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

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Climate Prediction Center / NCEP
13 March 2017

Outline

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Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The MJO weakened during the past week, as competing modes of tropical variability increasingly influenced the pattern.

- The MJO is destructively interfering with robust Rossby wave activity over the Maritime Continent and Indian Ocean. Any remnant MJO enhanced phase over the West Pacific is beginning to destructively interfere with the low frequency base state.

- Dynamical model RMM index forecasts generally depict a weak MJO signal during the next two weeks. The GFS guidance develops a weak intraseasonal signal over the Indian Ocean during Week-2, but the ECMWF shows no signal.

- Based on recent observations and the dynamical model guidance, the MJO is not anticipated to play a major role in the evolution of the global tropical convective pattern during the next two weeks.

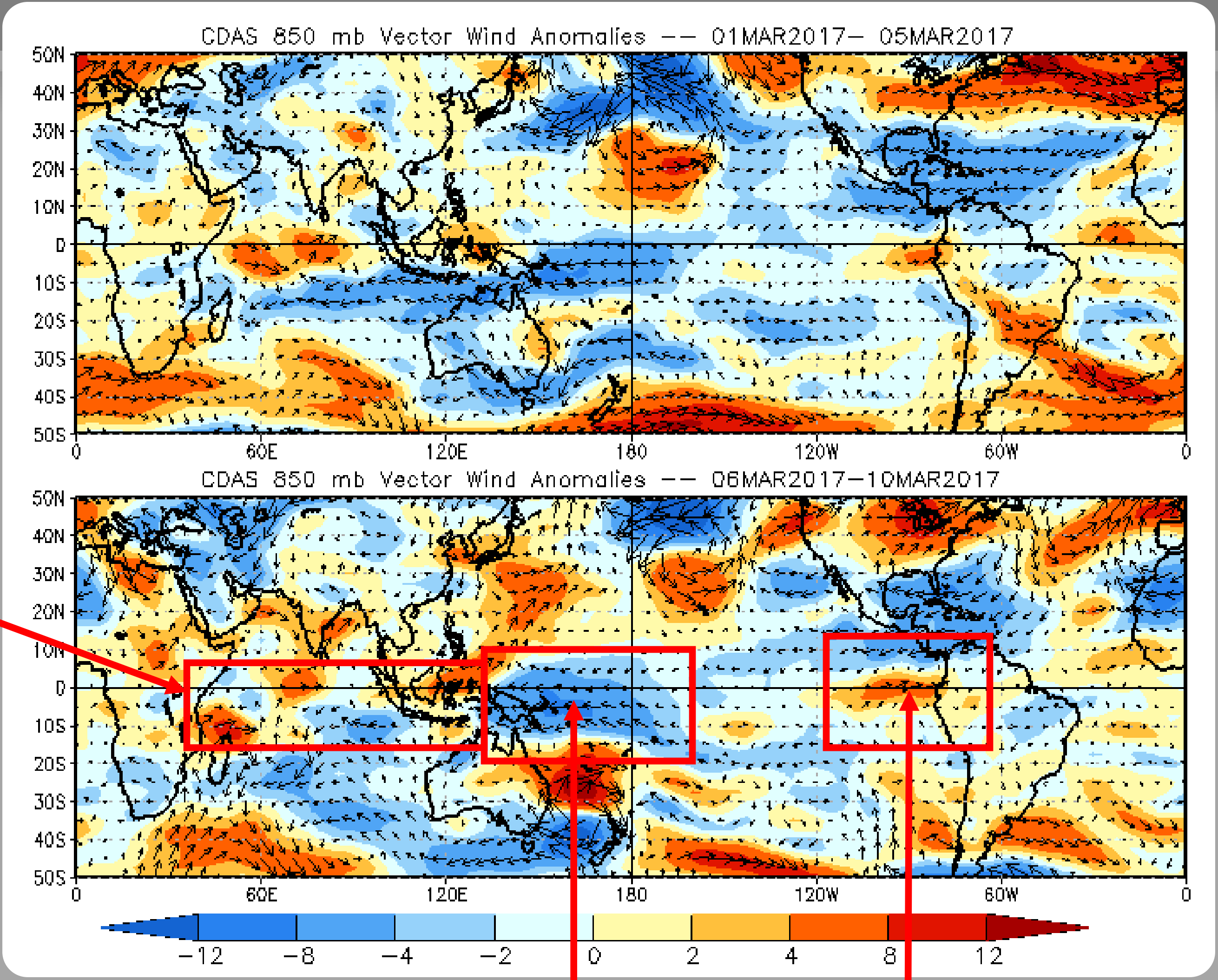
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Low-level wind anomalies, partly influenced by tropical cyclone activity, presented a disorganized pattern over the Indian Ocean.

A small area of westerly anomalies persisted over the western Maritime Continent.

Easterly anomalies persisted over the eastern Maritime Continent and West Pacific.

Westerly anomalies persisted over the far East Pacific.

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

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

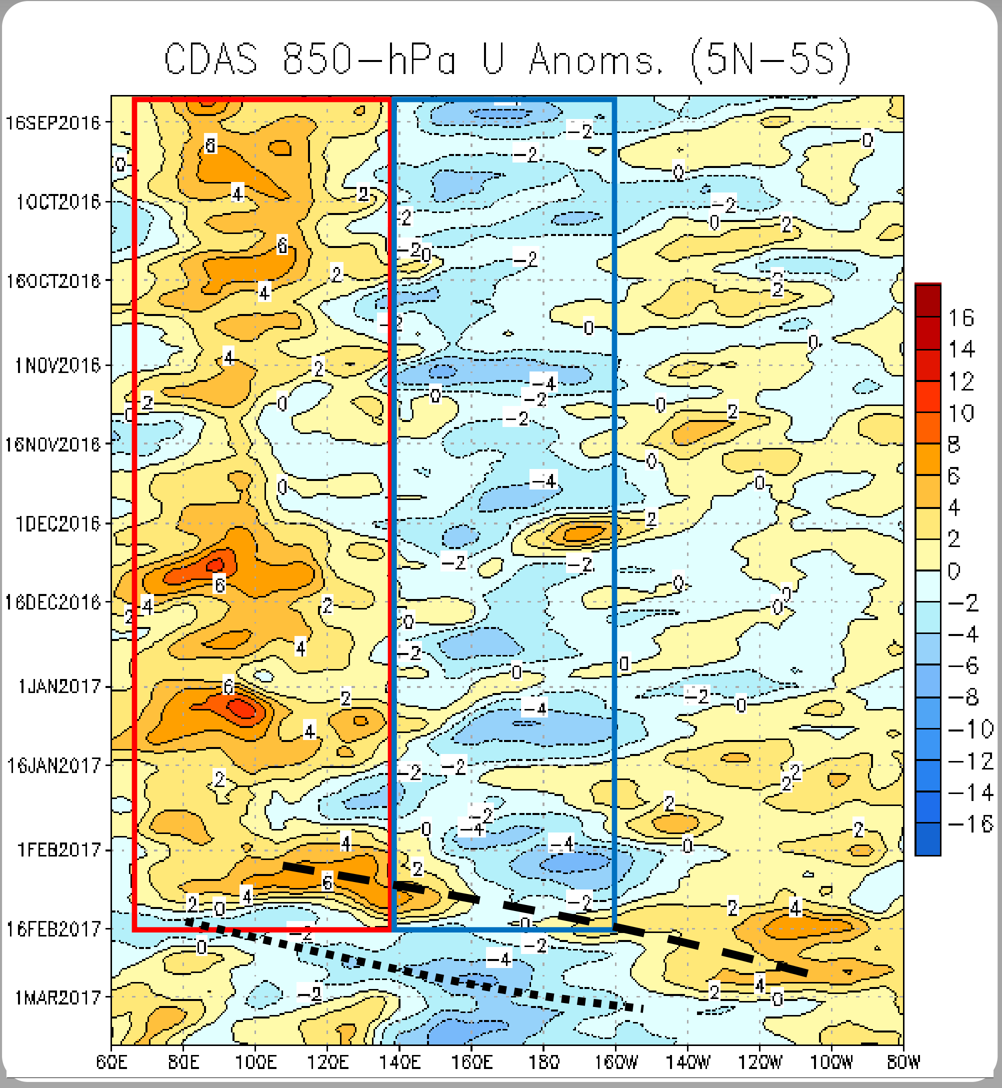
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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 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.

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

More recently, other modes interfered with the intraseasonal signal. Westward moving features are evident over the West Pacific and Maritime Continent.



OLR Anomalies - Past 30 days

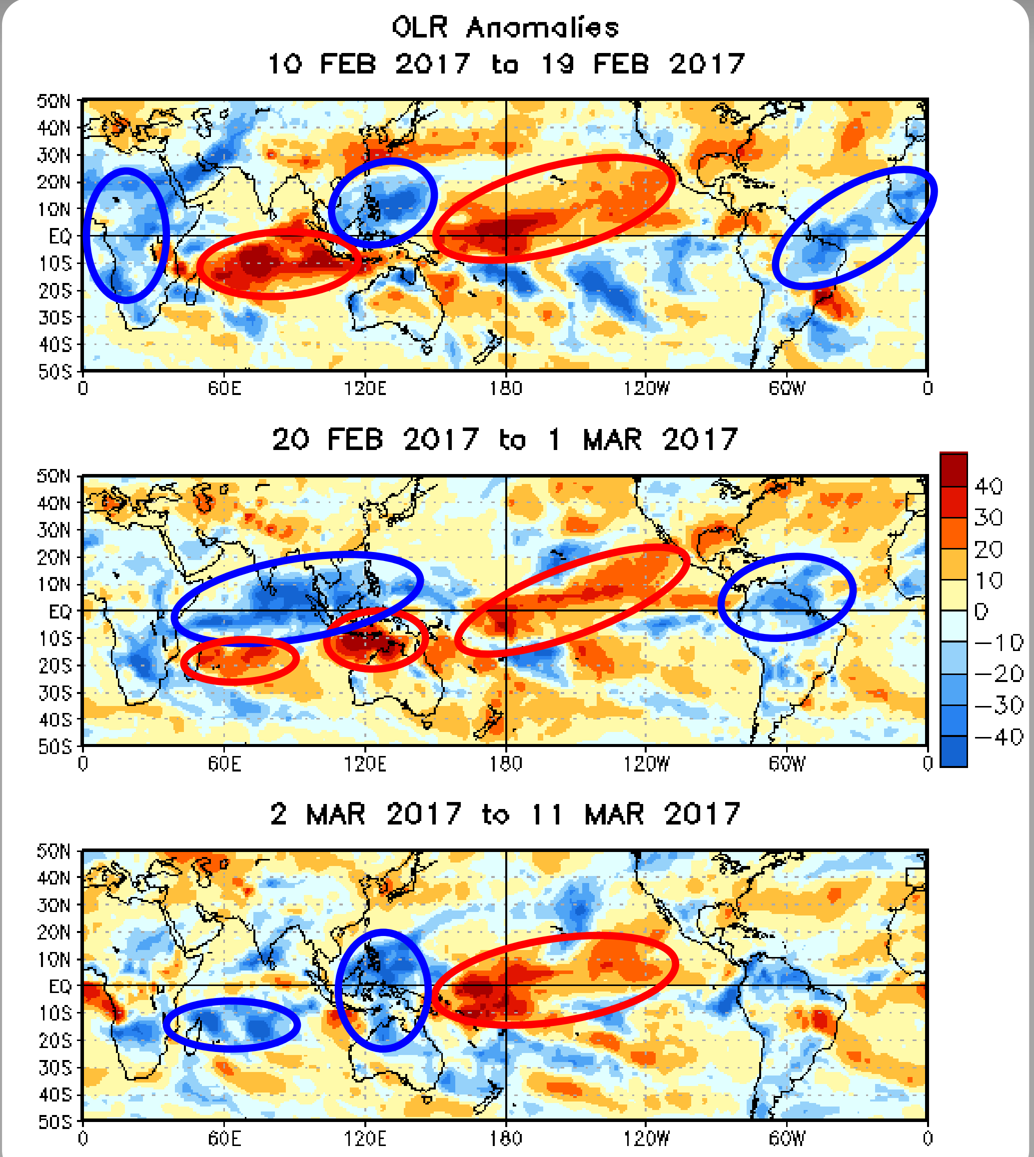
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid-February, enhanced (suppressed) convection was observed over the tropical Atlantic basin, South America, and Africa (Indian Ocean and Pacific), consistent with the MJO. Enhanced convection persisted over the northwestern Pacific.

As the intraseasonal signal returned to the Indian Ocean in late February, enhanced convection overspread the northern and equatorial Indian Ocean and interacted with a westward moving feature over the Maritime Continent.

During early March, tropical cyclone activity was evident over the southern Indian Ocean. Influence from Rossby wave activity and the remnant low frequency signal became increasingly apparent, resulting in a weakening intraseasonal signal.



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

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

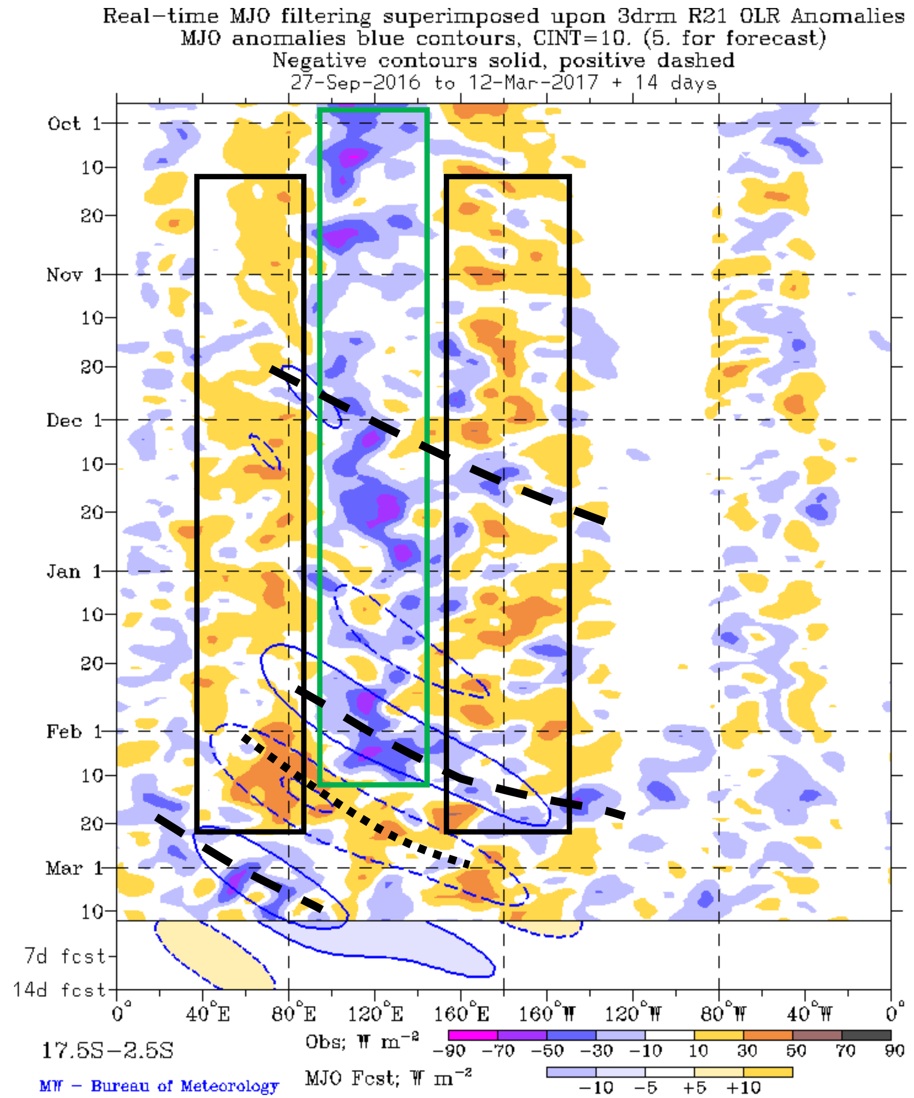
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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).

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

Since late January, an active MJO pattern became the dominant mode of intraseaonal tropical convective variability, with the suppressed phase reversing the low frequency enhanced convective signal over the Maritime Continent in late February.

More recently, the MJO signal weakened, with other modes, including tropical cyclones, evident in the OLR field.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

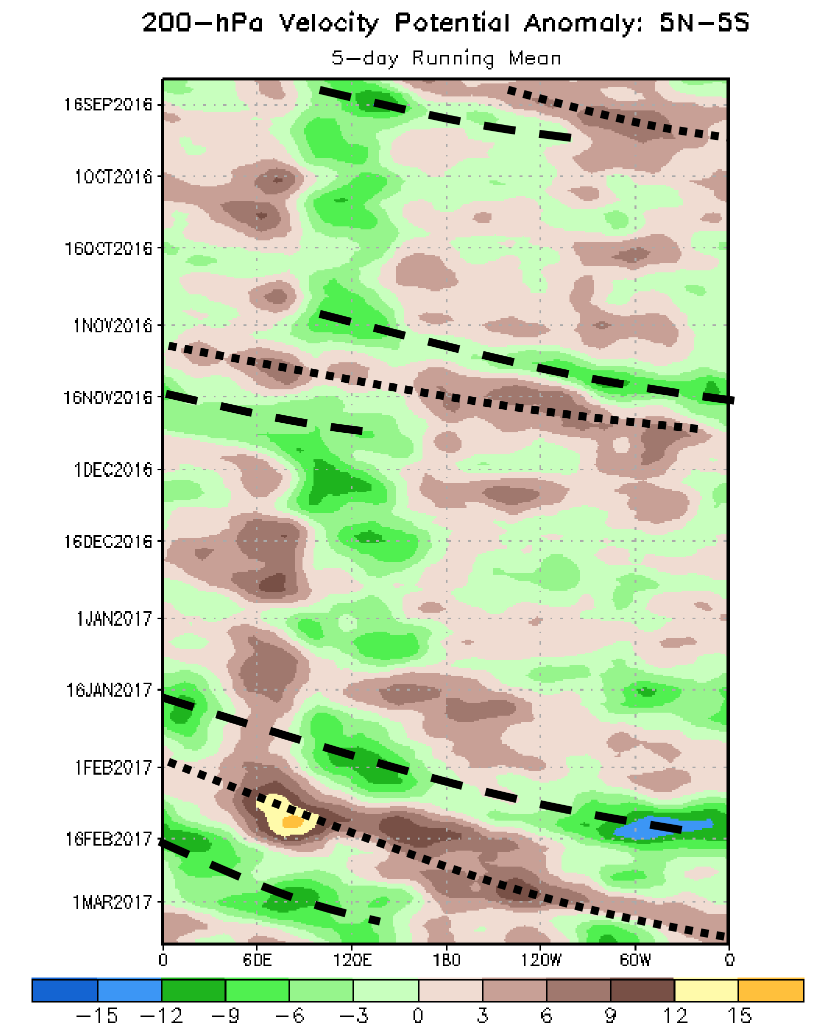
Negative anomalies (green shading) indicate favorable conditions for precipitation

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

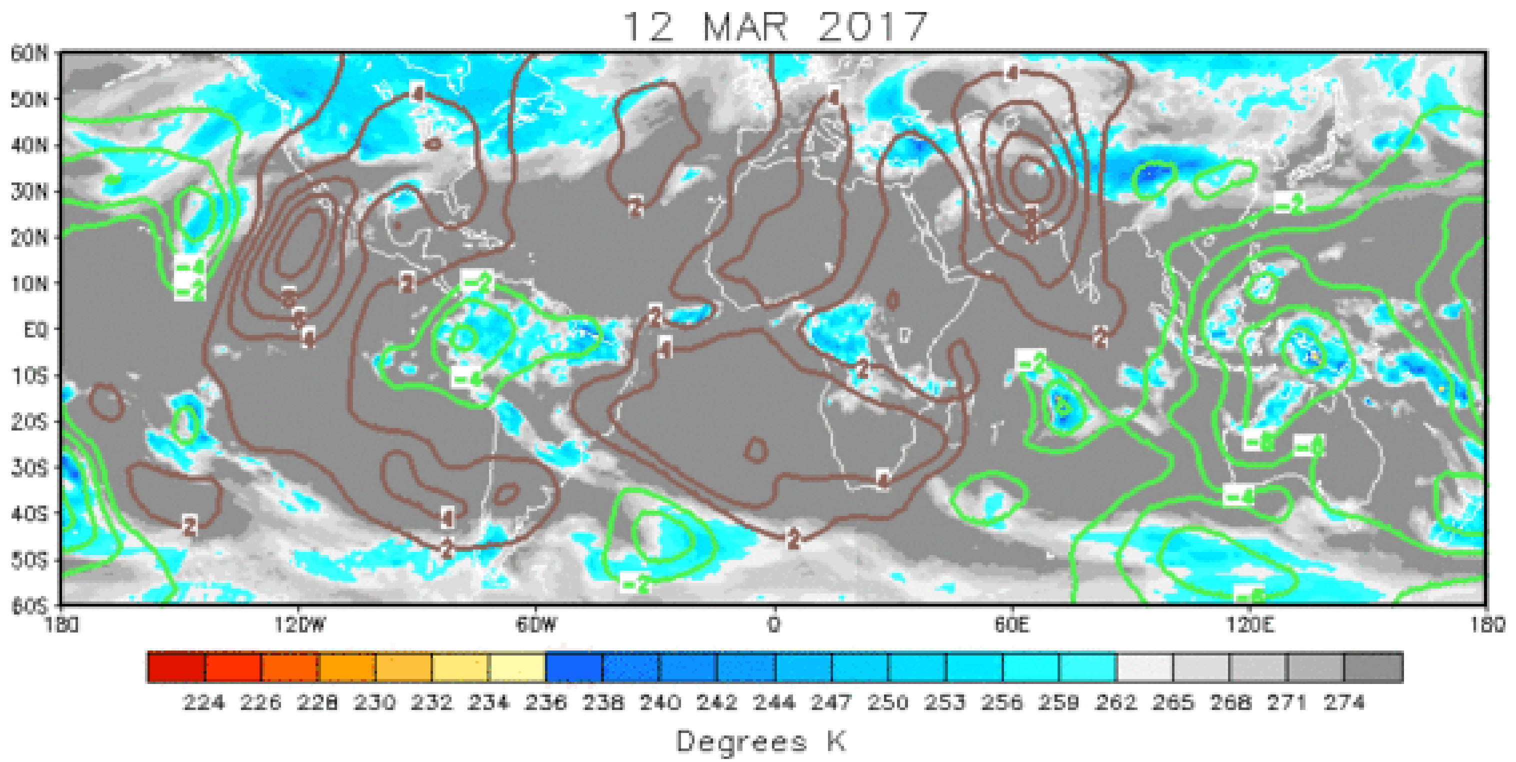
During November, eastward propagation was observed consistent with MJO activity on the fast end of the intraseasonal spectrum.

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

There have been alternating periods of constructive and destructive interference between the MJO and the low frequency state. Most recently, the remnant intraseasonal signal has begun destructively interfering with the base state over the central Pacific.



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



A remnant intraseasonal signal is still evident, with an enhanced (suppressed) convective envelope evident over the Maritime Continent (broadly speaking, the Western Hemisphere). The intraseasonal signal is competing with the base state suppressed signal over the central Pacific, and low frequency enhanced convection over the far East Pacific.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

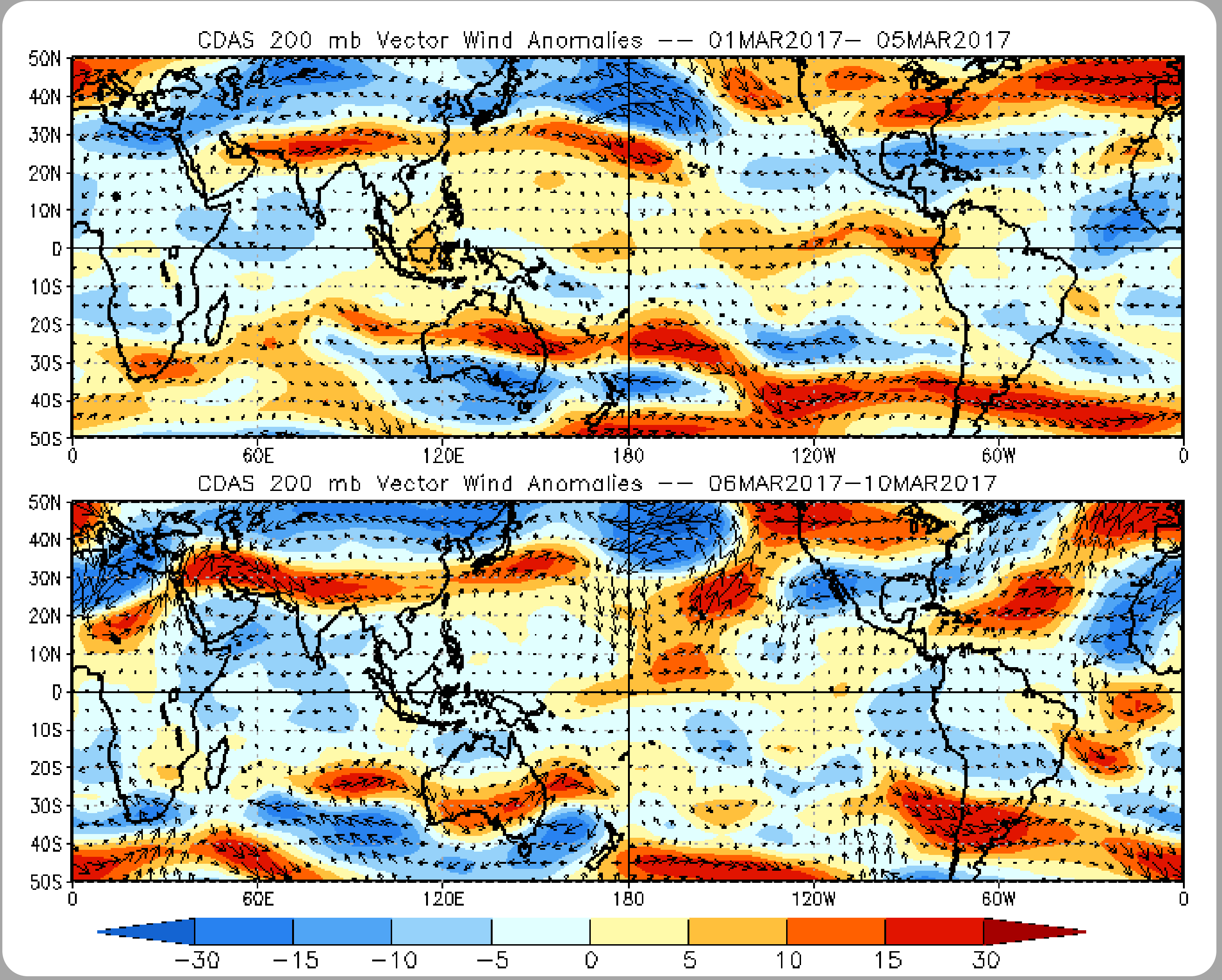
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

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

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



Zonal wind anomalies weakened over the East Pacific.

Anomalous cyclonic circulation moved southward over the central North Pacific.

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

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

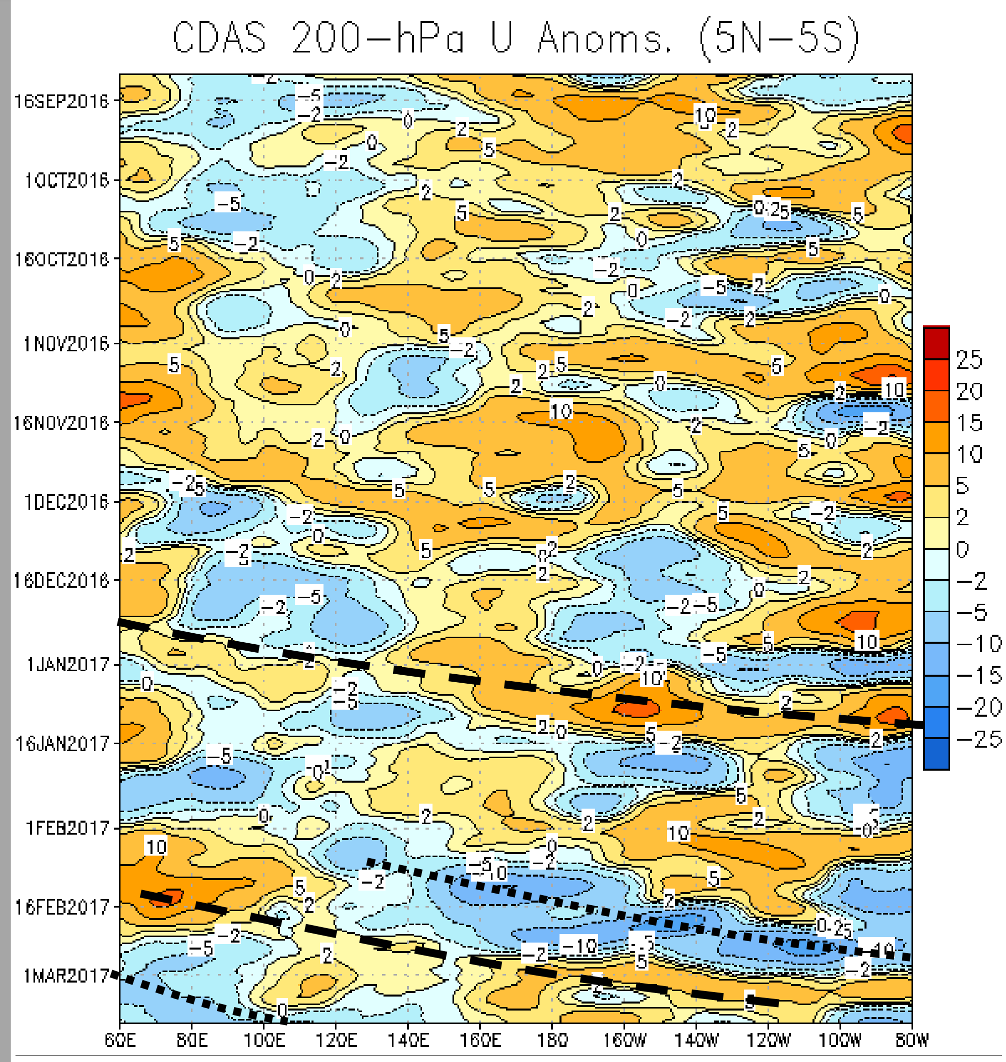
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

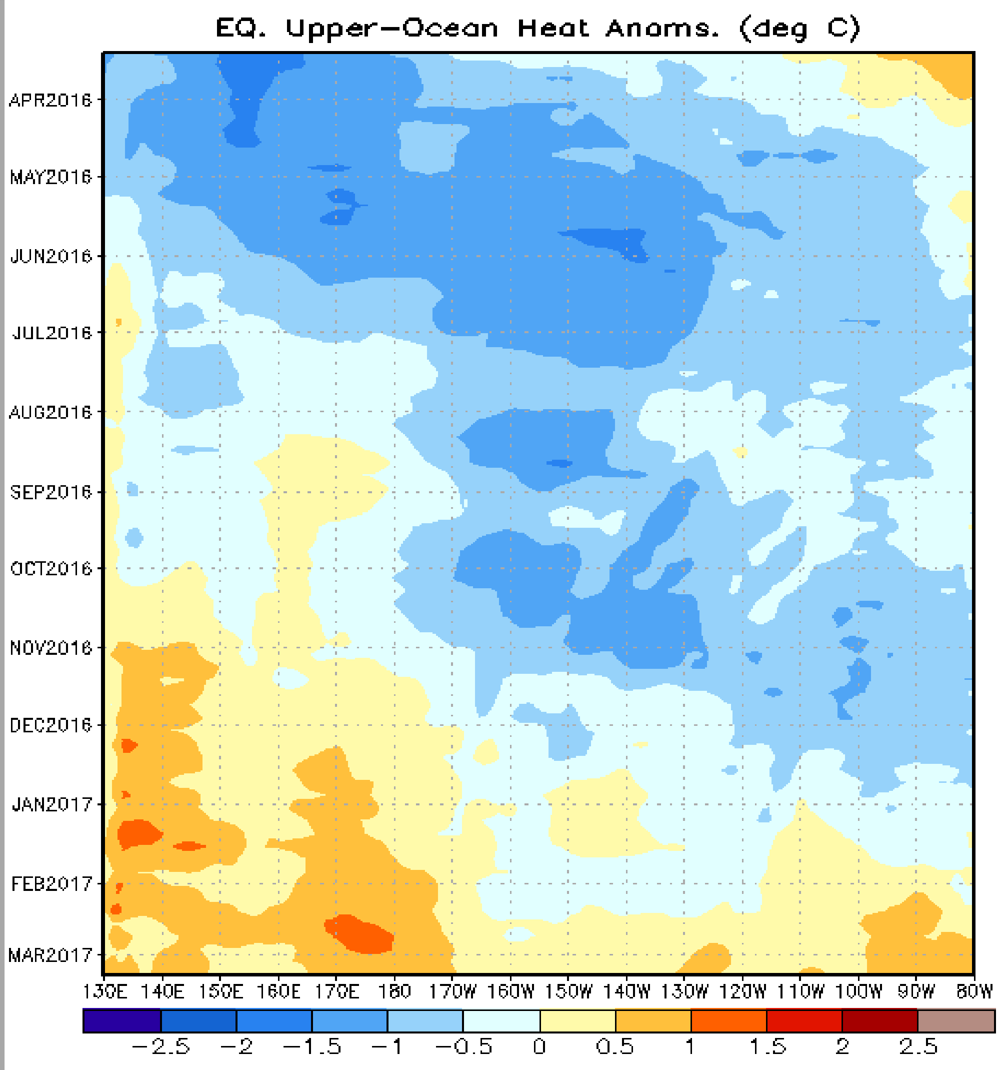


Weekly Heat Content Evolution in the Equatorial Pacific

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. 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

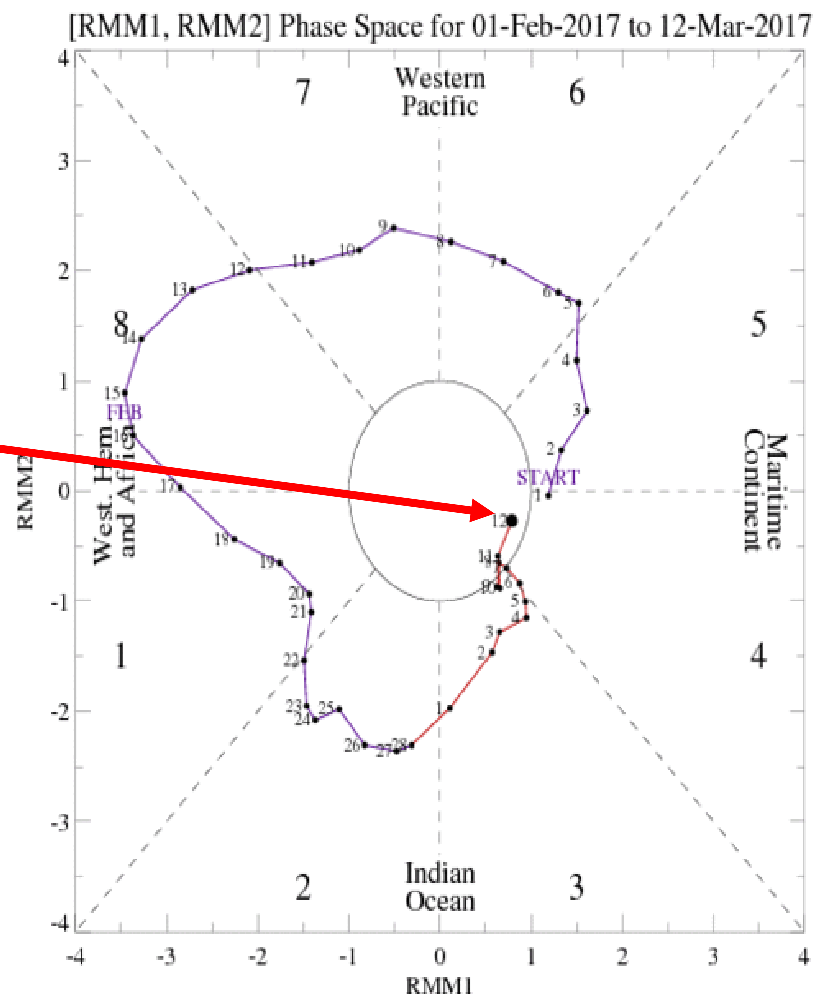
The triangular areas indicate the location of the enhanced phase of the MJO

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

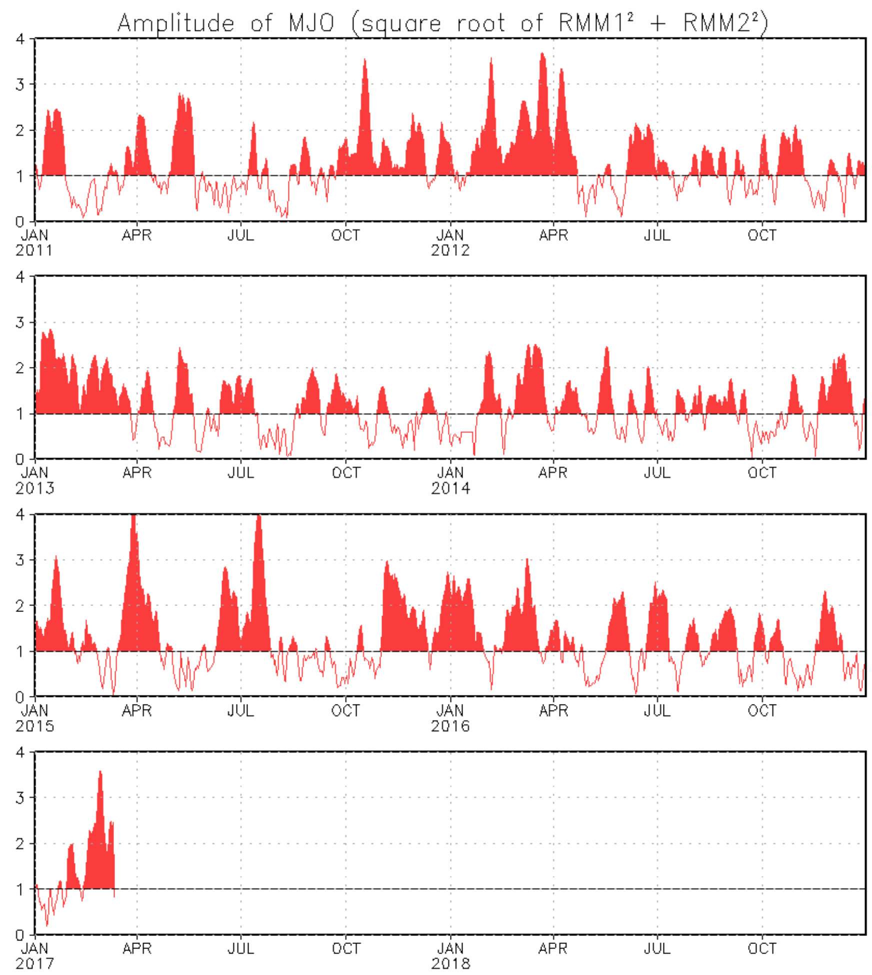
During the past week, the MJO index weakened.



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

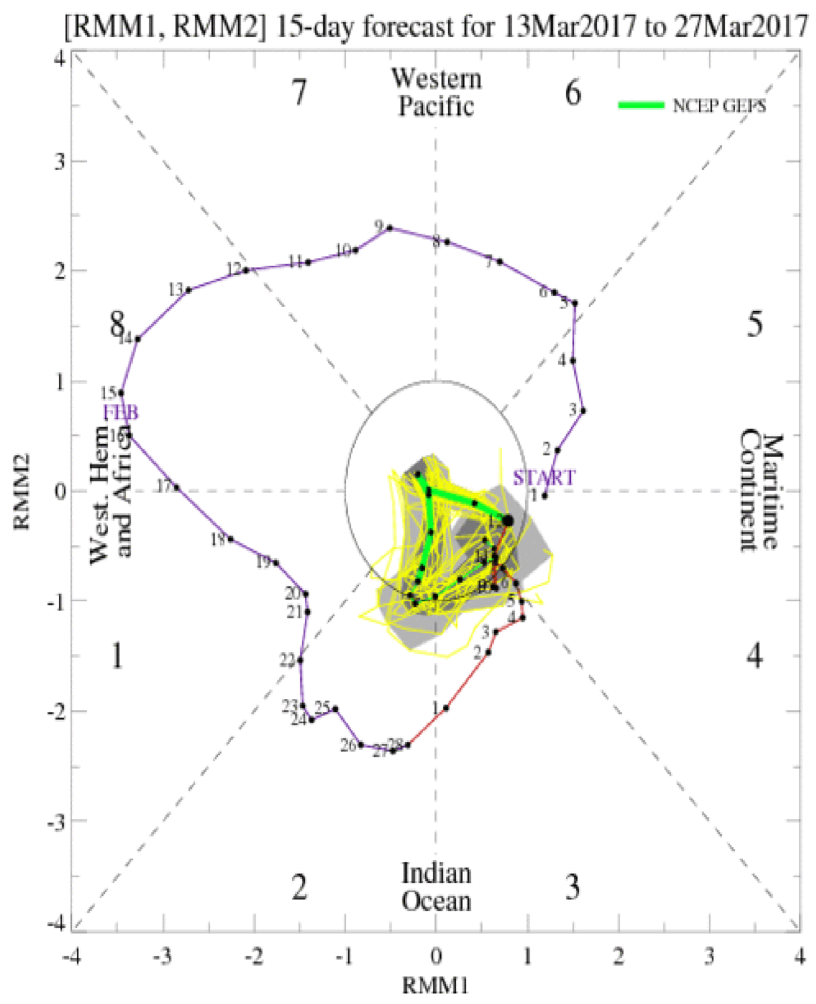
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

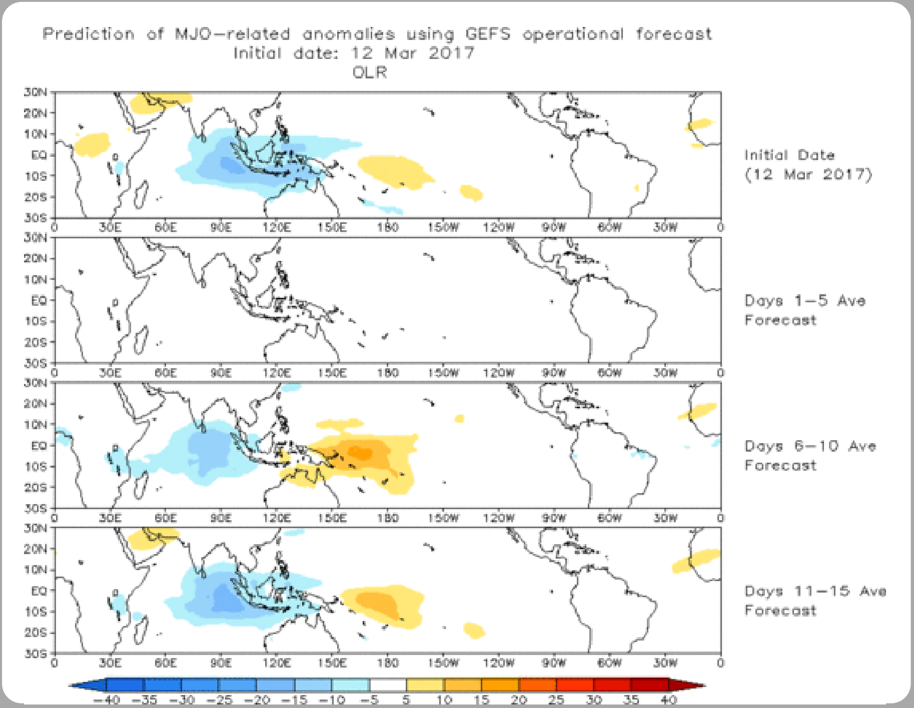
The GEFS depicts a weak MJO signal during Week-1, with the potential emergence of a weak eastward propagating signal over the Indian Ocean during Week-2.



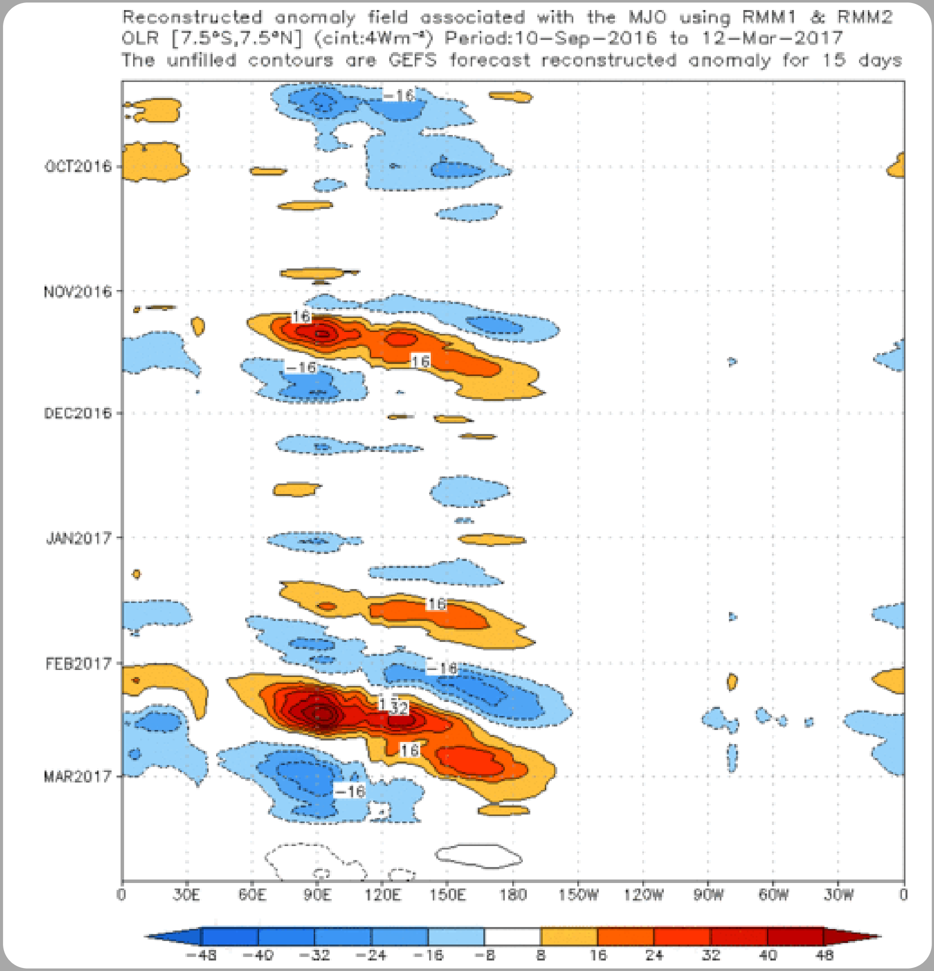
Ensemble GFS (GEFS) MJO Forecast

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

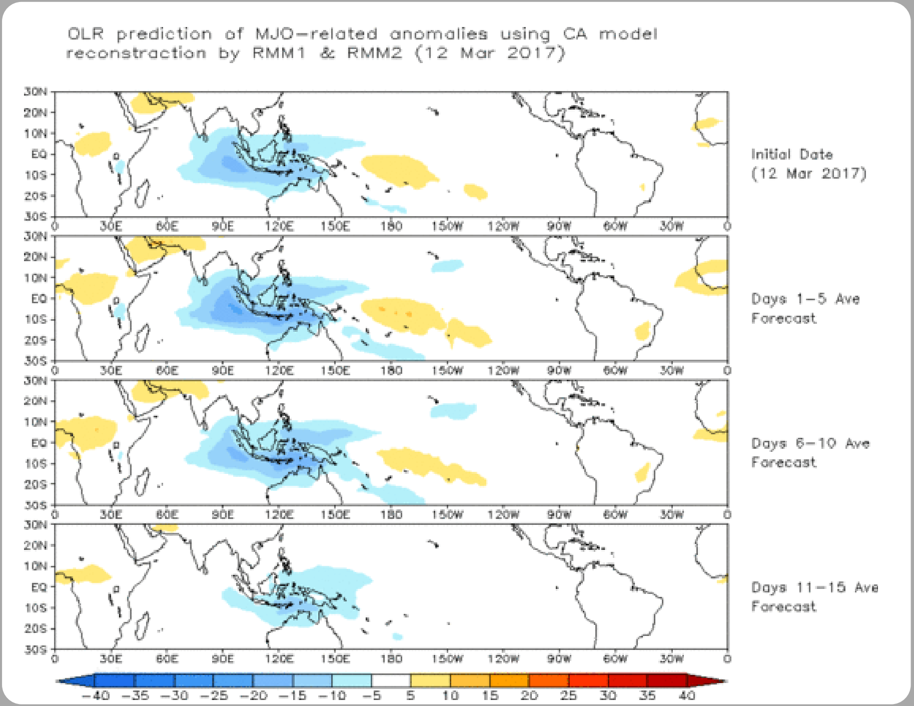


The GEFS prediction for RMM Index-based OLR anomalies over the next two weeks shows a weak anomaly pattern early in the period, with a low-amplitude Indian Ocean event during Week-2.

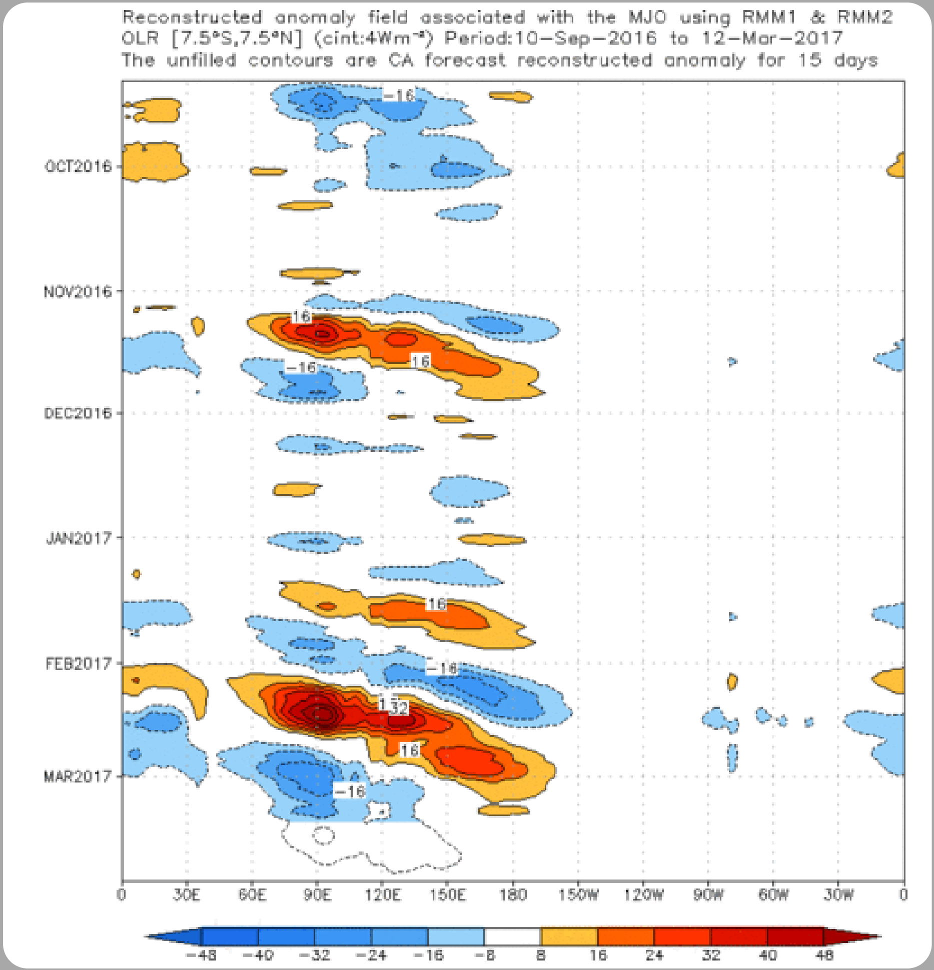
Constructed Analog (CA) MJO Forecast

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



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

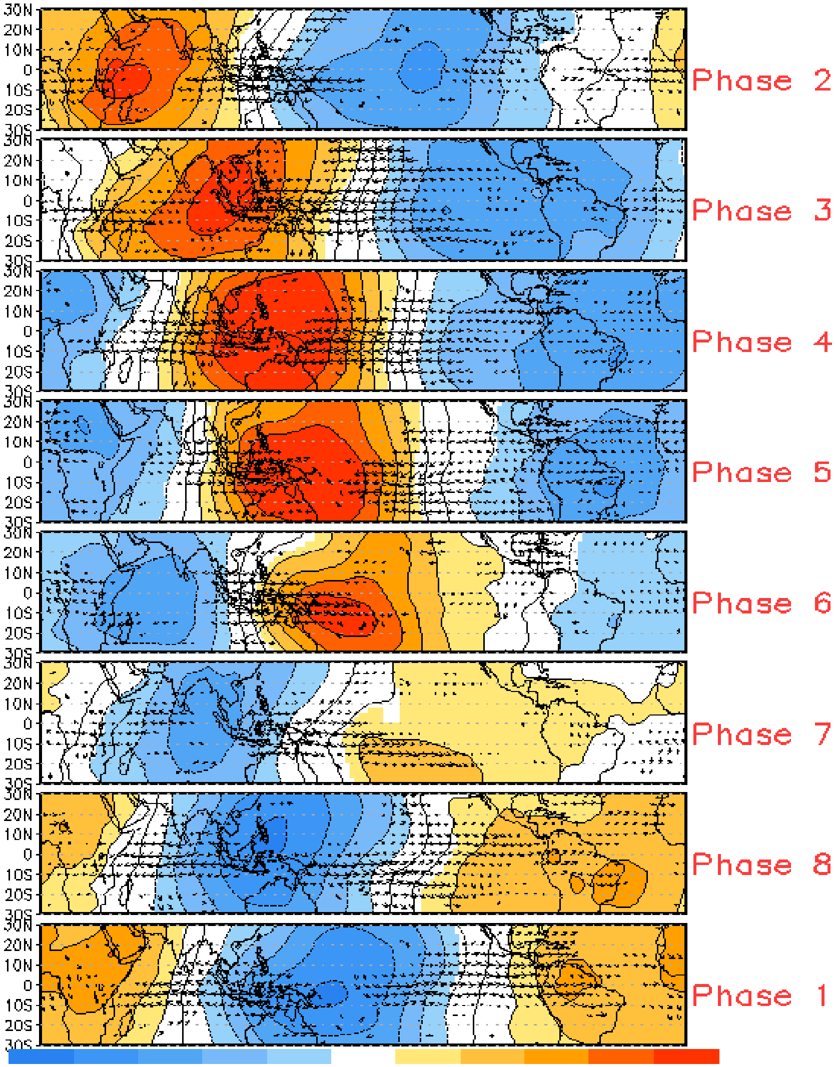


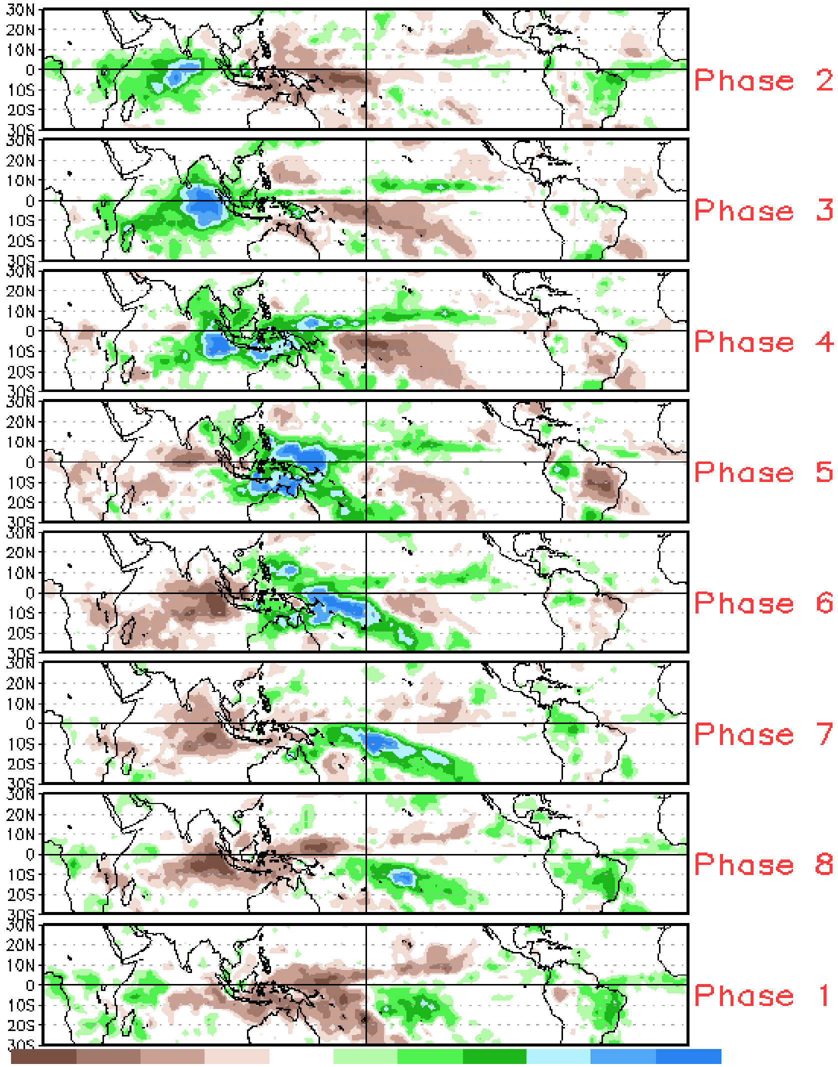
The statistical (Constructed Analog) RMM-based OLR anomaly prediction shows slow eastward propagation of an MJO signal at decreasing amplitude.

MJO Composites - Global Tropics

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

Precipitation Anomalies (Nov - Mar)

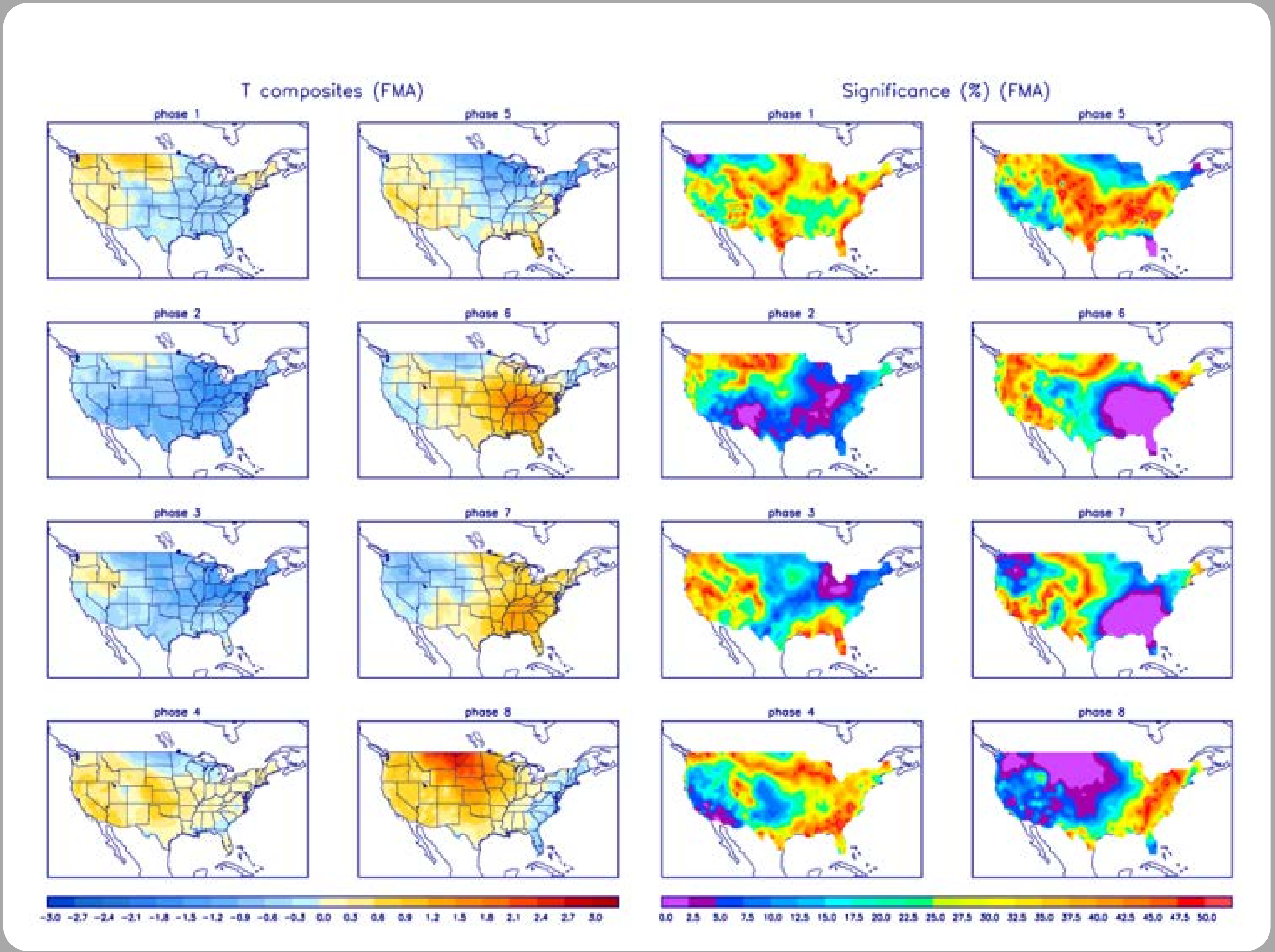




U.S. MJO Composites – Temperature

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.

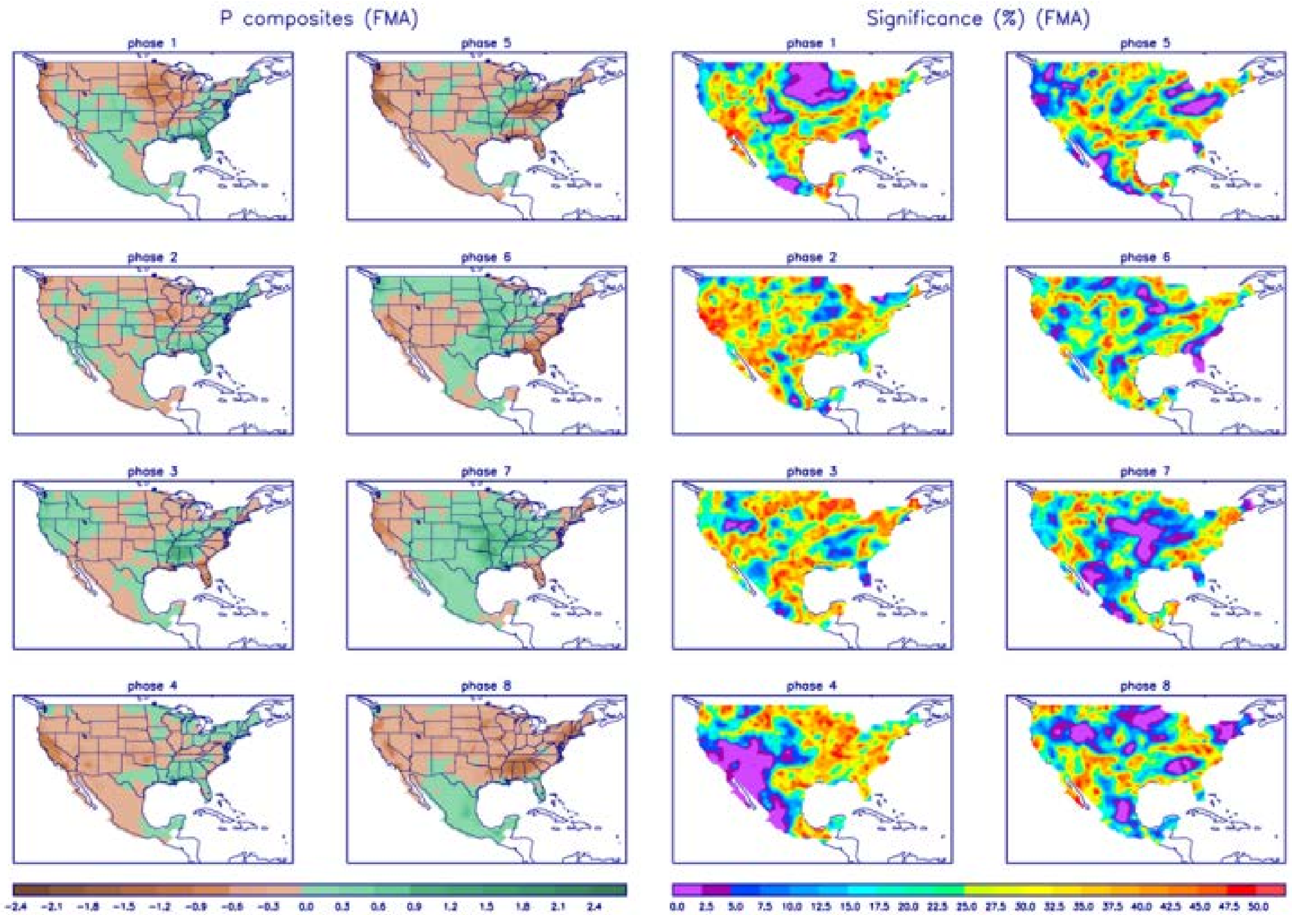
Right hand side plots show a measure of significance for the left hand side anomalies. Purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.



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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