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

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Outline

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MJO Index Information

MJO Index Forecasts

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Overview

- The MJO signal stalled over the eastern Pacific, where it destructively interfered with the emerging base state, and rapidly declined on the RMM-index over the past week. Rossby wave activity likely contributed to the slow eastward propagation.

- There is good agreement between the dynamical models on a re-emergence of the signal over the Indian Ocean and Maritime Continent (Phases 3/4) in Week-1. During Week-2, all models continue the propagation through phase 7 toward the central Pacific, with a possible weakening of the signal toward the end of the period.

- As the convective envelope moves toward the central and eastern Pacific during Week-2, the MJO signal could constructively interfere with the emerging El Nino base state. There has been a lack of typical El Nino atmospheric coupling so far with the anomalously warm waters of present in this region.

- MJO activity is not expected to have a large impact on the US for this two week period; extratropical variability is likely to play a larger role. Upper-level troughing and cold temperatures are forecast for much of the contiguous U.S. during the next two weeks, which is contrary to phases 4-7 of MJO activity that tend to favor upper-level ridging and warm temperatures.

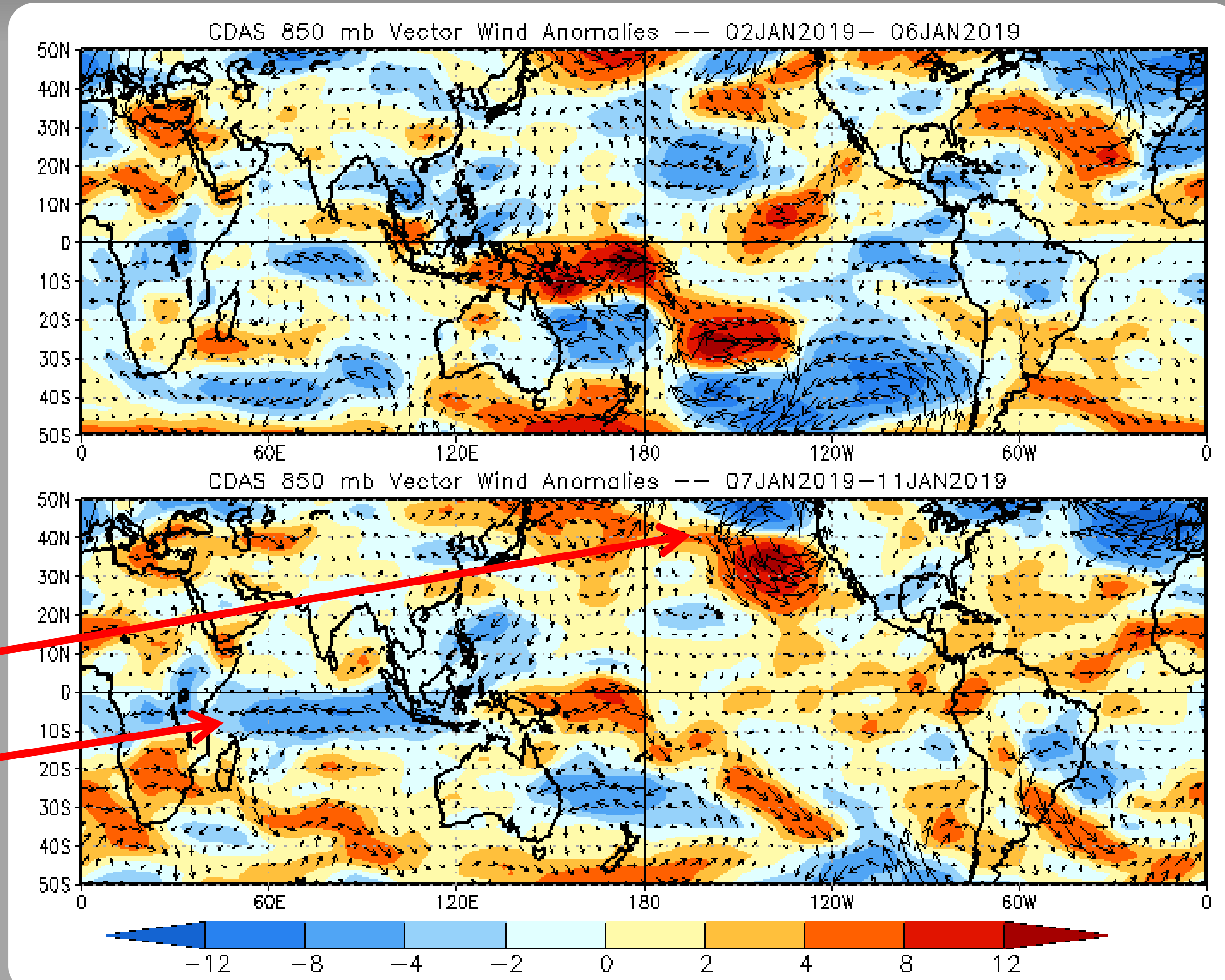
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Extratropical flow amplified off the west coast, enhanced onshore flow.

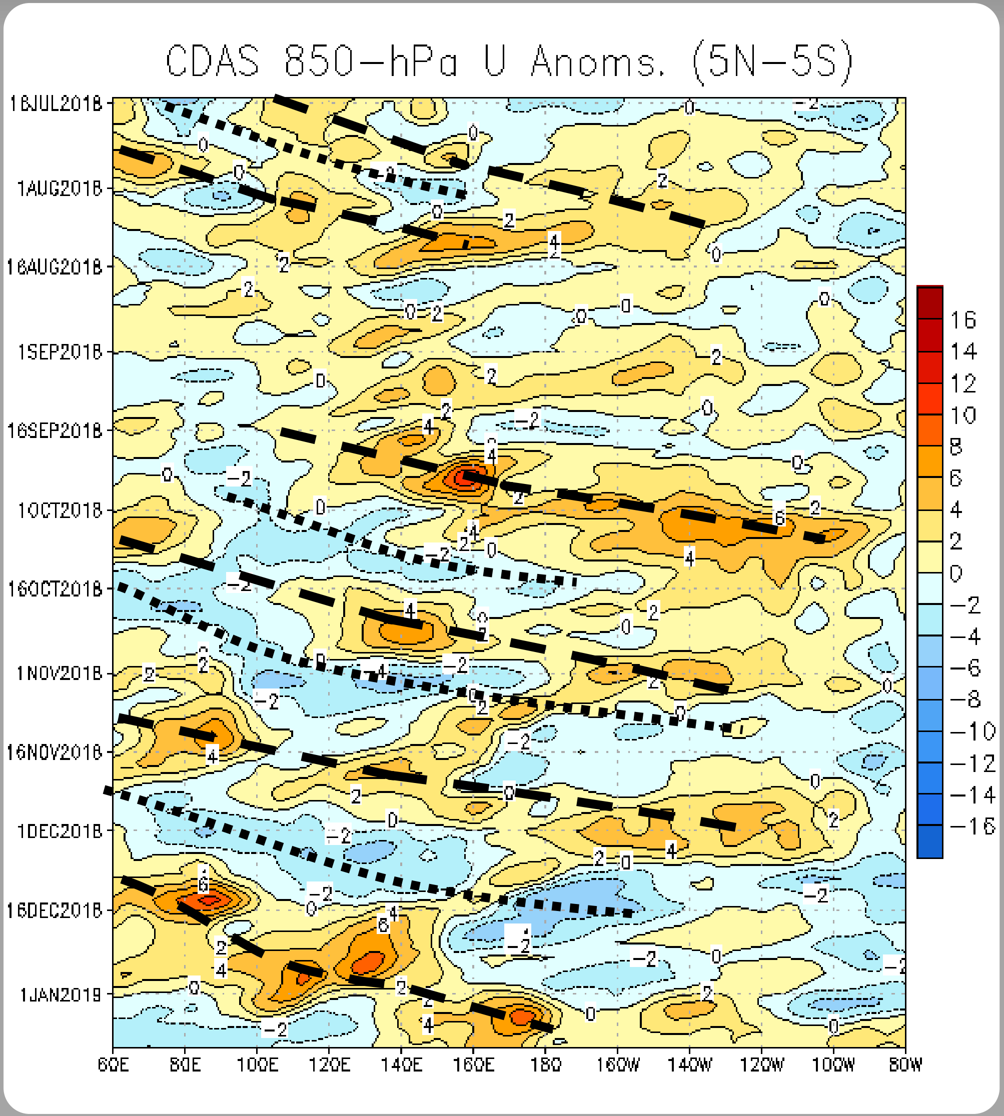
Easterly anomalies have strengthened over the IO.

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

A weak intraseasonal signal emerged during mid to late July.
From August through mid-September, other modes, including Rossby wave and tropical cyclone activity, influenced the pattern.
Another rapidly propagating intraseasonal feature during late September generated robust westerly wind anomalies across the Pacific.
Since late September, westerly anomalies increased in amplitude and duration over the equatorial Pacific, consistent with a gradual transition towards El Niño conditions. Over the last two months, other robust MJO events interfered with the base state. Most recently, pronounced Rossby wave activity interfered with the MJO and base state, resulting in a slowing of the eastward propagating convective signal and a brief interruption of the westerlies along the Date Line.



OLR Anomalies – Past 30 days

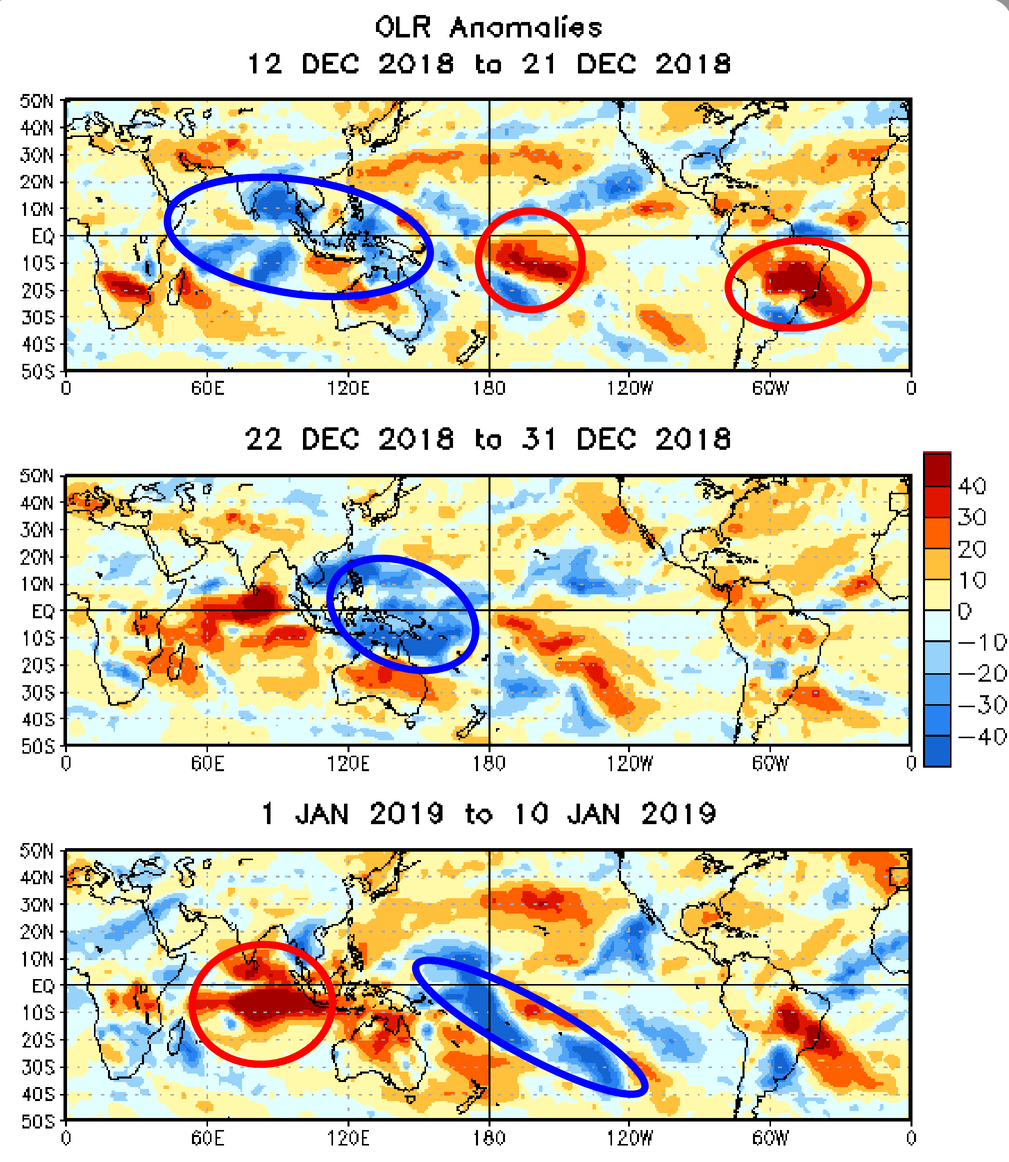
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

The MJO signal emerged over the Indian Ocean in early December. By mid-December, suppressed convection overspread the eastern Indian Ocean to the West Pacific. The exiting signal engendered tropical cyclone activity in the Indian Ocean. Strong suppressed convection was seen over Brazil.

Toward the end of December, the MJO propagated out of the Indian Ocean, toward Maritime Continent and Western Pacific. Suppressed anomalies over the central Pacific weakened. Pronounced Rossby wave activity supported TC activity over the western Pacific.

By early January, some of the convective activity associated with the MJO extended along the SPCZ into the southern mid-latitudes. Suppressed convection over the Indian Ocean has strengthened over the past week.



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

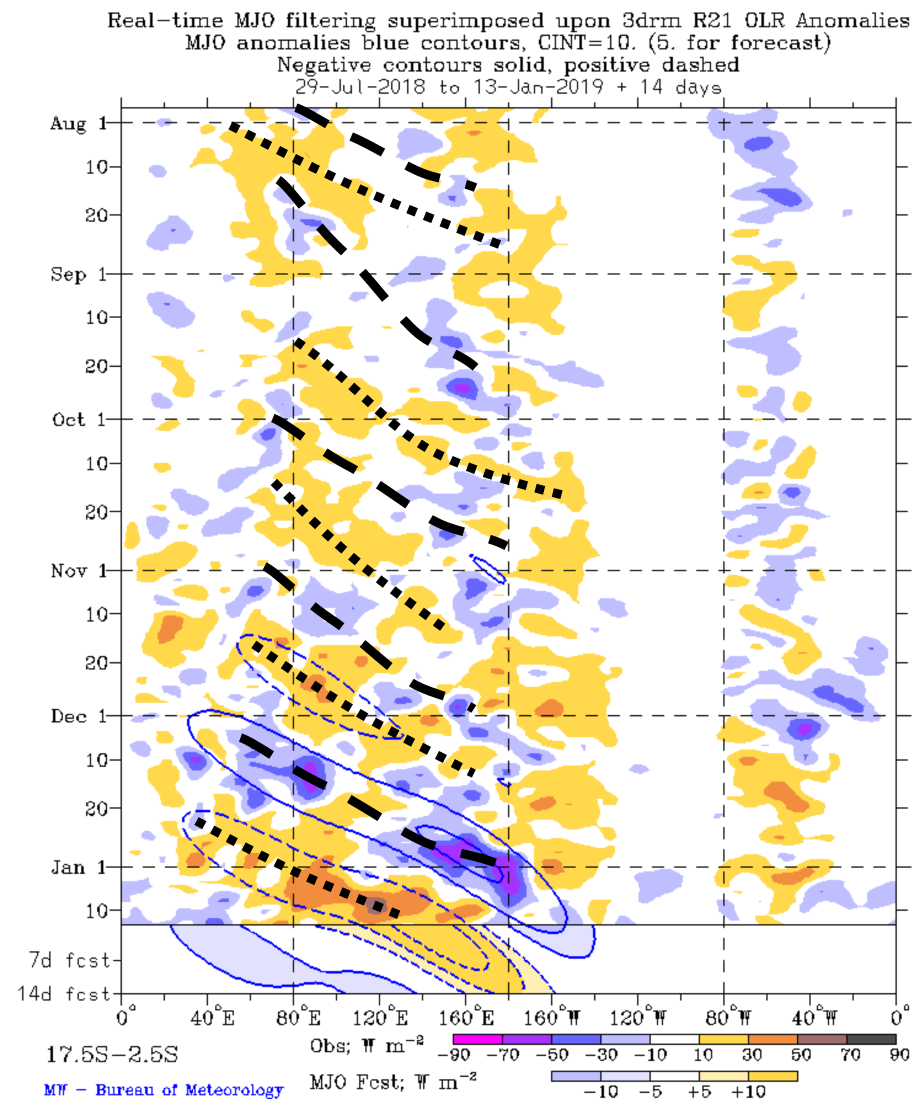
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During August, other modes of tropical (Kelvin waves, Rossby waves and tropical cyclones) variability dominated, with weak OLR anomalies continuing until mid-September. These variabilities also interfered with the emerging base state.

There is limited anomalous convection over the eastern Pacific, which suggests that the atmosphere has not coupled with the anomalously warm waters in the equatorial Pacific associated with the developing El Niño.

Since the end of September, the MJO signal has been apparent. At the start of the year, there may have been some constructive interference between the MJO and the low-frequency state near the Date Line.



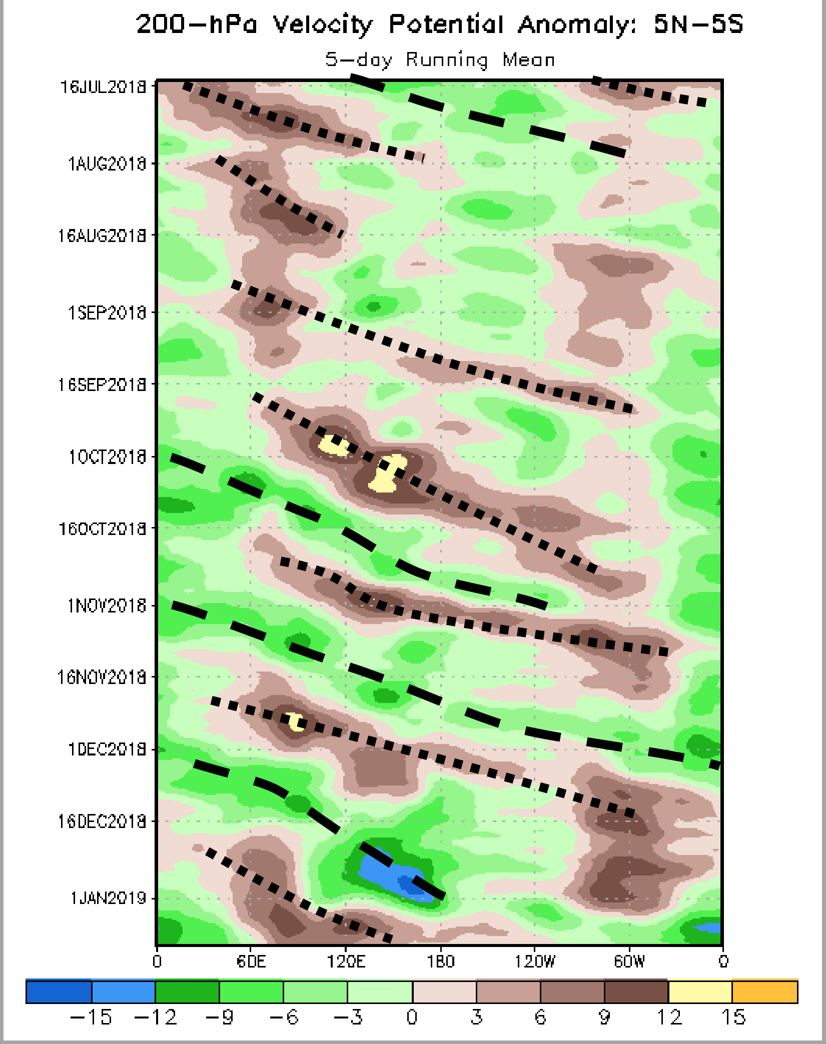
200-hPa Velocity Potential Anomalies (5ºS - 5ºN)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

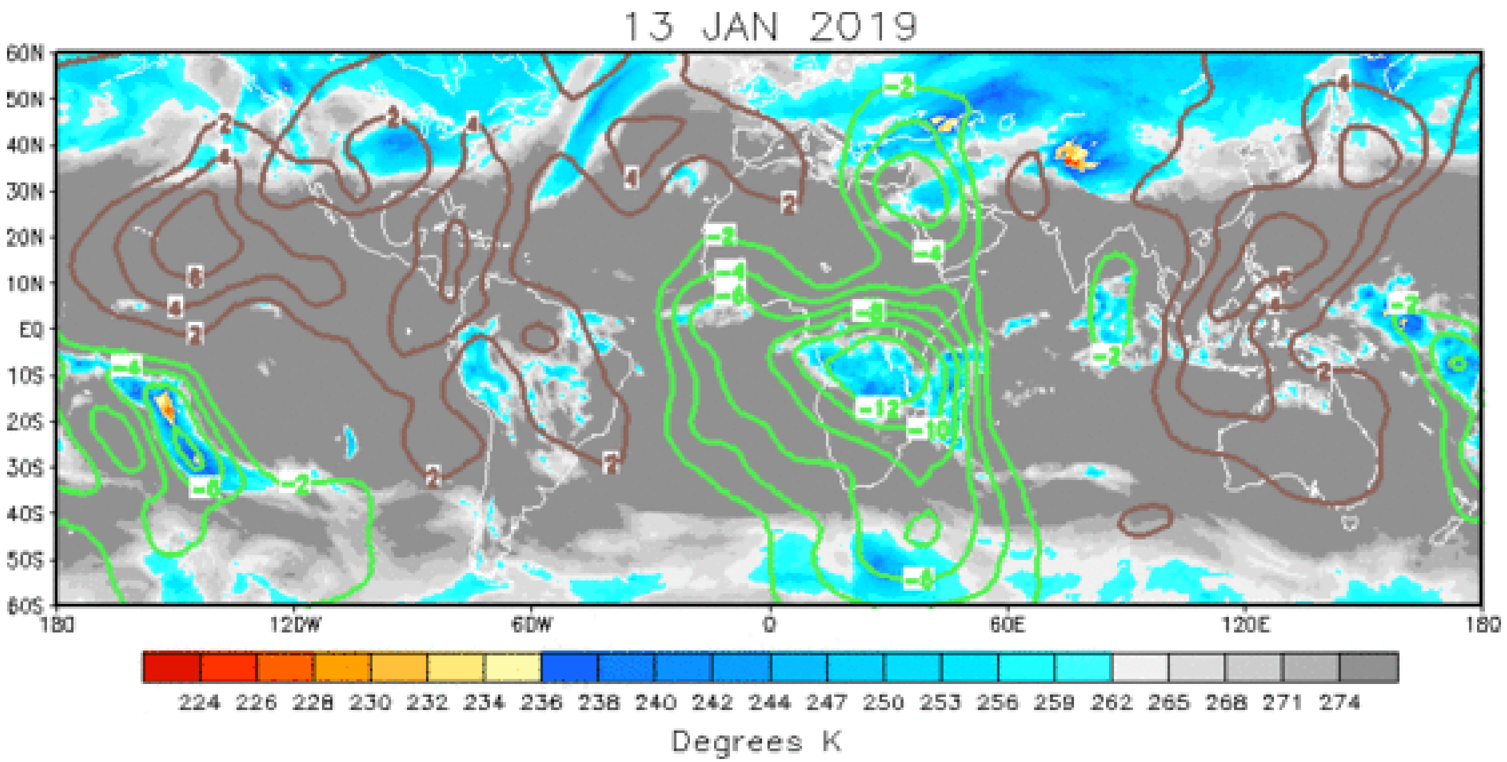
Negative anomalies (green shading) indicate favorable conditions for precipitation

The upper-level footprint of the MJO re-emerged during mid-July, with a broad divergent signal propagating from the Maritime Continent to the central Pacific. Around the same time, a low-frequency dipole favoring enhanced (suppressed) convection over the east-central Pacific (Indian Ocean) emerged, consistent with a gradual transition towards El Niño conditions. An active MJO pattern since September has overwhelmed this signal at times.

More recently, the interactions between the MJO and robust Rossby wave activity were apparent in the upper-level VP, but the overall envelope of enhanced divergence aloft continued propagating eastward to the West Pacific until mid-December. Convection has since become more stationary due to Rossby wave activity and the low-frequency state. Suppressed convection has now started to overspread the Indian Ocean to the Date Line.



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



The upper-level VP anomaly pattern exhibits a noisy Wave-2 pattern. Upper-level divergence is noted over Africa, eastern Europe, and the SPCZ. Upper-level convergence dominates the Americas and 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})

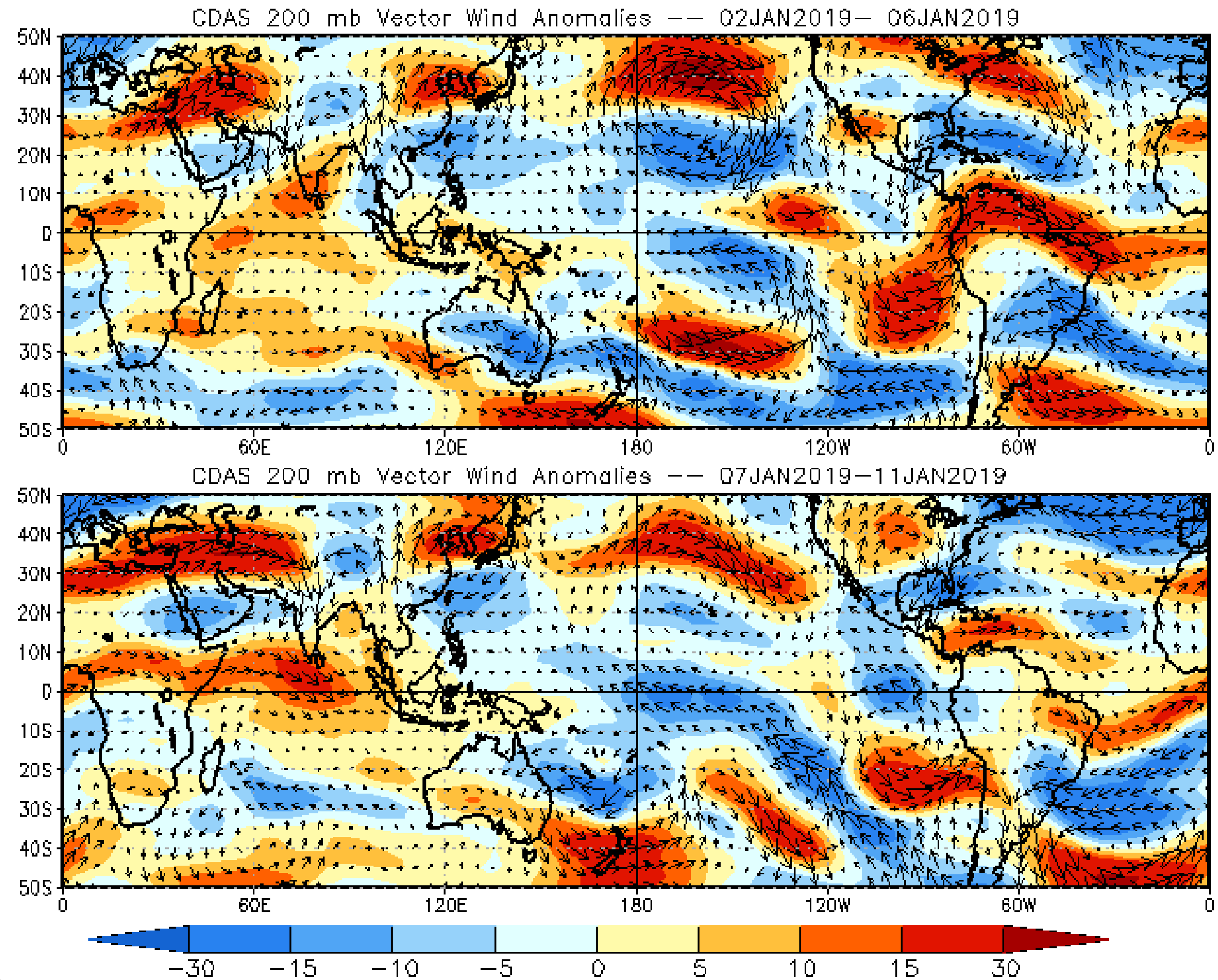
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

At the start of the year, the upper-level wind patterns appeared to be dominated by extratropical sourcing, with very amplified patterns over the Western Hemisphere. A large anomalous anticyclone is noted over the north central Pacific.

Over the past week, the anomalous anticyclone continued over the north Pacific, but weakened, as well as much of the anomalous activity over the Western Hemisphere. Easterly (westerly) anomalies along the Equator strengthened over the central Pacific (Indian Ocean).



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

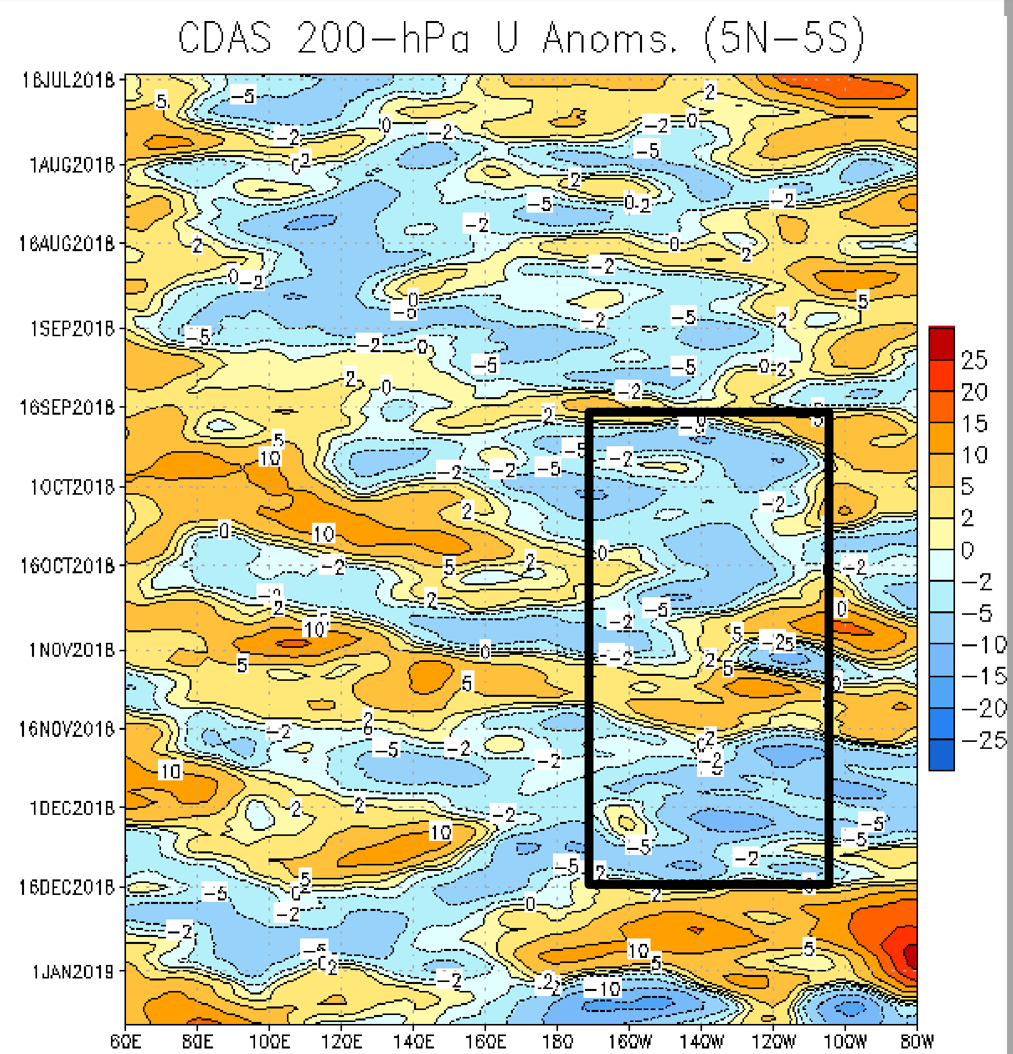
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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 pattern.

Since early October, the upper-level wind field has been marked by pronounced intraseasonal activity, interrupted at times by Rossby waves. A trend towards more persistent easterly anomalies over the Pacific (boxed area) may have been associated in part with the base state.

Mid-December, the MJO signal, along with Rossby wave activity interrupted the persistent easterlies over the eastern Pacific. Currently, easterly anomalies have re-established in the region. Another area of westerly anomalies is depicted from the Indian Ocean extending over the Maritime Continent.



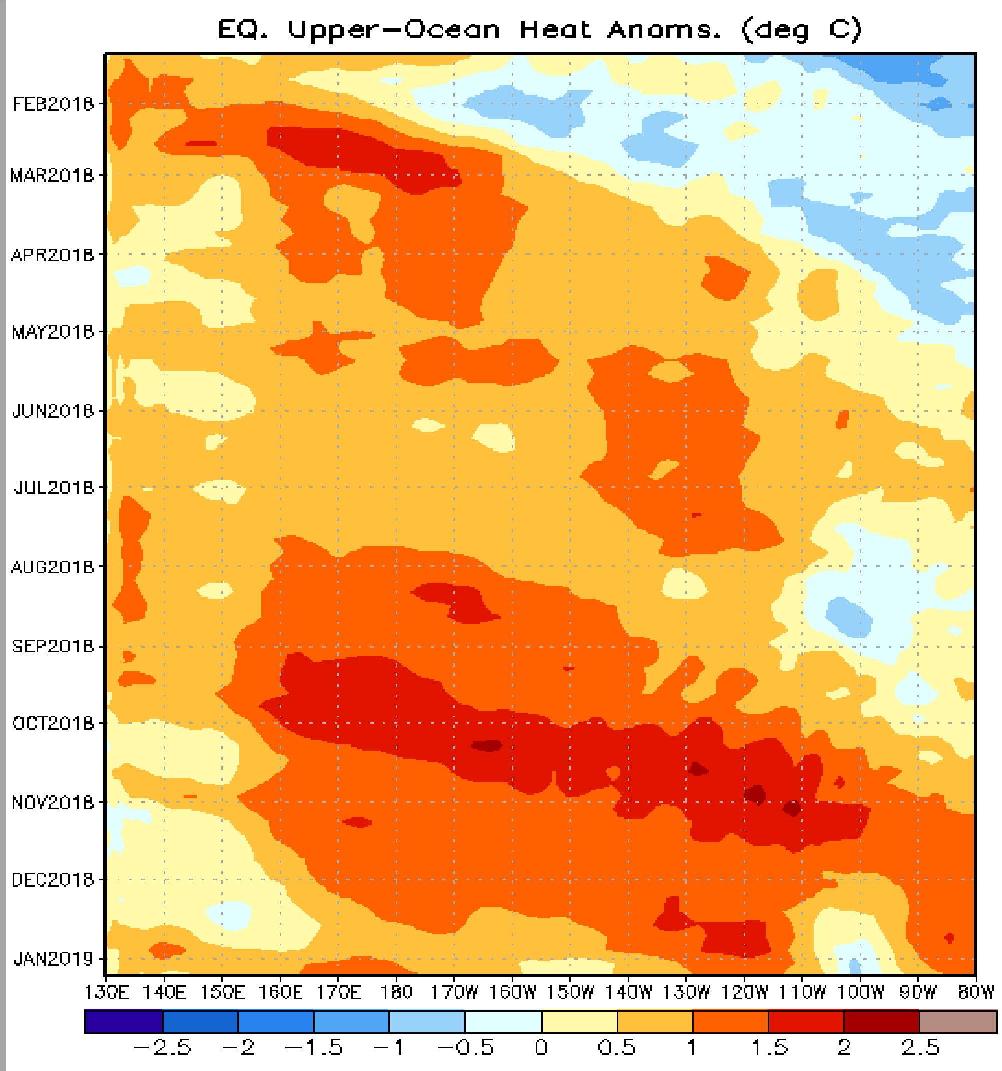
Weekly Heat Content Evolution in the Equatorial Pacific

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 in the central and eastern Pacific at the start of 2018. A downwelling Kelvin wave associated with the intraseasonal signal weakened the negative anomalies across the east-central Pacific during late January and early February.

Several downwelling oceanic Kelvin waves contributed to the eastward expansion of relatively warm subsurface water during February. 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 have decreased in magnitude over much of the Pacific recently.



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

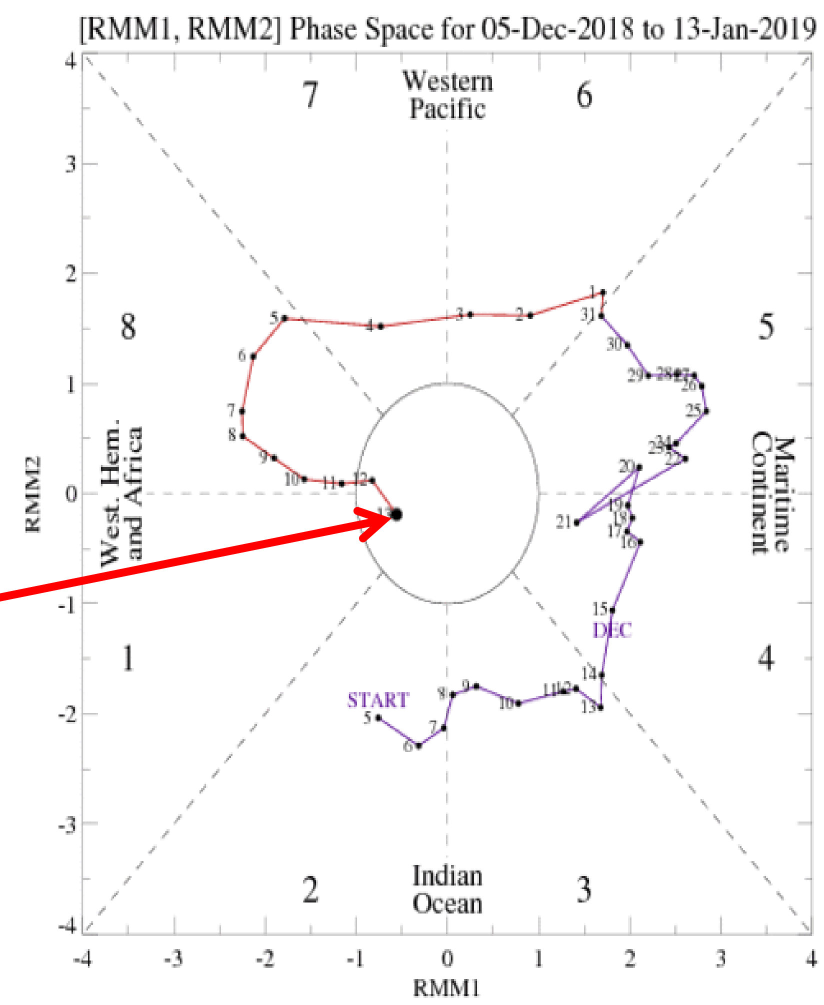
The triangular areas indicate the location of the enhanced phase of the MJO

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

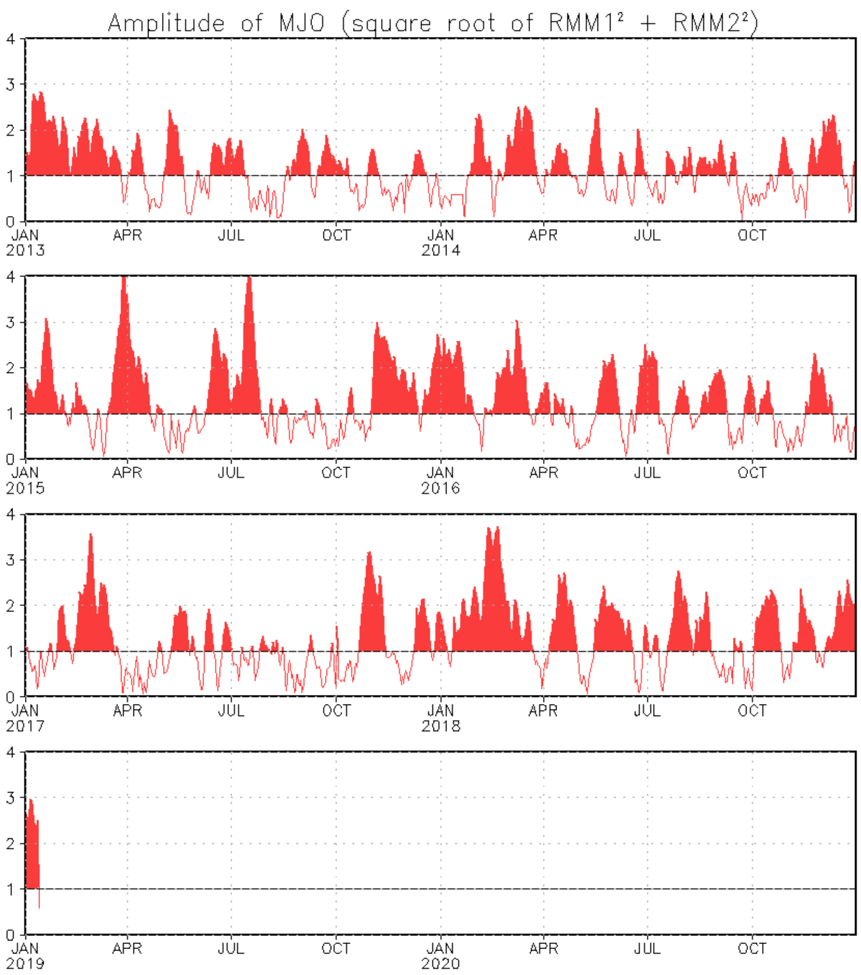
Over the past week, the MJO signal has seen a rapid decline and stall of eastward propagation on the RMM index as it continued over the Pacific toward the Western Hemisphere. This slowdown was likely influenced by Rossby wave activity.



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.



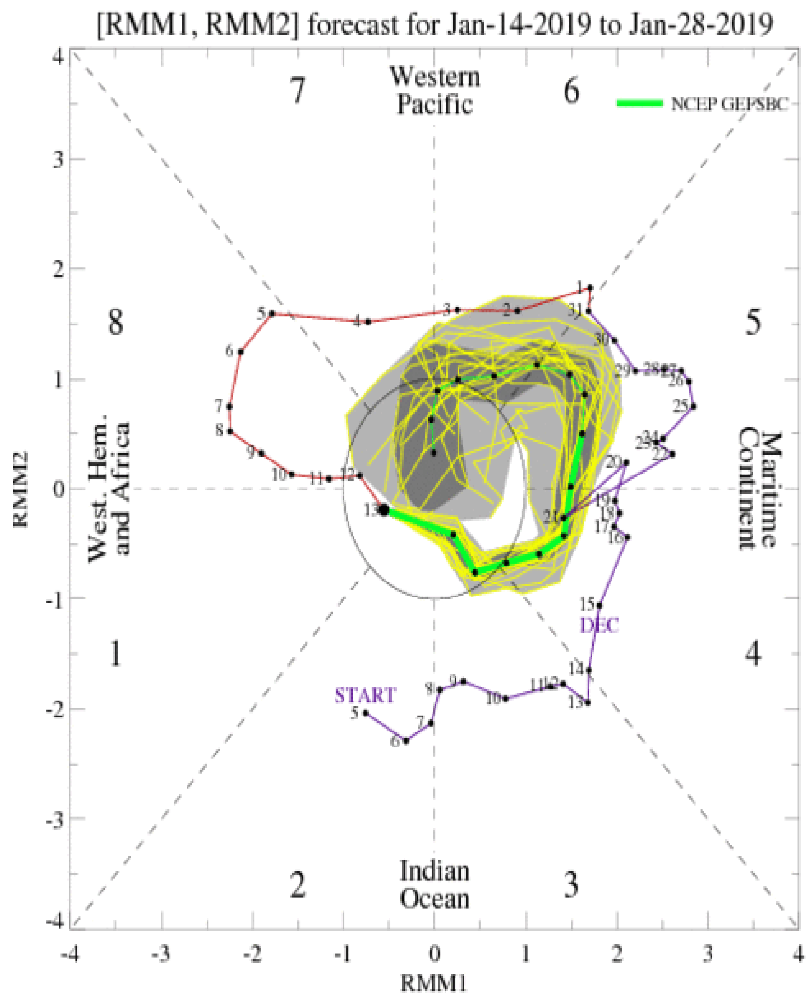
GFS Ensemble (GEFS) MJO Forecast

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

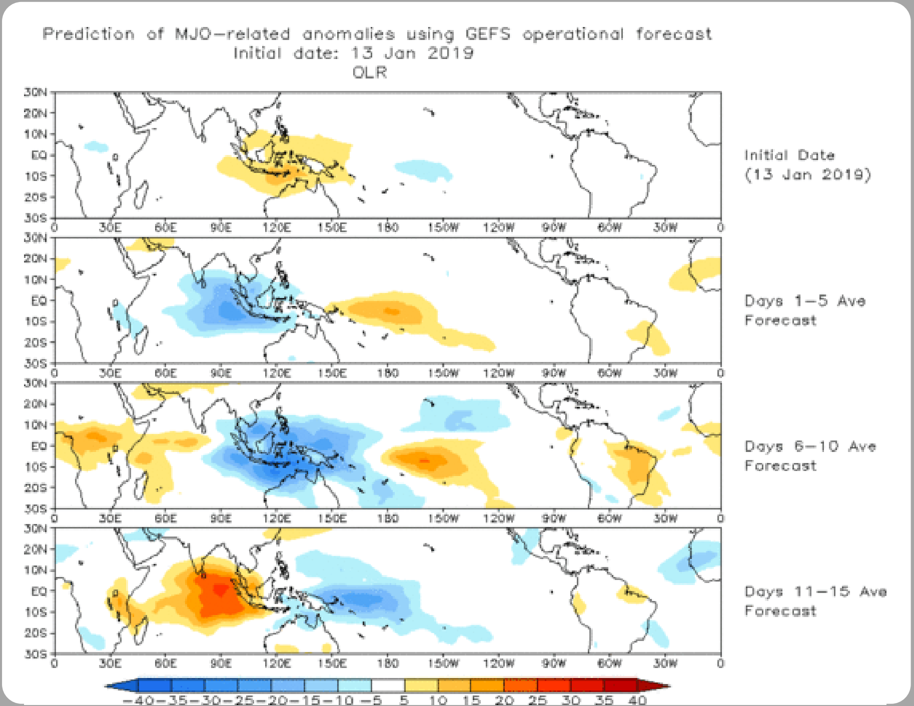


The GEFS forecasts the MJO to continue weak eastward propagation through the unit circle, with re-emergence over the Indian Ocean or Maritime Continent in Week-1. During Week-2, propagation toward the Western Pacific is forecast, where the signal is expected to again decay. Moderate ensemble spread indicates that the amplitude for the re-emergence is likely to be weaker than the past month's MJO activity.

Ensemble GFS (GEFS) MJO Forecast

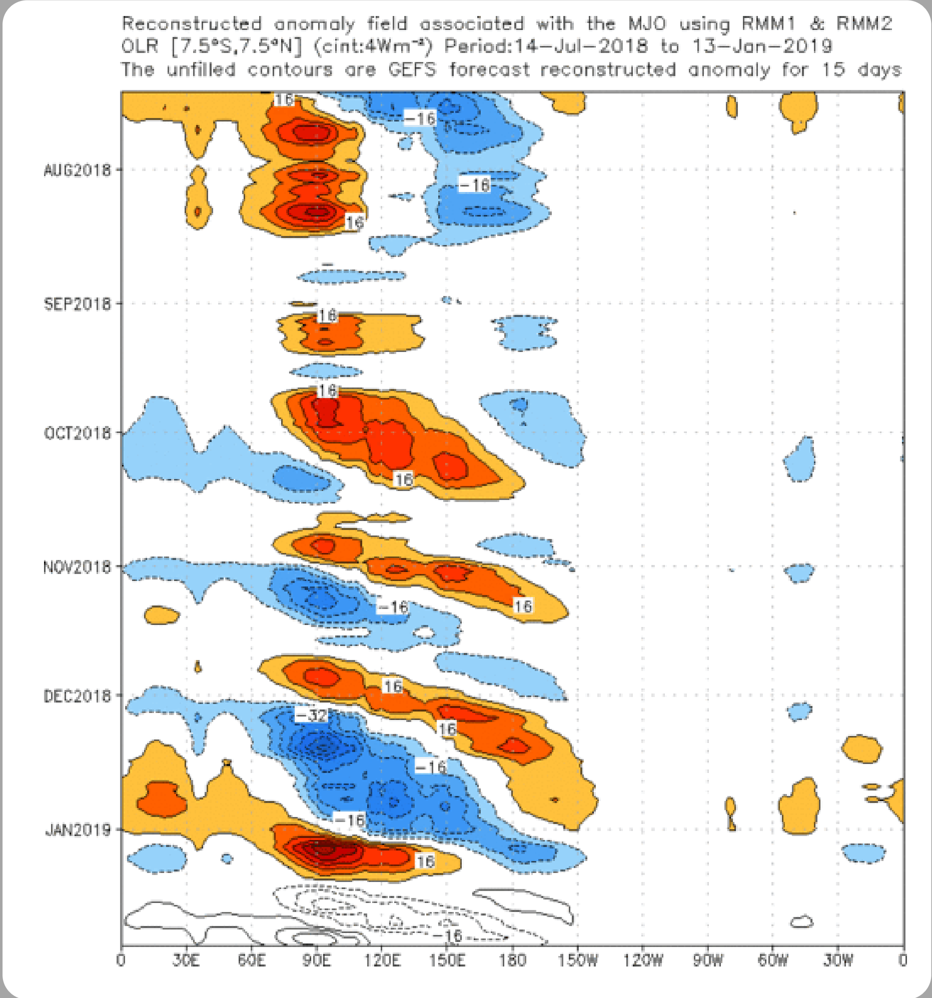
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



OLR anomalies based on the GEFS RMM-index forecast depict MJO-related convection strengthening over the Indian Ocean and Maritime Continent in Week-1, with propagation eastward over the Western Pacific in Week-2.

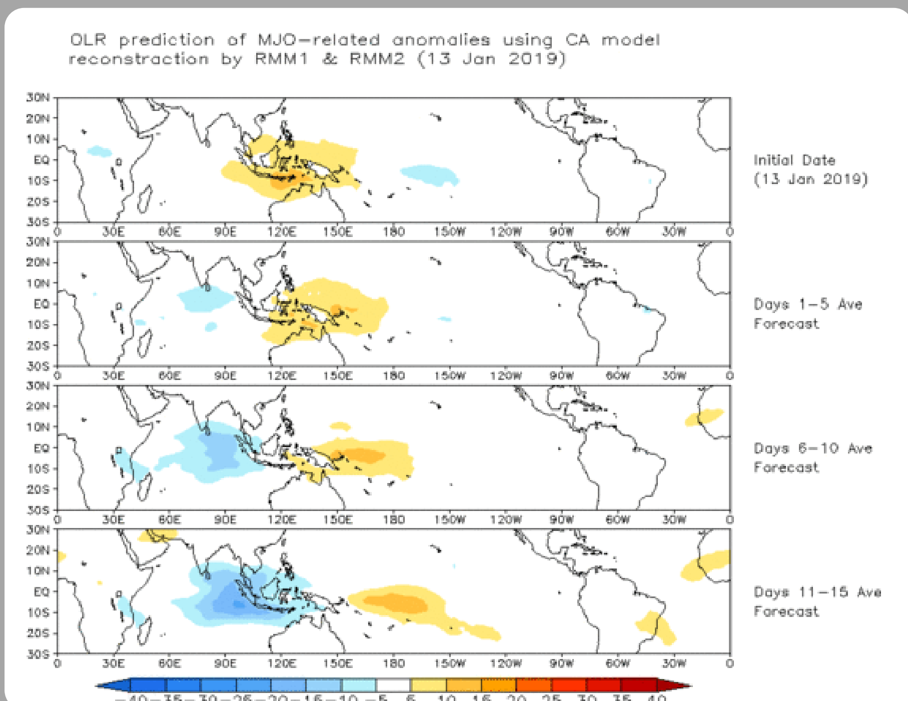
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



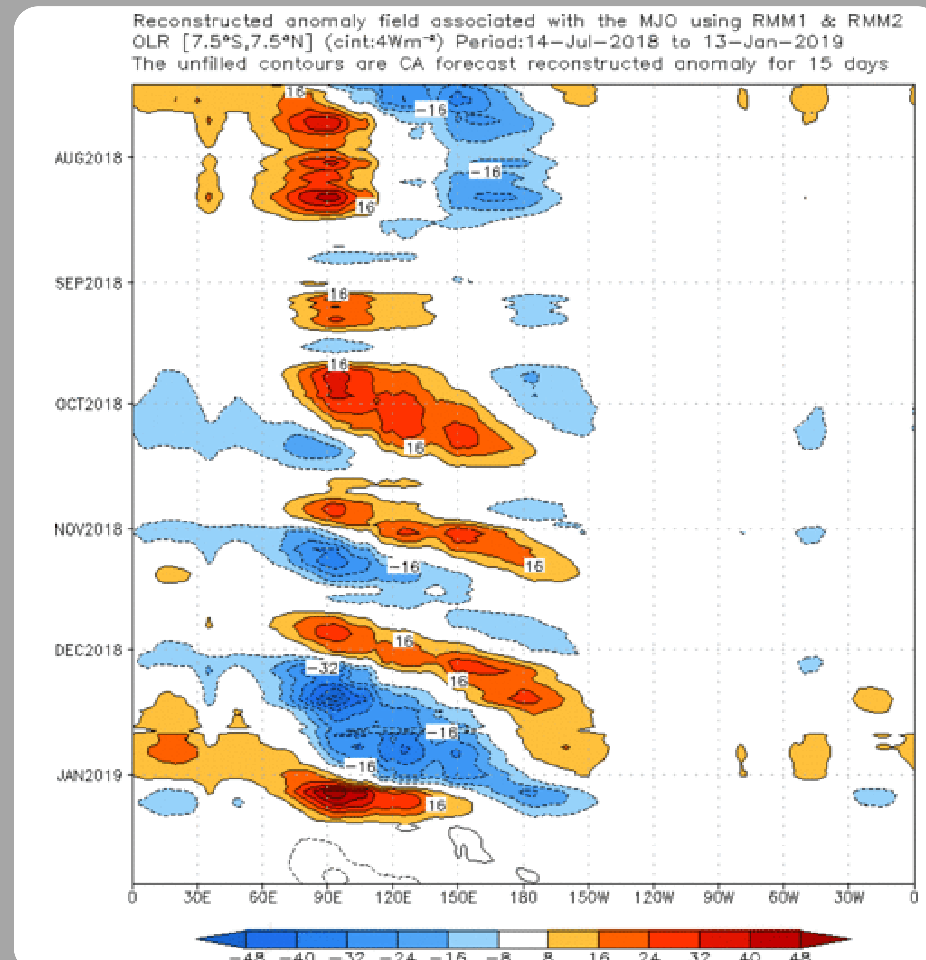
Constructed Analog (CA) MJO Forecast

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



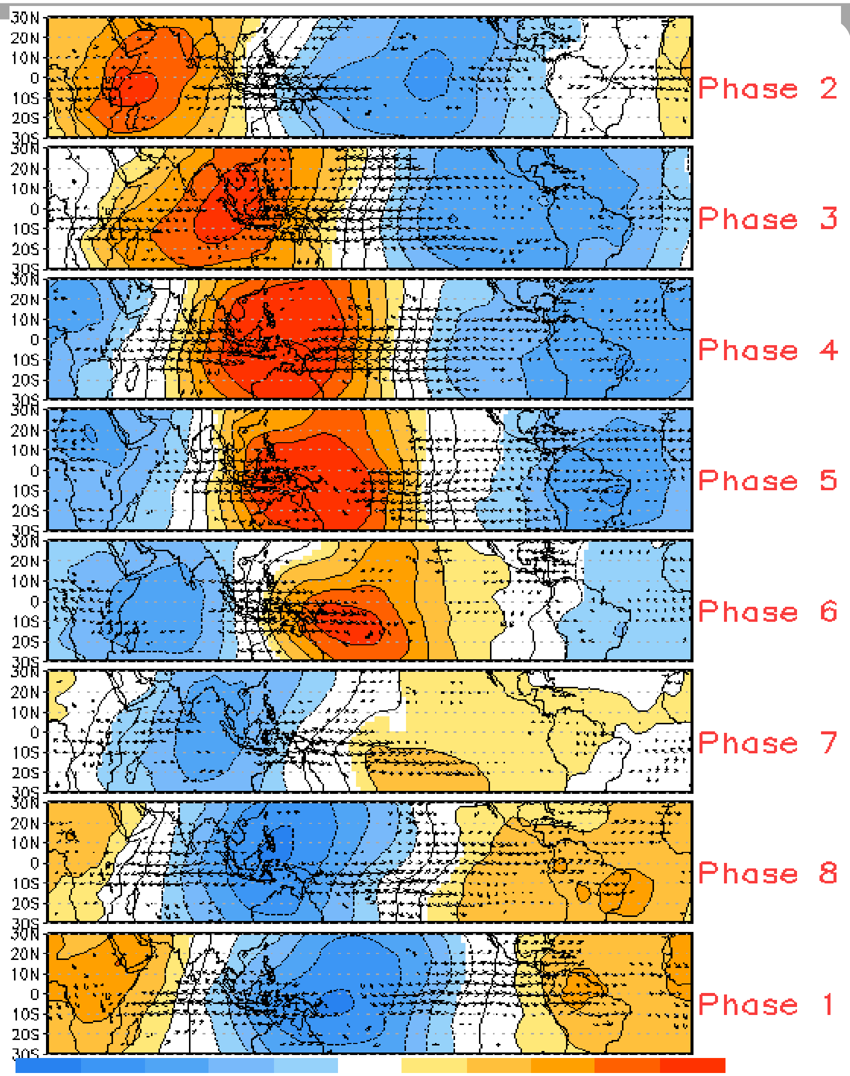
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



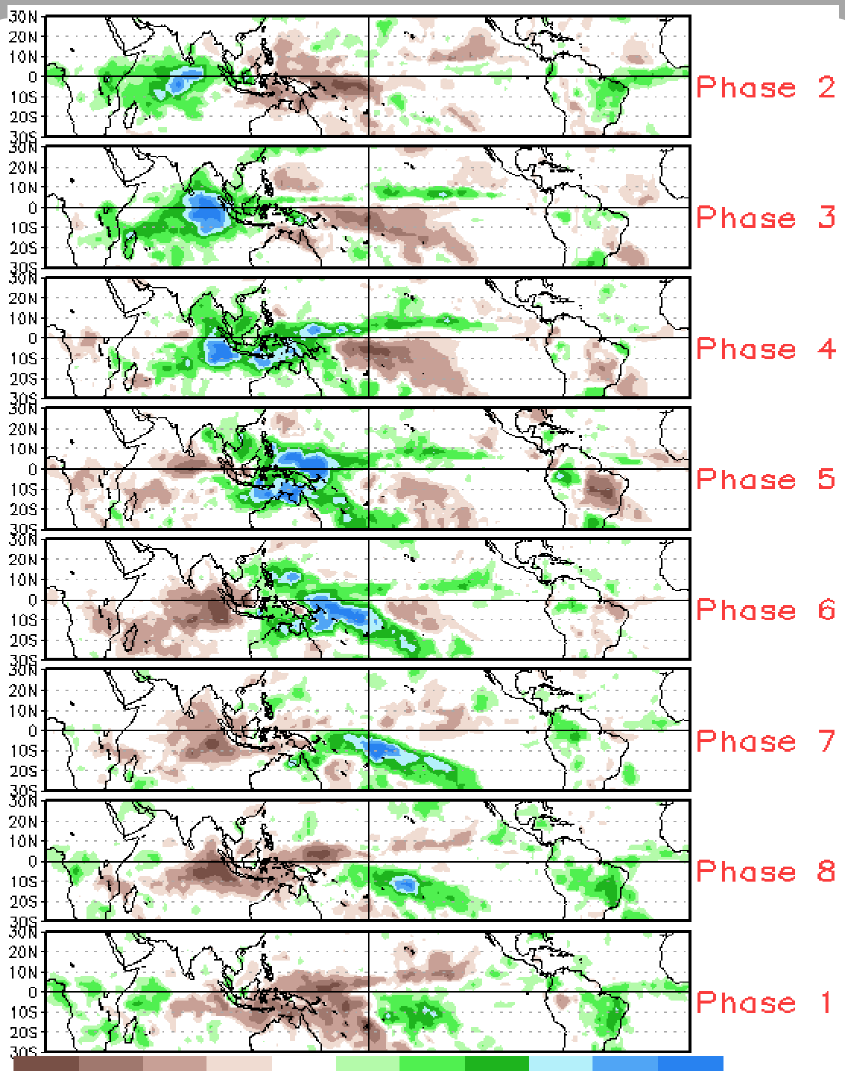
The constructed analog forecast also depicts MJO-related convection over Indian Ocean for Week-1. OLR anomalies are weaker though than in dynamical guidance, and the speed of the signal is much slower, with it reaching the Maritime Continent in Week-2.

MJO Composites - Global Tropics

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



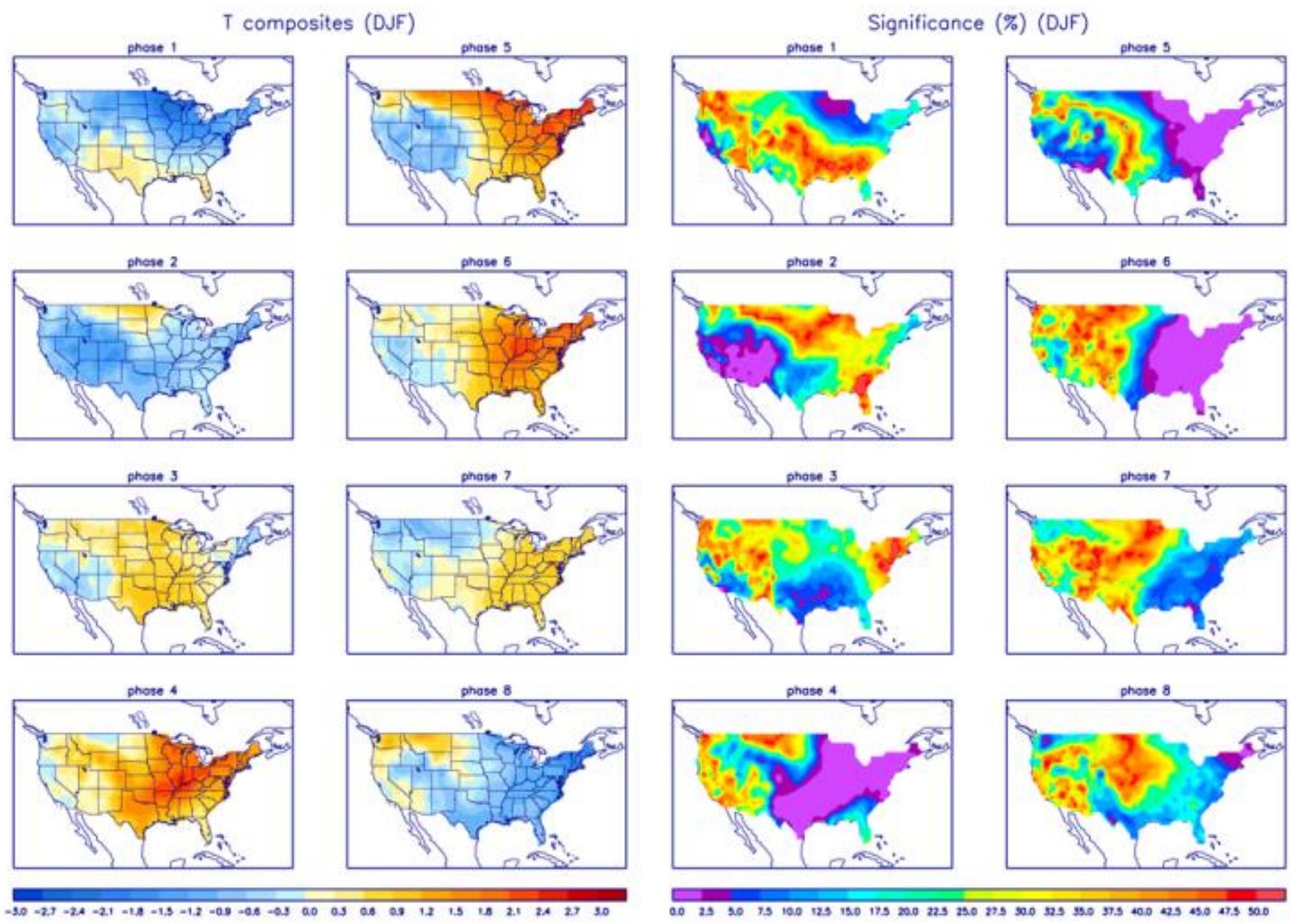
Precipitation Anomalies (Nov - Mar)



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.



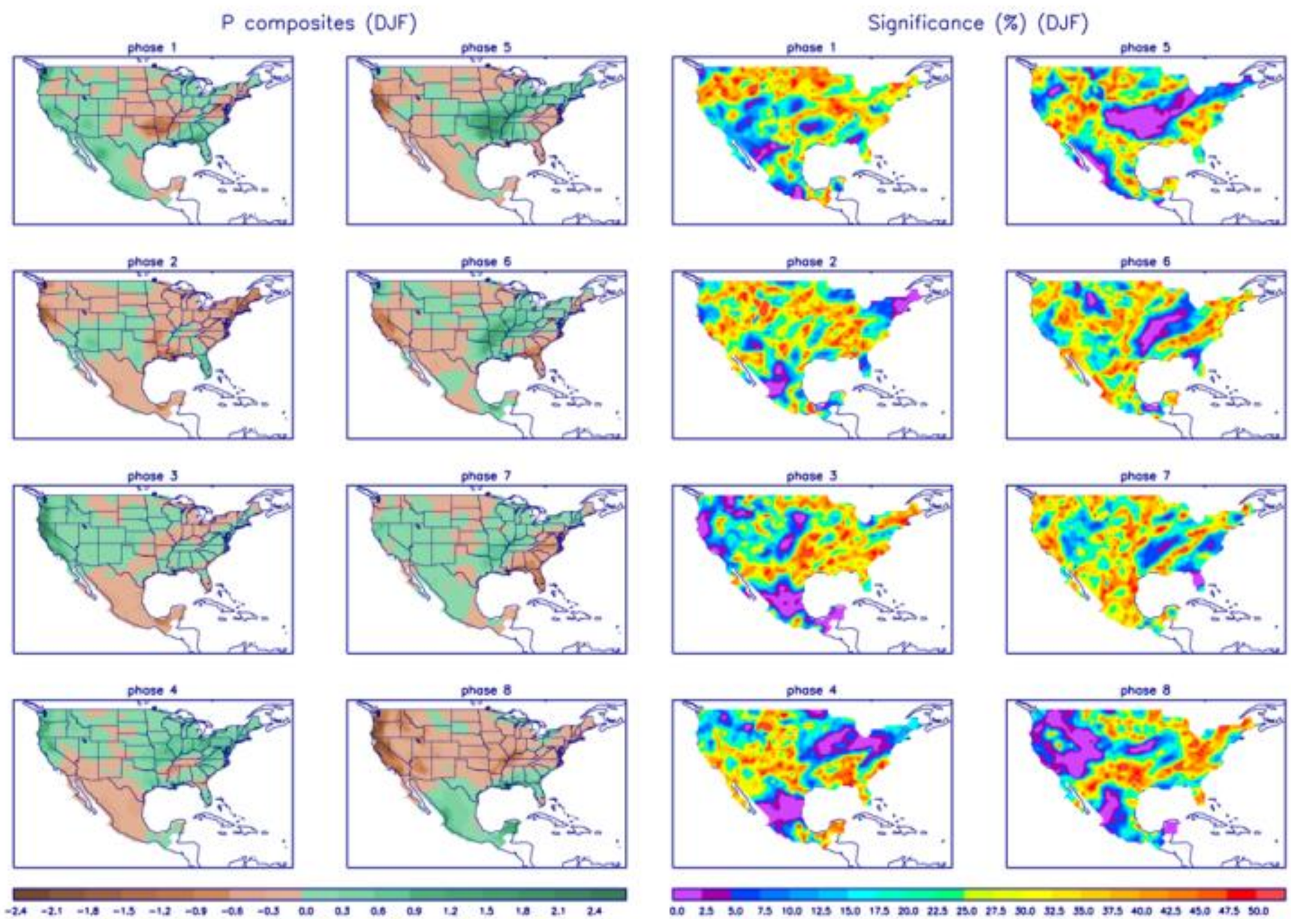
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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