

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



Update prepared by:
Climate Prediction Center / NCEP
9 July 2018

Outline

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Recent Evolution and Current Conditions

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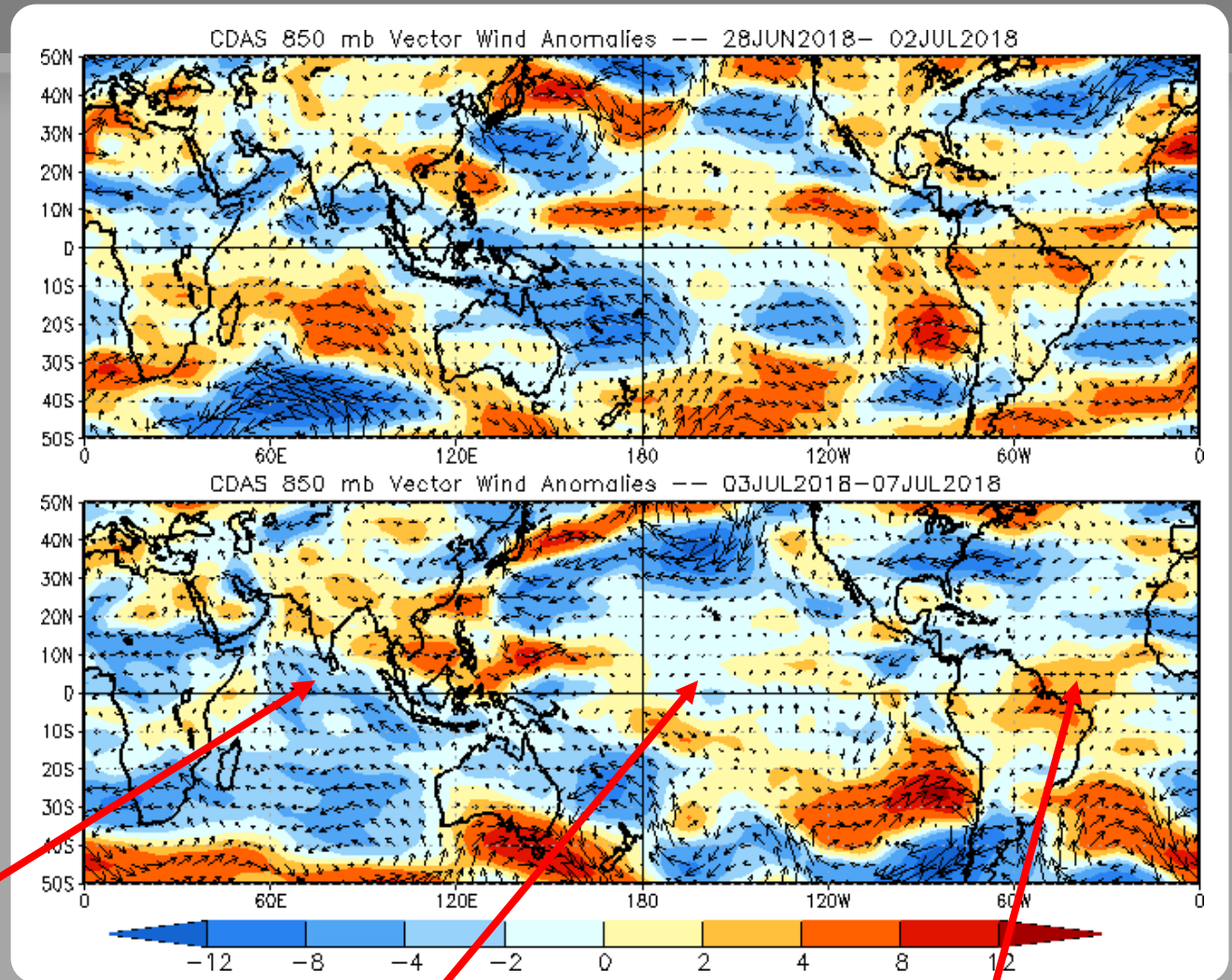
Overview

- The MJO signal was weak during most of June, but there are some signs, particularly in the upper-level velocity potential field, of a redeveloping signal with the enhanced phase over the Maritime Continent.
- Most dynamical and statistical model guidance depicts an amplifying signal over the next two weeks, with little or slow eastward propagation. The ECMWF is the most progressive with the signal, bringing it to the West Pacific by Week-2, but even this is still on the slower end of canonical MJO phase speeds.
- Based on recent observations and fair agreement among the forecast tools, the MJO may play a role in the evolution of the global tropical convective pattern over the next several 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



Easterly anomalies overspread Africa and much of the Indian Ocean basin.

Westerly anomalies diminished over the tropical North Pacific.

Westerly anomalies persisted over the Atlantic basin.

850-hPa Zonal Wind Anomalies (m s⁻¹)

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

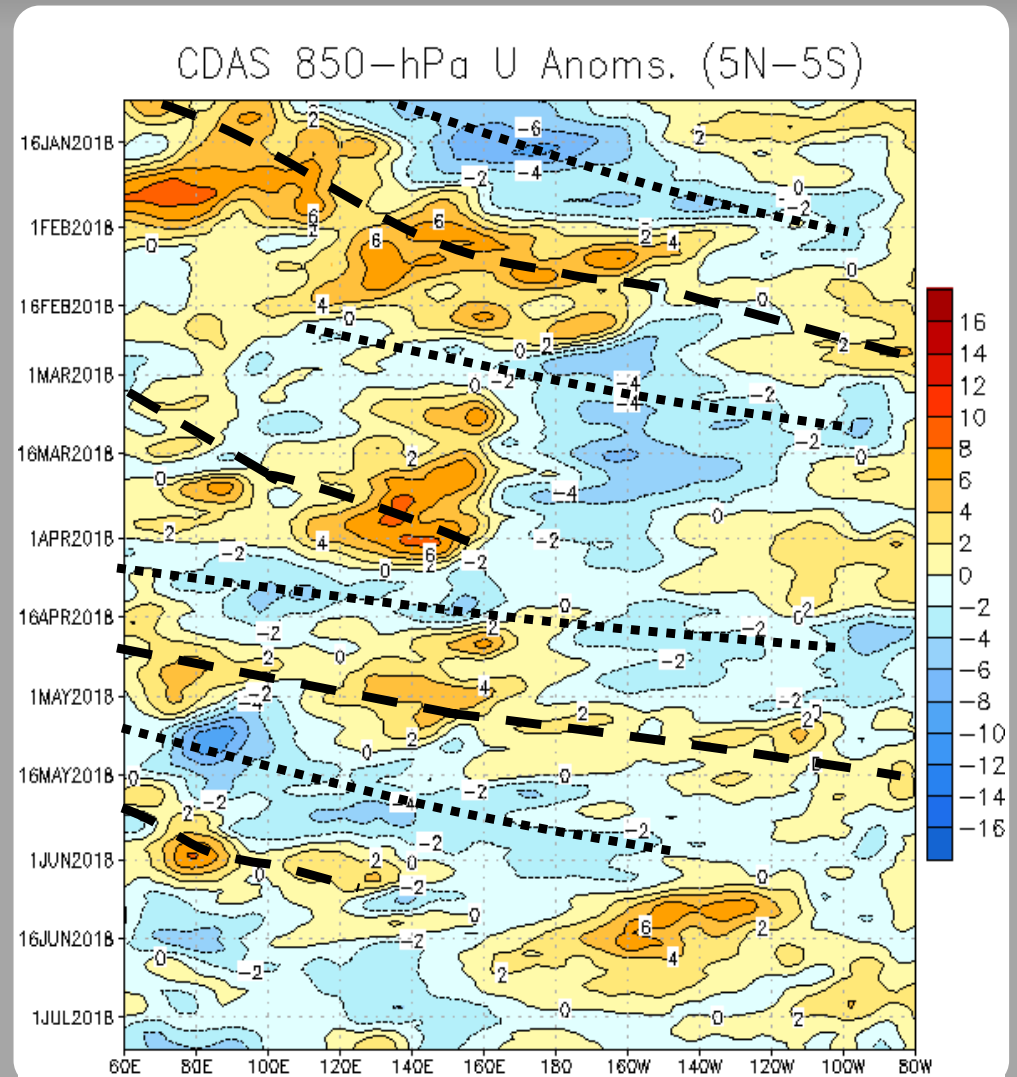
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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 was active during April and May, with a period near 30-40 days. During June, eastward propagation became 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

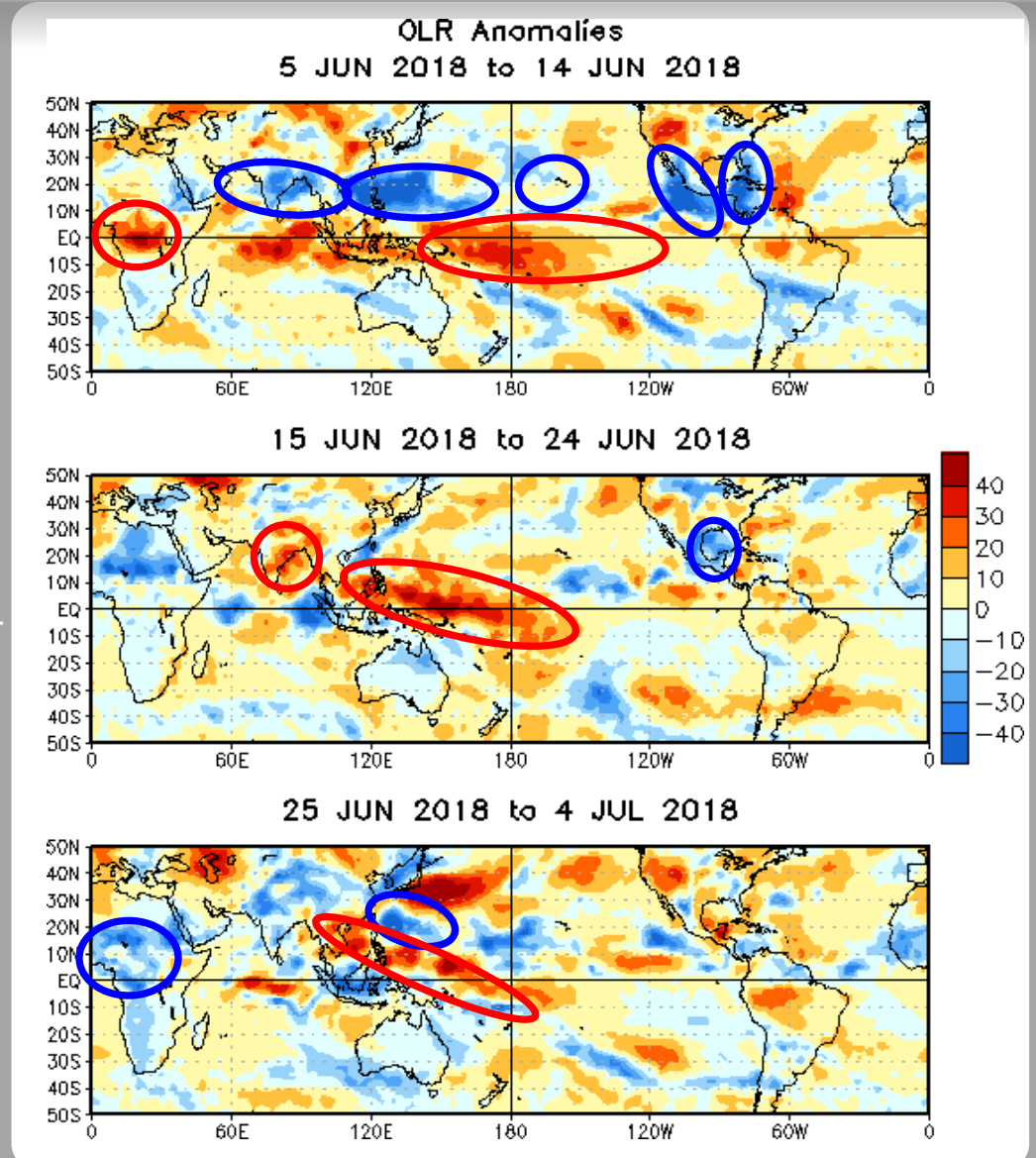
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During early June, suppressed convection was observed along much of the equator as the MJO enhanced phase broke down. Enhanced South and Southeast Asia monsoon activity persisted, and enhanced convection was also observed over the East Pacific and western Atlantic basins.

Suppressed convection continued to 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.



Outgoing Longwave Radiation (OLR) Anomalies (2.5°N - 17.5°N)

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

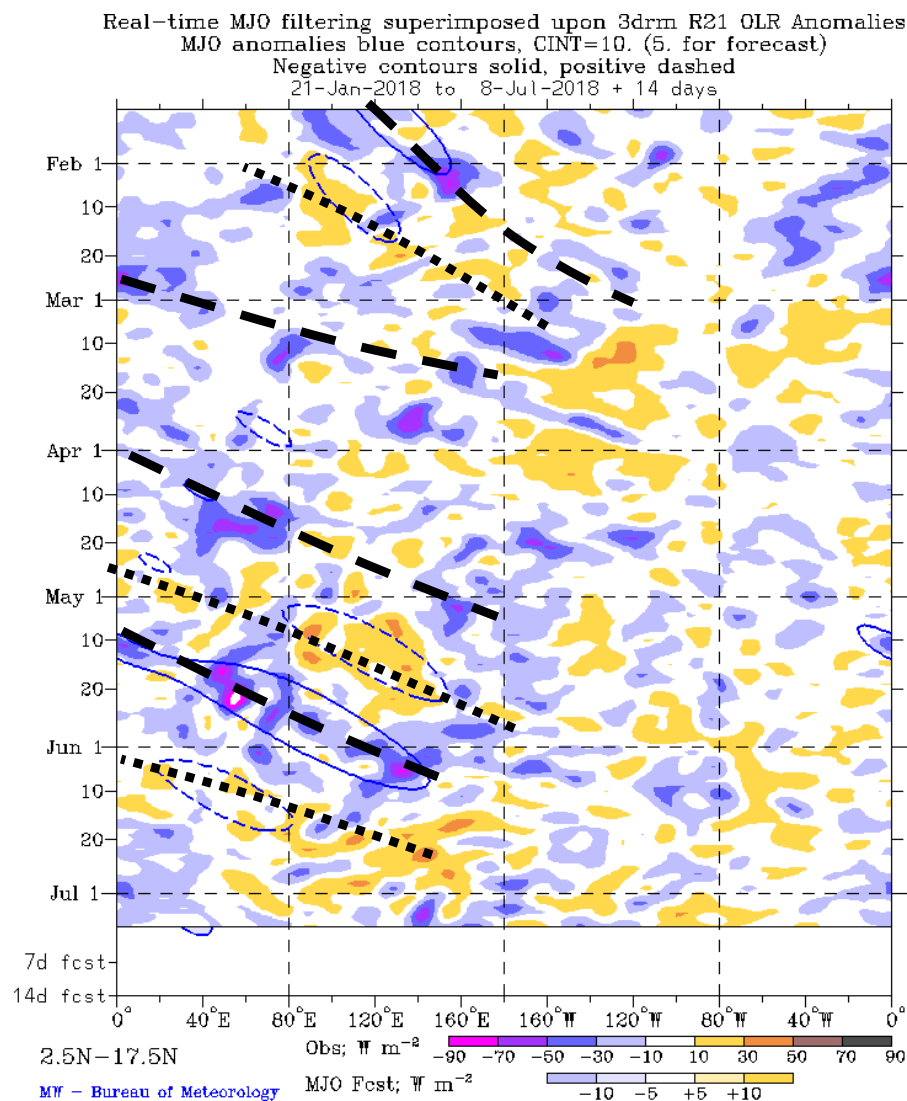
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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 (5°S - 5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

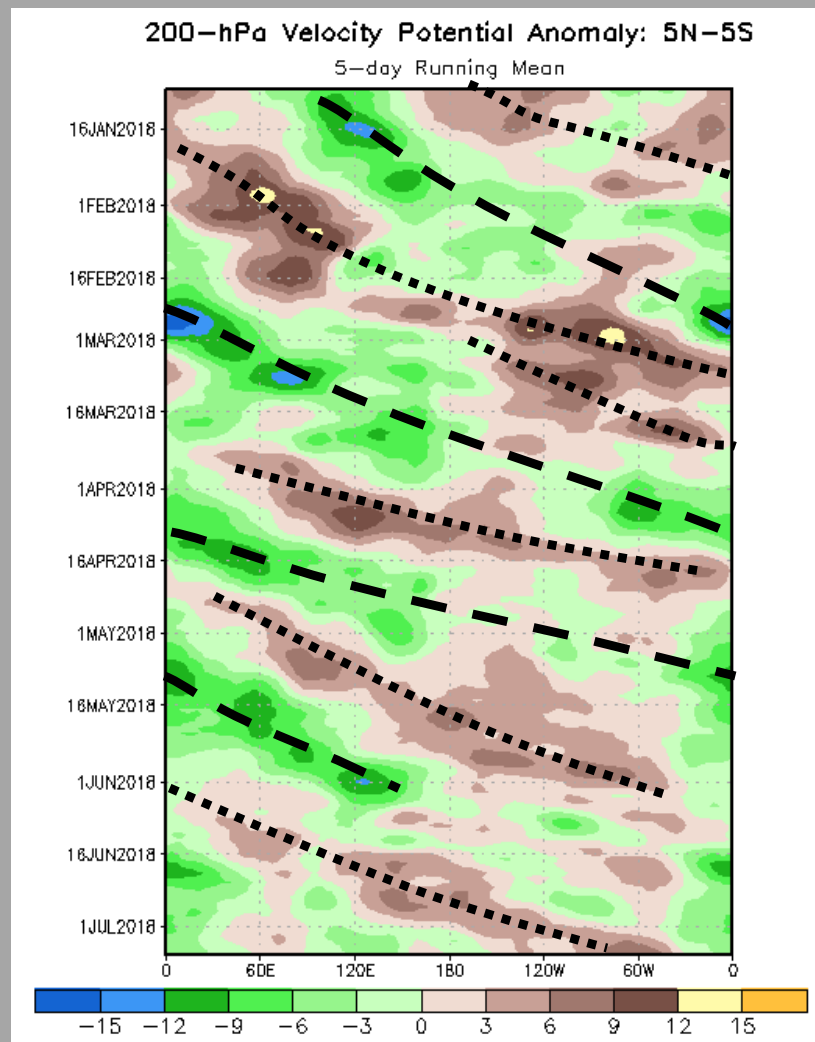
Negative anomalies (green shading) indicate favorable conditions for precipitation

The aforementioned consistent MJO activity since mid-October can be seen in the upper level velocity potential field. Additionally, there are indications of atmospheric Kelvin wave east of the Date Line during late February and early March.

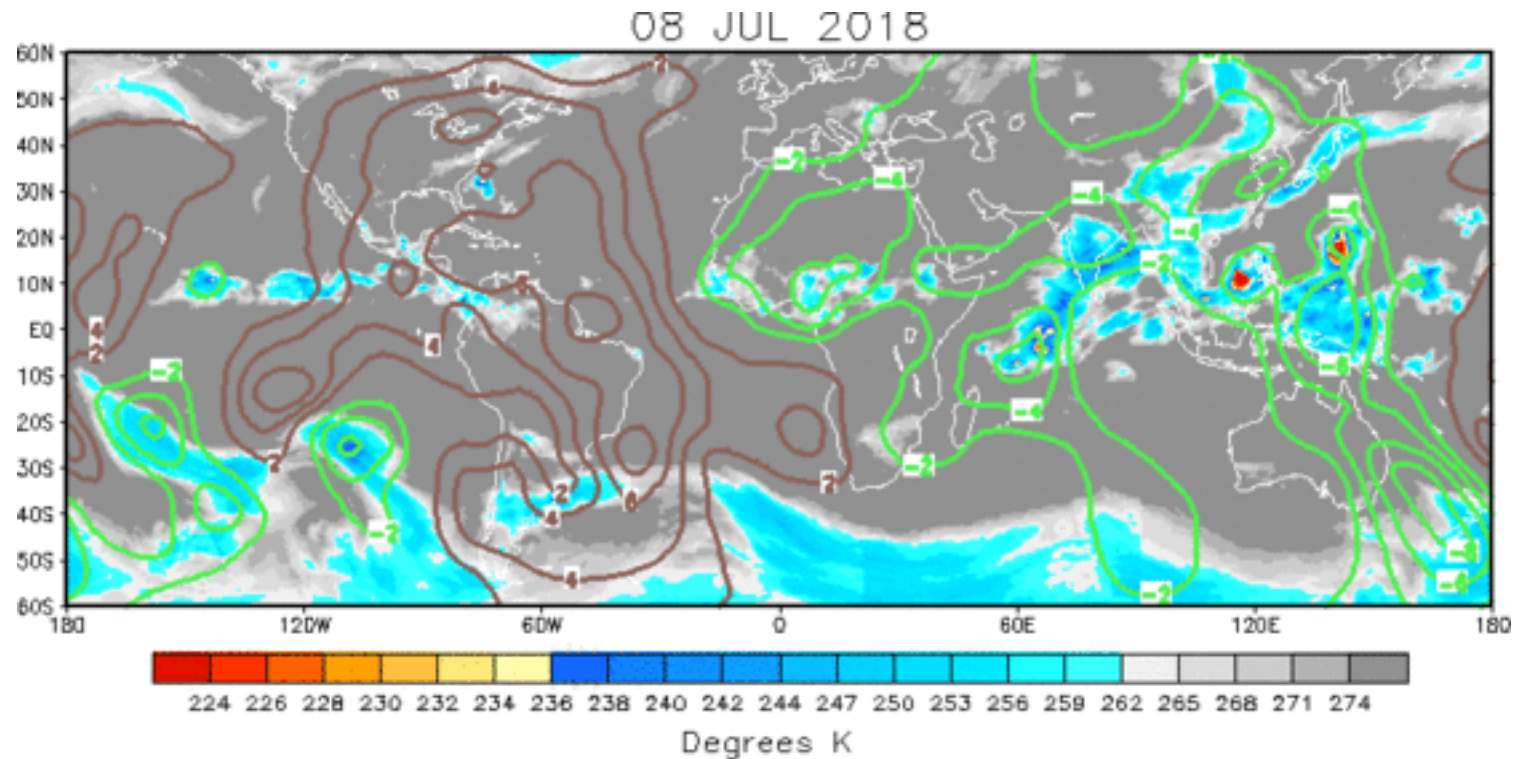
The large-scale region of suppressed convection along the Date Line associated with La Niña is less apparent in the velocity potential field than in the equatorial OLR field. This is primarily because velocity potential is a smoother field than OLR and is dominated by frequent MJO activity.

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.

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 spatial pattern of upper-level velocity potential anomalies has a fairly coherent Wave-1 asymmetry, which may indicate an emerging MJO signal, but eastward propagation of the signal has not been established.

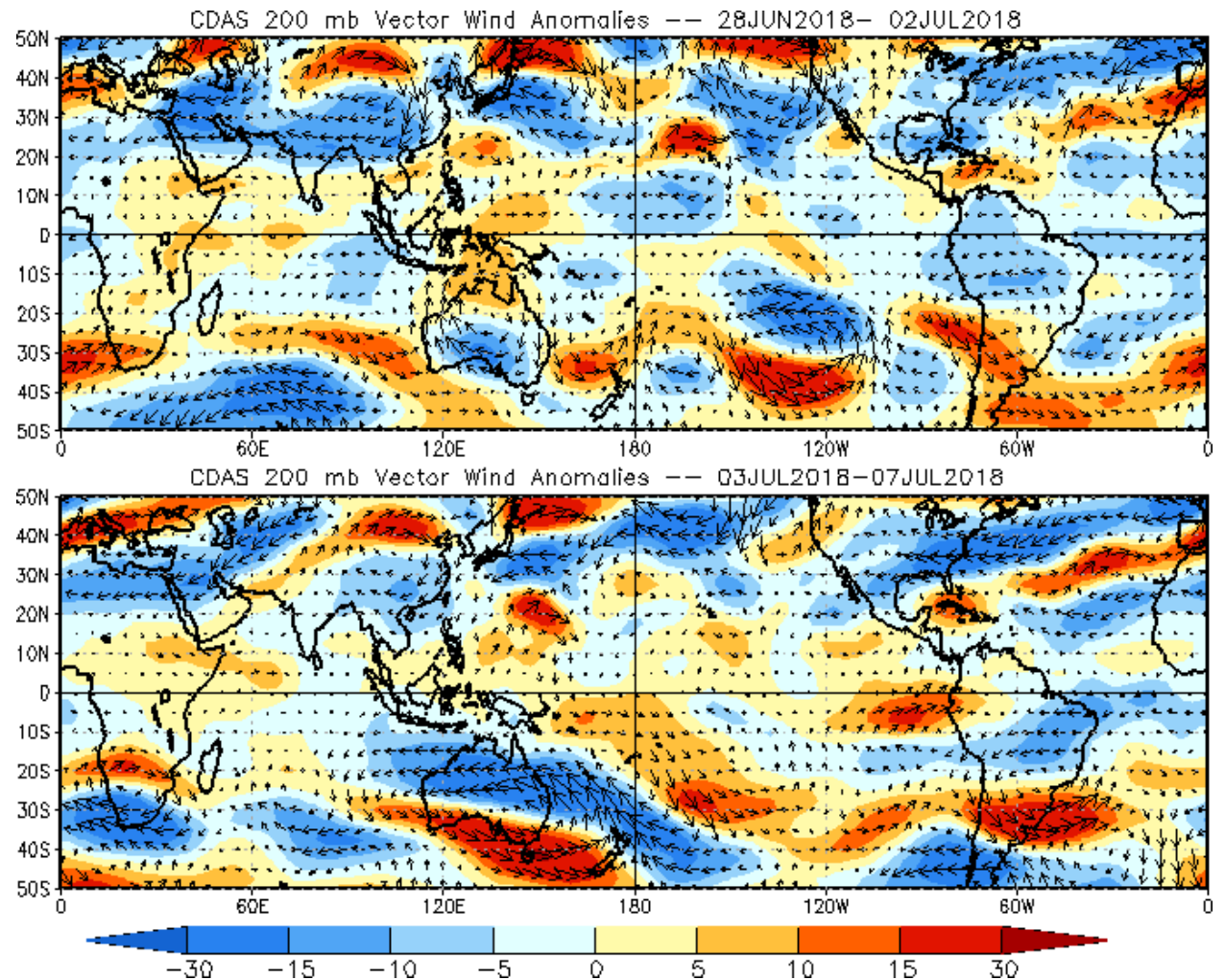
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation
Negative anomalies (green contours) indicate favorable conditions for precipitation

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 field is largely weak near the equator, with some ventilation apparent near and west of the Date Line. Another westerly maximum was observed over the equatorial East Pacific.

200-hPa Zonal Wind Anomalies (m s⁻¹)

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

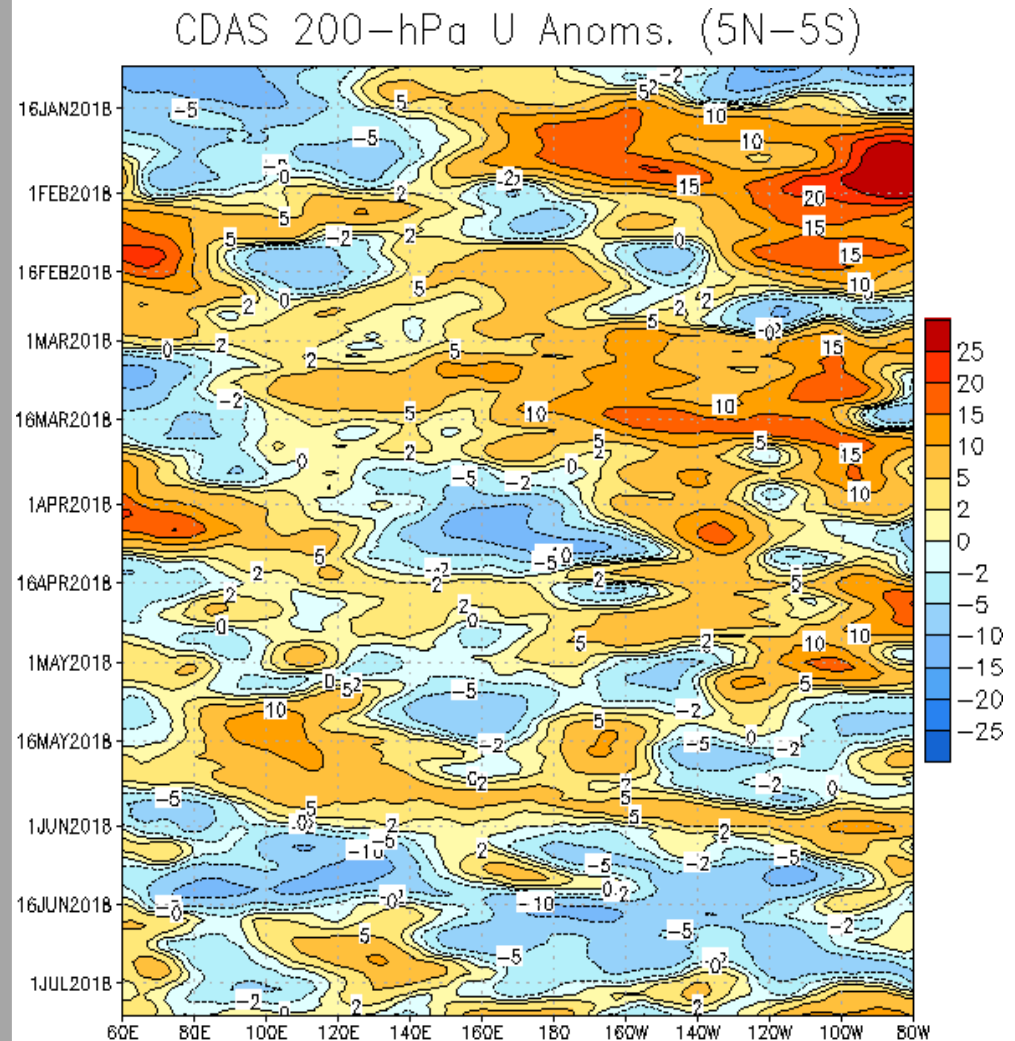
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

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 eastward from the Indian Ocean to the Americas; this pattern broke down in early June. During late June, westerly anomalies redeveloped over the Indian Ocean and propagated east to the West Pacific.

More recently, there are two regions of westerly anomalies near the equator.



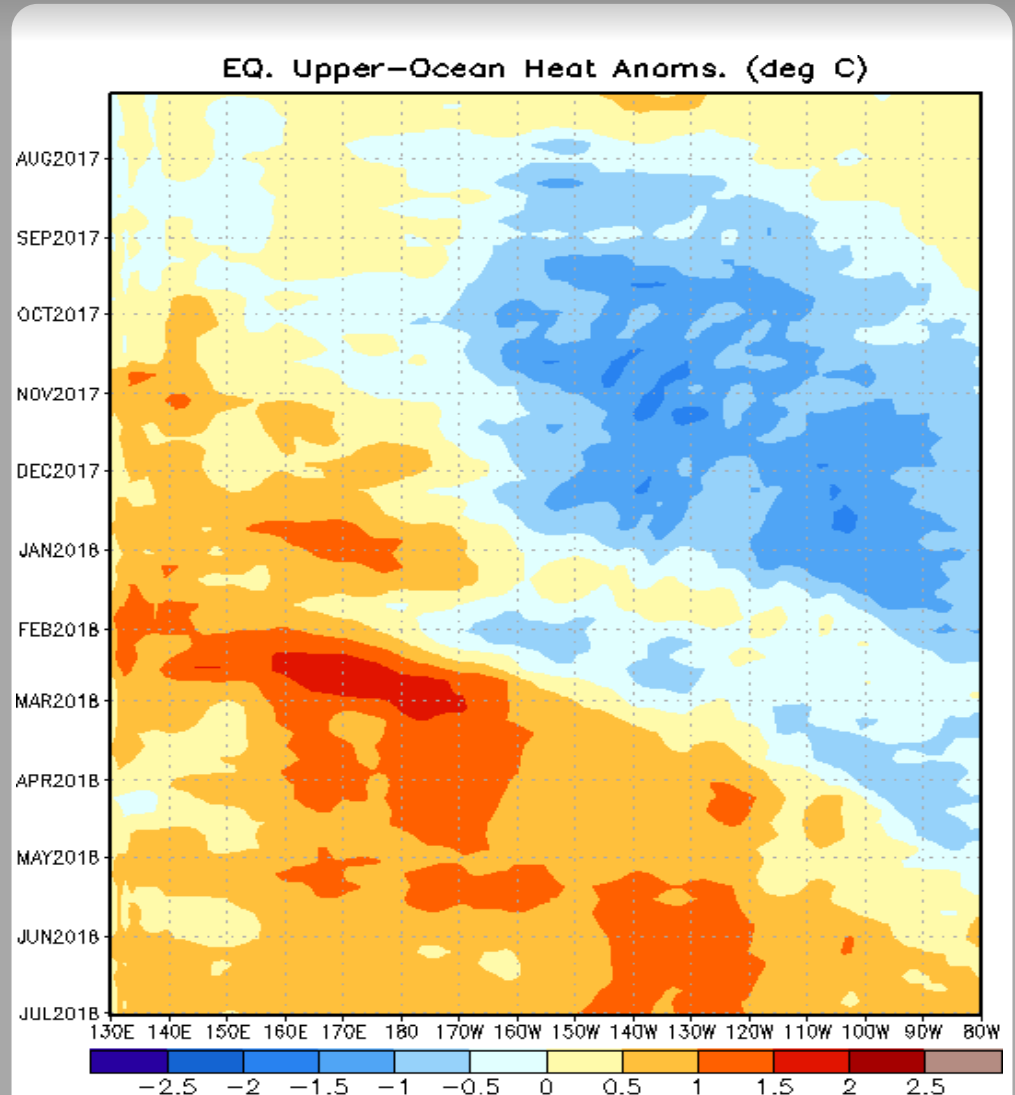
Weekly Heat Content Evolution in the Equatorial Pacific

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

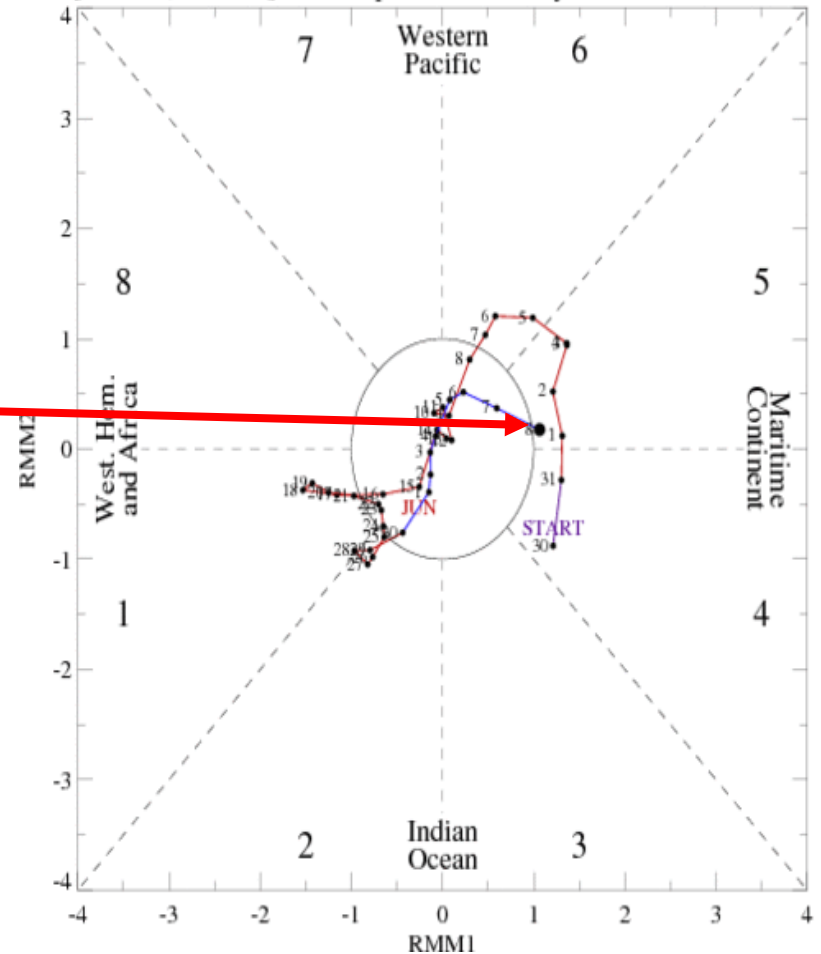
Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.

Distance from the origin is proportional to MJO strength

Line colors distinguish different months

There is a modest projection onto RMM1, suggesting an enhanced phase over the Maritime Continent.

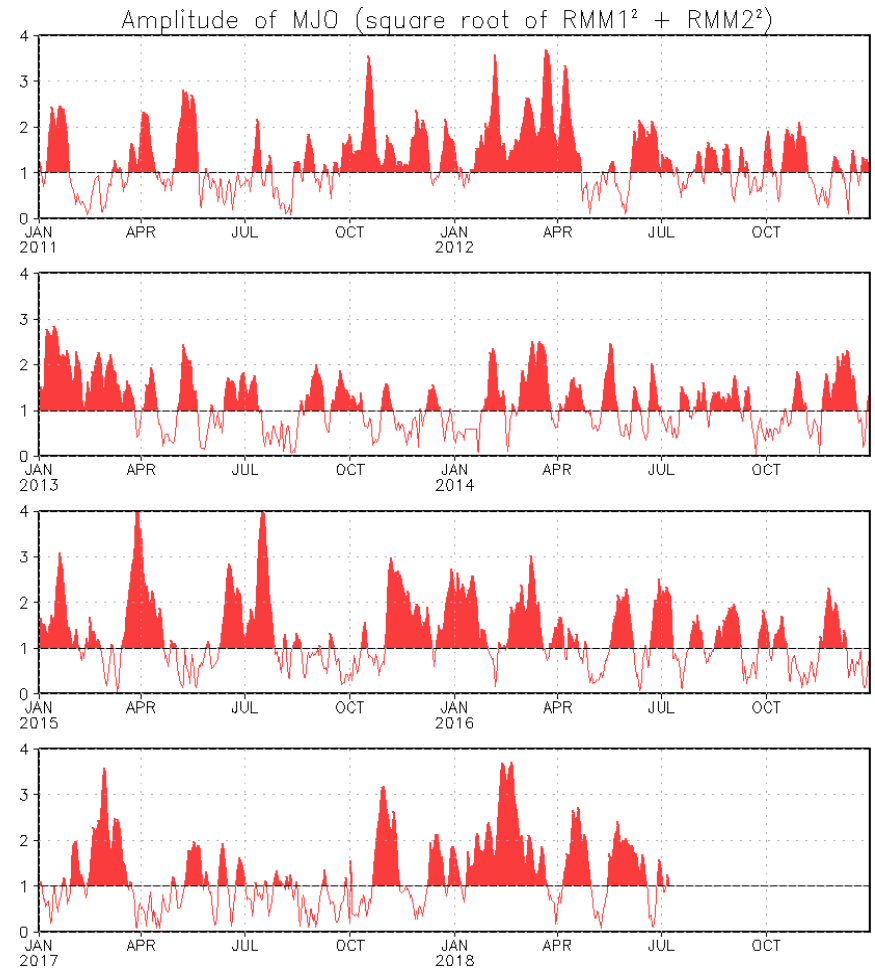
[RMM1, RMM2] Phase Space for 30-May-2018 to 08-Jul-2018



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

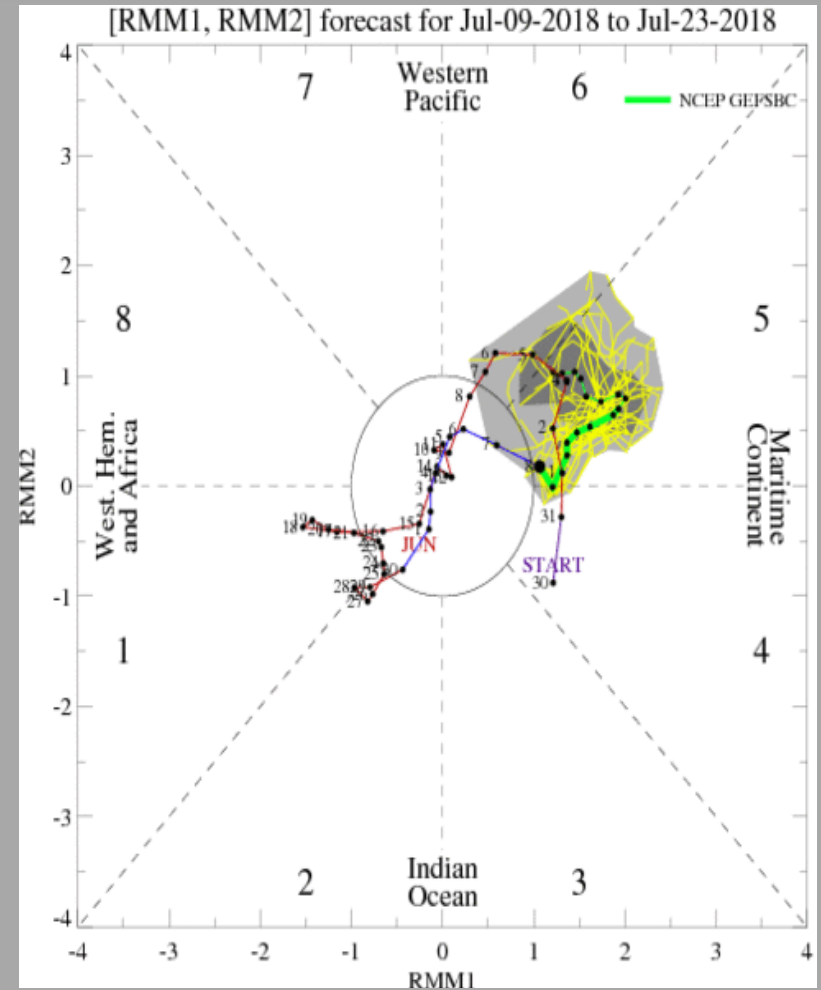
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

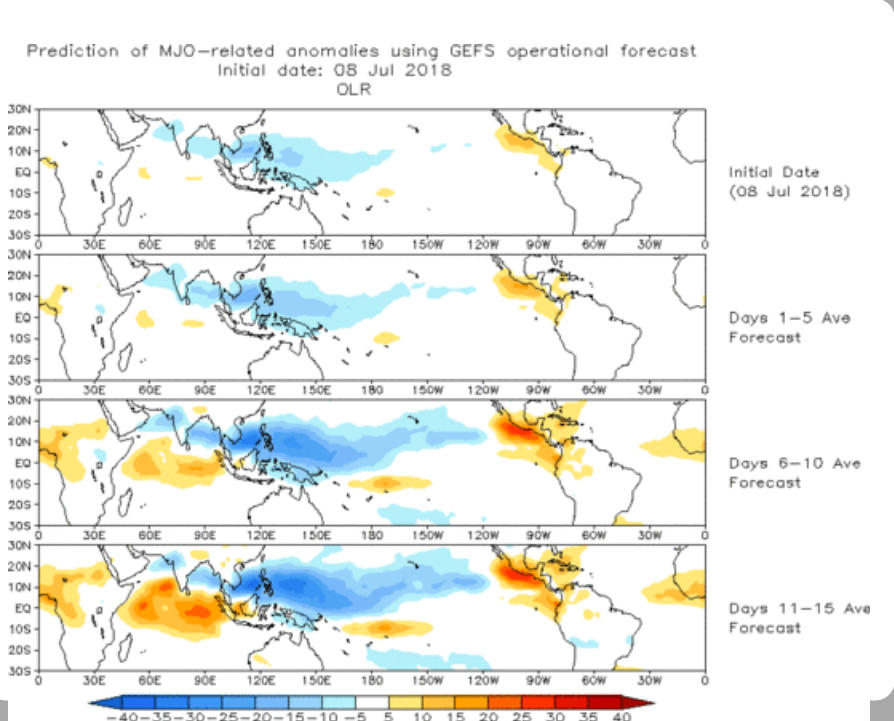
dark gray shading: 50% of forecasts

The GEFS MJO index forecasts show slow amplification of the MJO index, with some eastward propagation of the signal during Week-2.



Ensemble GFS (GEFS) MJO Forecast

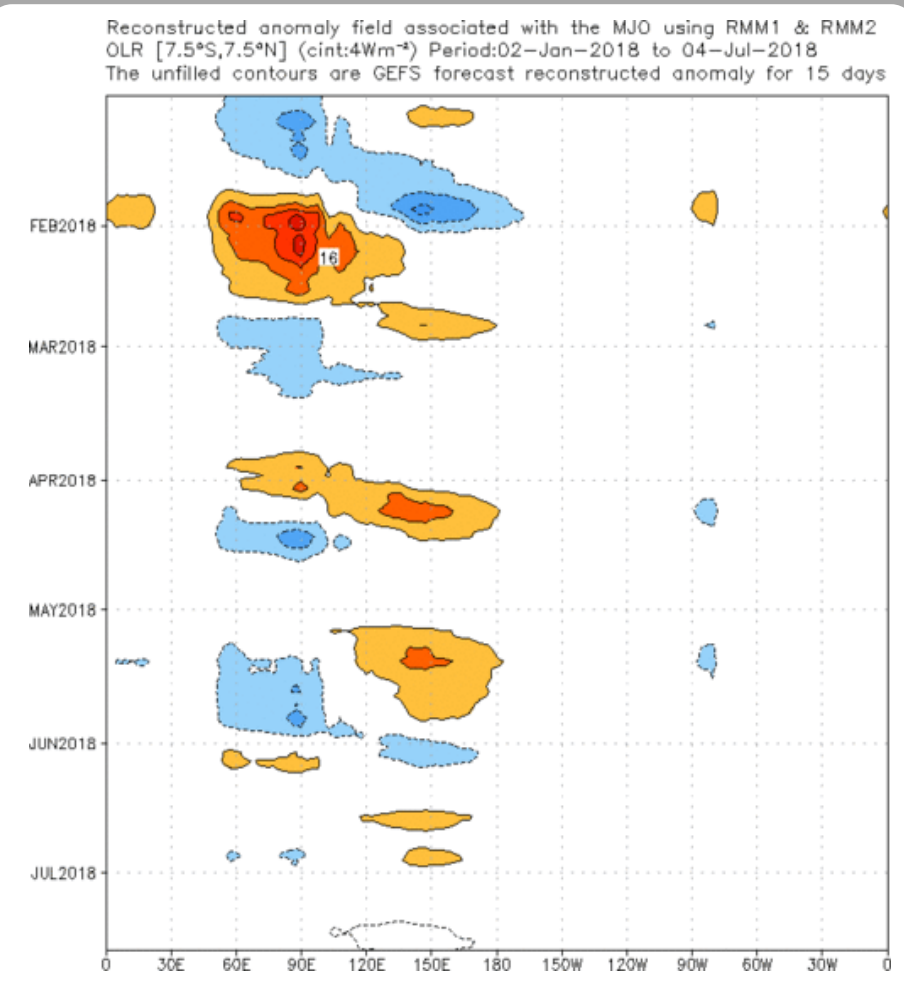
Spatial map of OLR anomalies for the next 15 days



GEFS-based OLR anomalies depict a strengthening anomaly field during the next two weeks, with little or very slow eastward propagation.

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.)

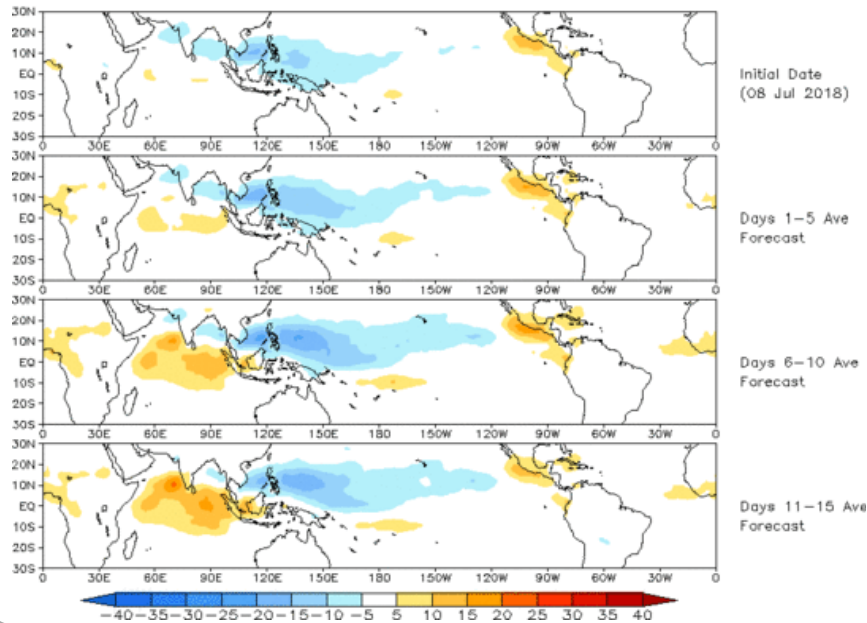
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

OLR prediction of MJO-related anomalies using CA model reconstruction by RMM1 & RMM2 (08 Jul 2018)

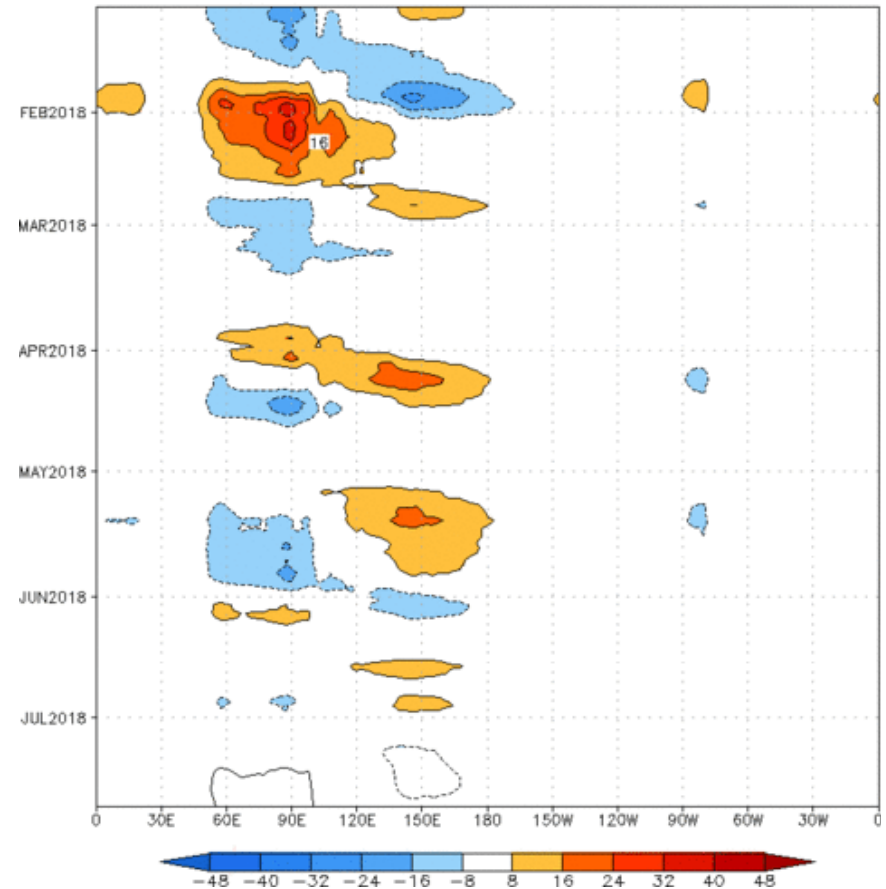


The OLR anomaly forecast based on the constructed analog MJO index forecast also depicts a slow-moving, amplifying signal.

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.)

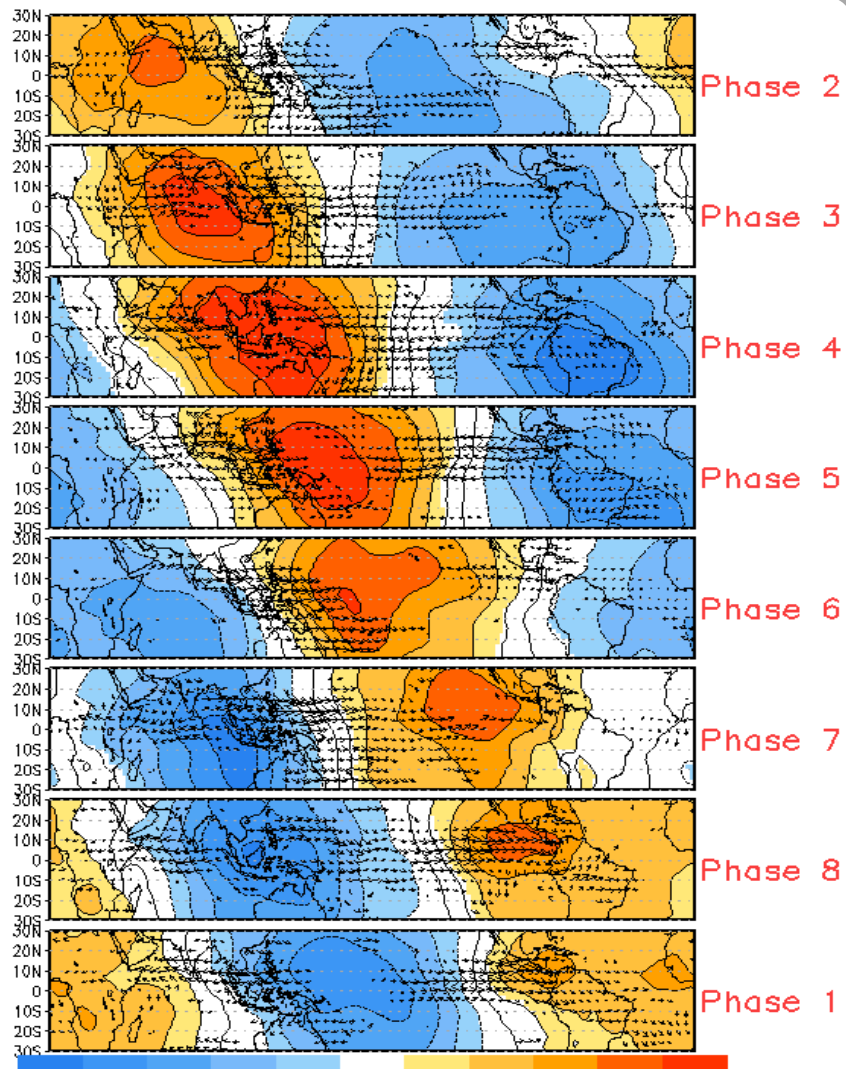
Time-longitude section of (7.5° S- 7.5° N) OLR anomalies - last 180 days and for the next 15 days

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [7.5° S, 7.5° N] (cont:4 Wm^{-2}) Period:06-Jan-2018 to 08-Jul-2018
The unfilled contours are CA forecast reconstructed anomaly for 15 days

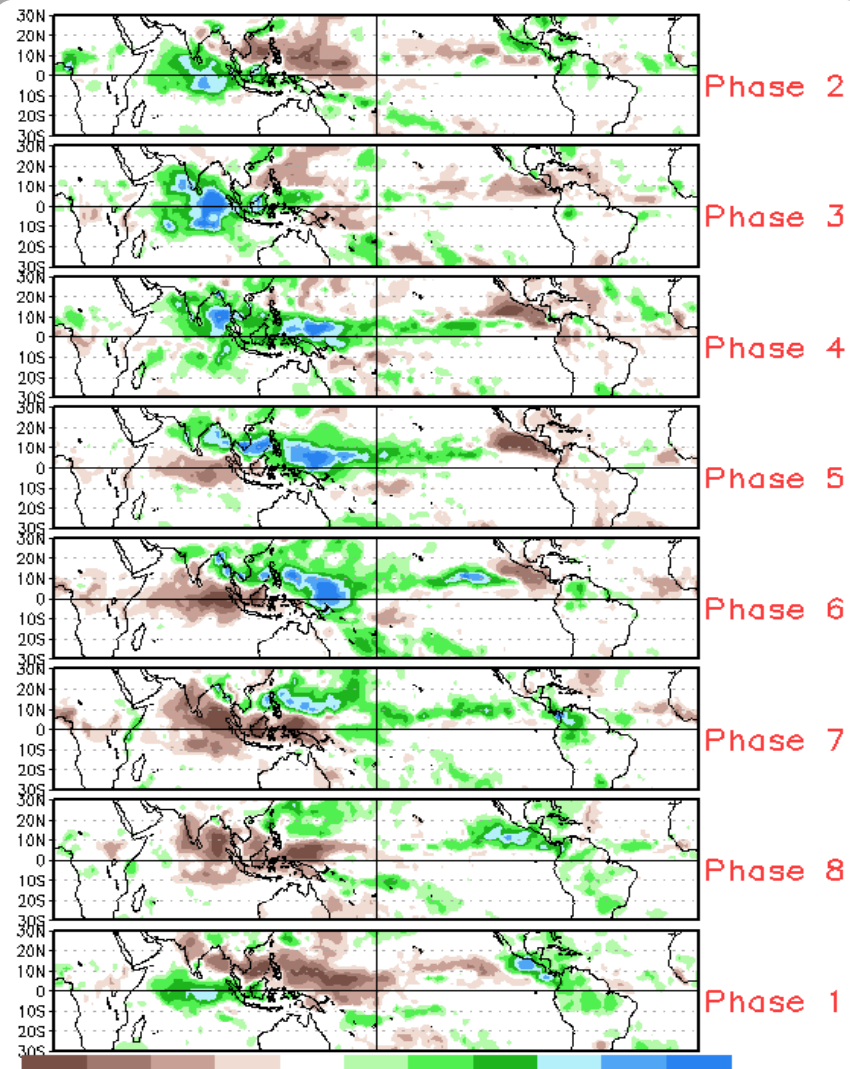


MJO Composites - Global Tropics

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



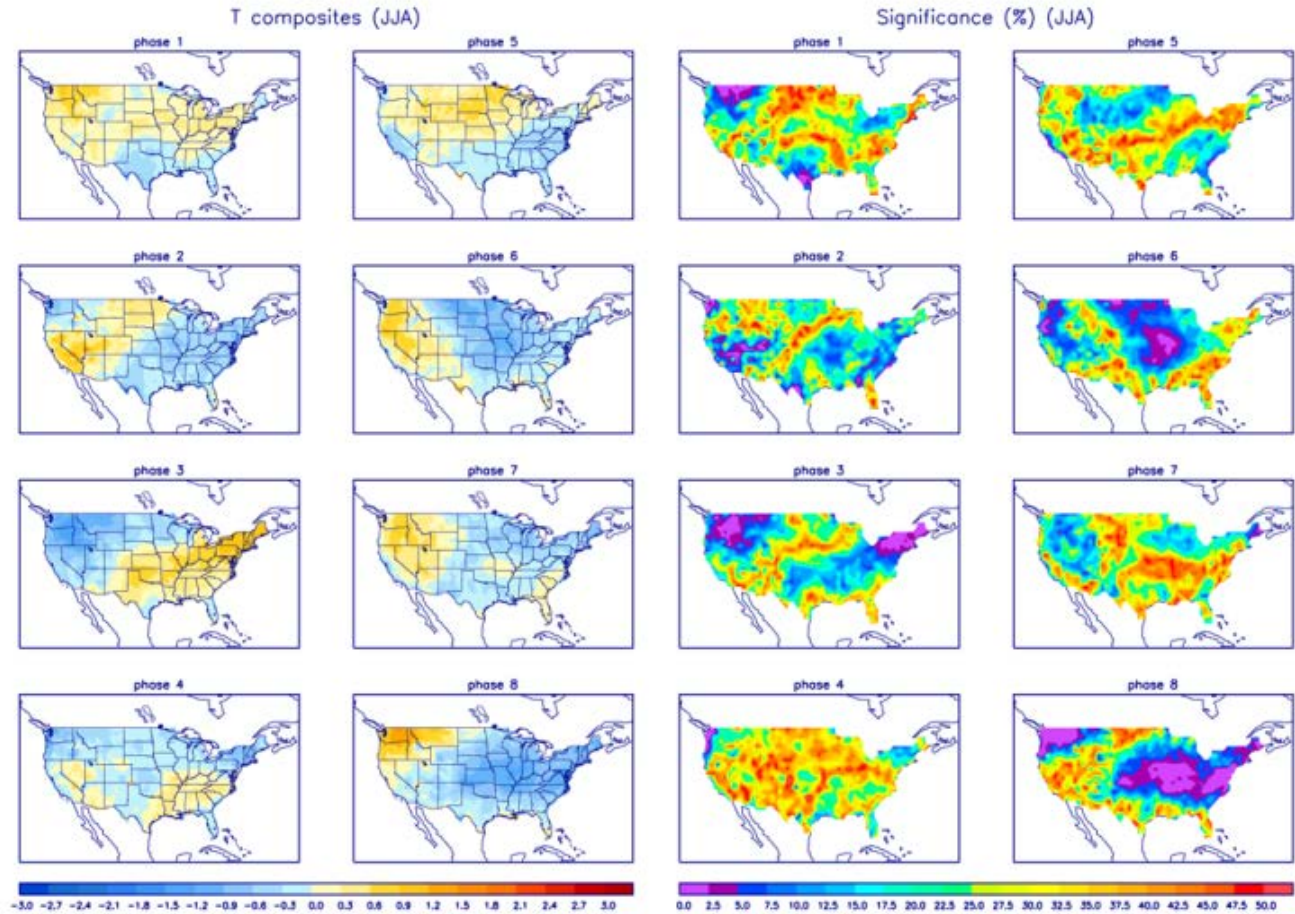
Precipitation Anomalies (May - Sep)



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.



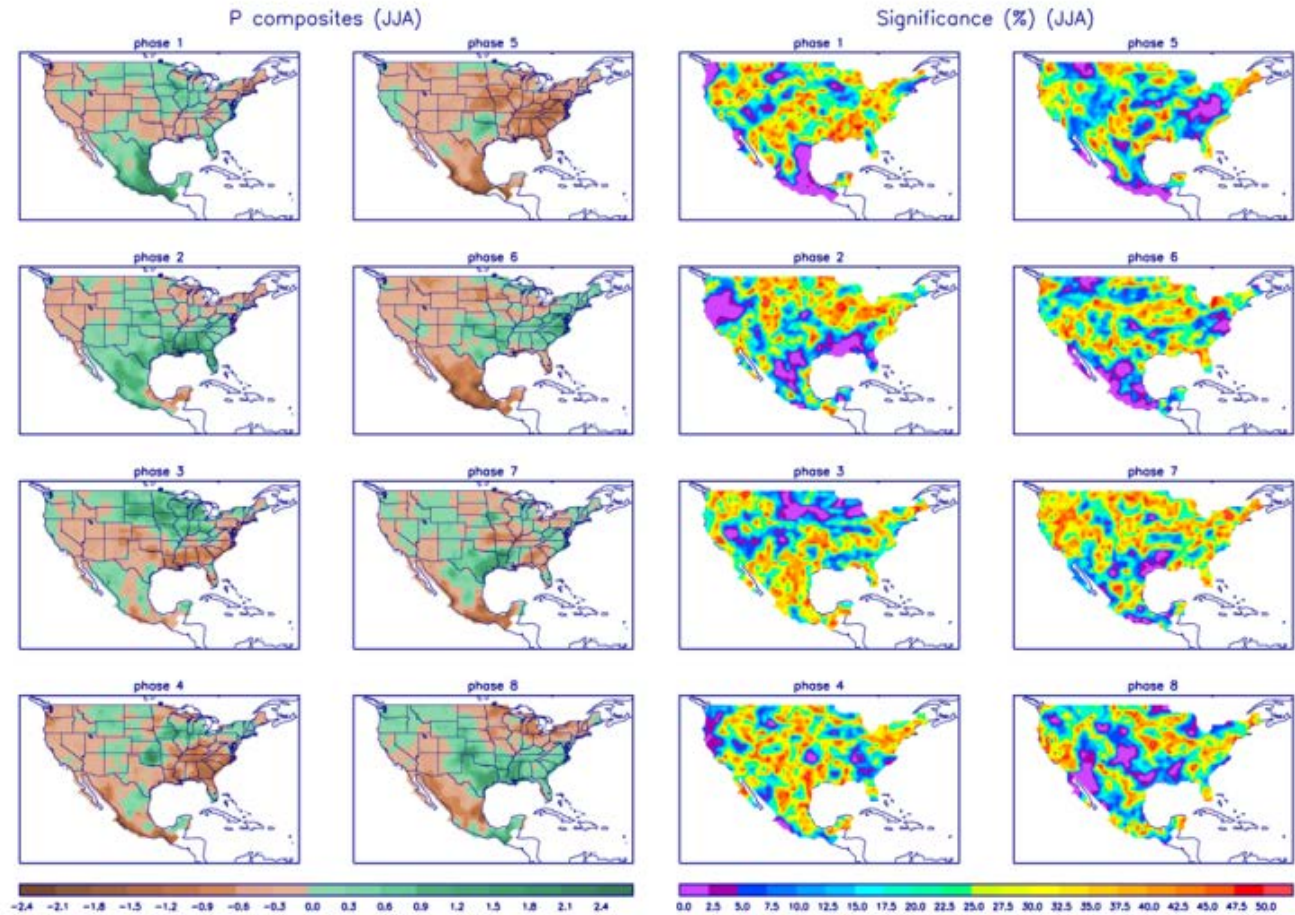
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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.



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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