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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Overview

- The enhanced convective phase of the MJO has moved over the Maritime Continent through the last week.

- Dynamical models show eastward propagation of the MJO signal, with enhanced convection over the Maritime Continent for Week-1 and expanding over parts of the western Pacific for Week-2. Dynamical and statistical tools forecast a rapid decay in the signal during Week-1 and Week-2, with the signal rebounding at the end of Week-2. This is likely due to expected Rossby wave activity over the Pacific.

- Based on dynamical and statistical model guidance, the suppressed envelope of the MJO is likely to continue to constructively interfere with the base state of La Niña. Enhanced convection is expected over the Maritime Continent, as well as parts of the western Pacific for Week-2.

- An active MJO over the Maritime Continent in boreal winter yields a fairly strong teleconnection response in the Northern Hemisphere, though significance for parts of the continental US are low. Typical lagged extratropical circulation responses favor a period of persistent ridging building over the lower-48, especially over the eastern seaboard.

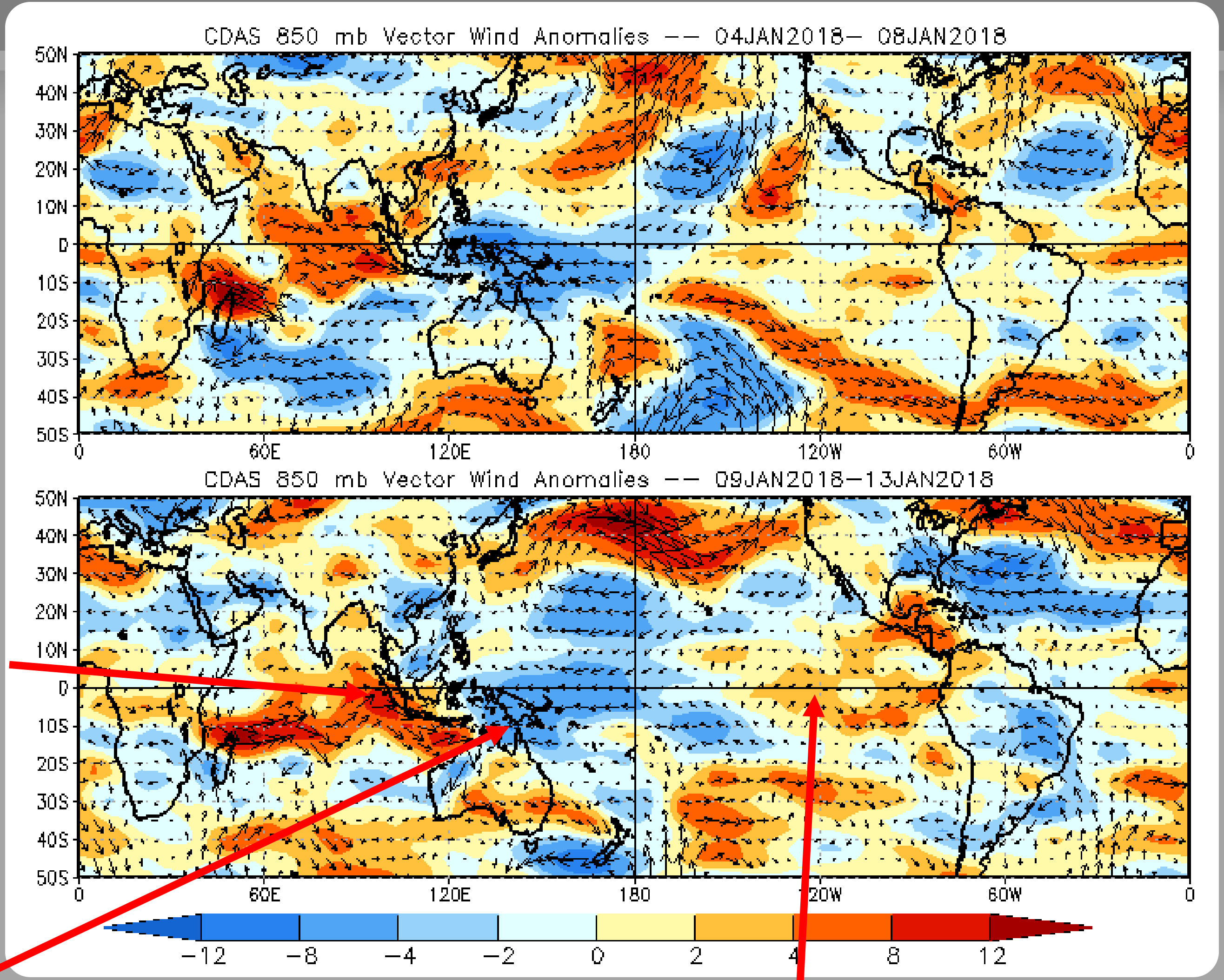
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 over the Maritime Continent in association with the active MJO signal moving from the Indian Ocean.

Low-level convergence over the Maritime Continent tied to the low frequency state shifted eastward as the MJO propagated eastward.

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

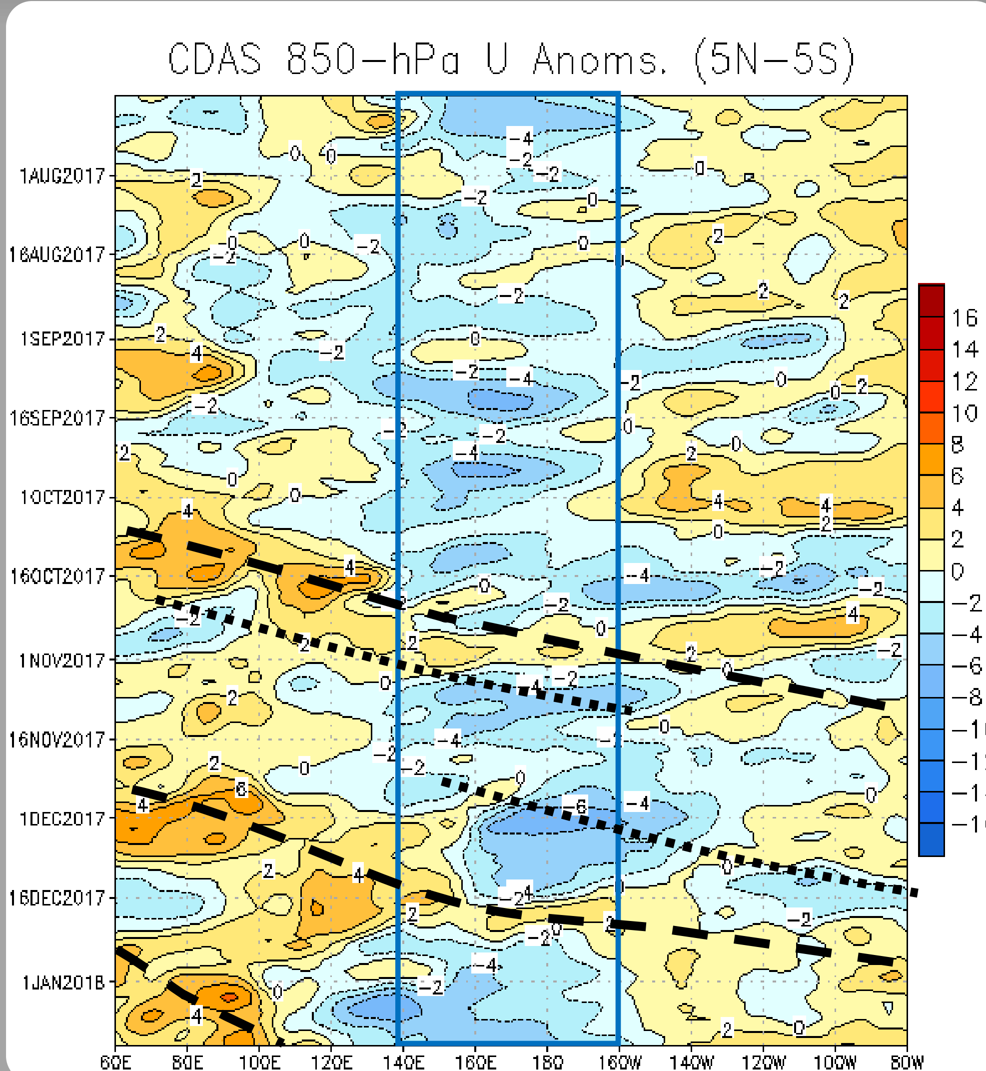
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

August and September were quiet for MJO activity, dominated by the low-frequency signal.

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 crossed the Western Hemisphere in late December, re-emerging over the Indian Ocean at the beginning of January. Recently, it continued an eastward propagation towards the Maritime Continent.



OLR Anomalies – Past 30 days

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

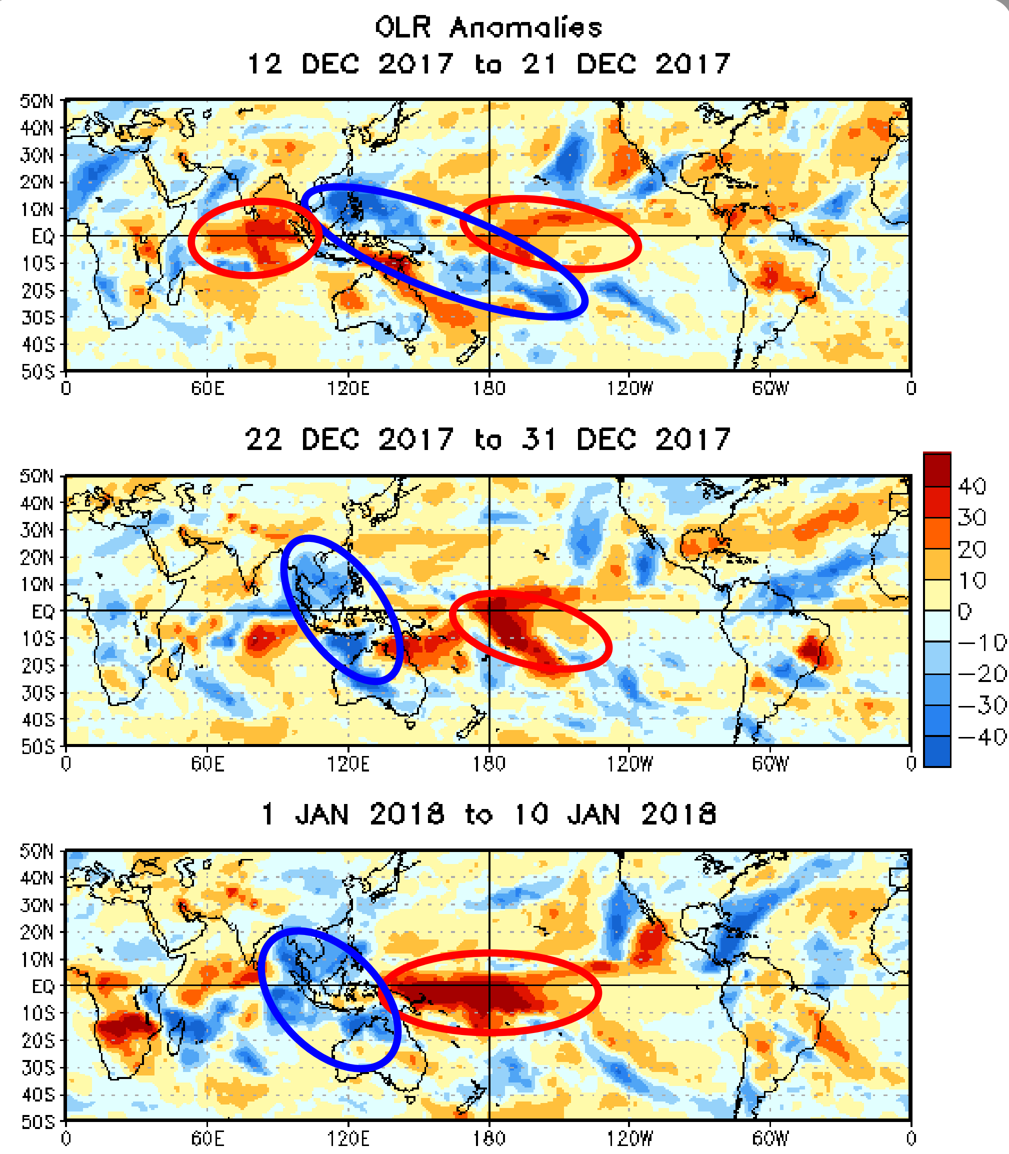
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

In 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.

Toward the end of December, the OLR field shows a more apparent MJO pattern as the signal moved across the Western Hemisphere and re-emerged in the Indian Ocean.

Through the beginning of January, little eastward propagation of the suppressed envelope occurred due to Rossby wave activity over the Indian Ocean.

During early January, enhanced convection strengthened and expanded across the Maritime Continent, while the suppressed convective signal intensified over the Pacific, constructively interfering with the low frequency state.



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

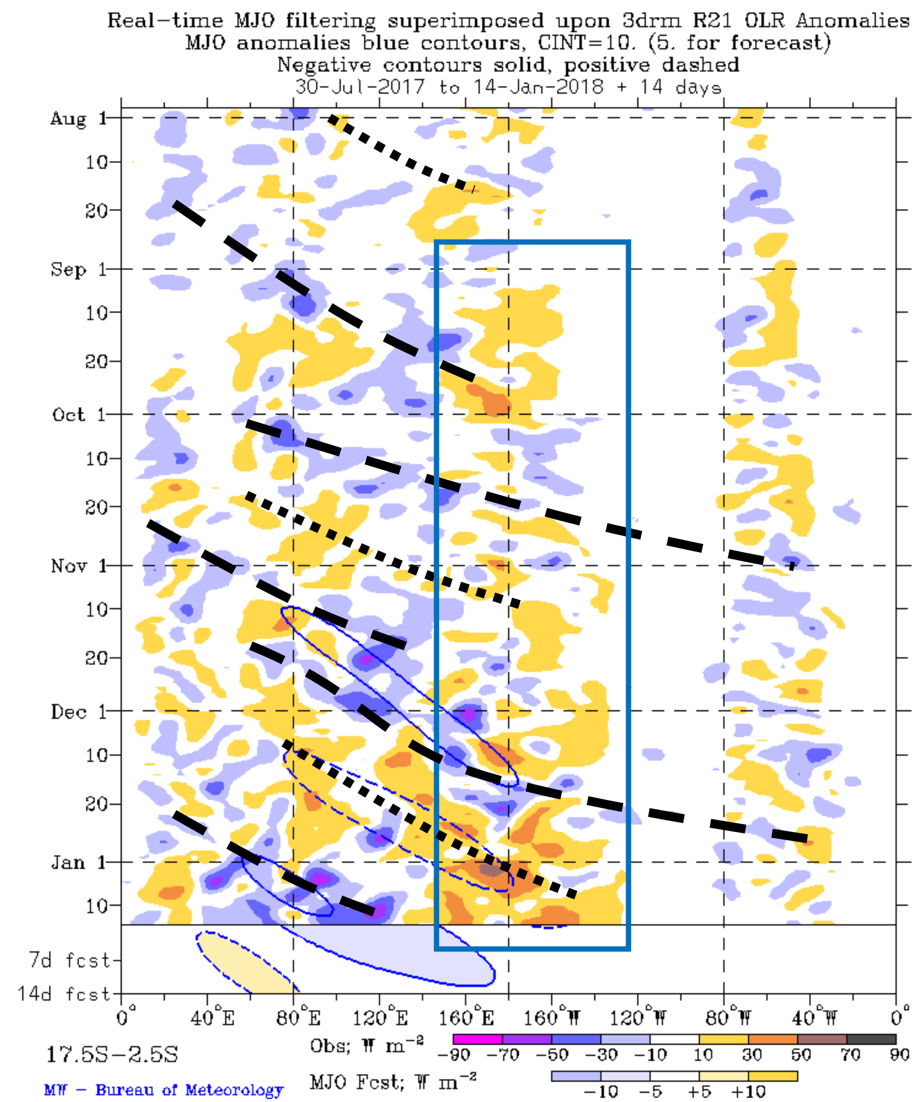
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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. It remerged in the Indian Ocean at the end of December and strengthened as it shifted east to the Maritime Continent during early January.



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

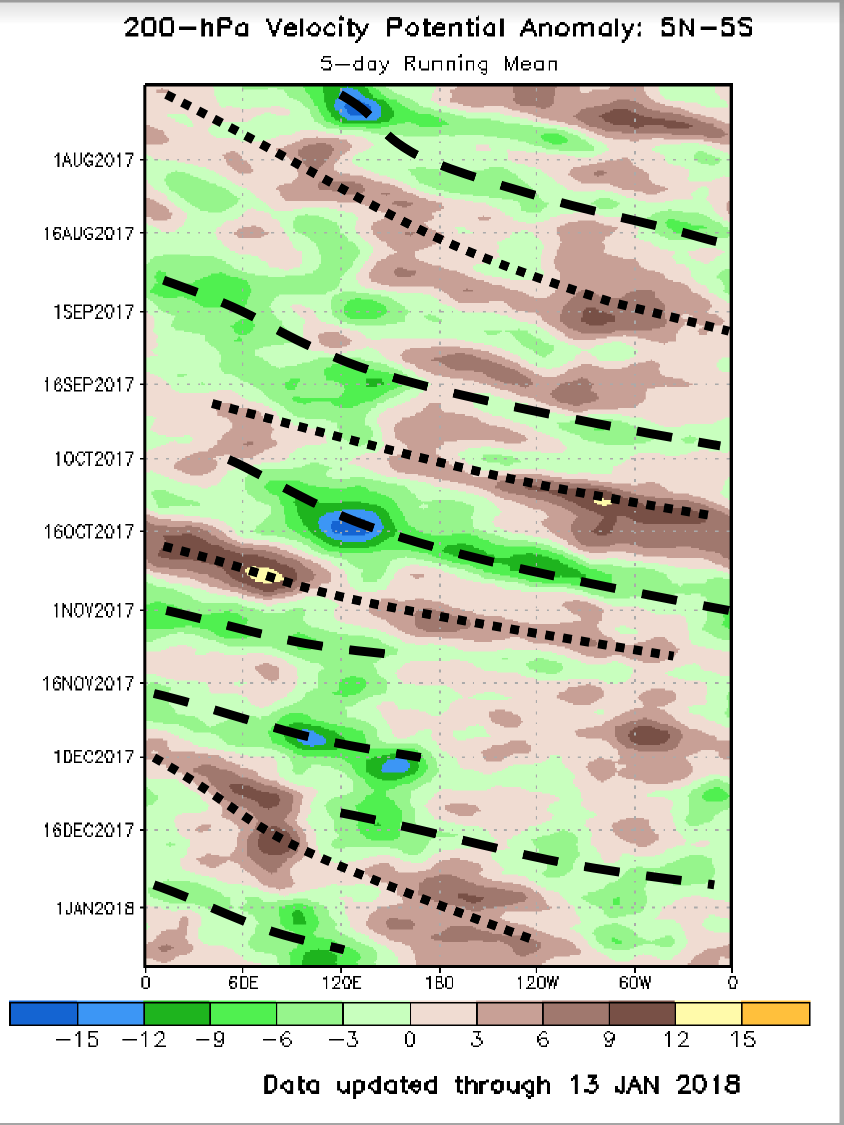
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

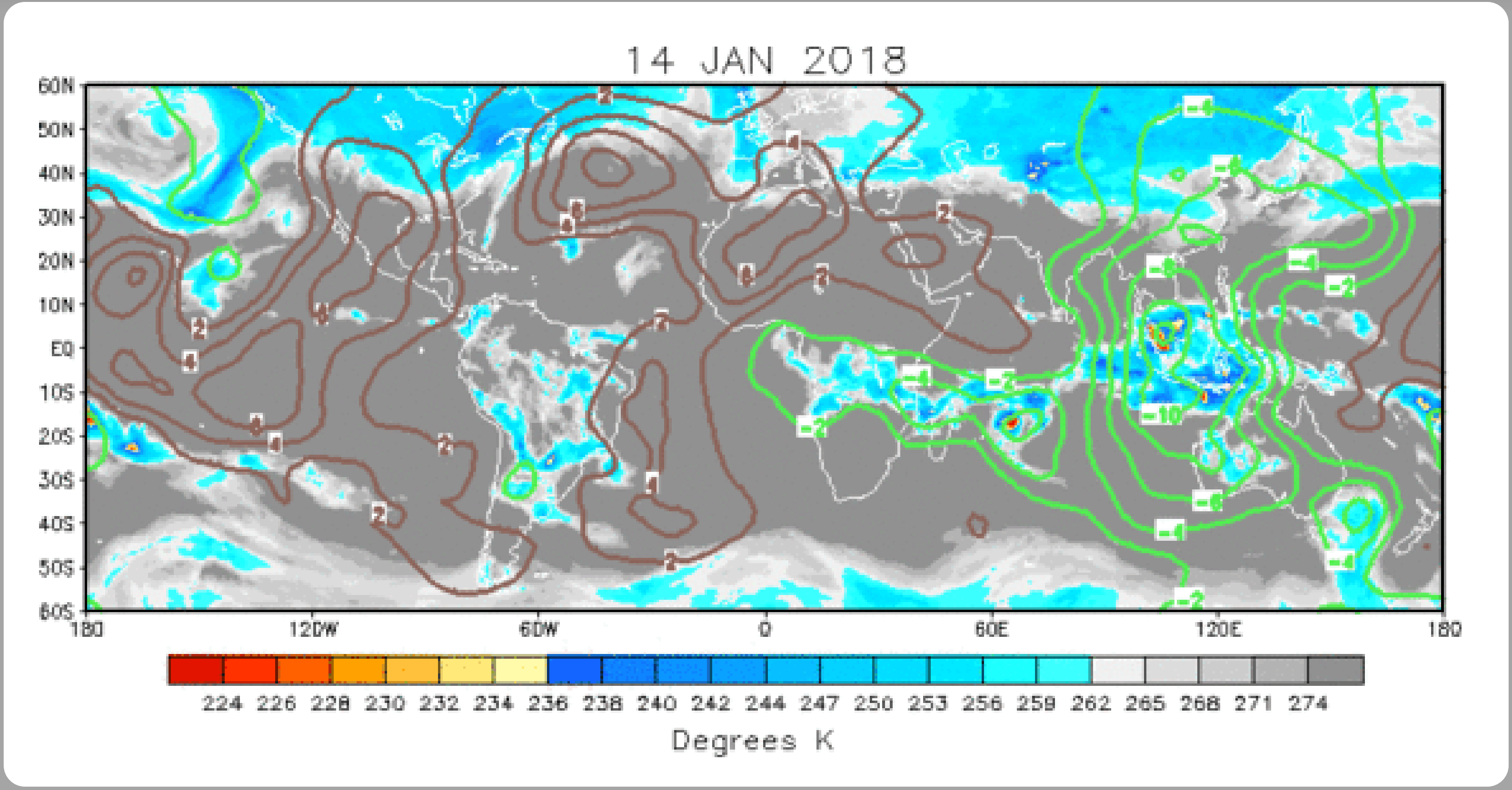
During July, an east-ward propagating enhanced convective signal strengthened over the Maritime Continent that was consistent with the MJO. Another signal on the MJO timescale is evident in this field during late August and September.

An 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 weaker than the previous episode, with disruption from Rossby wave activity. The signal destructively interfered with the base state through the end of December, crossing the Western Hemisphere into the Indian Ocean for the beginning of January. Since then, it has continued eastward and strengthened.



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



The upper-level anomalous velocity potential field shows a wave-1 pattern with enhanced (suppressed) convection through the Indian Ocean to the Maritime Continent (Pacific, Americas, and Atlantic), consistent with the Phase 3 MJO signal. Some noise in the positive pattern over the Americas is likely due to Kelvin 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)

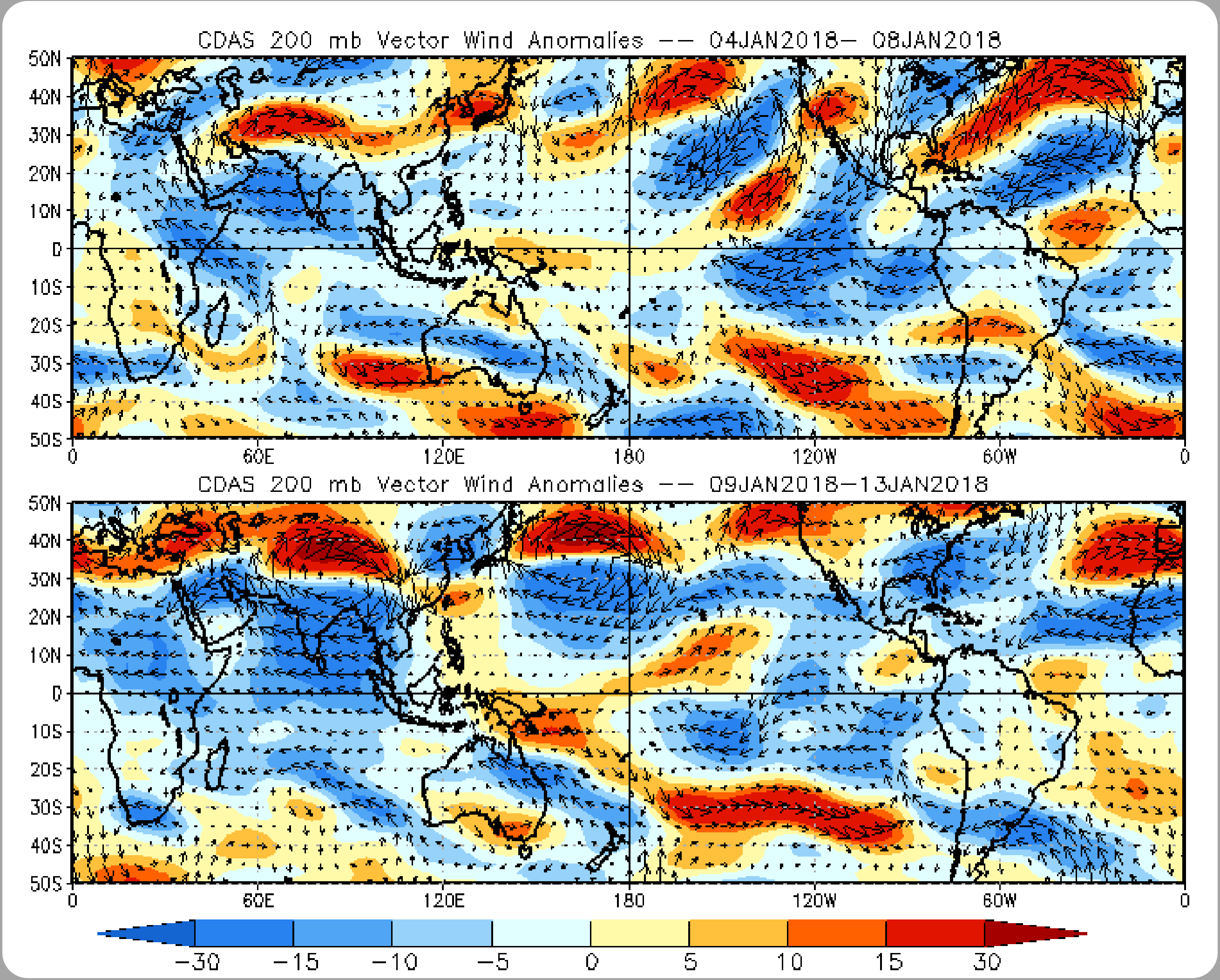
Note that shading denotes the zonal wind anomaly

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.

The westerly anomalies over the western Pacific strengthened during the past week as the MJO suppressed envelope propagated further eastward toward the Date Line. Easterly anomalies intensified over the Indian Ocean, consistent with the eastward shift of enhanced convection.



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

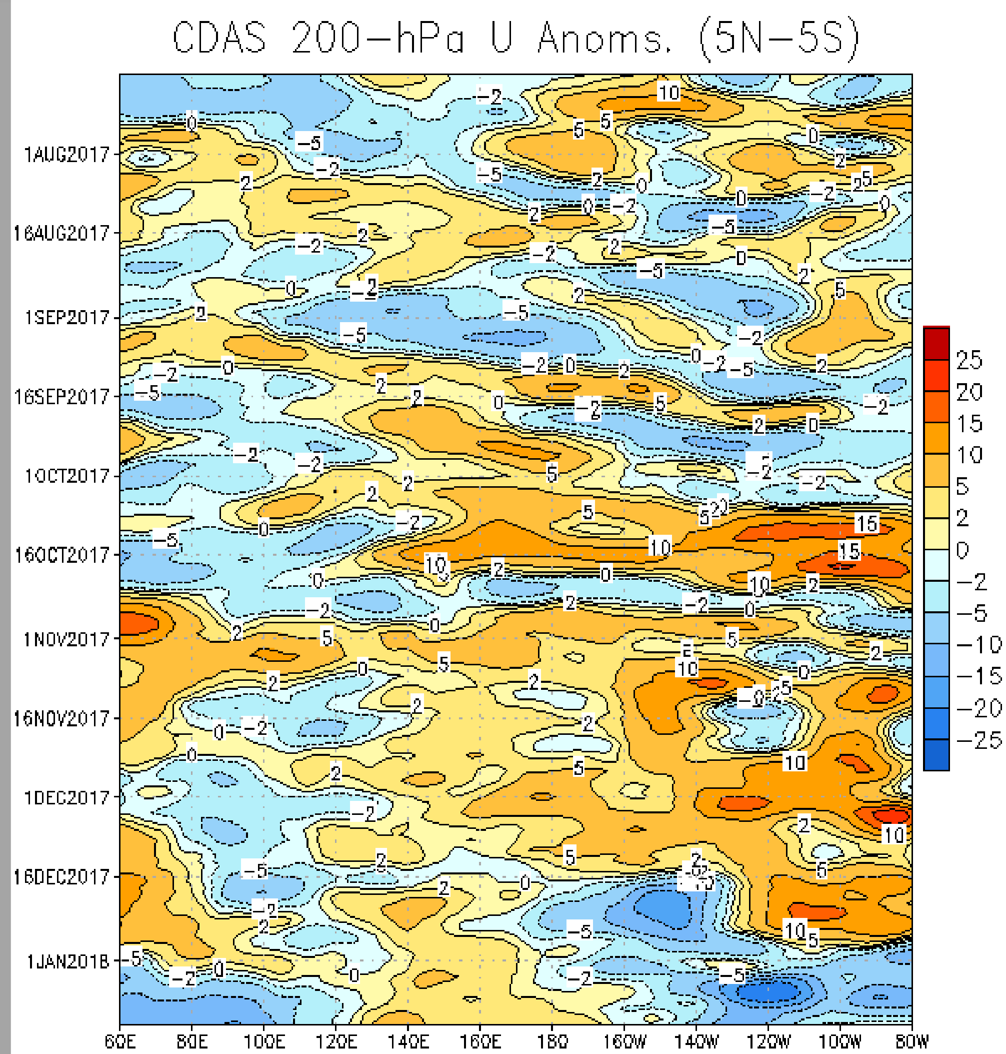
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

During 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.

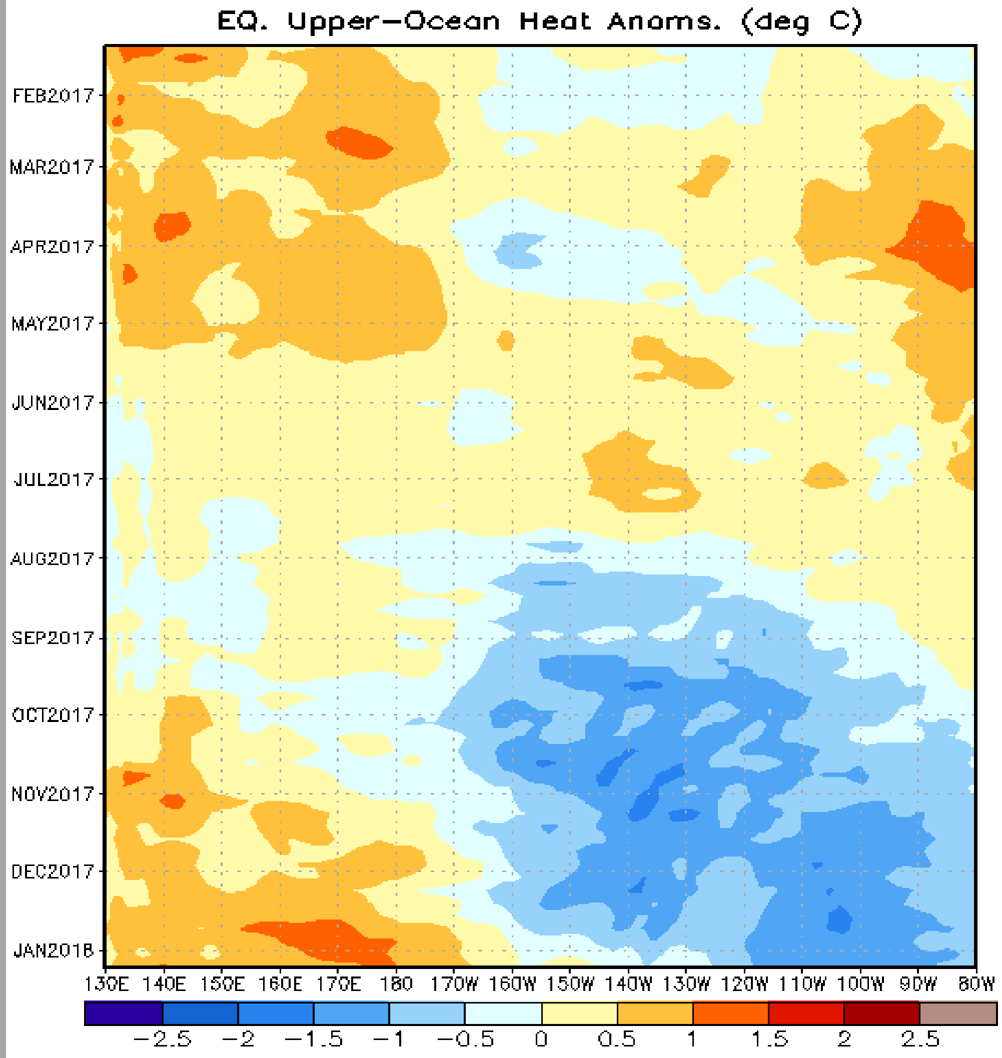
Low-frequency westerly anomalies remained in place east of 140E starting in October, with the exception of a brief period of easterlies in late October. There is also some recent evidence of easterlies over the far Eastern Hemisphere over the last week or so that appear to have extratropical sourcing.

In mid-December, easterly anomalies have developed in the east of the Date Line, replacing the westerly anomalies that had been generally present since October. These anomalies have been moving east from the central Pacific into the eastern Pacific in the past few weeks.



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.

Anomalous upper-ocean warmth has been building to the west of the Date Line over the last few months, tied to westerly wind bursts with the intraseasonal atmospheric envelope. Since the beginning of January, these warm anomalies increased and crossed 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

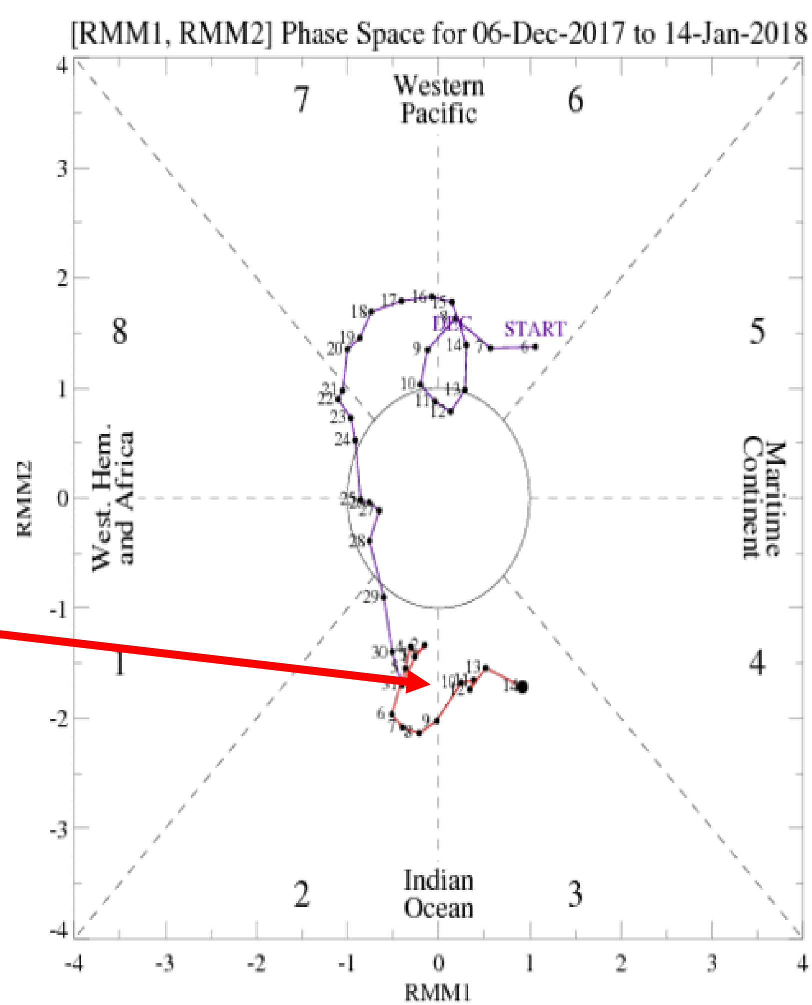
Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.

Distance from the origin is proportional to MJO strength

Line colors distinguish different months

As shown by the RMM-index, the MJO signal moved into Phase 3 over the past week.

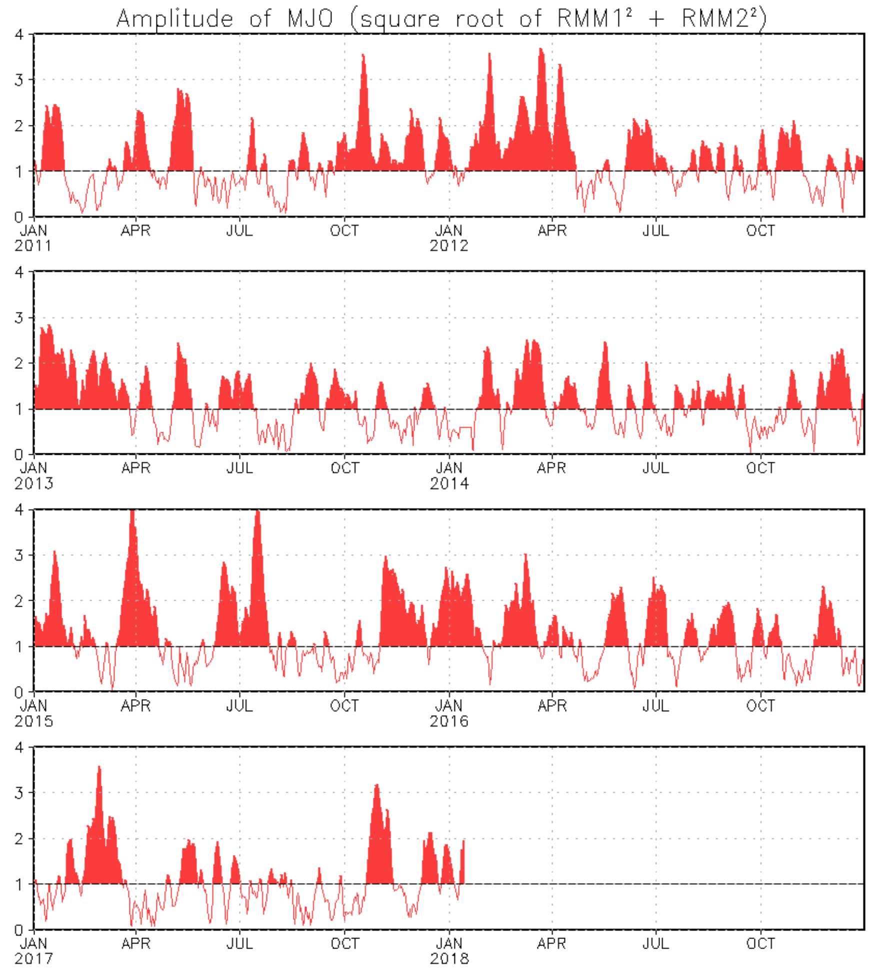
The signal strength weakened slightly throughout the past week, but has begun to rebound. Eastward propagation was slowed briefly, most likely due to tropical cyclone activity in the Indian Ocean.



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.



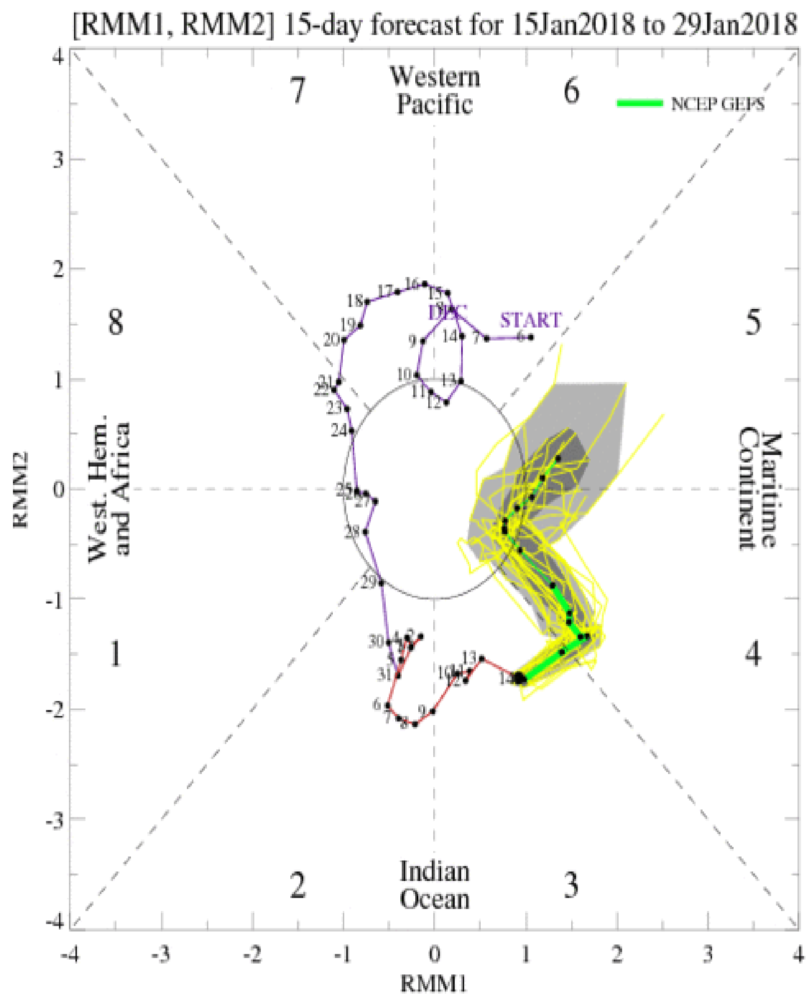
GFS Ensemble (GEFS) MJO Forecast

<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



The GEFS forecasts shows continued eastward propagation, moving into Phase 4 early in Week-1, maintaining its current amplitude. Toward the end of Week-1, the signal strength begins to rapidly decrease, most likely due to interference from Rossby wave activity.

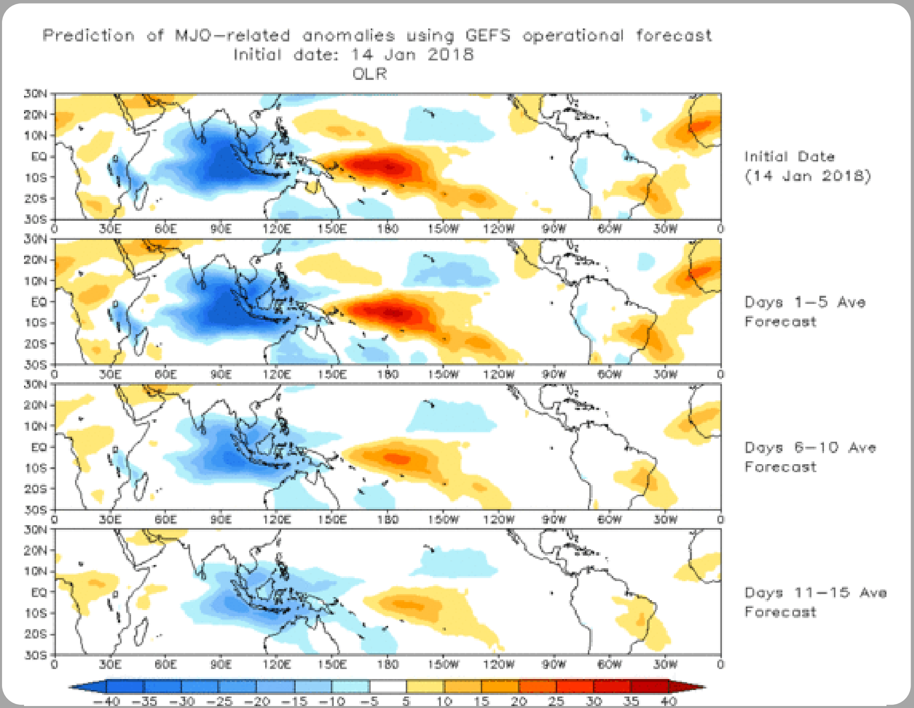
In Week-2, the weakening of the signal continues as the forecast moves through Phase 4. As it approaches Phase 5 at the end of Week-2, the signal begins to re-strengthen. Spread among the members shows uncertainty in the speed of the progression. Most members are in agreement about the deterioration in signal strength with a rebound toward the end of Week-2.

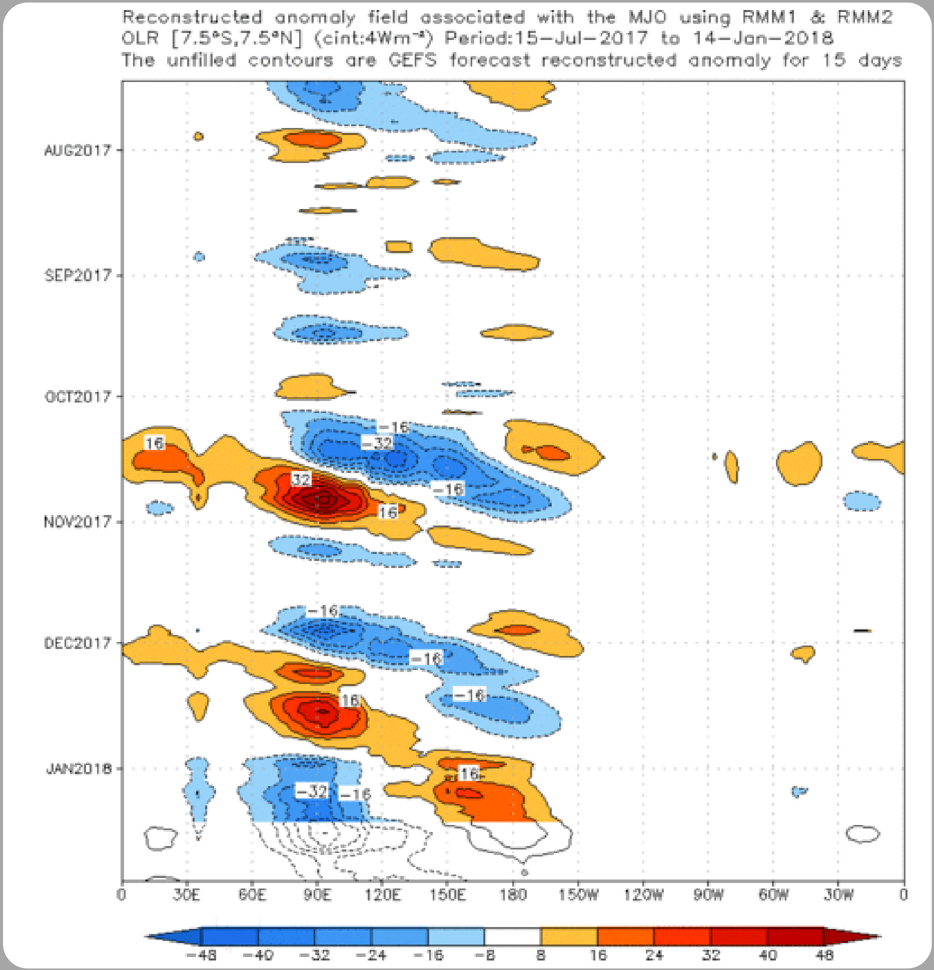
Ensemble GFS (GEFS) MJO Forecast

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



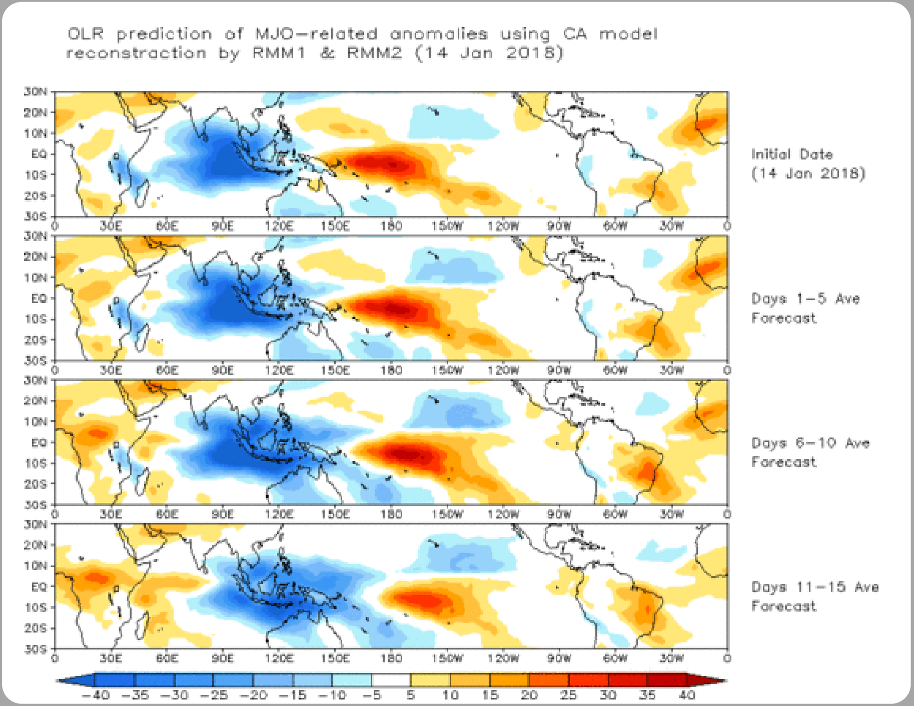


MJO-driven OLR anomalies based on the GEFS show the move into Phase 4 as the area of enhanced convection moves further east over the Maritime Continent. There is a decay in the signal in the OLR field through the next two weeks.

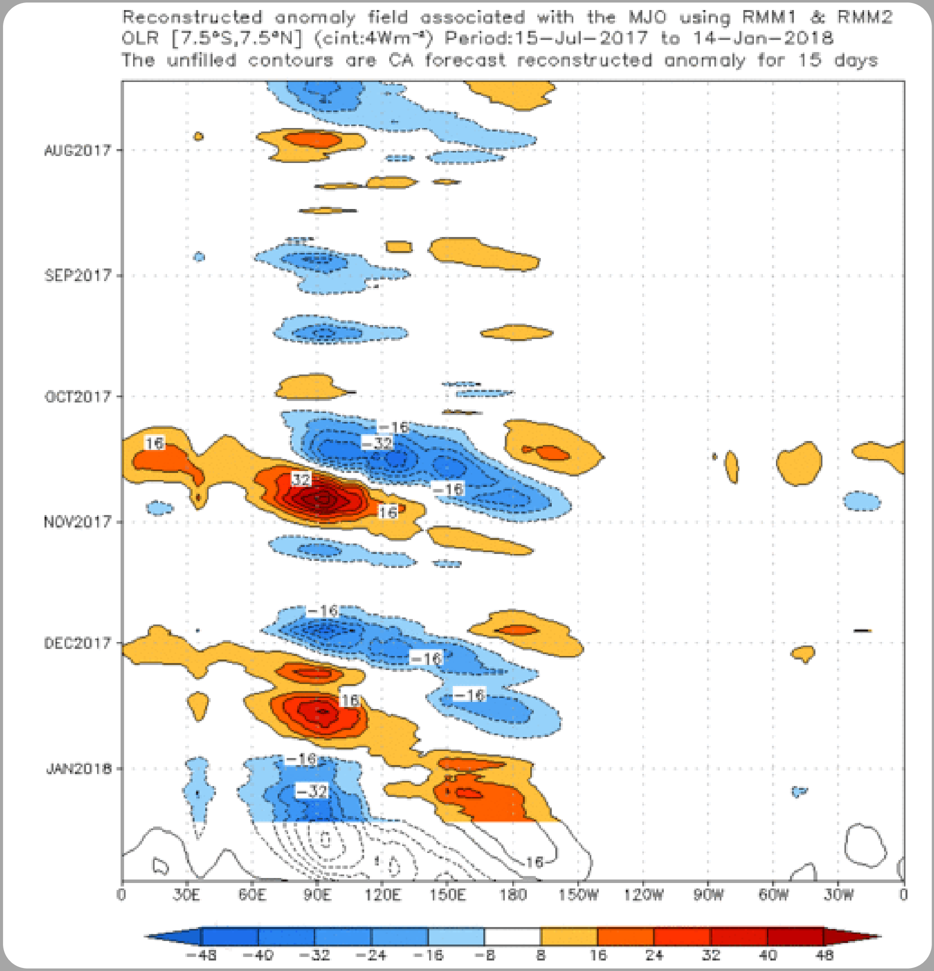
Constructed Analog (CA) MJO Forecast

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



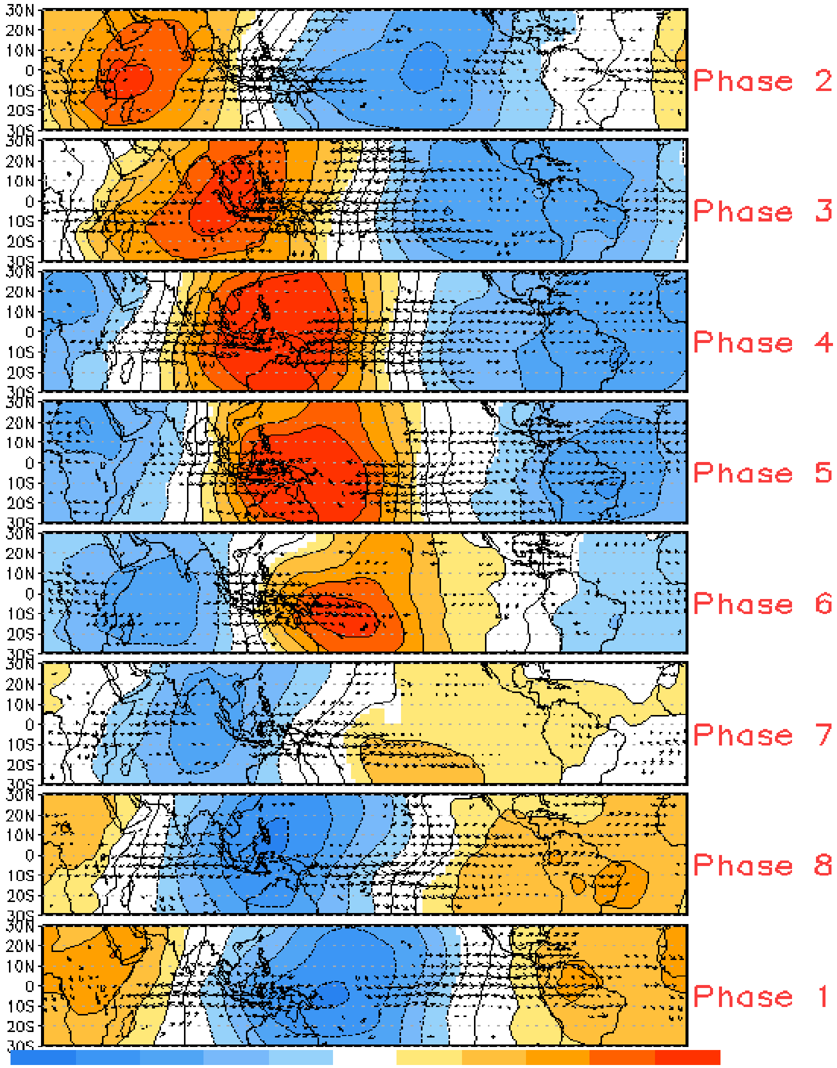
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



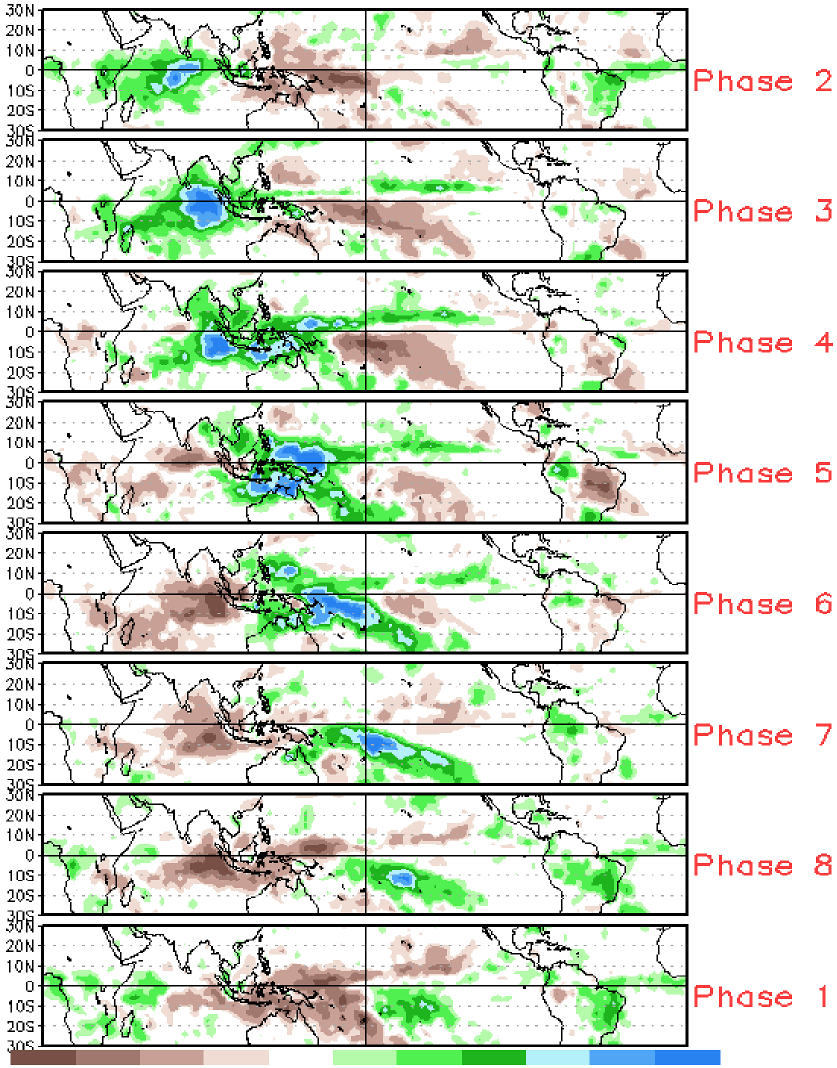
The constructed analog also supports the eastward propagation of the MJO signal that was seen in the GEFS. There is a weakening in the signal in the CA forecast; however, the signal decay is not nearly as pronounced as the dynamical forecast shows.

MJO Composites - Global Tropics

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



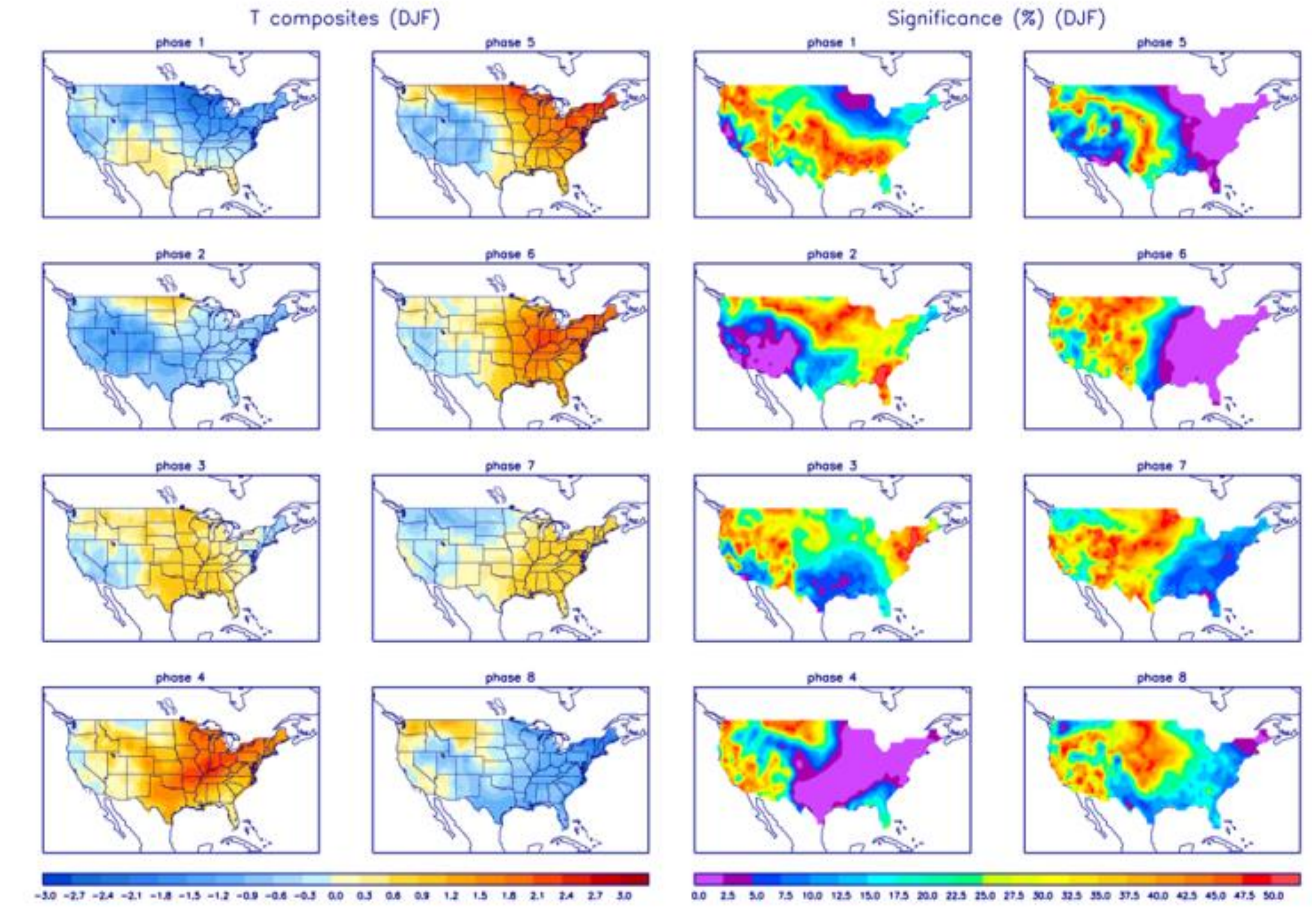
Precipitation Anomalies (Nov - Mar)



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.



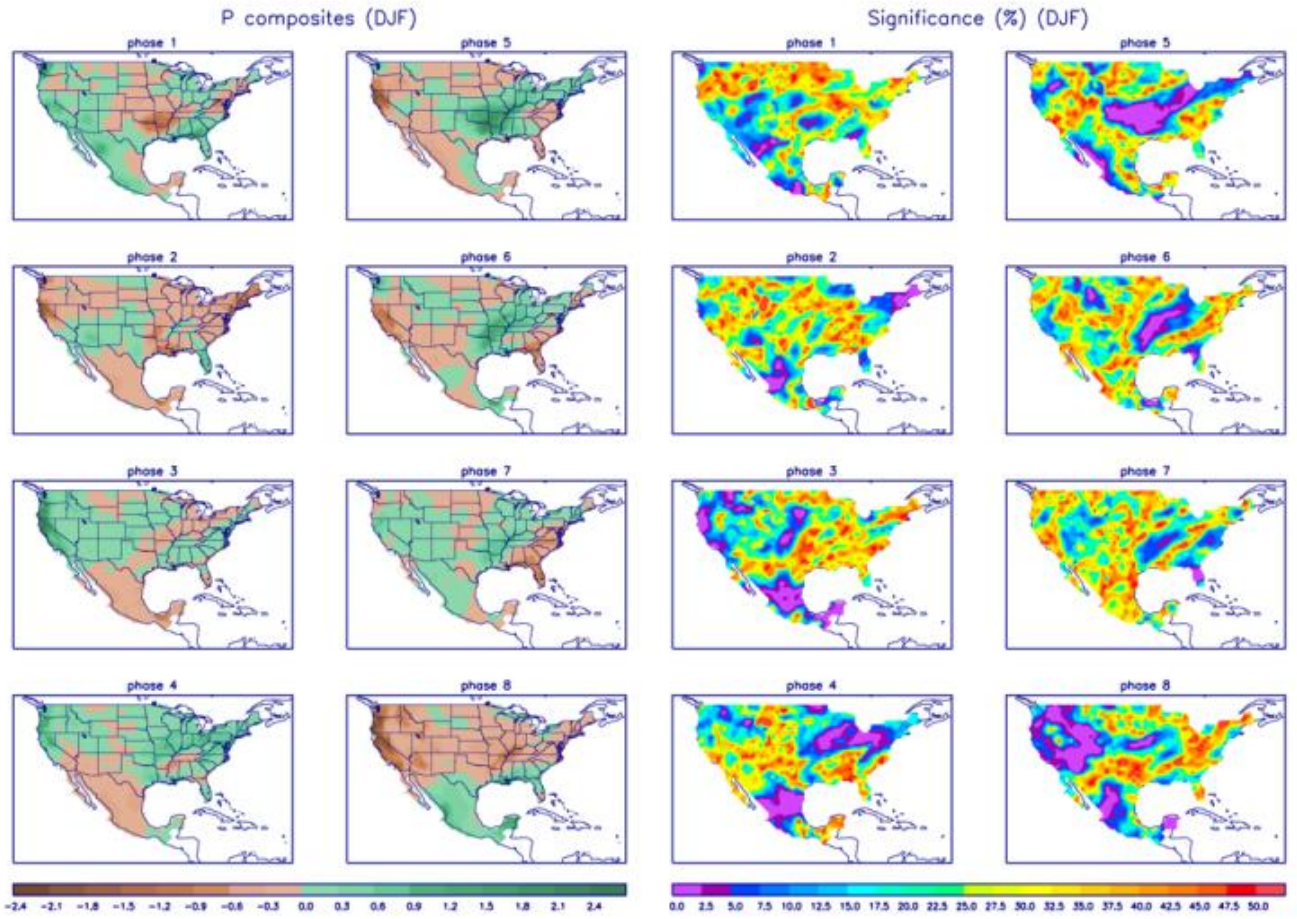
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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