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

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Climate Prediction Center / NCEP
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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 remained active during the past week, with its enhanced phase drifting eastward across the Western Hemisphere.

- Dynamical models guidance anticipates the MJO continuing eastward and approaching the Indian Ocean by mid-October.

- This evolution would contribute to increased chances of tropical cyclogenesis over the East Pacific while the MJO is active in Phase 1, with decreasing chances thereafter.

- Tropical influences on extratropical weather appear most likely to be tied to tropical cyclones, rather than large-scale modes of tropical variability. That said, the MJO in Phase-1 during boreal Autumn typically corresponds to a deepening trough over the western U.S. and anomalous ridging along the eastern seaboard, which is currently seen in forecast guidance.

- Also of note, the robust westerly wind burst in the Pacific may help push conditions towards El Niño as we head towards boreal Winter.

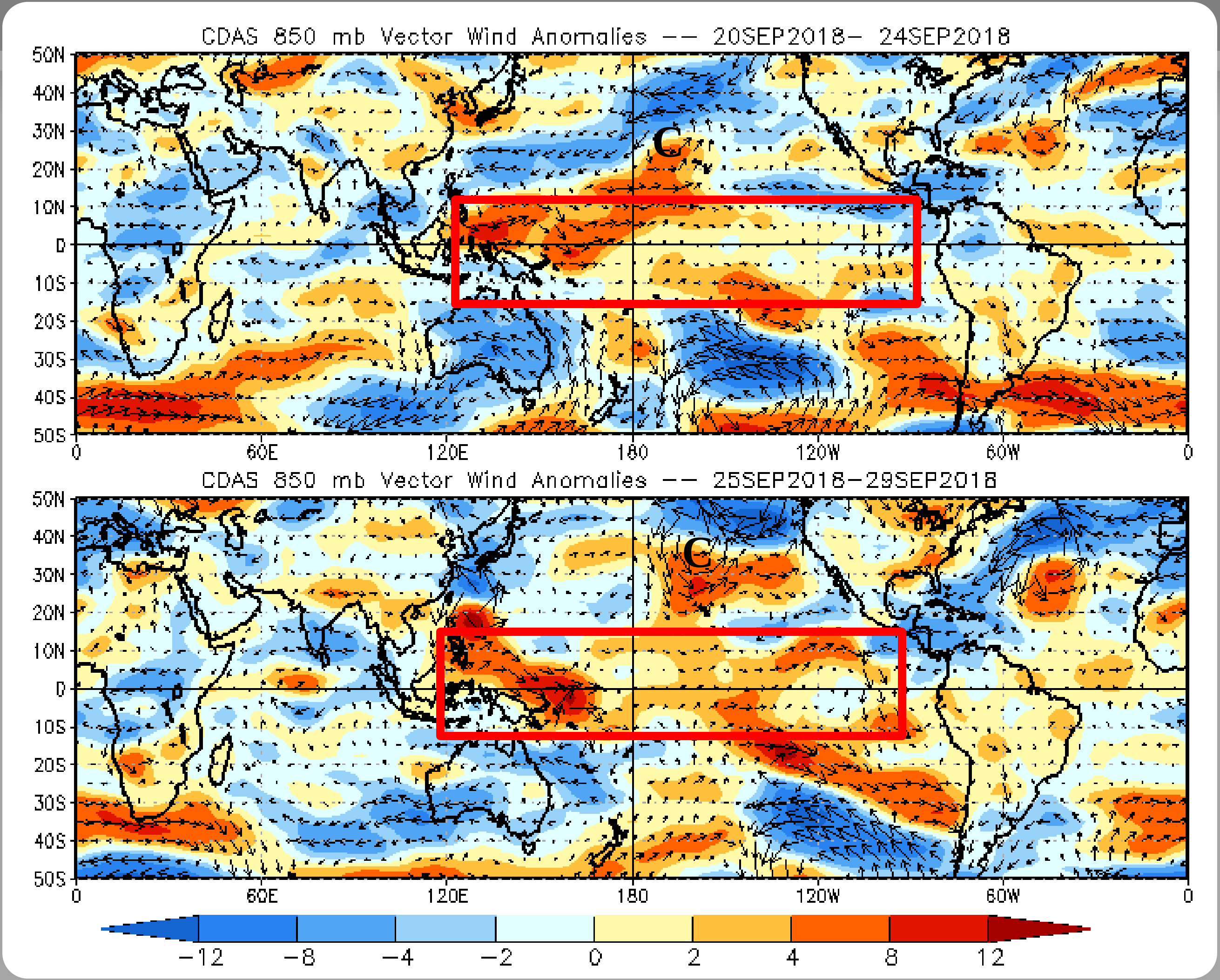
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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.

Evidence of a westerly wind burst continues to persist east of New Guinea.

An anomalous cyclone east of the Date Line in the North Pacific has helped to drive tropical moisture northeastward towards western North America.

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

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

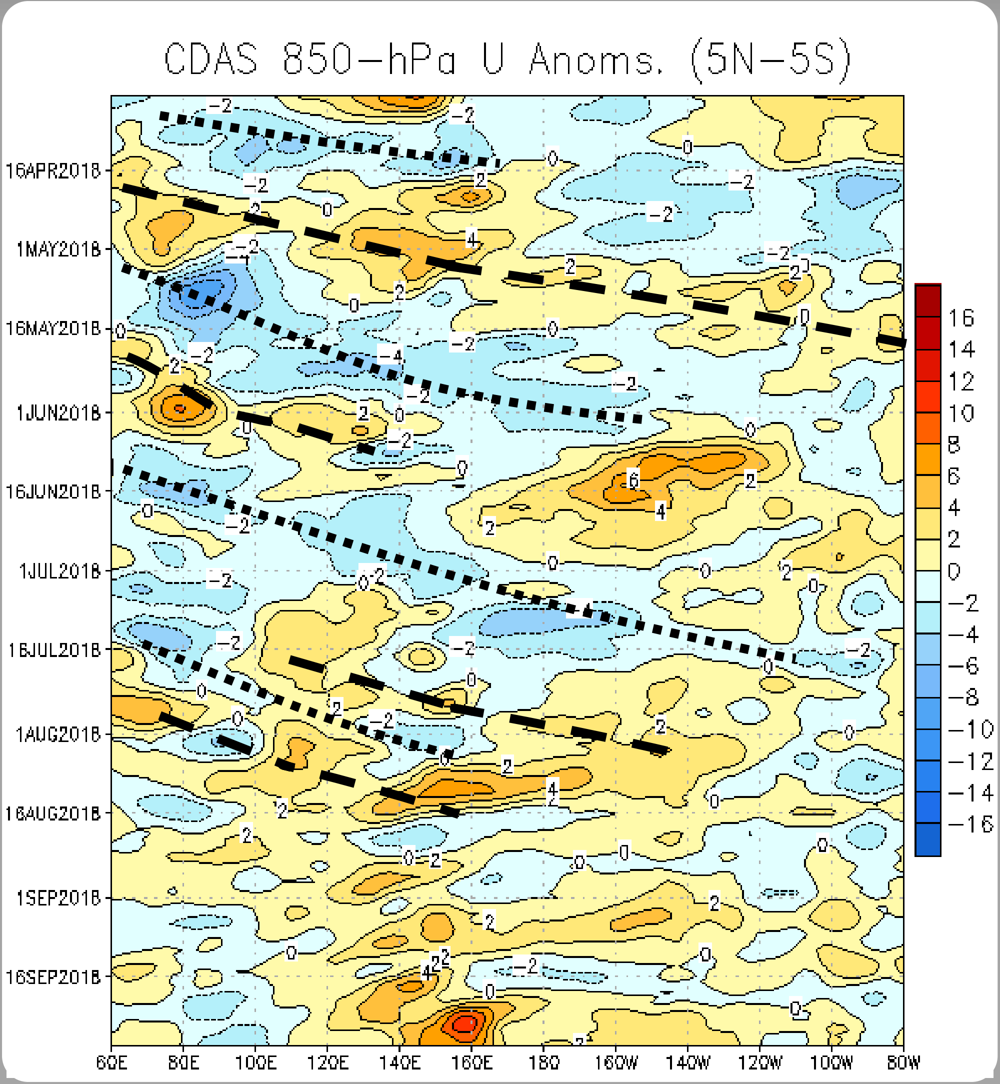
Easterly anomalies (blue shading) represent anomalous east-to-west flow

The MJO was active during late April and May. Westward moving variability, including TC activity over the Pacific and equatorial Rossby waves, 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.

More recently, Rossby wave activity continues to dominate the Pacific, while westerly anomalies overspread the equatorial Maritime Continent and equatorial Pacific.

Signs of a westerly wind burst near 160E during late September 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

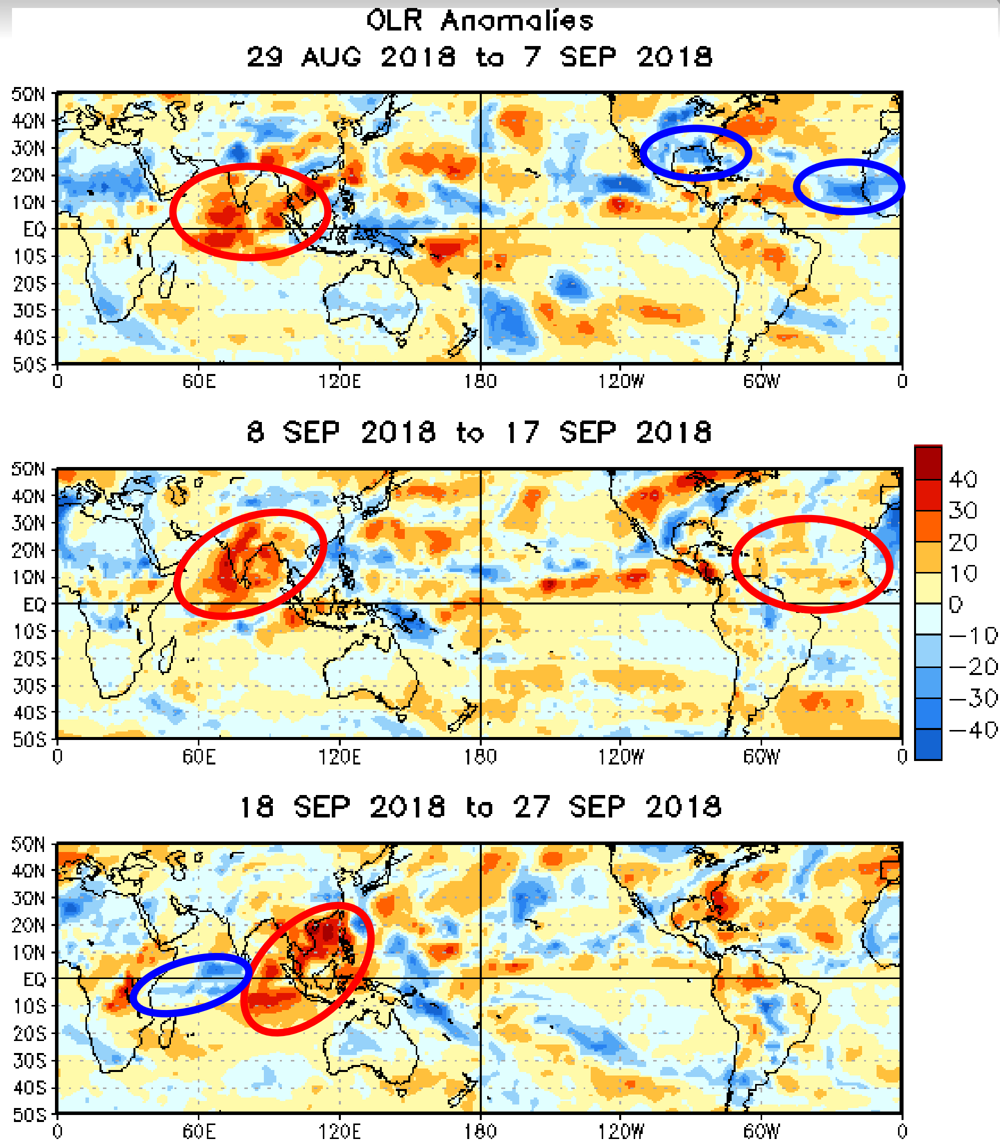
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

In late August and early September, suppressed convection became more prominent over the Indian Ocean, while TS Gordon is notable over the Gulf of Mexico and central U.S. 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. Indian Ocean convection remained suppressed.

Most recently, the suppressed Indian Ocean convection shifted eastward into the South China Sea, with enhanced convection emerging in the Western Indian Ocean as the active phase of the MJO shifted towards Phase 1.



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

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

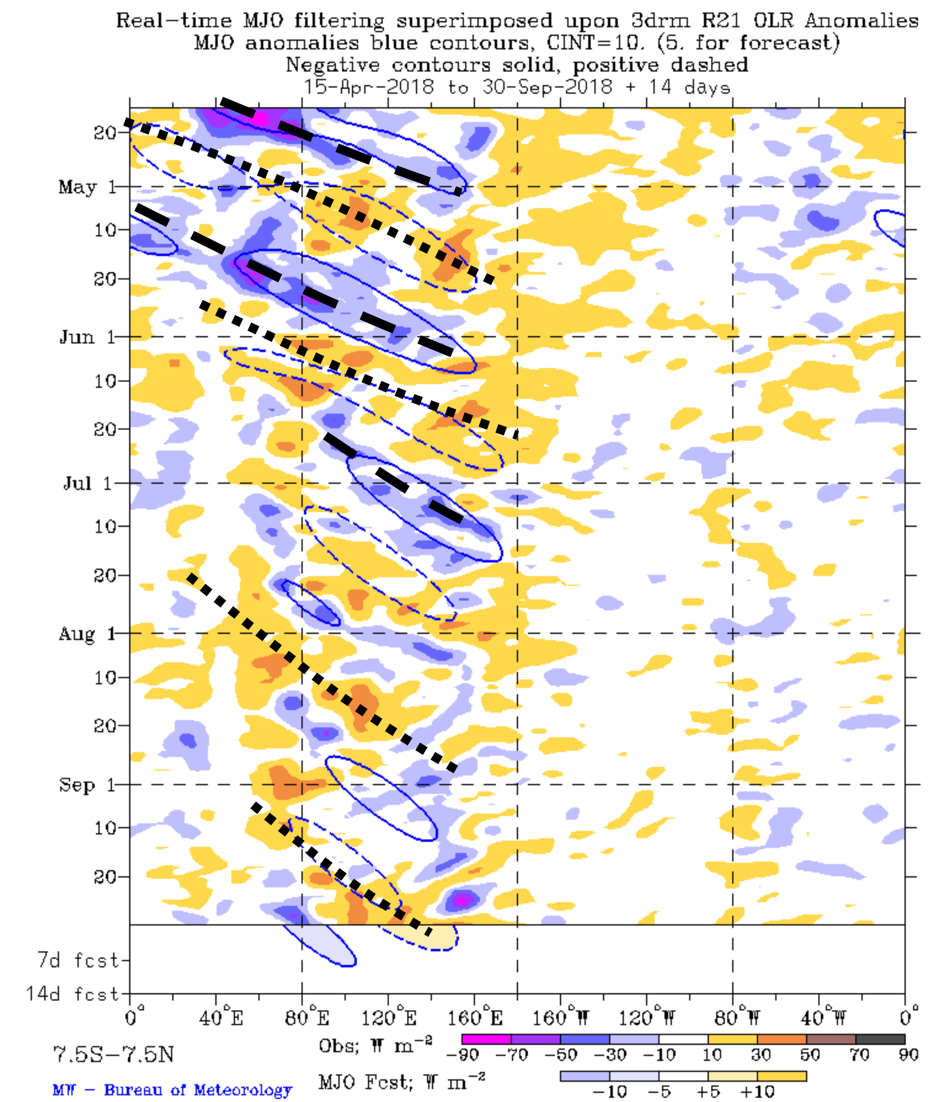
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

MJO activity from April weakened in early May as the suppressed phase destructively interfered with the low frequency La Niña base state. Stronger MJO activity emerged in late May, and weakened again during June coincident with pronounced Rossby wave activity.

The MJO remained weak for most of June.

During July, the intraseasonal signal re-emerged, with some eastward propagation evident in the OLR field.

Kelvin waves, Rossby waves, and tropical cyclones dominated the pattern during August and early September, while the intraseasonal signal remained fairly weak. Over the last 2 weeks, the suppressed phase of the MJO has emerged over the Eastern Indian Ocean and Maritime Continent.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

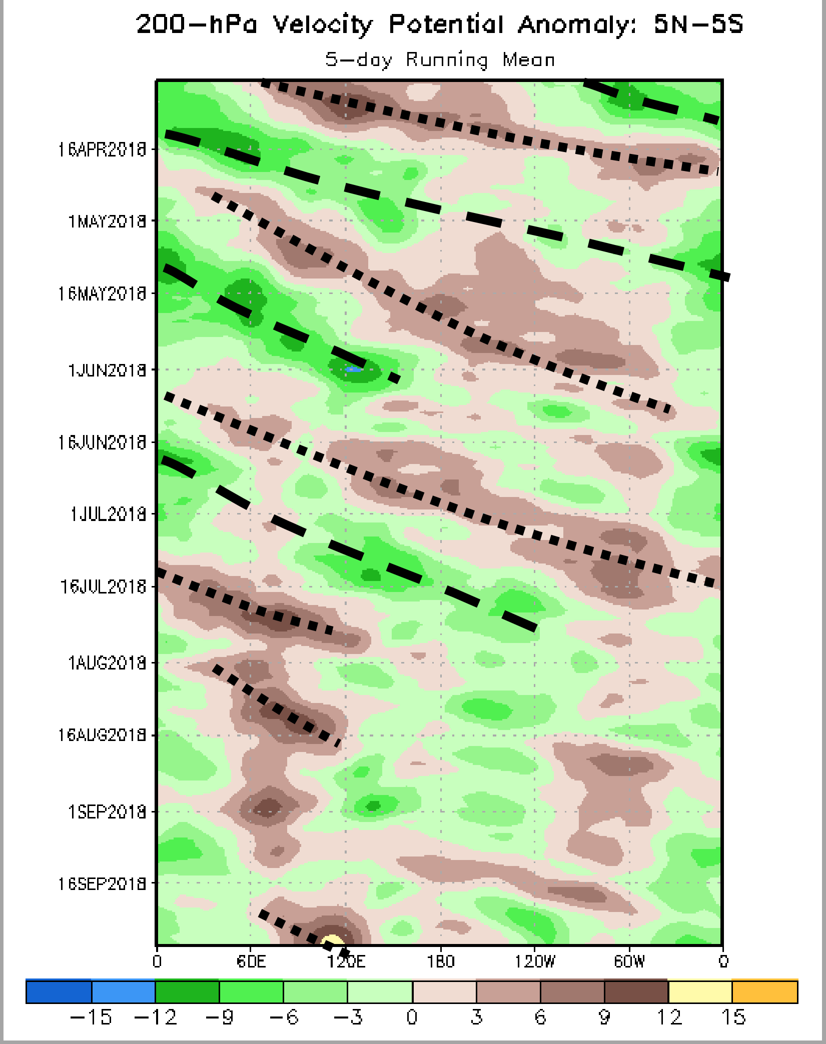
Negative anomalies (green shading) indicate favorable conditions for precipitation

There was robust MJO activity through boreal spring along with the decay of La Niña conditions.

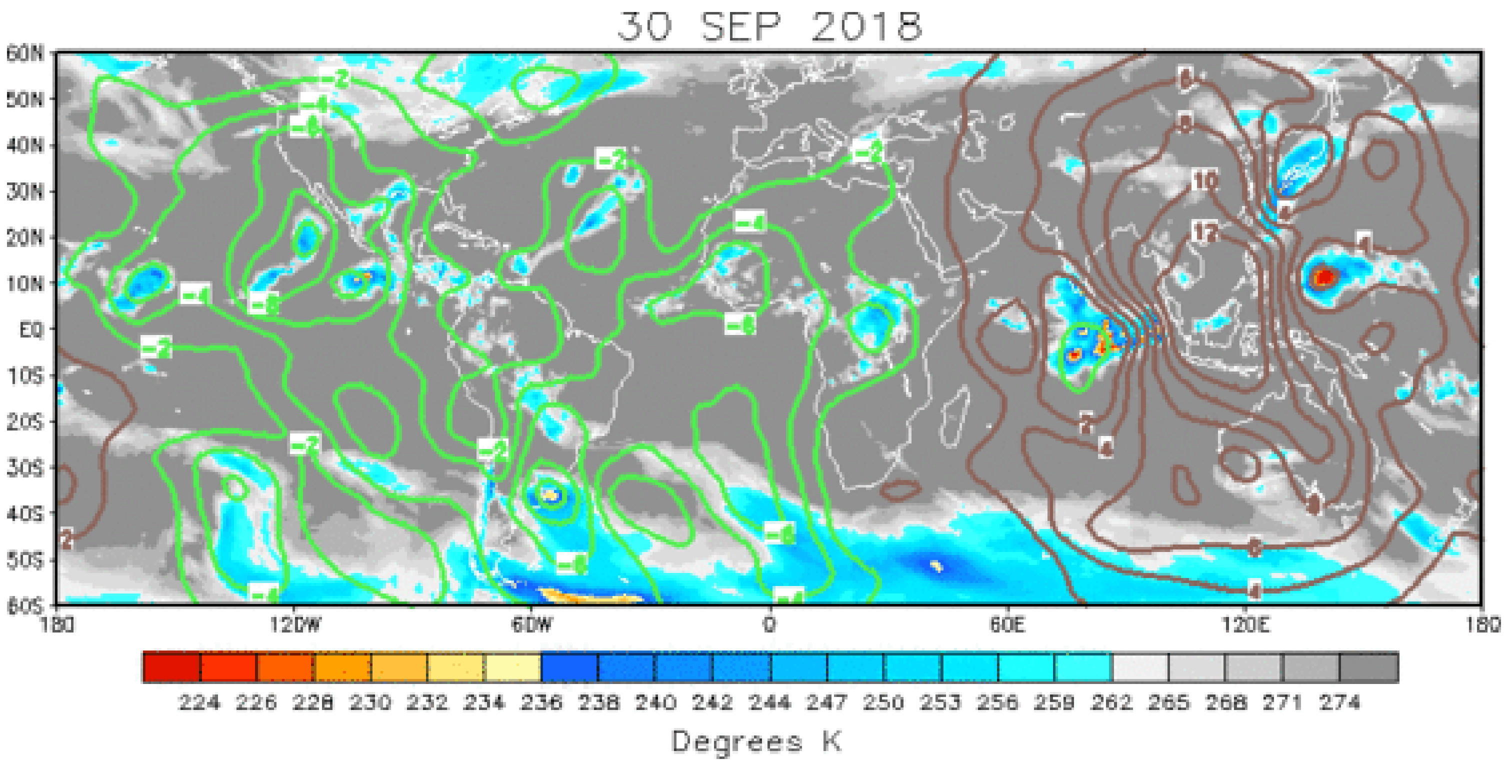
The enhanced phase of the MJO weakened east of the Date Line during June. Eastward propagation of broad suppressed convection continued into early July.

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, a somewhat stationary pattern of enhanced (suppressed) convection over the east-central Pacific (Indian Ocean) has emerged, 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



A wave-1 pattern is apparent with enhanced (suppressed) convection across the eastern Pacific, Americas, Atlantic, and Africa (Indian Ocean, Maritime Continent, and West Pacific), associated with the robust MJO event presently across the Western Hemisphere.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

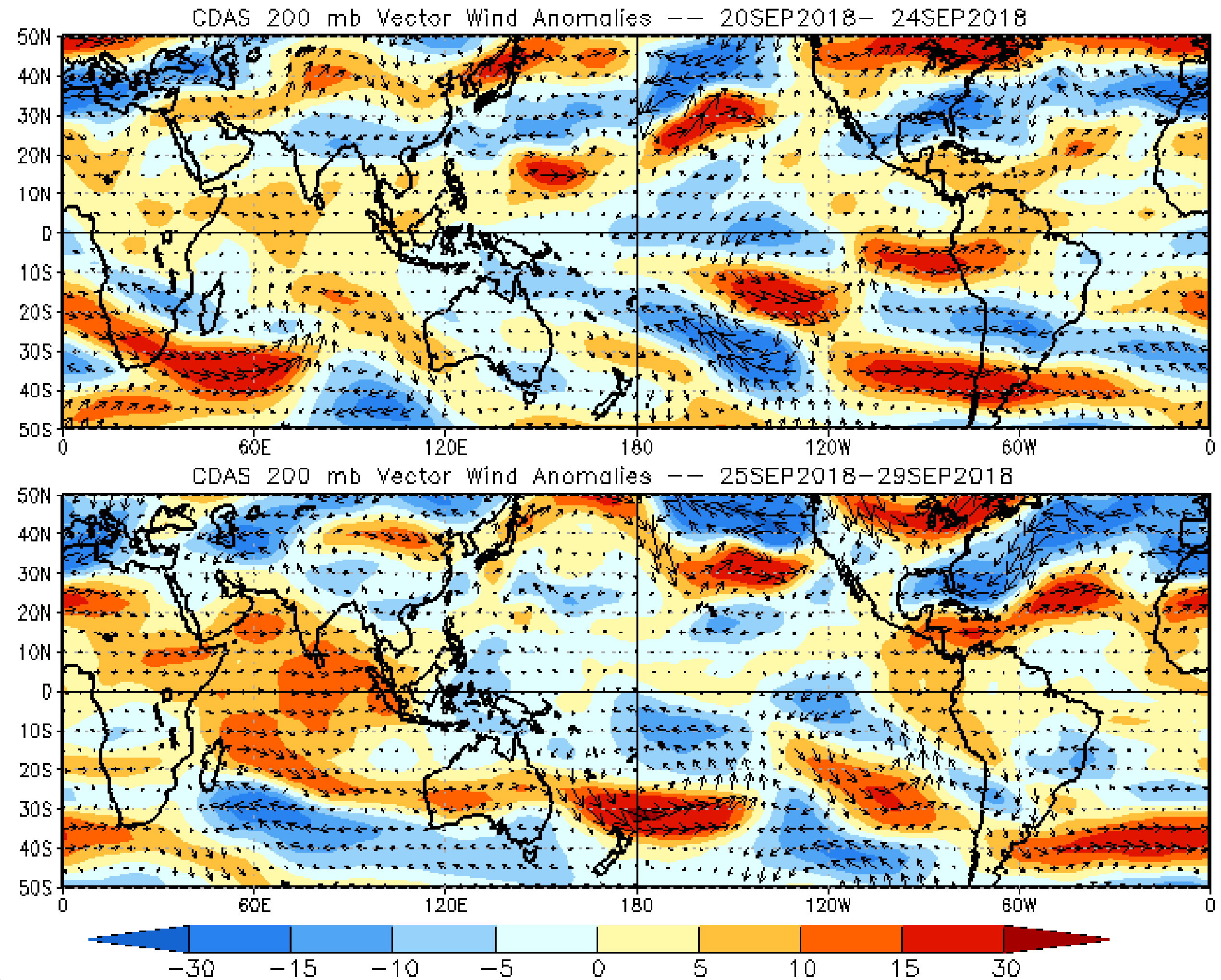
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Mass is converging across the far eastern Pacific associated with convergent flow from the extratropics in both hemispheres.

Anomalous westerlies across much of the Atlantic are likely contributing to the downturn in tropical cyclone activity after the active start to September.

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

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

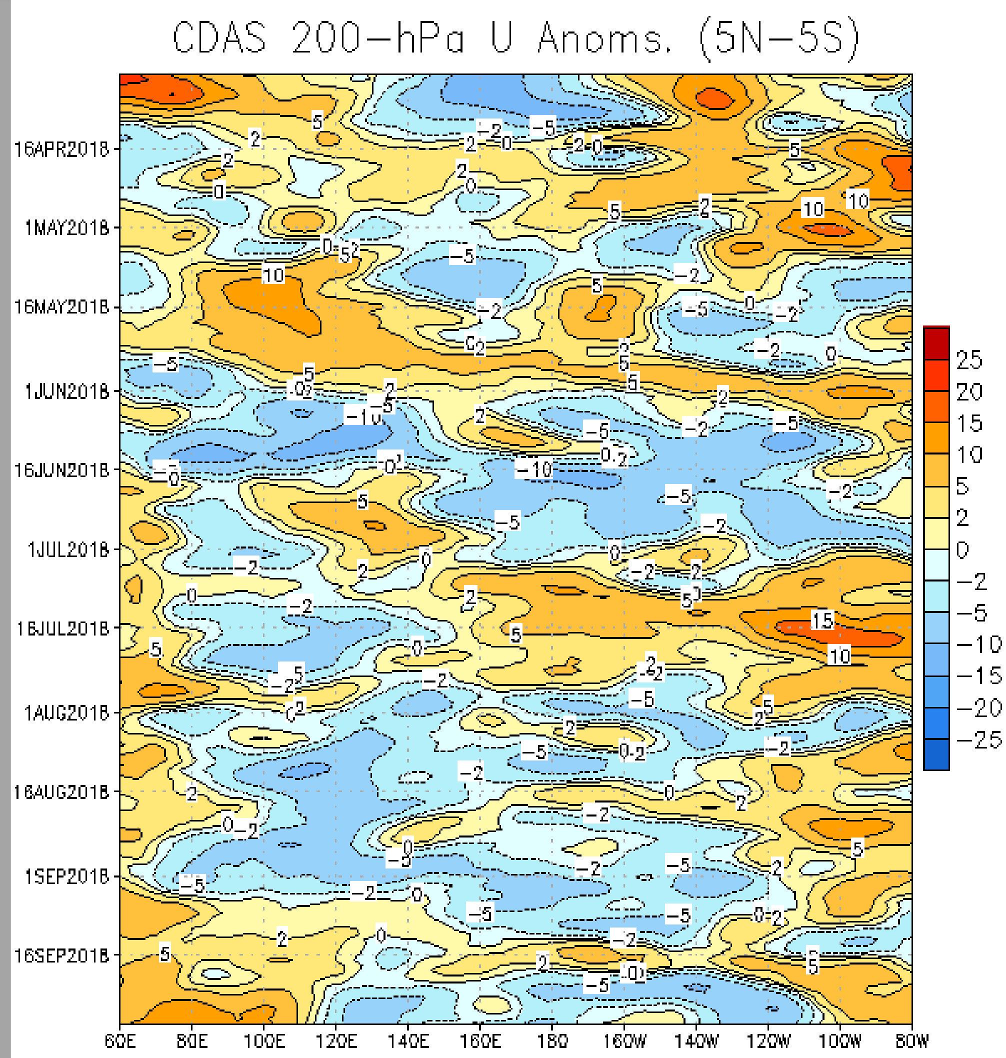
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Low-frequency anomalous westerlies remained in place east of 140E through late April 2018, with a few periods of brief interruptions.

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 westerlies continue over the far East Pacific, while easterly anomalies have been more prevalent over the central Pacific.



Weekly Heat Content Evolution in the Equatorial Pacific

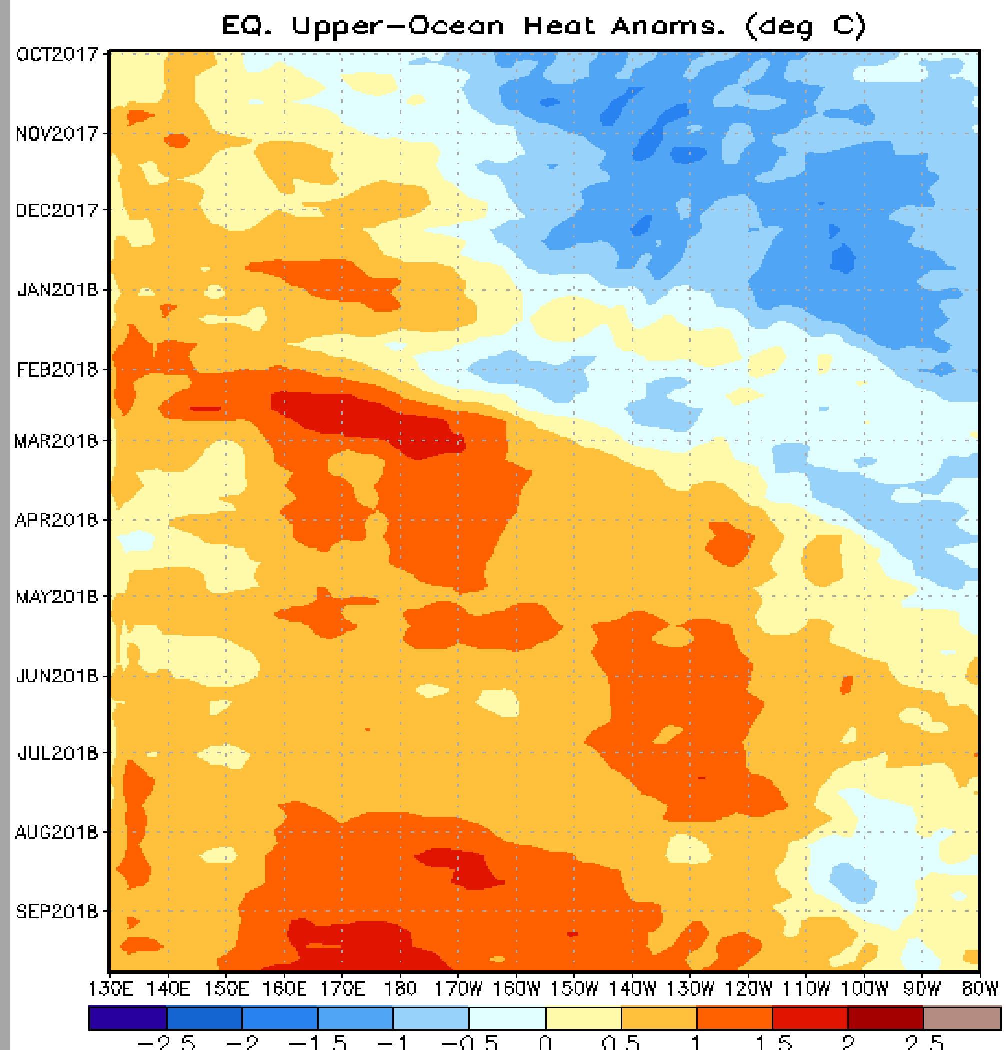
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

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 to work with.



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

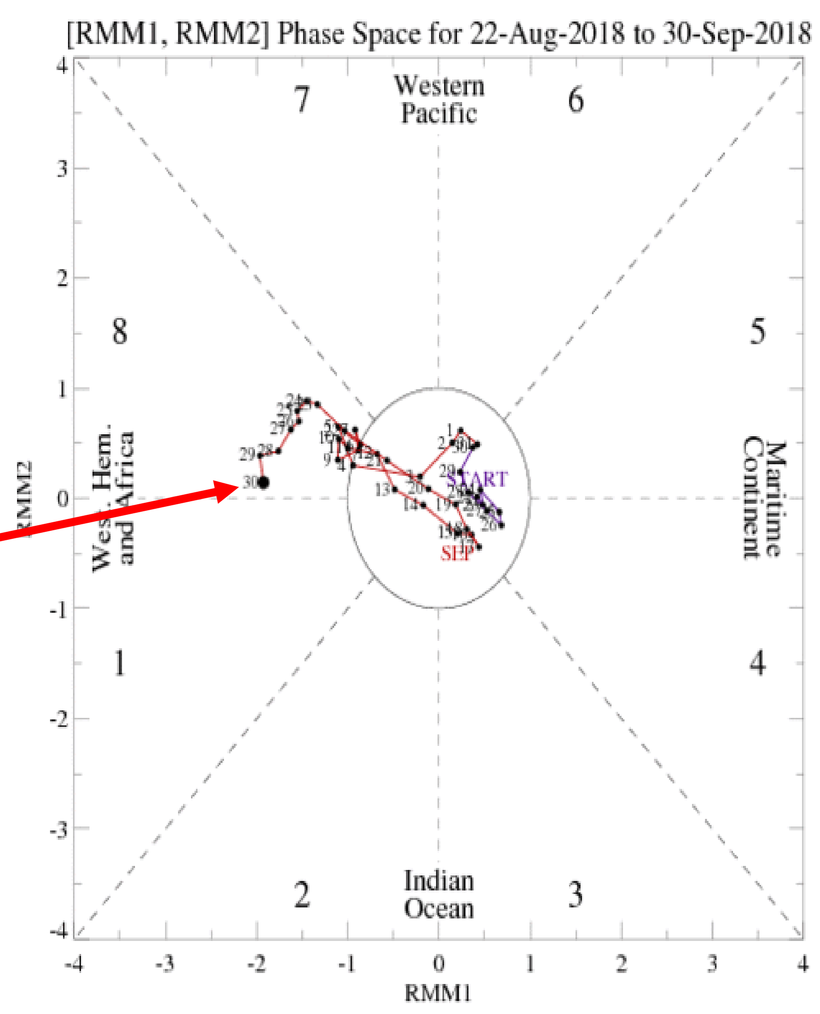
The triangular areas indicate the location of the enhanced phase of the MJO

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

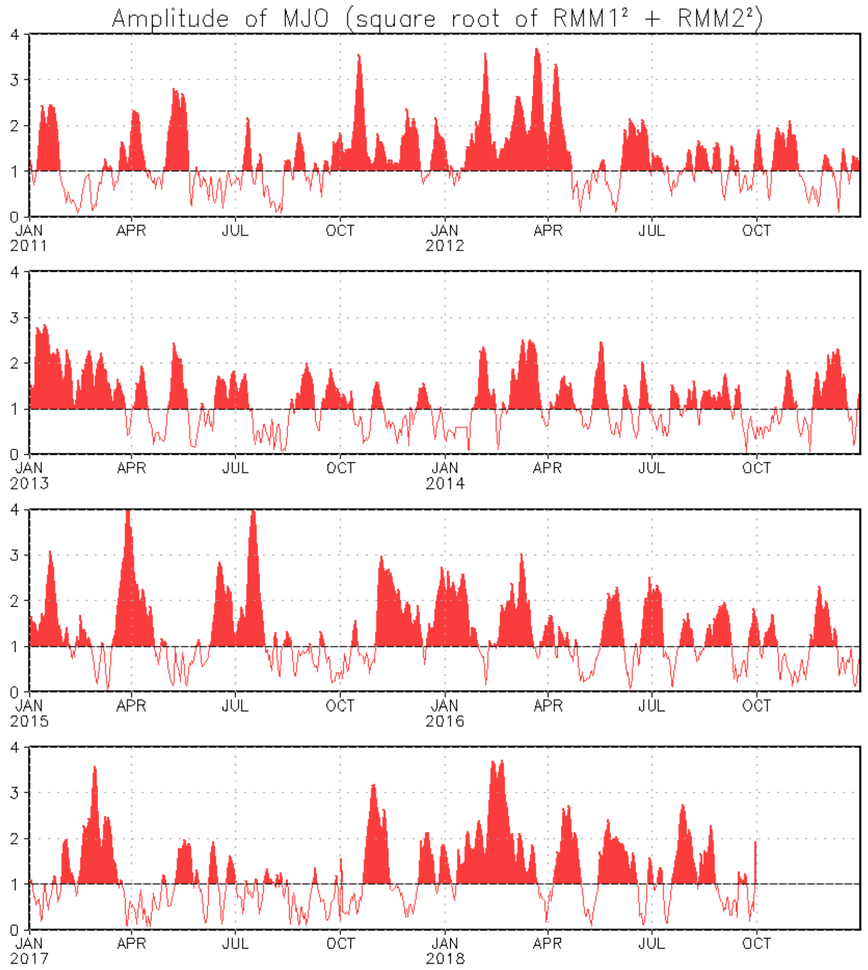
The MJO meandered eastward in Phase 8 during the past week, with some slight building of its amplitude.



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

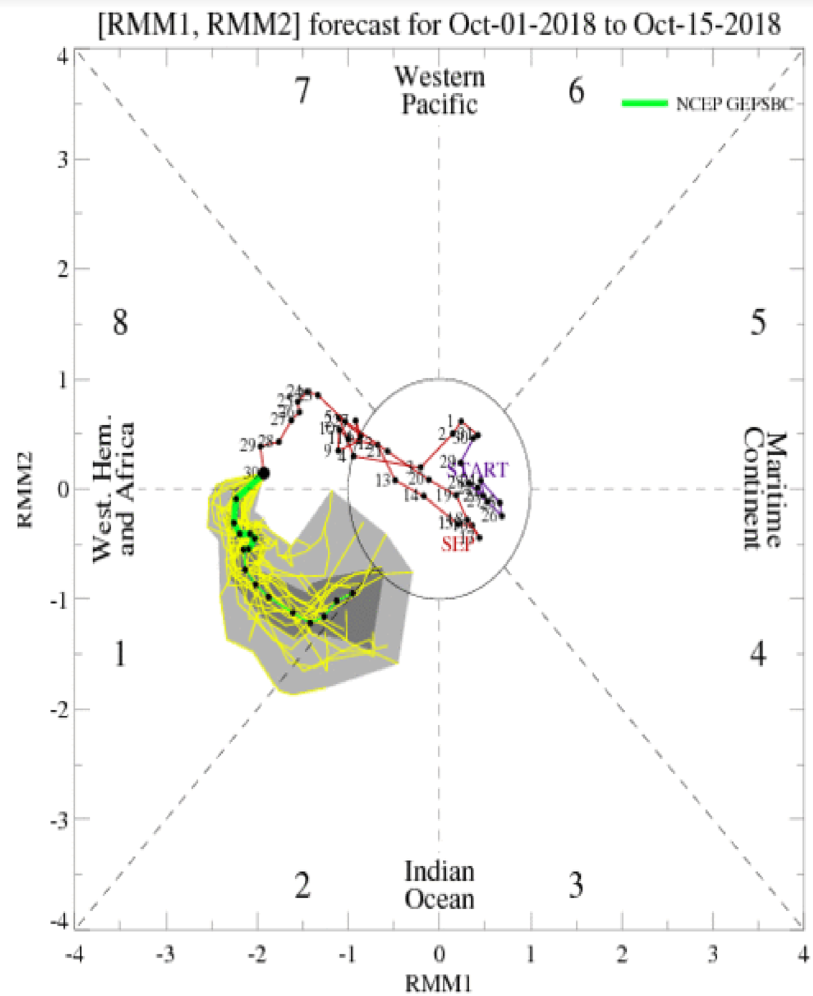
<u>Yellow Lines</u> - 20 Individual Members
<u>Green Line</u> - Ensemble Mean

RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

<u>light gray shading</u>: 90% of forecasts

<u>dark gray shading</u>: 50% of forecasts

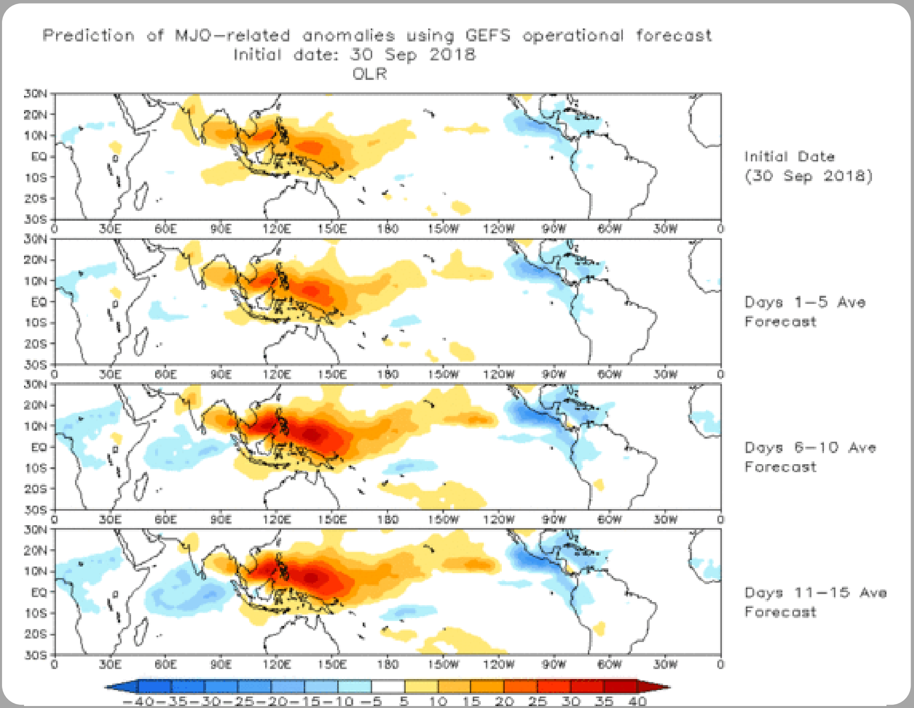
The GEFS predicts the MJO amplitude to continue to build during the next week as the signal transitions into Phase 1, with the active MJO envelope approaching the western Indian Ocean by mid-October.



Ensemble GFS (GEFS) MJO Forecast

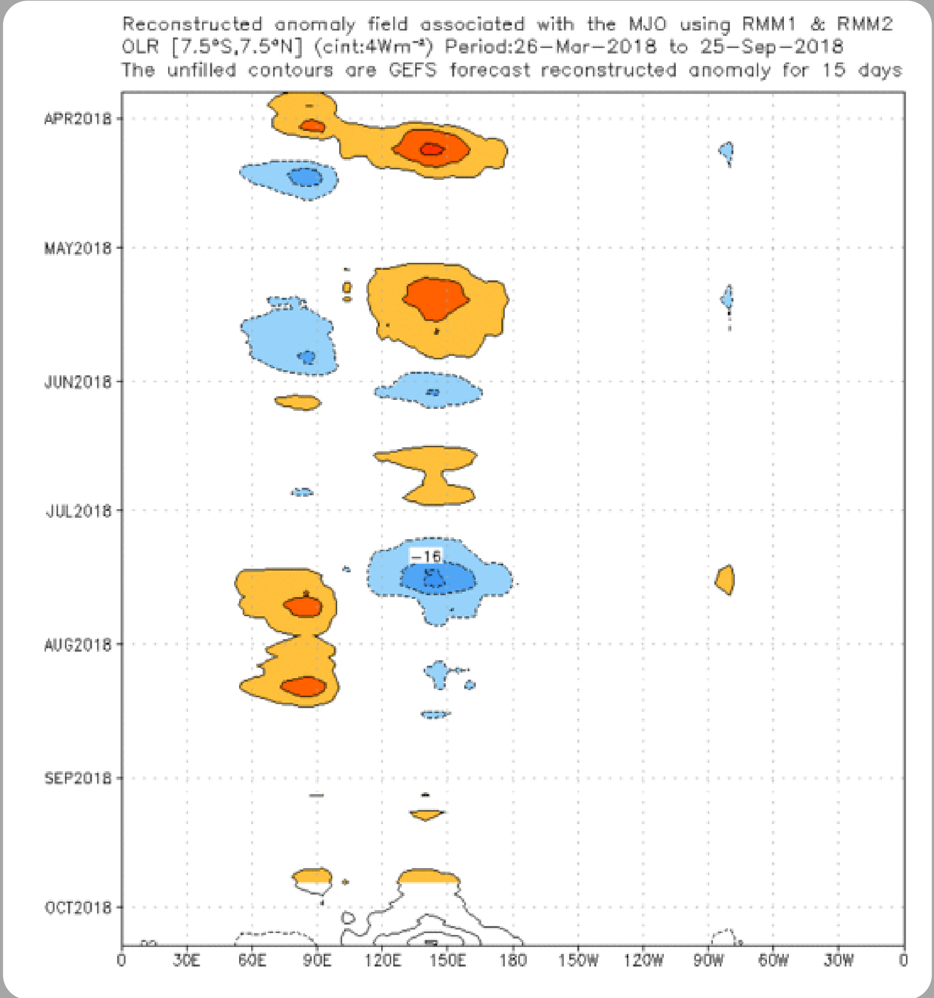
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS shows enhanced convection building across the Indian Ocean during the next two weeks, while stationary enhanced (suppressed) signals exist across the East Pacific and Western Caribbean (Maritime Continent, West, and Central Pacific).

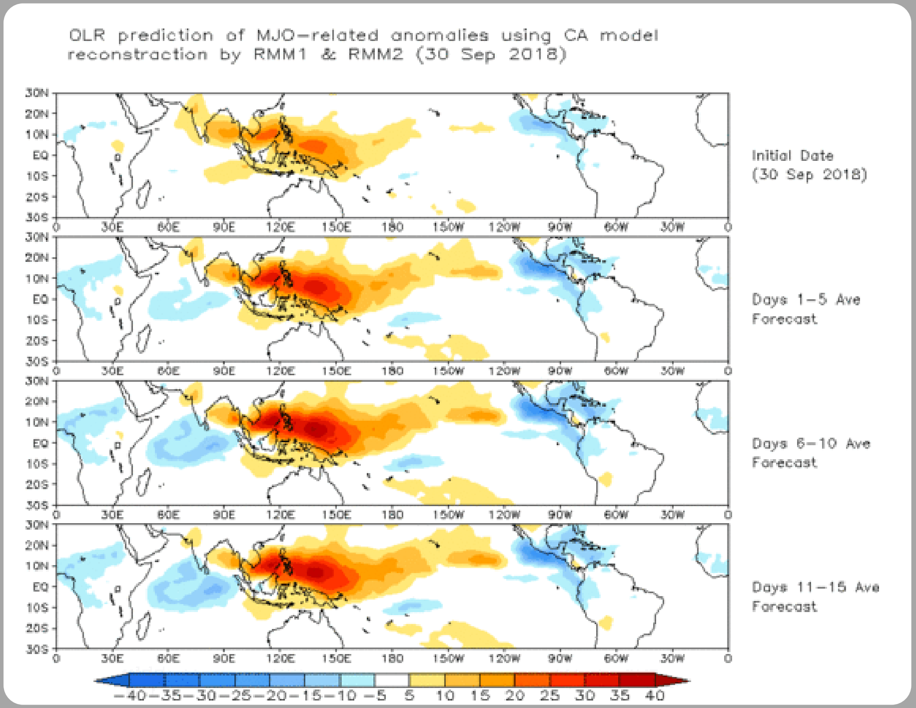
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



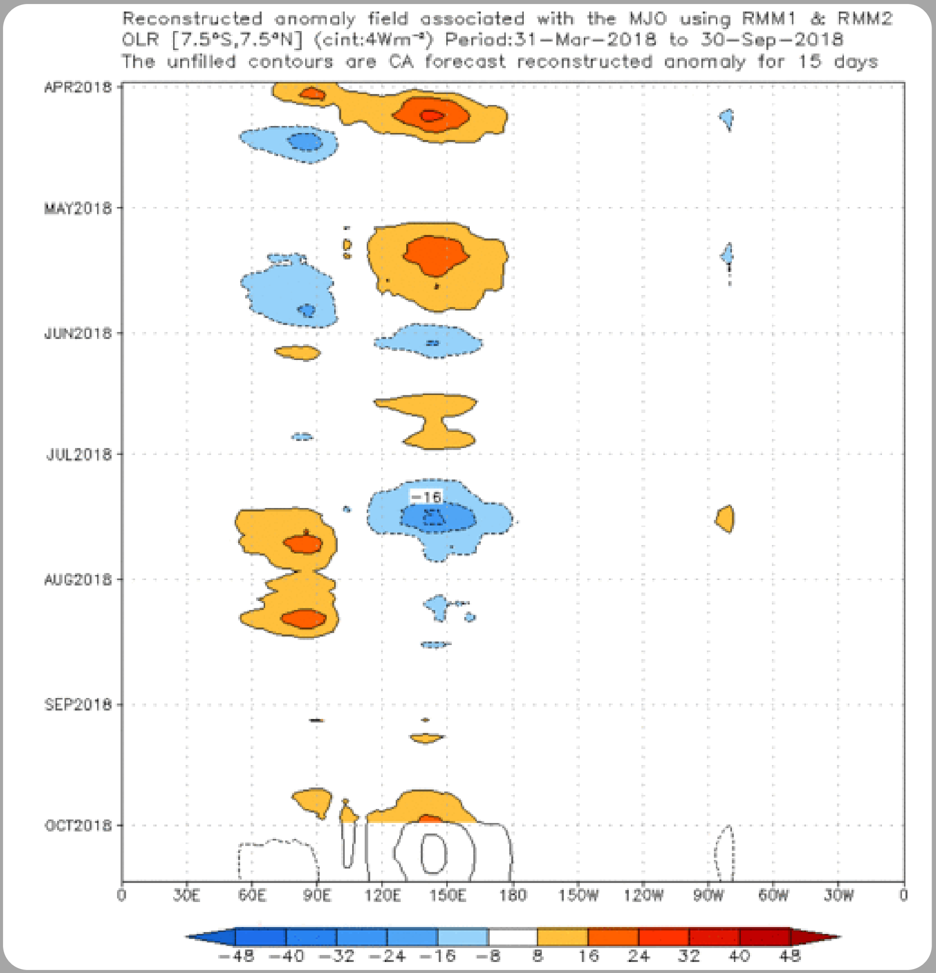
Constructed Analog (CA) MJO Forecast

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



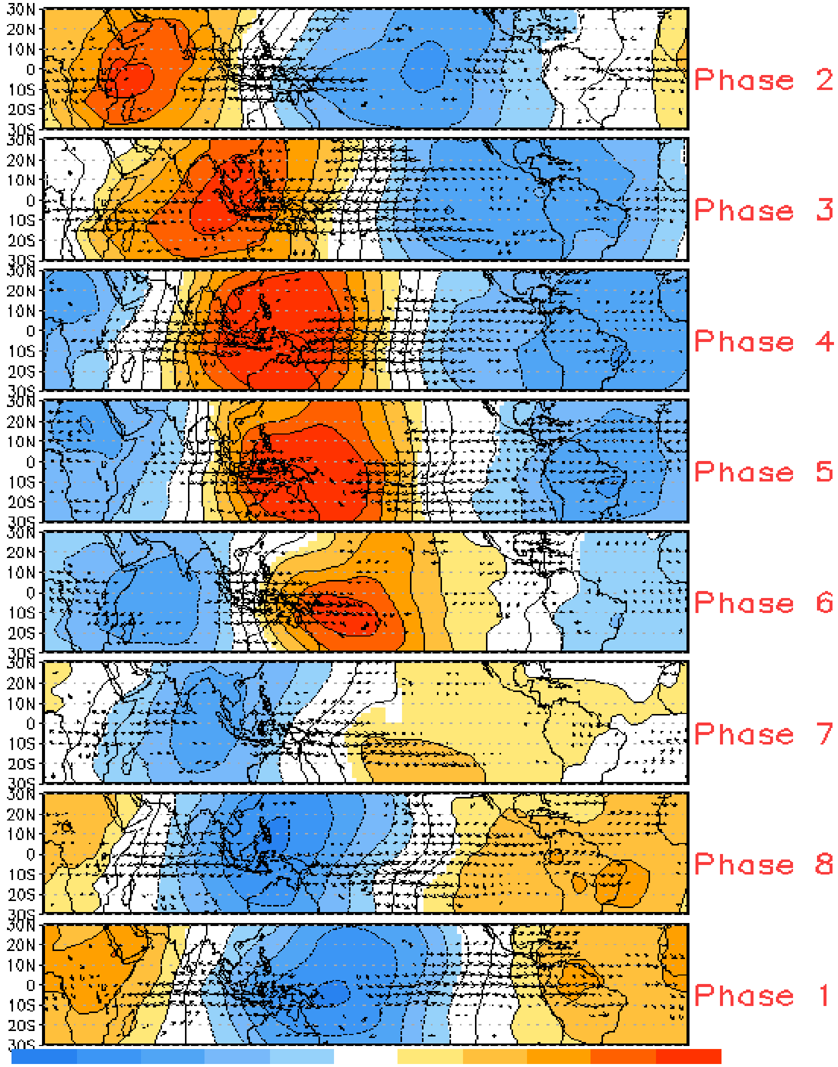
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



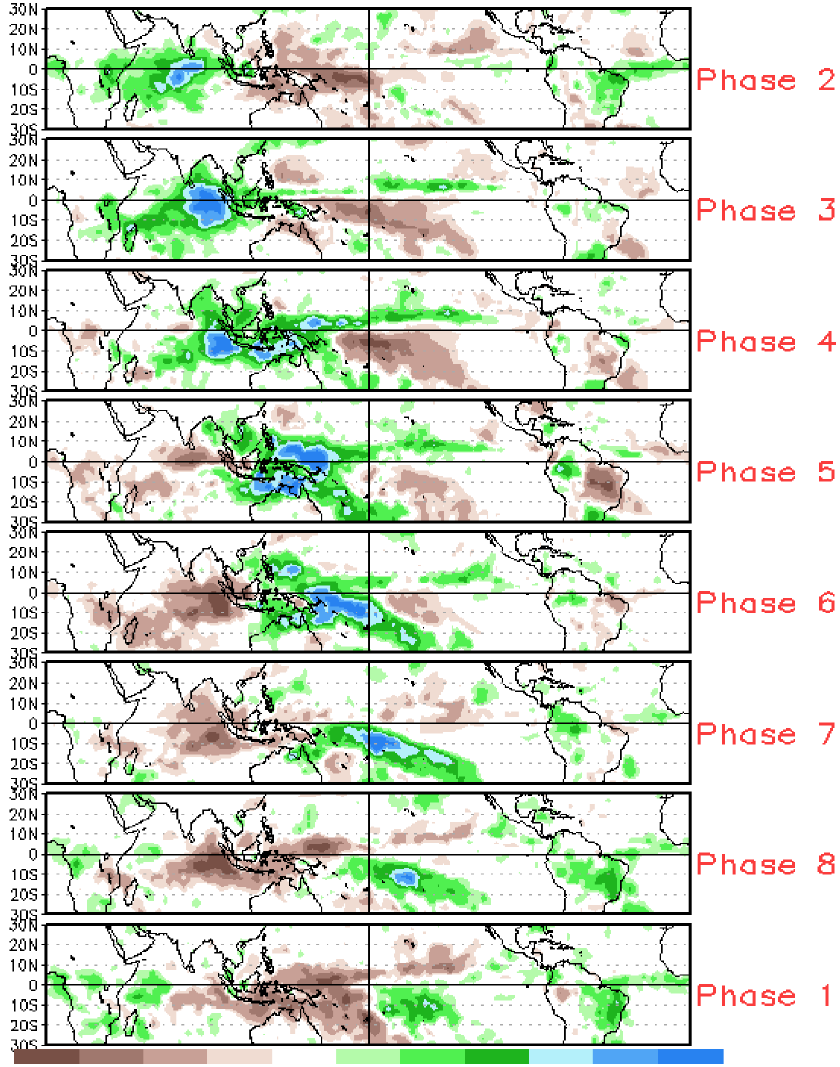
The constructed analog forecast closely mirrors the GEFS, with enhanced convection emerging over the Indian Ocean with lower frequency signals across much of the Pacific and Caribbean.

MJO Composites - Global Tropics

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



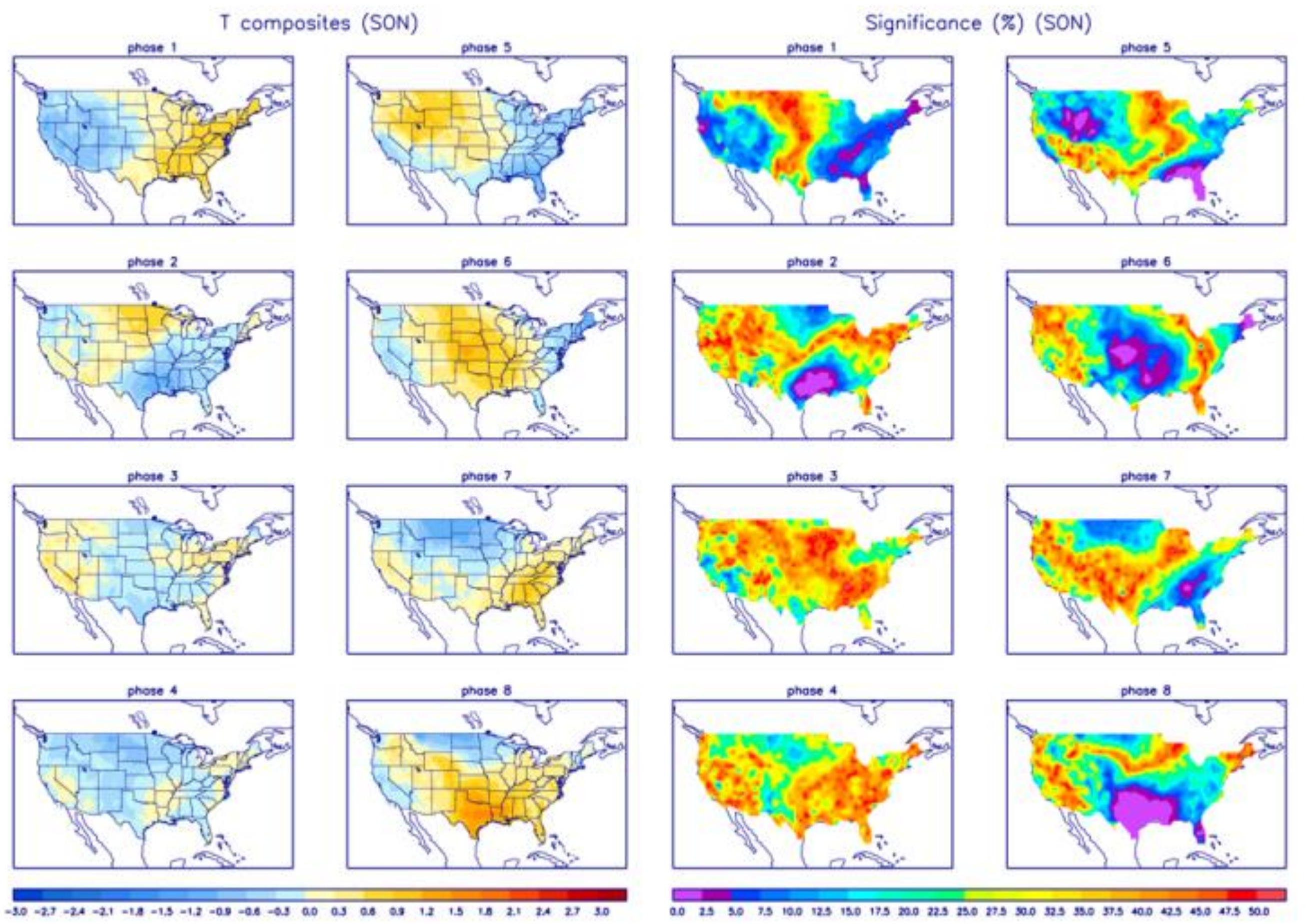
Precipitation Anomalies (May - Sep)



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.



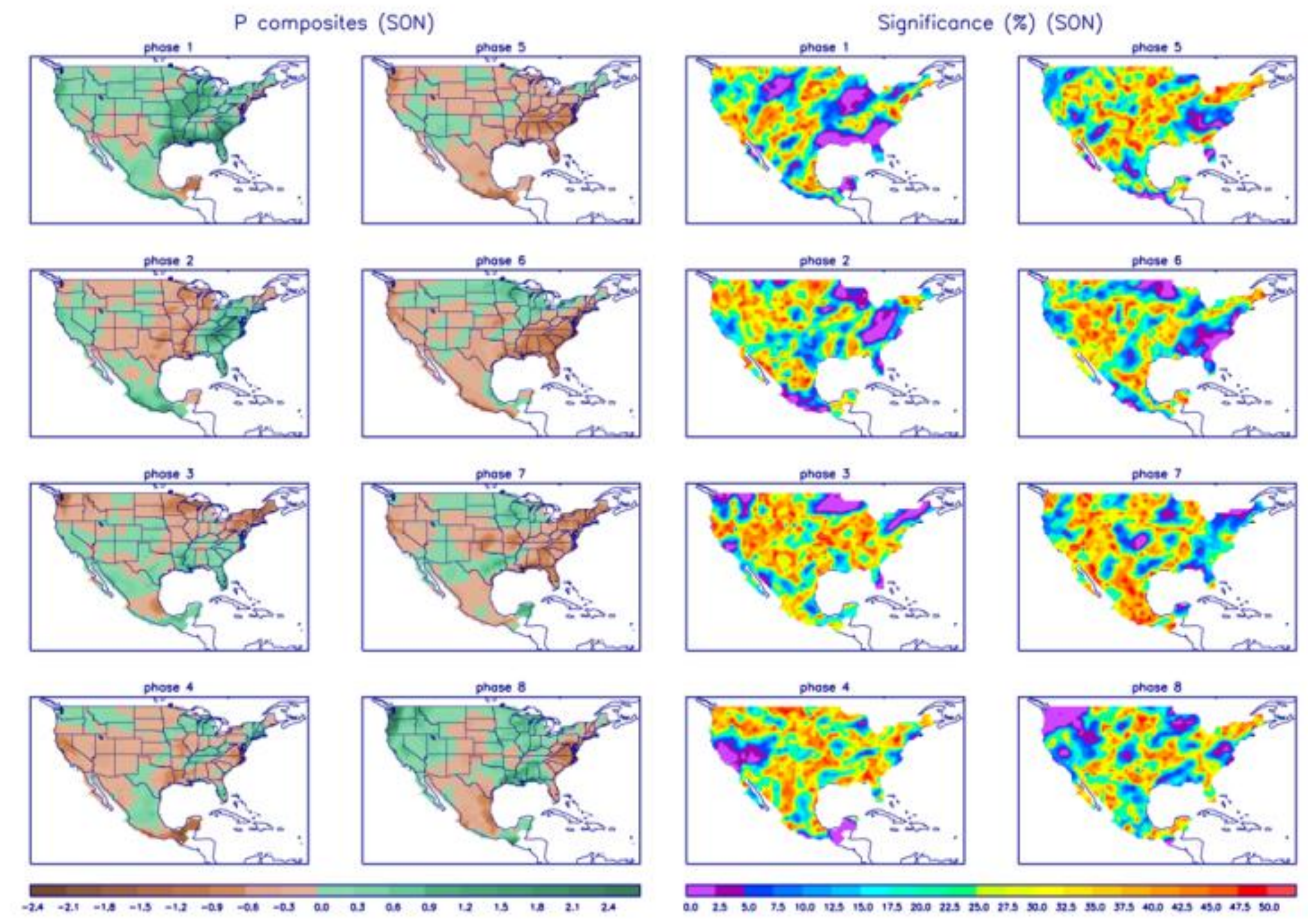
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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