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

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Climate Prediction Center / NCEP
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Overview

The MJO was active during the past week with the enhanced phase now centered over the Atlantic Ocean and Africa. The suppressed phase is centered over the Maritime Continent.

Some of the dynamical model MJO index forecasts support continued eastward propagation of a coherent signal, though all indicate a weakening signal. The constructed analog tool indicates a slightly stronger signal.

Destructive interference between the intraseasonal signal and the ENSO background state is likely during the latter portions of the period.

The MJO favors enhanced convection continuing for areas of the Africa and the Indian Ocean during week-1, with later impacts to Australia and the Maritime Continent, though the latter impacts are uncertain due to interactions with ENSO.

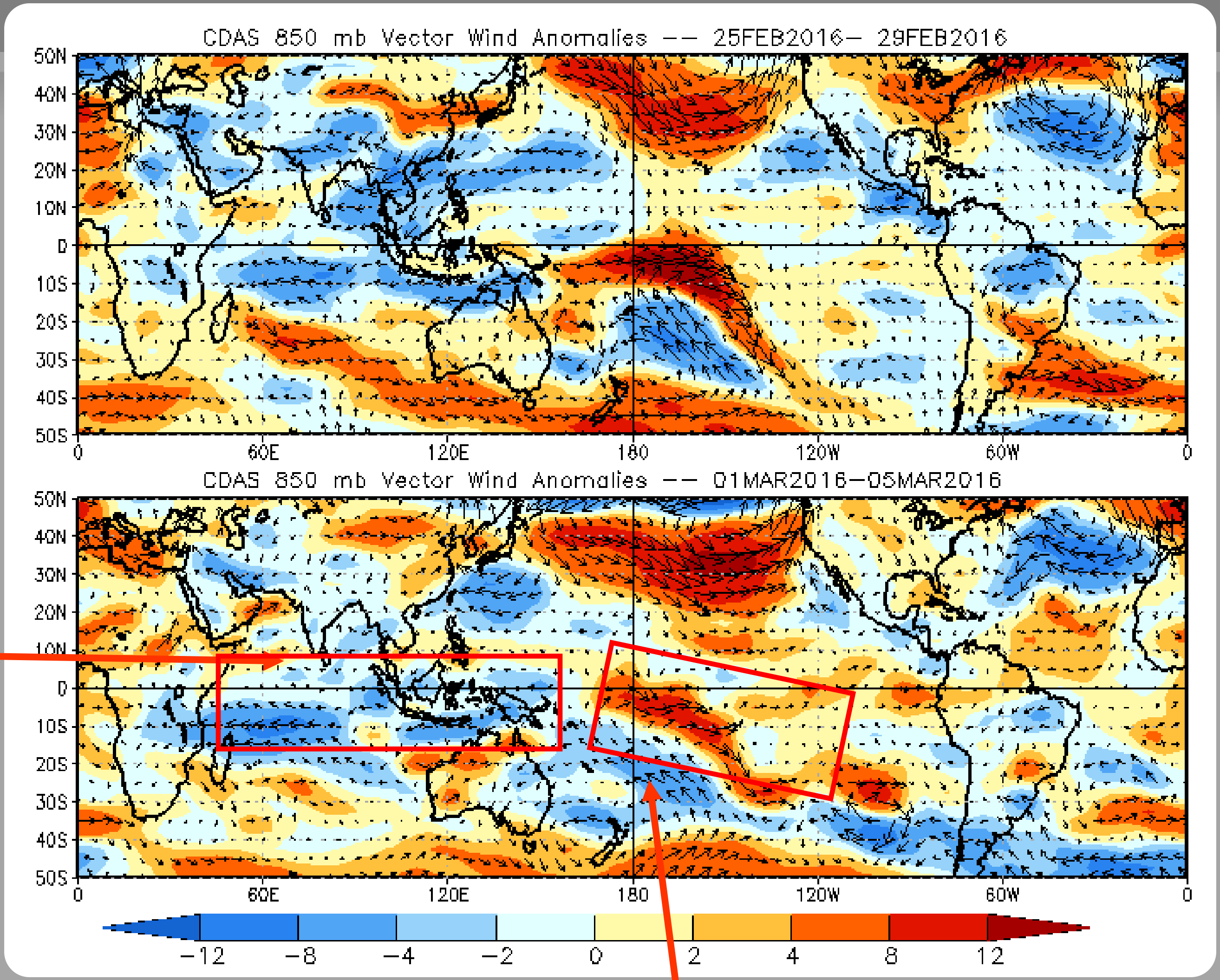
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 weakened over the northern Indian Ocean, but persisted over the southern Indian Ocean, while expanding eastward over the Maritime Continent during the most recent five days.

Strong westerly anomalies expanded over the southwest Pacific during the most recent five days.

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

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

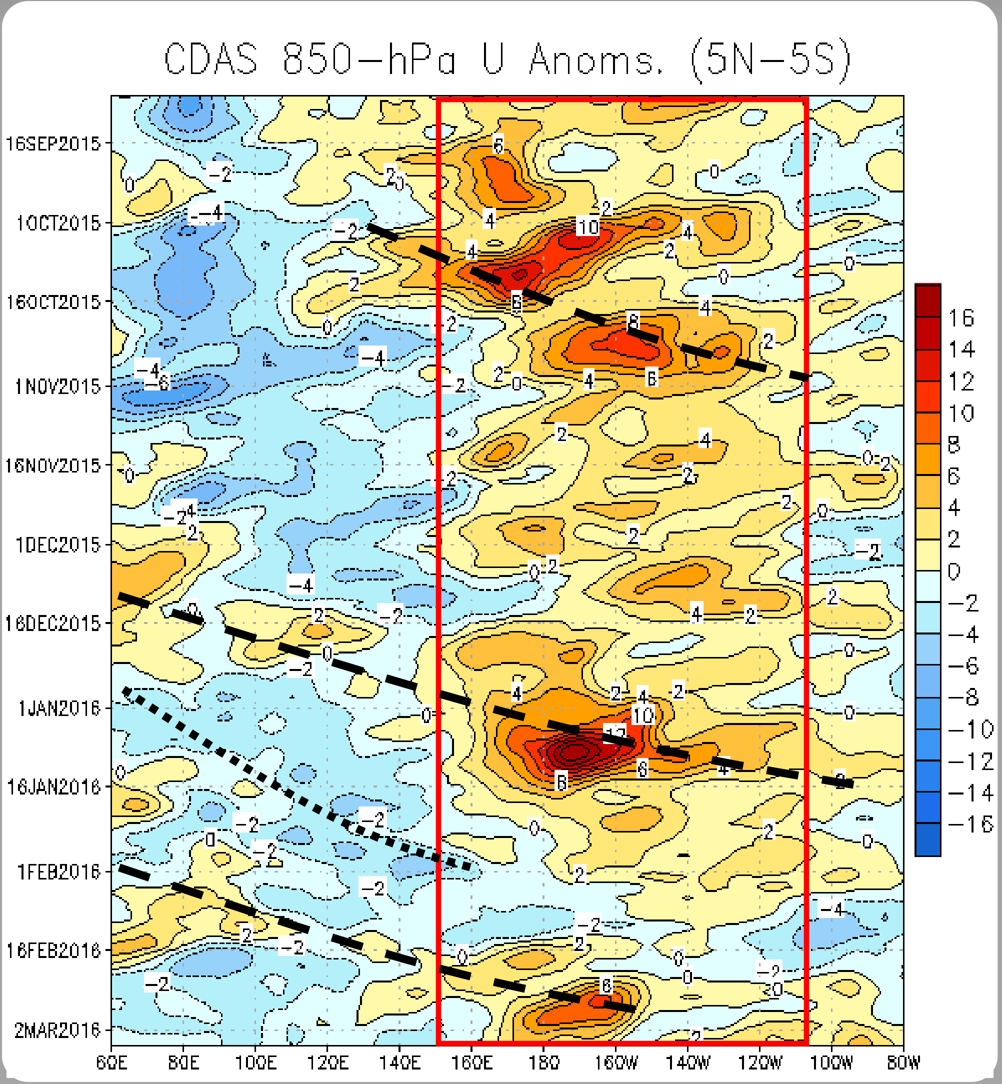
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

An eastward shift in the pattern was observed in late October, related to subseasonal activity.

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.

Most recently, easterly anomalies have overspread the Maritime Continent and westerly anomalies are increasing over the eastern Pacific.



OLR Anomalies – Past 30 days

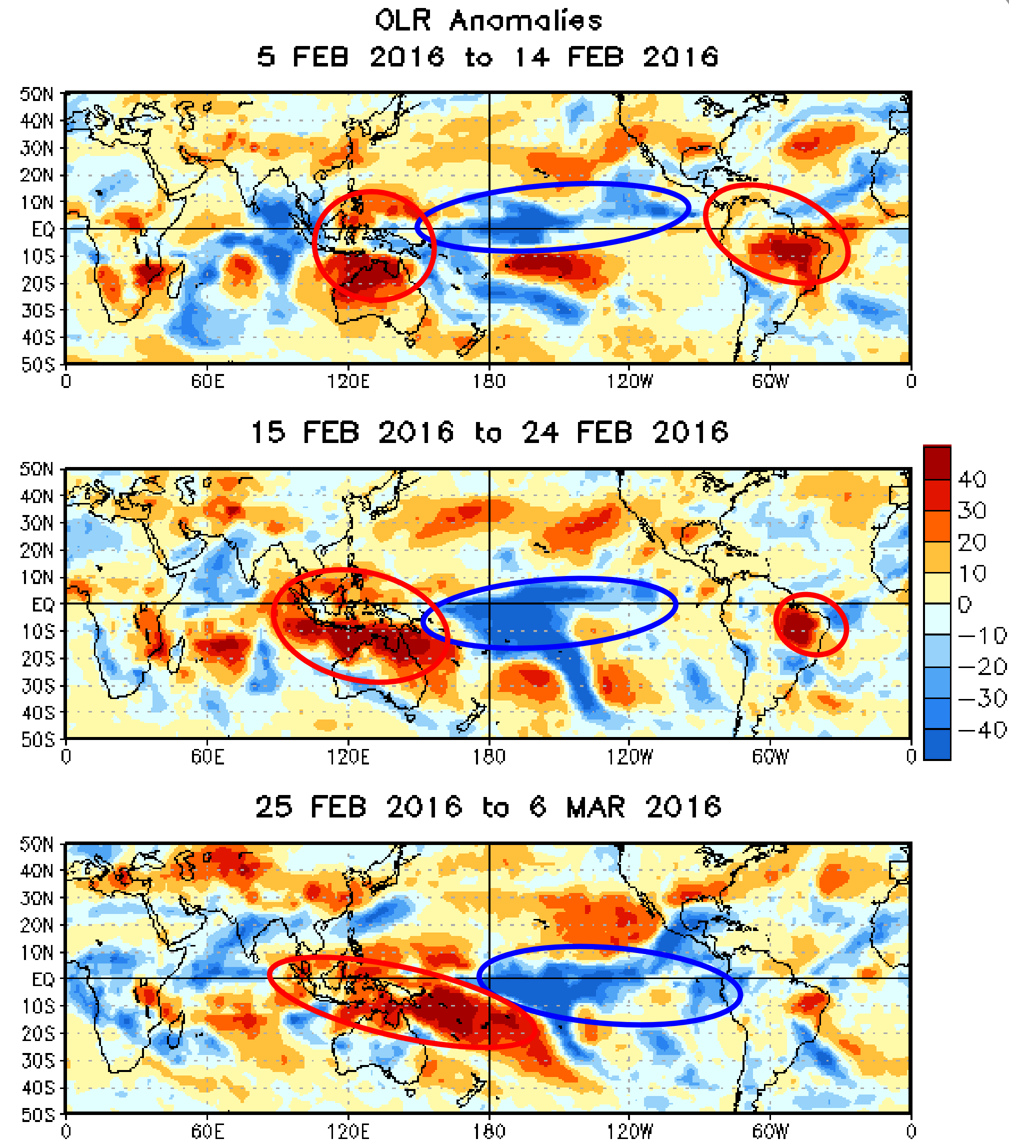
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late January, the pattern of anomalous tropical convection was largely consistent with ongoing El Nino conditions.

By early February, an emerging MJO signal resulted in enhanced convection across the eastern Indian Ocean and a disruption of the suppressed convective signal across the Maritime continent near the equator. Enhanced convection continued over the equatorial Pacific.

During mid to late February, MJO activity resulted in widespread enhanced convection over the western and central Pacific. Suppressed convection was evident over northern Australia, much of Indonesia, and Brazil.



Outgoing Longwave Radiation (OLR) Anomalies (5°N-5°S)

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

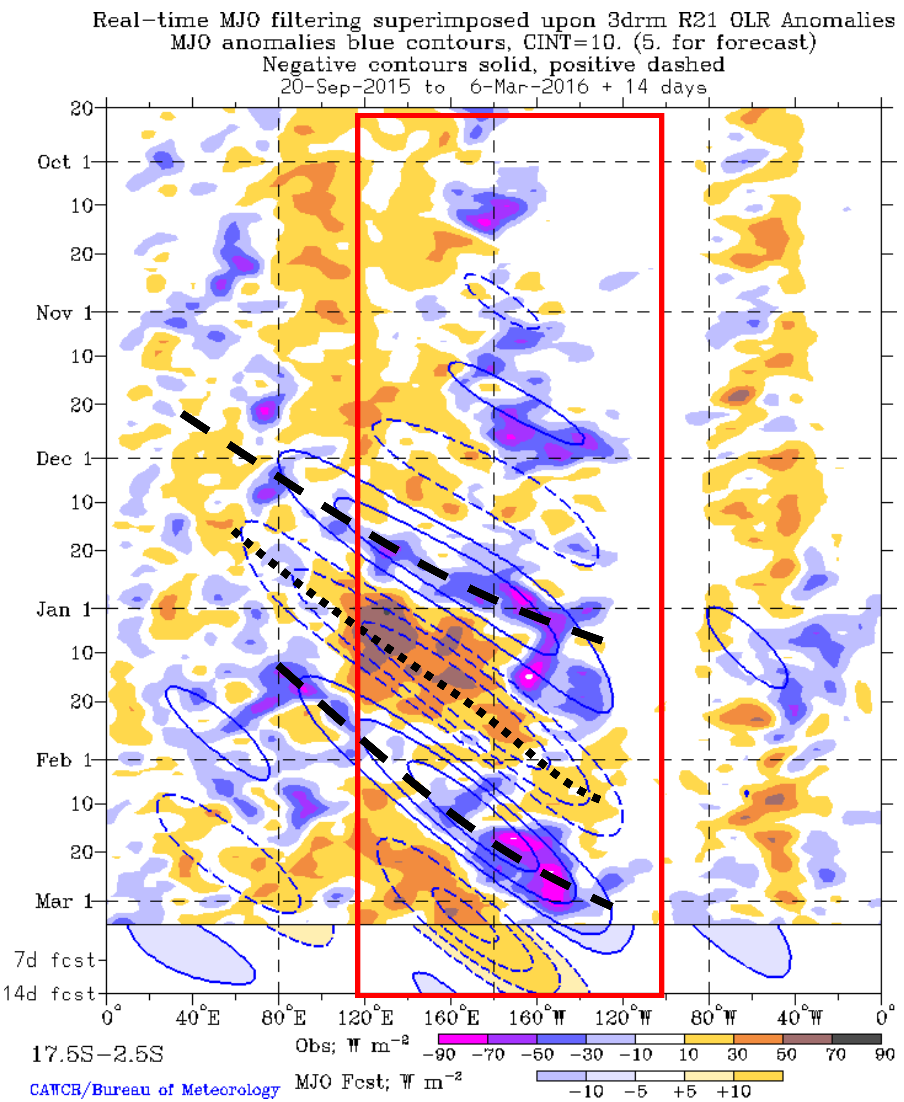
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

Since April, 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 again, with the enhanced phase propagating from the Indian Ocean to the west-central Pacific during the month.

Renewed MJO activity was evident during late January and February, with enhanced convection propagating over the Indian Ocean and a reduction of suppressed convection over the Maritime Continent.

Recently, the MJO is contributing to an eastward shift on convection over the eastern Pacific and suppressed rainfall over the western Pacific.



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

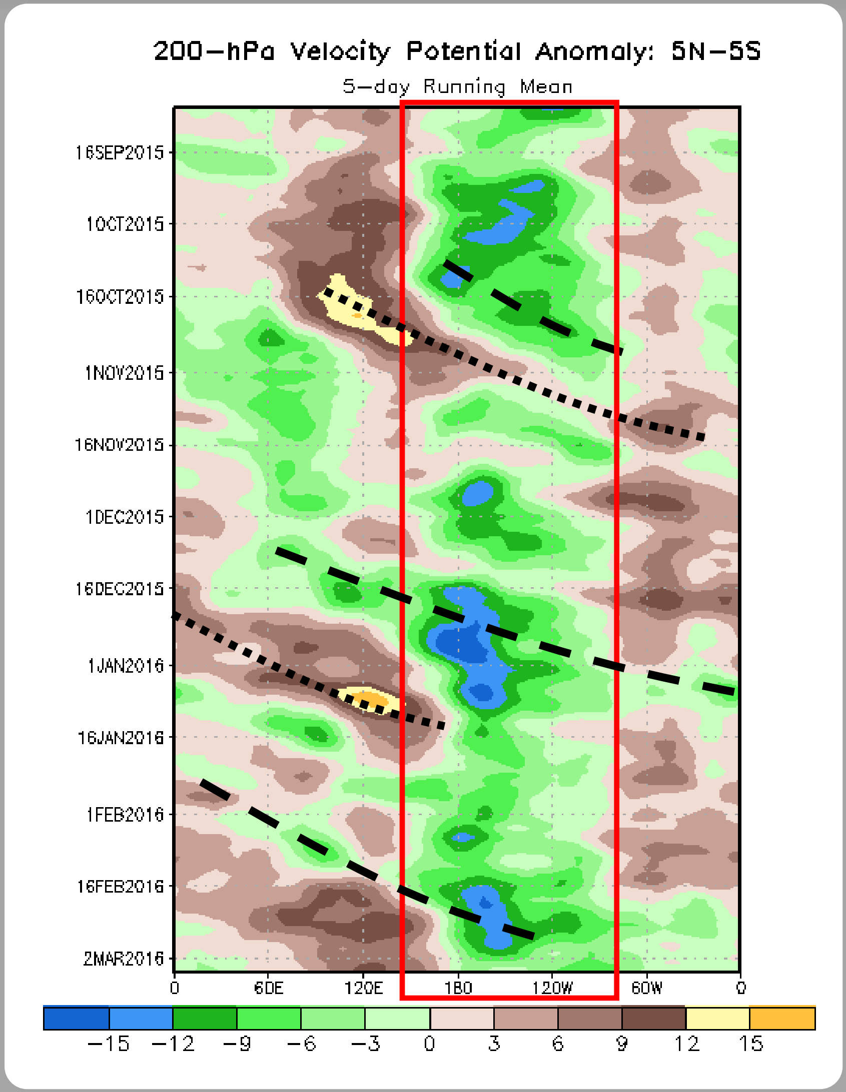
The ongoing ENSO state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

During June and early July, a high-amplitude MJO event was observed, constructively interfering with the El Niño signal in early July.

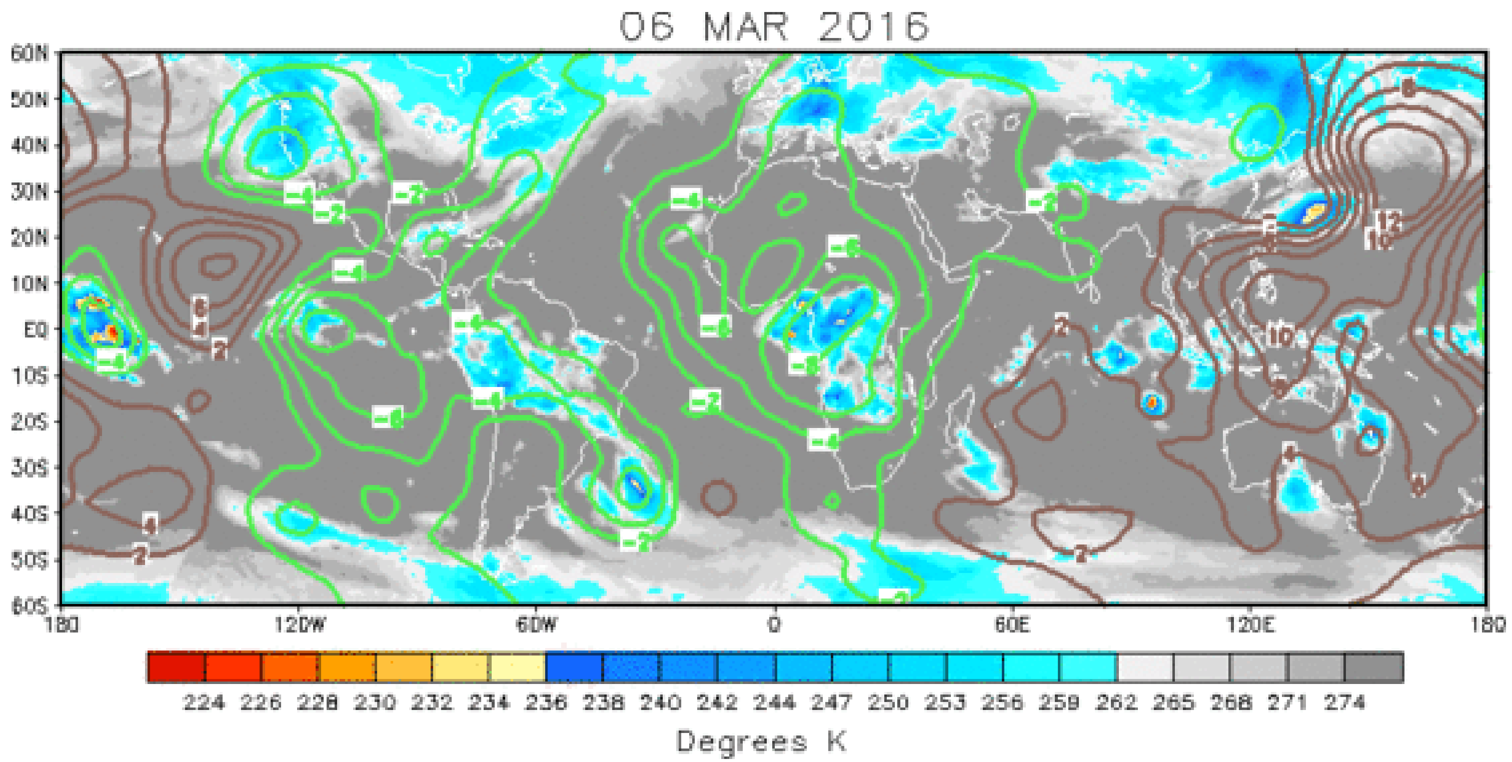
During late October, there was an eastward shift in the pattern. Renewed MJO activity was also observed during December and early January, yielding a robust signal in the upper levels. This signal weakened during mid-January.

During late February, intraseasonal variability constructively interfered with the ongoing El Nino.

Recently, a slight eastward shift is evident in the pattern, likely related to MJO activity.



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



The upper-level velocity potential anomalies depict a Wave-1 pattern, consistent with coherent MJO activity. The enhanced phase is centered over the Atlantic 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)

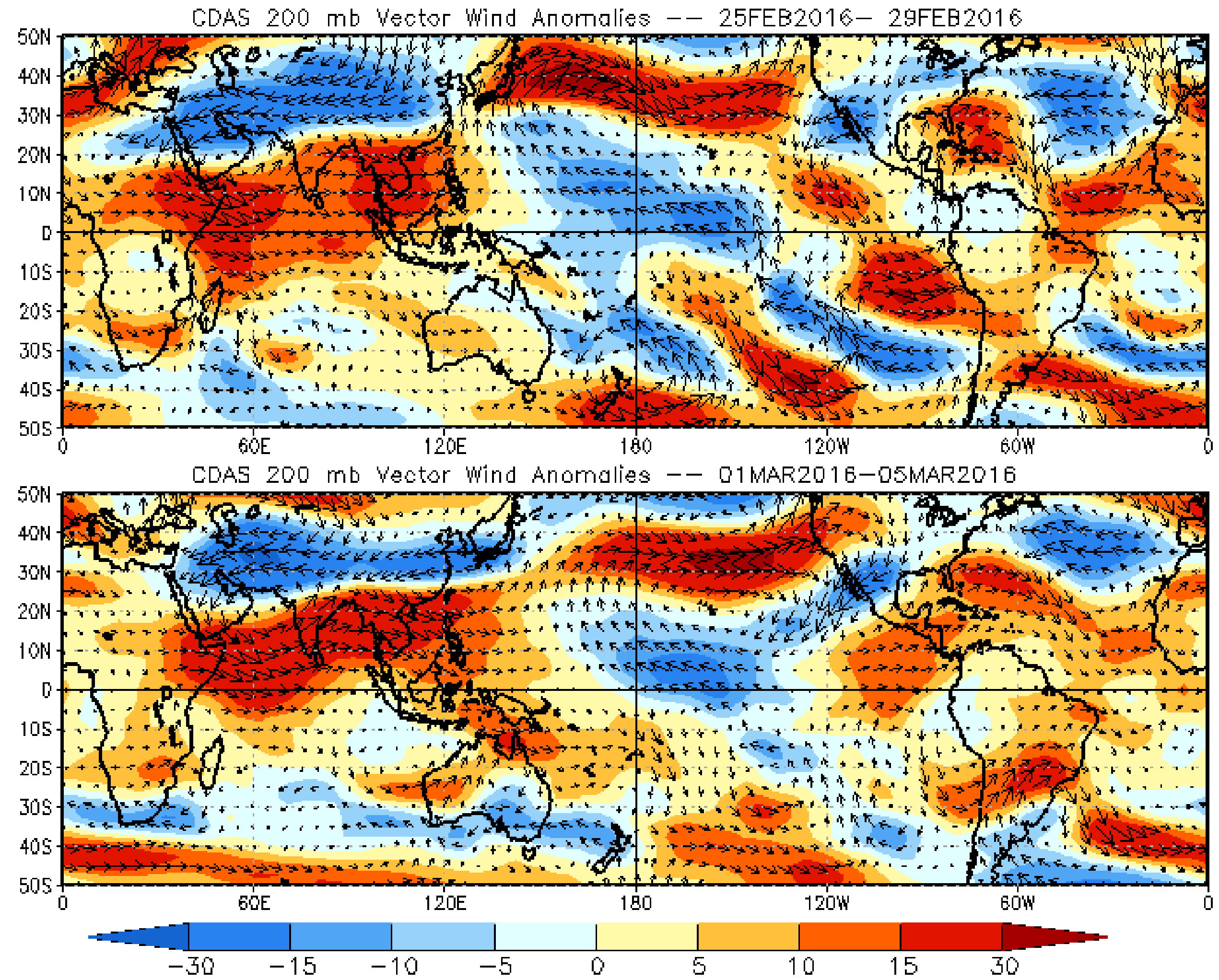
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Easterly anomalies over the central tropical Pacific shifted slightly eastward, while westerly anomalies over the Indian Ocean and Southeast Asia relaxed slightly but also expanded eastward.

A large subtropical High (common during El Nino events) has redeveloped over the eastern Pacific.



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

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

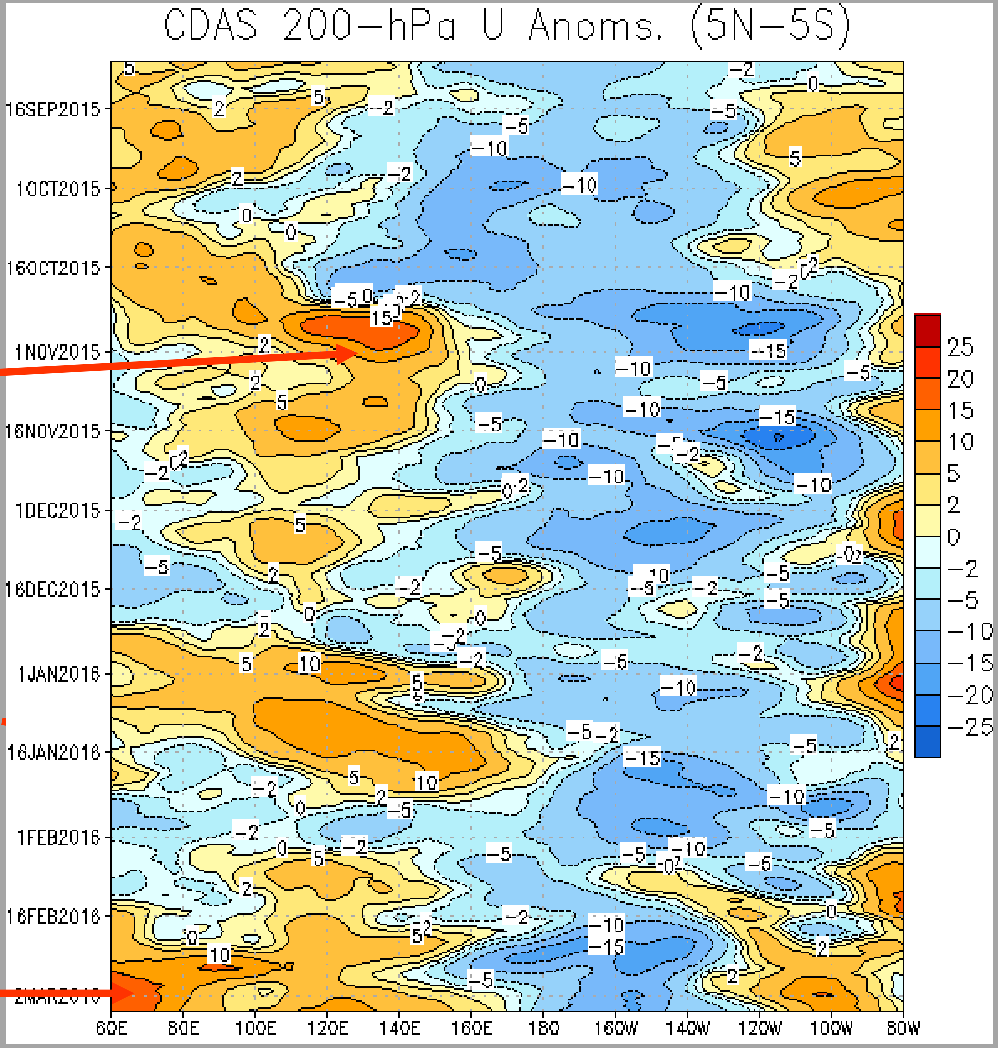
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

More recently, westerly anomalies returned to the Indian Ocean and Maritime Continent, while easterly anomalies persisted between about 170E – 120W.



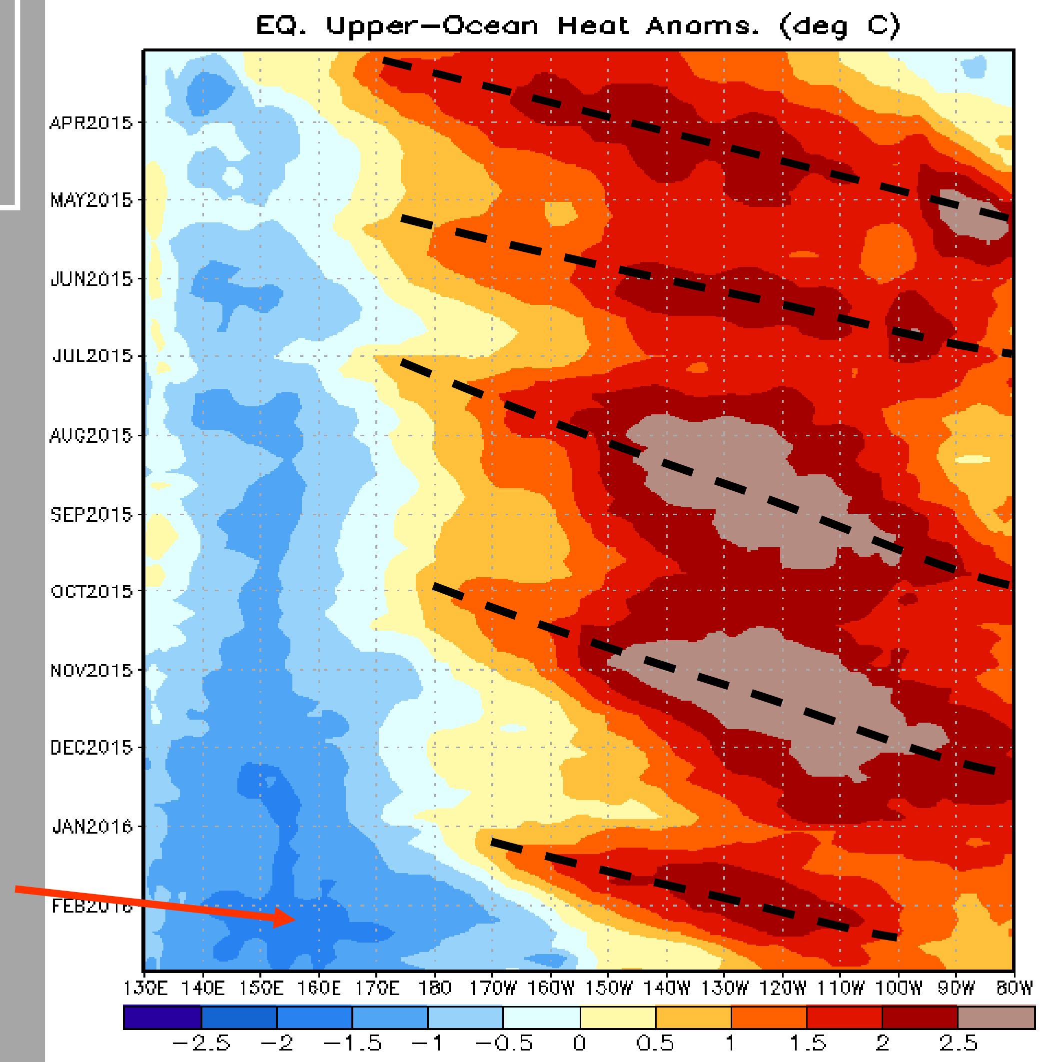
Weekly Heat Content Evolution in the Equatorial Pacific

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 has also increased in magnitude.



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

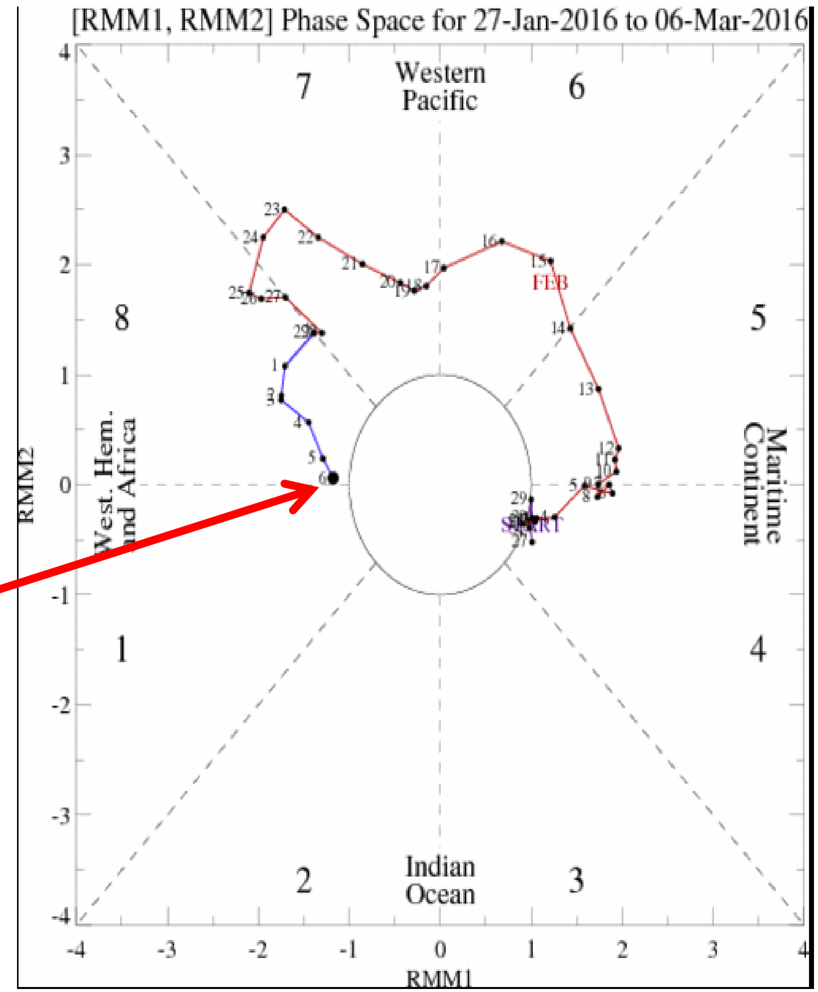
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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

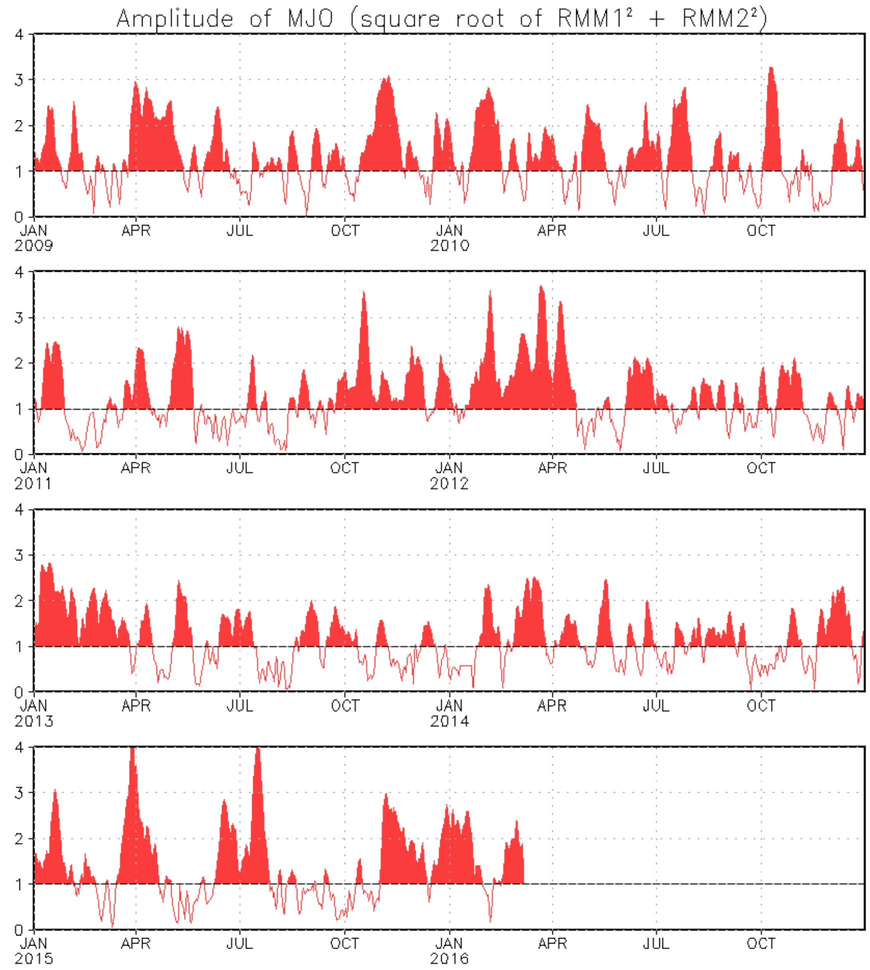


The MJO index indicates coherent MJO activity with the enhanced phase shifting eastward across the Americas during the past week.

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.



Ensemble GFS (GEFS) MJO Forecast

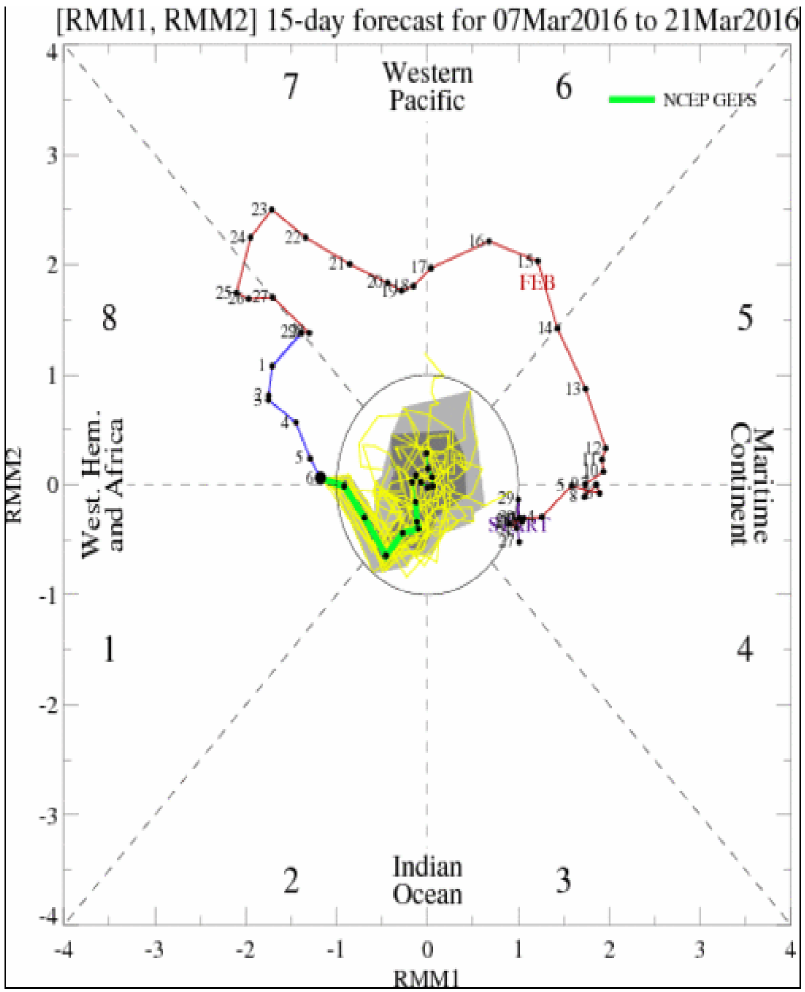
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

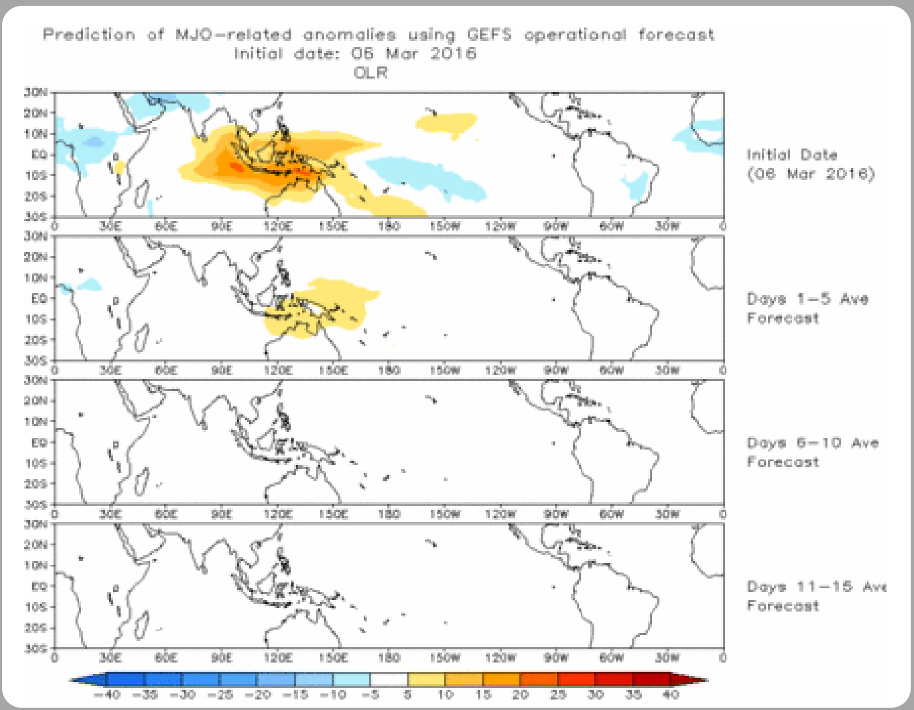
The GFS ensemble MJO index forecast depicts a continuation of MJO activity during the first week of the period through phase 1, but with a predicted decrease in amplitude to near 0 during week-2.



Ensemble GFS (GEFS) MJO Forecast

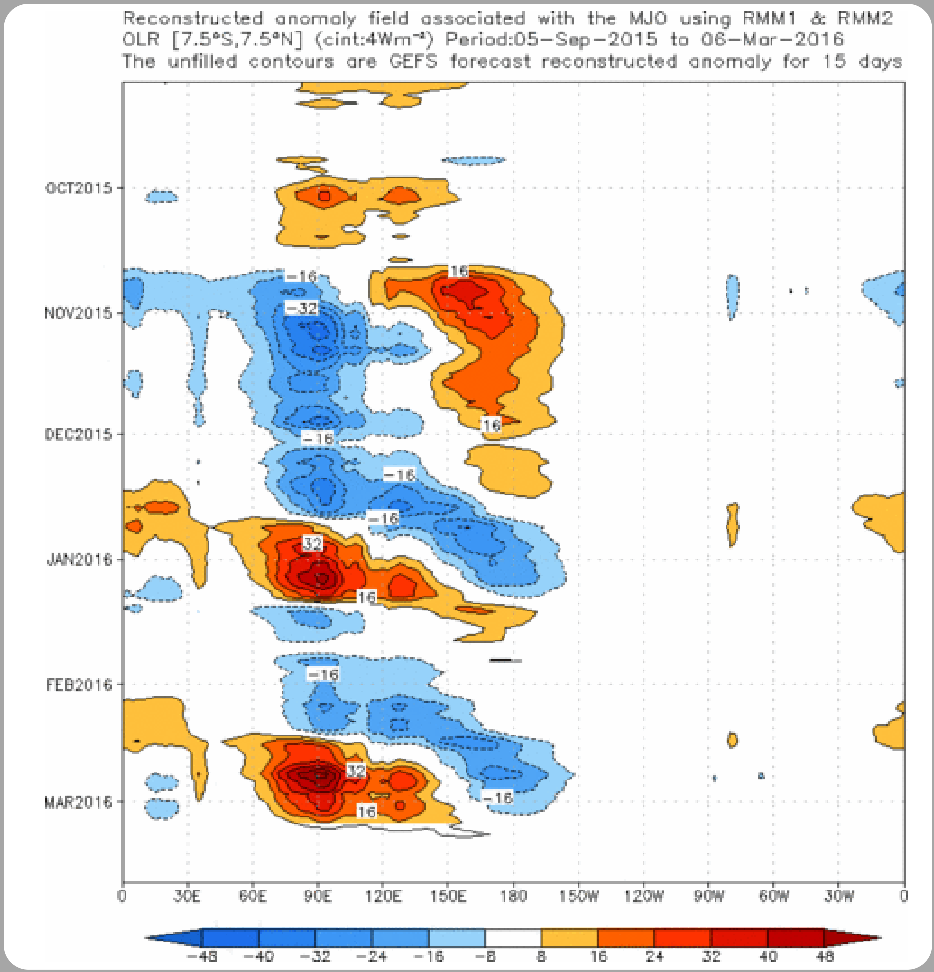
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS OLR forecast depicts slowly eastward shifting signal during week-1, with a decaying amplitude to near 0 by the beginning of week-2.

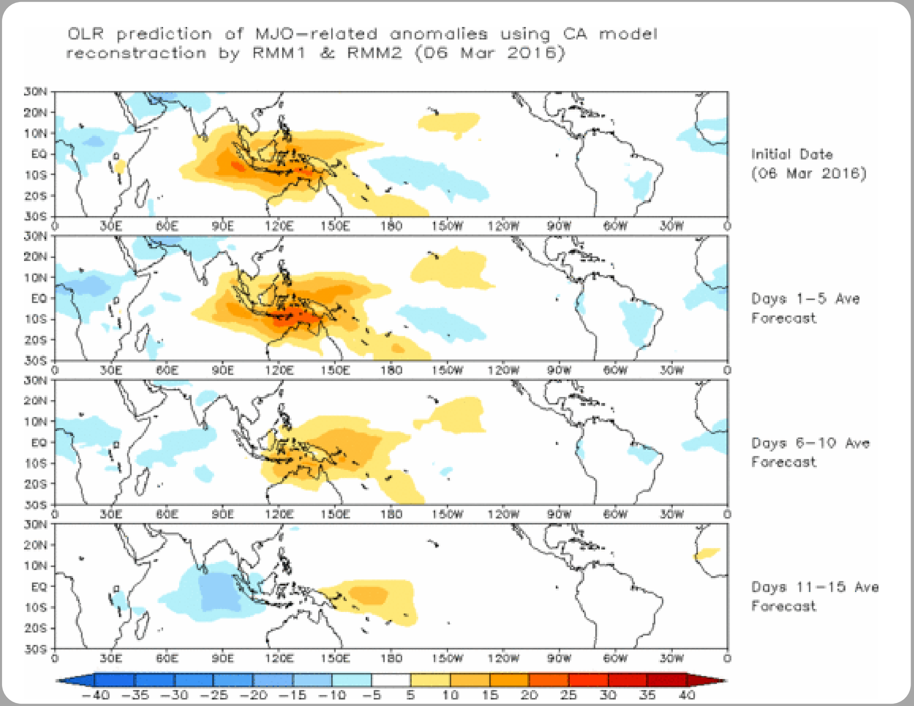
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



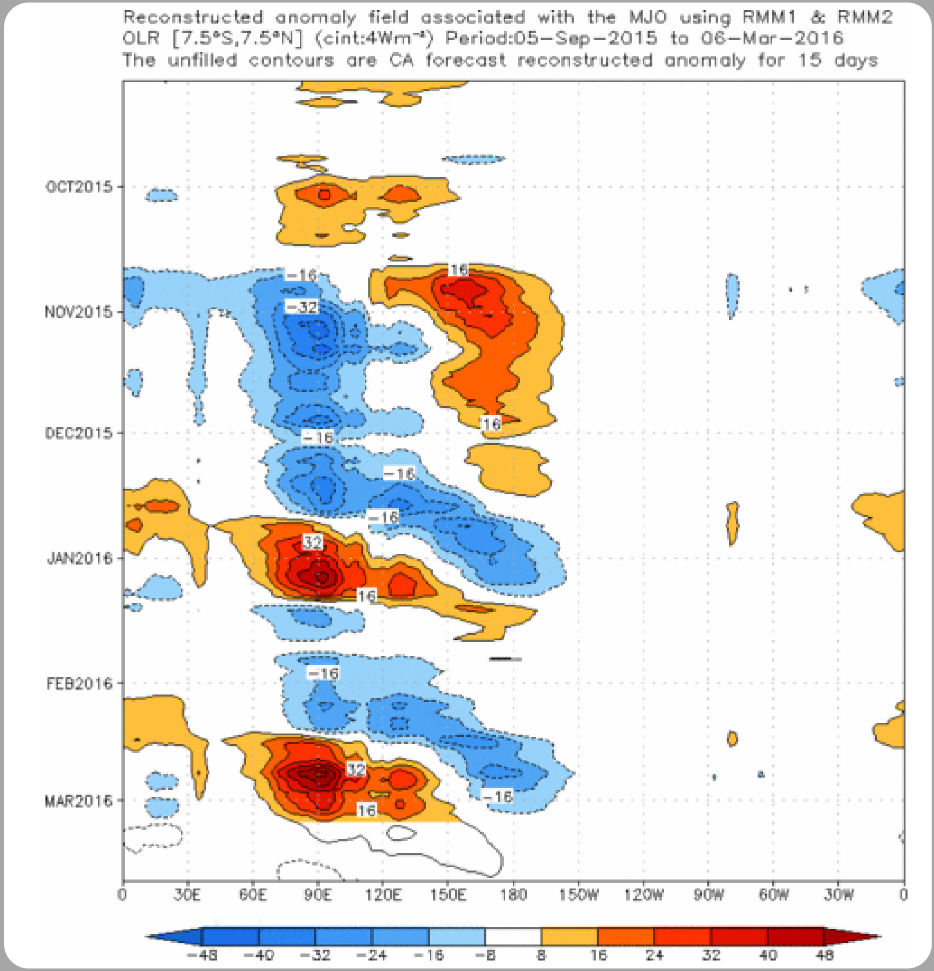
Constructed Analog (CA) MJO Forecast

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

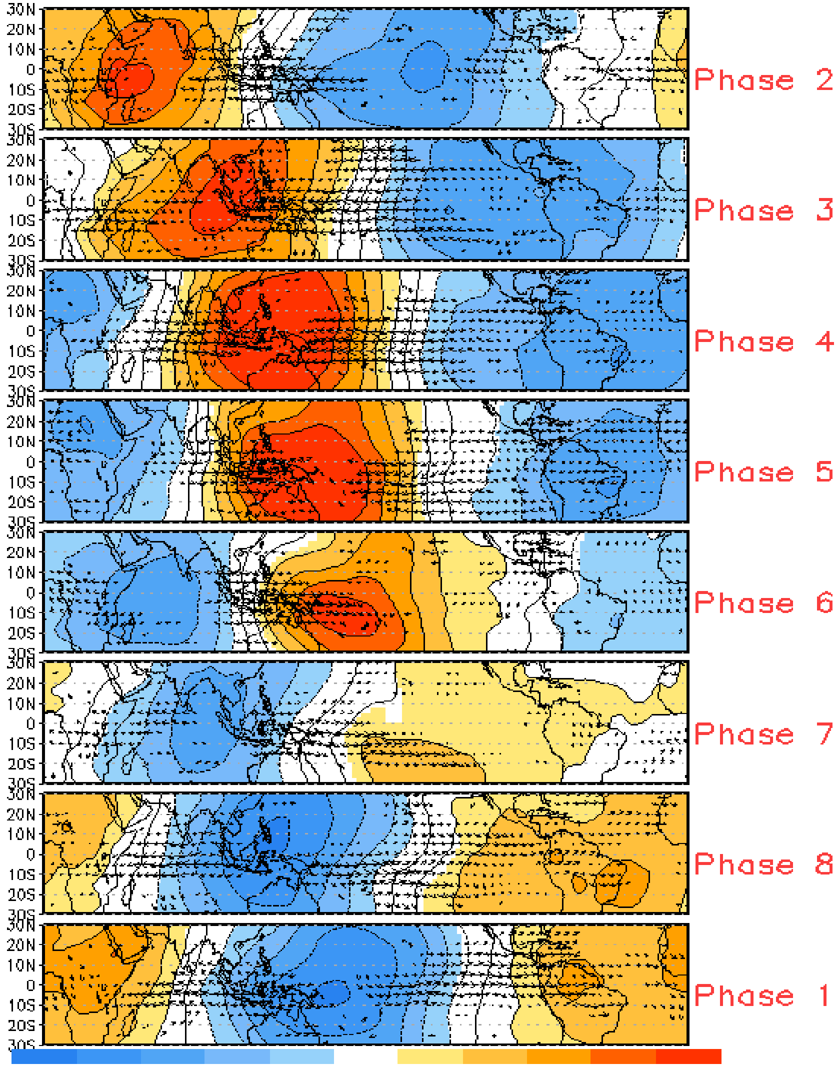


The constructed analog model depicts faster eastward propagation of the MJO-associated OLR anomalies with gradually diminishing amplitude. The CA maintains a stronger amplitude than the GEFS.

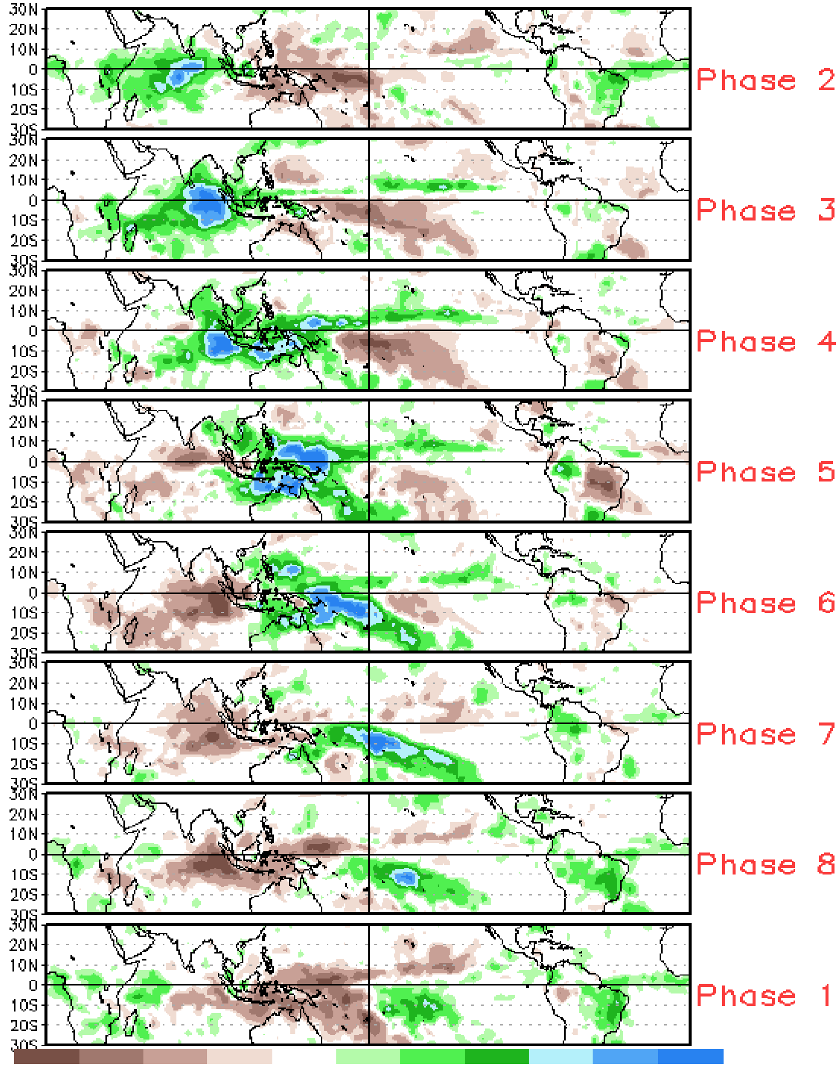
MJO Composites - Global Tropics

850-hPa Velocity Potential and

Wind Anomalies (Nov-Mar)



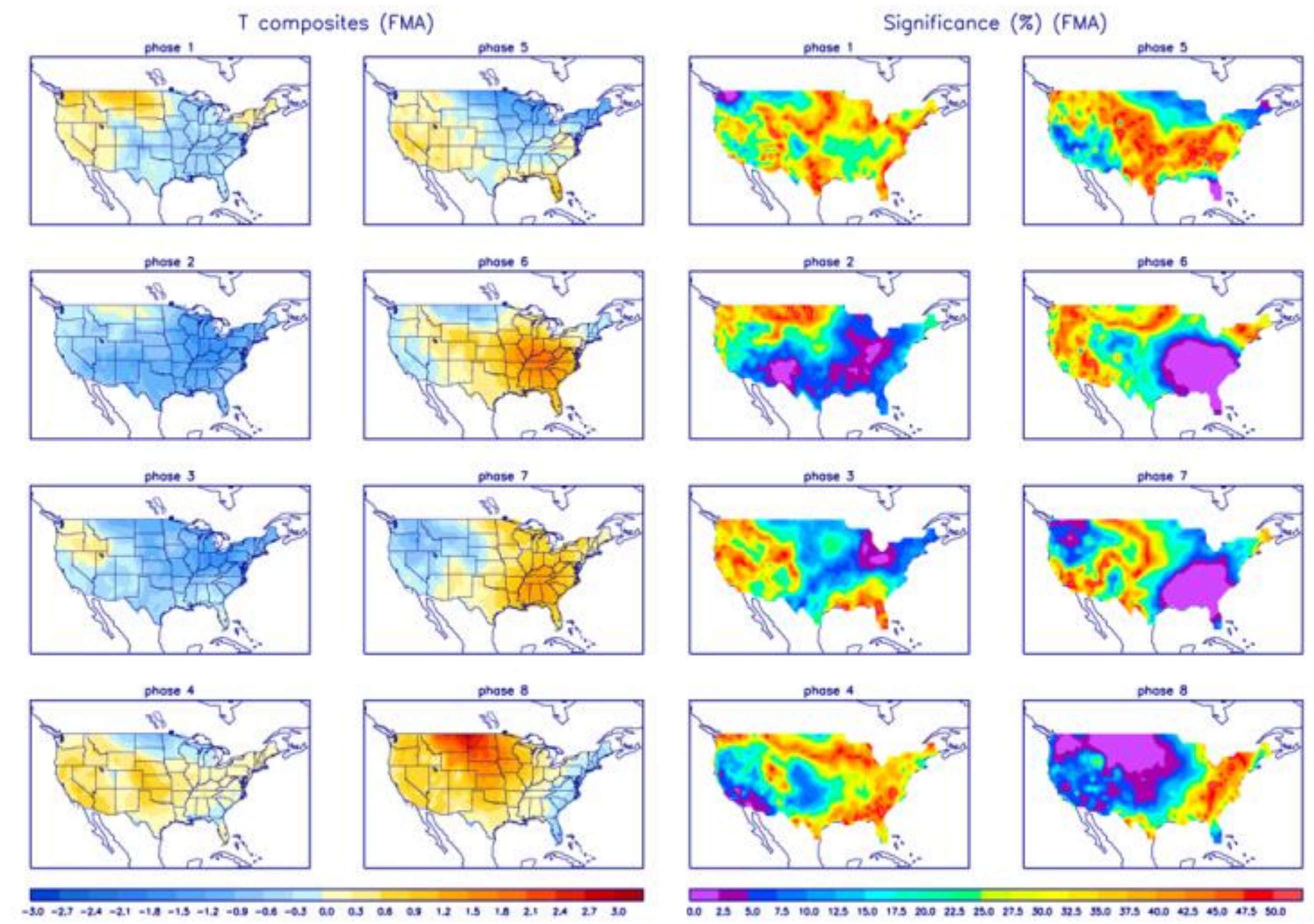
Precipitation Anomalies (Nov-Mar)



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.



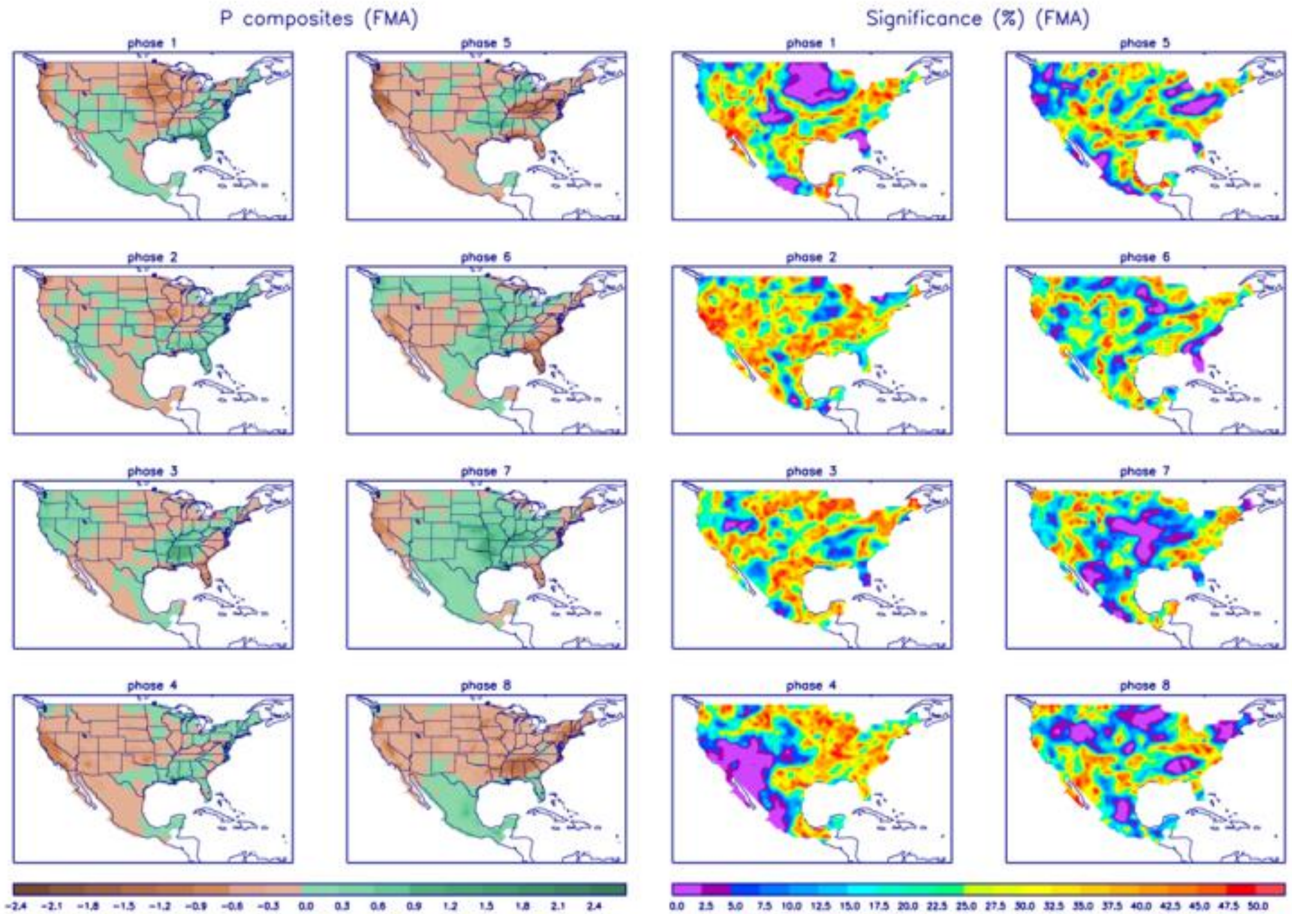
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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