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

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Climate Prediction Center / NCEP
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Overview

The MJO signal, as measured by a few variables and both the RMM and CPC indices, appears to be emerging over the western Indian Ocean.

Most dynamical models suggest continued strengthening of the signal over the Indian Ocean with some eastward propagation of the enhanced convection through the period. Statistical models are also indicating an eastward propagation, but with lower amplitude.

Extratropical impacts of the MJO on the U.S. are likely to be limited. Other factors may contribute to tropical cyclogenesis over the Gulf of Mexico and western Atlantic, later in Week-2.

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

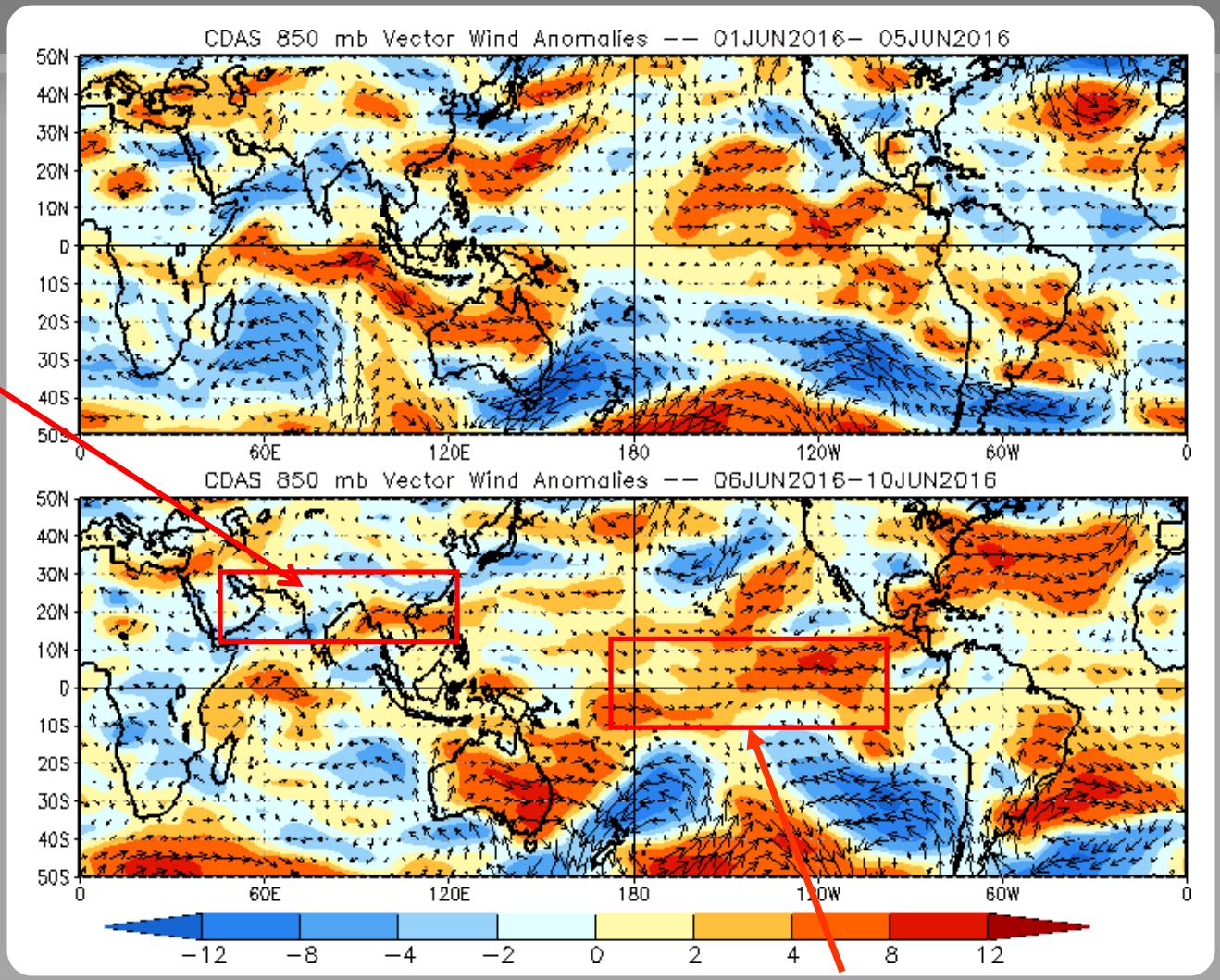
850-hPa Vector Wind Anomalies (m s-1)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Easterly anomalies over India relaxed while westerly anomalies built in over Southeast Asia.



Westerly anomalies intensified over the central and eastern 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

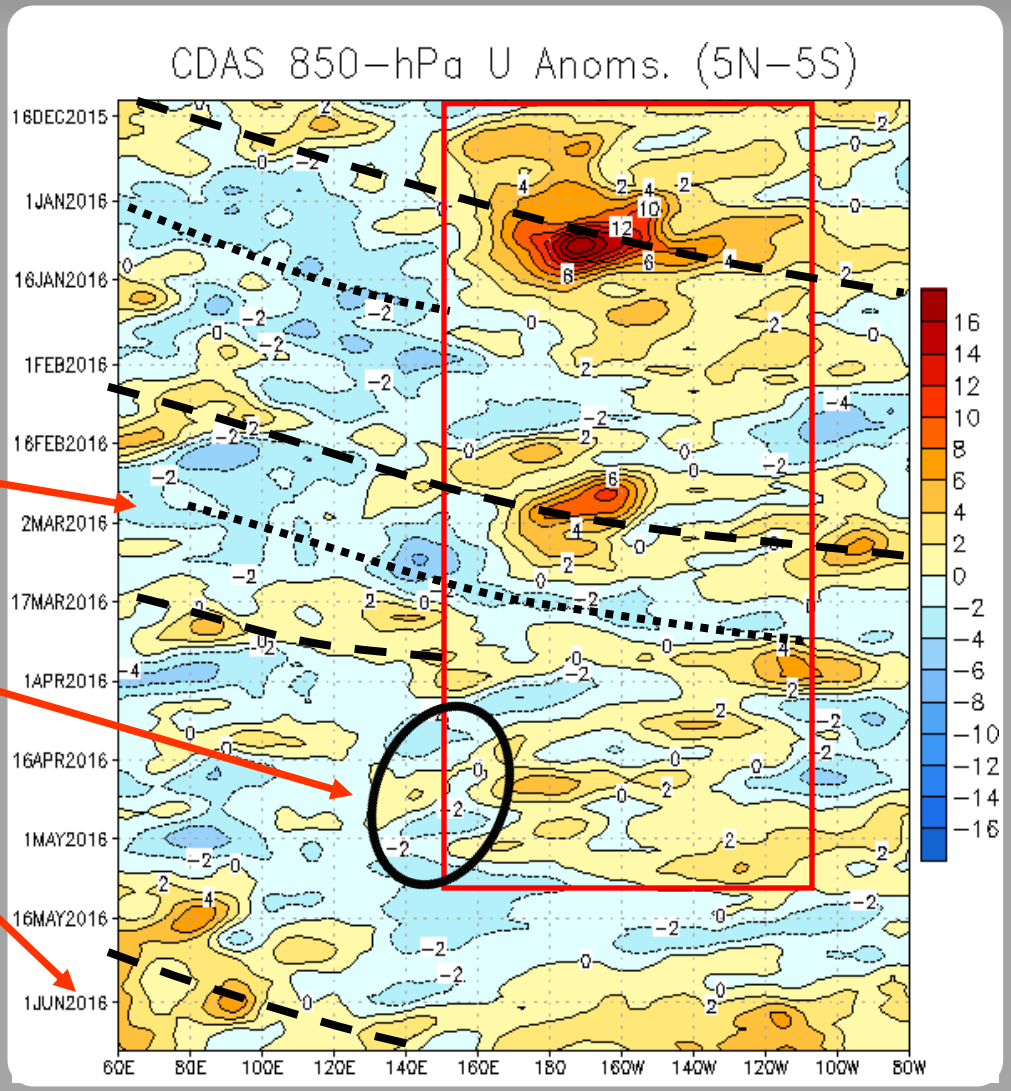
The red box highlights the persistent low-frequency westerly wind anomalies associated with the 2015-2016 El Niño background state.

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.

Recently, westerly anomalies expanded across the central and eastern Pacific.



OLR Anomalies – Past 30 days

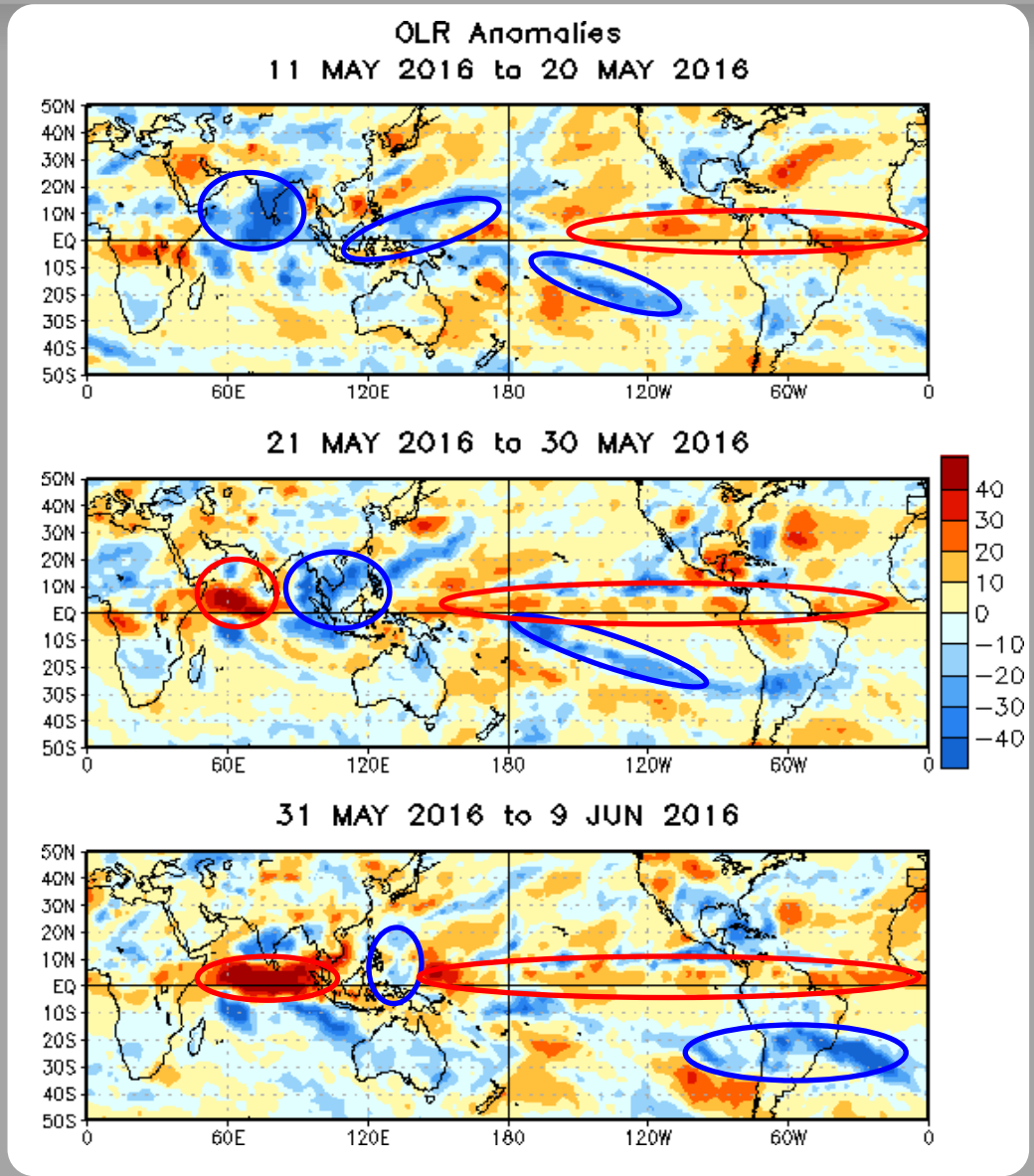
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid-to-late May, enhanced convection focused across the northern Indian Ocean and South Asia, extending eastward to the western North Pacific. Suppressed convection was observed along the equator over the eastern Pacific and the Atlantic.

During late May, enhanced convection became centered over the Maritime Continent, while the South Asian monsoon slightly waned. Suppressed convection generally remained from near the Date Line to the equatorial Atlantic.

Suppressed (enhanced) convection developed over the Indian Ocean (South Asia), while generally suppressed convection remained over the central and eastern Pacific. Convection was generally enhanced in off equatorial regions, especially near the Americas.



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

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

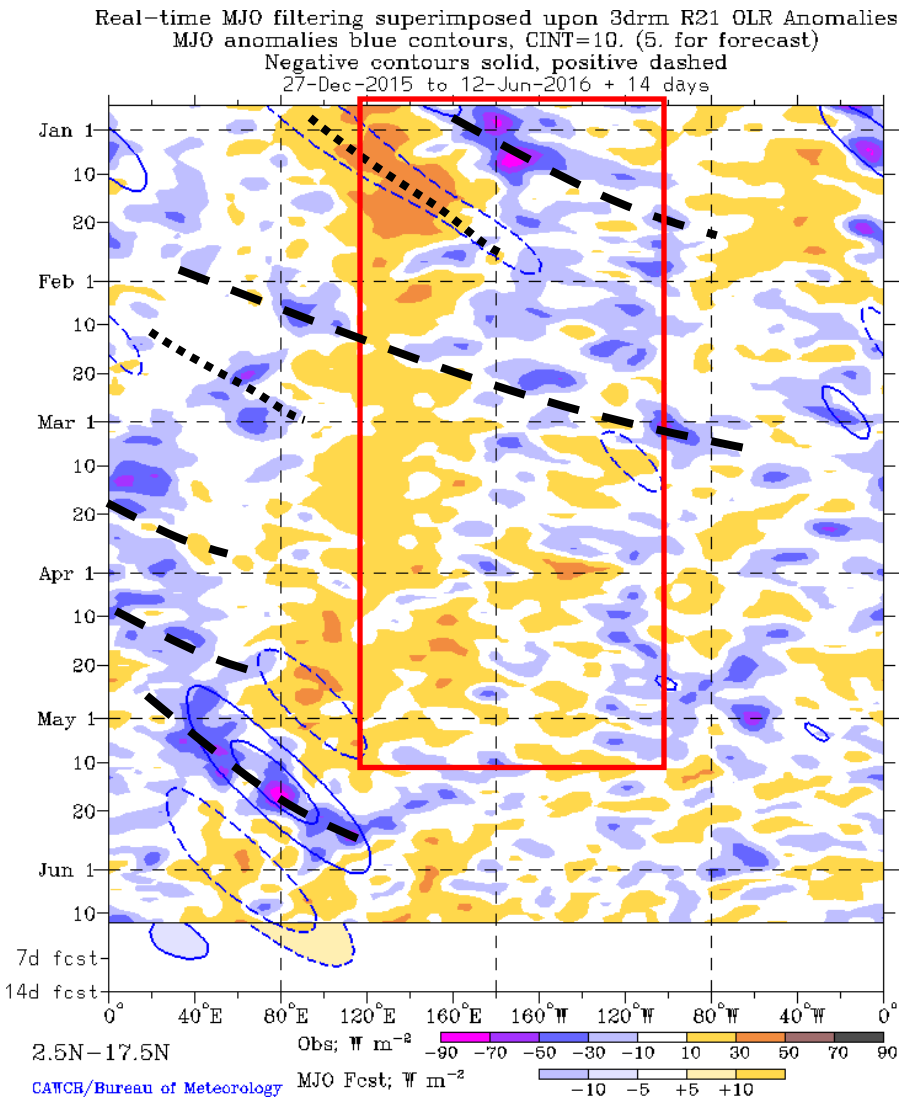
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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.

Recently, anomalies in equatorial OLR have been weak, except near and just east of the Prime Meridian.



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

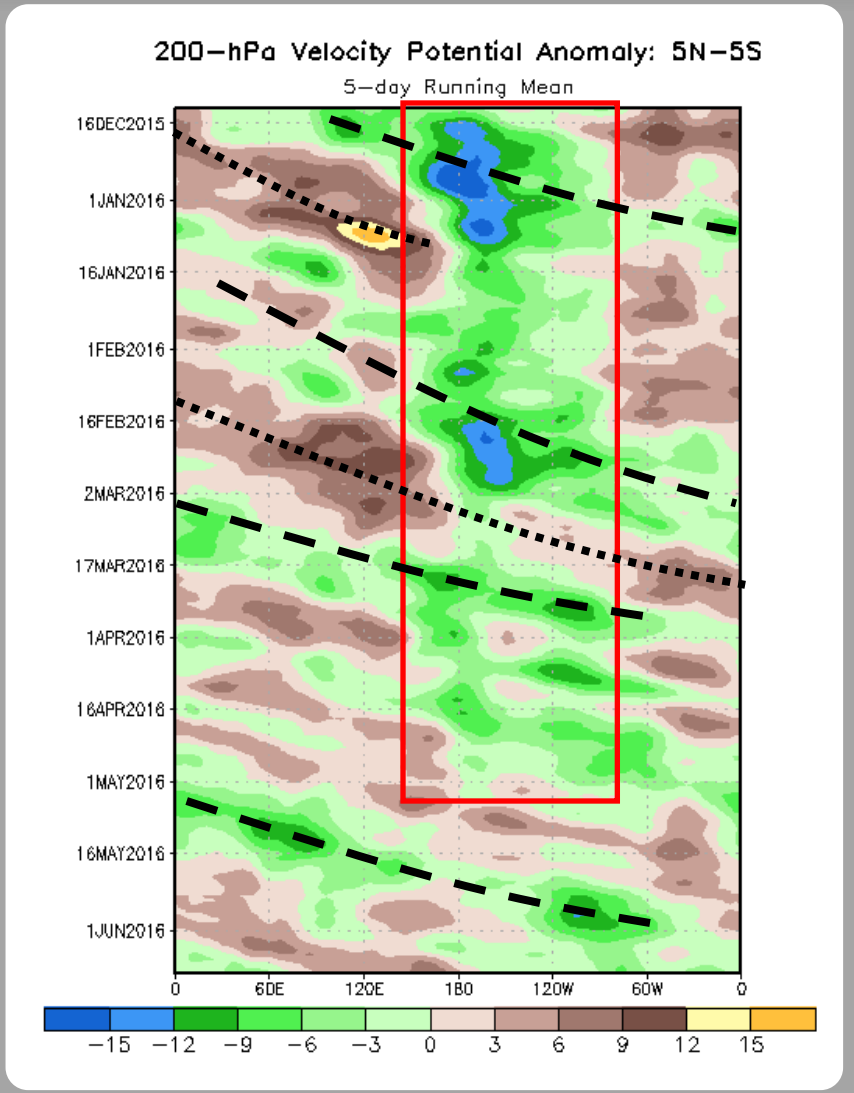
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

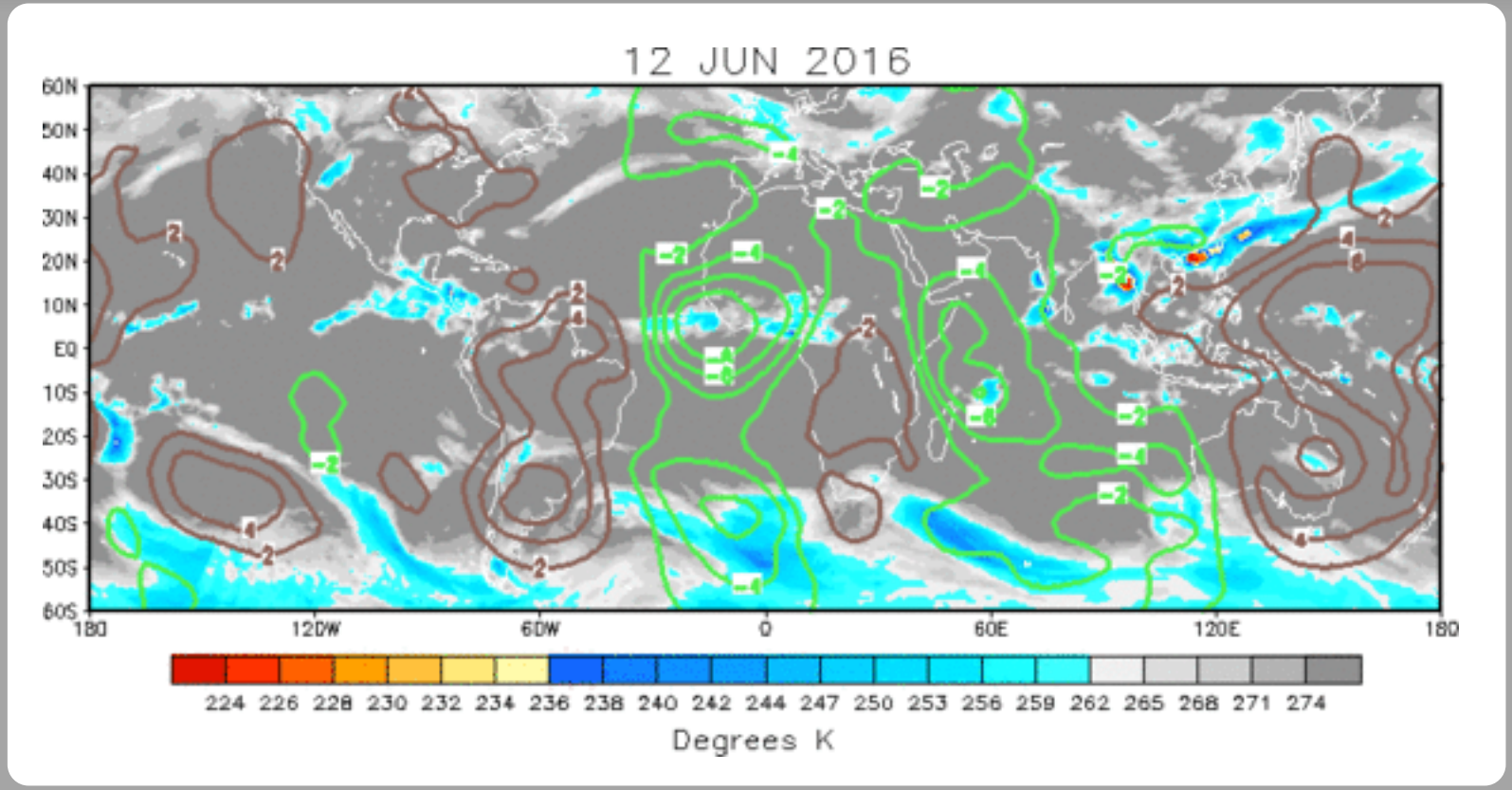
The 2015-16 El Niño background state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

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 May, enhanced divergence propagated from the Indian Ocean to the Americas, then the signal weakened. Recently, some enhanced divergence returned to the western Indian Ocean/eastern Africa.



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



The large scale upper-level velocity potential anomaly pattern is not coherent with an active MJO, but does display more organization than just a few days ago.

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)

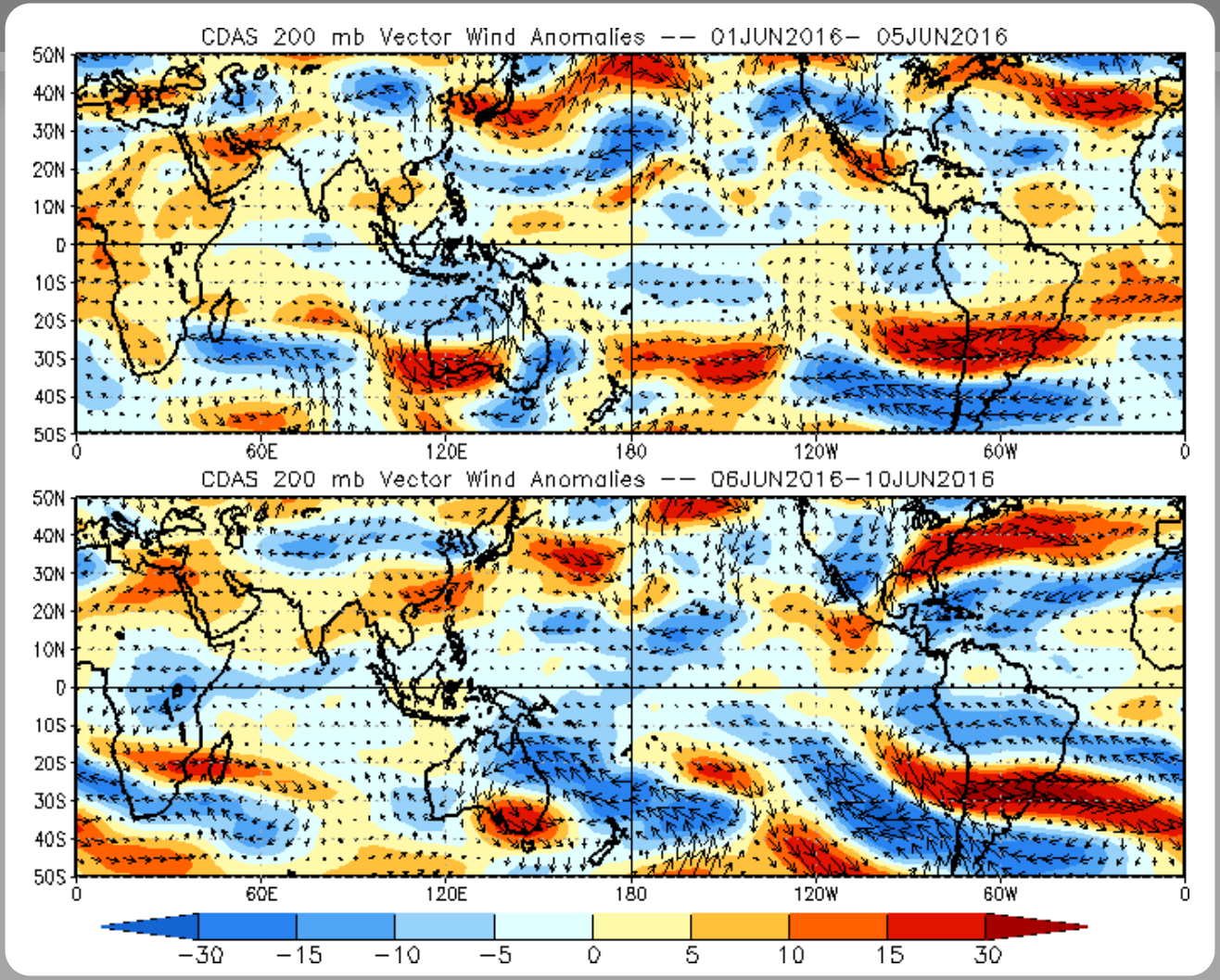
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

The pattern of upper-level anomalous winds is not coherent with an active MJO.

There are some signs of organization over the Indian Ocean and Africa.



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

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

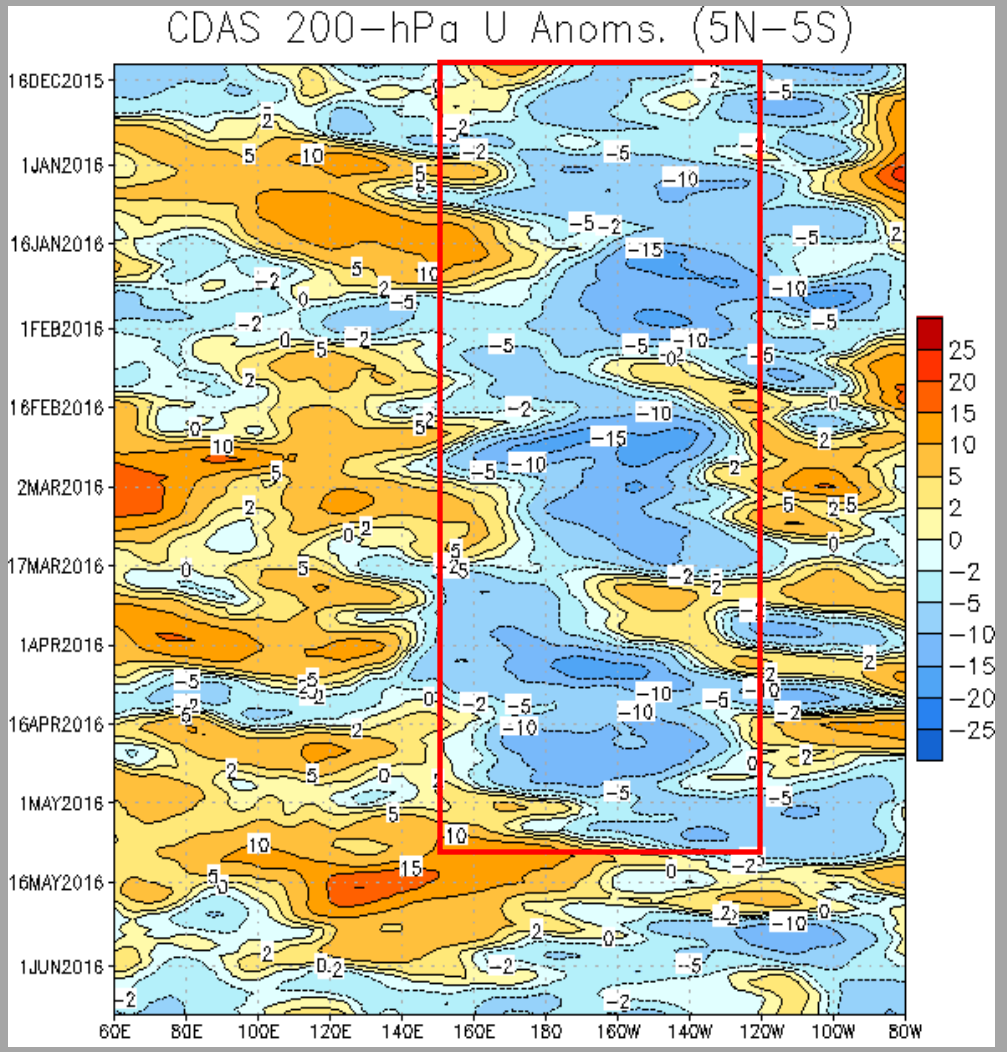
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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 have persisted across much of the tropics.



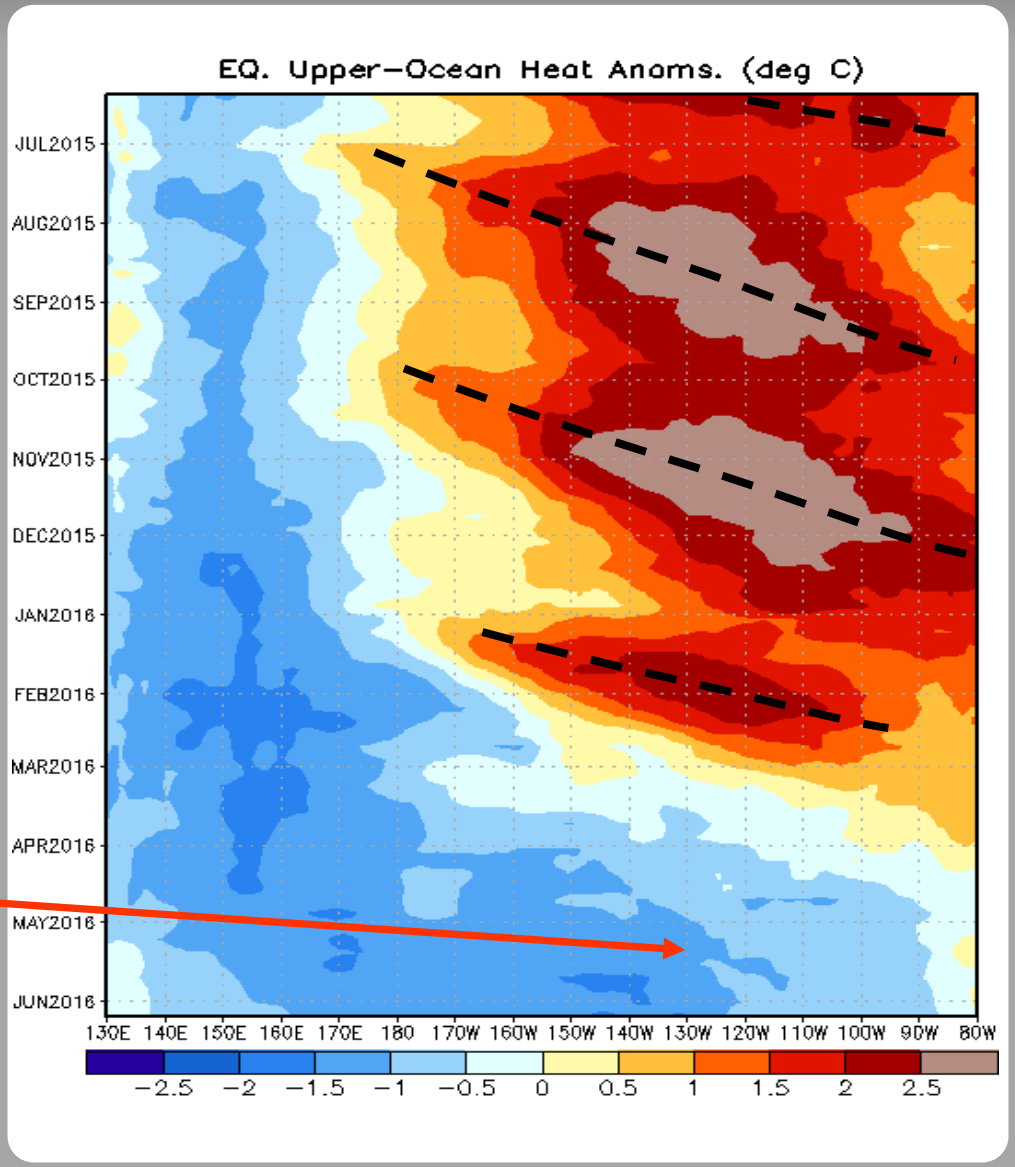
Weekly Heat Content Evolution in the Equatorial Pacific

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

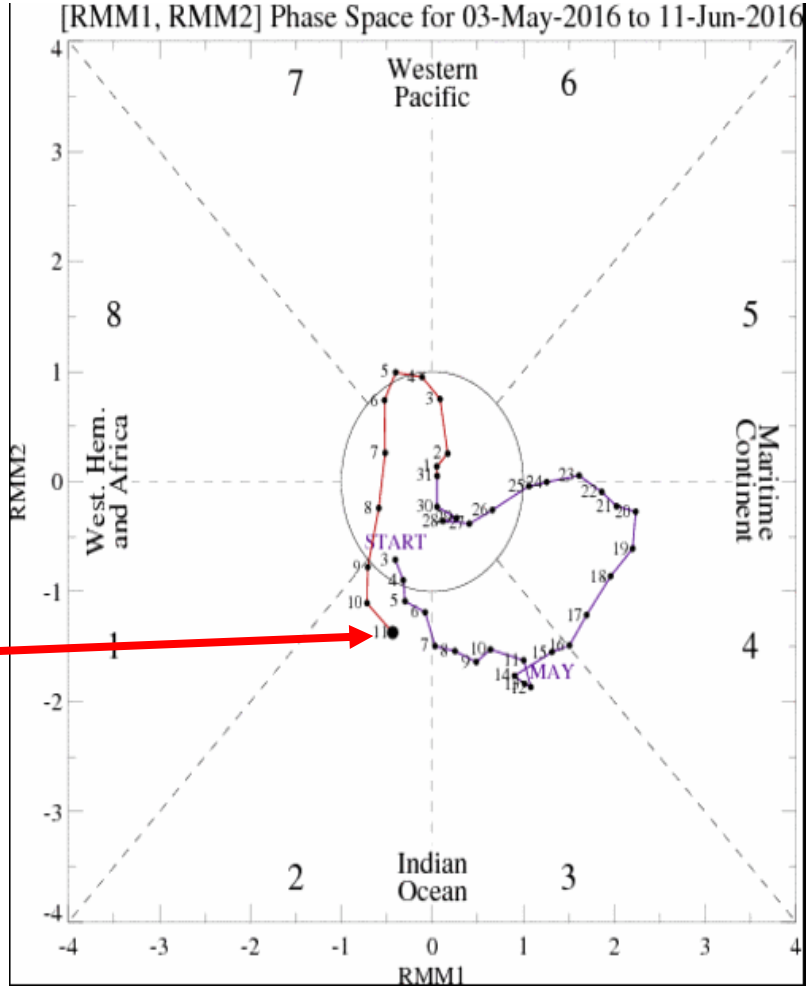
The triangular areas indicate the location of the enhanced phase of the MJO

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

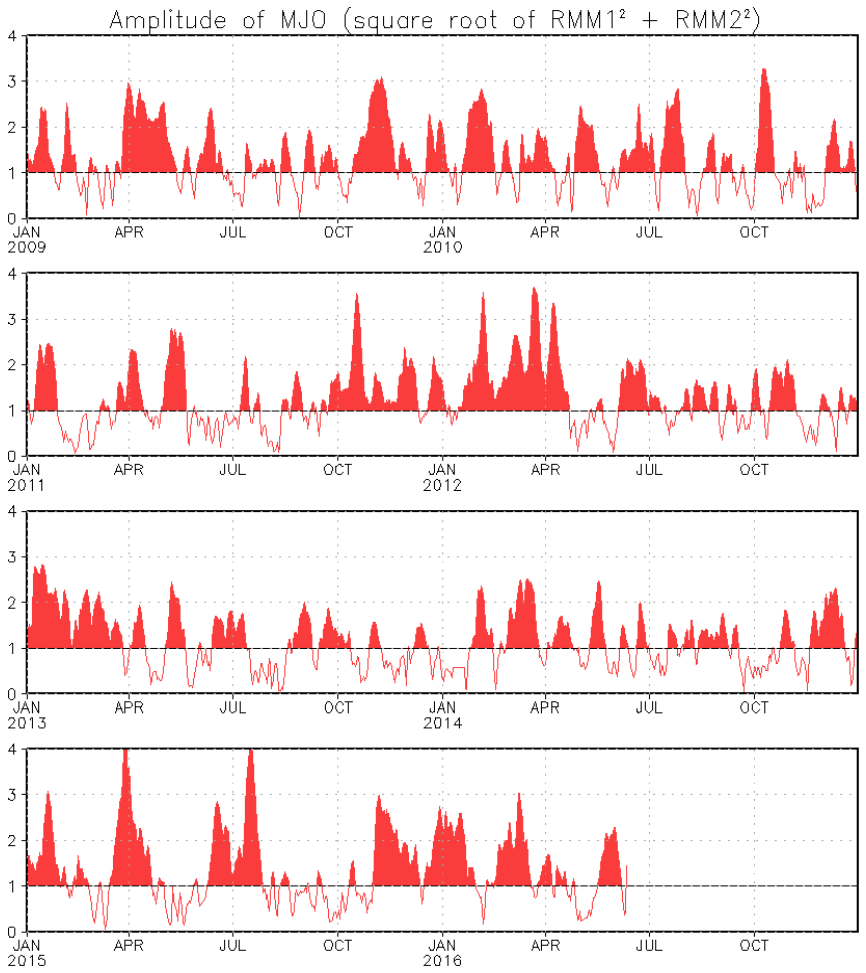
The MJO signal strengthened slightly during the last couple of days, with a signal emerging over the western Indian Ocean.



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

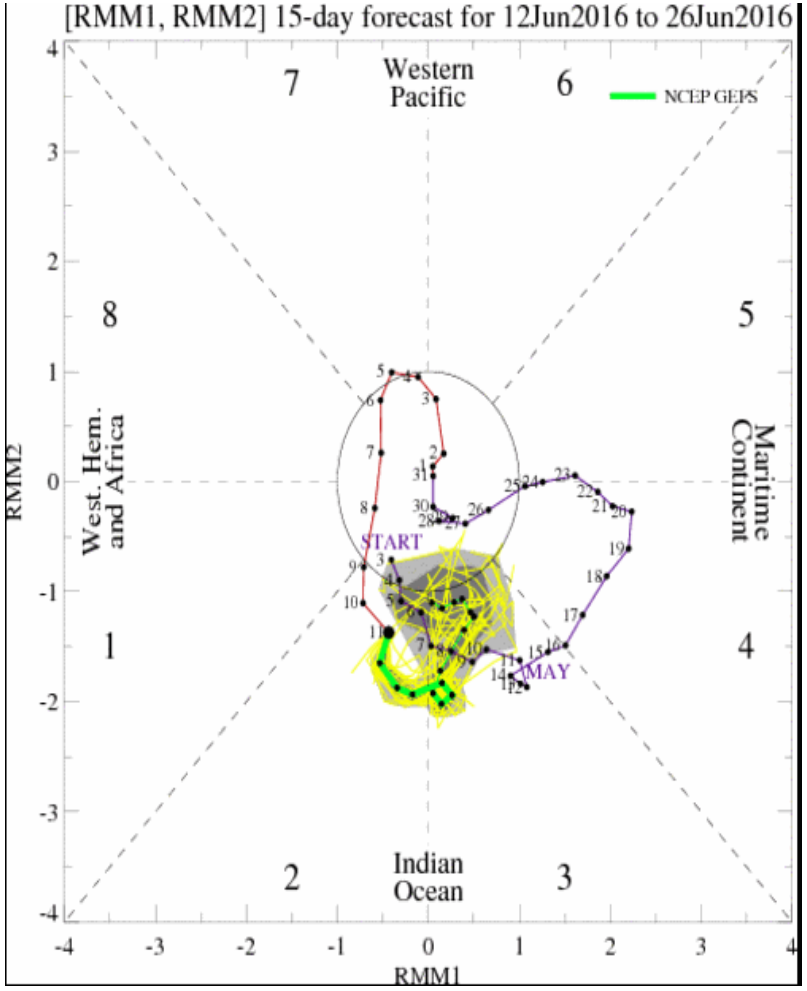
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

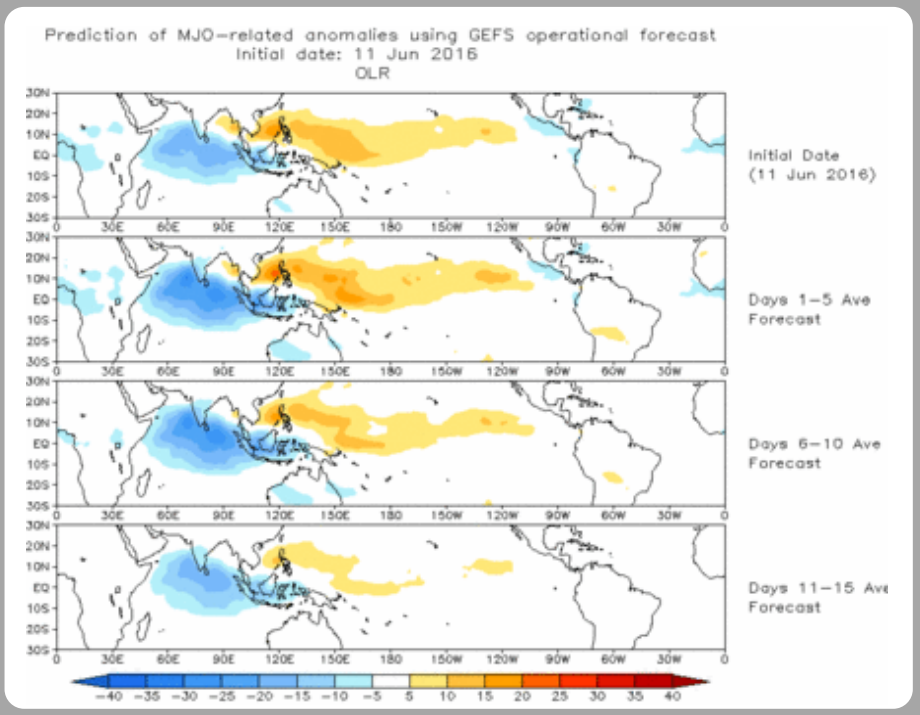
During the next two weeks, the GFS ensemble indicates a strengthening signal over the Indian Ocean, with little to no propagation during Week-2.



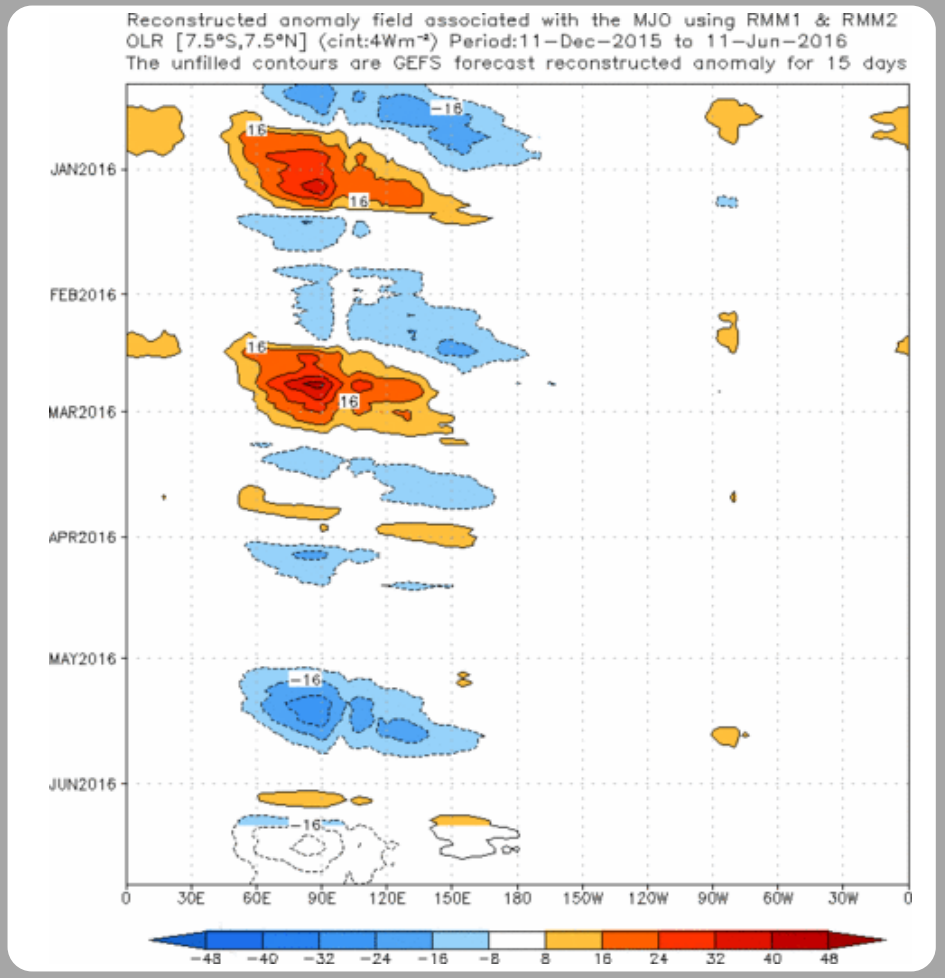
Ensemble GFS (GEFS) MJO Forecast

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

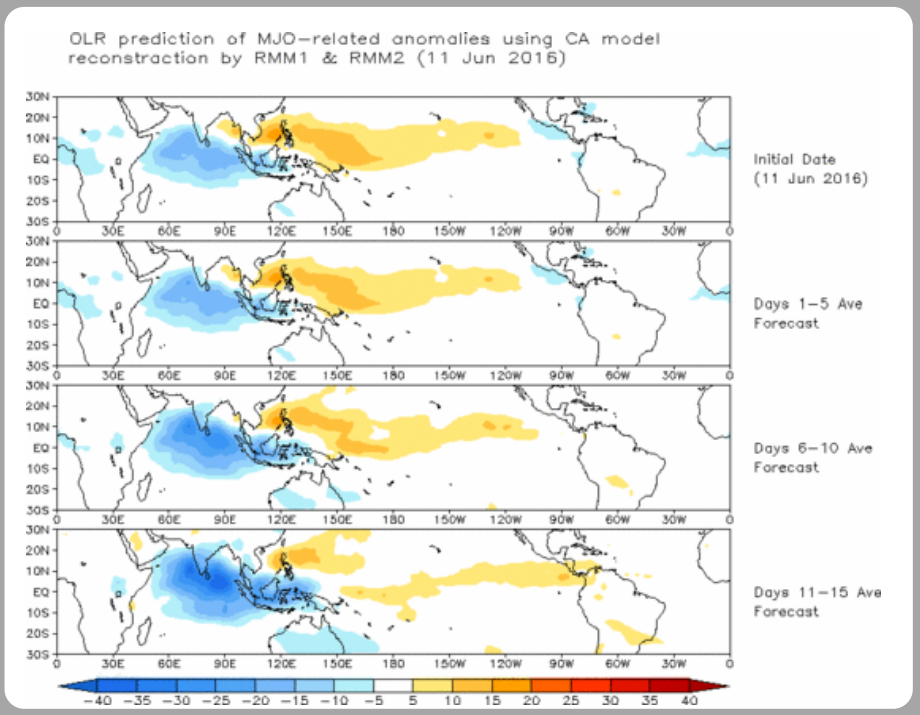


The GEFS OLR forecast based on the RMM Index depicts strengthening enhance (suppressed) convection over the Indian Ocean (western and central Pacific), with little propagation.

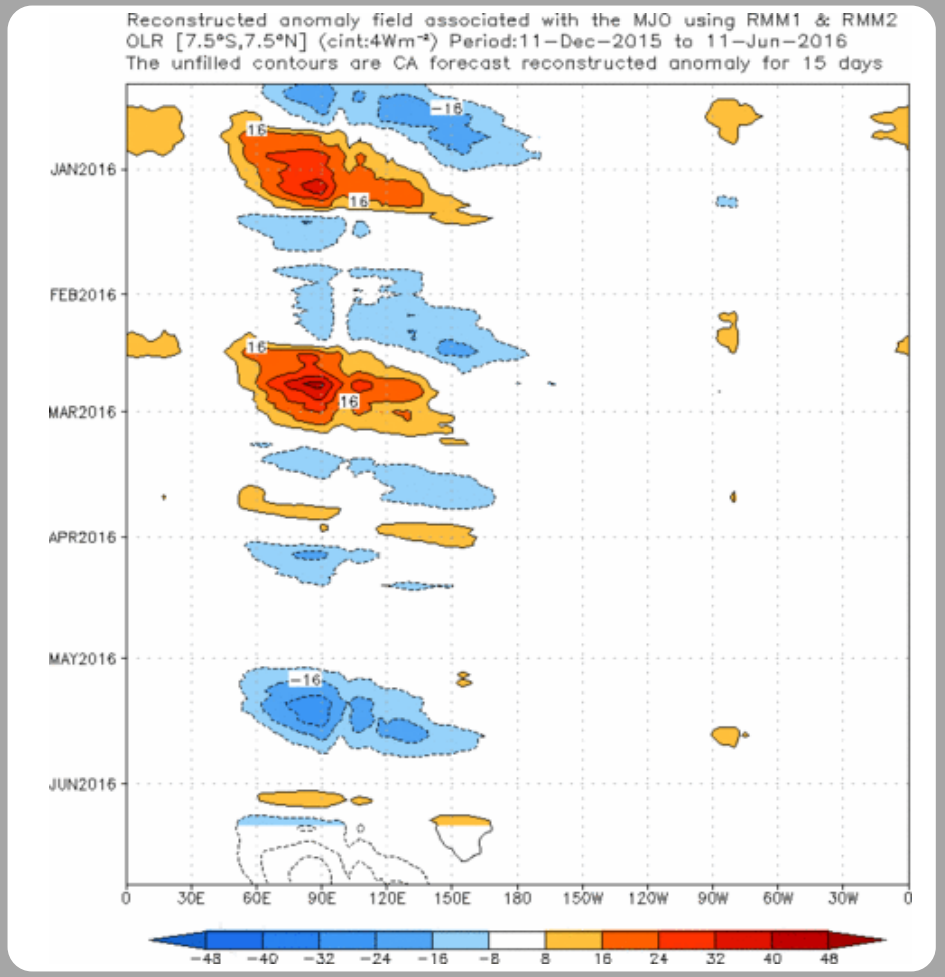
Constructed Analog (CA) MJO Forecast

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



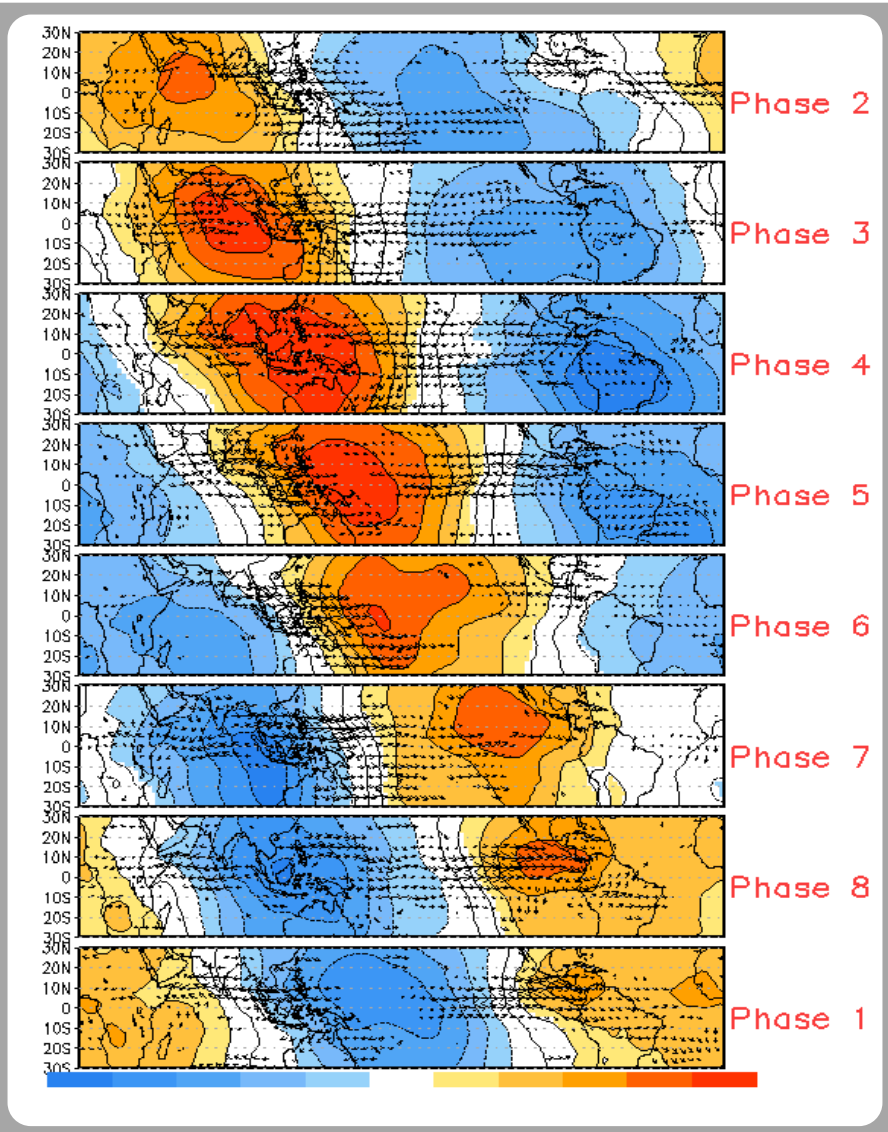
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



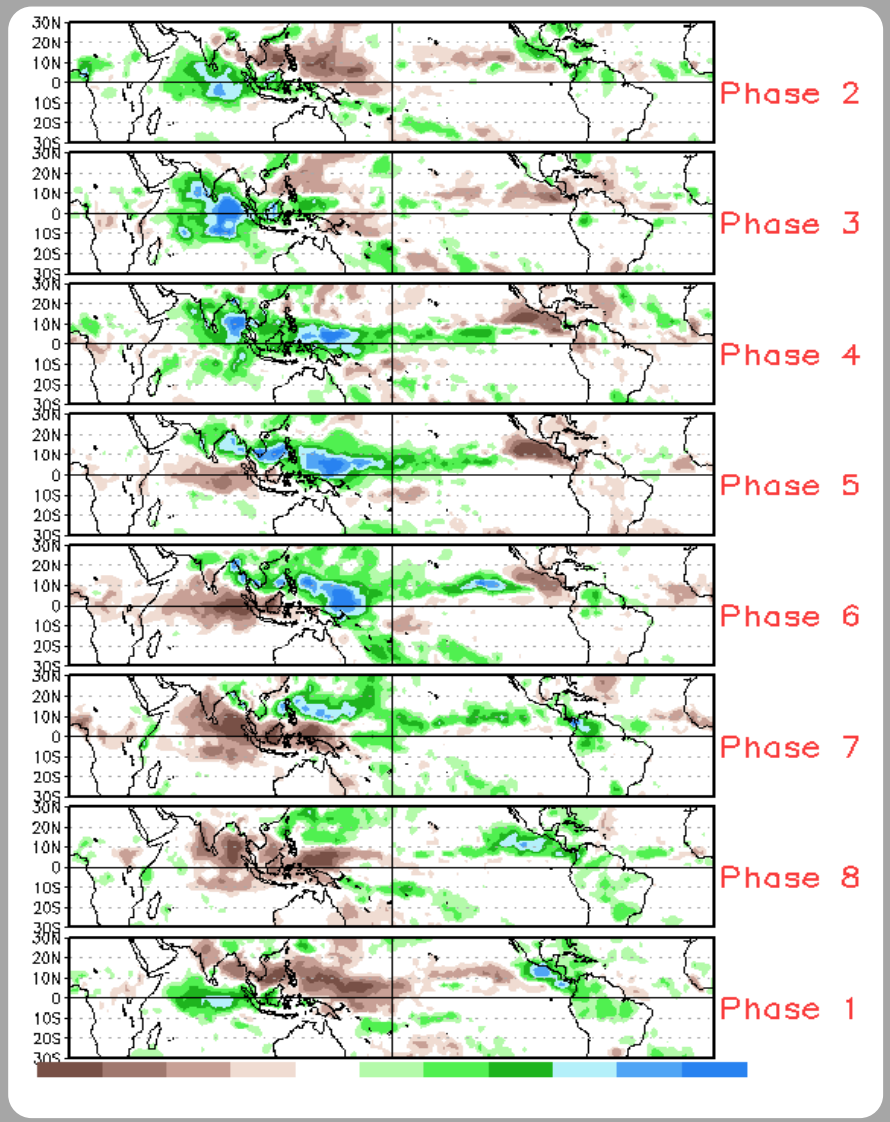
The Constructed Analog (CA) model predicts enhanced convection to move from the Indian Ocean to over the Maritime Continent with suppression reaching the Americas.

MJO Composites - Global Tropics

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



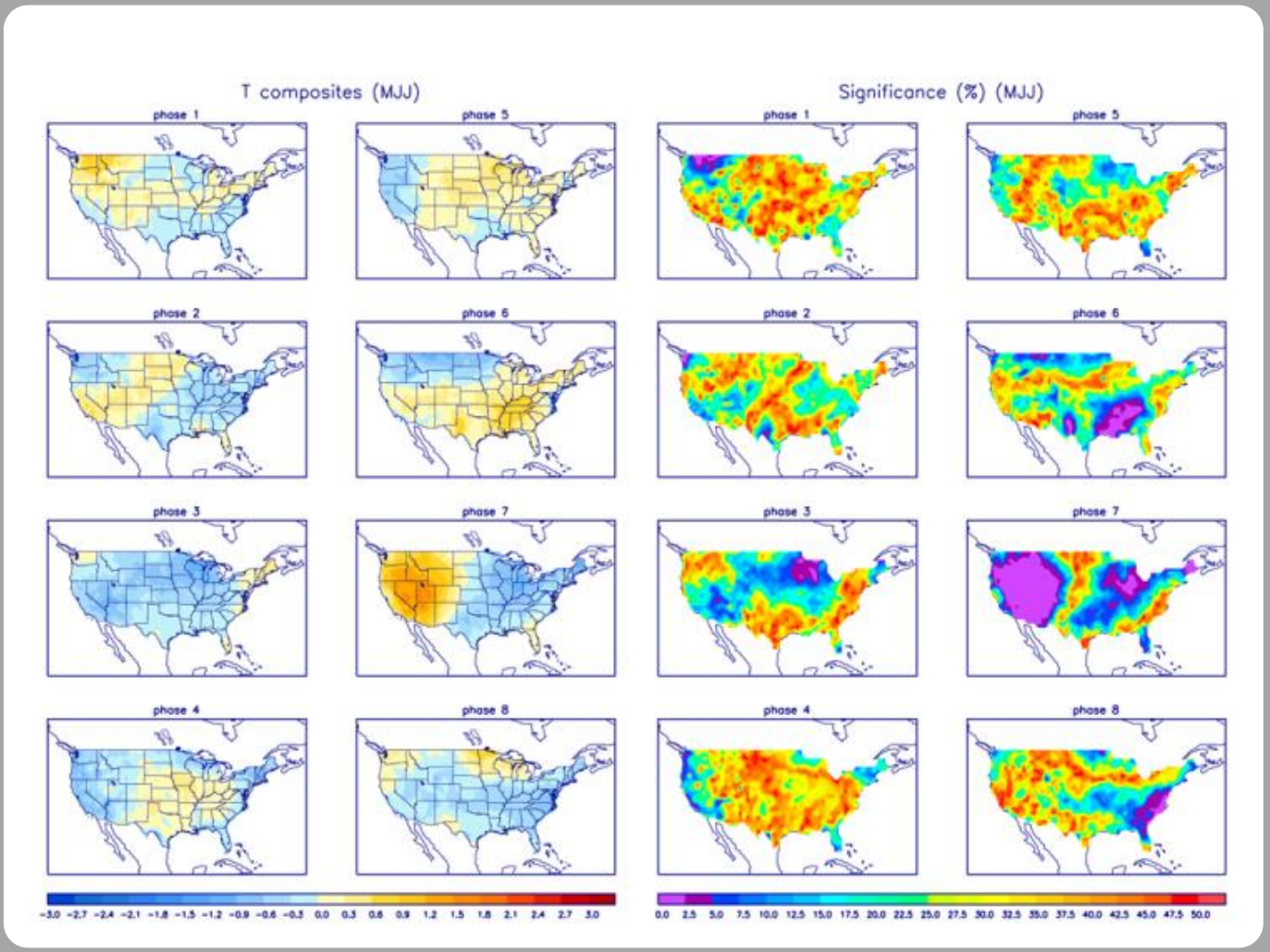
Precipitation Anomalies (May - Sep)



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.



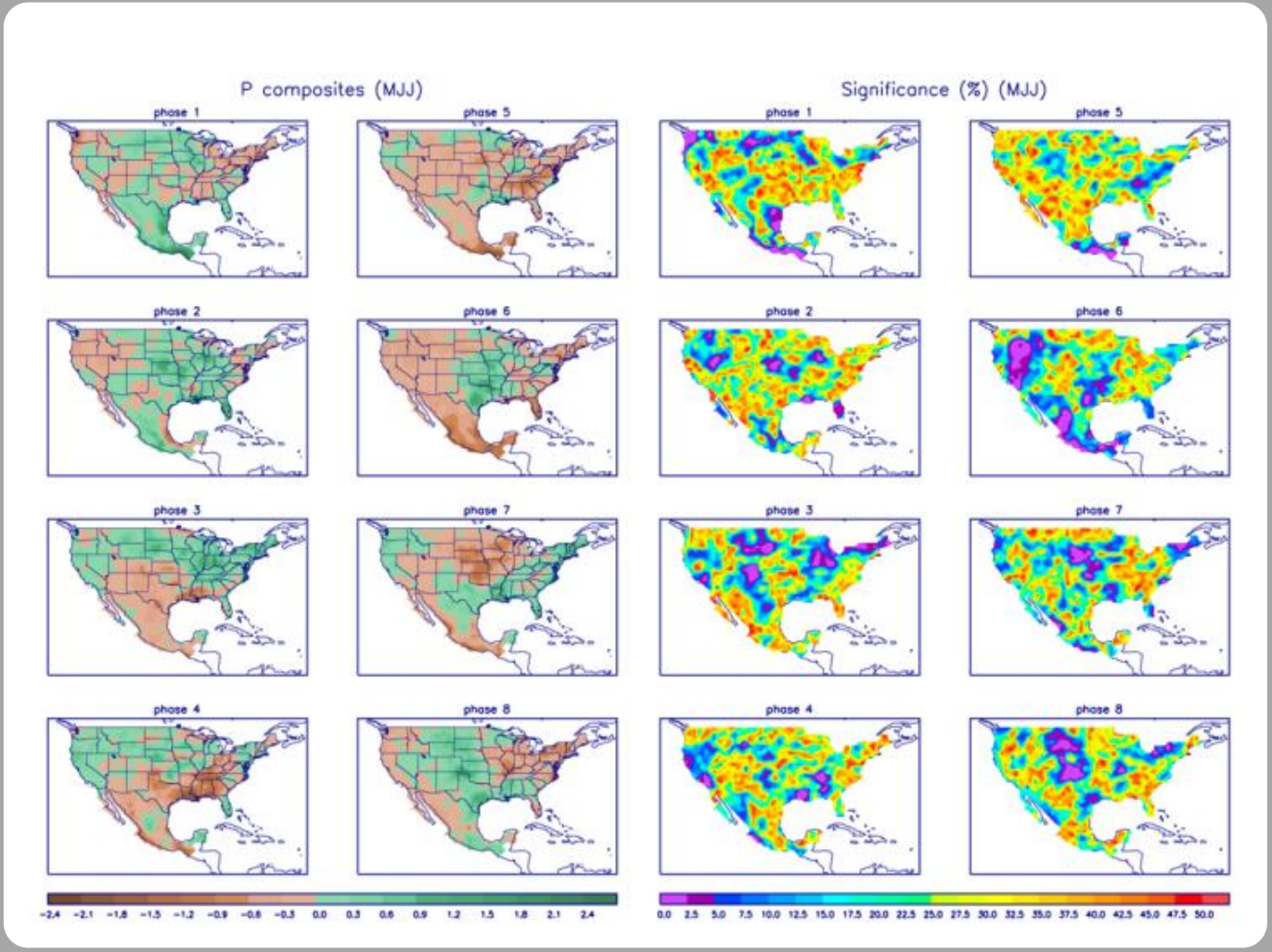
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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