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

Update prepared by: Climate Prediction Center / NCEP
25 April 2016

Outline

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Overview

The MJO signal continues to be incoherent during the past week.

Dynamical models generally support a weak, incoherent MJO during the next two weeks, though there are a few model solutions which show an emerging MJO signal during Week-2 over the Indian Ocean/Maritime Continent region. Confidence is reduced regarding potential impacts of the MJO and other modes of variability on the global tropical convective pattern.

At this time, the MJO is not expected to significantly contribute to the patterns of tropical rainfall during this period.

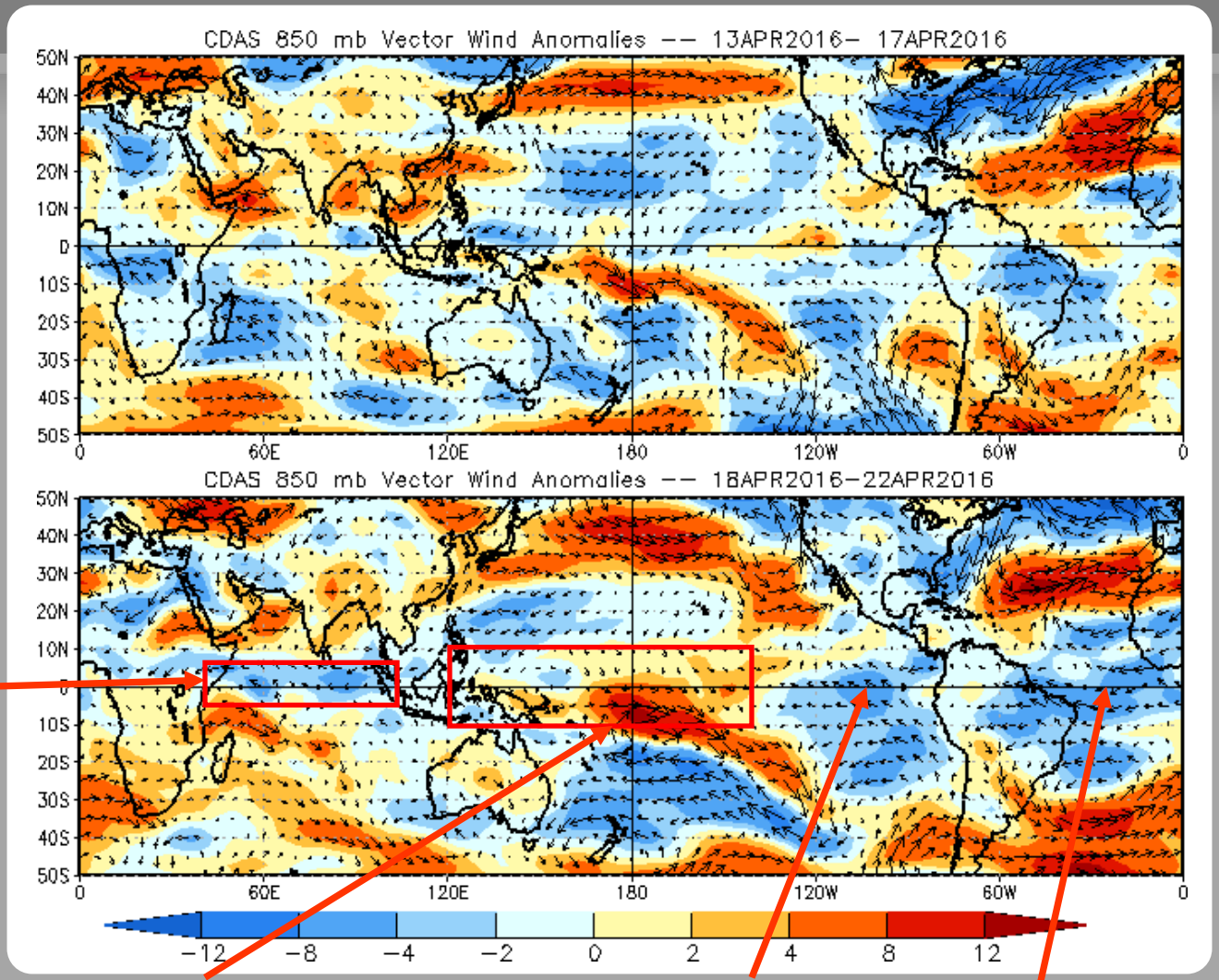
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 increased over the equatorial Indian Ocean.

Easterly anomalies over the eastern Maritime Continent switched to westerly anomalies; westerly anomalies increased during the past week in the vicinity of the Date Line and Equator.

Southeasterly, cross-equatorial flow is noted across the east Pacific.

Easterly anomalies returned to the tropical Atlantic.

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

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

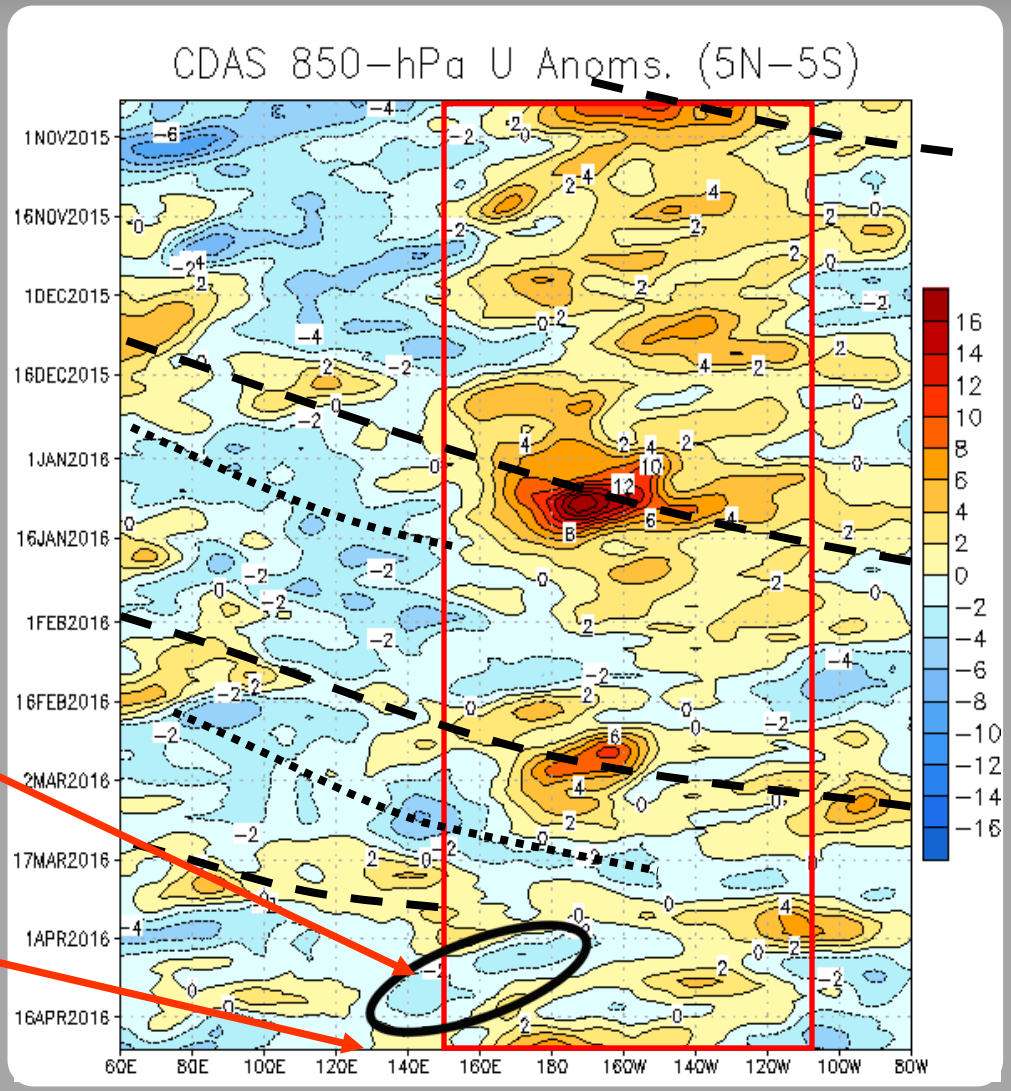
Easterly anomalies (blue shading) represent anomalous east-to-west flow

The red box highlights the persistent low-frequency westerly wind anomalies associated with ENSO.

A fast, eastward propagating intraseasonal signal crossed the Pacific, during March.

Recently, a weak tendency toward the background ENSO state is evident, but the pattern is includes more high frequency variability and little coherence.

An equatorial Rossby Wave (ERW) appears to have moved westward during the first half of April from near the Date Line to near 120 E. A probable Kelvin Wave is depicted near 140E. Westerlies are indicated in the vicinity of the Date Line.



OLR Anomalies – Past 30 days

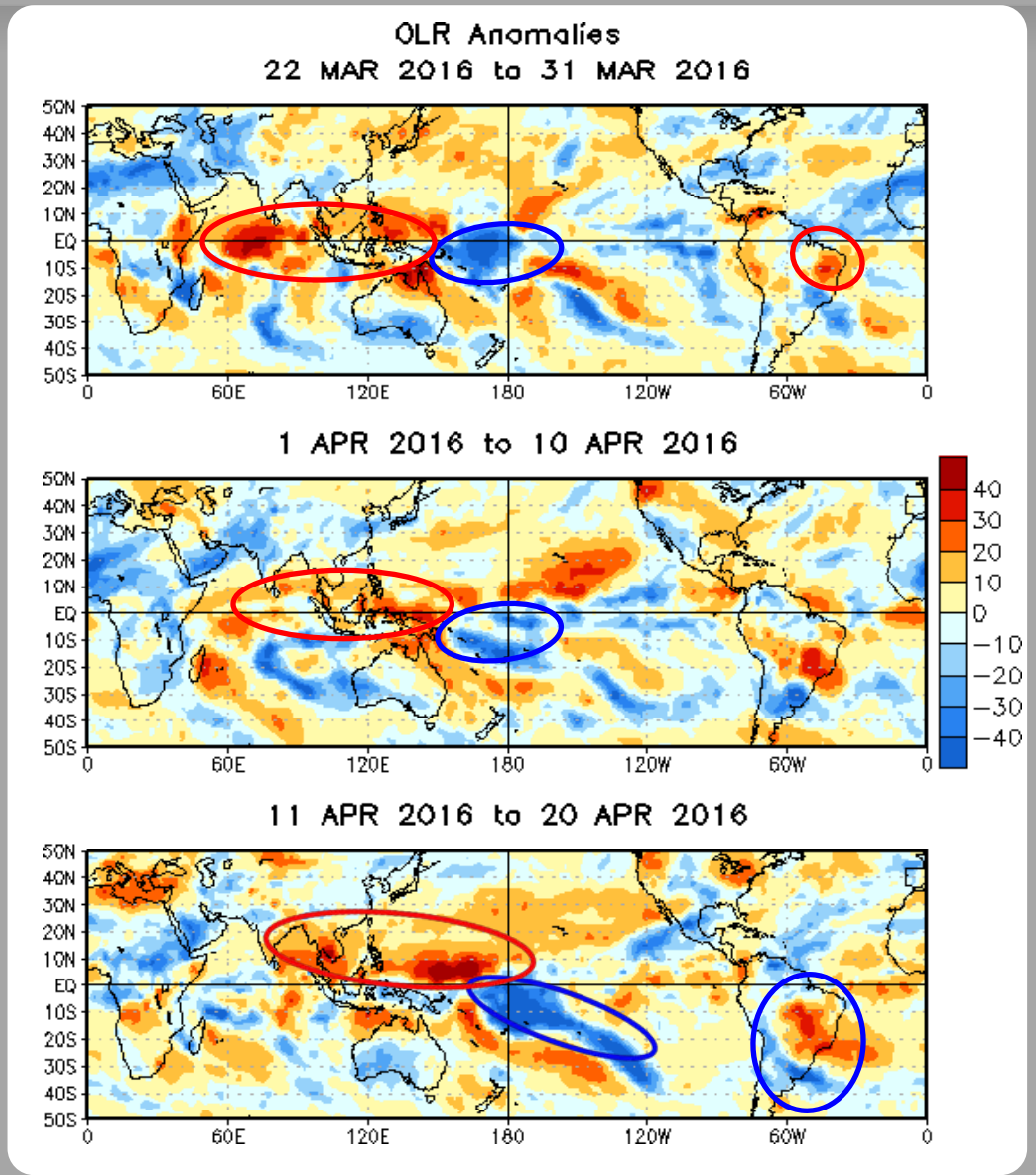
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

Subsidence spread from the Indian Ocean to the Maritime Continent, while subsidence was replaced by enhanced convection over Brazil. Enhanced convection remained near the Date Line. All of those areas and temporal variations are consistent with Kelvin Wave activity.

In early April, enhanced convection returned to the southeastern Indian Ocean. Enhanced convection shifted slightly eastward over the central Pacific while there was a slight uptick over the eastern Pacific.

An enhanced SPCZ is clearly indicated during the middle portion of April. Suppressed convection is noted from the Bay of Bengal eastward across the Maritime Continent to near the Date Line. An anomalous convective couplet is evident over South America.



Outgoing Longwave Radiation (OLR) Anomalies (7.5°S - 7.5°N)

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

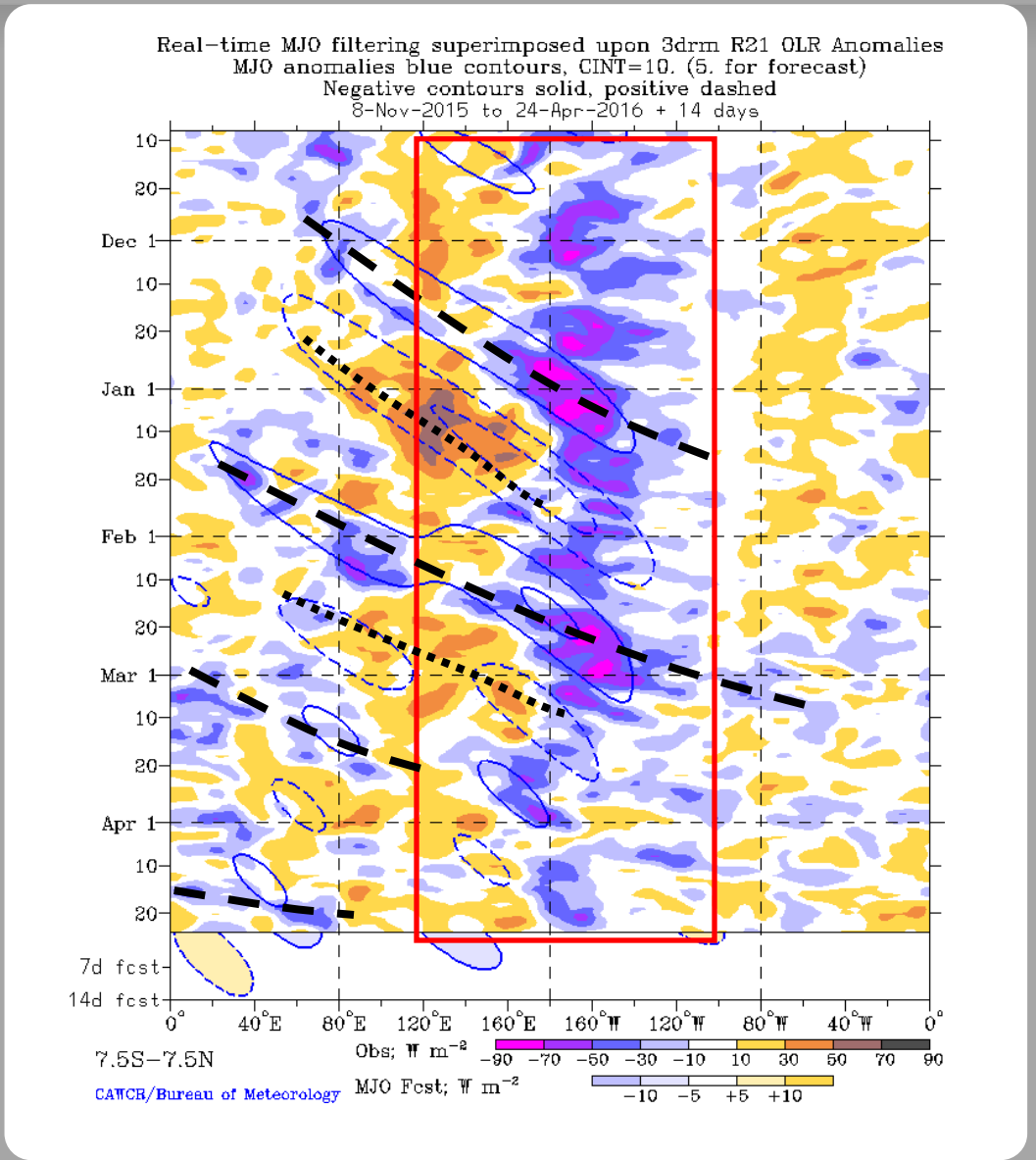
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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

Alternating periods of constructive/destructive interference with ENSO is evident. A fast eastward propagating signal raced across the Pacific during mid-March.

A fairly incoherent pattern continues across the Indian Ocean and Pacific, related to the dispersion of intra-seasonal modes.

A small area of weak enhanced convection associated with a Kelvin Wave over the West Pacific is interfering with the low-frequency background state.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

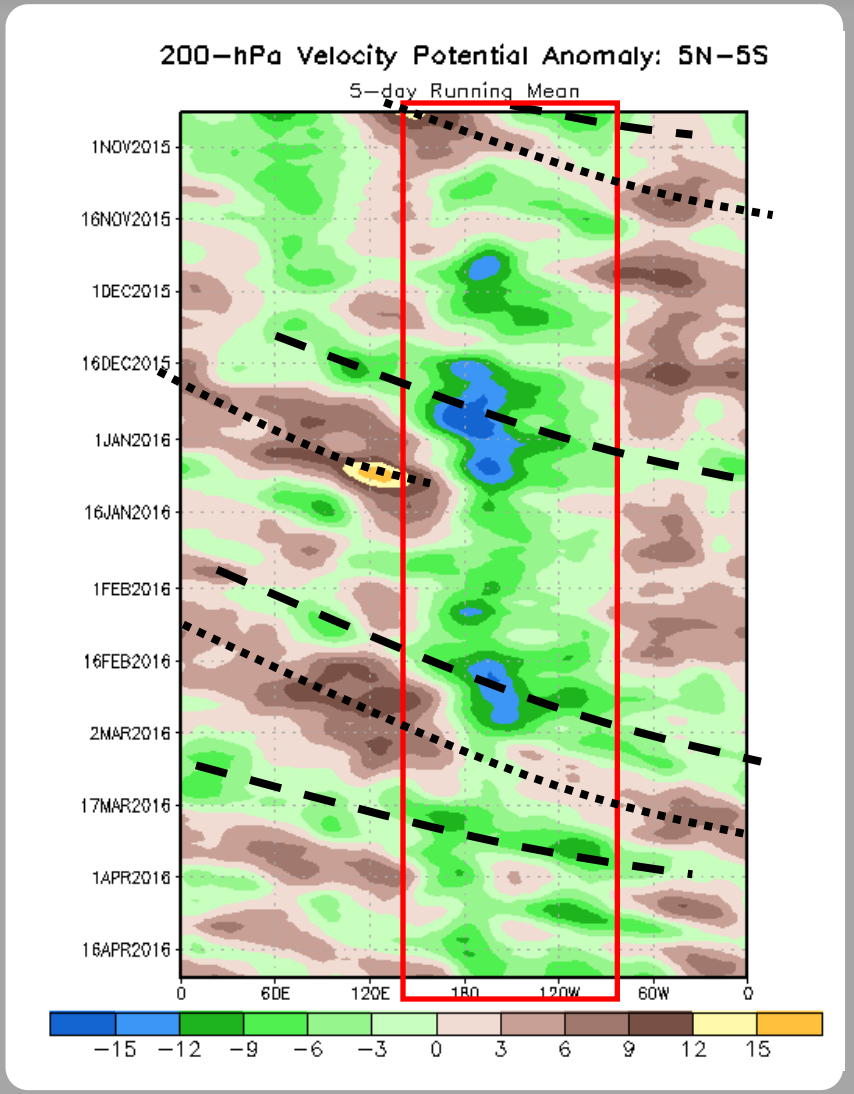
Negative anomalies (green shading) indicate favorable conditions for precipitation

The ongoing ENSO state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific.

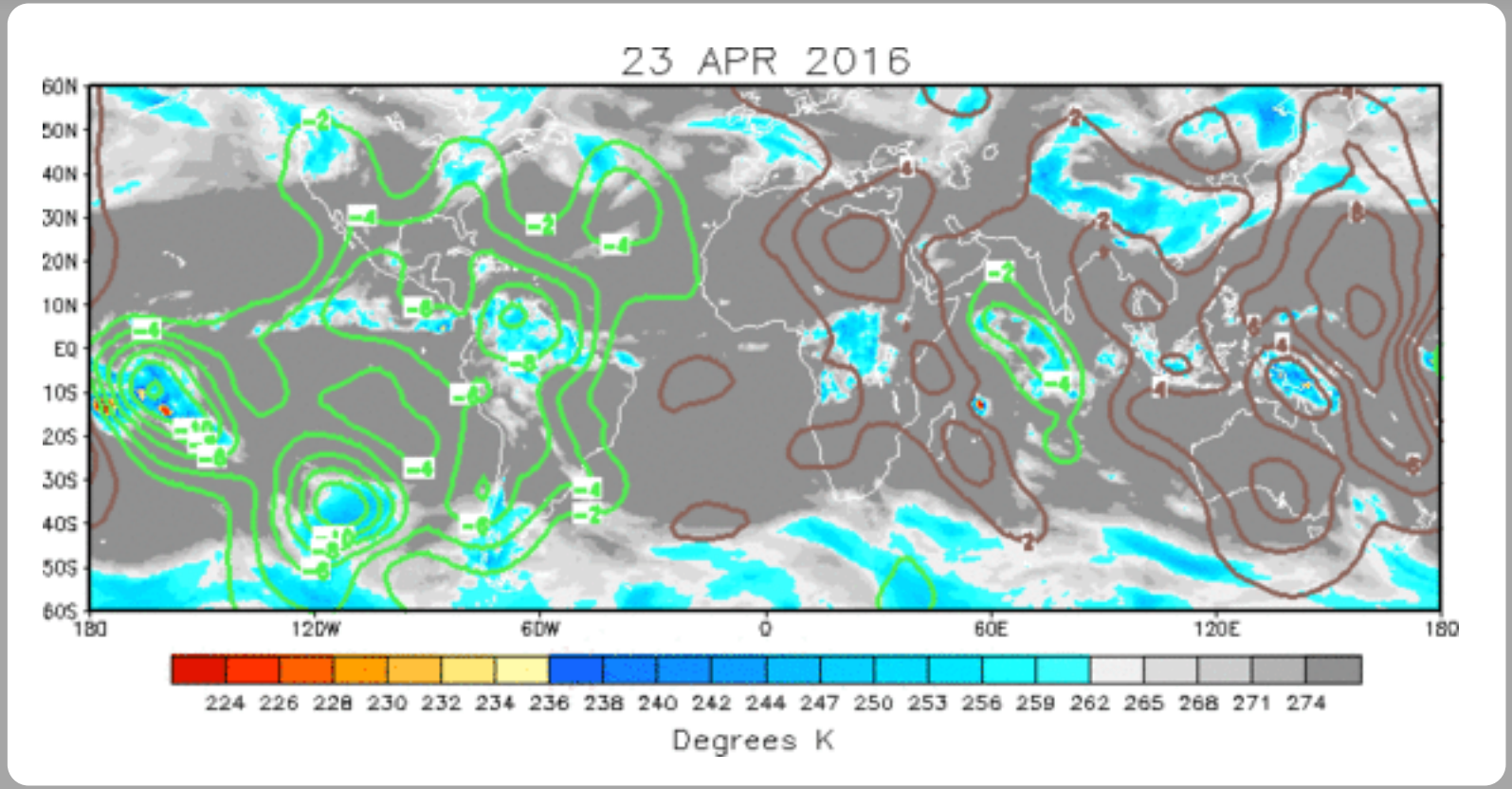
During late February, intraseasonal variability constructively interfered with the ongoing El Nino. During mid-March, the intraseasonal variability destructively interfered with the ENSO signal.

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

During the past month, a weak stationary signal for enhanced convection is noted near and east of the Date Line.



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



The large scale upper-level velocity potential anomaly pattern indicates little in the way of coherent MJO activity. A predominantly wave-1 structure is depicted , with a weakness across the western Indian Ocean.

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

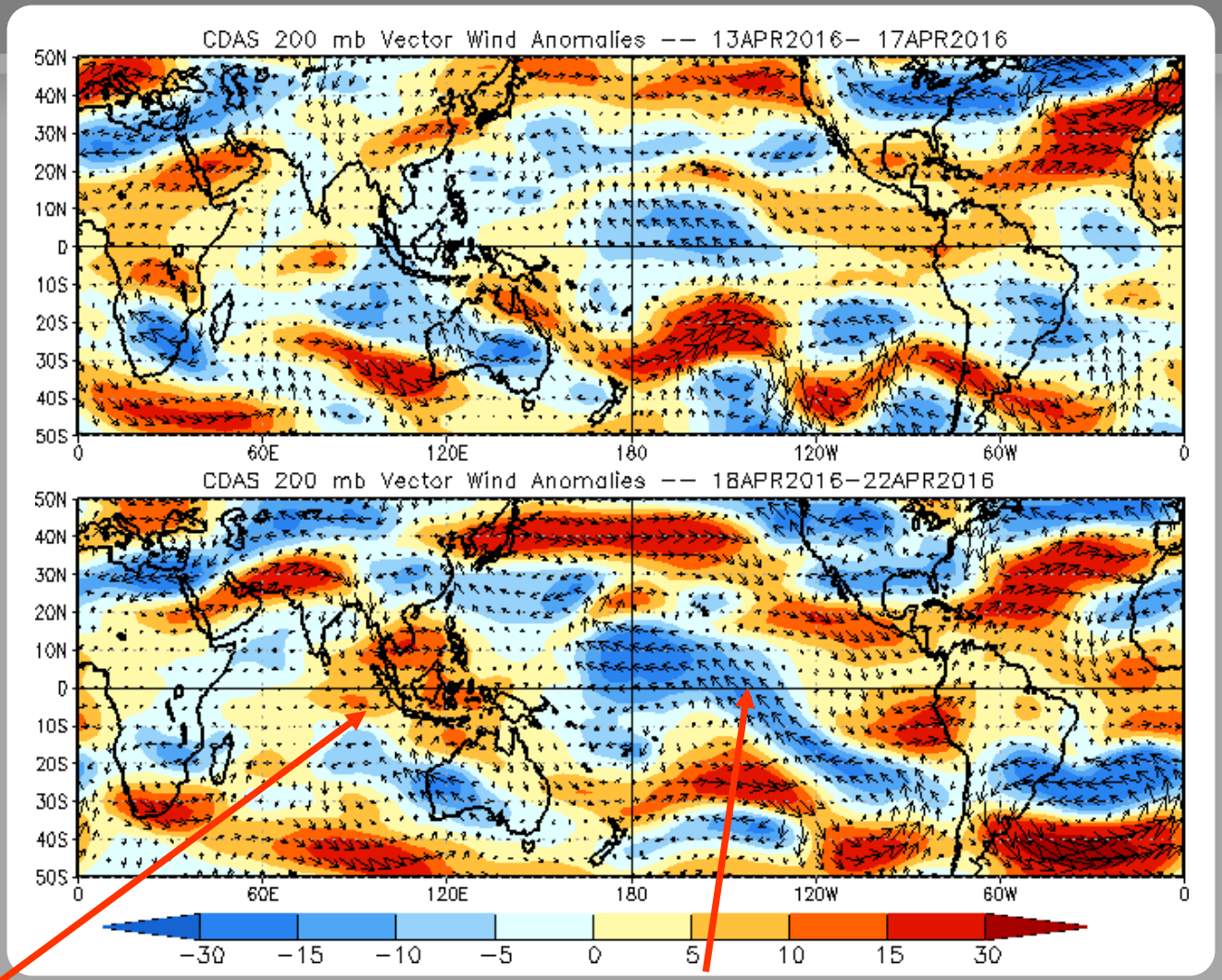
Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Easterly anomalies over the central Pacific have weakened notably, with poleward outflow only evident to the north.

An enhanced, mid-latitude jet is evident across the northern Pacific. It is disconnected from an anticyclonic anomaly to its south near the Date Line. This is consistent with lessened El Nino impacts on the mid-latitudes during the warm season.

During the past week, a large area of upper-level westerly anomalies developed over the Maritime Continent region.



Cross-equatorial flow is observed over the east-central Pacific, and an increase of easterly anomalies is clear mainly north of the Equator in the region of the Date Line.

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

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

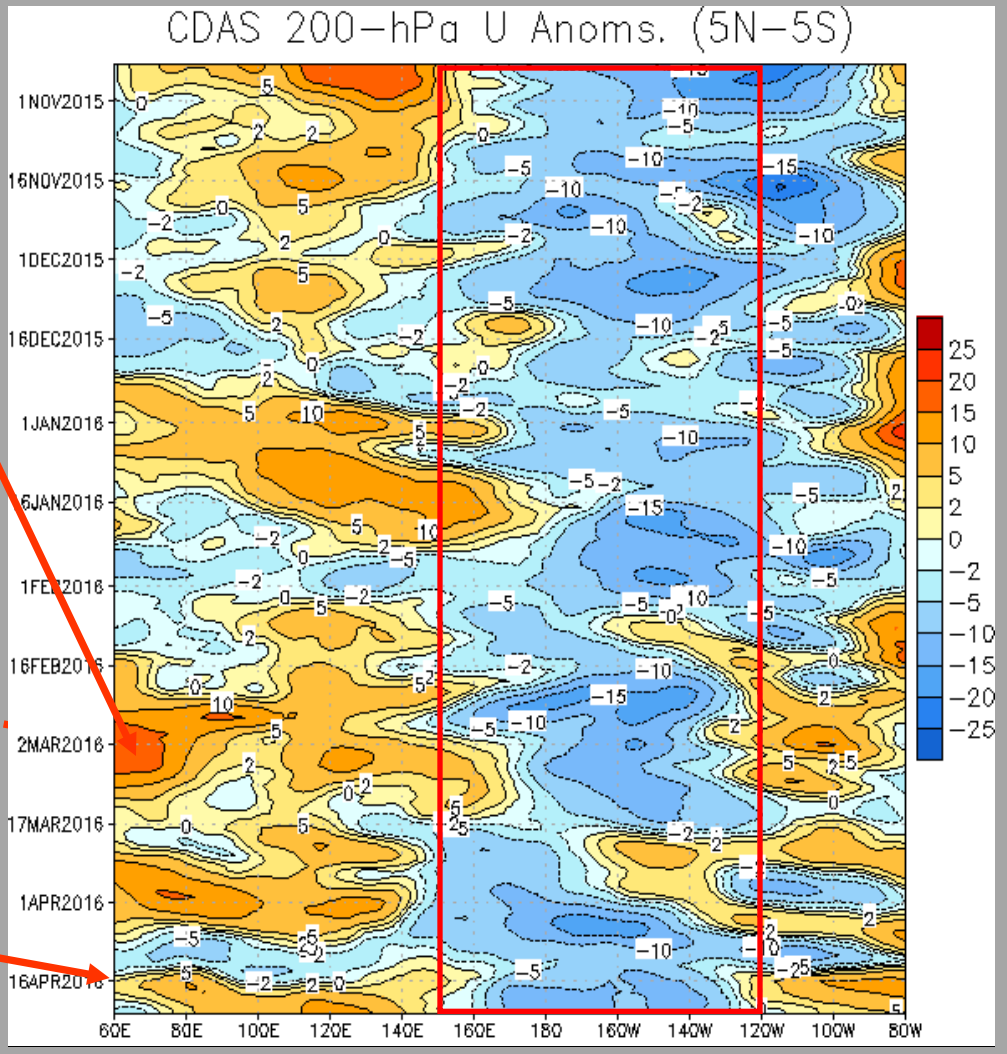
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Easterly anomalies have persisted over the central and eastern Pacific since June 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.

Easterly anomalies remained over the central Pacific, but are much weaker than during the past three months. Small areas of westerly anomalies are also evident, indicating the influence of other modes of variability.

Within the past week, a fairly stable pattern of upper-level westerlies prevailed over the Indian Ocean and Maritime Continent, and upper-level easterlies across most of the tropical Pacific basin.



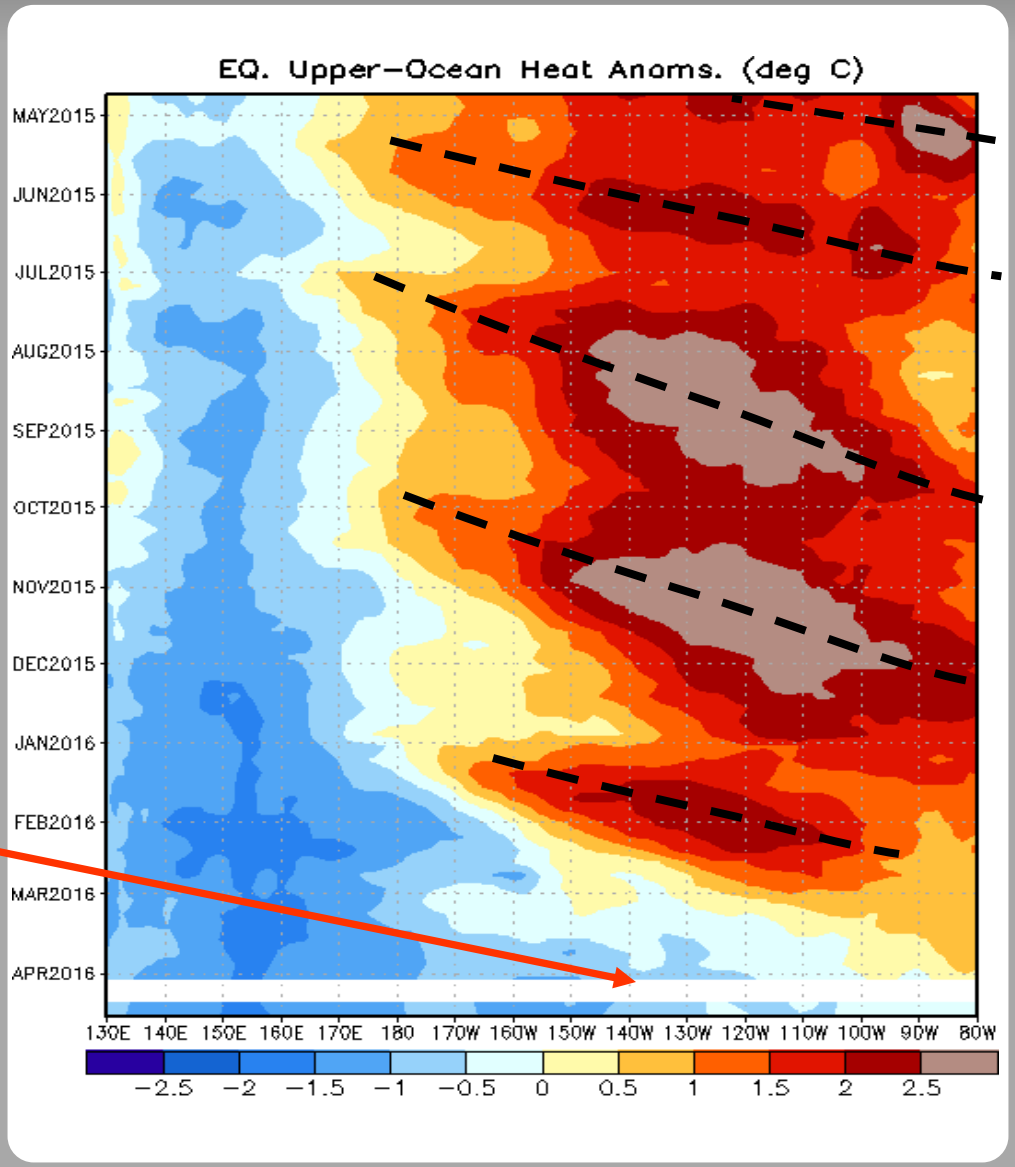
Weekly Heat Content Evolution in the Equatorial Pacific

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 have followed, 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, and negative anomalies spread east of the Date Line during February 2016.

Below-average heat content continued to expand eastward across the east-central Pacific in early to mid April.



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

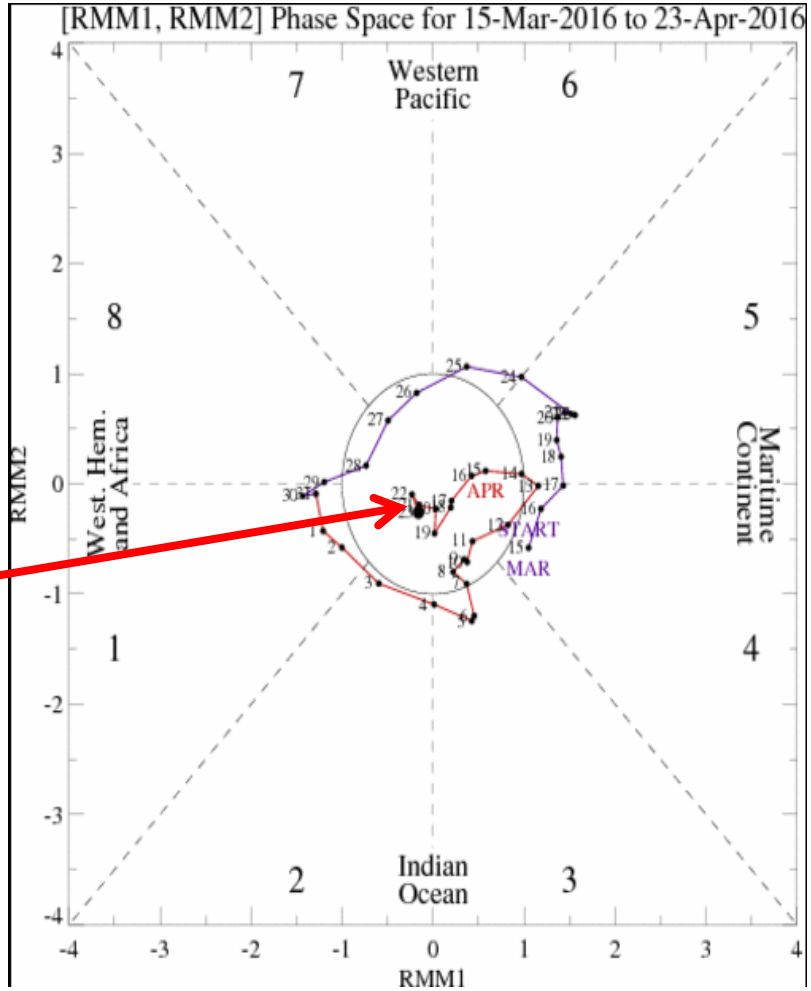
The triangular areas indicate the location of the enhanced phase of the MJO

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

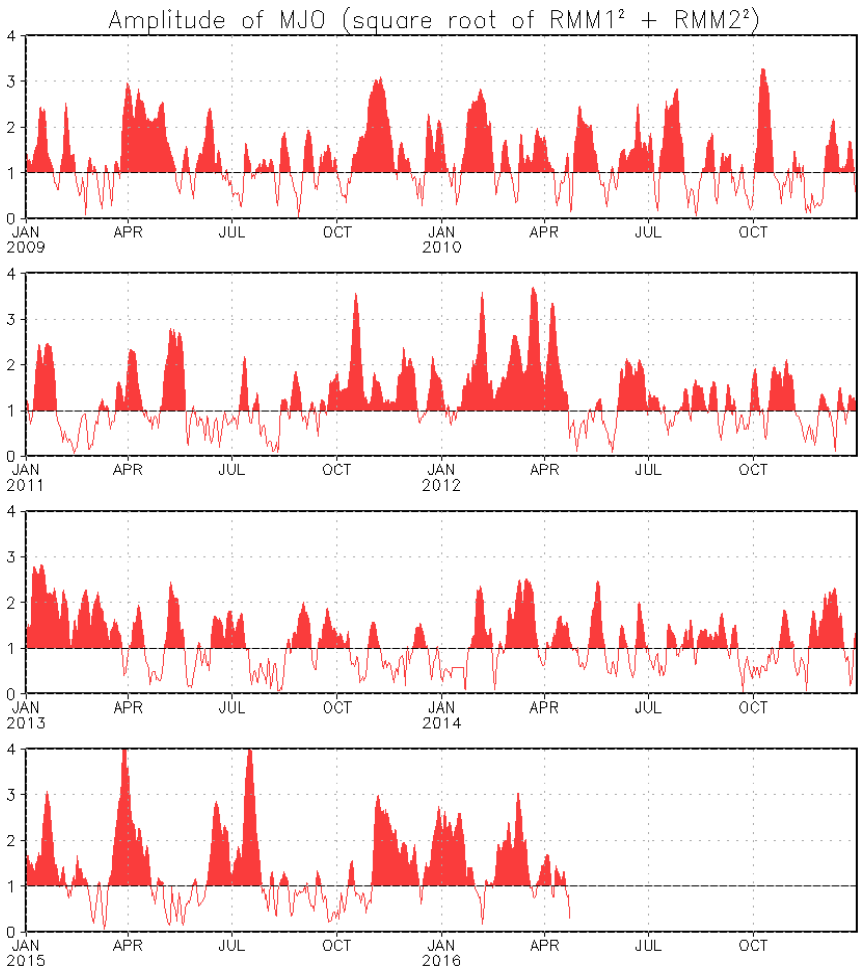
The RMM MJO index reflects little to no signal from the MJO.



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

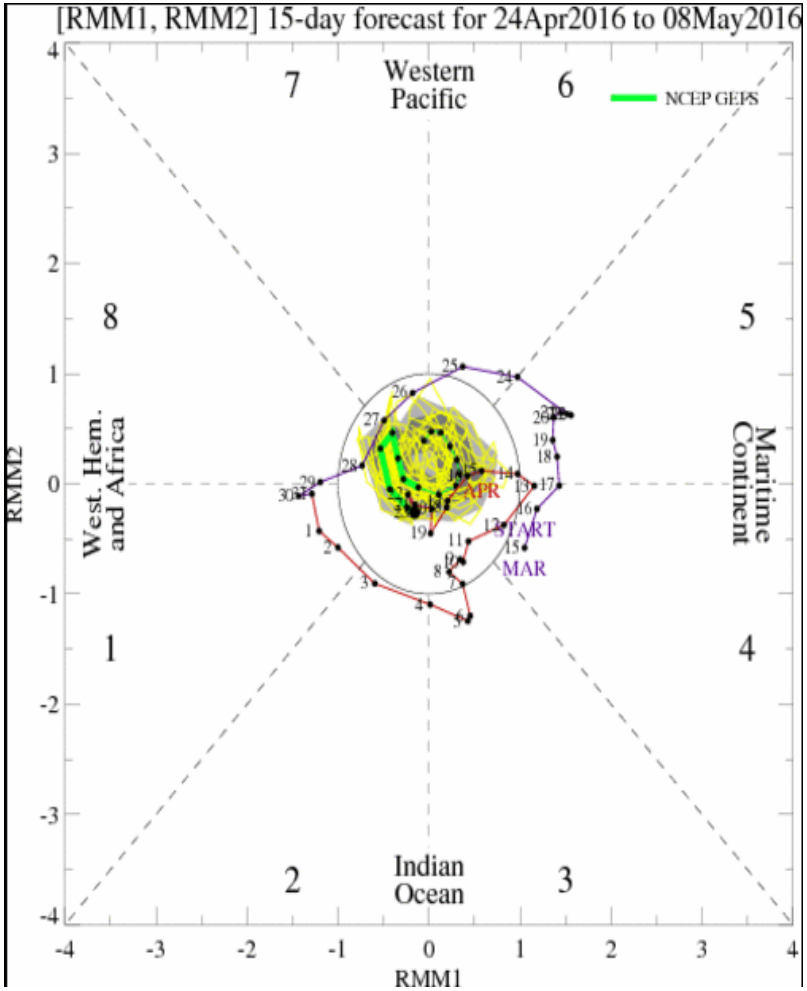
Yellow Lines – 20 Individual Members
Green Line – Ensemble Mean

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

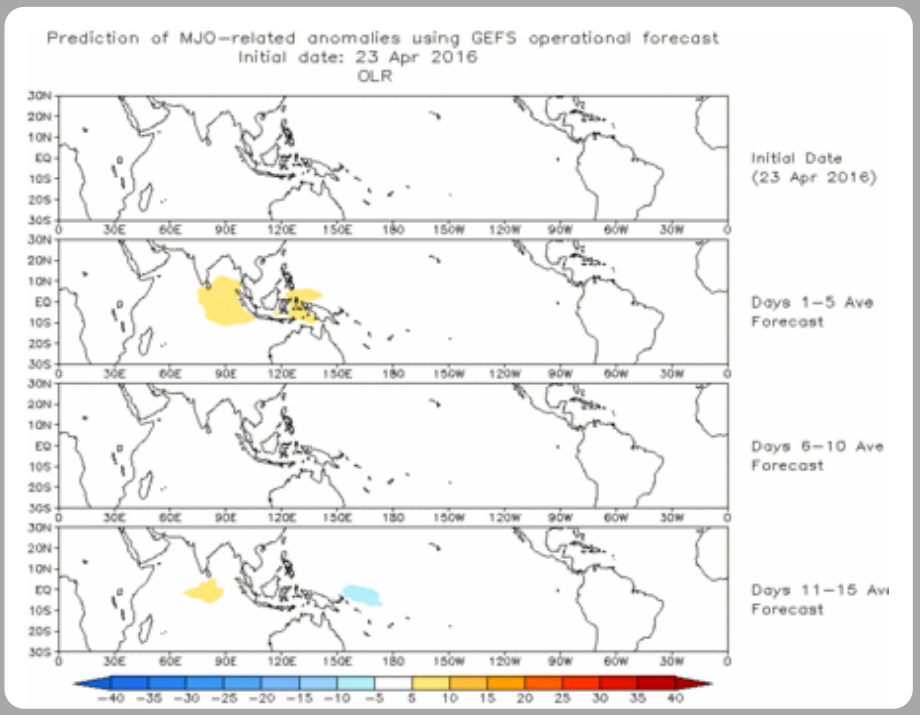
The GFS ensemble MJO index forecast depicts little to no signal during the next two weeks.



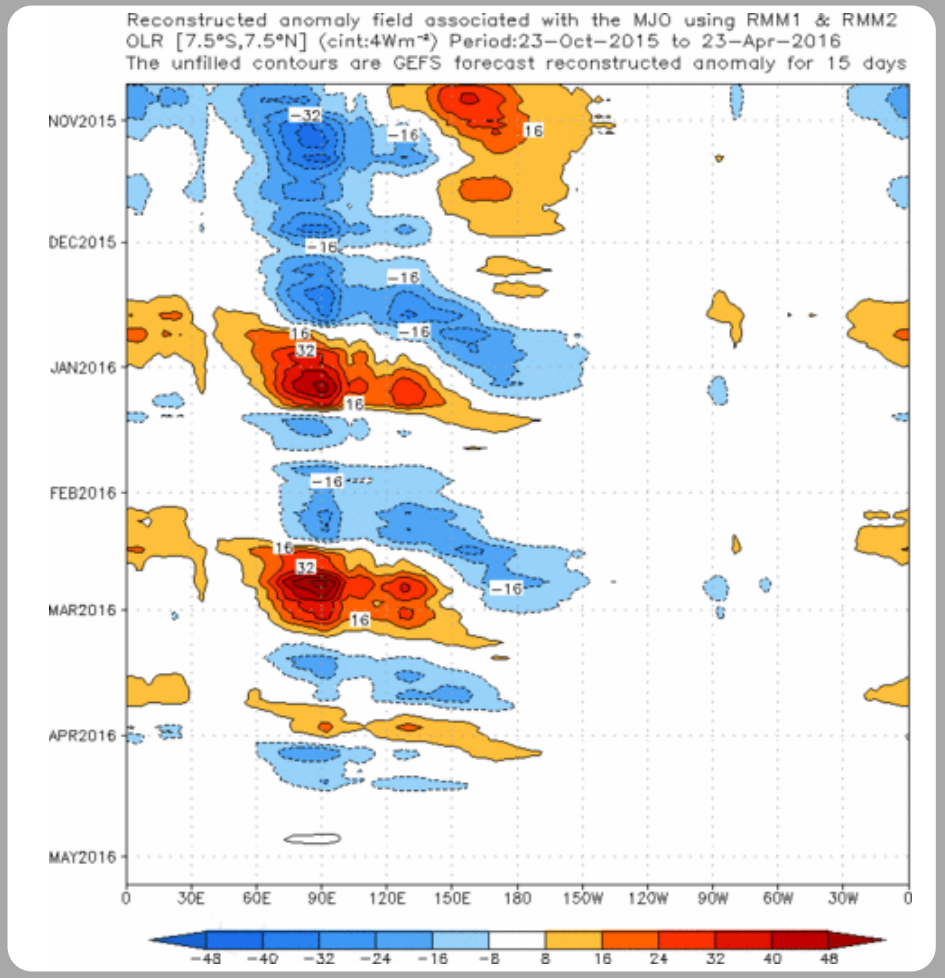
Ensemble GFS (GEFS) MJO Forecast

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

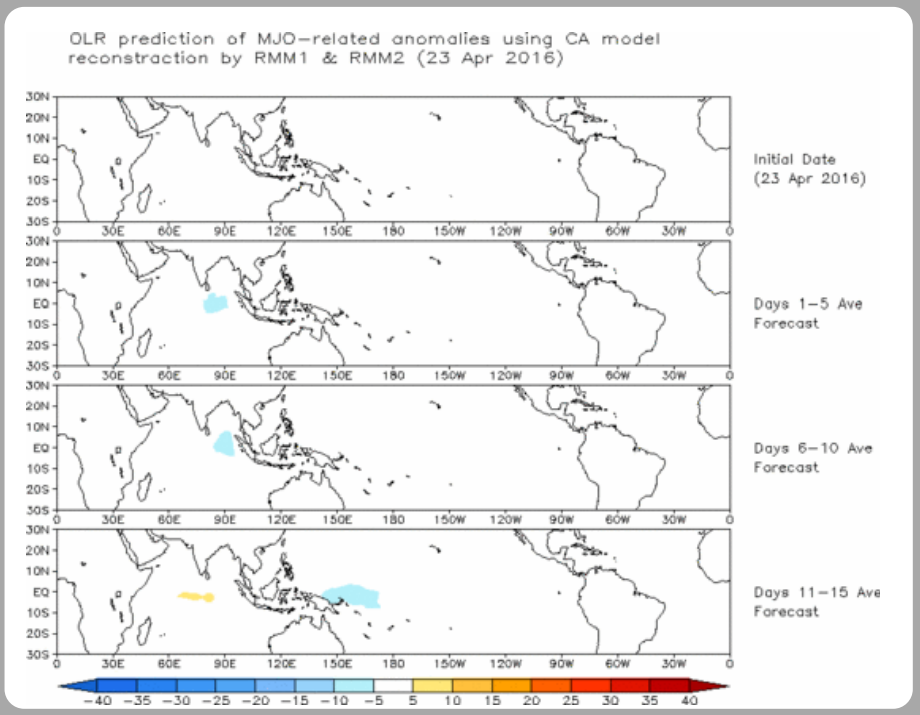


The GEFS OLR forecast based on the RMM Index depicts little to no signal during the next two weeks.

Constructed Analog (CA) MJO Forecast

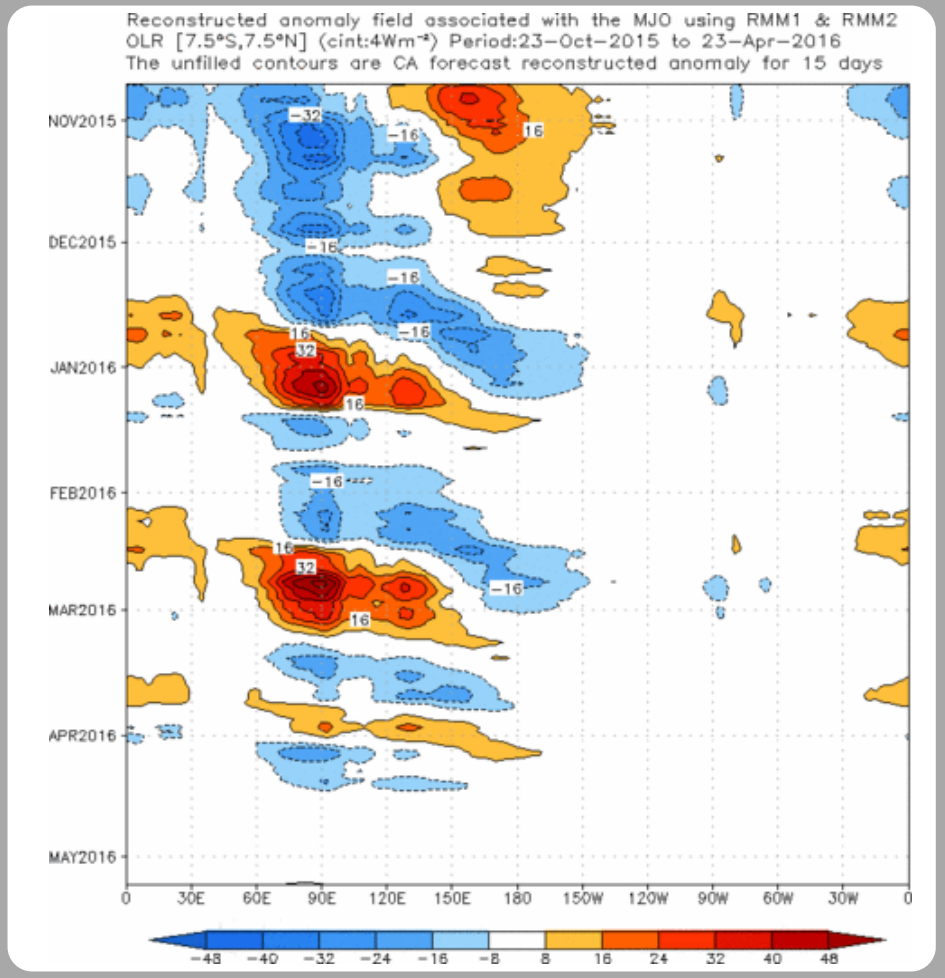
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



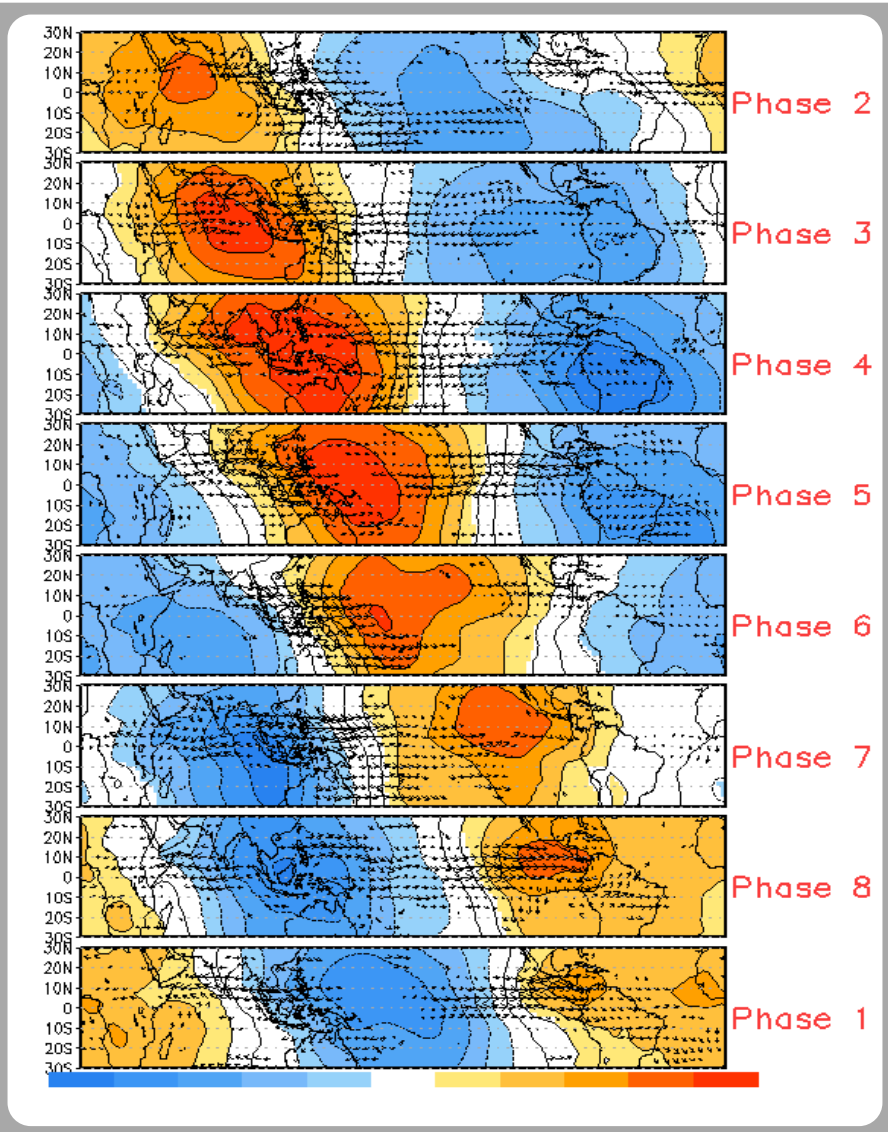
The constructed analog model predicts a negligible signal in the vicinity of the Maritime Continent.

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

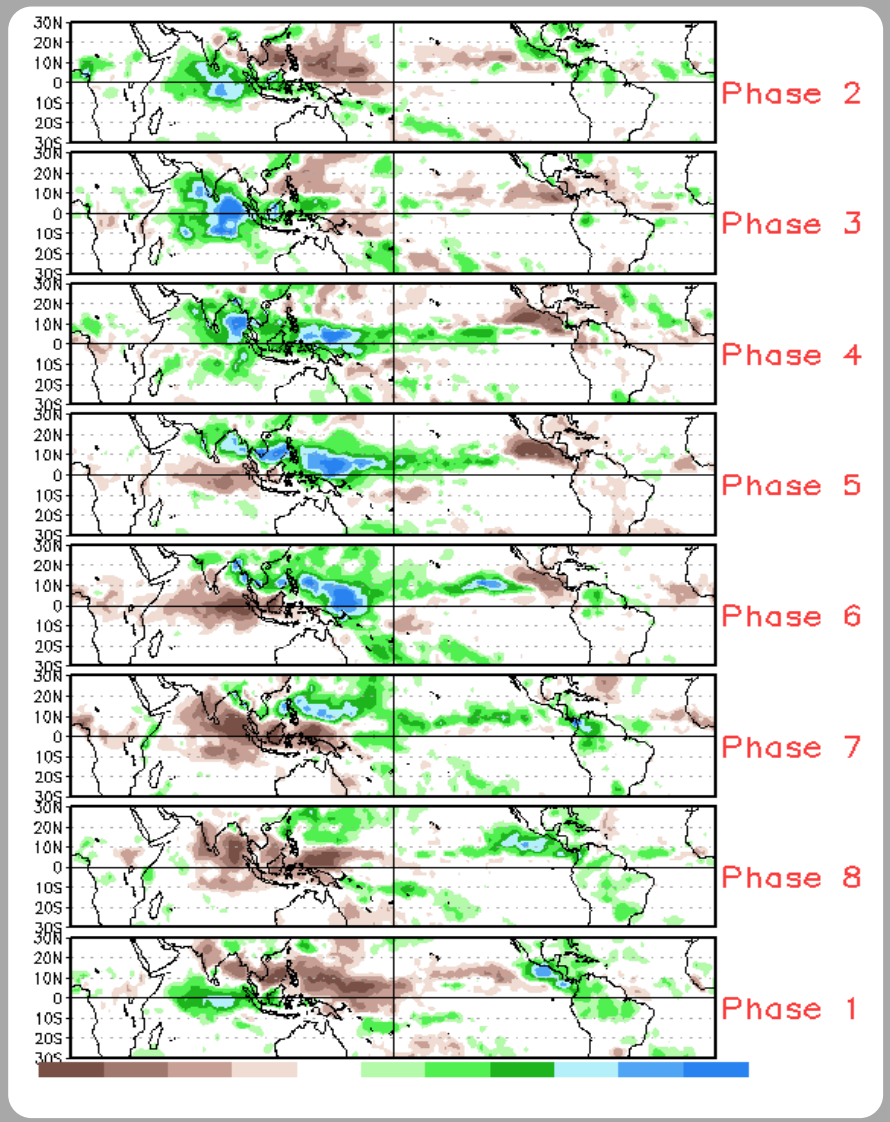


MJO Composites – Global Tropics

850-hPa Velocity Potential and Wind Anomalies (Nov-Mar)



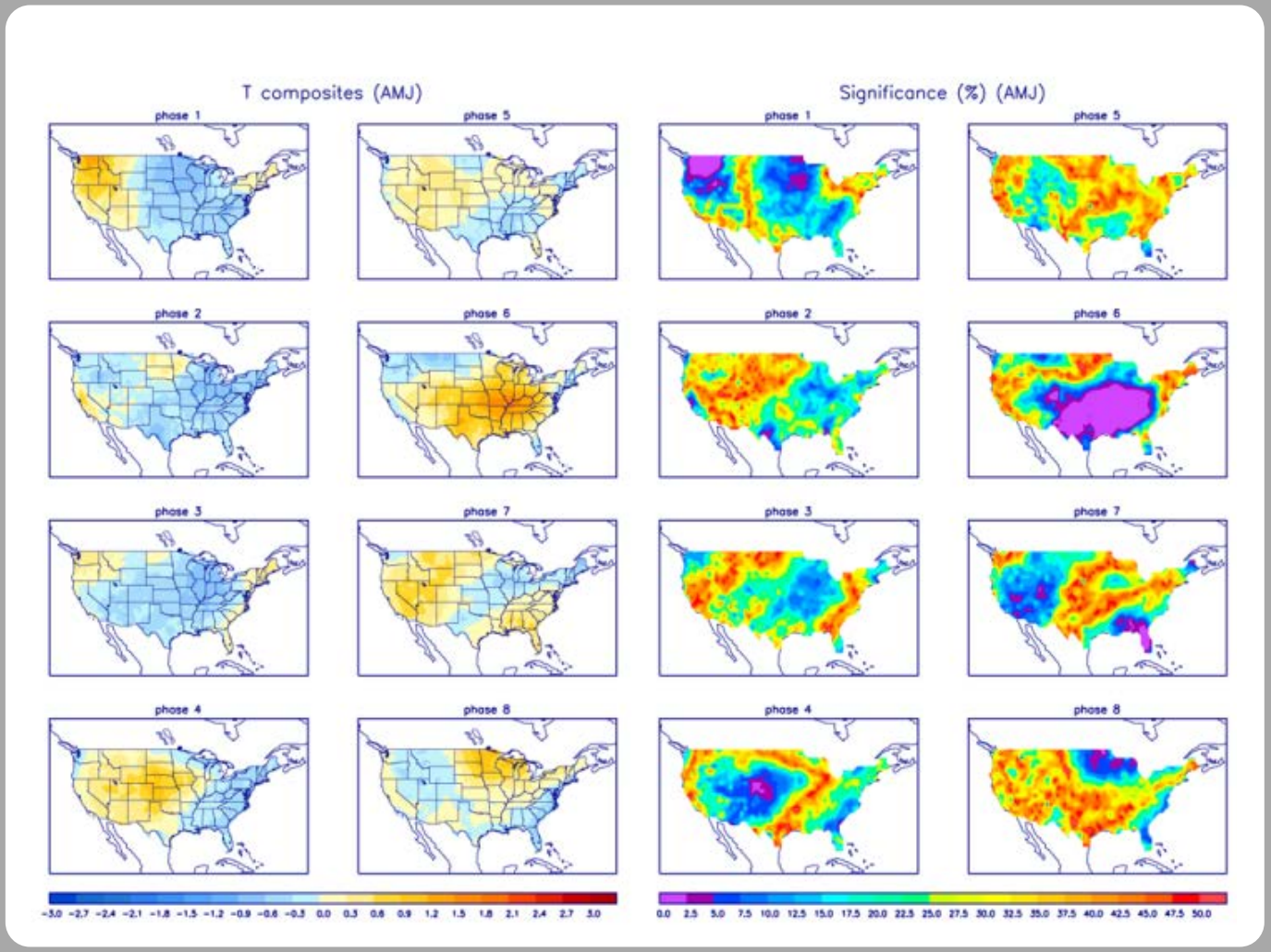
Precipitation Anomalies (Nov-Mar)



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.



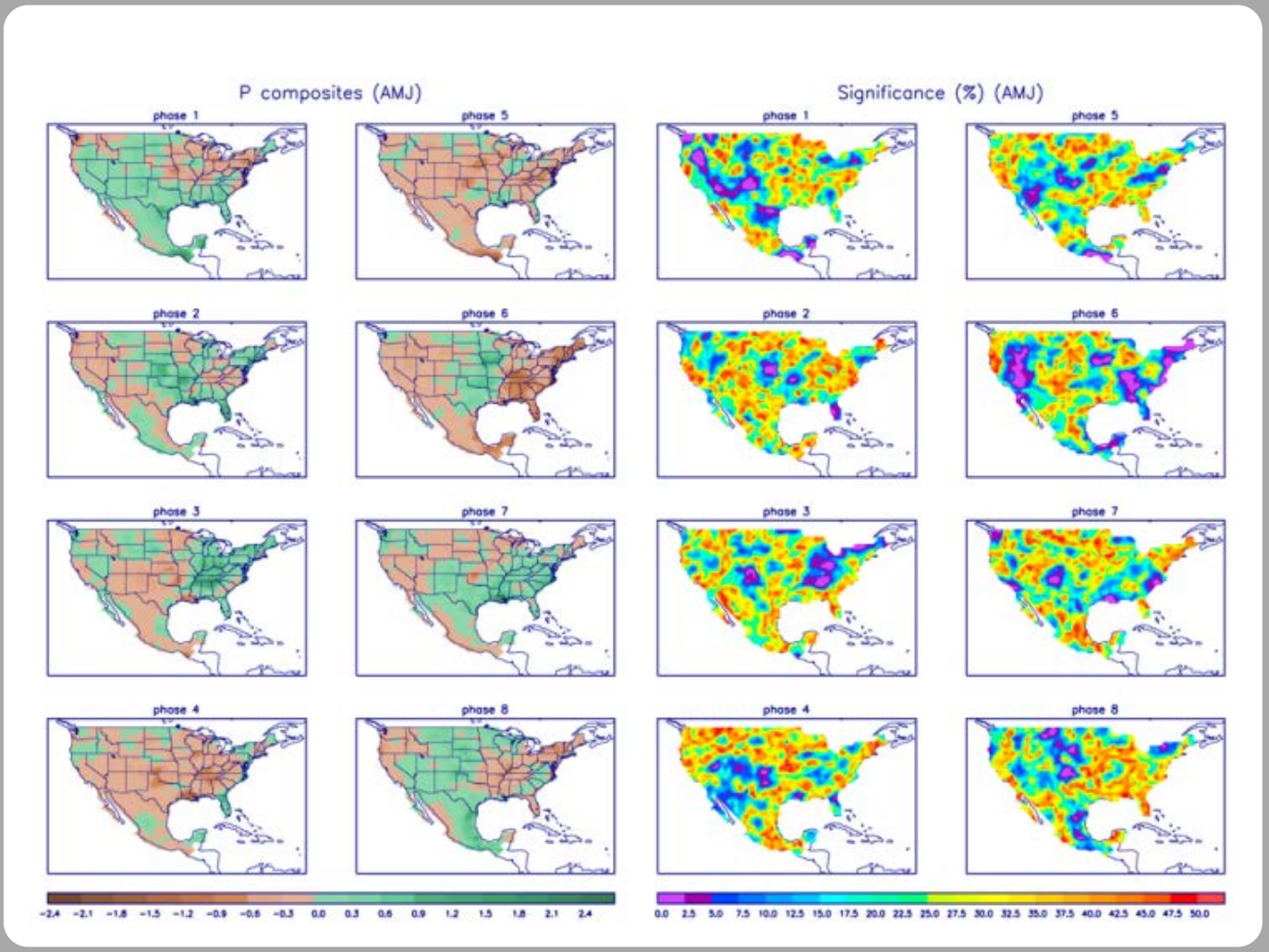
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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