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

Update prepared by
Climate Prediction Center / NCEP
June 9, 2014

Outline

- Overview

- Recent Evolution and Current Conditions

- MJO Index Information

- MJO Index Forecasts

- MJO Composites

Overview

- The MJO remained generally weak during the past few weeks. Nearly all indicators show a largely incoherent signal since the middle of May.

- There is large spread in dynamical model forecasts, some indicating an increase in amplitude of the MJO followed by rapid weakening. Some models show a bit more eastward propagation of an MJO like signal. Any subseasonal signal will have difficulty organizing given the background conditions evolving towards El Nino.

- Based on recent observations and the high spread in dynamical model forecasts, the MJO is forecast to remain weak and is expected to only be a minor contributor to the pattern of anomalous tropical convection.

- The MJO may contribute to enhanced rainfall across southern Asia to the South China Sea and elevated odds for tropical cyclogenesis in the Arabian Sea early in the period.

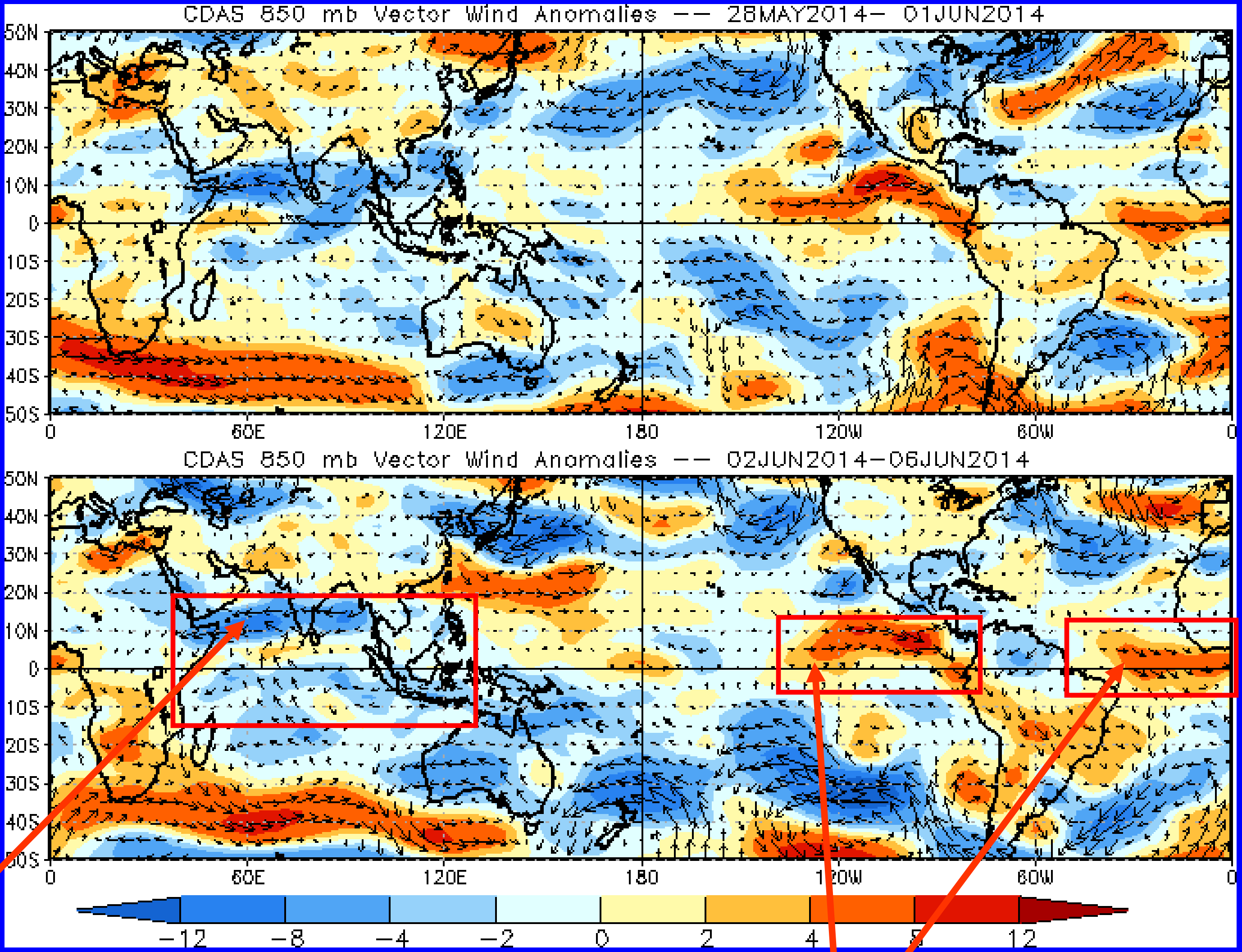
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



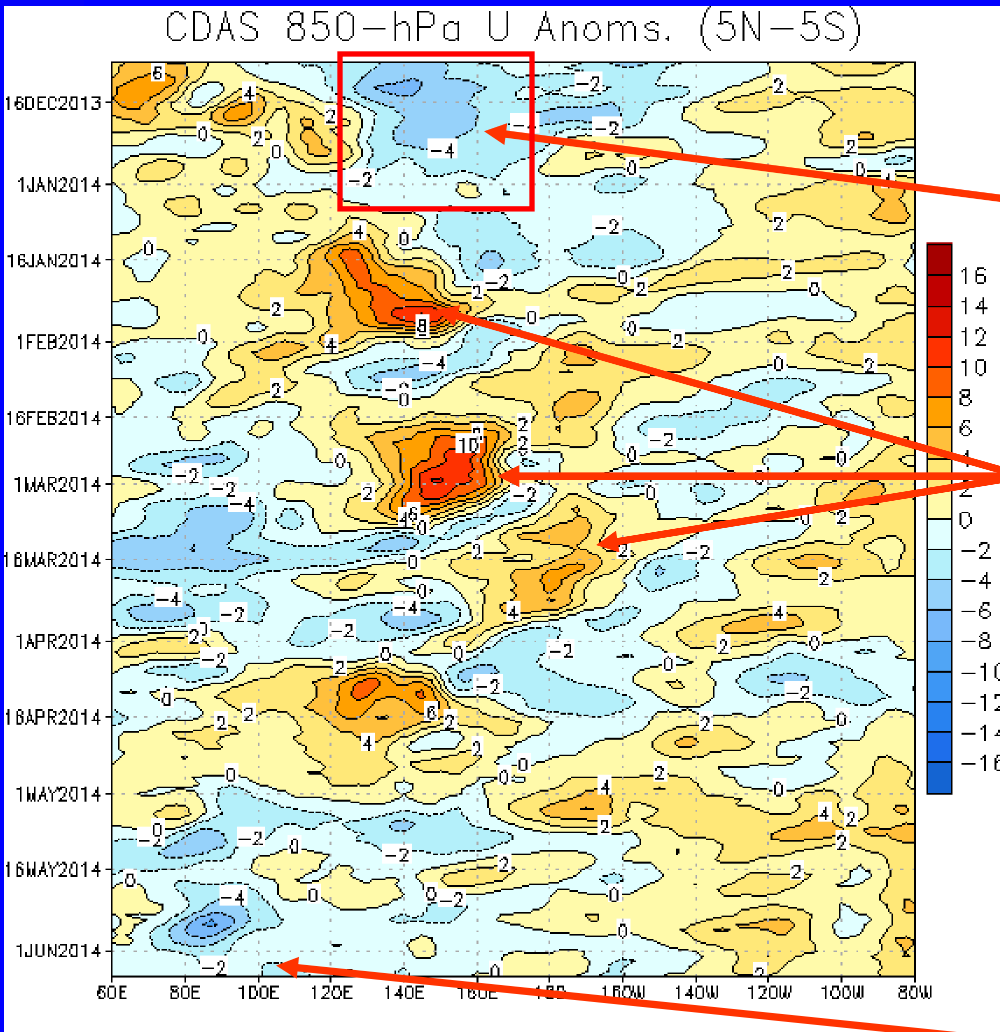
Easterly anomalies persisted over many areas of the Indian Ocean and the Arabian Sea and Bay of Bengal during the most five days. These anomalies, however, are somewhat smaller than the previous five days.

Westerly anomalies persisted over the eastern Pacific and Atlantic basins during the most recent five days.

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



Time

Longitude

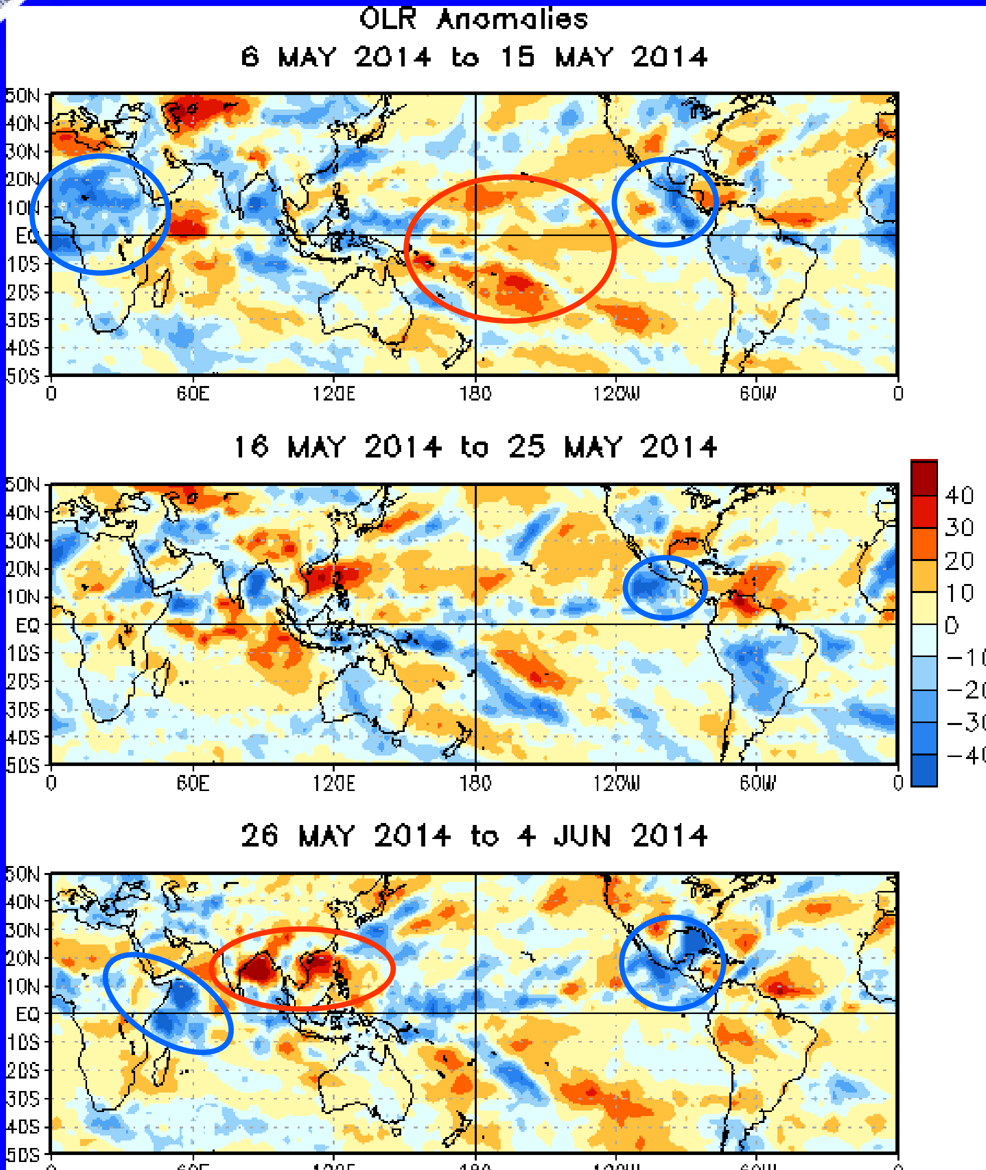
Easterly anomalies dominated from 120E to near the Date Line during December 2013 as MJO activity was weak.

Multiple westerly wind bursts were observed across the western Pacific between January and mid-March. Each westerly wind burst shifted slightly further east.

During April, winds near the Date Line were about average while westerly anomalies were generally persistent across the Maritime continent and far western Pacific.

During much of May, westerly anomalies were observed over the eastern Pacific and Atlantic. More recently, easterly anomalies developed over the eastern 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)

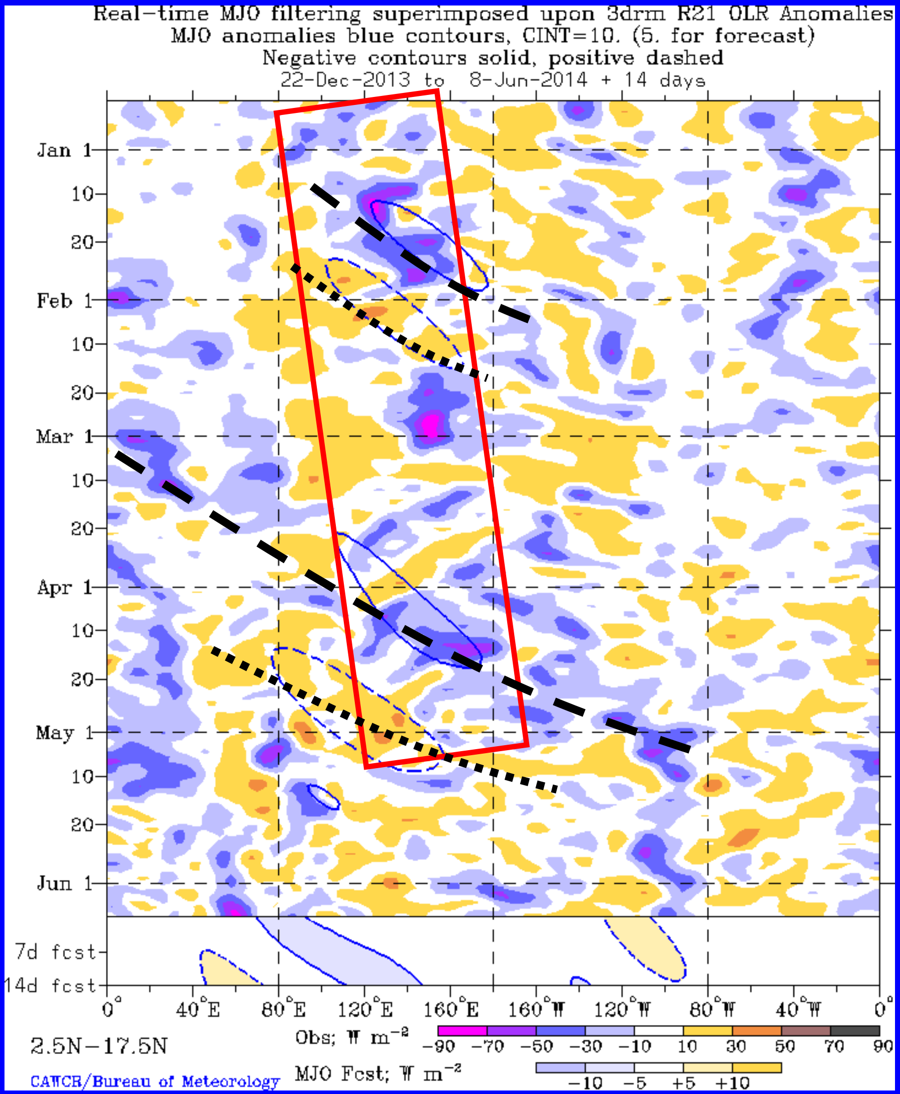
During early to mid May, enhanced (suppressed) convection was observed over the eastern Pacific and much of Africa (west-central Pacific).

The large scale patterns of anomalous convection weakened during mid-May, with only enhanced convection observed over east Pacific.

During late May into early June, enhanced convection associated in part with tropical cyclone activity persisted over the eastern Pacific, while enhanced (suppressed) convection was observed over parts of the western Indian Ocean (Bay of Bengal and the South China Sea).

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

Time



Longitude

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

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

(Courtesy of CAWCR Australia Bureau of Meteorology)

From January through April, enhanced convection propagated slowly eastward from the Maritime Continent to the western Pacific (red box), interrupted by positive OLR anomalies during late January and early February and again in March associated with the MJO.

The MJO became more coherent during April, with strongly enhanced convection over the west-central Pacific associated with constructive interference with the low frequency state.

During late April and early May, the suppressed phase of the MJO propagated over the western Pacific, destructively interfering with the low frequency state.

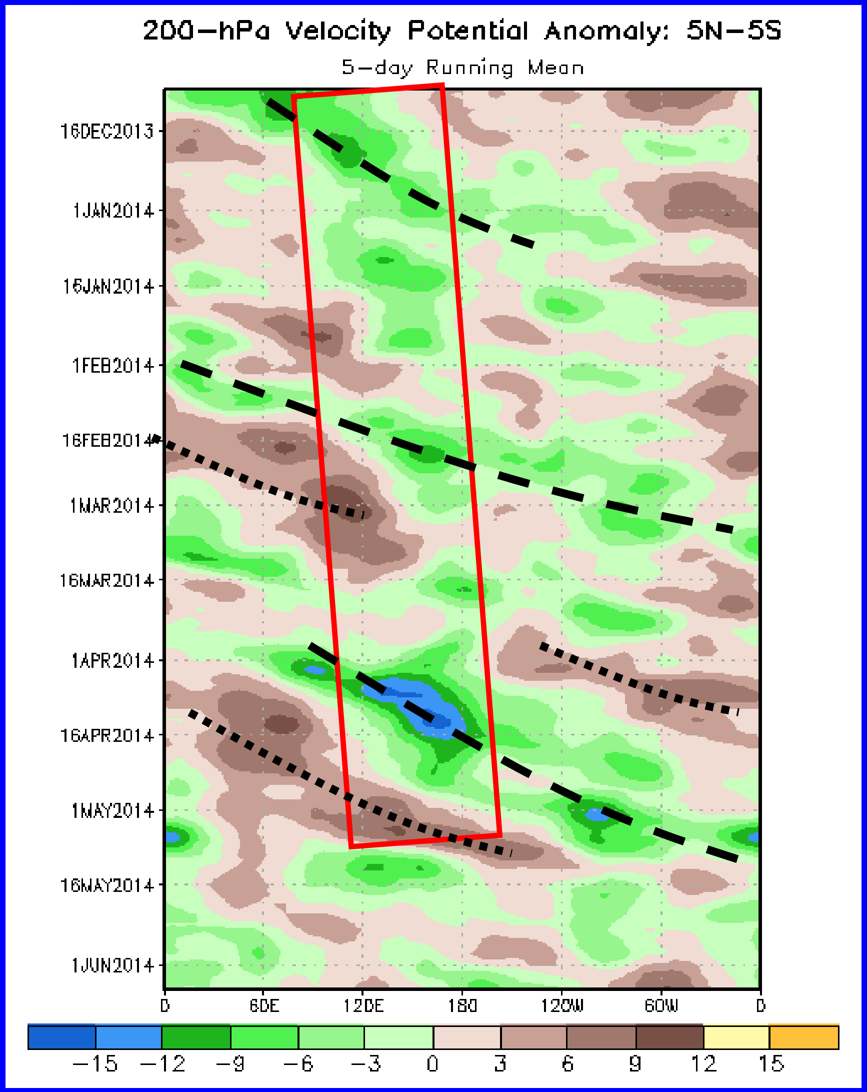
The pattern of anomalous tropical convection has been largely incoherent since the middle of May.

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

Time



Longitude

The enhanced phase of the MJO was evident during December (dashed black line) as negative anomalies propagated from the Indian Ocean to near the Date Line. No clear suppressed was evident thereafter.

At this time, a slow eastward progression of negative anomalies was observed from late December to the present across the Indo-Pacific warm pool region (red box).

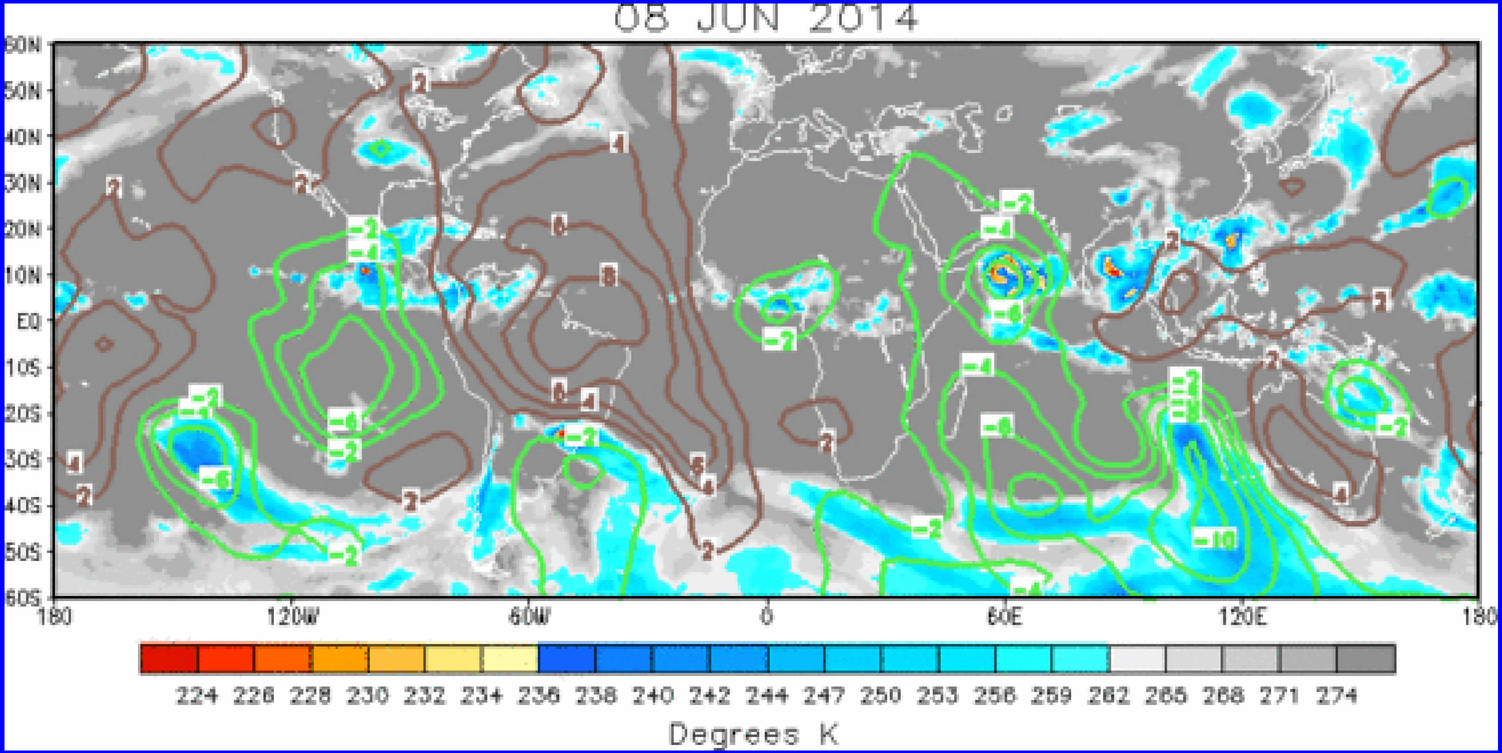
During February into early March, anomalies propagated eastward with time associated with the MJO before weakening.

The MJO strengthened once again during April as eastward propagation of both positive and negative anomalies are indicated. This signal weakened more recently in favor of higher frequency Kelvin waves.

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

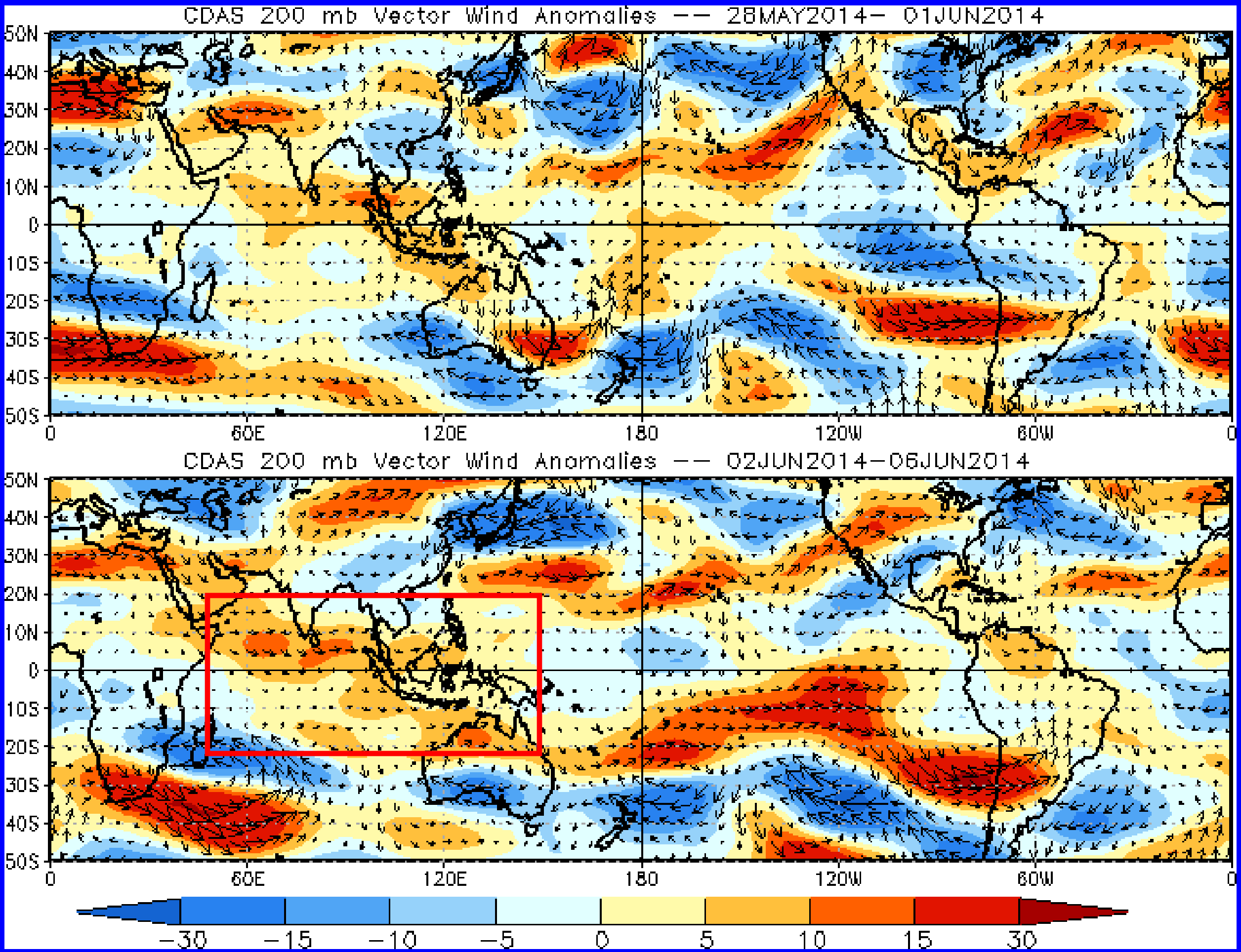
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



A coherent spatial pattern of upper-level velocity potential anomalies is not evident. Anomalous upper-level divergence (convergence) is evident over Africa and parts of the eastern Pacific (South America and the Maritime Continent).

200-hPa Vector Wind Anomalies (m s^{-1})



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

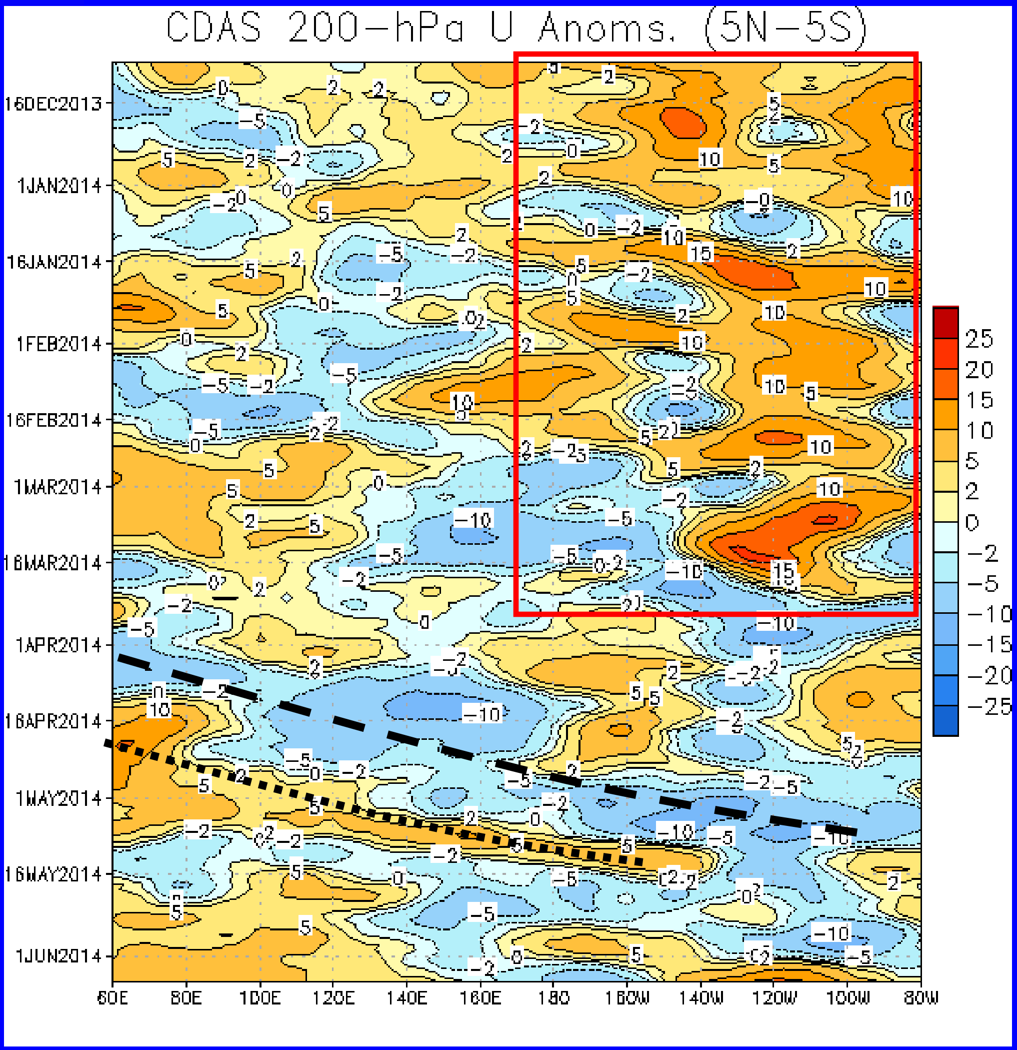
Over the last 10 days westerly anomalies have remained generally (red box) persistent across the Indian Ocean and western Maritime continent.

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

Time



Longitude

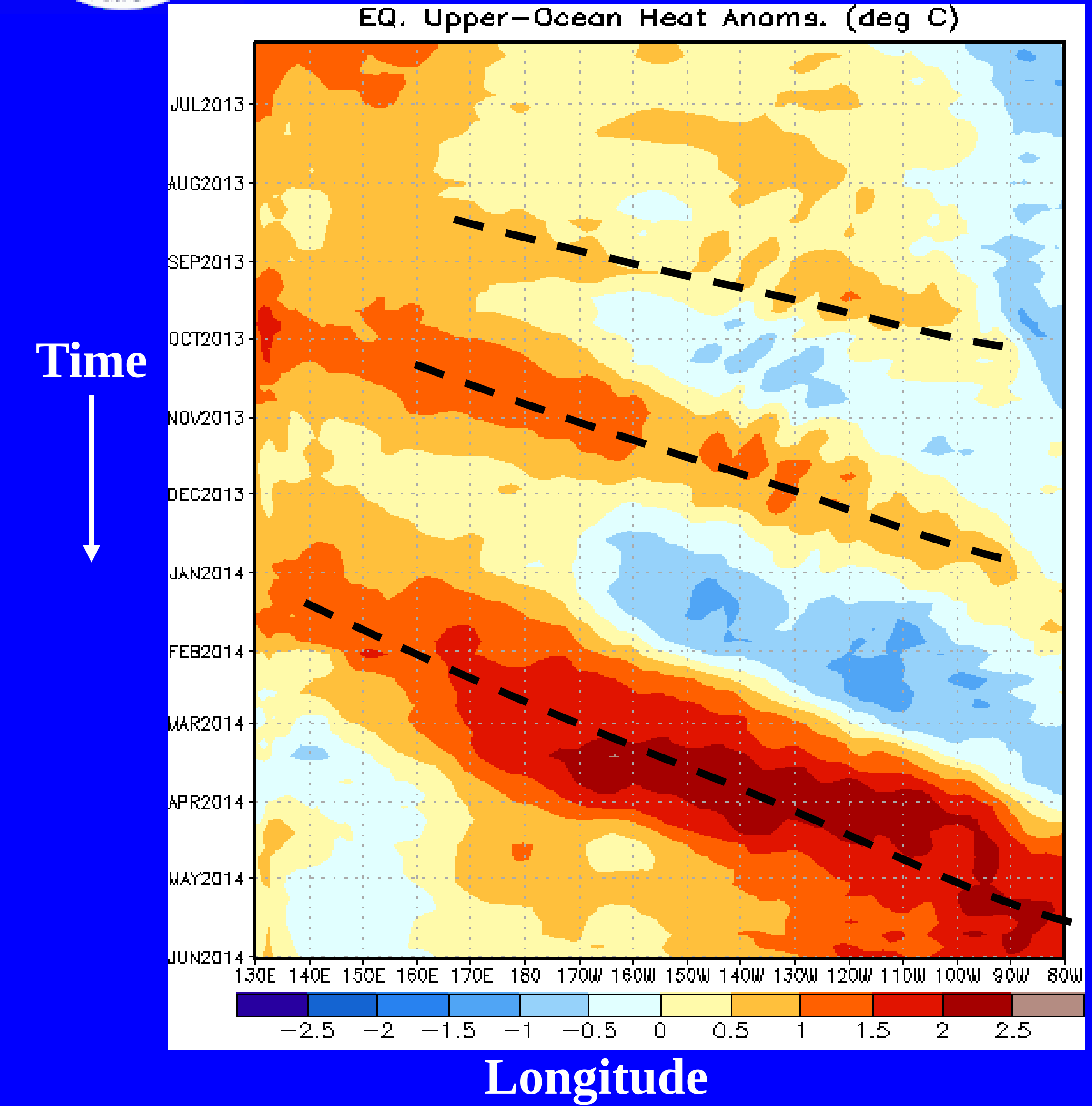
From December into March, westerly anomalies were most prevalent across the western Hemisphere (red box).

During mid-April, the slowly evolving background state has contributed to easterly anomalies expanding to the Date Line.

Recent MJO activity is evident in the eastward propagation of both easterly and westerly anomalies during April and early May.

This signal weakened during late May, though westerly anomalies increased over the Indian Ocean most recently.

Weekly Heat Content Evolution in the Equatorial Pacific



The influence of a downwelling oceanic Kelvin wave can be seen through late March 2013 as anomalies became positive in the east-central Pacific.

Oceanic downwelling Kelvin wave activity is evident in late August and once again during October through early December.

A considerably stronger downwelling event began in January and propagated across the Pacific.

Warm anomalies persisted over much of the Pacific during April and May.

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).

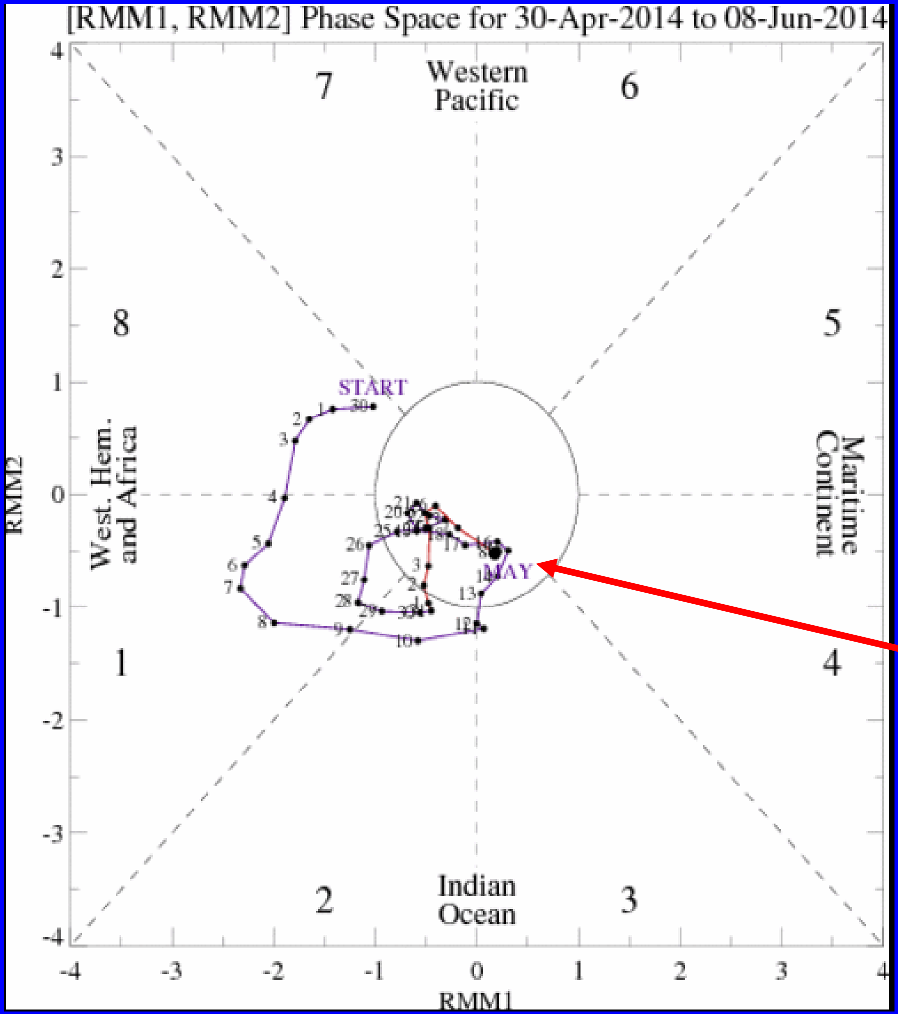
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

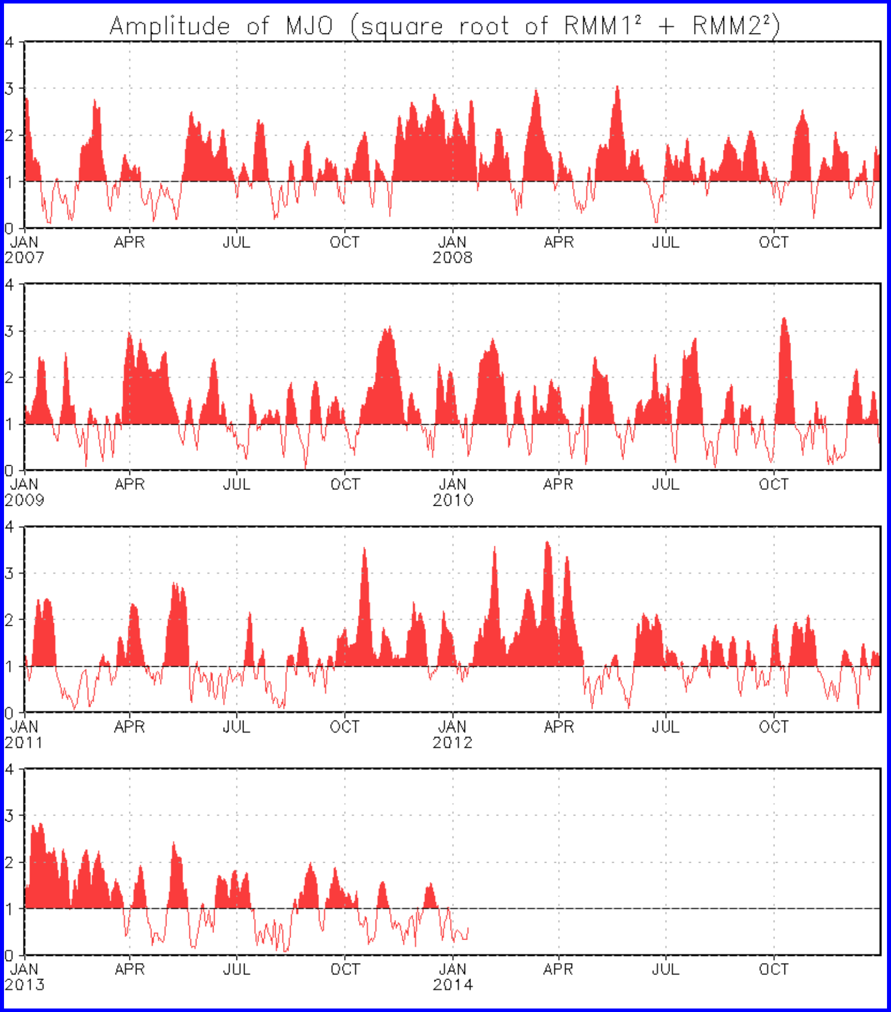
MJO Index -- Recent Evolution



- 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 index shows very weak amplitude over the past week.

MJO Index – Historical Daily Time Series



Time series of daily MJO index amplitude from 2007 to present.

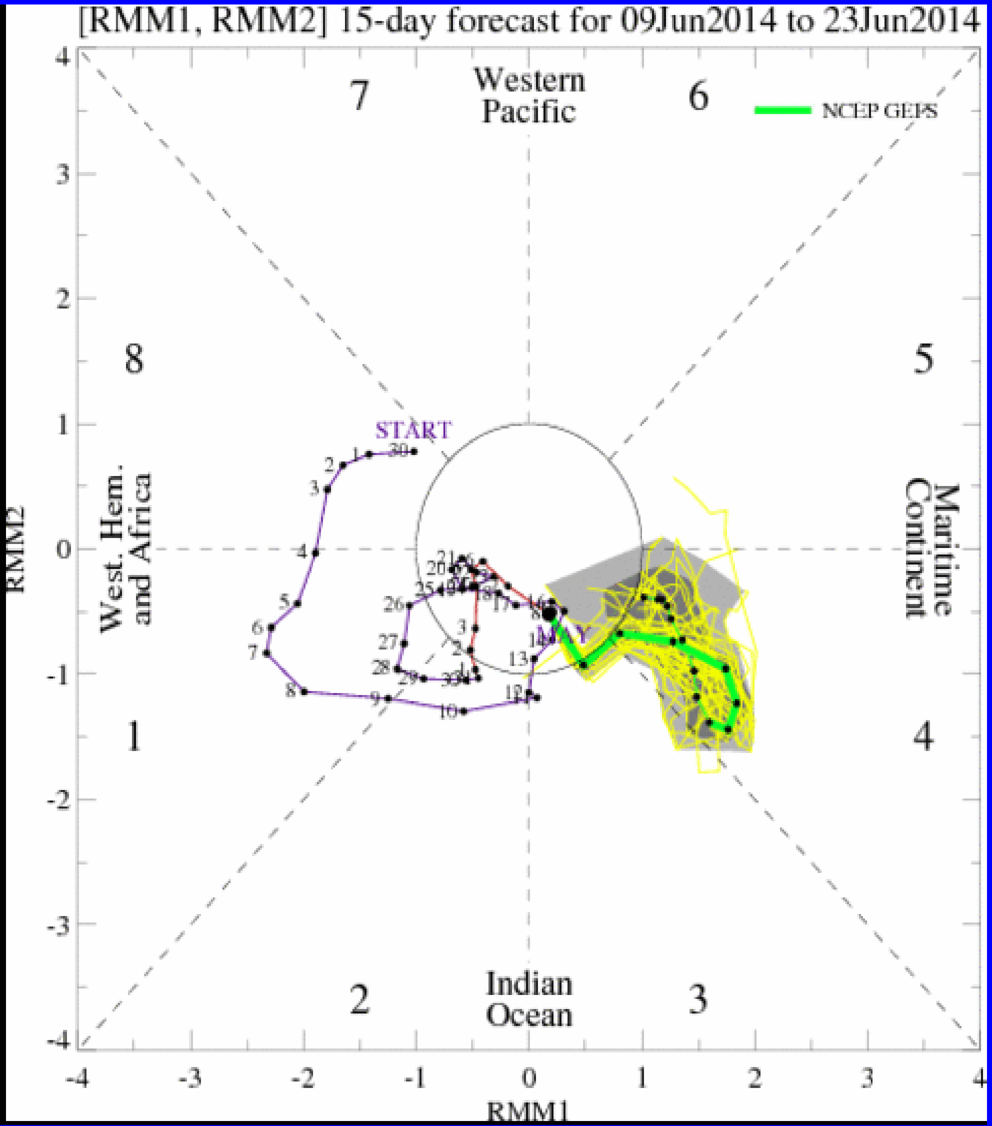
Plot puts current MJO activity in recent historical context.

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

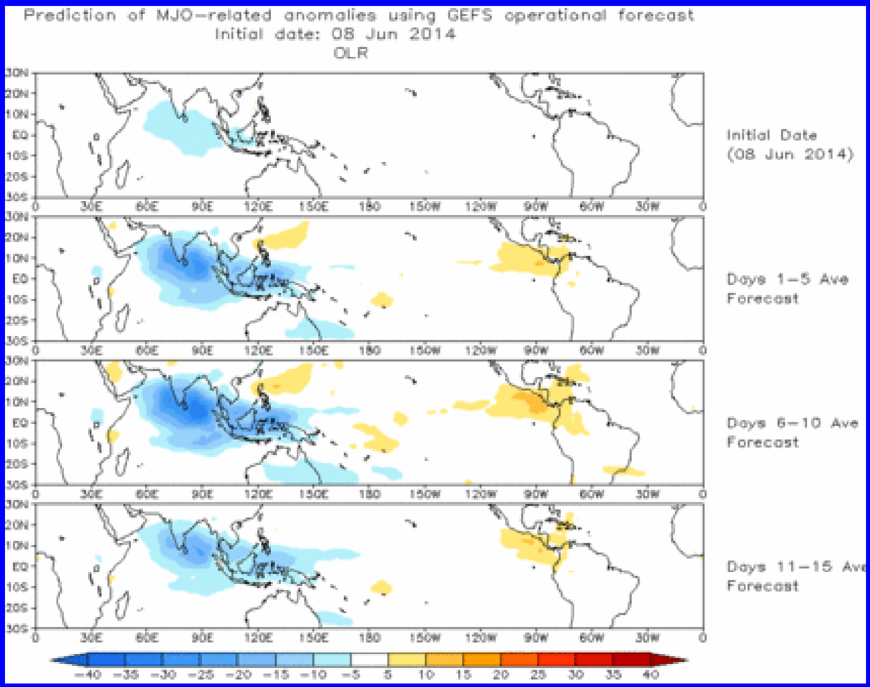


The ensemble GFS forecast indicates an increase in amplitude with some eastward propagation during Week-1 but a decrease in amplitude thereafter.

Ensemble Mean GFS MJO Forecast

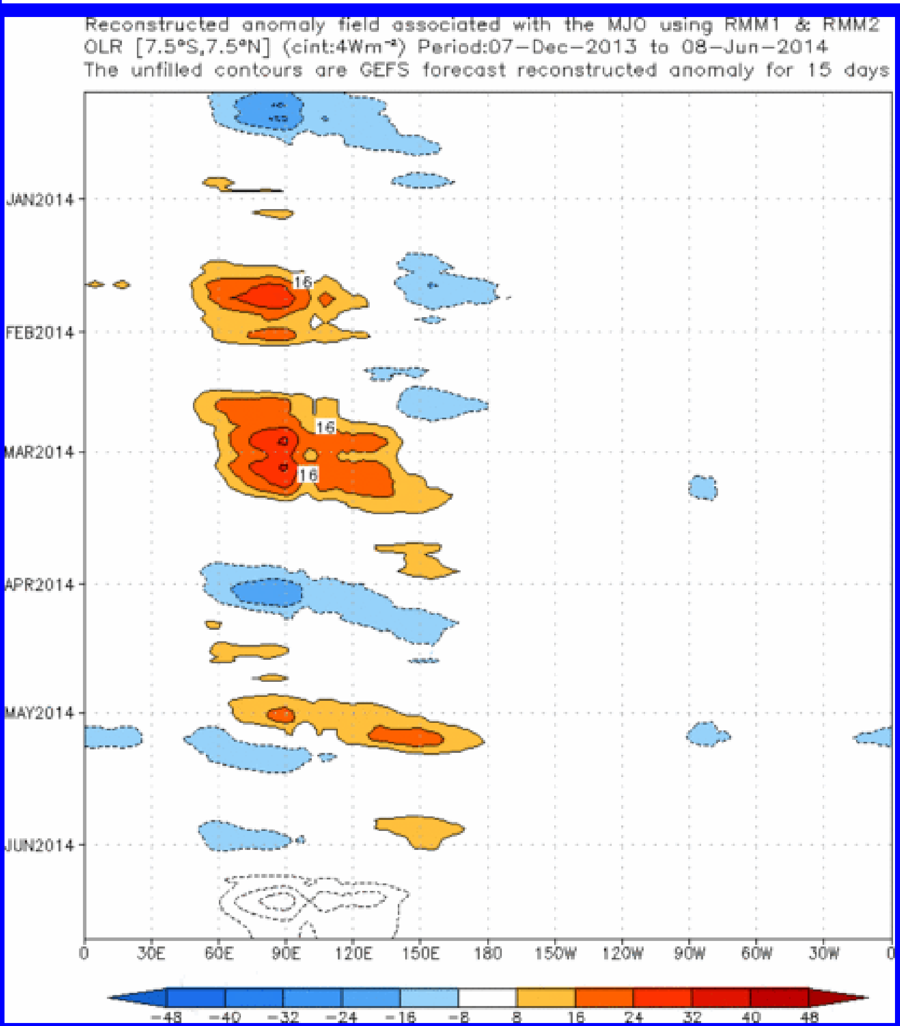
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecasts enhanced convection increasing during the period across the Indian Ocean and western Maritime continent while suppressed convection is forecast across the eastern Pacific and Central America.

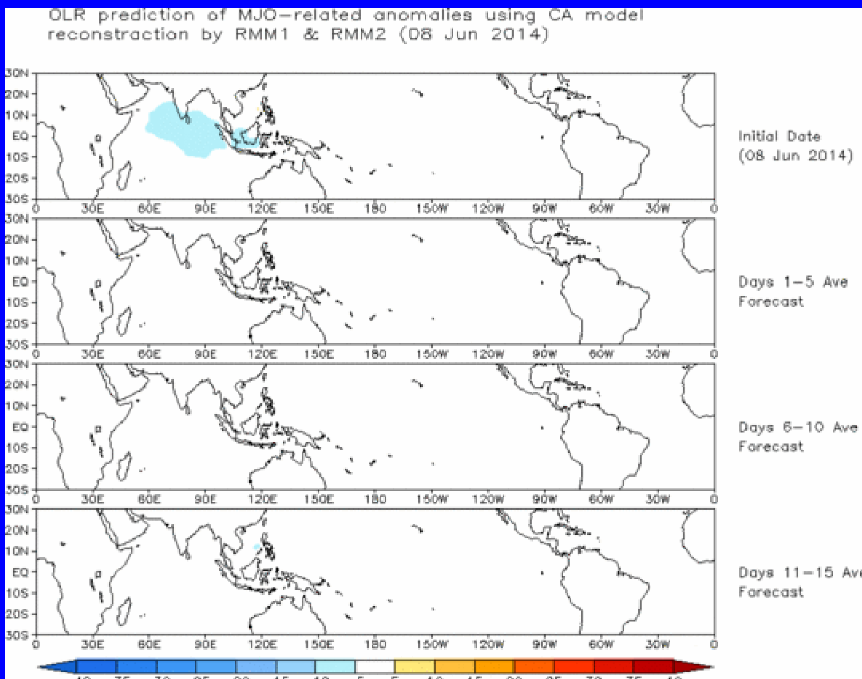
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

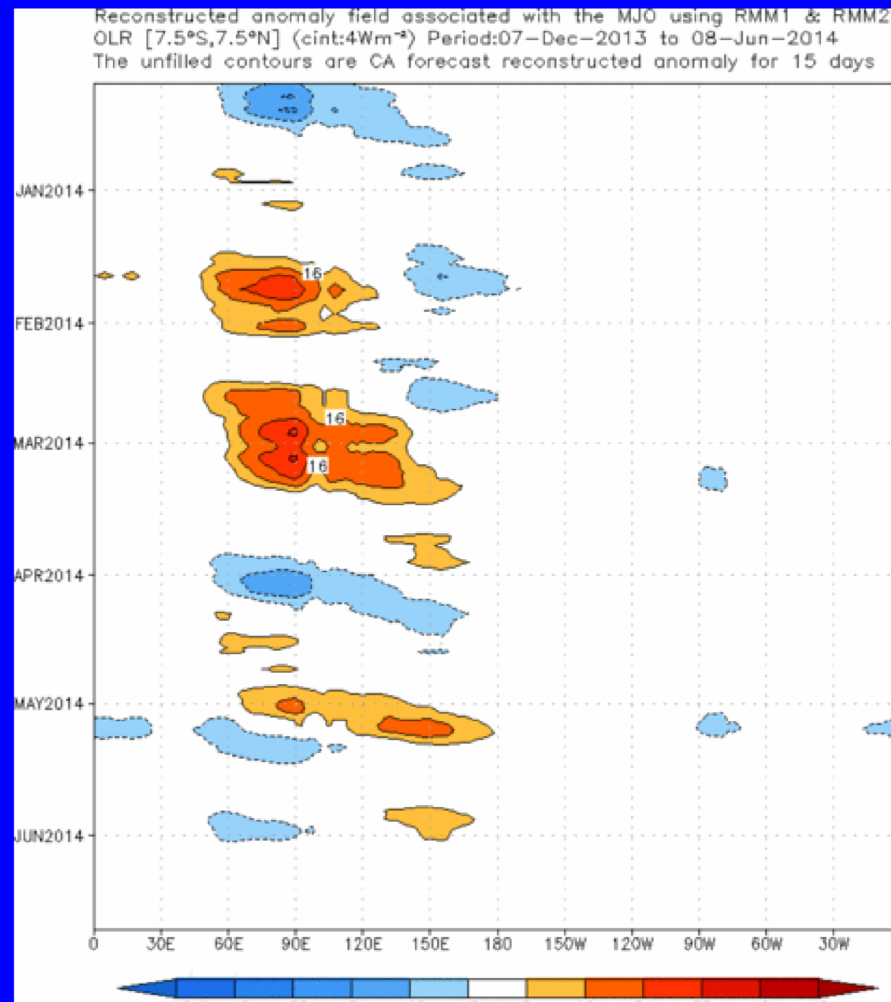
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



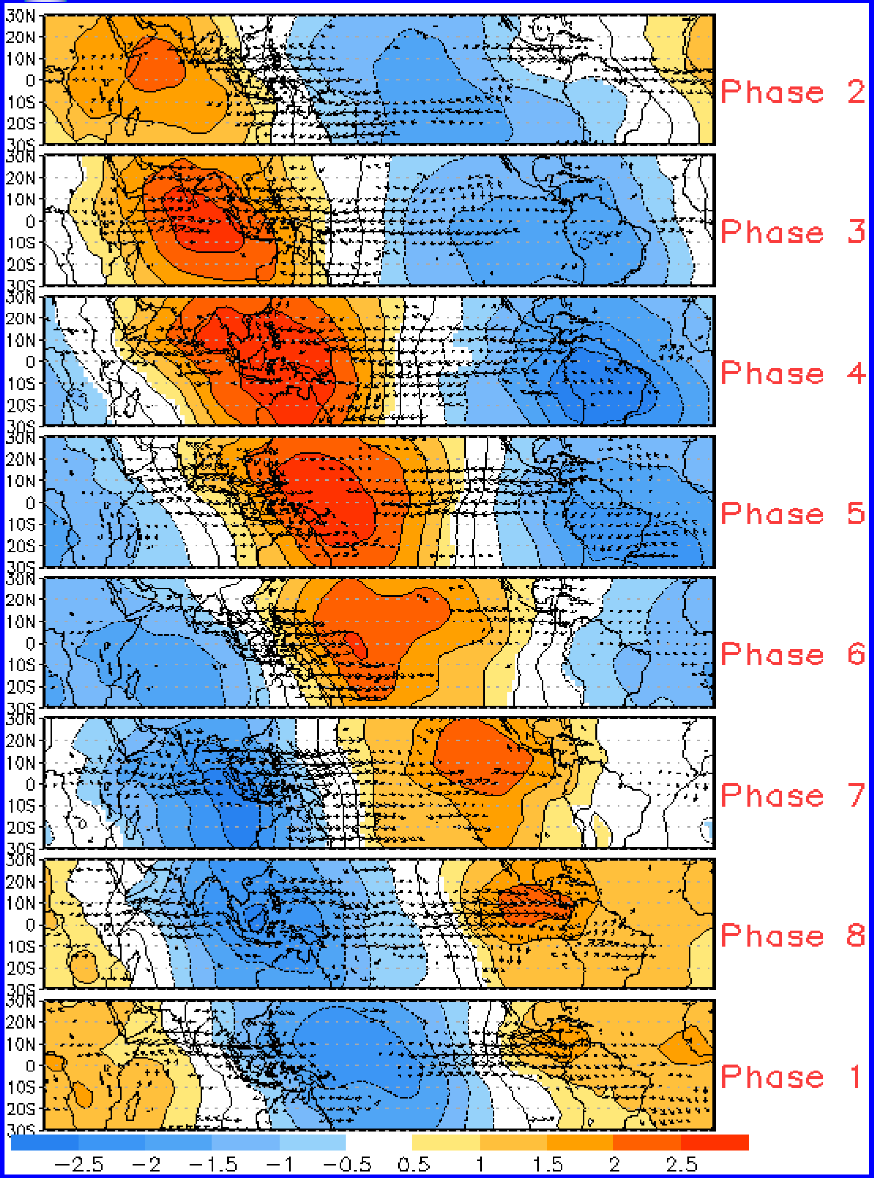
The constructed analog MJO forecast forecasts no signal during the next two weeks.

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

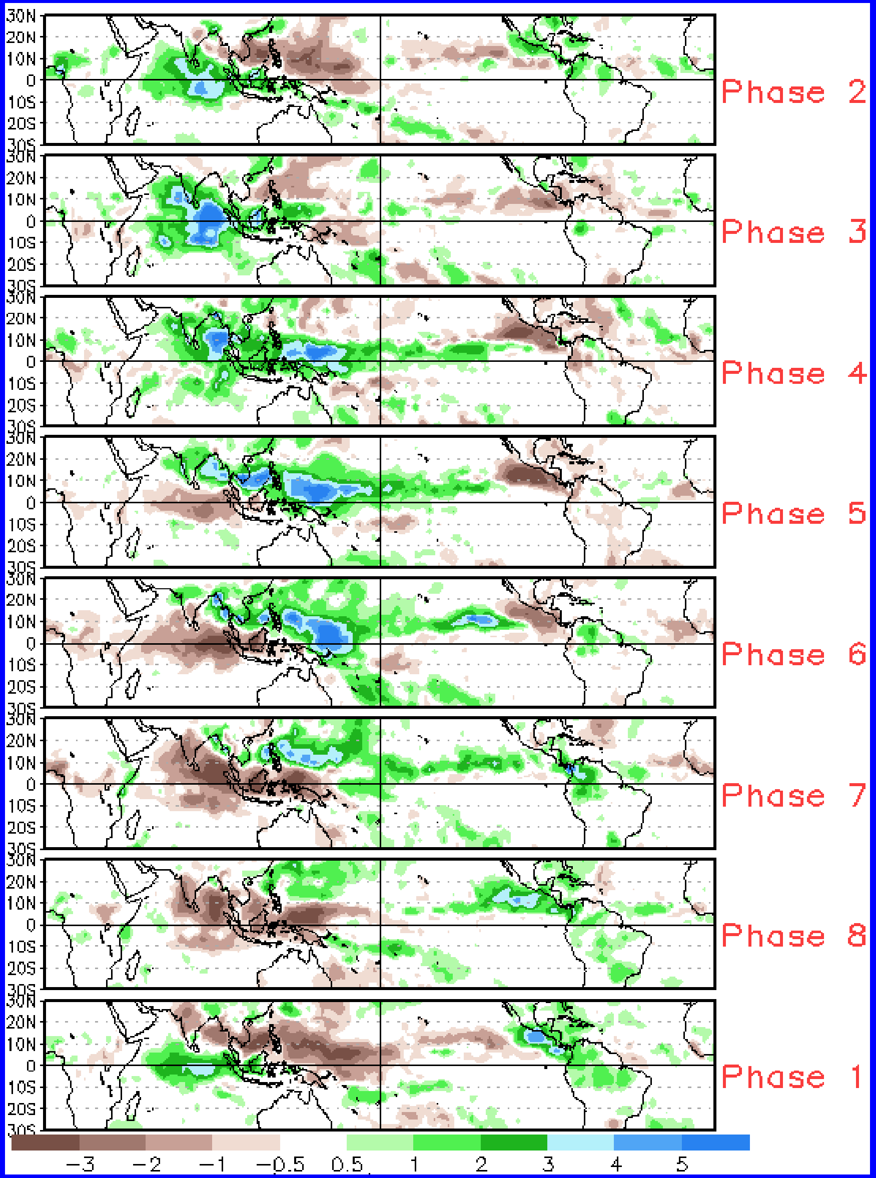


MJO Composites – Global Tropics

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

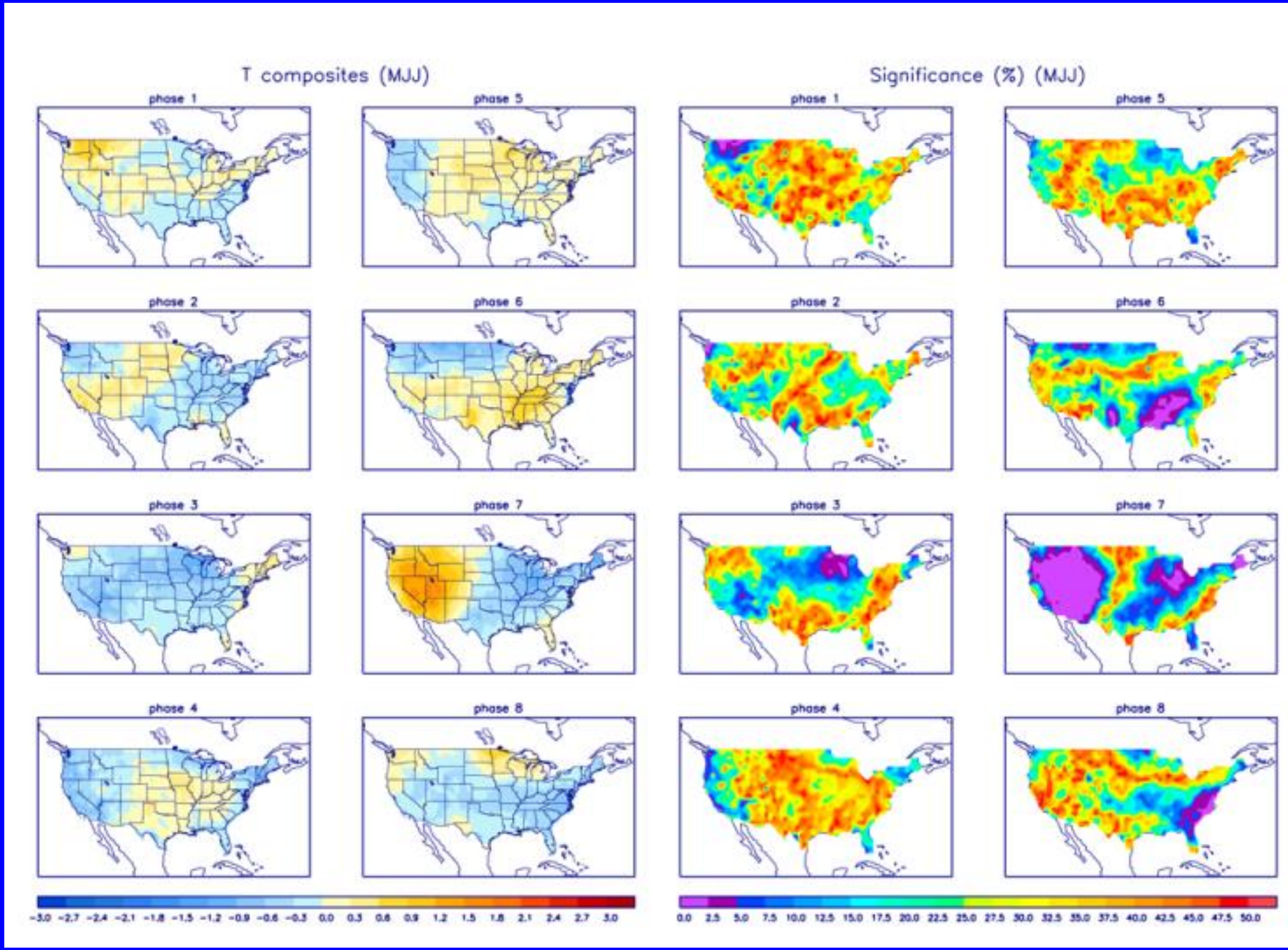


Precipitation Anomalies (May-Sep)



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.



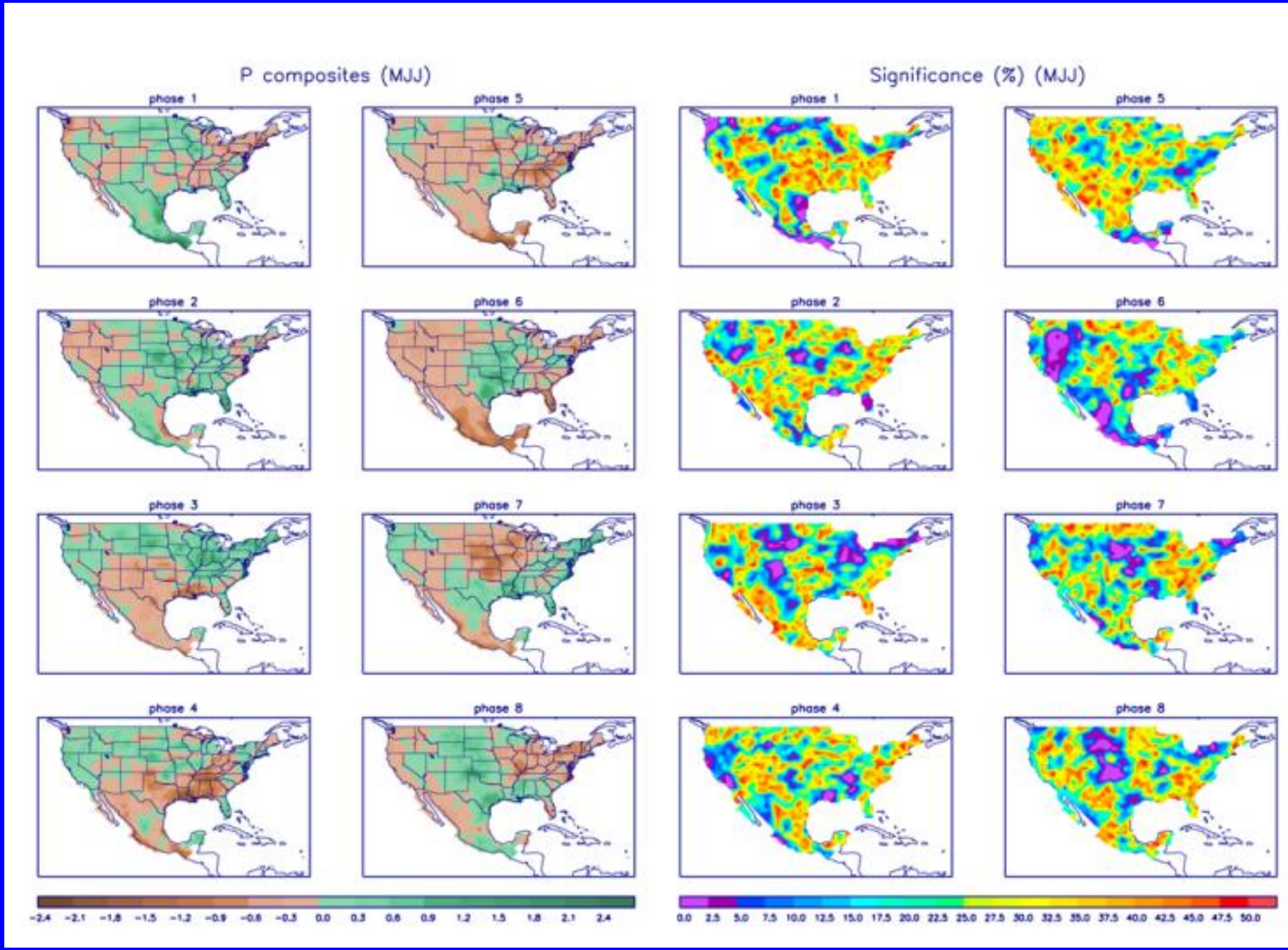
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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