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

Update prepared by: Anthony Artusa
Climate Prediction Center / NCEP
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Overview

The MJO signal has become increasingly incoherent over the last 1-2 weeks.

Dynamical models generally support a weak, incoherent MJO during the next 2 weeks, though there are significant differences between model solutions. Confidence is reduced regarding potential impacts of the MJO and other modes on the global tropical convective pattern.

At this time, it is not expected that the MJO will contribute largely to the patterns of tropical rainfall during this period, with the exception of the central Southern Indian Ocean, where there is a high risk of tropical cyclone formation very early in the period.

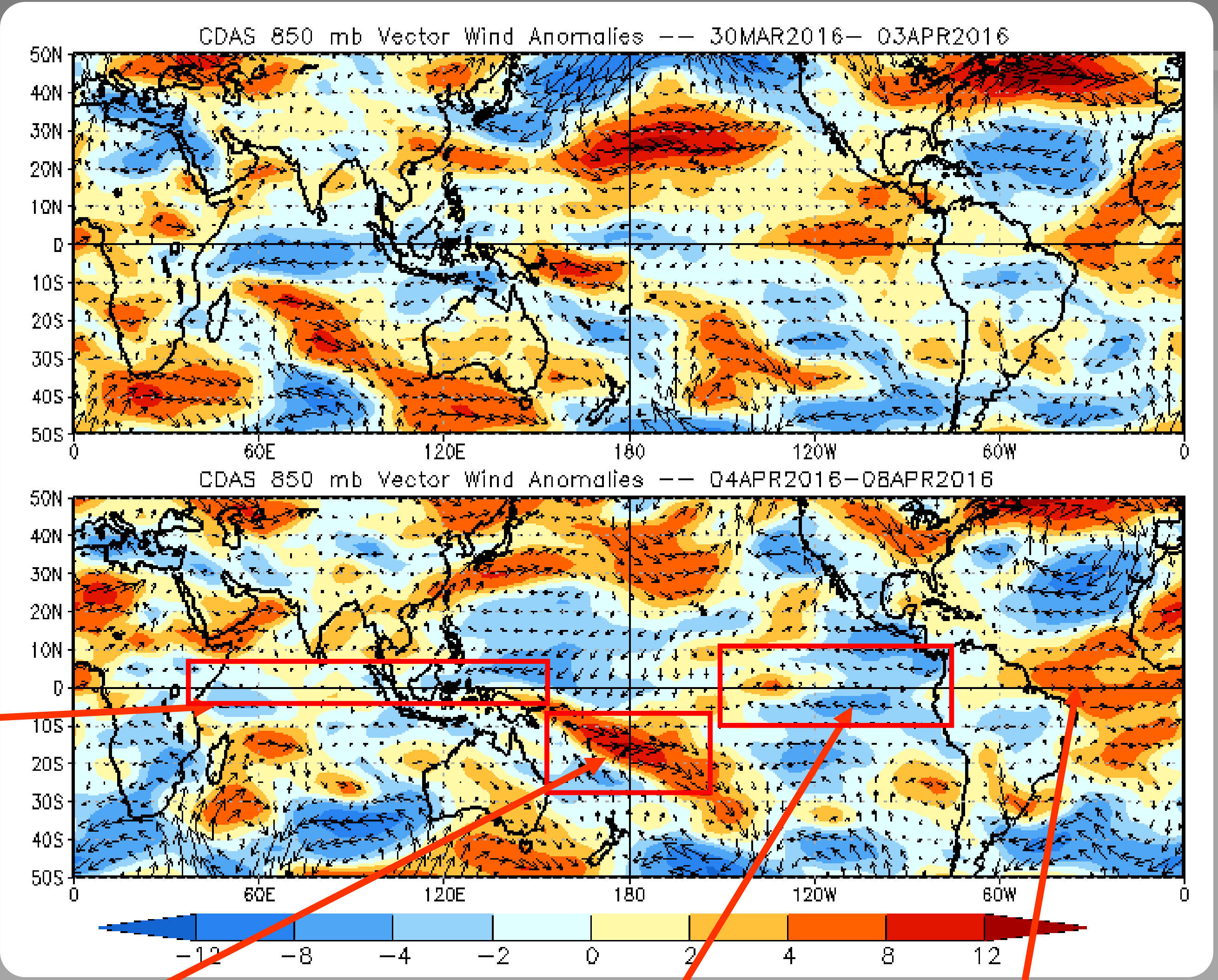
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

<u>Blue shades</u>: Easterly anomalies

<u>Red shades</u>: Westerly anomalies



Easterly anomalies weakened over most of the Indian Ocean, but strengthened over the West Pacific

In the South Pacific, westerly anomalies expanded eastward across the Date Line.

Easterlies returned to the East Pacific.

Westerly anomalies expanded near the coast of Brazil.

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

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

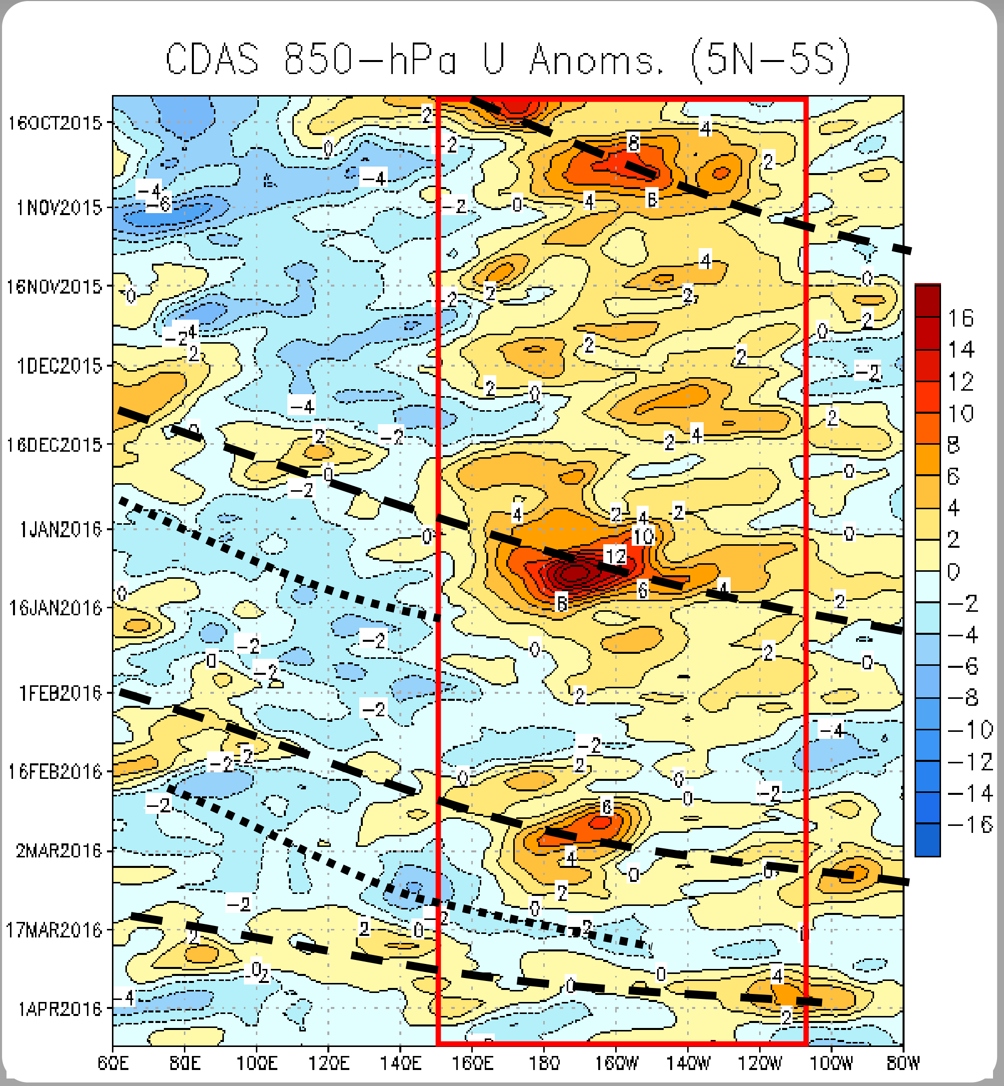
Easterly anomalies (blue shading) represent anomalous east-to-west flow

The red box highlights the persistent low-frequency westerly wind anomalies associated with ENSO.

MJO activity during December produced an eastward propagation of westerly anomalies from the Indian Ocean, which constructively interfered with El Nino during January, and lead to a westerly wind burst near the Date Line. Another period of constructive interference occurred in late February, followed by destructive interference in mid-March.

A fast eastward propagating intraseasonal signal crossed the Pacific, while westerlies persisted west of the Date Line during mid-March.

Easterlies weakened over the Indian Ocean, but returned to the vicinity of the Date Line, and the far eastern Pacific.



OLR Anomalies – Past 30 days

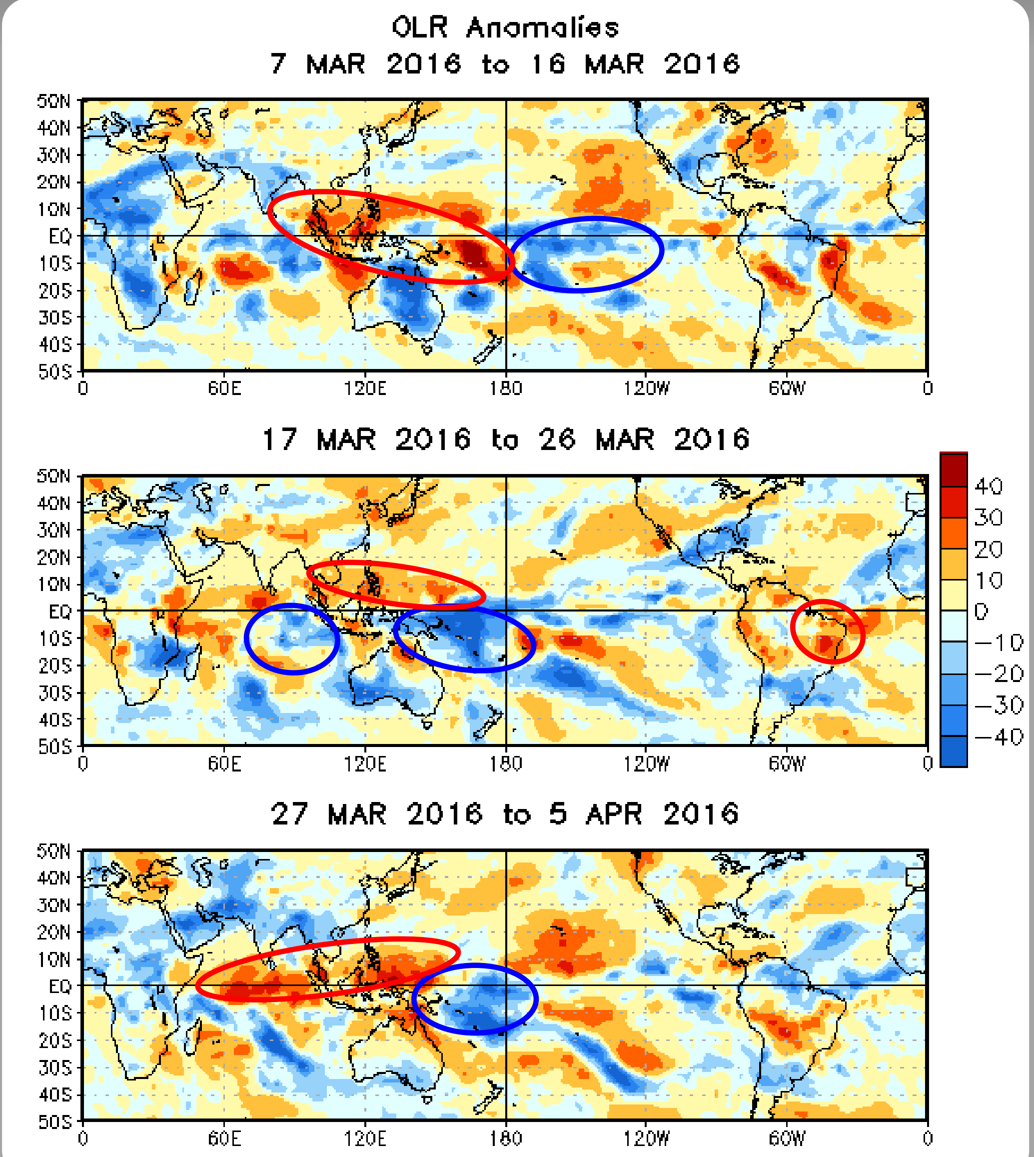
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

As the MJO propagated over the Indian Ocean and Maritime Continent, destructive interference with the El Niño base state was evident, and enhanced convection was observed over parts of the Indian Ocean and Maritime Continent.

During late March, suppressed convection returned to the equatorial Indian Ocean and much of the Maritime Continent. Slow-moving Rossby Wave activity resulted in enhanced convection just west of the Date Line.

Suppressed convection was pronounced across much of the Indian Ocean and eastern Maritime Continent. Enhanced convection was noted near and south of the Date Line across the west-central Pacific.



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

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

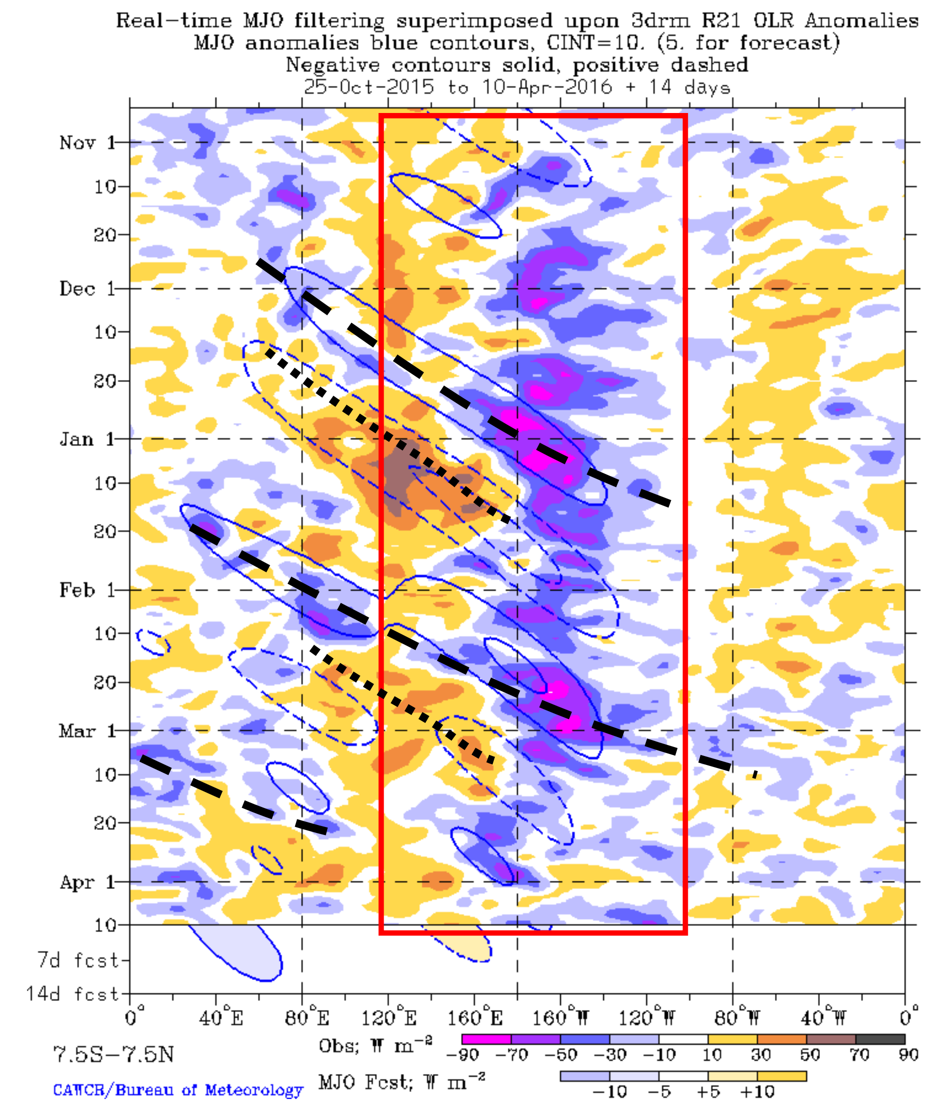
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

The ongoing El Niño is observed (red box) as a dipole of anomalous convection extending from the Maritime Continent to the East Pacific.

Renewed MJO activity was evident, beginning in late January and lasting through the current week. Alternating periods of constructive/destructive interference with ENSO is evident.

A fast eastward propagating signal raced across the Pacific during mid-March, while constructive interference between Rossby Wave activity and a Kelvin Wave was apparent west of the Date Line.

A fairly incoherent pattern is indicated across the Indian Ocean and Pacific, related to the dispersion of intra-seasonal modes.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

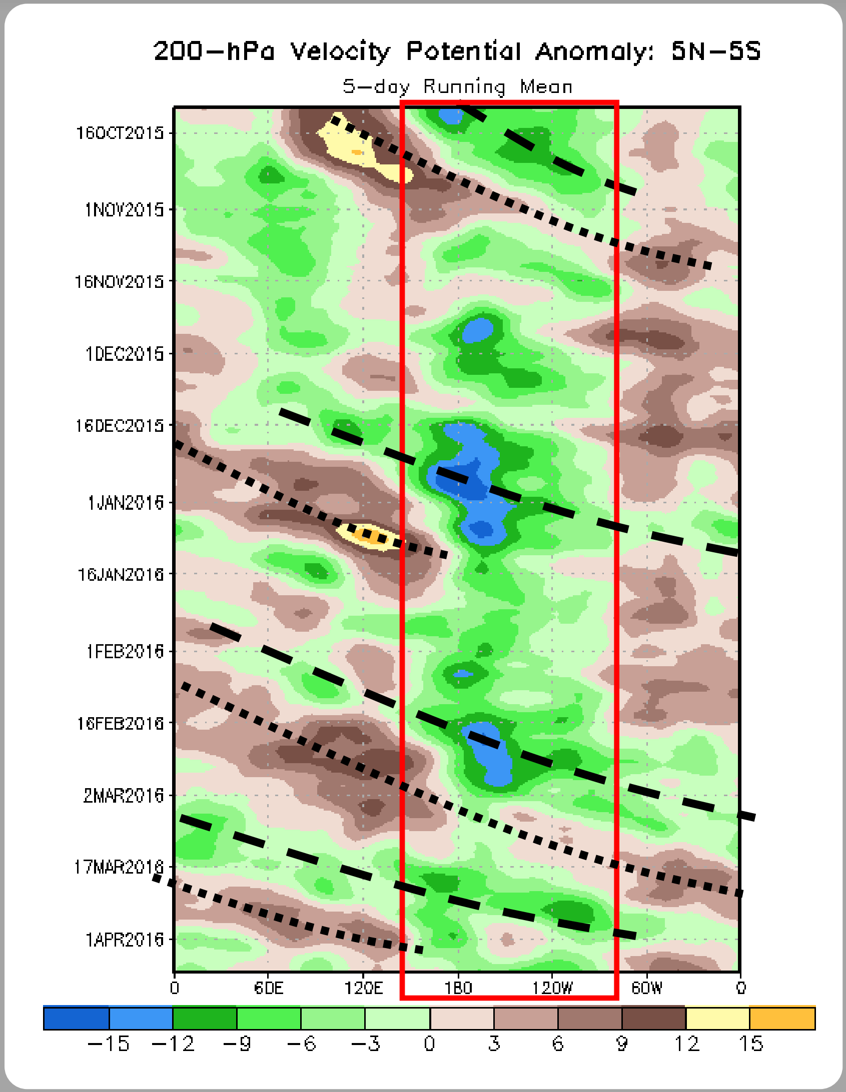
Negative anomalies (green shading) indicate favorable conditions for precipitation

The ongoing ENSO state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

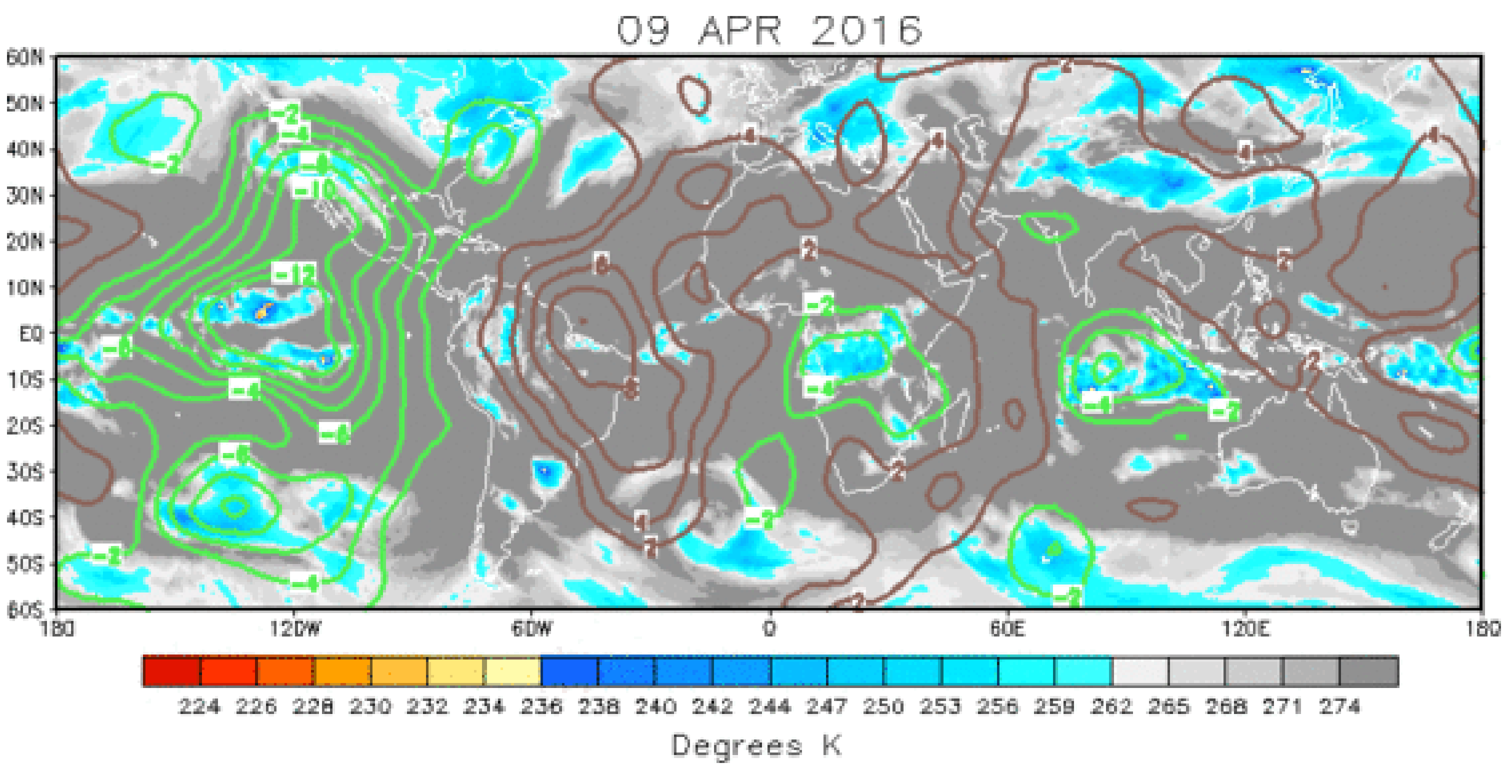
During late February, intraseasonal variability constructively interfered with the ongoing El Nino. During mid-March, the intraseasonal variability destructively interfered with the ENSO signal.

Complex interactions between the MJO, Rossby Wave activity, and the ENSO signal resulted in an increasingly incoherent pattern over the Pacific.

Suppressed convection was noted across the Indian Ocean and Maritime Continent during the second half of March, while enhanced convection is noted more recently in these areas, and also over the central and eastern Pacific.



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



The large scale upper-level velocity potential anomaly pattern has become less coherent, with the main area of upper-level divergence over the central and eastern Pacific, and two smaller areas of divergence aloft over Africa and over the eastern Indian Ocean.

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

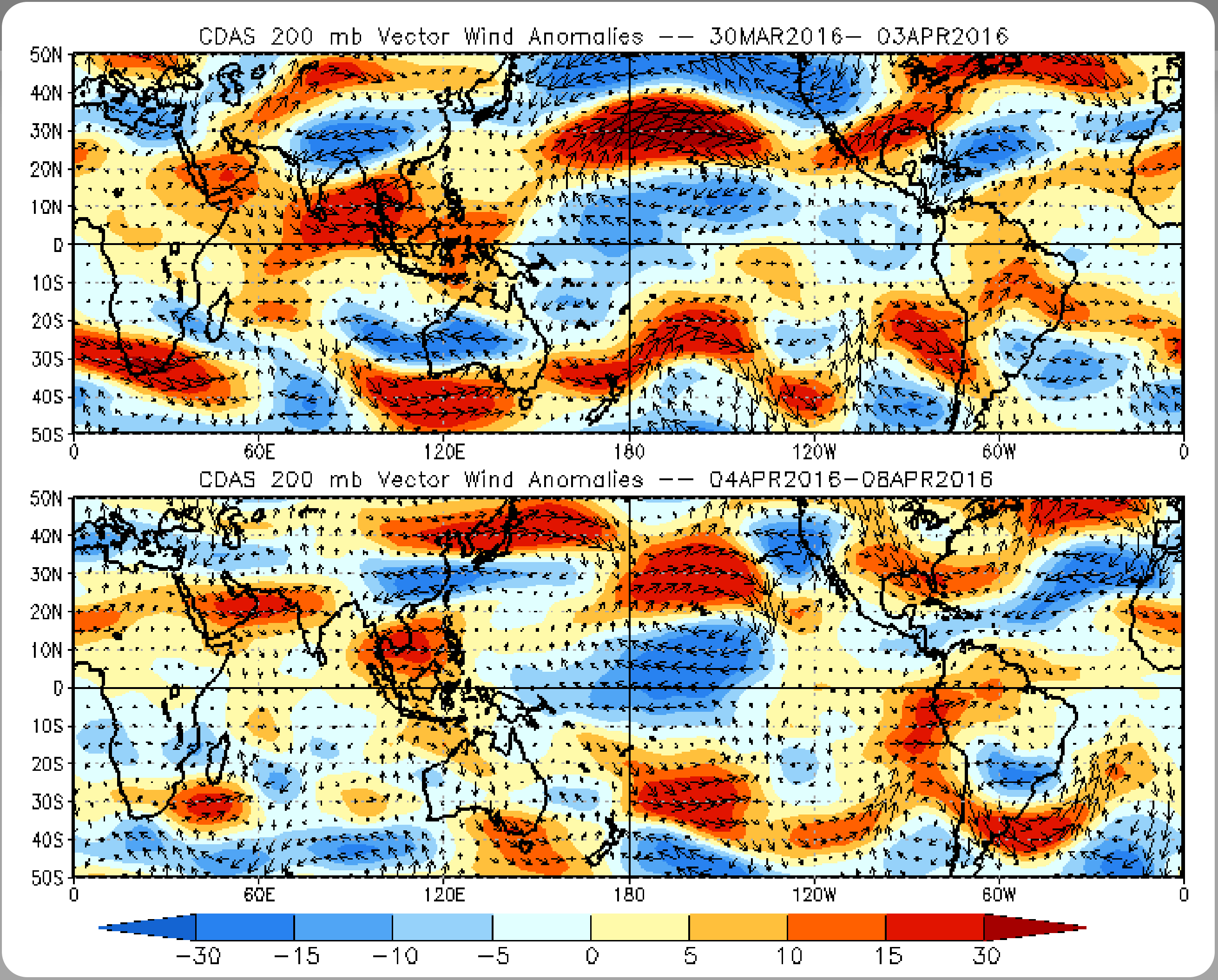
Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Significant upper-level poleward flow is evident over the West Pacific as a strong mid-latitude anticyclonic circulation cell shifted eastward to the Date Line.

Easterly anomalies returned to the East Pacific.

Anomalies weakened over western Australia and the adjacent eastern Indian Ocean. The strong westerlies that had been over the northern Indian Ocean weakened to near-normal.



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

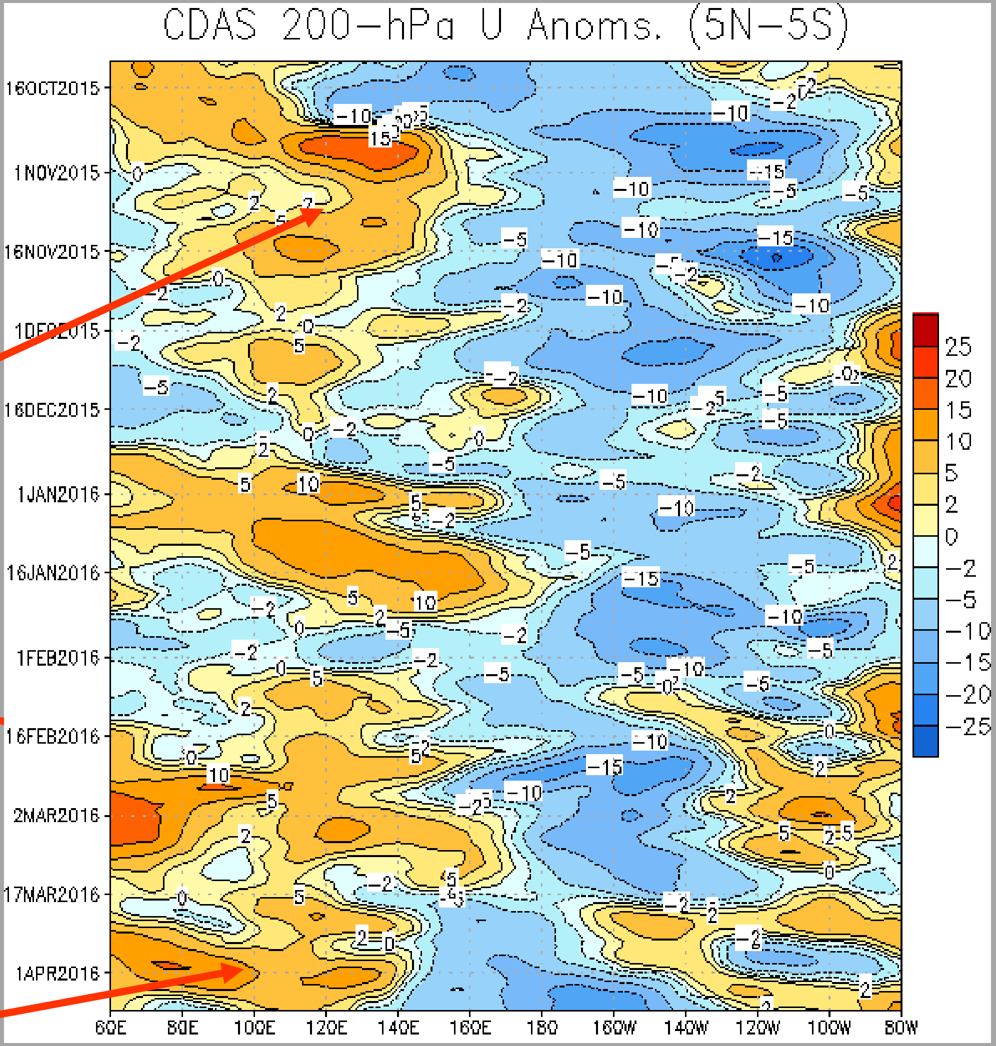
Easterly anomalies have persisted over the central and eastern Pacific since June associated with El Niño (red box).

Eastward propagation of upper-level zonal wind anomalies was apparent over the Maritime Continent and West Pacific during late December and early January, consistent with MJO activity.

During early March, westerly anomalies returned to the Indian Ocean and Maritime Continent, with easterly anomalies between about 170E - 120W.

Two discrete regions of easterlies are apparent over the West and East Pacific.

200-hPa westerly anomalies prevailed across the Indian Ocean/Maritime Continent, while easterlies prevailed across most of the western and central Pacific.



Weekly Heat Content Evolution in the Equatorial Pacific

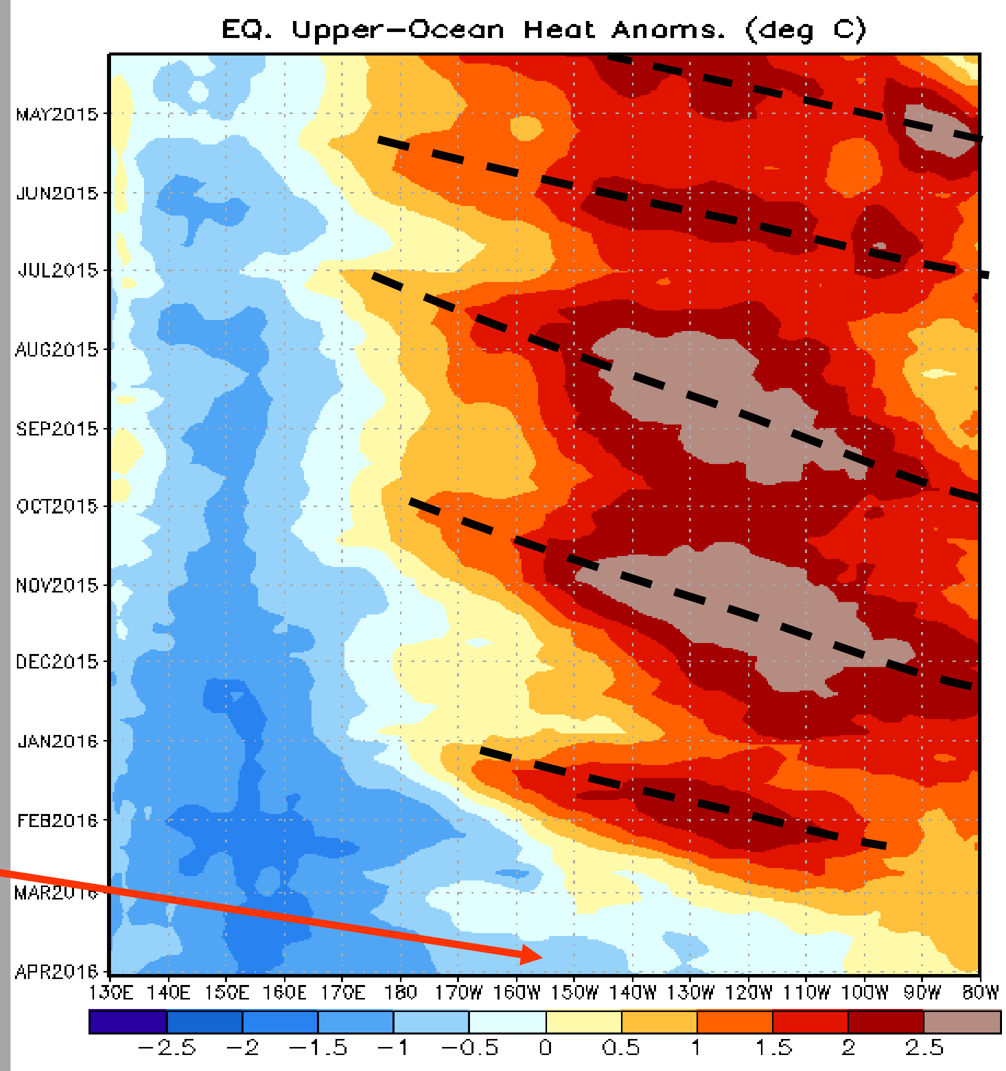
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

Reinforcing downwelling events have followed, resulting in persistently above-normal heat content from the Date Line to 80W throughout the period.

An eastward expansion of below average heat content over the western Pacific is evident since January, and negative anomalies spread east of the Date Line during February 2016.

The below average heat content continues to expand eastward.

Below-average heat content continues to expand eastward across the east-central Pacific in early April.



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

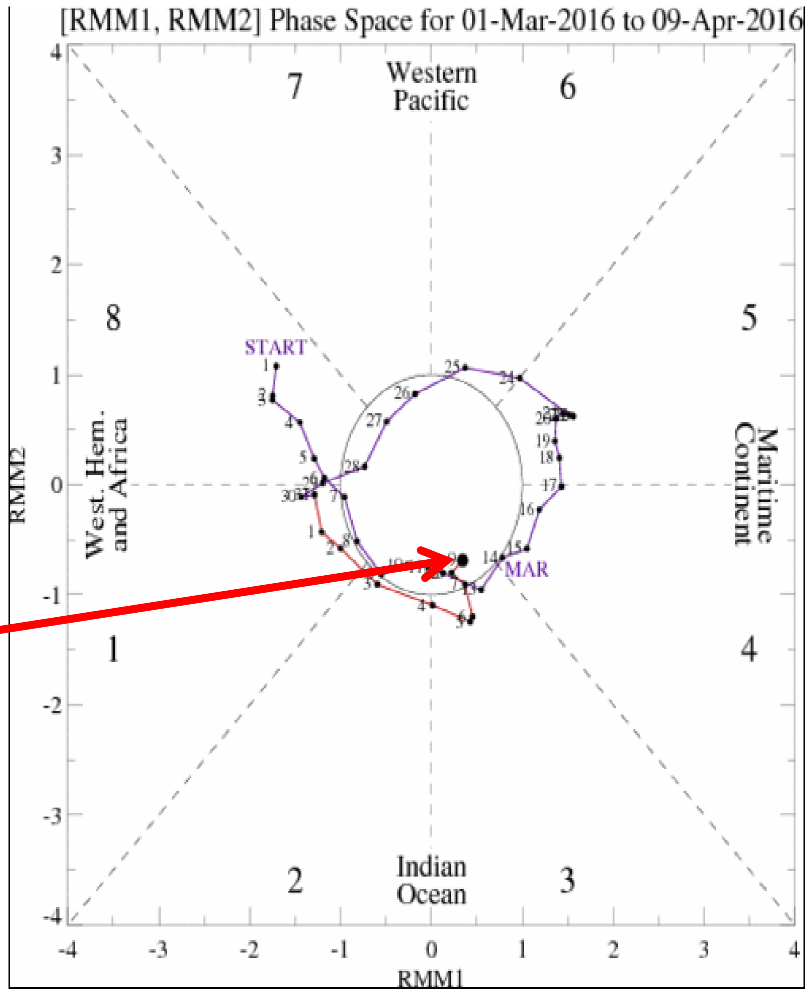
The triangular areas indicate the location of the enhanced phase of the MJO

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

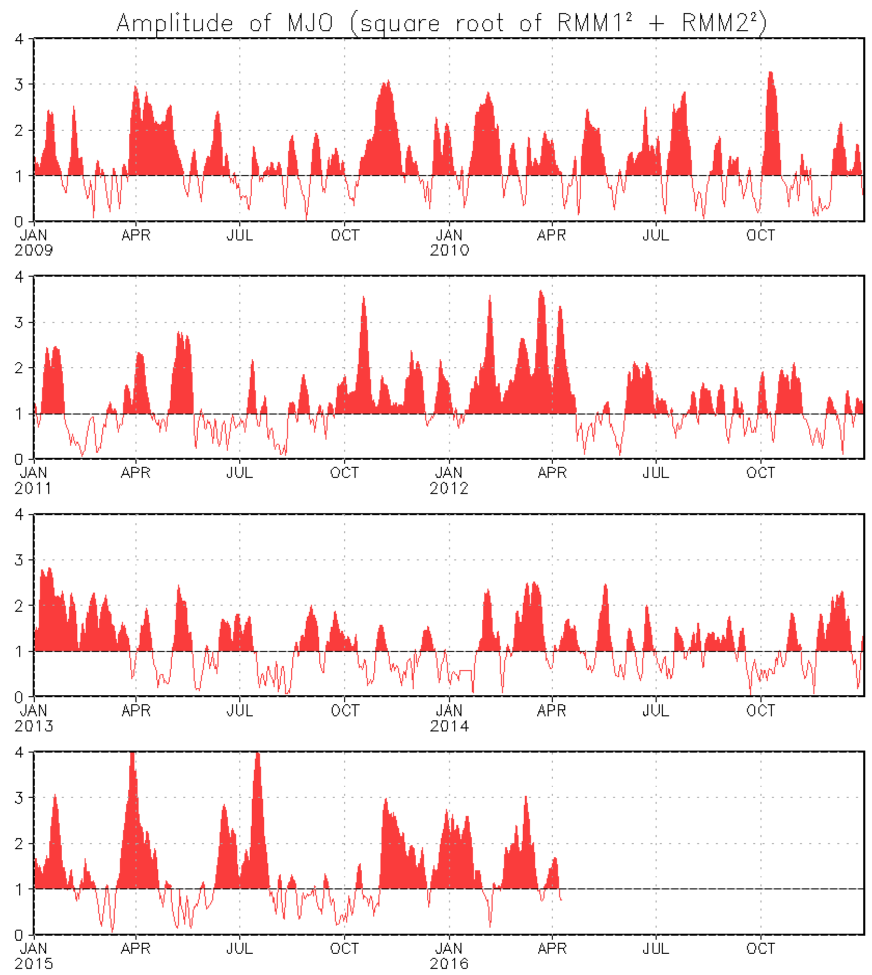
The RMM MJO index continues to reflect fast, eastward propagation of a weak Kelvin wave, with the enhanced phase over the eastern Indian Ocean.



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.



Ensemble GFS (GEFS) MJO Forecast

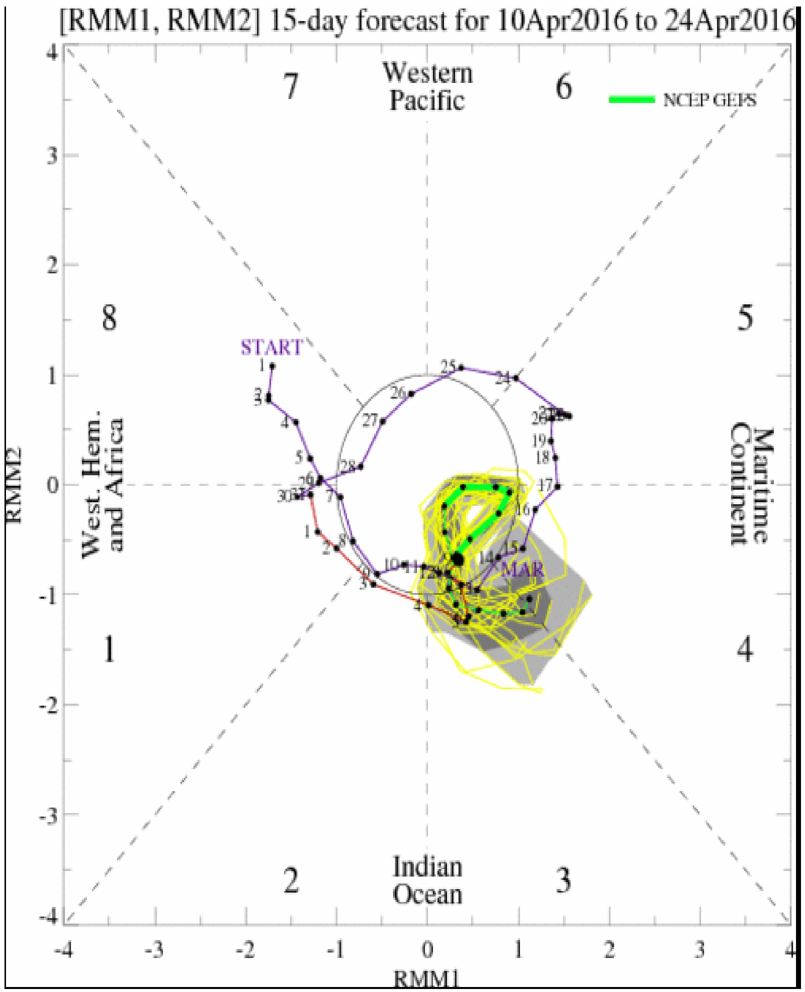
<u>Yellow Lines</u> - 20 Individual Members
<u>Green Line</u> - Ensemble Mean

RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

<u>light gray shading</u>: 90% of forecasts

<u>dark gray shading</u>: 50% of forecasts

The GFS ensemble MJO index forecast depicts looping of a weak MJO signal during Week-1, with slight strengthening and eastward propagation over the eastern Indian Ocean during Week-2.

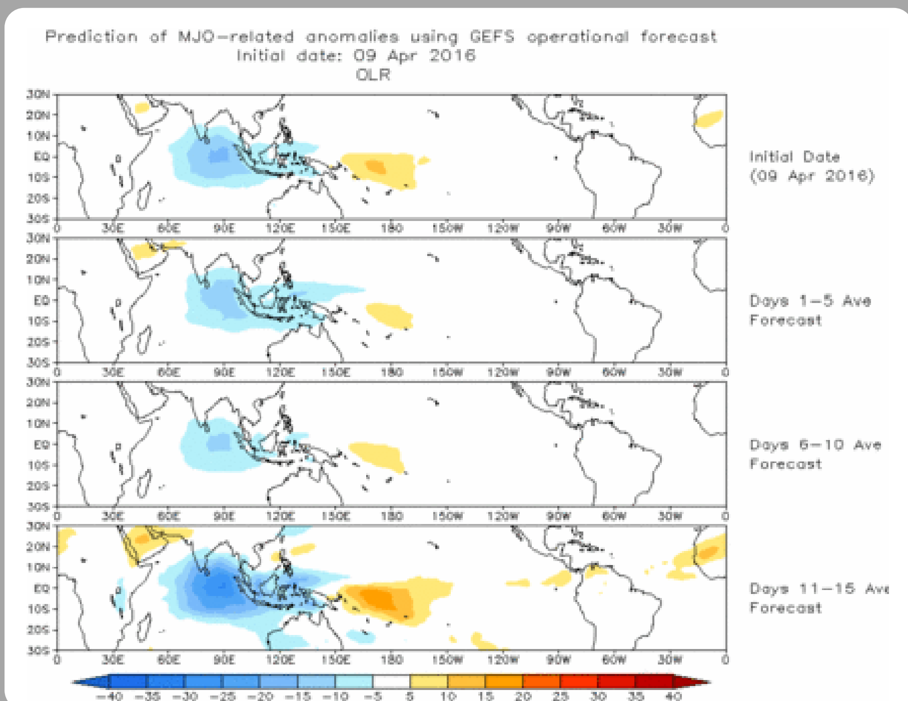


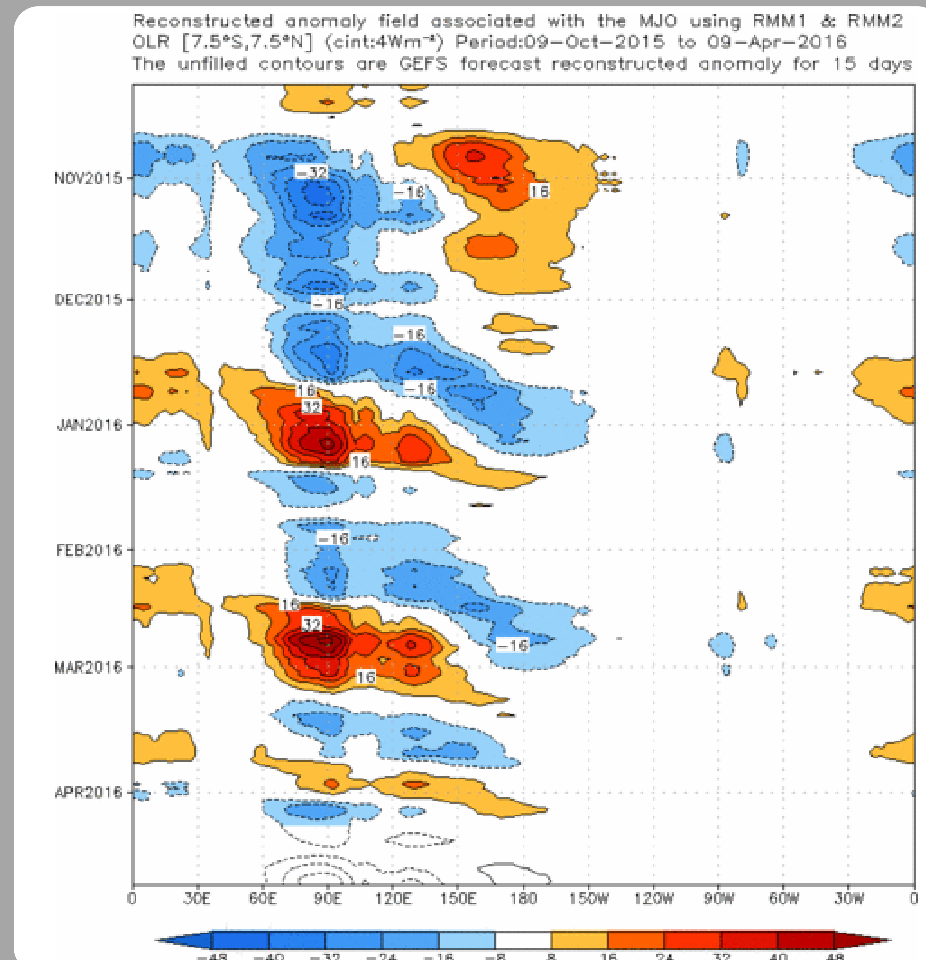
Ensemble GFS (GEFS) MJO Forecast

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



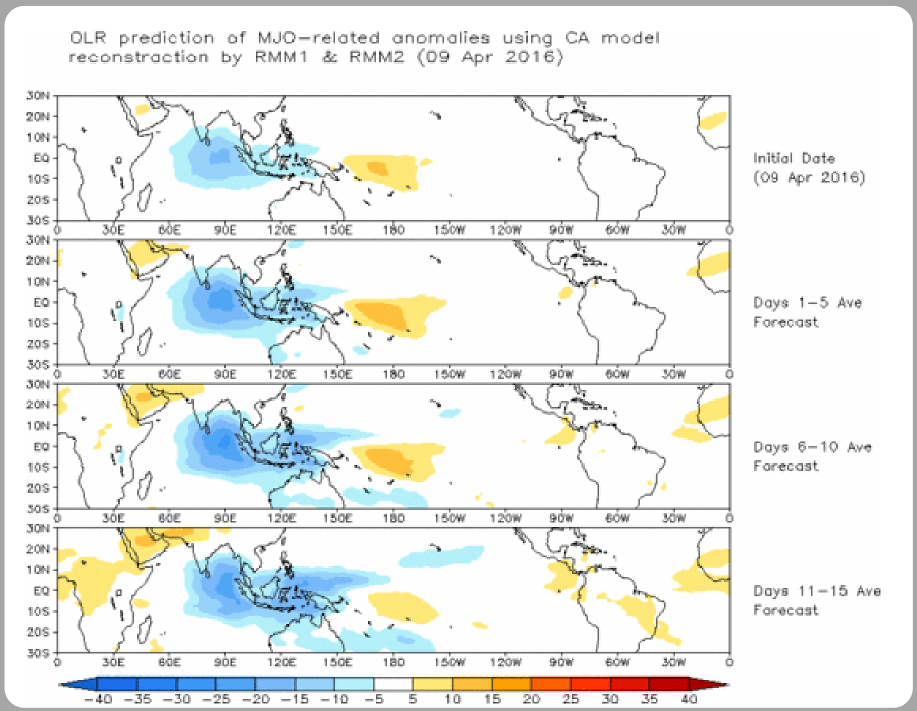


The GEFS OLR forecast based on the RMM Index depicts a weakening Indian Ocean event during Week-1, with a strengthening intraseasonal signal during Week-2, though little if any eastward propagation is expected.

Constructed Analog (CA) MJO Forecast

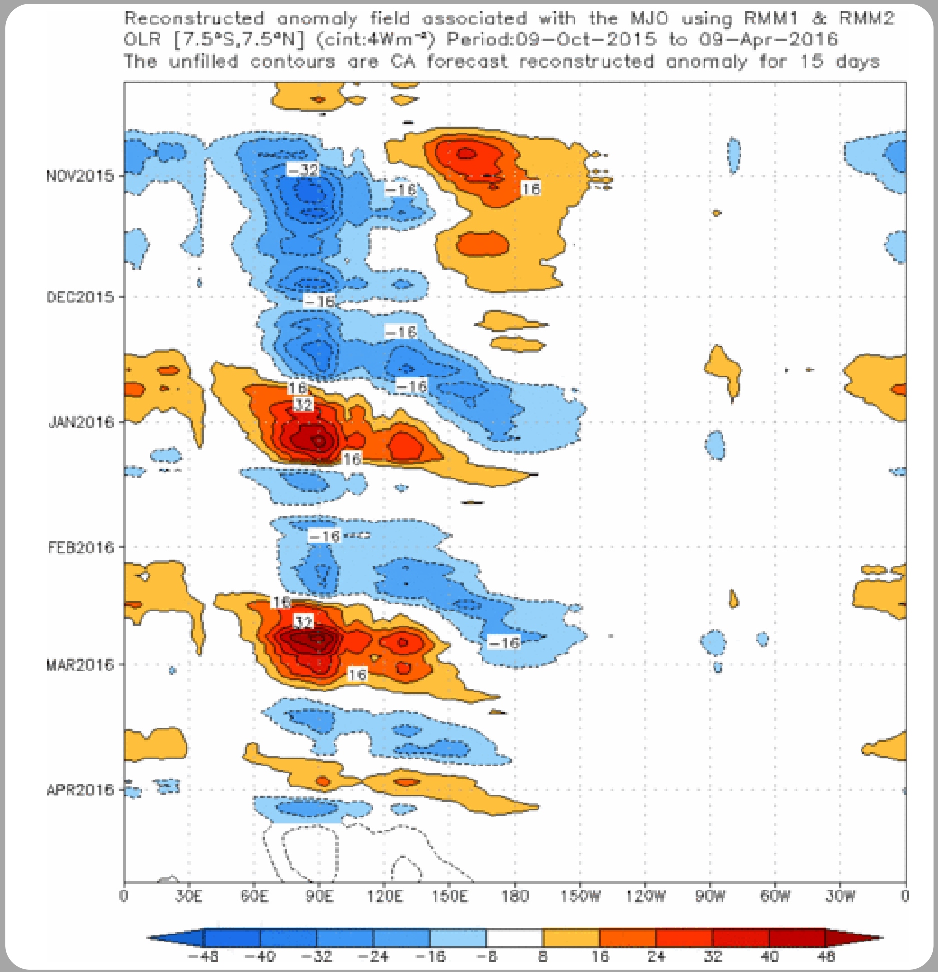
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



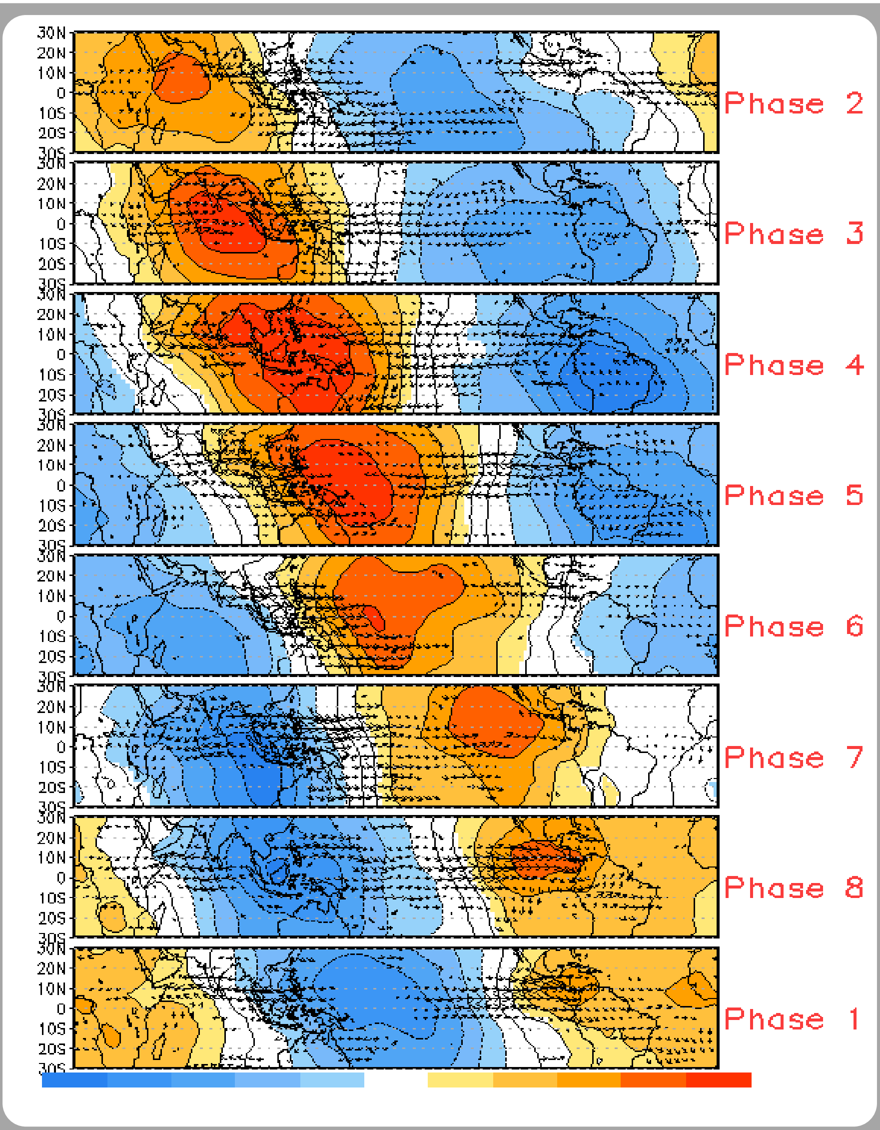
The constructed analog model predicts very little, if any, eastward propagation of a moderately strong signal over the Indian Ocean during the next 2 weeks.

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

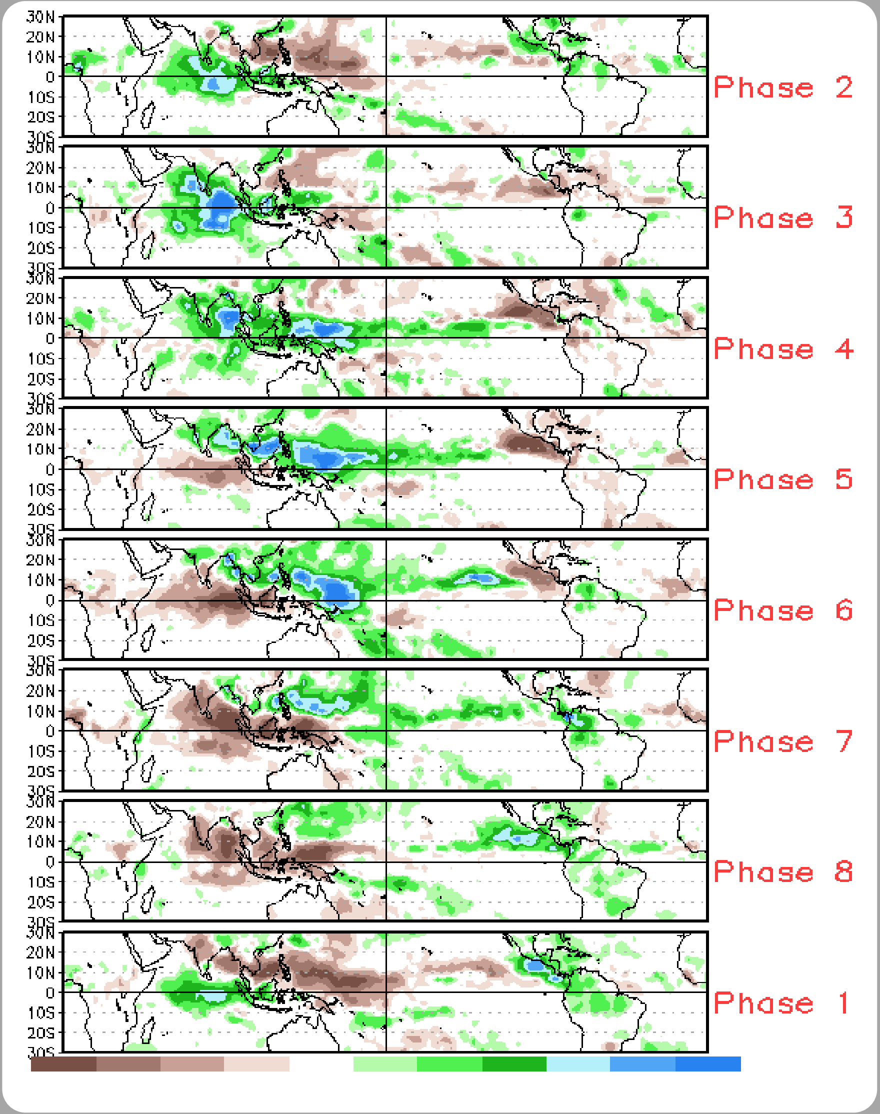


MJO Composites - Global Tropics

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



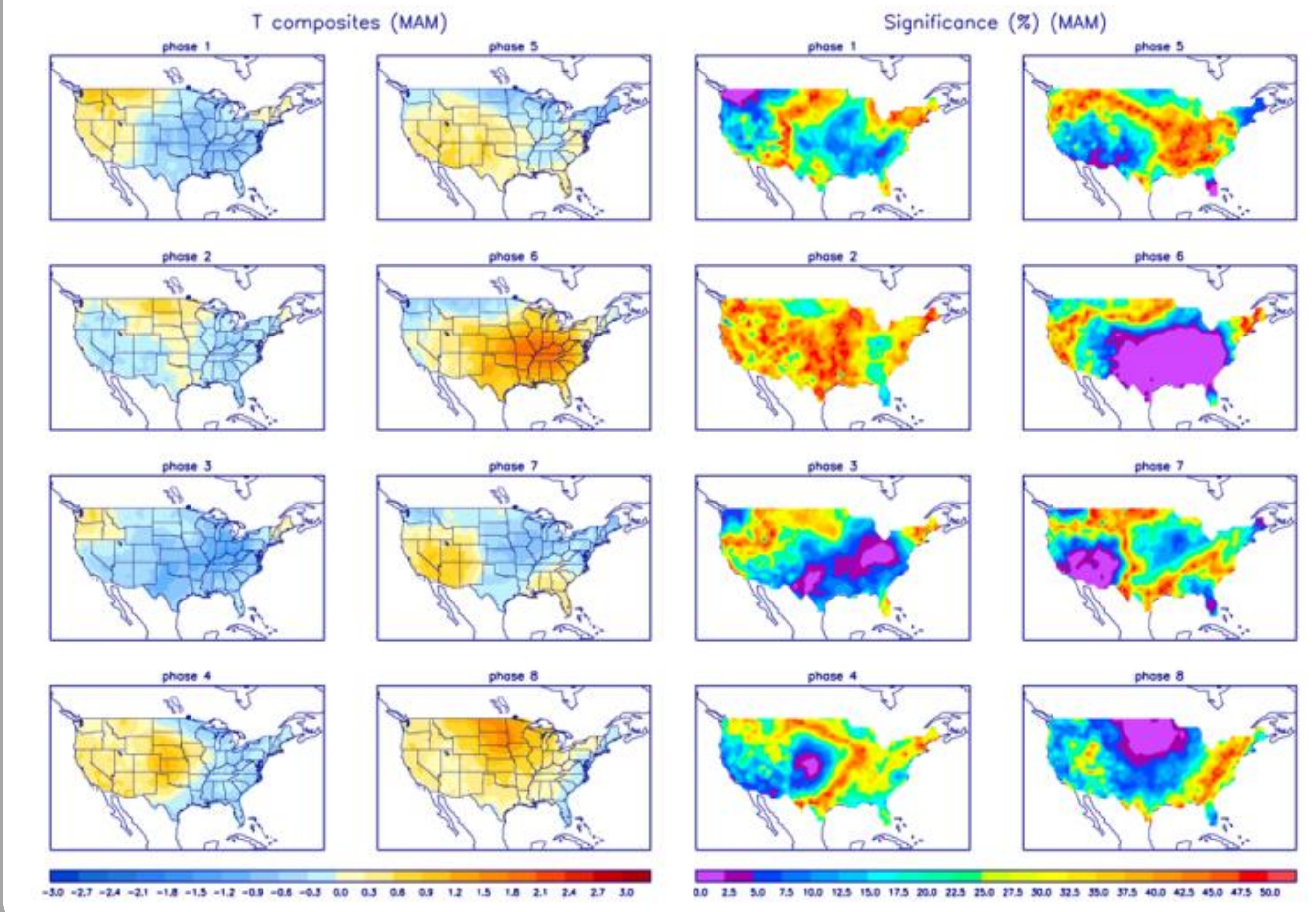
Precipitation Anomalies (Nov-Mar)



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.



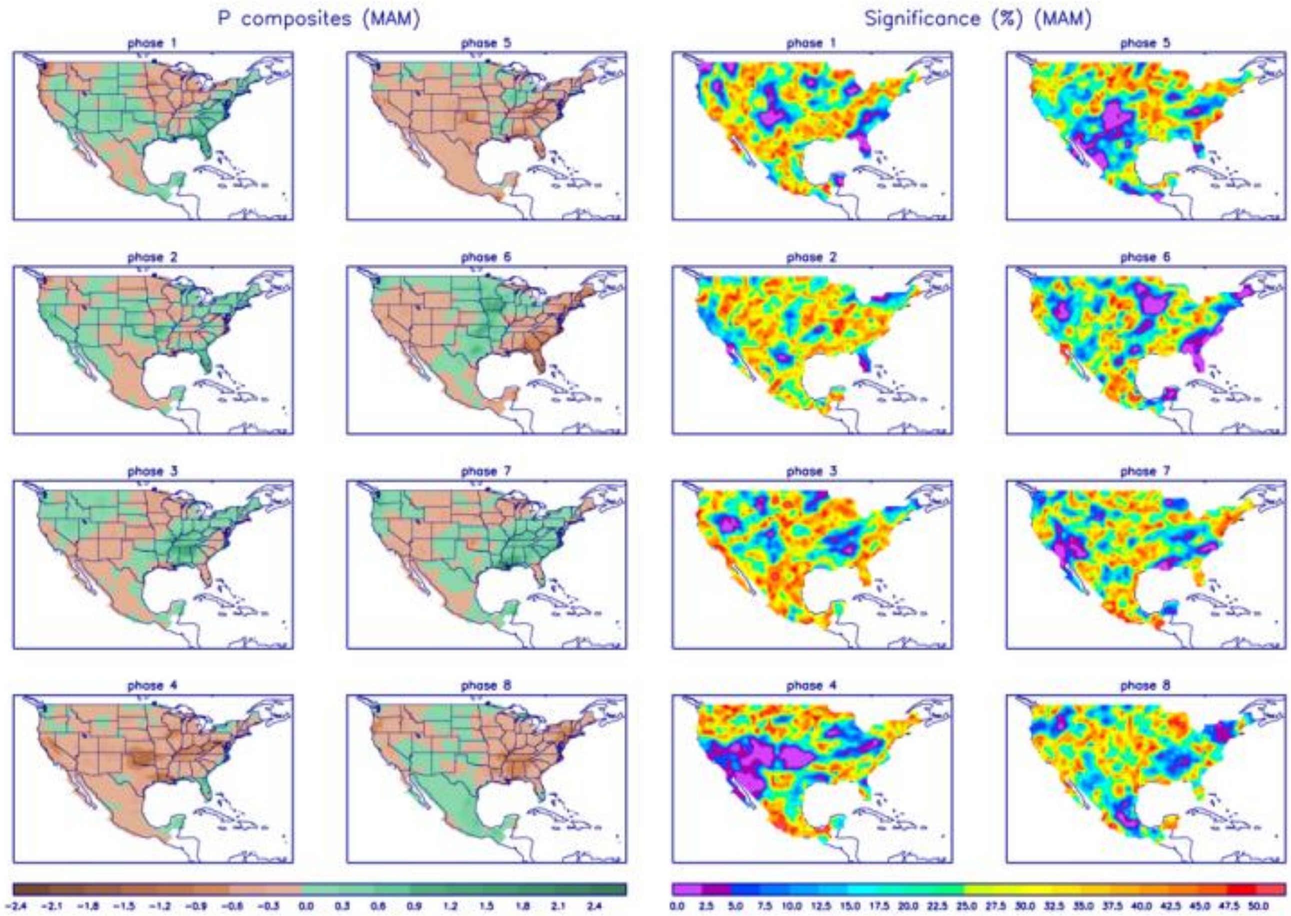
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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