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

- After crossing Africa, the MJO re-emerged over the Indian Ocean and its convective phase propagated quickly over the Indian Ocean and Maritime Continent, coincident with Kelvin wave activity.

- Dynamical models forecast a rapid weakening in the MJO signal in Week-1, with no indication of re-emergence in Week-2.

- An atmospheric Kelvin wave is likely to influence convection over the Pacific through early June, including the likelihood of two tropical cyclones forming in the east Pacific.

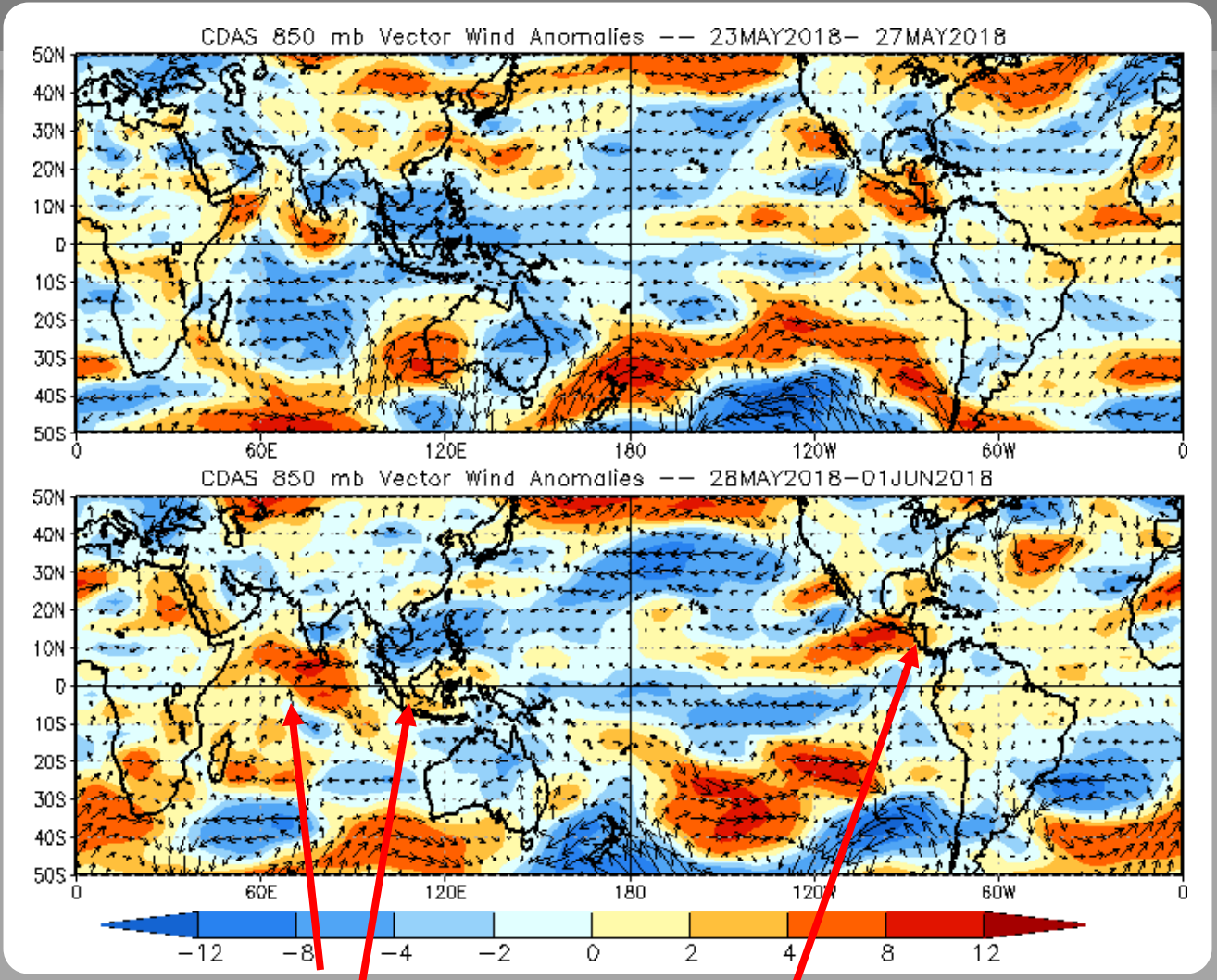
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies shifted east from the Indian Ocean to the Maritime Continent, pushing out persistent easterlies

Westerly anomalies continue to expand and strengthen east across Central America to the western Caribbean Sea

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

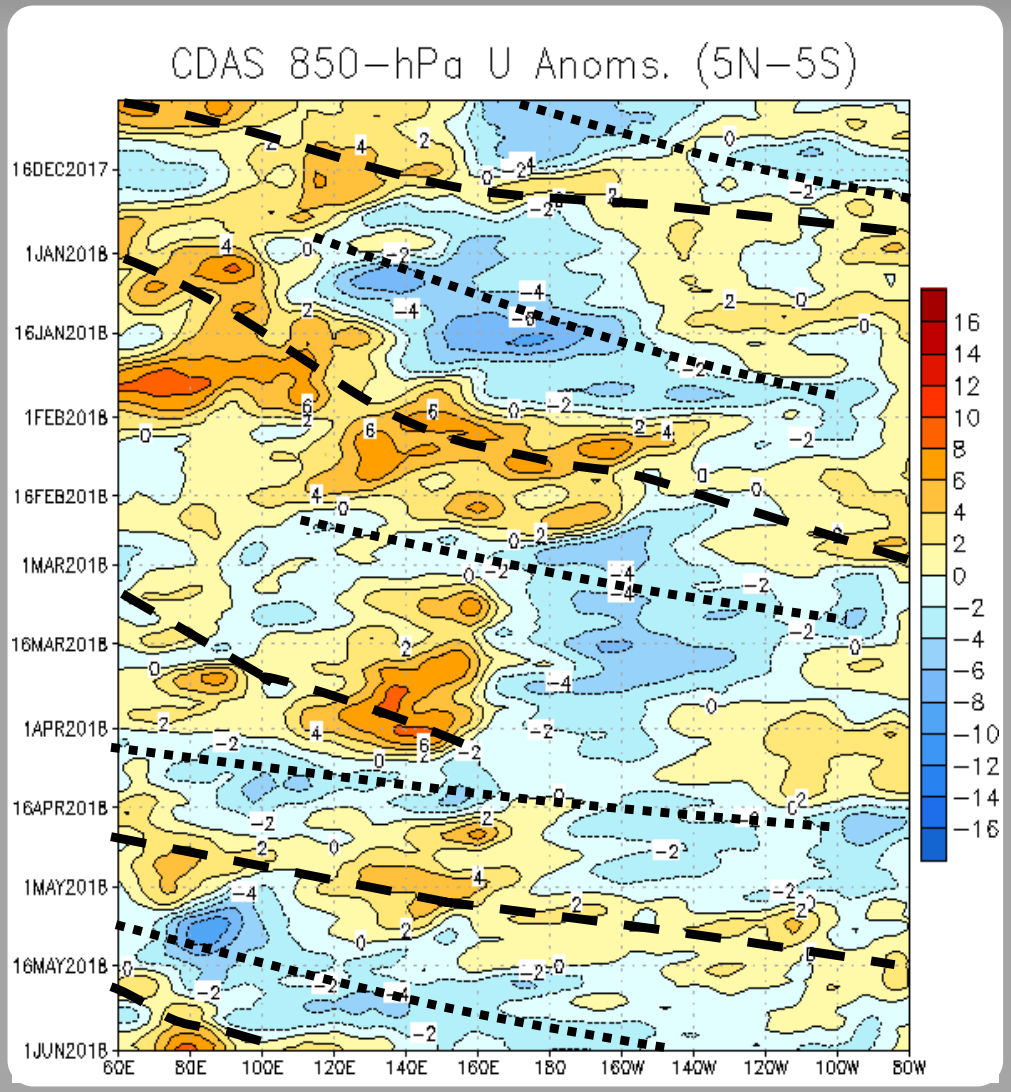
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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 most recent eastward moving packet of anomalous westerlies is currently moving back over the Indian Ocean, with time speeds on the relatively fast end of the MJO envelope (approximately 35-40 days).



OLR Anomalies – Past 30 days

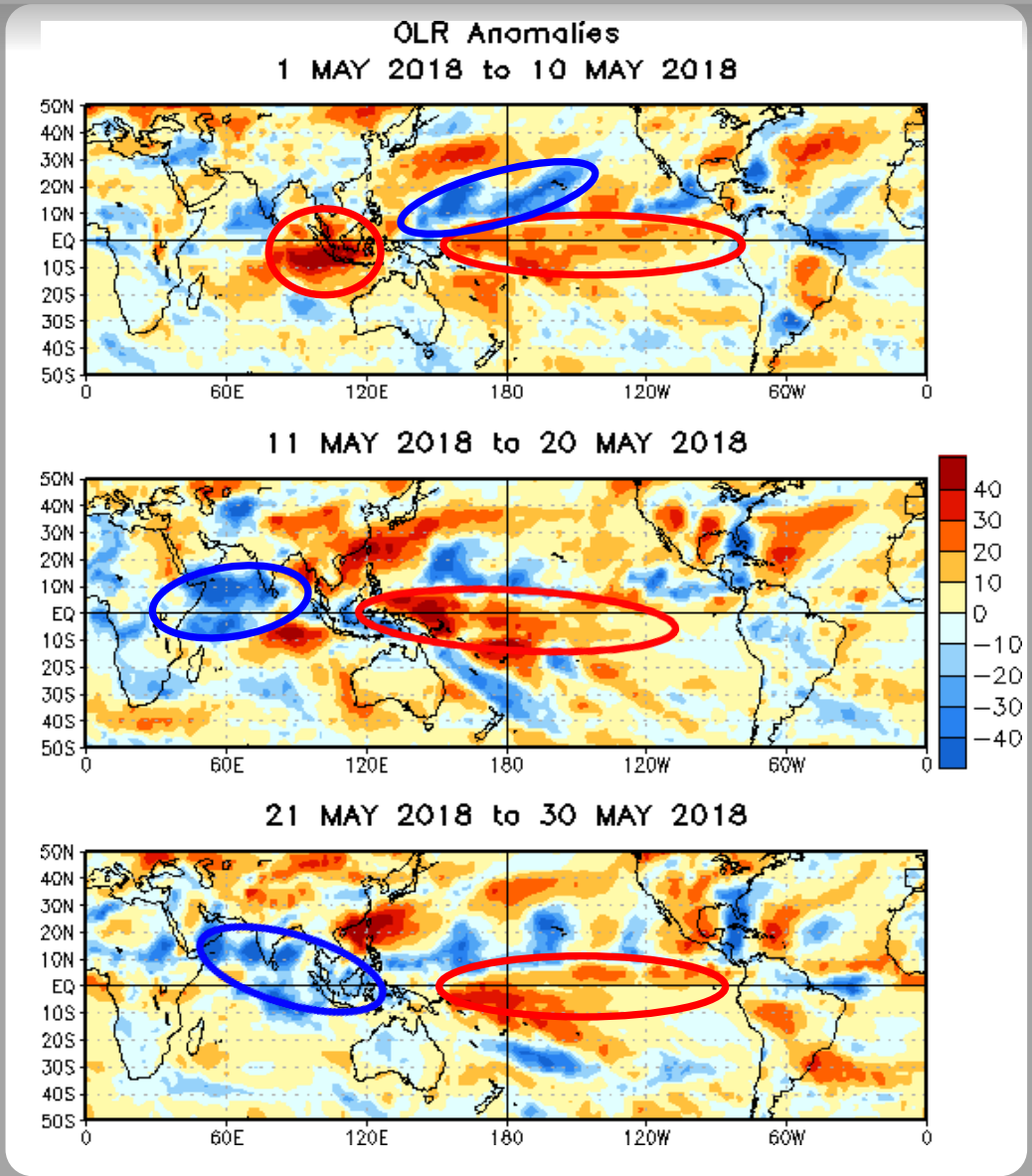
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During early May, enhanced convection was observed from the Philippines east to Hawaii, while the suppressed phase of the MJO shifted east over the Indian Ocean. Low frequency signals continued to suppress convection near the Date Line and across the East Pacific.

An equatorial Rossby Wave contributed to enhanced convection across the western Indian Ocean during early to mid-May, while enhanced convection across Africa was associated with reemergence of the MJO.

Toward the end of May, the enhanced convection expanded to cover most of the Indian Ocean and parts of the Maritime Continent, in association with the MJO. The magnitude of the anomalies has weakened from the previous week.



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

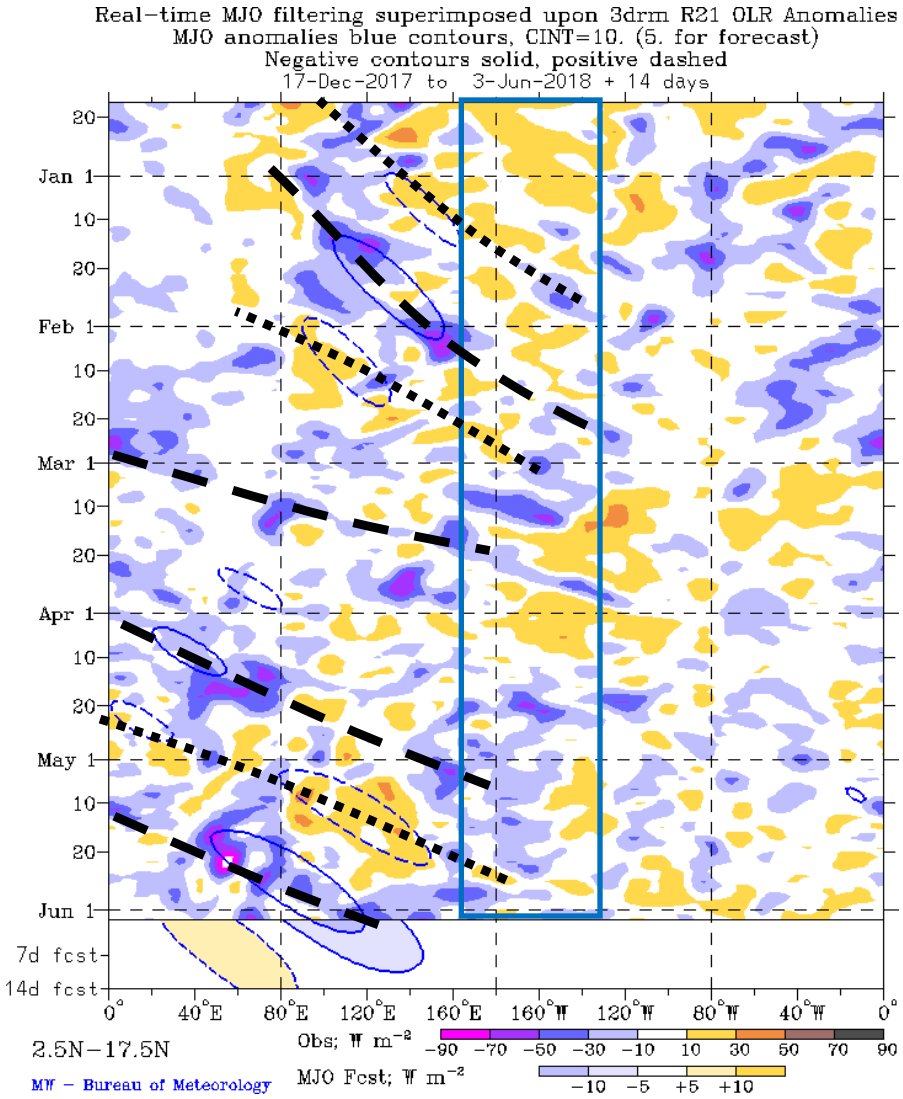
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

There has been consistent MJO activity since last October. During early February the MJO was strong enough to temporarily reverse the low-frequency dry signal associated with La Niña along the Date Line (blue box).

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. Recently, the enhanced phase of the MJO shifted east over the western Indian Ocean and parts of the Maritime Continent.



200-hPa Velocity Potential Anomalies (5°S - 5°N)

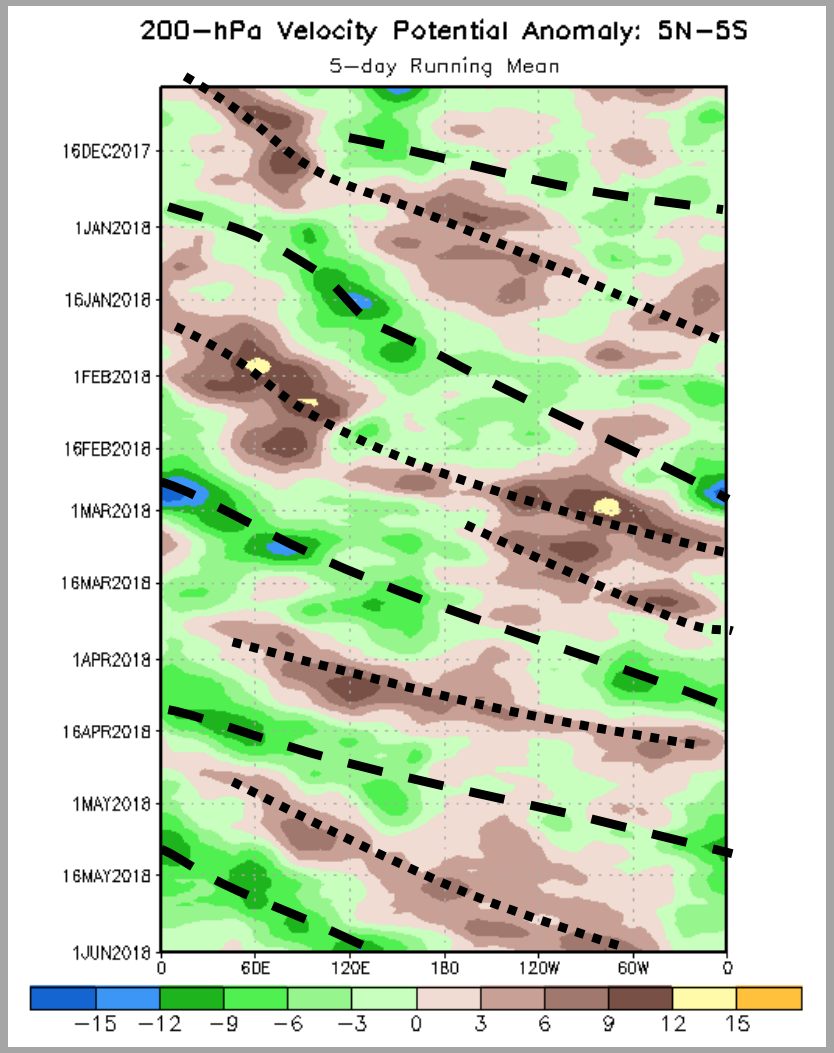
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

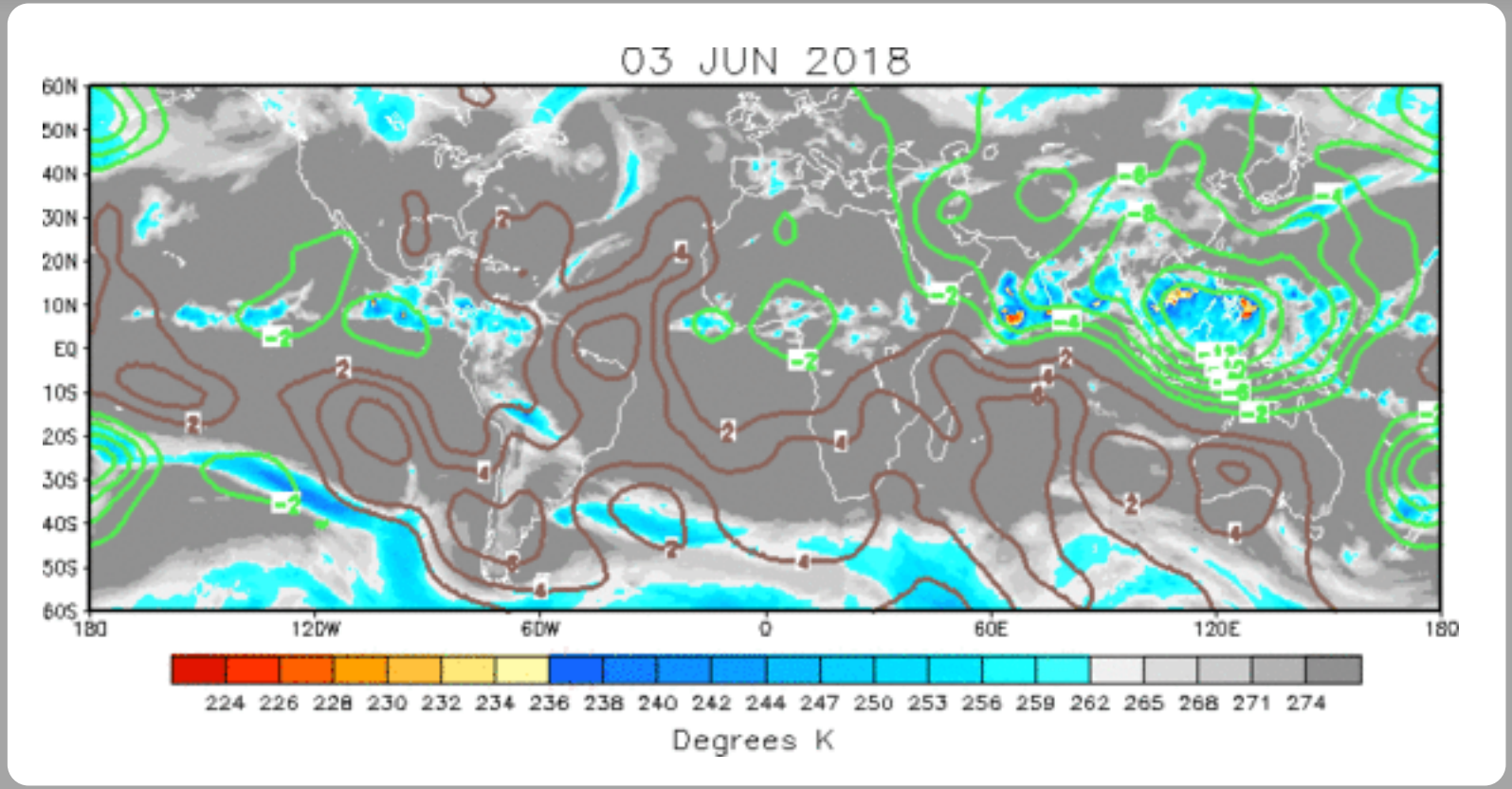
The aforementioned consistent MJO activity since mid-October can be seen in the upper level velocity potential field. Additionally, there are indications of atmospheric Kelvin wave east of the Date Line during late February and early March.

The large-scale region of suppressed convection along the Date Line associated with La Niña is less apparent in the velocity potential field than the 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. Multiple tropical modes of variability contributed to the enhanced convection over Africa and the western Indian Ocean, including the convective envelope of the MJO.



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



The upper-level velocity potential field is very noisy, with one strong convective signal over the Indian Ocean and Maritime Continent in association with the coherent active phase of the MJO. Suppression is currently widespread over much of the southern hemisphere. Weak Rossby wave activity is apparent over Africa.

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)

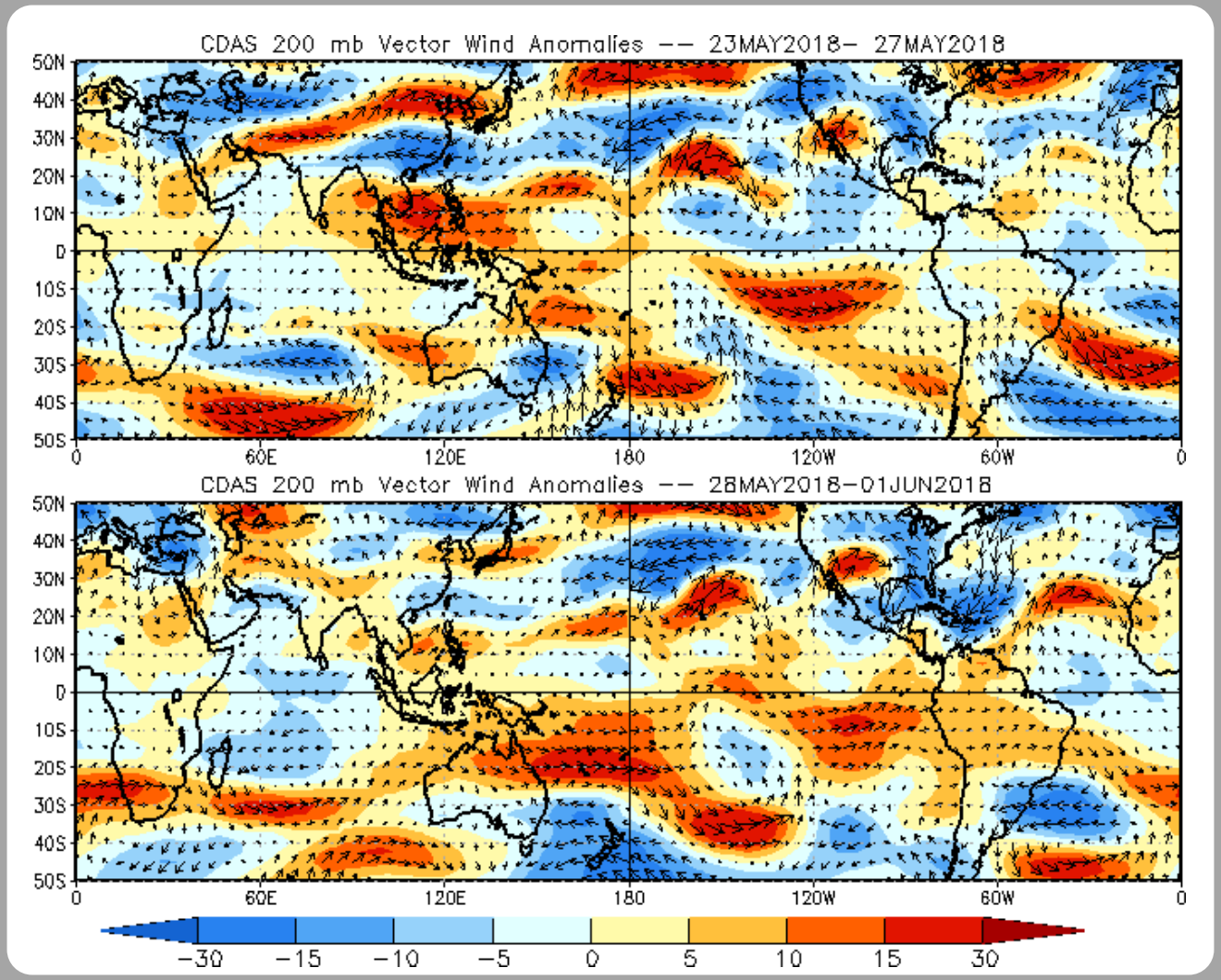
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

The upper-level zonal wind anomaly field has remained weak over through much of the equatorial region through the past few weeks, while anomalies in the Southern Pacific and parts of the Atlantic have strengthened.

The westerlies anomalies at 200-hPa over the Maritime Continent have weakened drastically over the past week.



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

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

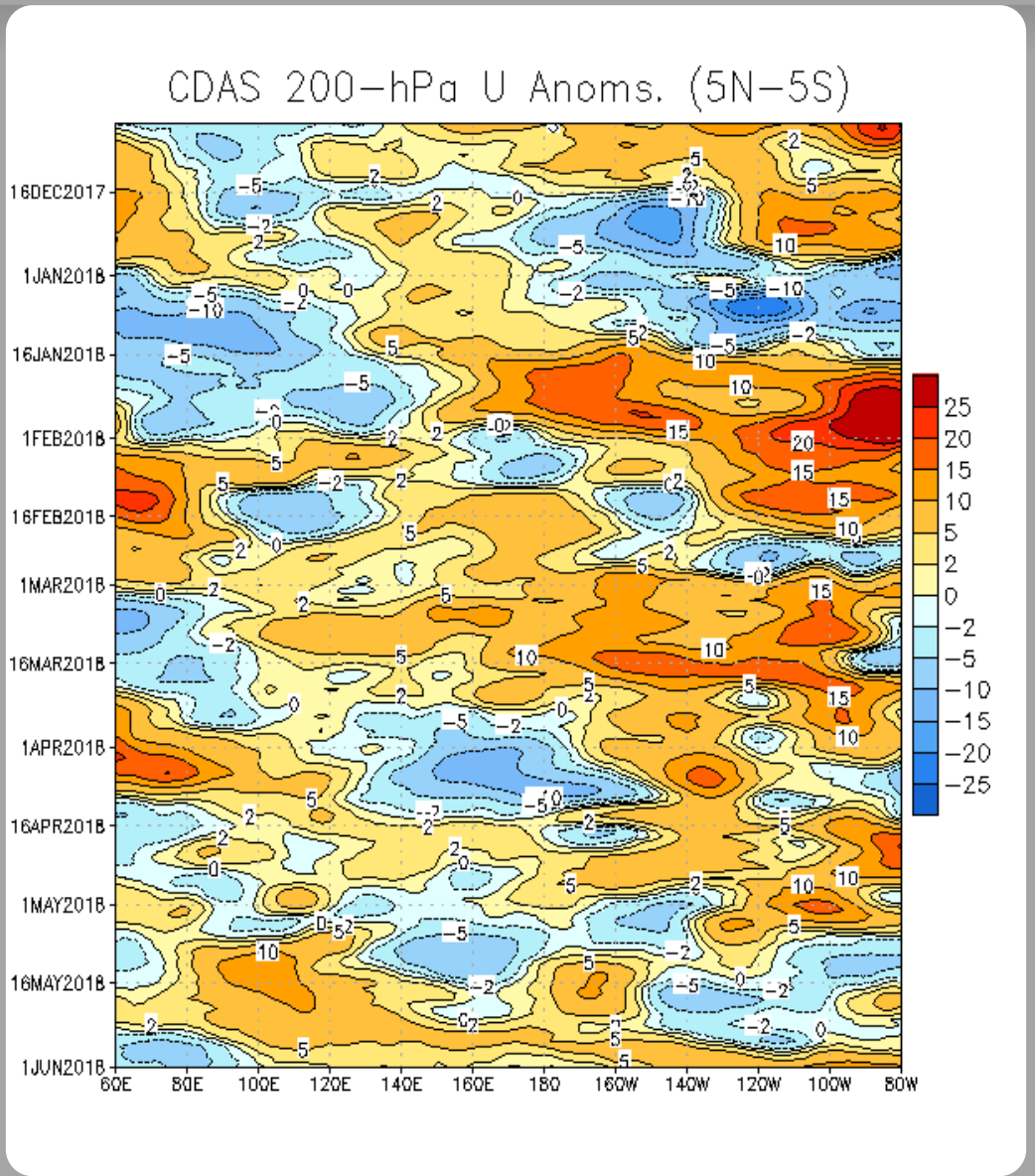
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

In mid-December, strong easterly anomalies developed east of the Date Line, briefly replacing the westerly anomalies that had been generally present since October.

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.



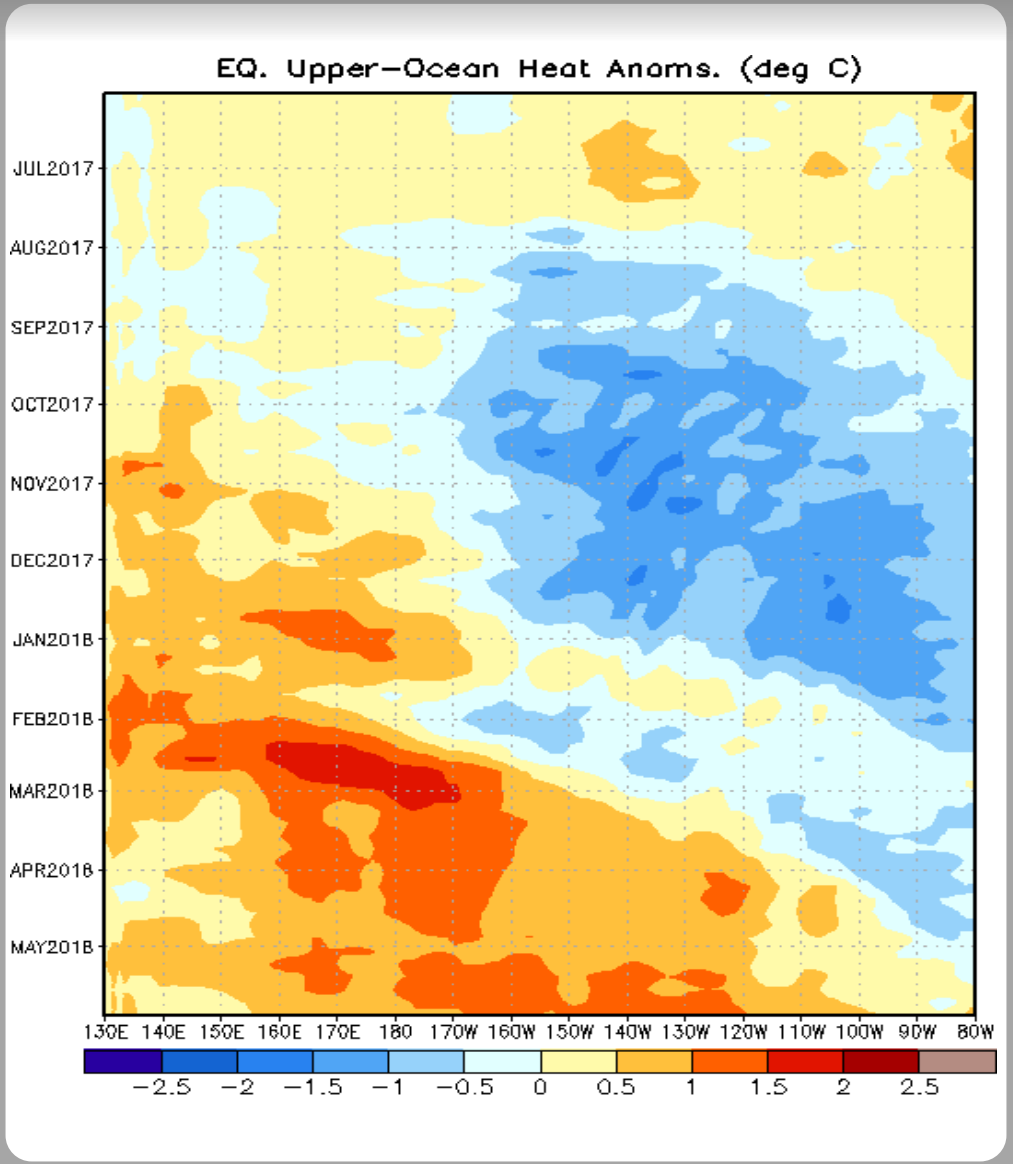
Weekly Heat Content Evolution in the Equatorial Pacific

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

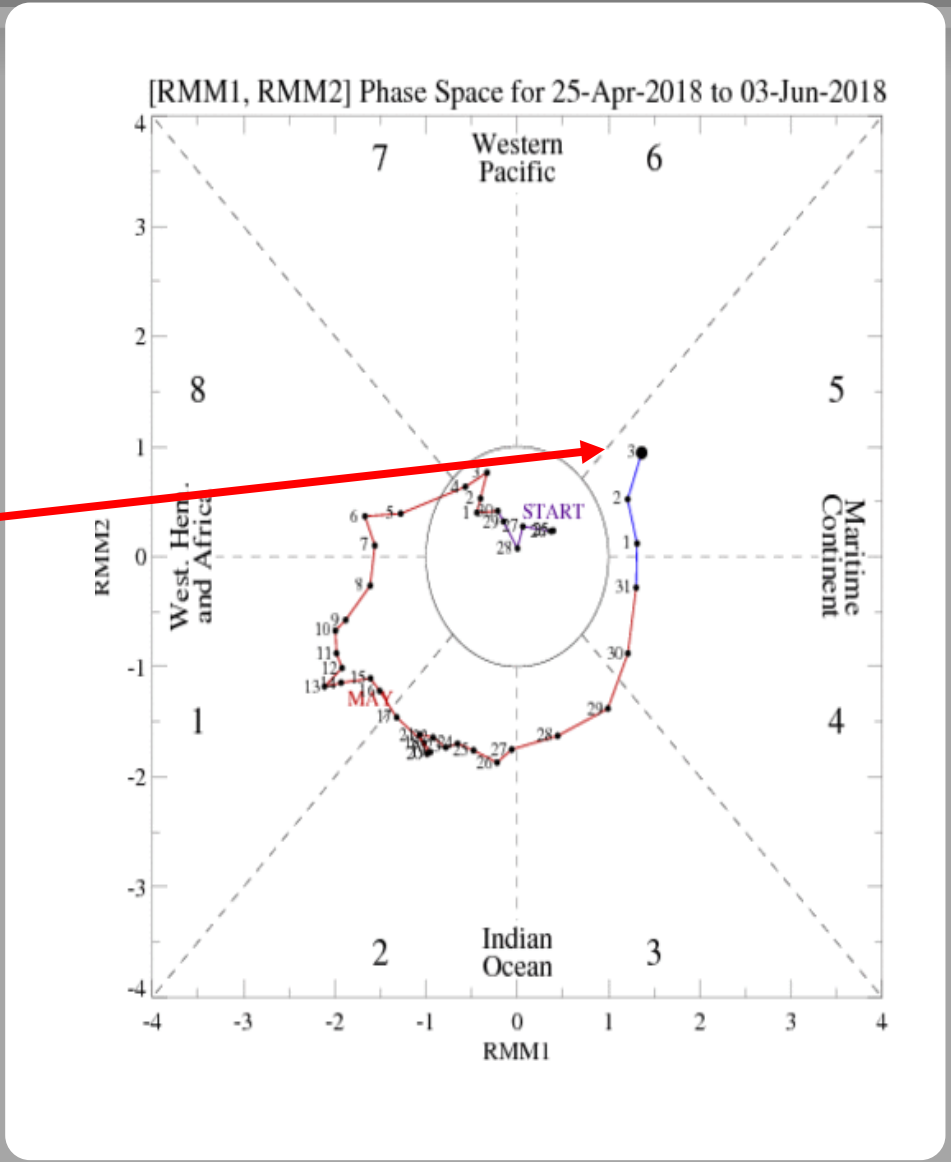
Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.

Distance from the origin is proportional to MJO strength

Line colors distinguish different months

The RMM-based MJO projection indicates continued eastward propagation of the MJO since early May with a fairly consistent amplitude.

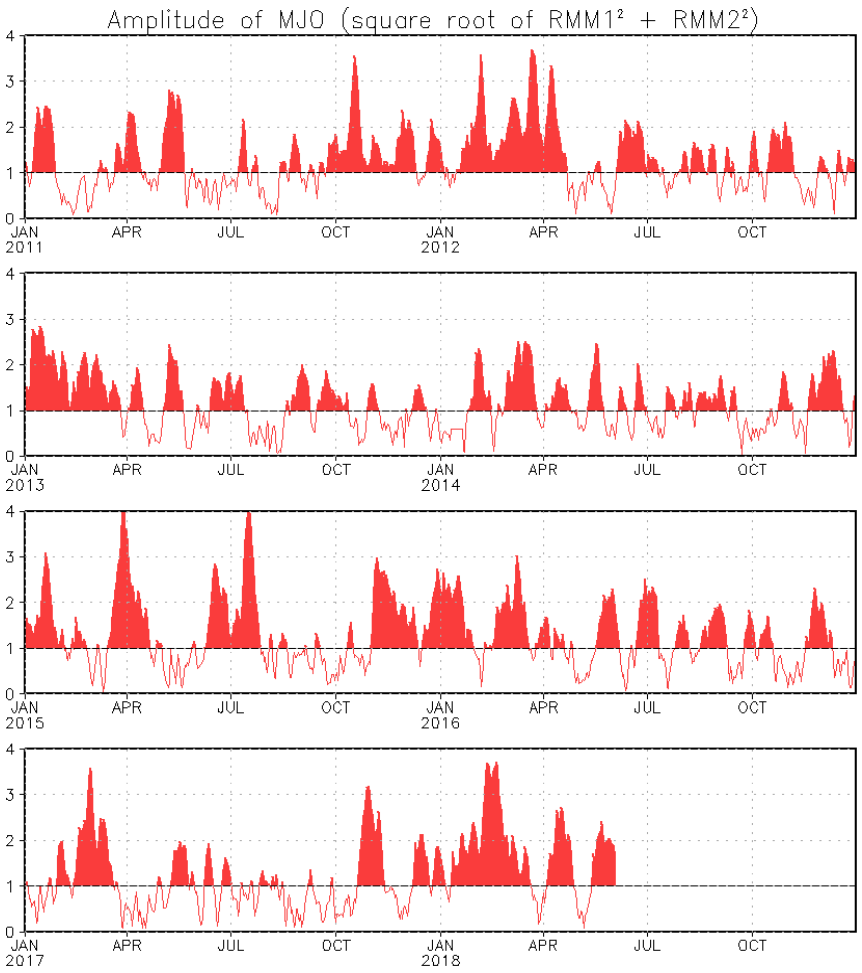
The most recent observations indicate that the MJO is in phase 5, with the enhanced convective envelope over the Maritime Continent.



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

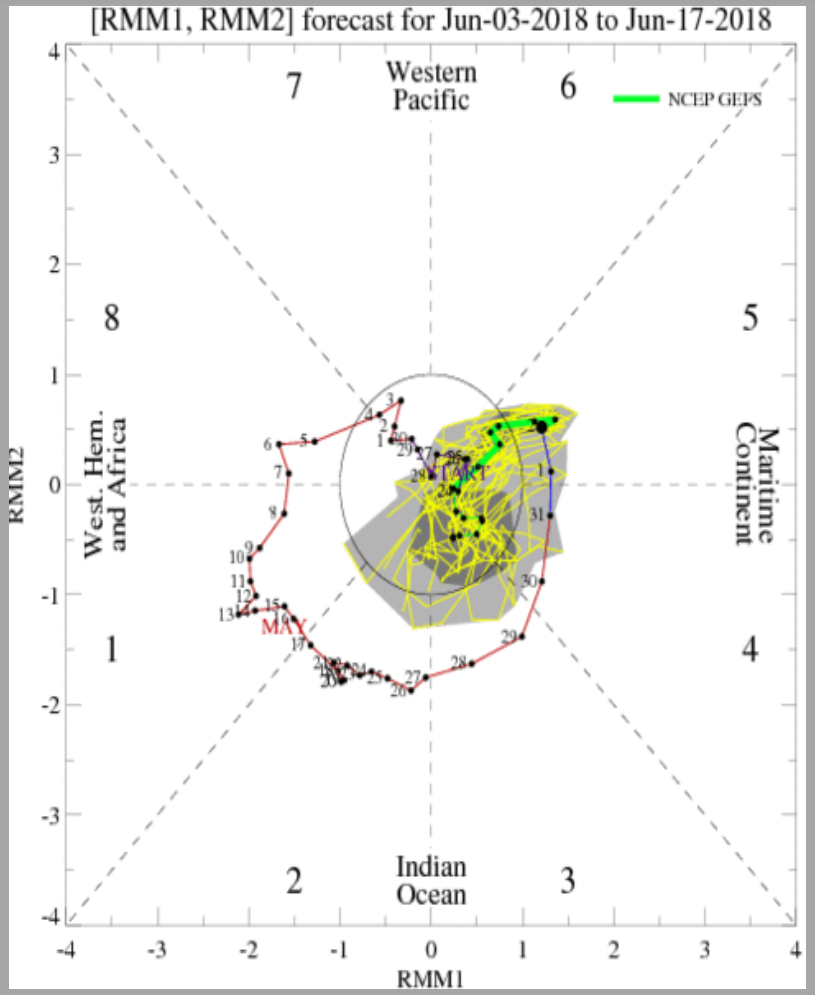
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

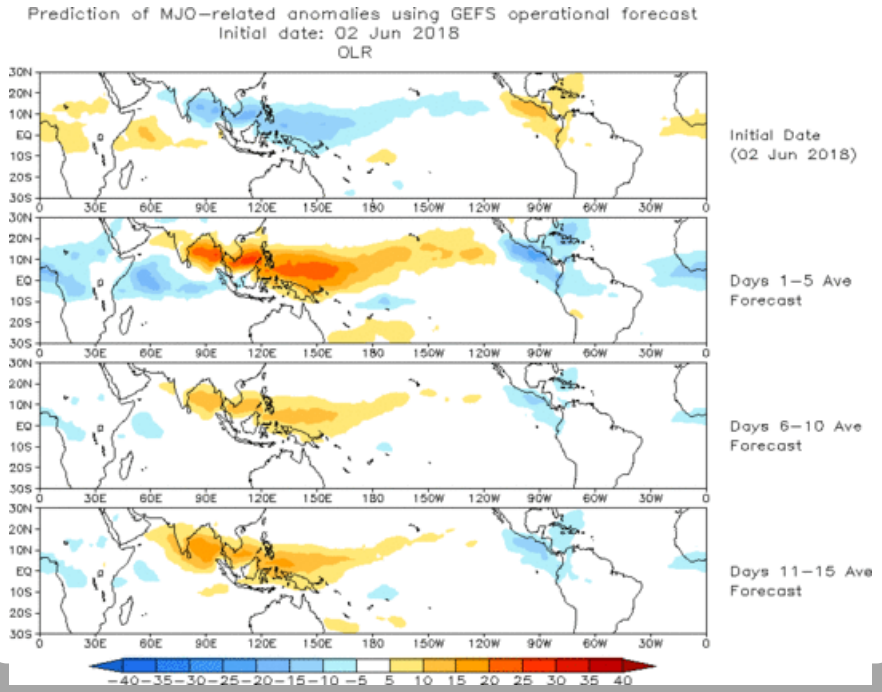
The GEFS depicts a rapid decline of the MJO signal in Week-1 inside the unit signal, with no apparent re-emergence in Week-2.



Ensemble GFS (GEFS) MJO Forecast

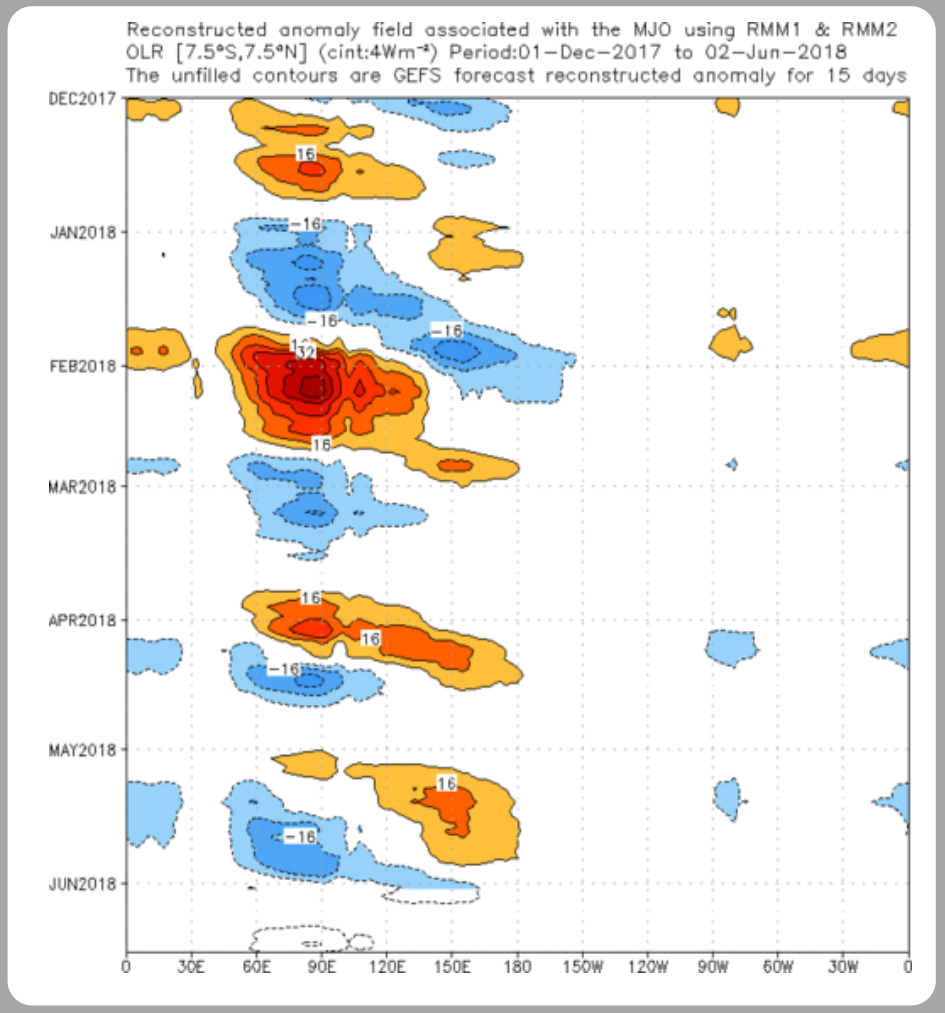
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



GEFS-based OLR anomalies depict suppressed convection becoming dominant over the Maritime Continent and eastern Indian Ocean, while enhanced convection is likely over the Americas, Africa and the western Indian Ocean.

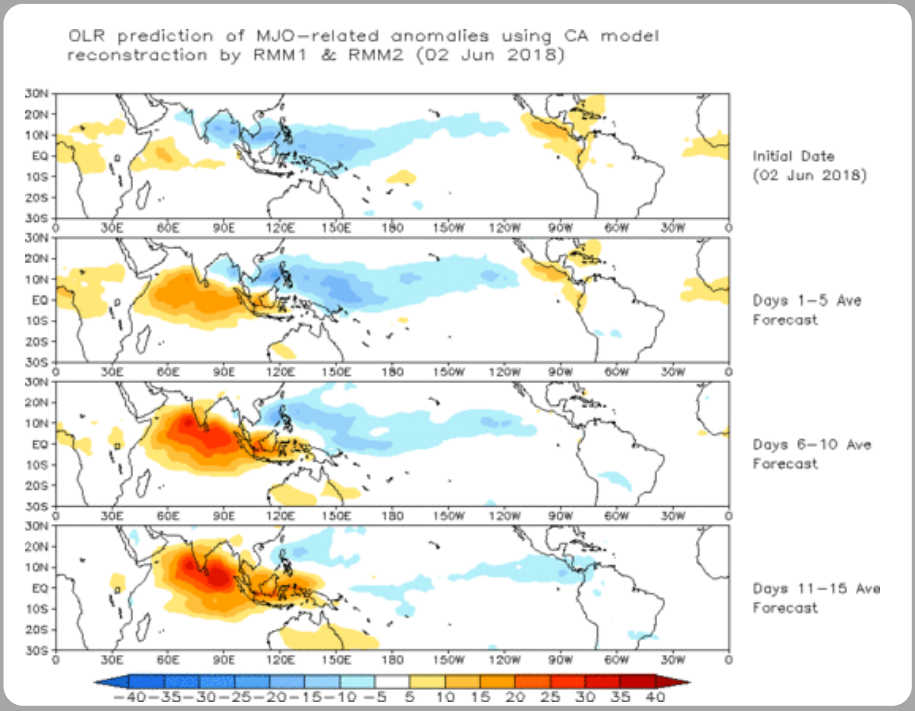
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



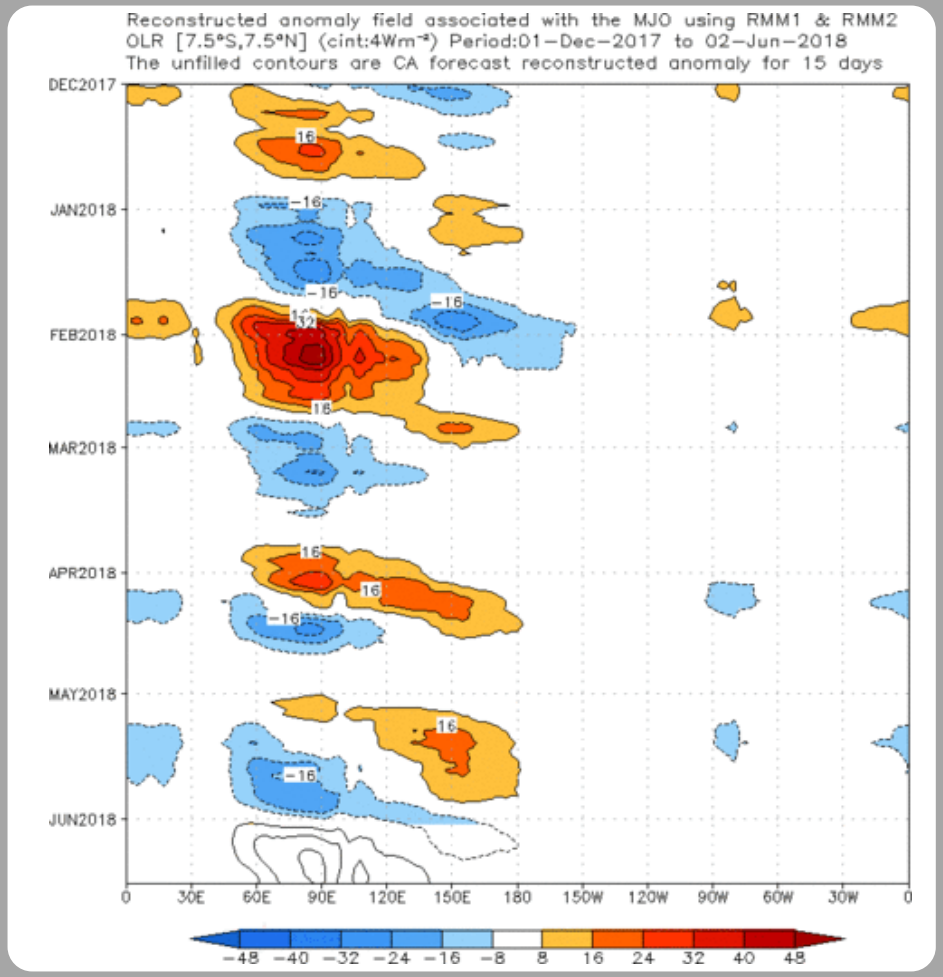
Constructed Analog (CA) MJO Forecast

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



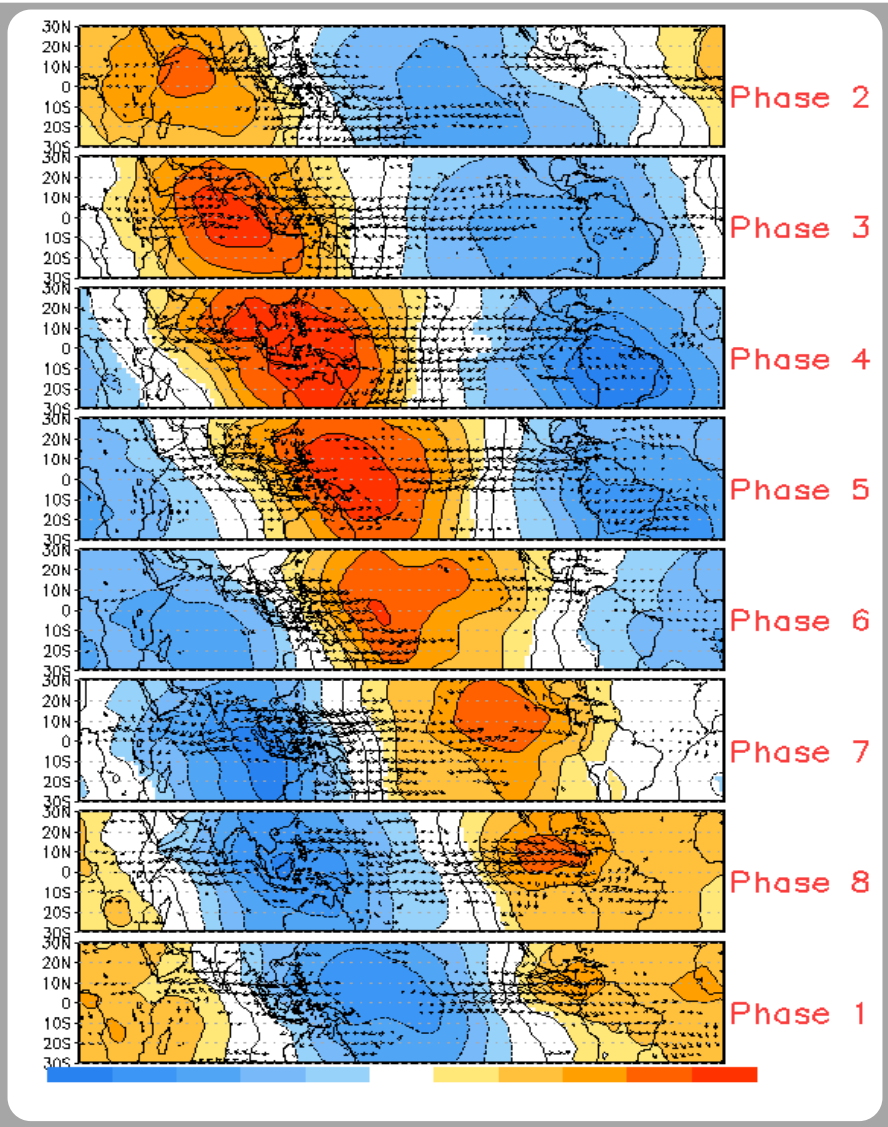
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



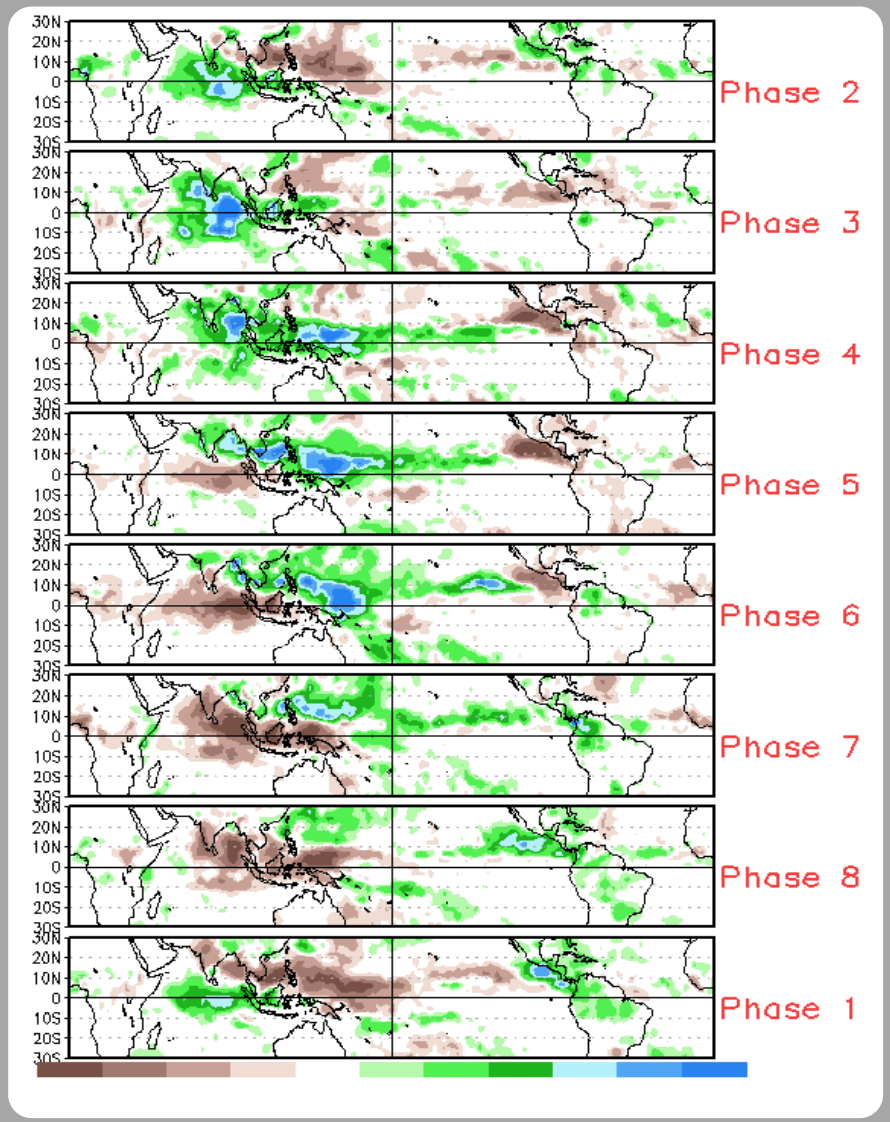
The OLR anomaly forecast based on the constructed analog MJO index forecast depicts enhanced convection shifting east from the Maritime Continent over the Pacific during the next two weeks. Suppressed convection is forecast to strengthen over the Indian Ocean.

MJO Composites - Global Tropics

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



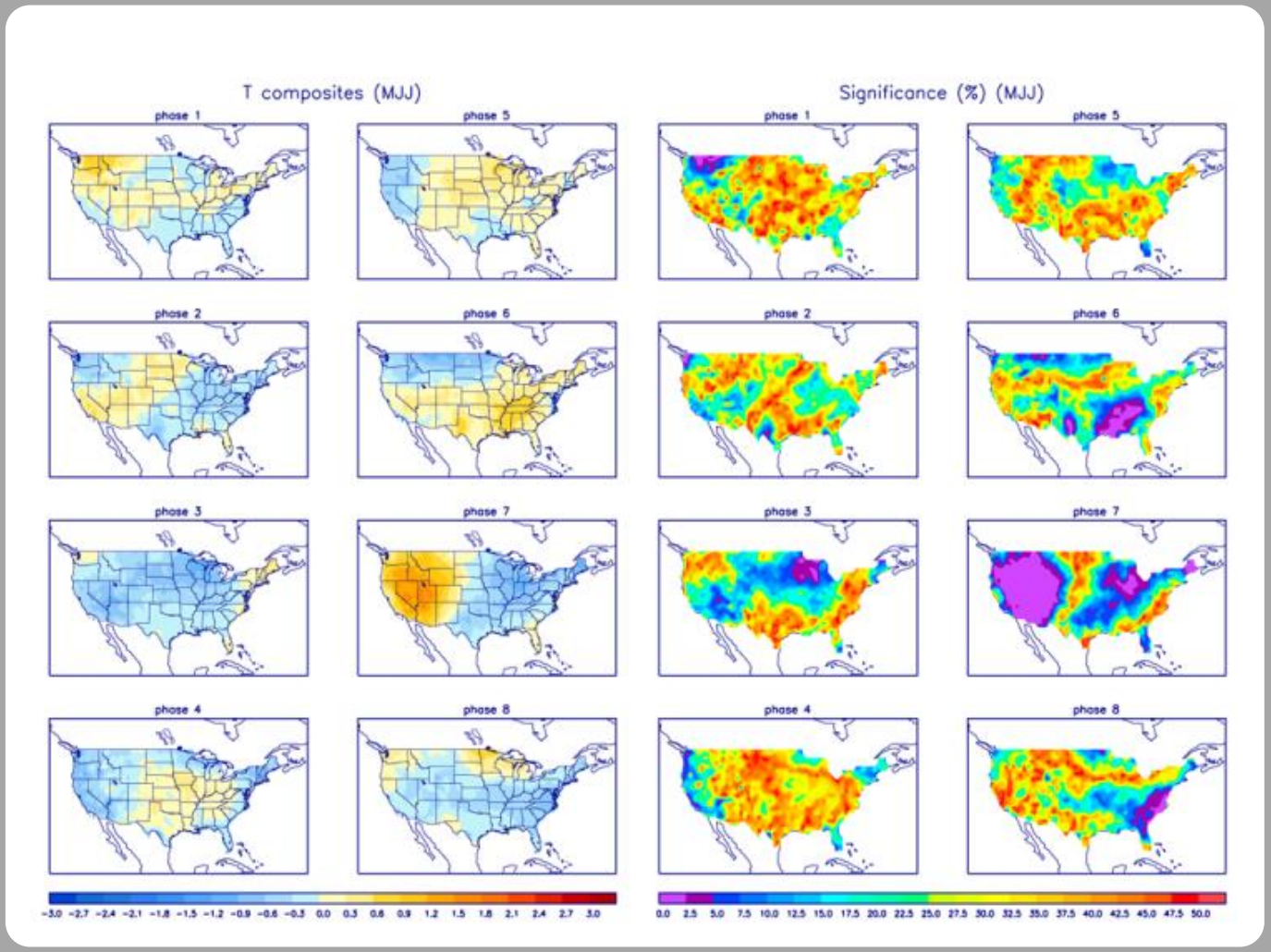
Precipitation Anomalies (May - Sep)



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.



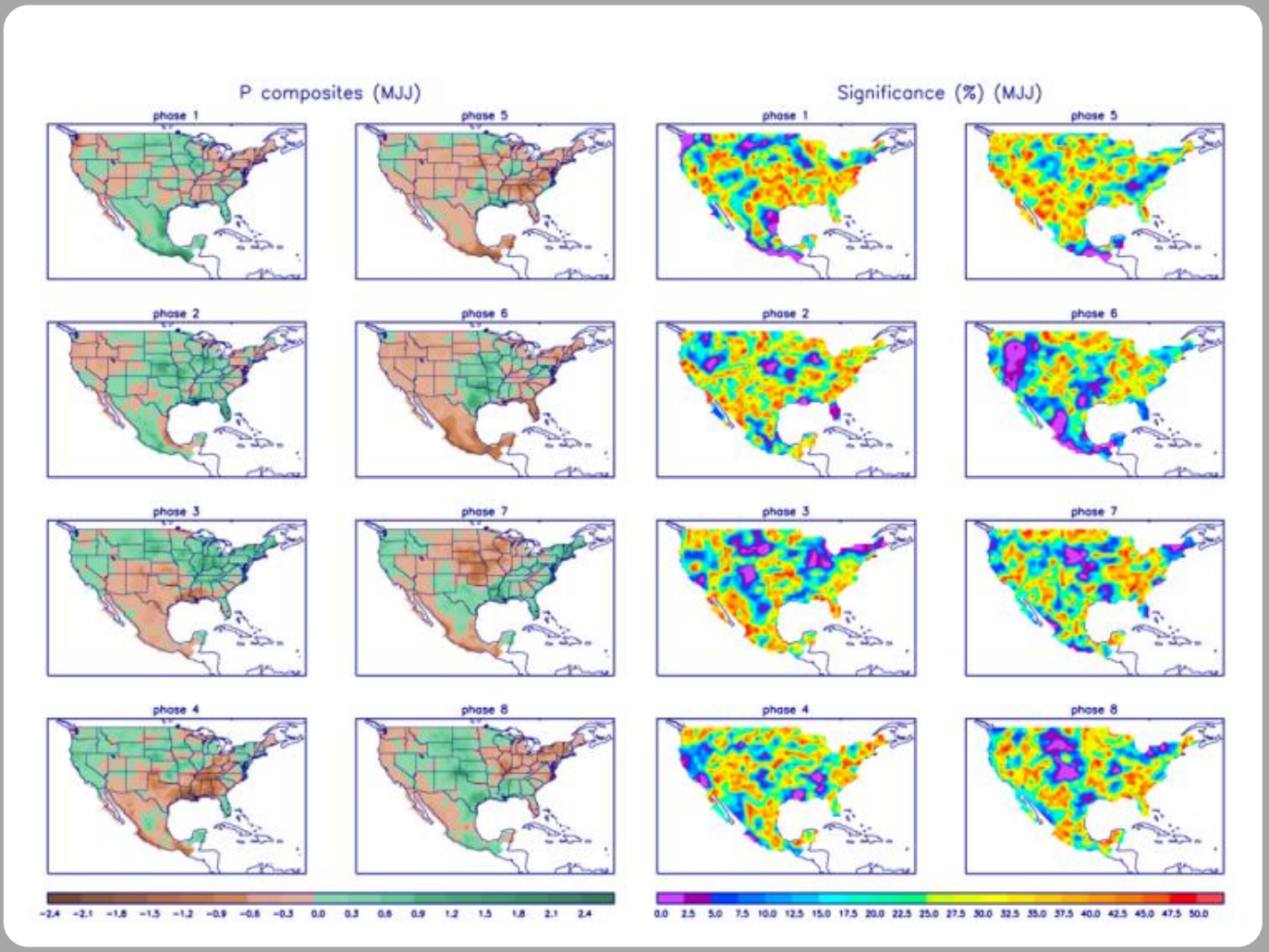
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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