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

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Climate Prediction Center / NCEP
11 September 2017

Outline

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MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The MJO remained weak during the past 7 days.
- All dynamical model guidance predicts a low-amplitude MJO signal during the next two weeks. An intraseasonal signal expected to move rapidly across the Indian Ocean and Maritime Continent during this time. The GEFS also hints at a weak signal emerging in phase 8 (Western Hemisphere and Africa) which appears to be related to Kelvin wave activity.
- 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.

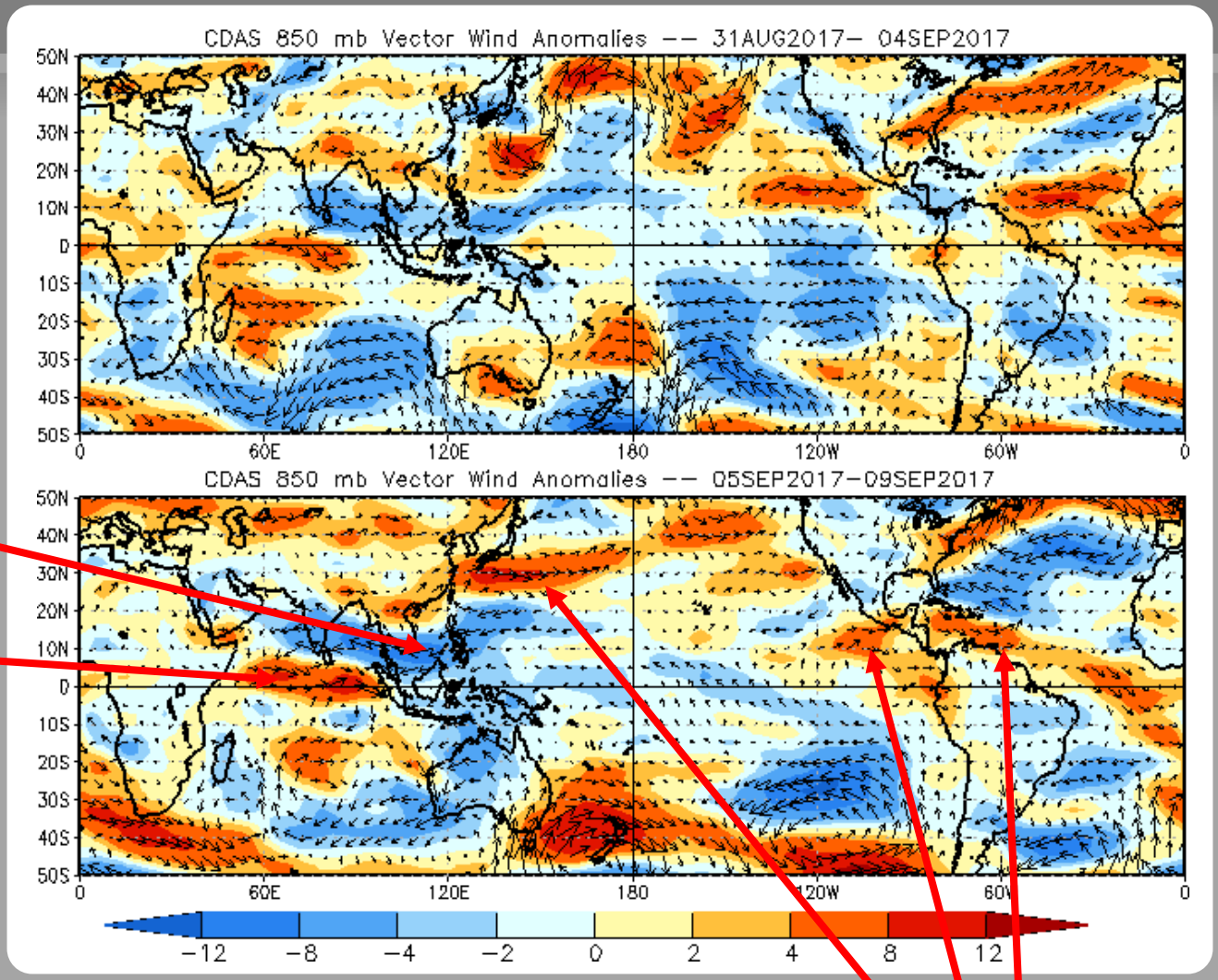
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 expanded over the Maritime Continent and western Pacific; westerly anomalies strengthened over the equatorial Indian Ocean. This has helped to develop a low-level, anomalous cyclonic circulation over the northern Indian Ocean.

Enhanced trade winds persisted near and east of the Date Line.

Westerly anomalies were observed in association with tropical cyclone activity in the Pacific and Atlantic basins.

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

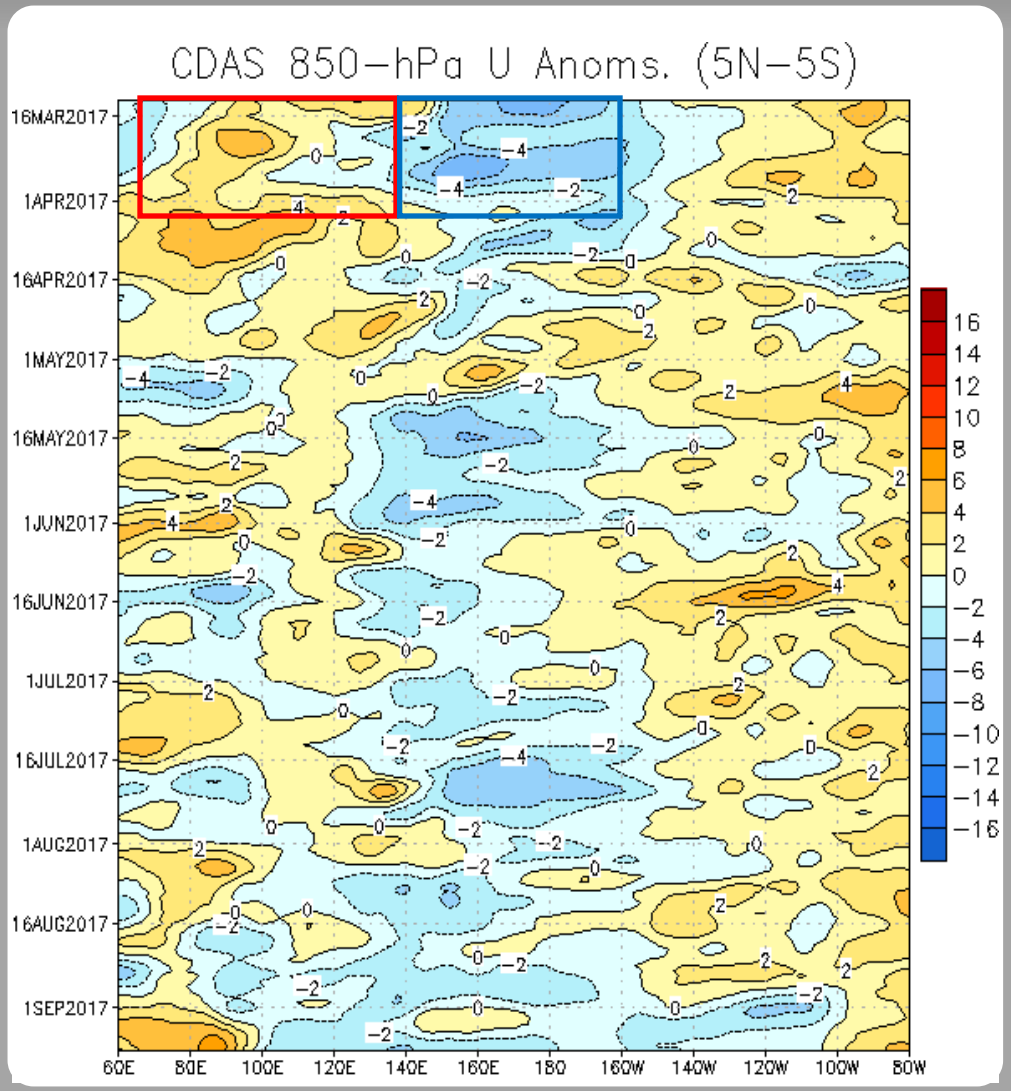
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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 and early September, easterly anomalies prevailed across the western Pacific/Maritime Continent region; most recently, westerly anomalies strengthened over the Indian Ocean (IO), and easterly wind anomalies developed over the eastern and east-central Pacific.



OLR Anomalies – Past 30 days

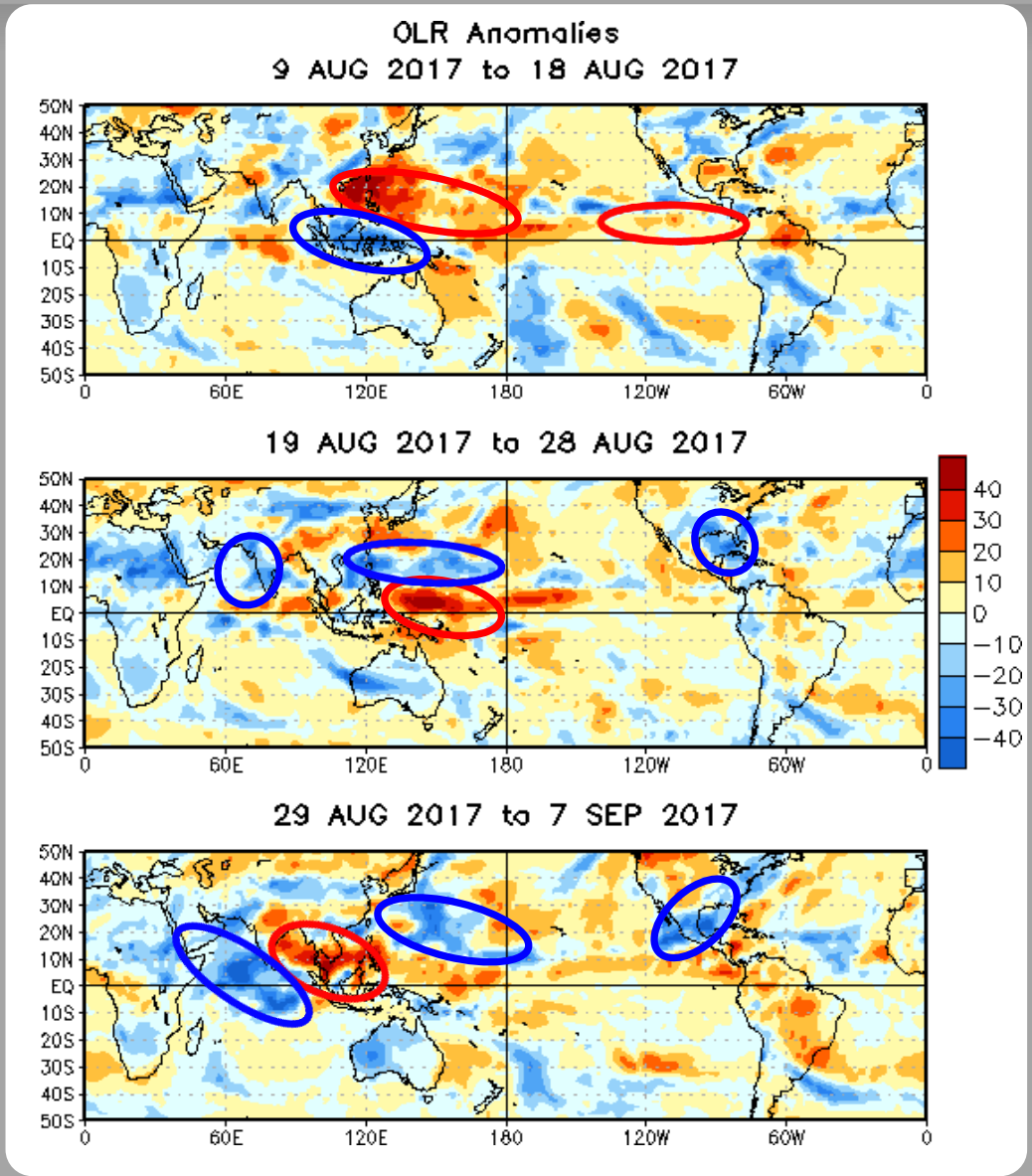
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

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 (MC). 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. Enhanced rainfall was notable over the northwest Pacific and western Indian Ocean. Tropical moisture influenced a large portion of the south-central and southeast U.S.

Enhanced convection became widespread over the Indian Ocean in very late August and early Sept. Enhanced convection persisted over the western North Pacific, Mexico, and the eastern U.S., while suppressed convection continued over the Maritime Continent/eastern Indian Ocean.



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

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

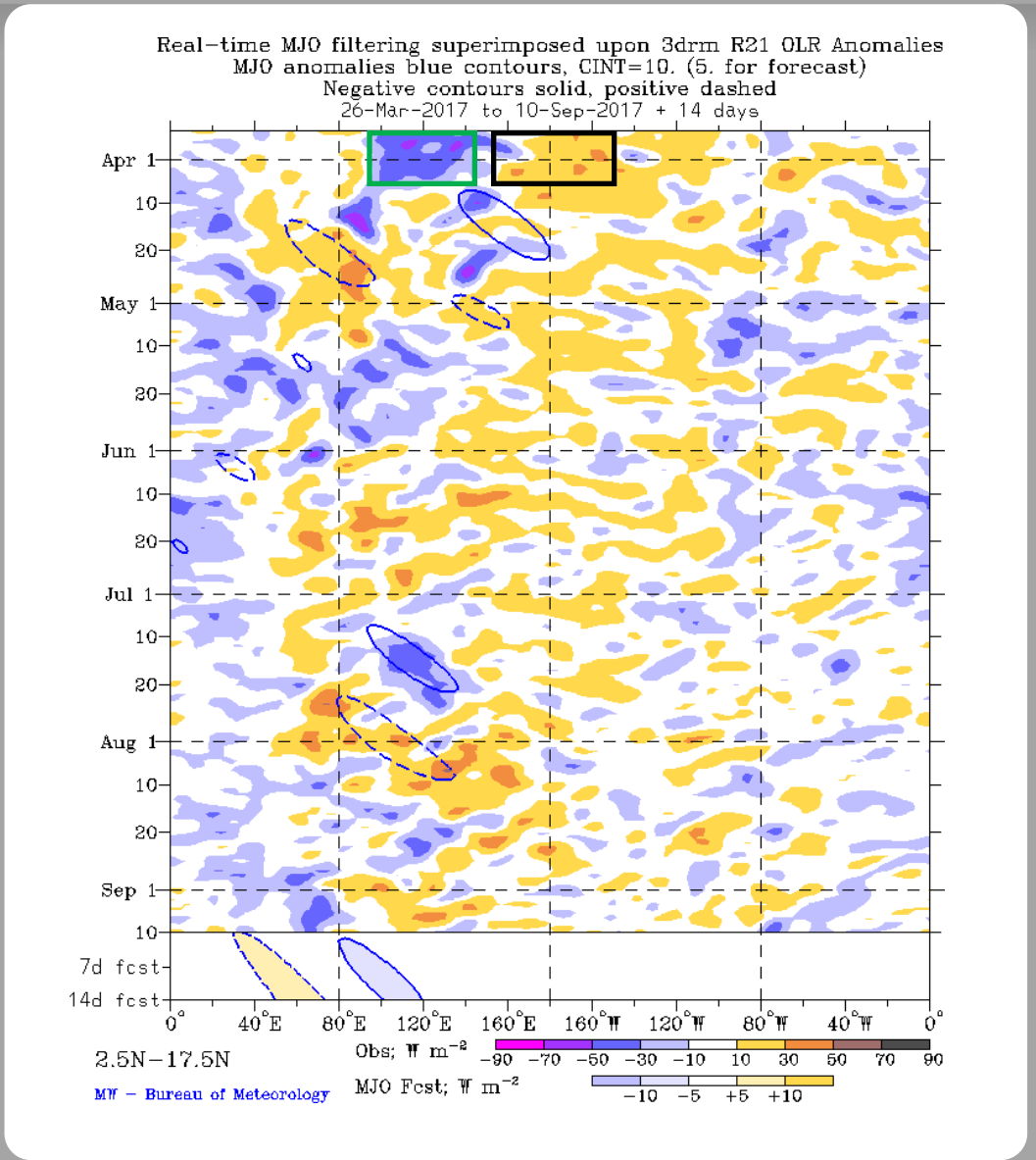
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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.

From mid-August through early Sept, 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)

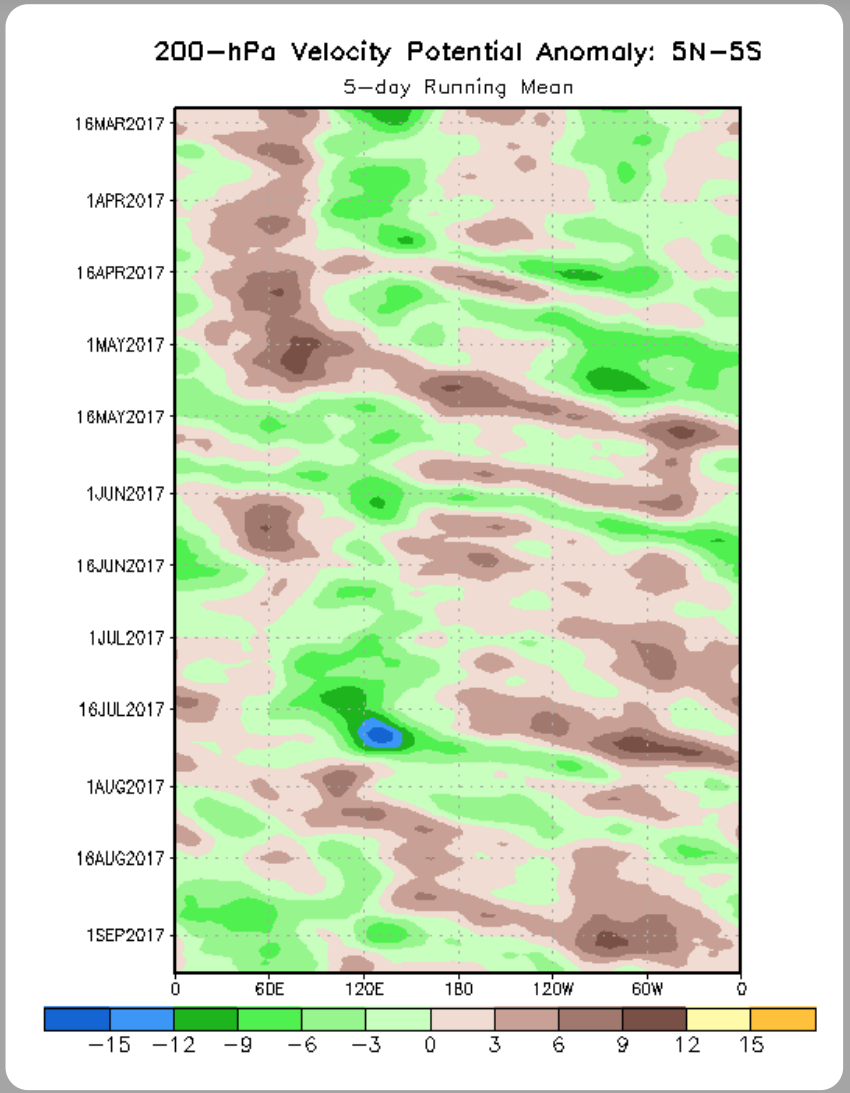
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

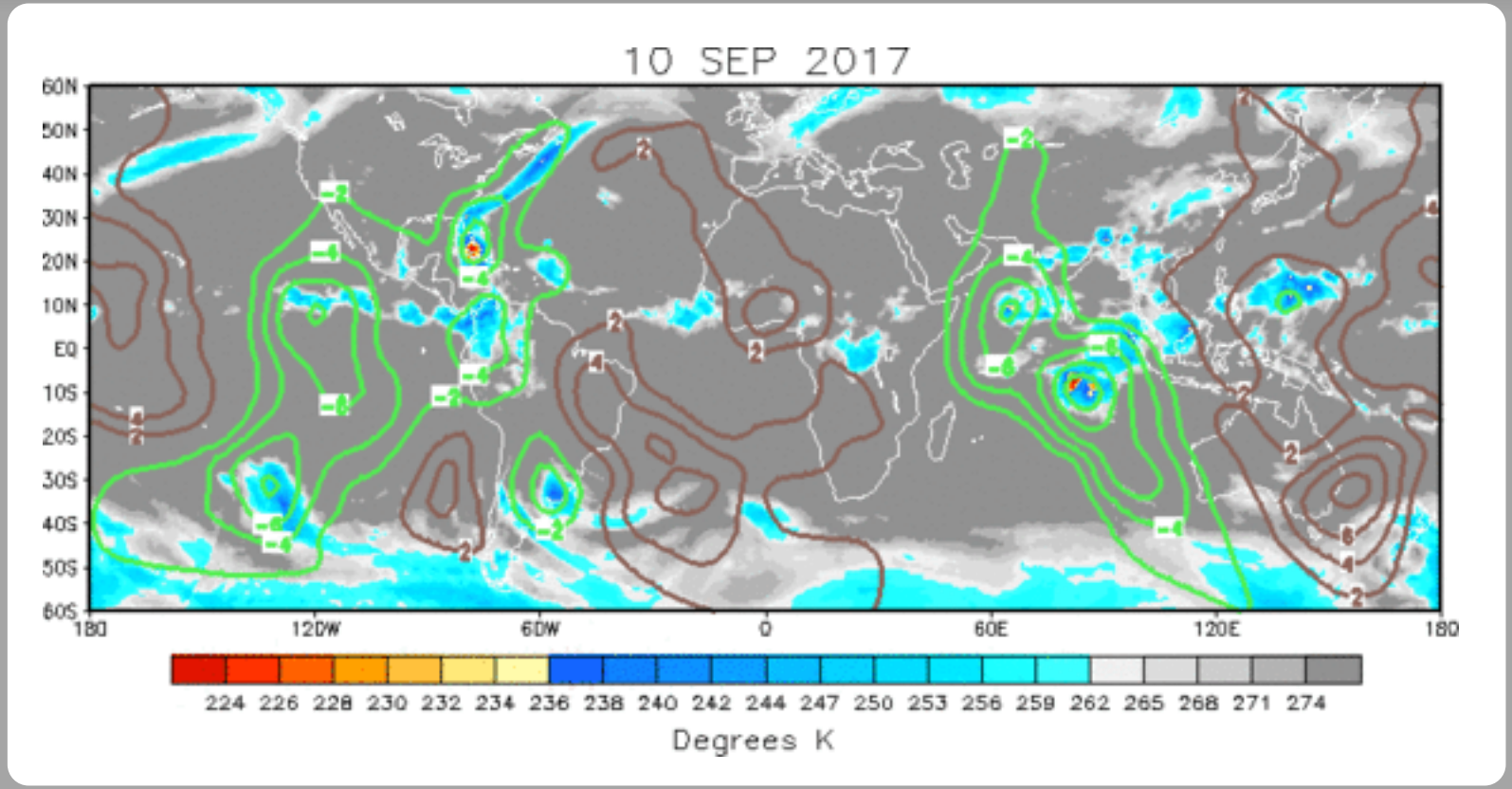
During March, a low frequency signal favoring enhanced (suppressed) convection over the Maritime Continent (Indian Ocean) became the primary component of the anomaly field.

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. In late August/early Sept, the main convective signal is located over Africa & the Indian Ocean. A rapidly moving subseasonal signal (likely a Kelvin wave) crossed the Pacific during the past two weeks.



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



A wave-2 type structure is indicated, with areas of enhanced upper-level divergence over the Indian and eastern Pacific Oceans; enhanced upper-level convergence is depicted over the Atlantic and western Pacific Oceans.

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)

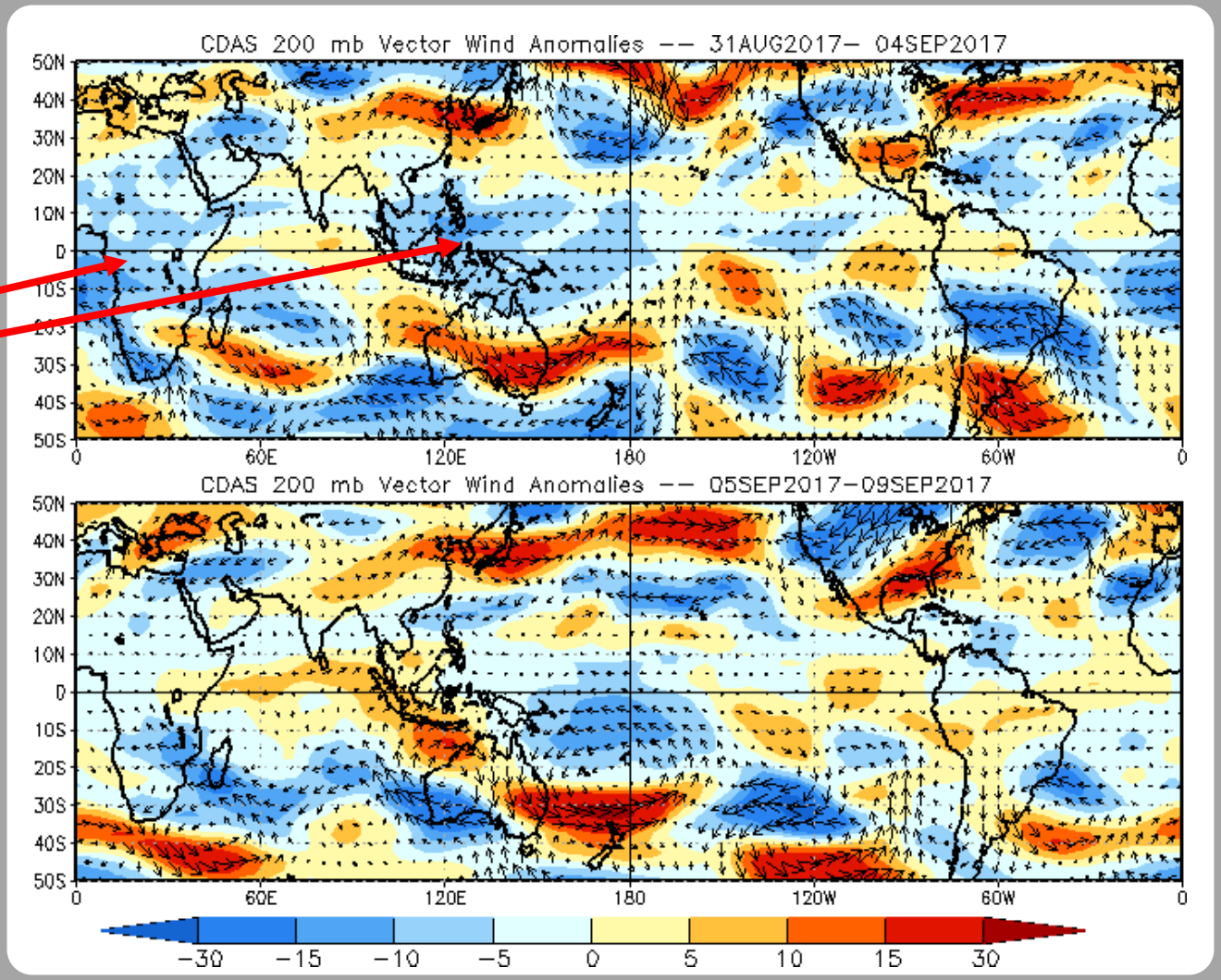
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Upper-level easterly zonal wind anomalies are depicted over tropical Africa, and the western Pacific/Maritime Continent.

Robust upper-level circulation anomalies continue over the wintertime (Southern) Hemisphere.



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

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

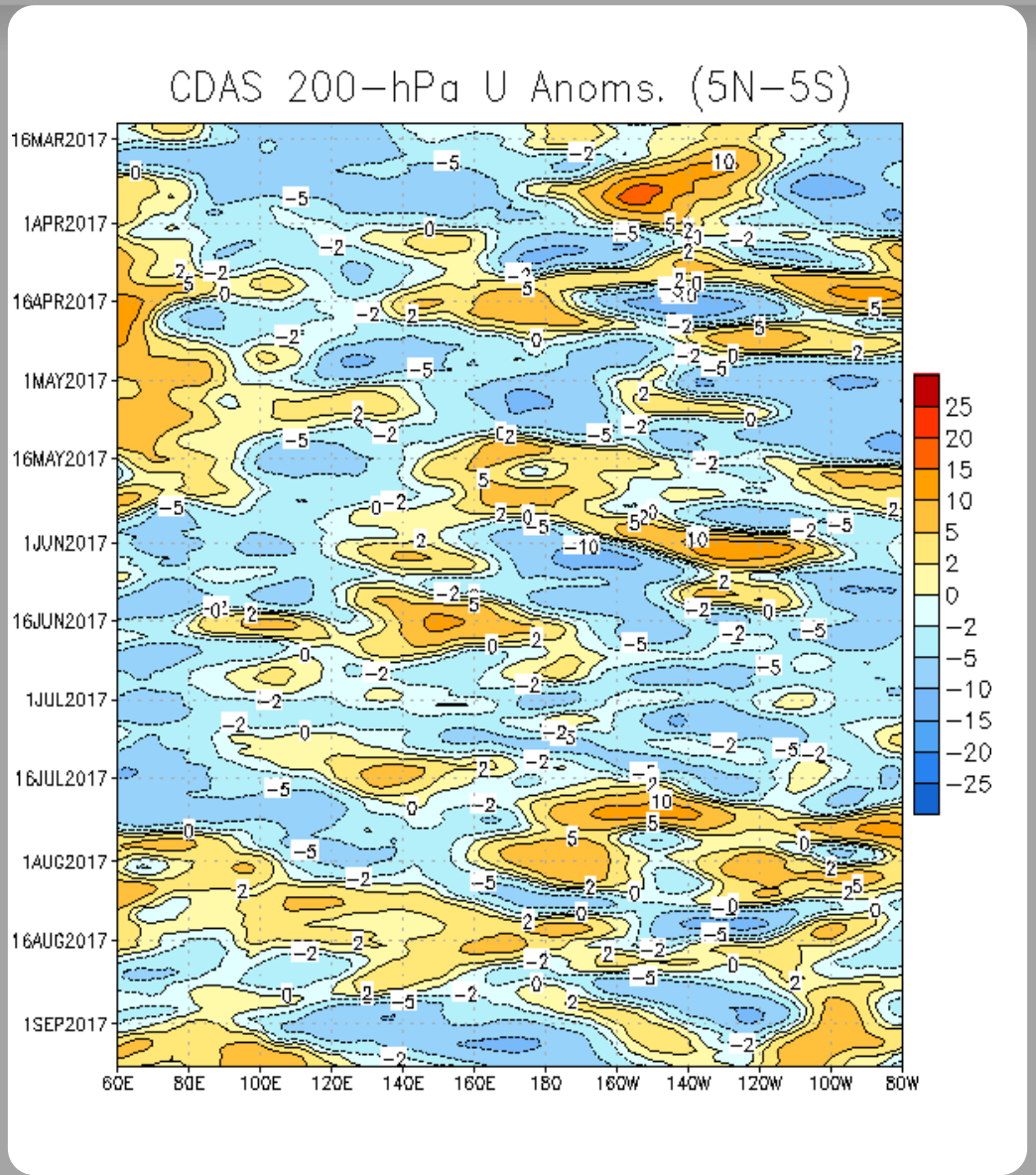
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

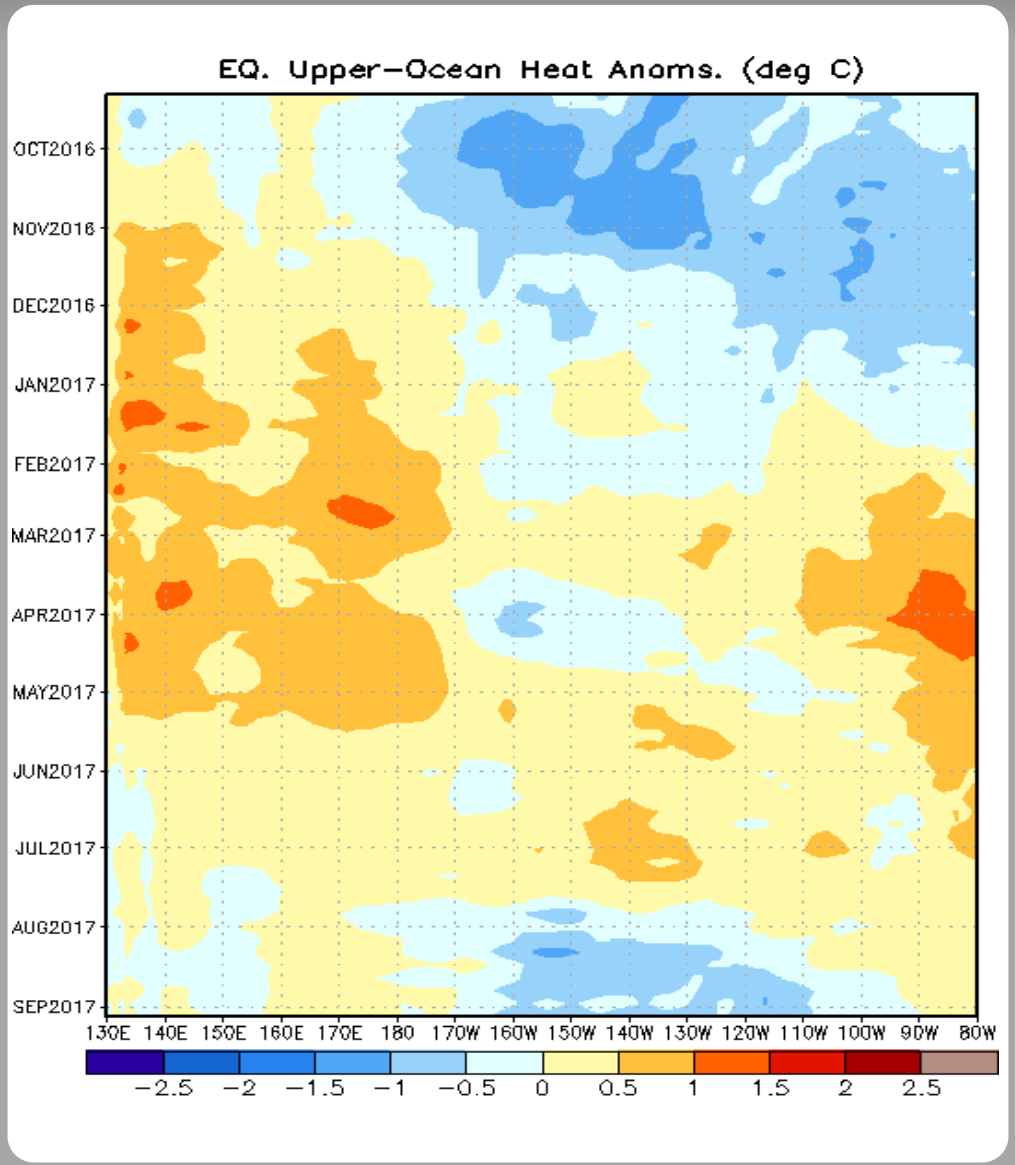
In early September, robust easterly anomalies prevail across the western and central North Pacific; westerly anomalies dominate most other portions of the global tropics.



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

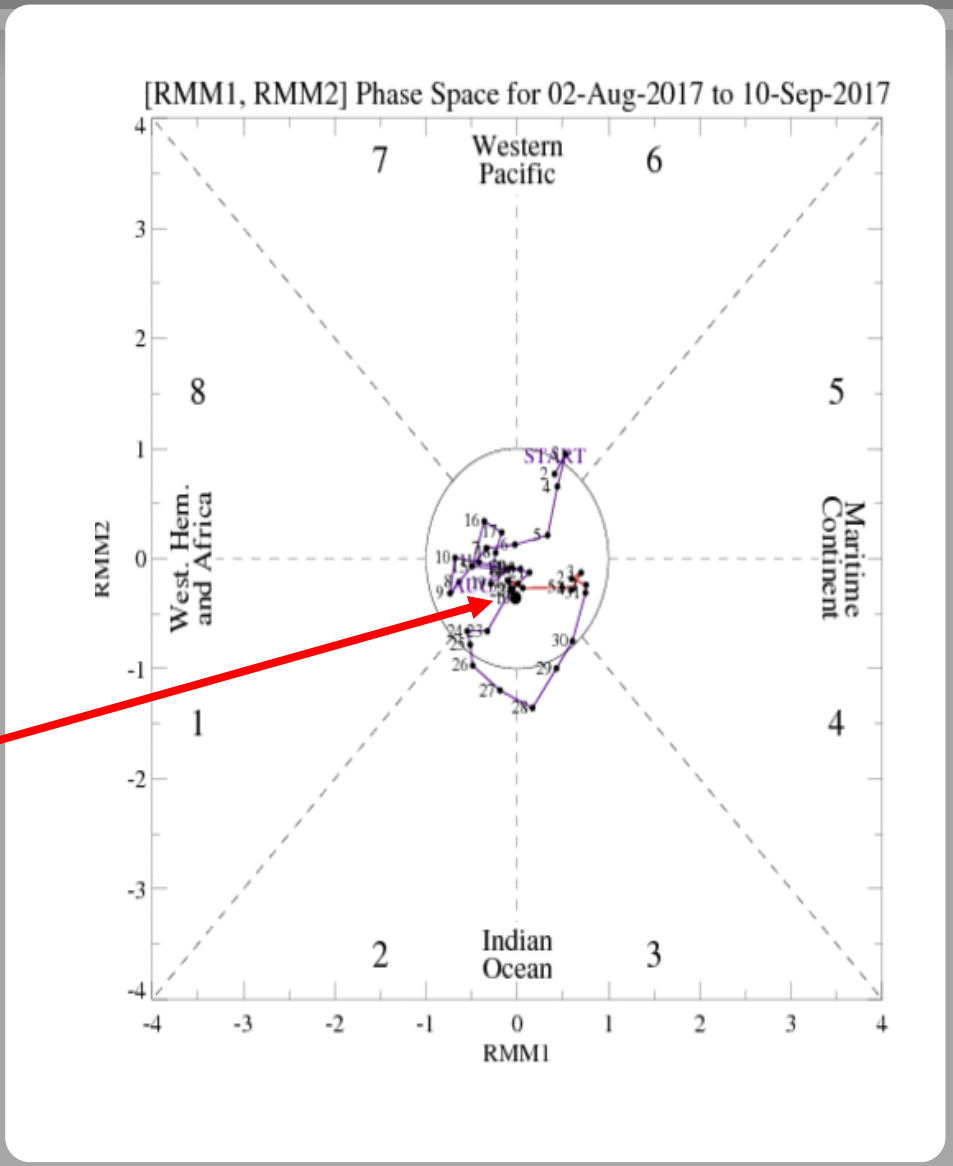
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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

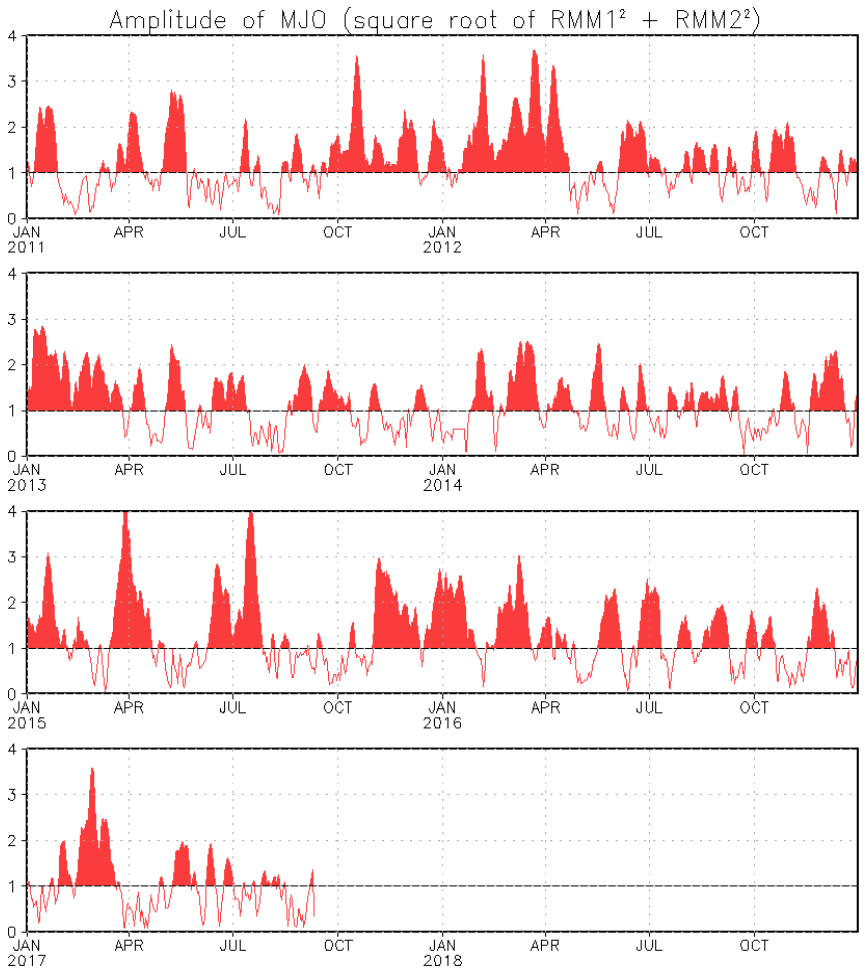


The MJO signal as monitored by the RMM index has been weak (well inside the unit circle) during the past ten days, with only a hint of a weak subseasonal signal located over the Indian Ocean.

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

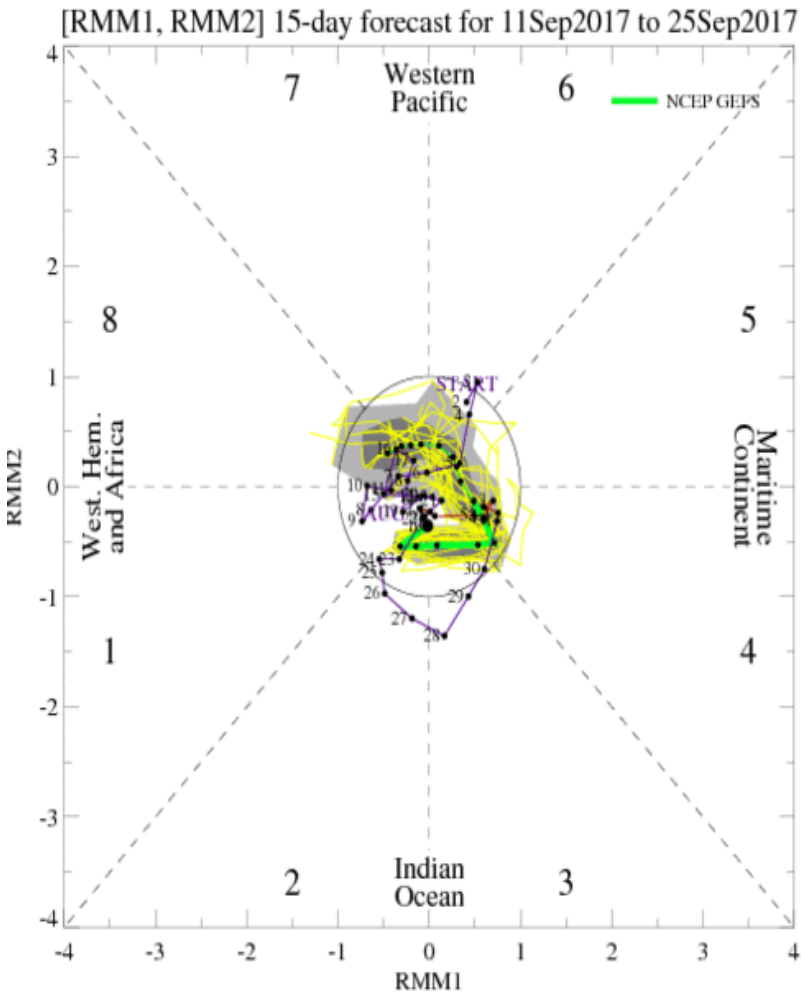
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

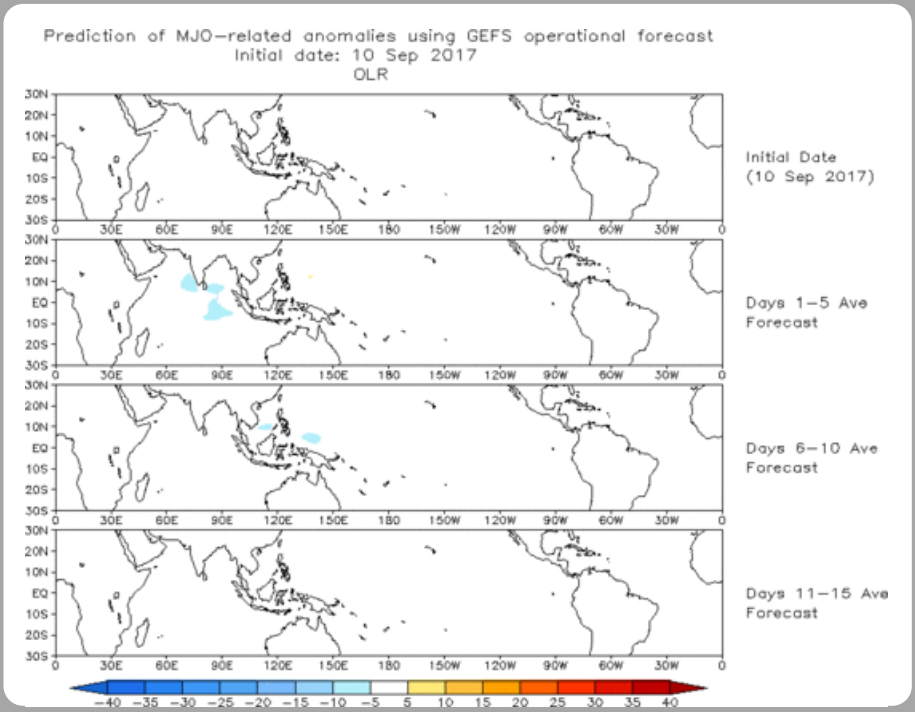
The GEFS consistently depicts an incoherent MJO signal over the next two weeks, with rapid propagation across the Indian Ocean.



Ensemble GFS (GEFS) MJO Forecast

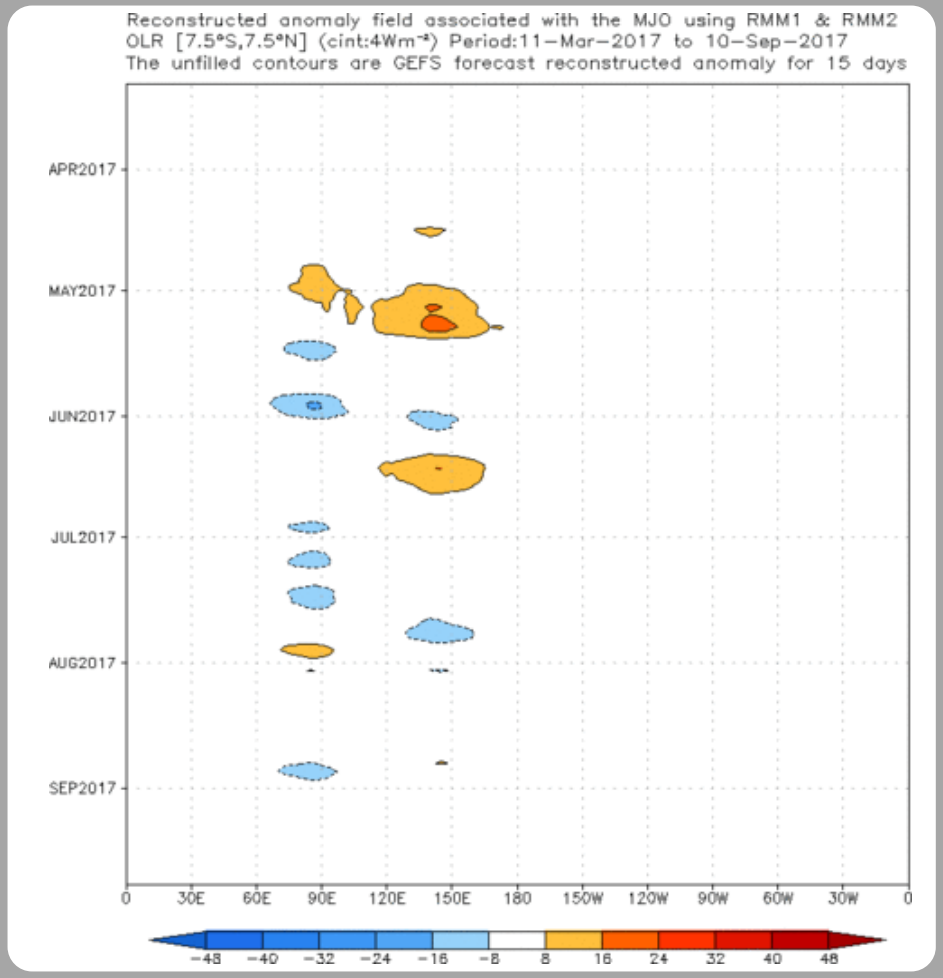
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS RMM-based OLR anomaly forecast indicates a weak signal over the Indian Ocean and Maritime Continent. No significant MJO signal is indicated.

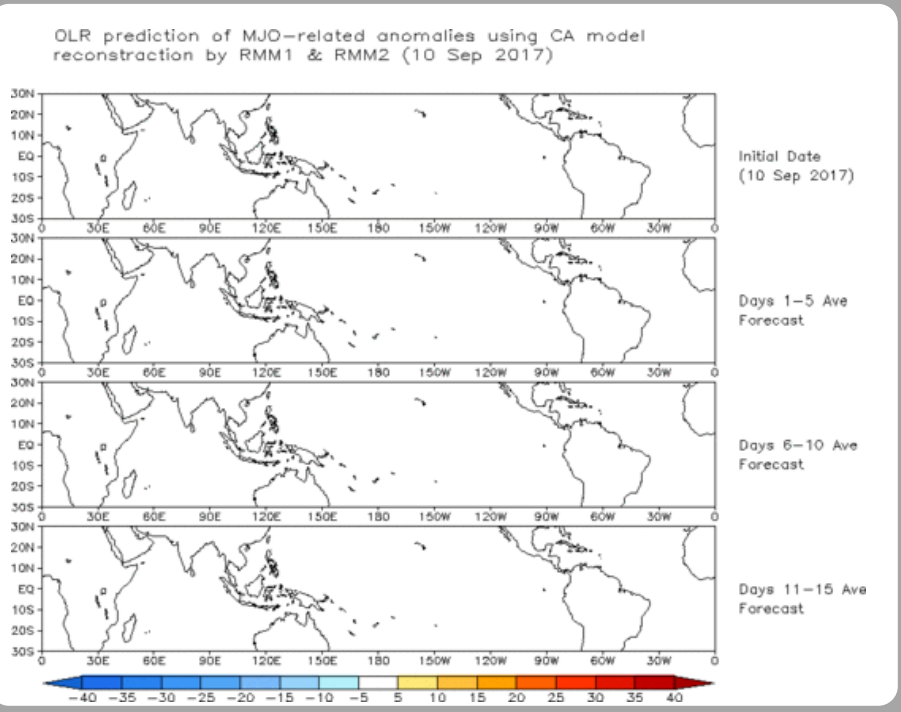
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

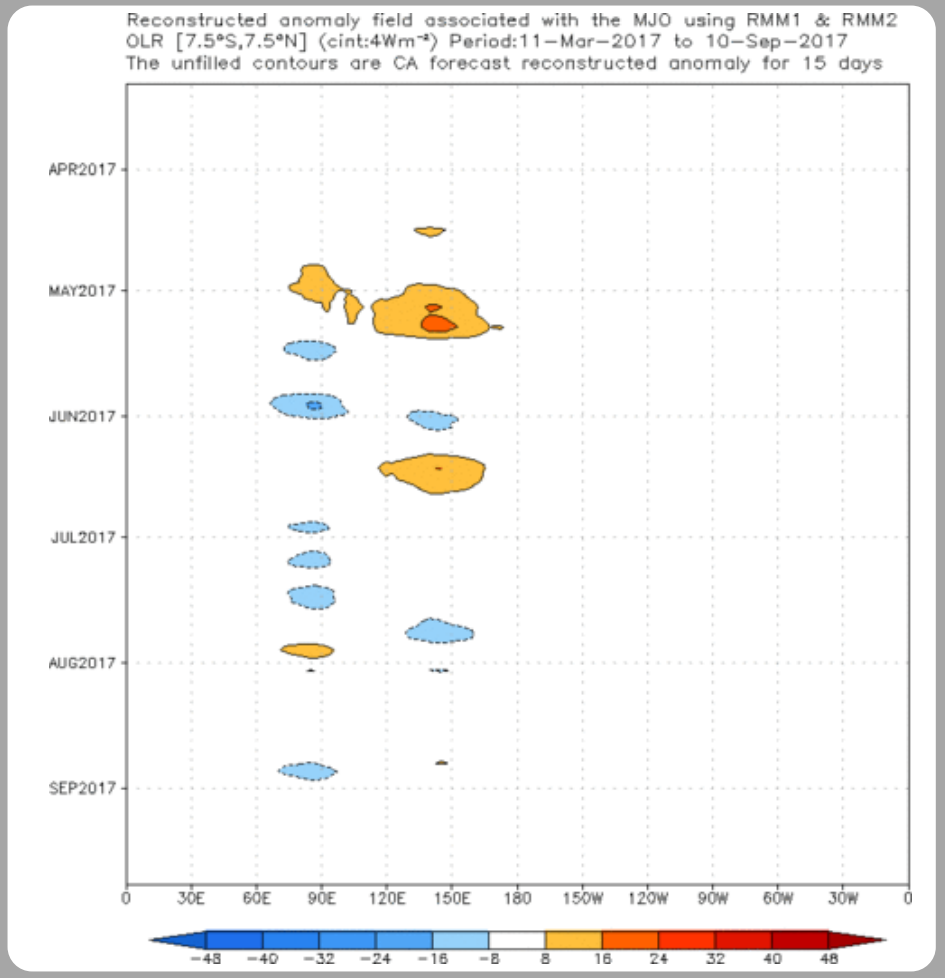
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



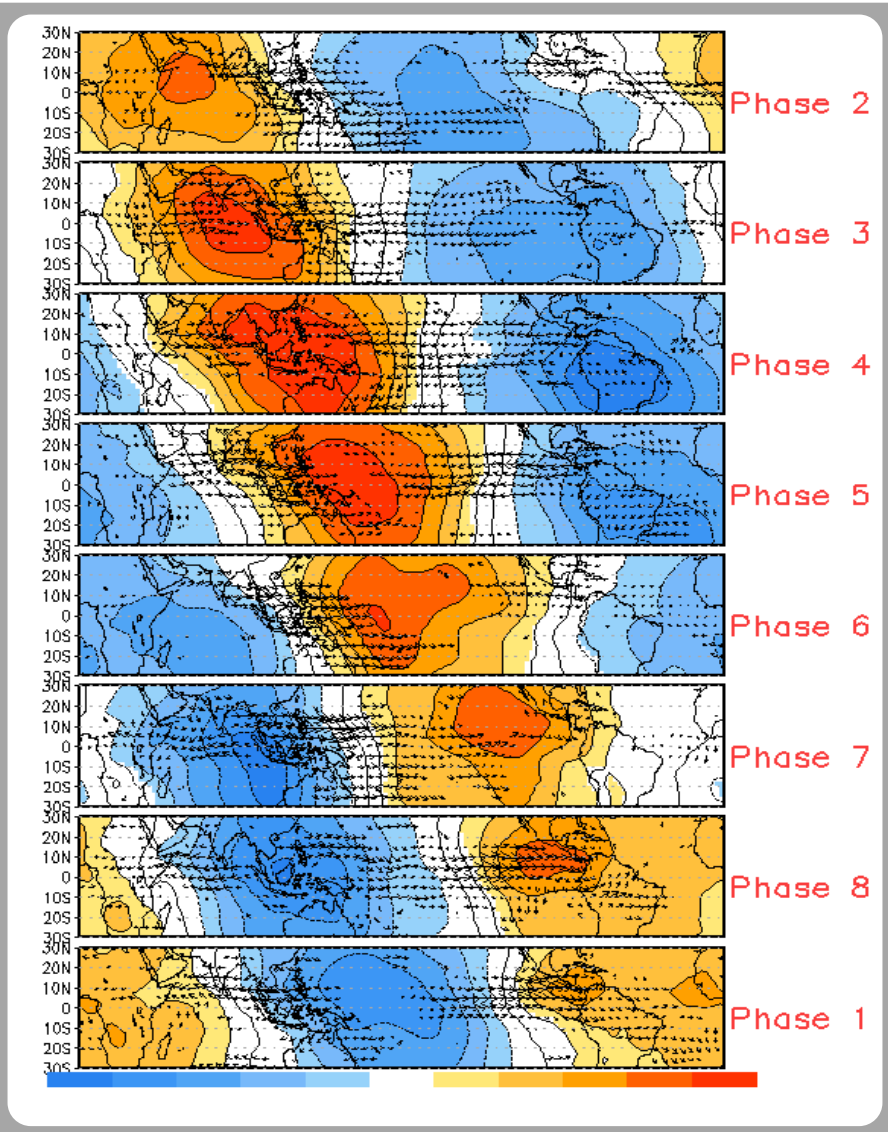
The constructed analog depicts no coherent signal.

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

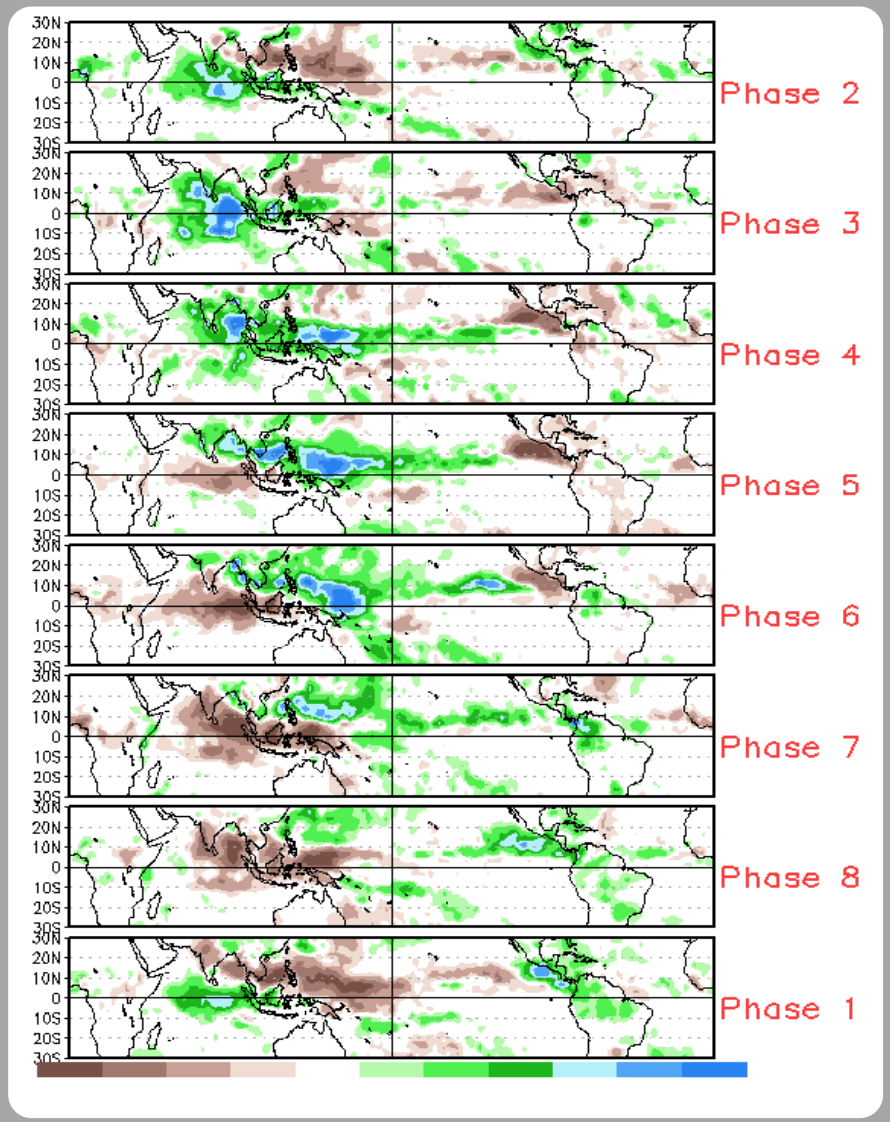


MJO Composites - Global Tropics

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



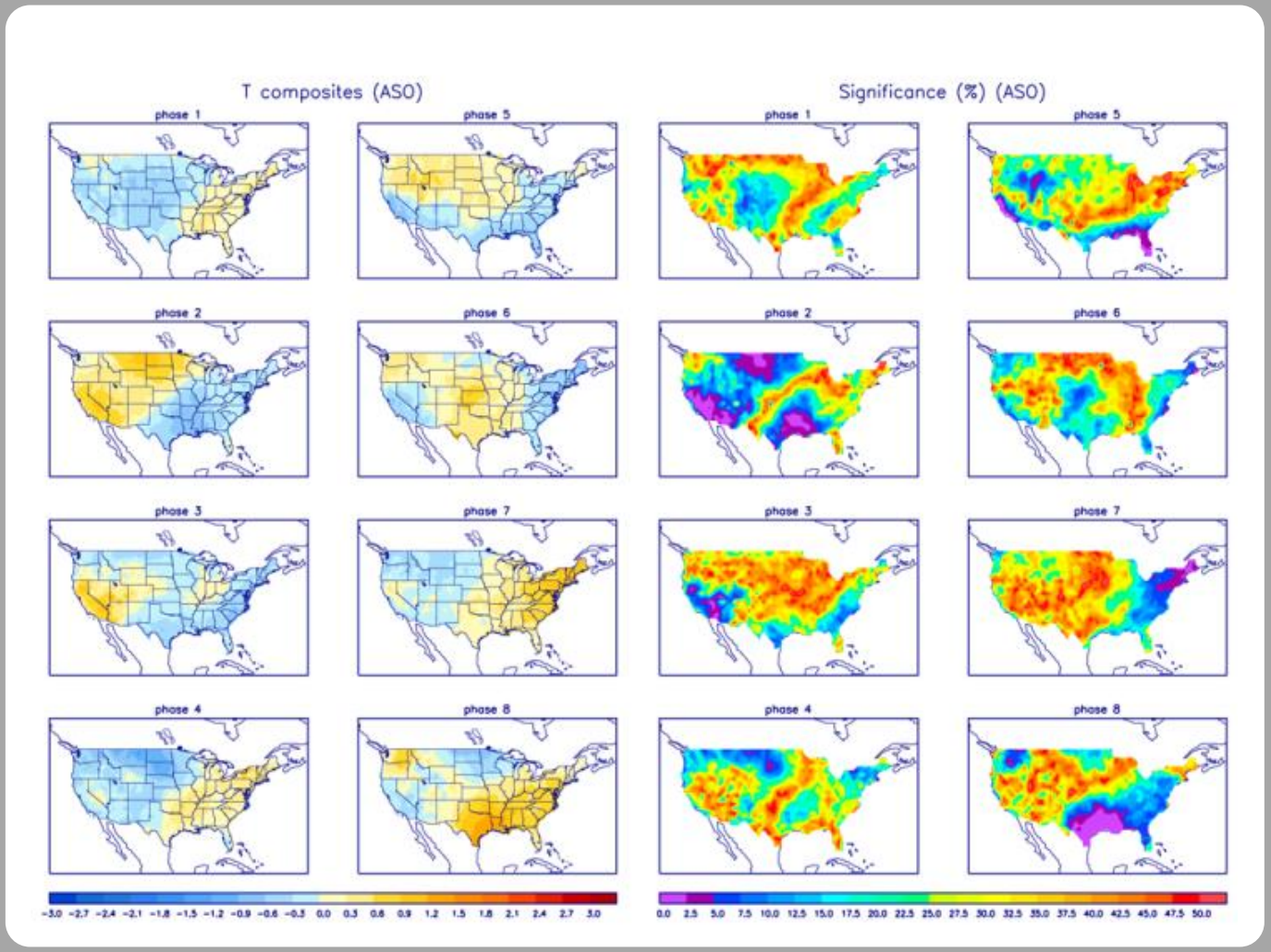
Precipitation Anomalies (May - Sep)



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.



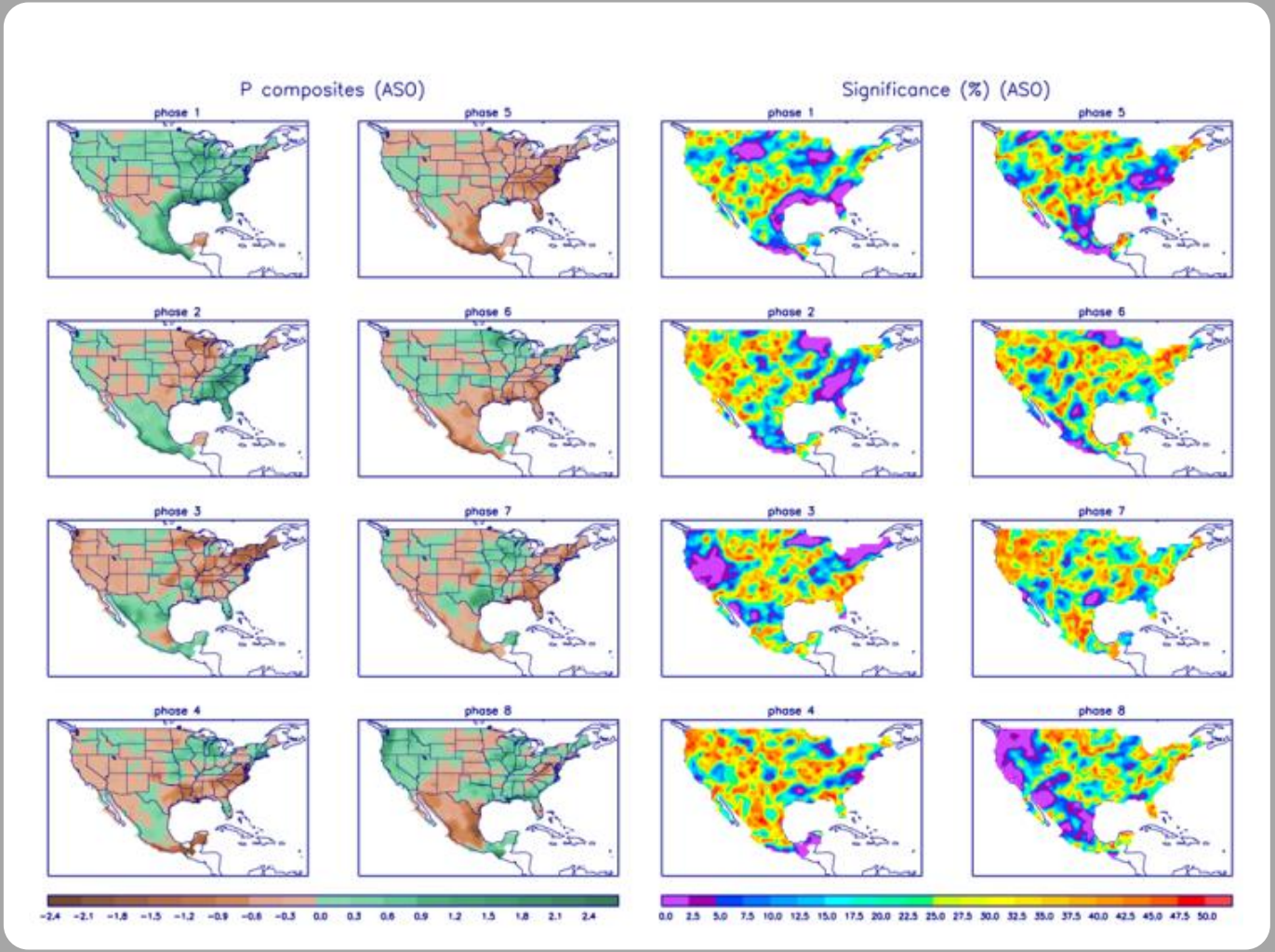
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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.



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