

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



Update prepared by: Brad Pugh
Climate Prediction Center / NCEP
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Outline

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Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- After the re-emergence of the MJO over the Western Hemisphere, its enhanced phase propagated east from Africa to the western Indian Ocean during the past week.
- Dynamical model forecasts indicate continued eastward propagation of the MJO with its enhanced phase shifting east from the Indian Ocean to the western Maritime Continent during the next two weeks.
- The MJO is expected to play a role in anomalous convection across the global tropics with enhanced convection likely across the eastern Indian Ocean. An increasing chance of tropical cyclone development exists across the central to eastern Gulf of Mexico later in Week-1.

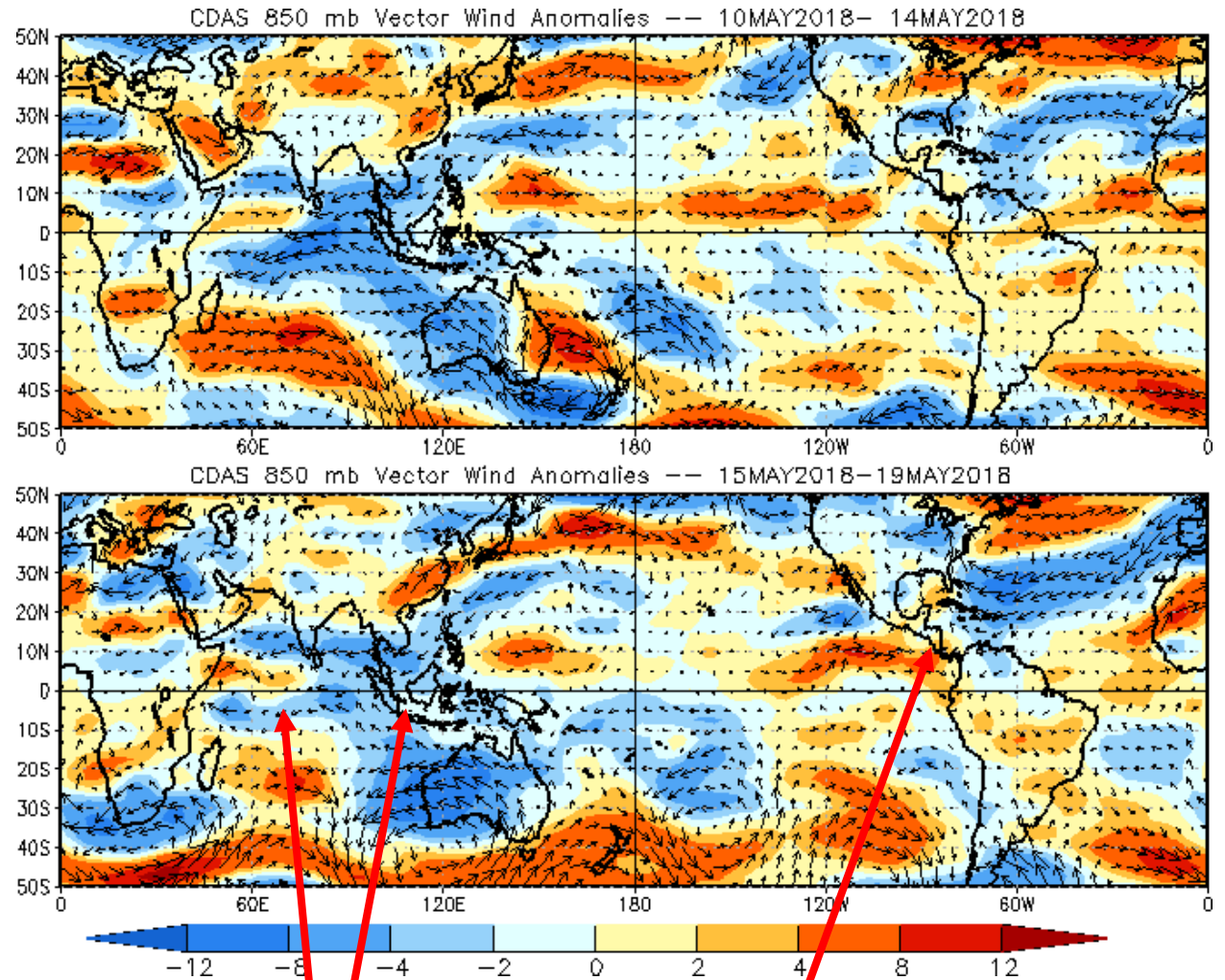
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php>

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 persisted over much of the Indian Ocean and Maritime Continent

Westerly anomalies expanded east across Central America to the western Caribbean Sea

850-hPa Zonal Wind Anomalies (m s⁻¹)

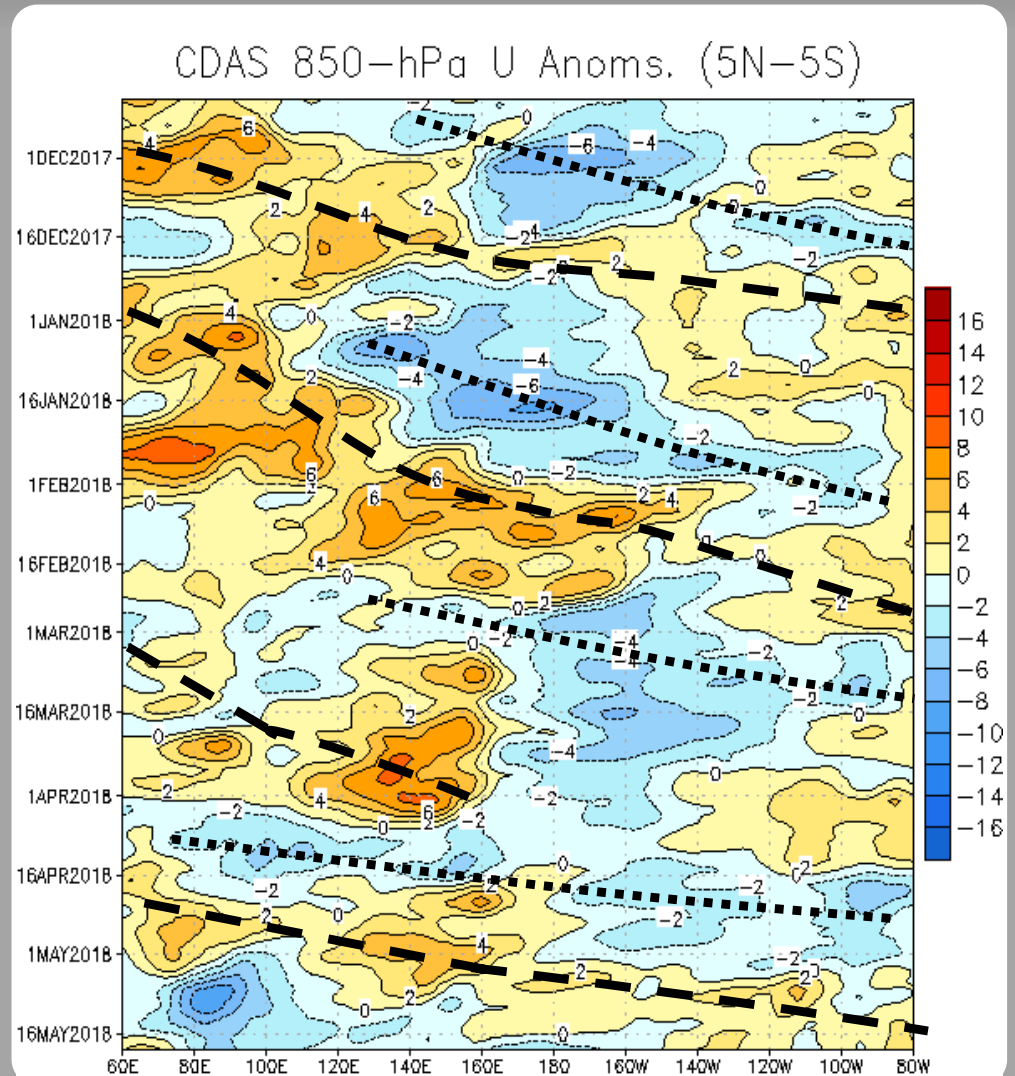
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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 over the eastern Pacific, with time speeds on the relatively fast end of the MJO envelope (approximately 35-40 days).



OLR Anomalies - Past 30 days

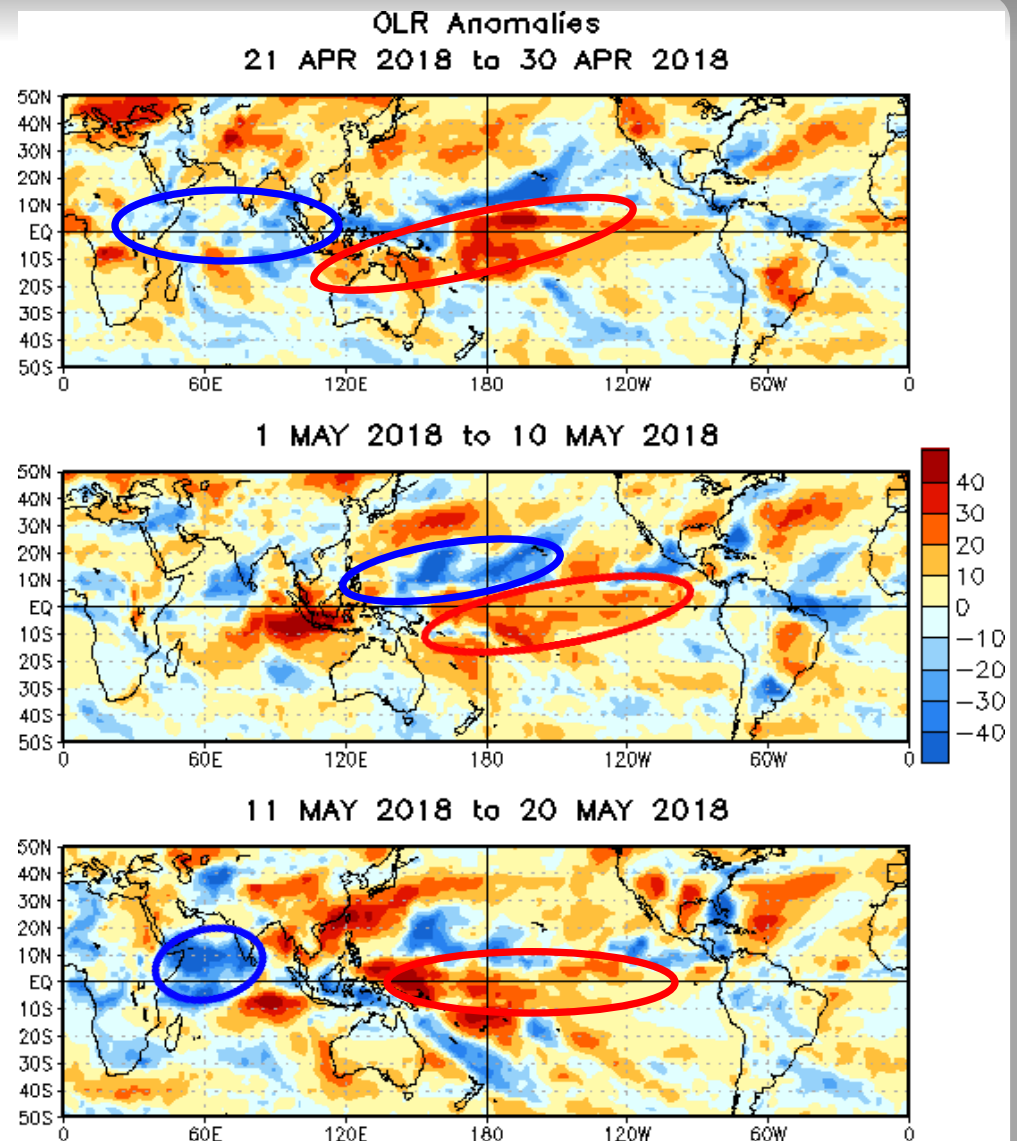
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid to late April, enhanced convection continued across the Horn of Africa and the equatorial Indian Ocean while propagating eastward to the western Maritime Continent. Suppressed convection persisted across northern Australia and the central Pacific.

During late April and 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.



Outgoing Longwave Radiation (OLR) Anomalies (7.5°S - 7.5°N)

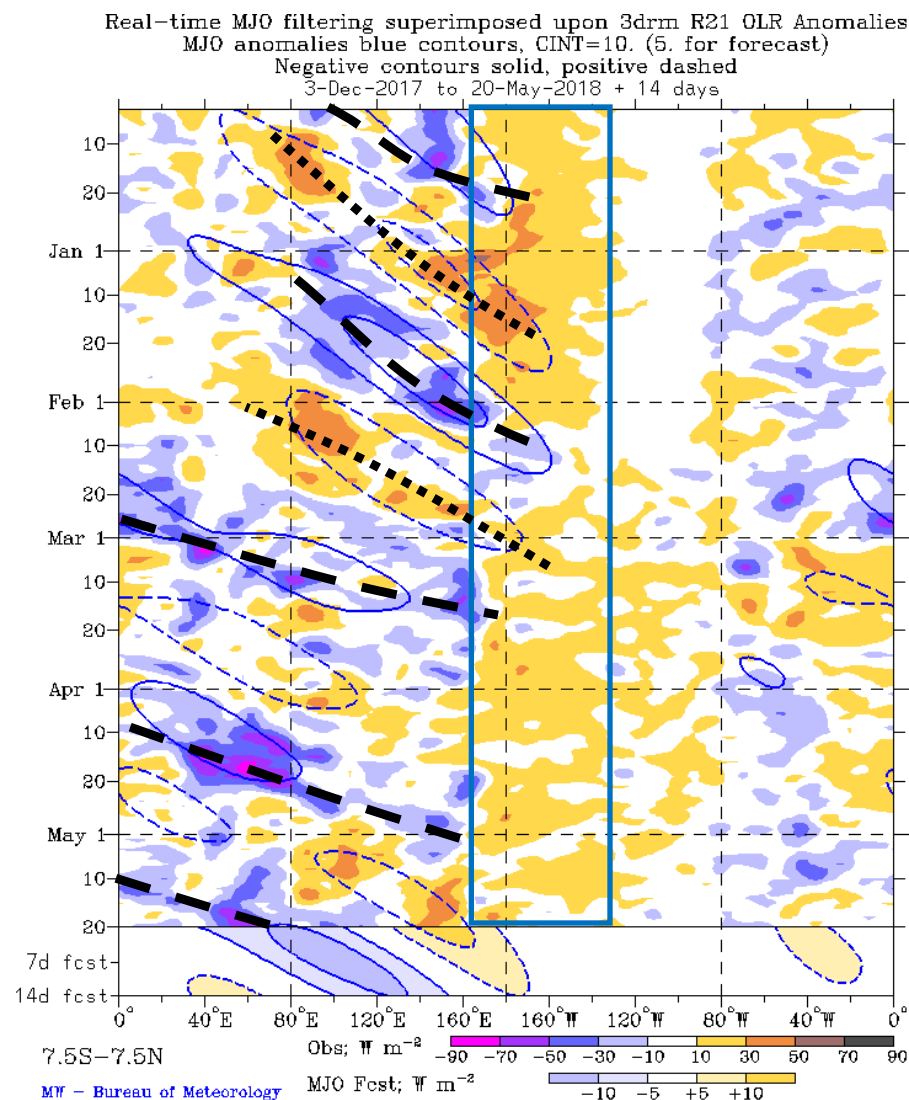
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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. This is the strongest MJO-related convective signal over the Indian Ocean during the past six months.

During early May, the OLR signature of the MJO weakened as the signal crossed the Maritime Continent and eventually destructively interfered with the La Niña footprint. Recently, the enhanced phase of the MJO shifted east over the western Indian Ocean, with some signs of a Kelvin wave ejecting to the east of the MJO envelope.



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

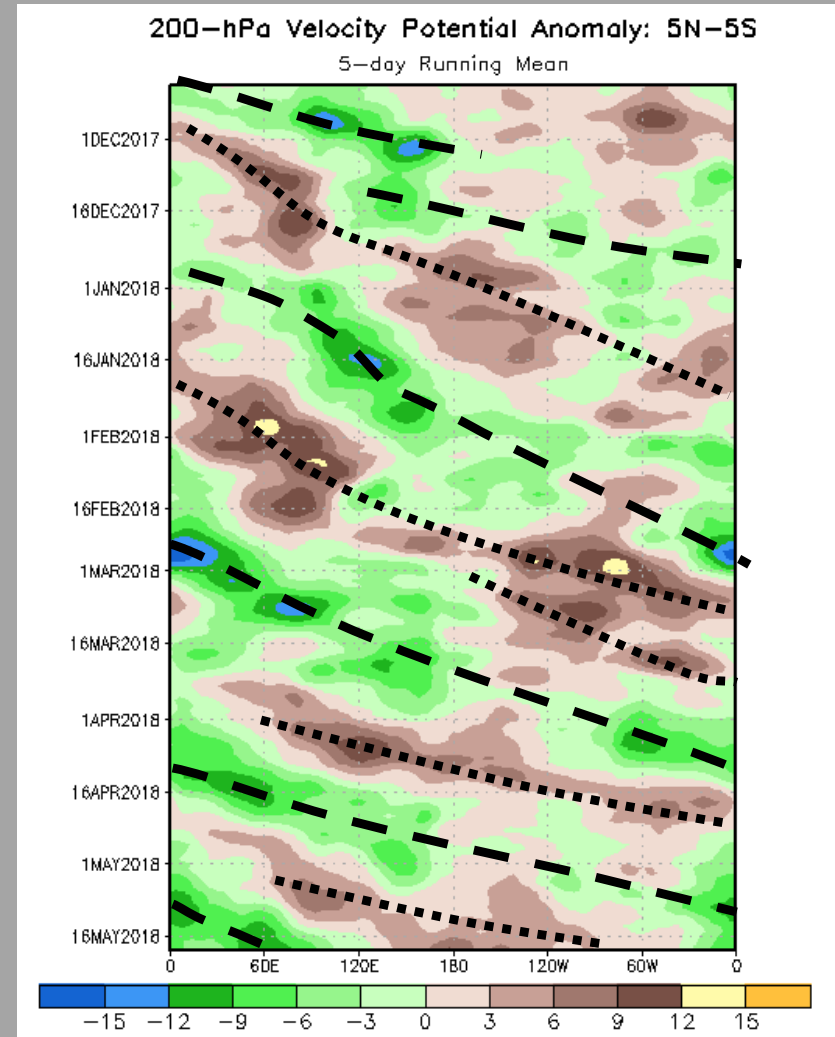
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

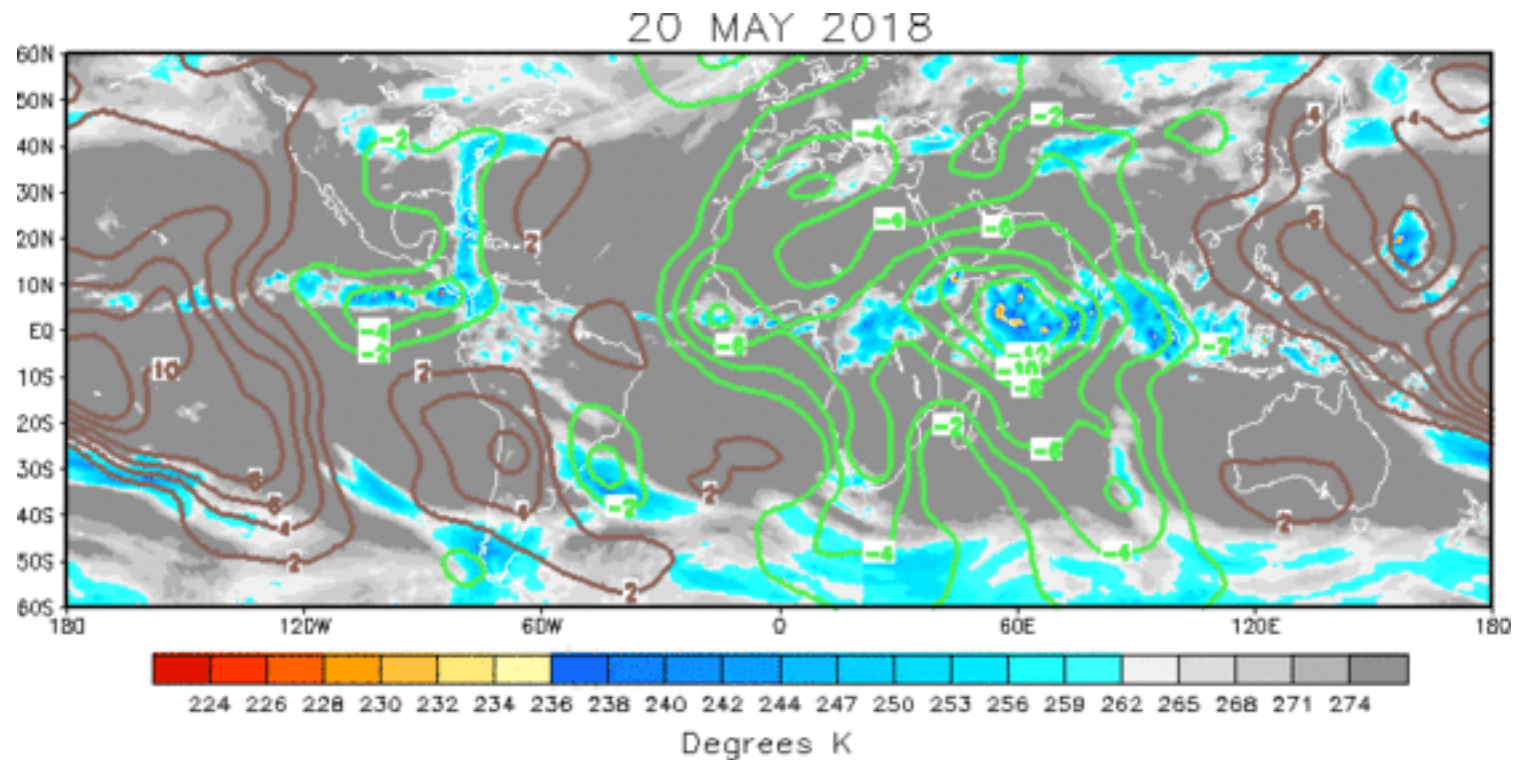
The aforementioned consistent MJO activity since mid-October can be seen in the upper level velocity potential field. Additionally, there are indications of atmospheric Kelvin wave east of the Date Line during late February and early March.

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 early to mid-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.



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



The upper-level velocity potential field indicates anomalous upper-level divergence (convergence) over Africa and the Indian Ocean (west-central Pacific Ocean) associated with the coherent active (suppressed) phase of the MJO. An equatorial Rossby Wave is apparent over west 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})

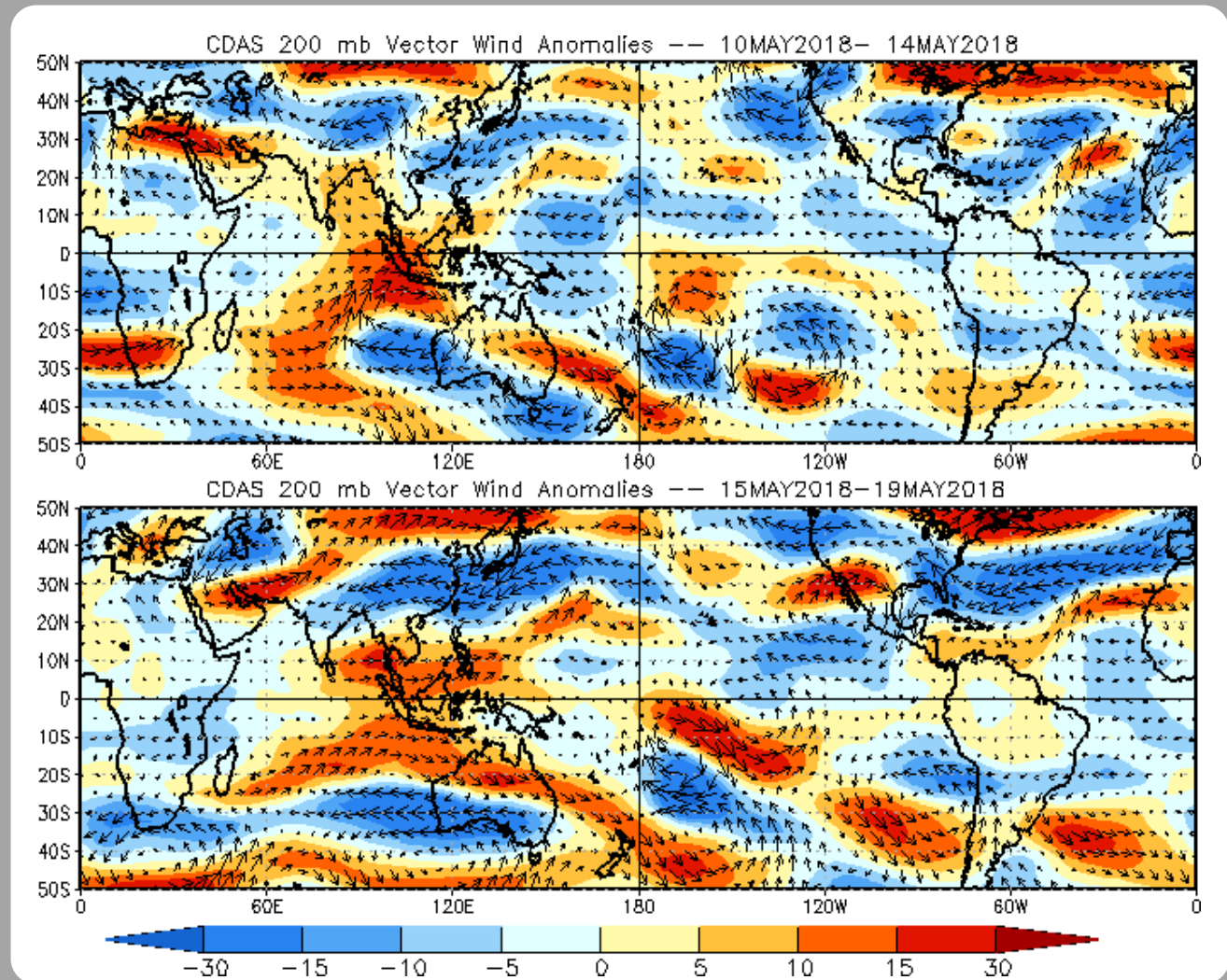
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

The upper-level zonal wind anomaly field was weak during late April and early May, with mid-latitude influences apparent across the Pacific and multiple areas of anomalous cross-equatorial flow.

Most recently, westerly anomalies at 200-hPa overspread the Maritime Continent.



200-hPa Zonal Wind Anomalies (m s⁻¹)

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

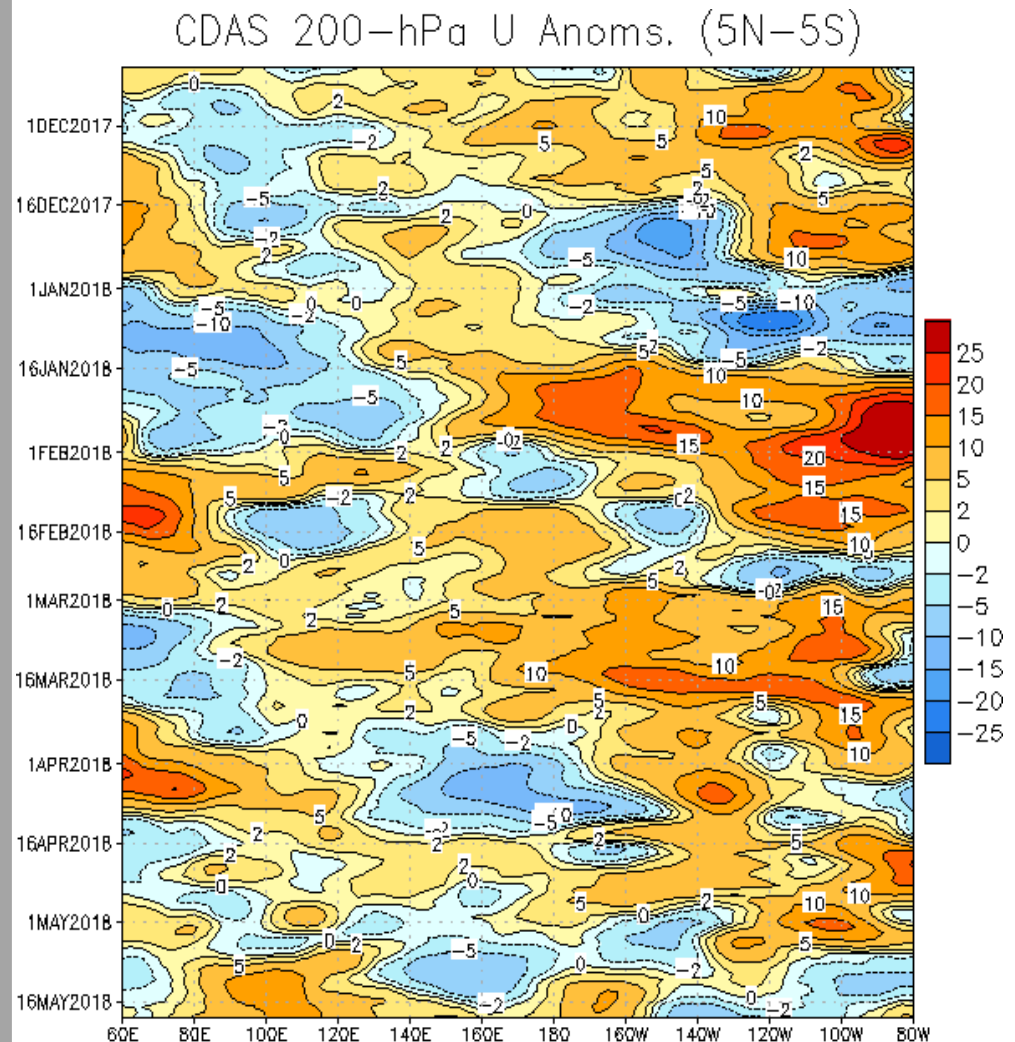
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Low-frequency anomalous westerlies remained in place east of 140°E starting in October, 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, westerly anomalies shifted east from the Indian Ocean to the west Pacific.



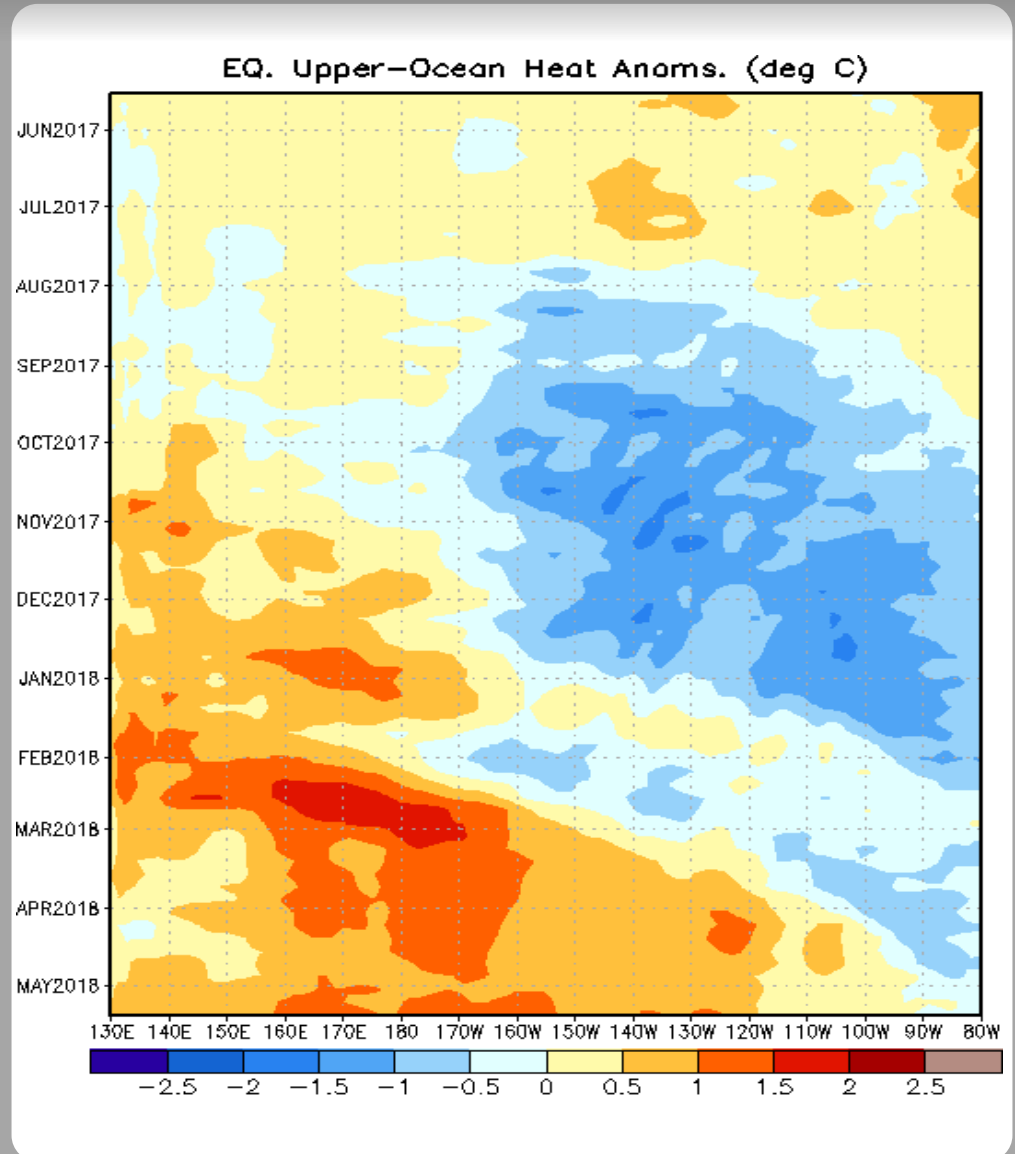
Weekly Heat Content Evolution in the Equatorial Pacific

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

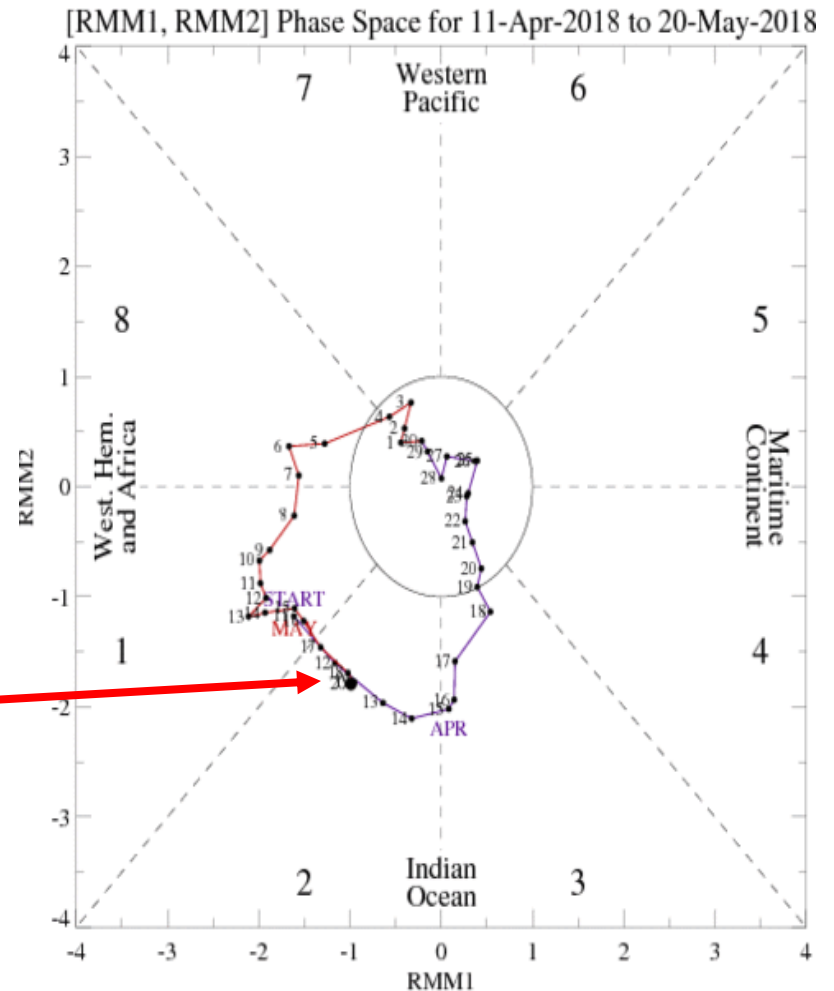
Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.

Distance from the origin is proportional to MJO strength

Line colors distinguish different months

The RMM-based MJO projection indicates continued eastward propagation of the MJO since early May.

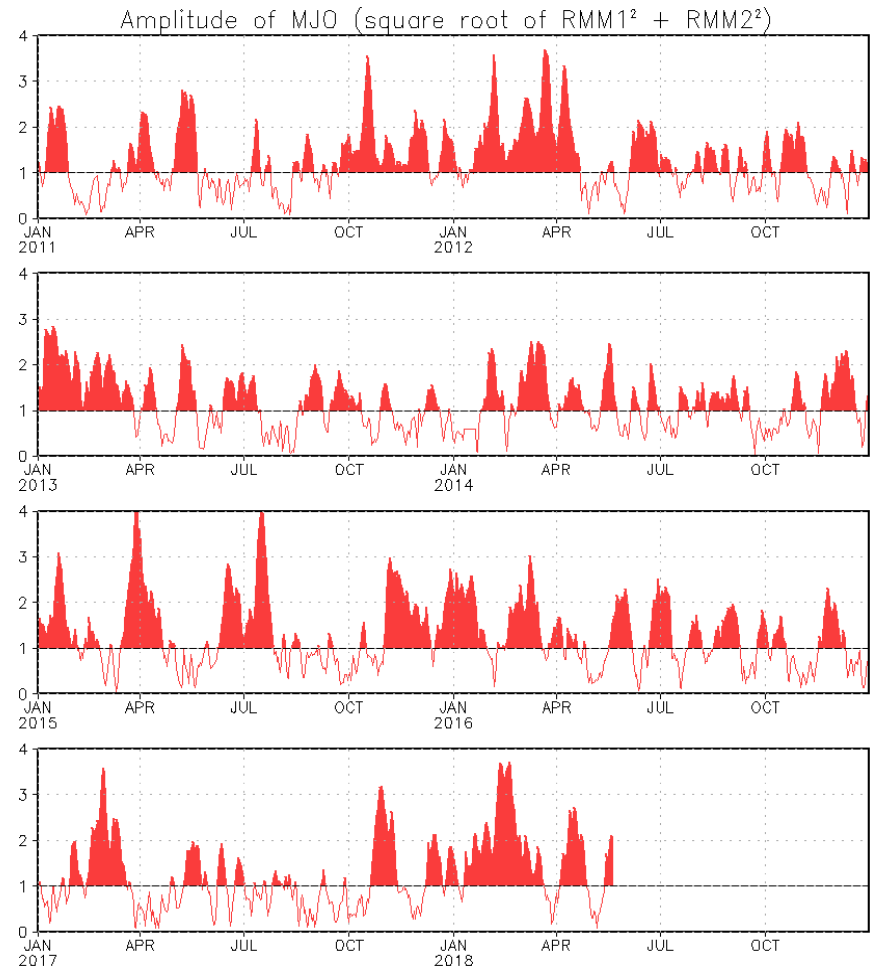
The most recent observations are nearly identical in amplitude to those from 30-40 days ago.



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

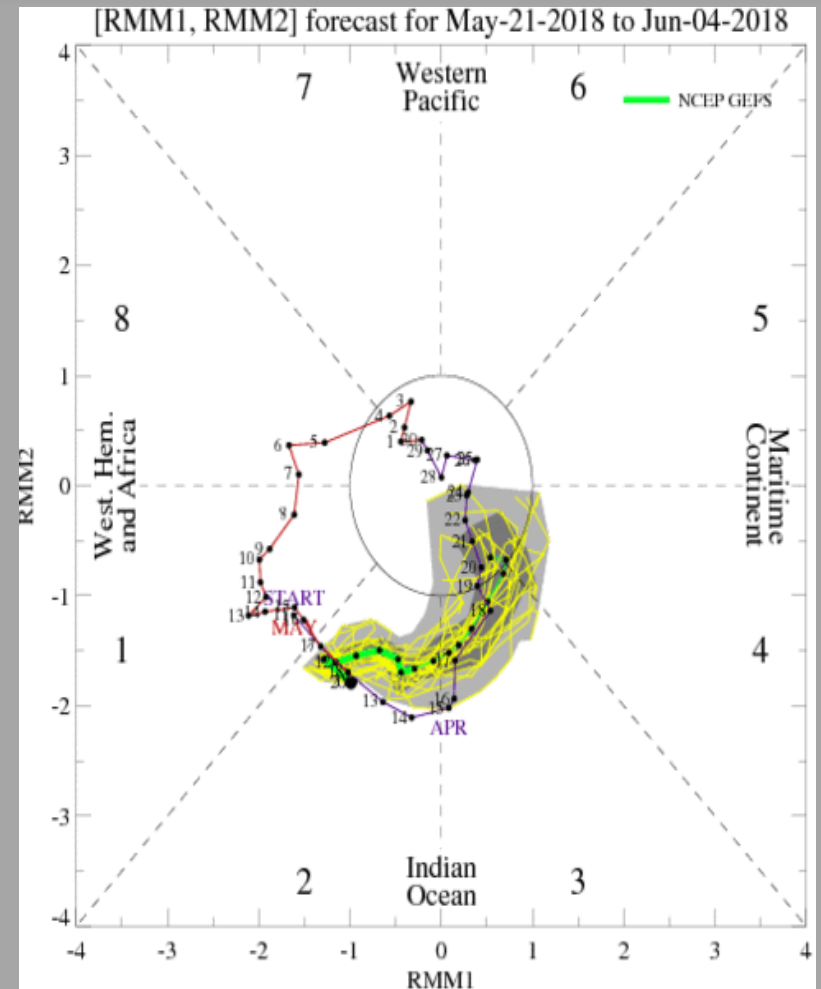
RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GEFS depicts eastward propagation resuming later in Week-1 with the enhanced phase of the MJO shifting east to the Maritime Continent by the end of Week-2.

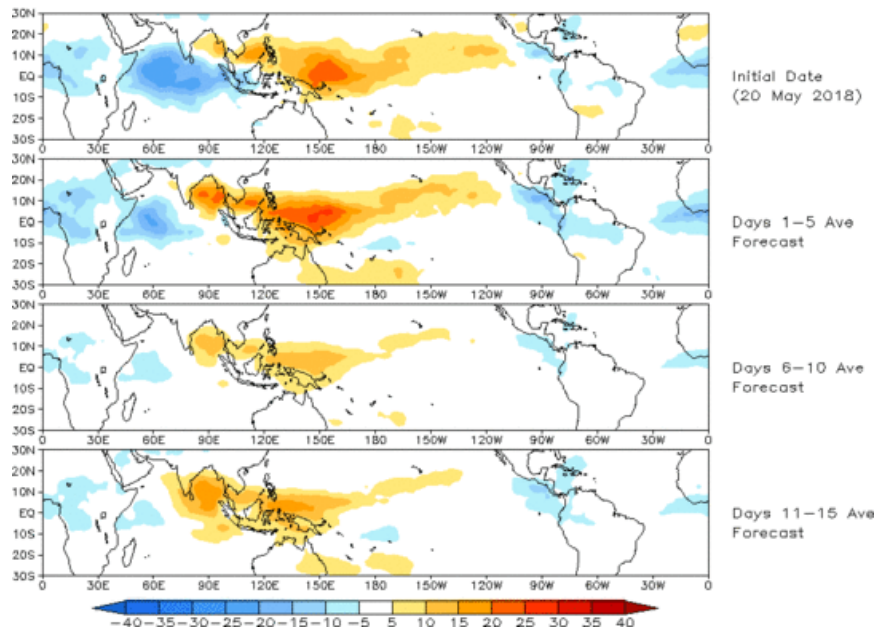
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean



Ensemble GFS (GEFS) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

Prediction of MJO-related anomalies using GEFS operational forecast
Initial date: 20 May 2018
OLR

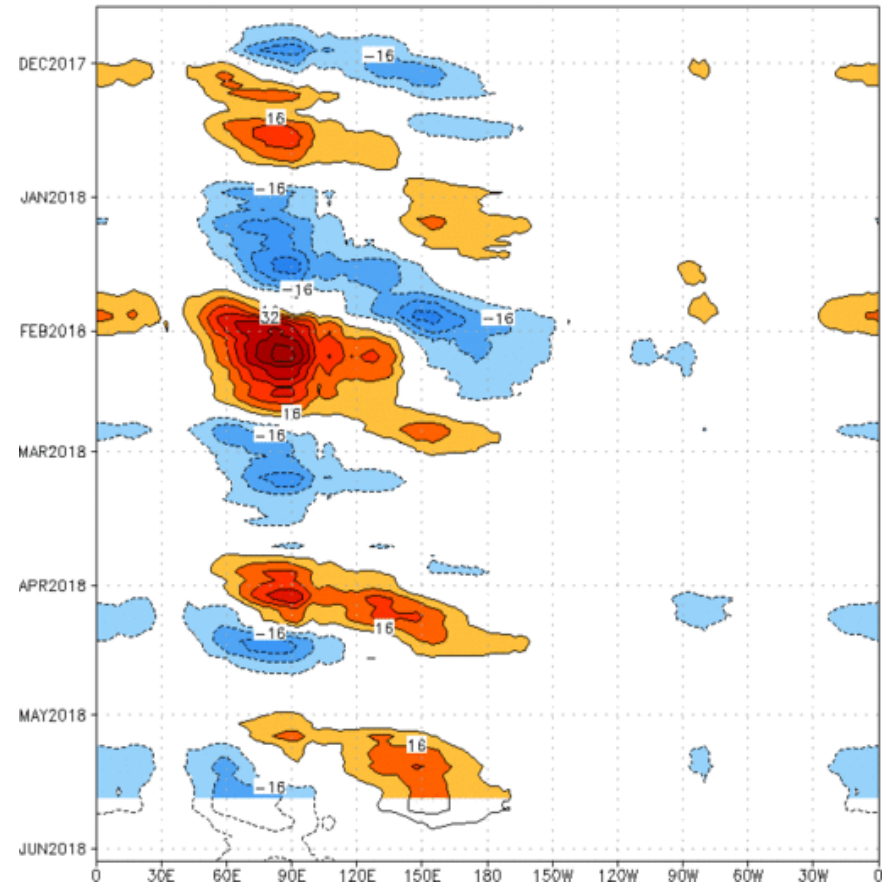


GEFS-based OLR anomalies depict suppressed convection expanding west to include the Maritime Continent and eastern Indian Ocean, while enhanced convection persists over the Americas, Africa and the western Indian Ocean.

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

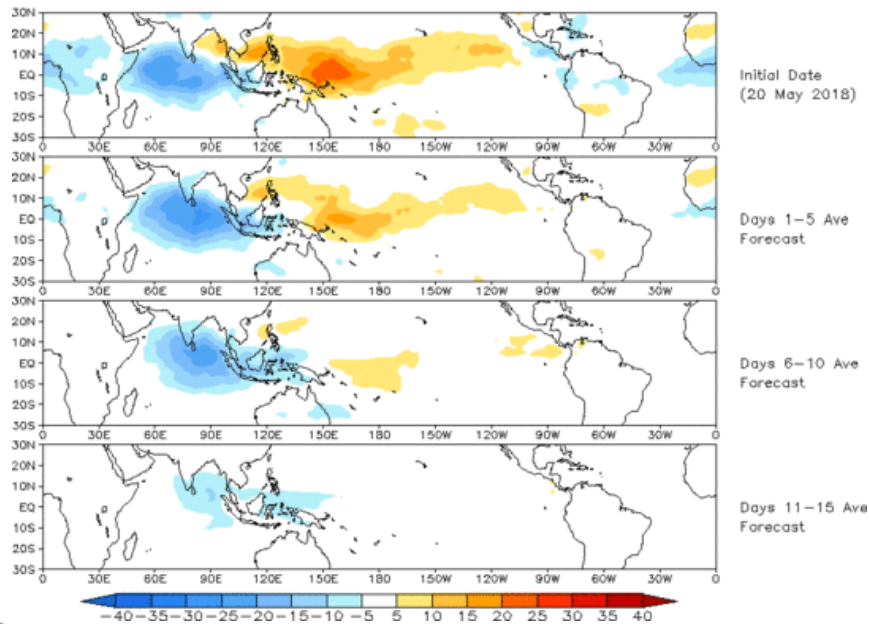
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2
OLR [7.5° S, 7.5° N] (cont: 4Wm^{-2}) Period: 18–Nov–2017 to 20–May–2018
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days



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 (20 May 2018)

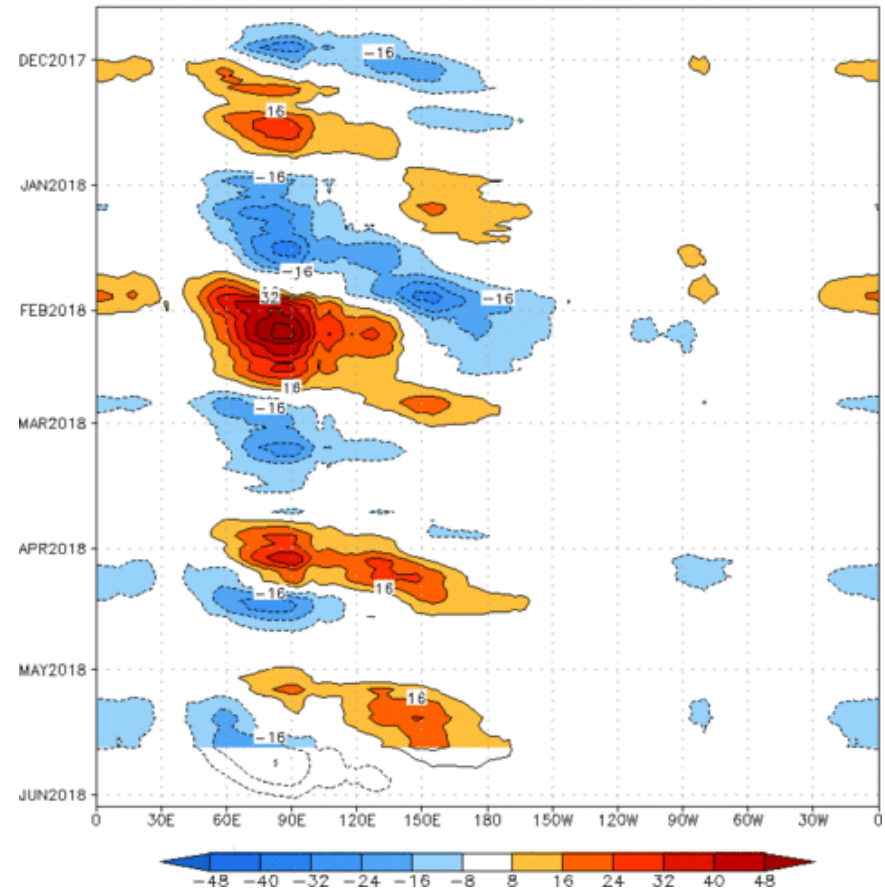


The OLR anomaly forecast based on the constructed analog MJO index forecast depicts enhanced convection shifting east to the Maritime Continent and west Pacific during the next two weeks.

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.)

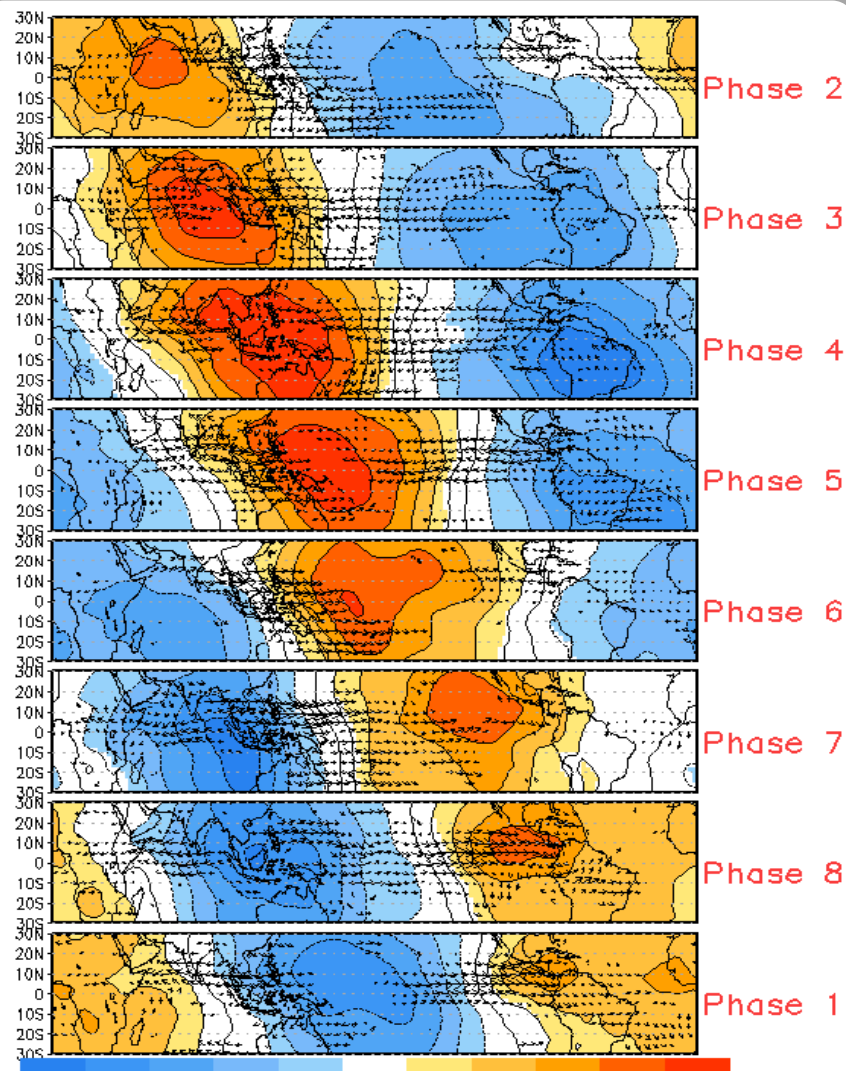
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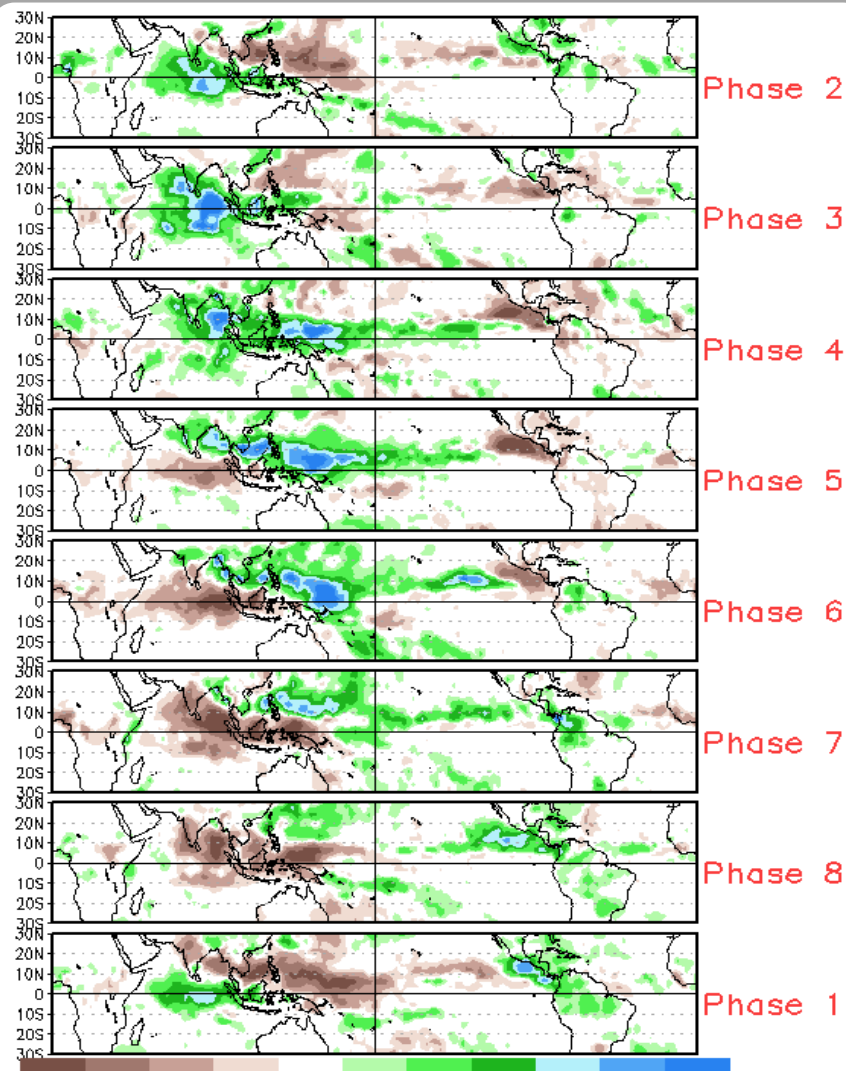


MJO Composites - Global Tropics

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



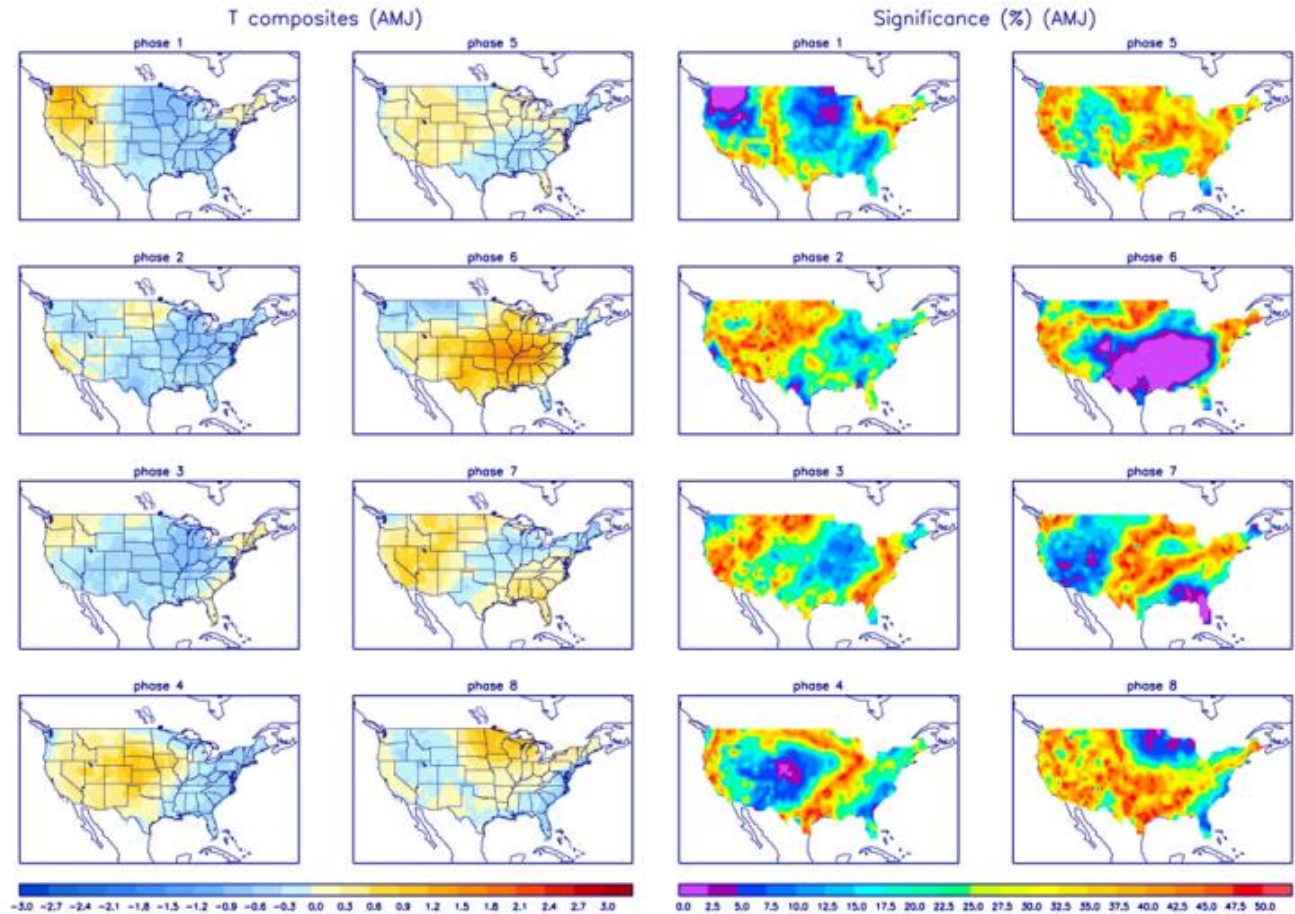
Precipitation Anomalies (May - Sep)



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.



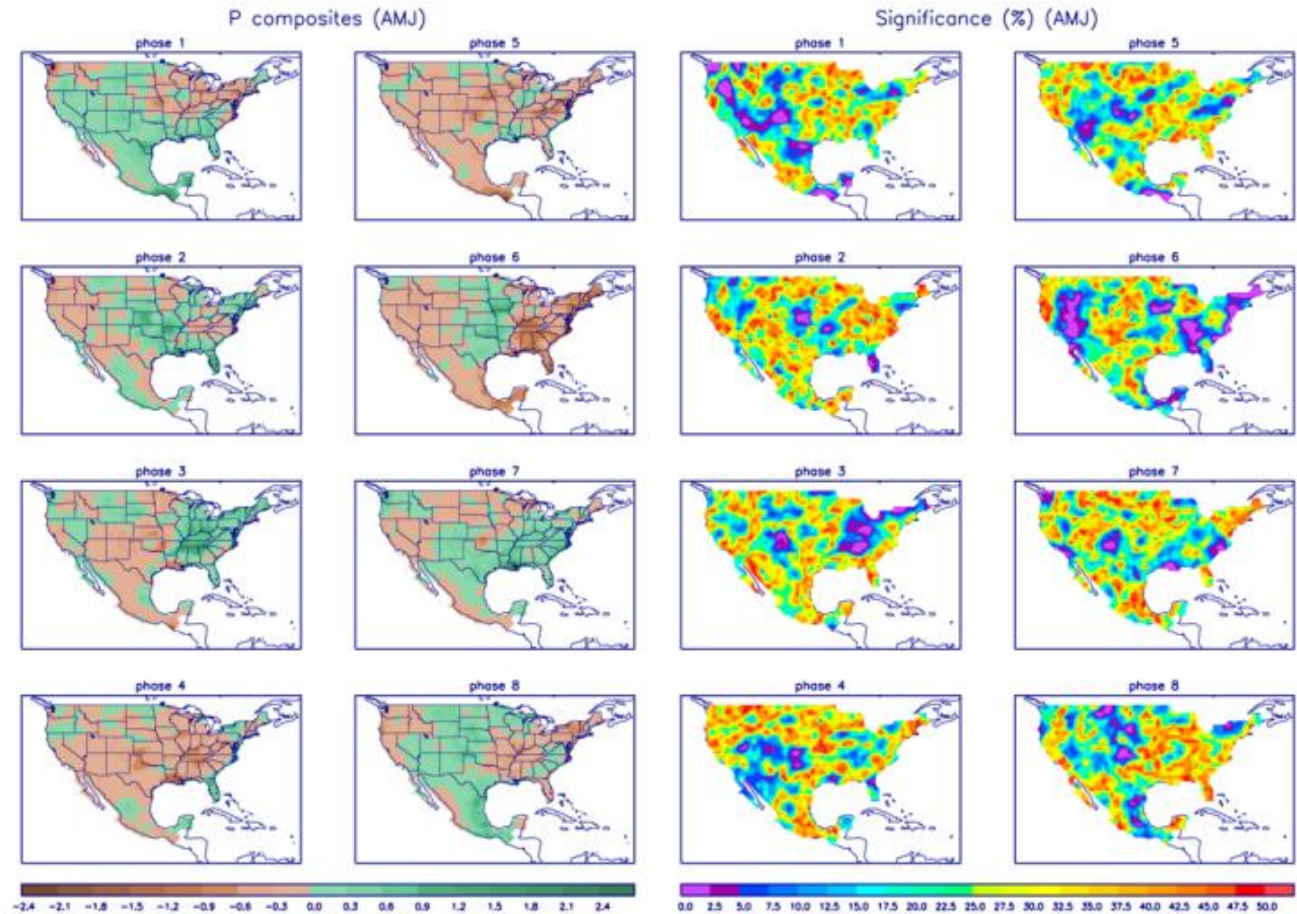
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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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