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

Update prepared by:
Climate Prediction Center / NCEP
28 August 2017

Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The MJO remained weak over the past 7-days, with limited signs of coherent intraseasonal tropical variability apparent throughout the globe.

- Dynamical model guidance is mixed, with models generally forecasting a weak eastward-moving signal from the Indian Ocean across much of the Pacific during the next two weeks. However, the CFS predicts a westward shift in the RMM index from phase 2 to phase 8 during the 2-week period, perhaps due in part to equatorial Rossby wave activity.

- Kelvin wave activity is more likely, than the 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.

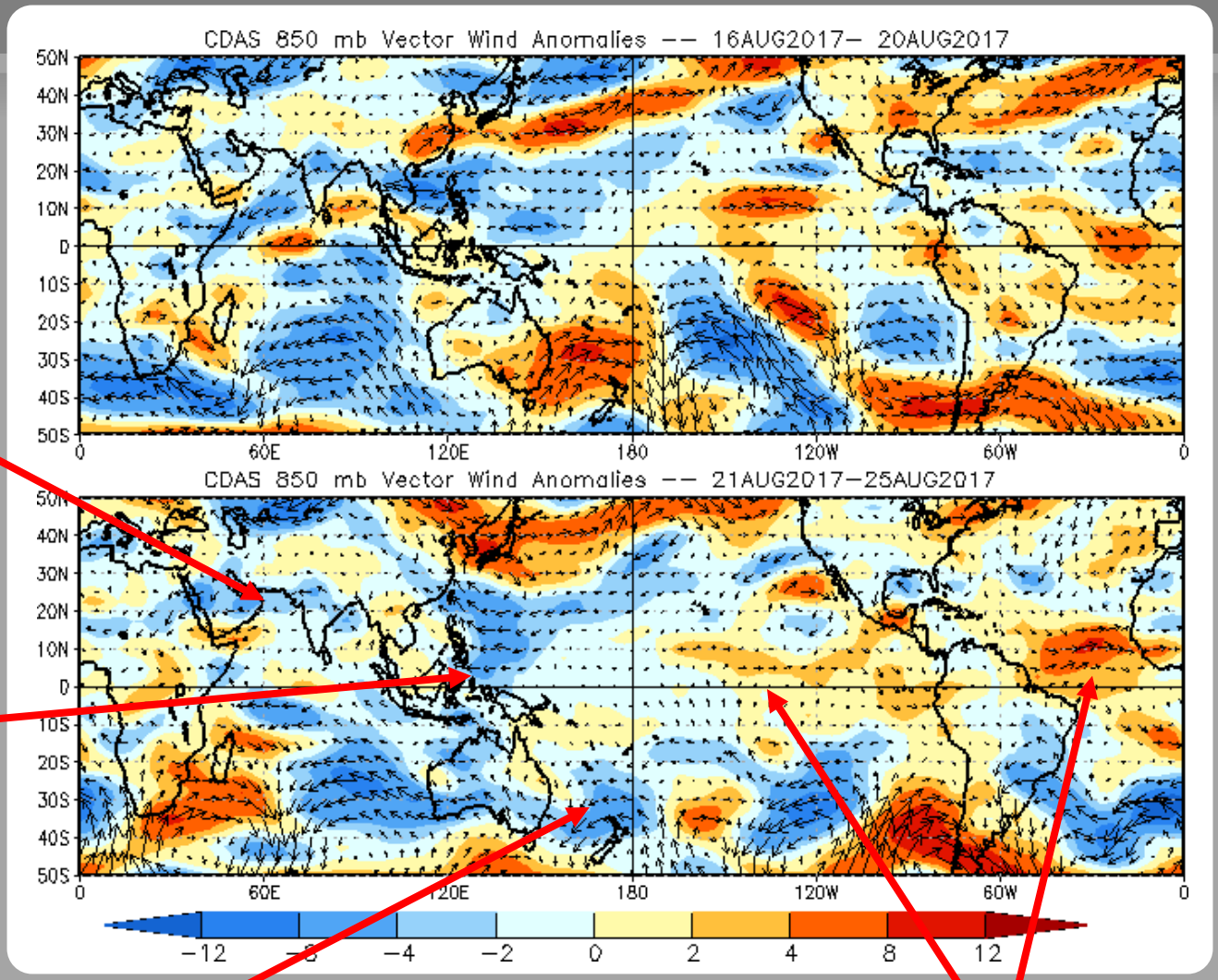
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



The pronounced easterly anomalies previously noted over the Arabian Sea weakened substantially this week.

Easterly anomalies persisted over the Western Pacific and built in over the Maritime Continent

Strong westerlies over the Tasman Sea region two weeks ago switched to easterlies this past week as the pattern deamplified.

Westerly anomalies generally prevailed from about 150W to the Prime Meridian, near and along the Equator.

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

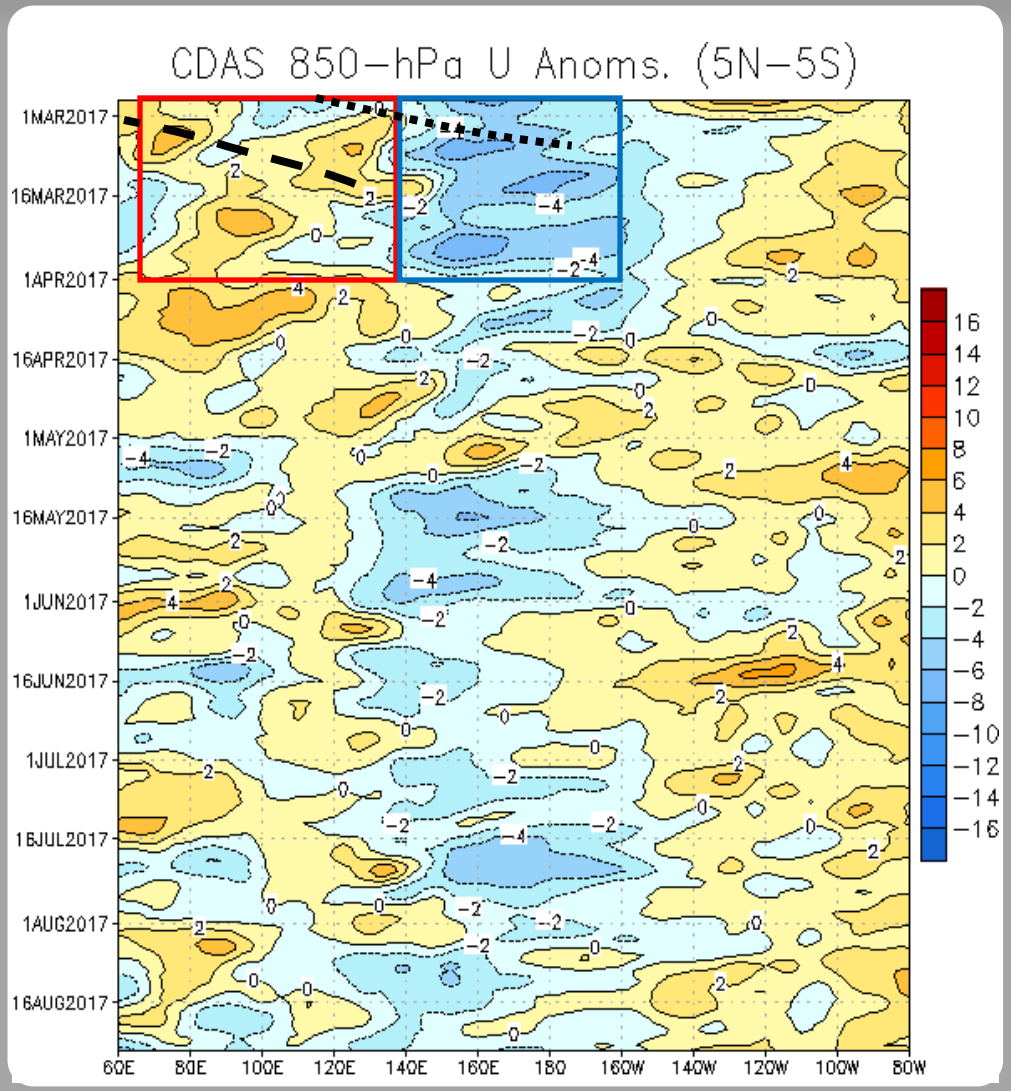
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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.

Equatorial flow was fairly close to climatology during June. During July, a slight eastward shift in the low-frequency pattern is noted, related to intraseasonal variability.

Recently, easterly anomalies have developed 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

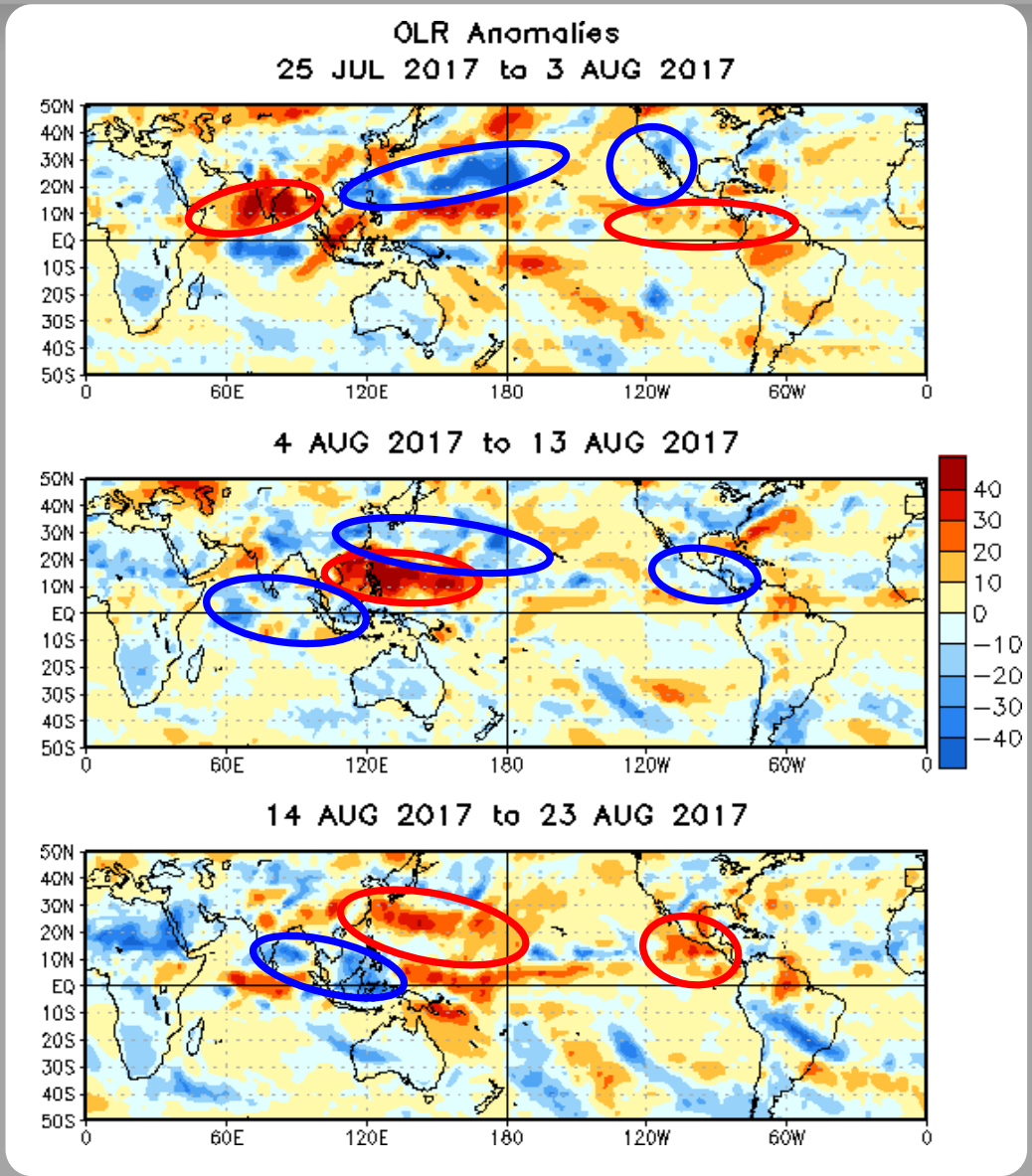
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late July and early August, anomalous dryness was observed from the Arabian Sea through the western Pacific, while wet conditions farther north were associated with tropical cyclone (TC) activity. TC activity in the East Pacific experienced a lull.

TC activity resumed in the East Pacific with Jova and Kenneth, while anomalous dryness extended from the South China Sea through the Date Line. Anomalously wet conditions returned to southern India and the Maritime Continent.

Wetter than average conditions lingered over the Maritime Continent and India, while convection over the Western Pacific waned. Drier conditions developed over Central America while convection increased over the Caribbean and Atlantic.



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

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

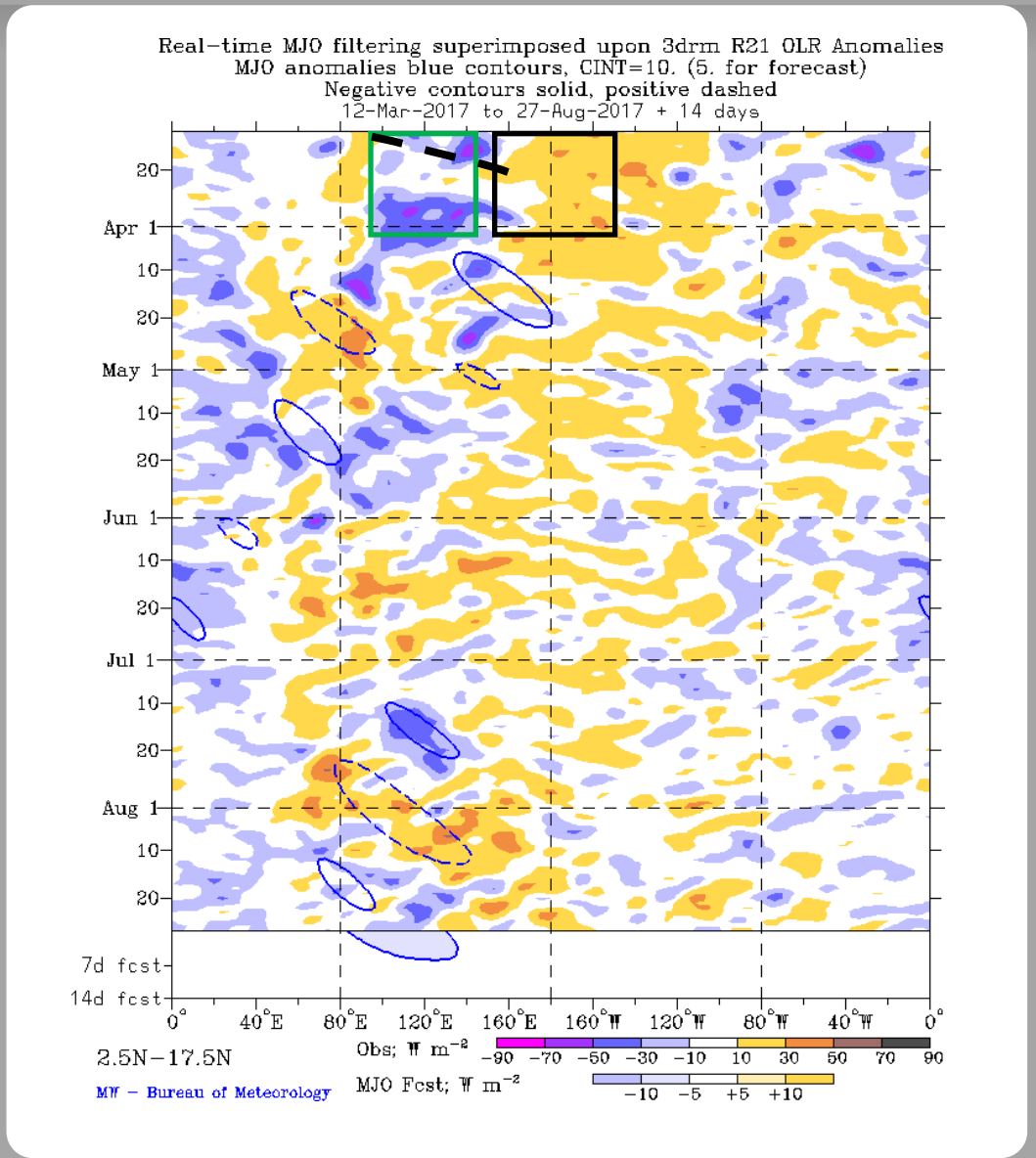
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

A low frequency state favoring enhanced convection over the eastern IO and the Maritime Continent was evident from July 2016 through 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.

More recently, 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

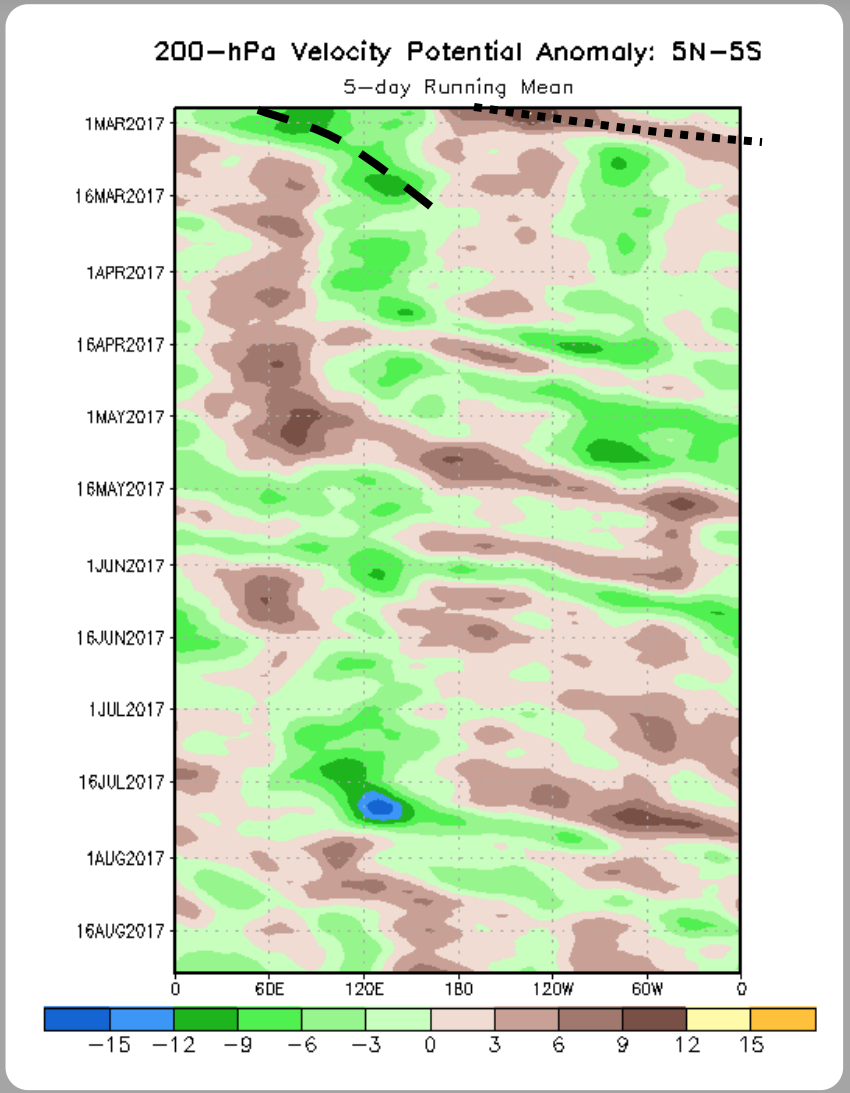
Negative anomalies (green shading) indicate favorable conditions for precipitation

A signal emerged over the Maritime Continent and continued propagating through early March, creating alternating periods of constructive and destructive interference with the base state.

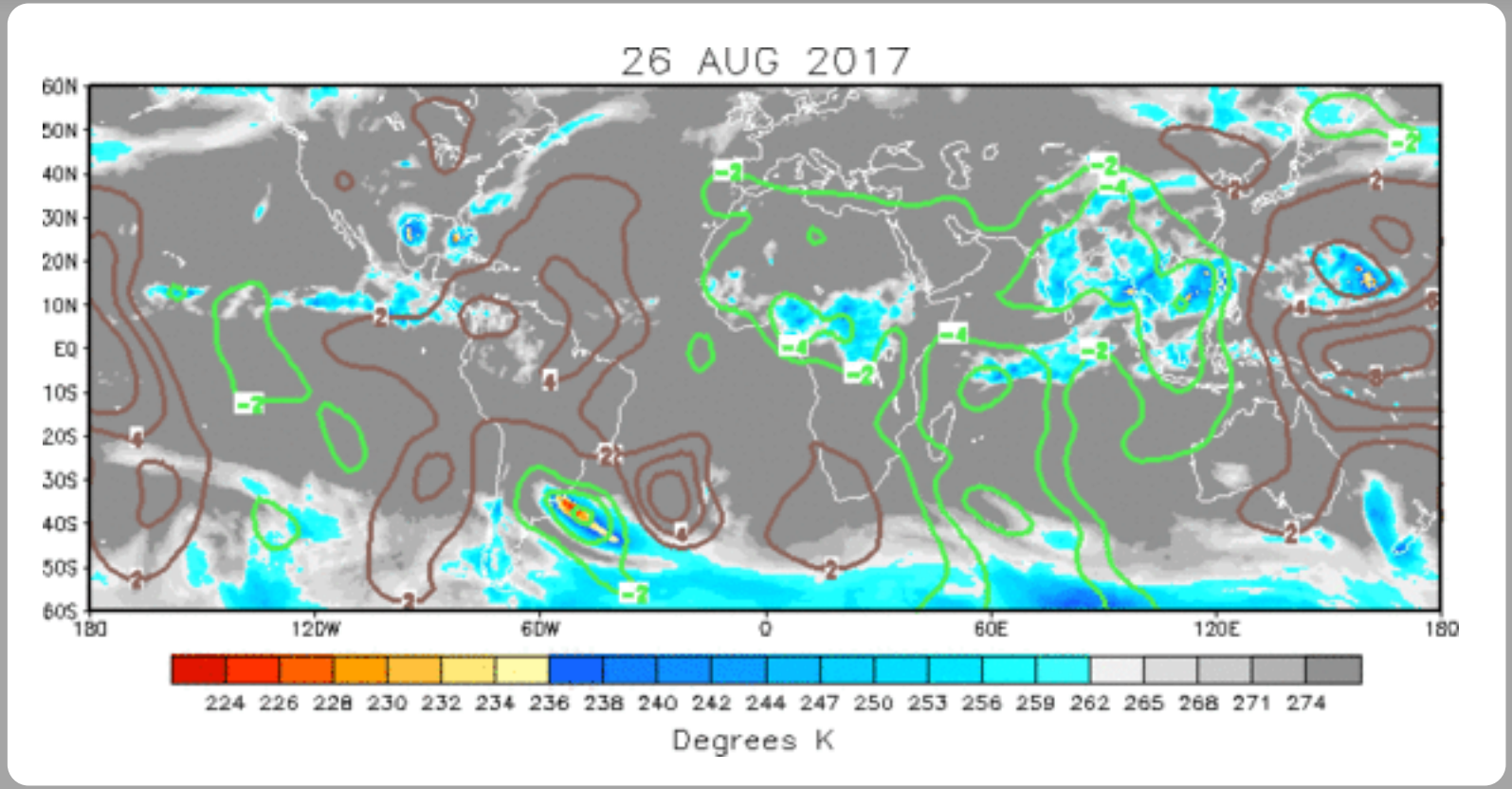
During March, a low frequency signal favoring enhanced (suppressed) convection over the Maritime Continent (Indian Ocean) became the primary component of the anomaly field.

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.

Recently, suppressed convection overspread the West Pacific, with weakly enhanced convection (Kelvin wave-related) over the Maritime Continent and Africa.



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



Widespread enhanced convection is depicted from Africa eastward through Asia, and suppressed convection is noted over much of the western and central Pacific, the Americas, and the Atlantic.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

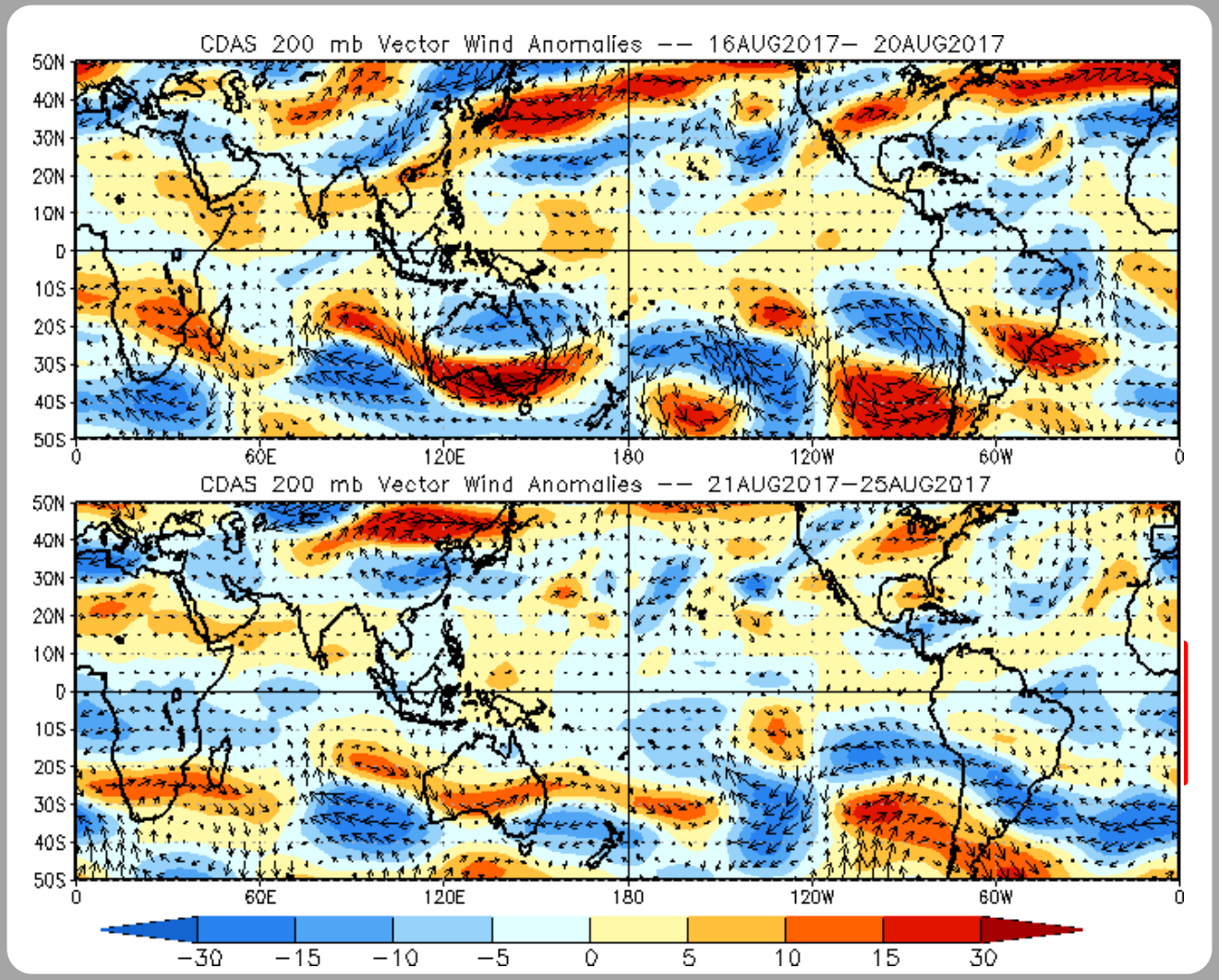
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Anomalous flow over both hemispheres weakened significantly this past week, though the winter (Southern) hemisphere remains fairly energetic.

Elsewhere, anomalous flow in the tropics was fairly weak.

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

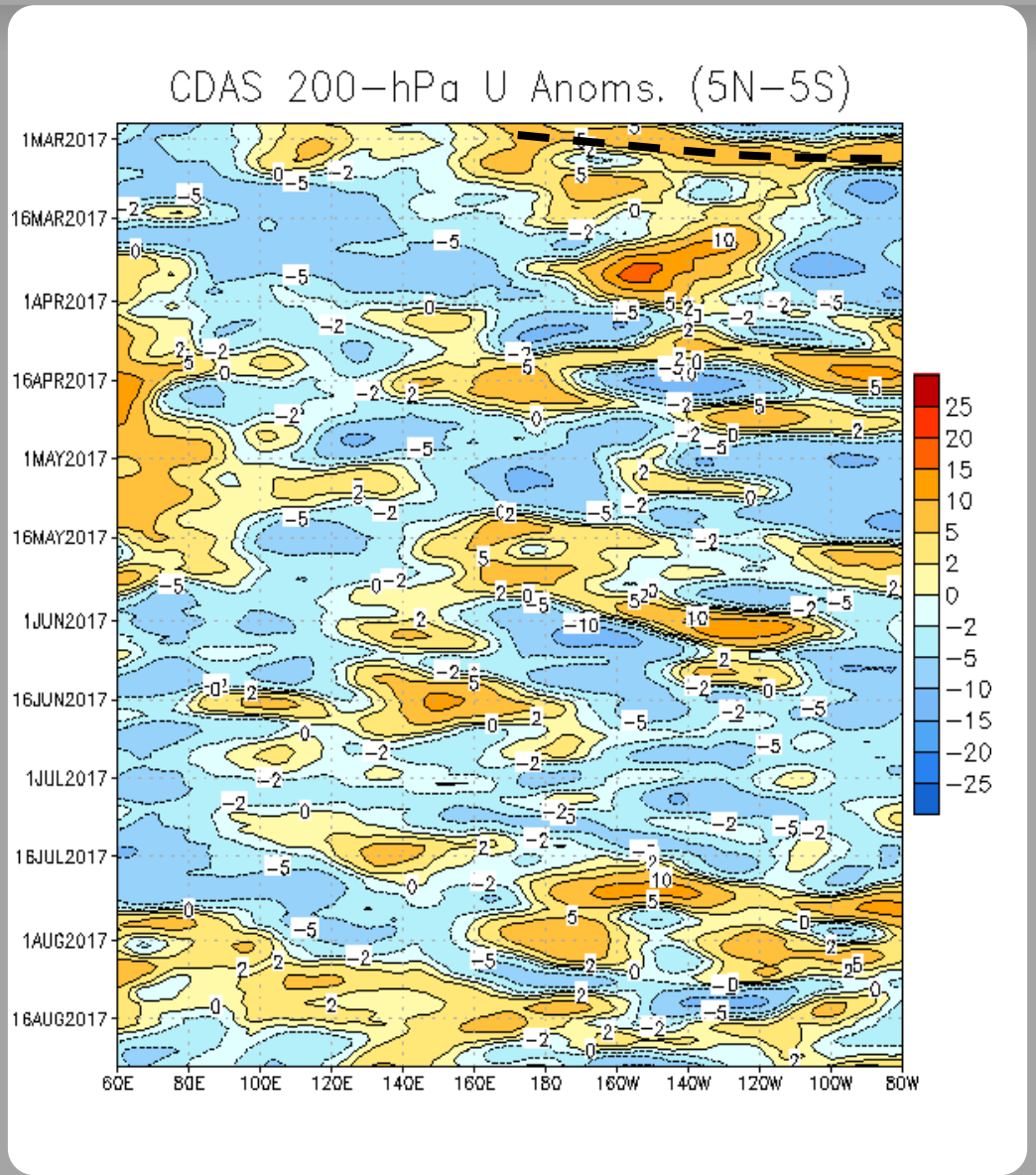
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

Easterly anomalies returned to the East Pacific during late April and persisted with some period 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.

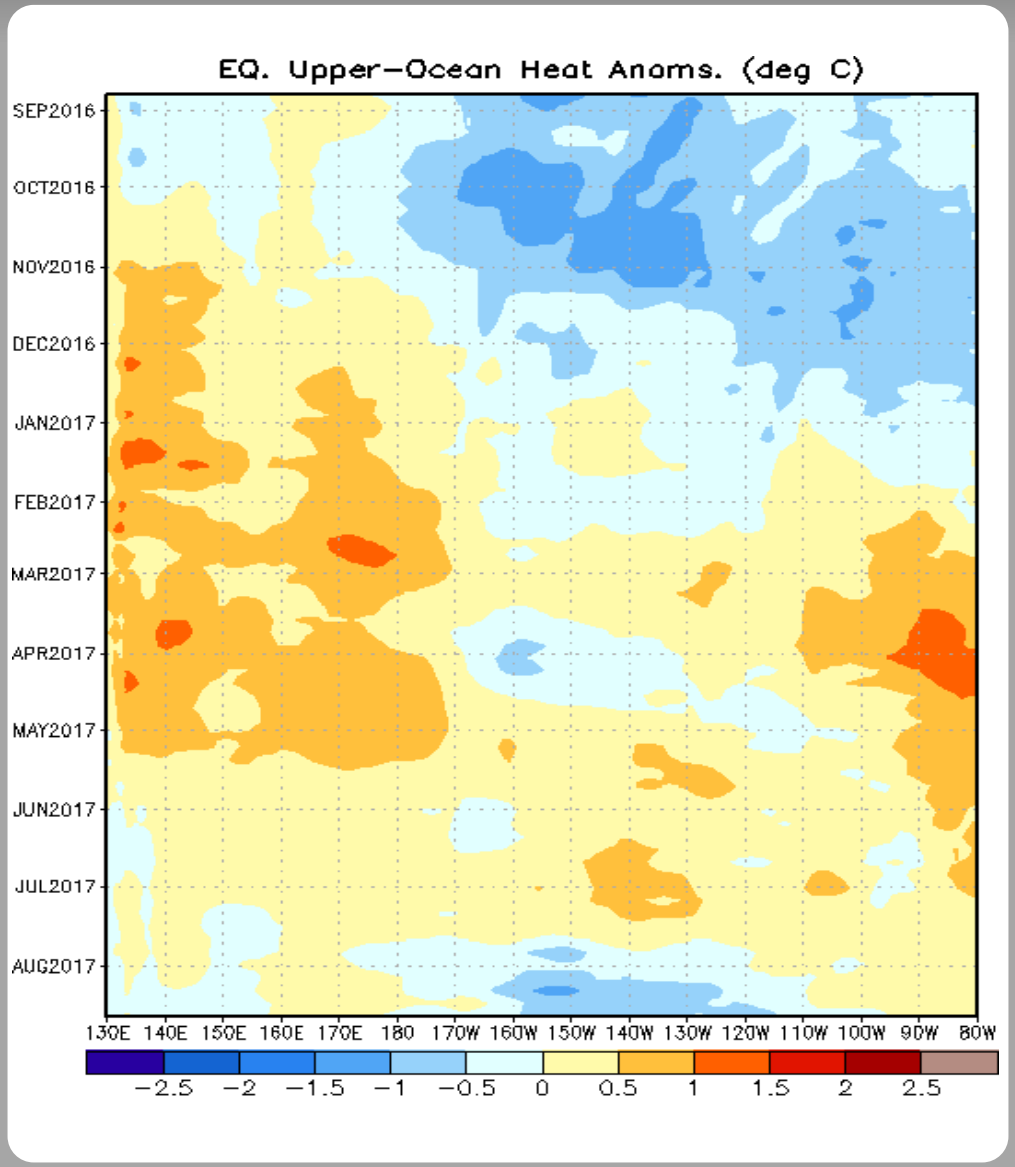
Starting in July, the anomaly patterns have been continually moving eastward. Most recently, westerly (easterly) anomalies are depicted over the eastern Maritime Continent and western Pacific (central and eastern Pacific). Smaller spatial scale anomalies (associated with higher-frequency variability) are also evident.



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

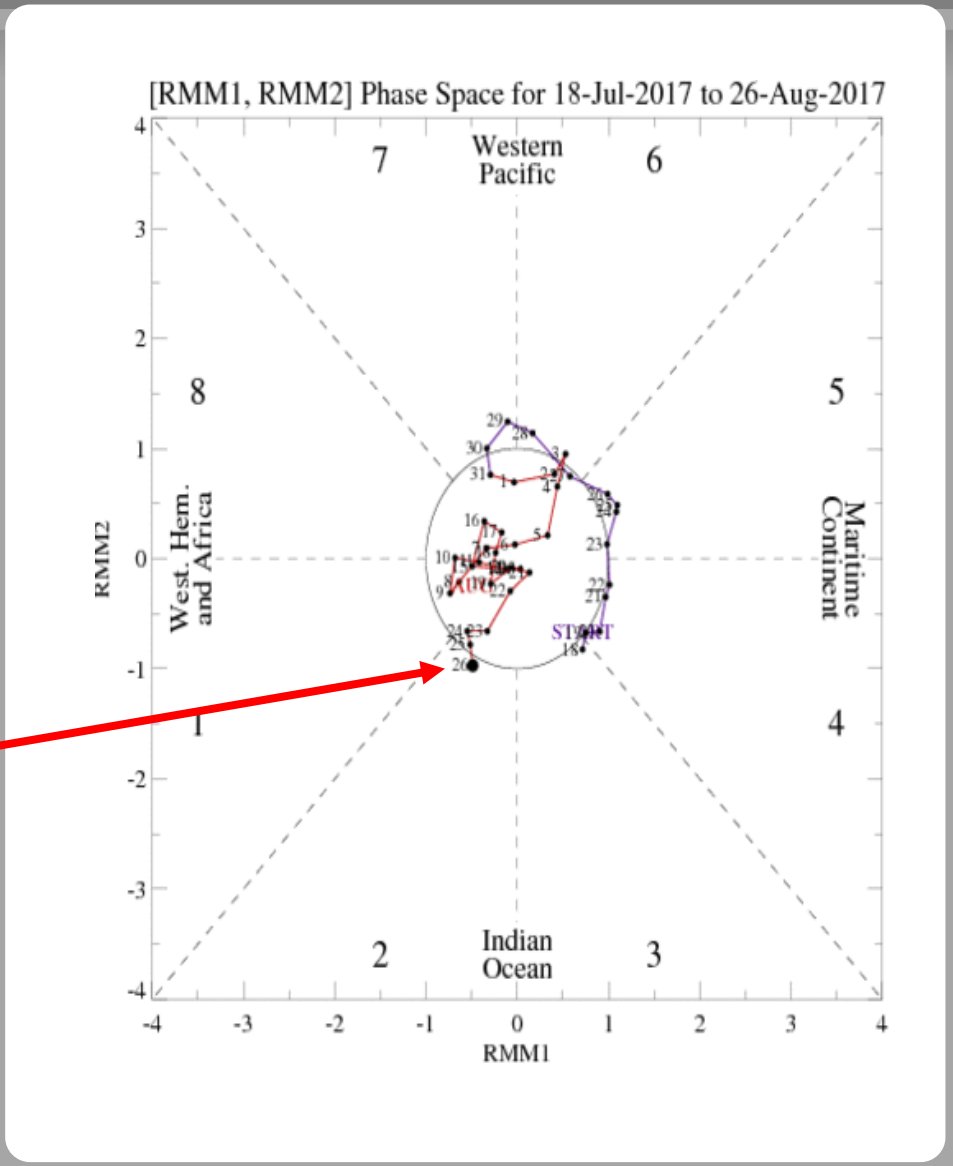
The triangular areas indicate the location of the enhanced phase of the MJO

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

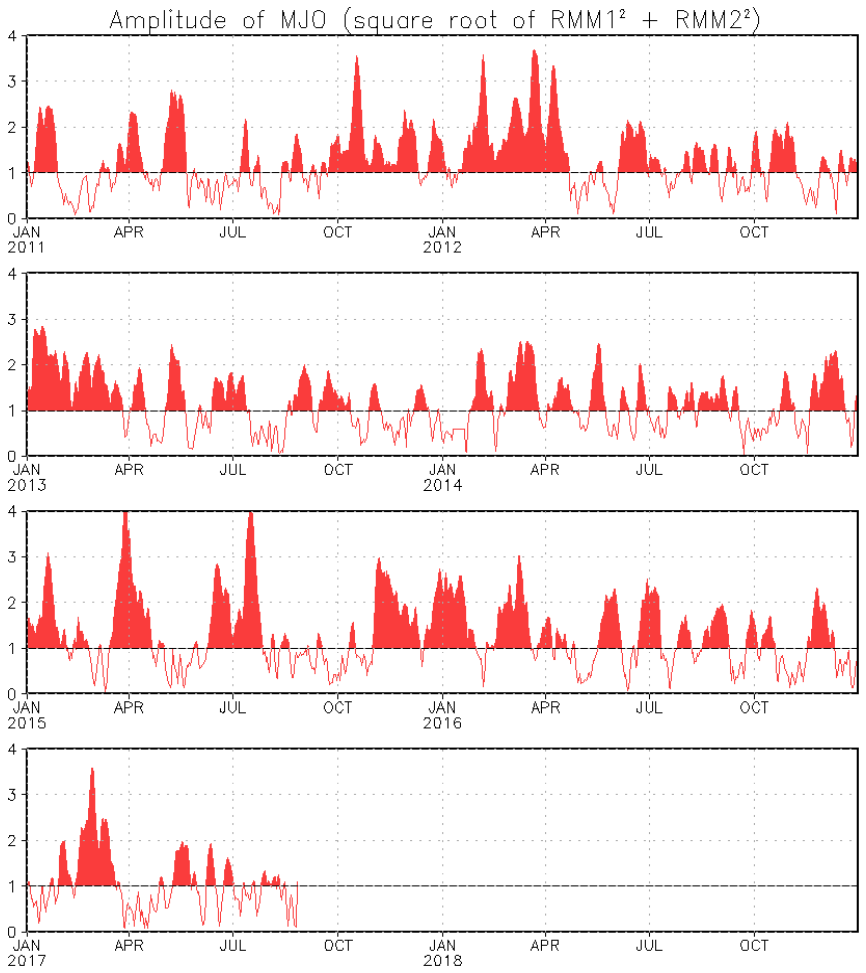
The MJO signal remained weak during the past 7 days, with the possible emergence of a weak intraseasonal signal over the western Indian Ocean.



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

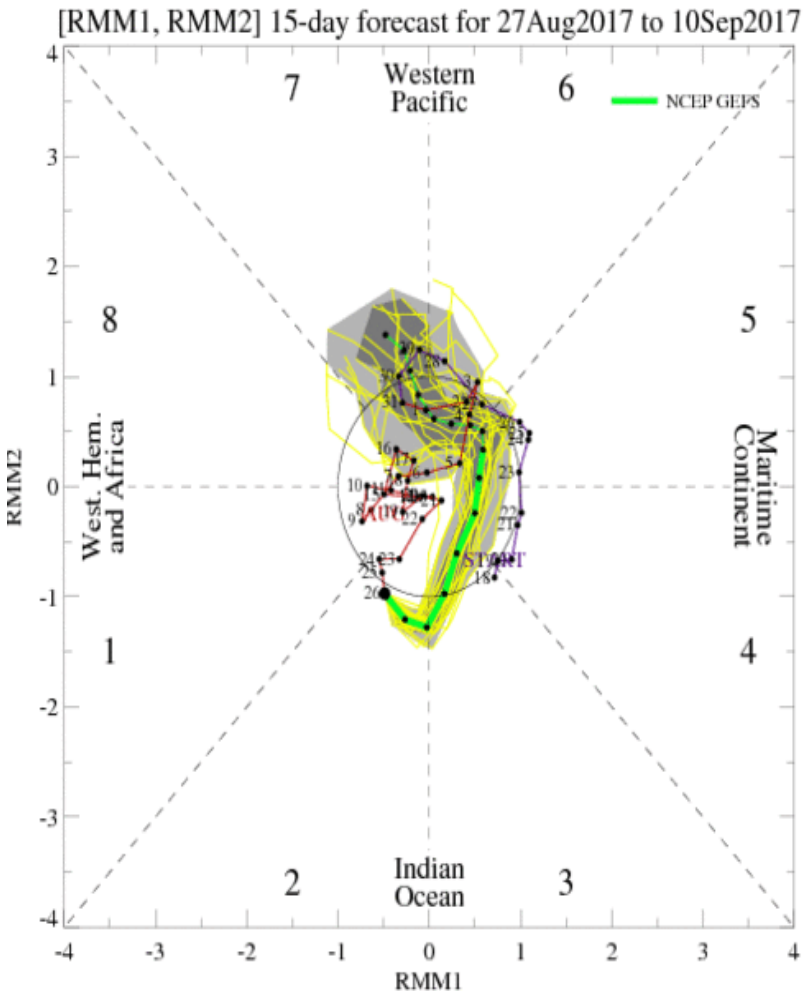
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

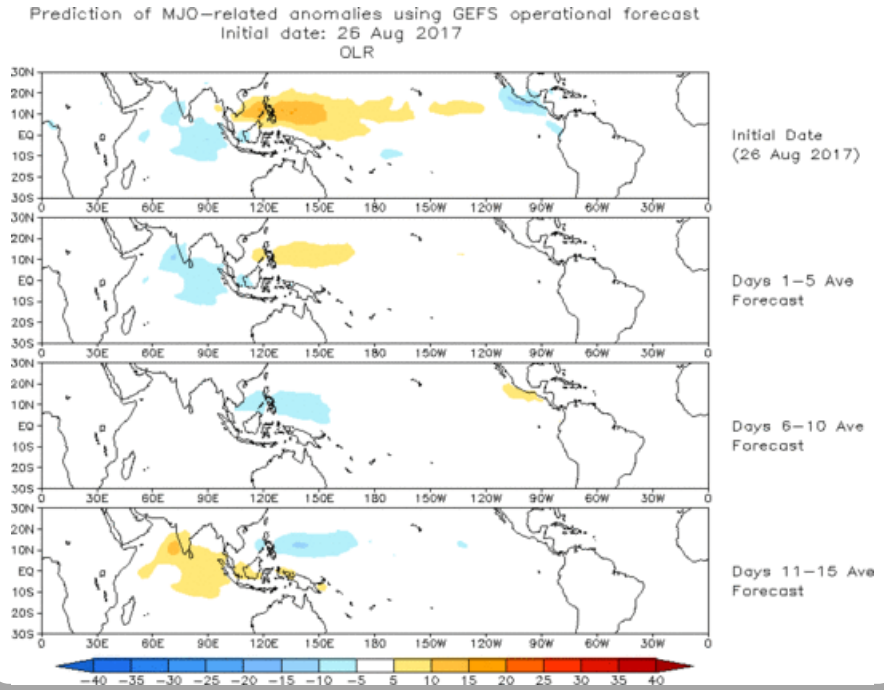
The GEFS consistently depicts an emerging intraseasonal signal over the western Indian Ocean early in Week-1 that decays as it propagates rapidly eastward across the eastern Indian Ocean and the Maritime Continent in Week-2.
The signal is likely related to Kelvin wave activity.



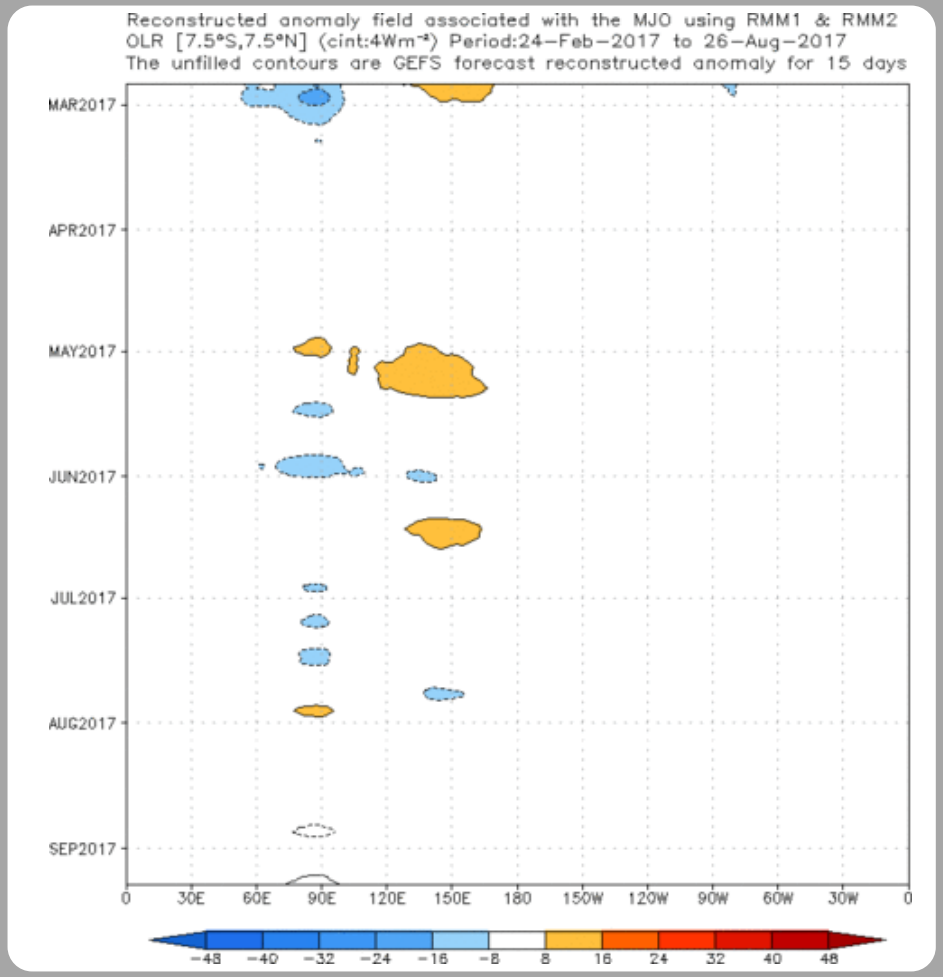
Ensemble GFS (GEFS) MJO Forecast

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

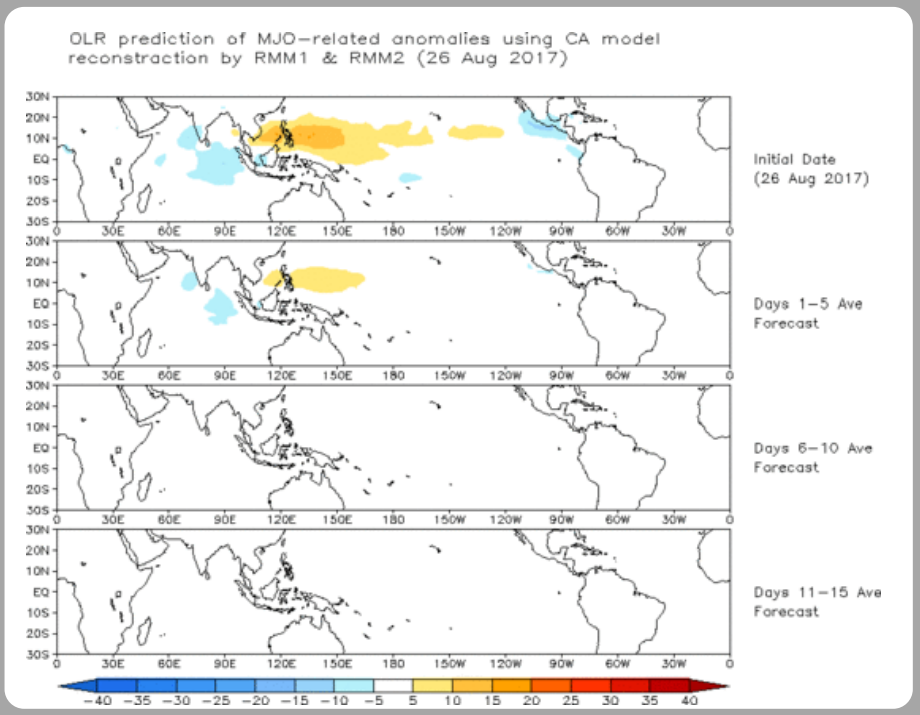


The GEFS RMM-based OLR anomaly forecast shows a weak signal emerging over the Indian Ocean during the next 5 days, which then propagates rapidly eastward and remains weak.

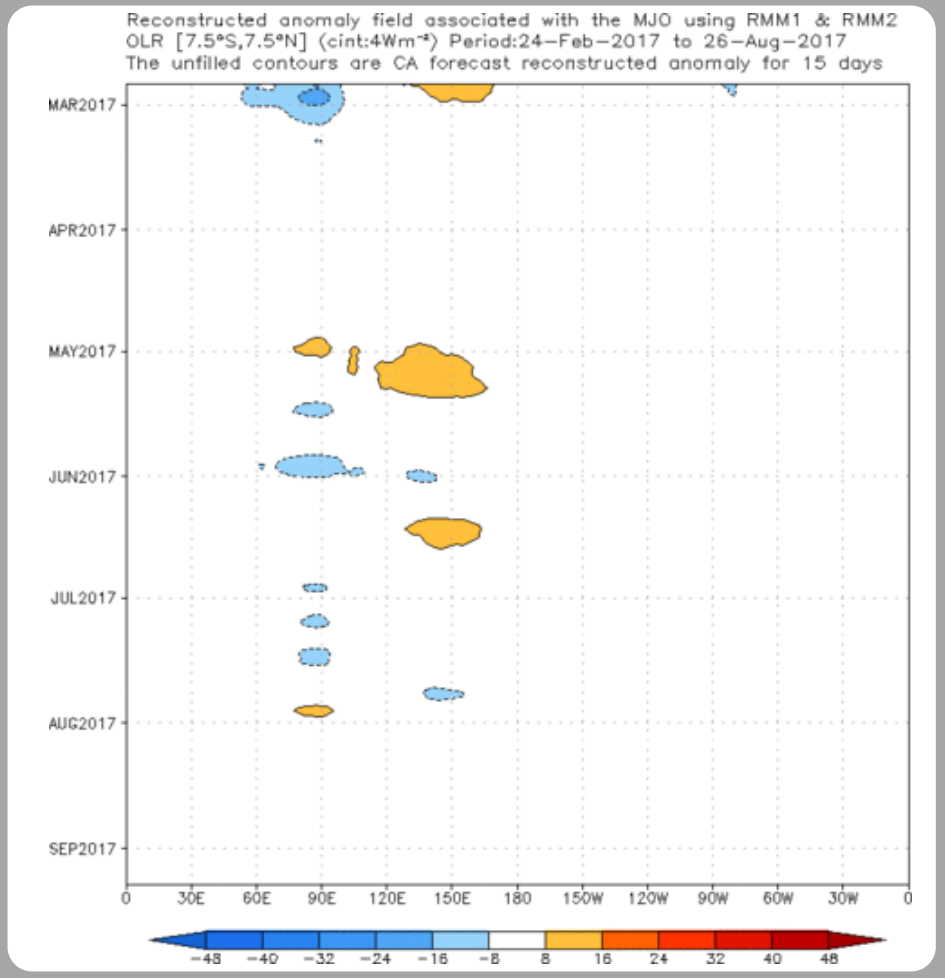
Constructed Analog (CA) MJO Forecast

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



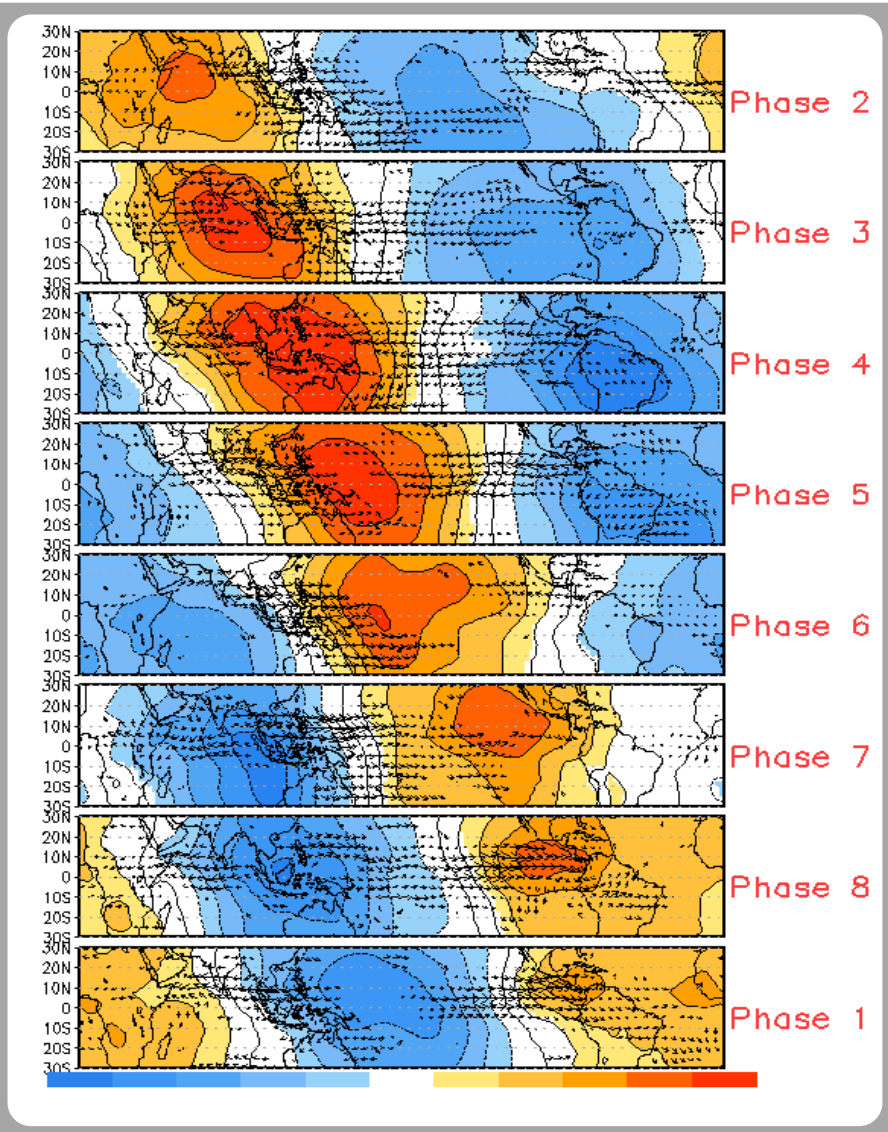
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



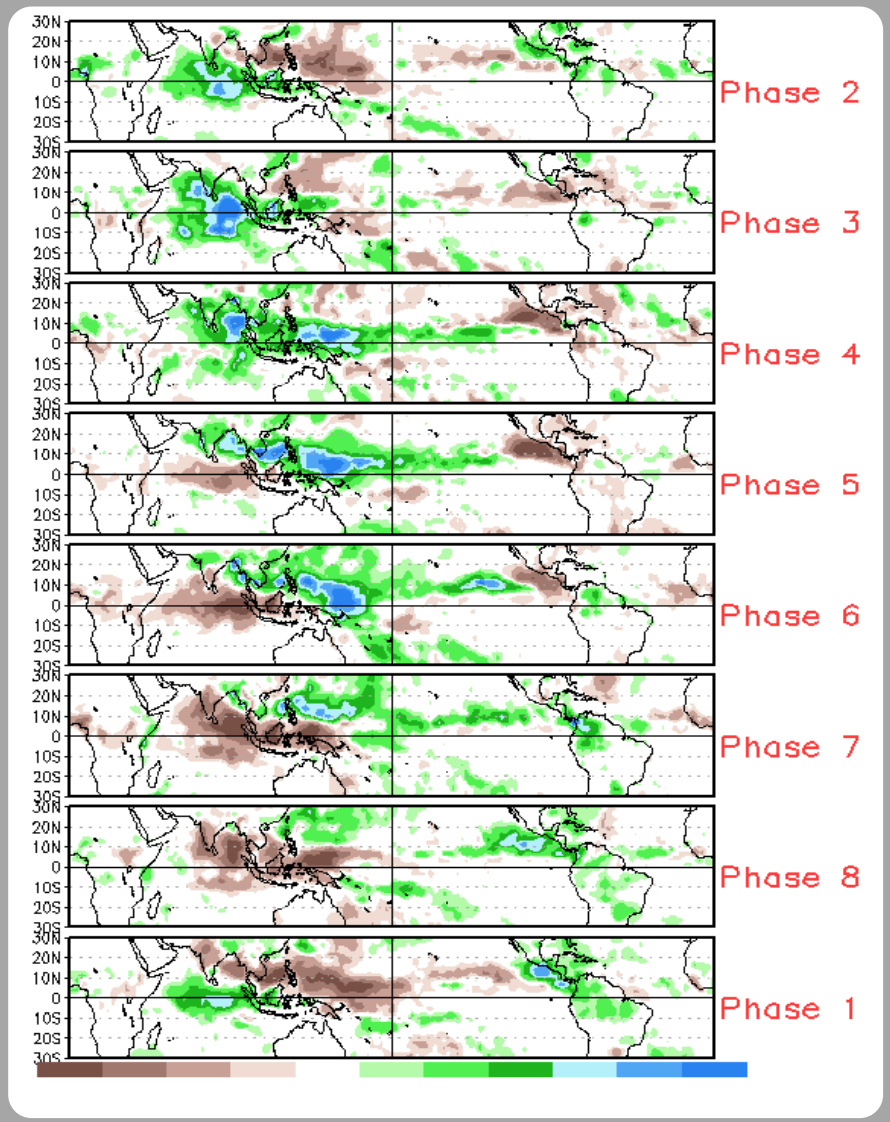
The constructed analog depicts little if any MJO-based signal.

MJO Composites - Global Tropics

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



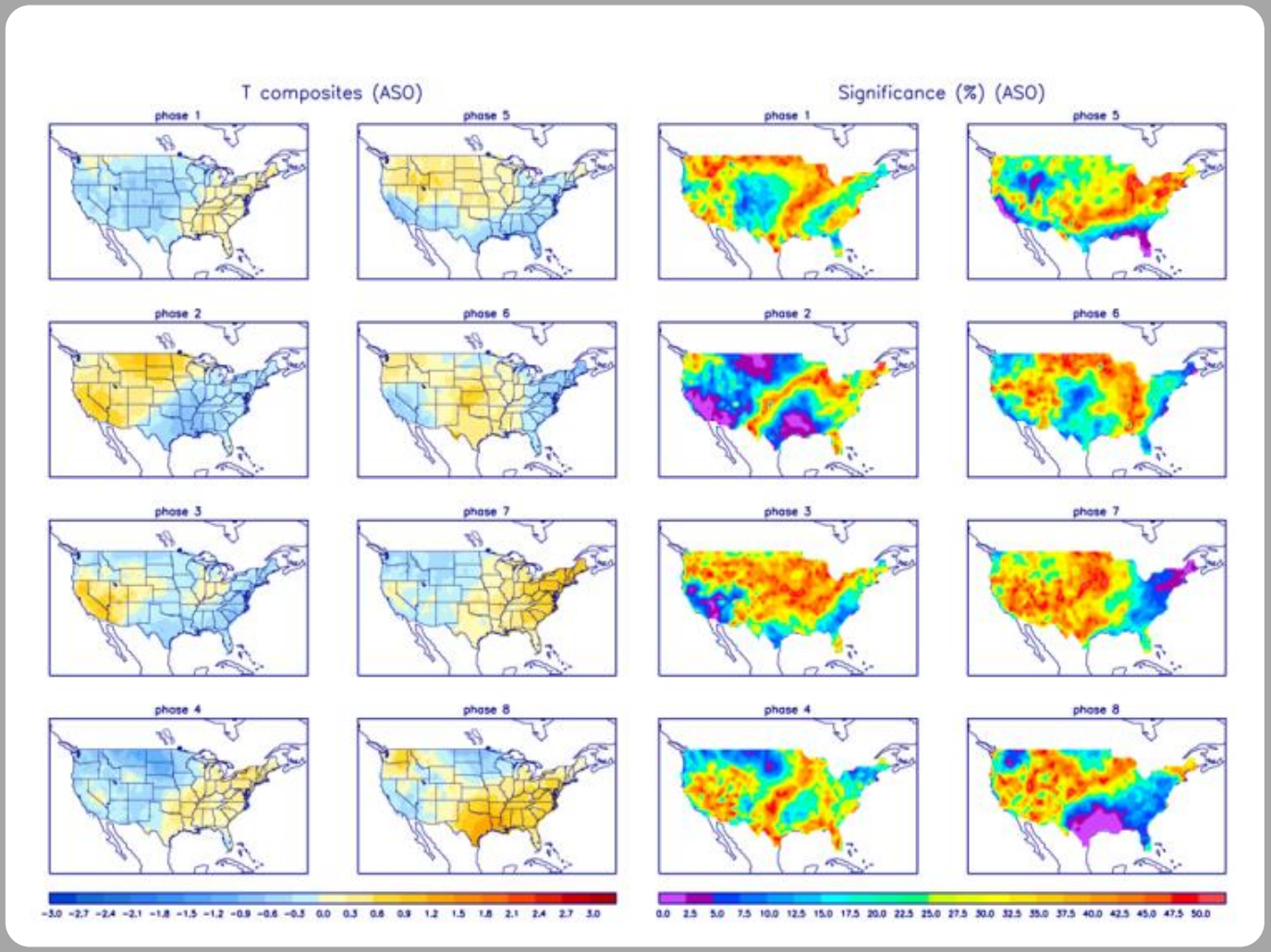
Precipitation Anomalies (May - Sep)



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.



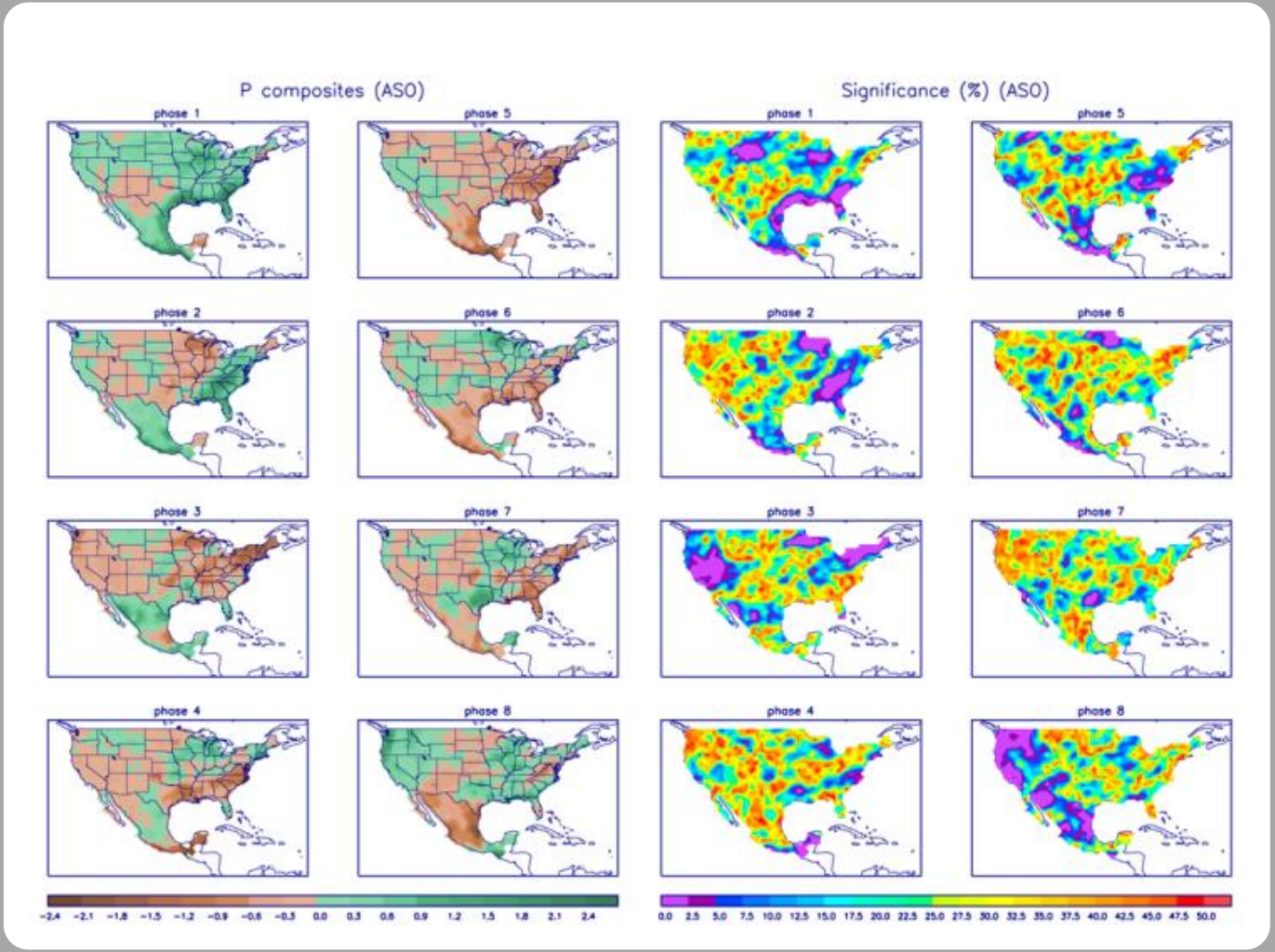
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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