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

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Climate Prediction Center / NCEP
3 April 2017

Outline

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Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The MJO remained weak during the past week, with the low frequency state most influential across the global tropics and favoring enhanced convection in the vicinity of the Maritime Continent and East Pacific.

- Dynamical model RMM index forecasts depict a continued weak MJO signal during the next week. During Week-2, some models indicated the potential emergence of a signal over the western Pacific.

- The MJO is not expected to play a major role in the evolution of the global tropical convective pattern during the next two weeks. Instead, the low frequency conditions and tropical cyclones are anticipated to be the primary drivers of convective anomalies in the tropics.

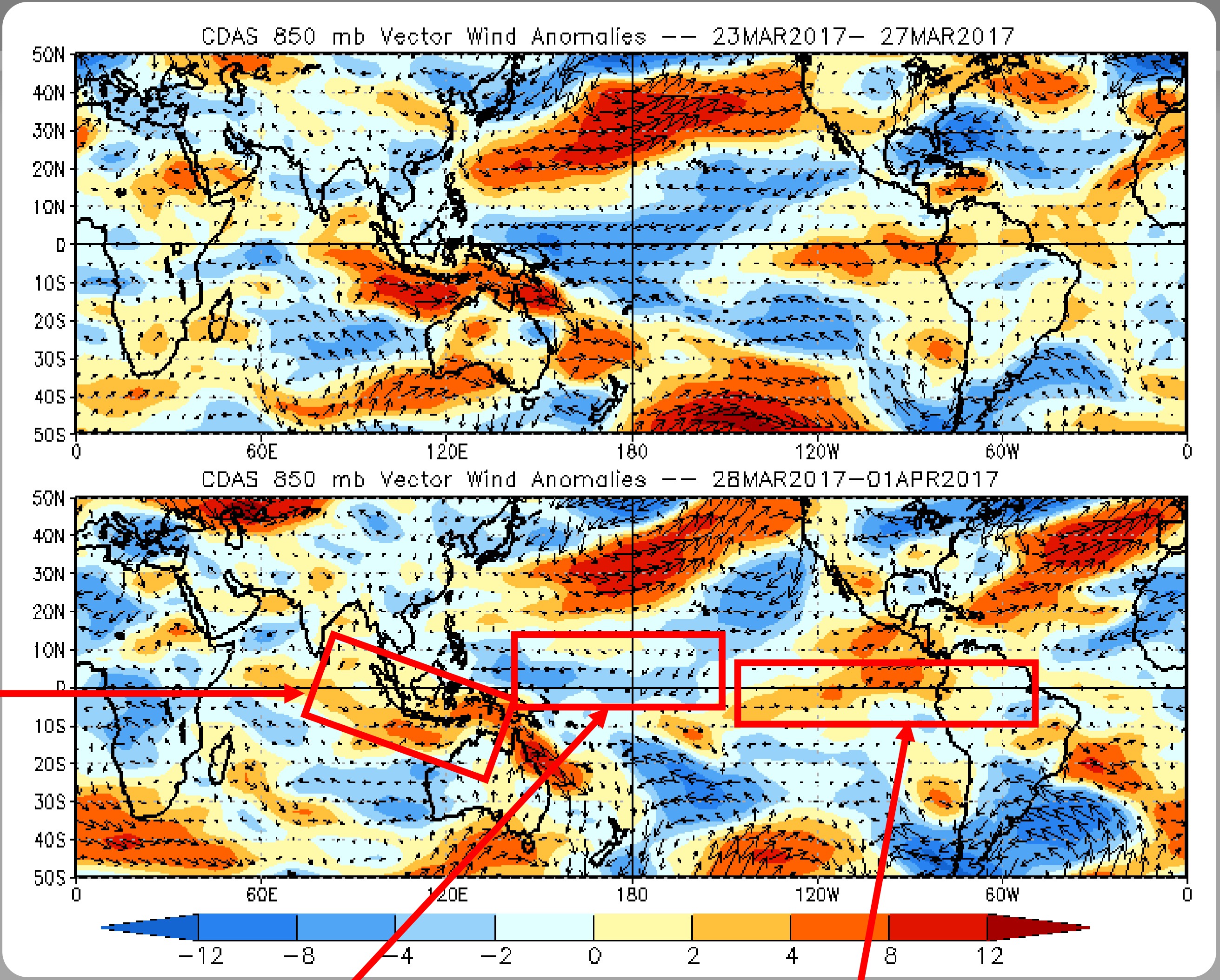
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 weakened over the western Maritime Continent but strengthened northeast of Australia.

Easterly anomalies persisted over the West Pacific but weakened, as well as contracting in coverage.

Westerly anomalies persisted over the far East Pacific and equatorial South America.

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

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

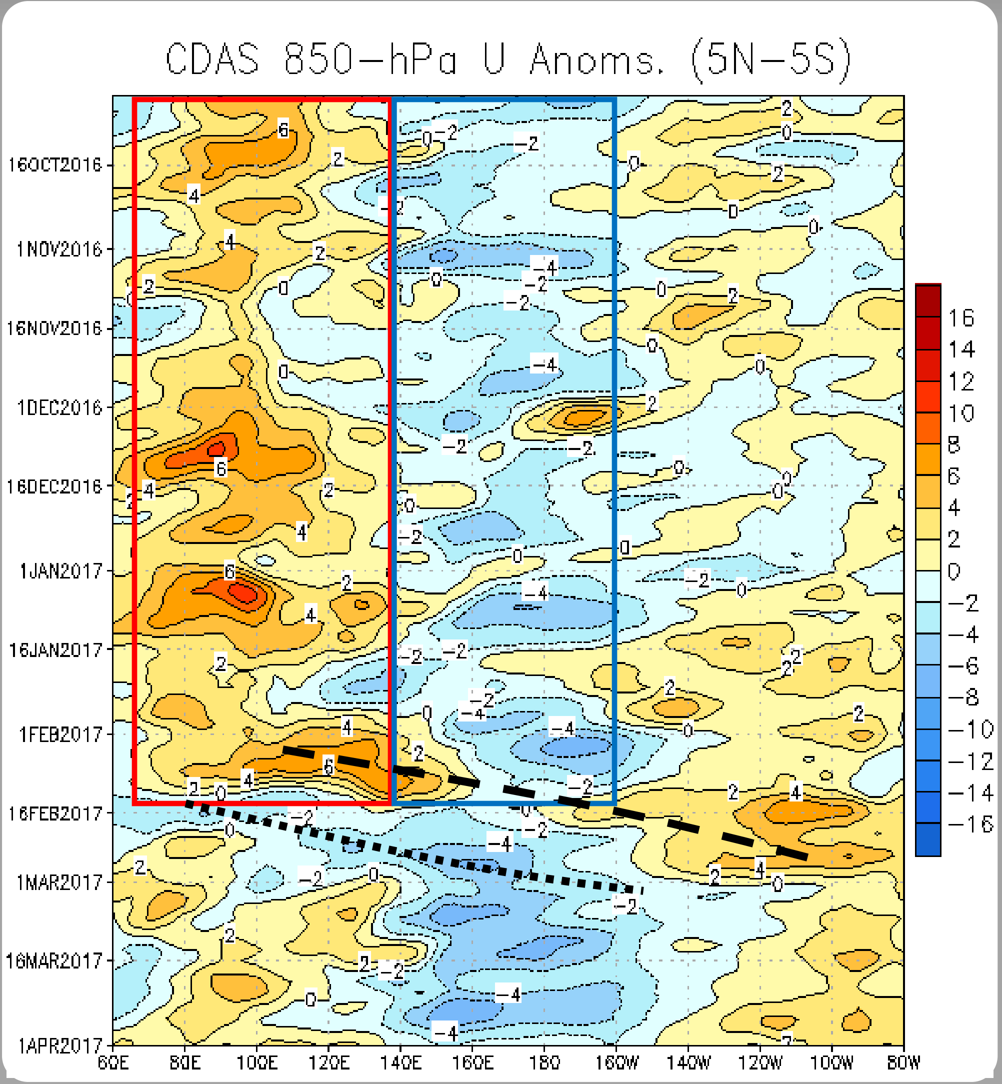
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

During February, eastward propagating anomalies were observed, consistent with ongoing MJO activity.

During mid-March, the low frequency state of anomalies returned similar to this past winter. Recently, westerly anomalies were showing some eastward propagation near 120E.



OLR Anomalies – Past 30 days

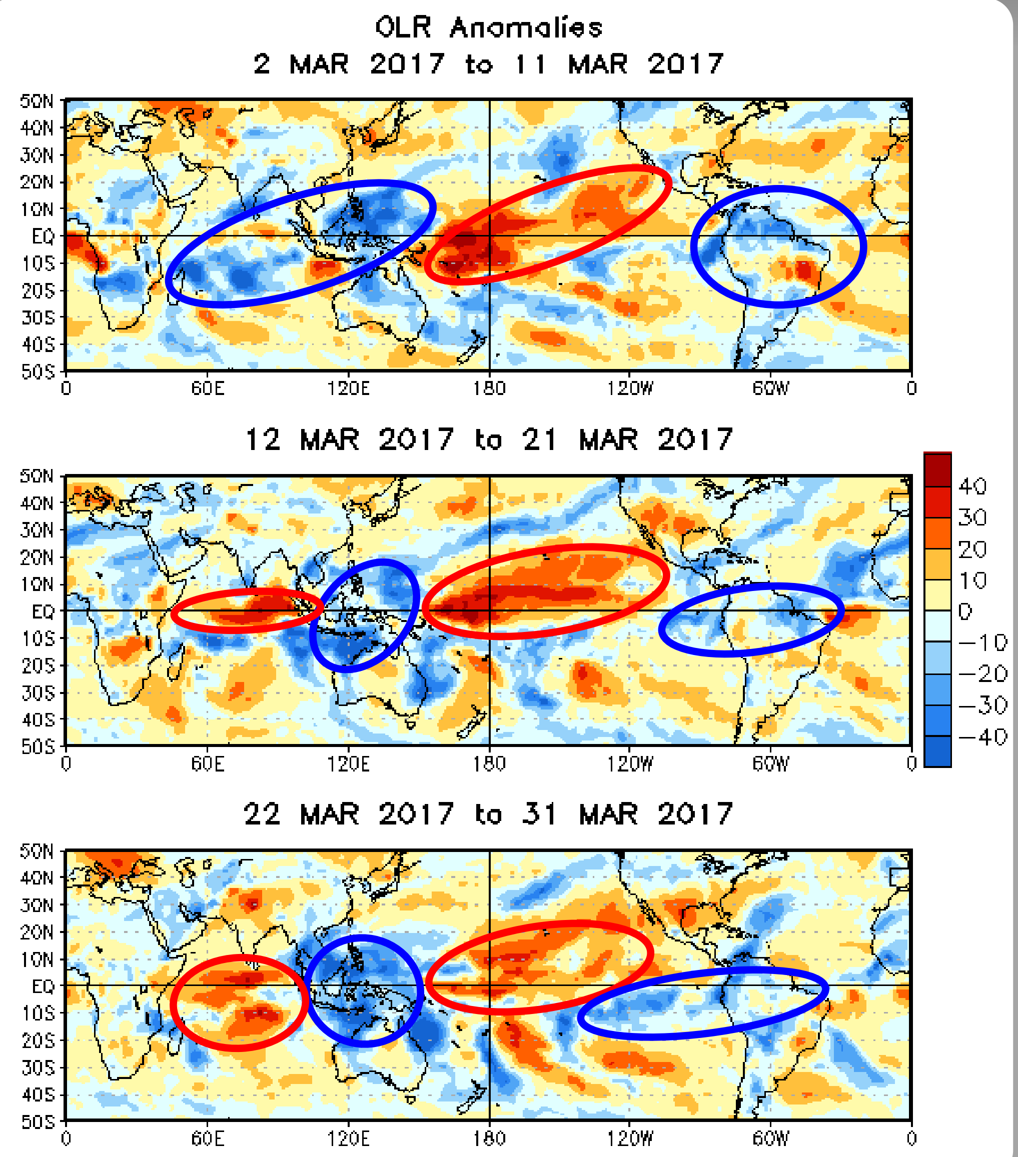
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

The intraseasonal signal returned to the Indian Ocean by early March, enhancing convection over the Indian Ocean and Maritime Continent. Tropical cyclones contributed over the Southwest Indian Ocean.

The remnant low frequency signal became more dominant during mid-March. The pattern supports enhanced (suppressed) convection over the Maritime Continent and eastern Pacific (central Pacific, Indian Ocean).

The low-frequency pattern continued during late March, with a slight eastward shift in the convective dipole over the western/central Pacific.



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

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

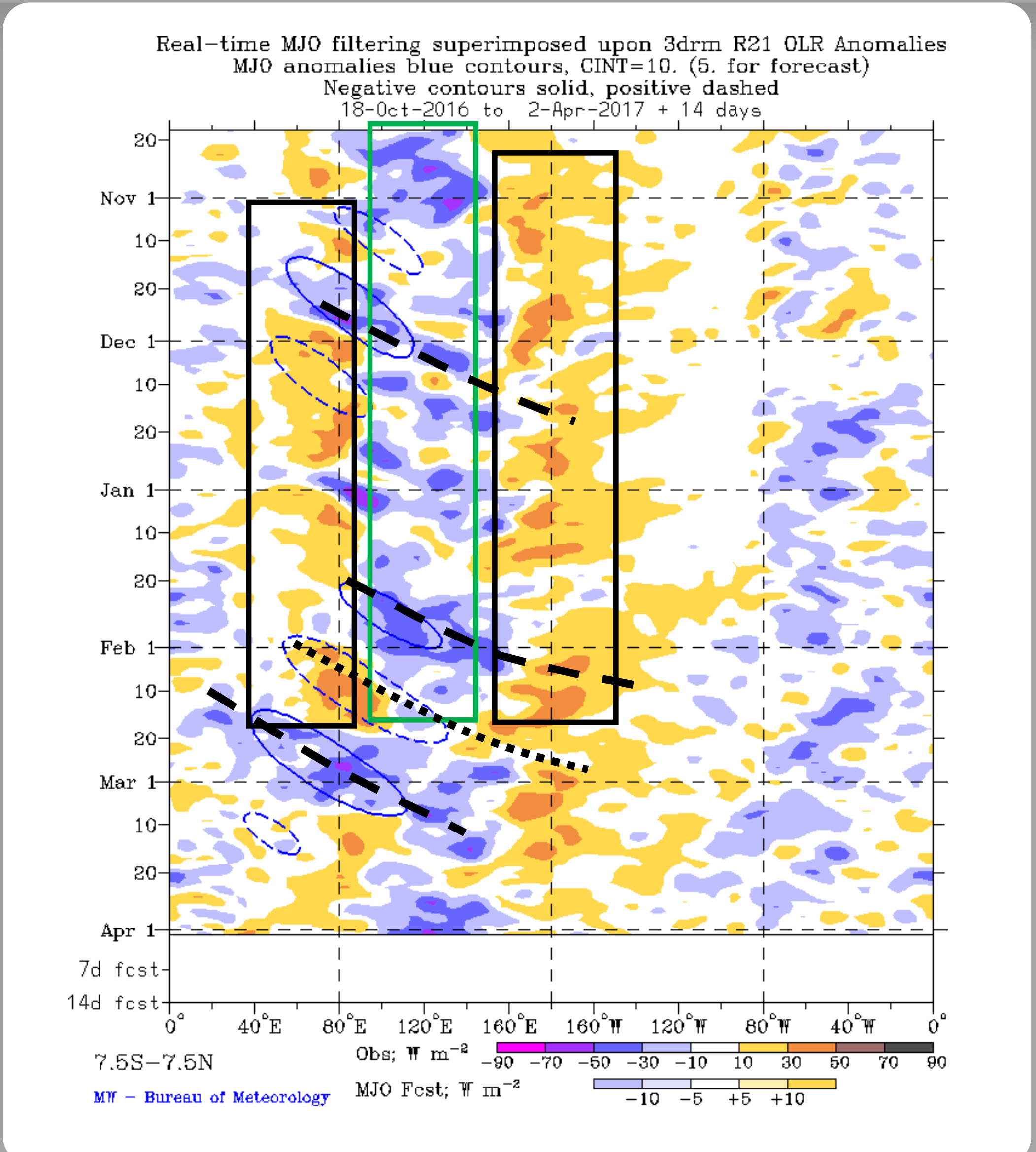
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

A low frequency state favoring enhanced convection over the eastern Indian Ocean and the Maritime Continent has been evident from July through Mid-February (green box), with suppressed convection over the Indian Ocean and near the Date Line (black boxes).

An intraseasonal event during late November and early December interfered with the background state.

From late January through mid-March, an active MJO pattern became the dominant mode of intraseasonal tropical convective variability, with the suppressed phase reversing the low frequency enhanced convective signal over the Maritime Continent in late February.

The MJO signal weakened by mid-March with a return of the low frequency state.



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

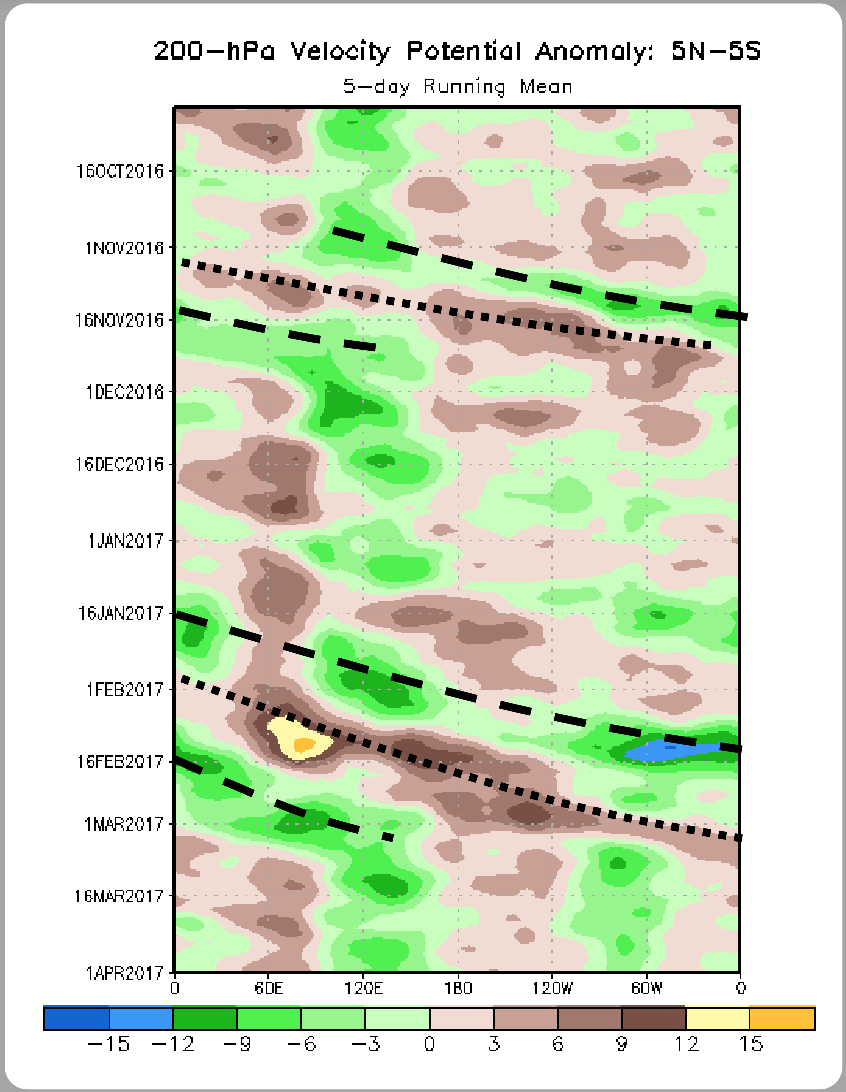
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

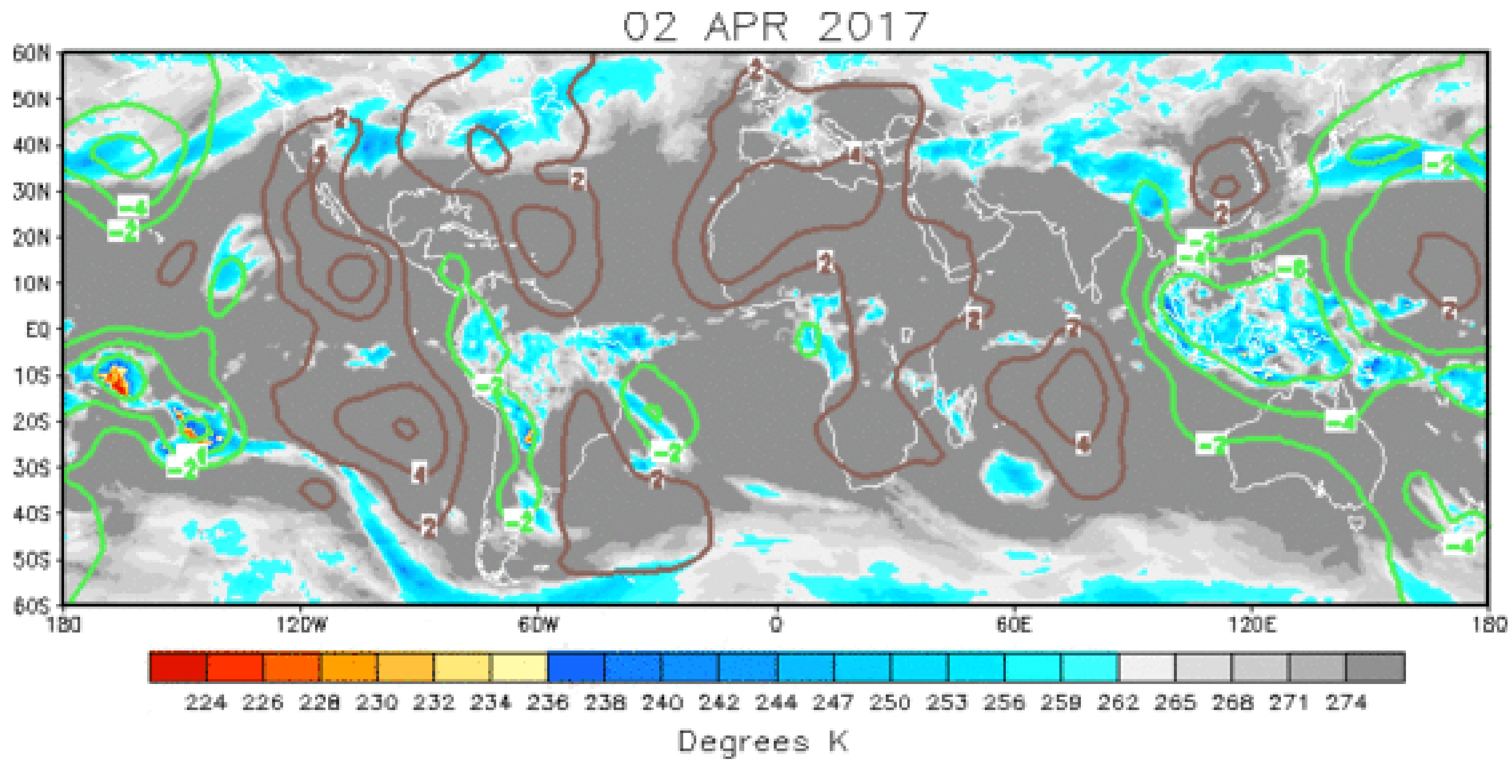
During November, eastward propagation was observed consistent with MJO activity on the fast end of the intraseasonal spectrum.

After a break in apparent MJO activity during December and early January, a signal emerged over the Maritime Continent and has continued propagating through early March.

There have been alternating periods of constructive and destructive interference between the MJO and the low frequency state from late January through the beginning of March.



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



Upper-level divergence (convergence) generally persisted over South America, the Maritime Continent, and Australia (Indian Ocean, Africa, and the central Pacific). There was a slight eastward shift in the pattern over the Pacific.

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)

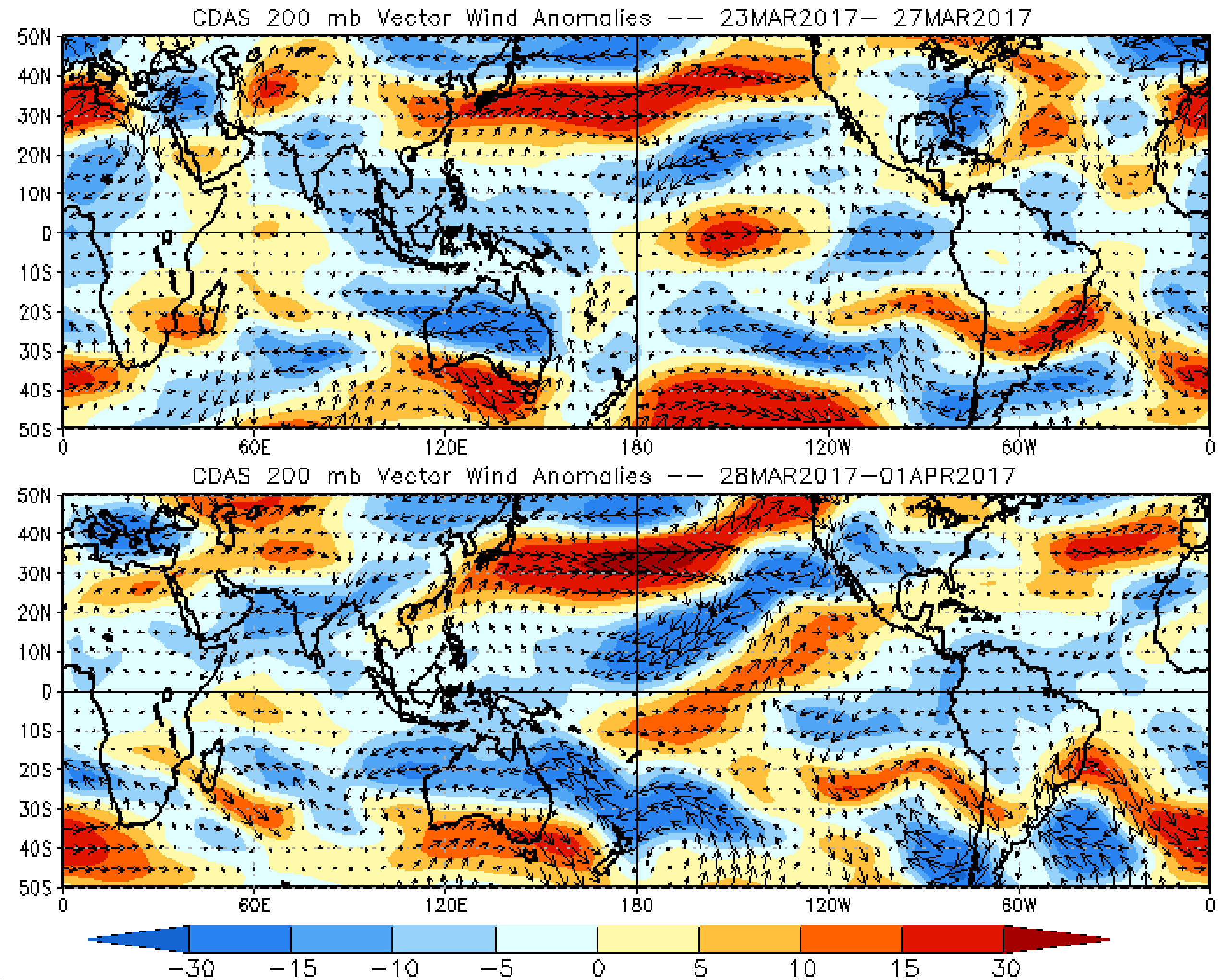
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Upper-level, anomalous anticyclones, located just west of the Date Line, intensified during the last week.

Upper-level easterly anomalies remained over northwest South America, along with westerly (easterly) anomalies over the central (west) Pacific.



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

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

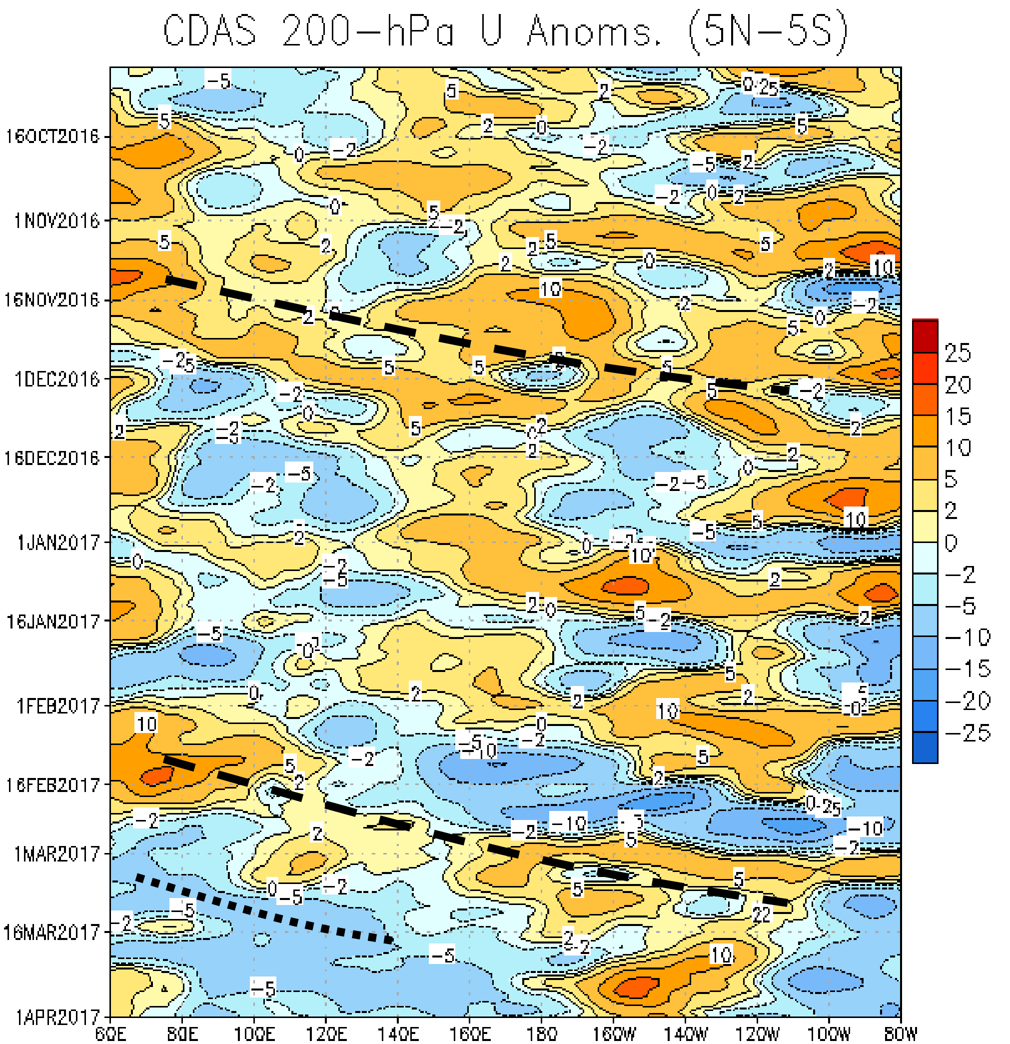
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

Recently, the pattern has become more temporally stable, with easterly (westerly) wind anomalies over the western (eastern) Pacific.

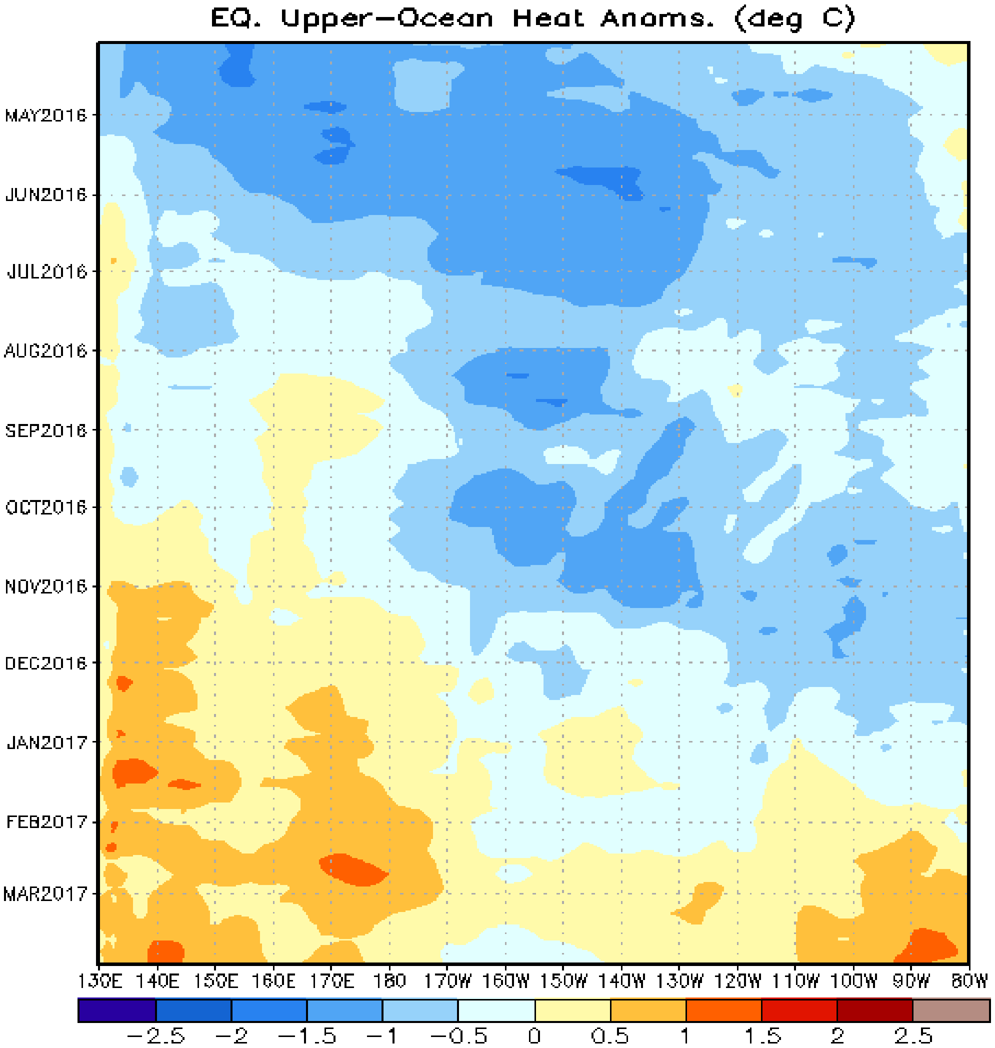


Weekly Heat Content Evolution in the Equatorial Pacific

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. Positive anomalies are now observed over the entire 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

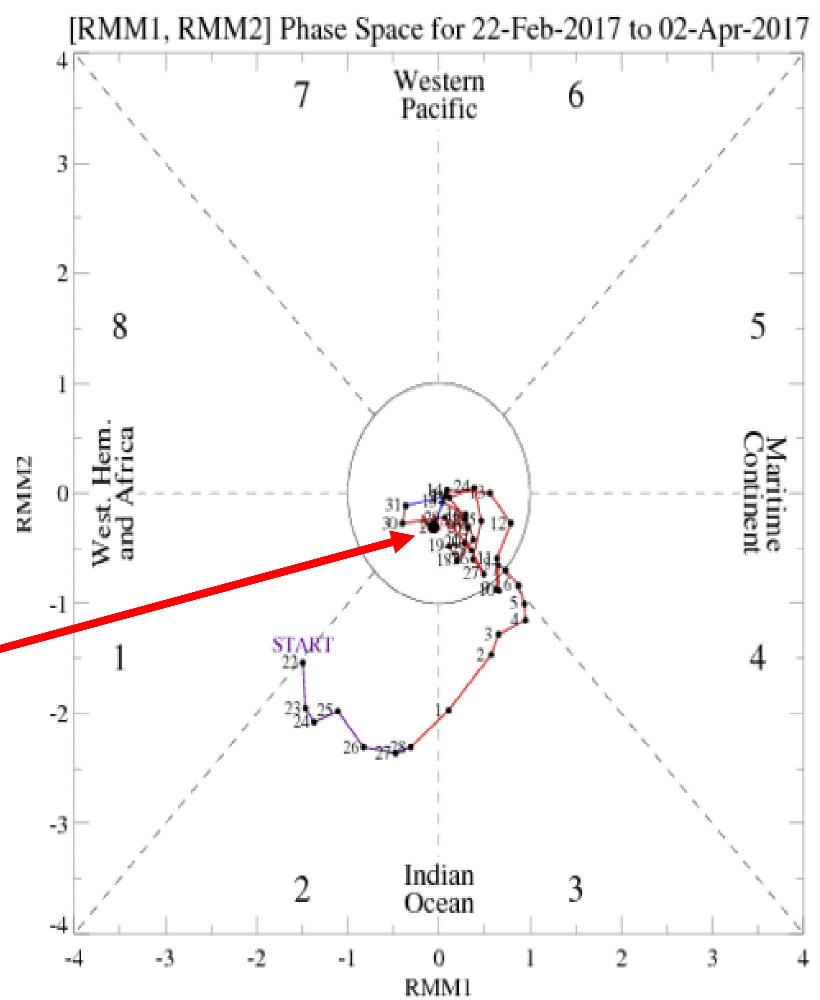
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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

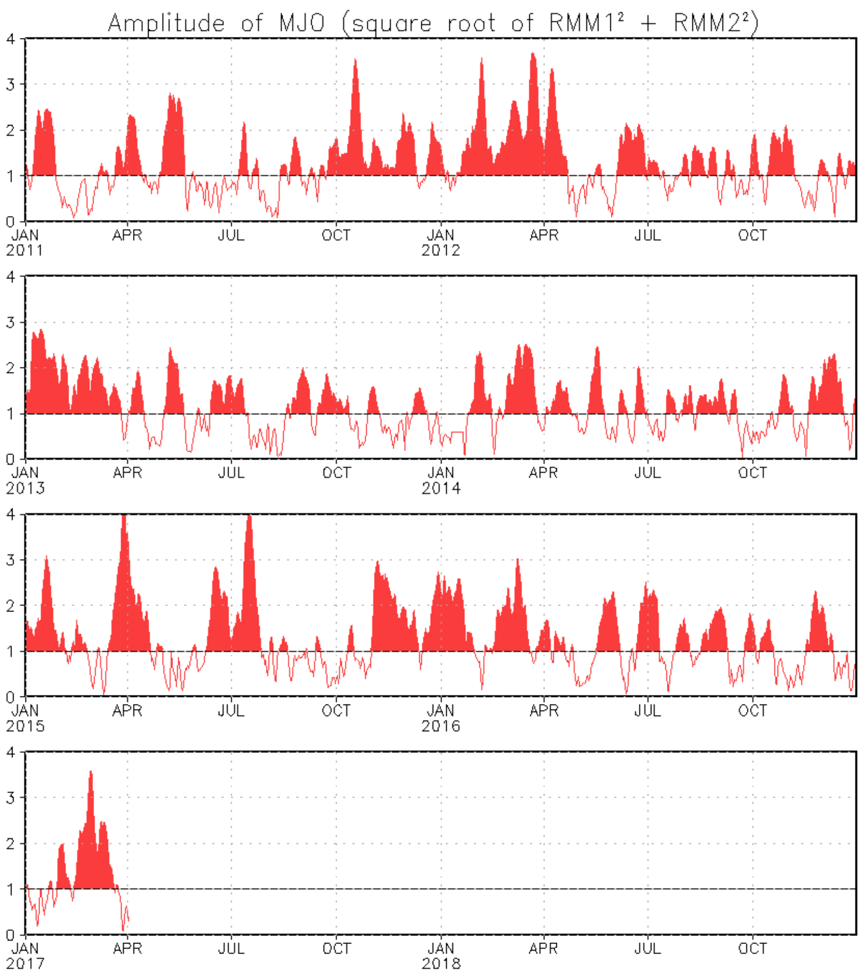


During the past two to three weeks, the RMM index continued to indicate weak MJO activity.

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.



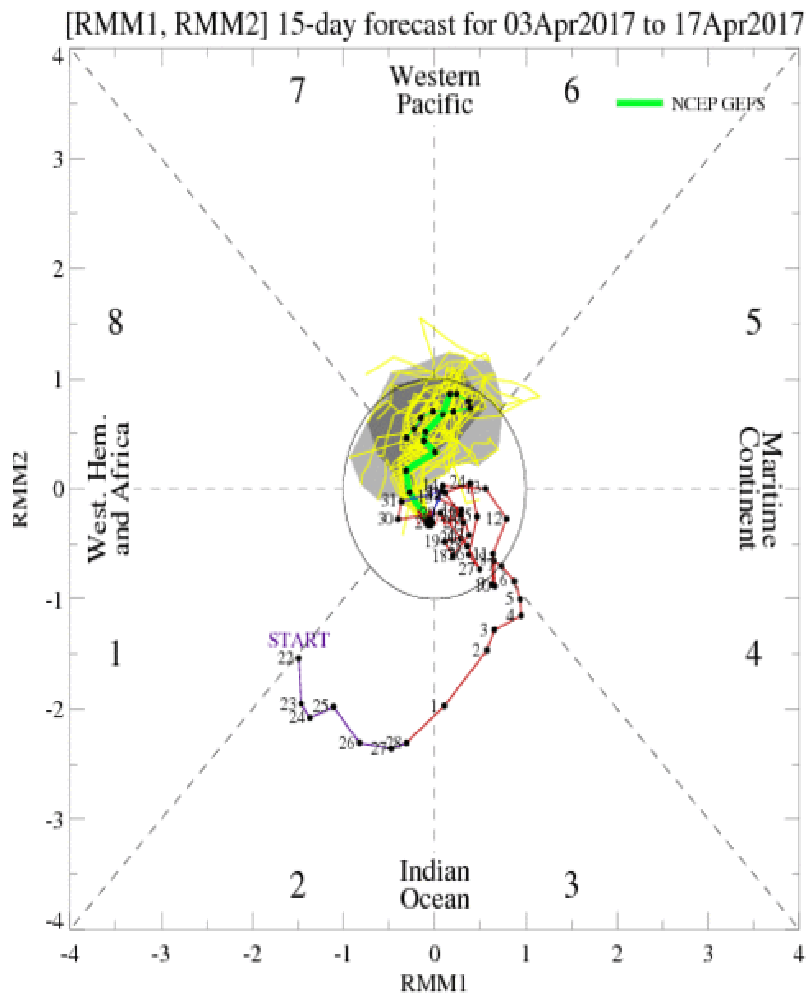
GFS Ensemble (GEFS) MJO Forecast

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

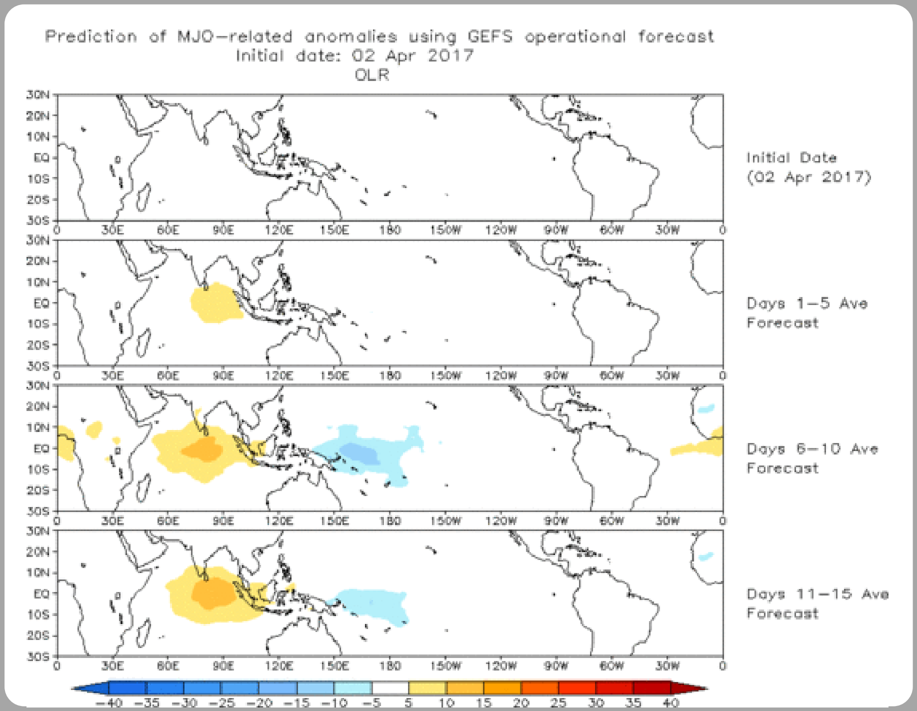


The GEFS depicts a weak MJO signal persisting into mid-April.

Ensemble GFS (GEFS) MJO Forecast

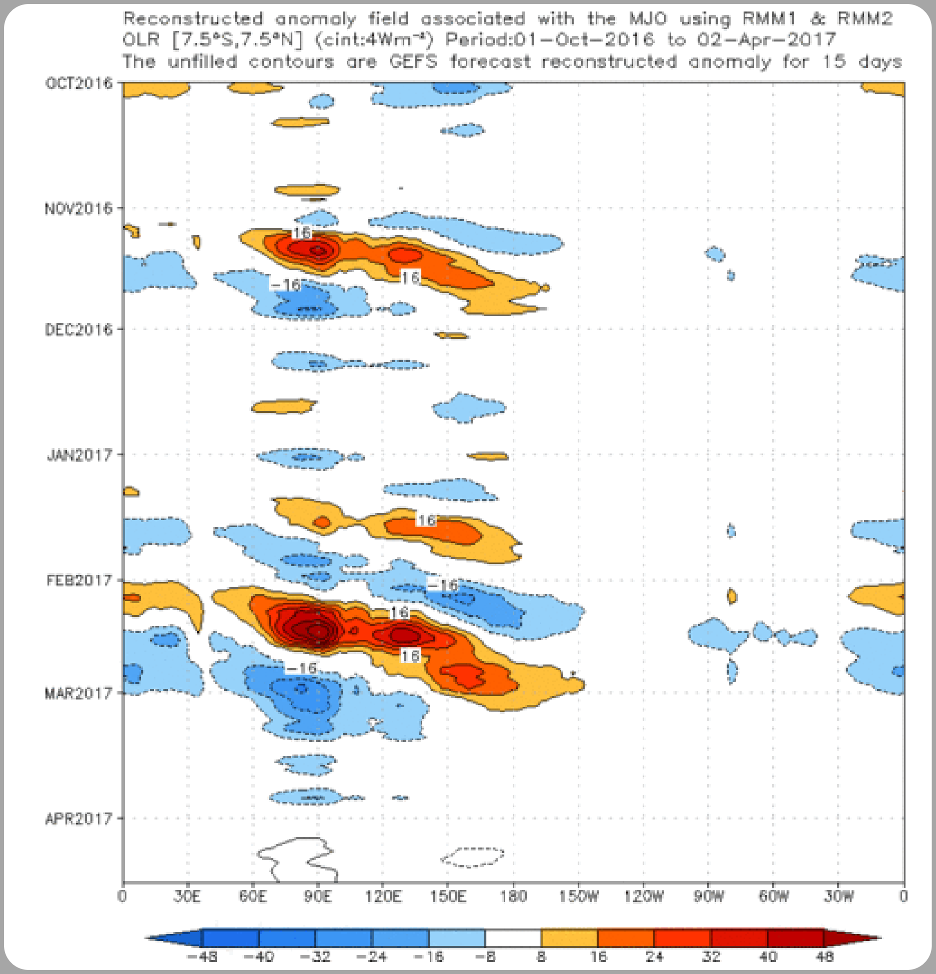
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS prediction features small anomalies with little eastward propagation.

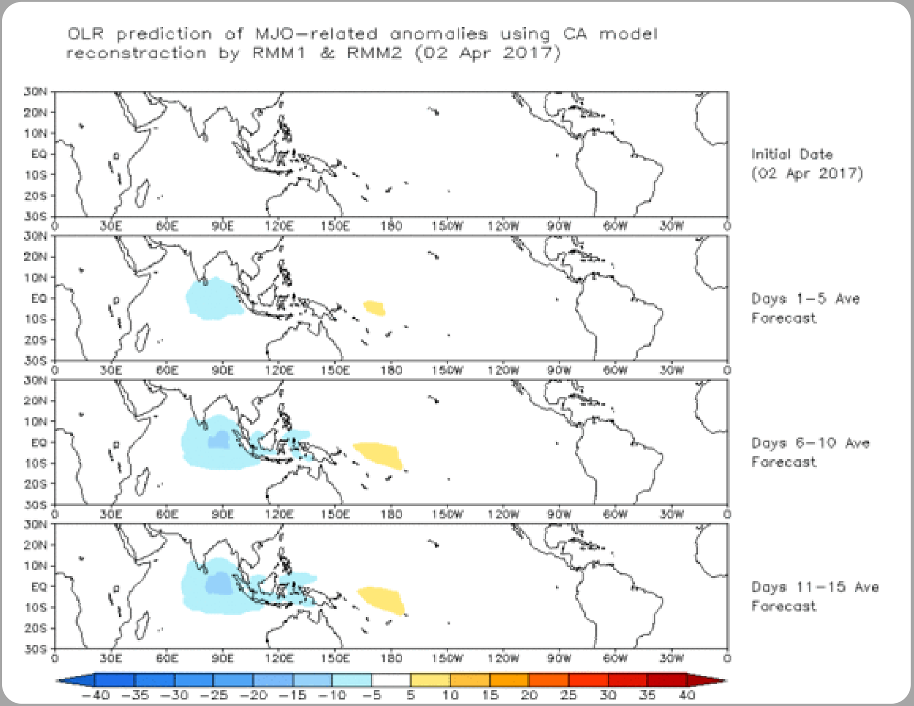
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



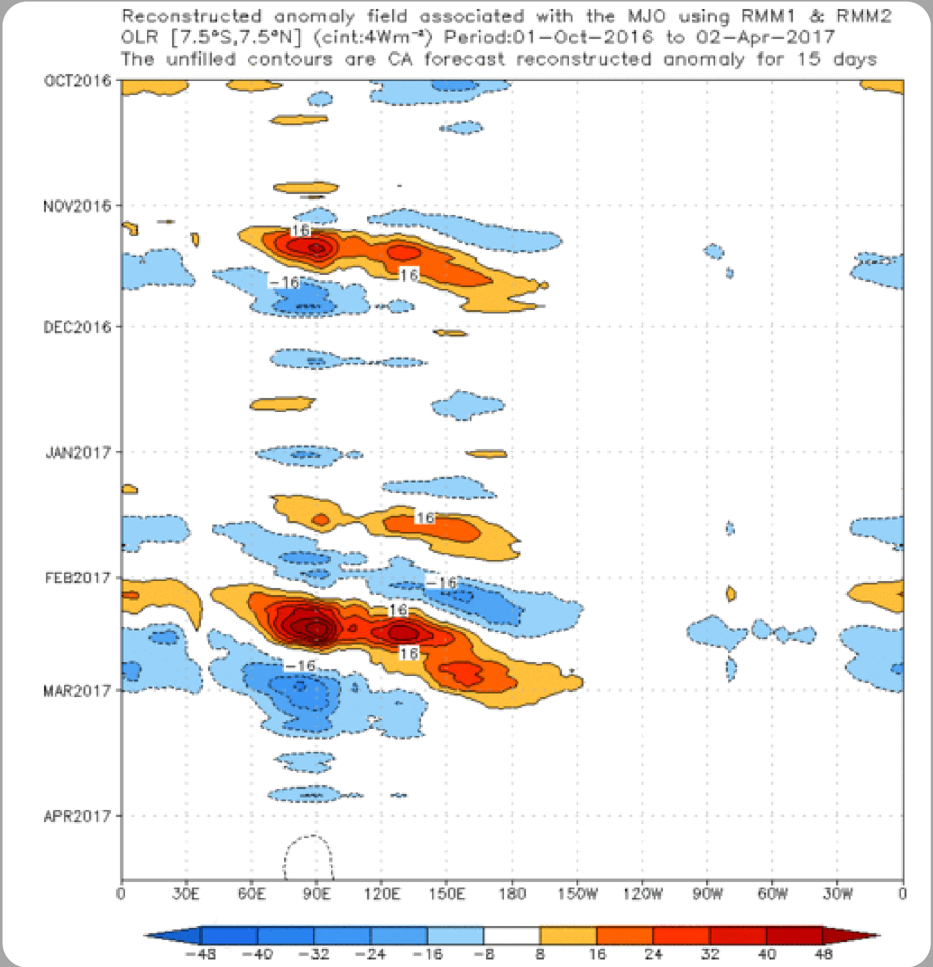
Constructed Analog (CA) MJO Forecast

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



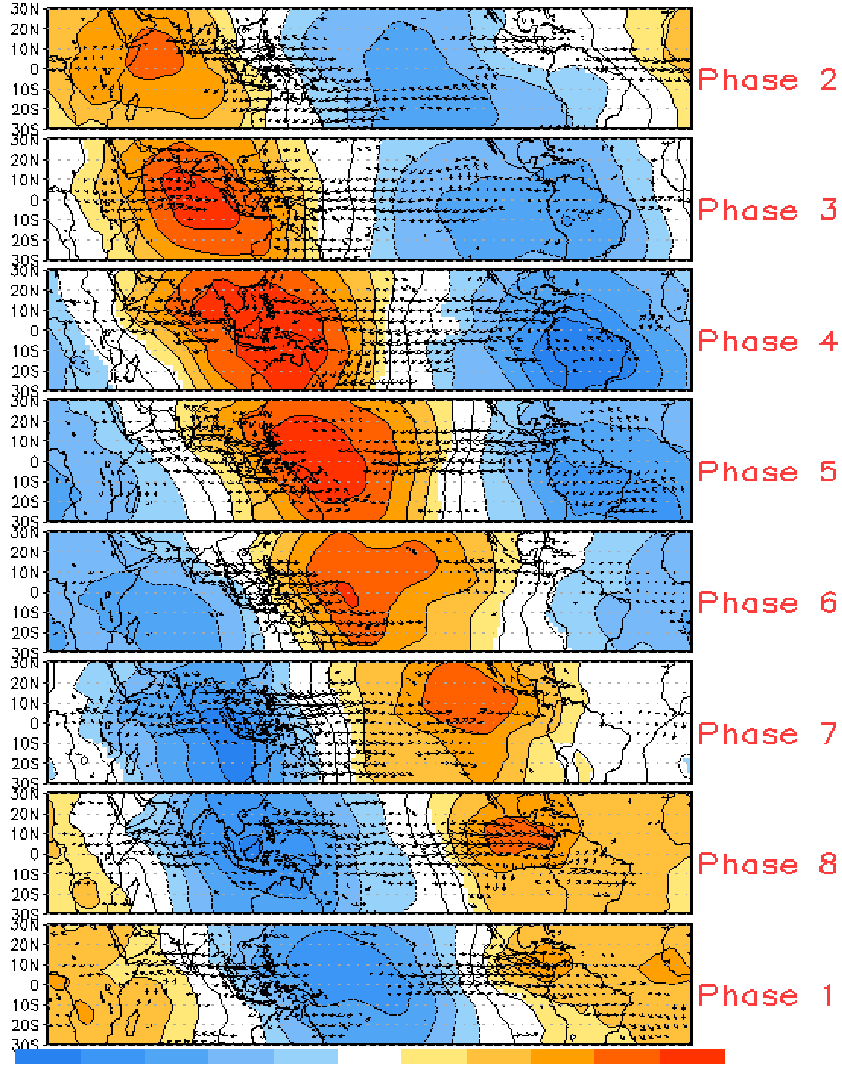
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



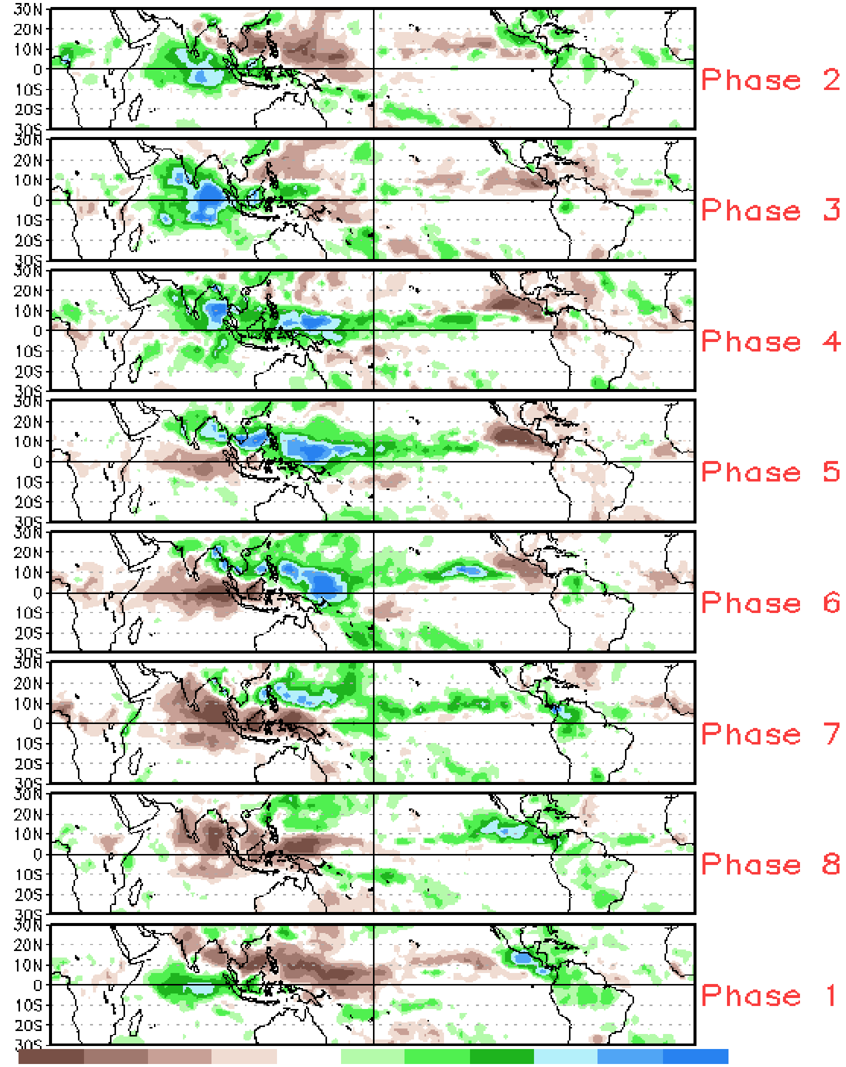
The statistical (Constructed Analog) RMM-based OLR anomaly prediction indicates a stable pattern of enhanced (suppressed) convection over the eastern Indian and Maritime Continent (equatorial central Pacific).

MJO Composites - Global Tropics

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



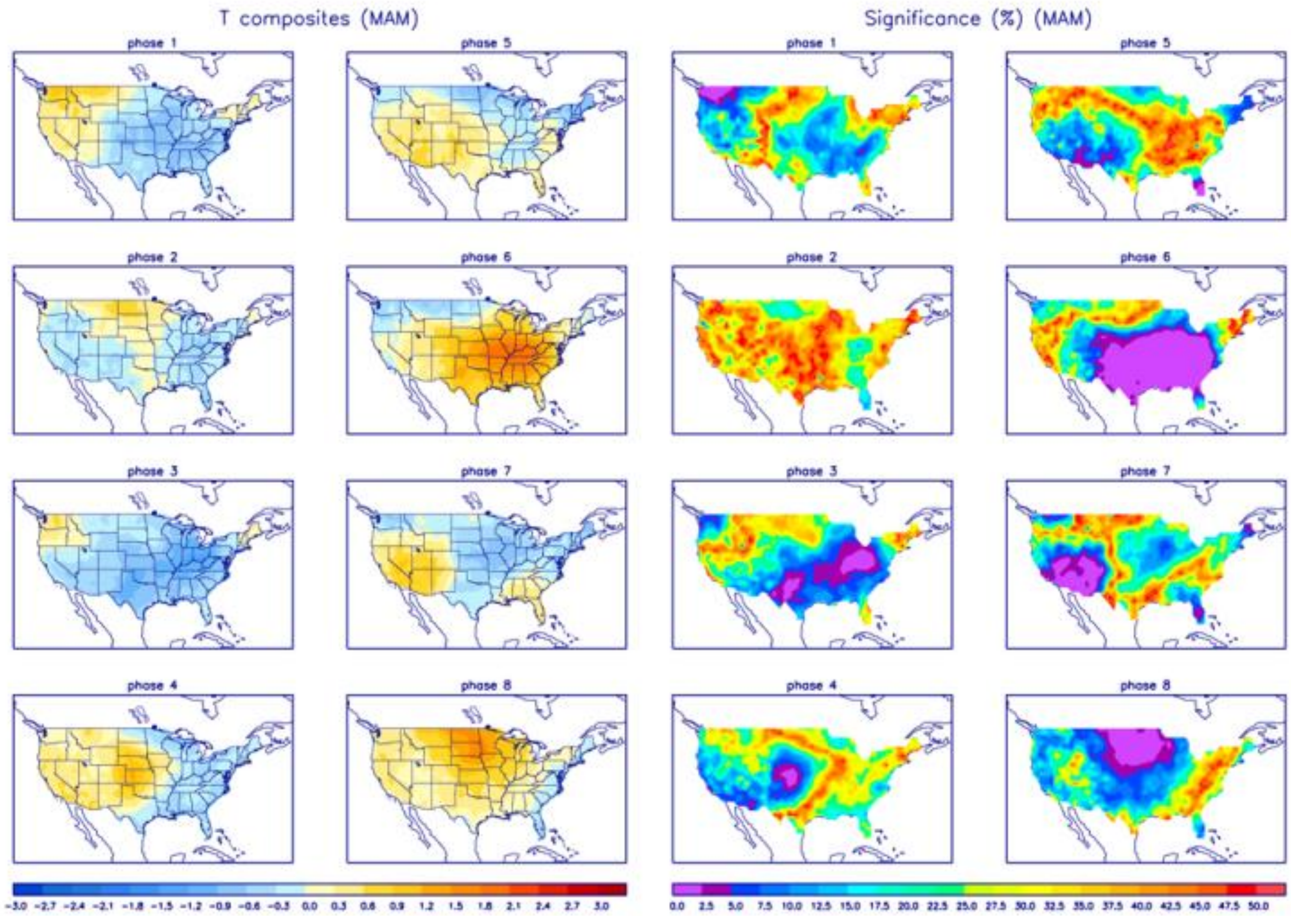
Precipitation Anomalies (Nov - Mar)



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.



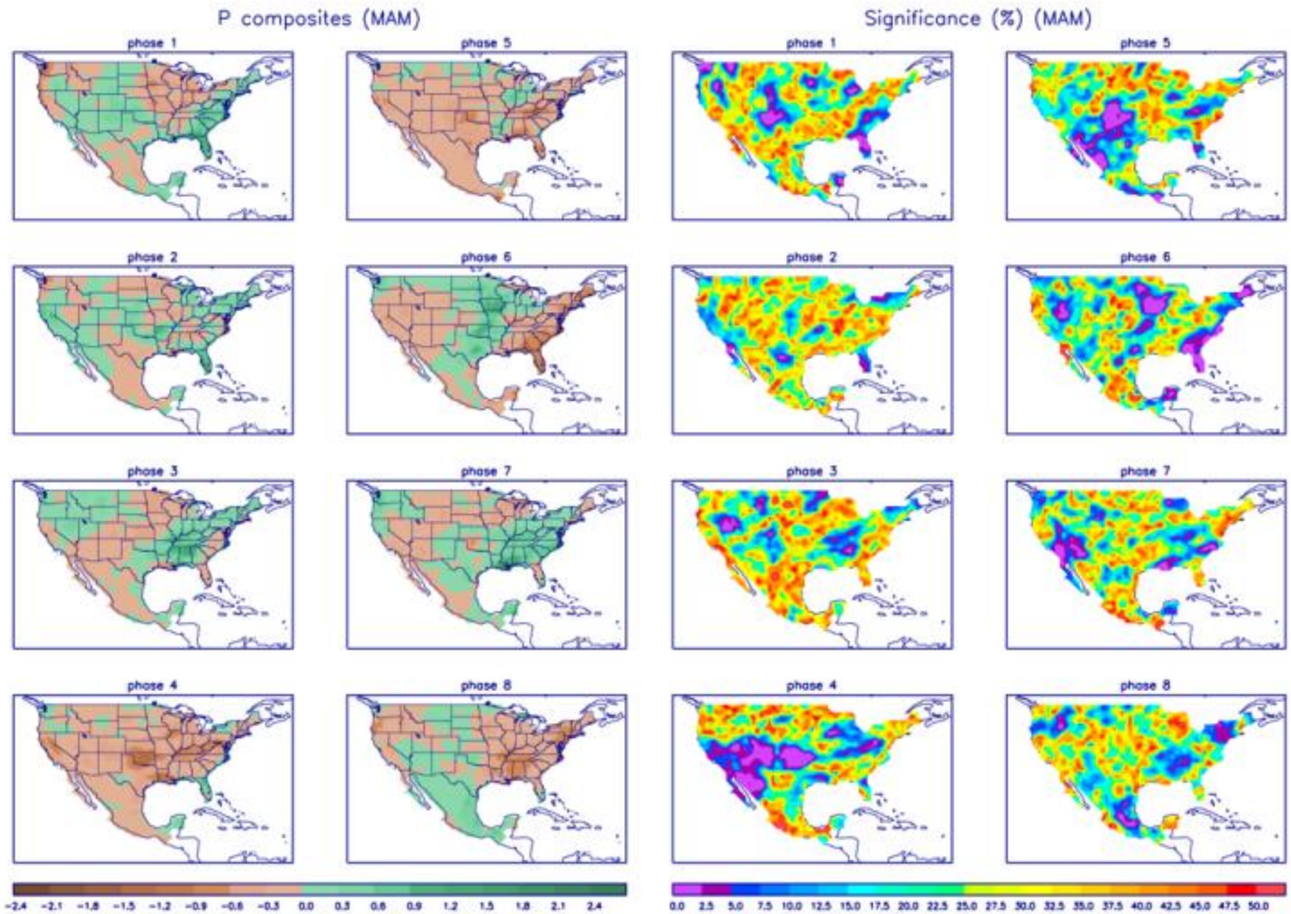
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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