

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



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Recent Evolution and Current Conditions

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MJO Index Forecasts

MJO Composites

Overview

The MJO indices remained fairly weak during the past week, with some indication of an enhanced phase over the West Pacific from CPC's velocity potential index. Influence from other modes, including a slowly evolving base state and the negative phase of the Indian Ocean Dipole, may be interfering with any MJO signal.

Dynamical model forecasts of the RMM-based MJO index are having difficulty resolving competing modes of variability. Lower-frequency modes favor enhanced convection over the Maritime Continent, while higher-frequency modes try to advance these convective envelopes eastward across the Pacific.

The role of the MJO in the evolution of the overall pattern of tropical convection is highly uncertain. 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 may influence tropical cyclone development 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)

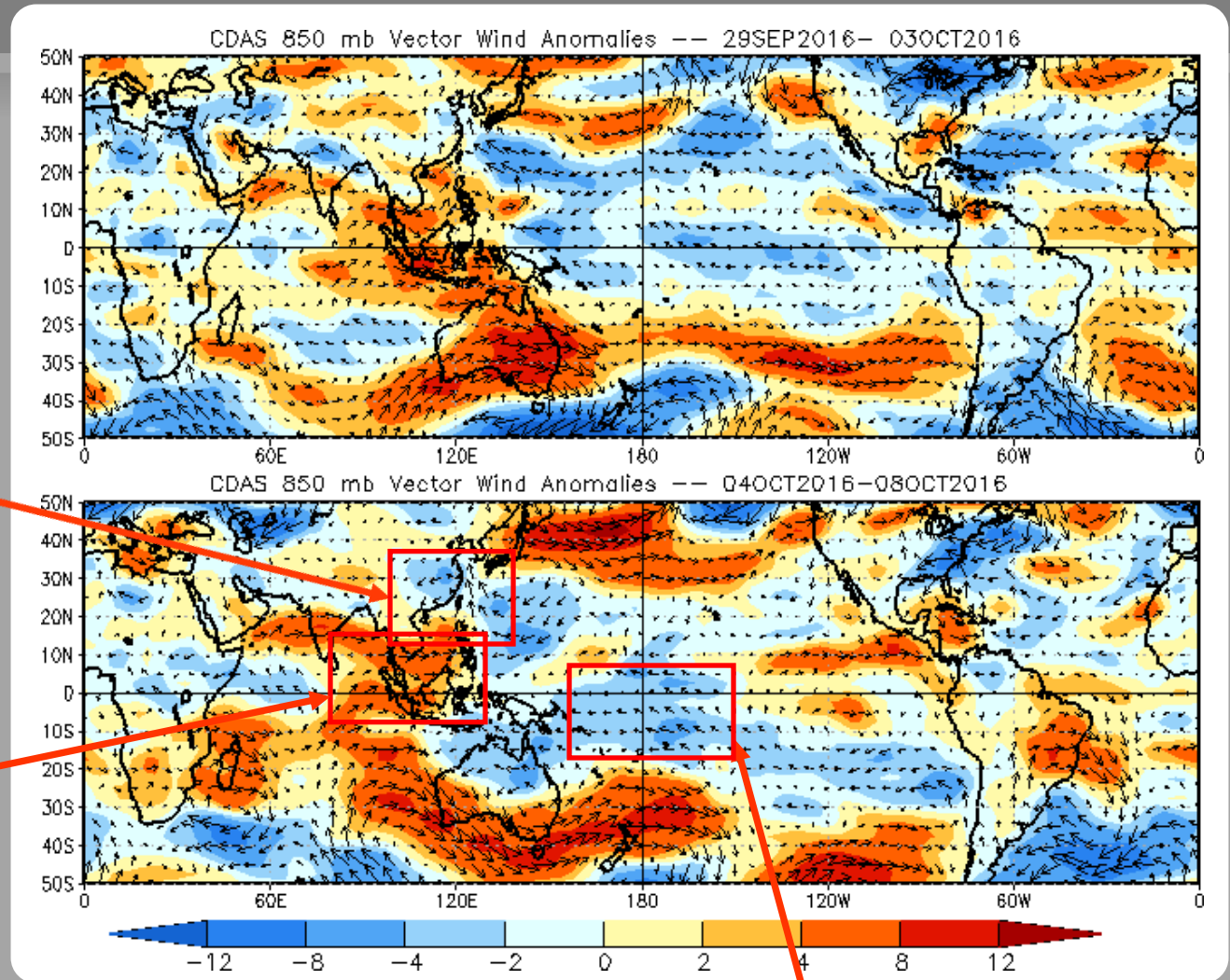
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

A low-level anomalous cyclonic circulation pattern associated with the monsoon gyre is indicated over China.

Anomalous low-level westerly (easterly) wind anomalies have persisted during the past week over the eastern Indian Ocean/Maritime Continent (western Pacific).



Easterly anomalies remain over the central equatorial Pacific basin.

850-hPa Zonal Wind Anomalies (m s⁻¹)

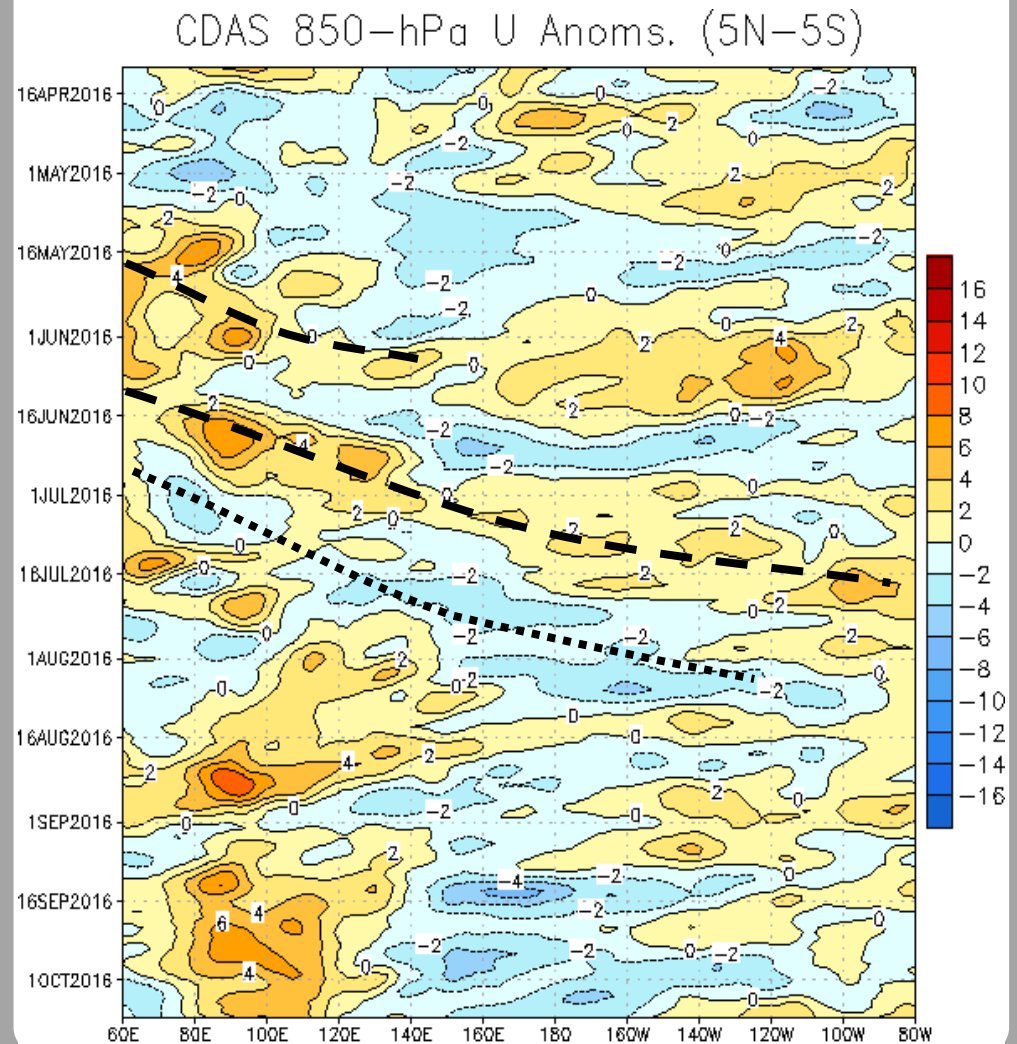
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

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 are low frequency in nature, and may reflect a developing La Niña base state as well as a negative phase of the Indian Ocean Dipole (IOD).



OLR Anomalies - Past 30 days

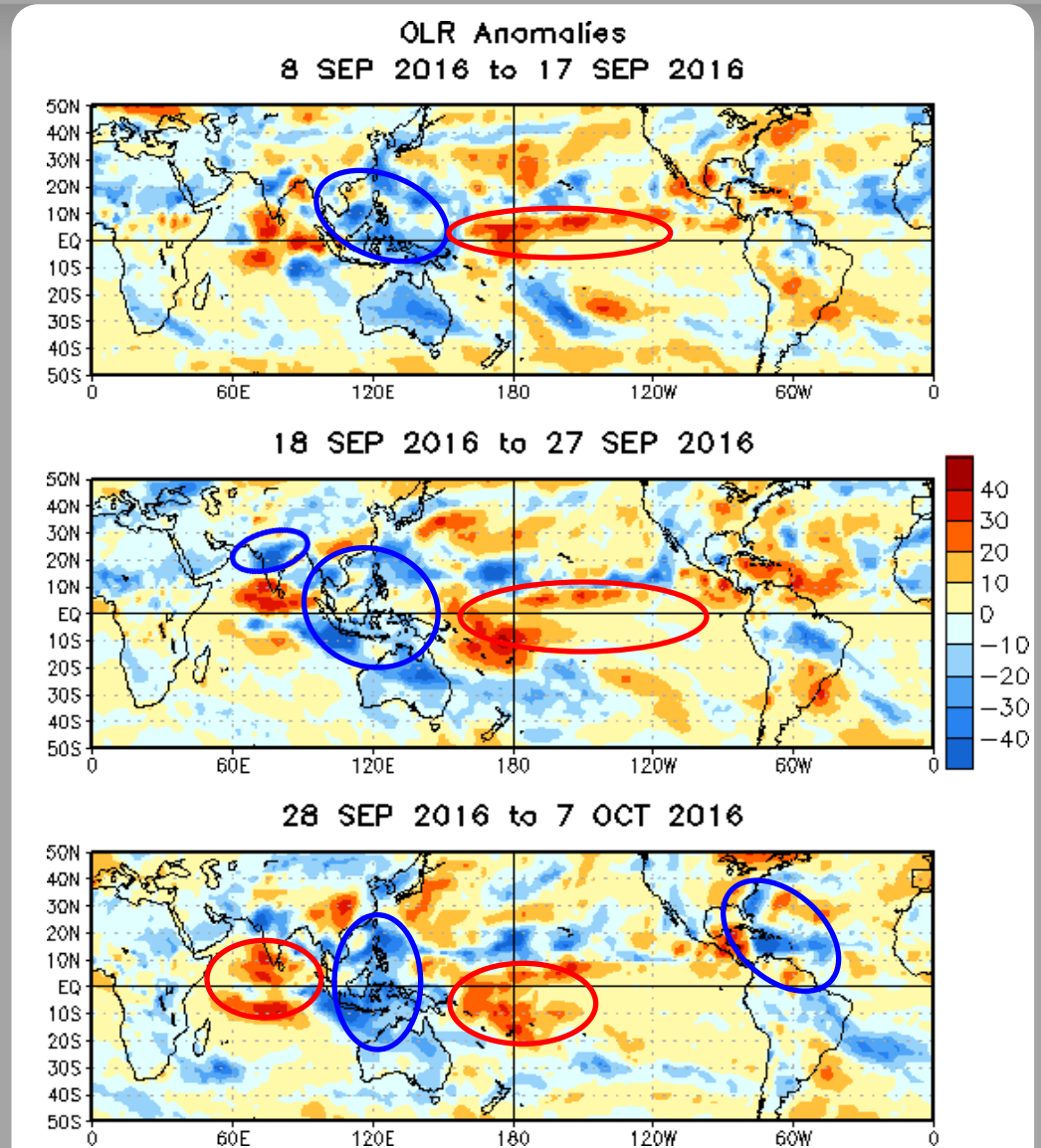
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During early to mid September, enhanced convection overspread the Maritime Continent, while suppressed convection persisted over the central Pacific.

During mid to late September, enhanced (suppressed) convection persisted over the Maritime Continent and northwest India (central and southern Pacific). Enhanced convection over northwest India was associated with monsoon activity.

Suppressed convection persisted over the central and southern Pacific, and the northern Indian Ocean, while enhanced convection remained in place over the Maritime Continent. The track of Hurricane Matthew is evident in the Atlantic basin.



Outgoing Longwave Radiation (OLR) Anomalies (7.5°S - 7.5°N)

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

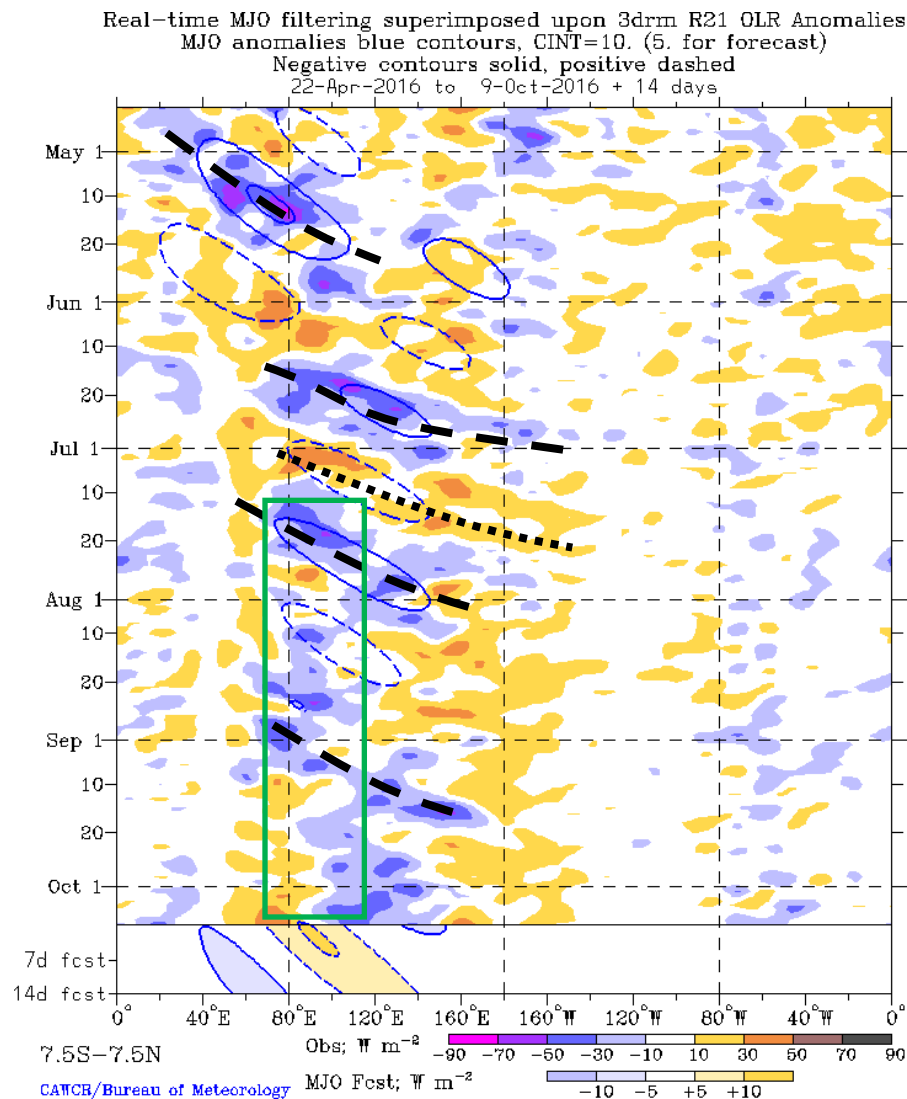
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

The 2015-2016 El Niño background state 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 related to a negative phase Indian Ocean Dipole event.

During September, a fast eastward moving convective envelope was evident, likely linked to intraseasonal activity. More recently, the OLR pattern became stationary, featuring enhanced (suppressed) convection near 120E (the Date Line).



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

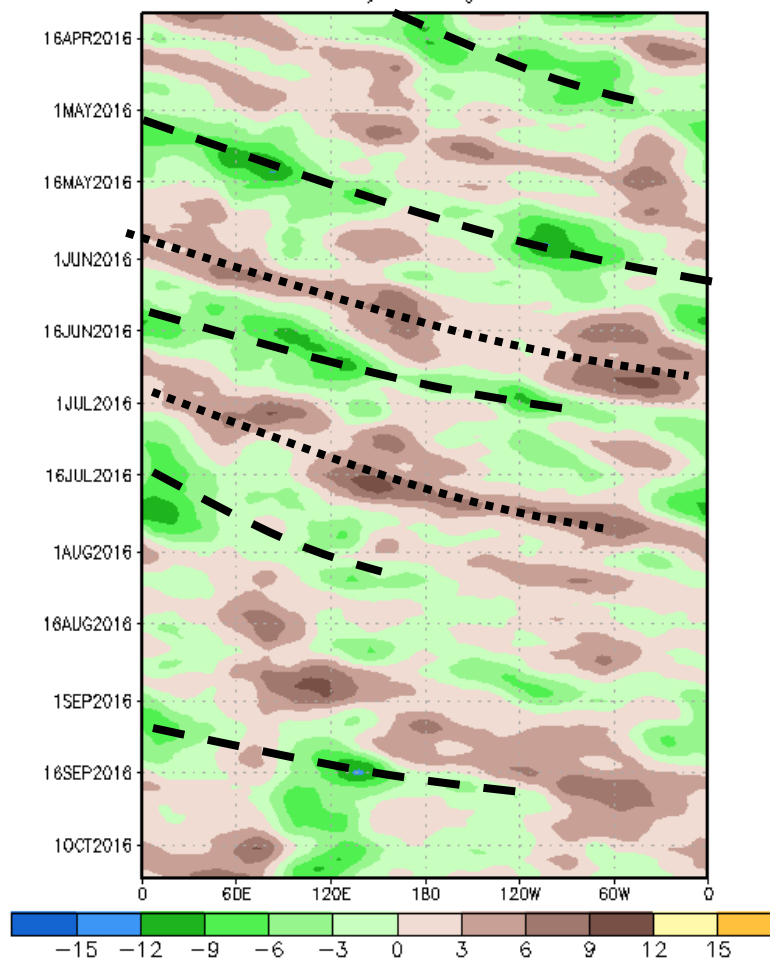
The upper-level velocity potential pattern became less coherent as El Niño waned during April.

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

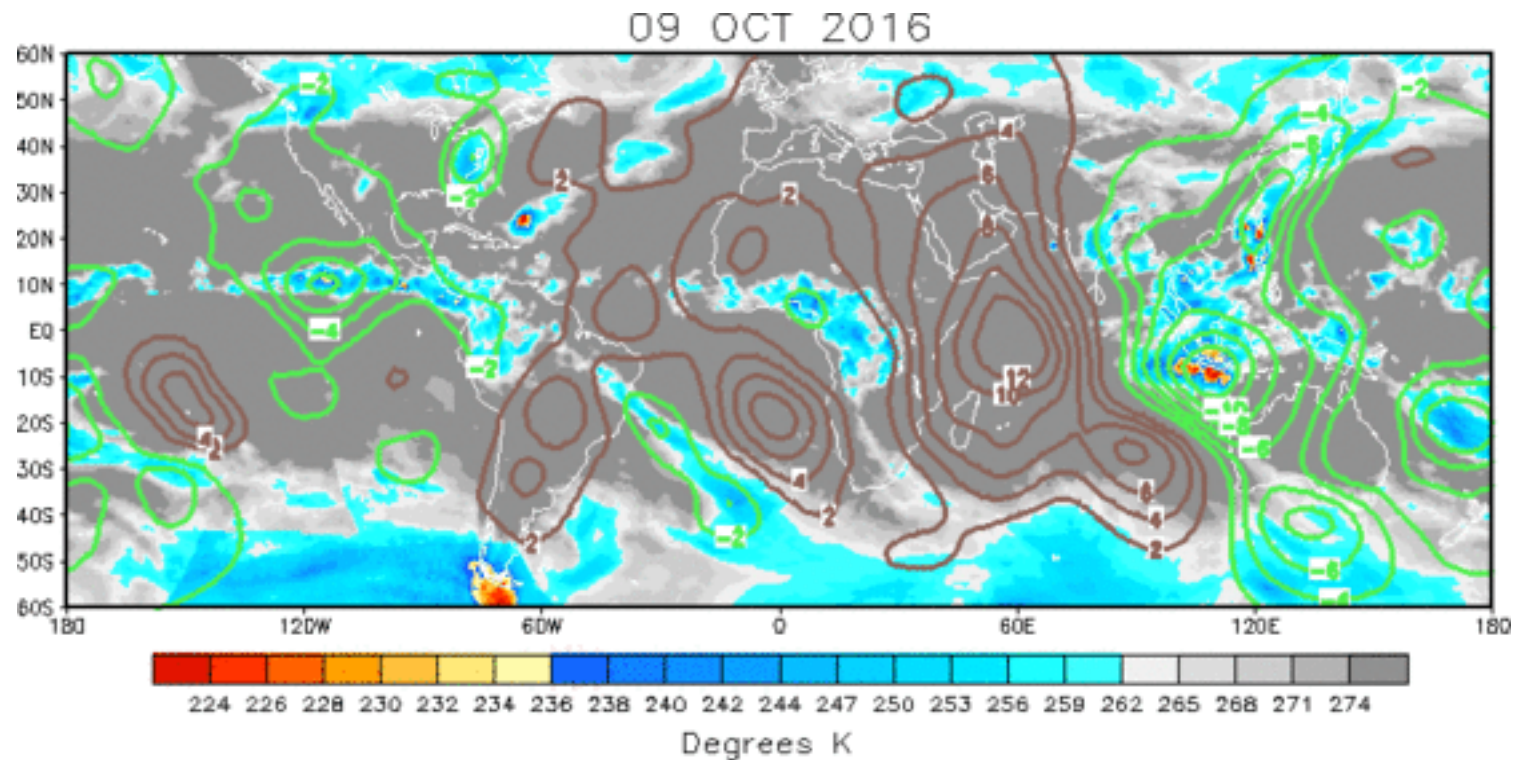
During August, the intraseasonal signal became less coherent, with a weaker and somewhat more stationary anomaly field in place. By late August and early September, there was renewed propagation of the intraseasonal signal.

More recently, probable Kelvin wave activity during the first half of September has given way to lower frequency modes and a quasi-stationary pattern.

200-hPa Velocity Potential Anomaly: 5N-5S
5-day Running Mean



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



A very strong dipole pattern is evident with anomalous divergence (convergence) centered over the Maritime Continent (western Indian Ocean). Elsewhere the velocity potential pattern is ill-defined.

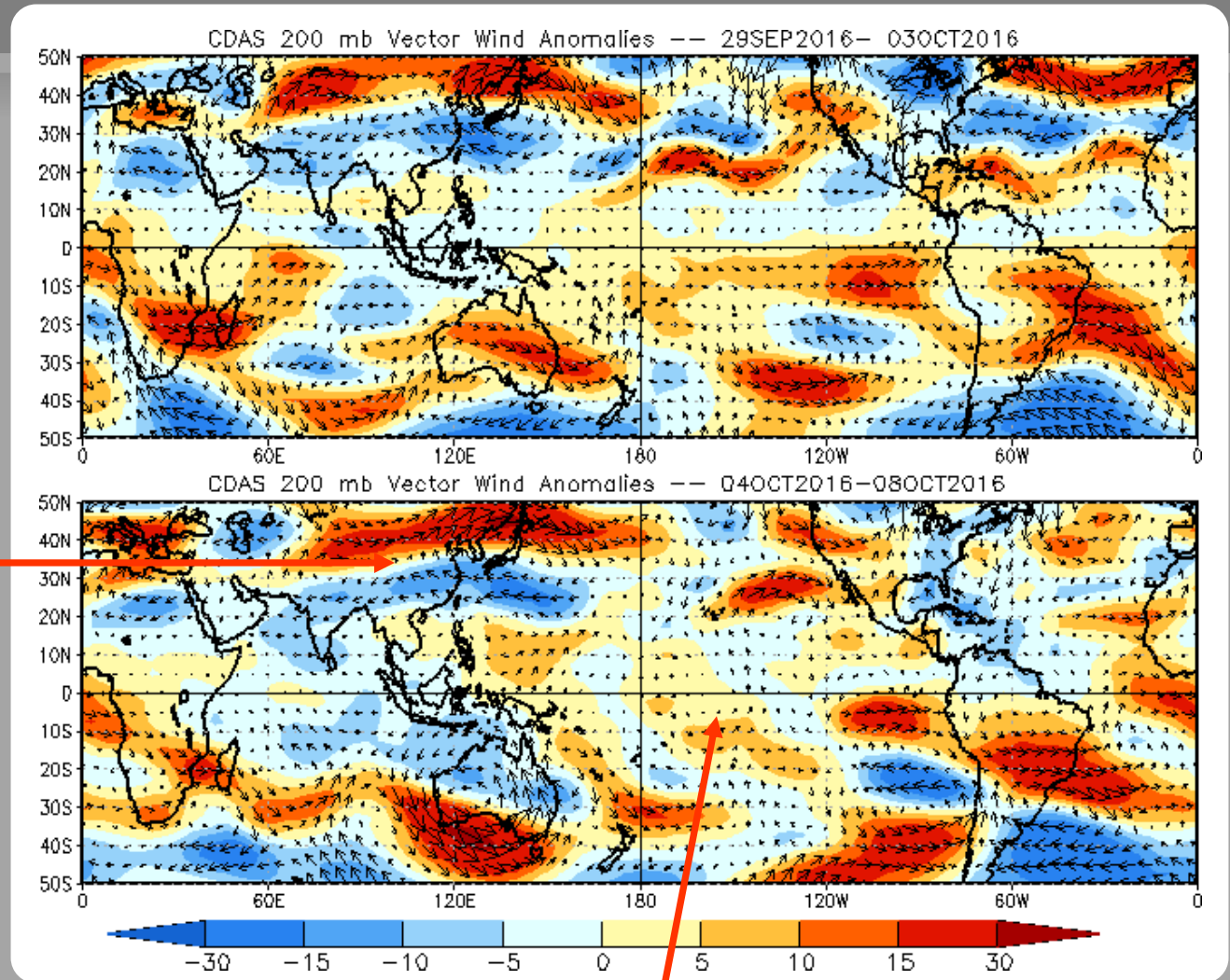
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation
Negative anomalies (green contours) indicate favorable conditions for precipitation

200-hPa Vector Wind Anomalies (m s⁻¹)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



An upper-level anomalous anticyclone is apparent over east Asia.

Weak upper-level westerly anomalies persist over the equatorial Pacific.

200-hPa Zonal Wind Anomalies (m s⁻¹)

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

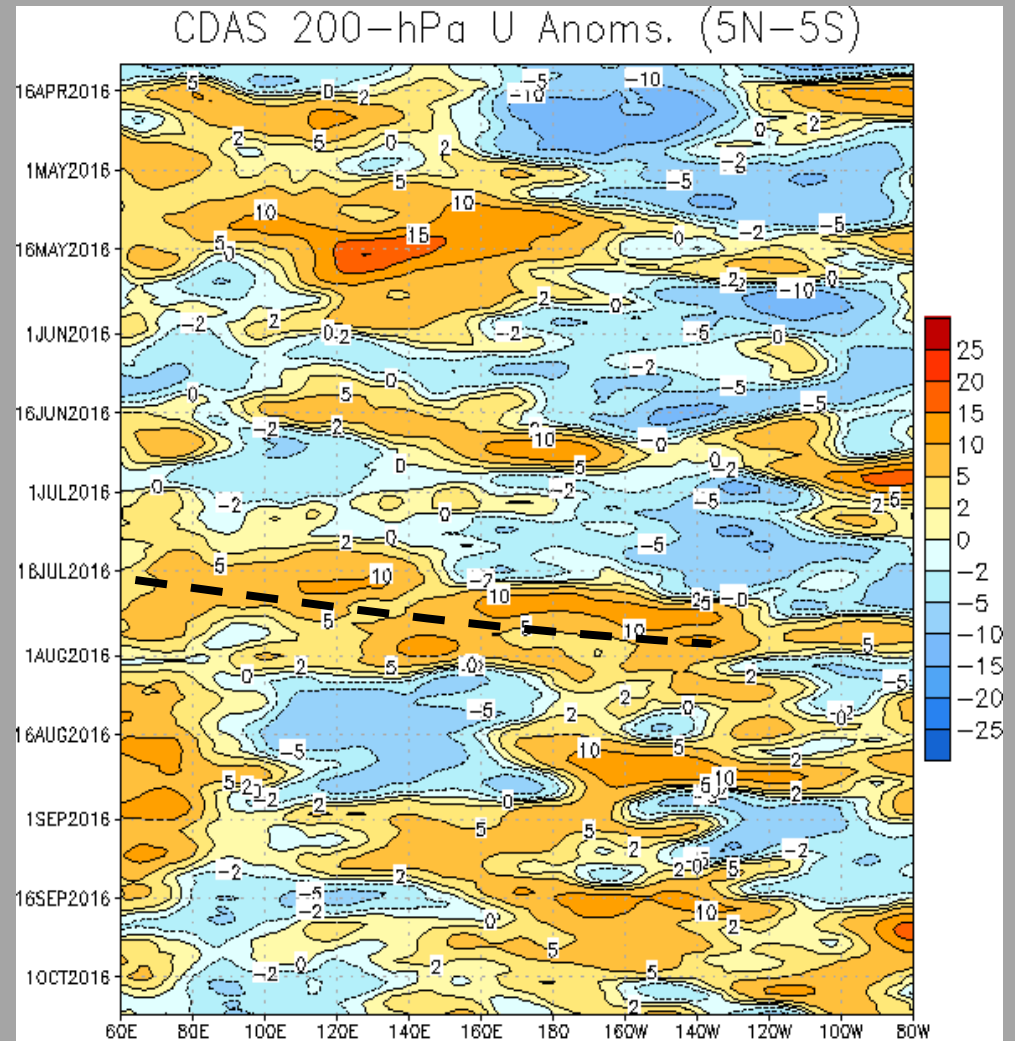
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Easterly anomalies associated with ENSO weakened by May.

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 remained fairly consistent with the low frequency state established during summer.



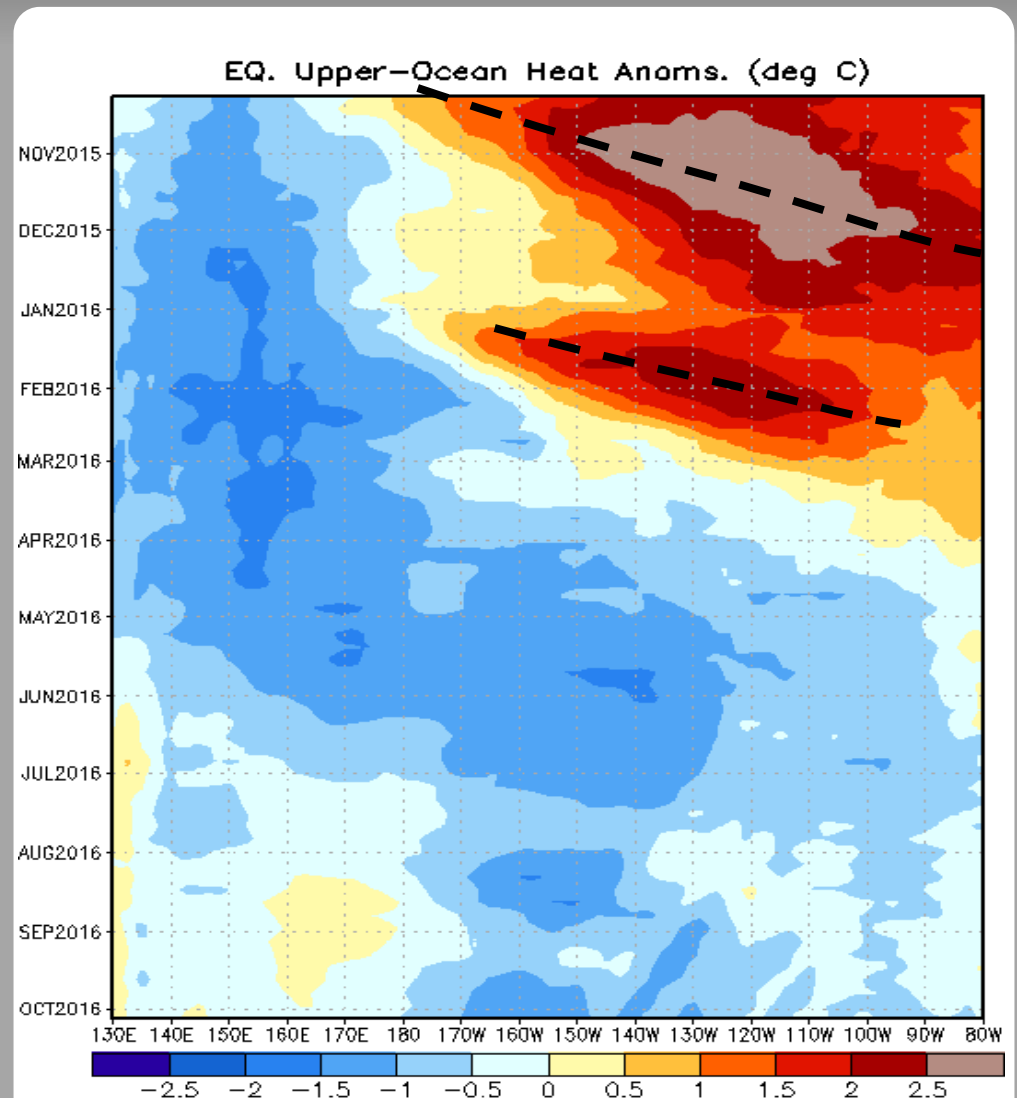
Weekly Heat Content Evolution in the Equatorial Pacific

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.



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

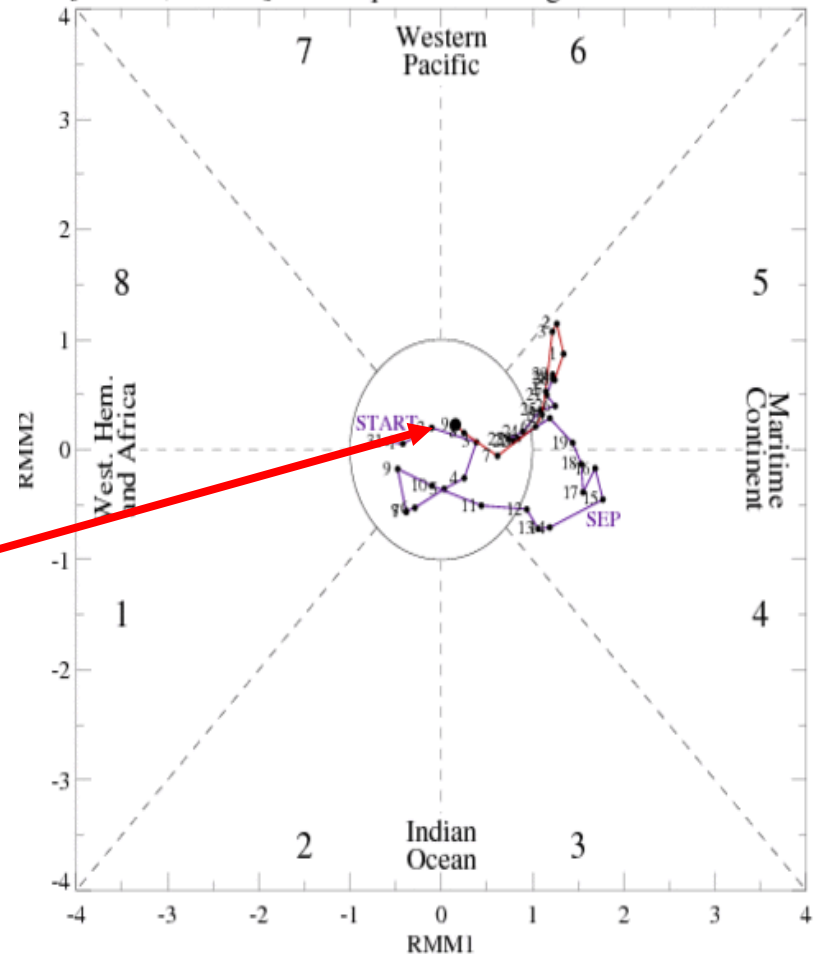
The triangular areas indicate the location of the enhanced phase of the MJO

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

[RMM1, RMM2] Phase Space for 31-Aug-2016 to 09-Oct-2016

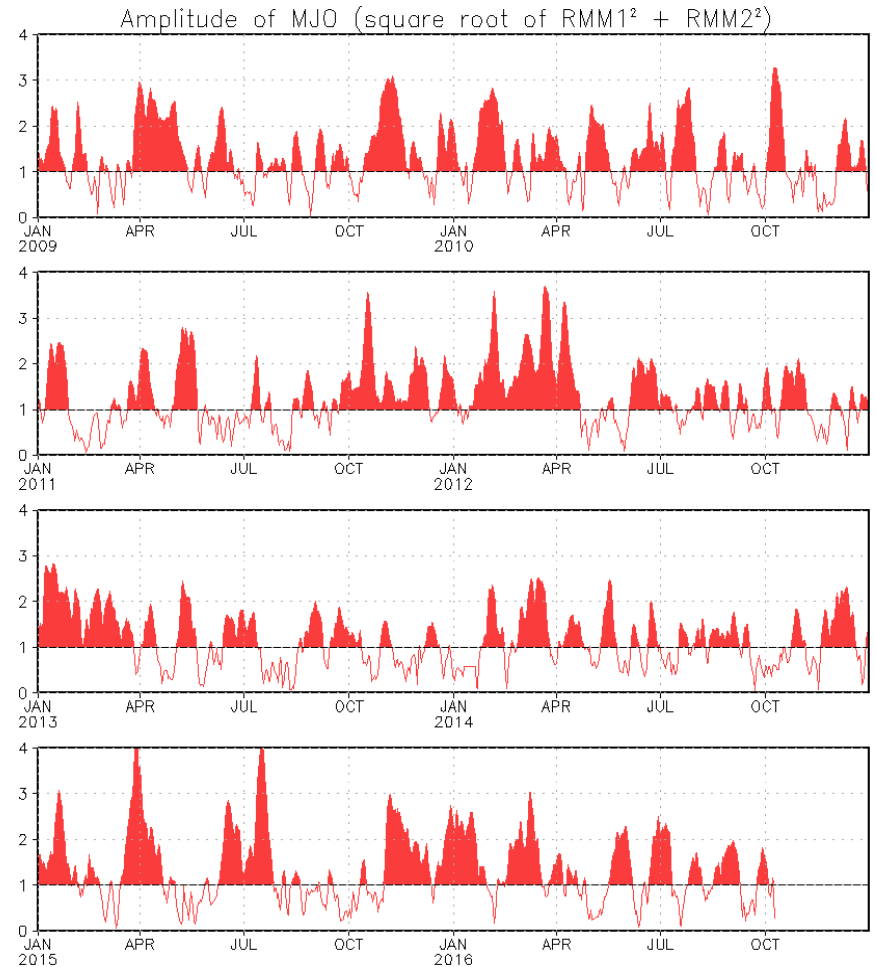


The RMM index shows no coherent MJO activity, with recent values within the unit circle.

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

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

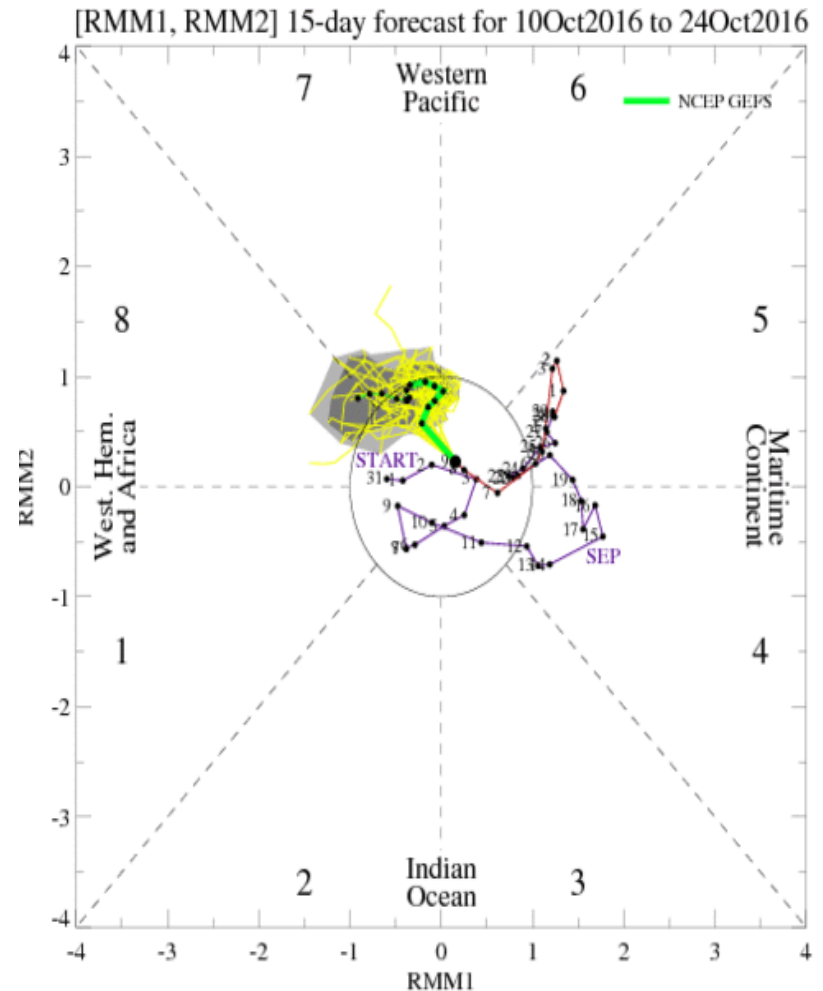
light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GFS ensemble forecasts depict a fairly weak, nearly stationary signal over the Pacific during the next two weeks.

Due to competing modes of variability, including the low-frequency state, the various dynamical models depict varying solutions with respect to the RMM index.

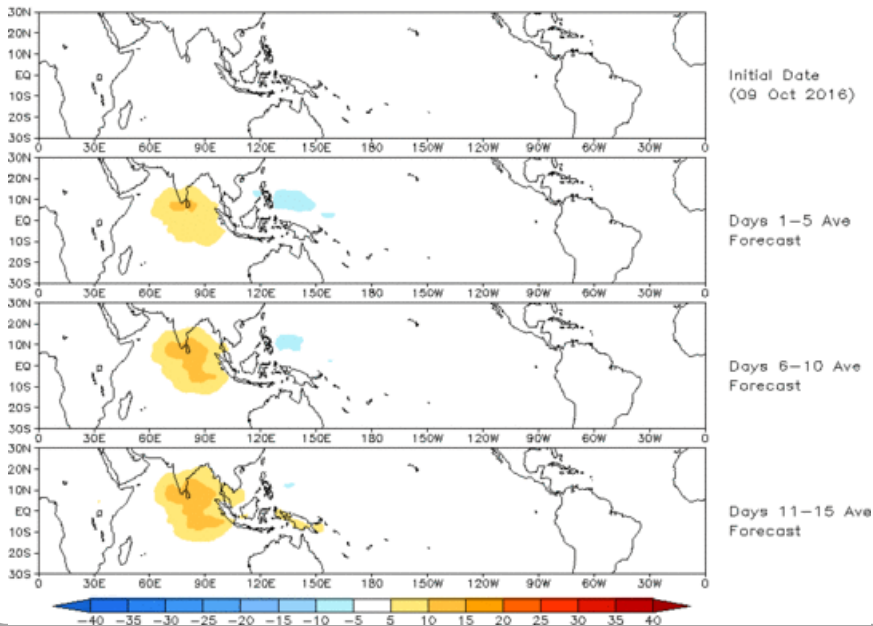
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean



Ensemble GFS (GEFS) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

Prediction of MJO-related anomalies using GEFS operational forecast
Initial date: 09 Oct 2016
OLR

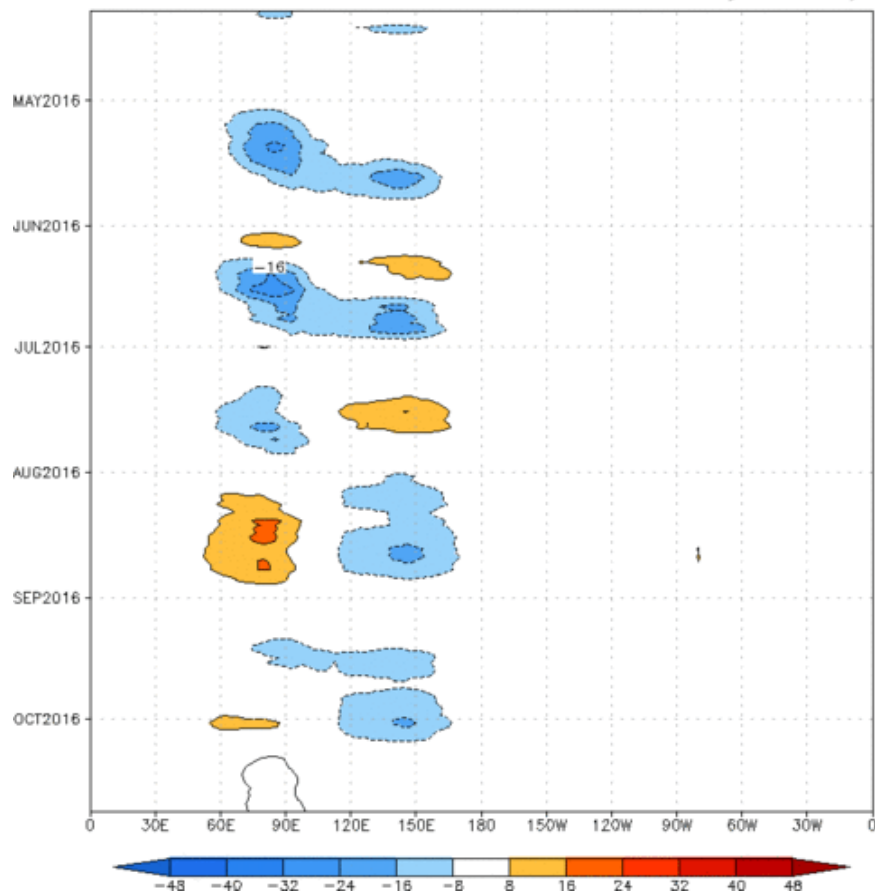


The GEFS RMM Index forecast based OLR anomalies depict a strengthening, quasi-stationary signal with suppressed convection over the Indian Ocean and weakly enhanced convection over the West Pacific over the next two weeks.

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.)

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

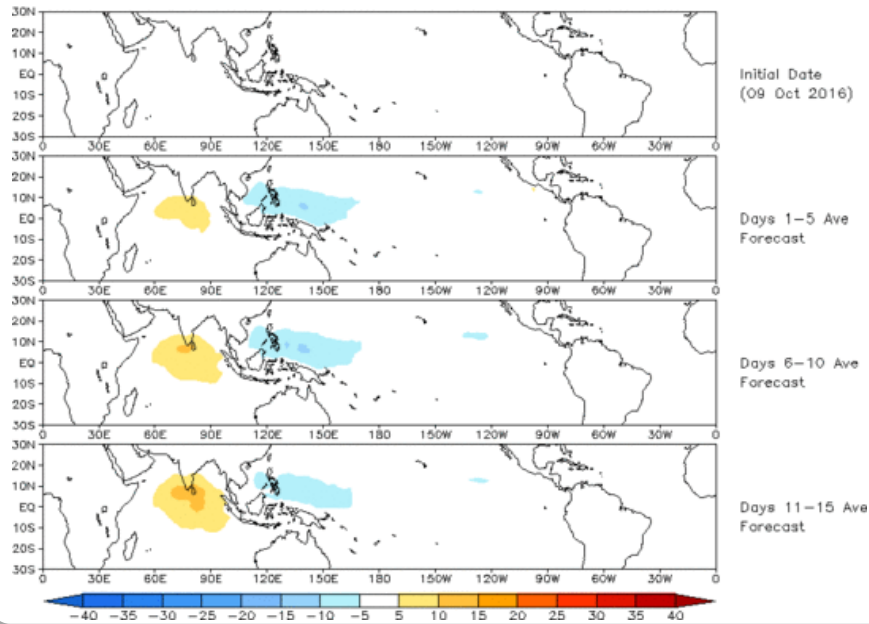
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2
OLR [7.5°S,7.5°N] (cont:4Wm⁻²) Period:09-Apr-2016 to 09-Oct-2016
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days



Constructed Analog (CA) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

OLR prediction of MJO-related anomalies using CA model reconstruction by RMM1 & RMM2 (09 Oct 2016)

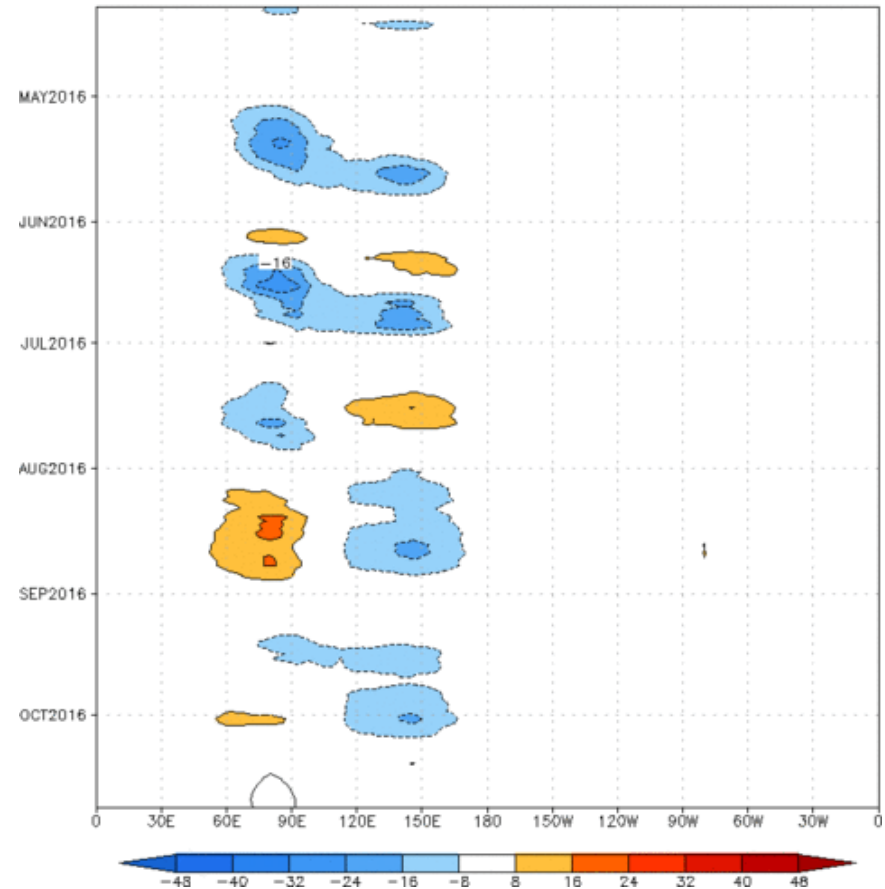


The Constructed Analog (CA) model predicts a stationary dipole in convection with suppressed (enhanced) activity favored over the Indian Ocean (West Pacific).

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.)

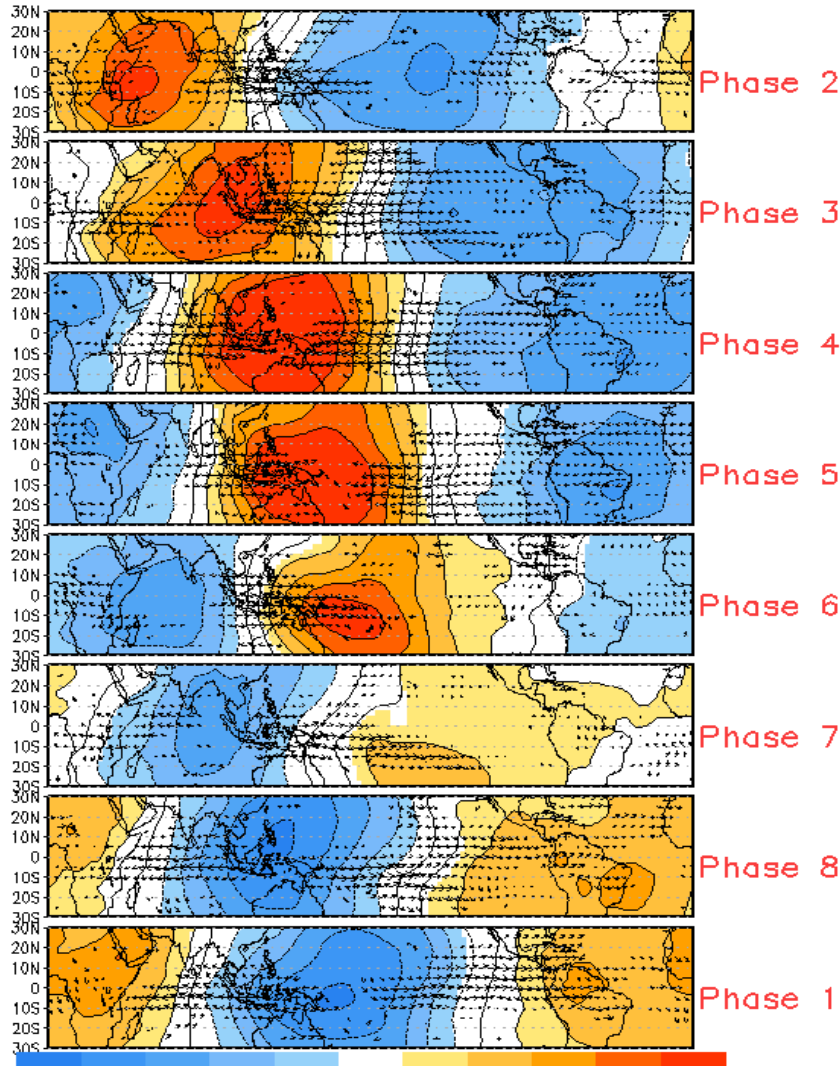
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [7.5°S,7.5°N] (cont:4Wm⁻²) Period:09-Apr-2016 to 09-Oct-2016 The unfilled contours are CA forecast reconstructed anomaly for 15 days

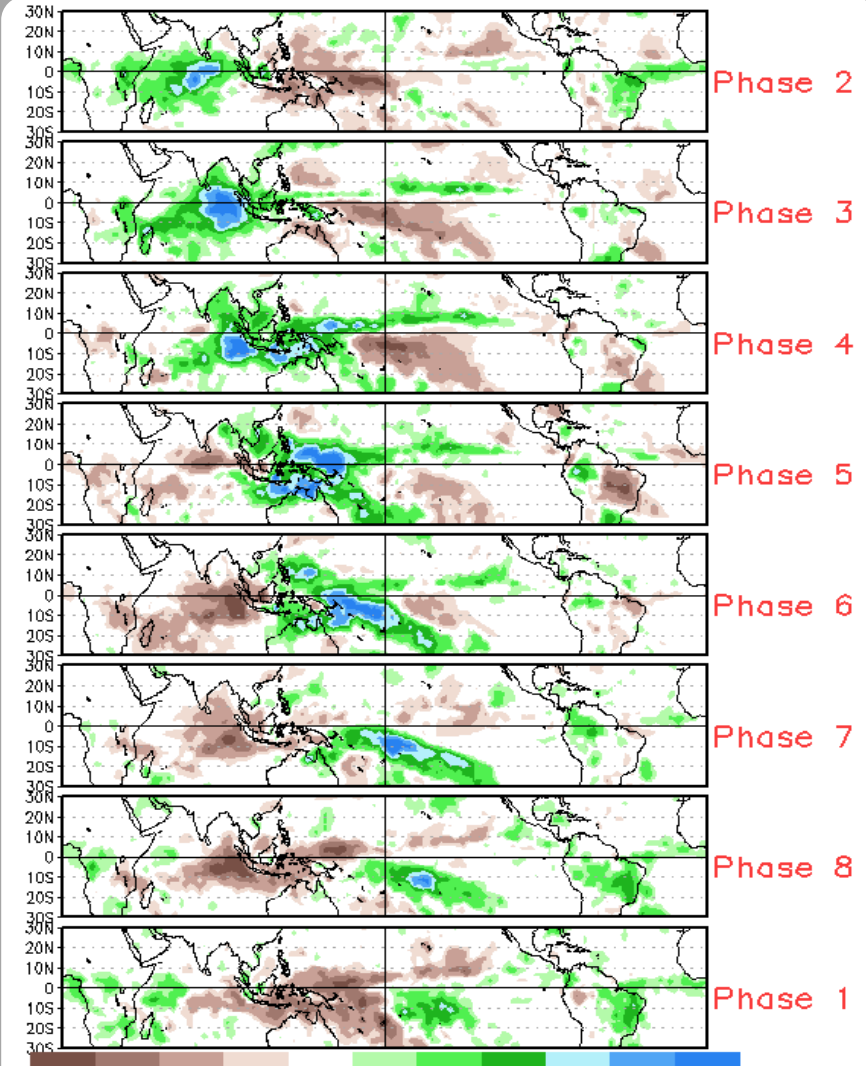


MJO Composites - Global Tropics

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



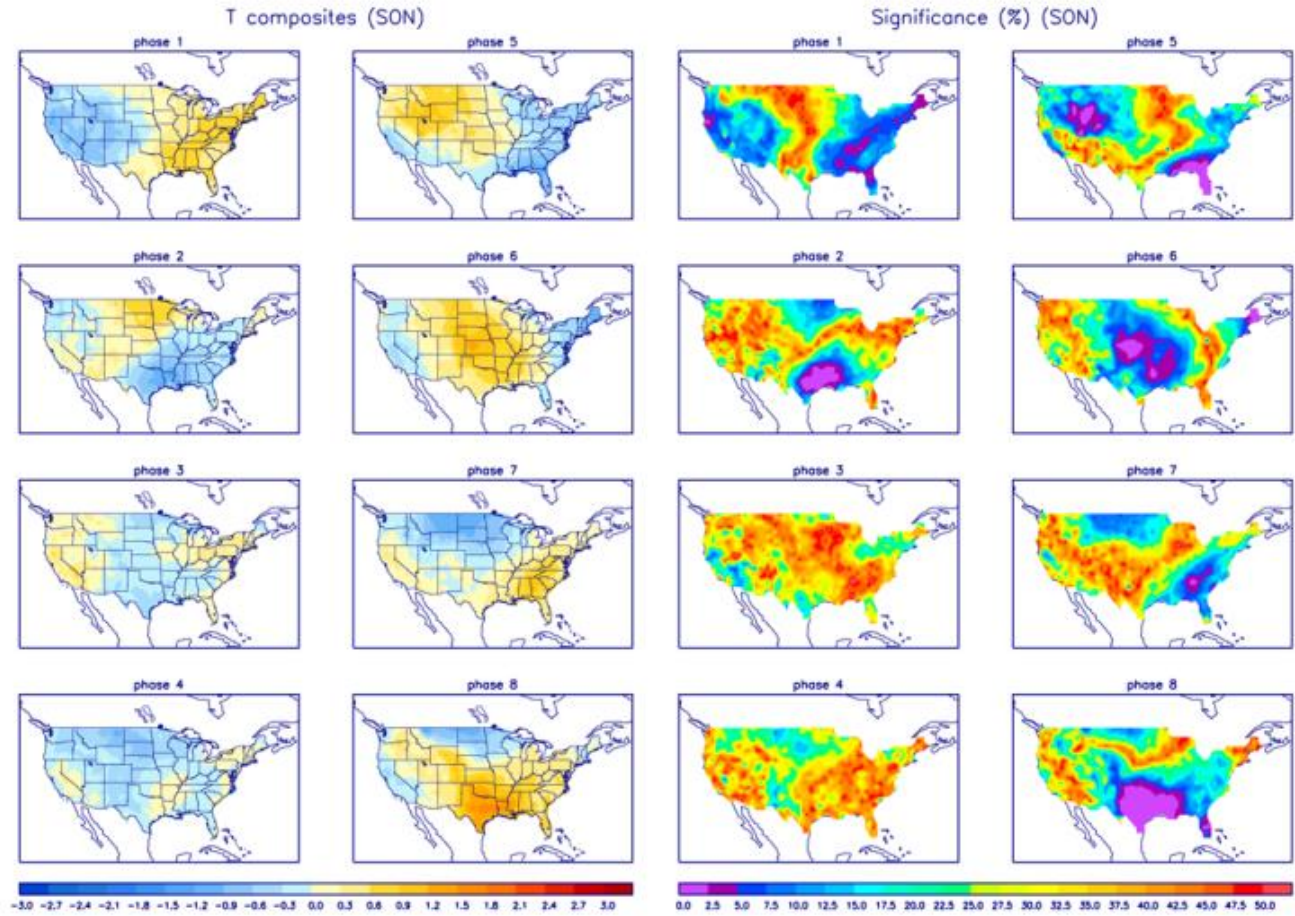
Precipitation Anomalies (May - Sep)



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.



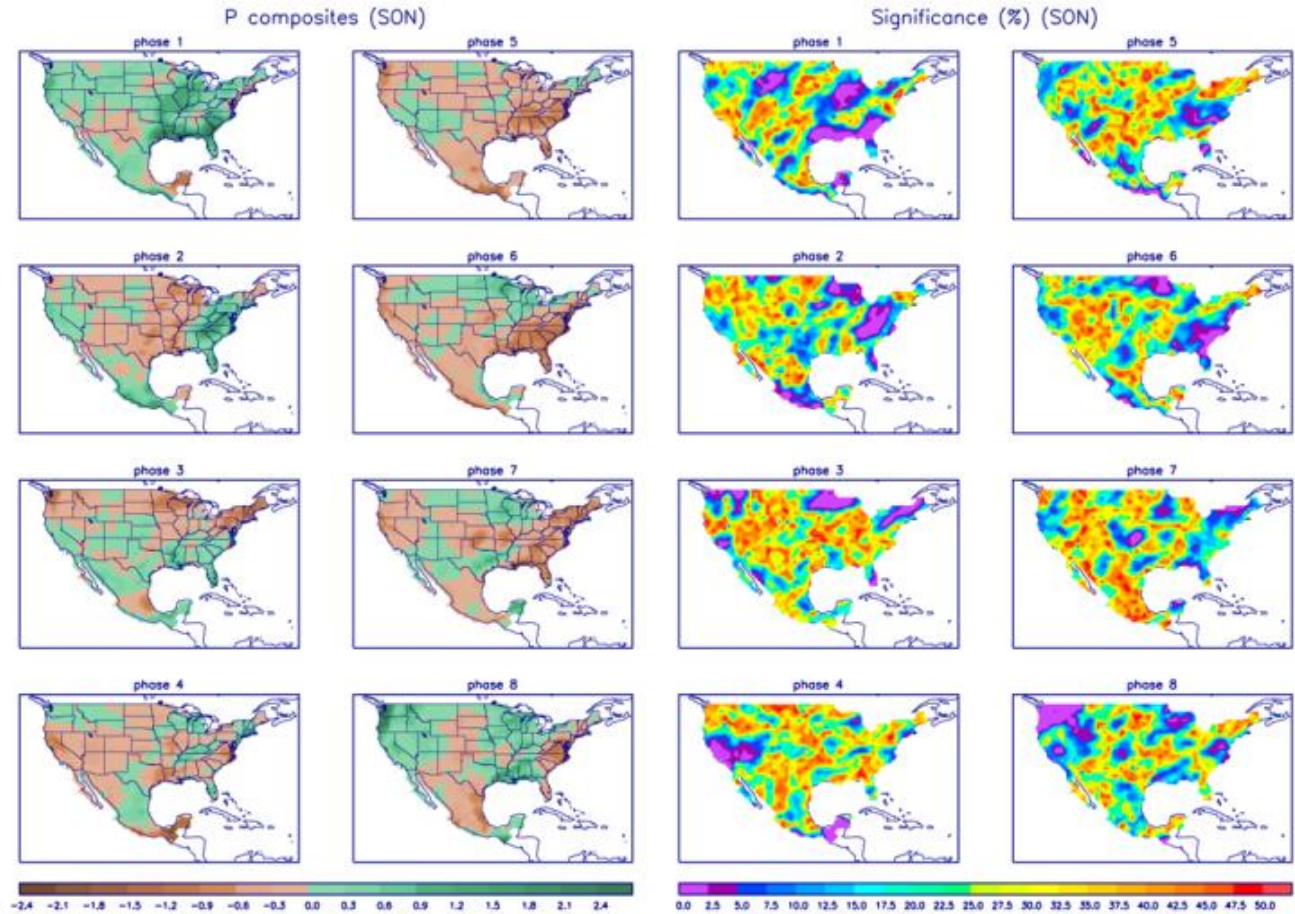
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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

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