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

Update prepared by:
Climate Prediction Center / NCEP
20 June 2016

Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

Several indicators, including the RMM-based MJO Index and the evolution of the upper-level velocity potential pattern, depict a coherent MJO event, with the enhanced phase over the eastern Indian Ocean and western Maritime Continent. The MJO signal is less apparent in the OLR field.

Most dynamical models suggest propagation of the signal to the Maritime Continent during Week-1, with rapid weakening of the signal during Week-2. Some of the anticipated weakening may be due to model depictions of Kelvin Wave activity and a lower frequency feature favoring suppressed convection over the western North Pacific.

Extratropical impacts of the MJO on the U.S. are likely to be limited. While an MJO event over the Maritime Continent is usually consistent with suppressed tropical cyclone activity over the Western Hemisphere, Kelvin Wave activity may contribute to tropical cyclone formation near the Bay of Campeche during 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

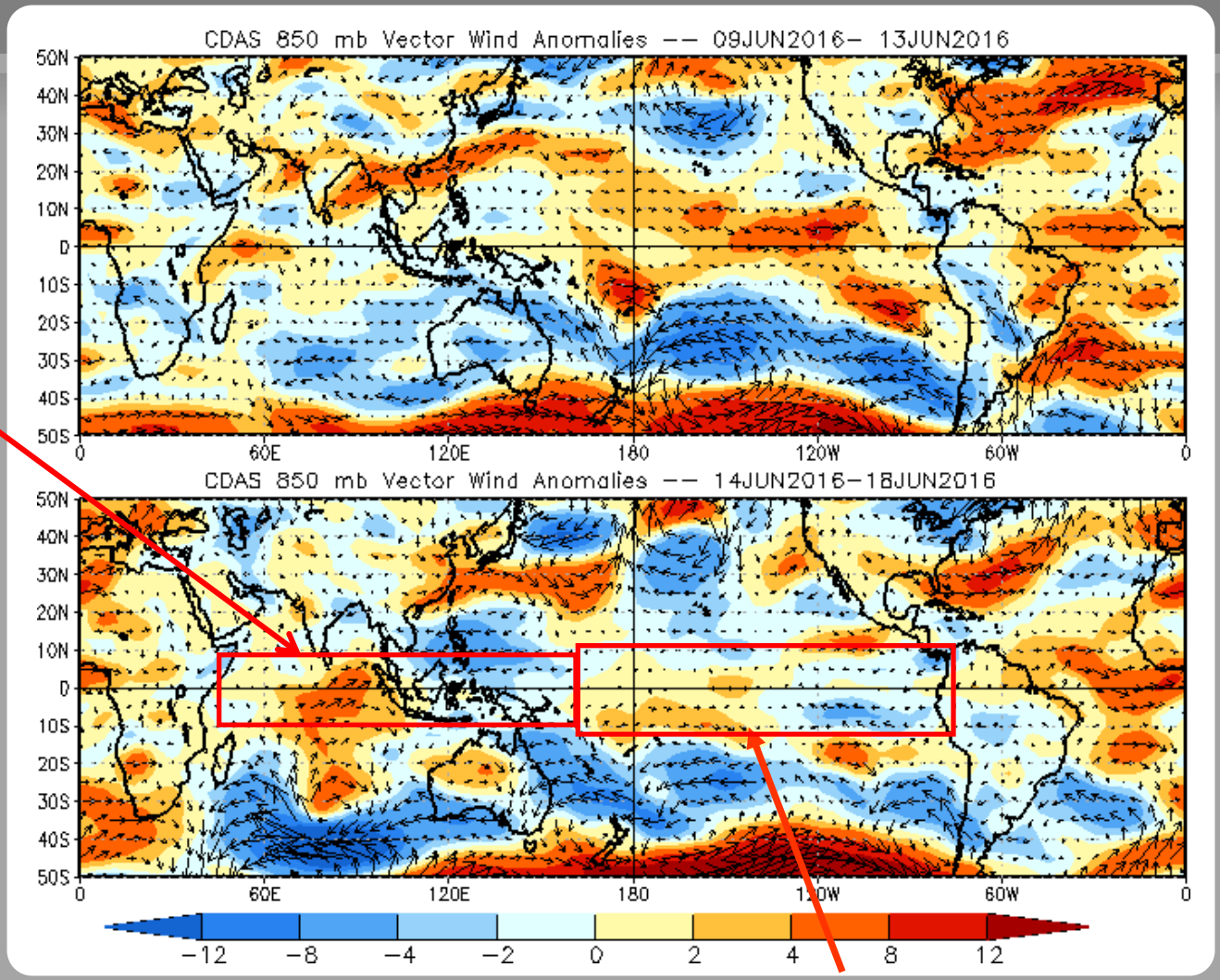
850-hPa Vector Wind Anomalies (m s-1)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Westerly (easterly) anomalies increased over the equatorial central and eastern Indian Ocean (Maritime Continent, primarily off-equator).



Westerly anomalies persisted near and east of the Date Line, while the anomaly field weakened over the East Pacific.

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

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

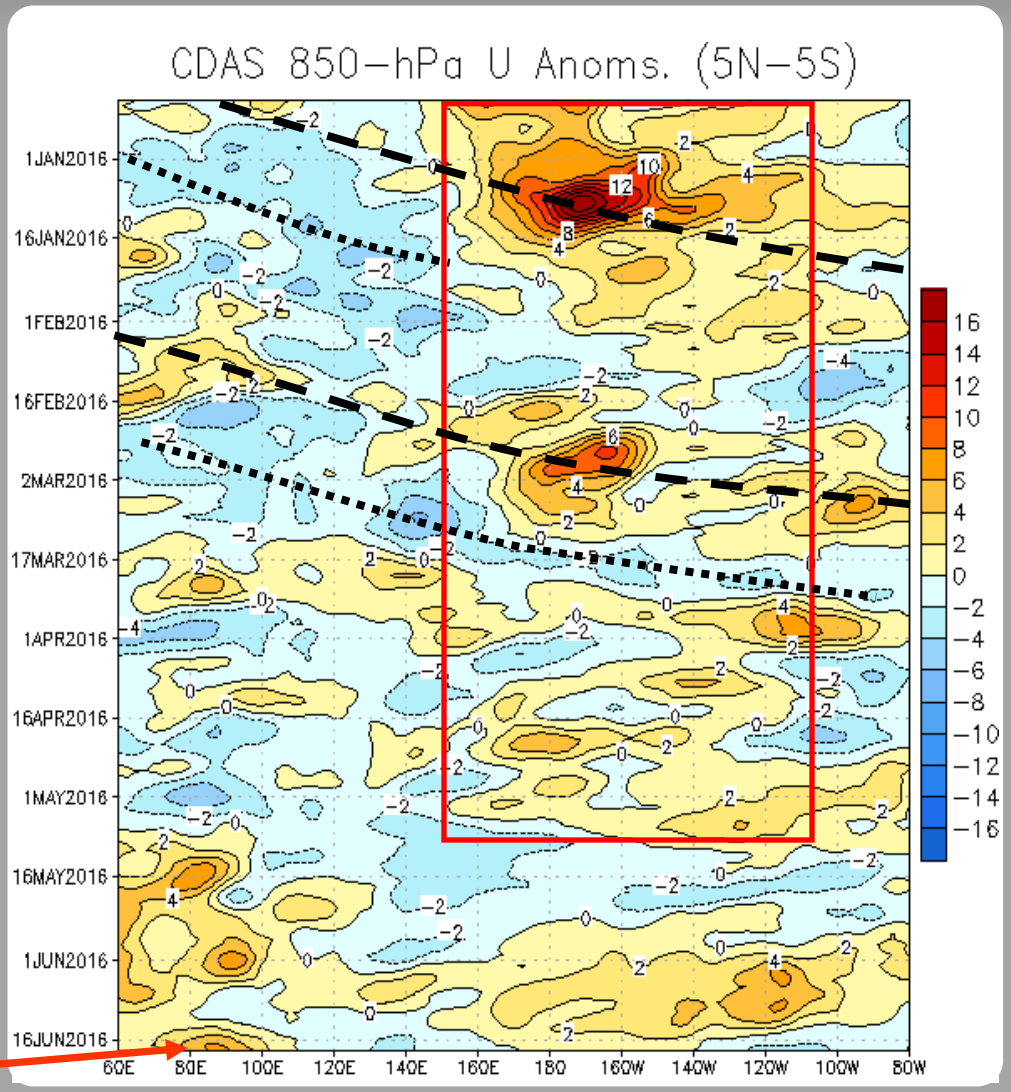
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

Several fast-propagating intraseasonal events modulated the El Niño base state, and are marked using long (short) dashed lines for the enhanced (suppressed) phase of the intraseasonal signal.

During April, the wind field became less coherent as El Niño conditions weakened. Westerly anomalies strengthened over the Indian Ocean in late May, with some eastward propagation.

During June, westerly anomalies increased once again over the central and eastern Pacific. More recently, a new burst of westerly anomalies developed over the Indian Ocean.



OLR Anomalies – Past 30 days

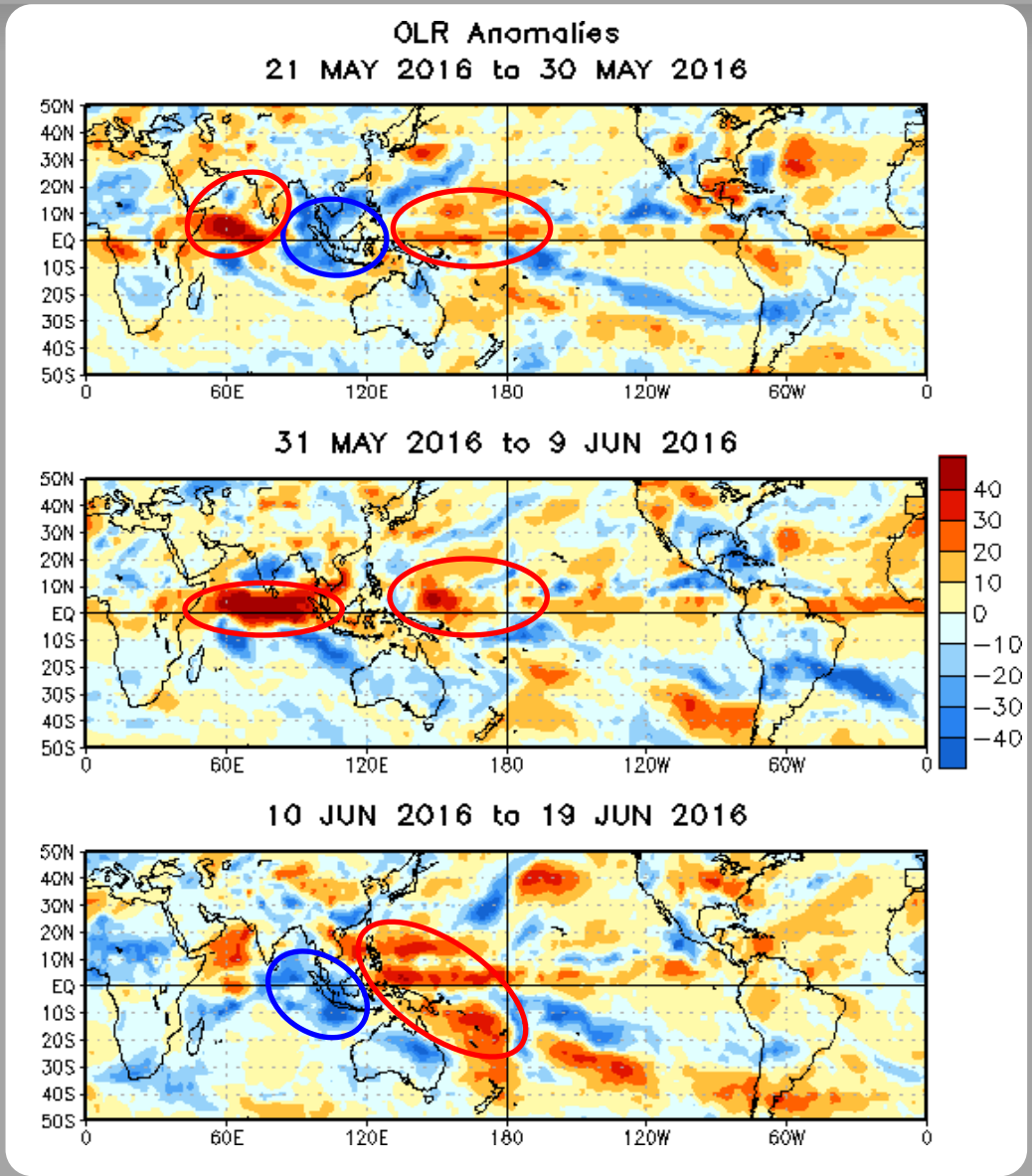
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late May, enhanced convection encompassed the western Maritime Continent, with suppressed convection across the western Indian Ocean. Suppressed convection was also observed over much of the equatorial Pacific and Western Asia.

During early June, suppressed convection overspread the equatorial Indian Ocean. The enhanced convective envelope over the Maritime Continent weakened, however, and did not enter the West Pacific.

Enhanced convection returned to the eastern Indian Ocean and western Maritime Continent during mid-June, while suppressed convection persisted over the western equatorial Pacific.



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

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

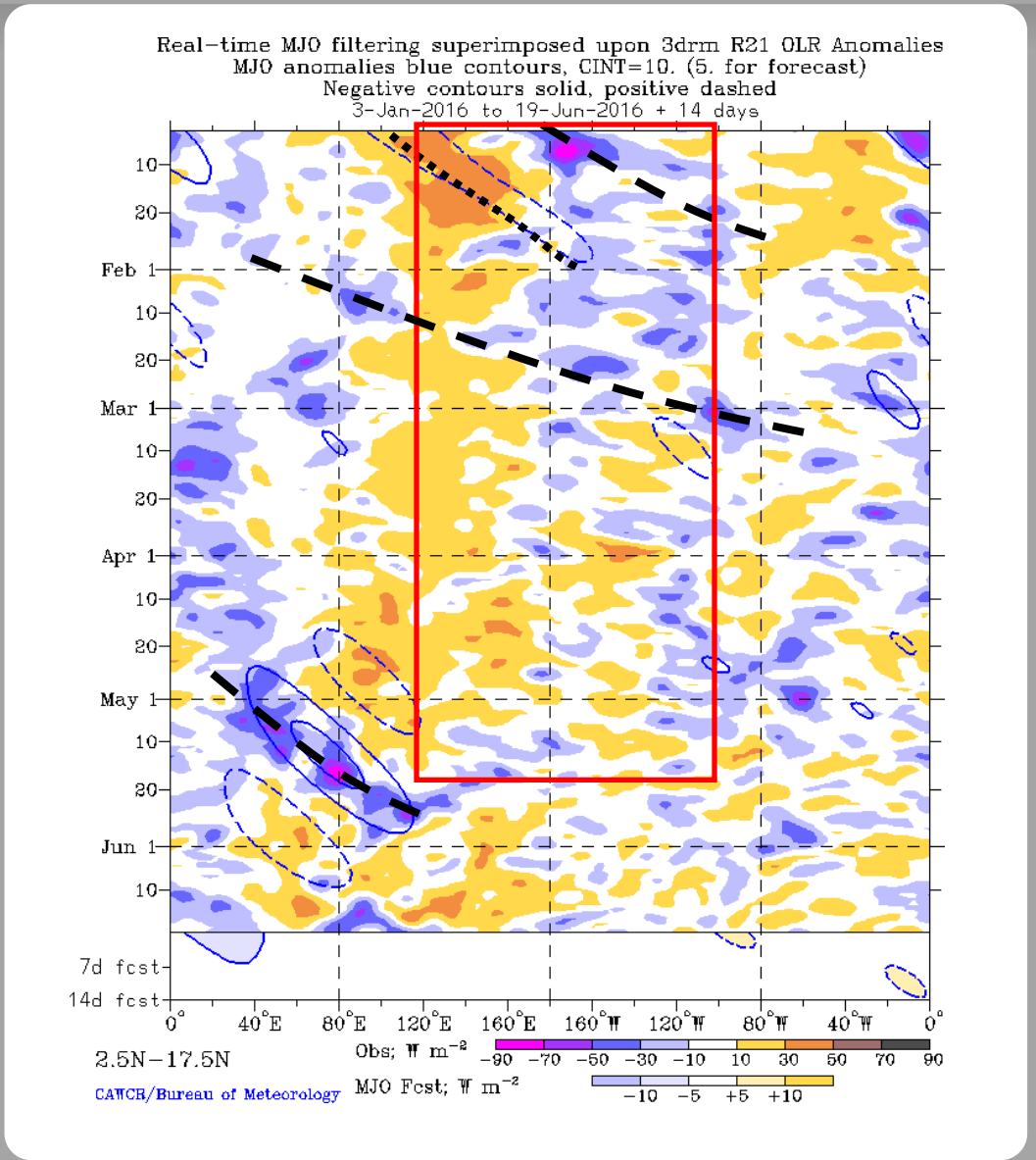
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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. The signal weakened steadily during the past several months.

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. This OLR signal weakened over the Pacific.

Recently, convection has redeveloped over the Indian Ocean.



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

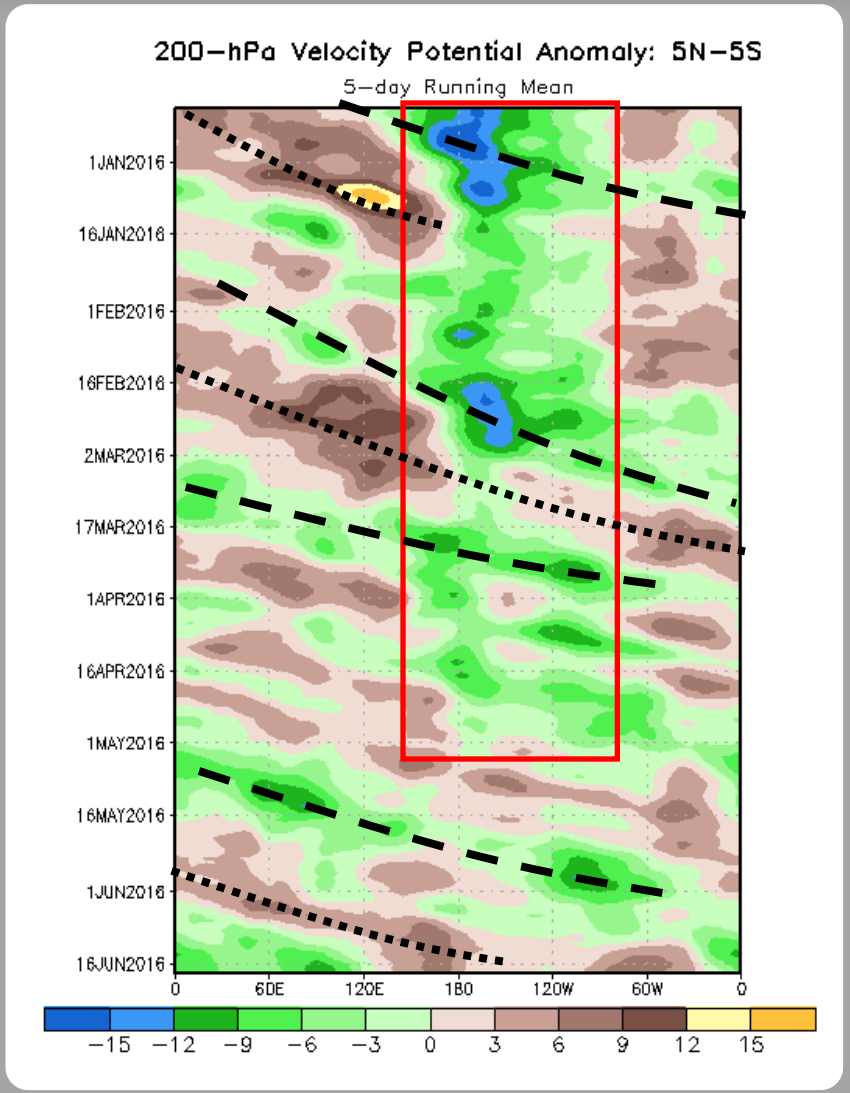
The 2015-16 El Niño background state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

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

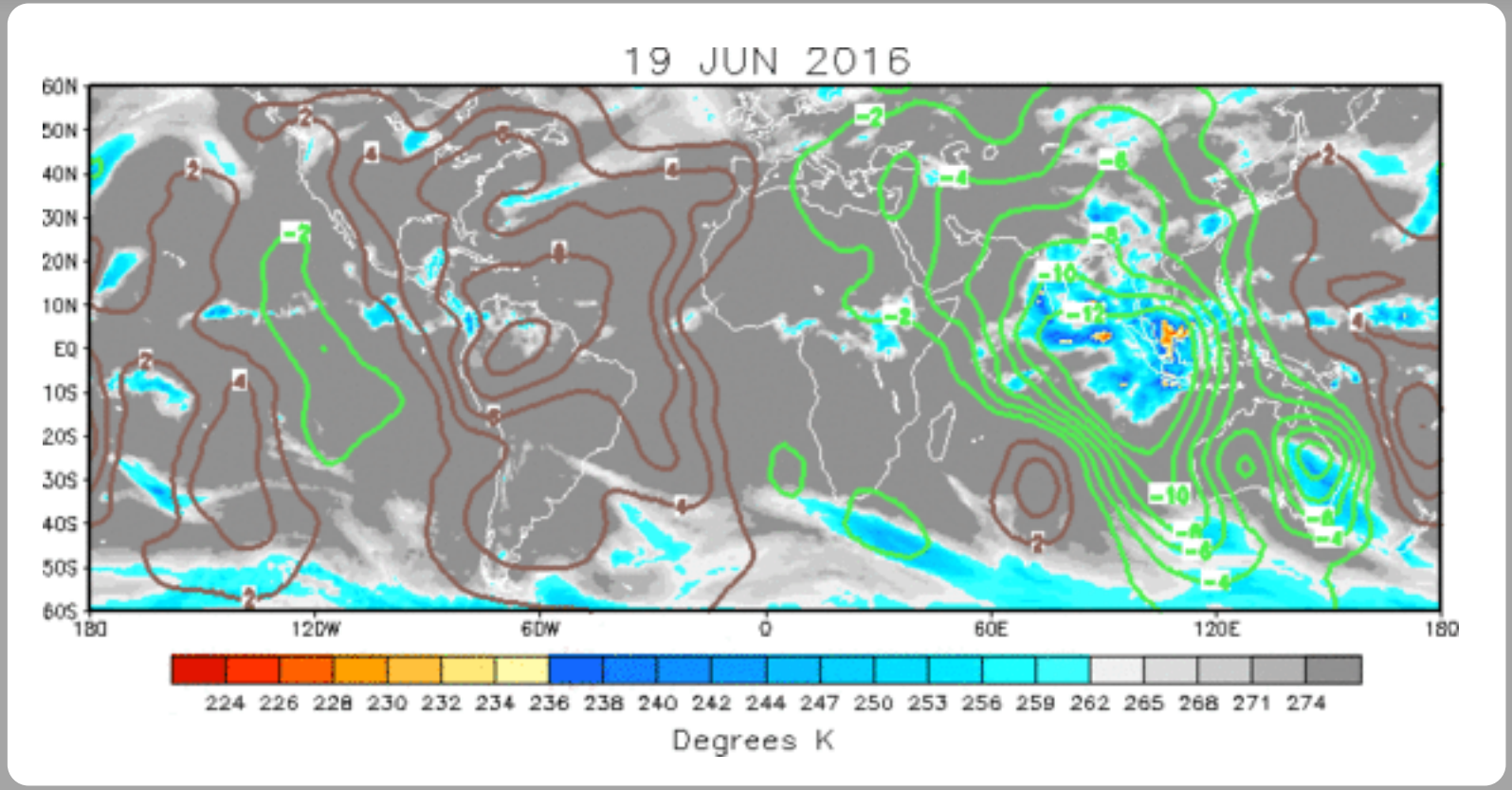
The upper-level velocity potential pattern became less coherent as the El Niño waned during April.

During May and early June, an eastward propagating signal was evident in the upper-level velocity potential field. This signal was more coherent than the low-level MJO indicators.

More recently, anomalous divergence returned to the Indian Ocean and western Maritime Continent.



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



The large scale upper-level velocity potential anomaly pattern presents a Wave-2 asymmetry, with robust negative (positive) anomalies over the Indian Ocean (Americas), and a weaker couplet over the Pacific.

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)

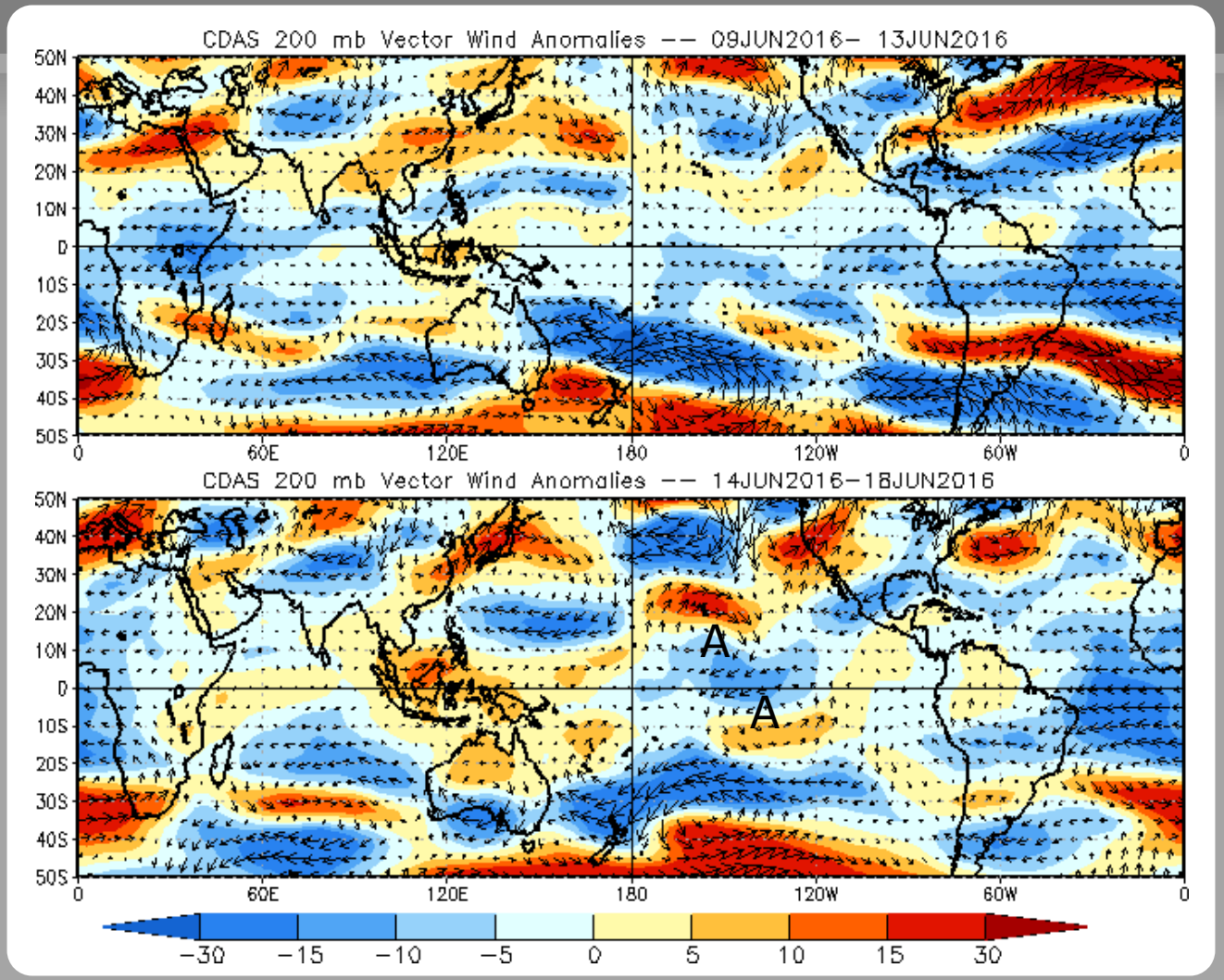
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Westerly upper-level wind anomalies increased over the Maritime Continent, while strong easterlies overspread the tropical Atlantic.

Small anticyclonic gyres in response to enhanced convection just north of the equator are evident over the east-central Pacific.



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

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

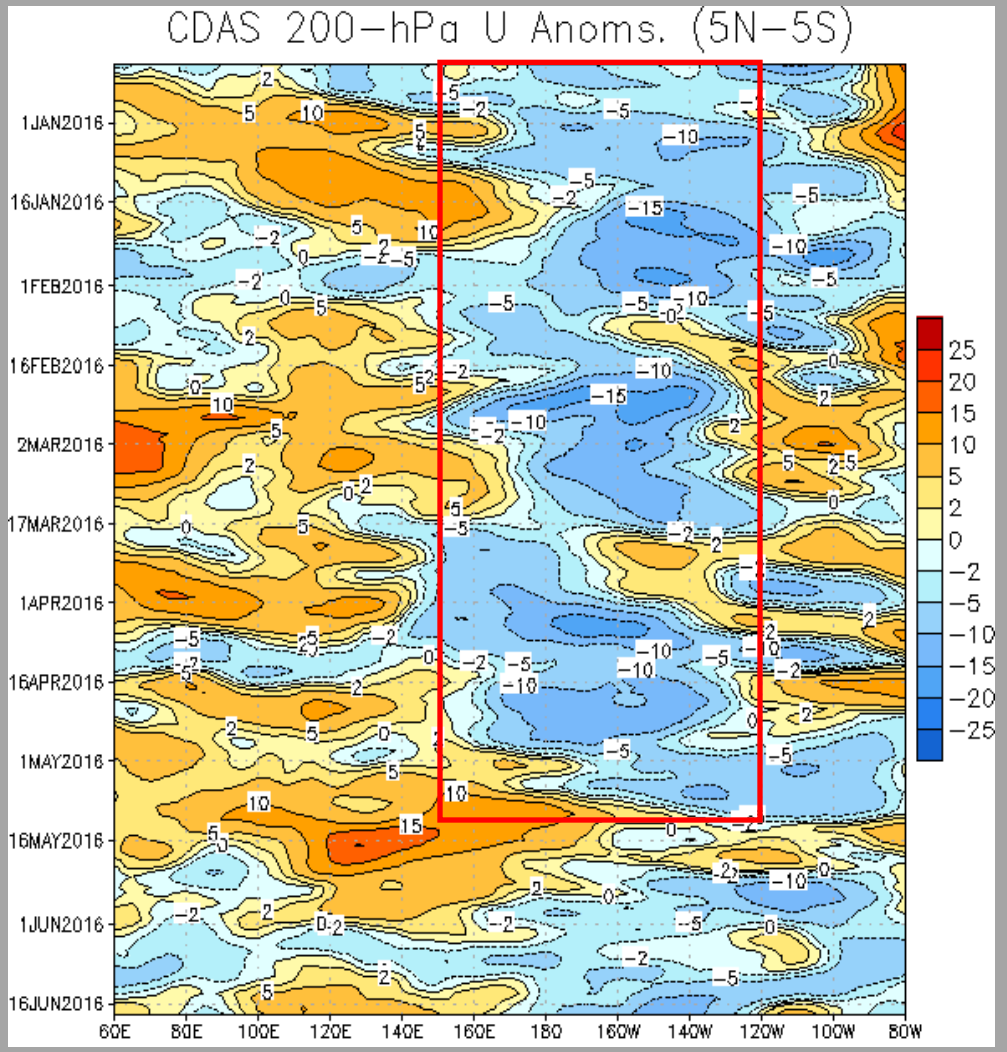
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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 the ENSO event weakened. Faster modes were evident in the upper-level wind field.

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

More recently, westerly (easterly) anomalies strengthened over the Indian Ocean and Maritime Continent (east-central Pacific).



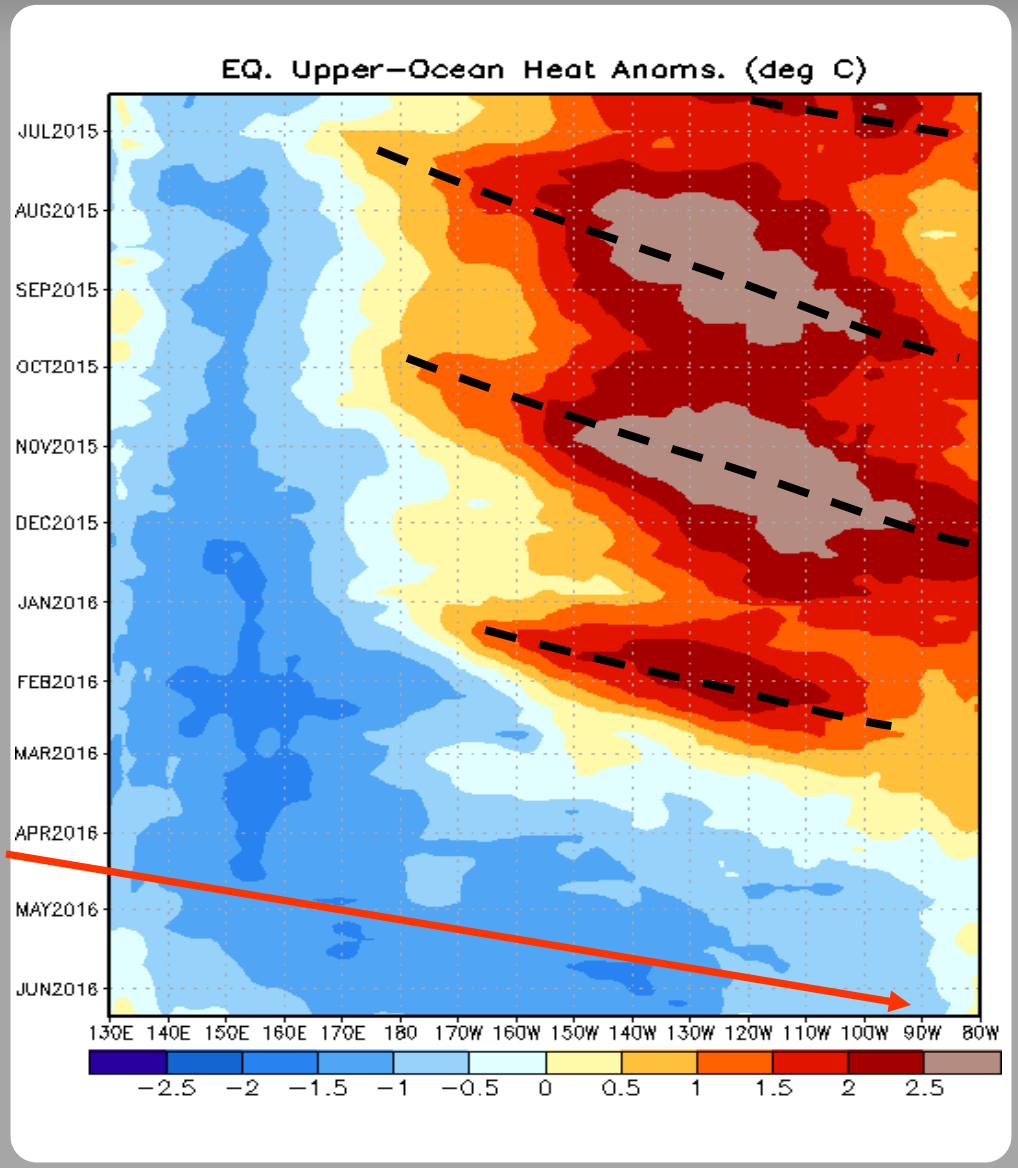
Weekly Heat Content Evolution in the Equatorial Pacific

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

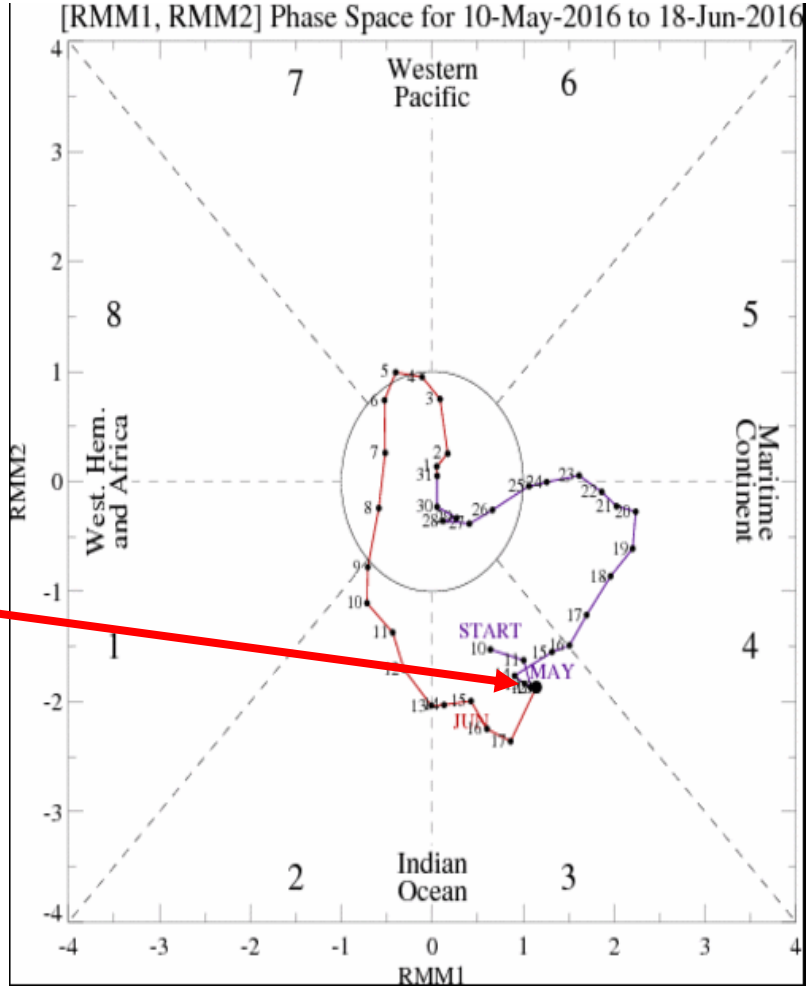
The triangular areas indicate the location of the enhanced phase of the MJO

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

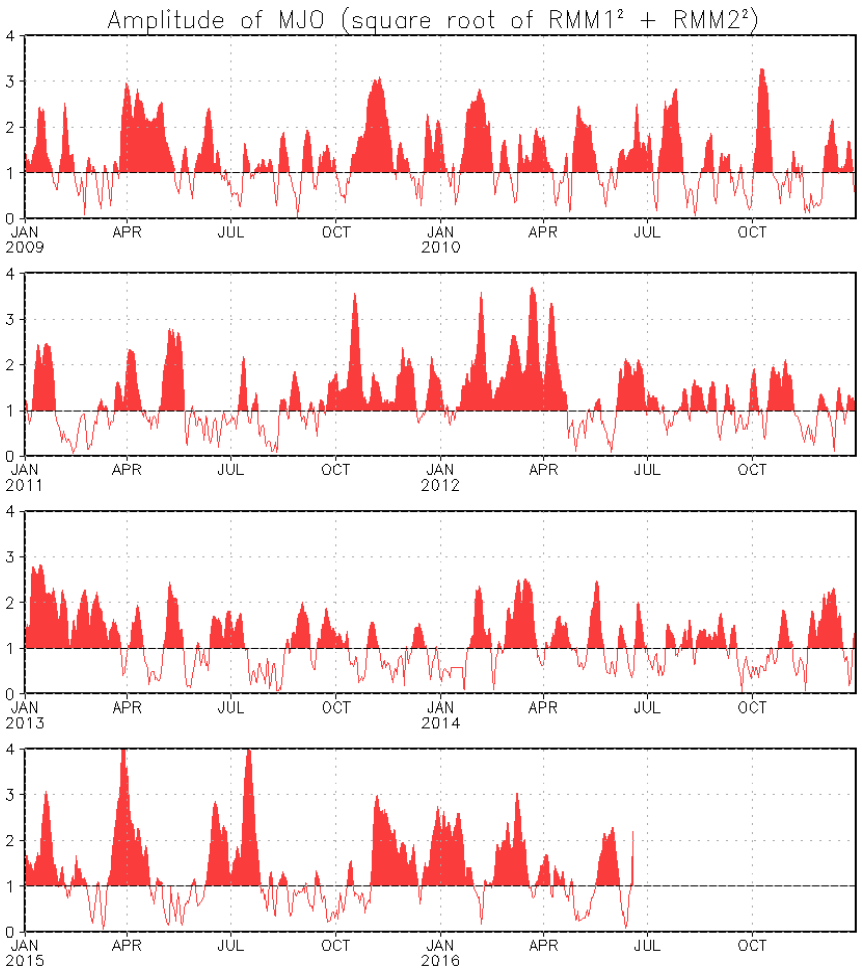
During the past week, the RMM index depicted steady eastward propagation of a robust MJO signal.



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.



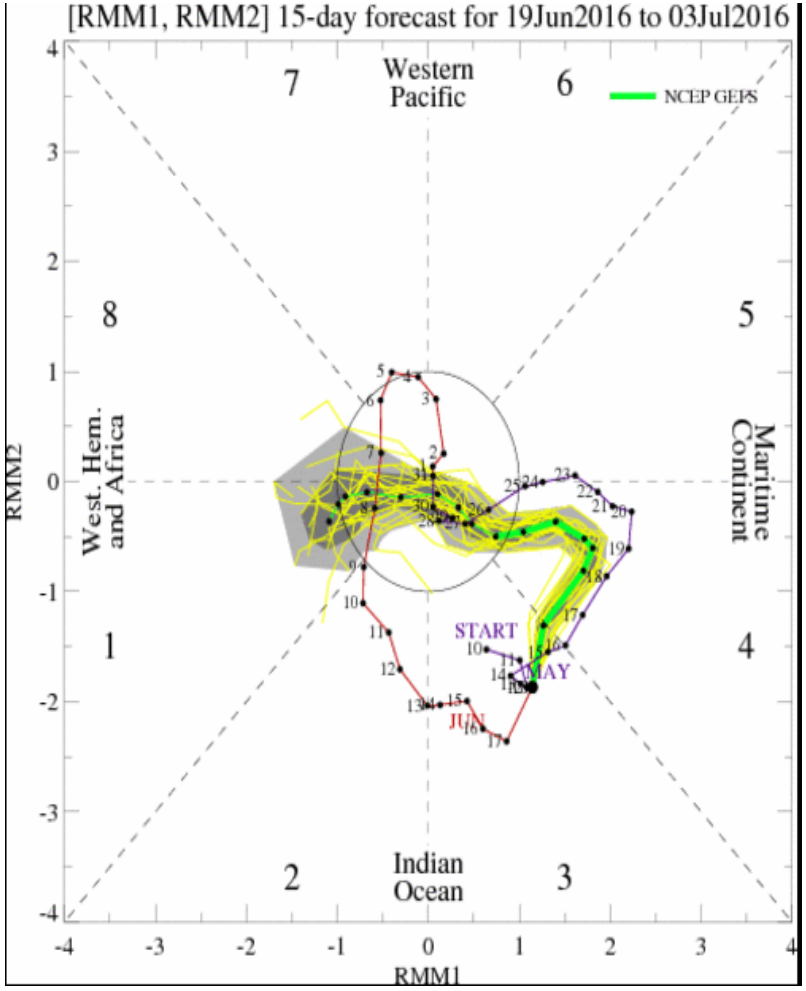
Ensemble GFS (GEFS) MJO Forecast

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



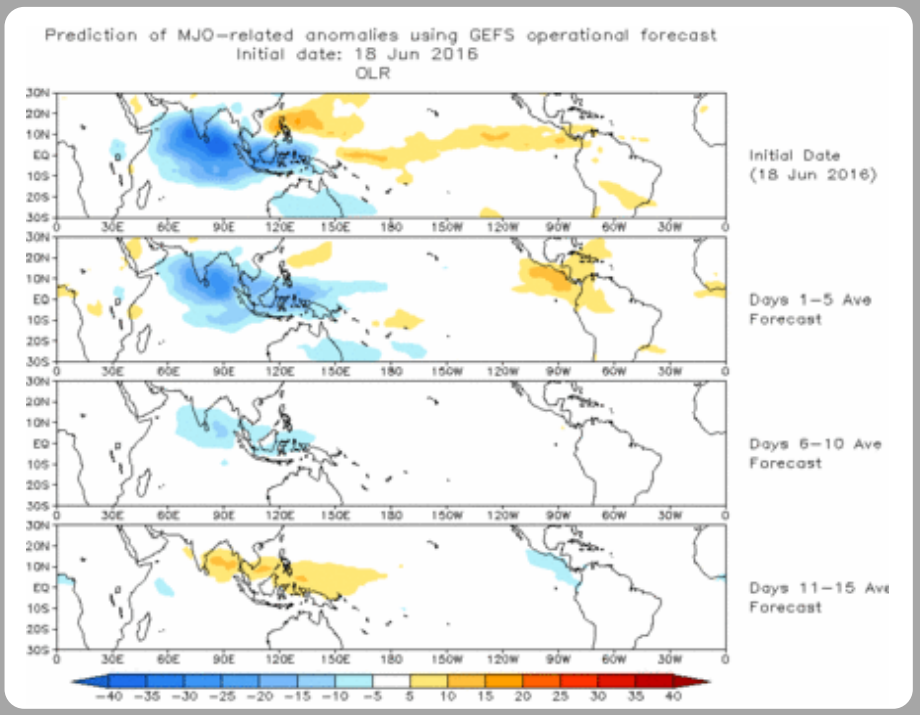
During the next two weeks, the GFS ensemble indicates rapid weakening of the MJO signal over the Maritime Continent, with a reversal of the convective signal during Week-2.

Questions about this potential propagation relate to changes in the background state with the decaying El Niño event being aliased into the 120-day mean state.

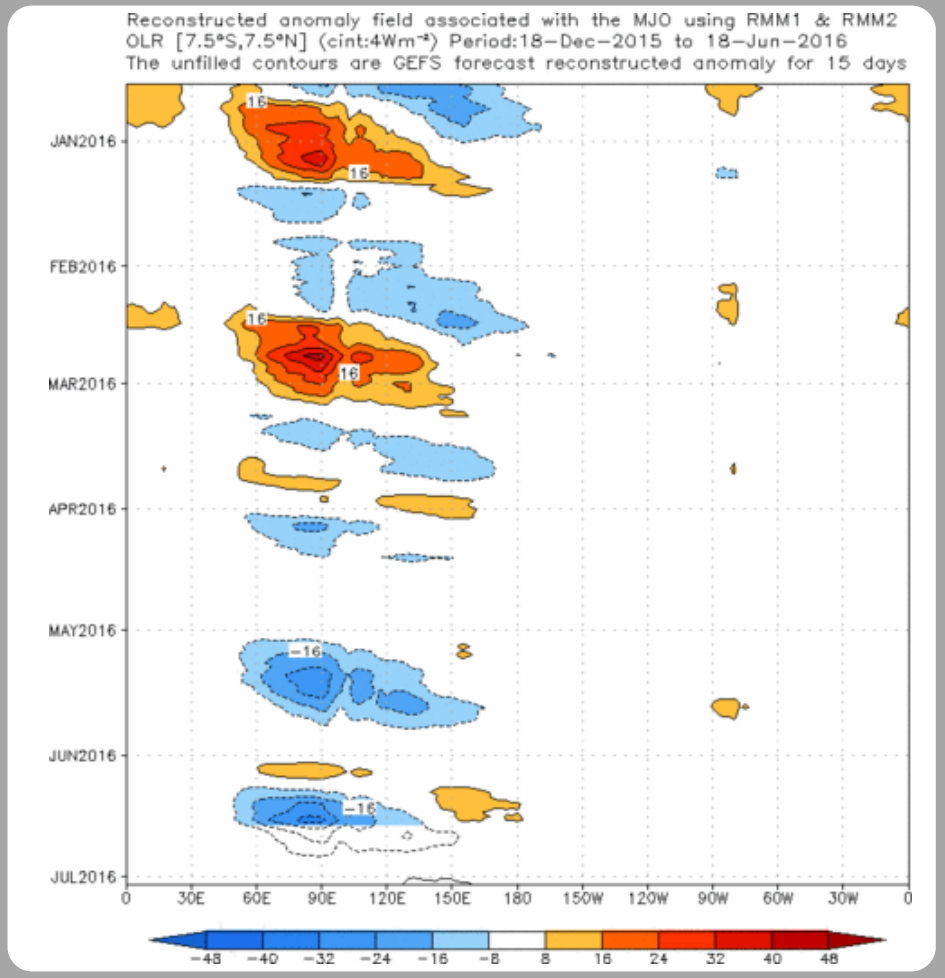
Ensemble GFS (GEFS) MJO Forecast

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

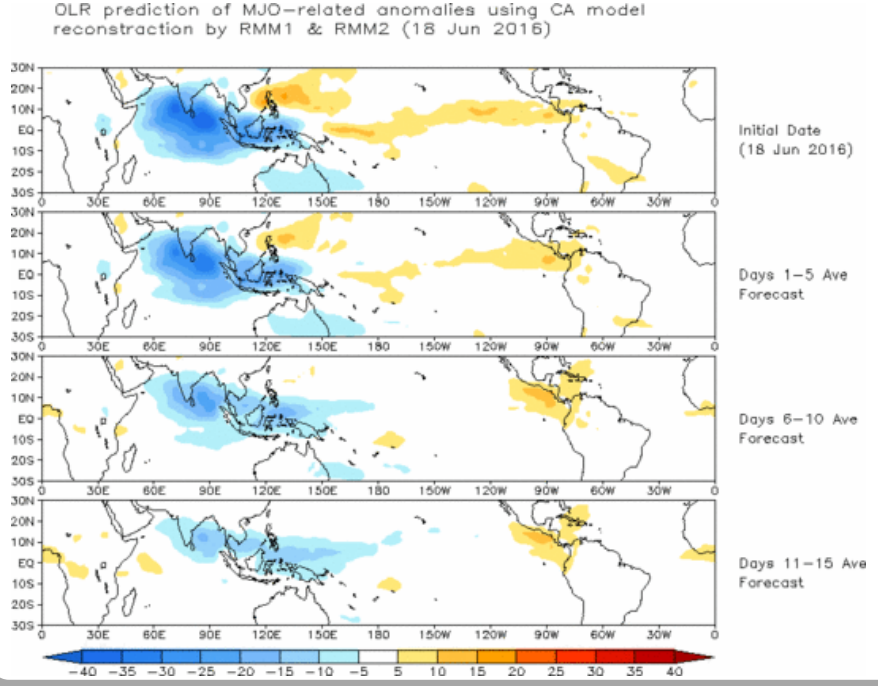


The GEFS OLR forecast based on the RMM Index depicts rapid weakening of robust convective anomalies by the end of Week-1, and a reversal of the pattern during Week-2.

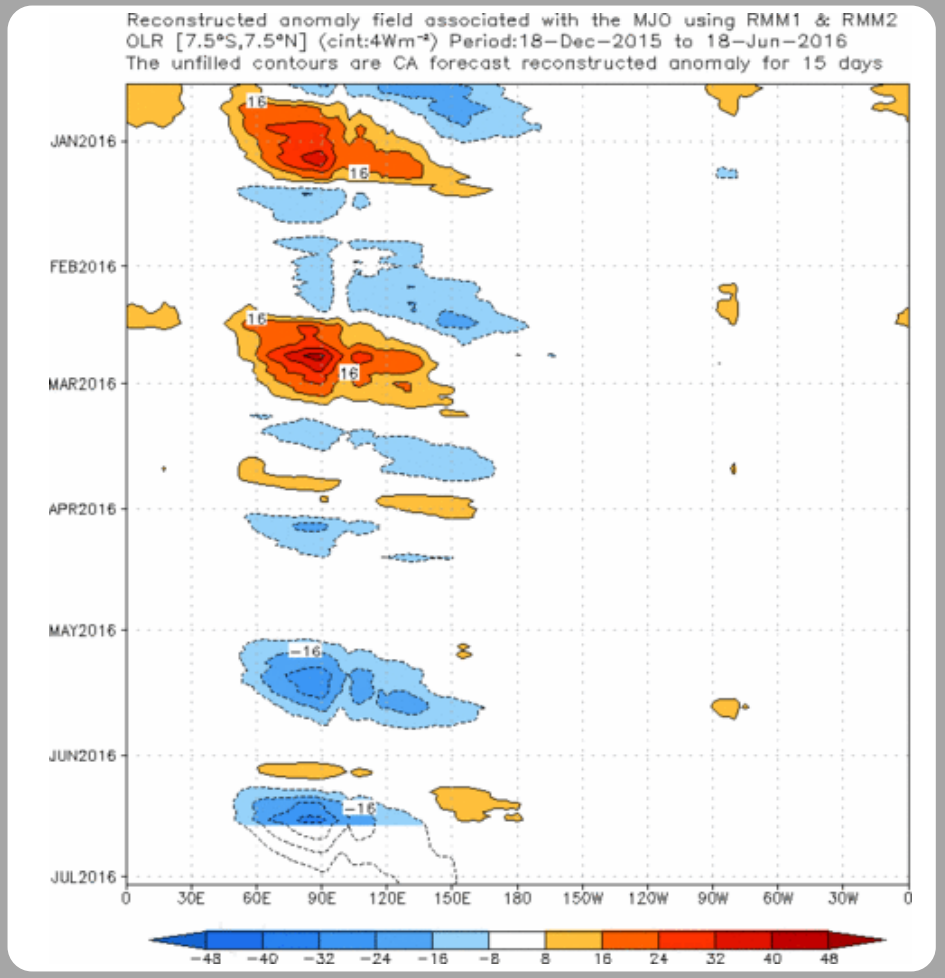
Constructed Analog (CA) MJO Forecast

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



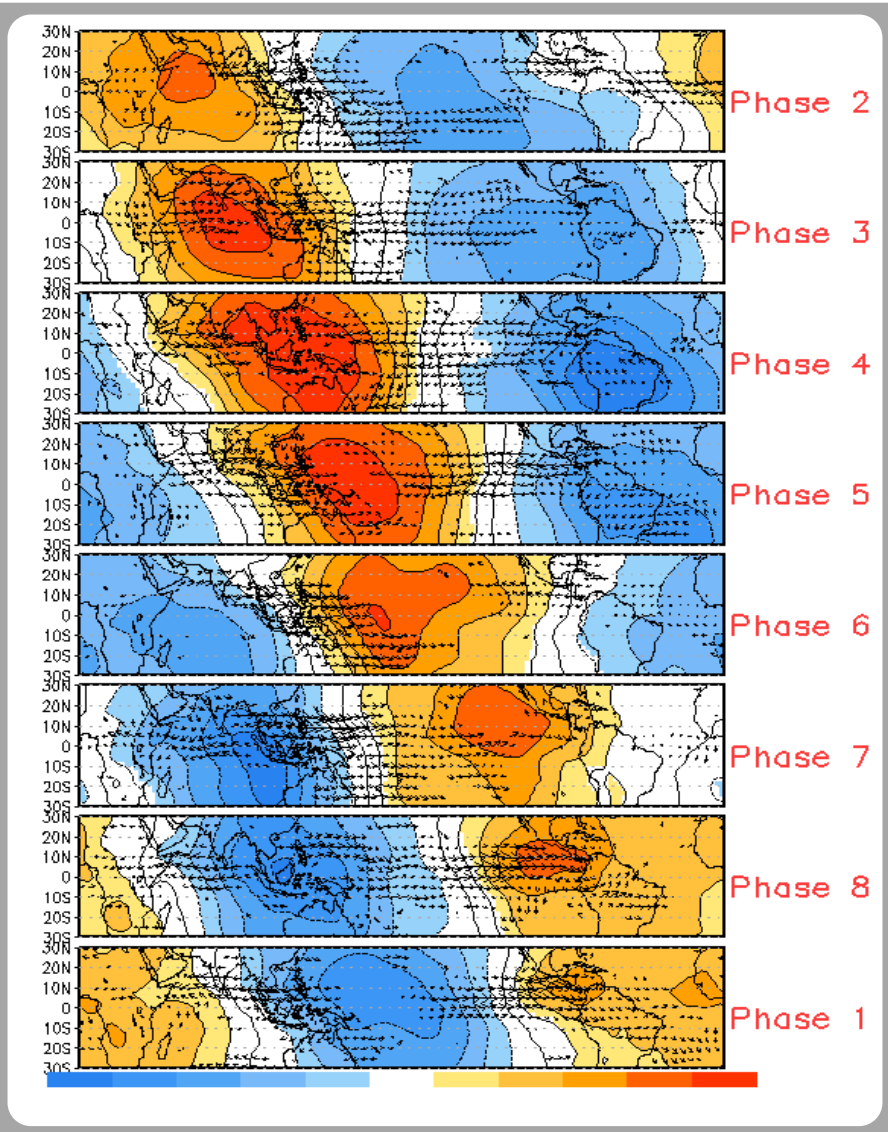
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



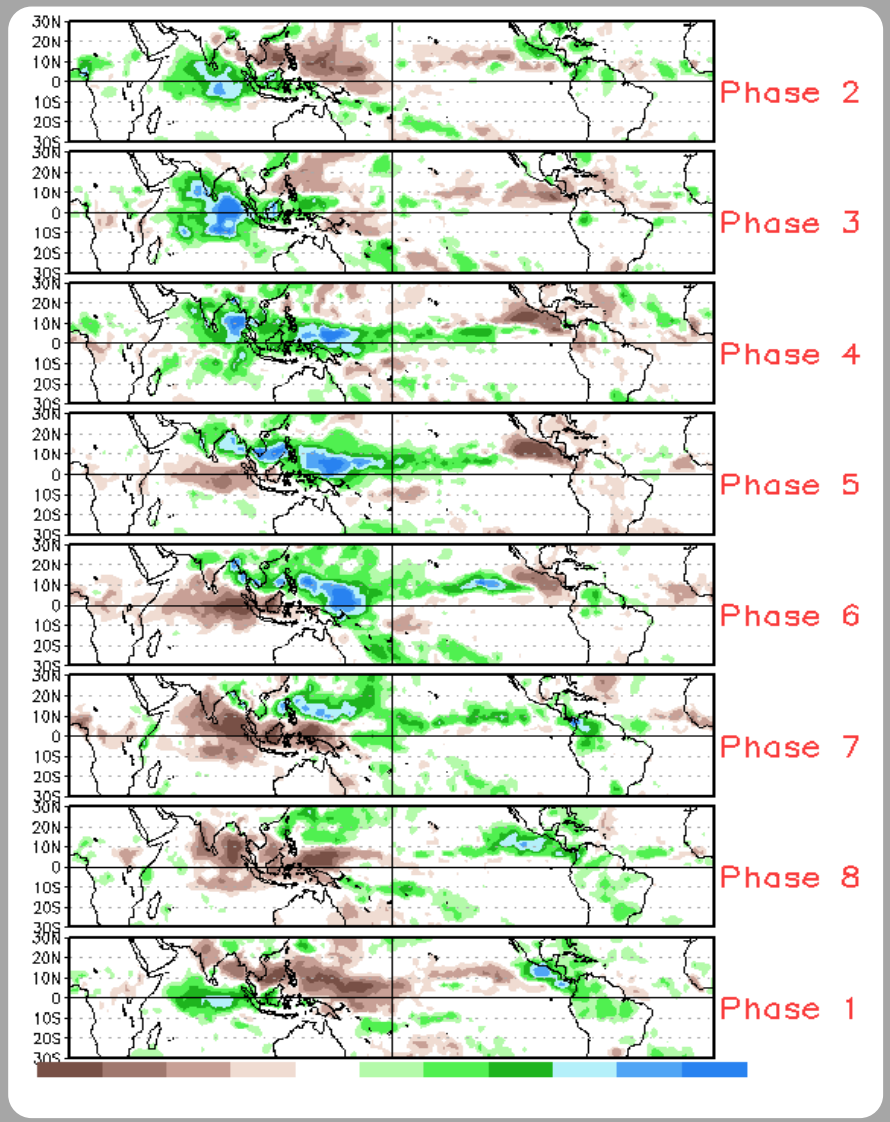
The Constructed Analog (CA) model predicts continued eastward propagation of the MJO signal to the Maritime Continent and West Pacific over the next two weeks.

MJO Composites - Global Tropics

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



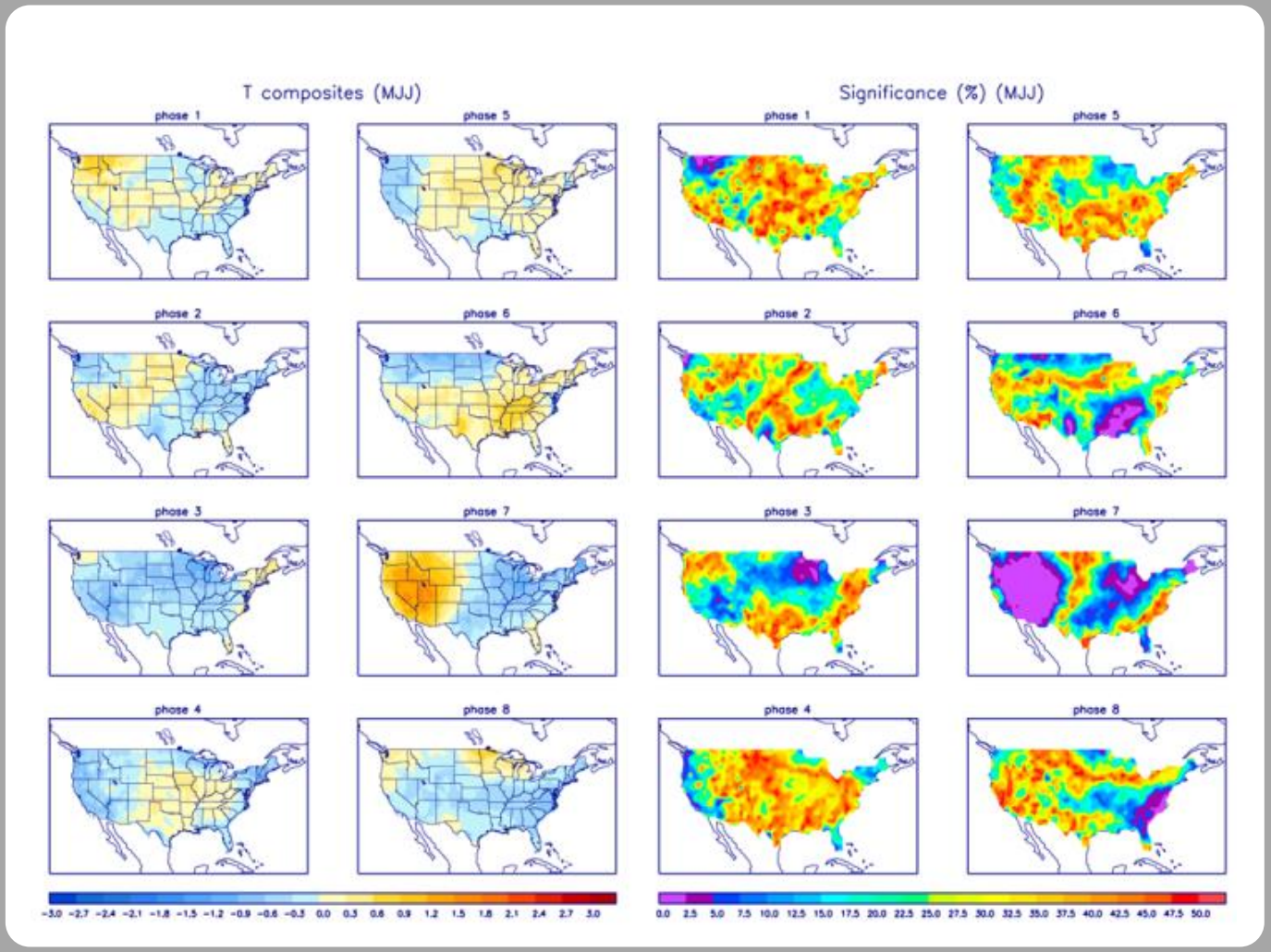
Precipitation Anomalies (May - Sep)



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.



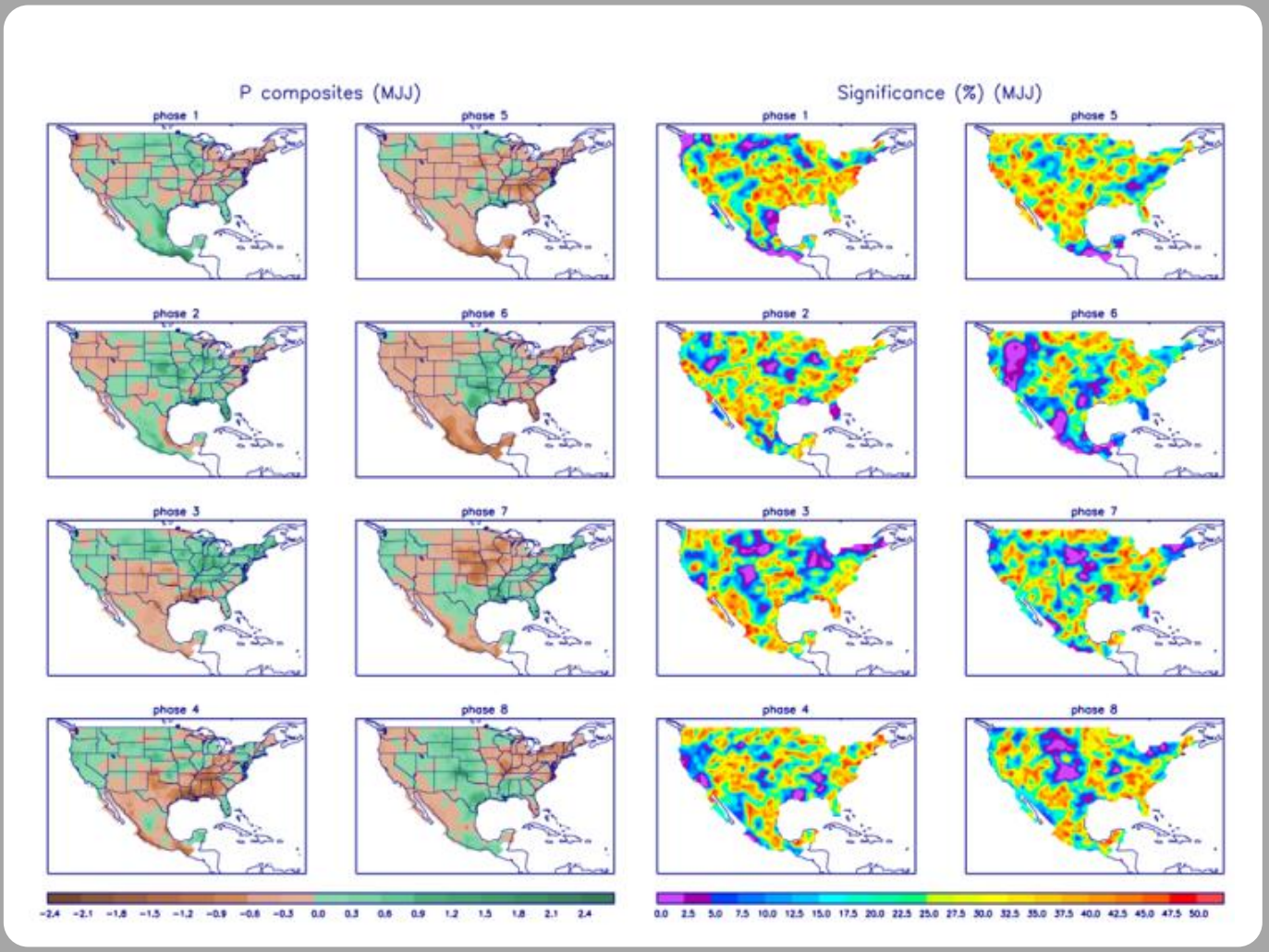
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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.



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