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

MJO Composites

Overview

- The MJO signal remains fairly disorganized, as other modes of tropical intraseasonal variability, including robust Pacific tropical cyclone activity, continue to influence the pattern.

- Broad enhanced (suppressed) convective envelopes persist over the Pacific (Western Hemisphere), but smaller-scale destructively interfering features yield a somewhat disorganized overall pattern.

- Dynamical model MJO index forecasts are mixed, with the GEFS depicting some eastward propagation of a weak signal over the Western Hemisphere, while the ECMWF depicts little to no MJO activity.

- Based on recent observations and the forecast guidance, the MJO is not anticipated to play a substantial role in the evolution of the global tropical convective pattern during the next few weeks. Other modes, including tropical cyclones, will continue to contribute to a somewhat disorganized large-scale convective regime across the tropics.

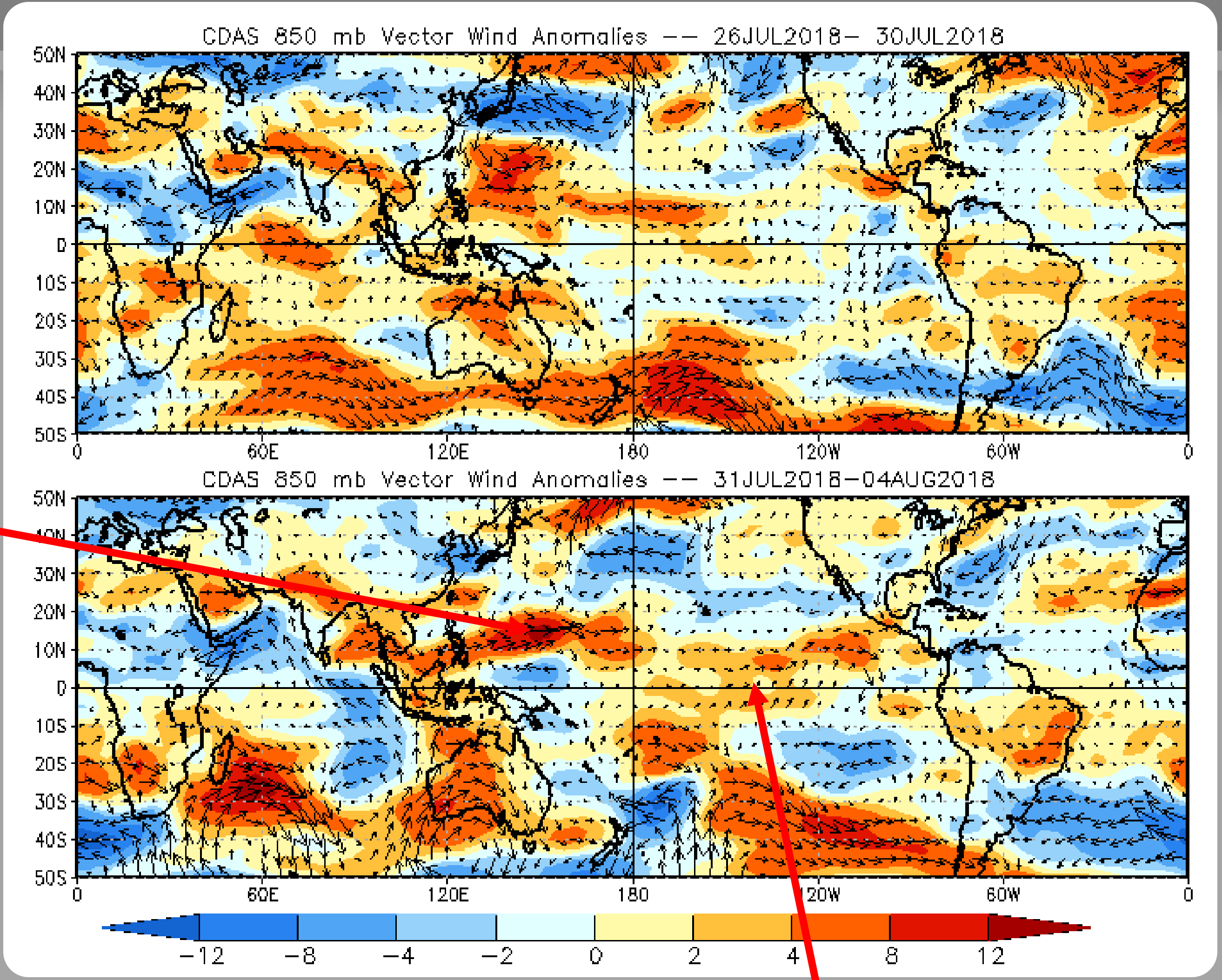
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

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

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



Strong westerlies, partly associated with tropical cyclone activity, overspread the tropical Northwest Pacific. Easterly anomalies were observed along the Equator.

Broad westerly anomalies overspread and central and eastern Pacific, with tropical cyclone activity also influencing this pattern.

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

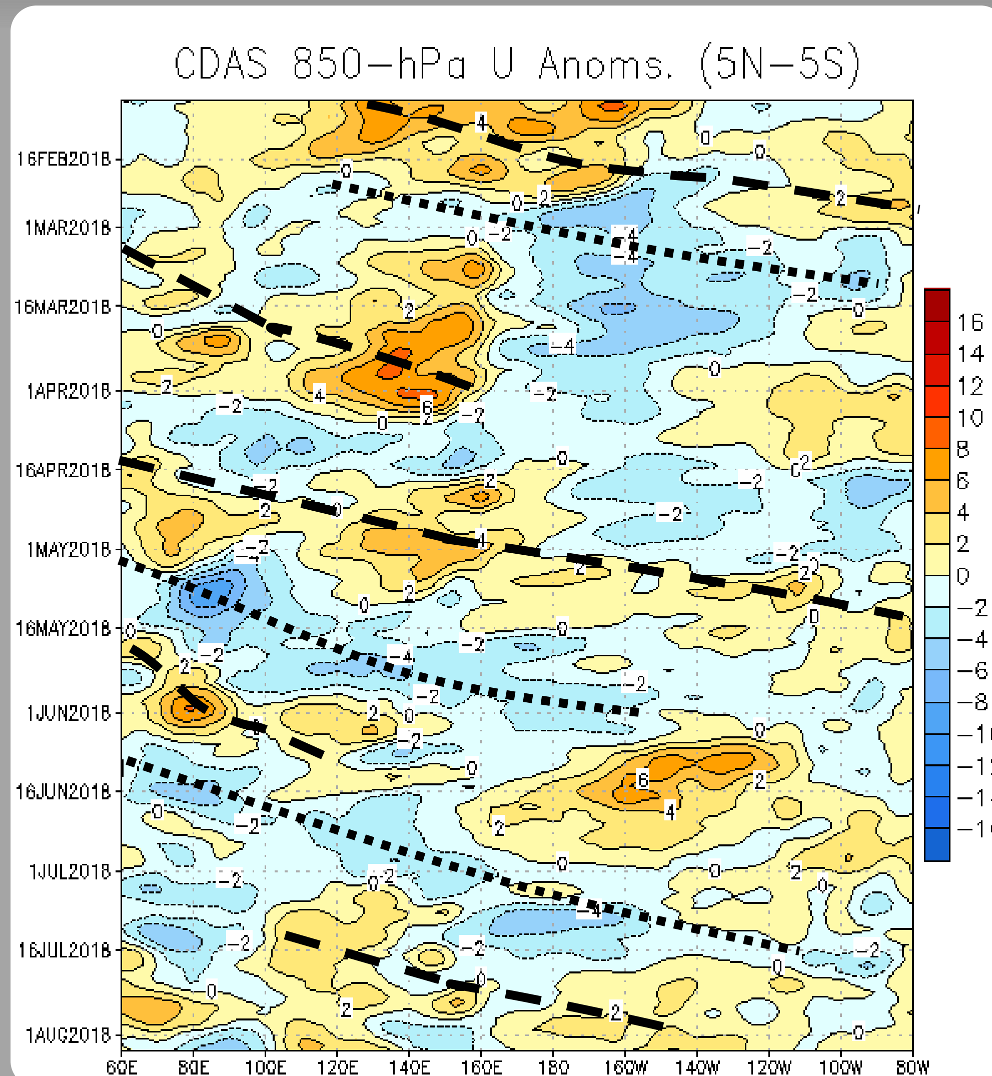
Strong MJO activity occurred during early February.

Renewed 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.

More recently, other modes, including tropical cyclone activity, are influencing the pattern.



OLR Anomalies – Past 30 days

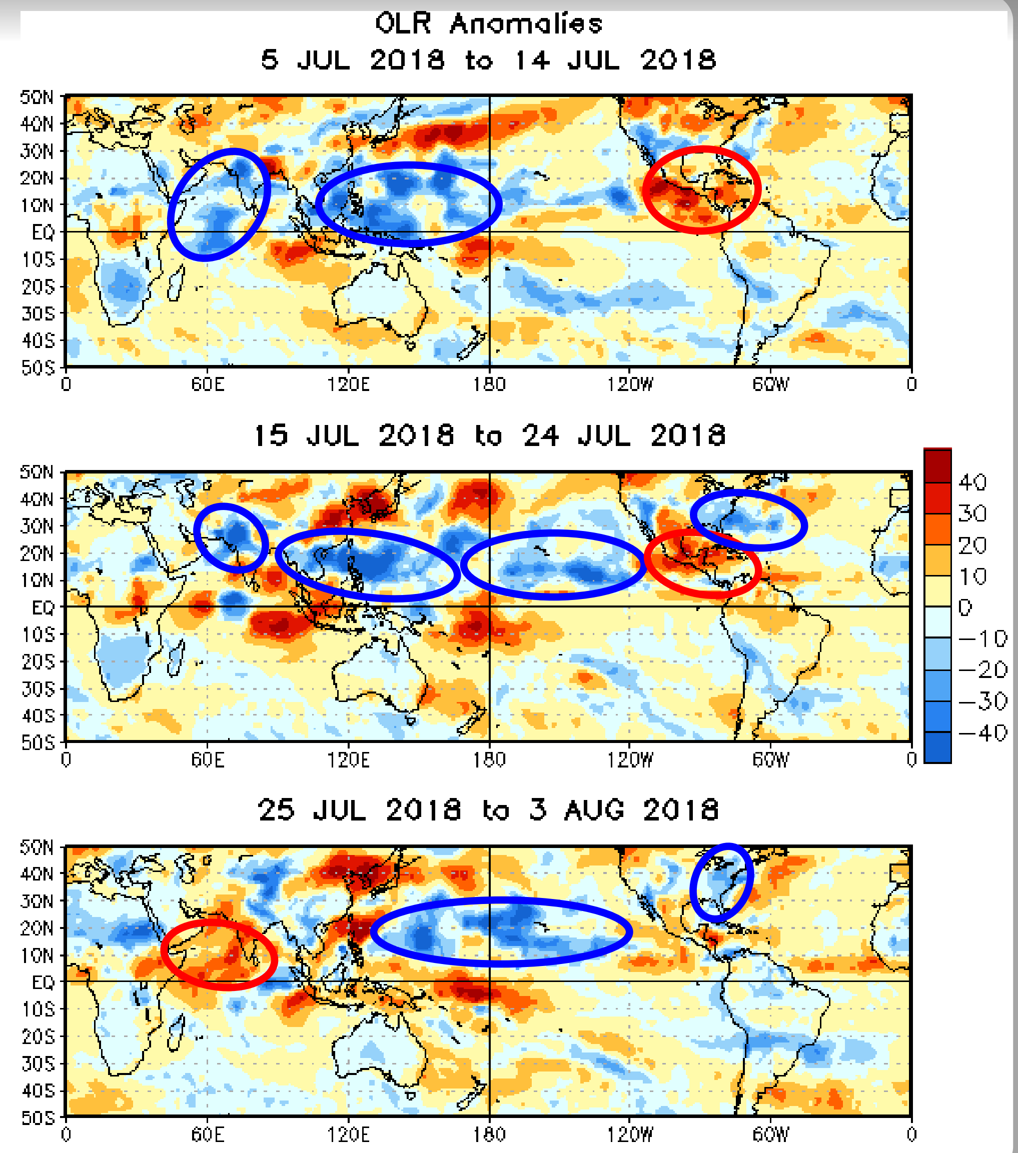
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During early July, the MJO signal emerged over the Maritime Continent. Consistent with this, enhanced (suppressed) convection was observed over much of the northwestern Pacific (East Pacific).

Enhanced convection shifted northward over Southeast Asia and the West Pacific during mid-July, while suppressed convection persisted over the far East Pacific. Enhanced convection spread eastward across the North Pacific, while a plume of tropical moisture brought torrential rainfall to the eastern CONUS.

During late July, suppressed convection overspread the western Indian Ocean and South Asia, while enhanced convection, including tropical cyclone activity, persisted over the North Pacific. An influx of tropical moisture persisted over the eastern U.S.



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

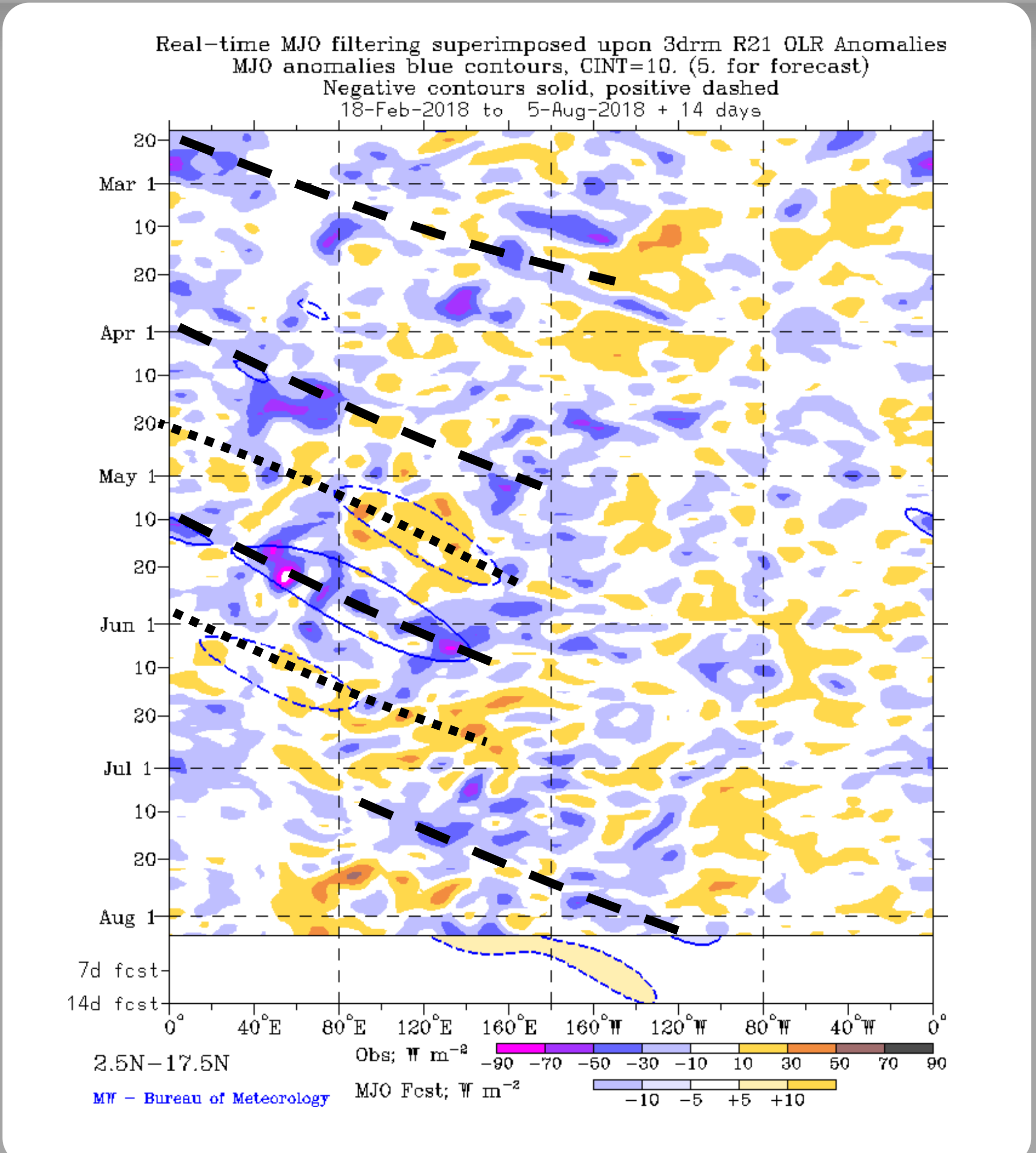
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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, particularly Rossby wave and tropical cyclone activity, continued to strongly influence the pattern.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

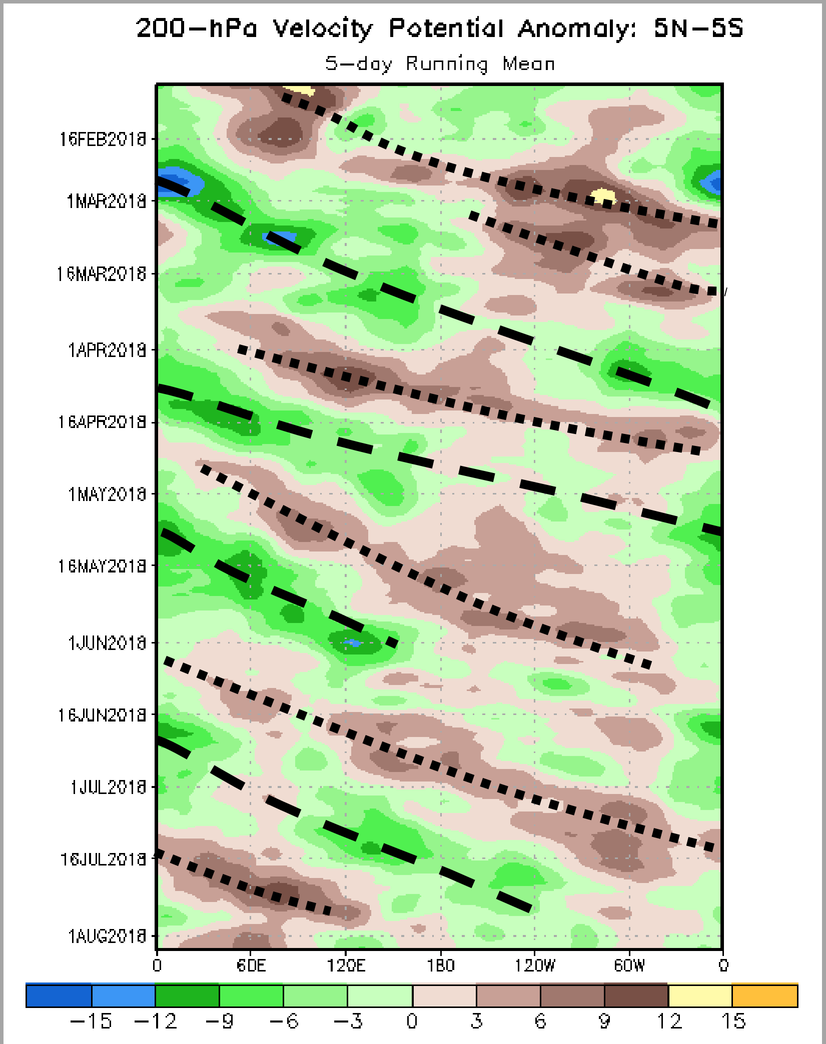
Negative anomalies (green shading) indicate favorable conditions for precipitation

Robust MJO activity was observed throughout the Boreal Winter and Spring months in the upper-level wind field, despite the background La Niña state. Stationary upper-level divergence over the Maritime Continent associated with the base state began to wane by April.

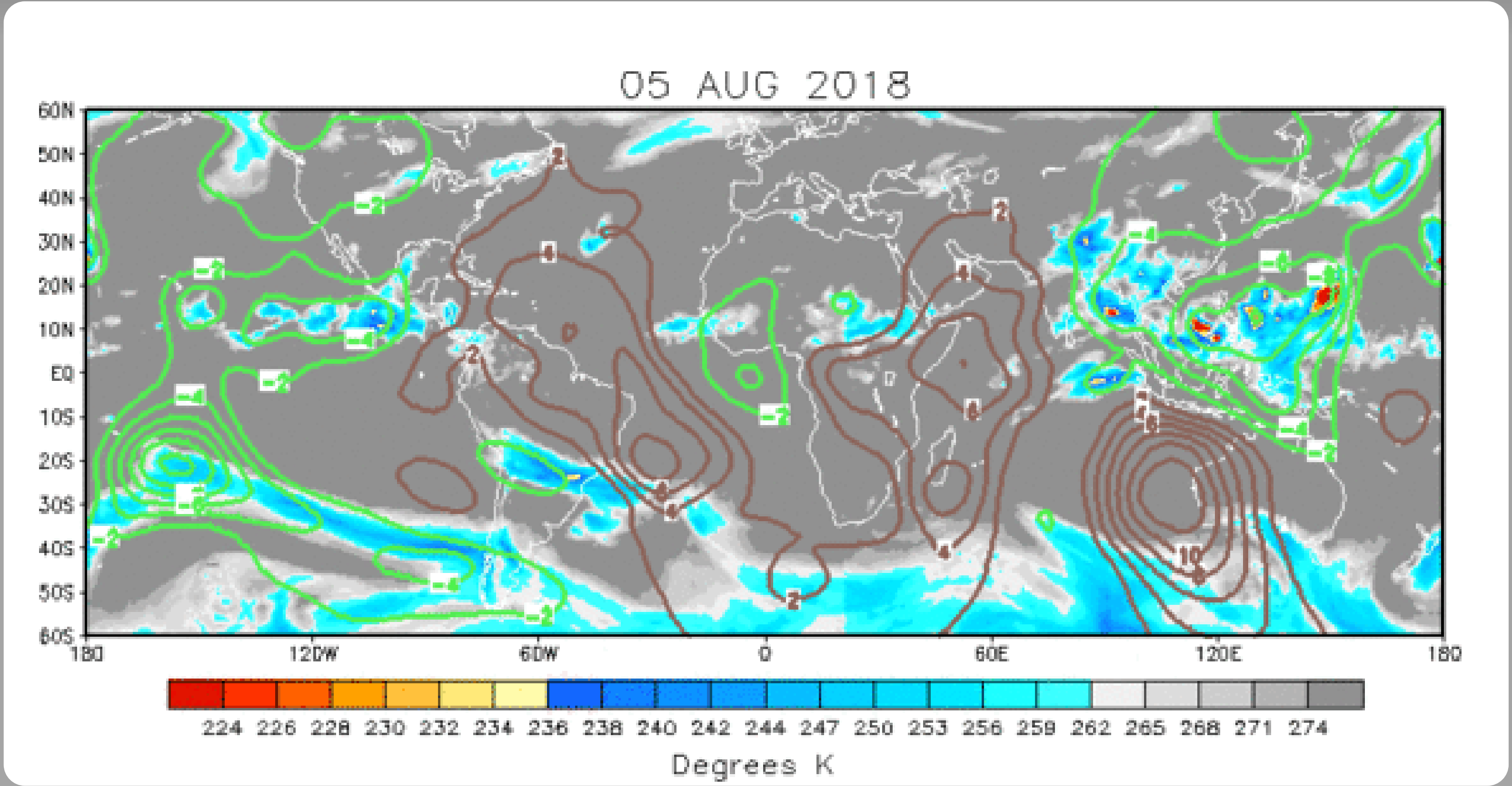
The enhanced phase of the MJO weakened east of the Date Line during June. Eastward propagation of broad suppressed convection continued into early July.

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. Influence from Rossby wave activity, including strong tropical cyclones, may be contributing to this slowdown.



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



The upper-level velocity potential pattern remains somewhat disorganized, but broad-scale enhanced divergence (convergence) is apparent over the Pacific (Western Hemisphere and western Indian Ocean). Robust Southeast Asia monsoon activity, tropical cyclone activity over the Northwest Pacific, and areas of enhanced convection over Sub-Saharan Africa continue to influence the pattern.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

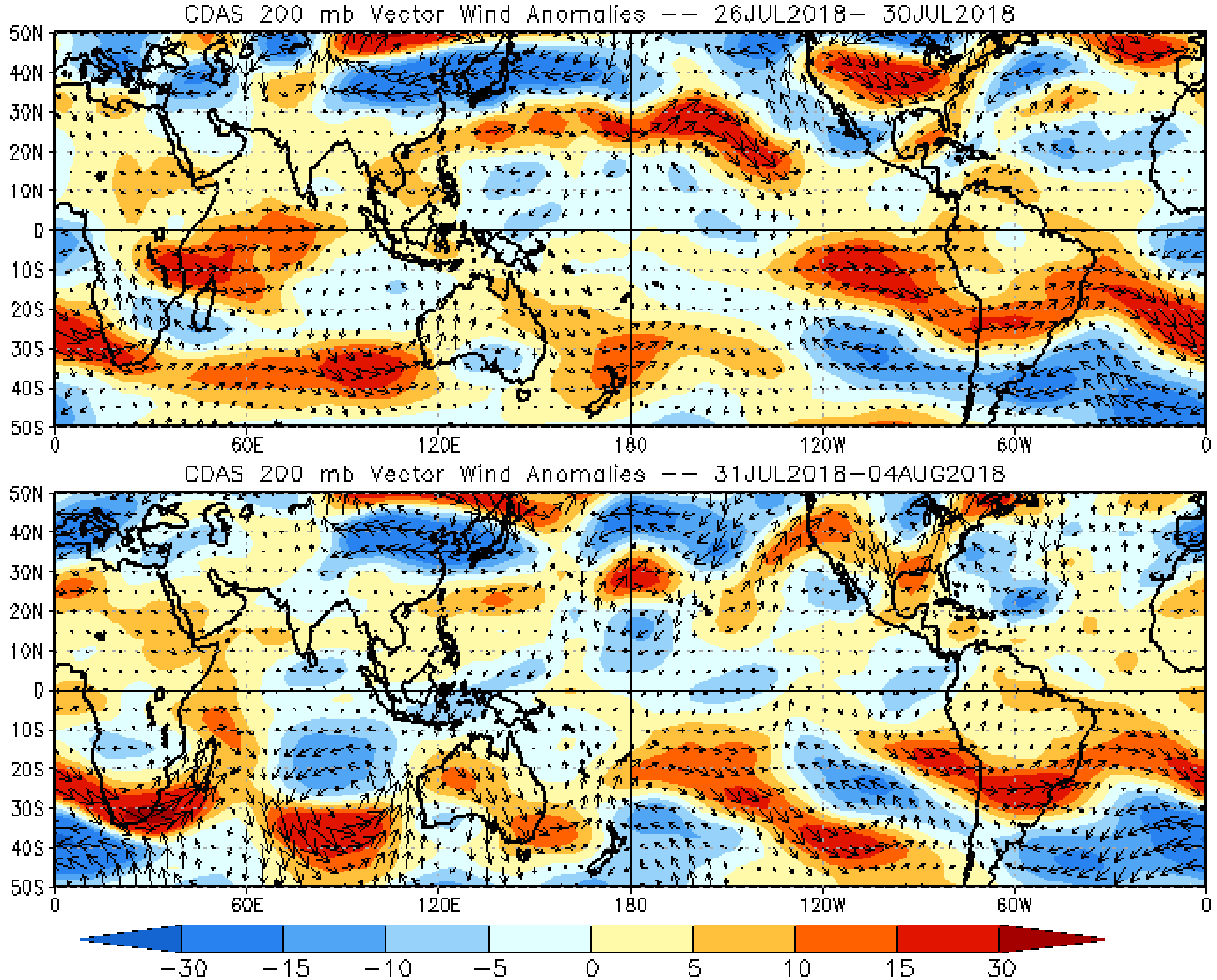
Negative anomalies (green contours) indicate favorable conditions for precipitation

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 Northern Hemisphere mid-latitude pattern remains active, with a pronounced anti-cyclonic gyre near the Date Line, enhanced ridging over the western CONUS, and a northward displaced Bermuda High feature over the western Atlantic.

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

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

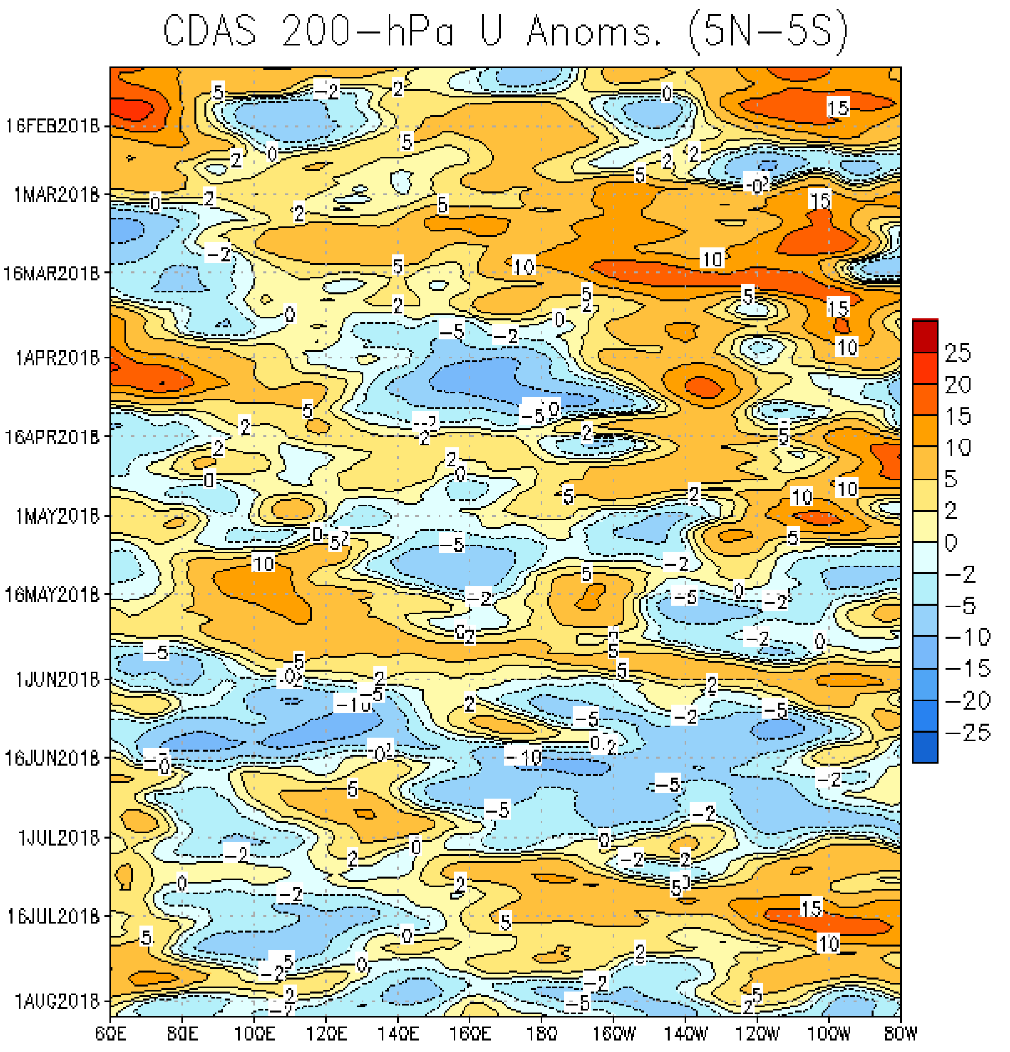
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

More recently, the intraseasonal pattern weakened, partly due to tropical cyclone and mid-latitude influences.



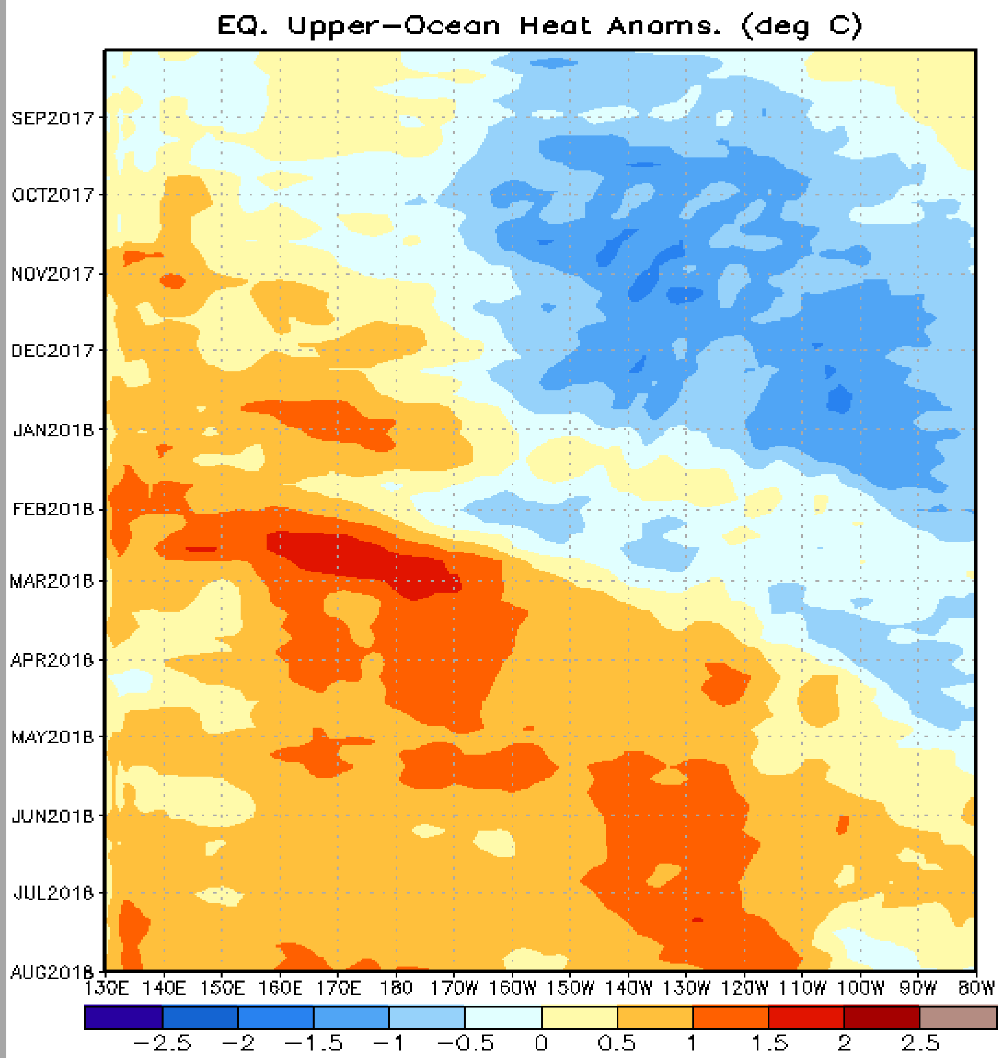
Weekly Heat Content Evolution in the Equatorial Pacific

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 most of the 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

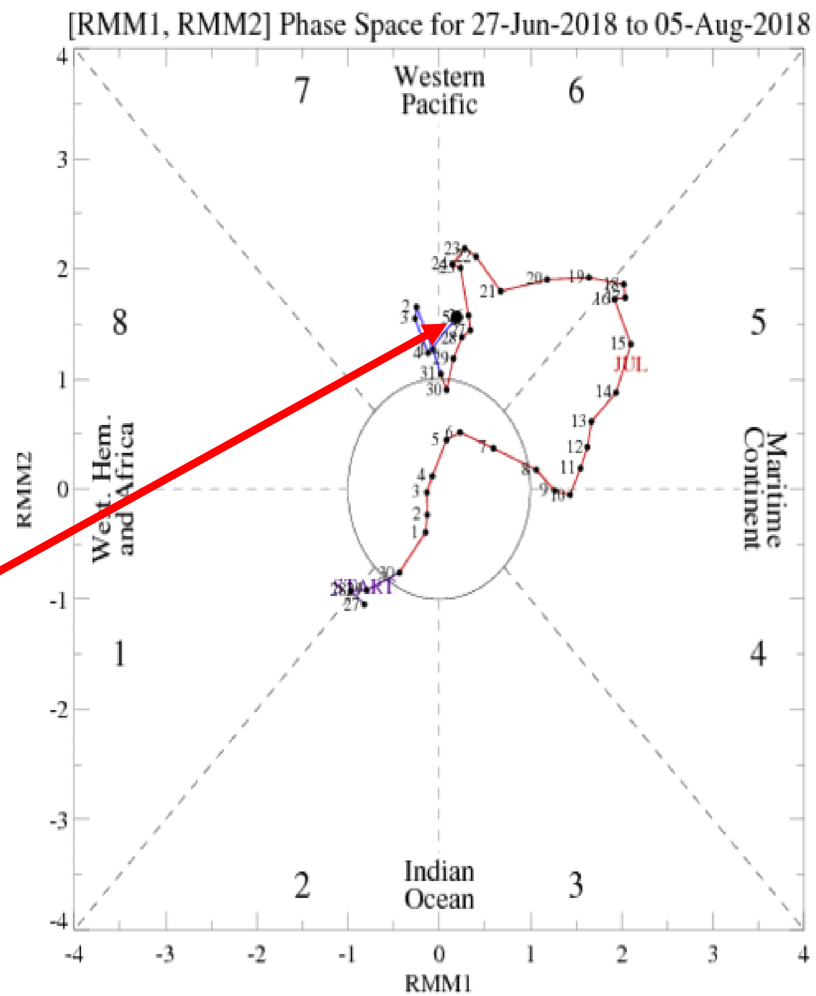
The triangular areas indicate the location of the enhanced phase of the MJO

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

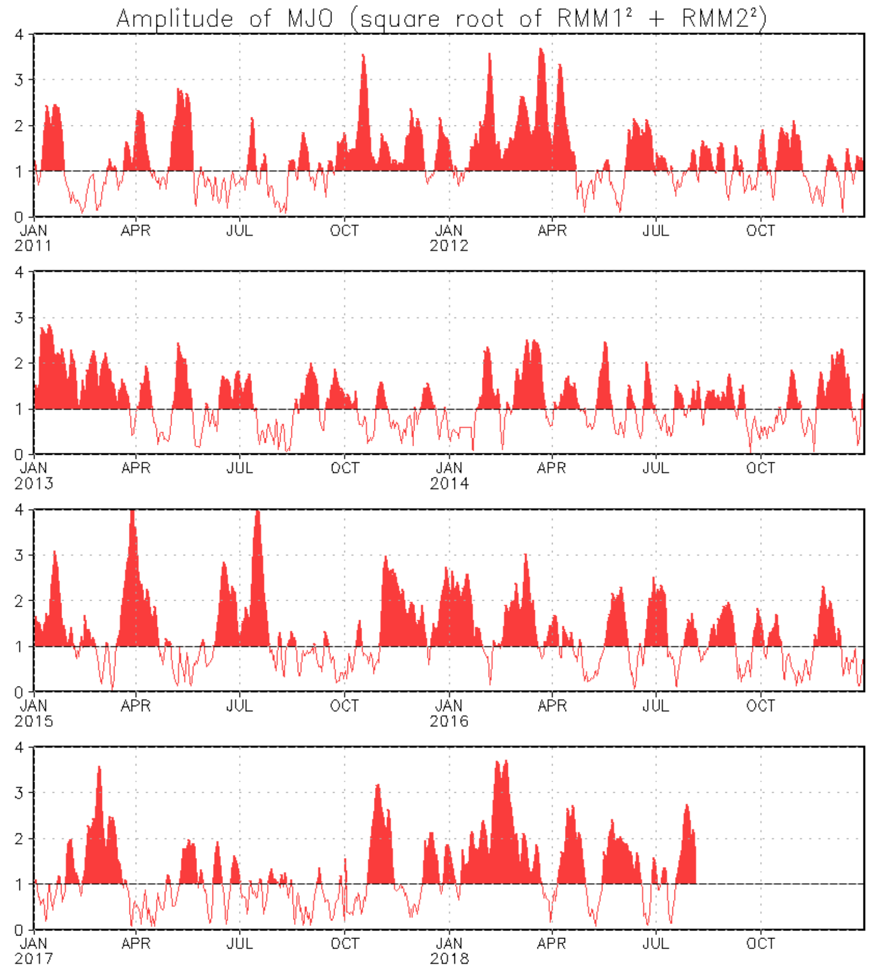
The RMM-based MJO index continues to project an enhanced convective phase over the West Pacific, but the index has been chaotic over the past few days, and there is little eastward propagation. Other modes, including tropical cyclone activity over the Pacific, may be influencing the index.



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

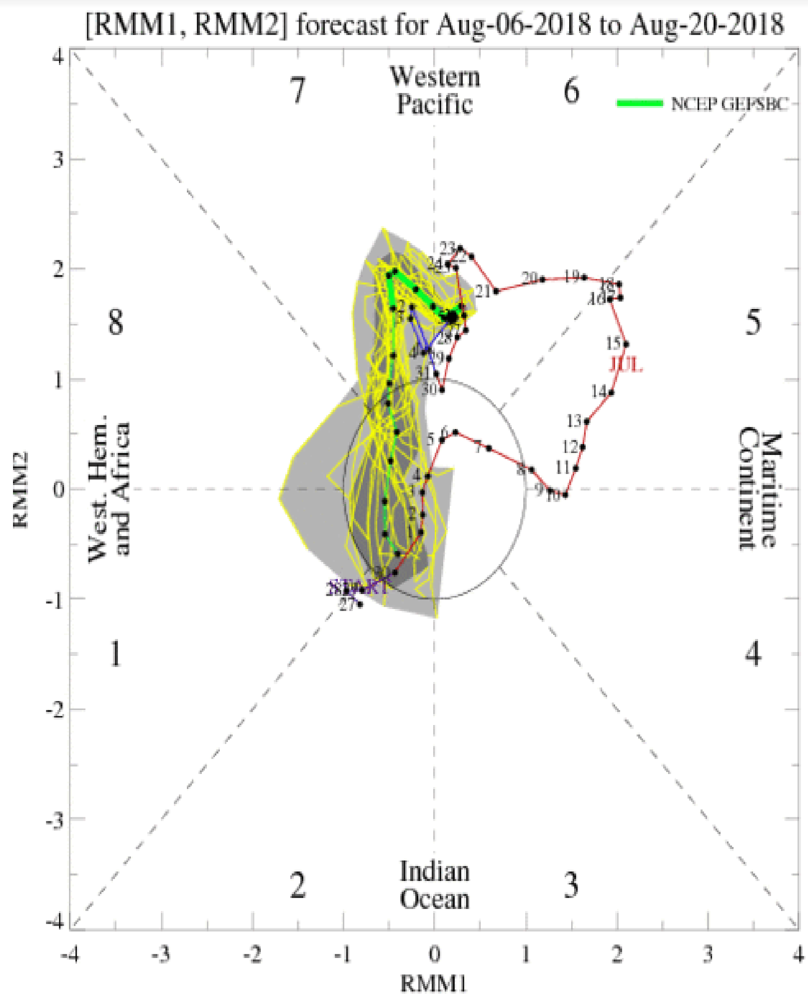
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

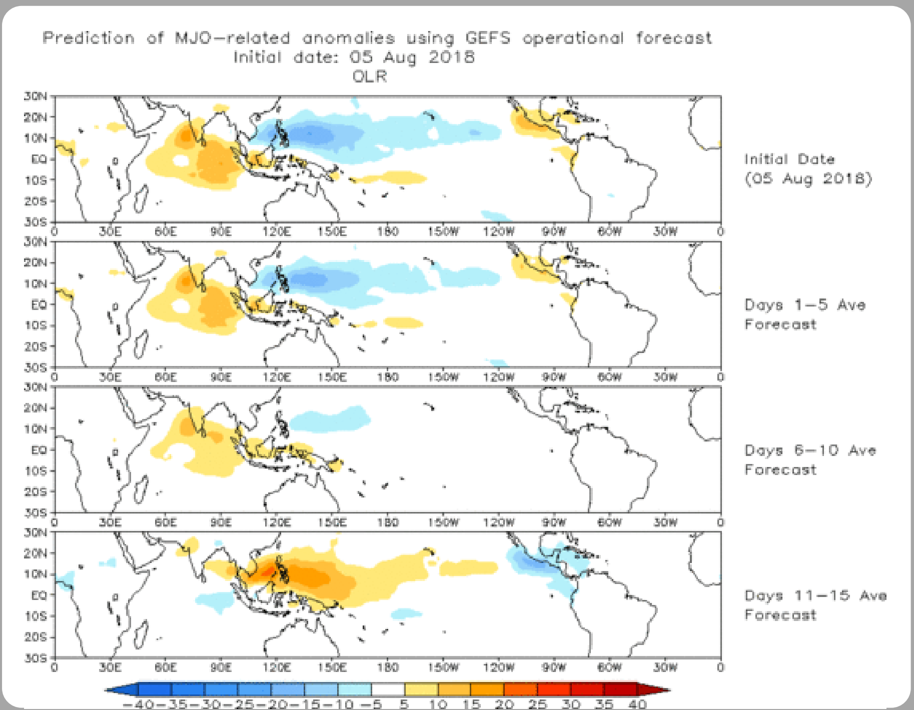
The GEFS RMM index forecast depicts continued West Pacific enhanced convection during Week-1, but weakens the amplitude during Week-2. Despite the weakened signal, the GEFS appears to propagate the intraseasonal signal across the Western Hemisphere during Week-2.



Ensemble GFS (GEFS) MJO Forecast

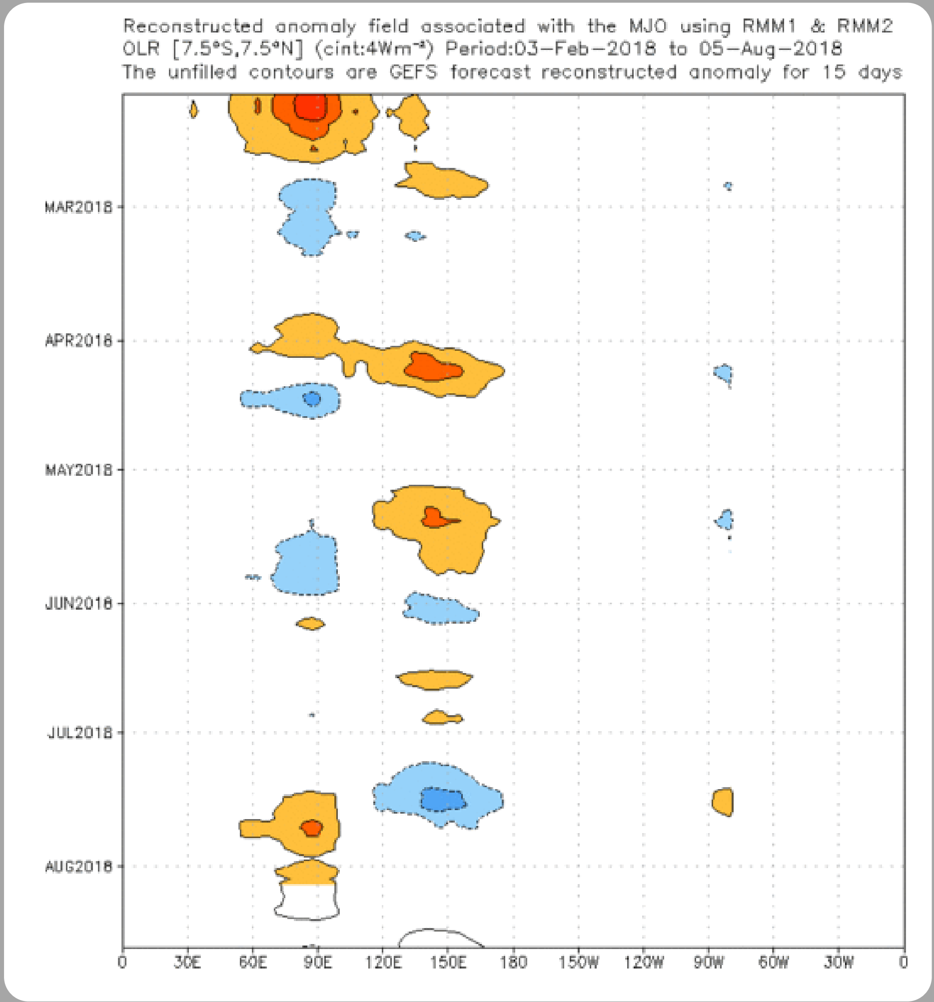
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



OLR anomalies based on the GEFS RMM-index forecast show weakening amplitude, albeit with robust eastward propagation during Week-2.

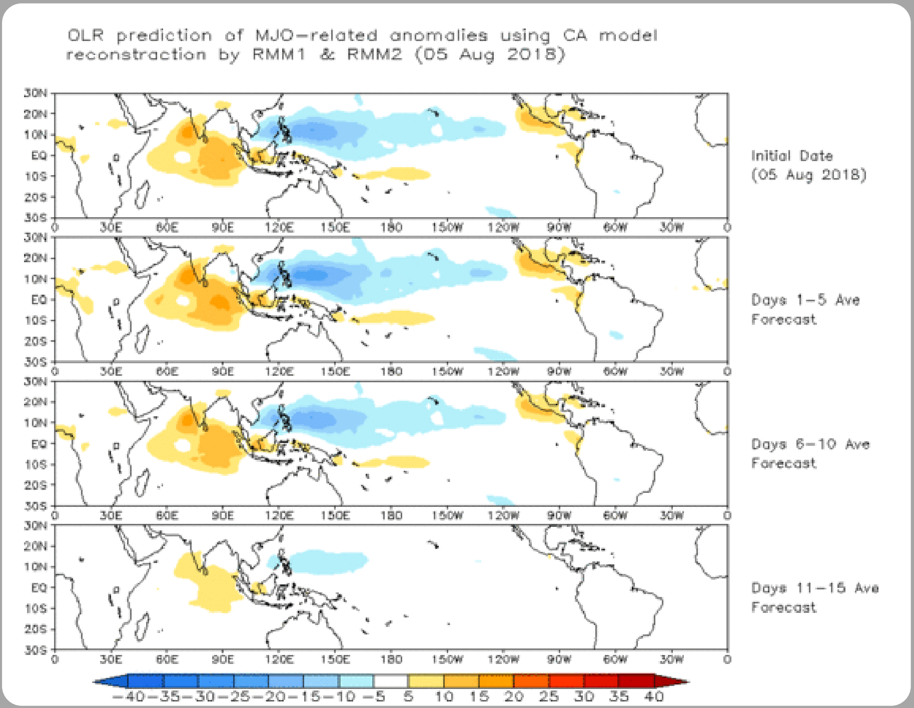
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



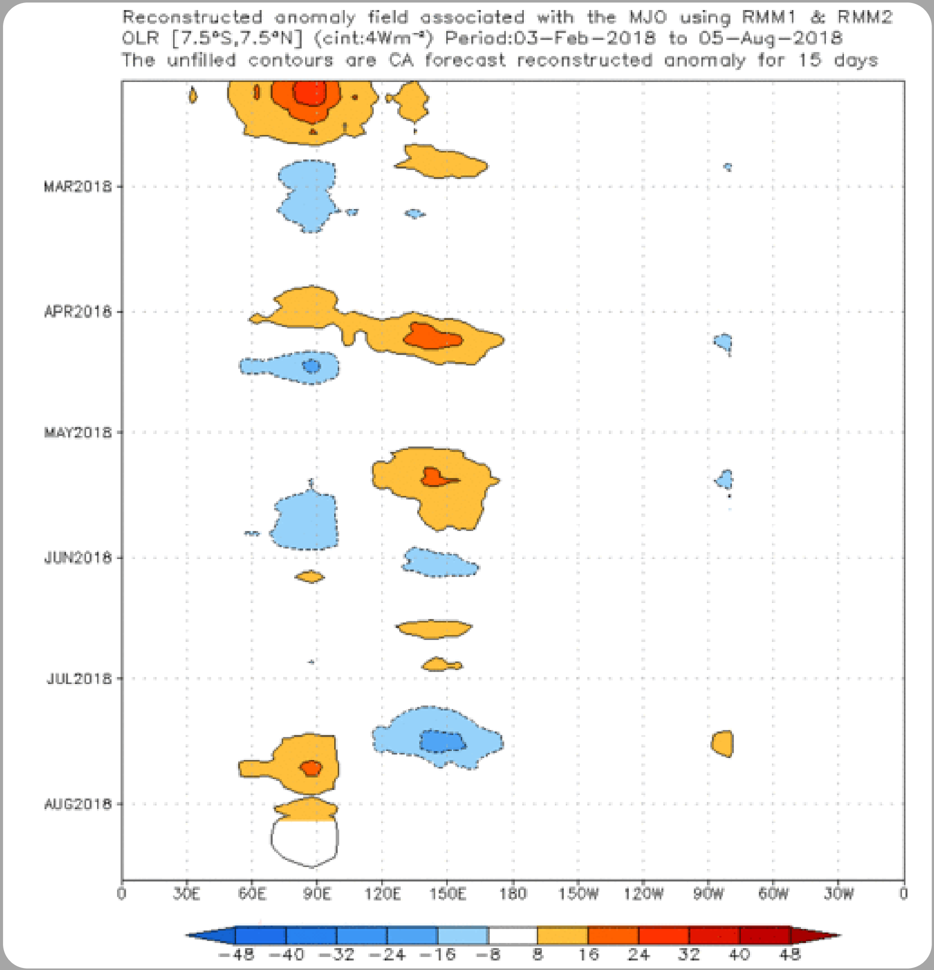
Constructed Analog (CA) MJO Forecast

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



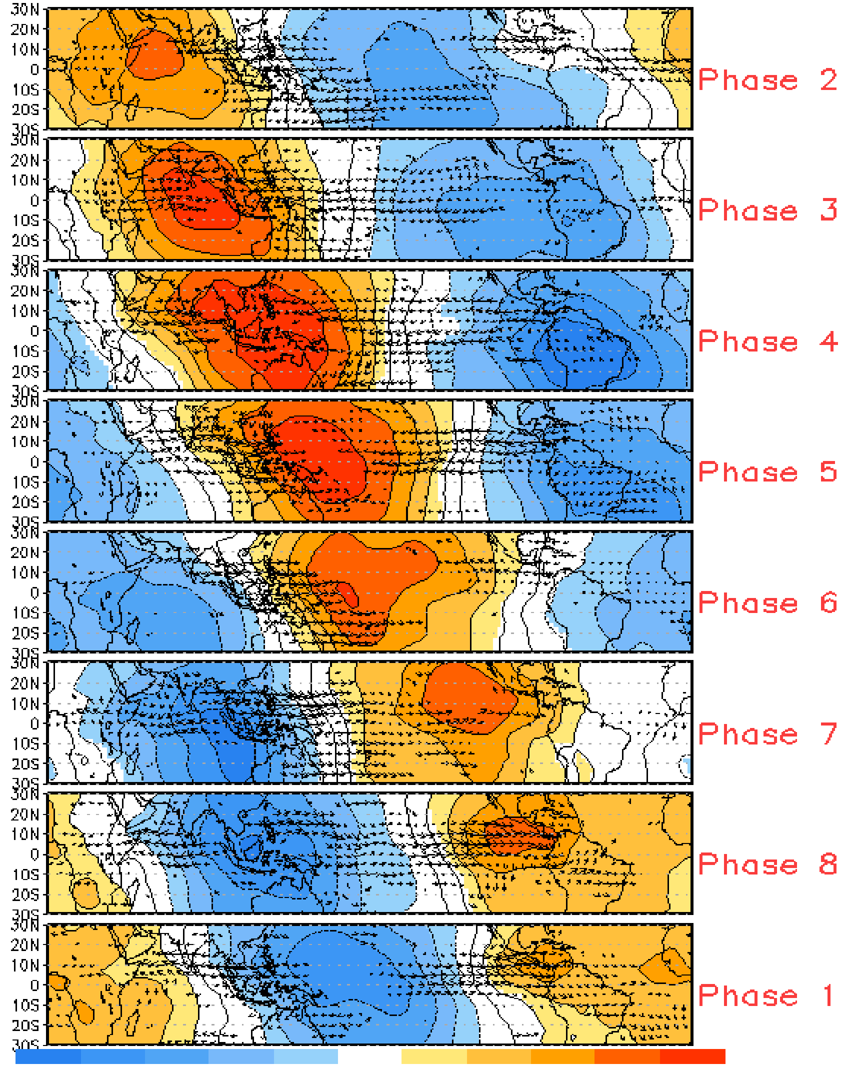
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



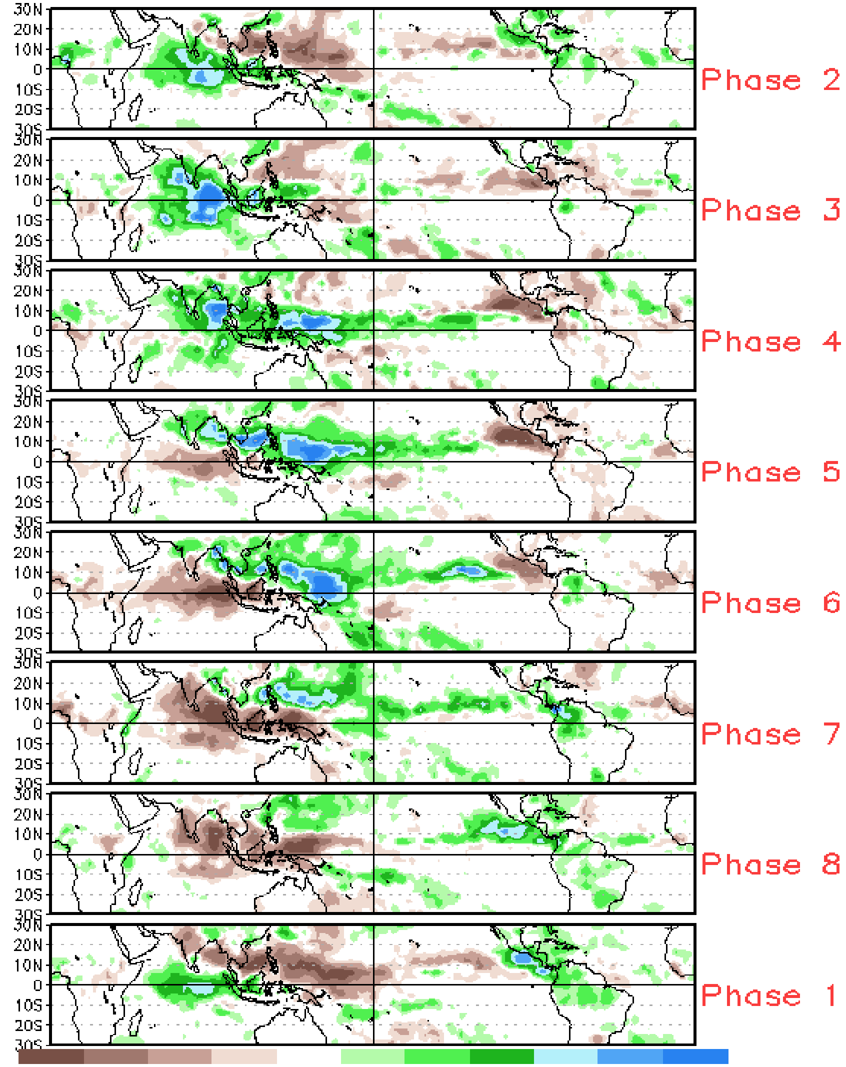
The constructed analog RMM-based OLR anomaly forecast shows both slower weakening of the signal and a slower eastward propagation.

MJO Composites – Global Tropics

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



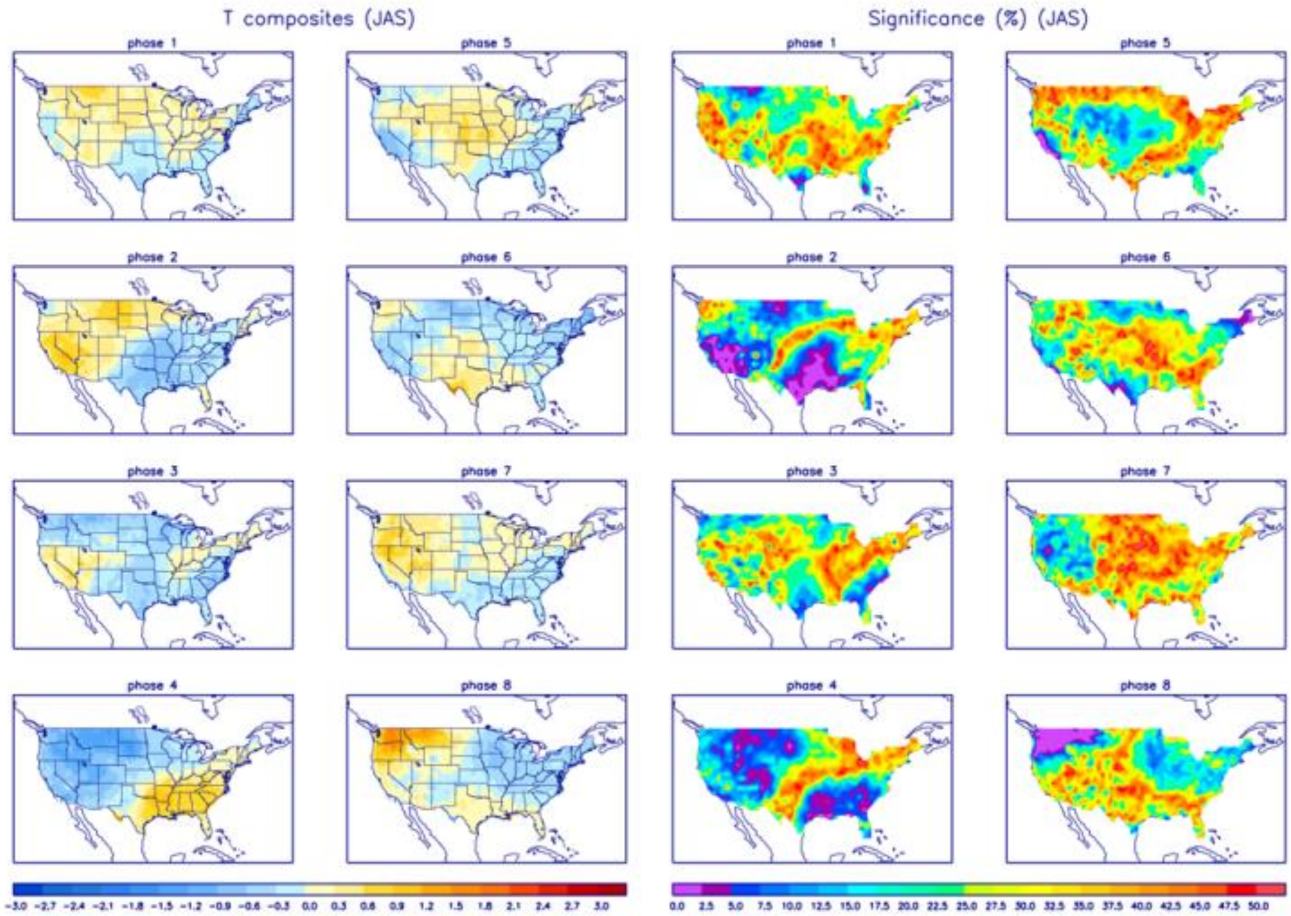
Precipitation Anomalies (May - Sep)



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.

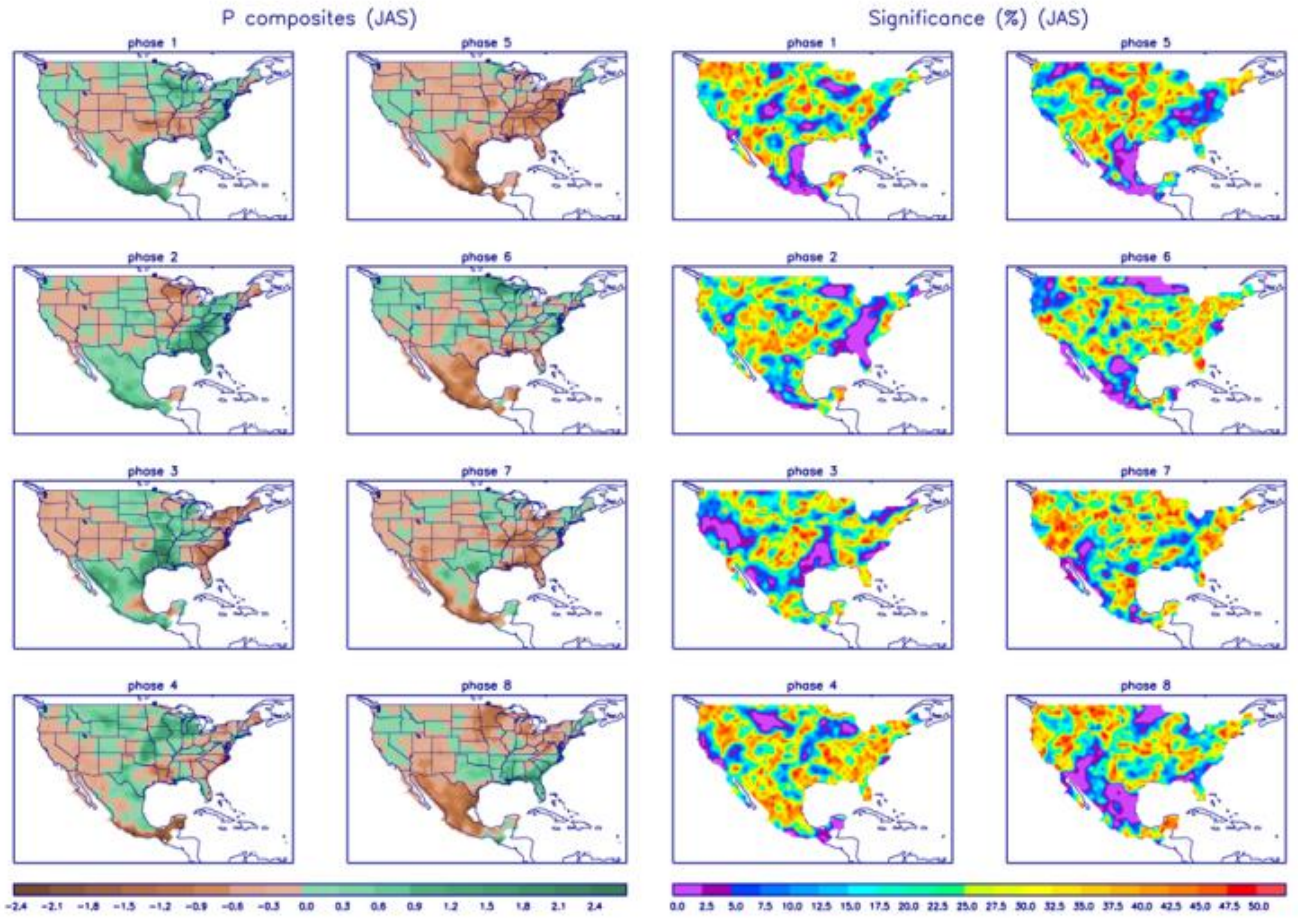
Right hand side plots show a measure of significance for the left hand side anomalies. Purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.



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

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