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

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Outline

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Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

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Overview

- Eastward propagation of the MJO across the Pacific Ocean slowed at the beginning of February due to a strong Rossby wave.

- Dynamical model forecasts are in reasonably good agreement that eastward propagation resumes with the enhanced phase of the MJO overspreading the Western Hemisphere during the next two weeks.

- The MJO is expected to increase the chance for tropical cyclone development over the South Pacific through mid-February.

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

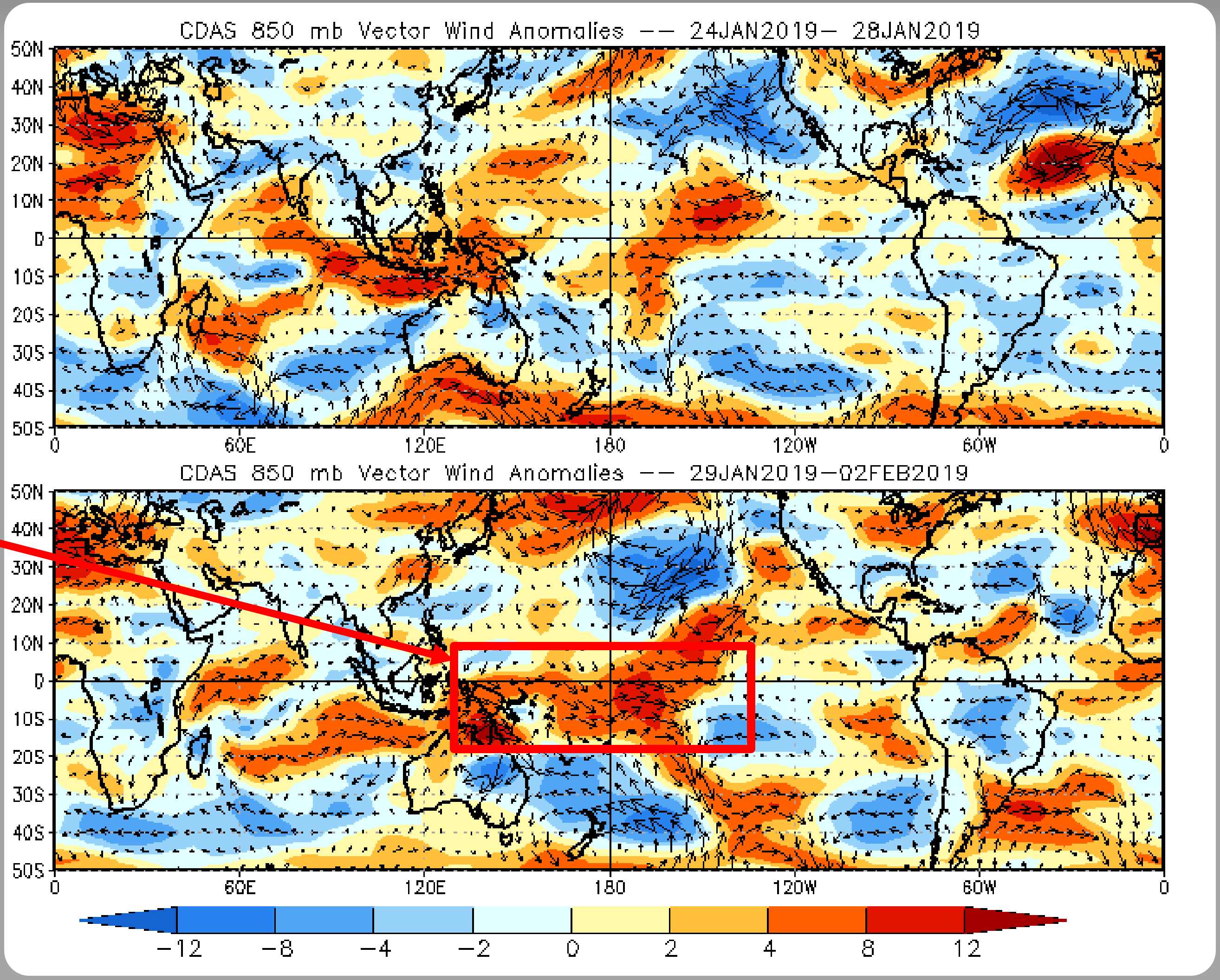
850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

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

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

Constructive interference between the MJO and an equatorial Rossby wave resulted in large westerly anomalies near the Date Line.



850-hPa Zonal Wind Anomalies (m s^{-1})

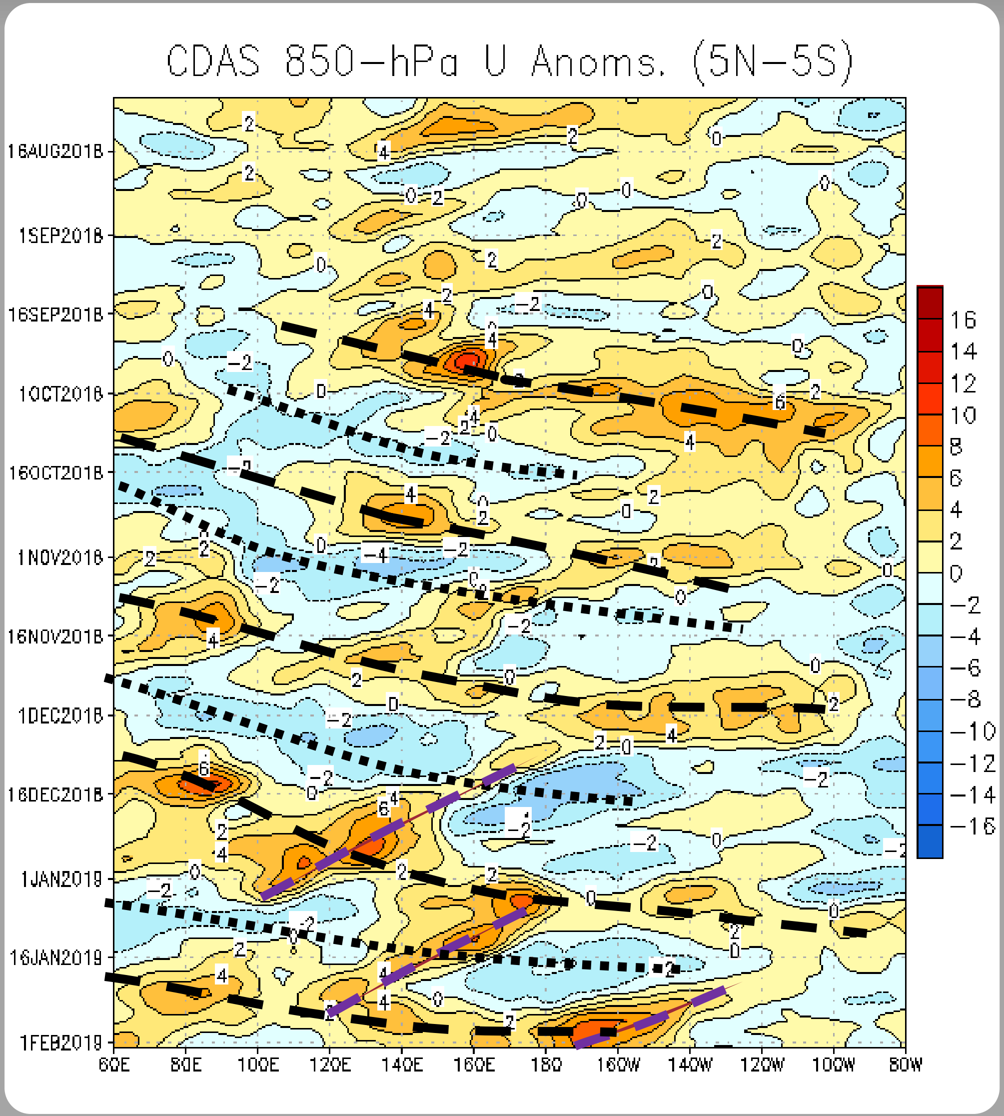
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

From August through mid-September, a variety of tropical waves including Rossby waves and tropical cyclones, influenced the pattern. Another rapidly propagating intraseasonal feature during late September generated robust westerly wind anomalies across the Pacific.

Since late September, anomalous westerlies increased in amplitude and duration over the equatorial Pacific, consistent with a gradual transition towards El Niño conditions.

There have been additional MJO events since September. Multiple equatorial Rossby waves (see purple lines) have crossed the Pacific Ocean since December.



OLR Anomalies – Past 30 days

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

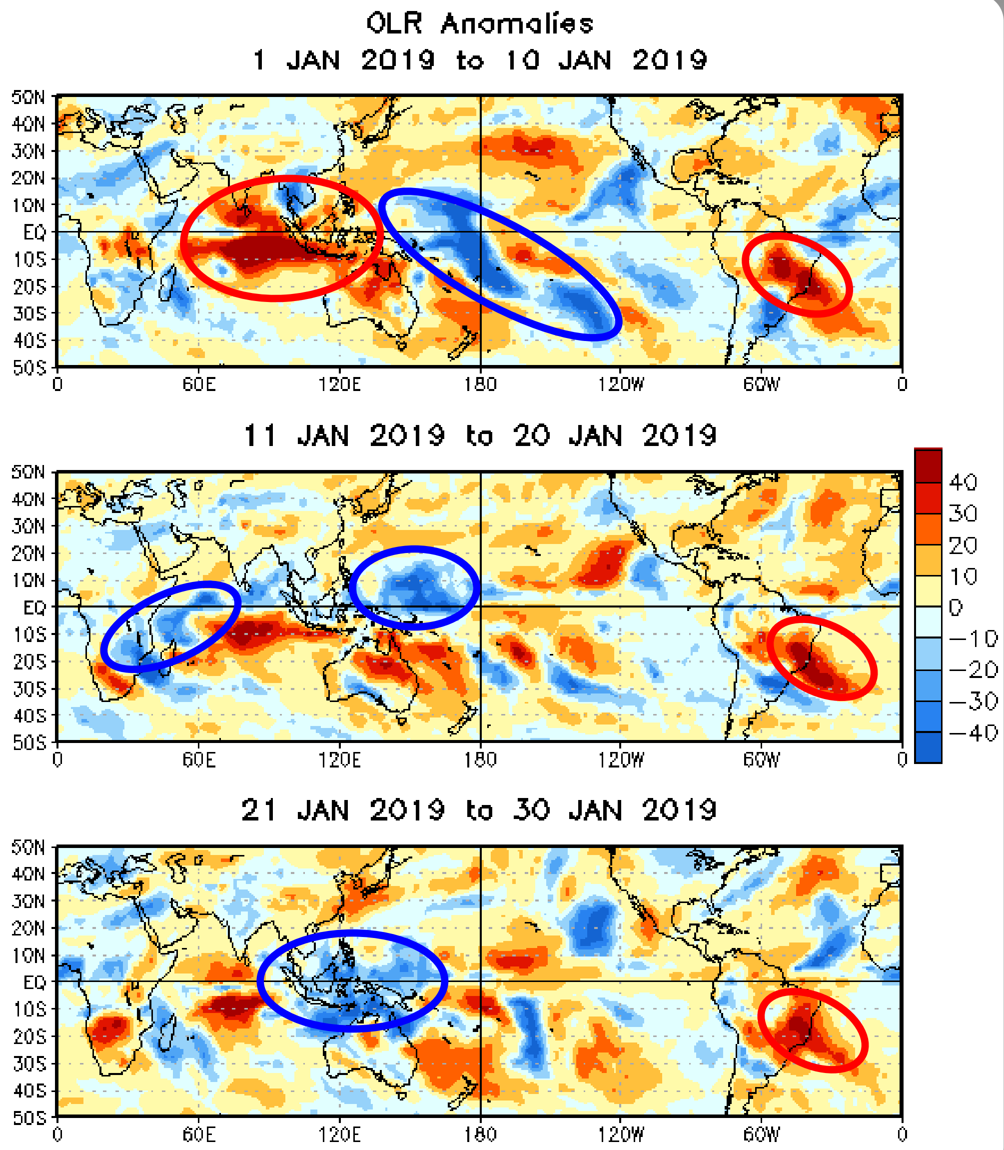
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

By early January, some of the convective activity associated with the MJO extended along the SPCZ into the southern mid-latitudes. In addition, suppressed convection over the Indian Ocean strengthened.

During mid-January, enhanced convection across the Indian Ocean (West Pacific) was tied to the active phase of the MJO (Rossby wave activity).

Enhanced convection shifted east from the Indian Ocean to the Maritime Continent during late January, consistent with the MJO.

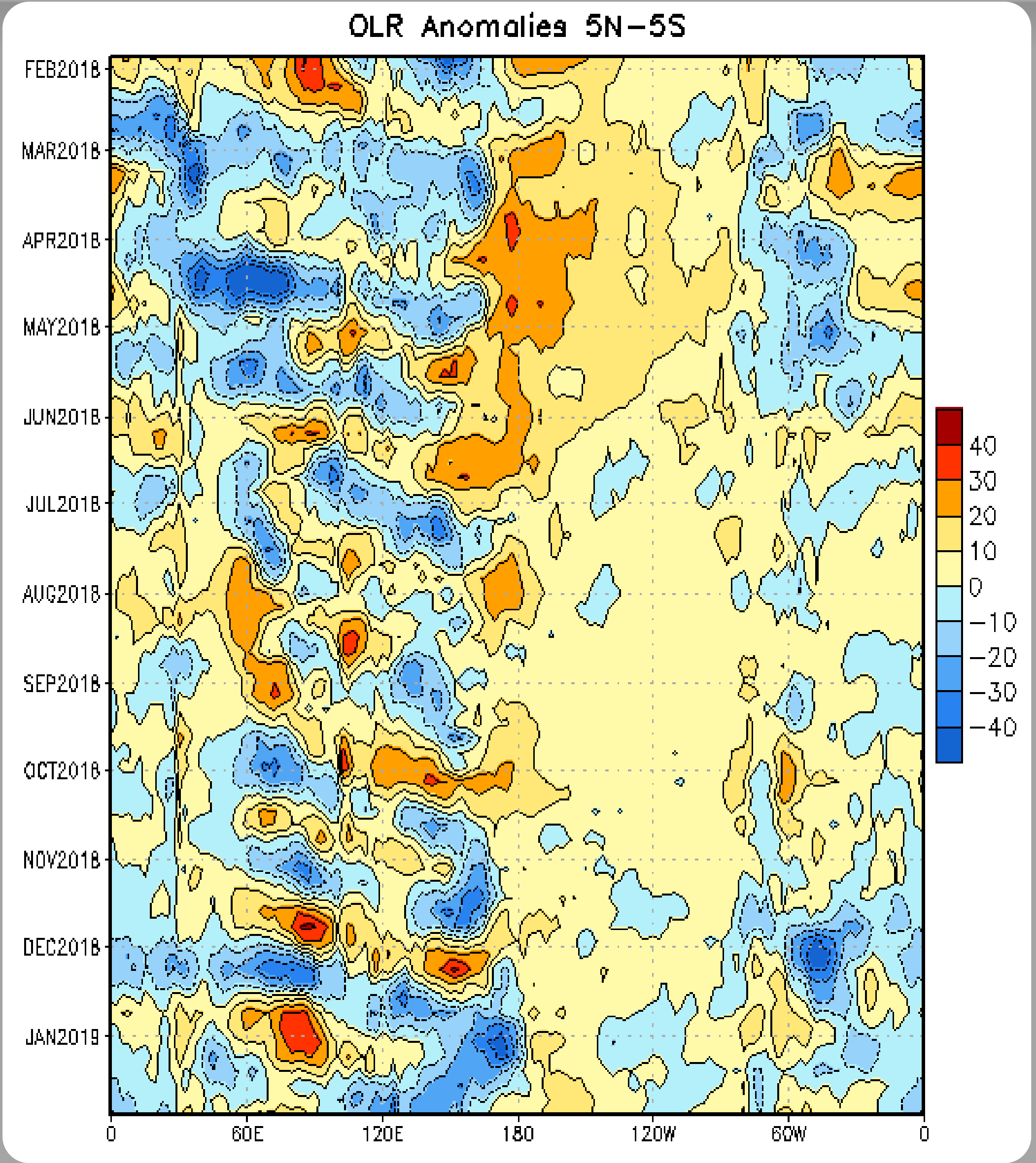
Suppressed convection persisted across partts of Brazil and the adjacent South Atlantic throughout January.



Outgoing Longwave Radiation (OLR) Anomalies (5ºN - 5ºS)

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

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



Since September, the MJO signal has seen alternative active and inactive phases crossing the Indian Ocean through the Central Pacific and influencing the convection for these regions.

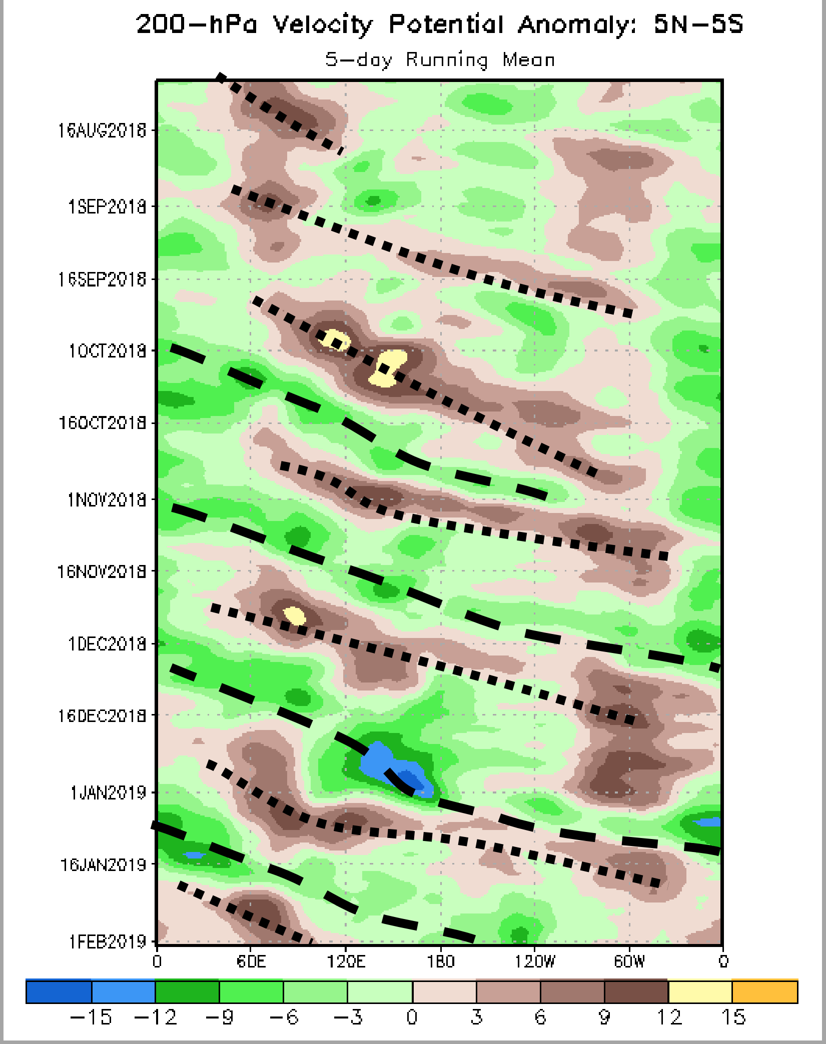
During December and January, convective anomalies increased due to a continued robust MJO along with contribution from a number of Rossby waves.

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

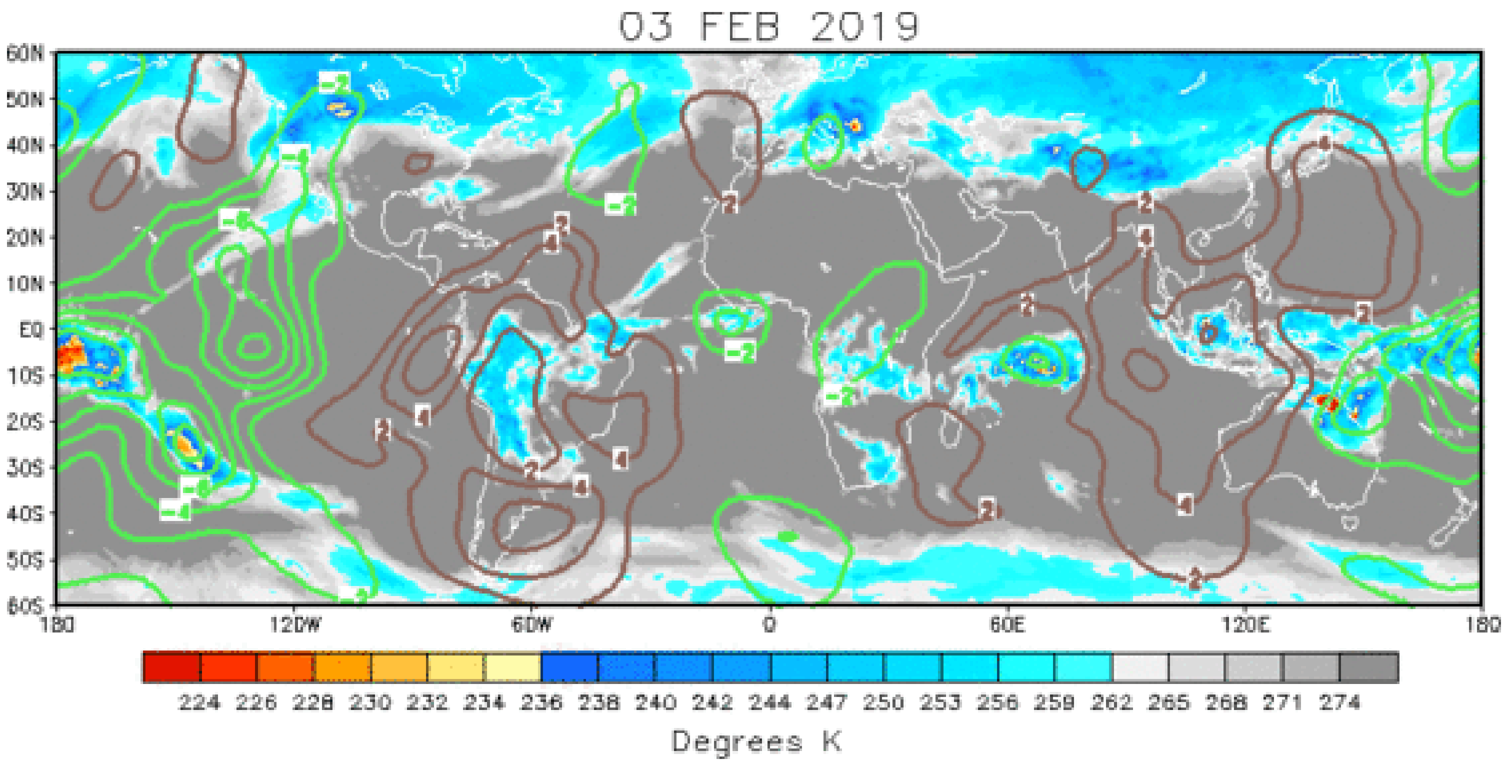
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

The intraseasonal MJO activity that began in early September can also be seen in the upper-level velocity potential field. Equatorial Rossby wave activity, increased since early December, is also noticeable in this field and likely contributed to the brief area of especially enhanced convection just west of the Date Line in late December.



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



Anomalous convection became less organized at the beginning of February with the most amplified enhanced convection across the Central Pacific.

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})

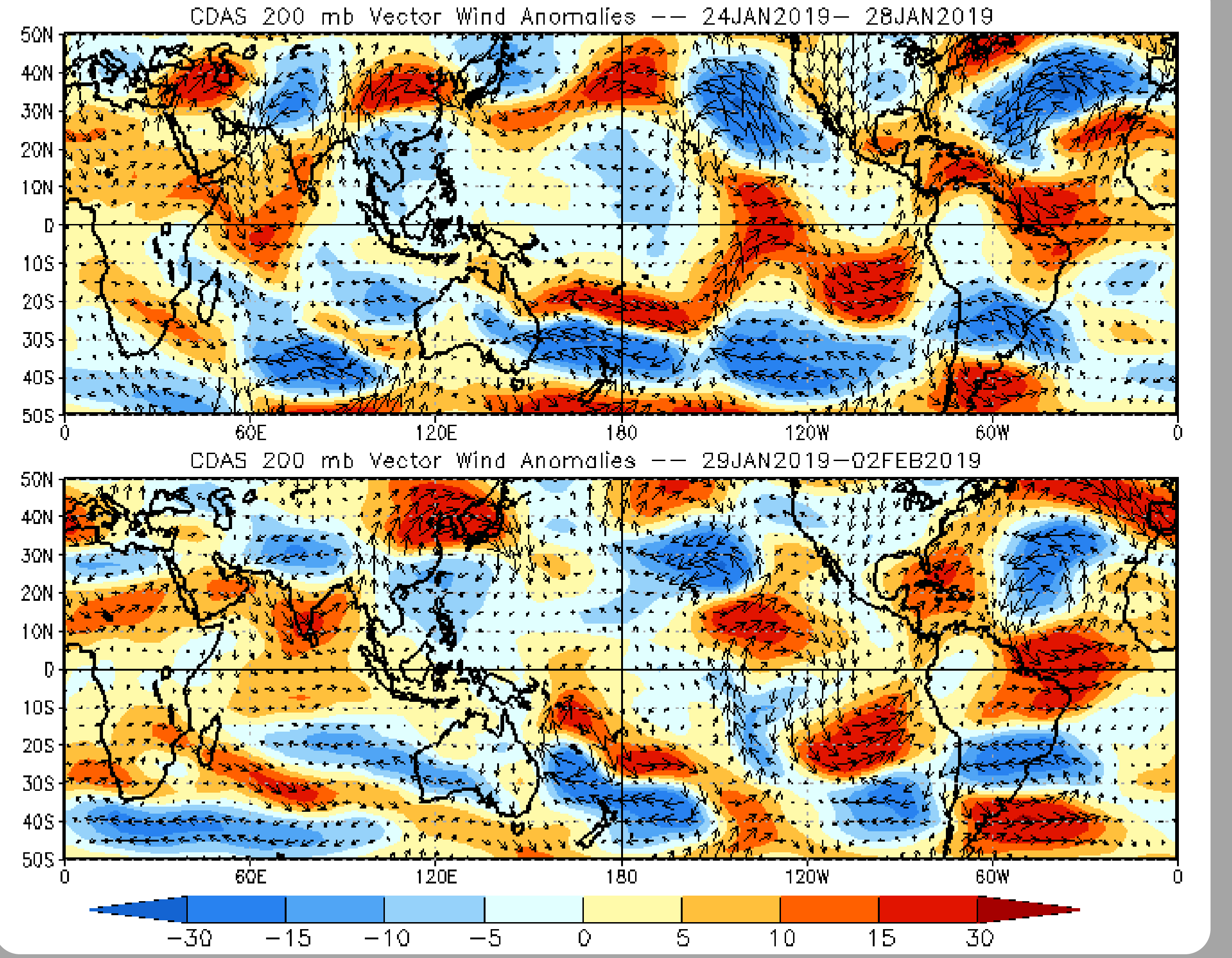
Note that shading denotes the zonal wind anomaly

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

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

Atmospheric mid-latitude wavebreaking can be seen in both maps near the West Coast of North America during the past two pentads.

There is considerable mid-latitude/tropical interaction over the eastern Pacific during the latest pentad as wave activity in both hemispheres combine to form a region of strong anomalous westerlies over the tropical East Pacific.



200-hPa Zonal Wind Anomalies (m s^{-1})

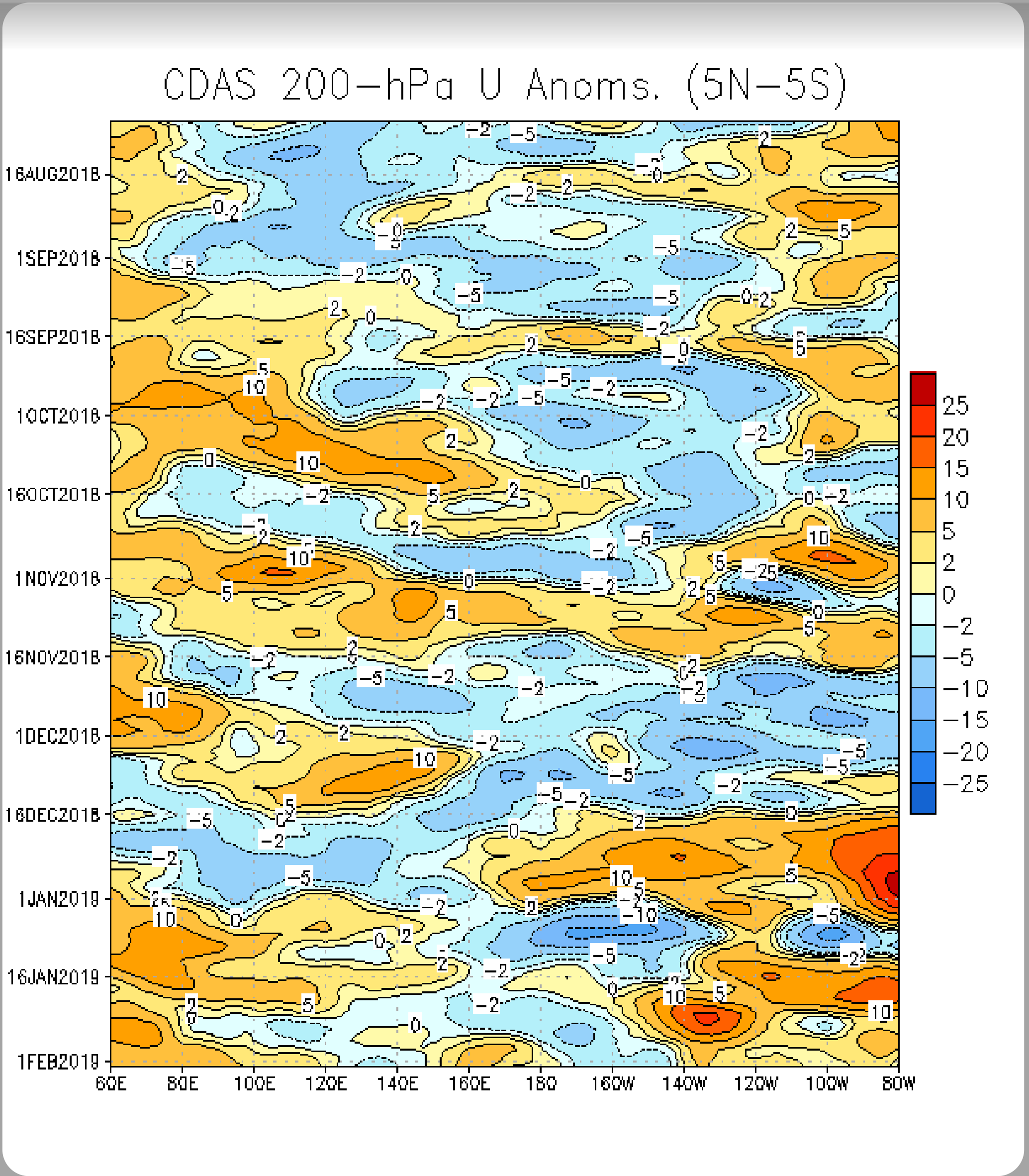
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

During August into September, the intraseasonal pattern weakened, with Rossby wave activity influencing the West Pacific.

Since mid-September through mid-December, upper-level winds have been marked by pronounced intraseasonal activity, interrupted by Rossby waves. There was a trend towards anomalous easterlies over the eastern Pacific from mid-November through mid-December.

MJO and mid-latitude wave activity have acted to reduce the anomalous easterlies in the East Pacific since mid-December.



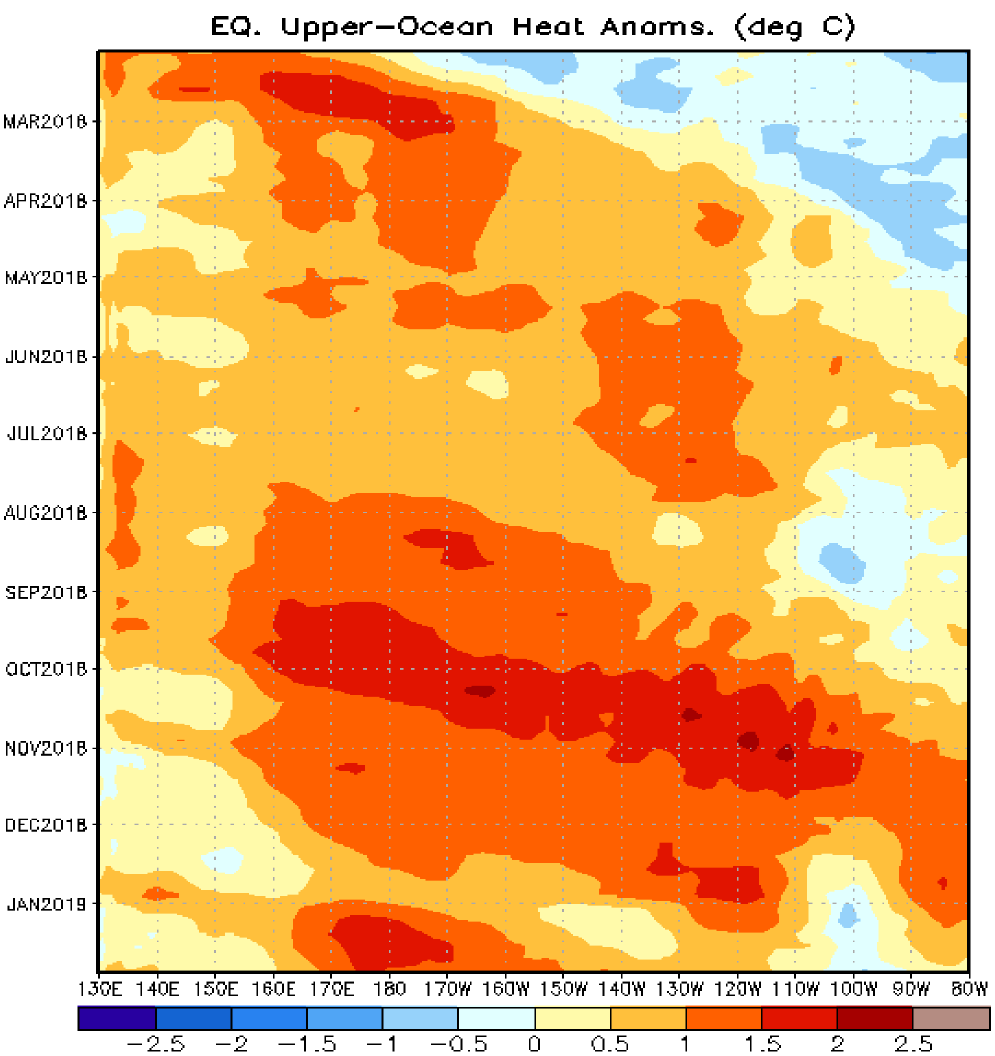
Weekly Heat Content Evolution in the Equatorial Pacific

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 decayed across the central and eastern Pacific during the first half of 2018 tied to multiple downwelling oceanic Kelvin waves. Positive anomalies have now been observed over most of the basin since April.

The westerly wind burst east of New Guinea in September triggered another oceanic Kelvin wave and round of downwelling, helping to reinforce the warm water availability for a potential El Niño event.

Heat content anomalies recently decreased in magnitude over much of the Pacific, with the warmest near-surface water focused just west of the Date Line. The strengthening meridional oceanic heat content gradient may be tied to the more robust appearance of low frequency convection in recent weeks over the West 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

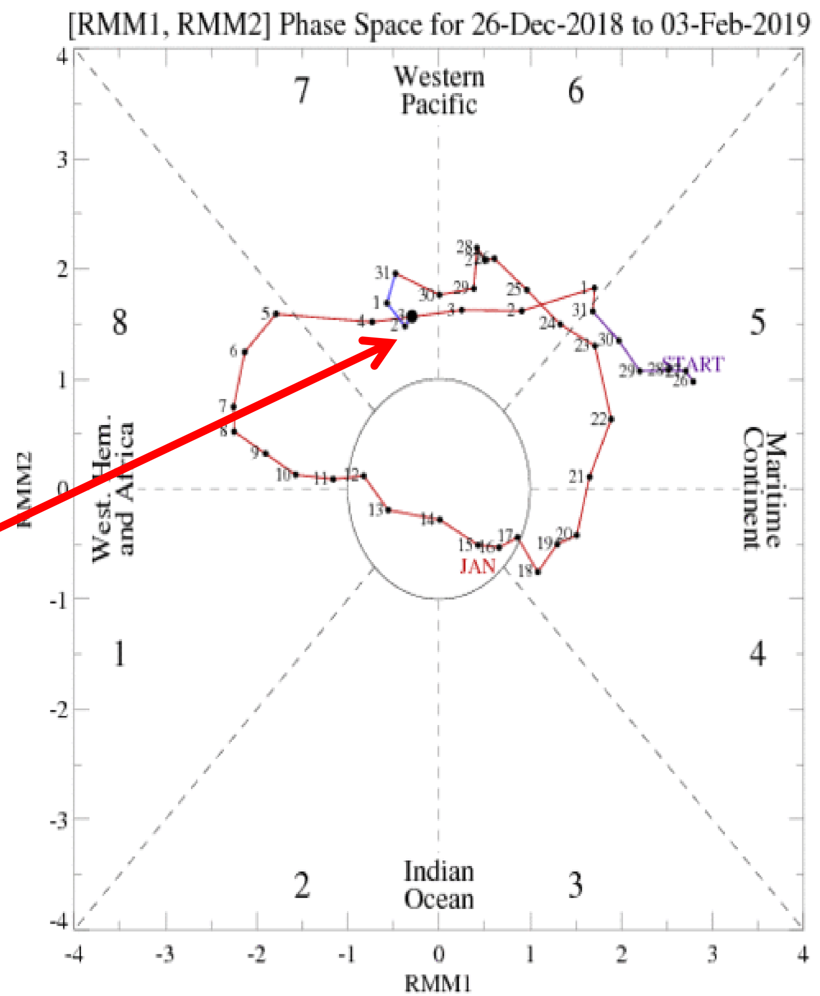
The triangular areas indicate the location of the enhanced phase of the MJO

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

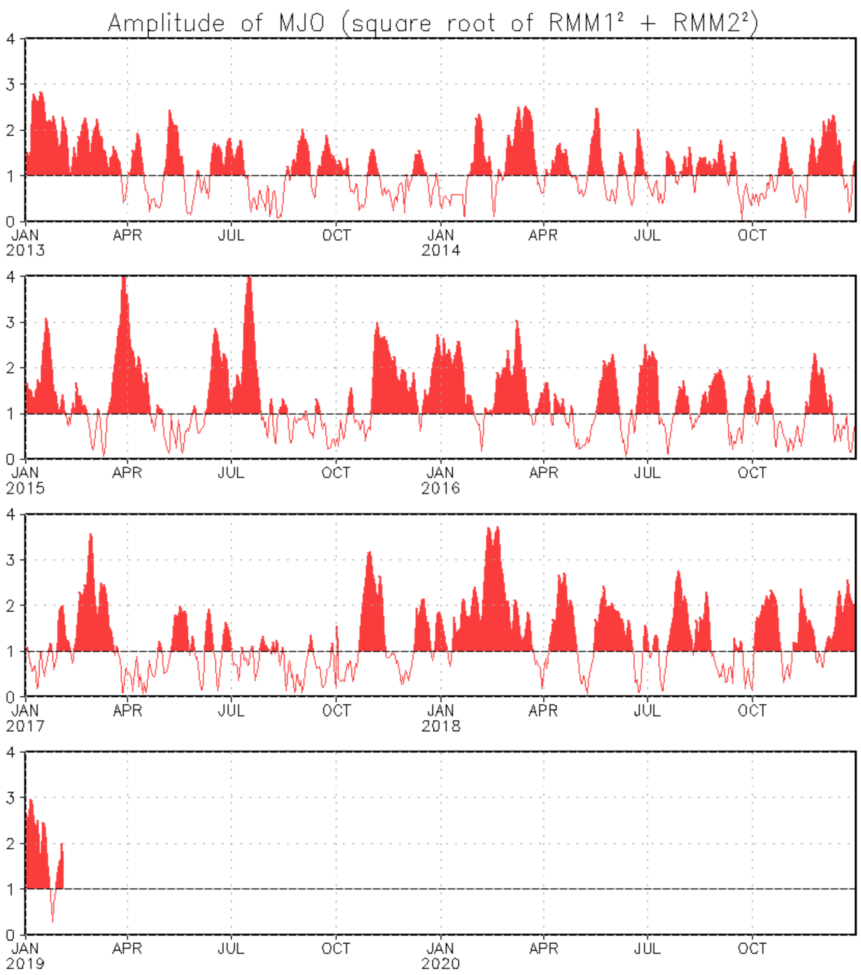
The eastward propagation of the MJO ended at the beginning of February as a strong equatorial Rossby wave is playing a role.



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

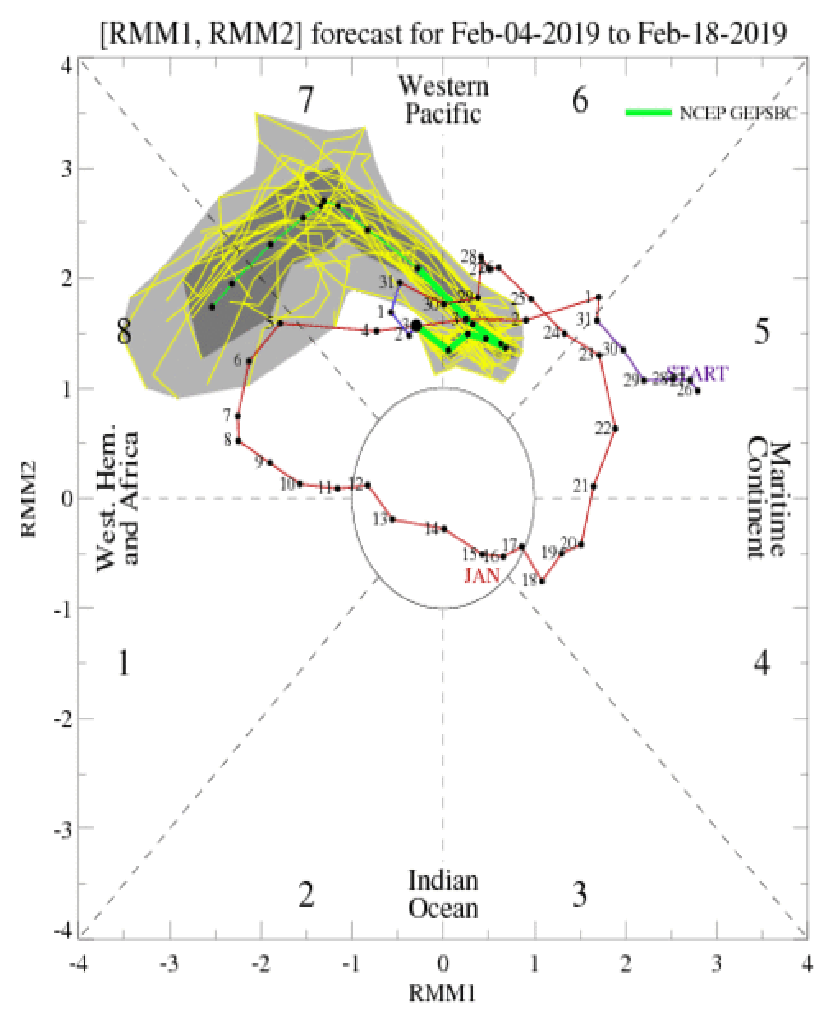
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

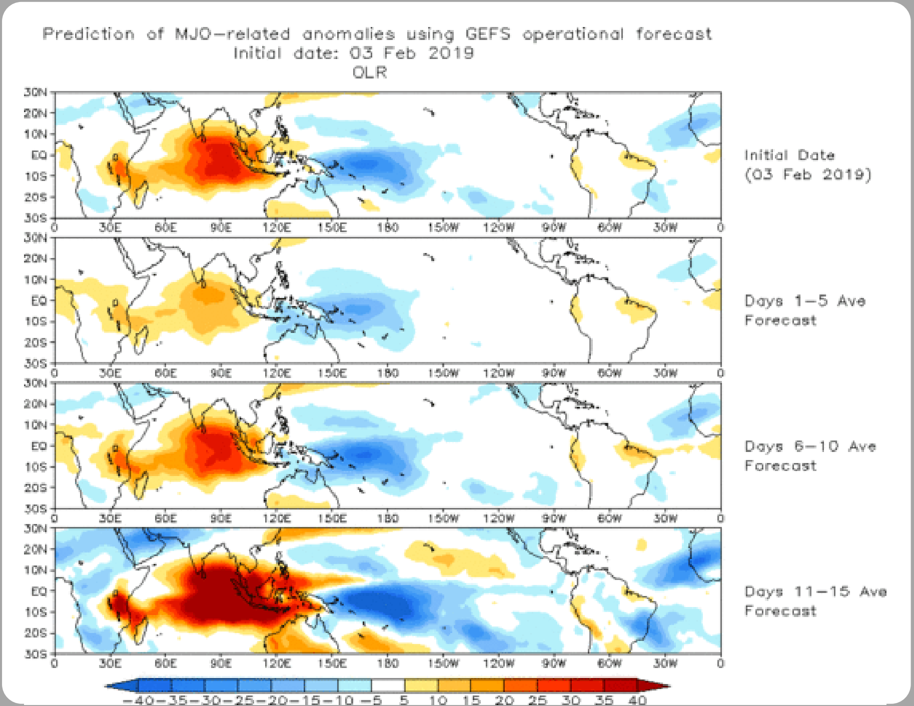
The GEFS forecasts the MJO to resume its eastward propagation later in Week-1 with the enhanced phase reaching Phase 8 by mid-February.



Ensemble GFS (GEFS) MJO Forecast

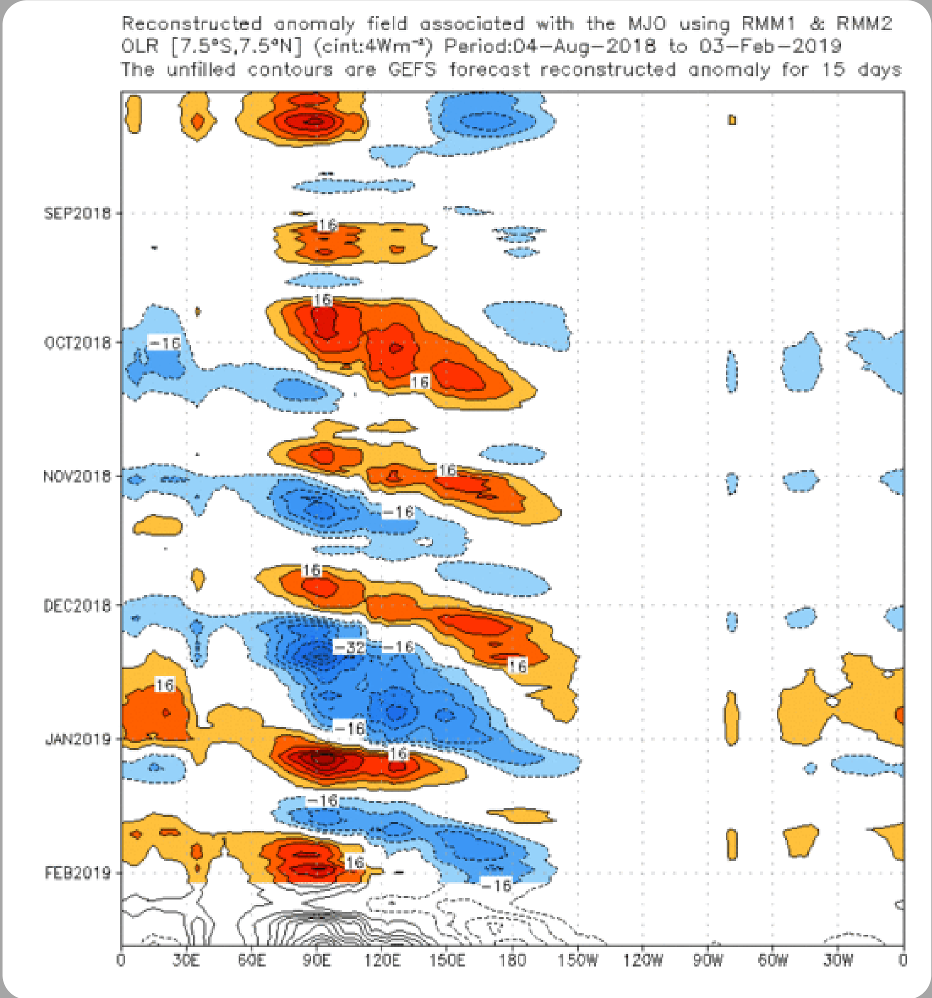
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS indicates enhanced convection overspreading the Western Hemisphere during the next two weeks, while suppressed convection shifts east to the Maritime Continent.

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

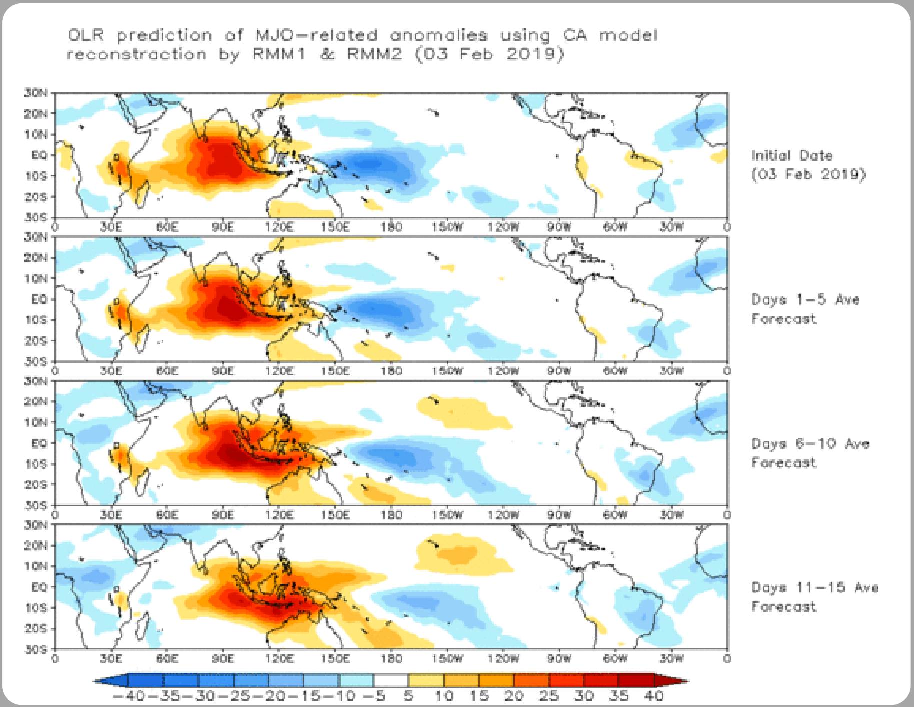


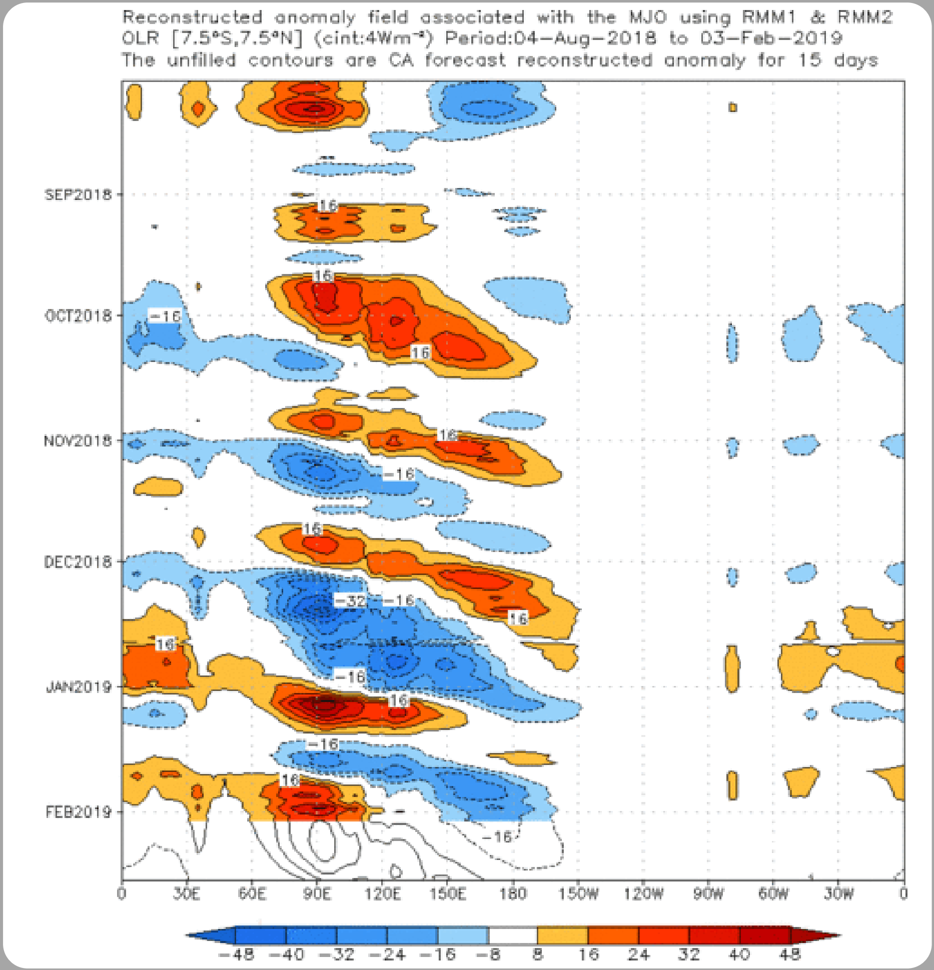
Constructed Analog (CA) MJO Forecast

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

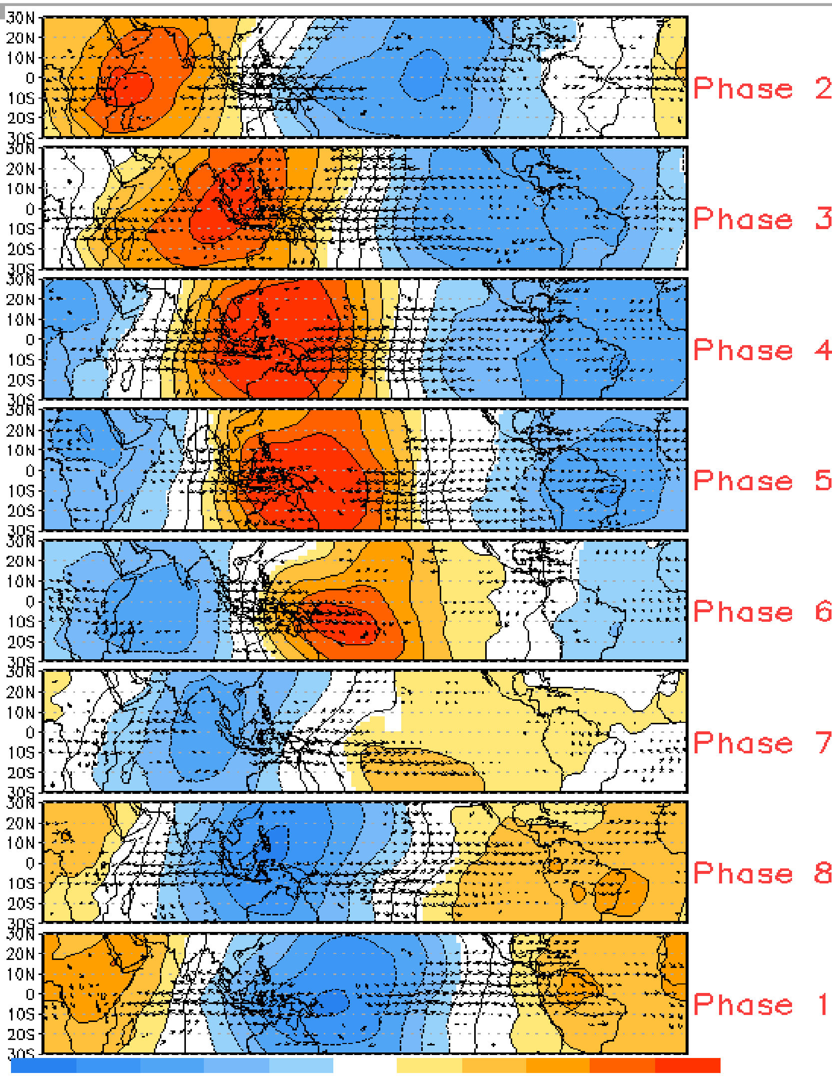




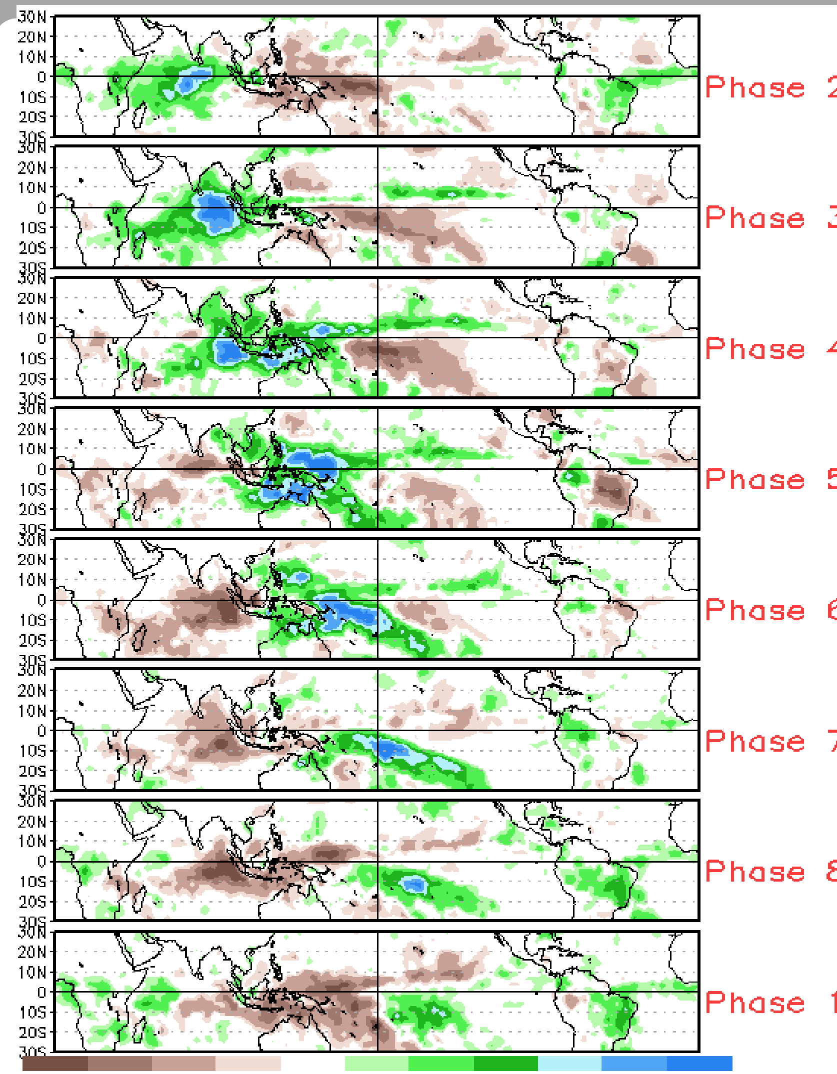
The constructed analog also depicts a similar pattern with enhanced (suppressed) convection shifting east across the Western Hemisphere (Maritime Continent).

MJO Composites - Global Tropics

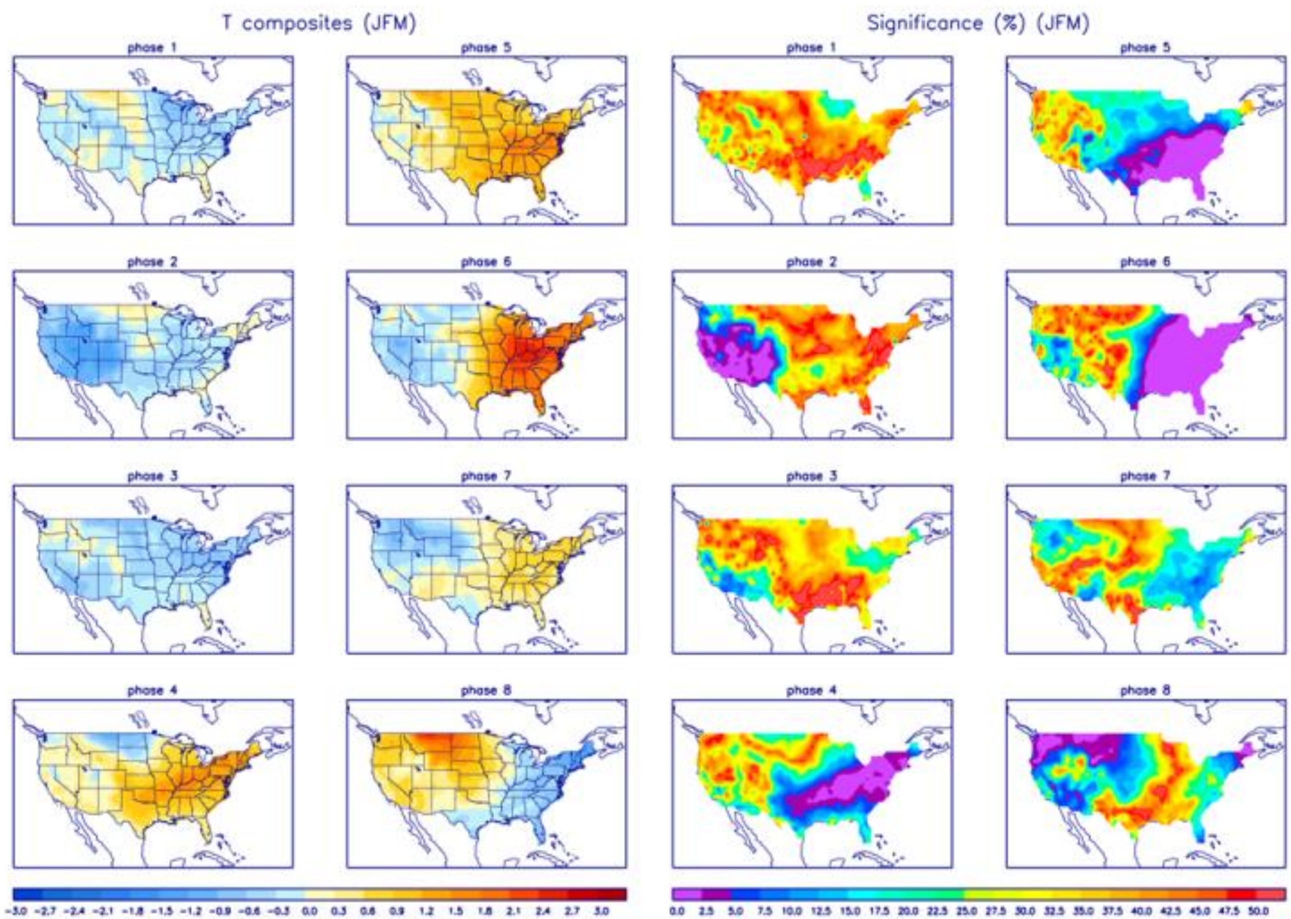
850-hPa Velocity Potential and Wind Anomalies (Nov - Mar)



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.

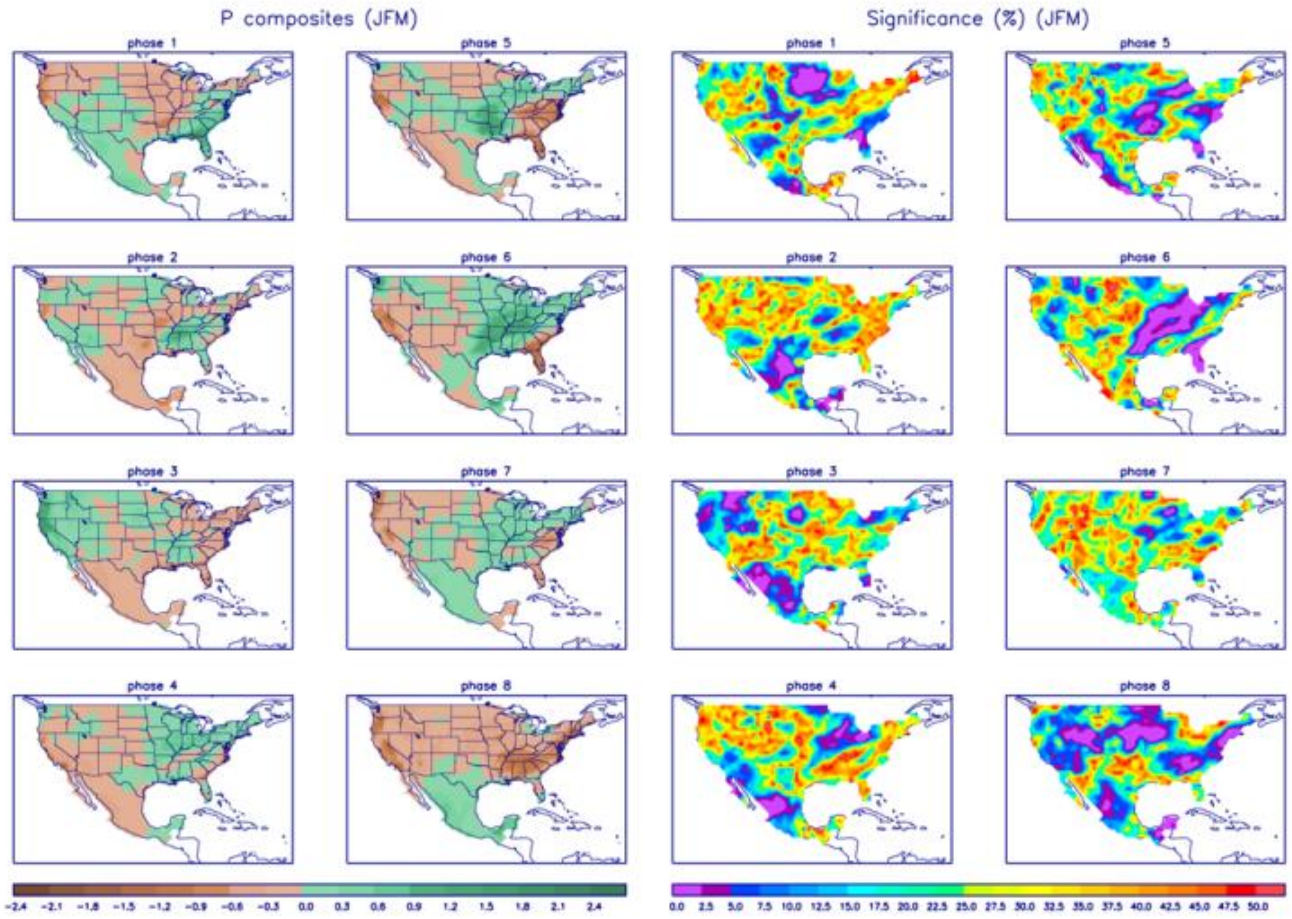
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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