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

Update prepared by:
Climate Prediction Center / NCEP
29 August 2016

Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

The MJO remains weak, with tropical cyclone activity over the Northwest Pacific influencing the amplitude of the RMM Index. Upper level velocity potential anomalies suggest that any enhanced phase of the intraseasonal signal is over the East Pacific, but observed OLR anomalies are not consistent with that pattern.

Dynamical model RMM-based MJO Index forecasts depict a wide range of solutions, with most ensemble members keeping the amplitude of the index low. Some GFS ensemble members depict amplification over the Western Hemisphere during Week-2, which may be related to model forecast tropical cyclone activity over the Atlantic.

The MJO is not anticipated to play a major role in the evolution of the global tropical convective pattern over the next several weeks. Influence is more likely to come from tropical cyclone activity and a slowly evolving low-frequency state.

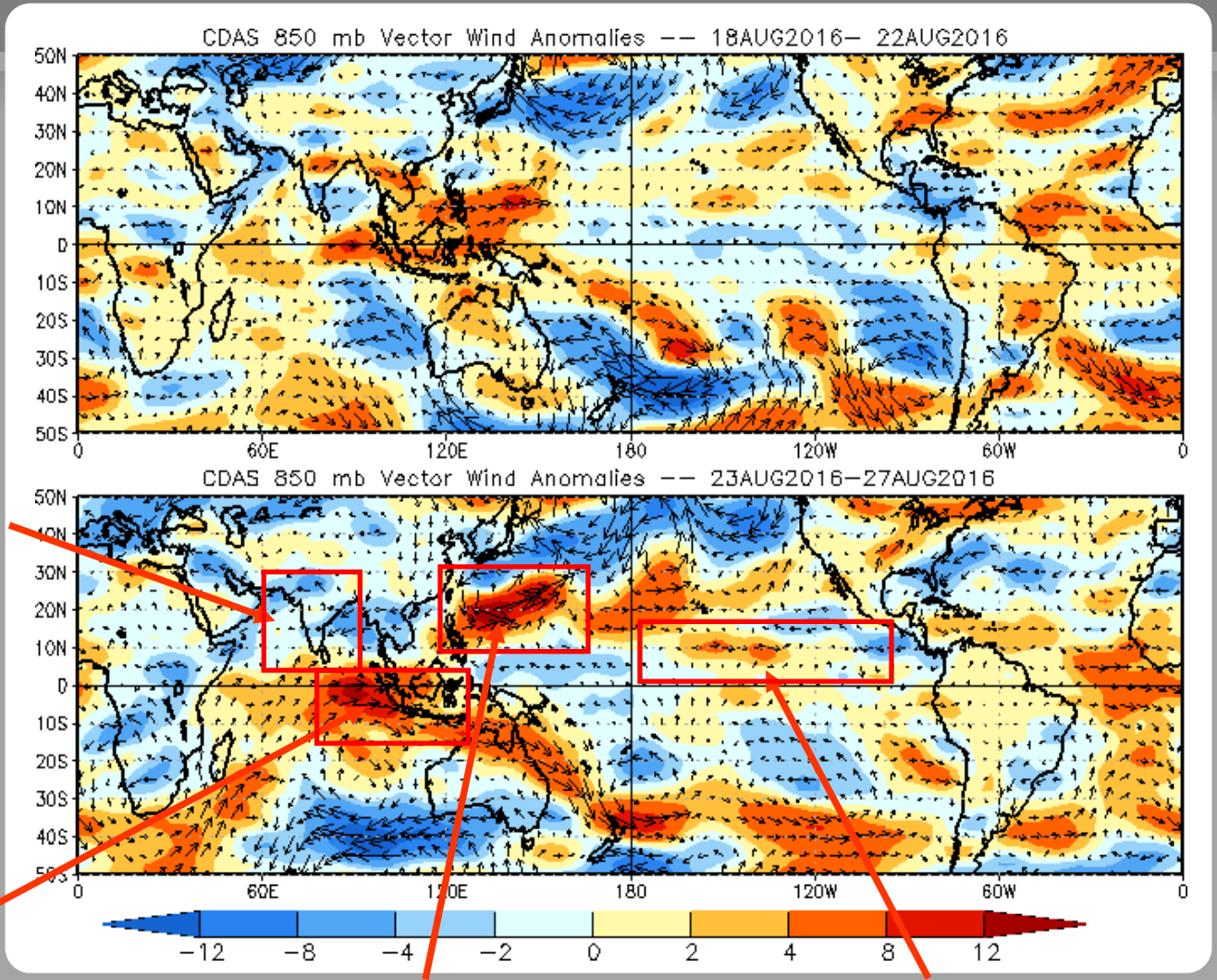
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 monsoon circulation weakened over South Asia during the past week.

Equatorial westerly wind anomalies strengthened substantially over the eastern Indian Ocean.

Westerly anomalies associated with the monsoon trough decreased in coverage and shifted northward recently.

The LL wind anomaly field remained weak and westerly over the equatorial east-central Pacific.

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

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

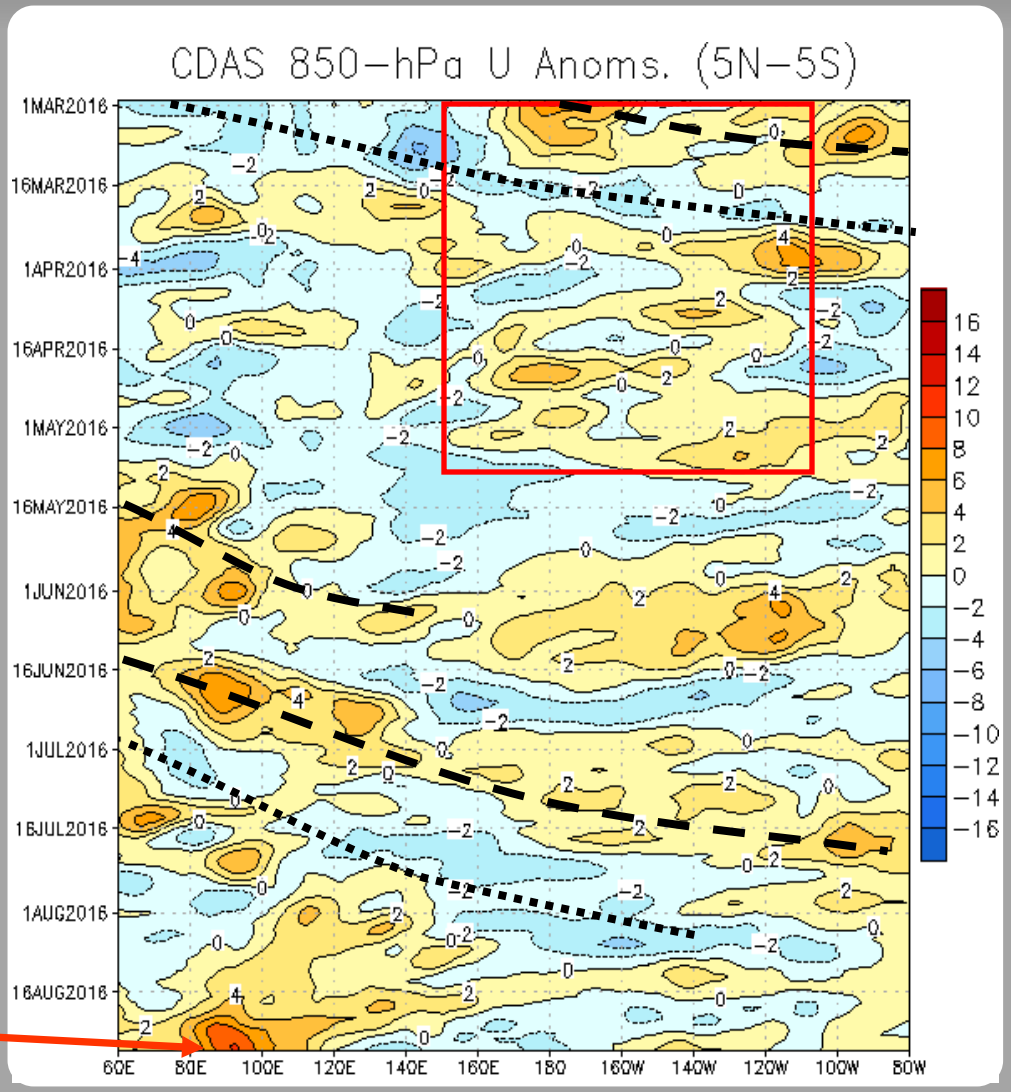
Easterly anomalies (blue shading) represent anomalous east-to-west flow

The red box highlights the persistent low-frequency westerly wind anomalies associated with the 2015-2016 El Niño background state.

Fast-propagating intraseasonal events (long (short) dashed lines for the enhanced (suppressed) phase, modulated the El Niño base state in March.

During April, the wind field became less coherent as El Niño conditions weakened. During May and June, westerly anomalies were persistent over the Indian Ocean, with higher frequency modes periodically propagating across the Pacific.

During August, westward moving features were evident across the West Pacific and Maritime Continent. More recently, a westerly wind burst developed over the eastern Indian Ocean.



OLR Anomalies – Past 30 days

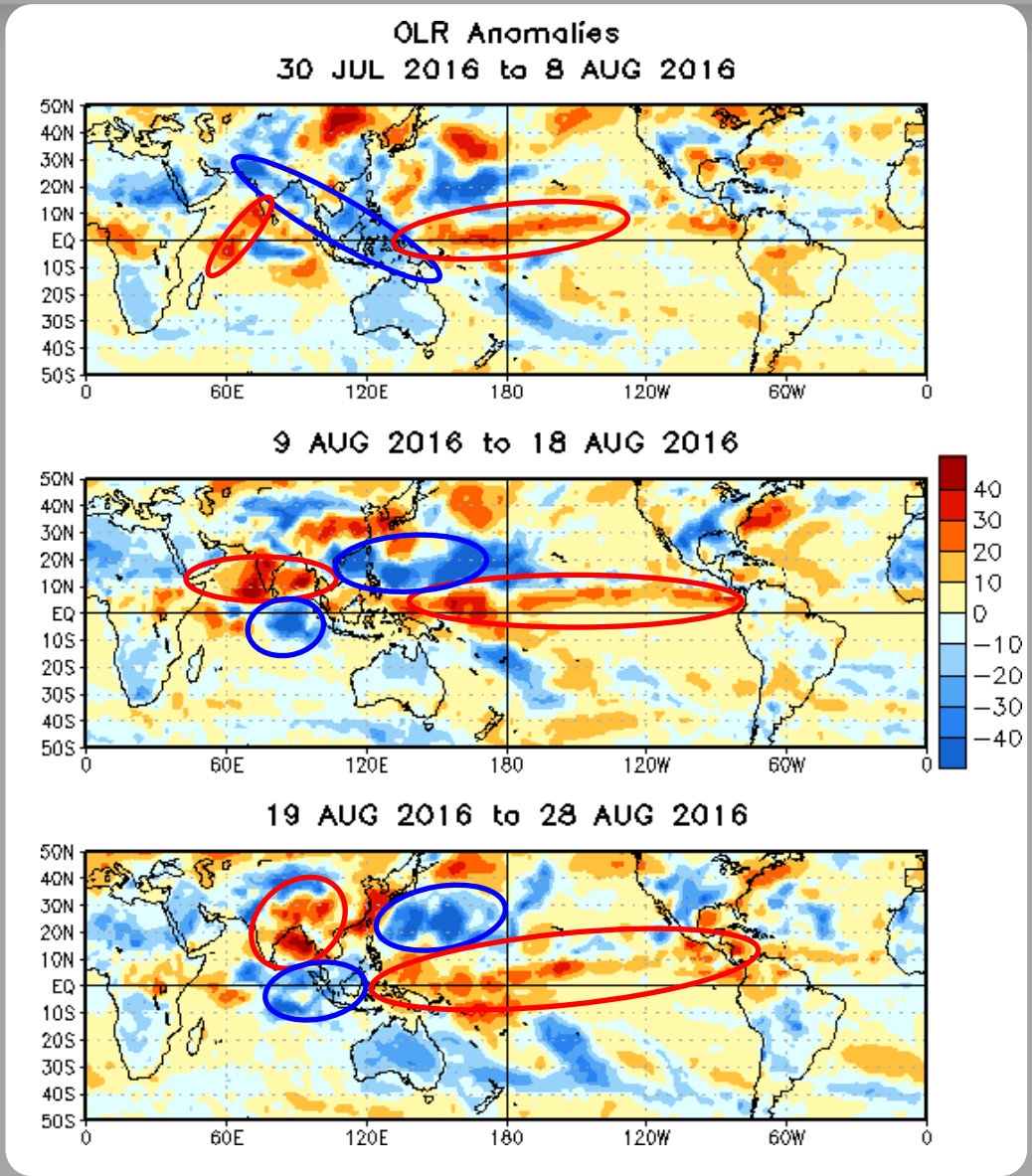
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late July and early August, areas of enhanced (suppressed) convection extended from parts of Indian and Pakistan through the equatorial Maritime Continent (western Indian Ocean and the equatorial western and central Pacific).

Suppressed convection returned to South Asia by mid-August, while a small area of enhanced convection developed over the eastern I.O. The Monsoon Trough was displaced northward, and extended from the South China Sea through much of the northwestern Pacific.

During mid August, suppressed (enhanced) convection persisted over parts of South and Southeast Asia (eastern Indian Ocean and western Maritime Continent), while enhanced convection, partly associated with TCs, shifted northward over the Northwest Pacific.



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

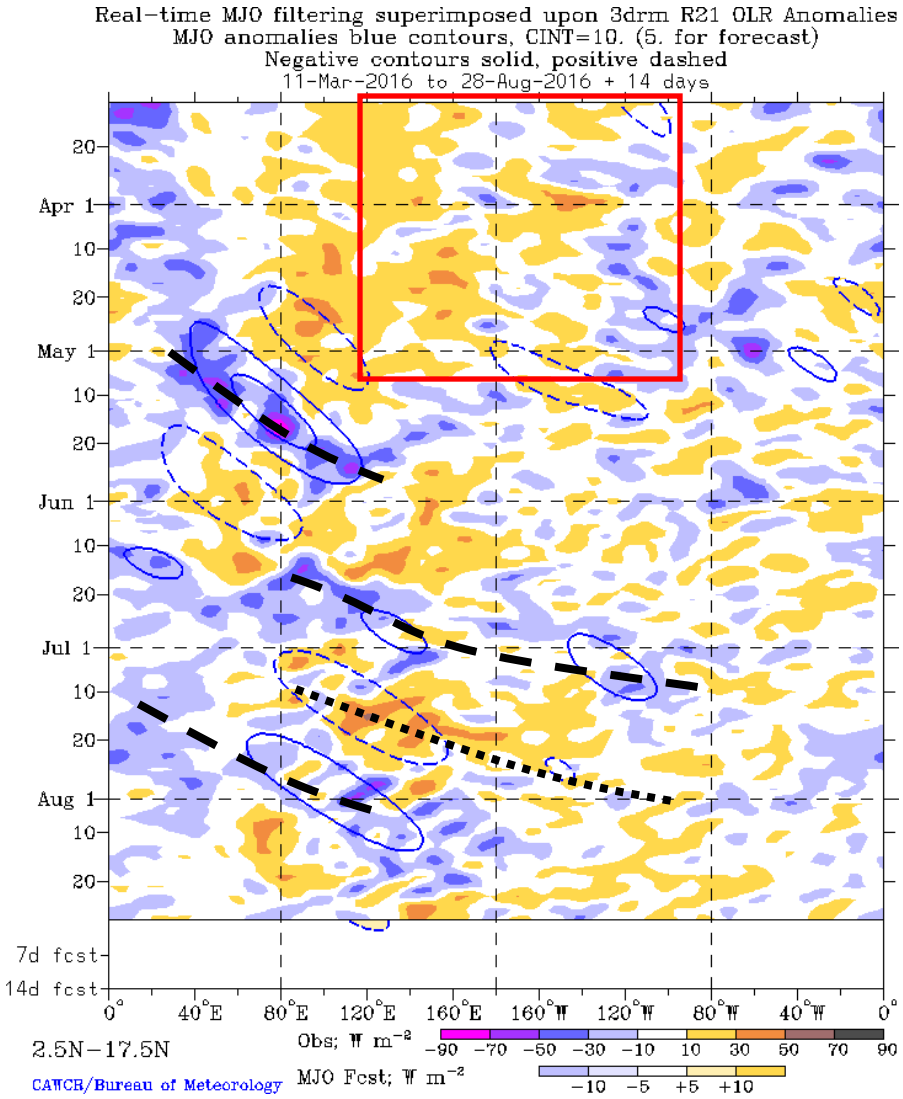
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

The 2015-2016 El Niño background state is observed (red box) as a dipole of anomalous convection extending from the Maritime Continent to the East Pacific. The signal weakened steadily through boreal Spring.

During early May, an eastward-propagating convective envelope associated with the MJO developed east of the Prime Meridian. During the latter half of June, another eastward propagating signal is evident. During July, the signal continued moving eastward, with interference from tropical cyclone activity.

During August, persistent suppressed convection over the northern Indian Ocean and adjacent monsoon regions is evident. Westward moving features (Rossby Waves or tropical cyclones) embedded in the monsoon trough appear to be the dominant feature over the Northwest Pacific.



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

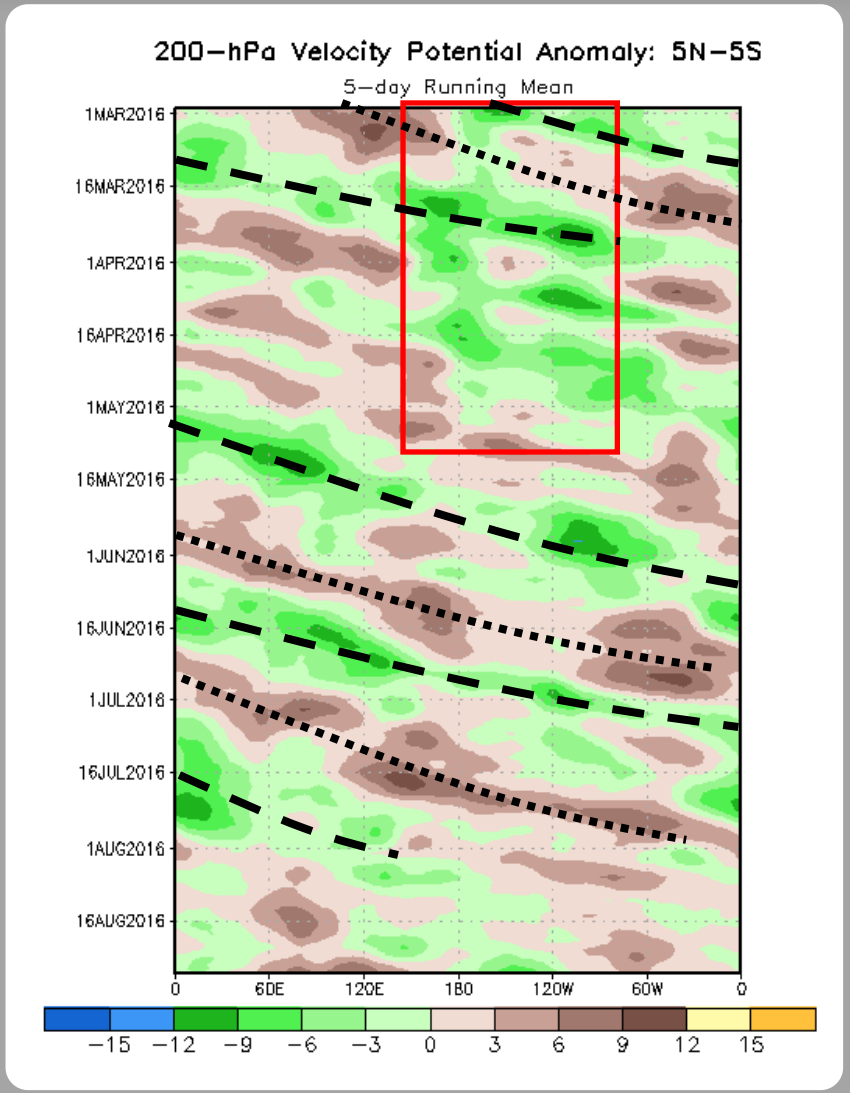
The 2015-16 El Niño background state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

MJO activity was evident in March, alternatively constructively and destructively interfering with the ENSO background state.

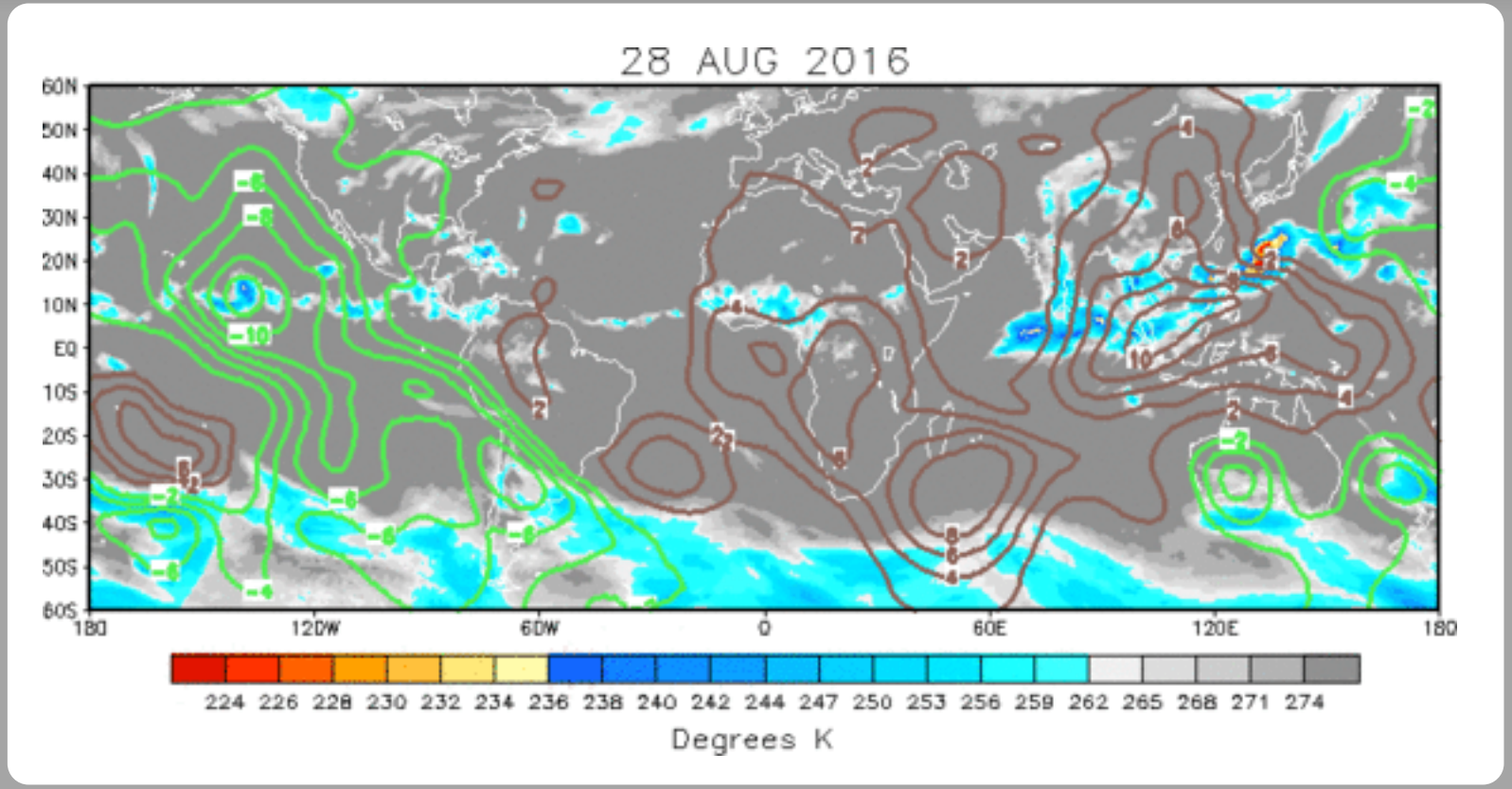
The upper-level velocity potential pattern became less coherent as El Niño waned during April.

From May through early August, a propagating signal was evident, with multiple periods of variability apparent.

During August, the intraseasonal signal became less coherent, with a weaker and more stationary anomaly field in place. Recently, enhanced convergence (divergence) developed over the Indian Ocean and Maritime Continent (eastern Pacific).



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



The spatial pattern of upper-level velocity potential anomalies is fairly coherent, though out of phase with the RMM Index projection.

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)

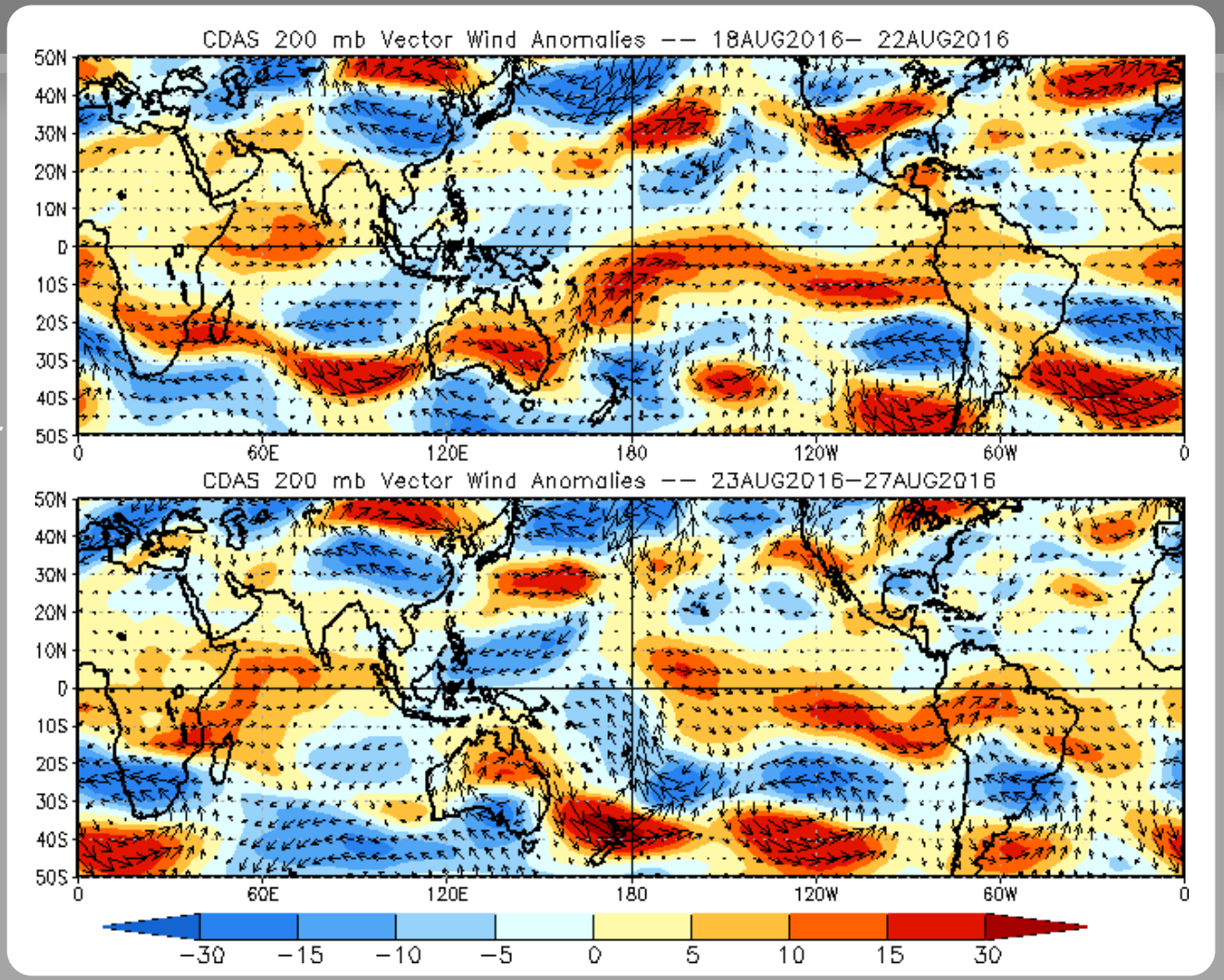
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Upper-level anticyclonic circulation associated with the monsoon trough increased over the Northwest Pacific during late August.

Westerly anomalies persisted over the central and eastern Pacific, while upper-level wind anomalies decreased over the Atlantic MDR.



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

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

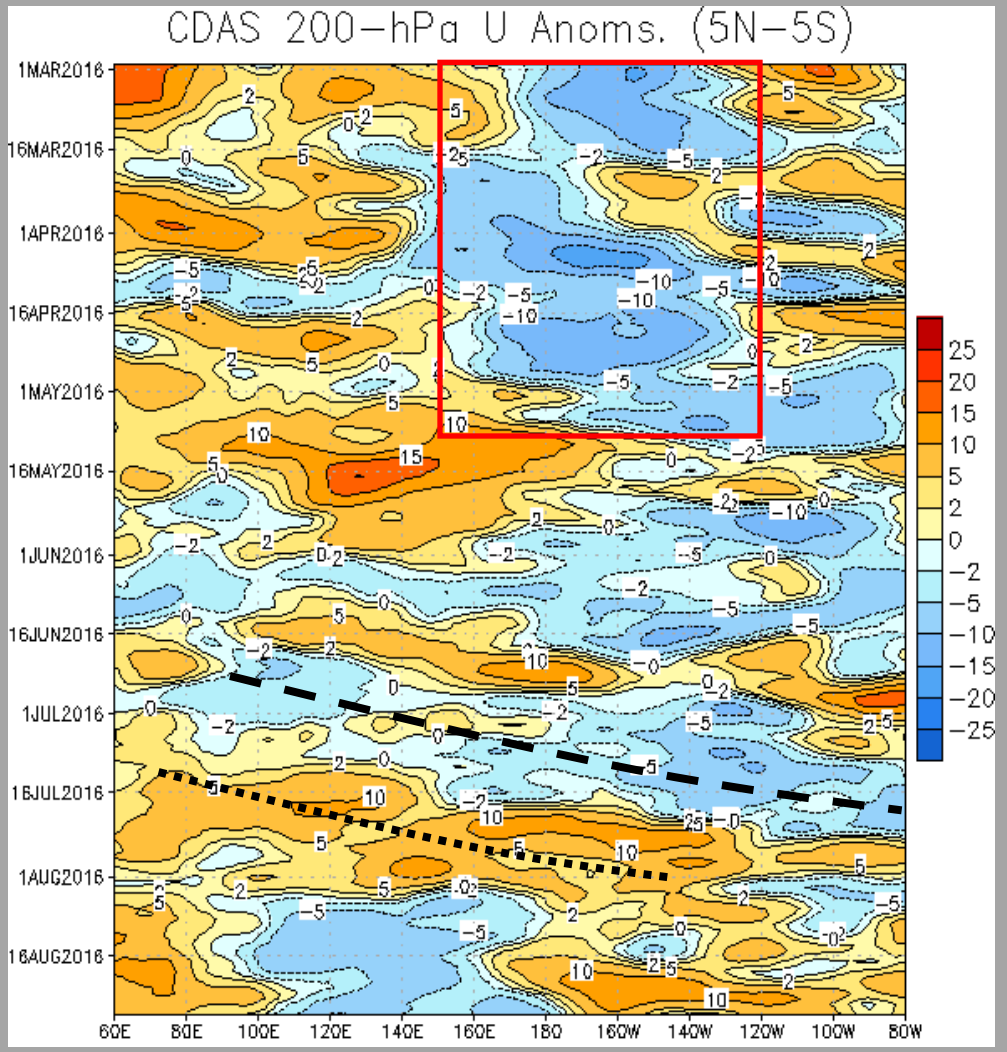
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Easterly anomalies have persisted over the central and eastern Pacific from June 2015 to May 2016 associated with El Niño (red box). Corresponding westerly anomalies persisted over the Maritime Continent.

During May, westerly anomalies expanded eastward to the Date Line as El Niño weakened. Faster propagating modes were evident in the upper-level wind field.

The upper-level zonal wind field became less coherent during late May and early June.

During July, some eastward propagation in large scale anomalies are evident, although the spatial consistency implies higher frequency variability than expected with MJO activity. During August the pattern has become relatively stationary, with westerlies (easterlies) over the central and eastern Pacific (Maritime Continent).



Weekly Heat Content Evolution in the Equatorial Pacific

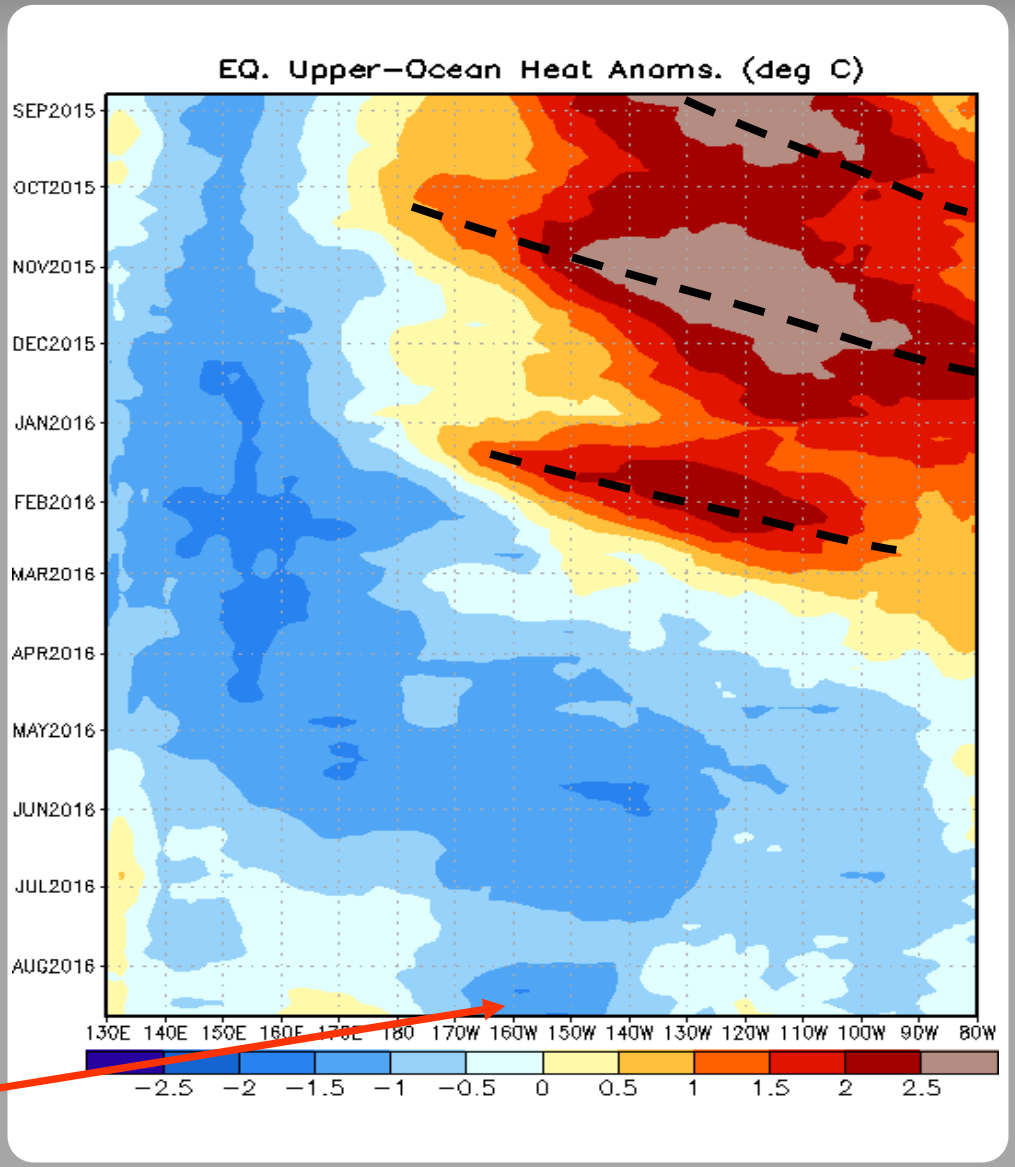
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

Reinforcing downwelling events were observed during the second half of 2015, resulting in persistently above-normal heat content from the DL to 80W throughout the period.

An eastward expansion of below average heat content over the western Pacific is evident since January, with negative anomalies beginning to spread east of the Date Line.

In the last three months, there has been a rapid eastward expansion of below-average oceanic heat content across the central and eastern Pacific. Negative anomalies now extend across the equatorial Pacific.

Heat content anomalies decreased in magnitude during July and August, although stronger negative anomalies persisted over the east-central Pacific.



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

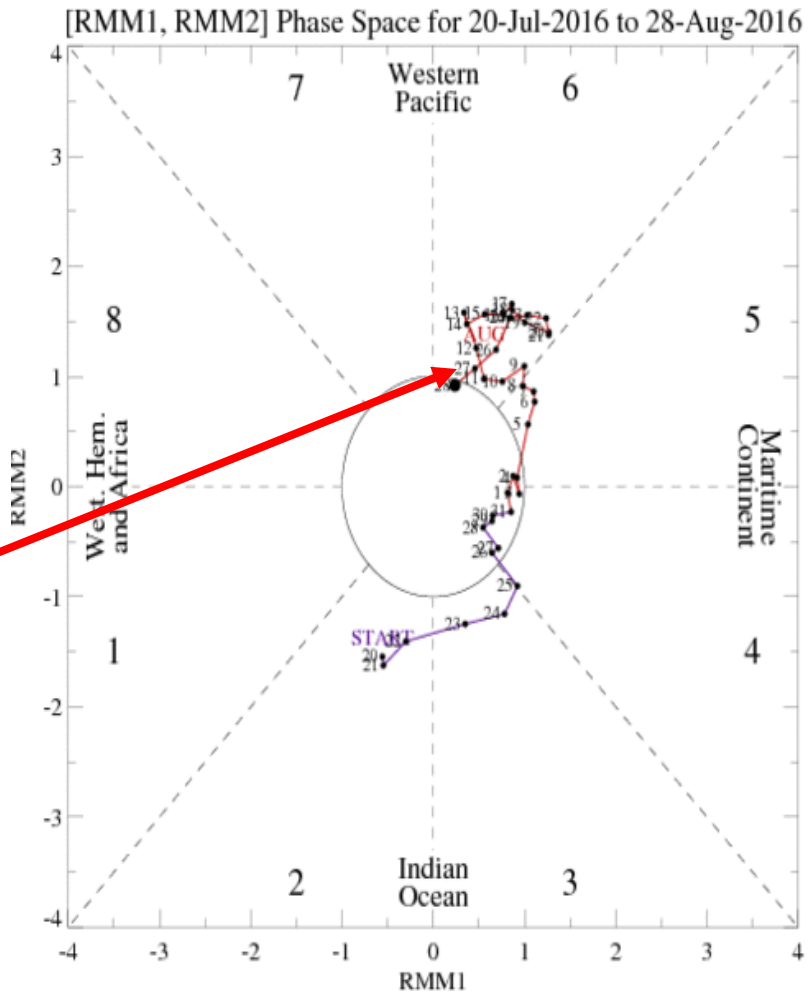
The triangular areas indicate the location of the enhanced phase of the MJO

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

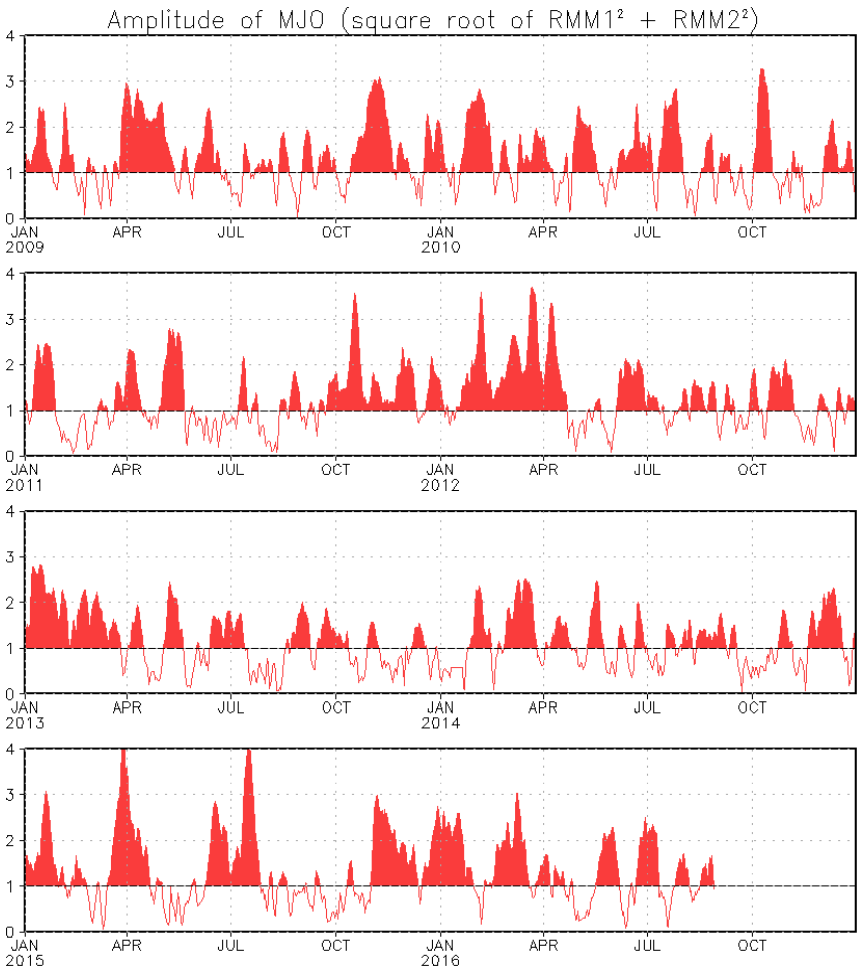
During the past several weeks, the RMM Index indicated an enhanced signal over the Western Pacific, with little eastward propagation. Tropical cyclone activity may be influencing the index.



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.



Ensemble GFS (GEFS) MJO Forecast

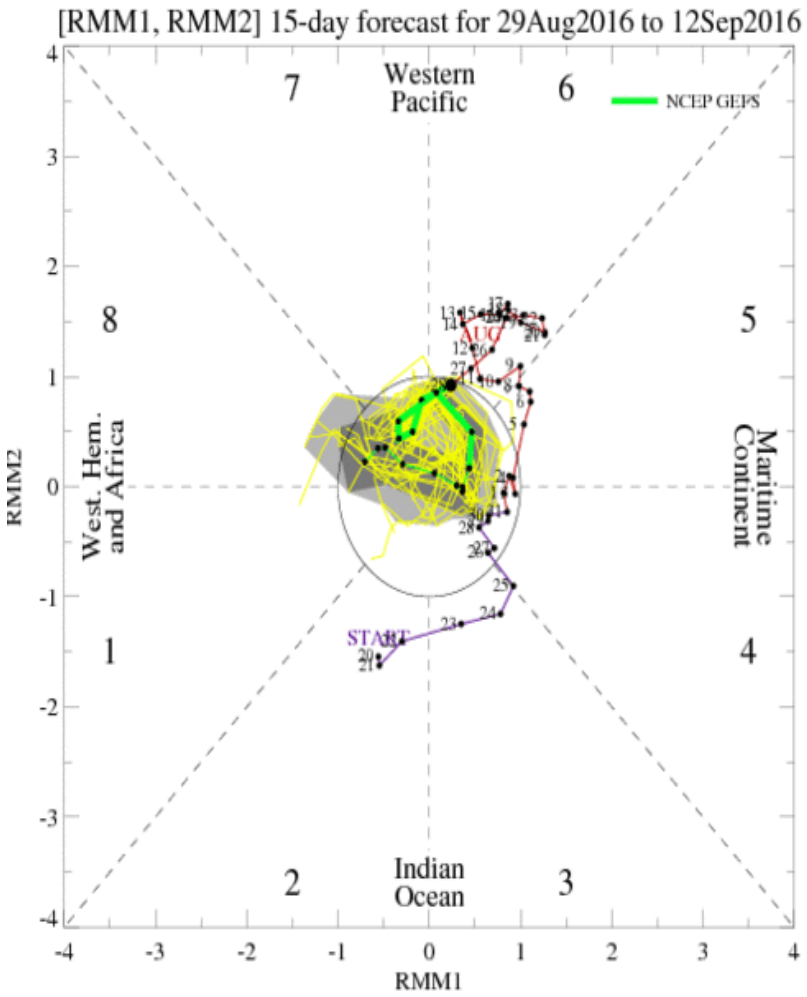
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

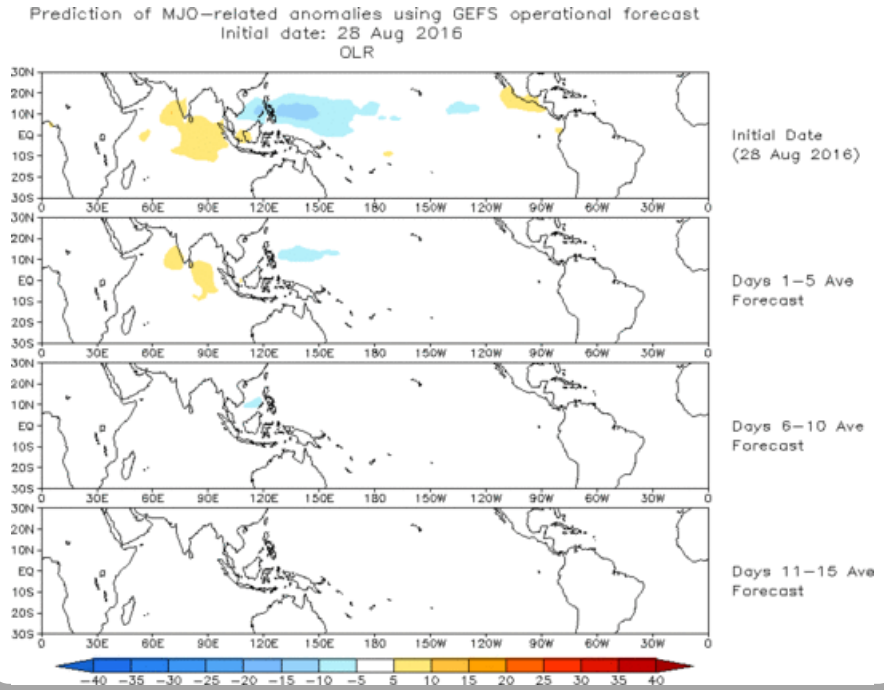
During the next two weeks, GFS ensemble RMM Index forecasts depict a weak signal.



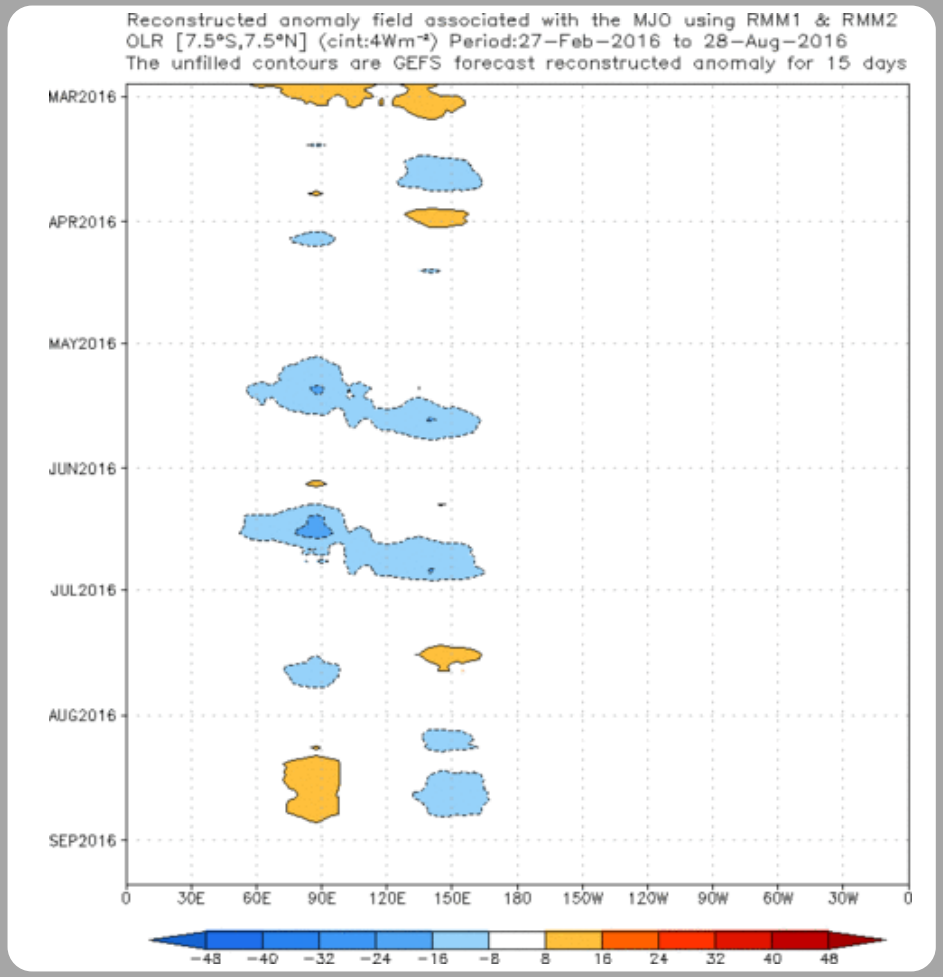
Ensemble GFS (GEFS) MJO Forecast

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

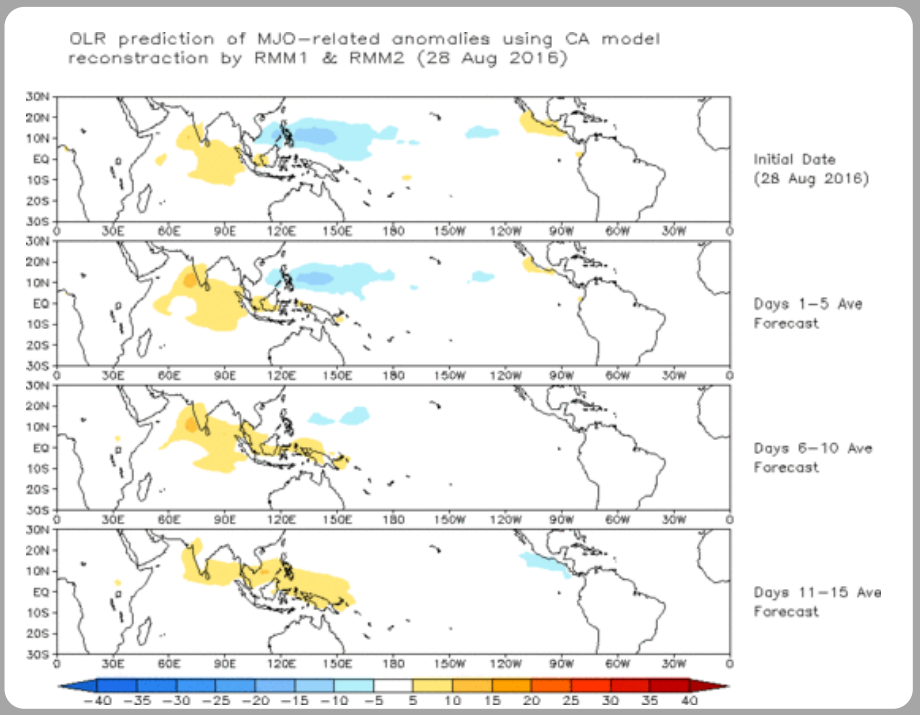


The GEFS RMM Index forecast based OLR anomalies are consistent with a West Pacific enhanced phase at the initialization, but anomalies rapidly weaken as the index goes inside the unit circle.

Constructed Analog (CA) MJO Forecast

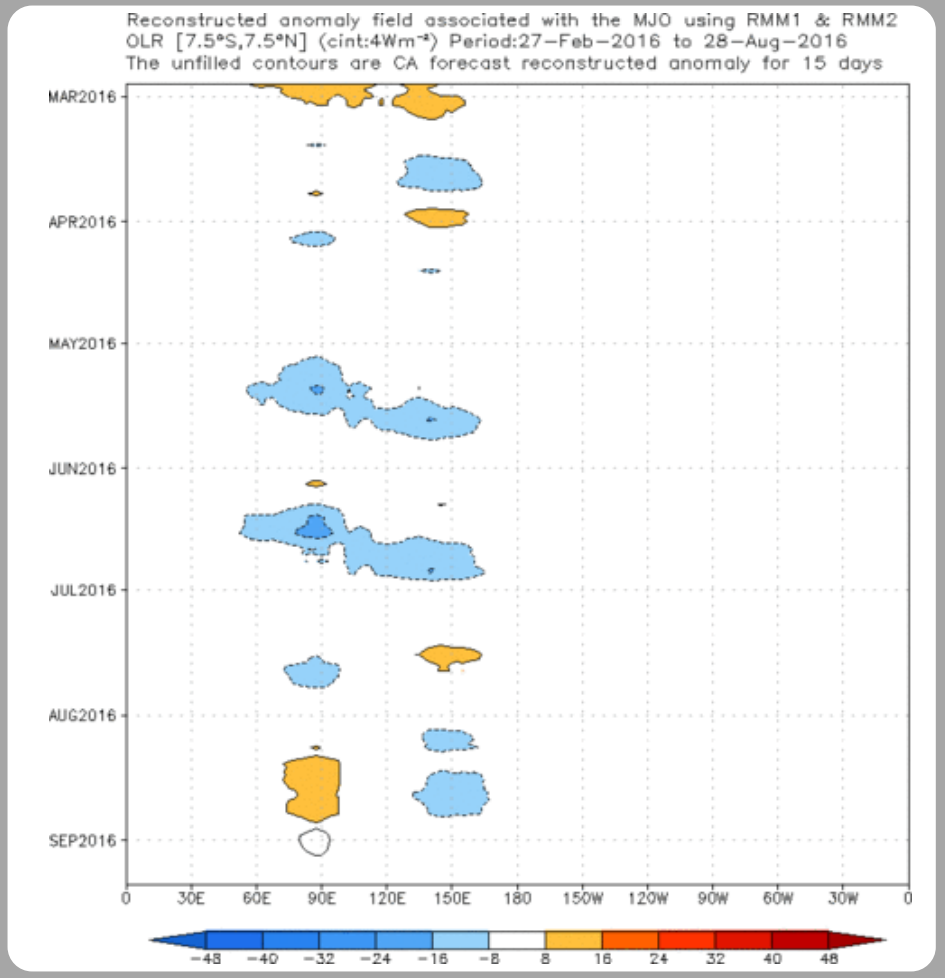
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



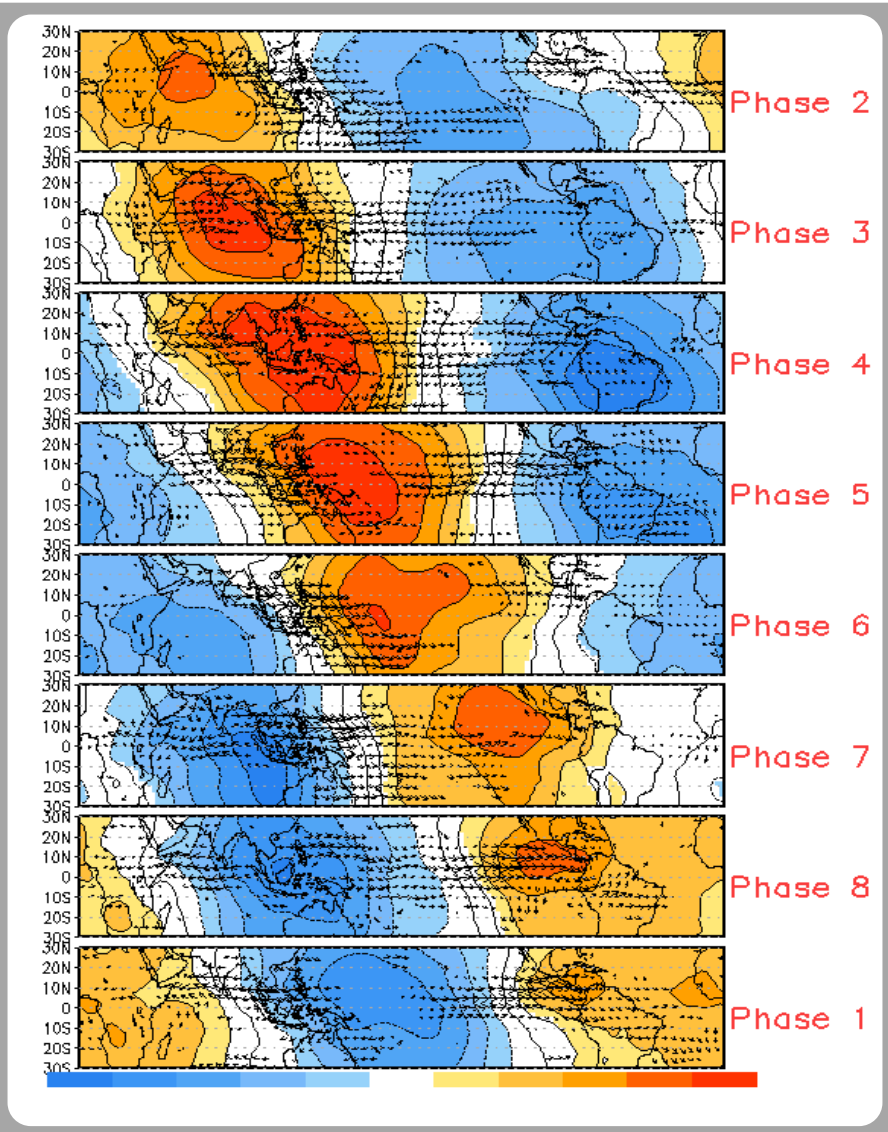
The Constructed Analog (CA) model predicts a more active eastward propagation of a weak OLR anomaly field.

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

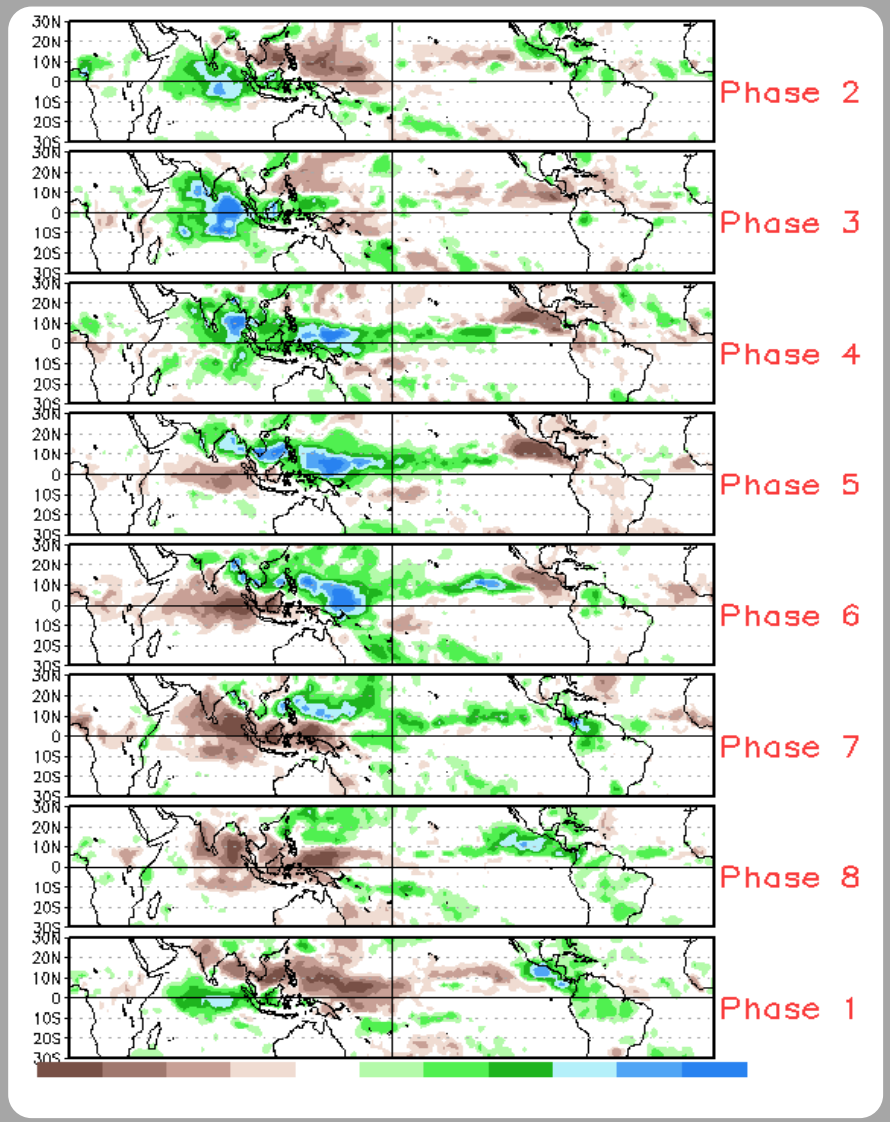


MJO Composites - Global Tropics

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



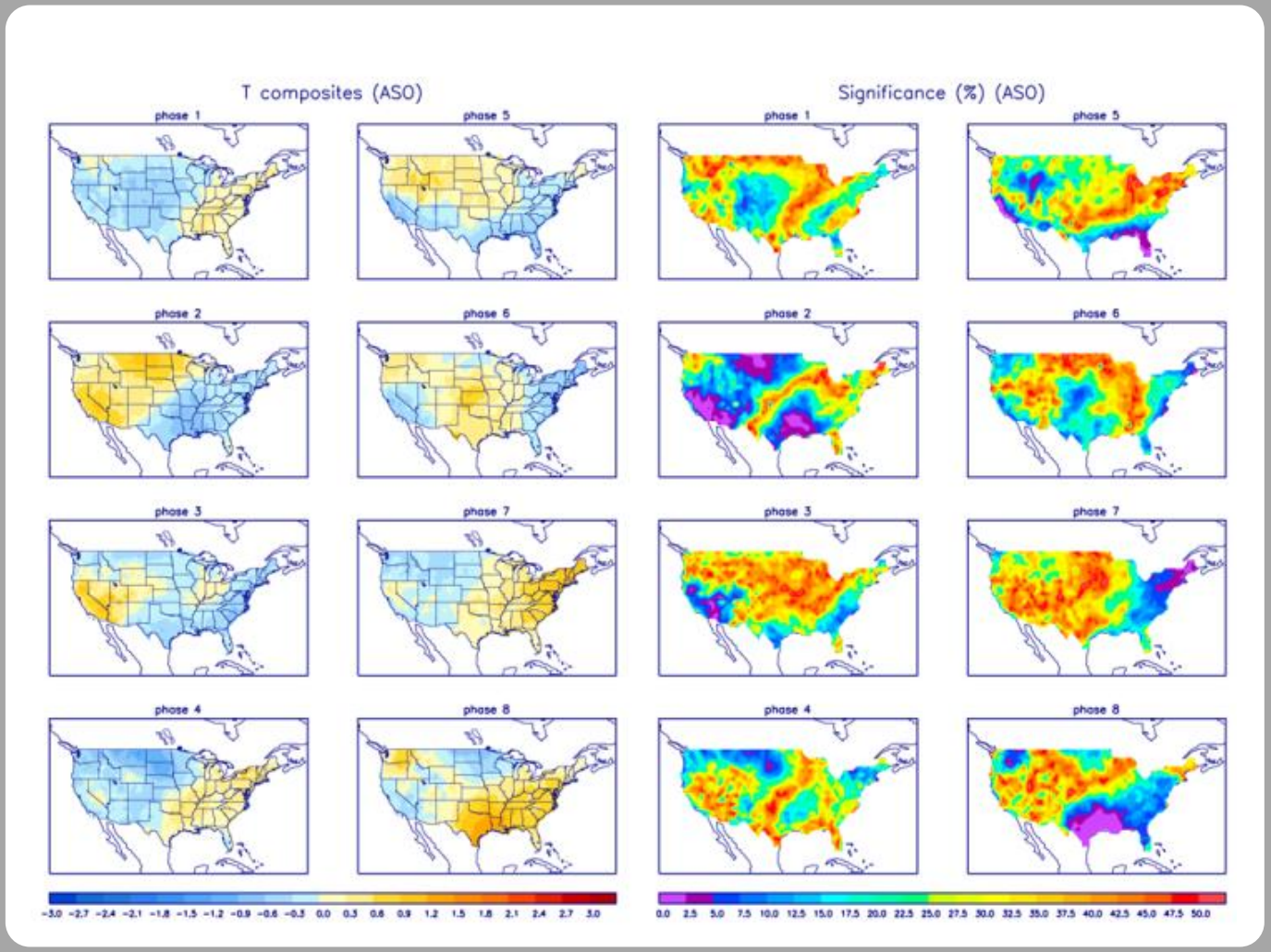
Precipitation Anomalies (May - Sep)



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.



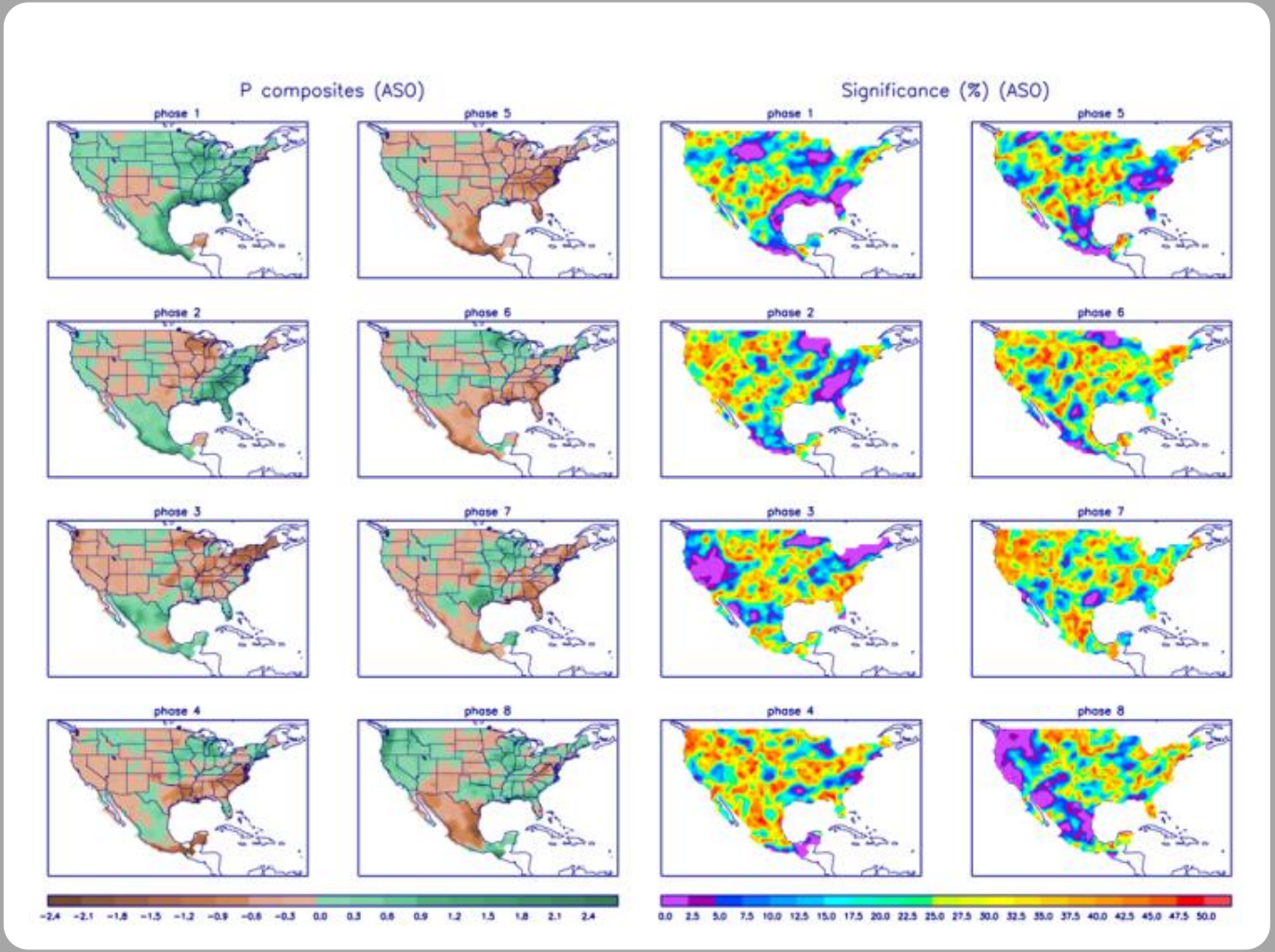
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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.



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