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

Update prepared by:
Climate Prediction Center / NCEP
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Outline

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MJO Index Forecasts

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Overview

During the last week, the MJO signal has become more coherent in both the RMM and CPC indices. The enhanced phase is centered over the Indian Ocean and western Maritime Continent.

There is little consensus among the various dynamical models, so the future evolution of the MJO and other tropical variability is very uncertain.

Tropical cyclone activity is ongoing over the East Pacific with below-average odds of formation over the next one to two weeks. There is some risk of the Atlantic main development region becoming active over the next two weeks.

Enhanced rainfall is likely over the Maritime Continent over the next two weeks. Suppressed rainfall is likely over parts of the central Pacific.

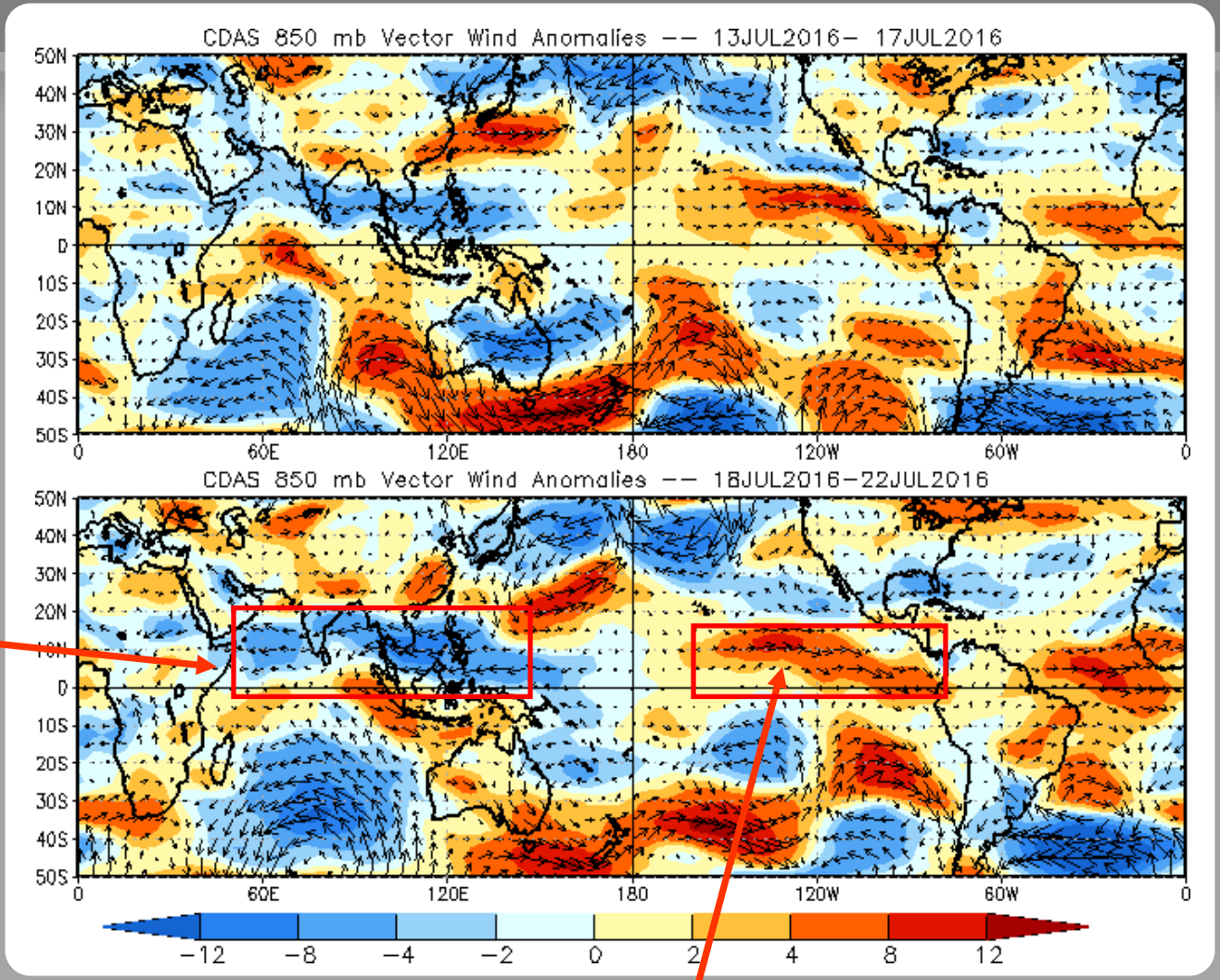
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 persisted over the northern Indian Ocean, extending into the West Pacific .

Westerly anomalies persisted over the East Pacific associated with ongoing tropical cyclone activity.

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

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

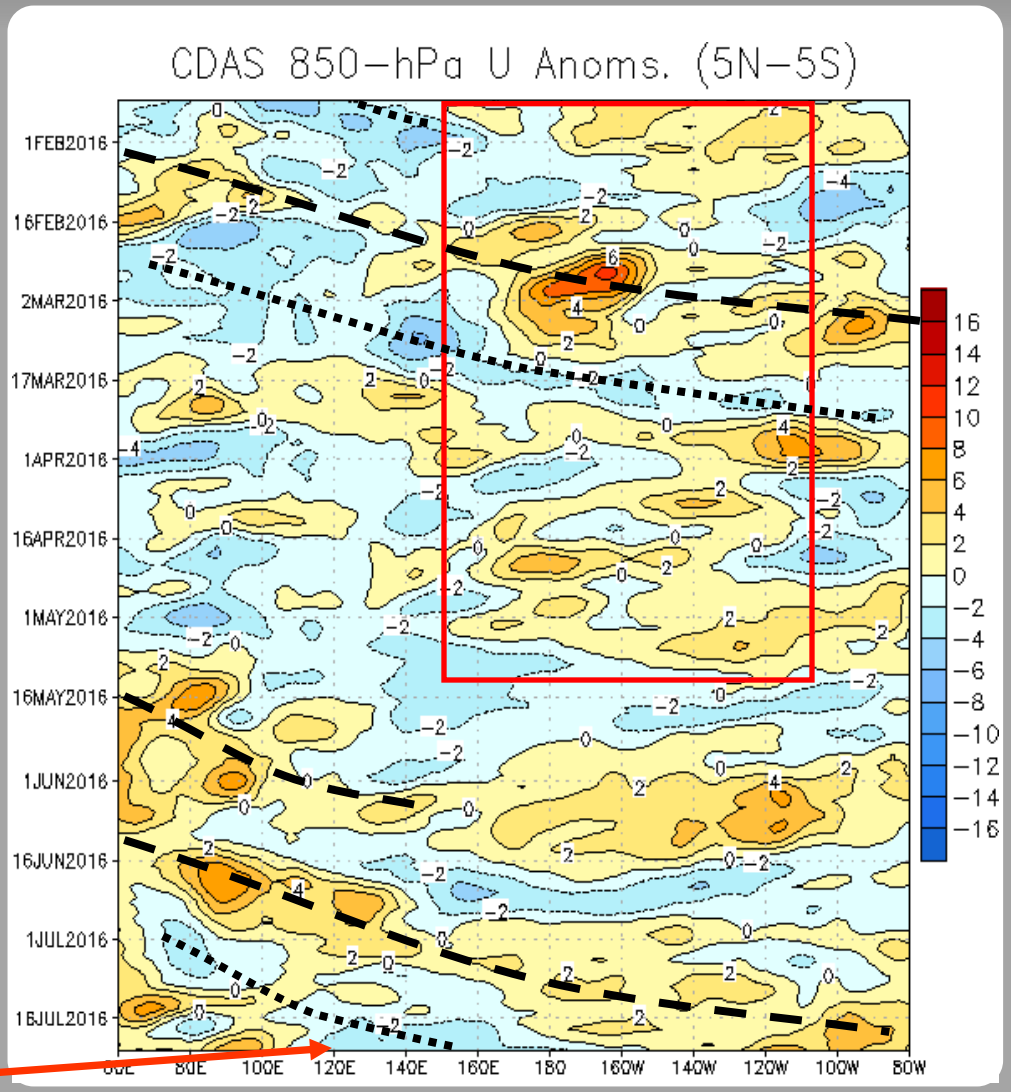
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

Fast-propagating intraseasonal events (long (short) dashed lines for the enhanced (suppressed) phase, modulated the El Niño base state.

During April, the wind field became less coherent as El Niño conditions weakened, while in early May, westerly anomalies move across the Indian Ocean. During June, westerly anomalies generally prevailed across the Indian Ocean and Pacific, with the exception of a brief transition in mid-month.

Recently, easterly anomalies have emerged over the Maritime Continent and western Pacific.



OLR Anomalies – Past 30 days

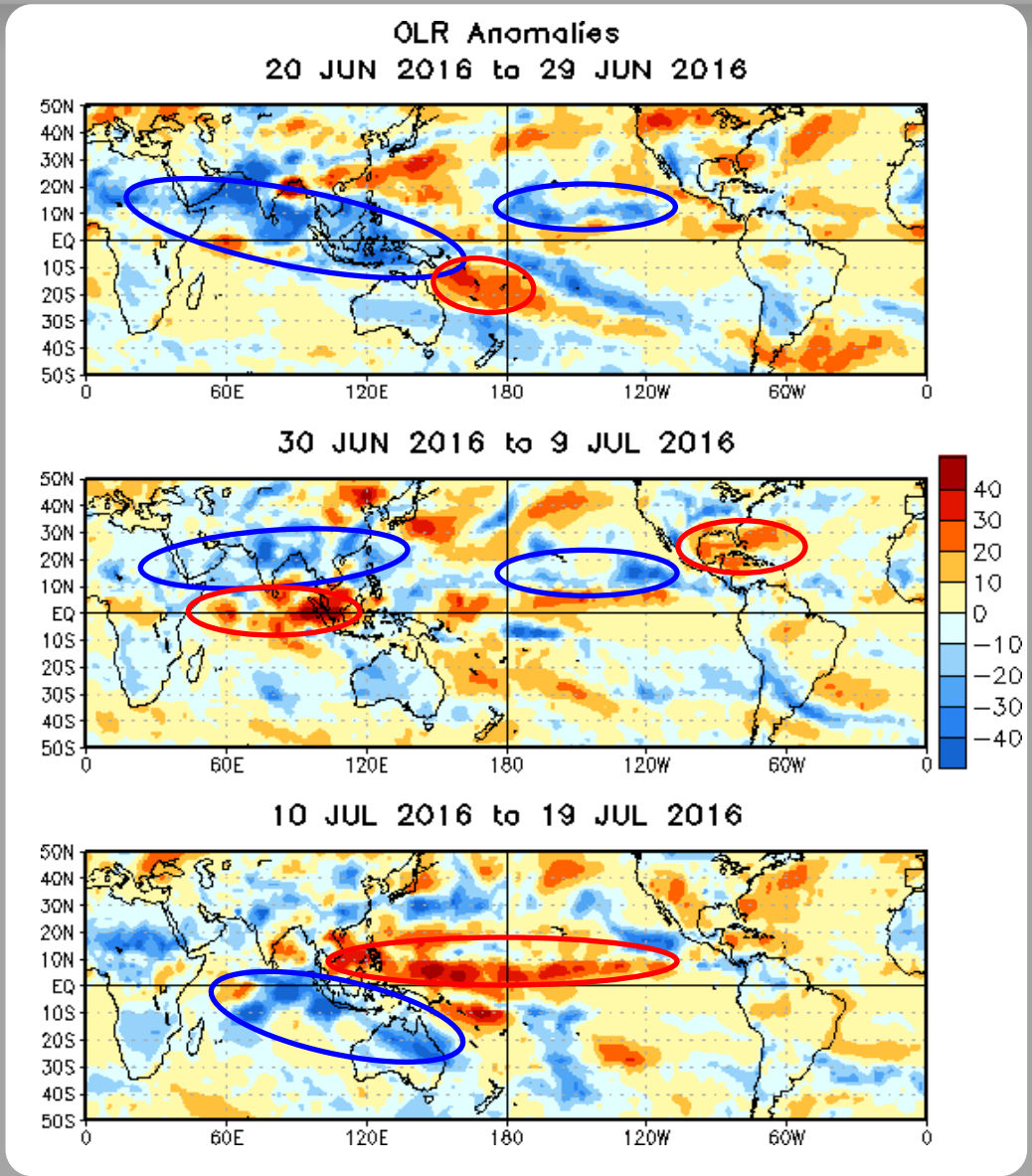
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

Enhanced convection stretched from Africa to the Maritime Continent, while suppressed convection was observed over the South Pacific Islands in late June.

In early July, enhanced convection shifted northward over Southern Asia, while suppressed convection developed over the equatorial Indian Ocean. Off-equatorial, enhanced convection remained in place over the eastern Pacific as tropical cyclone activity picked up.

During mid-July, suppressed convection extended from the South China Sea eastward across the equatorial Pacific. Enhanced convection stretched from the Indian Ocean to the southern Maritime Continent and northern Australia.



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

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

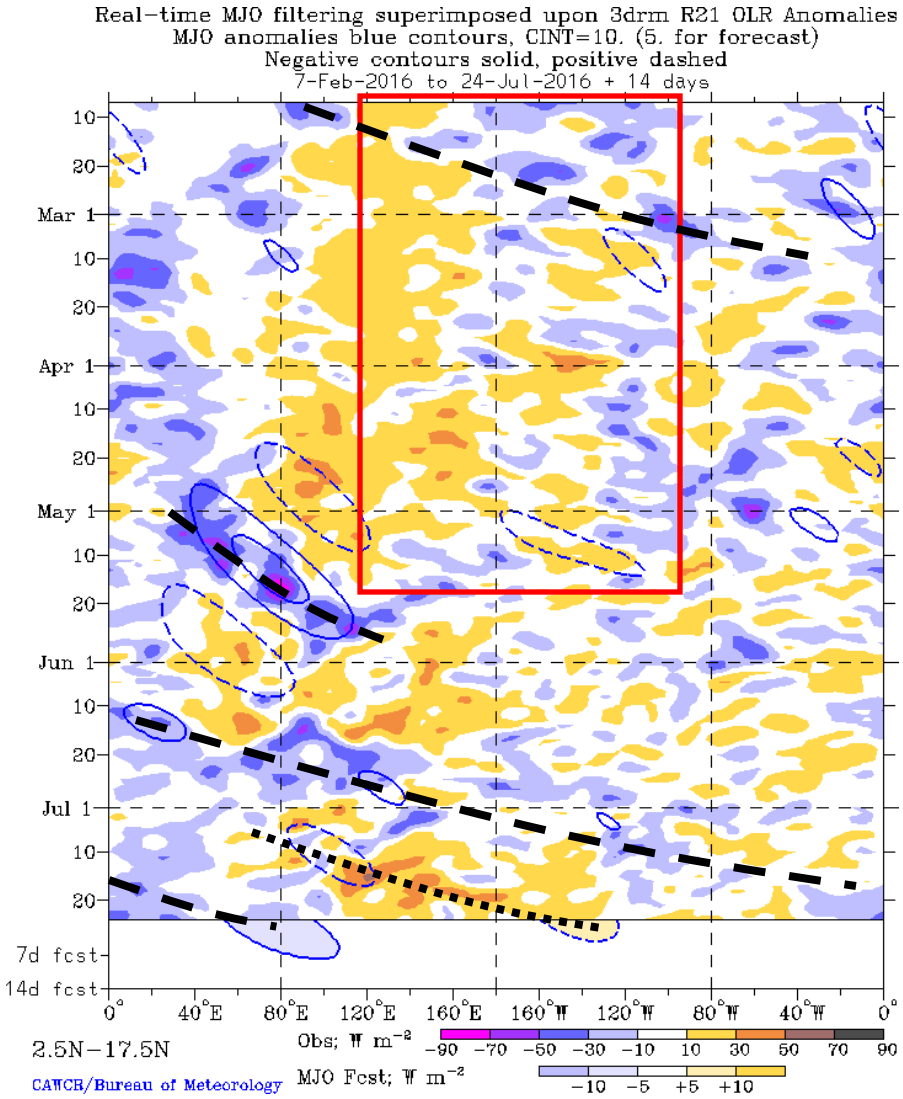
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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. The signal weakened steadily through boreal Spring.

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

During early May, an eastward-propagating convective envelope associated with the MJO developed east of the Prime Meridian. During mid-June, some enhanced convection was evident over Maritime Continent.

Recently, signals have been mixed, with tropical cyclone activity evident in the patterns, especially over the eastern Pacific.



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

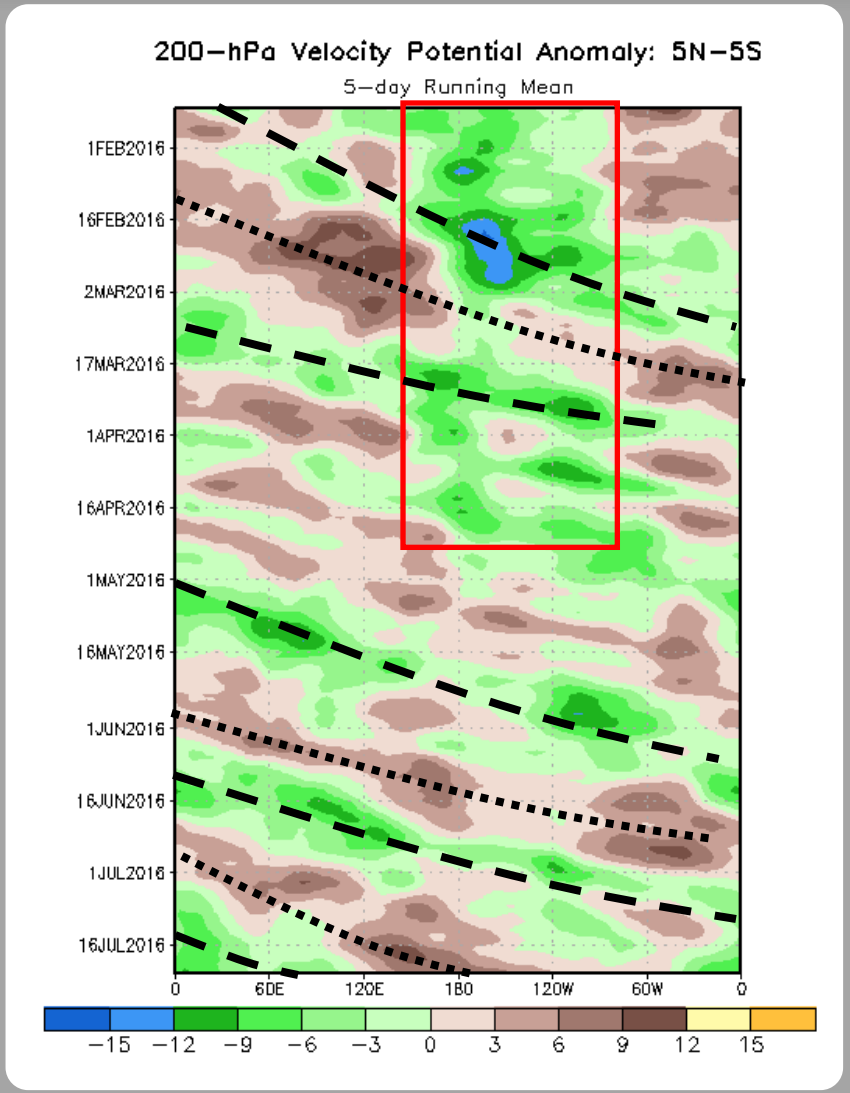
The 2015-16 El Niño background state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

MJO activity was evident in February and March, alternatively constructively and destructively interfering with the ENSO background state.

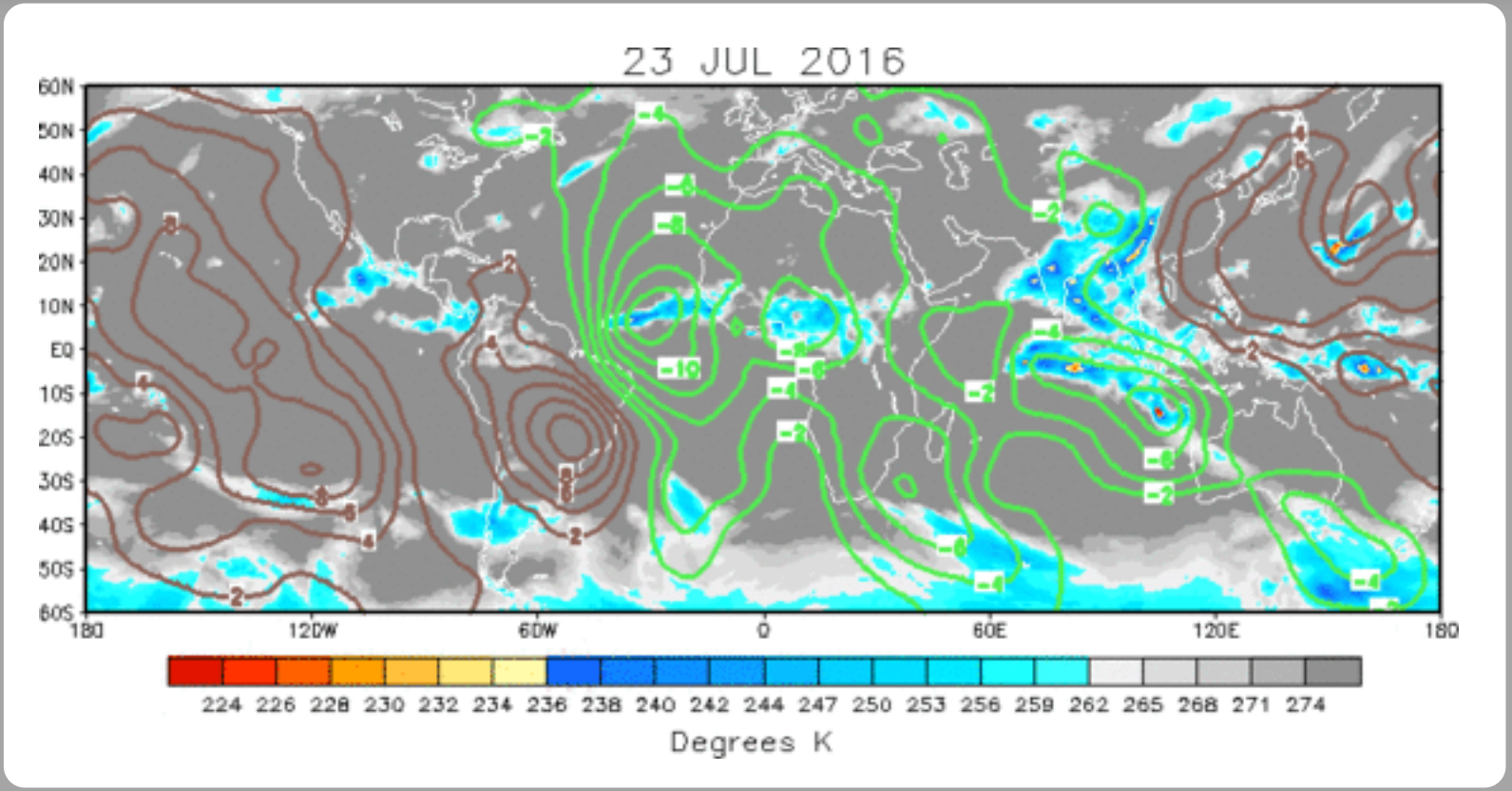
The upper-level velocity potential pattern became less coherent as the El Niño waned during April.

From May through the present time, an eastward propagating signal was evident in the upper-level velocity potential field. This signal was more coherent in time and space than the low-level MJO indicators.

Anomalous divergence is now evident over Africa and the Indian Ocean, as well as the Maritime Continent. Anomalous convergence is centered just east of the Date Line.



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



The large scale upper-level velocity potential anomaly pattern exhibits a coherent Wave-1 structure. The anomalies indicate enhanced divergence (convergence) from the eastern Atlantic eastward to the Maritime Continent (West Pacific to the Americas).

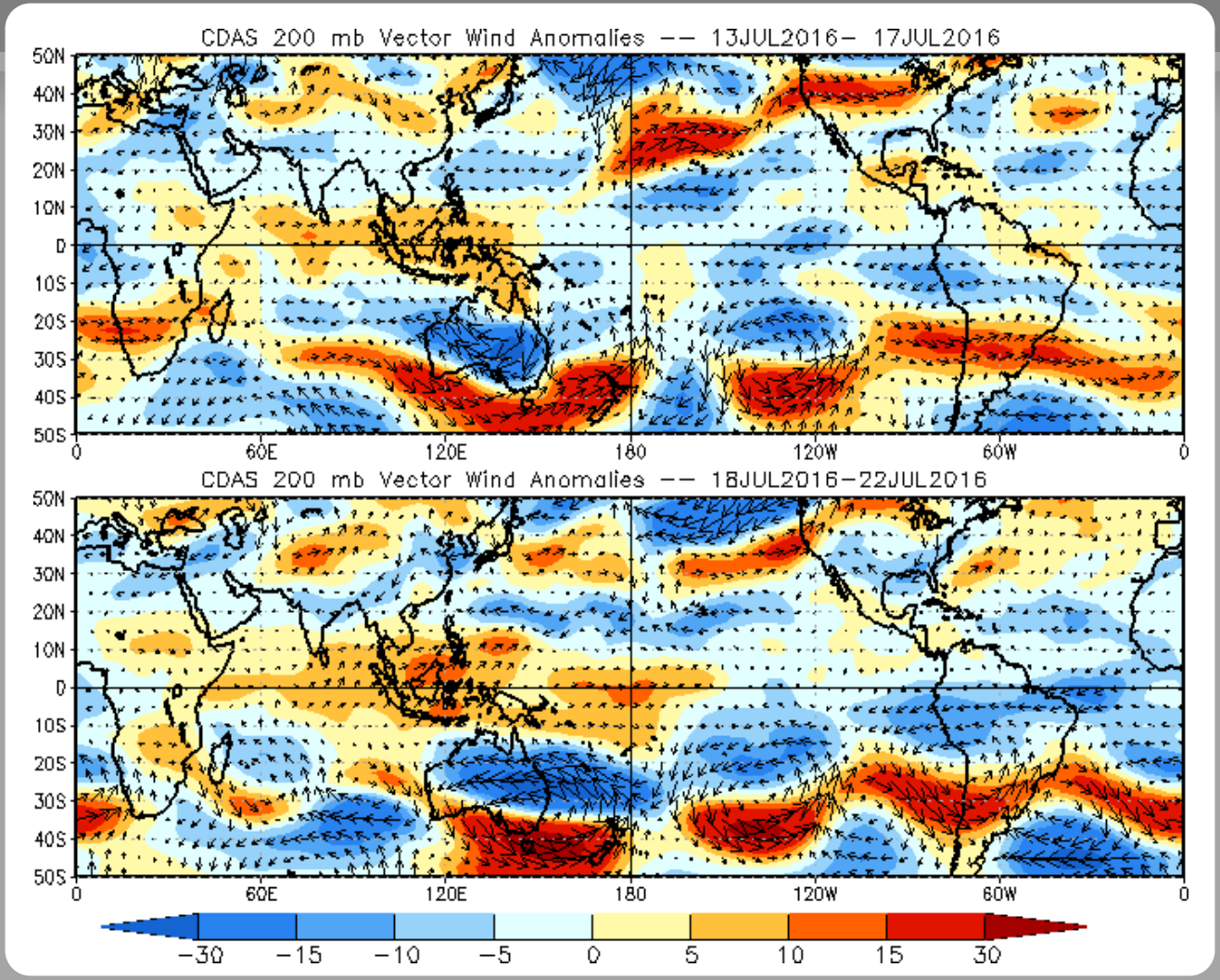
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies have extended eastward into the western and central equatorial Pacific.

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

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

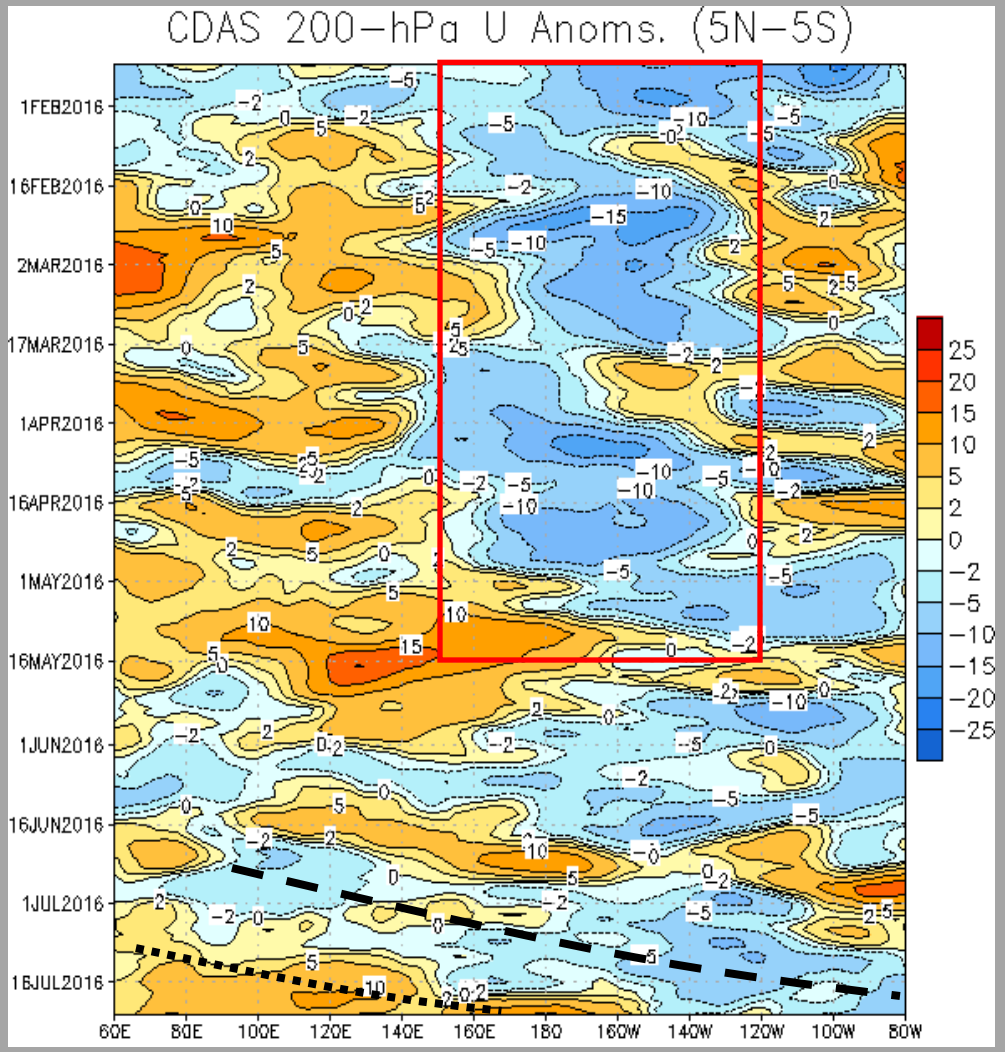
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

During May, westerly anomalies expanded eastward to the Date Line as El Niño weakened. Faster propagating modes were evident in the upper-level wind field.

The upper-level zonal wind field became less coherent during late May and early June.

Most recently easterly/westerly anomalies have propagated eastward across the equatorial Tropics.



Weekly Heat Content Evolution in the Equatorial Pacific

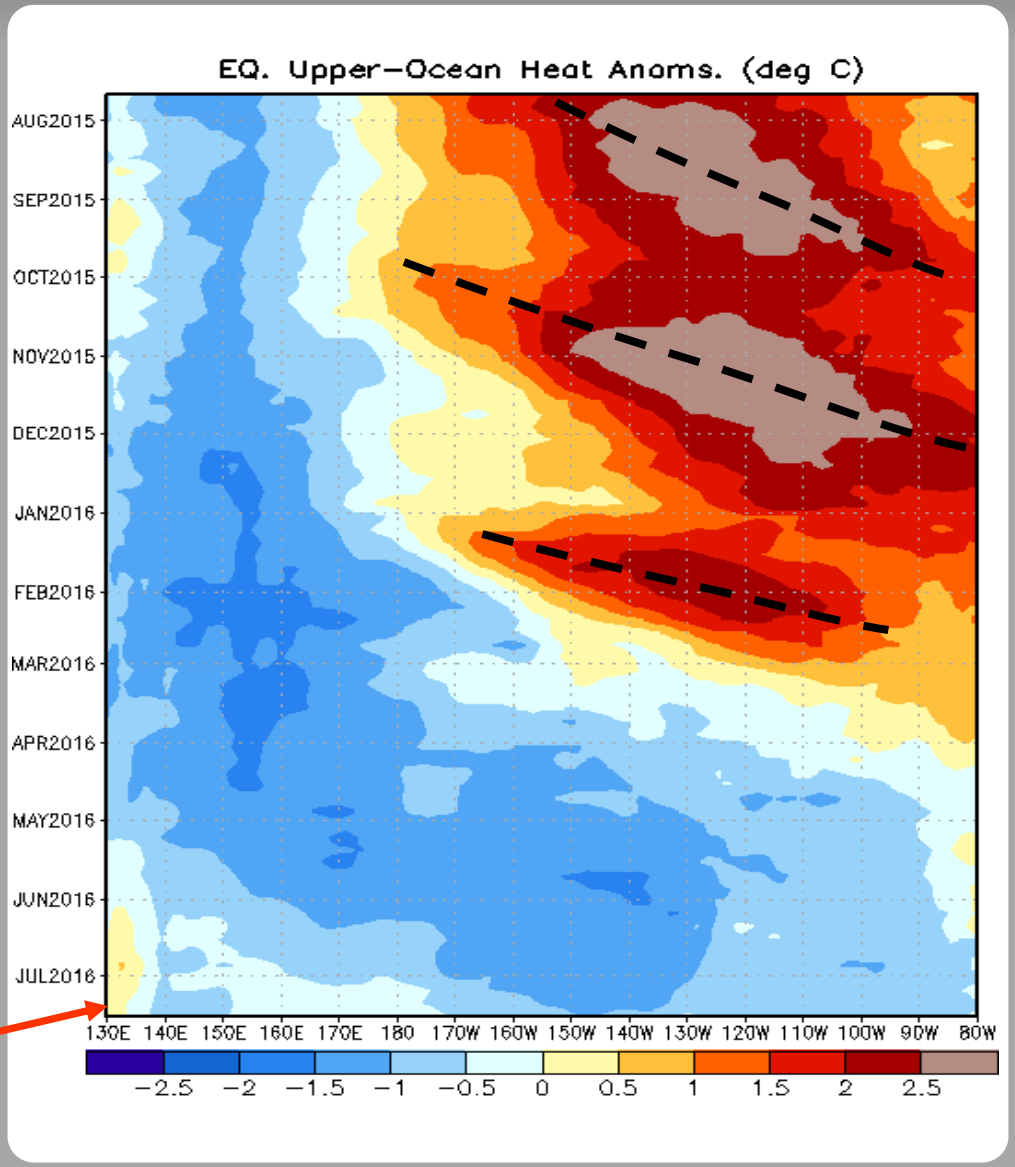
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

Reinforcing downwelling events were observed during the second half of 2015, resulting in persistently above-normal heat content from the DL 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 equatorial Pacific.

A small area of positive SST anomalies is evident near 135E.



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

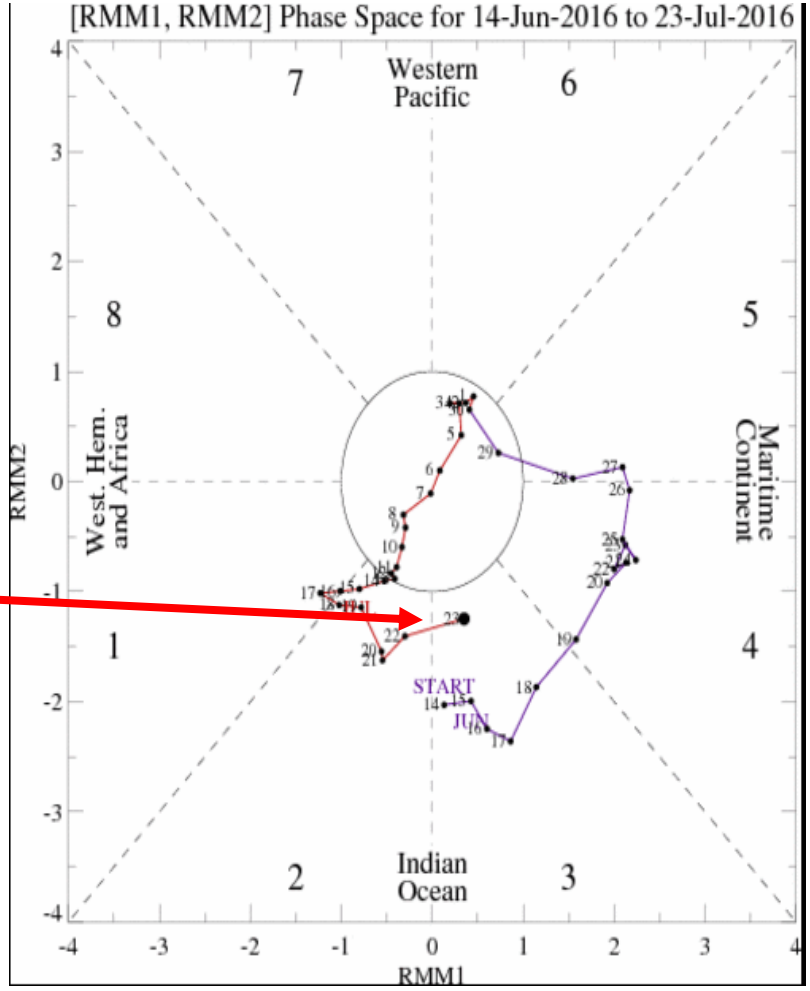
The triangular areas indicate the location of the enhanced phase of the MJO

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

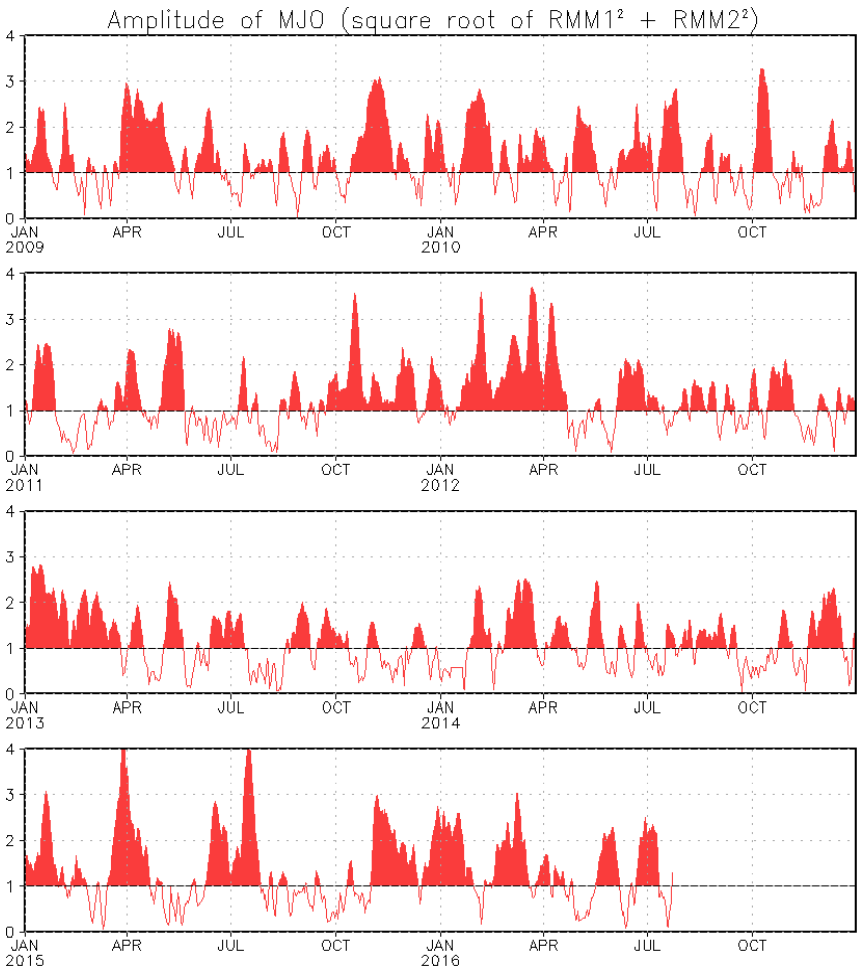
During the past week, the RMM index indicated eastward propagation of the MJO signal across the Indian Ocean.



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

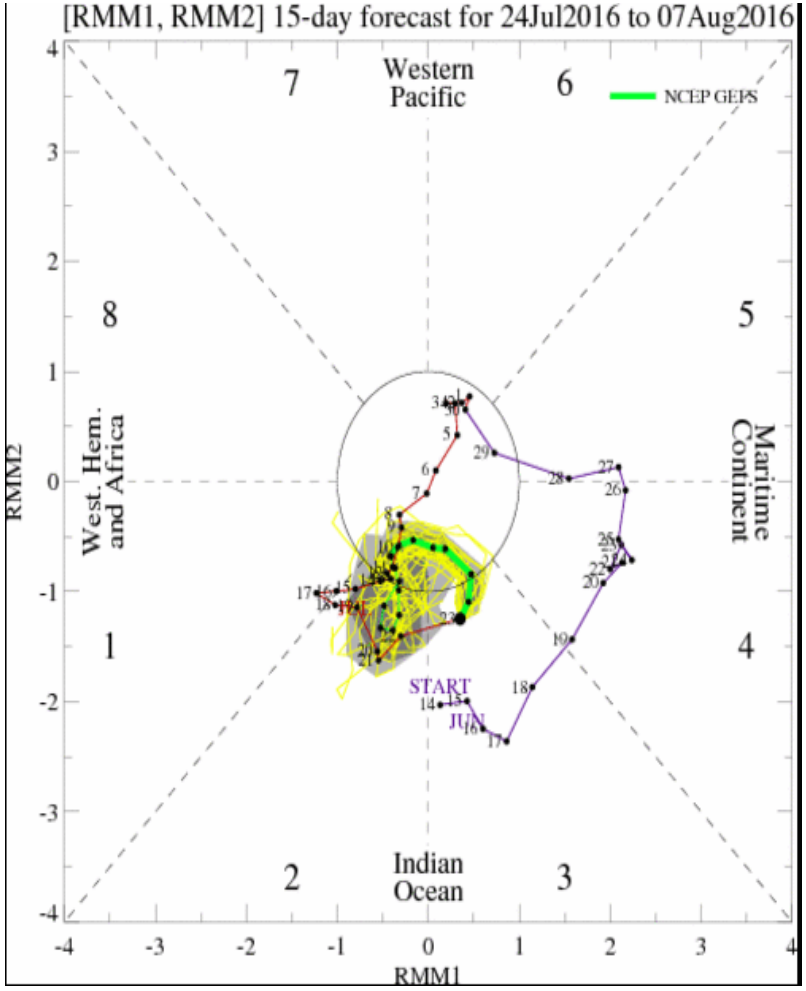
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

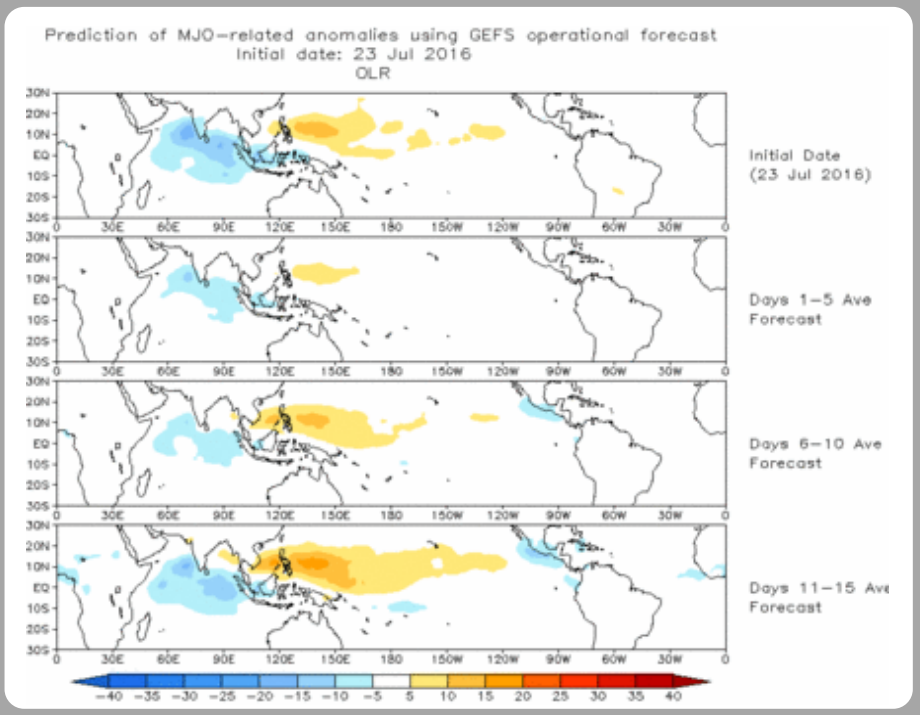
During the next two weeks, the GFS ensemble indicates little coherent MJO signal.



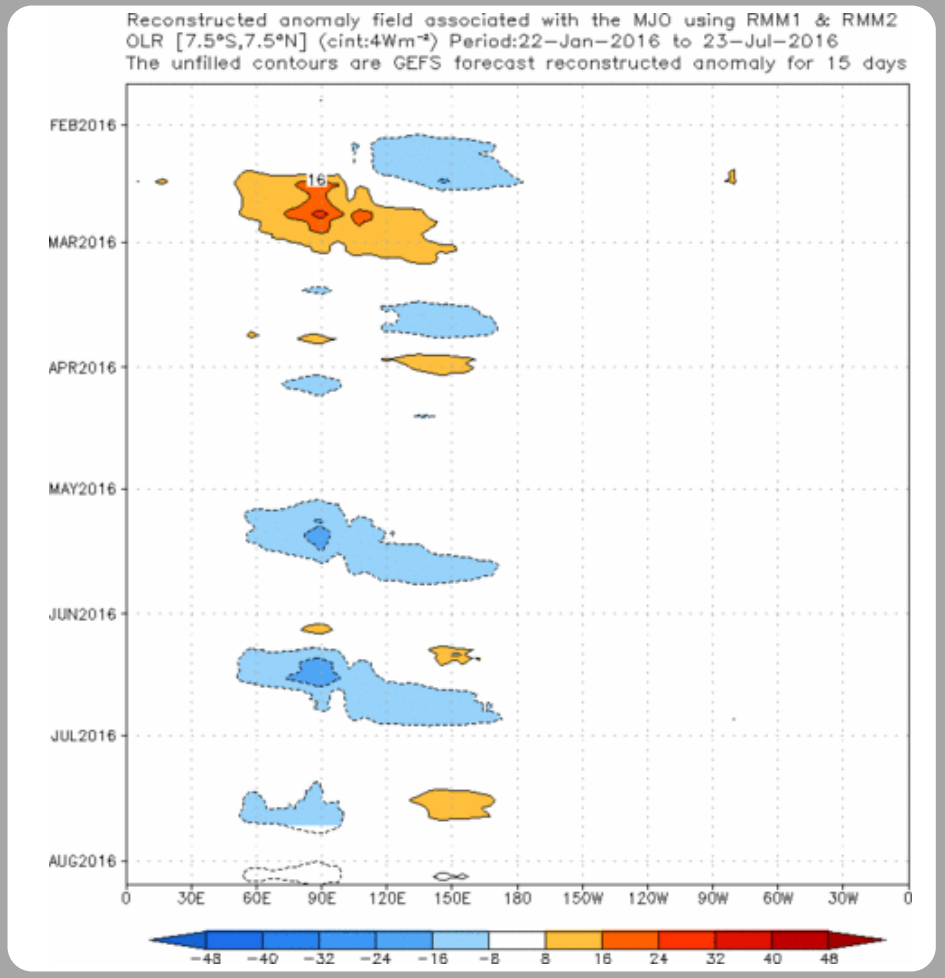
Ensemble GFS (GEFS) MJO Forecast

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

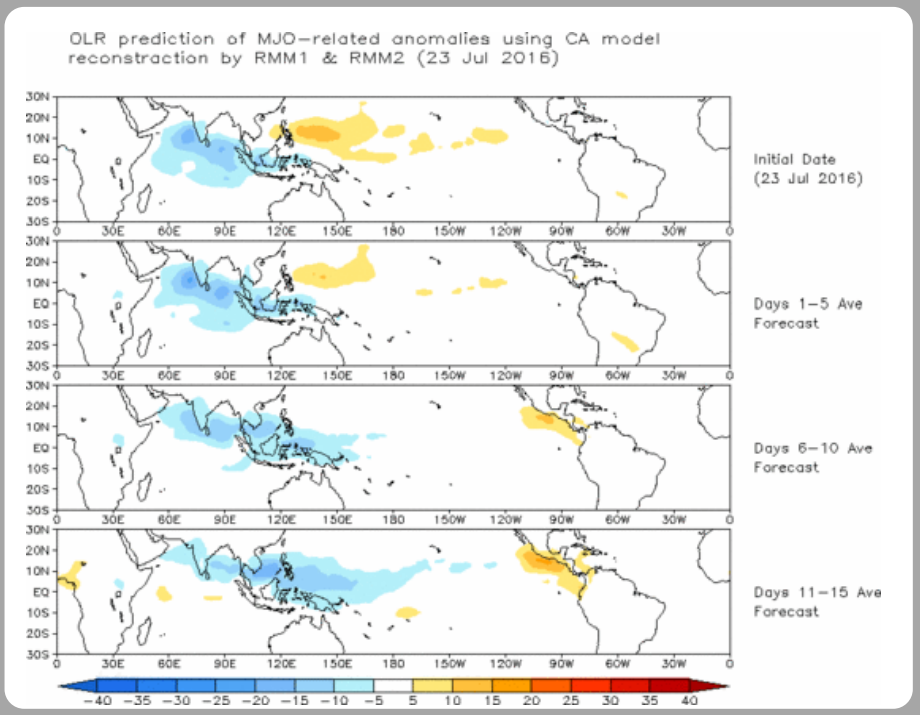


The GEFS OLR forecast based on the GEFS forecast of the RMM Index depicts a stationary signal over the next two weeks.

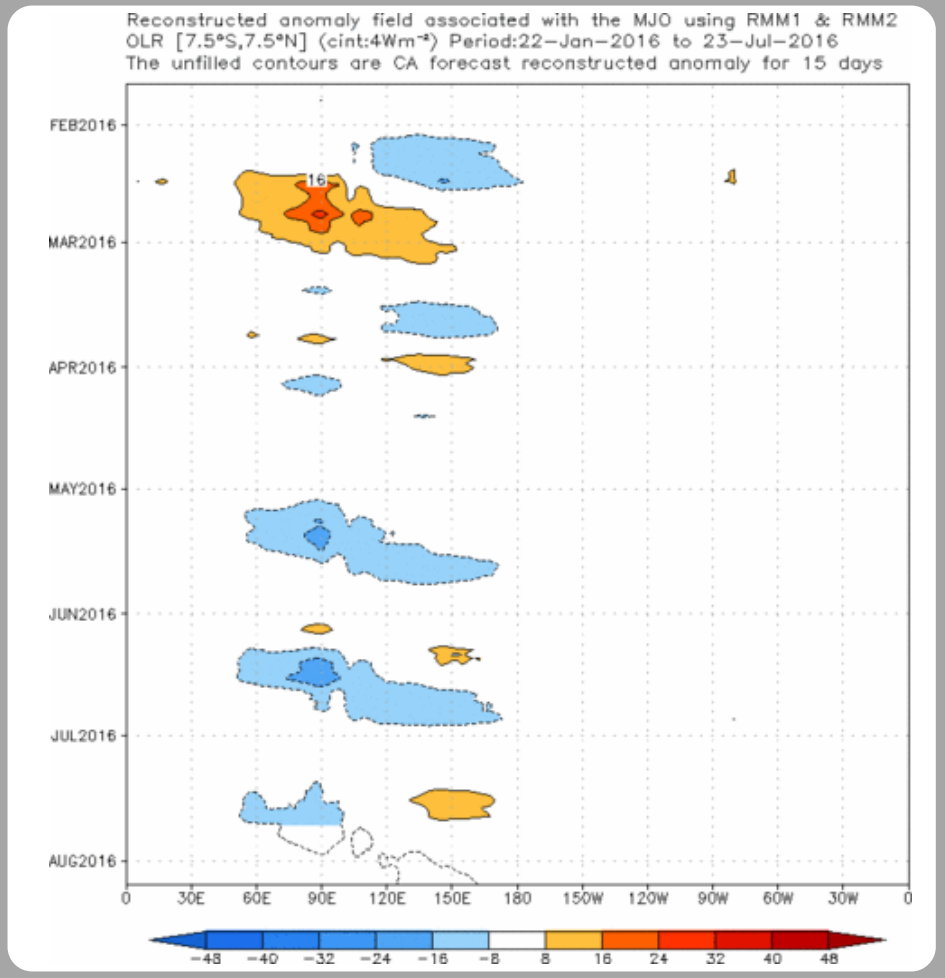
Constructed Analog (CA) MJO Forecast

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



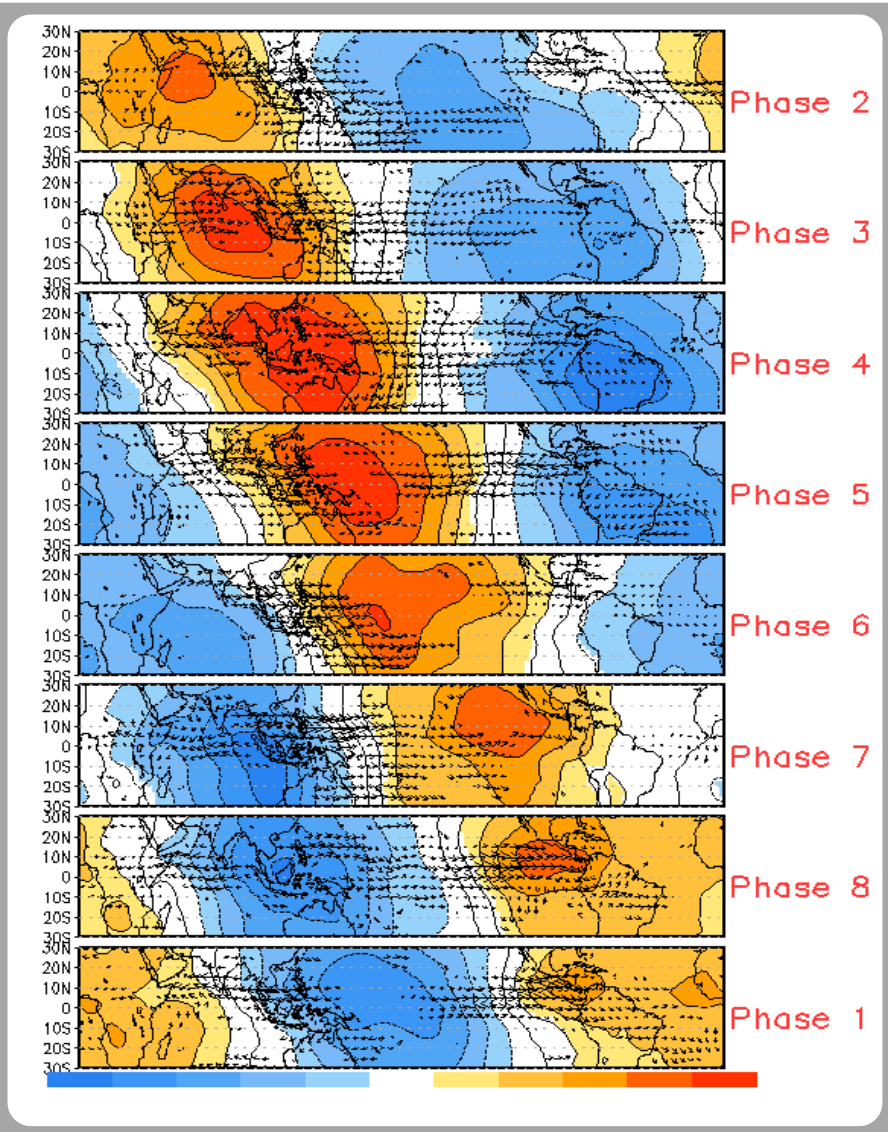
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



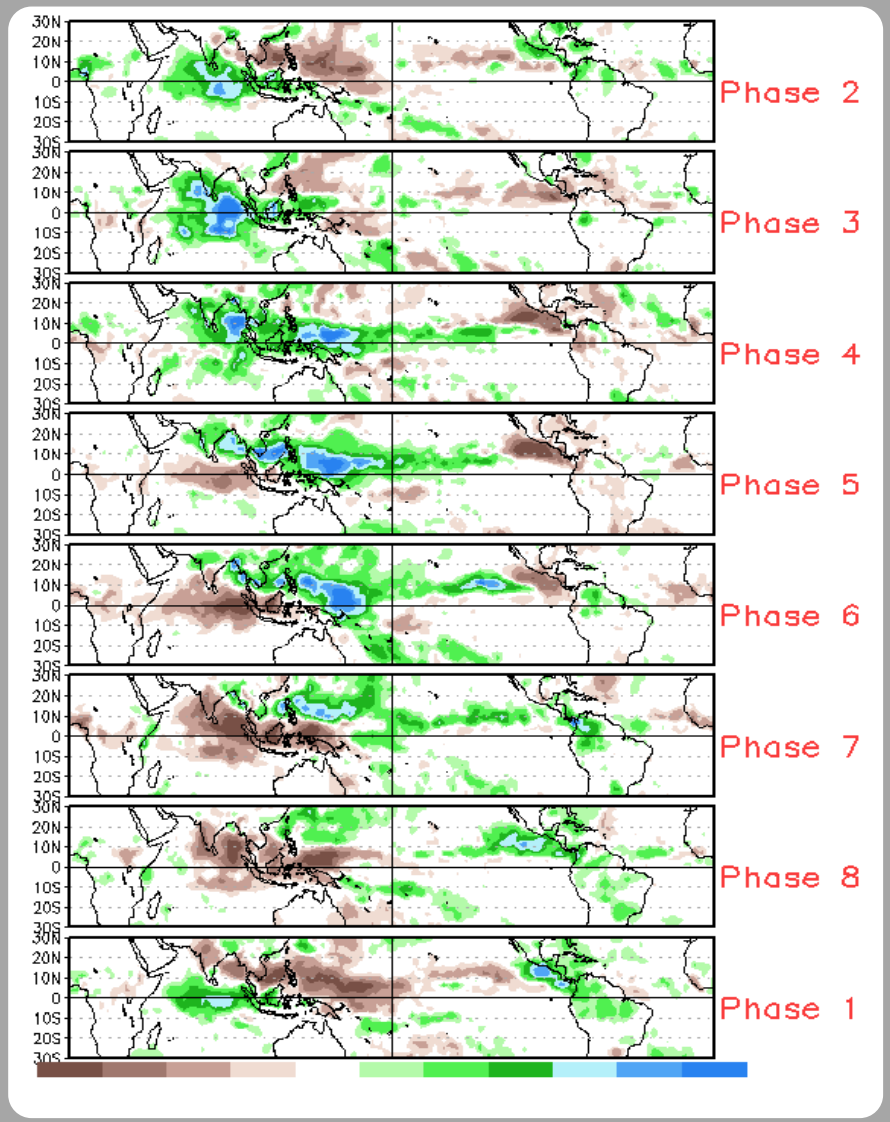
The Constructed Analog (CA) model predicts an eastward propagating signal during the next two weeks.

MJO Composites - Global Tropics

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



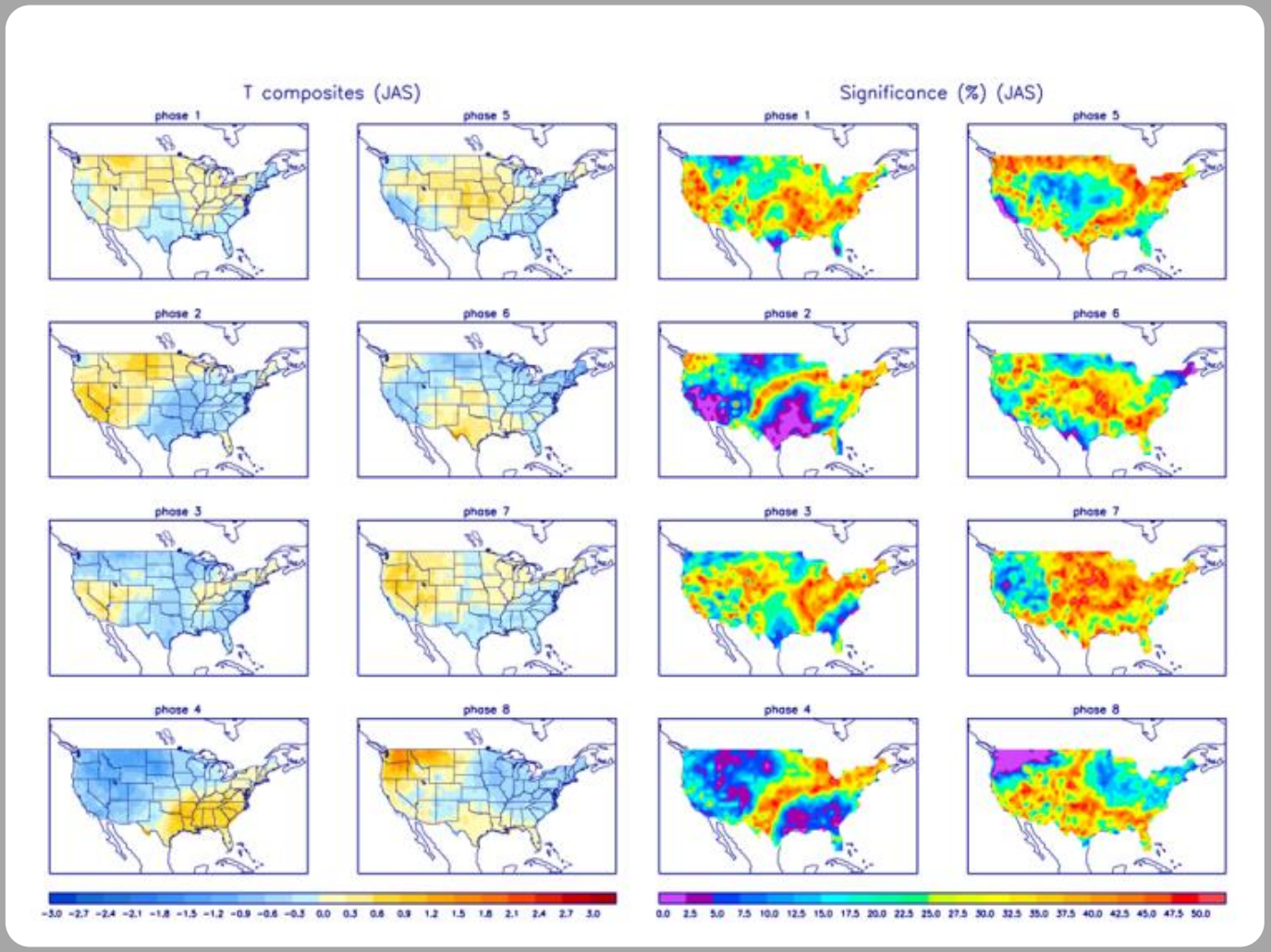
Precipitation Anomalies (May - Sep)



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.



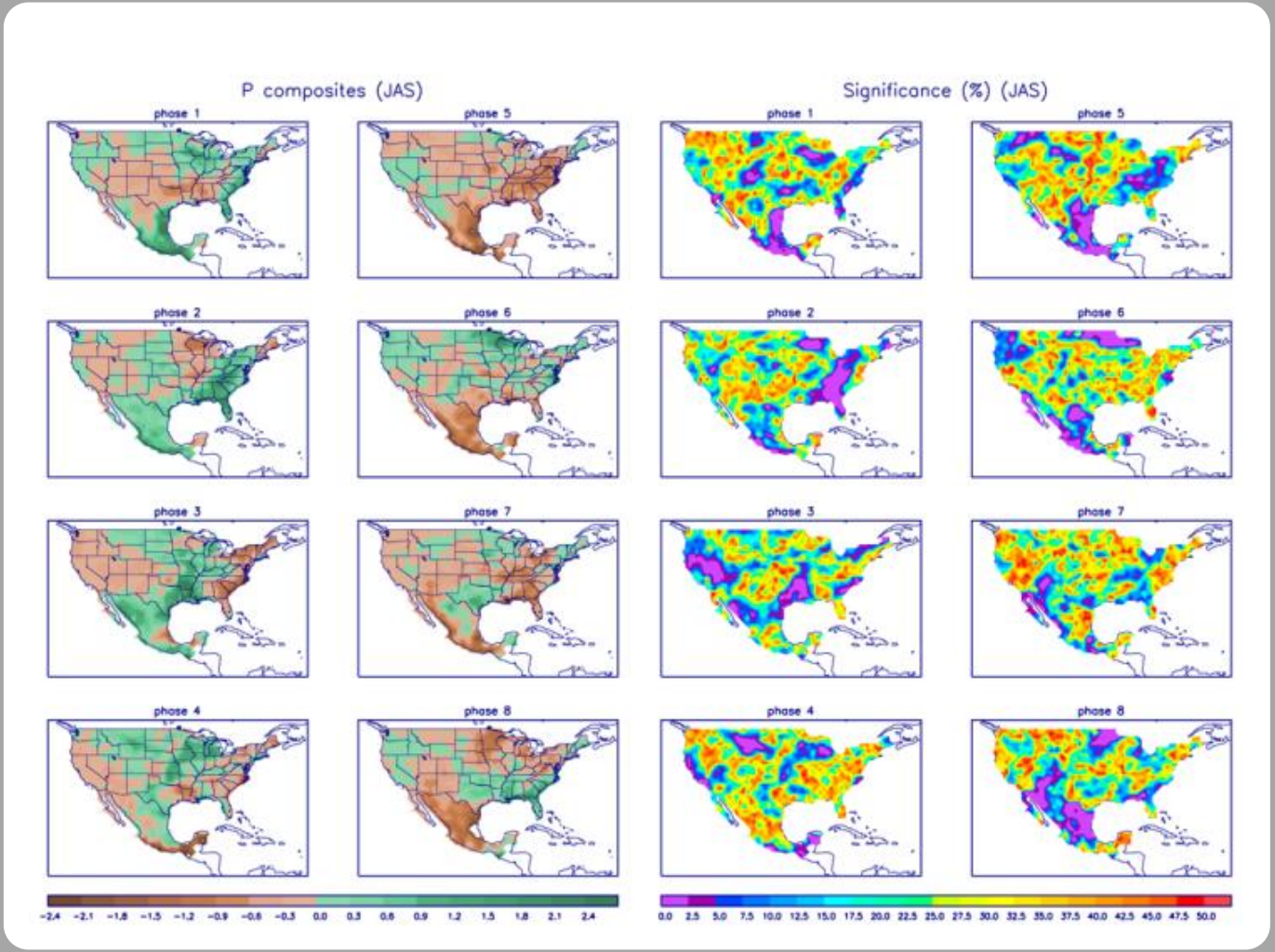
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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