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

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Outline

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Overview

- Eastward propagation of the MJO across the Pacific Ocean slowed at the beginning of February due to interference with a strong Rossby wave. Although some eastward propagation is expected to resume during the next two weeks over the Western Hemisphere, much of the convection is expected to remain near the Date Line.

- Dynamical model forecasts generally agree that the subseasonal signal will interfere with a Rossby wave over the west-central Pacific during Week-1, with most models thereafter predicting eastward propagation into phases 7/8/1. The Canadian and ECMWF solutions are the farthest east with this propagation (Phase 1), and the JMA is the farthest west
- (Phase 7).

- The MJO is expected to increase the chance for tropical cyclone (TC) development over the western Pacific (north and south of the equator) for the next 1-2 weeks.

<u>Additional potential impacts across the global tropics and a discussion for the U.S. are available at:</u>
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

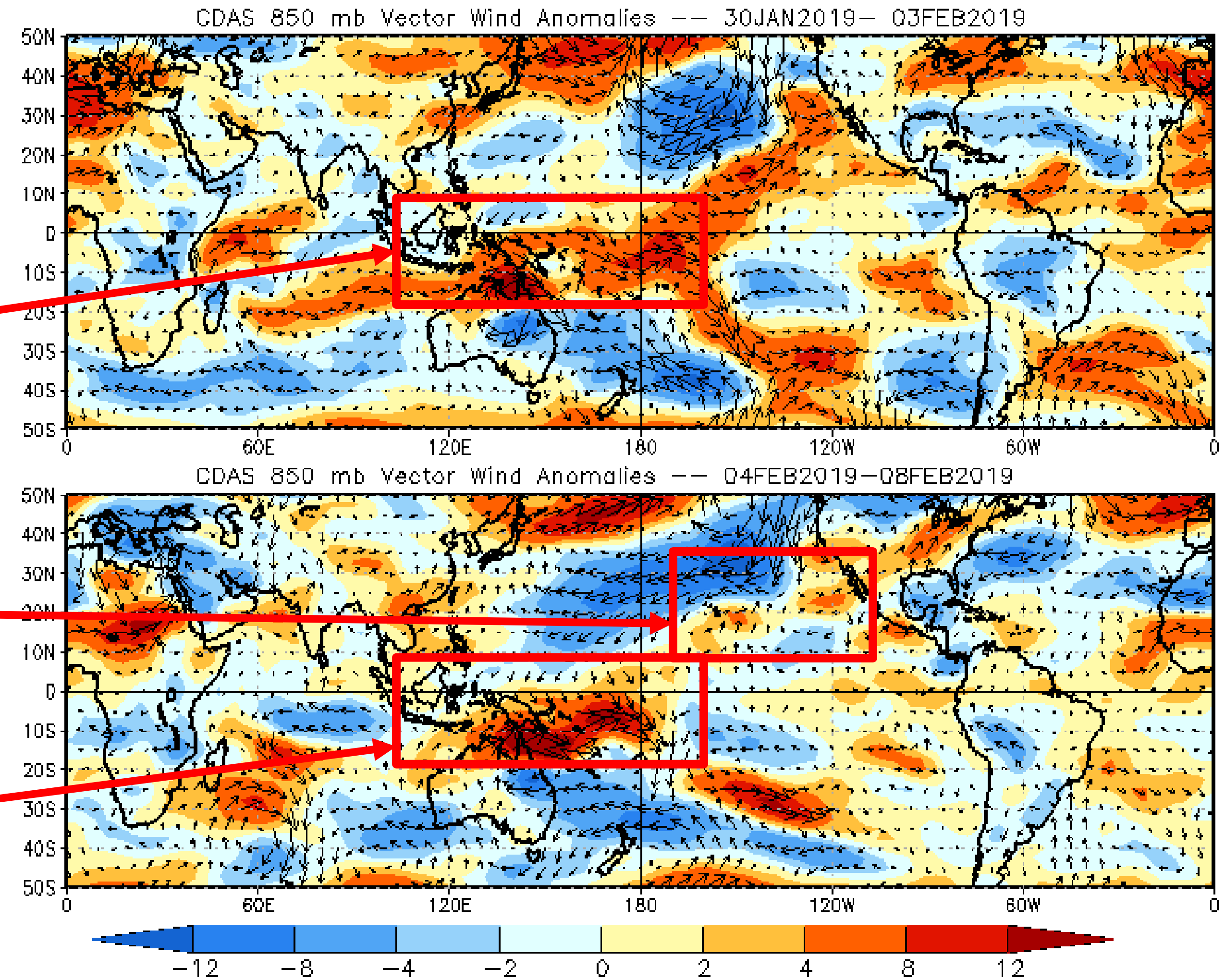
Blue shades: Easterly anomalies

Red shades: Westerly anomalies

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

The subtropical connection from near Hawaii northeast to California weakened this past week

Large westerly anomalies continue near and west of the Date Line.



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

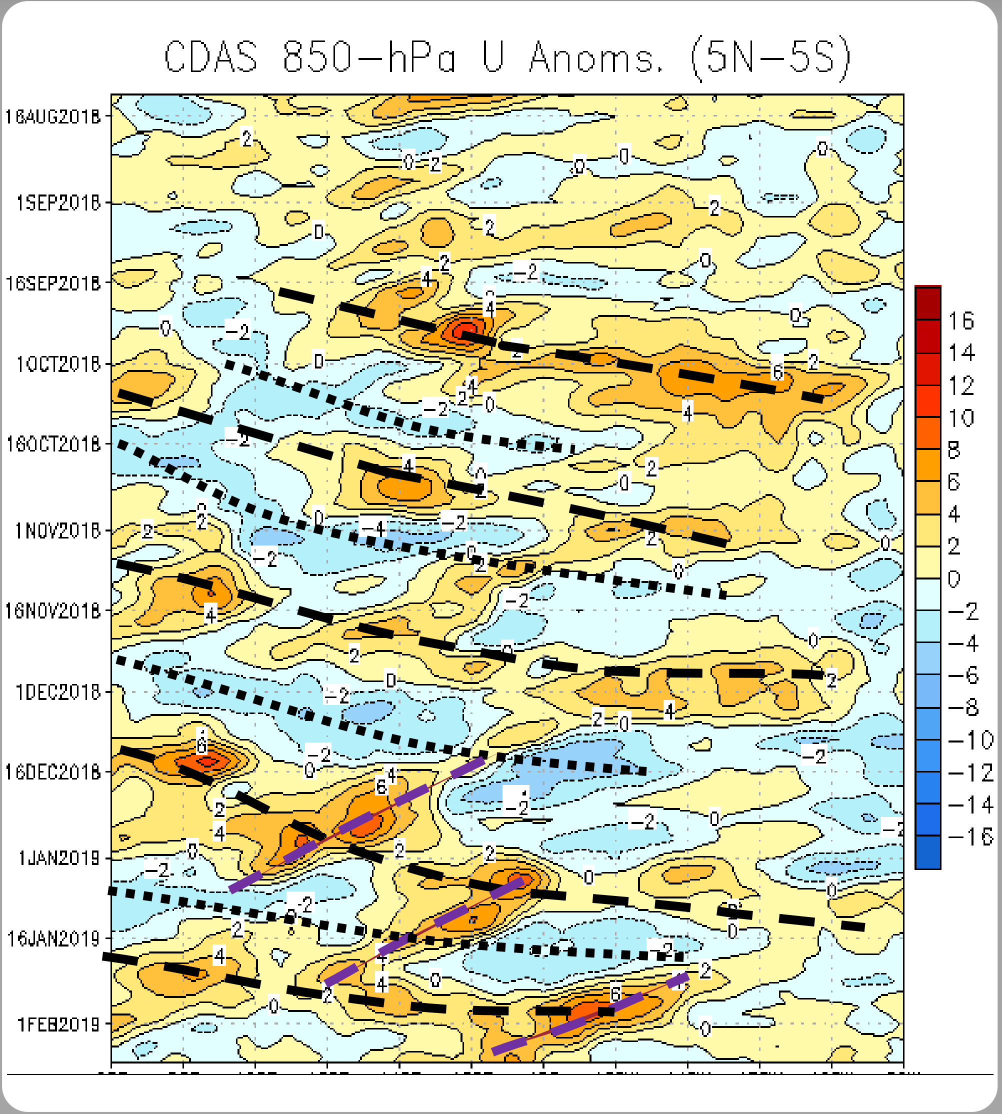
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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, right up to the present time.



OLR Anomalies – Past 30 days

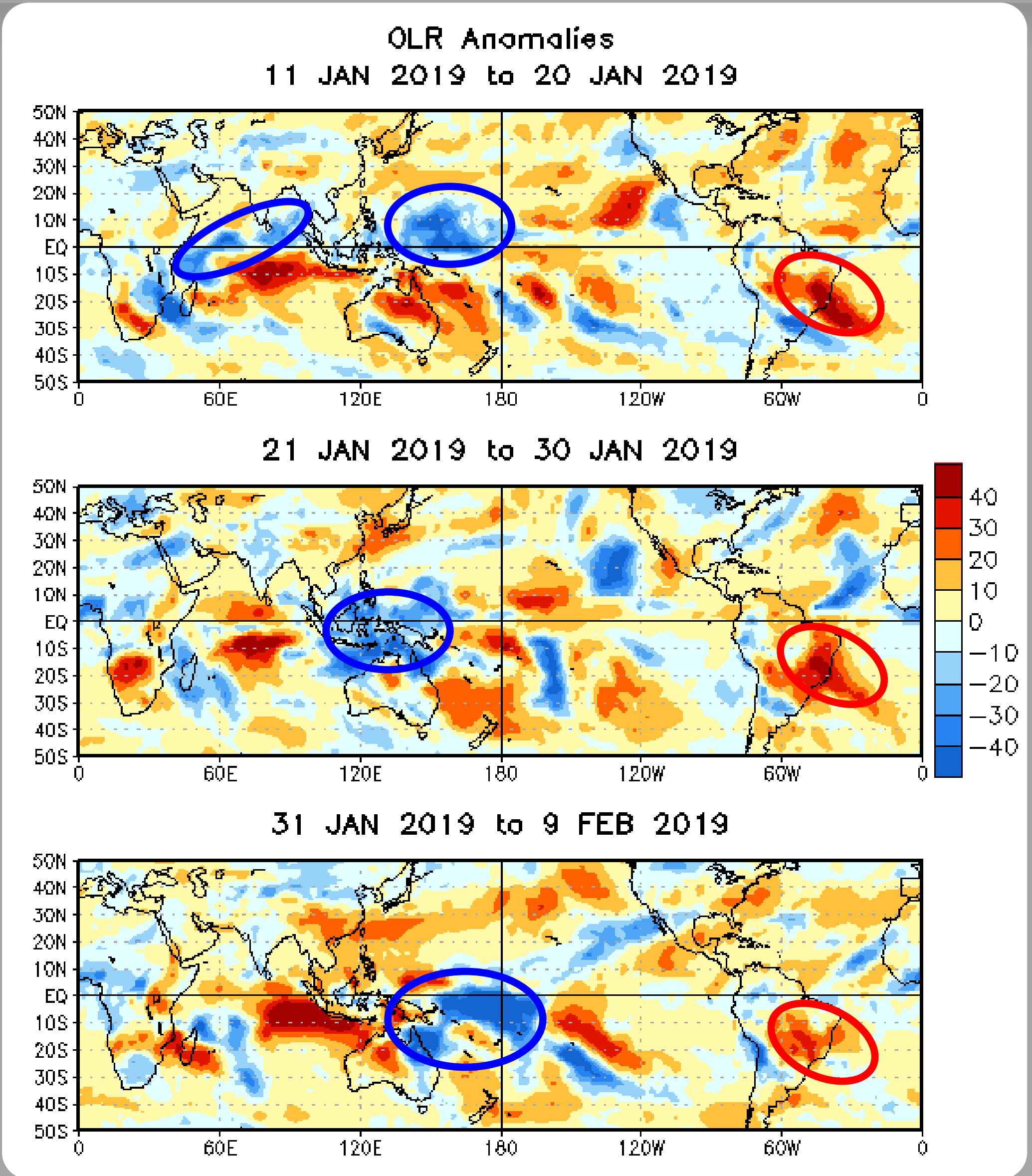
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid-January, enhanced convection across the Indian Ocean (West Pacific) was tied to the active phase of the MJO (Rossby wave activity). Suppressed convection persisted over parts of Brazil and the adjacent South Atlantic (all panels).

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

In early February, enhanced convection continued to propagate eastward, from northeast Australia to near the Date Line.



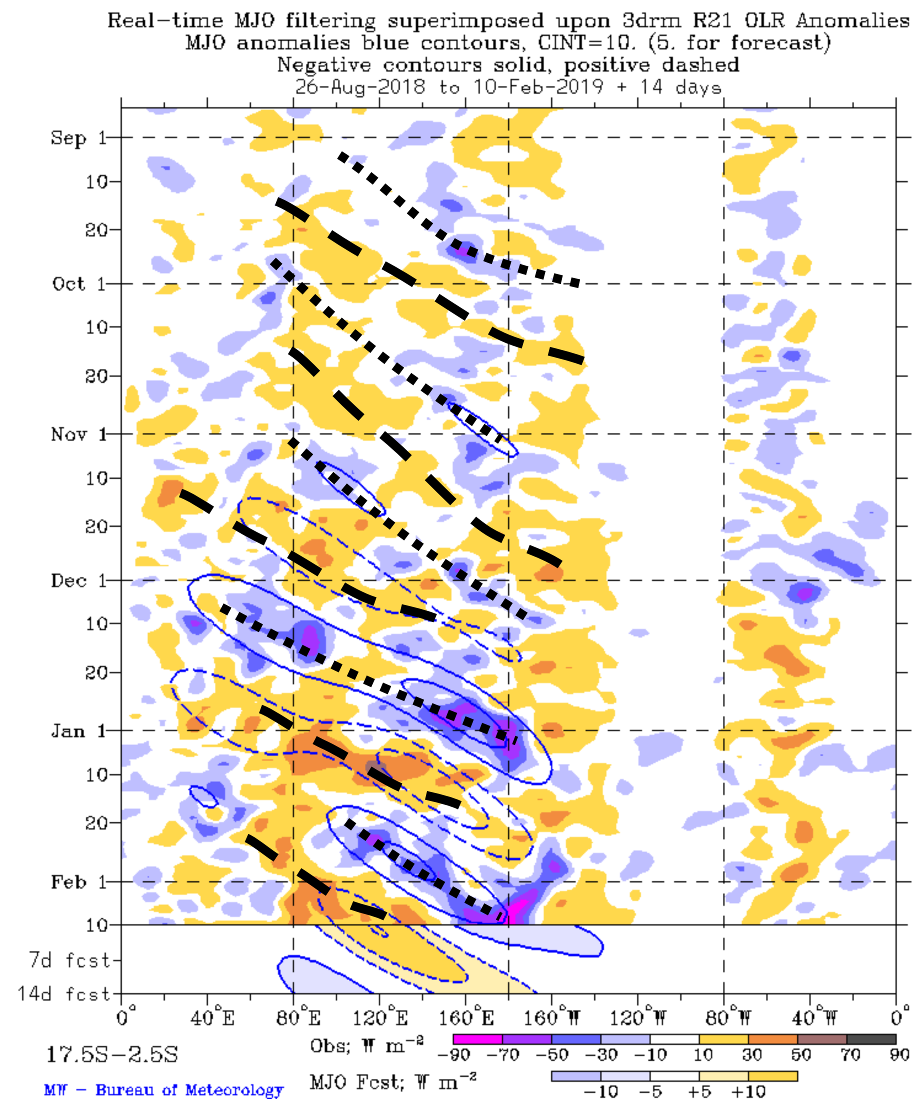
Outgoing Longwave Radiation (OLR) Anomalies (2.5ºS - 17.5º S)

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

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

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.



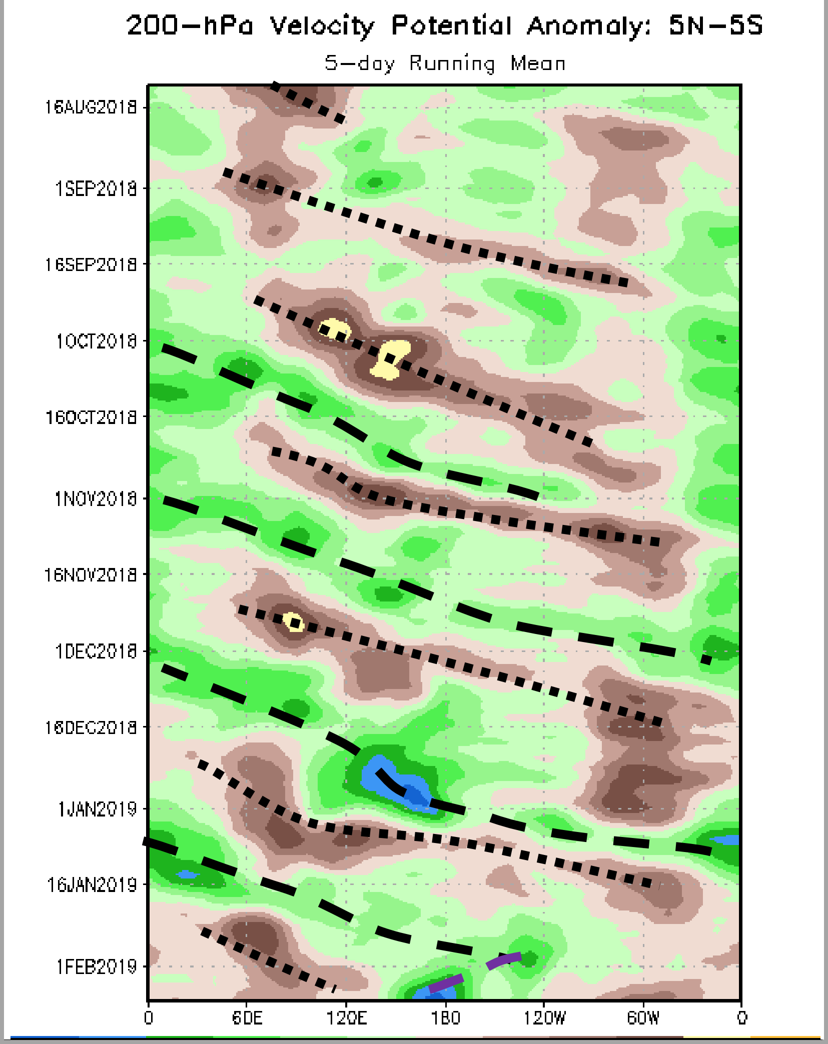
200-hPa Velocity Potential Anomalies (5ºS - 5ºN)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

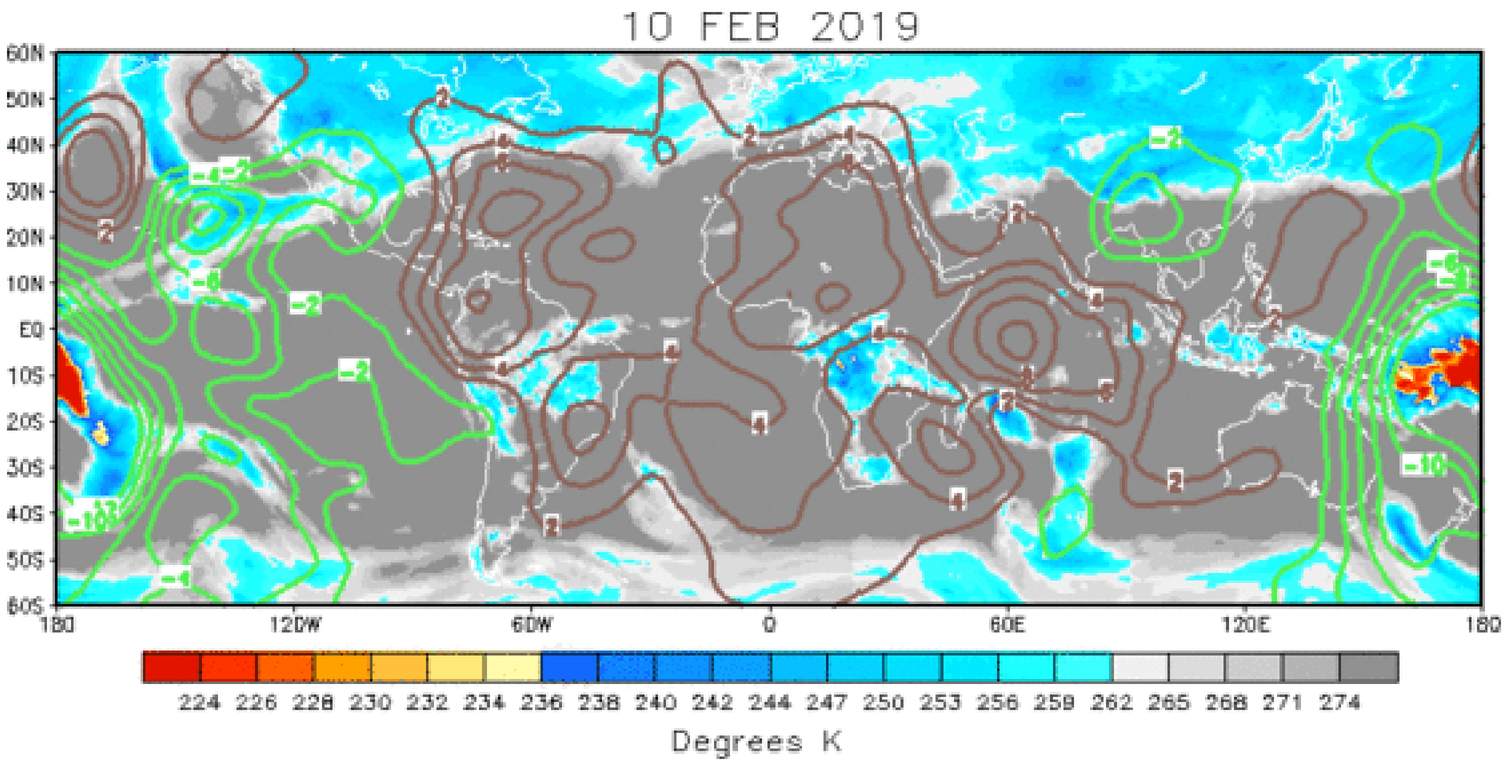
Negative anomalies (green shading) indicate favorable conditions for precipitation

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.

MJO-related convection and upper-level divergence propagated eastward from Africa in early January to the eastern Pacific by the start of February before fading. The most recent week depicts the likely influence of an equatorial Rossby wave near the Date Line.



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



The anomalous convective pattern became more coherent this past week, and is consistent with a wavenumber-1 pattern. Enhanced convection is situated across the Pacific at this time.

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})

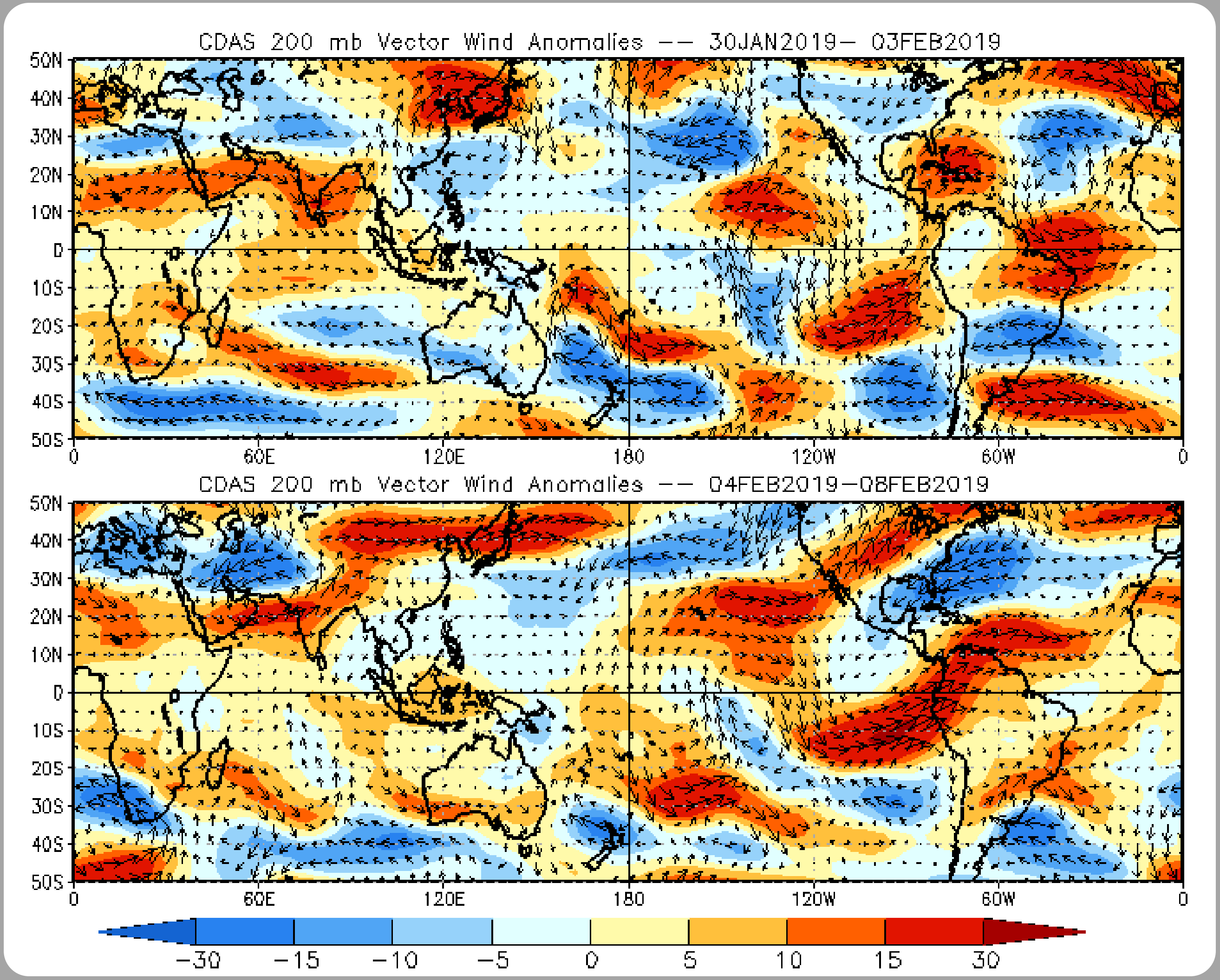
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

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

Strong cross-equatorial flow at 200-hPa can be seen over the eastern tropical Pacific, as well as a subtropical connection from near Hawaii to southern California and the Baja Peninsula (associated with several atmospheric rivers).



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

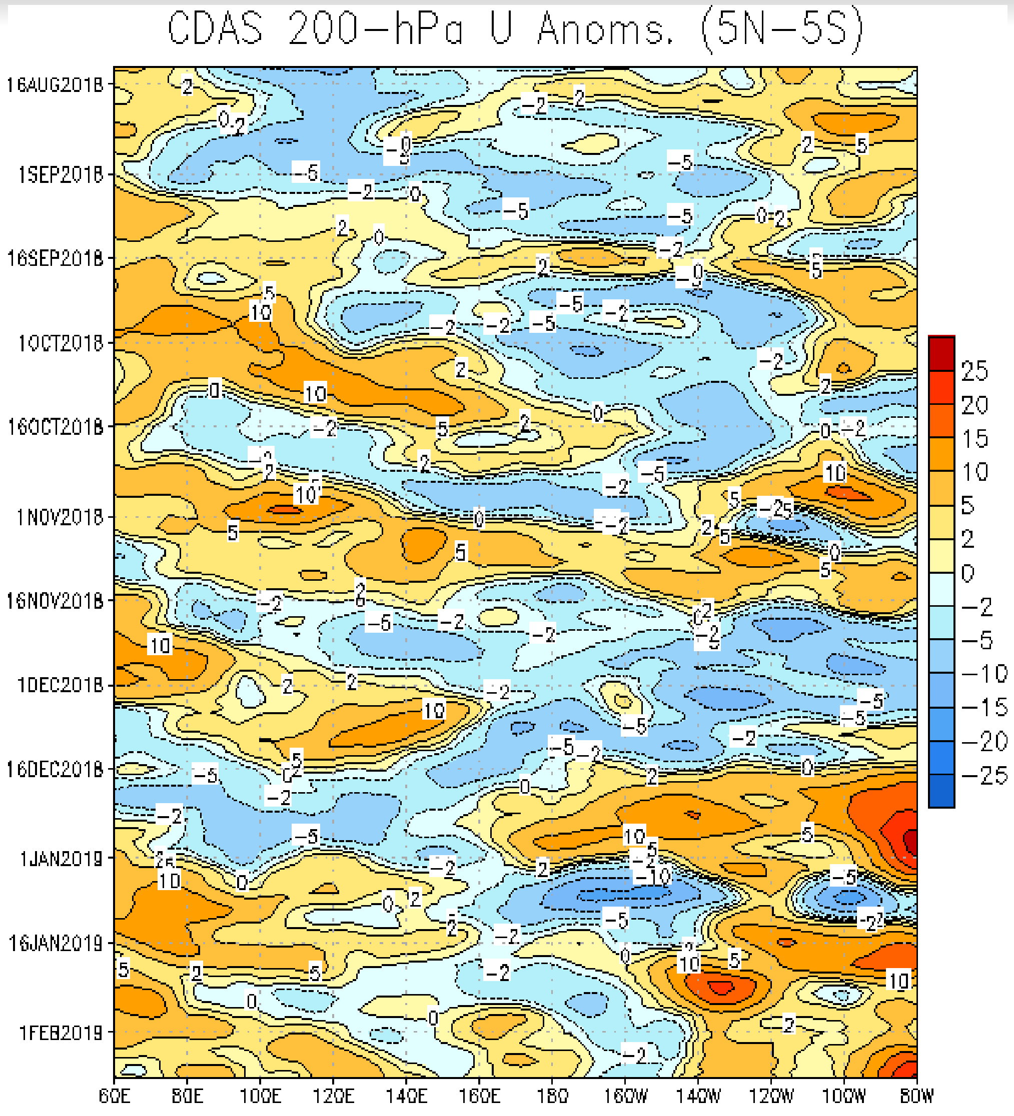
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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.

The MJO and mid-latitude wave activity have acted to reduce the anomalous easterlies in the East Pacific since mid-December. The most recent data depict anomalous westerlies over most of the domain.



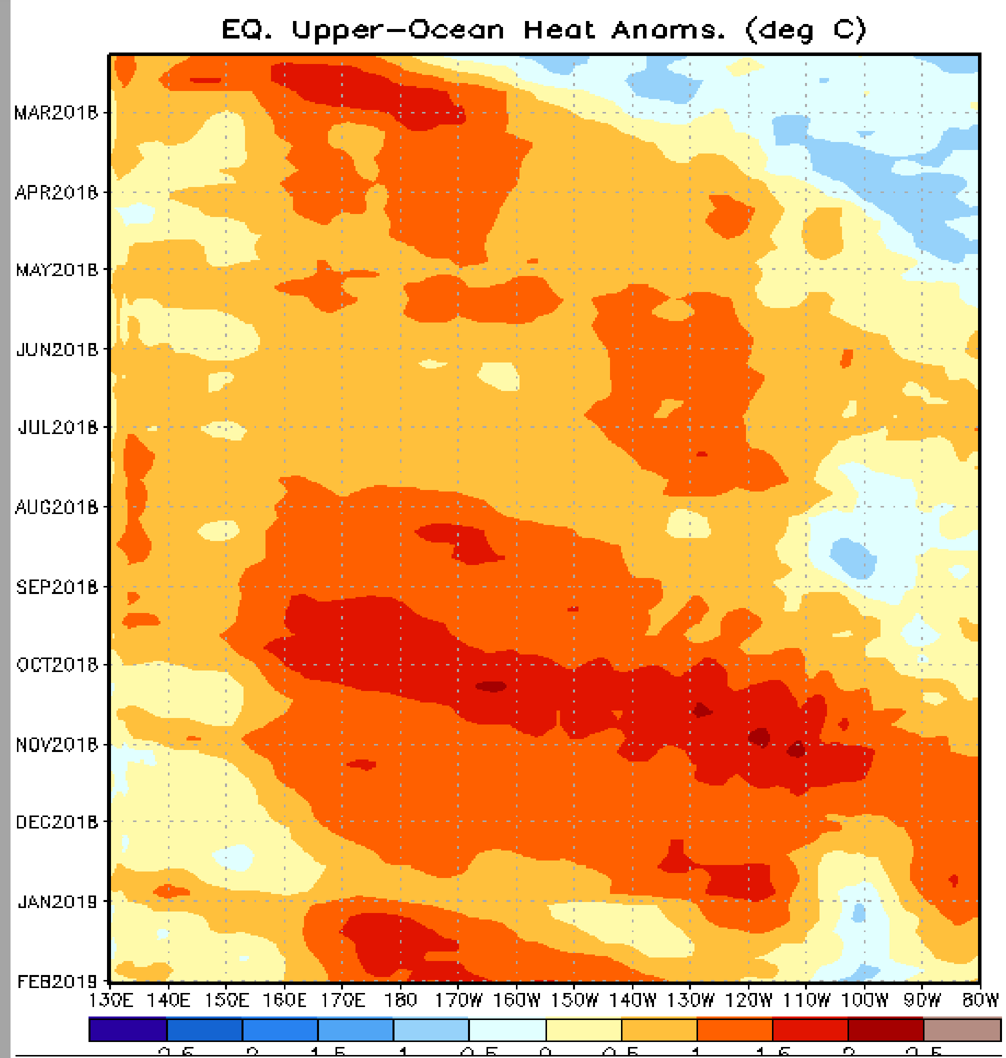
Weekly Heat Content Evolution in the Equatorial Pacific

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 in early January, though a downwelling Kelvin wave is now evident. 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

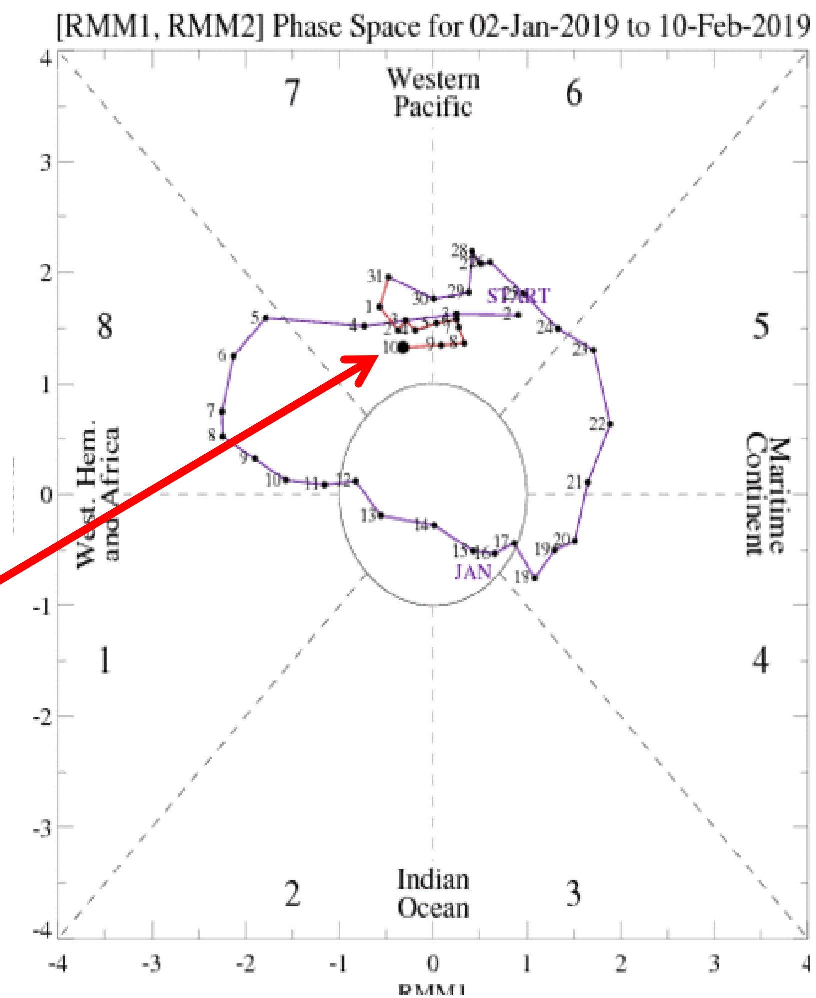
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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

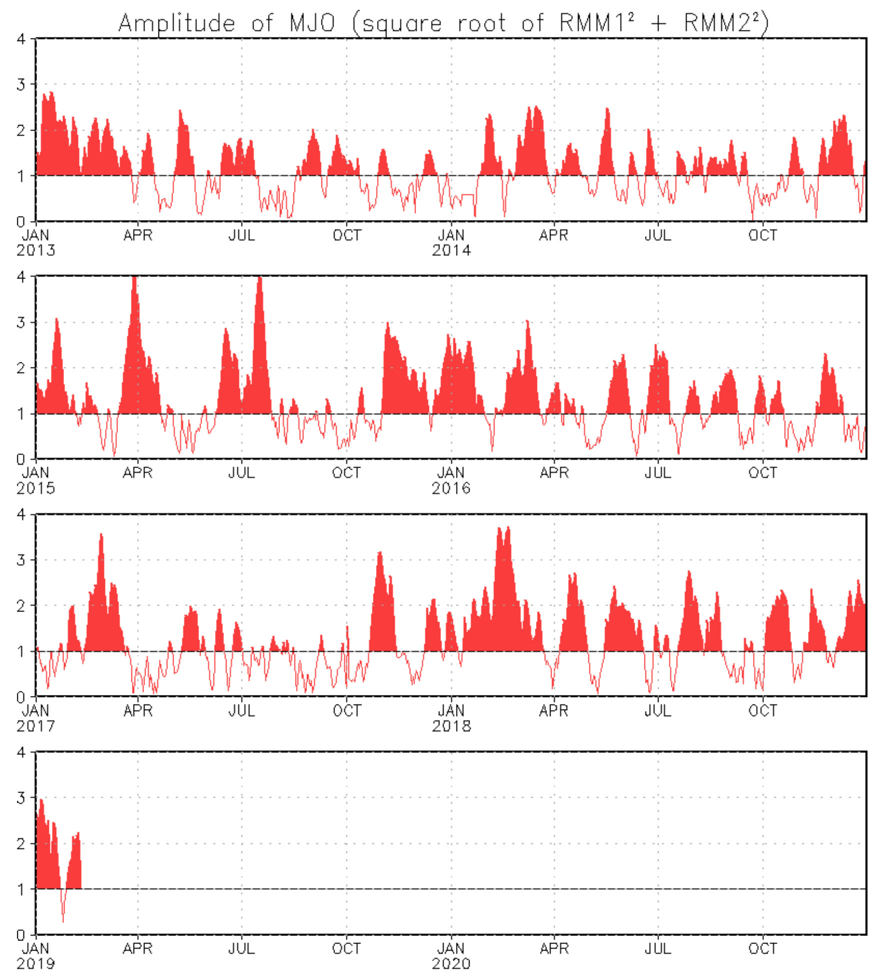


The eastward propagation of the MJO ended at the beginning of February, likely due to interference from a strong equatorial Rossby wave. Since then, the intraseasonal signal has resumed its eastward propagation, and is currently centered in Phase 7.

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

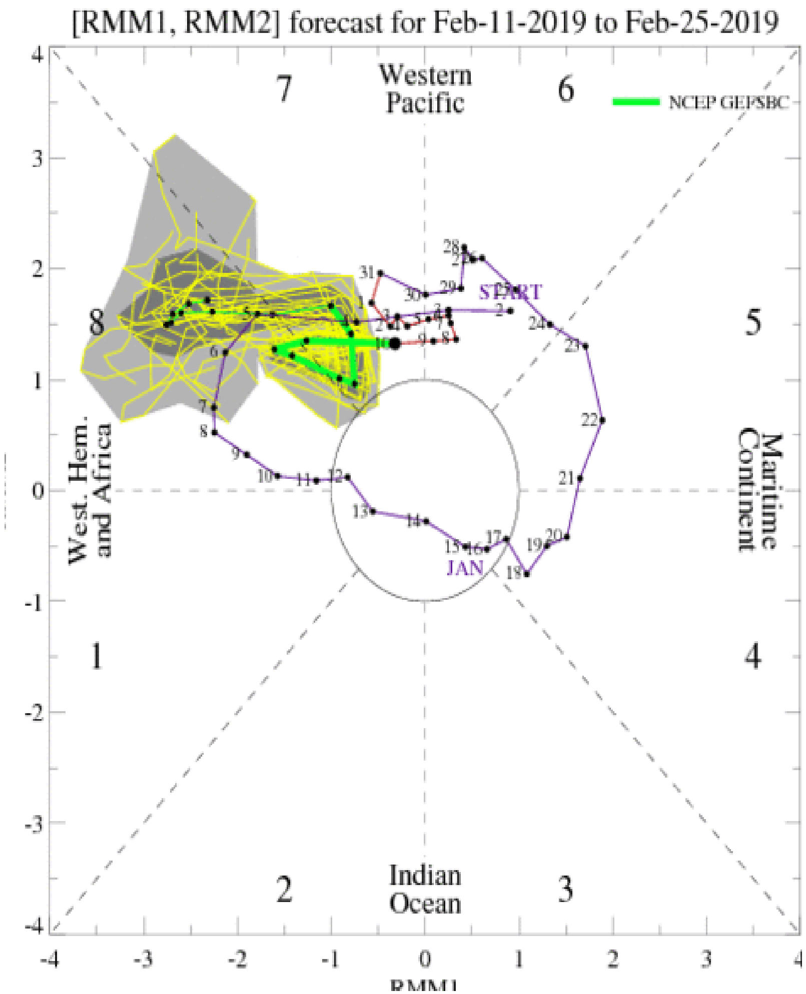
RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GEFS forecasts the MJO to resume its eastward propagation in Week-1, reaching Phase 8 before briefly doubling back; then resuming its eastward propagation once again. This track is likely related to continued interference from an equatorial Rossby wave near the Date Line. The GEFS also predicts a pronounced amplification of the signal across Phase 8 during Week-2.

Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

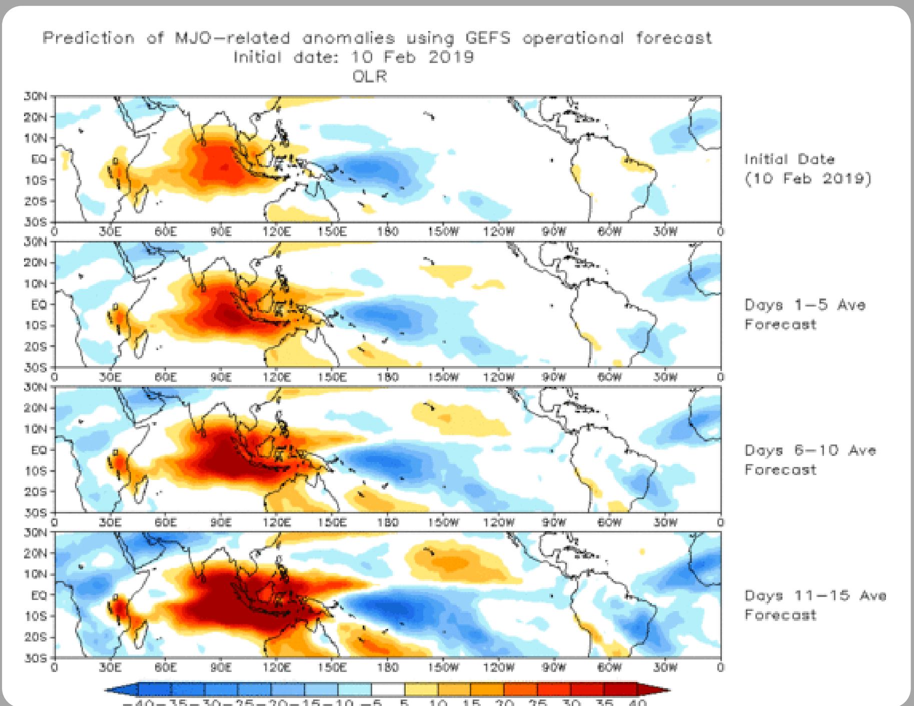


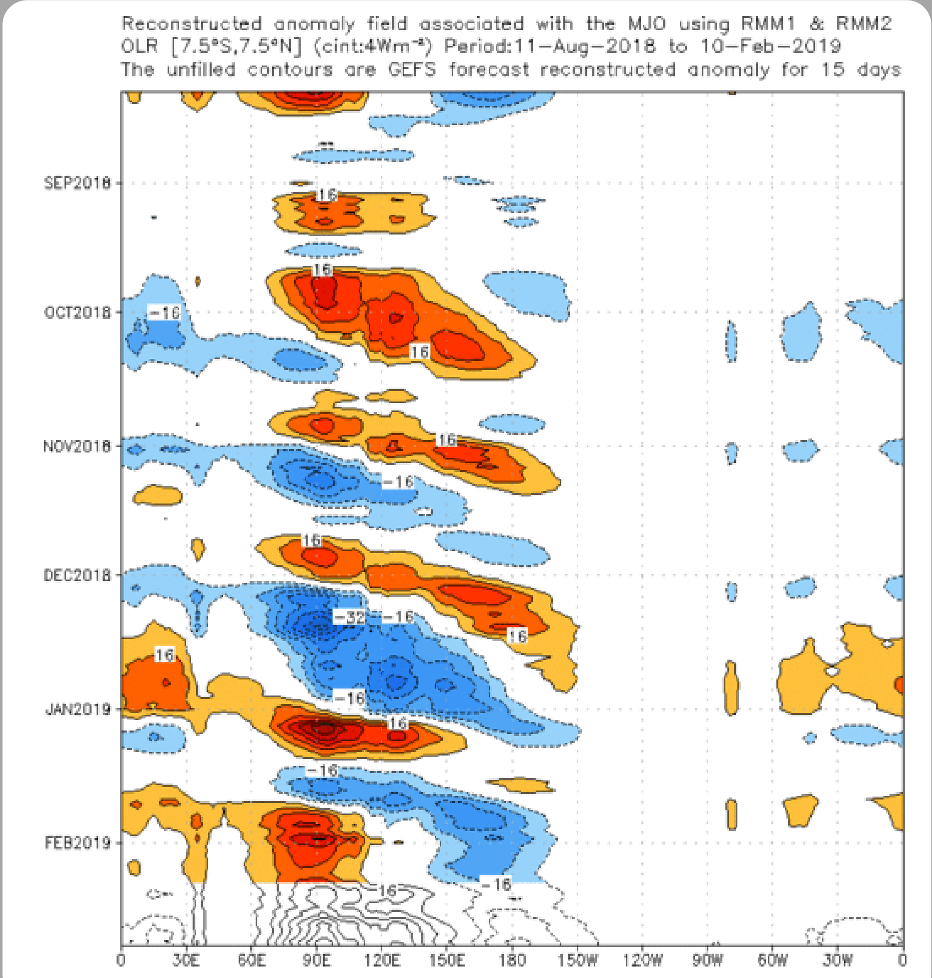
Ensemble GFS (GEFS) MJO Forecast

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



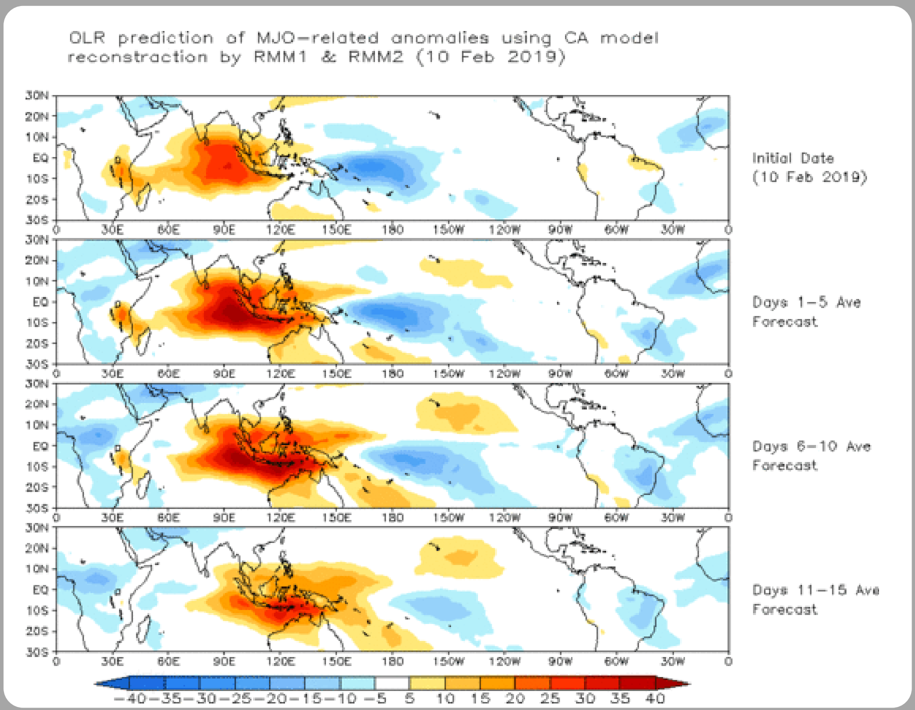


The GEFS indicates enhanced convection remains focused near the Date Line, though some of the convection propagates eastward over the central and eastern Pacific during the next two weeks. Suppressed convection remains widespread across the Indian Ocean and Maritime Continent.

Constructed Analog (CA) MJO Forecast

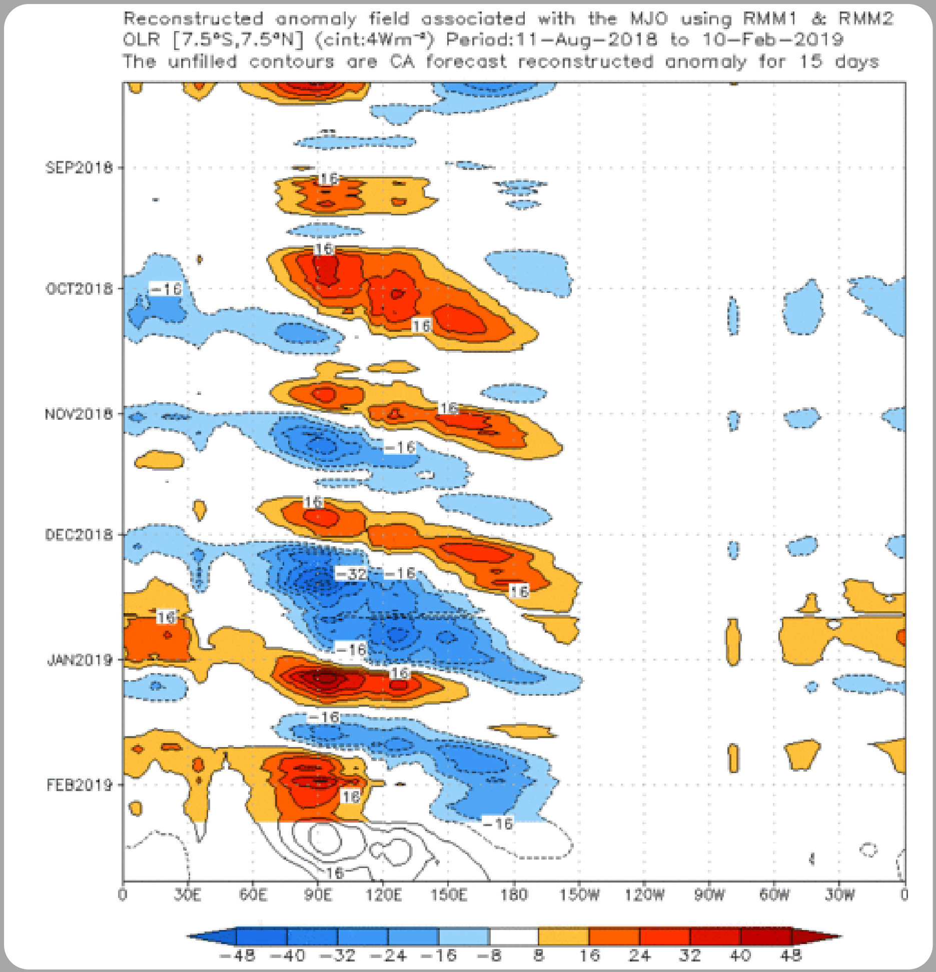
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



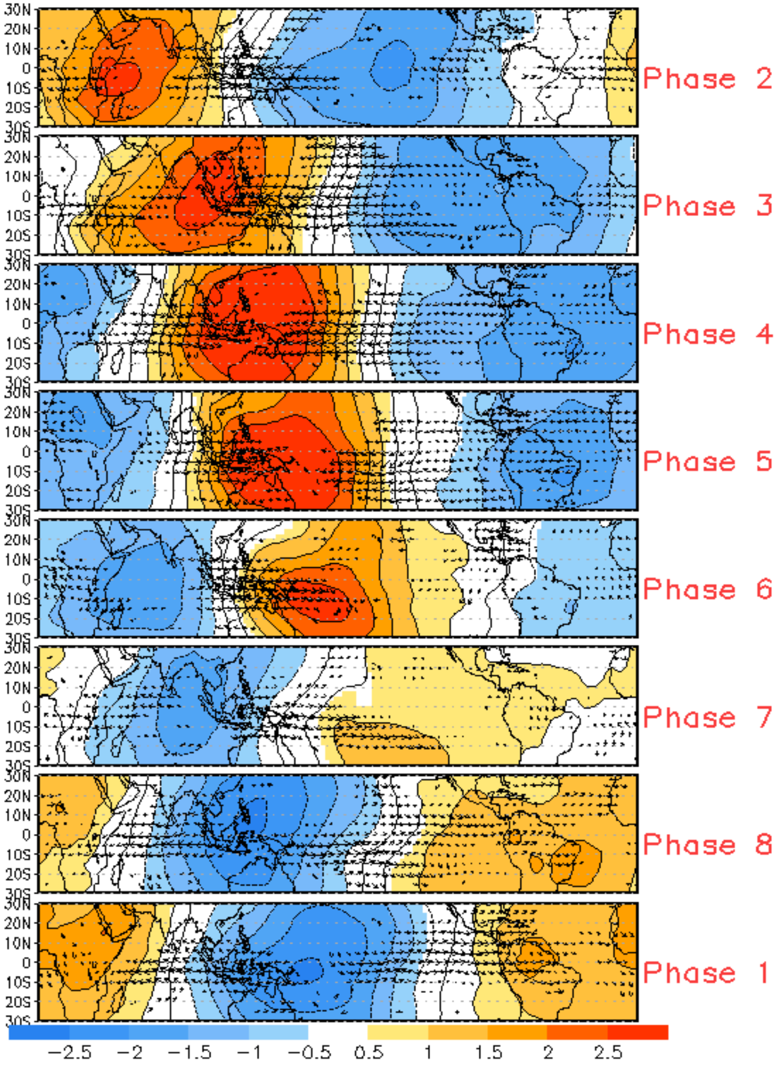
The constructed analog depicts a similar pattern to the GEFS, though with more eastward propagation overall. In addition the enhanced convective signal is forecast to de-amplify during Week-2.

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

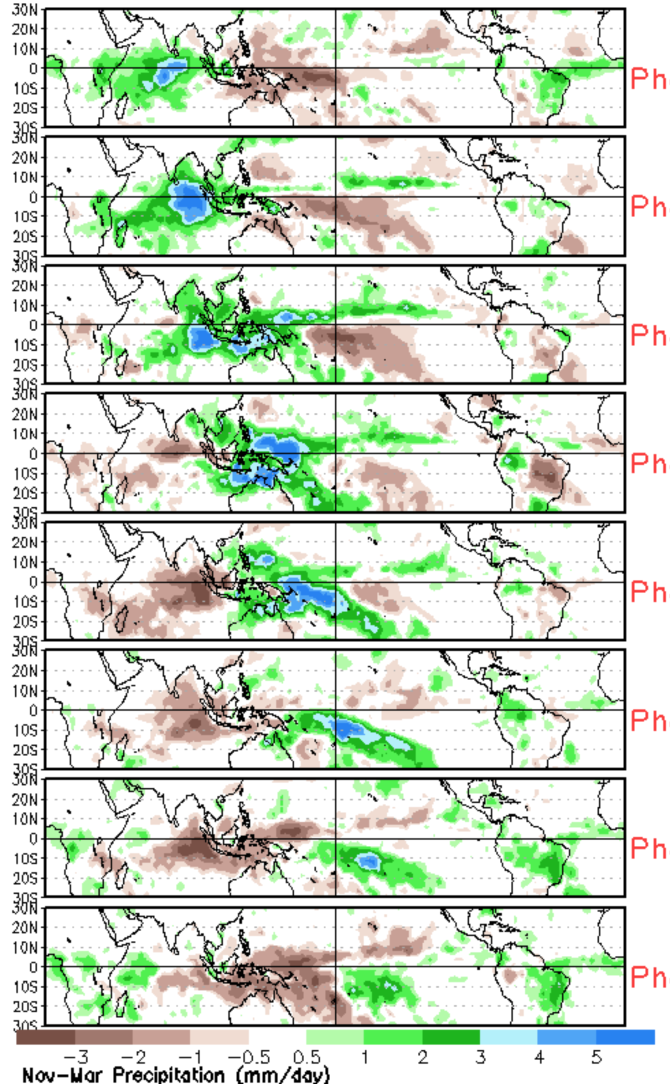


MJO Composites - Global Tropics

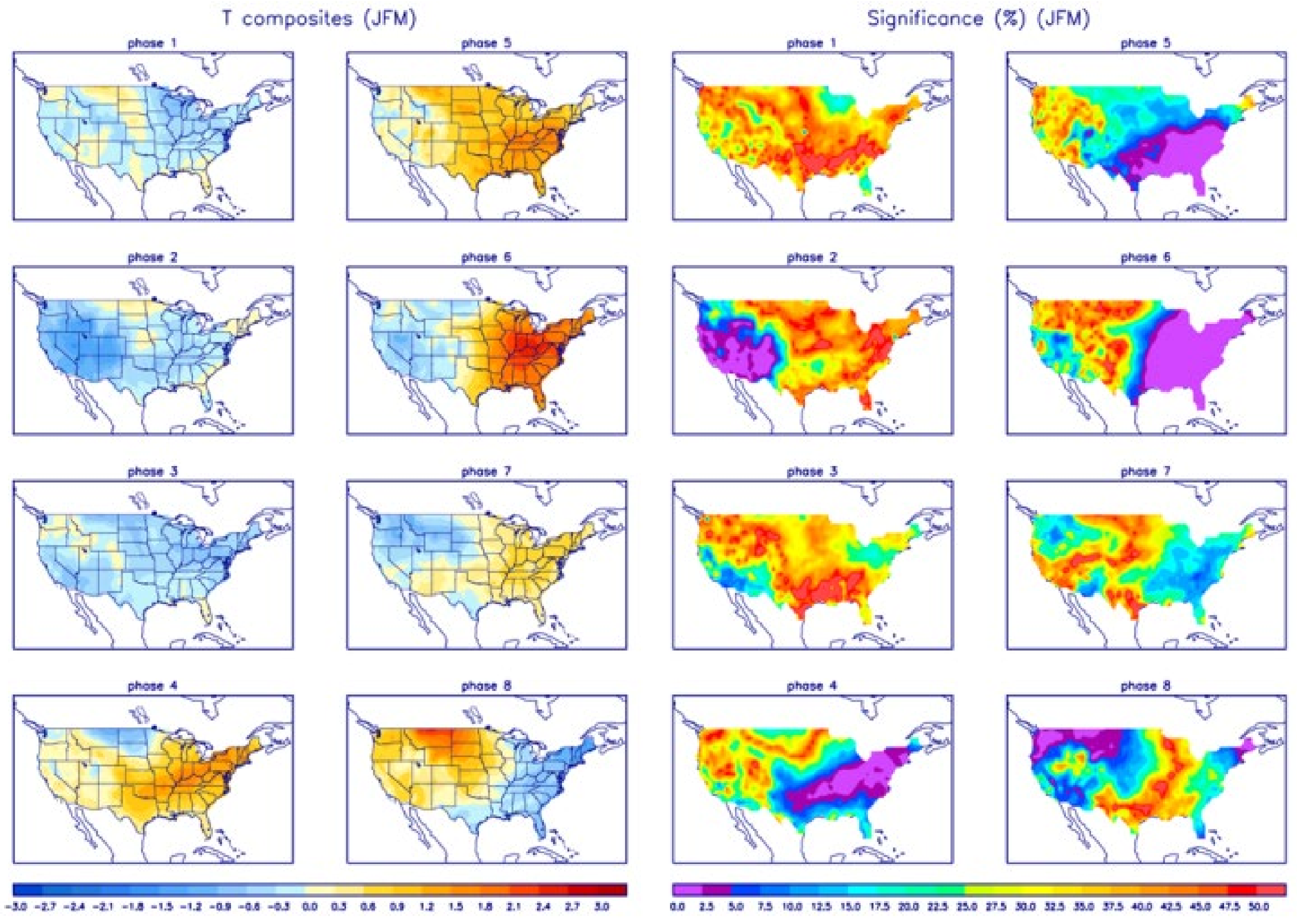
850-hPa Velocity Potential and Wind Anomalies (Nov - Mar)



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.

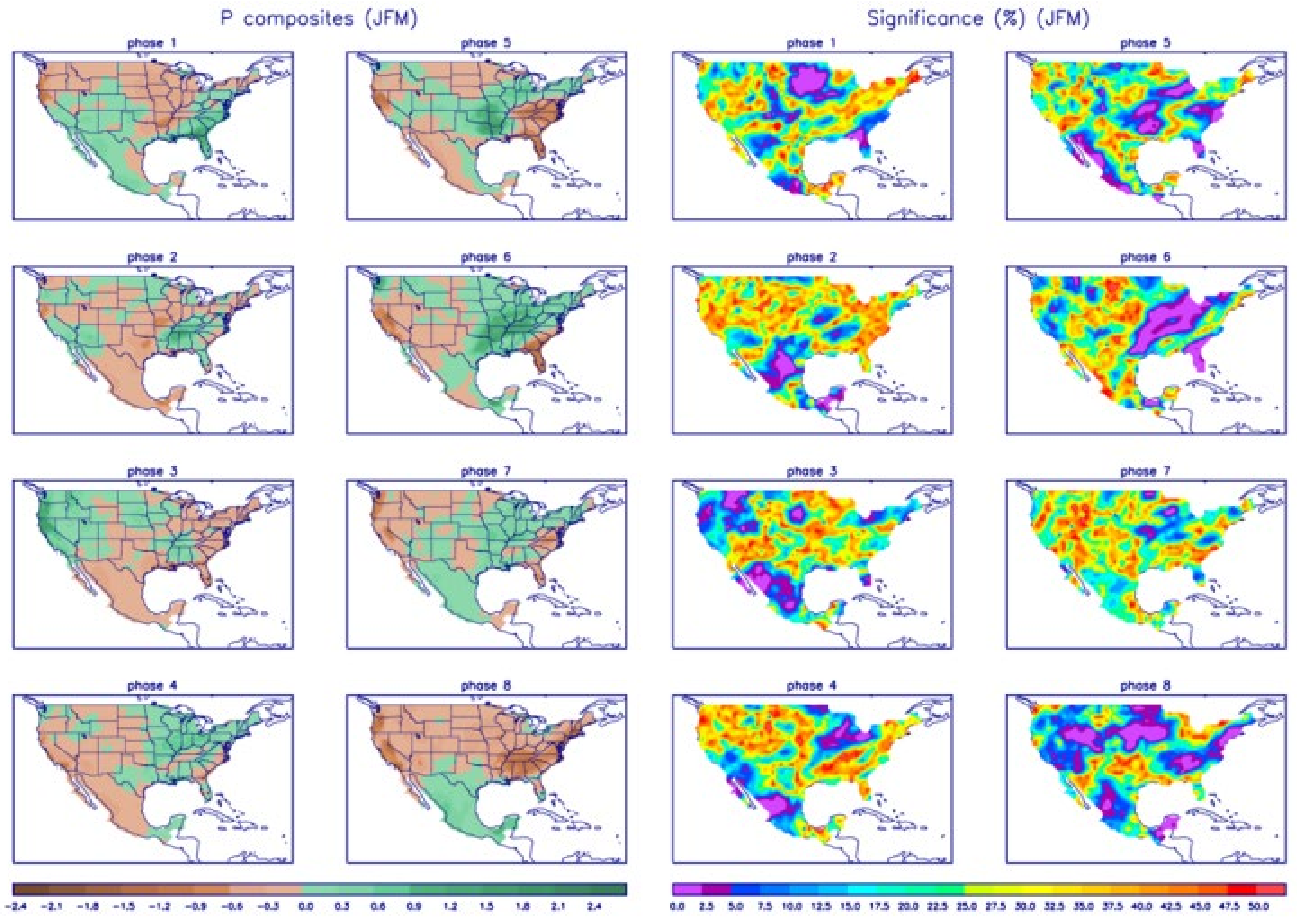
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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