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

Update prepared by:
Climate Prediction Center / NCEP
1 January 2018

Outline

Overview

- The enhanced convective phase of the MJO has crossed Africa and reached the Indian Ocean in the course of the last week.

- Dynamical models build the amplitude of the MJO signal across the western Indian Ocean during Week-1, and bring a robust event into the eastern Indian Ocean for Week-2.

- Based on dynamical and statistical model guidance, the suppressed portion of the MJO is likely to initially destructively interfere with enhanced convection over the Maritime Continent, before shifting further eastward and constructively interfering with suppressed convection near the Date Line tied to La Niña in Week-2.

- An active MJO over the Indian Ocean during boreal winter is generally one of the more coherent scenarios for yielding a teleconnection response in the Northern Hemisphere. Typical lagged extratropical circulation responses favor enhancement and extension of the jet across the North Pacific in addition to building troughing (ridging) over western (eastern) North America.

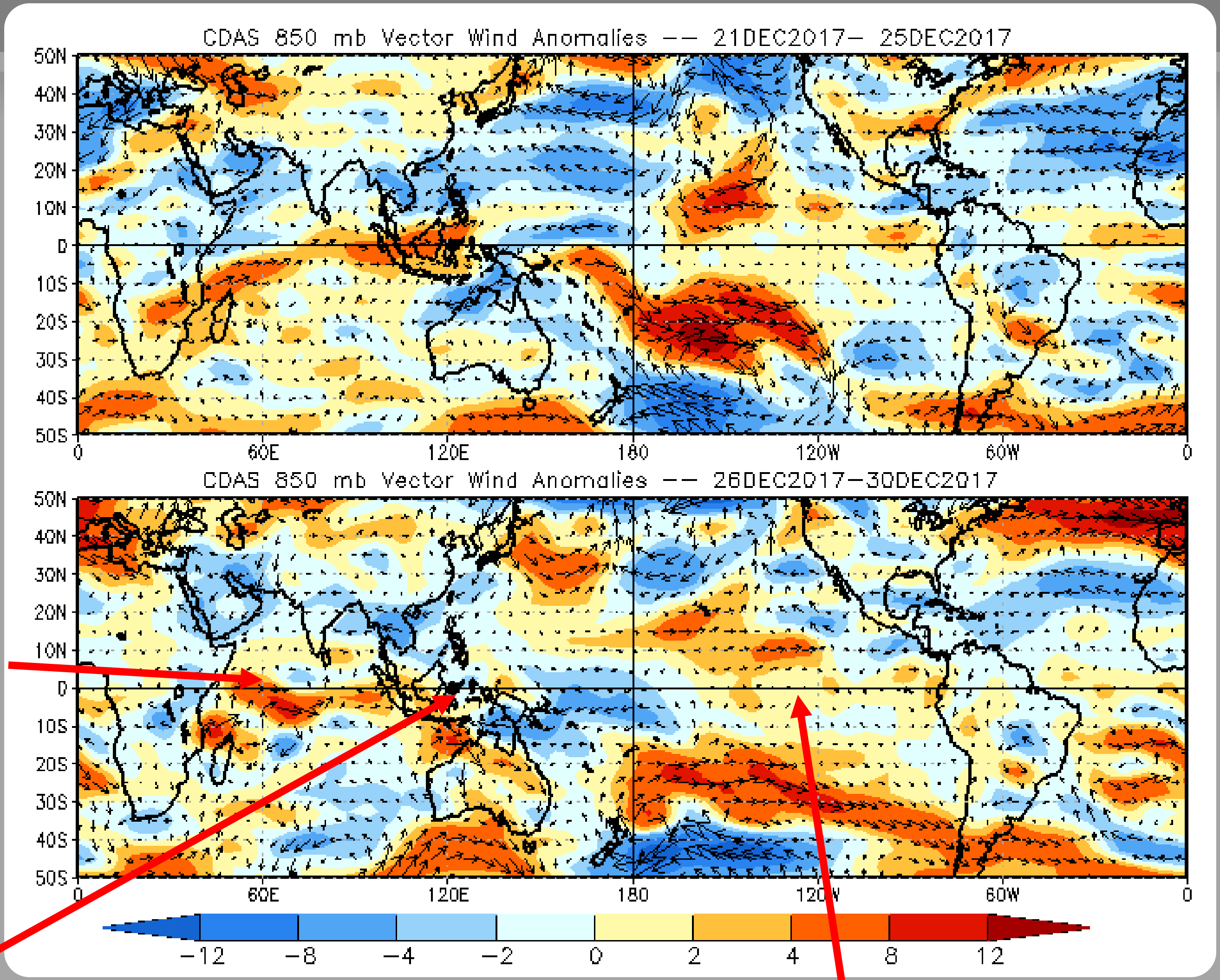
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerlies emerged over the Indian Ocean in association with the active MJO signal reaching the basin.

Low-level convergence persisted over the Maritime Continent tied to the low frequency state.

Weak anomalous westerlies continued east of the Date Line in the Pacific and across much of the Western Hemisphere.

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

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

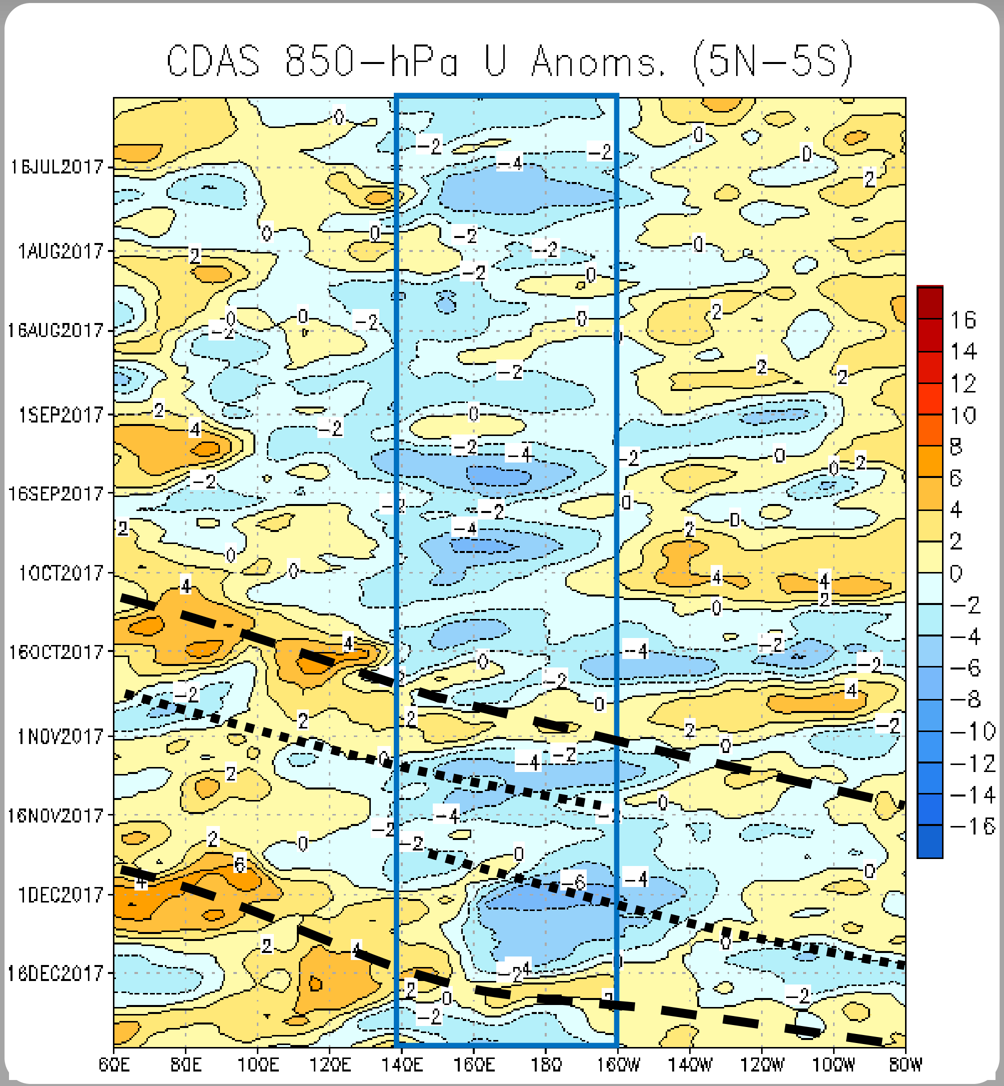
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

During July, a slight eastward shift in the low-frequency pattern is noted, related to short-lived MJO activity. By August and September, the low-frequency envelope of easterly anomalies re-established from 140E to just east of the Date Line.

During October and early November, a robust MJO event developed, with eastward propagation of westerly and easterly anomalies. This event weakened in early to mid-November.

A new MJO event became organized in December, propagating from the Indian Ocean to the Pacific. During the past two weeks this signal has crossed the Western Hemisphere to re-emerge over the Indian Ocean.



OLR Anomalies – Past 30 days

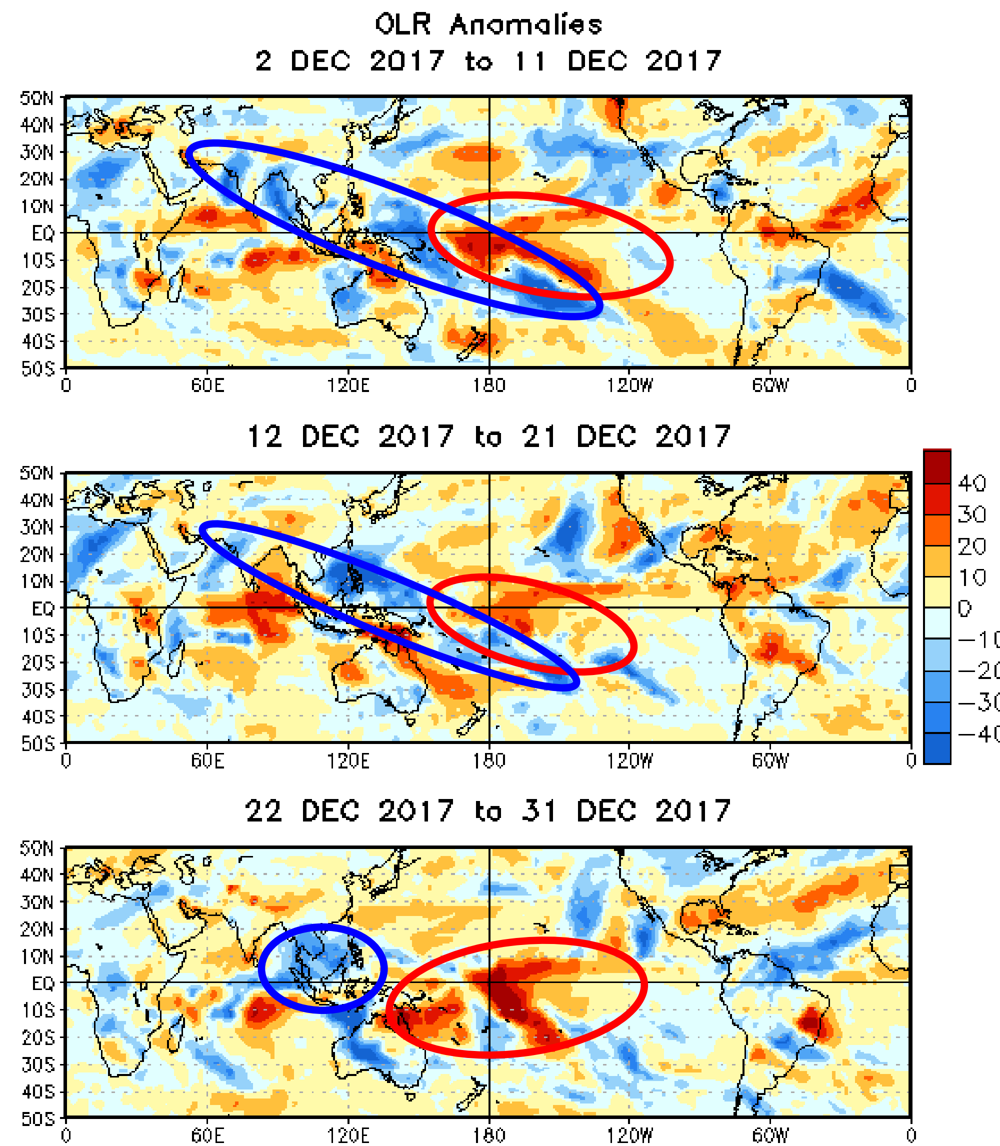
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

In early December, tropical cyclone (TC) activity was evident over the Bay of Bengal and Arabian Sea. The MJO enhanced phase moved into the western Pacific, but minimally impacted the La Niña atmospheric response aside from enhancing the South Pacific Convergence Zone (SPCZ).

During mid-December, little eastward propagation of the MJO signal was evident, as Rossby wave activity, and associated TCs, over the West Pacific influenced the convective pattern. Suppressed convection overspread the Indian Ocean, and remained entrenched over the central Pacific.

In late December, enhanced convection continued over the South China Sea tied to TC activity. The SPCZ became obscured as the suppressed MJO envelope approached the Date Line. Constructive interference of suppressed convection near the Date Line tied to the joint influences of La Niña and the suppressed MJO envelope is also apparent.



Outgoing Longwave Radiation (OLR) Anomalies (2.5ºS - 17.5º S)

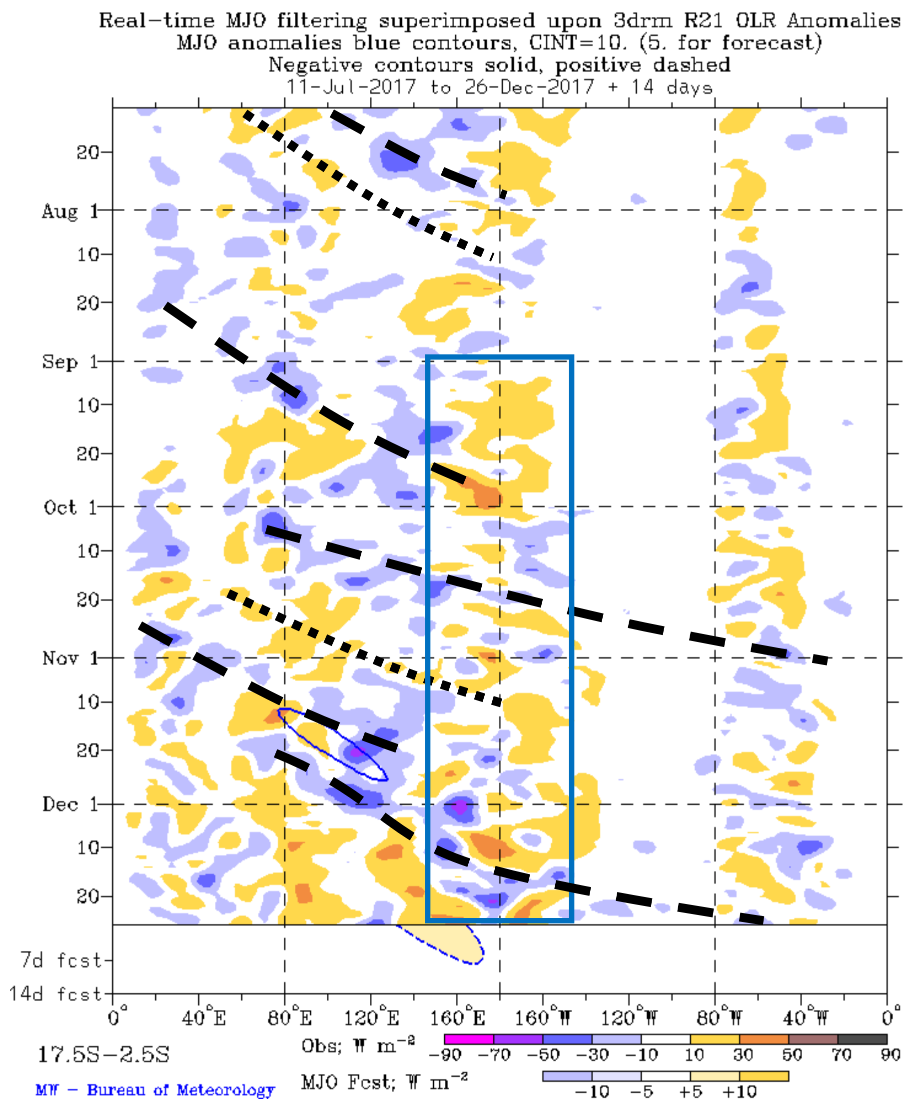
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

Multiple modes of variability, including tropical cyclones, contributed to the pattern of anomalous convection during August and September. The low-frequency signal emerged more fully in August.

The MJO became active in October, with a stronger projection in the upper-levels than in the equatorial OLR field. After circumnavigating the globe, the signal weakened in early to mid November.

Another MJO event developed in late November over the eastern Indian Ocean and Maritime Continent that was able to briefly disrupt the La Niña convective suppression near the Date Line.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

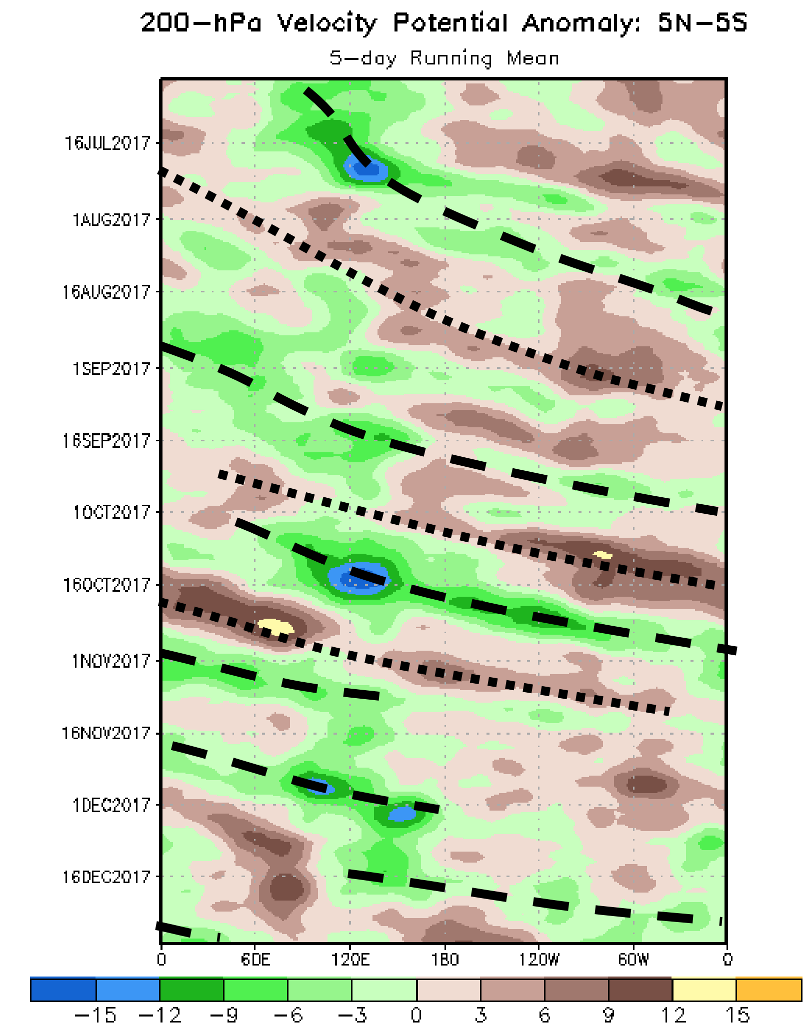
Negative anomalies (green shading) indicate favorable conditions for precipitation

During July, an east-ward propagating enhanced convective signal strengthened over the Maritime Continent that was consistent with the MJO.

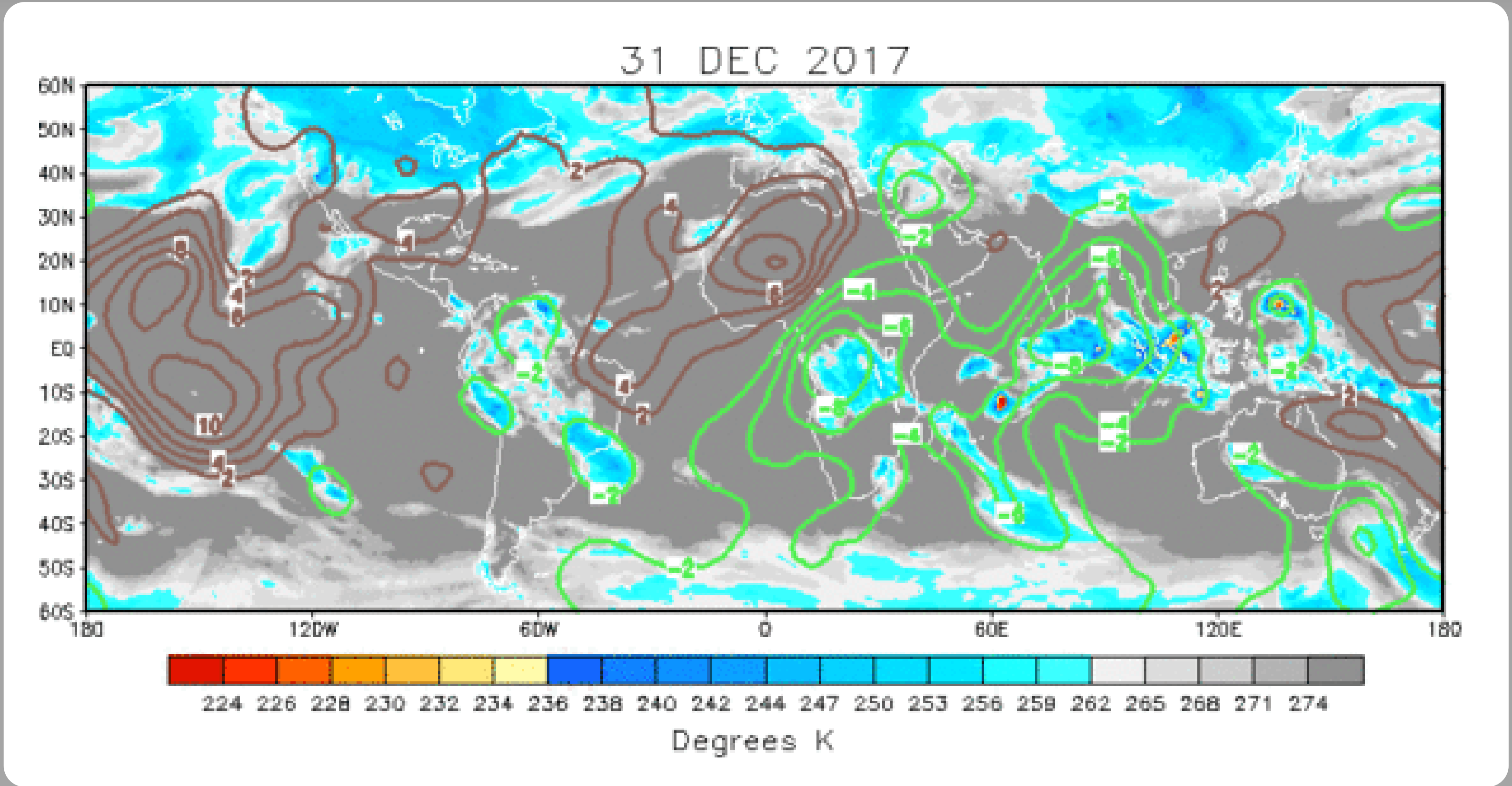
Another signal on the MJO timescale is evident in this field during late August and September.

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, weakening at that time.

Since mid-November, renewed MJO activity has been observed. This intraseasonal signal has been somewhat weaker, and was briefly disrupted by Rossby wave activity. More recently, the signal has managed to destructively interfere with the base state and cross the Western Hemisphere into the Indian Ocean.



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



The upper-level anomalous velocity potential field is consistent with an MJO event over the Indian Ocean as a general wave-1 signature is apparent with enhanced (suppressed) convection over Africa through the Maritime Continent (Pacific and Americas). A small break in positive anomalies over South America appears tied to Rossby wave activity.

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)

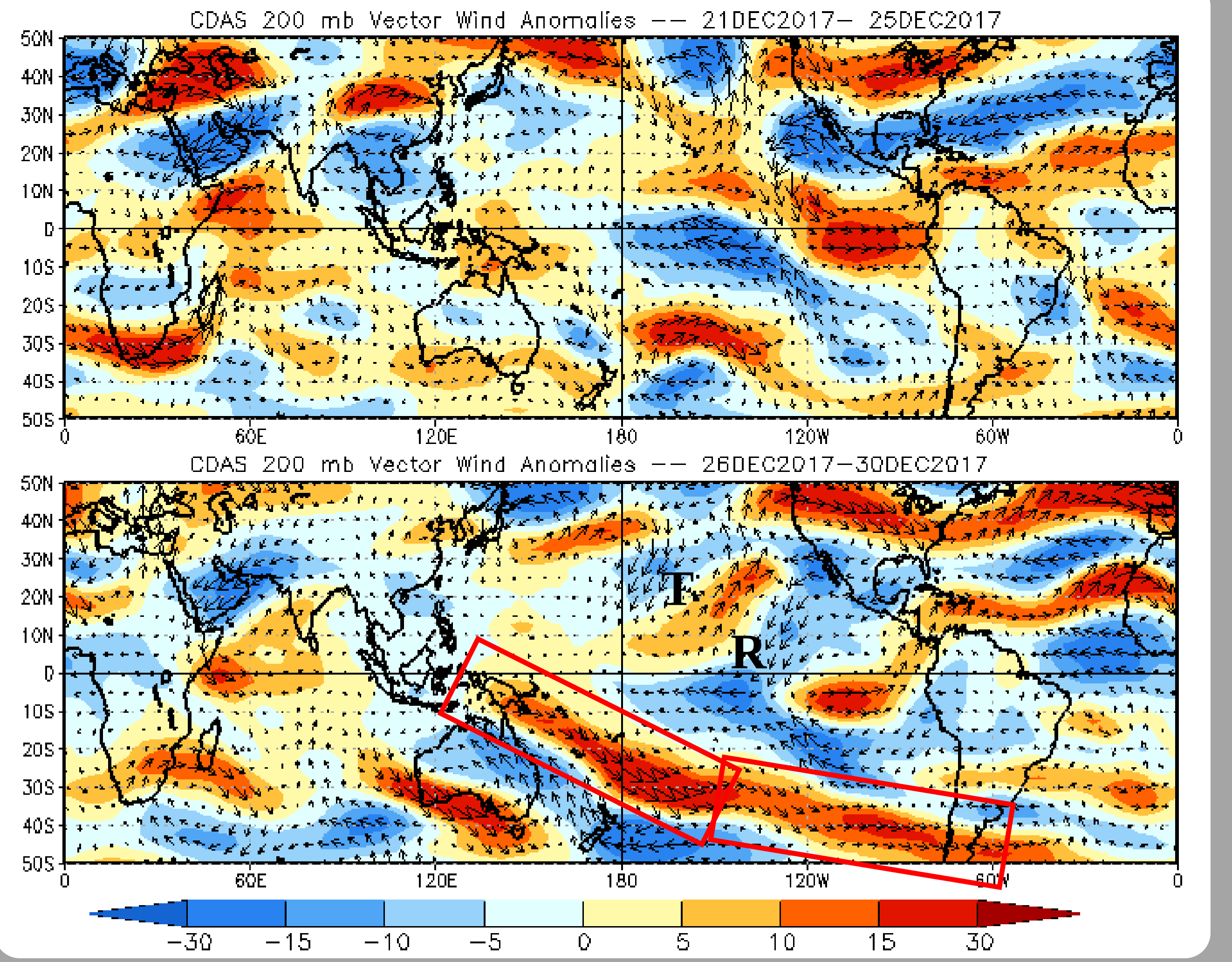
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Both feedback of wave-breaking from the mid-latitudes and extratropical influences from the anomalous tropical convective state are apparent across both hemispheres.

This is highlighted by the troughing near Hawaii and associated downstream ridge forcing easterlies along the equator east of the Date Line. Anomalous westerlies also extended from the anomalous divergence near New Guinea across the entire South Pacific.



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

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

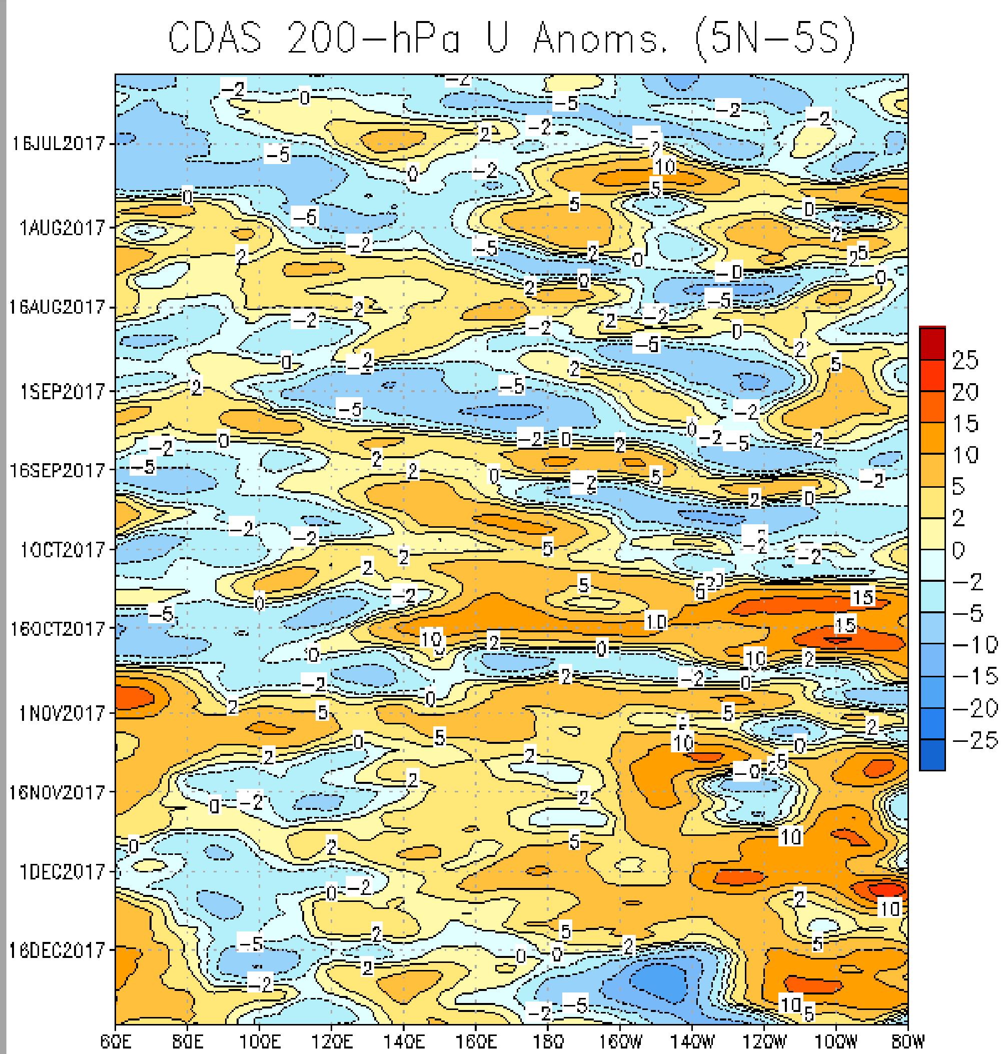
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

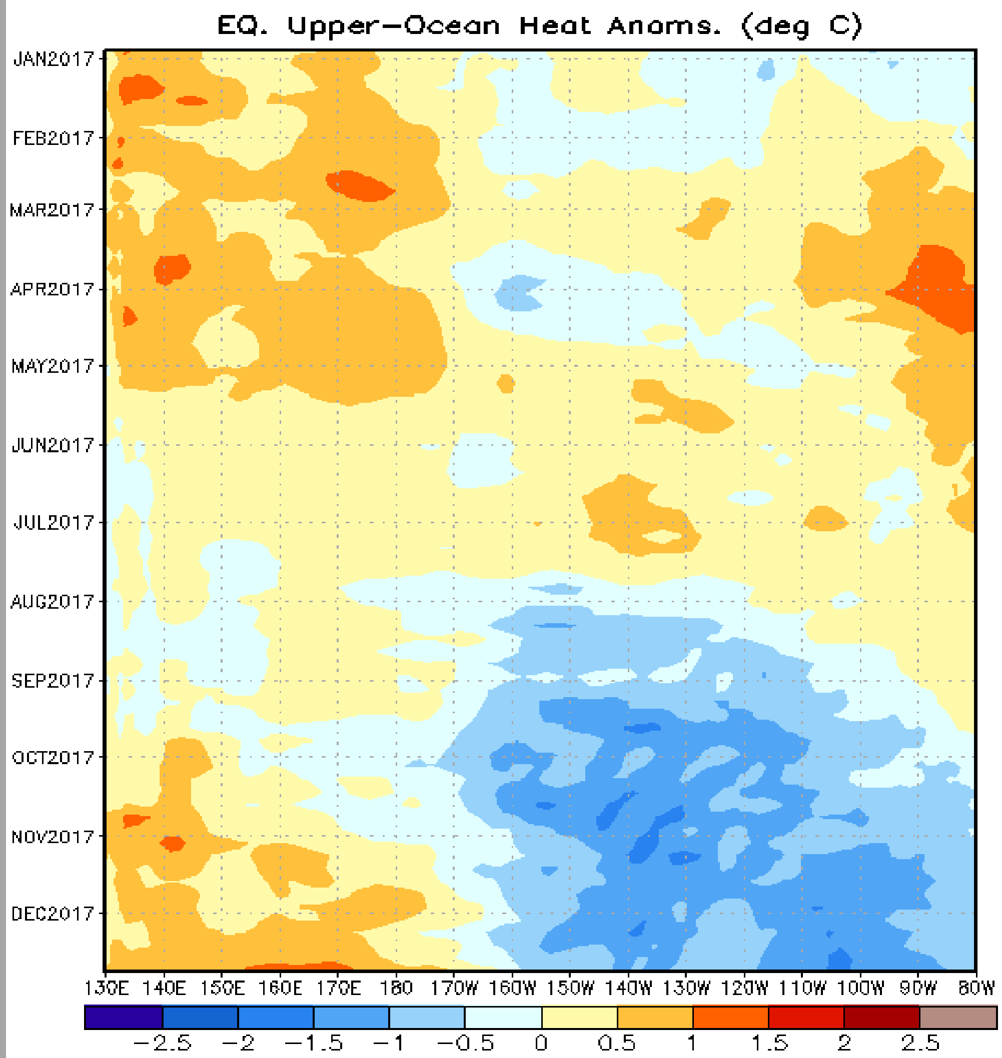
Low-frequency westerly anomalies have remained in place east of 140E since October, with the exception of a brief period of easterlies in late October. There is also some recent evidence of easterlies over the far Eastern Hemisphere over the last week or so that appear to have extratropical sourcing.

More recently, easterly anomalies have developed over the east-central Pacific.



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 persisted over the eastern Pacific.

There have been signs of building anomalous upper-ocean warmth to the west of the Date Line over the last month tied to westerly wind bursts with the intraseasonal atmospheric envelope.

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

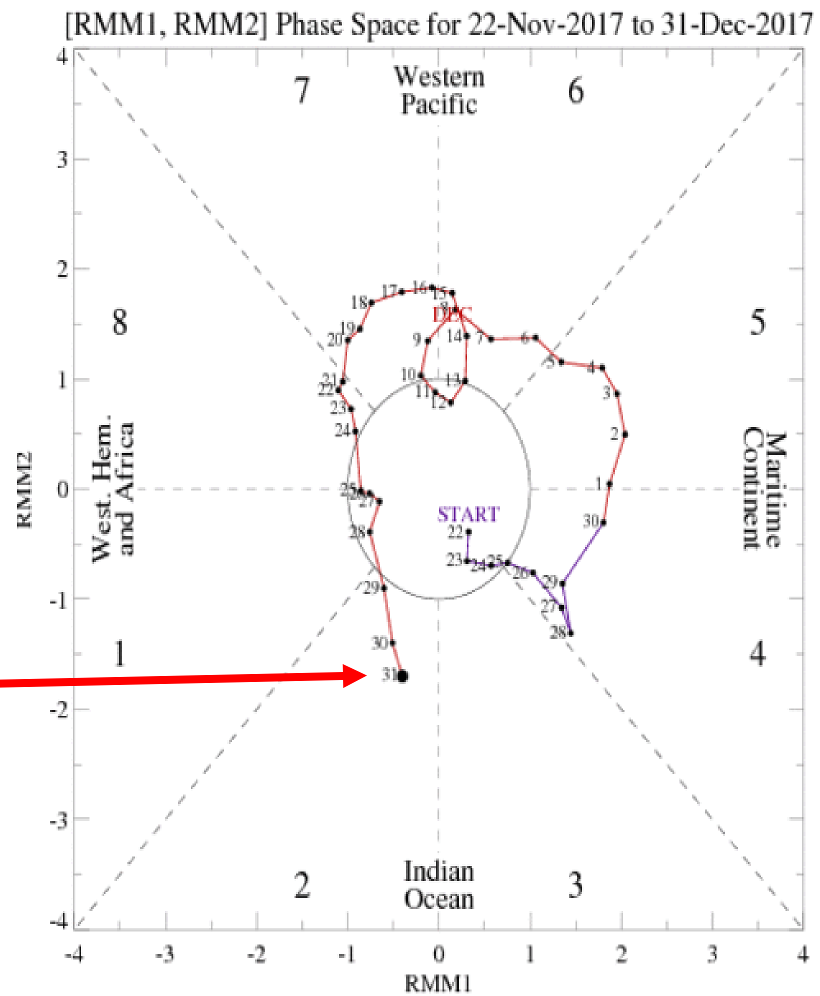
Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.

Distance from the origin is proportional to MJO strength

Line colors distinguish different months

The RMM-index exhibited eastward propagation across the Western Hemisphere over the past week.

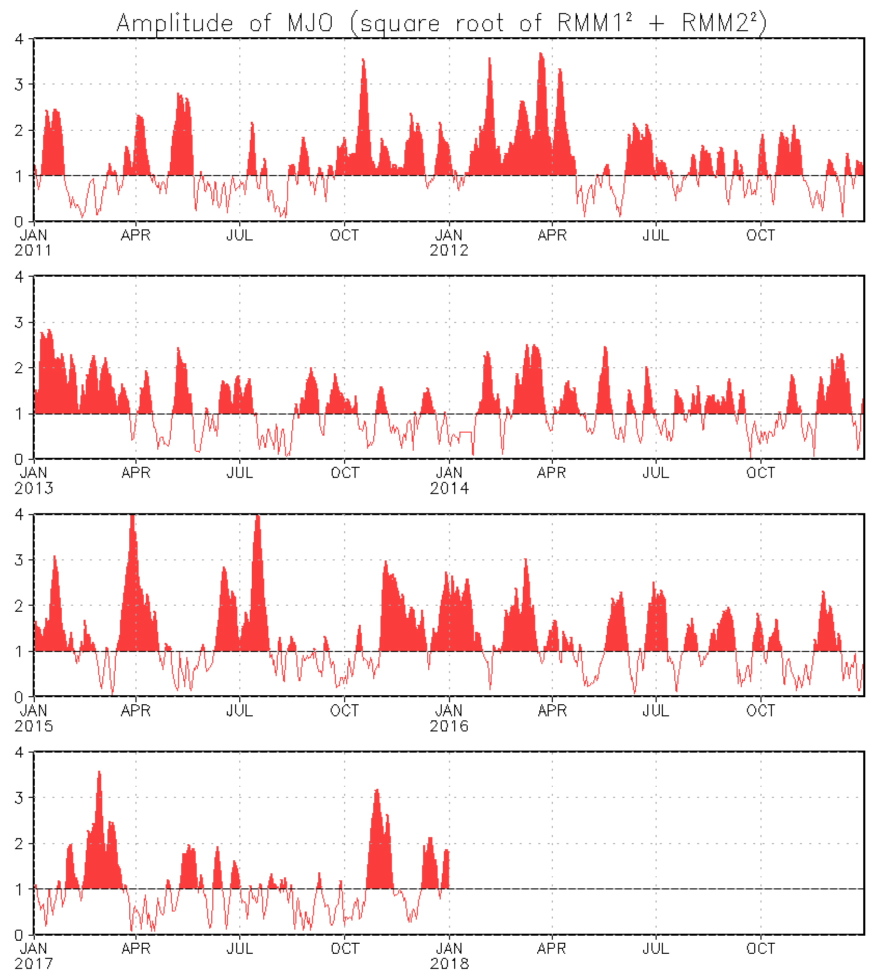
The signal briefly fell within the unit circle, potentially tied to removal of the building low frequency convective enhancement over the Maritime Continent biasing the signal towards Phases 4/5 and away from Phases 8/1.



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.



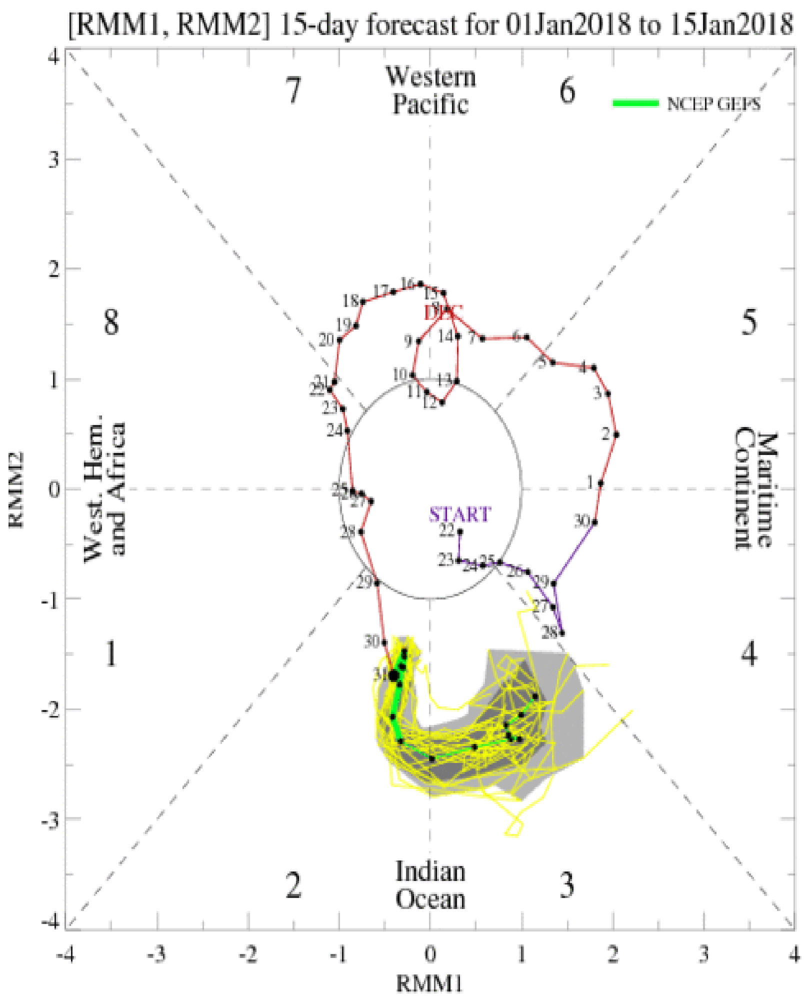
GFS Ensemble (GEFS) MJO Forecast

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



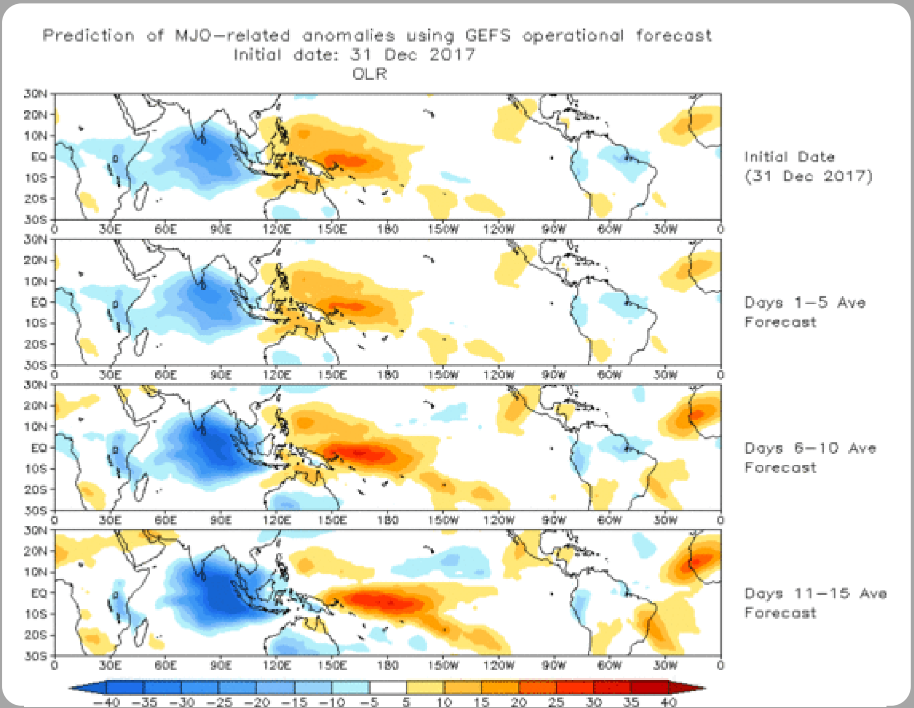
The GEFS consistently forecasts growth in amplitude of the MJO envelope over the Indian Ocean during Week-1 over the Western Indian Ocean.

In Week-2, continued eastward propagation into the eastern Indian Ocean is forecast, with most members maintaining a high-amplitude event. Spread late in Week-2 does become relatively large, resulting in a weakening of the ensemble mean signal.

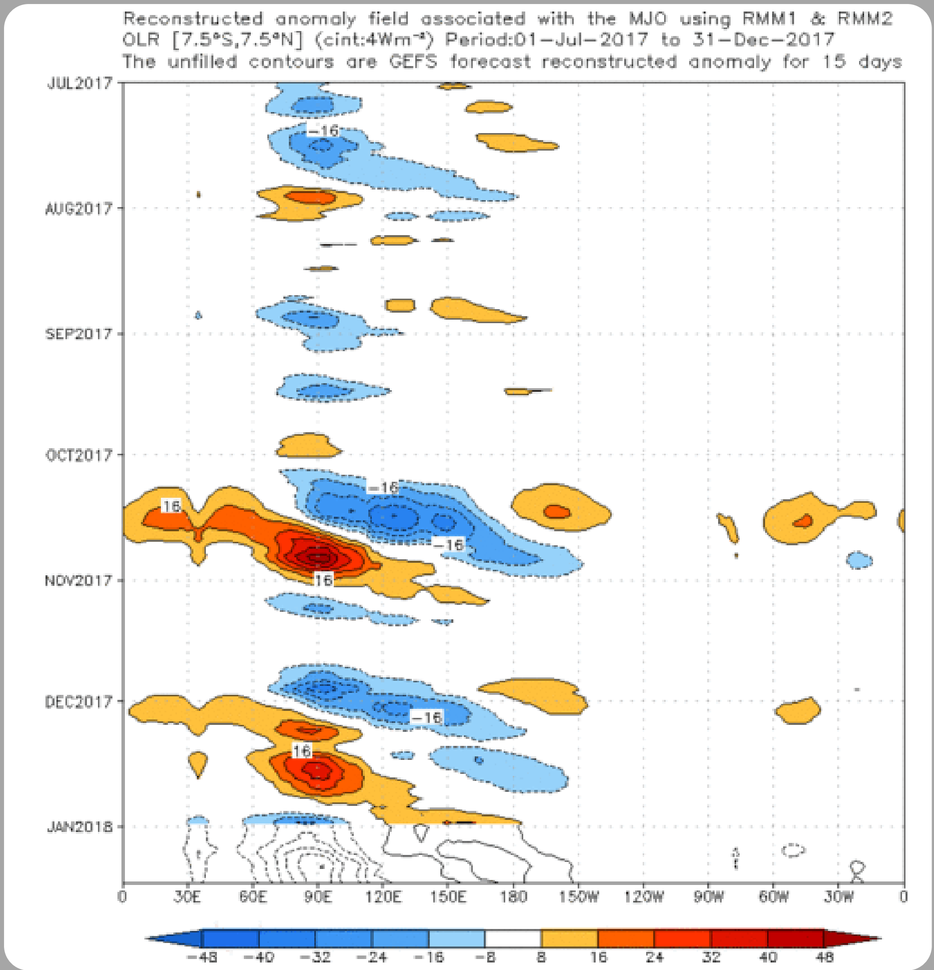
Ensemble GFS (GEFS) MJO Forecast

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



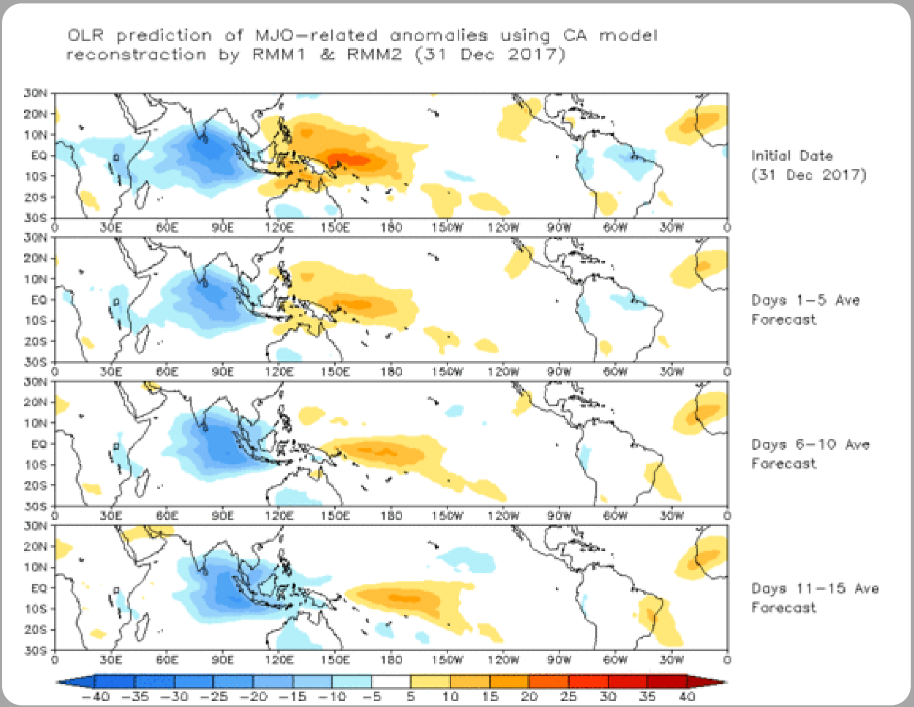
OLR anomalies based on the GEFS RMM-index forecast support the building convective signal over the Indian Ocean during the next two weeks, with enhanced suppression of convection shifting from the Maritime Continent to West Pacific.

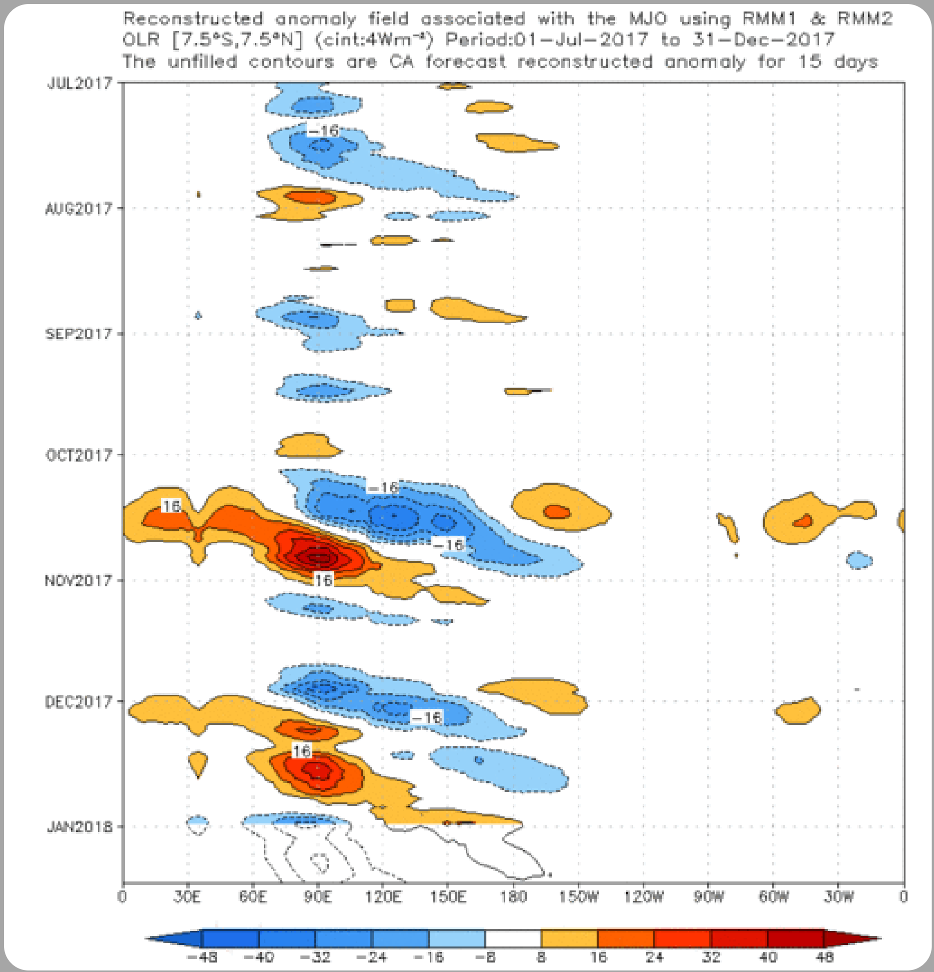
Constructed Analog (CA) MJO Forecast

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

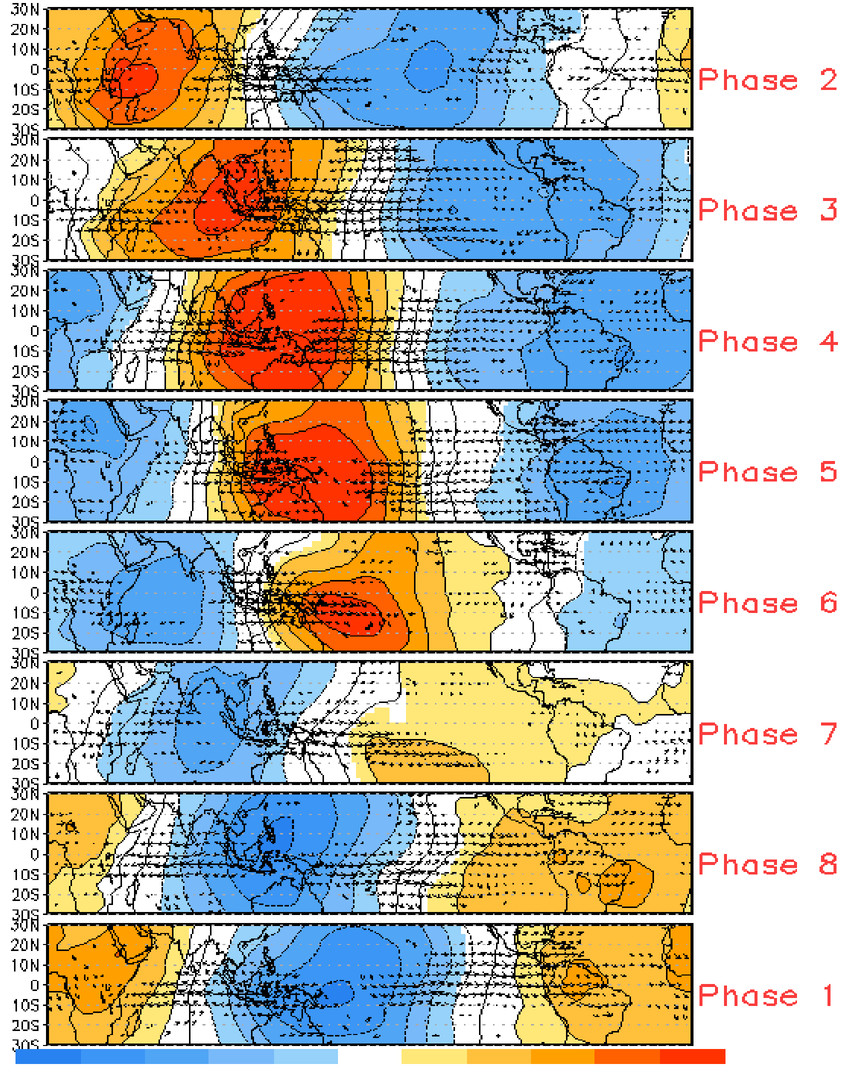




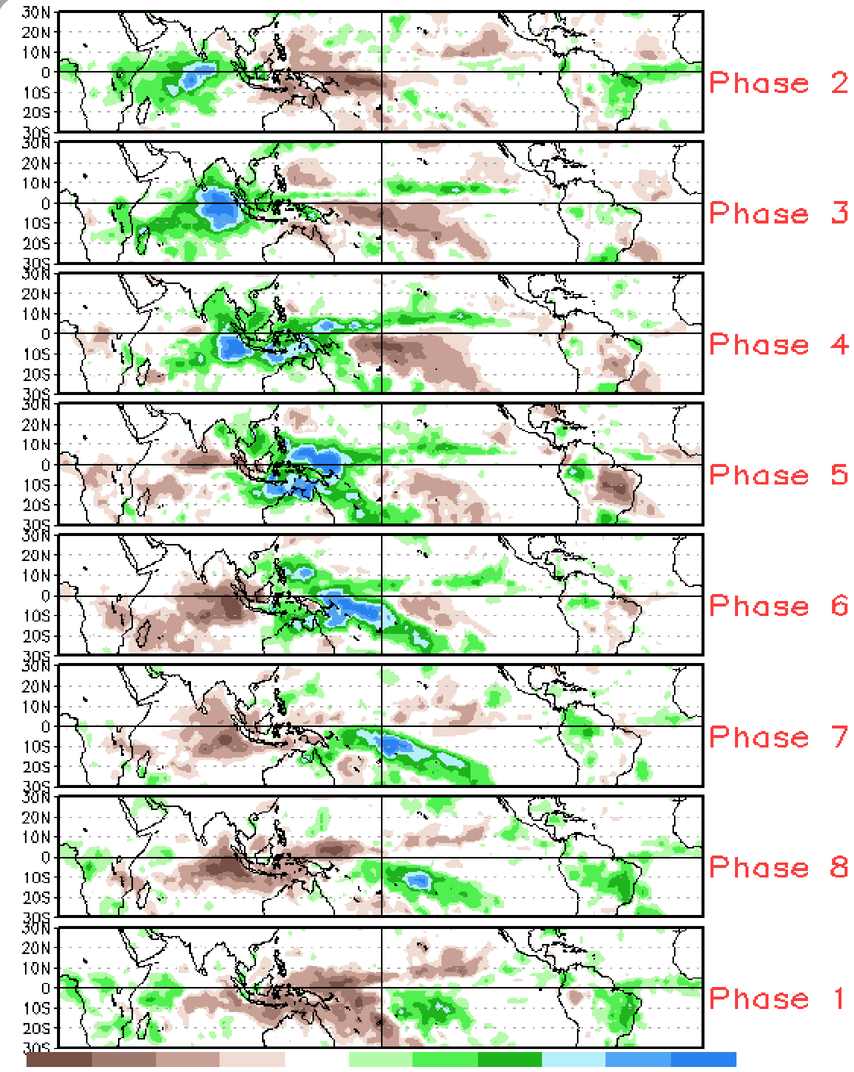
The constructed analog depicts a similar perspective to the GEFS, although at a reduced amplitude with increased forecast lead.

MJO Composites - Global Tropics

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



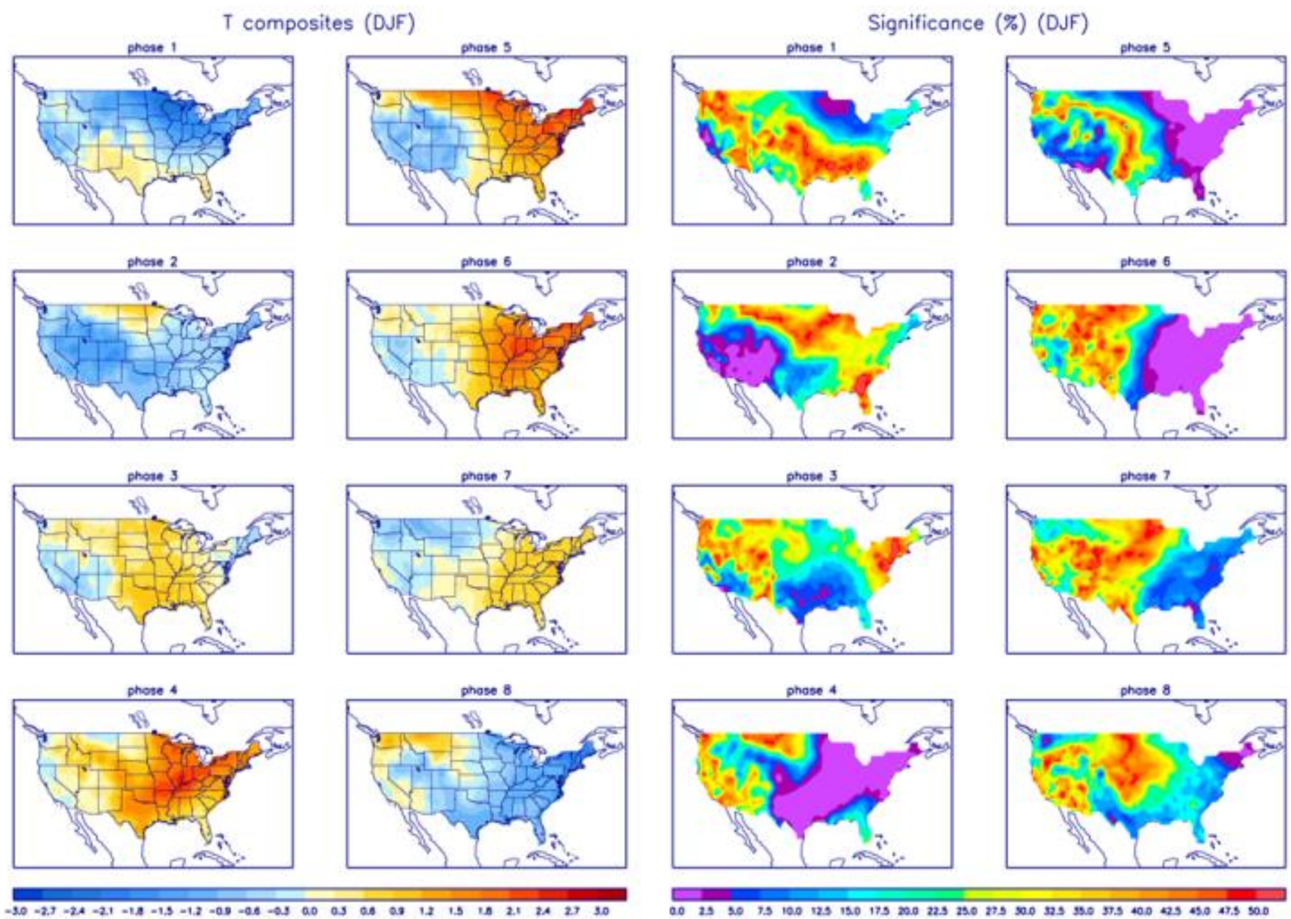
Precipitation Anomalies (Nov - Mar)



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.



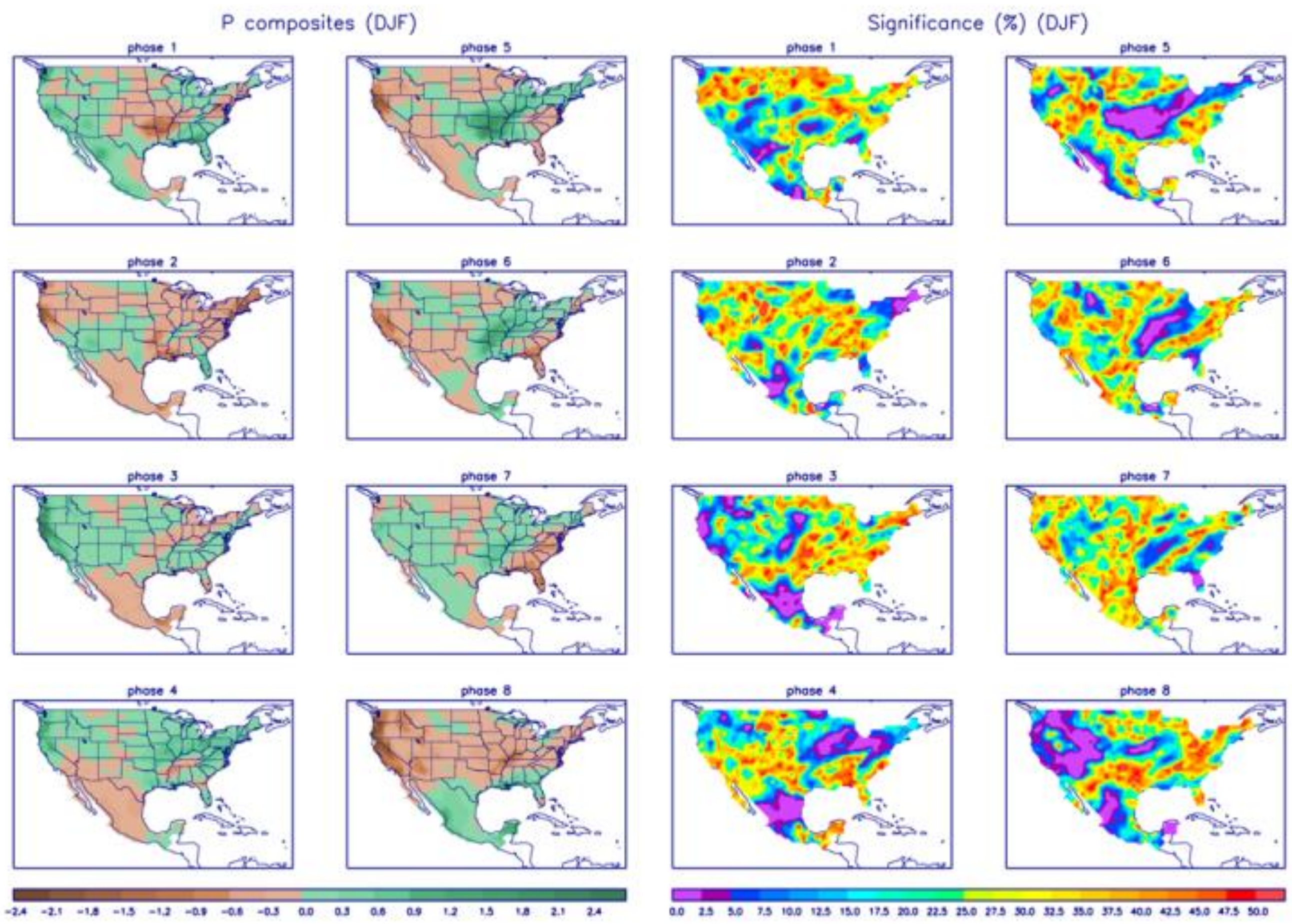
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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