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 MJO showed signs of organization over the past week to ten days, but the overall pattern of tropical variability is mixed, with various modes contributing. Based on upper-level divergence alone, any MJO signal is shifting eastward from the Maritime Continent to the West Pacific.

- Dynamical model guidance is fairly good agreement on a weak MJO signal over the next two weeks. An enhanced convective signal in the western Indian Ocean conflicts with the upper-level circulation signal that favors enhanced convection over the West Pacific. This appears in both the GEFS and ECMWF systems as a weak MJO signal that tends toward Africa by Week-2.

- Kelvin wave activity is more likely than canonical MJO to impact weather throughout the global tropics, while indirectly influencing the extratropics, via locally increasing/decreasing tropical cyclone formation chances, during the next two weeks.

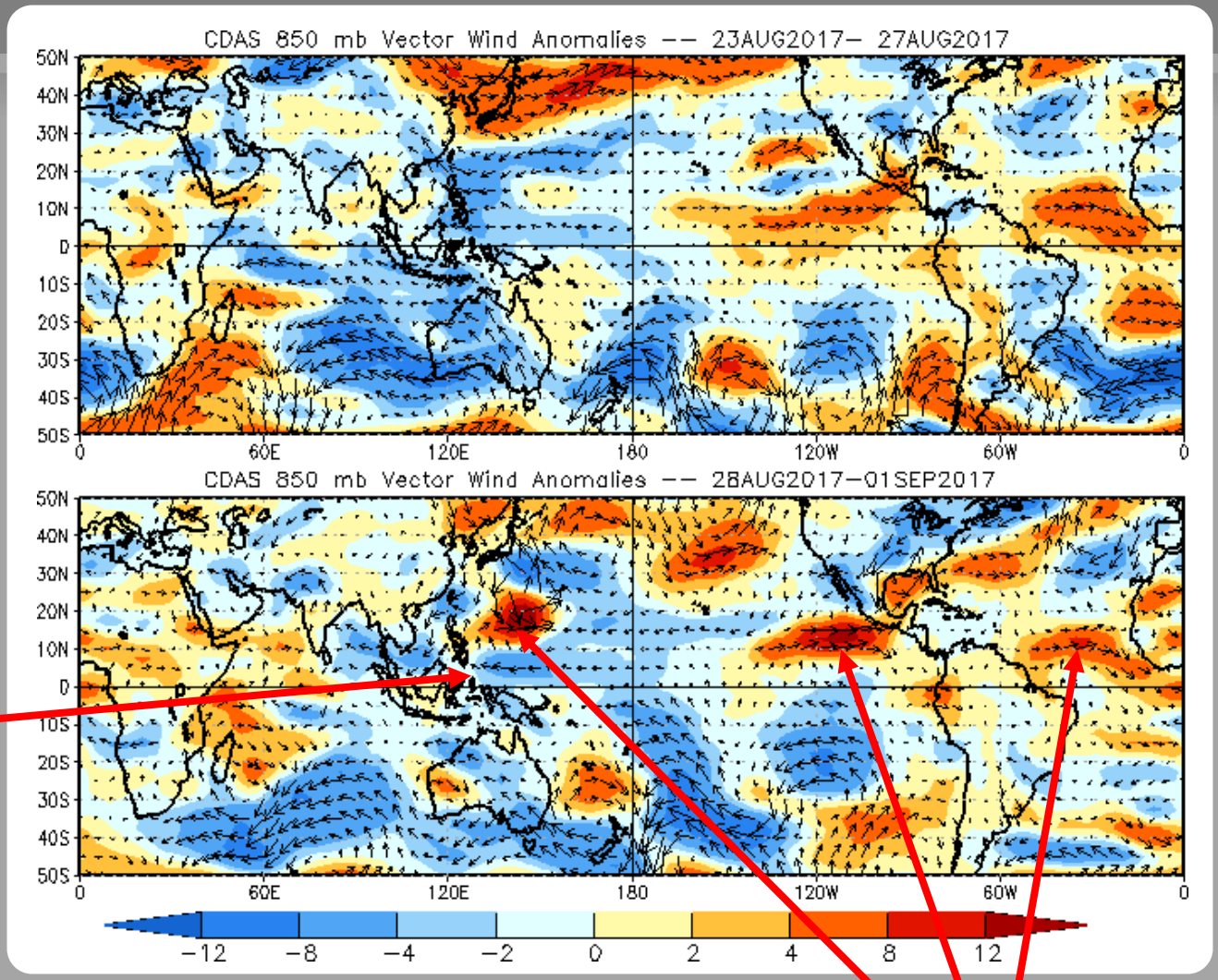
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies persisted over the Maritime Continent and west-central Pacific

Robust westerly anomalies were observed in association with tropical cyclone activity in the major Northern Hemisphere basins .

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

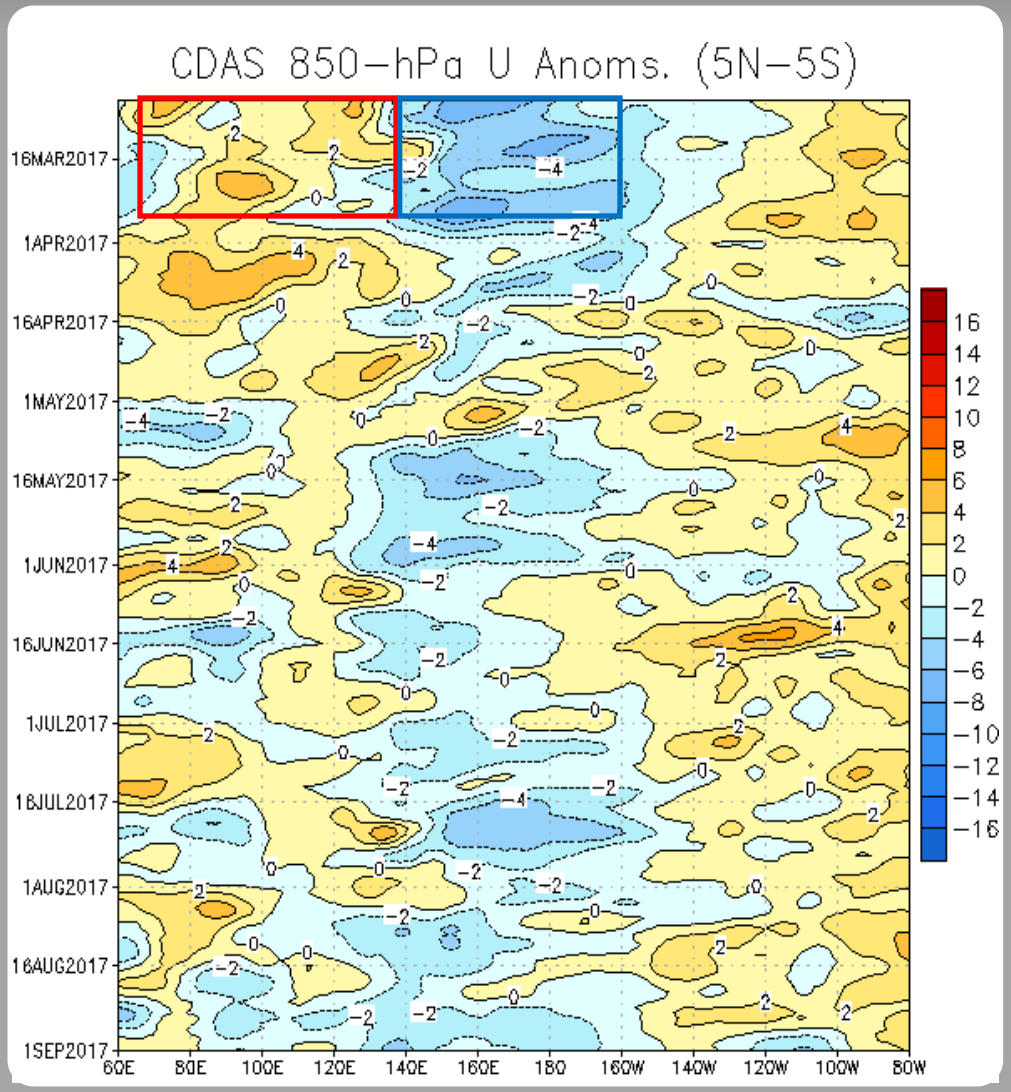
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

In March and April, persistent westerly (easterly) anomalies, shown by the red (blue) box at right, were associated with the negative phase of the Indian Ocean Dipole (IOD), and a weakening La Niña. Some intra-seasonal variability is evident in late March. Low-frequency easterly anomalies have largely persisted over the west-central Pacific throughout the summer.

Equatorial zonal wind anomalies were notably of low amplitude in June. During July, a slight eastward shift in the low-frequency pattern is noted, related to intraseasonal variability.

During August easterly anomalies were observed over the Maritime Continent and portions of the Indian Ocean, with westerly anomalies over the eastern Pacific and western Atlantic.



OLR Anomalies – Past 30 days

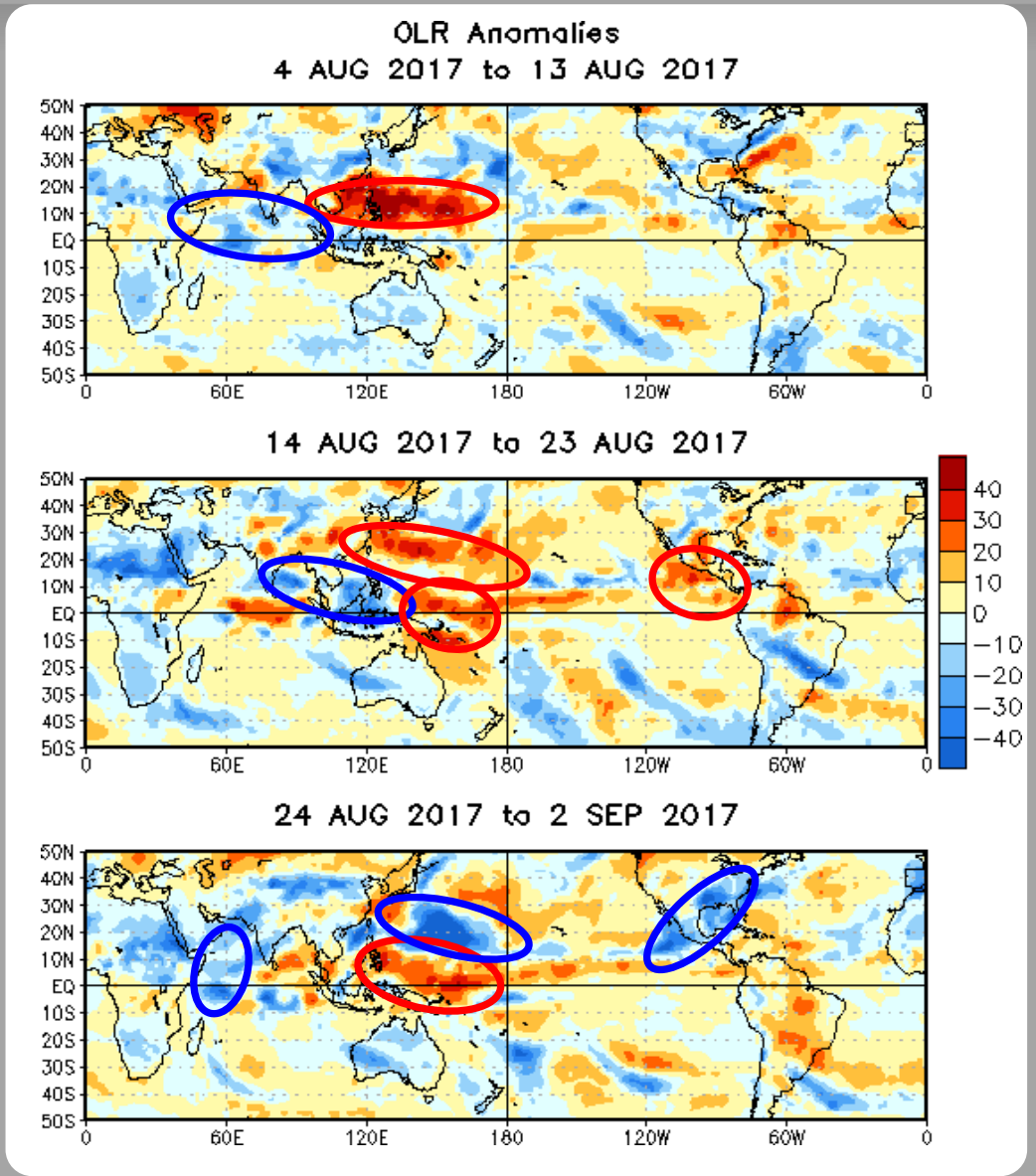
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During early August, anomalous dryness was observed over much of the northwestern tropical Pacific, with TC activity shifted to the north. Some enhanced convection was observed over the Indian Ocean.

Much of the West Pacific remained drier than normal during the middle part of August, with enhanced rainfall shifting eastward from the Indian Ocean to the Maritime Continent. Suppressed convection was observed over the main development region of the East Pacific basin.

Suppressed convection continued over the equatorial West Pacific during late August and very early September. Enhanced rainfall was notable over the northwest Pacific and western Indian Ocean. Tropical moisture influenced a large portion of North America; Hurricane Harvey is especially notable.



Outgoing Longwave Radiation (OLR) Anomalies (2.5°N - 17.5°N)

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

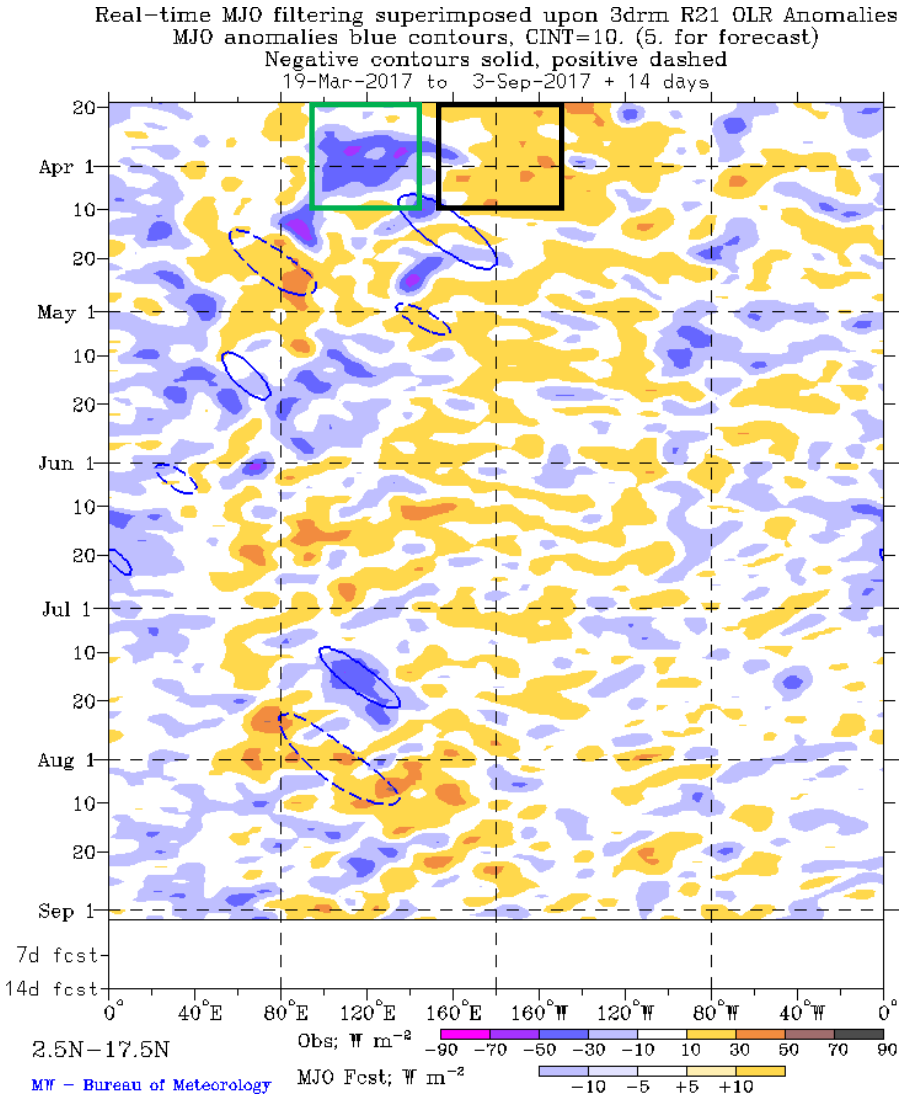
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

A low frequency state favoring enhanced convection over the eastern IO and the Maritime Continent was evident into early April 2017 (green box), with suppressed convection near the Date Line (black box).

Starting in mid-April, convective anomalies were generally weak. In mid-May, enhanced convection was noted over the Indian Ocean with some eastward propagation.

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

During mid to late August, another enhanced intraseasonal envelope developed over the eastern Indian Ocean, with multiple modes of variability contributing.



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

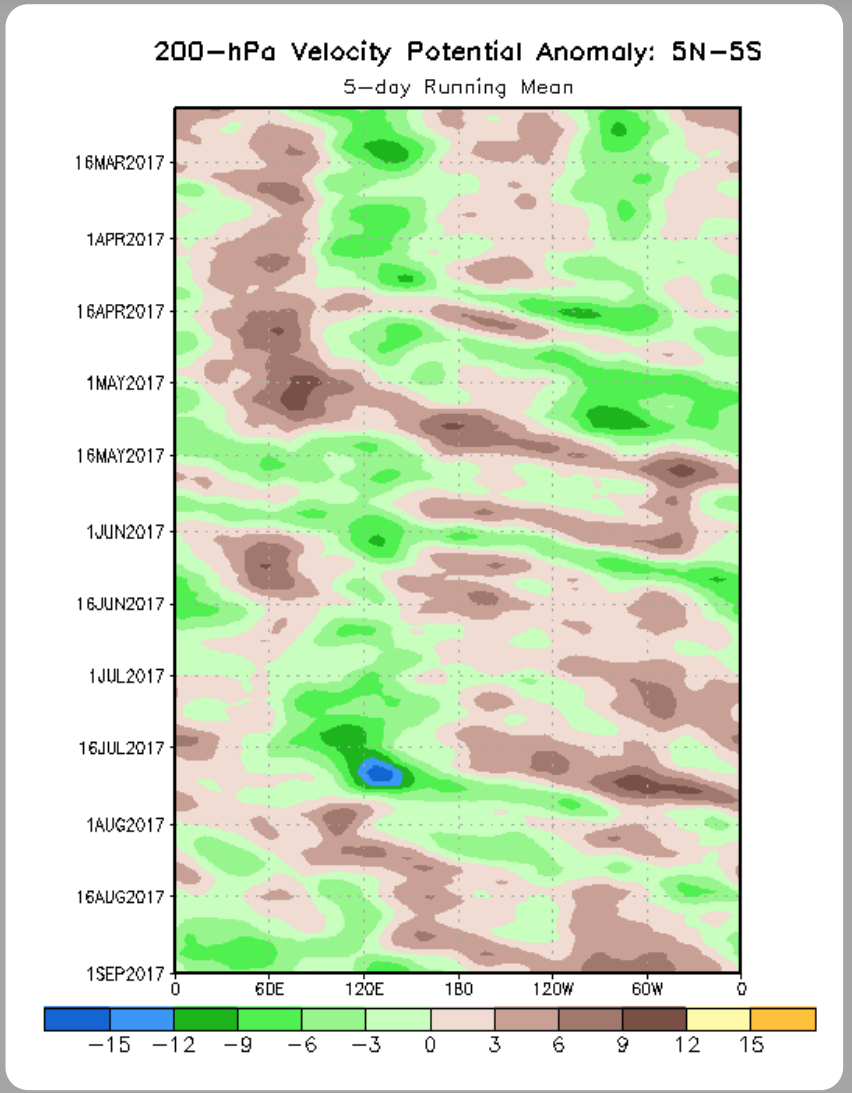
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

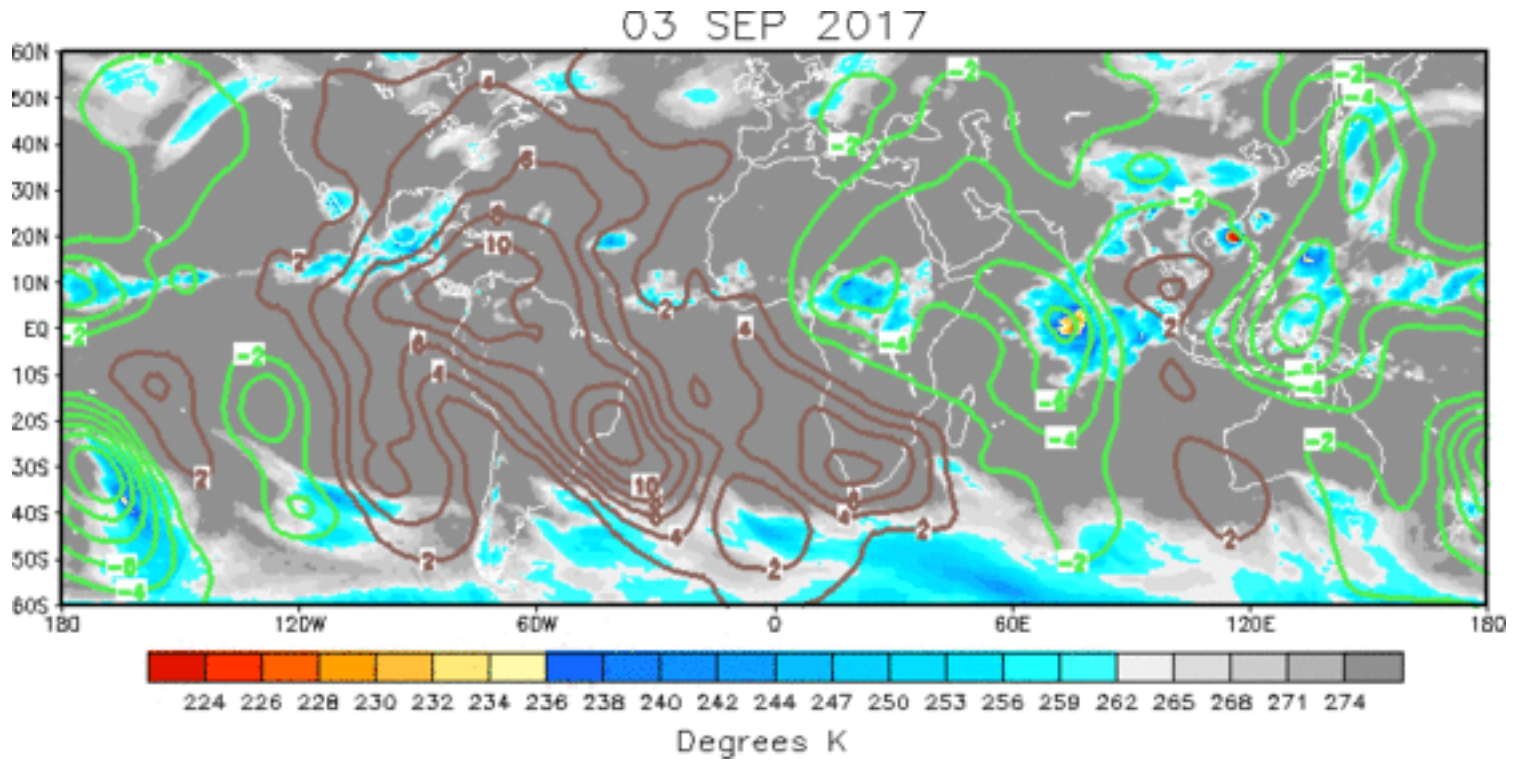
During March, a low frequency signal favoring enhanced (suppressed) convection over the Maritime Continent (Indian Ocean) became the primary component of the anomaly field.

Kelvin wave activity was apparent from April through early June, as seen in the rapidly propagating eastward signals. During July, enhanced convection strengthened over the Maritime Continent as the low-frequency signal constructively interfered with an easterly propagating signal.

This eastward propagating signal appears more or less intact with a period in line with canonical MJO phase speeds. Other variability, however, has combined to create an unclear picture of ongoing MJO activity.



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



Widespread enhanced convection is depicted from Africa eastward through the West Pacific, and suppressed convection is noted over the Americas. The pattern is now closer to a wave-2 structure, with a small area of upper-level convergence observed over the eastern Indian Ocean.

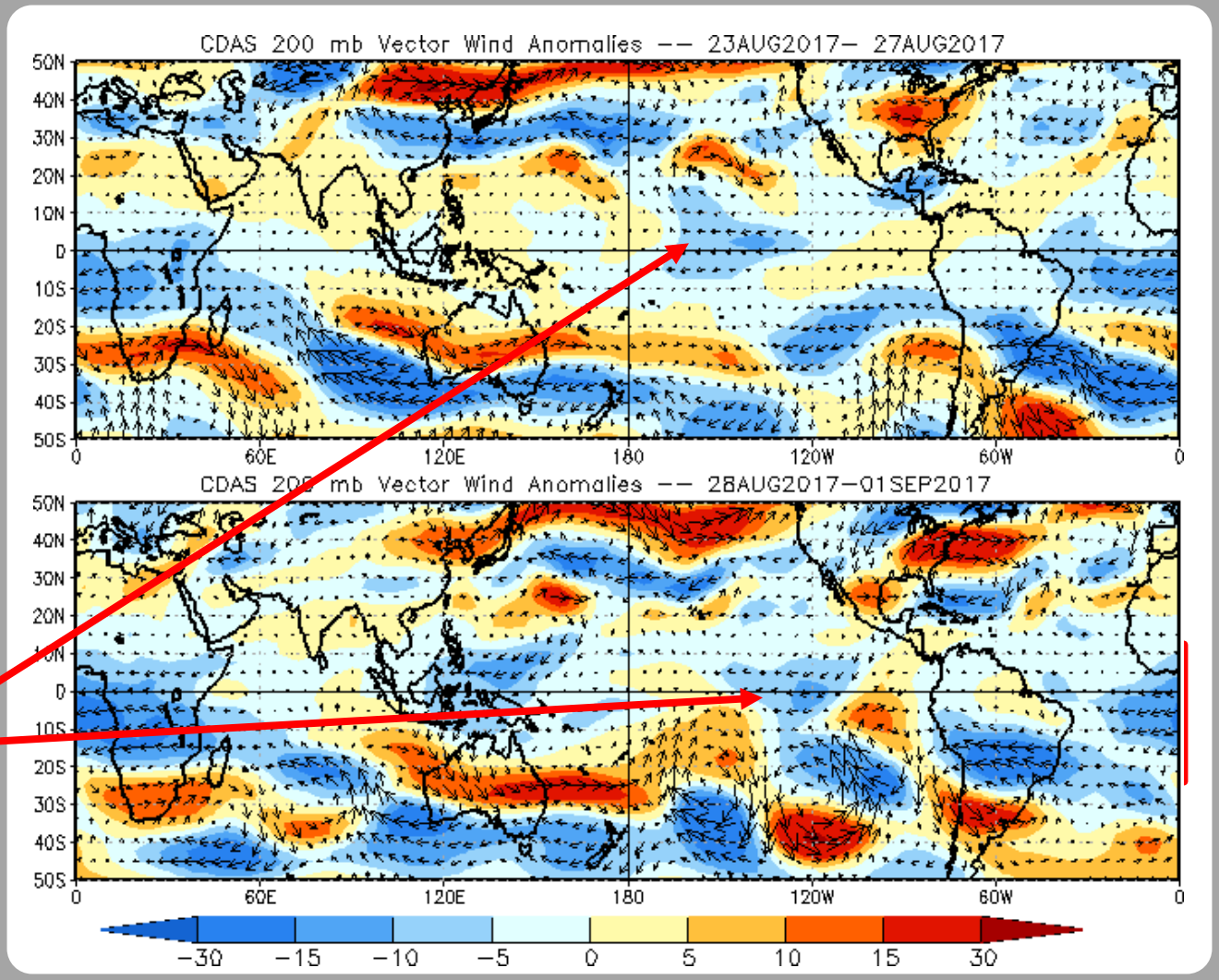
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Upper-level zonal wind anomalies over the deep Tropics do not appear particularly coherent.

Some eastward propagation associated with an atmospheric Kelvin wave is observed between the two periods.

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

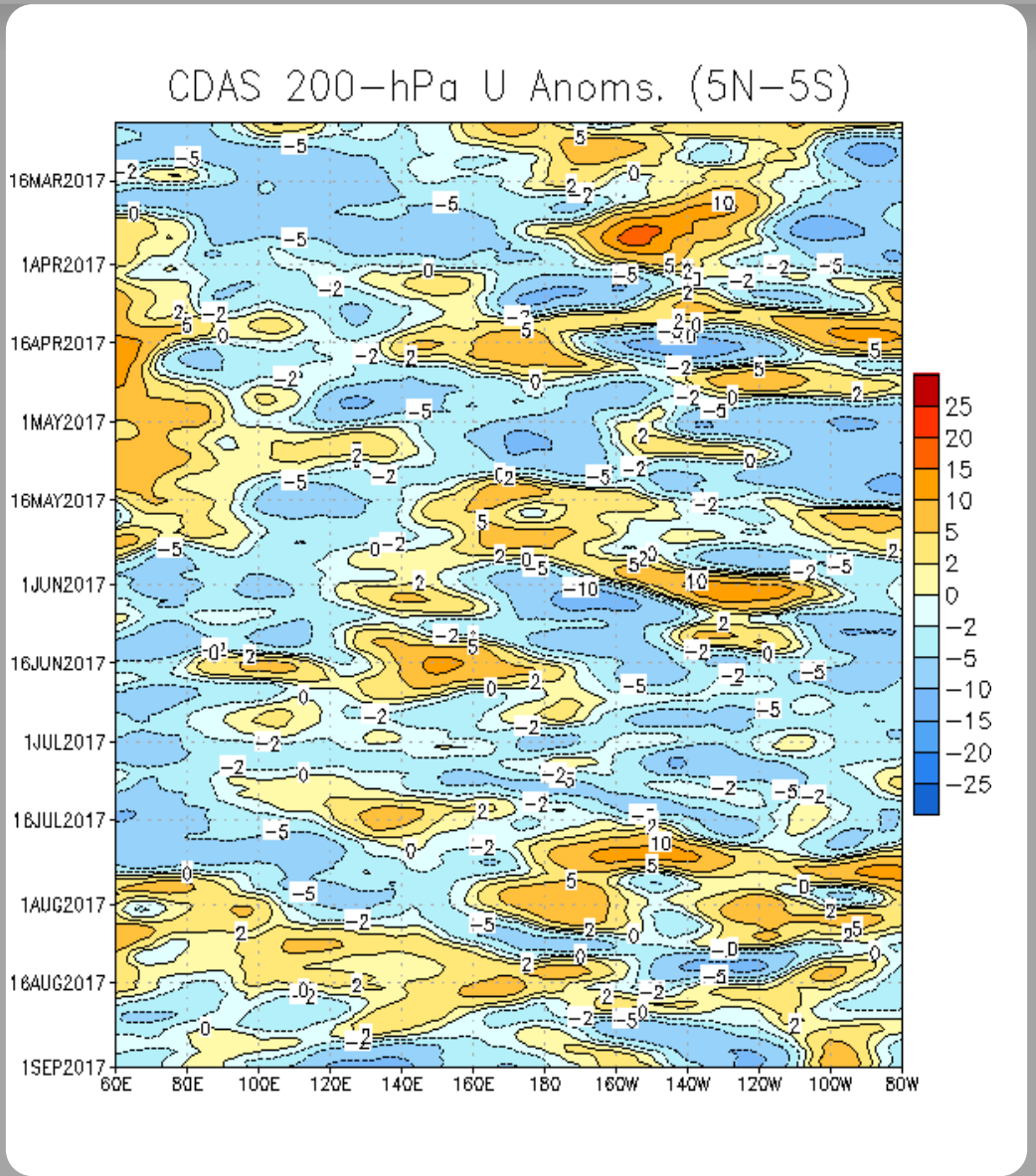
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

Easterly anomalies returned to the East Pacific during late April and persisted with some periods of high-frequency interference.

During early to mid-June, easterly anomalies were most prominent across the global tropics, in part due to mid-latitude influences.

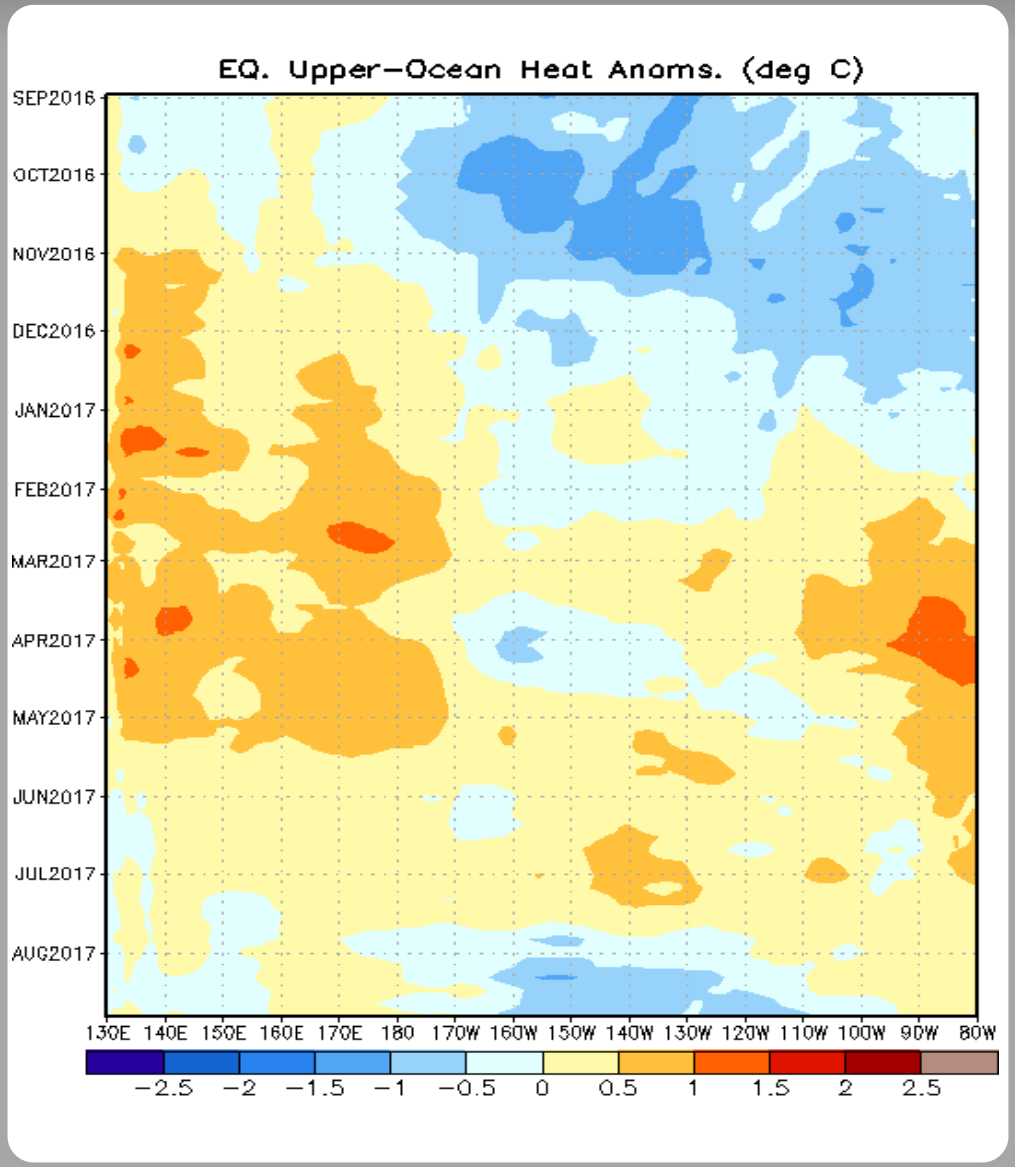
Starting in July, the anomaly patterns have been continually moving eastward associated with weak MJO activity and atmospheric Kelvin waves.



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.

Upper-ocean heat content values continued to drop in the central Pacific as trade winds were near to above average from Late July and early August, while temperature anomalies 50-200 meters below the surface continued to cool.



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

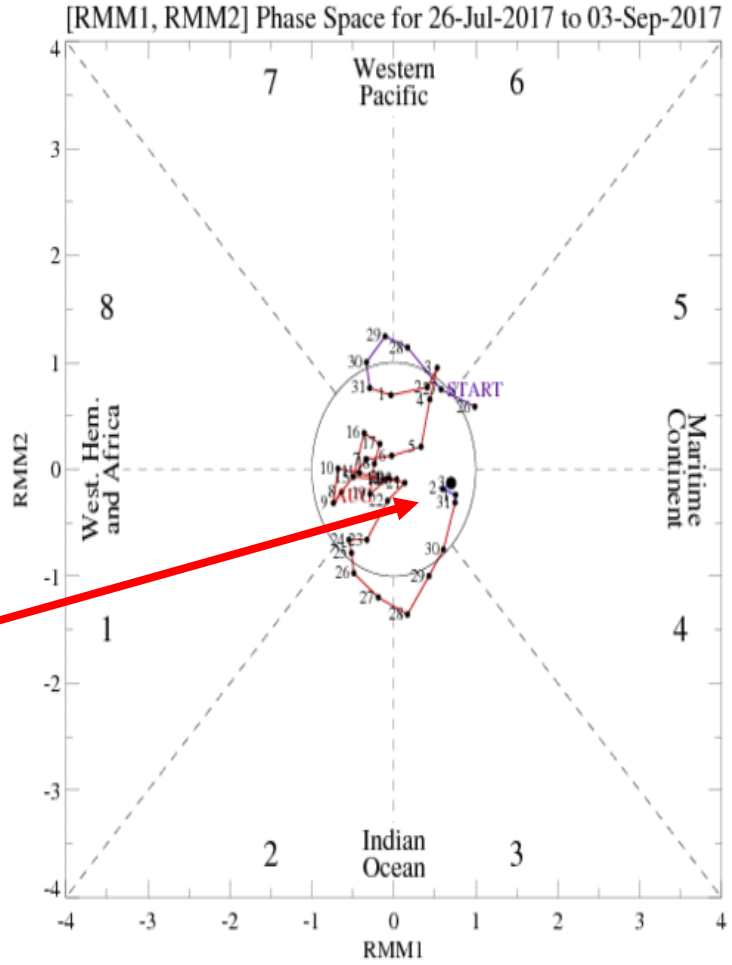
The triangular areas indicate the location of the enhanced phase of the MJO

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

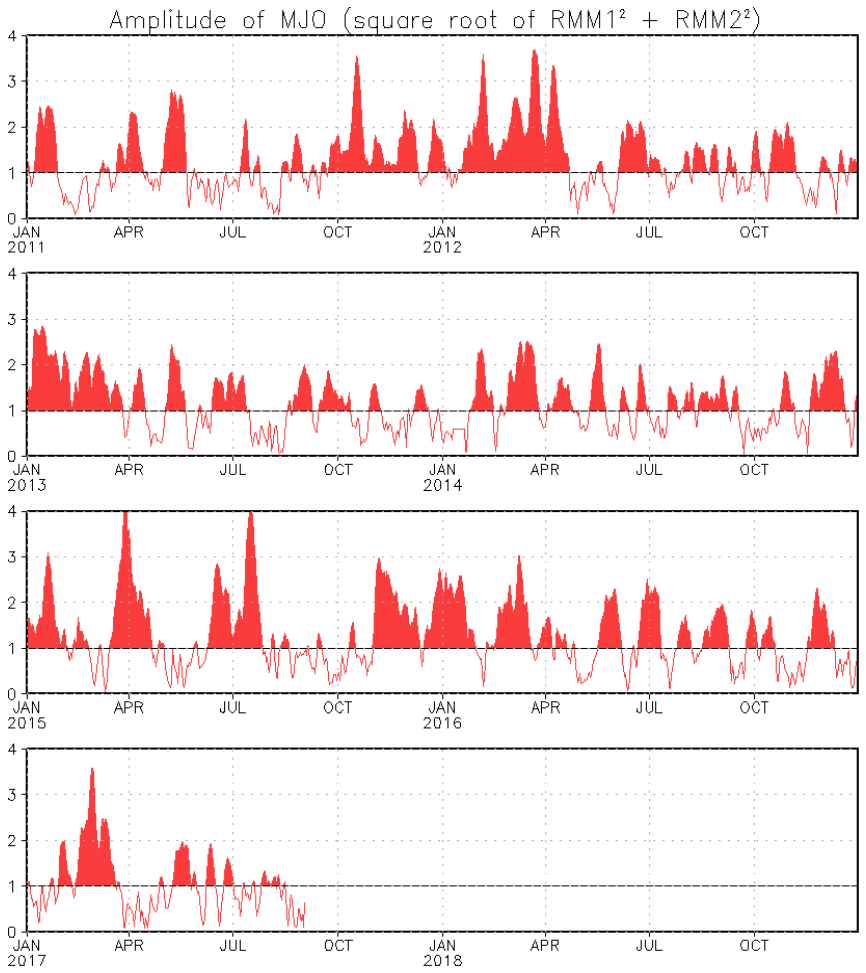
The MJO signal as monitored by the RMM index had emerged over the Indian Ocean, but weakened over past several days.



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

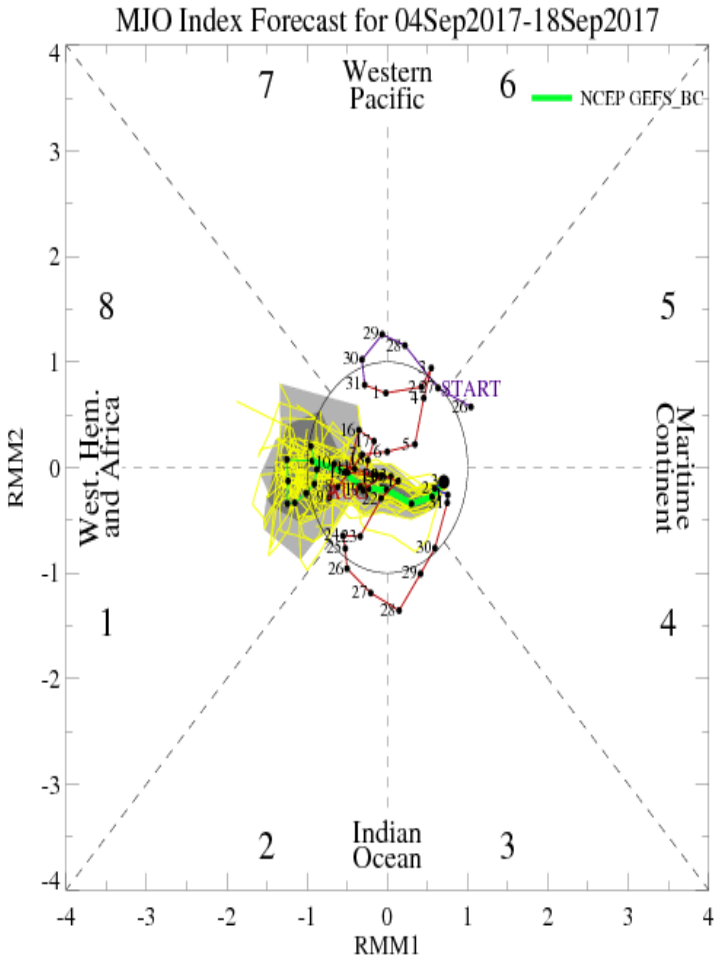
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

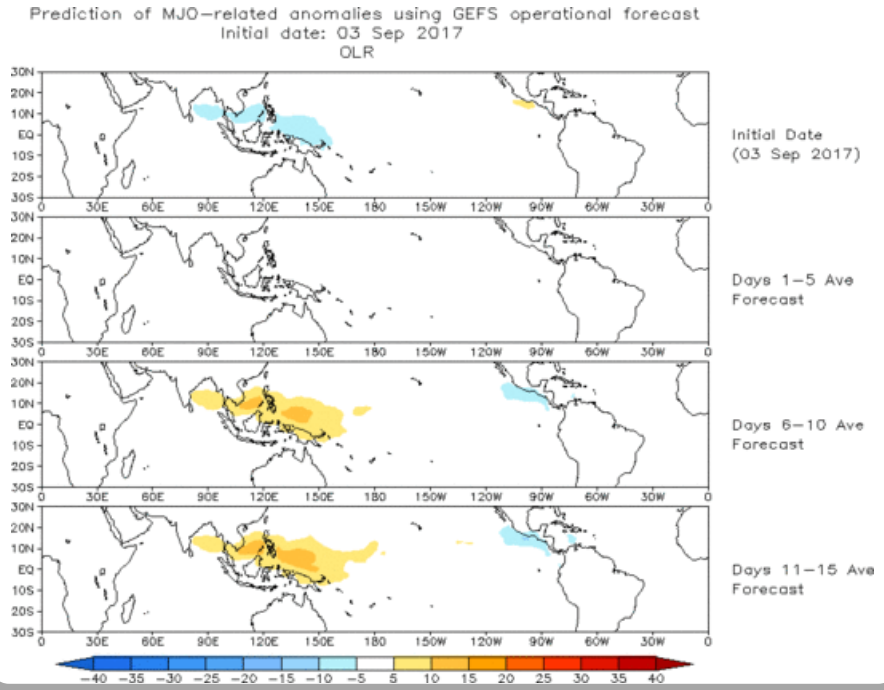
The GEFS consistently depicts an incoherent MJO signal over the next two weeks, with rapid propagation to the Western Hemisphere and Africa.



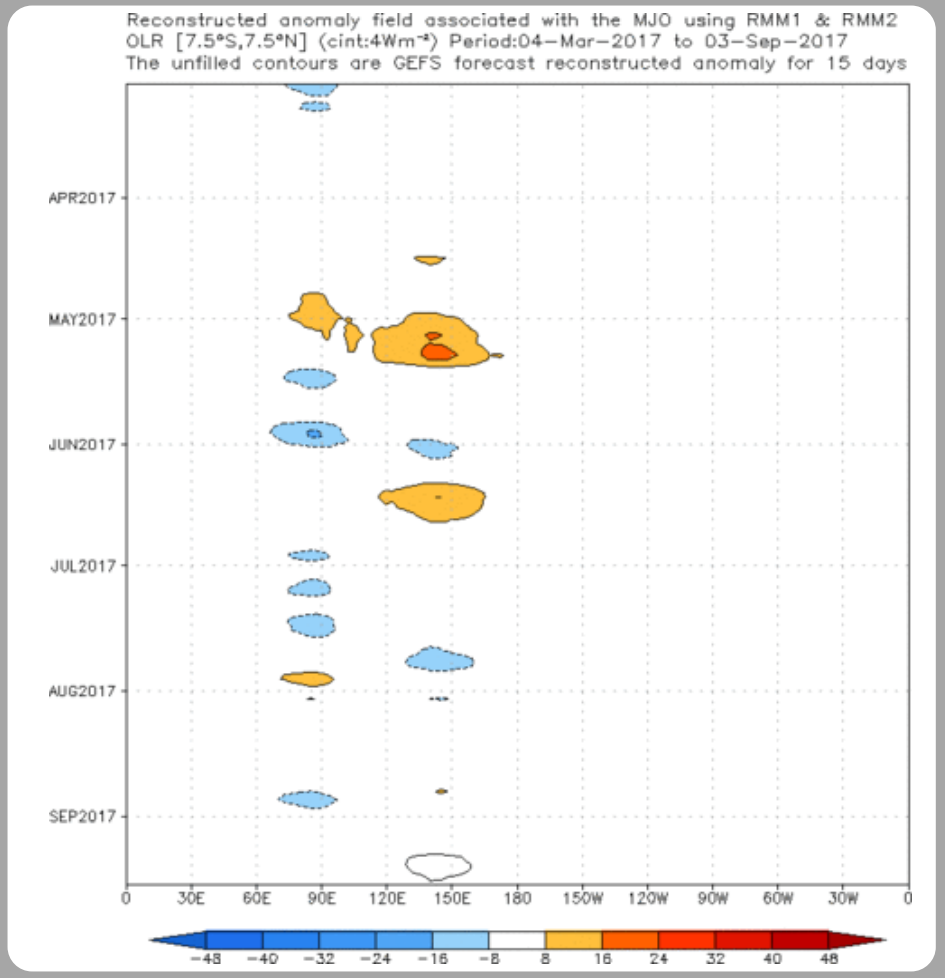
Ensemble GFS (GEFS) MJO Forecast

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

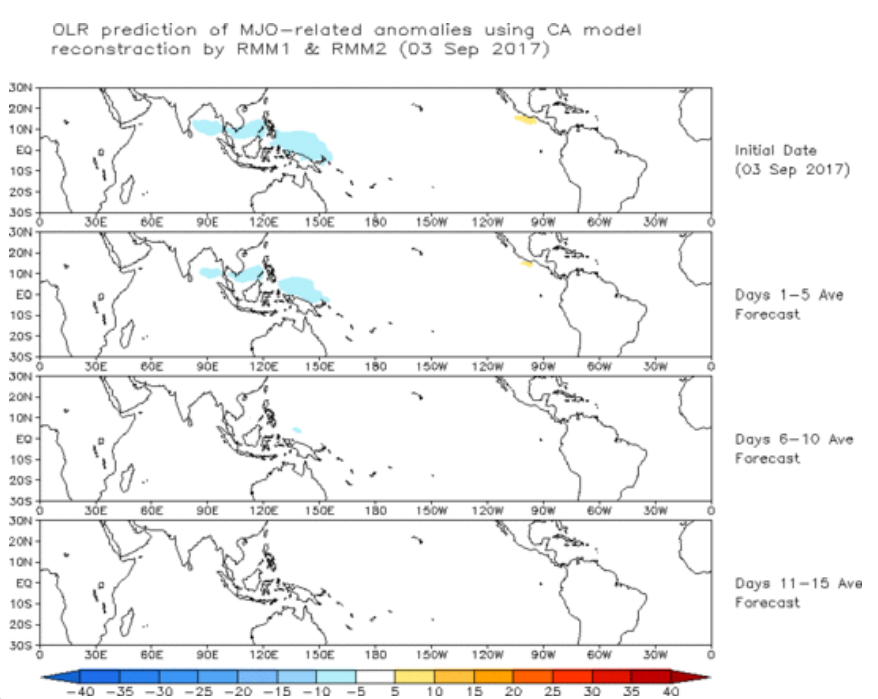


The GEFS RMM-based OLR anomaly forecast shows a weak and rapidly propagating convective signal. By the end of the period, the enhanced phase is centered over the Western Hemisphere.

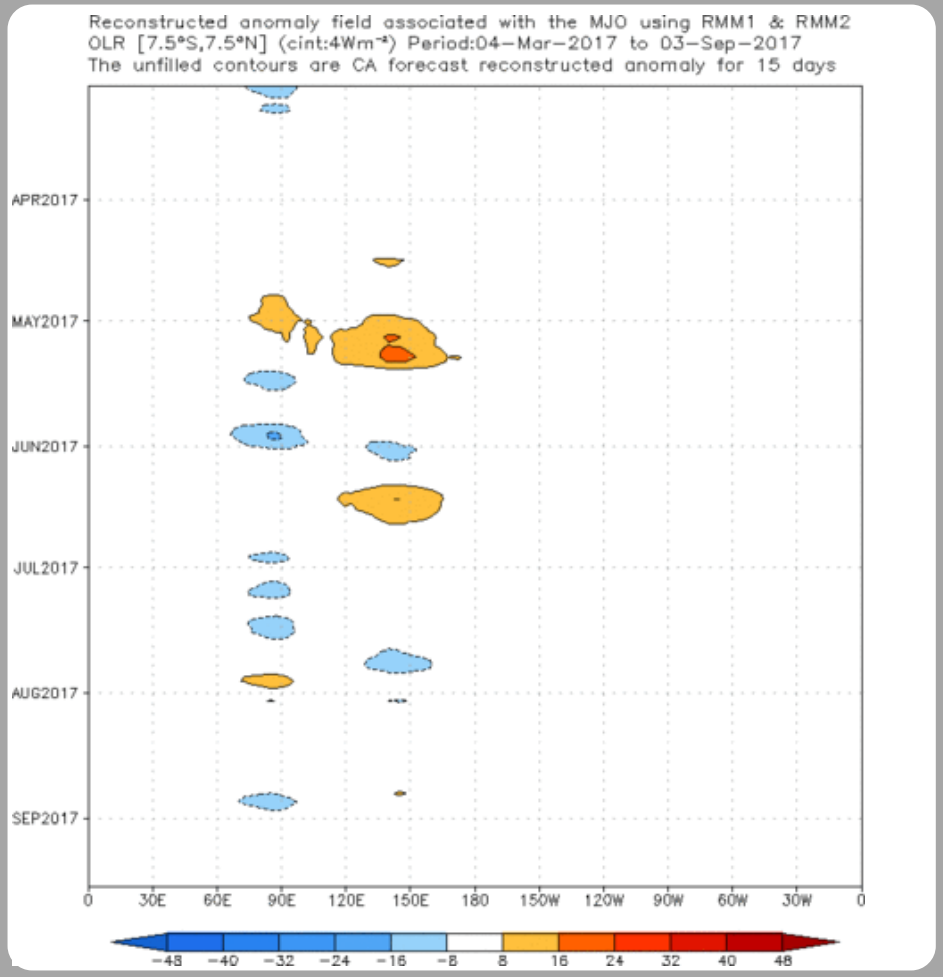
Constructed Analog (CA) MJO Forecast

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



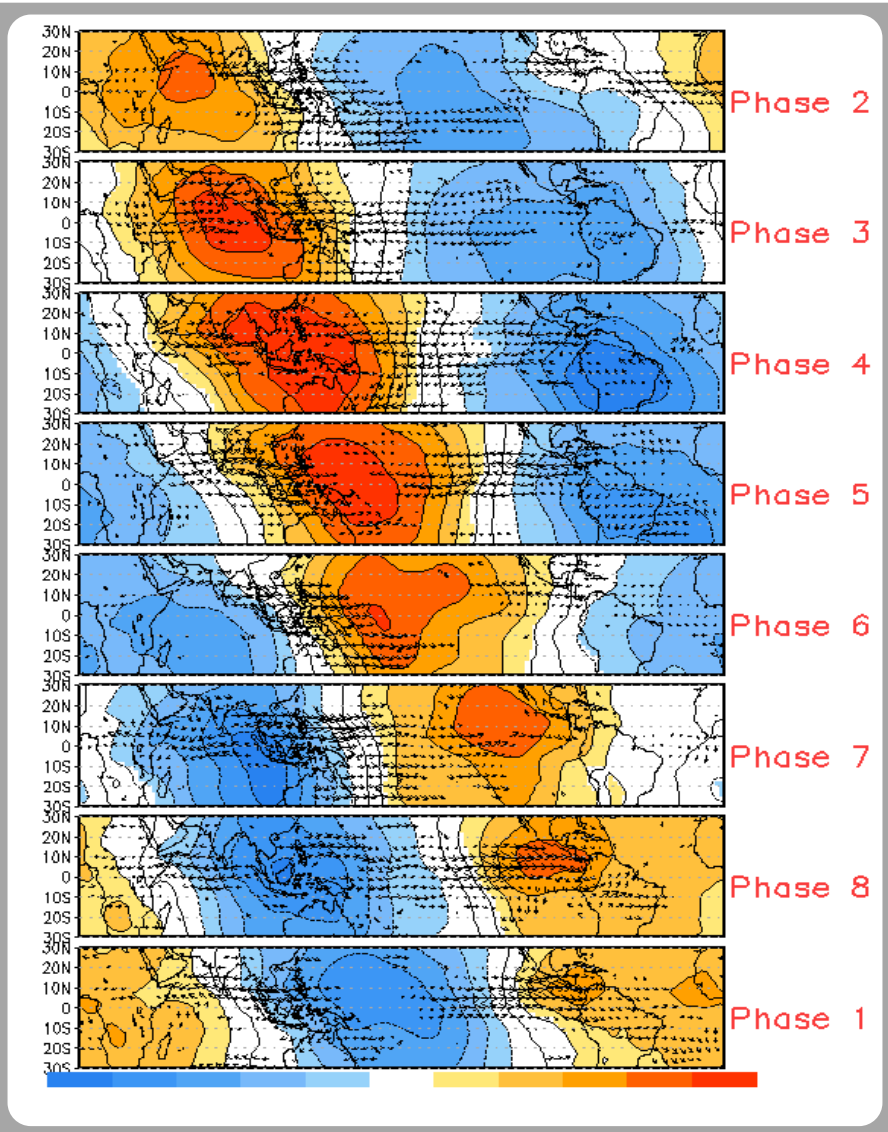
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



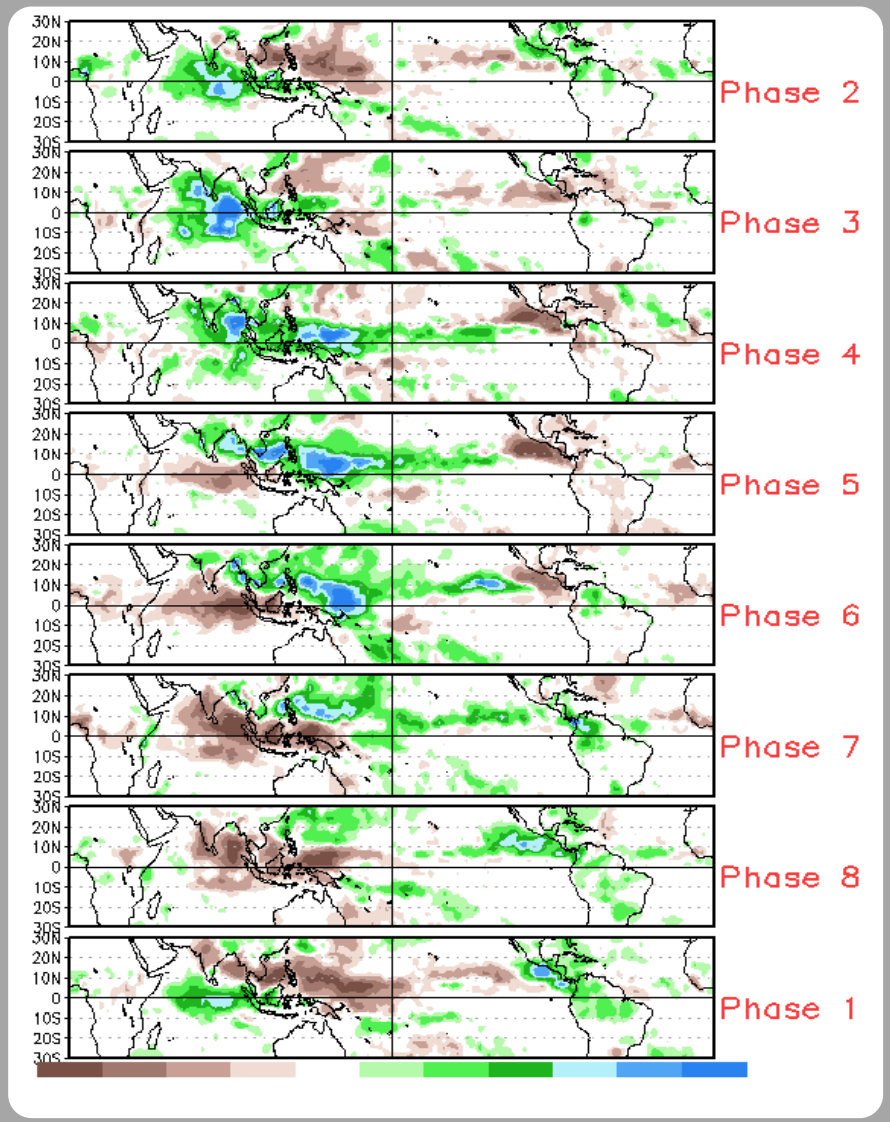
The constructed analog depicts little if any MJO-based signal.

MJO Composites - Global Tropics

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



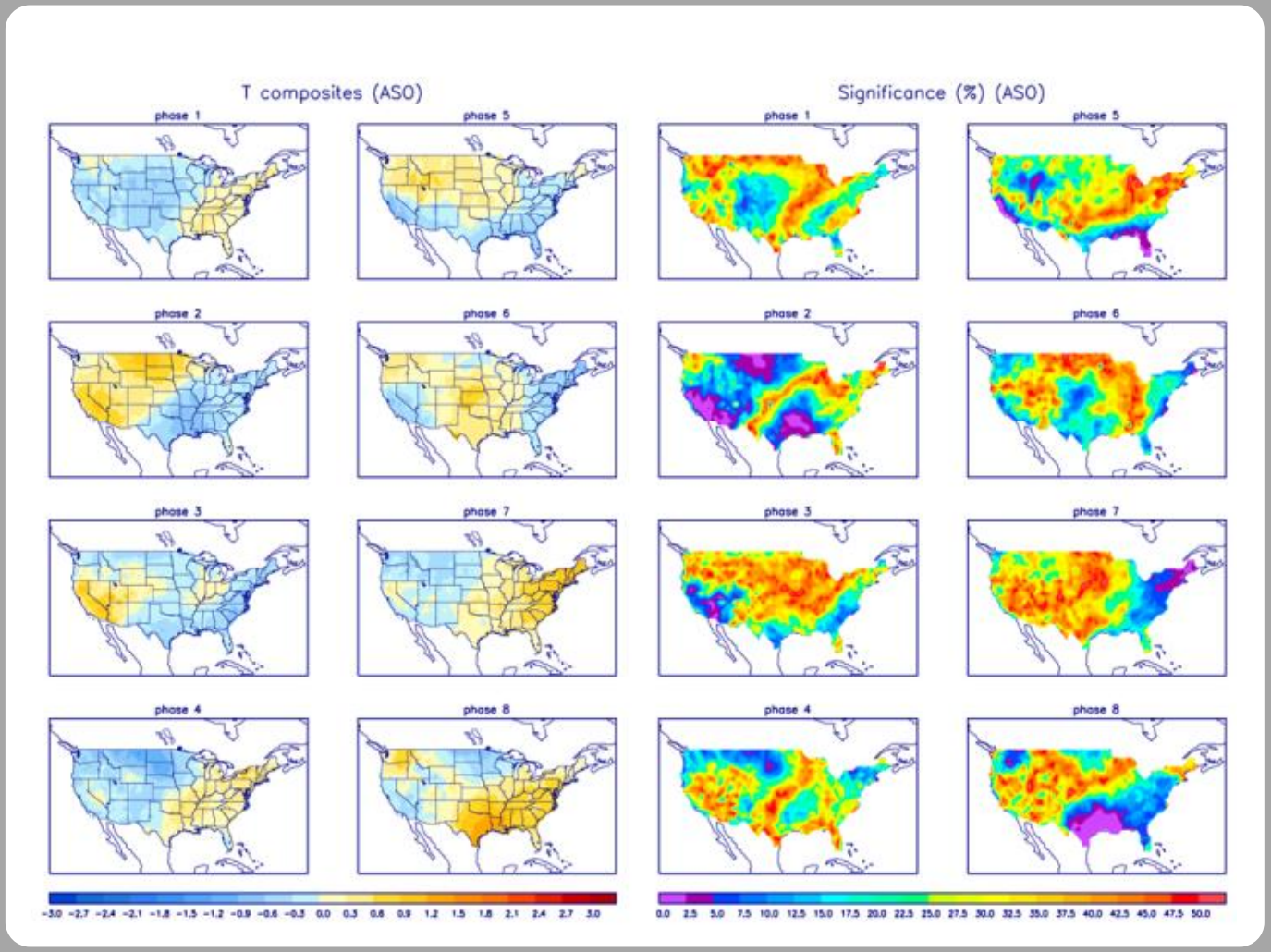
Precipitation Anomalies (May - Sep)



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.



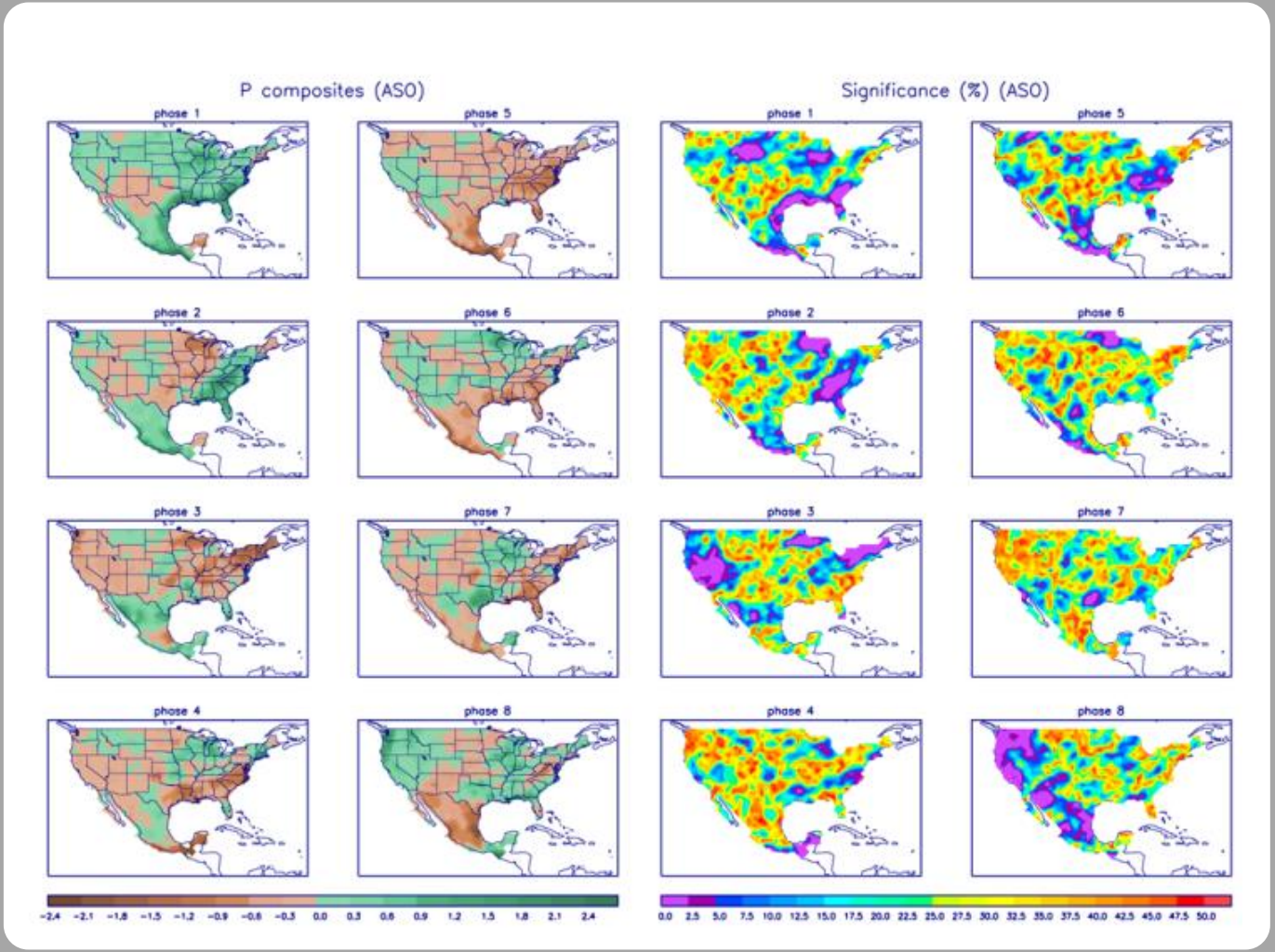
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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