# 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

- The active phase of the MJO is currently approaching the Western Hemisphere, but is interfering with the background La Niña state that is suppressing convection near the Date Line.

- Models show eastward propagation of the MJO envelope for at least the next week or so, before diverging on whether the signal will weaken or continue across the Western Hemisphere.

- Some caution should be taken with the aforementioned model forecasts that show a weak MJO over the Western Hemisphere, as low frequency enhanced convection building over the Maritime Continent in association with La Niña could be biasing the RMM index towards Phases 4/5 and away from Phases 8/1.

- Even if the MJO does make it across the Western Hemisphere, any substantive extratropical teleconnections are unlikely until the signal reaches the Indian Ocean.

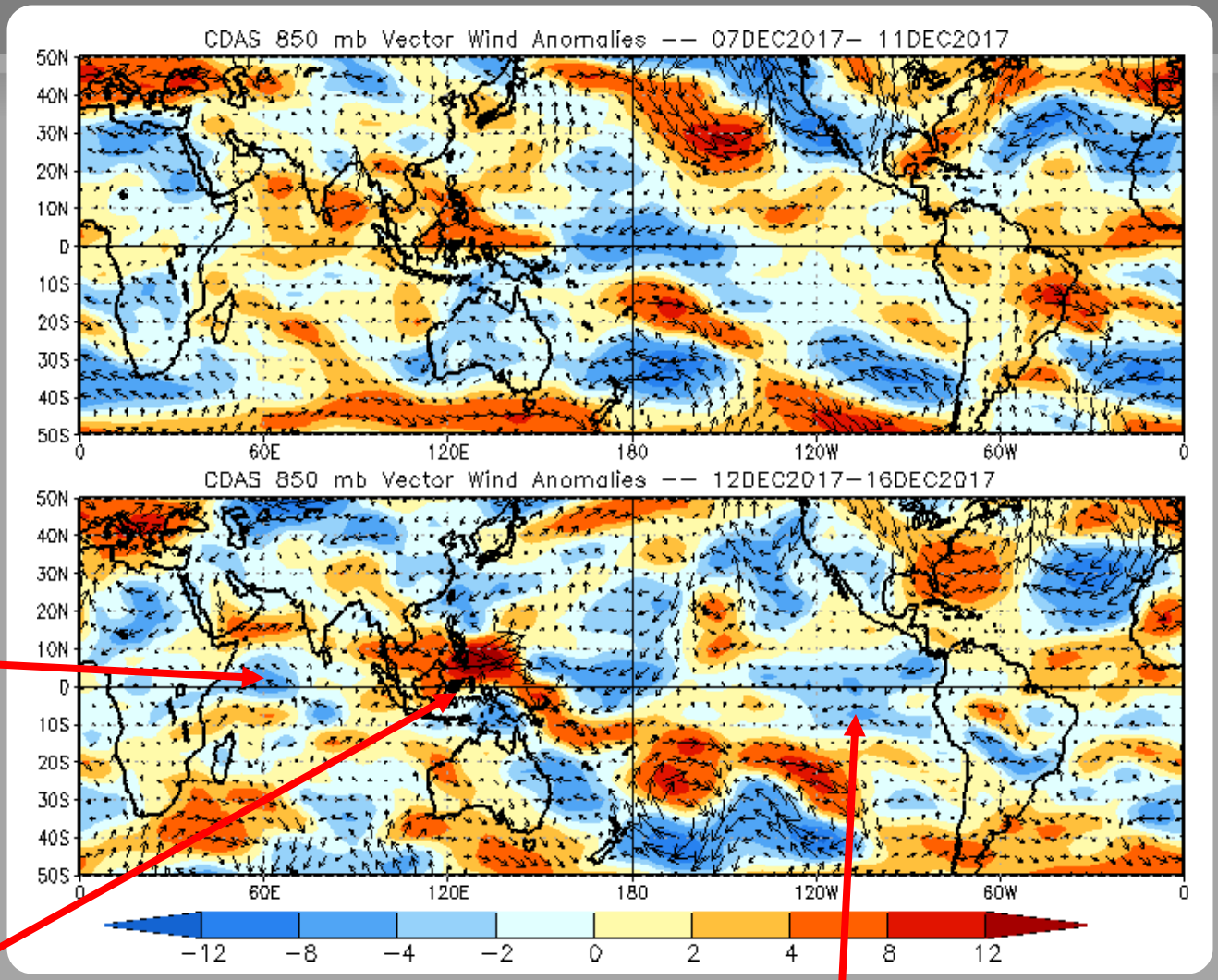
**Additional potential impacts across the global tropics and a discussion for the U.S. are available at:**
**http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php**

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies




Easterlies emerged over the Western Indian Ocean

Highly anomalous westerlies existed to the east of the Philippines, tied to Tropical Storm Kai-Tak.

A shift to easterlies occurred across the East Pacific.

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

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

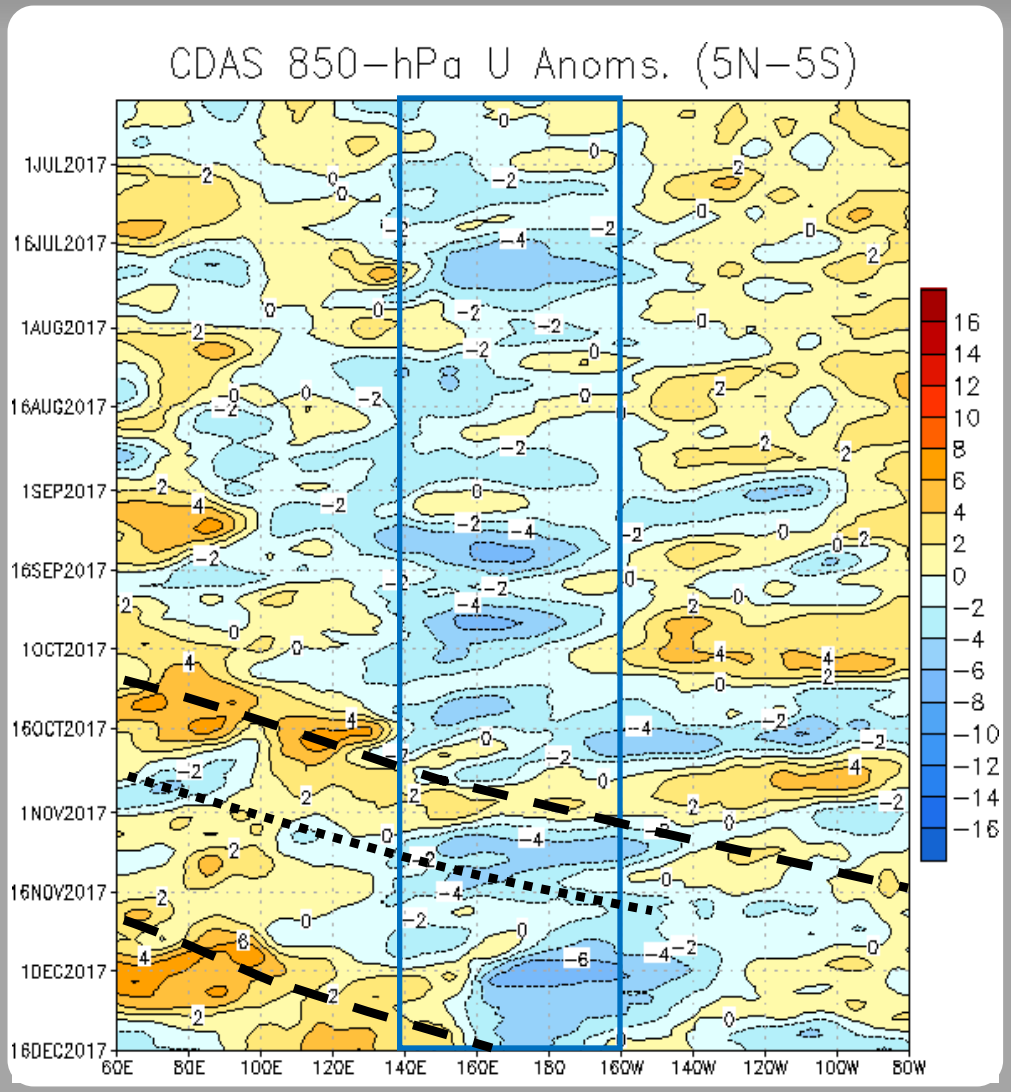
**Easterly anomalies (blue shading) represent anomalous east-to-west flow**

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

During July, a slight eastward shift in the low-frequency pattern is noted, related to short-lived MJO activity. By August and September, the low-frequency envelope of easterly anomalies re-established from 140E to just east of the Date Line.

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.

MJO activity during December has damped the low-frequency anomalous easterlies somewhat, but not across the full extent of the west-central Pacific as in October.



# OLR Anomalies – Past 30 days

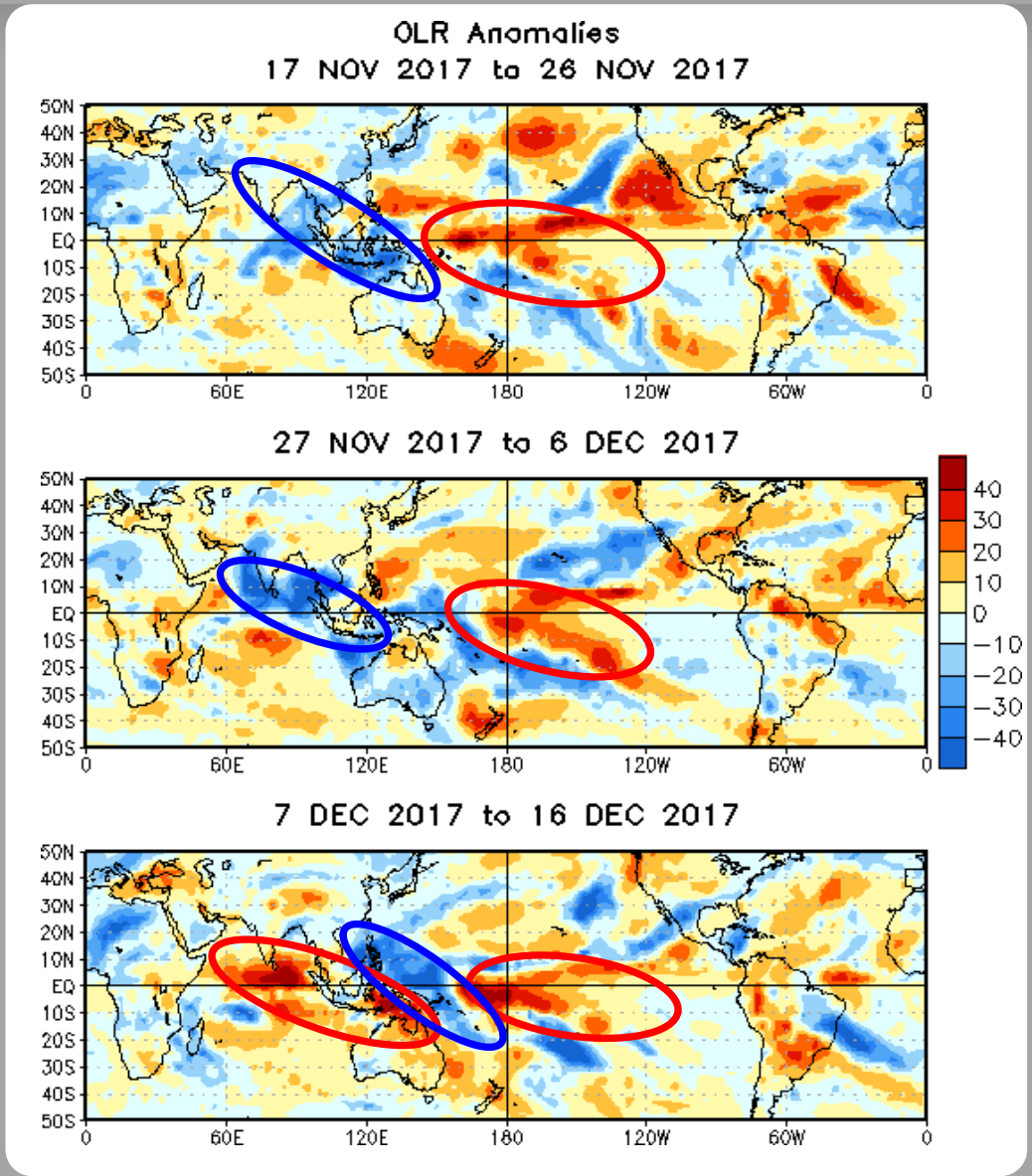
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid- to late November, the remnant MJO signal existed over the eastern Indian Ocean and was approaching the Maritime Continent. Low frequency suppressed convection associated with La Niña persisted near the Date Line.

During late November and early December, enhanced convection increased over the eastern Indian Ocean and western Maritime Continent, partly due to tropical cyclone and Rossby wave activity, but also the new MJO event.

In early to mid-December the MJO crossed the Maritime Continent into the Pacific, and coupled with active equatorial Rossby wave activity, enhanced convection in the West Pacific. Suppressed convection with the inactive phase of the MJO emerged across the Indian Ocean.



# Outgoing Longwave Radiation (OLR) Anomalies (7.5°S - 7.5°N)

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

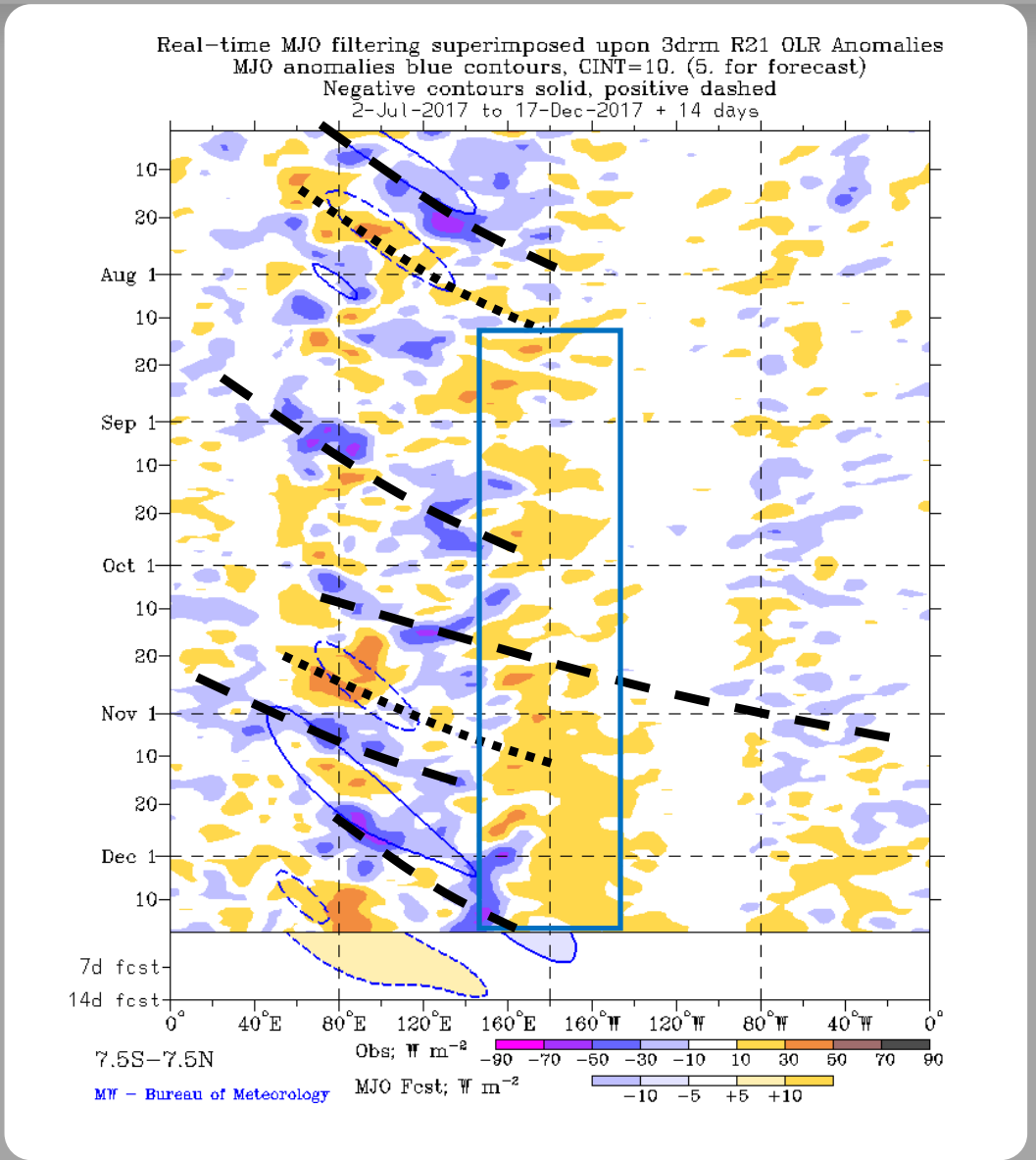
**Wetter-than-normal conditions, negative OLR anomalies (blue shading)**

During mid-July, there was a burst of enhanced convection over the Maritime Continent, due to interactions between a short-lived intraseasonal signal and the low-frequency state.

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, with some eastward propagation evident.



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

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

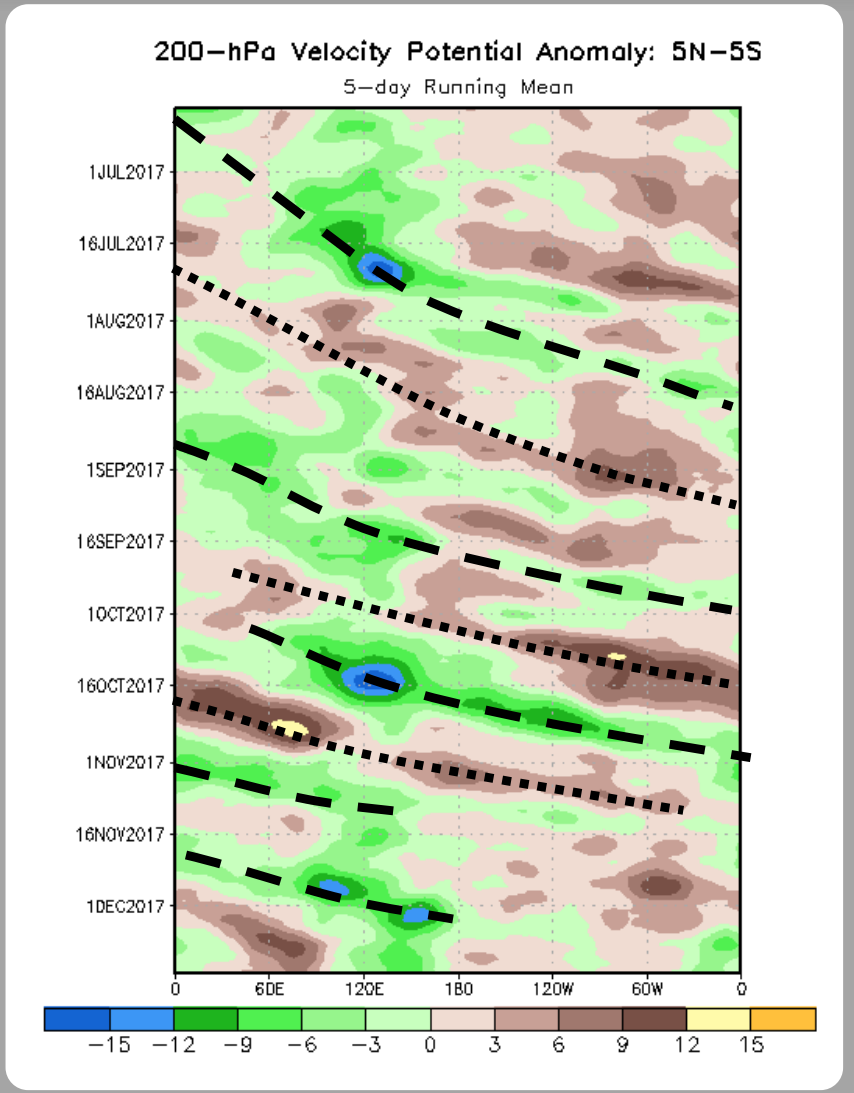
**Negative anomalies (green shading) indicate favorable conditions for precipitation**

During July, enhanced convection strengthened over the Maritime Continent. This eastward propagating signal appears more or less intact with a period in line with canonical MJO phase speeds.

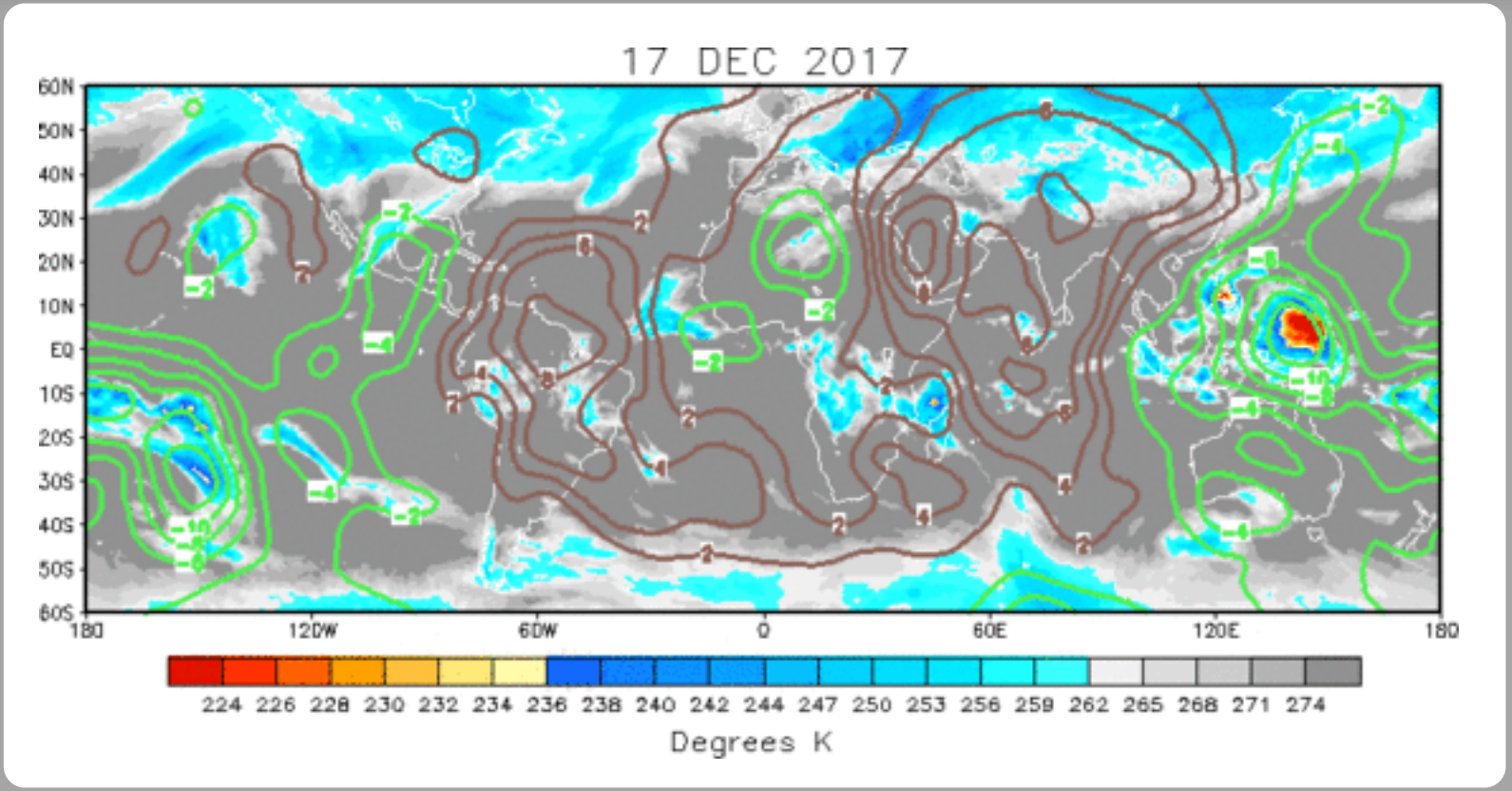
A signal on the MJO timescale is evident in this field during late August and September.

Another 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, beginning over the eastern Indian Ocean and propagating eastward. This intraseasonal signal has been somewhat weaker, with it being unable to enhance convection east of the Date line relative to the more dominant La Niña suppressed state.



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




A broadly Wave-1 pattern is apparent, with enhanced (suppressed) convection over the Maritime Continent and Pacific (Atlantic through Indian Ocean, with the exception of across West Africa).

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)

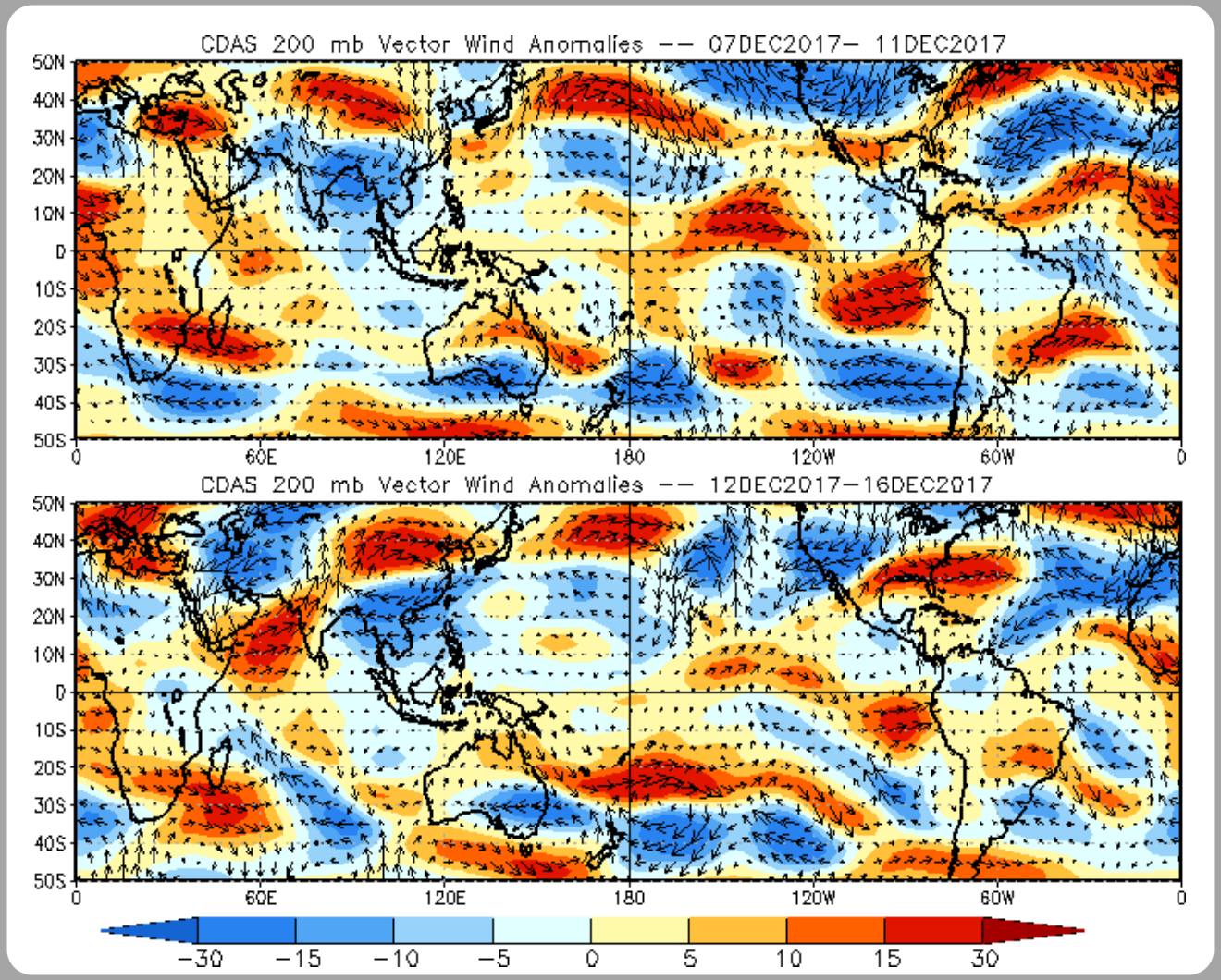
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Upper-level westerlies appear persistent and organized over the equatorial Pacific, with some weakening over the Central Pacific during the last 5 days. Wave-breaking and mid-latitude influences are apparent over the Western Hemisphere.

Extratropical influences are also apparent from the Southern Hemisphere in recent days, with cross-equatorial flow east of Madagascar extending northward to the Arabian Sea.



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

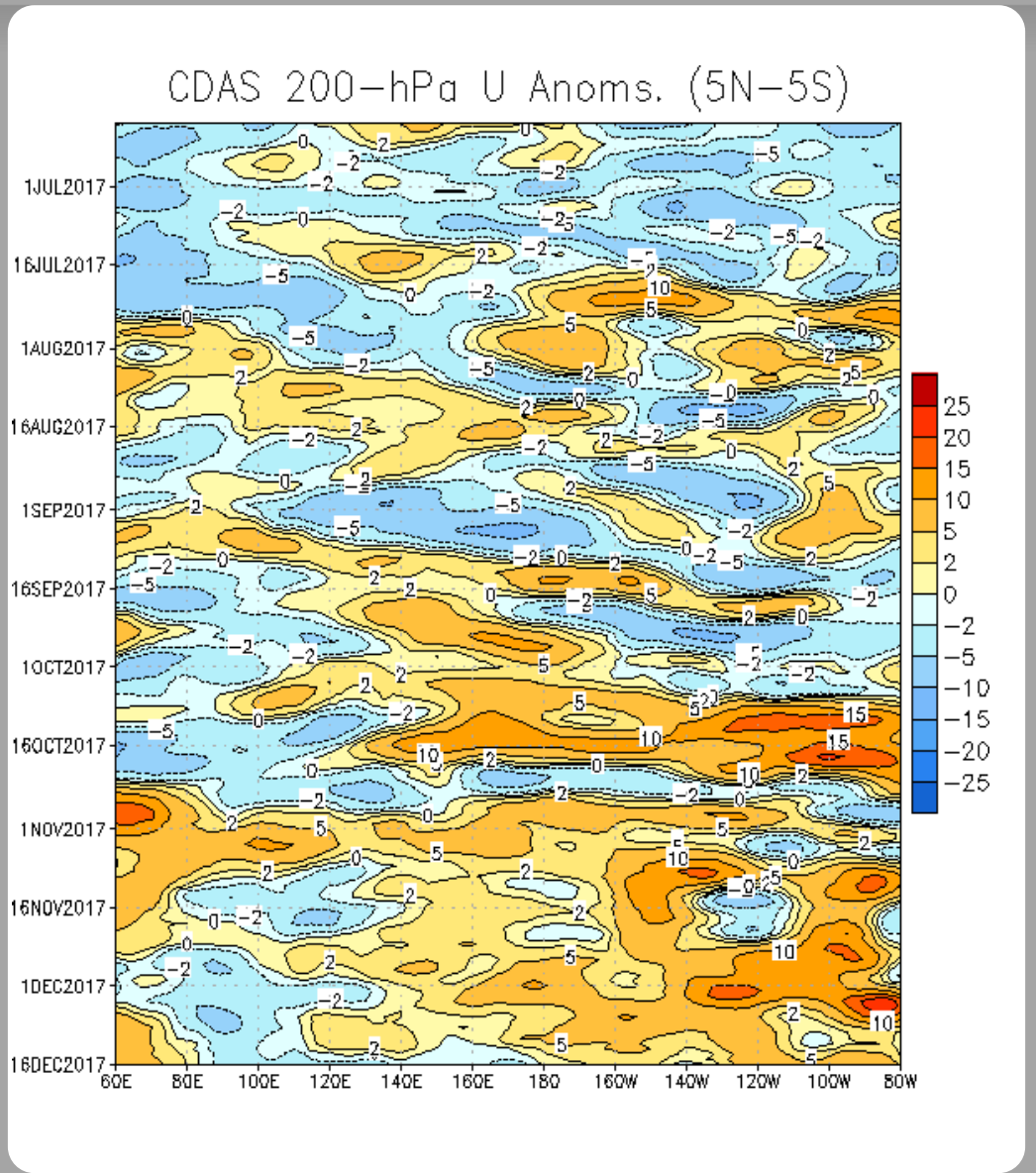
**Westerly anomalies (orange/red shading) represent anomalous west-to-east flow**

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

Starting in July, the anomaly patterns propagated eastward associated with weak MJO activity and atmospheric Kelvin waves.

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.

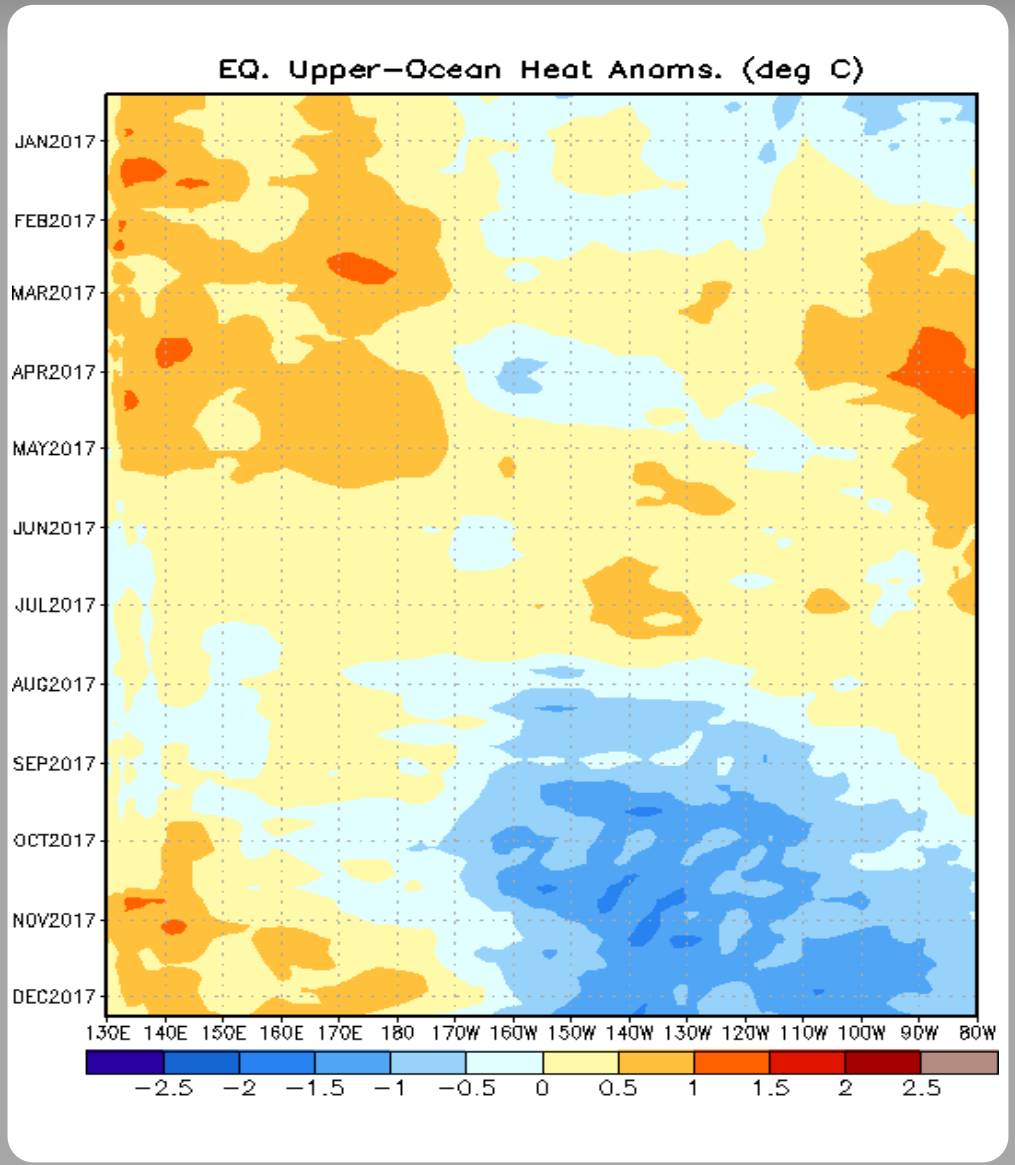
Low-frequency westerly anomalies have remained in place east of 140E since October, with the exception of a brief period of easterlies in late October. There is also some recent evidence of easterlies over the far Eastern Hemisphere over the last week or so that appear to have extratropical sourcing.



# 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 over the 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**

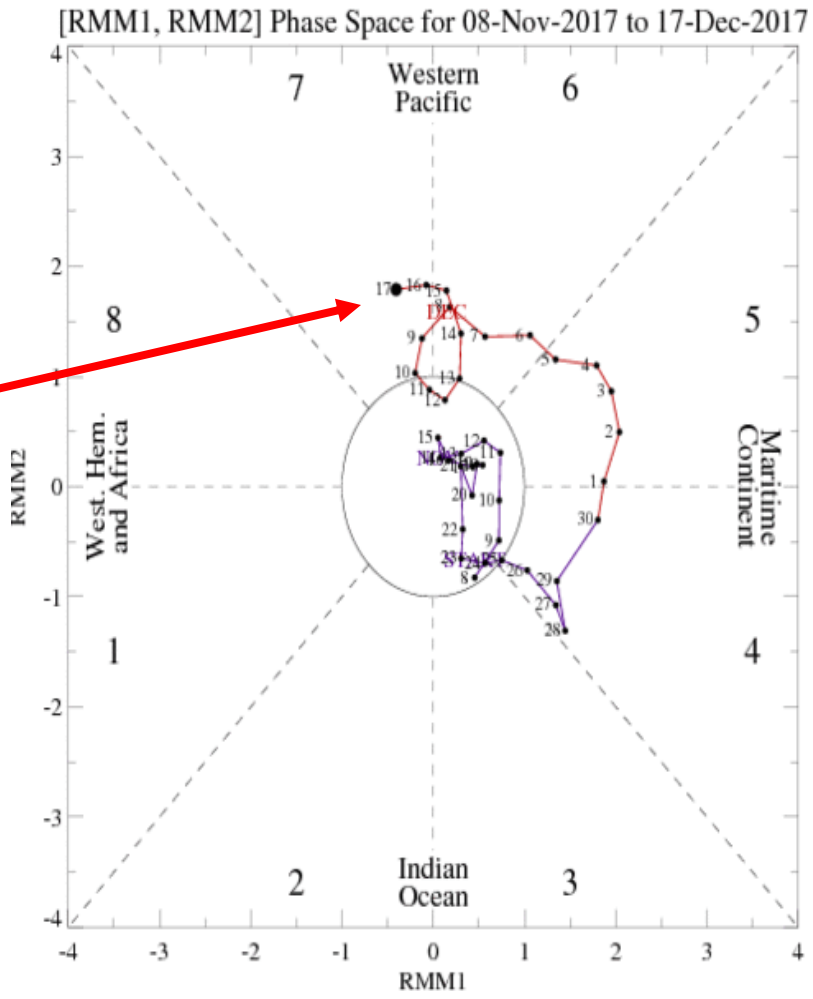
**The triangular areas indicate the location of the enhanced phase of the MJO**

**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**

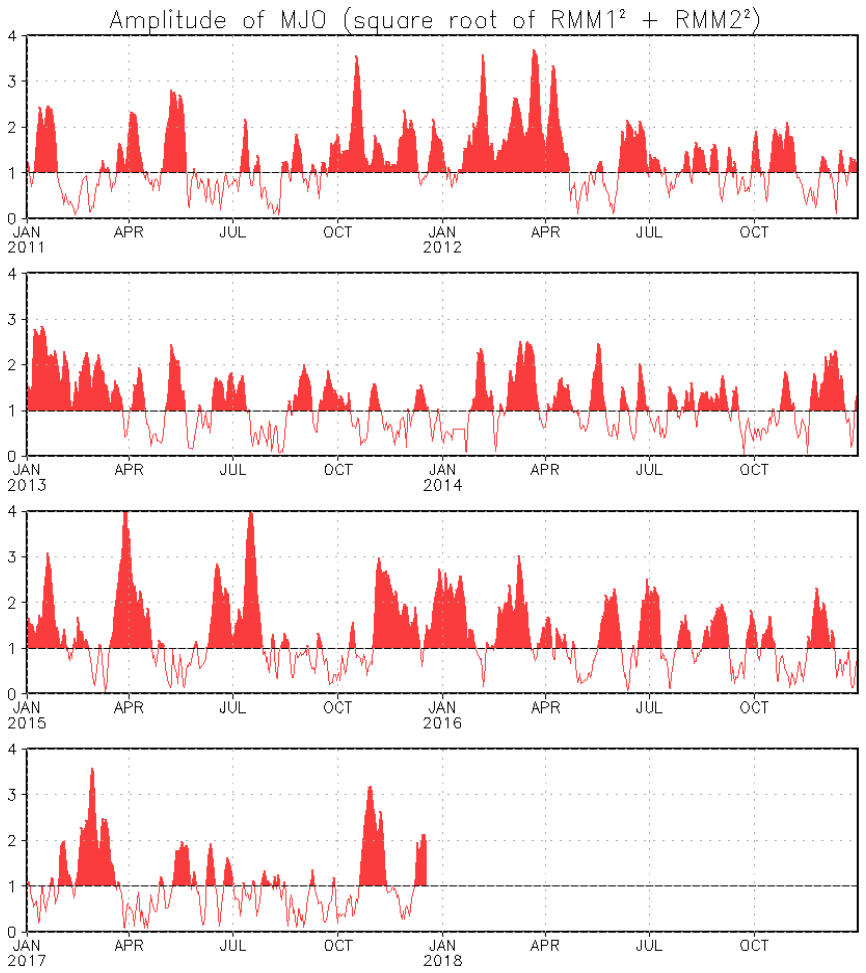
The RMM-index took a looping course between Phases 6 and 7 over the past 10 days in association with Rossby wave activity in the Central Pacific.



# 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.**



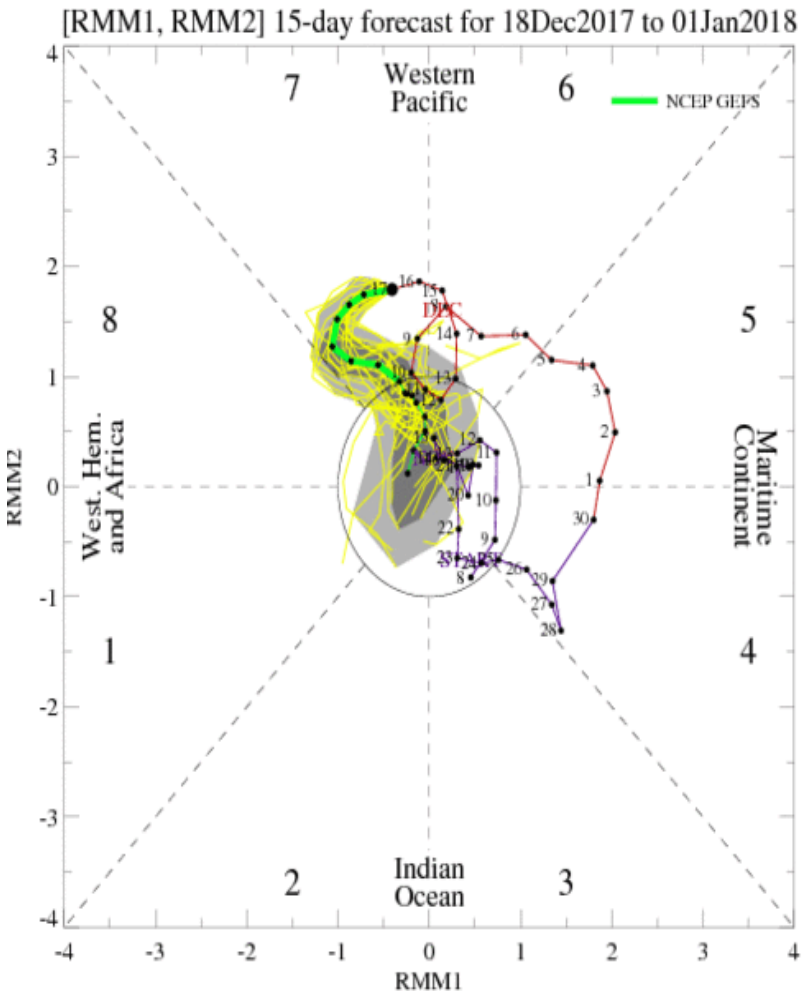
# GFS Ensemble (GEFS) MJO Forecast

**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**



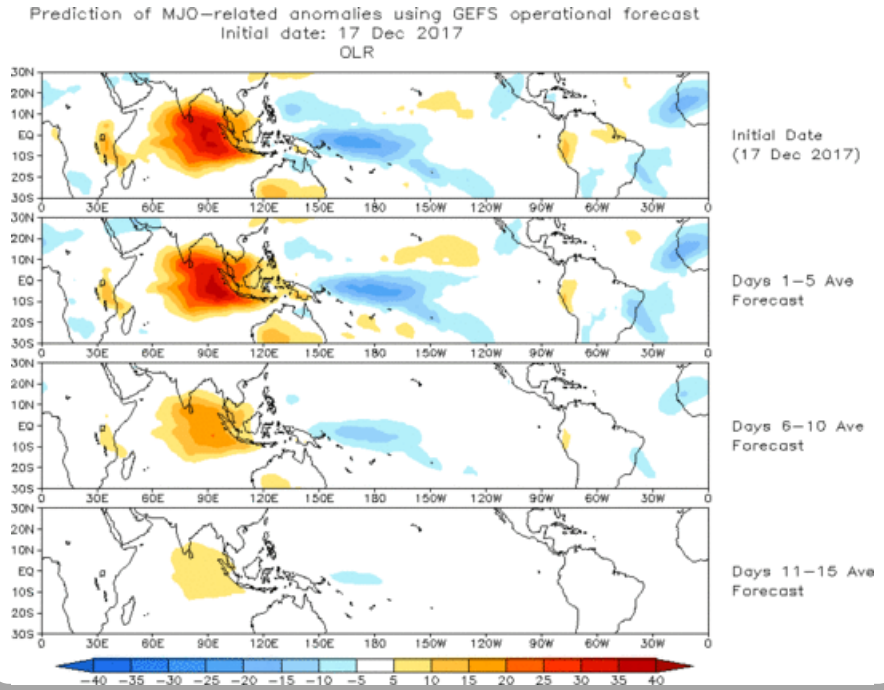

The GEFS forecasts the intraseasonal signal to progress towards the Western Hemisphere before decaying near the start of Week-2.

Some caution has to be taken with this solution given the building low-frequency enhanced convection over the Maritime Continent (Phases 4/5) in recent months that could bias the signal towards those phases and away from a signal over the Western Hemisphere (Phases 8/1).

# Ensemble GFS (GEFS) MJO Forecast

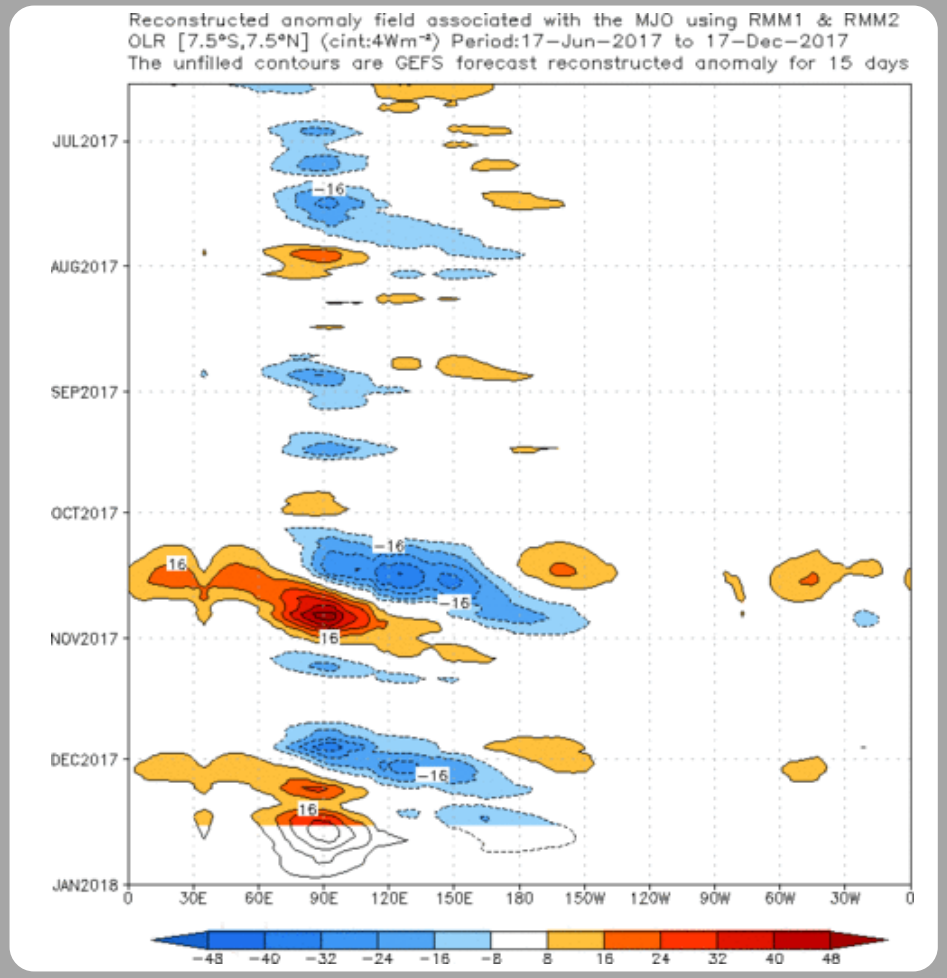
**Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)**

**Spatial map of OLR anomalies for the next 15 days**




OLR anomalies based on the GEFS RMM-index forecast reflects a relatively stationary and weakening pattern with suppressed convection over the Indian Ocean and enhanced convection from the eastern Maritime Continent through the Date Line.

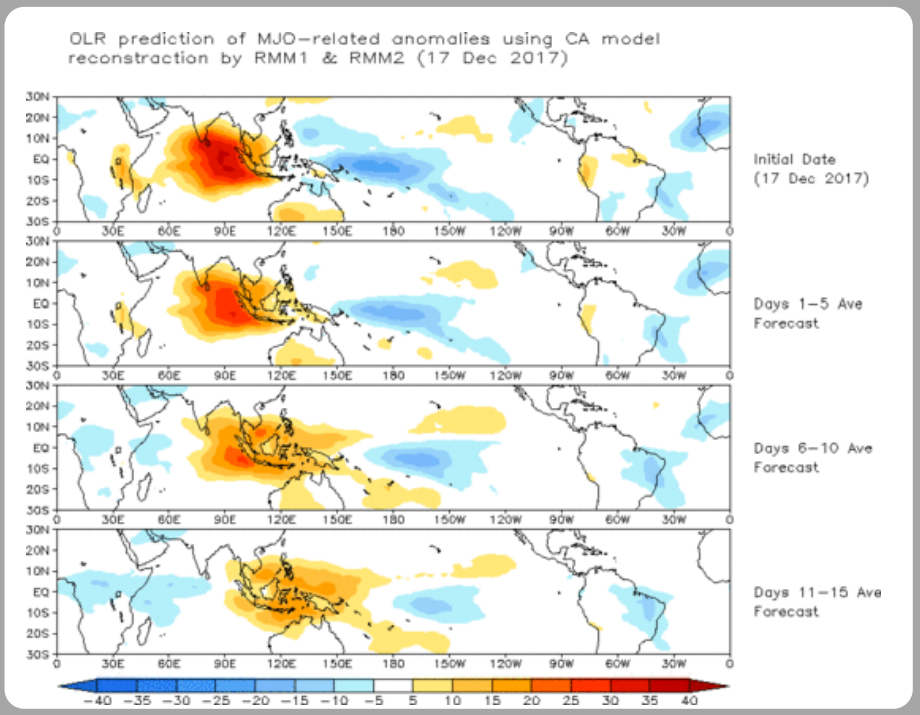
**Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days**



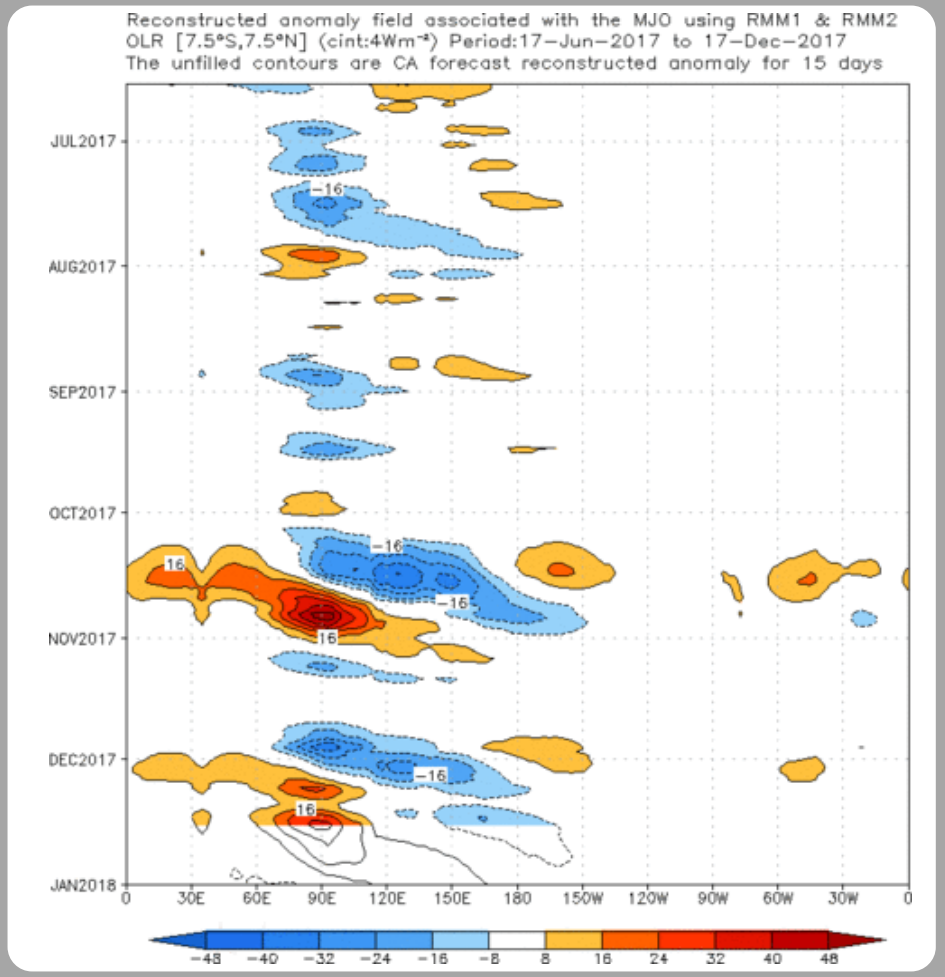
# Constructed Analog (CA) MJO Forecast

**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



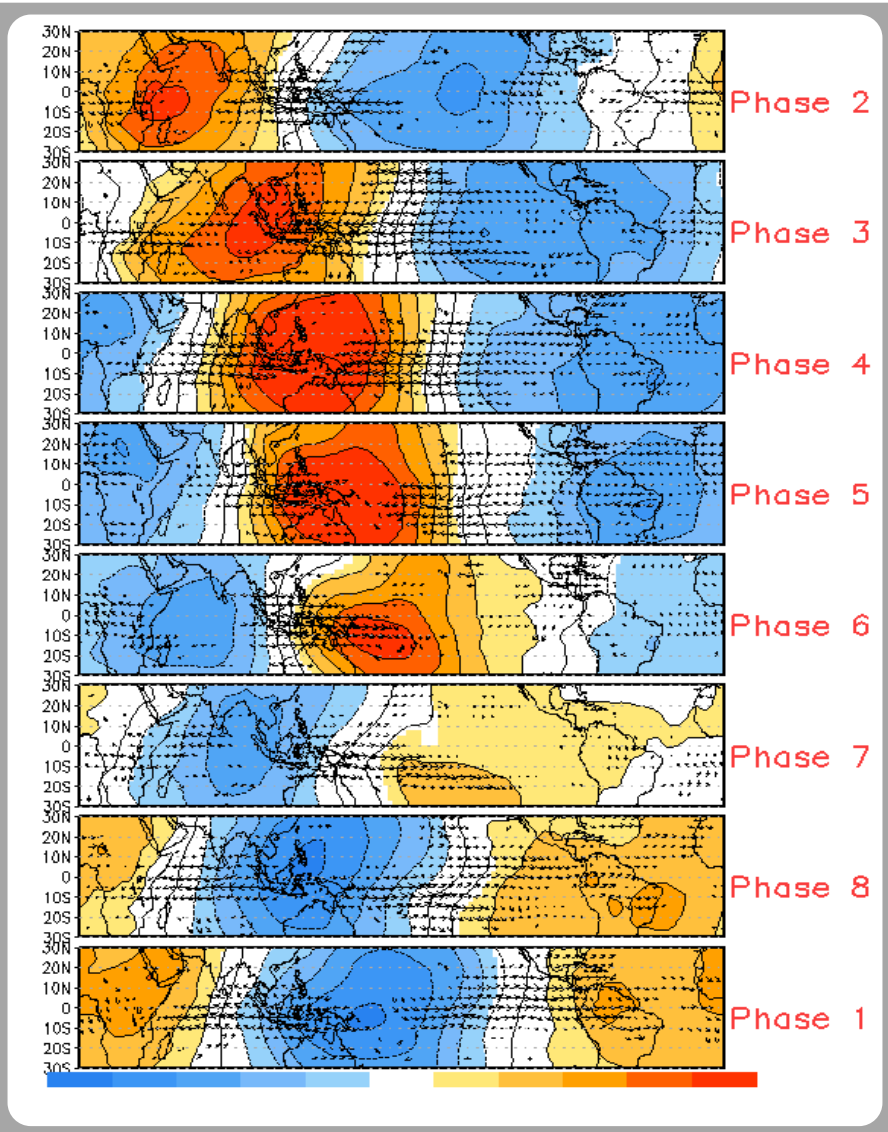

Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



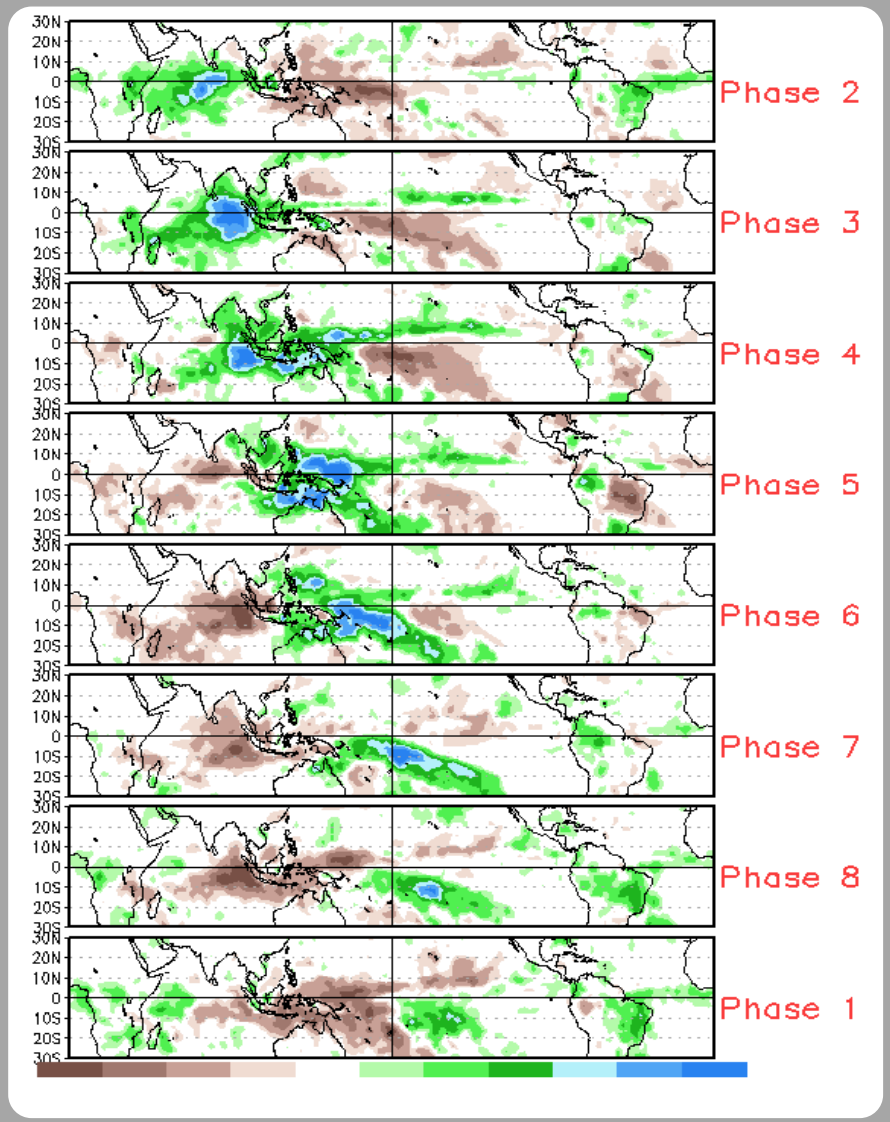

The constructed analog depicts a more progressive MJO envelope relative to the GEFS, but still towards the slower end of canonical MJO activity.

# MJO Composites - Global Tropics

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



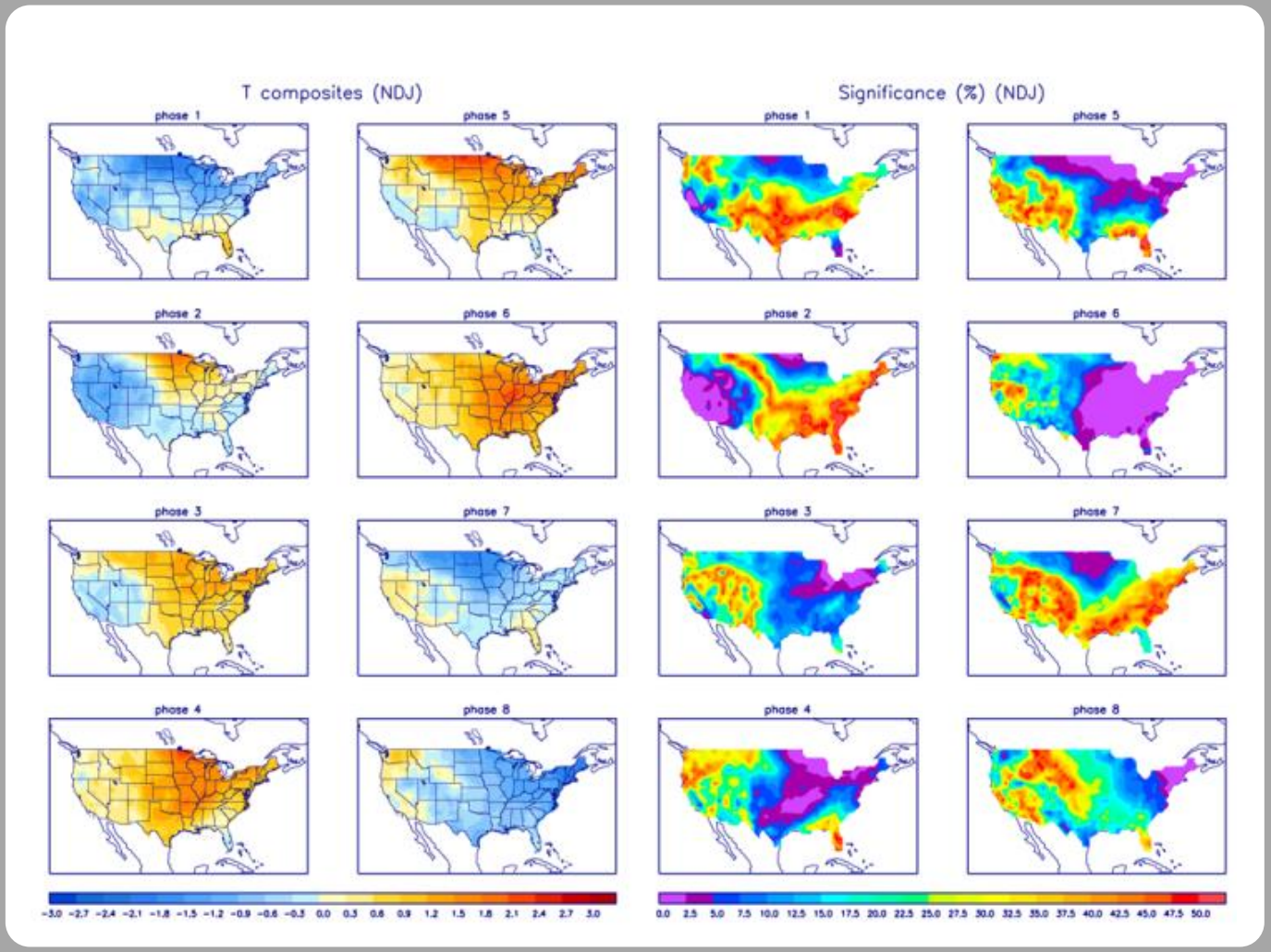

**Precipitation Anomalies (Nov - Mar)**



# 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.**



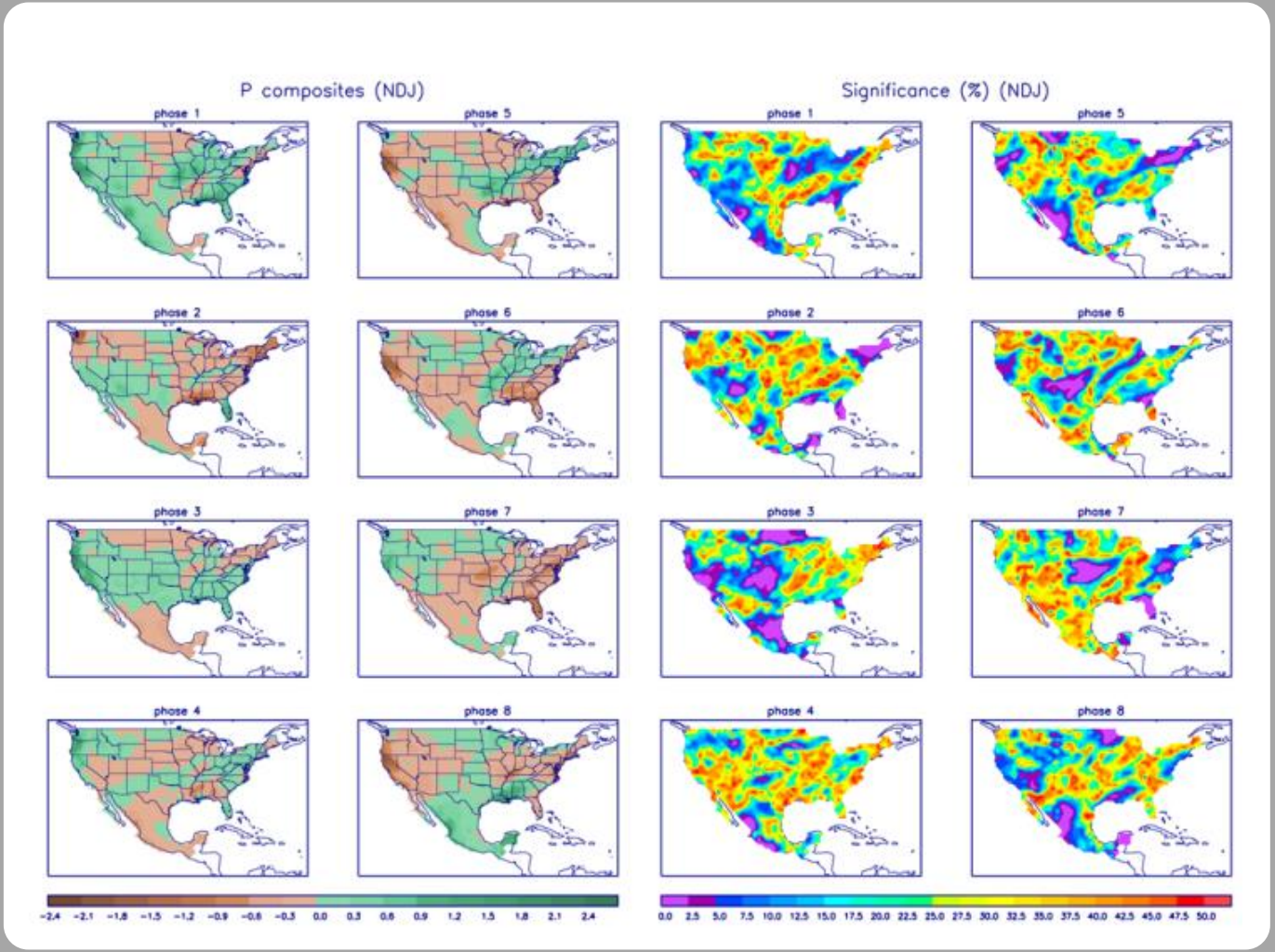

Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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