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

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Overview

A complex intraseasonal pattern has taken shape during the past week, with continued fast eastward propagation of an MJO signal over the Western Hemisphere, and persistent convection over the West Pacific associated with other modes (Rossby Wave and Kelvin Wave interactions). The dipole of West Pacific convection and subsidence over the Indian Ocean and western Maritime Continent has generated a substantial response in the mid-latitudes.

Dynamical model MJO Index forecasts generally support a weakening intraseasonal signal as the remnant MJO enhanced phase crosses the Indian Ocean. Statistical guidance supports a more robust Indian Ocean MJO event.

Due to the increasingly incoherent pattern, there is reduced confidence regarding the impacts of the MJO and other modes on the global tropical convective pattern.

Dynamical models favor persistence of the enhanced convection over the West Pacific, with potential tropical cyclogenesis over the southwestern Pacific. The remnant MJO signal may contribute to enhanced (suppressed) convection over parts of Africa and the Indian Ocean (the Maritime Continent) during the next two weeks.

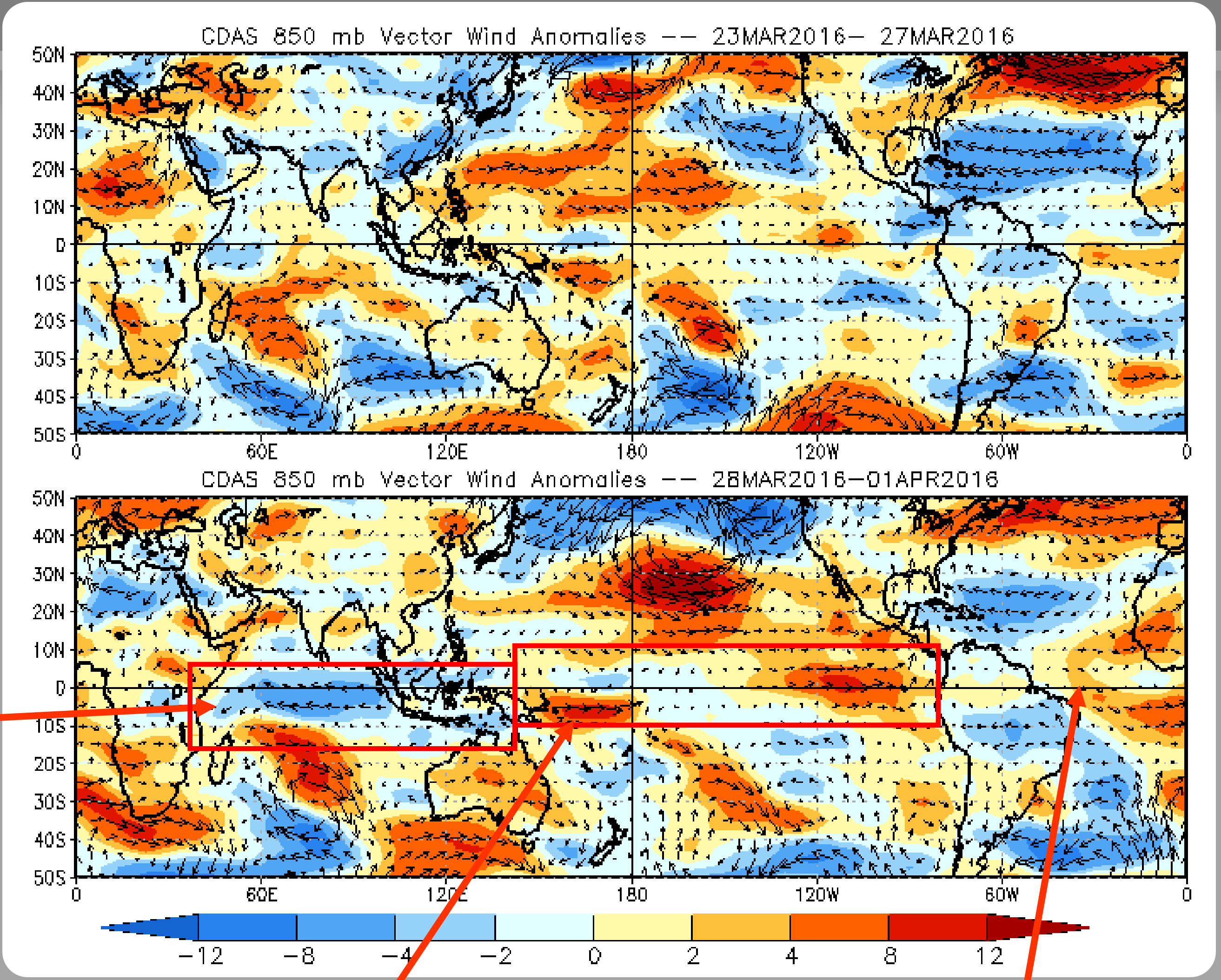
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 expanded over the Indian Ocean and western Maritime Continent

Westerly anomalies persisted over the South Pacific west of the Date Line, and increased over the East Pacific.

Weak westerly anomalies returned to the Atlantic.

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

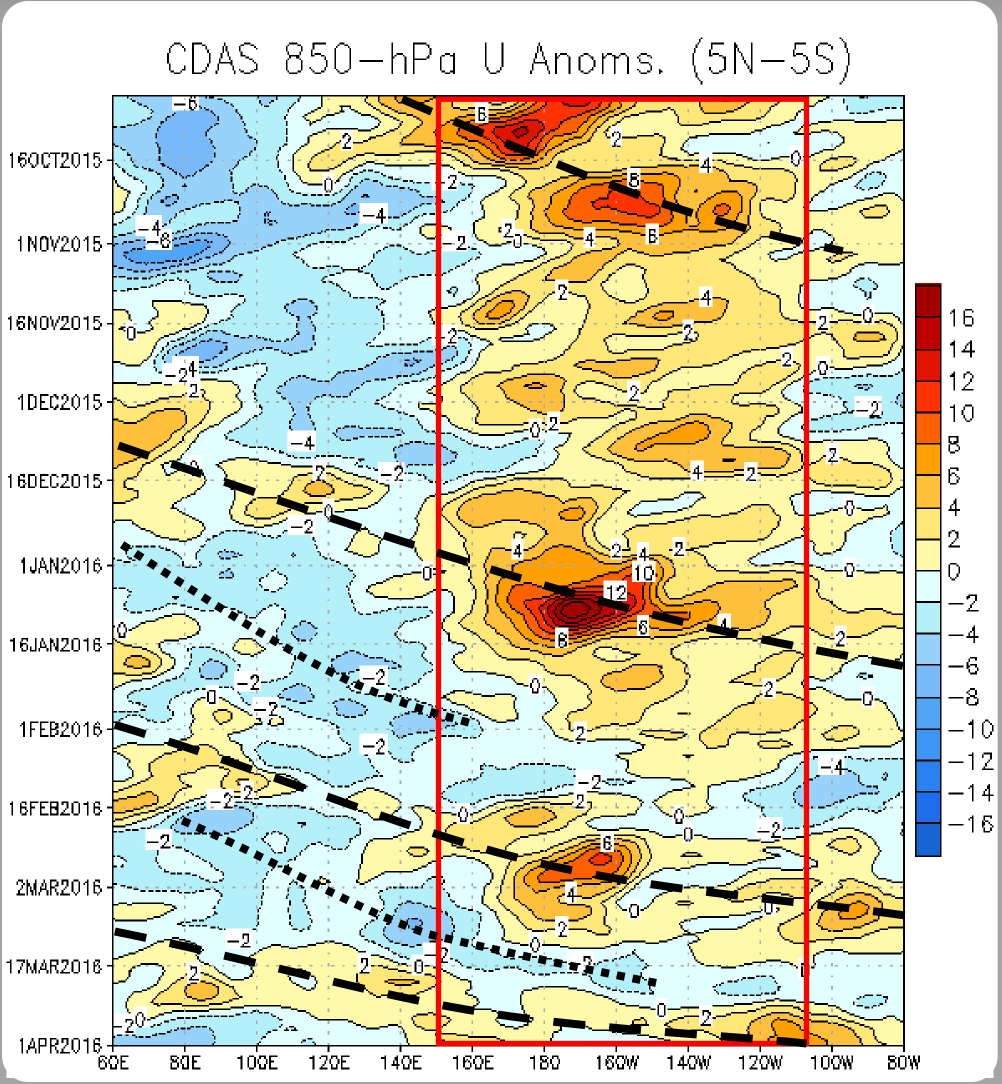
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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.

More recently, a fast eastward propagating intraseasonal signal crossed the Pacific, while westerlies persisted west of the Date Line.



OLR Anomalies – Past 30 days

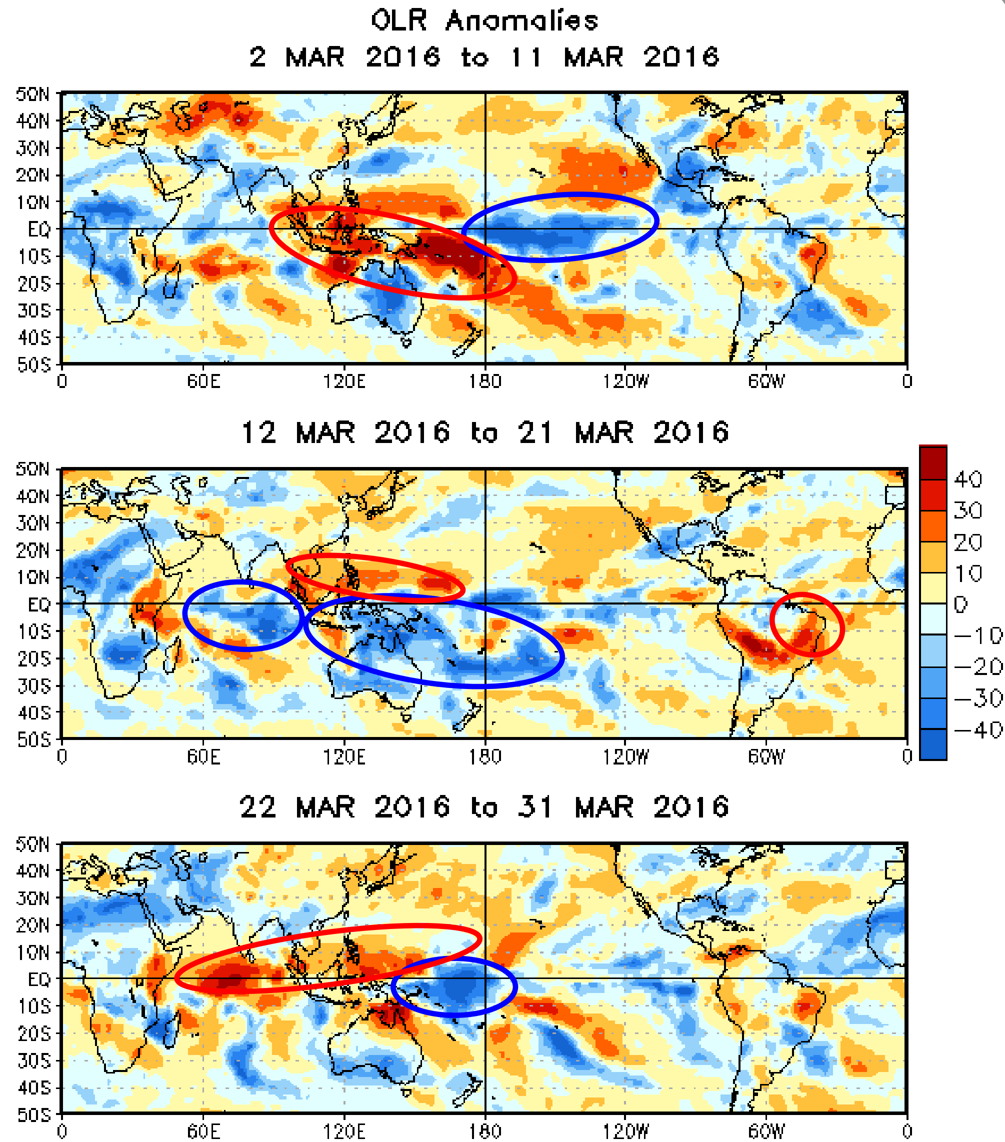
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During early March, constructive interference between the MJO and ENSO led to widespread enhanced (suppressed) convection over the central and eastern Pacific (Maritime Continent and West Pacific).

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.



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

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

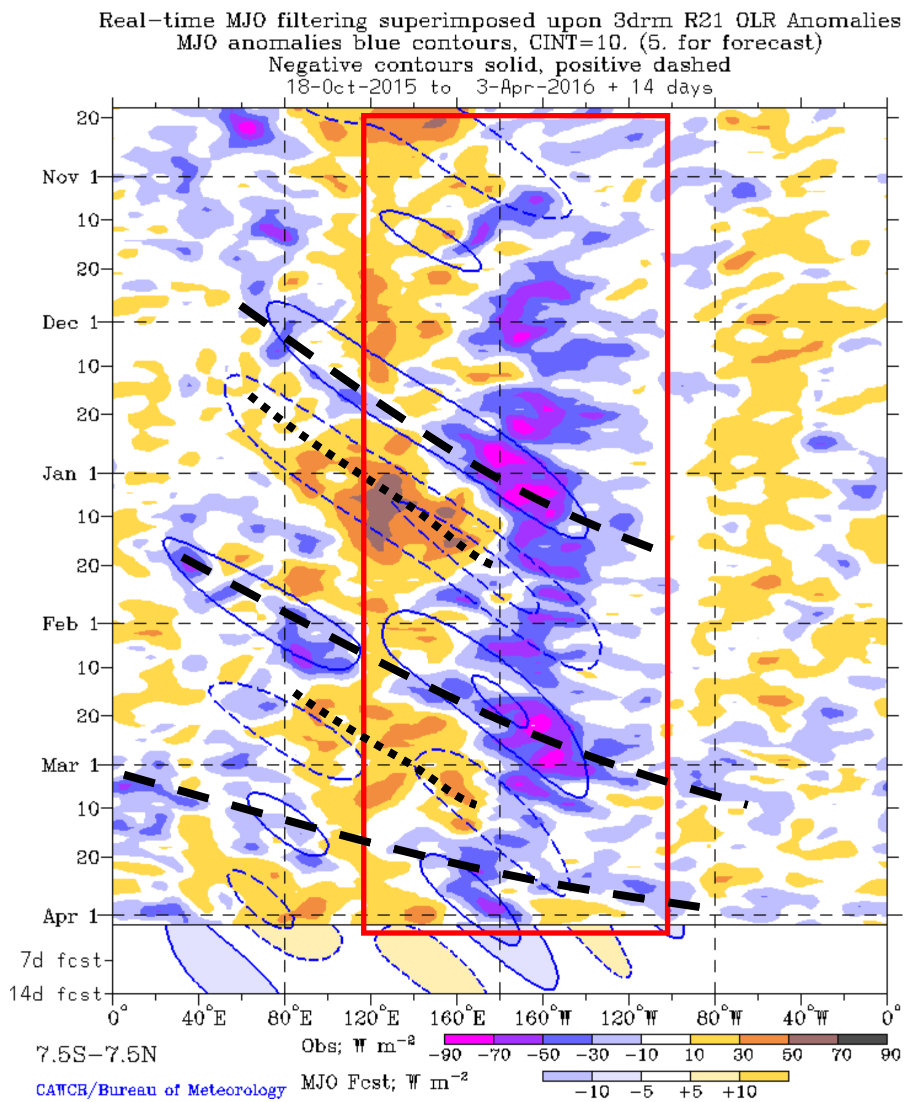
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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

During December, the MJO became active, with the enhanced phase propagating from the Indian Ocean to the west-central Pacific during the month.

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.

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



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

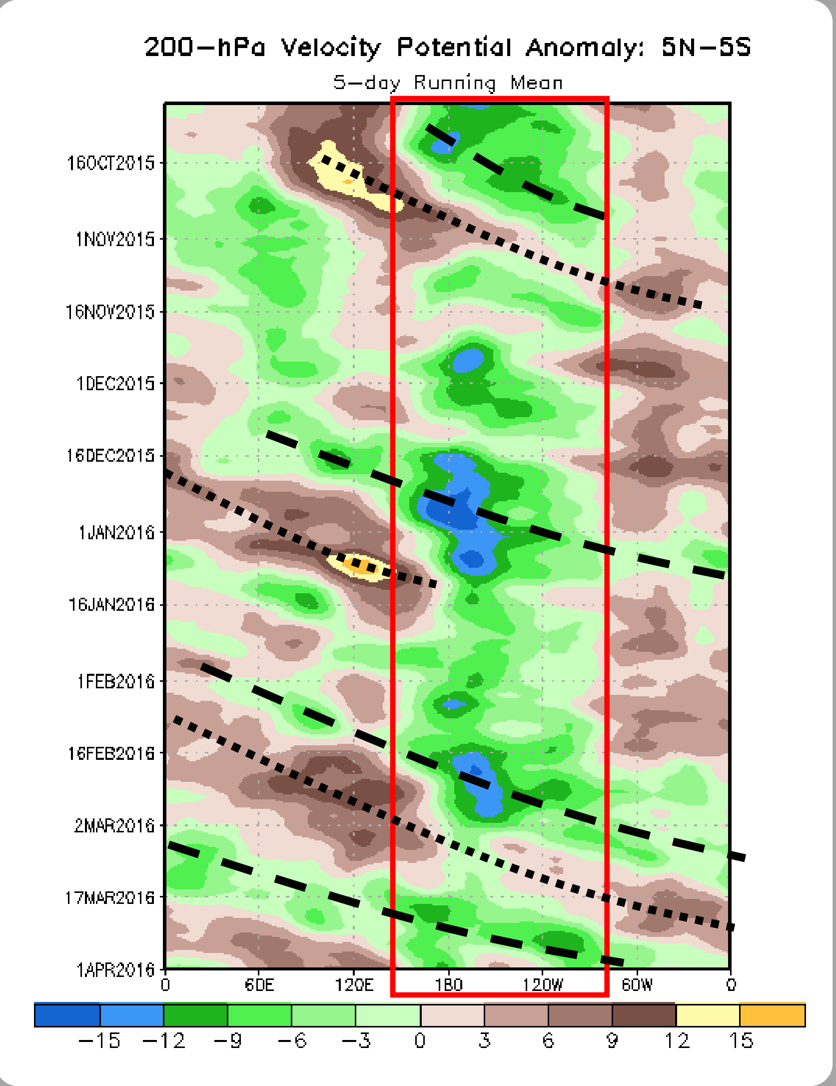
Negative anomalies (green shading) indicate favorable conditions for precipitation

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

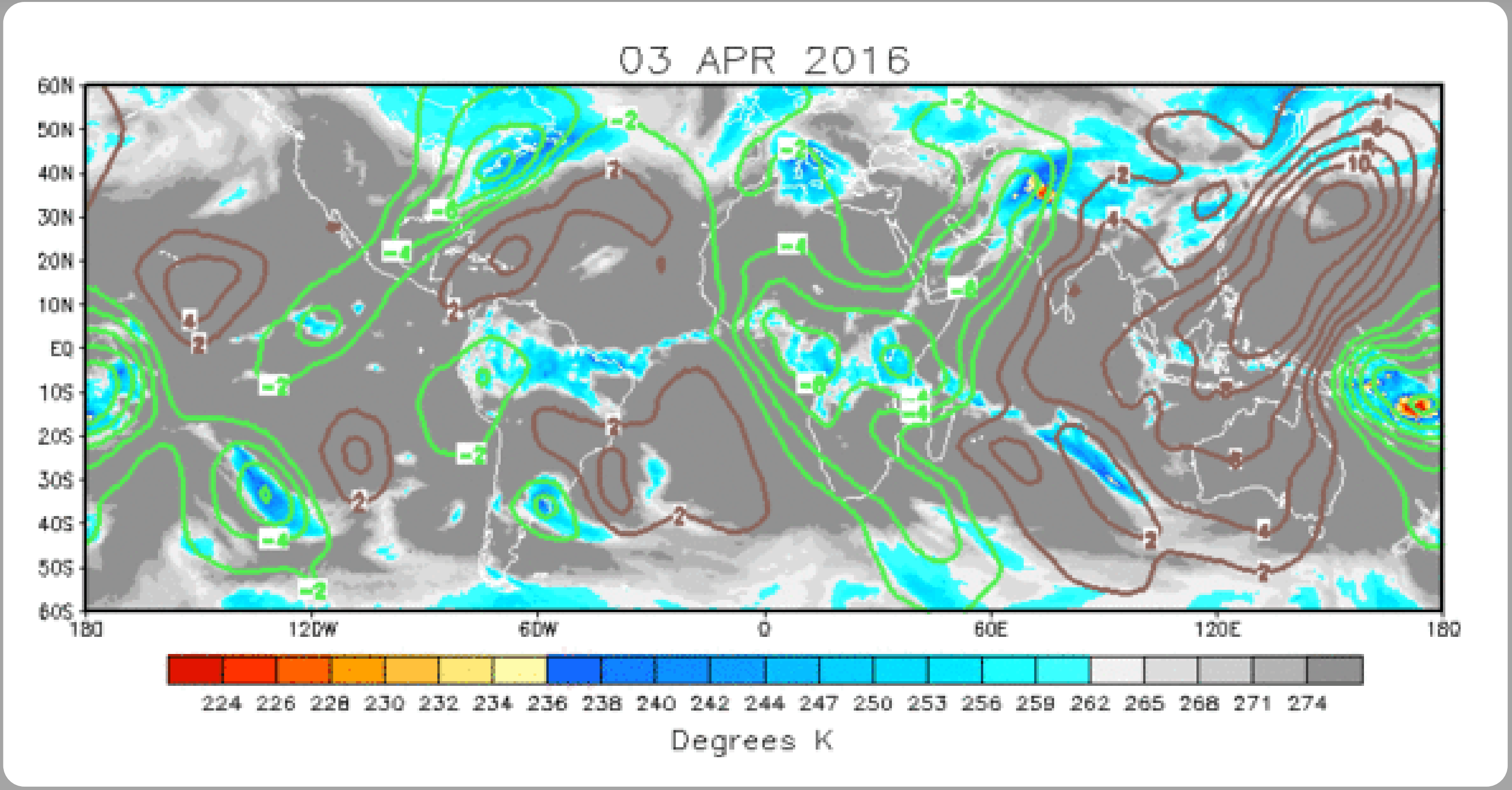
During late October, there was an eastward shift in the pattern. Renewed MJO activity was also observed during December and early January, yielding a robust signal in the upper levels. This signal weakened during mid-January.

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

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



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



The large scale upper-level velocity potential anomaly pattern has become less coherent, with two discrete negative anomaly features over Africa and the West Pacific, and weak anomalies across the eastern Pacific and Atlantic.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

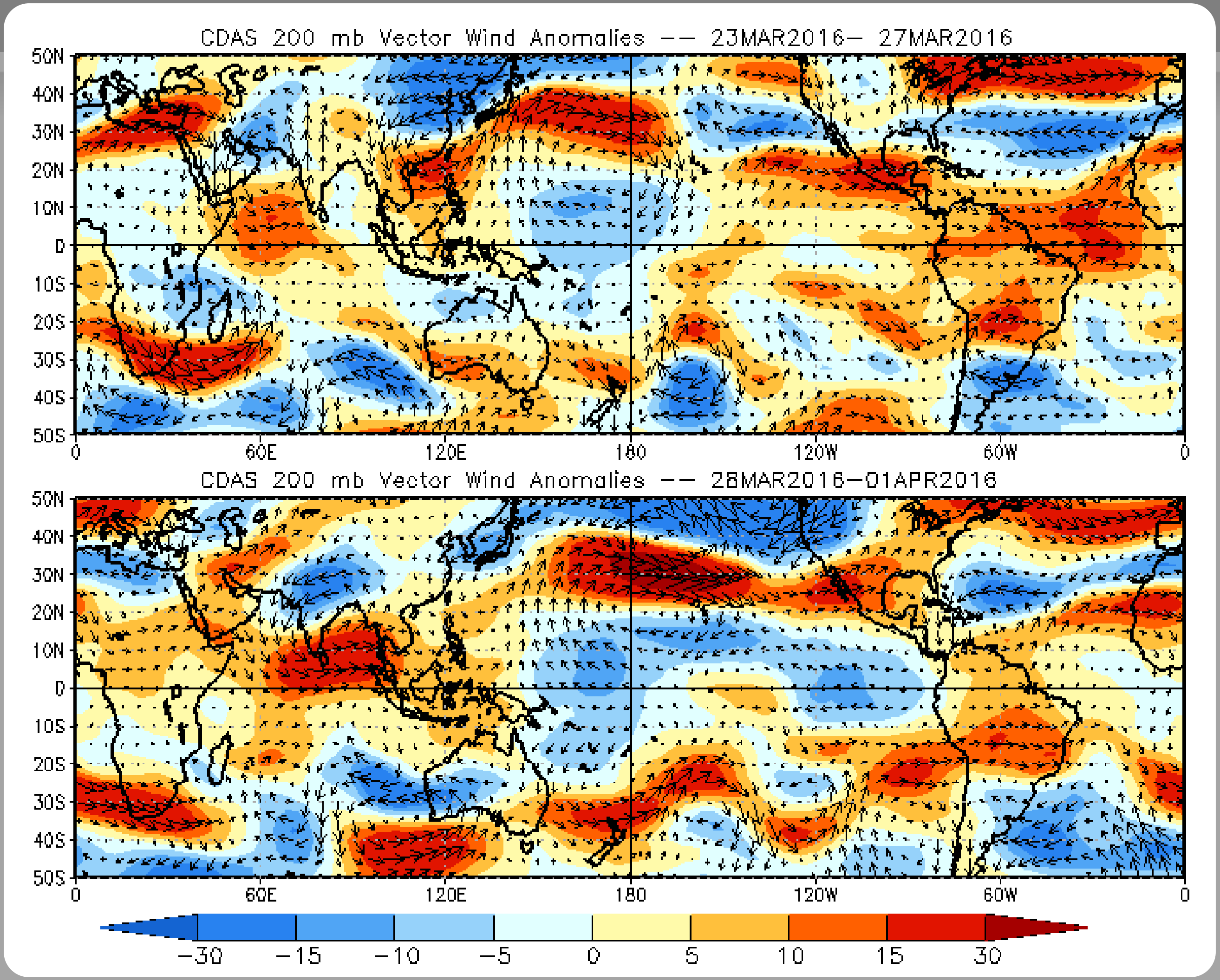
Negative anomalies (green contours) indicate favorable conditions for precipitation

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.

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

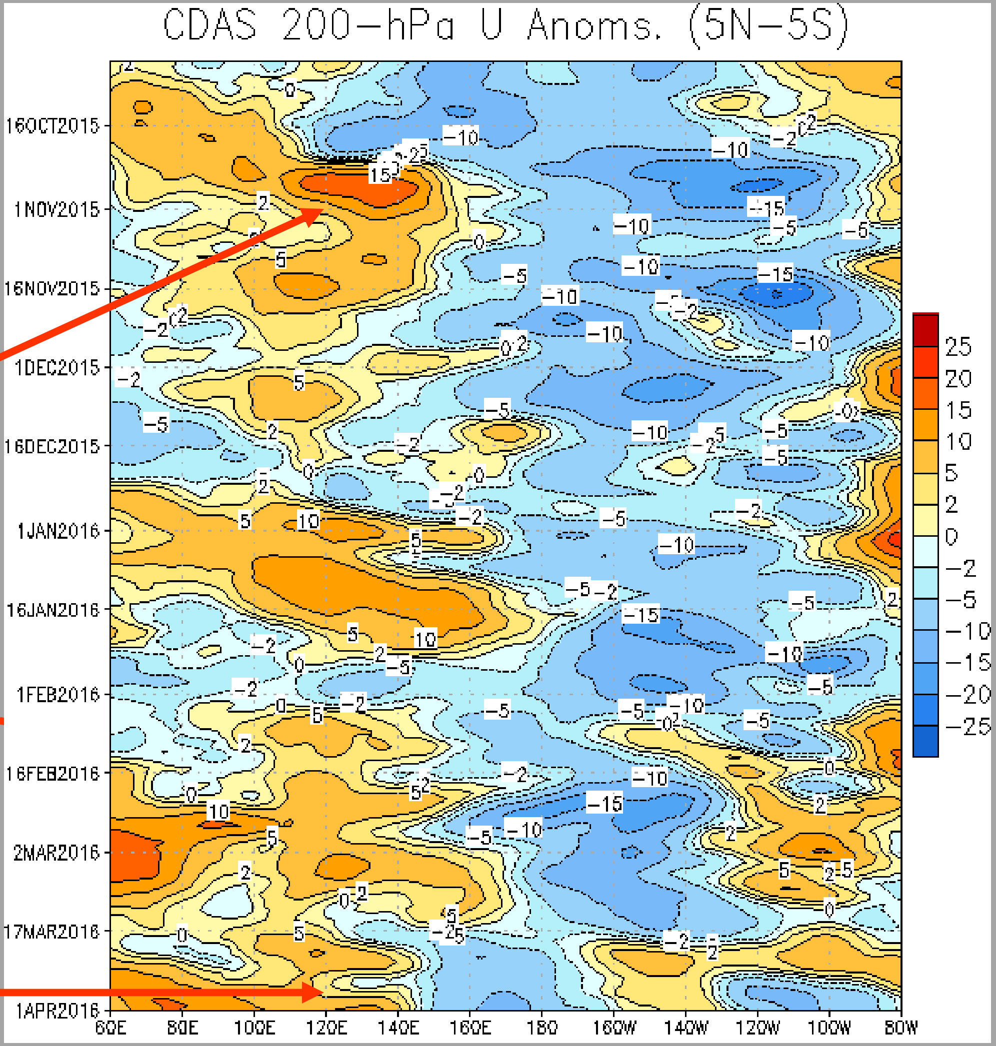
Easterly anomalies have persisted over the central and eastern Pacific since June associated with El Niño (red box).

During late October, a temporary eastward shift in the westerly anomalies was evident across the Pacific.

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.

Recently, two discrete regions of easterlies are apparent over the West and East Pacific.



Weekly Heat Content Evolution in the Equatorial Pacific

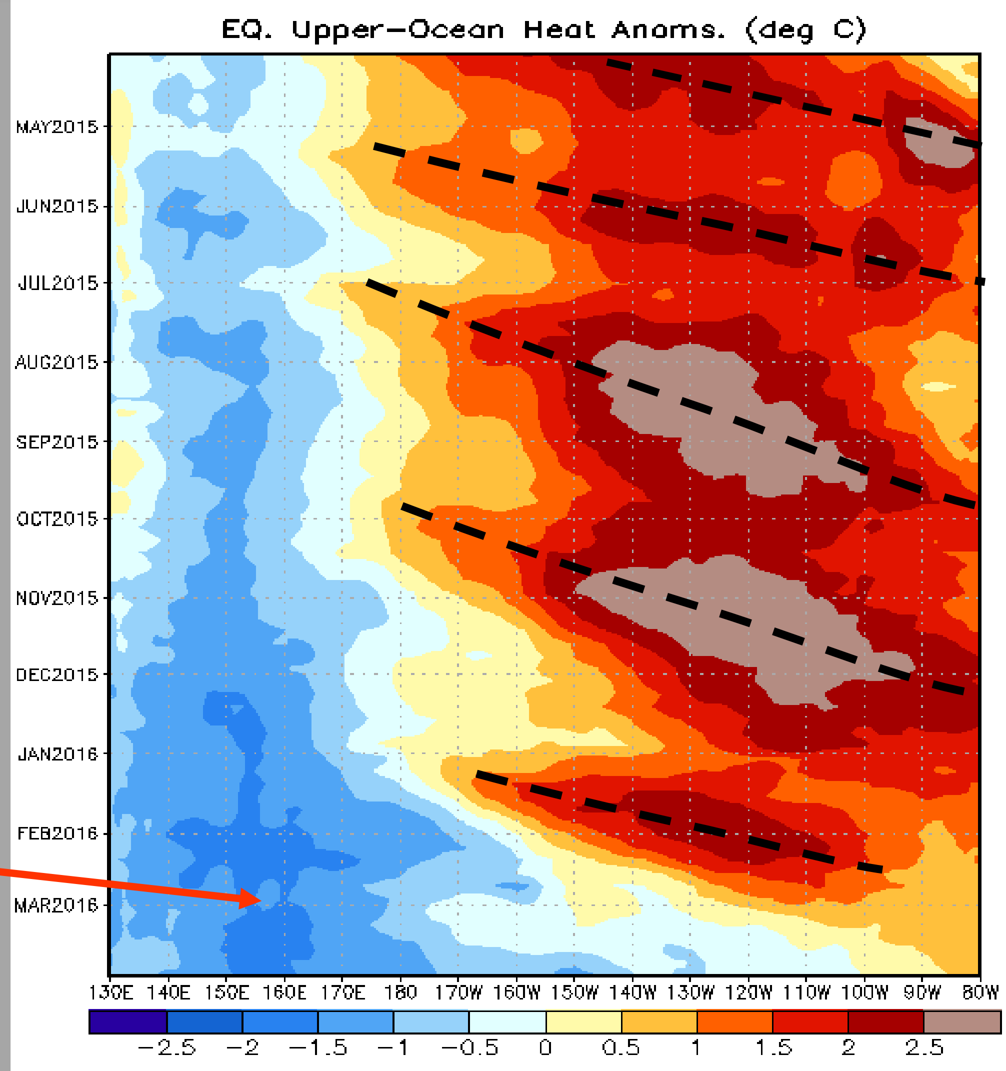
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

Following a strong westerly wind burst in March, a strong downwelling phase of a Kelvin wave propagated eastward, reaching the South American coast during May.

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.



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

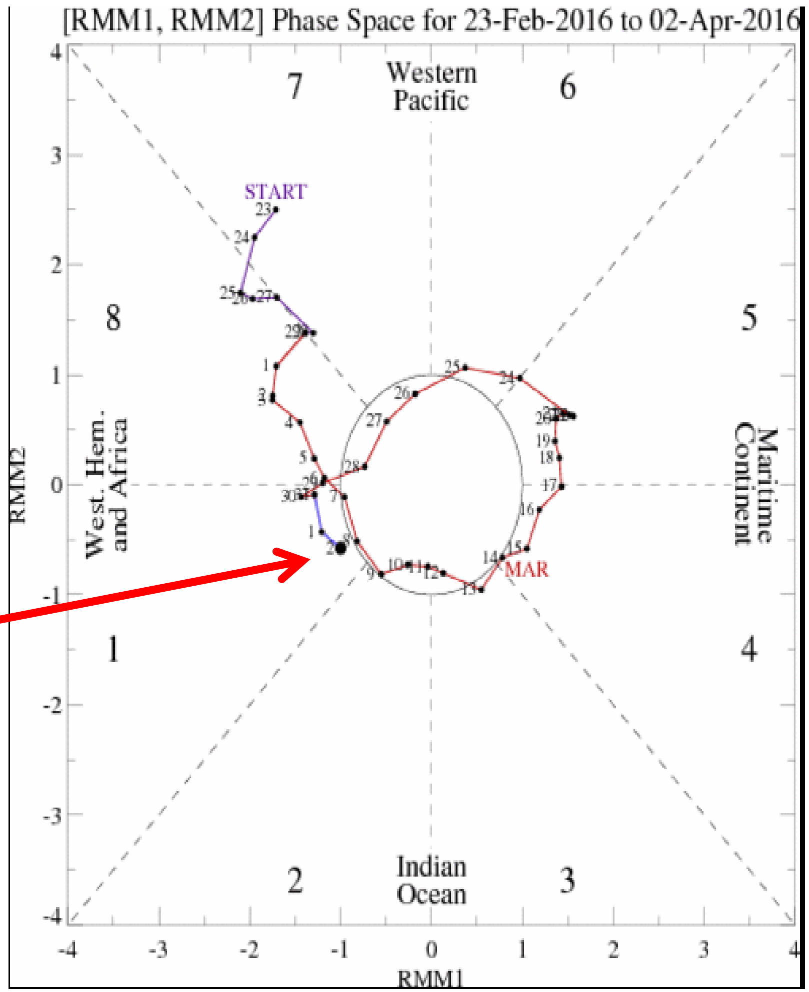
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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

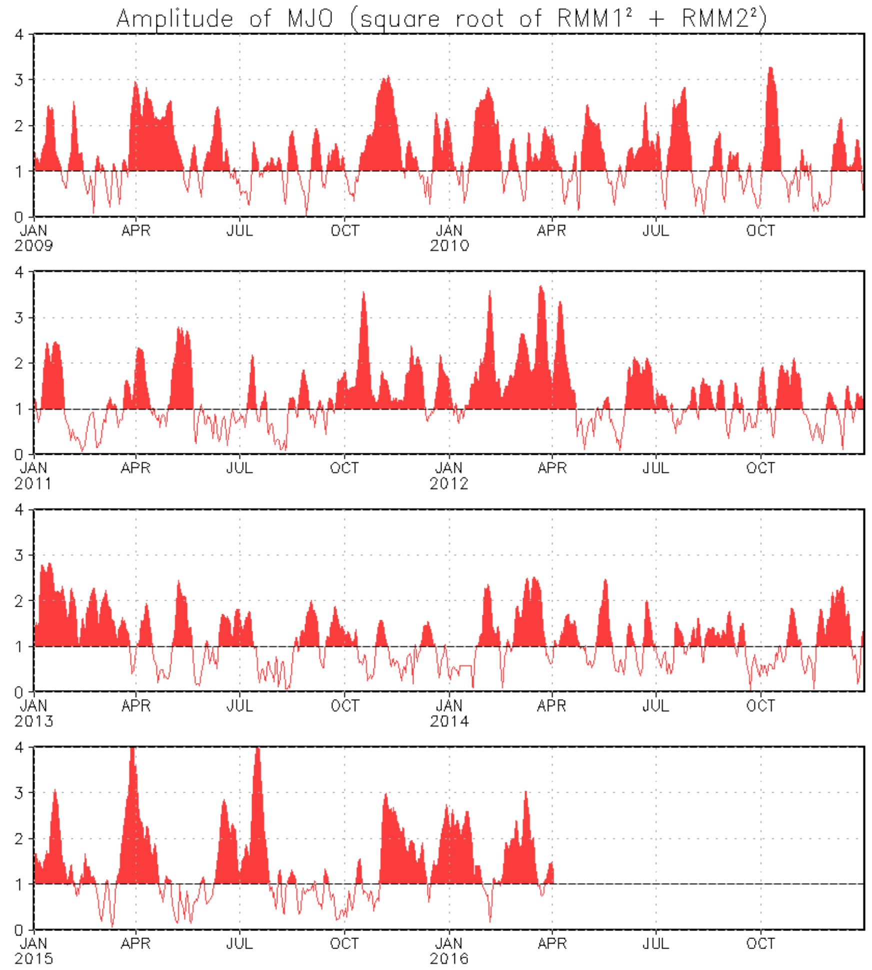


After fast, weak propagation over the Pacific, the RMM MJO index continues to reflect eastward propagation, with the enhanced phase over Africa.

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

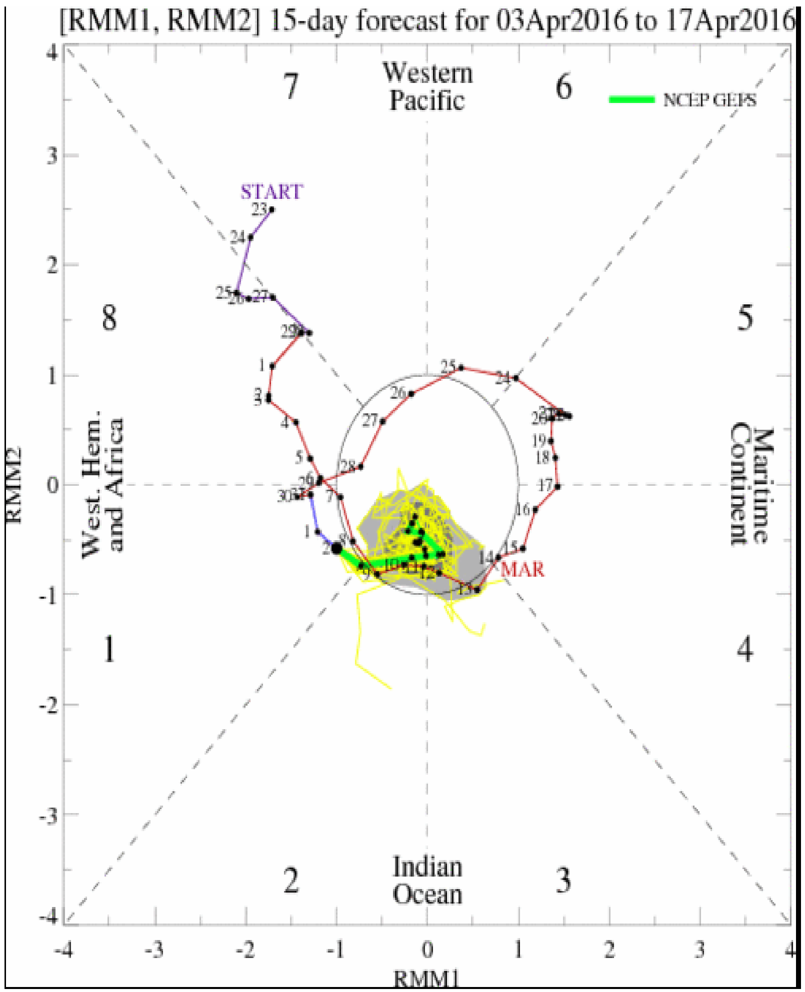
<u>Yellow Lines</u> - 20 Individual Members
<u>Green Line</u> - Ensemble Mean

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

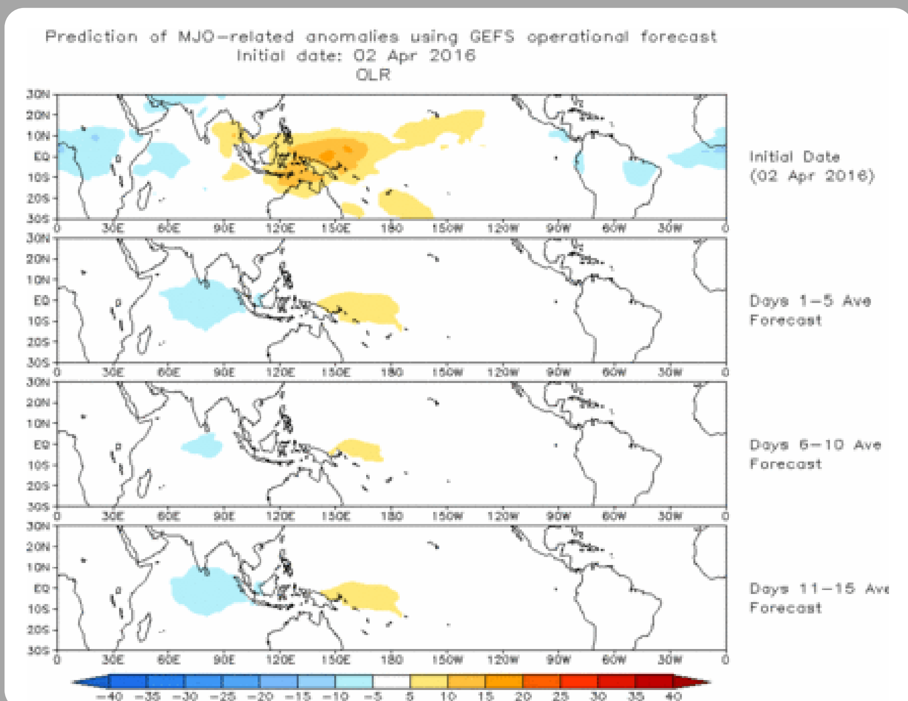
The GFS ensemble MJO index forecast depicts some continued eastward propagation of the MJO during Week-1, with a weakening of the index during Week-2.



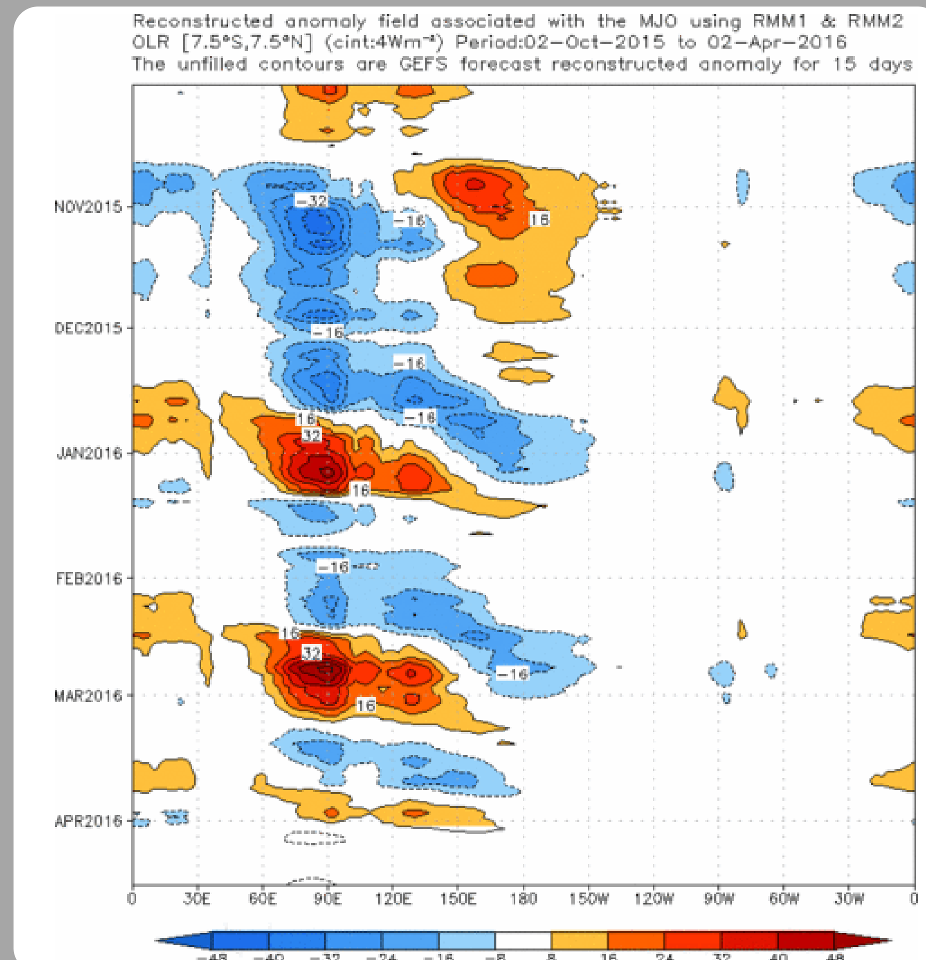
Ensemble GFS (GEFS) MJO Forecast

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

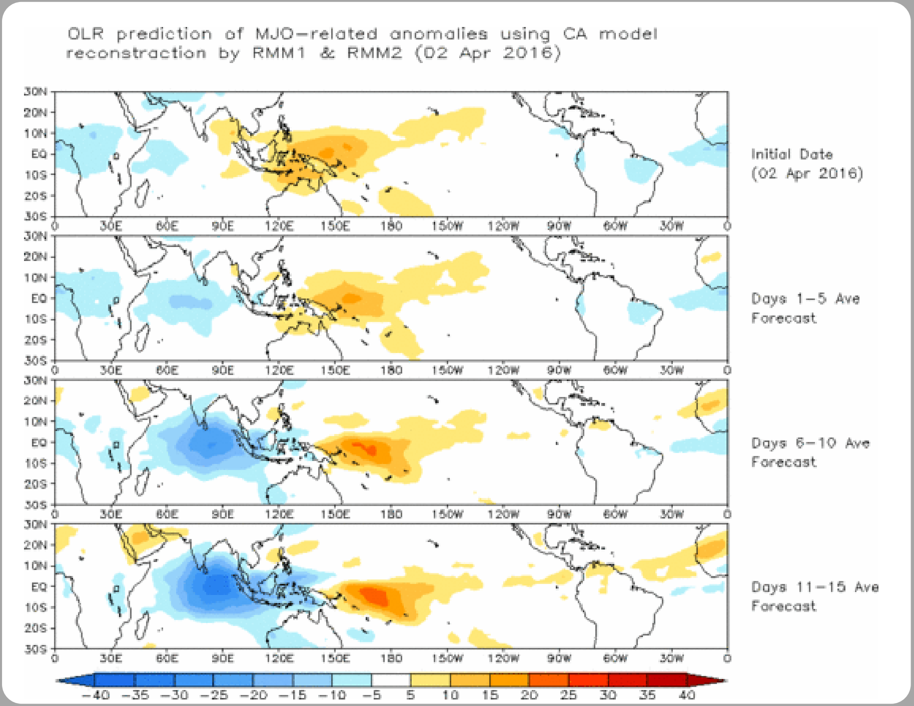


The GEFS OLR forecast based on the RMM Index depicts a weak Indian Ocean event during Week-1, with little additional eastward propagation during Week-2.

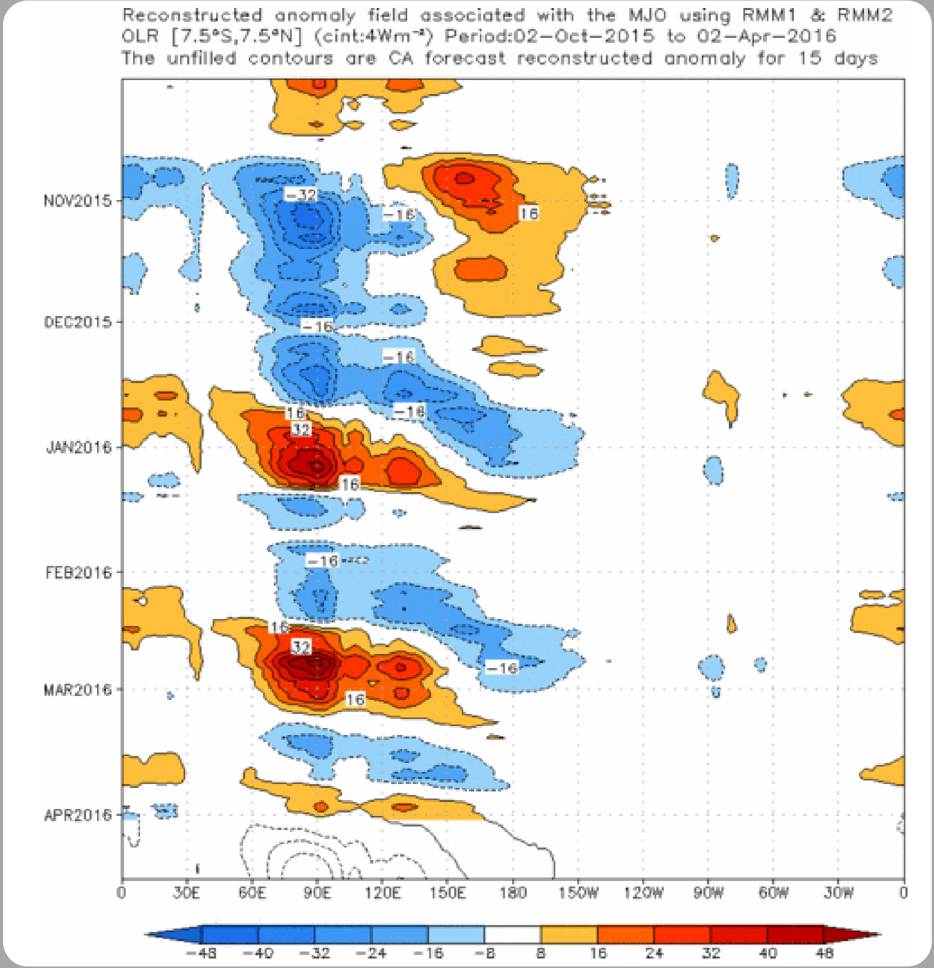
Constructed Analog (CA) MJO Forecast

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



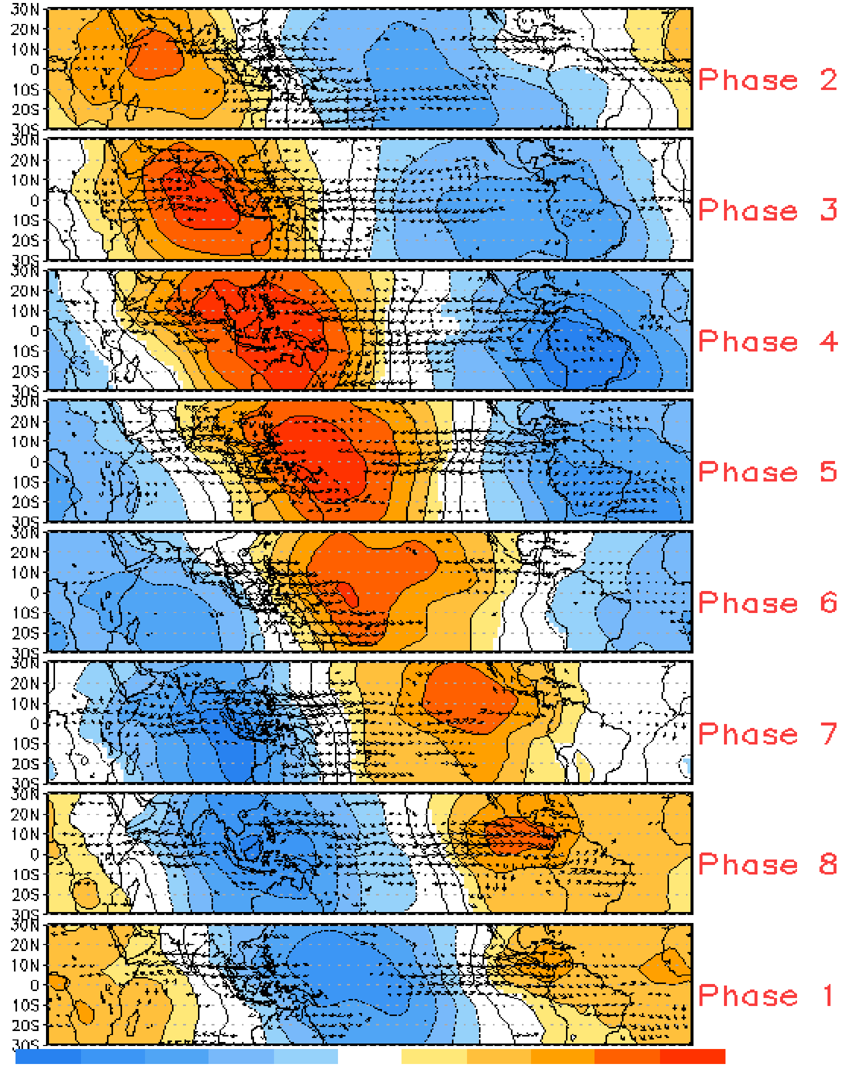
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



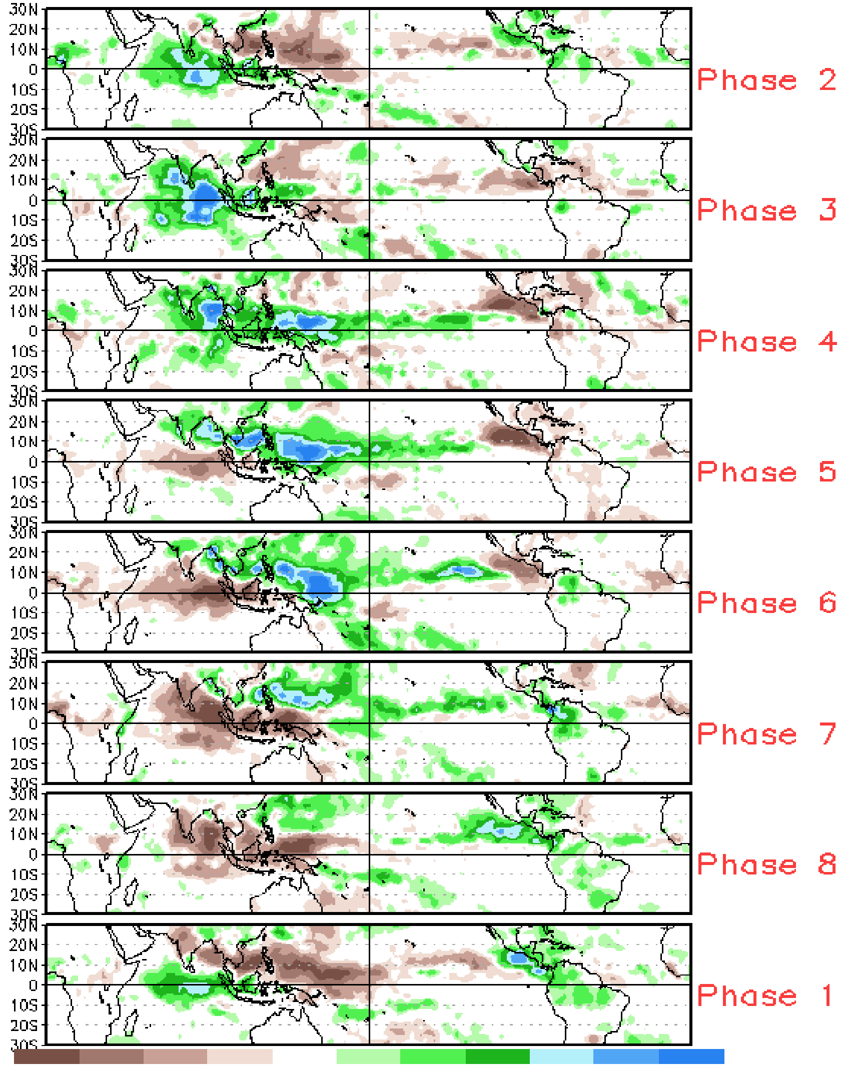
The constructed analog model depicts eastward propagation of a much more robust MJO event.

MJO Composites - Global Tropics

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



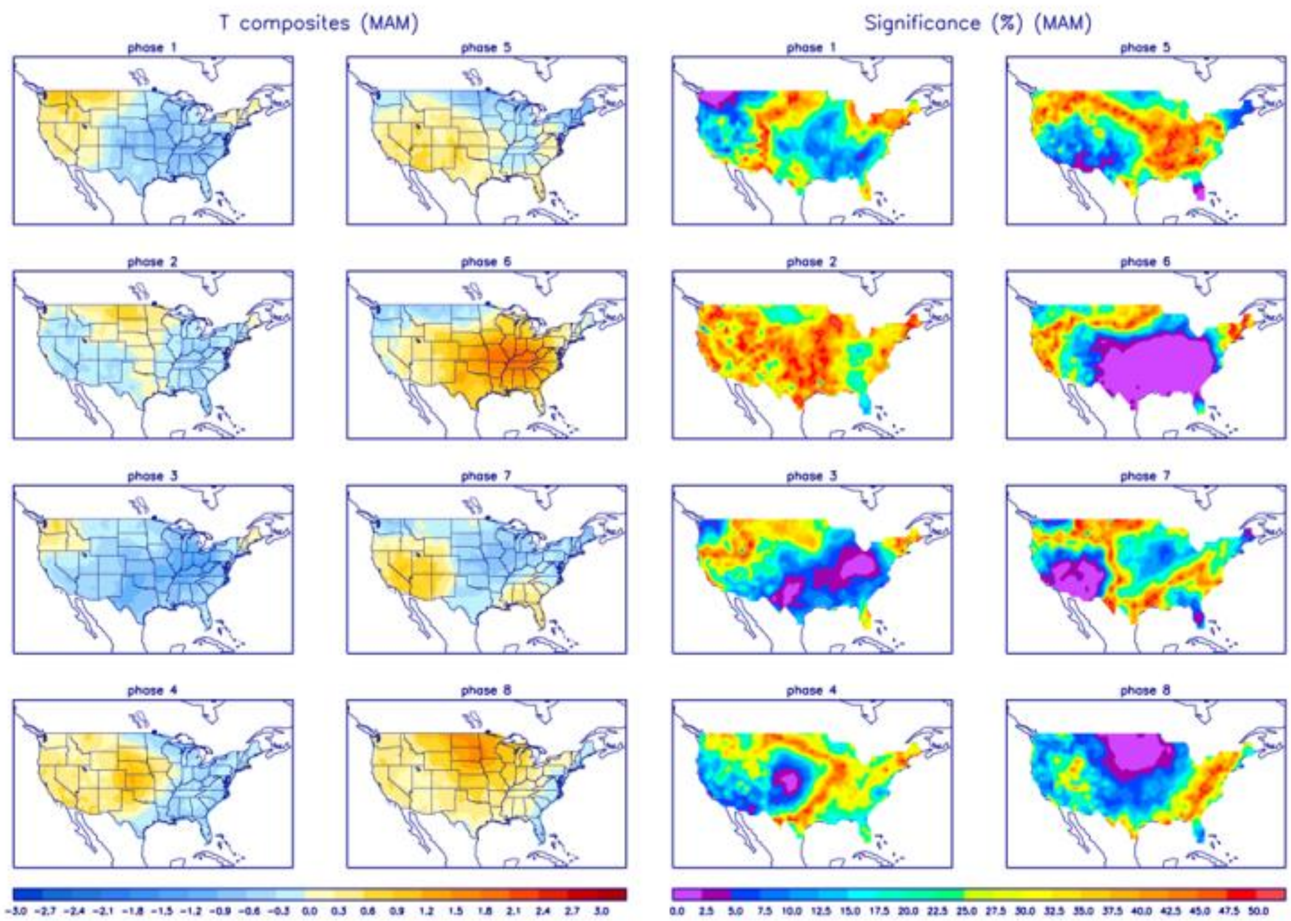
Precipitation Anomalies (Nov-Mar)



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.



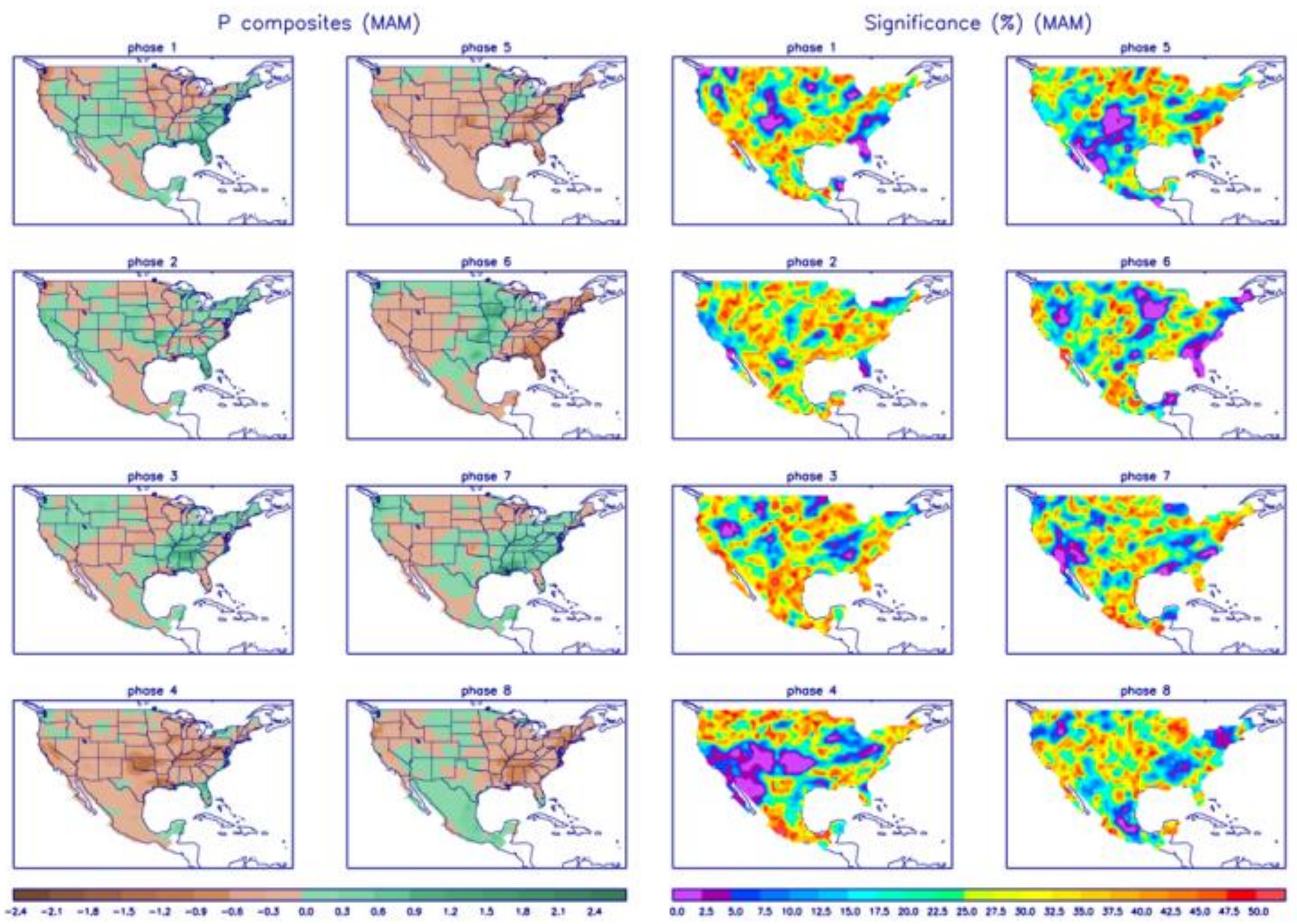
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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