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

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18 June 2018

# Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

# Overview

- The MJO signal is weak but some dynamical guidance indicates that the MJO could re-develop over Africa during the upcoming week.

- Statistical guidance and the CFS are forecasting a stronger MJO developing during the end of Week-1 than the GFS and ECMWF models.

- A convectively coupled atmospheric Kelvin wave is forecast to move over the East Pacific during Week-2 and might provide a conducive environment for tropical cyclogenesis.

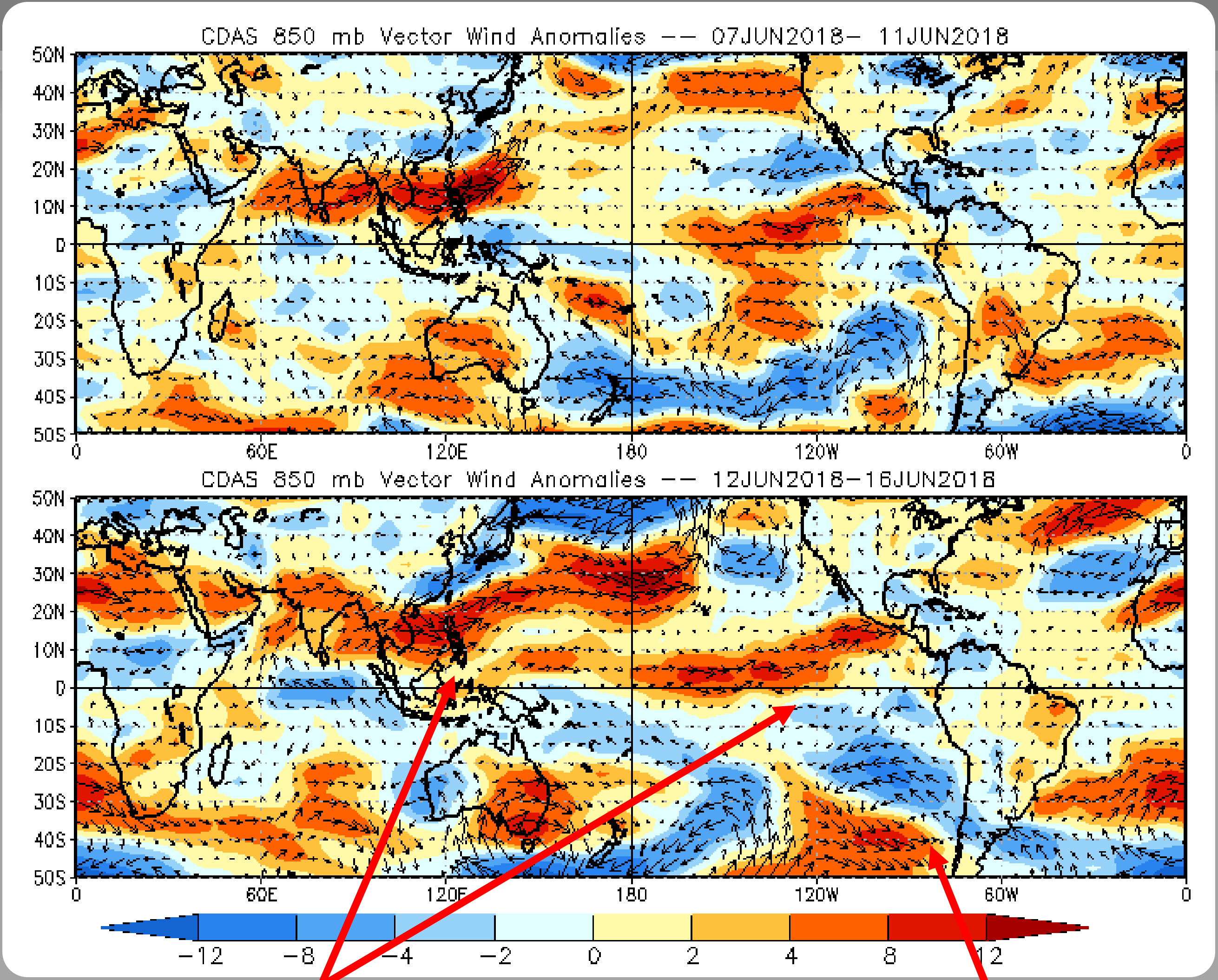
**Additional potential impacts across the global tropics and a discussion for the U.S. are available at:**
**http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php**

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies




Strong low-level anomalous westerlies have strengthened from earlier this month

Amplified flow in the Southern Hemisphere

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

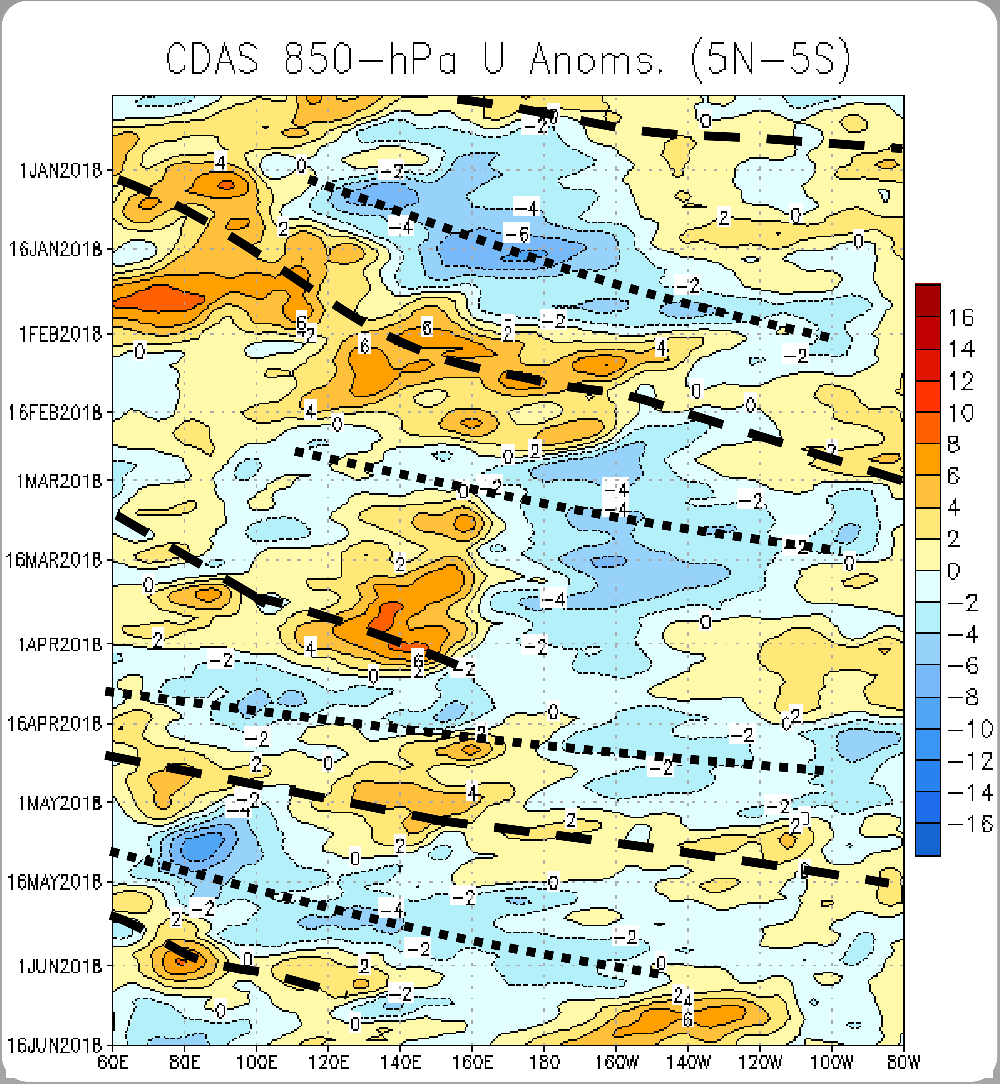
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

A strong MJO event formed in early December and circumnavigated the globe twice through January and mid-February.

During mid to late March, anomalous westerlies shifted east from the Indian Ocean to the Maritime Continent as the MJO signal re-emerged. These westerlies were associated with the envelope of active MJO convection. This signal began to break down during April.

The MJO has been active over the past several weeks, with a period near 30-40 days. Recently eastward propagation became obscured by westward moving variability, including TC activity over the Pacific and equatorial Rossby waves.



# OLR Anomalies – Past 30 days

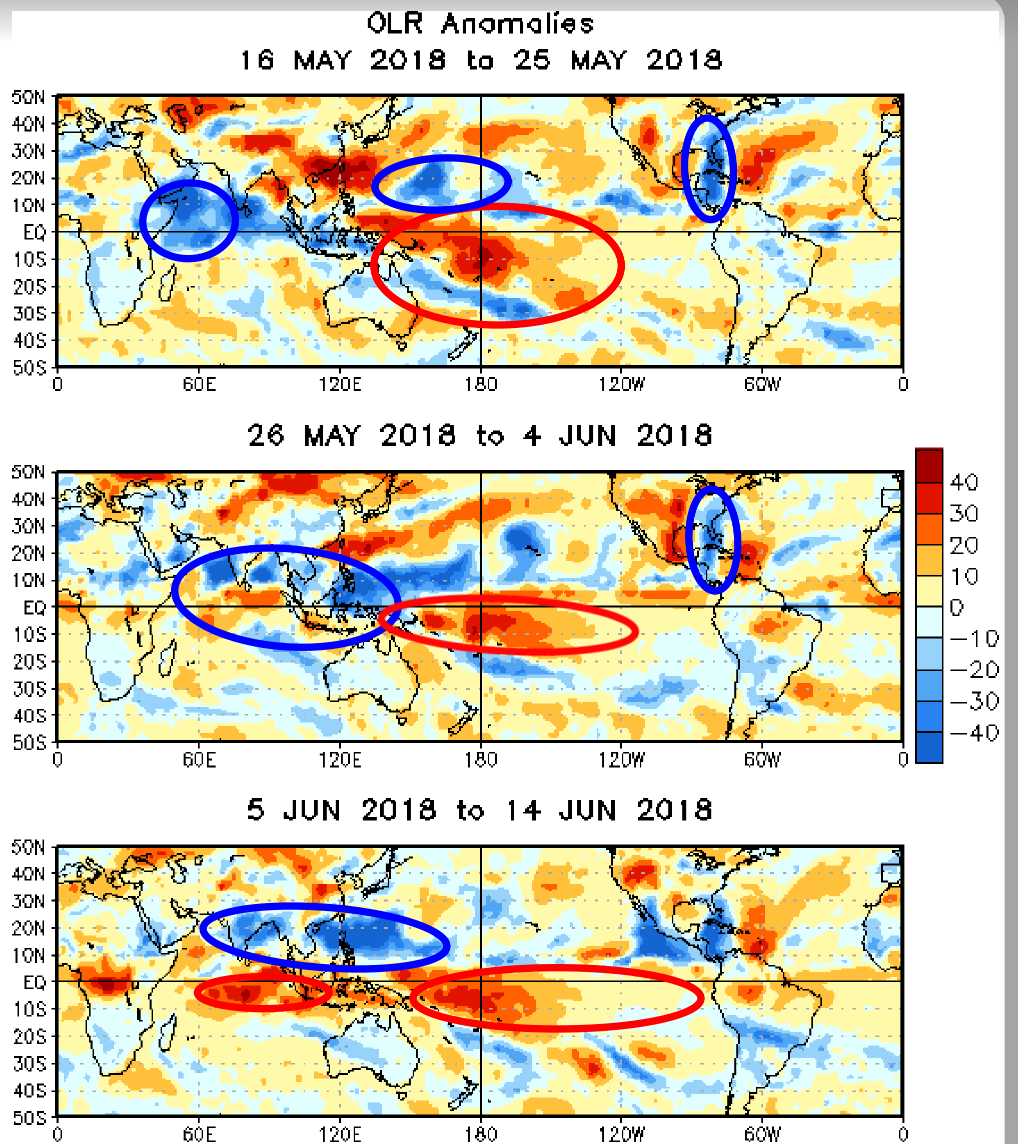
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid-May the enhanced MJO phase emerged over the western Indian Ocean, while suppressed convection continued over the equatorial Pacific. A surge of tropical moisture impacted the Southeast CONUS as well.

The MJO-related pattern shifted eastward during late May, while the effects of an upper-level low and Tropical Storm Alberto are seen over the Southeast CONUS.

In early June suppressed convection pushed eastward past the Date Line while enhanced convection north and south of the Equator weakened.



# Outgoing Longwave Radiation (OLR) Anomalies (2.5ºN - 17.5ºN)

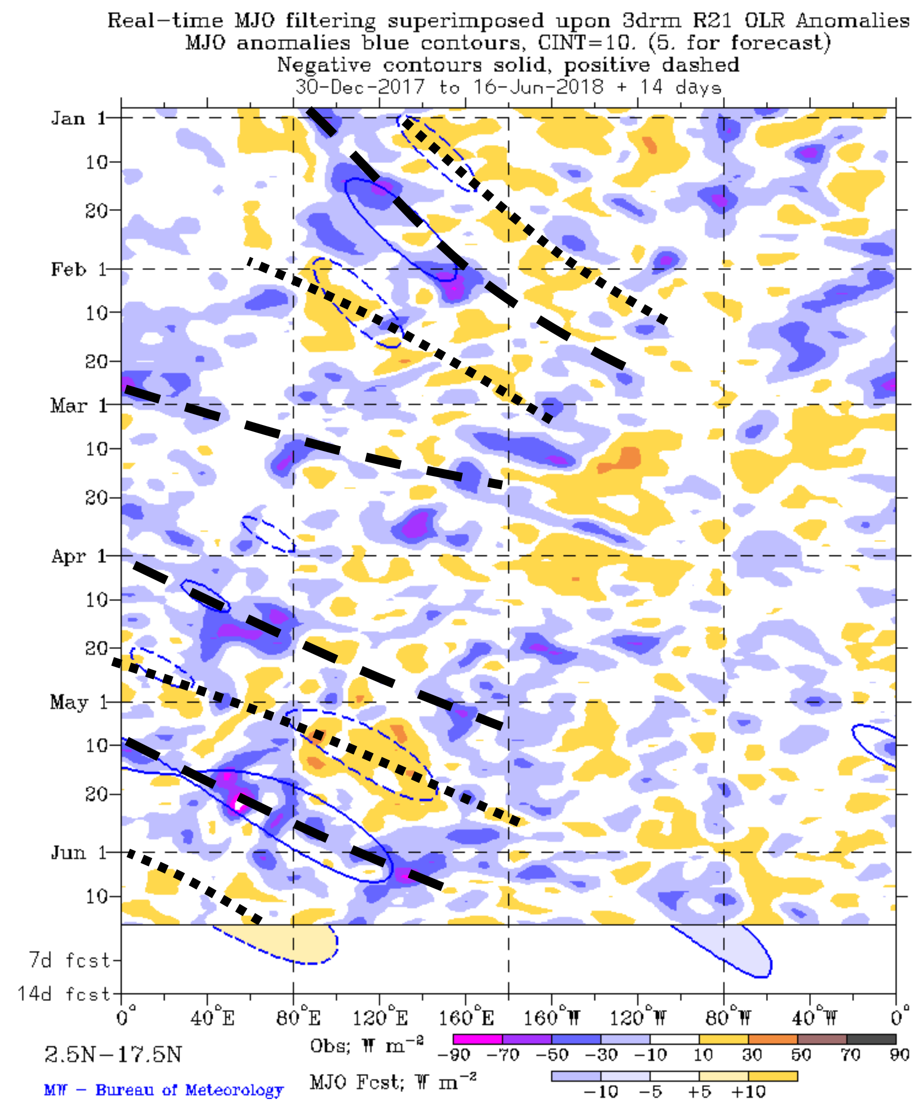
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

There has been consistent MJO activity since last October. Over the northern tropical Pacific, the low-frequency La Niña signal is weaker than over the equator.

An active MJO event propagated east from Africa to the Indian Ocean during early to mid-April.

During early May, the OLR signature of the MJO weakened as the signal crossed the Maritime Continent and eventually destructively interfered with the weakening La Niña footprint. During early June, the enhanced phase of the MJO shifted eastward from the Indian Ocean to the Maritime Continent before constructively interfering with westward-moving variability.



# 200-hPa Velocity Potential Anomalies (5ºS - 5ºN)

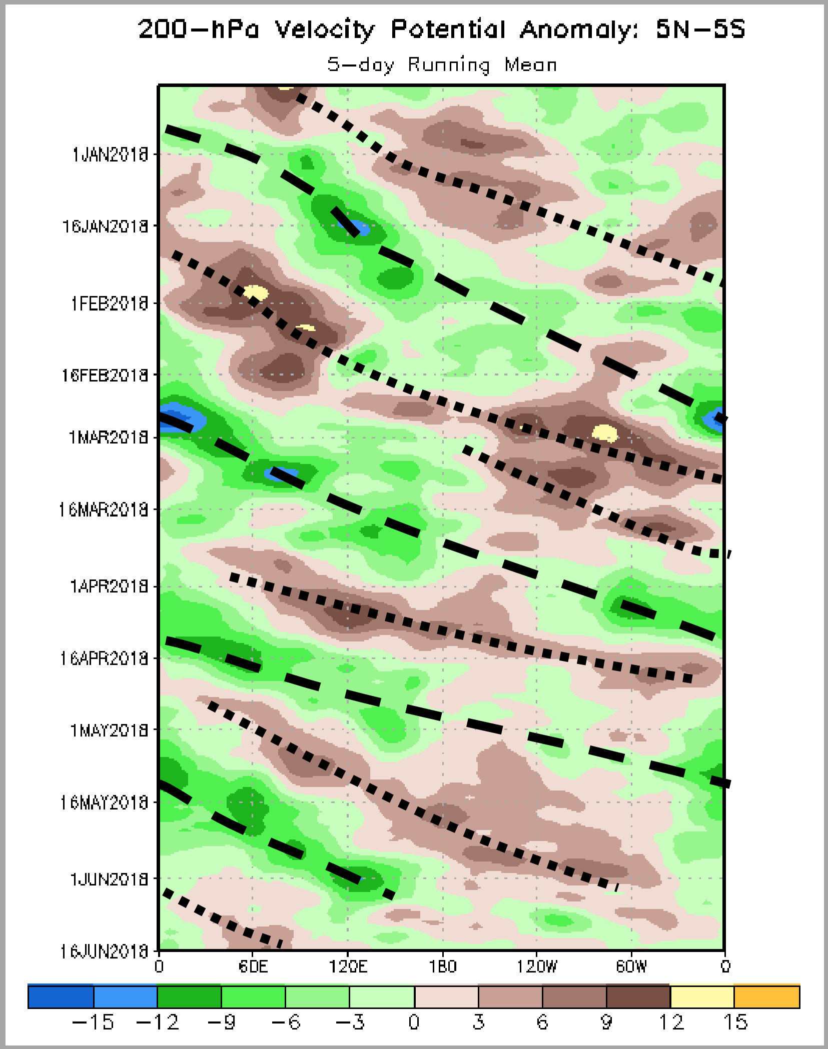
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

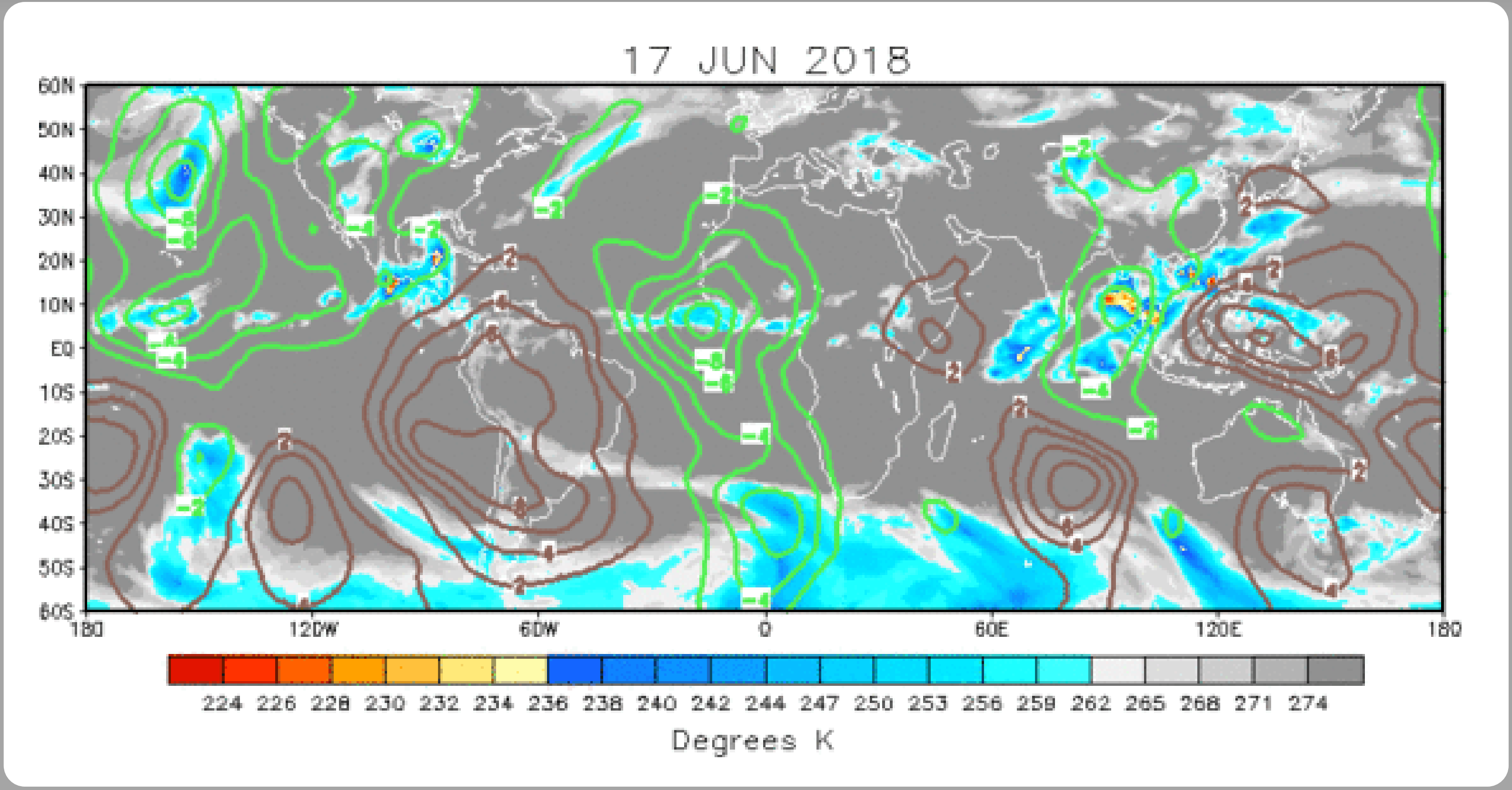
The aforementioned consistent MJO activity since mid-October can be seen in the upper level velocity potential field. Additionally, there are indications of atmospheric an Kelvin wave east of the Date Line during late February and early March.

The large-scale region of suppressed convection along the Date Line associated with La Niña is less apparent in the velocity potential field than in the equatorial OLR field. This is primarily because velocity potential is a smoother field than OLR and is dominated by frequent MJO activity.

During the month of May, the MJO signal strengthened as measured by the velocity potential. MJO propagation from Africa to the Maritime Continent was observed before the signal weakened in recent days. The MJO signal weakened during June. There is currently a weak signal showing the suppressed phase propagating over the Indian Ocean.



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




The upper level velocity potential field is noisy. There are centers of suppressed convection over the South Pacific and eastern Africa, as well as enhanced convection over the Indian Ocean.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation

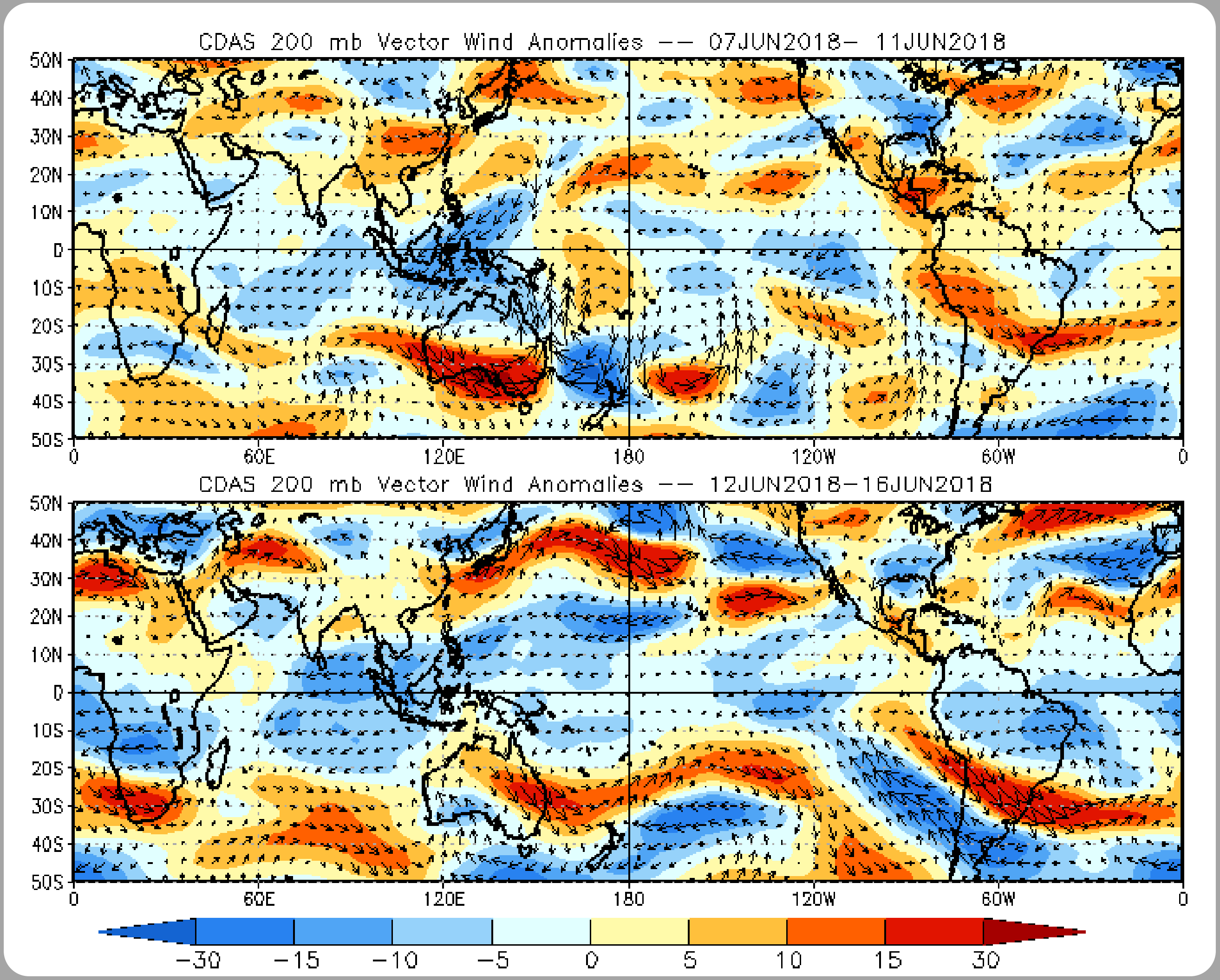
# 200-hPa Vector Wind Anomalies (m s-1)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

The upper-level zonal wind anomaly field has remained weak over through much of the equatorial region through the past few weeks, while anomalies in the Southern Pacific and parts of the Atlantic have strengthened.



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

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

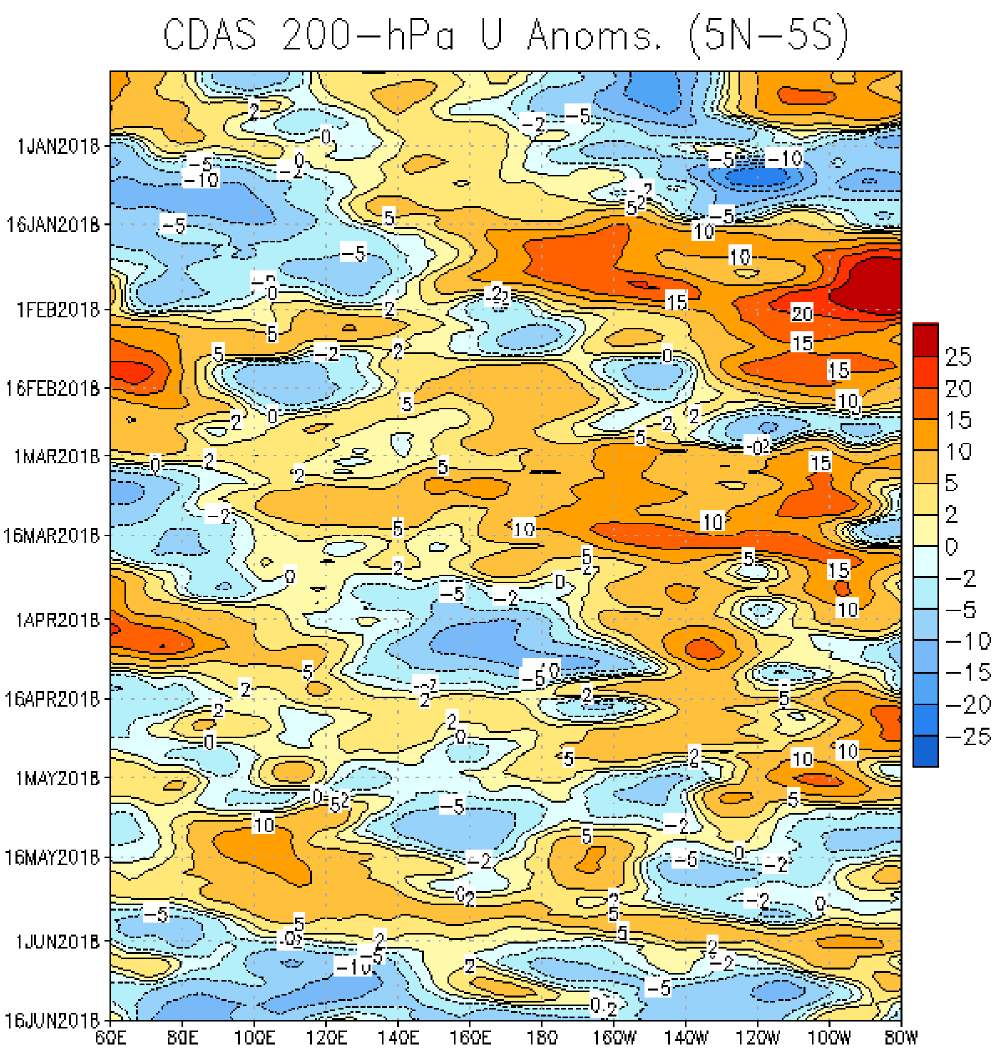
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Low-frequency anomalous westerlies remained in place east of 140E starting in October through late April, with a few periods of brief interruptions.

In mid-December, strong easterly anomalies developed east of the Date Line, briefly replacing the westerly anomalies that had been generally present since October.

Strong anomalous westerlies that formed in early January just west of the Date Line propagated eastward, consistent with a strong MJO event during this period.

Since the beginning of May, weak westerly anomalies have continued to propagate east from the Indian Ocean to the Americas. During early June this pattern broke down due to competing modes of variability.



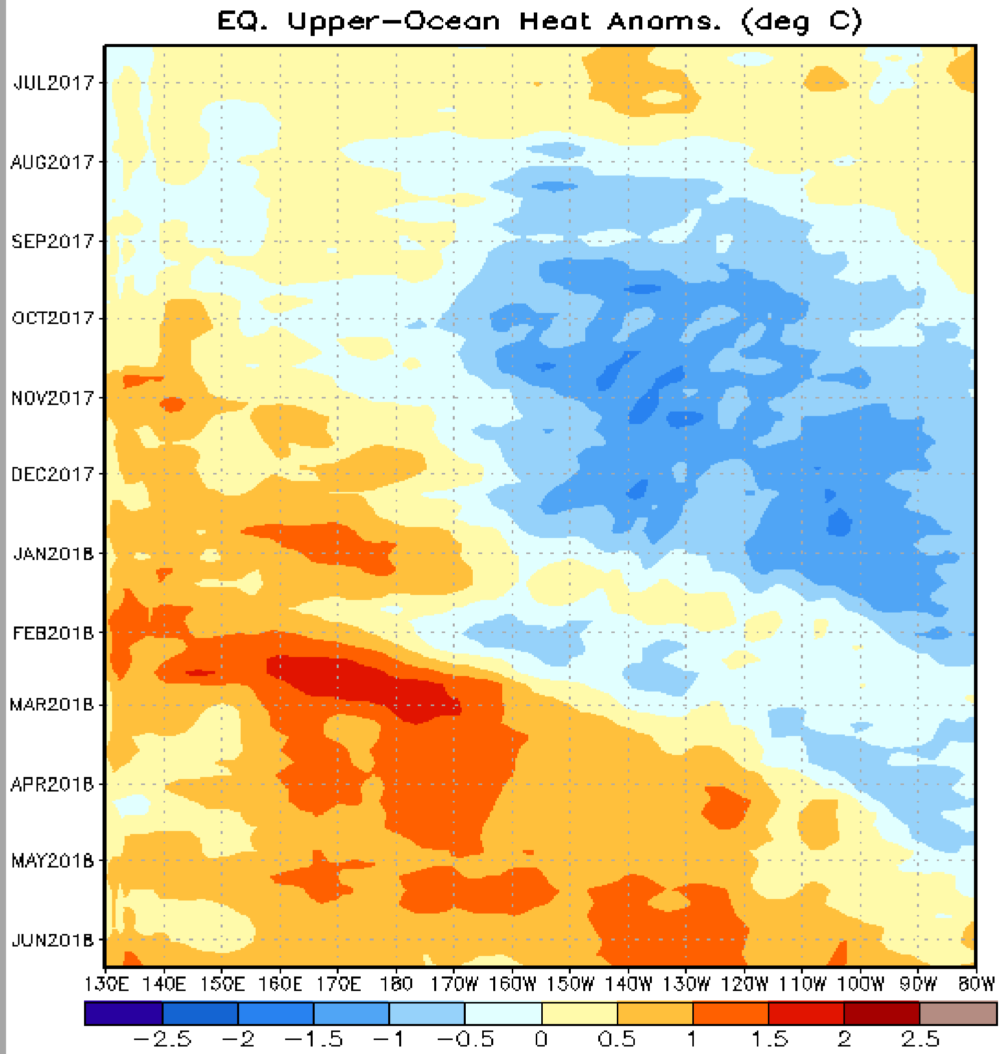
# Weekly Heat Content Evolution in the Equatorial Pacific

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 from August-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 (associated with a relaxation of the trade winds) have contributed to the eastward expansion of relatively warm subsurface water (as much as 1.5-2.0°C above normal between 160E and 170W during February). Positive anomalies are now observed over nearly the entire basin.



# 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**

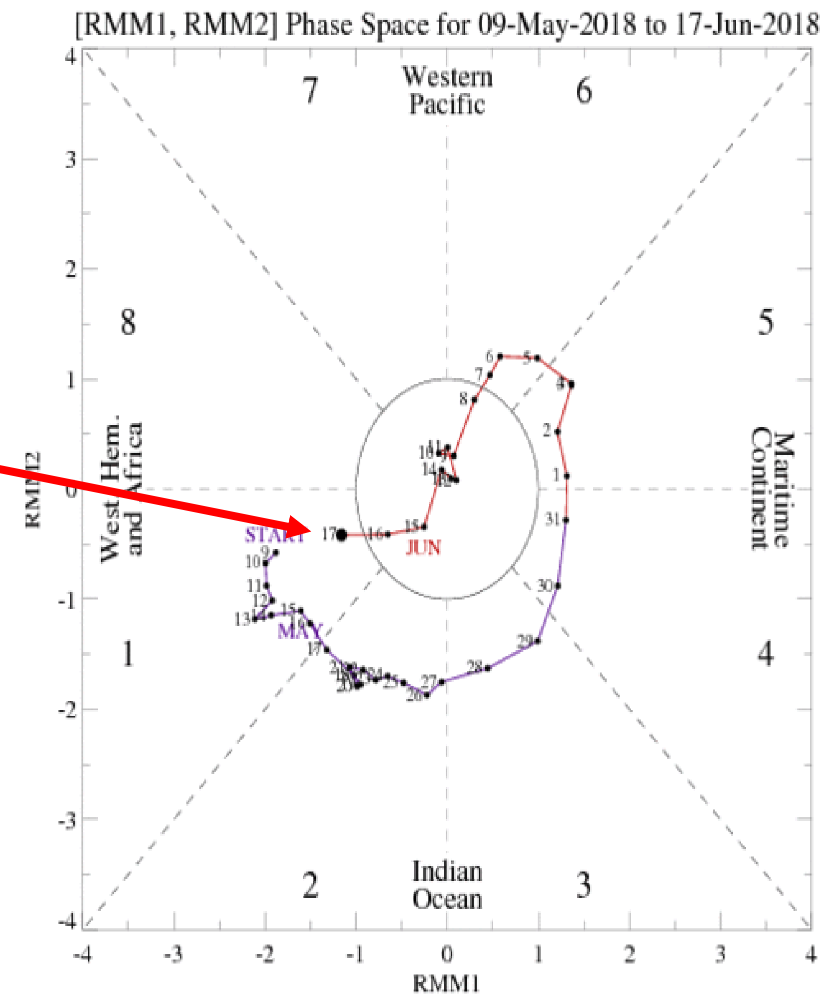
**The triangular areas indicate the location of the enhanced phase of the MJO**

**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**

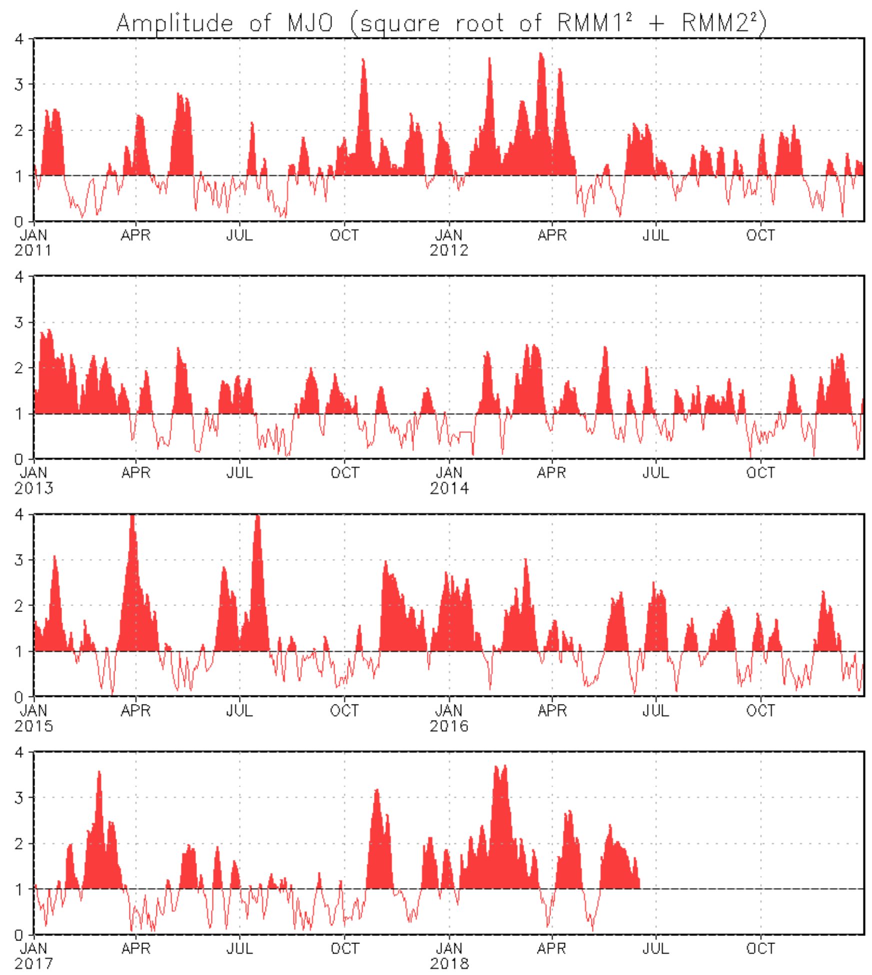
**The RMM-based MJO projection indicates a weak MJO signal.**



# 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

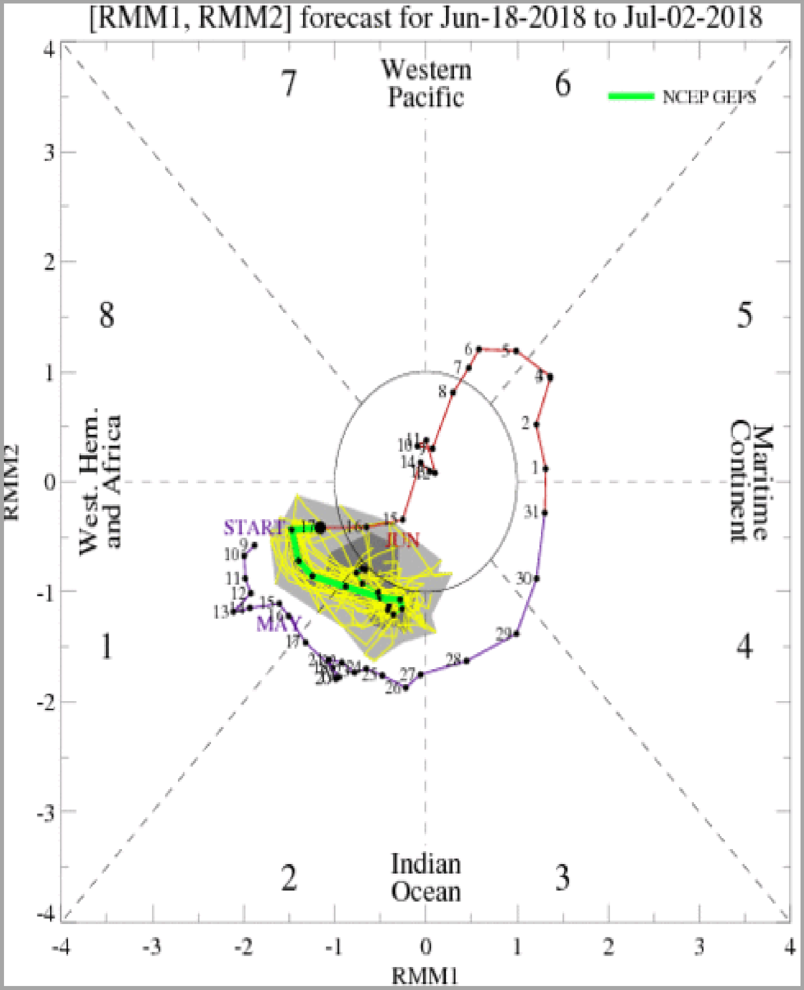
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

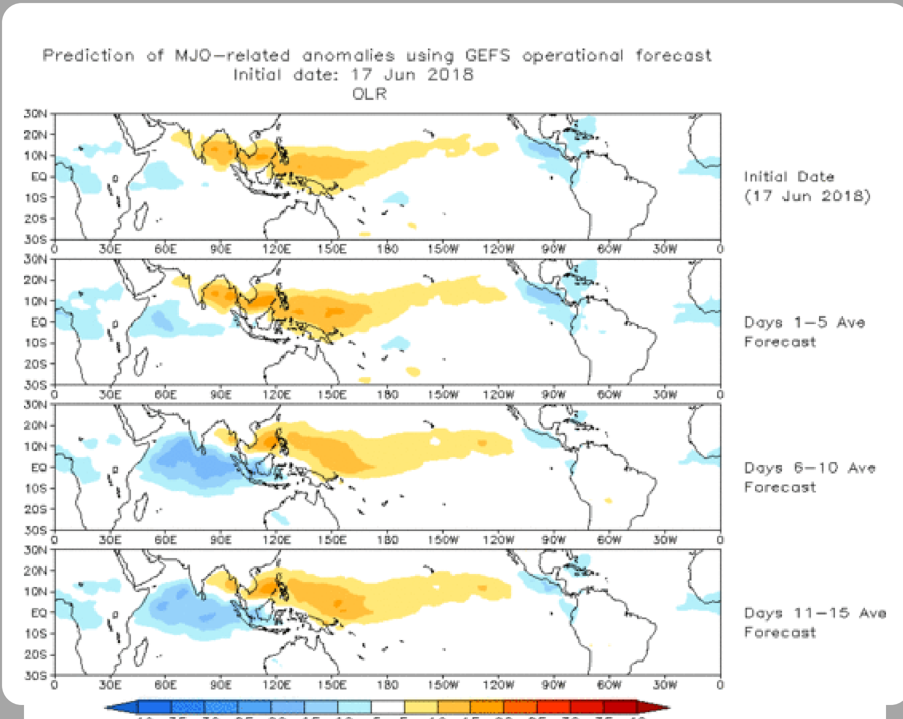
The GEFS forecasts the MJO to reemerge over Africa and the western Indian Ocean during Week-1, with little additional eastward propagation during Week-2.



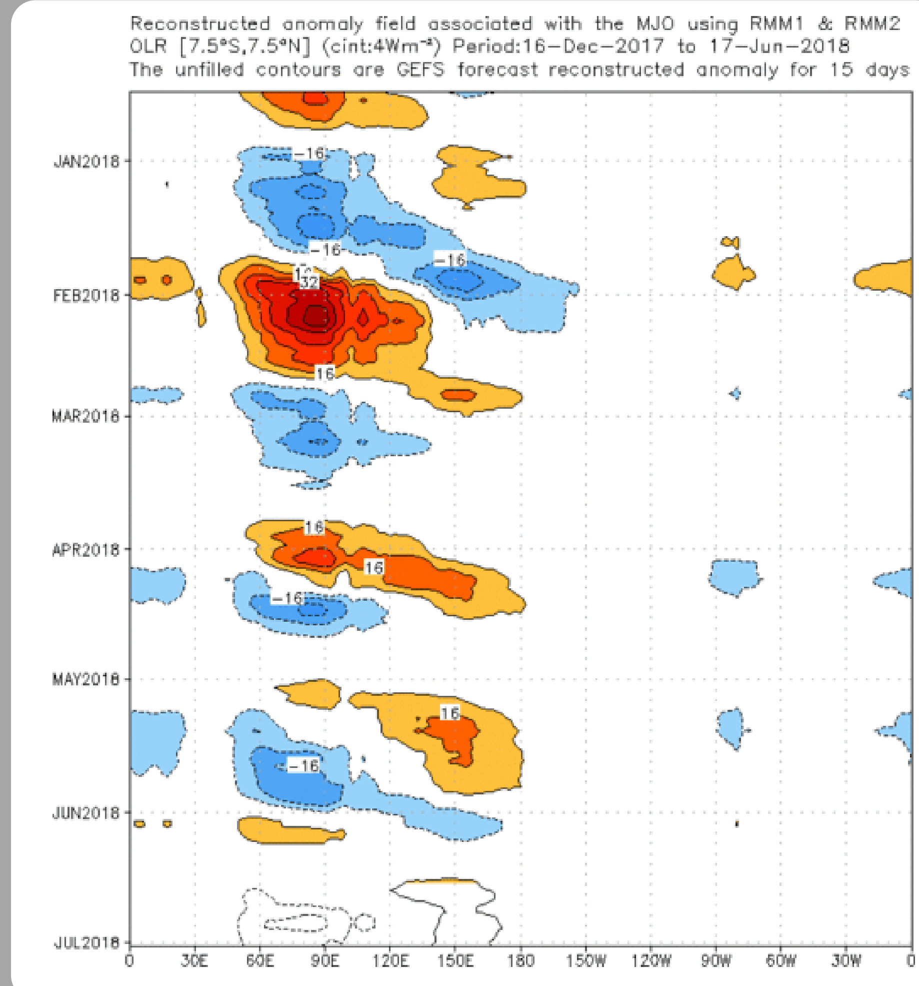
# Ensemble GFS (GEFS) MJO Forecast

**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

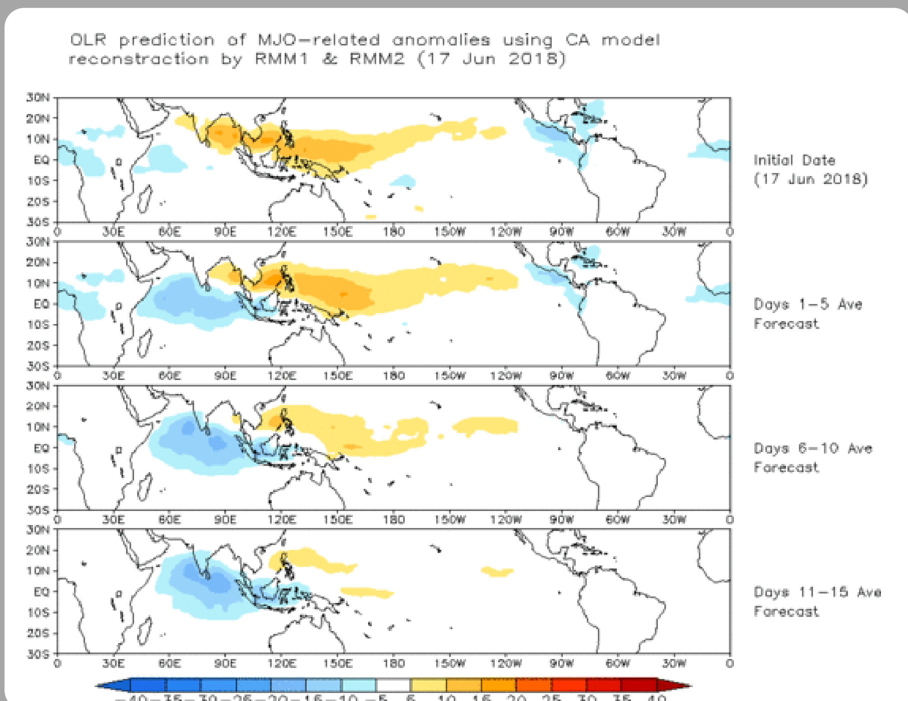



GEFS-based OLR anomalies depict suppressed convection becoming dominant over the Maritime Continent and eastern Indian Ocean, while enhanced convection develops over Africa and the western Indian Ocean during Week-2.

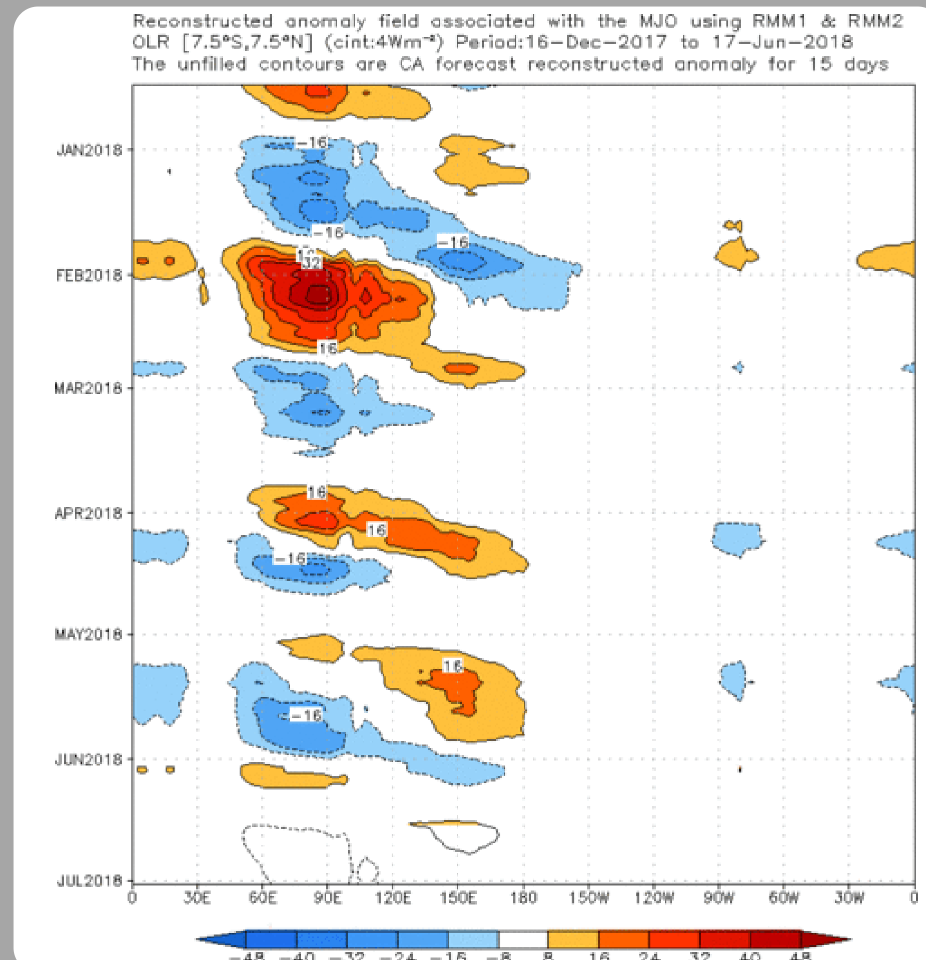
# Constructed Analog (CA) MJO Forecast

**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

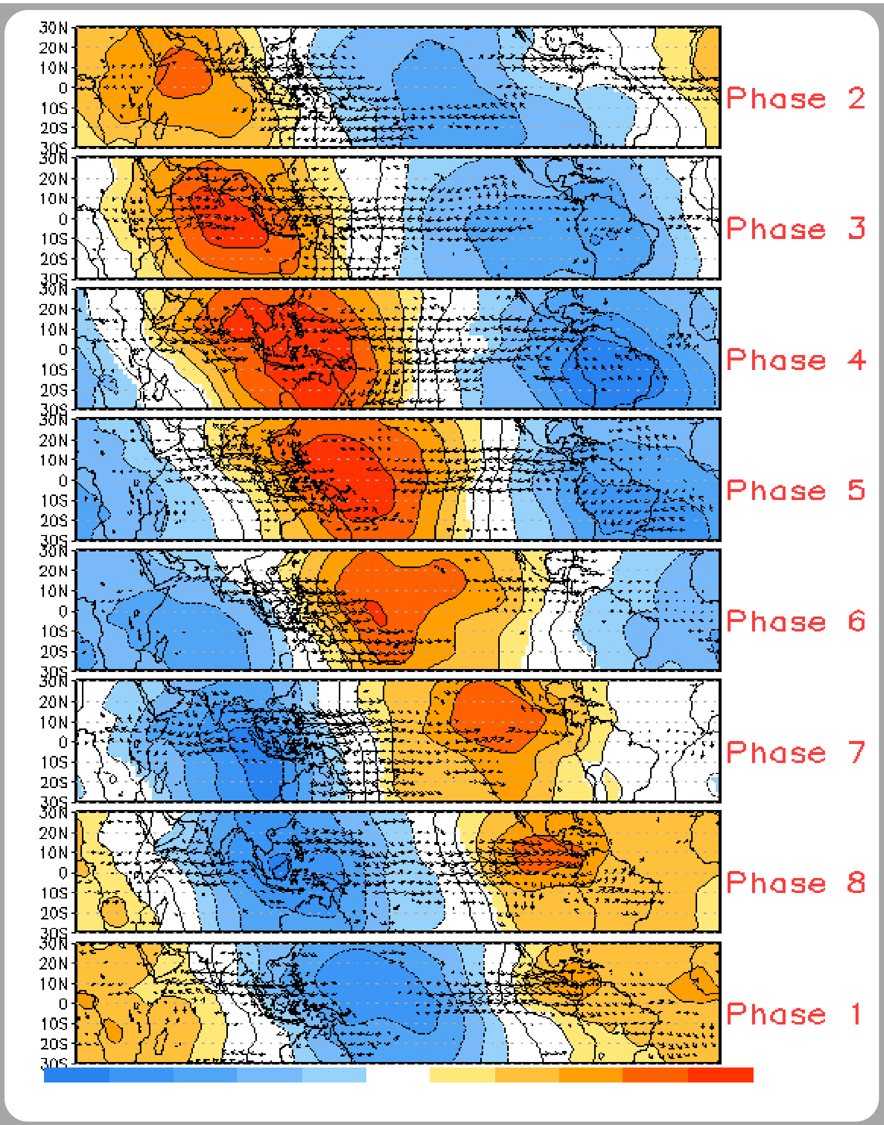



The OLR anomaly forecast based on the constructed analog MJO index forecast depicts a weak signal over the next two weeks.

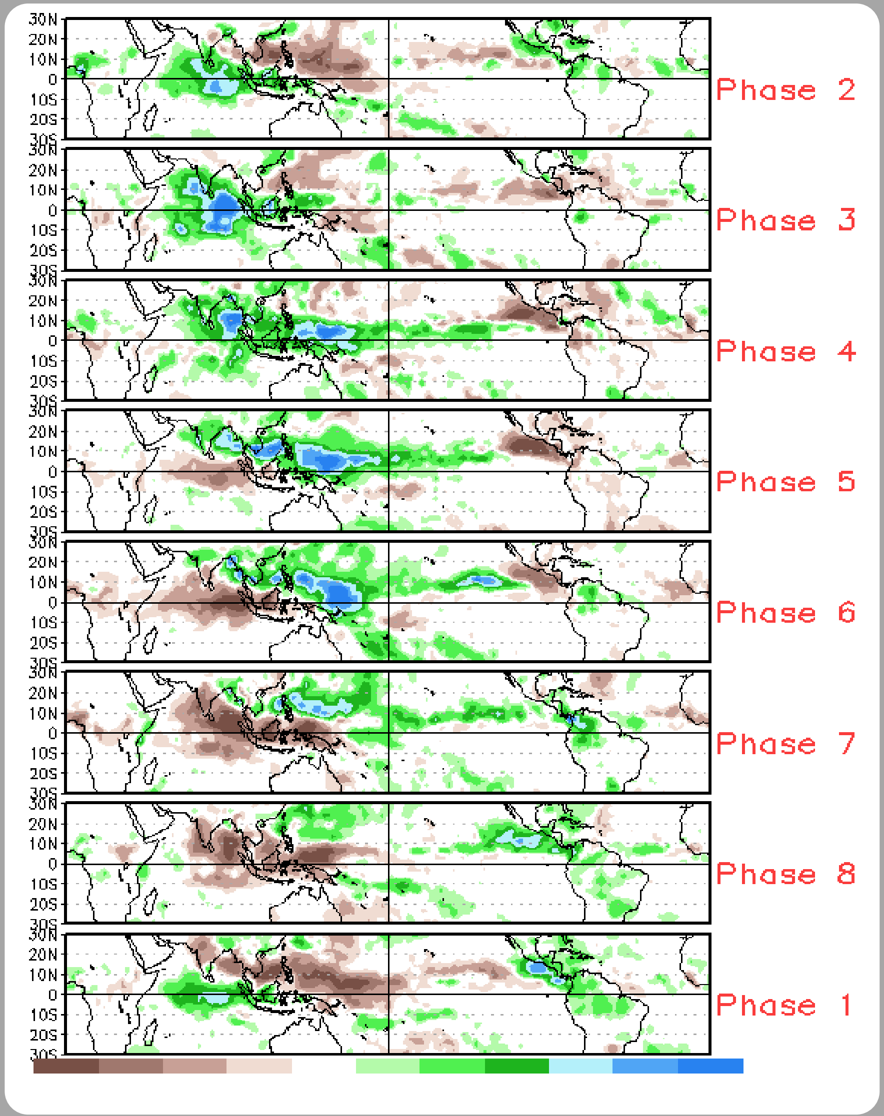
# MJO Composites - Global Tropics

850-hPa Velocity Potential and

Wind Anomalies (May - Sep)



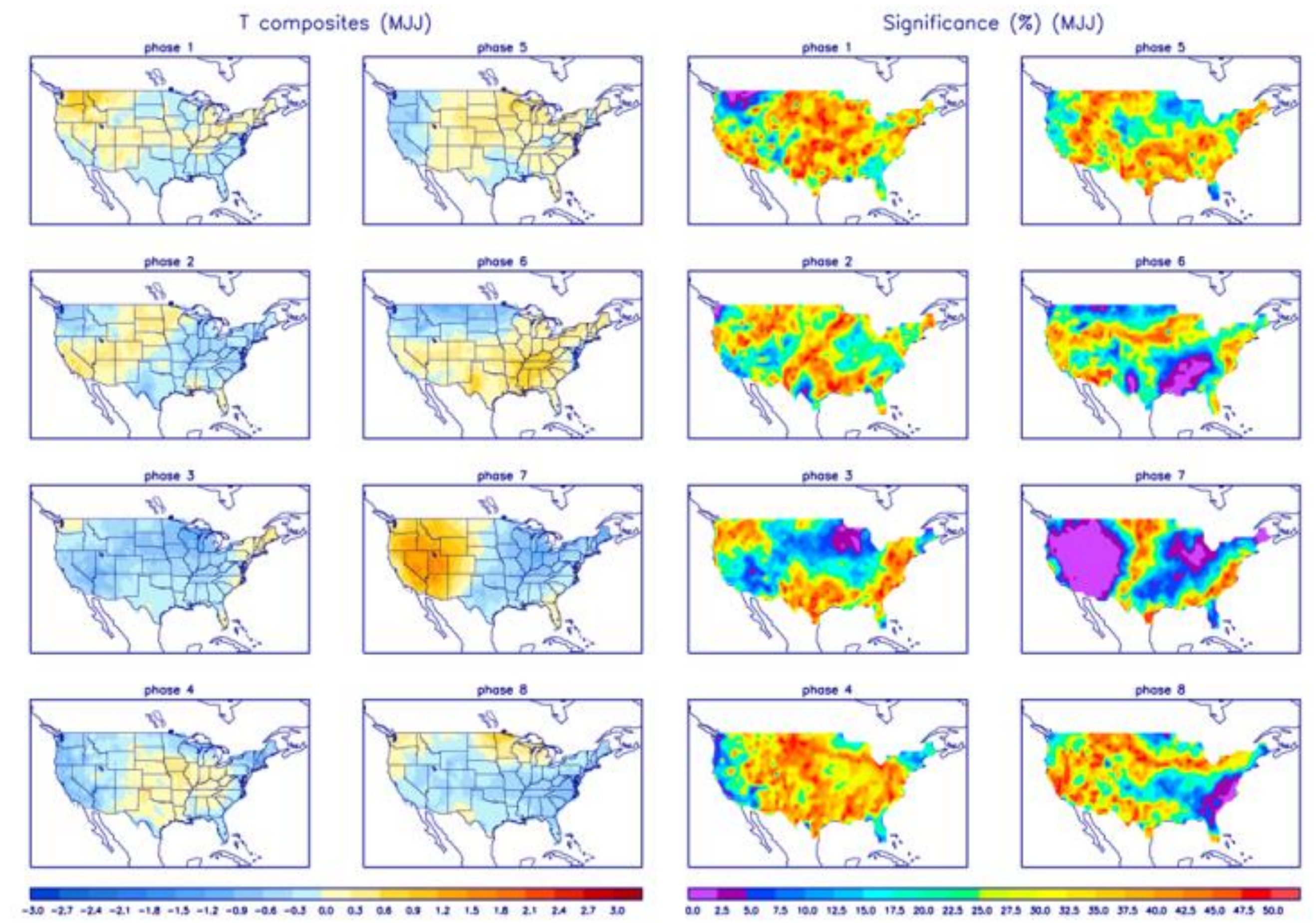

Precipitation Anomalies (May - Sep)



# 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.**



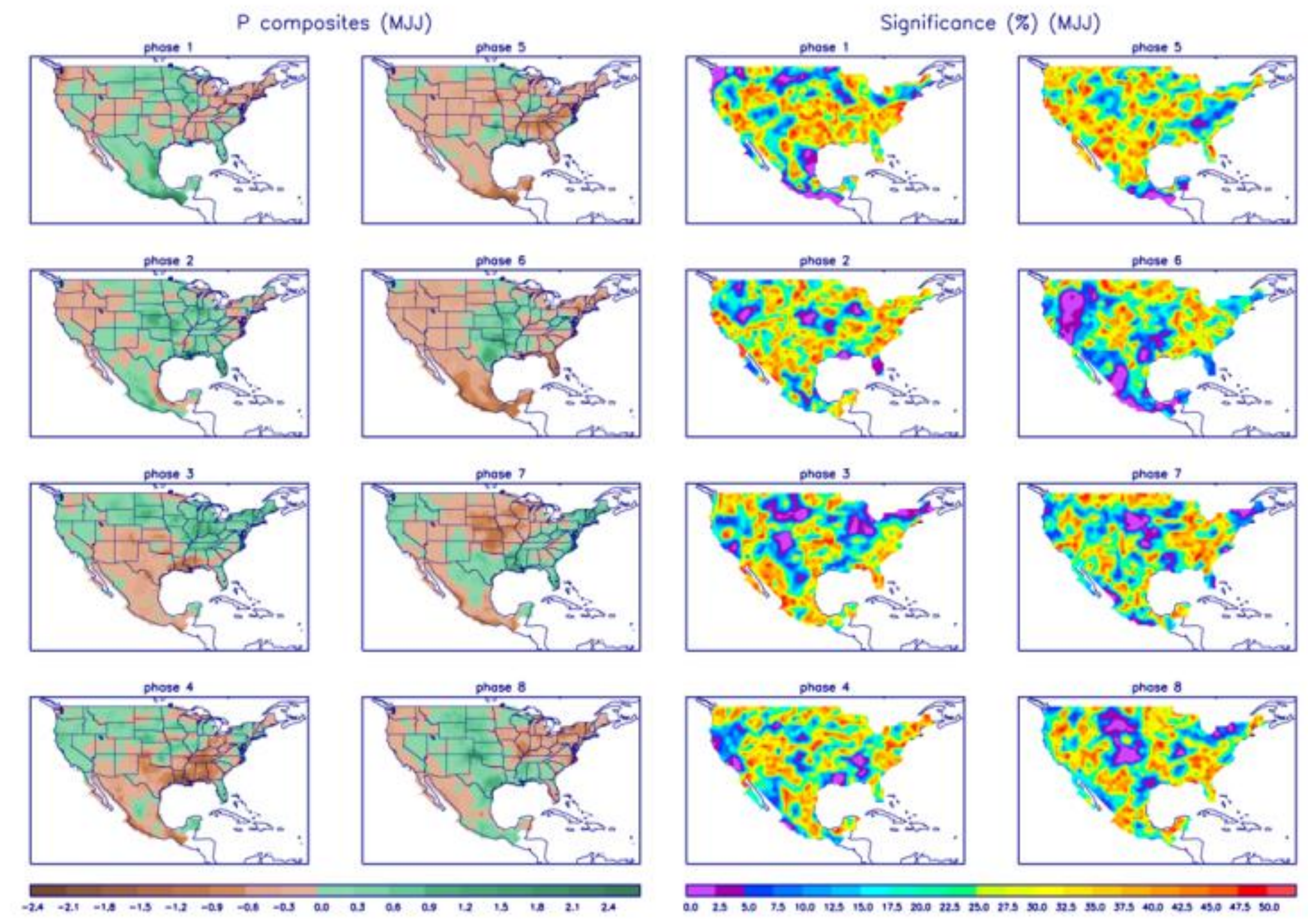

Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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.

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