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

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Climate Prediction Center / NCEP
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Overview

The MJO has continued to become more organized based on various analysis tools, and the enhanced phase is centered over the far eastern Maritime Continent and West Pacific.

Dynamical model forecasts of the RMM based MJO index generally support eastward propagation of a coherent signal across the Pacific basin. These tools also indicate interference with westward-moving variability during the next two weeks.

Destructive interference between the intraseasonal signal and the ENSO background state reduces forecast confidence of convective anomalies early in the period.

The ongoing and forecast MJO activity could impact the extratropical circulation during Weeks 2-4, favoring anomalous troughing (ridging) across eastern North America (northwestern North America).

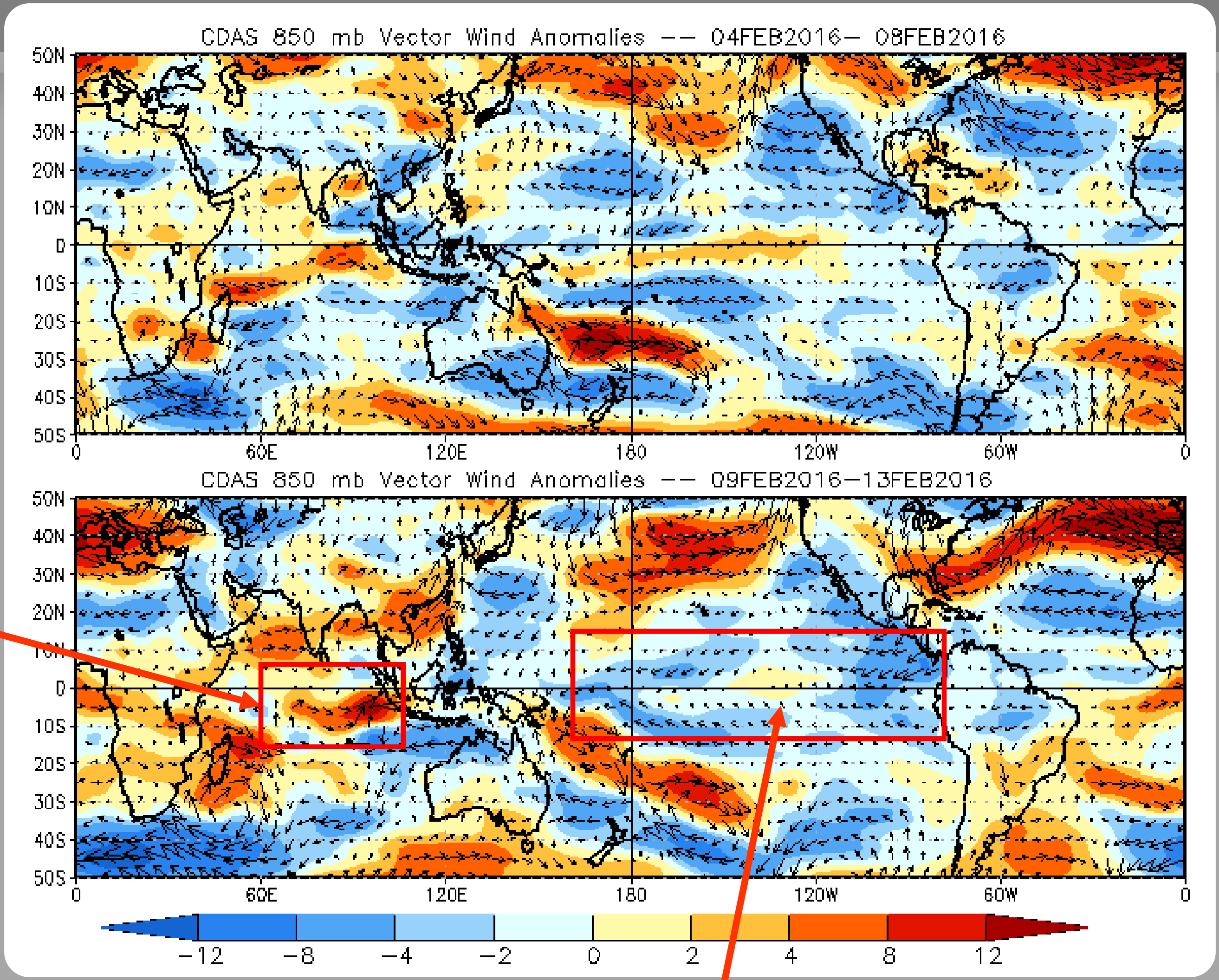
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies intensified somewhat over the Indian Ocean, partly due to tropical cyclone activity south of the equator.

Westerly anomalies weakened over the eastern Pacific and were replaced by easterly anomalies over much of the region.

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

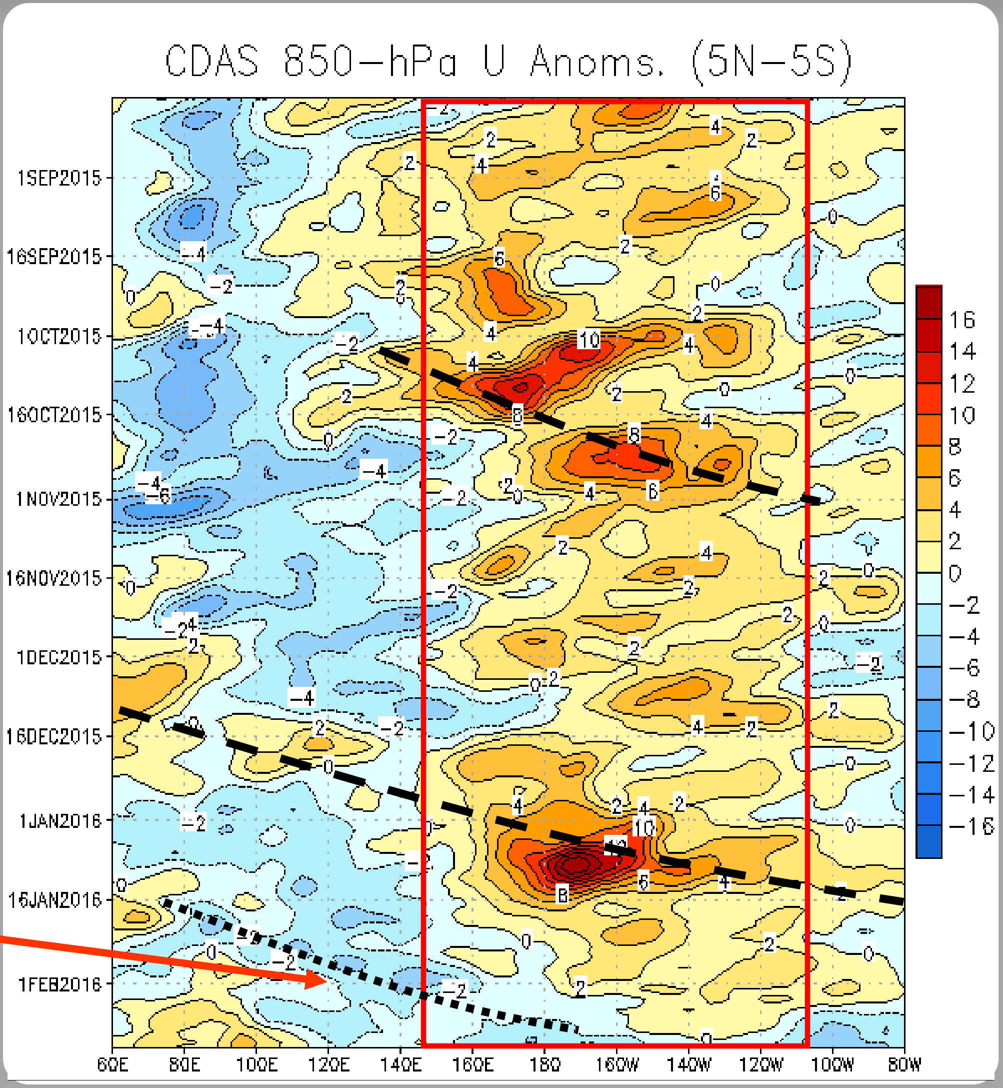
The red box highlights the persistent low-frequency westerly wind anomalies associated with ENSO.

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

Renewed MJO activity during December produced an eastward propagation of westerly anomalies from the Indian Ocean.

During early January, a strong westerly wind burst near the Date Line was related to constructive interference with the ongoing El Niño.

The intraseasonal signal is imparting an eastward shift in the pattern of low-level wind anomalies, destructively interfering with the background state..



OLR Anomalies - Past 30 days

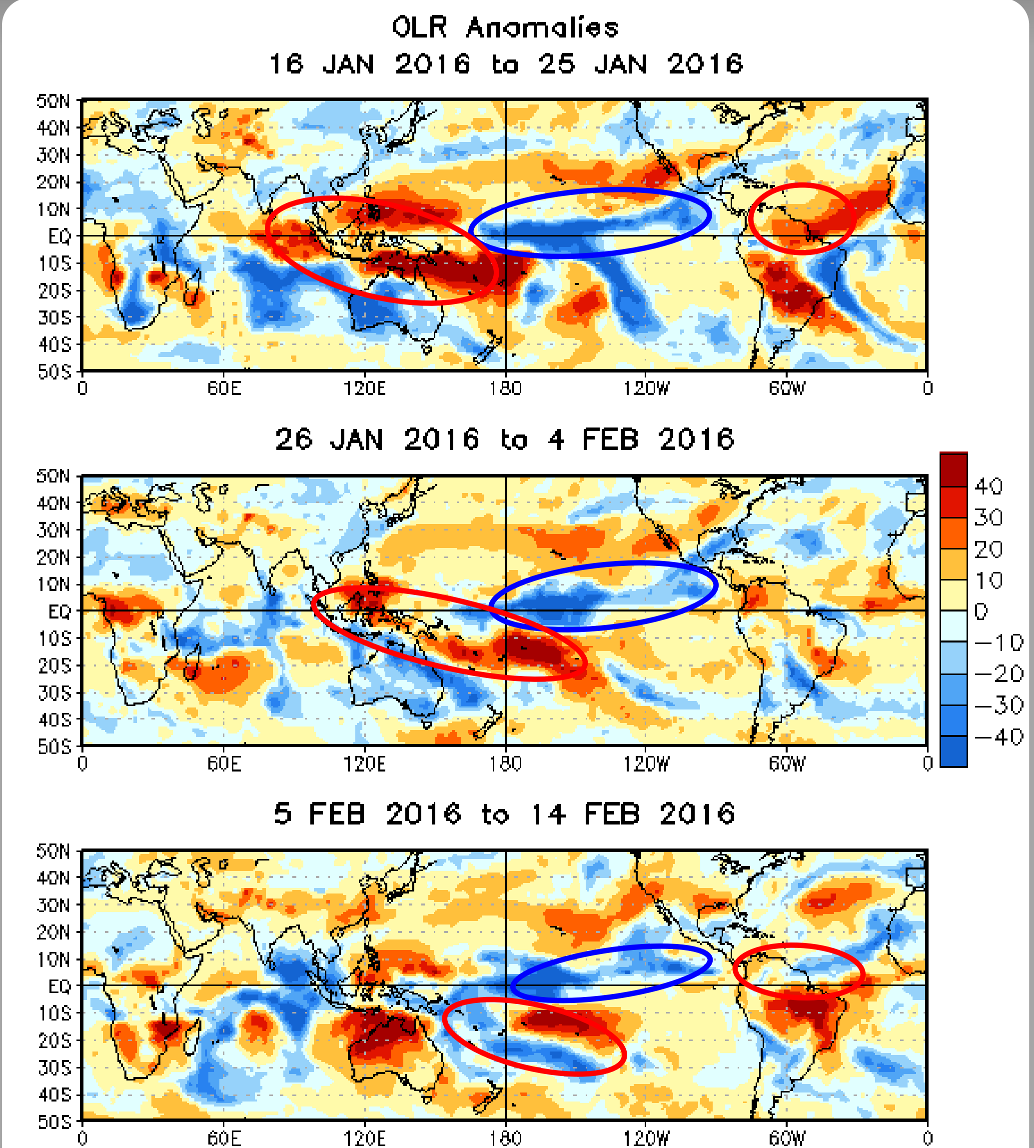
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid-January, suppressed convection continued over the Maritime Continent and enhanced convection intensified over the Pacific, largely related to the ongoing the El Niño.

By late January and early February, the pattern of tropical convection was largely consistent with ENSO.

During early to mid-February, some destructive interference is observed, with enhanced convection spanning from the eastern Indian Ocean to the central Pacific. The intraseasonal variability competing with ENSO over the Maritime Continent led to a mixed signal there.



Outgoing Longwave Radiation (OLR) Anomalies (5ºN-5ºS)

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

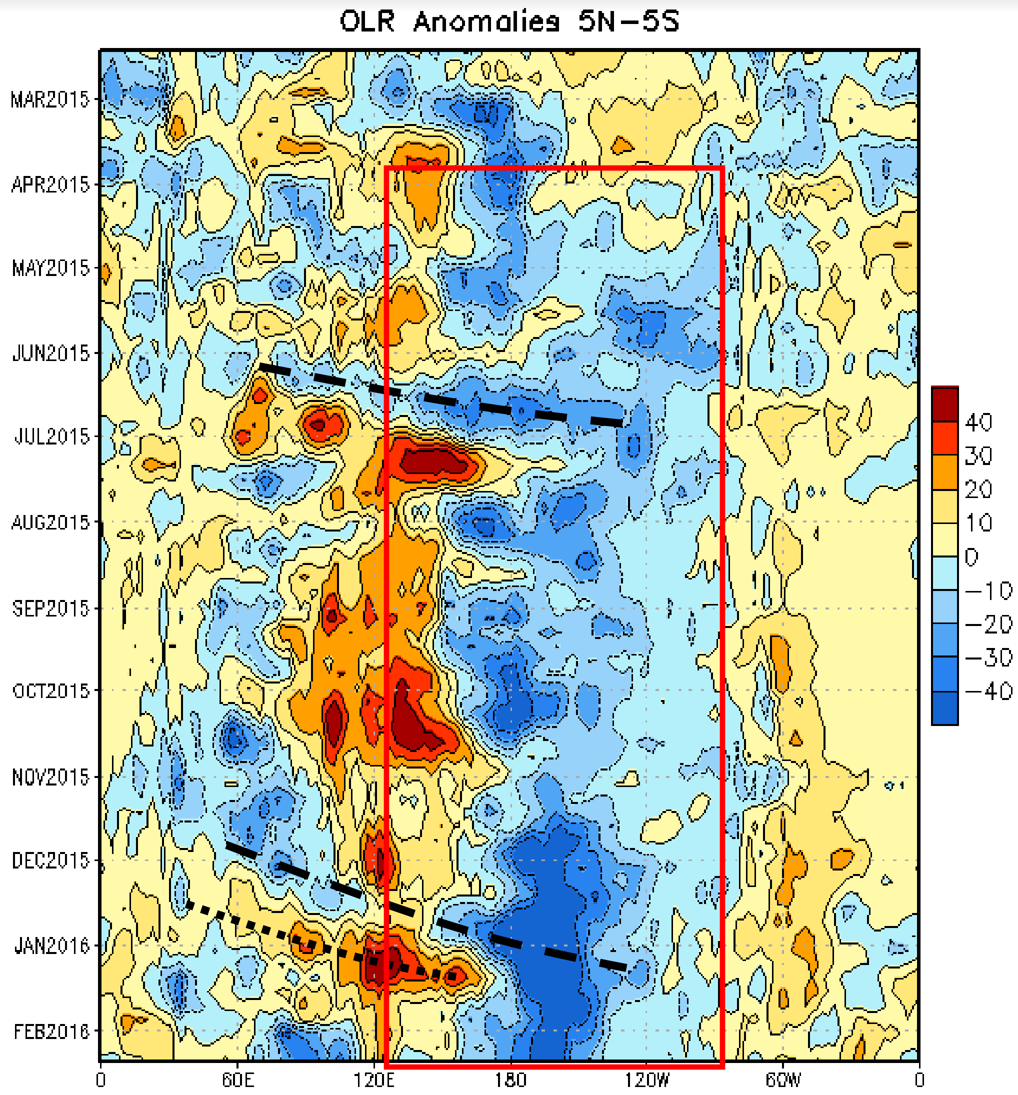
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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 June and early July, the MJO became active, interfering with the ENSO signal at times. From August through October, other modes of subseasonal activity did impact tropical convection.

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

During January, some destructive interference was observed, but recently eastward propagation of the MJO signal has nearly overwhelmed the suppressed ENSO signal over the Maritime Continent.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

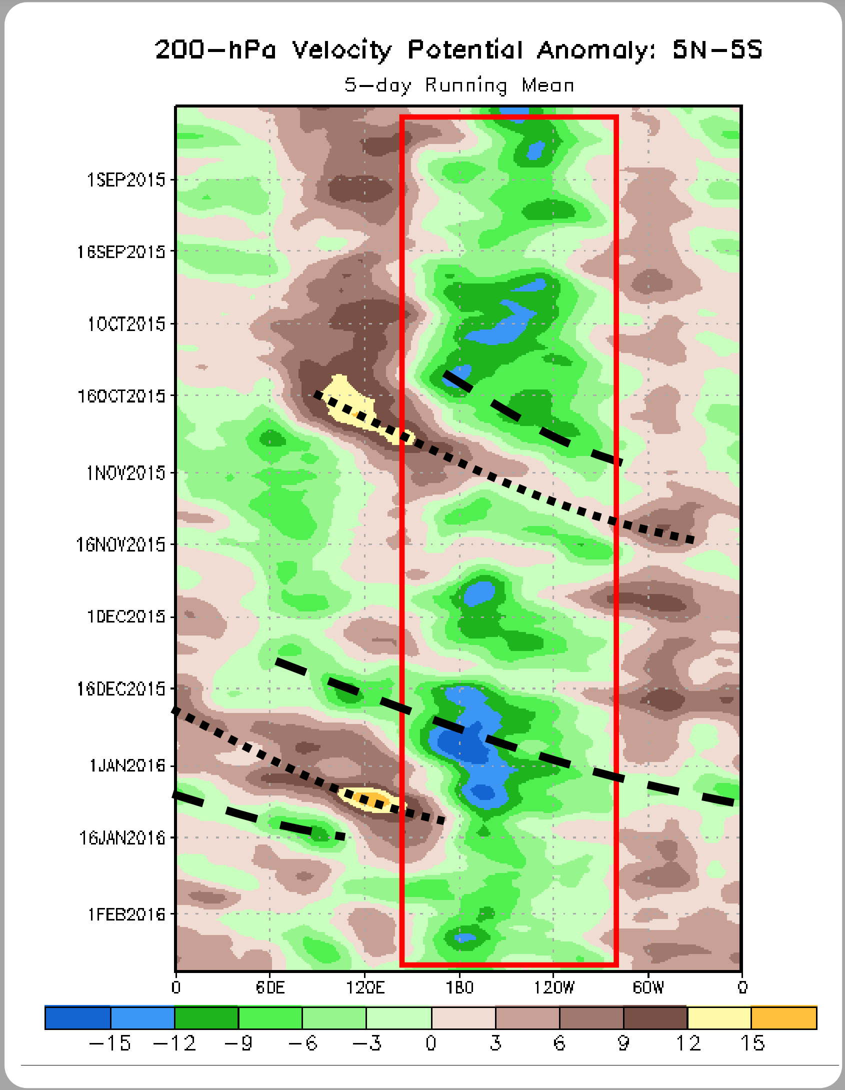
Negative anomalies (green shading) indicate favorable conditions for precipitation

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

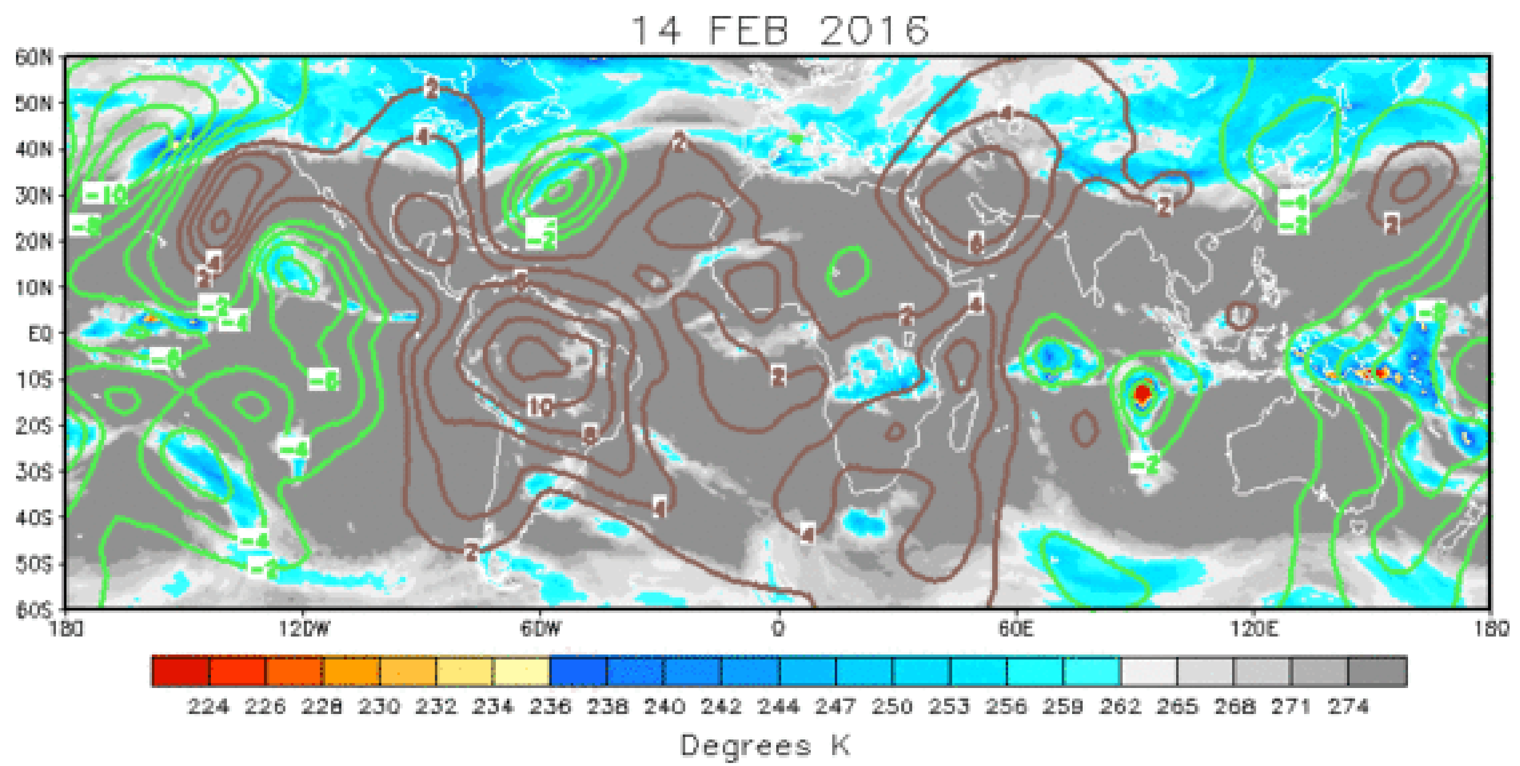
During June and early July, a high-amplitude MJO event was observed, constructively interfering with the El Niño signal in early July.

From July through early October, a generally stationary pattern, reflective of El Niño conditions, was observed. During late October, there was an eastward shift in the pattern.

Renewed MJO activity was observed during December and early January, yielding a robust signal in the upper levels. This signal weakened during mid-January as destructive interference with the El Niño background state increased. Recently, the pattern has begun to take on a wave-1 structure, consistent with coherent MJO activity.



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



The upper-level velocity potential anomalies now depict a wave-1 pattern, consistent with coherent MJO activity. The enhanced phase is centered over the West Pacific and far eastern Maritime Continent.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

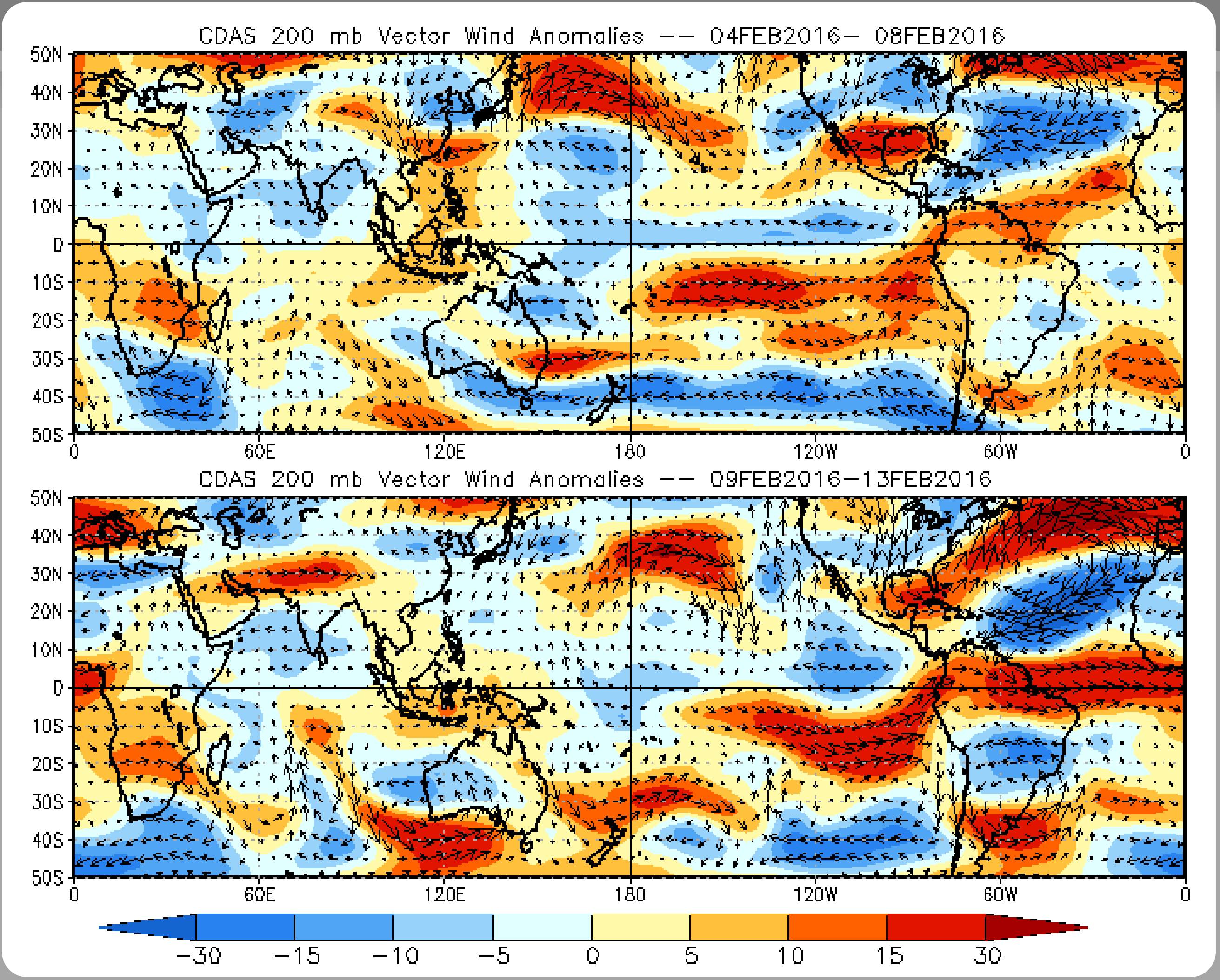
Negative anomalies (green contours) indicate favorable conditions for precipitation

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



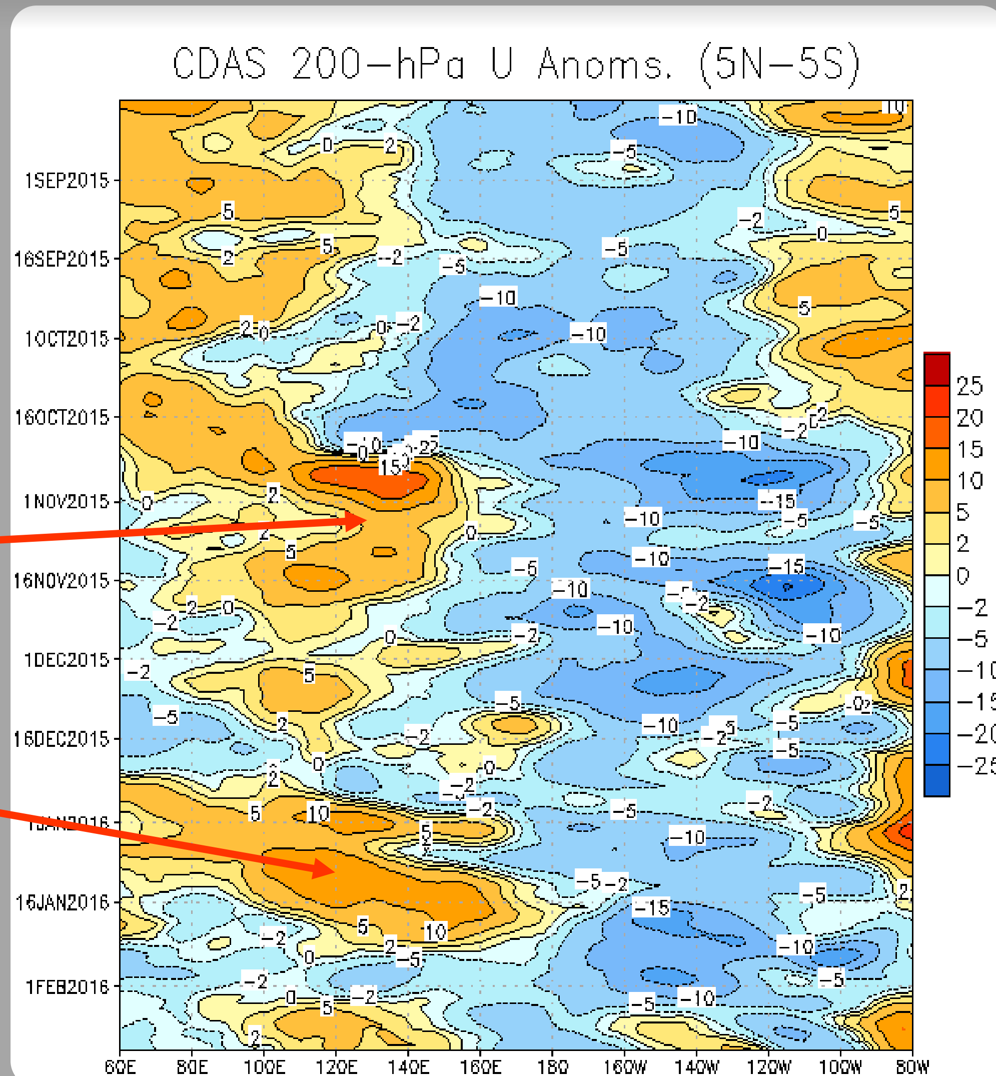
An amplified wave pattern is evident during the recent period over the Pacific and North America domains.

Notably, the canonical subtropical ridge associated with El Niño is not evident.

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 near 120E, while easterly anomalies persisted near the Date Line.

Weekly Heat Content Evolution in the Equatorial Pacific

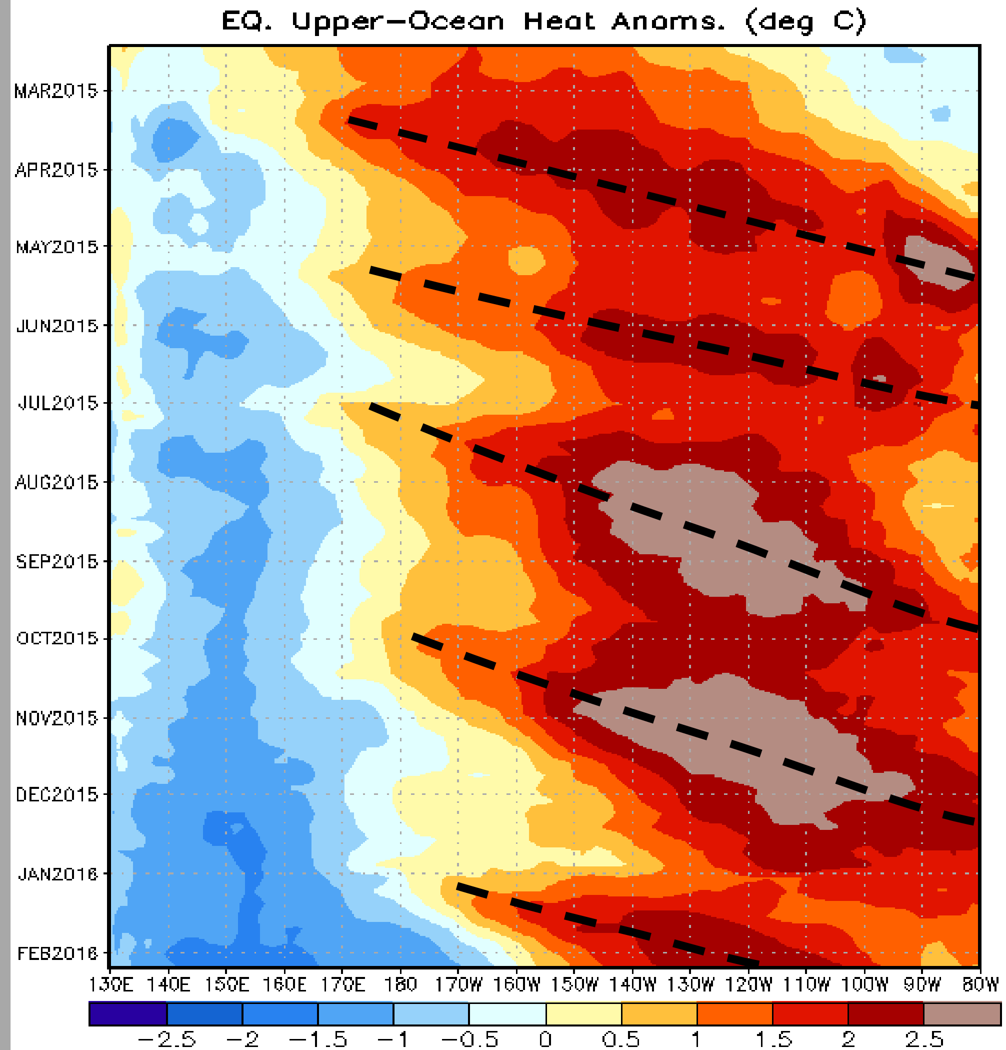
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

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 expansion of below average heat content over the western Pacific is evident since spring and this area has increased since November 2015.

More recently, negative anomalies spread to east of the Date Line, while positive anomalies consolidated near 130W.



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

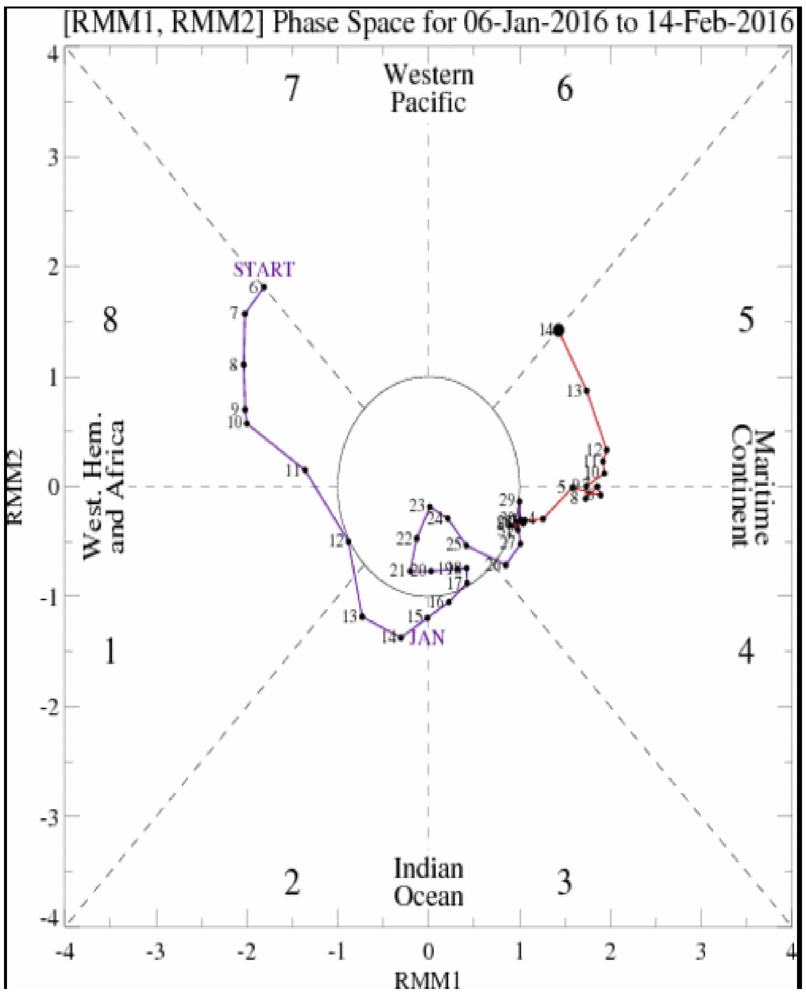
The triangular areas indicate the location of the enhanced phase of the MJO

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

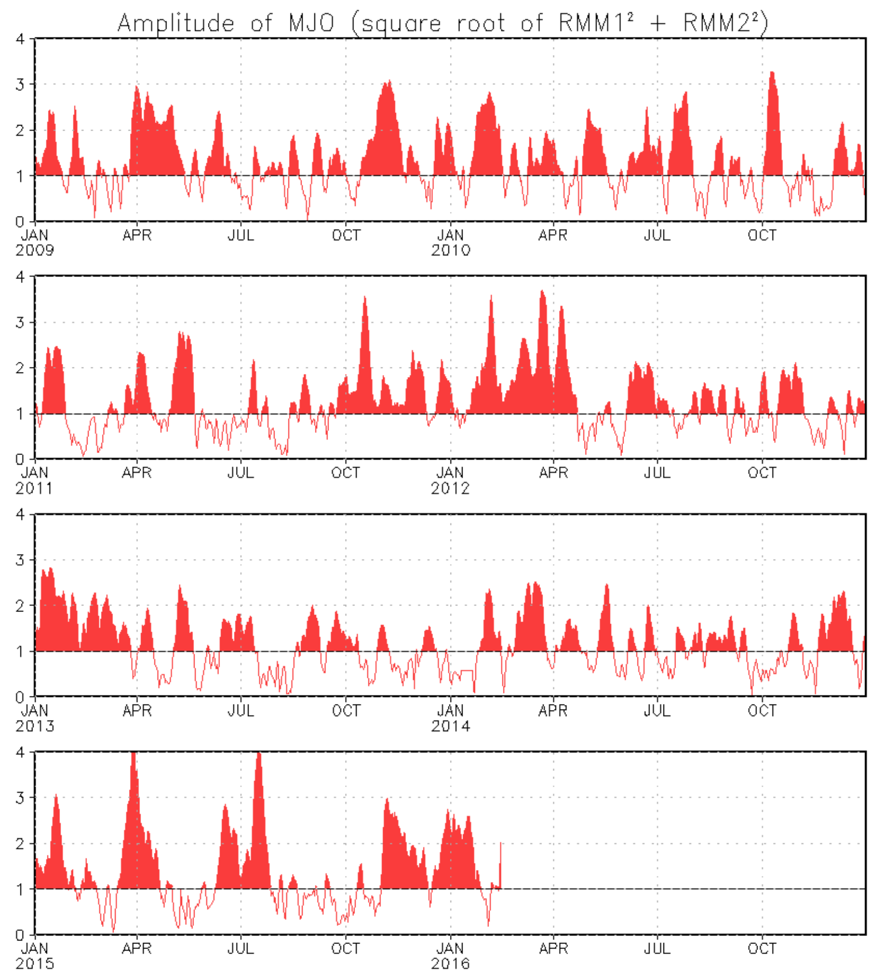
The RMM based MJO index maintained amplitude over the past week, but began propagating eastward.



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.



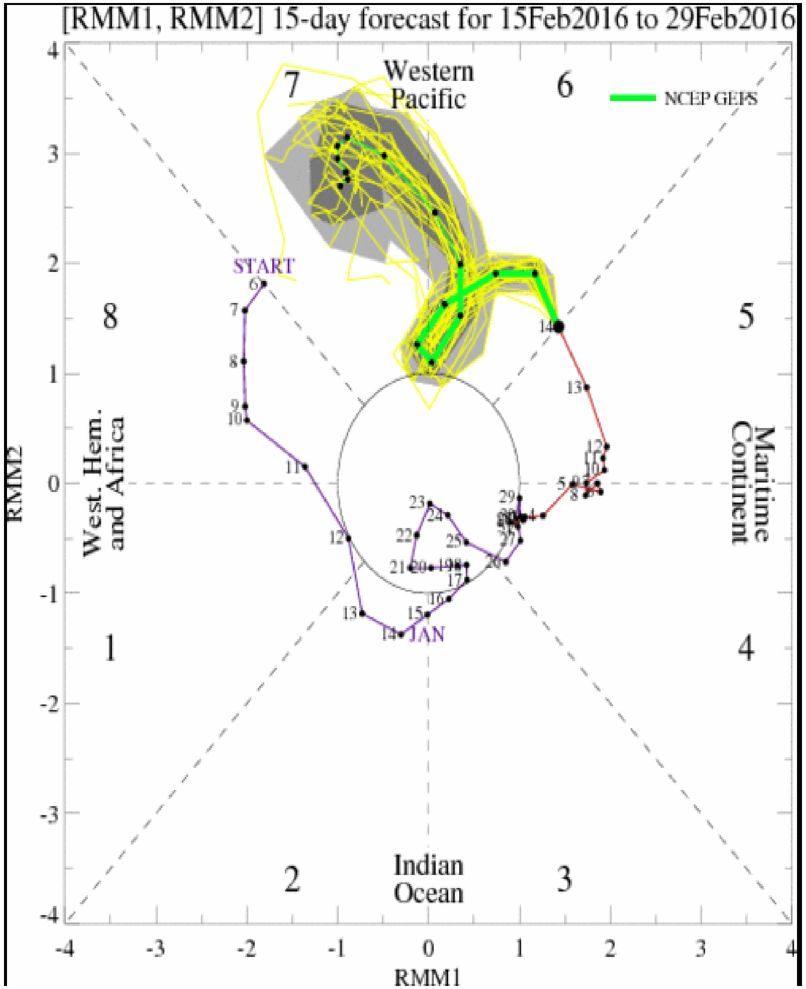
Ensemble GFS (GEFS) MJO Forecast

<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

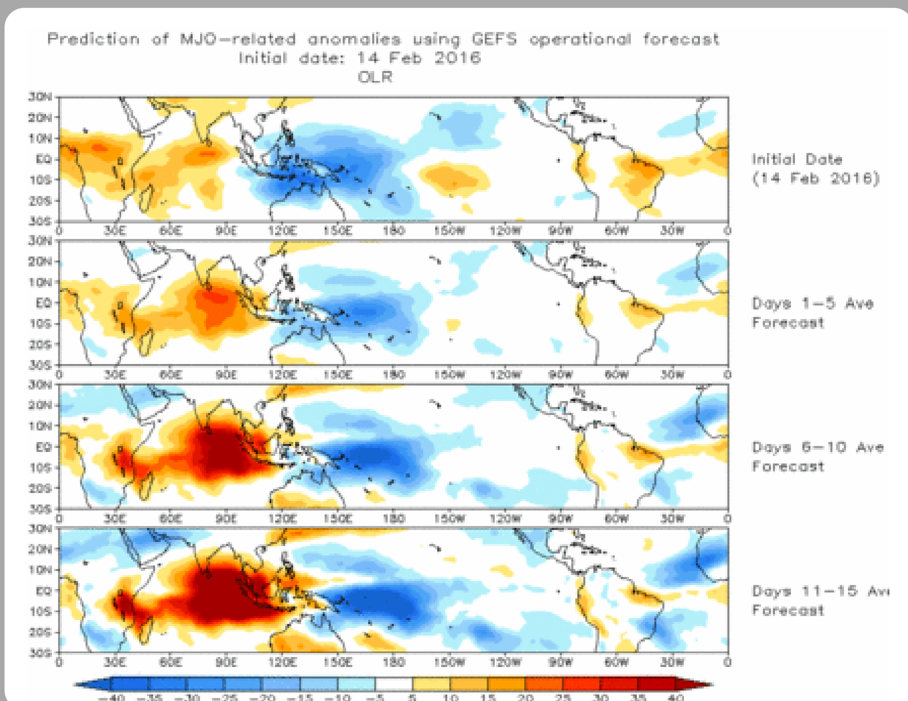


The GFS ensemble MJO index forecast depicts a generally eastward propagation during the period. The forecast loop in Phase 6 is indicative of interference with westward-moving subseasonal variability.

Ensemble GFS (GEFS) MJO Forecast

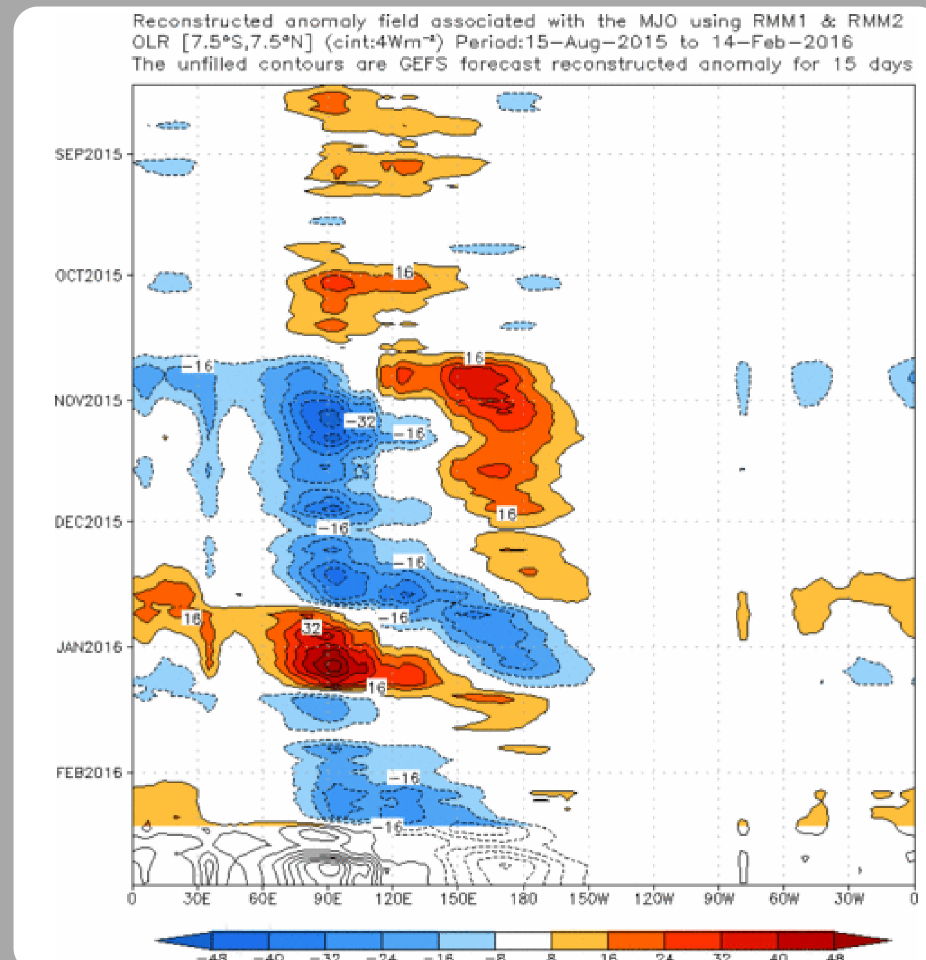
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS OLR forecast depicts eastward shifting negative (positive) OLR anomalies over the West Pacific (Indian Ocean). Constructive interference with the ENSO signal is possibly by late in the period.

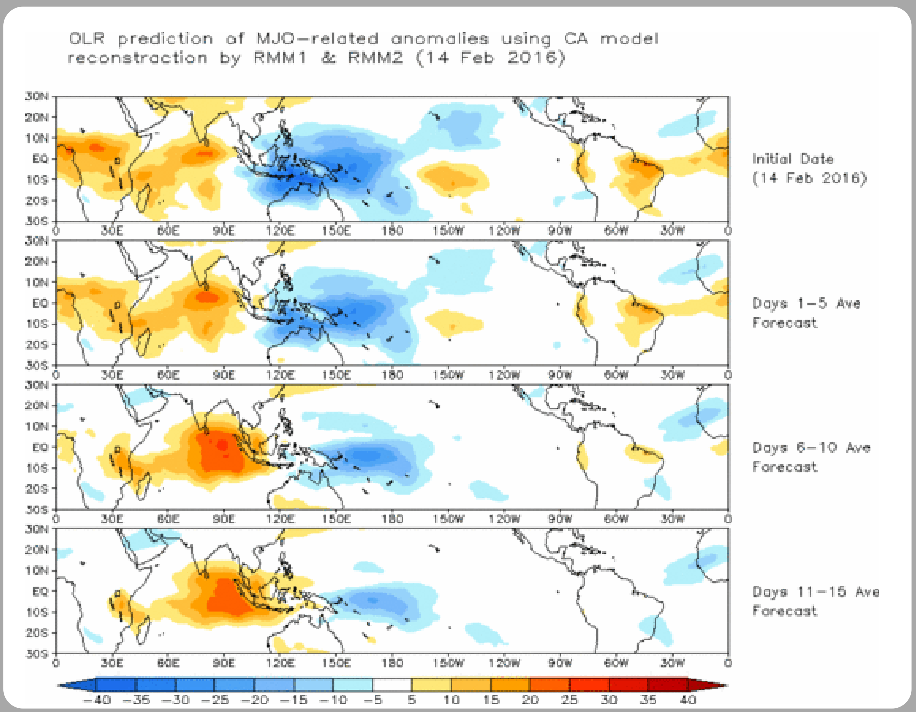
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

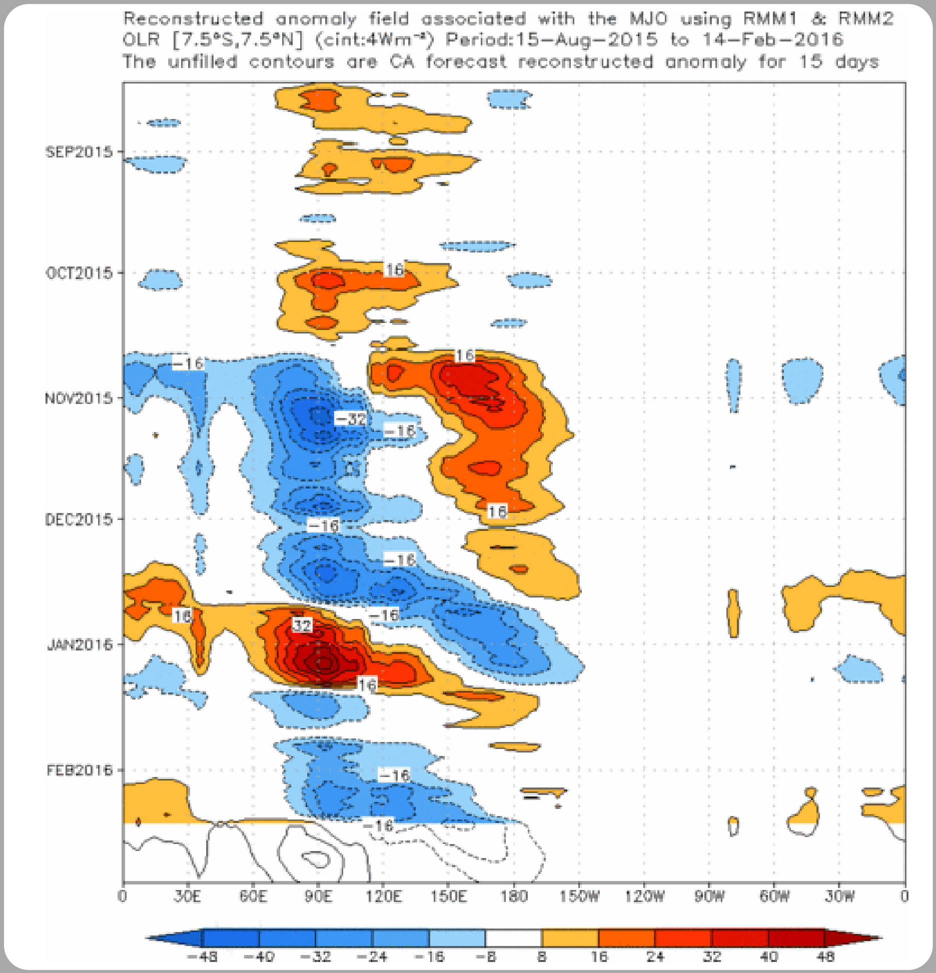
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



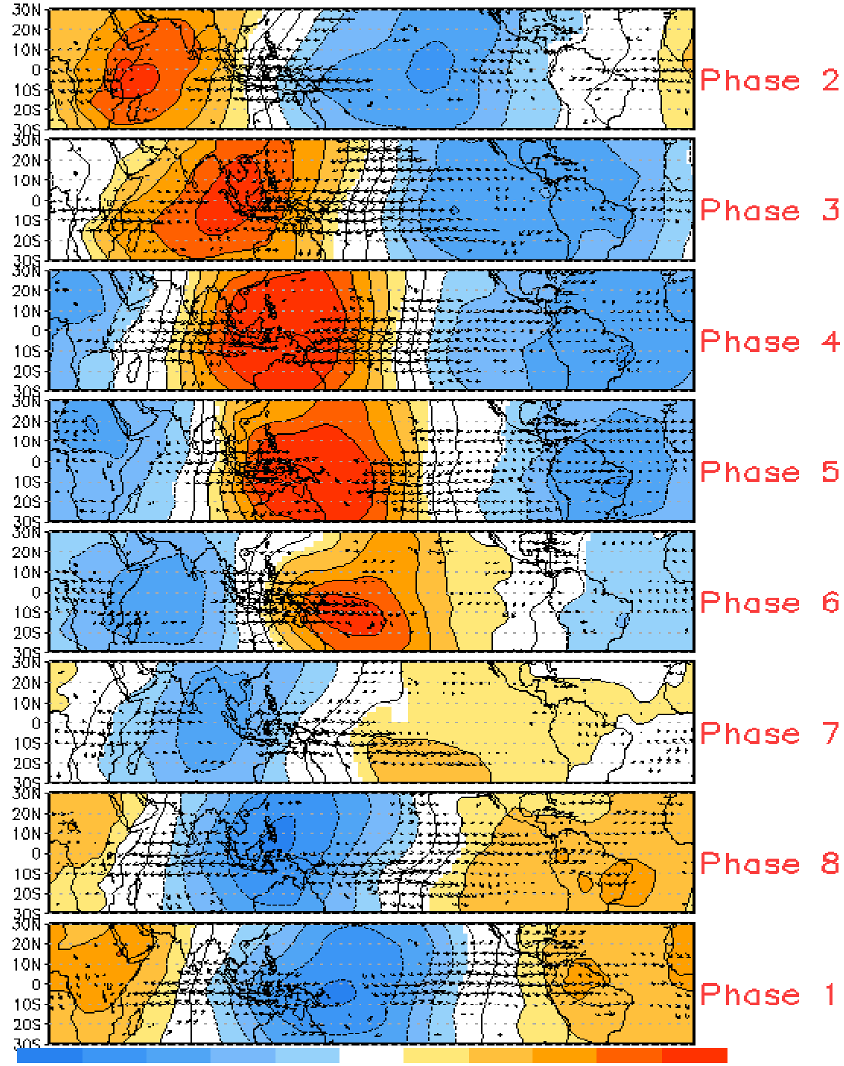
The constructed analog model depicts eastward propagation of the MJO-associated OLR anomalies with gradually diminishing amplitude.

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

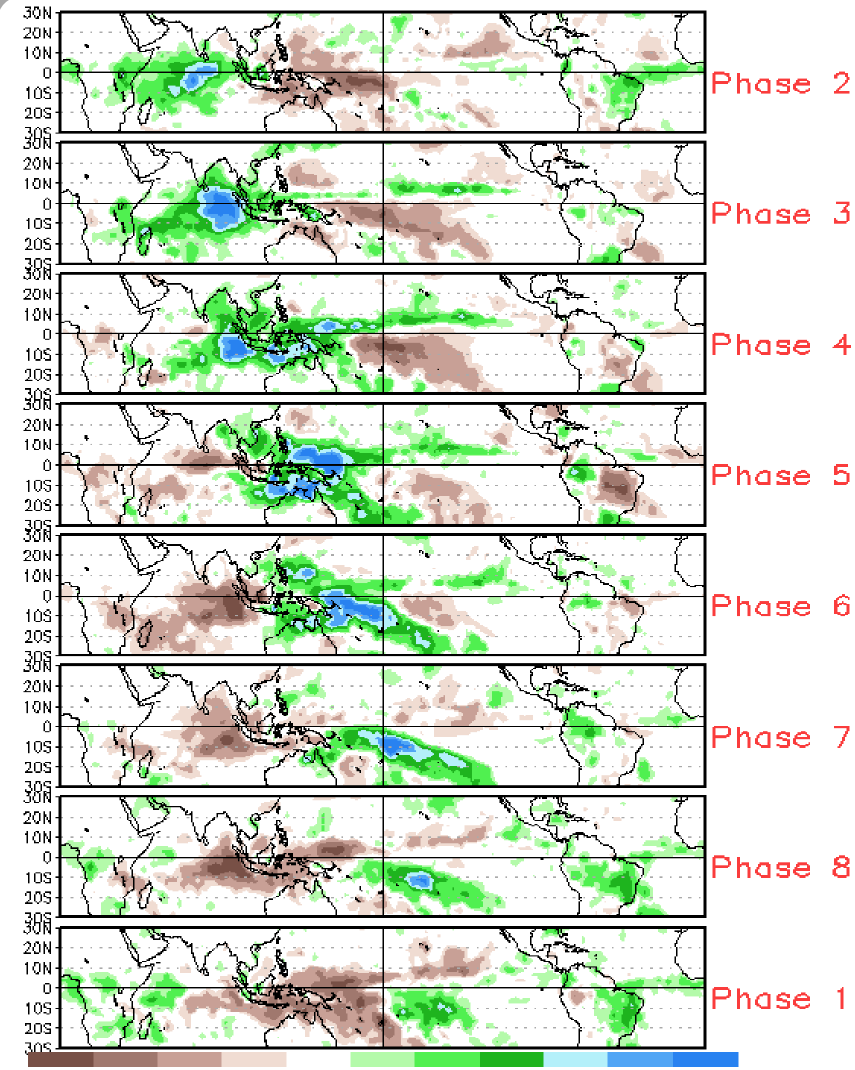


MJO Composites - Global Tropics

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



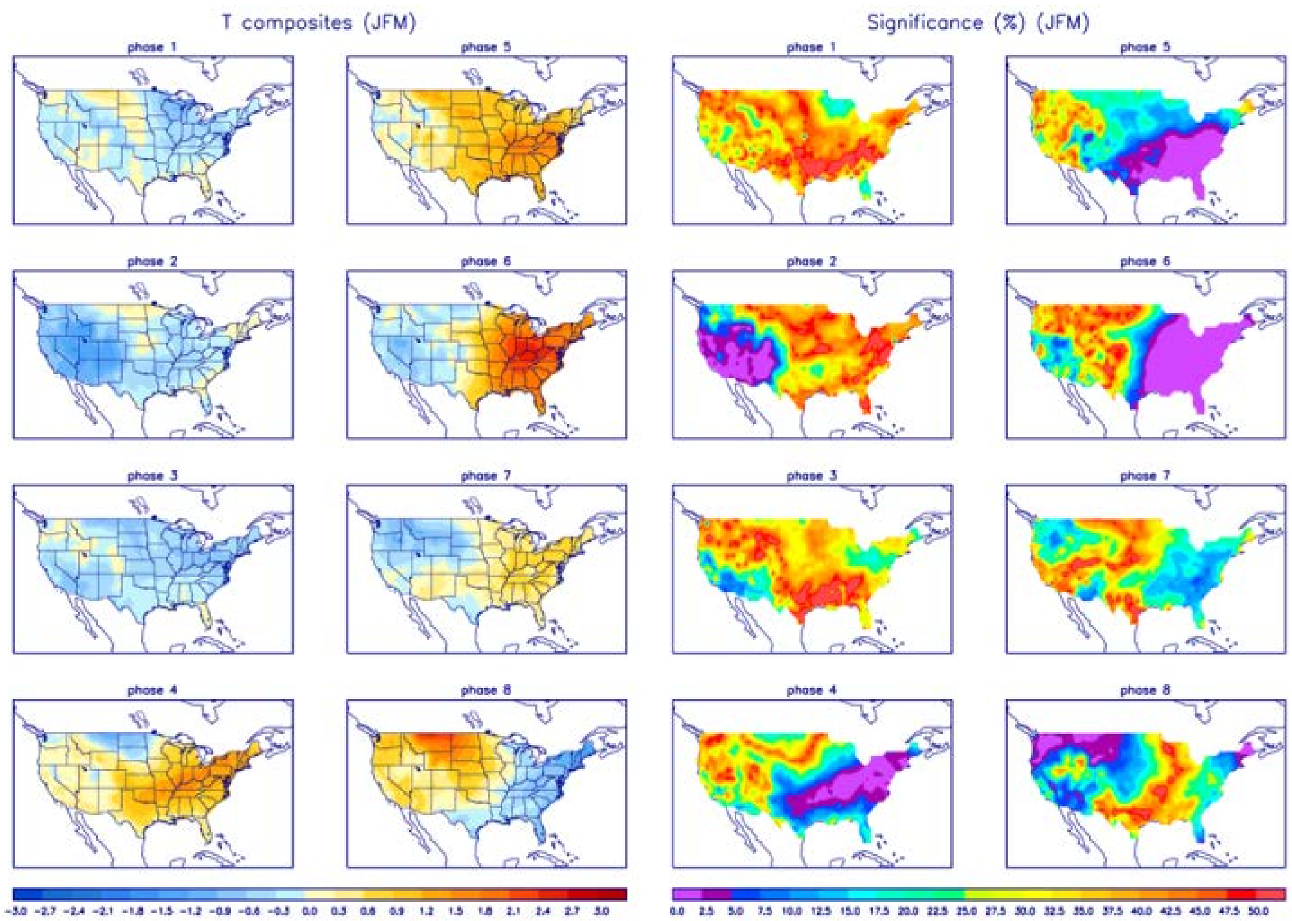
Precipitation Anomalies (Nov-Mar)



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.



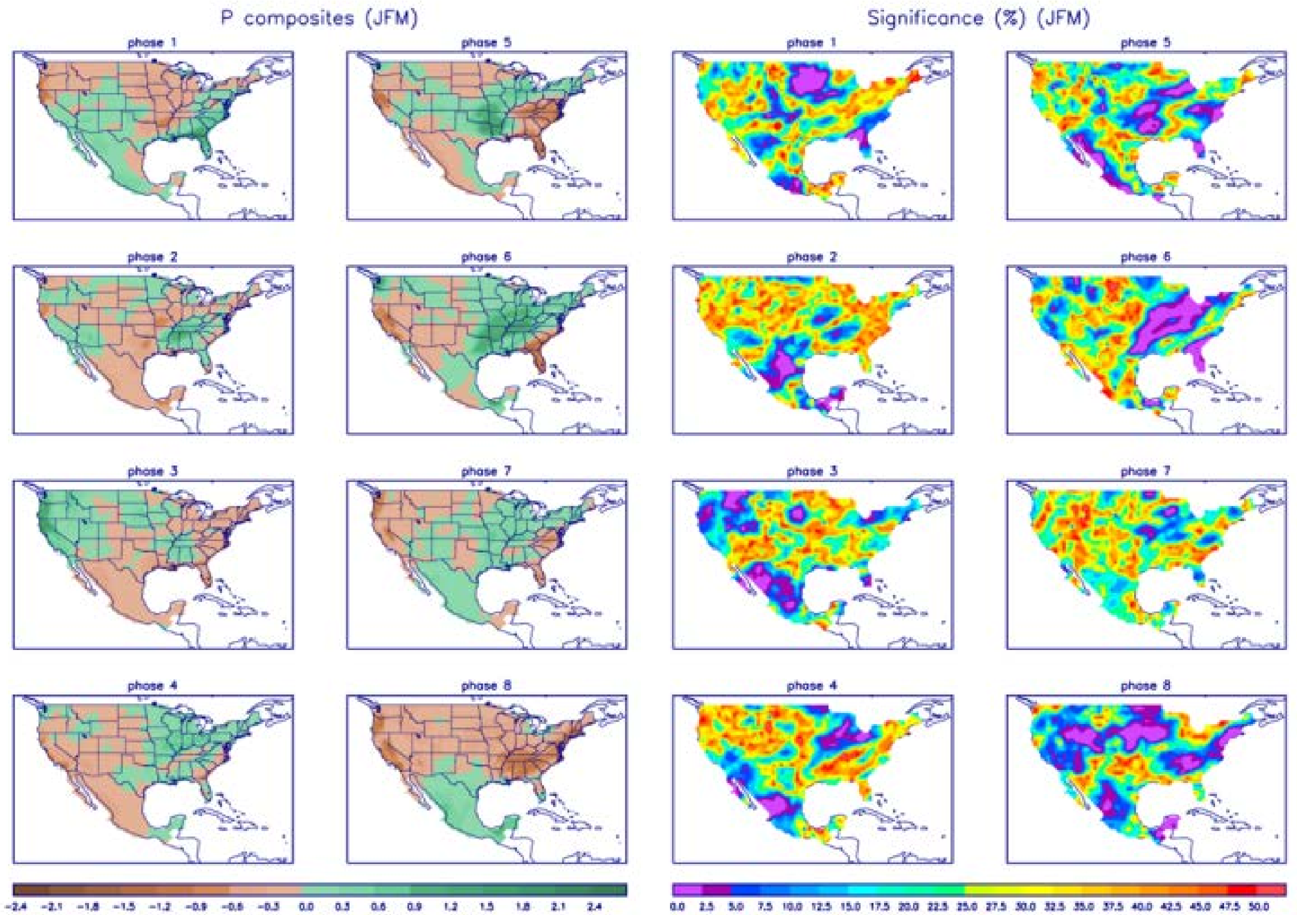
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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