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

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Climate Prediction Center / NCEP
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# 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 across the West Pacific.

- Dynamical and statistical models strongly support continued MJO activity, with the GEFS maintaining a signal near the Date Line due to Rossby wave activity in the Pacific, while the constructed analog is more progressive.

- A robust West Pacific MJO event favors potential transition towards cooler temperatures over the eastern U.S. while a warming trend is favored over the West. Odds also tilt towards below-normal precipitation across the U.S. as the MJO continues towards the Western Hemisphere.

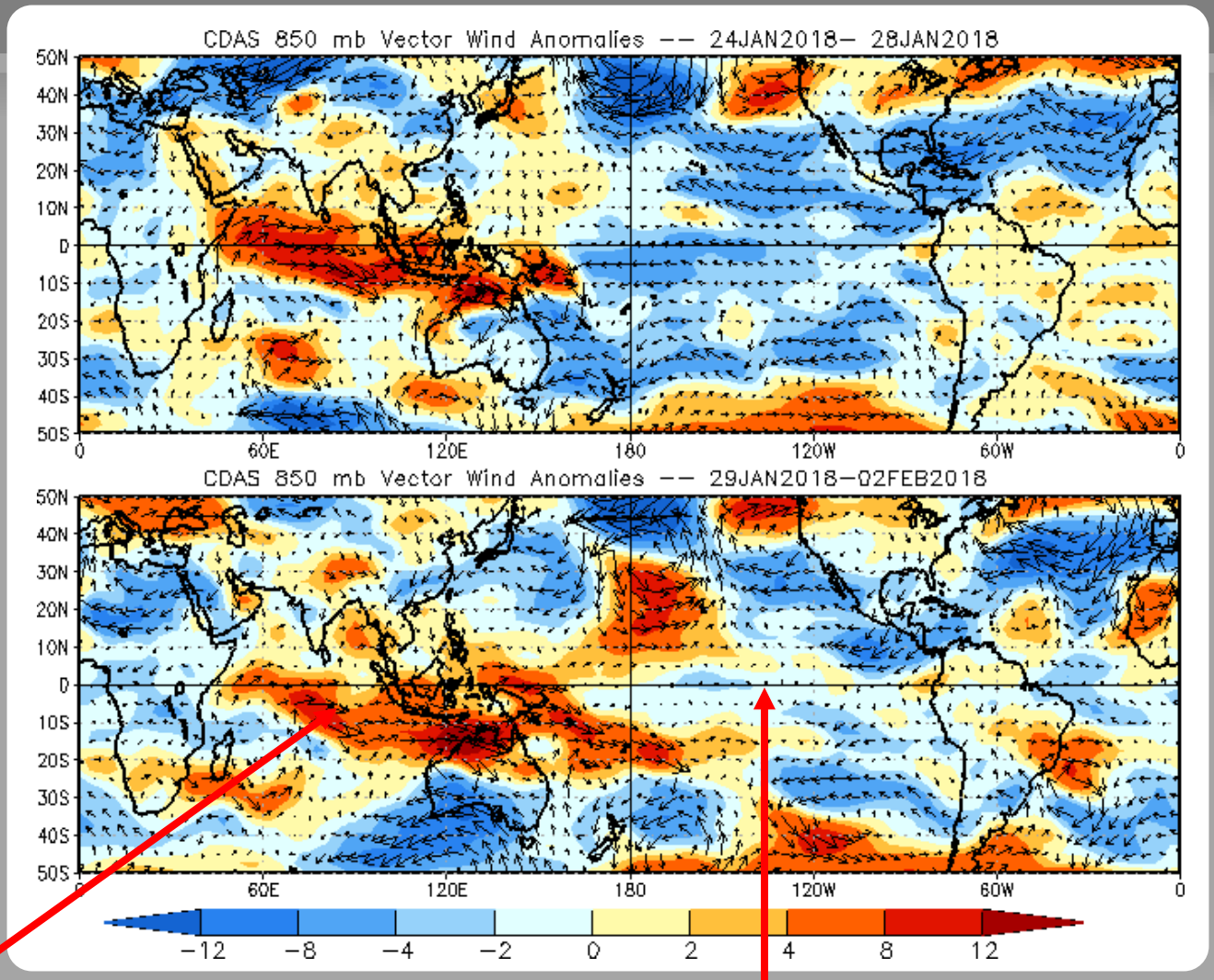
**Additional potential impacts across the global tropics and a discussion for the U.S. are available at:**
**http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php**

# 850-hPa Vector Wind Anomalies (m s-1)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies




Westerly anomalies persisted across the Indian Ocean with some eastward translation pushing the signal into the West Pacific.

Easterly anomalies weakened over the Pacific to the east of the Date Line.

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

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

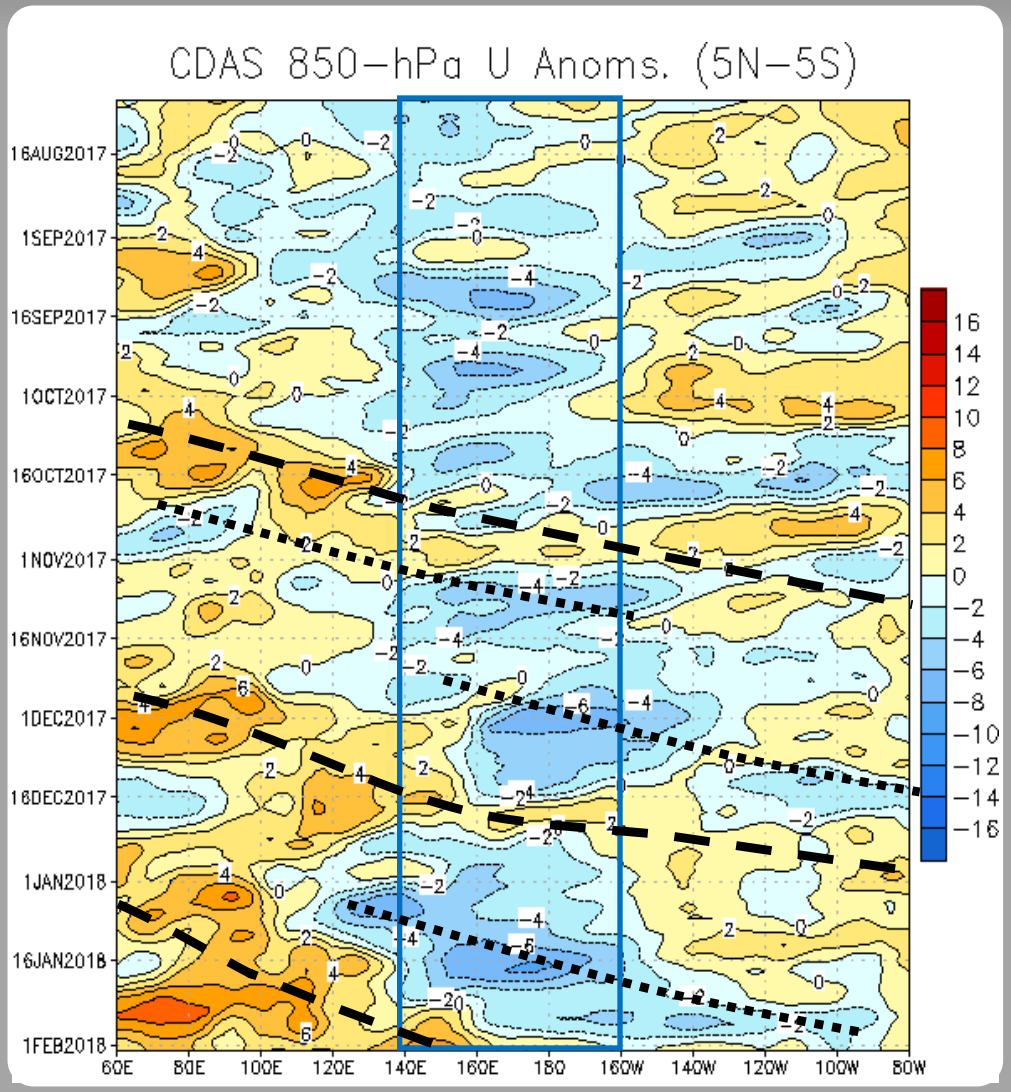
**Easterly anomalies (blue shading) represent anomalous east-to-west flow**

Low-frequency easterly anomalies (blue box) have largely persisted over the west-central Pacific throughout the last 180 days.

August and September had little MJO activity, dominated instead 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

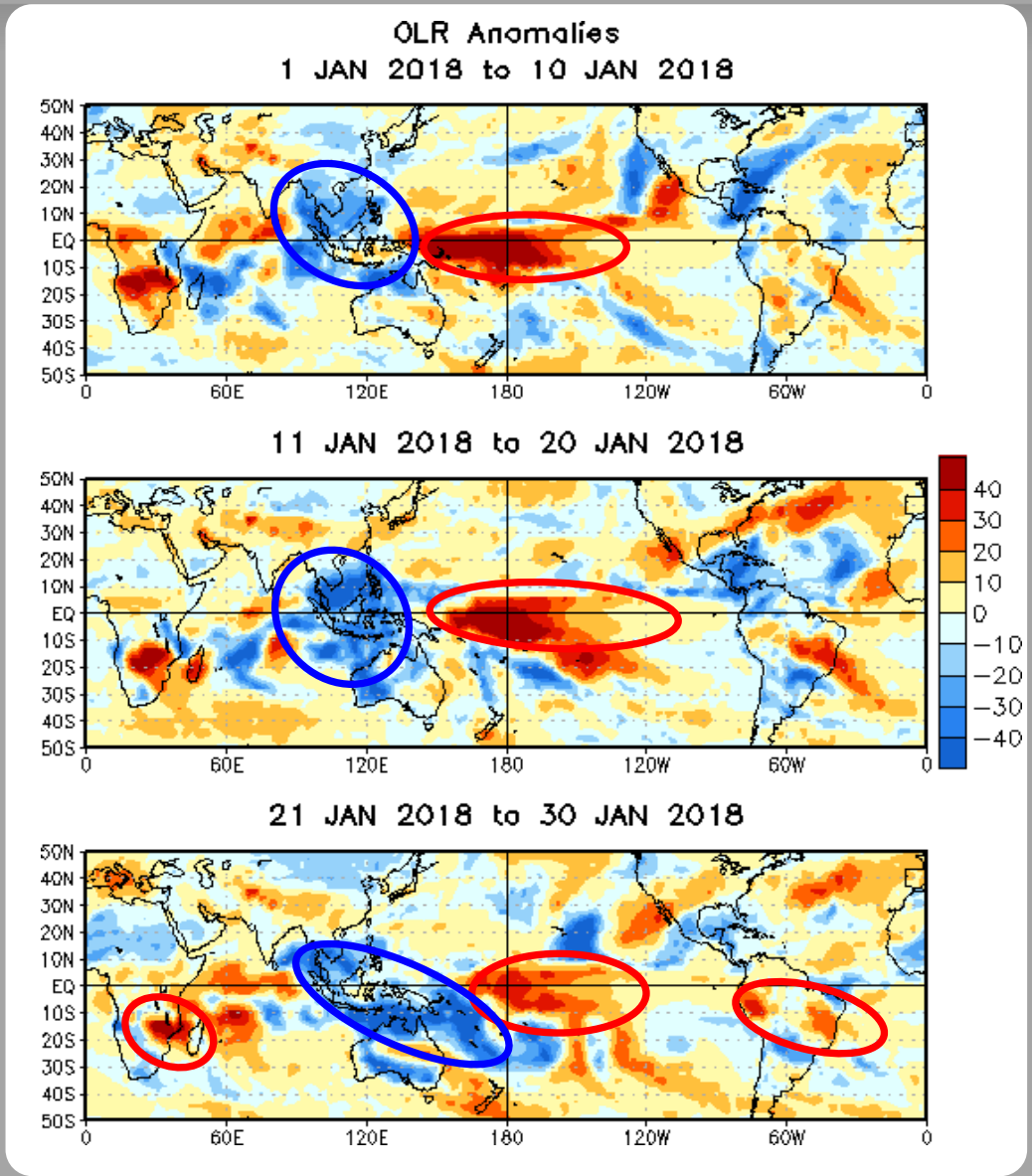
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During early January, the MJO propagated over the eastern Indian Ocean. Enhanced convection was largely confined to the southern Indian Ocean, and began to overspread the Maritime Continent. Suppressed rainfall persisted over southern Africa and the central Pacific.

The enhanced phase of the MJO reached the Maritime Continent during mid-January, and constructive interference between this signal and the La Niña base state resulted in a large, organized OLR anomaly field. Continued dryness over southern Africa aggravated ongoing drought conditions.

Eastward propagation of the enhanced (suppressed) convective anomalies from the Maritime Continent to the West Pacific (Western Hemisphere to the western Indian Ocean) was apparent in late January as robust MJO activity continued. Suppressed convection persisted near the Date Line and over southern Africa.



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

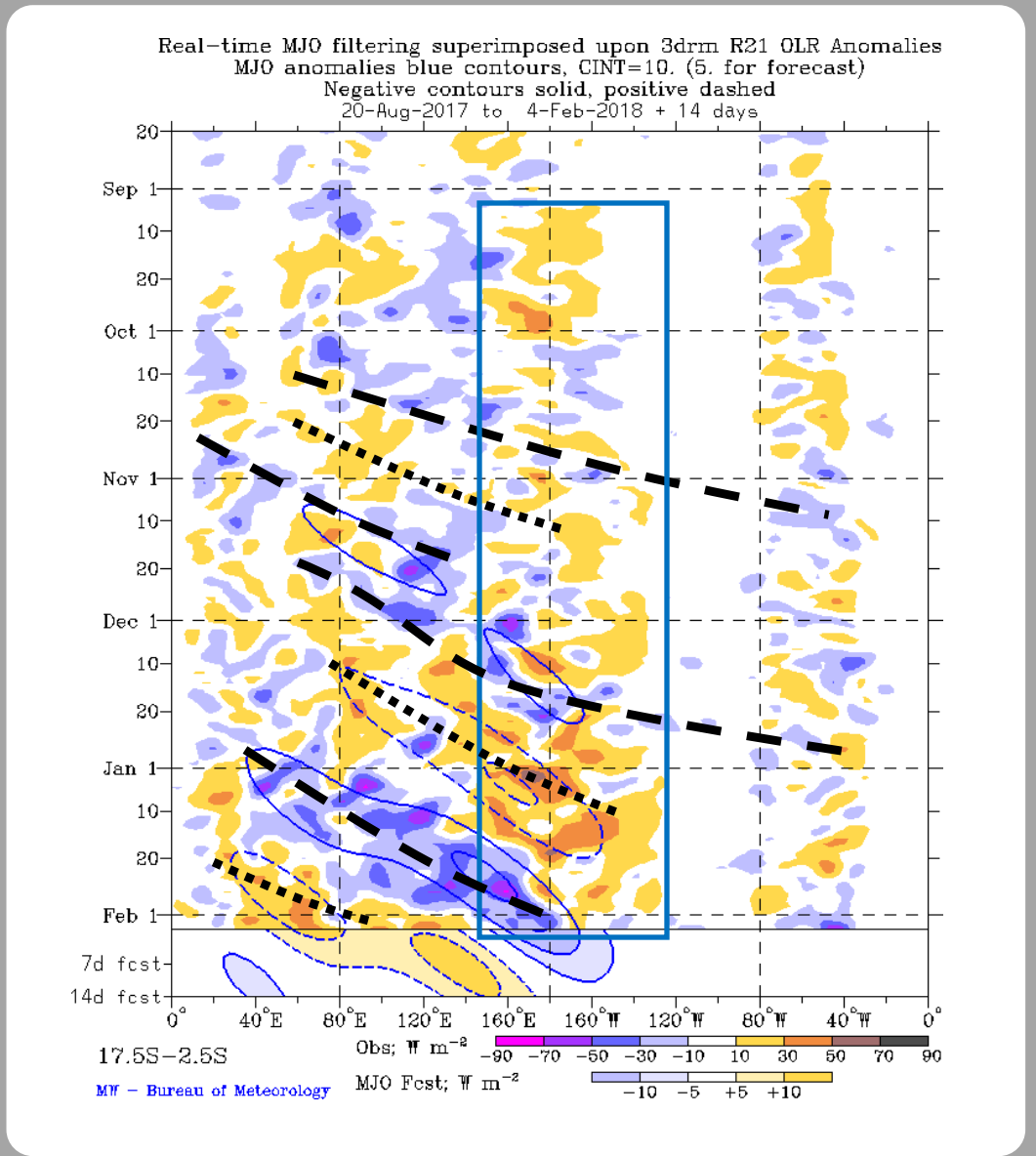
**Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)**

**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 September.

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 towards the Date Line at present.



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

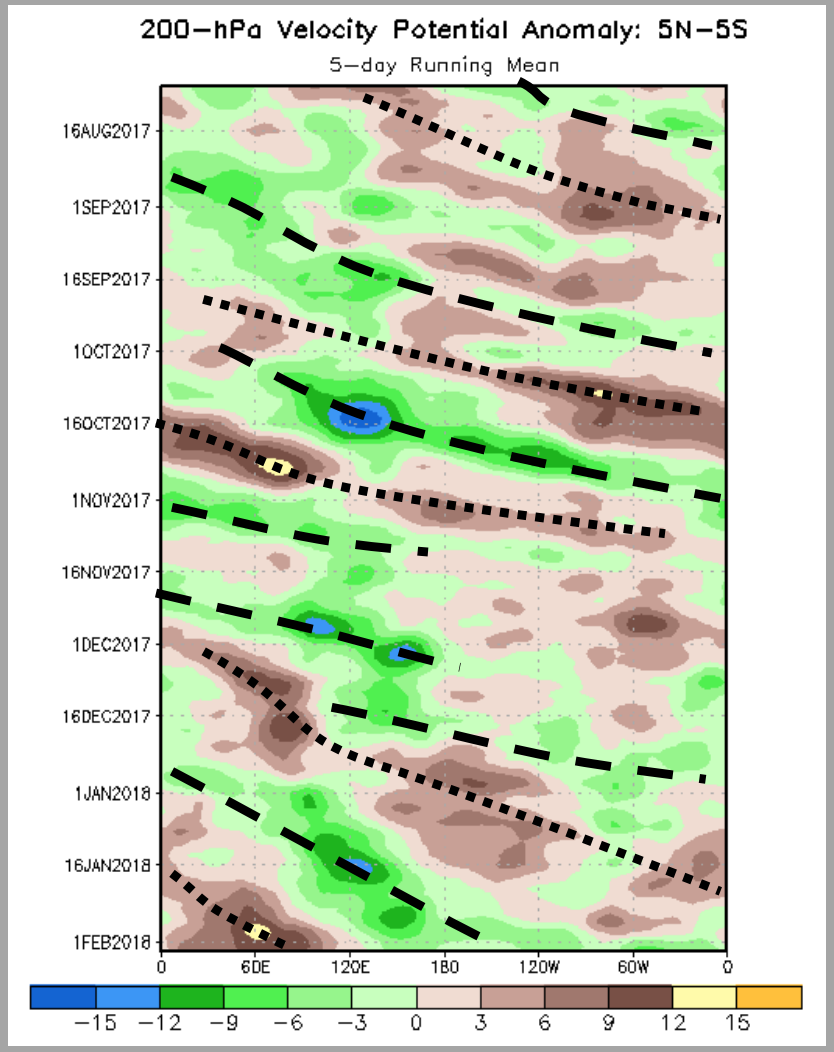
**Positive anomalies (brown shading) indicate unfavorable conditions for precipitation**

**Negative anomalies (green shading) indicate favorable conditions for precipitation**

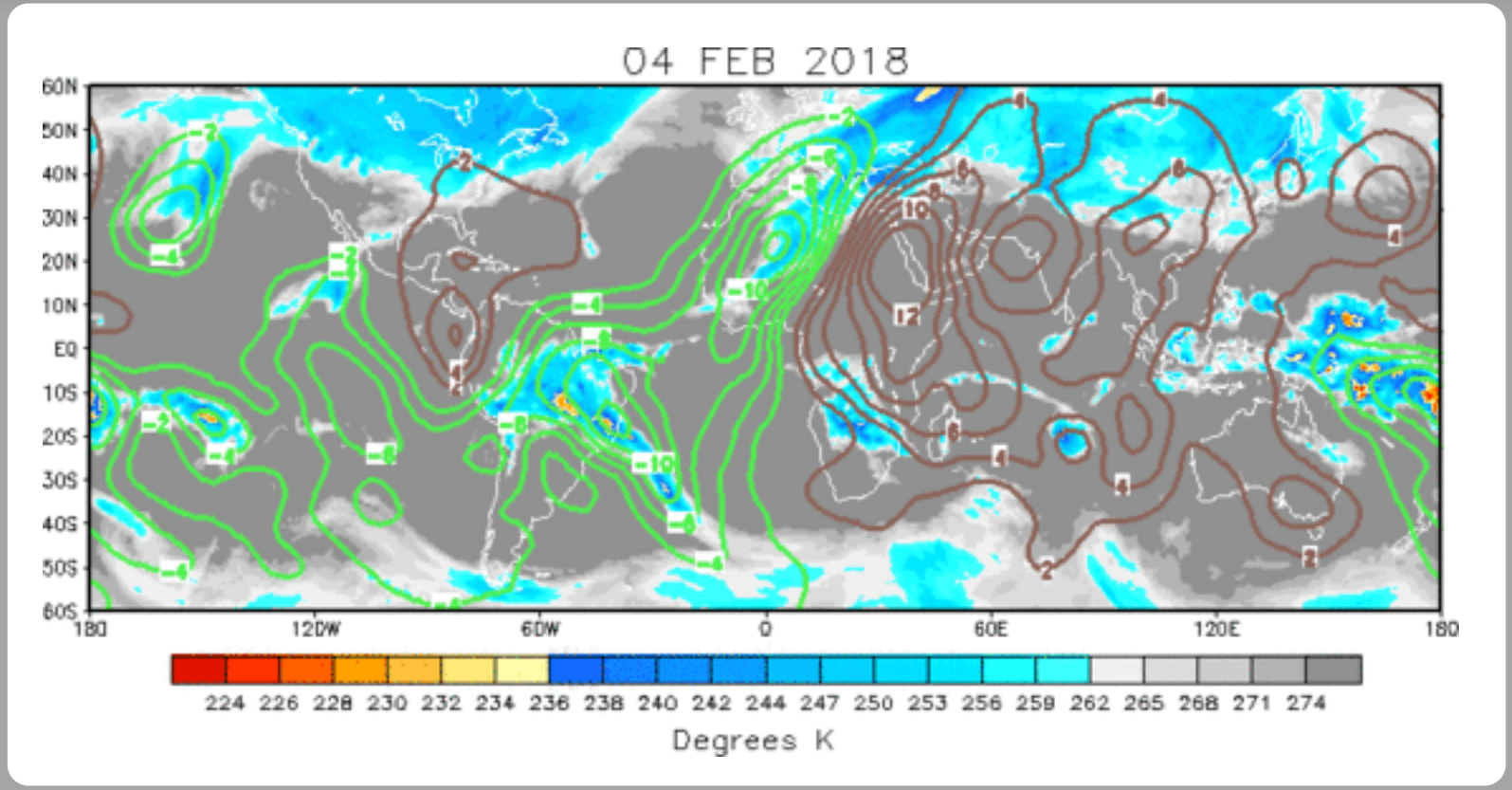
During July, an eastward propagating enhanced convective signal strengthened over the Maritime Continent that was consistent with the MJO. Another signal on the MJO timescale is evident in this field during late August and September.

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 stretches across the Pacific and Western Hemisphere.

| |
|---|
| 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

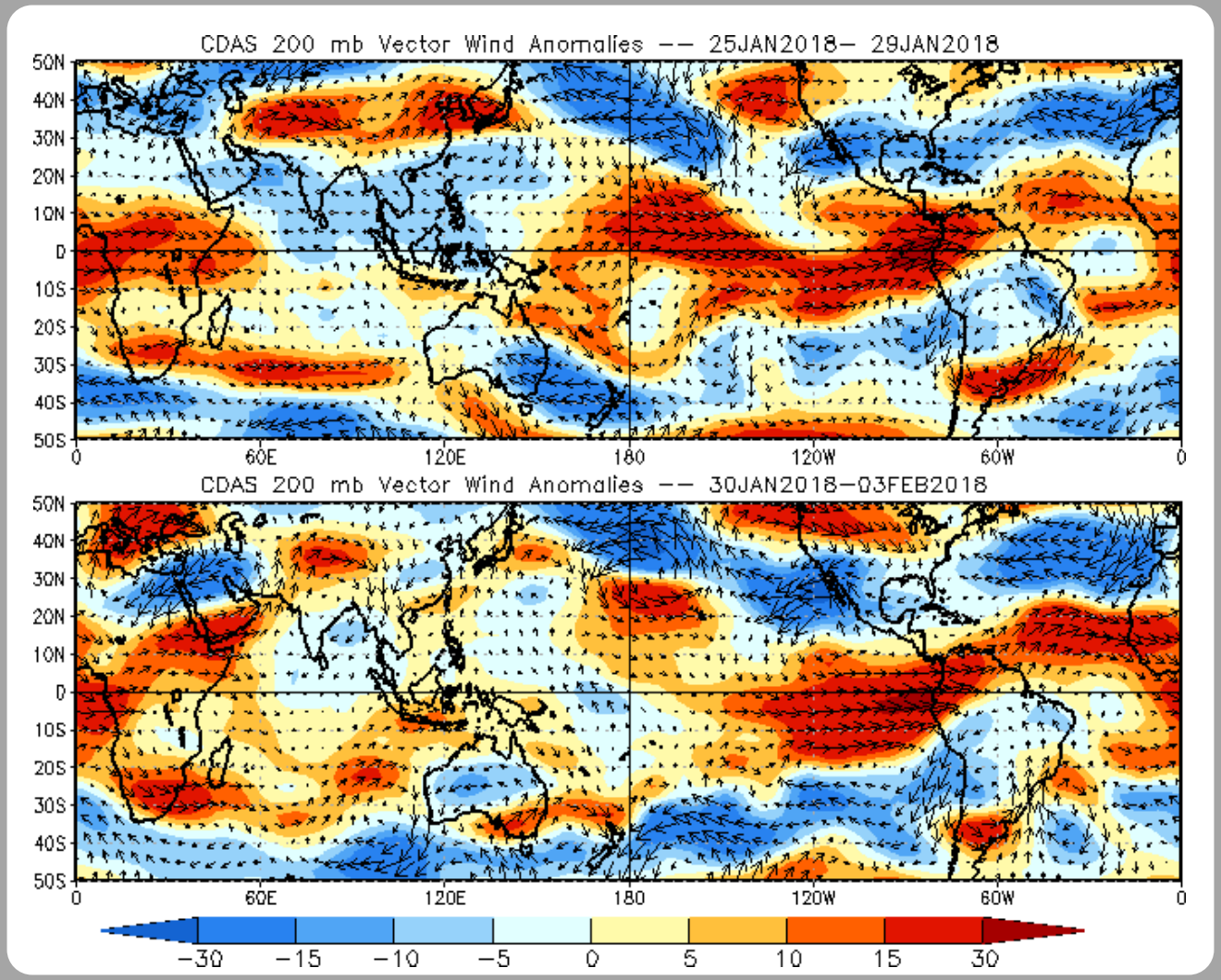
Blue shades: Easterly anomalies

Red shades: Westerly anomalies

The eastward shifting envelope of anomalous westerlies initially across the Pacific and now stretching from the East Pacific through Africa is consistent with a robust MJO event.

Cyclonic anomalies centered over the Baja Peninsula and Central Atlantic appear well teleconnected with the tropical circulation.

Lastly, the shift from retraction to extension of the jet over East Asia appears to be underway.



# 200-hPa Zonal Wind Anomalies (m s-1)

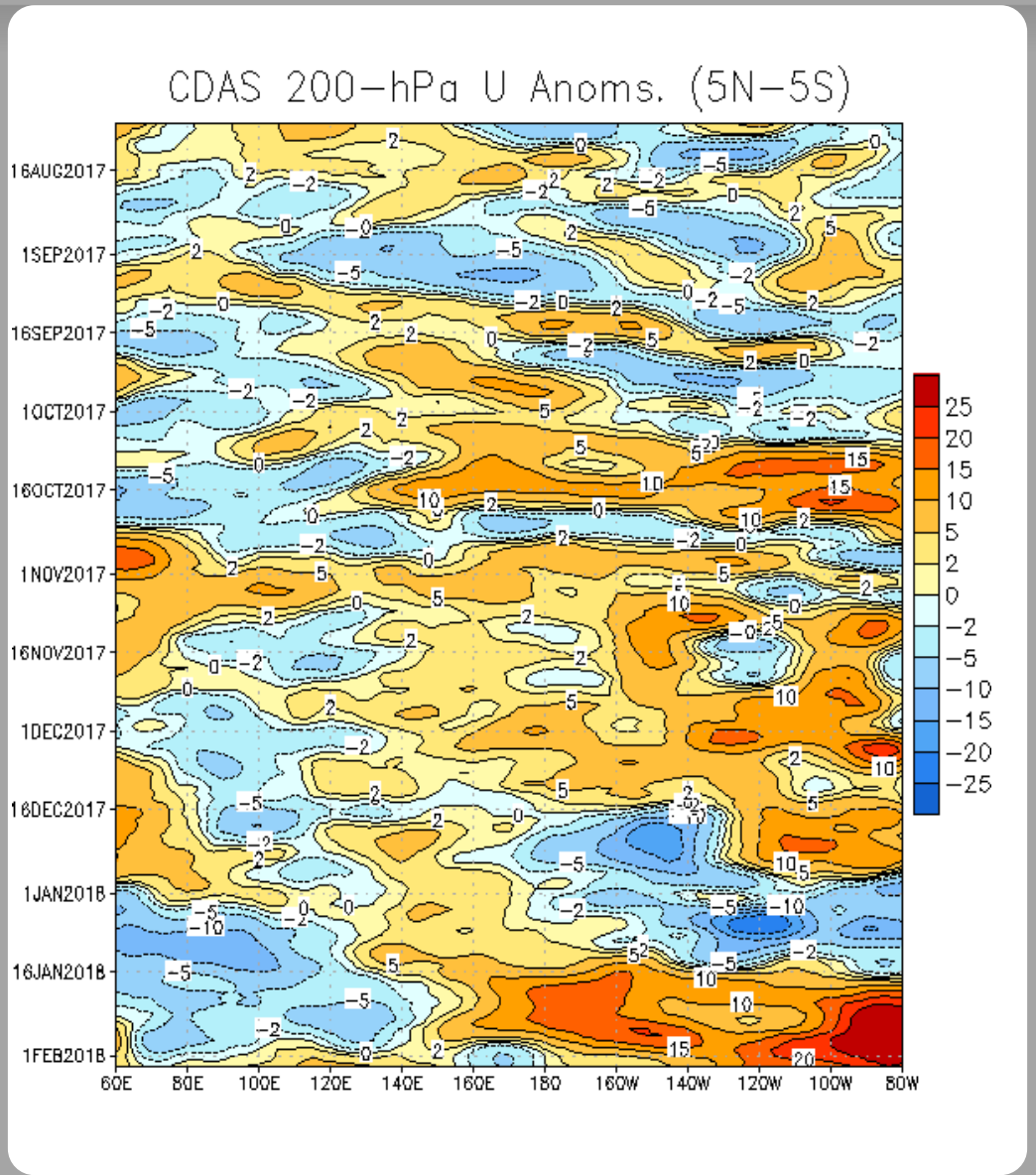
**Westerly anomalies (orange/red shading) represent anomalous west-to-east flow**

**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.

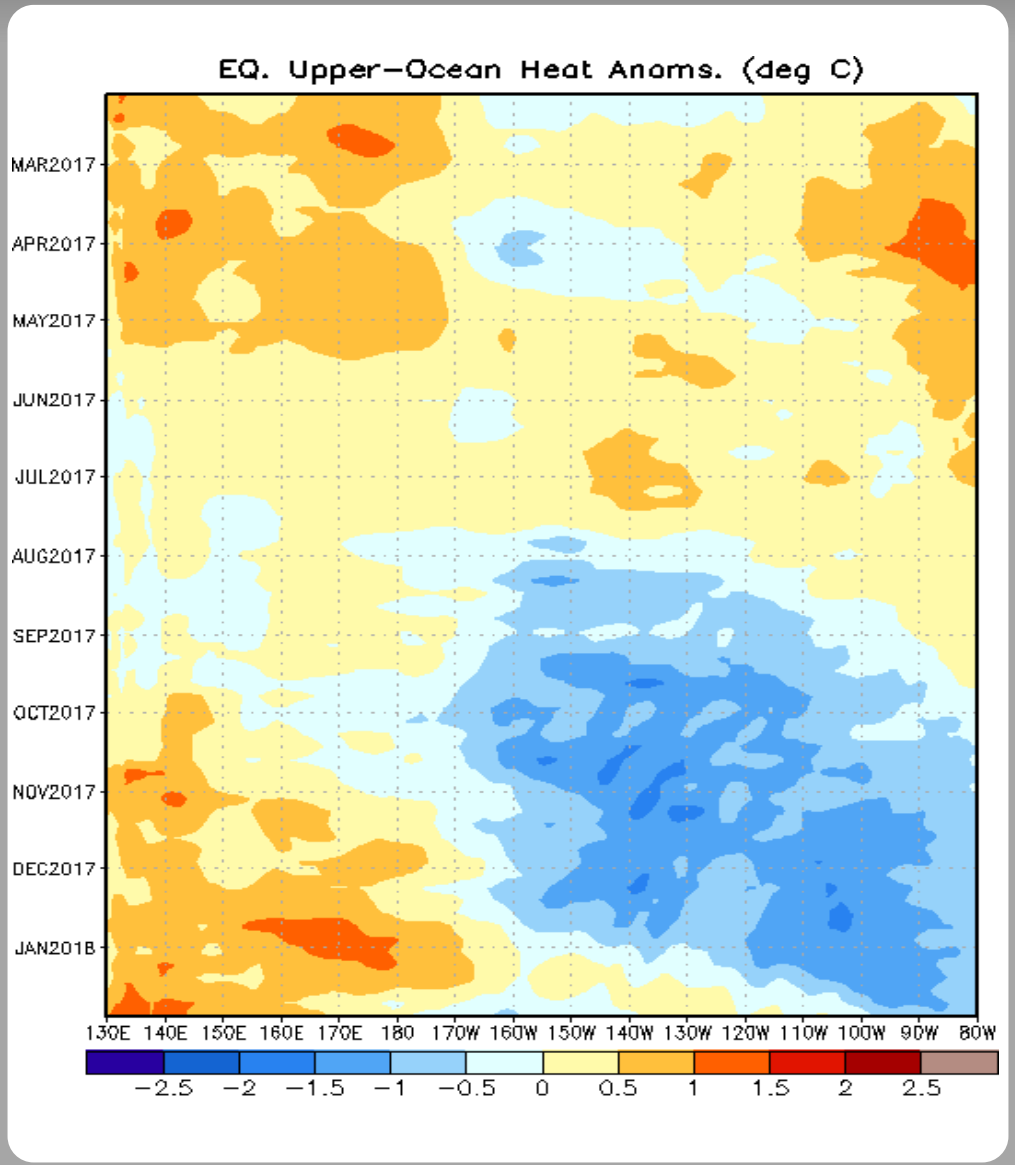
In mid-December, easterly anomalies have developed in the east of the Date Line, replacing the westerly anomalies that had been generally present since October. These anomalies propagated eastward over the past few weeks, and are now approaching the Date Line. Strong westerly anomalies have returned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



# 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**

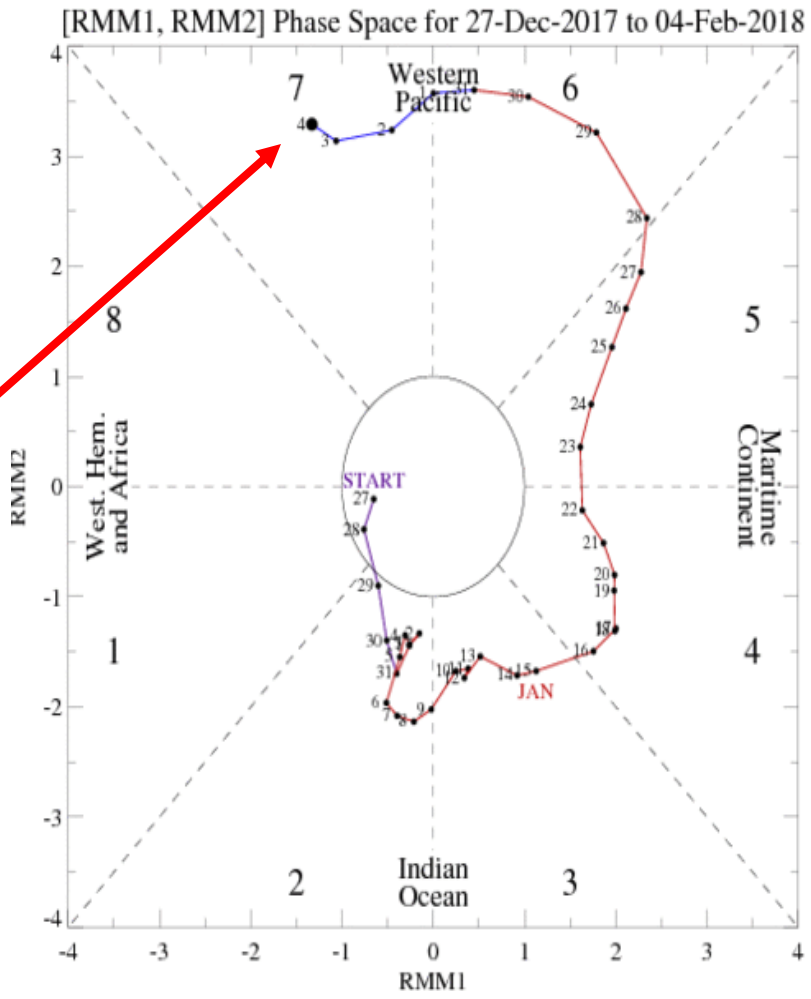
**The triangular areas indicate the location of the enhanced phase of the MJO**

**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**

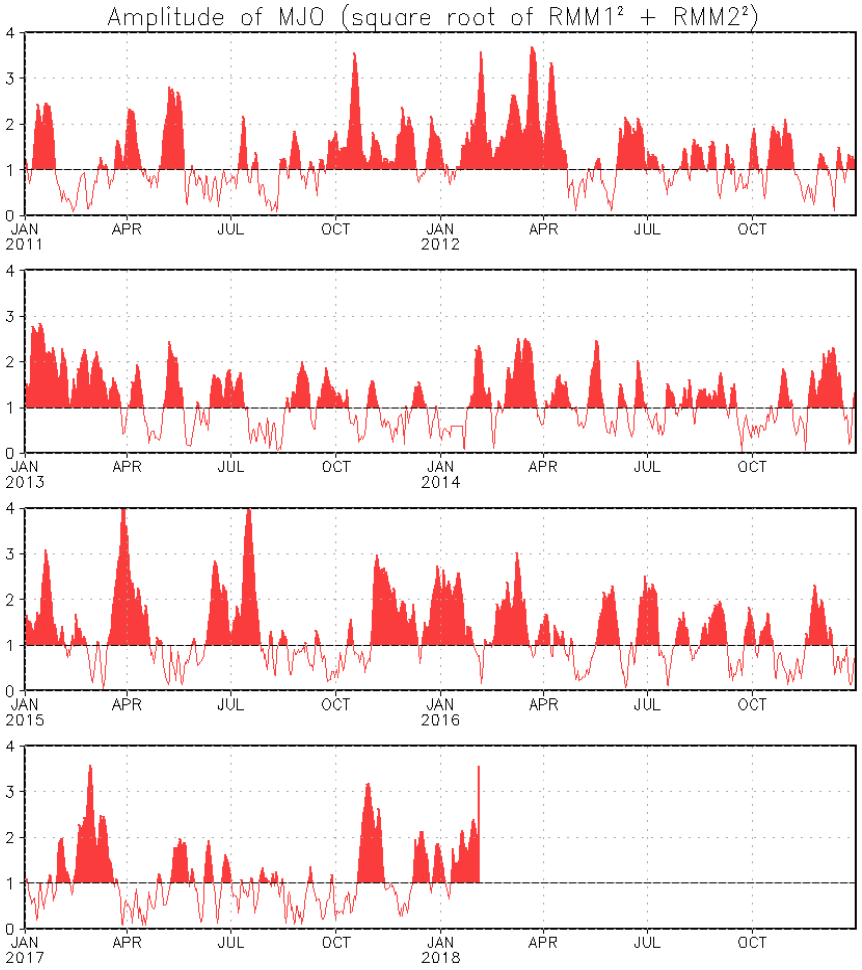
The RMM-based MJO index continues to depict robust MJO activity, with the enhanced phase propagating across the West Pacific and largely maintaining its amplitude the past week.



# 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

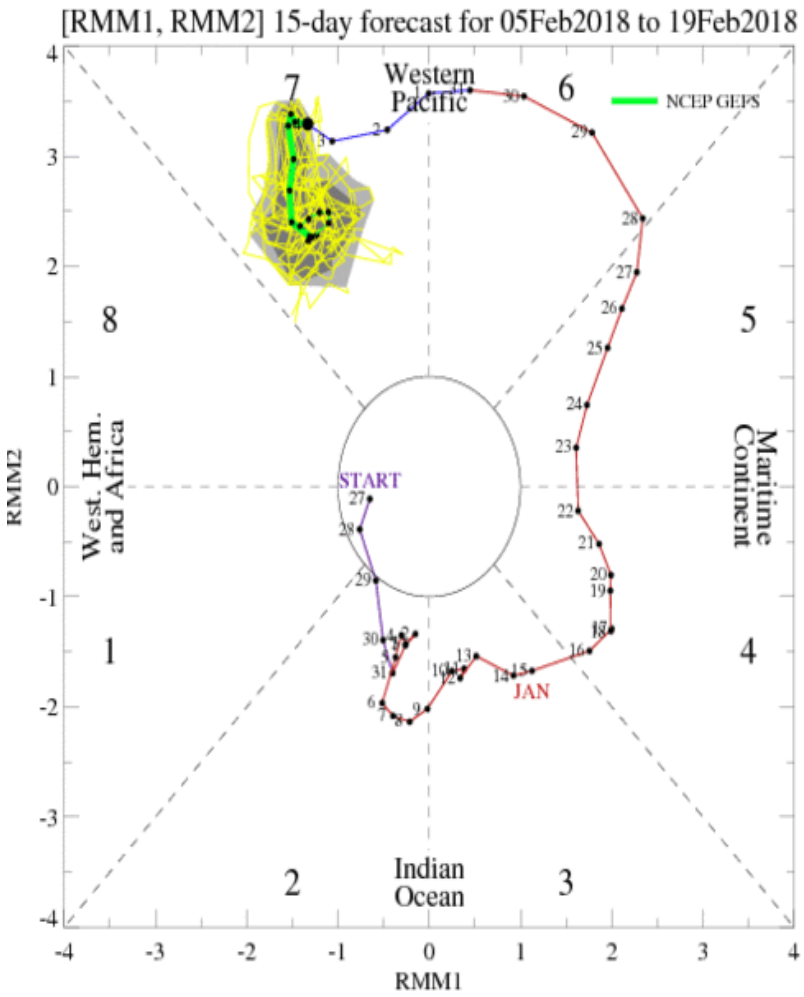
**Yellow Lines** - 20 Individual Members
**Green Line** - Ensemble Mean

**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**

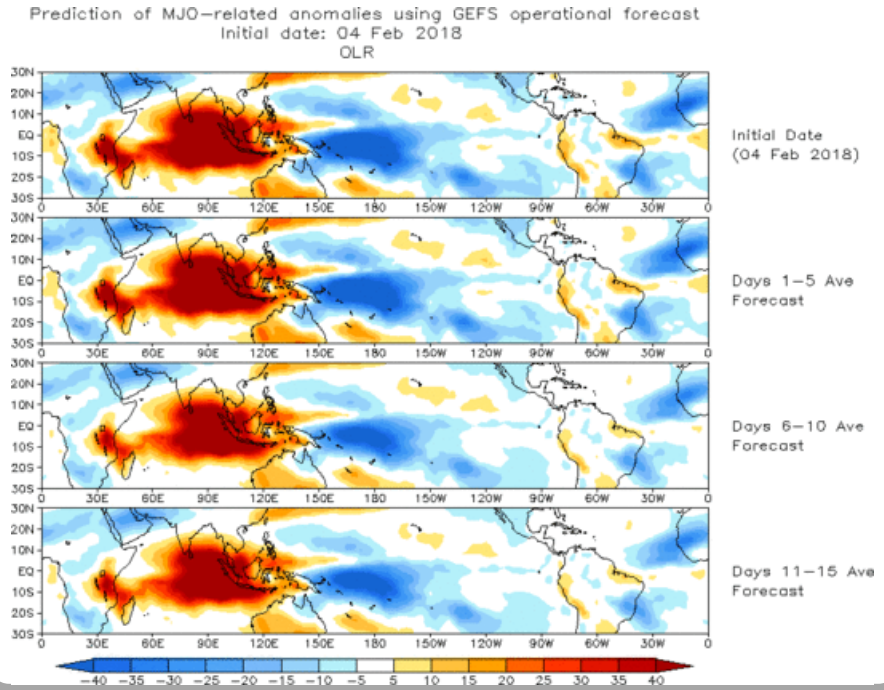
The GEFS forecast depicts a continued robust MJO, but a slowing of the signal due to forecast Rossby wave activity early in the forecast and near the end of Week-2.



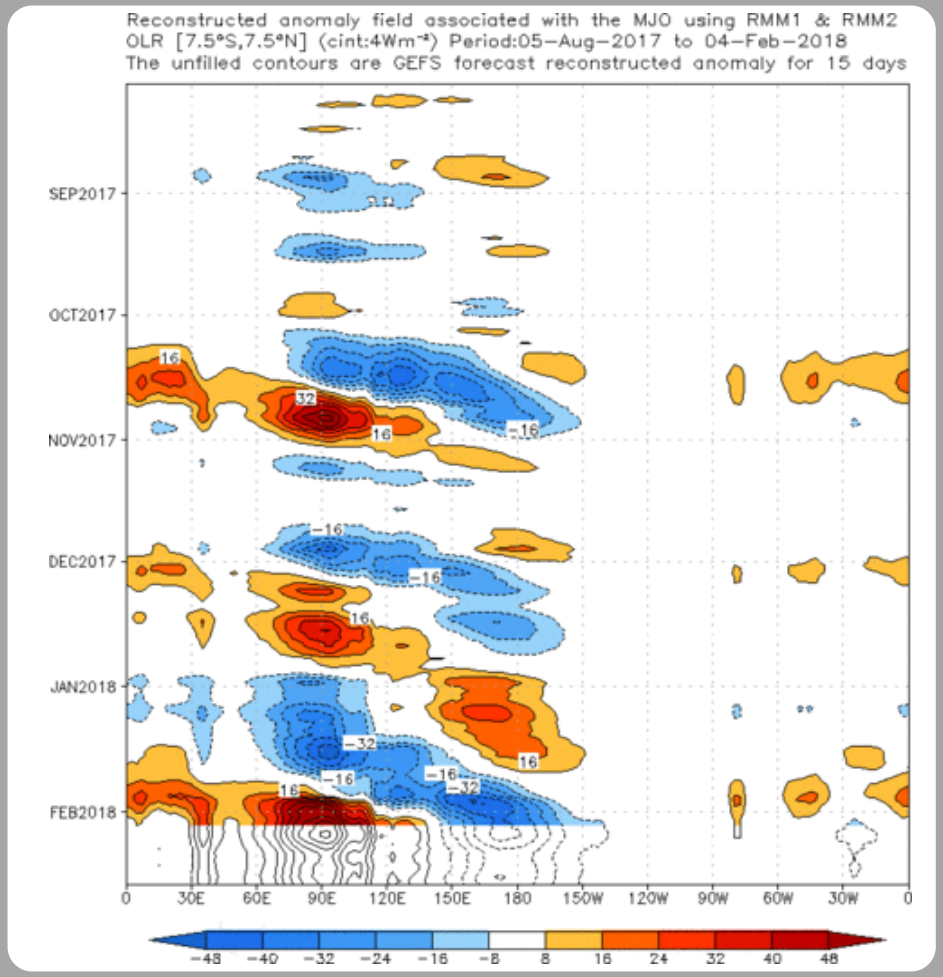
# Ensemble GFS (GEFS) MJO Forecast

**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

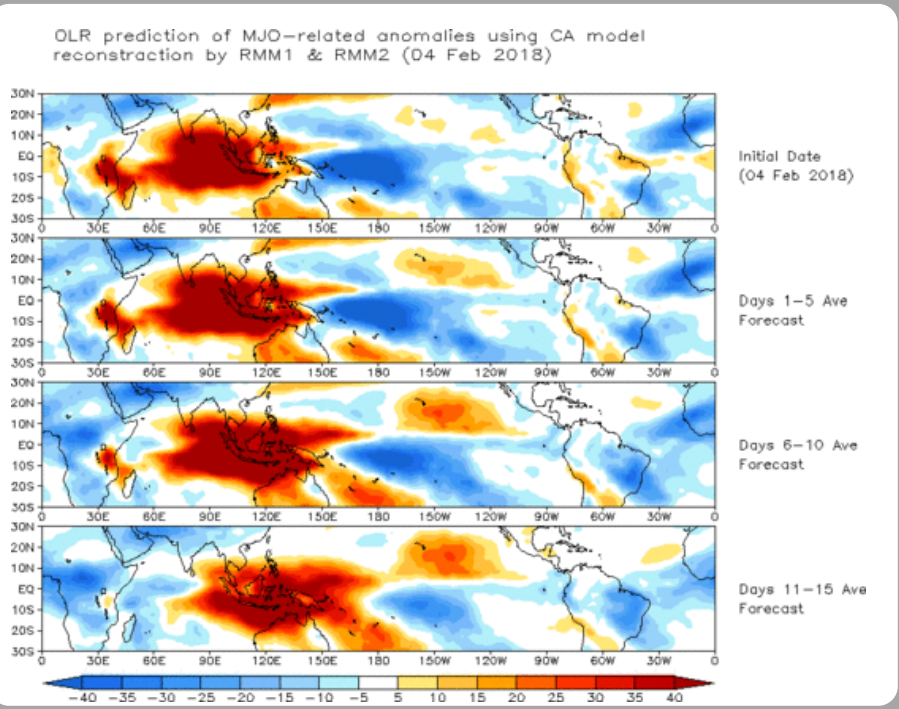



OLR anomalies associated with the MJO based on the GEFS show a relatively stationary pattern, despite the typical tendency for the intraseasonal envelope to speed up across the Western Pacific as convection decouples from the ocean.

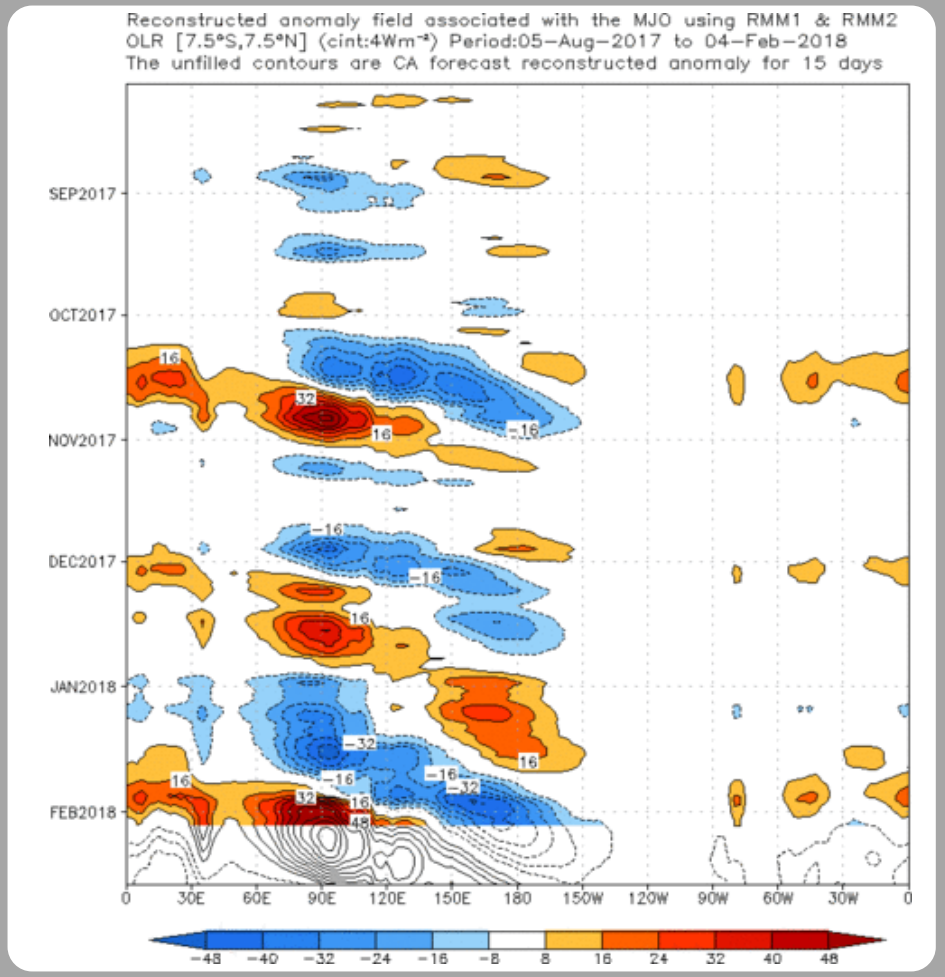
# Constructed Analog (CA) MJO Forecast

**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



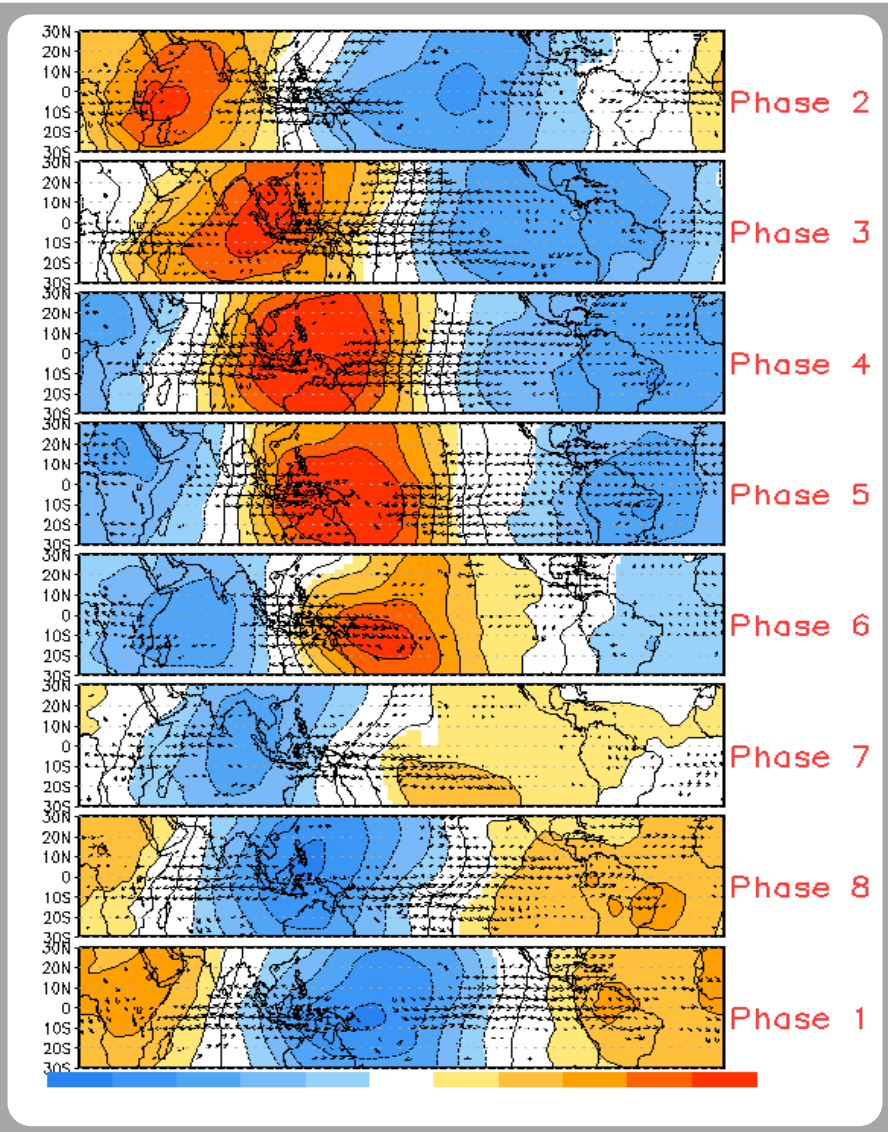

Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



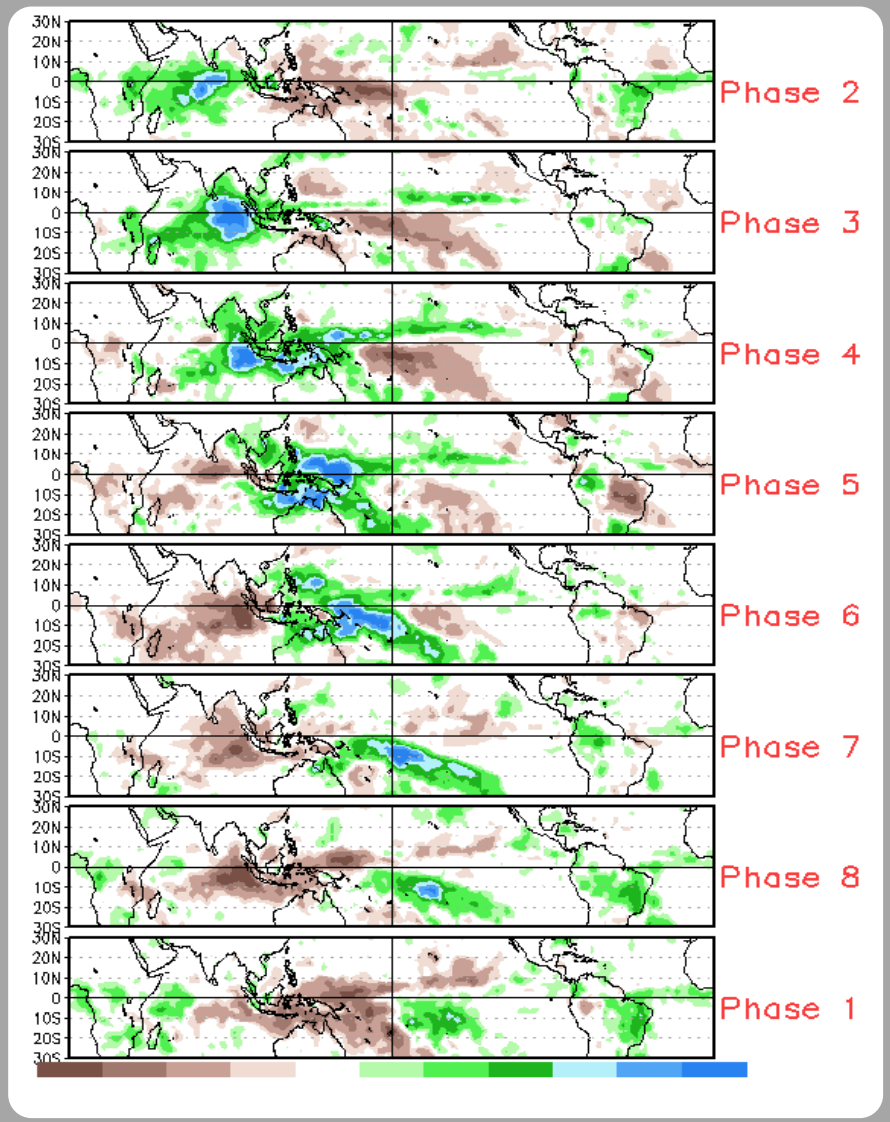

The constructed analog supports a more progressive response in convective anomalies from the MJO during the next two weeks.

# MJO Composites - Global Tropics

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



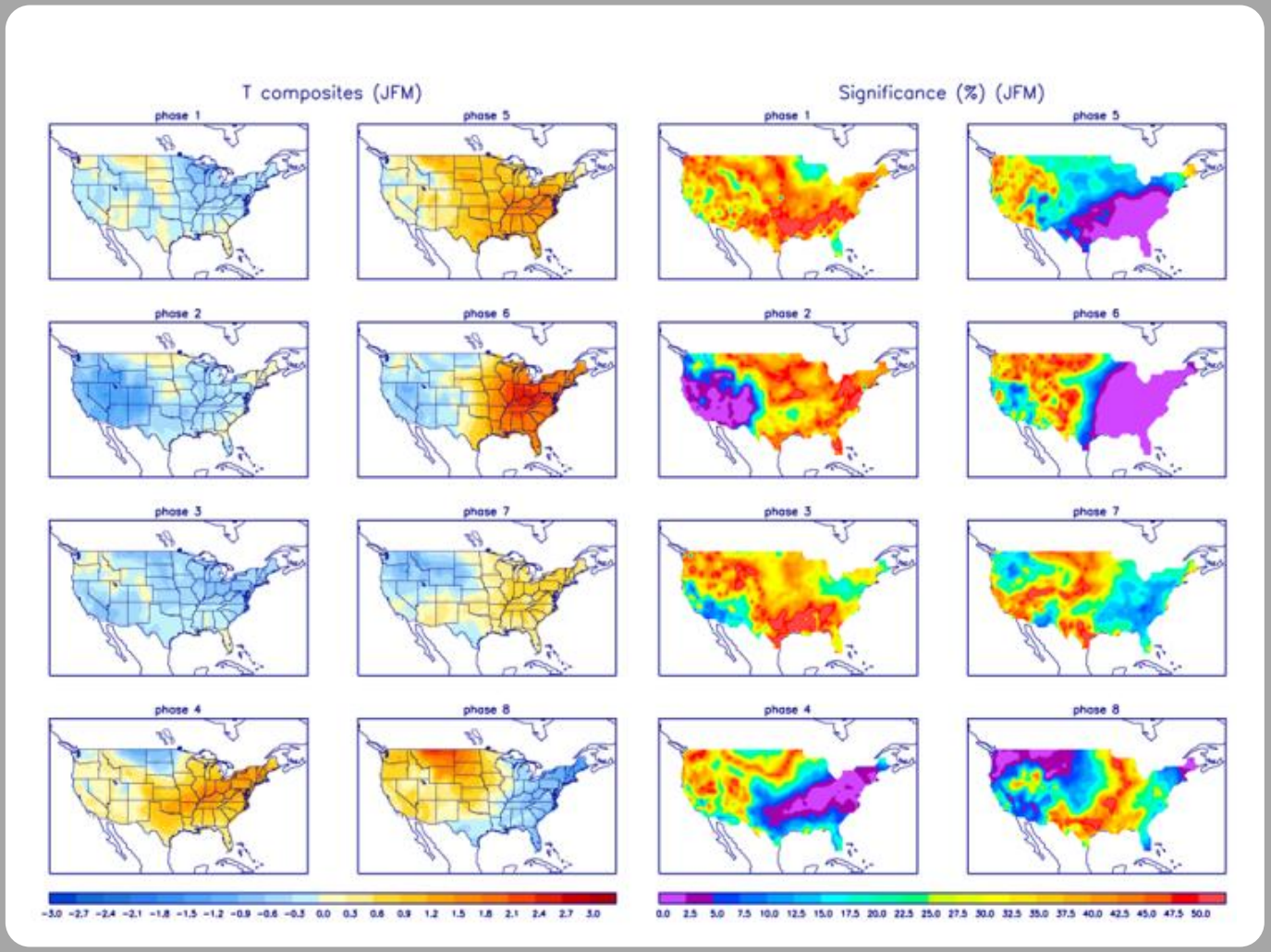

**Precipitation Anomalies (Nov - Mar)**



# 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.**



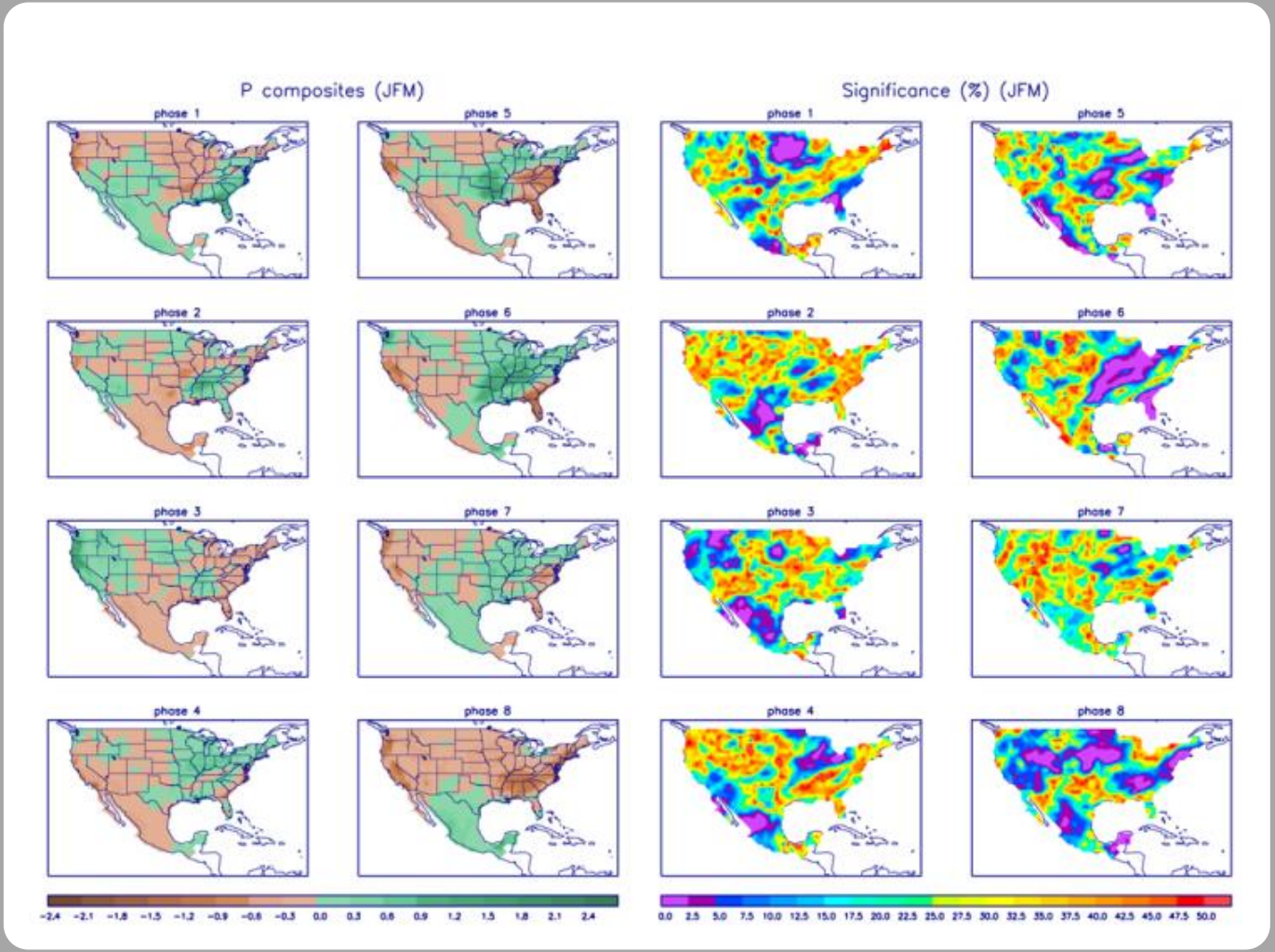

Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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