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

Update prepared by:
Climate Prediction Center / NCEP
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Overview

The MJO remained active during the past week, with the enhanced phase now over the east-central Pacific.

Dynamical model forecasts of the MJO index generally support a continued eastward propagation of the MJO signal, although there is considerable spread among the guidance and the forcing mechanisms by which the models continue the signal is unclear.

The MJO is likely to continue to constructively interfere with the ongoing El Nino for at least the first week of the outlook period. Week-2 has high uncertainty with some models completely eliminating any MJO signal.

The MJO is likely to continue playing a role in the pattern of anomalous convection along with the ongoing El Nino.

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

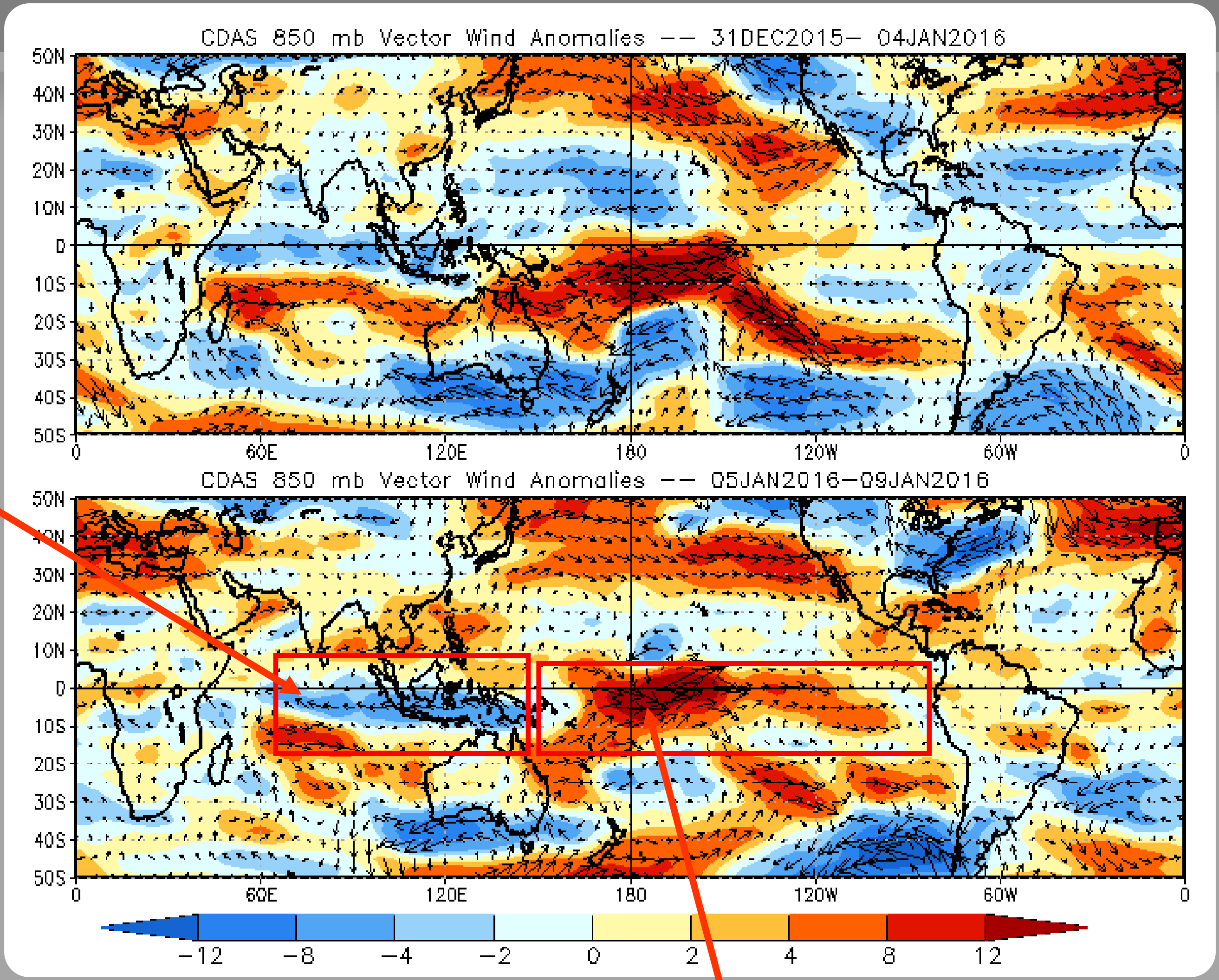
850-hPa Vector Wind Anomalies (m s-1)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Easterly anomalies shifted slightly eastward over the Indian Ocean and Maritime Continent.



A strong westerly wind burst continued over the Central Pacific Ocean, with some westerly anomalies expanding eastward to near 90W.

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

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

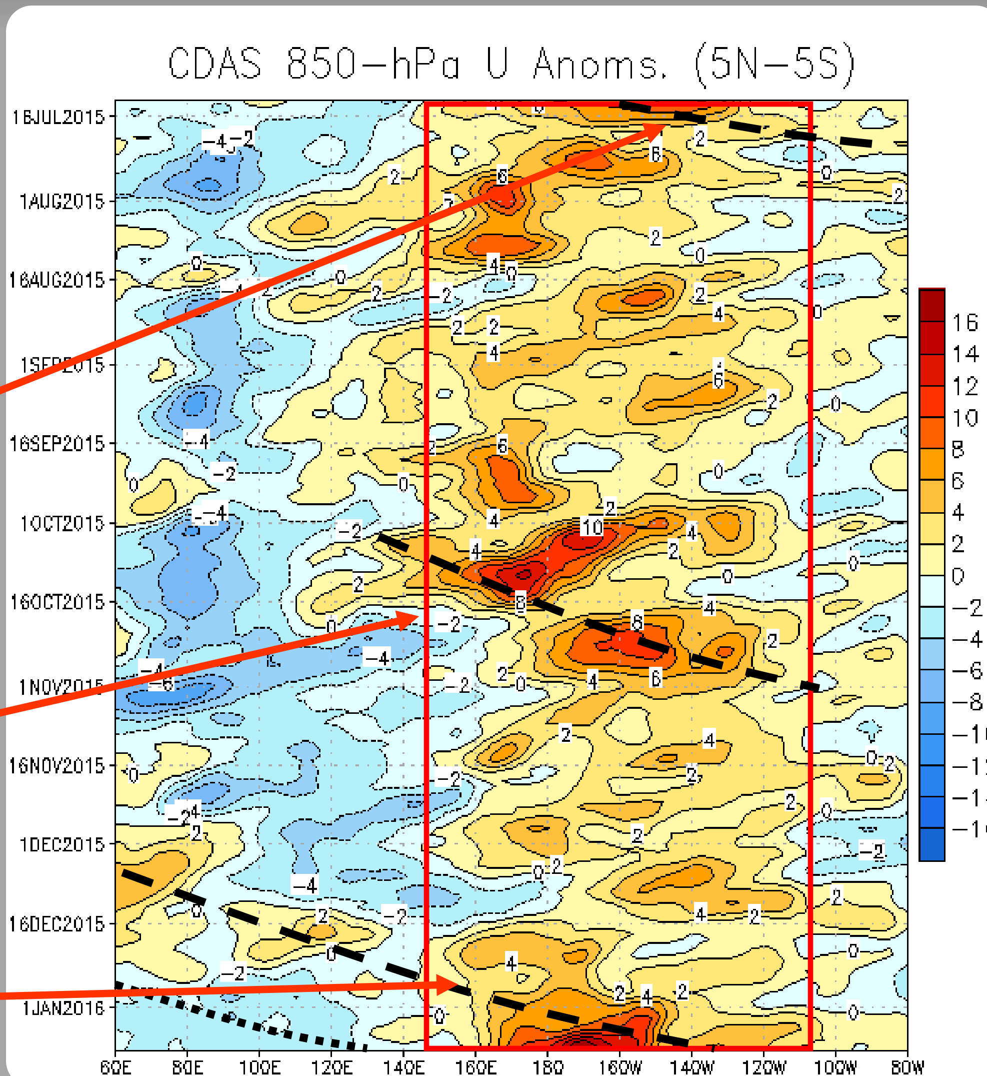
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

A robust MJO event was observed in late June through mid-July. Otherwise, tropical cyclone activity across much of the Pacific provided the primary transient influence on the overall ENSO pattern for much of the NH summer.

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

More recently, renewed MJO activity produced an eastward propagation of westerly anomalies from the Indian Ocean to the central Pacific.



OLR Anomalies – Past 30 days

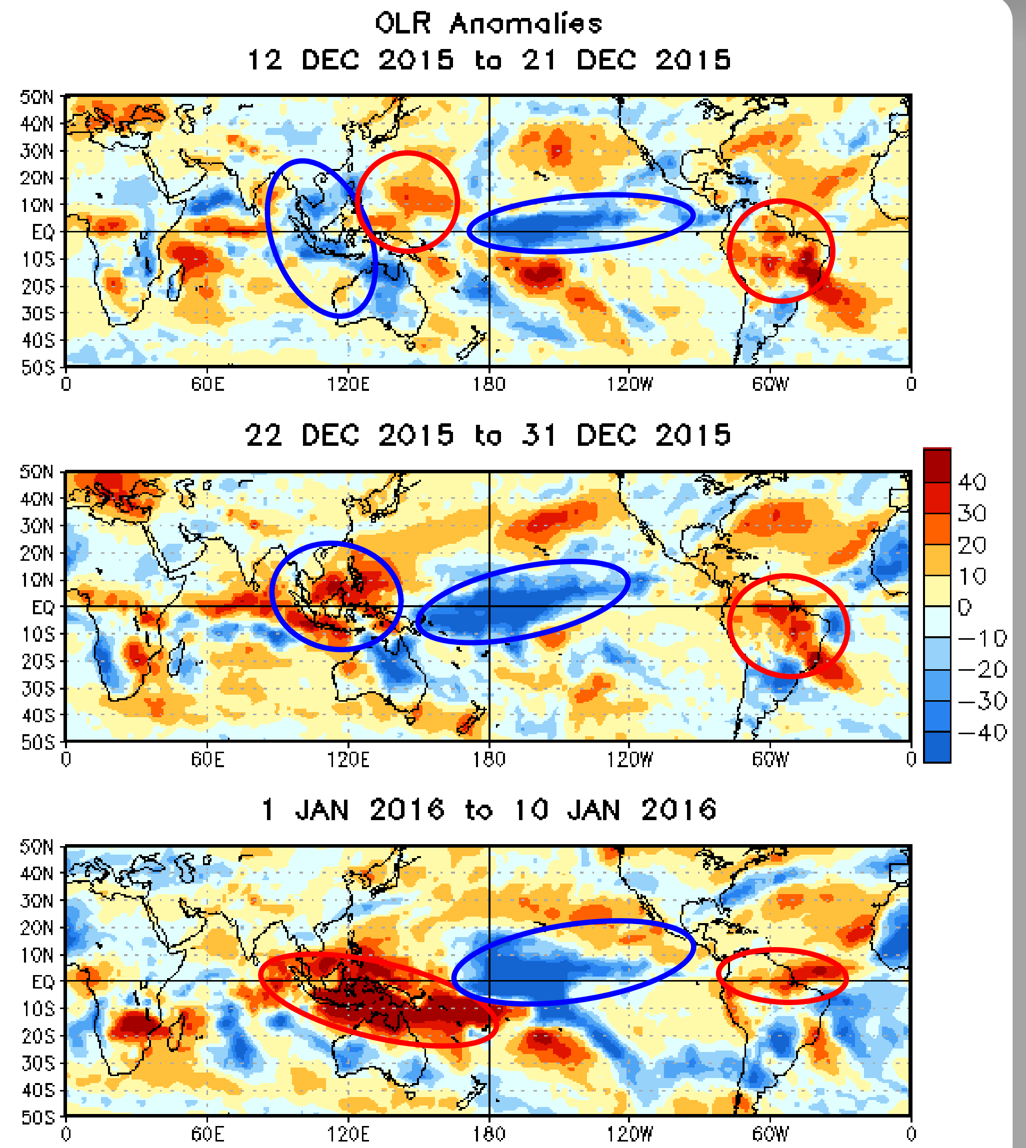
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid-December, the MJO signal was destructively interfering with the ongoing El Nino and enhancing convection over the Maritime Continent.

During later December, suppressed (enhanced) convection returned to the Maritime Continent (western Pacific) as the MJO signal propagated eastward. Suppressed convection continued over Brazil.

During early January, the MJO constructively interfered with the ongoing El Nino, suppressing (enhancing) convection over the Maritime Continent/western Pacific (central Pacific). Some influence from the prior interactions is evident in a shifted SPCZ.



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

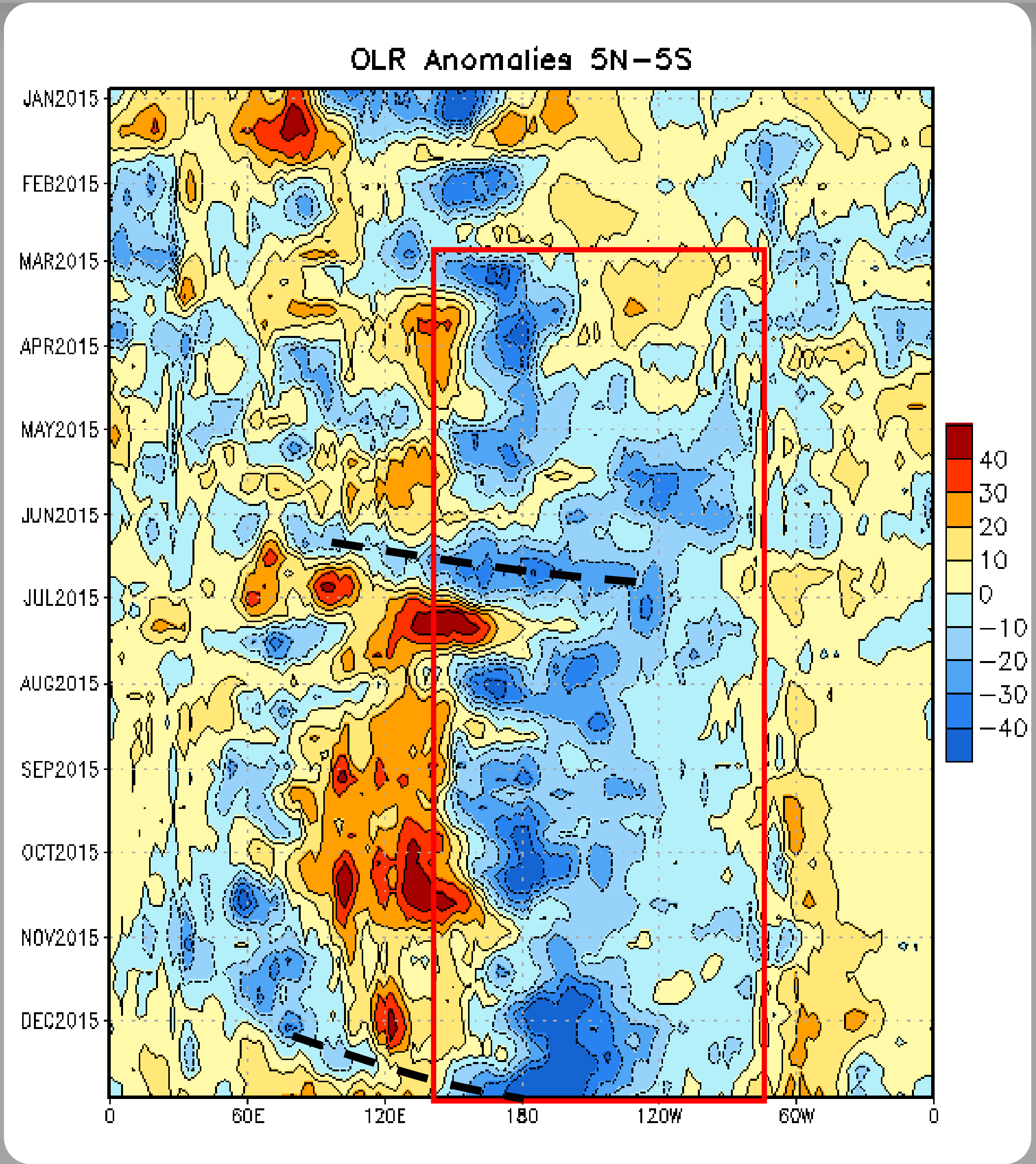
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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, the MJO remained weak, although some subseasonal activity did modulate the pattern of tropical convection during October.

During December, the MJO became active again, with the enhanced phase propagating from the Indian Ocean to the west-central Pacific during the month. Constructive interference between the MJO and ENSO signals resulted in widespread convection across the central Pacific.



200-hPa Velocity Potential Anomalies (5°S - 5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

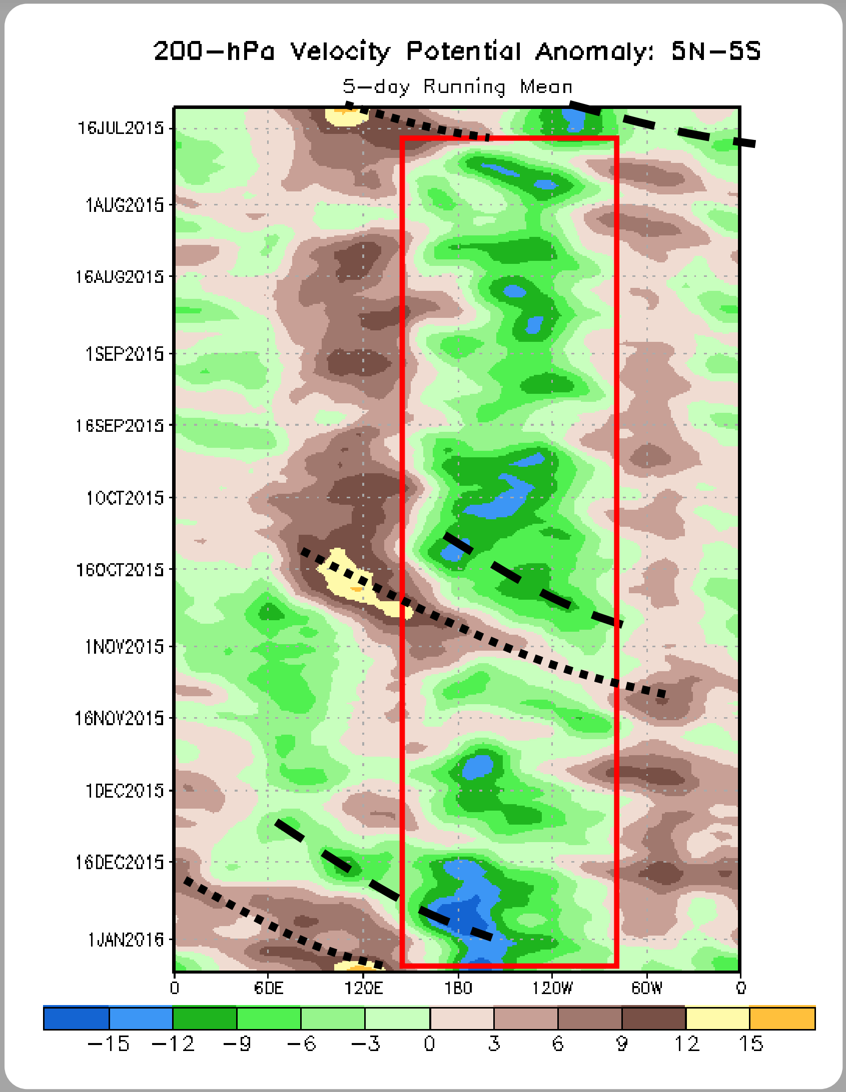
Negative anomalies (green shading) indicate favorable conditions for precipitation

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.

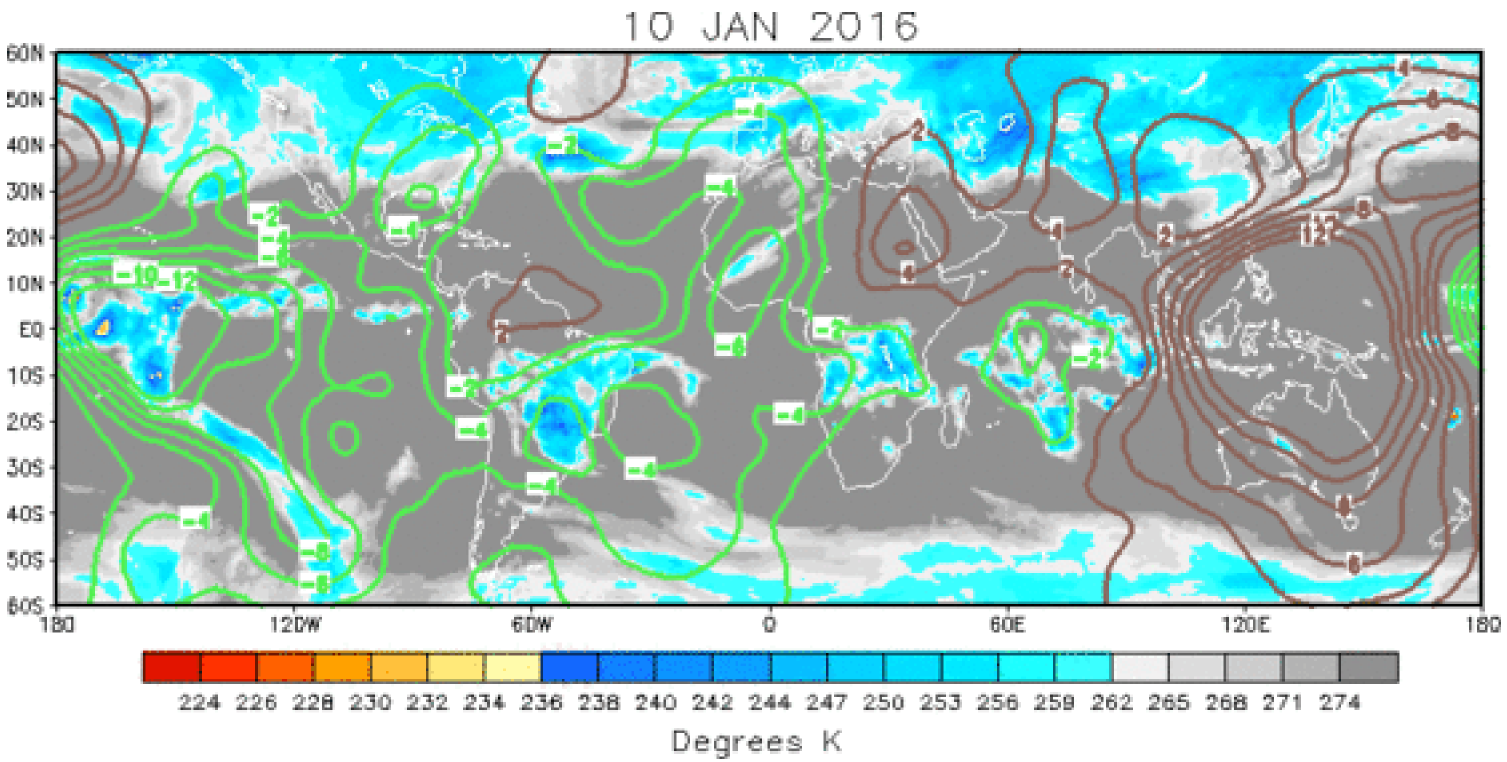
During June and early July, a high-amplitude MJO event was observed, constructively interfering with the El Niño signal in early July.

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 associated with subseasonal activity.

Renewed MJO activity was observed during December and early January, yielding a robust signal in the upper levels. Recently, the MJO signal and the El Nino signal have constructively interfered.



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



The upper-level velocity potential anomaly pattern is coherent as the robust MJO constructively interferes with the El Niño. A Wave-2 pattern is evident, with evidence of influence from other modes of variability. Enhanced upper-level divergence (convergence) is inferred over the Pacific, Africa, and the Indian Ocean (Maritime Continent and Brazil).

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

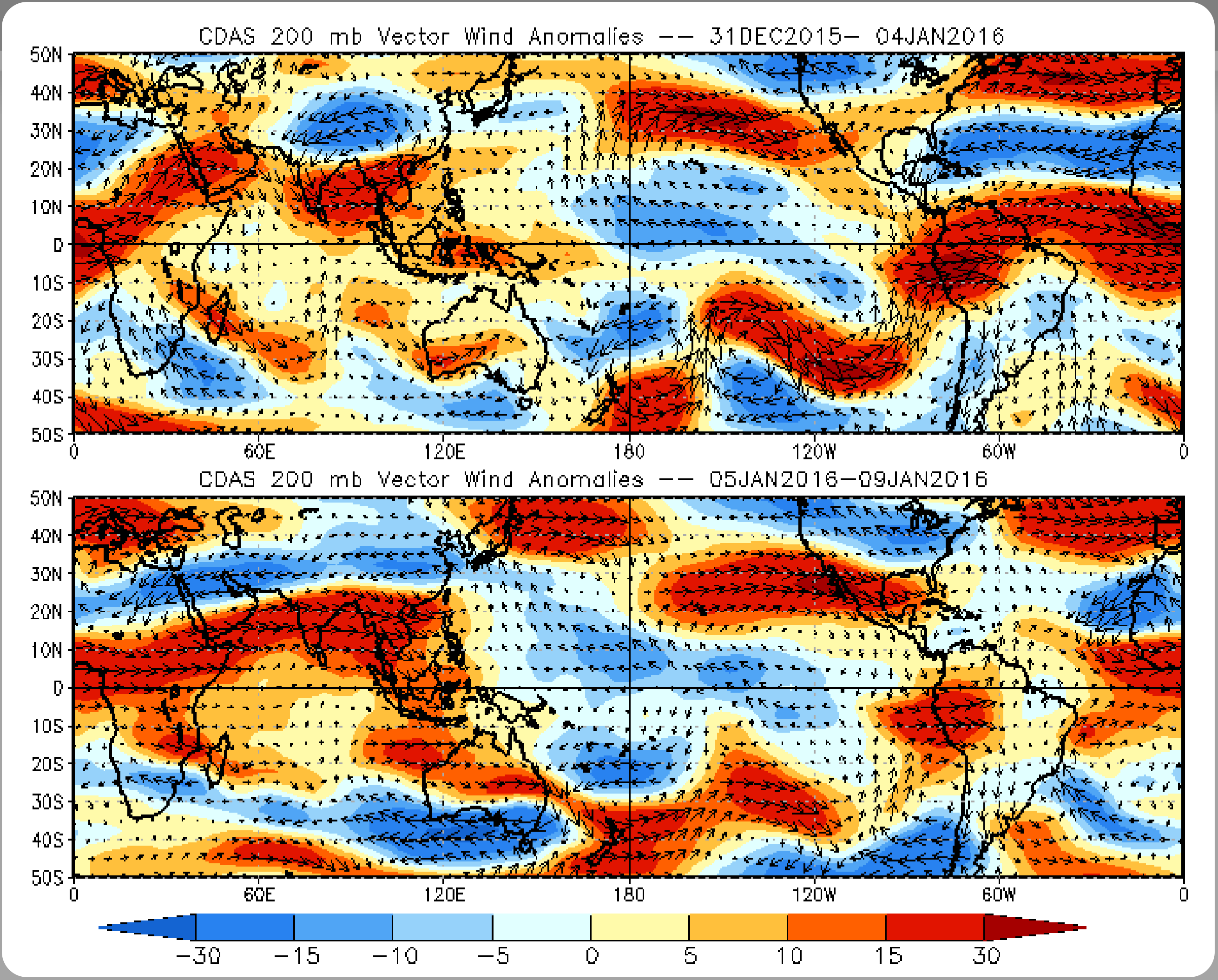
Negative anomalies (green contours) indicate favorable conditions for precipitation

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 westerly anomalies persisted over South Asian and the Maritime Continent.

Strong upper-level meridional divergence is apparent near and east of the Date Line.

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

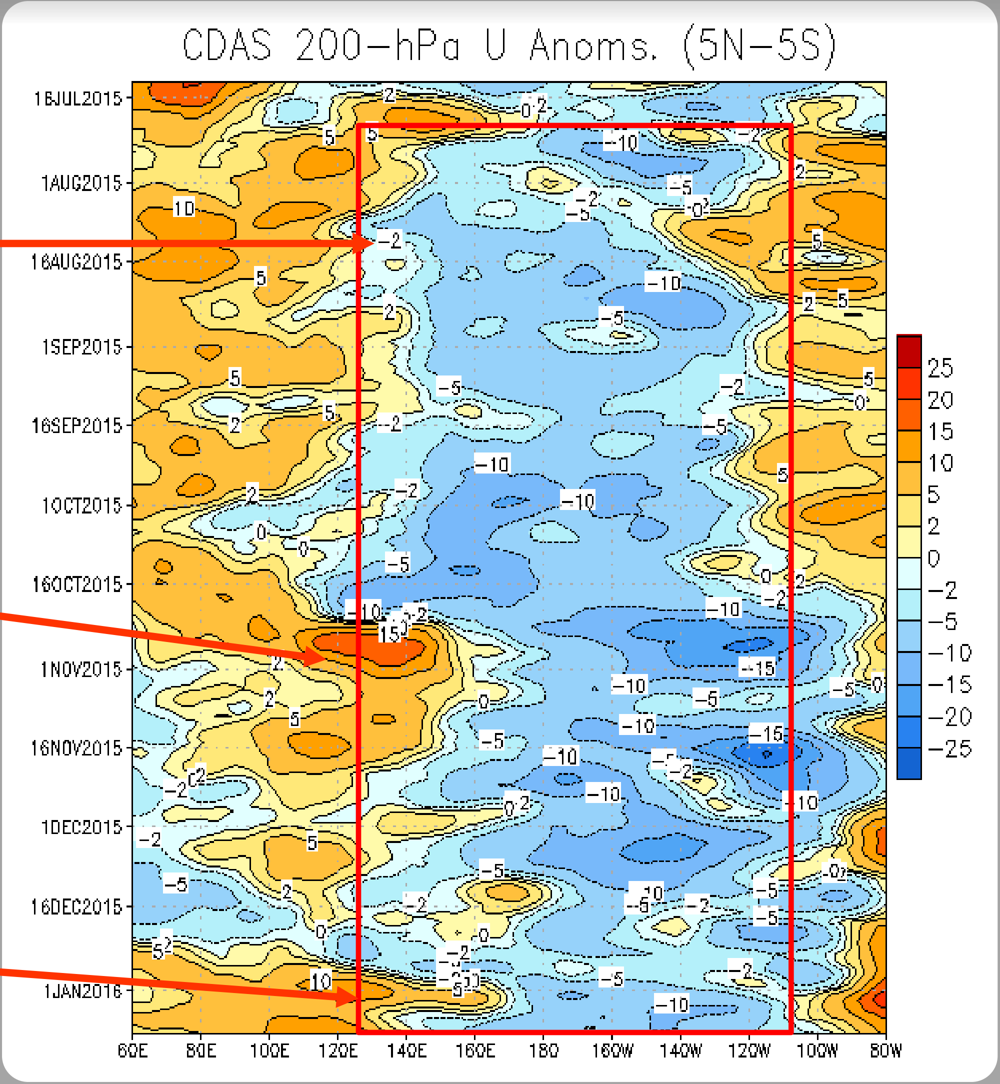
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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 June and July, these easterly anomalies were briefly interrupted by robust atmospheric Kelvin wave/MJO activity.

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.



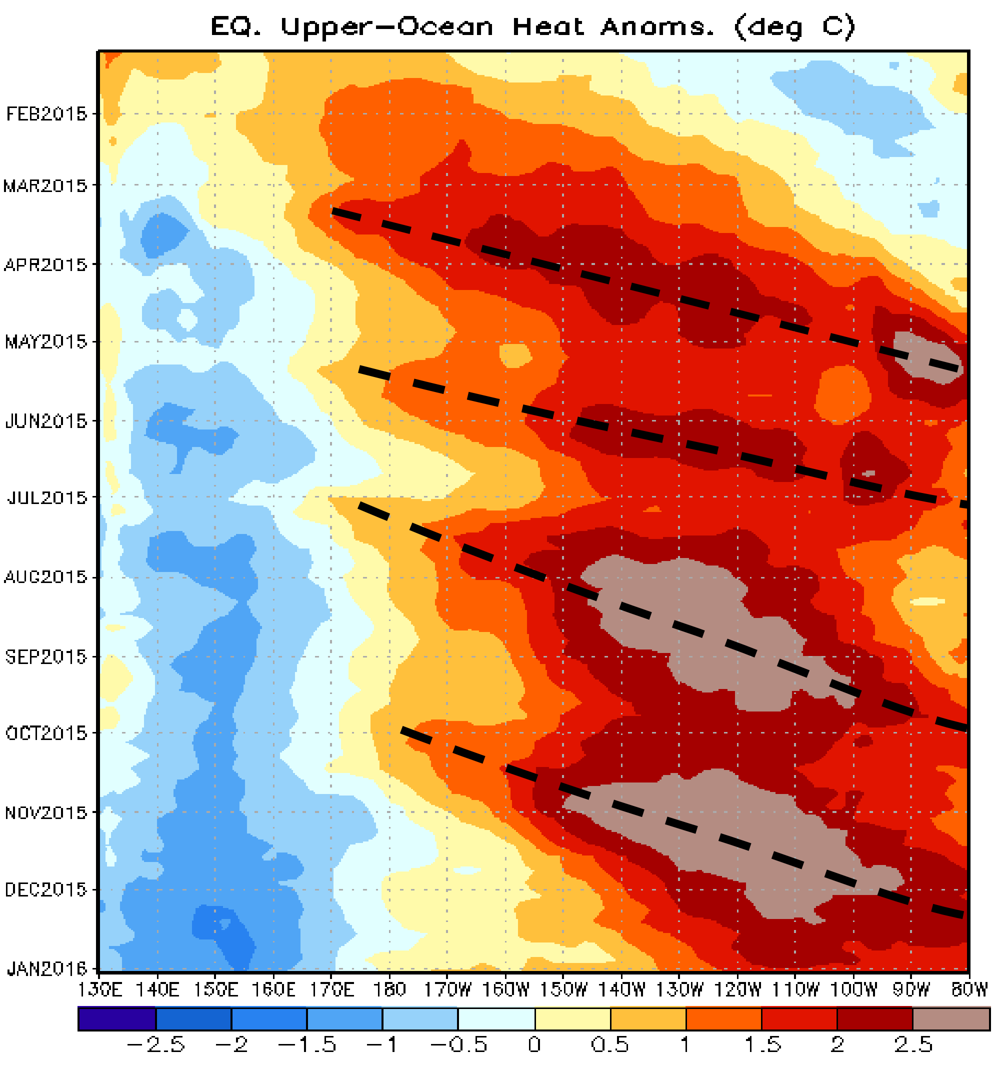
Weekly Heat Content Evolution in the Equatorial Pacific

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.



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

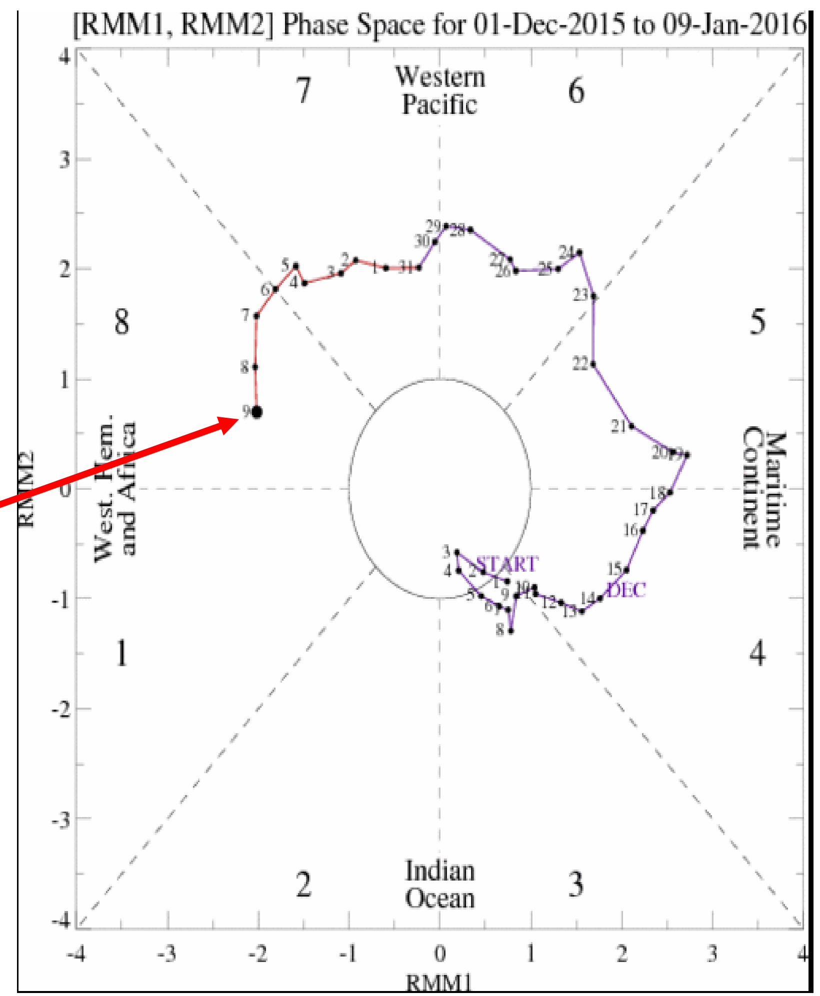
The triangular areas indicate the location of the enhanced phase of the MJO

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

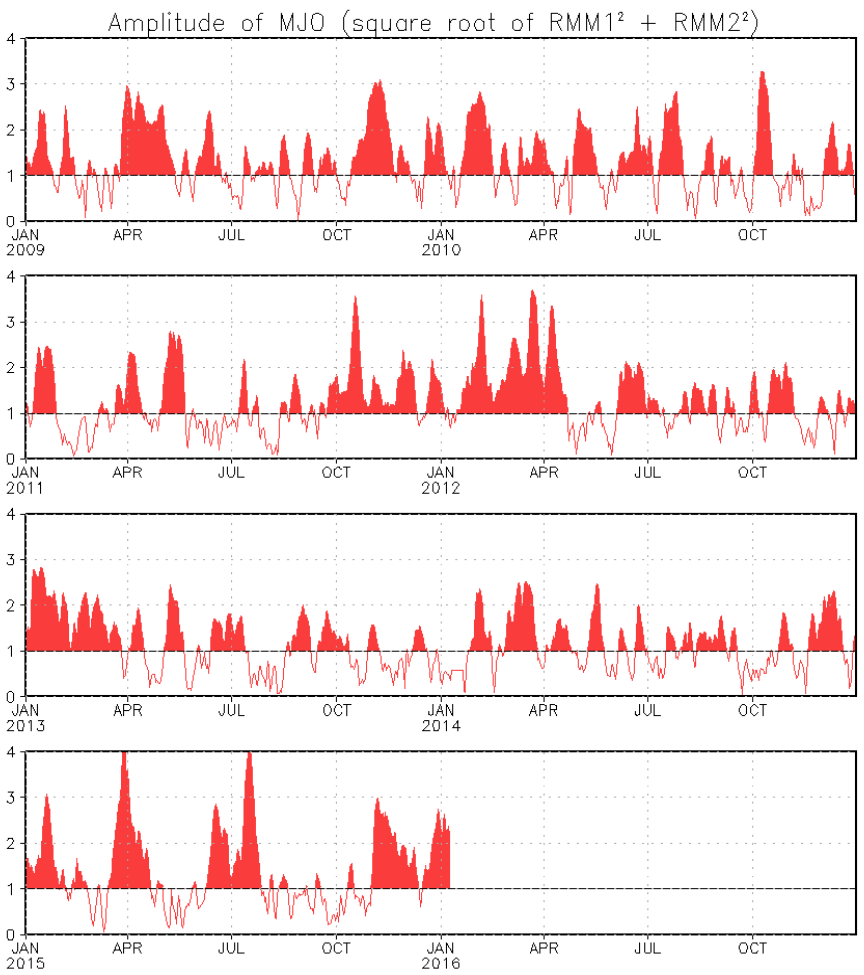
The MJO index remained highly amplified, with continued eastward propagation across the Pacific during the past week.



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

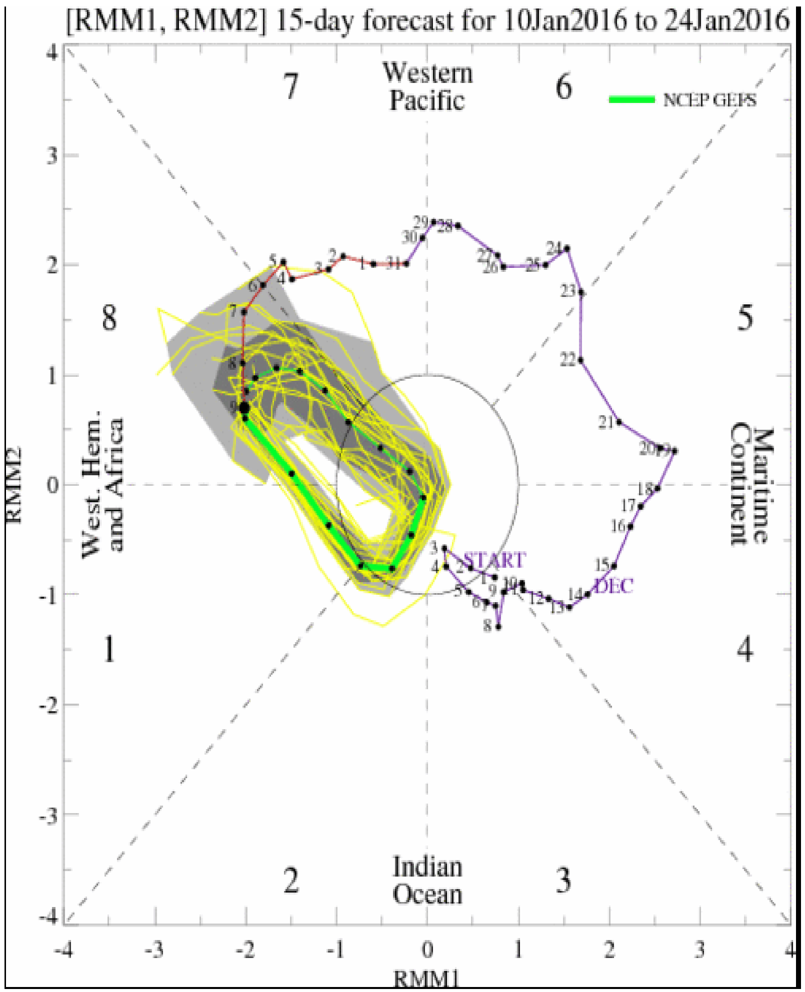
__Yellow Lines__ - 20 Individual Members
__Green Line__ - Ensemble Mean

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

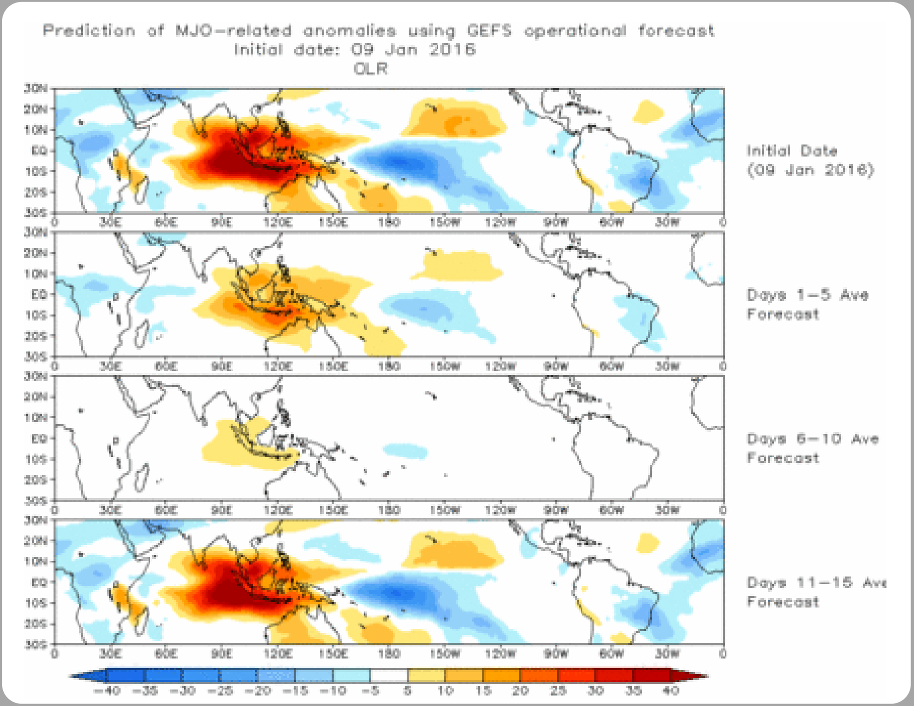
The GFS ensemble MJO index forecast depicts a fast propagation during Week-1, a weakening signal during early Week-2 with a re-emerging signal later.



Ensemble GFS (GEFS) MJO Forecast

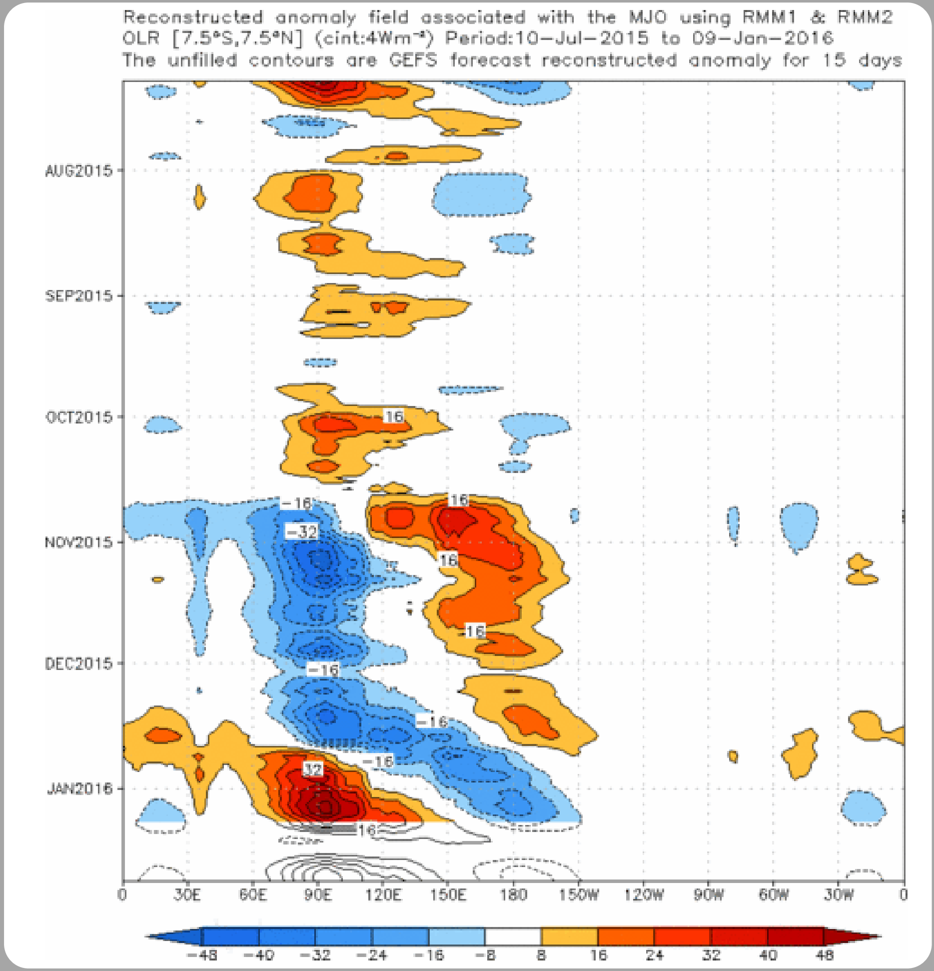
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS MJO index-based OLR forecast depicts a high amplitude anomaly pattern early in the period, with weakening, then re-emerging later in Week-2.

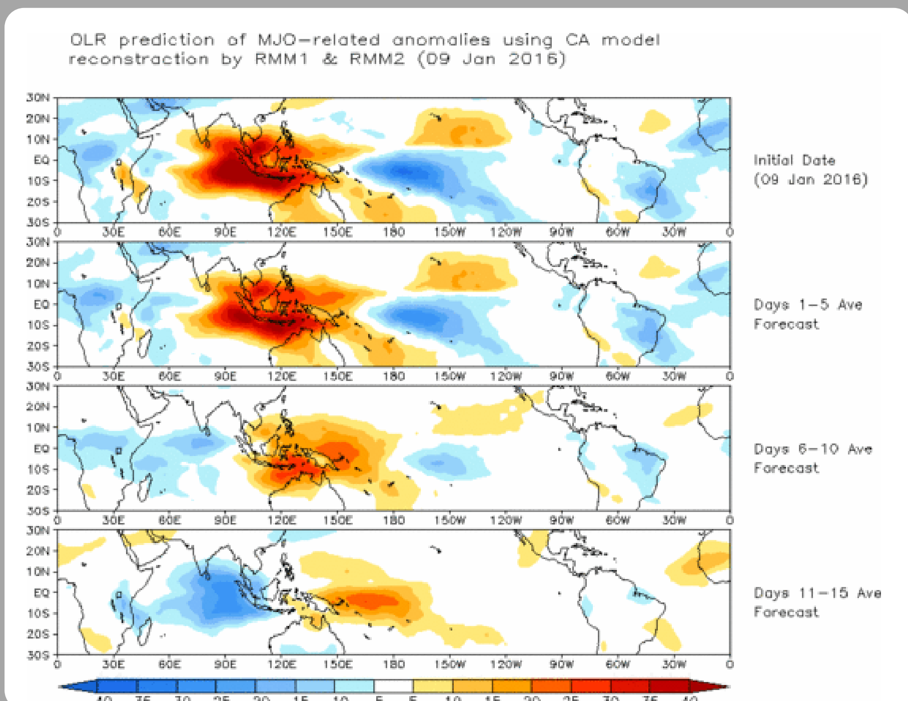
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



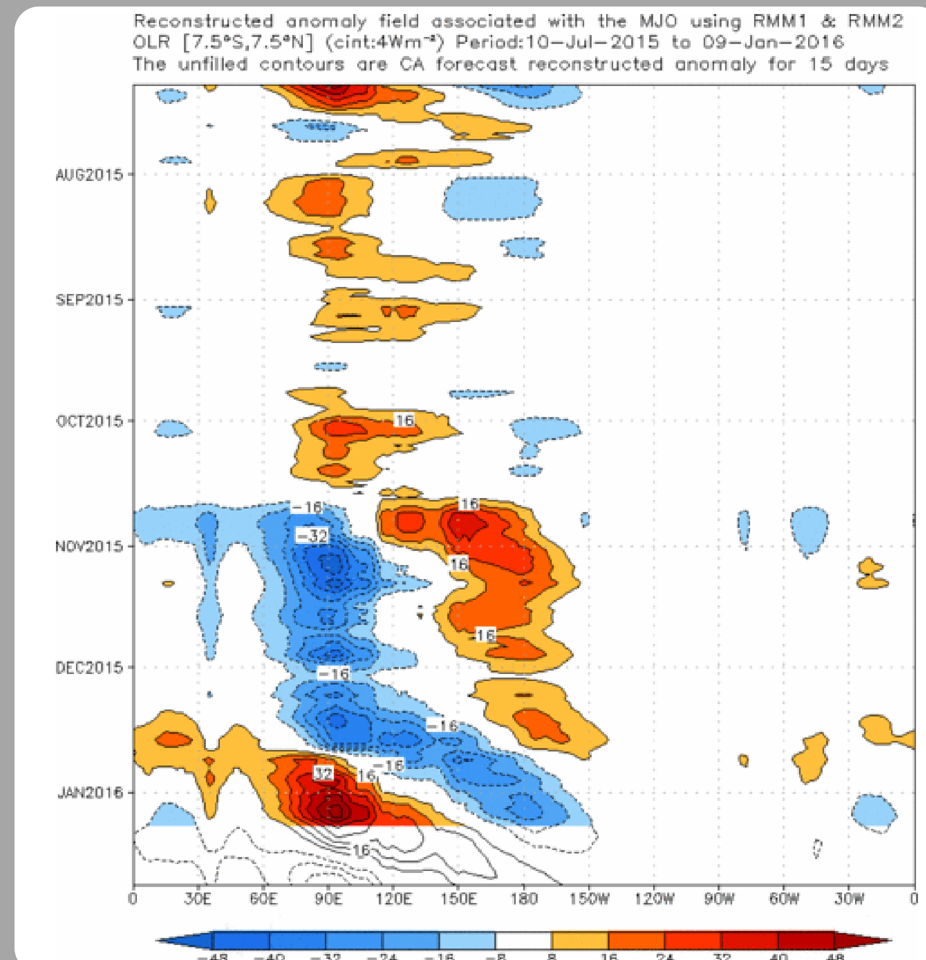
Constructed Analog (CA) MJO Forecast

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



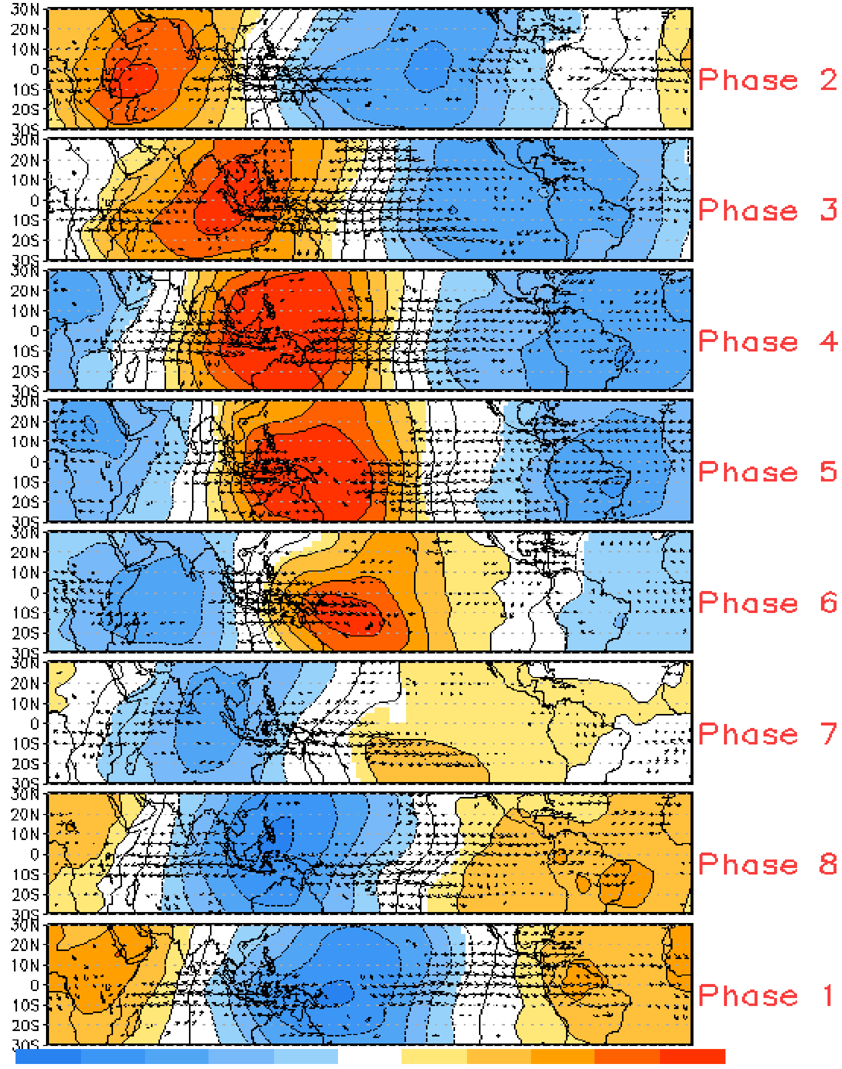
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



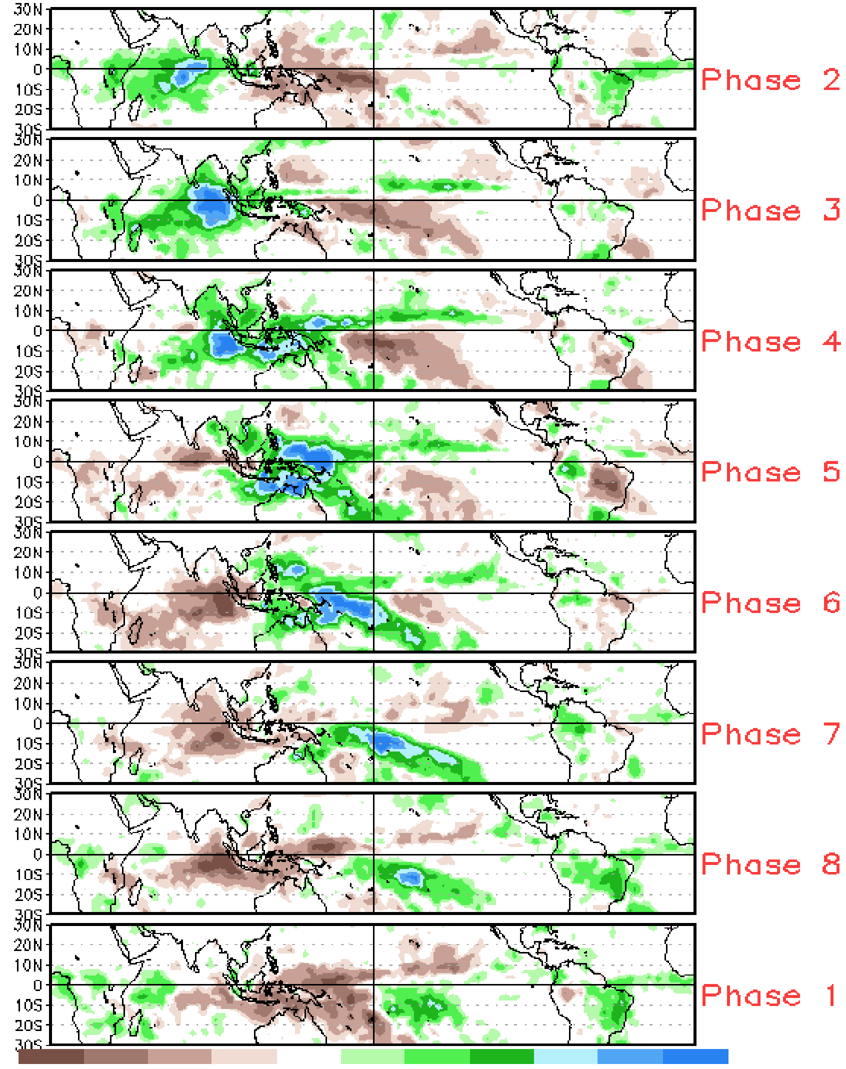
The constructed analog model depicts a more robust eastward propagation of moderate strength OLR anomalies.

MJO Composites - Global Tropics

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



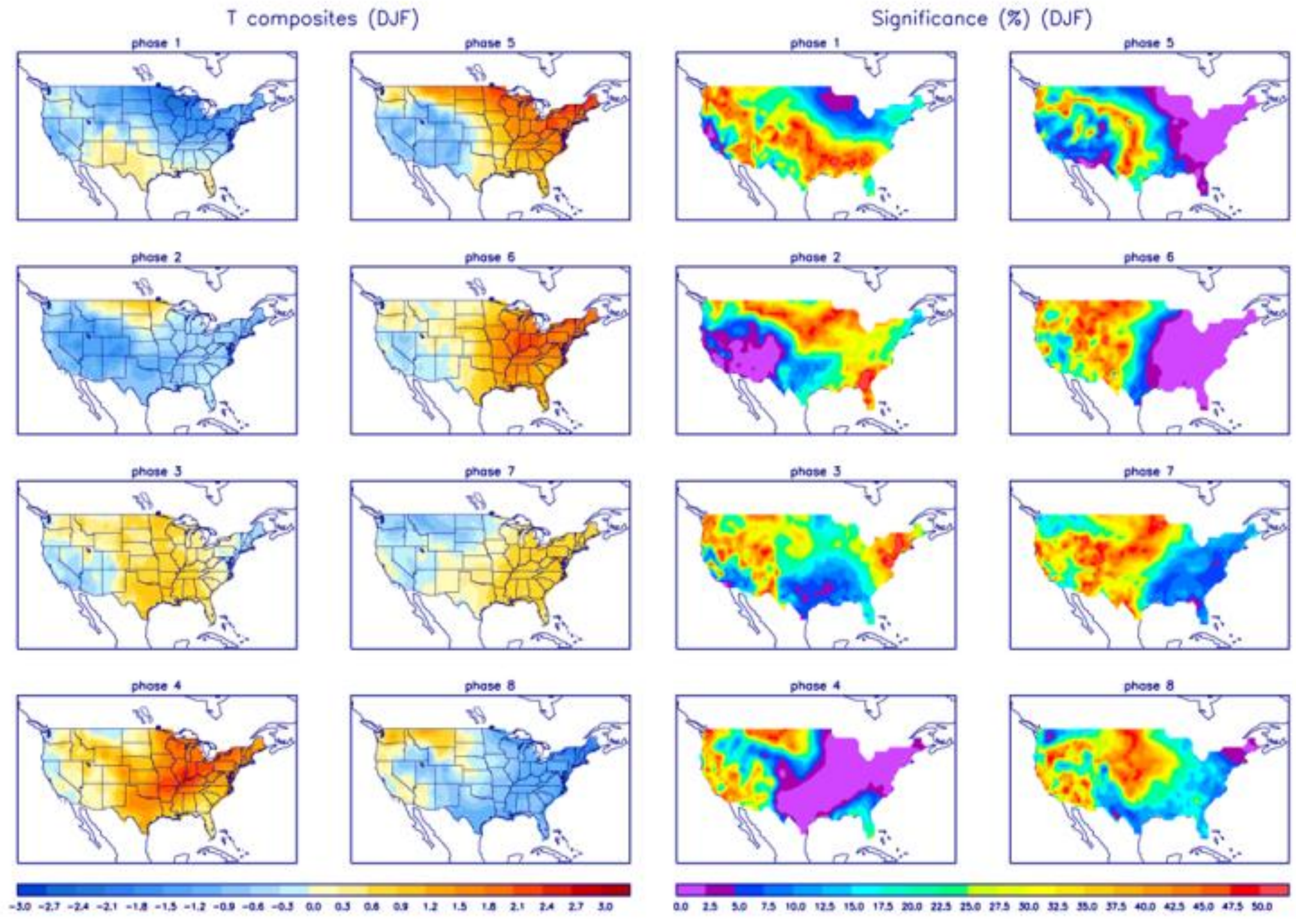
Precipitation Anomalies (Nov-Mar)



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.



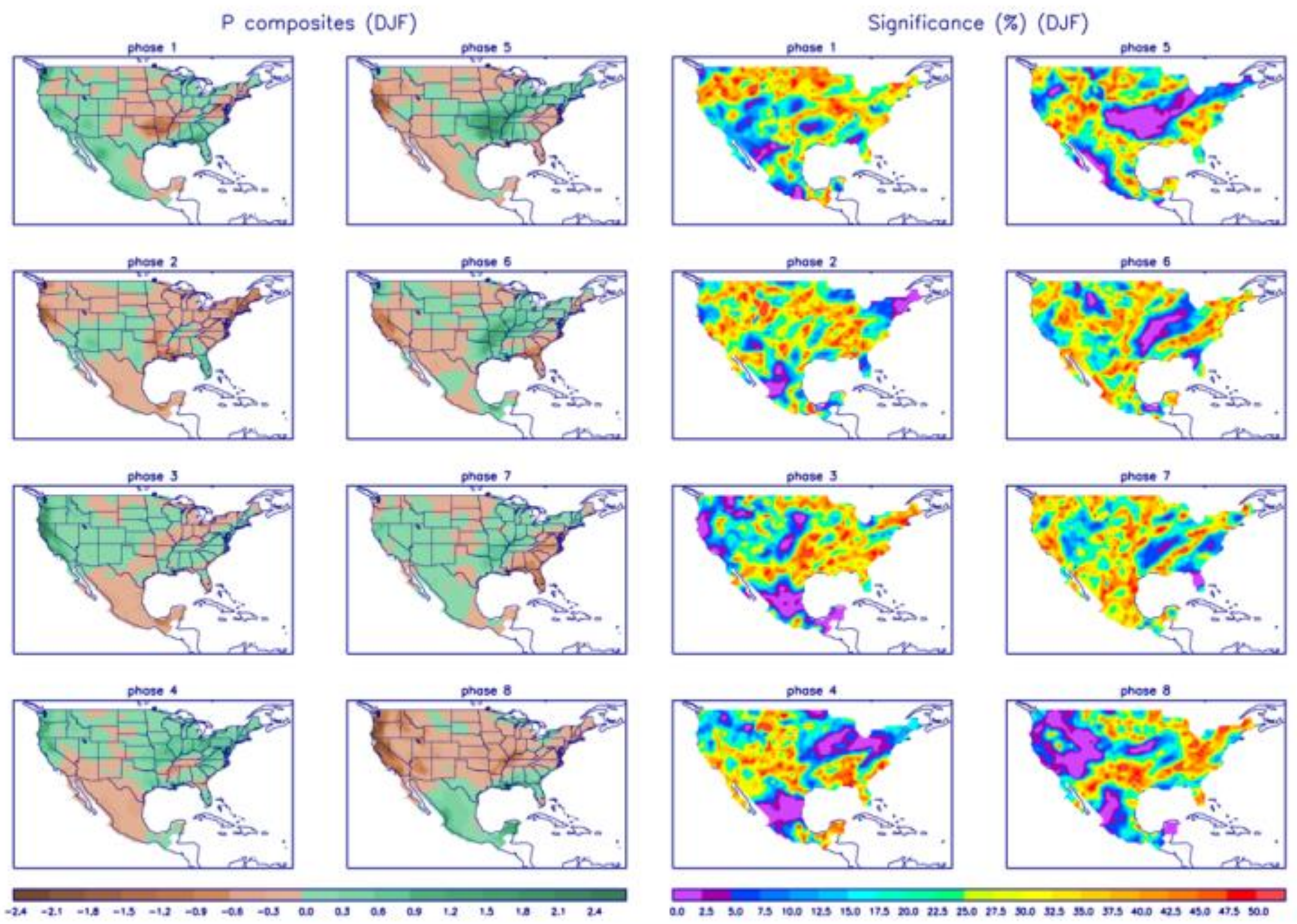
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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