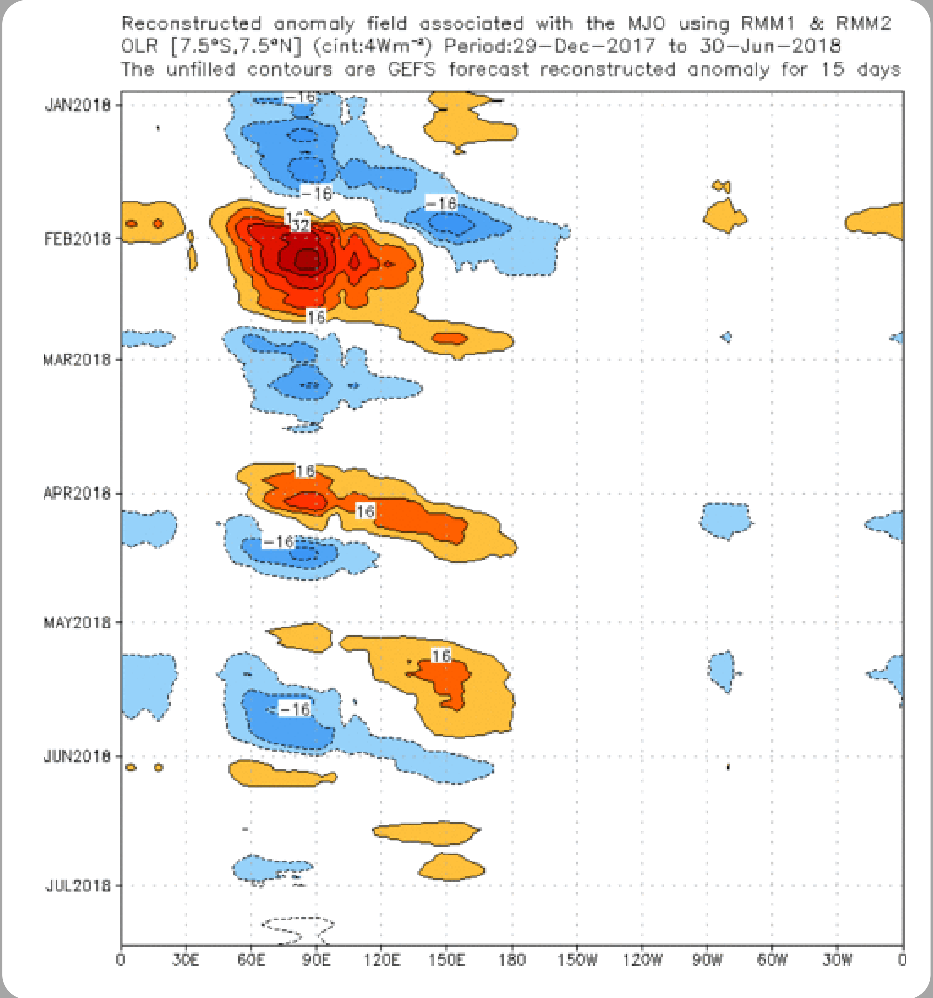
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



GEFS-based OLR anomalies are practically non-existent throughout the next 10 days. Shortly thereafter, enhanced convection may build over the Indian Ocean with suppressed conditions in the West Pacific.

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

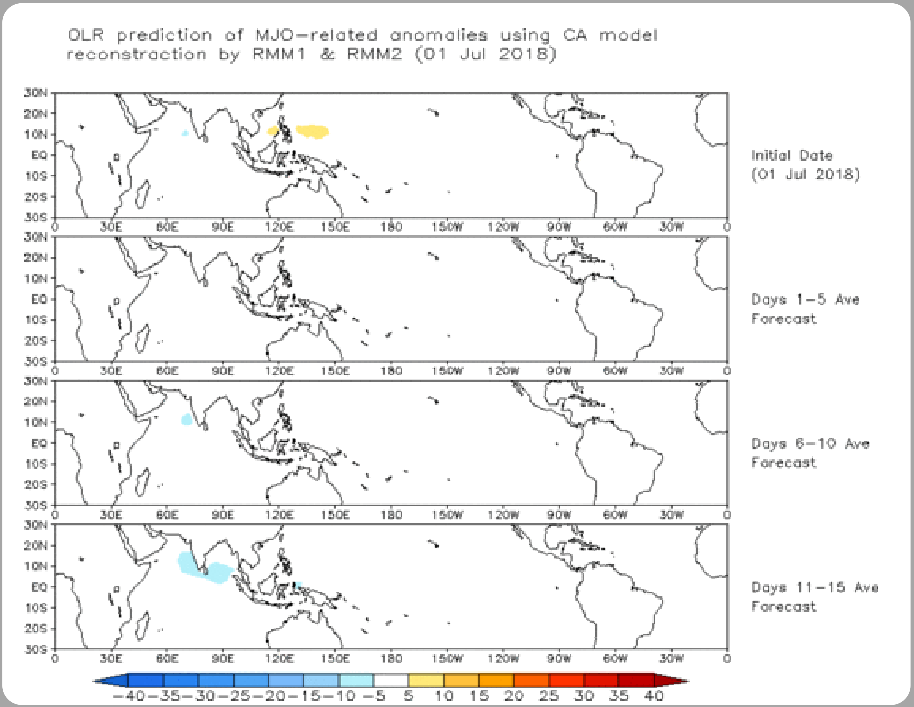


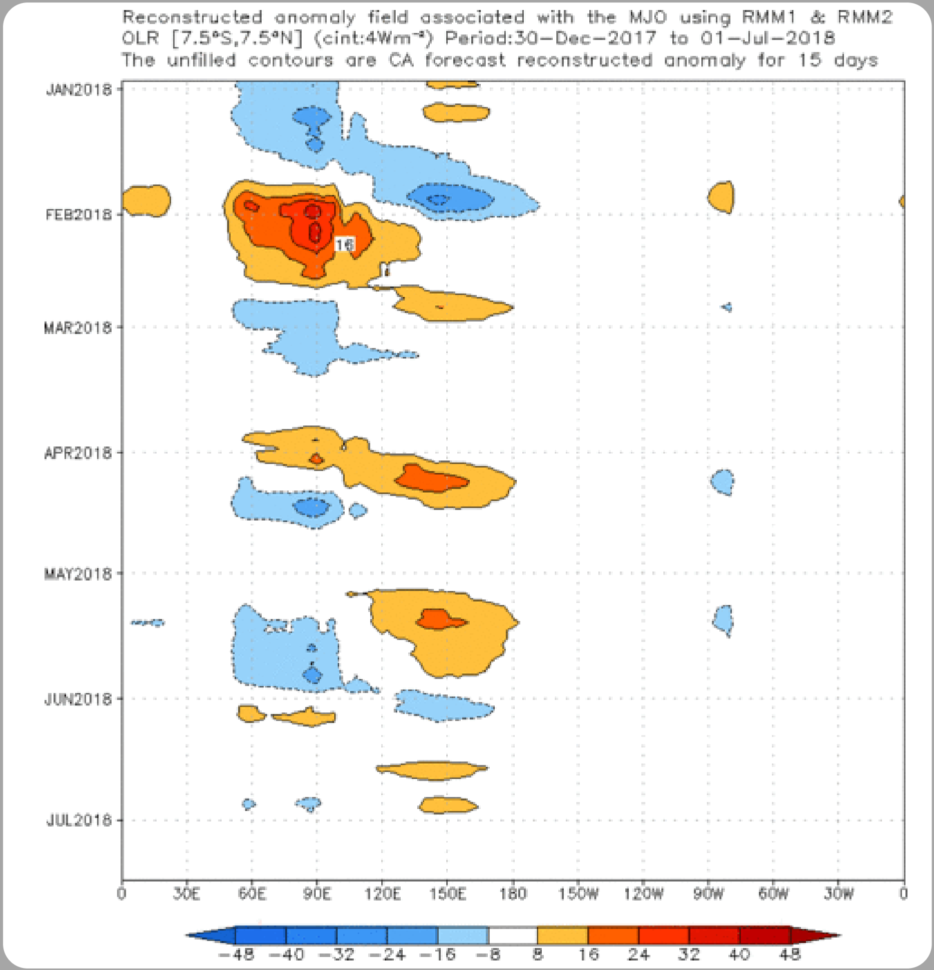
Constructed Analog (CA) MJO Forecast

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

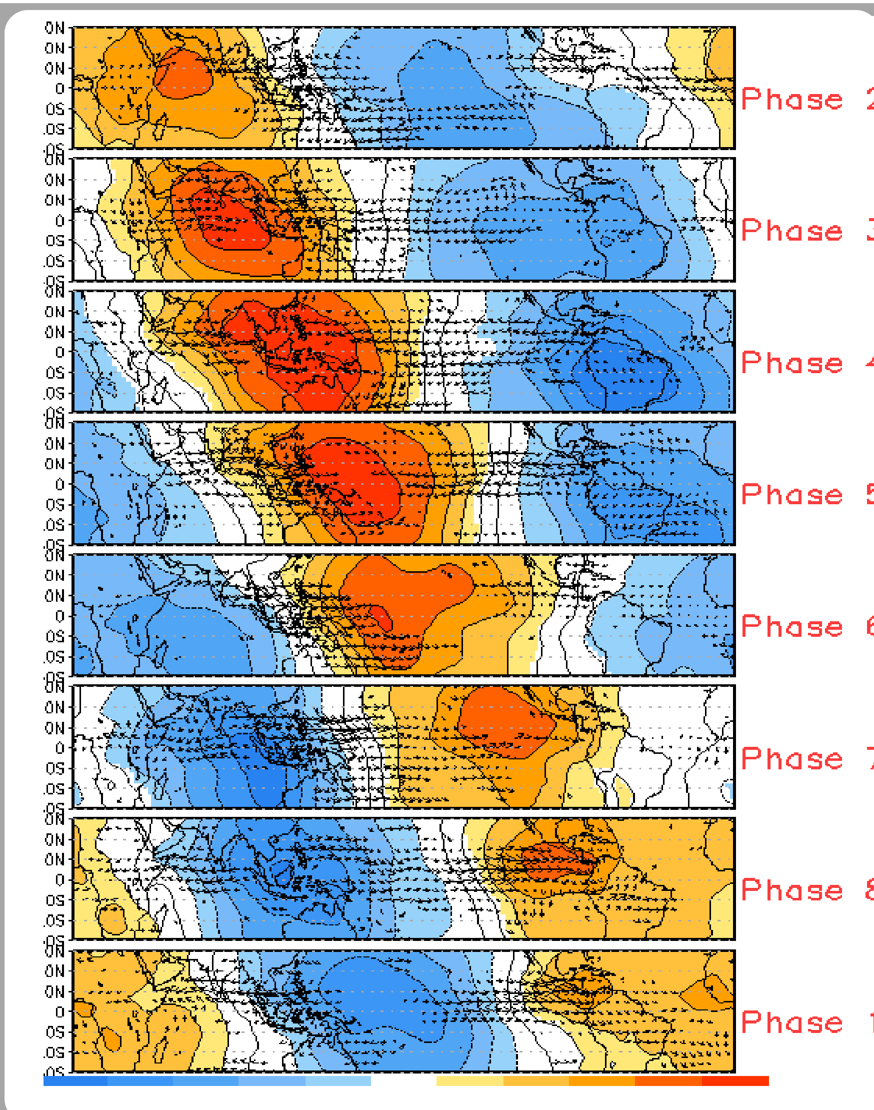




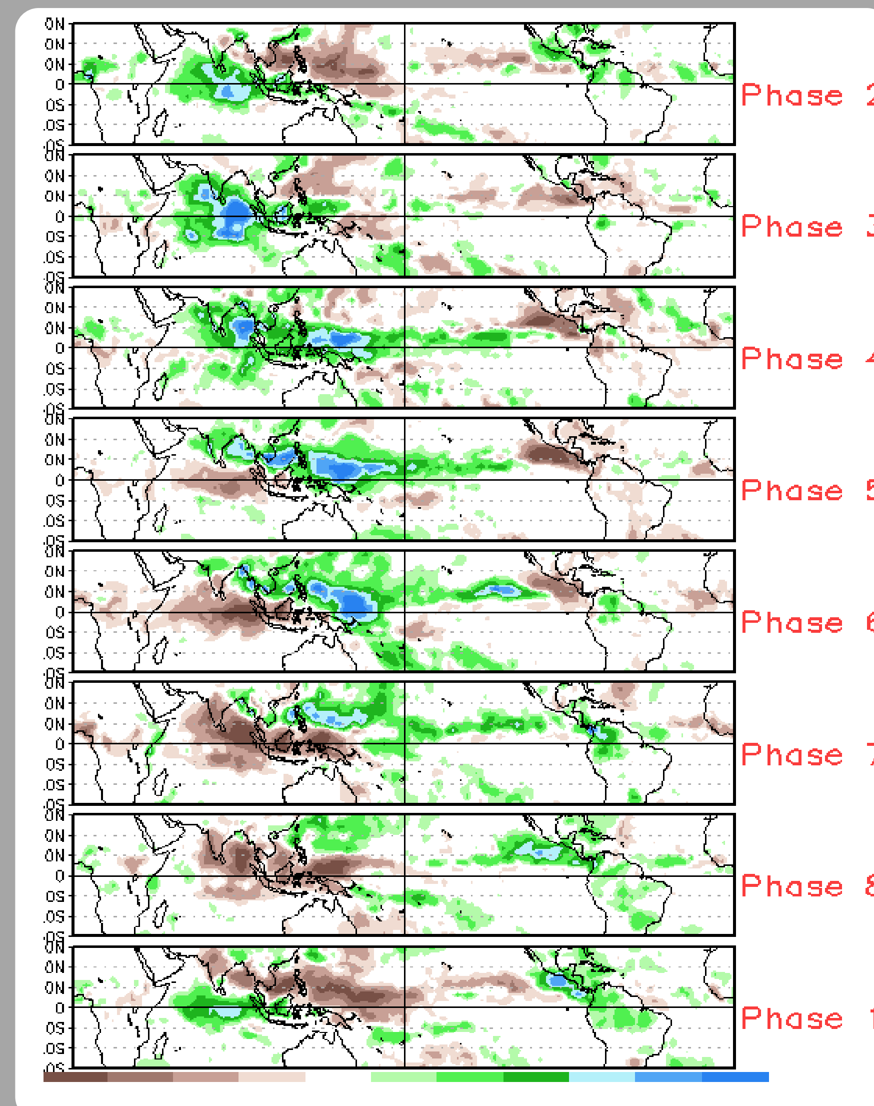
The OLR anomaly forecast based on the constructed analog MJO index forecast depicts little to no discernible signal during the next two weeks.

MJO Composites - Global Tropics

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



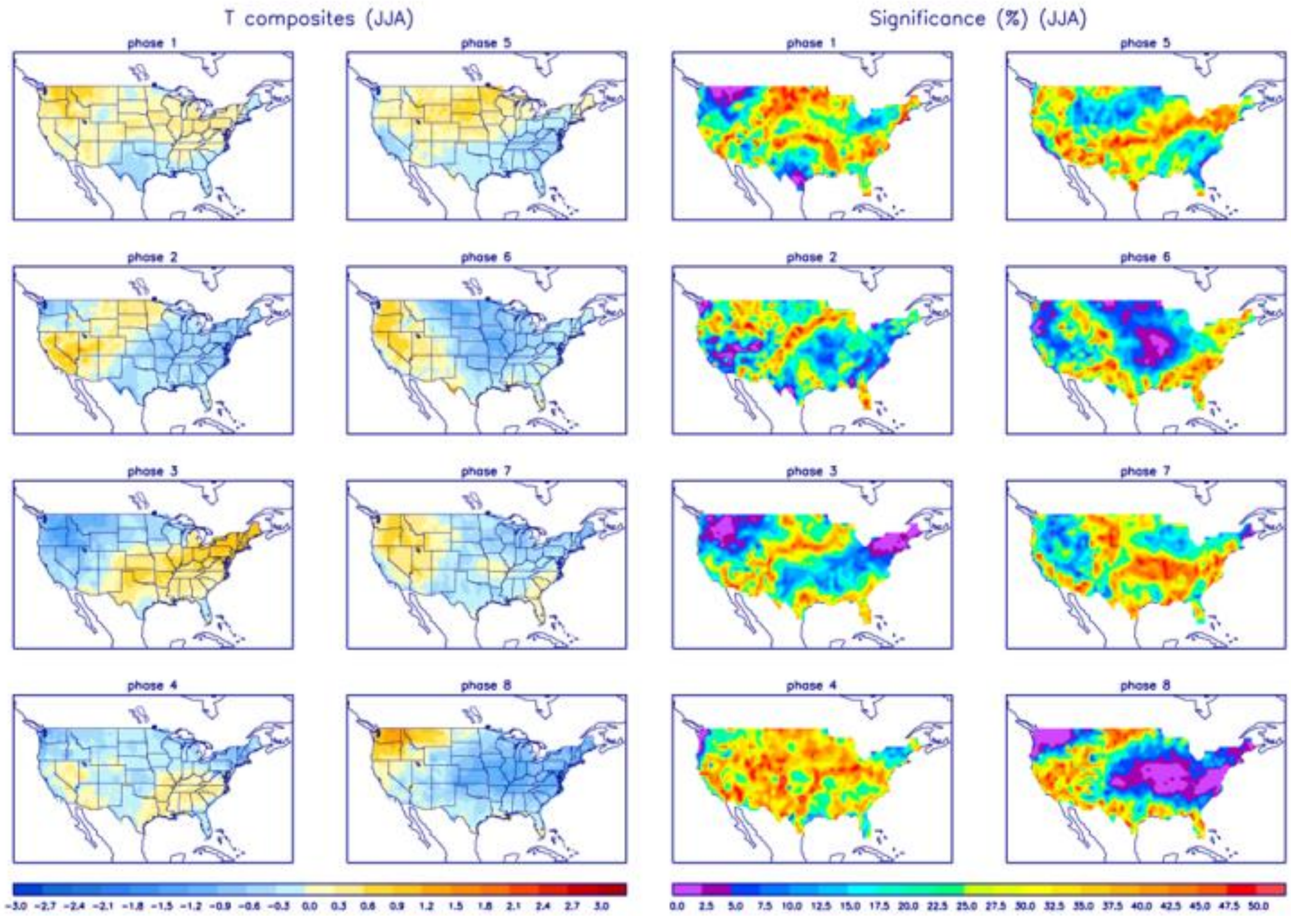
Precipitation Anomalies (May - Sep)



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.



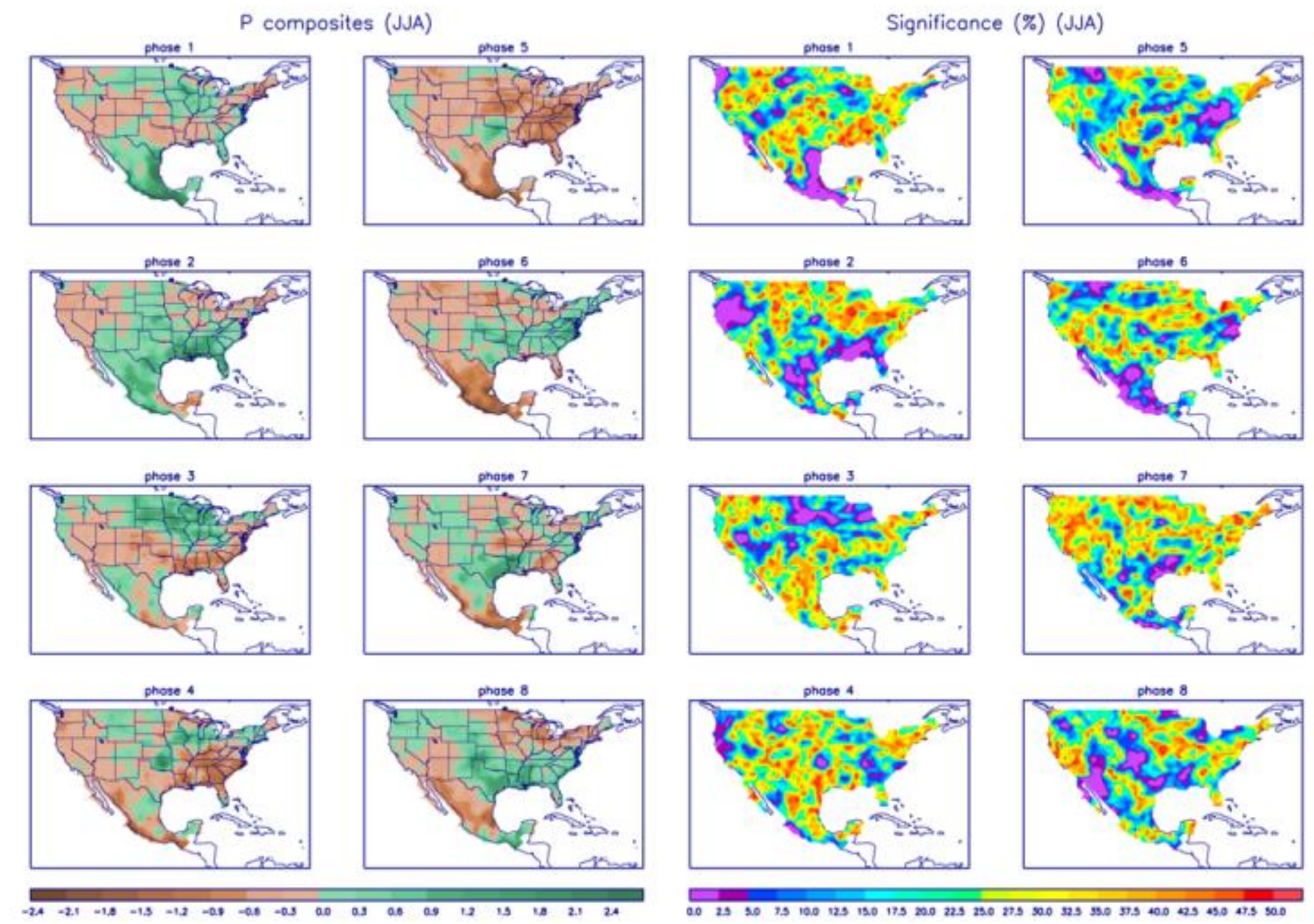
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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