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

Update prepared by:
Climate Prediction Center / NCEP
17 April 2017

Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The Wheeler-Hendon index suggests an active MJO over the Western Hemisphere that appears to best manifest in the low-level wind field. Velocity potential and outgoing-longwave-radiation proxies lack this feature.

- Dynamical model forecasts are varied, with no indications of eastward propagations of a MJO envelope, if one were to exist. Some models indicate an increase in the intraseasonal signal's amplitude, but it remains uncharacteristically stationary.

- Doubts exist about the presence of a true MJO event, with a Kelvin wave potentially being aliased into the Wheeler-Hendon index. With this in mind, no MJO impacts are anticipated throughout the global tropics or subtropics in the next two weeks.

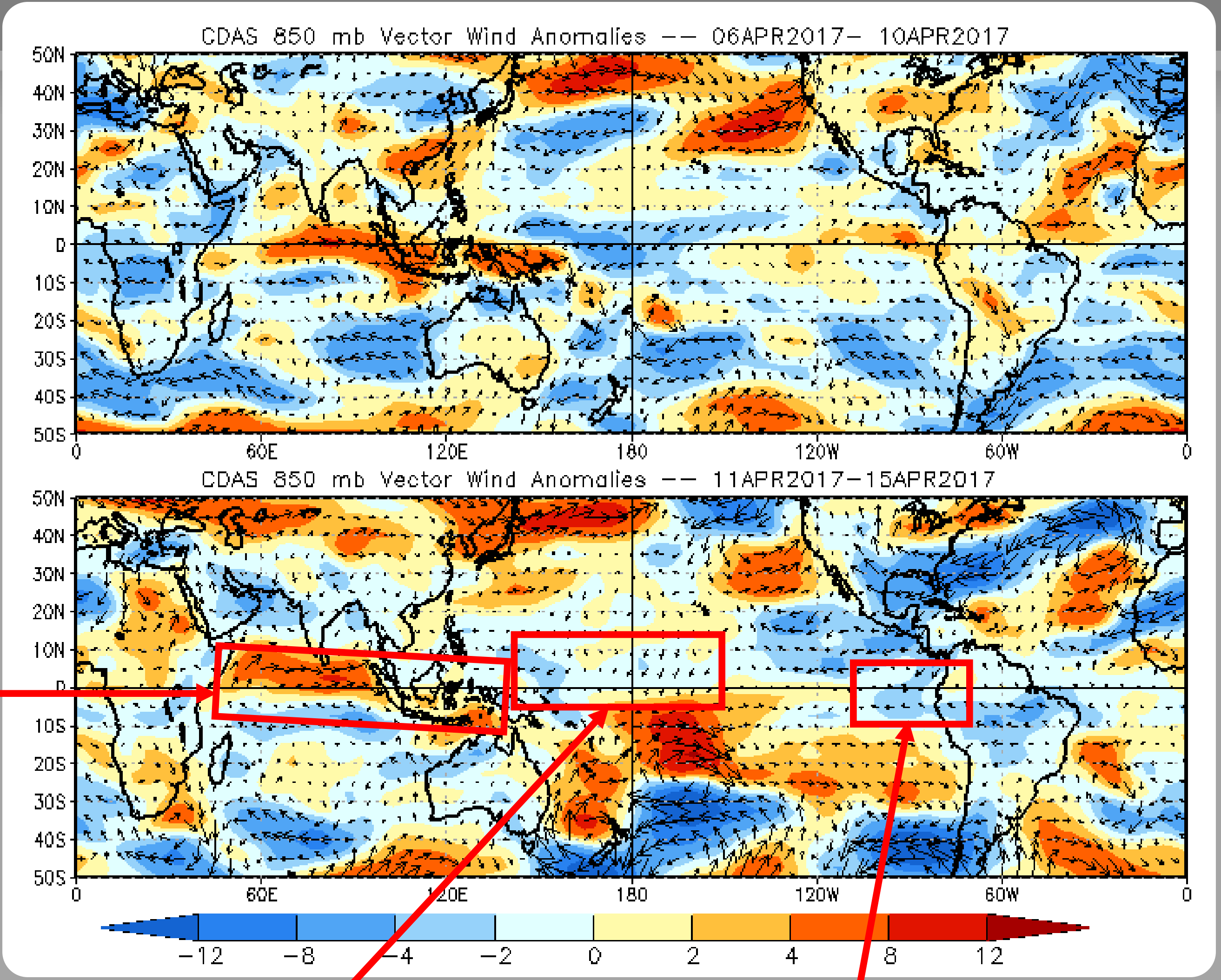
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Anomalous westerlies persisted over the Indian Ocean with some weakening over the Maritime Continent.

Easterly anomalies weakened across the West and Central Pacific.

Easterly anomalies emerged in the far East Pacific

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

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

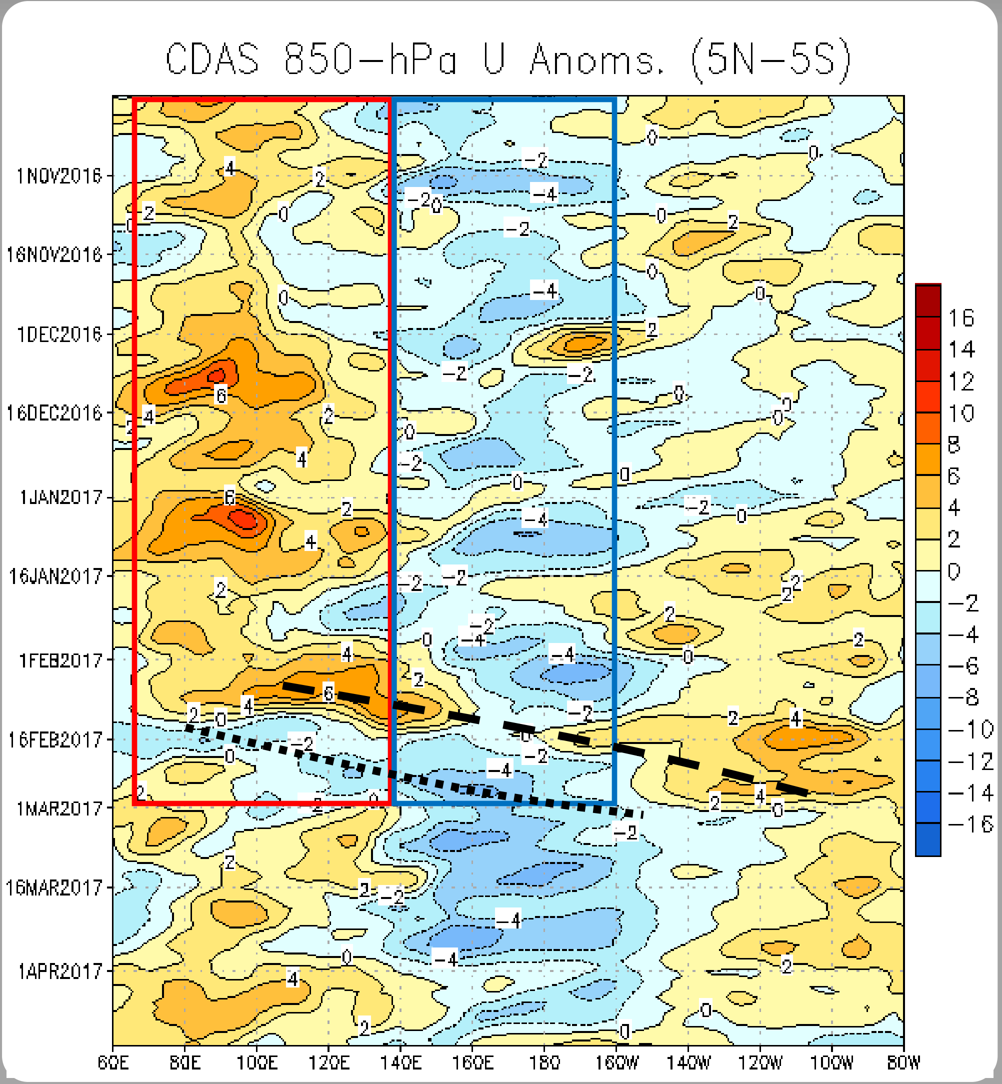
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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 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. More recently, westerlies have emerged over the Central Pacific.



OLR Anomalies – Past 30 days

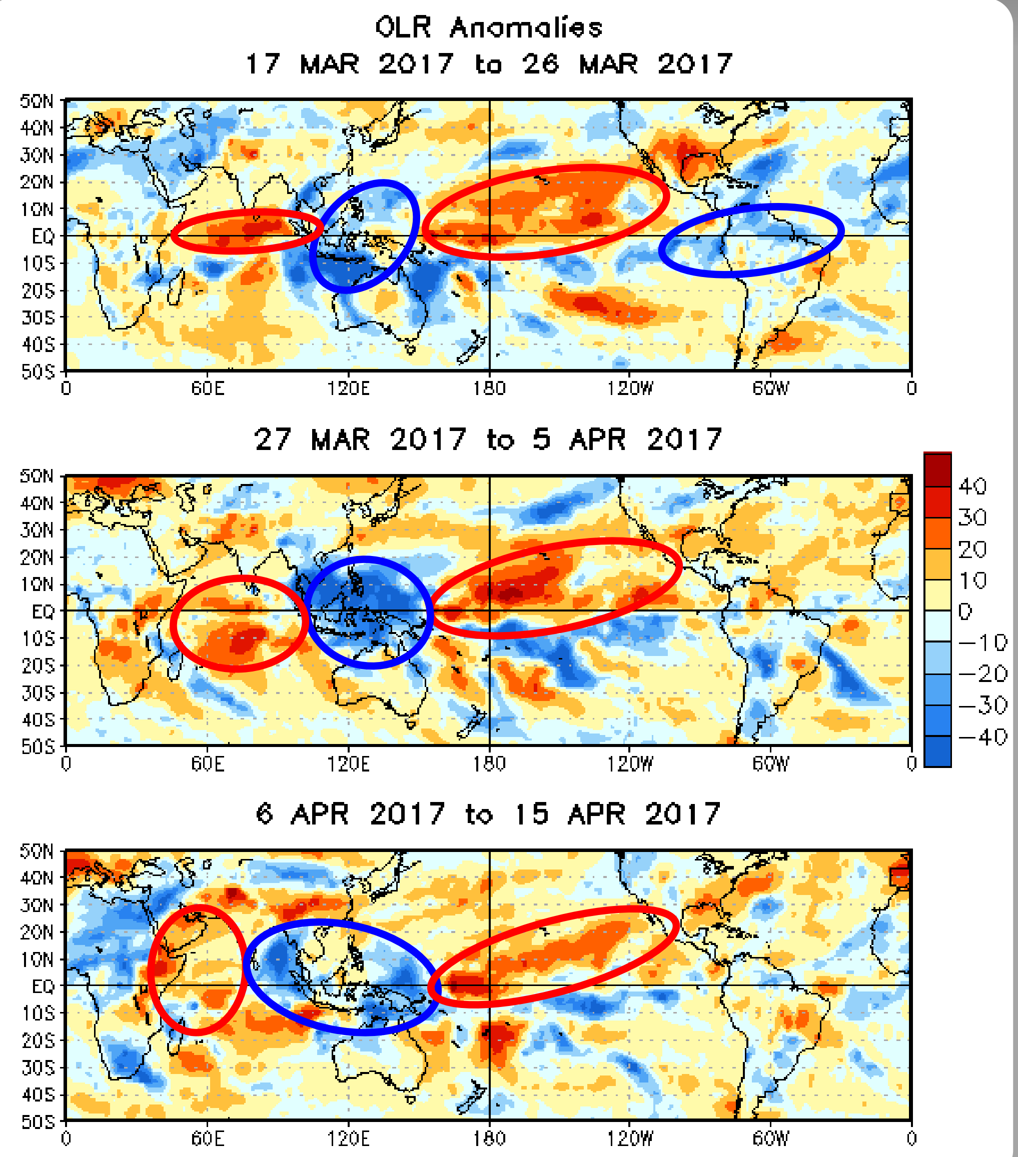
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

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 into early April, with a slight eastward shift in the convective dipole over the western/central Pacific. Convection waned in the East Pacific.

In early/mid-April, remnants of the low frequency convective tripole remained apparent. Enhanced convection in the Bay of Bengal was associated with Cyclone Maarutha.



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

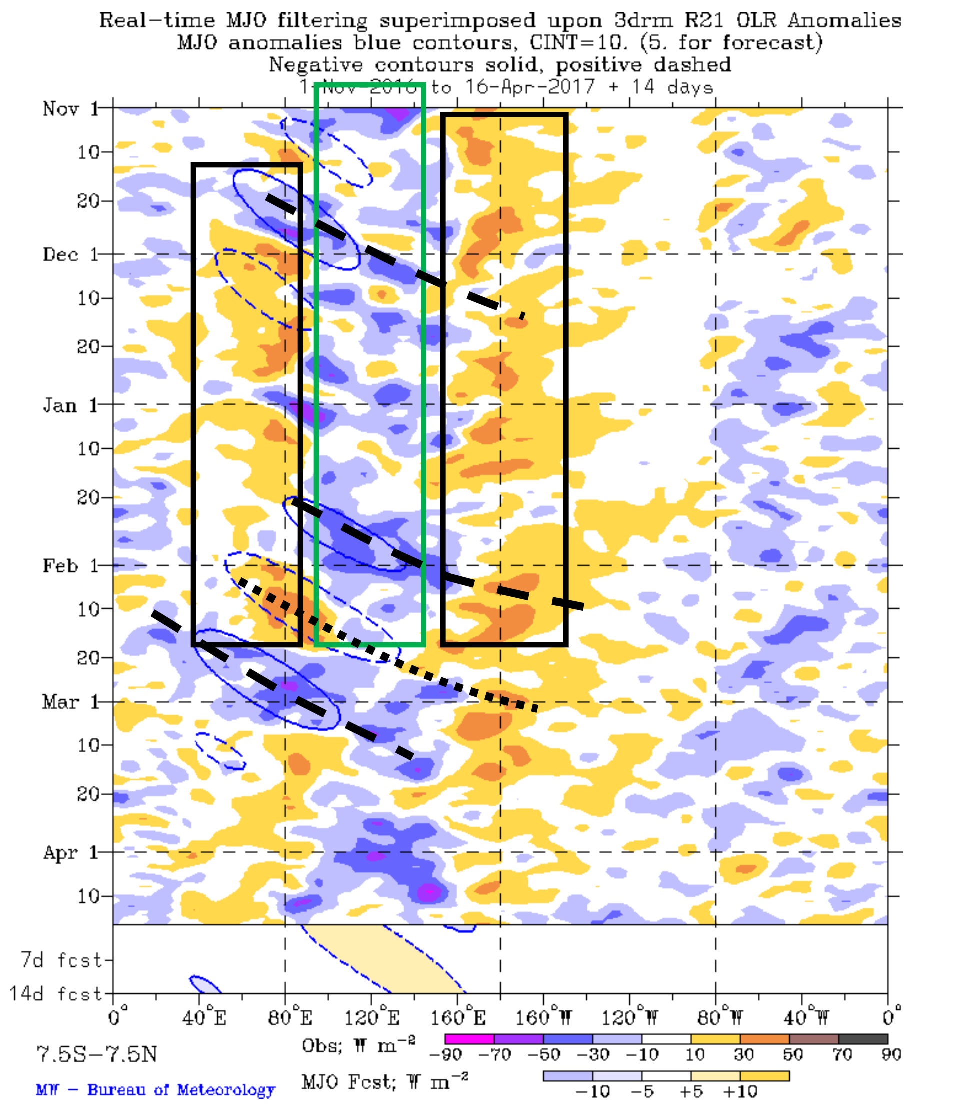
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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).

Intraseasonal events in November/December and January through mid-March have served to alter the low frequency states. Particularly, 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. Some eastward propagation of enhanced convection has been apparent between 120-160E since early April.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

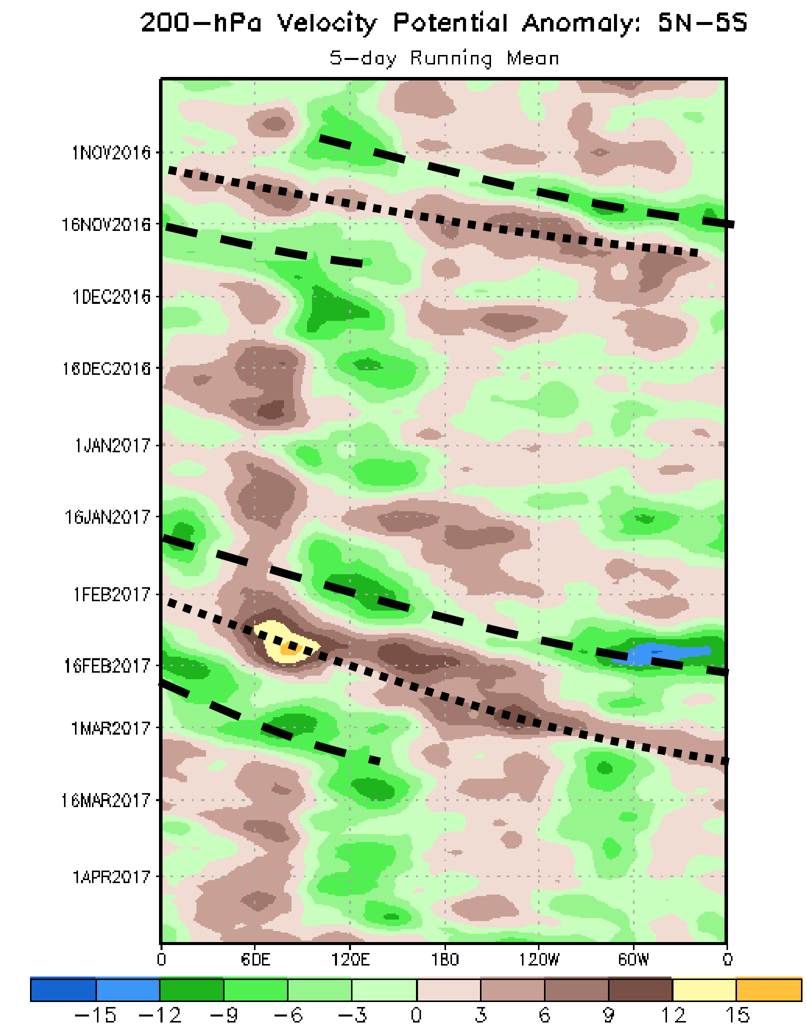
Negative anomalies (green shading) indicate favorable conditions for precipitation

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

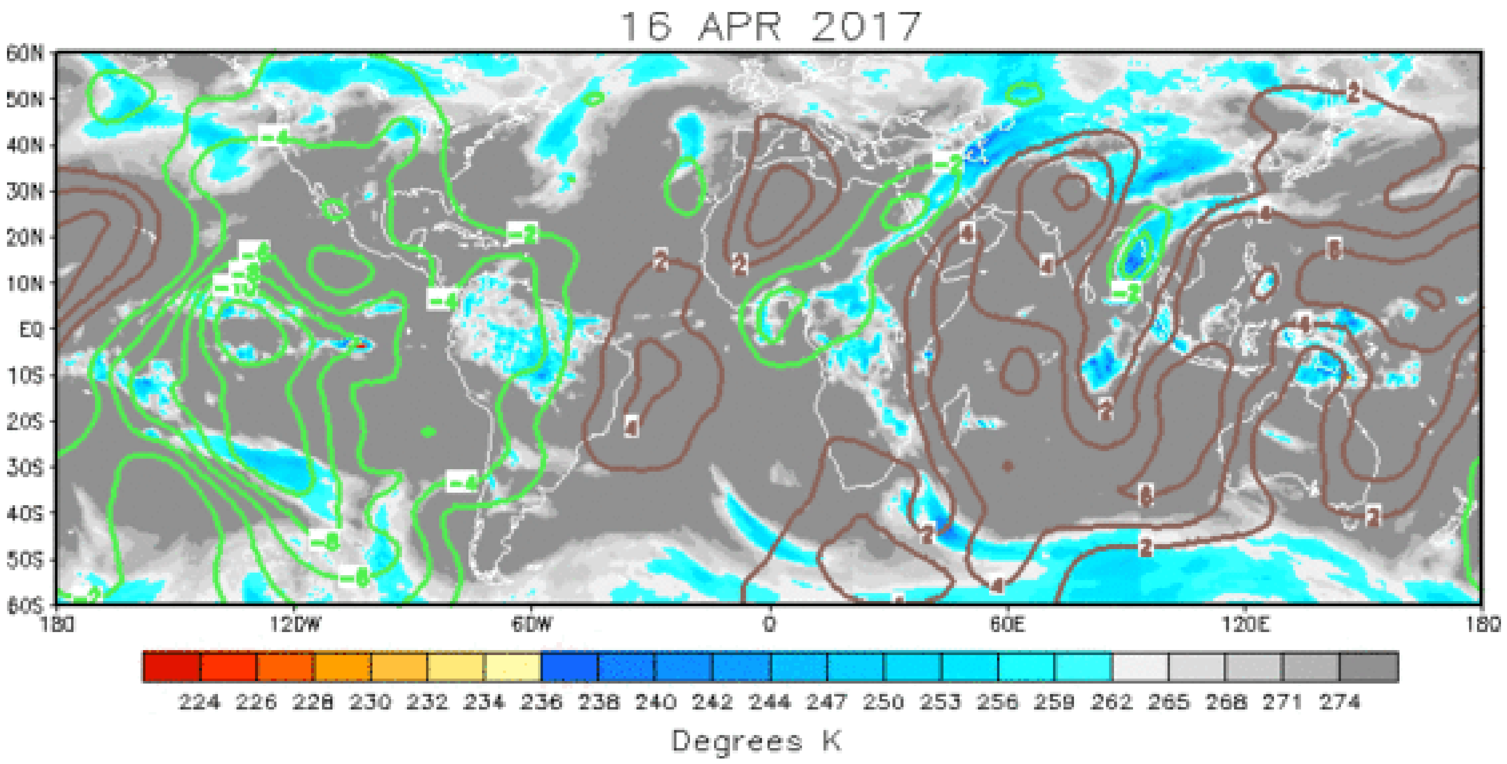
After a break in apparent MJO activity during December and early January, a signal emerged over the Maritime Continent and has continued propagating through early March.

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

A fast propagating eastward mode has been apparent from near 120E in early April through the Western Hemisphere at present.



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



A broadly wave-1 pattern with enhanced (suppressed) convection in the Western (Eastern) Hemisphere is apparent. Mixed signals existed over the Atlantic, while remnants of Cyclone Maarutha are apparent in the Bay of Bengal.

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)

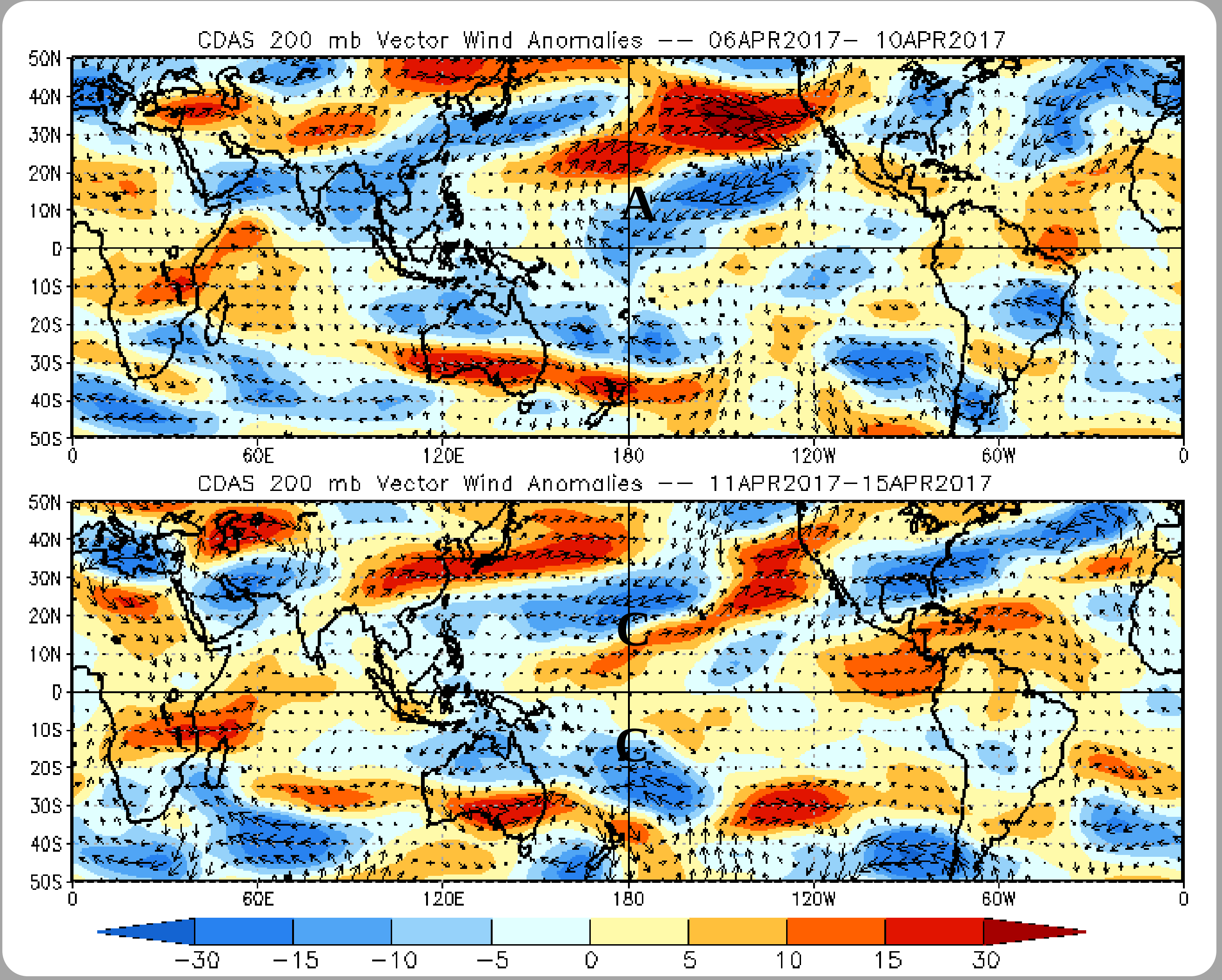
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

An anomalous anticyclone near the Date Line in the Northern Hemisphere has been replaced with anomalous cyclones in each hemisphere.

Anomalous westerlies in the East Pacific have helped in limiting the persistent heavy rains in western South America from the last several months.



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

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

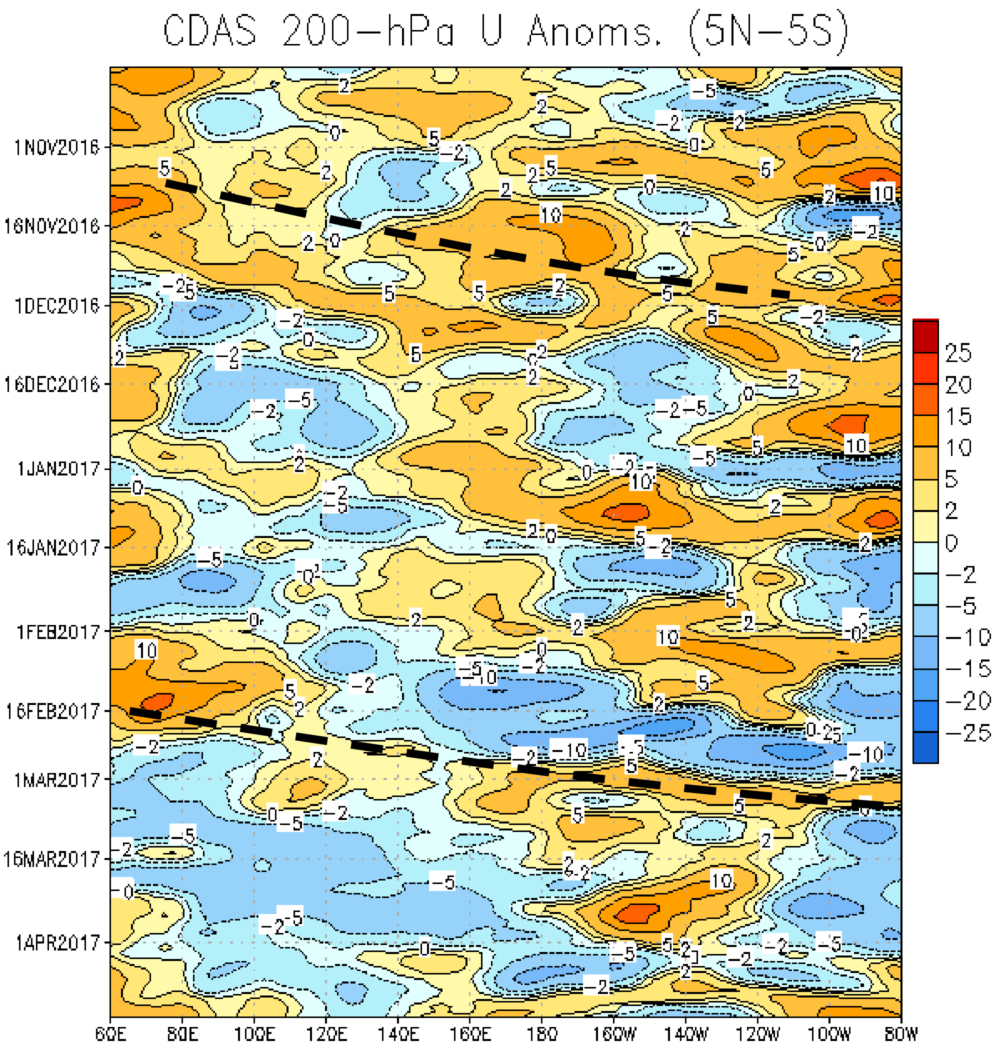
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

Upper-level convergence has shifted from near 140W to 170W in recent days, with divergence near 120E. Westerlies in the East Pacific over April have helped limit convection over coastal South America.

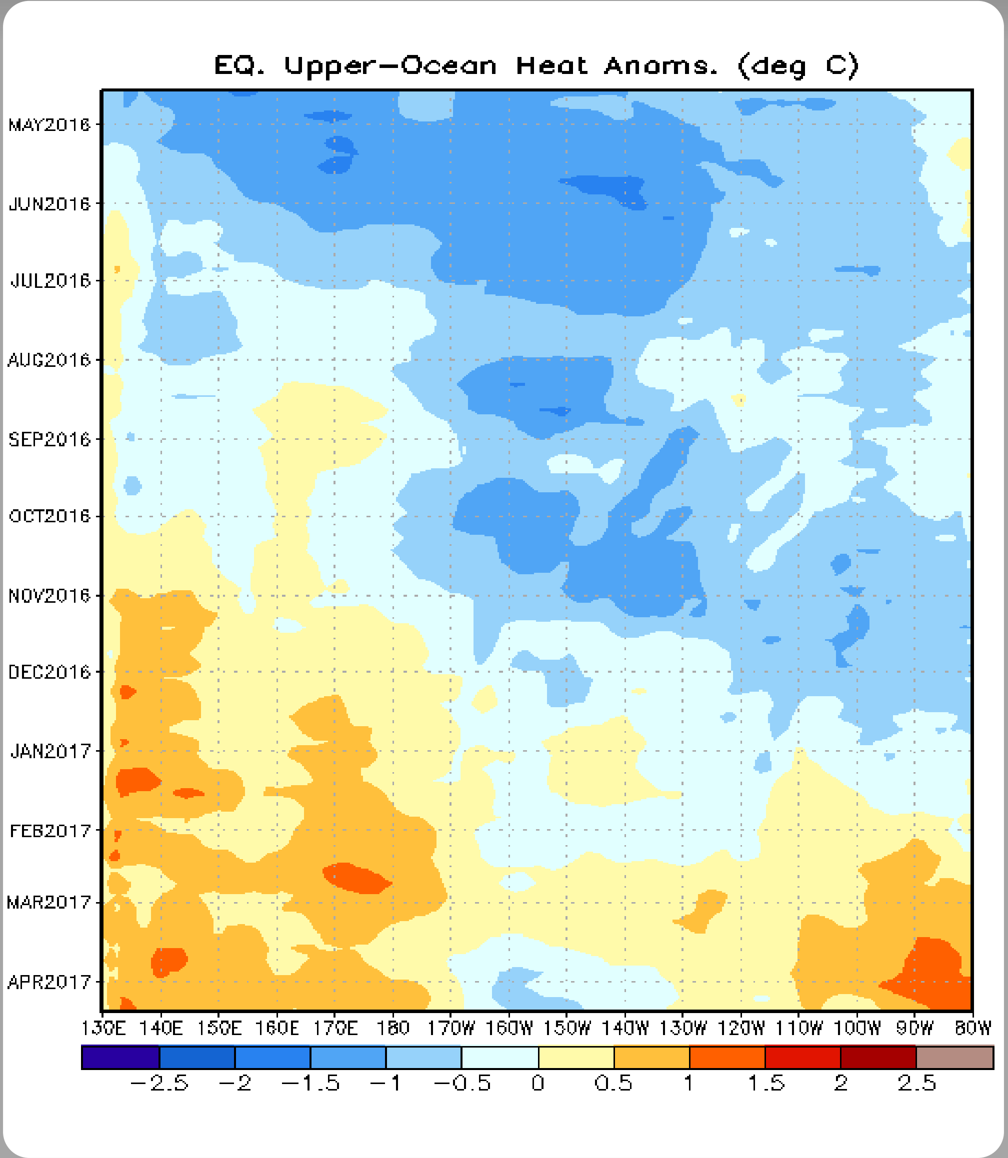


Weekly Heat Content Evolution in the Equatorial Pacific

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.

Negative anomalies have recently returned to the central Pacific while large positive anomalies continue offshore of South America.



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

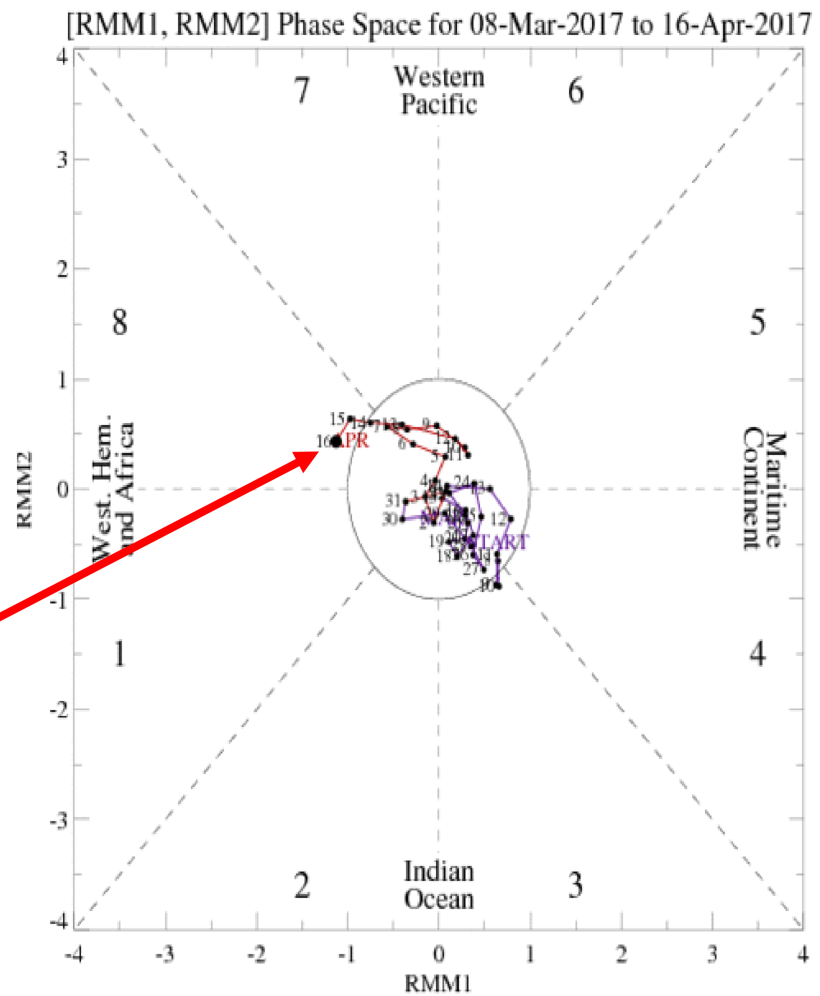
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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

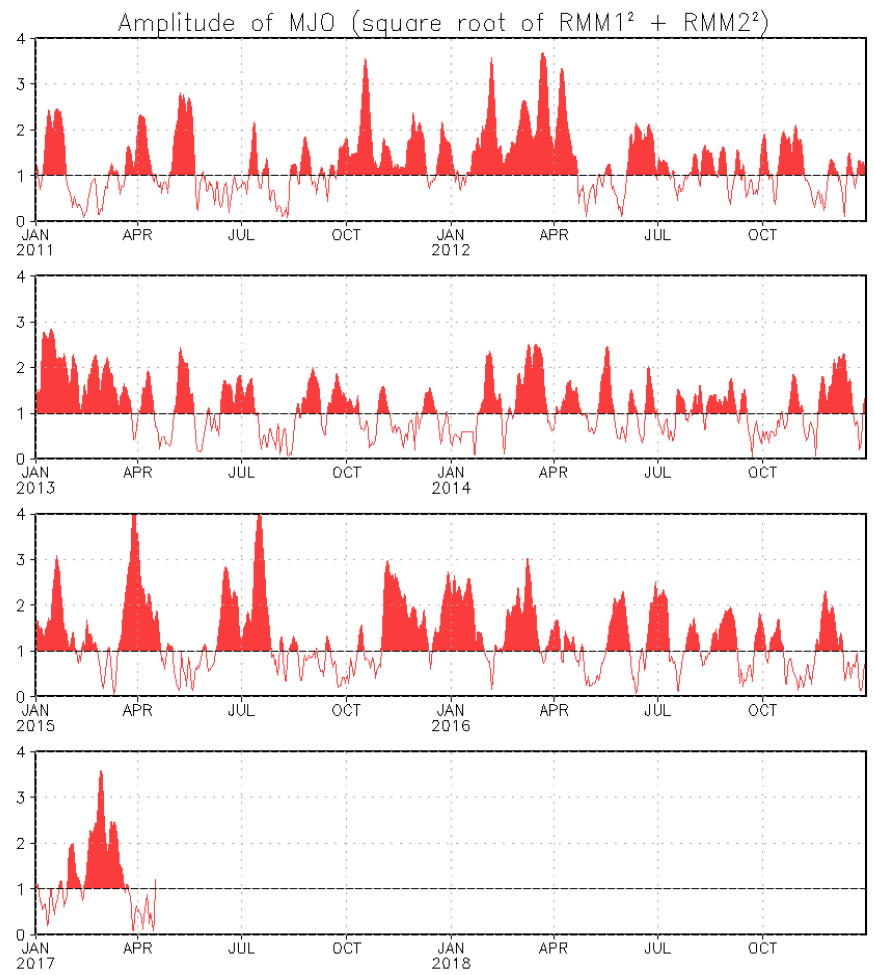


The amplitude of the RMM index increased with the signal emerging in Phase 8 in recent days.

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.



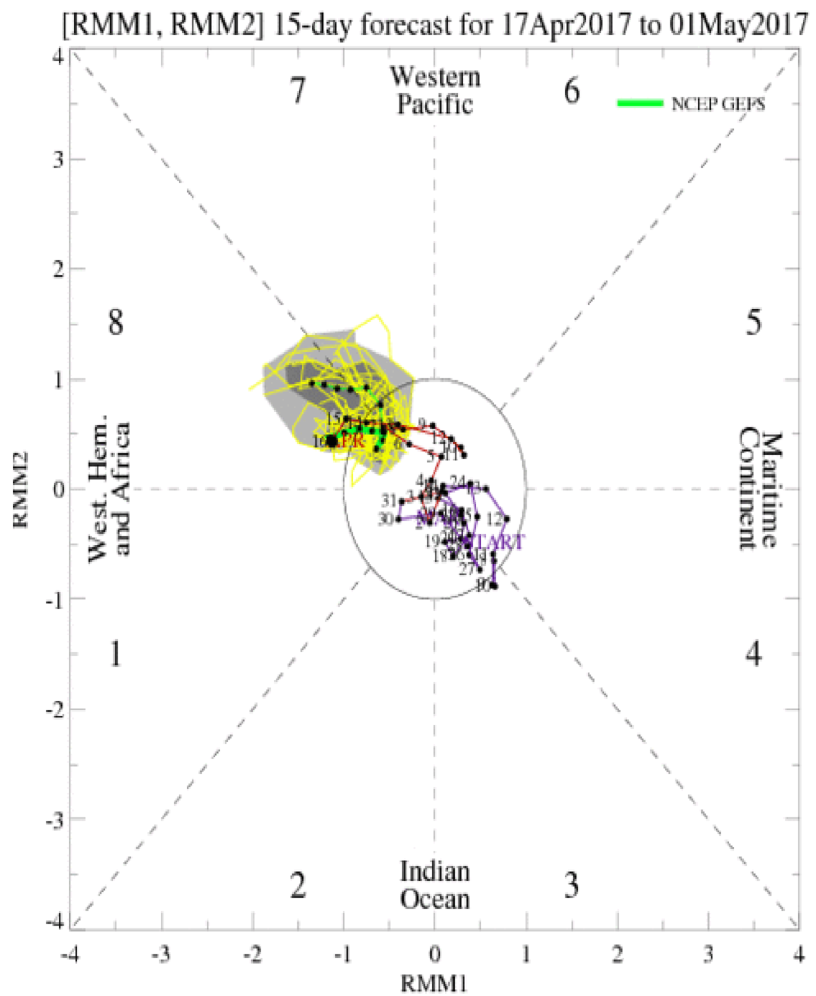
GFS Ensemble (GEFS) MJO Forecast

__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



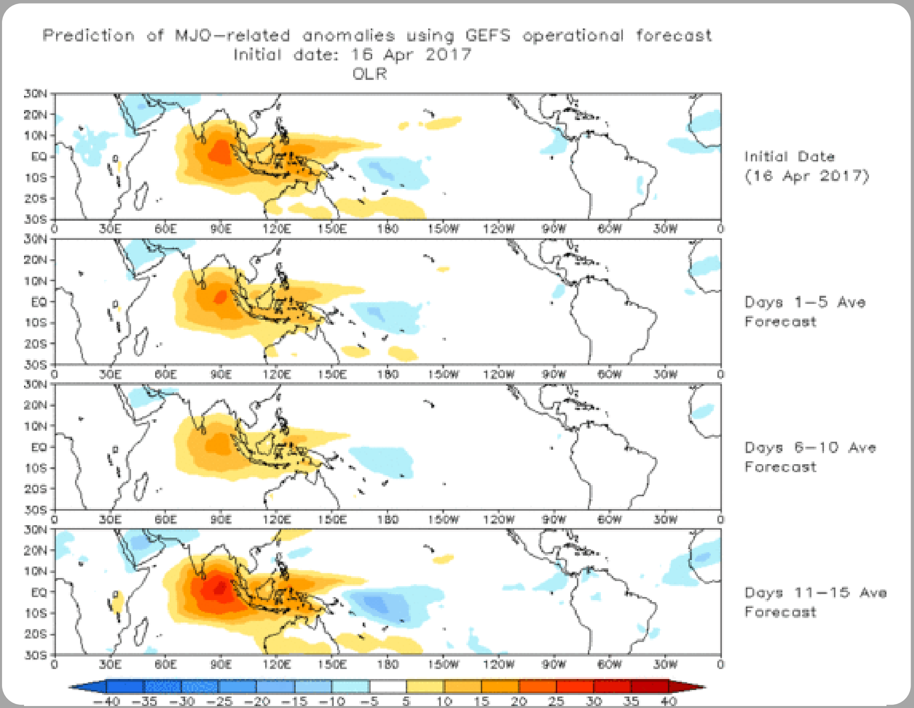
The GEFS depicts an amplifying MJO signal despite no indication of eastward propagation.

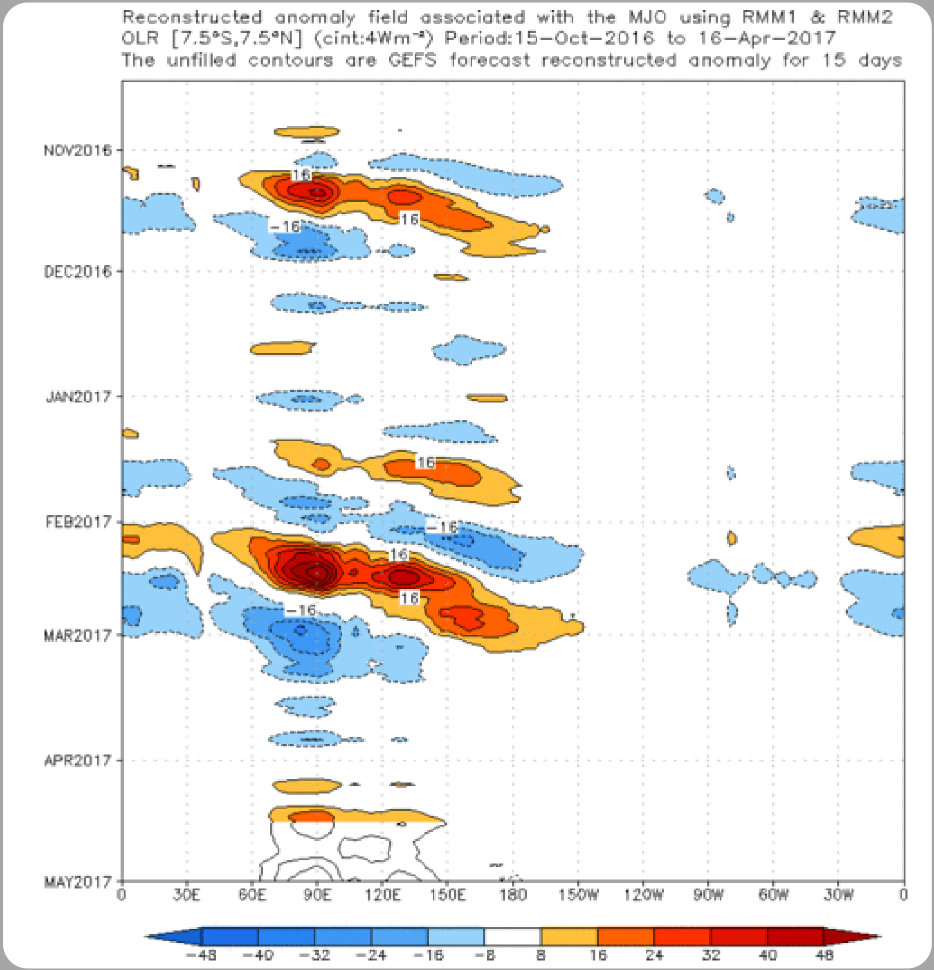
Ensemble GFS (GEFS) MJO Forecast

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



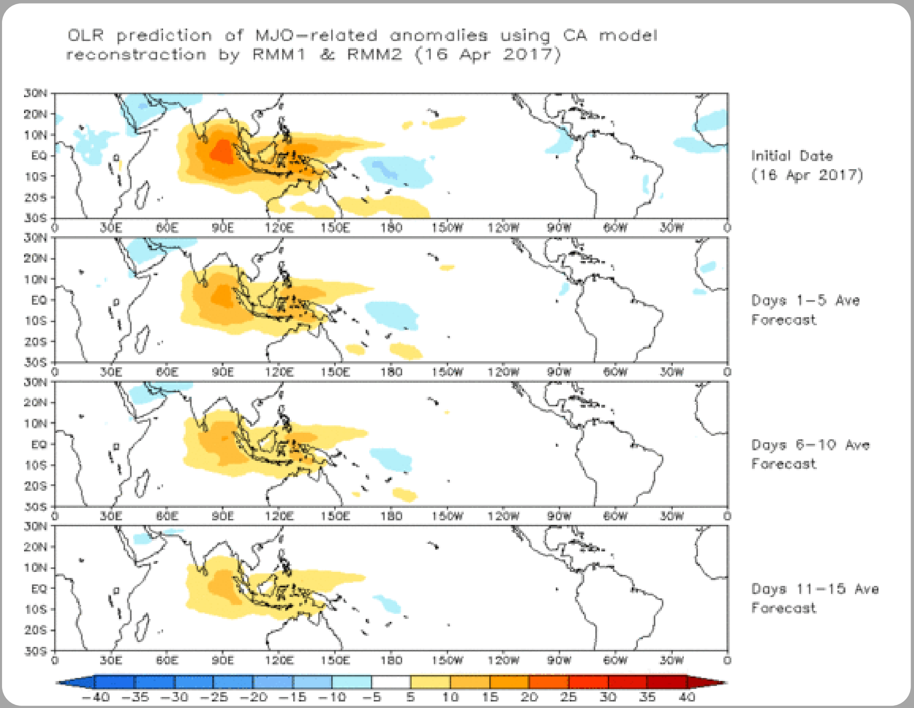


The GEFS forecast a stationary pattern to amplify over the next two weeks, with suppressed (enhanced) convection over the eastern Indian Ocean and Maritime Continent (east of New Guinea).

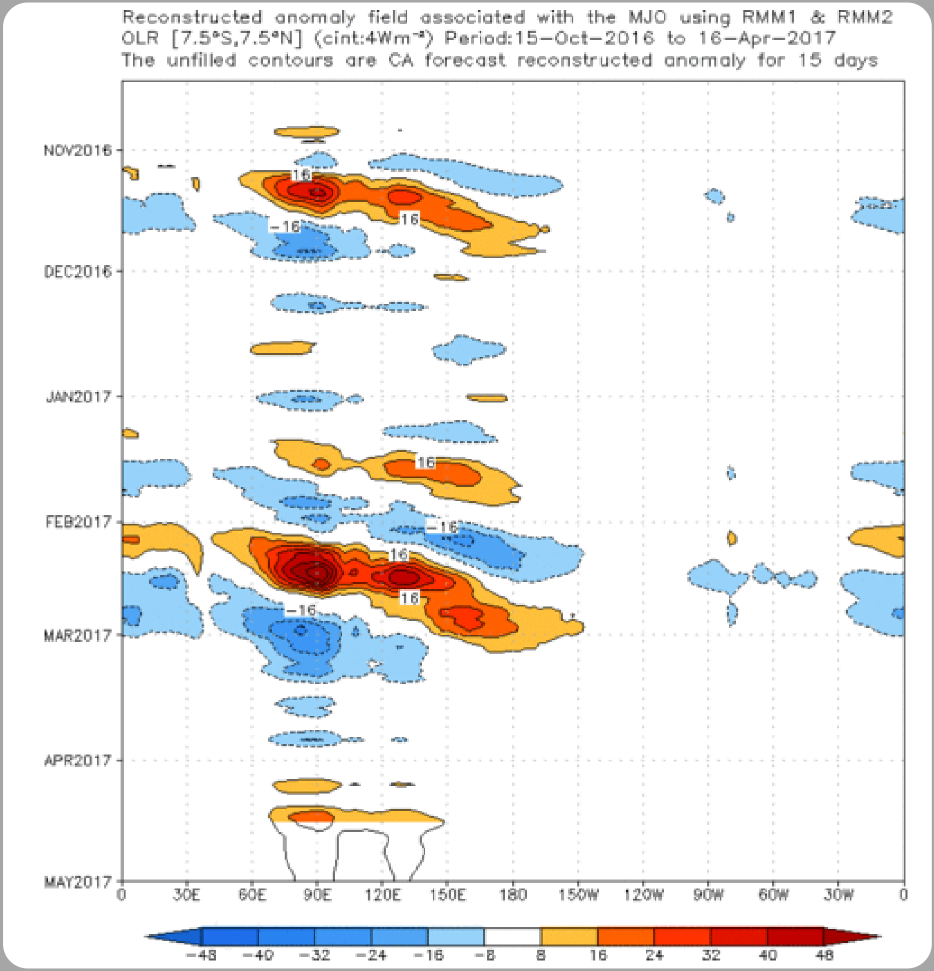
Constructed Analog (CA) MJO Forecast

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



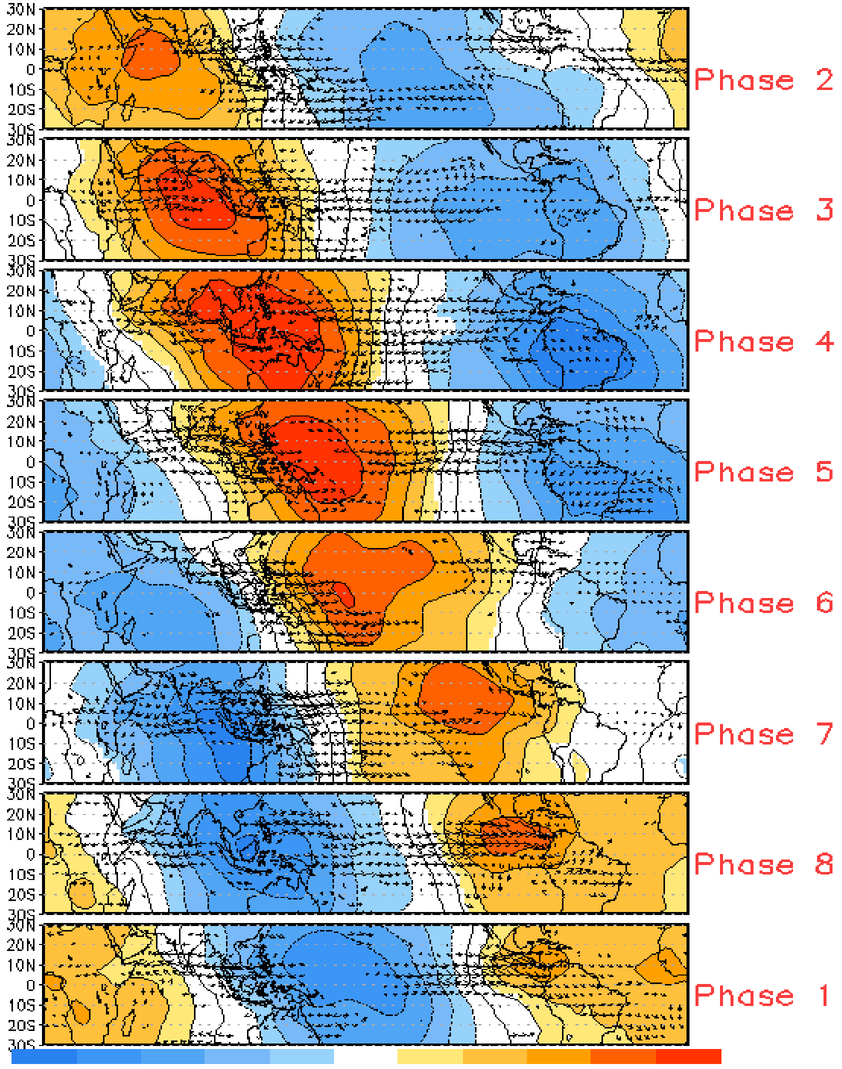
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



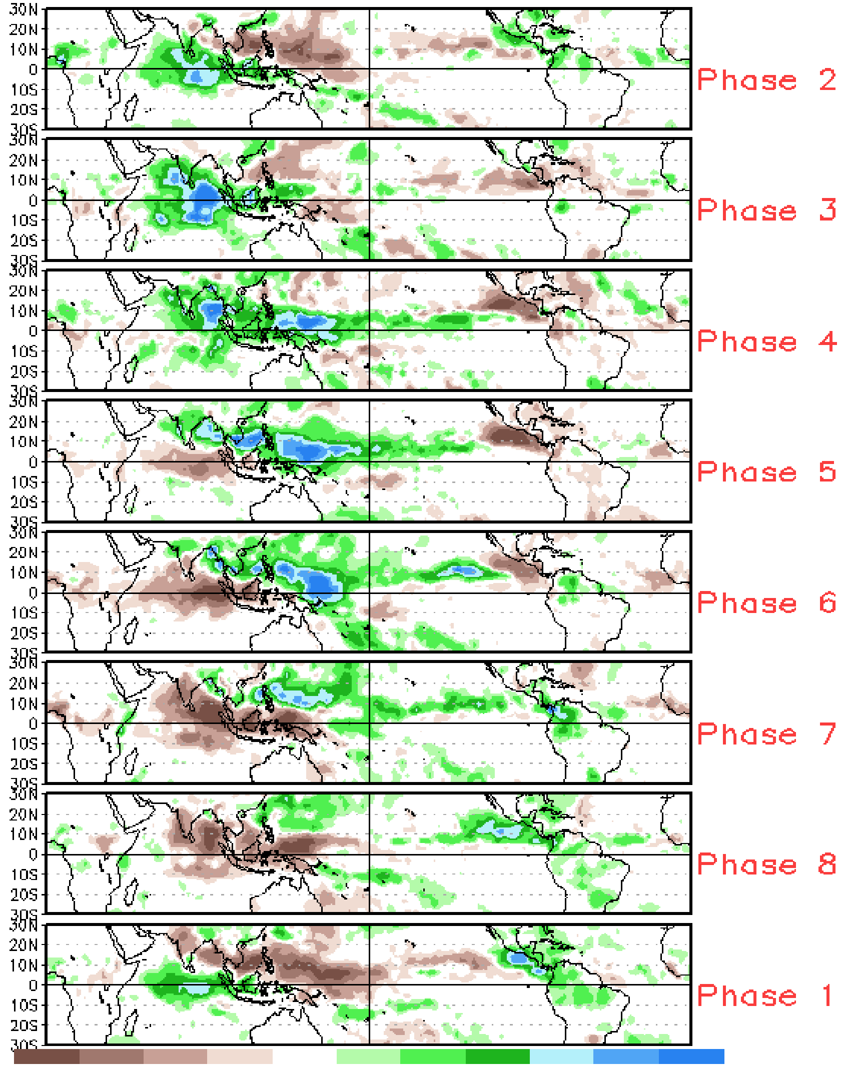
The statistical (Constructed Analog) RMM-based OLR anomaly prediction indicates a weakening pattern of suppressed (enhanced) convection over the eastern Indian Ocean and Maritime Continent (east of New Guinea).

MJO Composites - Global Tropics

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



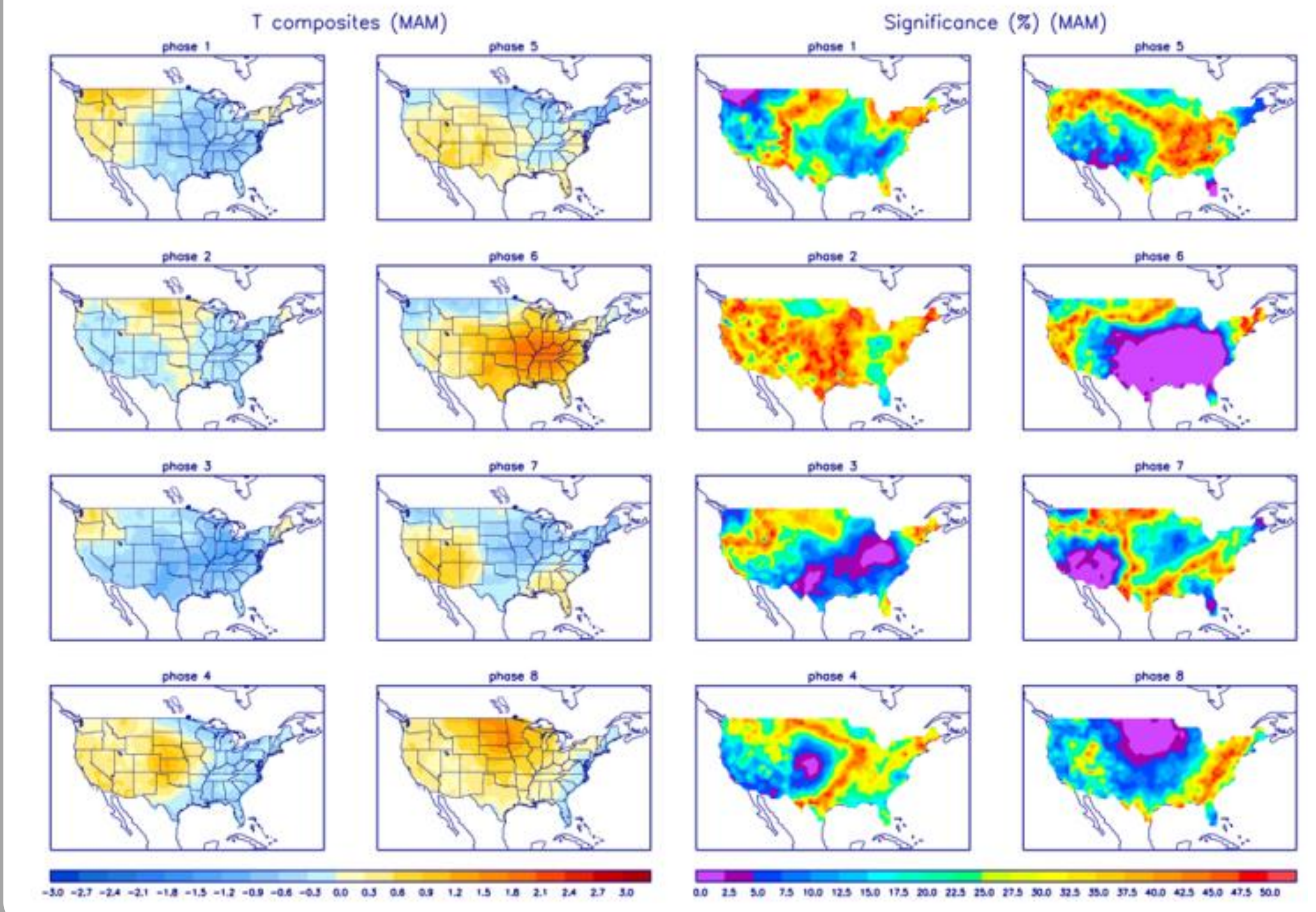
Precipitation Anomalies (Nov - Mar)



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.

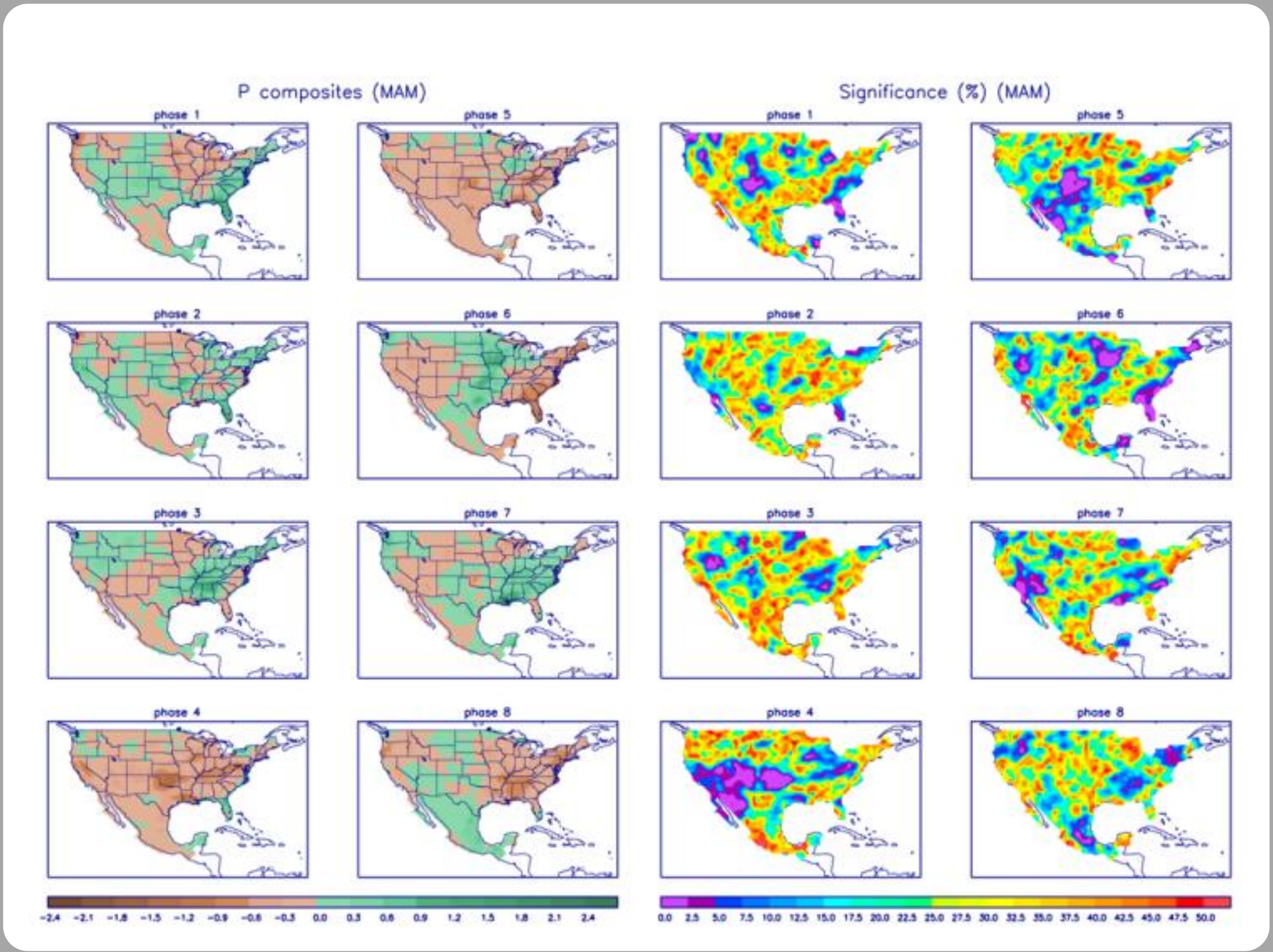
Right hand side plots show a measure of significance for the left hand side anomalies. Purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.



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.

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