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

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Climate Prediction Center / NCEP
25 December 2017

Outline

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Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The enhanced convective phase of the MJO is currently over the Western Hemisphere, and has recently achieved some disruption of the La Niña base state.

- Dynamical models show some further weakening of the MJO signal during Week-1 as it continues to destructively interfere with the base state; however, there is good model agreement that the MJO will remain coherent and emerge over the Indian Ocean during Week-2.

- Based on dynamical and statistical model guidance, the MJO will likely continue to dampen the La Niña atmospheric response during Week-1, and the signal may contribute to enhanced convection across the Indian Ocean during Week-2.

- Extratropical teleconnections from the MJO to the midlatitude pattern over North America are fairly weak when the enhanced phase is over the Western Hemisphere. If the signal does emerge over the Indian Ocean in Week-2, however, the MJO midlatitude response becomes more robust and would favor a pattern change during the second half of January.

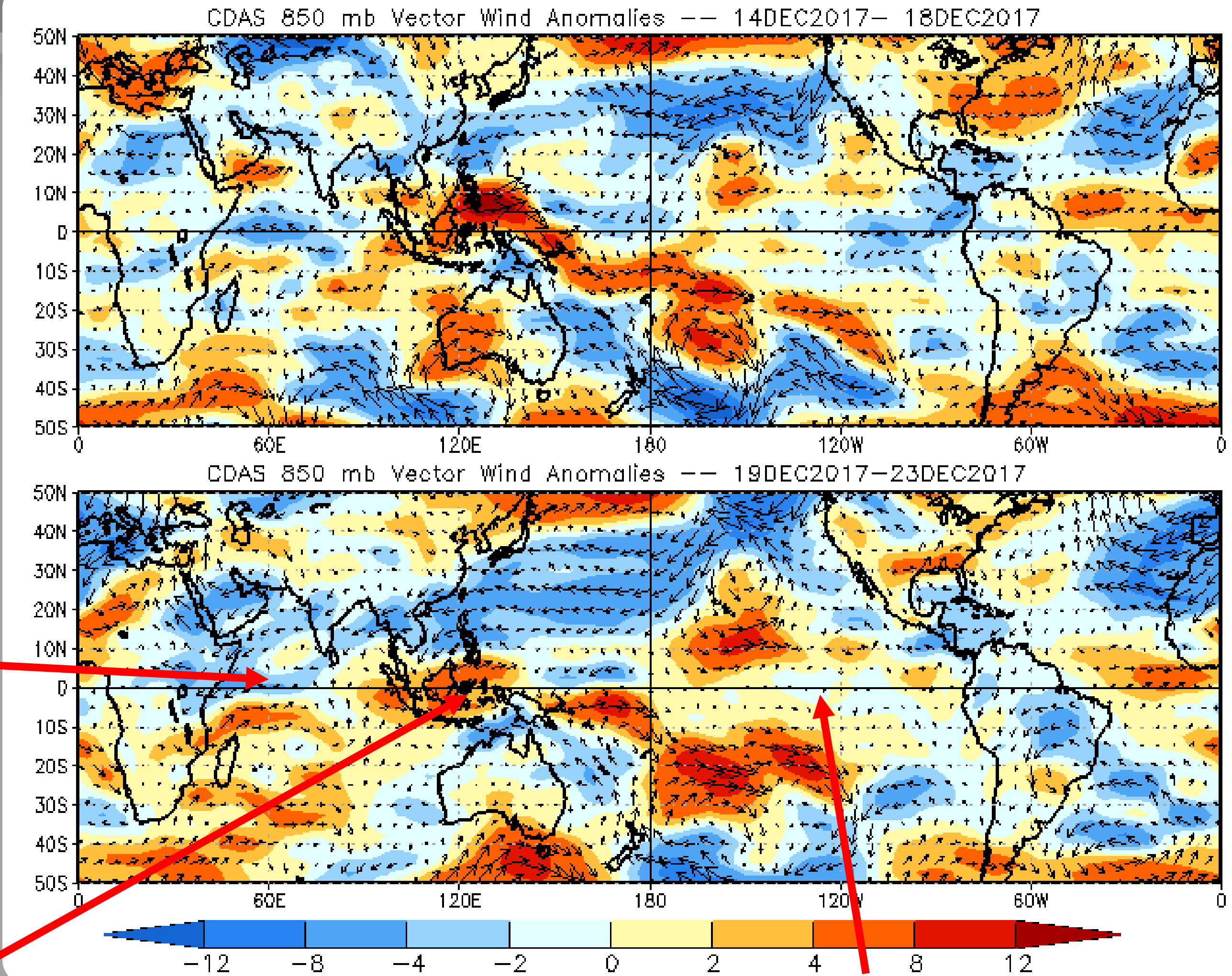
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Weak easterlies persisted over the Indian Ocean with no evident propagation.

Westerly anomalies persisted over the Maritime Continent and east of New Guinea.

Easterly anomalies weakened across the Pacific as midlatitude features and the intraseasonal signal destructively interfered with the La Niña base state.

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

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

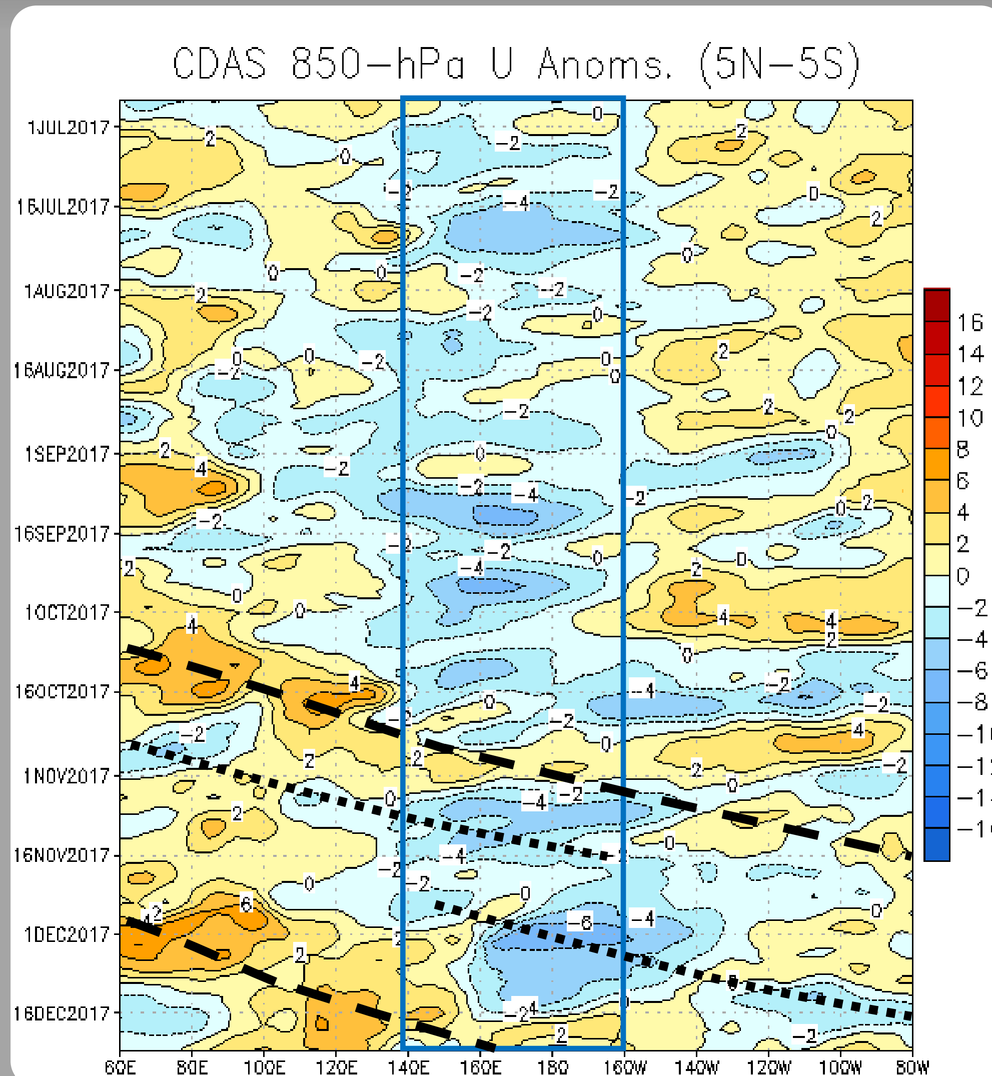
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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. The signal has been destructively interfering with the La Niña signal over the past two weeks.



OLR Anomalies – Past 30 days

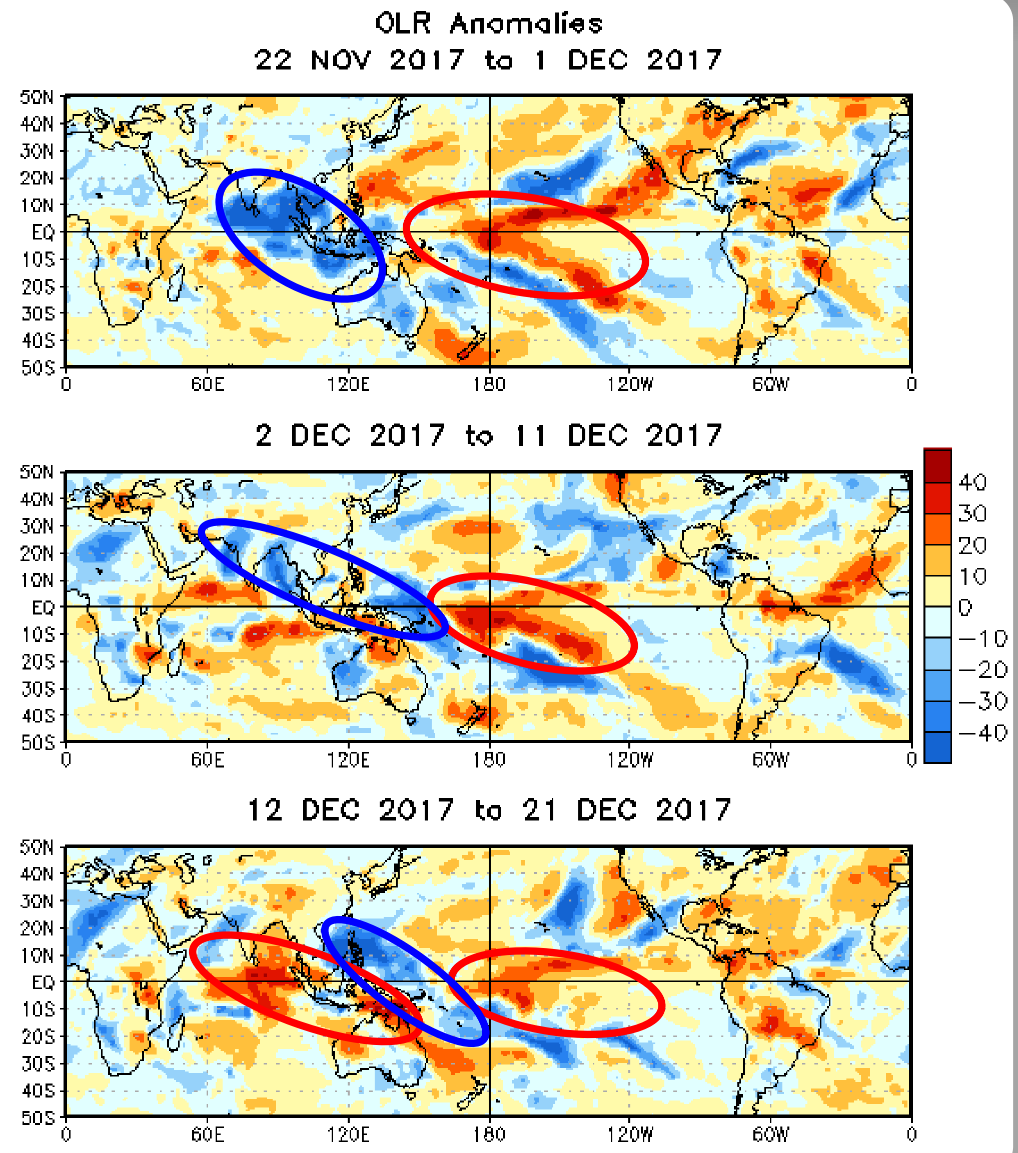
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late November, enhanced convection overspread the eastern Indian Ocean basin and the Maritime Continent as a newly organizing MJO signal constructively interfered with a robust Rossby wave.

During early December, tropical cyclone activity spurred by the enhanced convective envelope was evident over the Bay of Bengal and Arabian Sea. The MJO enhanced phase moved out to the western Pacific, but did not substantially disrupt the La Niña atmospheric response over the central Pacific.

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



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

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

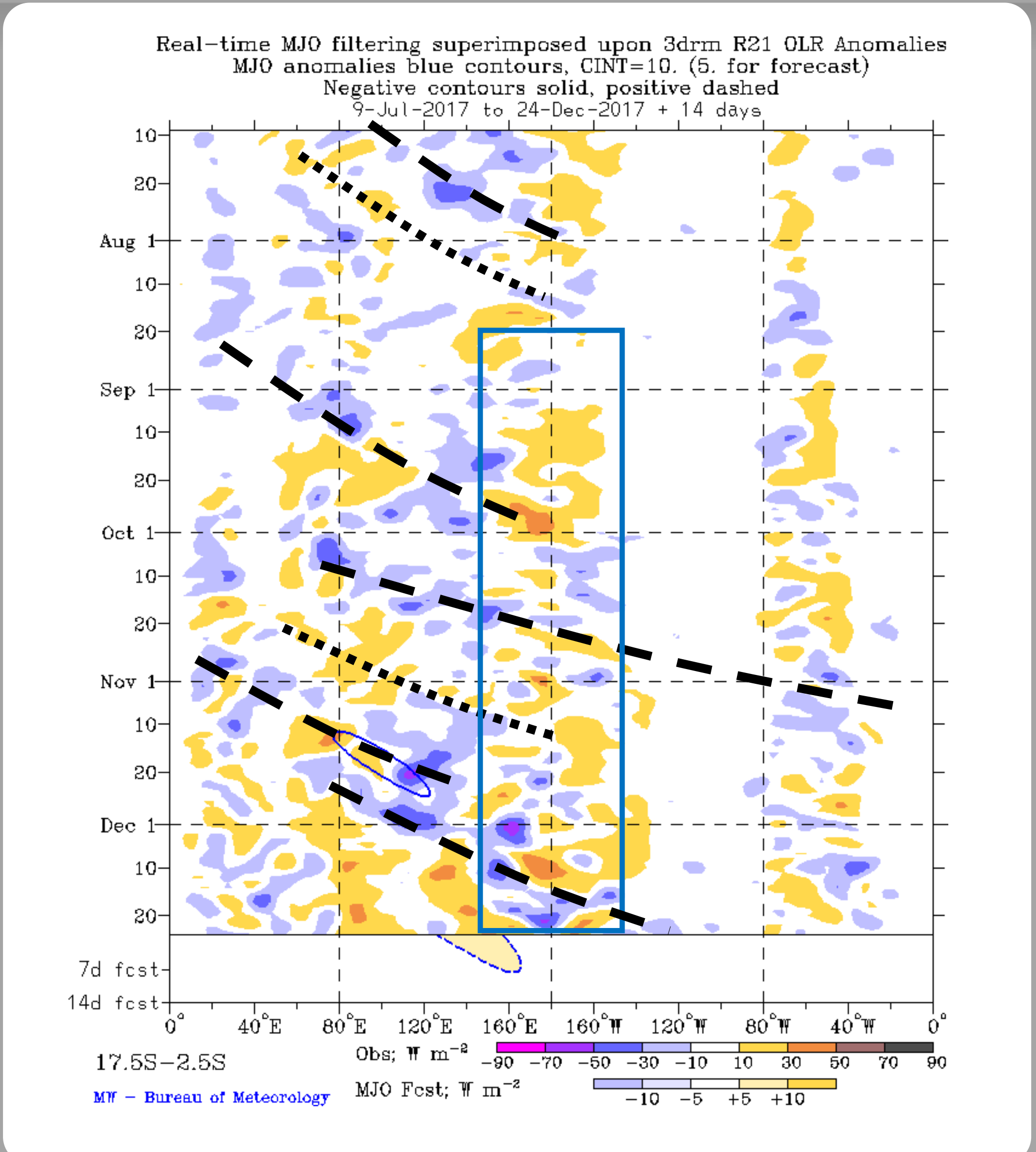
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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. 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, with some eastward propagation evident.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

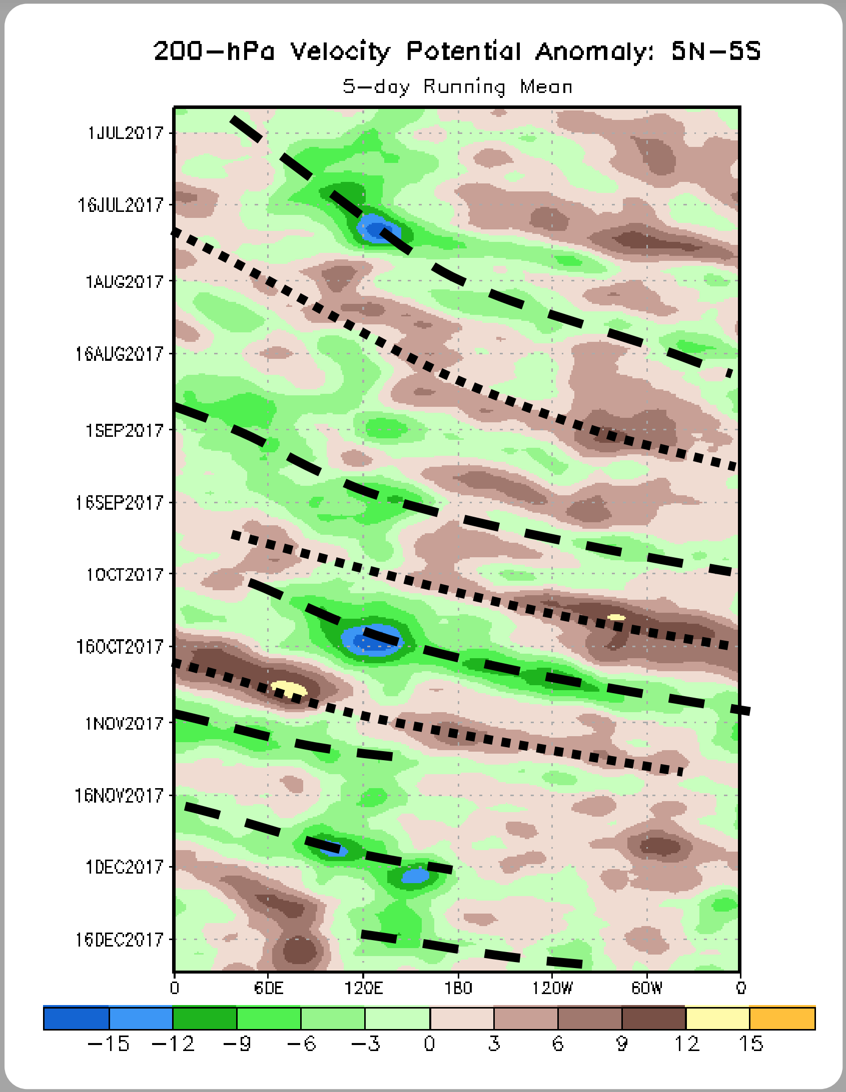
Negative anomalies (green shading) indicate favorable conditions for precipitation

During July, enhanced convection strengthened over the Maritime Continent. This eastward propagating signal appears more or less intact with a period in line with canonical MJO phase speeds.

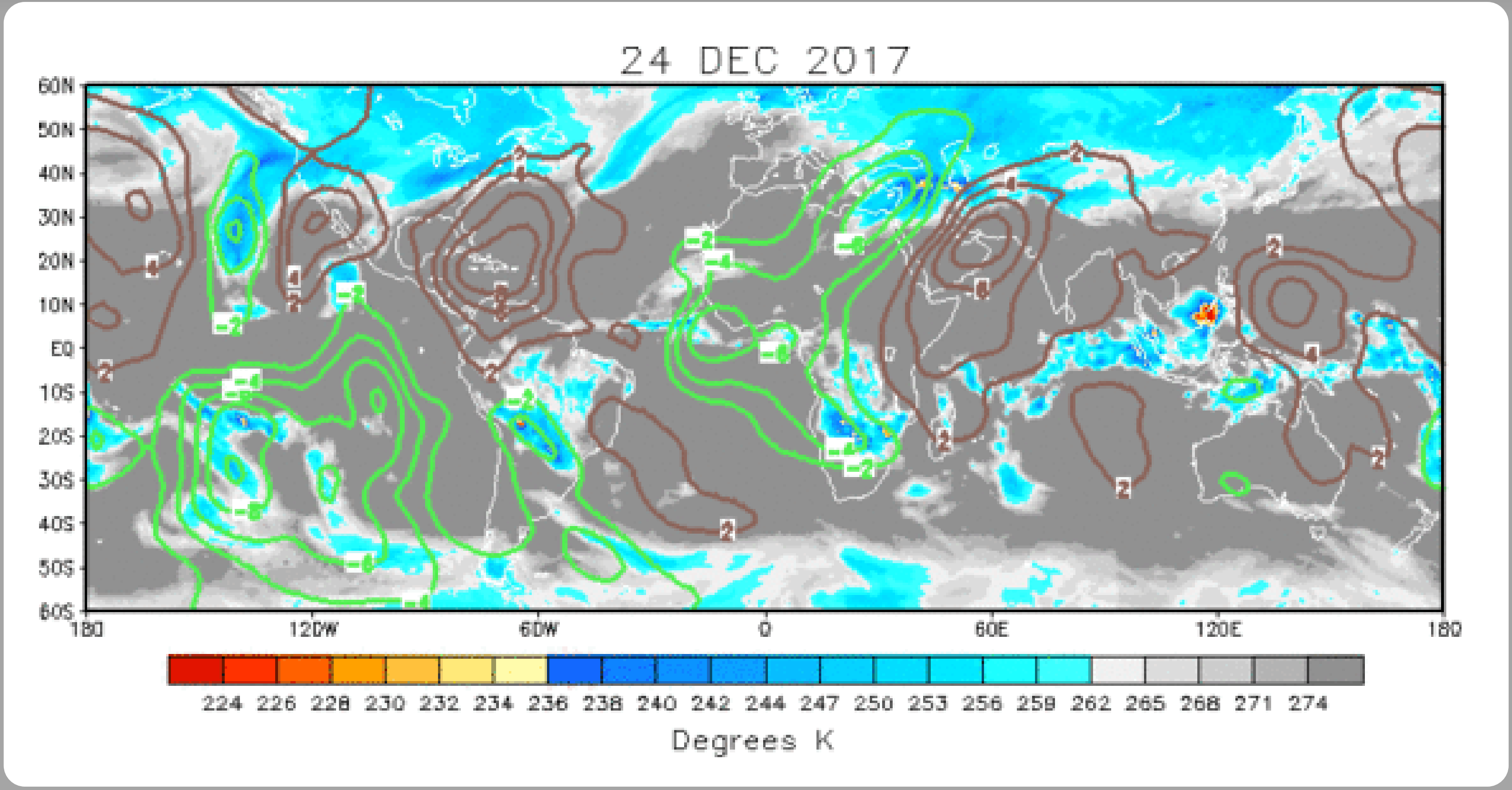
A signal on the MJO timescale is evident in this field during late August and September.

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, weakening at that time.

Since mid-November, renewed MJO activity has been observed, beginning over the eastern Indian Ocean and propagating eastward. 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.



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



The upper-level VP anomaly field does not exhibit robust MJO-like organization, with the broader divergent signal over the Western Hemisphere broken up due to possible Kelvin wave activity over Africa. The suppressed signal is weak due to destructive interference with the base state over the Maritime Continent.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

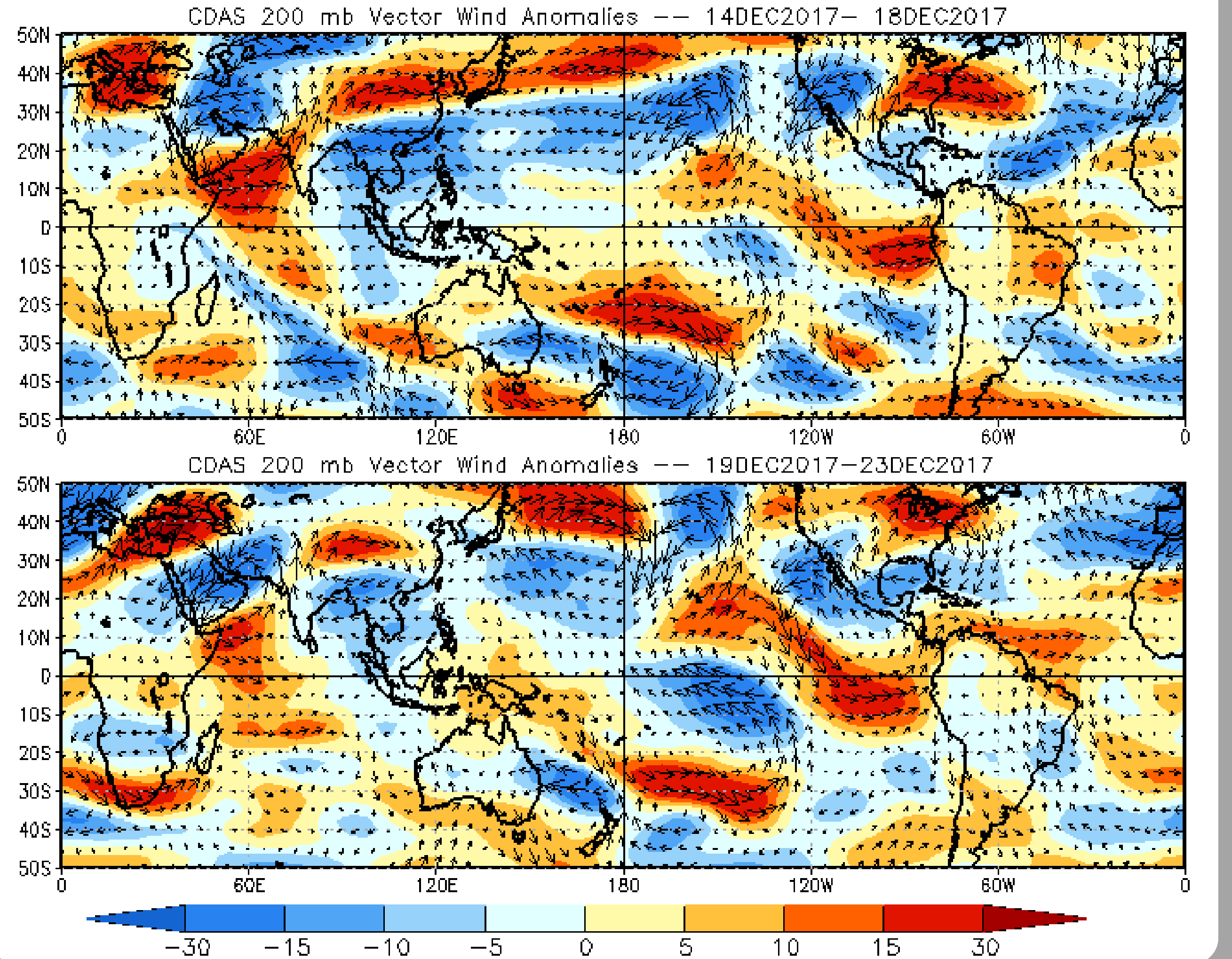
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

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

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



Upper-level easterlies overspread the east-central Pacific as both extratropical wave breaking features and the tropical intraseasonal signal interfered with the La Niña base state.

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

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

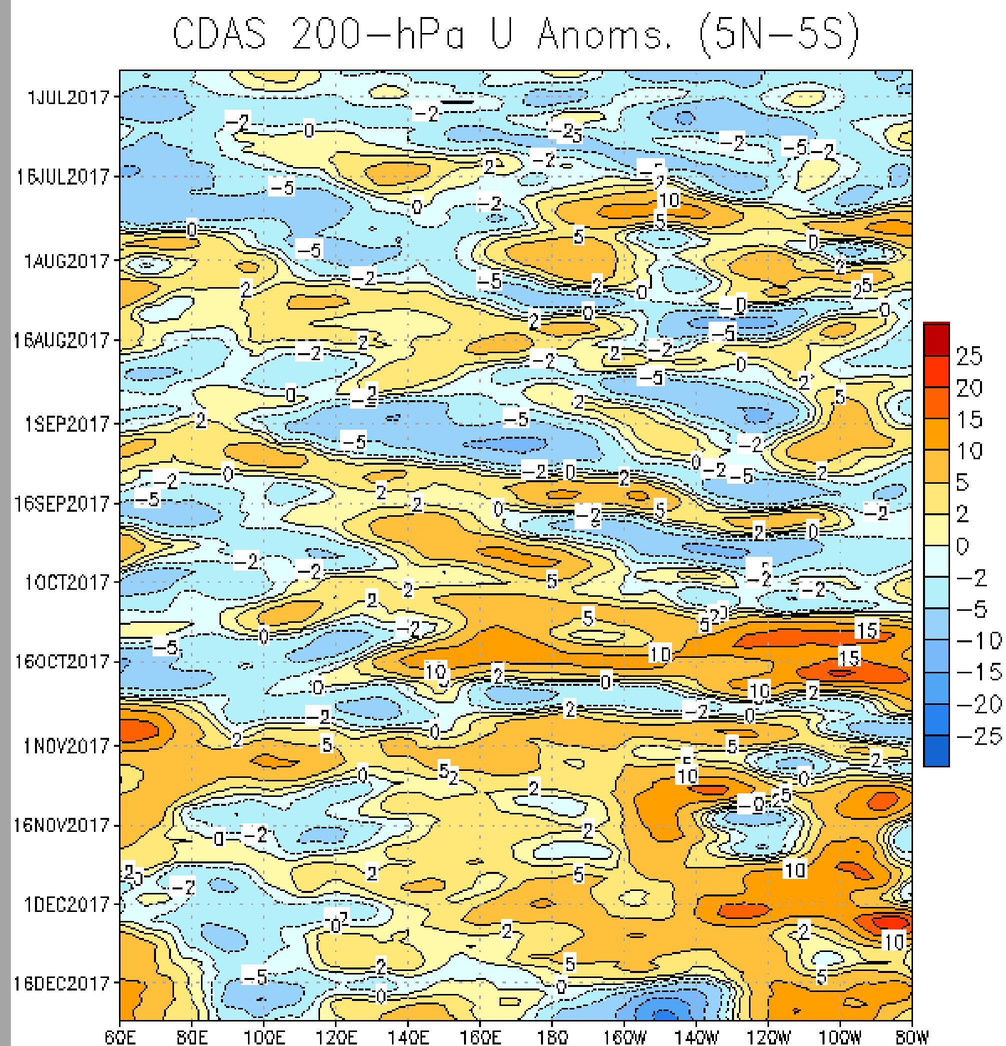
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

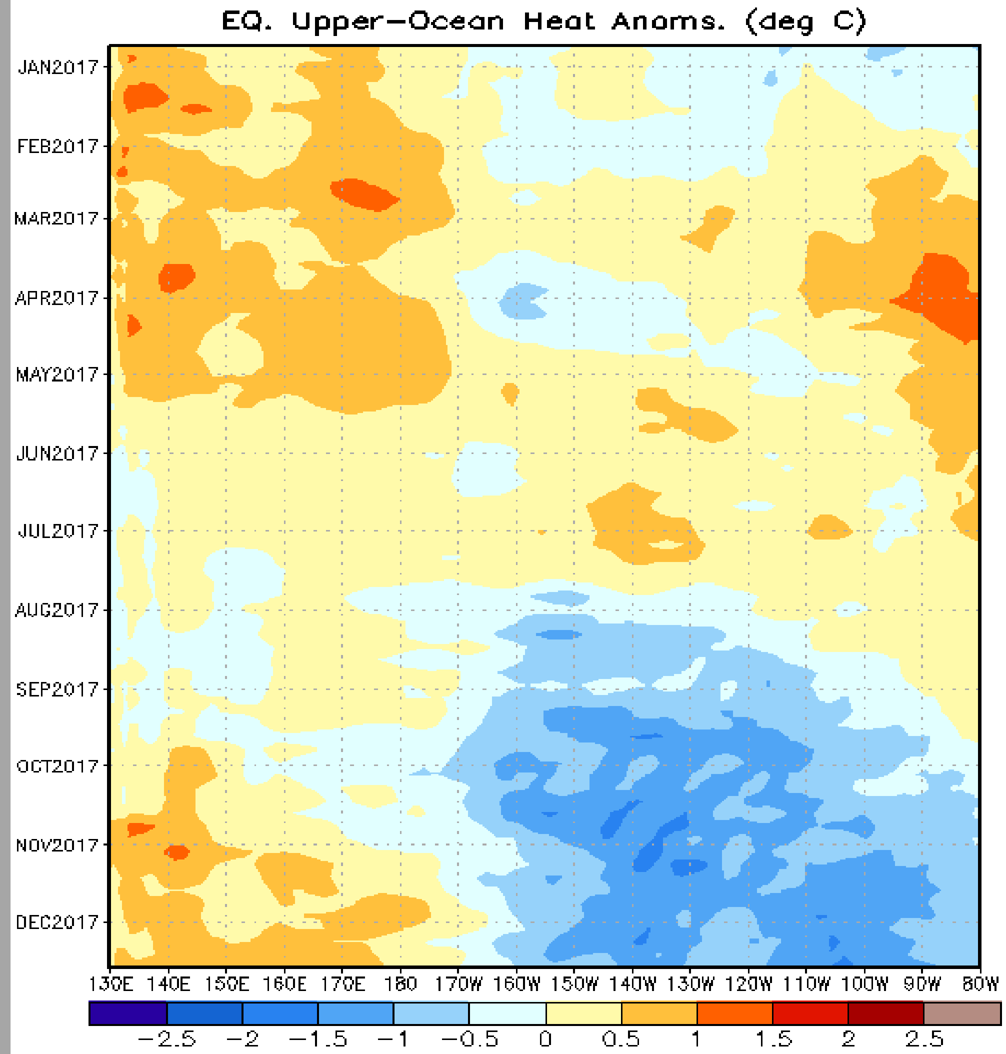
More recently, easterly anomalies have developed over the east-central Pacific.



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.



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

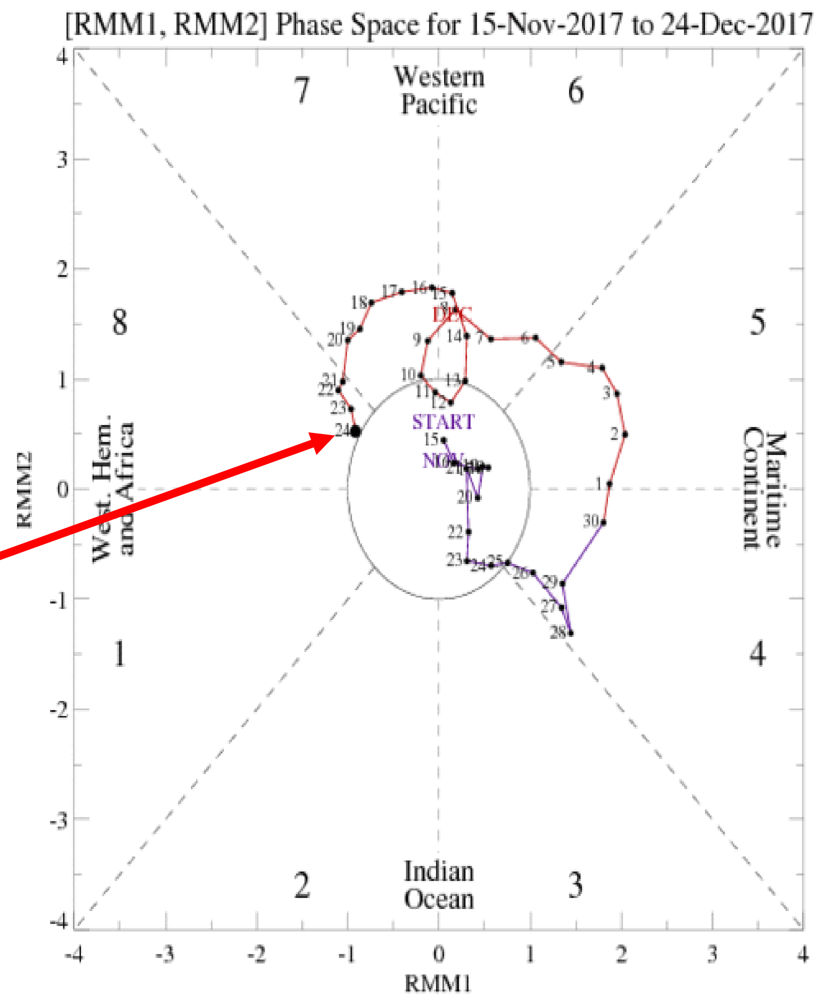
The triangular areas indicate the location of the enhanced phase of the MJO

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

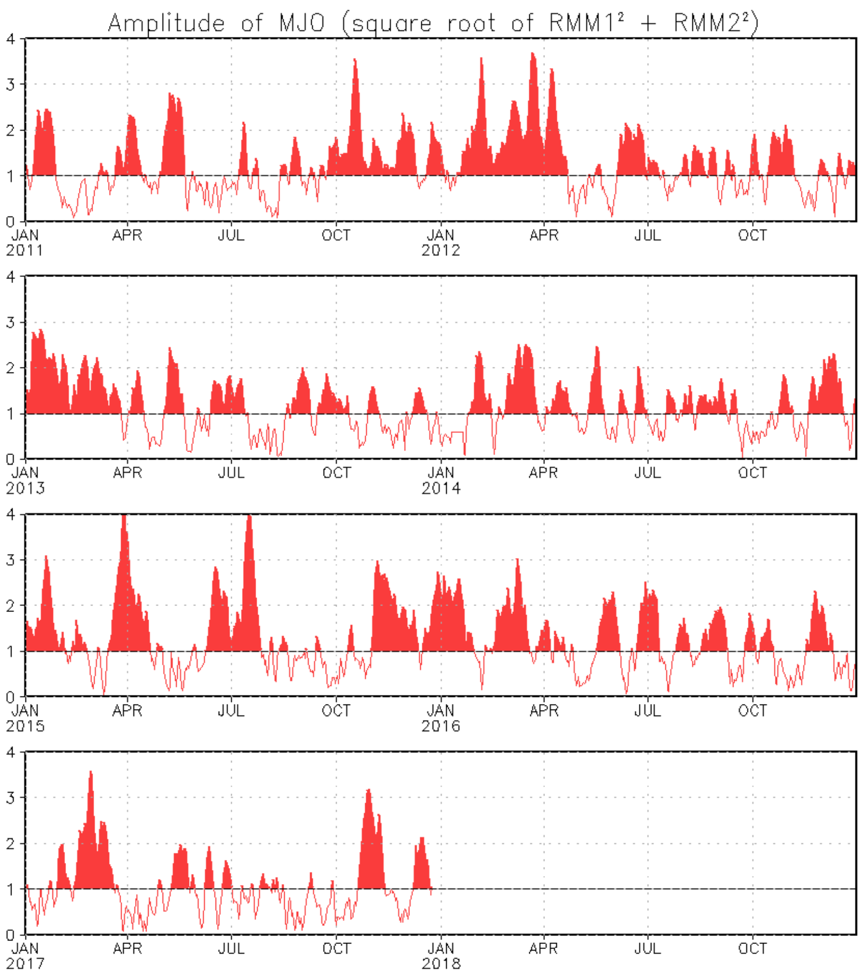
The RMM-index exhibited robust eastward propagation over the Pacific during the past week, with the index weakening slightly over the past couple of days as the MJO enhanced phase destructively interfered with the La Niña base state.



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

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

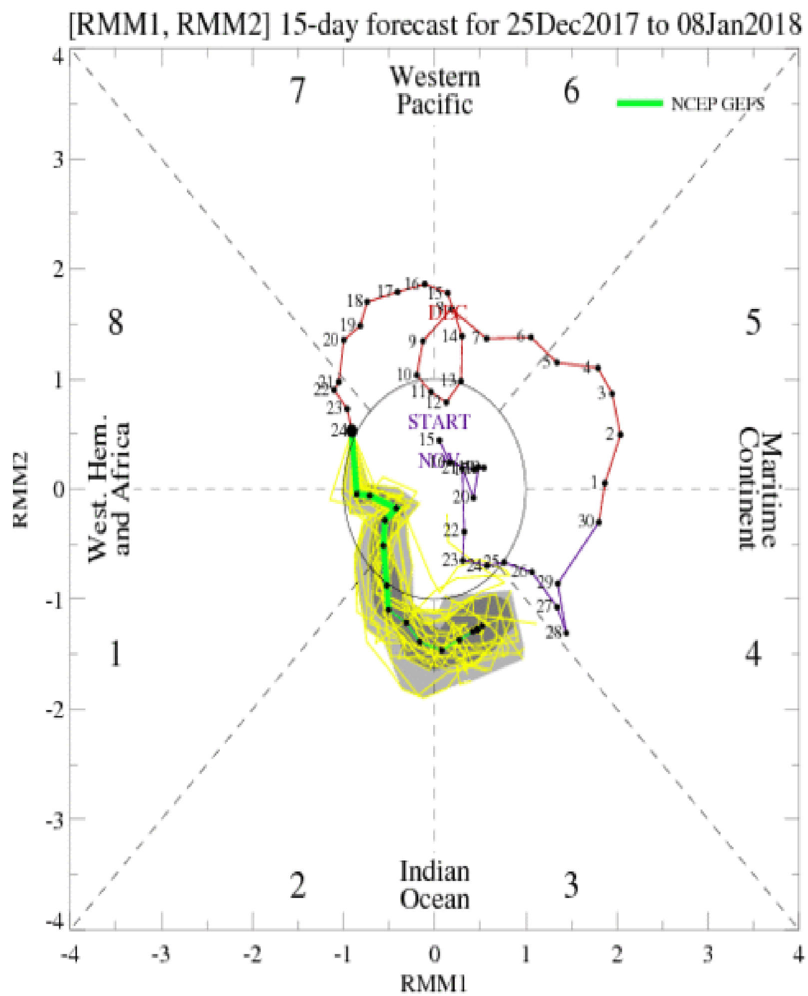
RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

<u>light gray shading</u>: 90% of forecasts

<u>dark gray shading</u>: 50% of forecasts

Given the destructive interference from the base state, which would favor enhanced convection over the Maritime Continent, the GEFS forecast shows a robust evolution of the MJO, with re-emergence over the Indian Ocean during Week-2.

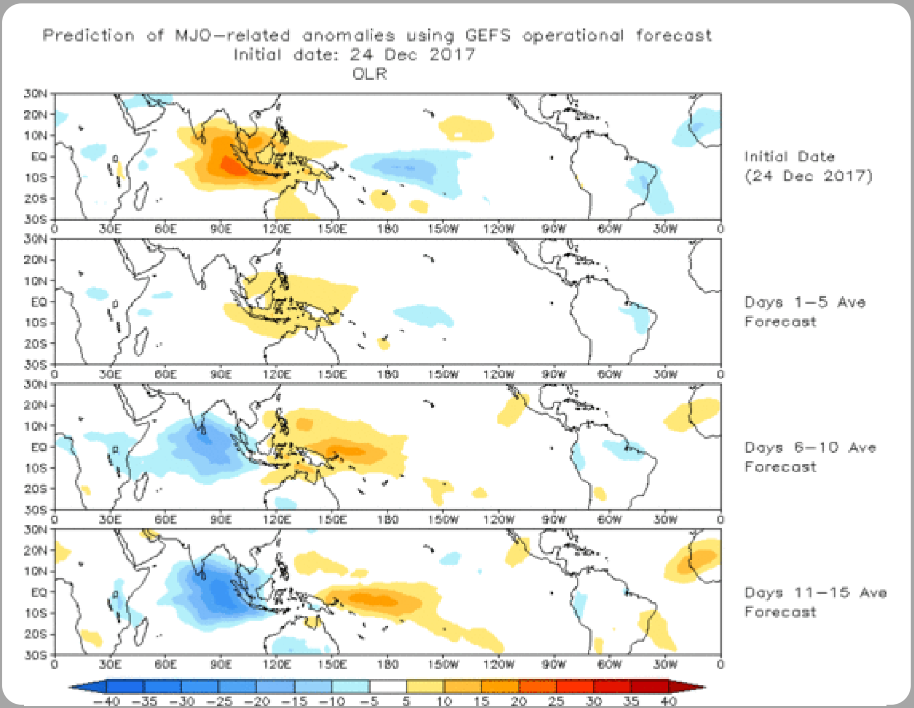
The ensemble members are also clustered fairly close together on this solution.



Ensemble GFS (GEFS) MJO Forecast

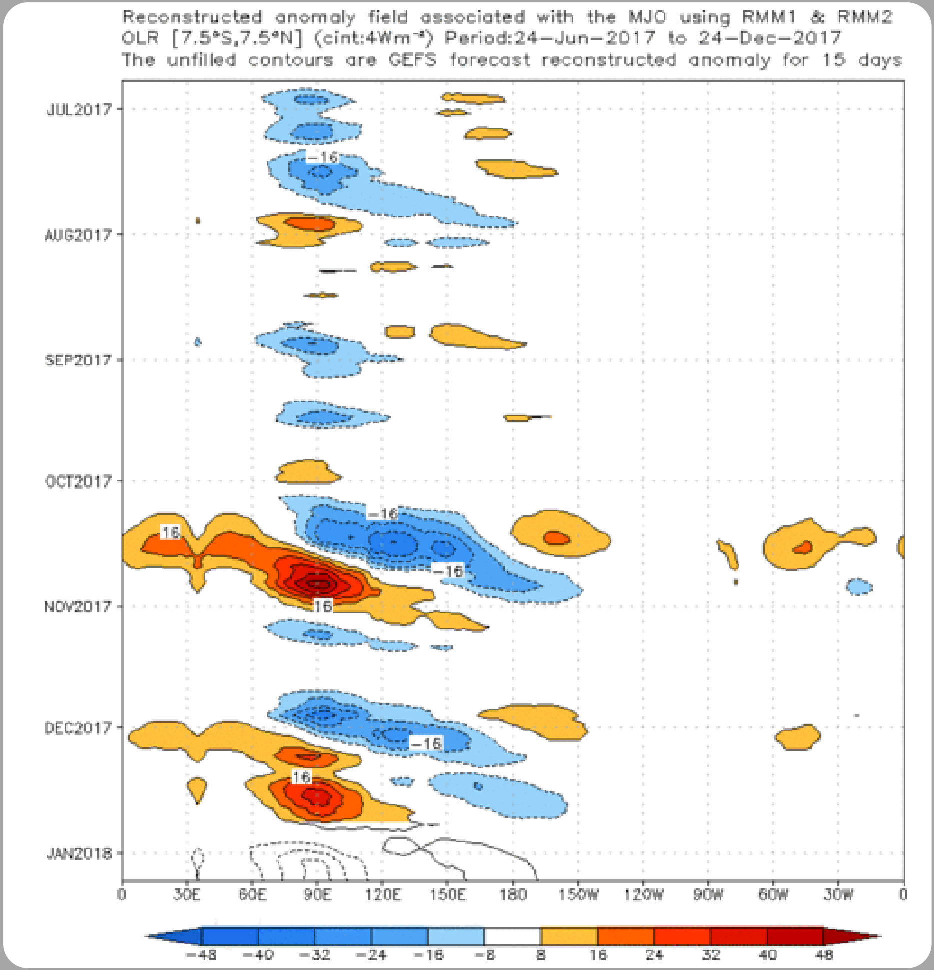
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



OLR anomalies based on the GEFS RMM-index forecast are relatively weak during Week-1 as the MJO competes with the base state. During Week-2, the MJO anomaly pattern becomes much stronger.

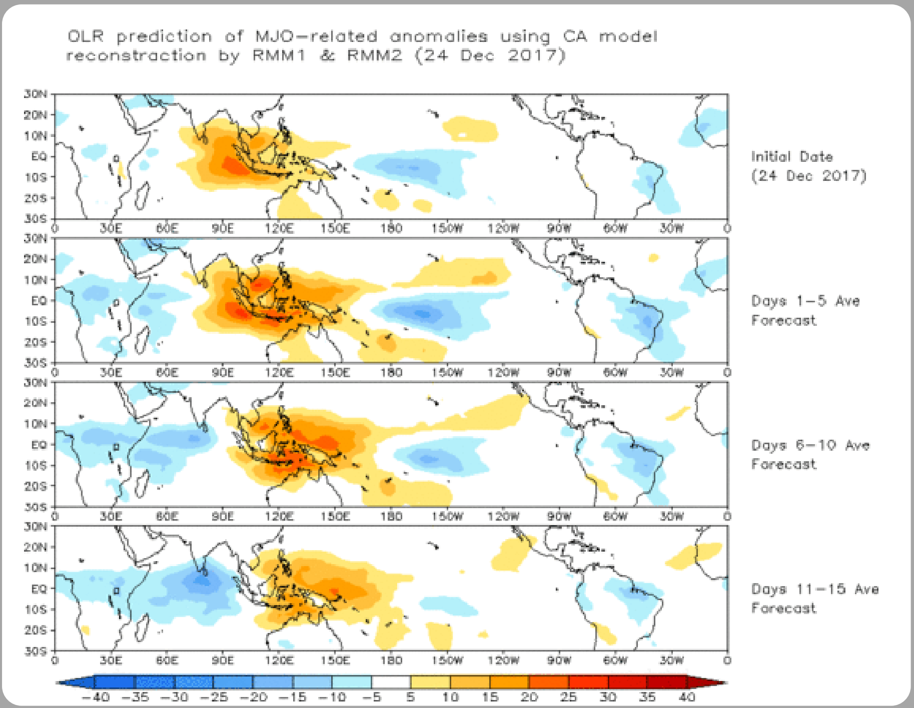
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



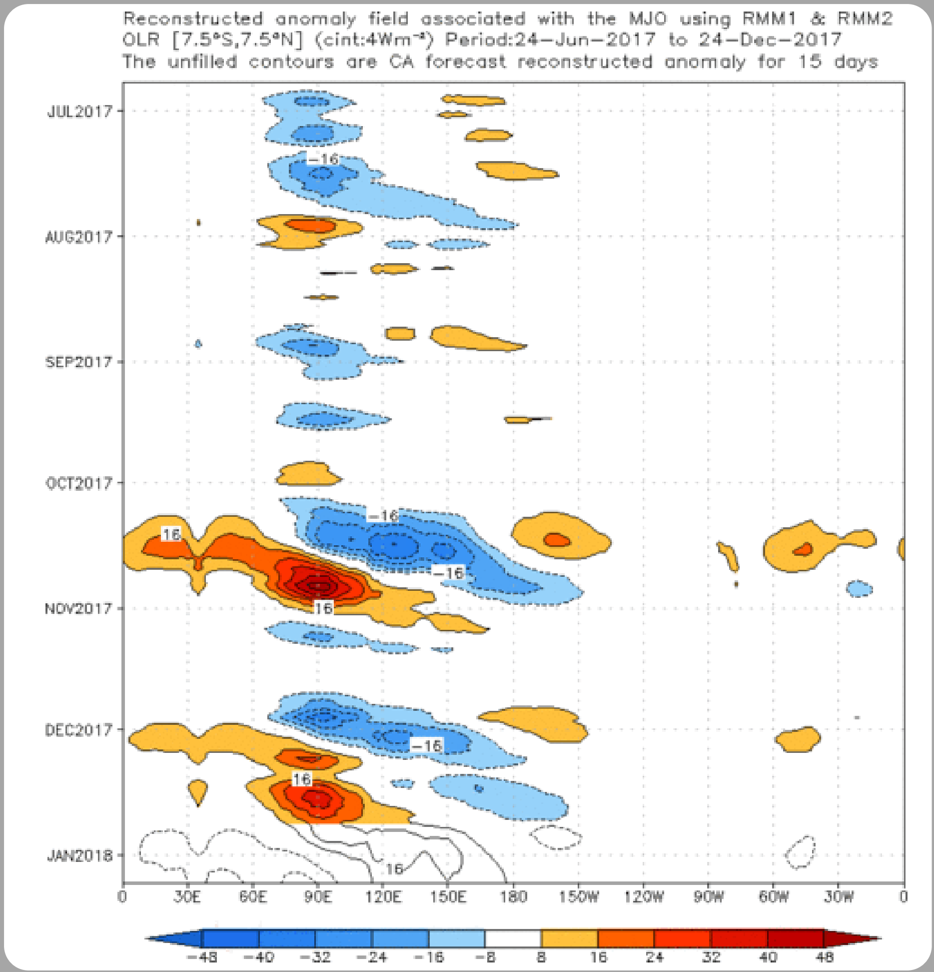
Constructed Analog (CA) MJO Forecast

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



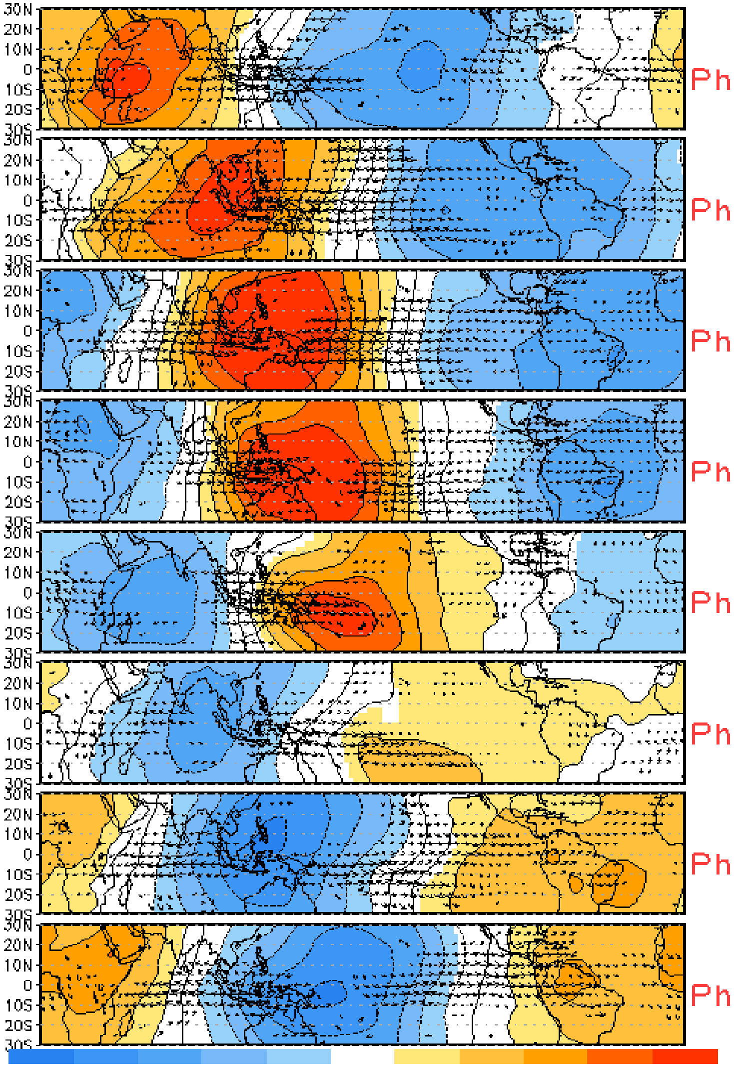
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



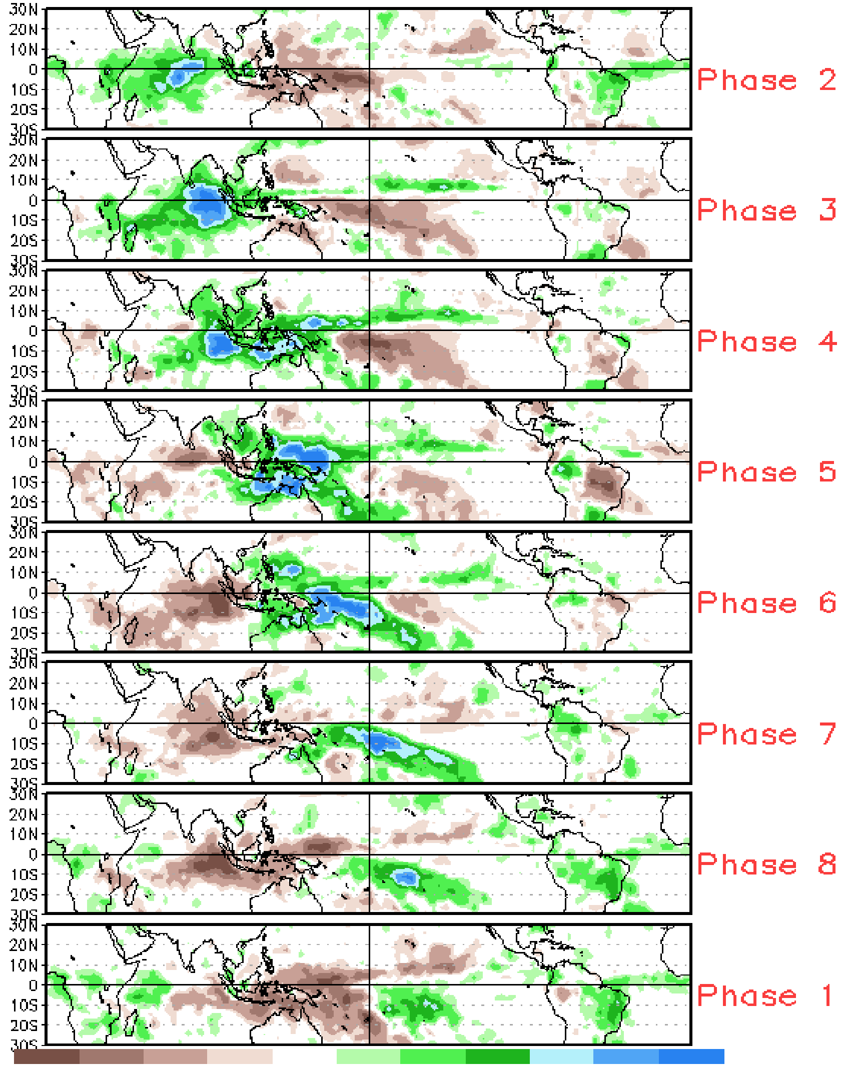
The constructed analog depicts a robust MJO event emerging over the Indian Ocean during Week-2. The propagation speed depicted by the statistical tool is slightly slower than the GEFS solution.

MJO Composites - Global Tropics

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



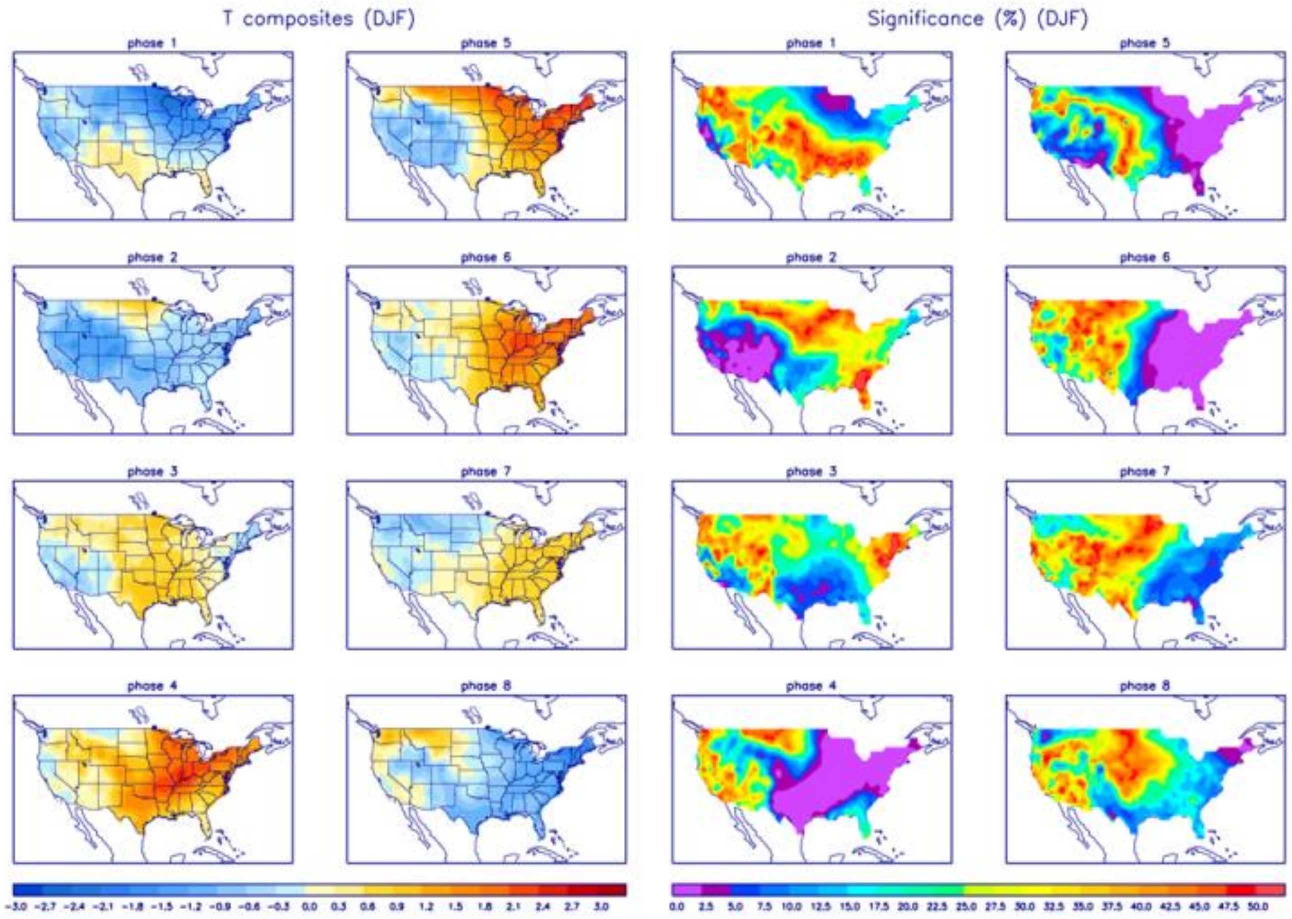
Precipitation Anomalies (Nov - Mar)



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.

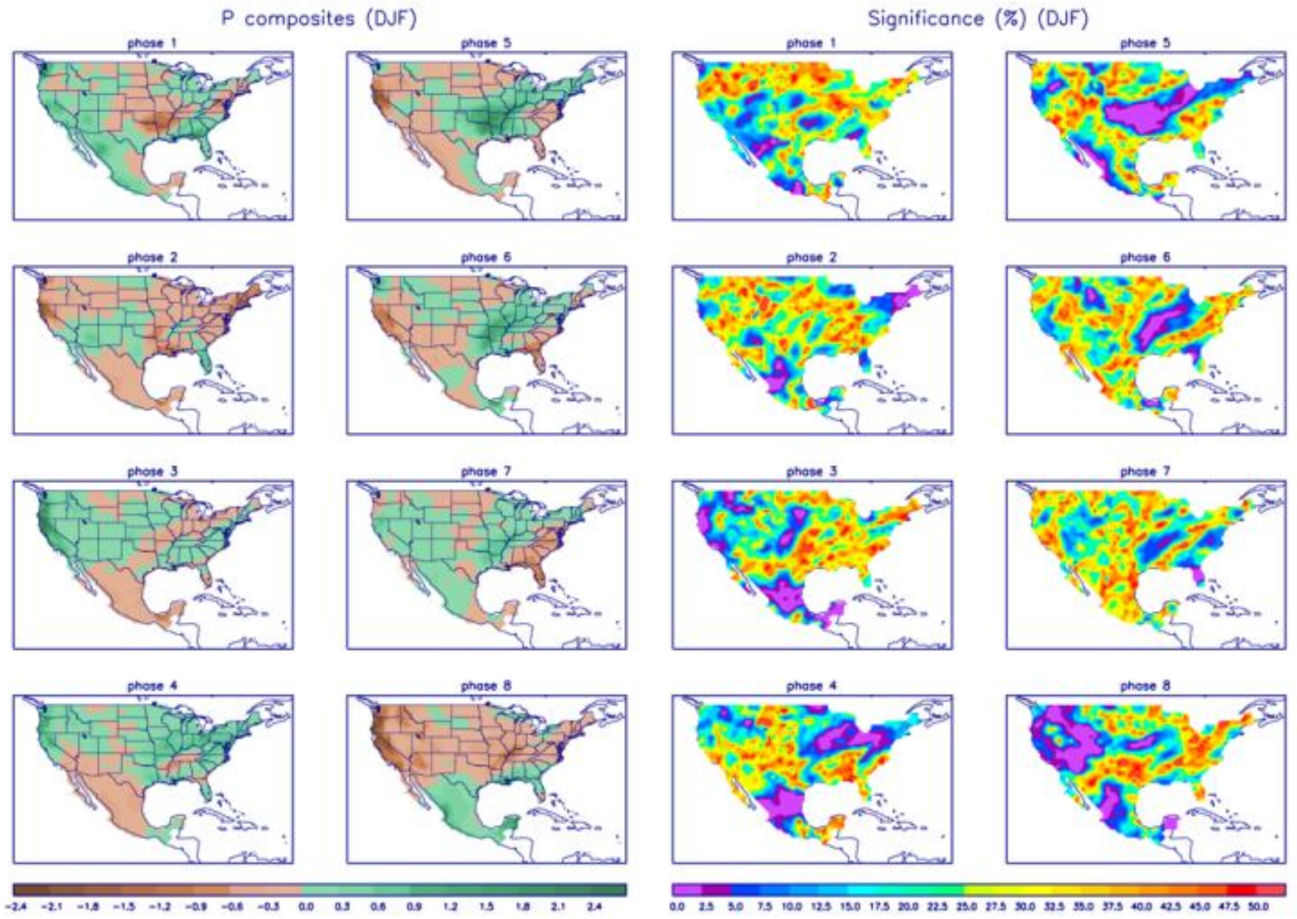
Right hand side plots show a measure of significance for the left hand side anomalies. Purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.



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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