

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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Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The MJO remains active, with the enhanced phase over the Maritime Continent and the suppressed phase over the Pacific.
- The MJO is currently constructively interfering with the La Niña base state, with an observed increase in the extent, amplitude, and organization of OLR and upper-level velocity potential anomalies.
- Dynamical and statistical models strongly support continued MJO activity, with the enhanced phase propagating from the Maritime Continent to the West Pacific over the next two weeks.
- Other modes of tropical variability, including Rossby waves or developing tropical cyclones, may modulate the amplitude and phase speed of the overall MJO envelope.
- Recent MJO activity teleconnects well with the current extratropical pattern over the CONUS. If a robust West Pacific MJO event occurs, the extratropical response may favor a transition to a colder pattern for the central and eastern U.S. during 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})

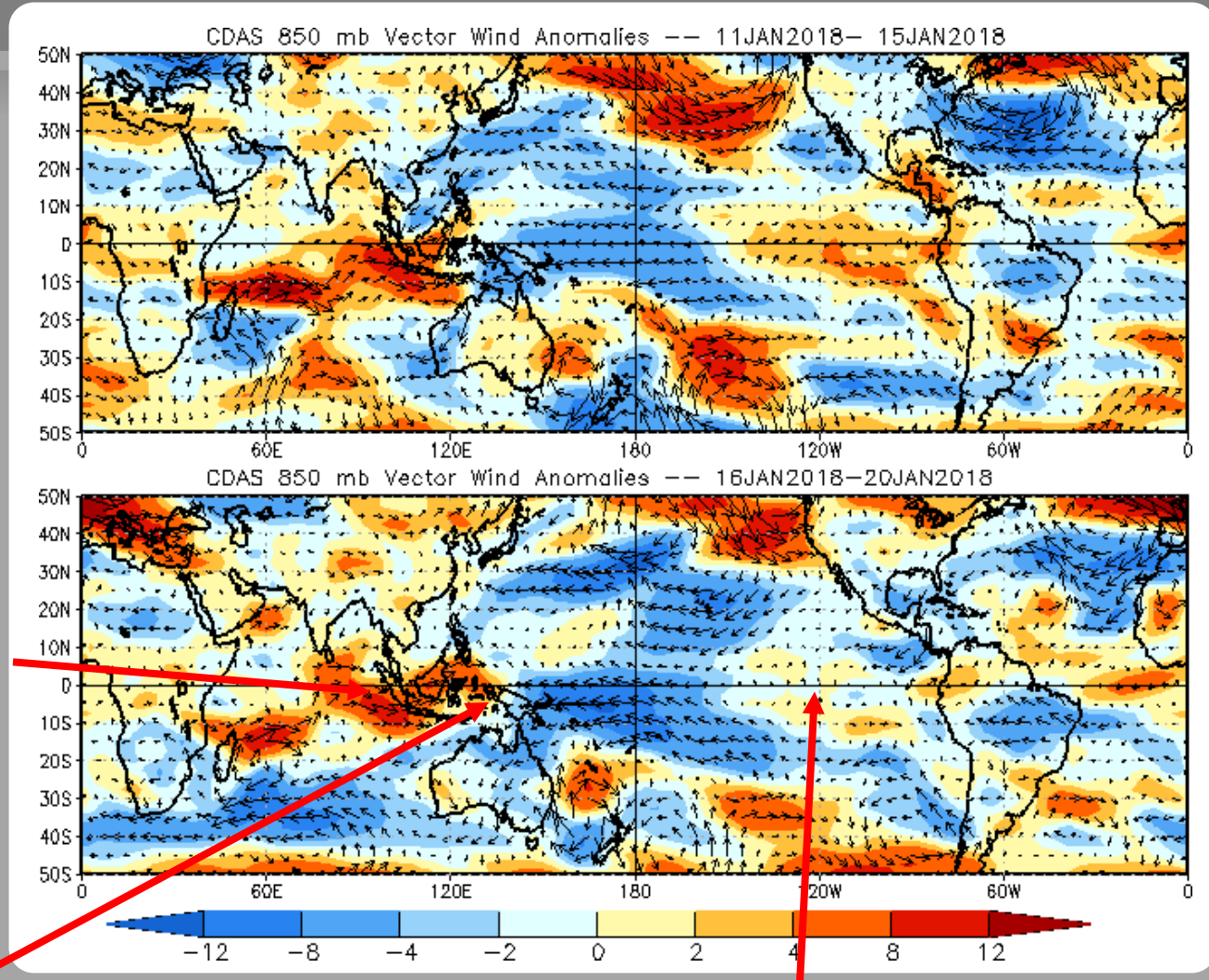
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

A robust couplet of westerly and easterly anomalies propagated slowly eastward over the Maritime Continent, consistent with MJO activity

The MJO is constructively interfering with the La Niña base state, resulting in enhanced low-level convergence over the Maritime Continent.



Westerly anomalies weakened over the East Pacific.

850-hPa Zonal Wind Anomalies (m s⁻¹)

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

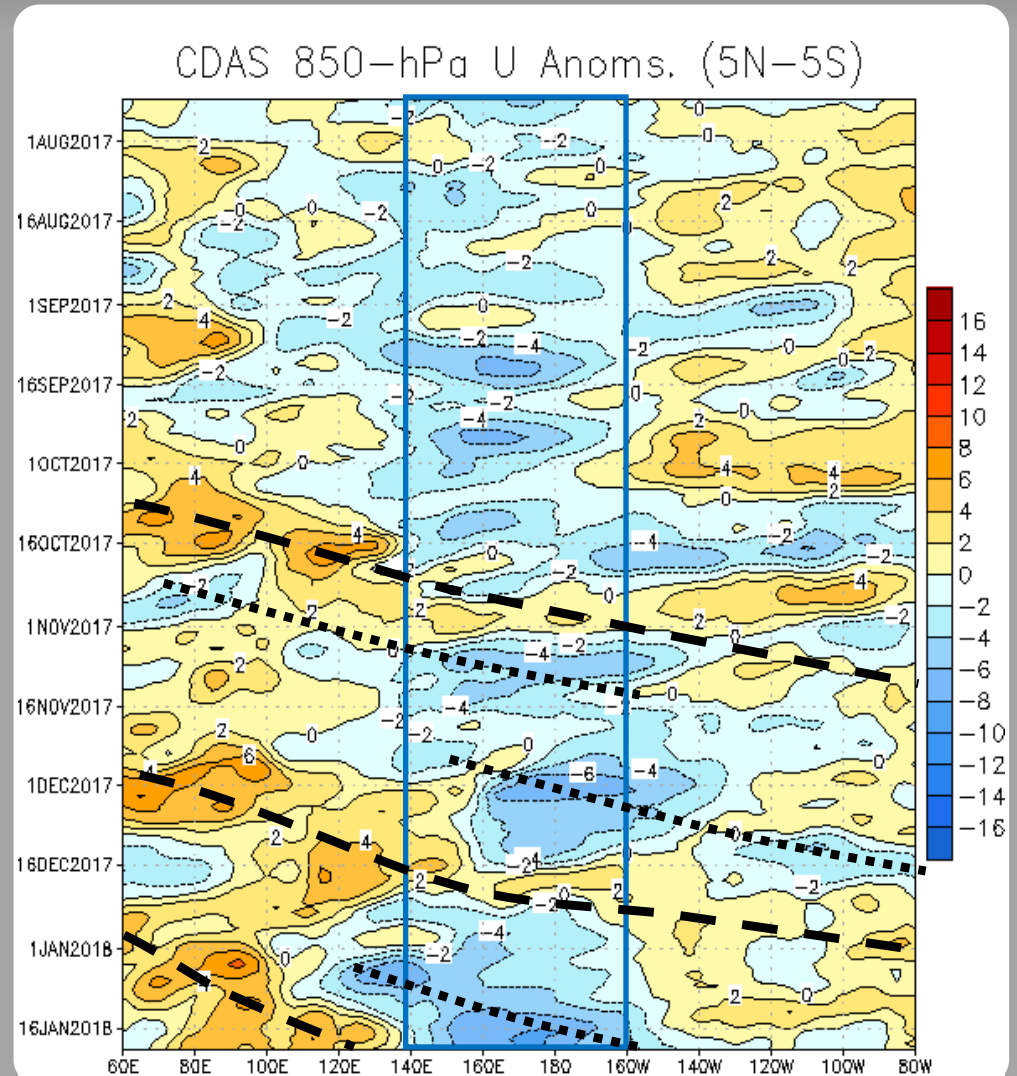
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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 propagated over the Maritime Continent.



OLR Anomalies - Past 30 days

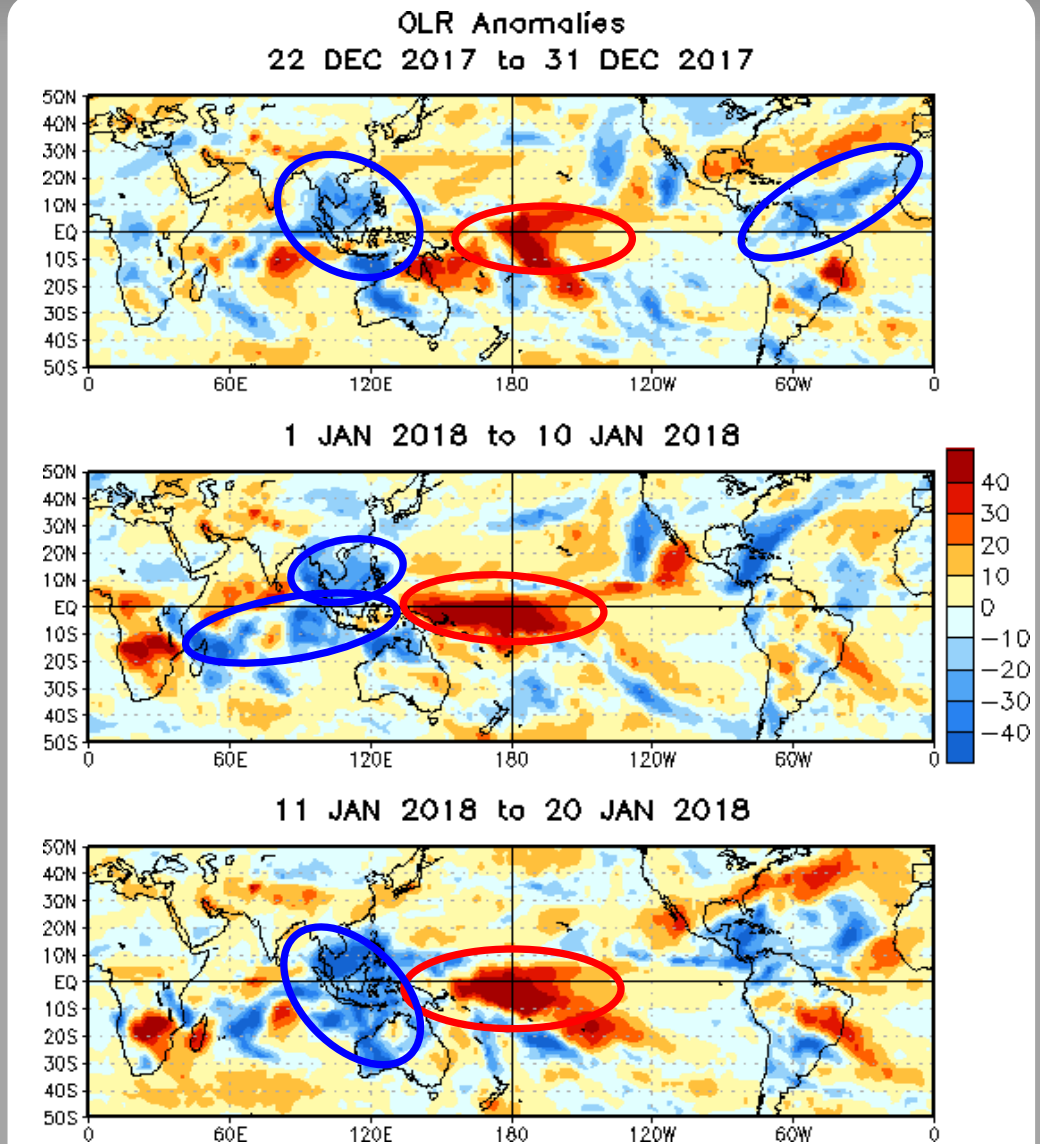
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

In late December, the MJO propagated over the Western Hemisphere, with a characteristic reduction in the convective footprint. Enhanced convection over the Maritime Continent was partly associated with the La Niña base state.

During early January, the MJO emerged over the Indian Ocean, producing some enhanced convection, but less widespread than typically observed during canonical events. Enhanced convection persisted over parts of the Maritime Continent, with strongly suppressed convection over the West Pacific.

During mid-January, the MJO propagated from the Indian Ocean to the Maritime Continent, constructively interfering with the base state. This resulted in widespread enhanced (suppressed) convection over the Maritime Continent (central Pacific).



Outgoing Longwave Radiation (OLR) Anomalies (2.5°S - 17.5° S)

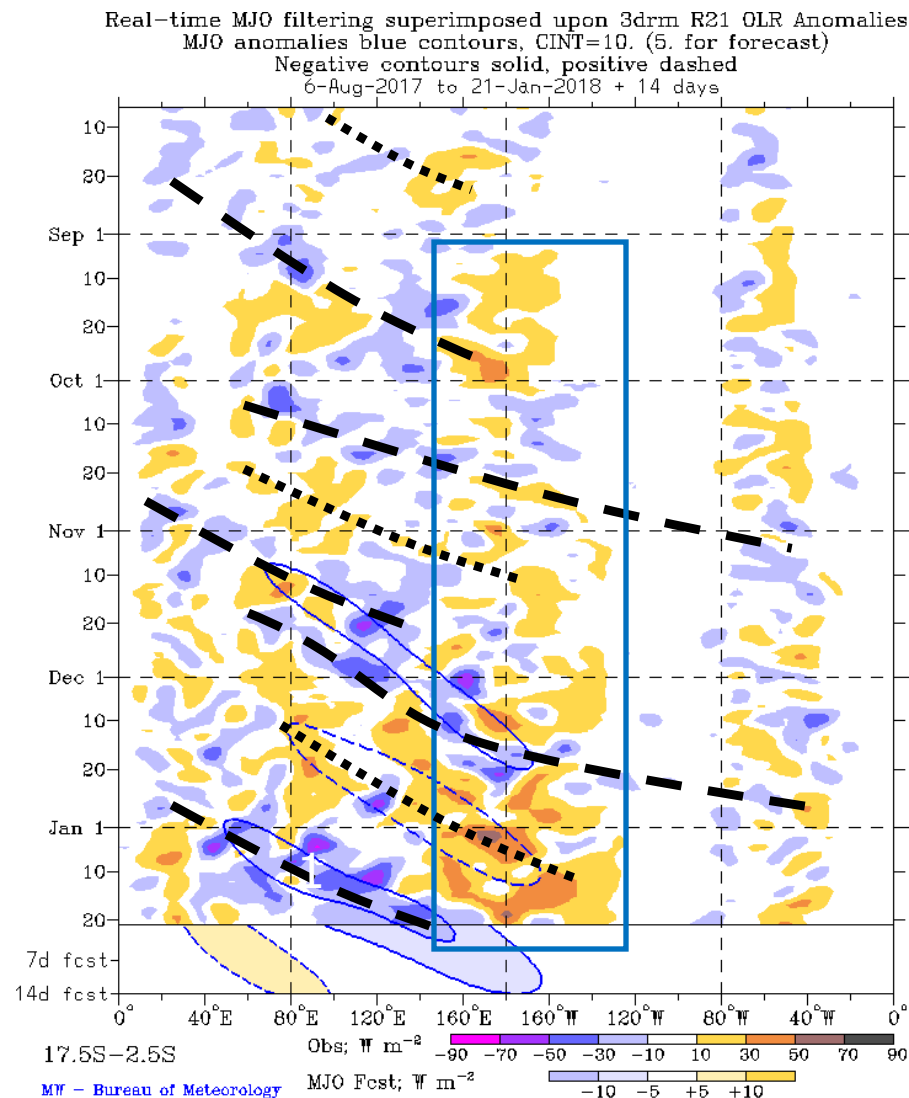
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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 re-emerged in the Indian Ocean at the end of December and strengthened as it shifted east to the Maritime Continent during January.



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

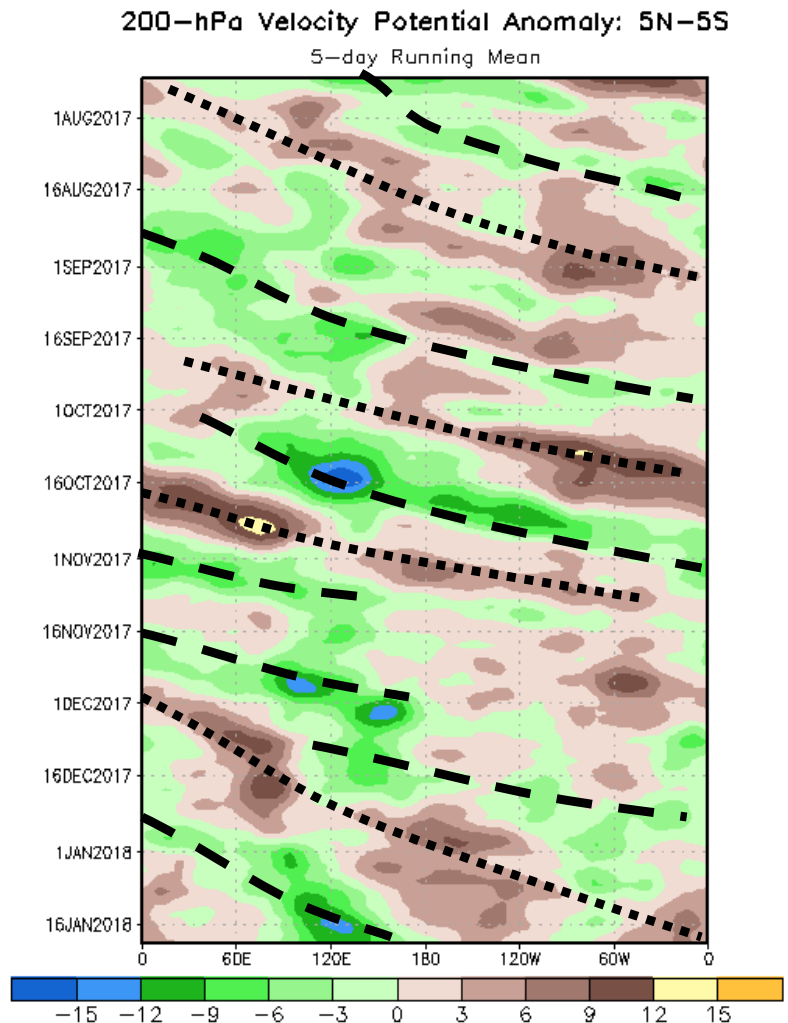
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

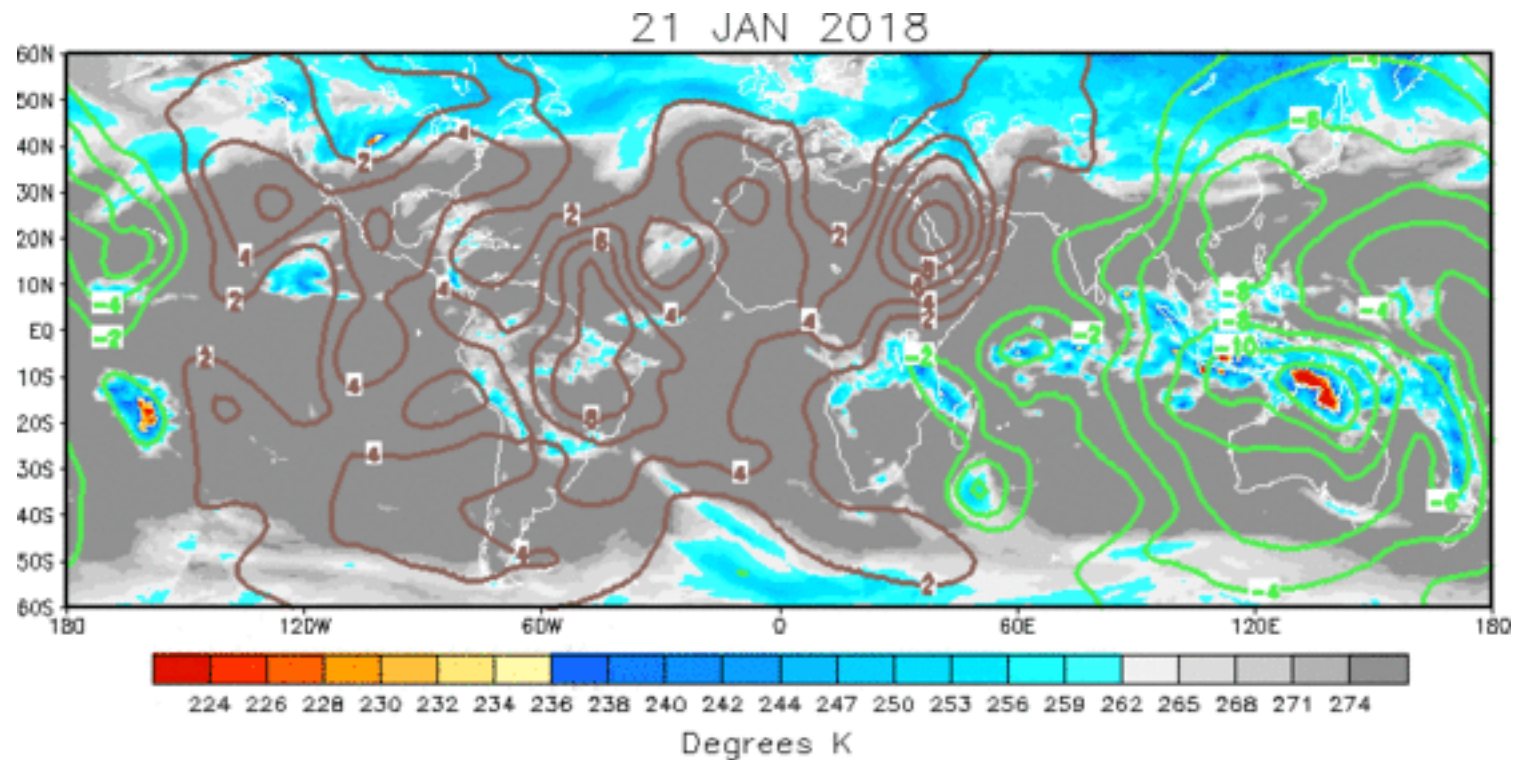
During July, an eastward propagating enhanced convective signal strengthened over the Maritime Continent that was consistent with the MJO. Another signal on the MJO timescale is evident in this field during late August and September.

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



A robust Wave-1 asymmetry remains very apparent in the upper-level circulation pattern, reflecting an organized MJO event. Weaker upper-level VP anomalies over the Pacific may be due to destructive interference between the base state and a Kelvin wave ahead of the main MJO convective envelope.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation

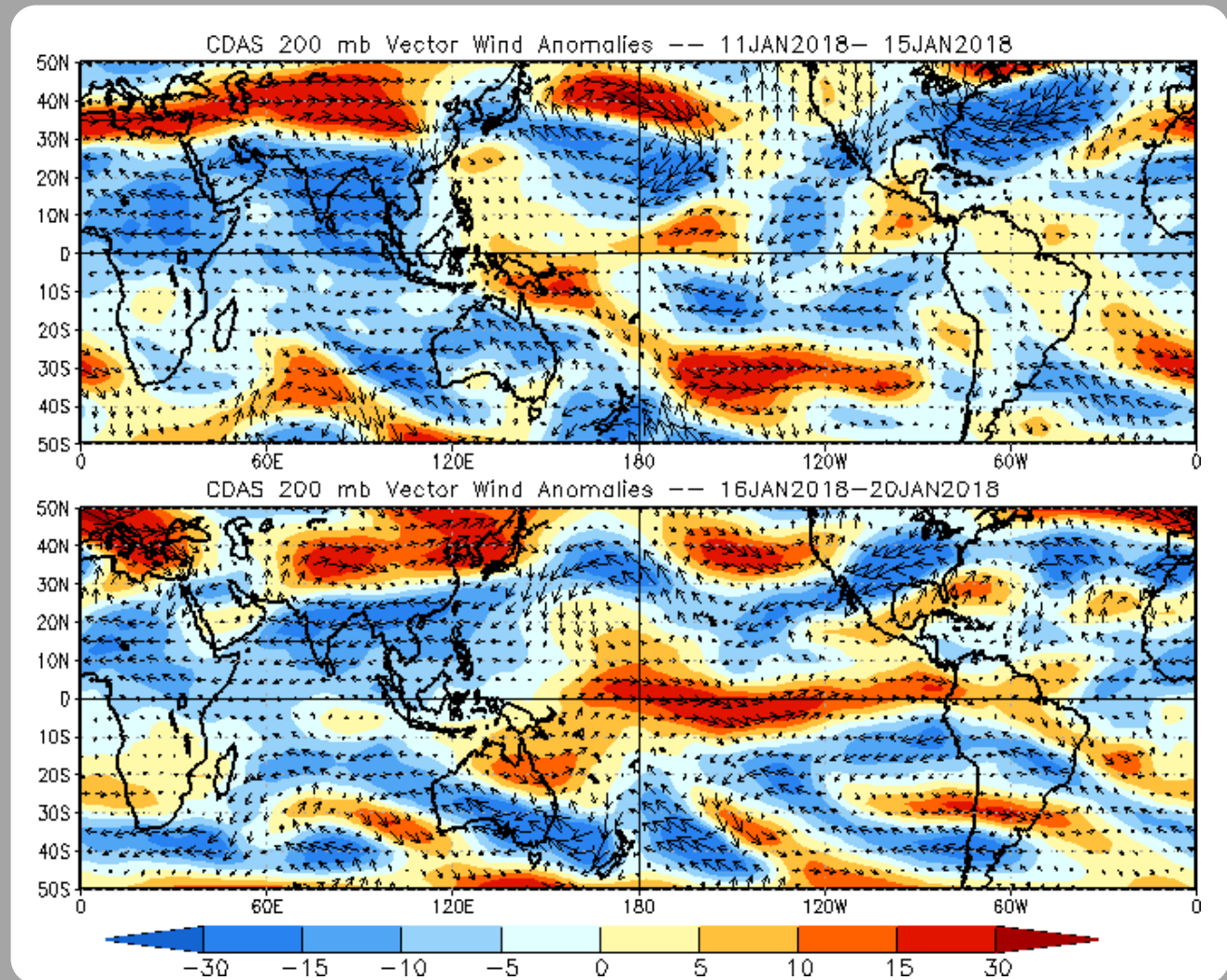
200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Easterly anomalies propagated eastward to the Northwest Pacific, while equatorial westerly anomalies strengthened considerably over the central and eastern Pacific. These patterns are consistent with recent MJO activity and the base state.



200-hPa Zonal Wind Anomalies (m s⁻¹)

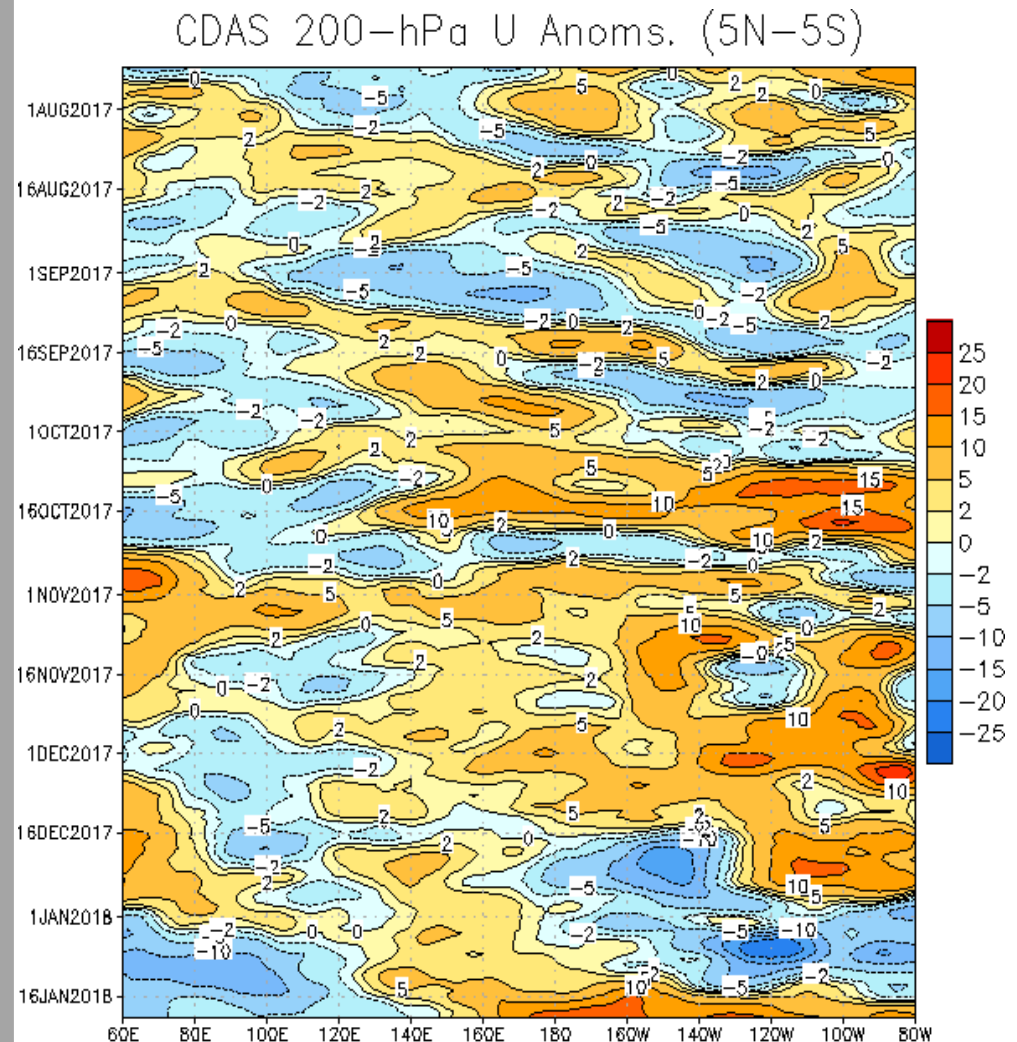
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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.

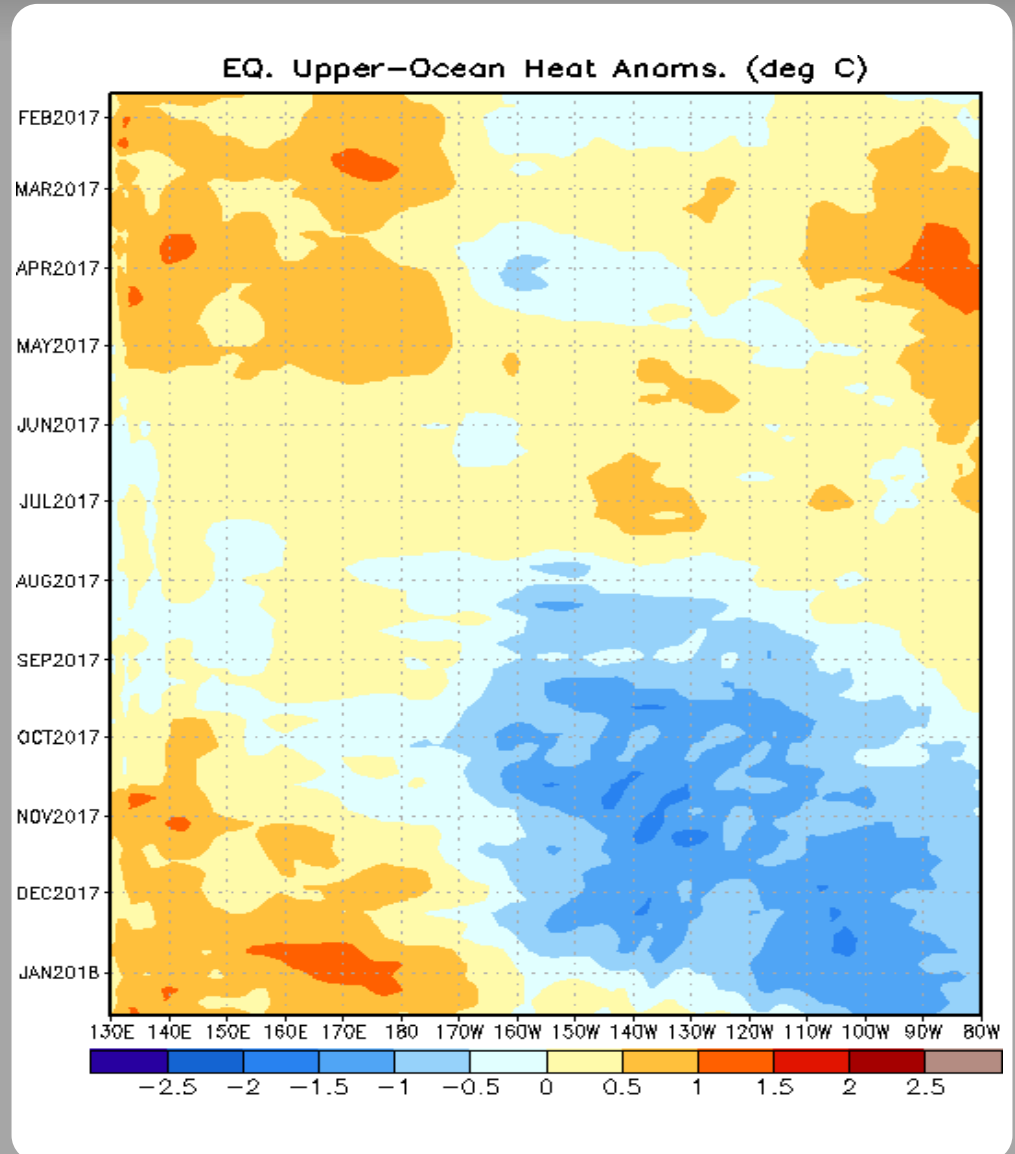
In mid-December, easterly anomalies have developed in the east of the Date Line, replacing the westerly anomalies that had been generally present since October. These anomalies propagated eastward over the past few weeks, and are now over the Maritime Continent. Strong westerly anomalies returned to the central and 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.

A downwelling Kelvin wave associated with the intraseasonal signal has weakened the negative anomalies across the east-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

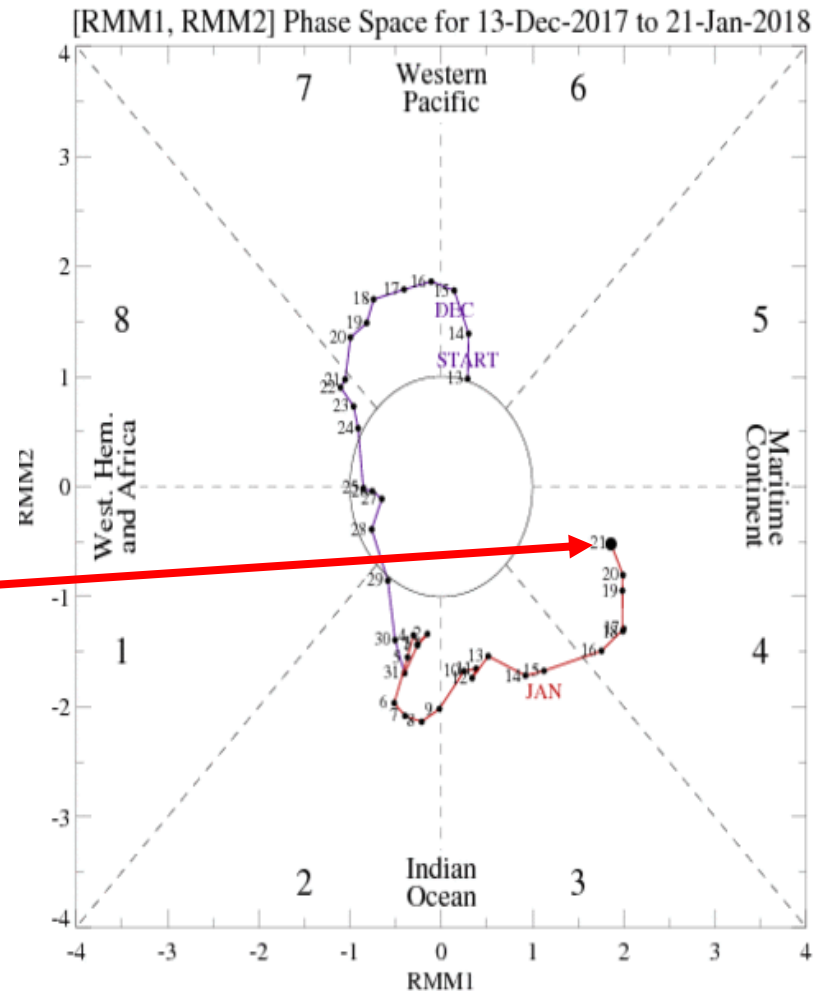
The triangular areas indicate the location of the enhanced phase of the MJO

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

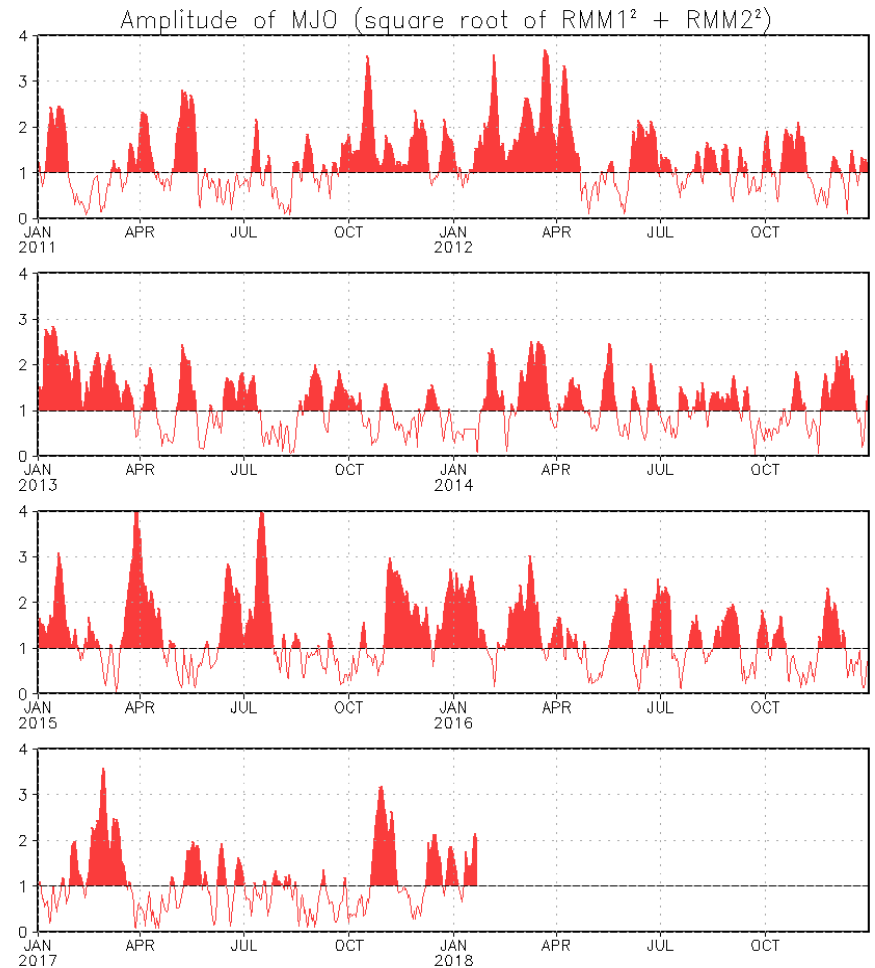
The RMM-based MJO index continues to depict robust MJO activity, with the enhanced phase now over the Maritime Continent.



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

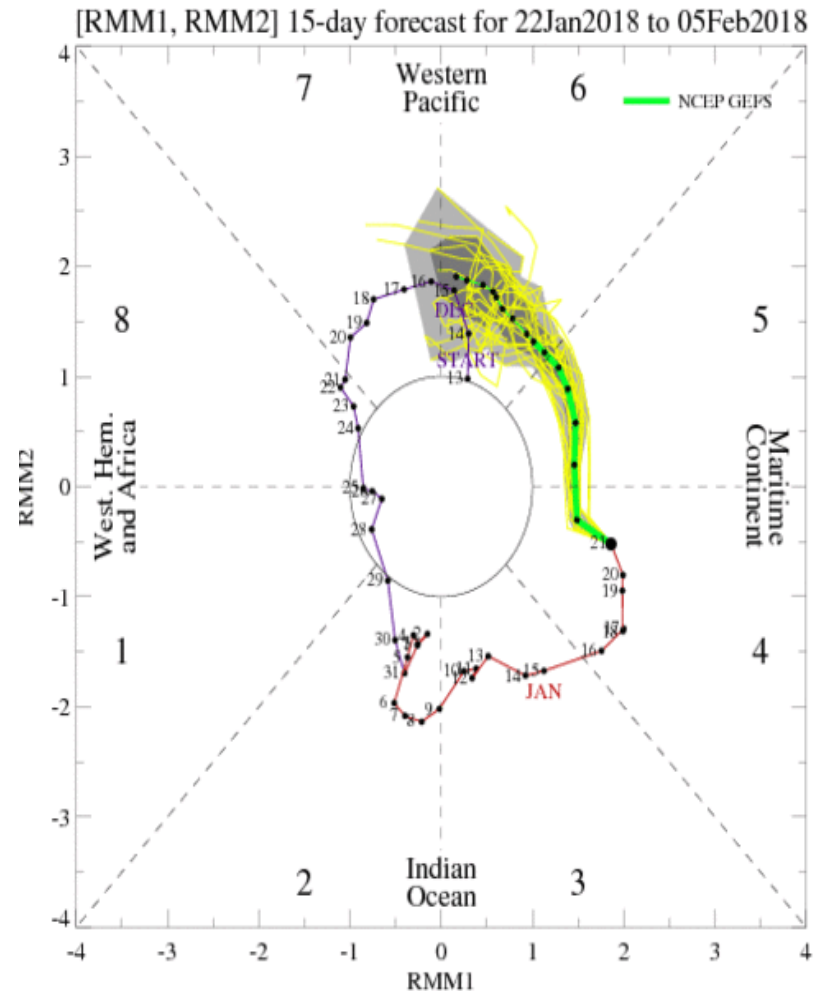
RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GEFS forecast depicts continued robust MJO propagation, with the enhanced phase propagating from the Maritime Continent to the West Pacific over the next two weeks.

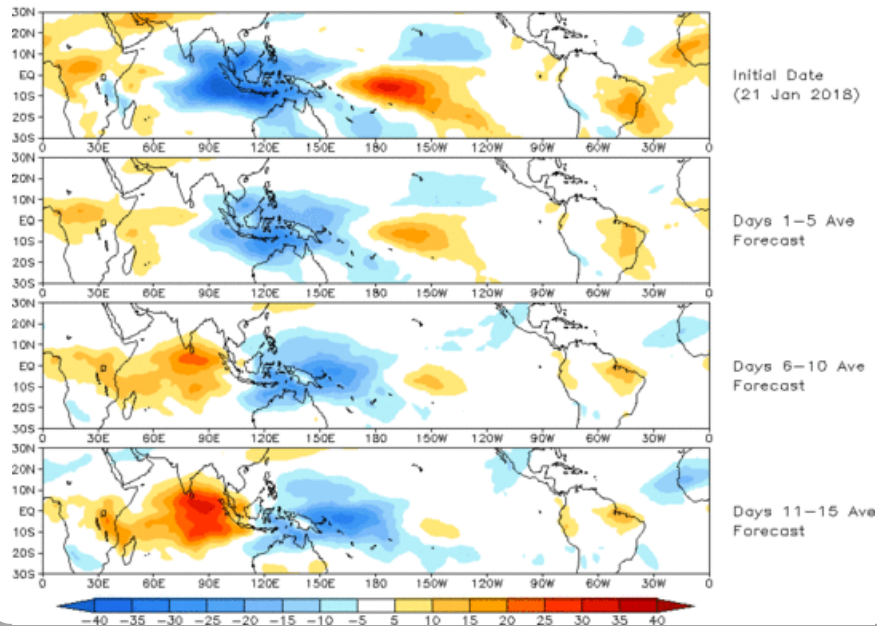
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean



Ensemble GFS (GEFS) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

Prediction of MJO-related anomalies using GEFS operational forecast
Initial date: 21 Jan 2018
OLR

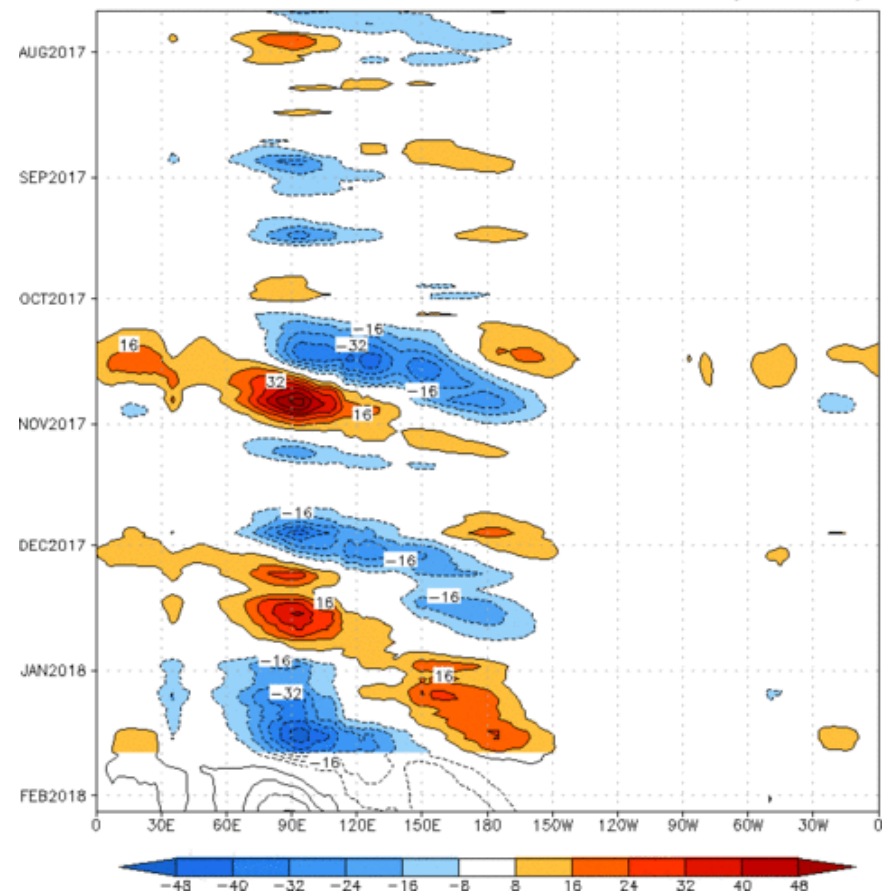


OLR anomalies based on the GEFS are consistent with robust MJO activity, with the enhanced convective footprint over the West Pacific by Week-2.

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.)

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

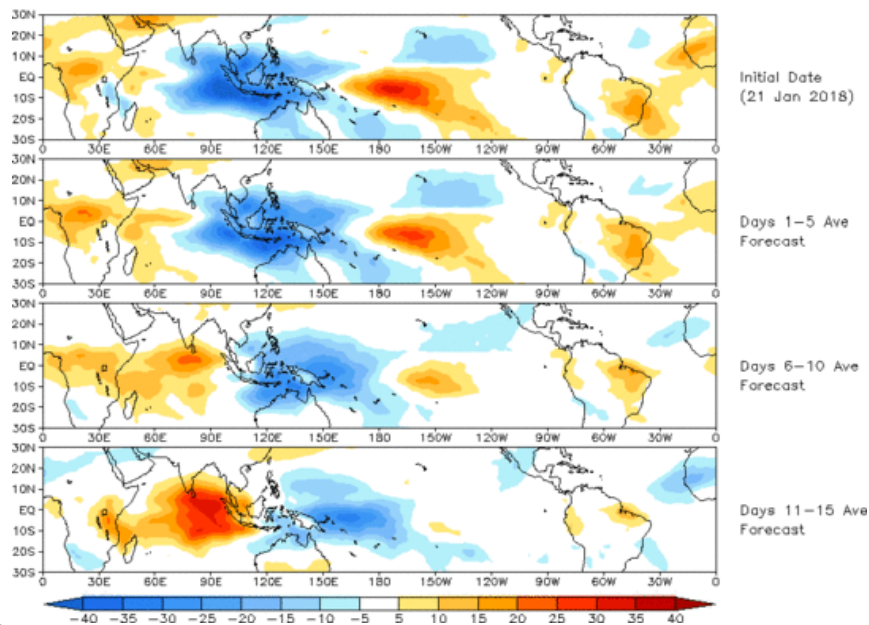
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2
OLR [7.5°S,7.5°N] (cint:4Wm²) Period:22-Jul-2017 to 21-Jan-2018
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days



Constructed Analog (CA) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

OLR prediction of MJO-related anomalies using CA model
reconstruction by RMM1 & RMM2 (21 Jan 2018)

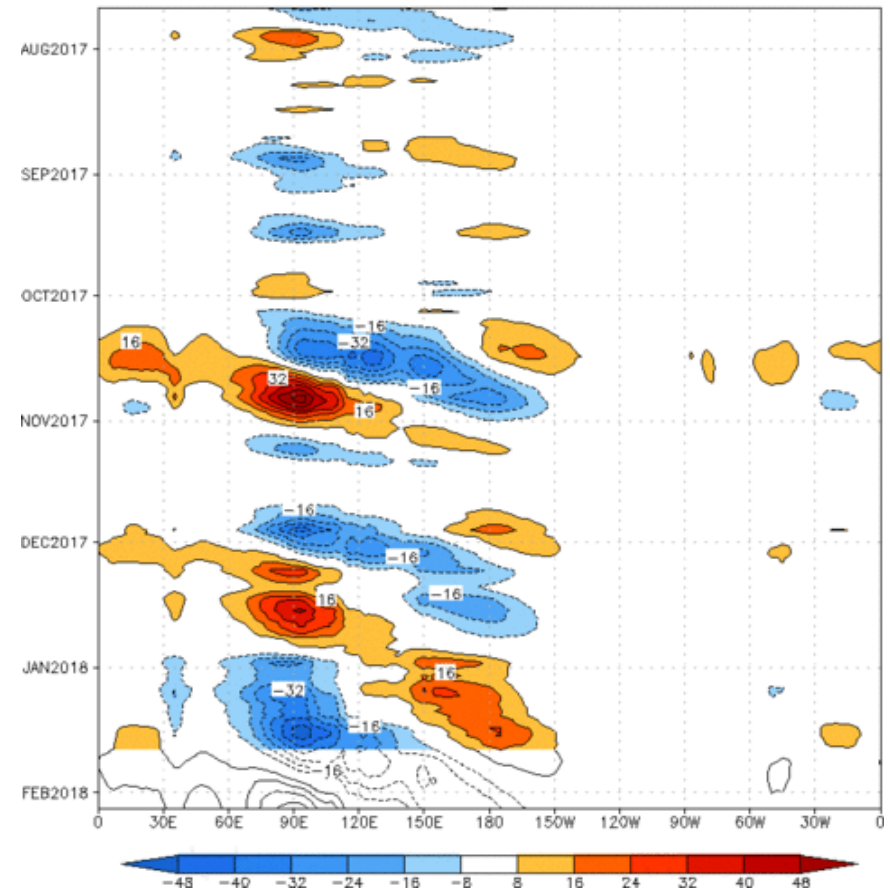


The constructed analog is very similar to the GEFS solution, depicting the MJO enhanced convective envelope propagating from the Maritime Continent to the West Pacific over the next two weeks.

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.)

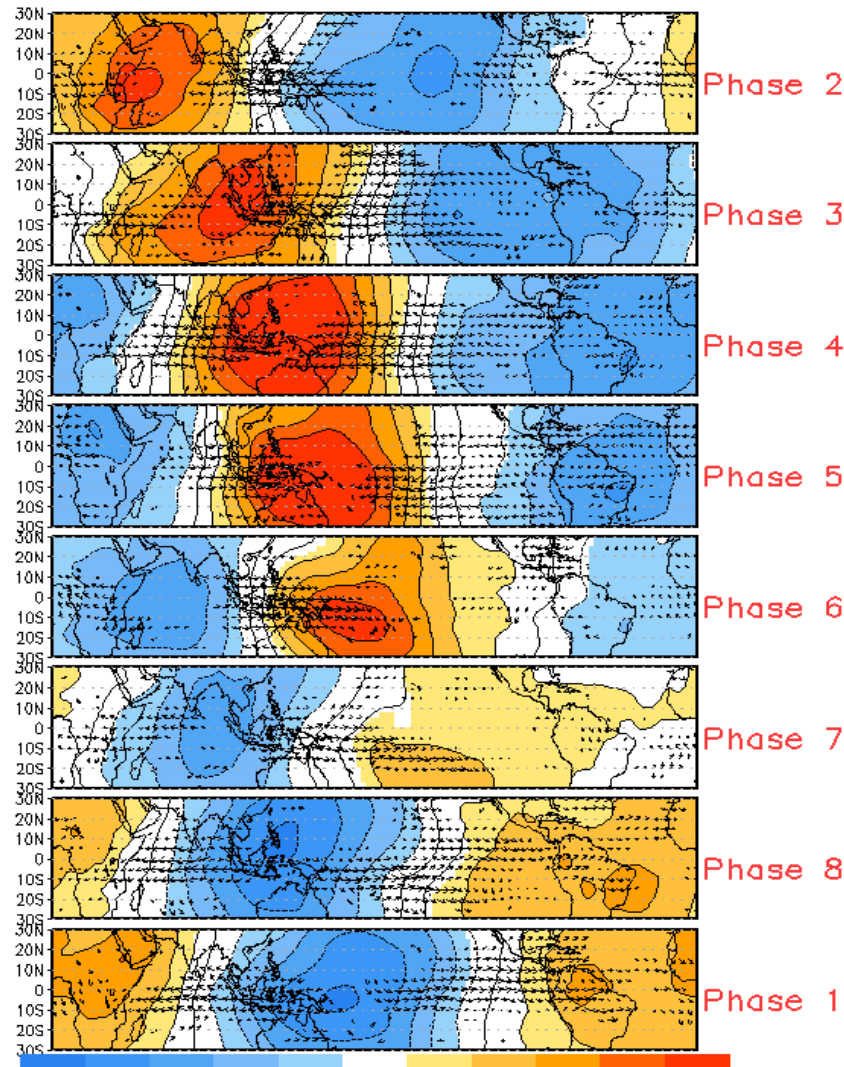
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The unfilled contours are CA forecast reconstructed anomaly for 15 days

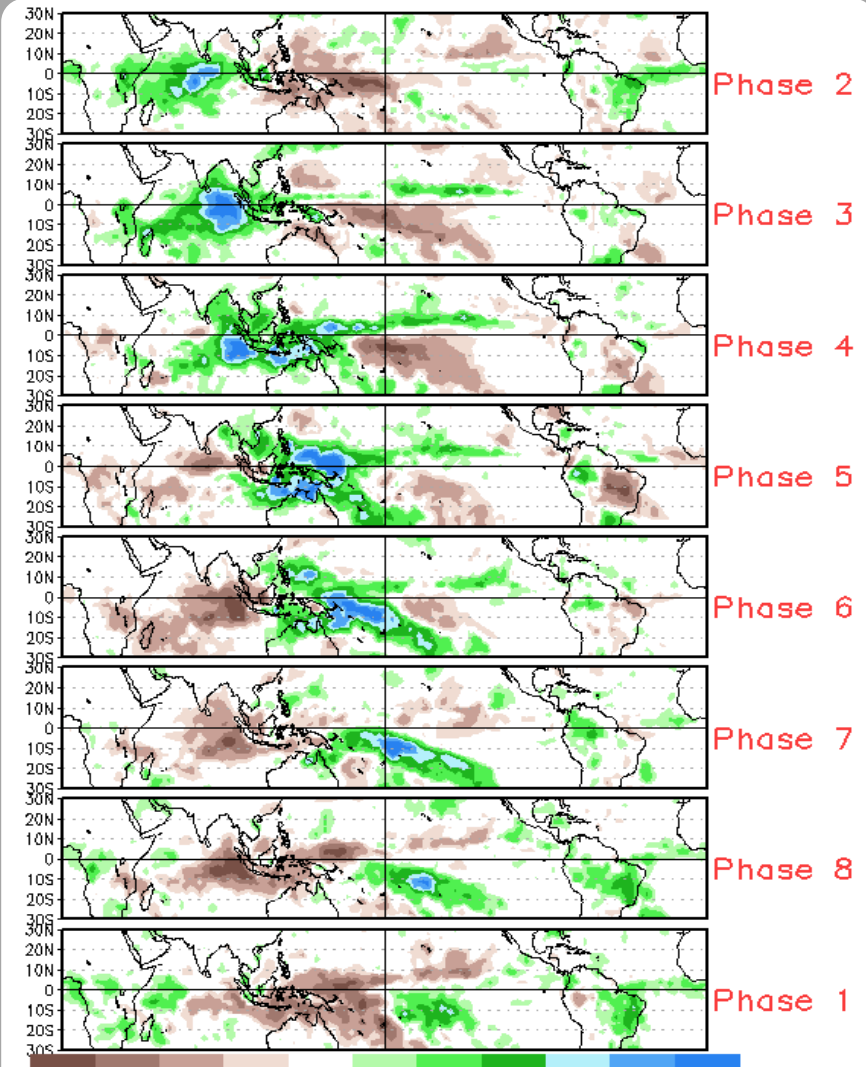


MJO Composites - Global Tropics

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



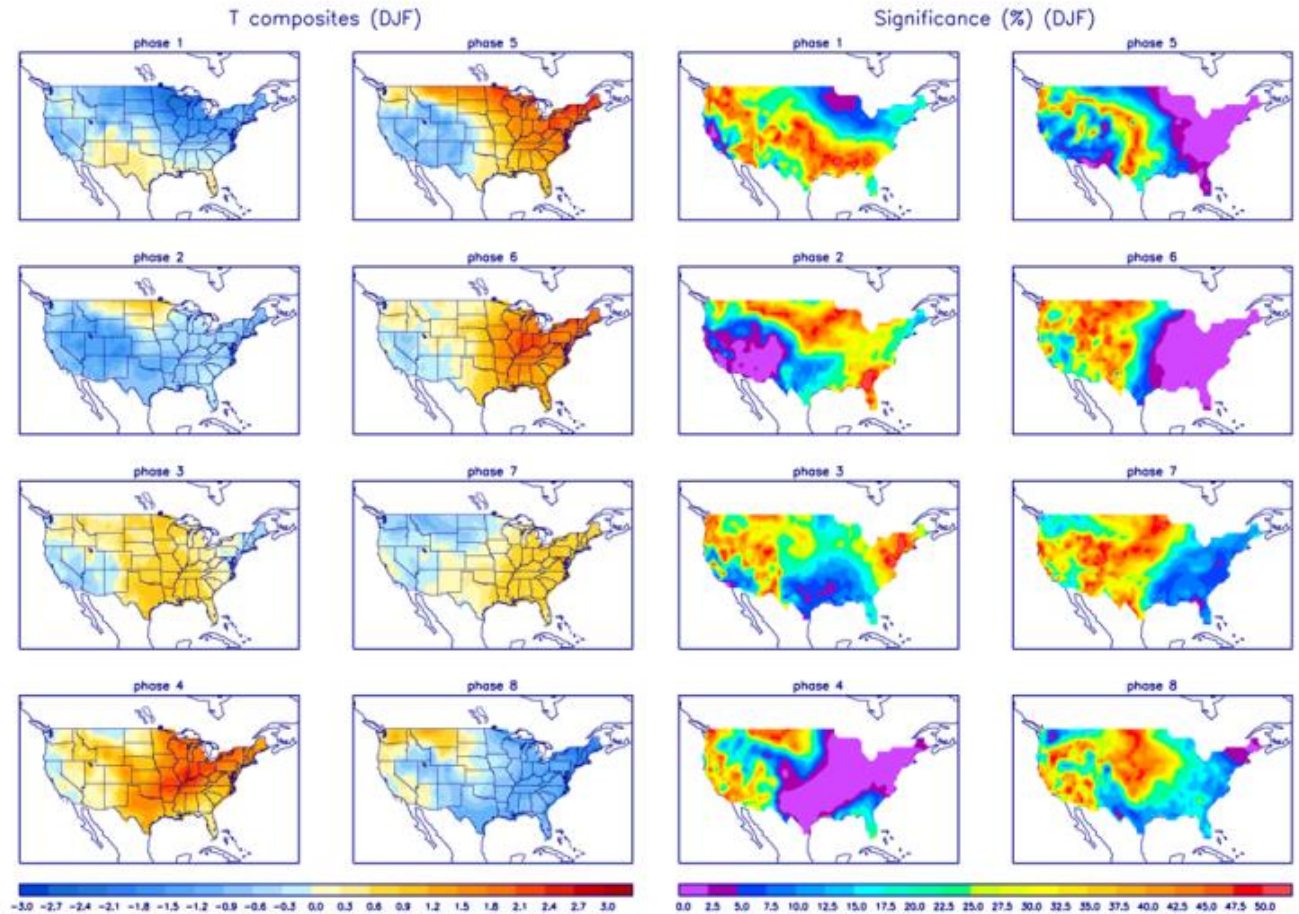
Precipitation Anomalies (Nov - Mar)



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.



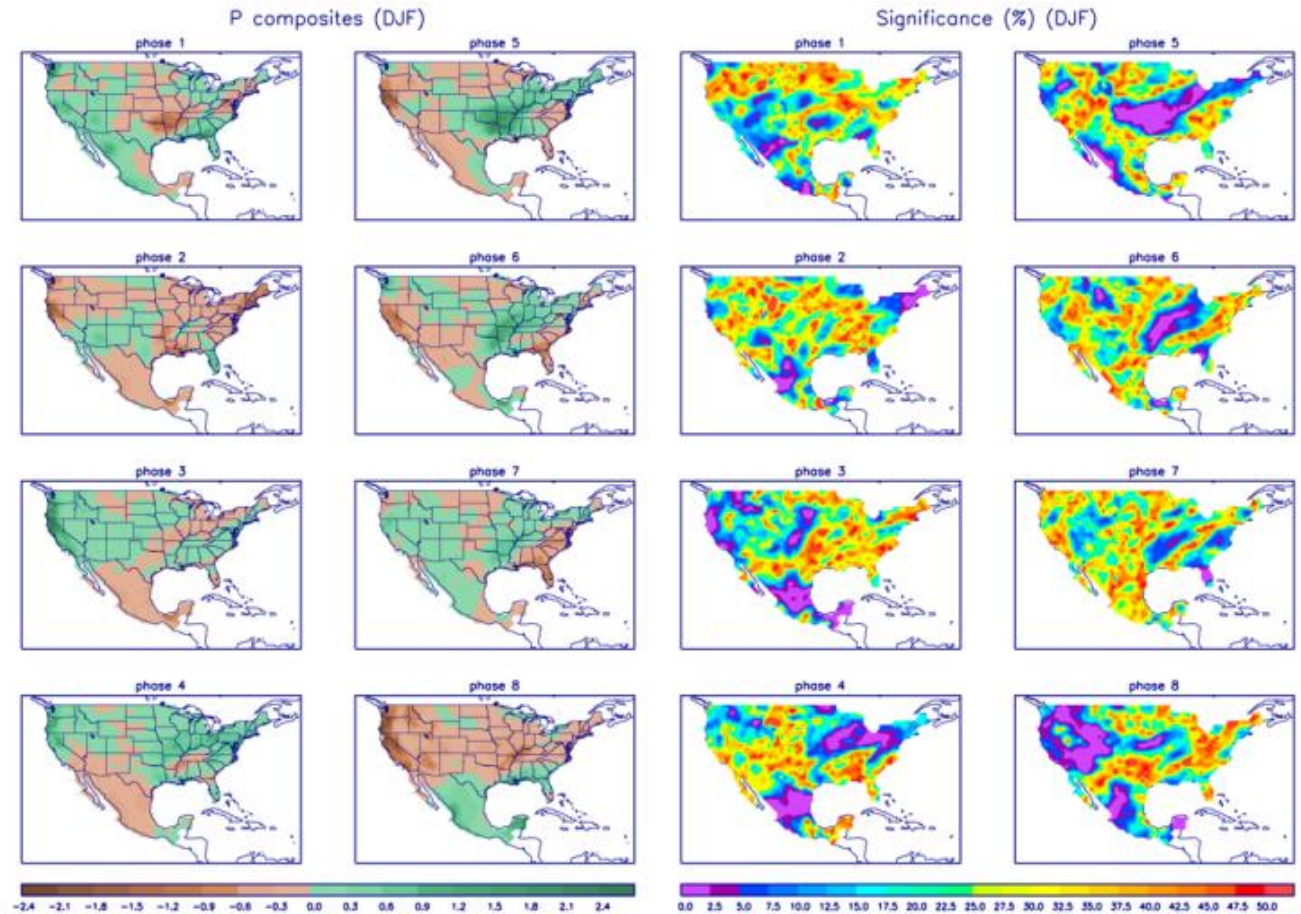
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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.



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>