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

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Climate Prediction Center / NCEP
13 February 2017

Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The MJO is active, with both the RMM based and CPC velocity potential based MJO indices depicting robust eastward propagation of an enhanced (suppressed) convective envelope to the Western Hemisphere (Eastern Hemisphere).

- The MJO is currently destructively interfering with the low-frequency state.

- Dynamical model RMM index forecasts indicate continued propagation early, followed by a reduction in amplitude. Some solutions depict rapid reemergence of an enhanced signal over the West Pacific, possibly due to the evolving base state.

- The MJO is anticipated to influence the evolution of the global tropical convective pattern. Impacts to the extratropics are uncertain given the interaction between the MJO and an evolving low-frequency state.

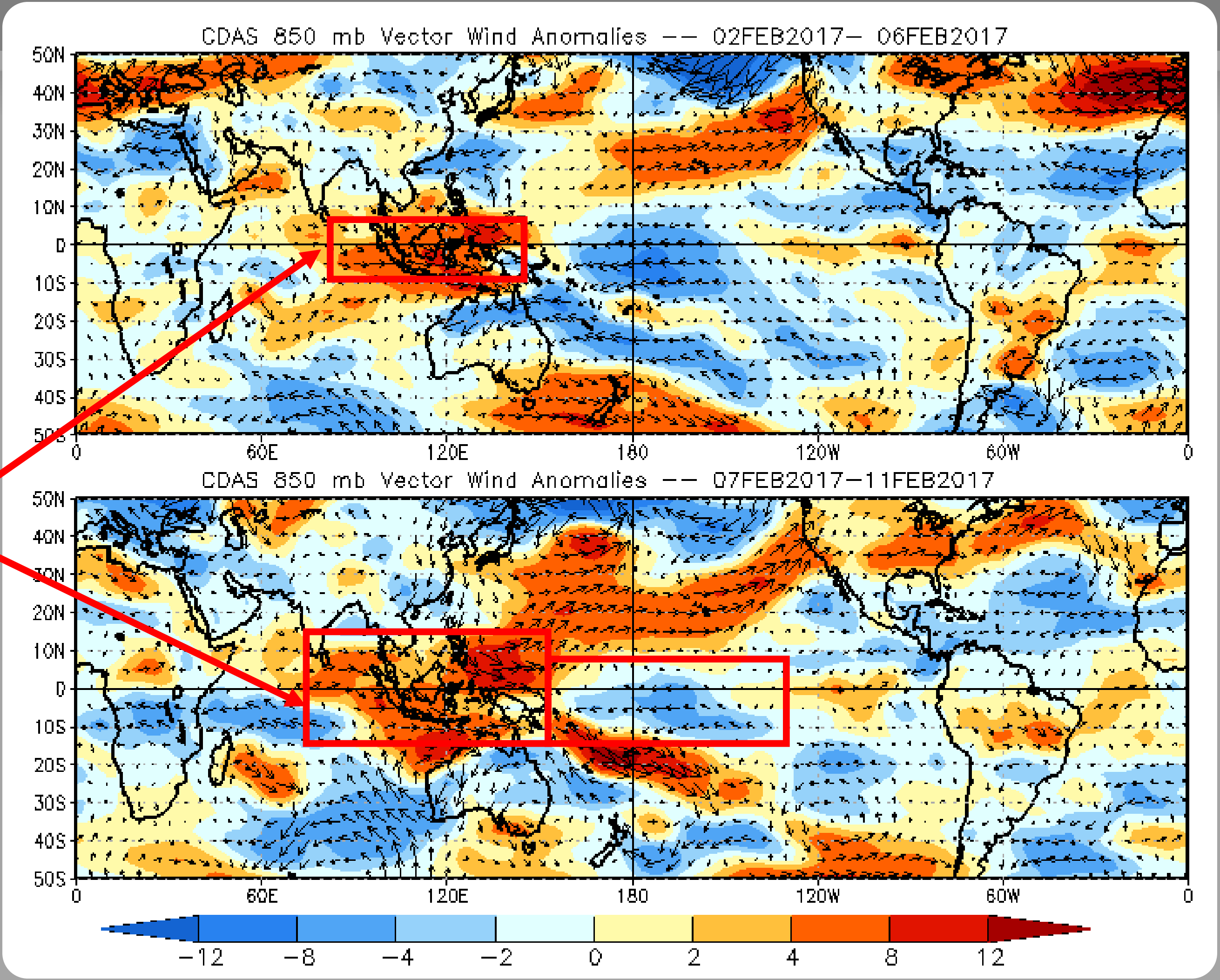
<u>**Additional potential impacts across the global tropics and a discussion for the U.S. are available at:**</u>
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 shifted eastward across the Maritime Continent to the far western Pacific.

Easterly anomalies decreased in coverage over the central Pacific.

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

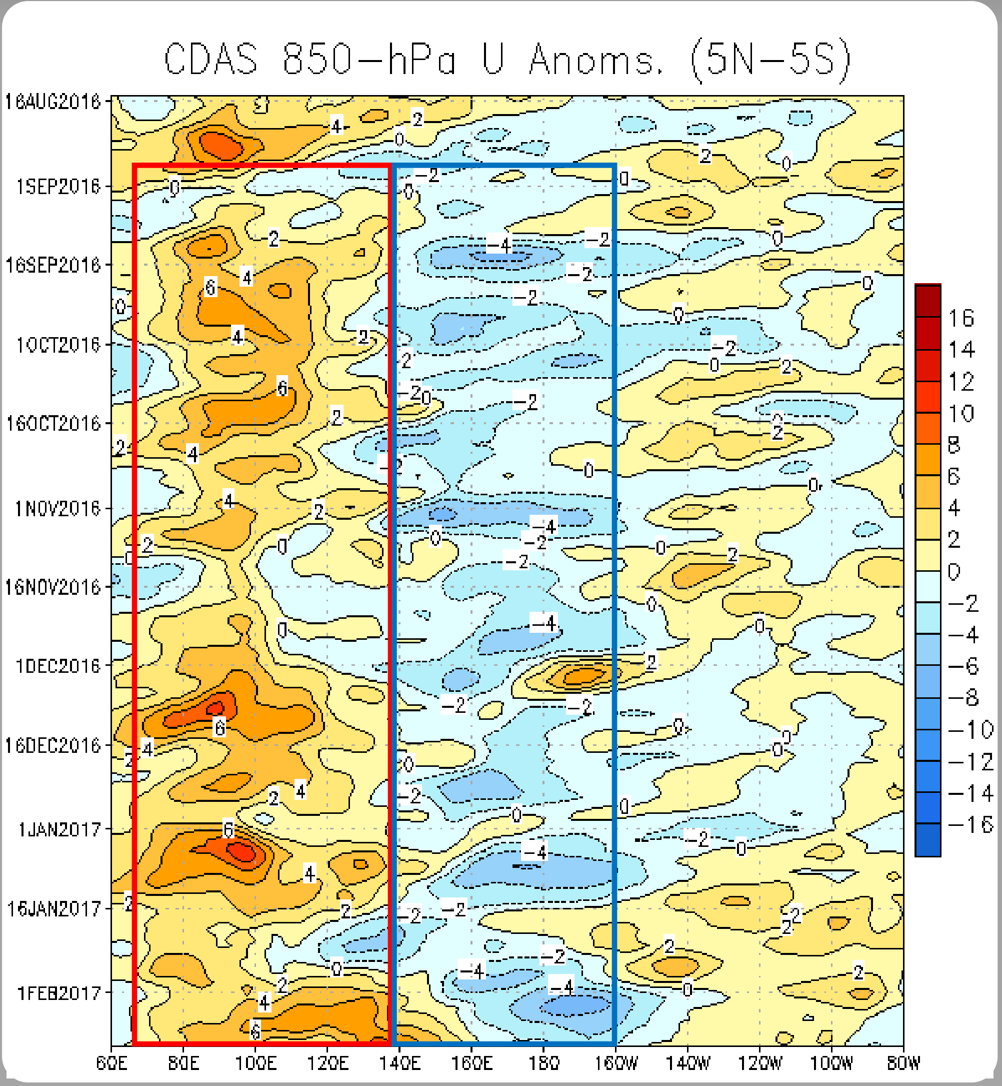
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

Since late August, persistent westerly (easterly) anomalies were evident over the eastern Indian Ocean and western Maritime Continent (central and western Pacific) as shown by the red (blue) box at right. These anomalies are low frequency in nature, associated with the negative phase of the Indian Ocean Dipole (IOD), and later, La Niña.

During mid-January, Rossby Wave activity was evident, with destructive interference on the base state evident through 100E.

Over the past couple of weeks, eastward propagating anomalies were observed, consistent with ongoing MJO activity.



OLR Anomalies – Past 30 days

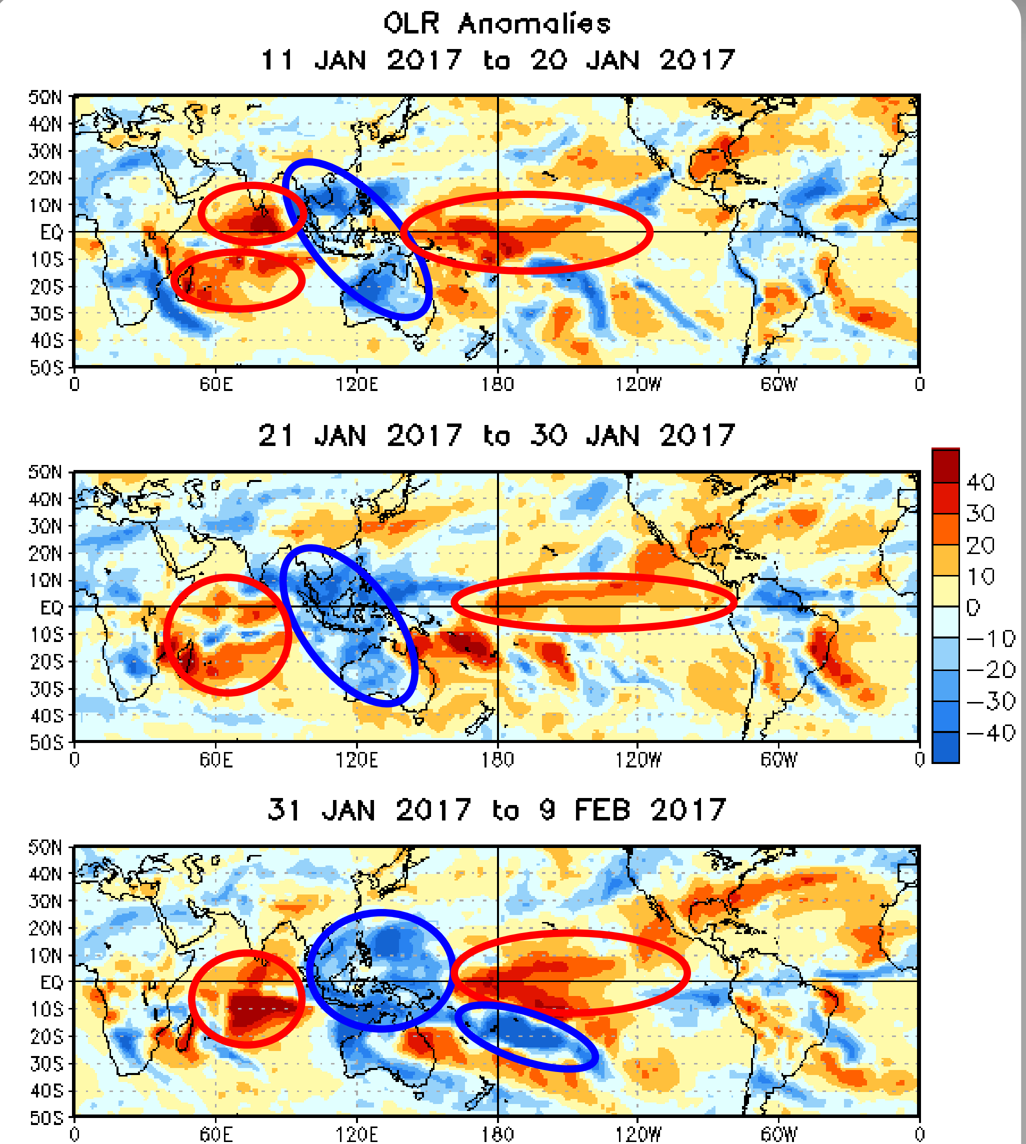
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid-January, the low frequency state with enhanced (suppressed) convection over the Maritime Continent (Indian Ocean and Central Pacific) dominated.

In late January, enhanced convection associated with the subseasonal state shifted over the Atlantic and Africa, while the low frequency background state persisted.

The low frequency pattern continued in early February, though eastward propagation associated with MJO activity was observed. Enhanced convection developed over the South Pacific during this time.



Outgoing Longwave Radiation (OLR) Anomalies (2.5ºS - 17.5º S)

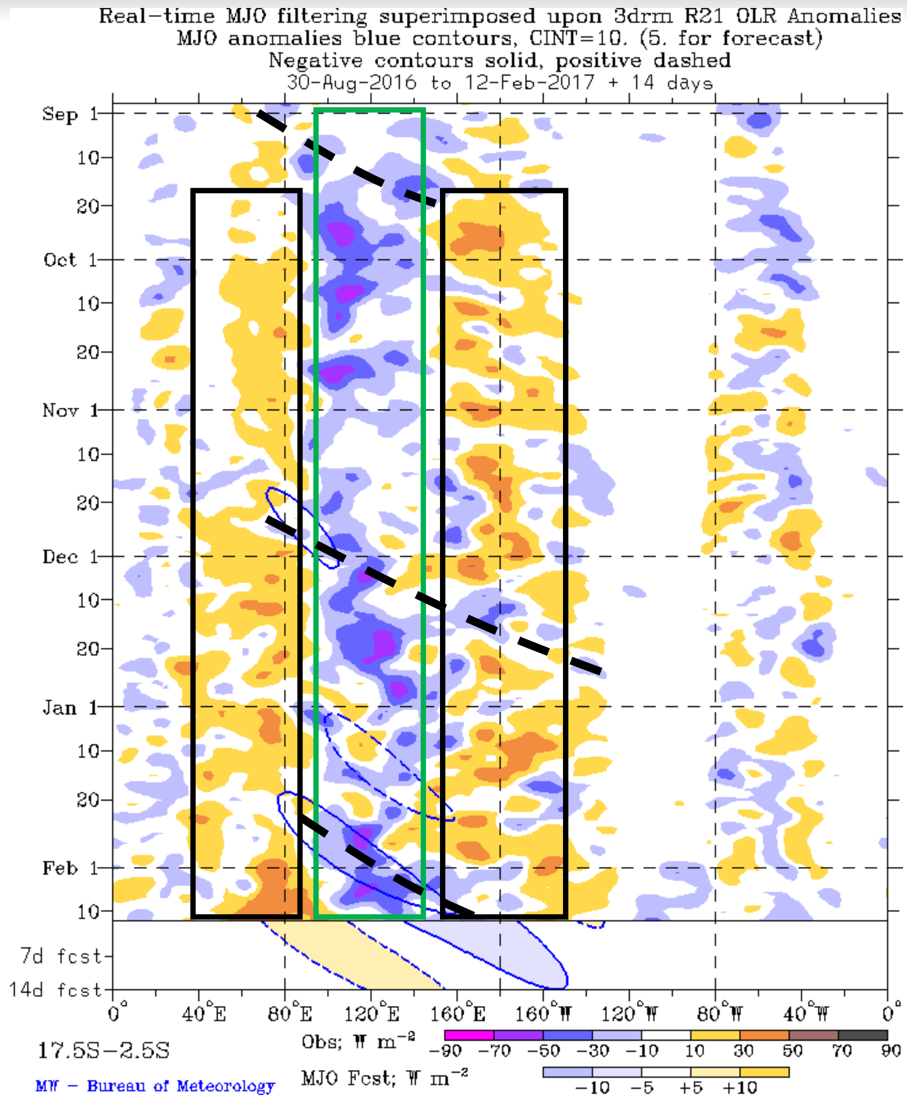
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

A low frequency state favoring enhanced convection over the eastern Indian Ocean and the Maritime Continent has been evident since July (green box), with suppressed convection over the Indian Ocean and near the antimeridian (black boxes).

A fast eastward propagating convective envelope was evident during early September. Another intraseasonal event occurred during late November and early December. Each briefly interfered with the background state.

Since late January, another eastward propagating event has interacted with the low frequency background as it shifted from the Indian Ocean to the Maritime Continent and West Pacific.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

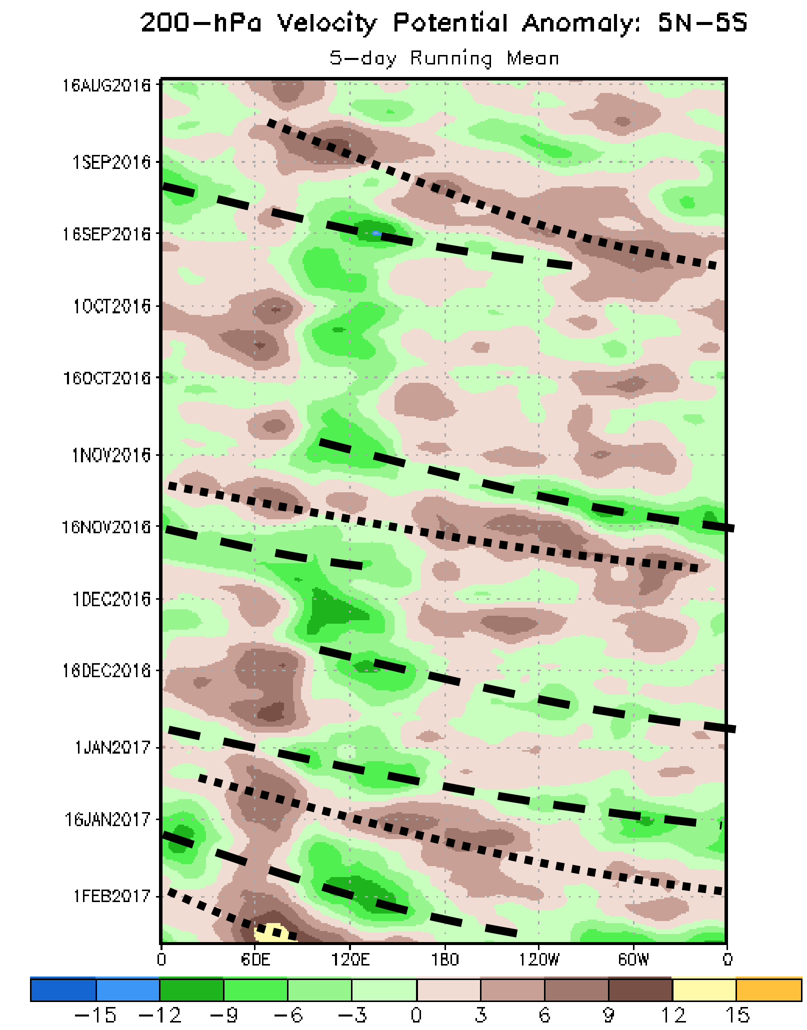
Negative anomalies (green shading) indicate favorable conditions for precipitation

In late August and early September, intraseasonal activity was apparent, before reversion to the low frequency pattern associated with the negative IOD and La Niña through late October.

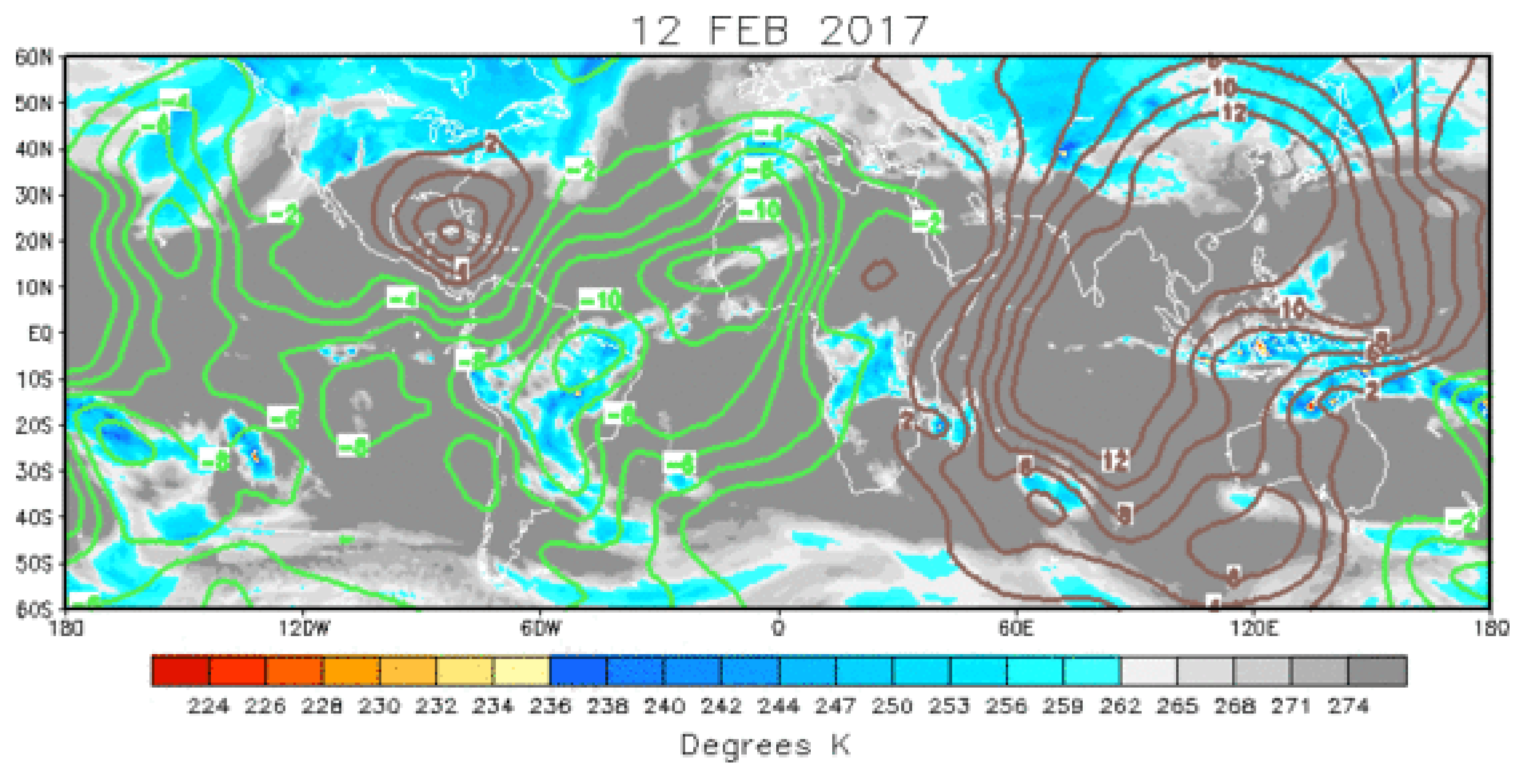
During November, eastward propagation was observed consistent with MJO activity on the fast end of the intraseasonal spectrum.

After a break in intraseasonal activity during early December, a signal emerged over the Maritime Continent and has continued propagating through the present.

The aforementioned intraseasonal signal constructively interfered with the low frequency state over the Maritime Continent near the beginning of February.



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



Upper-level velocity potential anomalies continue to reveal a robust wavenumber-1 pattern, with enhanced (suppressed) convection generally over the Western (Eastern) Hemisphere. This pattern is now destructively interfering with the low-frequency state.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

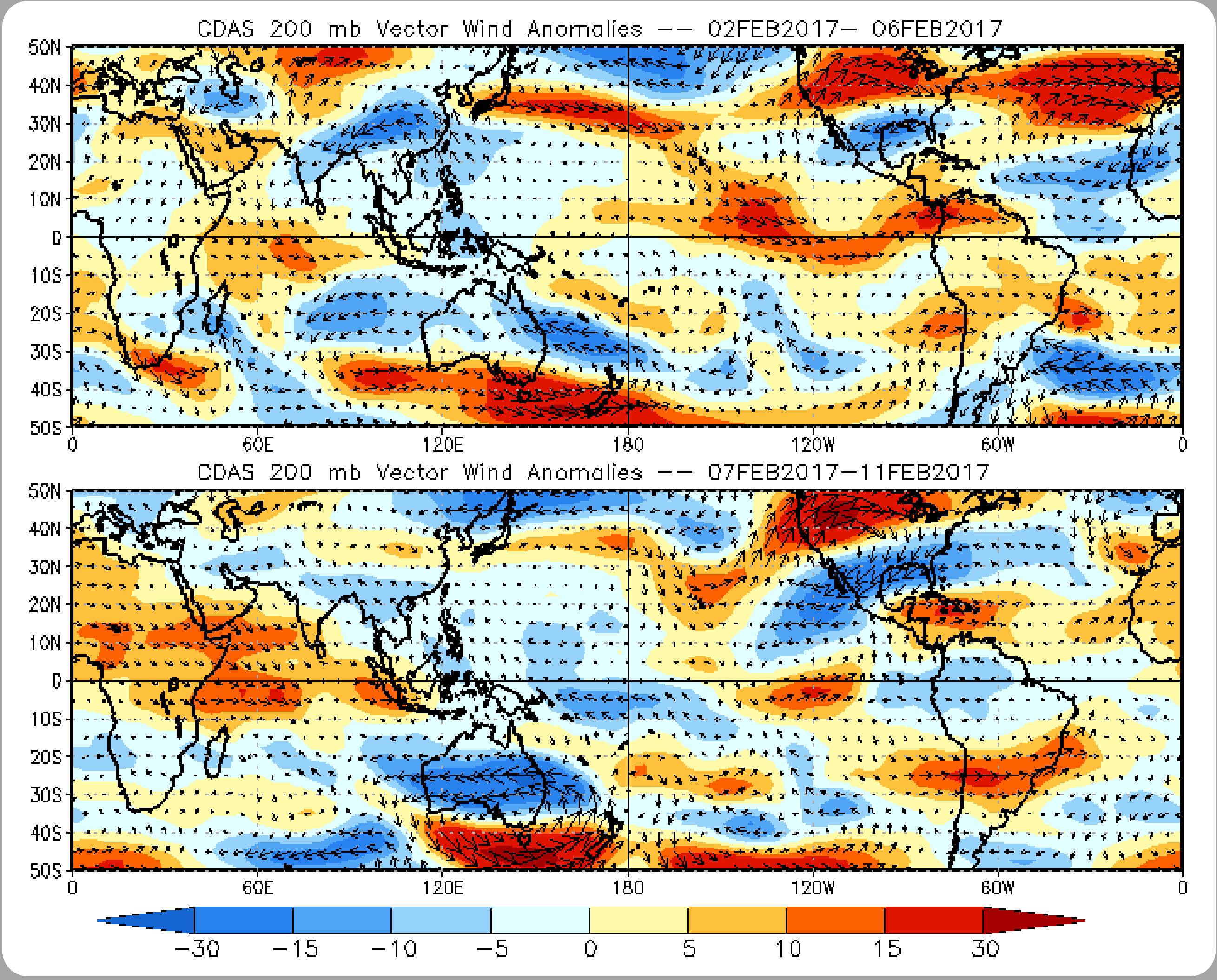
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Anomalous convergence is now evident over the Maritime Continent, with fairly low-amplitude anomalies over much of the Tropics.

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

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

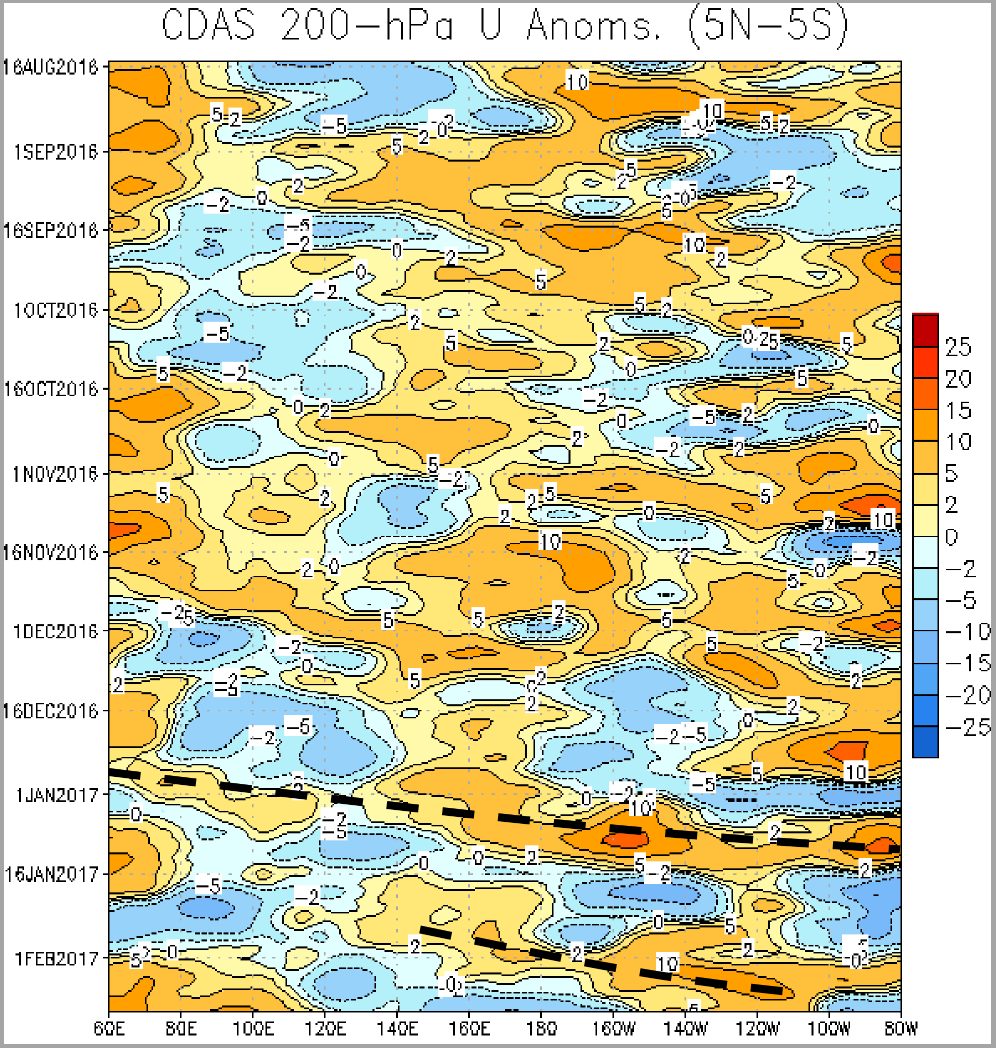
Easterly anomalies (blue shading) represent anomalous east-to-west flow

After a quiet August, eastward propagation of westerly anomalies was broadly consistent with organized MJO activity during September.

In November, anomalous westerlies persisted near the Date Line, though intraseasonal variability associated with the MJO is evident.

In late November, easterly anomalies re-emerged across the Indian Ocean and Maritime Continent, consistent with the passage of sub-seasonal activity and the re-alignment of the low frequency base state.

Near the end of 2016 a period of westerlies disrupted the low frequency state between 80-130E and continued propagating eastward through the Western Hemisphere. This subseasonal activity has continued, with alternating anomalous westerlies/easterlies being observed over the Pacific.

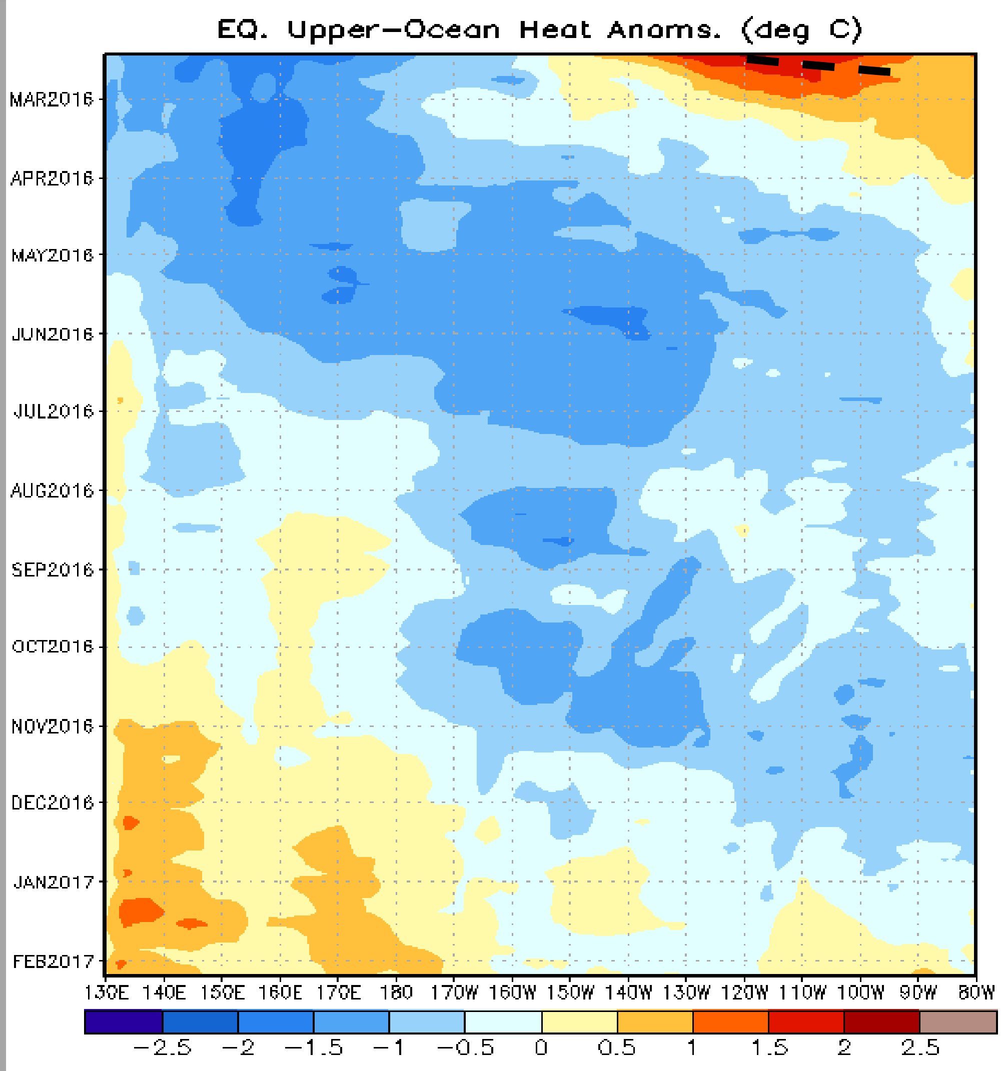


Weekly Heat Content Evolution in the Equatorial Pacific

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.

An eastward expansion of below average heat content over the western Pacific is evident through June, with widespread negative anomalies building across the Pacific over the course of boreal spring and summer.

More recently, upper-ocean heat content anomalies have been low amplitude, consistent with the forecast transition to ENSO-neutral conditions.



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

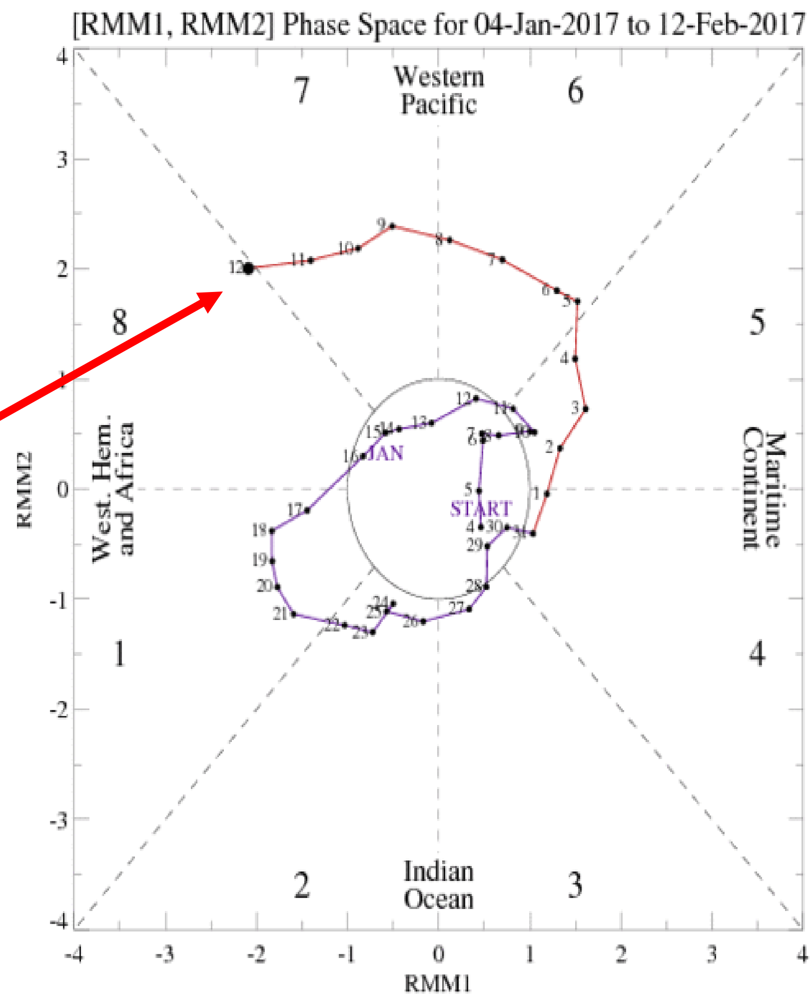
The triangular areas indicate the location of the enhanced phase of the MJO

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

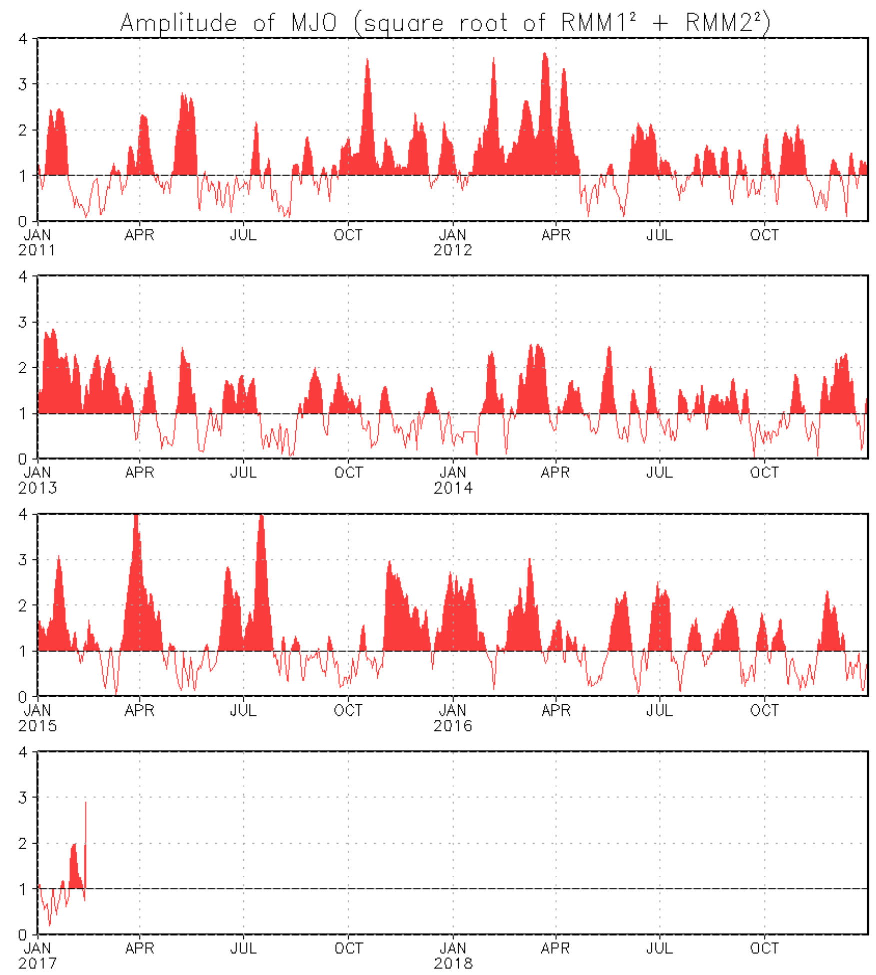
During the past week, continued eastward propagation of an MJO signal was evident across the Western Pacific into the Western Hemisphere.



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

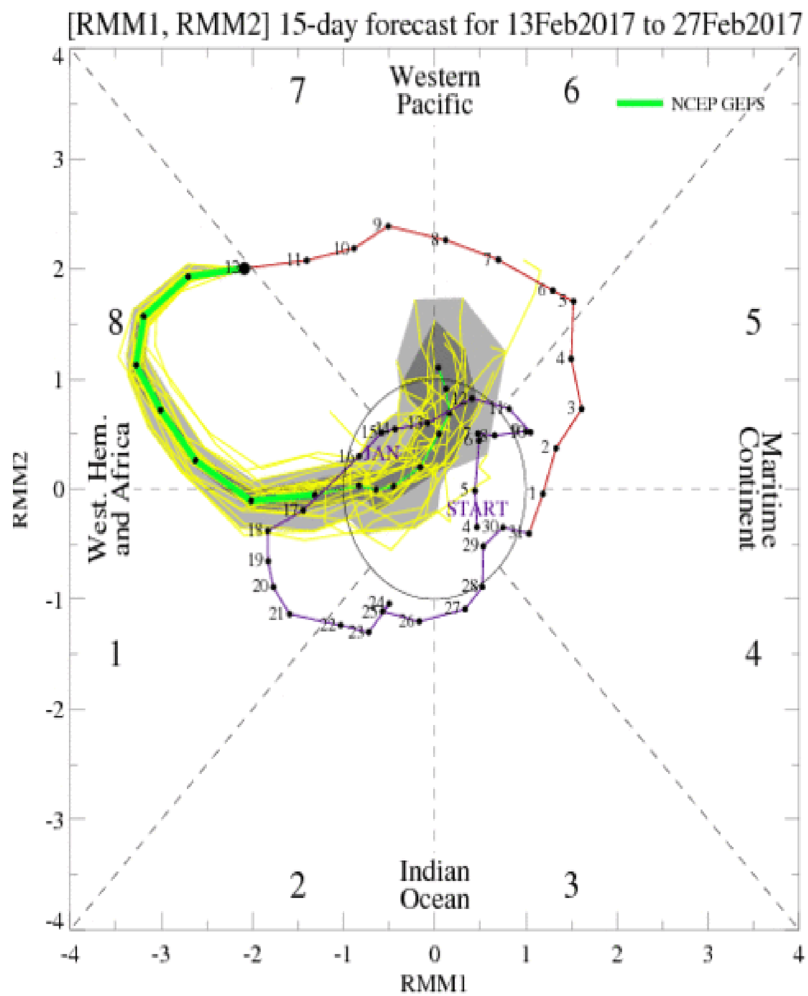
RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GEFS depicts eastward propagation early, followed by reduction in amplitude and subsequent reemergence over the West Pacific.

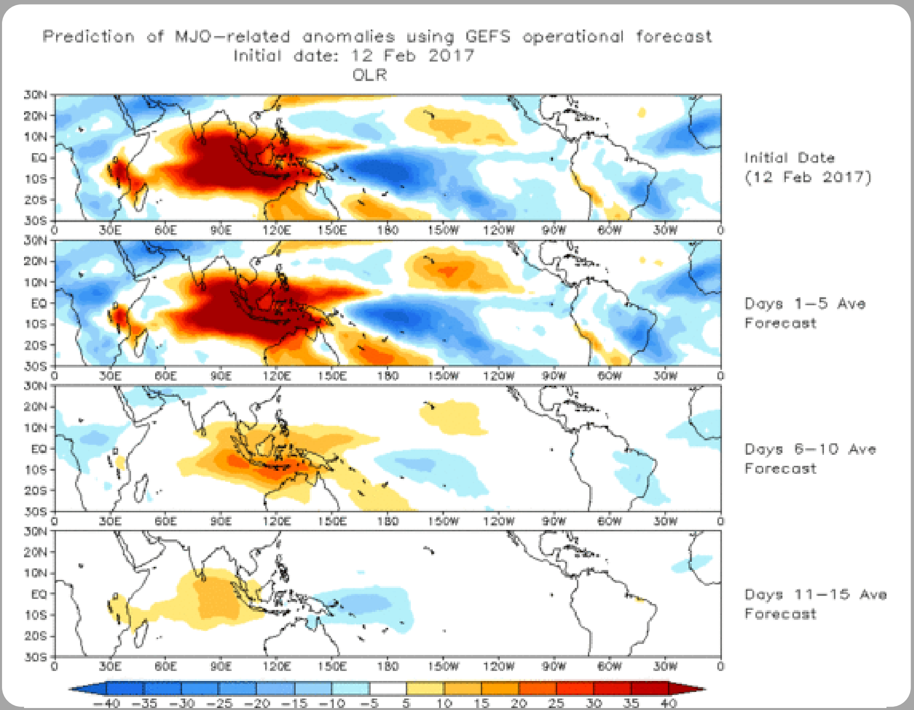
The displacement of a counterclockwise propagating signal in RMM phase space could be a result of a changing base state.



Ensemble GFS (GEFS) MJO Forecast

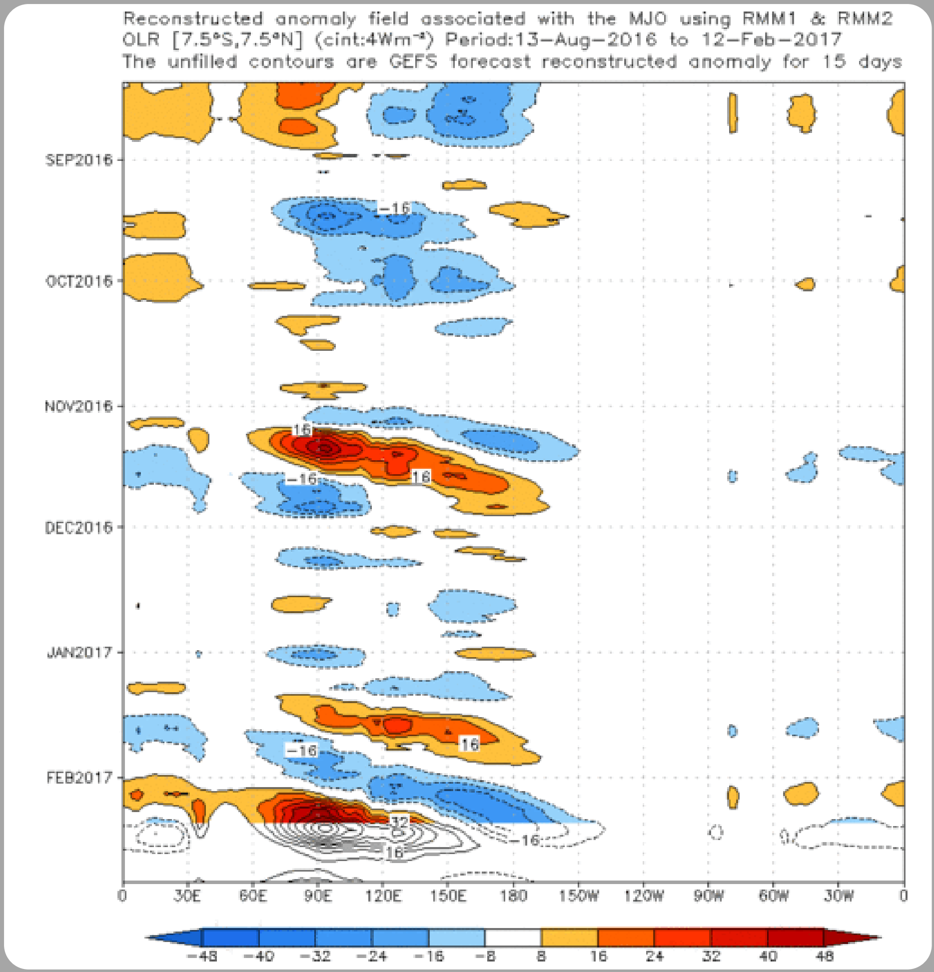
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS prediction for RMM Index-based OLR anomalies over the next two weeks shows a more stationary pattern, possibly due to the forecast evolution of the base state.

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

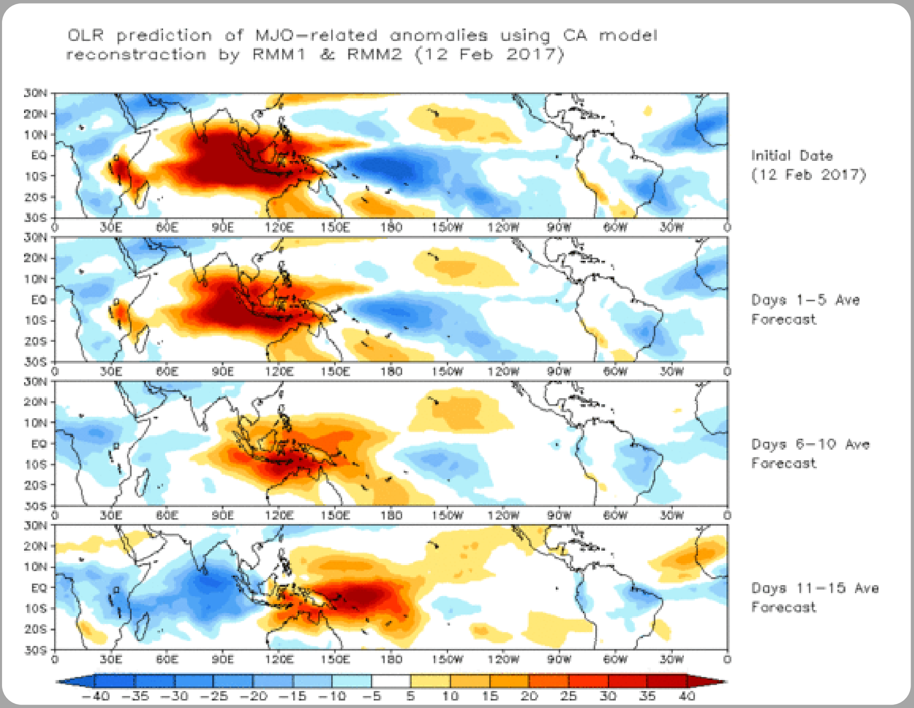


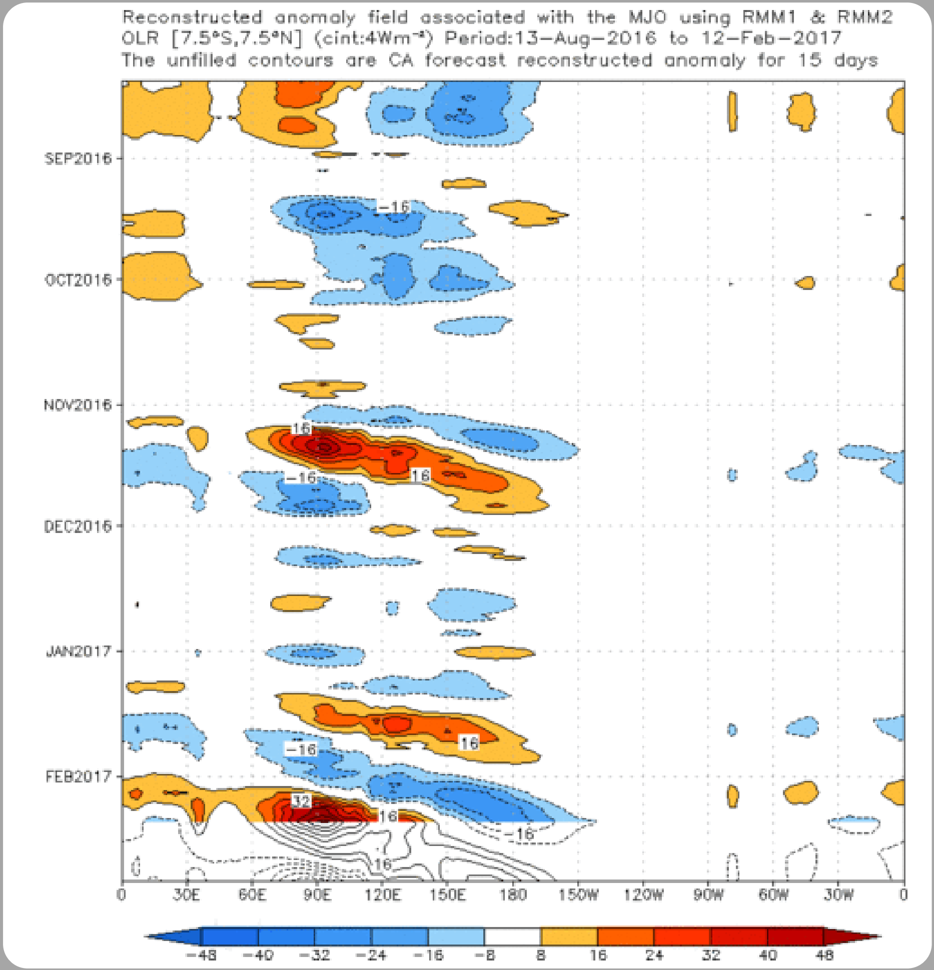
Constructed Analog (CA) MJO Forecast

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

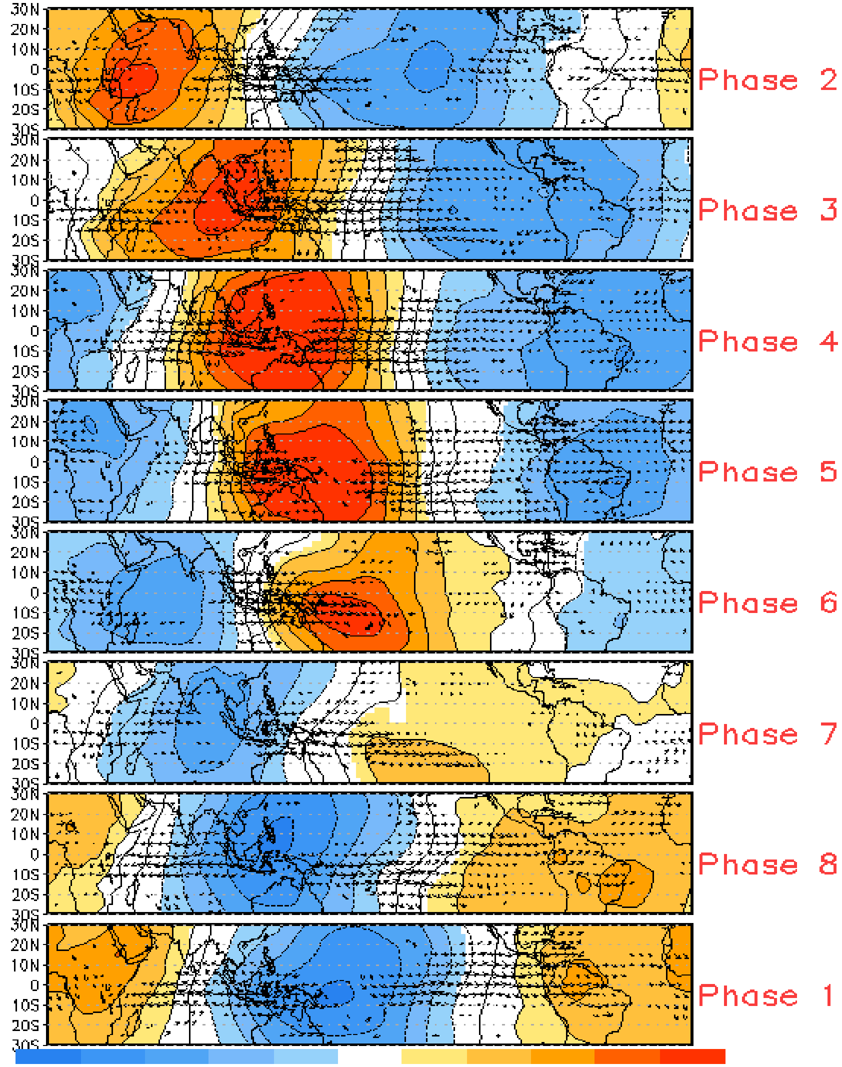




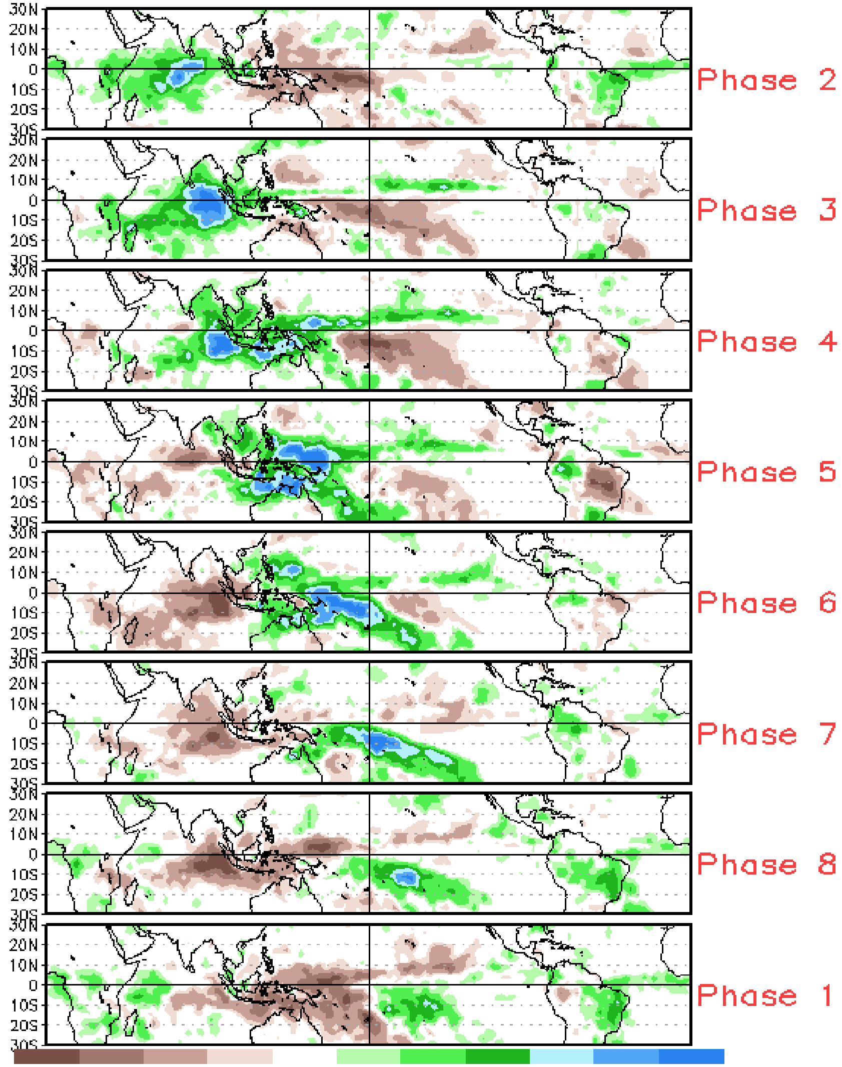
The statistical (Constructed Analog) RMM-based OLR anomaly prediction shows more canonical eastward propagation of the MJO signal.

MJO Composites - Global Tropics

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



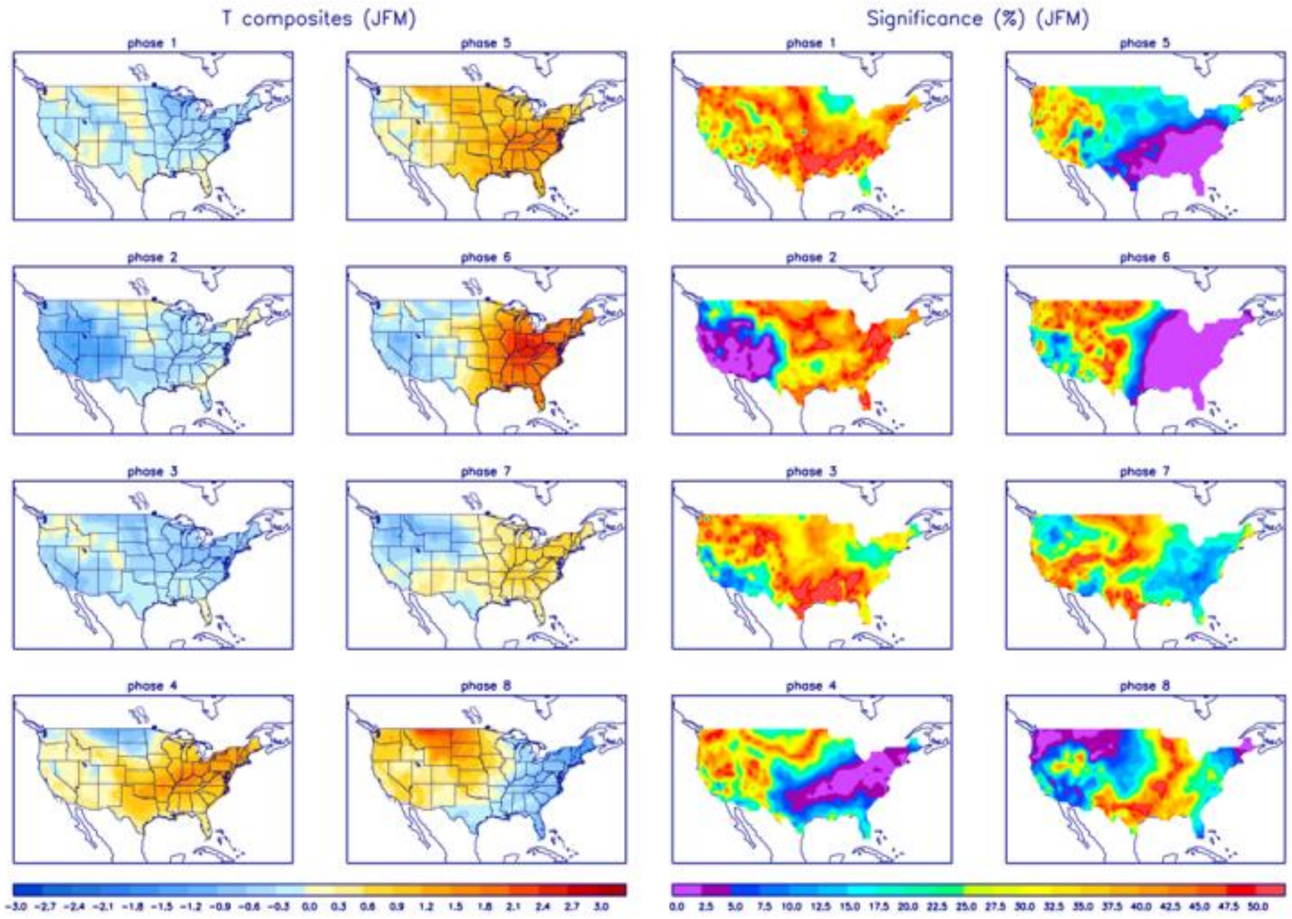
Precipitation Anomalies (Nov - Mar)



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.



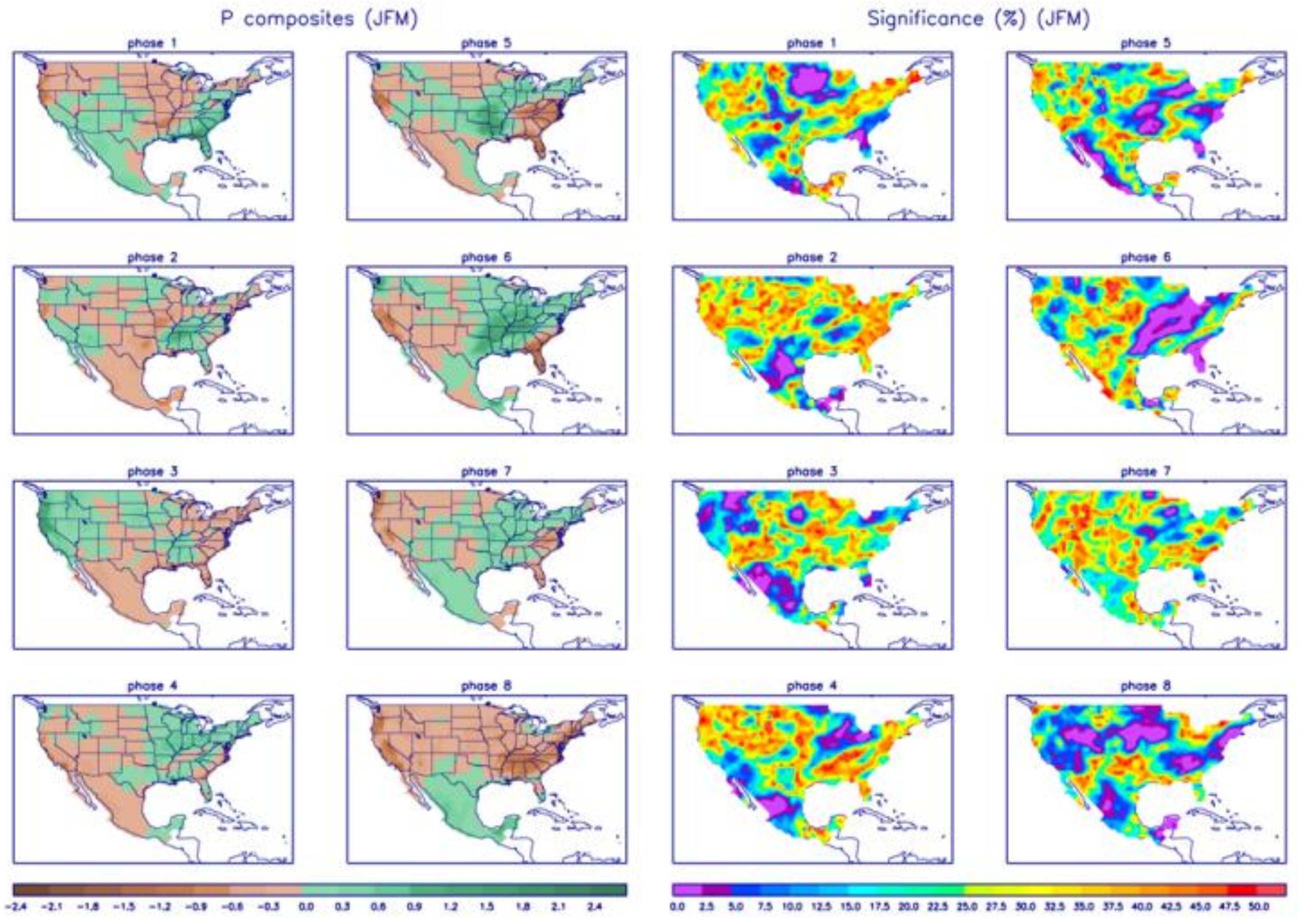
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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