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

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Overview

The MJO remained active, with the enhanced phase currently over the Maritime Continent. The intraseasonal signal is destructively interfering with the ENSO background state.

Several dynamical model MJO index forecasts weaken the MJO signal substantially over the next two weeks, while others depict continued eastward propagation of a weaker signal. Statistical tools favor some additional eastward propagation of the MJO.

Destructive interference between the intraseasonal signal and the ENSO background state is likely to continue during the next week. Any remnant MJO signal will begin to constructively interfere with the El Niño signal towards the end of Week-2.

The MJO may contribute to enhanced convection across the equatorial West Pacific during the period, which is out of phase with climate anomalies associated with El Niño.

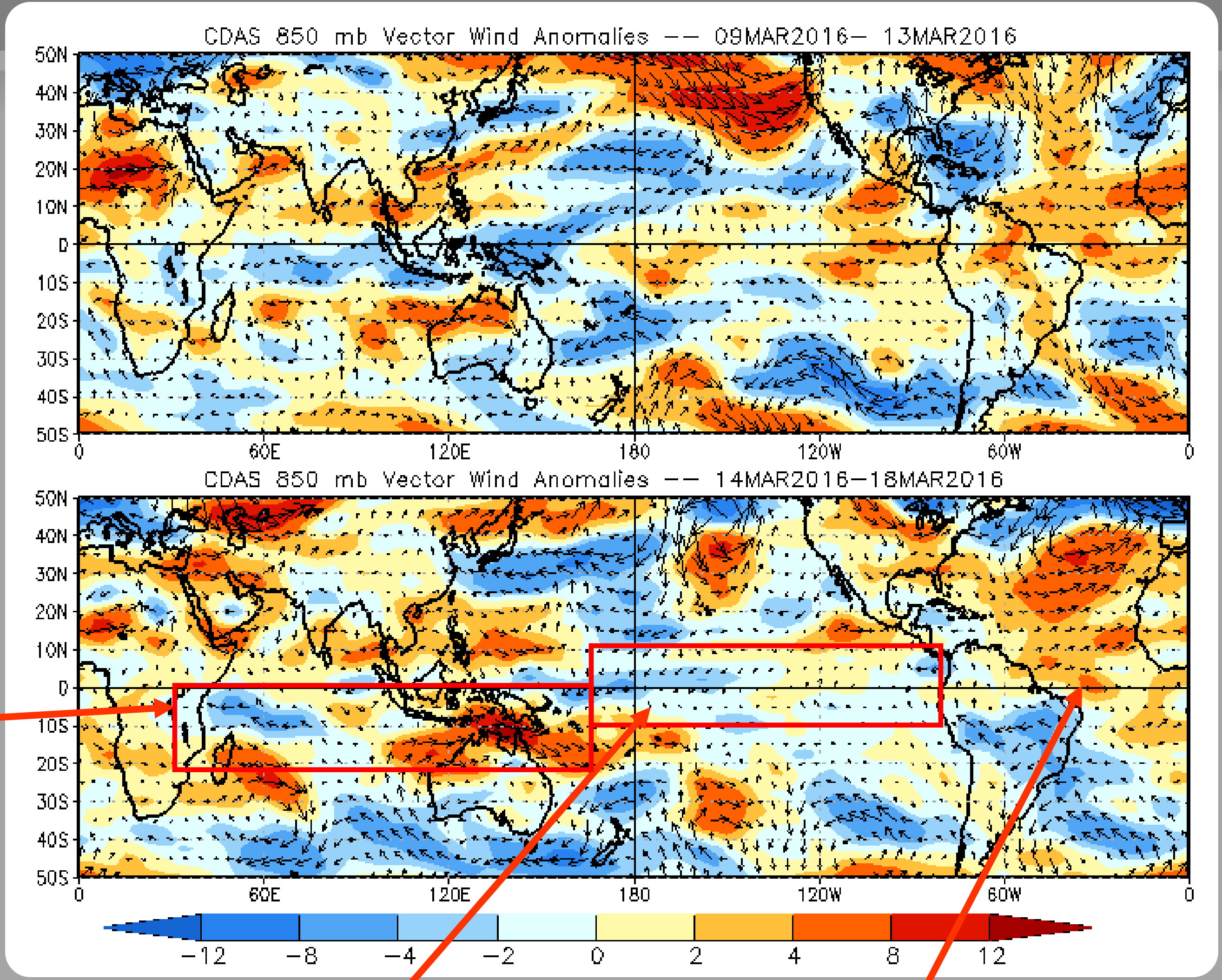
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



The anomaly pattern was incoherent over the Indian Ocean, while westerly anomalies strengthened over the southern Maritime Continent.

Easterly anomalies propagated east of the Date Line. The low-level wind anomaly field was weak across the remainder of the Pacific basin as the intraseasonal signal interfered with the weakening El Niño.

Westerly anomalies persisted over the tropical Atlantic.

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

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

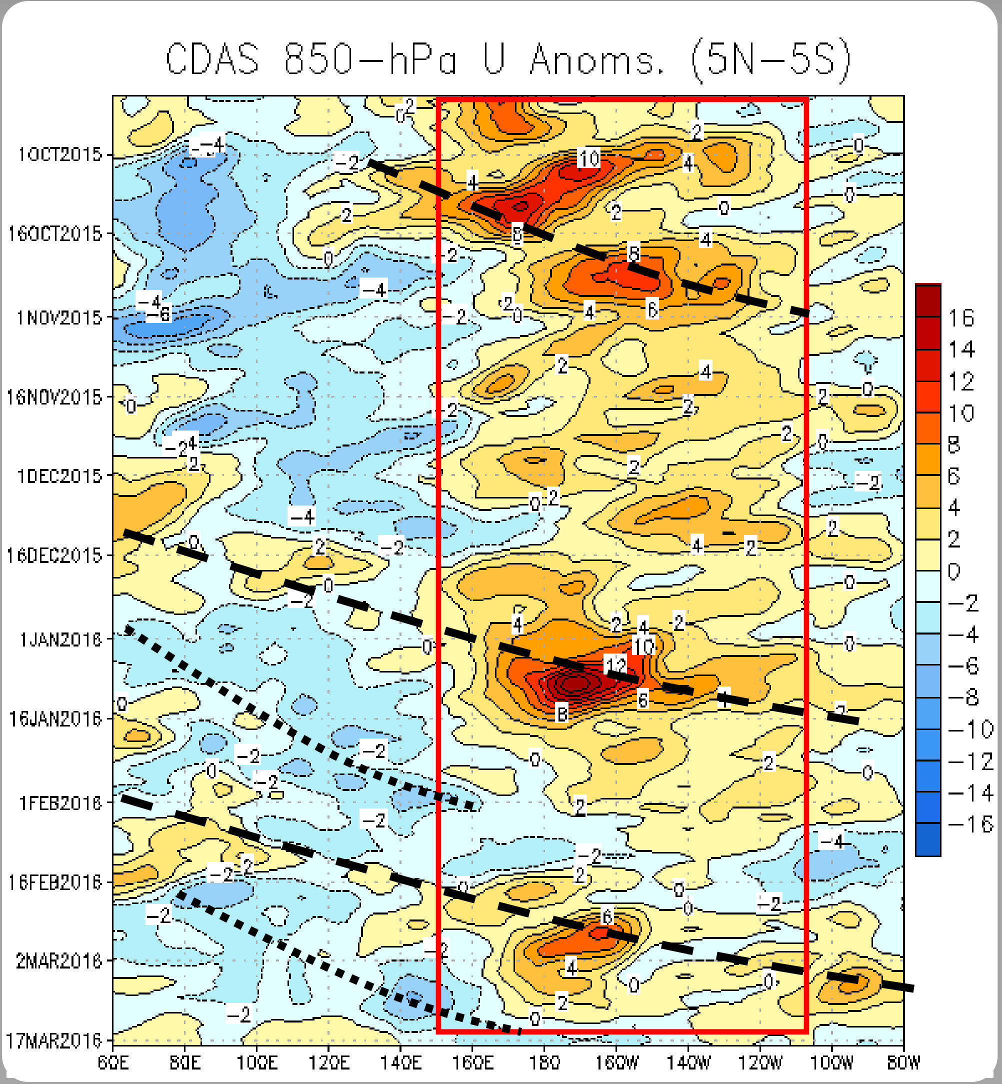
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

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.

More recently, destructive interference with the intraseasonal signal resulted in a weakening of the El Niño climate anomalies.



OLR Anomalies – Past 30 days

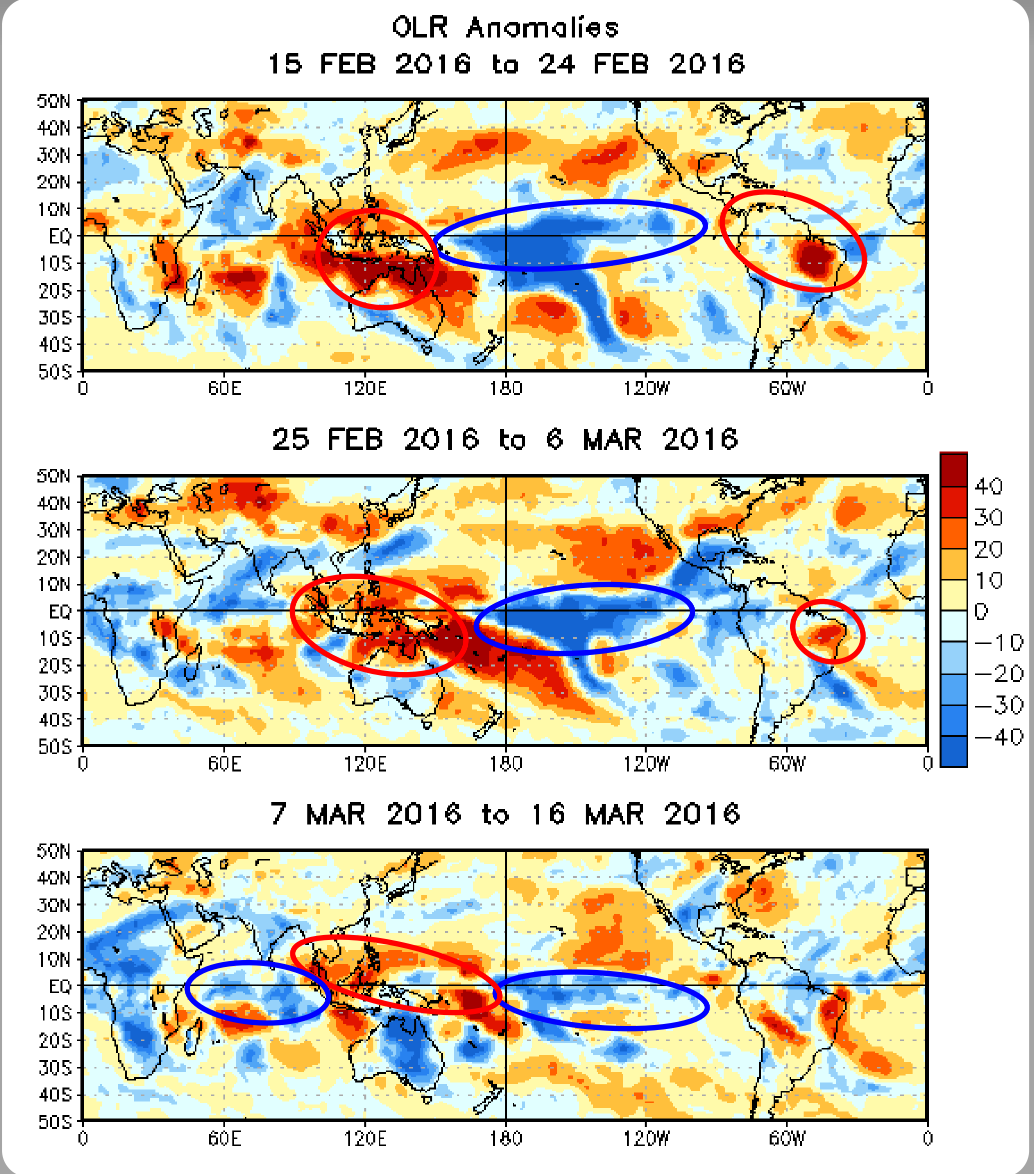
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

The pattern of anomalous convection was consistent with ENSO during mid-February as the enhanced phase of the MJO constructively interfered with the base state.

During late February and early March, constructive interference between the MJO and ENSO signals continued, with an eastward shift in the enhanced (suppressed) convective anomalies to the Western Hemisphere (west Pacific).

As the intraseasonal signal propagated to the Indian Ocean, convective anomalies began to weaken due to destructive interference with the El Niño background state.



Outgoing Longwave Radiation (OLR) Anomalies (17.5°S-2.5S)

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

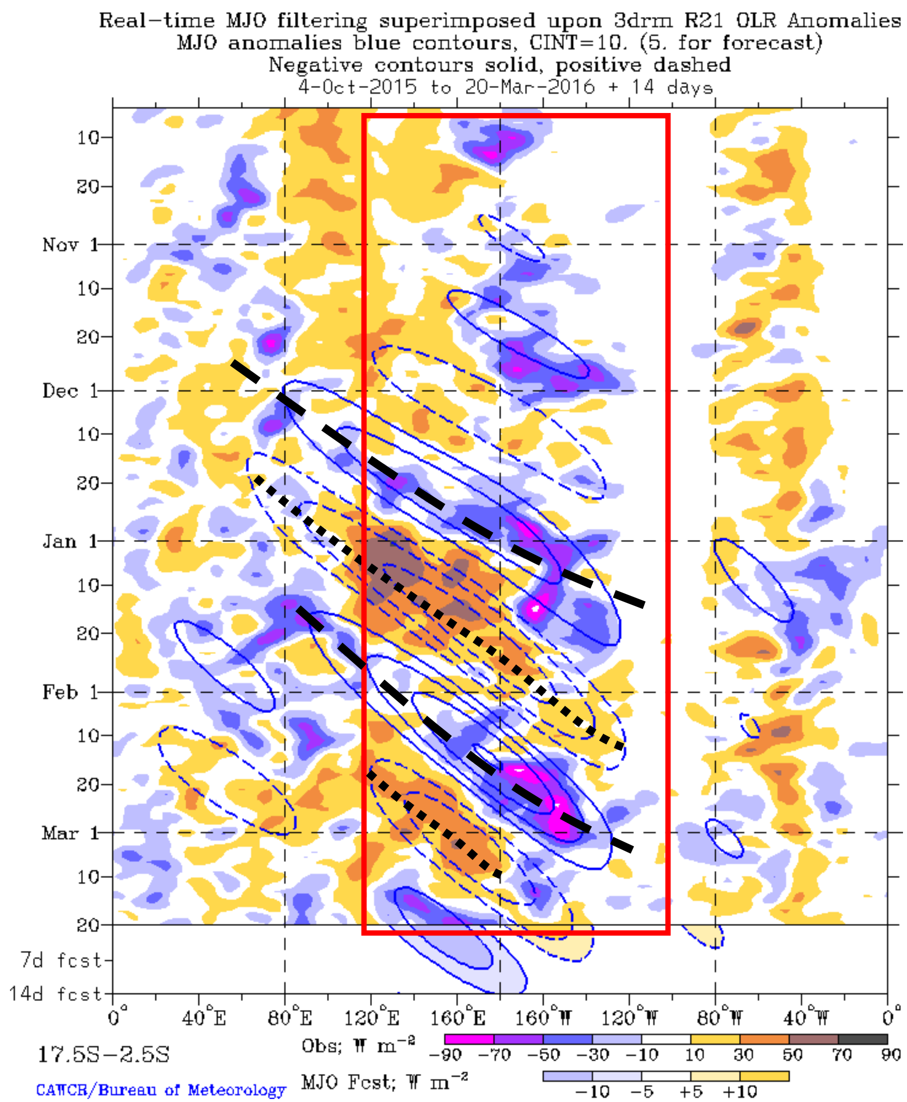
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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, 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 destructively interfered with the ENSO base state, resulting in a weak convective pattern over the Pacific, and enhanced convection over the northern Australia.



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

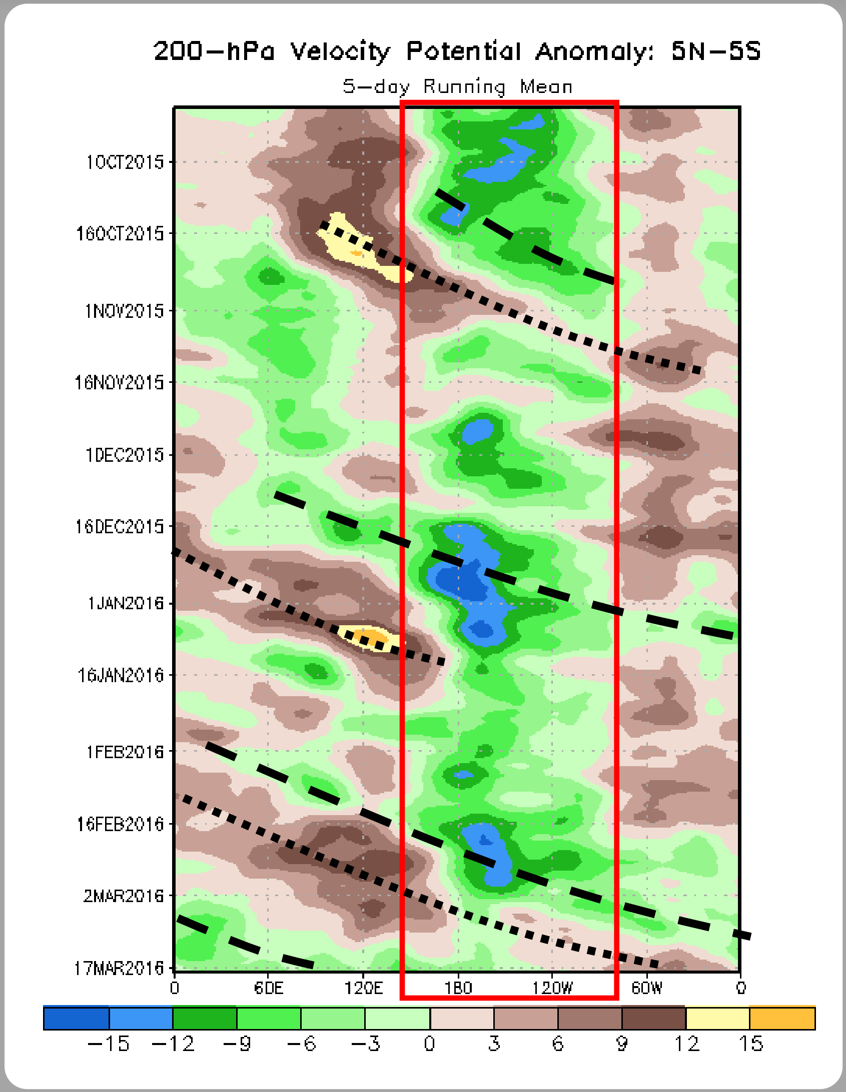
The ongoing ENSO state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

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

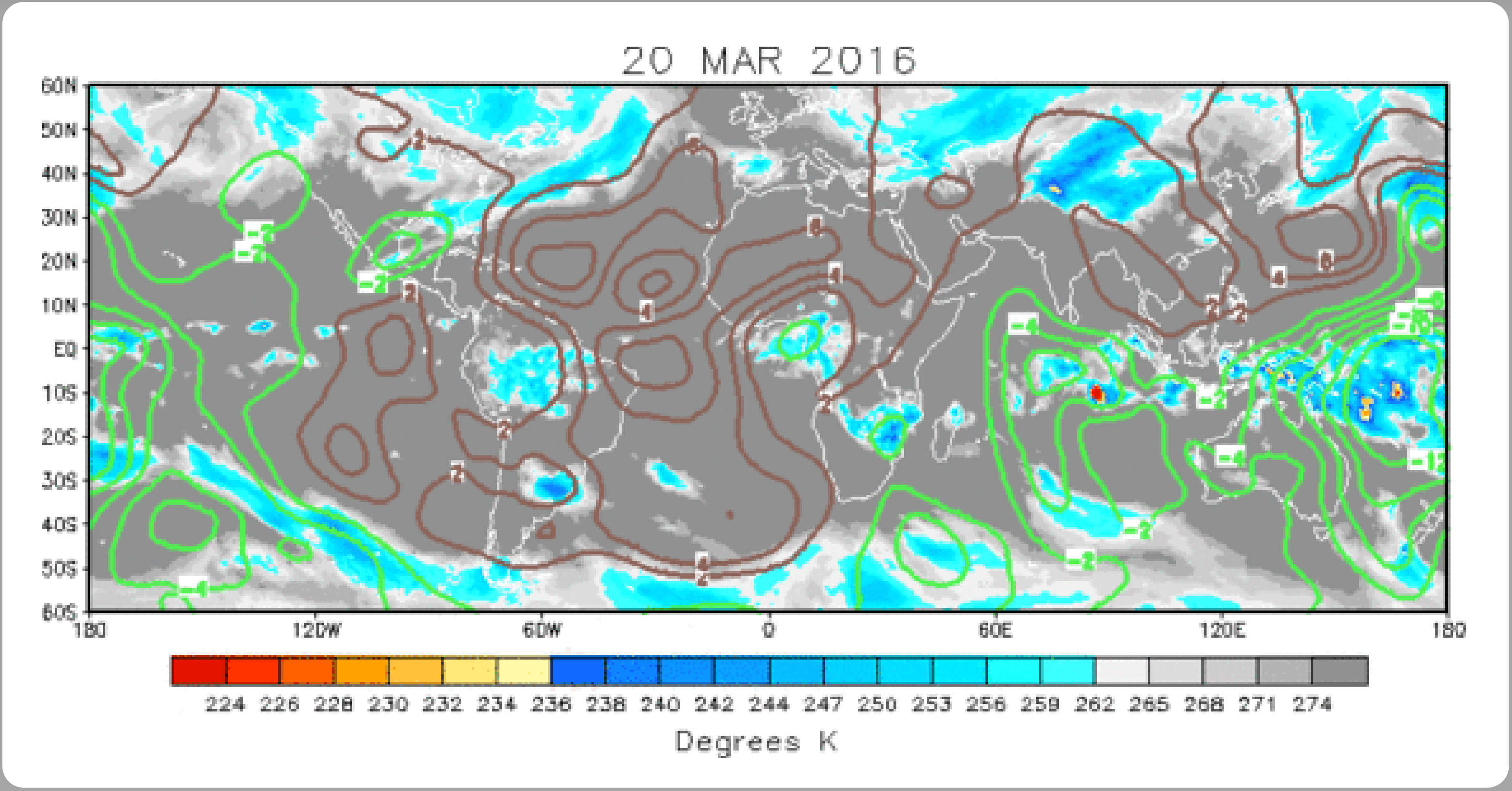
During late October, there was an eastward shift in the pattern. Renewed MJO activity was also observed during December and early January, yielding a robust signal in the upper levels. This signal weakened during mid-January.

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

During mid-March, the intraseasonal variability destructively interfered with the ENSO signal.



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



The large scale upper-level velocity potential anomaly pattern exhibits a coherent Wave-1 structure, with large scale anomalous ascent extending from the Indian Ocean to the central Pacific, and anomalous descent over the 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)

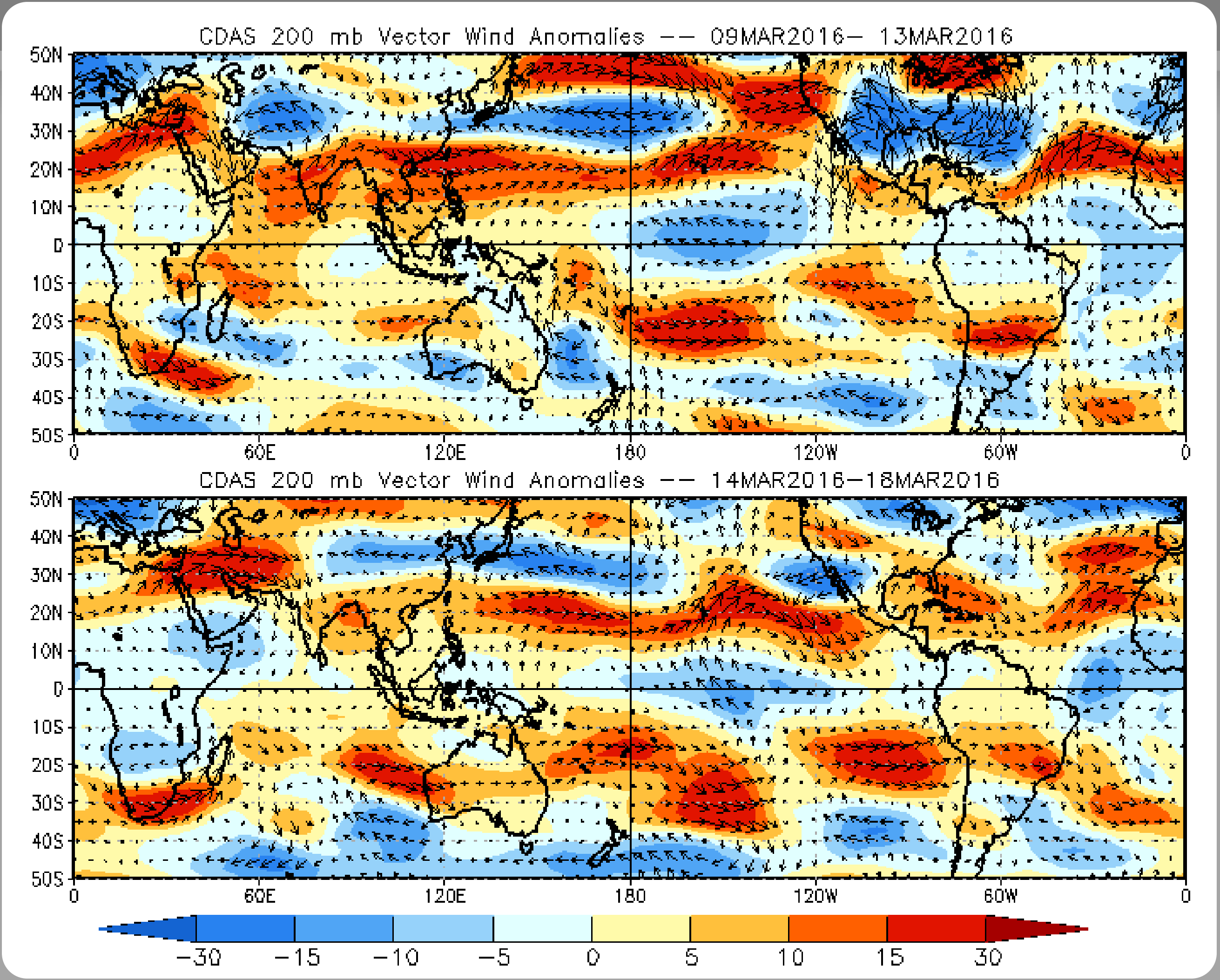
Note that shading denotes the zonal wind anomaly

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

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

Easterly (westerly) anomalies persisted over the eastern and central Pacific (Indian Ocean).

Despite the destructive interference with the intraseasonal signal, the ENSO atmospheric response remains robust, with a large subtropical high over the eastern Pacific, albeit displaced southward.



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

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

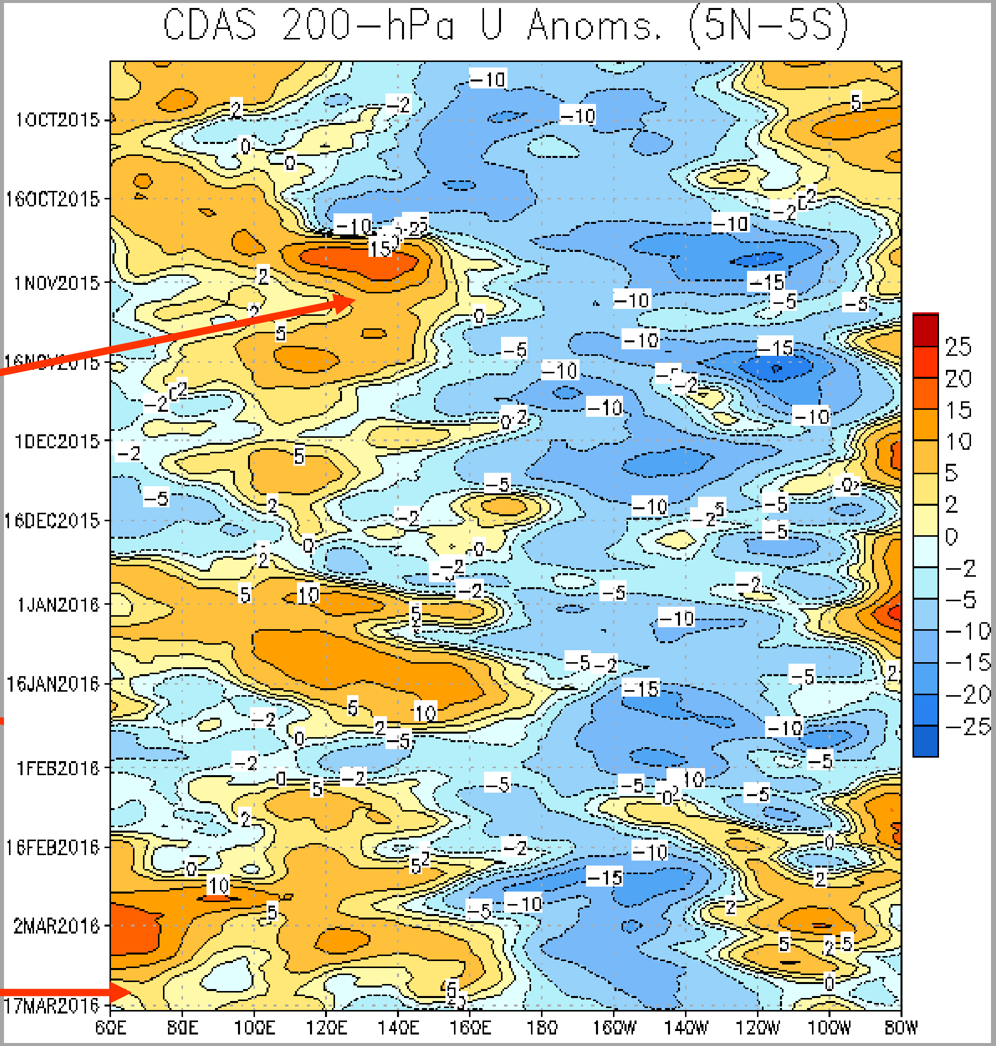
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.



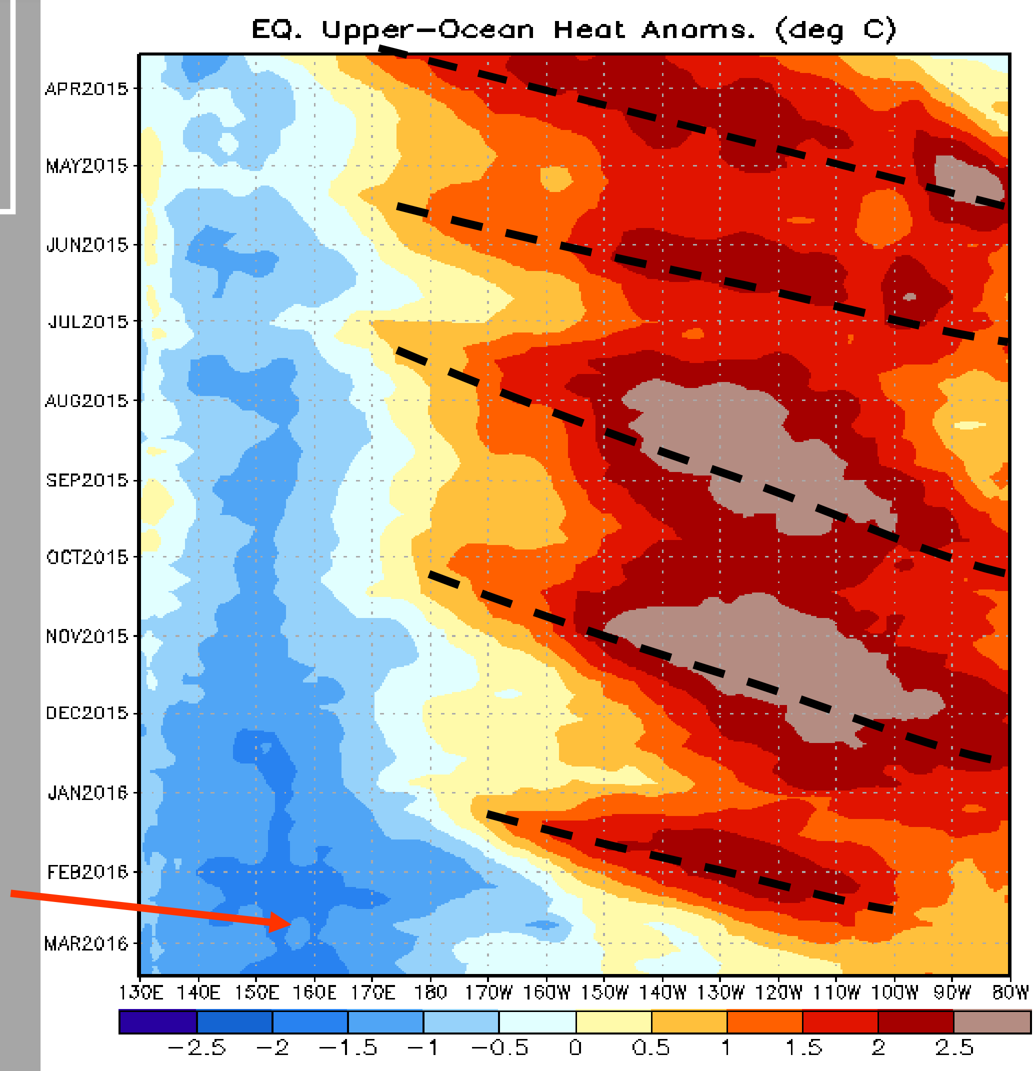
Weekly Heat Content Evolution in the Equatorial Pacific

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, while anomalous warmth weakened over the 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

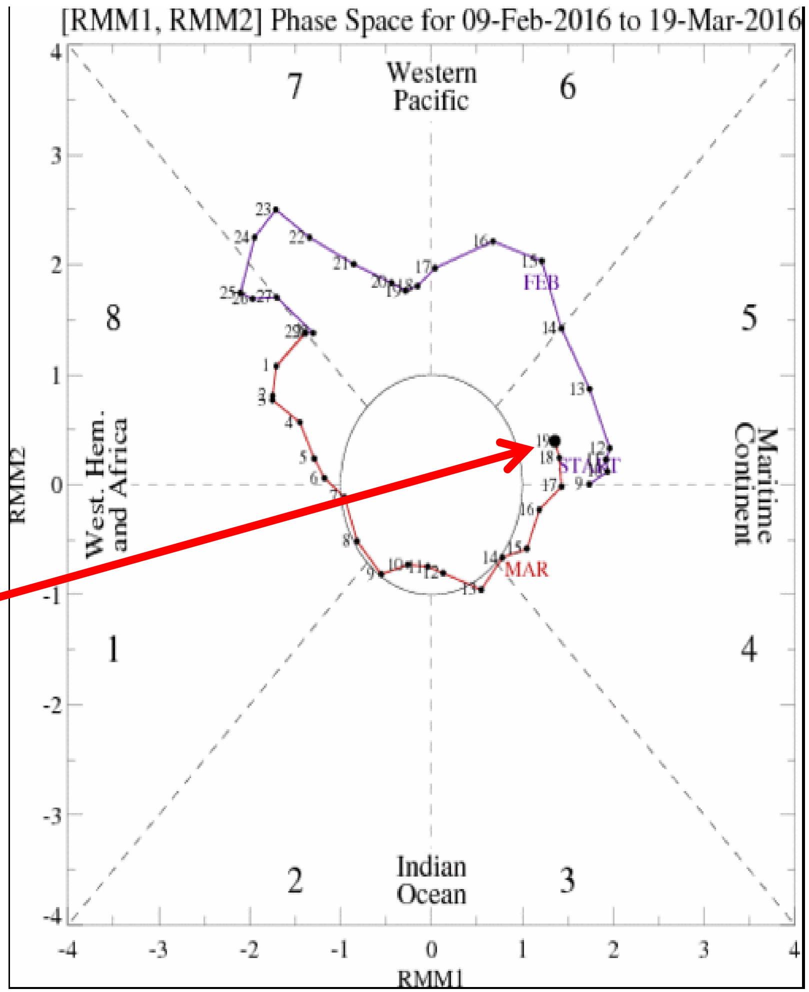
The triangular areas indicate the location of the enhanced phase of the MJO

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

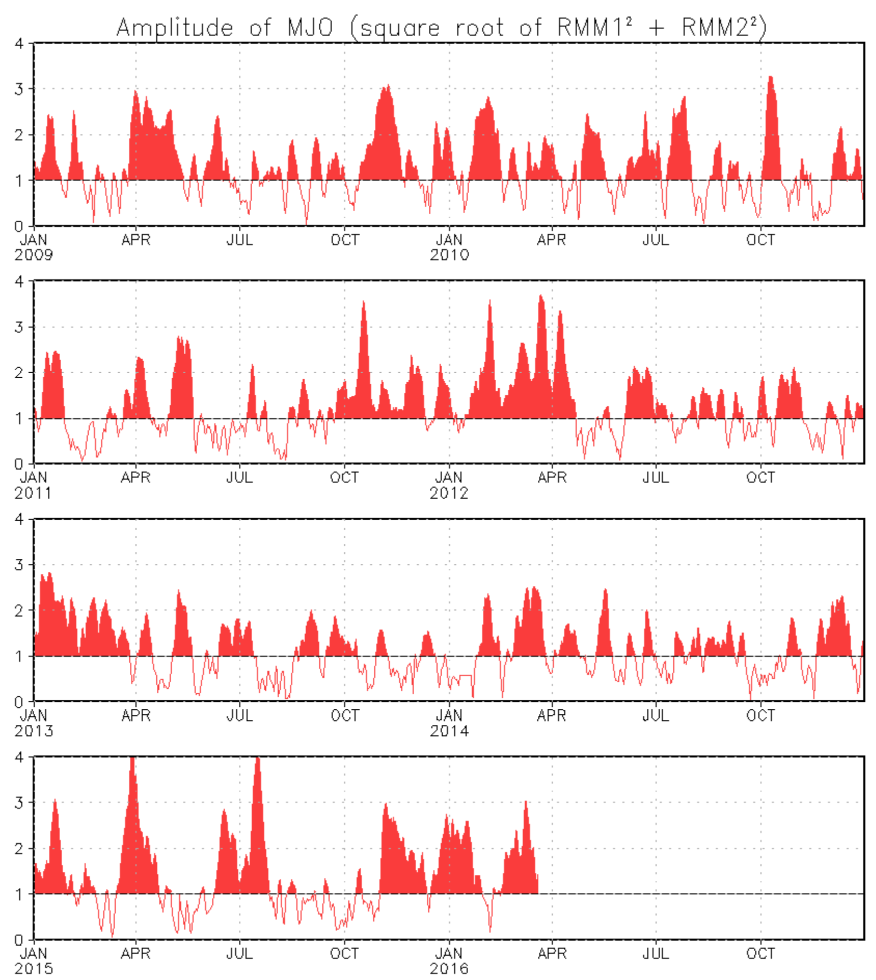
The MJO index depicts fast propagation over the Maritime Continent.



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

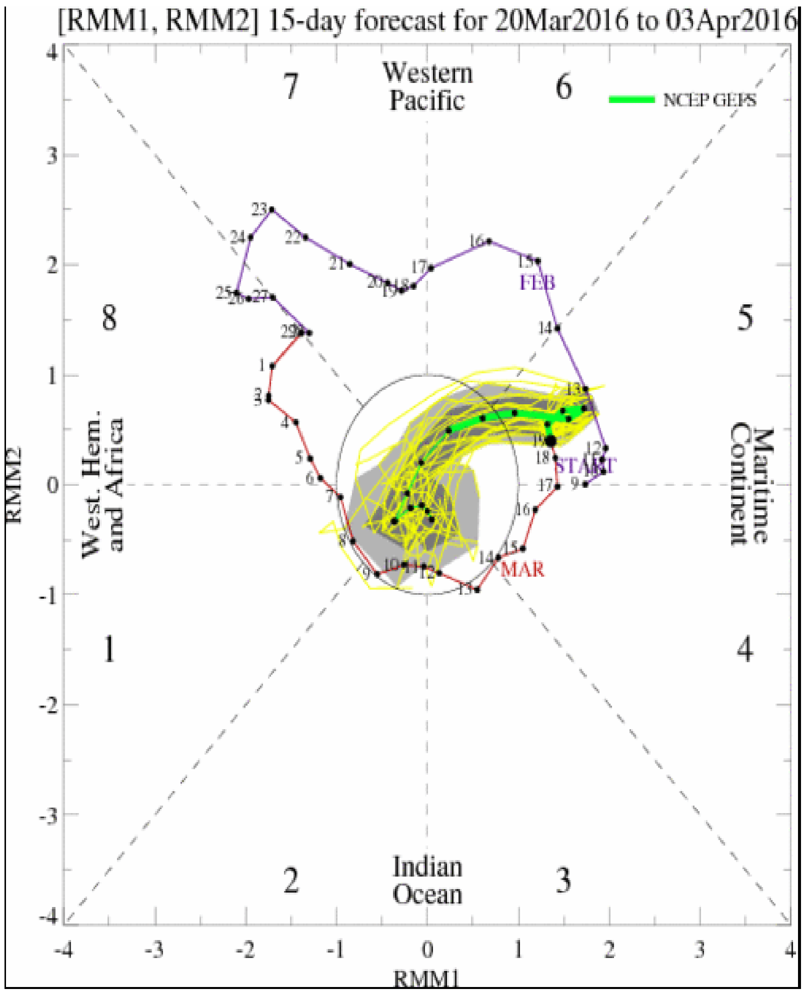
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

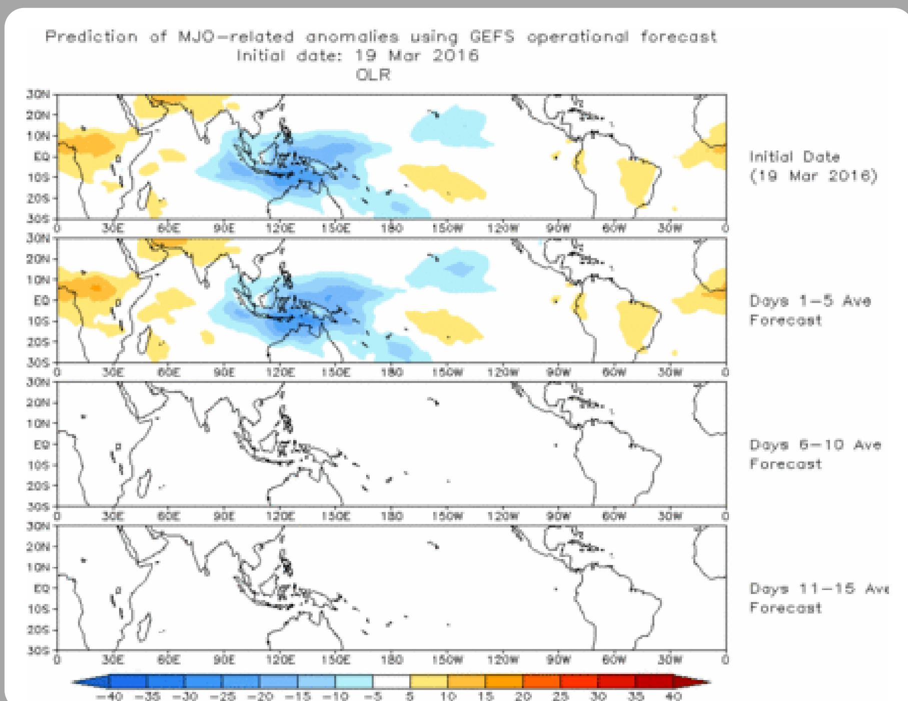
The GFS ensemble MJO index forecast depicts a rapid weakening of the MJO signal over the next two weeks.



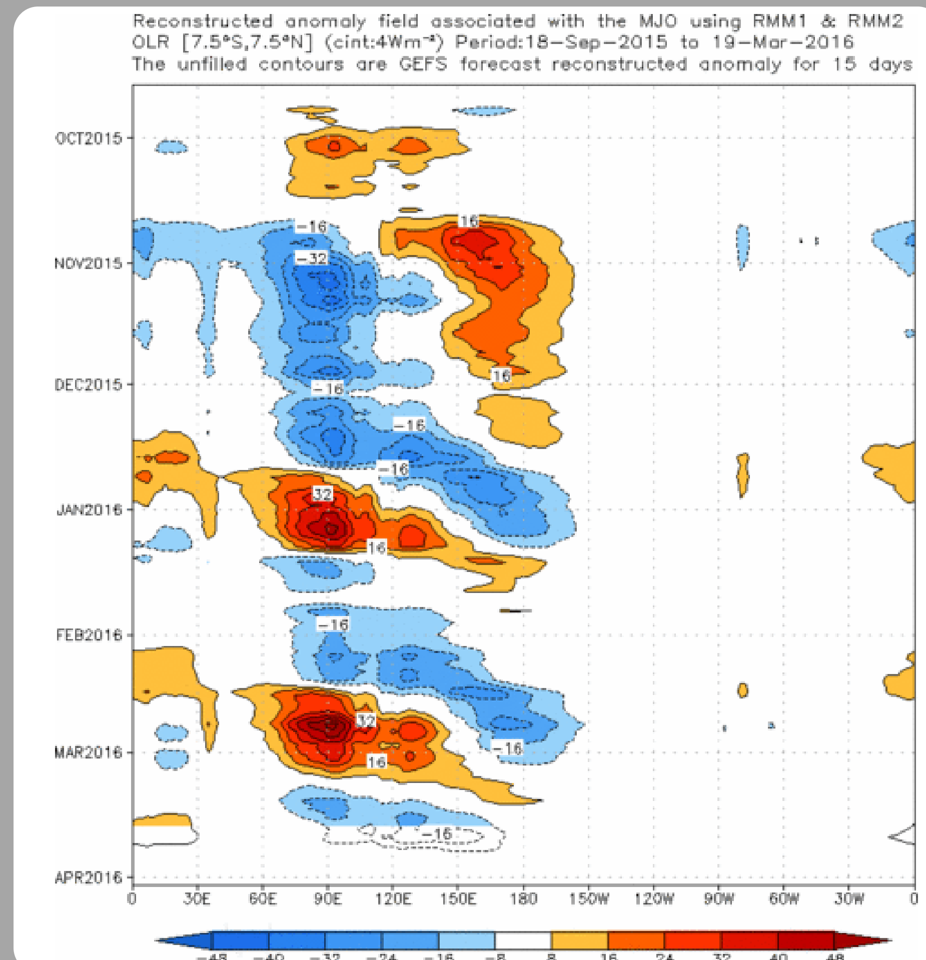
Ensemble GFS (GEFS) MJO Forecast

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

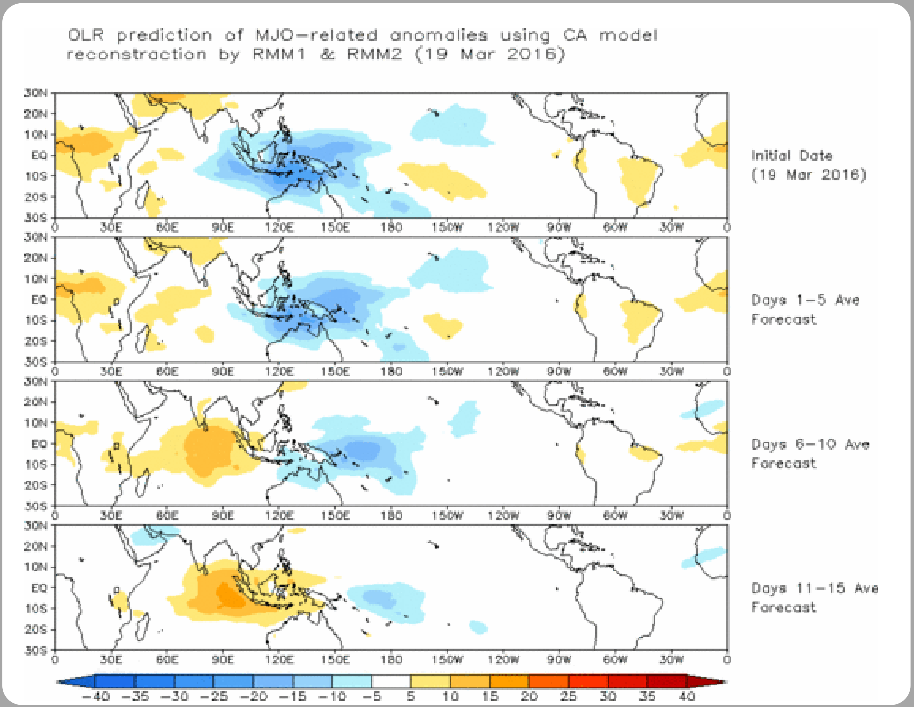


The GEFS OLR forecast depicts rapid weakening of the MJO-based convective anomalies during the next two weeks.

Constructed Analog (CA) MJO Forecast

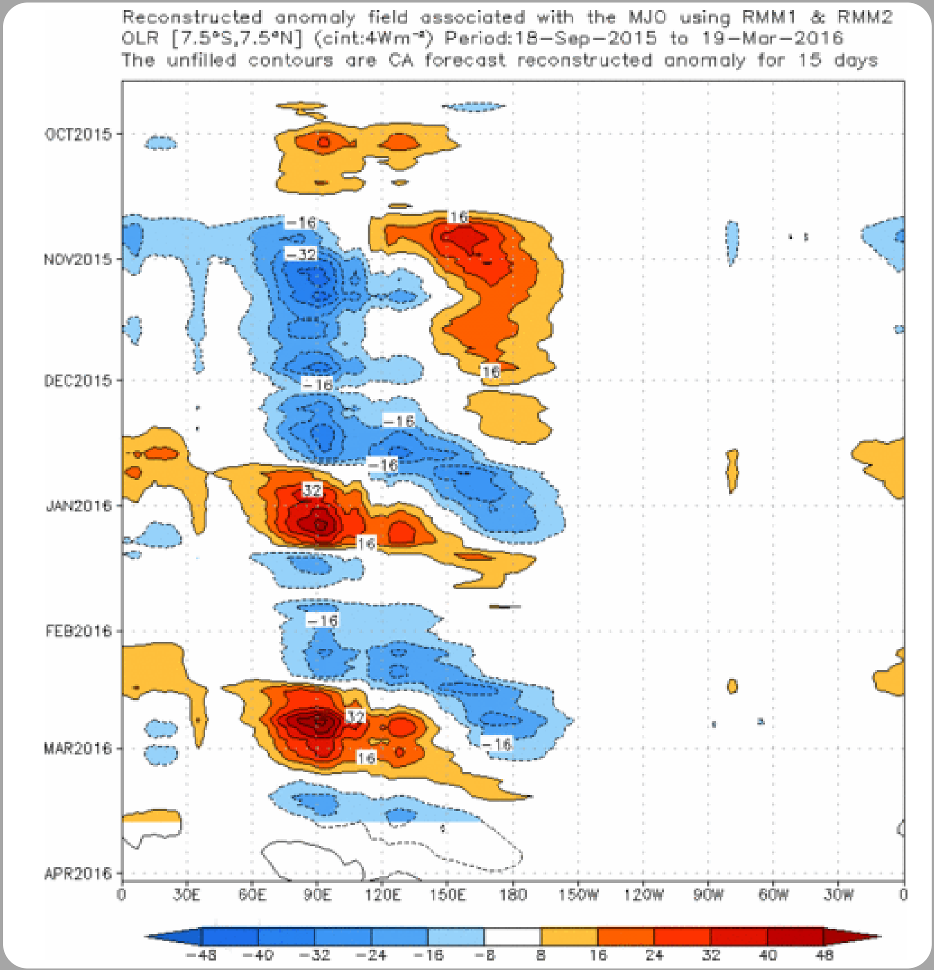
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



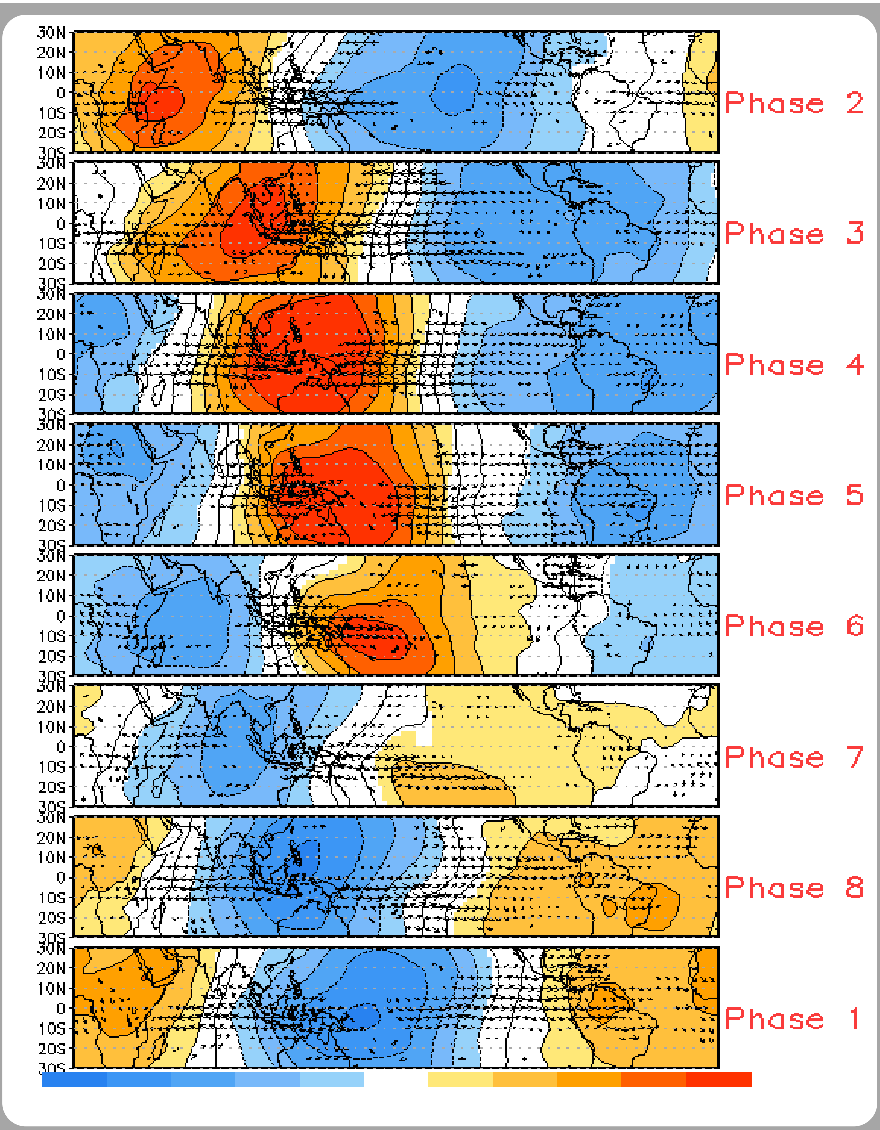
The constructed analog model depicts continued eastward propagation of the MJO signal.

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

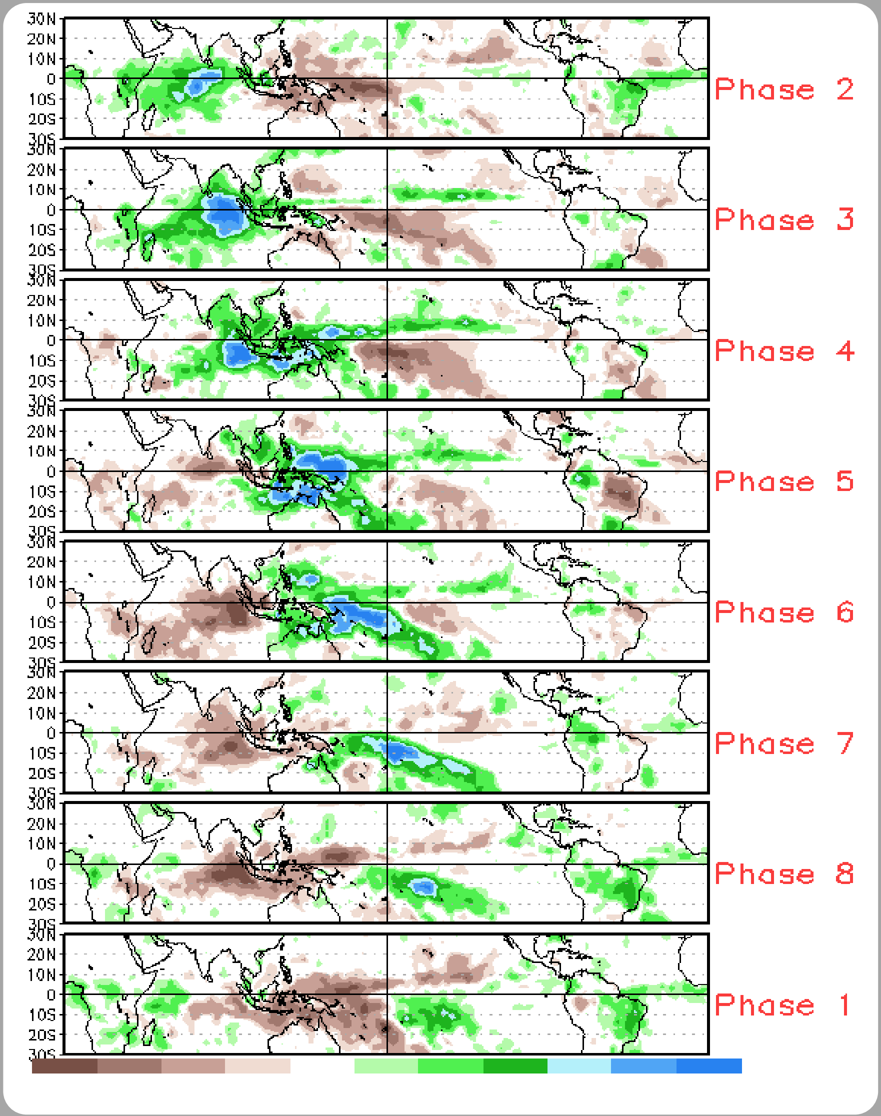


MJO Composites - Global Tropics

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



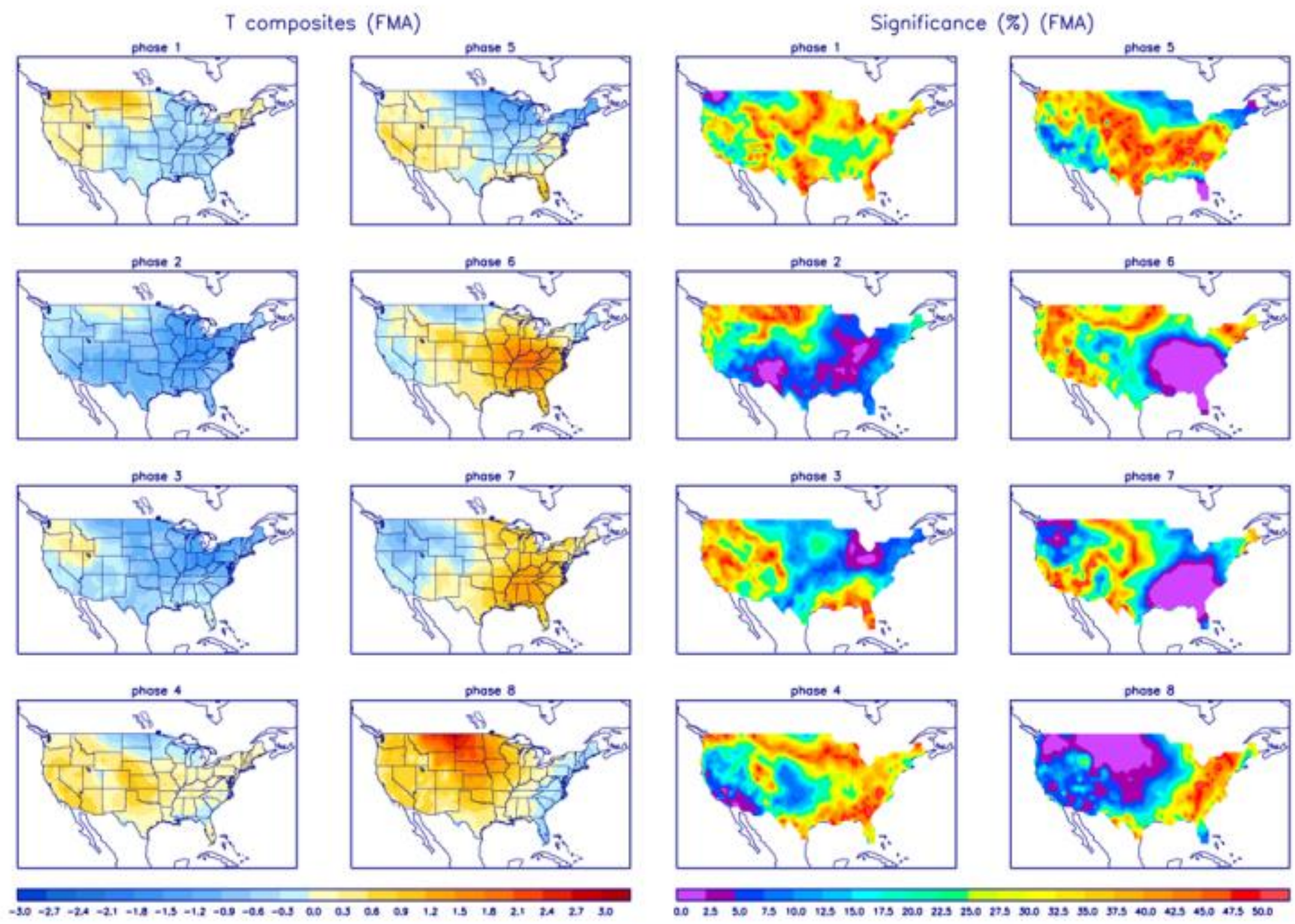
Precipitation Anomalies (Nov-Mar)



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.



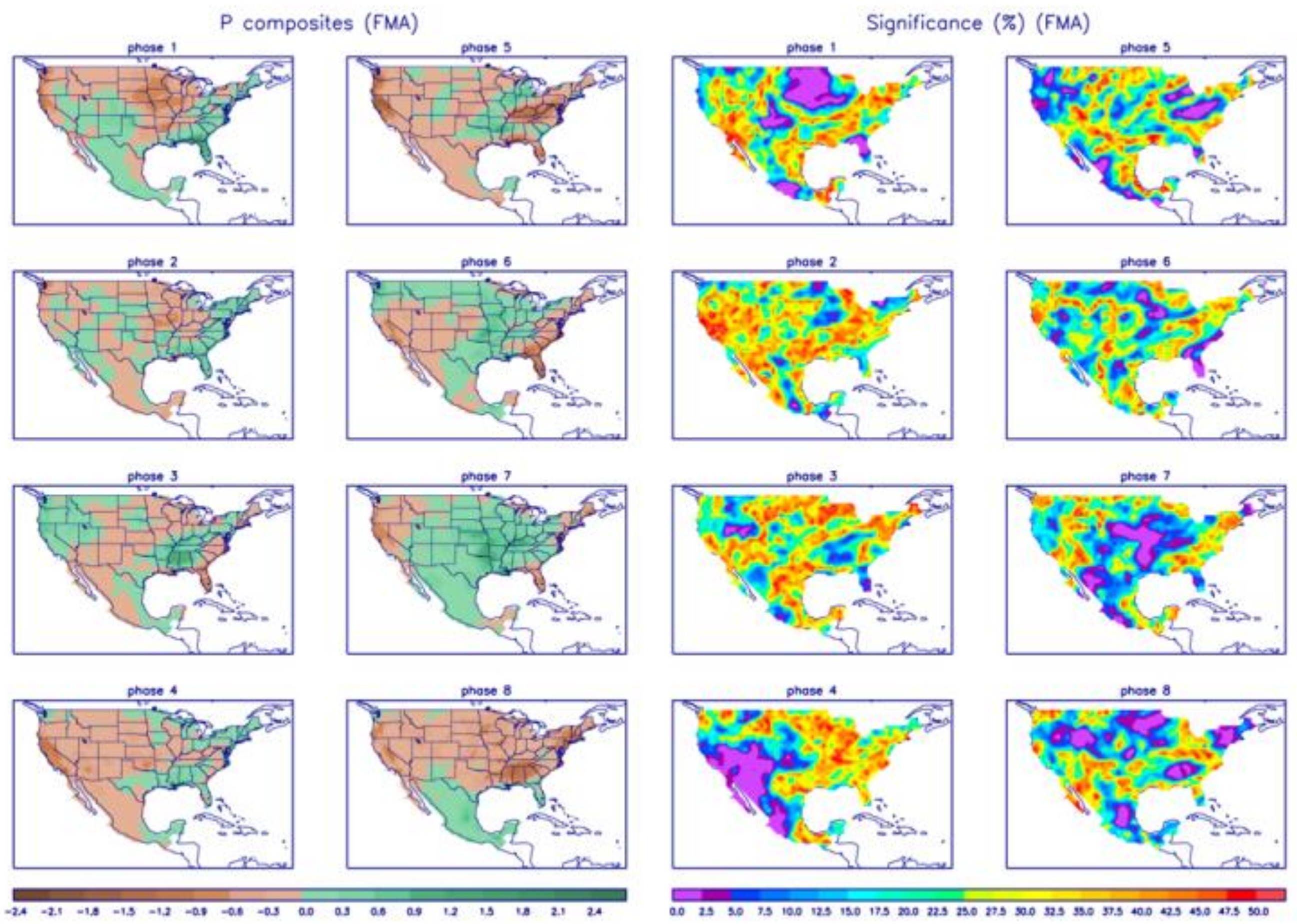
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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