

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



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Climate Prediction Center / NCEP
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Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- Both the RMM-based and CPC velocity potential-based MJO indices indicate weakened MJO activity over the past 1-2 weeks.
- There remains considerable other coherent tropical subseasonal variability contributing to the pattern of anomalous tropical convection in addition to background La Nina conditions.
- Dynamical model forecasts of the RMM index and statistical forecasts of the MJO predict predominately weak MJO activity over the next two weeks but some potential exists for the enhancement of convection across the western Pacific during Week-2.
- The evolution of the tropical intraseasonal signal over the next 1-2 weeks is highly uncertain making it difficult to reliably state both potential tropical and extratropical impacts linked to the MJO.

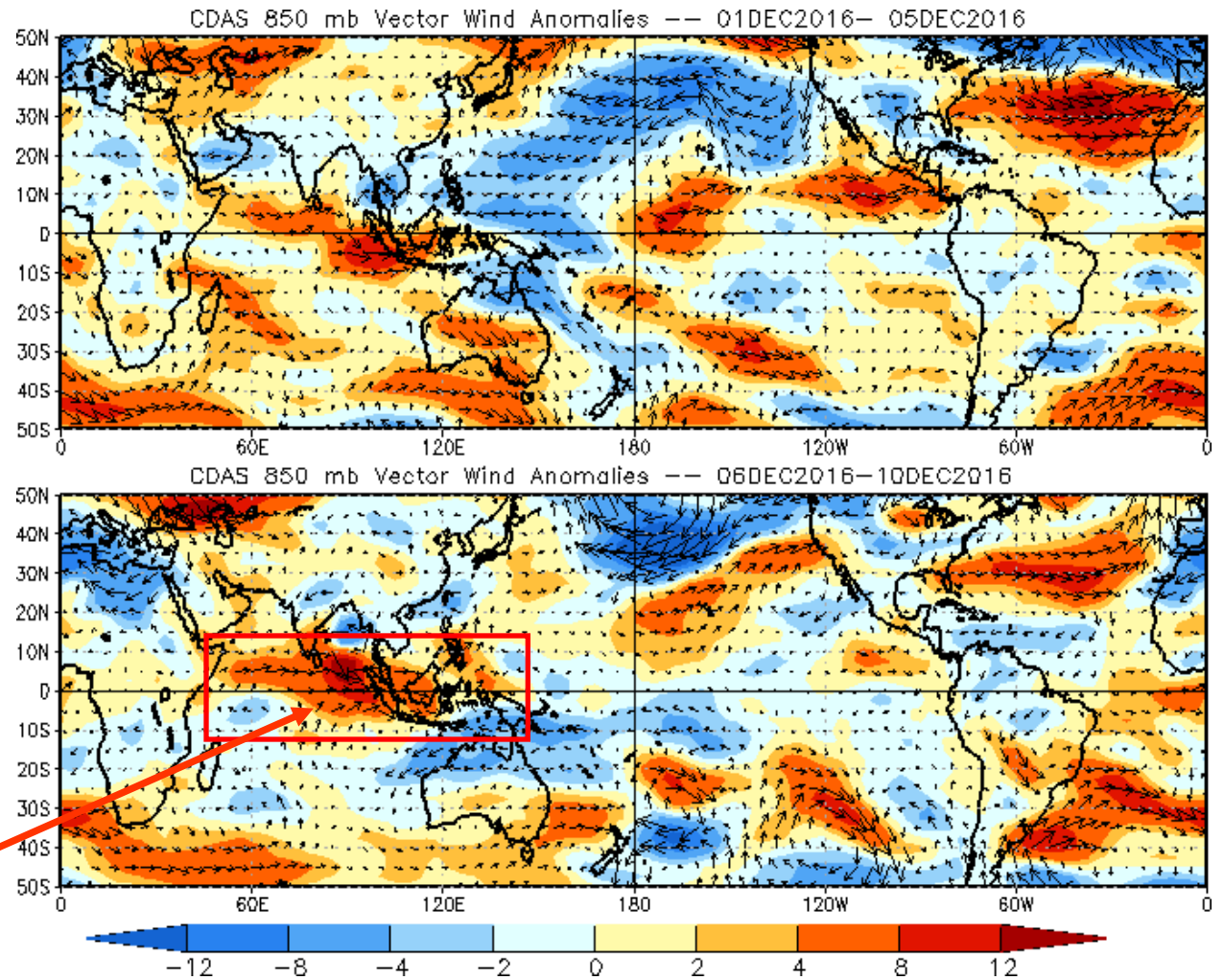
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php>

850-hPa Vector Wind Anomalies (m s⁻¹)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Anomalous westerlies continue over most of the equatorial Indian Ocean and Maritime continent consistent with the low-frequency background state.

850-hPa Zonal Wind Anomalies (m s⁻¹)

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

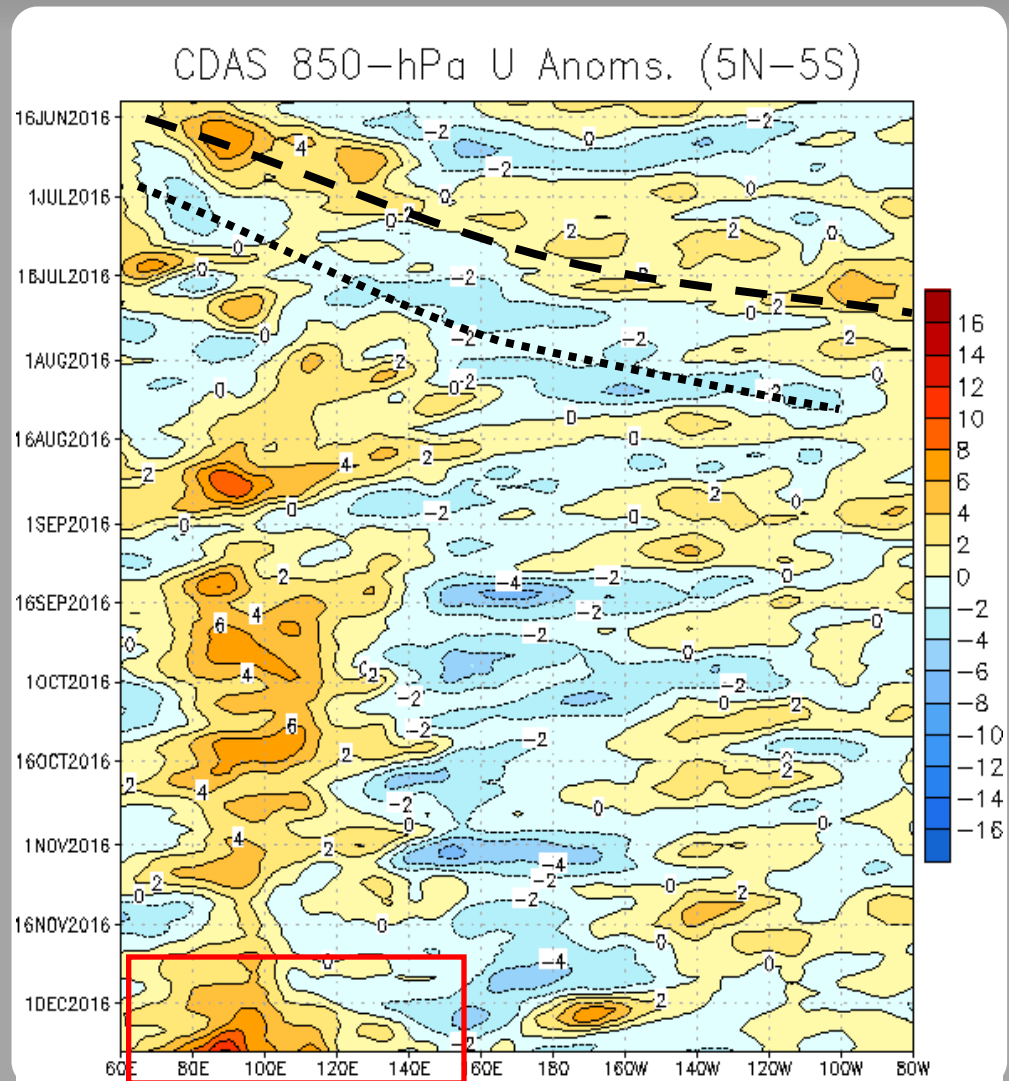
Easterly anomalies (blue shading) represent anomalous east-to-west flow

During June, westerly anomalies were persistent over the Indian Ocean (IO), with higher frequency modes periodically propagating across the Pacific.

During late August, westerly anomalies were evident across the IO and western Pacific.

During September and October, persistent westerly (easterly) anomalies were evident over the eastern Indian Ocean and western Maritime Continent (central Pacific). These anomalies are low frequency in nature, and reflect a developing La Niña base state as well as a negative phase of the Indian Ocean Dipole (IOD).

In early December, westerly anomalies continued to persist across the Indian Ocean but also increased in coverage and intensity (red box).



OLR Anomalies - Past 30 days

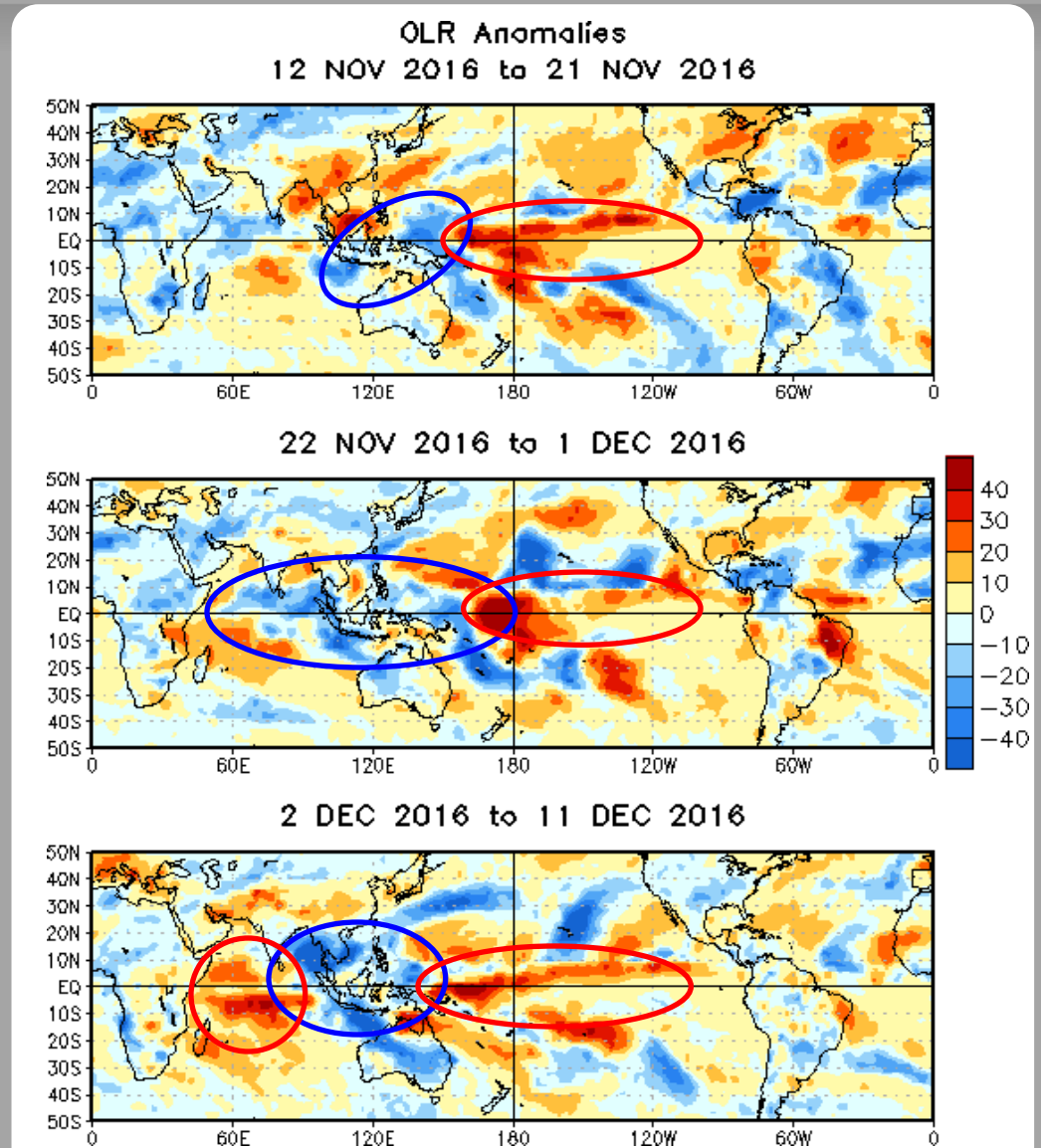
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid November, enhanced (suppressed) convection was observed over the Maritime Continent (equatorial Pacific basin). This activity was primarily associated with the base state.

The low-frequency base state continued to influence the pattern of anomalous convection in late November, but subseasonal variability resulted in an increase in convection over portions of Africa and the Indian Ocean during the period.

In early December, a tripole of anomalous convection returned to the Indian-Pacific Ocean region with suppressed convection evident across the western Indian and central Pacific Oceans and enhanced convection noted over the Maritime continent.



Outgoing Longwave Radiation (OLR) Anomalies (7.5°S - 7.5°N)

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

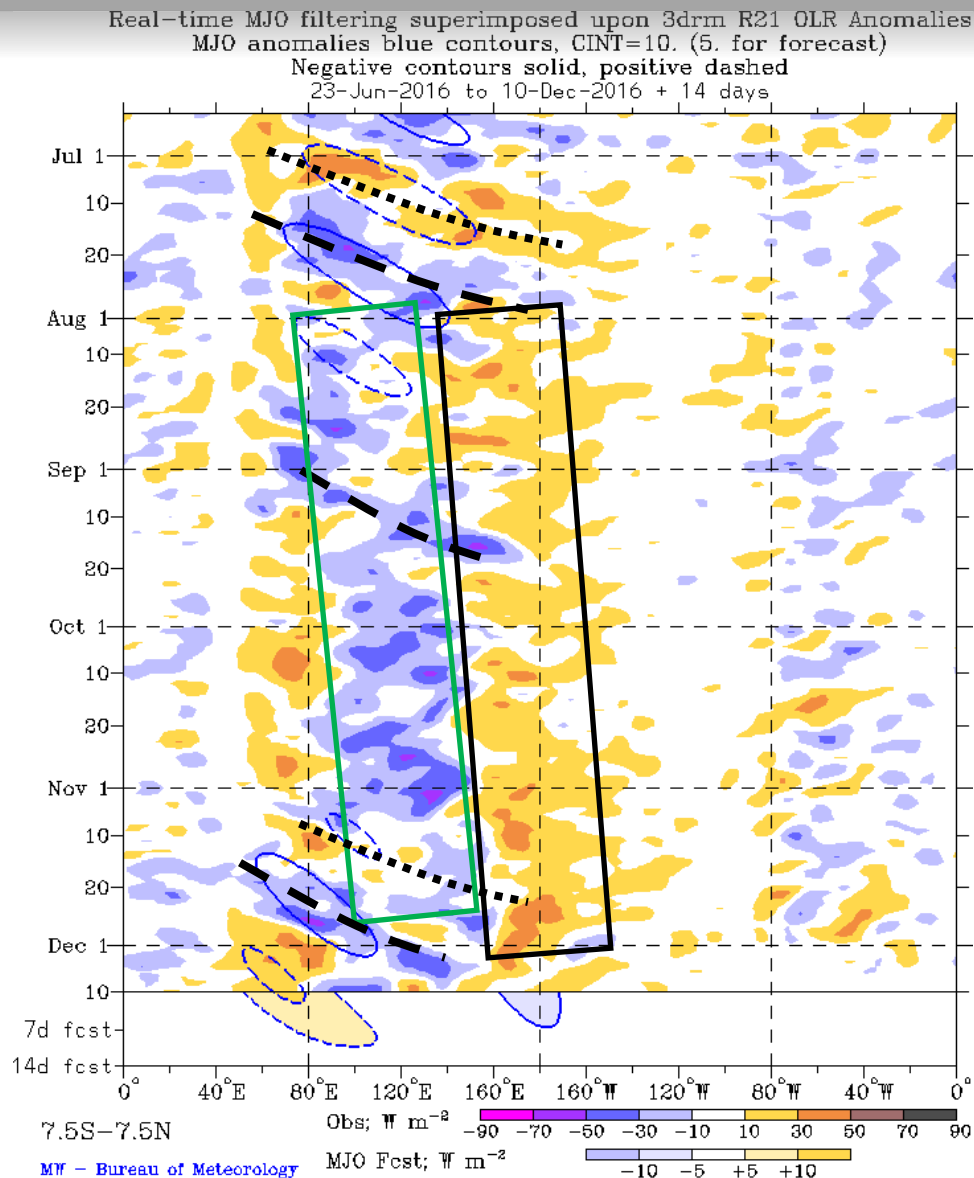
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

Several intraseasonal events were observed through July, with other modes such as tropical cyclone activity also influencing the pattern.

A low frequency state favoring enhanced convection shifted slowly east from the eastern Indian Ocean to the Maritime Continent has been evident since July (green box). Low-frequency suppressed convection, tied to building La Niña conditions, has been apparent near the Date Line since late July (black box).

A fast eastward propagating convective envelope was evident during early September.

More recently, faster moving modes (Kelvin waves, possibly MJO) were evident in the OLR field.



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

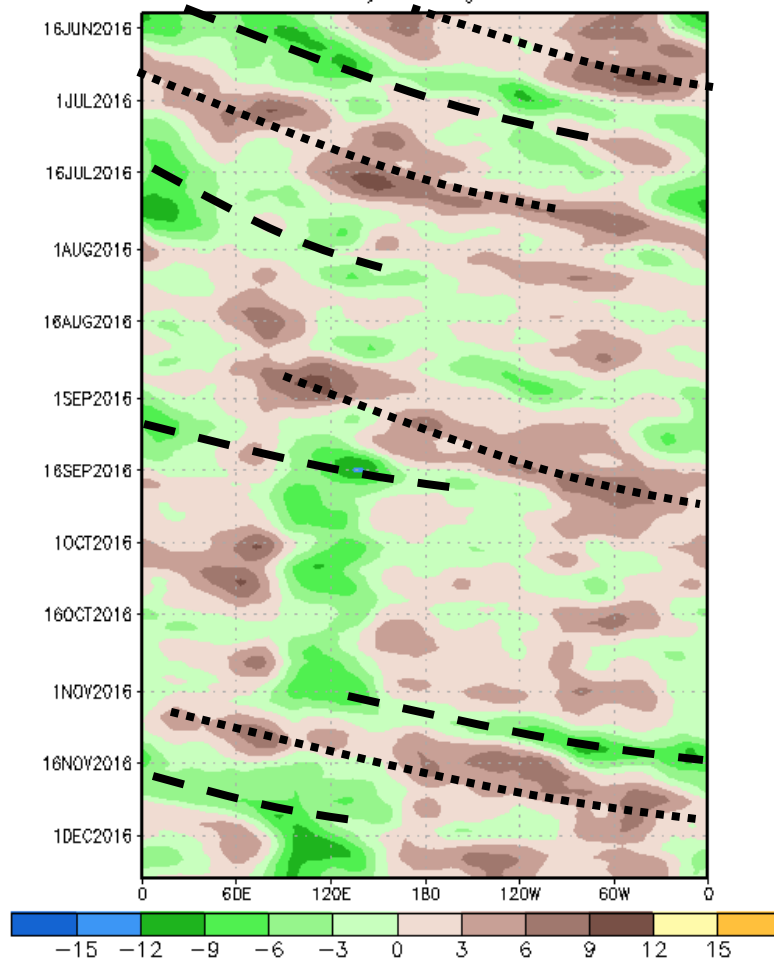
From June through early August, an eastward propagating signal was evident, with multiple periods of variability apparent.

During August, the intraseasonal signal became less coherent, with a weaker and somewhat more stationary anomaly field in place. By late August and early September, there was renewed propagation of the intraseasonal signal.

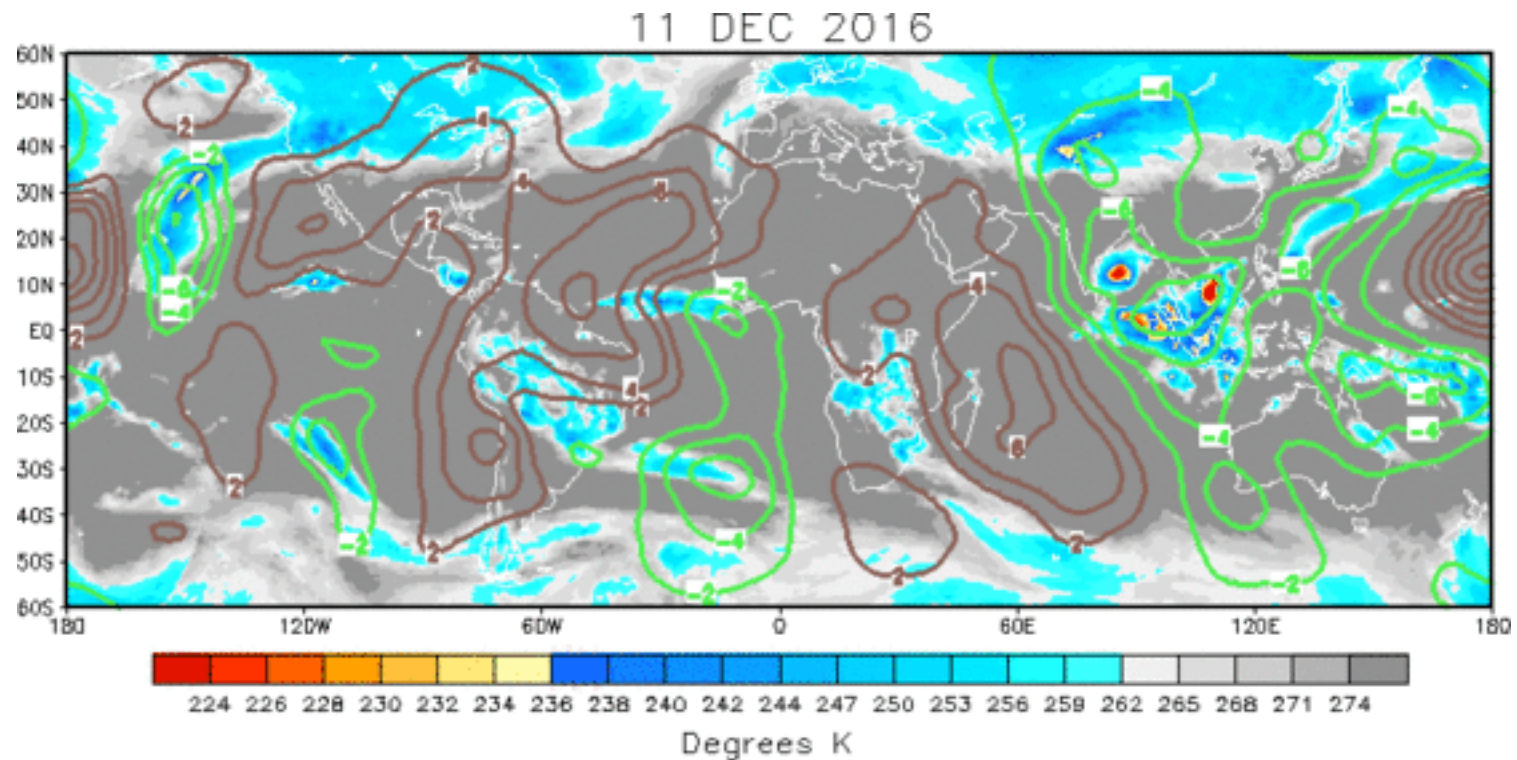
From mid-September to late October, the low frequency signal dominated the pattern. An absence of intraseasonal variability during that period resulted in the standing negative velocity potential anomalies near 120E associated with the negative IOD event.

During November, rapid eastward propagation has been observed consistent with MJO activity on the fast end of the intraseasonal spectrum, with negative anomalies most recently returning to the Maritime Continent.

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



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



The spatial pattern of upper-level velocity potential anomalies highlights anomalous divergence over the Maritime Continent with primarily positive velocity potential anomalies elsewhere of slightly lower amplitude over most of the remainder of the Tropics.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation

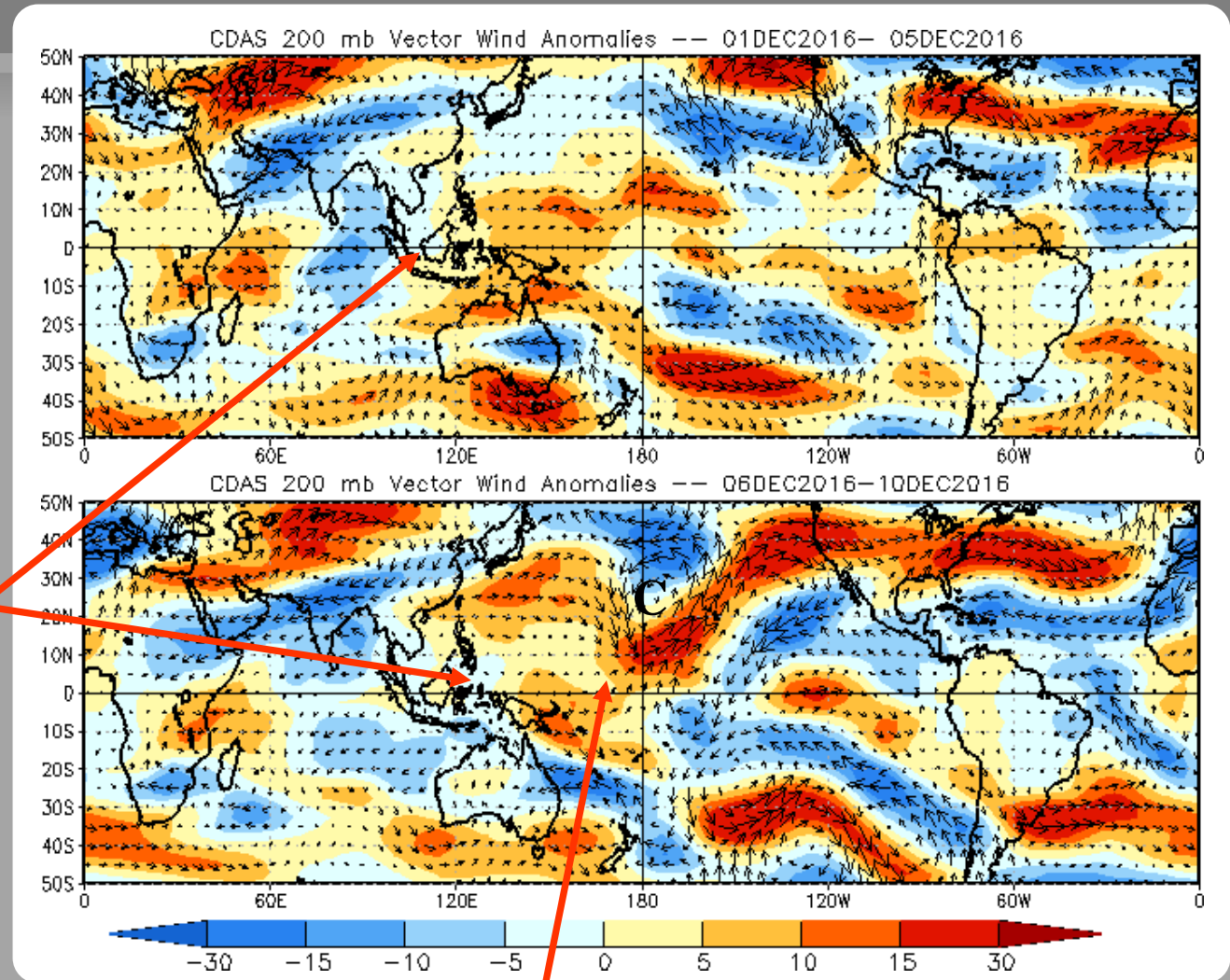
200-hPa Vector Wind Anomalies (m s⁻¹)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Anomalous divergence of the zonal component of the upper-level wind field is evident over the Maritime Continent recently.



Westerly anomalies persisted over the western Pacific during the period with a well established cyclonic circulation north of the equator near the Date Line.

200-hPa Zonal Wind Anomalies (m s⁻¹)

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

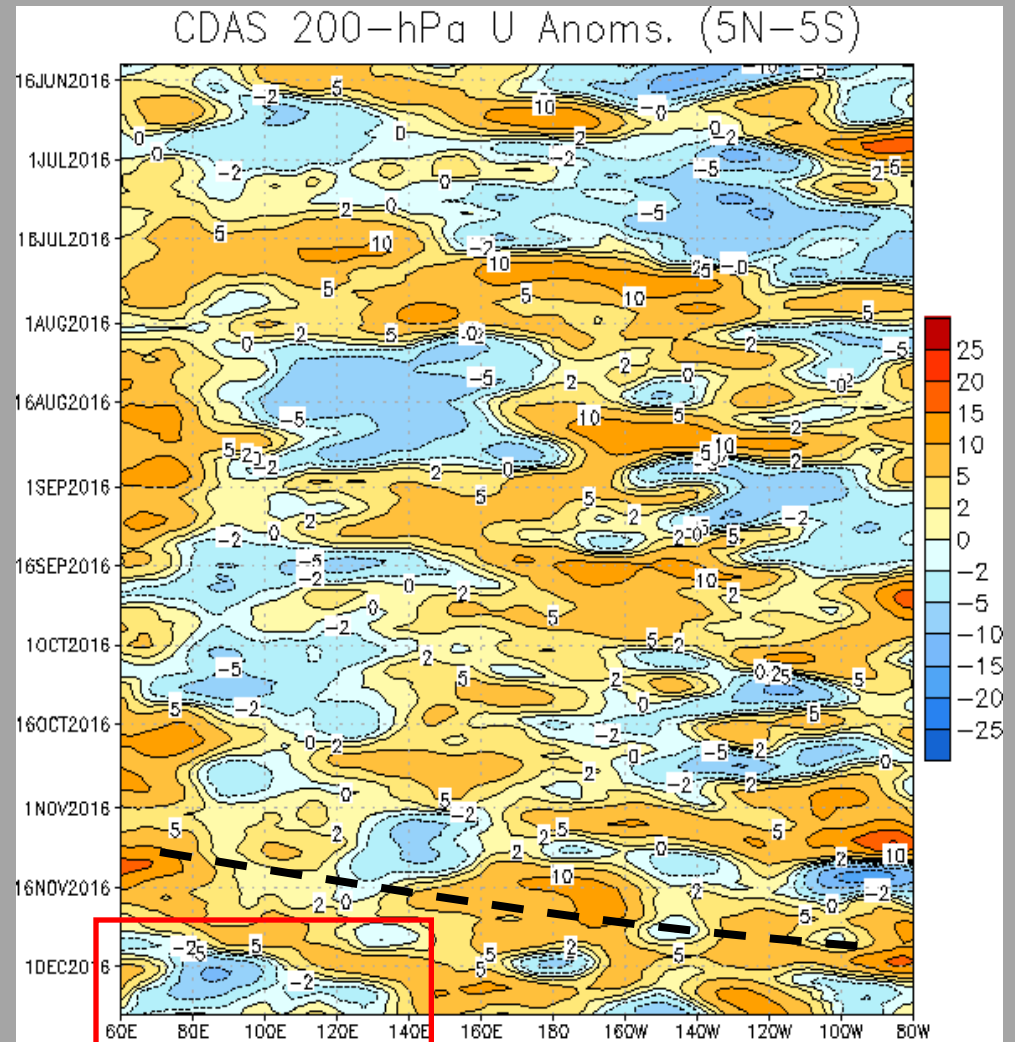
Easterly anomalies (blue shading) represent anomalous east-to-west flow

During July, some eastward propagation in large scale anomalies was evident, although the spatial consistency implies higher frequency variability than expected with MJO activity.

During September, eastward propagation of westerly anomalies was broadly consistent with organized MJO activity.

During November, anomalous westerlies persisted near the Date Line, though intraseasonal variability associated with the MJO is evident.

Most recently in December, easterly anomalies have re-emerged across the Indian Ocean consistent with the passage of subseasonal activity and the re-alignment of the low frequency base state (red box).



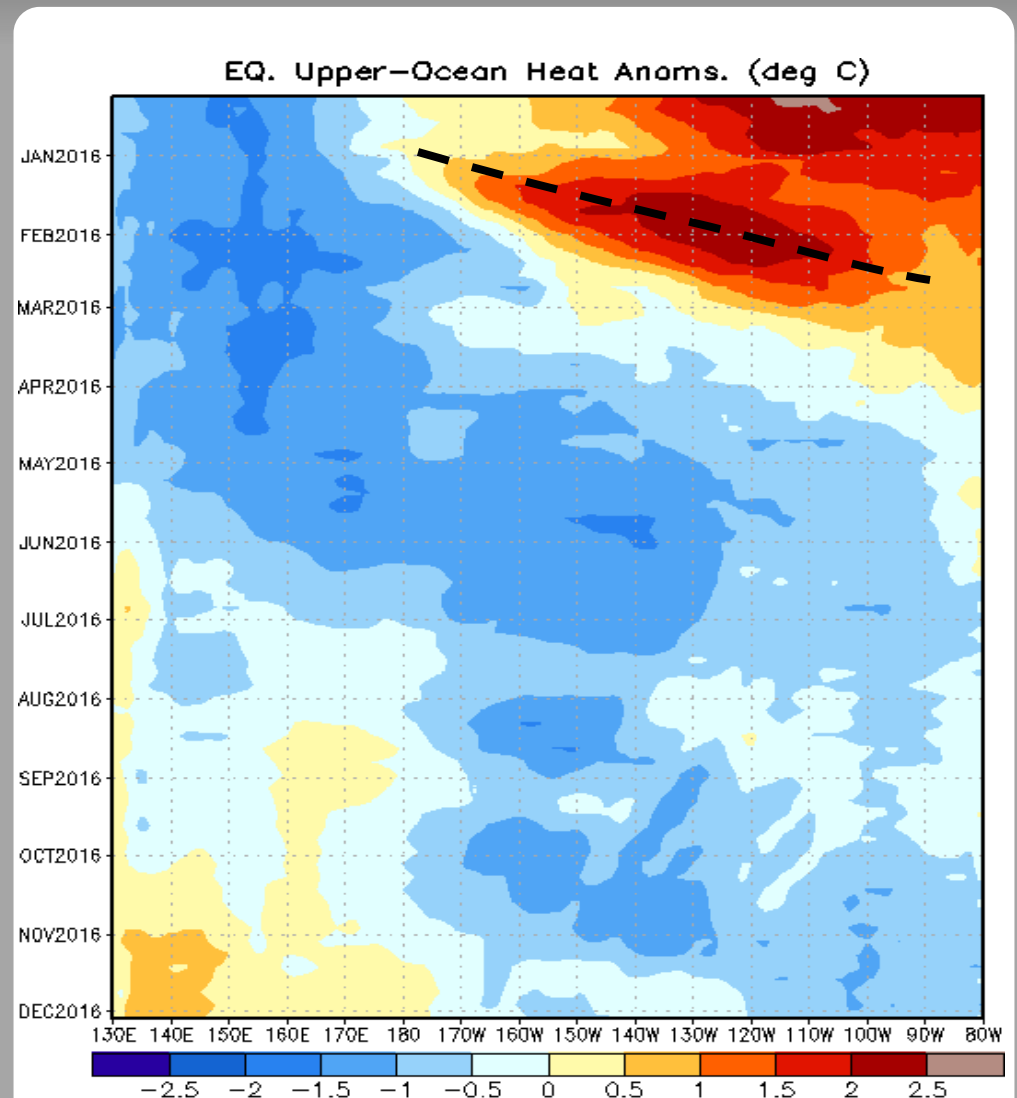
Weekly Heat Content Evolution in the Equatorial Pacific

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.

Downwelling events were observed through early February, resulting in persistently above-normal heat content from the Date Line to 80W over that period.

An eastward expansion of below average heat content over the western Pacific is evident since January, with widespread negative anomalies building across the Pacific over the course of the spring and summer months.

The strongest negative anomalies now persist in the East Pacific as the negative oceanic heat content anomalies have decreased across the central 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

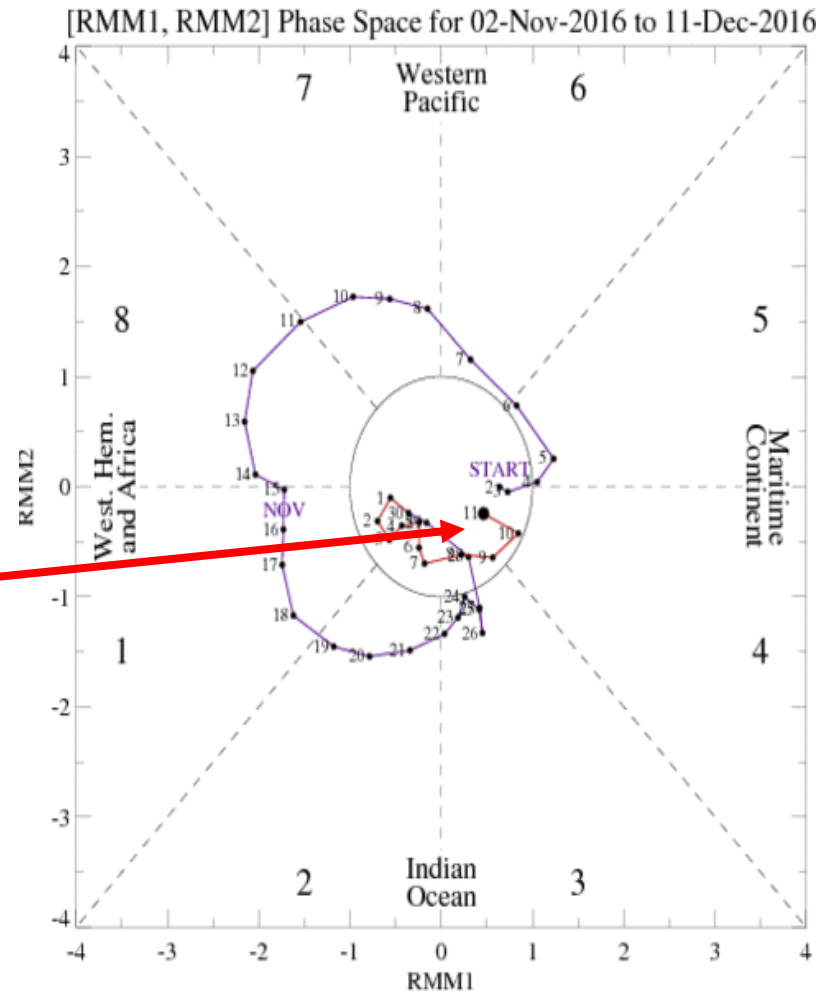
The triangular areas indicate the location of the enhanced phase of the MJO

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

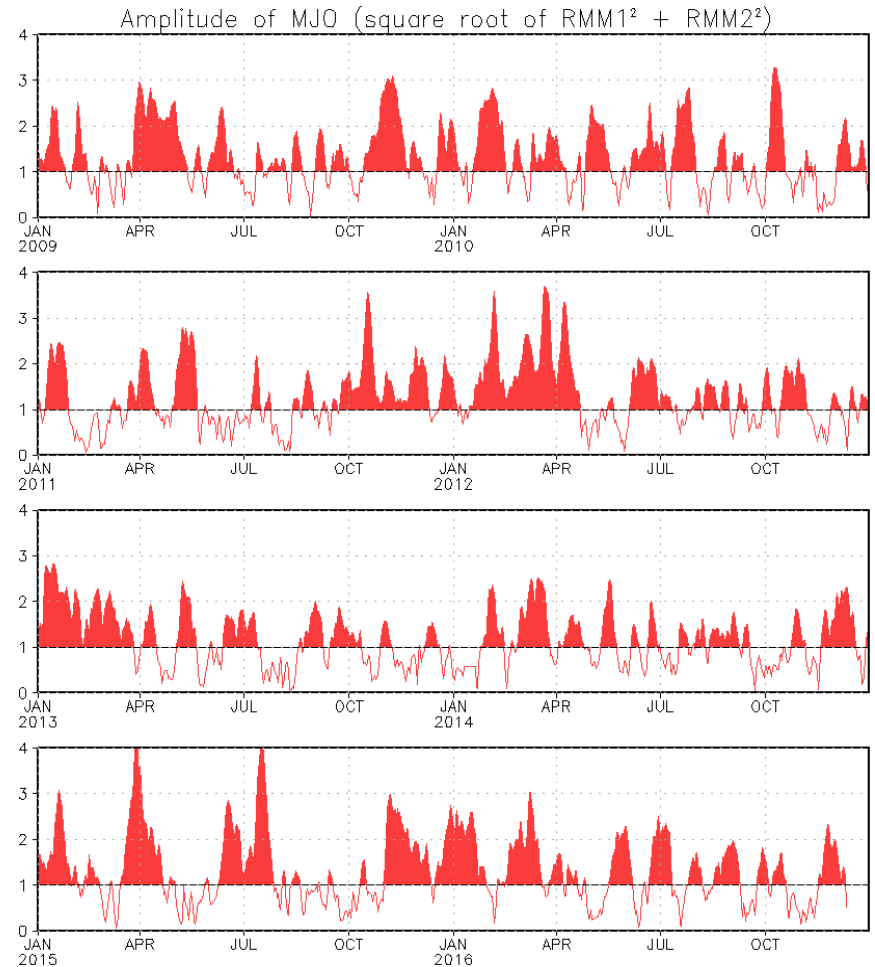
The MJO index remained low in amplitude during the past week.



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

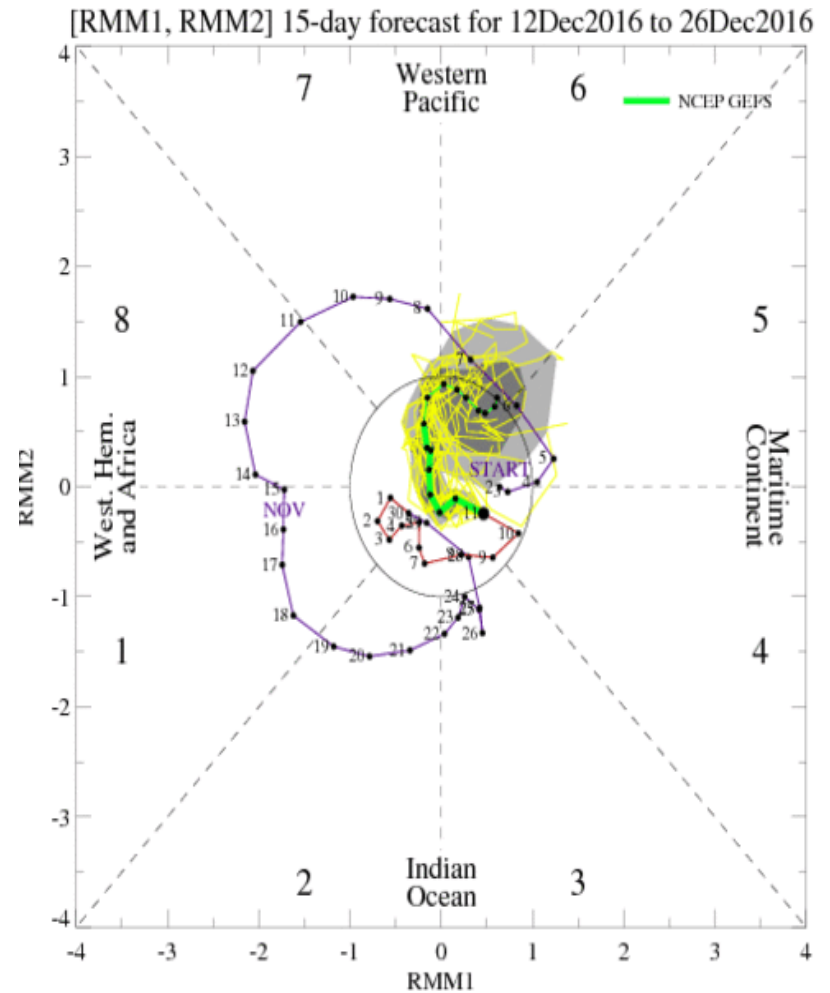
RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

At the current time, the GFS ensemble forecast depicts a generally incoherent MJO signal for the next two weeks.

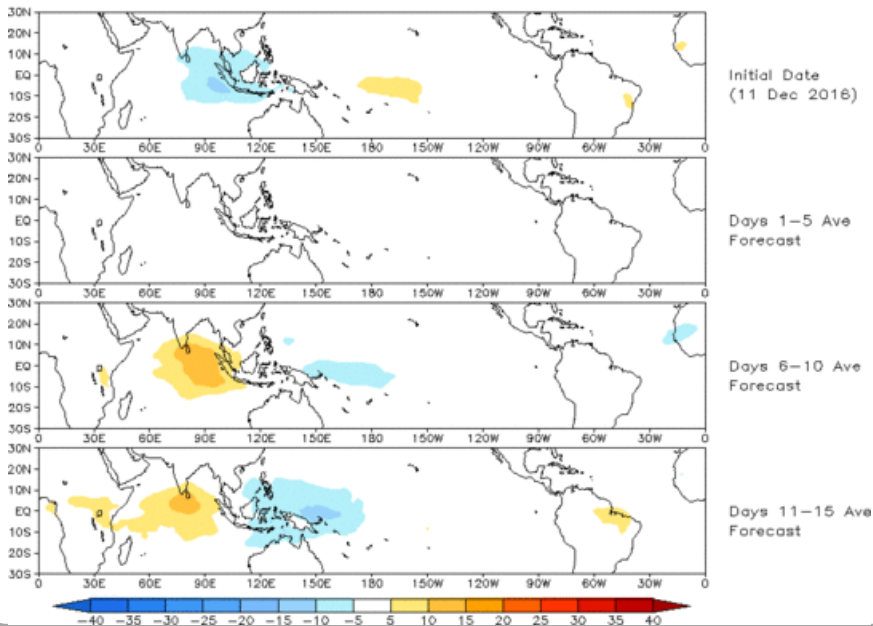
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean



Ensemble GFS (GEFS) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

Prediction of MJO-related anomalies using GEFS operational forecast
Initial date: 11 Dec 2016
OLR

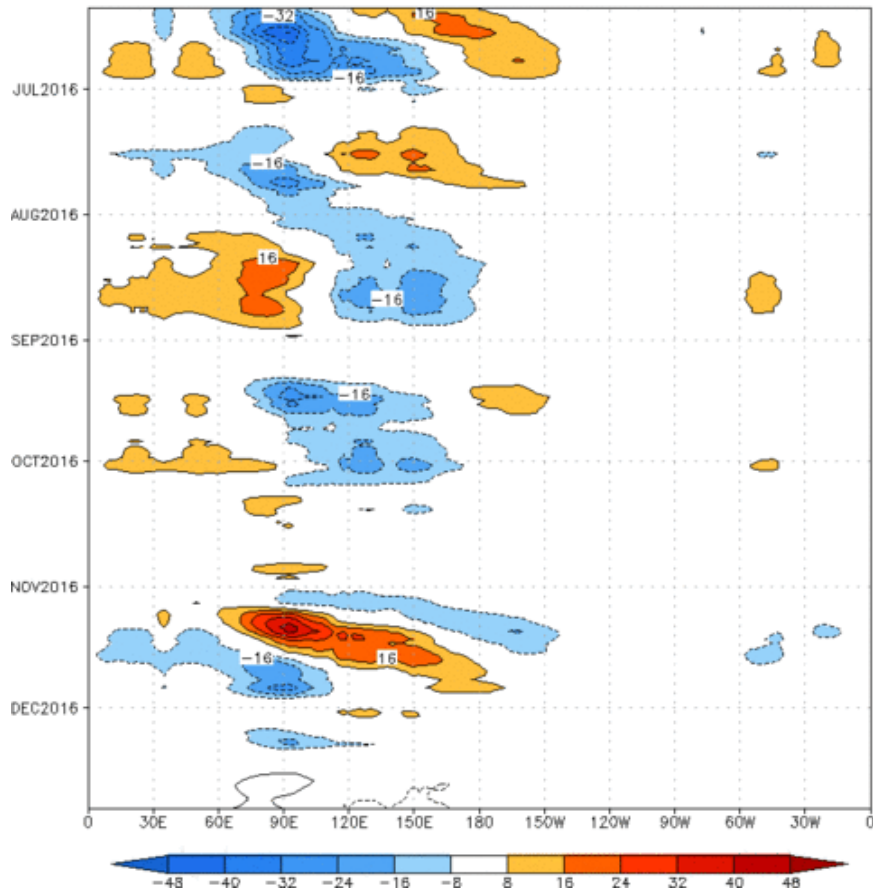


The prediction for OLR anomalies over the next two weeks based on the GEFS RMM forecast indicates weak conditions over the period.

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

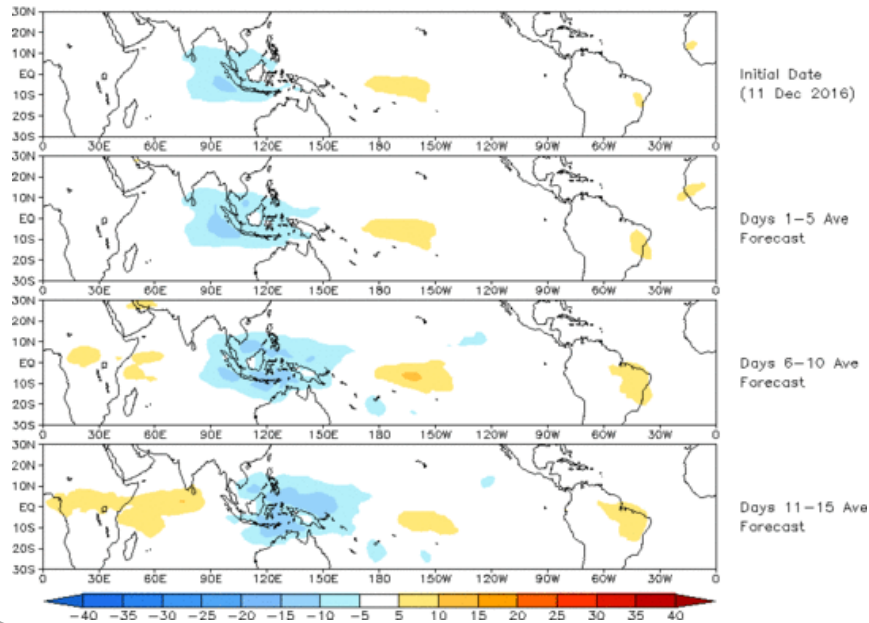
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2
OLR [7.5°S,7.5°N] (cont:4Wm⁻²) Period:11-Jun-2016 to 11-Dec-2016
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days



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 (11 Dec 2016)

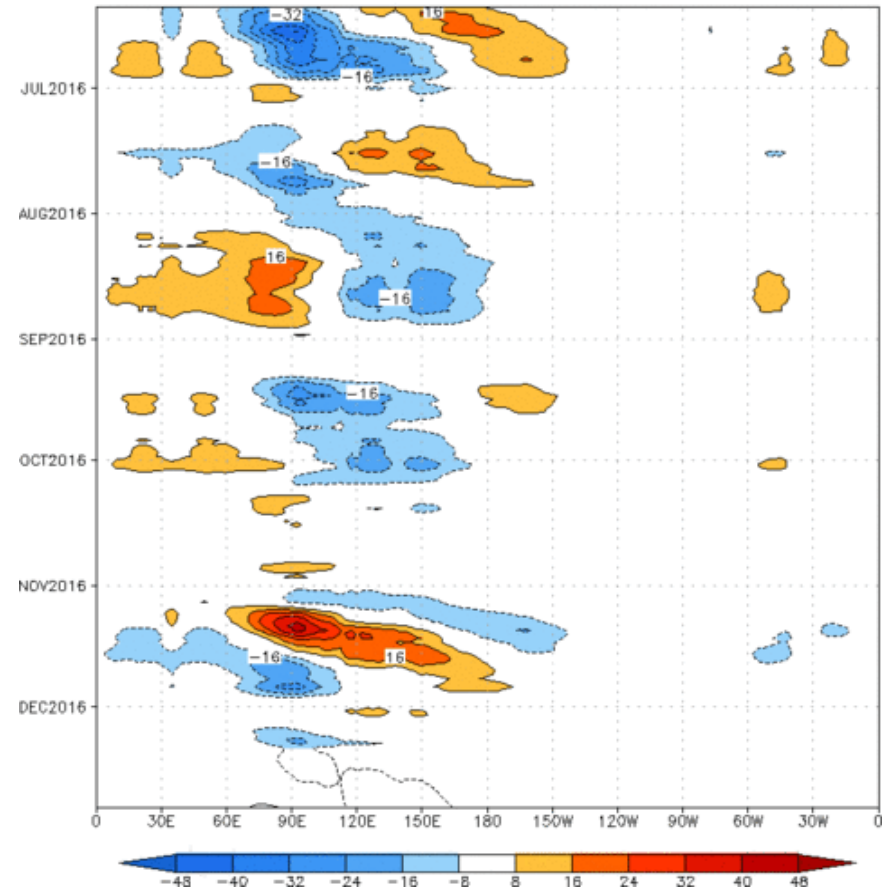


The prediction for OLR anomalies based on the Constructed analog RMM forecast indicates weak MJO activity. Enhanced convection slowly shifts from the eastern Indian Ocean to the far western Pacific while suppressed convection enters the Indian Ocean by the end of Week-2.

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.)

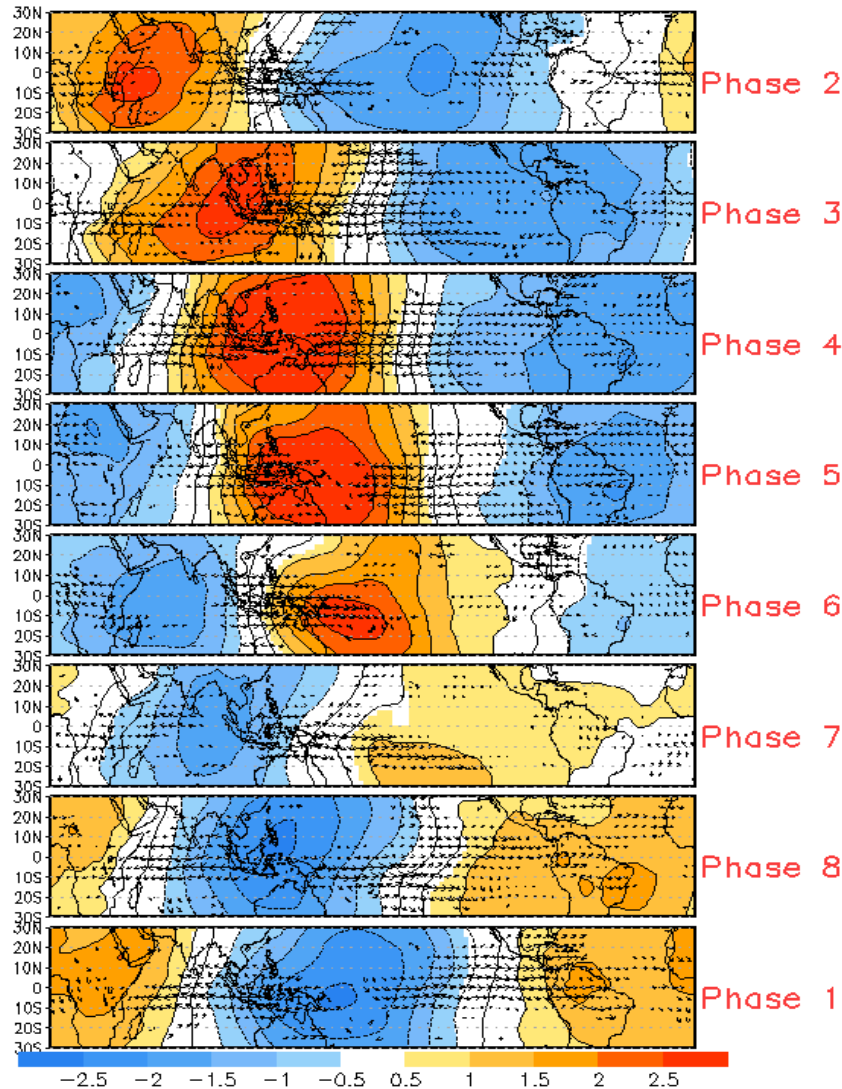
Time-longitude section of (7.5° S- 7.5° N) OLR anomalies - last 180 days and for the next 15 days

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [7.5° S, 7.5° N] (cont:4 Wm^{-2}) Period:11-Jun-2016 to 11-Dec-2016 The unfilled contours are CA forecast reconstructed anomaly for 15 days

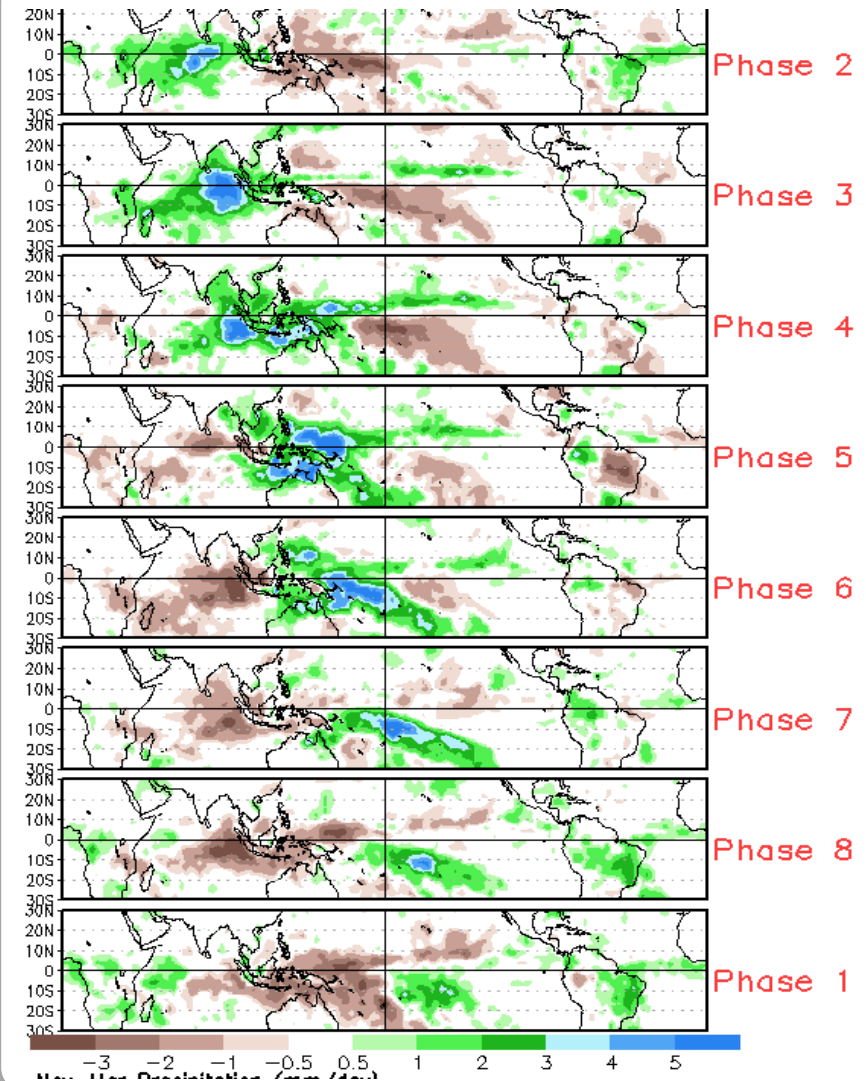


MJO Composites - Global Tropics

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



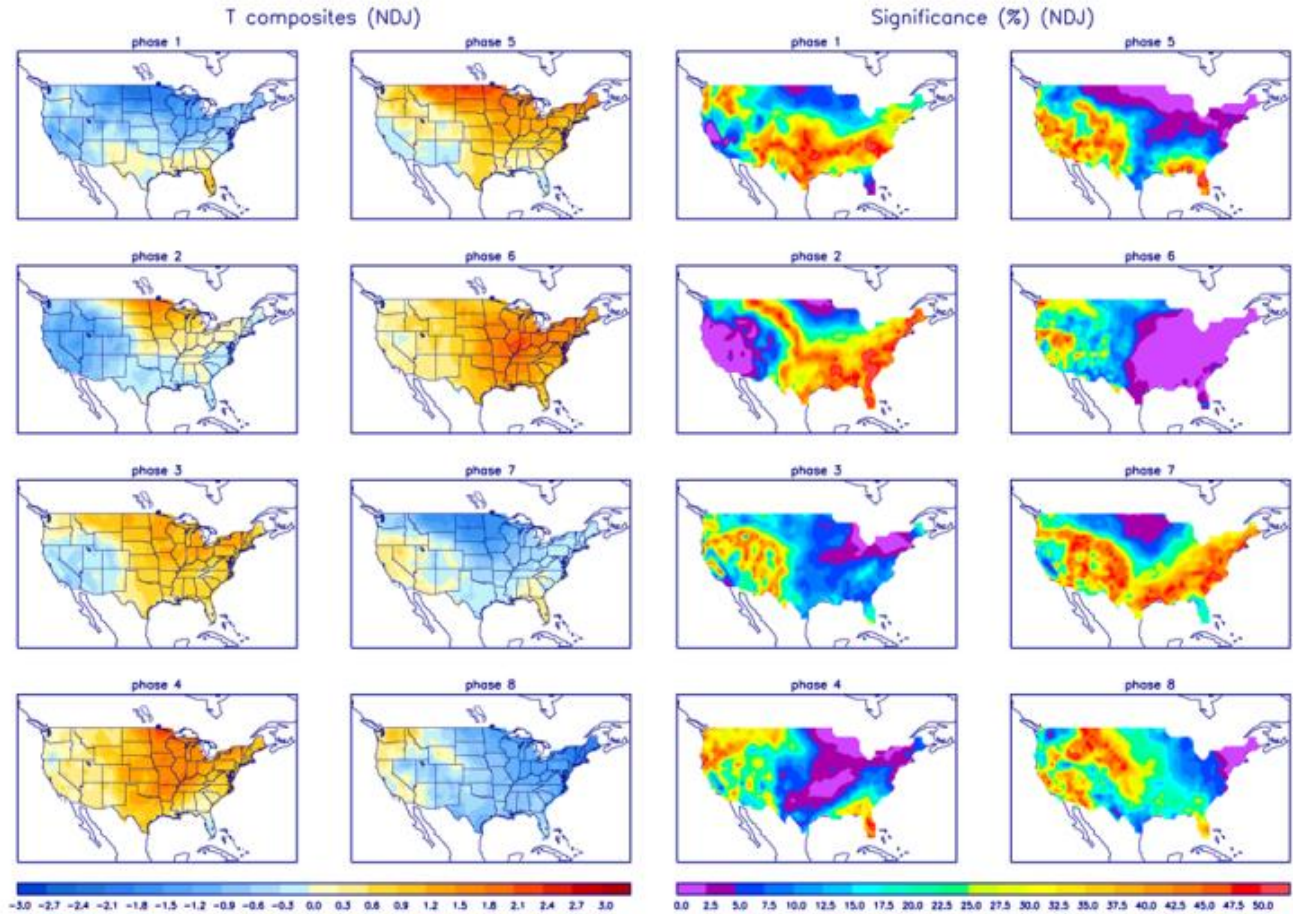
Precipitation Anomalies (Nov - Mar)



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.



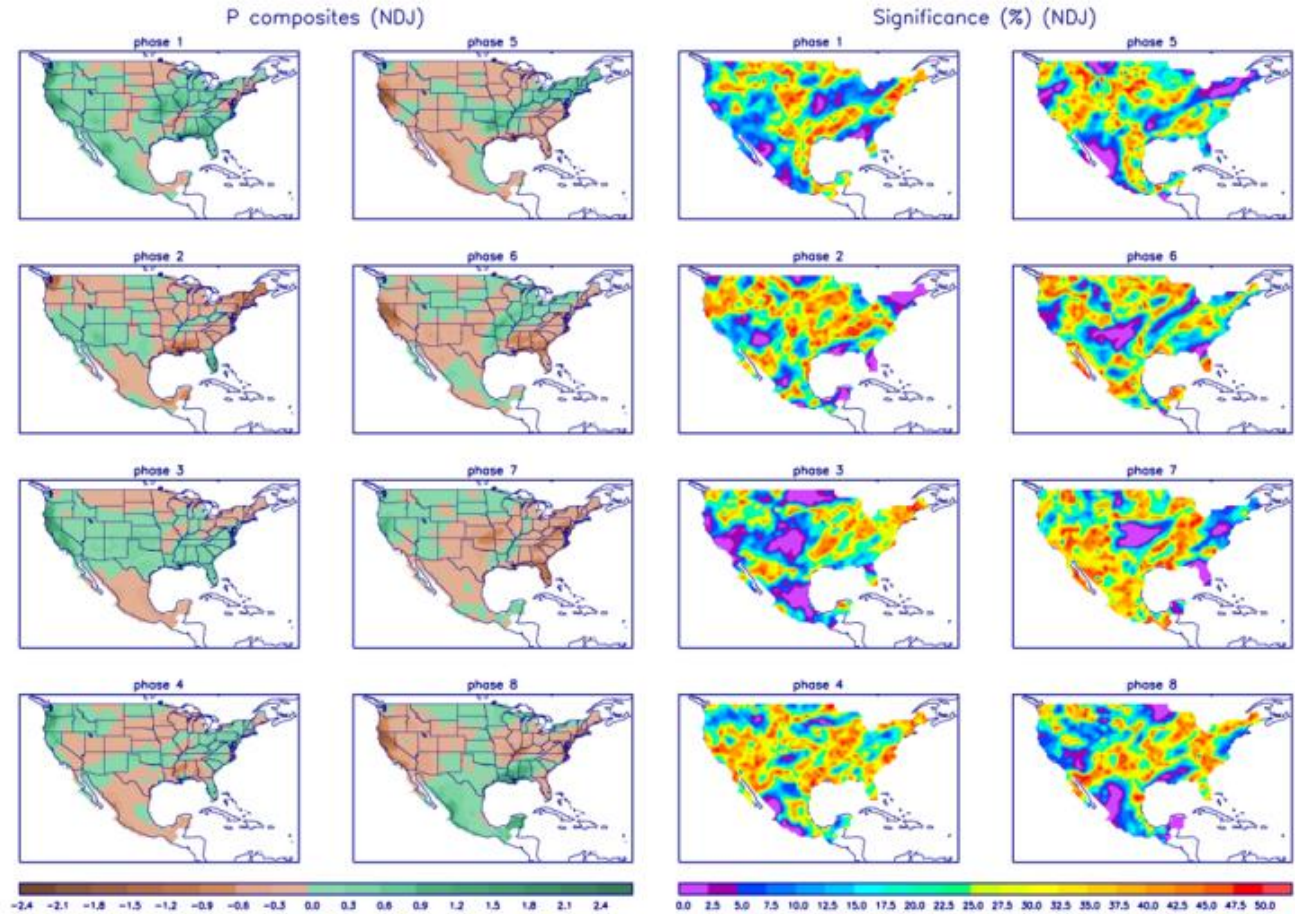
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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

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