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

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Climate Prediction Center / NCEP
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Overview

The MJO indices weakened during the past week, with some indications of an enhanced phase over the Maritime Continent, but with less apparent eastward propagation. Influence from other modes, including a slowly evolving base state and the negative phase of the Indian Ocean Dipole, may be destructively interfering with the intraseasonal signal.

Dynamical model forecasts of the RMM-based MJO index generally weaken the index as the enhanced phase enters the West Pacific. The GFS ensembles depict faster eastward propagation, with a potential emergence of the signal over the East Pacific by the end of Week-2. The ECMWF depicts a slower evolution of a weak signal.

The MJO is anticipated to continue playing a role in the evolution of the global tropical convective pattern, but there is considerable uncertainty regarding the strength of the signal. Other modes, including the base state, IOD, and tropical cyclones, will continue to play a significant role. Regardless of the amplitude of the MJO, Kelvin wave activity emerging from the Maritime Continent may influence tropical cyclone development over the East Pacific during the next week.

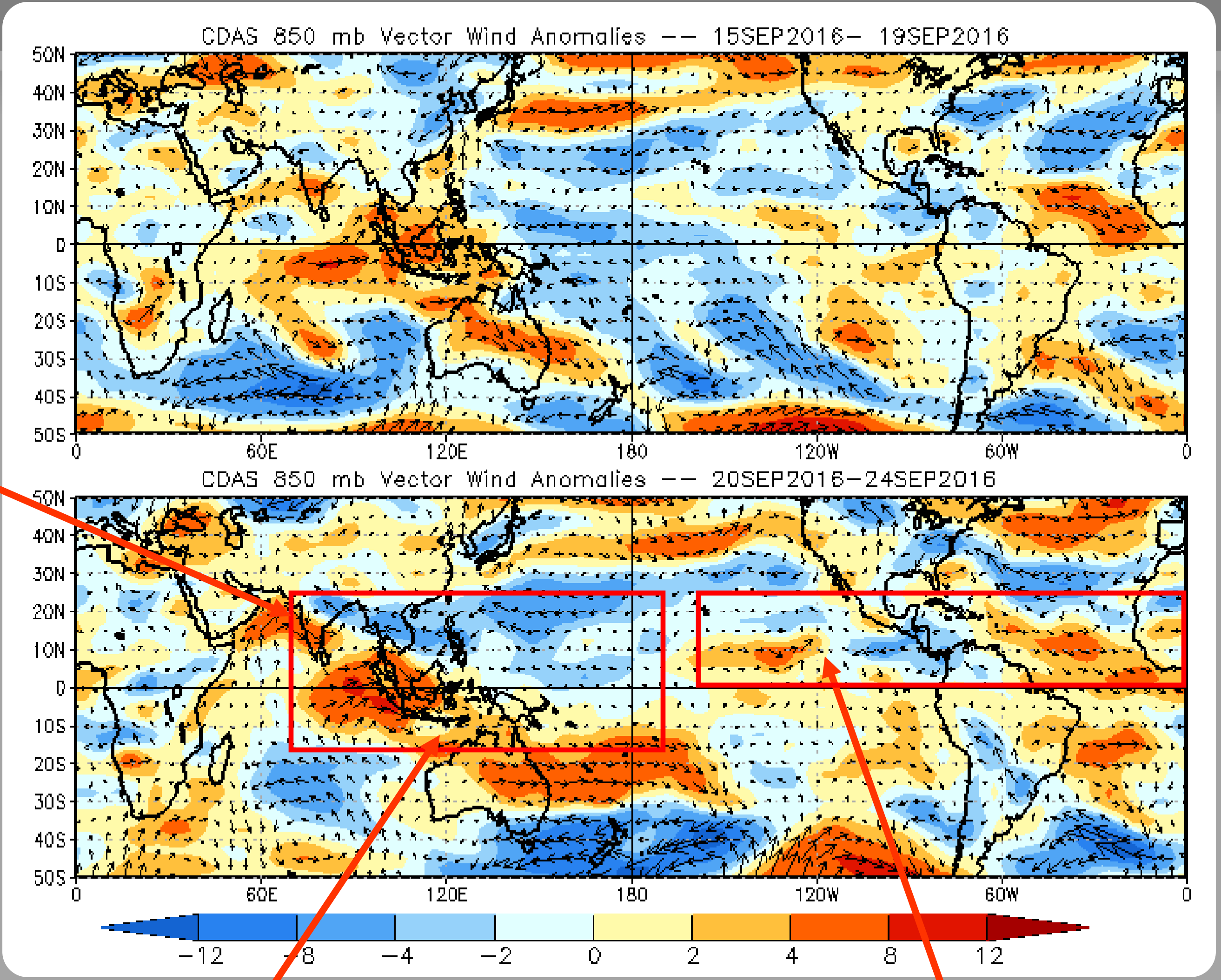
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



A low-level anomalous cyclonic circulation pattern persisted over South Asia.

Westerly anomalies strengthened over the eastern Indian Ocean and western Maritime Continent, while easterlies expanded across the western North Pacific and South China Sea.

A generally weak anomaly field remained over the East Pacific, while westerly anomalies persisted over the Atlantic.

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

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

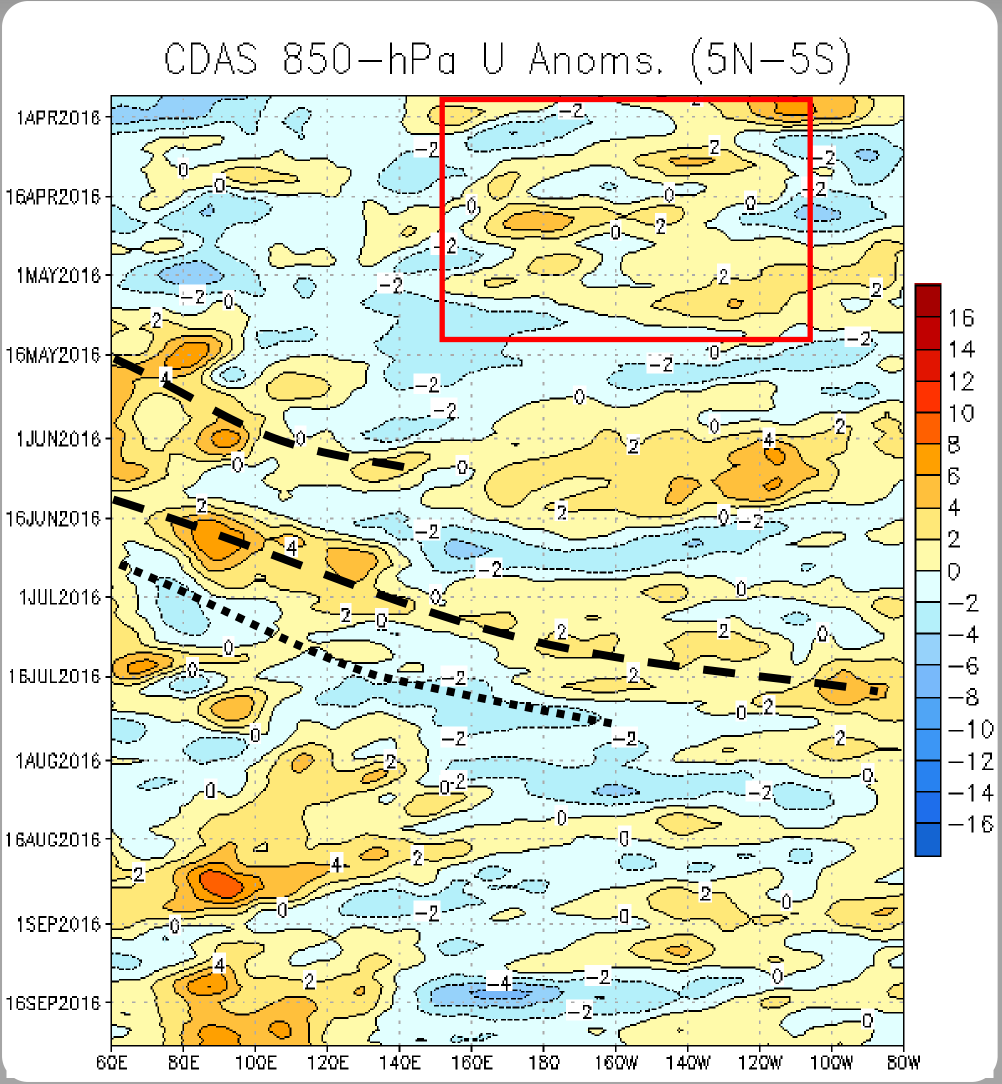
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

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 (IO), with higher frequency modes periodically propagating across the Pacific.

During late August, westerly anomalies were evident across the IO and western Pacific.

During September, persistent westerly (easterly) anomalies were evident over the eastern Indian Ocean and western Maritime Continent (central Pacific). These anomalies may be occurring in response to lower frequency modes such as a negative Indian Ocean Dipole event.



OLR Anomalies – Past 30 days

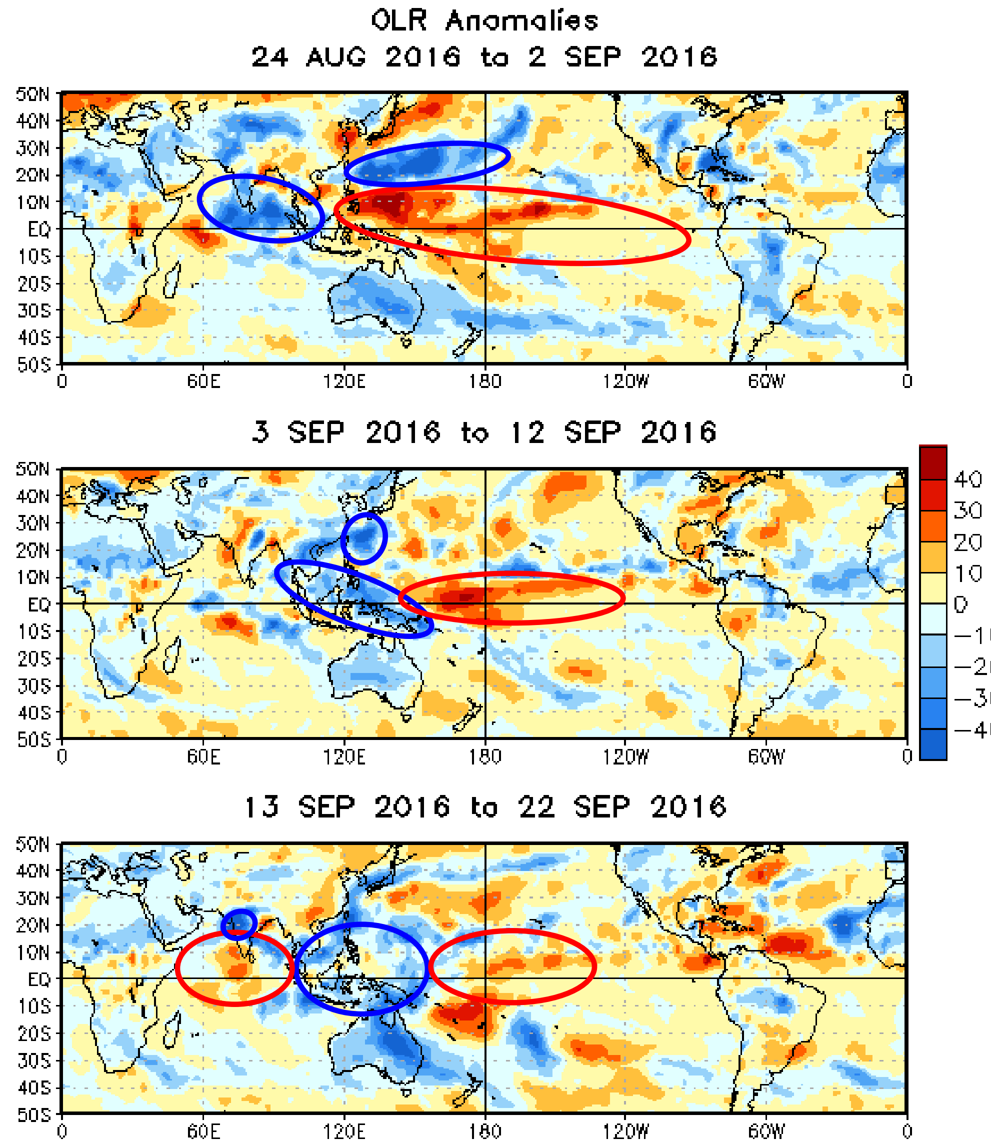
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late August and the beginning of September, northward displacement of the Monsoon trough was evident over the western Pacific. Enhanced (suppressed) convection overspread much of the Indian Ocean basin (west and central Pacific).

During early September, enhanced convection overspread the Maritime Continent, while suppressed convection persisted over the central Pacific. Tropical cyclone activity was evident, including Super Typhoon Meranti east of Taiwan.

During mid-September, the overall pattern became less coherent, though generally enhanced (suppressed) convection persisted over the Maritime Continent (central Pacific).



Outgoing Longwave Radiation (OLR) Anomalies (7.5ºS - 7.5ºN)

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

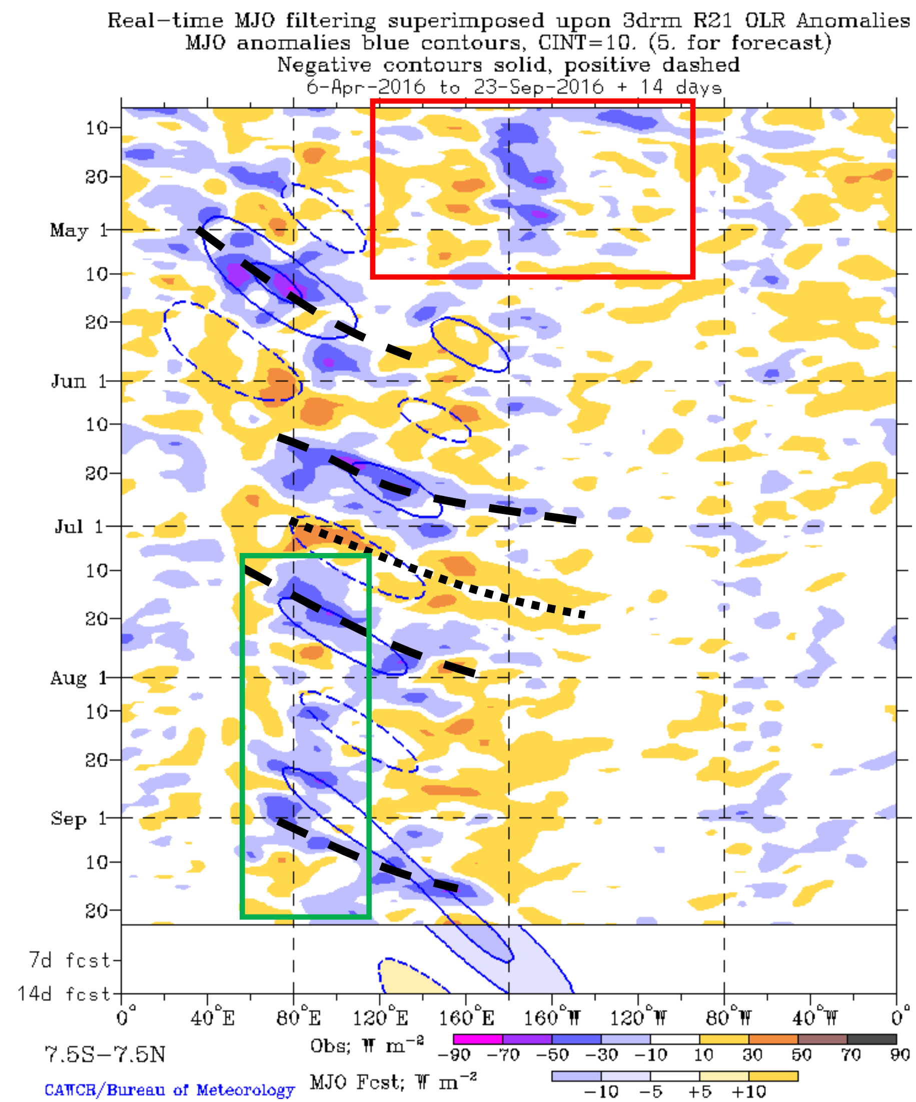
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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.

Several intraseasonal events were observed during May through July, with other modes such as tropical cyclone activity also influencing the pattern.

A low frequency state favoring enhanced convection over the eastern Indian Ocean has been evident since July (green box). This activity is likely related to a negative phase Indian Ocean Dipole event.

During September, a fast eastward moving envelope was evident, likely linked to intraseasonal activity. More recently, the OLR pattern became increasingly incoherent.



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

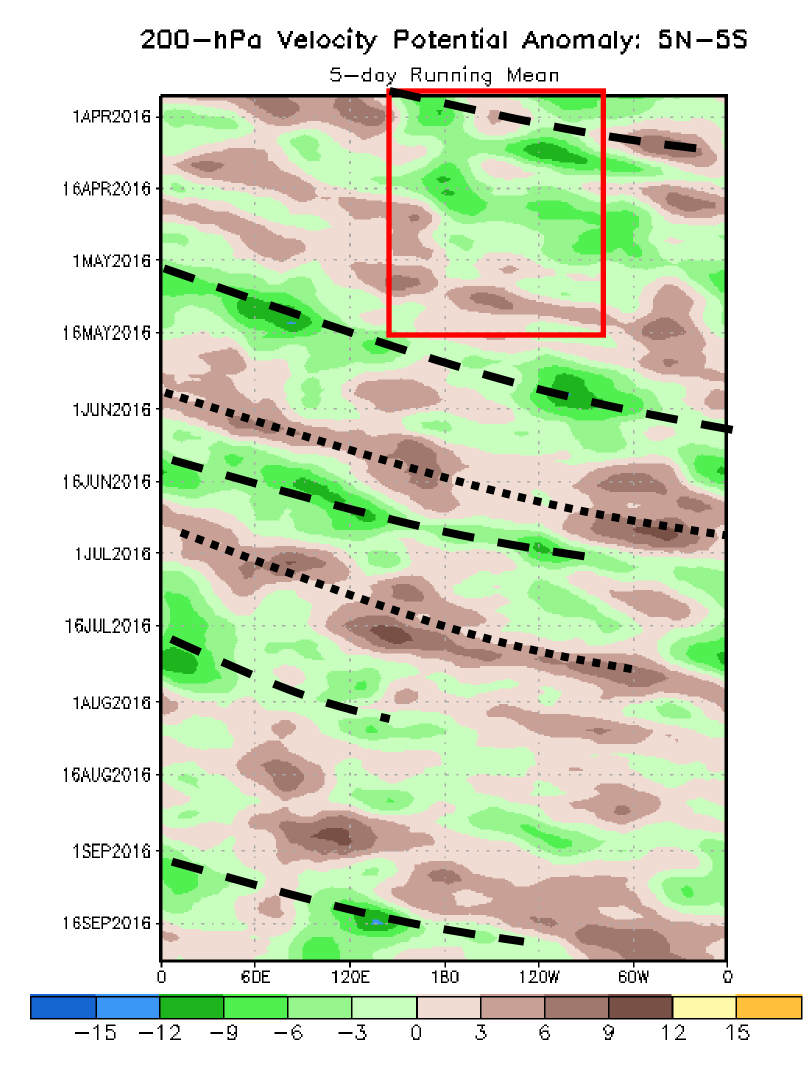
The 2015-16 El Niño background state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

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

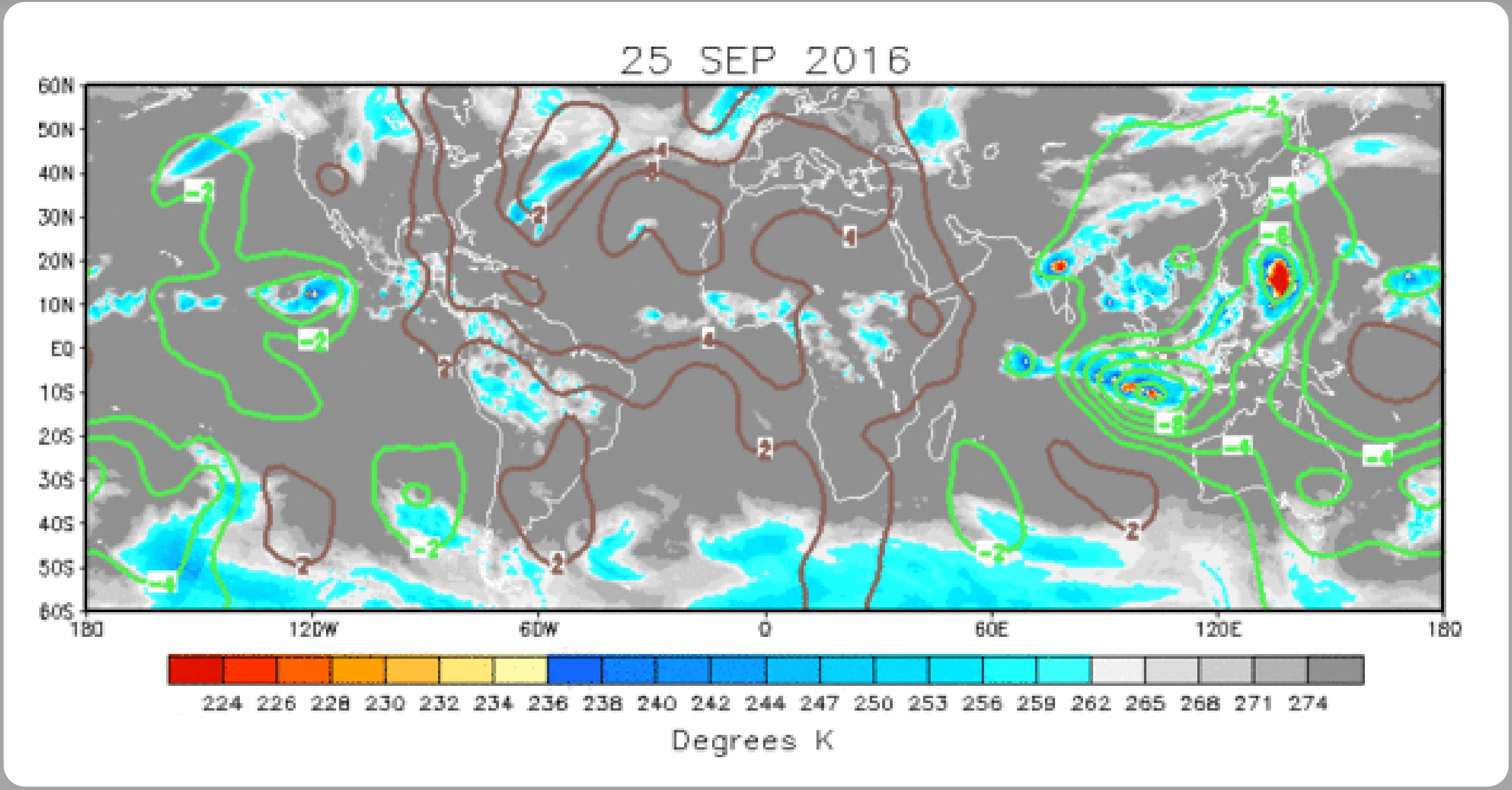
From May through early August, an eastward propagating signal was evident, with multiple periods of variability apparent.

During August, the intraseasonal signal became less coherent, with a weaker and somewhat more stationary anomaly field in place. By late August and early September, there was renewed propagation of the intraseasonal signal.

More recently, the intraseasonal signal became less apparent, with negative VP anomalies persisting over the eastern Indian Ocean and western Maritime Continent.



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



The strongest negative velocity potential anomalies are over the eastern Indian Ocean and western Maritime Continent. A broad weak suppressed envelope is evident over the Western Hemisphere, while the anomaly field is weak over the Pacific.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

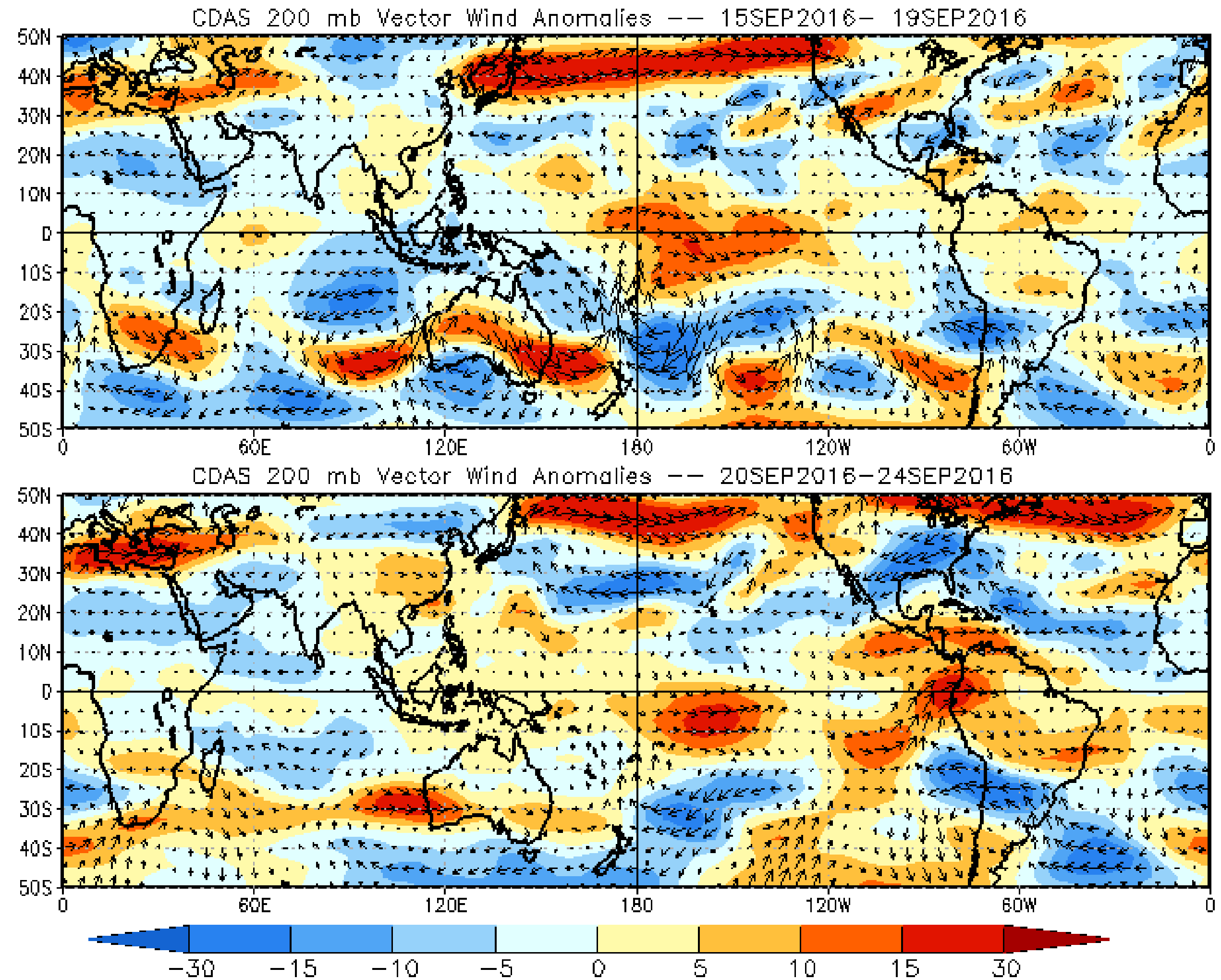
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Broad westerly anomalies continued over the equatorial Pacific through mid to late September, while off-equator easterly anomalies persisted over the Indian Ocean. Weak westerly anomalies overspread the Maritime Continent.

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

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

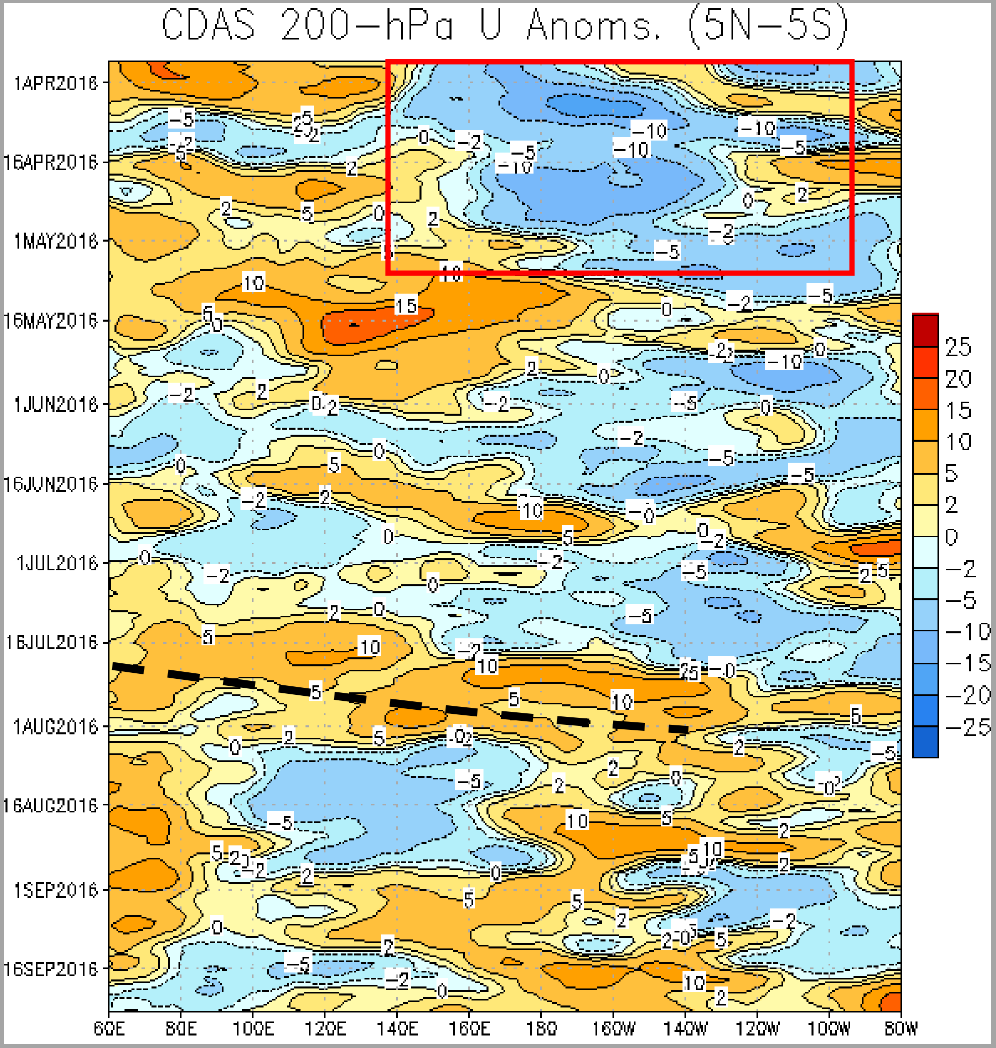
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Easterly anomalies 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. Faster modes were evident in the upper-level wind field.

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 and early September, the pattern became relatively stationary, with an interruption during early September.

Recently, the pattern has somewhat reverted to being relatively stationary, although displaced further west.



Weekly Heat Content Evolution in the Equatorial Pacific

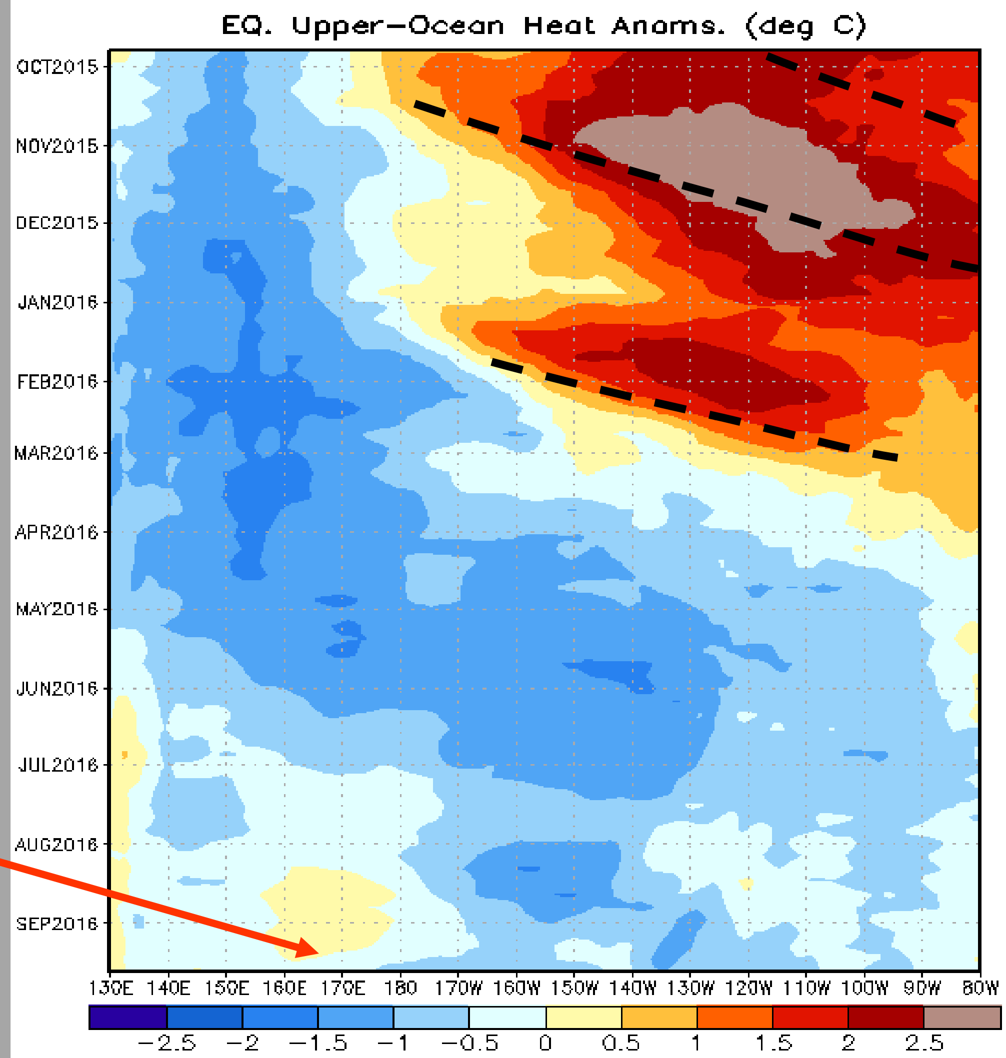
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

Reinforcing downwelling events were observed during late 2015, resulting in persistently above-normal heat content from the DL to 80W over that period.

An eastward expansion of below average heat content over the western Pacific is evident since January, with widespread negative anomalies building across the Pacific.

Strongest negative anomalies now persist over the east-central Pacific.

Some positive oceanic heat anomalies remain just west of the Date Line and in the vicinity of the Maritime Continent.



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

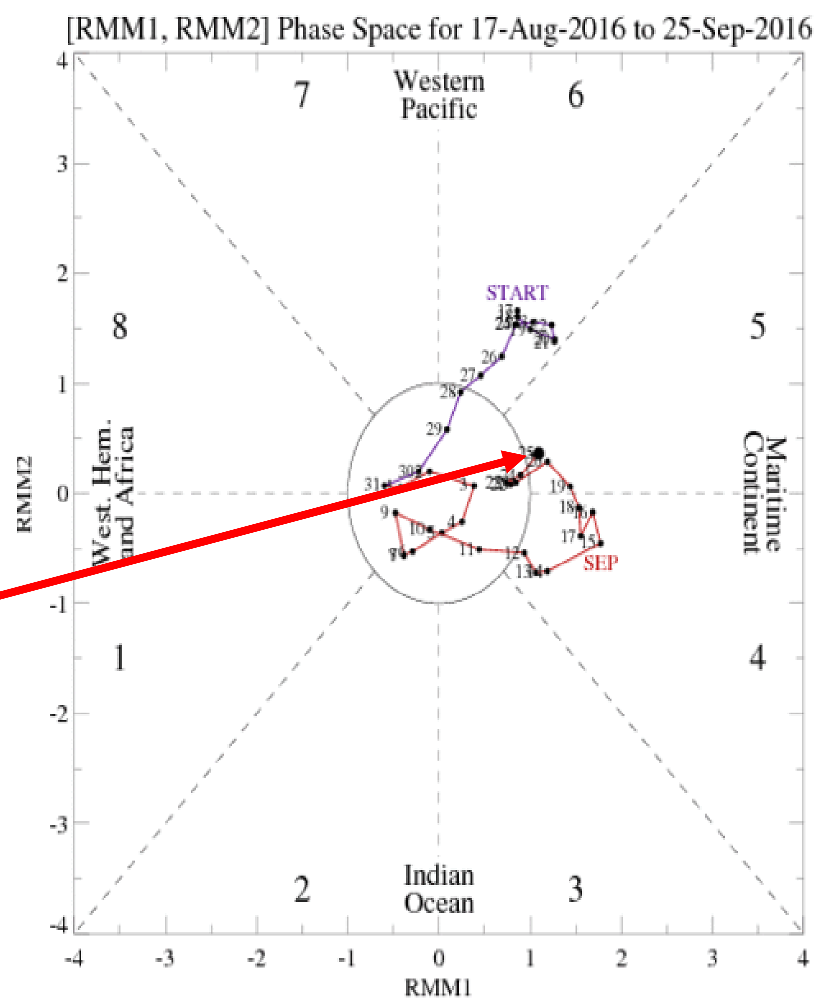
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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

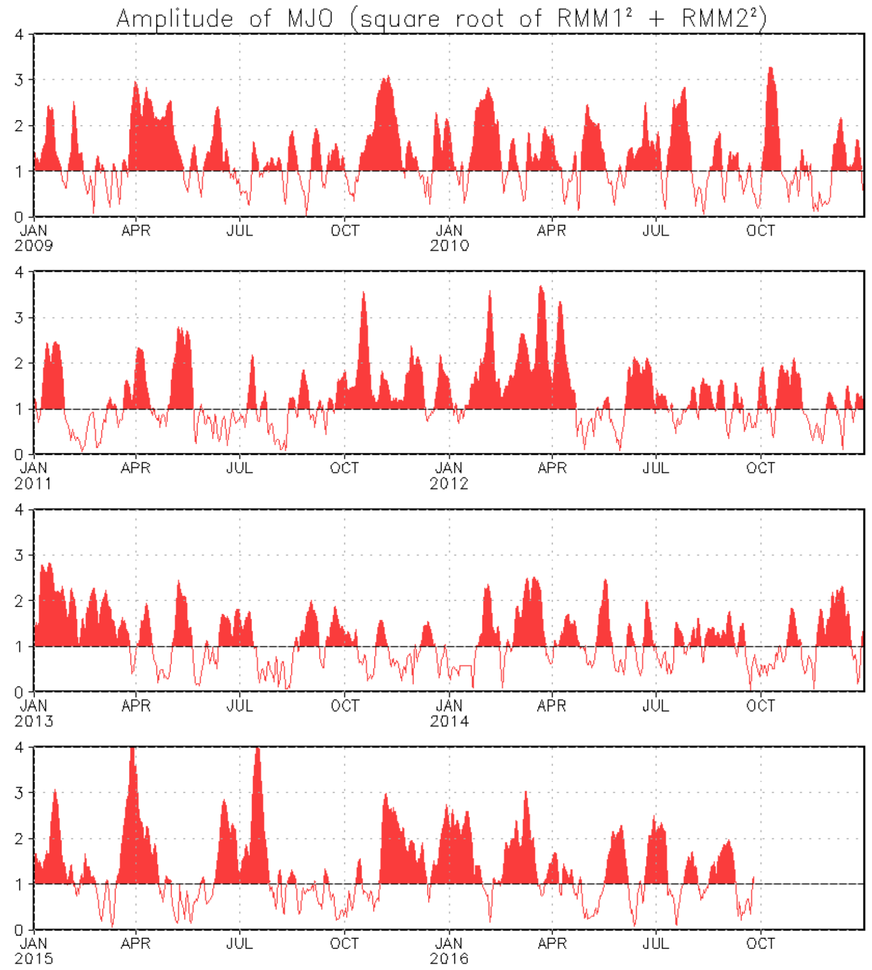


The RMM index continues to indicate activity over the Maritime Continent, although with little eastward propagation during the past several days.

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.



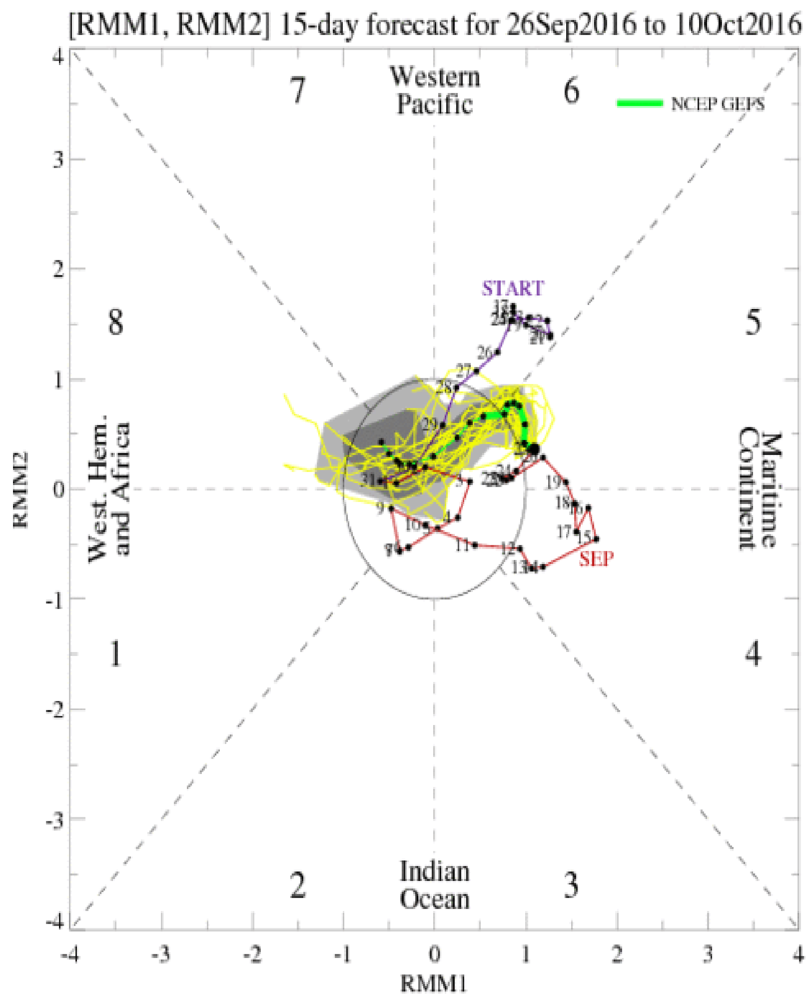
Ensemble GFS (GEFS) MJO Forecast

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



The GFS ensemble forecasts indicate a weakening of the signal during Week-1, with some ensemble members depicting a strengthening signal over the East Pacific by the end of Week-2.

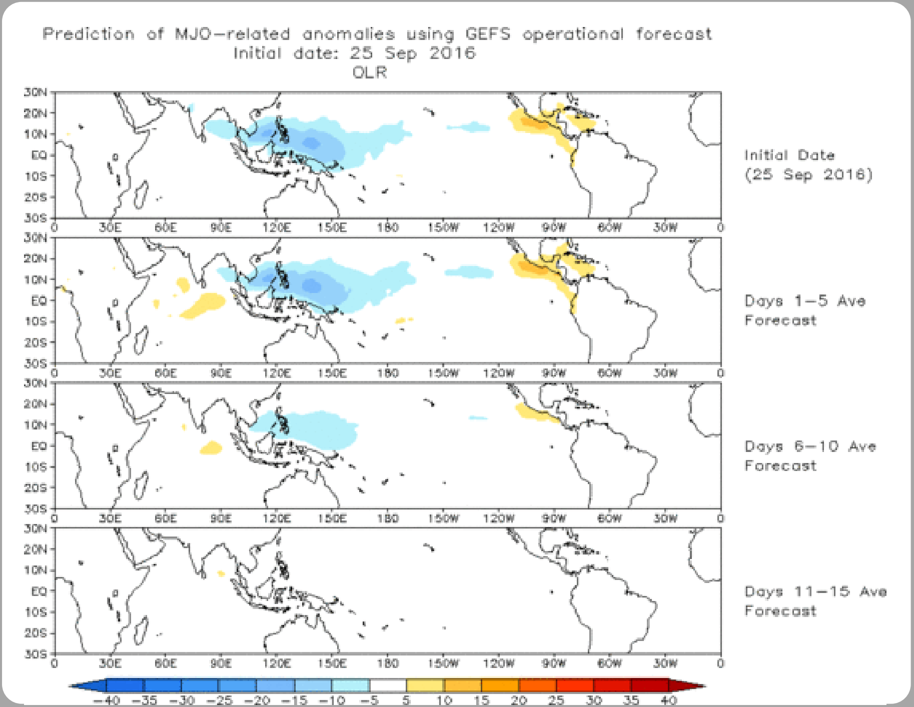
Although the signal is weak, some eastward propagation of an intraseasonal signal is suggested by this forecast.

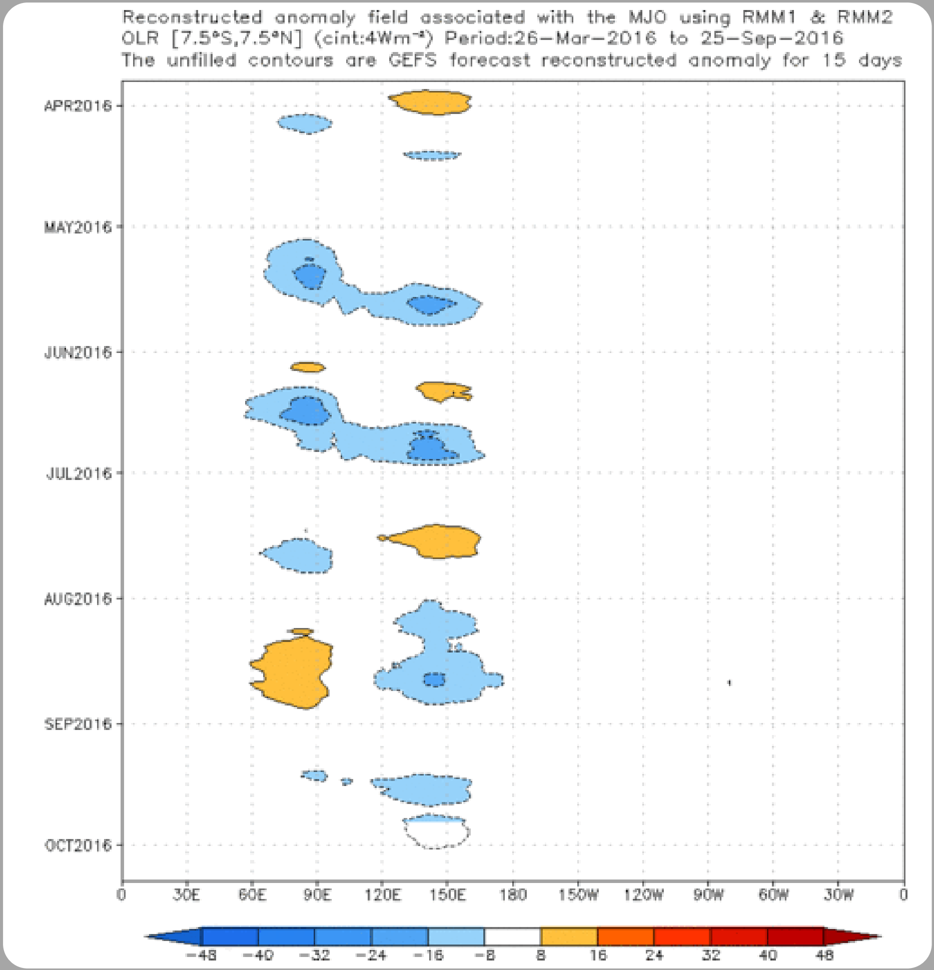
Ensemble GFS (GEFS) MJO Forecast

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



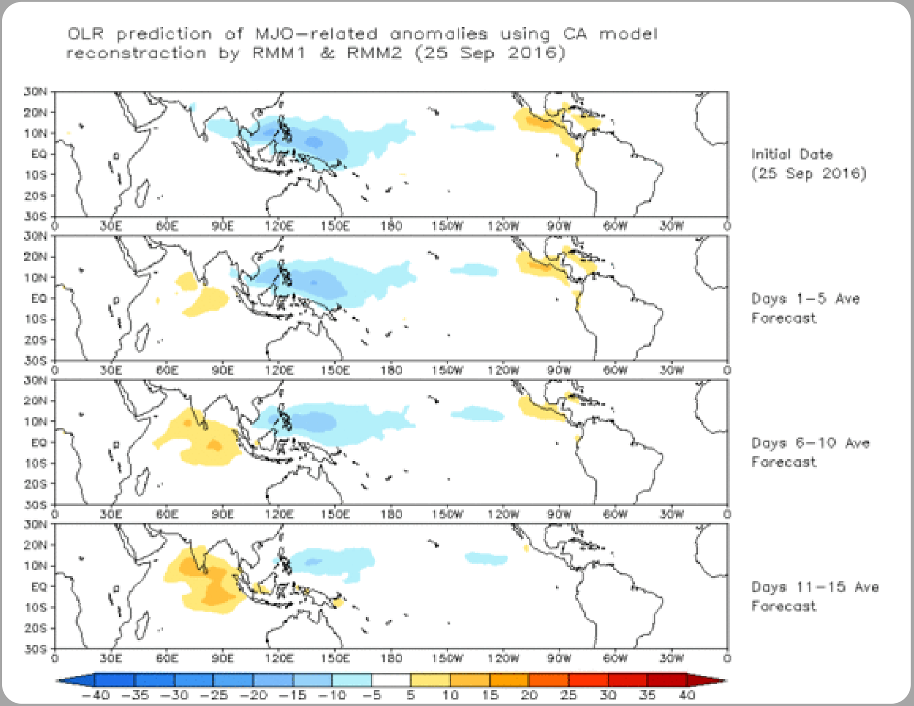


The GEFS RMM Index forecast based OLR anomalies depict a weakening signal over the next two weeks.

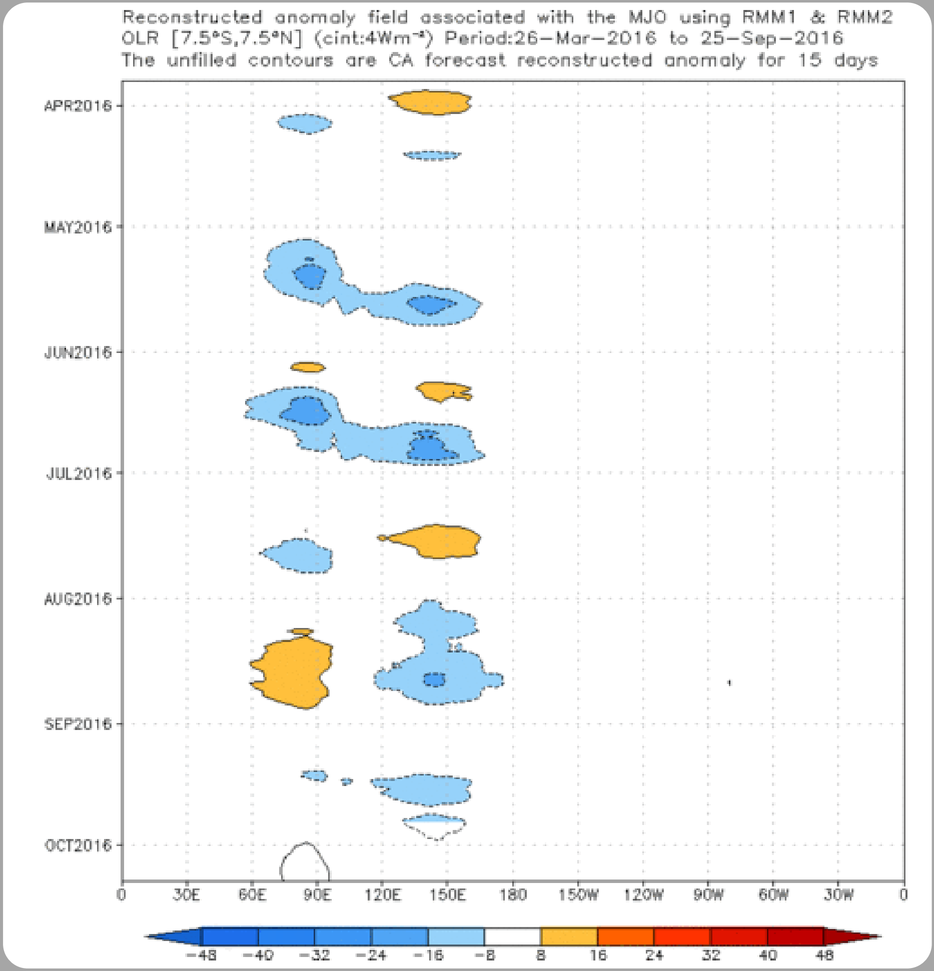
Constructed Analog (CA) MJO Forecast

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



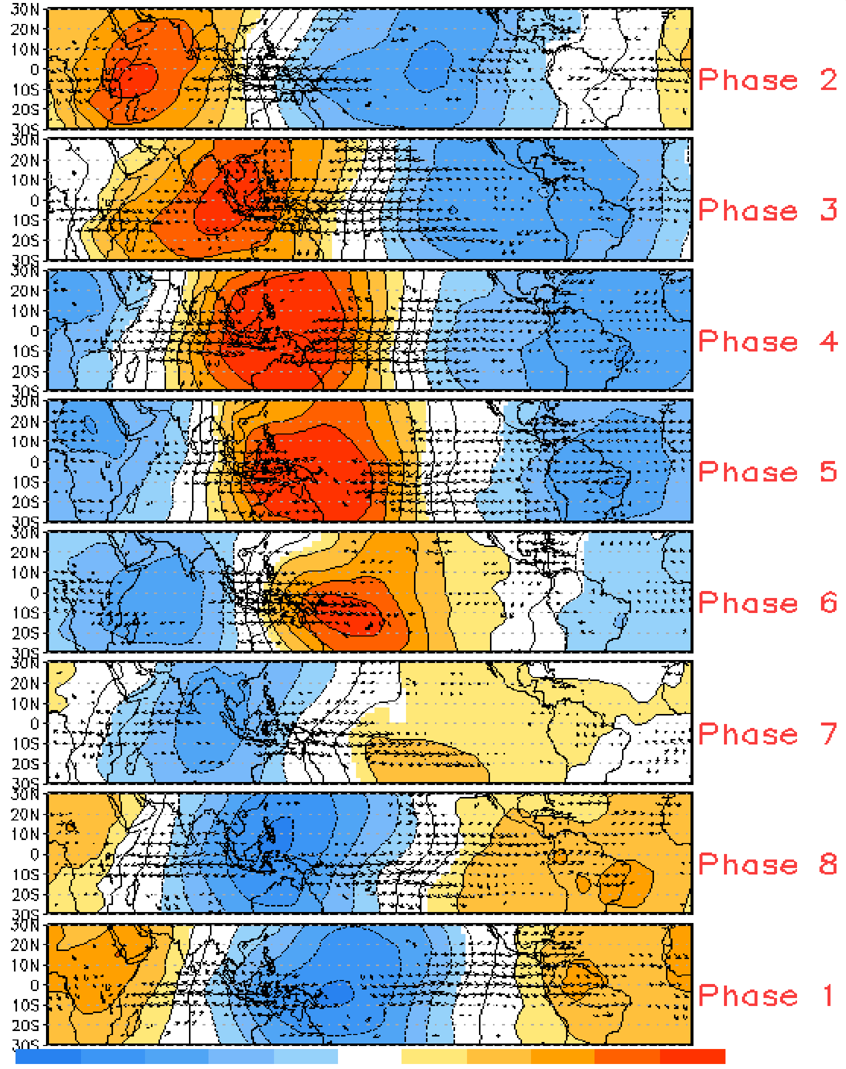
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



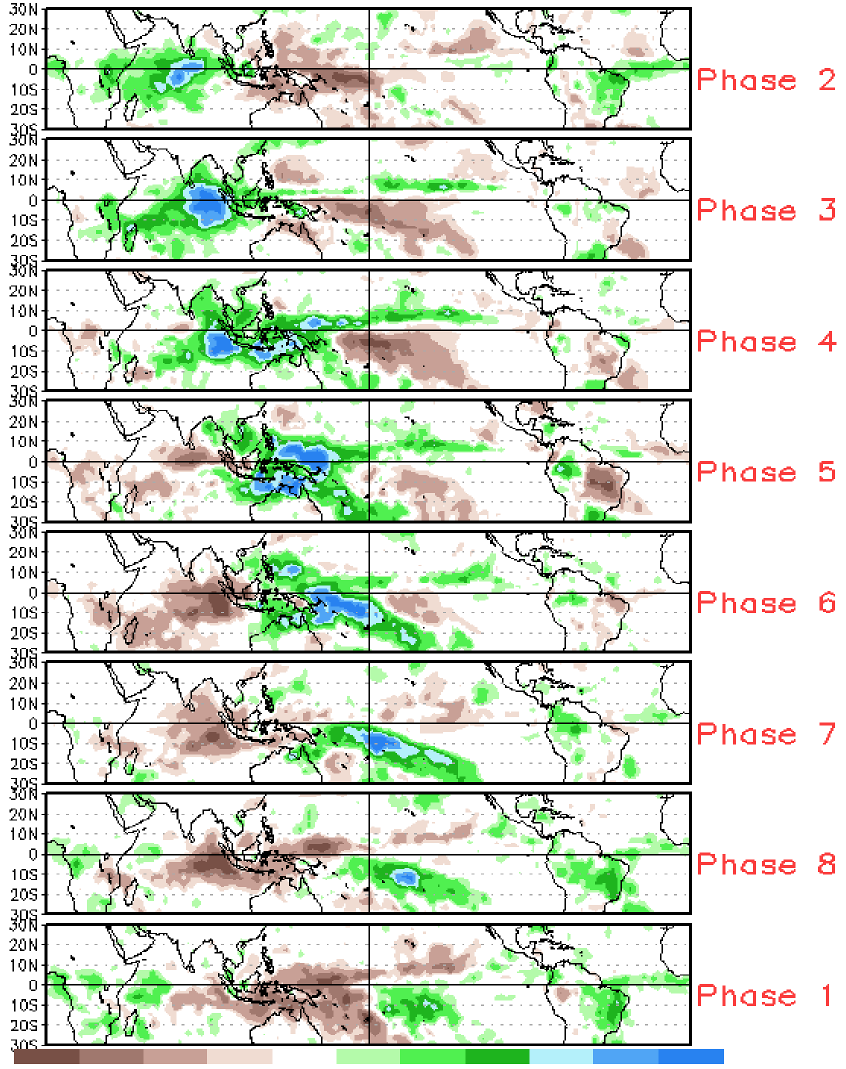
The Constructed Analog (CA) model predicts a slowly evolving and quasi-stationary intraseasonal signal during the next two weeks.

MJO Composites - Global Tropics

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



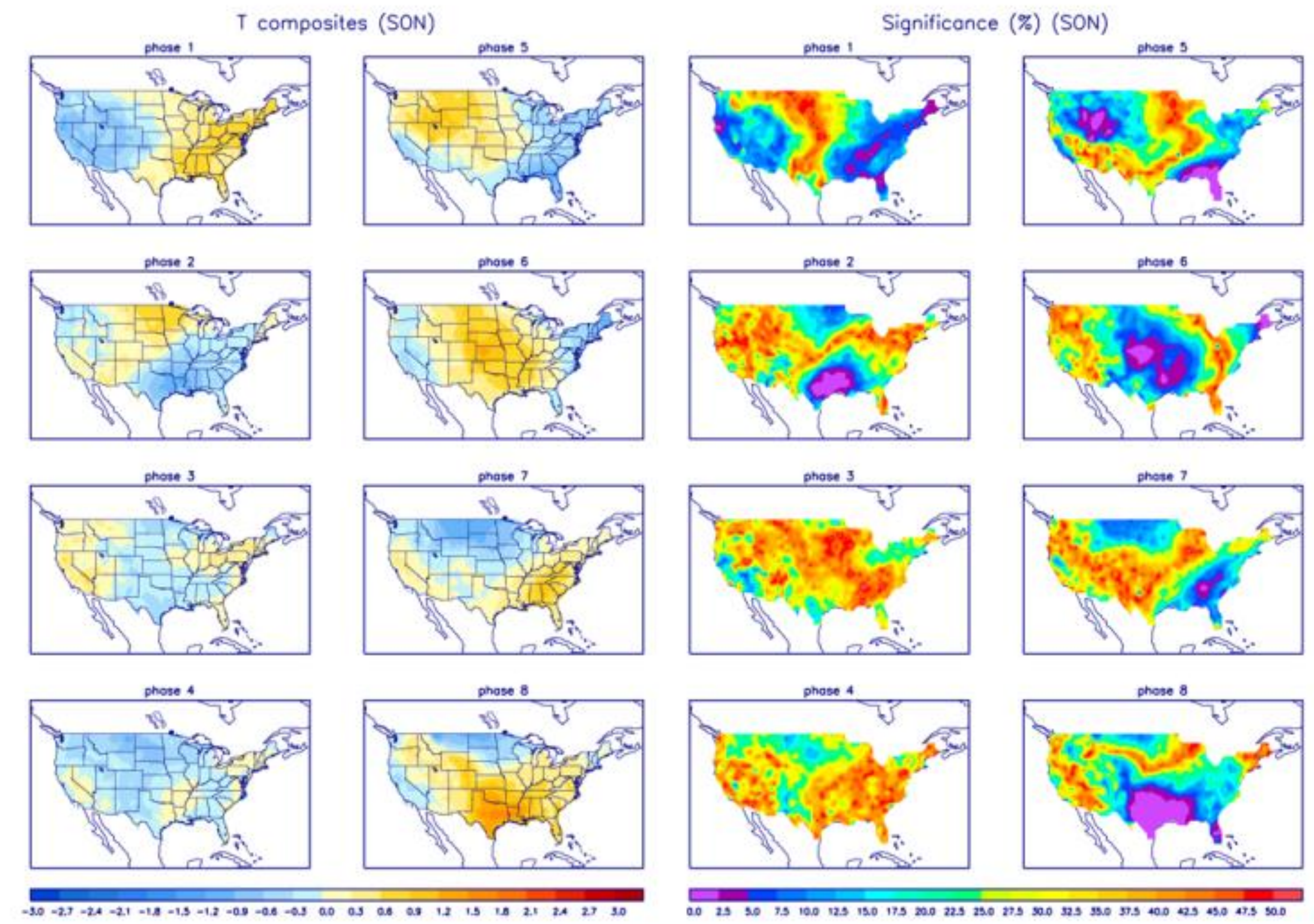
Precipitation Anomalies (May - Sep)



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.



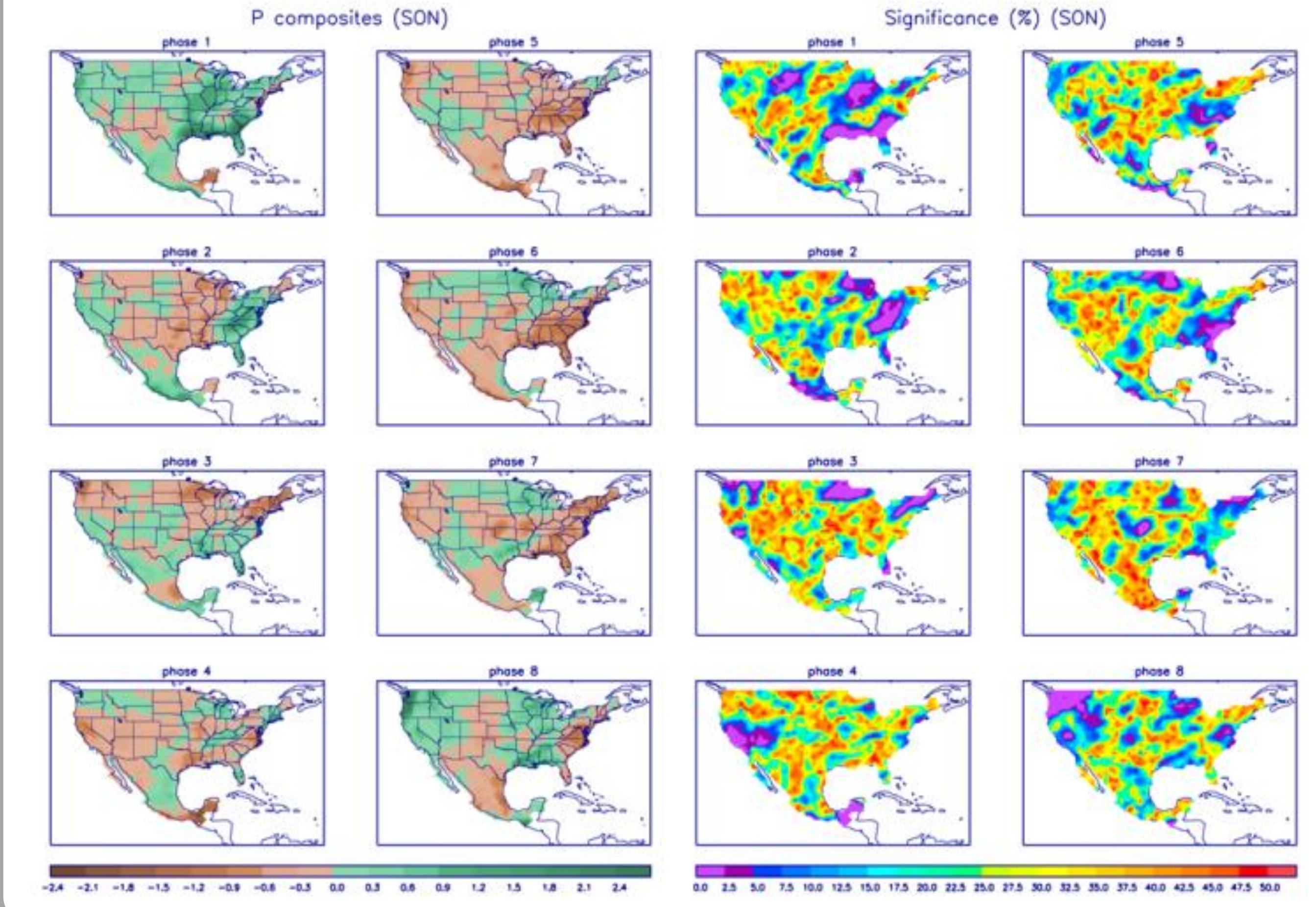
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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