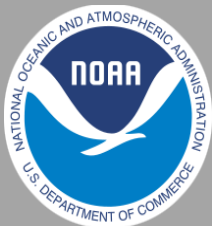


Madden-Julian Oscillation: Recent Evolution, Current Status and Predictions



Update prepared by:
Climate Prediction Center / NCEP
8 February 2016

Outline

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Overview

The MJO became more organized based on multi-dimensional analysis tools, but remained unorganized according to other analysis methods.

Dynamical model forecasts of the RMM based MJO index generally support eastward propagation of a coherent signal to the West-Central Pacific, although the amplitude of the signal varies considerably across the model tools.

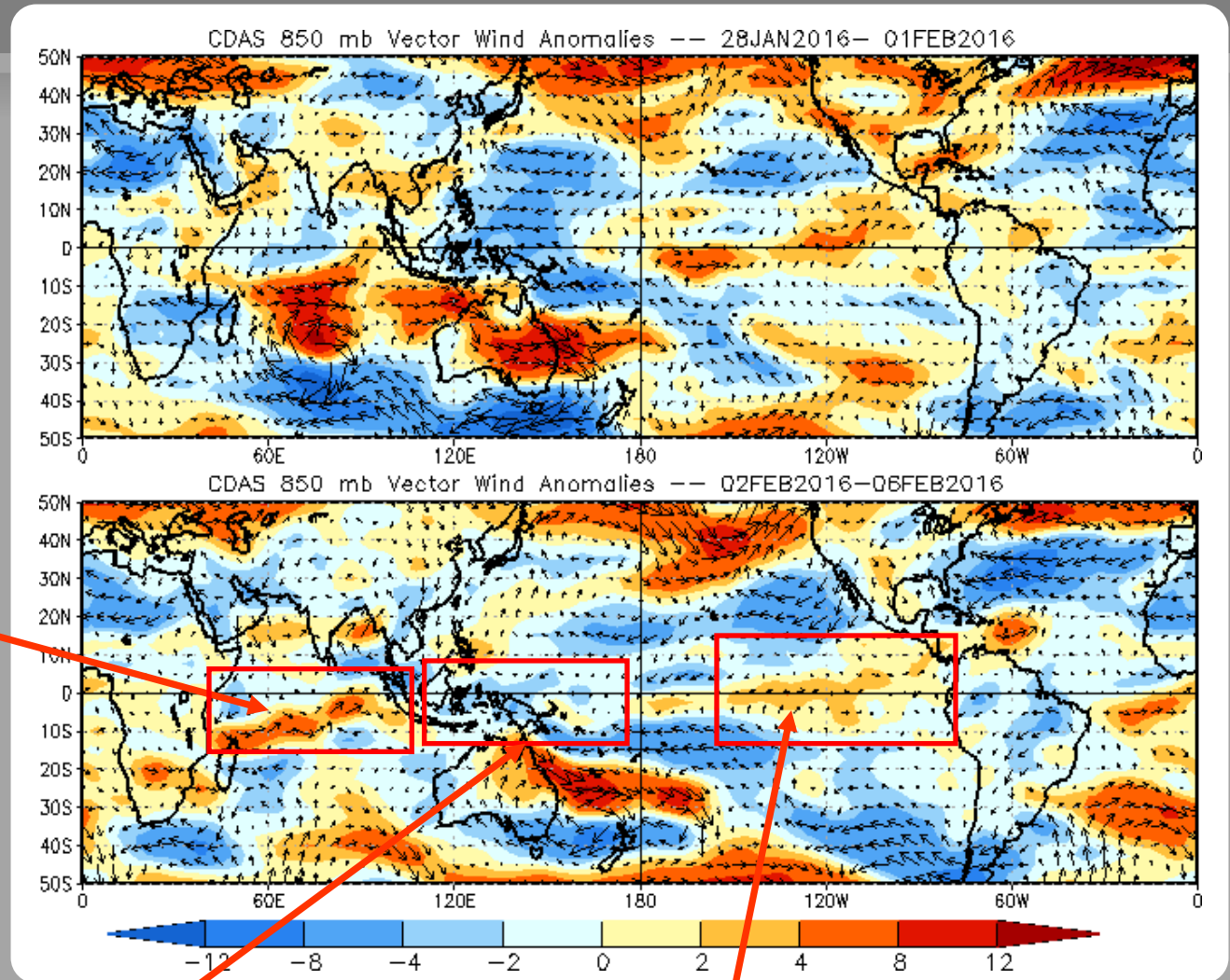
Destructive interference between the intraseasonal signal and the ENSO background state reduces forecast confidence of convective anomalies, particularly across the Maritime Continent and northern Australia.

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 decreased in coverage and intensity across the southern Indian Ocean.



Easterly anomalies decreased in intensity and coverage, while shifting slightly eastward over the central Pacific Ocean.

Westerly anomalies shifted slightly eastward and relaxed over the eastern Pacific Ocean.

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

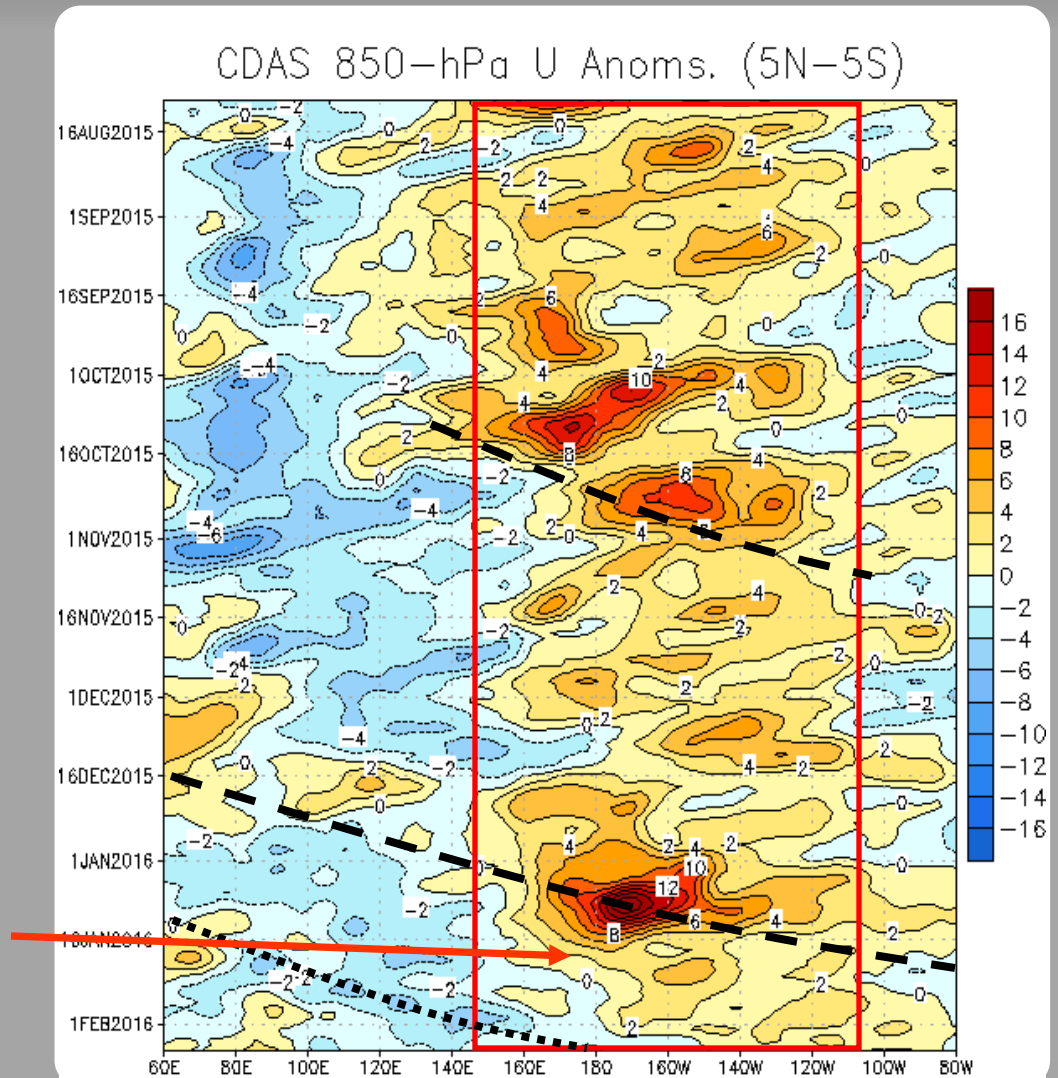
The red box highlights the persistent low-frequency westerly wind anomalies associated with ENSO.

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

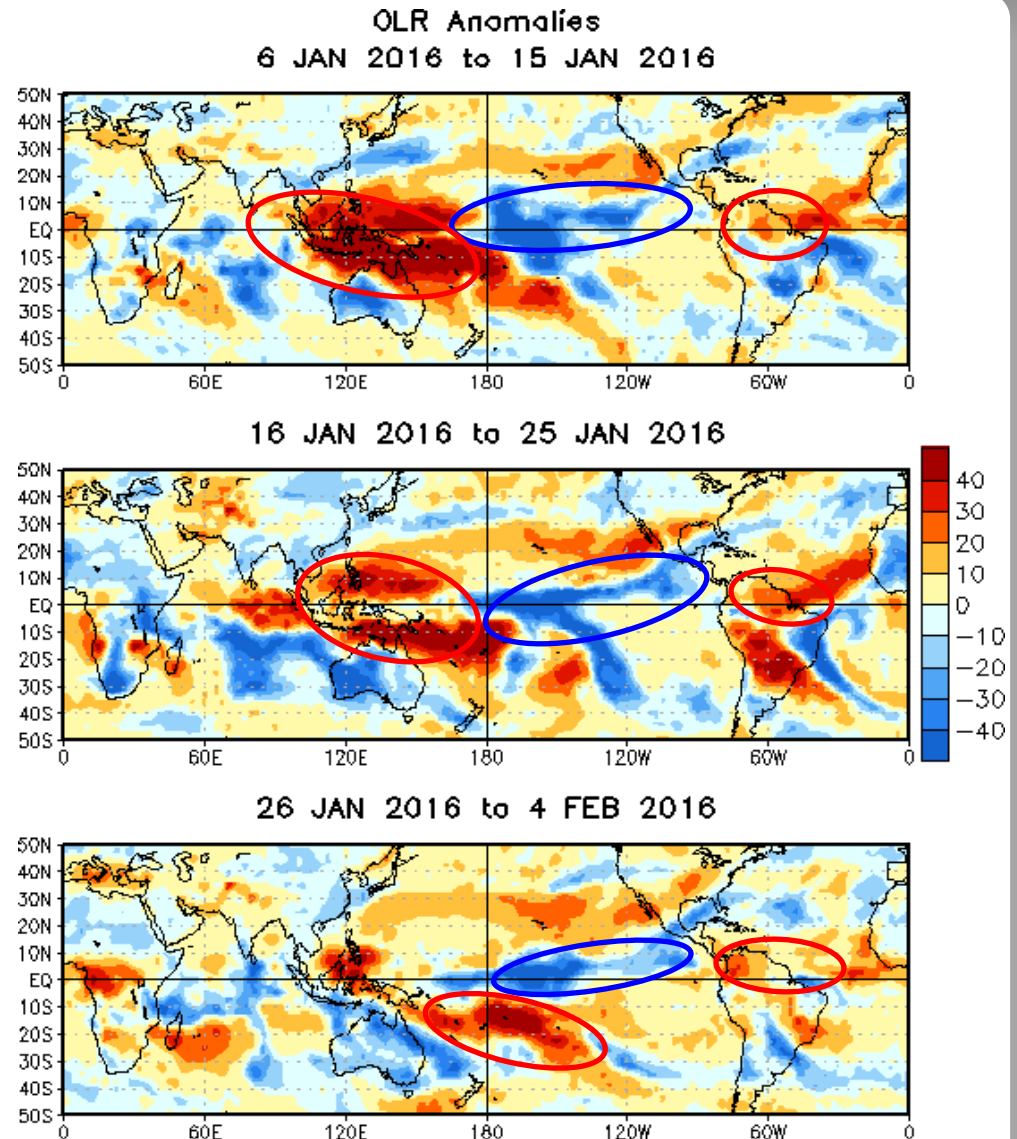
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During early January, suppressed convection returned to the Maritime Continent and enhanced convection intensified over the Pacific as the MJO constructively interfered with the El Niño.

Constructive interference between the MJO and ENSO continued during early to mid-January resulting in enhanced (suppressed) anomalies over the central Pacific (Maritime Continent and equatorial West Pacific).

The intraseasonal signal weakened by late January as it destructively interfered with the El Niño. Suppressed convection became less widespread across the Maritime Continent and shifted eastward to the SPCZ.



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

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

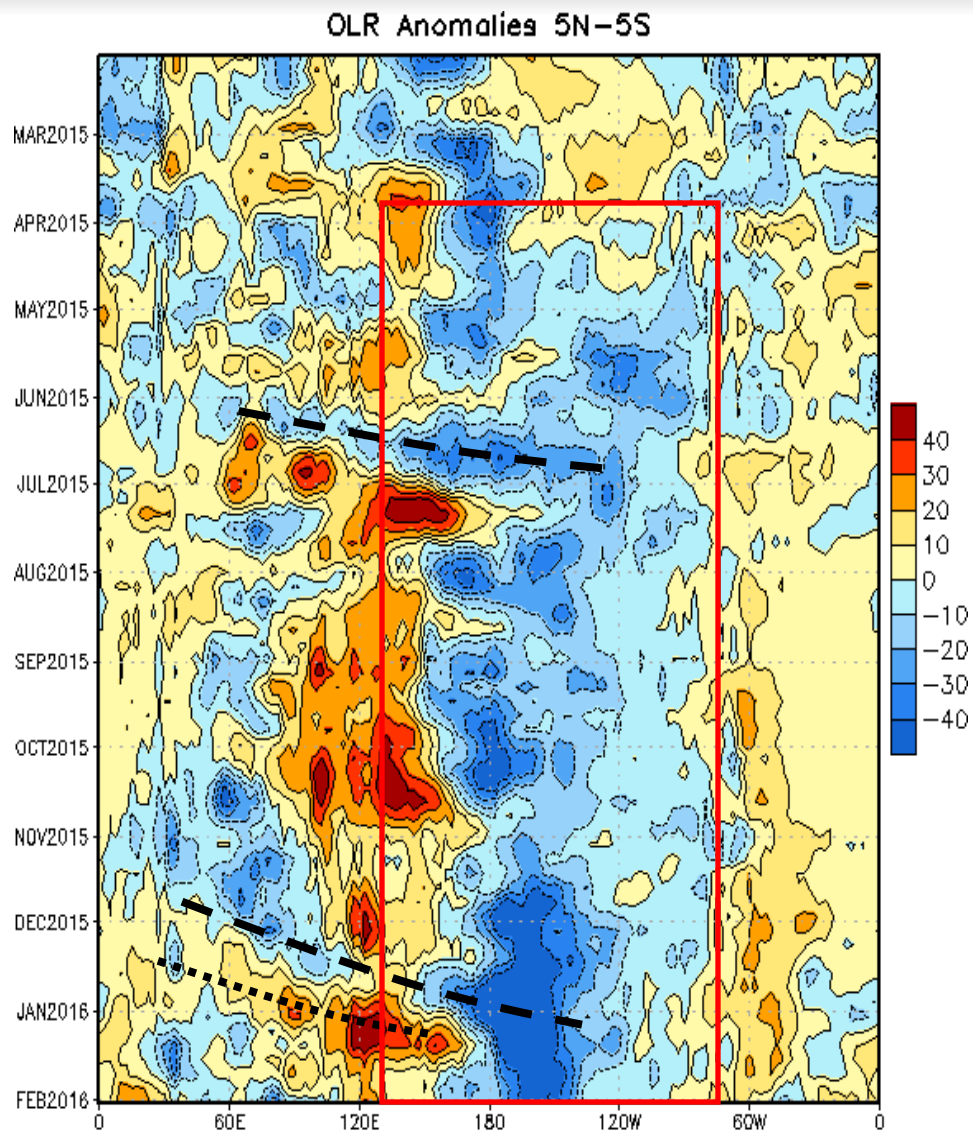
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

Since April, the ongoing El Niño is observed (red box) as a tendency toward a dipole of anomalous convection extending from the Maritime Continent (suppressed) to the East Pacific (enhanced).

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 measured, but not enough to completely disturb the background state.



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

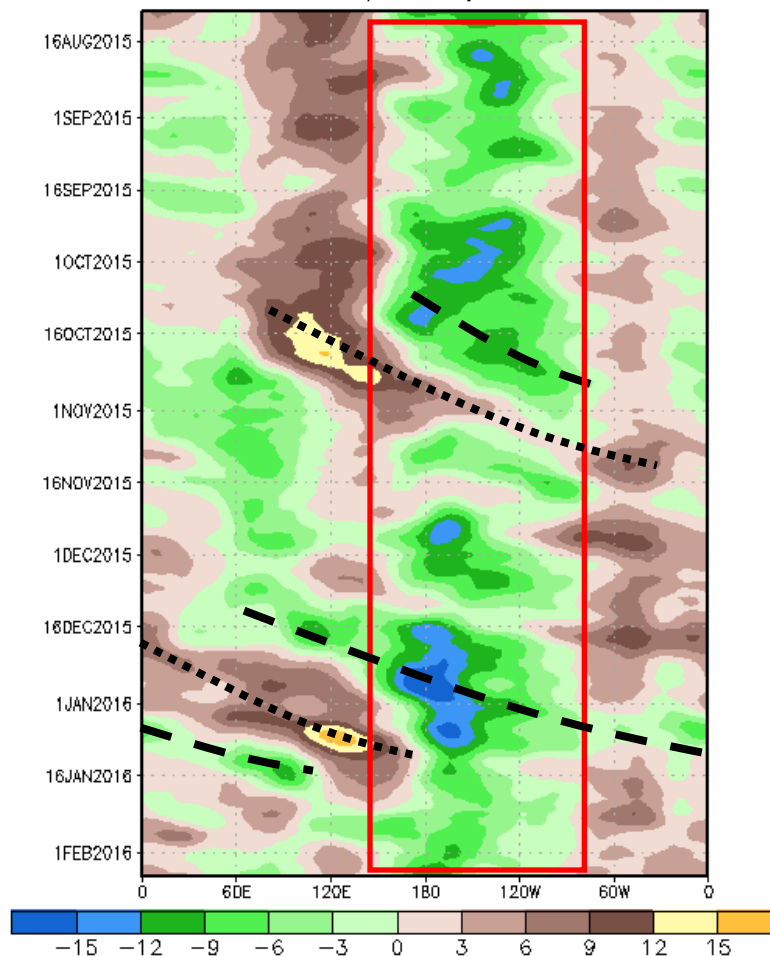
The ongoing ENSO state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific. This pattern has only been temporarily interrupted by strong Kelvin wave/MJO activity at times.

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

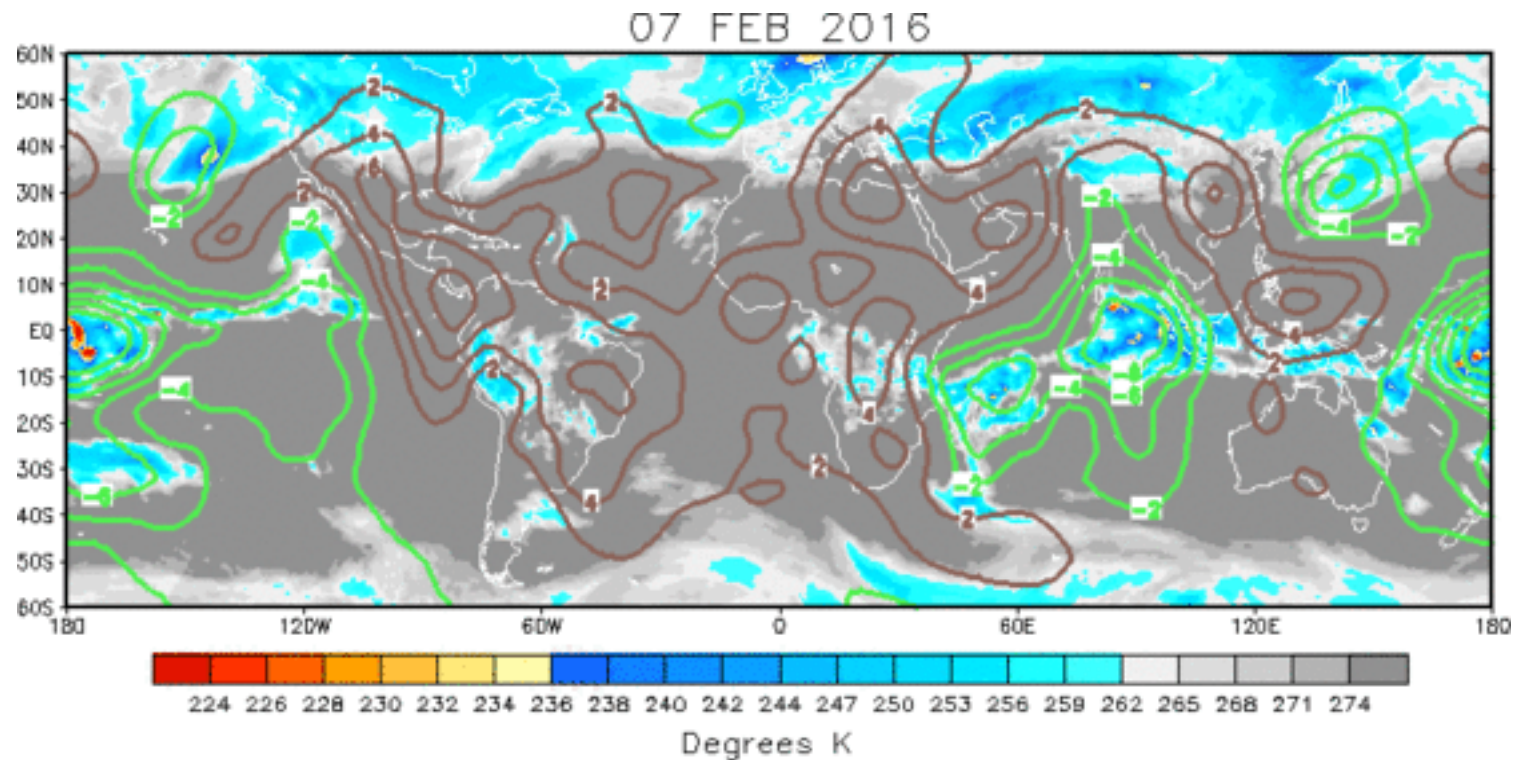
From July through early October, a generally stationary pattern, reflective of El Niño conditions, was observed. During late October, there was an eastward shift in the pattern.

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.

200-hPa Velocity Potential Anomaly: 5N-5S
5-day Running Mean



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



A Wave-2 pattern of velocity anomalies developed during early February, indicative of interference with the background state and not consistent with robust MJO activity.

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)

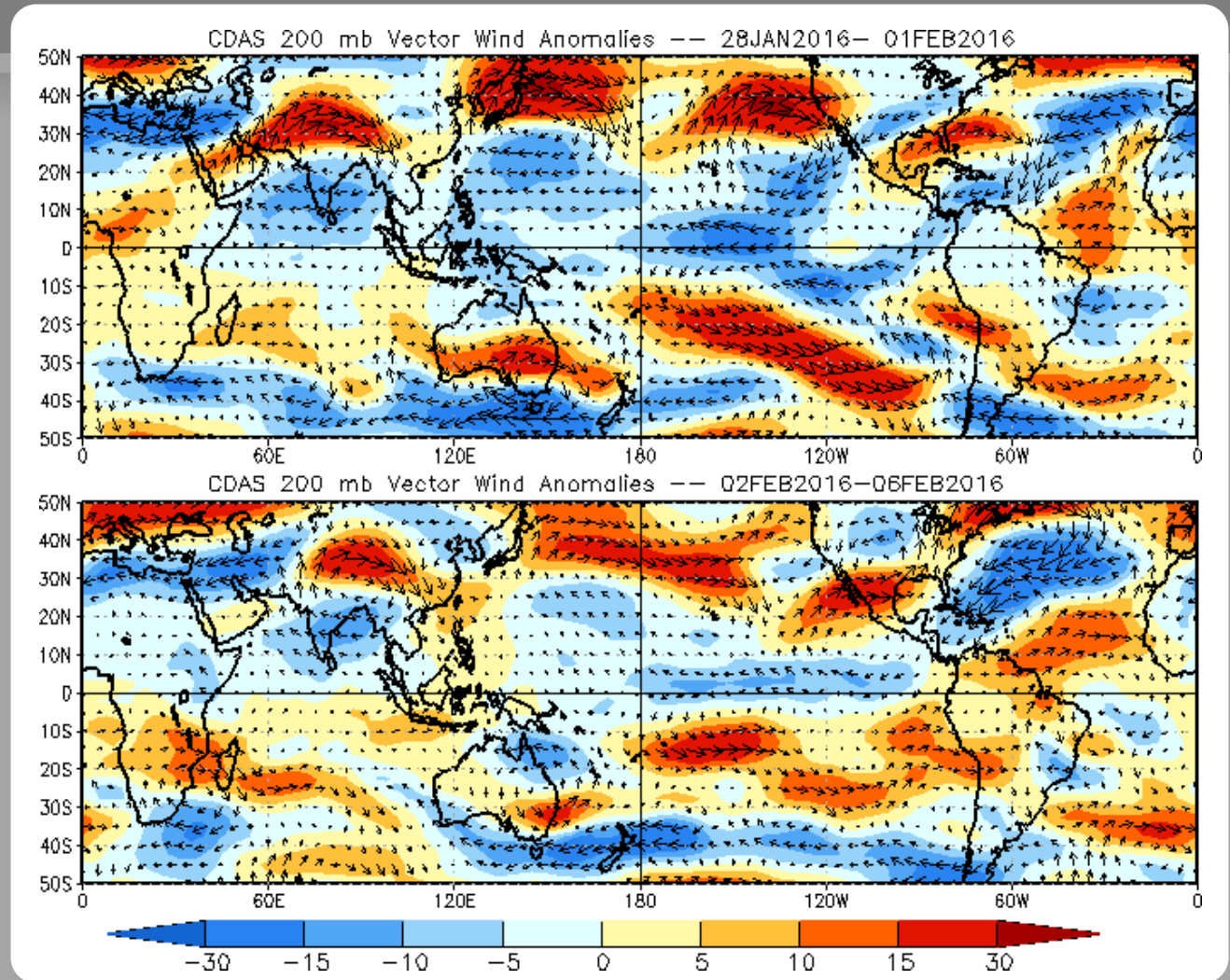
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Upper-level meridional divergence remains apparent near and east of the Date Line, although the Northern Hemisphere portion appears to have weakened.

Some mid-latitude influence is evident over the Maritime Continent.



200-hPa Zonal Wind Anomalies (m s⁻¹)

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

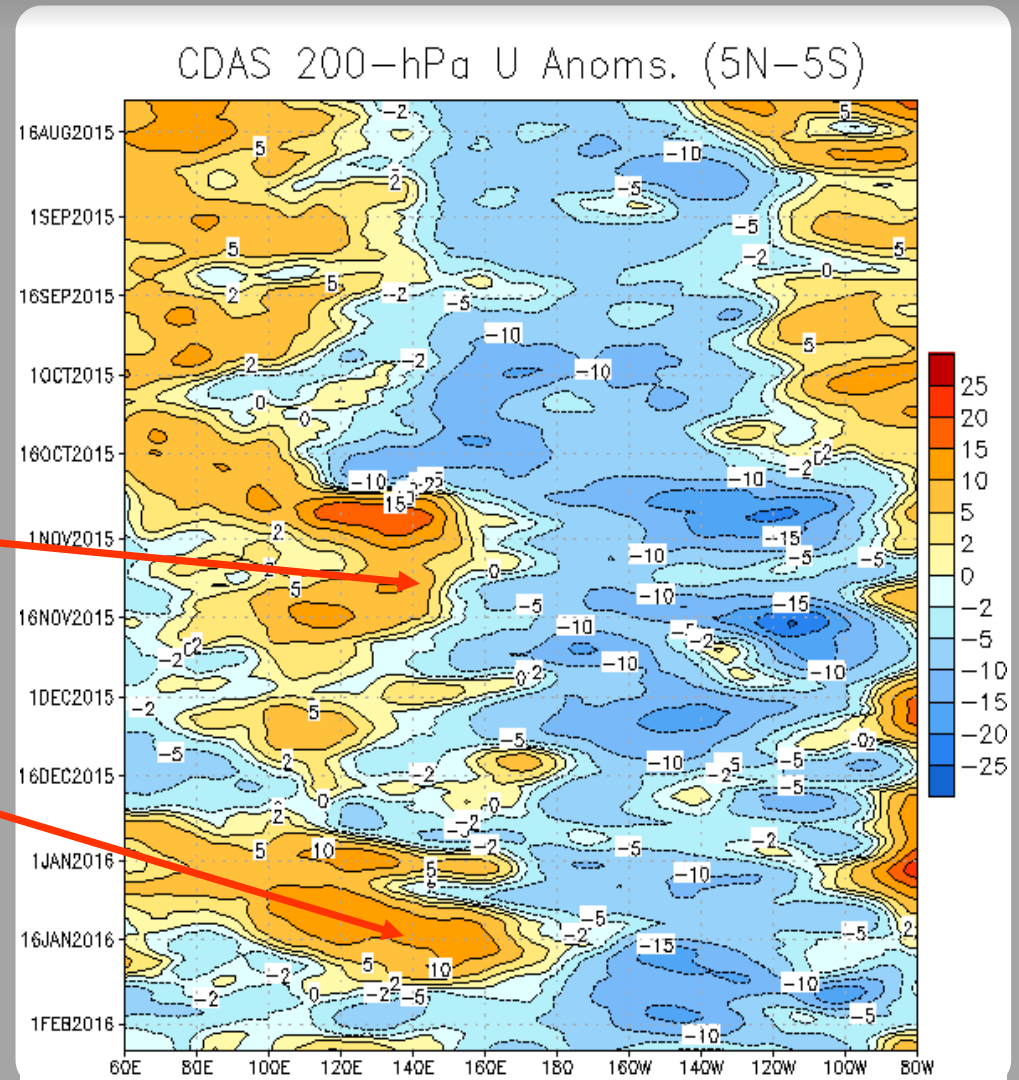
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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 waned slightly near 140W.



Weekly Heat Content Evolution in the Equatorial Pacific

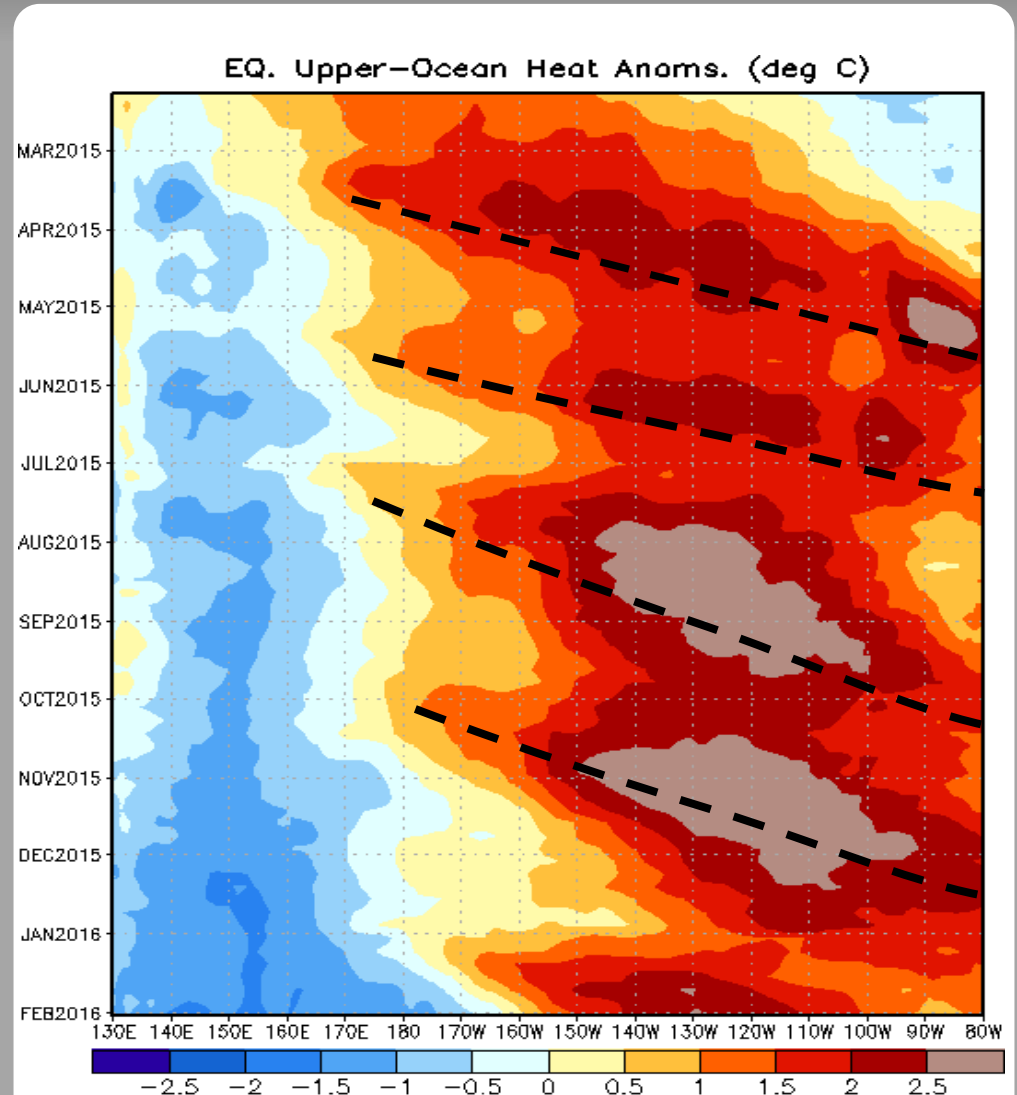
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

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

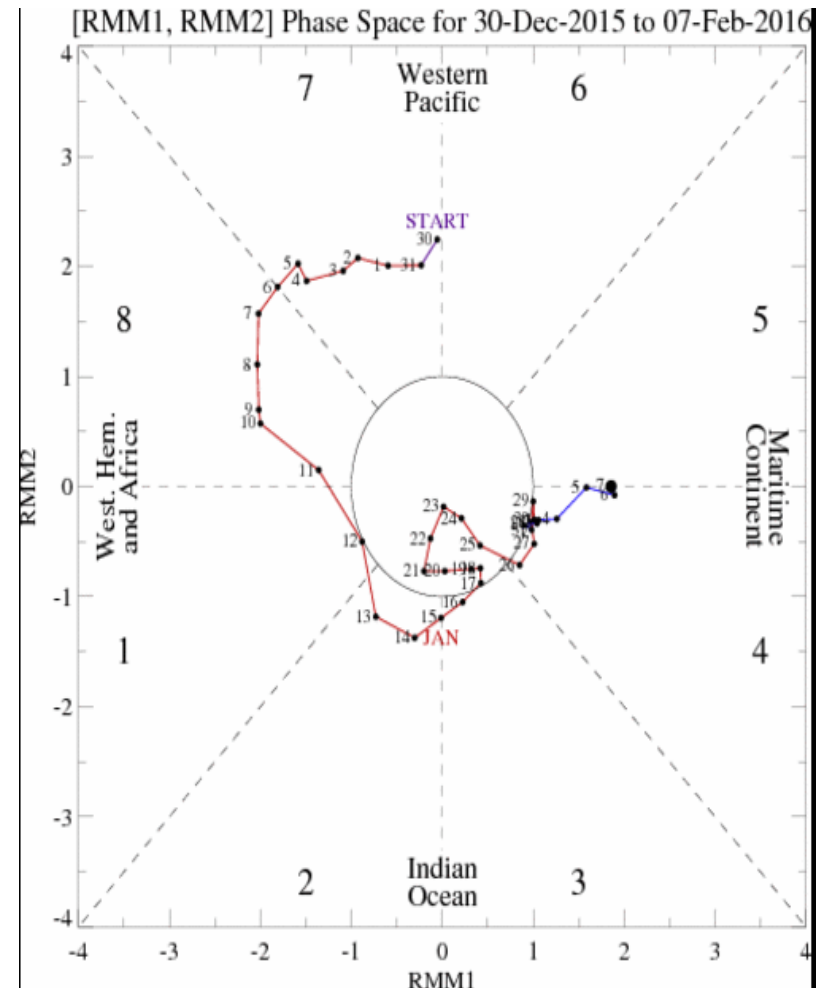
The triangular areas indicate the location of the enhanced phase of the MJO

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

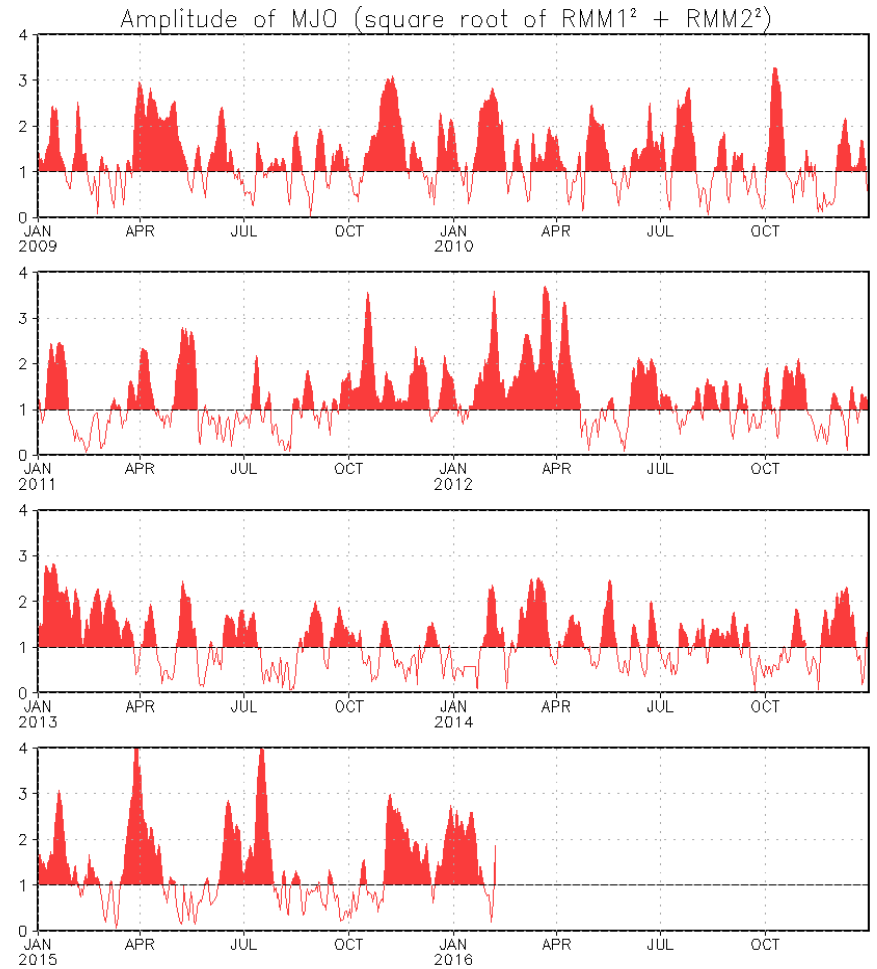
The RMM based MJO index increased in amplitude during the past week.



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

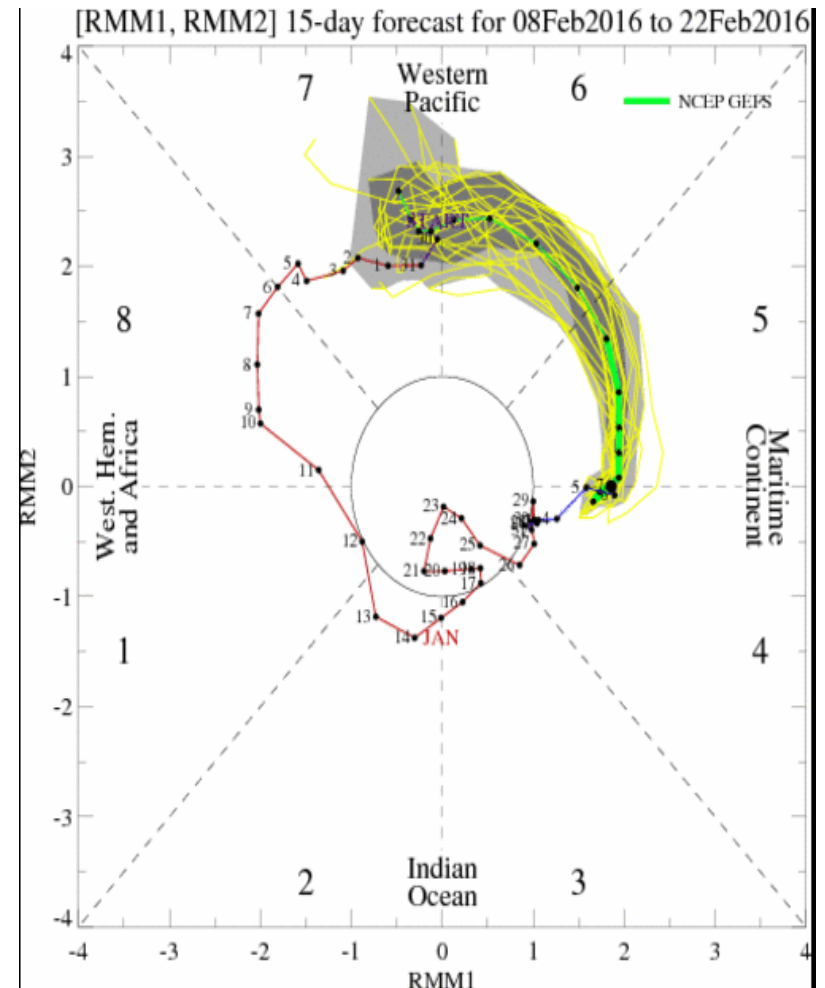
RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

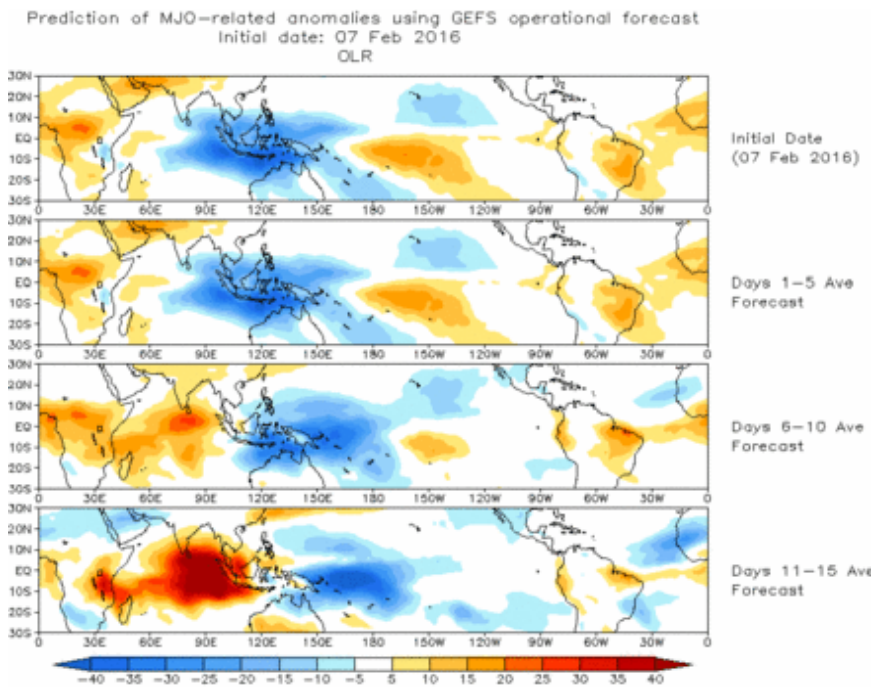
The GFS ensemble MJO index forecast depicts a slight amplification and eastward propagation during the outlook period.

Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean



Ensemble GFS (GEFS) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

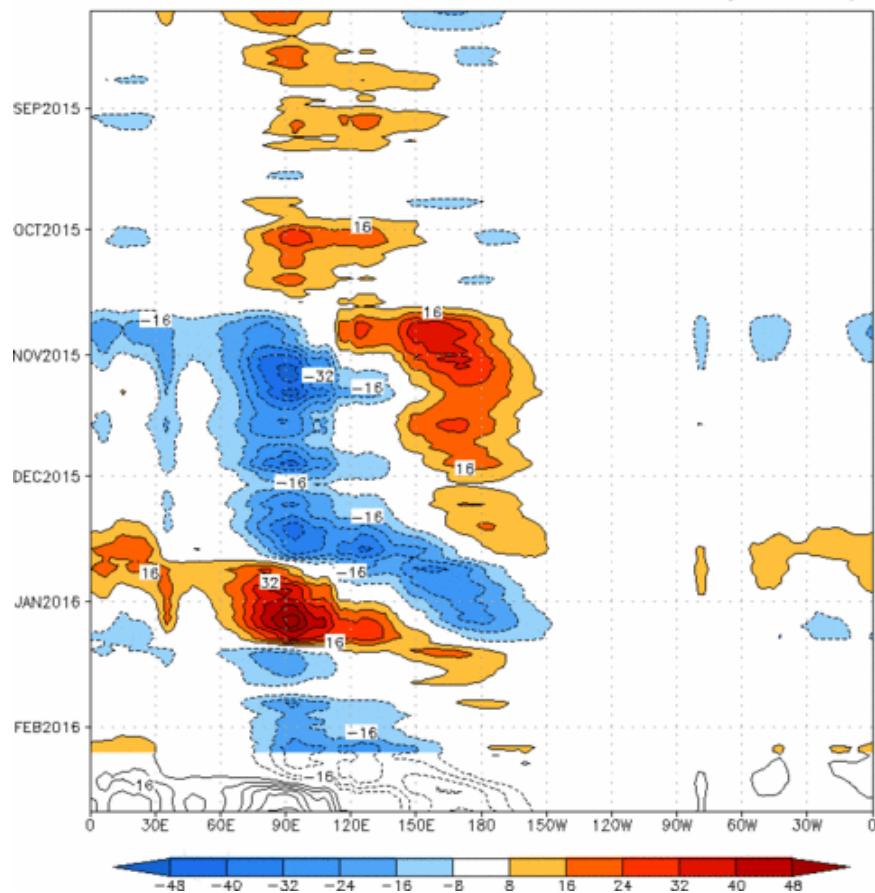


The GEFS OLR forecast depicts strengthening negative (positive) OLR anomalies over the Maritime Continent (Indian Ocean); inconsistent with the ongoing El Niño event. Later in the period, the anomalies shift eastward.

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.)

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

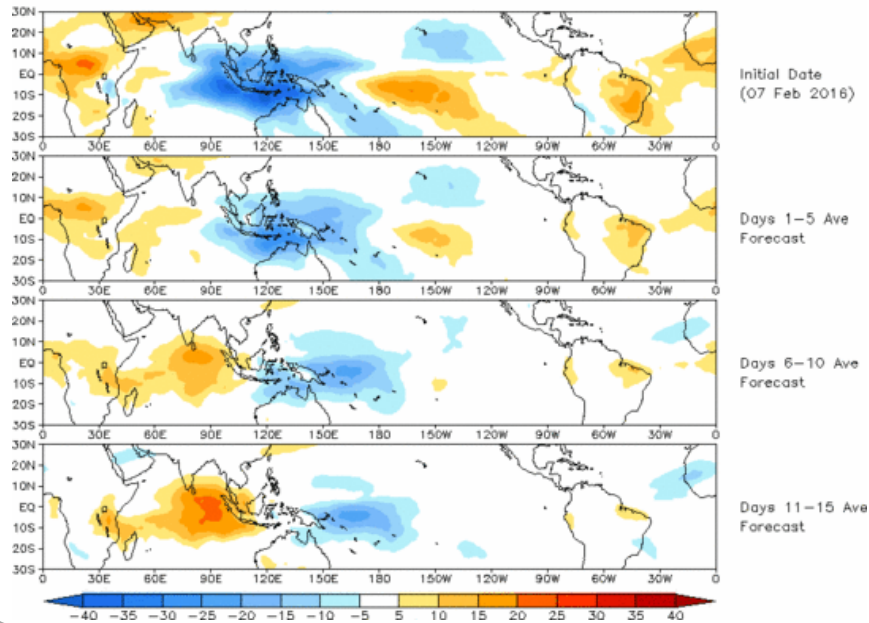
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2
OLR [7.5°S,7.5°N] (cont:4Wm⁻²) Period:08-Aug-2015 to 07-Feb-2016
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days



Constructed Analog (CA) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

OLR prediction of MJO-related anomalies using CA model reconstruction by RMM1 & RMM2 (07 Feb 2016)

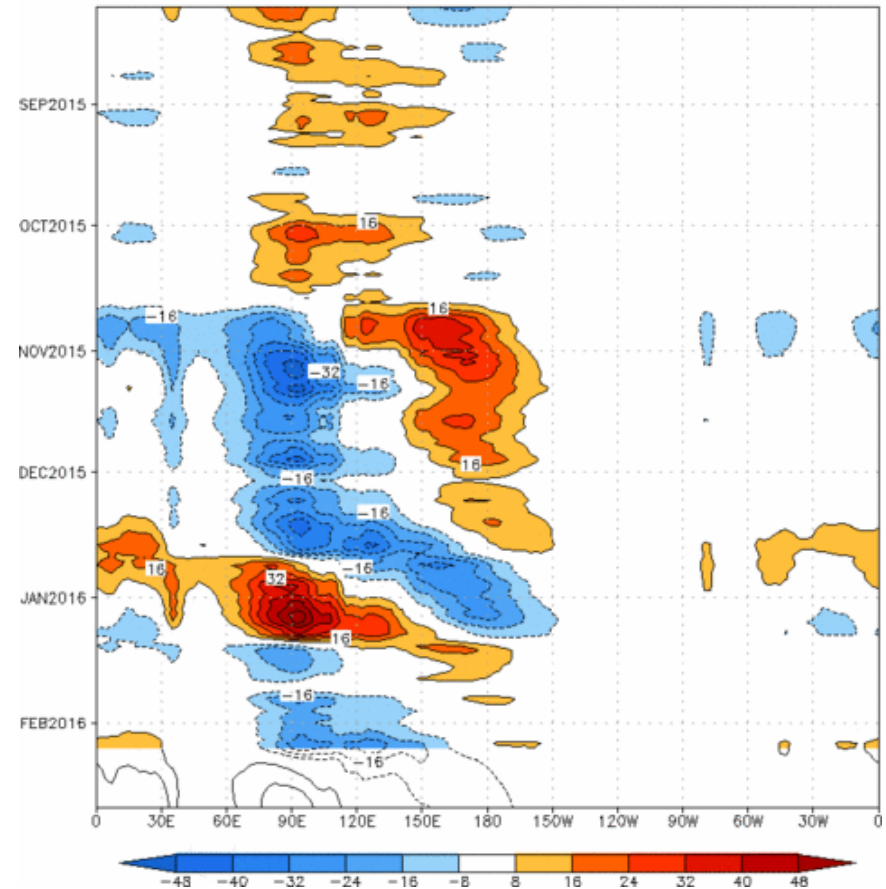


The constructed analog model depicts eastward propagation of the MJO-associated OLR anomalies with smaller magnitude during Week-2. The anomalies are out of phase with the ongoing El Nino.

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.)

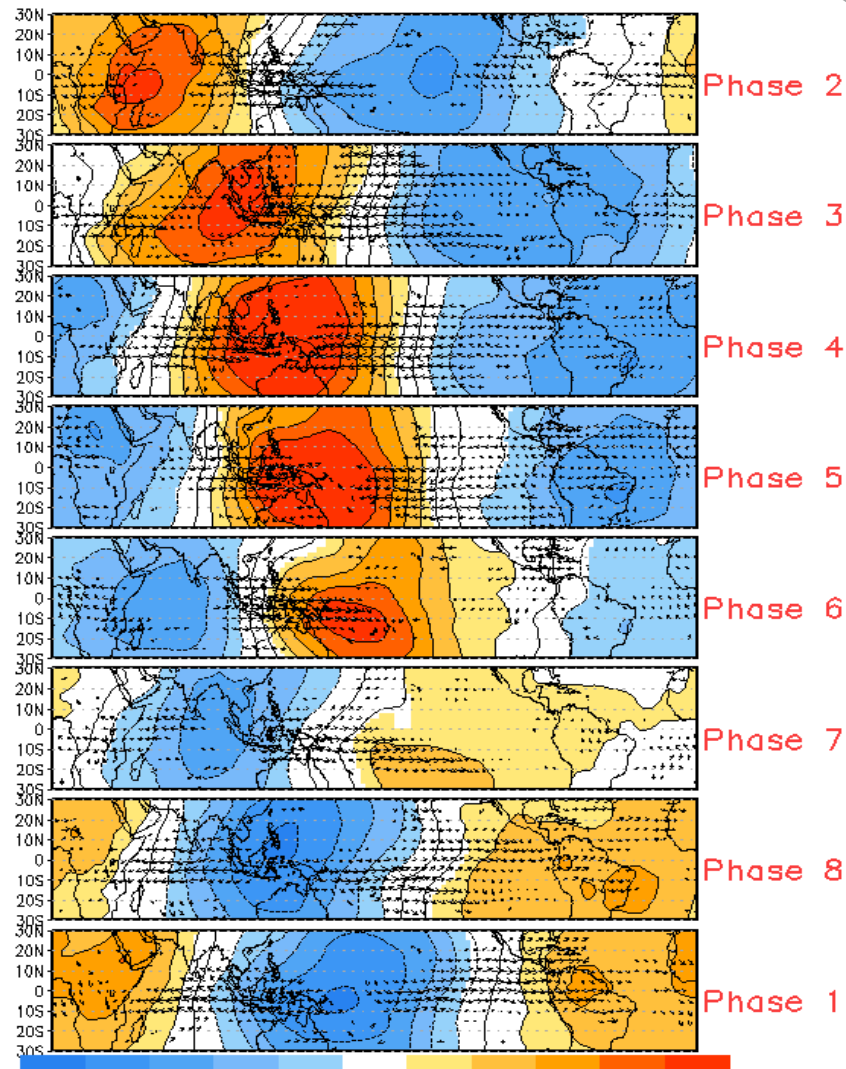
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [7.5°S,7.5°N] (cont:4Wm⁻²) Period:08-Aug-2015 to 07-Feb-2016
The unfilled contours are CA forecast reconstructed anomaly for 15 days

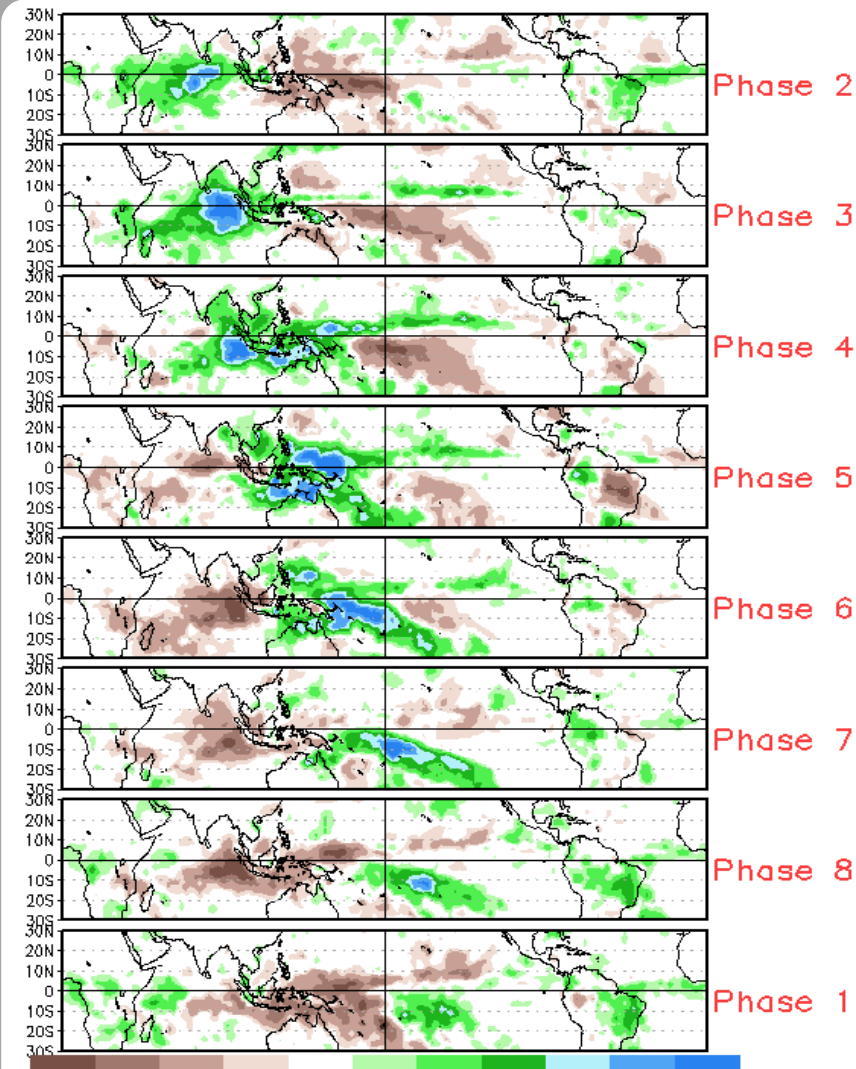


MJO Composites - Global Tropics

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



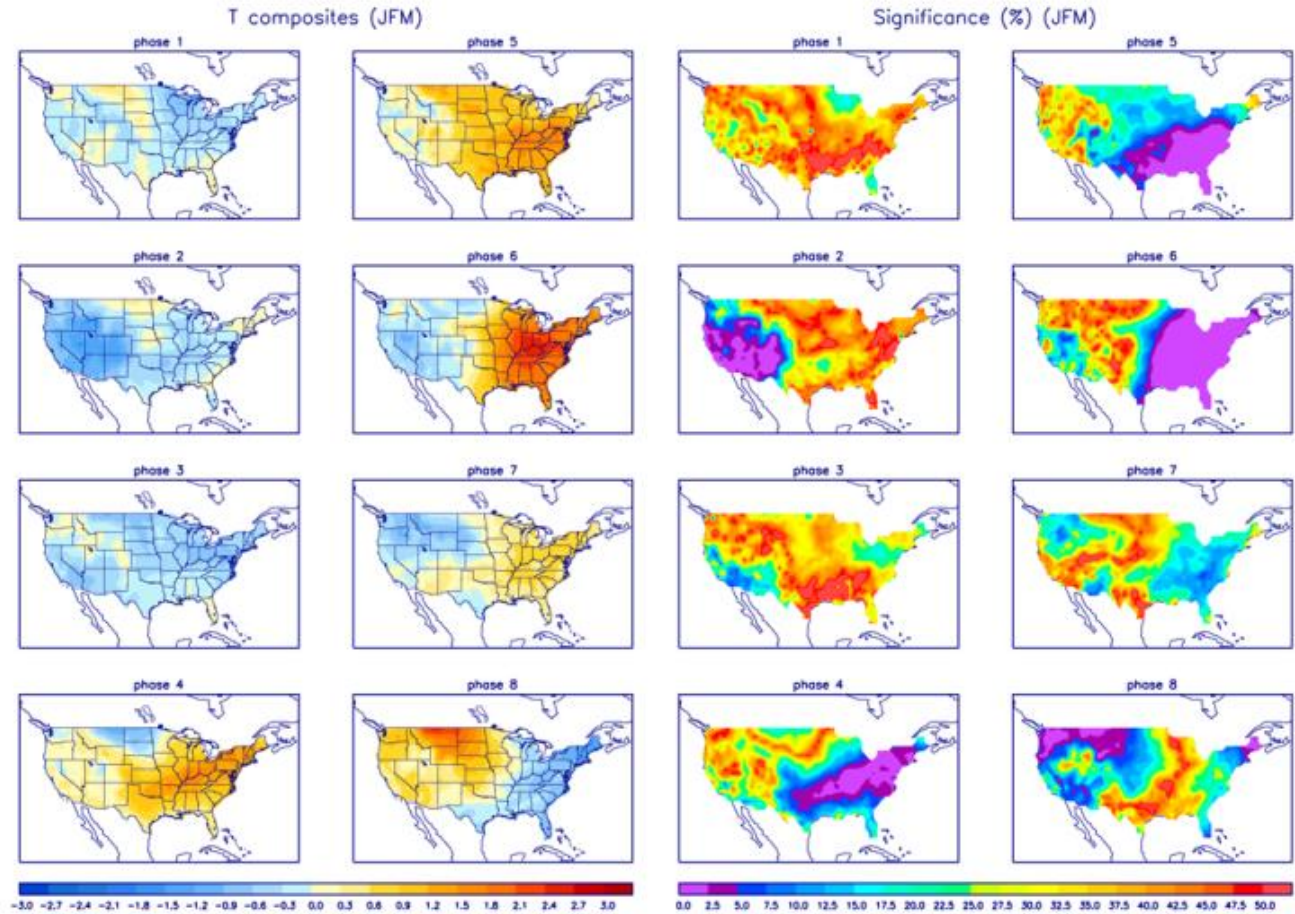
Precipitation Anomalies (Nov-Mar)



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.



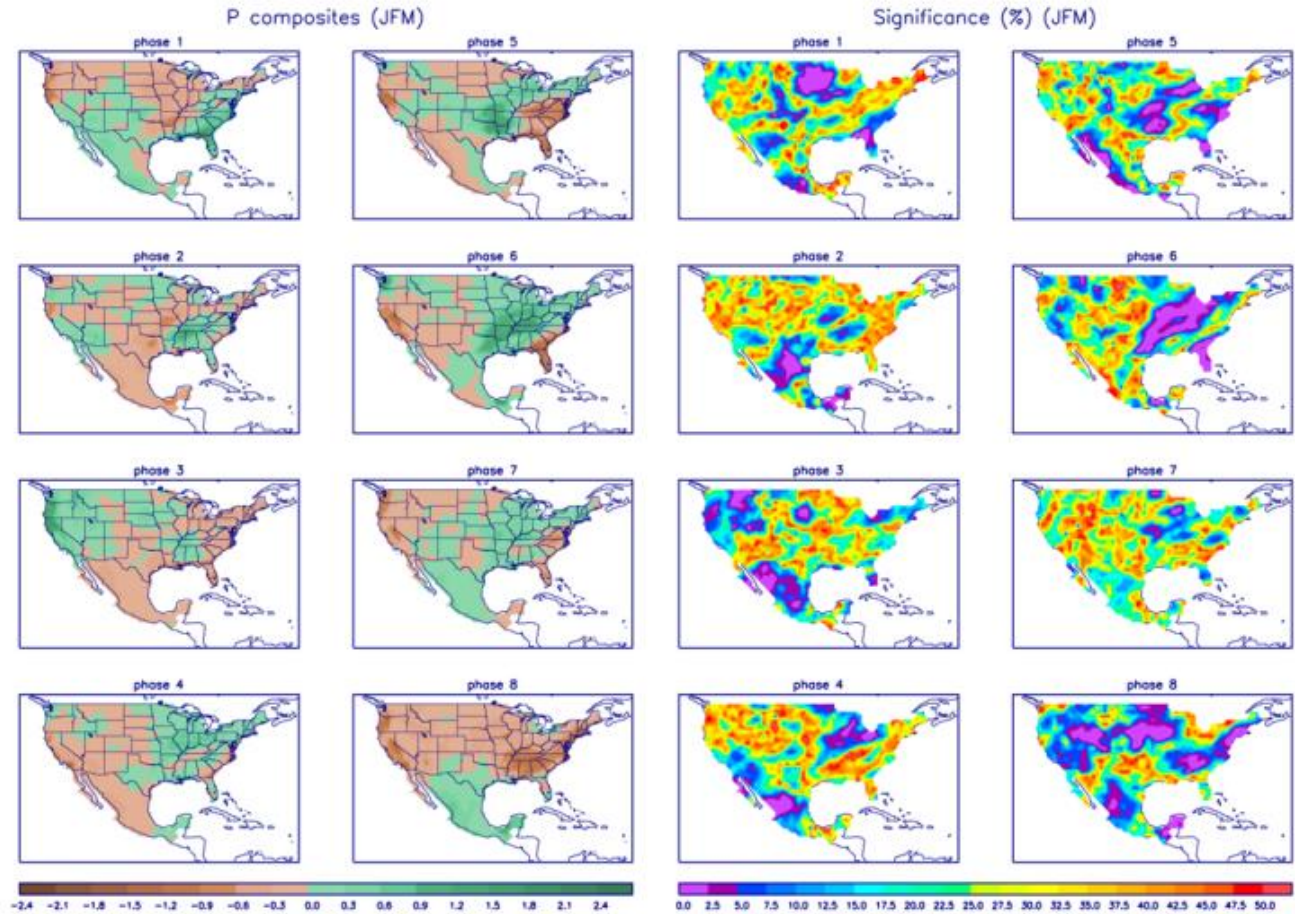
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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.



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>