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

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Outline

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MJO Index Information

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Overview

- The MJO signal has slowed in the past week, as its enhanced phase remains over the eastern Pacific. There has been significant weakening to the signal.

- The convectively active (suppressed) phase of the MJO envelope remains over the equatorial Date Line (Indian Ocean), though the robust signal in the OLR anomaly field seen prior has weakened.

- The GEFS forecasts the MJO to continue to propagate eastward across the Western Hemisphere and Africa. The signal is likely to continue to weaken, especially into Week-2.

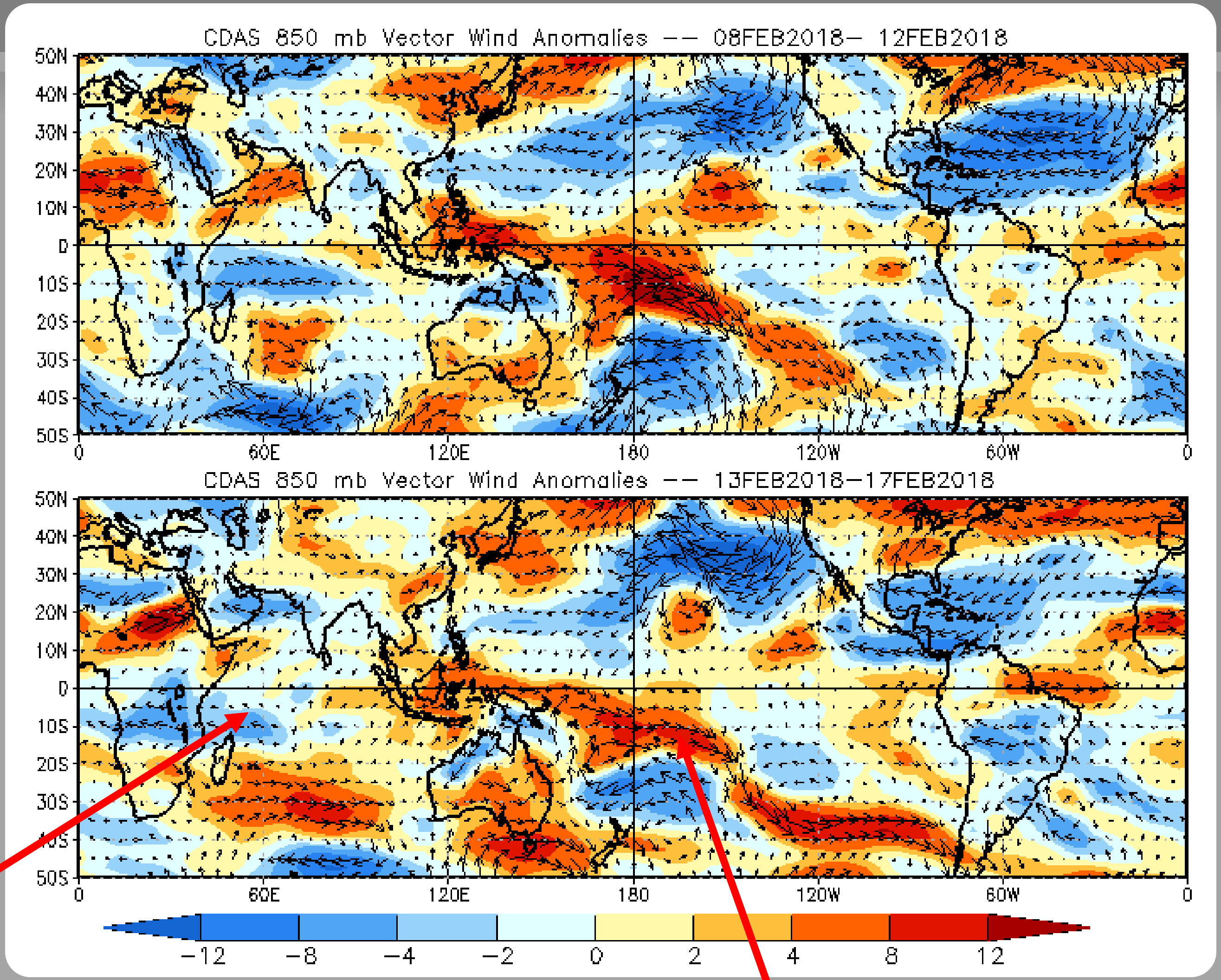
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies are still persistent in the Indian Ocean, but have weakened relative to the prior week.

Near equatorial anomalous westerlies have weakened as the MJO signal has remained in Phase 7, but reduced in amplitude.

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

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

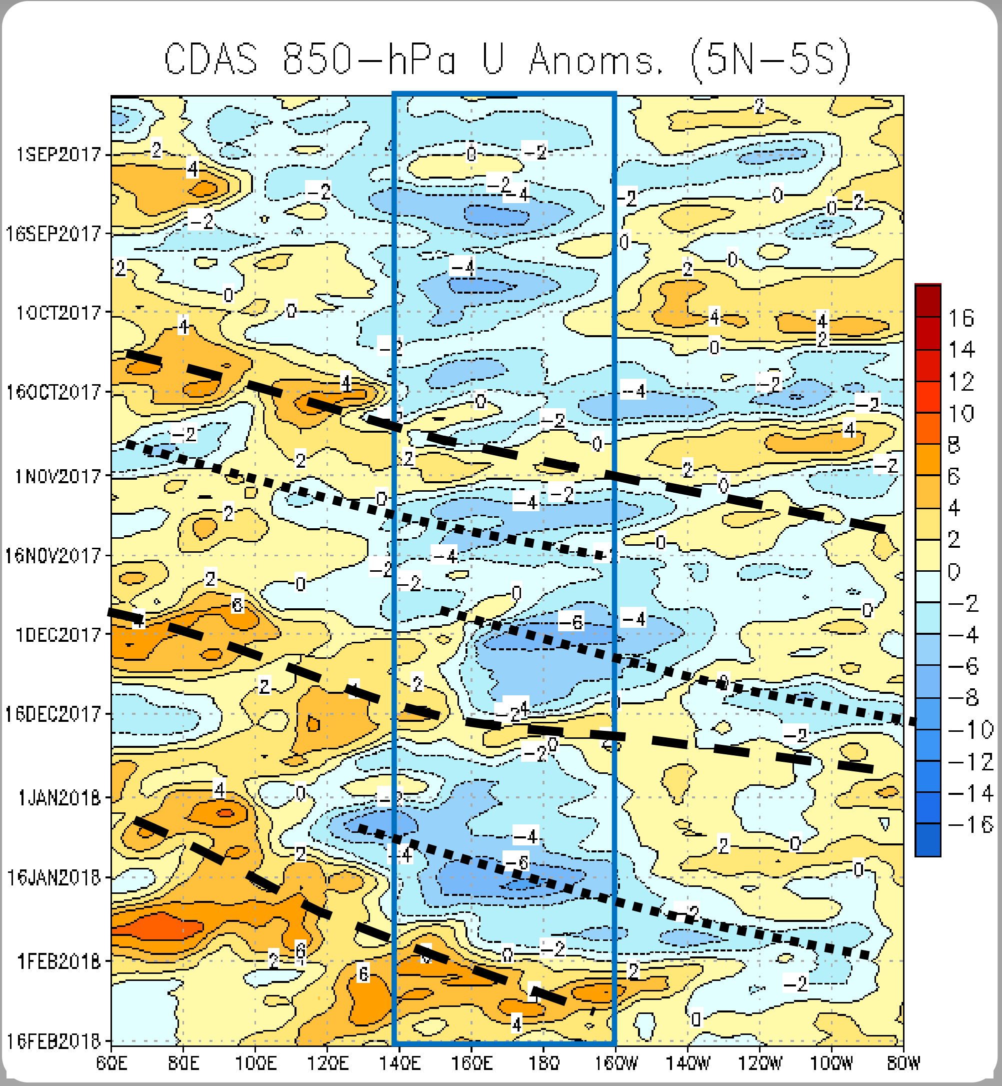
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Low frequency anomalous easterlies, which have been present over the past 180 days, have been replaced by anomalous westerlies over the past 2 weeks.

August and September had little MJO activity, dominated instead 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 early January. The signal has continued to propagate eastward, moving into the central and eastern Pacific.



OLR Anomalies – Past 30 days

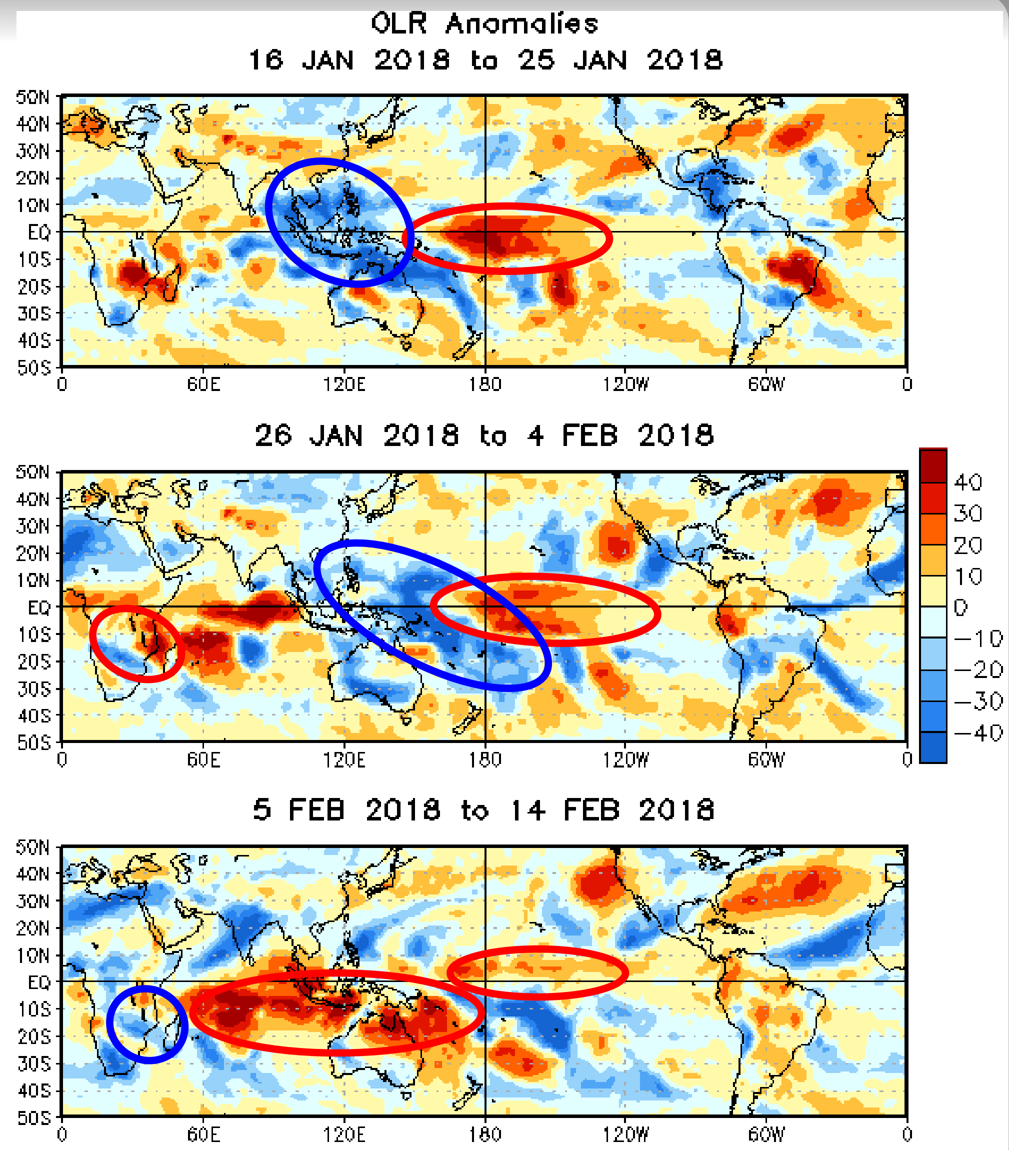
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

The enhanced phase of the MJO reached the Maritime Continent during mid-January, and constructive interference between the suppressed envelope and the La Niña base state resulted in a robust OLR signal. Dryness continued over southern Africa.

Eastward propagation of the enhanced (suppressed) convective anomalies from the Maritime Continent to the West Pacific (Western Hemisphere to the western Indian Ocean) was apparent in late January as robust MJO activity continued. Suppressed convection persisted near the Date Line and over southern Africa.

Positive OLR anomalies have weakened (strengthened) near the Date Line (Indian Ocean and Maritime Continent) during early February as the MJO continued propagating eastward and destructively interfered with the base state. Suppressed convection in the western Indian Ocean has been replaced by enhanced convection.



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

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

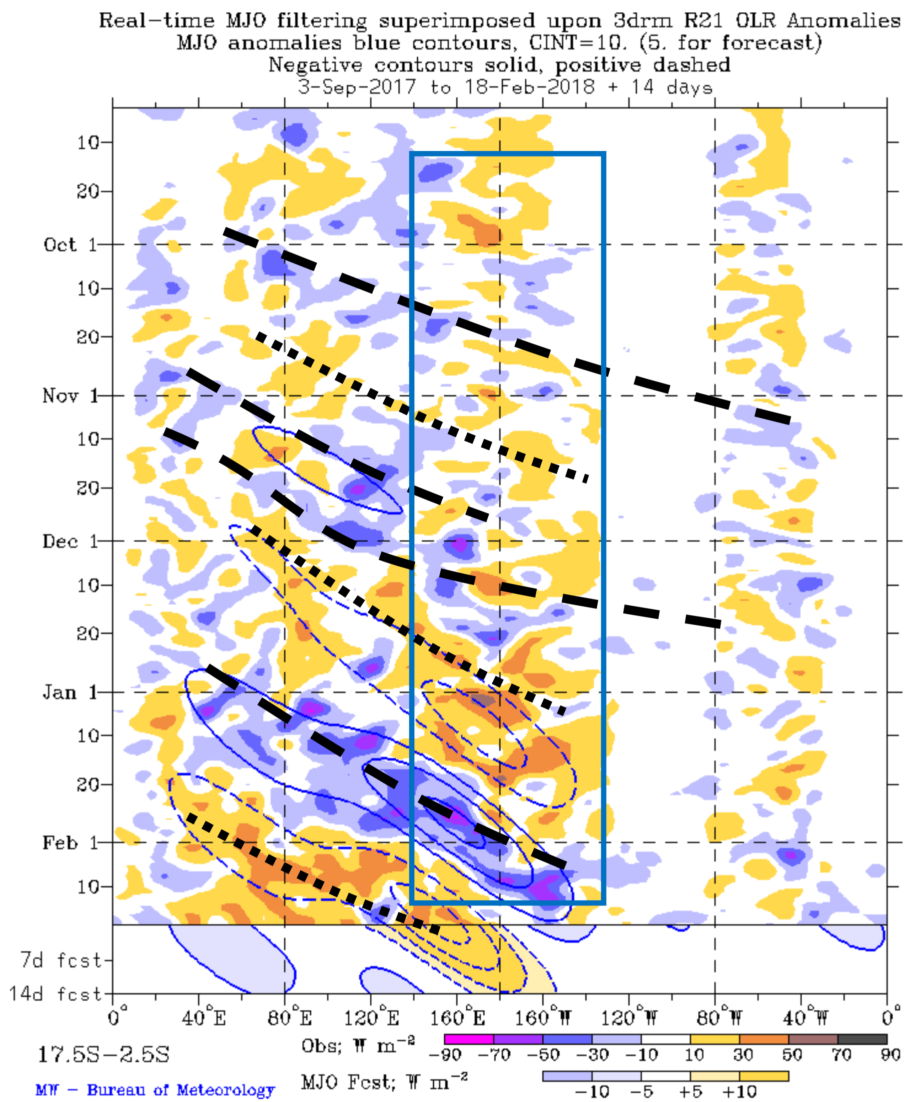
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

A low-frequency positive OLR signal, indicating anomalously dry conditions, emerged during September.

An active MJO formed in early October and circumnavigated the globe by early 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 re-emerged in the Indian Ocean at the end of December and strengthened as it shifted east towards the Date Line at present.

Another MJO event developed during January, leading to a reversal of the La Niña convective signal over the Date Line in early February.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

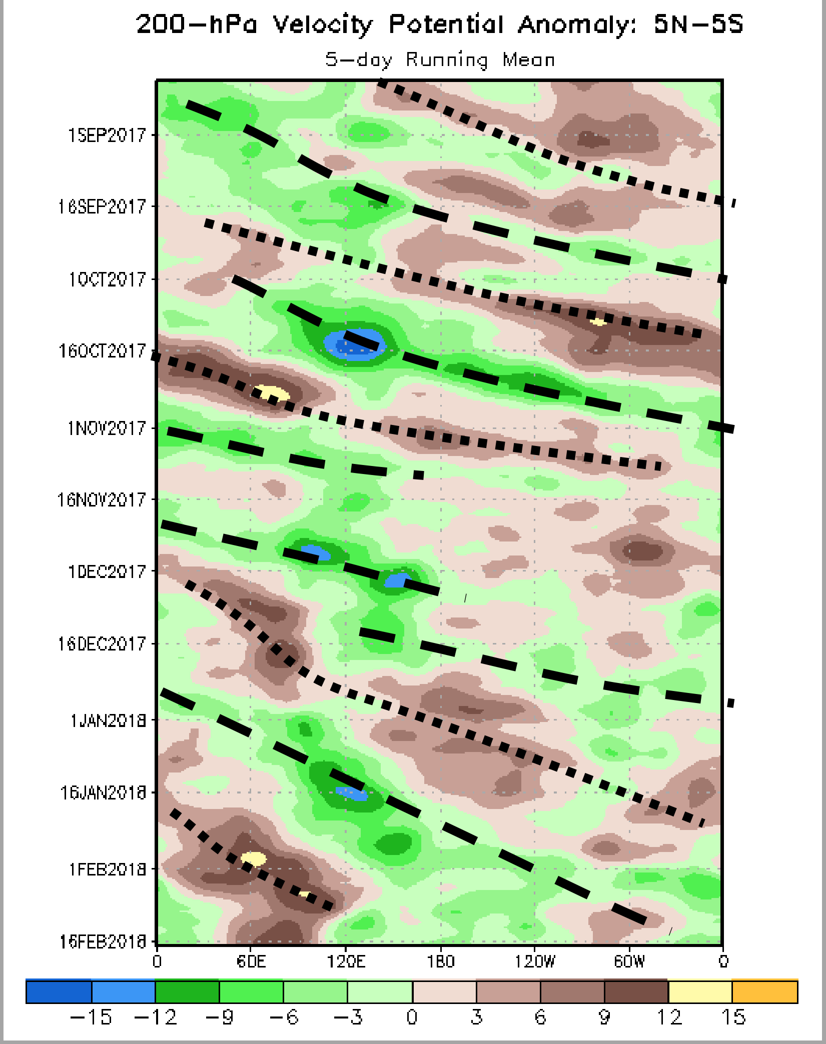
Negative anomalies (green shading) indicate favorable conditions for precipitation

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

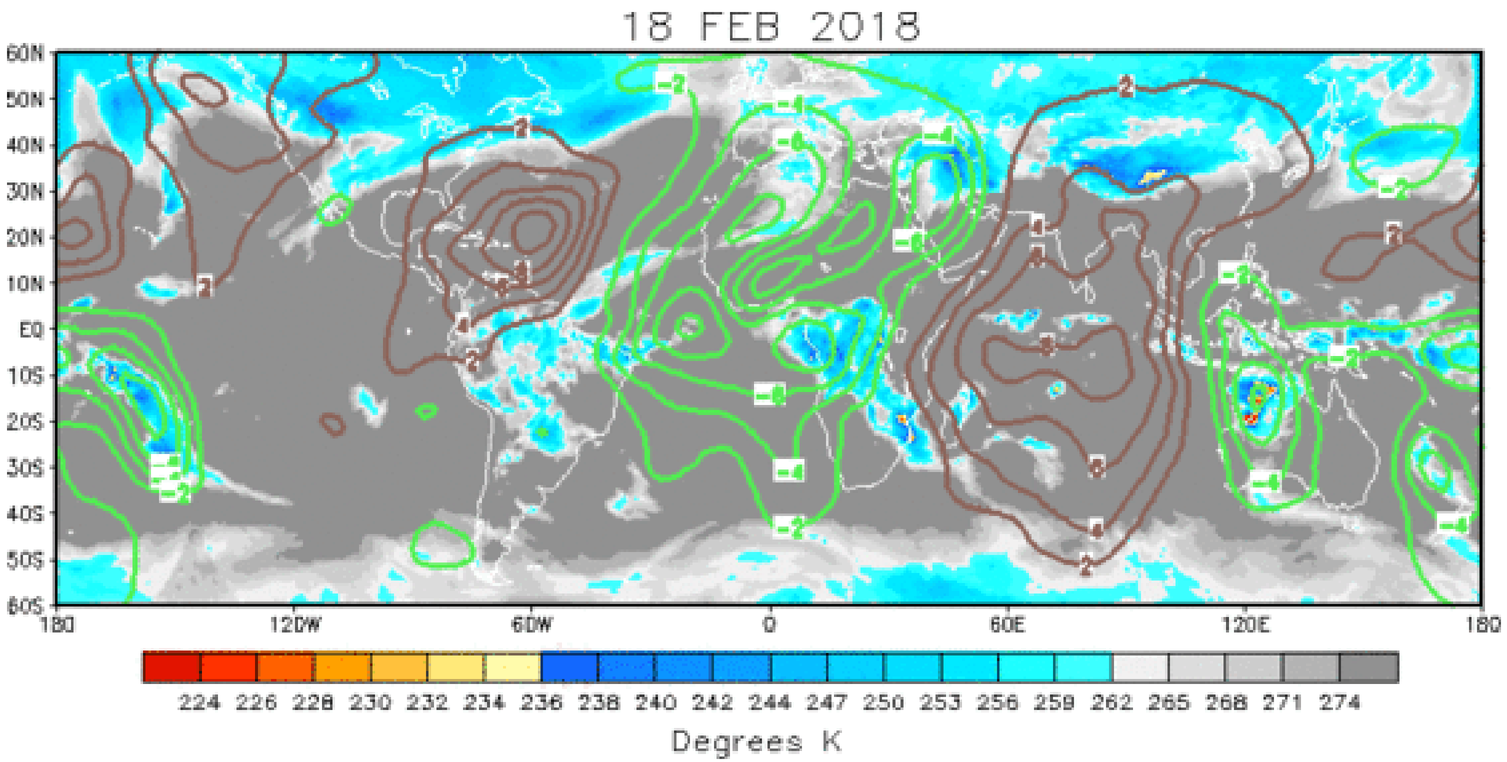
An MJO event developed near the Maritime Continent during early October, with a large upper-level footprint near 120E and robust eastward propagation. The signal circumnavigated the global tropics, reaching the Maritime Continent region about 30 days later, weakening at that time.

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.

This MJO event further intensified during January and early February. The signal currently is crossing the Pacific and has weakened significantly over the past week.



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



The previous Wave-1 pattern seen in January and early February, associated with MJO activity, has broken down over the past two weeks. Anomalous upper-level divergence associated with the enhanced convection remains over the equatorial Date Line and parts of the Maritime Continent, as well as the Atlantic, likely due 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)

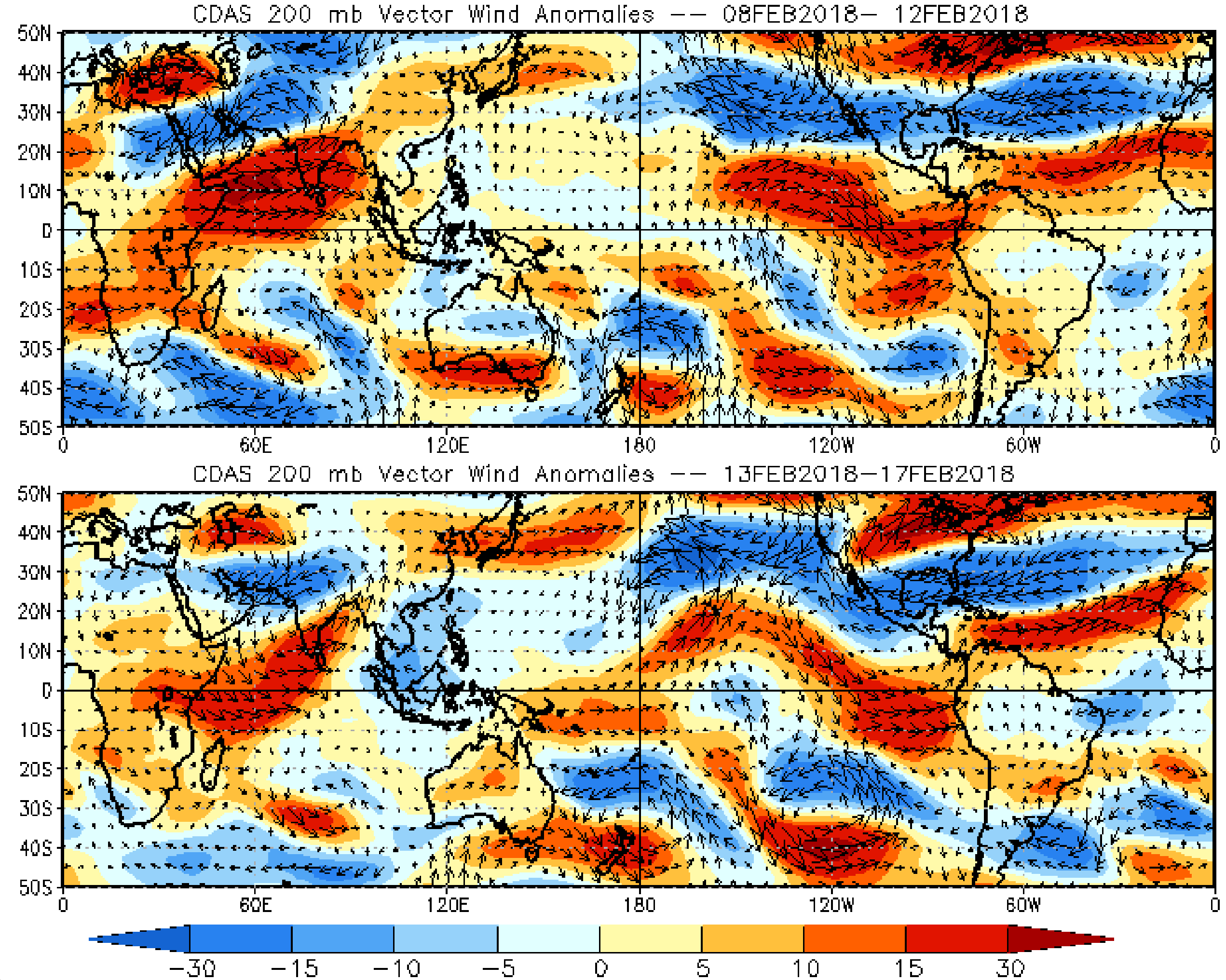
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Upper level anomalous westerlies over the Eastern Pacific are consistent with the active MJO and appear to interact with the circulation over the Atlantic.

Westerly anomalies in the Indian Ocean have weakened over the past week. Easterly anomalies are strengthening over the Western Pacific and Maritime Continent. Strong westerly anomalies in the Central Pacific have weakened over the past week, likely due to the MJO enhanced convective signal moving over the area.



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

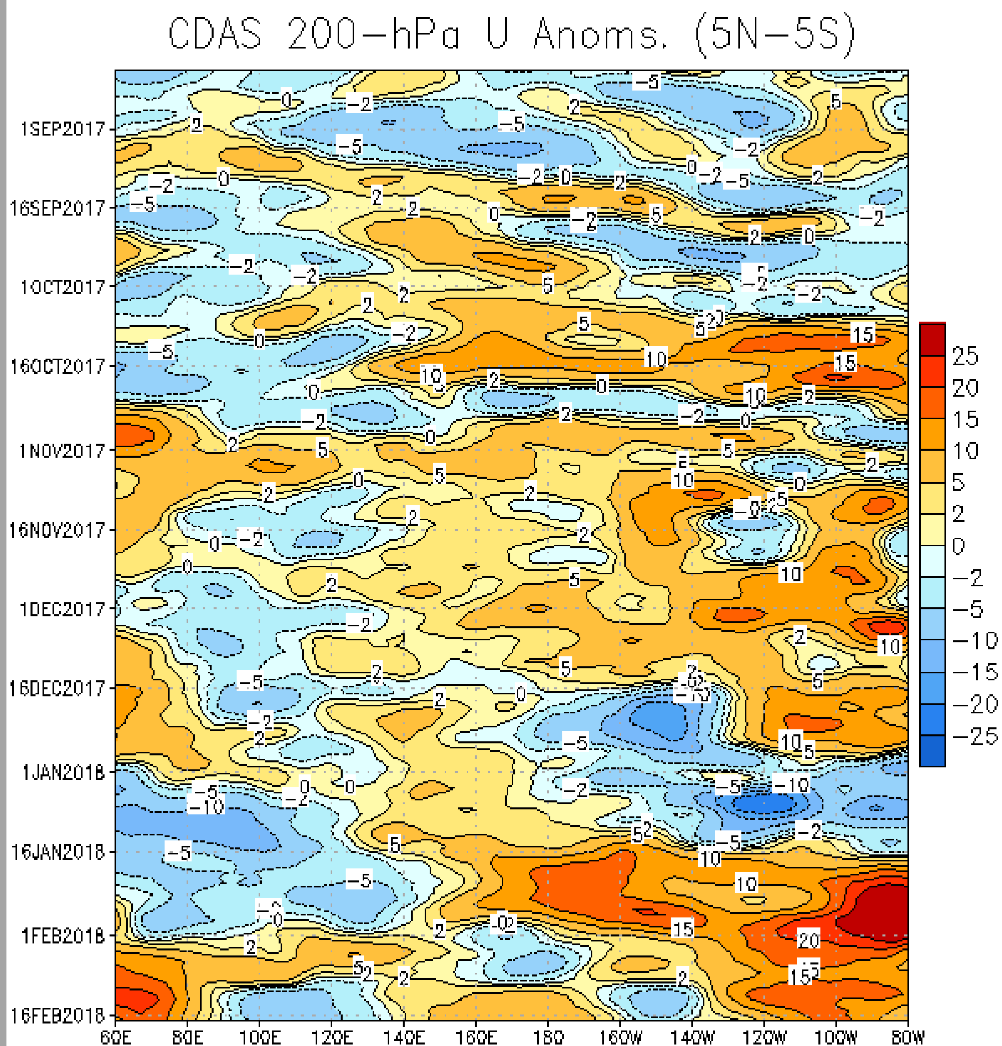
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

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

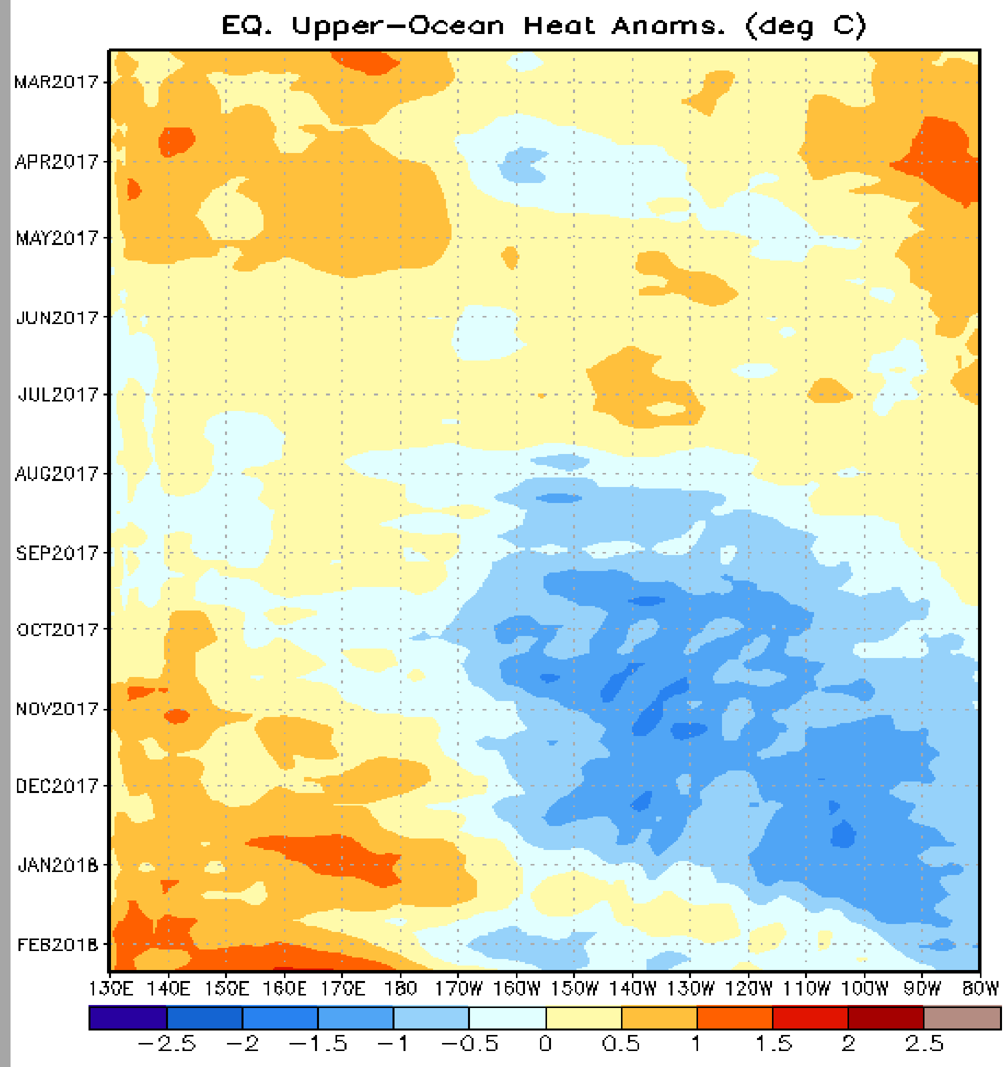
Low-frequency westerly anomalies remained in place east of 140E starting in October, with the exception of a brief period of easterlies in late October. There is also some recent evidence of easterlies over the far Eastern Hemisphere over the last week or so that appear to have extratropical sourcing.

In mid-December, easterly anomalies developed east of the Date Line, replacing the westerly anomalies that had been generally present since October. These anomalies propagated eastward over the past few weeks, replacing westerlies near the Date Line and central Pacific. Strong westerly anomalies continue in the eastern 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 have persisted in the central and eastern Pacific since late summer.

A downwelling Kelvin wave associated with the intraseasonal signal has weakened the negative anomalies across the east-central Pacific during late January and early February.

More recently, the negative upper-ocean heat content anomalies have returned to the central 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

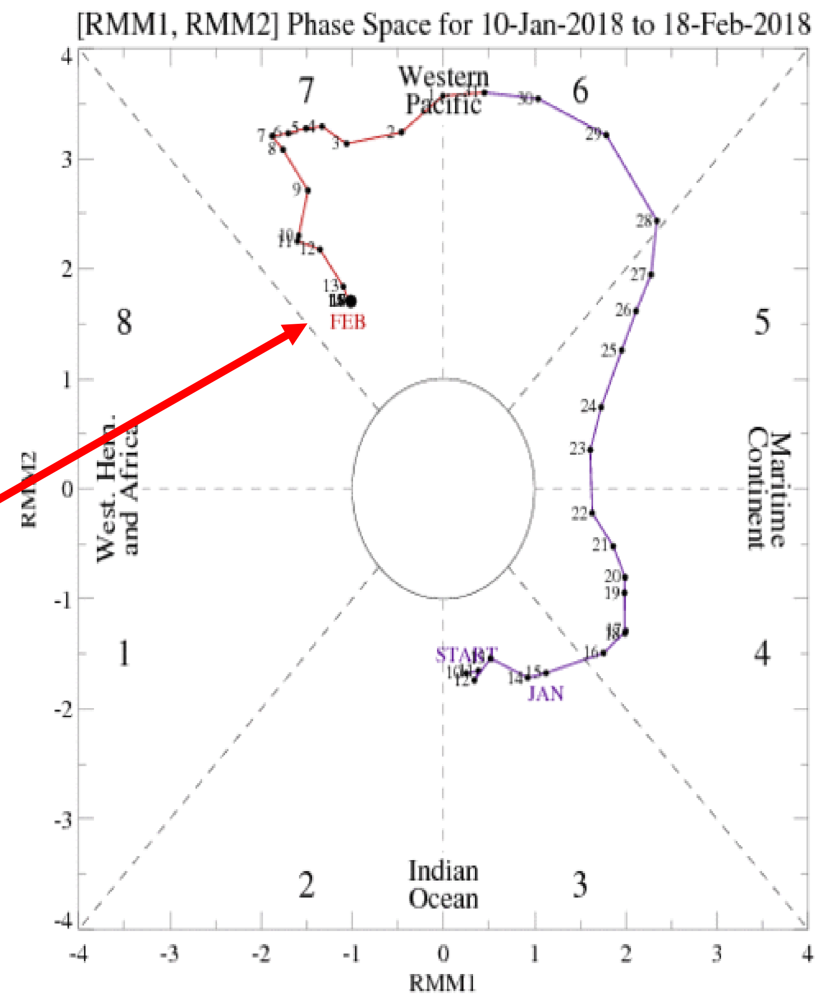
The triangular areas indicate the location of the enhanced phase of the MJO

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

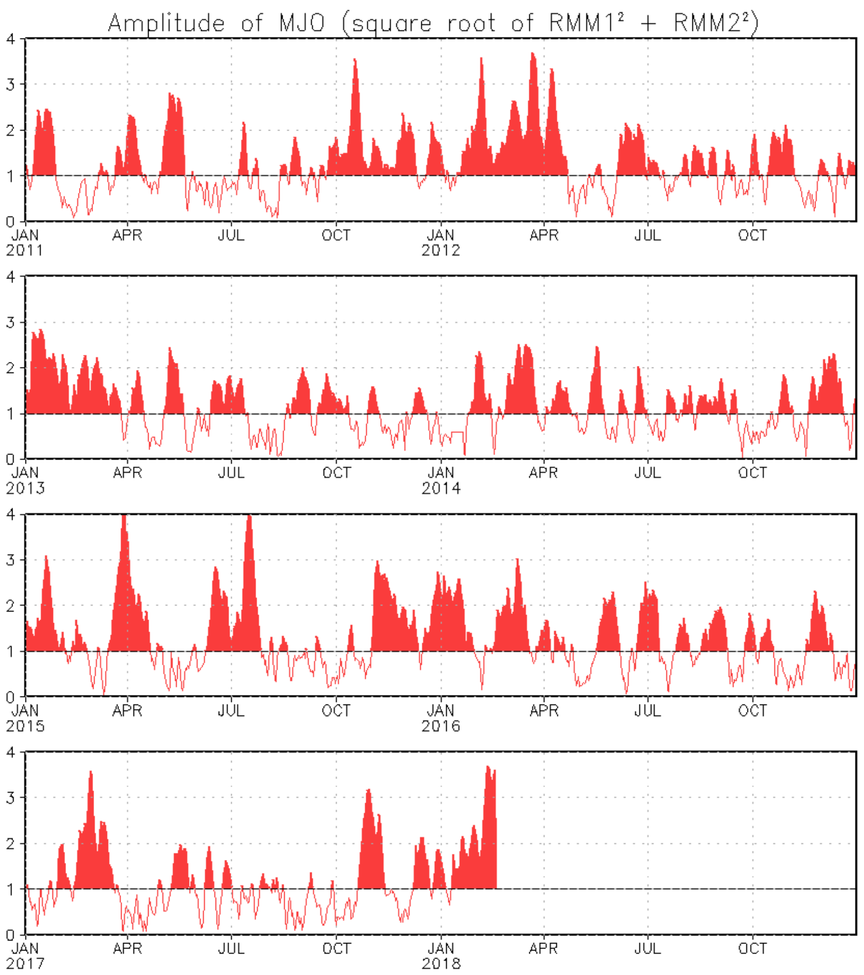
The RMM-based MJO index depicts a rapid weakening of the signal over the past week. Eastward propagation has stalled, and the signal has remained in Phase 7 through the past week.



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.



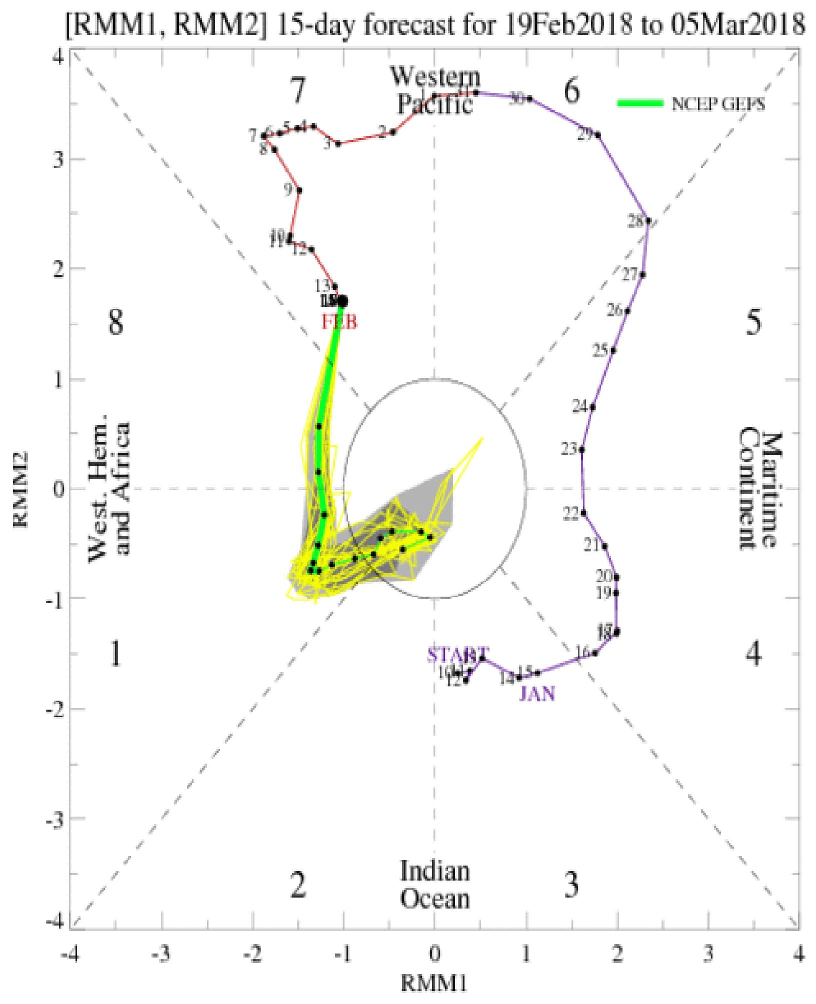
GFS Ensemble (GEFS) MJO Forecast

<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



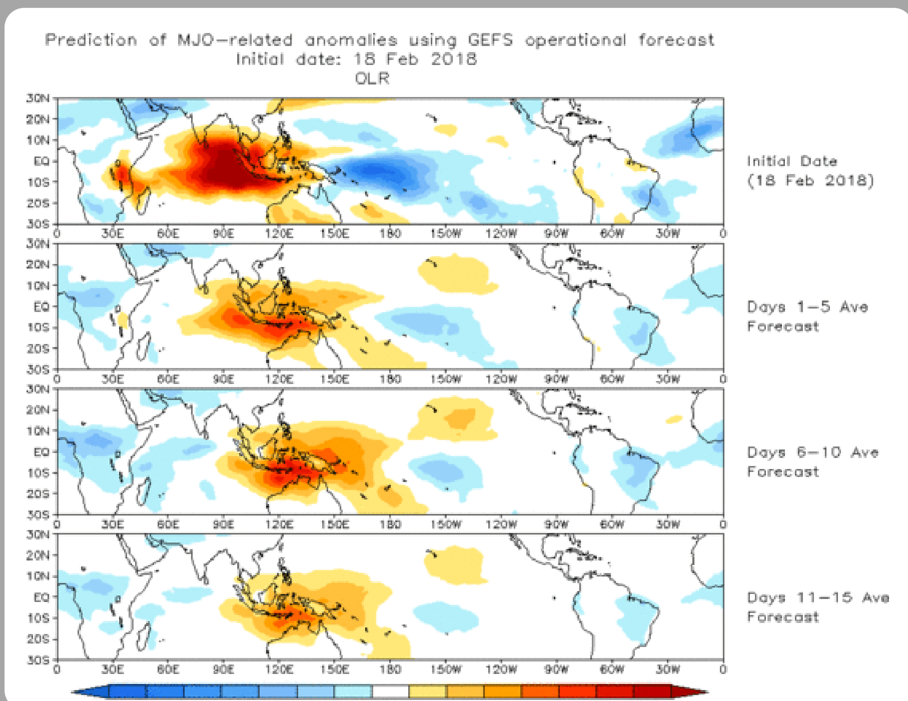
The GEFS forecasts a continued weak MJO signal, with propagation through Phase 8 and into Phase 1 before further weakening. Rossby wave activity is likely contributing to the weakening over the next two weeks.

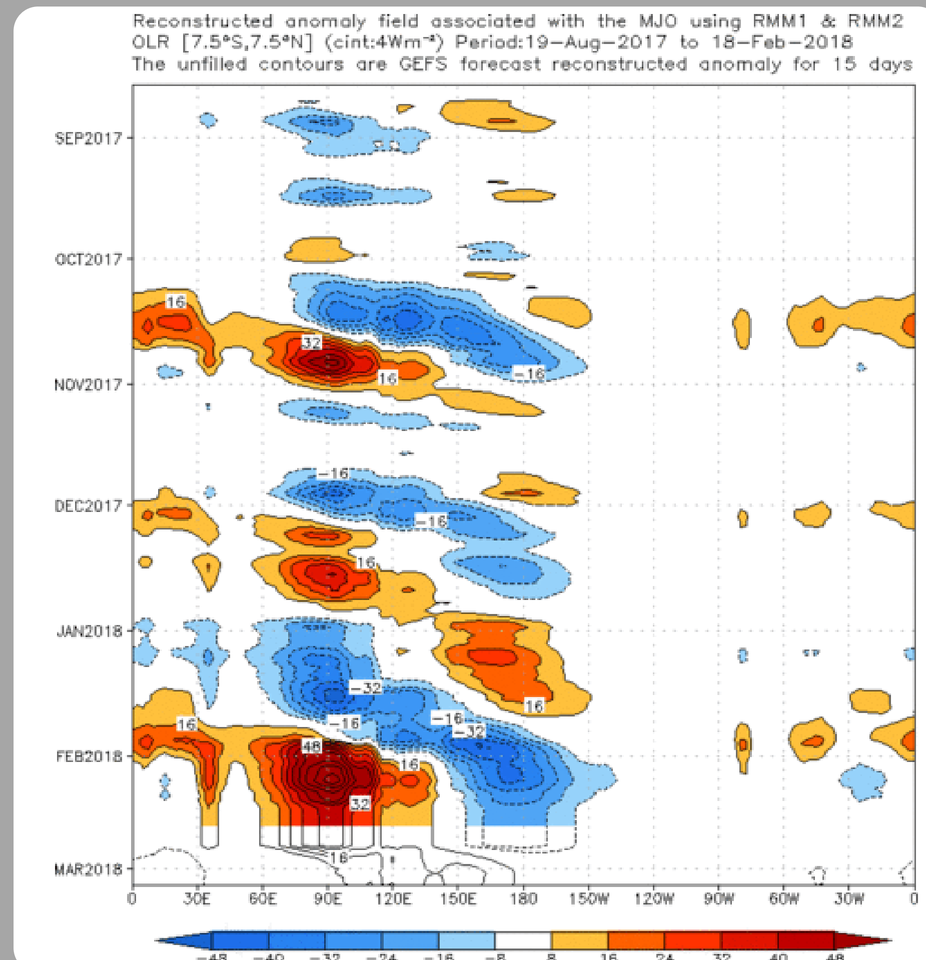
Ensemble GFS (GEFS) MJO Forecast

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



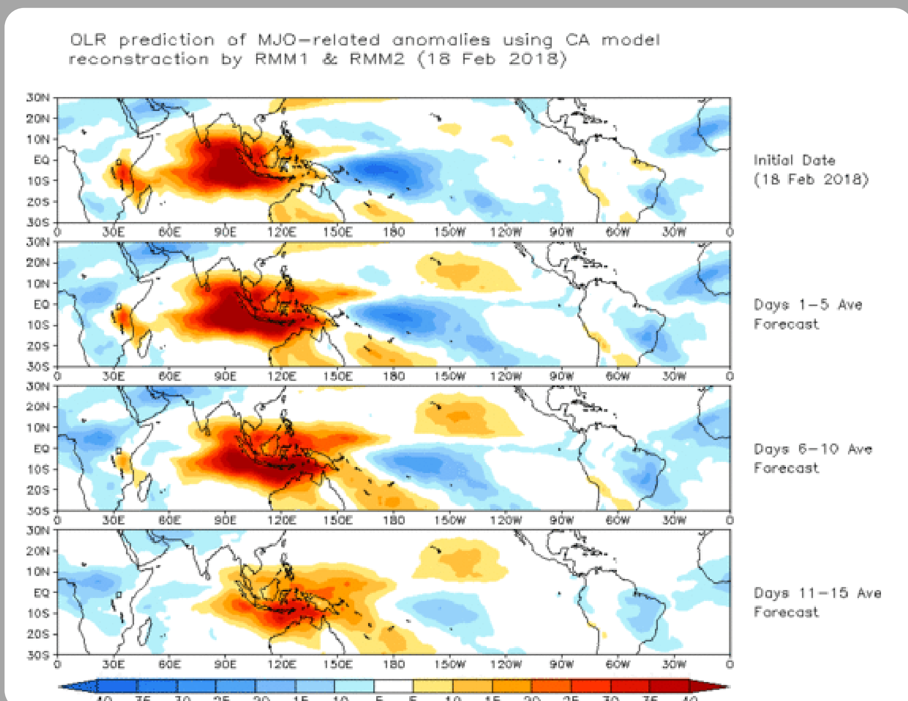


OLR anomalies associated with the MJO based on the GEFS show slow eastward propagation, as well as rapid weakening in the suppressed convection and enhanced convection signals.

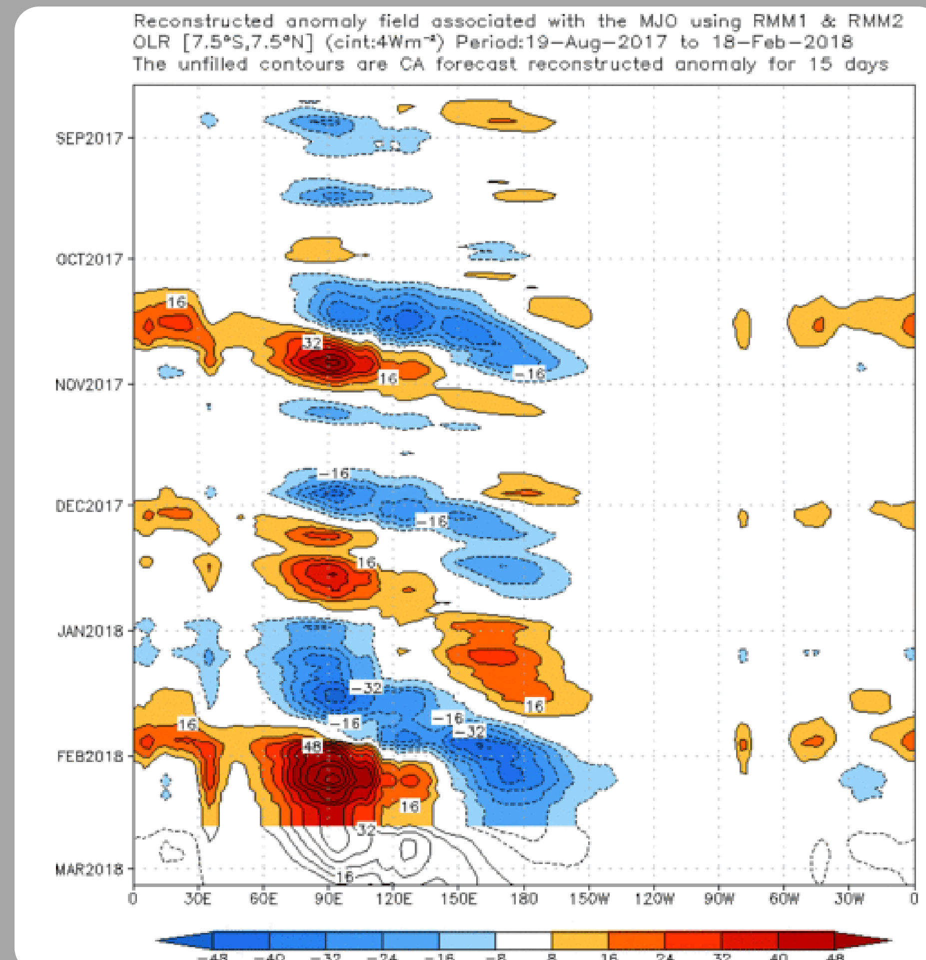
Constructed Analog (CA) MJO Forecast

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



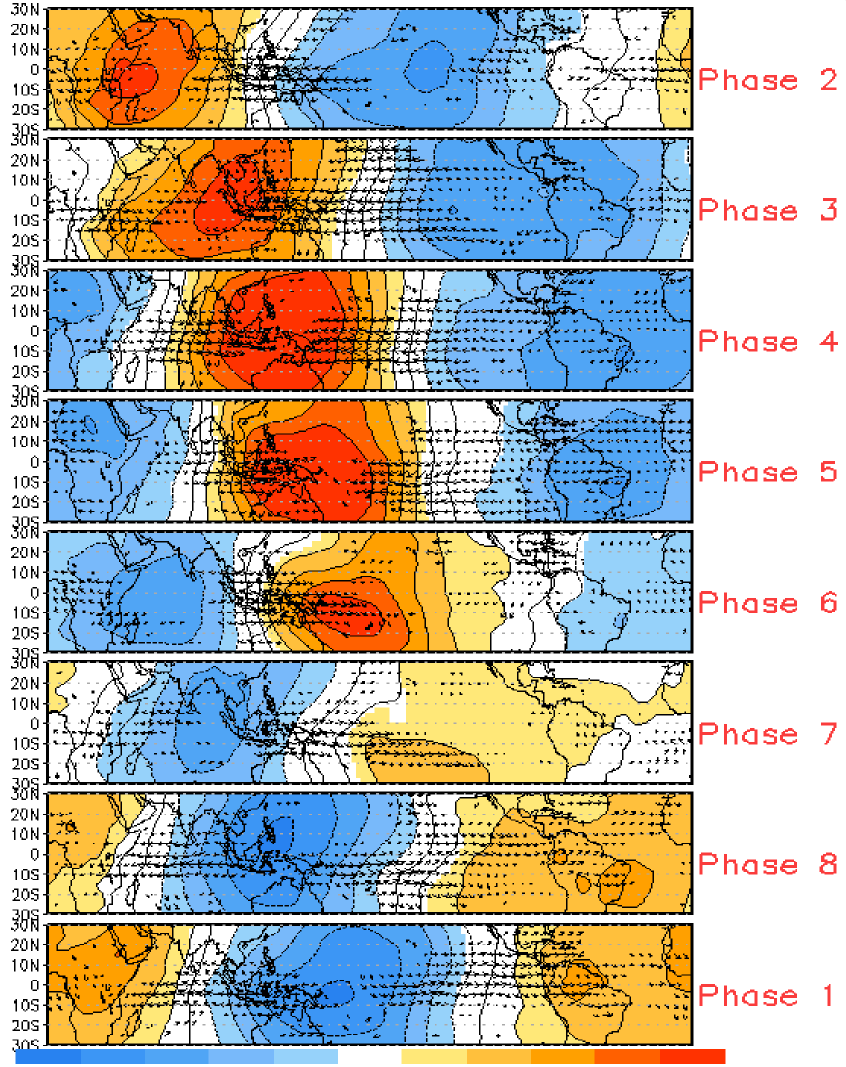
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



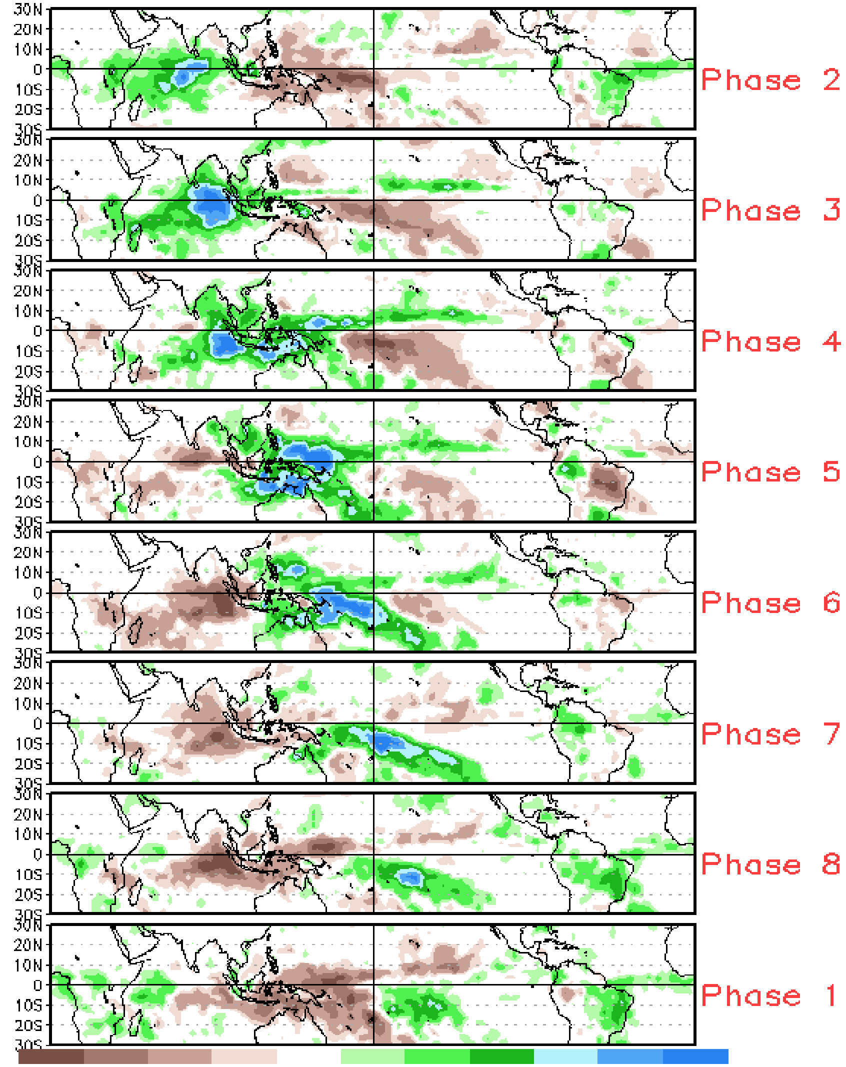
The constructed analog supports the slow propagation seen in the GEFS forecast; however, the weakening of the anomalies is not as pronounced in this solution.

MJO Composites - Global Tropics

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



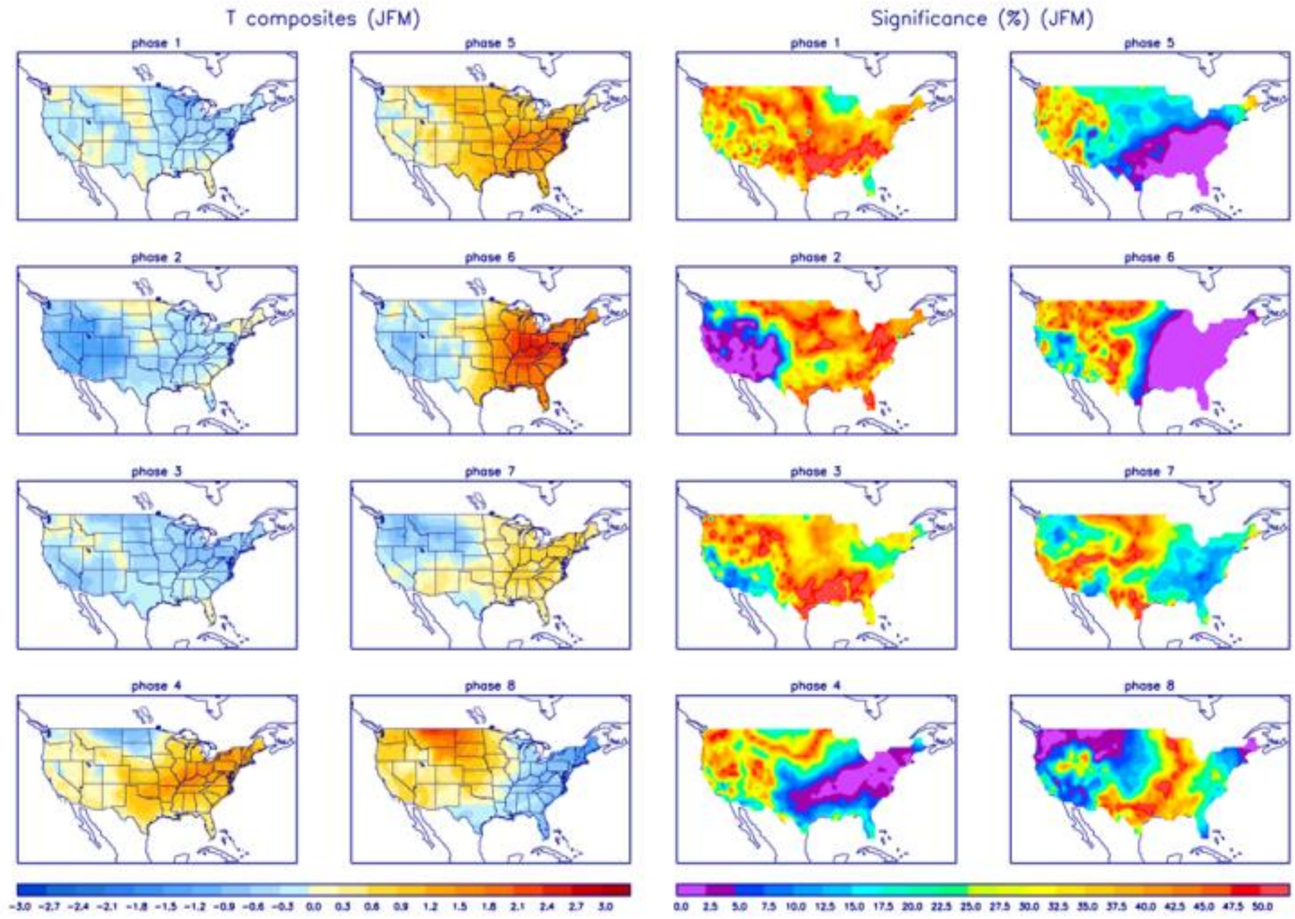
Precipitation Anomalies (Nov - Mar)



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.



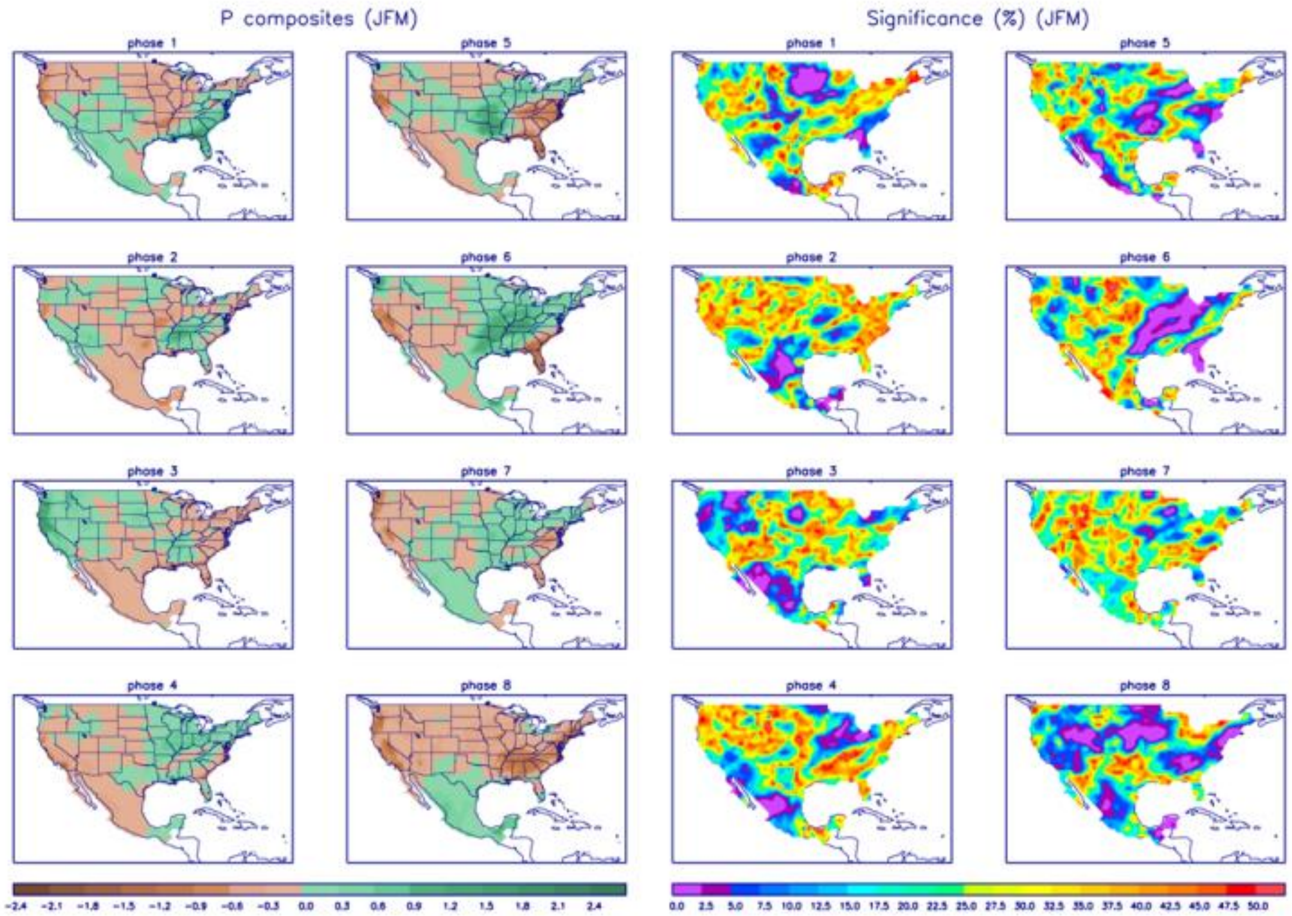
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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.



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