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 has re-emerged over the past week and is now in Phase 7. The GEFS forecast shows a propagation of the signal through Phase 8 in Week-1, with a rapid decay in Week-2 back inside the unit circle.

- Areas of suppressed convection over the Indian Ocean and Maritime Continent and enhanced convection over the western Pacific are likely associated with the MJO signal.

- The suppressed convection signal over the central and eastern Pacific from the La Nina state has become more organized again and intensified.

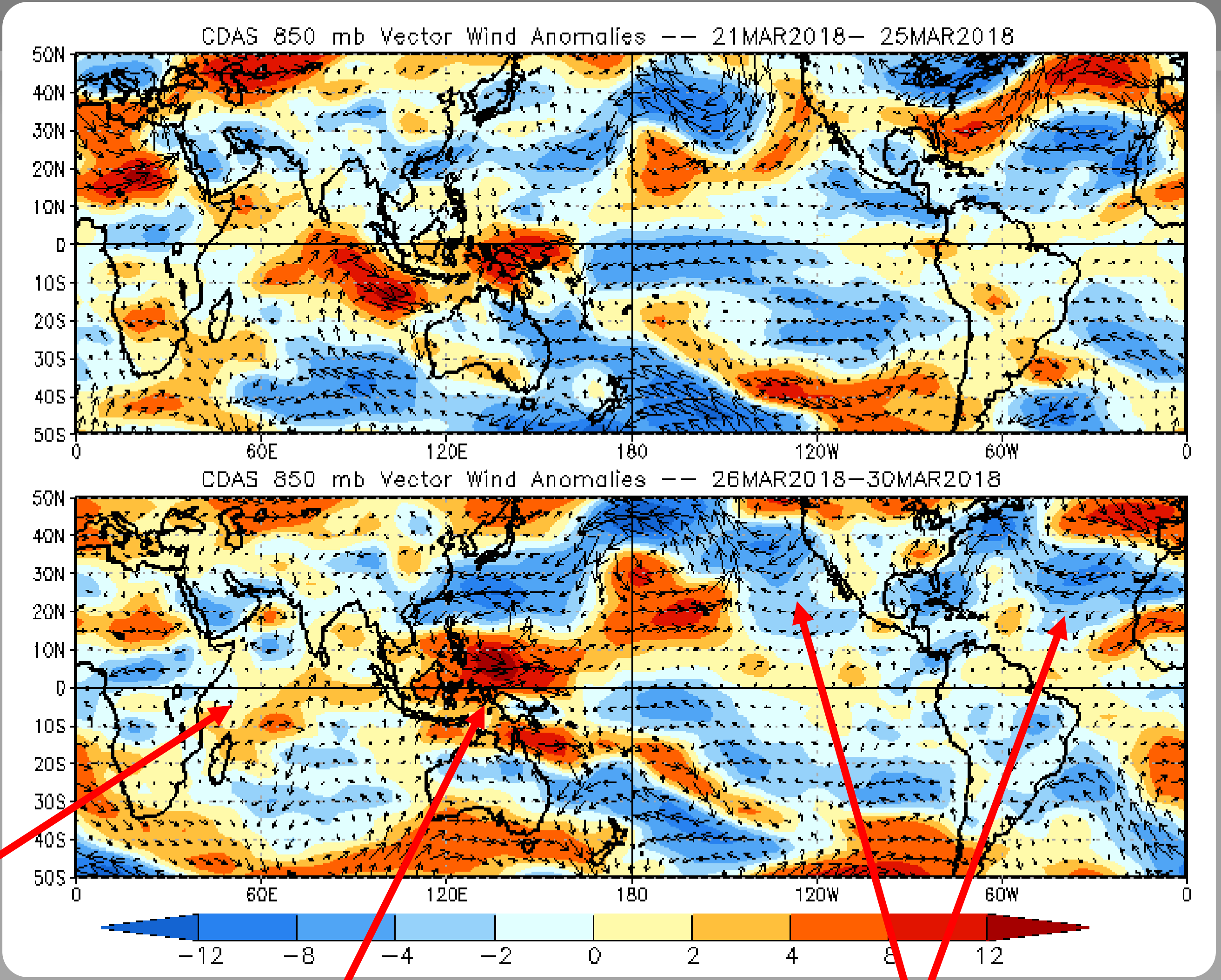
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Winds continued to weaken over the western Indian Ocean as the MJO signal strengthens.

Anomalous westerlies are present over the Maritime Continent, consistent with the re-emerging MJO.

Mid-latitude waves dominate the northern Pacific and Atlantic flows.

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

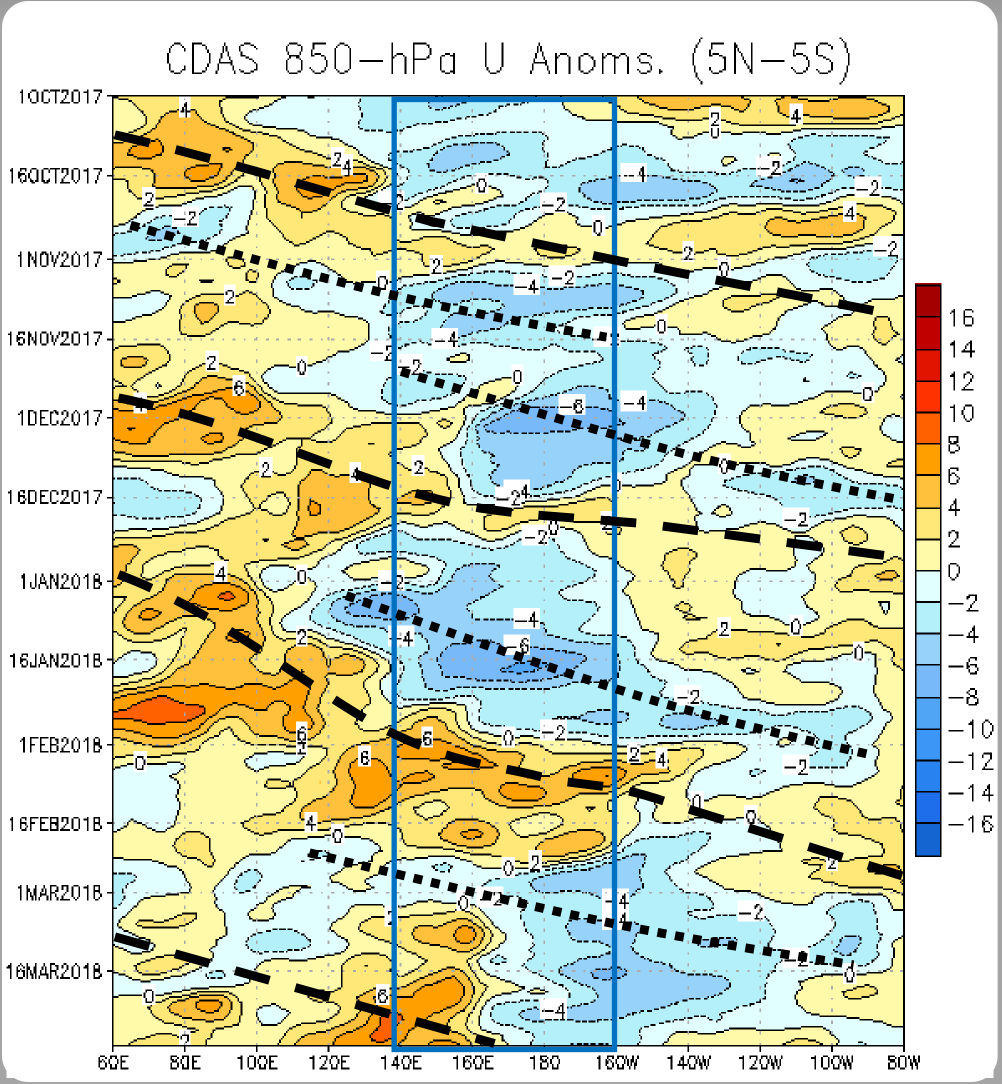
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

Low frequency anomalous easterlies that had been present since September reversed sign during February.

During October and early November, a robust MJO event developed, with eastward propagation of westerly and easterly anomalies. This event weakened in early to mid-November.

A new MJO event became organized in December, propagating from the Indian Ocean to the Pacific. The signal crossed the Western Hemisphere in late December, re-emerging over the Indian Ocean in early January. The signal continued to propagate eastward, moving into the central and eastern Pacific and began weakening during mid-February. Most recently, westerly anomalies have strengthened around the Maritime Continent as a MJO signal begins to re-emerge.



OLR Anomalies – Past 30 days

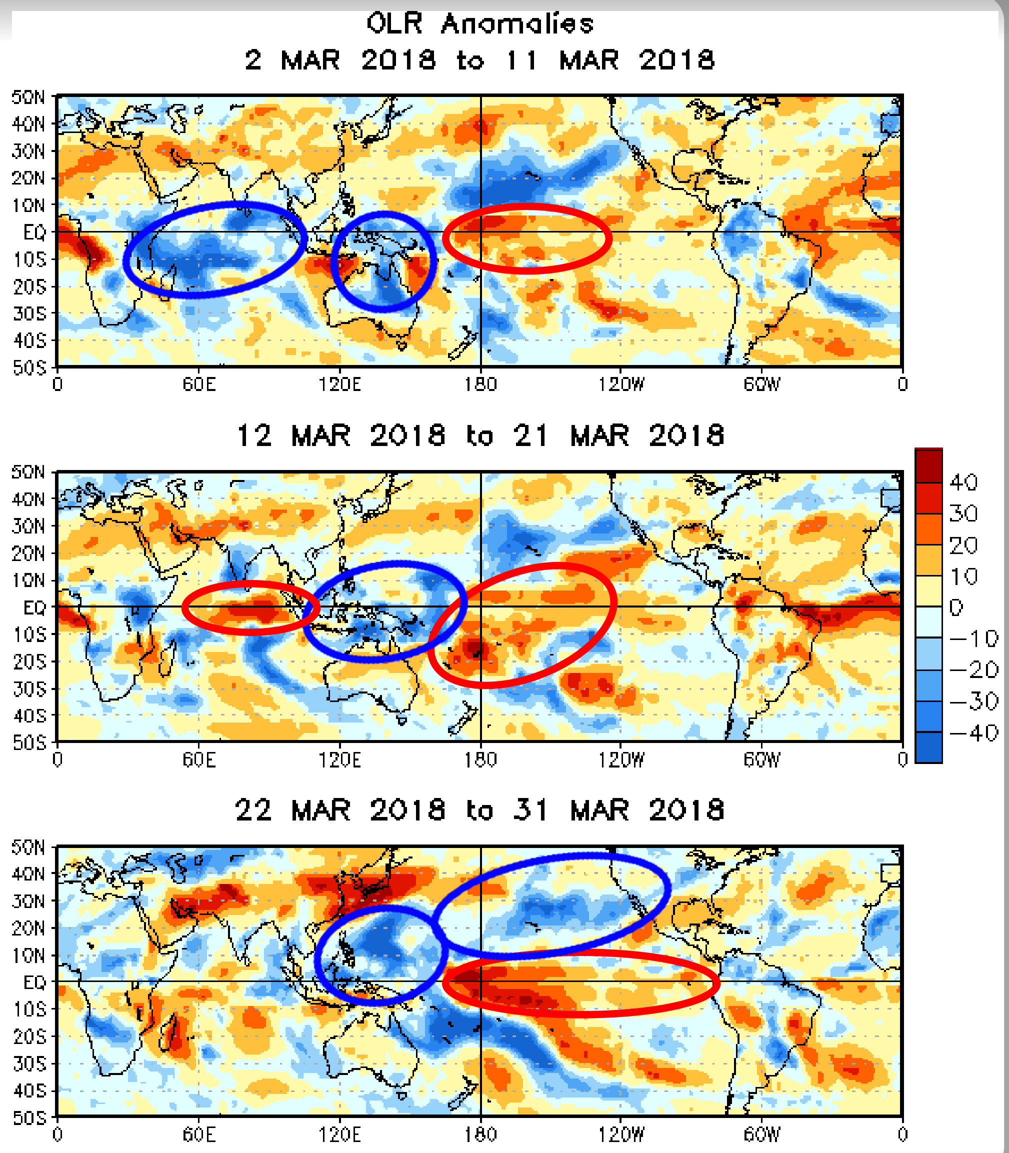
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During early March, negative OLR anomalies dominated the Indian Ocean and moved over the Maritime Continent, breaking up the previous positive OLR anomalies along 10S. Positive OLR anomalies over the central Pacific are associated with low cloud cover and suppressed convection.

Negative OLR anomalies expanded over the Maritime Continent and positive OLR anomalies appeared over the Indian Ocean in mid-March as convection weakened. Areas of positive OLR anomalies expanded around the Date Line.

Toward the end of March, OLR signals become more organized and strengthened. The enhanced convection over the Maritime Continent has begun to propagate eastward. The suppressed convection over the central Pacific has intensified. The extended region of negative OLR anomalies stretching from Hawaii to the west coast of North America is consistent with a subtropical moisture feed that has been in place since early March.



Outgoing Longwave Radiation (OLR) Anomalies (7.5ºS - 7.5ºN)

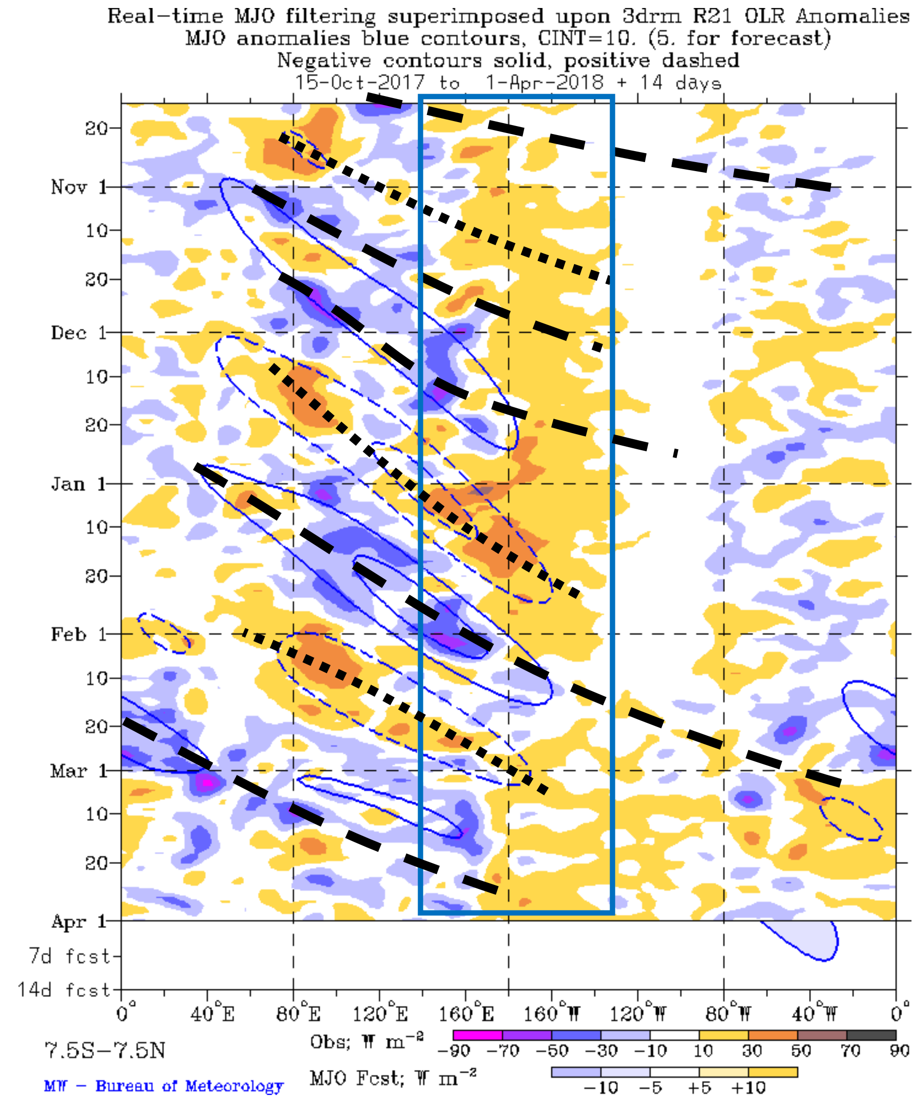
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

An active MJO formed in early October and circumnavigated the globe by early November.

Another MJO event developed in late November over the eastern Indian Ocean and Maritime Continent that was able to briefly disrupt the La Niña convective suppression near the Date Line in mid-December.

The MJO re-emerged in the Indian Ocean at the end of December and strengthened as it shifted east toward the Date Line. This led to a reversal of the canonical La Niña convective suppression signal in early February. This MJO signal circumnavigated the global tropics during February, reaching the Indian Ocean and weakening substantially by mid-March.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

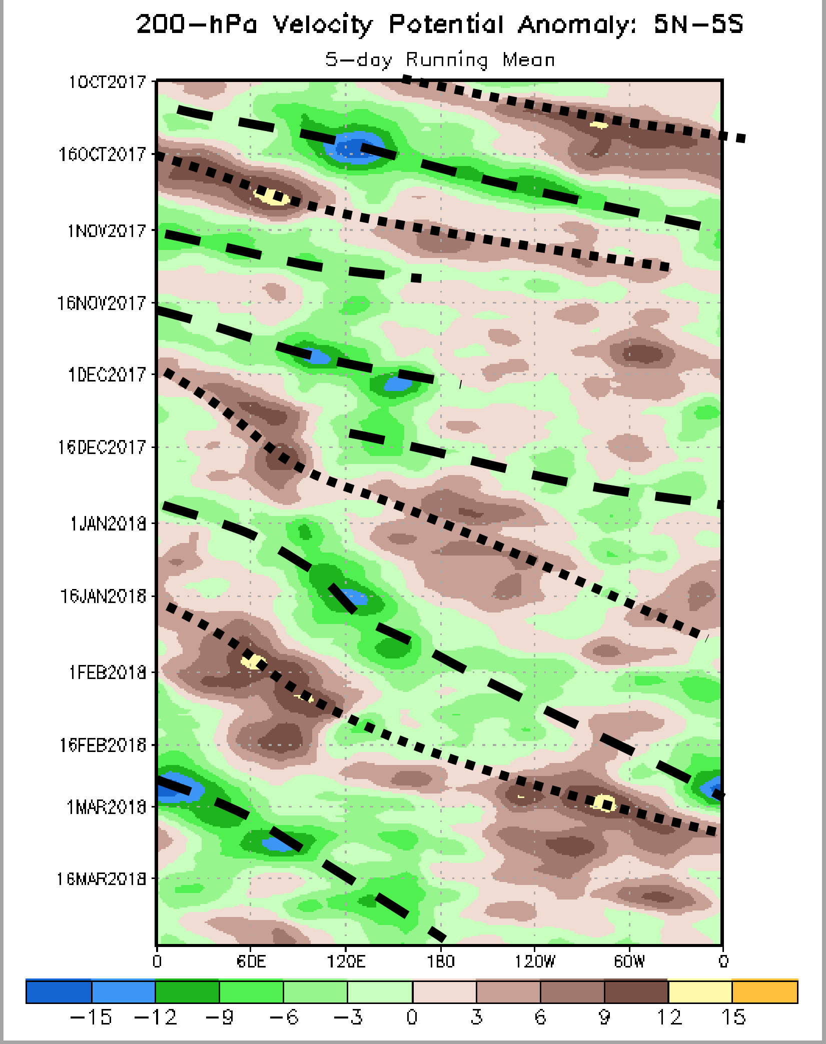
Negative anomalies (green shading) indicate favorable conditions for precipitation

An MJO event developed near the Maritime Continent during early October with strong anomalous upper-level winds near 120E. The signal circumnavigated the global tropics and weakened about 30 days later.

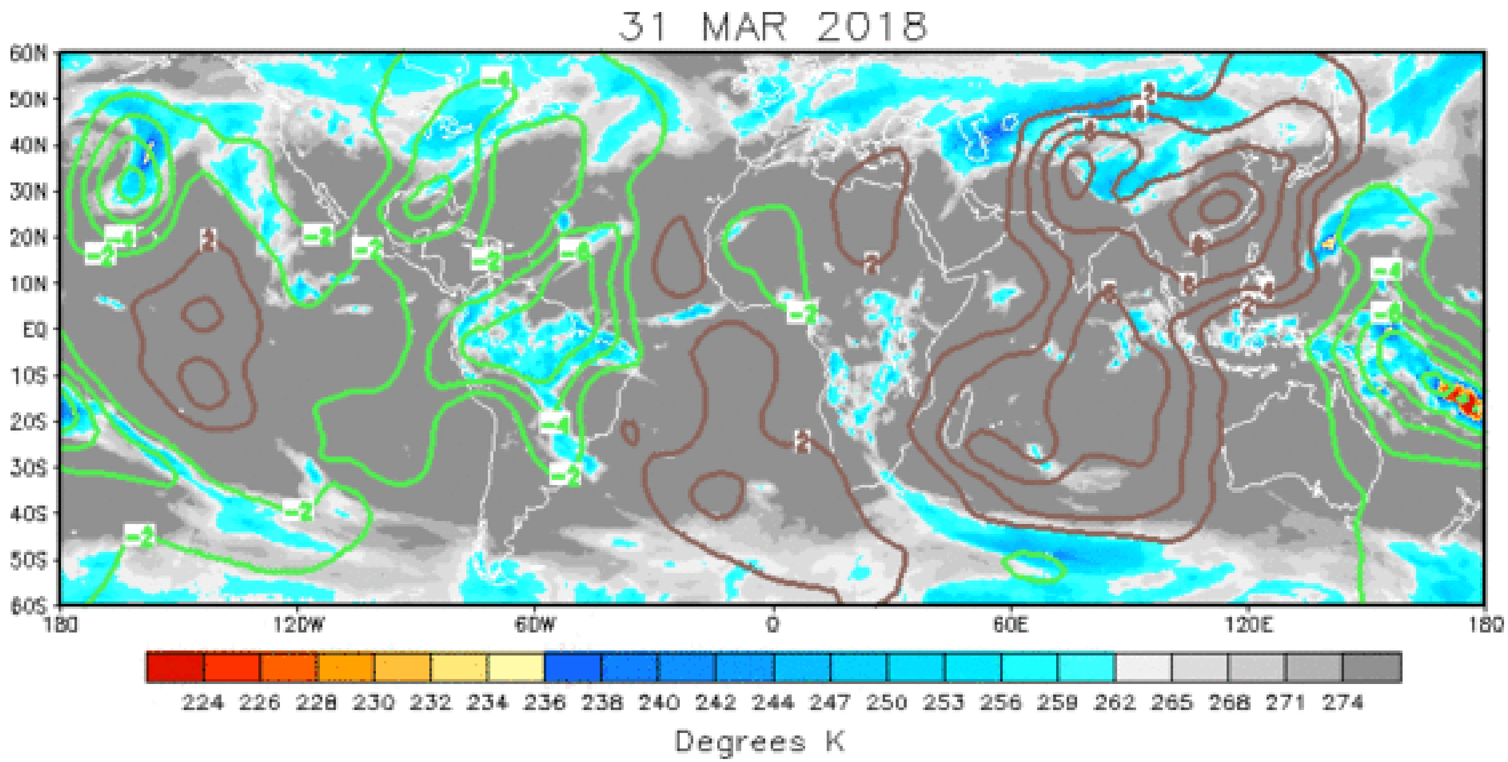
MJO activity renewed in November. The intraseasonal signal associated with this MJO event was weaker than the previous episode due to destructive interference from an equatorial Rossby wave.

The signal destructively interfered with the base state through the end of December, crossing the Western Hemisphere into the Indian Ocean during the beginning of January.

This MJO event further intensified during January and early February, leading to another period of destructive interference with the ENSO state, prior to weakening during March.



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



A noisy Wave-1 pattern is present with suppressed (enhanced) convection generally over the Eastern (Western) Hemisphere. The large area of enhanced convection over the Maritime Continent is related to the active phase of the MJO. The intrusion of suppressed convection over the central Pacific is likely related to ENSO.

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)

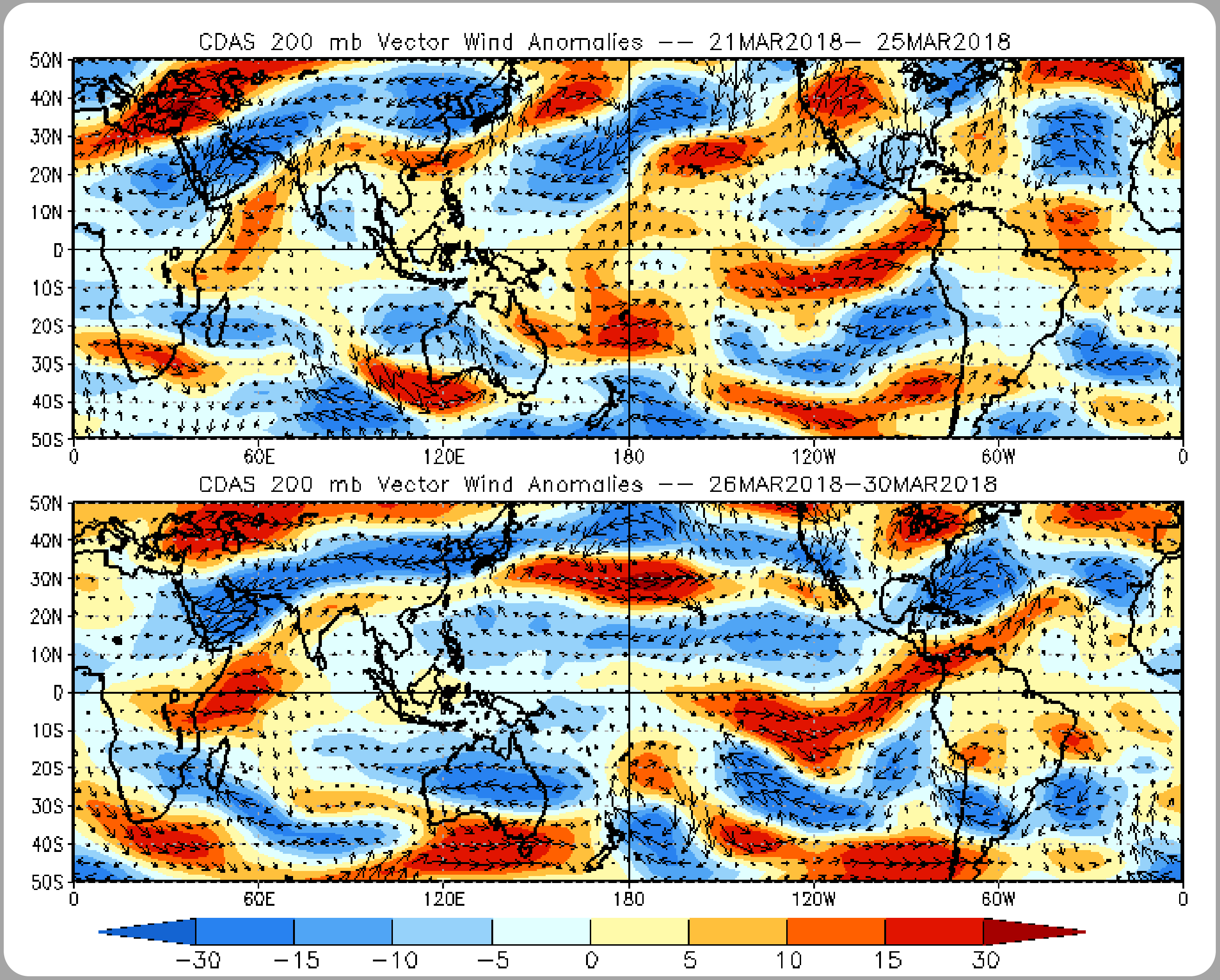
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

A bifurcating jet stream is depicted over the central Pacific, with cross-equatorial flow indicated downstream over the eastern Pacific.

The anomalous westerlies which stretched from Hawaii to California broke down at the end of March, cutting off the moisture feed that had been in place over the past month. They have been replaced by a band of easterly anomalies, consistent with cyclone activity over the North Pacific.



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

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

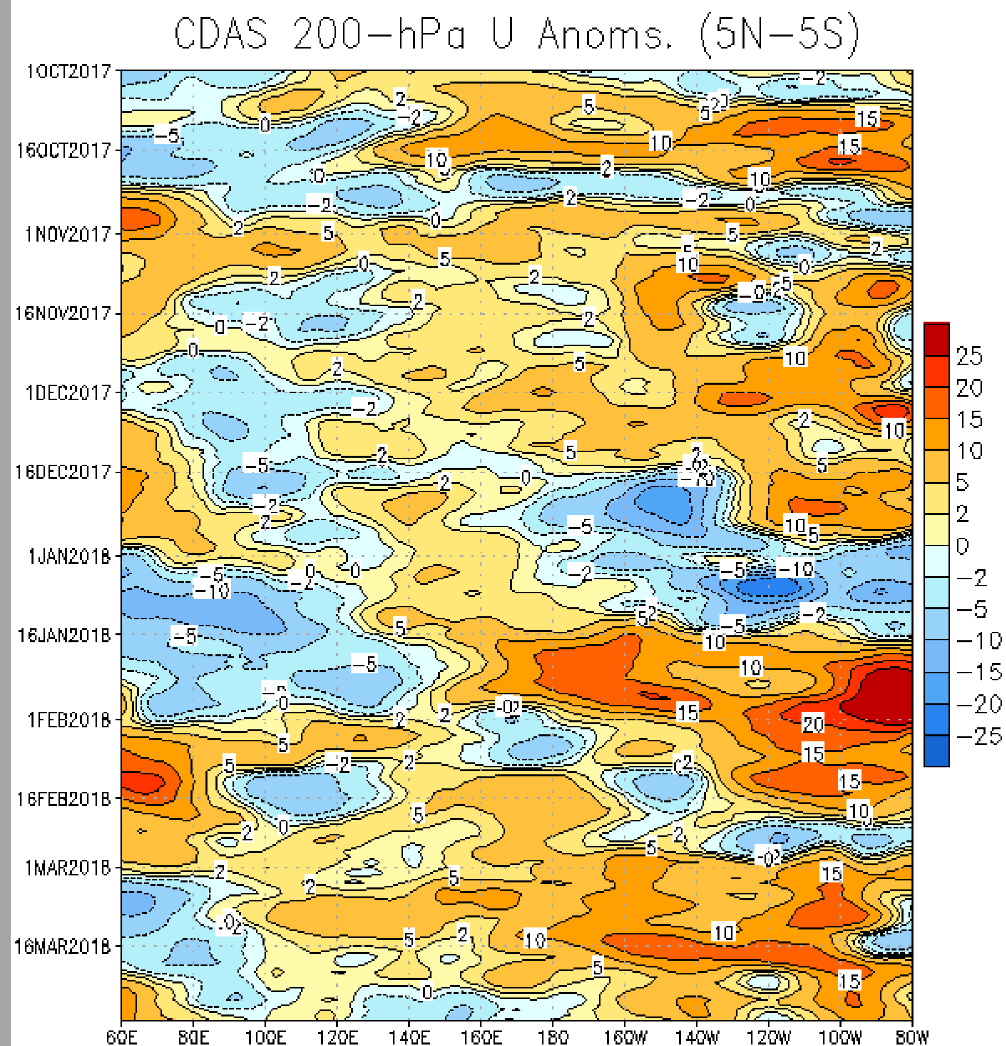
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Low-frequency anomalous westerlies remained in place east of 140E 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.

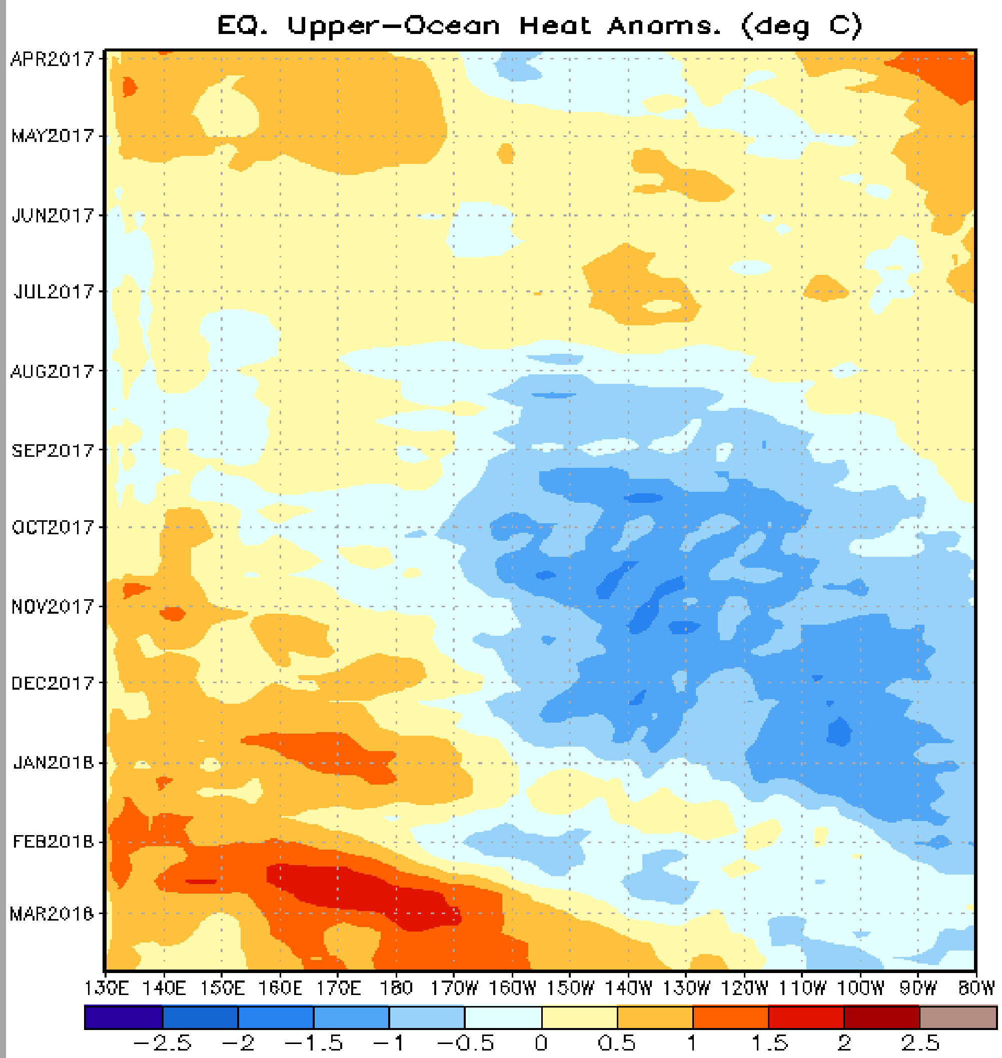
Strong anomalous westerlies that formed in early January just west of the Date Line propagated eastward, consistent with a strong MJO event during this period.

More recently, easterly anomalies have begun to develop between 120E and 160E, interrupting the relatively stationary anomalous westerlies that have persisted across the Pacific since the end of February.



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.

Another downwelling Kelvin wave is leading to highly positive, eastward-propagating anomalies near and east of the Date Line.

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

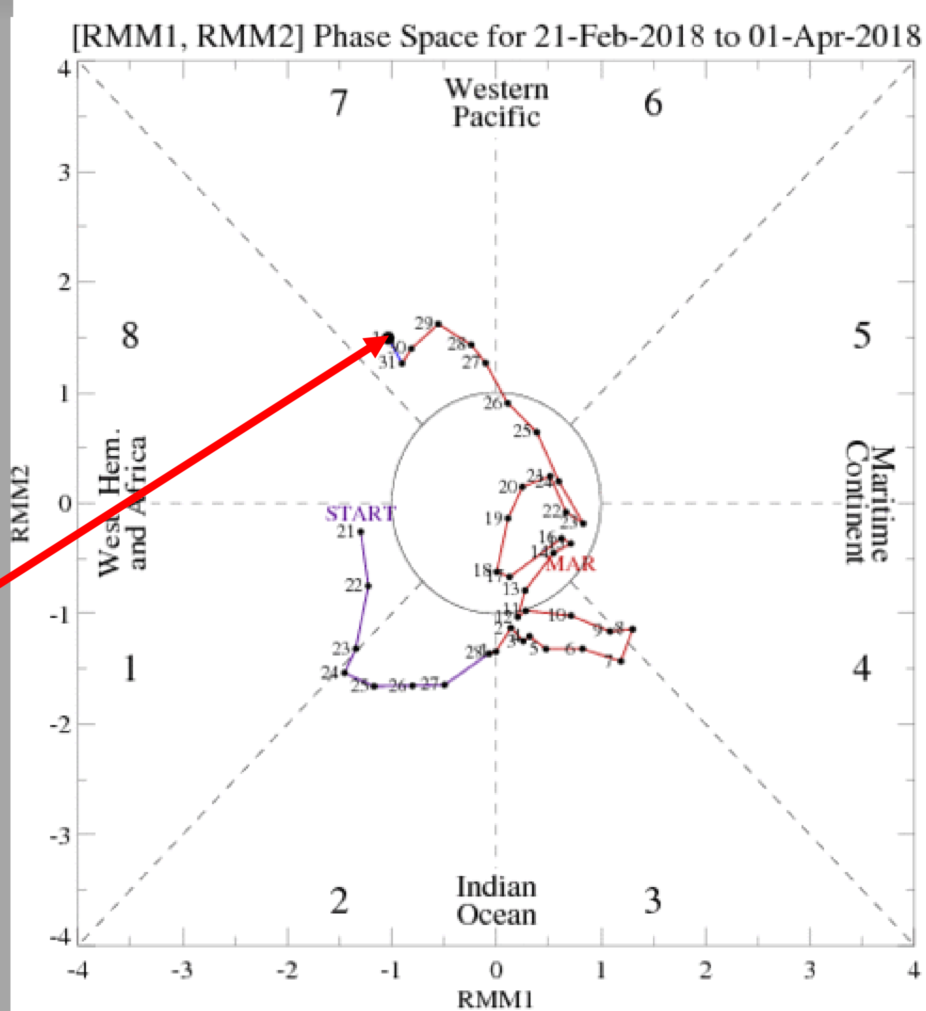
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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

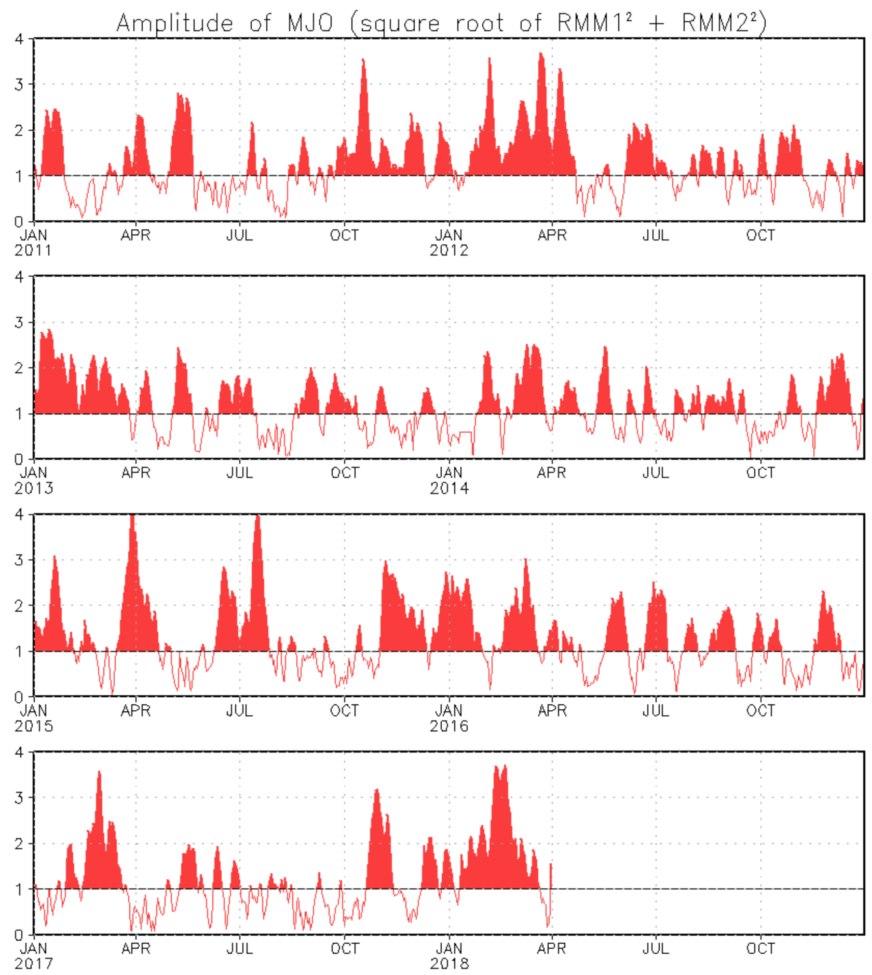


The RMM index depicts a re-emerging MJO signal over the Western Pacific during the past week.

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

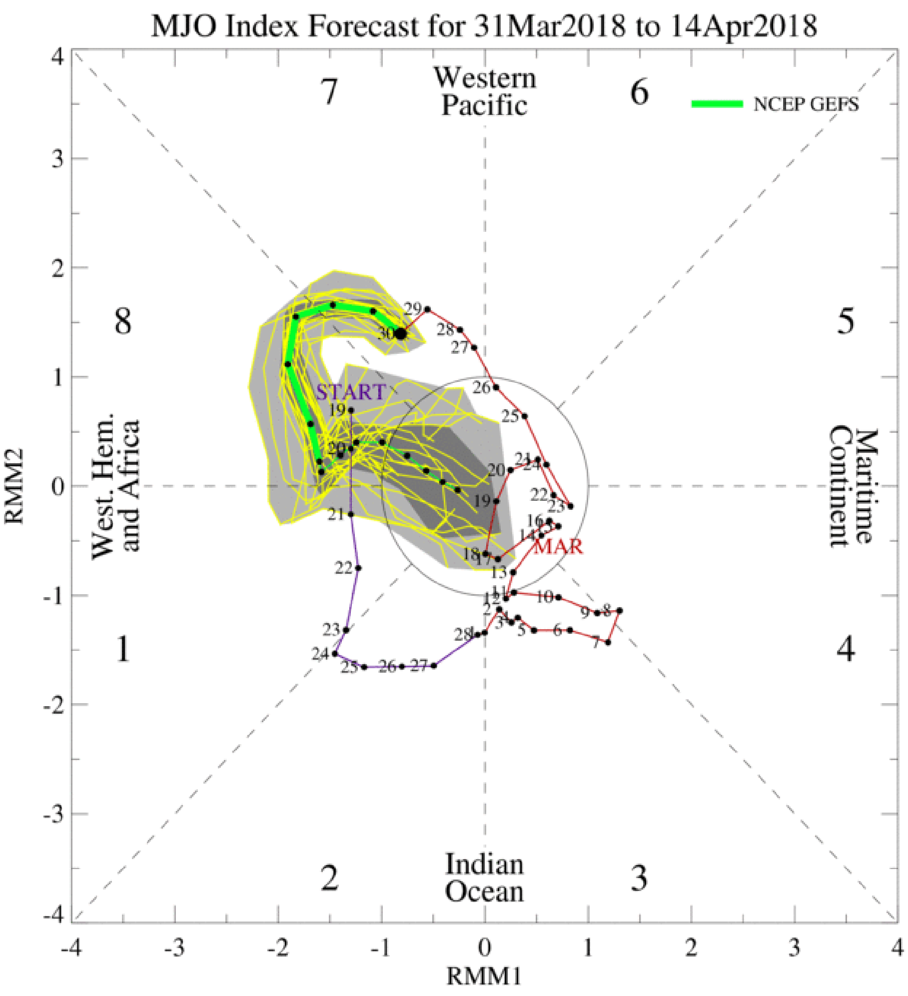
<u>Yellow Lines</u> - 20 Individual Members
<u>Green Line</u> - Ensemble Mean

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 predicts that the MJO will remain active over the Western Pacific during the Week-1 period, before rapidly weakening in Week-2.

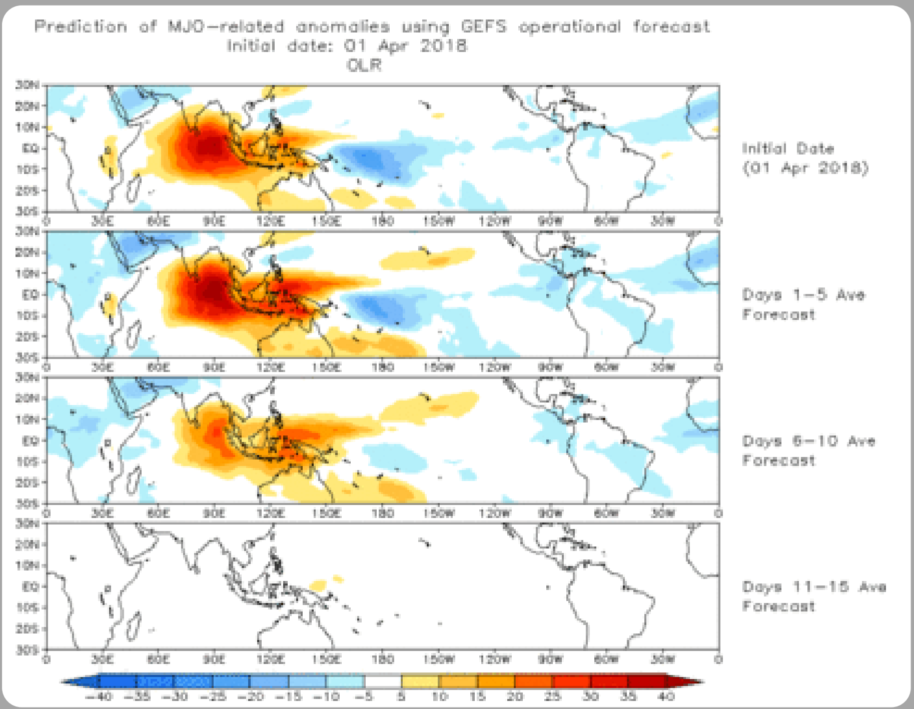


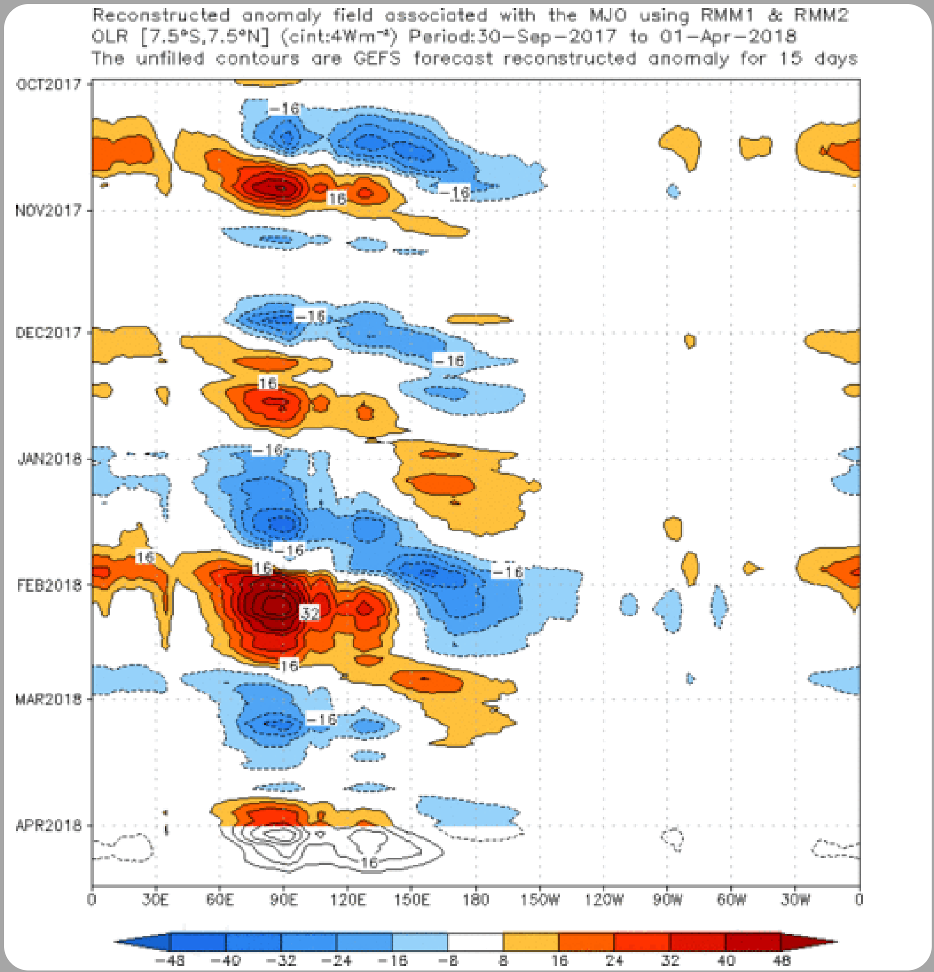
Ensemble GFS (GEFS) MJO Forecast

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

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



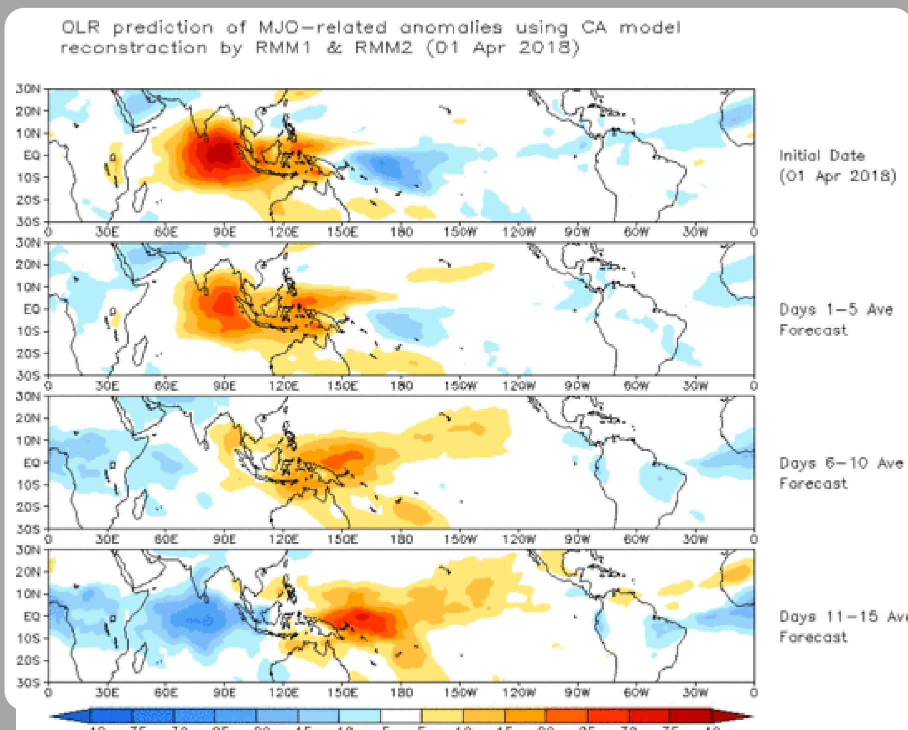


OLR anomalies associated with the MJO based on the GEFS show the MJO signal quickly intensifying, with the suppressed convective phase forecast to move across the Maritime Continent. Rapid decay is forecast for Week-2.

Constructed Analog (CA) MJO Forecast

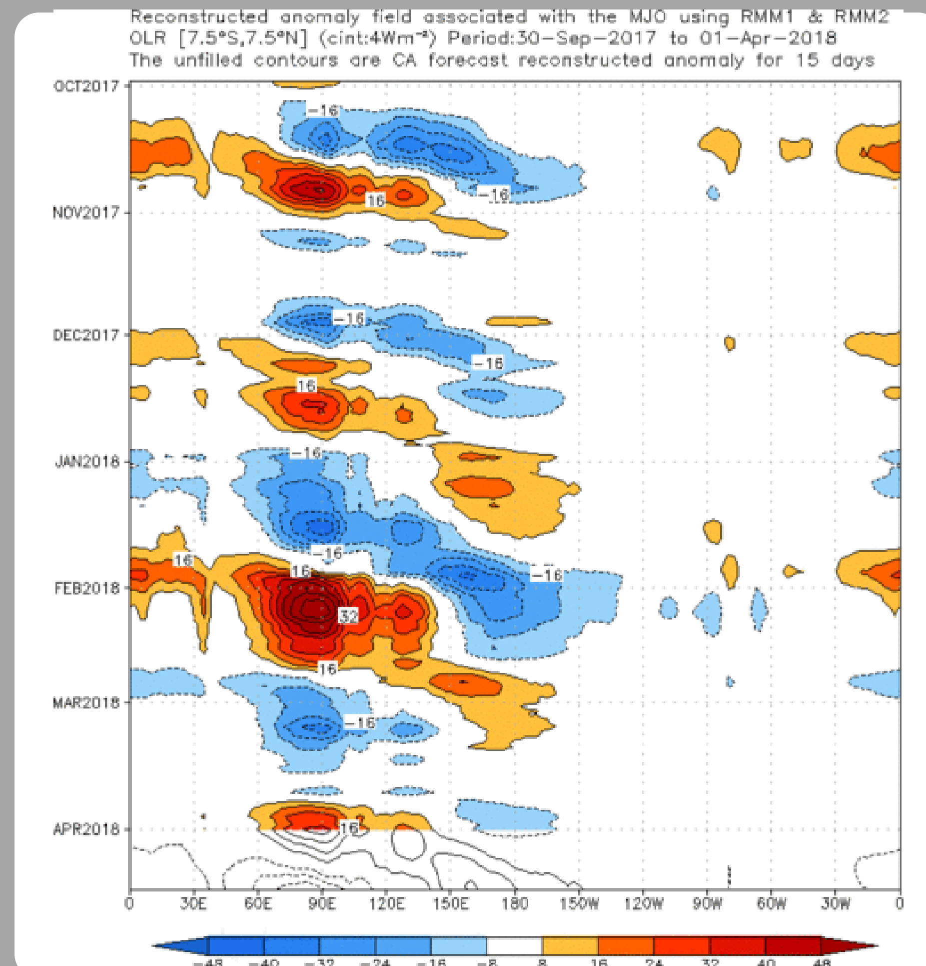
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



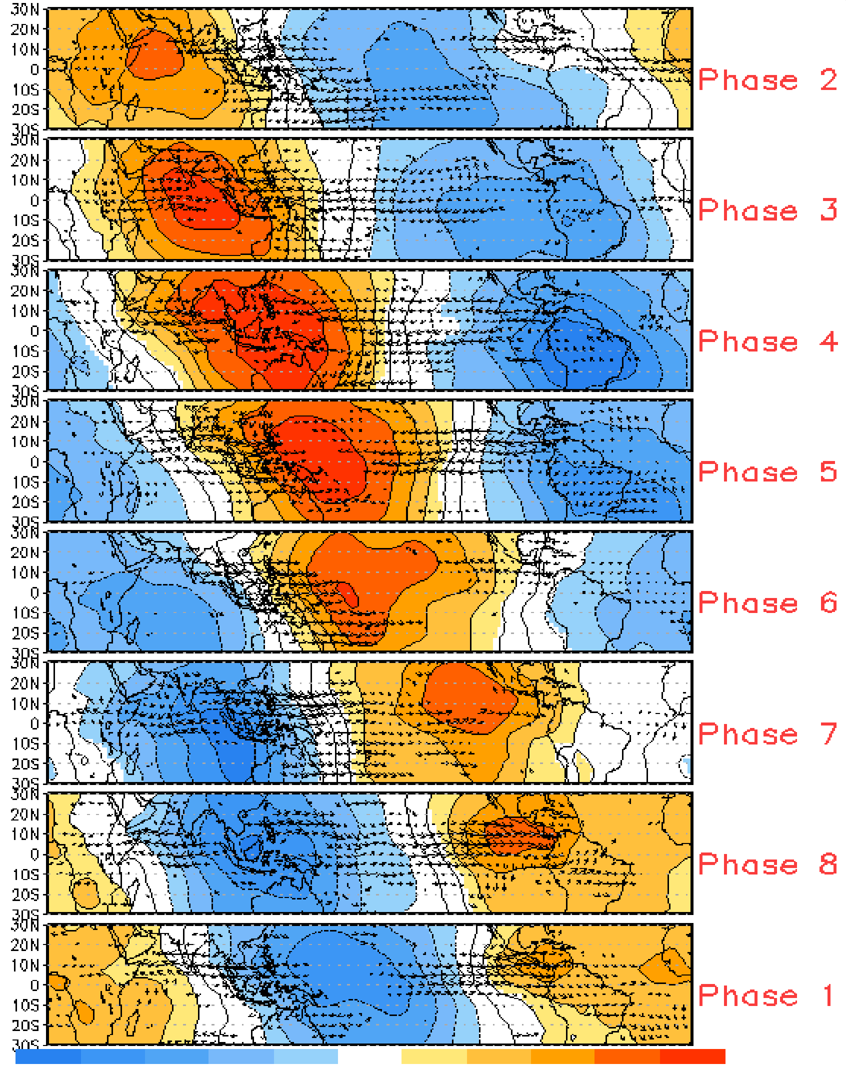
The constructed analog predicts a slower propagating signal than the GEFS solution, with less of a weakening of the signal during Week-2.

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

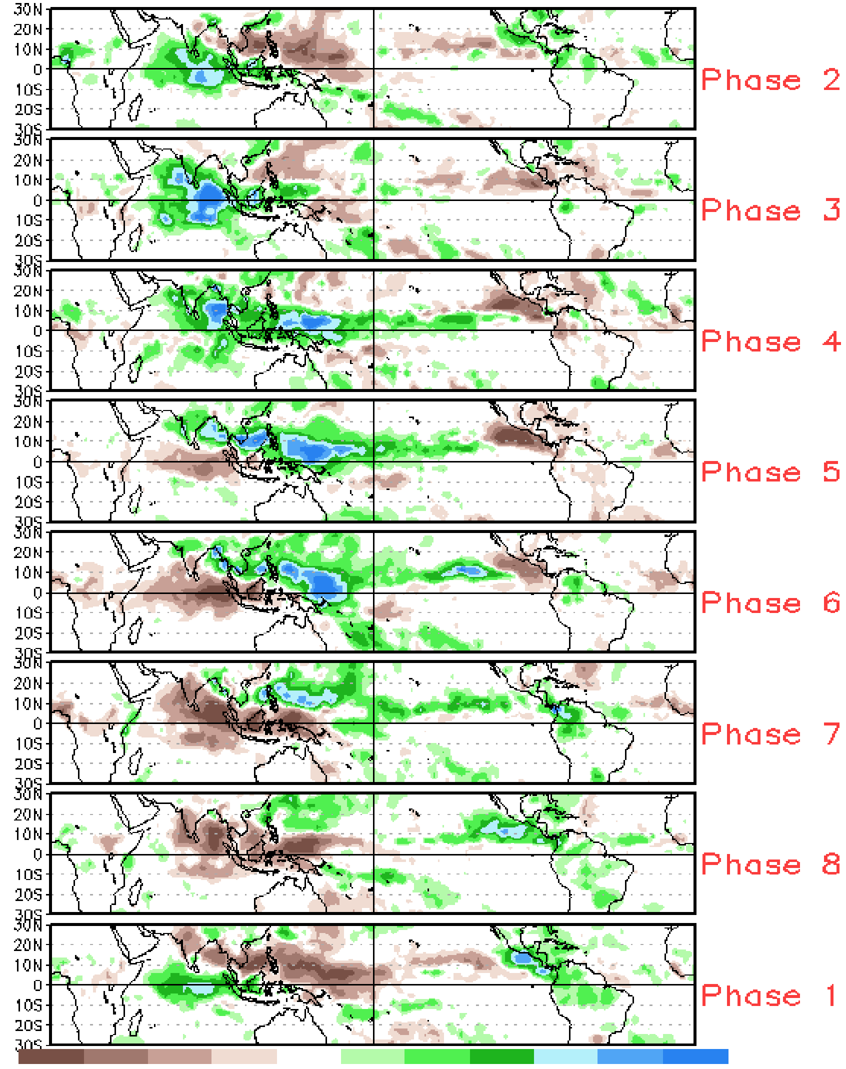


MJO Composites - Global Tropics

850-hPa Velocity Potential and Wind Anomalies (Nov - Mar)



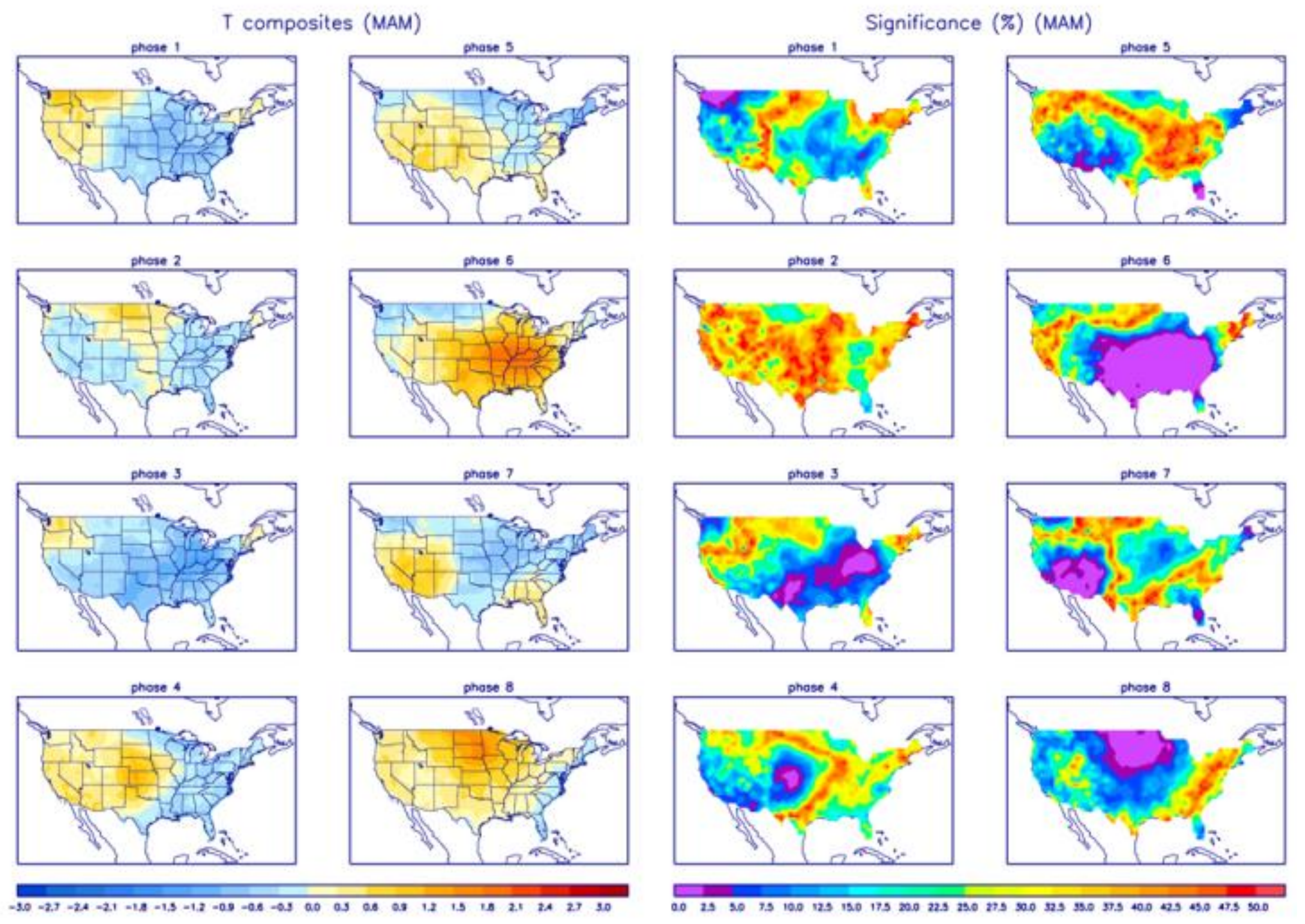
Precipitation Anomalies (Nov - Mar)



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.



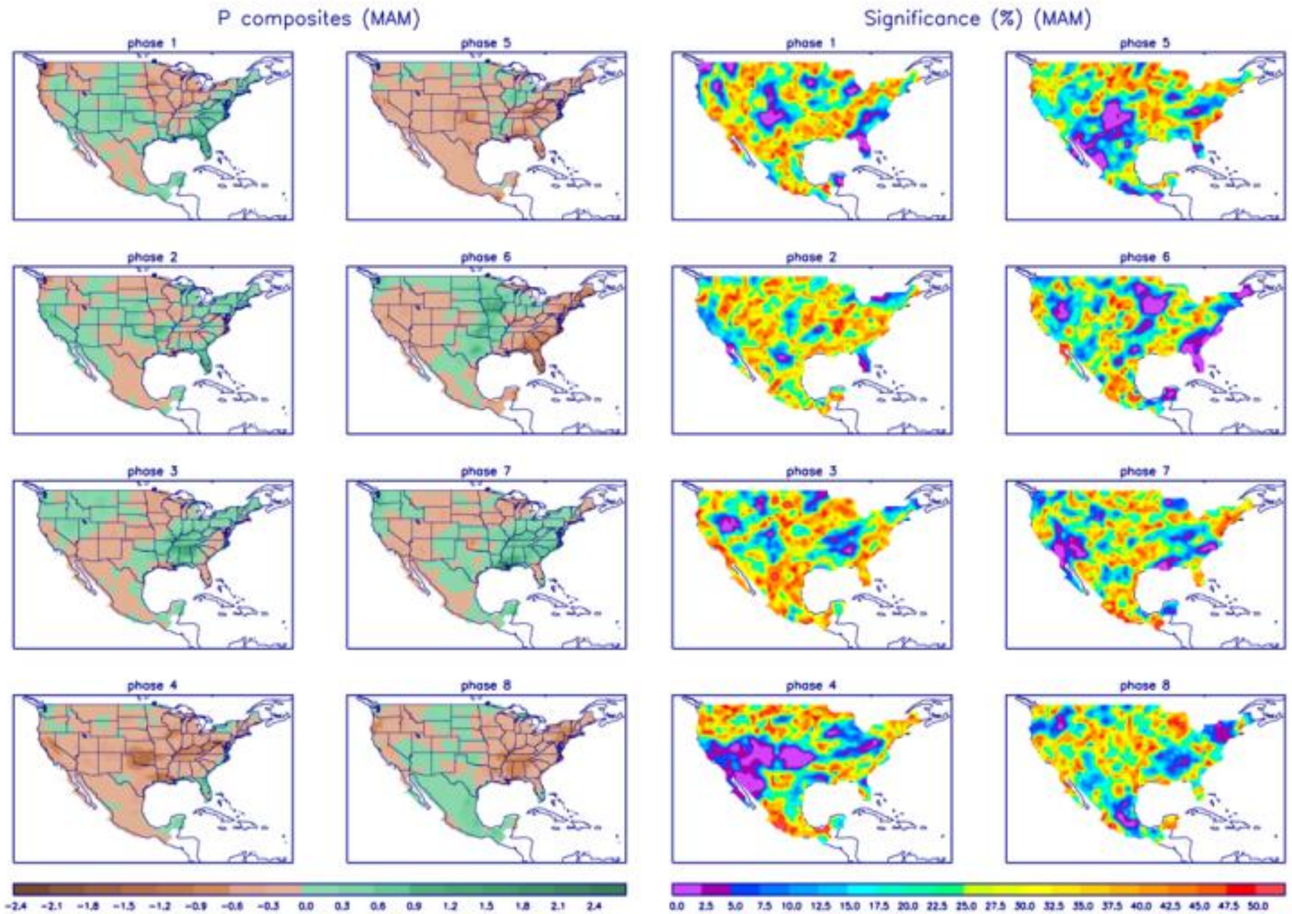
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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