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

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12 November 2018

Outline

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Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

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Overview

- MJO activity has remained robust through the past week, as the enhanced signal shifted from the Indian Ocean eastward over the Maritime Continent. Constructive kelvin wave activity likely enhanced the speed of the moving signal.

- Model guidance forecasts slight eastward propagation further over the Maritime Continent toward the Western Pacific (Phase 5) for the MJO signal on the RMM index during Week-1. Toward the end of the week and into Week-2, a rapid decay in the MJO amplitude is forecast with the index back inside the unit circle.

- With the El Niño event building in the Eastern Pacific, destructive interference between the MJO signal and the low frequency state are likely leading to the forecast for a rapid decay in the MJO signal. An El Niño state has been shown to bias the RMM index toward a Phase 7/8 MJO, which could be the case in the forecast for this rapid decay.

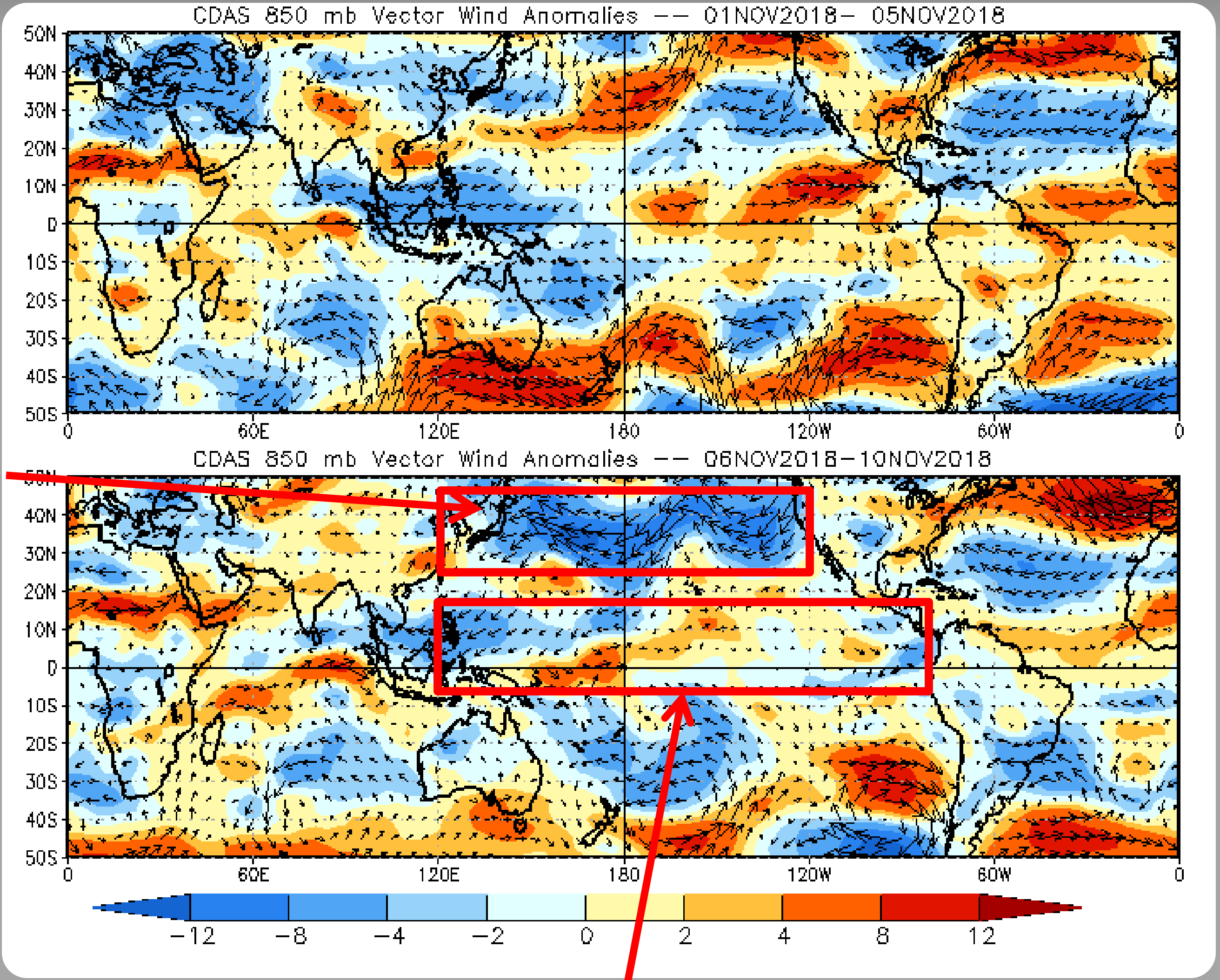
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

<u>Blue shades</u>: Easterly anomalies

<u>Red shades</u>: Westerly anomalies



Robust easterlies in the extratropics in contrast with previous cyclonic activity.

General weakening in the wind pattern over the tropical Pacific through the past five days.

850-hPa Zonal Wind Anomalies ($m\ s^{-1}$)

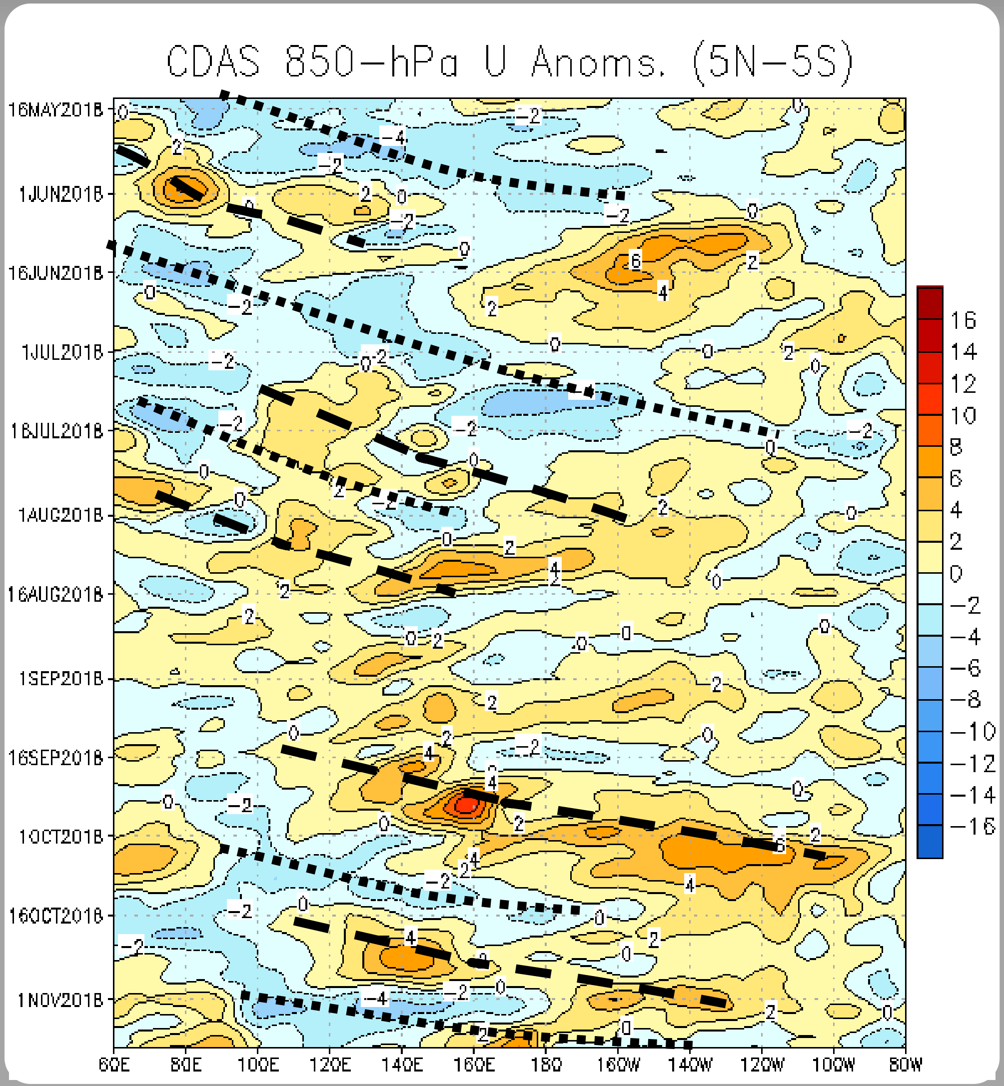
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

The MJO was active during 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 in the Pacific, while westerly anomalies overspread the equatorial Pacific with another rapidly propagating intraseasonal feature late in the month.

During September and October, westerly anomalies increased in amplitude and duration over the equatorial Pacific, consistent with a gradual transition towards El Niño conditions. Another eastward propagating intraseasonal feature is apparent from mid-October through early November.



OLR Anomalies – Past 30 days

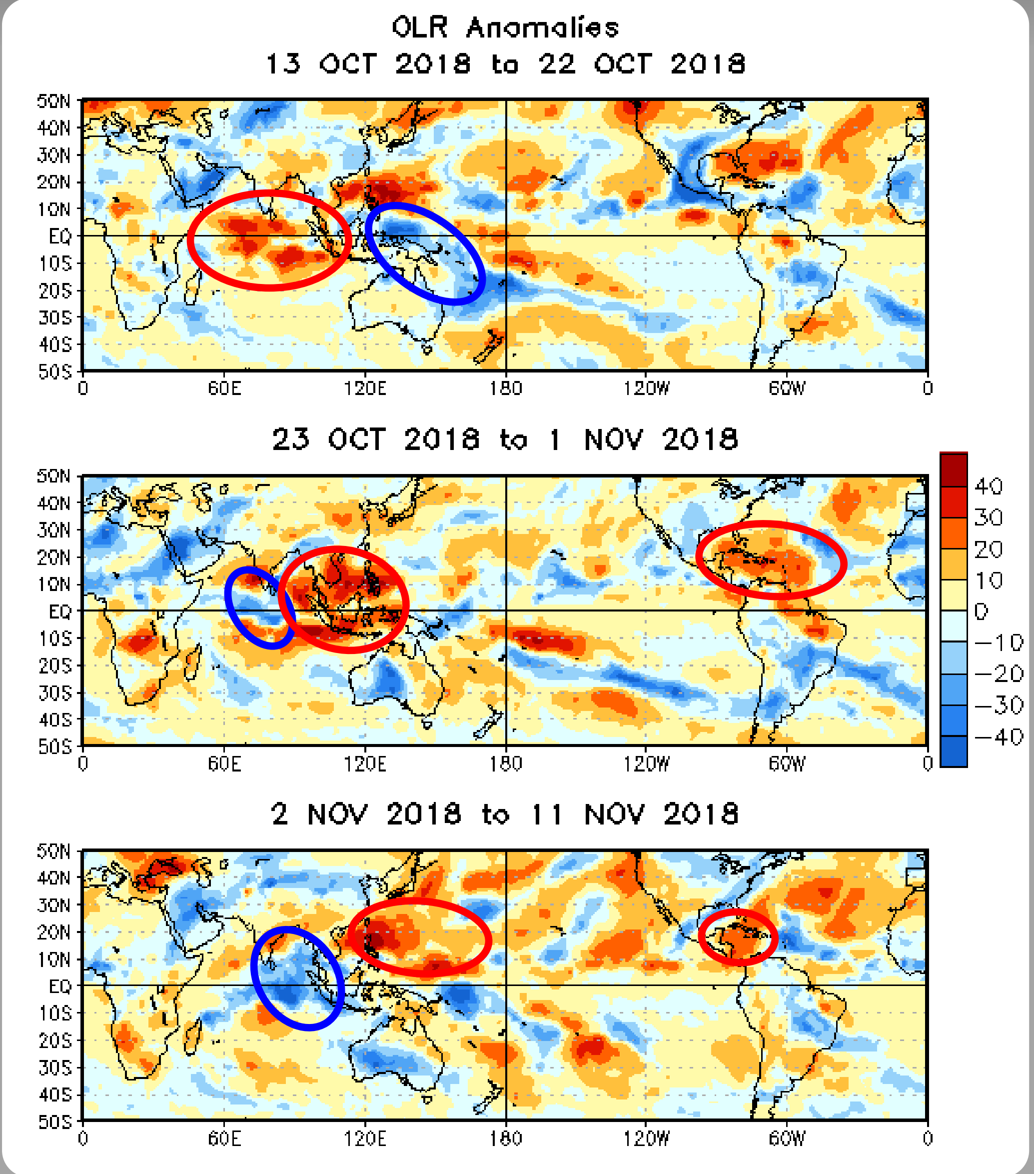
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

By mid-October, convective signals over the Maritime Continent are disorganized, with suppressed convection building over the Indian Ocean and the South China Sea. Some general enhanced convection is seen over the western Pacific.

Toward the end of the month, suppressed convection has shifted eastward over the Maritime Continent, becoming more organized and indicative of MJO activity. Signals over the equatorial Pacific are fairly weak and a small region of enhanced convection is apparent over the central Indian Ocean.

For the start of November, suppressed convection shifts northeastward, over parts of the South China Sea and western Pacific. The enhanced convective signal over the Indian Ocean has expanded over the western Maritime Continent. Widespread suppressed convection over the Caribbean has weakened.



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

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

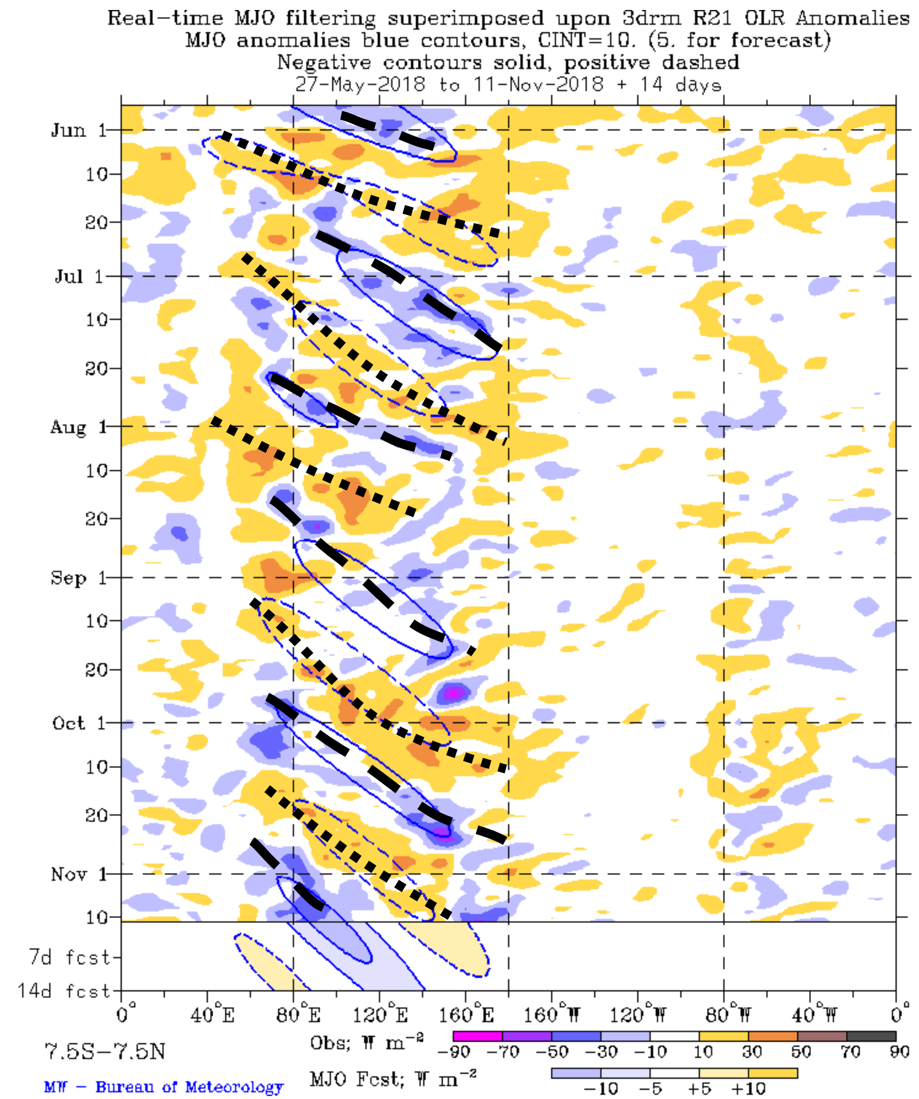
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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. During early October, the suppressed signal propagated further east and enhanced convection emerged over the western Indian Ocean.

More recently, enhanced convection has reappeared over the Indian Ocean, and a weak suppressed signal continues eastward over western Pacific, interfering with enhanced convection centered at160° E.



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

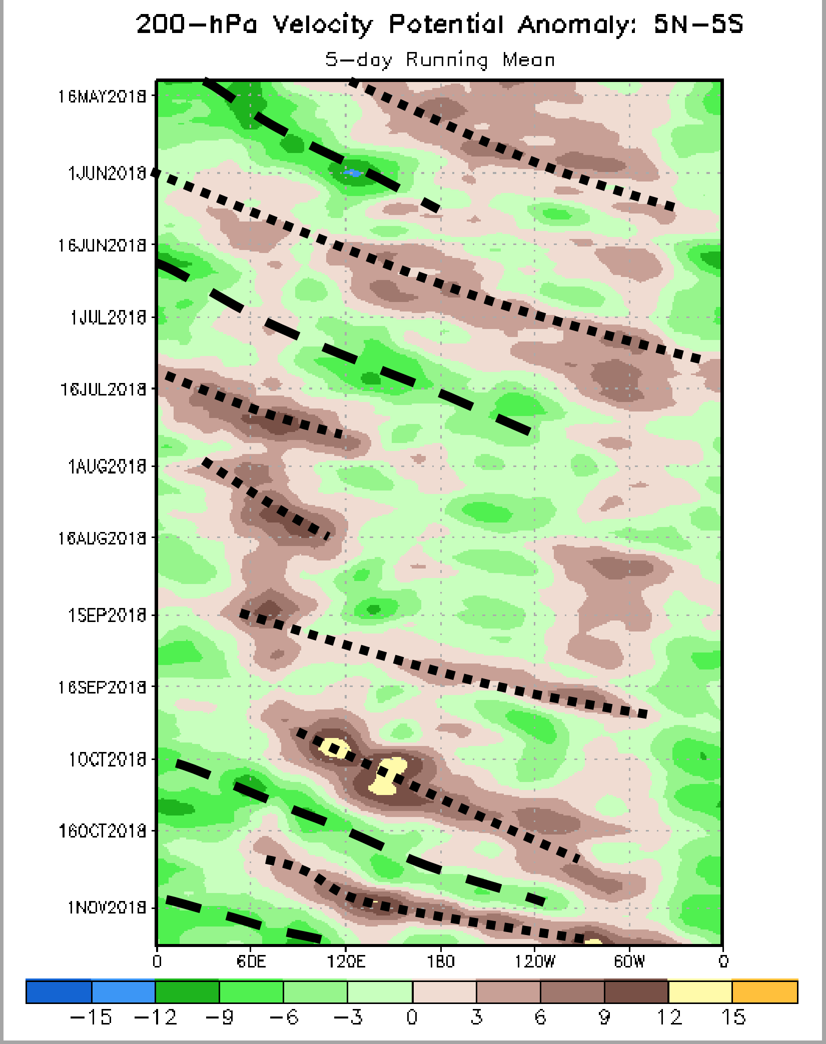
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

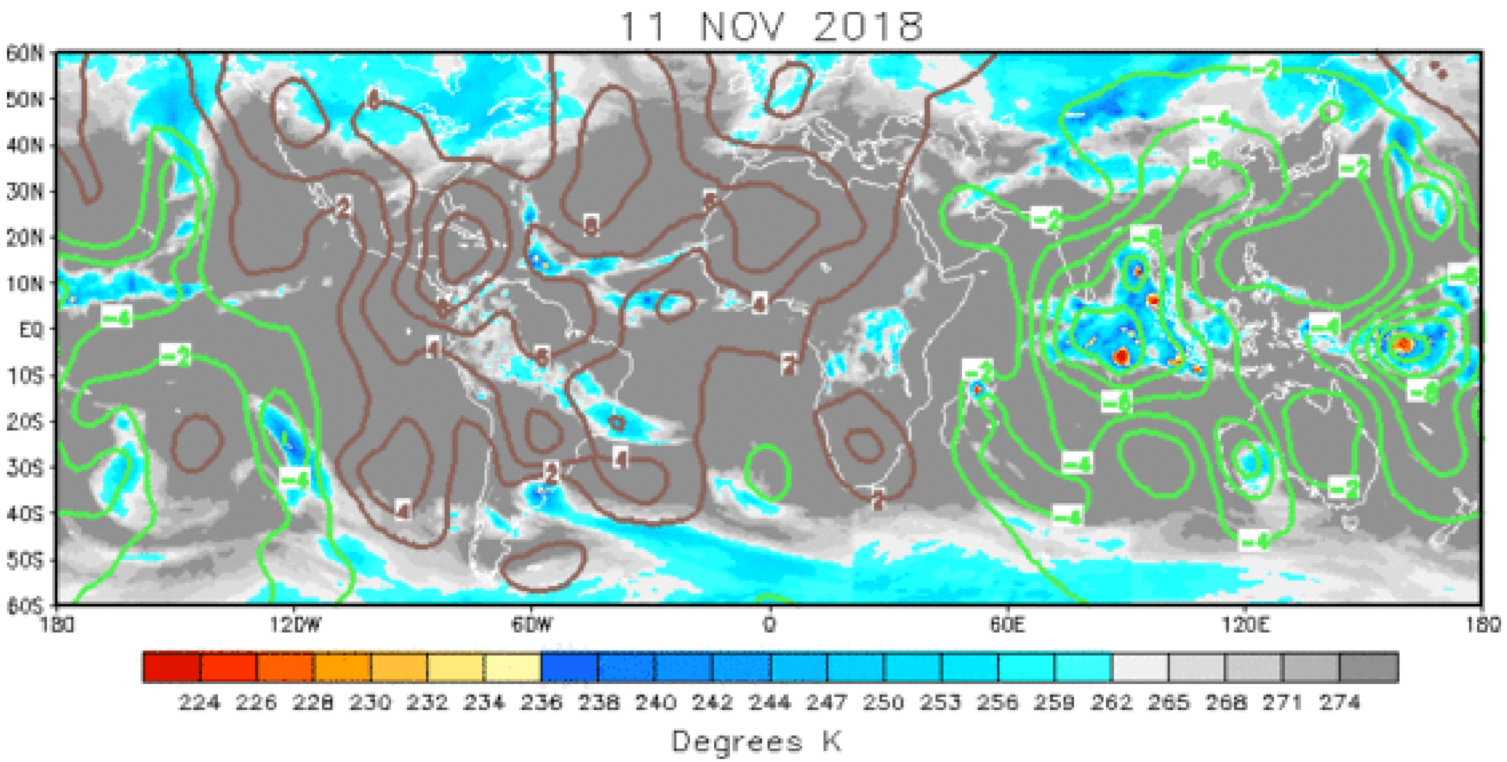
There was robust MJO activity through boreal spring along with the decay of La Niña conditions. The enhanced phase of the MJO weakened east of the Date Line during June. Eastward propagation of broad suppressed convection continued into early July. The upper-level footprint of the MJO re-emerged during mid-July, with a broad divergent signal propagating from the Maritime Continent to the central Pacific.

Starting in mid-July, a low-frequency dipole favoring enhanced (suppressed) convection over the east-central Pacific (Indian Ocean) emerged, consistent with a gradual transition towards El Niño conditions.

During mid-September, a robust intraseasonal signal constructively interfered with the base state over the Maritime Continent. The MJO signal persisted into October, and destructively interfered with the base state. More recently, upper-level divergence has propagated eastward toward the Western Hemisphere. Enhanced convection is starting to spread toward the Date Line.



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



A Wave-1 pattern is well organized in the upper levels, with enhanced convection extending from the Indian Ocean (IO) toward the central Pacific. Enhanced convection over the IO contributed to the development of three tropical cyclones. Less amplified suppressed convection is apparent over the Americas and Atlantic.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

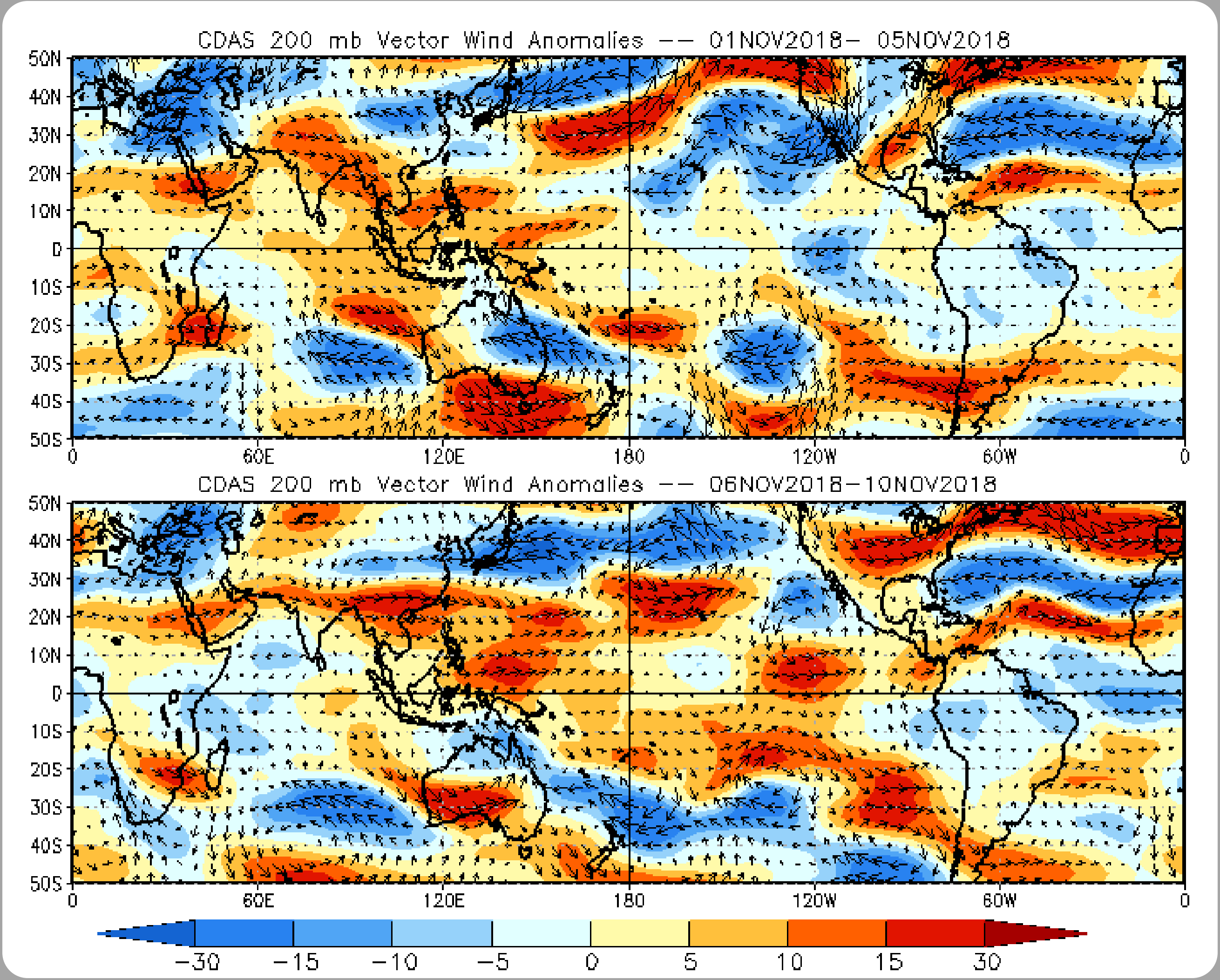
Negative anomalies (green contours) indicate favorable conditions for precipitation

200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Anomalies westerlies seen the previous week over the eastern IO and Maritime Continent have strengthened and shifted eastward, now spreading over the equatorial Pacific.

The upper-level jet over the northern Pacific has weakened significantly from last week, interrupted by robust easterlies extending across the northern portion of basin.

200-hPa Zonal Wind Anomalies (m s^{-1})

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

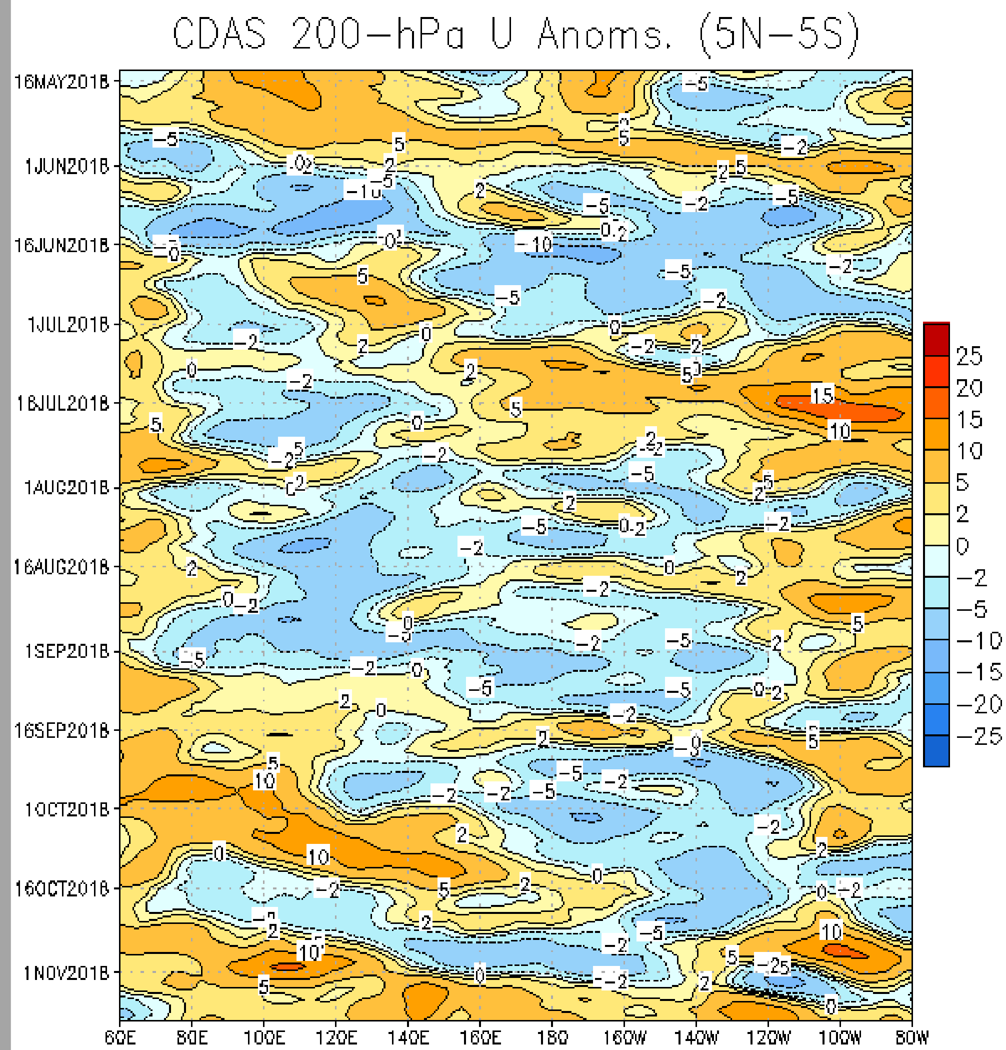
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

Toward the end of October, anomalous westerlies strengthened over the Indian Ocean and since early November, have shifted east, persisting across the entire tropical Pacific.



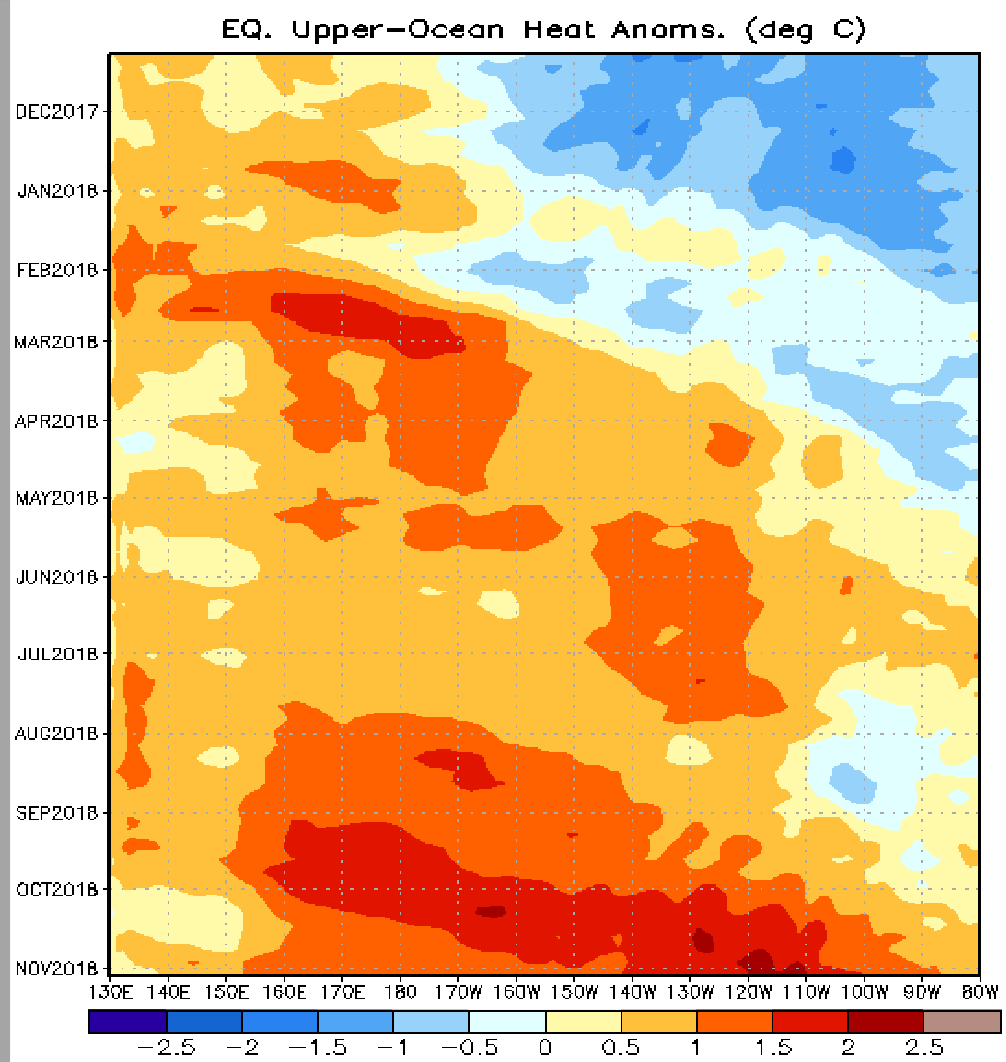
Weekly Heat Content Evolution in the Equatorial Pacific

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 westerly wind burst east of New Guinea in September triggered another oceanic Kelvin wave and round of downwelling, helping to reinforce the warm water availability for a potential El Niño event. Currently, westerly wind anomalies have returned to much of the basin.



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

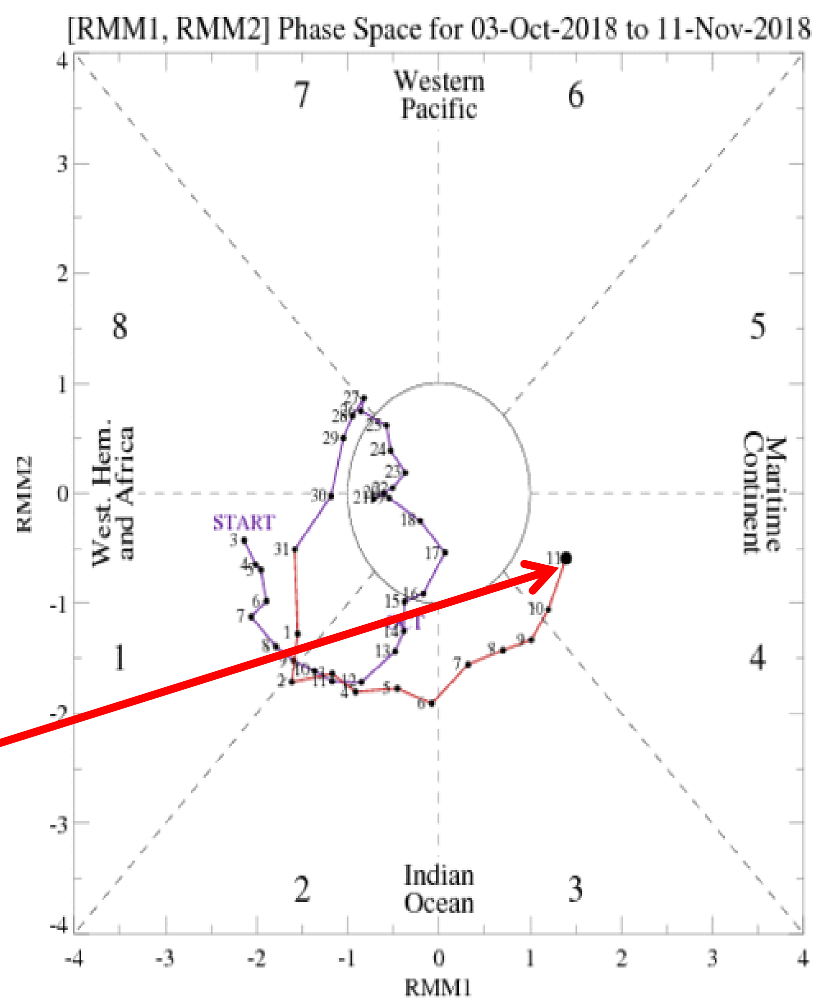
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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

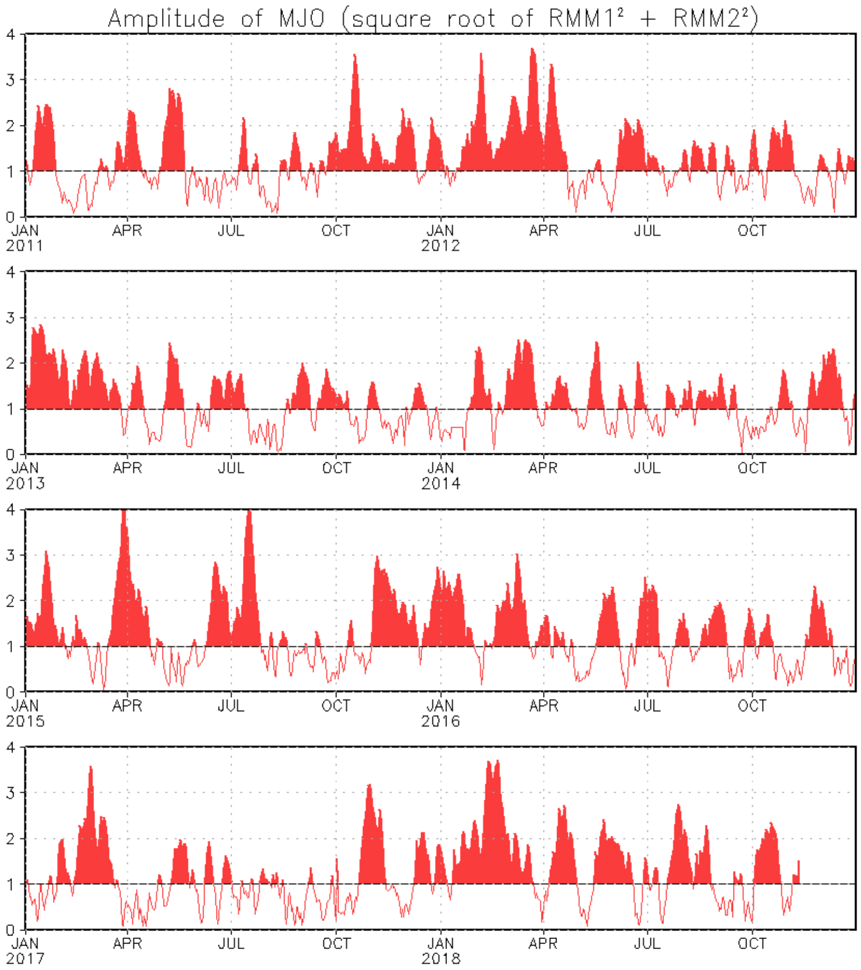


The RMM-based MJO index has maintained amplitude during the past week, propagating eastward toward the Maritime Continent.

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.



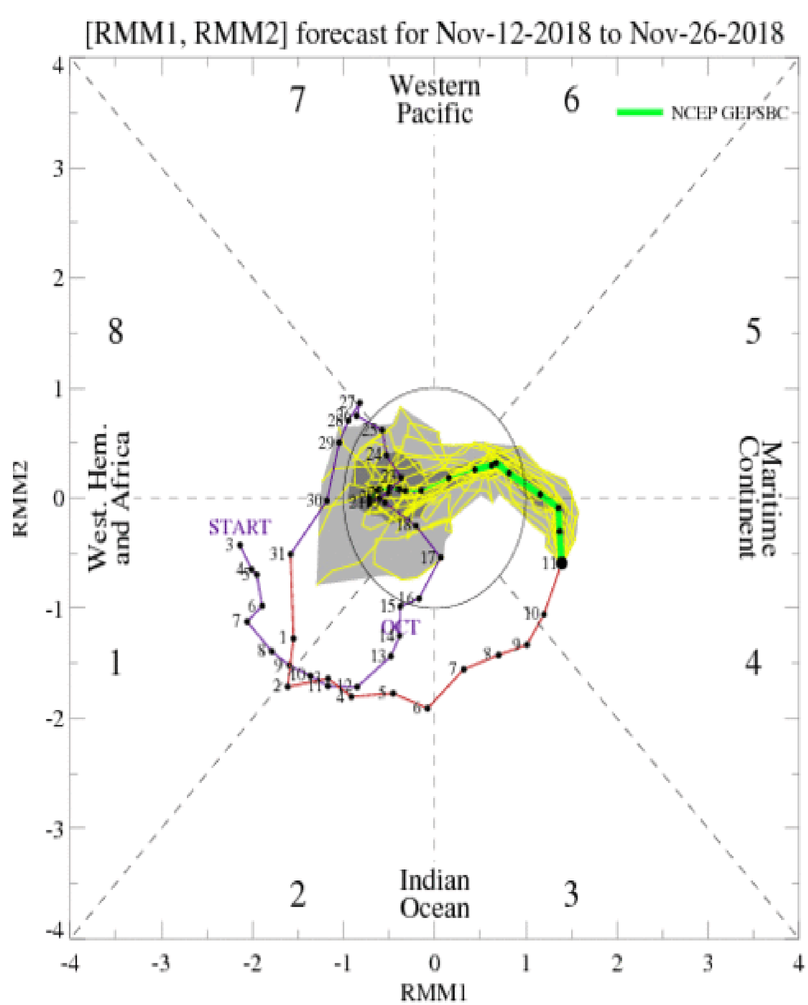
GFS Ensemble (GEFS) MJO Forecast

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

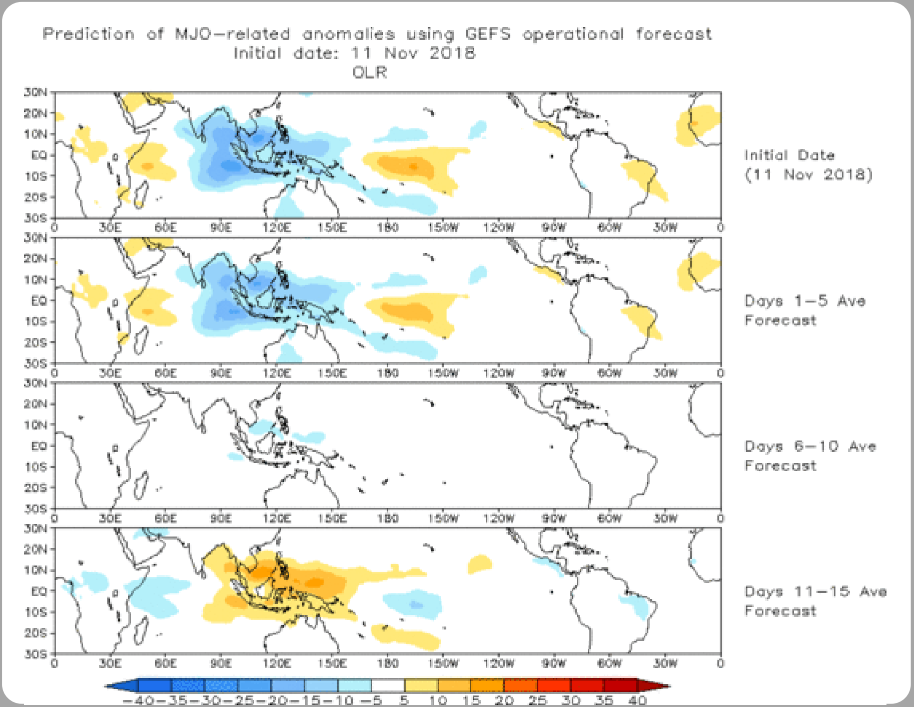


The GEFS-based RMM-index forecast forecasts a rapid decay of the signal, propagating into Phase 5 during Week-1, before quickly moving back inside the Unit Circle.

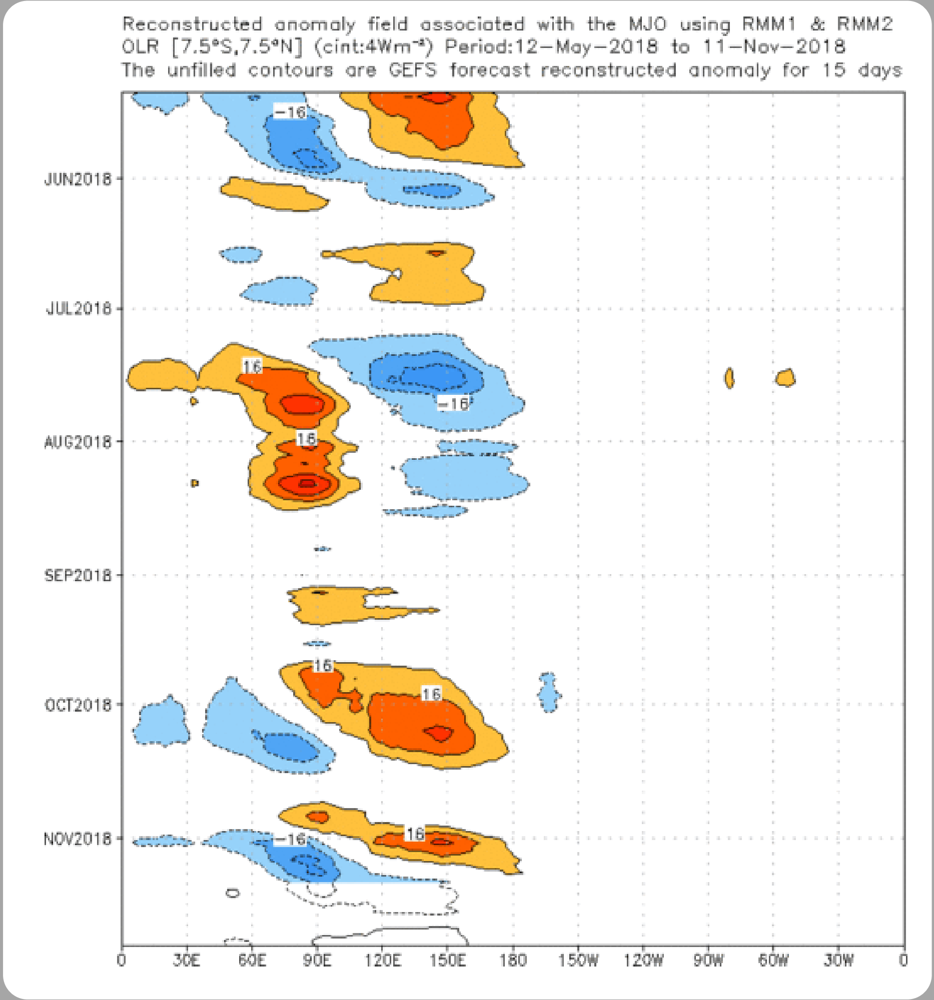
Ensemble GFS (GEFS) MJO Forecast

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

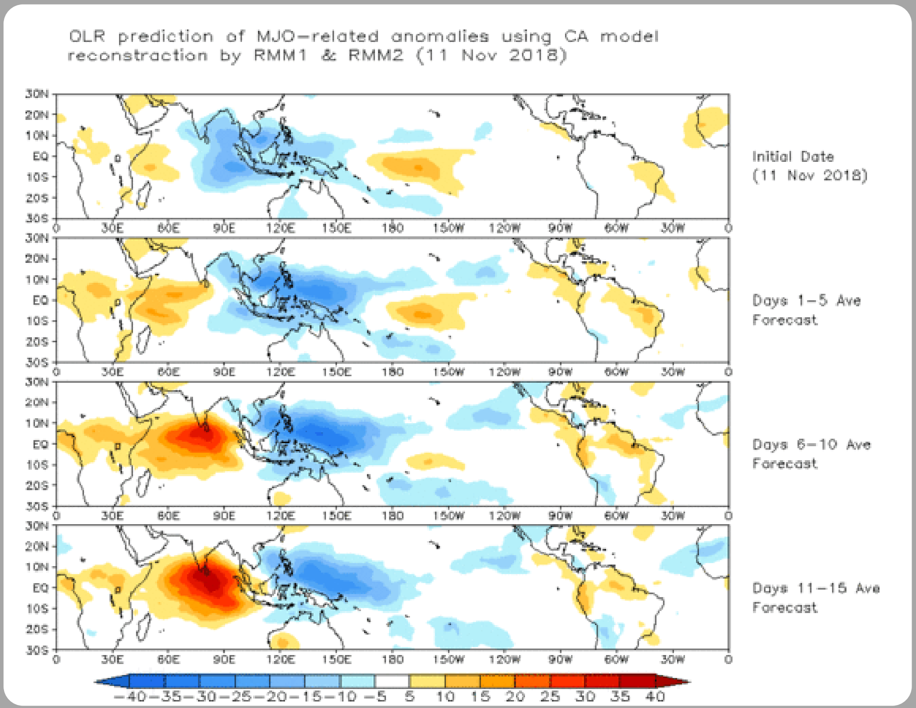


The GEFS RMM-based OLR forecast indicates not much movement in the spatial signal over the next week. Rapid decay is seen toward the end of Week-1, with the convective signals disappearing. Widespread suppressed convection is forecast for the Maritime Continent at the end of Week-2.

Constructed Analog (CA) MJO Forecast

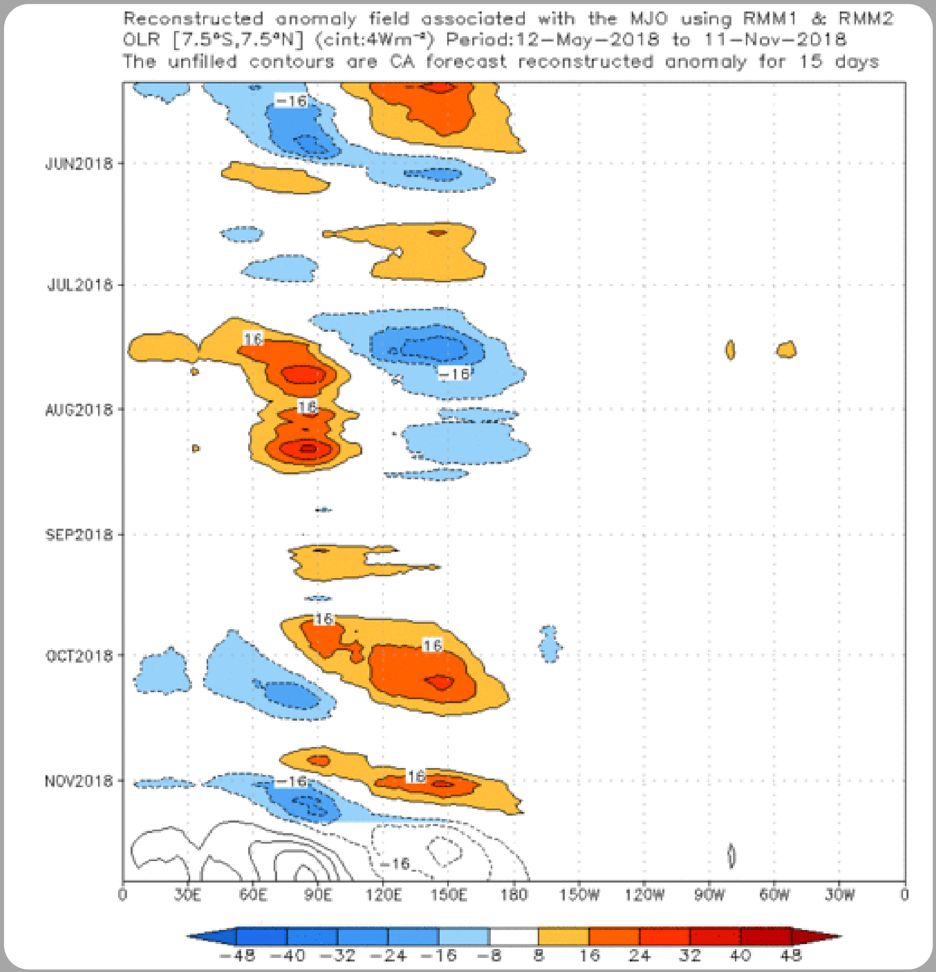
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



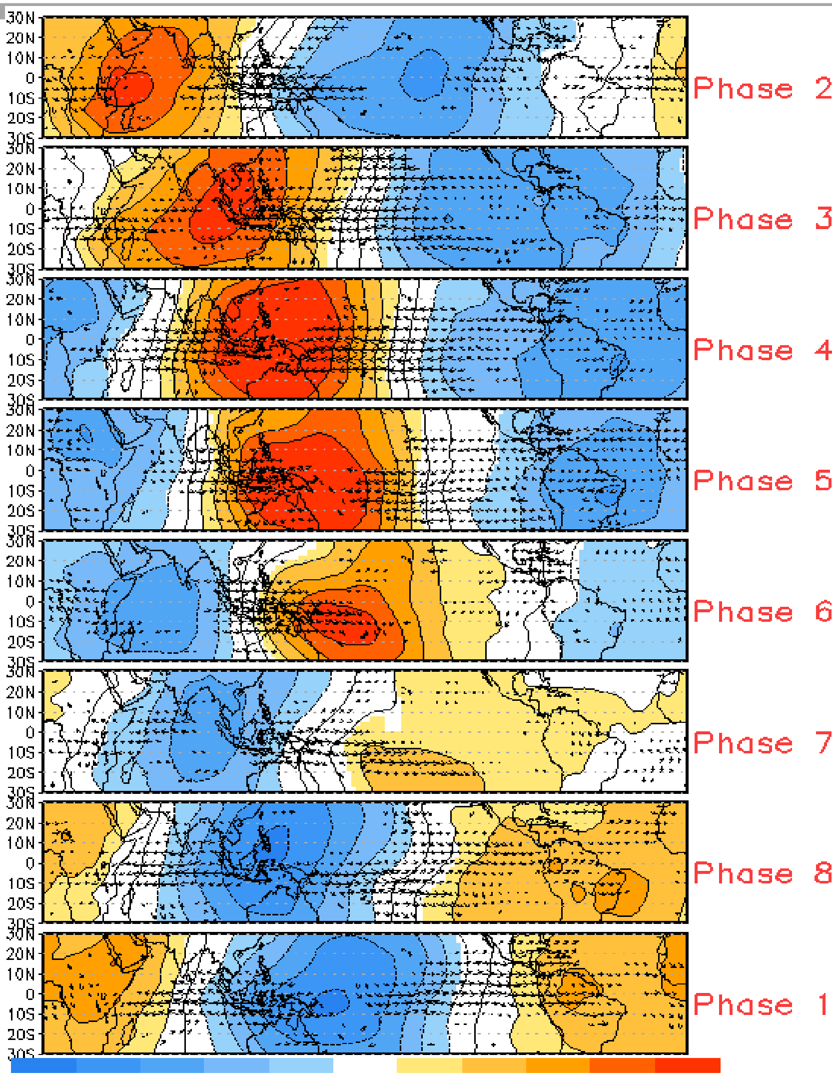
The OLR forecast based on the constructed analog RMM-index forecasts shows more of an eastward propagation of the convective signals through the next two weeks. It indicates that the suppressed envelope will reach the Indian Ocean by Week-2.

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

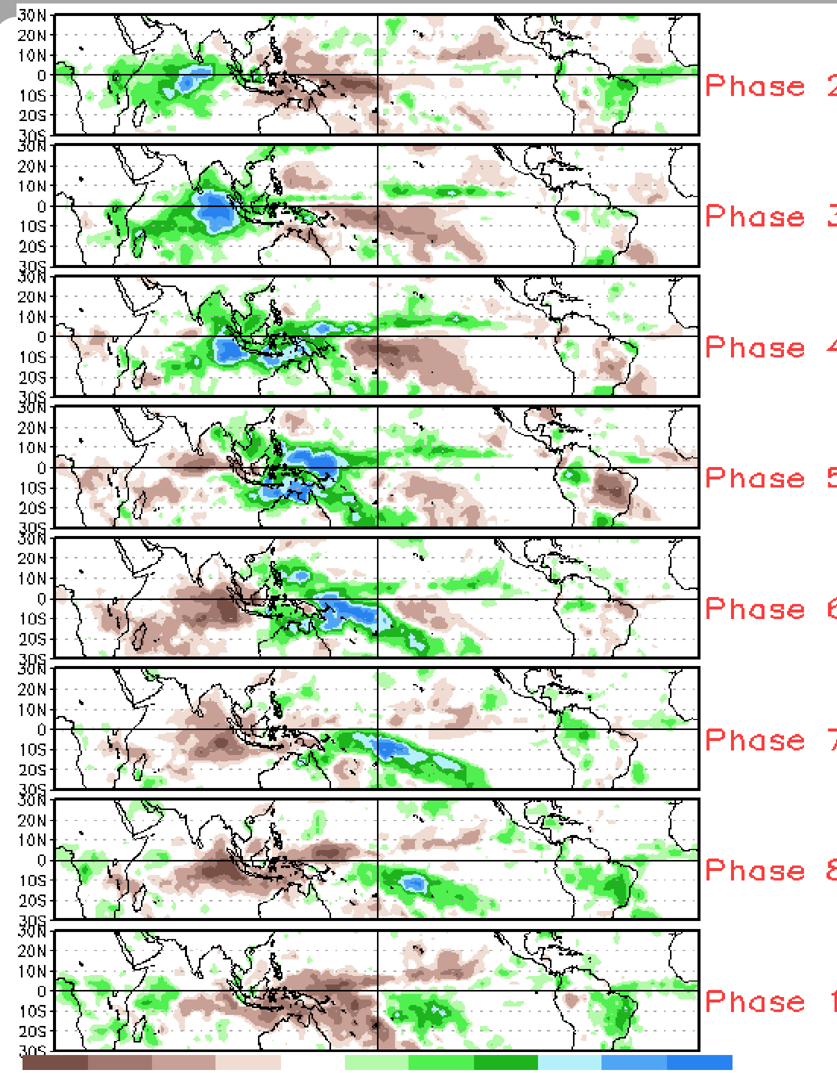


MJO Composites - Global Tropics

850-hPa Velocity Potential and Wind Anomalies (Nov - Mar)



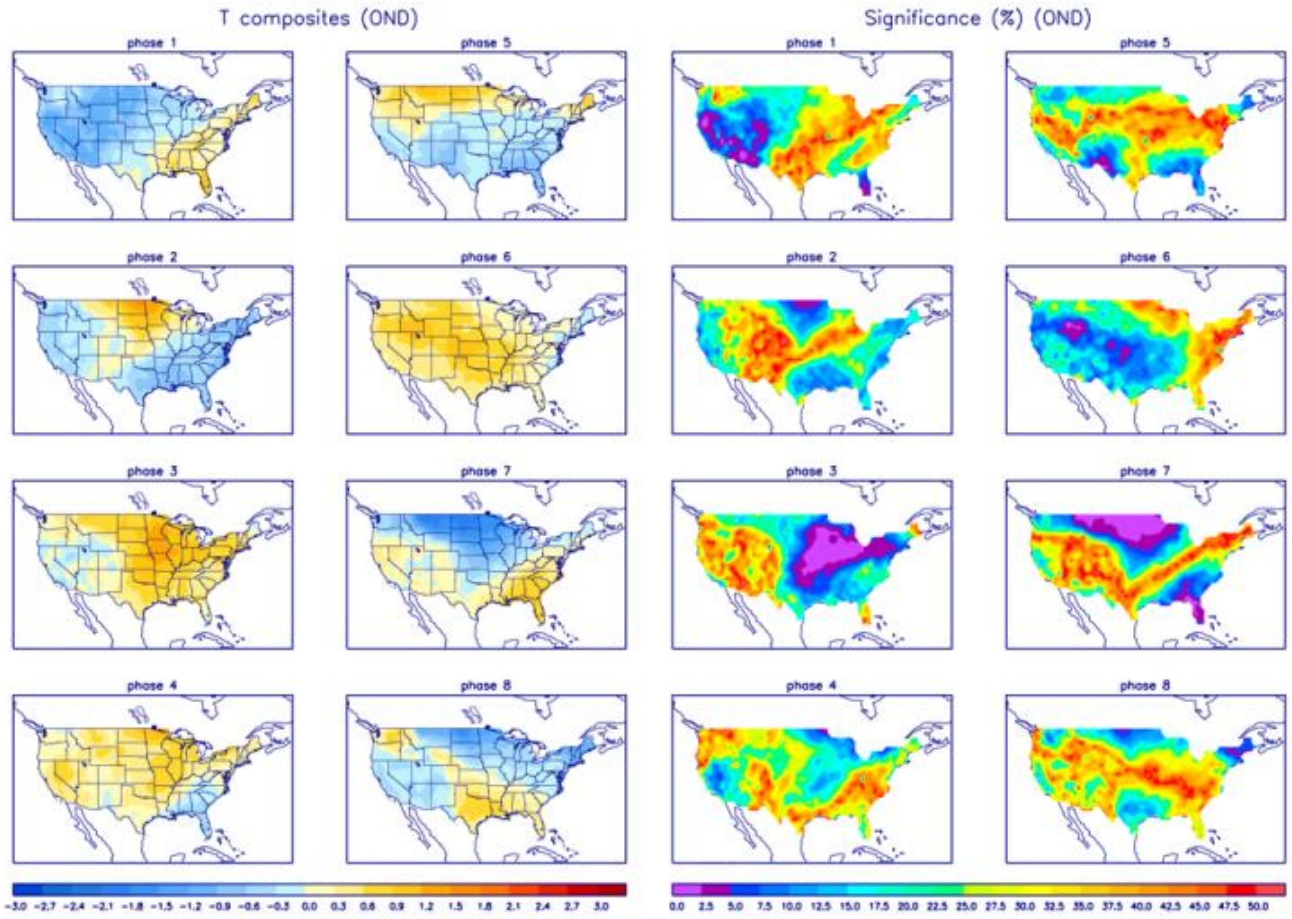
Precipitation Anomalies (Nov - Mar)



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.



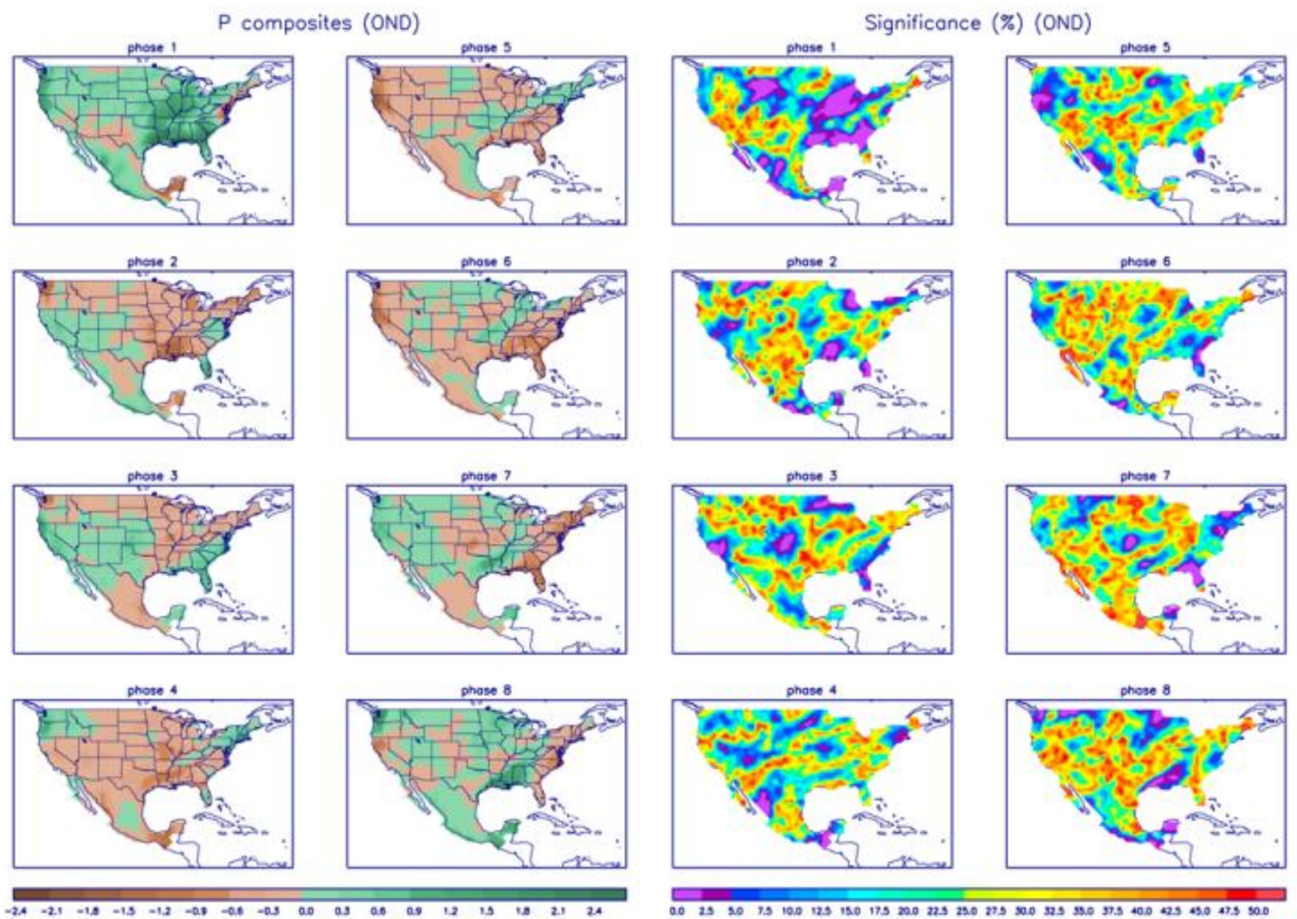
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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