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 remained active this past week, as it moved across the Western Hemisphere and into Africa.

- Most dynamical model forecasts depict the MJO signal to rapidly propagate across phases 1 and 2 during Week-1, and then weaken rapidly during Week-2. The very rapid eastward propagation that is anticipated is more consistent with the phase speed of a Kelvin wave.

- Tropical Cyclone (TC) Keni, currently northeast of Australia, is expected to track southeastward, remaining east of New Zealand. Little, if any, TC activity is forecast during the upcoming two-week period.

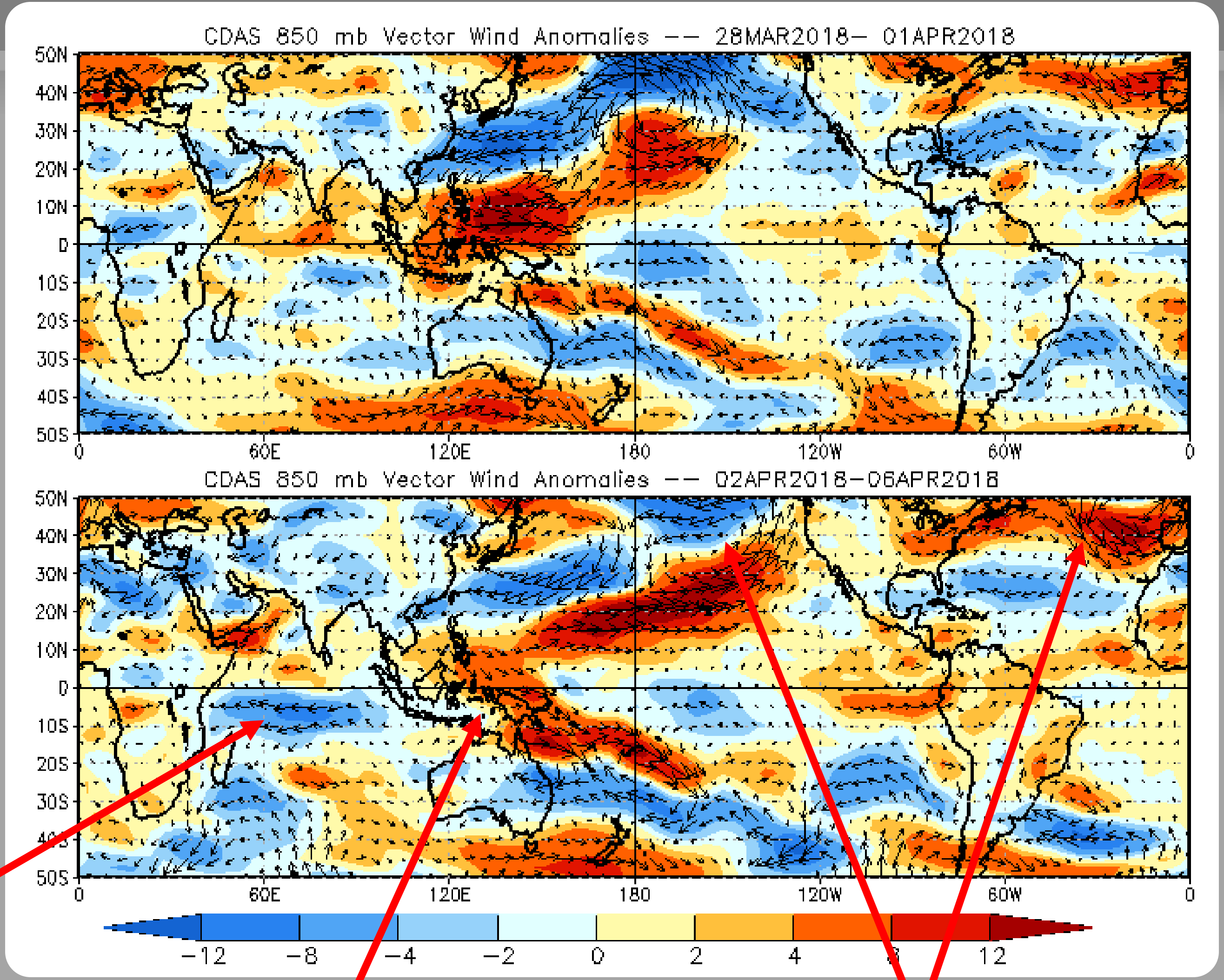
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Strong easterly anomalies developed during the past week over the S. Indian Ocean

Anomalous westerlies persist over the Maritime Continent, consistent with the MJO and low frequency state.

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

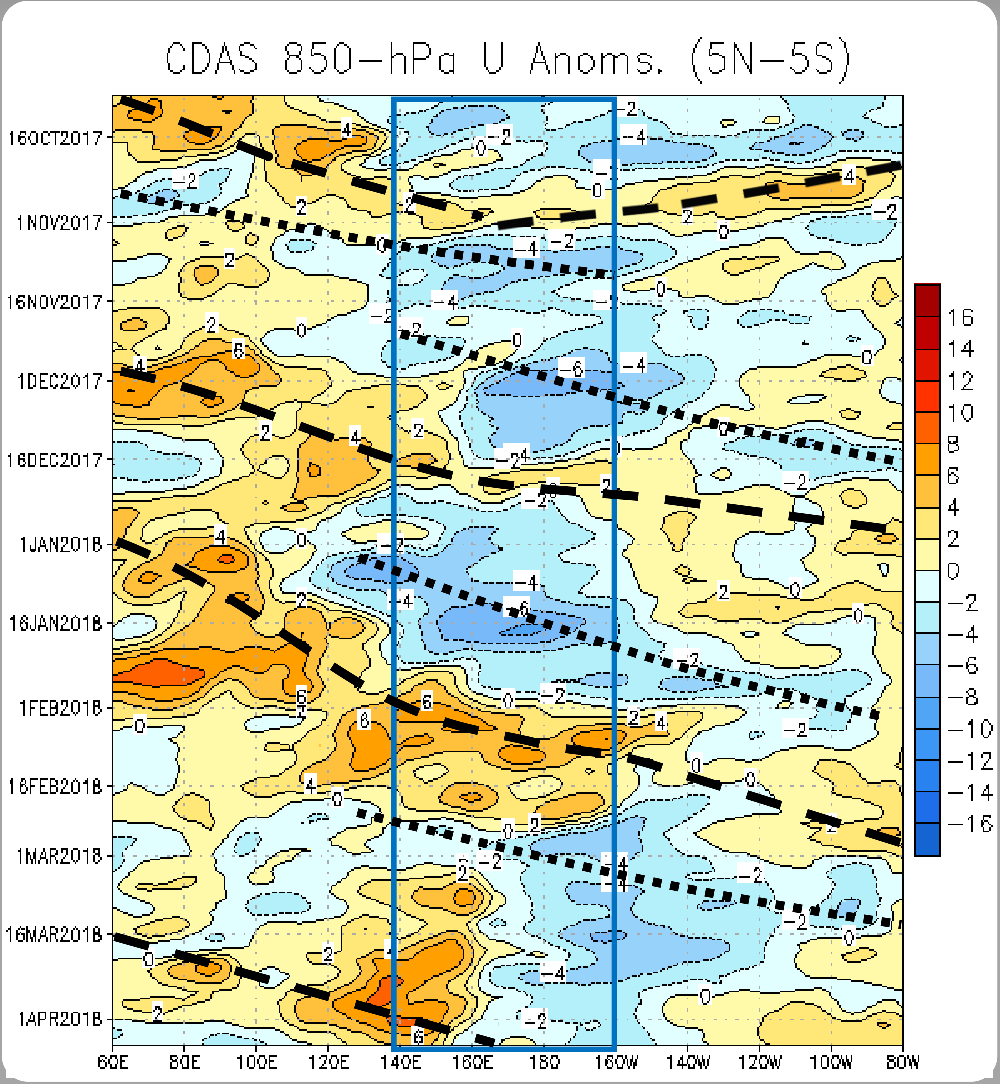
850-hPa Zonal Wind Anomalies (m s-1)

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

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

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 the MJO signal re-emerges. The ENSO-related low-frequency dry signal with easterly anomalies returned to the central Pacific in late February and continued into early April.



OLR Anomalies – Past 30 days

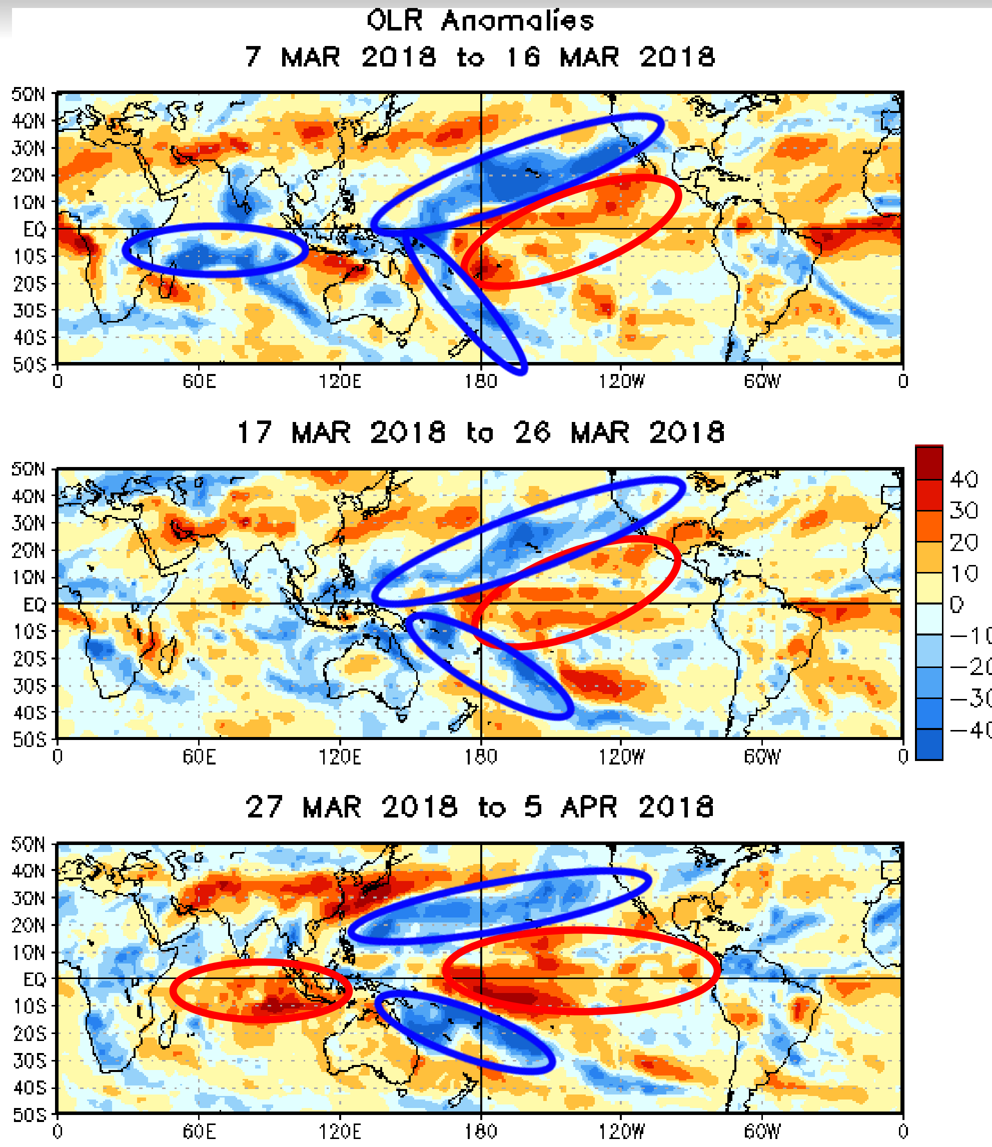
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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. 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.

By late March/early April, there was a switch in the convective anomaly sign from negative to positive over the IO (a drier pattern). Suppressed convection over the central Pacific 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 generally been in place since early March. Enhanced convection has also been generally persistent along the South Pacific Convergence Zone (SPCZ).



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

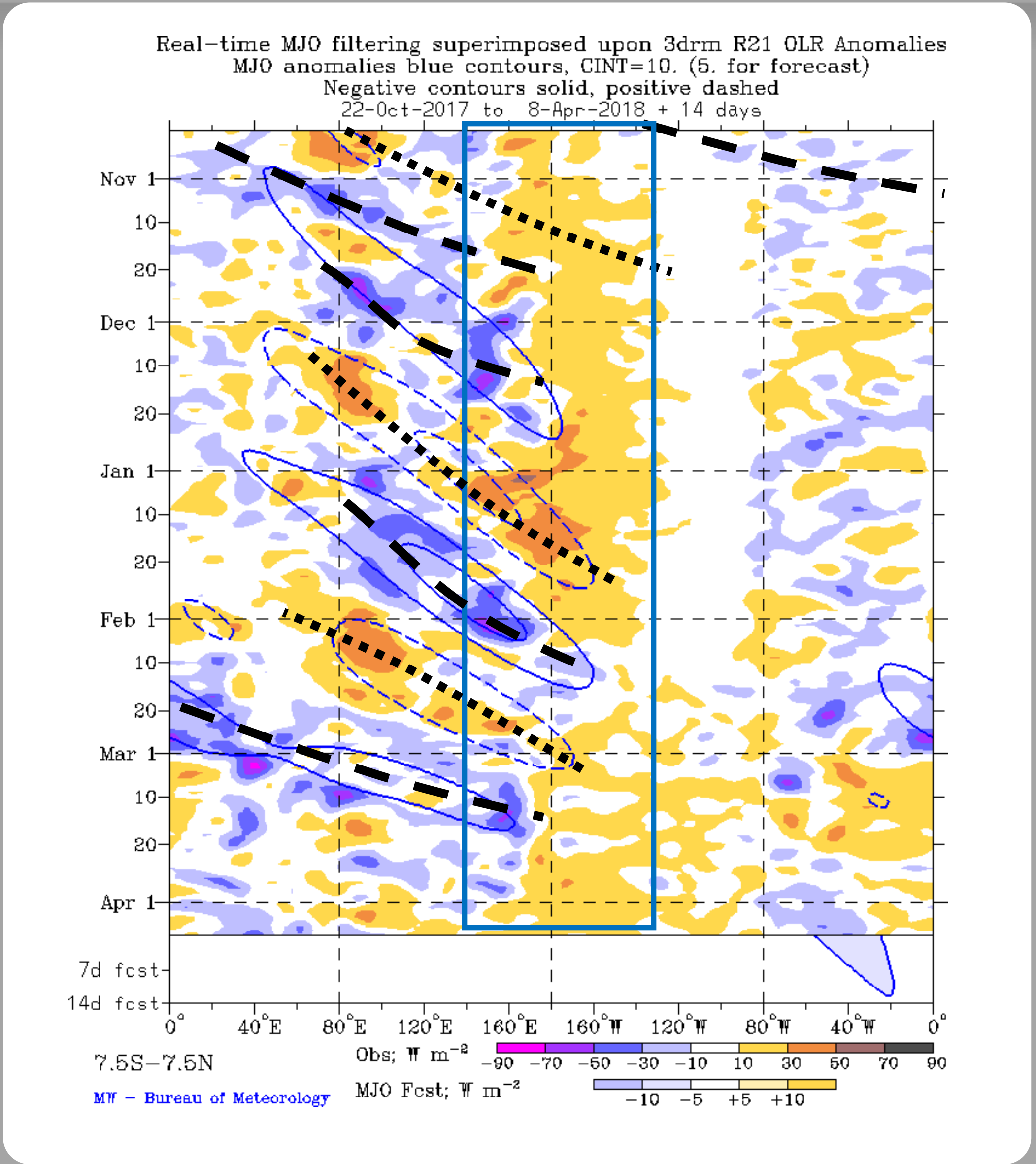
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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 Maritime Continent before weakening substantially by mid-March. Anomalous convection is flaring over Africa in recent days.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

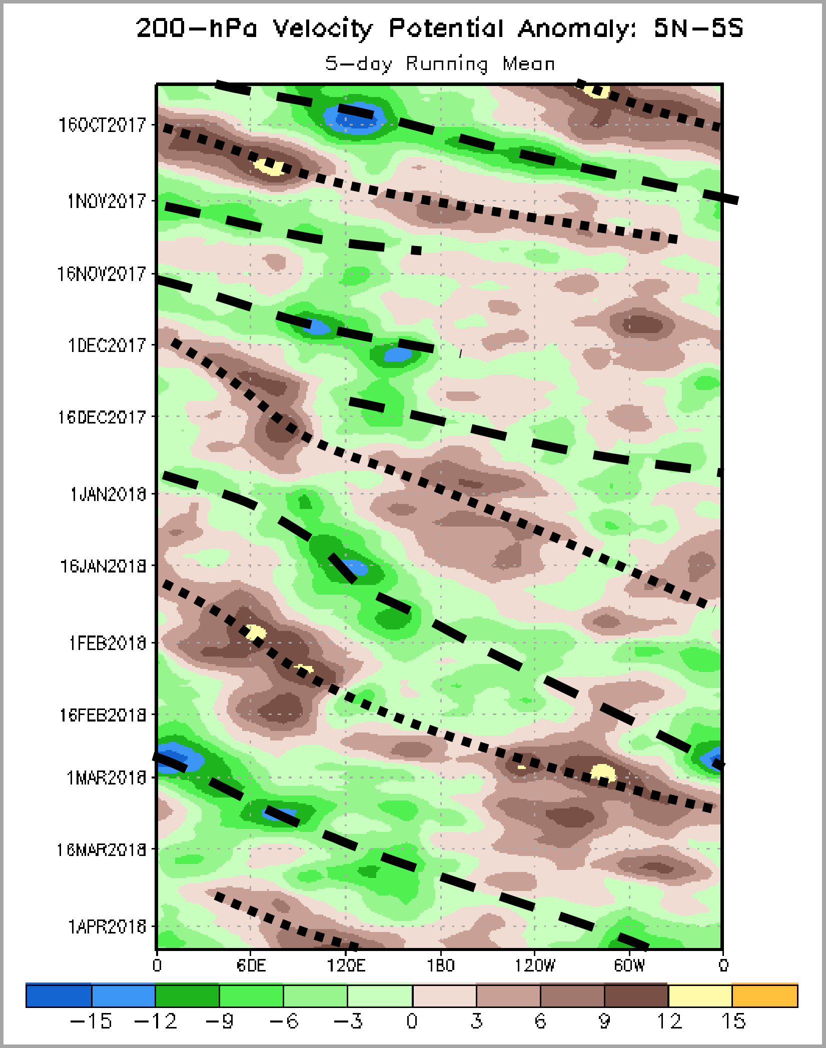
Negative anomalies (green shading) indicate favorable conditions for precipitation

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.

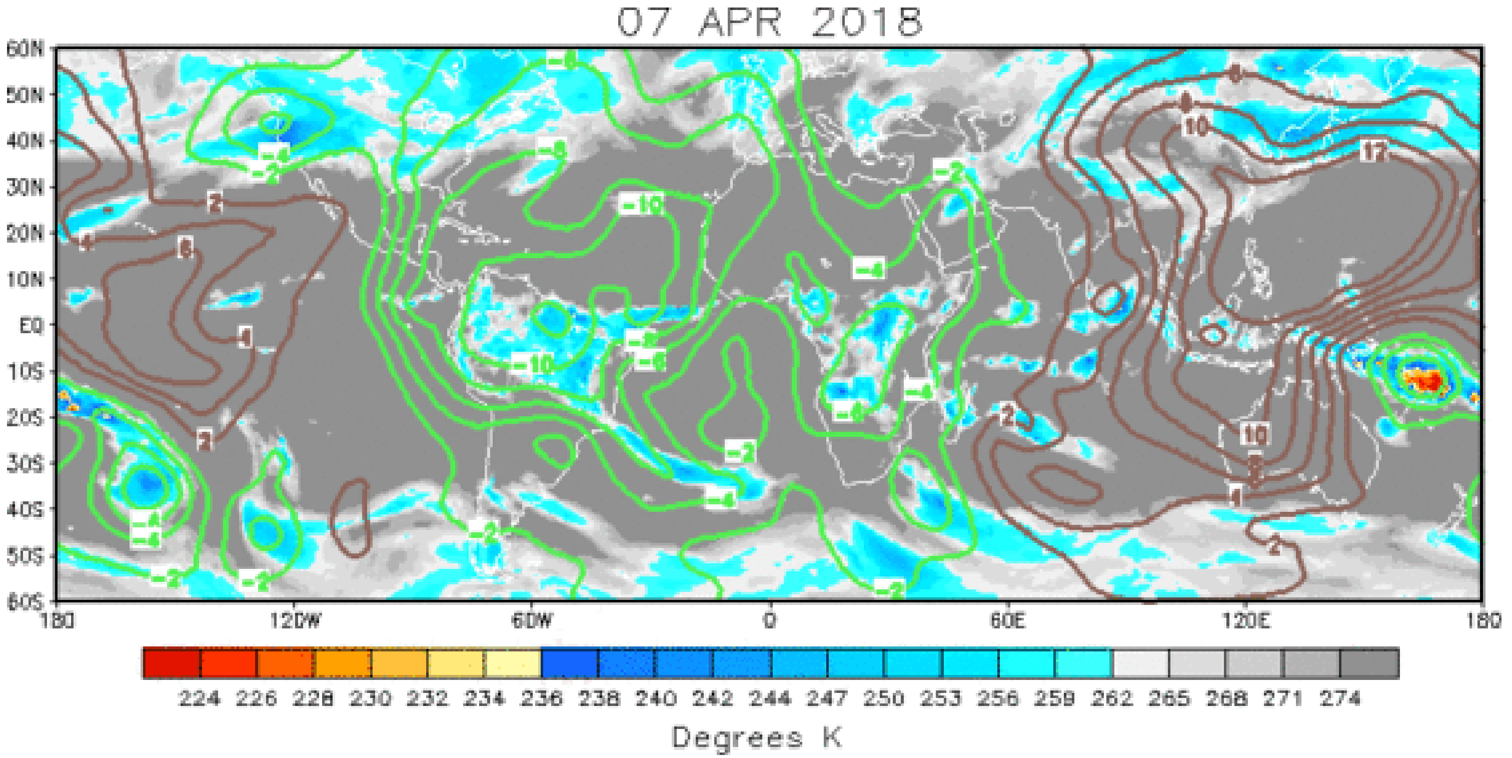
MJO activity renewed in November. The intraseasonal signal associated with this MJO event was weaker than the previous episode due to destructive interference from an equatorial Rossby wave.

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. By late March/early April, upper-level divergence returned to Africa and the western Indian Ocean, with upper-level convergence noted from the eastern IO eastward across the Pacific.



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



A Wave-1 pattern is present with suppressed (enhanced) convection over much of the Eastern (Western) Hemisphere. This is generally consistent with the MJO signal moving from phase 8 into phase 1 in RMM space. The circular cloud area northeast of Australia is associated with Tropical Cyclone 19P (Keni).

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)

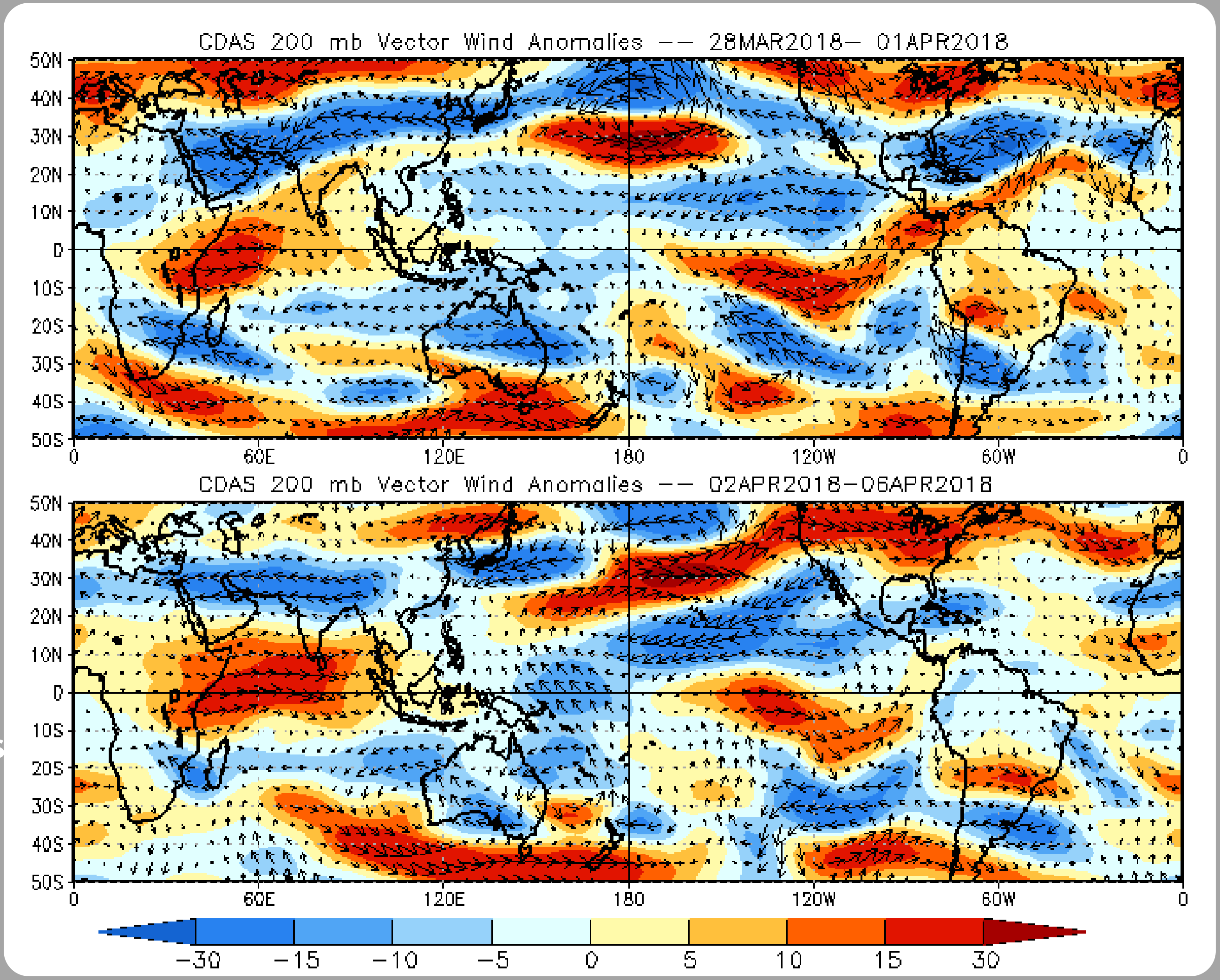
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

A bifurcating jet stream is depicted over the central Pacific, with cross-equatorial anomalous 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 subtropical moisture feed that had been in place over the past month. The anomalous westerlies have since been re-established over much of the northern Pacific. Anomalous westerlies also strengthened and expanded eastward across the tropical Indian Ocean.



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

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

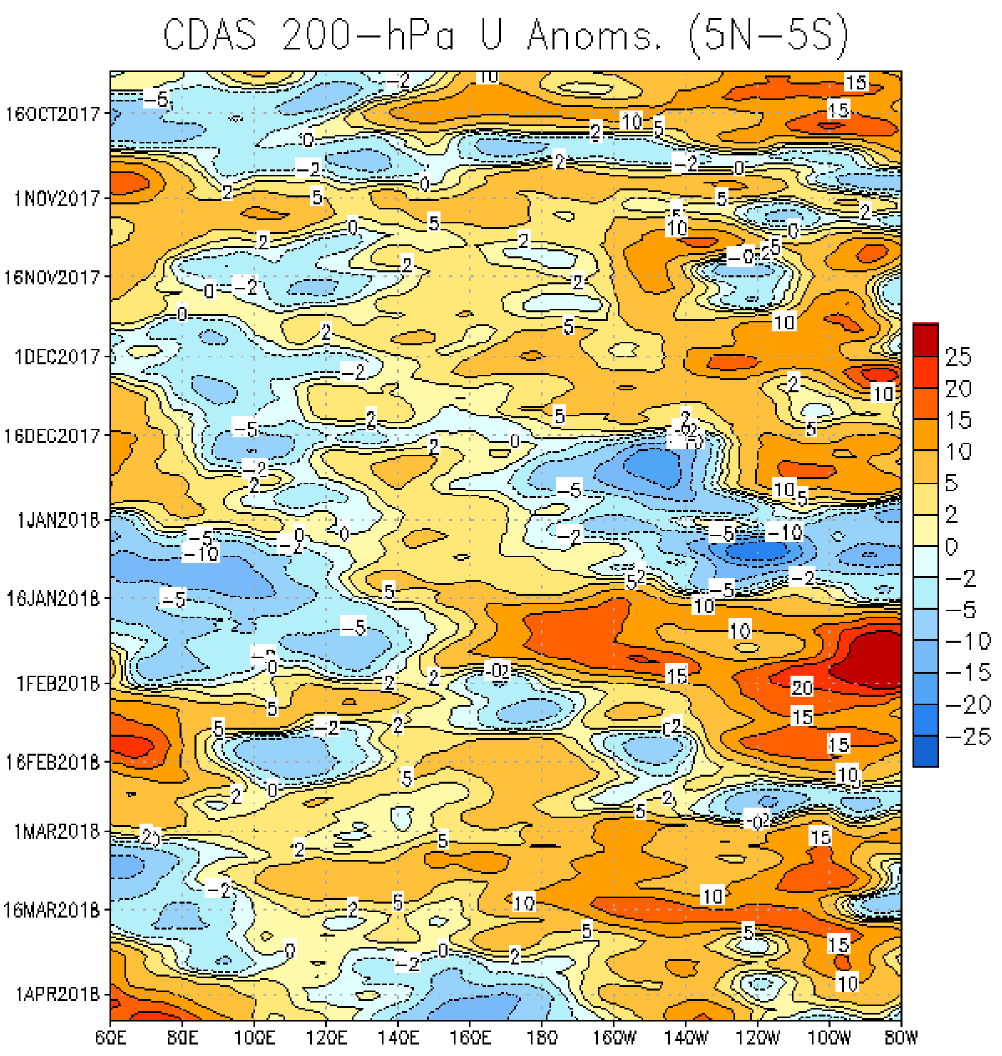
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

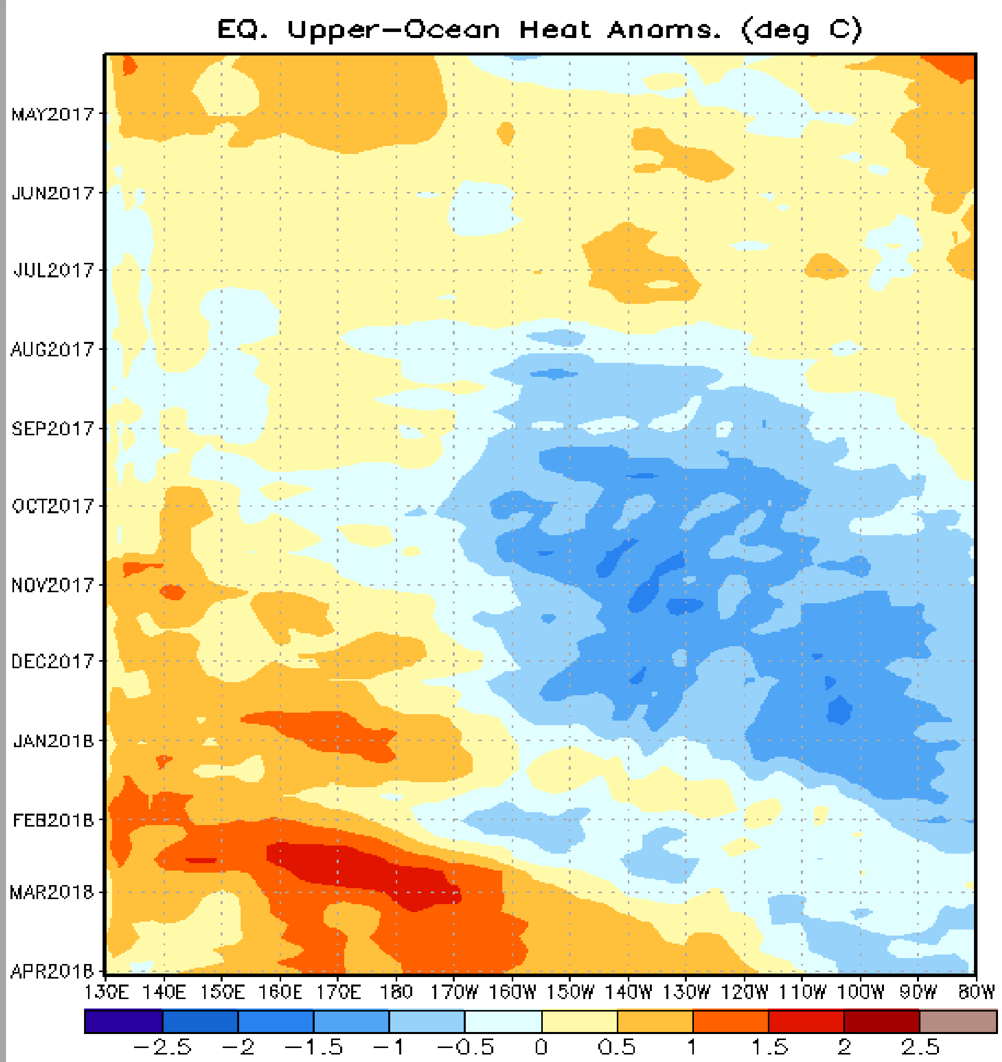
Strong anomalous westerlies that formed in early January just west of the Date Line propagated eastward, consistent with a strong MJO event during this period.

Recently, easterly anomalies have developed between 130E and 160W, interrupting the relatively stationary anomalous westerlies that have persisted across the Pacific since the middle of March. Westerly anomalies are also becoming established over the eastern Indian Ocean.



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 deg C above normal between 160E and 170W). Residual, negative heat content anomalies are now found only over the far eastern Pacific.

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

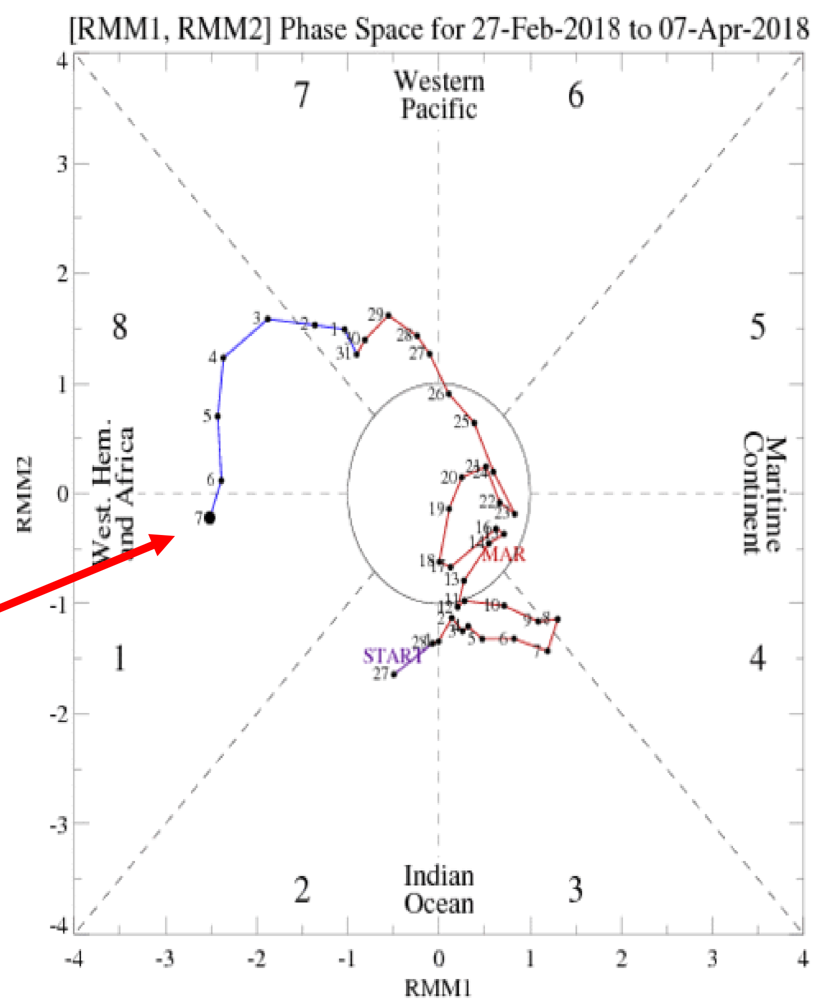
The triangular areas indicate the location of the enhanced phase of the MJO

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

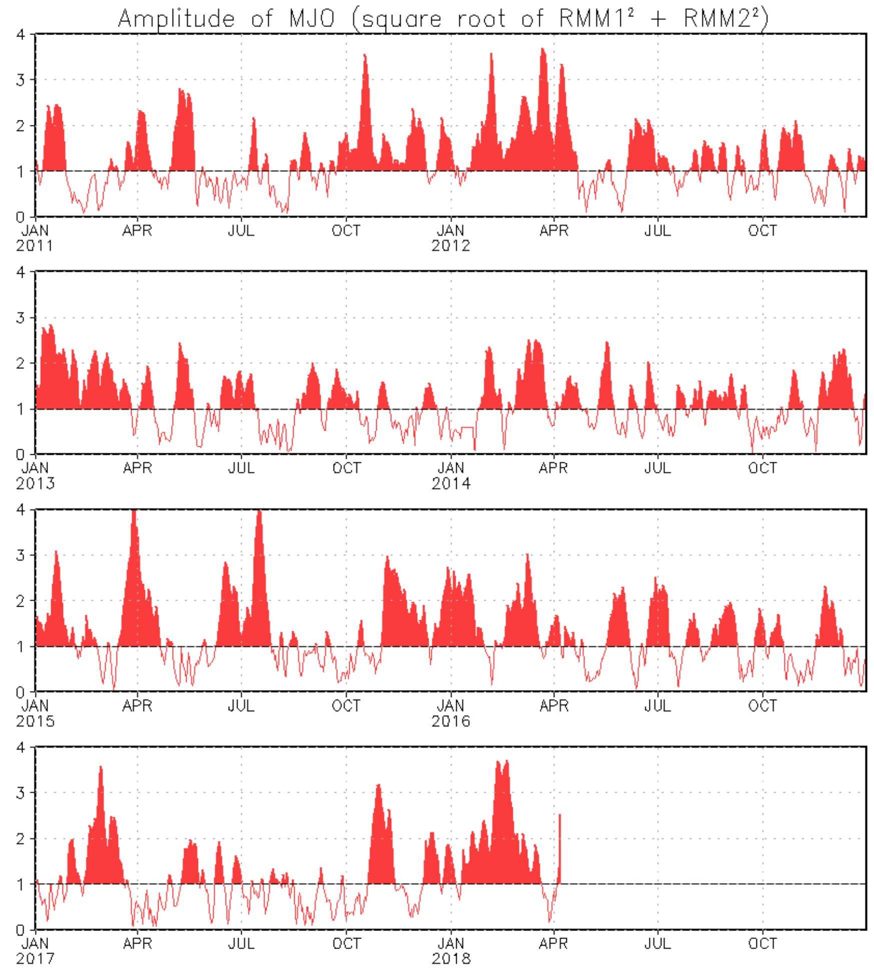
The RMM index depicts a strong MJO signal moved across phase 8 during the past week (Western Hemisphere and into Africa) and crossed over into phase 1 within the past few days.



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

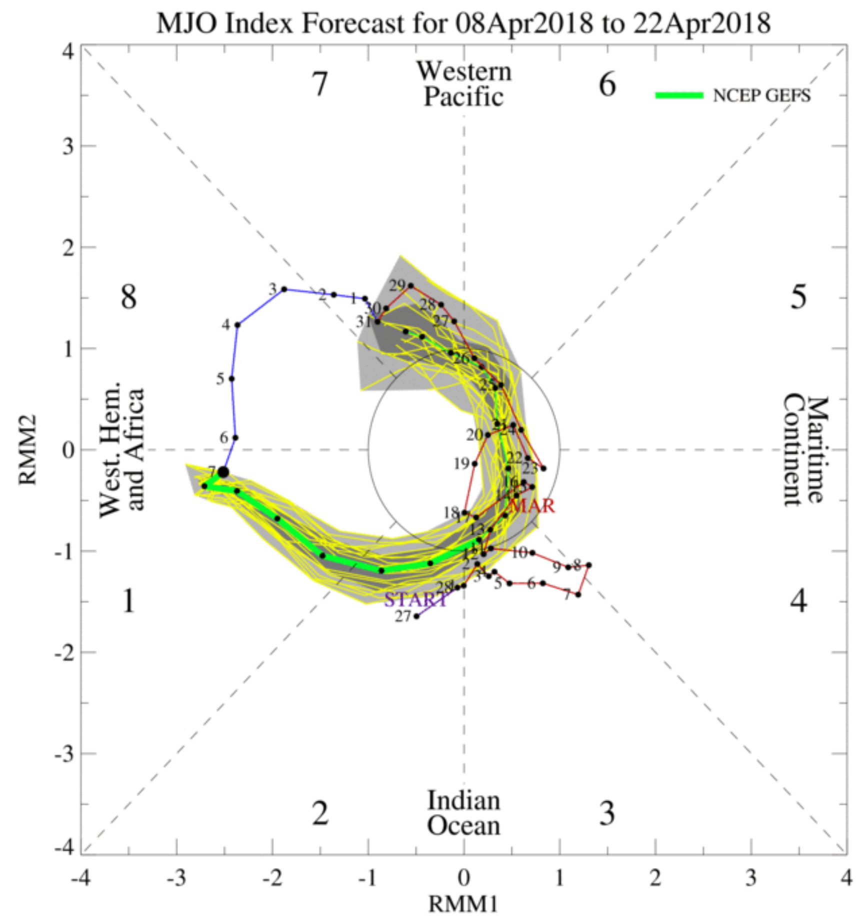
RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GEFS predicts that the MJO will remain active across Africa and the Indian Ocean during Week-1, before some weakening and continued rapid propagation during Week-2.

This signal appears more consistent with Kelvin wave activity relative to the MJO given the ~20 day period.

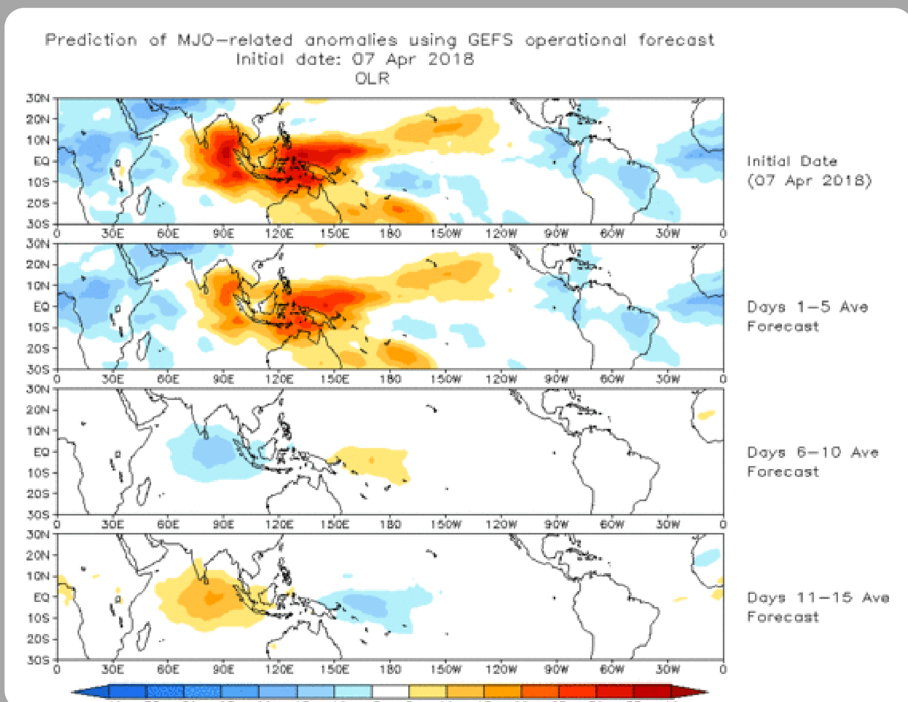


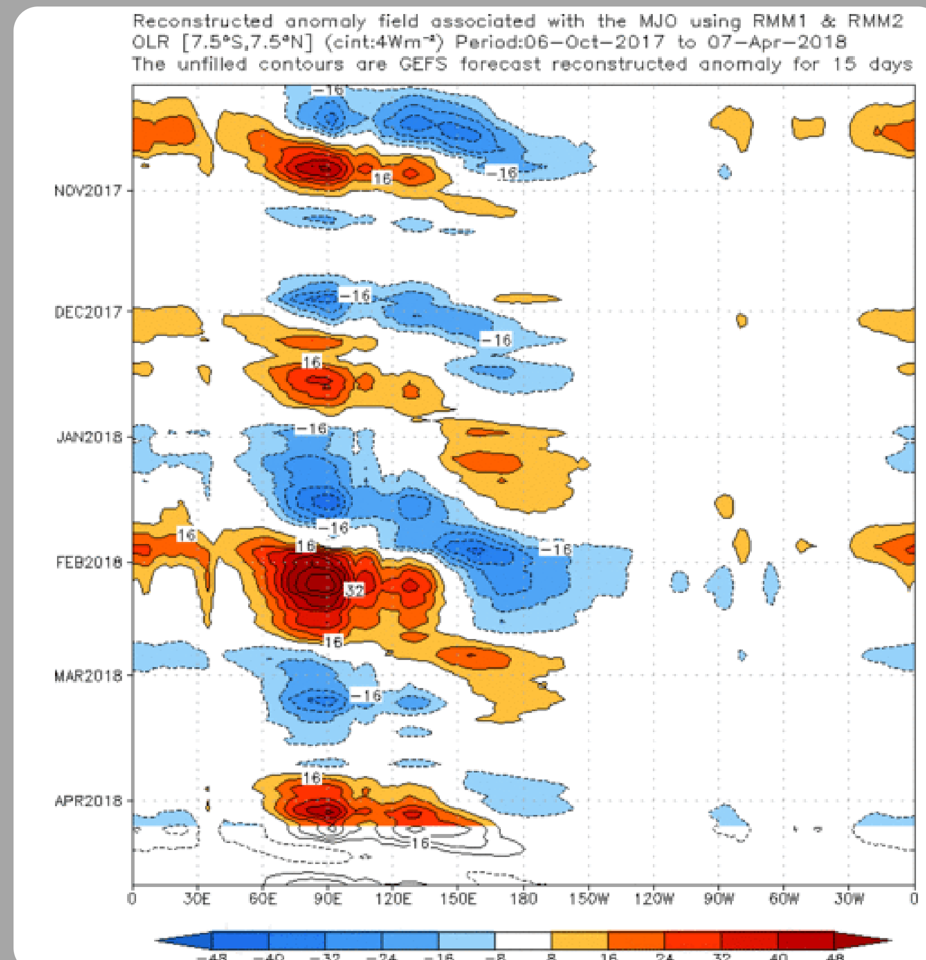
Ensemble GFS (GEFS) MJO Forecast

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



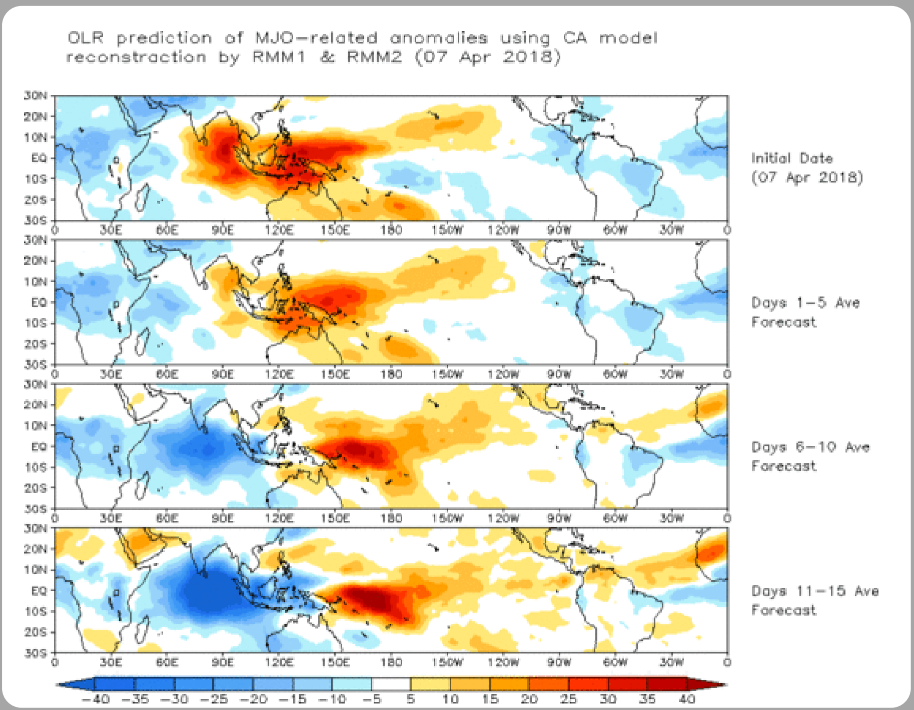


OLR anomalies associated with the MJO (based on the GEFS) show the enhanced convective MJO signal taking shape over the Indian Ocean in Week-1, followed by more rapid propagation and some weakening of the signal over the Maritime Continent and western Pacific in Week-2.

Constructed Analog (CA) MJO Forecast

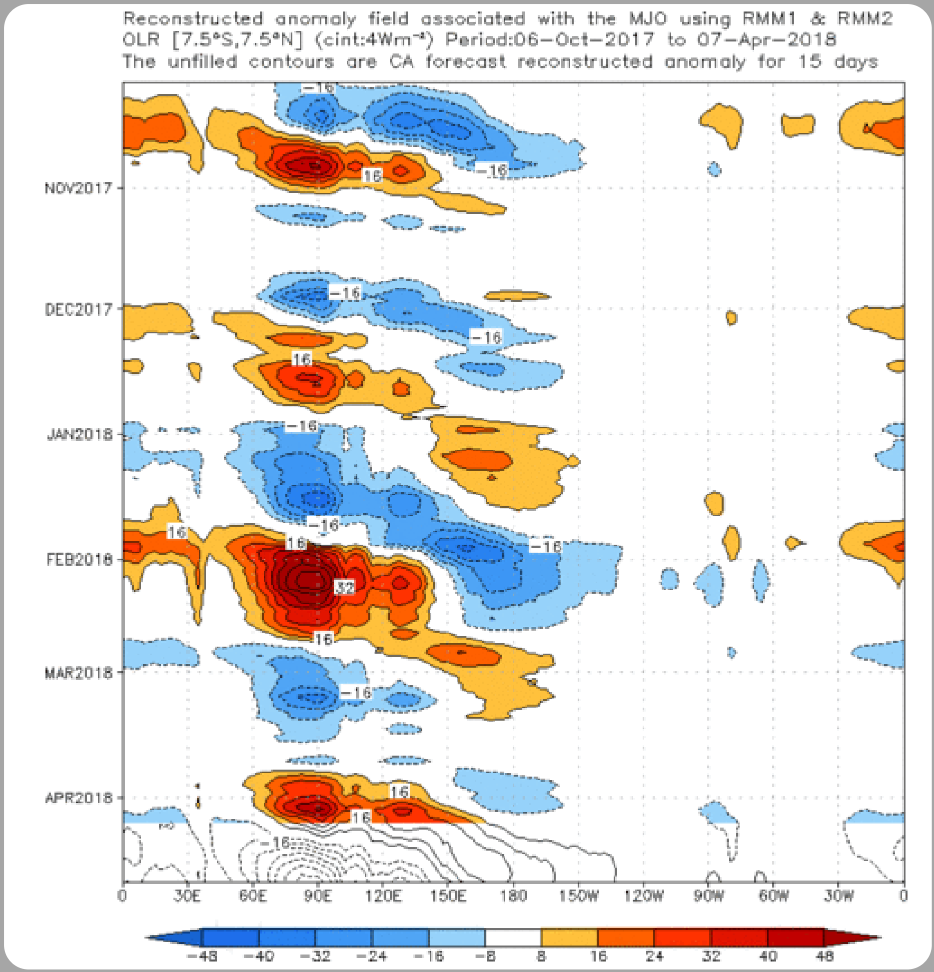
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



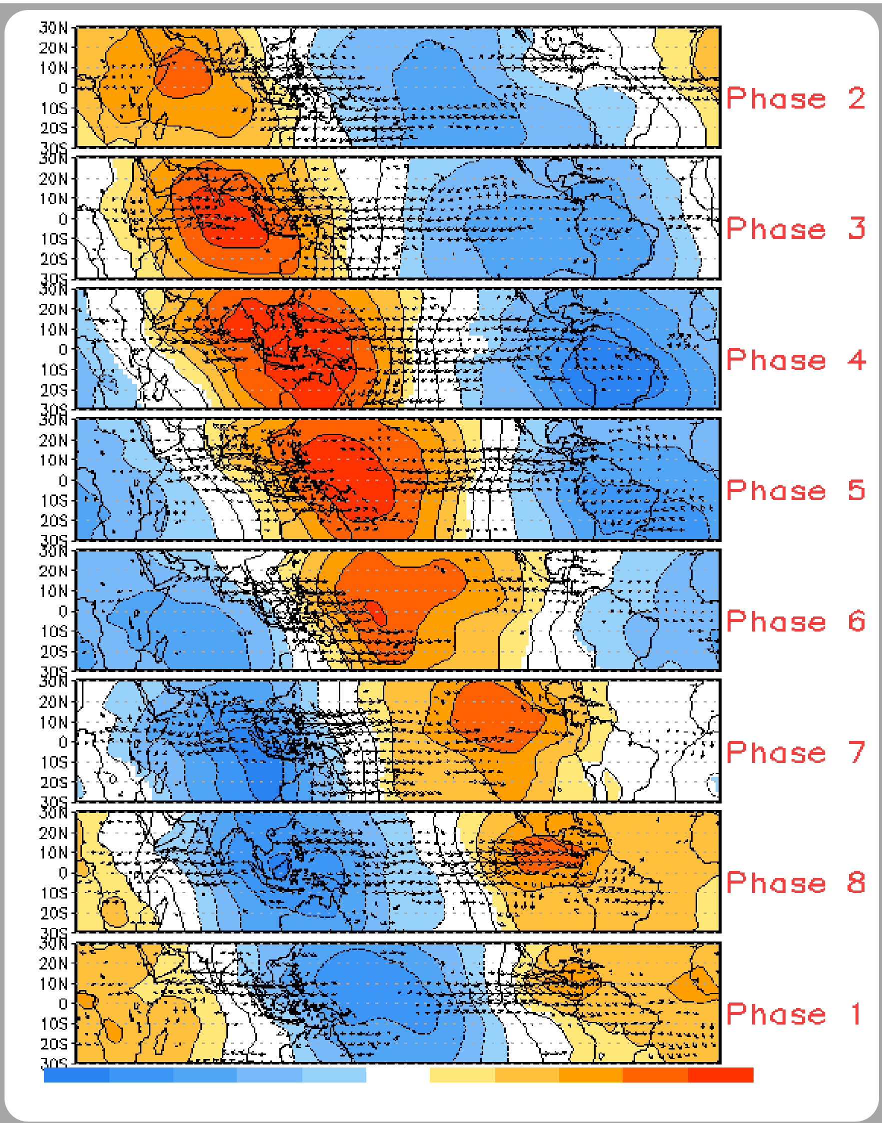
The constructed analog predicts an amplifying MJO signal during the next two weeks, which slowly propagates across the Indian Ocean.

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

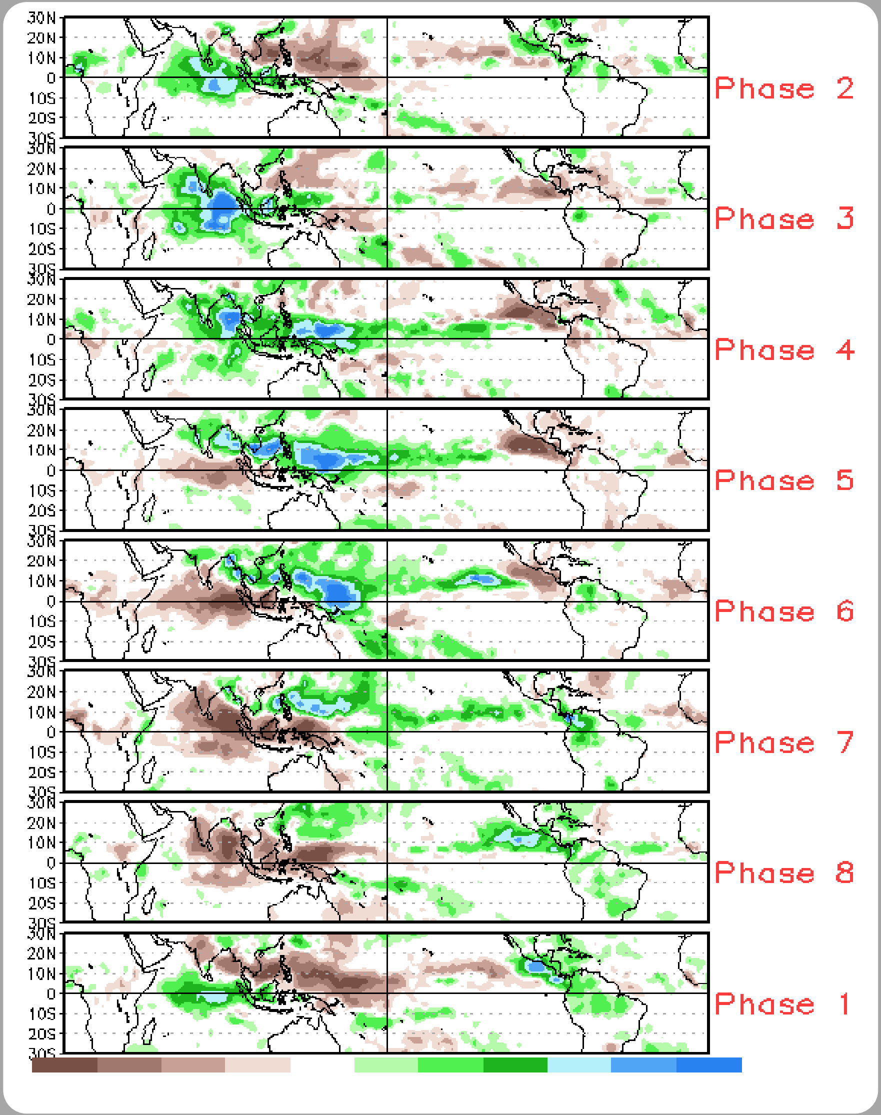


MJO Composites - Global Tropics

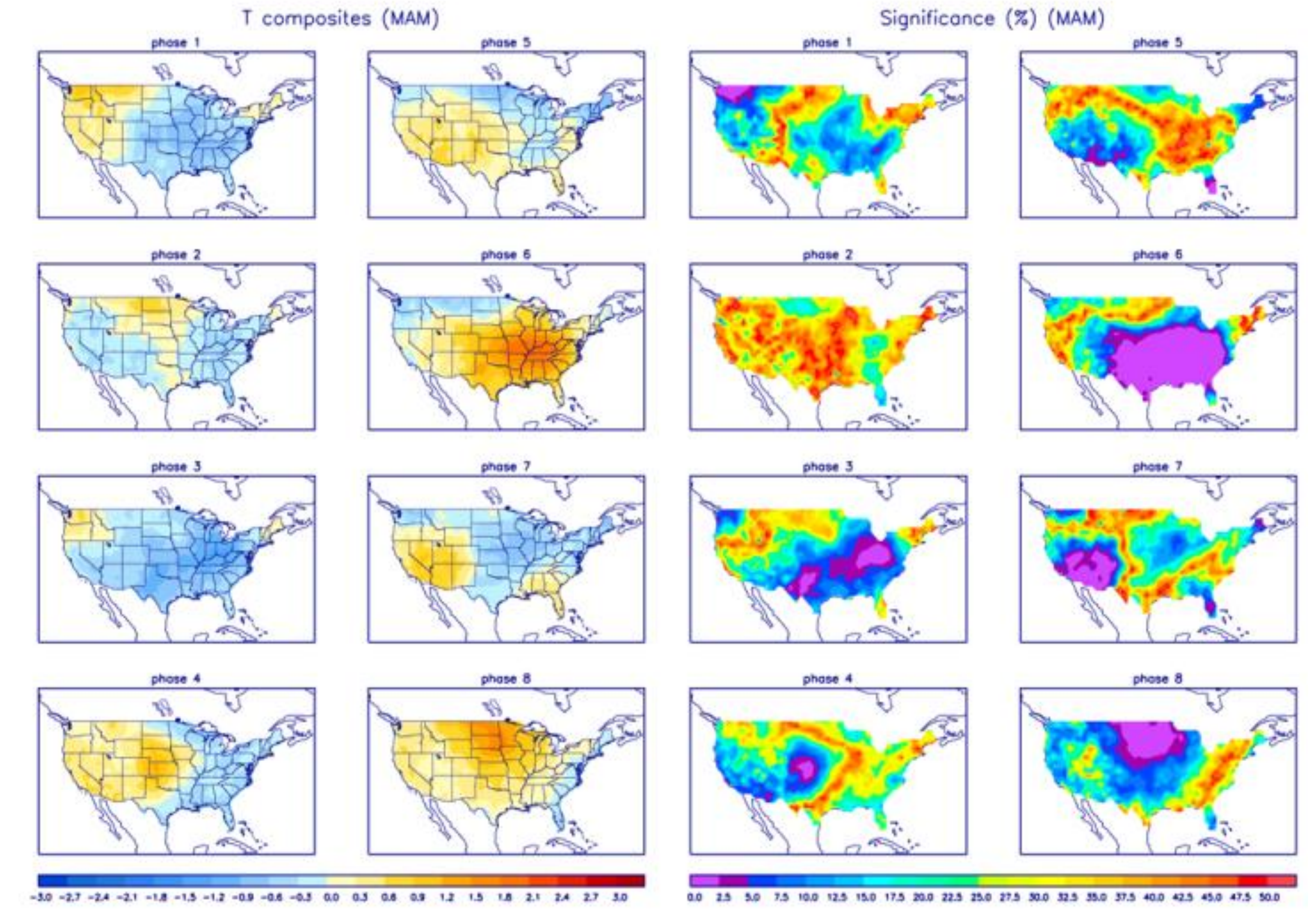
850-hPa Velocity Potential and Wind Anomalies (Nov - Mar)



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.

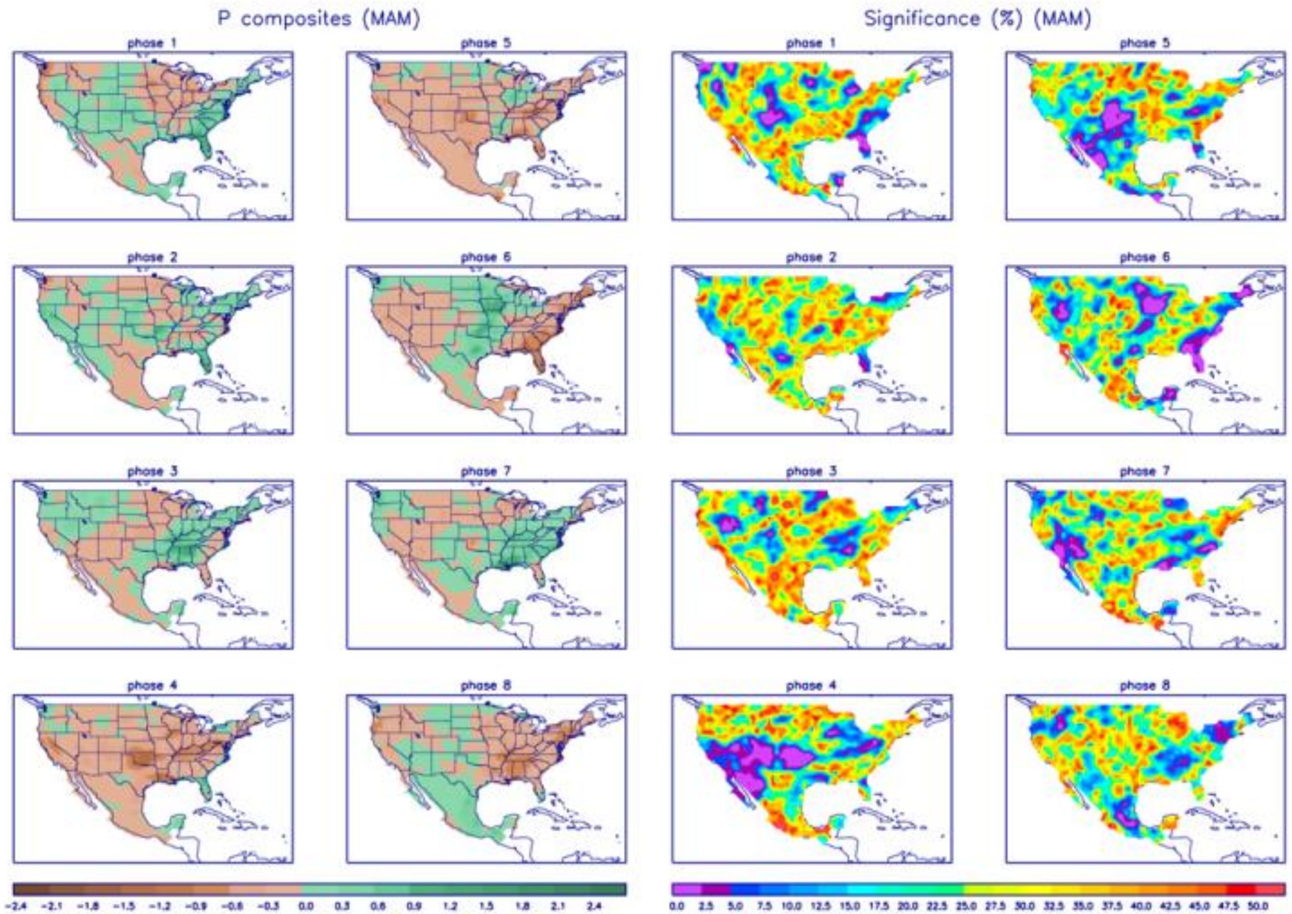
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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