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

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6 June 2016

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Overview

The MJO signal, as observed by the RMM index, remained relatively weak and incoherent during the past week. A signal was more evident in the upper-level velocity potential field, with the enhanced convective phase located over the Western Hemisphere. Enhanced convection has lingered over the eastern Indian Ocean and Southeast Asia, complicating the large-scale pattern.

Most dynamical models suggest that a weak MJO signal will propagate over the Western Hemisphere, followed by development of a more robust signal later in Week-2 over the Indian Ocean.

Extratropical impacts of the MJO on the U.S. may include the development of another tropical cyclone in the general vicinity of the Gulf of Mexico, the Southeast United States, and the Bahamas.

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)

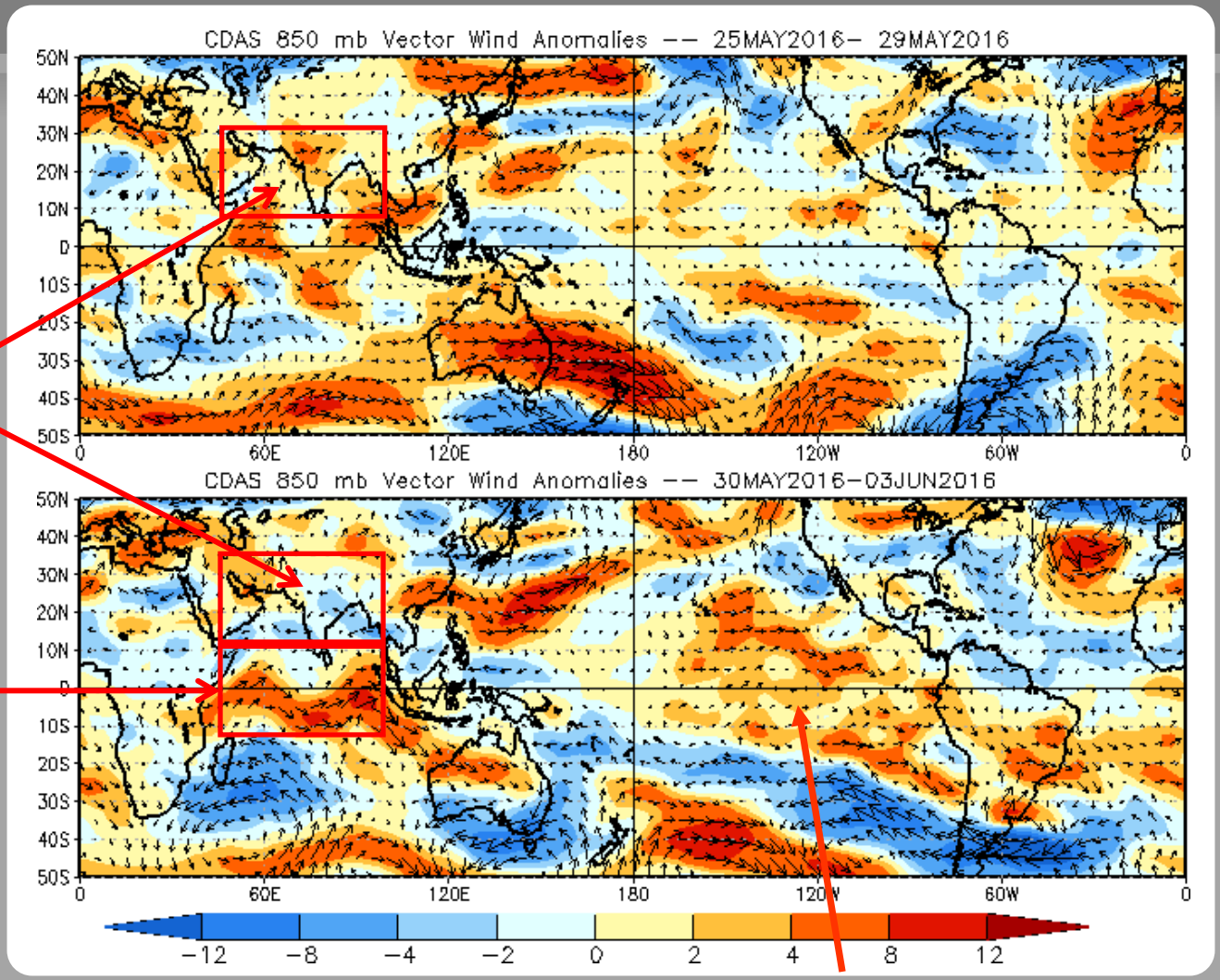
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Westerly anomalies over much of India have switched to easterly anomalies during the past week, indicating a delayed onset of the Indian Monsoon.

Westerly anomalies and cross-equatorial flow remain evident across much of the tropical Indian Ocean.



Westerly anomalies developed across parts of the eastern equatorial Pacific.

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

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

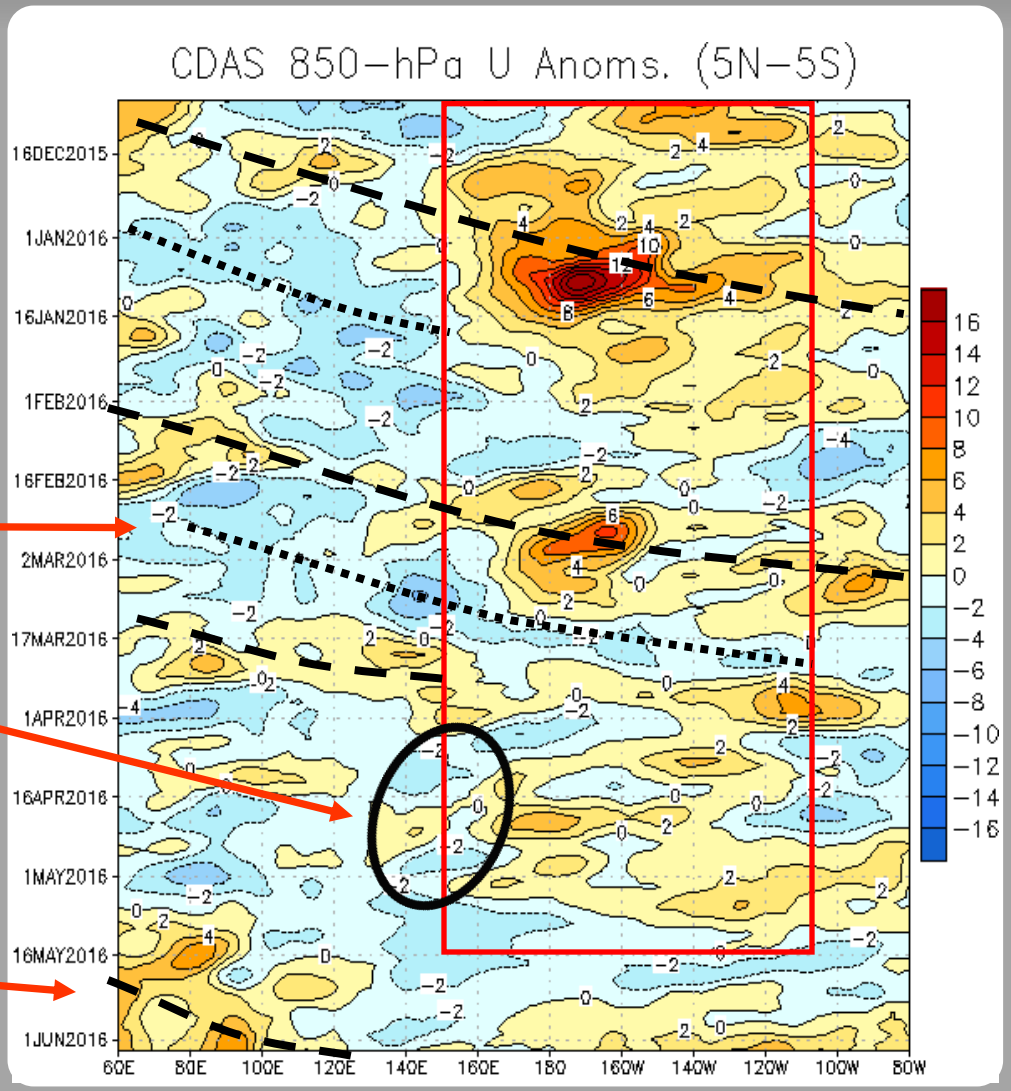
Easterly anomalies (blue shading) represent anomalous east-to-west flow

The red box highlights the persistent low-frequency westerly wind anomalies associated with the 2015-2016 El Niño background state.

During March, a fast eastward propagating intraseasonal signal crossed the Pacific.

During April, the pattern included more high frequency variability including Equatorial Rossby Wave activity (ERW) that shifted westward from near the Date Line to 130 E.

Low-level westerlies emerged across much of the Indian Ocean during mid-May, and exhibited some eastward propagation.



OLR Anomalies – Past 30 days

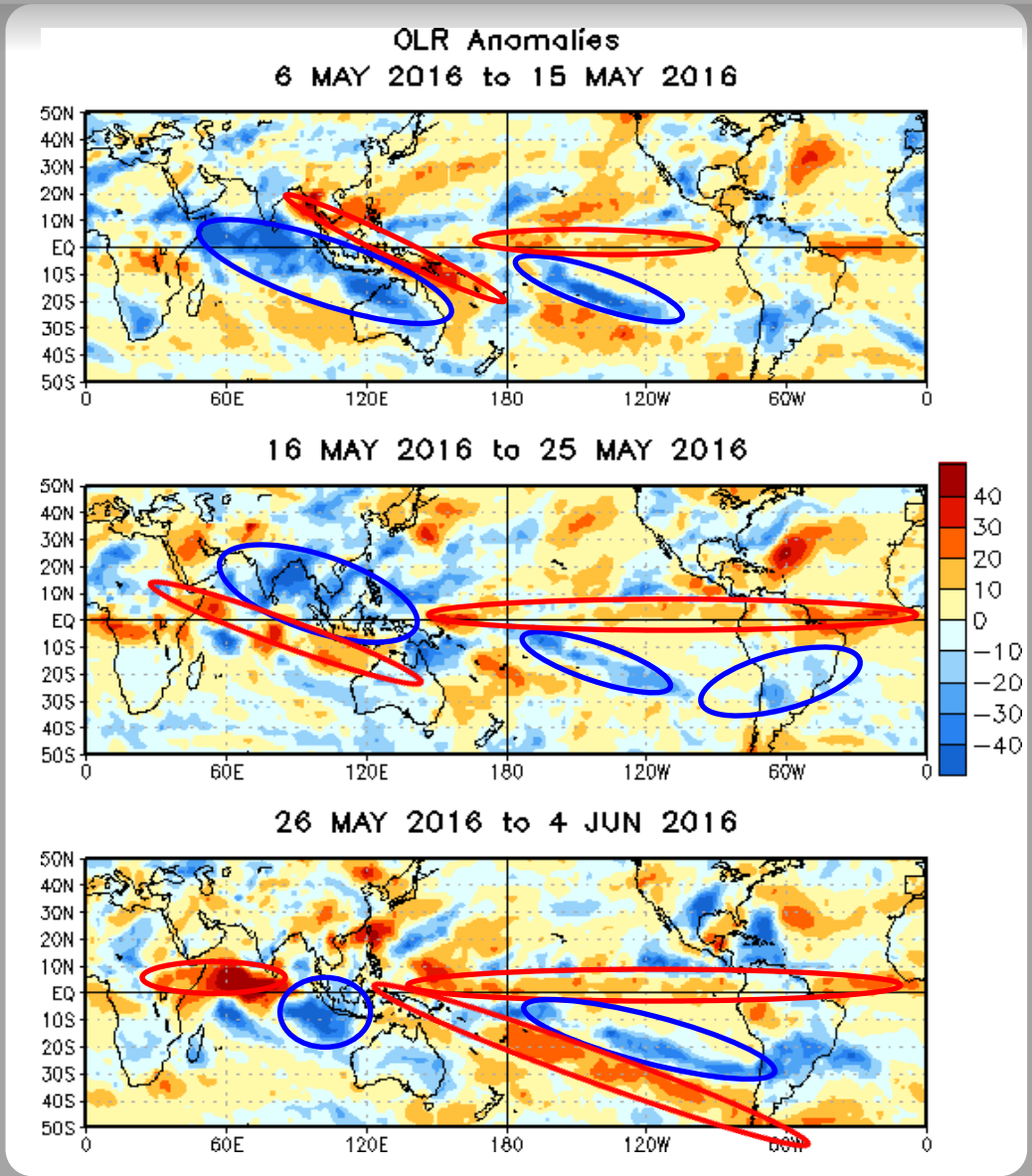
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During early to mid-May, enhanced convection filled in over the Indian Ocean, while generally suppressed convection developed over the eastern Pacific. Some convection redeveloped over the Southeast Pacific.

During mid-to-late May, enhanced convection was focused across the northern Indian Ocean and Indian subcontinent, extending eastward to the western North Pacific. Generally suppressed convection was observed along the equator from west of the Date Line to the tropical Atlantic.

From late May into early June, long, narrow bands of suppressed convection were evident over the global tropics, and from Papua New Guinea to the southern tip of South America. Enhanced convection was evident in the eastern Indian Ocean, and parts of the Southeast Pacific.



Outgoing Longwave Radiation (OLR) Anomalies (2.5°N - 17.5°N)

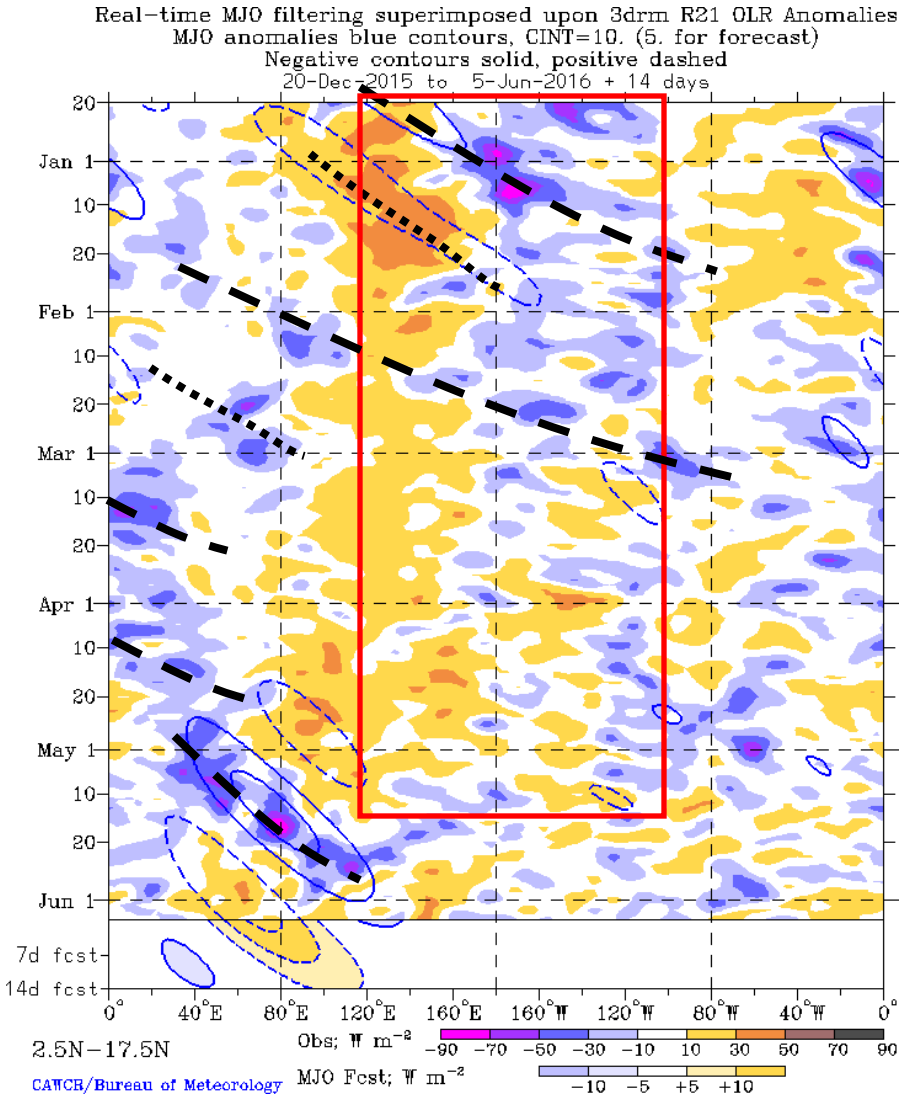
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

The 2015-2016 El Niño background state is observed (red box) as a dipole of anomalous convection extending from the Maritime Continent to the East Pacific.

Alternating periods of constructive and destructive interference with ENSO is evident. A fast eastward propagating signal raced across the Pacific during February.

Since early May an eastward-propagating convective envelope associated with the MJO developed east of the Prime Meridian. This OLR signal has weakened over the past week.



200-hPa Velocity Potential Anomalies (5°S - 5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

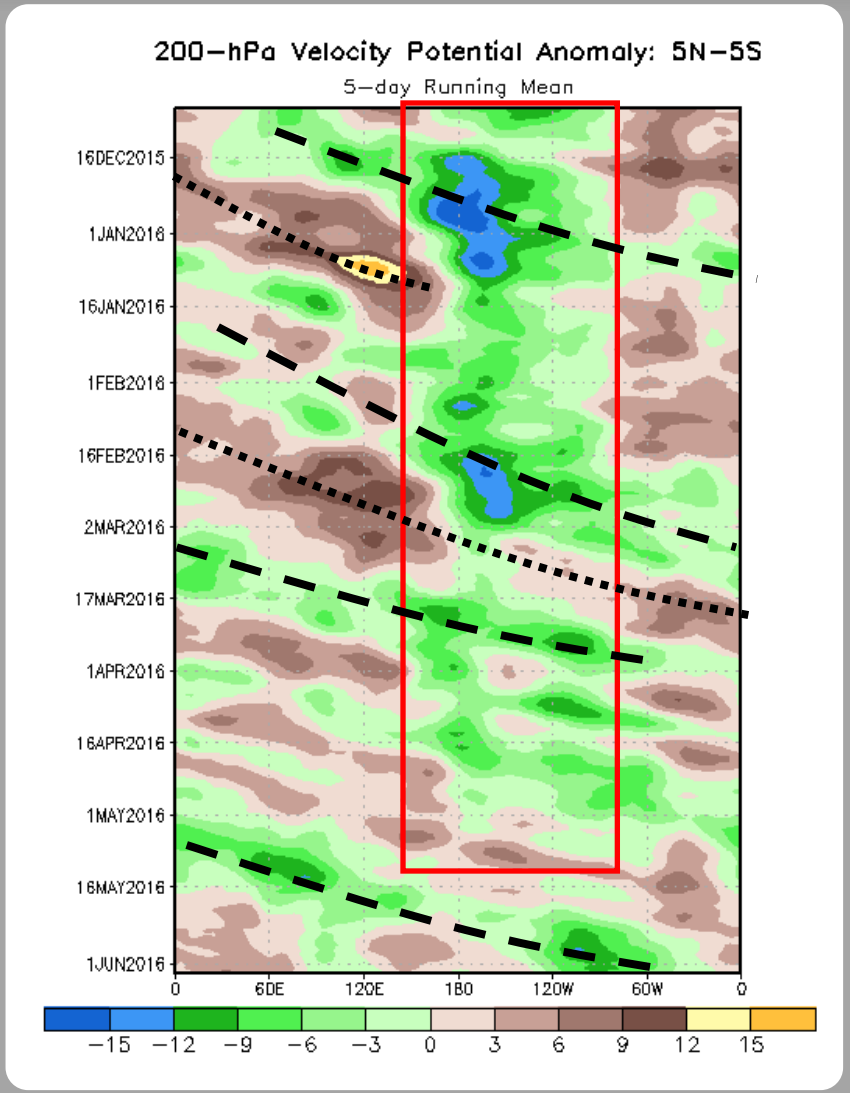
Negative anomalies (green shading) indicate favorable conditions for precipitation

The 2015-16 El Niño background state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

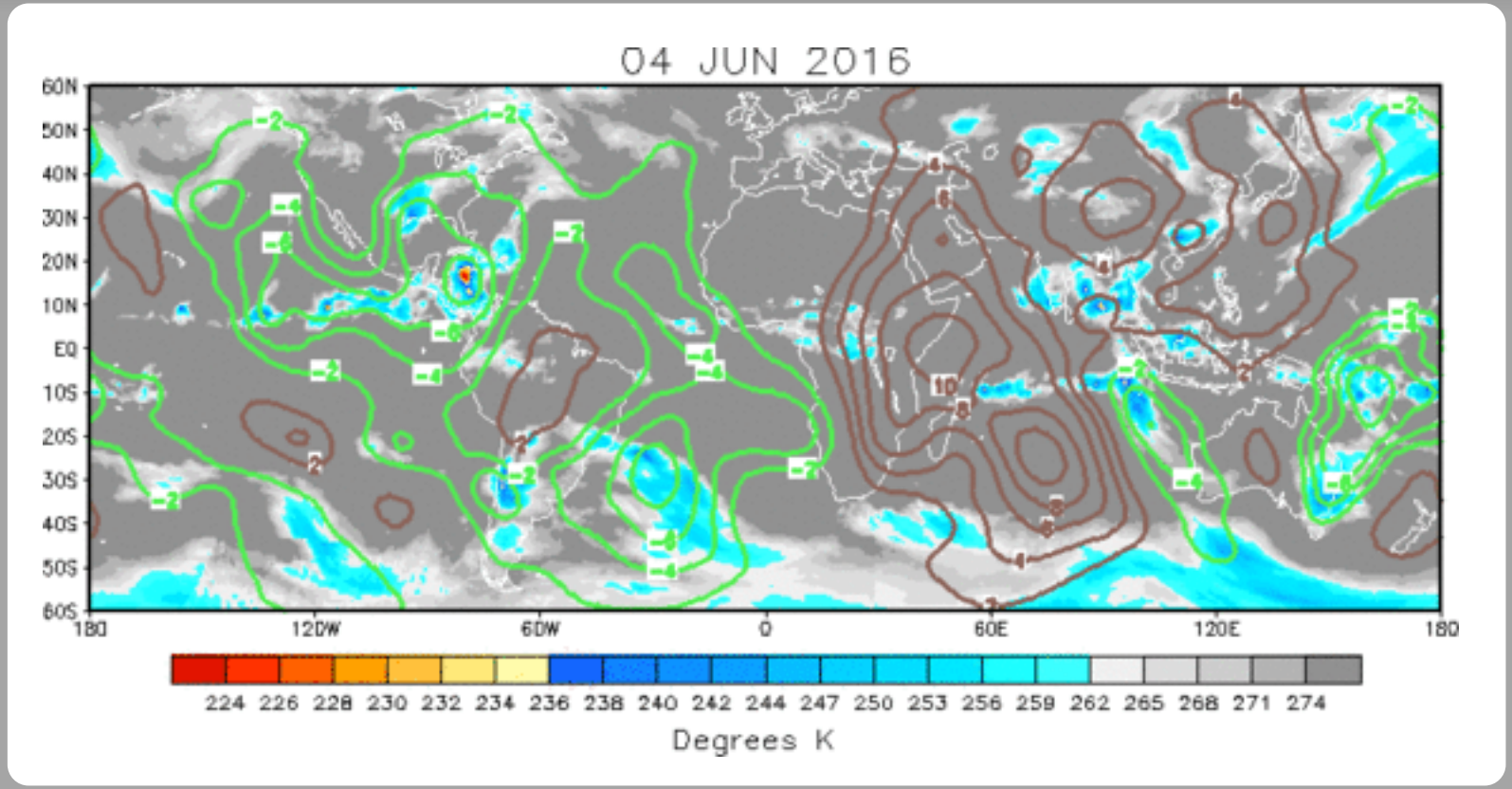
During late February, intraseasonal variability constructively interfered with the ongoing El Niño. During early-March, the intraseasonal variability destructively interfered with the ENSO signal.

In April, the pattern in upper-level velocity potential anomalies was incoherent with respect to MJO activity, and more reflective of other modes of tropical variability.

During the past month, an area of upper-level divergence associated with MJO activity propagated from the Indian Ocean to the Pacific. More recently, the signal was over the Western Hemisphere.



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



The large scale upper-level velocity potential anomaly pattern generally indicates a coherent structure, with anomalous upper-level divergence (convergence) generally centered over the Western Hemisphere (Indian Ocean). Anomalous divergence over parts of the Maritime Continent and western Pacific interrupts this coherent structure.

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)

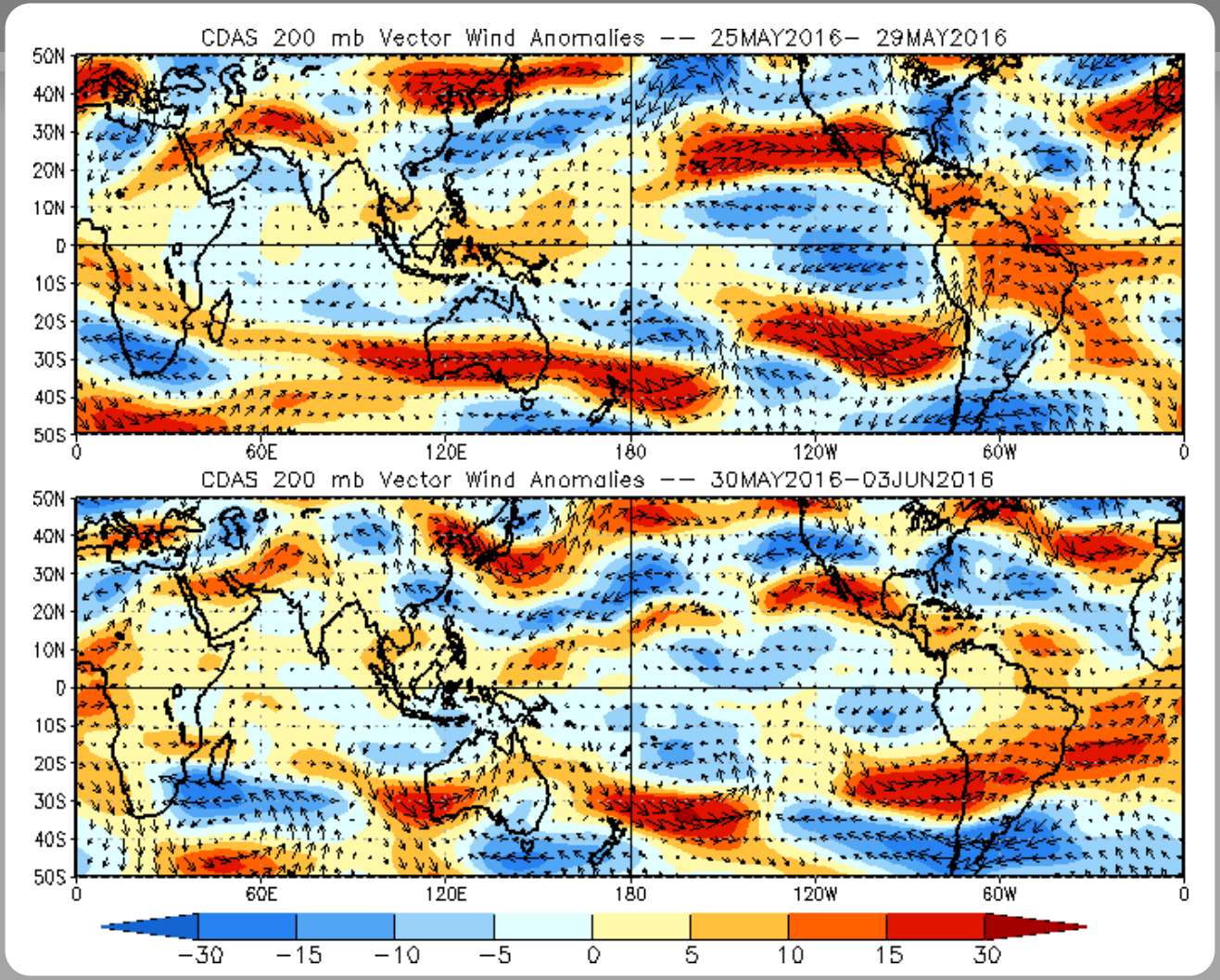
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

An anomalous anticyclonic couplet is observed over the East Pacific, straddling the Equator.

A well-defined anomalous anticyclone is also apparent centered near the west coast of Australia.



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

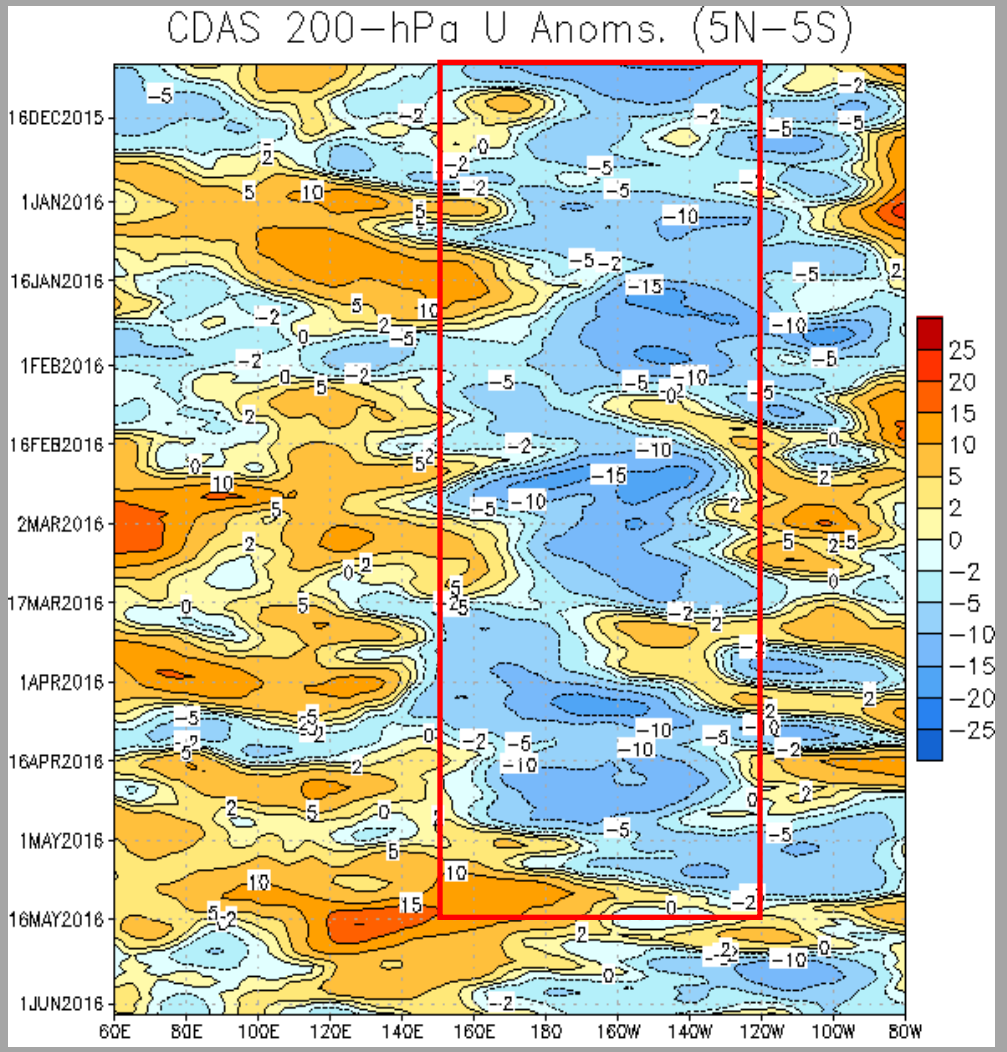
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

Easterly anomalies have persisted over the central and eastern Pacific from June 2015 through May 2016 associated with El Niño (red box).

During early March, westerly anomalies returned to the Indian Ocean and Maritime Continent, with easterly anomalies between about 170E-120W.

Since mid April, westerly anomalies weakened and then re-strengthened over the Indian Ocean & Maritime Continent. These westerlies extended eastward across much of the Pacific basin. Recently, easterly anomalies redeveloped over the eastern Pacific.



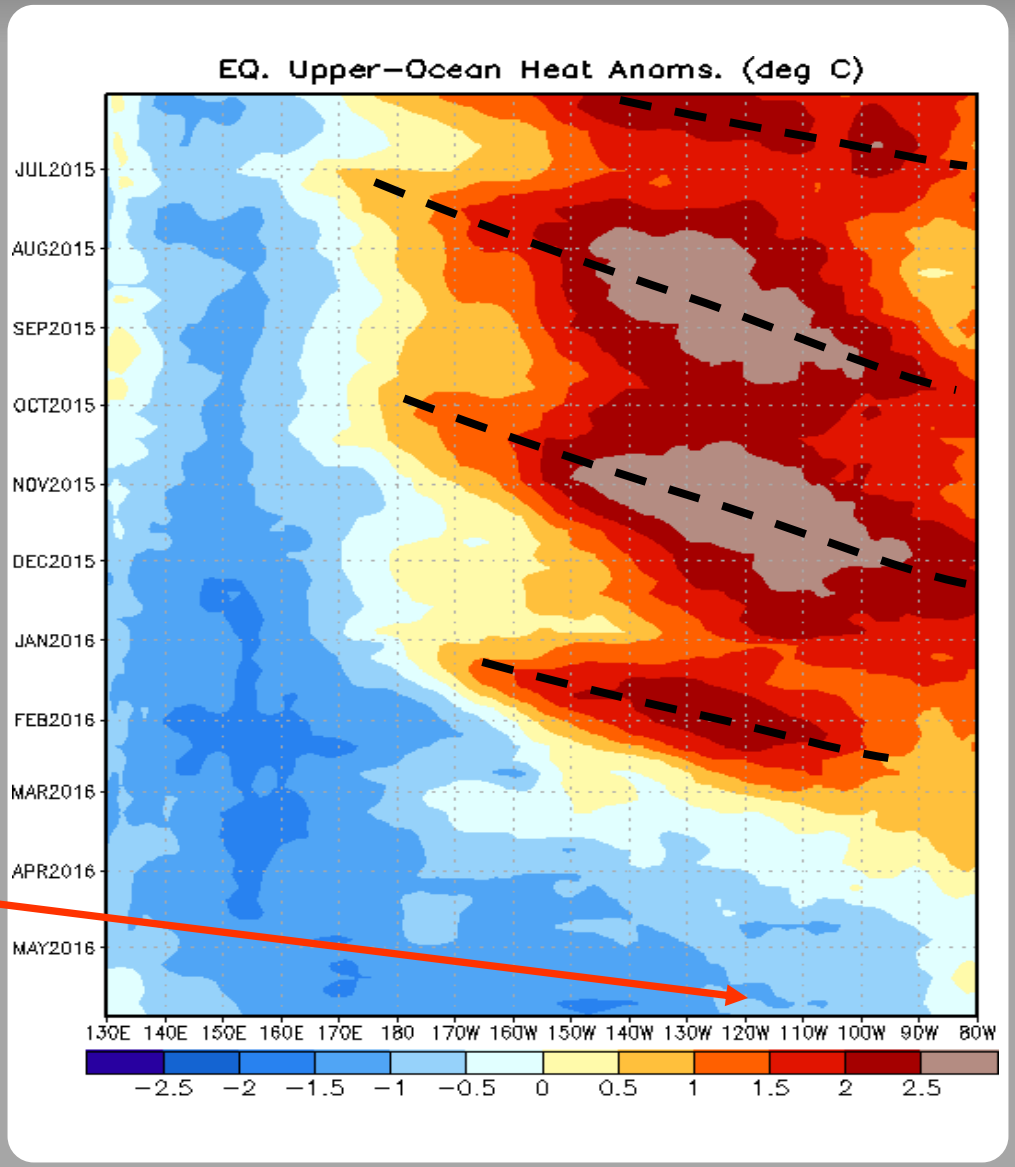
Weekly Heat Content Evolution in the Equatorial Pacific

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.

Reinforcing downwelling events were observed during the second half of 2015, resulting in persistently above-normal heat content from the Date Line to 80W throughout the period.

An eastward expansion of below average heat content over the western Pacific is evident since January, with negative anomalies beginning to spread east of the Date Line.

In the last three months, there has been a rapid eastward expansion of below-average oceanic heat content across the central and eastern Pacific. Negative anomalies now extend across the entire equatorial 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

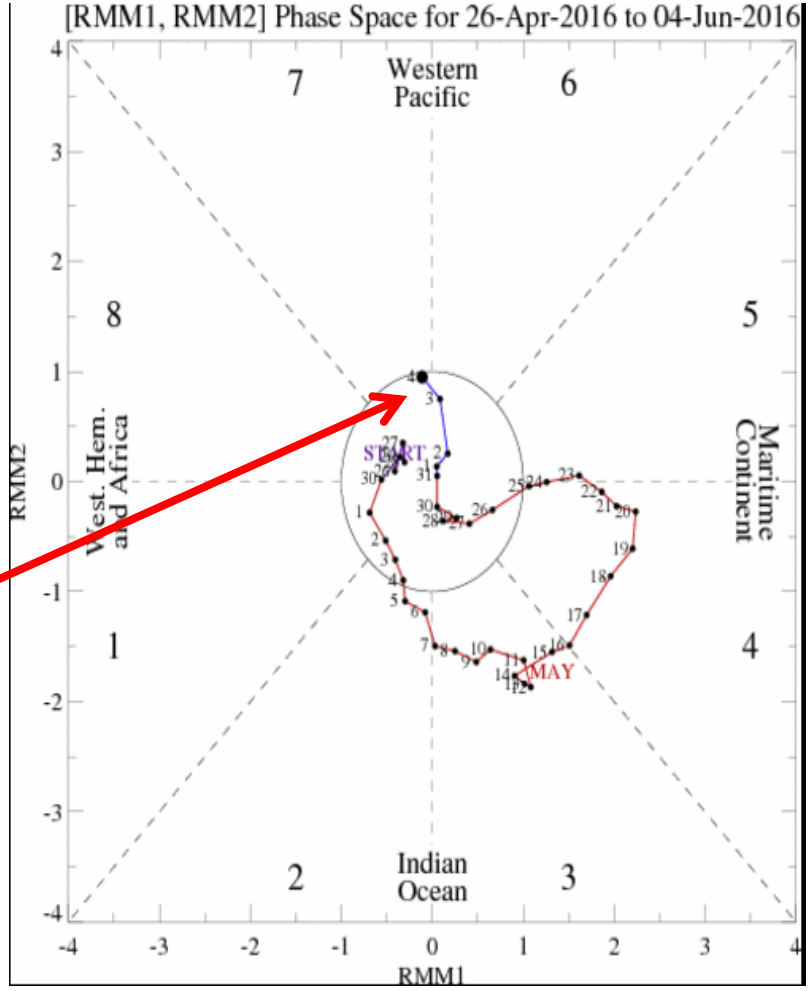
The triangular areas indicate the location of the enhanced phase of the MJO

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

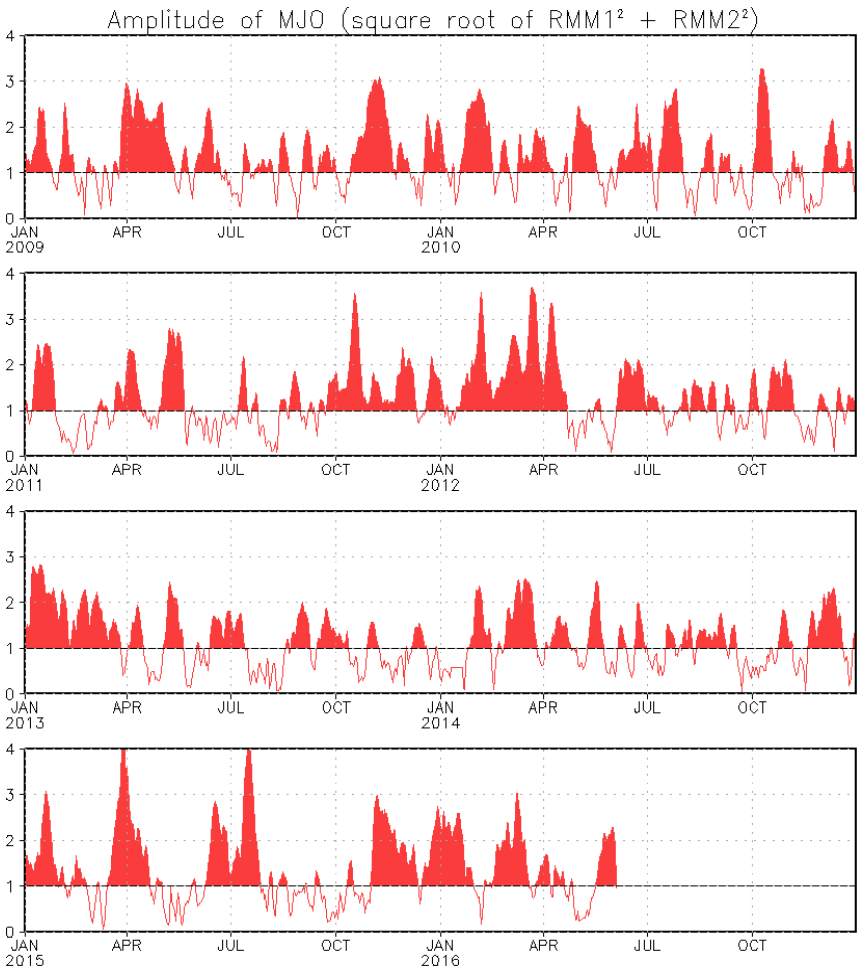
The MJO signal was weak as observed by the RMM index. This is likely due to interference between two competing centers of enhanced upper-level divergence over the Western Hemisphere and Maritime Continent/West Pacific.



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.



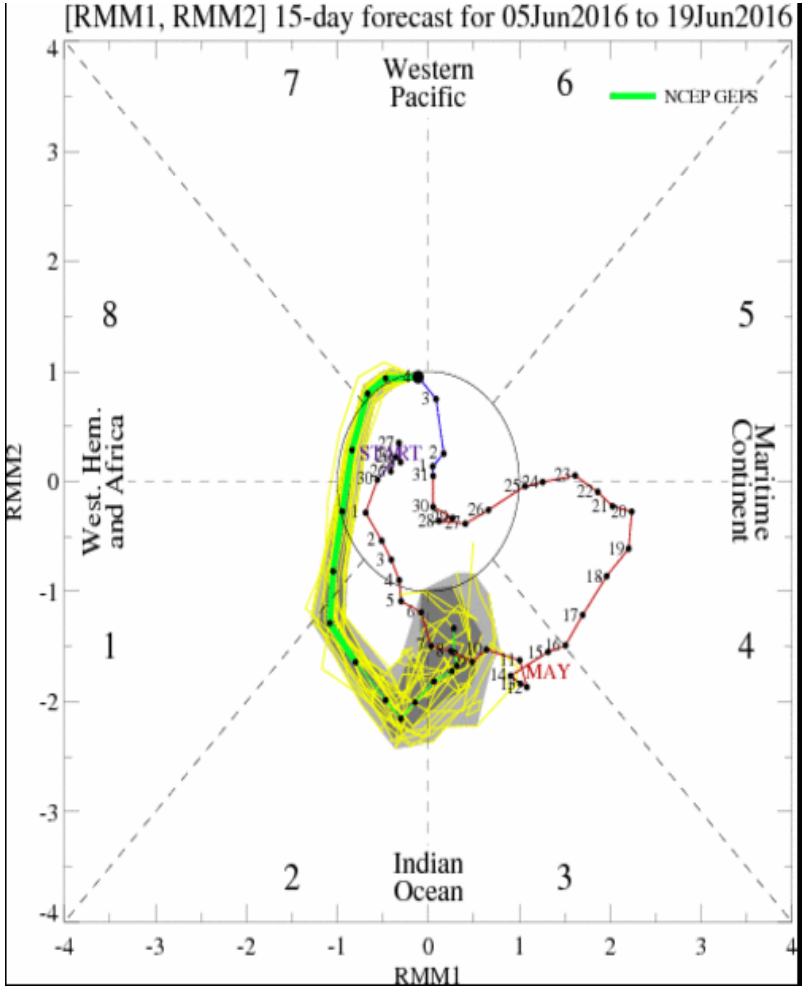
Ensemble GFS (GEFS) MJO Forecast

Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts



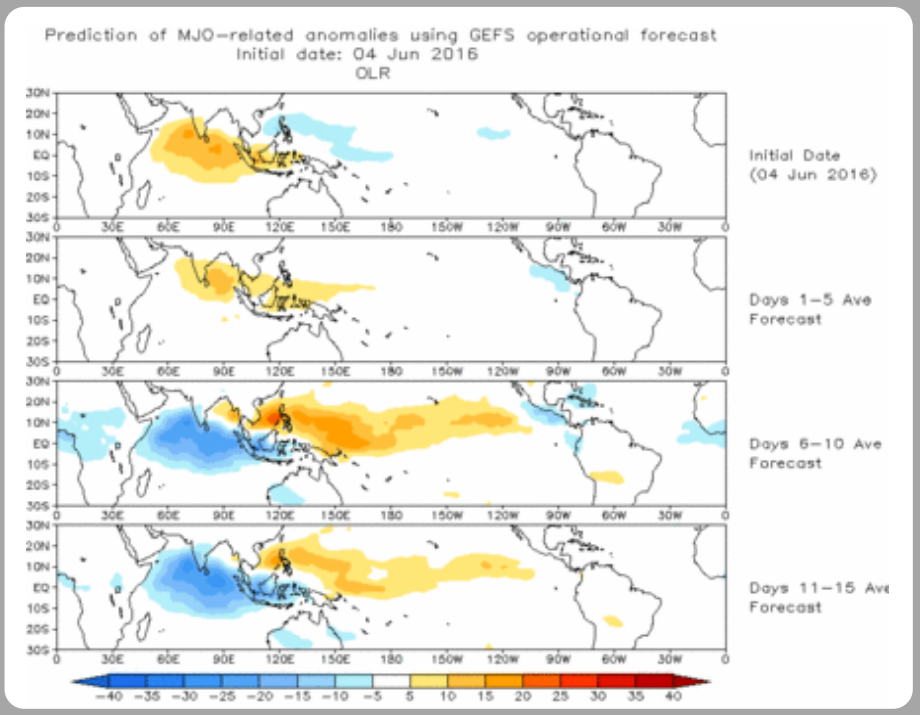
During the next two weeks, the GFS ensemble MJO index forecast depicts a weak MJO signal in Phase 7 early, which then propagates rapidly eastward across the Western Hemisphere, later increasing in amplitude over the Indian Ocean during Week-2.

Some of this complicated signal may be due to the decaying El Niño event being aliased into the RMM indices through the changing of the background 120-day mean state.

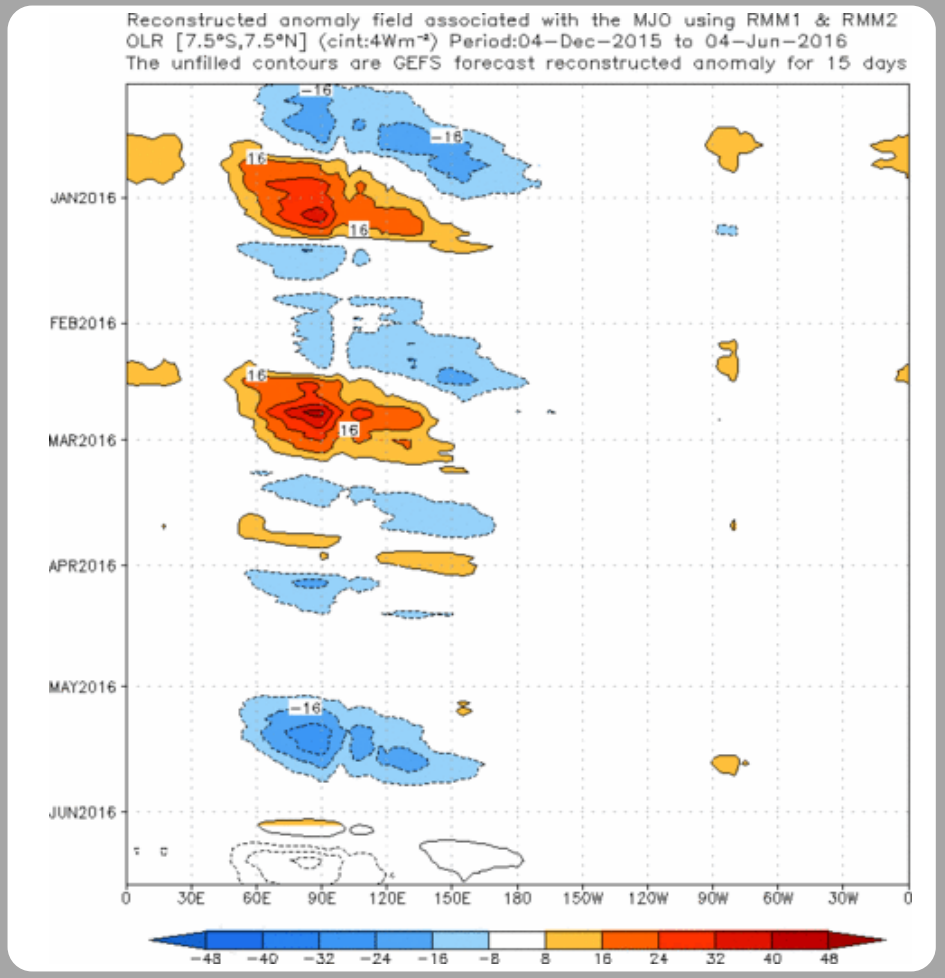
Ensemble GFS (GEFS) MJO Forecast

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



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

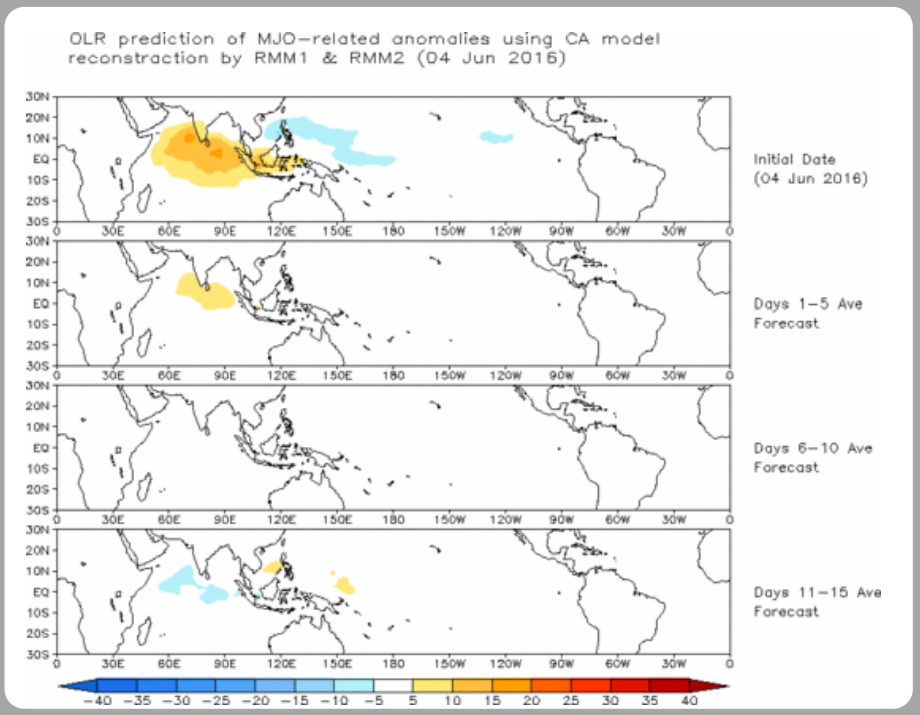


The GEFS OLR forecast based on the RMM Index depicts a strengthening convective dipole late in the period with enhanced (suppressed) convection over the Indian Ocean (West Pacific).

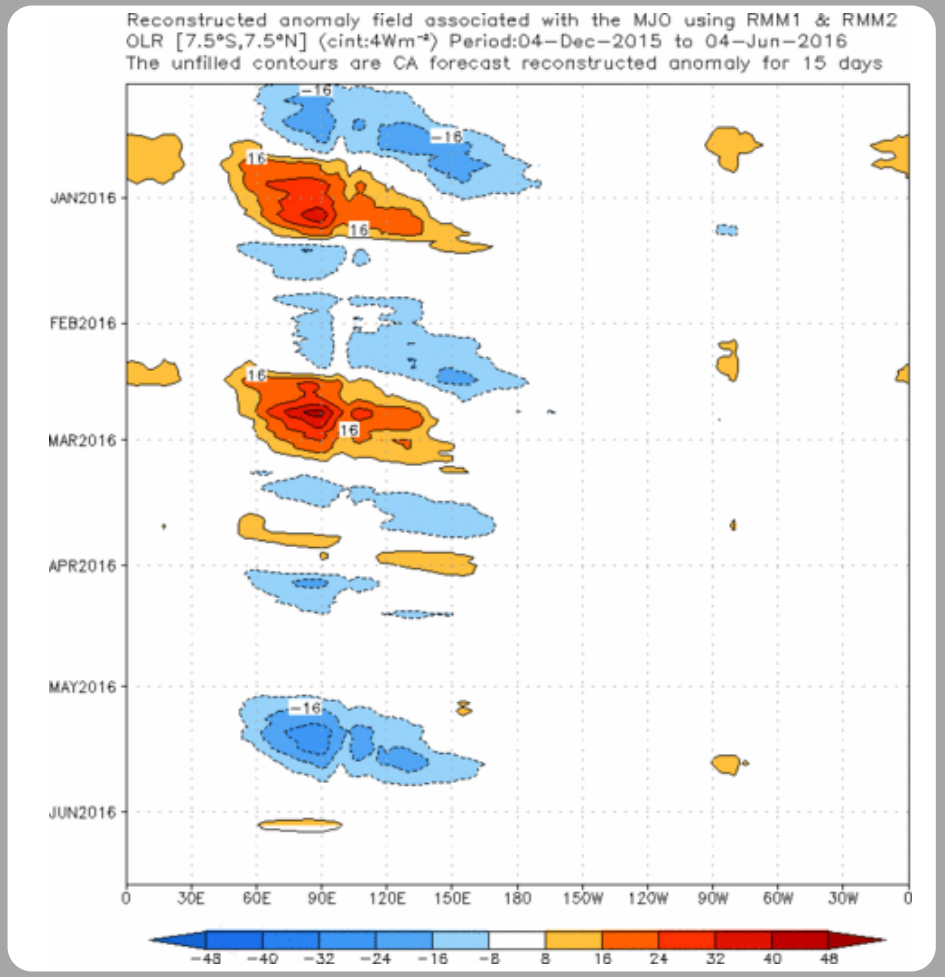
Constructed Analog (CA) MJO Forecast

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



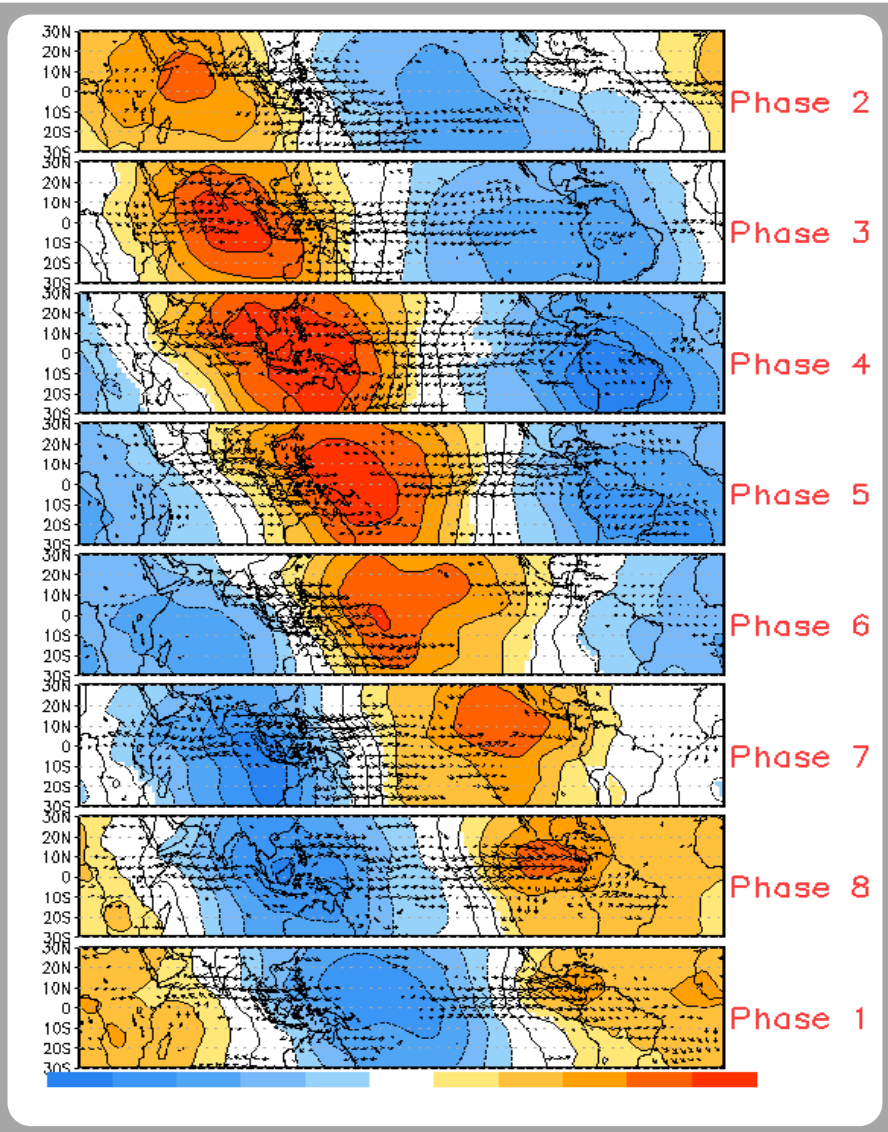
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



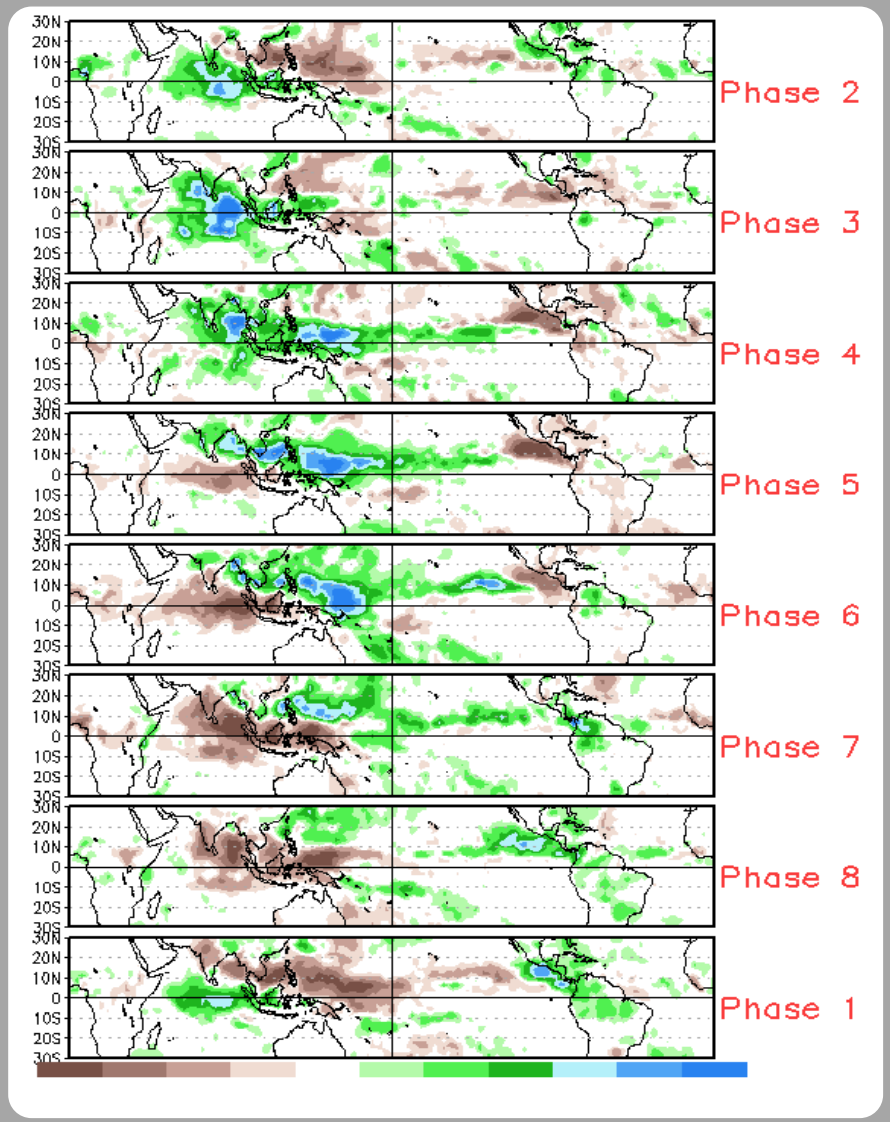
The Constructed Analog (CA) model predicts a weakening of the suppressed convection initially located over the Indian Ocean, and little if any useable signal during Week-2.

MJO Composites - Global Tropics

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



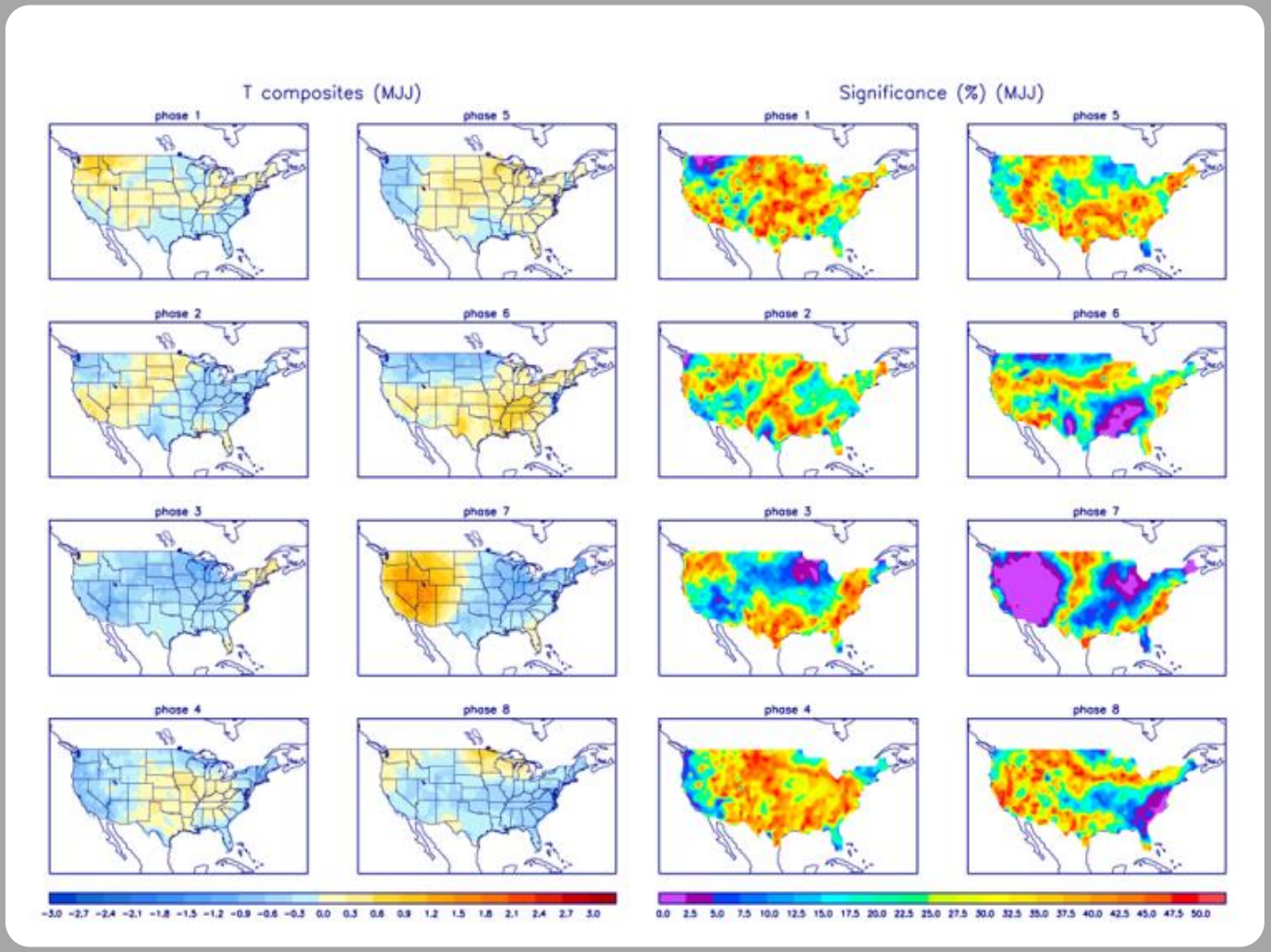
Precipitation Anomalies (May - Sep)



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.



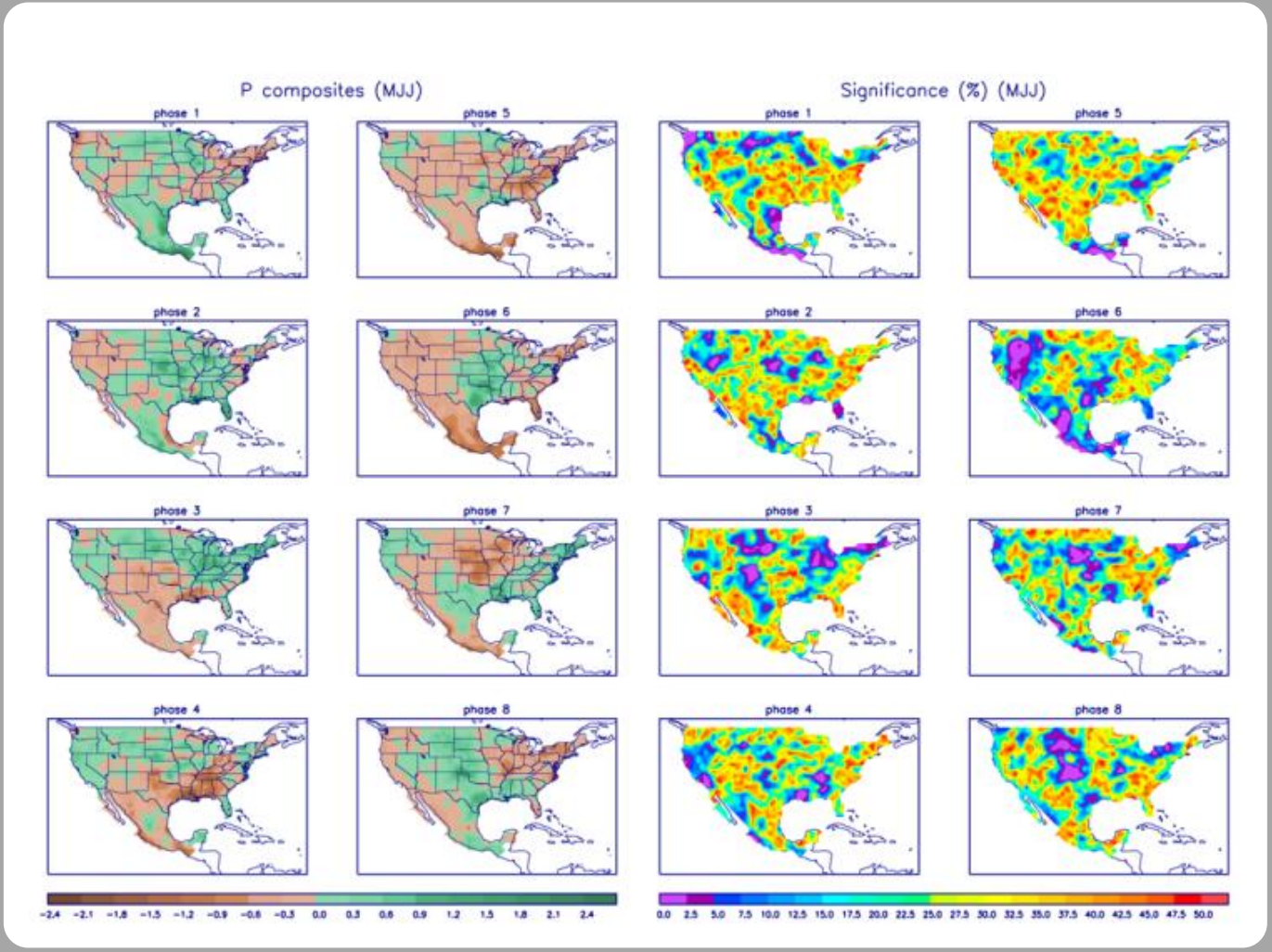
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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