

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



Update prepared by:
Climate Prediction Center / NCEP
31 October 2016

Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- MJO indices remained weak during the past week, with circulation anomalies in the tropics primarily reflecting the low frequency state favoring enhanced (suppressed) convection over the Maritime Continent (central Pacific) due in part to the IOD and a potentially developing La Niña event.
- Dynamical model forecast solutions are now consistently indicating the development of a robust MJO signal over the West Pacific by Week-2. The dynamical model precipitation forecasts are a bit less reflective of canonical MJO activity, however, and any central Pacific signal will encounter destructive interference from the low frequency state.
- Given the robust dynamical model support, the MJO is favored to play a role in the evolution of the global tropical convective pattern during the next two weeks. In particular, enhanced (suppressed) convection due to MJO activity is favored across parts of the Northwest Pacific (central Indian Ocean) over the next two weeks. Enhanced convection over the East Pacific is more likely during late Week-2.

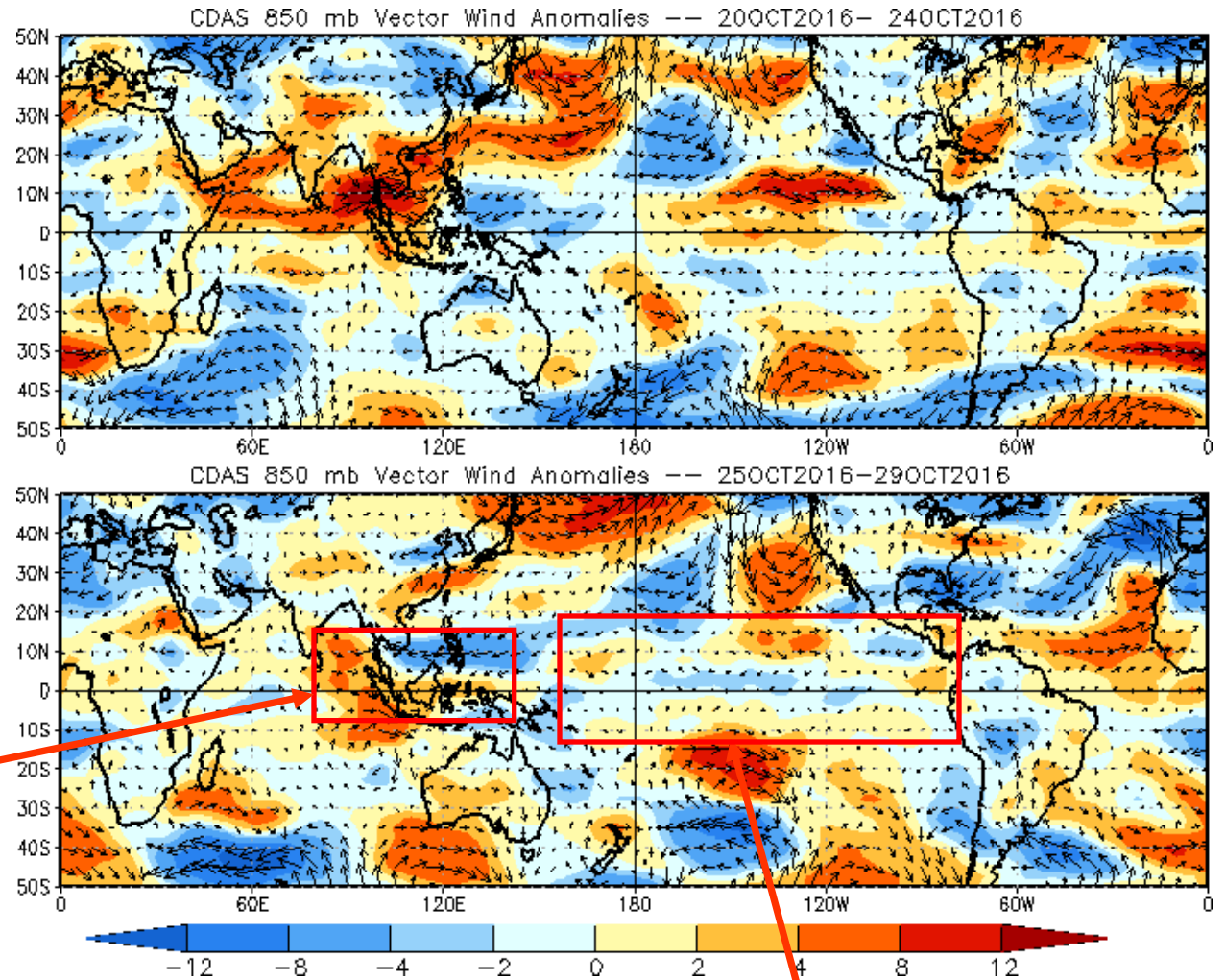
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php>

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 persisted over the eastern Indian Ocean and western Maritime Continent, while easterlies shifted northward across the Philippines.

A weak anomaly pattern was present over the Pacific basin.

850-hPa Zonal Wind Anomalies (m s⁻¹)

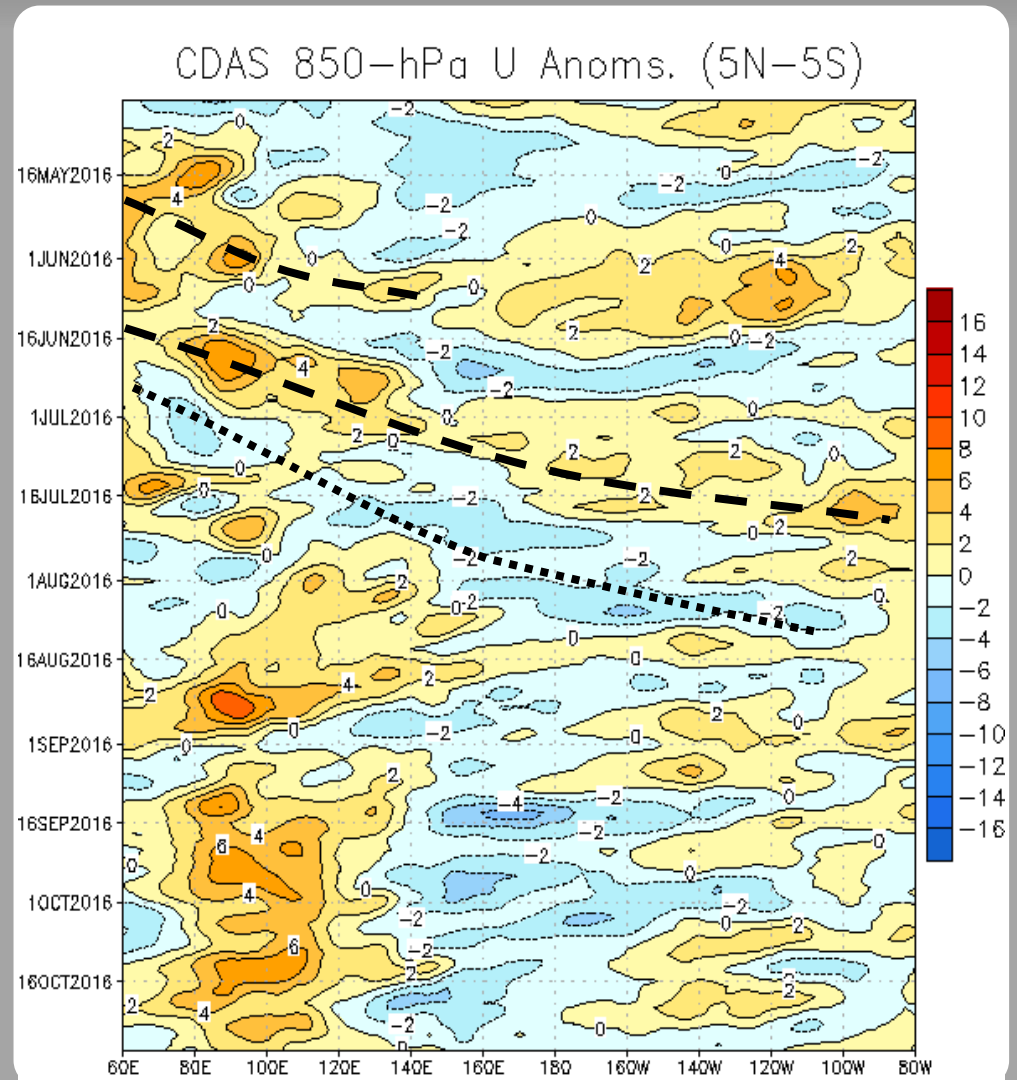
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

During May and 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 early 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 may reflect a developing La Niña base state as well as a negative phase of the Indian Ocean Dipole (IOD).



OLR Anomalies - Past 30 days

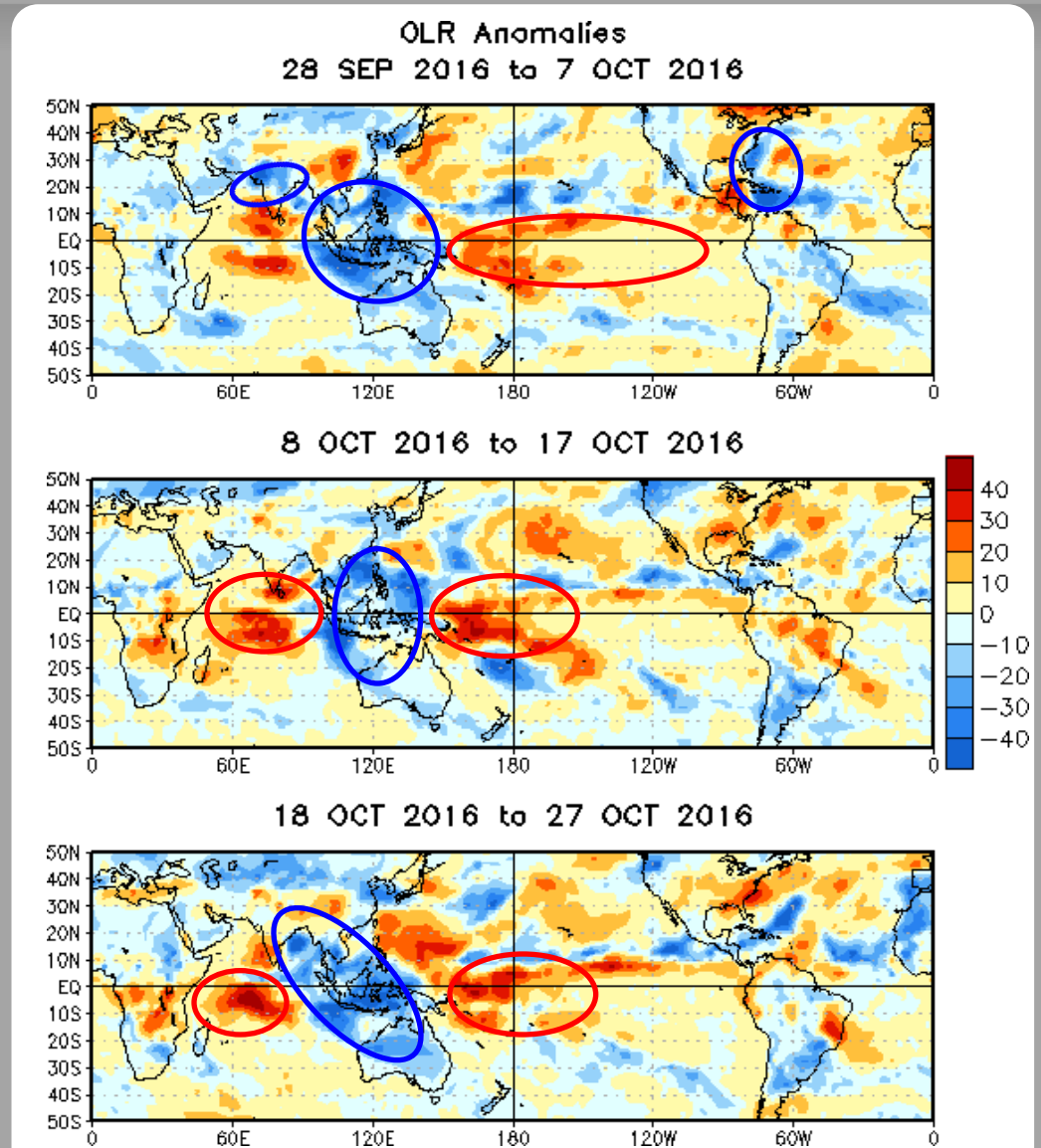
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late September into early October, enhanced (suppressed) convection persisted over the Maritime Continent and northwest India (Central and South Pacific). Enhanced convection over northwest India was associated with monsoon activity. The track of Hurricane Matthew is evident in the Atlantic basin.

Suppressed convection persisted over the Central and South Pacific and the northern Indian Ocean, while enhanced convection remained in place over the Maritime Continent.

The stationary pattern continued through late October. Enhanced convection overspread the Bay of Bengal, with continued low-frequency enhanced (suppressed) convection over the Maritime Continent (Central and South Pacific).



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

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

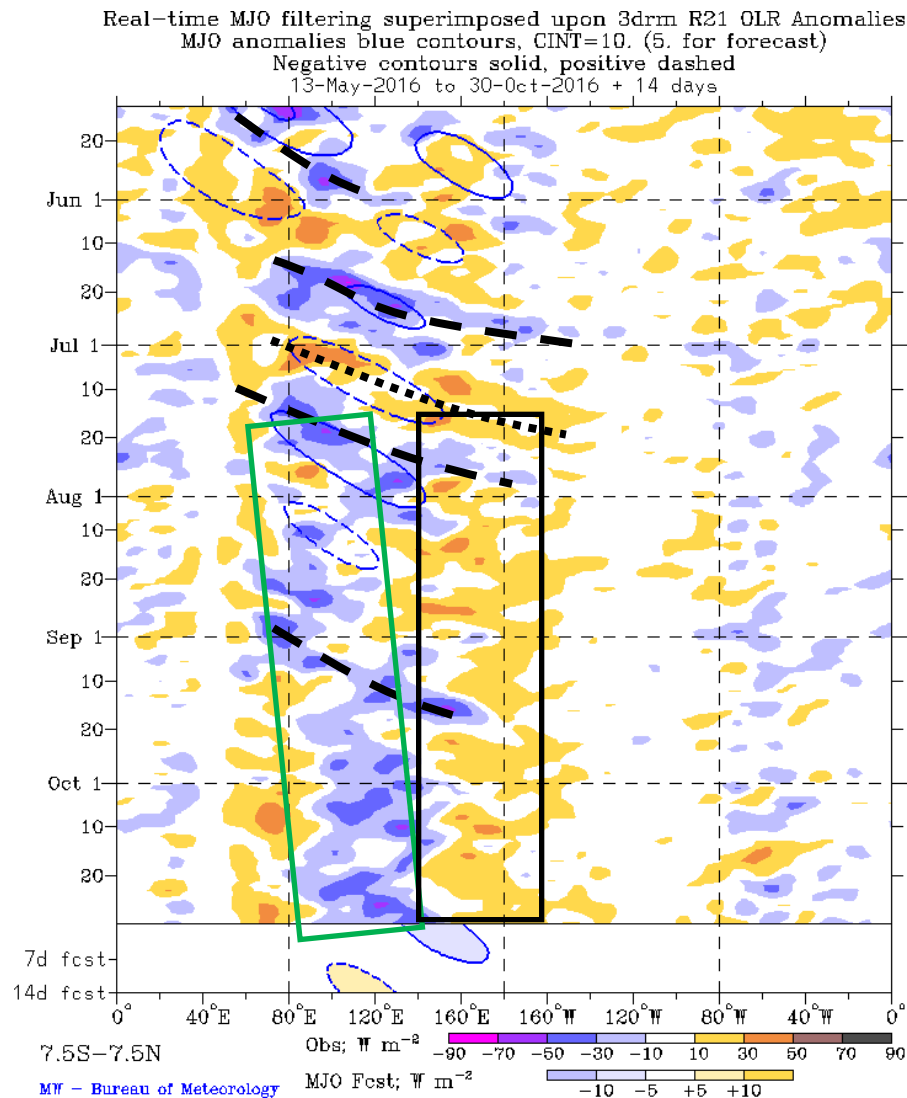
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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 the potentially developing La Niña, has been apparent near the Date Line since July (black box). A fast eastward propagating convective envelope was evident during early September

More recently, another fast eastward propagating convective envelope is evident in the OLR pattern.



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

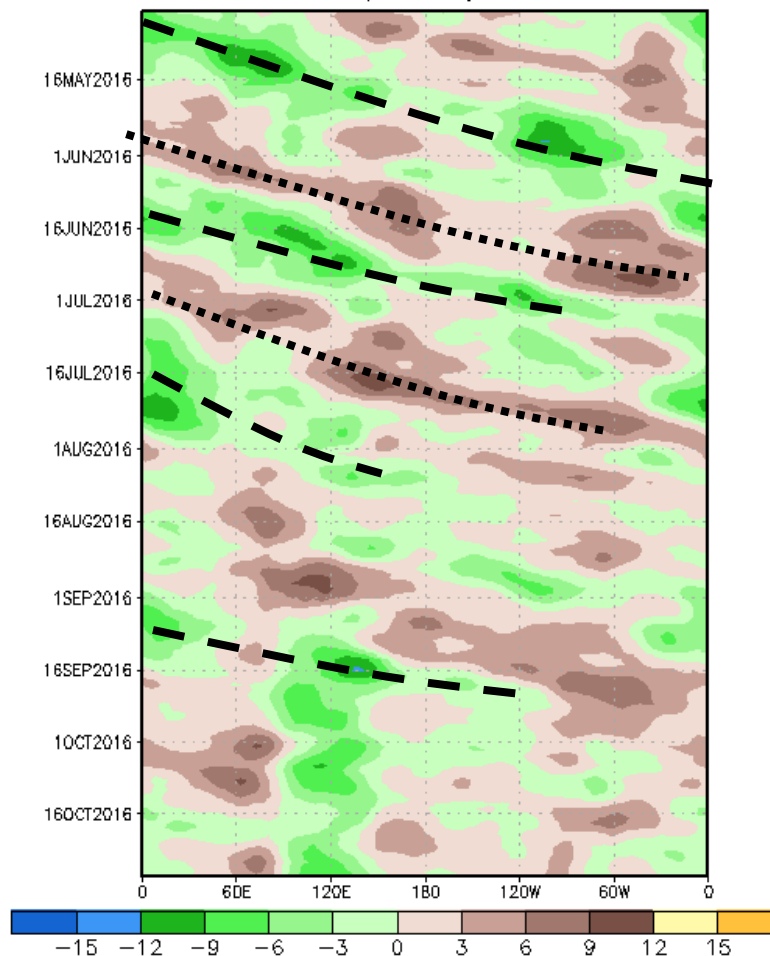
From May through early August, an eastward propagating signal was evident, with multiple periods of variability apparent.

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.

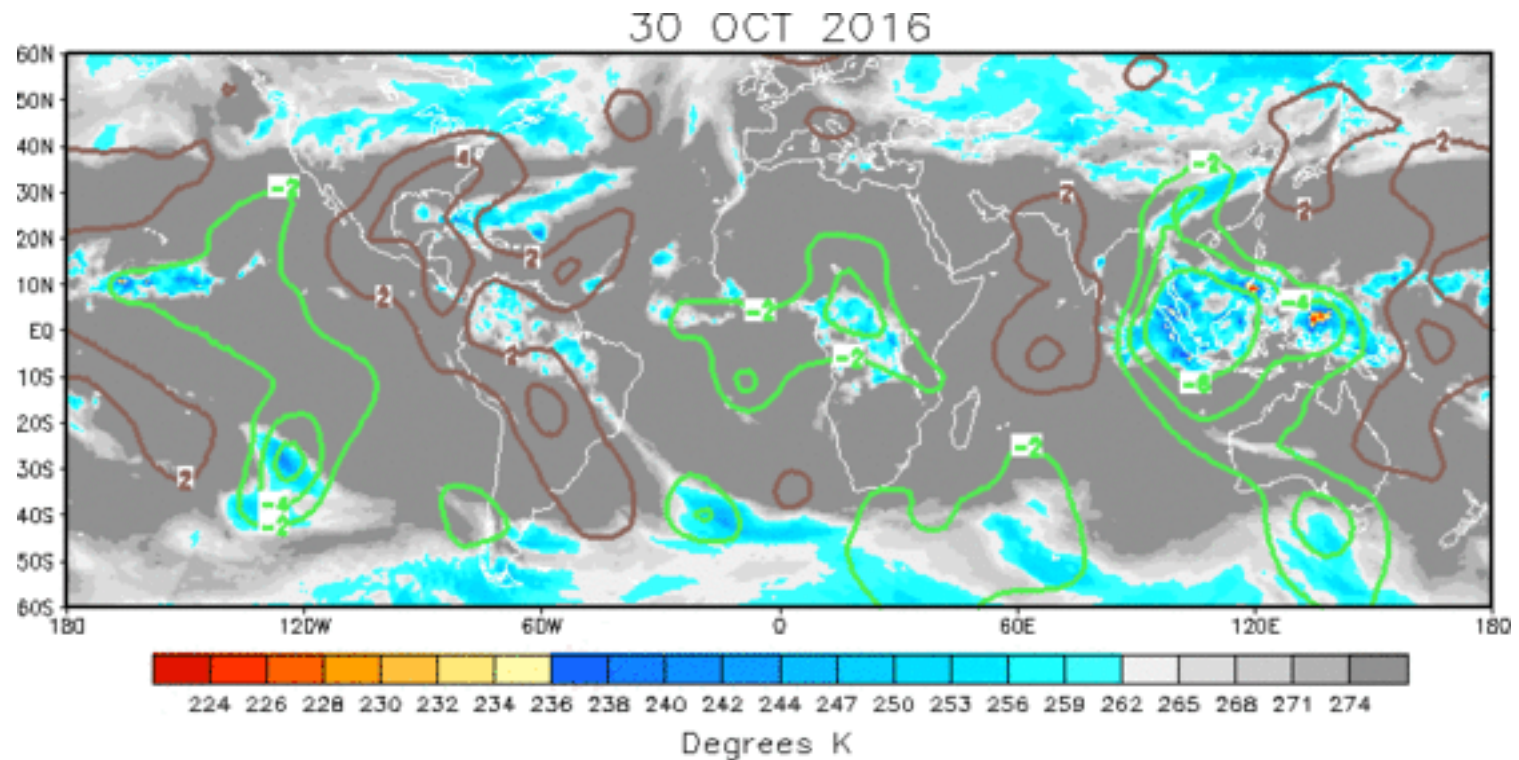
Since probable Kelvin wave activity during the first half of September, the pattern has given way to lower frequency modes and a quasi-stationary state. In the recent absence of intraseasonal variability, the standing negative velocity potential anomalies near 120E associated with the negative IOD event are apparent.

More recently, a potential eastward moving feature is evident over the Maritime Continent.

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



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



The overall spatial pattern of upper-level velocity potential anomalies was weak, with the exception of more pronounced negative anomalies over the Maritime Continent.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation
Negative anomalies (green contours) indicate favorable conditions for precipitation

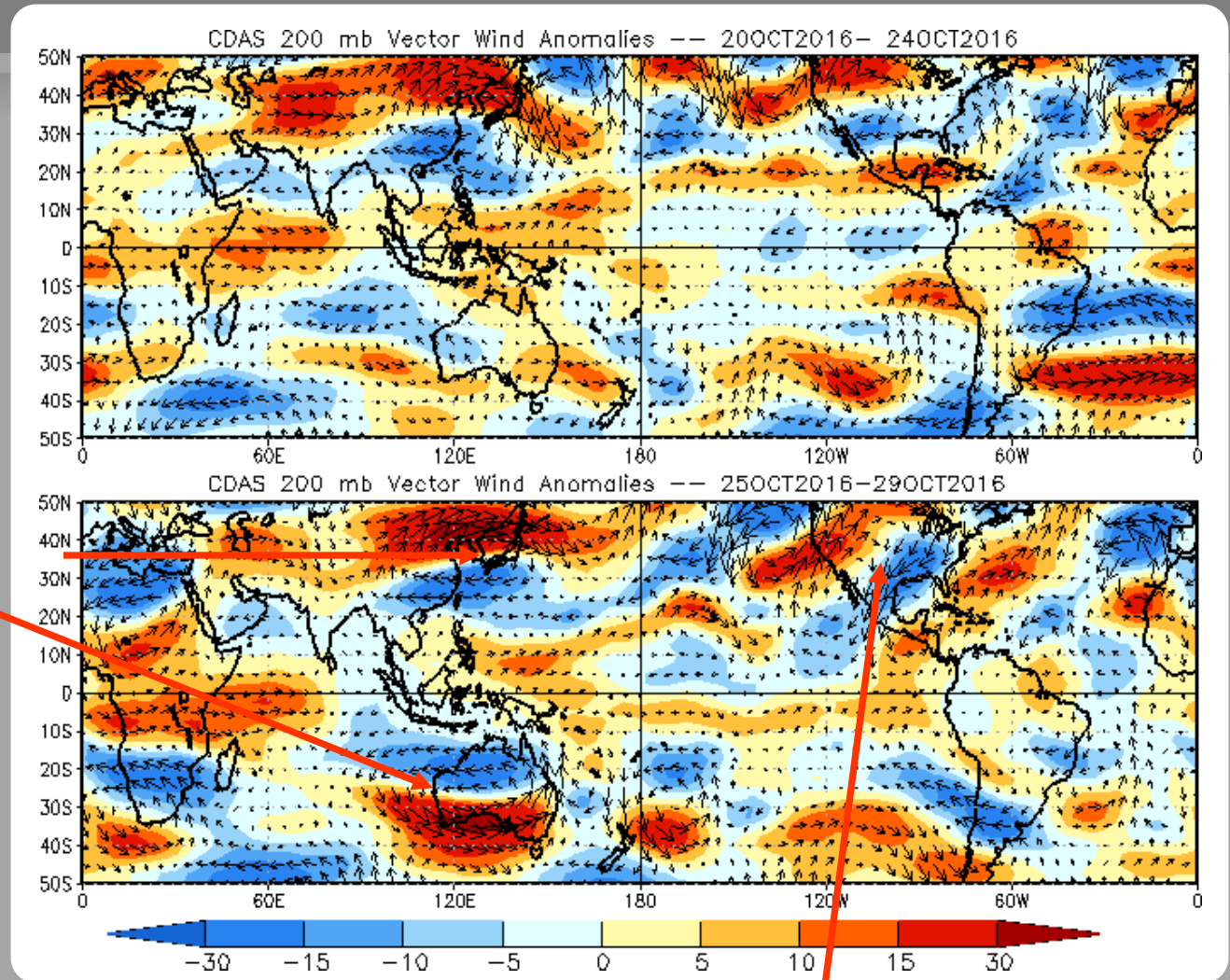
200-hPa Vector Wind Anomalies (m s⁻¹)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Large mid-latitude anticyclones were evident poleward of the low frequency enhanced convective envelope over the Maritime Continent.



Upper-level anomalous westerlies persisted over the western Indian Ocean and Africa.

A highly amplified pattern was evident across North America.

200-hPa Zonal Wind Anomalies (m s⁻¹)

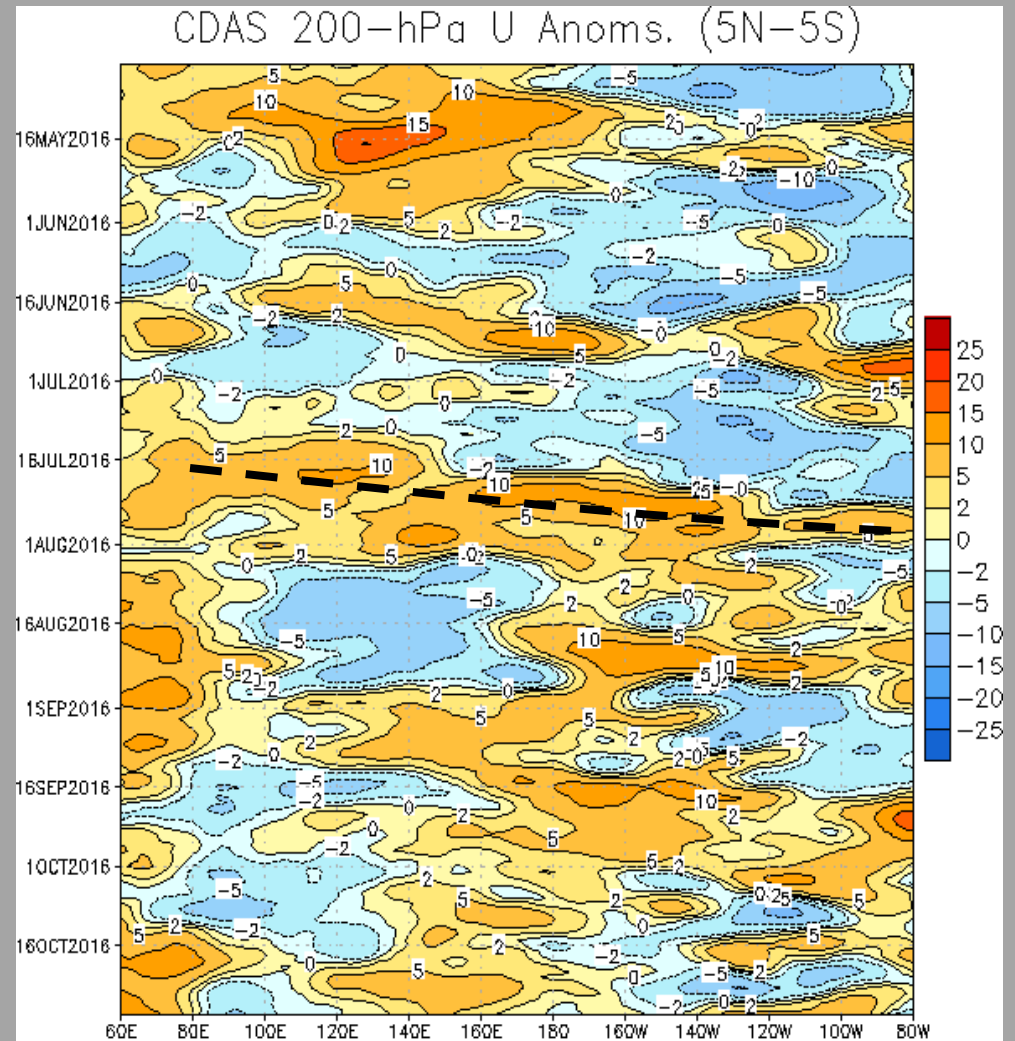
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

During May, westerly anomalies expanded eastward to the Date Line. Faster modes were evident in the upper-level wind field.

During July, some eastward propagation in large scale anomalies are evident, although the spatial consistency implies higher frequency variability than expected with MJO activity. During August and early September, the pattern became relatively stationary, with an interruption during early September.

Recently, the pattern has remained fairly consistent with the low frequency state established during summer.



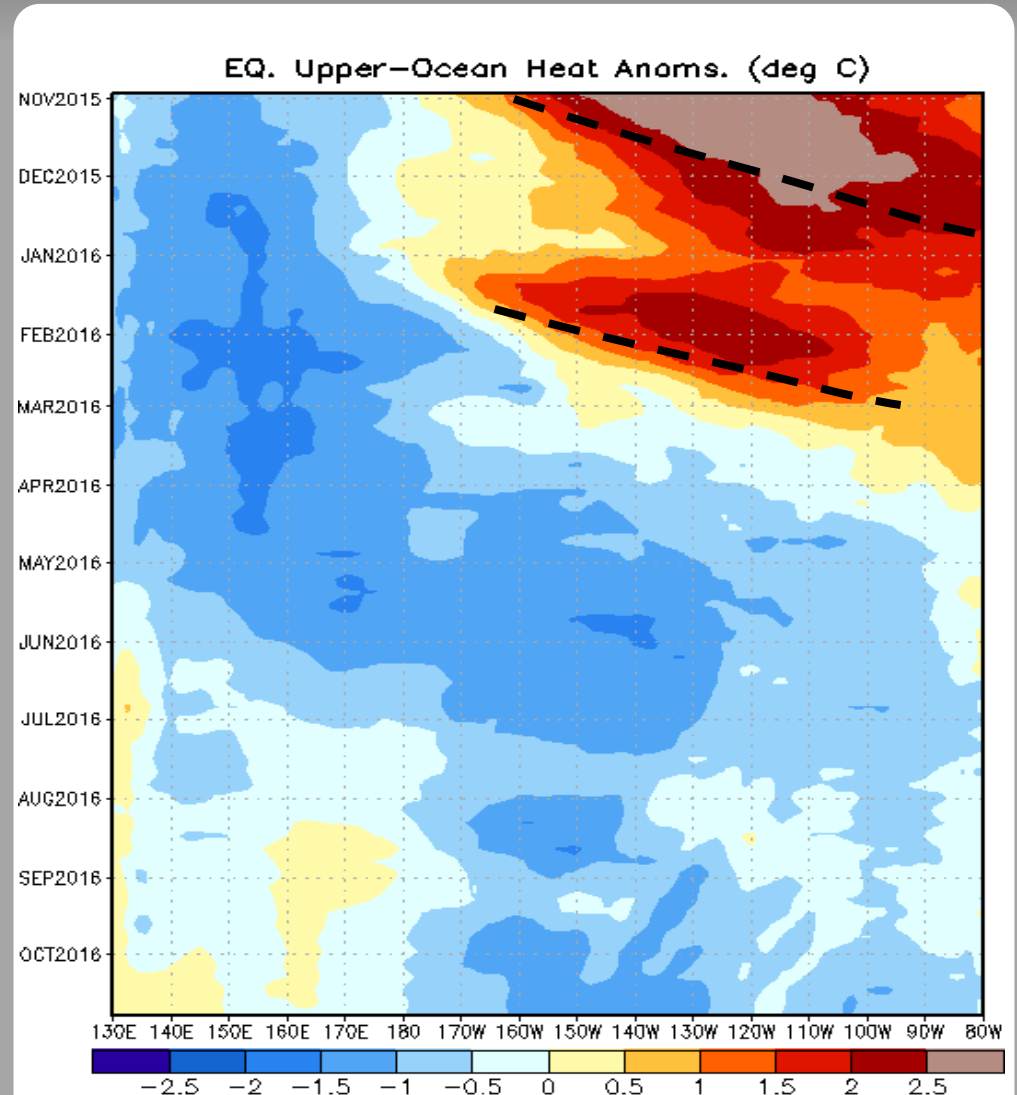
Weekly Heat Content Evolution in the Equatorial Pacific

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.

Reinforcing downwelling events were observed during late 2015, 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.

The strongest negative anomalies now persist east of the Date Line.



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

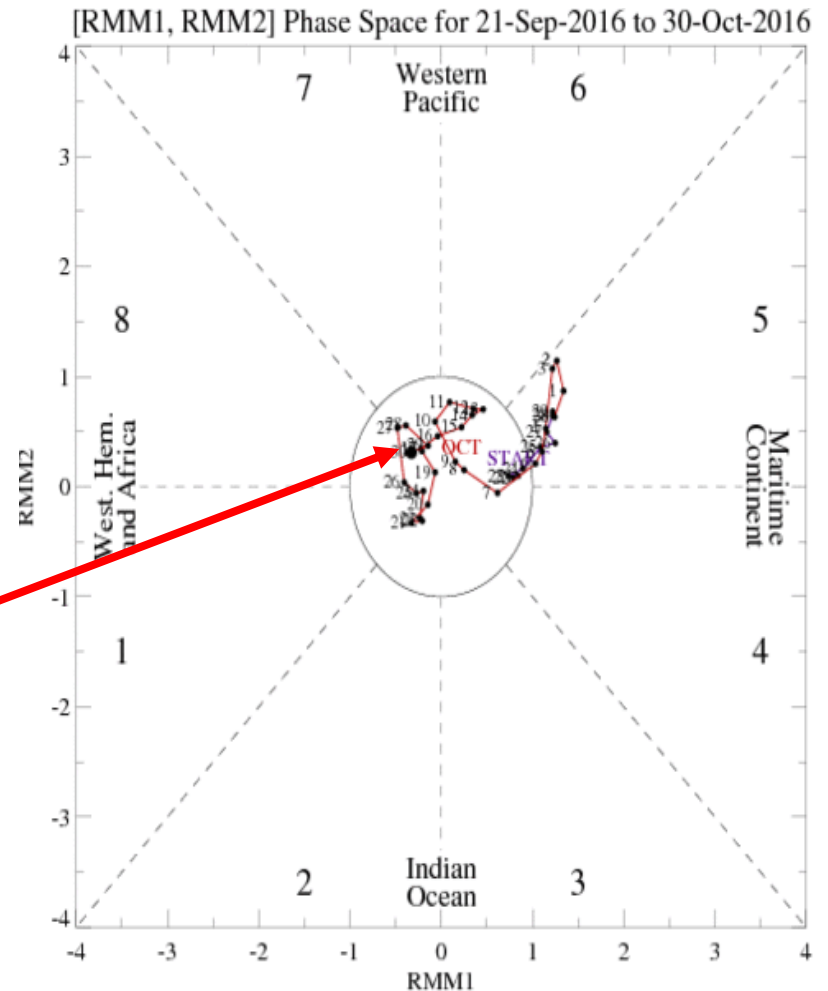
The triangular areas indicate the location of the enhanced phase of the MJO

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

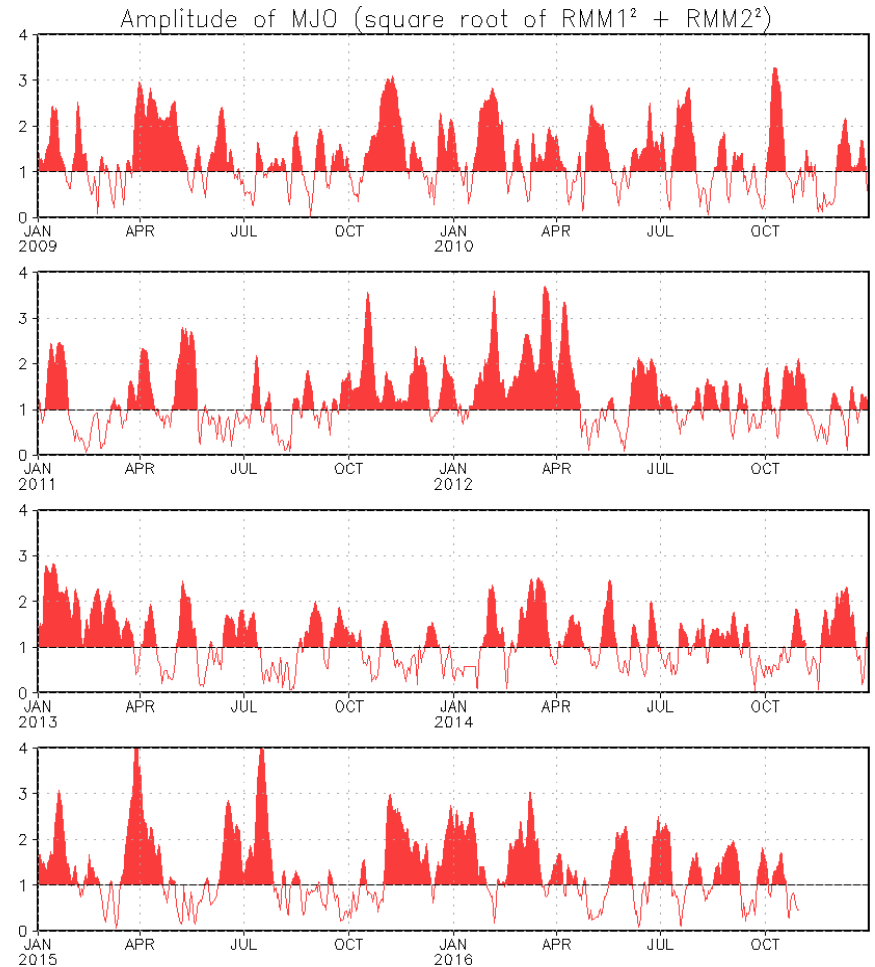
The RMM index shows no coherent MJO activity, with recent values within the unit circle.



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

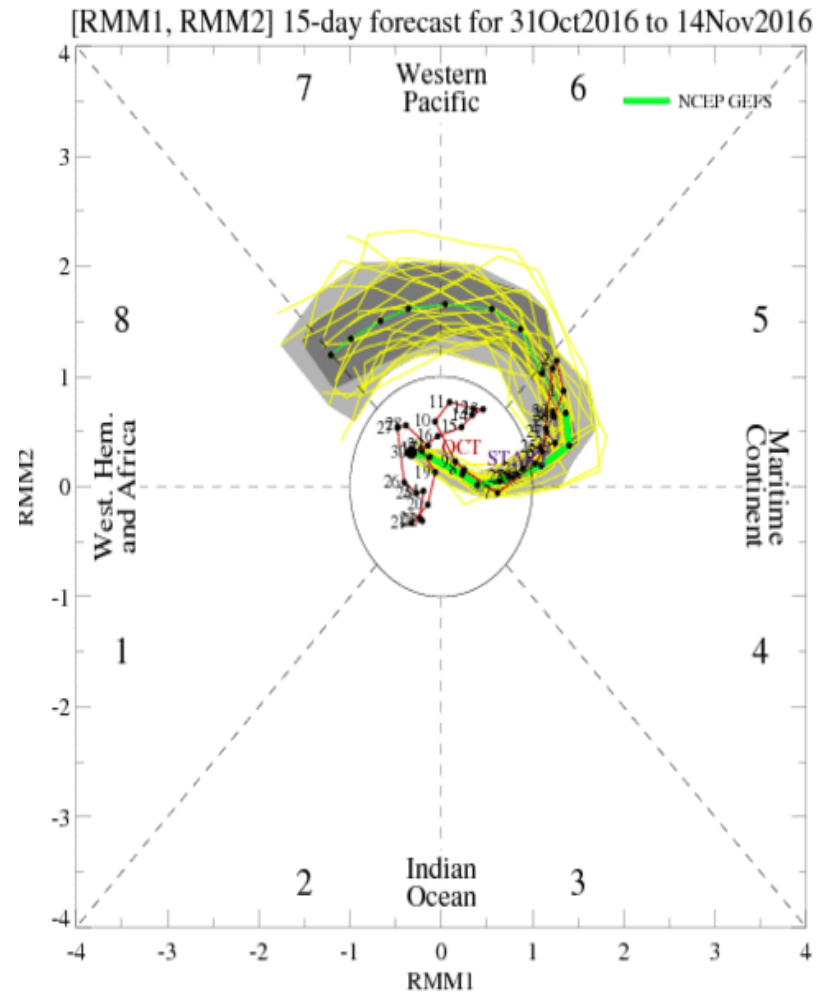
RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GFS ensemble forecasts depicts the development of a robust MJO event propagating from the Maritime to the West Pacific during the next two weeks.

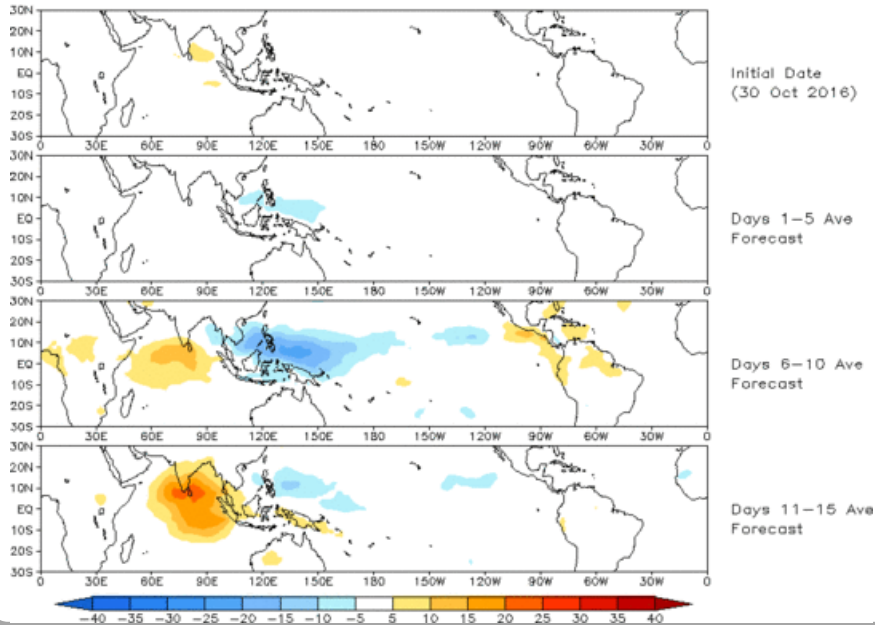
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean



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: 30 Oct 2016
OLR

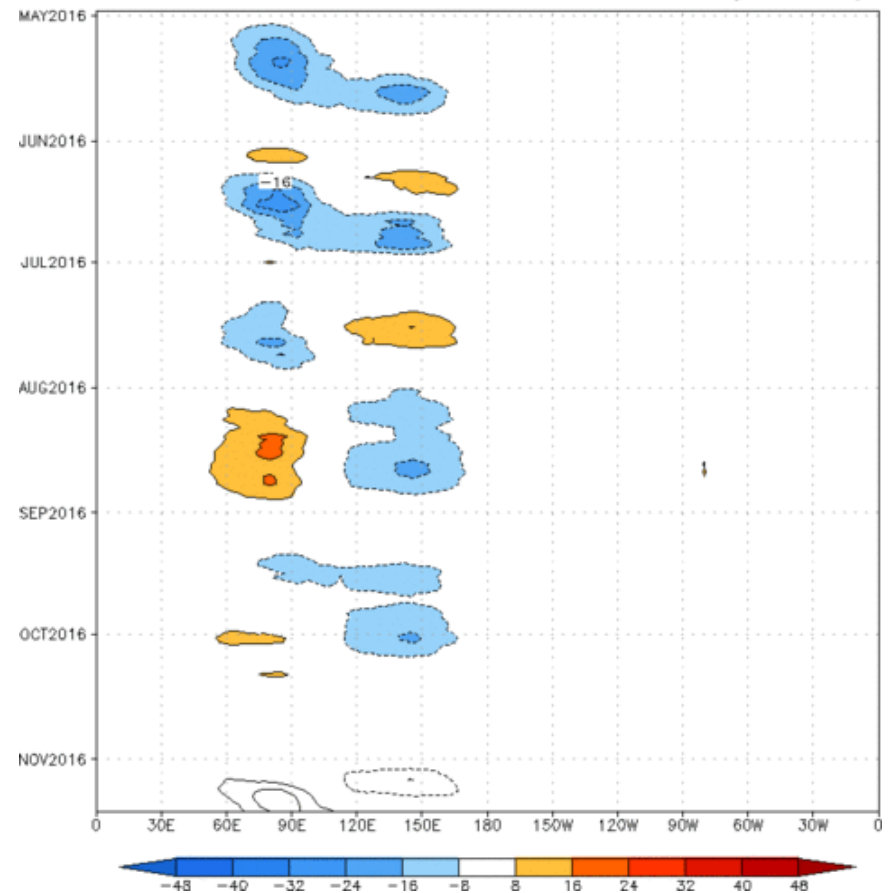


The GEFS RMM Index forecast OLR anomalies show increasing amplitude and a canonical West Pacific MJO structure during Week-2.

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

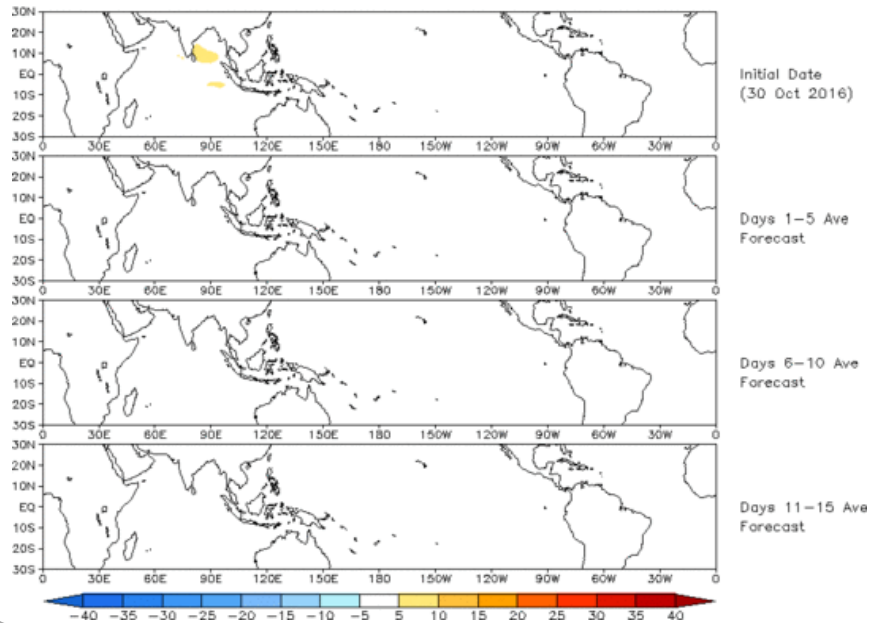
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2
OLR [7.5° S, 7.5° N] (cont:4Wm⁻²) Period:30-Apr-2016 to 30-Oct-2016
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days



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 (30 Oct 2016)

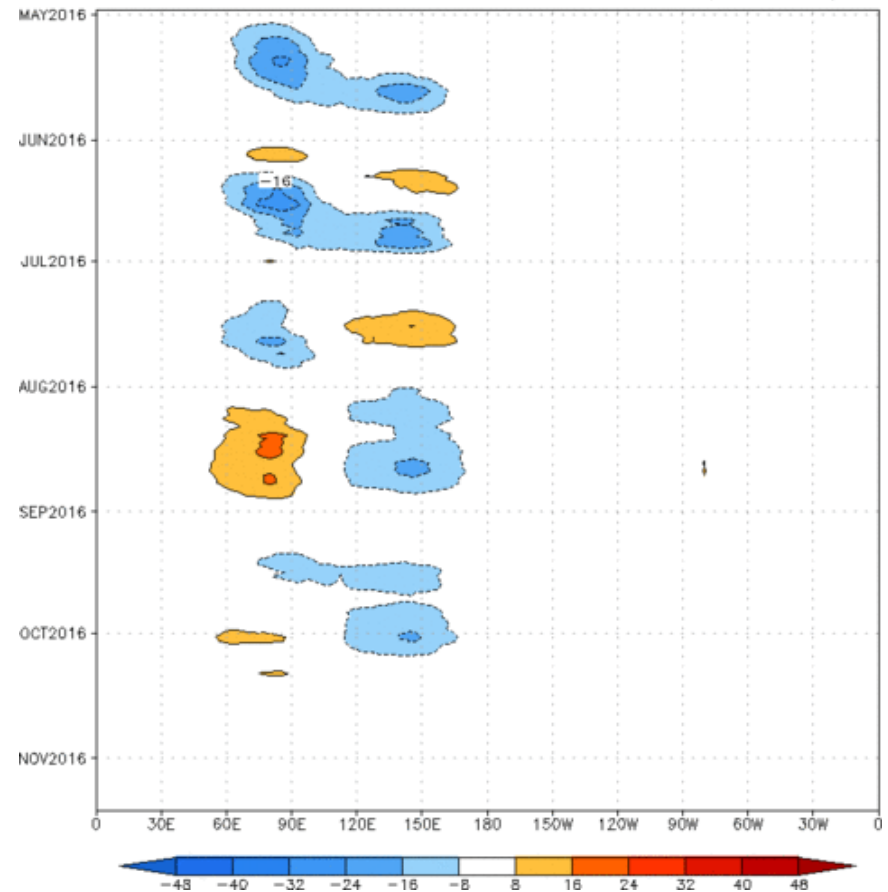


The Constructed Analog model suggests little to no convective anomalies associated with the MJO over the next two weeks.

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.)

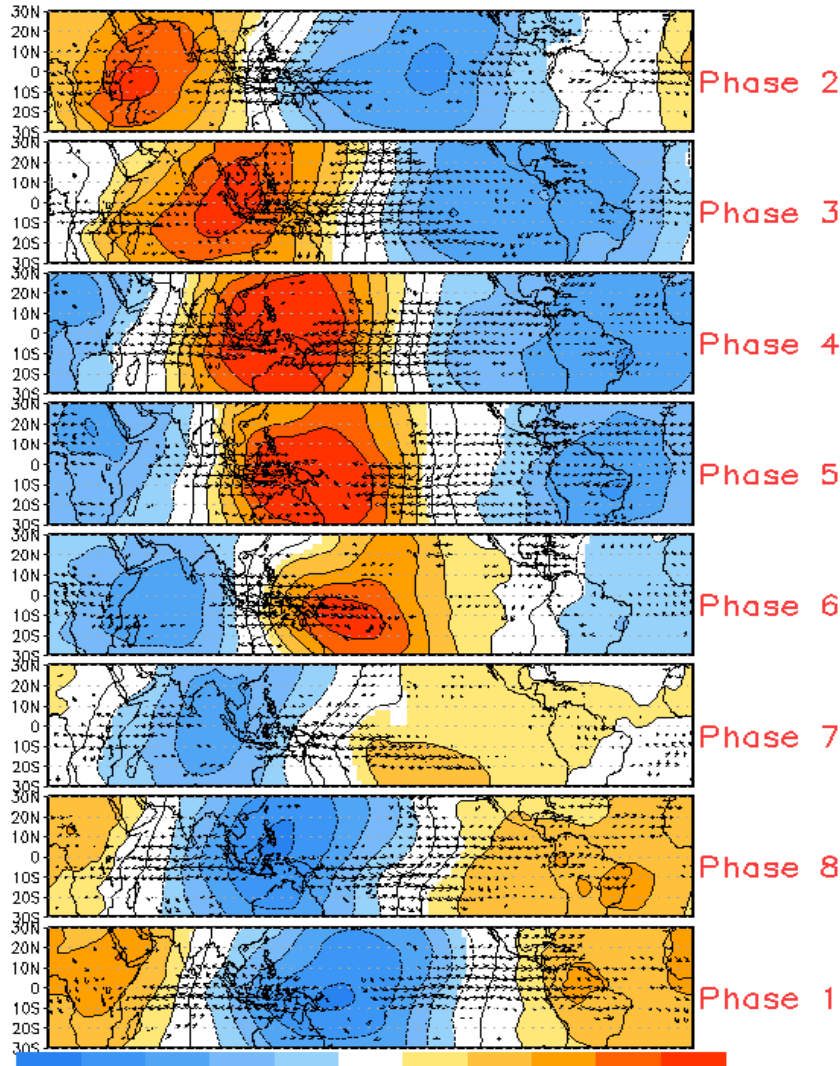
Time-longitude section of (7.5° S- 7.5° N) OLR anomalies - last 180 days and for the next 15 days

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [7.5° S, 7.5° N] (cont: 4Wm^{-2}) Period: 30-Apr-2016 to 30-Oct-2016
The unfilled contours are CA forecast reconstructed anomaly for 15 days

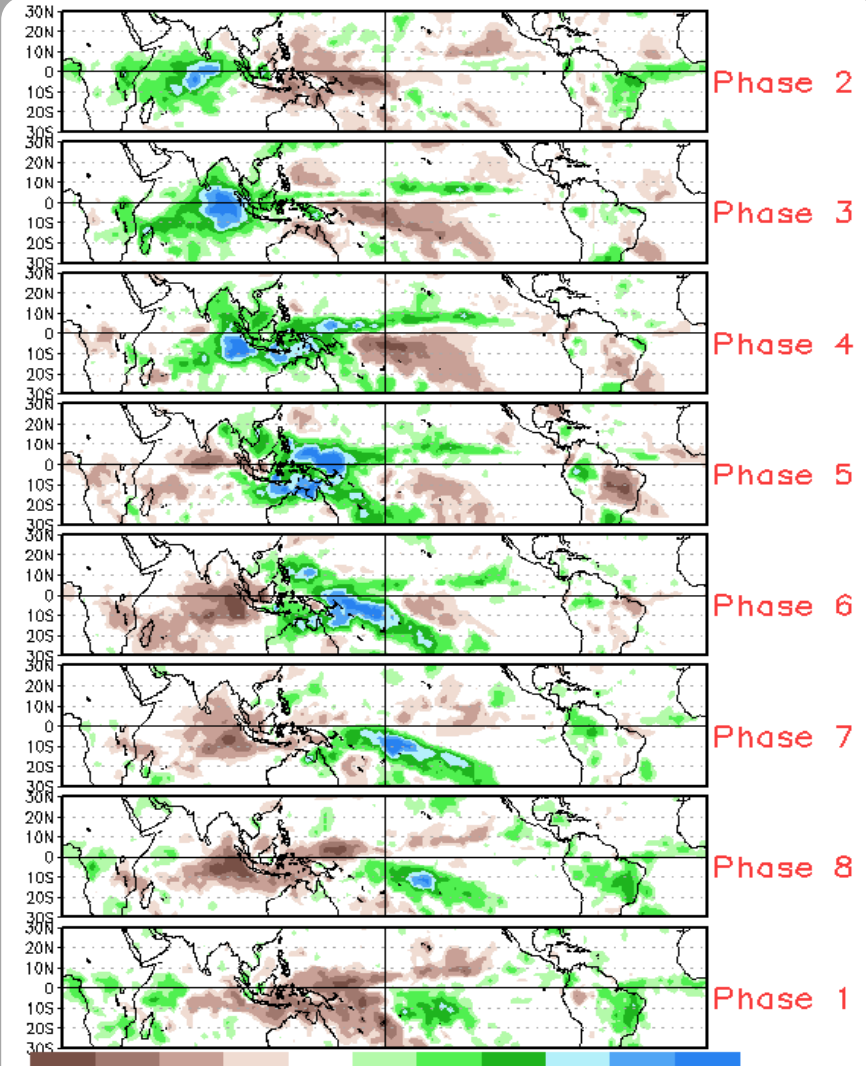


MJO Composites - Global Tropics

850-hPa Velocity Potential and
Wind Anomalies (May - Sep)



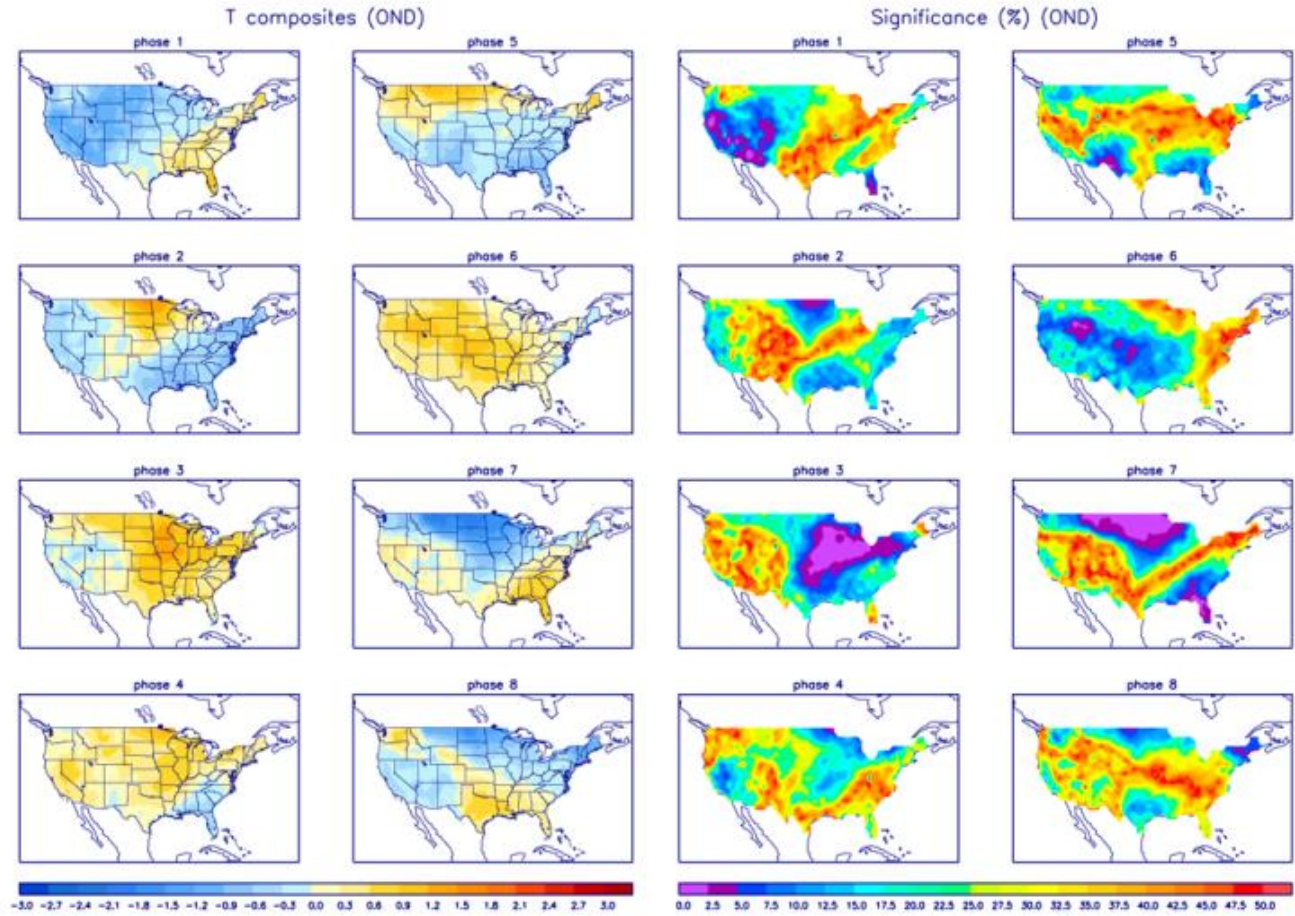
Precipitation Anomalies (May - Sep)



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.



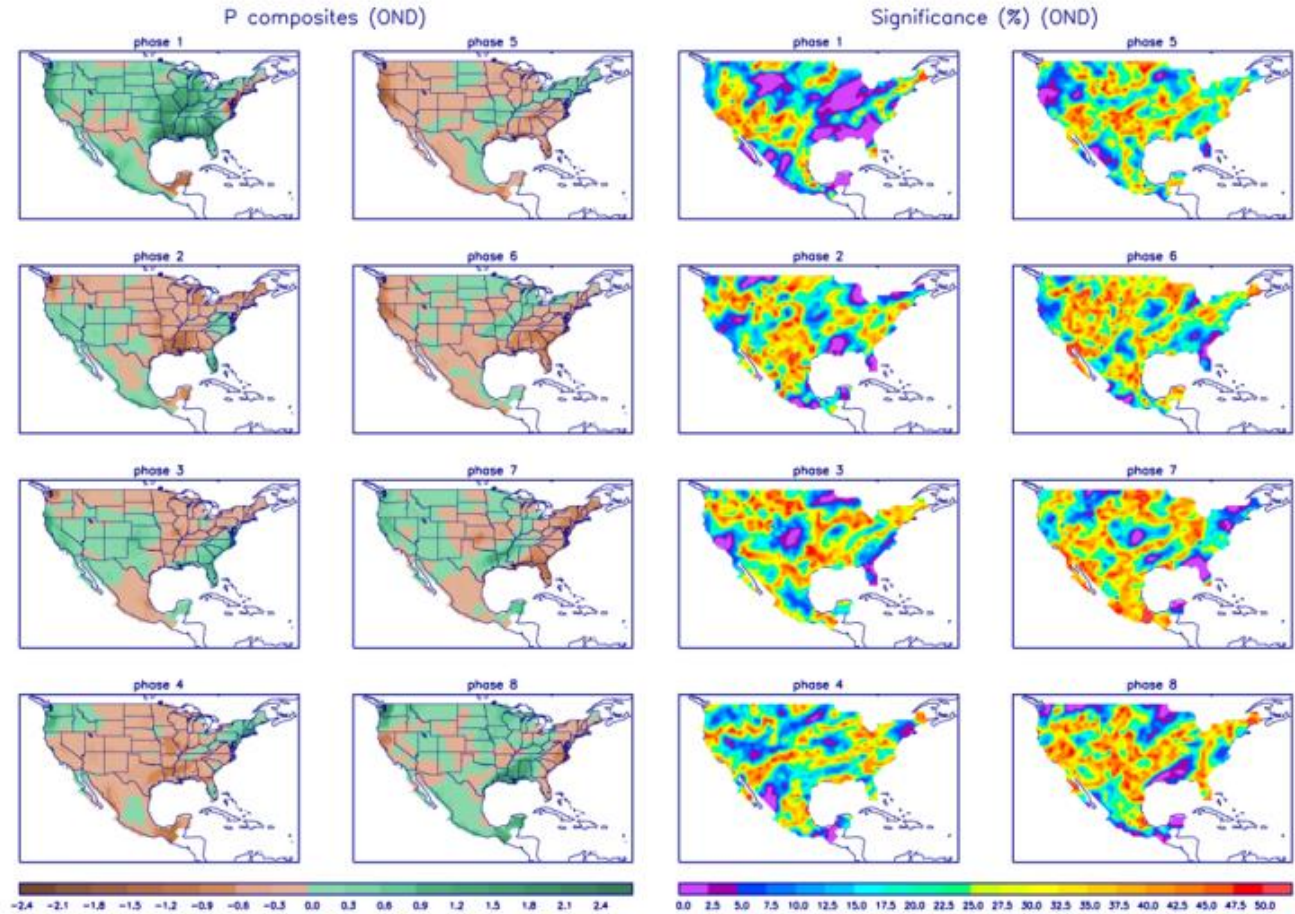
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>