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

Update prepared by:
Climate Prediction Center / NCEP
30 November 2015

Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

The MJO remained weak during the past week.

Equatorial Rossby Wave (ERW) activity over the west-central Pacific and slowly re-emerging atmospheric conditions consistent with El Niño are primarily responsible for the current pattern of tropical anomalous convection.

Dynamical model forecasts of the MJO index indicate a general weakening MJO signal over the next two weeks, although some models do indicate some eastward movement during the period.

The MJO is not anticipated to play a significant role in the evolution of the global tropical convective pattern during the next two weeks.

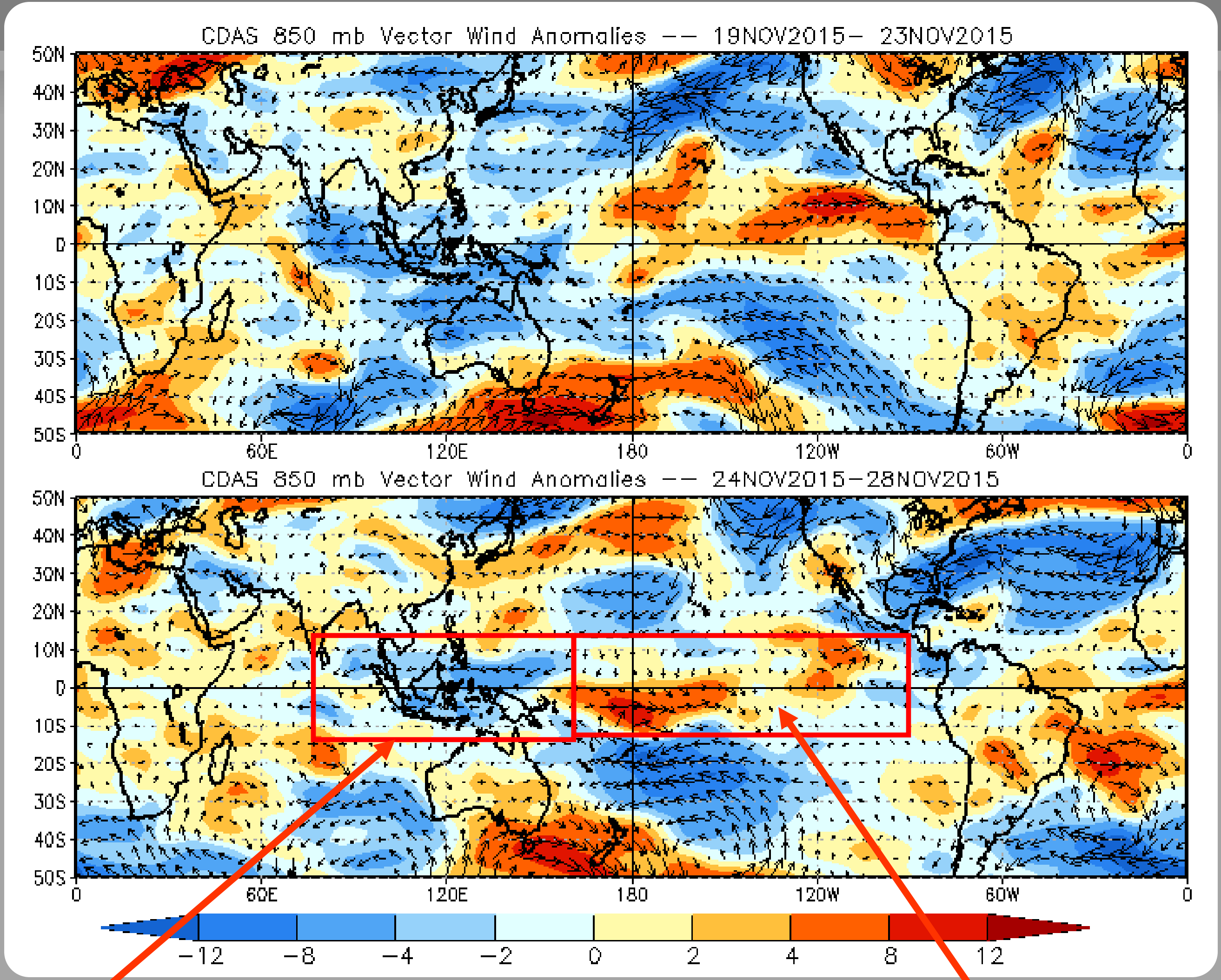
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

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

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



Easterly anomalies persisted over the eastern Indian Ocean and Maritime Continent during the latest five days.

Westerly anomalies persisted across areas of the central and eastern Pacific during the last five days.

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

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

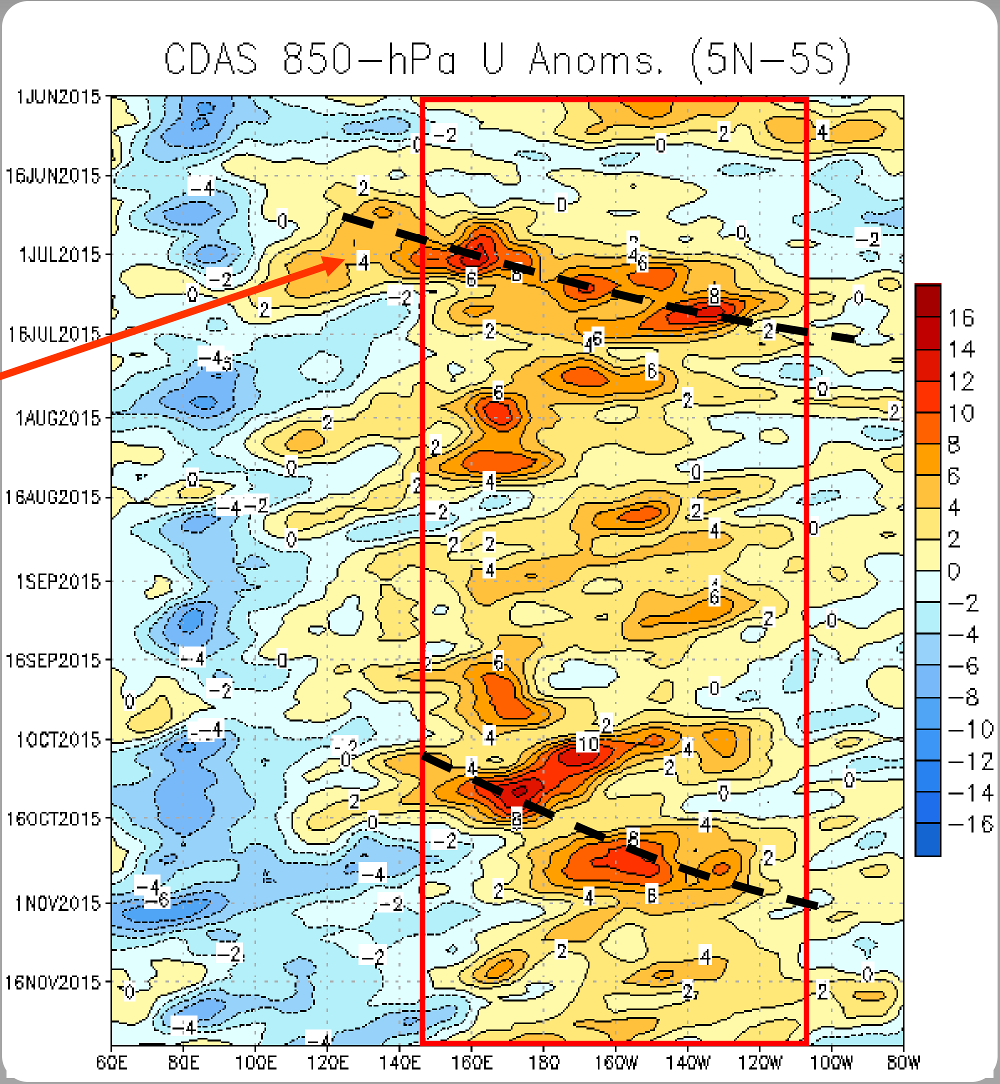
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

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.

The entire pattern continues to show a slow eastward shift over time.



OLR Anomalies – Past 30 days

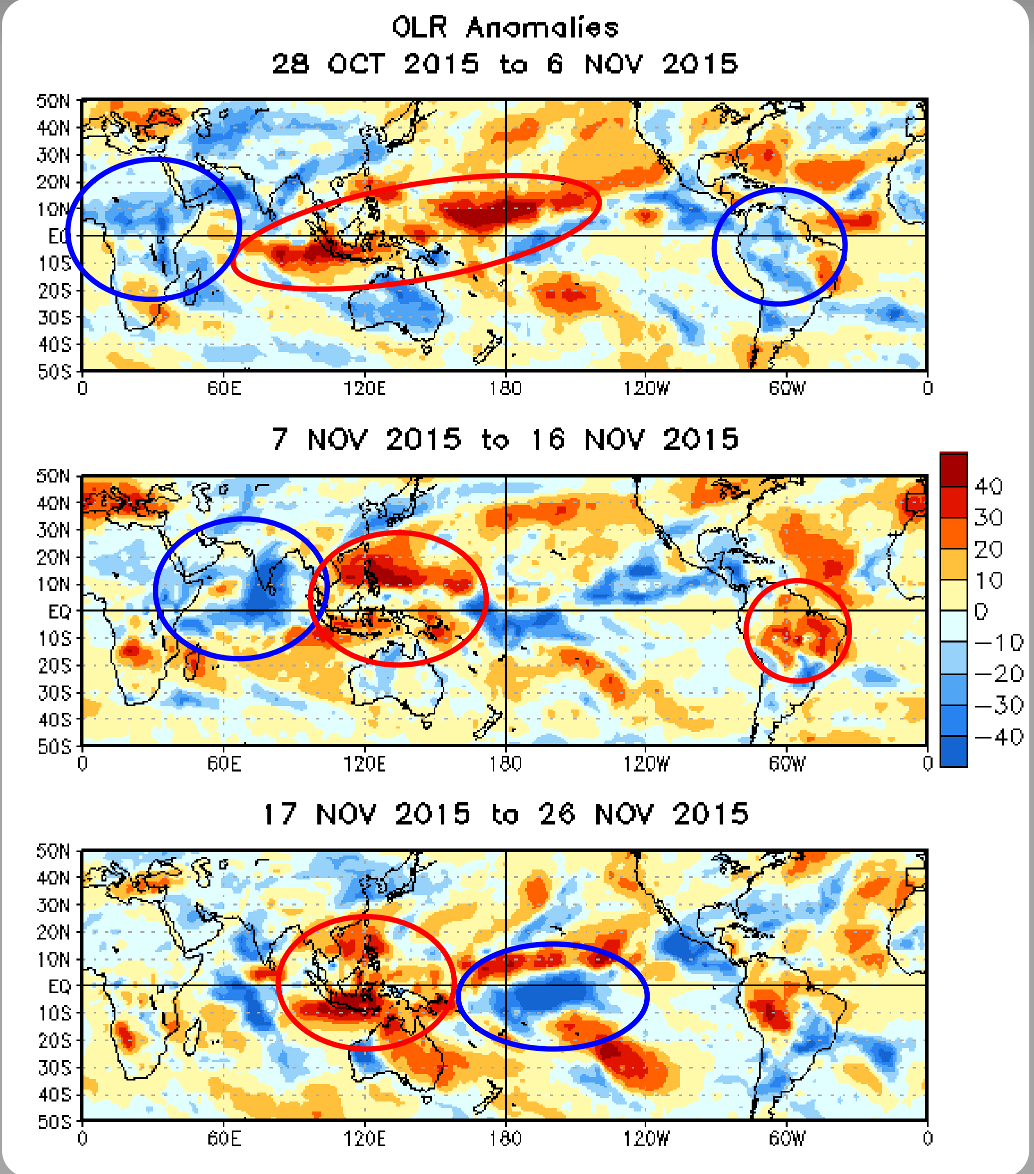
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

Enhanced convection was evident across central Africa and parts of northern South America while suppressed convection stretched from the Maritime Continent to the Central Pacific. Enhanced convection was limited over the central/eastern Pacific.

Enhanced (suppressed) convection was evident over the central Indian Ocean (Maritime continent) during early-mid November. Enhanced convection increased in the central and eastern Pacific while suppressed convection developed over northern South America.

Suppressed convection persisted over the Maritime Continent during mid-late November. Enhanced convection intensified in the central Pacific during the period.



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

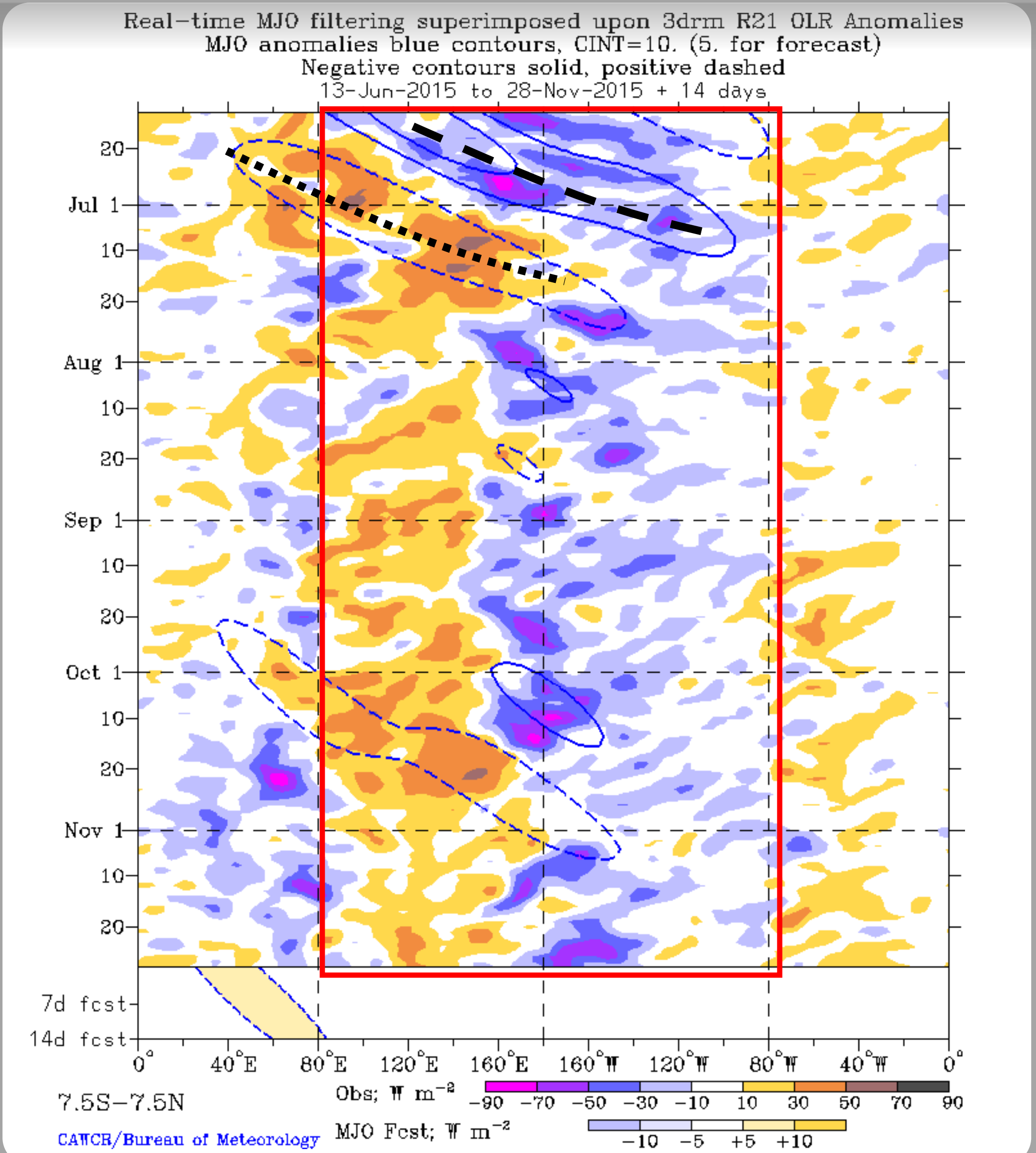
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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 become active, interfering with the ENSO signal at times. Since July, the MJO has remained weak, with strong El Niño conditions and tropical cyclone activity dominating the pattern.

A couplet of enhanced/suppressed convection intensified over the western Indian Ocean/Maritime Continent early in October. Enhanced convection has remained over the Indian Ocean but the suppression over the Maritime Continent is weaker during November.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

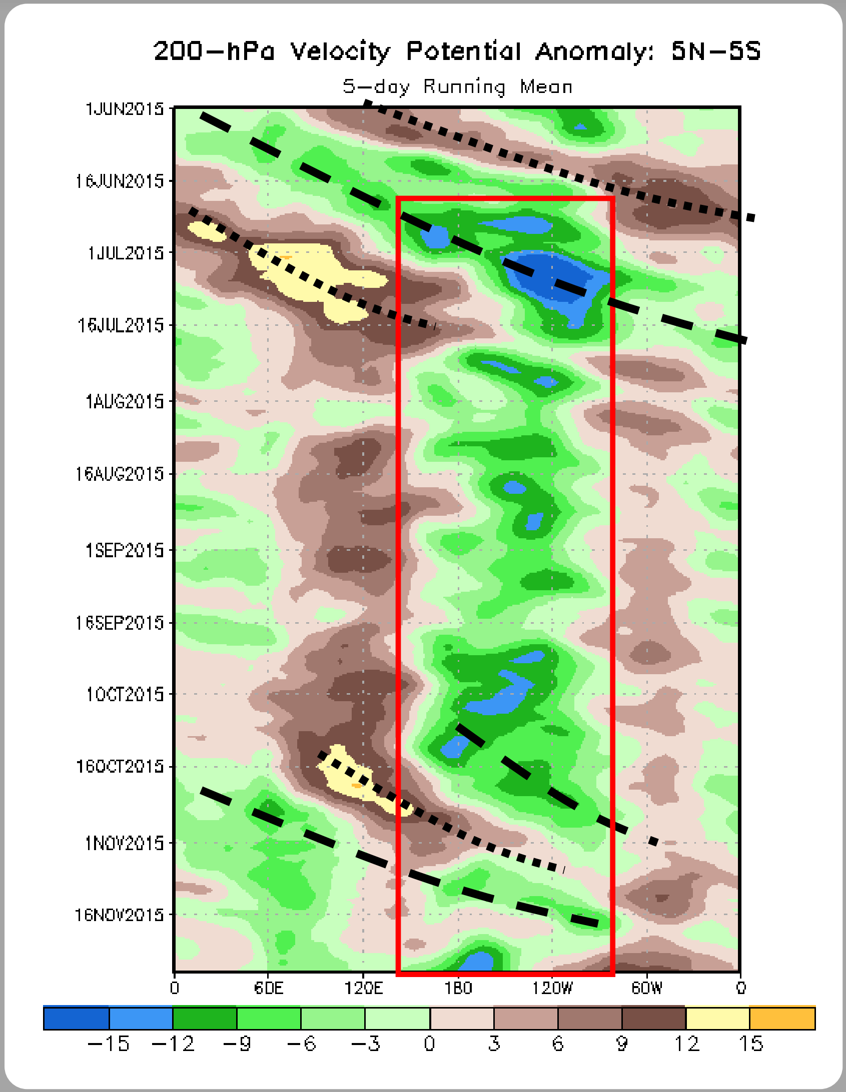
Negative anomalies (green shading) indicate favorable conditions for precipitation

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

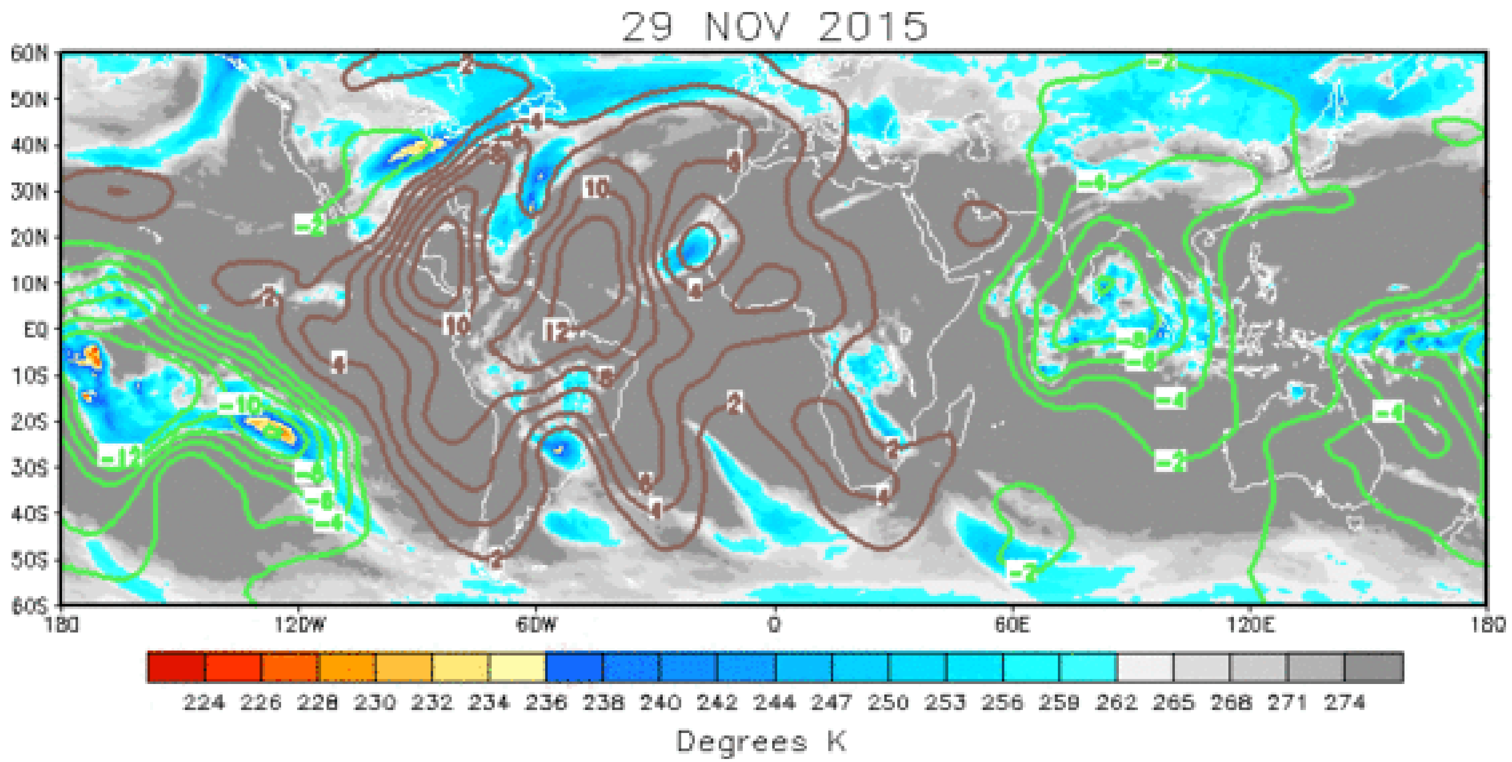
During June and early July, a high-amplitude MJO event was observed, constructively interfering with the El Niño signal in early July.

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 followed by evidence of equatorial Rossby Wave and Kelvin wave activity impacting the central Pacific. Most recently, strong enhanced divergence is once again evident near the Date Line.



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



The upper-level velocity potential anomaly pattern once again resembles a more 'Wave-1' pattern, with strong anomalous upper-level divergence primarily centered over the central Pacific and upper-level convergence centered across the Atlantic.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

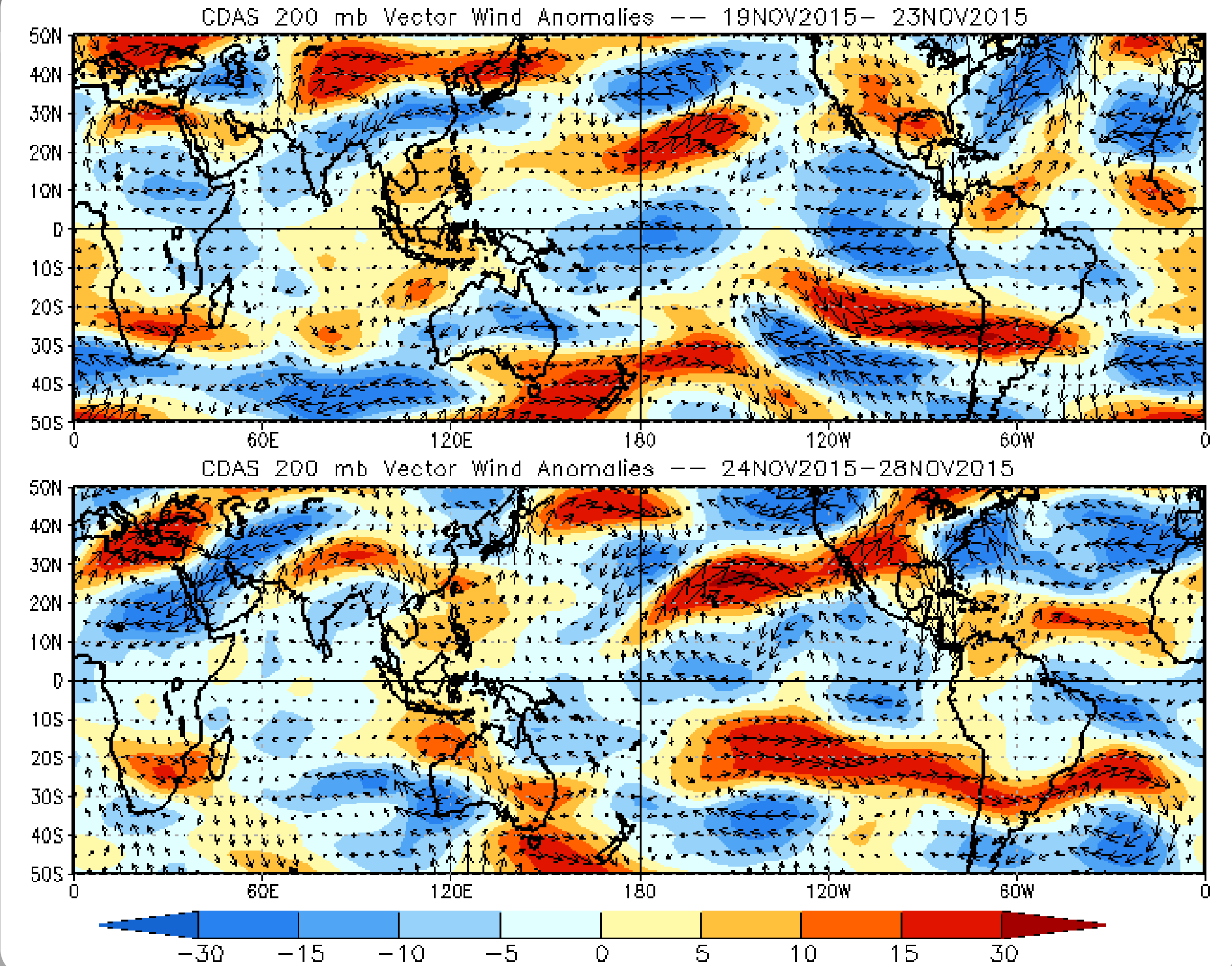
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly (westerly) anomalies remain somewhat weak over the central Pacific (Maritime Continent) during the past five to ten days indicative of the impacts of subseasonal variability during much of November.

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

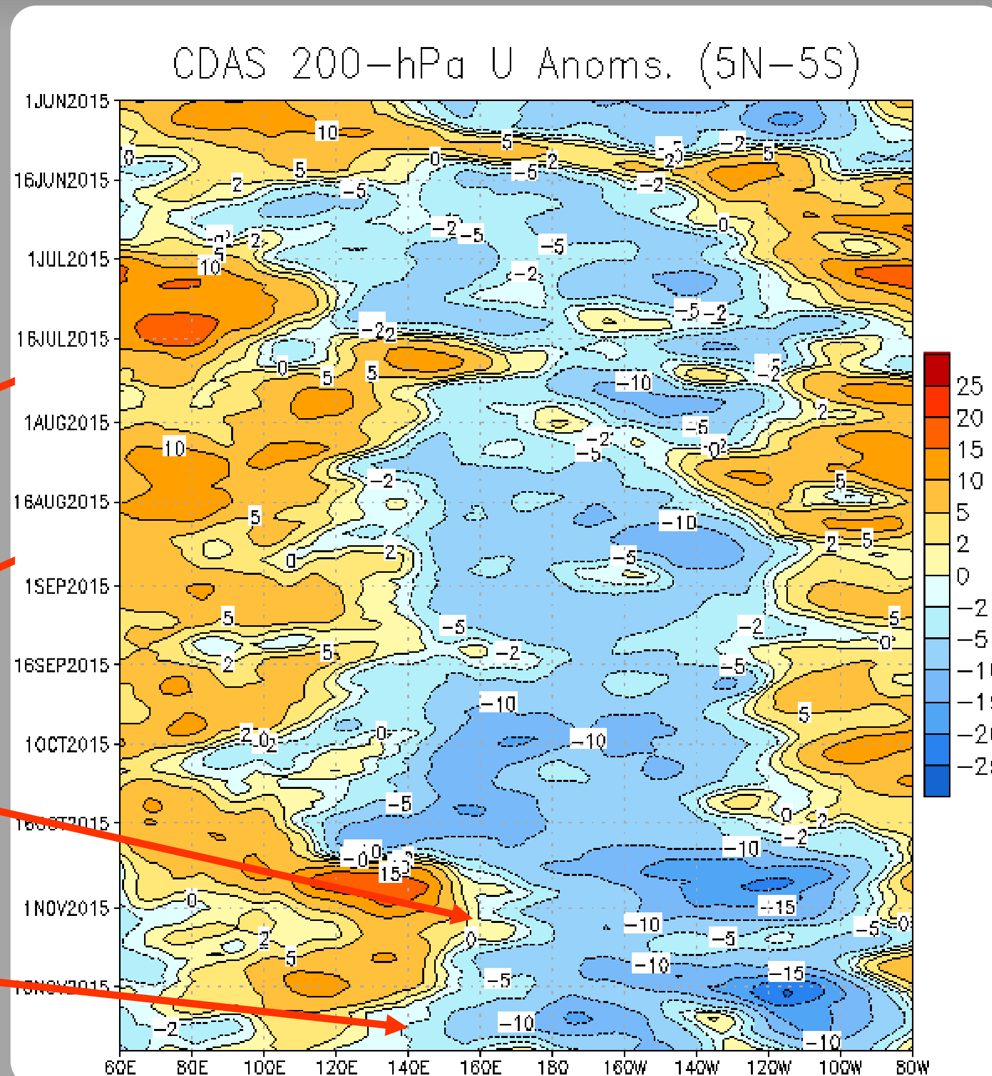
Easterly anomalies have persisted over the central and eastern Pacific associated with El Niño since mid-June (red box).

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

During August, some westward propagation of westerly anomalies from the Maritime Continent to the Indian Ocean was evident.

During late October, an eastward shift in the pattern was evident, with westerly anomalies propagating as far as 160E.

Recently, Equatorial Rossby wave activity was evident, along with a return to conditions more consistent with the ENSO base state.



Weekly Heat Content Evolution in the Equatorial Pacific

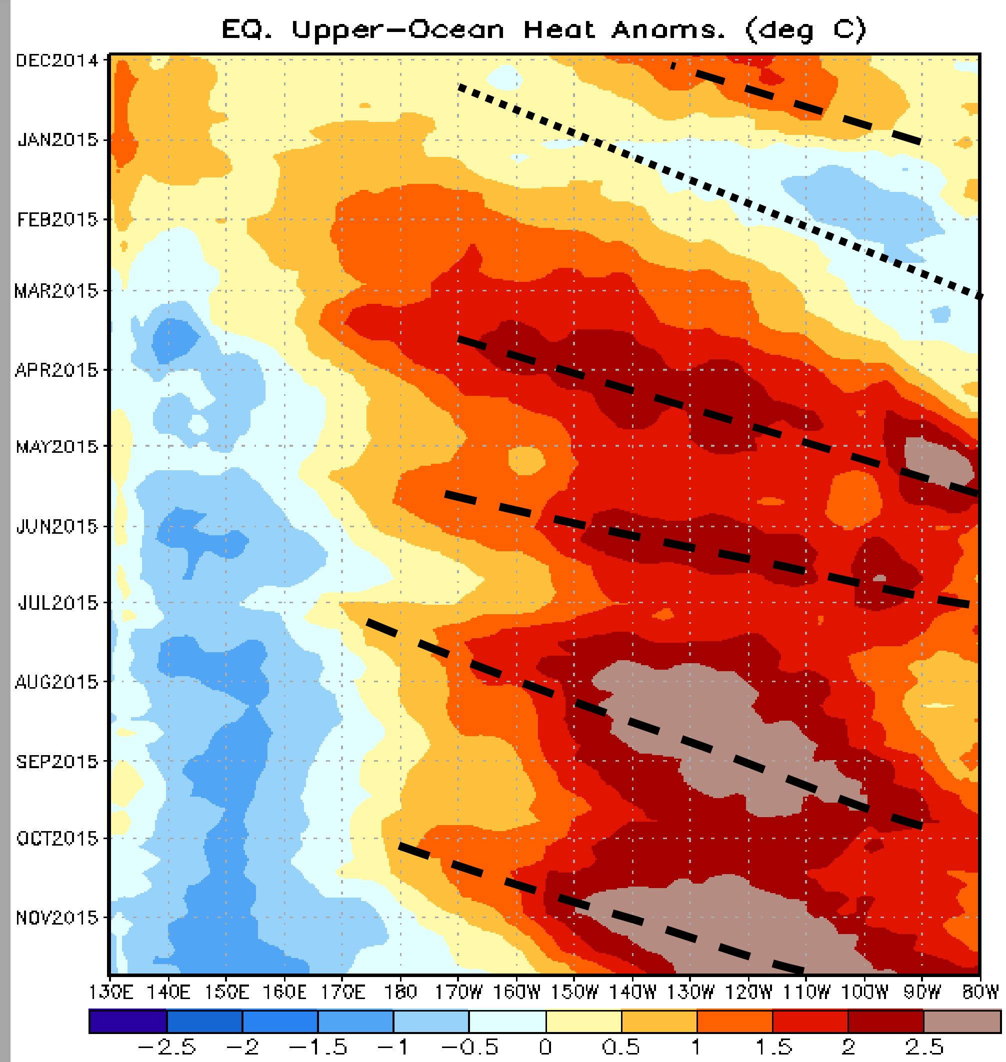
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

During November, positive subsurface temperature anomalies increased and shifted eastward in association with the downwelling phase of a Kelvin wave. During November - January, the upwelling phase of a Kelvin wave shifted eastward.

Following a strong westerly wind burst in March, another 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 90W.

There is also an expansion of below average heat content over the western Pacific, and a general eastward progression evident.



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

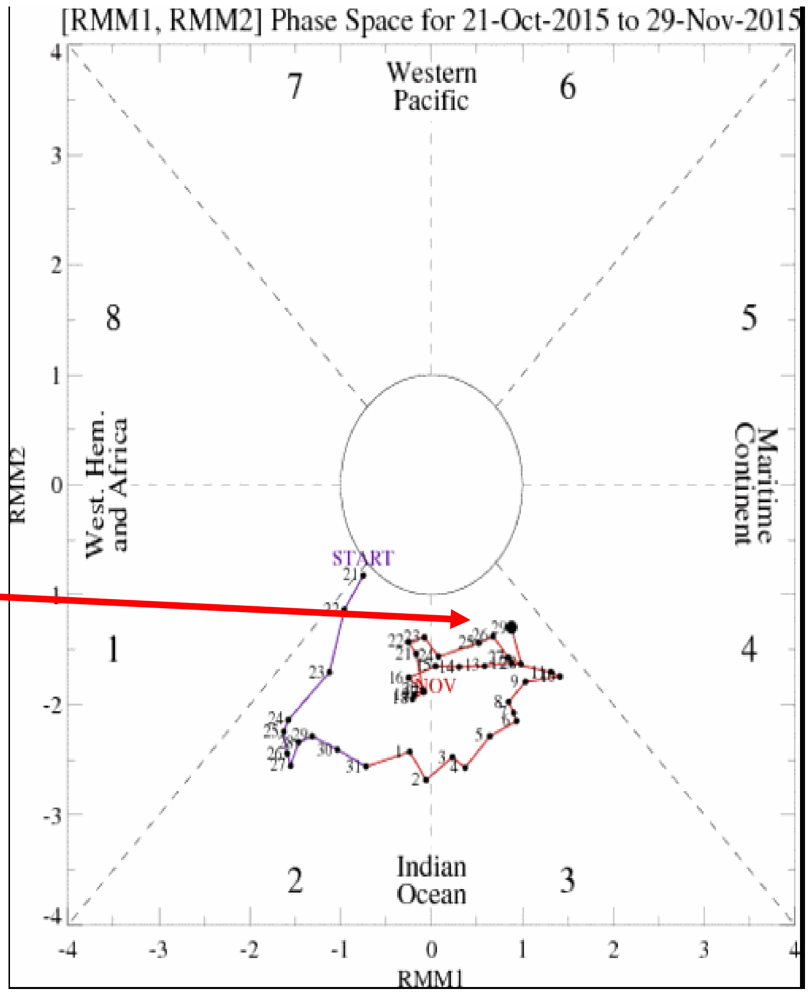
The triangular areas indicate the location of the enhanced phase of the MJO

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

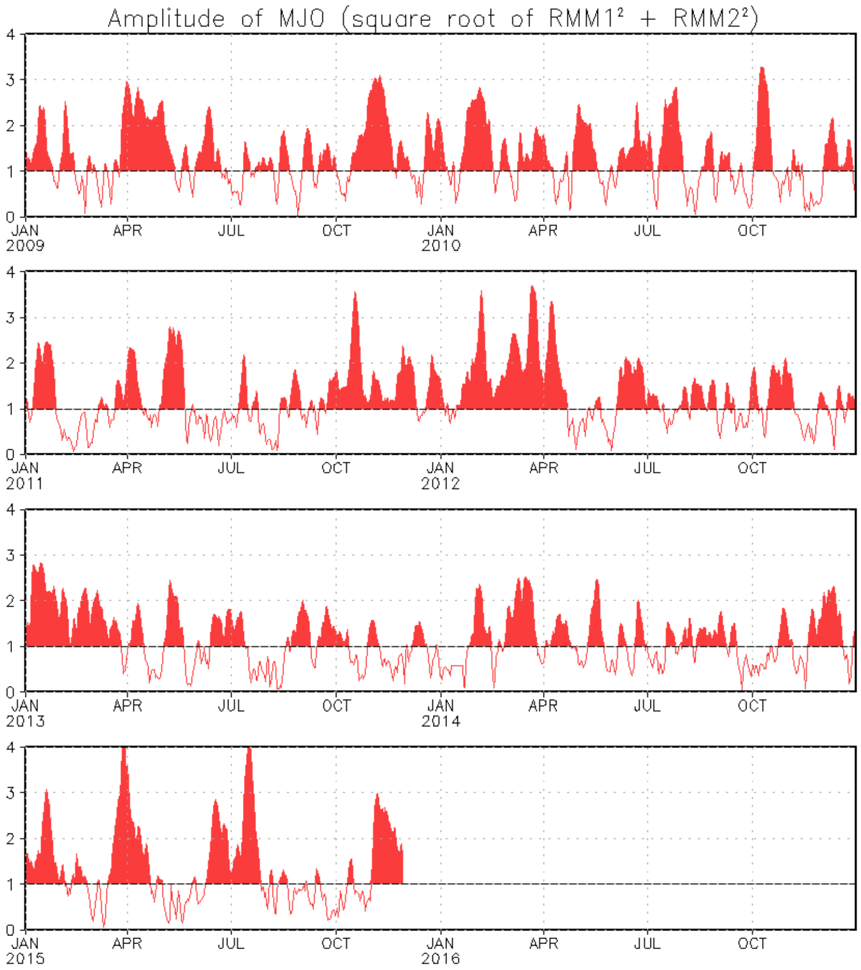
The RMM index has shown on minor eastward propagation over the last two weeks.



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

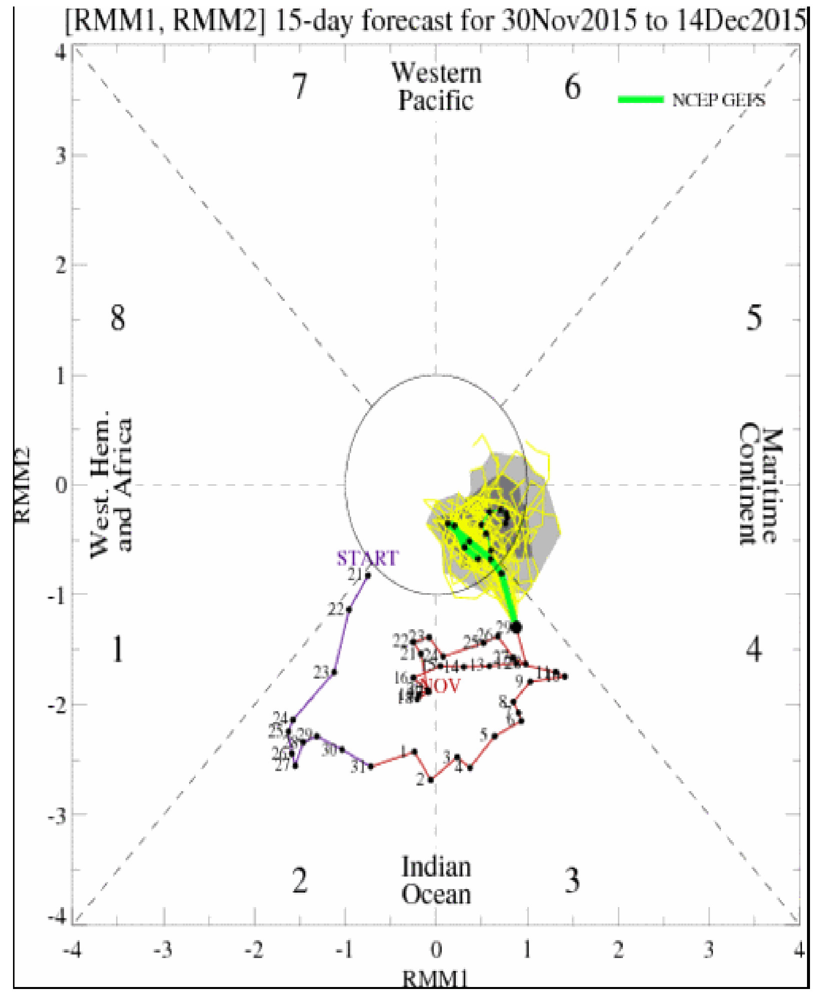
<u>Yellow Lines</u> - 20 Individual Members
<u>Green Line</u> - Ensemble Mean

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 some eastward propagation of a weakening signal over the next two weeks.

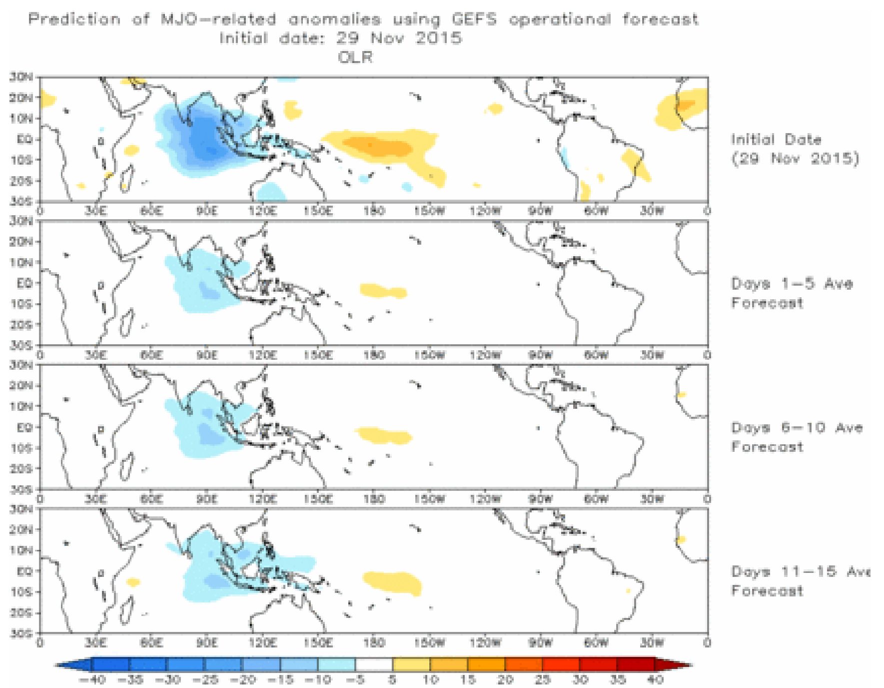


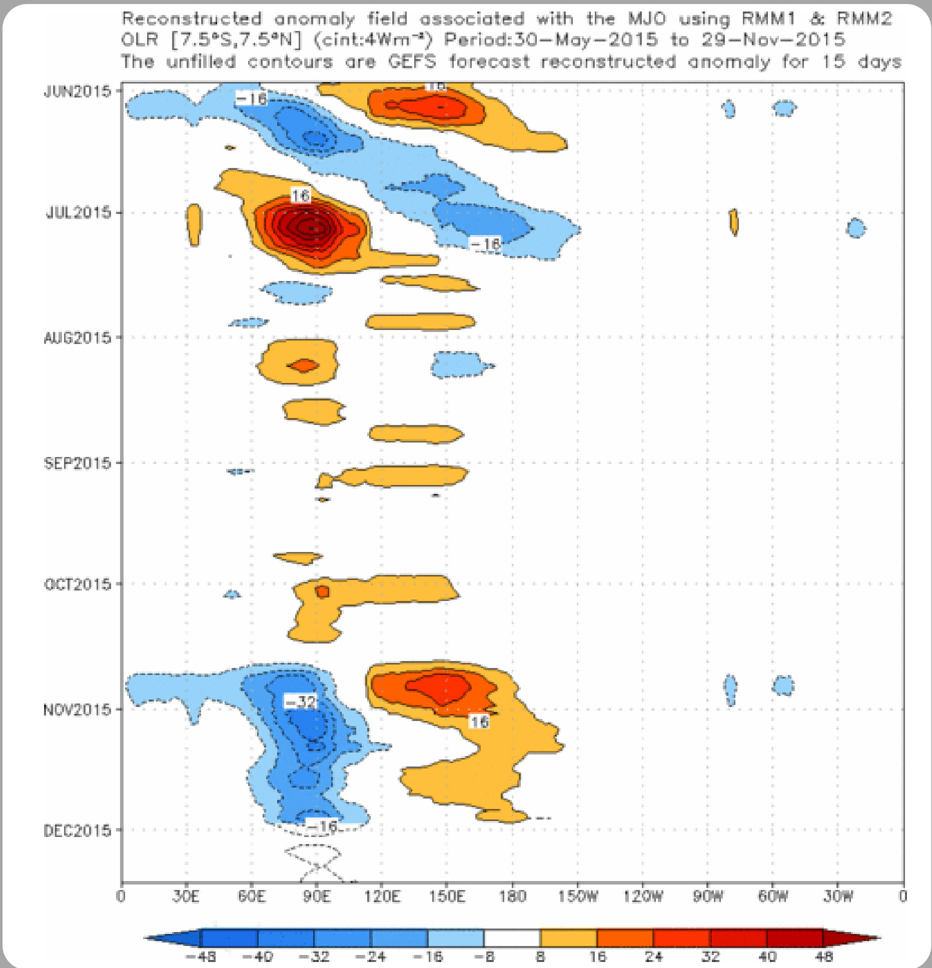
Ensemble GFS (GEFS) MJO Forecast

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



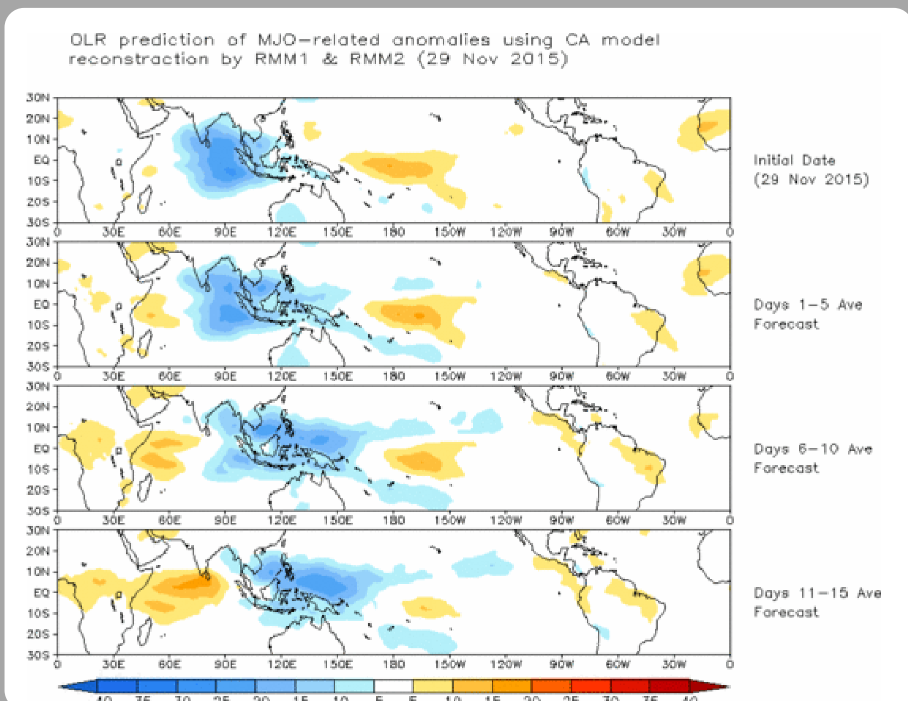


The GEFS MJO index-based OLR forecast depicts a generally stationary anomaly pattern favoring enhanced (suppressed) convection over the Indian Ocean/western Maritime continent (west-central Pacific) during the next two weeks.

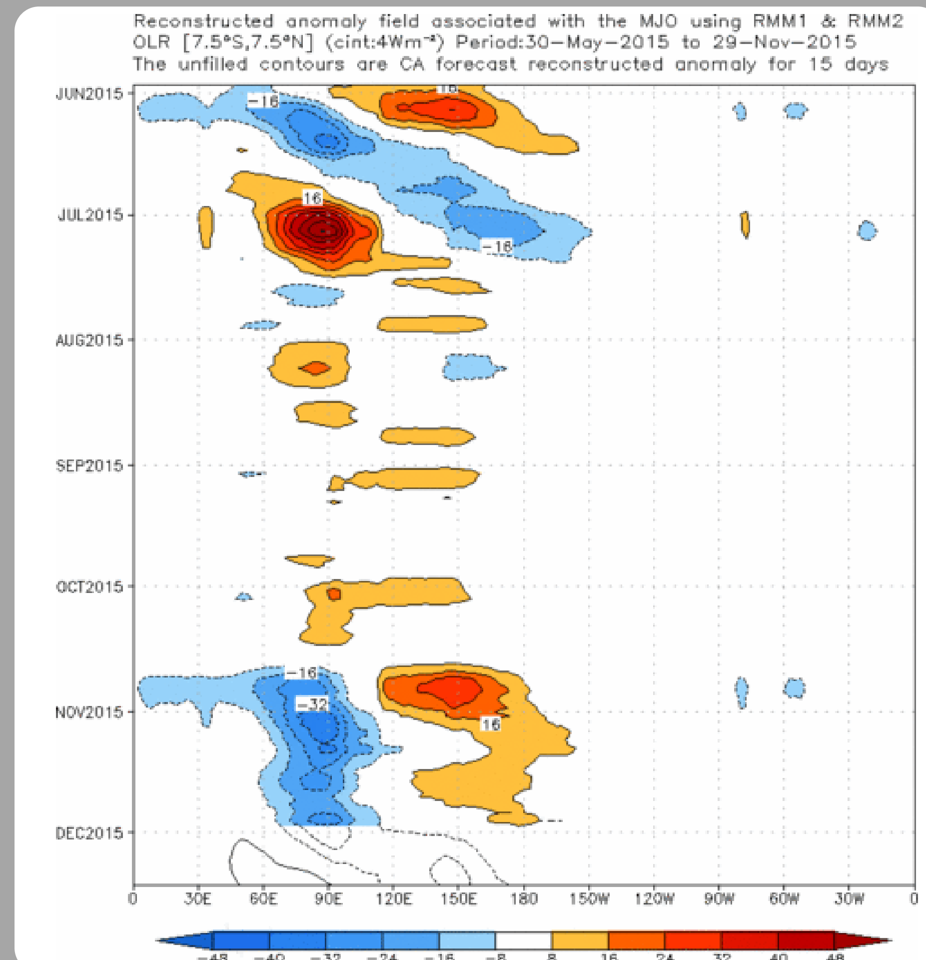
Constructed Analog (CA) MJO Forecast

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



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

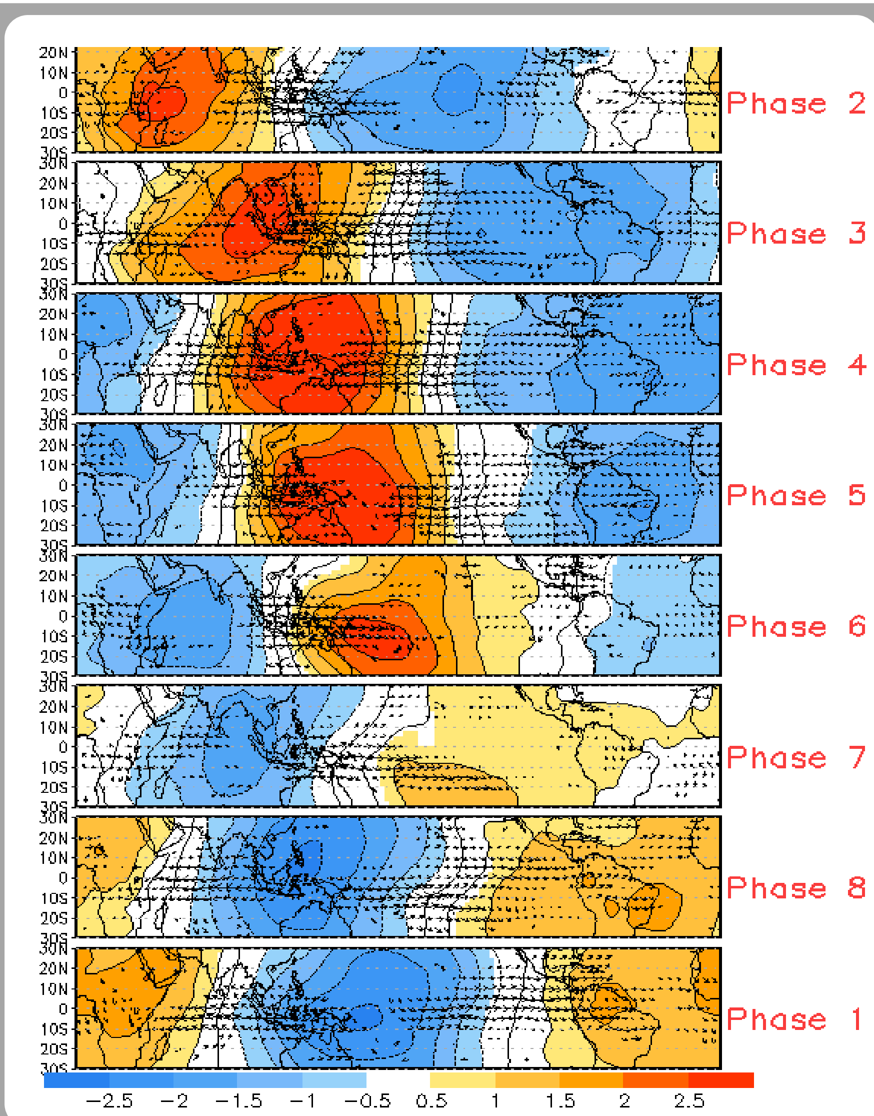


The constructed analog model depicts more eastward propagation of the subseasonal signal, with enhanced (suppressed) convection propagating from the Indian Ocean to the West Pacific (over the Americas and Africa).

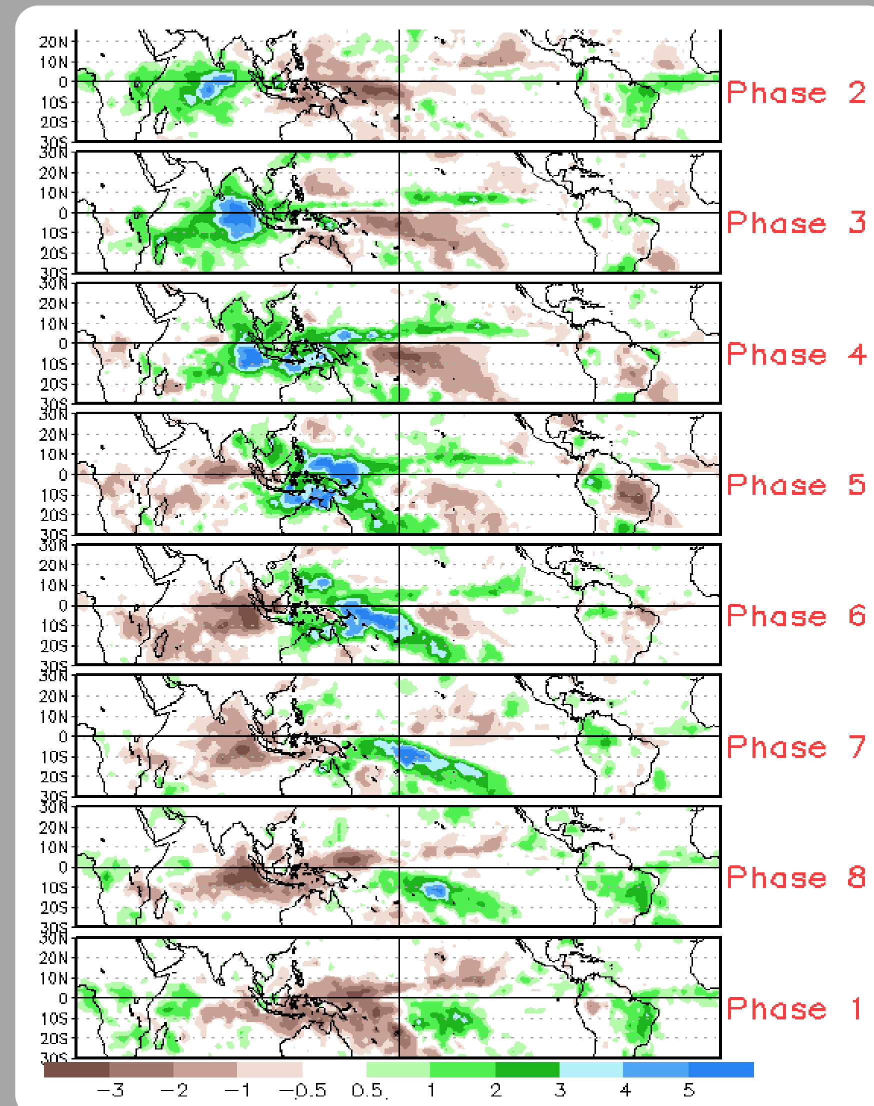
MJO Composites - Global Tropics

850-hPa Velocity Potential and

Wind Anomalies (Nov-Mar)



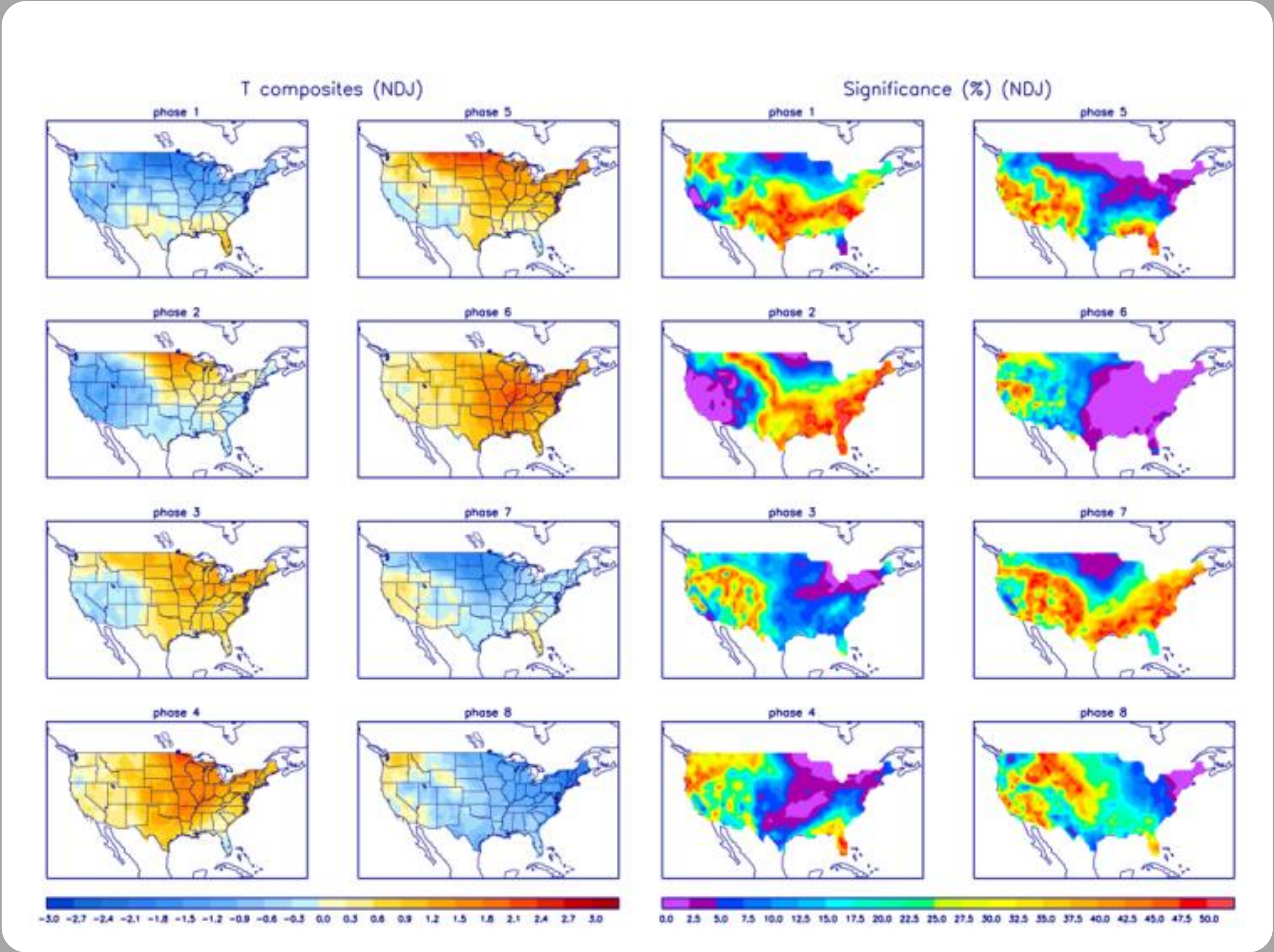
Precipitation Anomalies (Nov-Mar)



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.

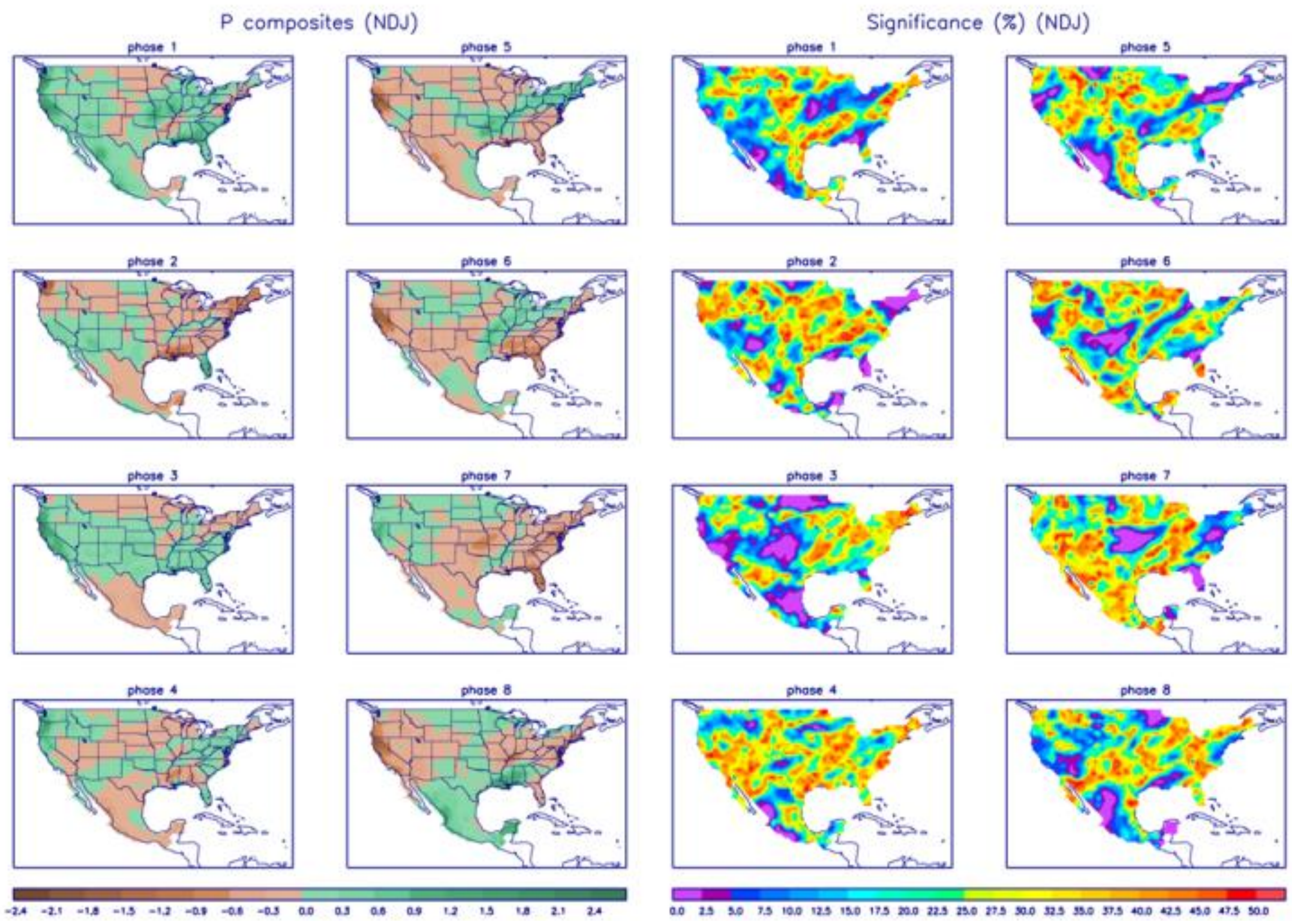
Right hand side plots show a measure of significance for the left hand side anomalies. Purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.



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