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

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Climate Prediction Center / NCEP
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Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The MJO is active, with robust amplitude and eastward propagation evident on both the CPC velocity potential based and RMM-based MJO indices.
- The enhanced phase of the MJO is currently over the West Pacific. There is some destructive interference between the MJO signal and the base state (potentially emerging La Niña conditions), and the suppressed phase of a Rossby wave over the far West Pacific.
- Dynamical model RMM-index forecasts generally support continued eastward propagation of the MJO over the next two weeks, although the amplitude may be impacted by continued destructive interference with the base state.
- The MJO is expected to continue playing a major role in the global tropical convective pattern over the next two weeks, and may affect the evolution of the extratropical pattern. West Pacific MJO events are associated with a pattern shift towards increased upper-level troughing over the central CONUS.

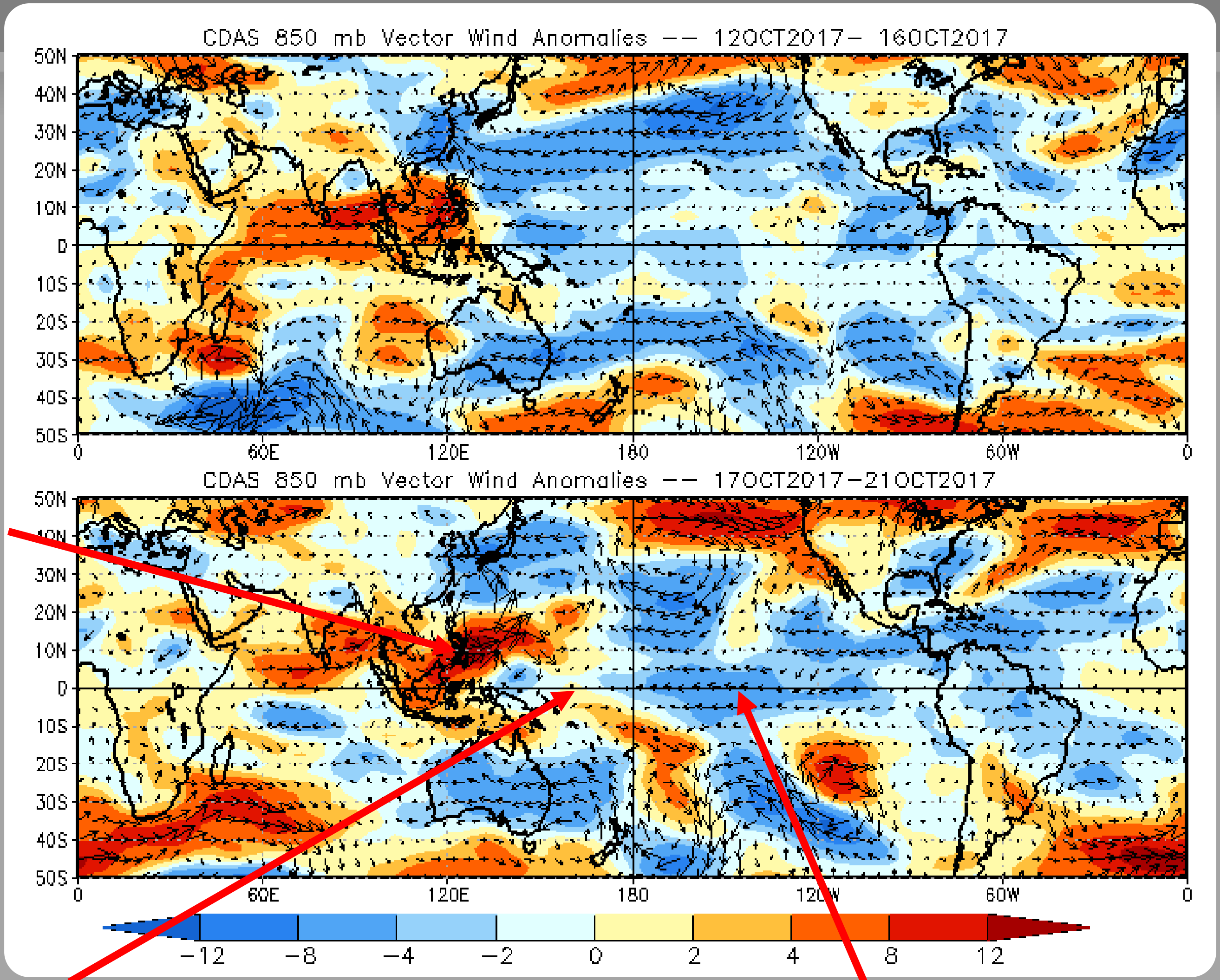
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies south of a broad low-level cyclonic gyre propagated eastward over the northwestern Pacific.

Easterly anomalies weakened west of the Date Line, but westerly anomalies made little eastward progress as the MJO destructively interfered with the base state.

The robust envelope of easterly anomalies shifted eastward across the central and East Pacific.

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

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

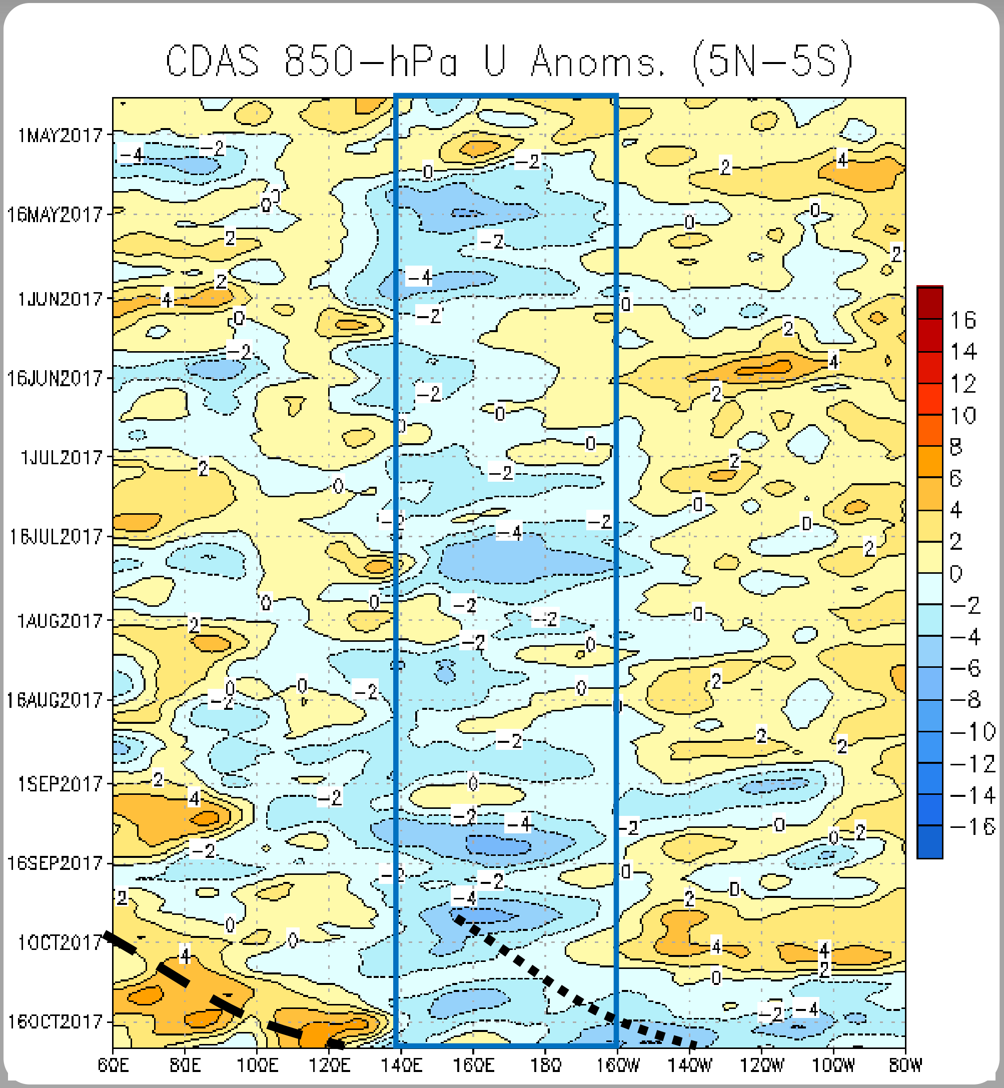
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Low-frequency easterly anomalies (blue box) have largely persisted over the west-central Pacific throughout the last 180 days.

Equatorial zonal wind anomalies were of low amplitude in June. During July, a slight eastward shift in the low-frequency pattern is noted, related to short-lived MJO activity.

During August and September, the low-frequency envelope of easterly anomalies became re-established further west, extending from 140E to just east of the Date Line.

During October, a robust MJO event became established, with eastward propagation of westerly (easterly) anomalies apparent over the Maritime Continent (Pacific). More recently, interference with the base state and a Rossby Wave over the West Pacific is evident.



OLR Anomalies – Past 30 days

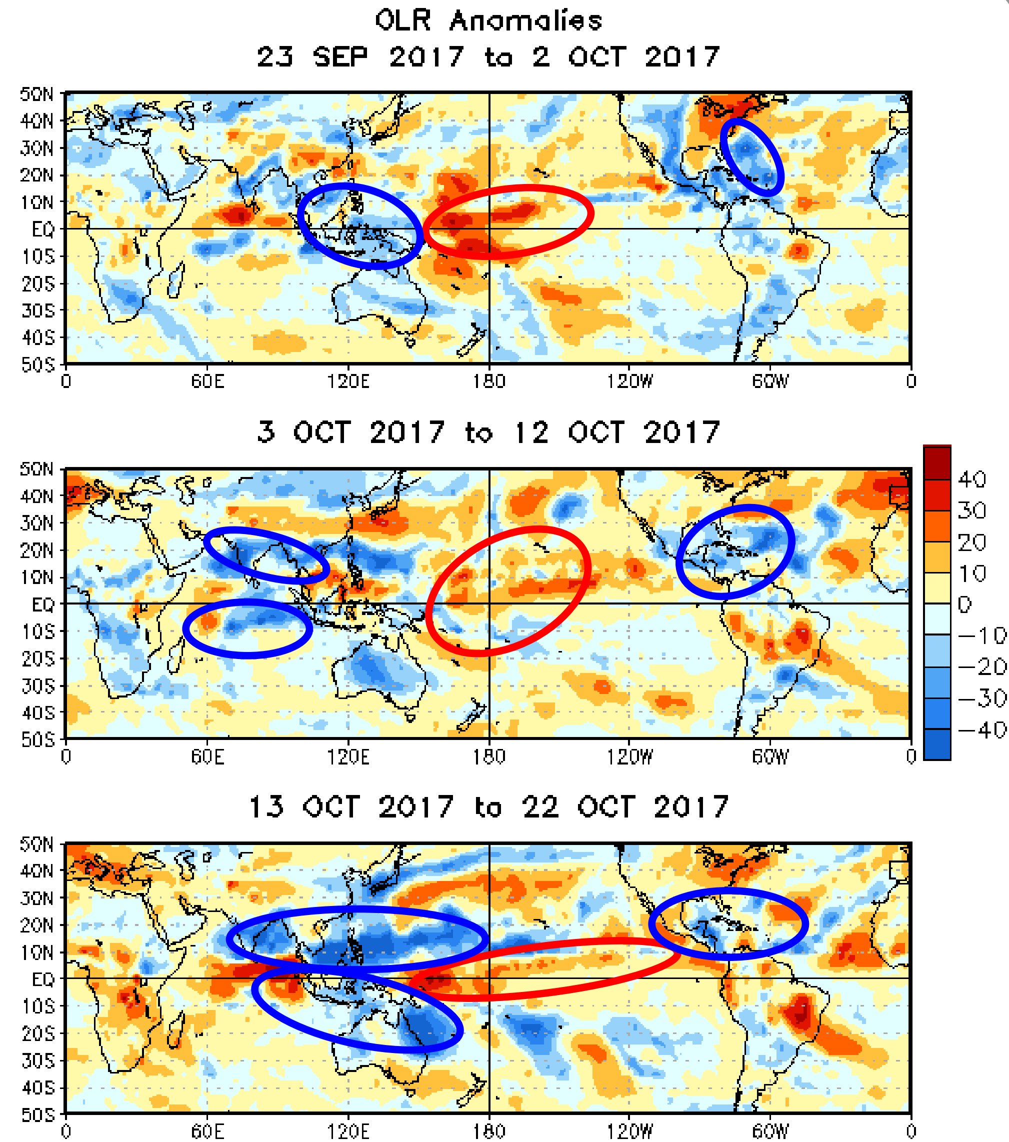
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late September, zonally narrow envelopes of enhanced (suppressed) convection were observed over the Maritime Continent (central Pacific). The track of Hurricane Maria was evident over the North Atlantic.

During late September and early October, enhanced convection developed across central America and the western Atlantic basin, as well as over parts of the Indian Ocean basin away from the Equator. Suppressed convection persisted over the Pacific.

By mid-October, a broader envelope of enhanced convection associated with MJO activity developed over much of the Maritime Continent. Suppressed convection remained entrenched over the central and eastern Pacific.



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

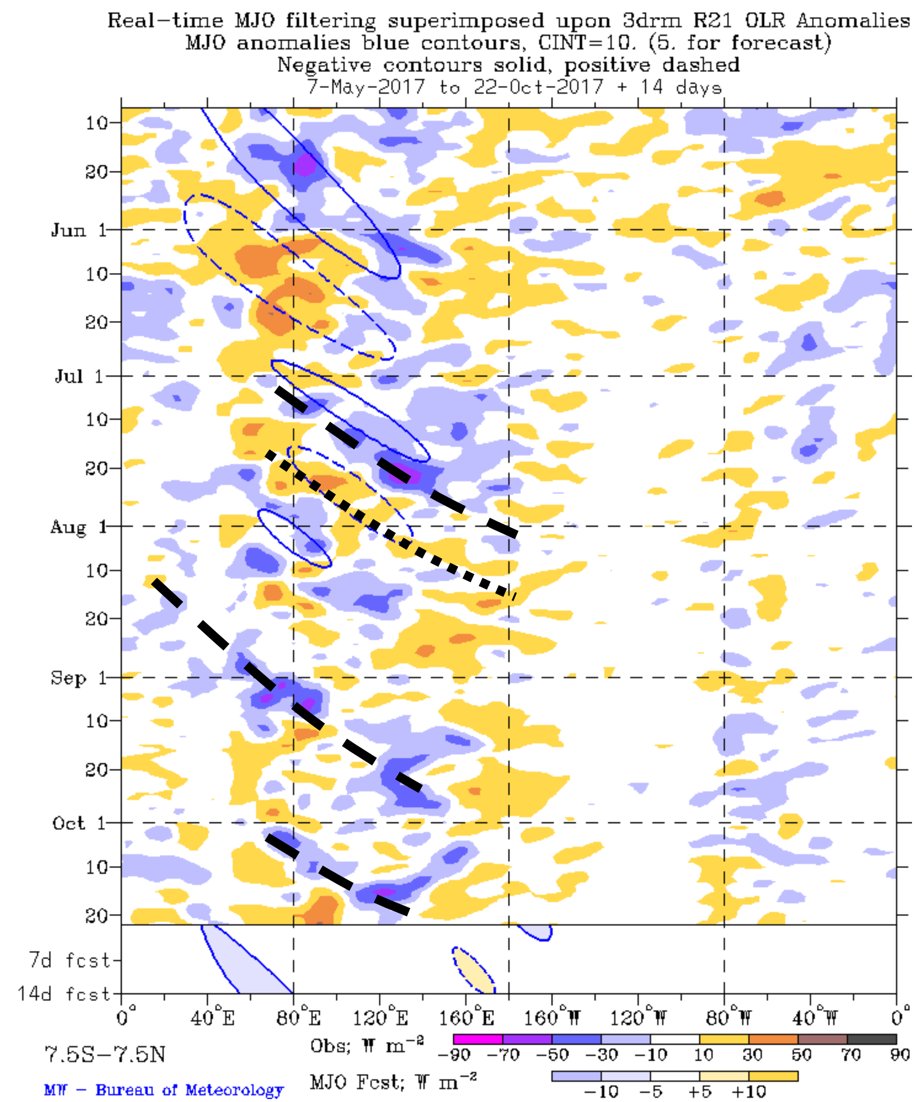
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid-July, there was a burst of enhanced convection over the Maritime Continent, due to interactions between a short-lived intraseasonal signal and the low-frequency state.

Multiple modes of variability including tropical cyclones contributed to the pattern of anomalous convection during August and September. Weak MJO activity was present during August and early September, but the signal became overwhelmed by destructive interference with the base state.

More recently, a renewed MJO signal emerged over the Maritime Continent. Although the OLR response has been fairly weak near the equator, there is a larger envelope of enhanced convection, particularly across the Northern Hemisphere tropics.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

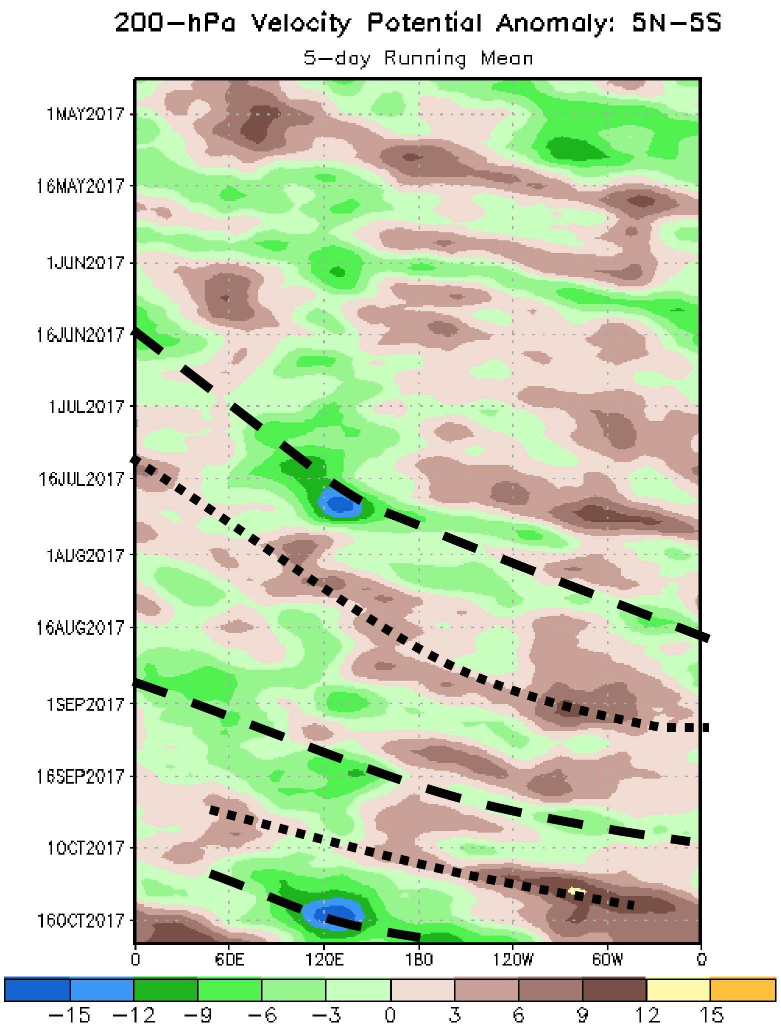
Negative anomalies (green shading) indicate favorable conditions for precipitation

Kelvin wave activity was apparent from late April through early June, as seen in the rapidly propagating eastward signals.

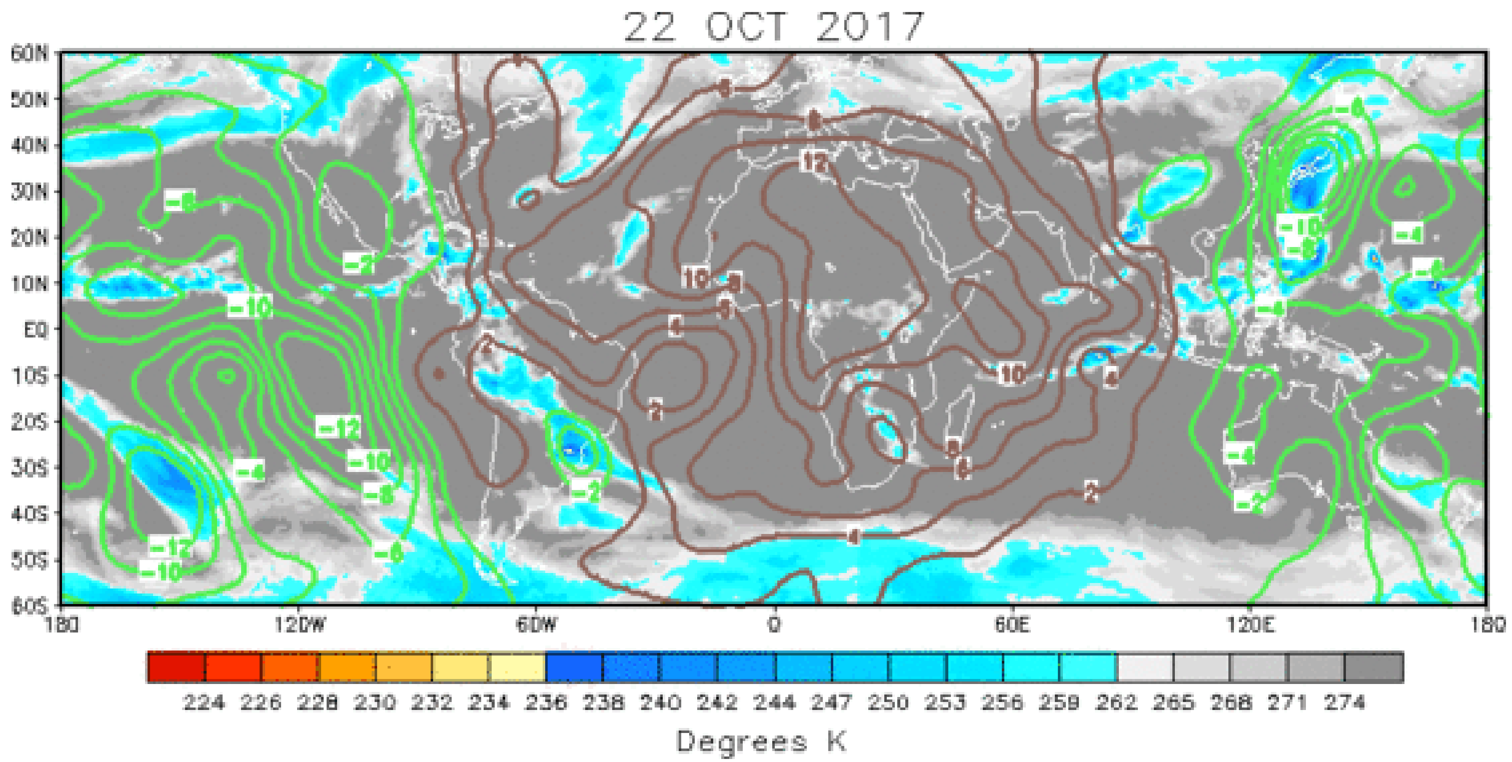
During July, enhanced convection strengthened over the Maritime Continent as the low-frequency signal constructively interfered with an easterly propagating signal. This eastward propagating signal appears more or less intact with a period in line with canonical MJO phase speeds.

A signal on the MJO timescale is evident in this field during late August and September.

More recently, another MJO event developed over the Maritime Continent, with a large upper-level footprint near 120E and robust eastward propagation. The leading edge of the enhanced phase is moving across the Pacific, which is generating destructive interference with the base state.



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



The robust Wave-1 asymmetrical upper-level velocity potential pattern reflects canonical MJO activity, with the enhanced (suppressed) phase over the Pacific (Western Hemisphere and western Indian Ocean).

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation

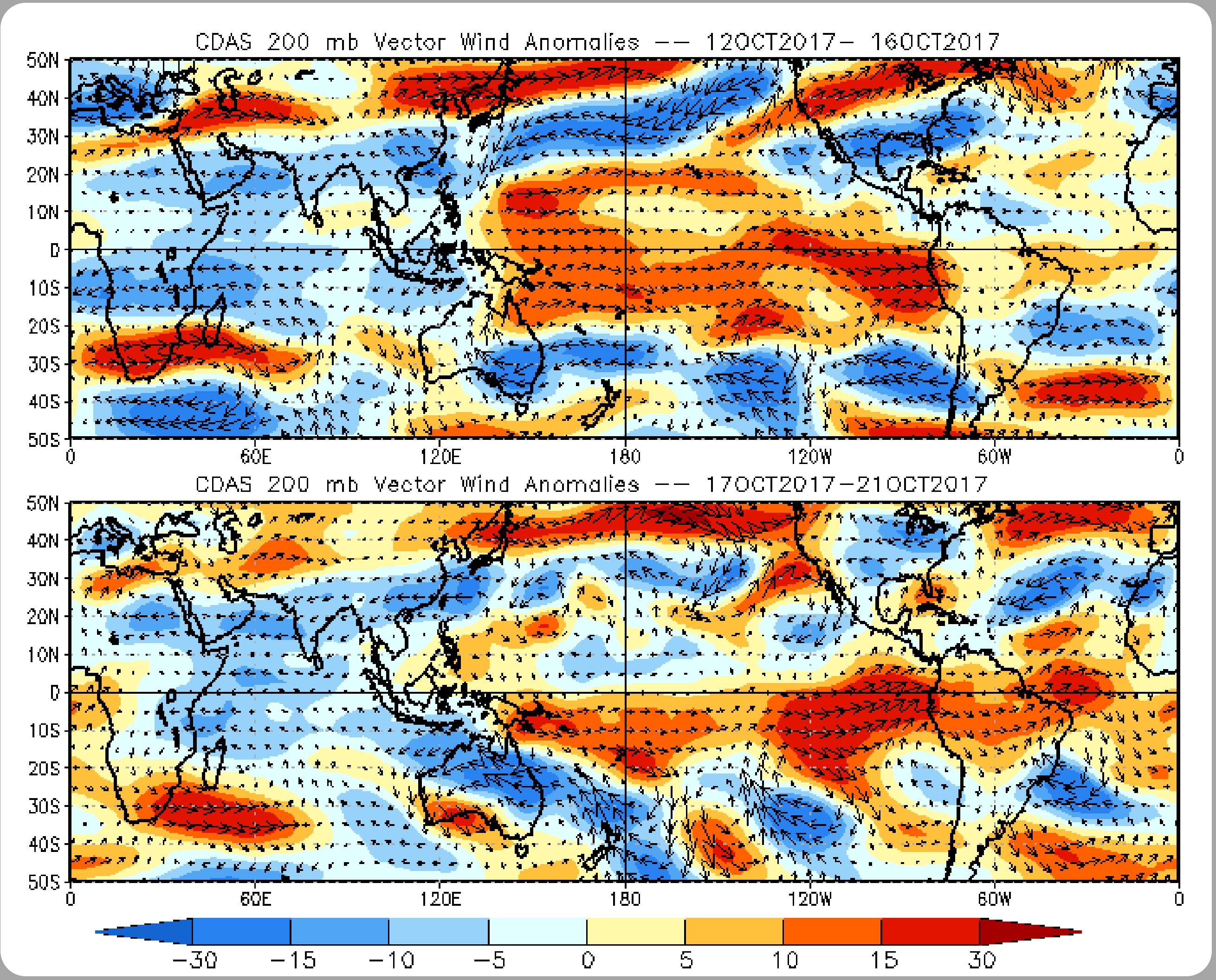
200-hPa Vector Wind Anomalies (m s-1)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

The upper-level zonal wind pattern also reflects a robust Wave-1 asymmetry characteristic of a strong MJO event. There is less eastward propagation evident in this field, however, with Rossby wave activity over the West Pacific.



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

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

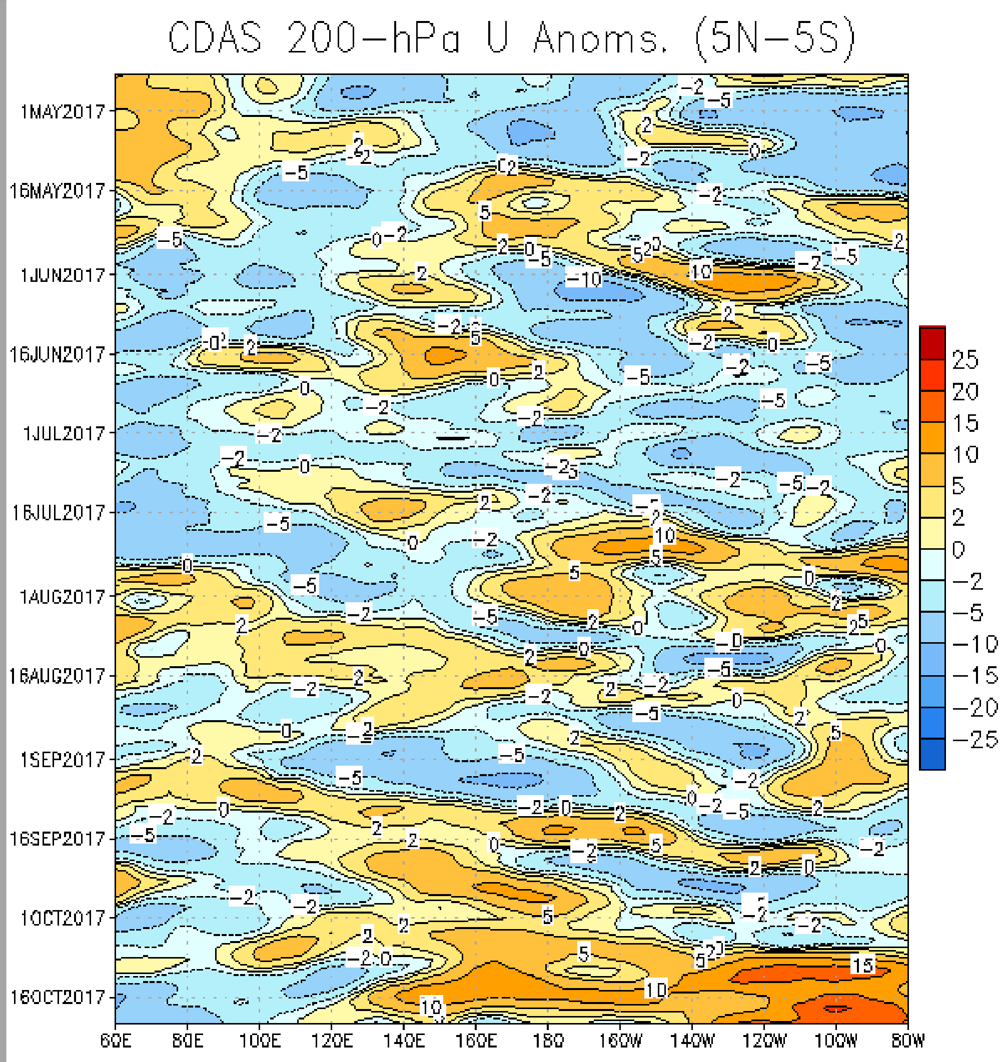
Easterly anomalies (blue shading) represent anomalous east-to-west flow

During early to mid-June, easterly anomalies were most prominent across the global tropics, in part due to mid-latitude influences.

Starting in July, the anomaly patterns propagated eastward associated with weak MJO activity and atmospheric Kelvin waves.

During September, fast-moving eastward propagation of anomalies continued, consistent with additional atmospheric Kelvin Waves. A slower signal was evident over the eastern Maritime Continent and west Pacific before decaying near 160 W.

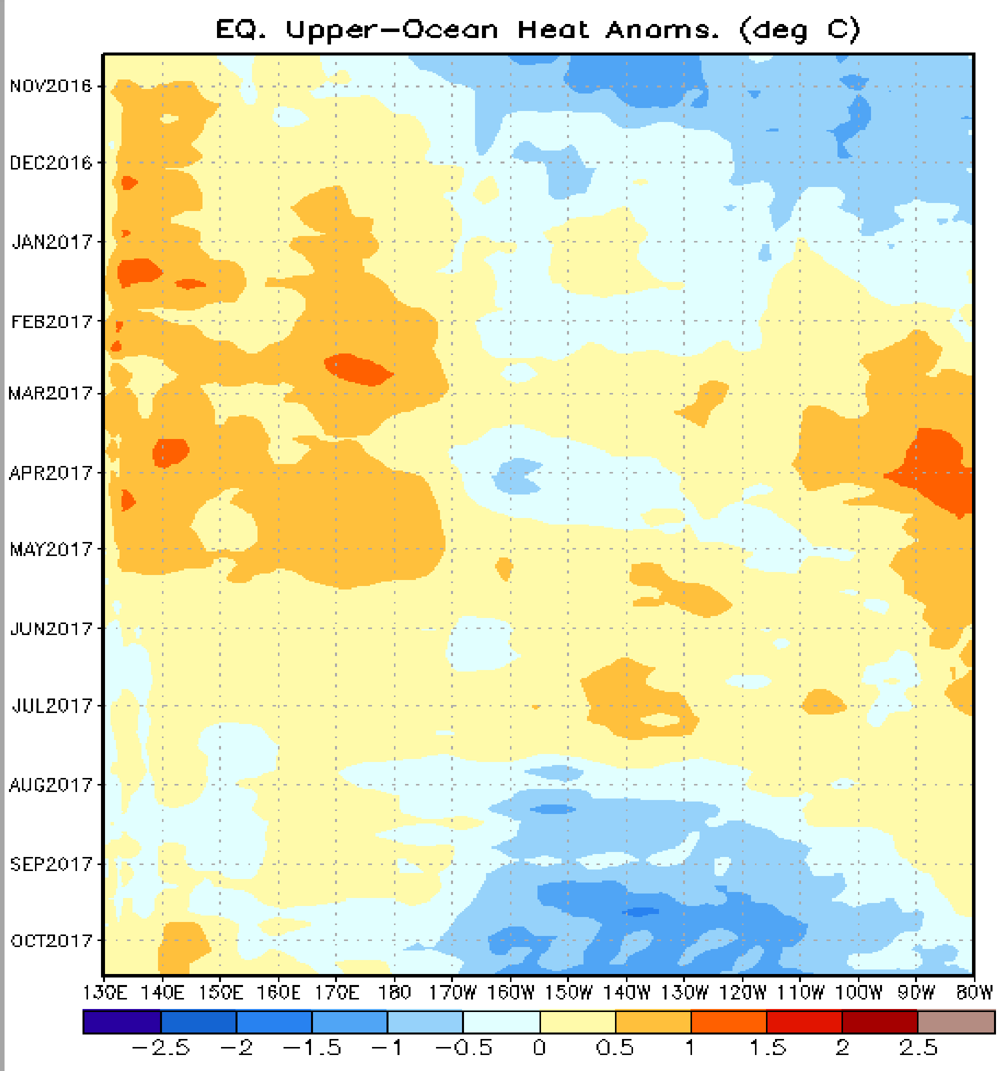
Westerly anomalies expanded across much of the Pacific during October. More recently, these anomalies weakened across the Pacific, particularly north of the equator.



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 have slowly increased across the equatorial Pacific east of the Date Line.



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

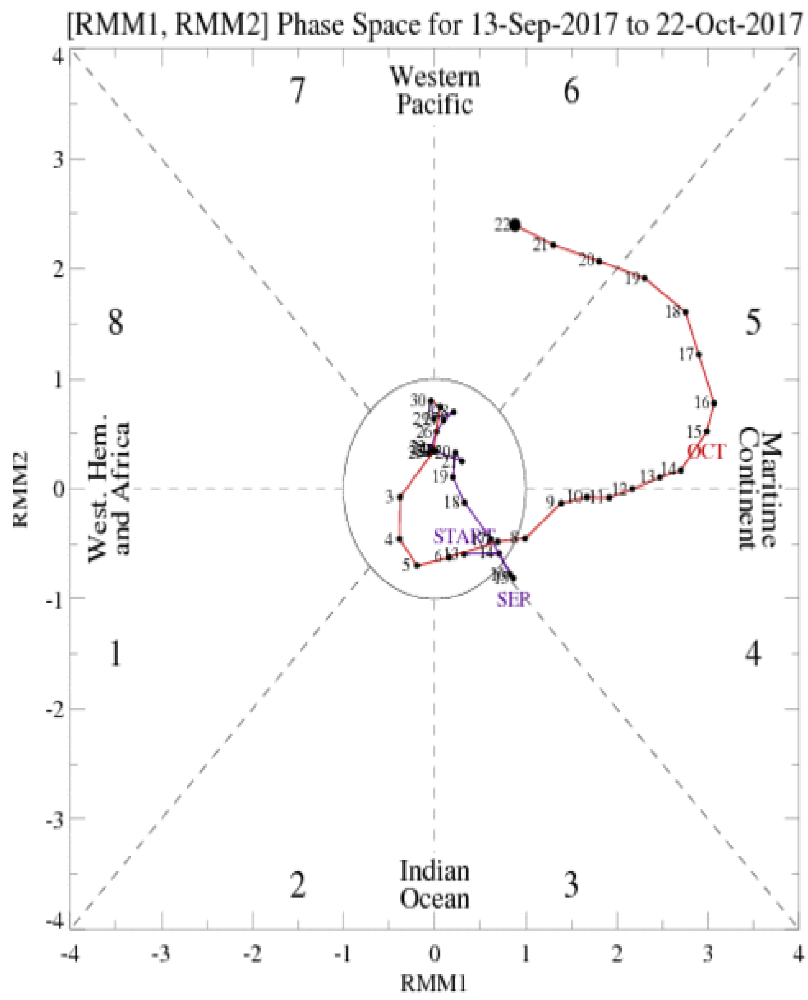
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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

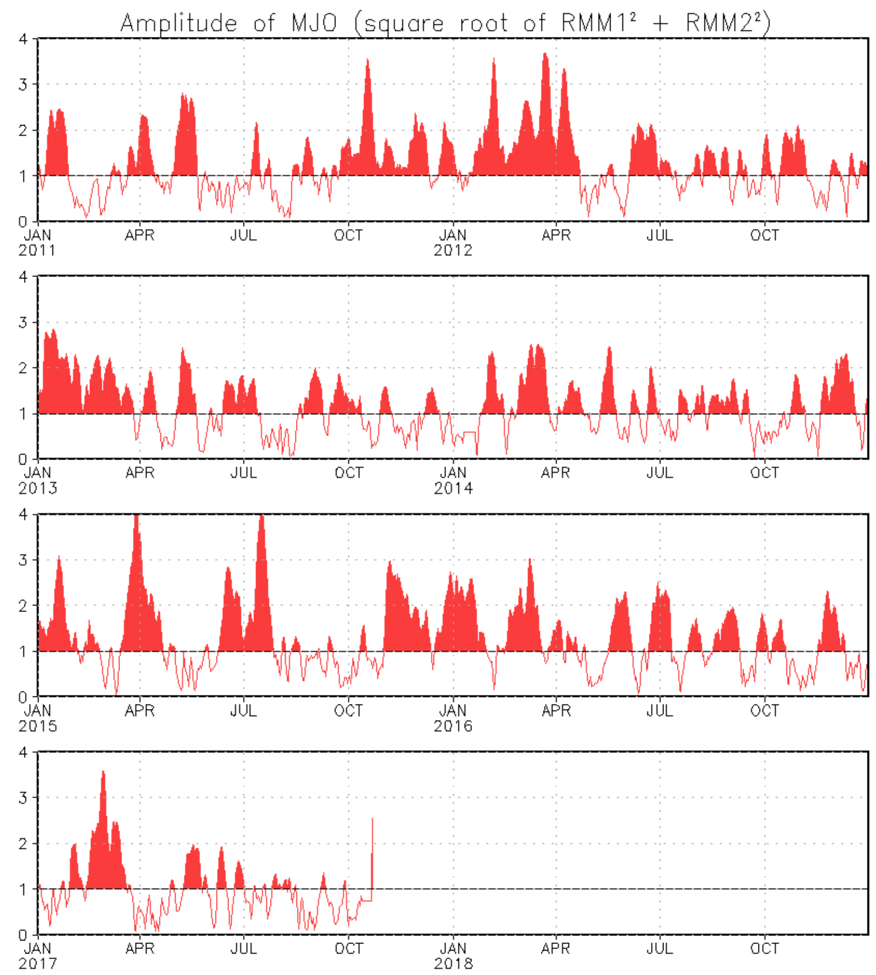


Robust MJO activity is evident on the RMM-based index, with the enhanced phase moving from the Maritime Continent to the West Pacific during the past few days.

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.



GFS Ensemble (GEFS) MJO Forecast

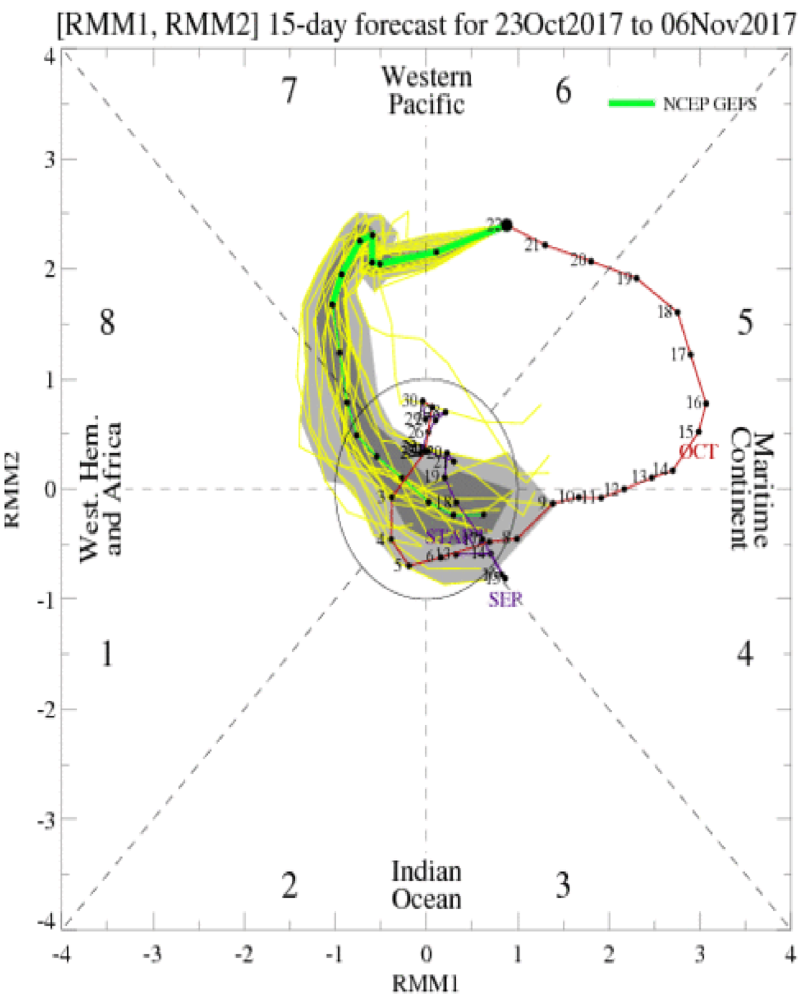
<u>Yellow Lines</u> - 20 Individual Members
<u>Green Line</u> - Ensemble Mean

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 bias-corrected GEFS forecast depicts continued MJO activity through much of the period, with the enhanced phase moving across the Pacific, although the signal weakens rapidly towards the end of Week-2.

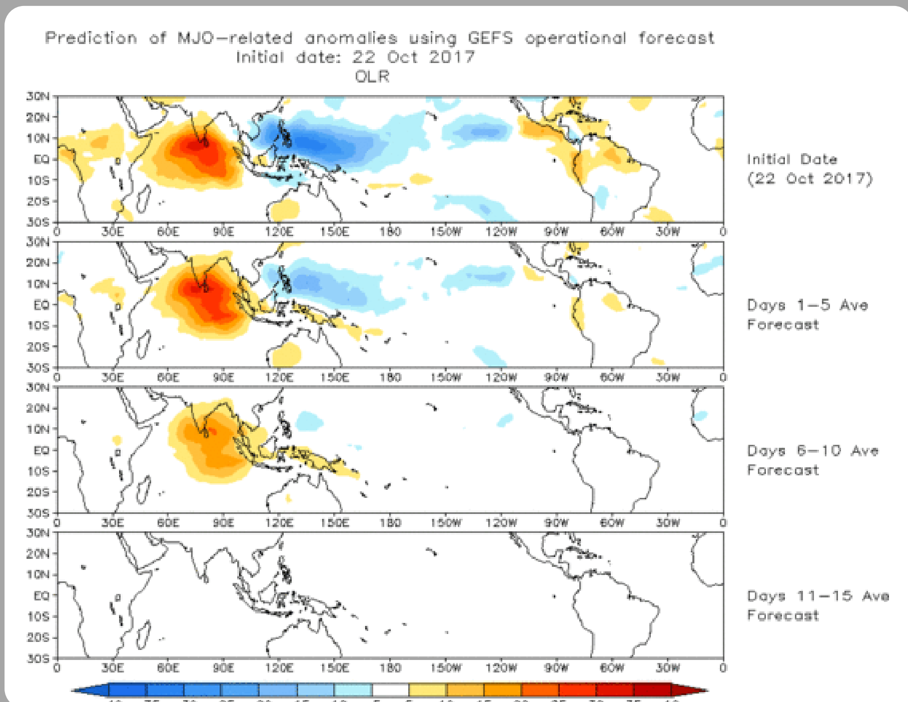


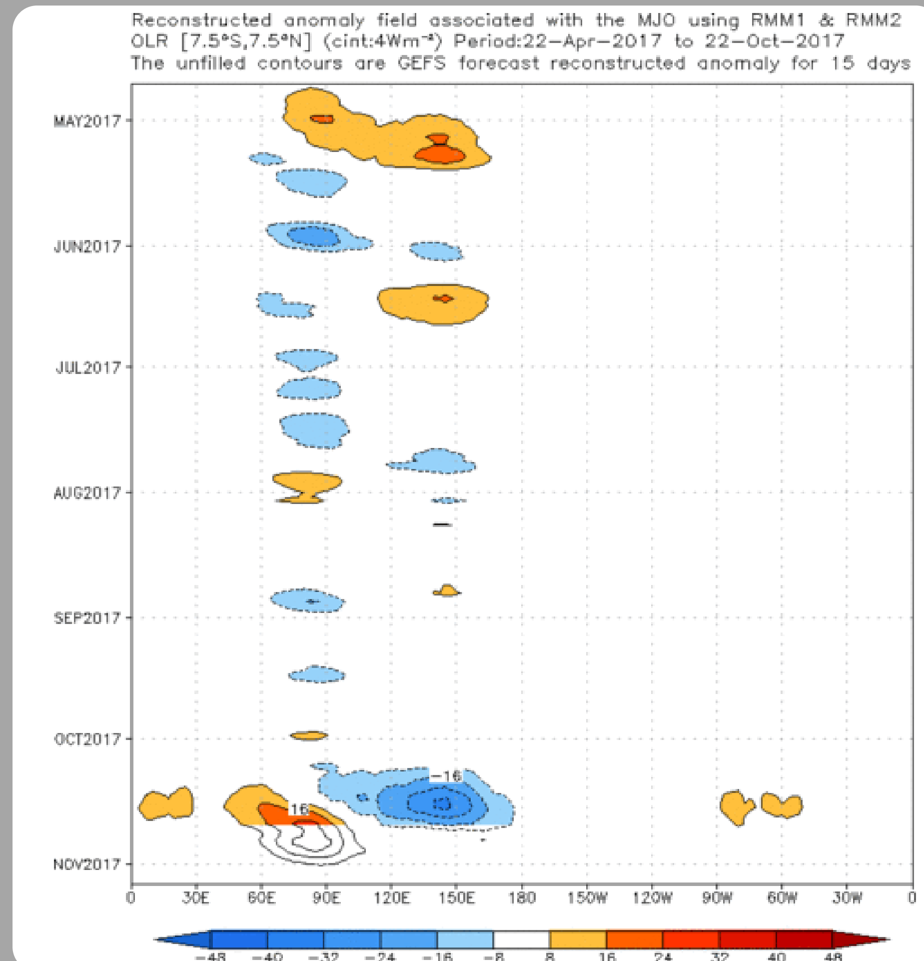
Ensemble GFS (GEFS) MJO Forecast

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





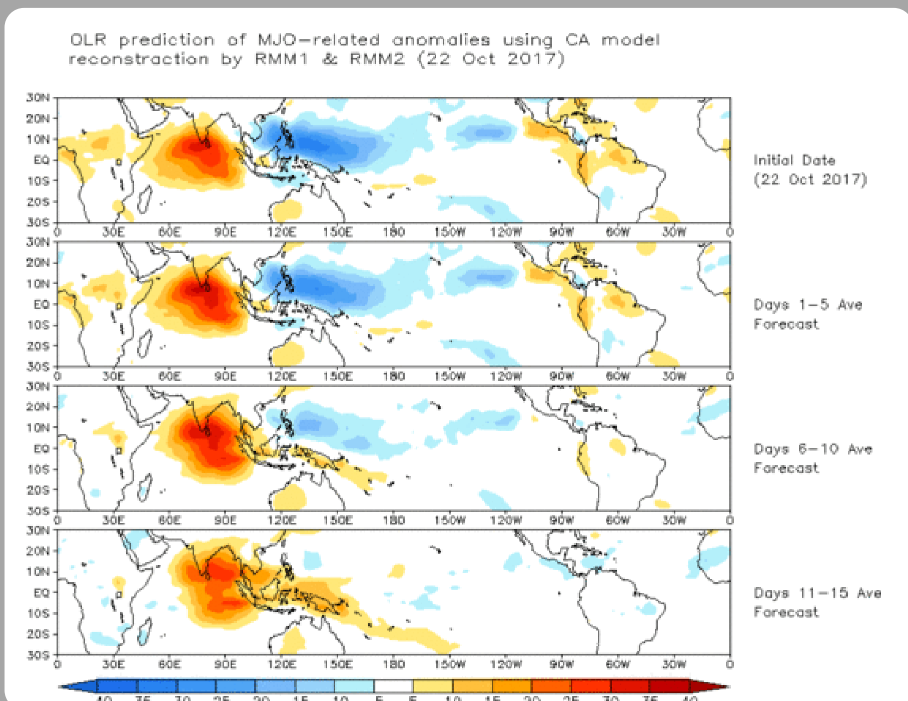
OLR anomalies based on the GEFS RMM-index forecast depict a fairly robust Pacific MJO event that weakens rapidly by the end of the two-week period.

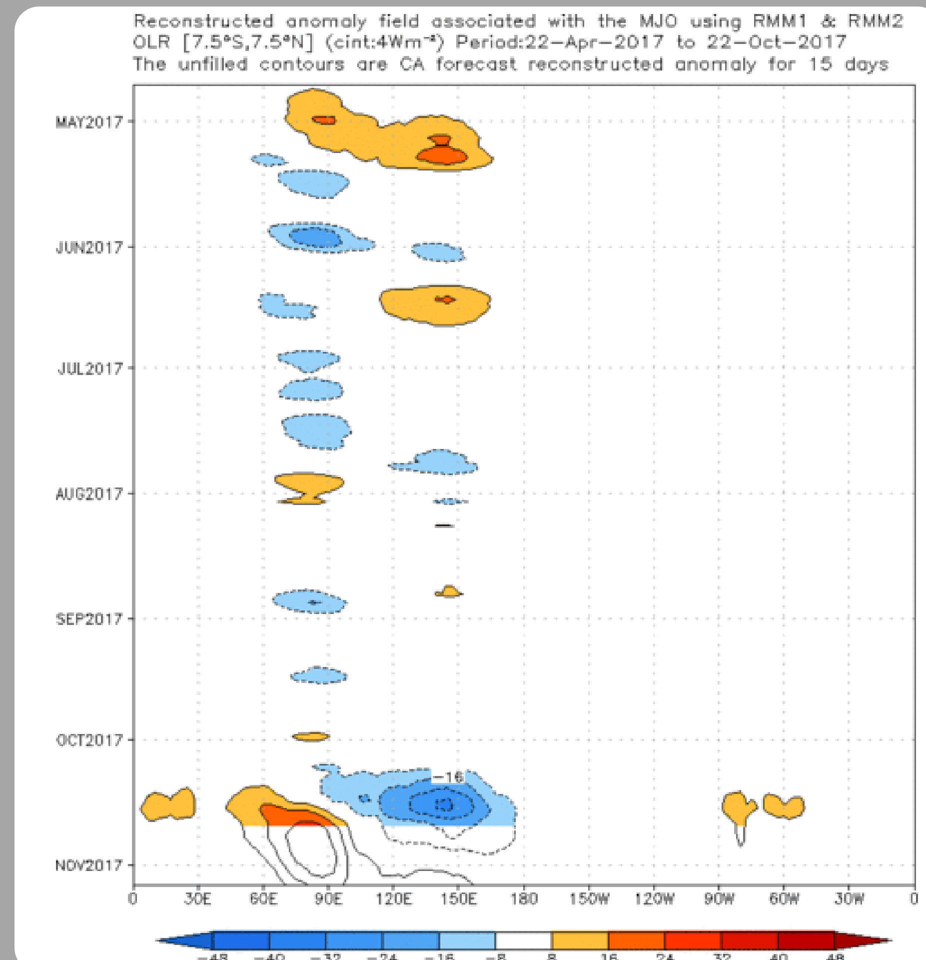
Constructed Analog (CA) MJO Forecast

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



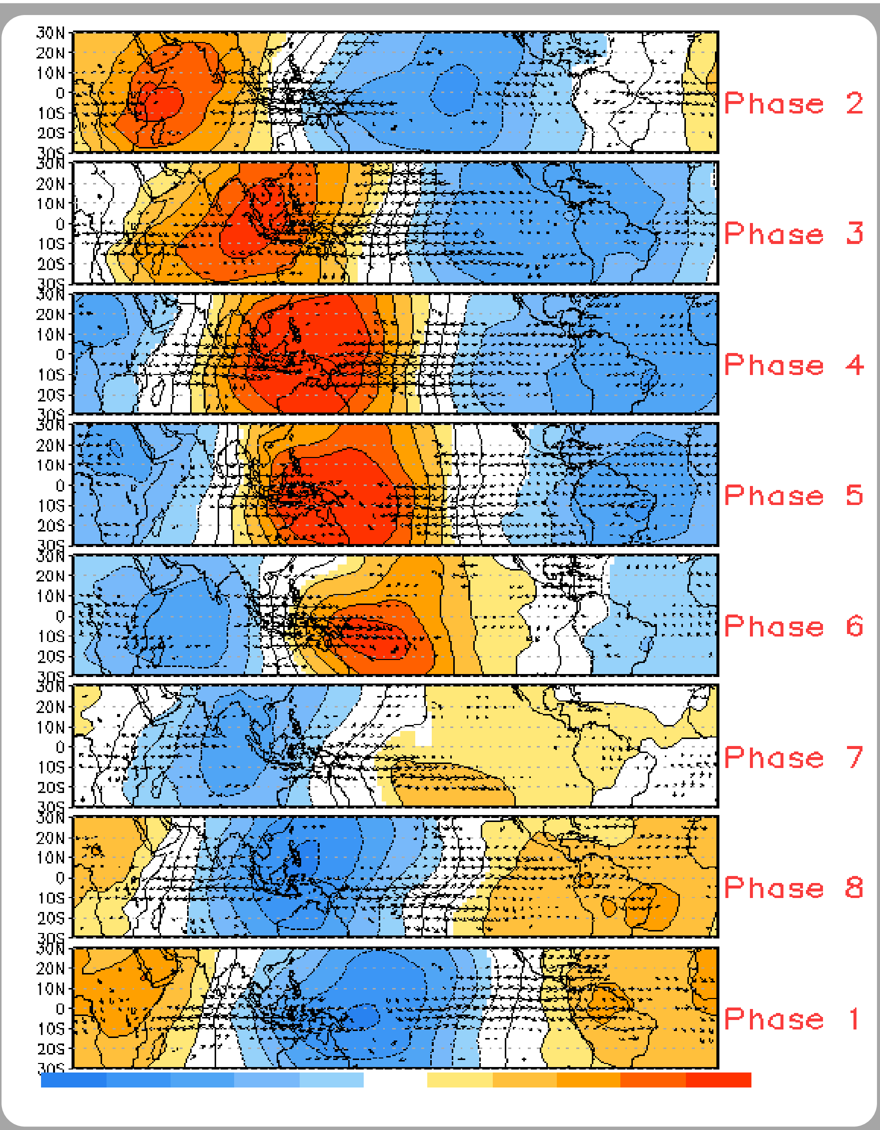


OLR anomalies based on the constructed analog RMM-index forecast also reflect the eastward propagation of the MJO, with a slower decay than depicted by the GEFS.

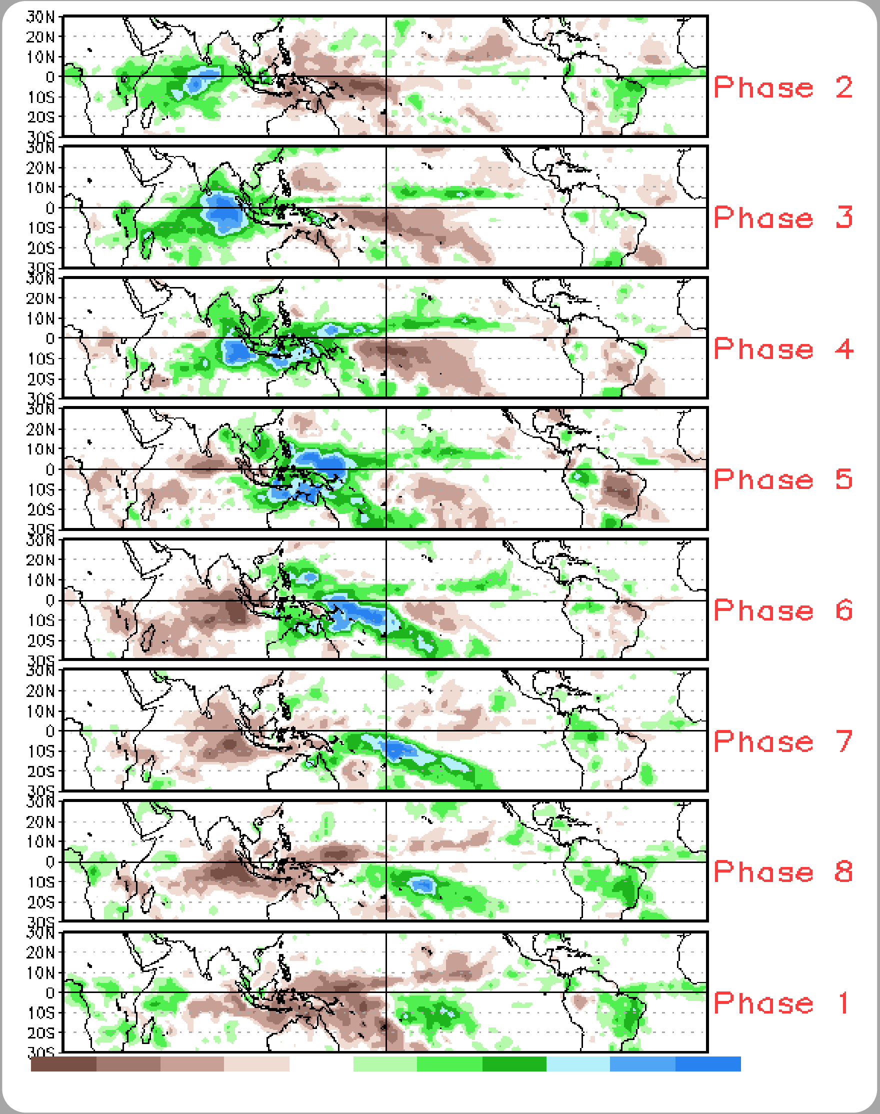
MJO Composites - Global Tropics

850-hPa Velocity Potential and

Wind Anomalies (Nov - Mar)



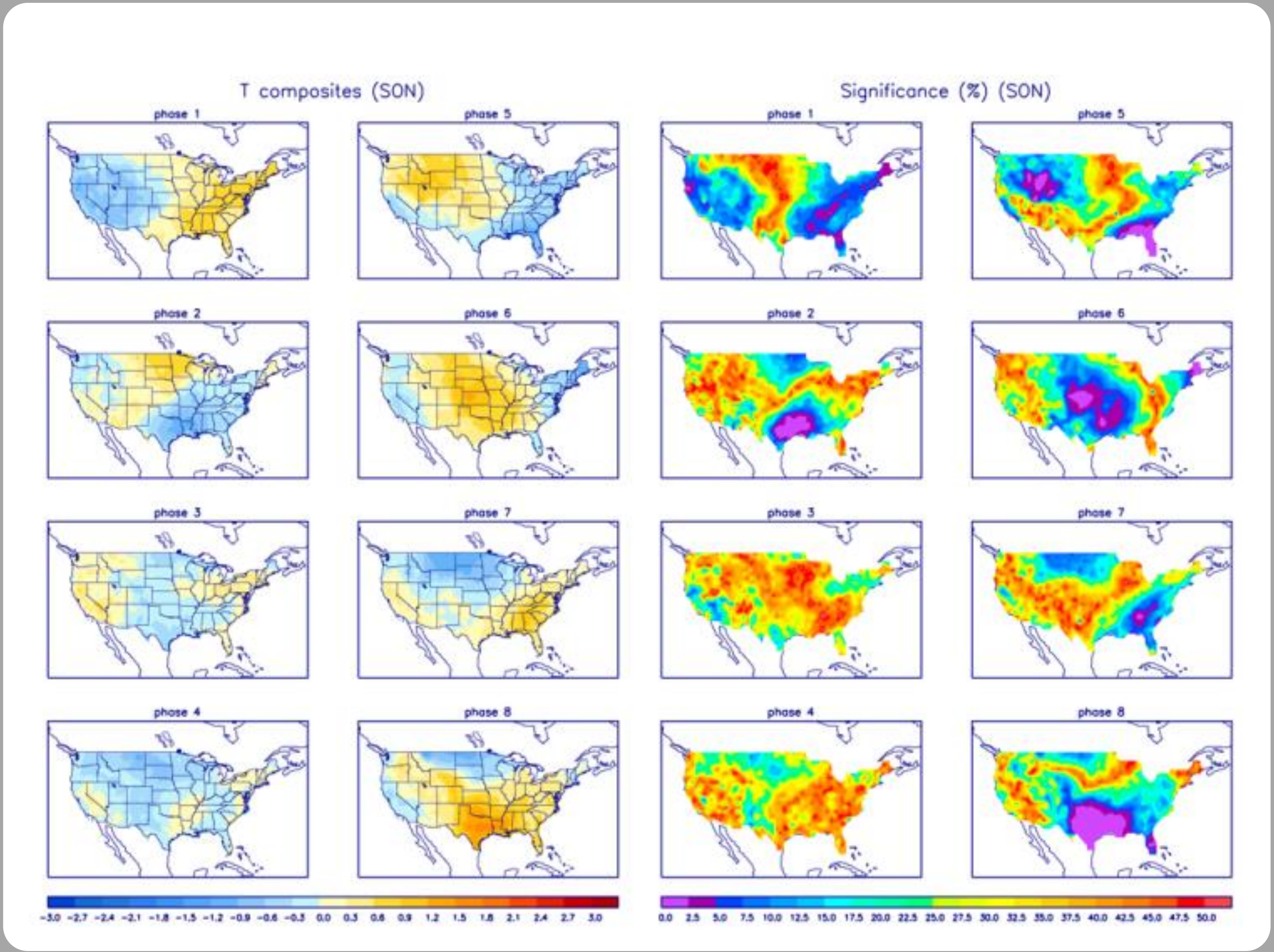
Precipitation Anomalies (Nov - Mar)



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.



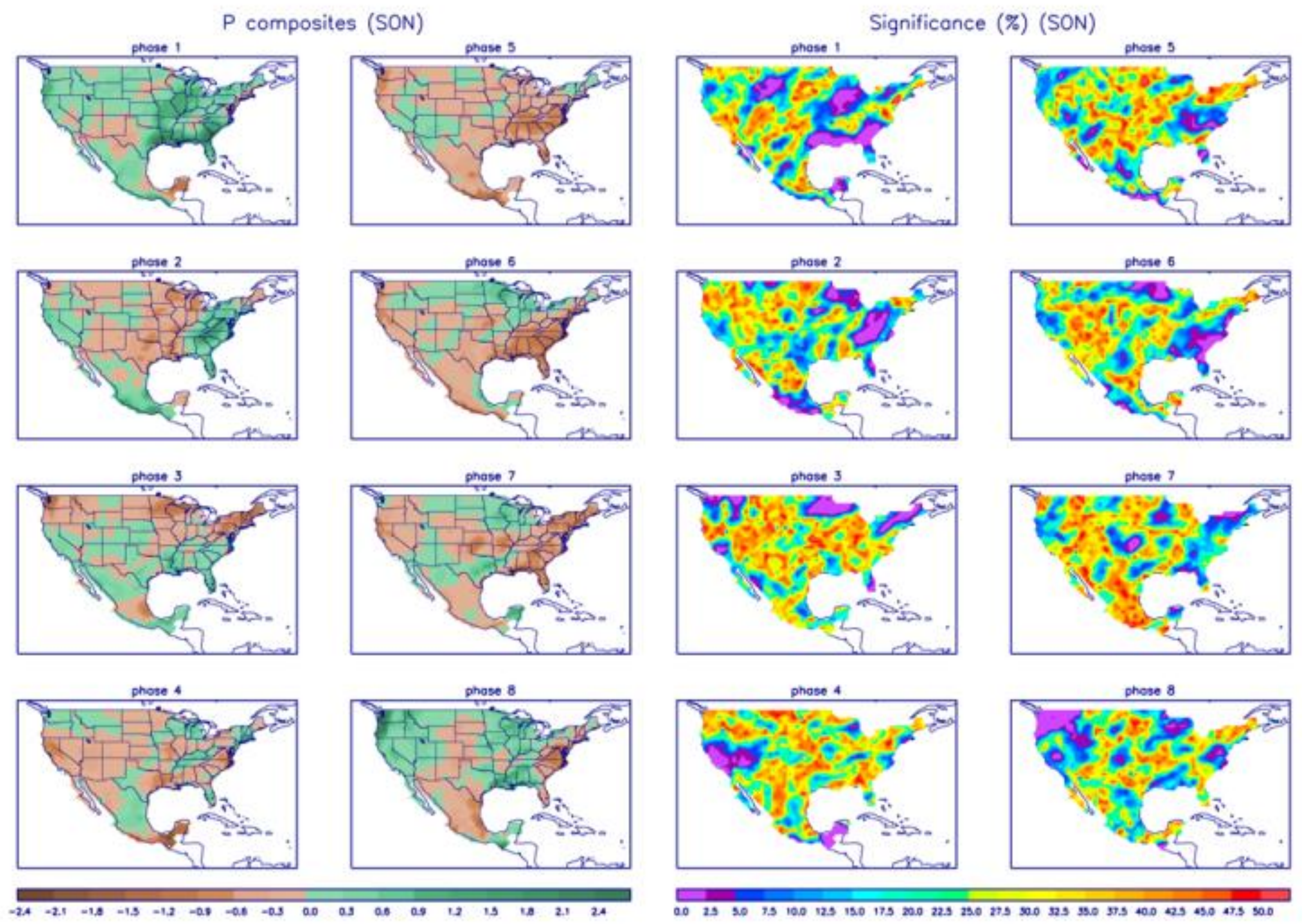
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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