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

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Climate Prediction Center / NCEP
8 August 2016

Outline

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MJO Index Forecasts

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Overview

The atmosphere appears to be more consistent with an emerging MJO over the Maritime Continent.

Convection is expected to amplify over the Maritime Continent and western North Pacific, consistent with an MJO. Propagation and consistency throughout the two week period is non certain to remain coherent with MJO related variability.

Tropical cyclone formation odds are enhanced over the western North Pacific, with a return to near climatologically normal level over the East Pacific. Tropical cyclone activity over the Atlantic is likely to remain damped. Enhanced (suppressed) rainfall is likely over the western Pacific associated with tropical cyclone activity, while vacillations in the South Asian monsoon are also likely.

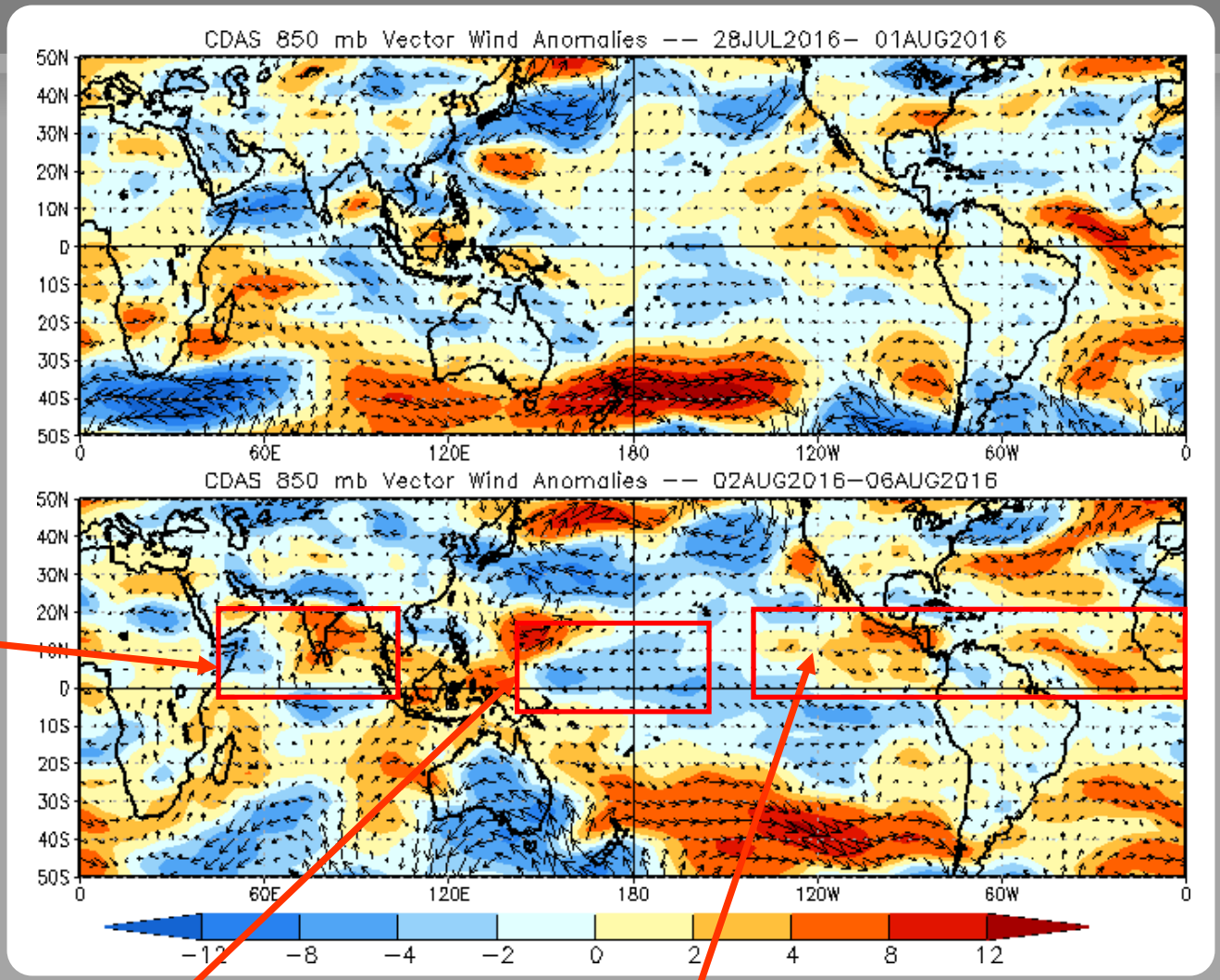
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 built in over South Asia, while easterly anomalies concentrated over the equatorial Indian Ocean.

Easterly anomalies intensified and expanded over the western and central Pacific

Westerly anomalies shifted eastward and northward to near the coast of Central America, while weakening slightly.

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

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

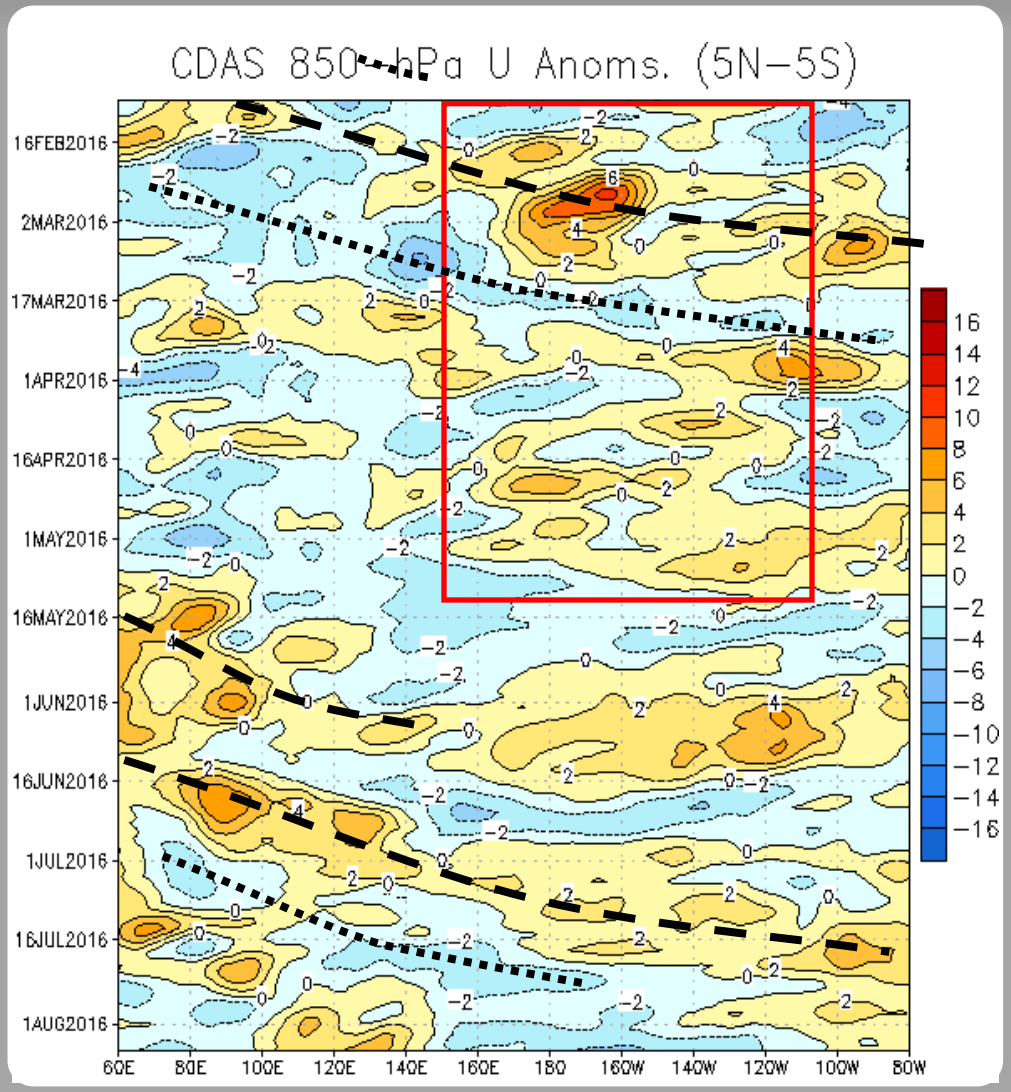
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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. 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. The coherent signal faded during mid July.

Recently, a signal has emerged over the Maritime Continent, although any propagation is not evident.



OLR Anomalies – Past 30 days

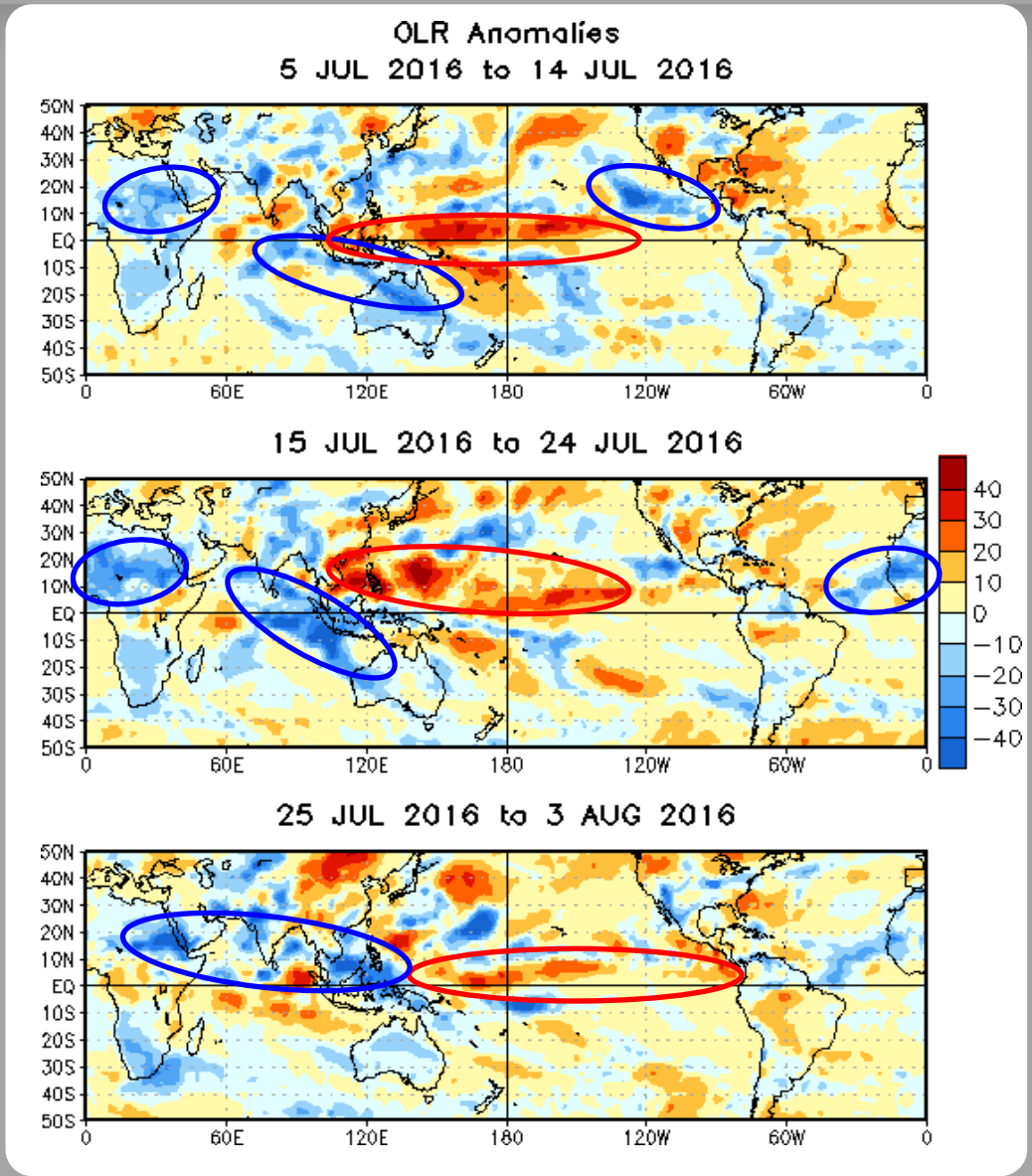
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During early to mid-July, convection was enhanced (suppressed) over Africa, portions of the Indian Ocean, and the East Pacific (West and Central Pacific).

During mid-July, suppressed (enhanced) convection remained over the western and central Pacific (Indian Ocean), but intensified over Africa and South Asia. The intensification was consistent with an intraseasonal signal.

Enhanced convection remained over the area from Africa to the Maritime Continent, while the suppressed convection shifted slightly eastward, both consistent with an eastward shift of an intraseasonal signal in the MJO time band.



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

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

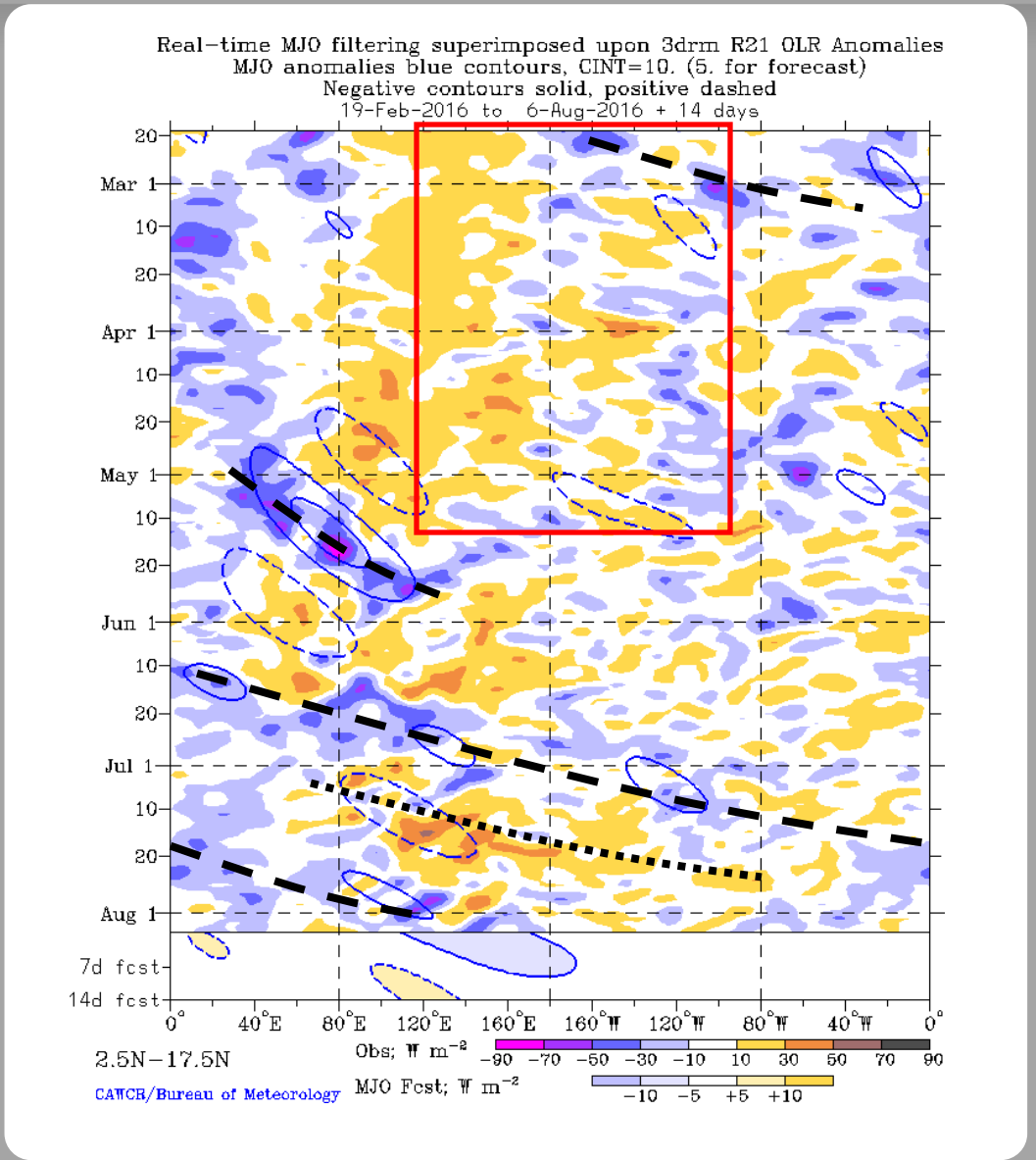
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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.

A fast eastward propagating signal raced across the Pacific during February, interfering with the ENSO signal.

During early May, an eastward-propagating convective envelope associated with the MJO developed east of the Prime Meridian. During the latter half of June, an eastward propagating signal is evident. During July, the signal continued moving eastward, with interference from tropical cyclone activity.

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

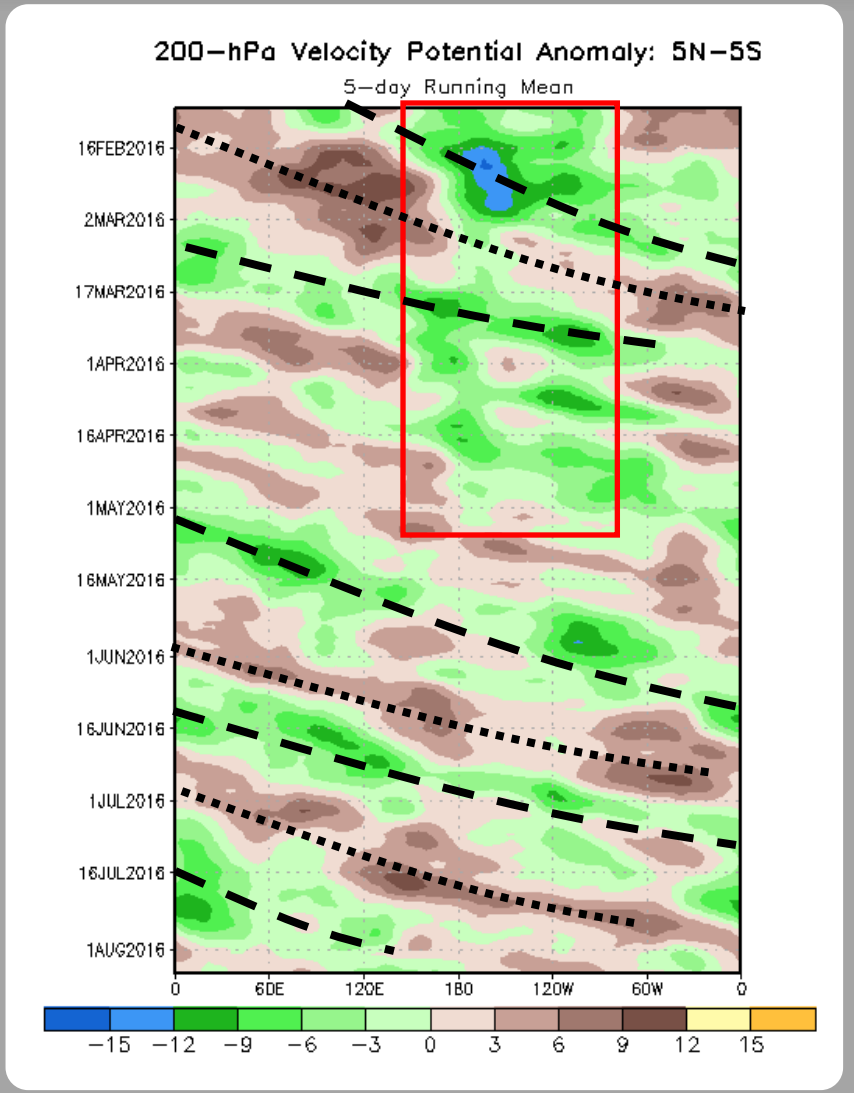
The 2015-16 El Niño background state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

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

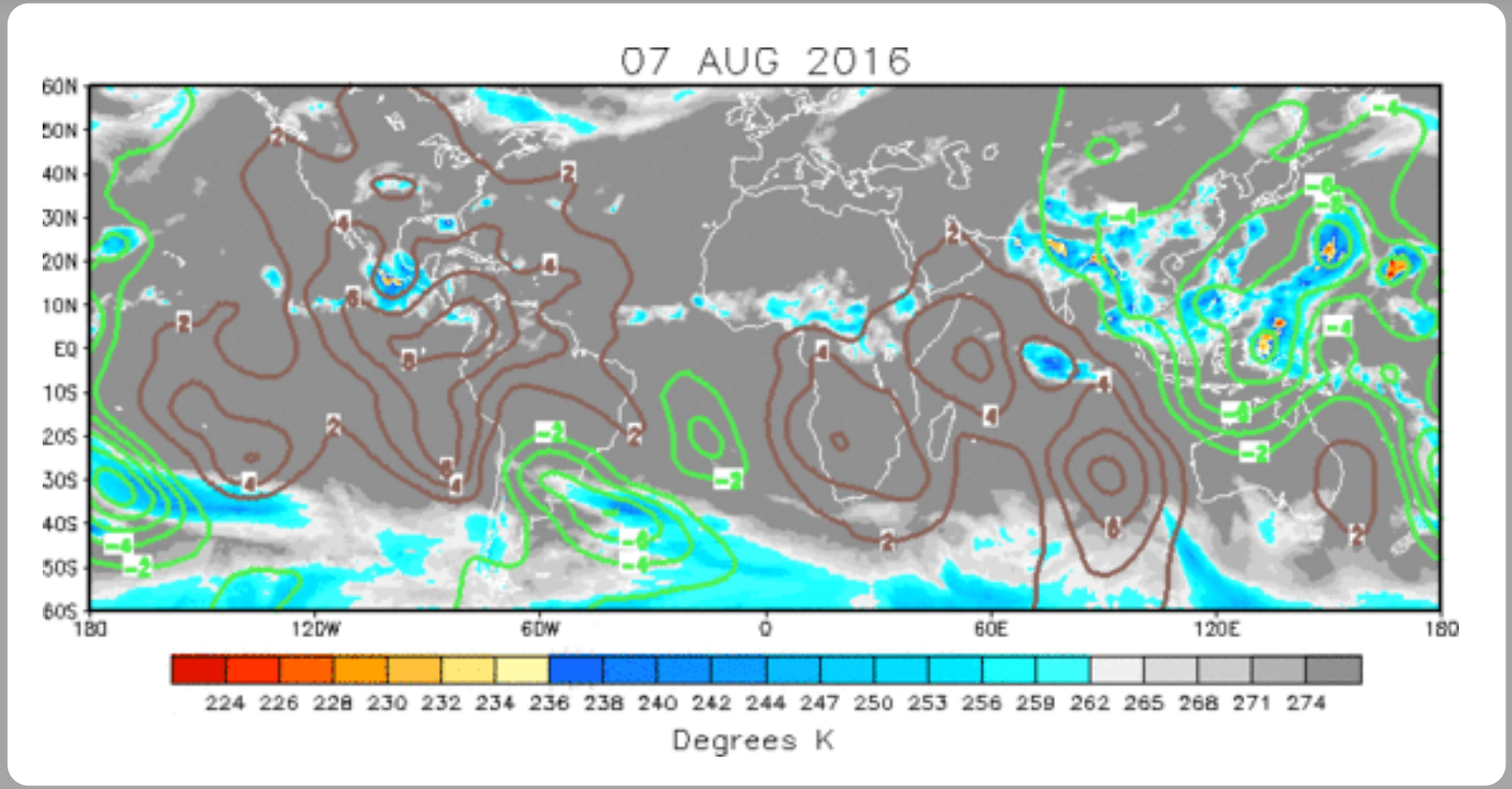
The upper-level velocity potential pattern became less coherent as the El Niño waned during April.

From May through the present time, a propagating signal was evident, with multiple periods of variability evident.

Recently, the signal has broken down slightly as anomalies have weakened. Enhanced divergence (convergence) is evident over the Maritime Continent (East Pacific), potentially indicating an new emerging signal.



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



The upper-level velocity potential anomalies generally indicate a wave-1 pattern, more organized than last week, with some strengthening of the anomalies.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

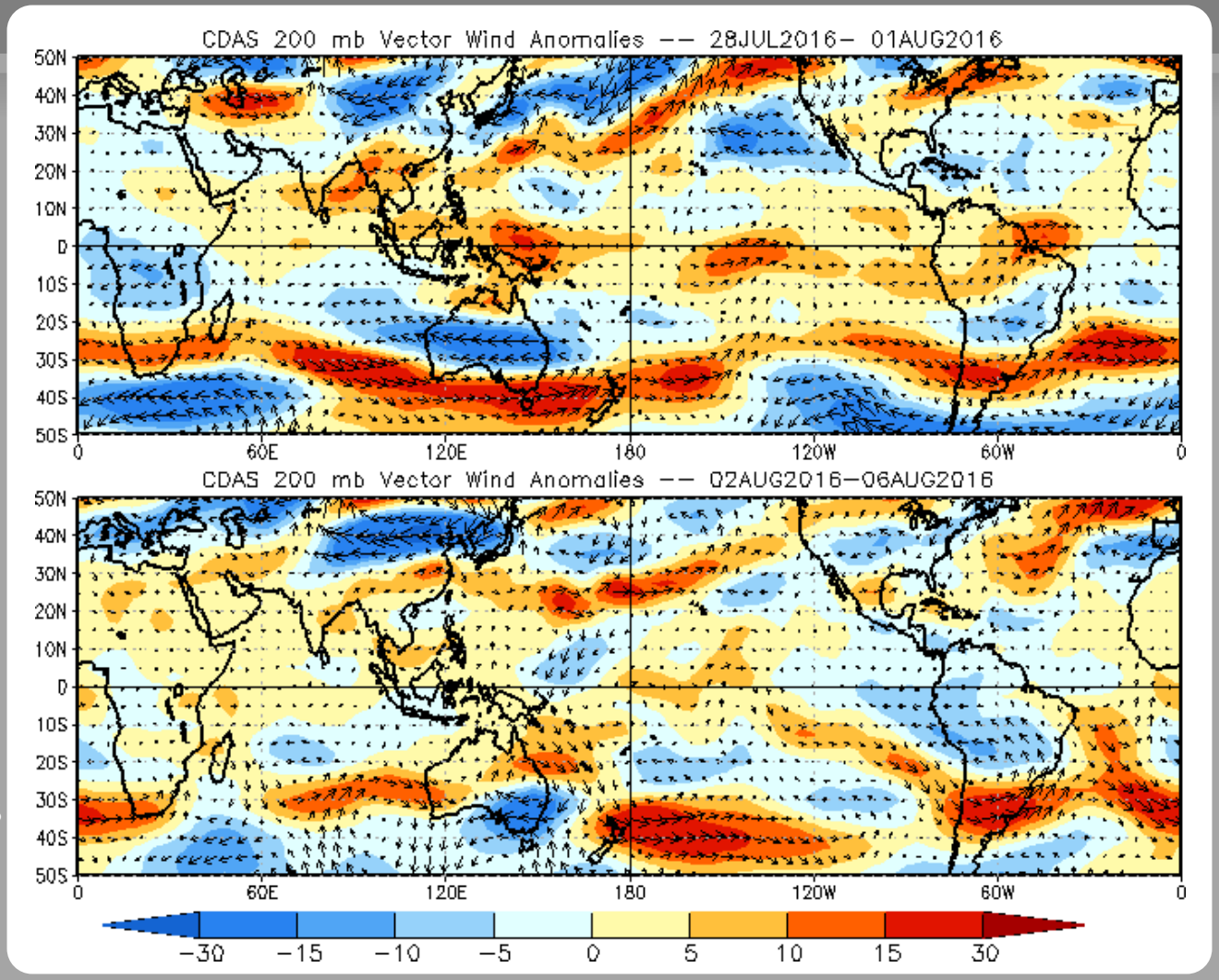
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



During the first week of August, some mid-latitude influence is evident over the central and eastern Pacific.

Anomaly signs generally reversed over the eastern Pacific, though the amplitudes are weak.

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

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

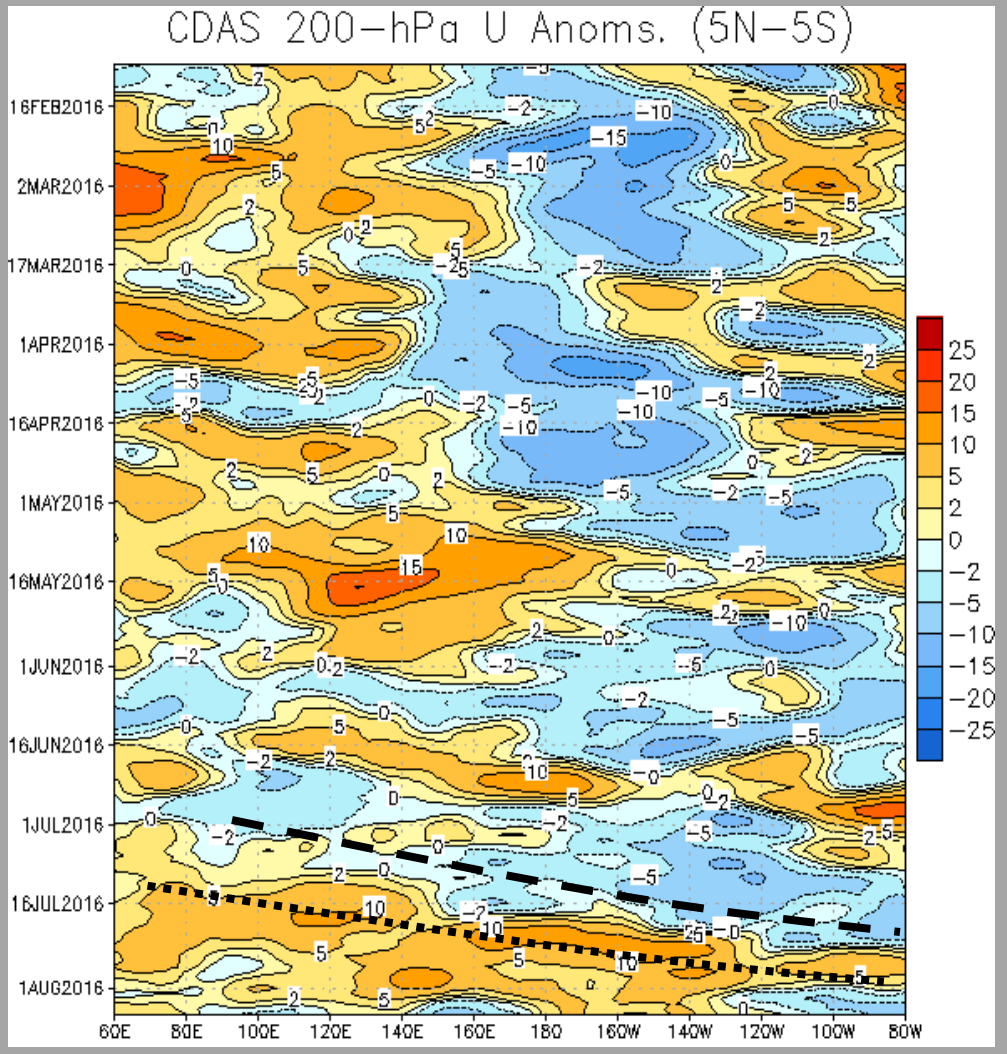
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

During July, some eastward propagation in large scale anomalies are evident, although the spatial consistency implies higher frequency variability than expected with MJO activity.



Weekly Heat Content Evolution in the Equatorial Pacific

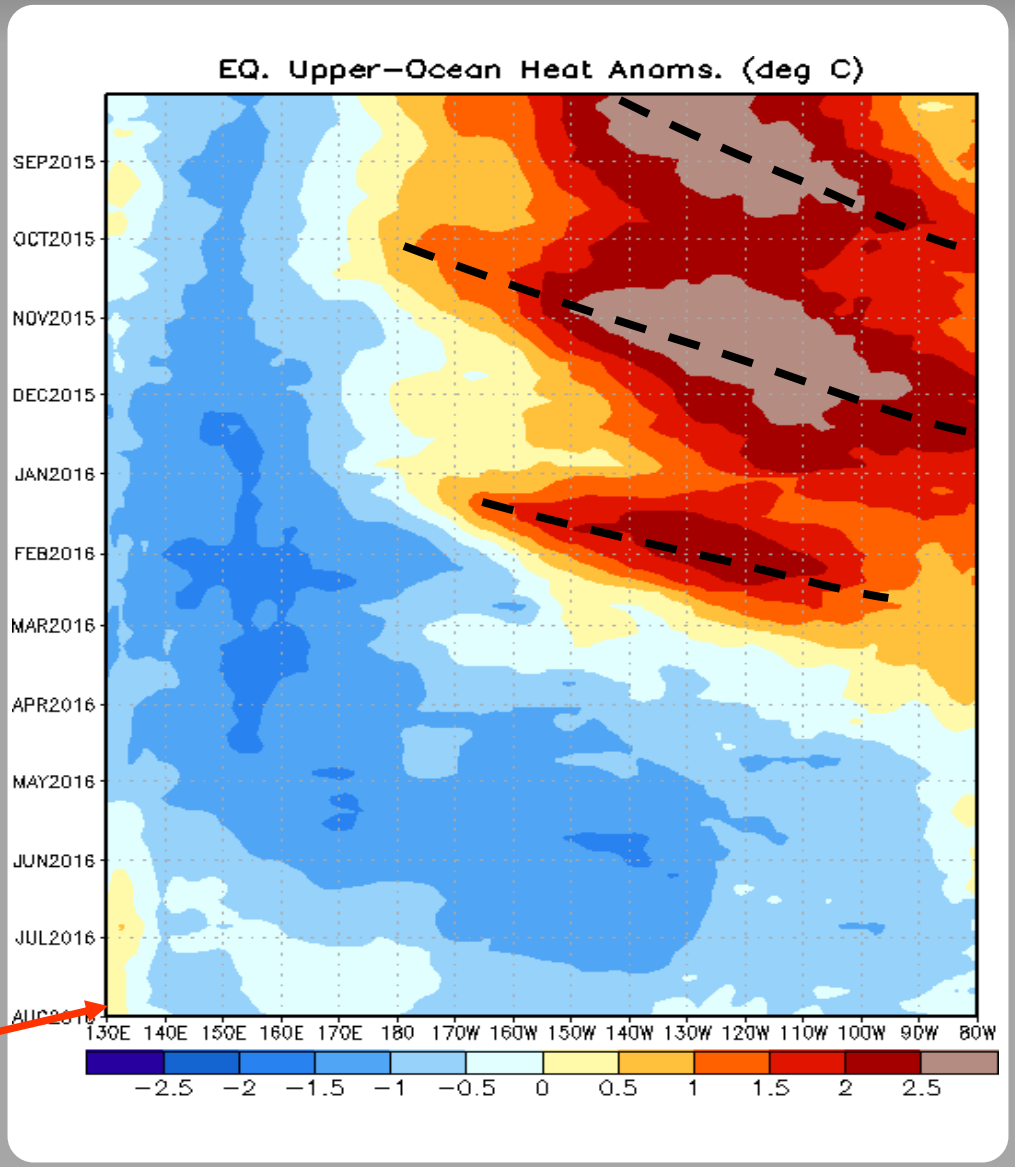
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

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

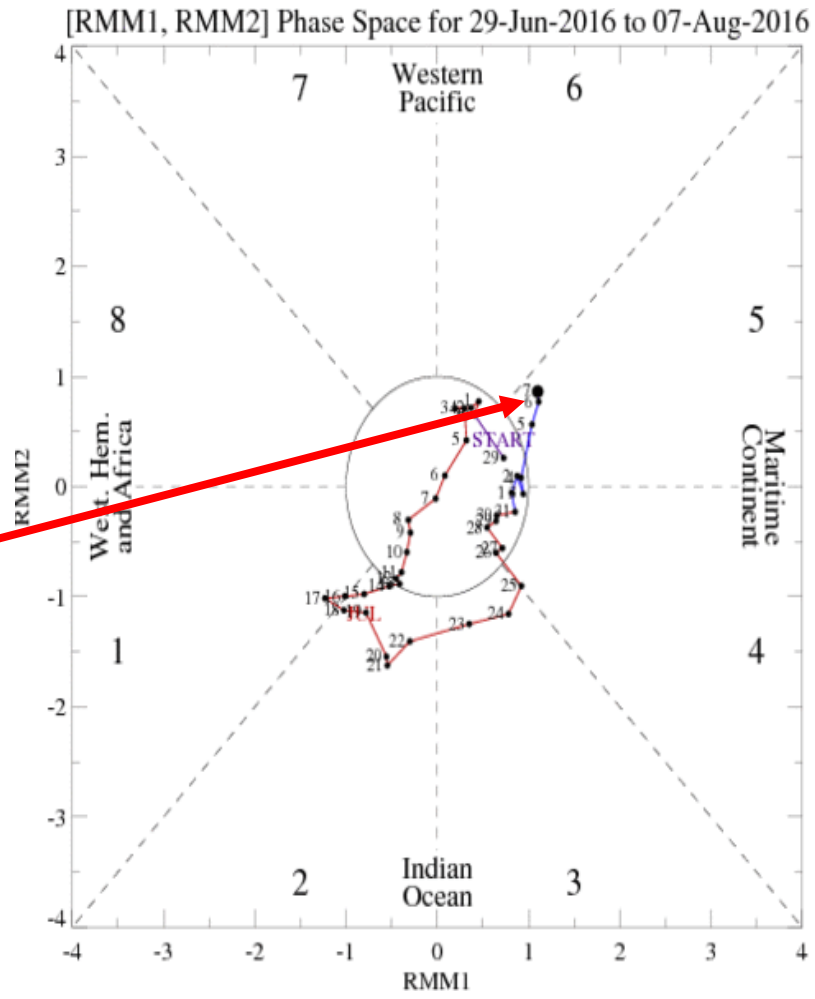
The triangular areas indicate the location of the enhanced phase of the MJO

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

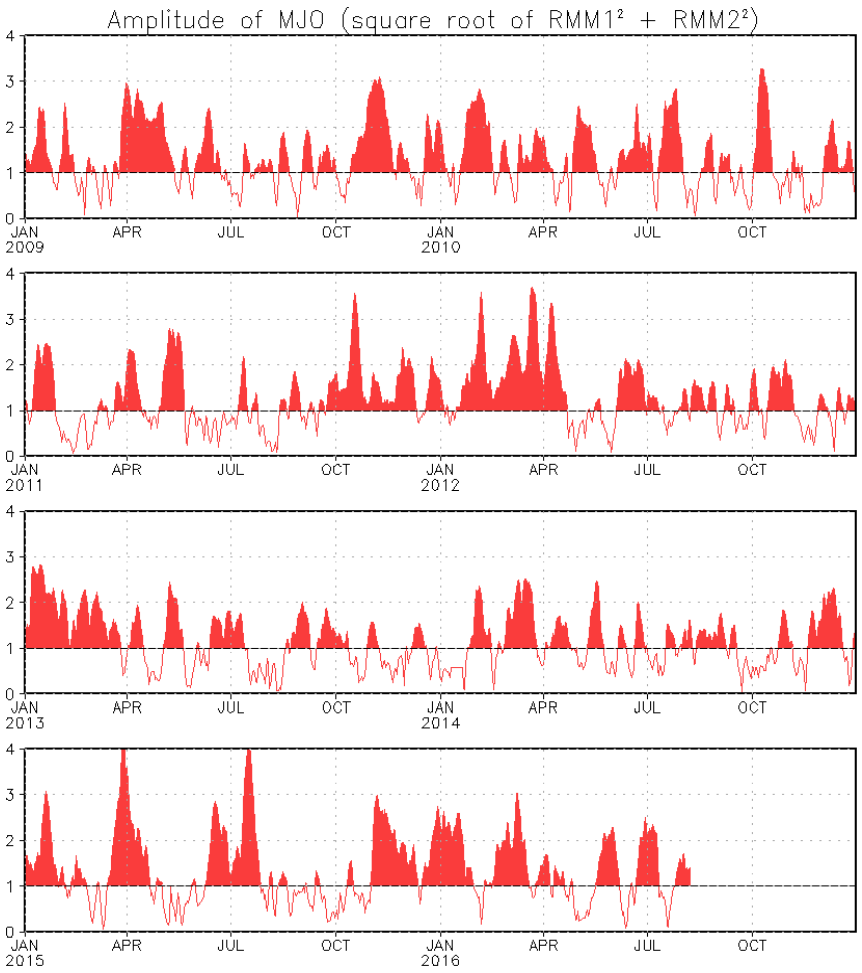
During the past week, the RMM index indicated a slight strengthening of an emerging signal over the western Pacific.



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

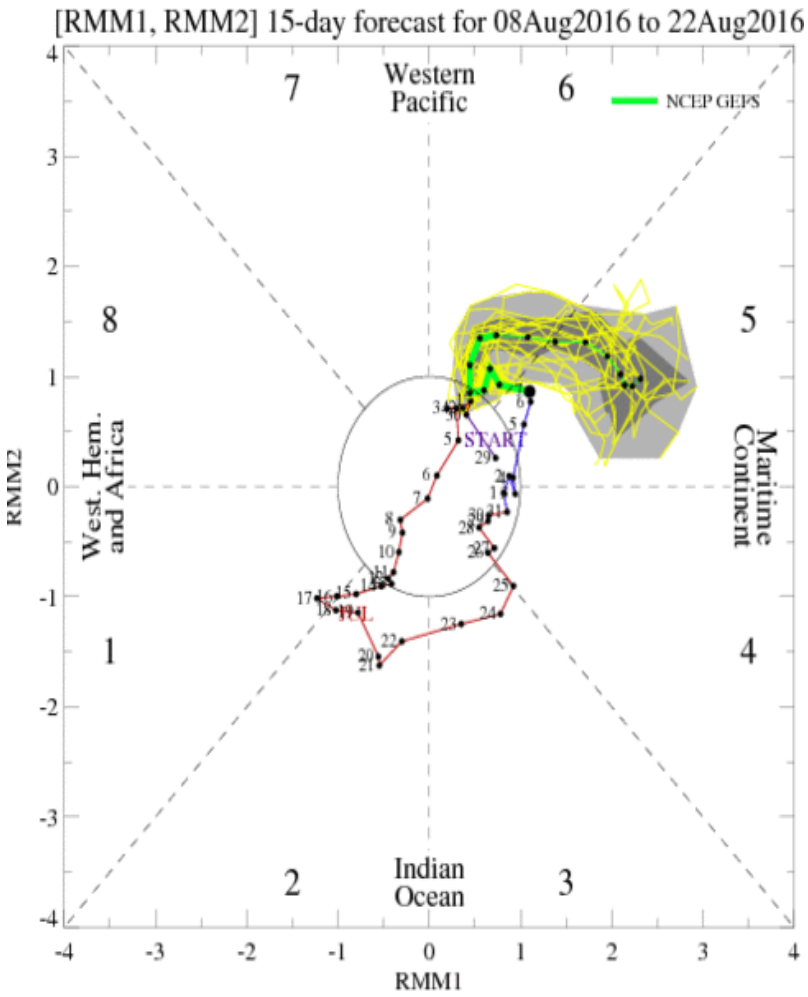
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

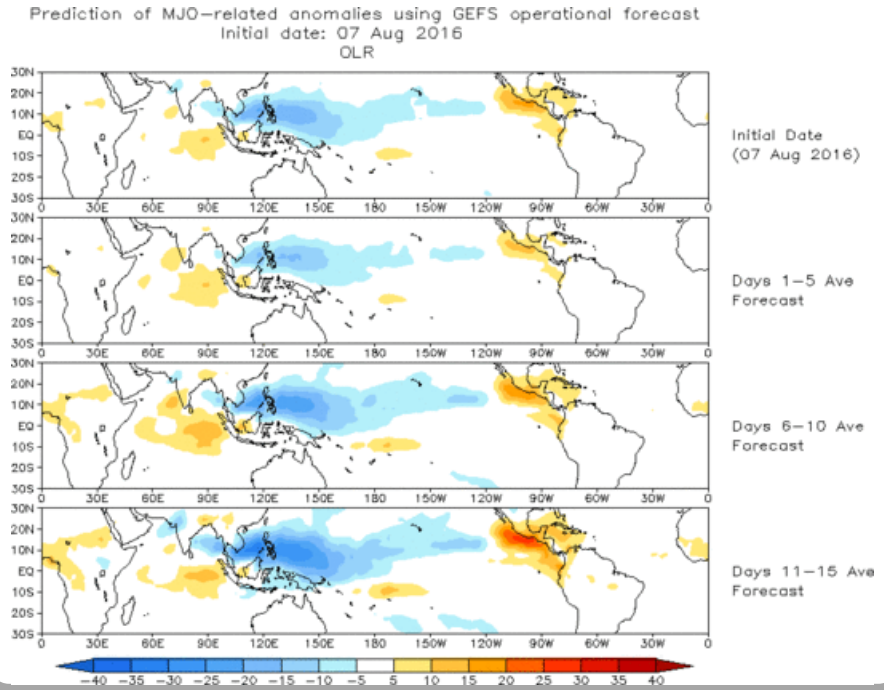
During the next two weeks, the GFS ensemble indicates an amplifying, yet stagnant signal.



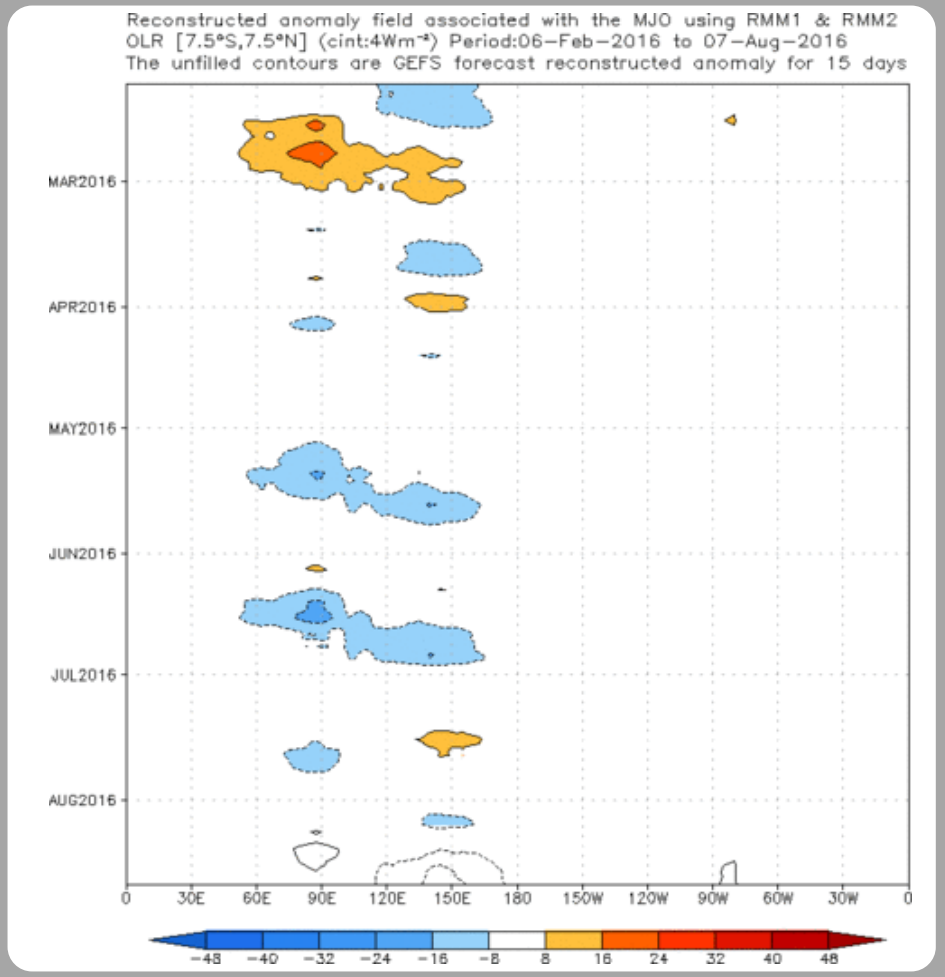
Ensemble GFS (GEFS) MJO Forecast

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

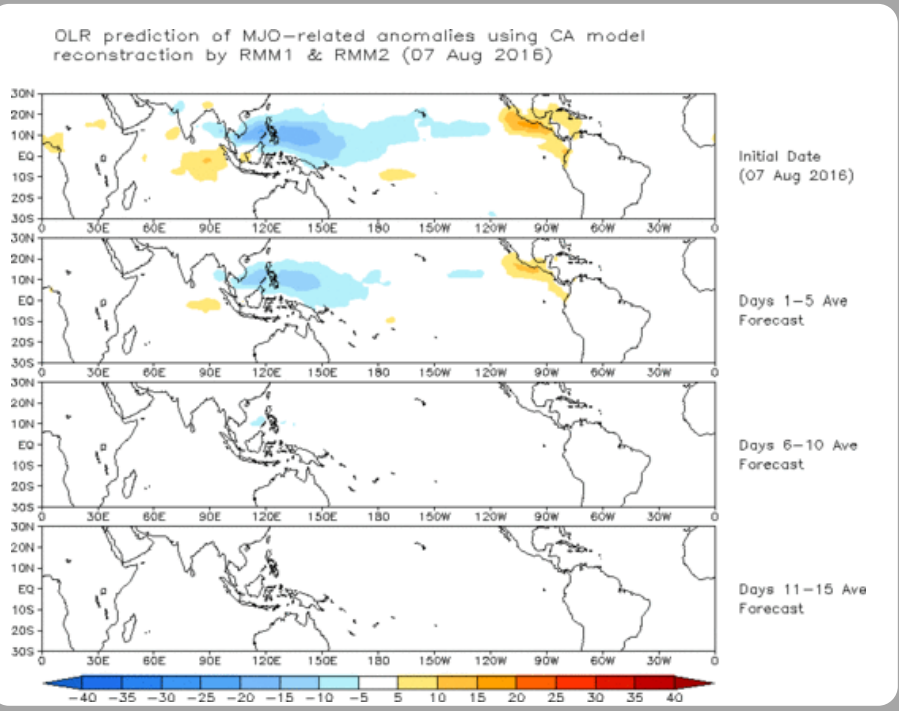


The GEFS OLR forecast based on the GEFS forecast of the RMM Index depicts an amplifying but spatially stagnant signal.

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



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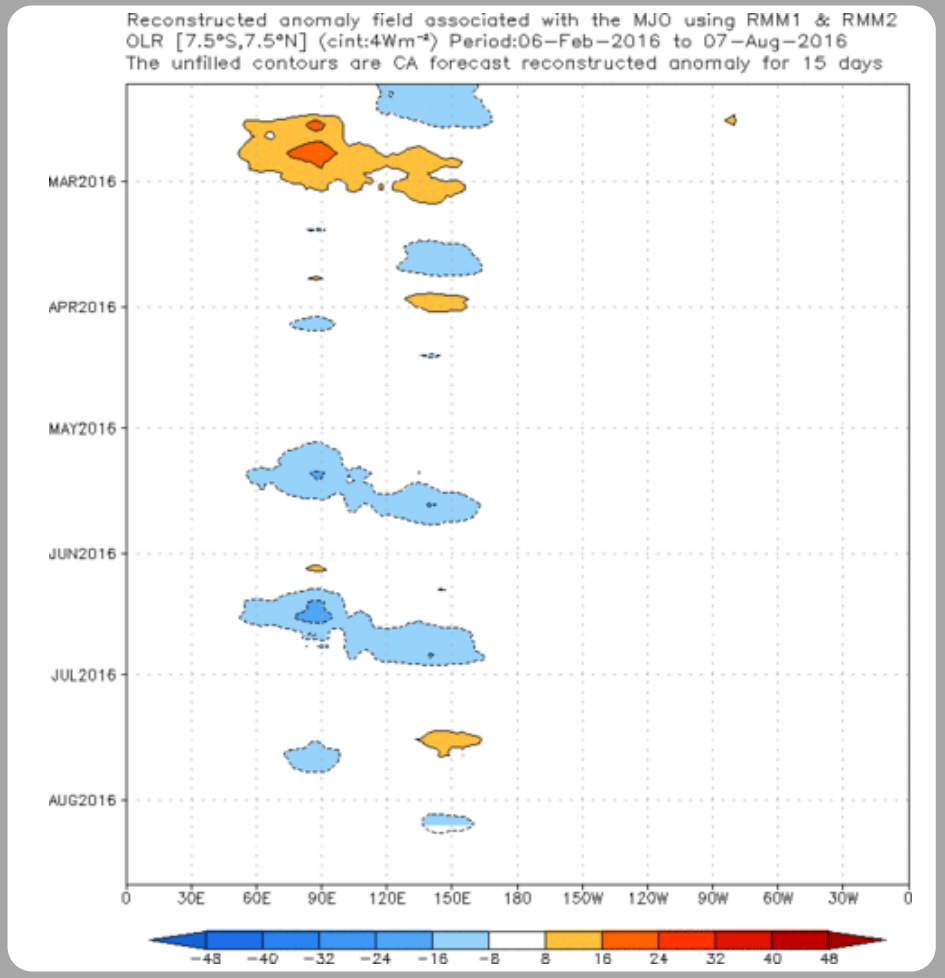
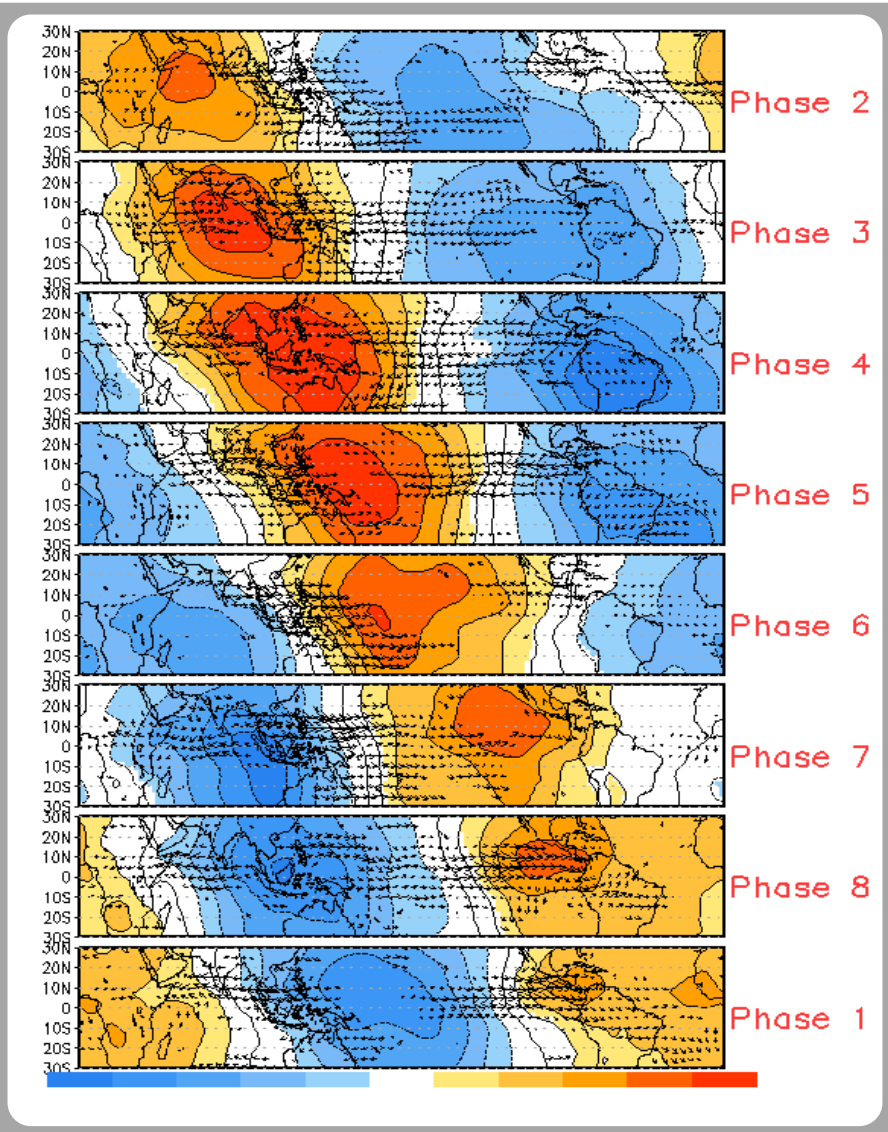


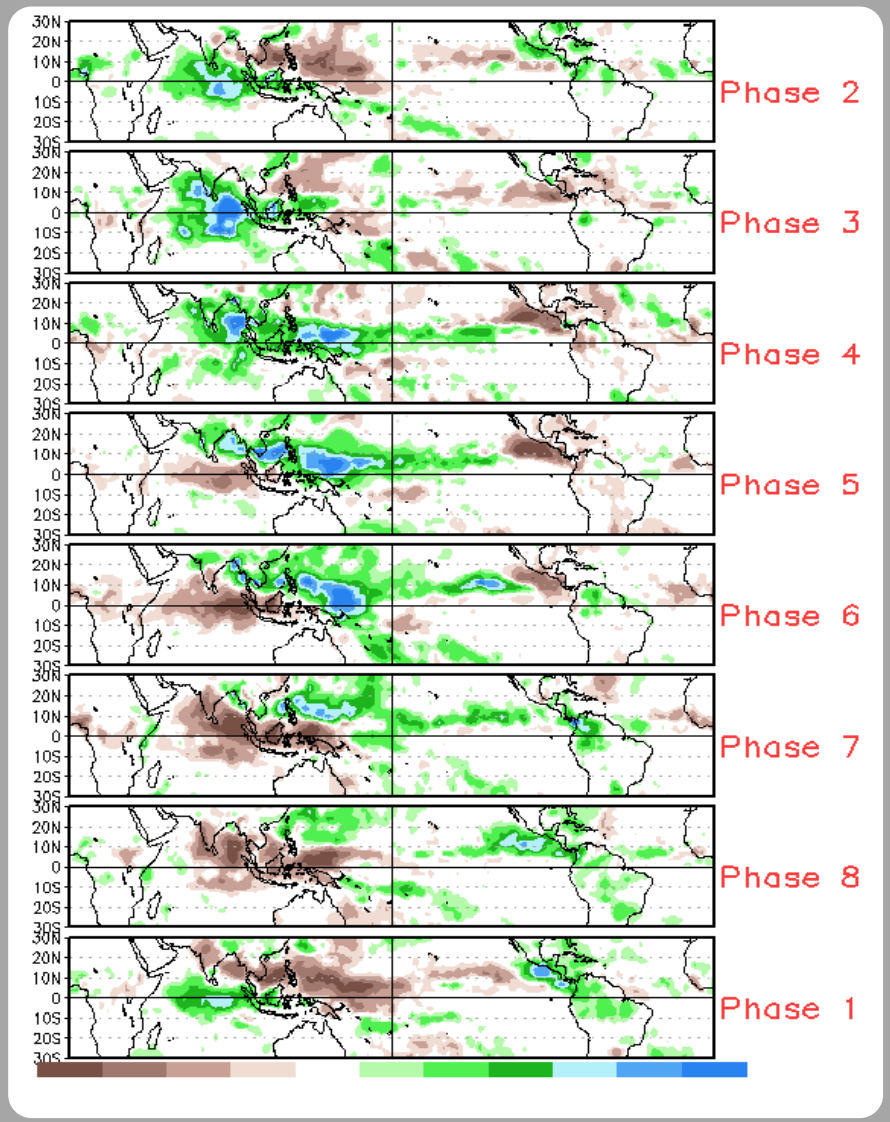
The Constructed Analog (CA) model predicts a rapidly weakening signal, with enhanced convection over the western Pacific.

MJO Composites - Global Tropics

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



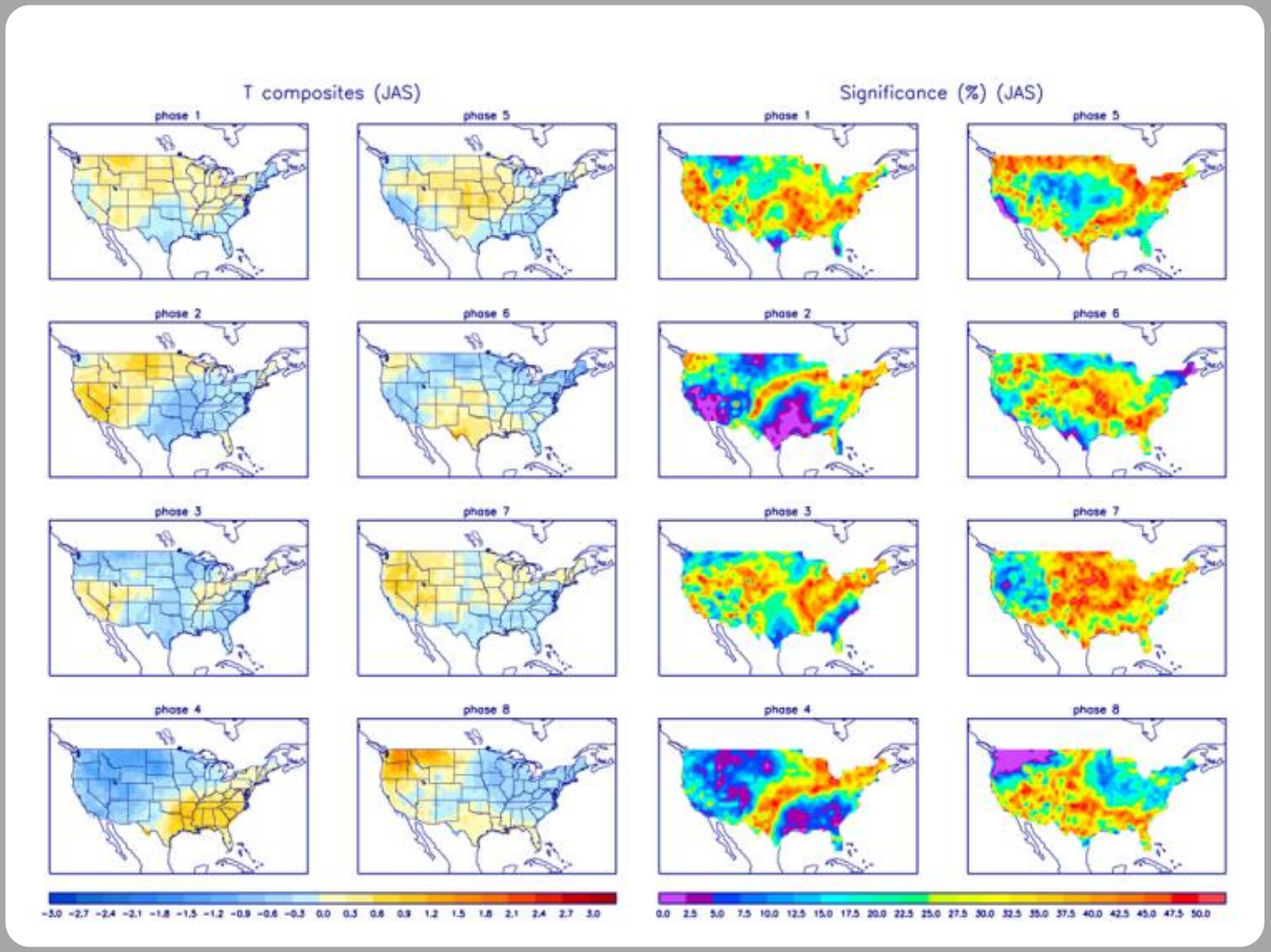
Precipitation Anomalies (May - Sep)



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.



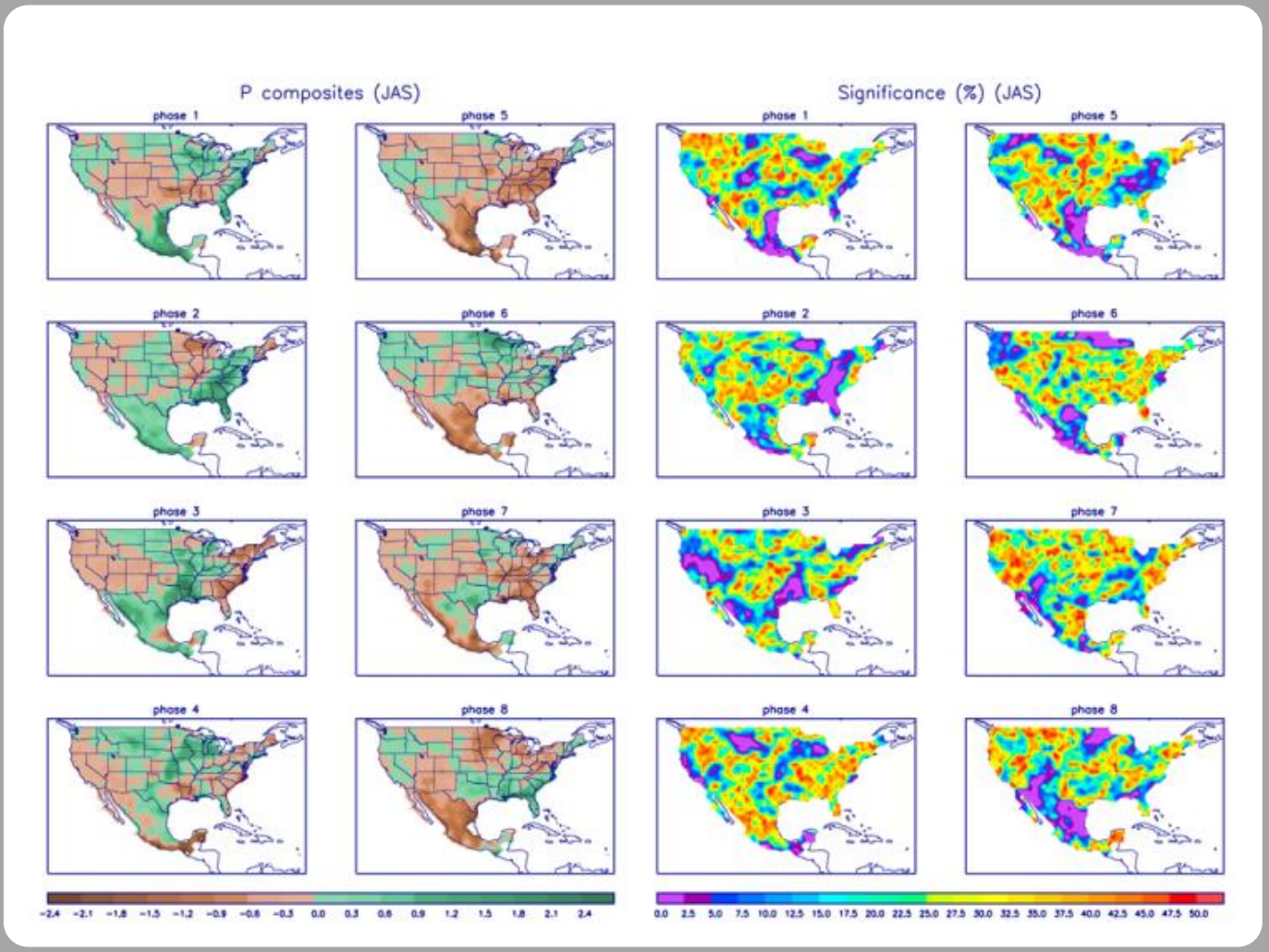
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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