

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



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29 January 2018

# Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

# Overview

- An active MJO continues as the enhanced phase propagated east from the Maritime Continent to the West Pacific during late January, while the suppressed phase entered the western Indian Ocean.
- Dynamical and statistical models strongly support continued MJO activity, with the enhanced phase propagating east across the West Pacific and destructively interfering with La Nina by Week-2.
- Other modes of tropical variability, including Rossby waves or developing tropical cyclones, may modulate the amplitude and phase speed of the overall MJO envelope.
- A robust West Pacific MJO event favors the continuation of below-normal temperatures across the central and eastern U.S. later in February.

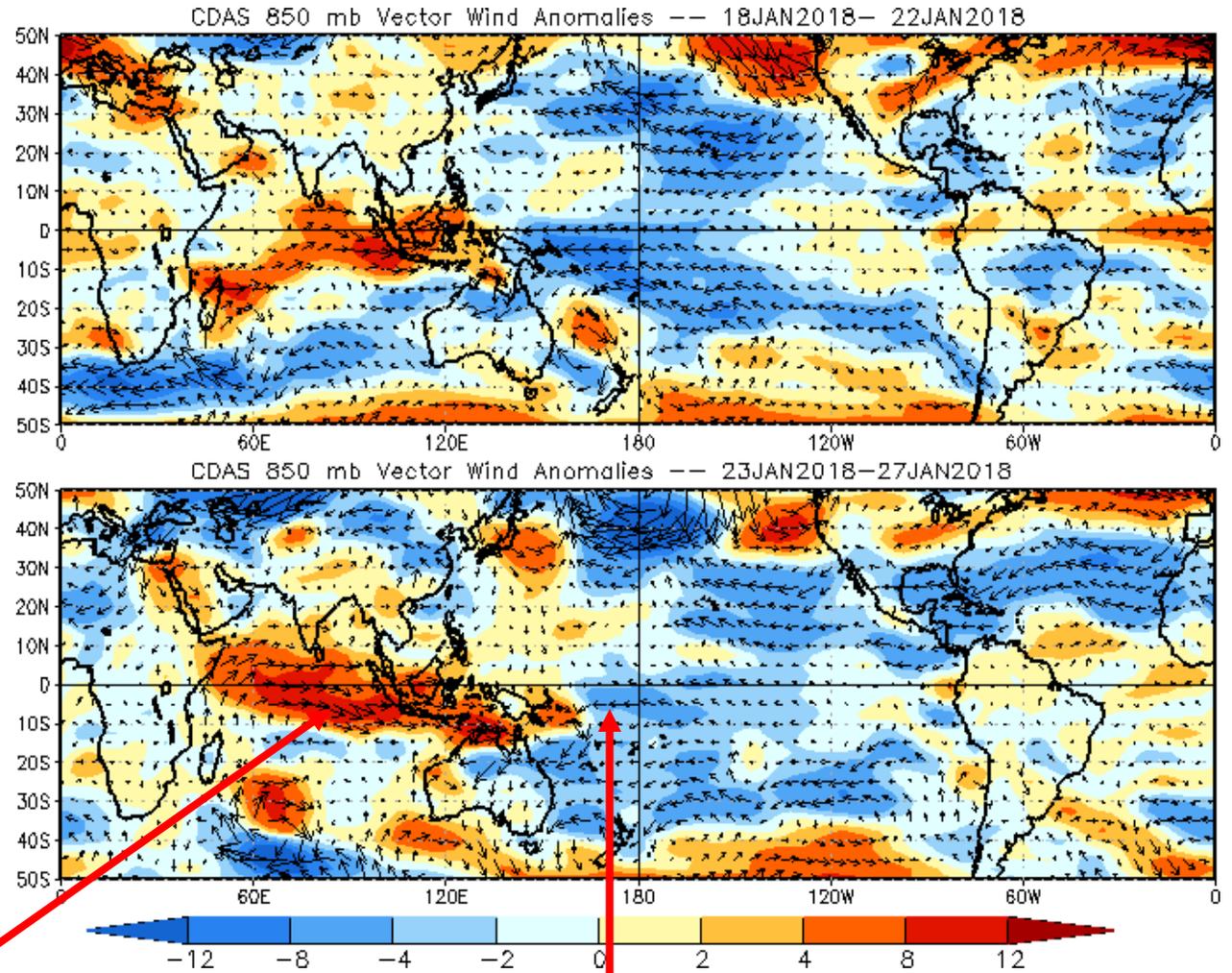
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:  
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php>

# 850-hPa Vector Wind Anomalies (m s<sup>-1</sup>)

Note that shading denotes the zonal wind anomaly

**Blue shades:** Easterly anomalies

**Red shades:** Westerly anomalies



Westerly anomalies remained strong over the Indian Ocean and shifted east across the Maritime Continent and northern Australia, consistent with an active MJO.

Easterly anomalies weakened over the Central Pacific.

# 850-hPa Zonal Wind Anomalies (m s<sup>-1</sup>)

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

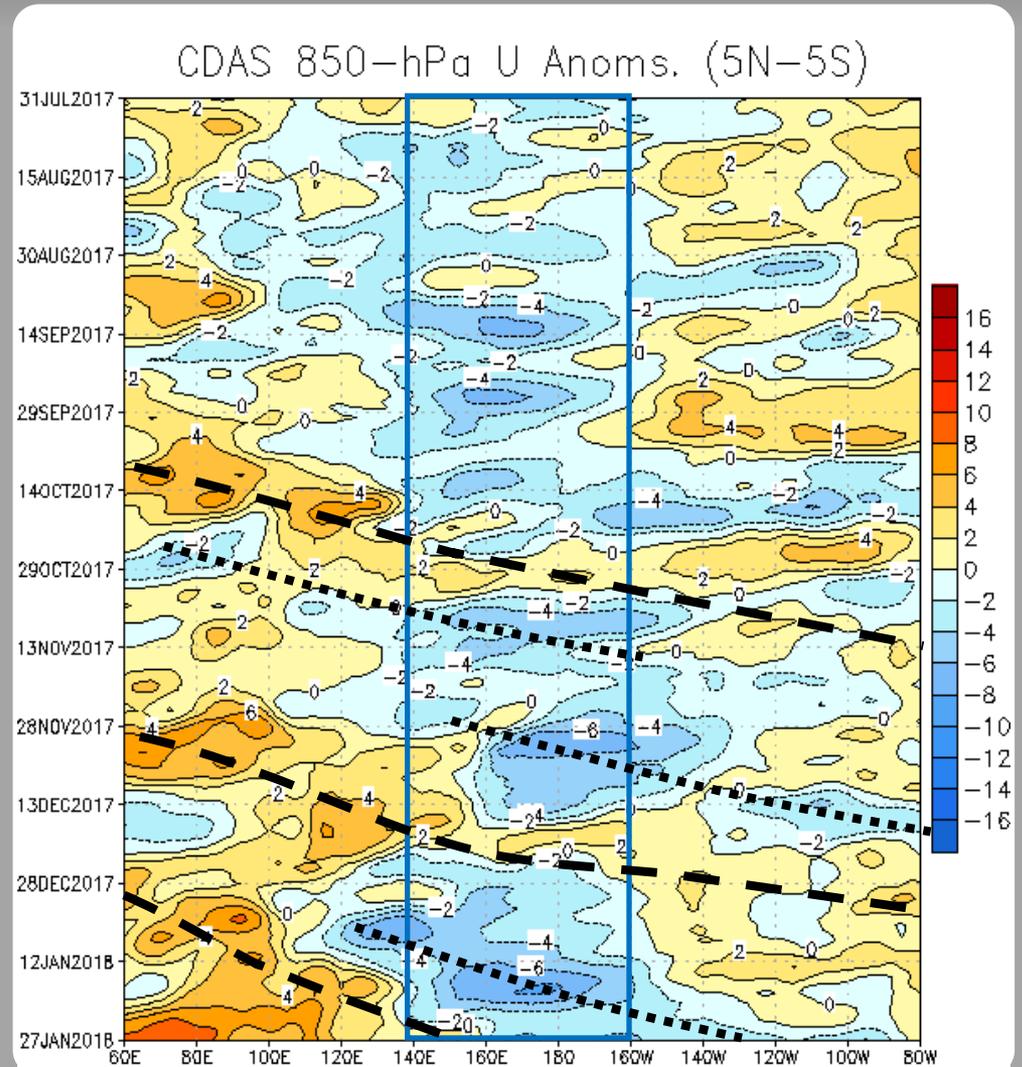
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

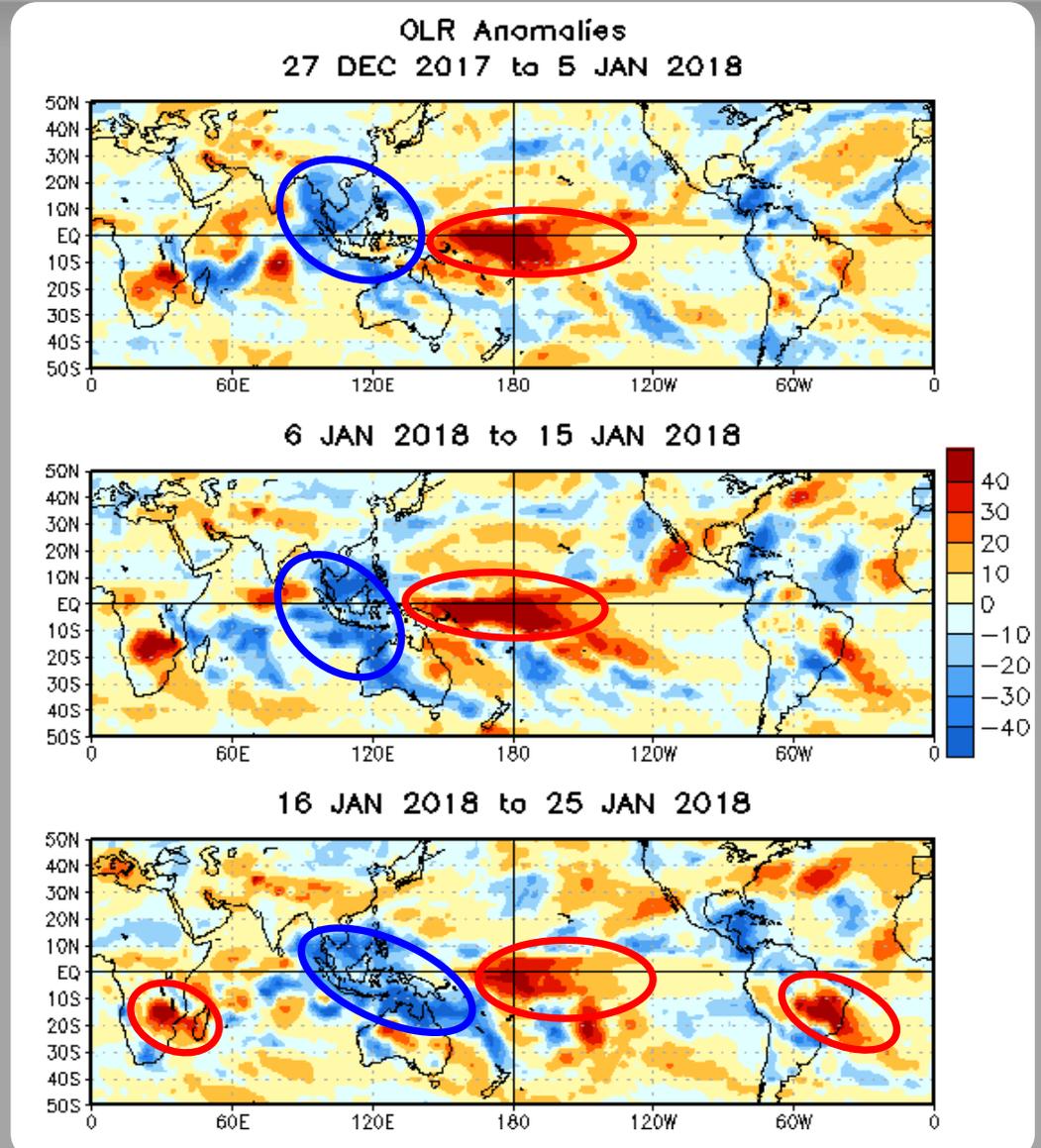
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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 to 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 and Kimberley Coast of Australia (central Pacific).

Enhanced convection expanded east from the Maritime Continent and northern Australia to the South Pacific during mid-January. Suppressed convection associated with the MJO developed across parts of Brazil and Africa during mid to late January.



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

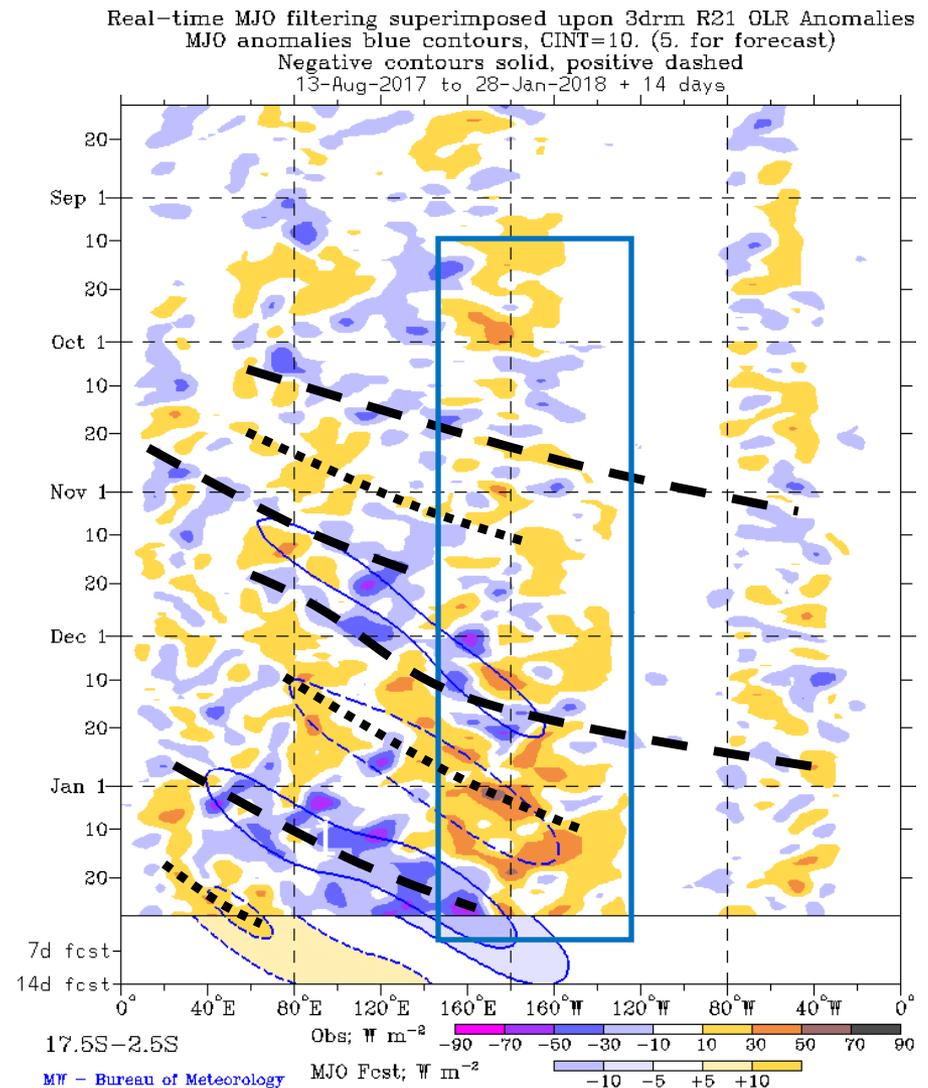
**Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)**

**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)

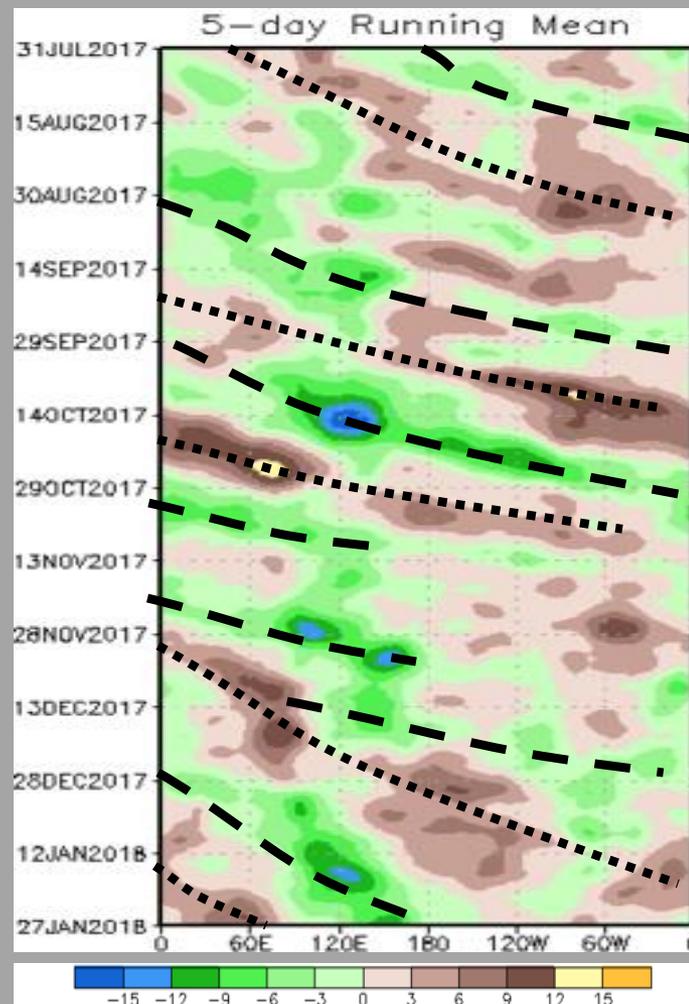
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

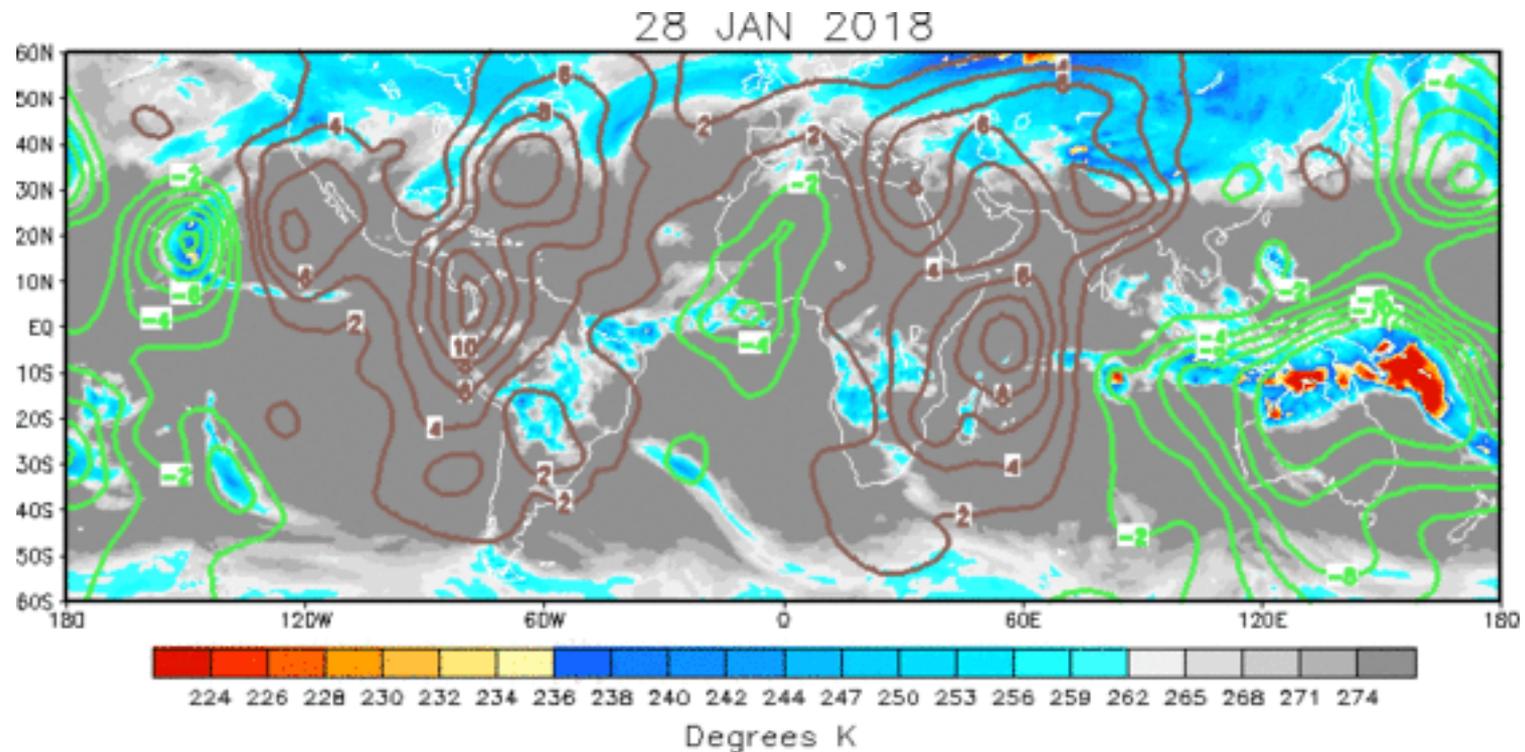
During July, an eastward propagating enhanced convective signal strengthened over the Maritime Continent that was consistent with the MJO. Another signal on the MJO timescale is evident in this field during late August and September.

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 predominantly Wave-1 pattern continues in the upper-level circulation pattern, reflecting an organized MJO event. Anomalous upper-level divergence consistent with the MJO is centered over the eastern Maritime Continent and northern Australia.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation

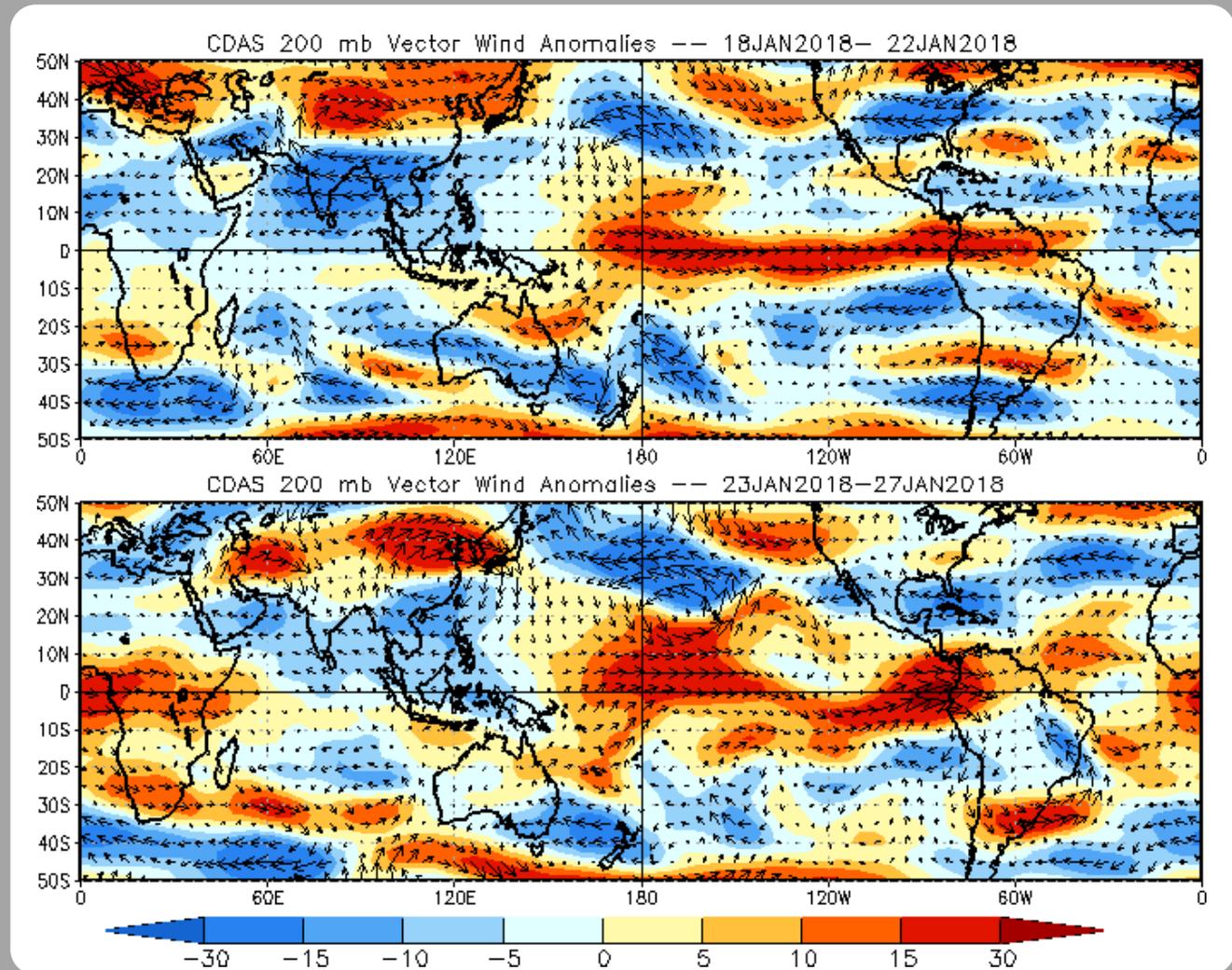
# 200-hPa Vector Wind Anomalies (m s<sup>-1</sup>)

Note that shading denotes the zonal wind anomaly

**Blue shades:** Easterly anomalies

**Red shades:** Westerly anomalies

A couplet of anomalous easterlies (westerlies) are observed over the Maritime Continent (Central and East Pacific). This pattern is consistent with a robust enhanced phase of the MJO shifting east across the Maritime Continent and northern Australia.



# 200-hPa Zonal Wind Anomalies (m s<sup>-1</sup>)

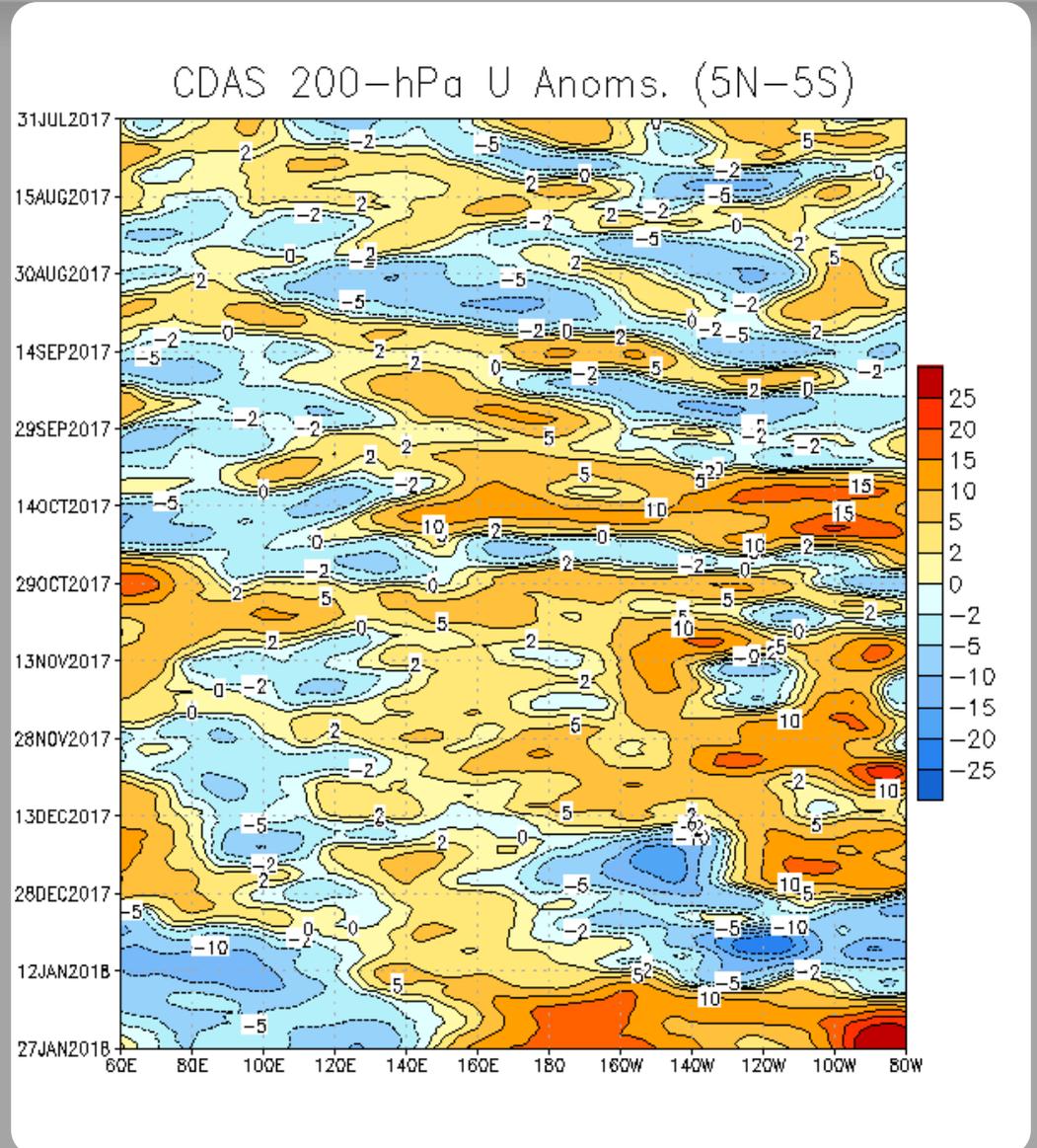
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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.





# 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

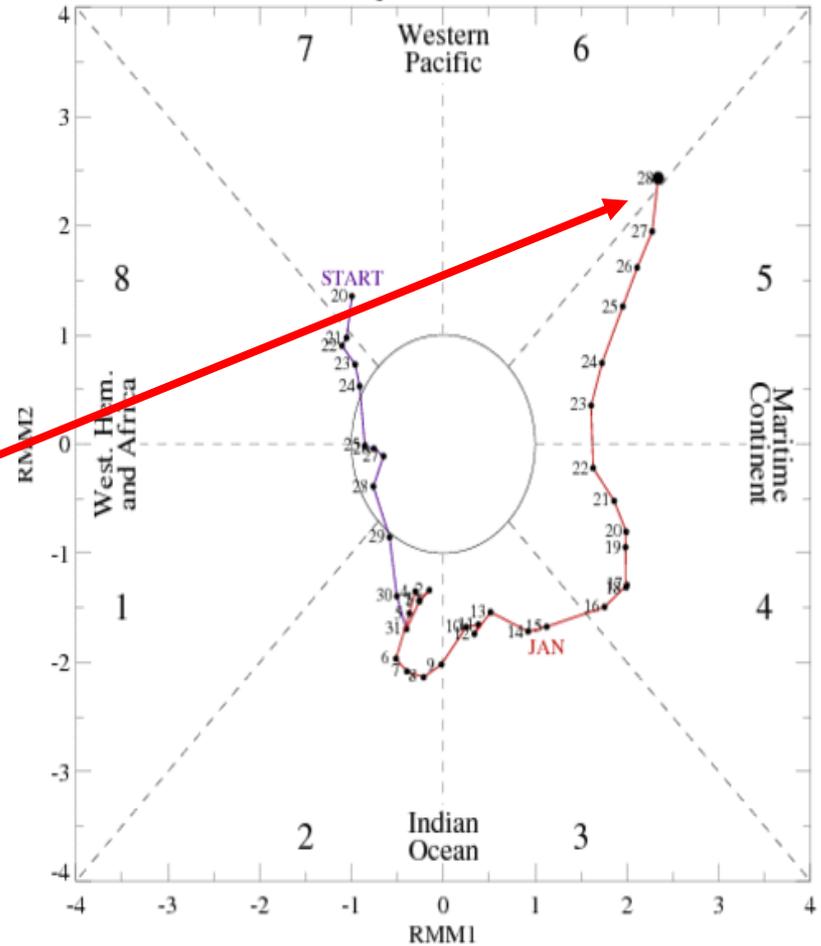
Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.

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 propagating east across the Maritime Continent during late January.

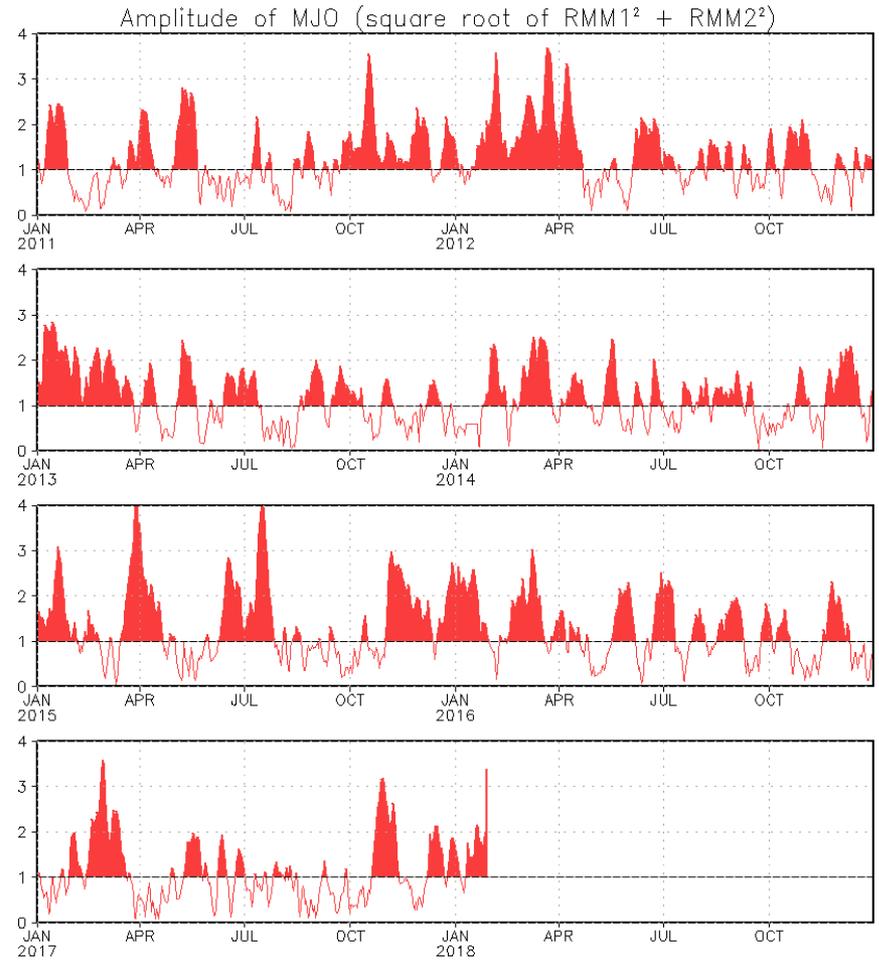
[RMM1, RMM2] Phase Space for 20-Dec-2017 to 28-Jan-2018



# 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

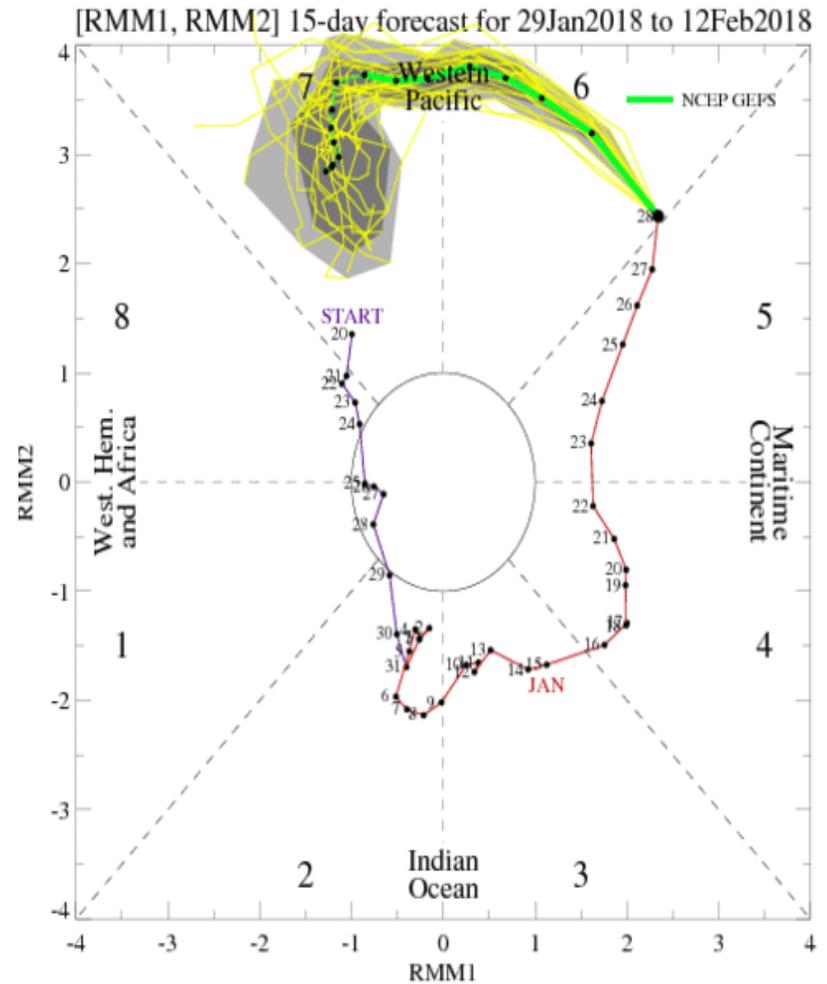
RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GEFS forecast depicts a continued robust MJO, with the enhanced phase propagating east across the West Pacific during the next two weeks.

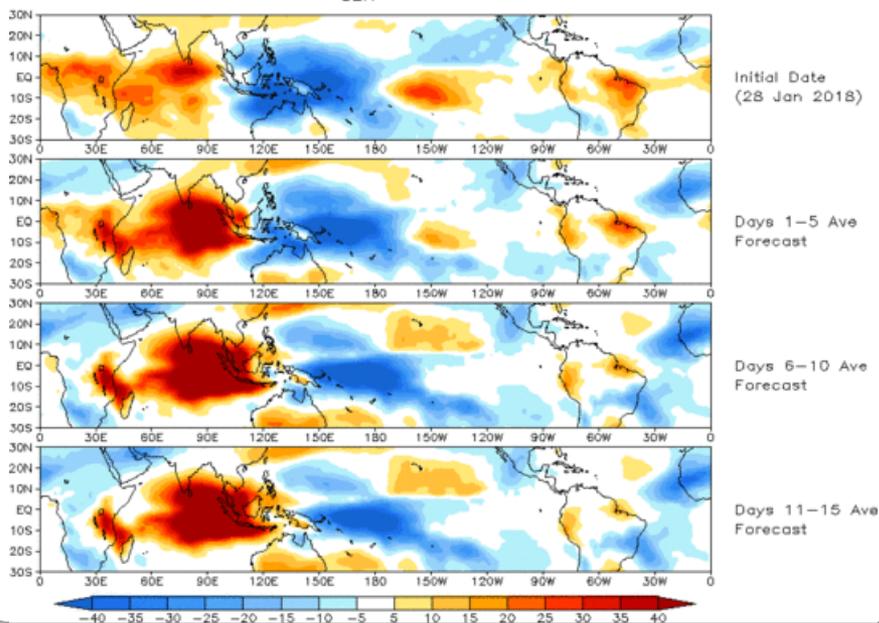
Yellow Lines - 20 Individual Members  
Green Line - Ensemble Mean



# 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: 28 Jan 2018  
OLR

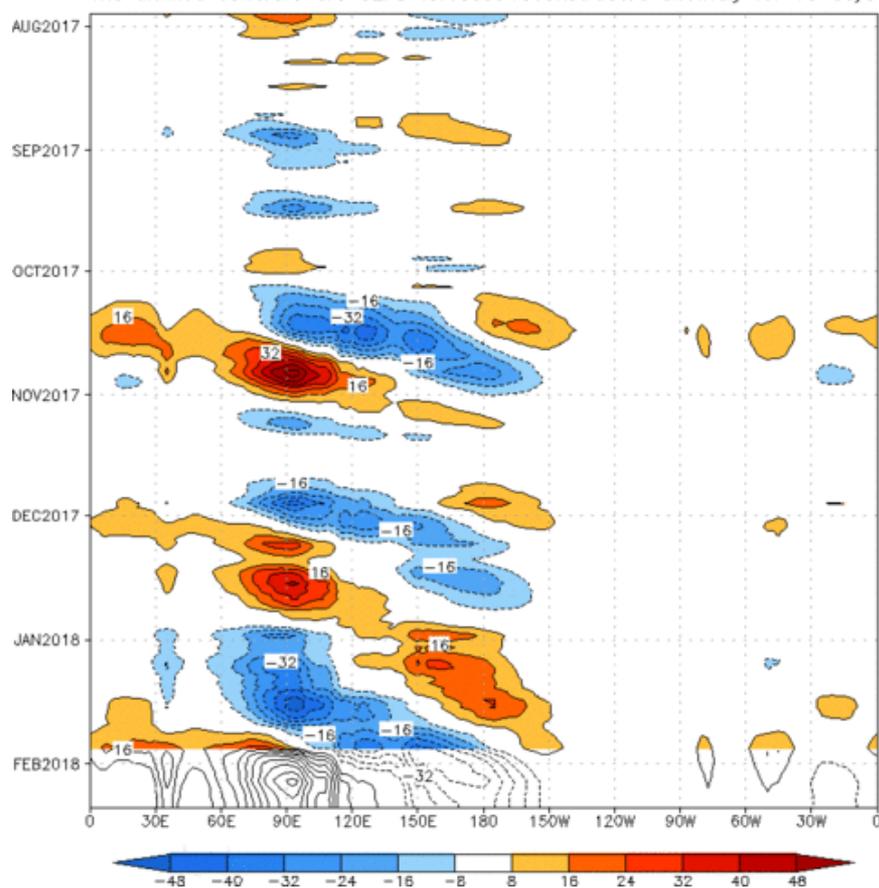


OLR anomalies based on the GEFS are consistent with robust MJO activity, with enhanced convection over the West Pacific during the next two weeks. Suppressed convection is forecast to shift east to the Maritime Continent.

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

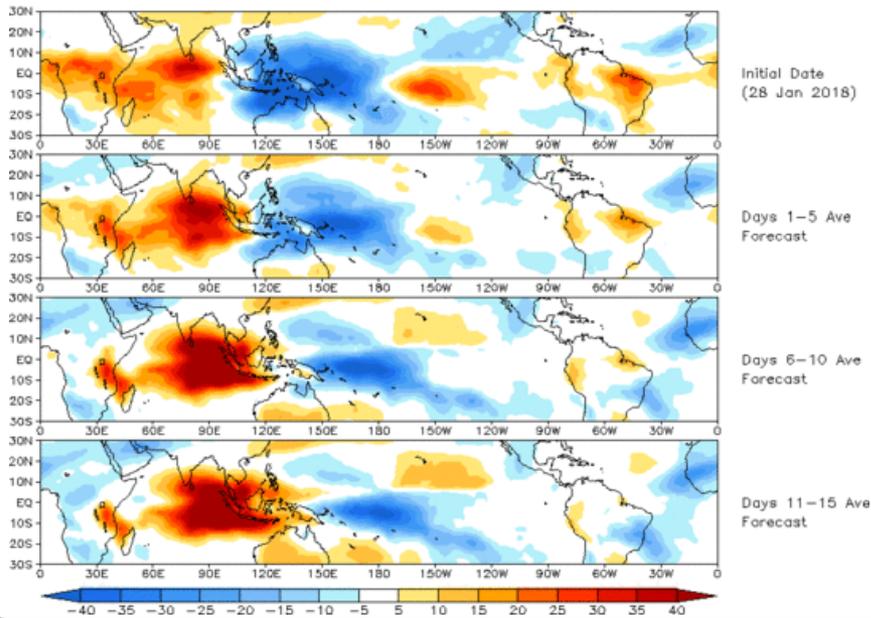
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2  
OLR [7.5°S,7.5°N] (cint:4Wm<sup>-2</sup>) Period:29-Jul-2017 to 28-Jan-2018  
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days



# 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 (28 Jan 2018)

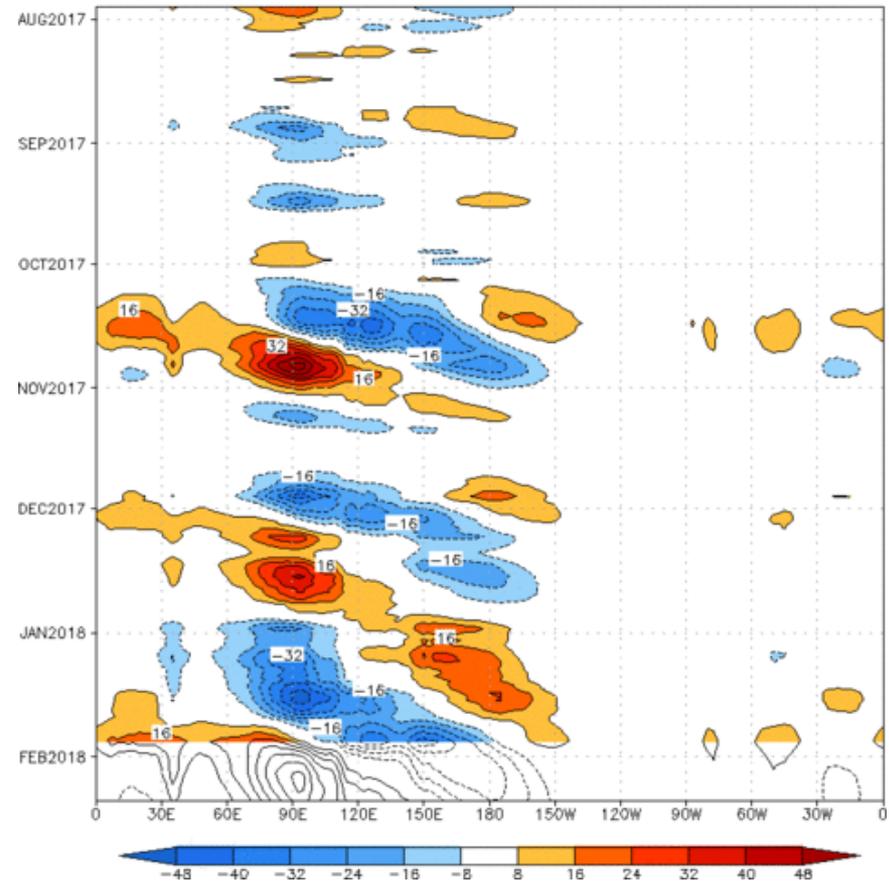


The constructed analog is very similar to the GEFS solution, depicting the MJO enhanced (suppressed) convective envelope propagating east across the West Pacific (Indian Ocean).

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.)

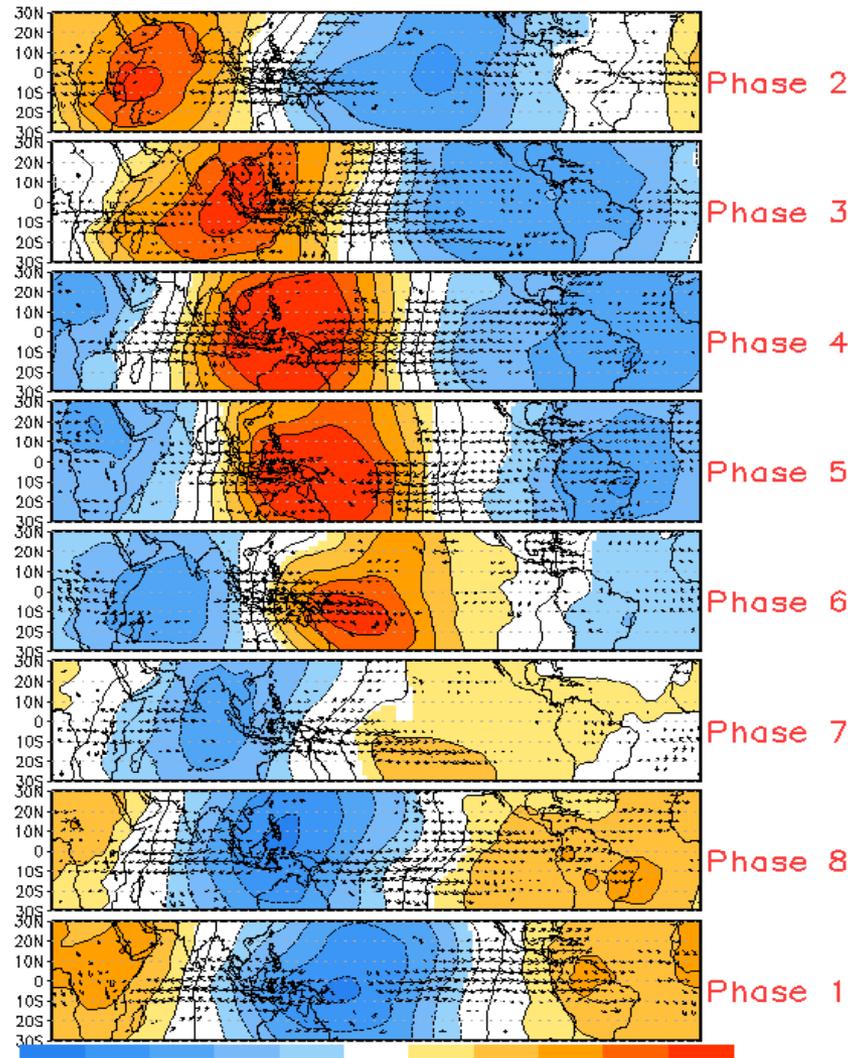
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [7.5°S,7.5°N] (cont:4Wm<sup>-2</sup>) Period:29-Jul-2017 to 28-Jan-2018  
The unfilled contours are CA forecast reconstructed anomaly for 15 days

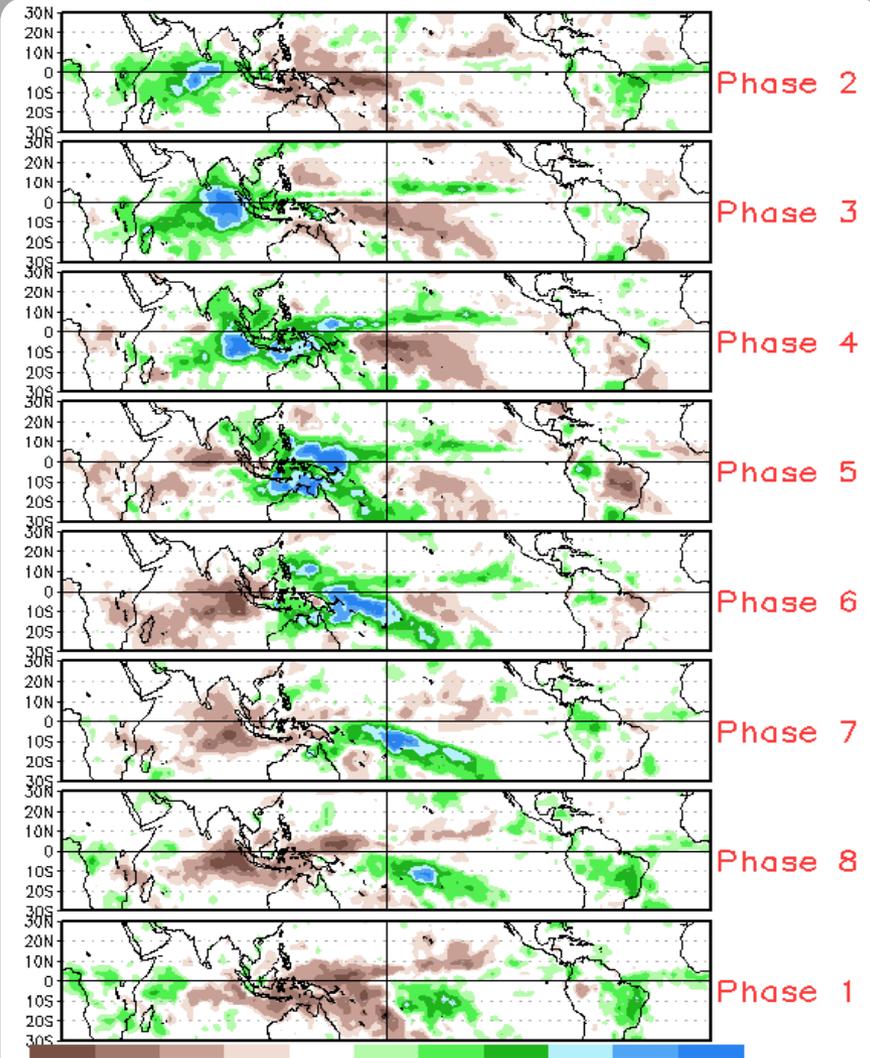


# MJO Composites - Global Tropics

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



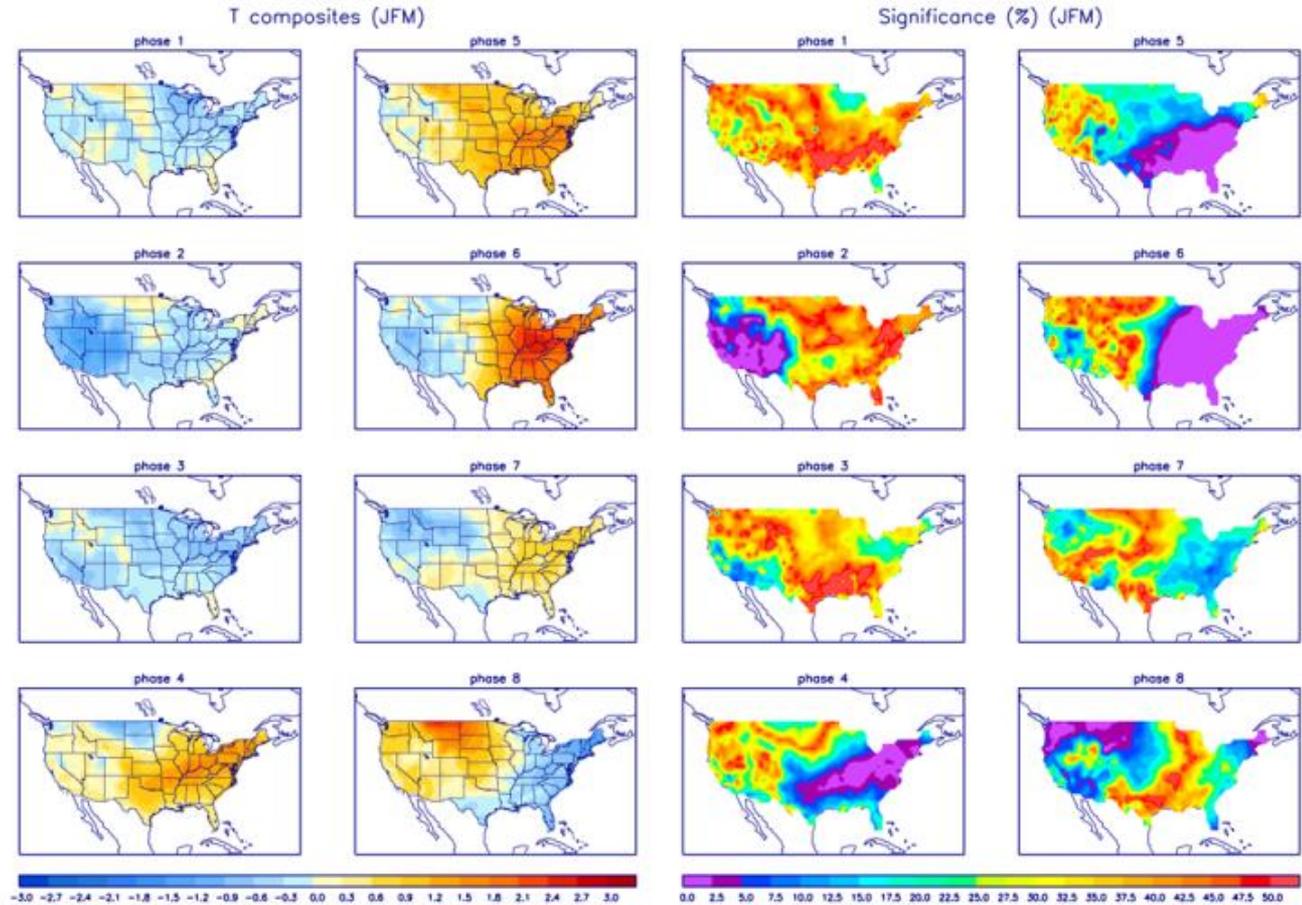
Precipitation Anomalies (Nov - Mar)



# 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.



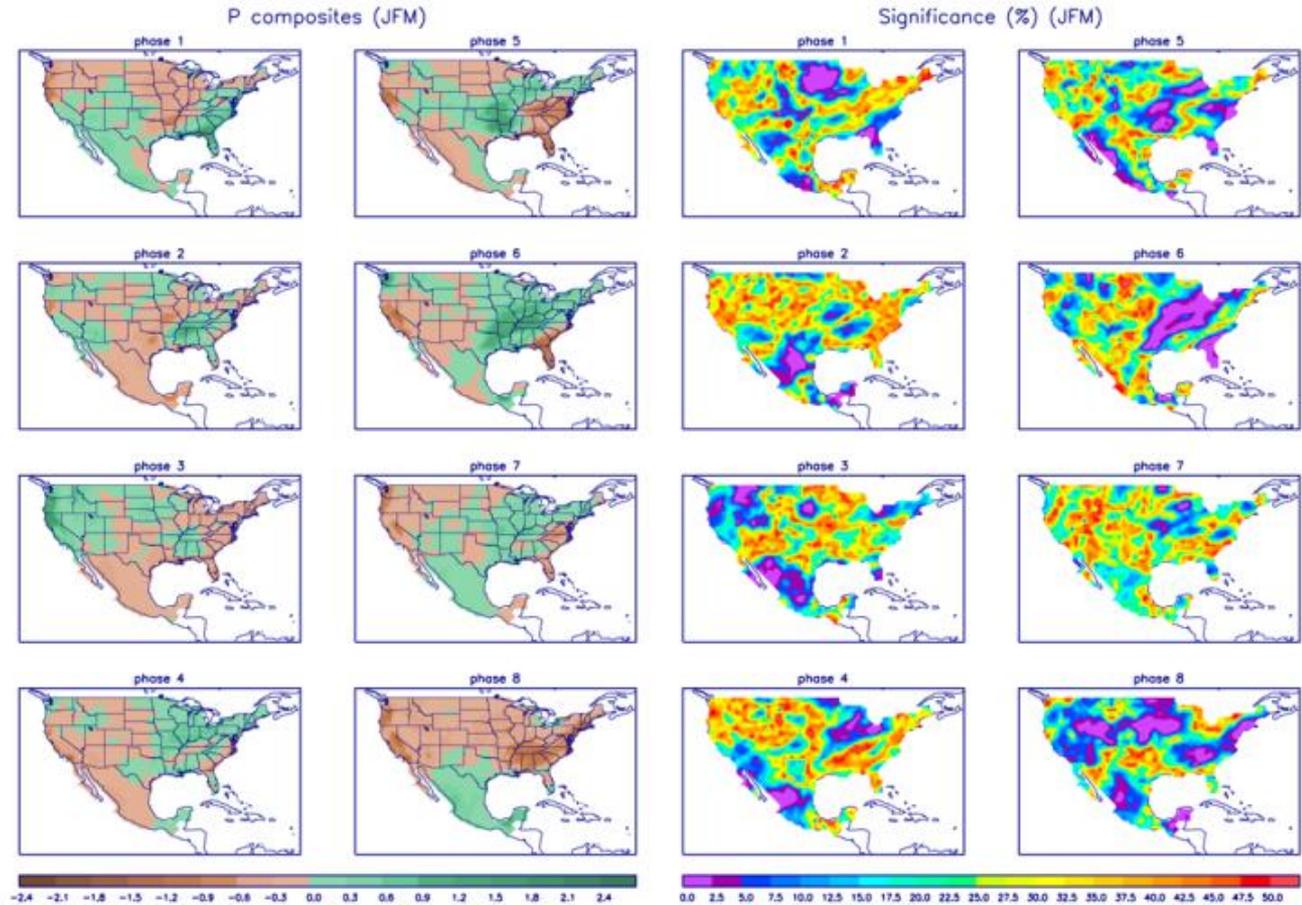
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>