

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



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29 October 2018

# Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

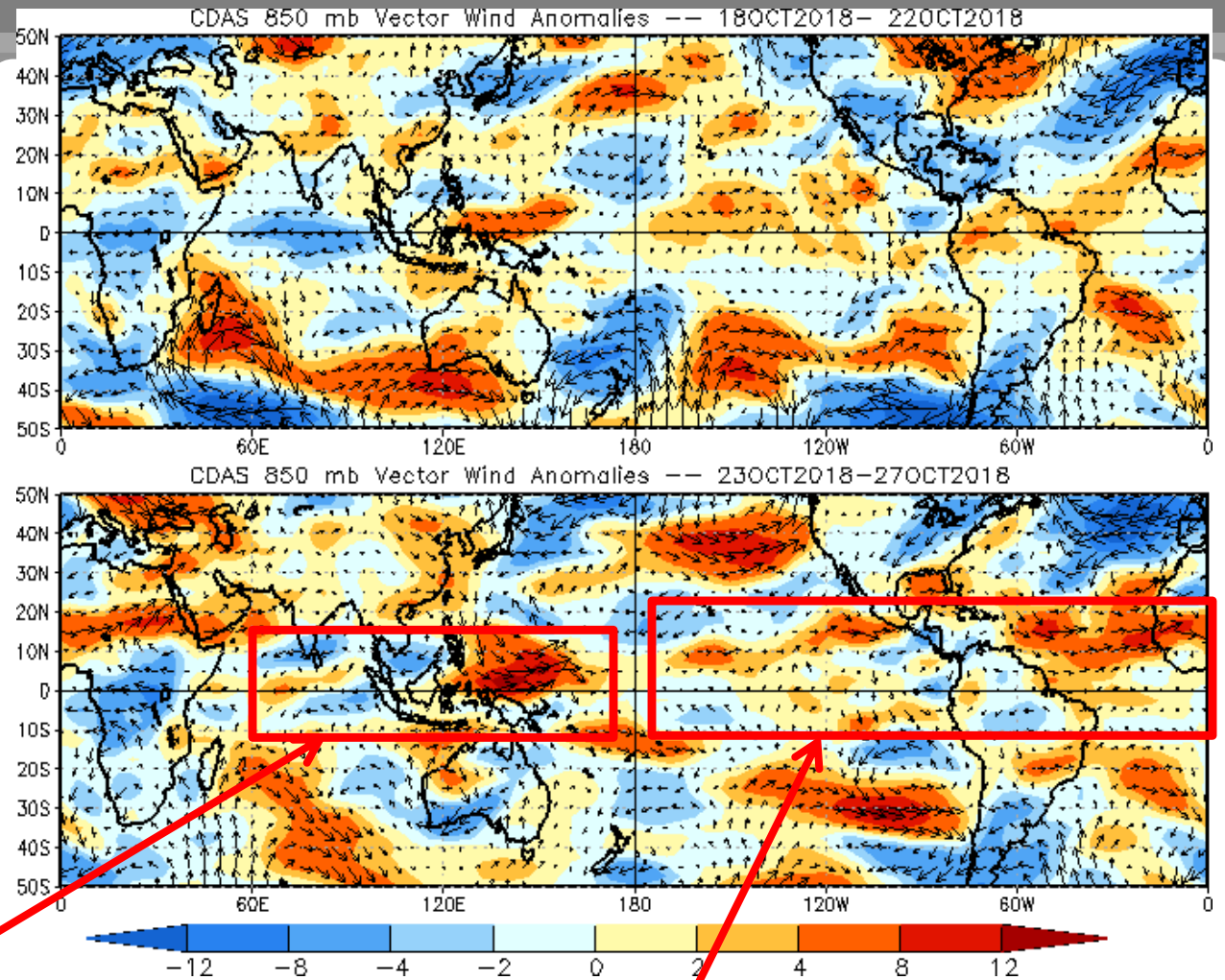
# Overview

- The MJO remained weak during mid to late October. Enhanced (suppressed) convection over the Pacific (Maritime Continent) that became more coherent recently is consistent with a developing MJO.
- Dynamical RMM index forecasts indicate fast eastward propagation of a MJO from the Western Hemisphere to the Indian Ocean during the next two weeks.
- This strengthening MJO is expected to play a role in anomalous convection across the global tropics. Later in Week-2, this MJO may destructively interfere with the emerging El Nino.

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



Easterly anomalies shifted east from the Indian Ocean to the western Maritime Continent, while westerly anomalies strengthened over the West Pacific.

Westerlies persisted over the equatorial eastern Pacific and the tropical North Atlantic.

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

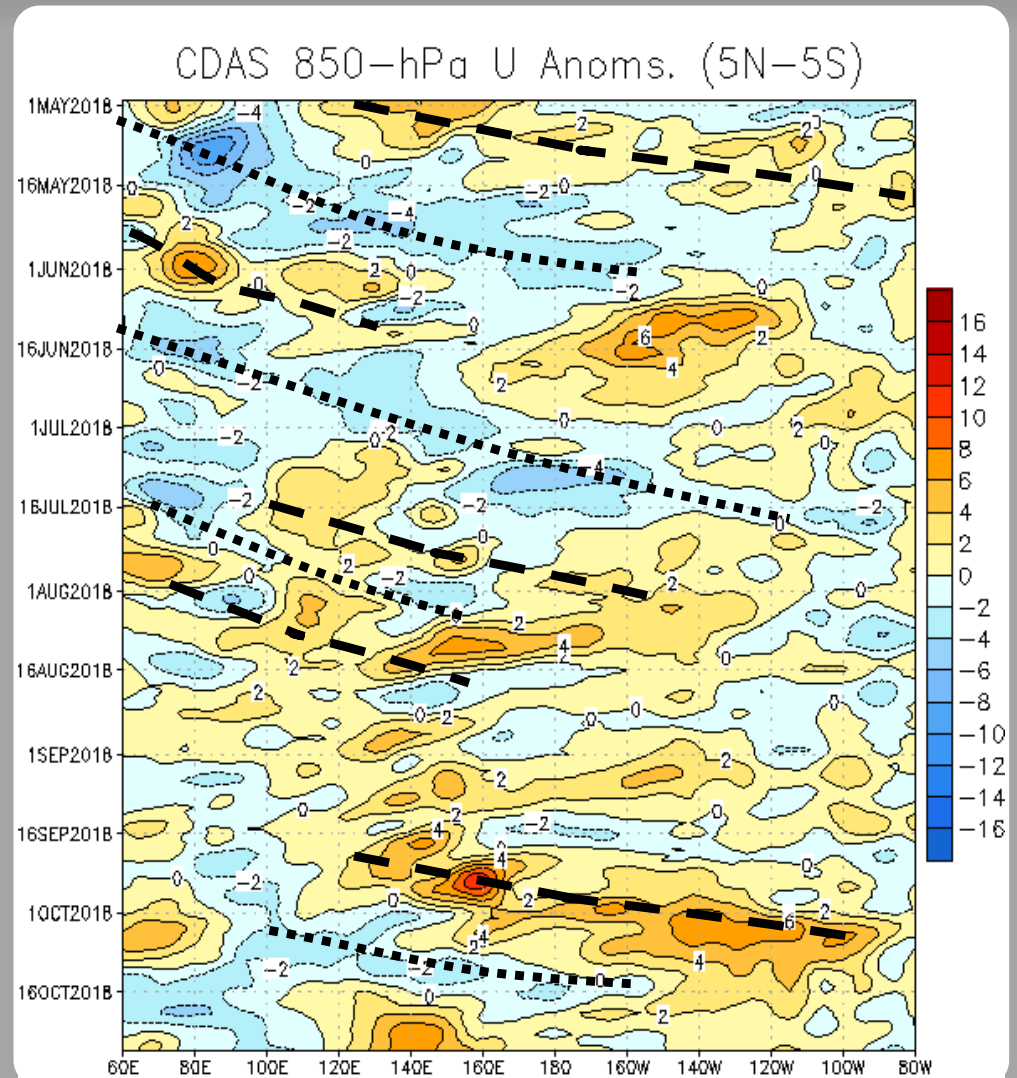
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

The MJO was active during May. Westward moving variability weakened the signal in June. A weak intraseasonal signal re-emerged during mid to late July. During August, the intraseasonal signal weakened, and other modes, including Rossby wave and tropical cyclone activity, influenced the pattern.

Through much of September, Rossby wave activity continued to dominate the Pacific, while westerly anomalies overspread the equatorial Pacific.

During September and October, westerly anomalies increased in amplitude and duration over the equatorial Pacific, consistent with a gradual transition towards El Niño conditions. A large westerly anomaly developed at 140E during late October.



# OLR Anomalies - Past 30 days

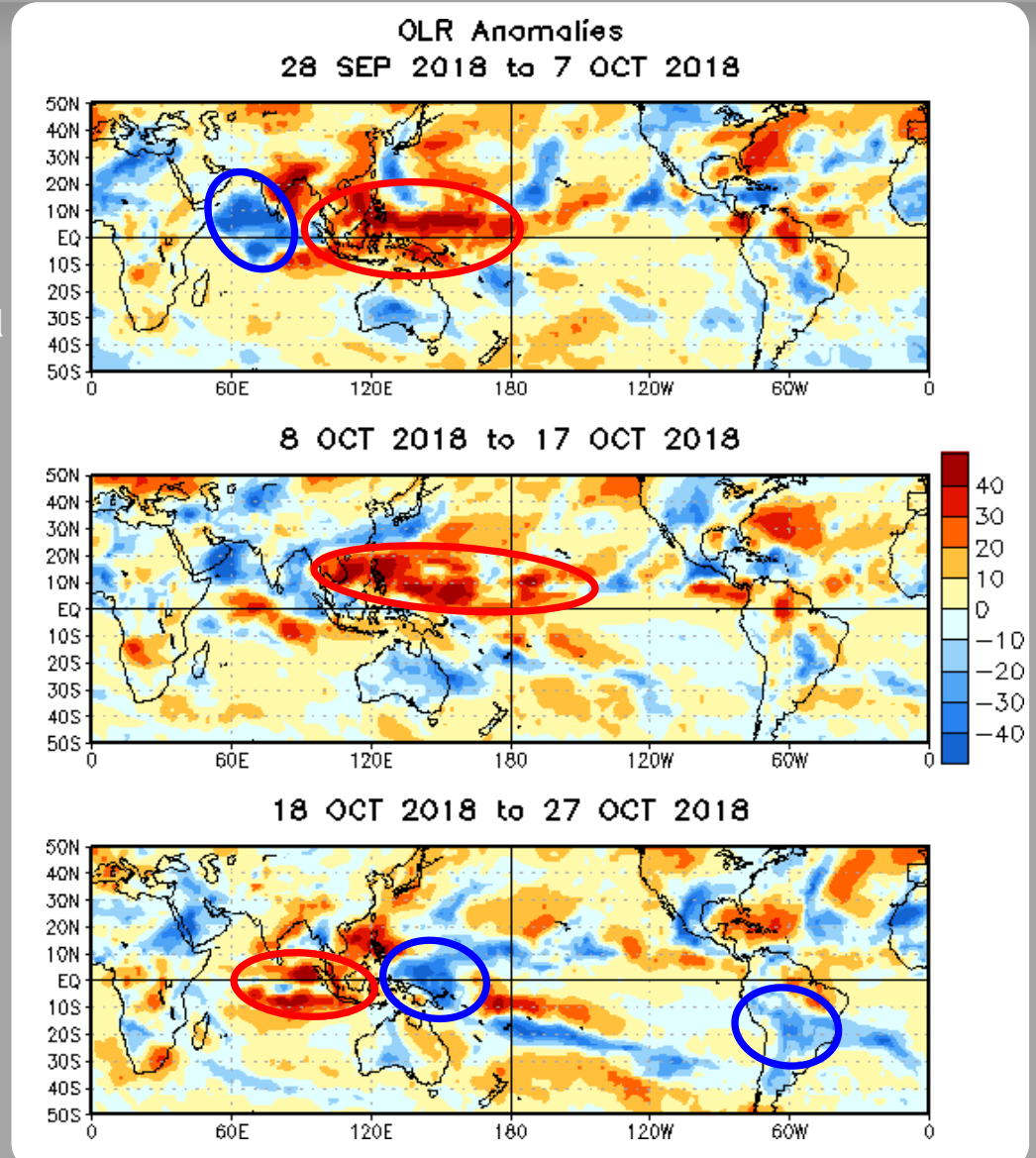
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

By the end of September and early October, suppressed convection moved over the entire Maritime Continent and parts of the equatorial West and Central Pacific, interfering with the base state. Enhanced convection began building over the western Indian Ocean.

During mid-October, convective anomalies weakened along the equator as the MJO signal began breaking down. A large swath of suppressed convection lifted northward over Southeast Asia and the tropical northwestern and central Pacific.

Enhanced convection developed to the north of Papua New Guinea and across much of South America during the latter half of October, while suppressed convection expanded from the Indian Ocean east to the western Maritime Continent.



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

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

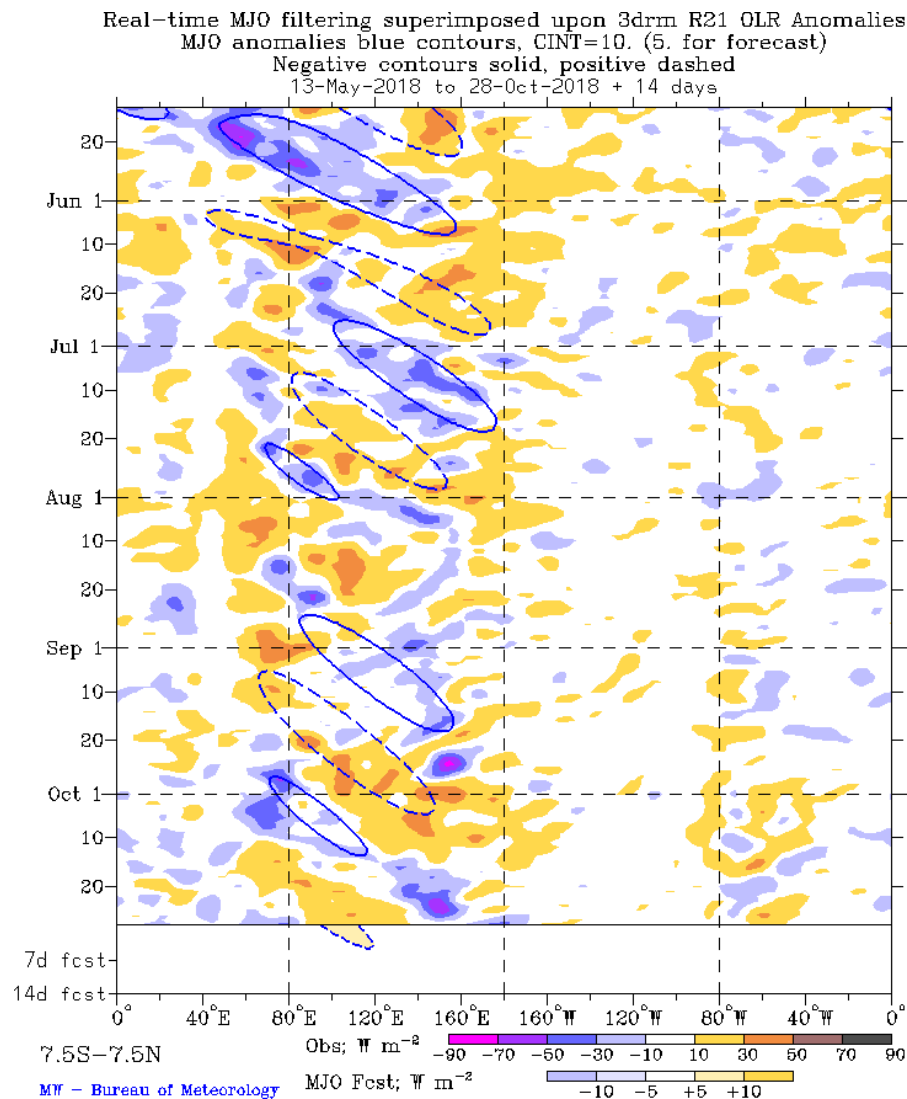
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

The MJO was active during May. The signal weakened in June, but re-emerged during July.

Kelvin waves, Rossby waves, and tropical cyclones dominated the pattern during August and early September, while the intraseasonal signal remained fairly weak.

During mid-September, the suppressed phase of the MJO emerged over the Eastern Indian Ocean and Maritime Continent. During early October, the suppressed signal propagated further east and enhanced convection emerged over the western Indian Ocean.

More recently, the intraseasonal signal weakened, though weak convection has developed over the far western Pacific east of 120° E.





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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

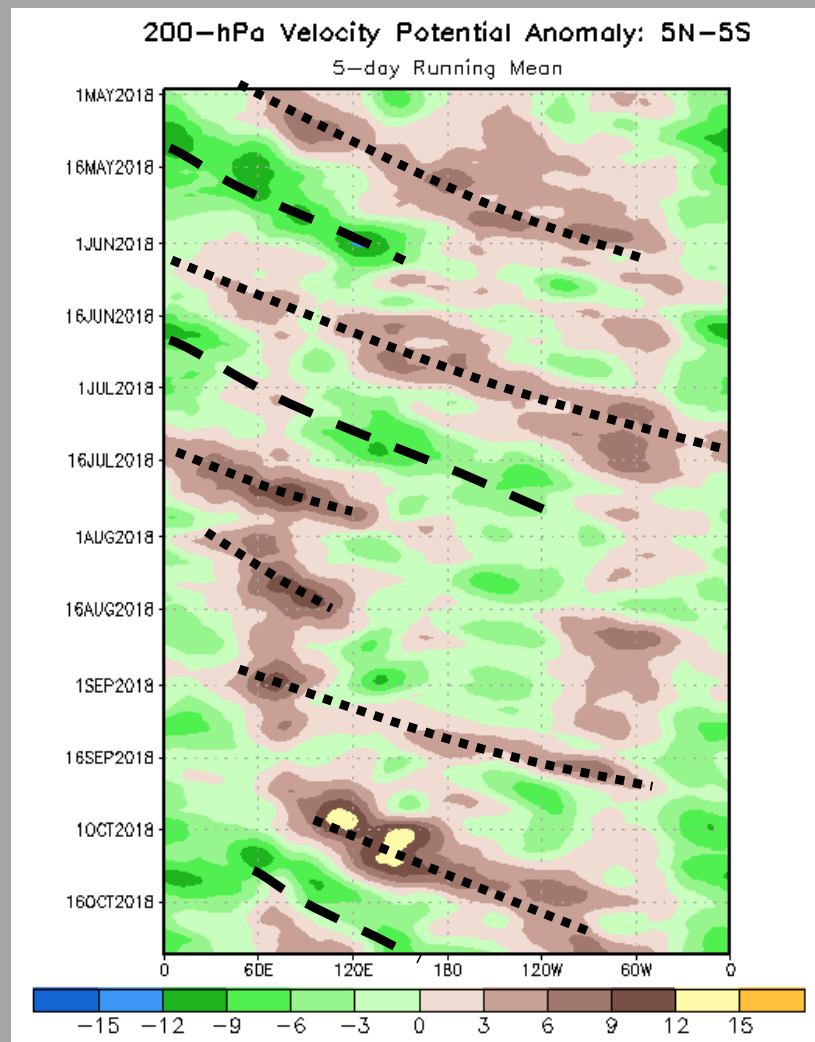
Negative anomalies (green shading) indicate favorable conditions for precipitation

There was robust MJO activity through boreal spring along with the decay of La Niña conditions. The enhanced phase of the MJO weakened east of the Date Line during June. Eastward propagation of broad suppressed convection continued into early July.

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.

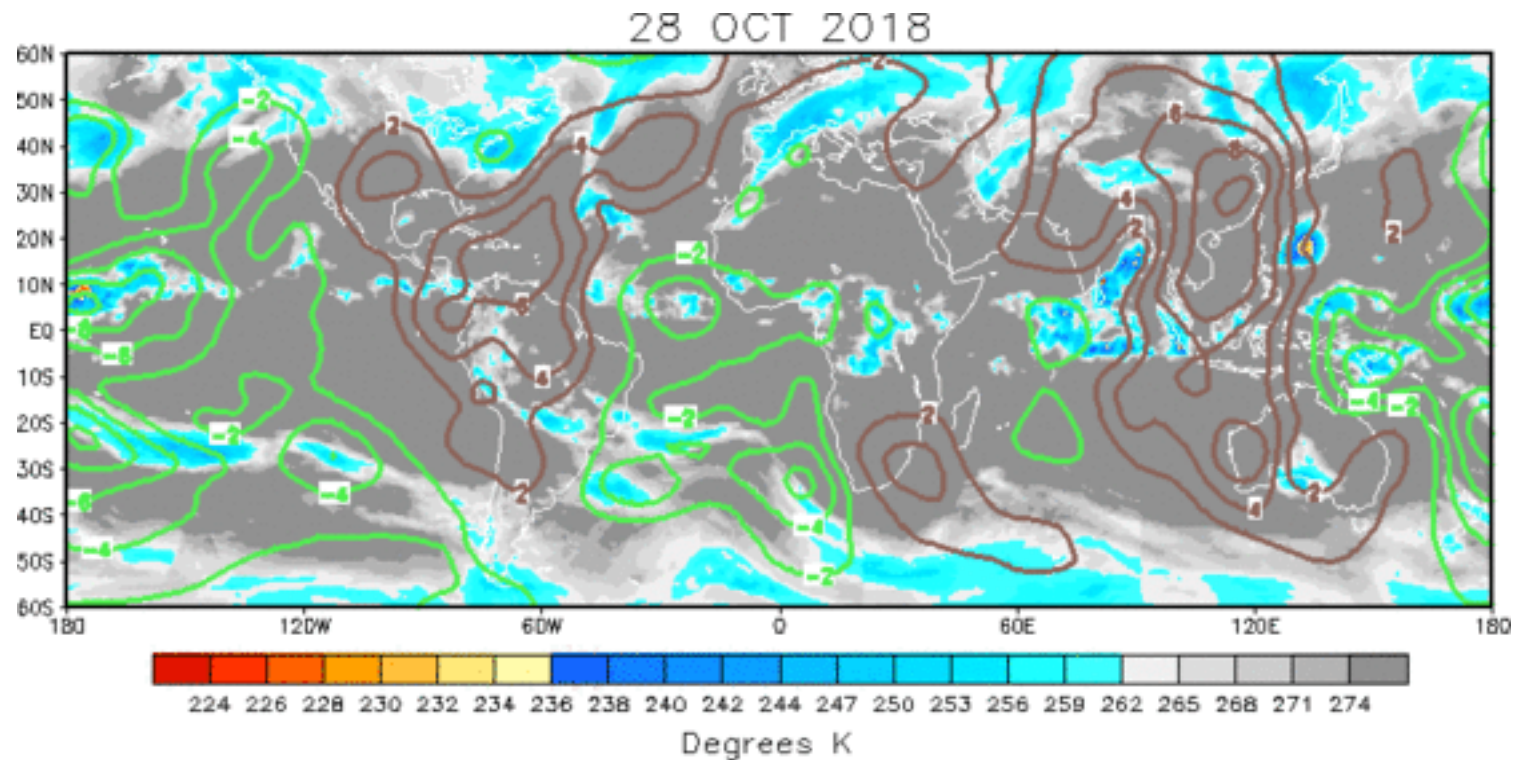
Starting in mid-July, a low-frequency dipole favoring enhanced (suppressed) convection over the east-central Pacific (Indian Ocean) emerged, consistent with a gradual transition towards El Niño conditions.

During mid-September, a robust intraseasonal signal constructively interfered with the base state. The MJO signal persisted into October, and destructively interfered with the base state. More recently, upper-level divergence shifted east over the west Pacific.





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



The upper-level velocity potential's spatial pattern became more coherent recently with upper level divergence (convergence) over the west and central Pacific (Maritime Continent).

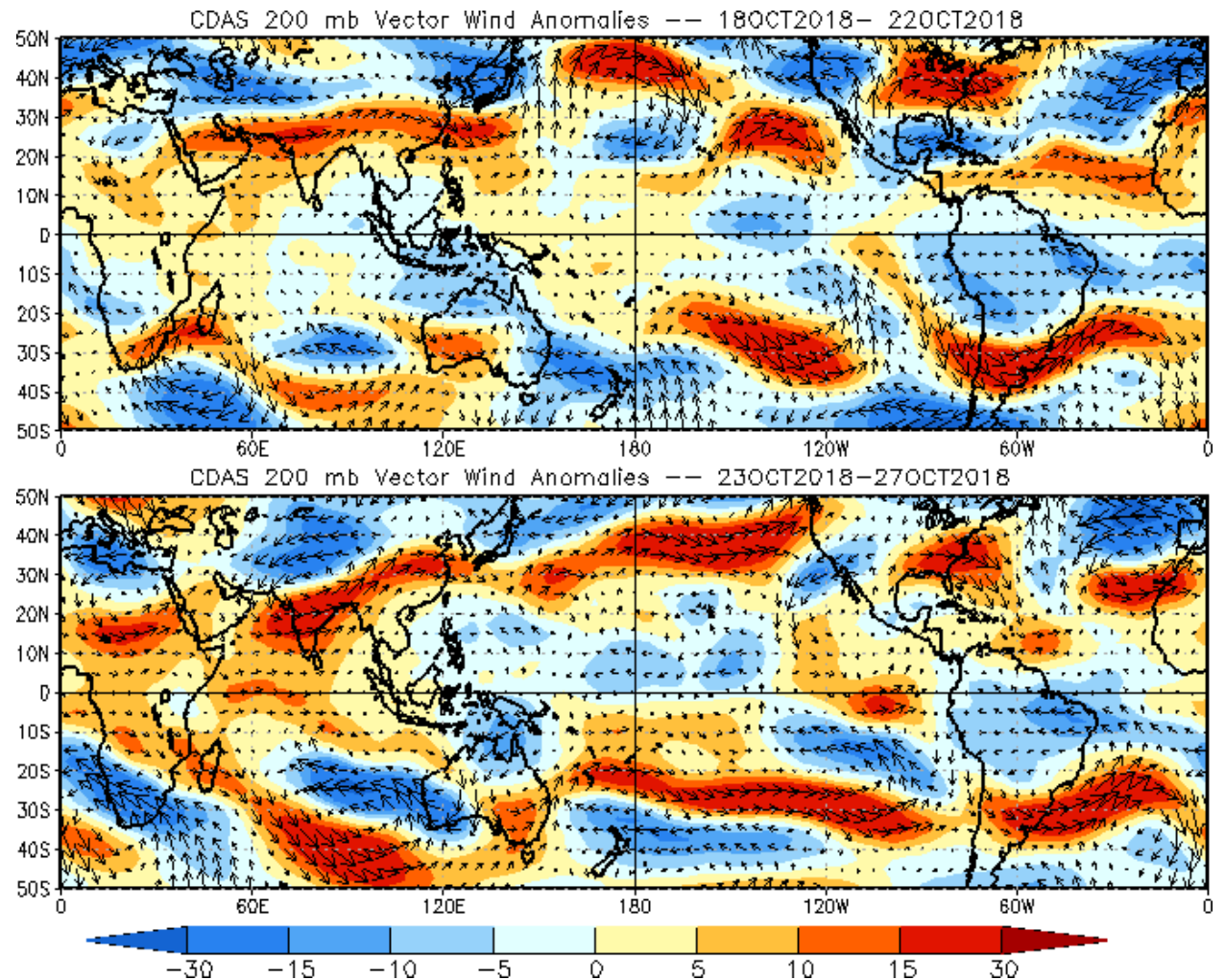
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation  
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

**Blue shades:** Easterly anomalies

**Red shades:** Westerly anomalies



Weak easterly anomalies expanded over the equatorial Pacific during the past 5 days, while an upper-level jet extended east in the north Pacific.

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

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

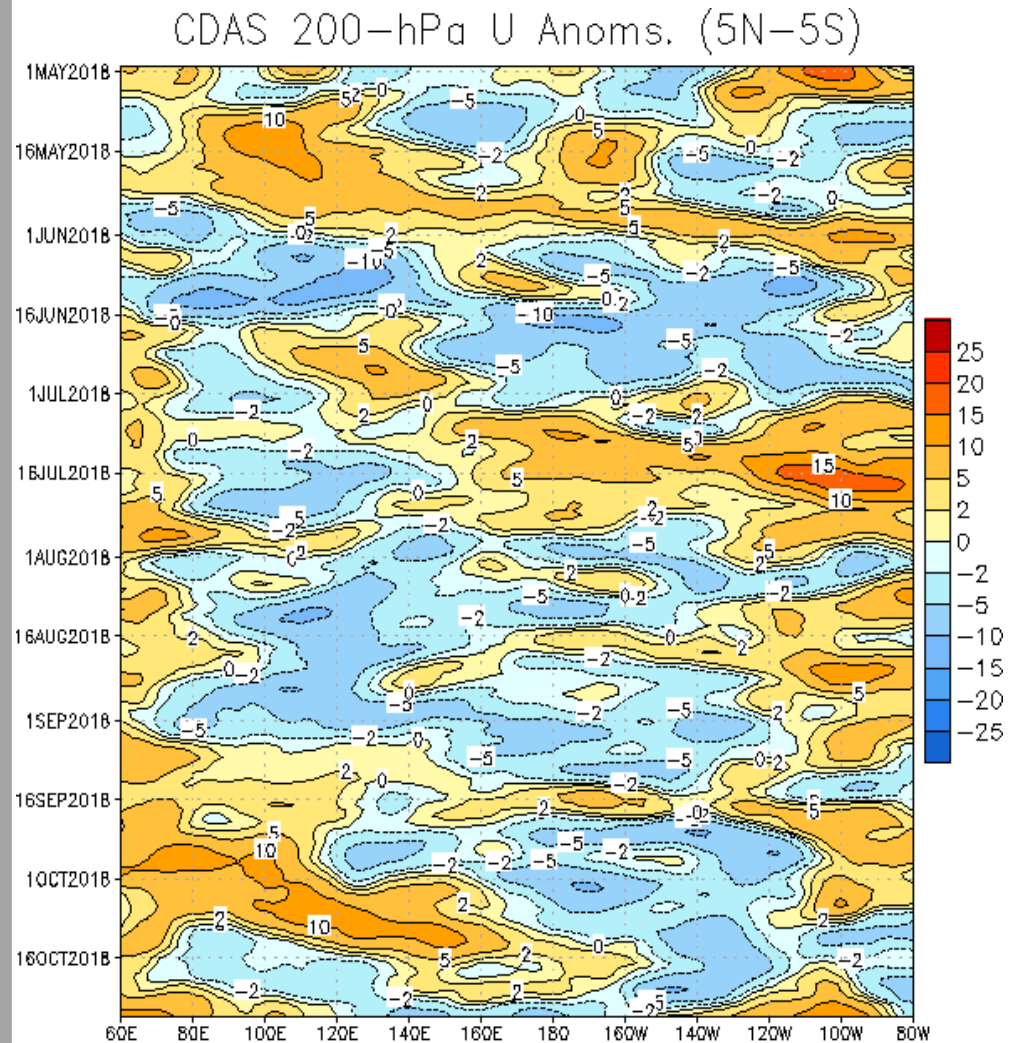
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Weak westerly anomalies propagated eastward from the Indian Ocean to the Americas in early May; this pattern broke down in early June.

Anomalous westerlies amplified over the Maritime Continent in mid-June and propagated eastward at MJO-like phase speeds.

During August the intraseasonal pattern weakened, with Rossby wave activity influencing the West Pacific pattern.

Anomalous westerlies weakened as they shifted east from the Indian Ocean to the west Pacific during the past month. Recently, anomalous easterlies returned to the west and central Pacific.



# Weekly Heat Content Evolution in the Equatorial Pacific

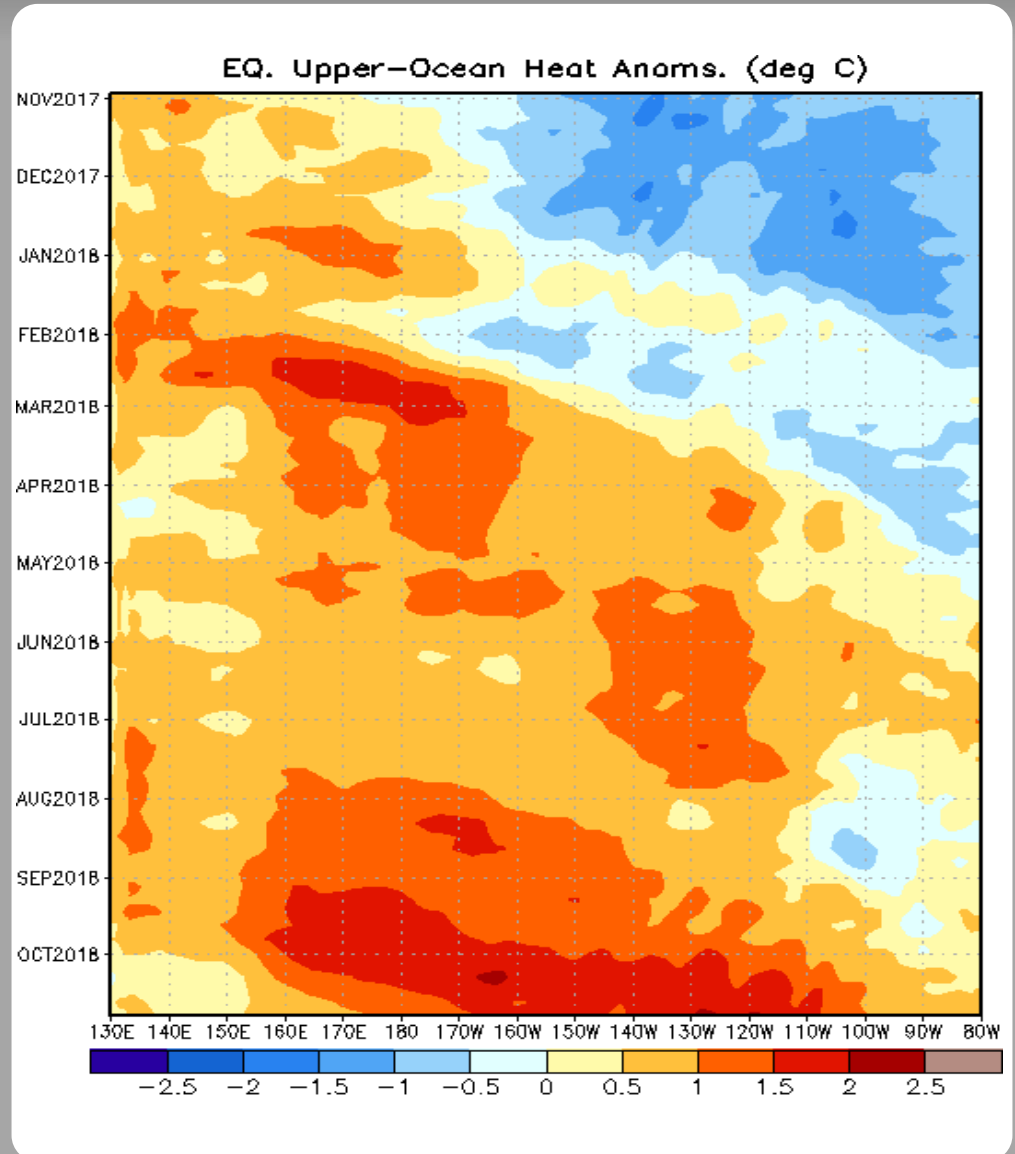
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

Negative upper-ocean heat content anomalies persisted in the central and eastern Pacific through December.

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 recent westerly wind burst east of New Guinea appears to have triggered another oceanic Kelvin wave and round of downwelling, helping to reinforce the warm water availability for a potential El Niño event.



# 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

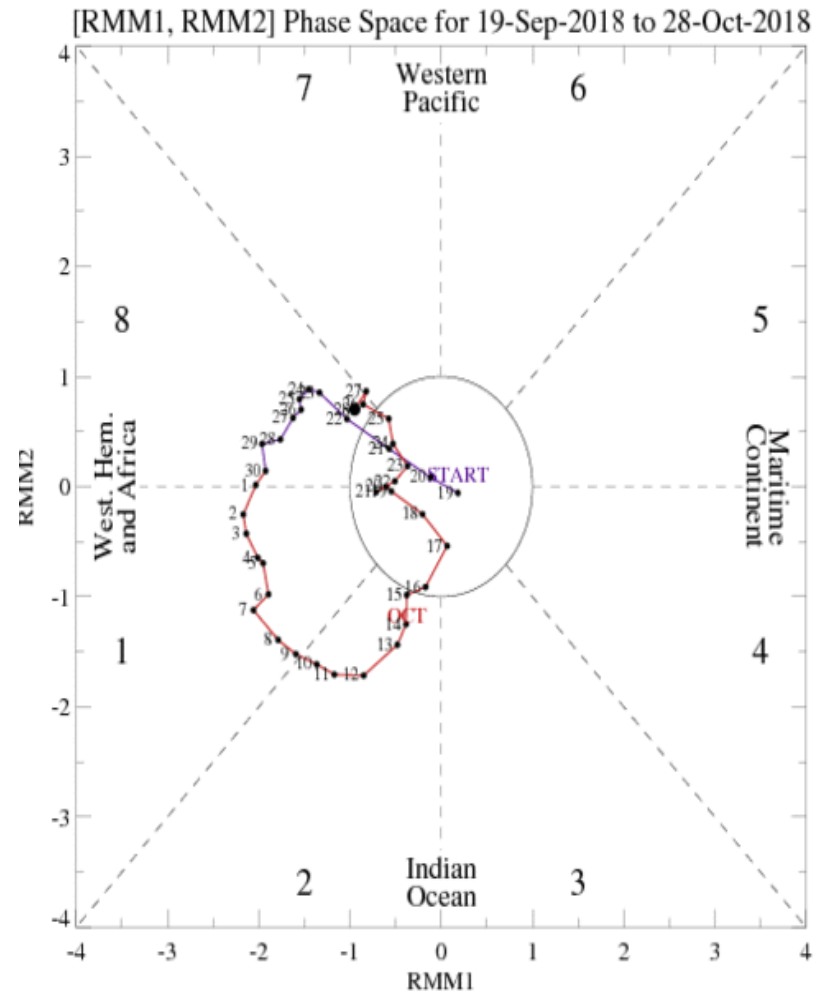
The triangular areas indicate the location of the enhanced phase of the MJO

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

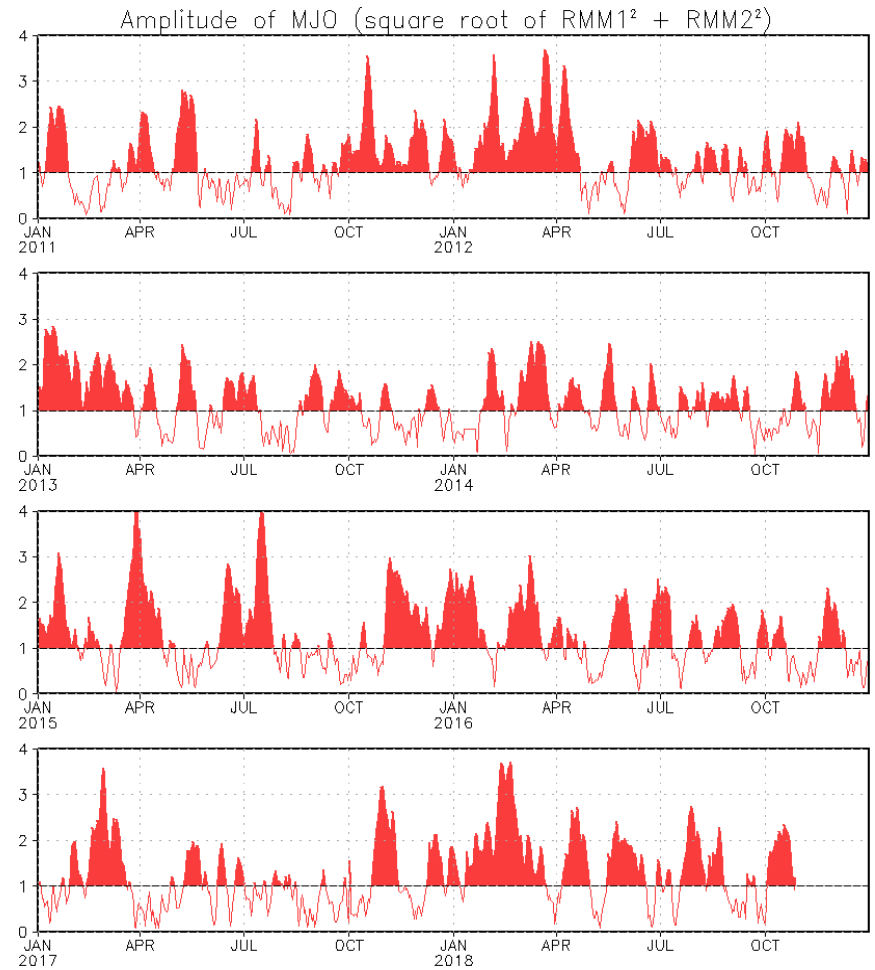
The RMM-based MJO index increased in amplitude during the past few days as enhanced convection became more prevalent over the Pacific.



# 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

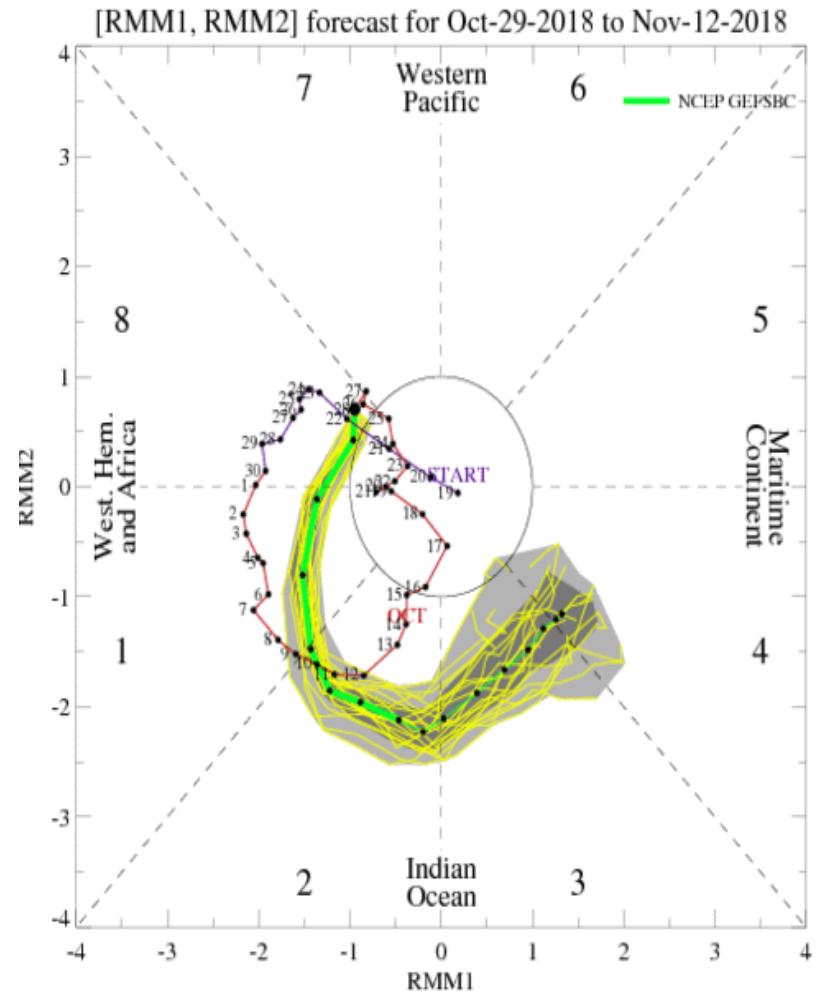
RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GEFS-based RMM-index forecast depicts a fast eastward propagation of a signal over the Western Hemisphere during Week-1 with a continued eastward propagation across the Indian Ocean during Week-2.

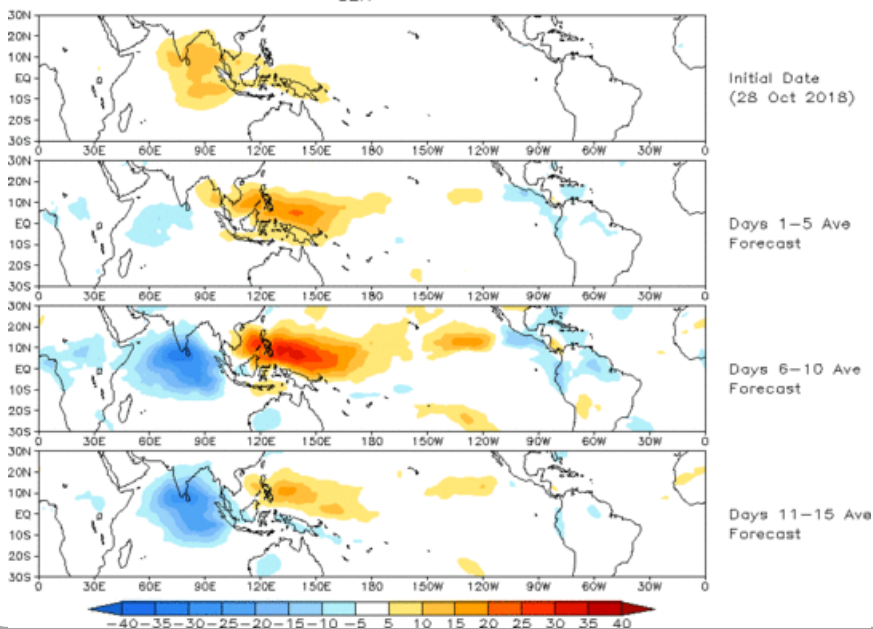
Yellow Lines - 20 Individual Members  
Green Line - Ensemble Mean



# 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 Oct 2018  
OLR

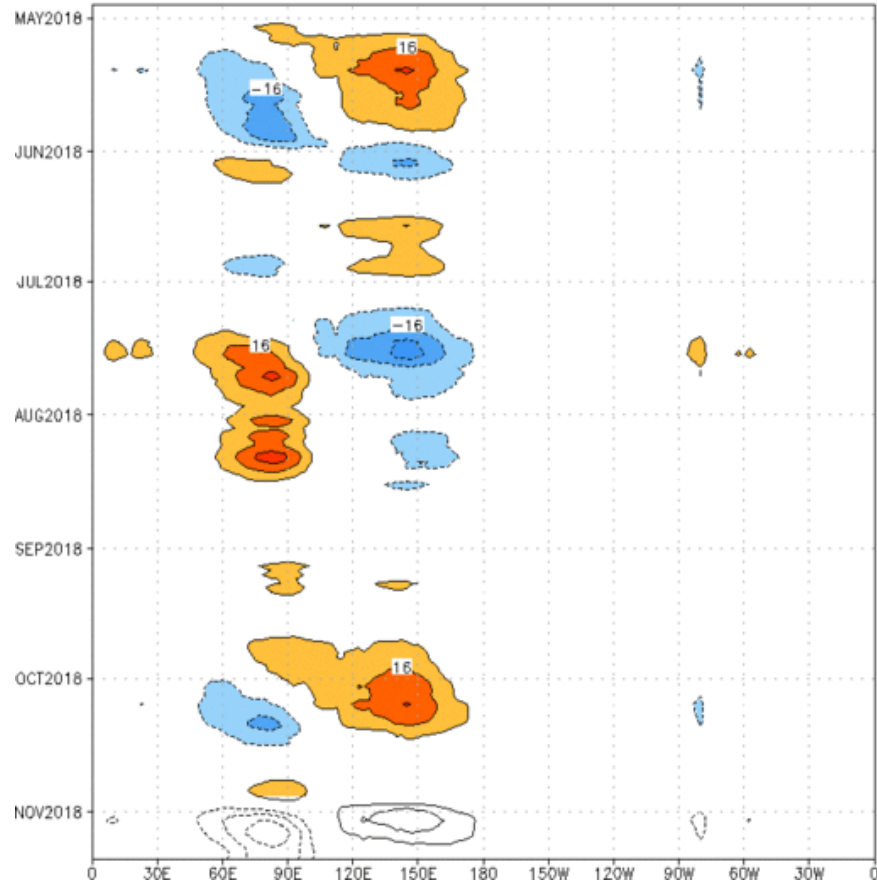


The GEFS RMM-based OLR forecast indicates a strengthening of enhanced (suppressed) convection over the Indian Ocean (west Pacific) during the next week to ten days.

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

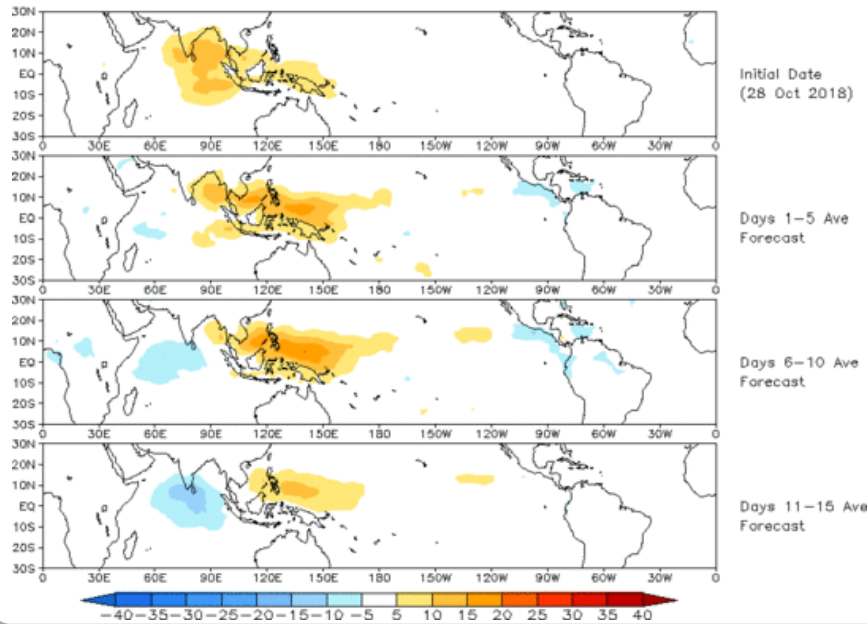
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2  
OLR [7.5°S,7.5°N] (cont:4Wm<sup>-2</sup>) Period:28-Apr-2018 to 28-Oct-2018  
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days



# 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 Oct 2018)

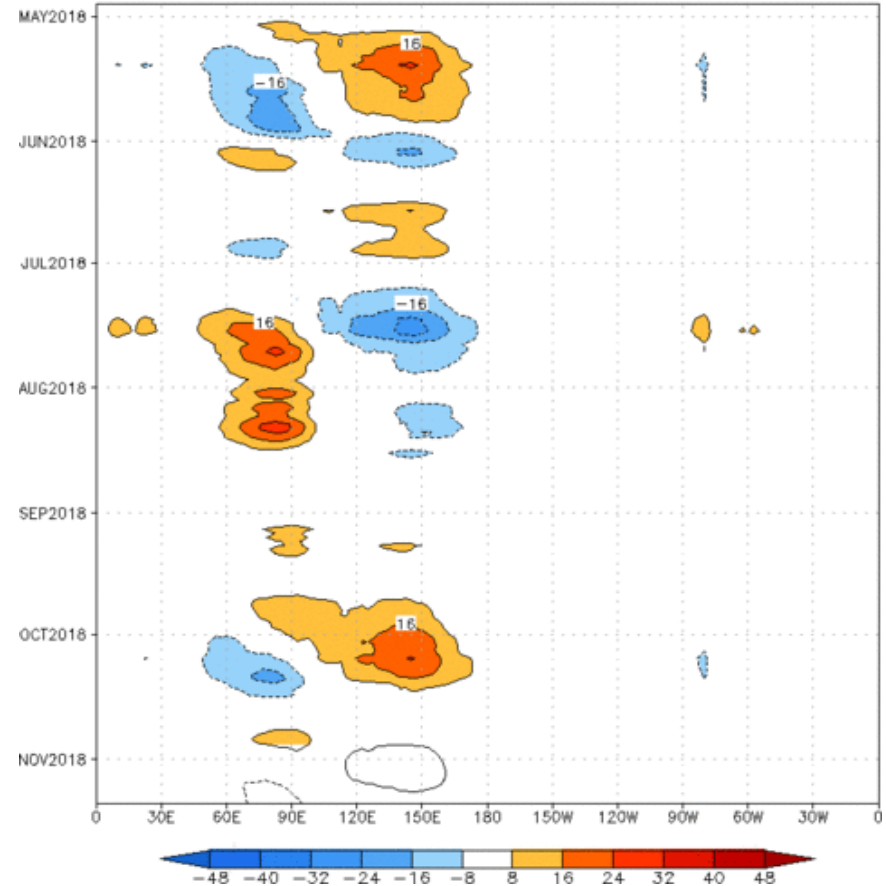


The OLR forecast based on the constructed analog RMM-index forecasts is quite similar to the GEFS spatial pattern of anomalous convection.

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.)

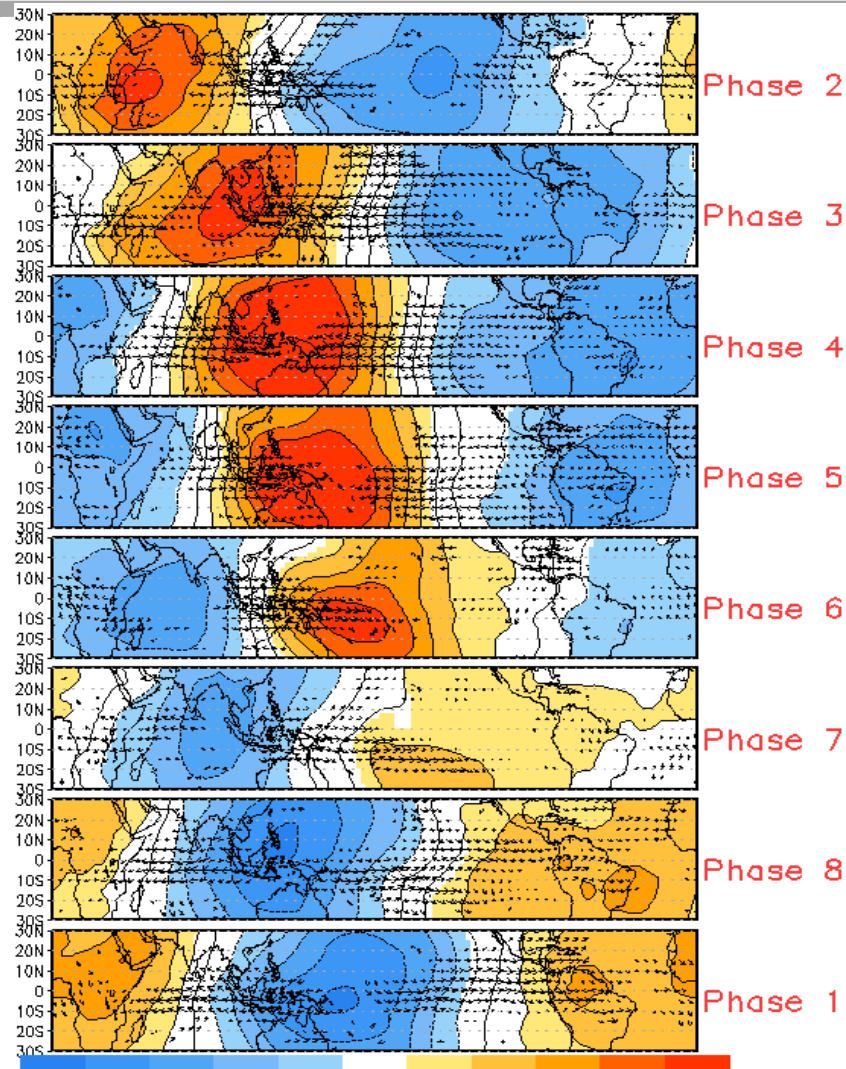
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days

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

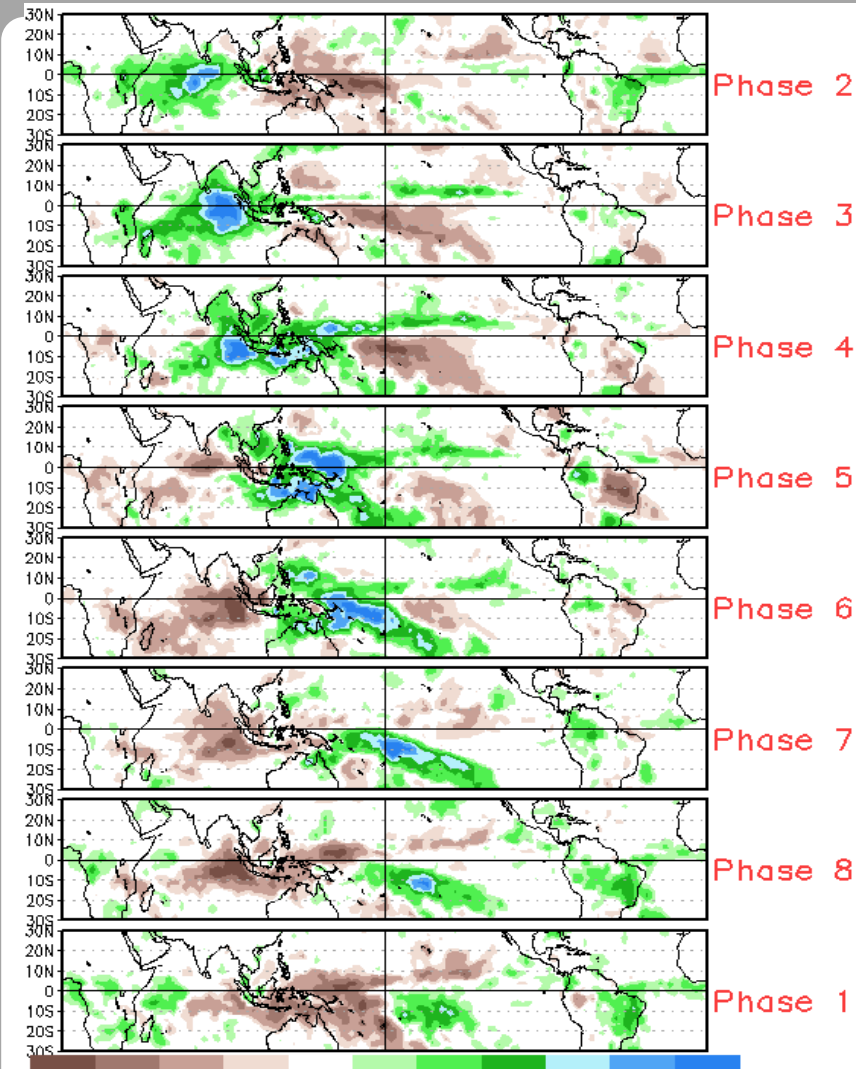


# MJO Composites - Global Tropics

850-hPa Velocity Potential and  
Wind Anomalies (May - Sep)



Precipitation Anomalies (May - Sep)

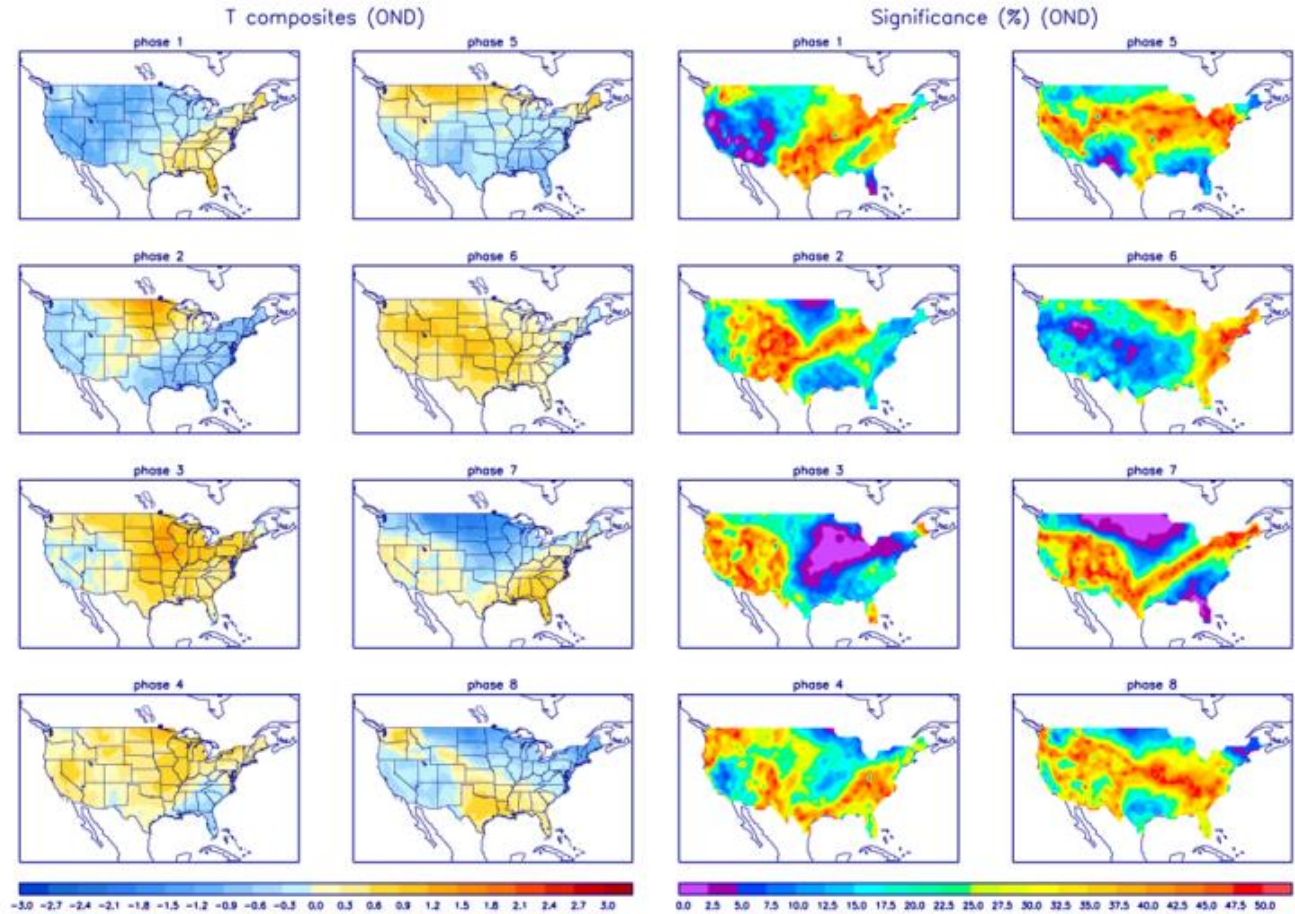




# U.S. MJO Composites - Temperature

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.



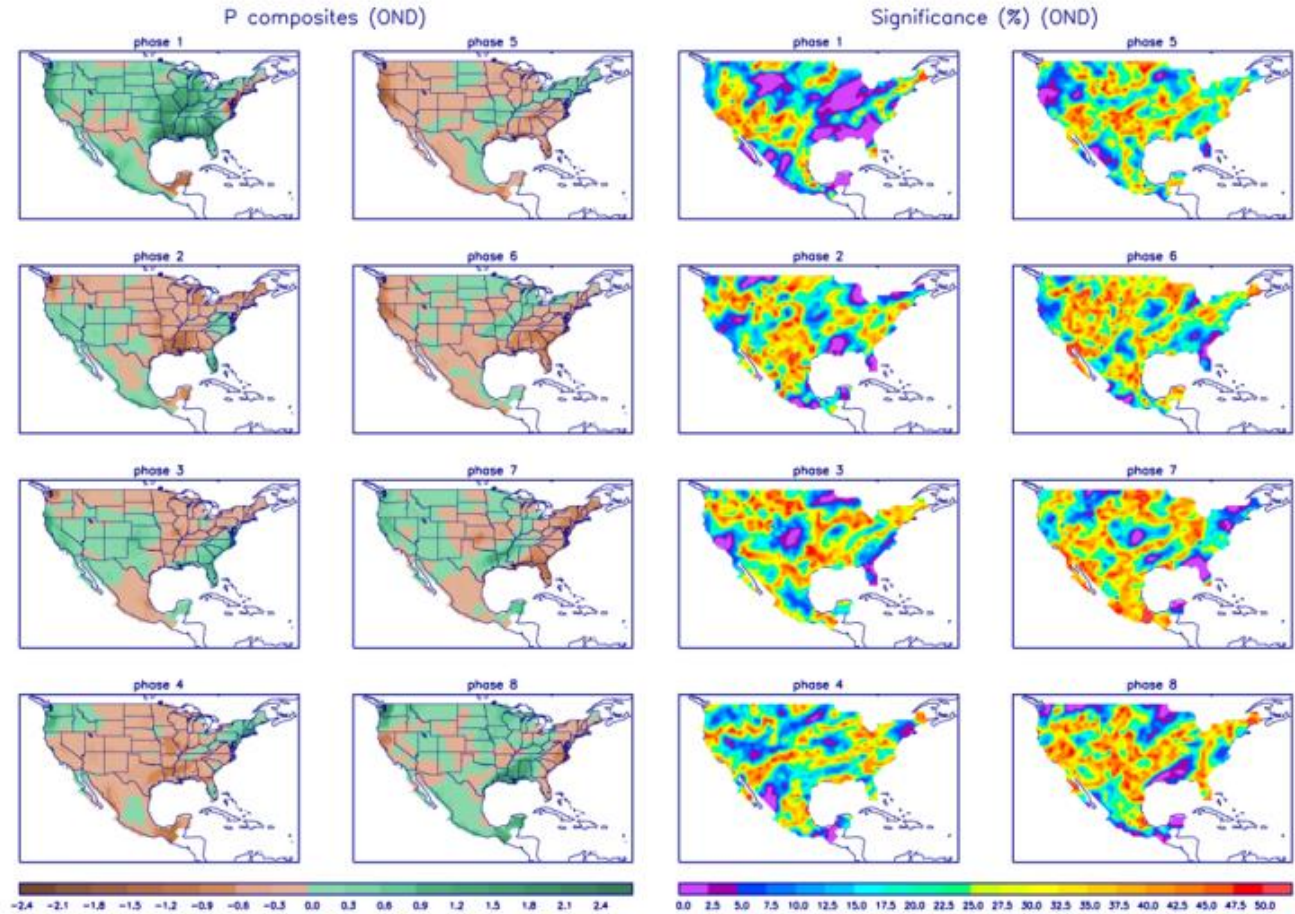
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>