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

Update prepared by:
Climate Prediction Center / NCEP
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Outline

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MJO Index Information

MJO Index Forecasts

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Overview

- The CPC velocity potential-based and RMM-based MJO indices indicate that the MJO weakened during early November. The residual signal has since dissipated over the Maritime Continent/Western Pacific region.

- Dynamical model RMM-index forecasts differ, but a general consensus indicates an increase in signal amplitude in phases 3/4 with some eastward propagation during Week-2.

- The tropical cyclone season is winding down rapidly across the Northern Hemisphere tropics. One area where a tropical cyclone may form is the southern Bay of Bengal early in Week-2.

- The base state (La Niña conditions) is likely to be modulated by an occasional Kelvin wave during the next two weeks, with only modest MJO influence expected across the global tropics.

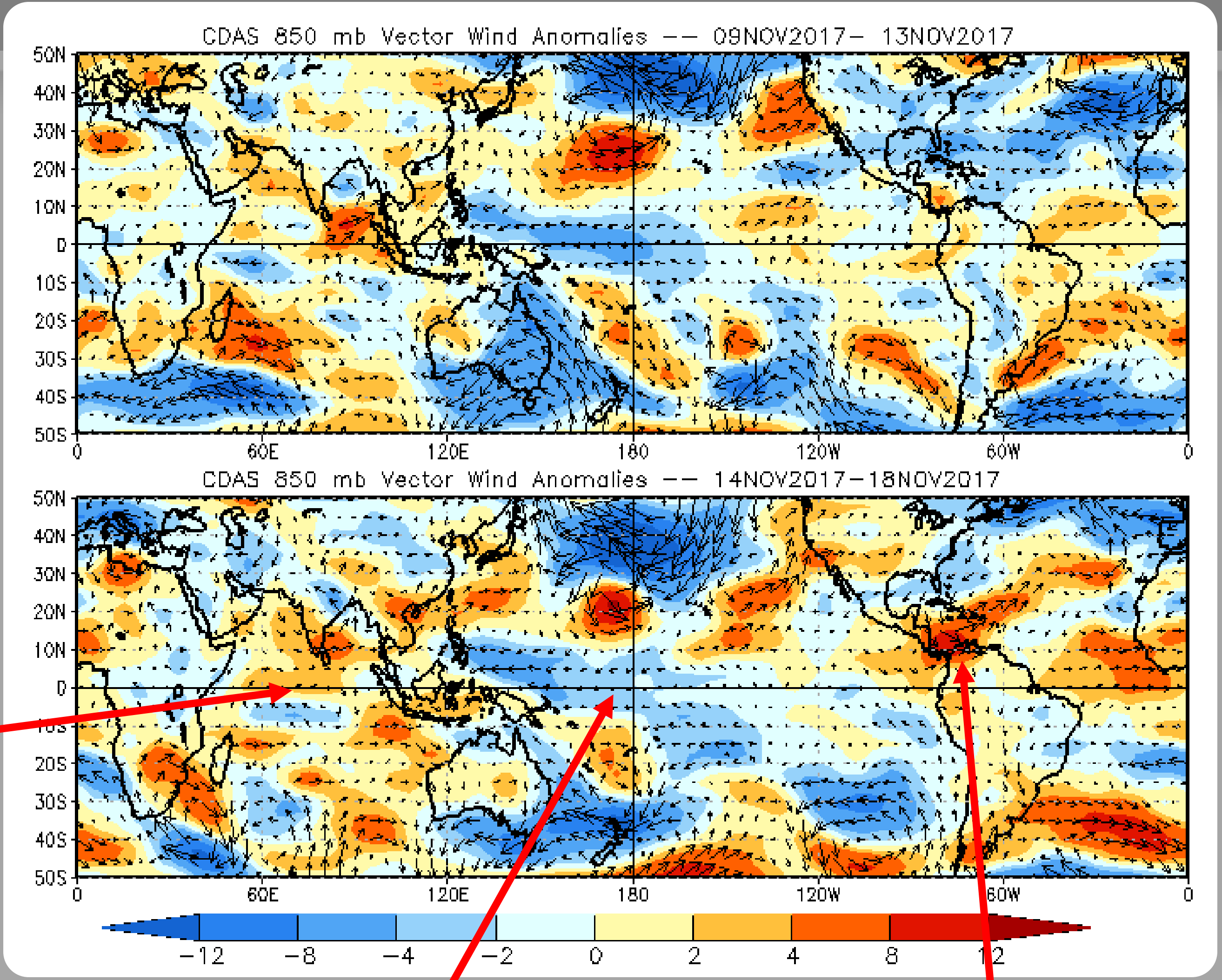
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 dominated the tropical North Indian Ocean during the recent period.

Easterly anomalies weakened slightly near the Date Line.

A reversal from easterly to westerly wind anomalies was noted over the Caribbean Sea.

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

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

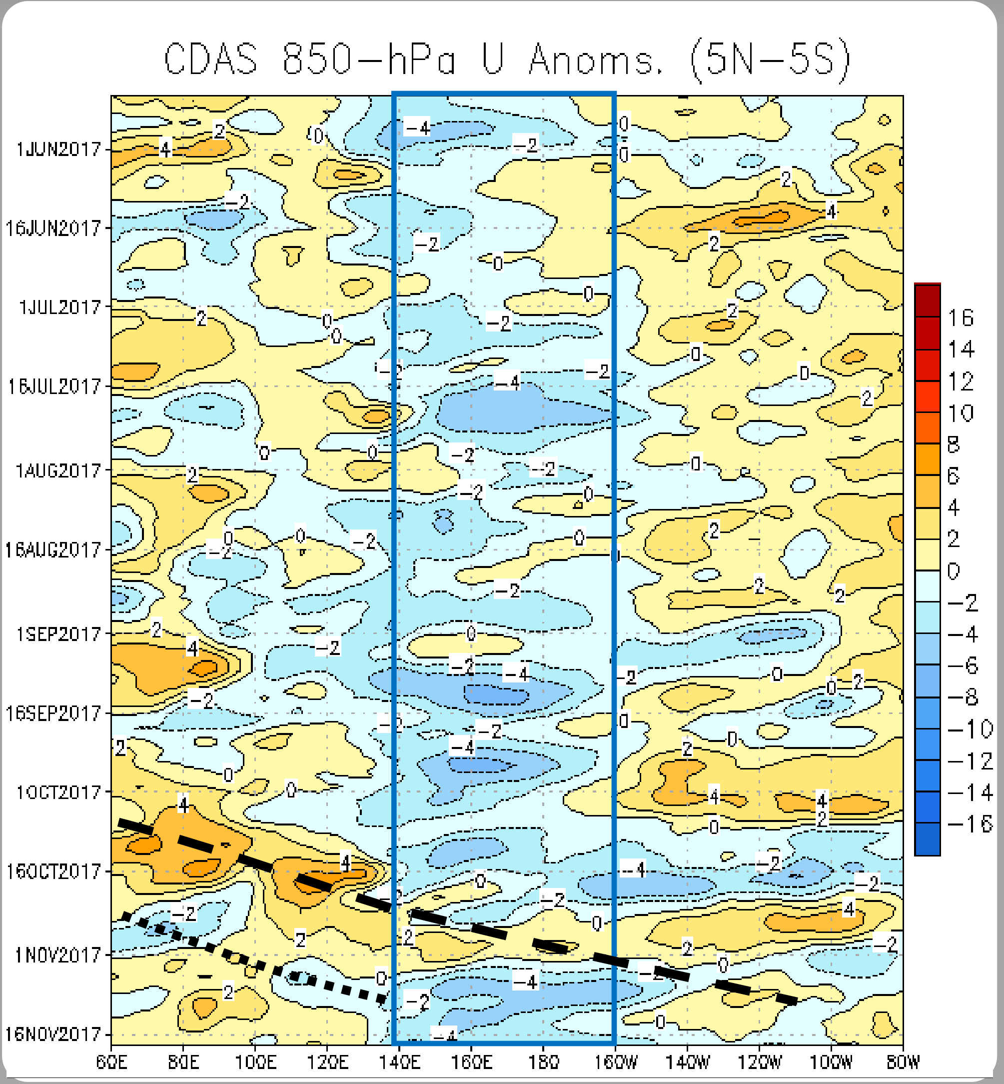
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Low-frequency easterly anomalies (blue box) have largely persisted over the west-central Pacific throughout the last 180 days.

Equatorial zonal wind anomalies were of low amplitude in June. During July, a slight eastward shift in the low-frequency pattern is noted, related to short-lived MJO activity.

During August and September, the low-frequency envelope of easterly anomalies re-established from 140E to just east of the Date Line. During October, a robust MJO event developed, with eastward propagation of westerly anomalies.

Recently, residual MJO activity may have constructively interfered with the low-frequency state.



OLR Anomalies - Past 30 days

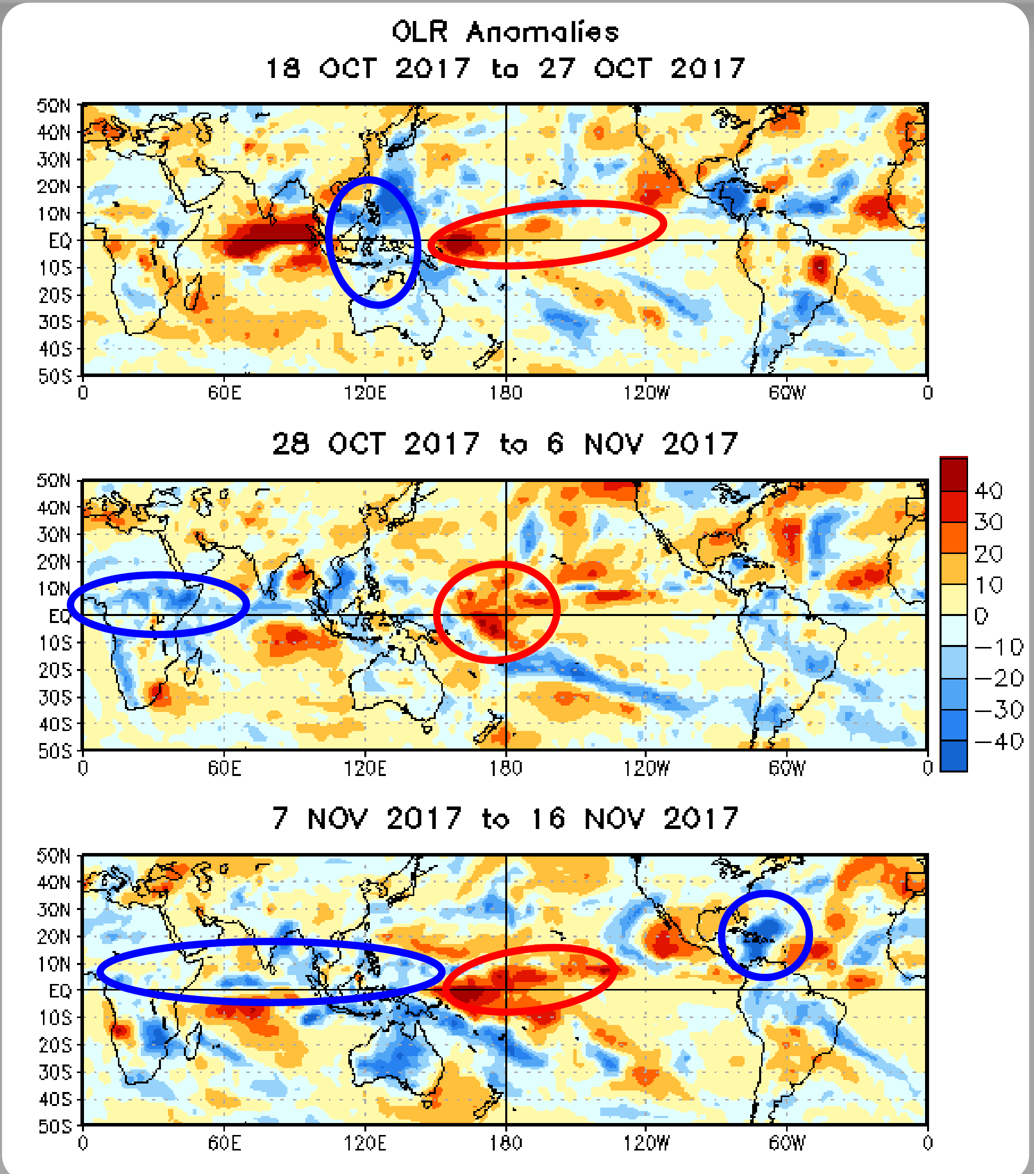
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid to late October, enhanced convection associated with a strengthening MJO developed over the eastern Indian Ocean and western Maritime Continent. Suppressed convection remained entrenched over the central and eastern Pacific.

During late October & early November, the MJO rapidly propagated east across the Western Hemisphere with convection increasing once again across Africa. The low frequency state continued to support suppressed convection across the equatorial central Pacific.

During early/mid November, the remaining MJO signal moved across the Indian Ocean, enhancing convection in the area, while suppressed convection remained over the Central Pacific. Enhanced convection related to a stalled baroclinic zone is indicated from the Sargasso Sea to the Central Caribbean.



Outgoing Longwave Radiation (OLR) Anomalies (7.5ºS - 7.5ºN)

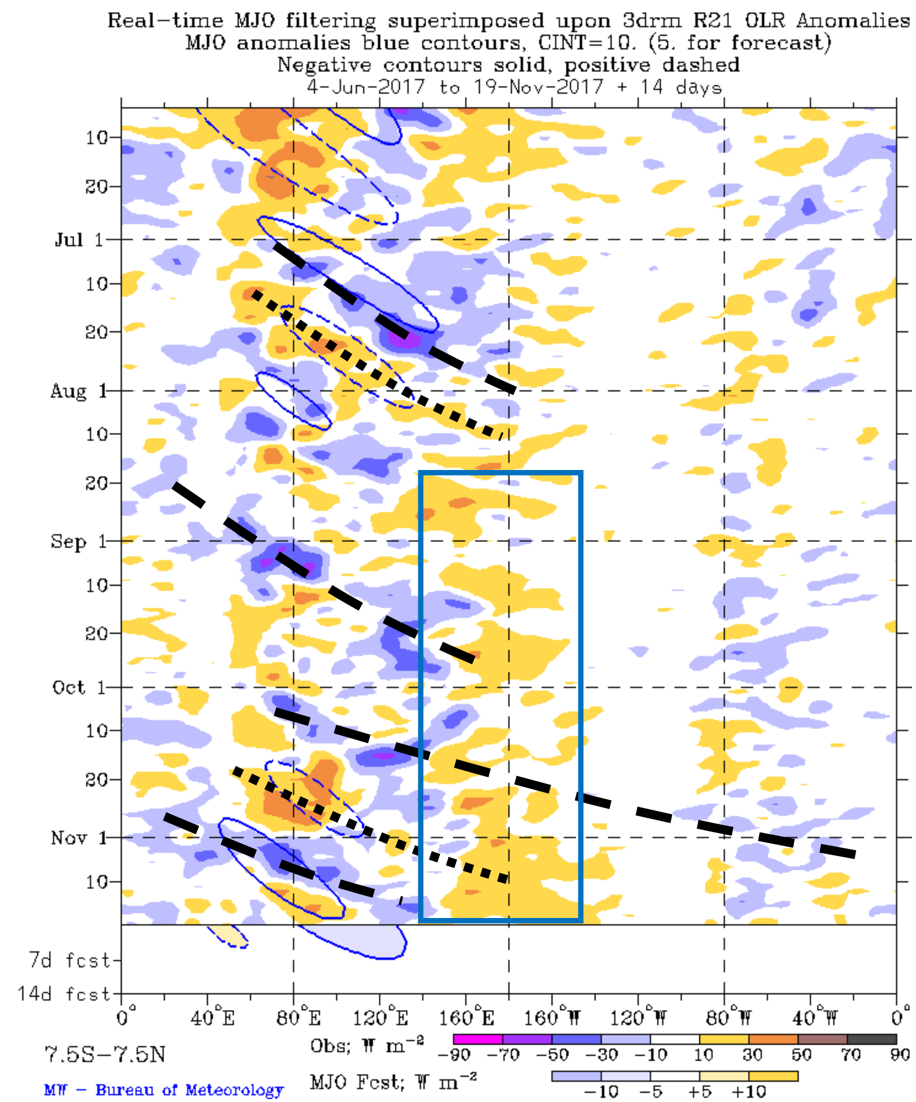
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid-July, there was a burst of enhanced convection over the Maritime Continent, due to interactions between a short-lived intraseasonal signal and the low-frequency state.

Multiple modes of variability including tropical cyclones contributed to the pattern of anomalous convection during August and September. Weak MJO activity was present during August and early September. The low-frequency signal emerged more fully in August.

An MJO signal emerged over the Maritime Continent during early October and propagated eastward rapidly during the past month. One month later, the MJO signal had circumnavigated the globe, with a weakened signal returning to the Maritime Continent region. The enhanced phase now more closely aligns with the low-frequency state.



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

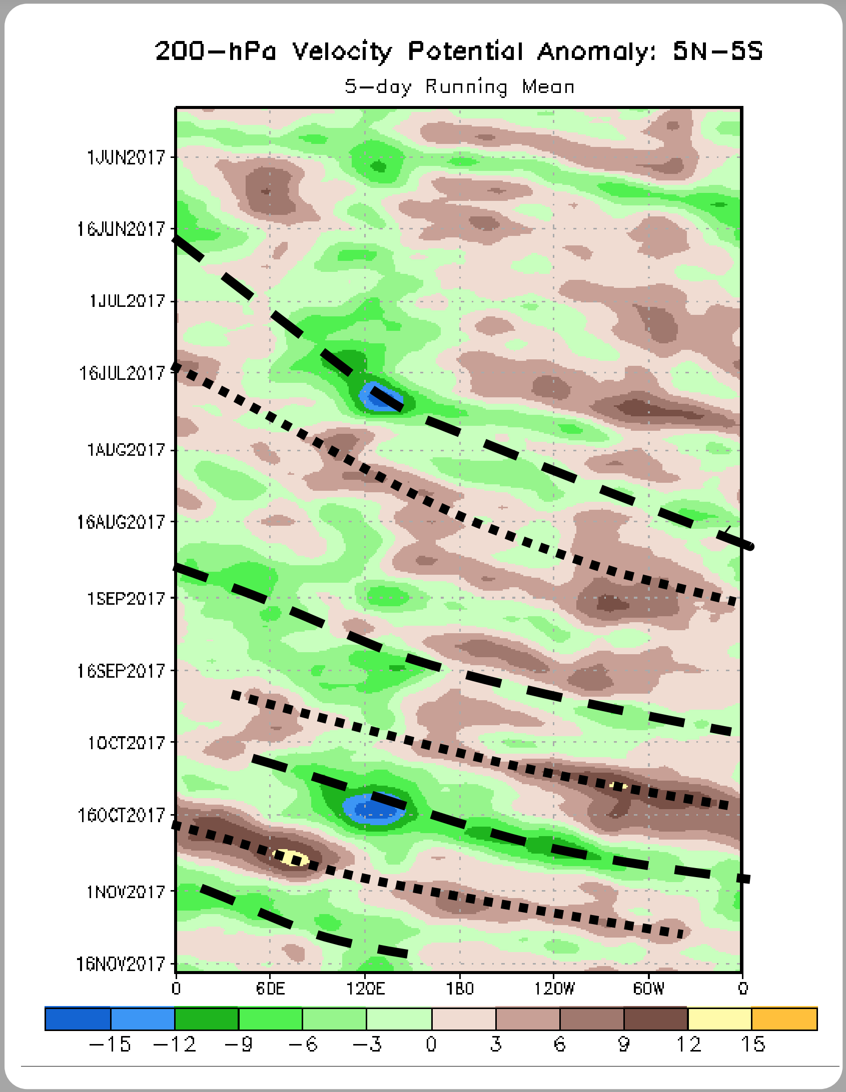
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

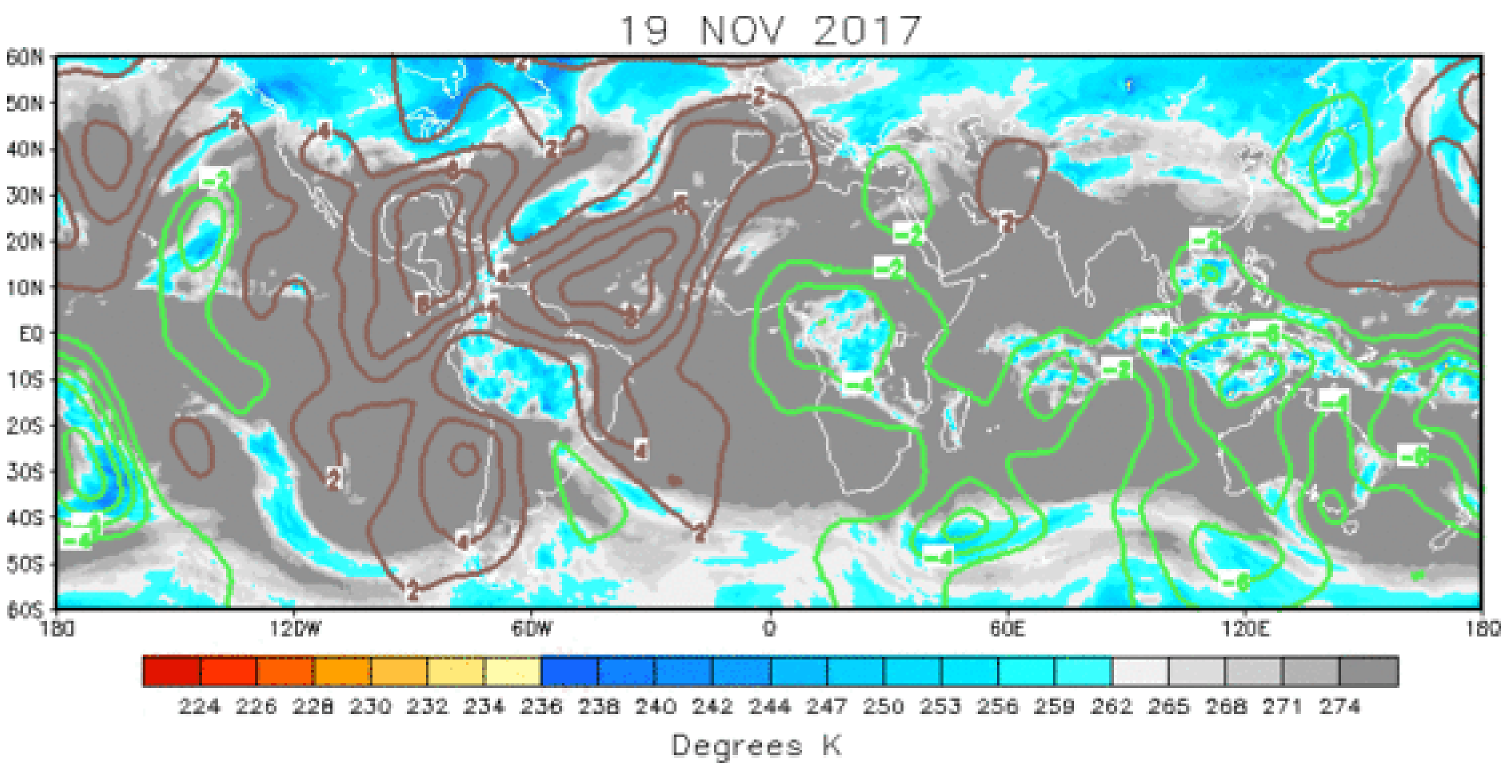
During July, enhanced convection strengthened over the Maritime Continent as the low-frequency signal constructively interfered with an easterly propagating signal. This eastward propagating signal appears more or less intact with a period in line with canonical MJO phase speeds.

A signal on the MJO timescale is evident in this field during late August and September.

Another MJO event developed near the Maritime Continent during early October, with a large upper-level footprint near 120E and robust eastward propagation. The signal circumnavigated the global tropics, reaching the Maritime Continent region about 30 days later, and is beginning to constructively interfere with the low-frequency wet signal over the region. The subseasonal signal, however, has weakened substantially.



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



Generally the upper-level velocity potential anomaly pattern reflects a wave-1 structure, though some noise from non-MJO modes of variability continue. The enhanced (suppressed) phase broadly extends across much of the Eastern Hemisphere (Western Hemisphere).

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)

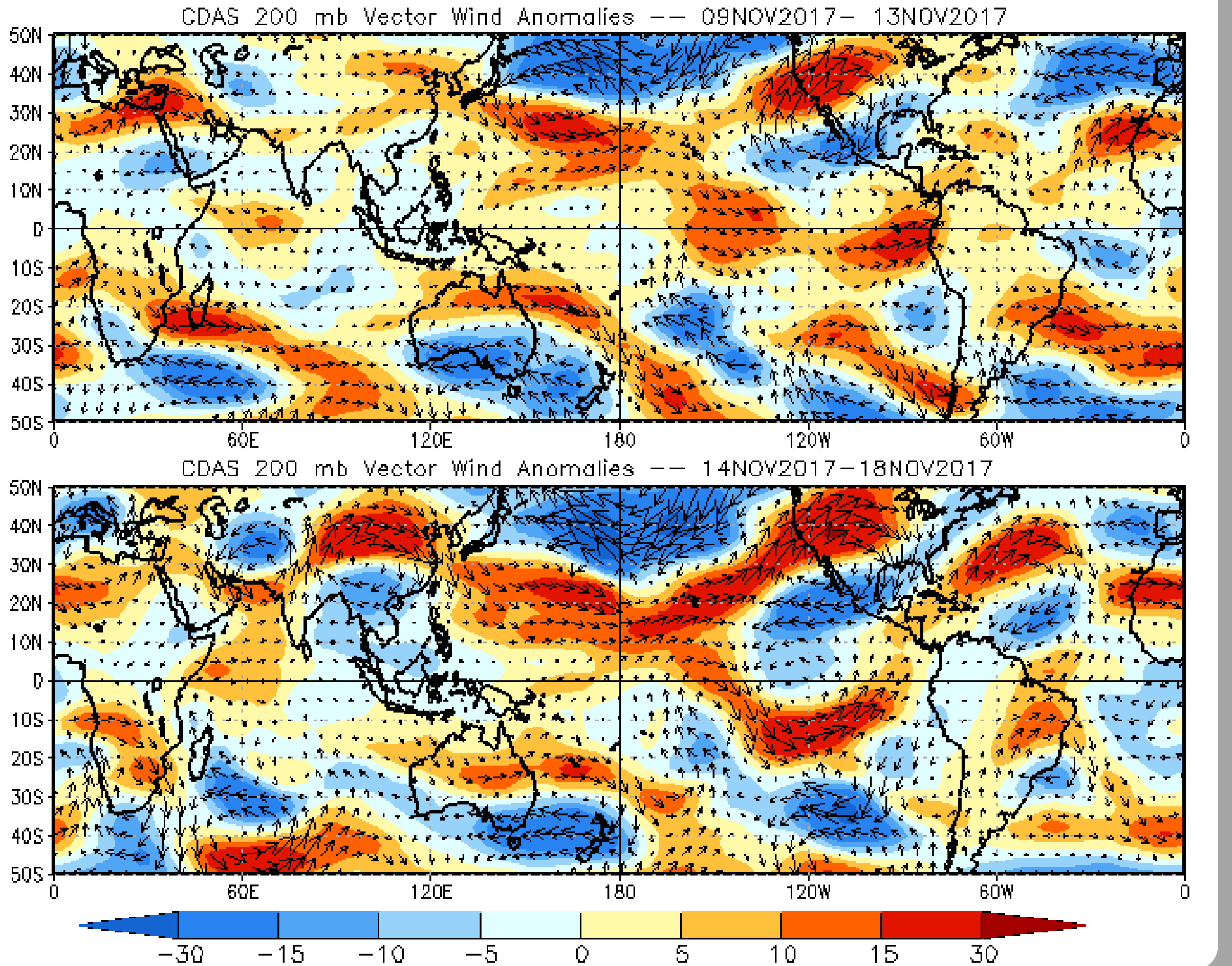
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Westerly anomalies are prevalent over the western North Indian Ocean, and easterly anomalies are indicated over the eastern North Indian Ocean.

Mid-latitude influences from both hemispheres can be seen in the wind anomaly pattern over the eastern Pacific.



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

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

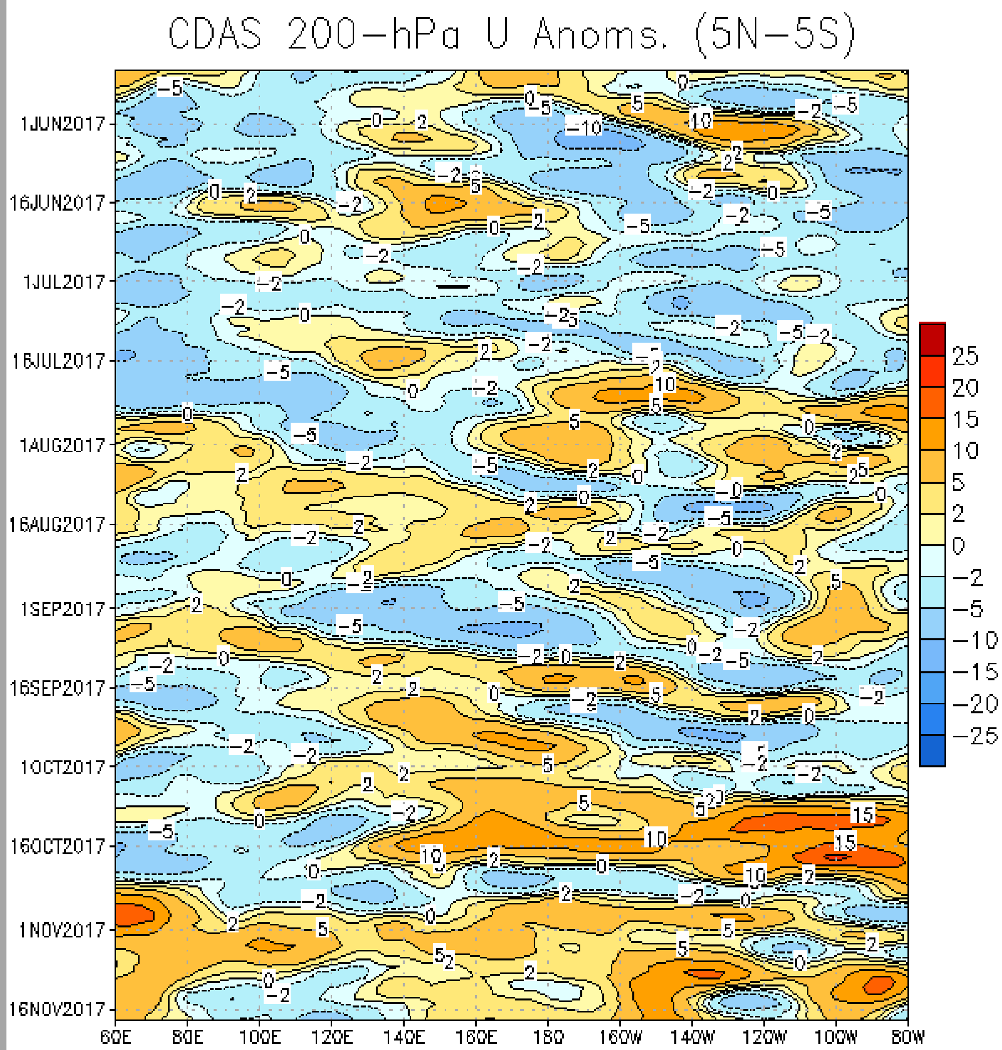
Easterly anomalies (blue shading) represent anomalous east-to-west flow

During early to mid-June, easterly anomalies were most prominent across the global tropics, in part due to mid-latitude influences.

Starting in July, the anomaly patterns propagated eastward associated with weak MJO activity and atmospheric Kelvin waves.

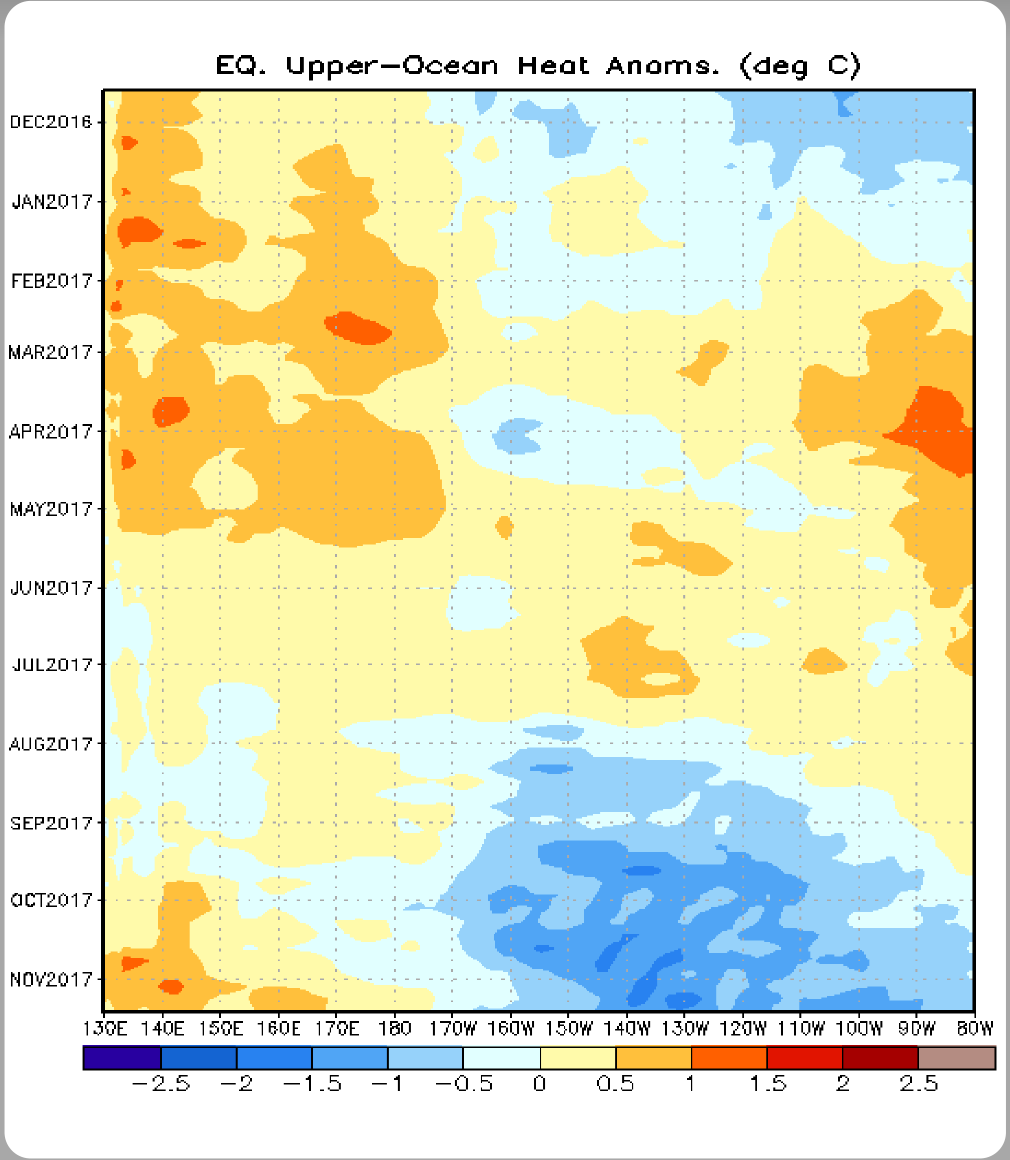
During September, fast-moving eastward propagation of anomalies continued, consistent with additional atmospheric Kelvin Waves. A slower signal was evident over the eastern Maritime Continent and west Pacific.

Westerly (easterly) anomalies expanded across much of the Pacific (Indian Ocean) during late October, and have remained. Upper-level divergence is inferred in the region around 140E, consistent with low-level mass convergence and rising motion.



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.



Negative upper-ocean heat content anomalies remain entrenched in the eastern Pacific, with some strengthening near 100W.

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

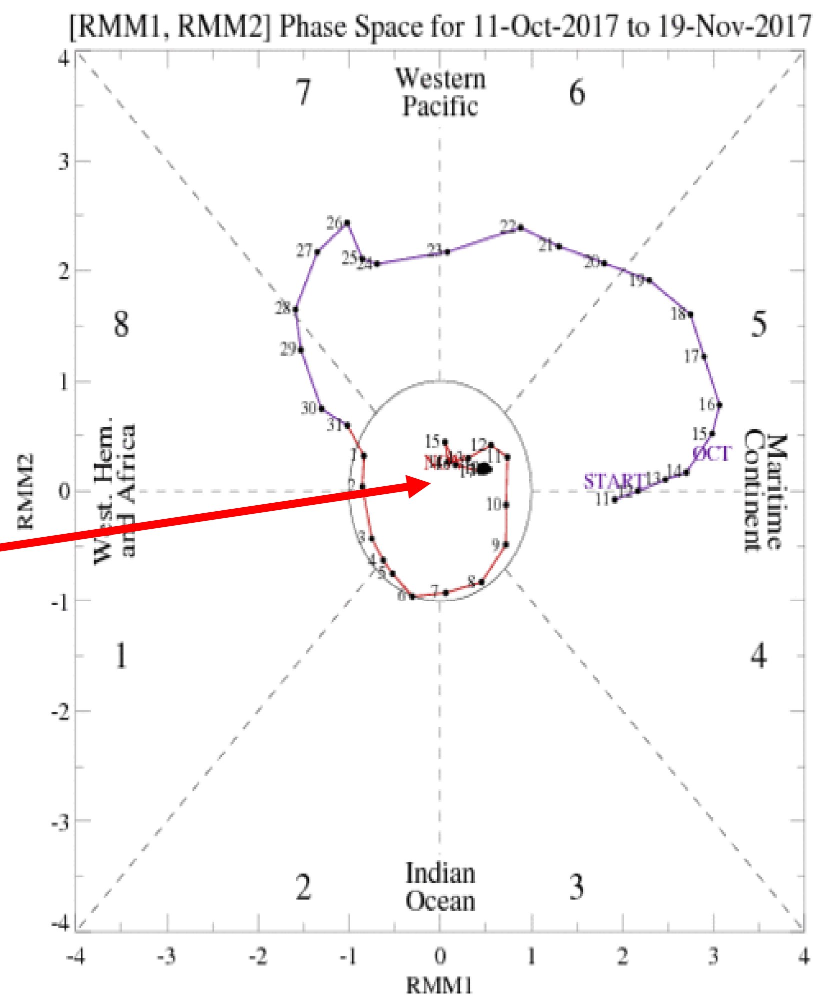
The triangular areas indicate the location of the enhanced phase of the MJO

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

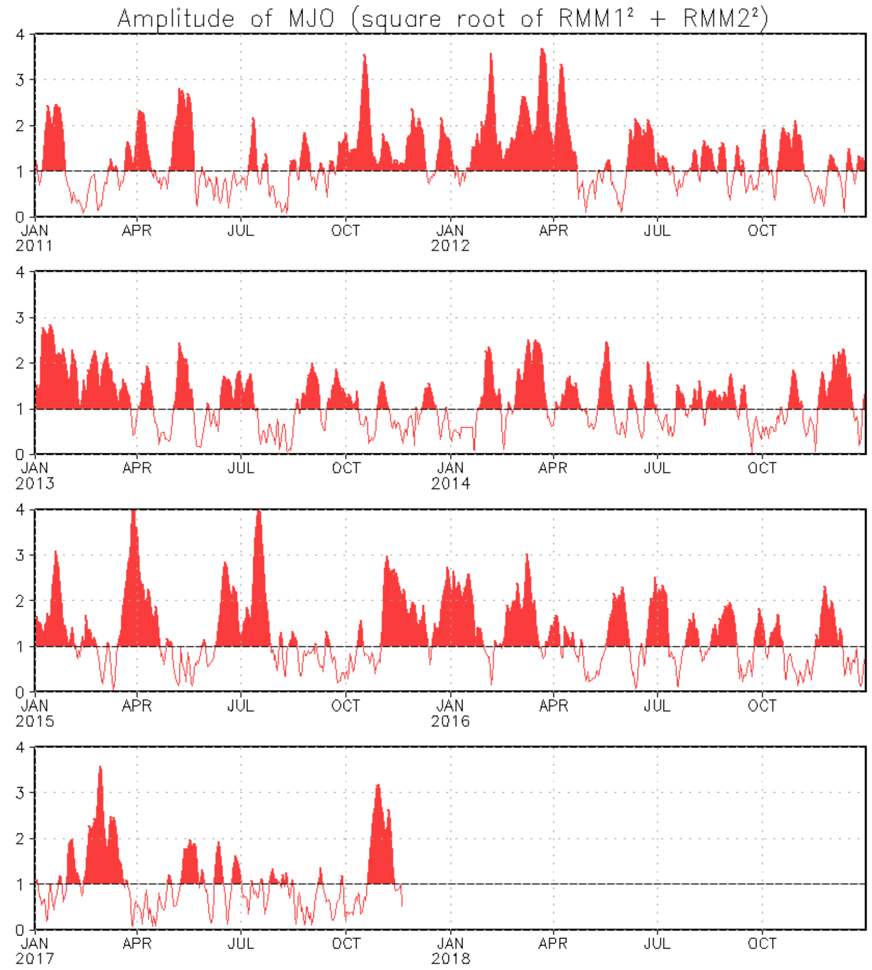
The RMM-index indicates a weak signal over the Maritime Continent, with the signal remaining within (or on) the unit circle since Nov 1.



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.



GFS Ensemble (GEFS) MJO Forecast

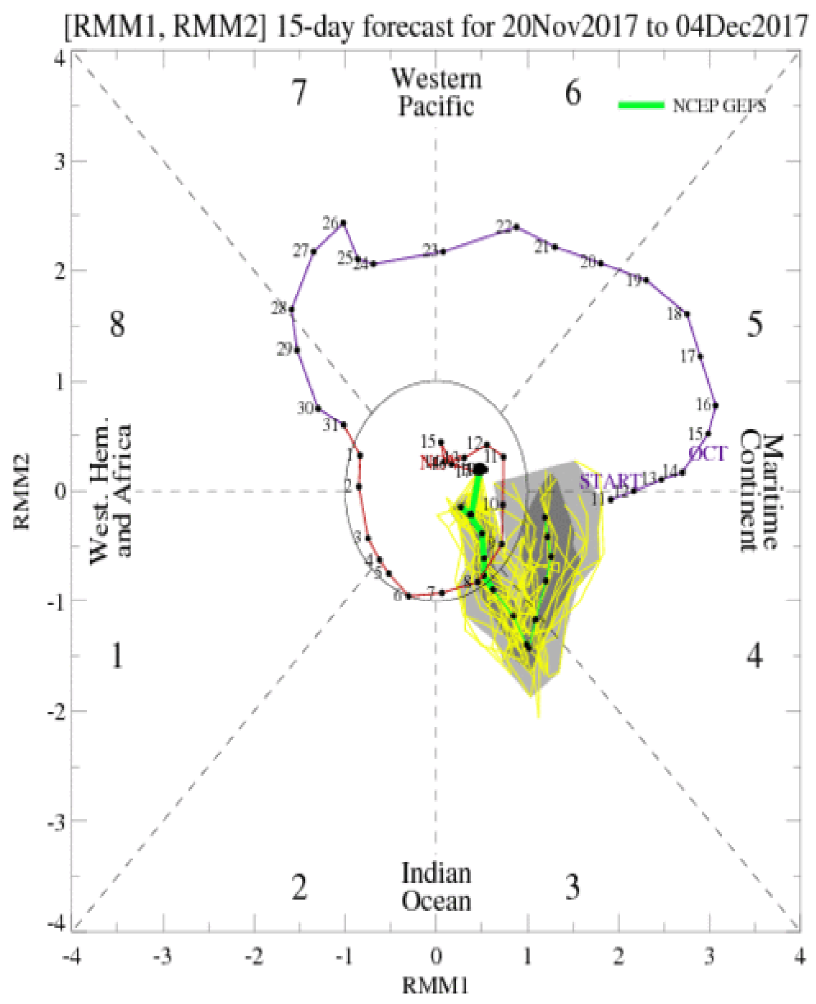
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GEFS forecasts an increase in the amplitude of the MJO signal over the eastern Indian Ocean/western Maritime Continent region during Week-1, followed by some eastward propagation during Week-2.

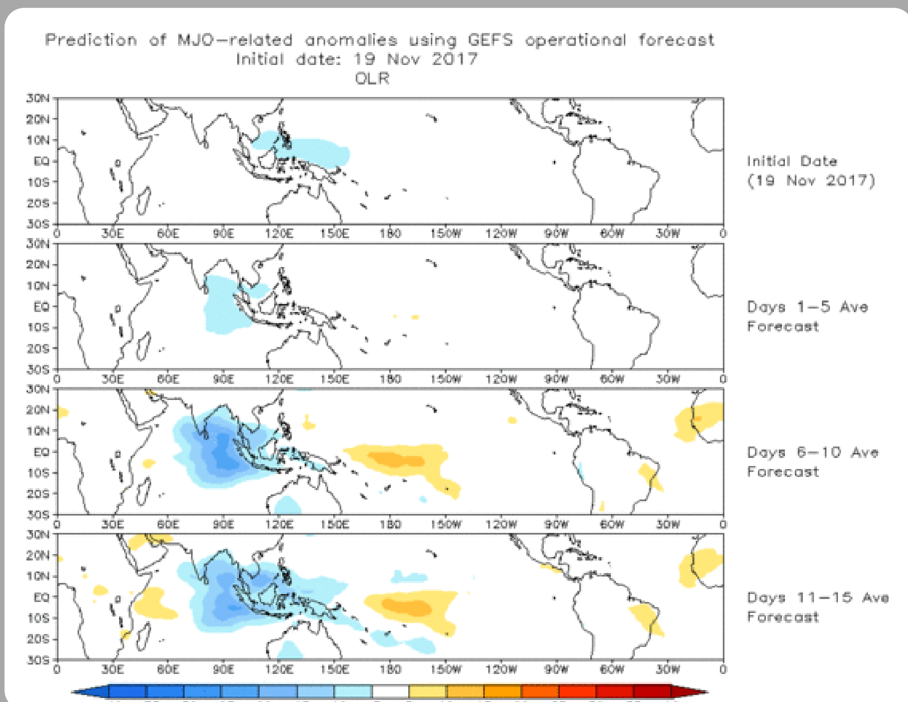


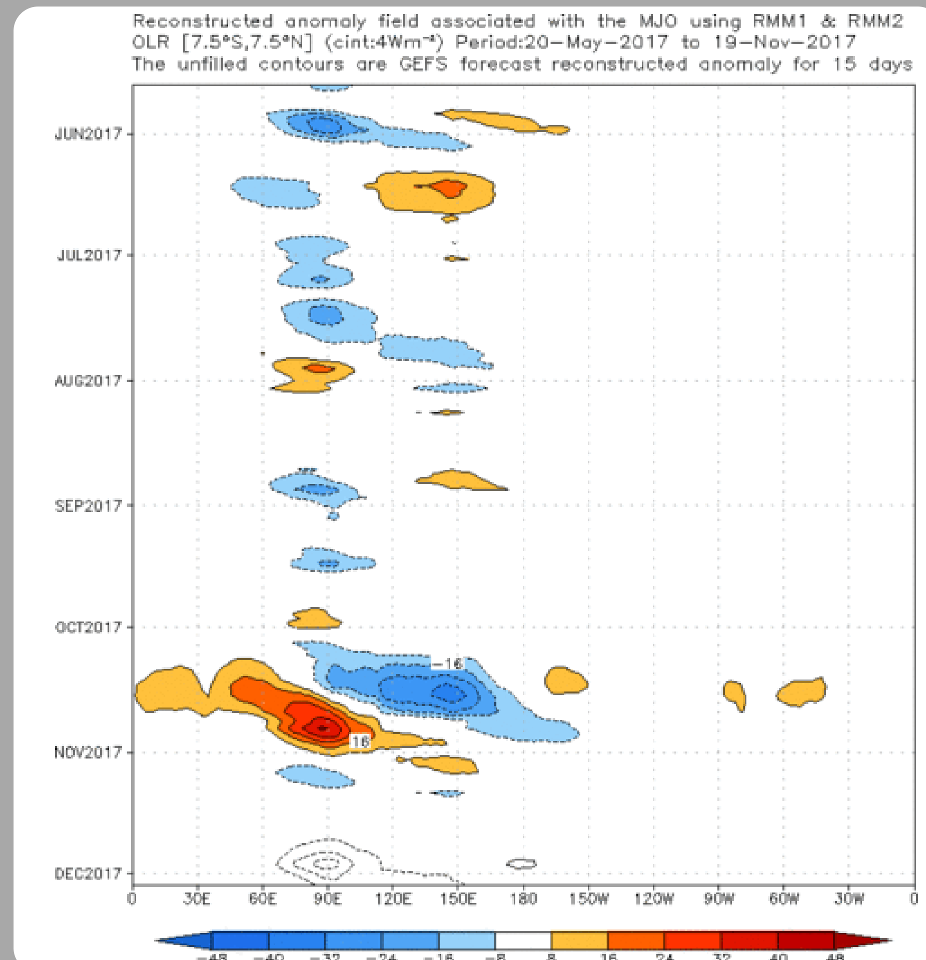
Ensemble GFS (GEFS) MJO Forecast

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



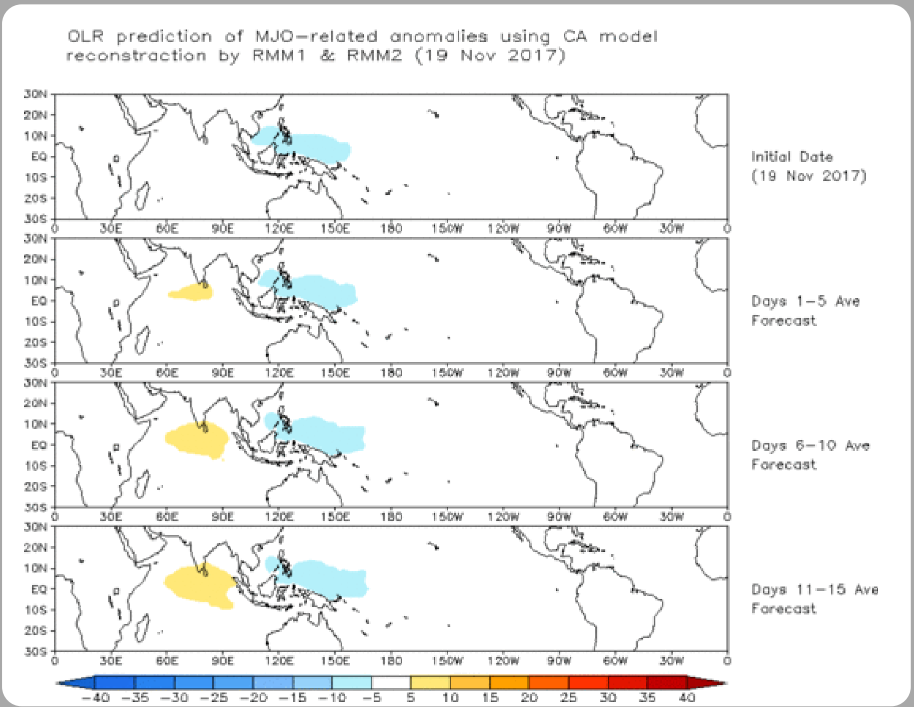


OLR anomalies based on the GEFS RMM-index forecast reflect a developing MJO signal over the eastern Indian Ocean, especially during Week-2. Suppressed convection is indicated over the central Pacific.

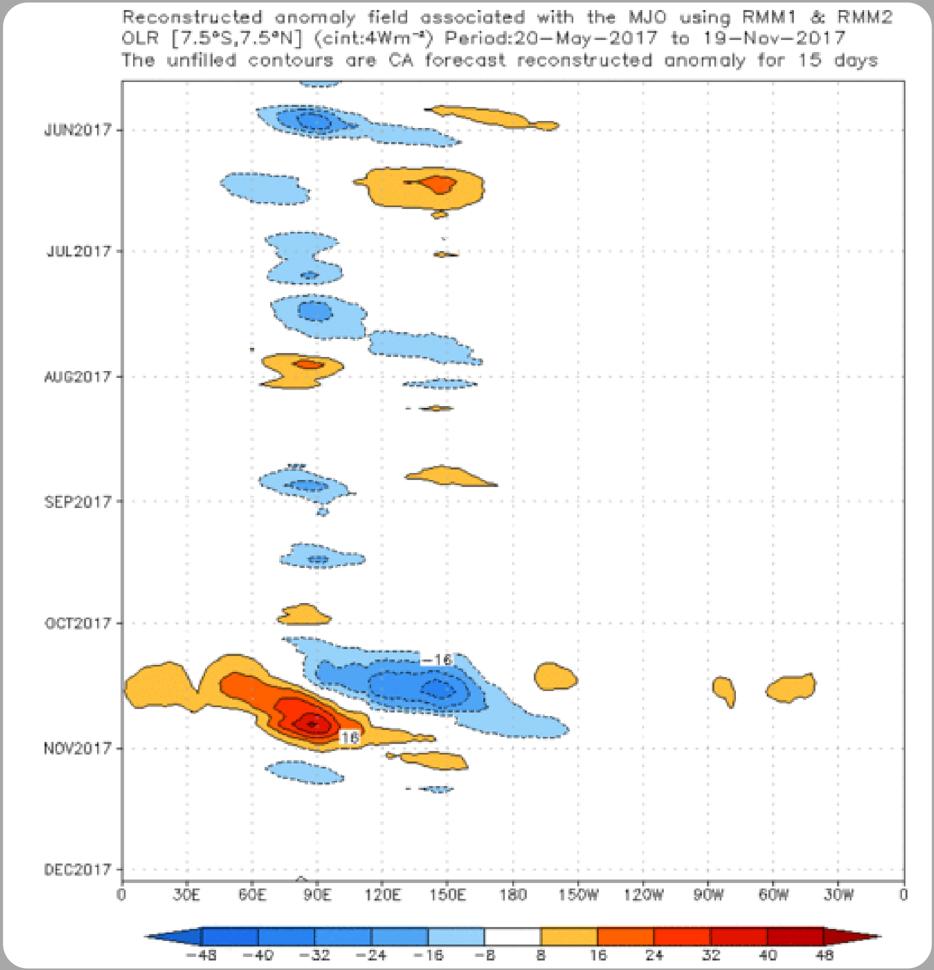
Constructed Analog (CA) MJO Forecast

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



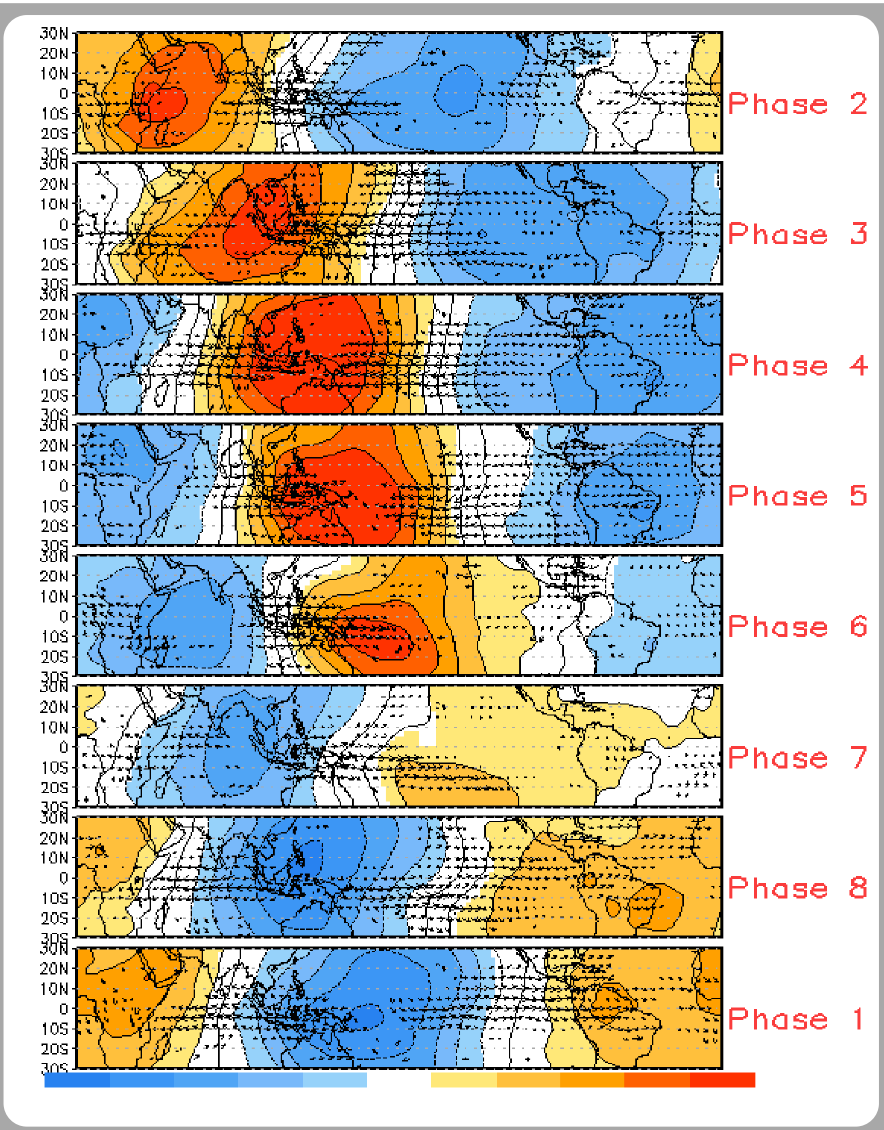
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



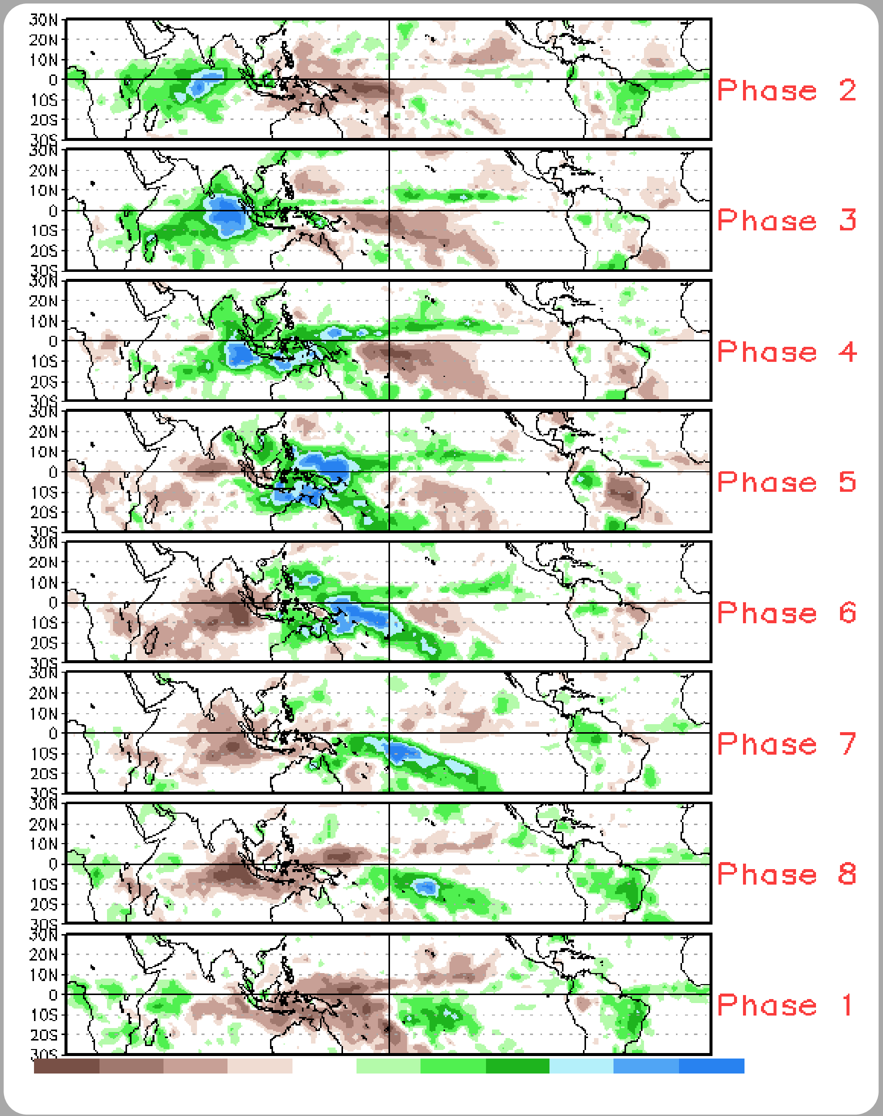
In contrast to the GEFS MJO forecast, the constructed analog RMM-index forecast depicts a much weaker, out-of-phase signal throughout the next two weeks.

MJO Composites - Global Tropics

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



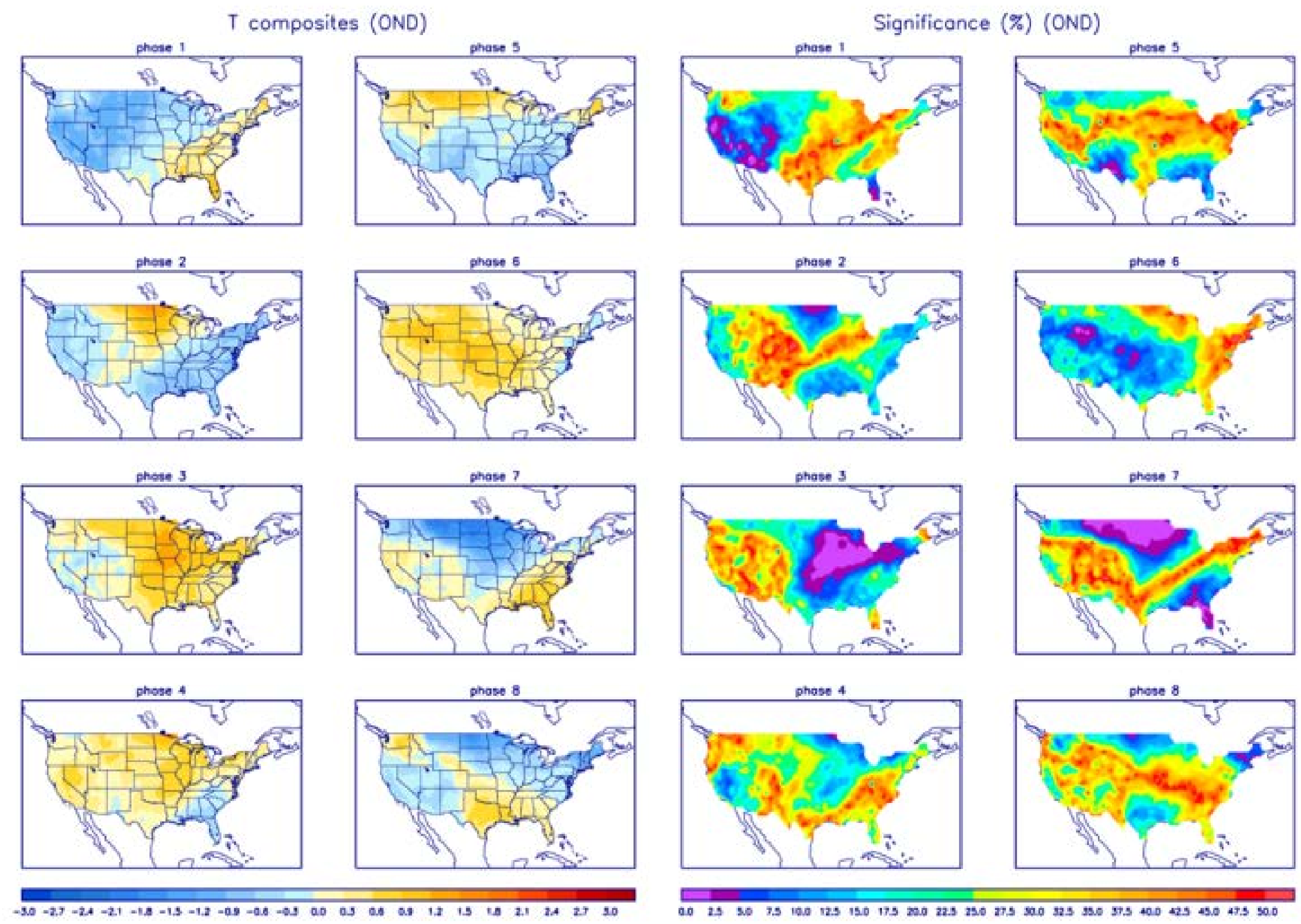
Precipitation Anomalies (Nov - Mar)



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.



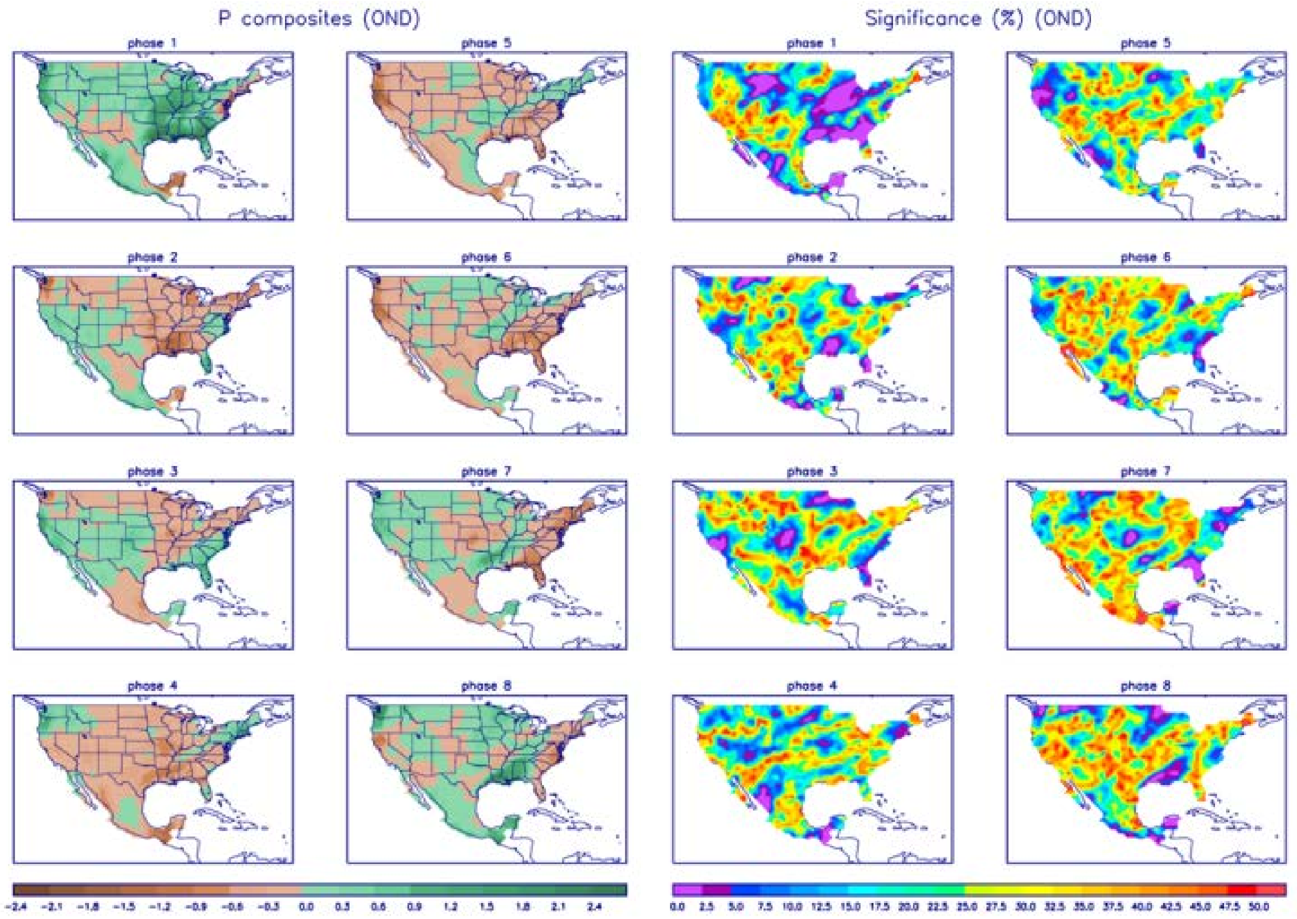
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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