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

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Climate Prediction Center / NCEP
22 May 2017

Outline

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Recent Evolution and Current Conditions

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MJO Index Forecasts

MJO Composites

Overview

- Both RMM-based and CPC velocity potential-based MJO indices indicate the continuation of a weak subseasonal signal, and some eastward propagation.

- Most dynamical models predict that other tropical variability will obscure the MJO signal over the next week. Some dynamical models redevelop an eastward-moving convective signal over the Indian Ocean during Week-2, with a few models taking the intraseasonal signal across the Maritime Continent.

- The continued propagation of the MJO across toward the Maritime Continent is favored in this week's outlook, with the MJO playing a role in the overall pattern of tropical convection. Other modes of variability are also likely to influence the pattern over the Maritime Continent and Indian Ocean.

- During the end of Week-1 and the start of Week-2, the MJO may play a role in making conditions favorable for tropical cyclogenesis over the Bay of Bengal. During Week-2, the convective signal from the MJO may be centered just east of the Maritime Continent.

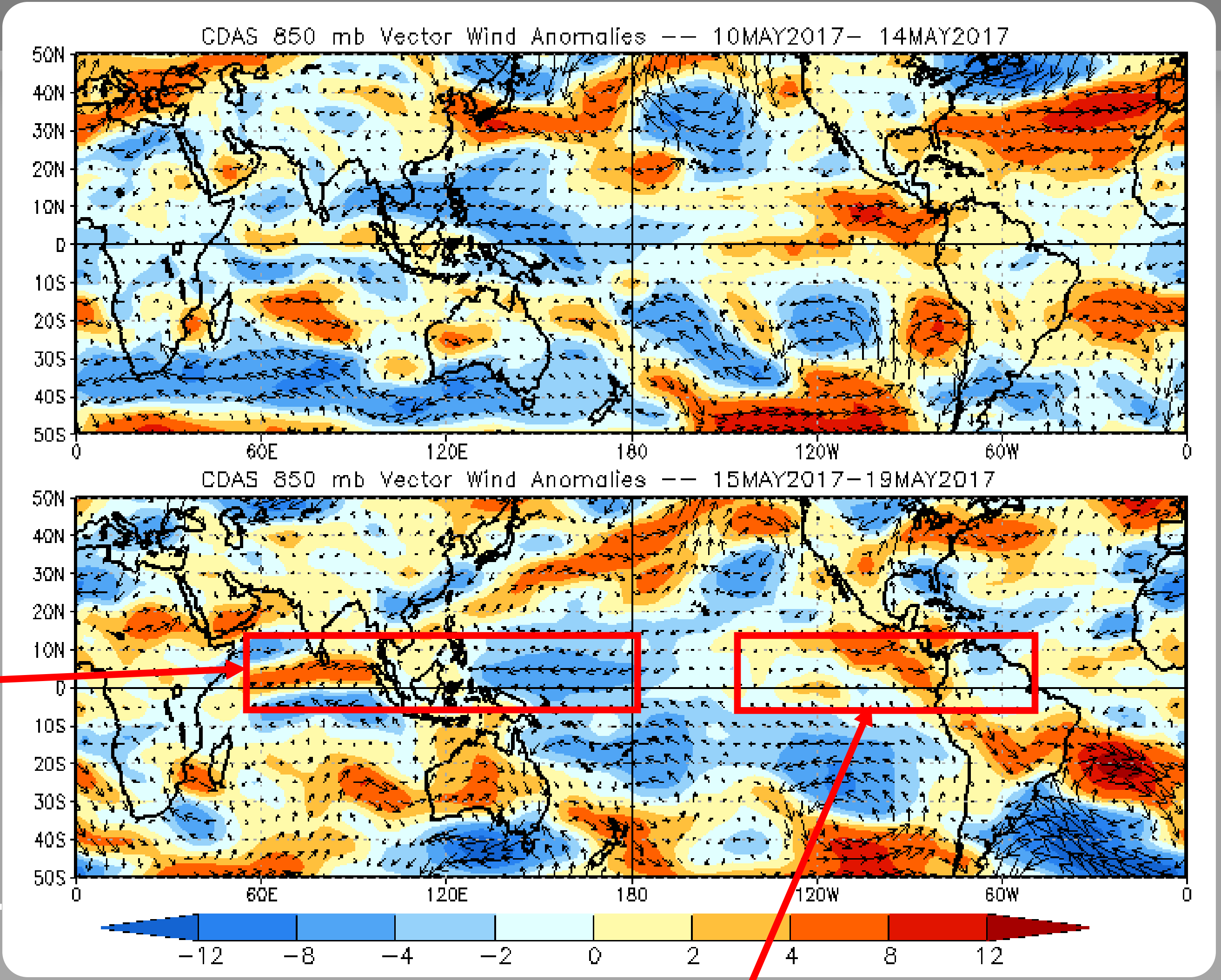
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

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

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



In the past week, westerly anomalies became larger just north of the equator in the Indian Ocean. Easterly anomalies over Southeast Asia and the South China Sea reversed sign, becoming weak westerlies. Easterly anomalies persisted over the West Pacific.

Westerly anomalies weakened a bit over the East Pacific.

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

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

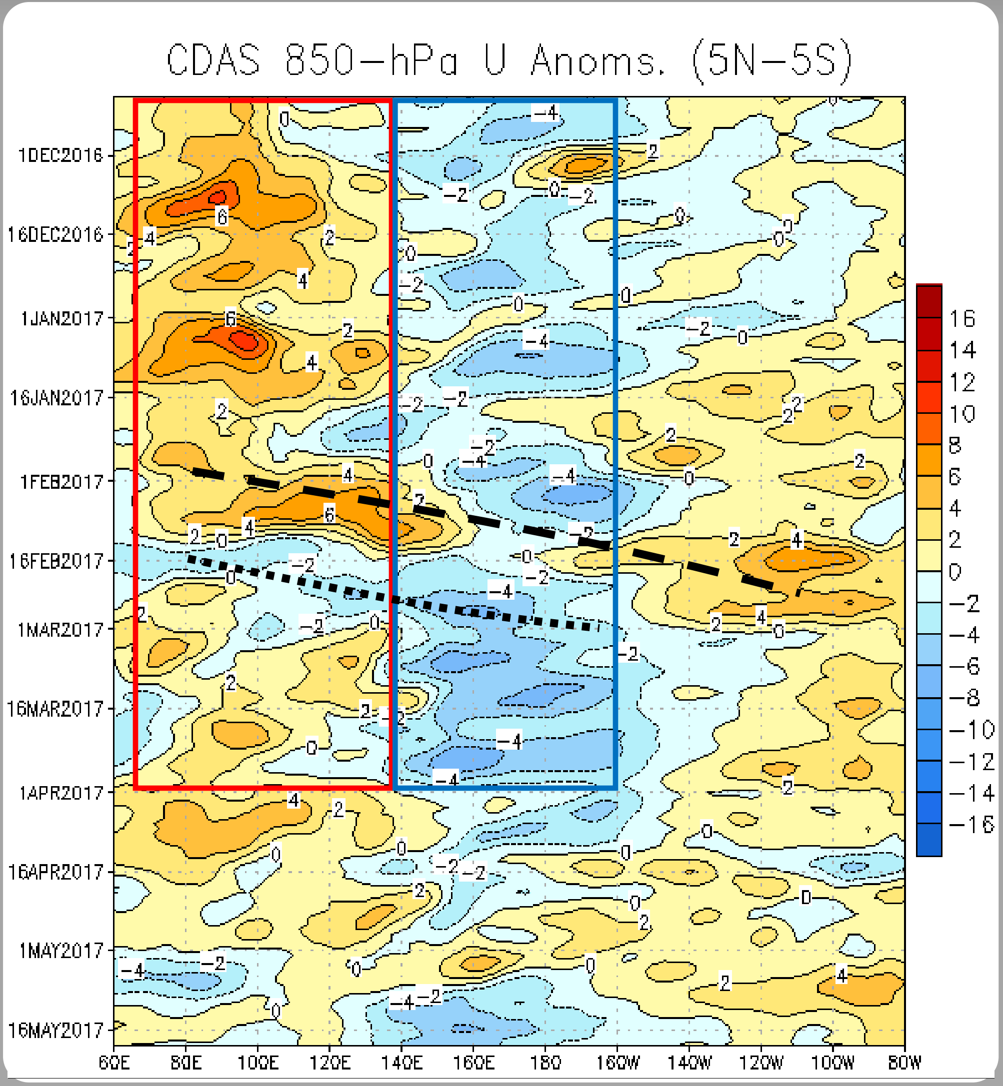
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Persistent westerly (easterly) anomalies, shown by the red (blue) box at right, were 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, MJO activity also destructively interfered with the base state. During mid-March and early April, the low frequency state seemed to reemerge, with some intraseasonal variability evident in late March.

Recently, weak westerlies have appeared over the Indian Ocean/Maritime Continent region, while easterlies persisted across the western and central Pacific.



OLR Anomalies - Past 30 days

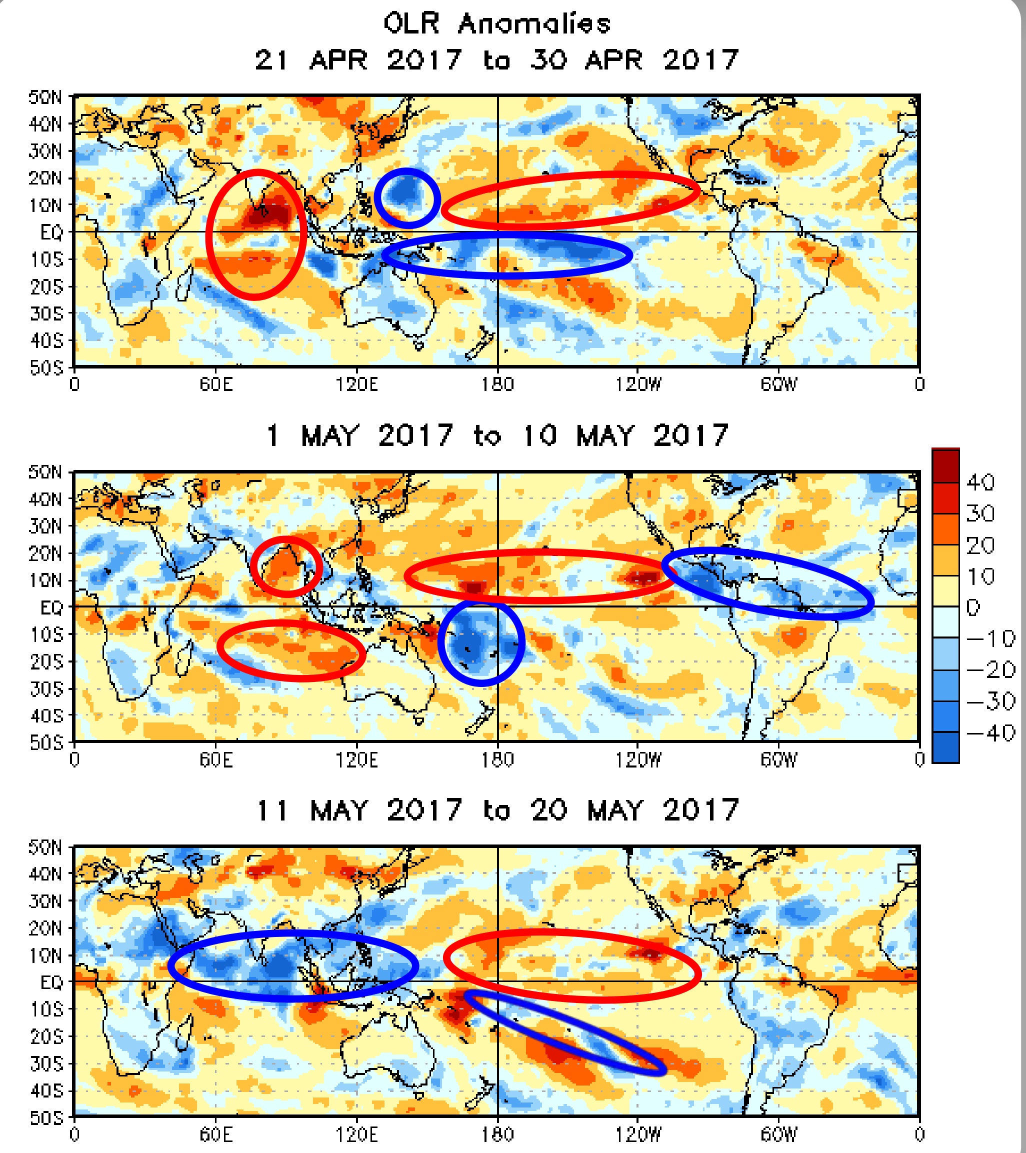
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late April, suppressed convection persisted over much of the Indian Ocean. Over the Pacific north (south) of the equator suppressed (enhanced) convection developed in long, west-east oriented patterns.

During early May, suppressed convection remained over much of the Indian Ocean. Enhanced convection developed over the Americas and Atlantic Ocean. Tropical cyclone activity impacted the pattern over the South and East Pacific.

In mid-May, enhanced convection was wide-spread across the tropical Indian Ocean and Maritime Continent region. Suppressed convection extended across the central and eastern tropical Pacific. The SPCZ appears to be displaced slightly east of normal.



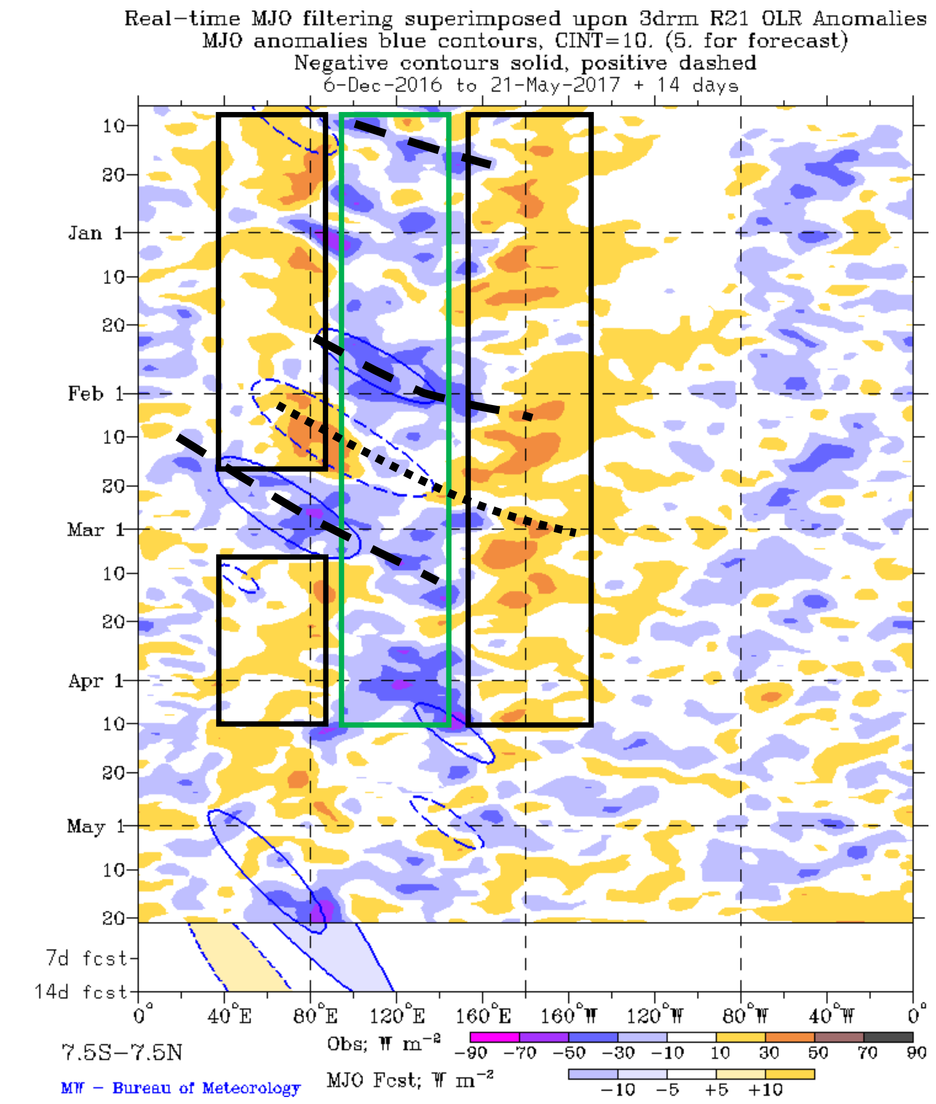
Outgoing Longwave Radiation (OLR) Anomalies (7.5ºS - 7.5ºN)

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 IO and the Maritime Continent has been evident from July through early April (green box), with suppressed convection near the Date Line (right black box). The remainder of the IO generally had suppressed convection during this period (left black boxes), with the exception of an MJO-related wet period from mid-Feb to early March.

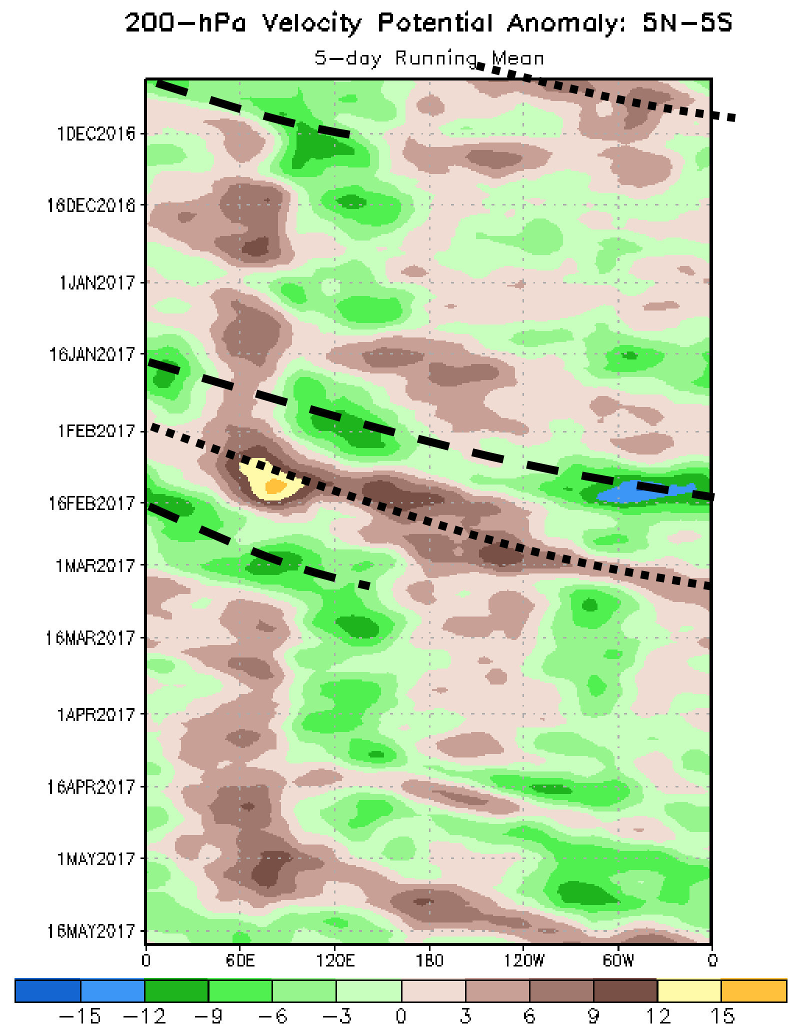
From mid-April to mid-May, convective anomalies were generally weak; by mid-May, enhanced convection was noted over the Indian Ocean.



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

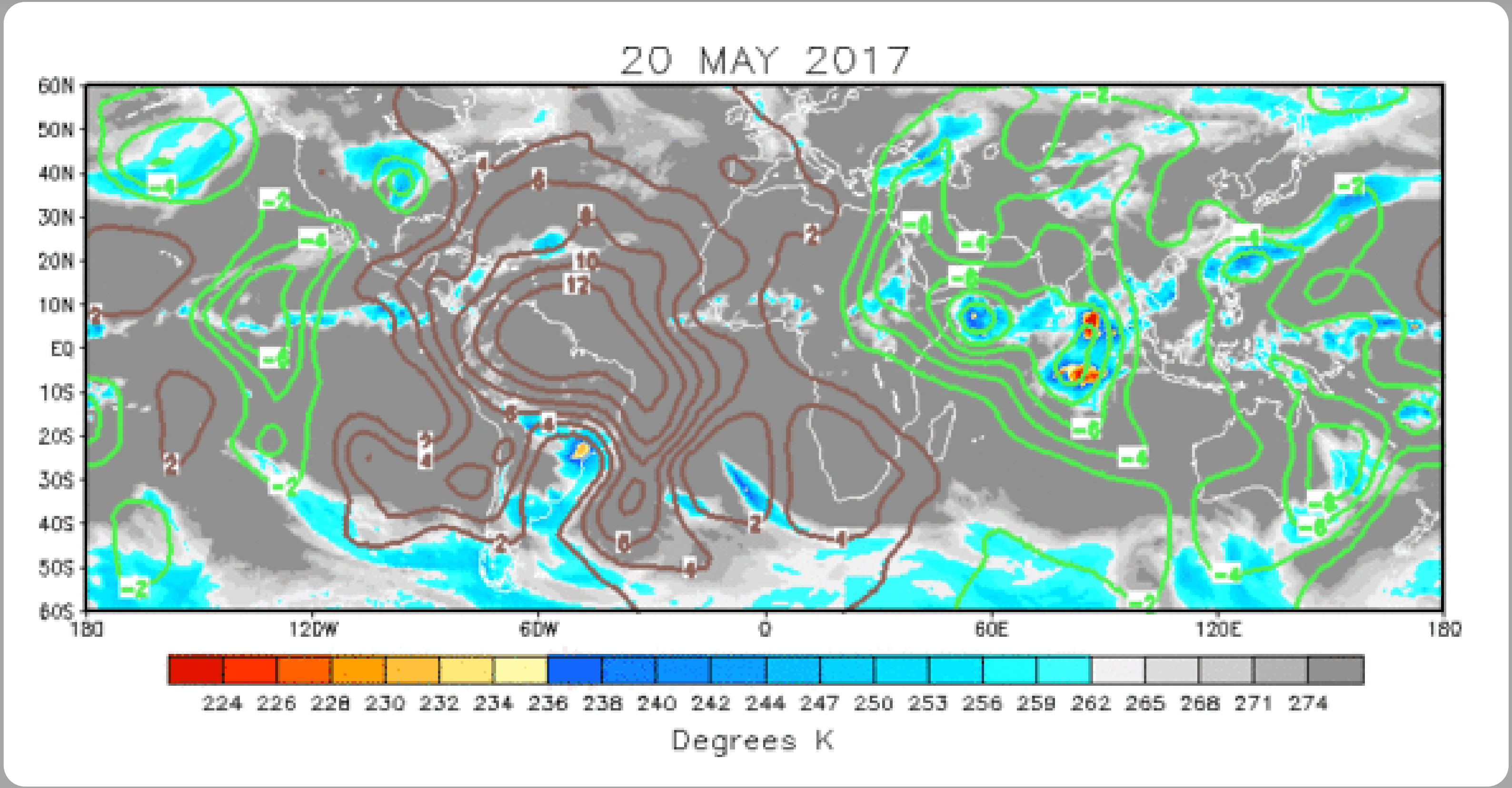


During November, eastward propagation was observed consistent with MJO activity on the fast end of the intraseasonal spectrum. The pattern, during December and January, was more related to seasonal variability.

A signal emerged over the Maritime Continent and continued propagating through early March, creating alternating periods of constructive and destructive interference with the base state.

During March, a low frequency signal favoring enhanced (suppressed) convection over the Maritime Continent (Indian Ocean) once again became the primary component of the anomaly field. Kelvin wave activity has been apparent during April and into May, primarily east of the Date Line. During May, a disruption of the low-frequency state is evident, with enhanced convection overspreading the IO/Maritime Continent, and suppressed convection over the Western Hemisphere.

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



The spatial distribution of the upper-level VP anomaly field is, to a first approximation, a wave-1 pattern. Upper-level divergence dominates the Eastern Hemisphere, and upper-level convergence dominates much of the Western Hemisphere. The large extent of divergence aloft over the Indian Ocean suggests that the onset of the Indian Monsoon may not be far away.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

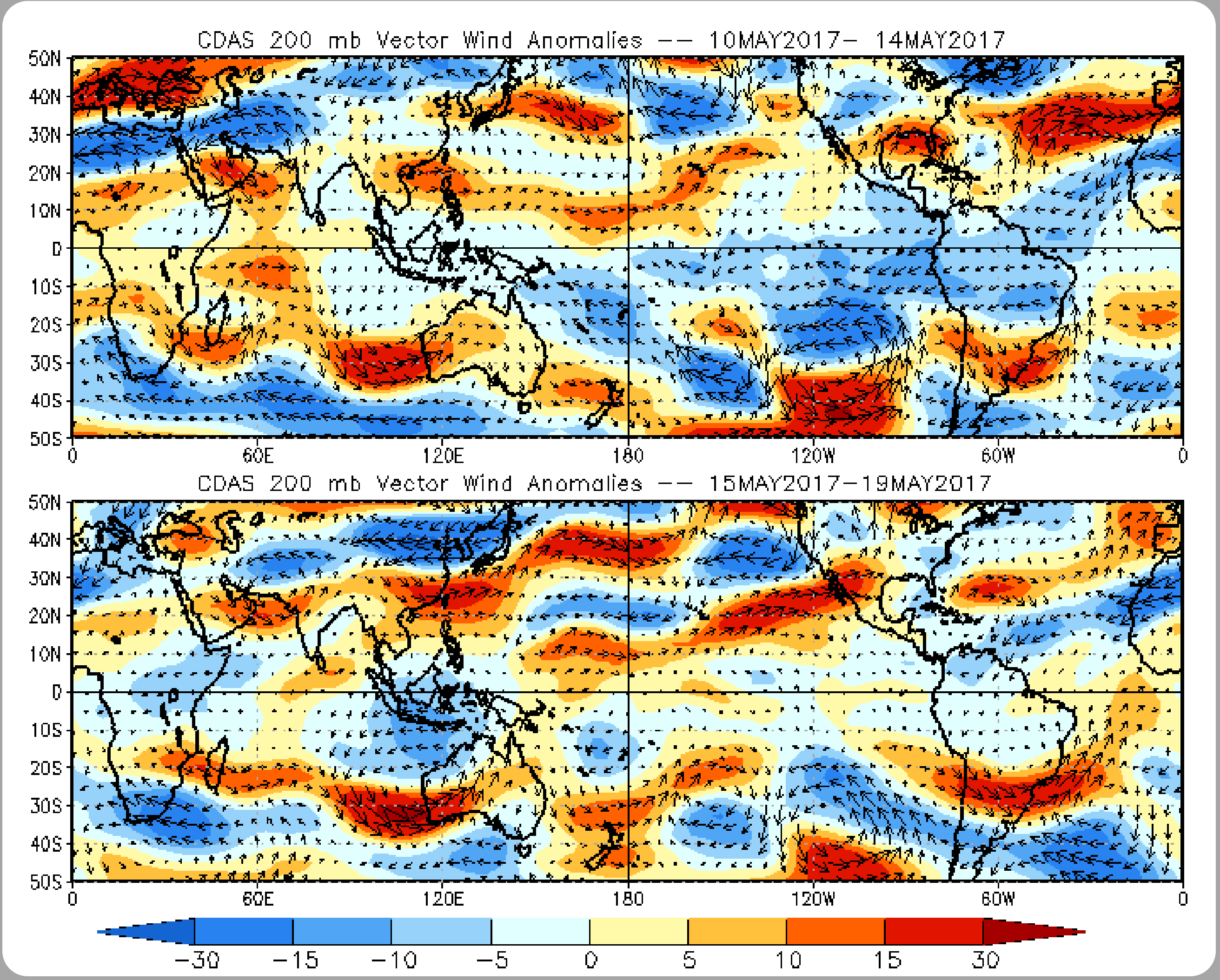
Negative anomalies (green contours) indicate favorable conditions for precipitation

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 top panel generally depicts westerly (easterly) anomalies over Africa and the Indian Ocean (Pacific Ocean and Americas). It also shows an upper-level cyclonic vortex centered near the Pakistani coast.

The bottom panel also shows the presence of the upper-level cyclonic vortex noted above. Northwest of Australia, an area of anomalous easterlies formed, helping to close off a 200-hPa anticyclone centered near the west coast of Australia.

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

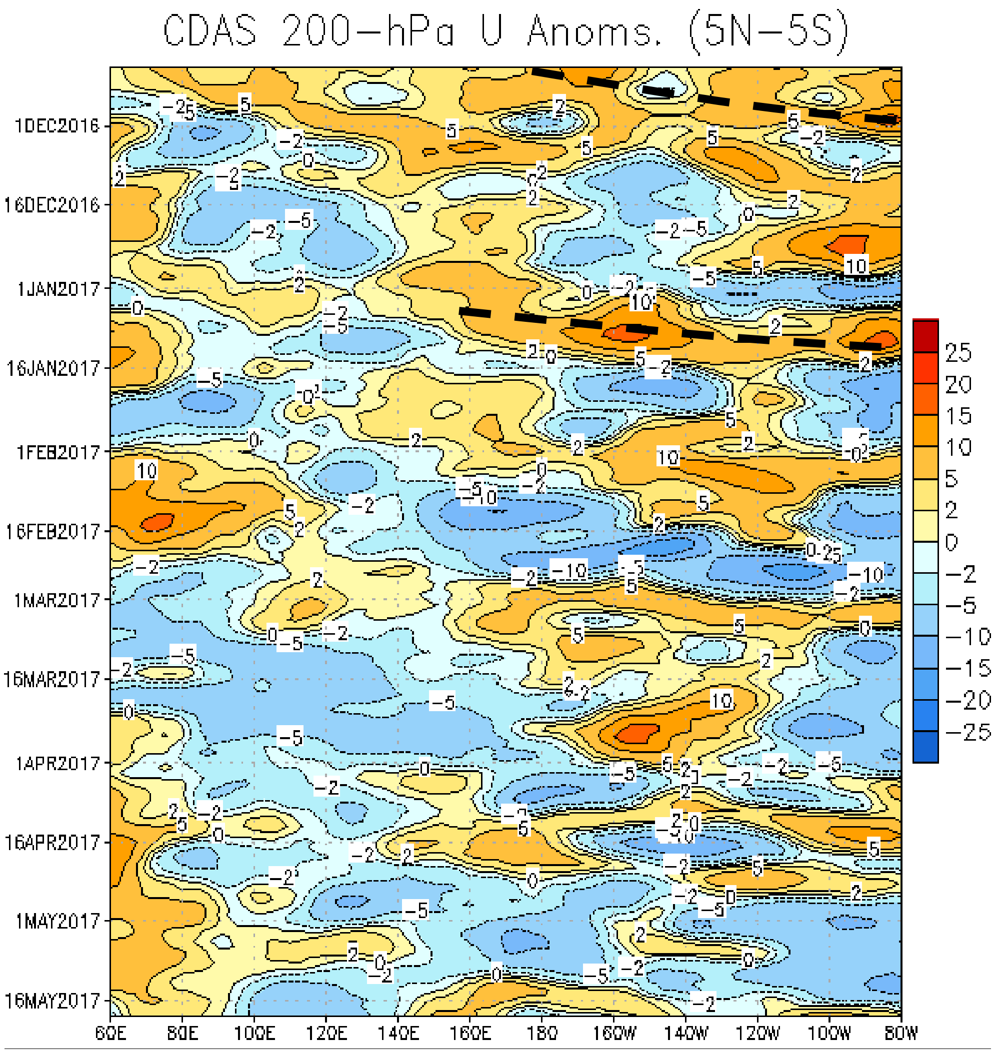
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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.

Easterly anomalies returned to the East Pacific during late April. In recent days, easterly (westerly) anomalies returned to the Maritime Continent (much of the Pacific) . The pattern suggests there is upper-level divergence centered in the approximate area of 140E.

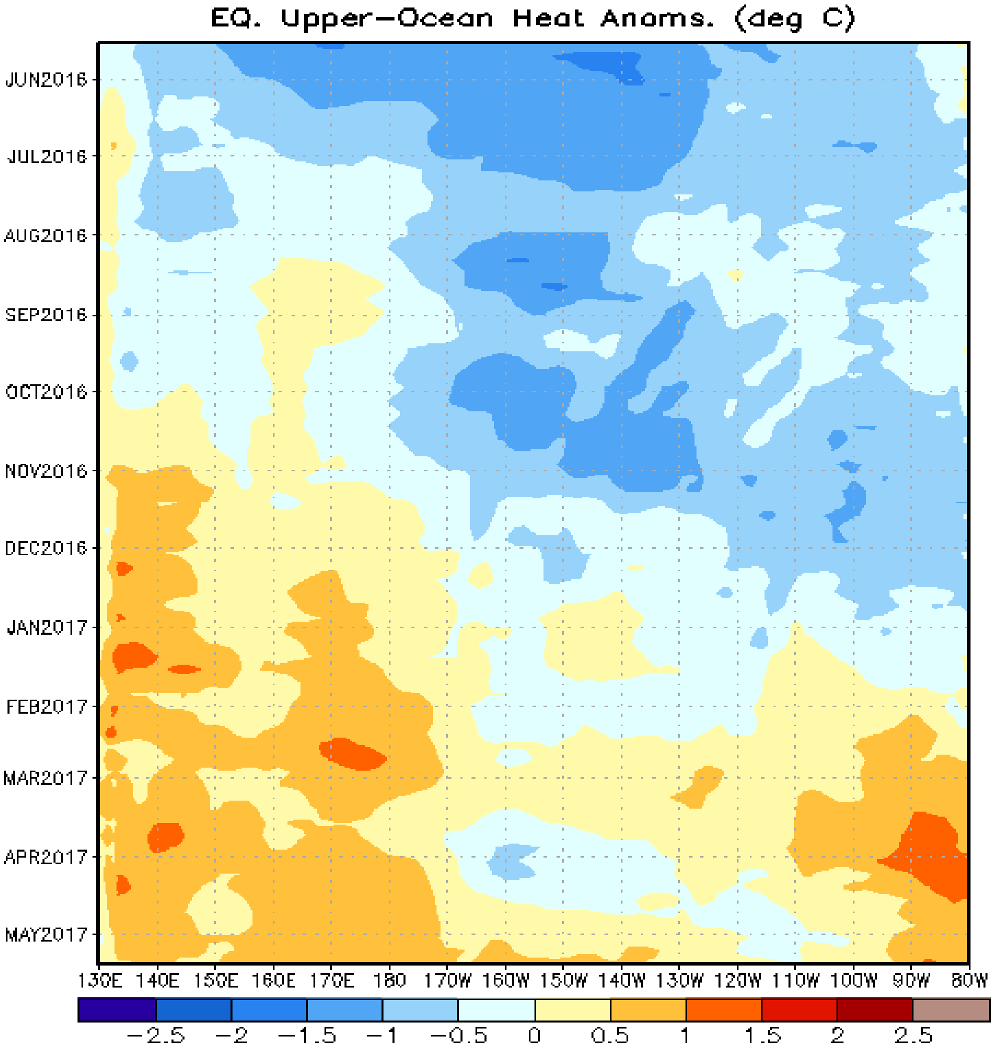


Weekly Heat Content Evolution in the Equatorial Pacific

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.

The anomaly field has weakened across the central and eastern Pacific, with positive anomalies persisting over much of the Pacific, except for a small portion of the eastern Pacific. By mid-May 2017, positive anomalies returned to most of the central and eastern Pacific.



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

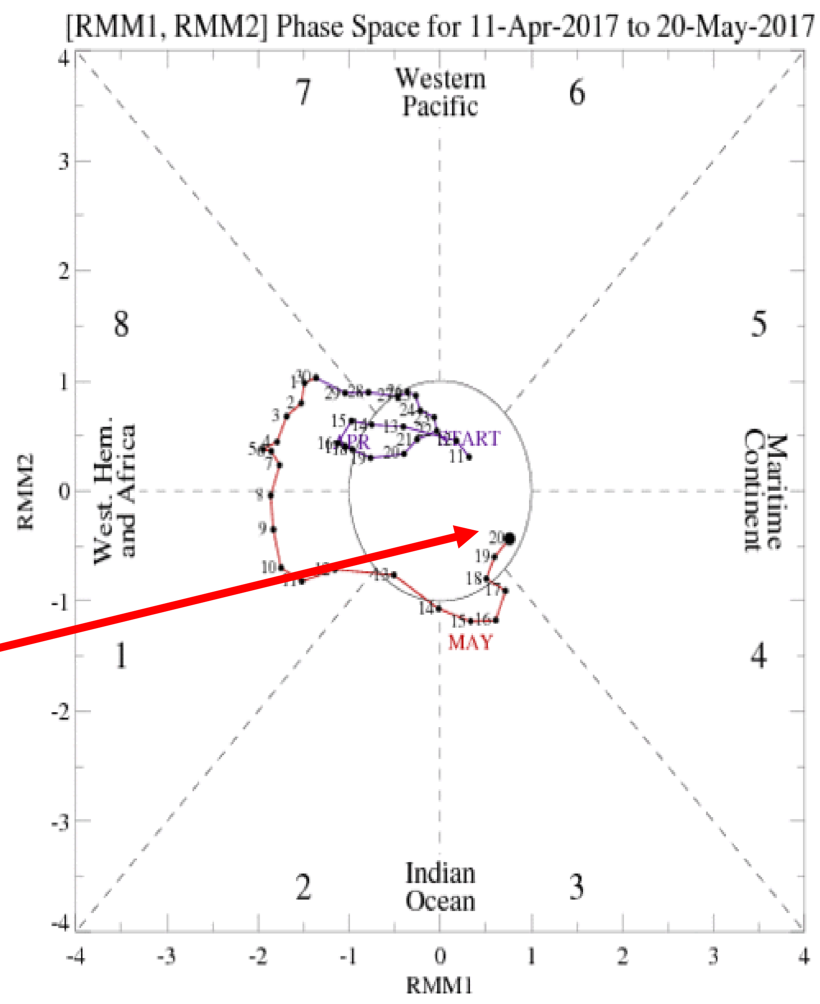
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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

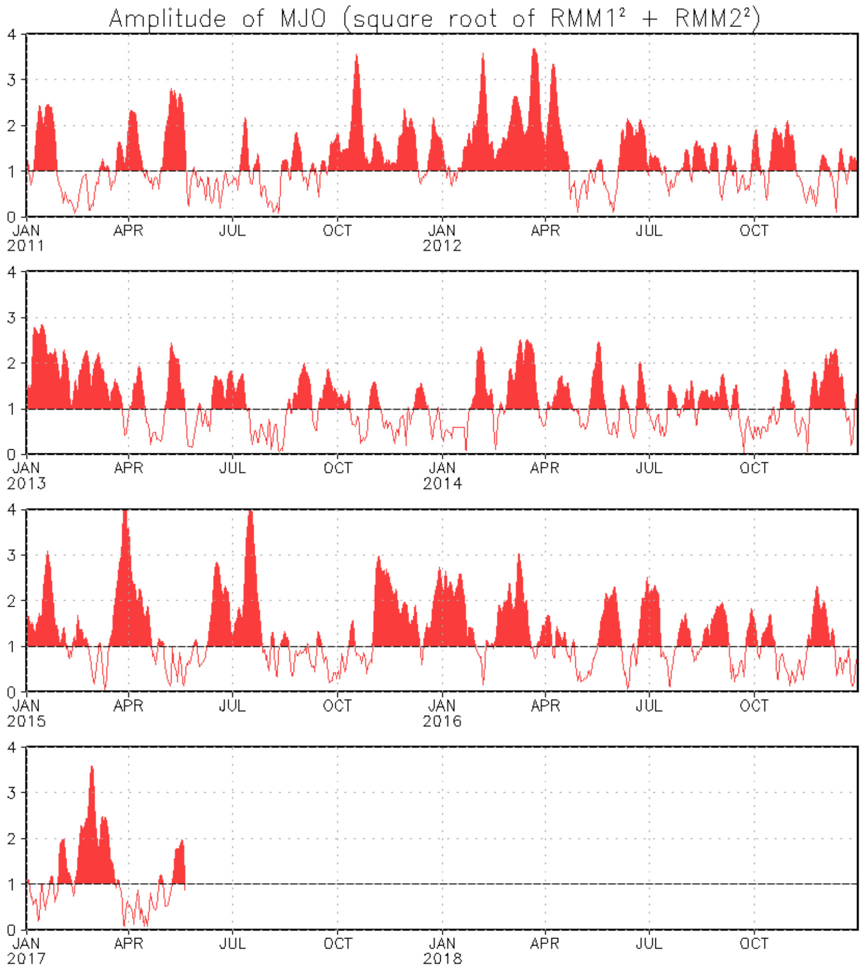


During the past two weeks, the amplitude of the RMM-based MJO index has decreased, though still maintaining some eastward propagation.

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.



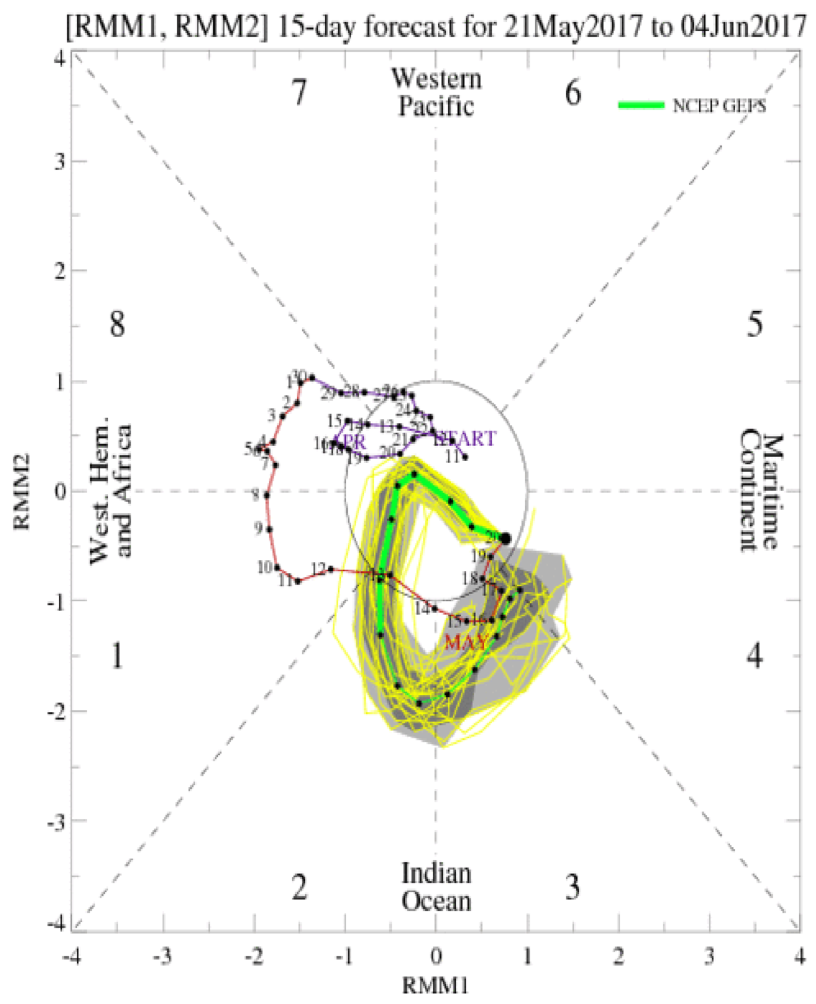
GFS Ensemble (GEFS) MJO Forecast

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



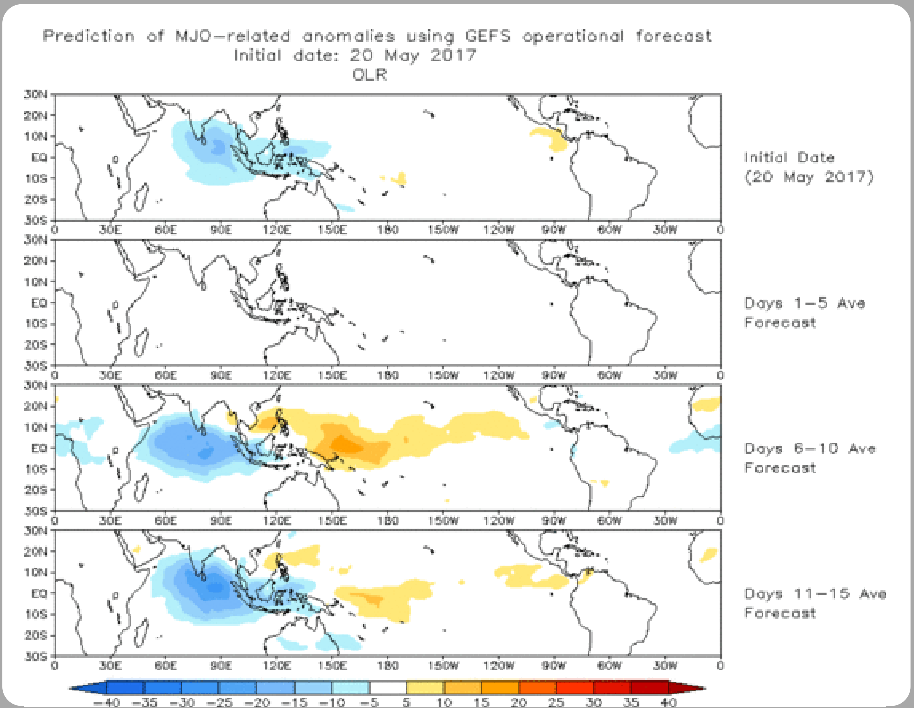
The GEFS depicts a very weak signal in the RMM index over the next week, with the potential emergence of a significant signal in Week-2 over the Indian Ocean.

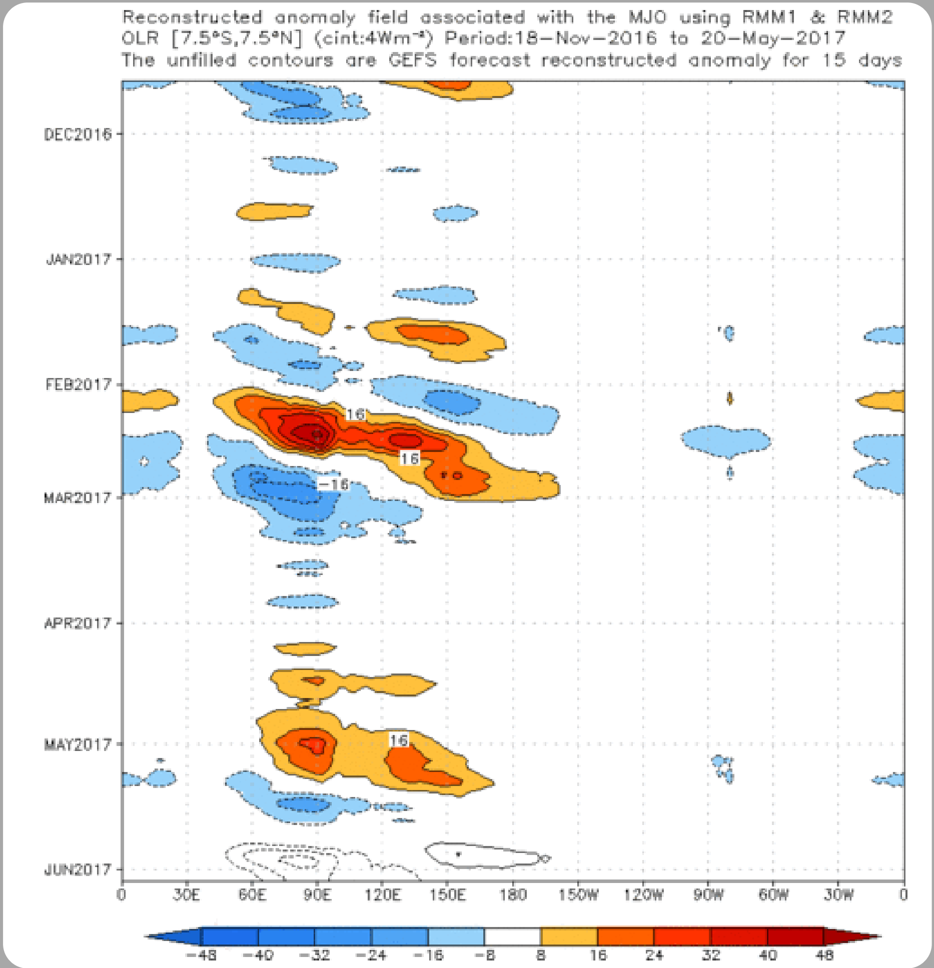
Ensemble GFS (GEFS) MJO Forecast

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



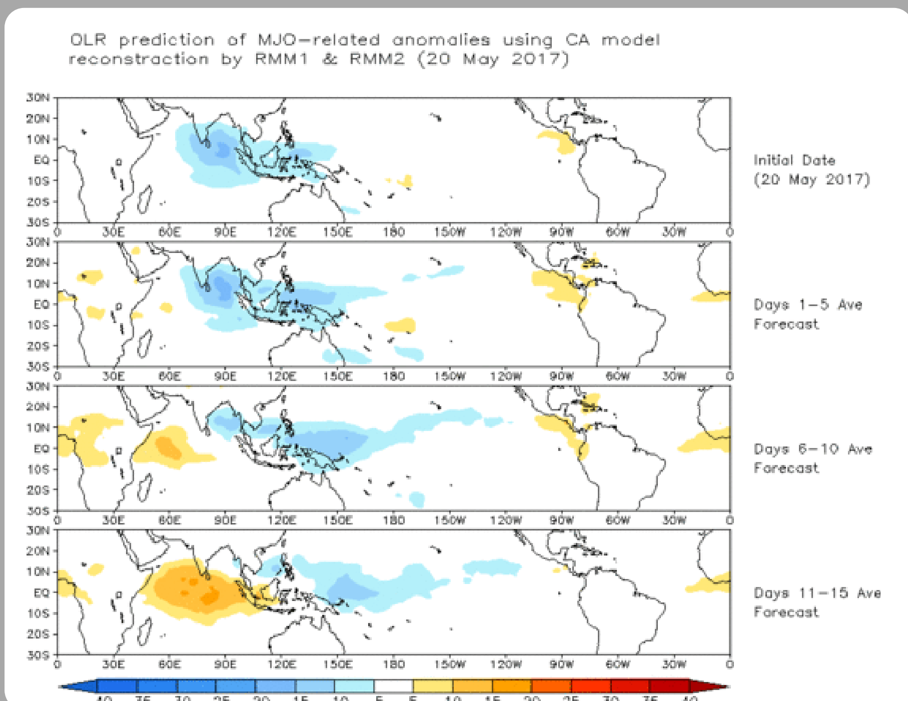


The GEFS RMM-based OLR anomaly forecasts show a stationary pattern, with enhanced convection strengthening over the Indian Ocean over the Indian Ocean, and suppressed convection over the western Pacific.

Constructed Analog (CA) MJO Forecast

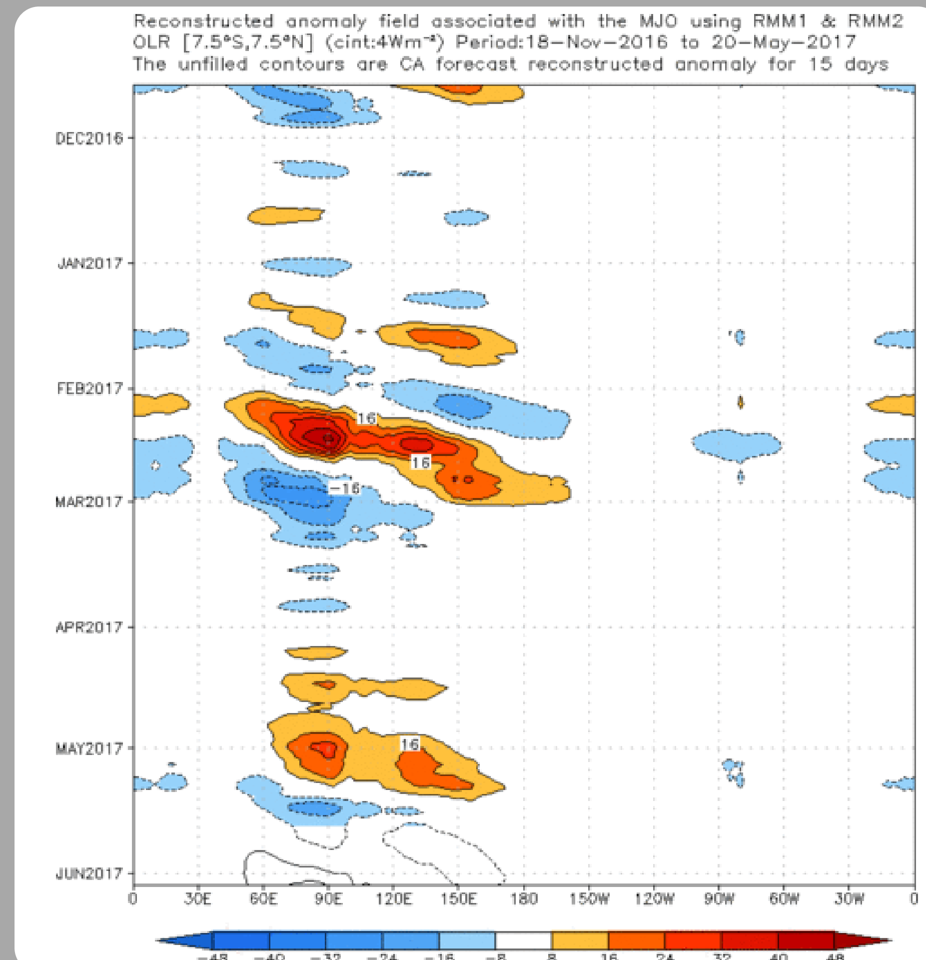
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



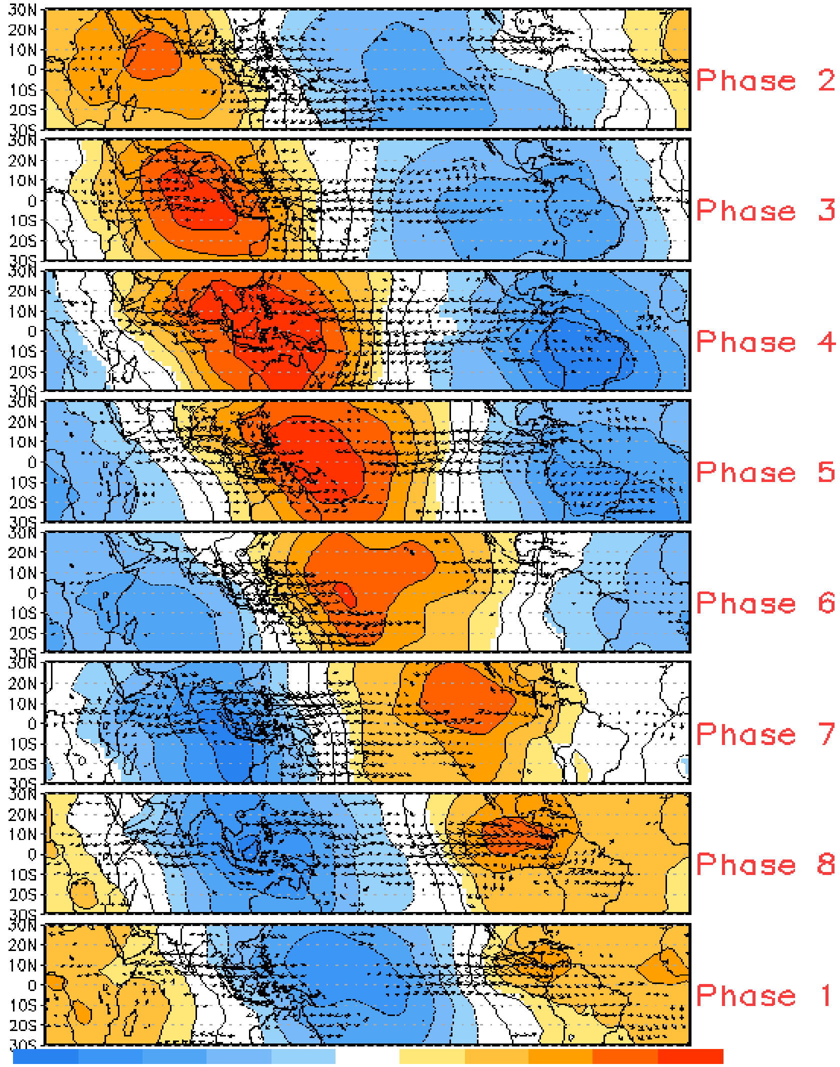
The statistical RMM-based OLR anomaly prediction indicates more robust eastward propagation of the anomaly pattern, with the enhanced phase of the MJO emerging over the West Pacific by the end of the period, and suppressed convection returning to the Indian Ocean.

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

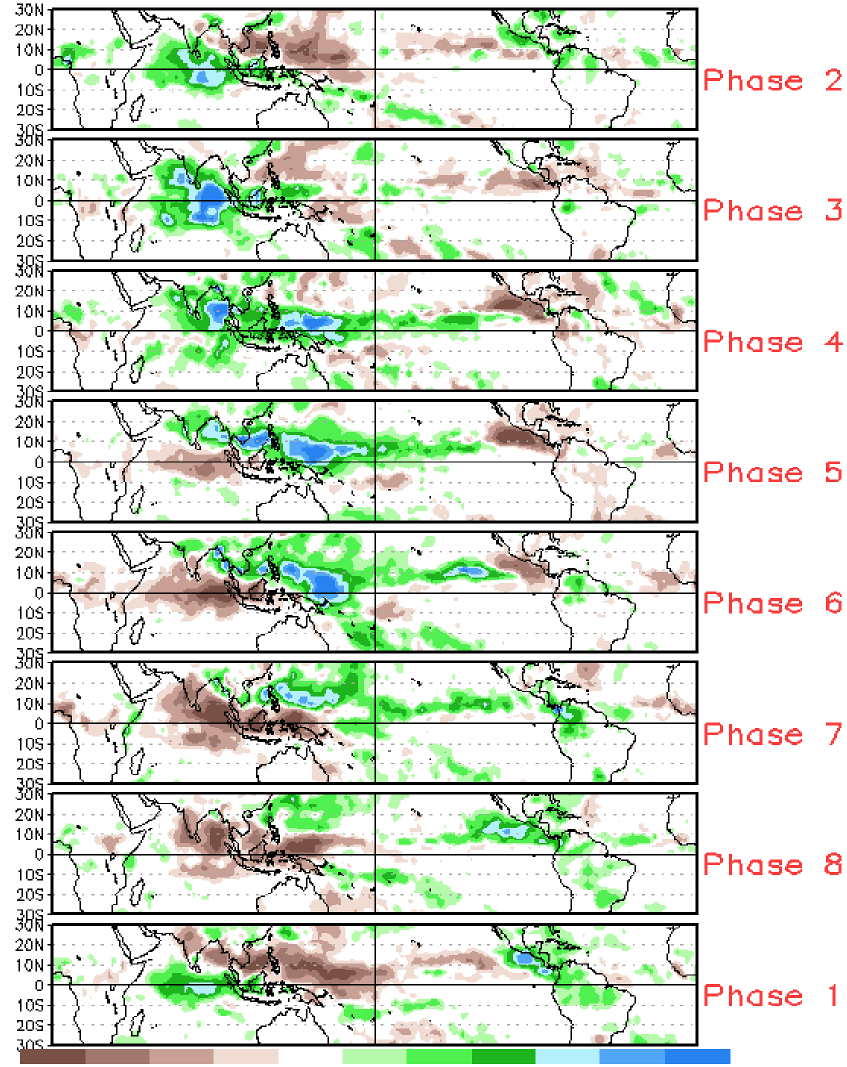


MJO Composites - Global Tropics

850-hPa Velocity Potential and Wind Anomalies (May - Sep)



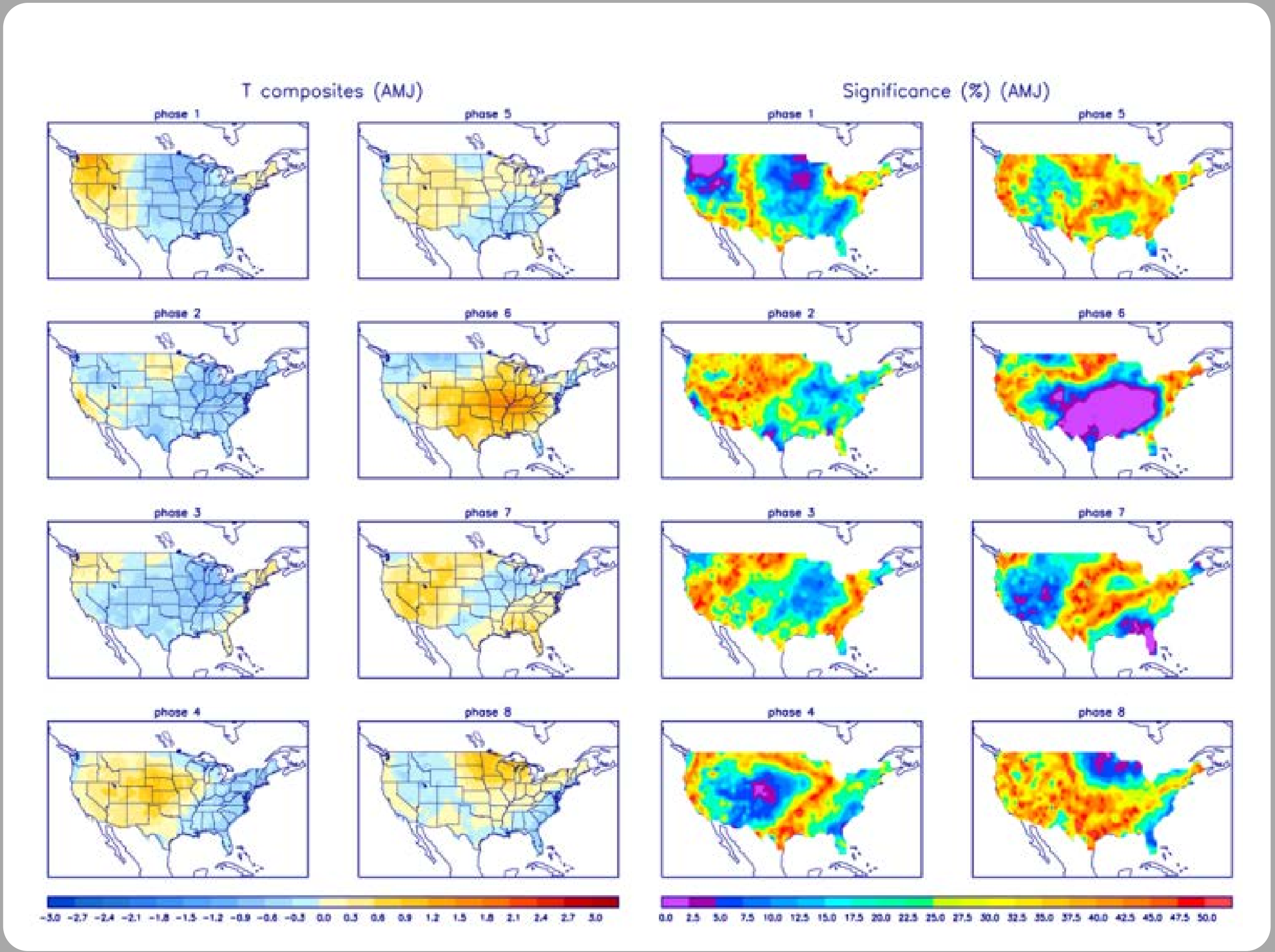
Precipitation Anomalies (May - Sep)



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.



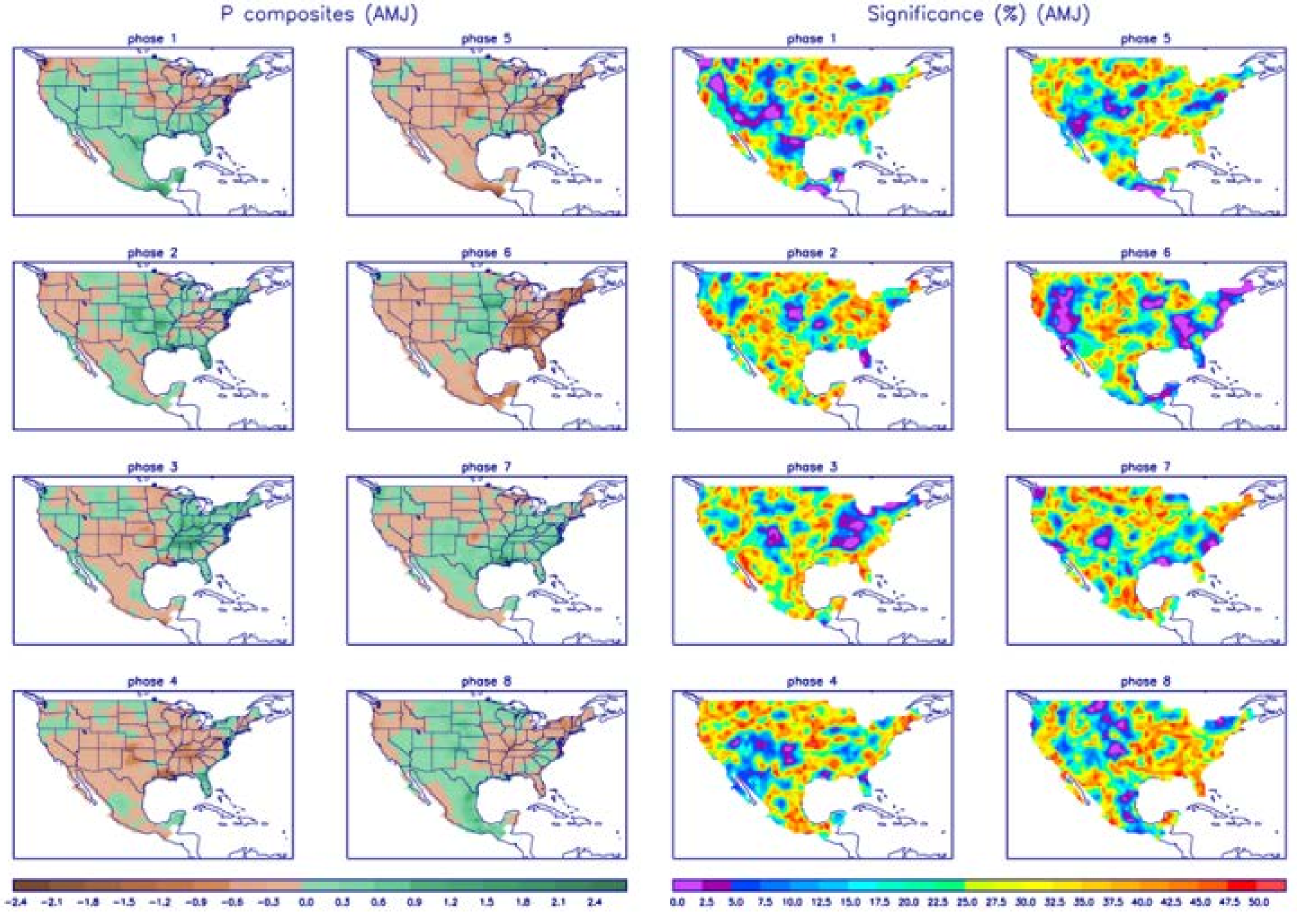
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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