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

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Outline

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Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The MJO is in Phase 2 and its convectively active region is approaching the Maritime Continent.

- The MJO is likely to continue propagating eastward for the next week or so, but interference with Kelvin and Rossby waves is adding considerable noise to the RMM signal.

- The MJO's future is uncertain. The most likely situation is that it peters out during Week-2 and then re-emerges over the Indian Ocean around the end of the month.

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)

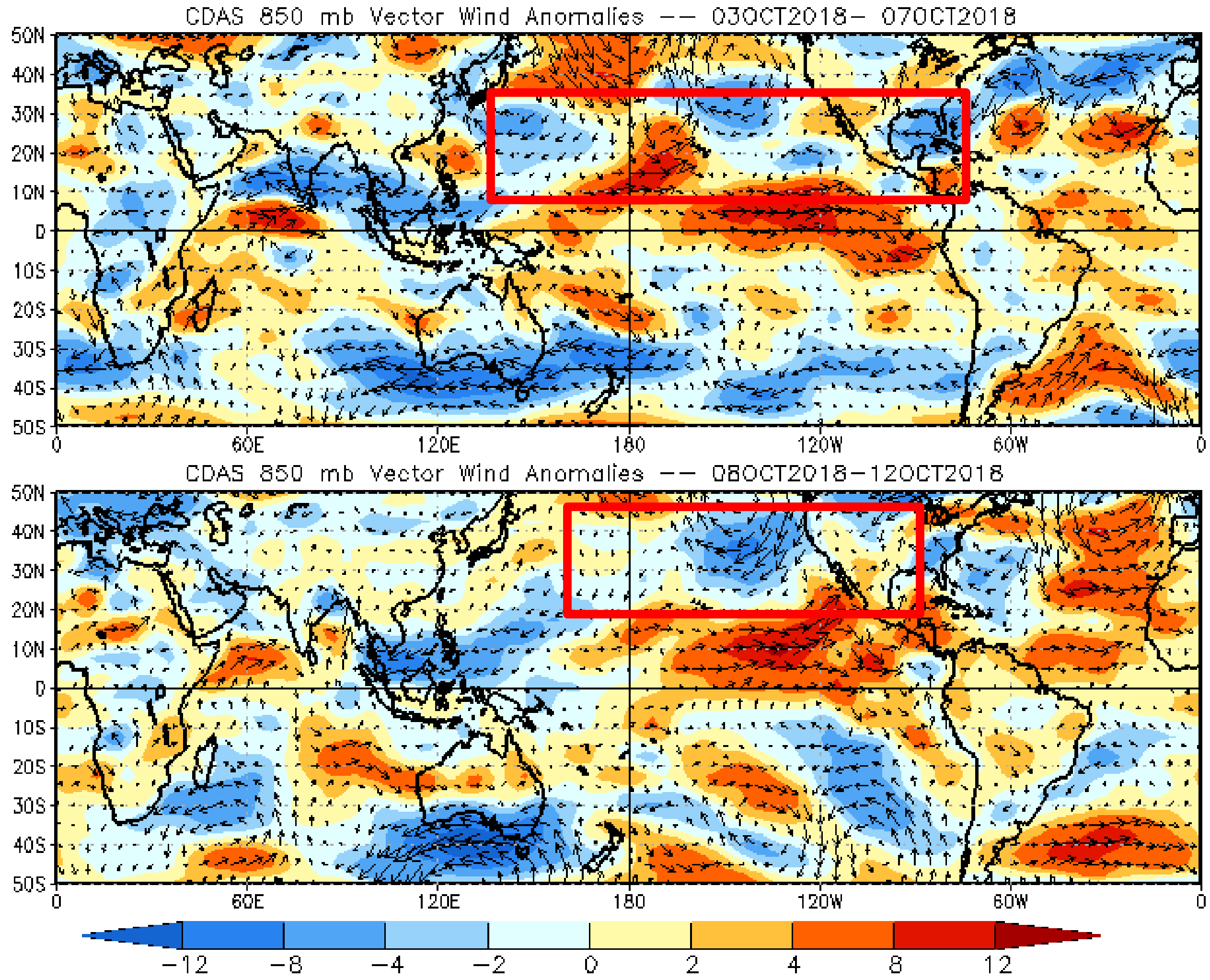
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Low-level anomalous westerlies persisted across much of the tropical pacific during late September.

The strongest East Pacific anomalous westerlies have moved northeast. Extratropical wave trains are present in both hemispheres.



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

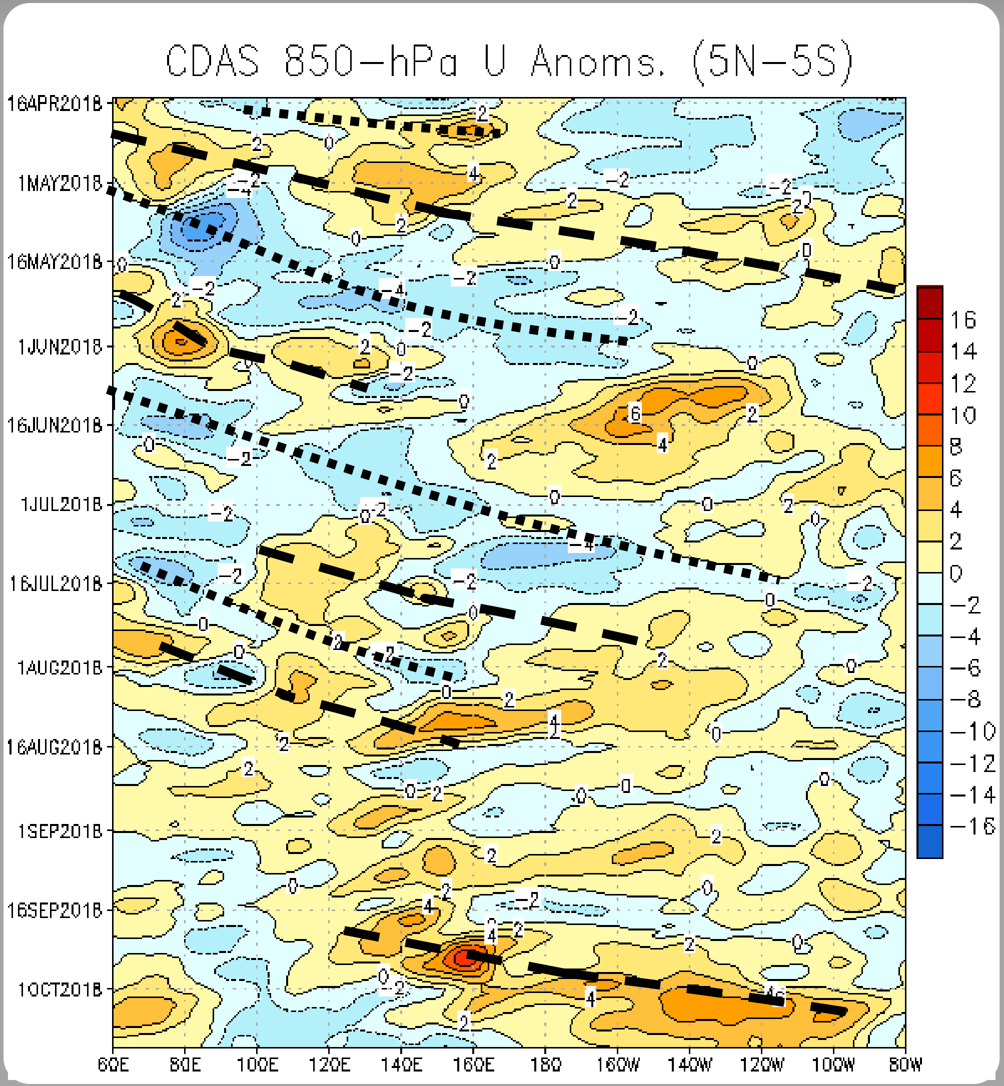
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

The MJO was active during late April and May. Westward moving variability weakened the signal in June. A weak intraseasonal signal re-emerged during mid to late July. During August, the intraseasonal signal weakened, and other modes, including Rossby wave and tropical cyclone activity, influenced the pattern.

Through much of September, Rossby wave activity continued to dominate the Pacific, while westerly anomalies overspread the equatorial Pacific.

During late September, signs of a westerly windburst near 160 E are evident. Westerly anomalies have continued to strengthen over the central and eastern Pacific. This may foreshadow a transition towards El Niño conditions and an increase in the warm water volume availability in the Central Pacific.



OLR Anomalies – Past 30 days

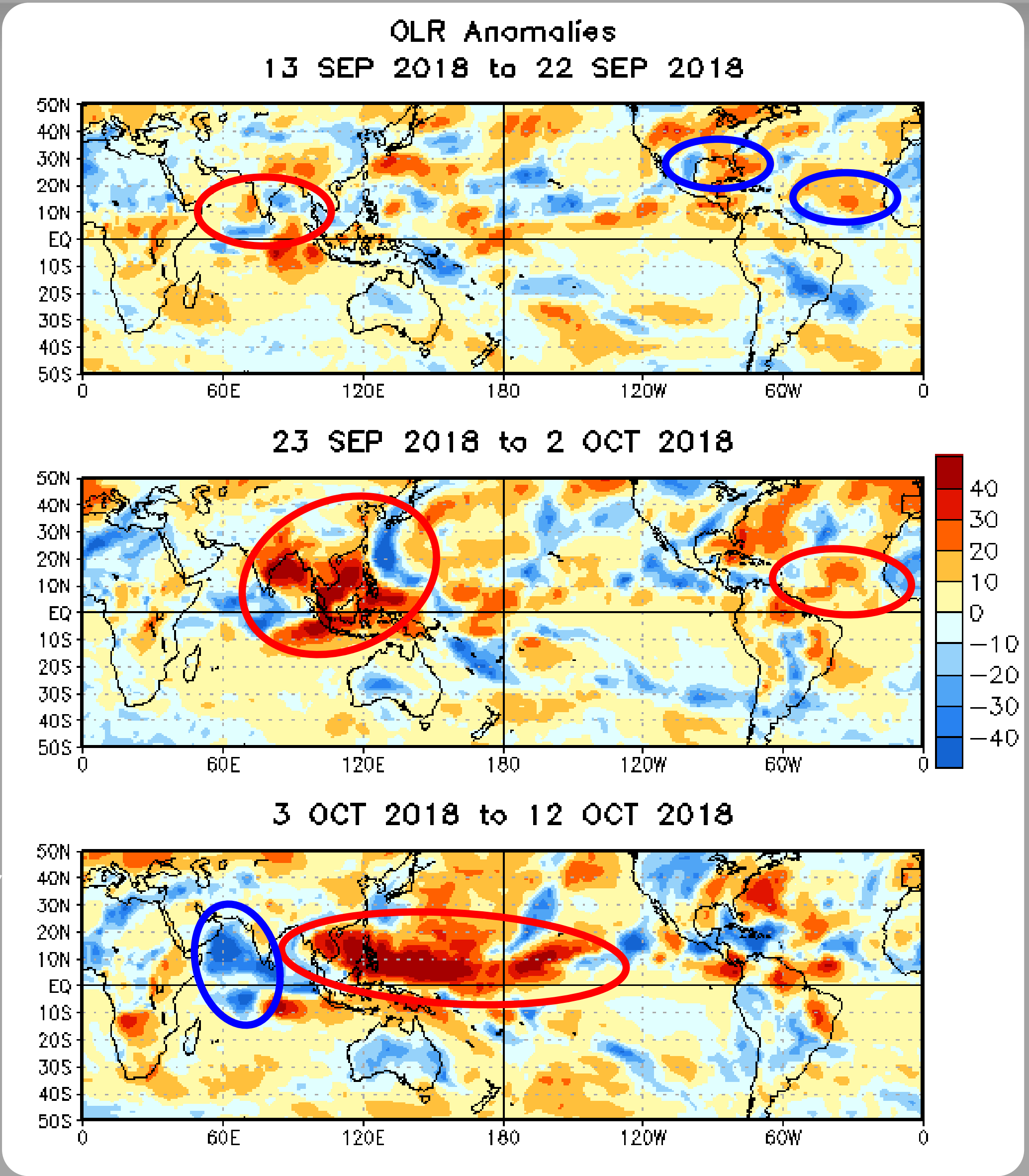
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

In early September, suppressed convection became more prominent over the Indian Ocean. An uptick in easterly waves resulted in three tropical cyclones forming over the Atlantic.

Easterly wave activity waned by mid-September, with suppressed convection across much of the tropical Atlantic as wind shear increased. Suppressed convection over the Indian Ocean shifted eastward toward the Maritime Continent, as small regions of enhanced convection are seen over the western Indian Ocean.

Most recently, suppressed convection over the Indian Ocean shifted east and strengthened over the Maritime Continent, while enhanced convection emerging in the Western Indian Ocean became more widespread as the active phase of the MJO continued through Phase 1.



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

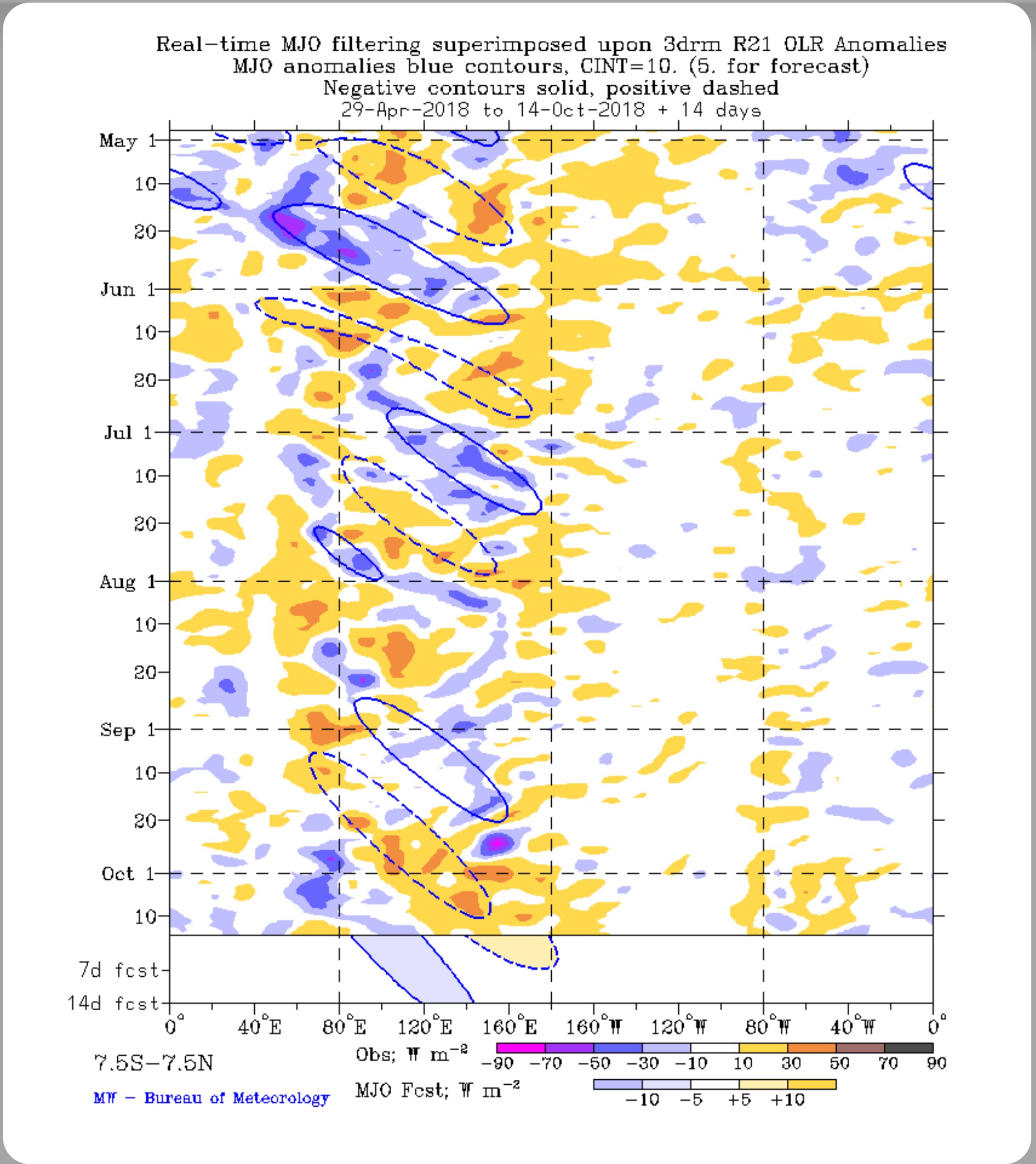
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

The MJO was active during May. The signal weakened in June, but re-emerged during July.

Kelvin waves, Rossby waves, and tropical cyclones dominated the pattern during August and early September, while the intraseasonal signal remained fairly weak.

During mid-September, the suppressed phase of the MJO emerged over the Eastern Indian Ocean and Maritime Continent. Since then, the suppressed signal has propagated further east and enhanced convection has emerged over the western Indian Ocean.



200-hPa Velocity Potential Anomalies (5ºS - 5ºN)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

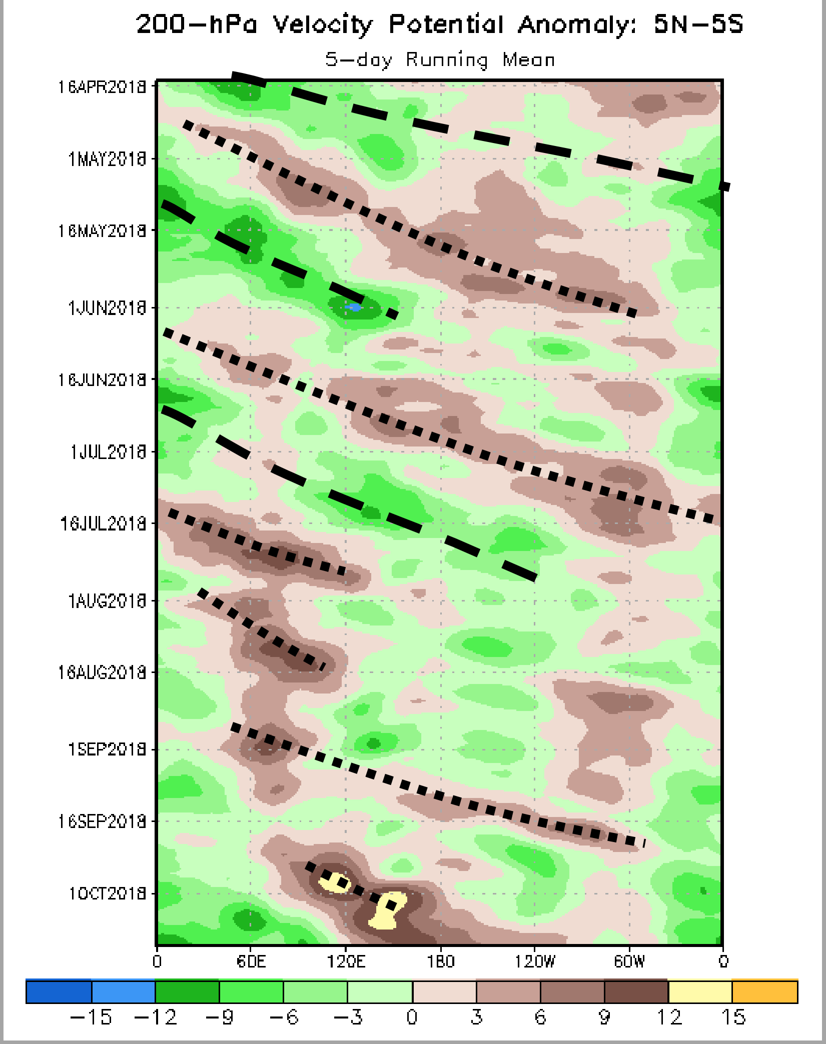
Negative anomalies (green shading) indicate favorable conditions for precipitation

There was robust MJO activity through boreal spring along with the decay of La Niña conditions. The enhanced phase of the MJO weakened east of the Date Line during June. Eastward propagation of broad suppressed convection continued into early July.

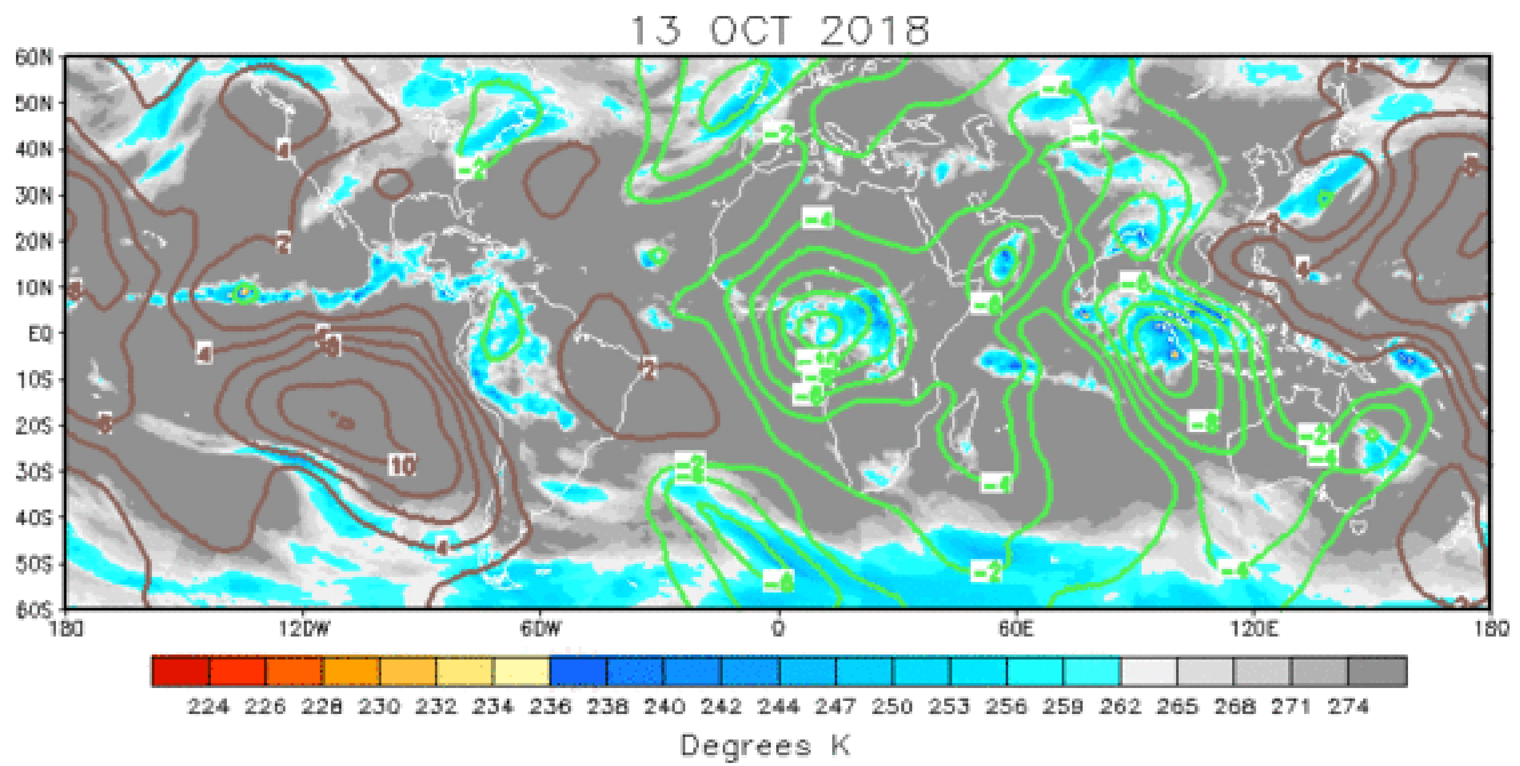
The upper-level footprint of the MJO re-emerged during mid-July, with a broad divergent signal propagating from the Maritime Continent to the central Pacific.

From mid-July to early September there was a stationary pattern of enhanced (suppressed) convection over the east-central Pacific (Indian Ocean), associated with the transition towards El Niño conditions.

The suppressed phase of the MJO recently constructively interfered with the base state across the eastern Indian Ocean and western Maritime Continent.



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



There is a mostly Wave-1 signal anchored by MJO-related convection over the Indian Ocean and convection over Africa.

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)

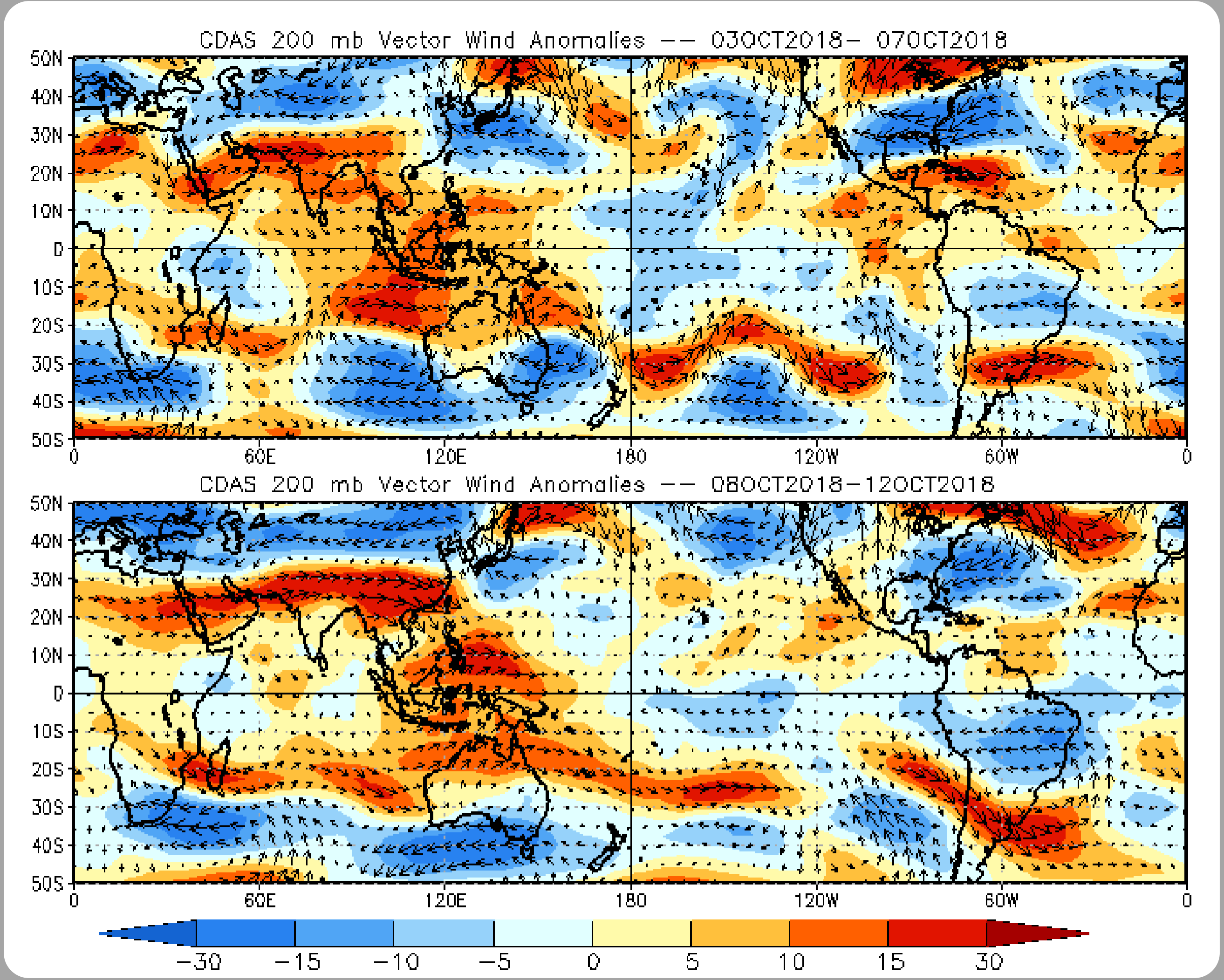
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

The extratropics have amplified over eastern Asia and across the Pacific to the East Coast of North America.

Upper-level winds have remained fairly weak over the Central Pacific.



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

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

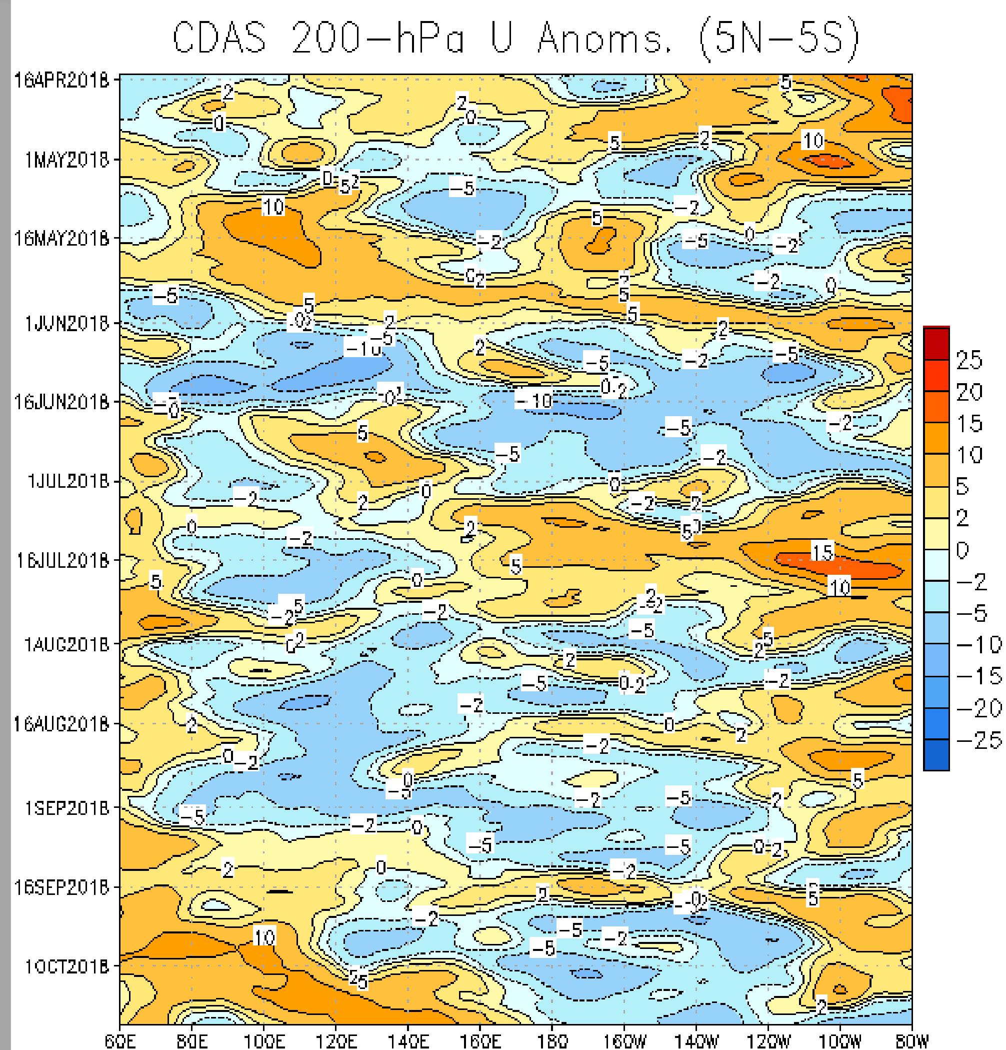
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Weak westerly anomalies propagated eastward from the Indian Ocean to the Americas in early May; this pattern broke down in early June.

Anomalous westerlies amplified over the Maritime Continent in mid-June and propagated eastward at MJO-like phase speeds.

During August the intraseasonal pattern weakened, with Rossby wave activity influencing the West Pacific pattern.

Persistent anomalous westerlies broke down over the far East Pacific, while anomalous easterlies have been more prevalent over the central Pacific. Anomalous westerlies have shifted eastward from the Indian Ocean over the Maritime Continent.



Weekly Heat Content Evolution in the Equatorial Pacific

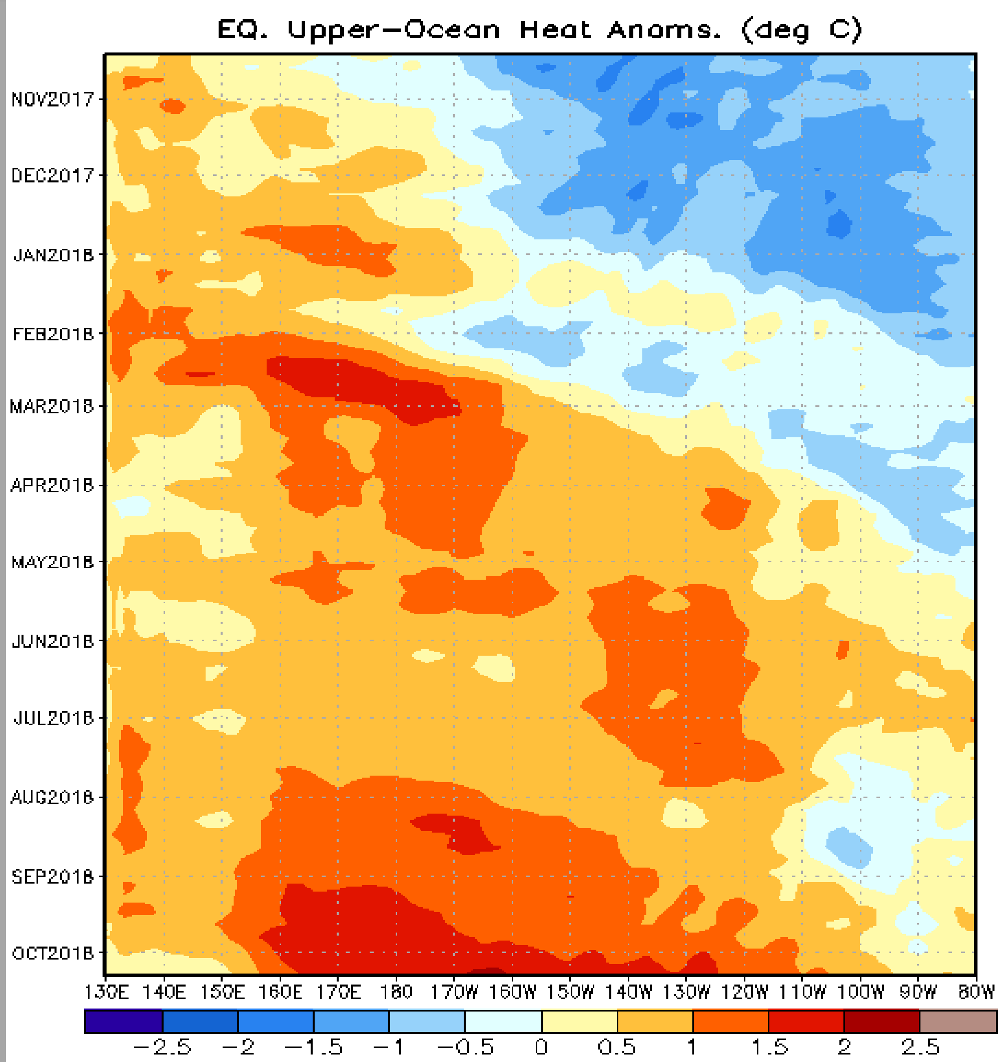
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

Negative upper-ocean heat content anomalies persisted in the central and eastern Pacific through December.

A downwelling Kelvin wave associated with the intraseasonal signal weakened the negative anomalies across the east-central Pacific during late January and early February.

Several downwelling oceanic Kelvin waves contributed to the eastward expansion of relatively warm subsurface water during February. Positive anomalies have now been observed over most of the basin since April.

The recent westerly wind burst east of New Guinea appears to have triggered another oceanic Kelvin wave and round of downwelling, helping to reinforce the warm water availability for a potential El Niño event.



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

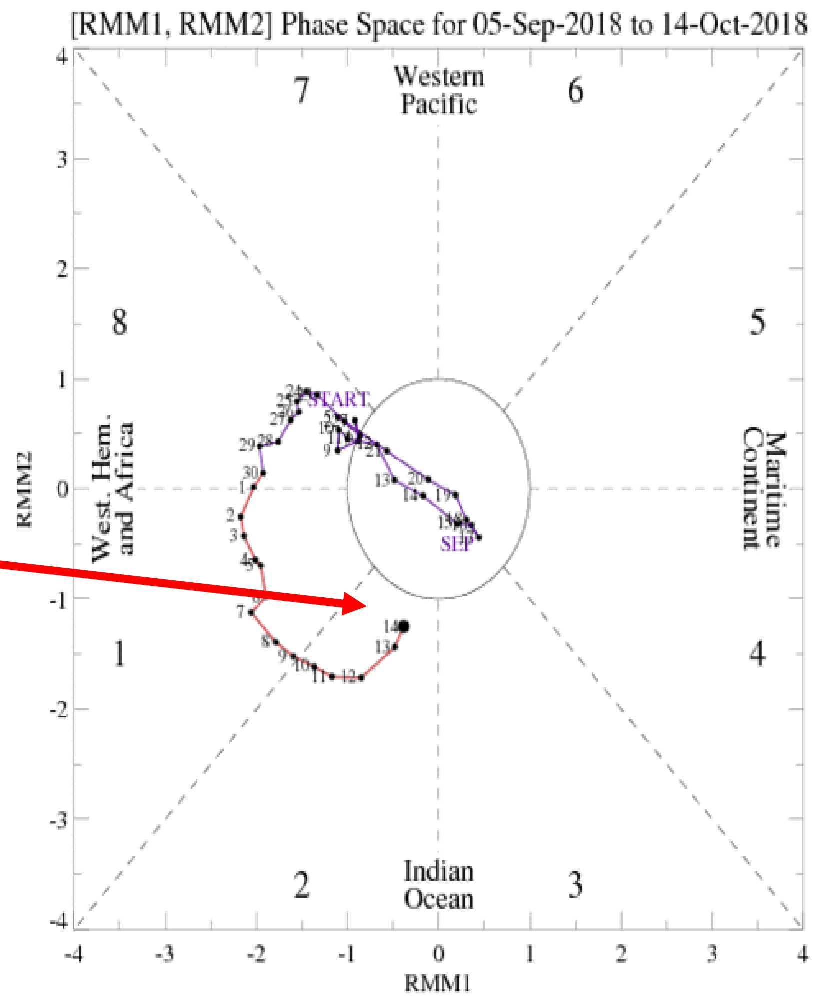
The triangular areas indicate the location of the enhanced phase of the MJO

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

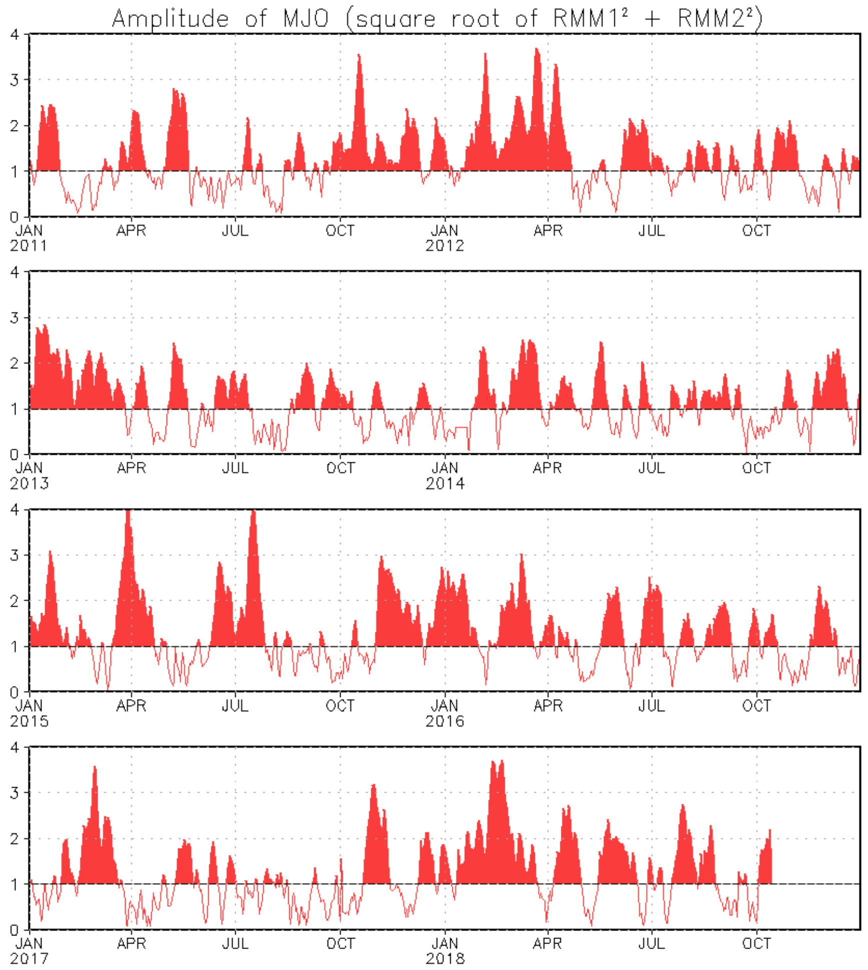
The MJO remains in Phase-2 but has weakened over the past few days. This is partially due to equatorial wave interference.



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

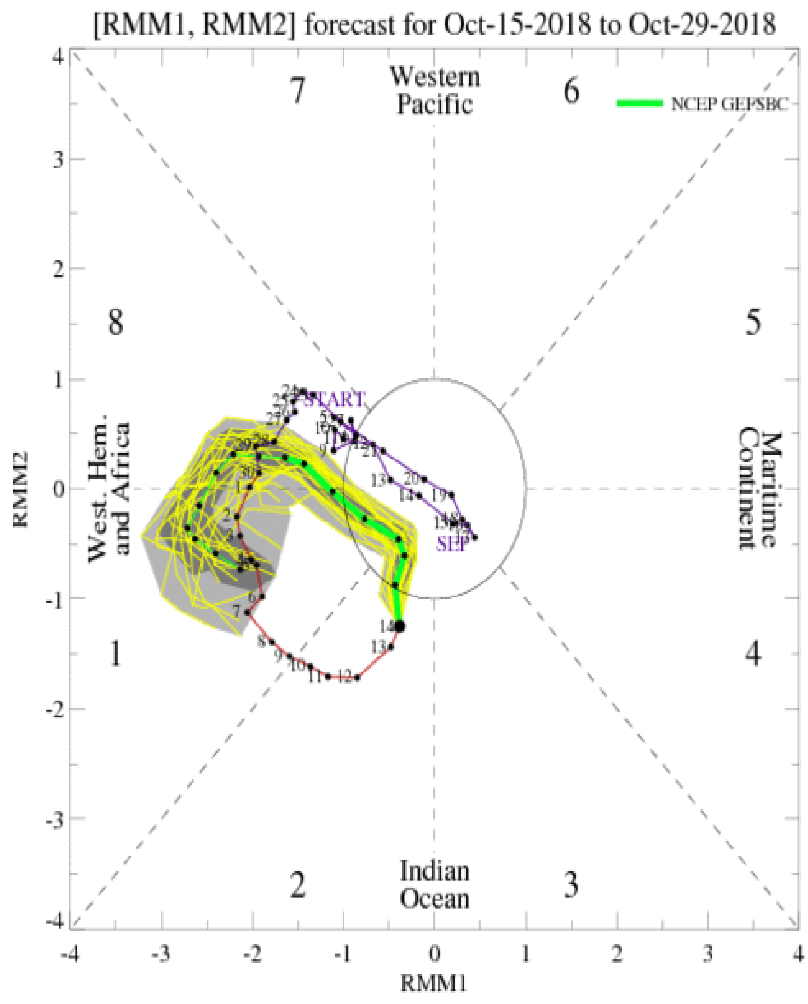
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

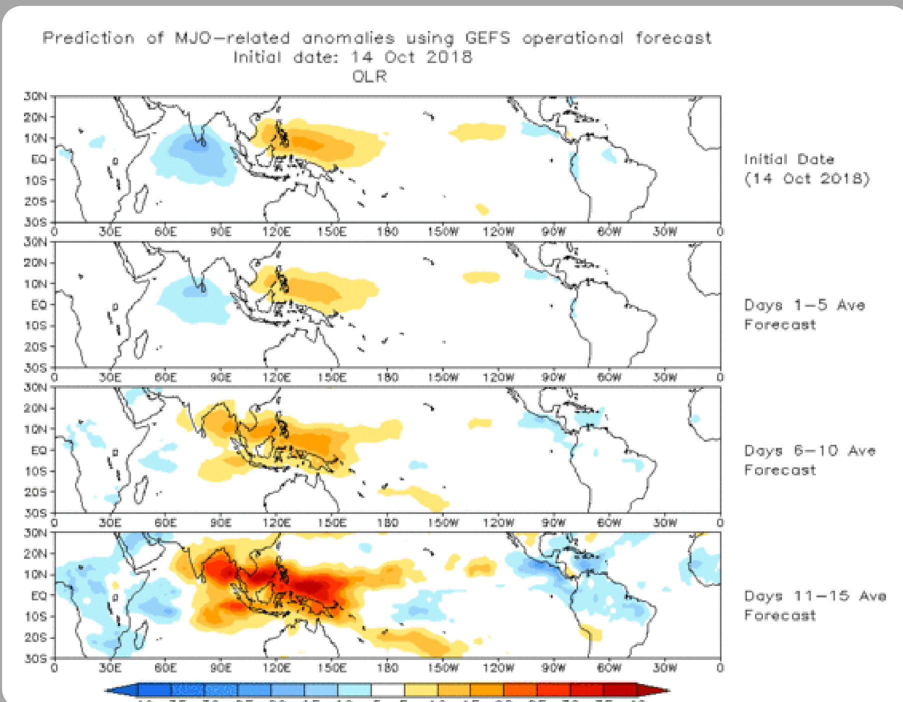
The GEFS forecasts the MJO to weaken substantially over the next few days before re-emerging in Phase 8. This forecast appears to be strongly influenced by equatorial Rossby and Kelvin wave activity.



Ensemble GFS (GEFS) MJO Forecast

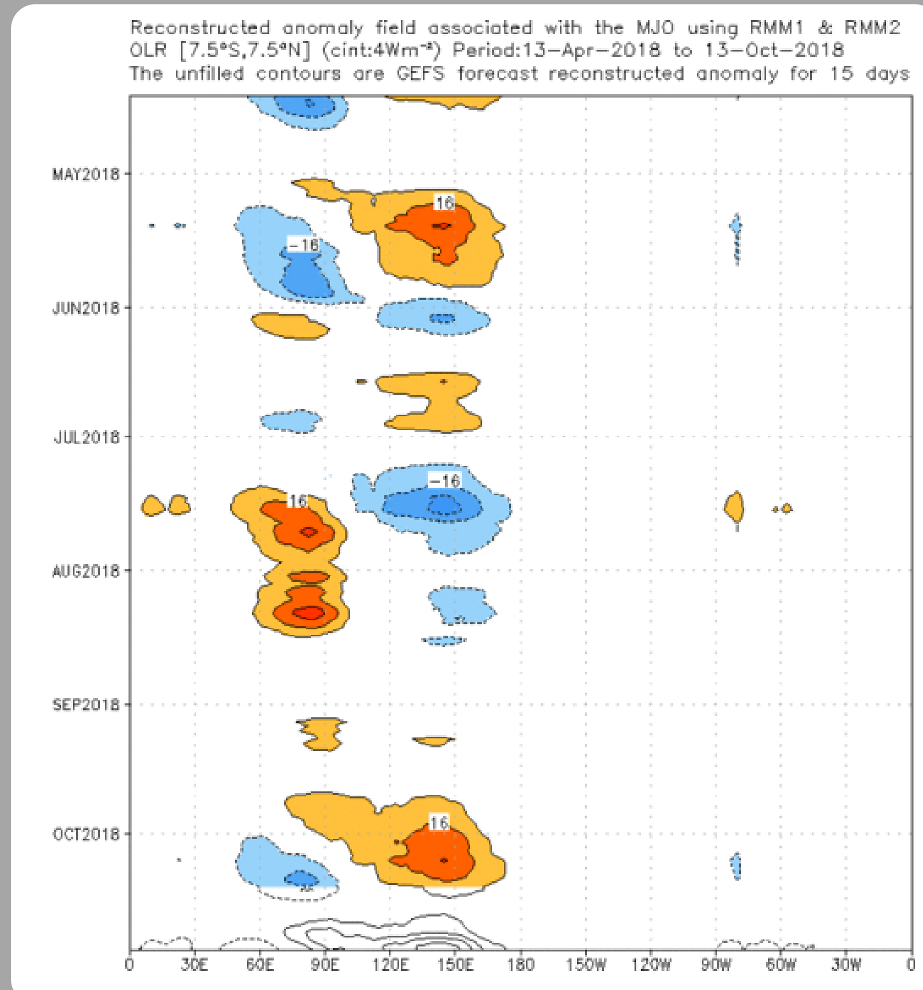
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS forecasts the MJO to weaken over the next few days before strengthening again early in Week-2.

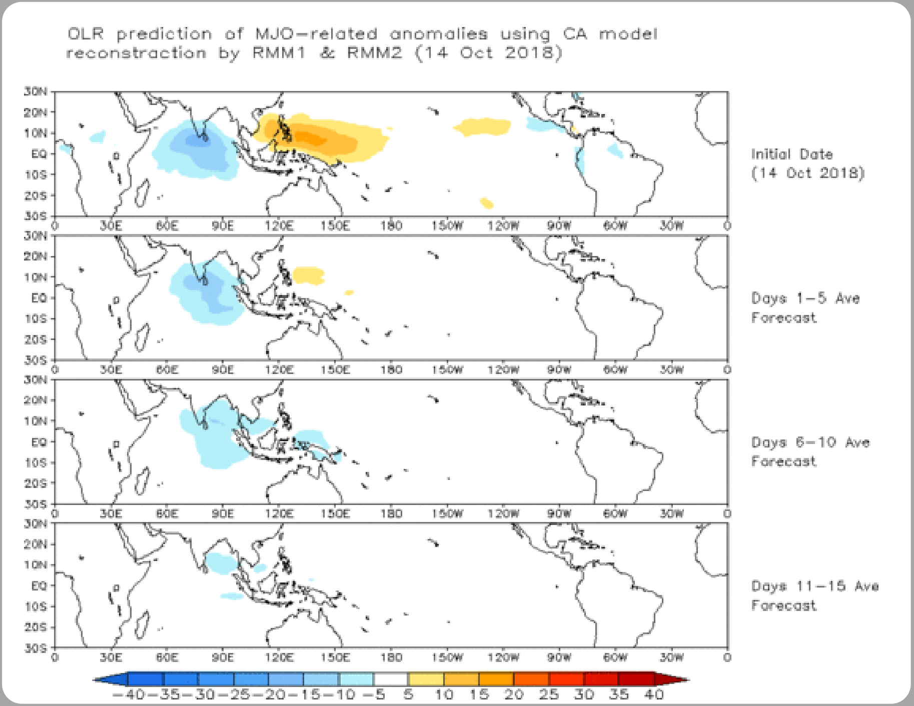
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

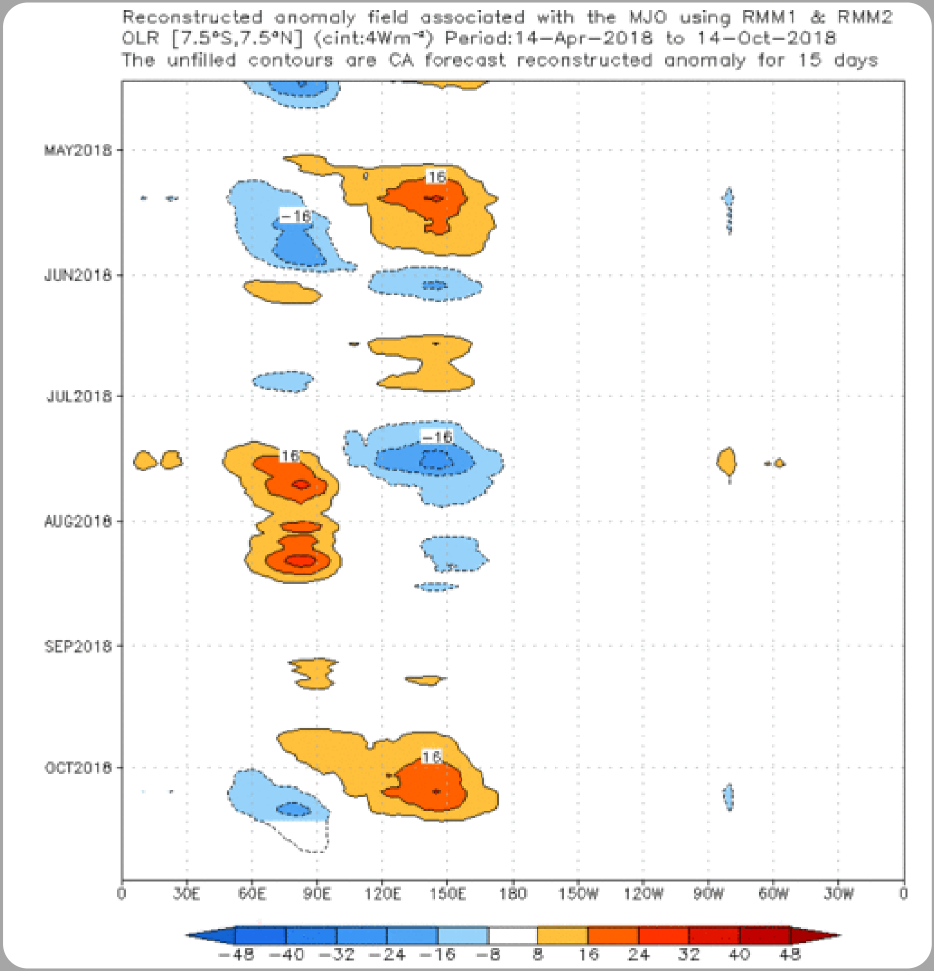
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The constructed analog forecasts the MJO to weaken and not strengthen by Week-2 (unlike the GEFS).

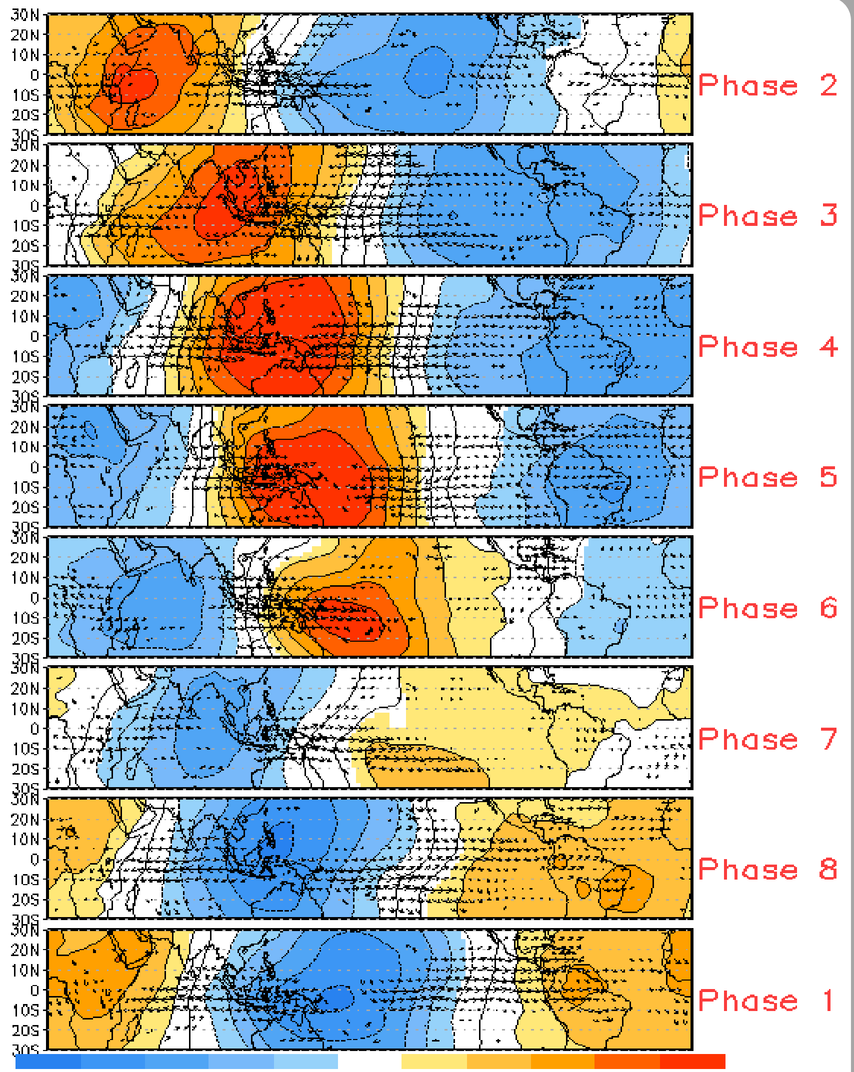
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



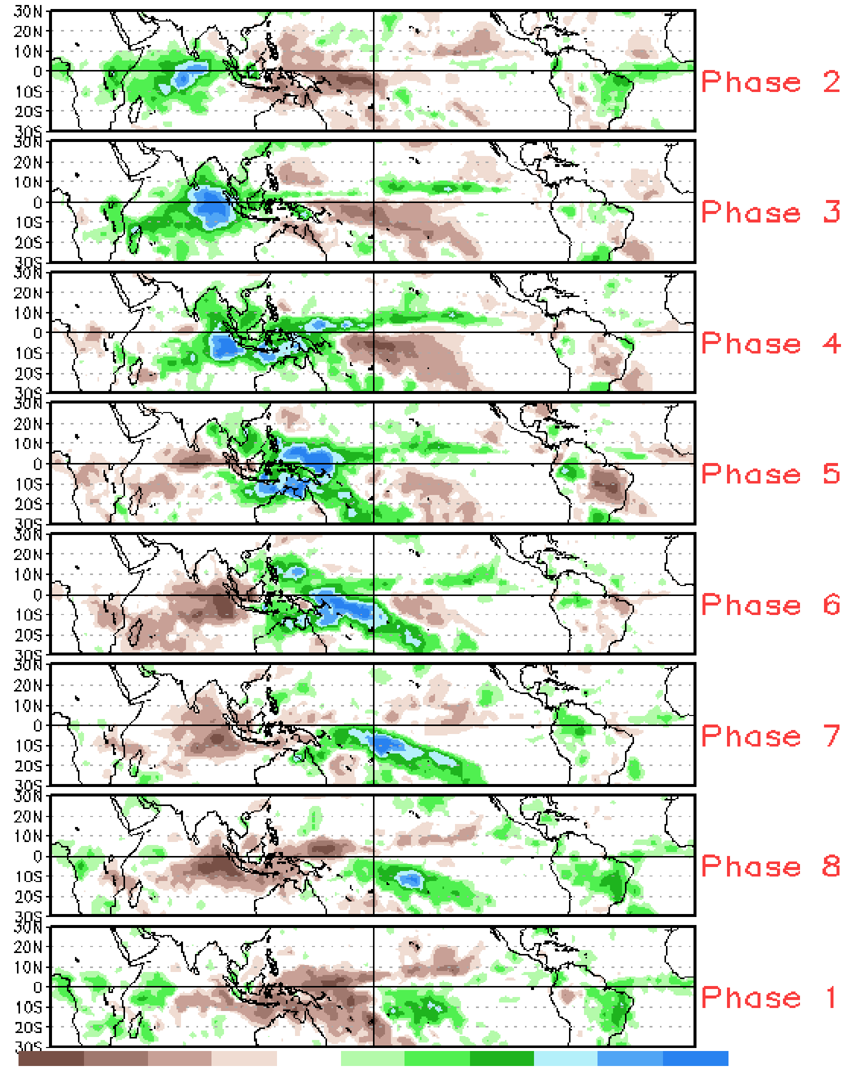
MJO Composites - Global Tropics

850-hPa Velocity Potential and

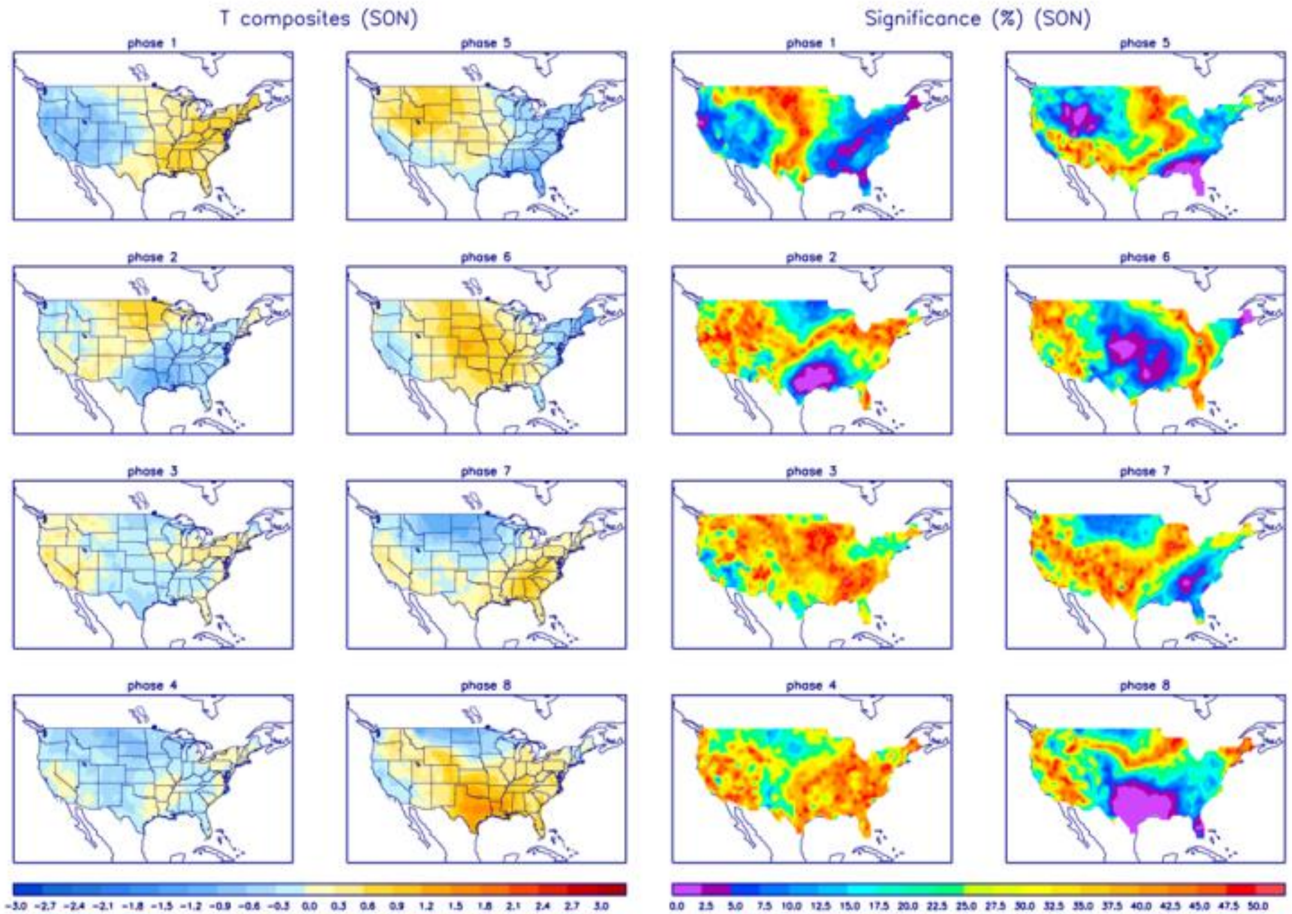
Wind Anomalies (May - Sep)



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.

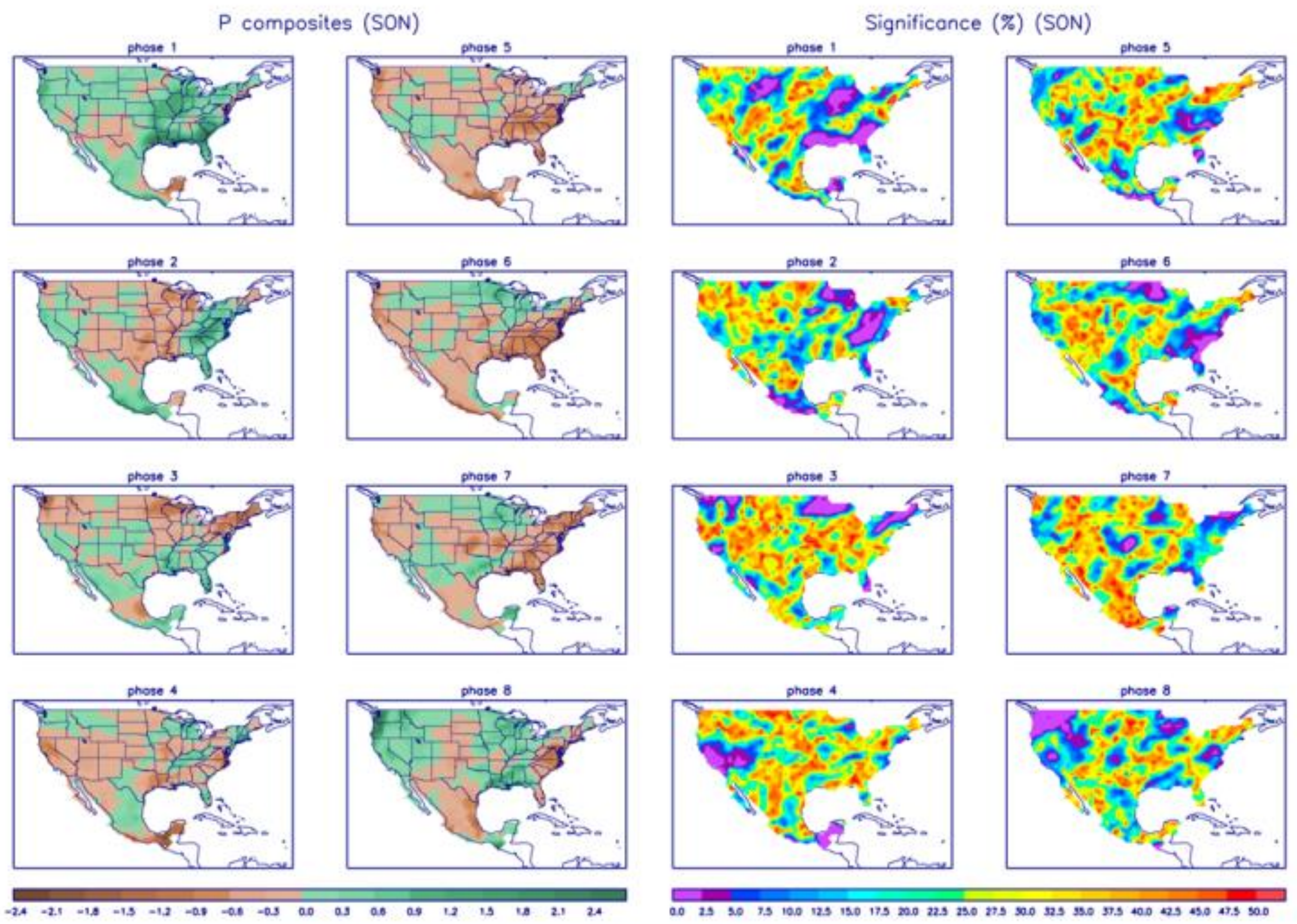
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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