



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

**Update prepared by
Climate Prediction Center / NCEP
June 2, 2014**



Outline

- **Overview**
- **Recent Evolution and Current Conditions**
- **MJO Index Information**
- **MJO Index Forecasts**
- **MJO Composites**



Overview

- **The MJO became more coherent during the previous week, with the convective phase propagating over the western Indian Ocean. Other coherent modes, however, continue to strongly influence the pattern of global tropical convection.**
- **The dynamical tools diverge in their MJO forecasts over the next two weeks, although most favor propagation of the convective phase over the Maritime Continent during Week-2 with differences in amplitude and phase speed.**
- **Based on recent observations and model forecasts, the MJO is forecast to be a contributor to the pattern of global tropical convective anomalies, but perhaps not the dominant driver.**
- **The MJO may contribute to enhanced (suppressed) convection over the western and central Indian Ocean (northwestern Pacific). The current MJO phase favors tropical cyclogenesis over the Arabian Sea.**

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>

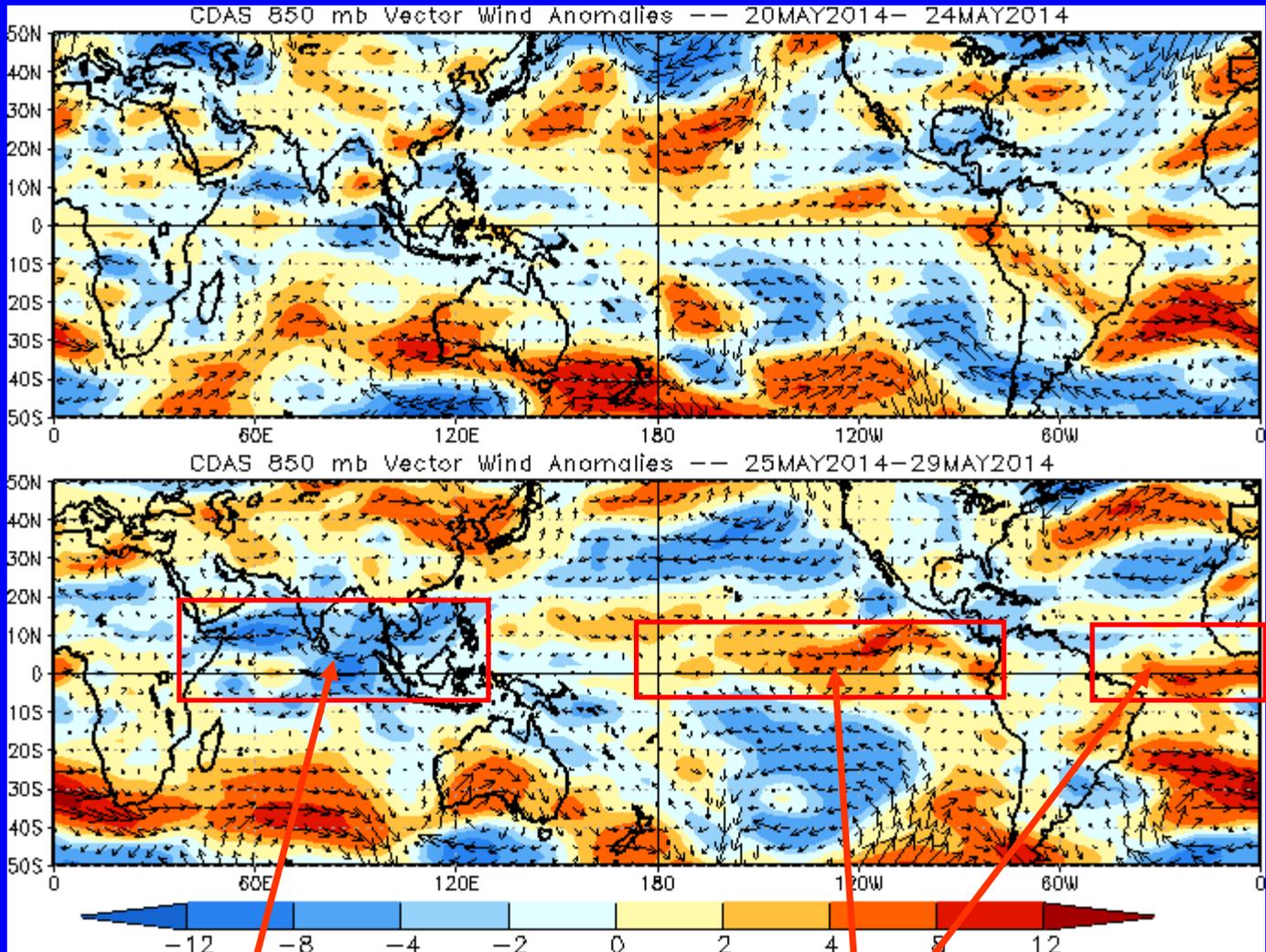


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



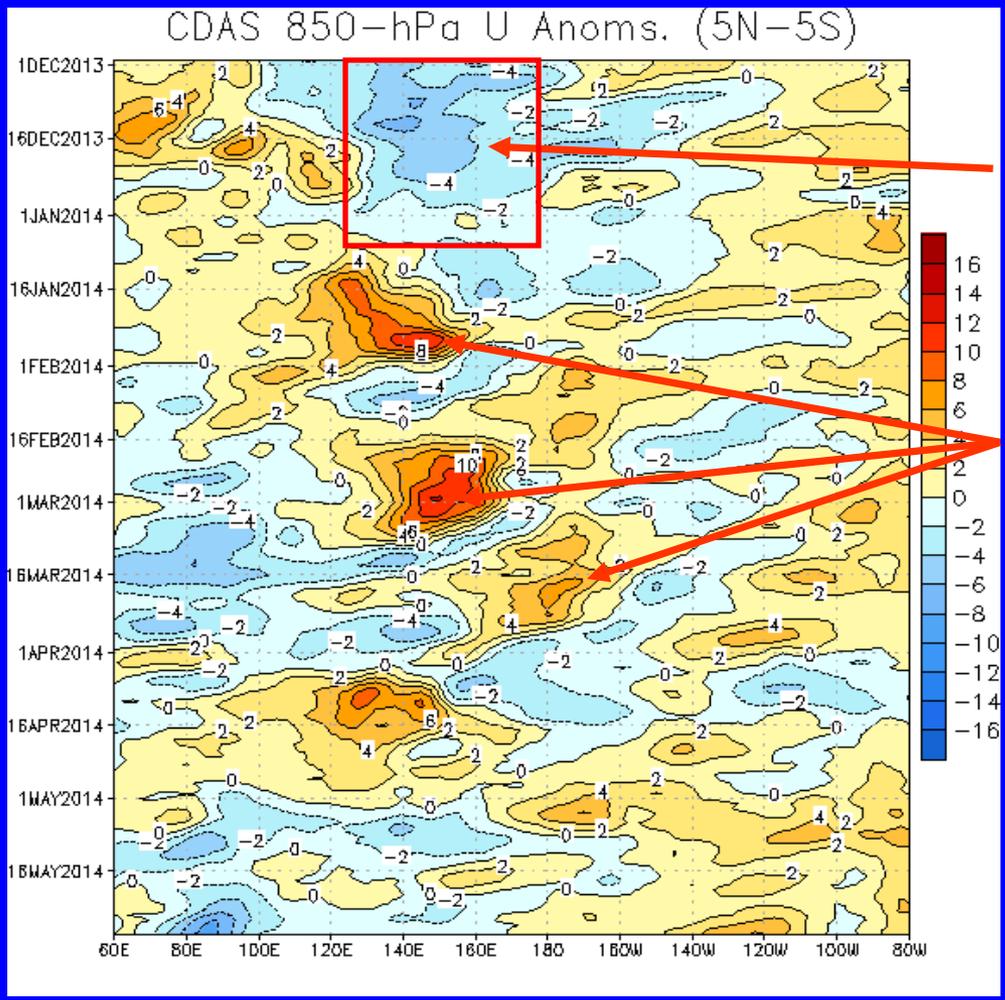
Easterly anomalies increased over the northern and eastern Indian Ocean.

Westerly anomalies persisted over the eastern Pacific and 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



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.

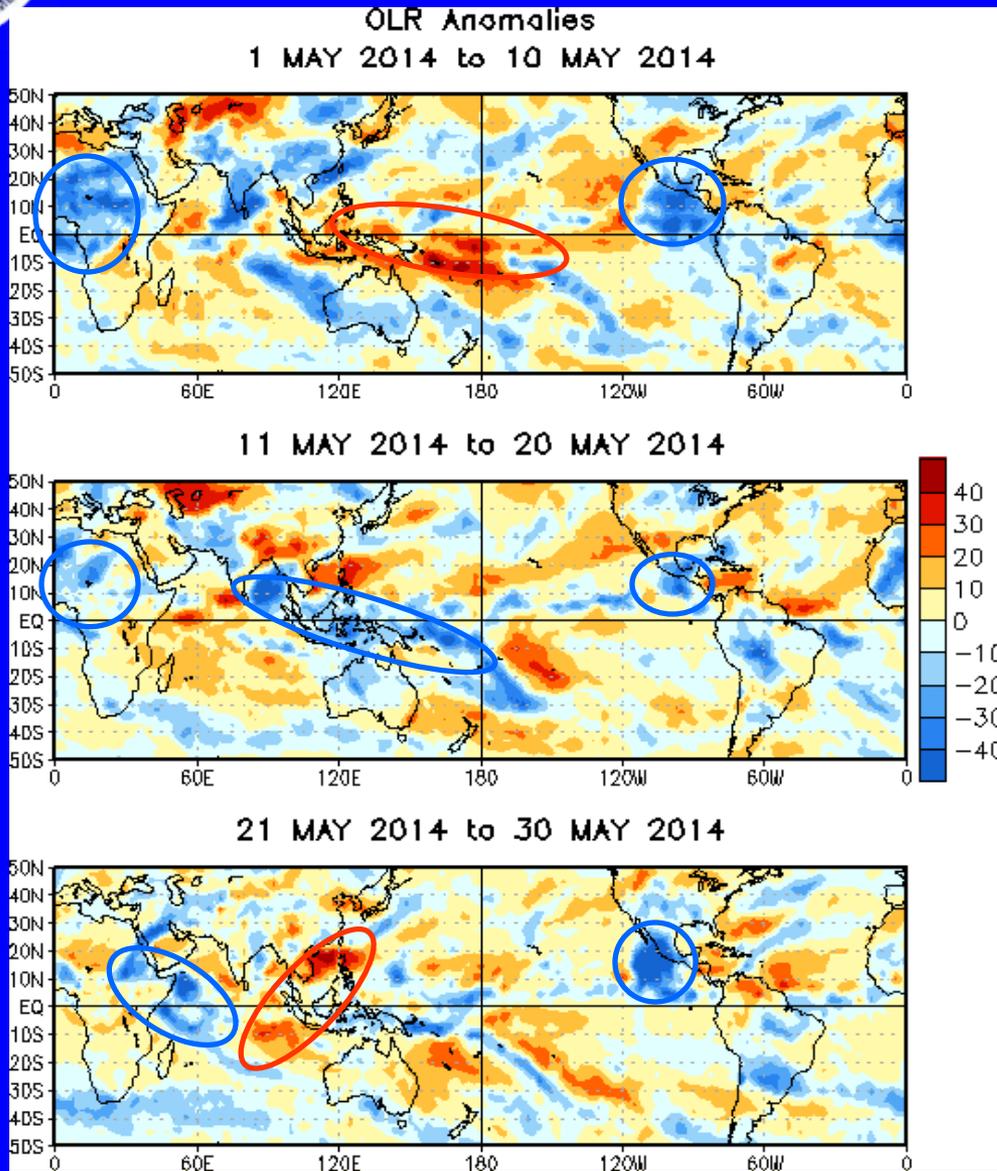
During April, winds near the Date Line were about average while westerly anomalies were generally persistent across the Maritime continent and far western Pacific.

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 May, enhanced (suppressed) convection was observed over the eastern Pacific and much of Africa (parts of the Maritime Continent and the southwestern Pacific).

The large scale patterns of anomalous convection largely broke down during mid-May, with weakly enhanced convection observed over parts of the eastern Indian Ocean, Maritime Continent, and West Pacific.

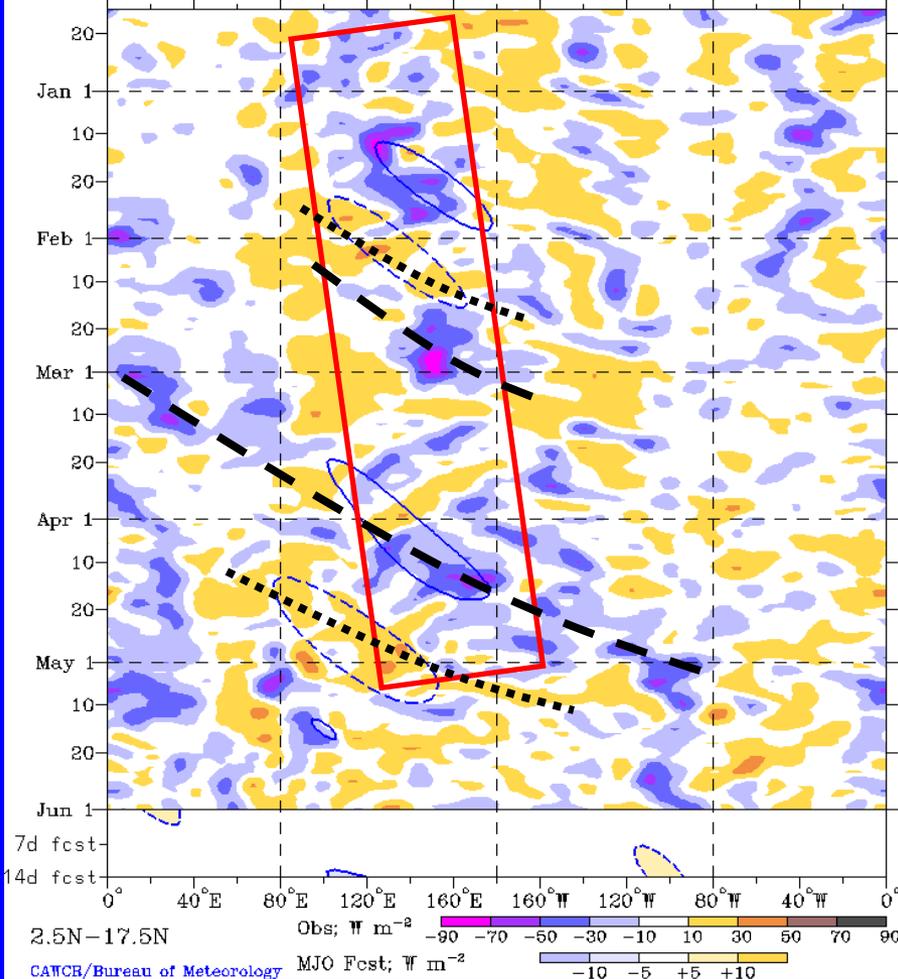
During late May, enhanced convection associated in part with TC activity persisted over the far eastern Pacific, while enhanced (suppressed) convection was observed over parts of the western Indian Ocean (eastern Indian Ocean and the South China Sea).



Outgoing Longwave Radiation (OLR)

Anomalies (2.5°N-17.5°N)

Real-time MJO filtering superimposed upon 3drmm R21 OLR Anomalies
MJO anomalies blue contours, CINT=10. (5. for forecast)
Negative contours solid, positive dashed
15-Dec-2013 to 1-Jun-2014 + 14 days



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 large-scale signal became less coherent during the middle part of May.

Longitude

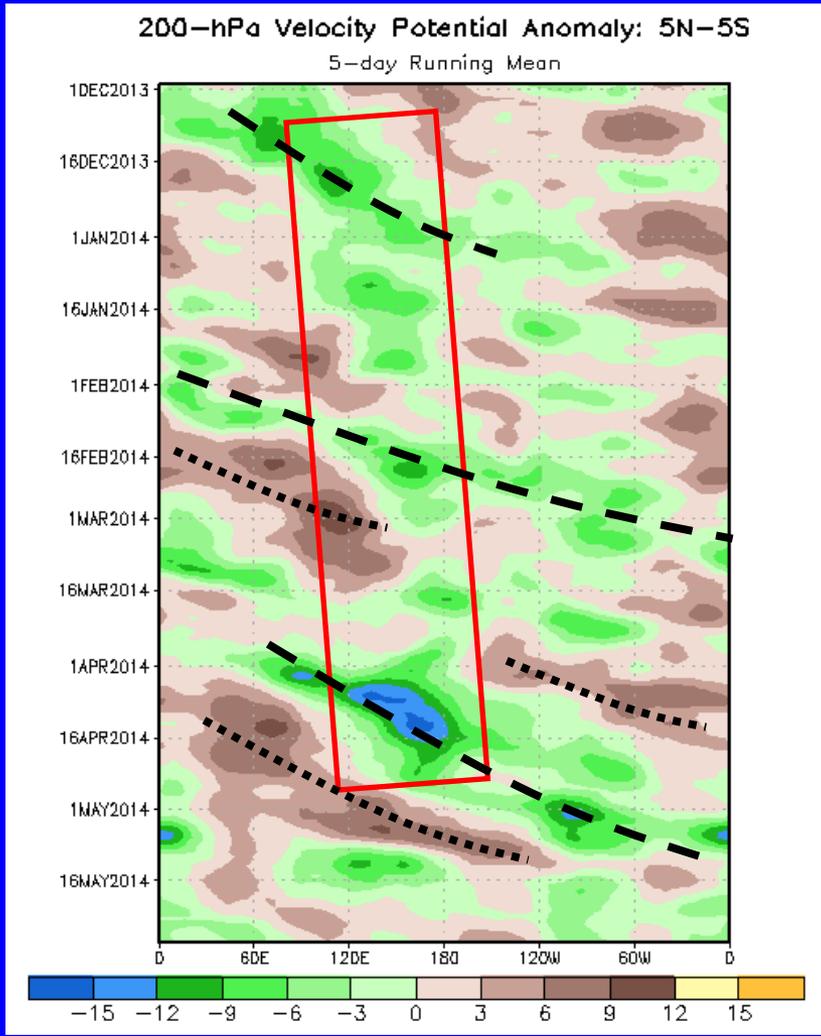
Time
↓



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 broke down more recently in favor of higher frequency Kelvin waves.

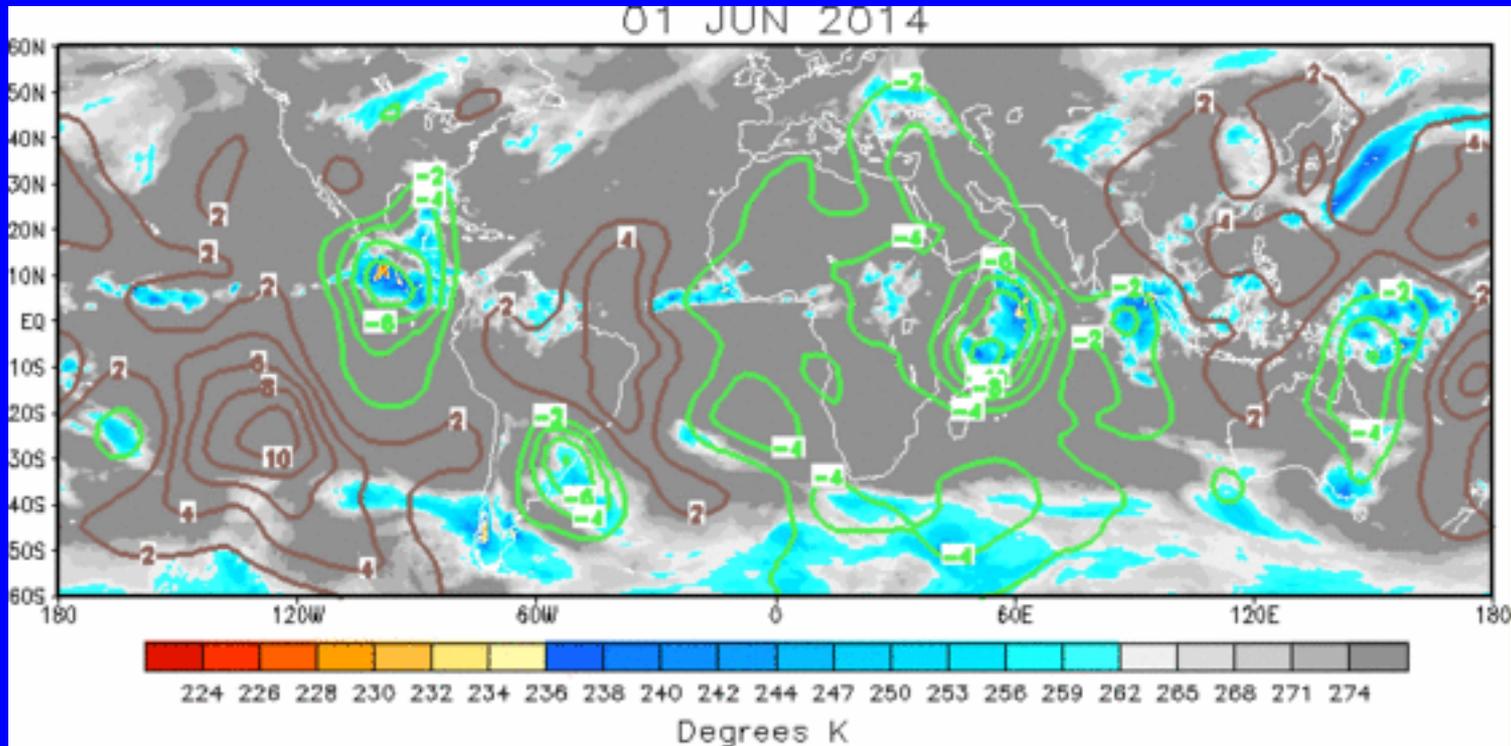
A more coherent pattern of velocity potential anomalies has developed recently.



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



The spatial upper-level velocity potential pattern has become more coherent, with anomalous upper-level divergence (convergence) over Africa and parts of the Indian Ocean and Maritime Continent (central Pacific).

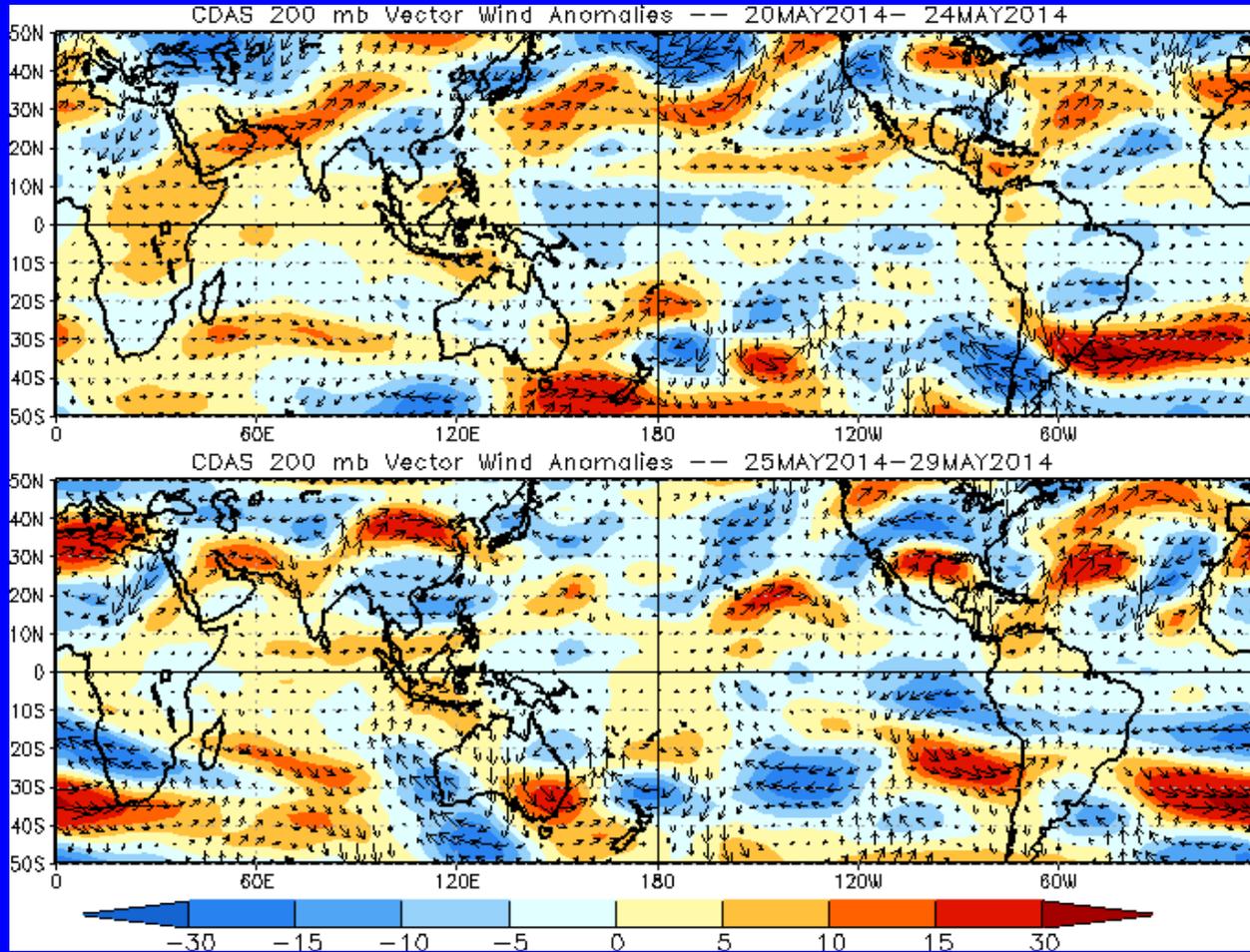


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



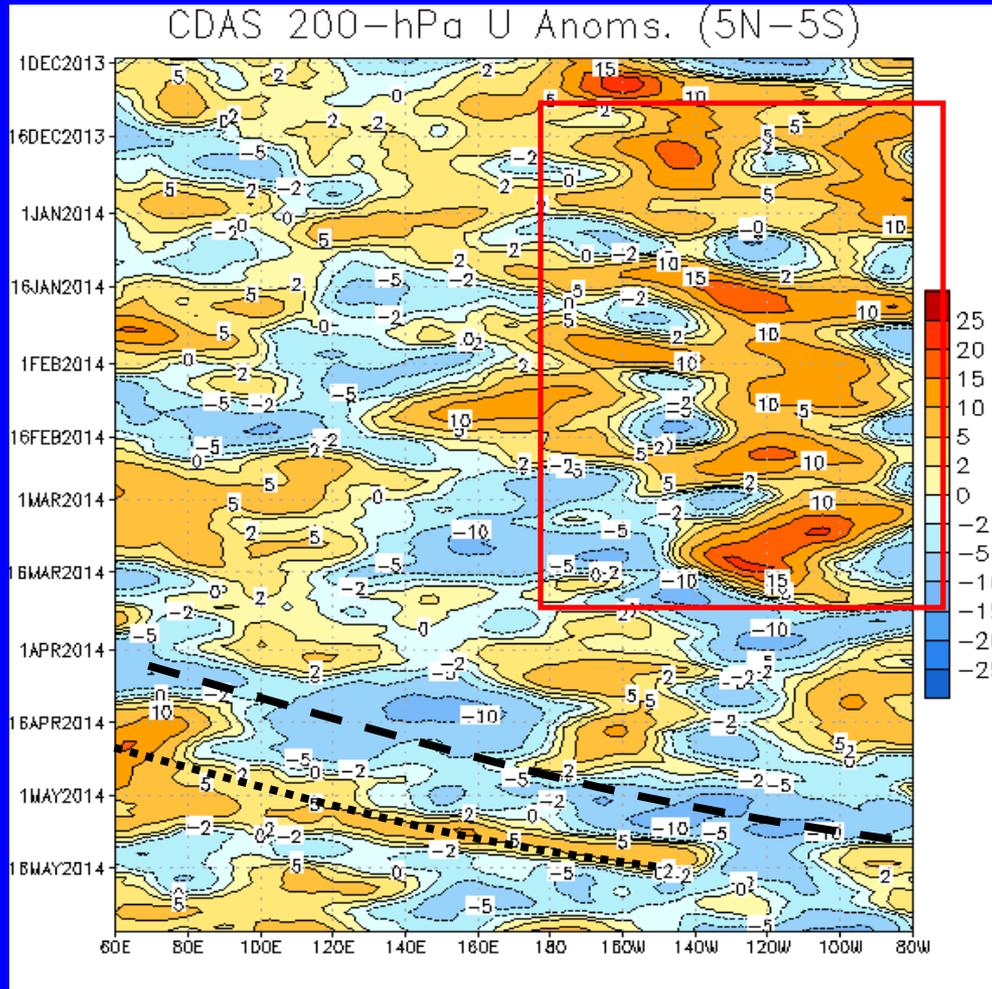
The upper-level zonal wind field remains largely incoherent across the global tropics.



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



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

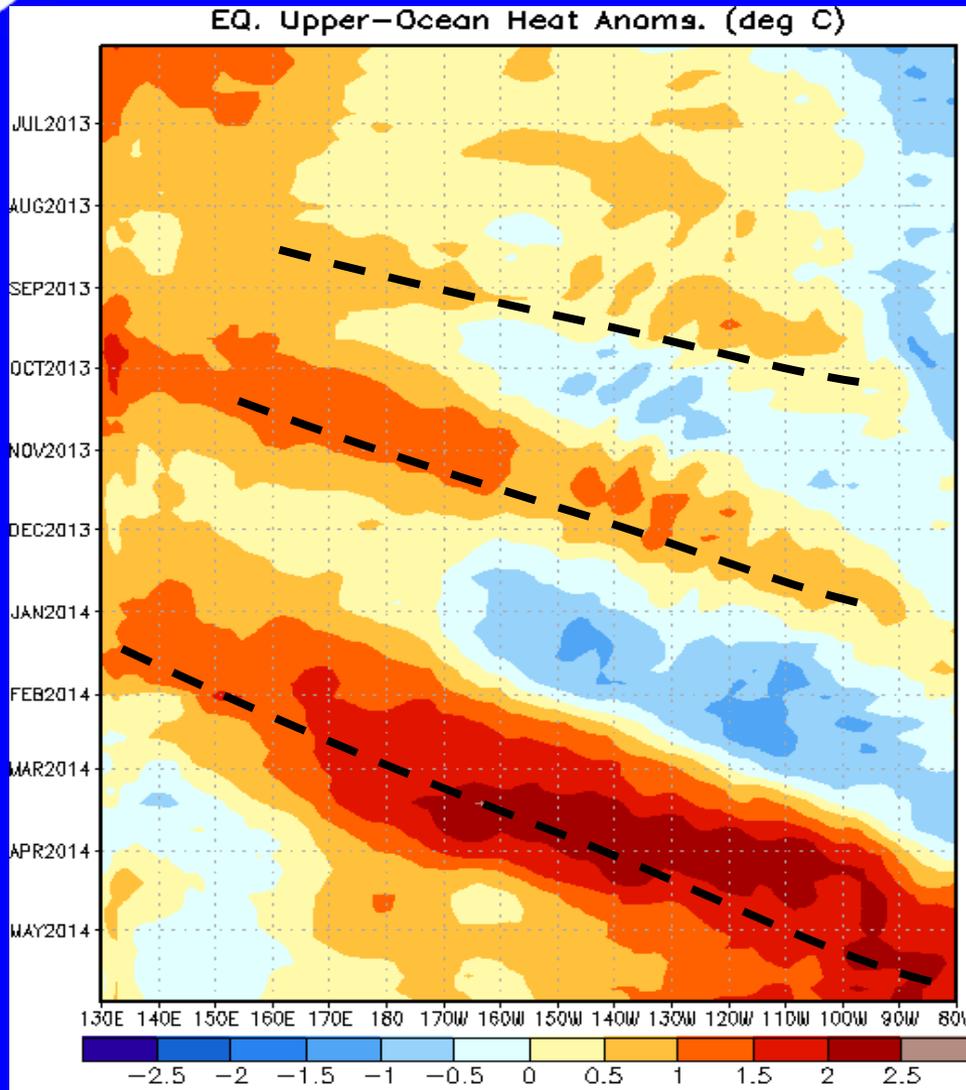
During mid-April, the slowly evolving background state has contributed to easterly anomalies expanding to the Date Line.

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

This signal broke down during late May, though westerly anomalies increased over the Indian Ocean more 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.

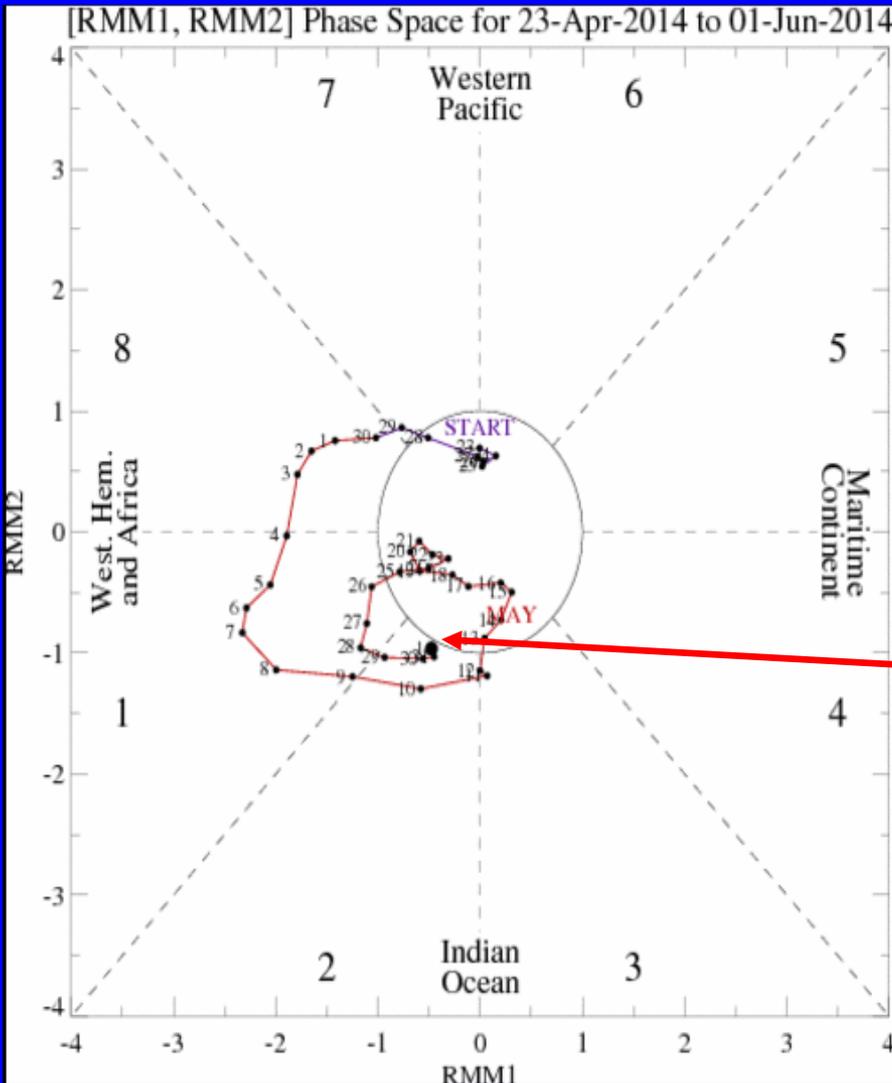
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

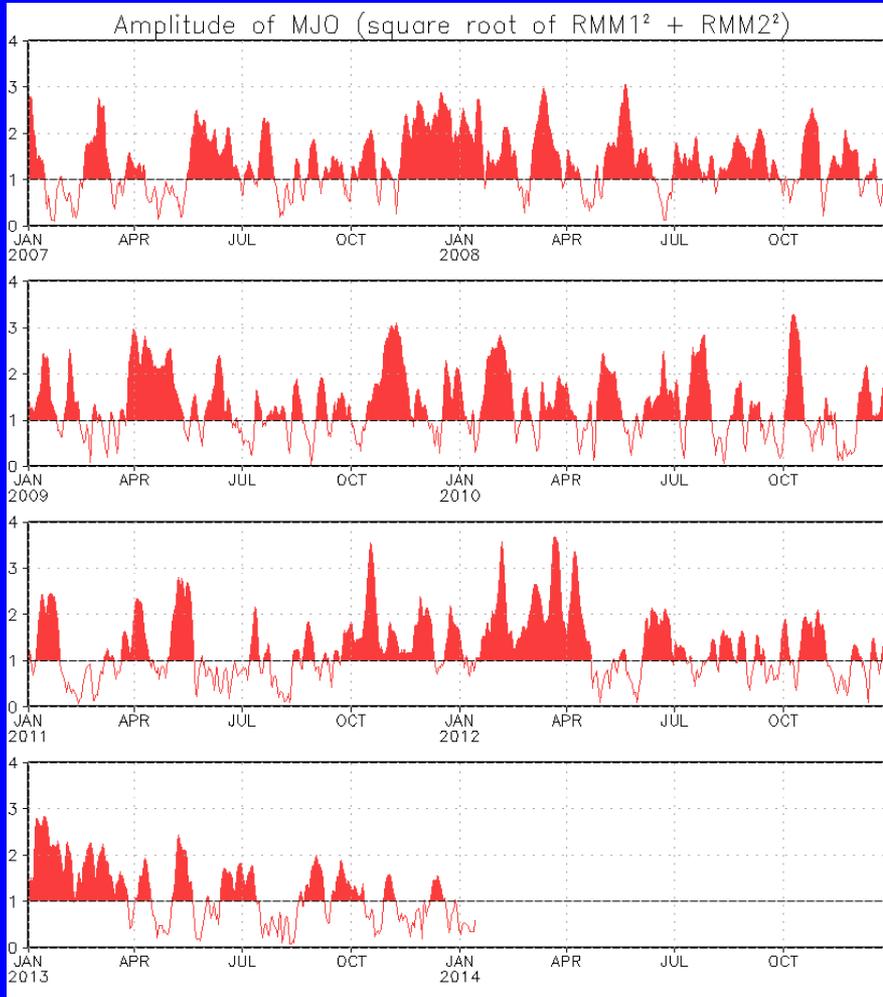


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the origin is proportional to MJO strength
- Line colors distinguish different months

The MJO index propagated eastward over Africa and the Indian Ocean during the previous 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.



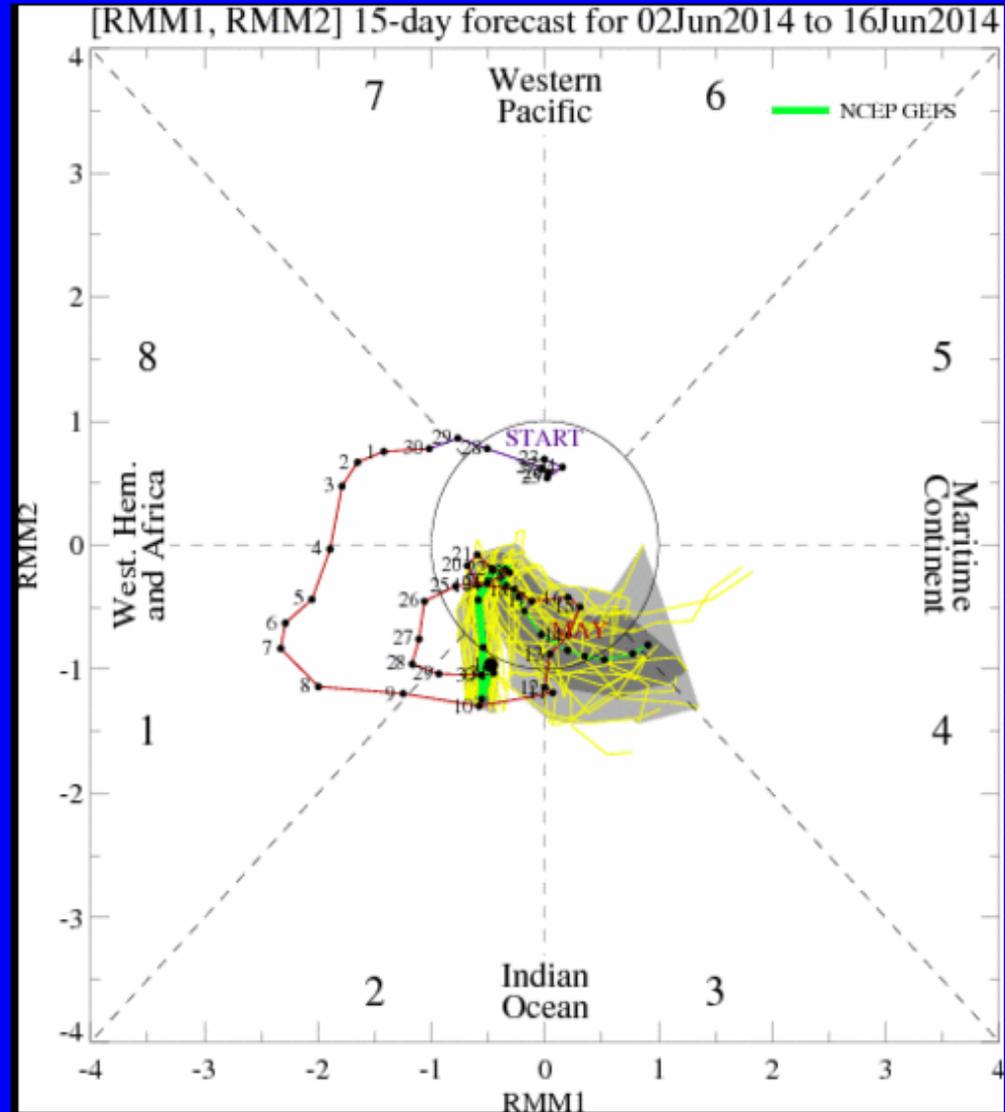
Ensemble GFS (GEFS) MJO Forecast

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 a weakening MJO signal during Week-1, with some eastward propagation of a weak signal over the Maritime Continent during Week-2.

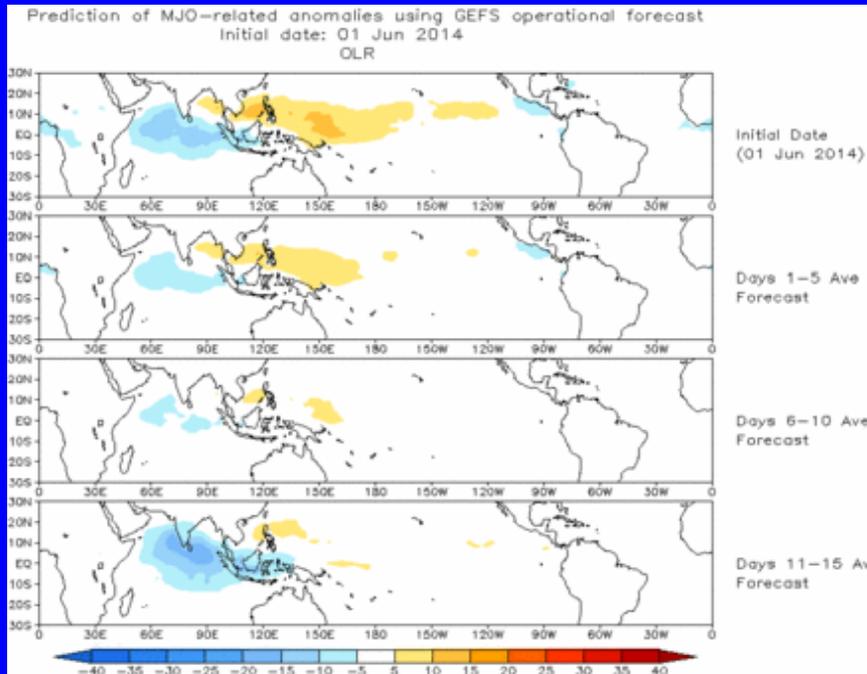




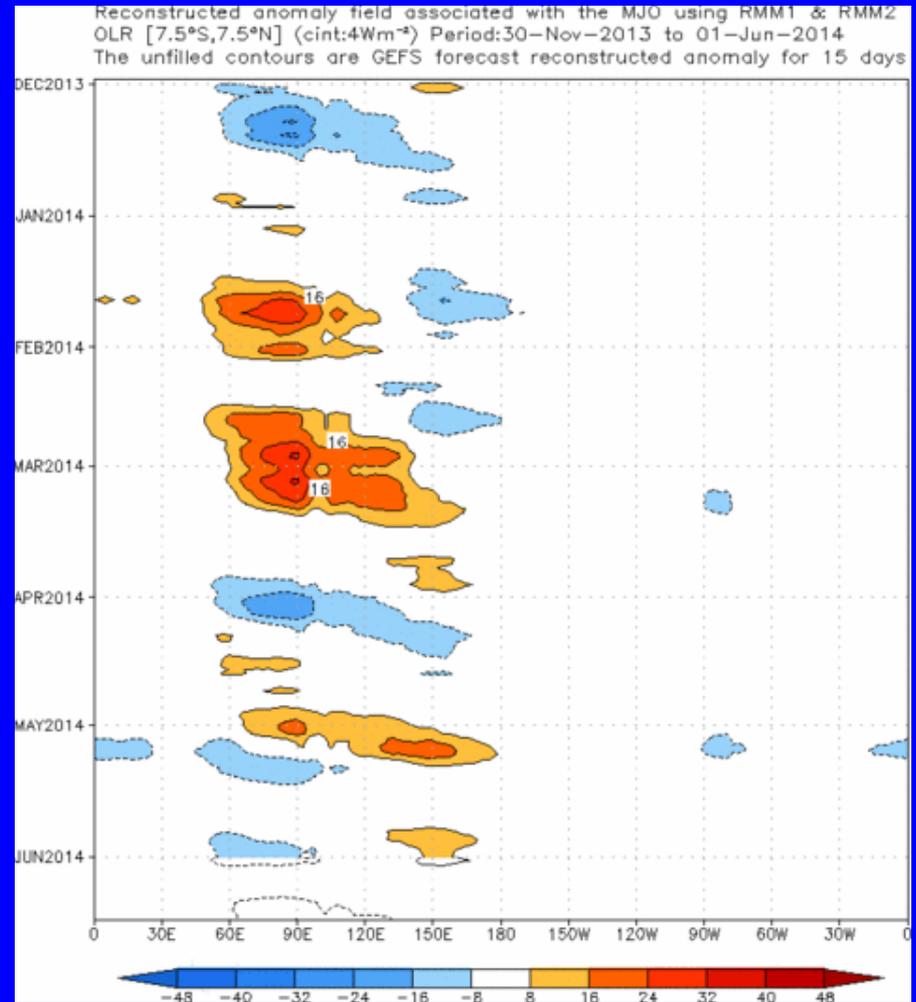
Ensemble Mean GFS MJO Forecast

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



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



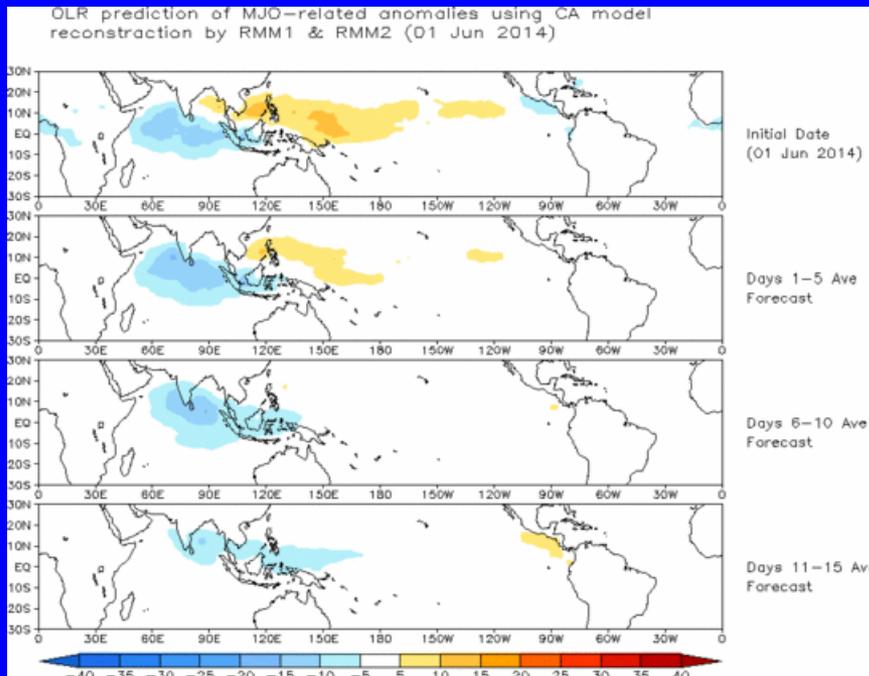
The ensemble mean GFS forecasts a slowly eastward propagating pattern of anomalous convection during the next two weeks.



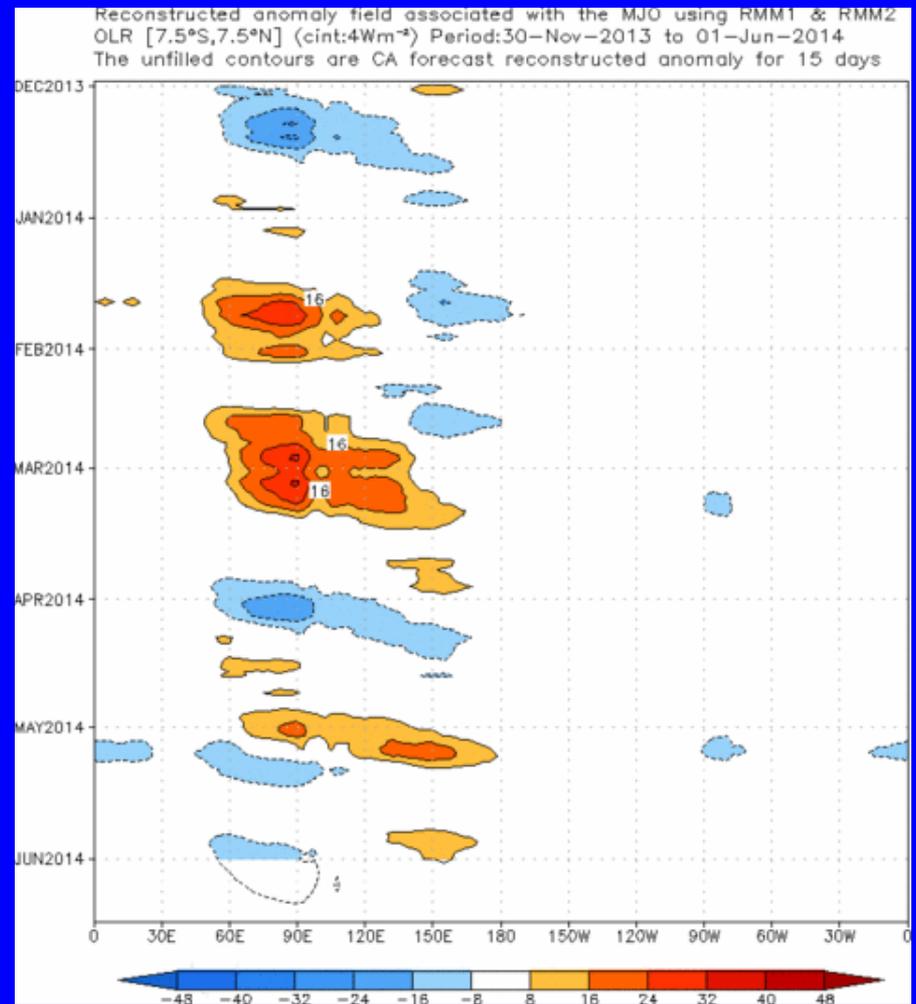
Constructed Analog (CA) MJO Forecast

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



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



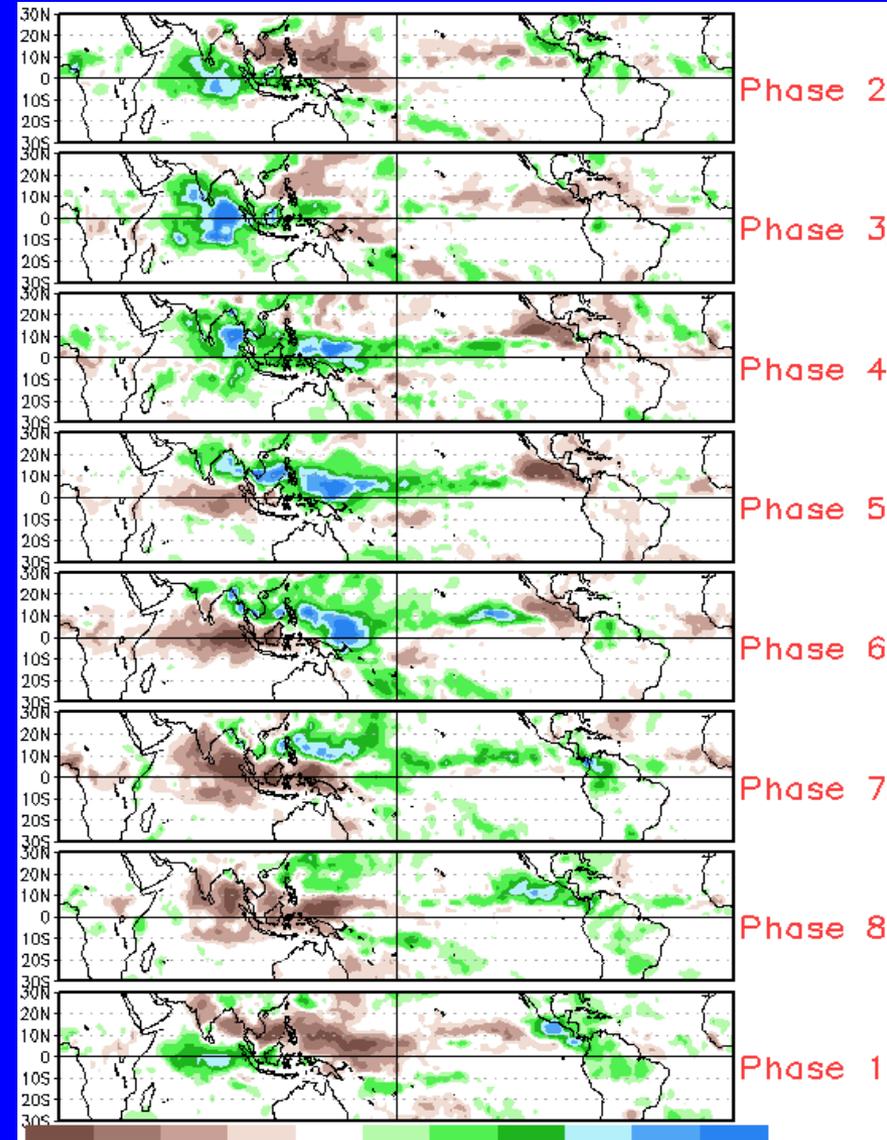
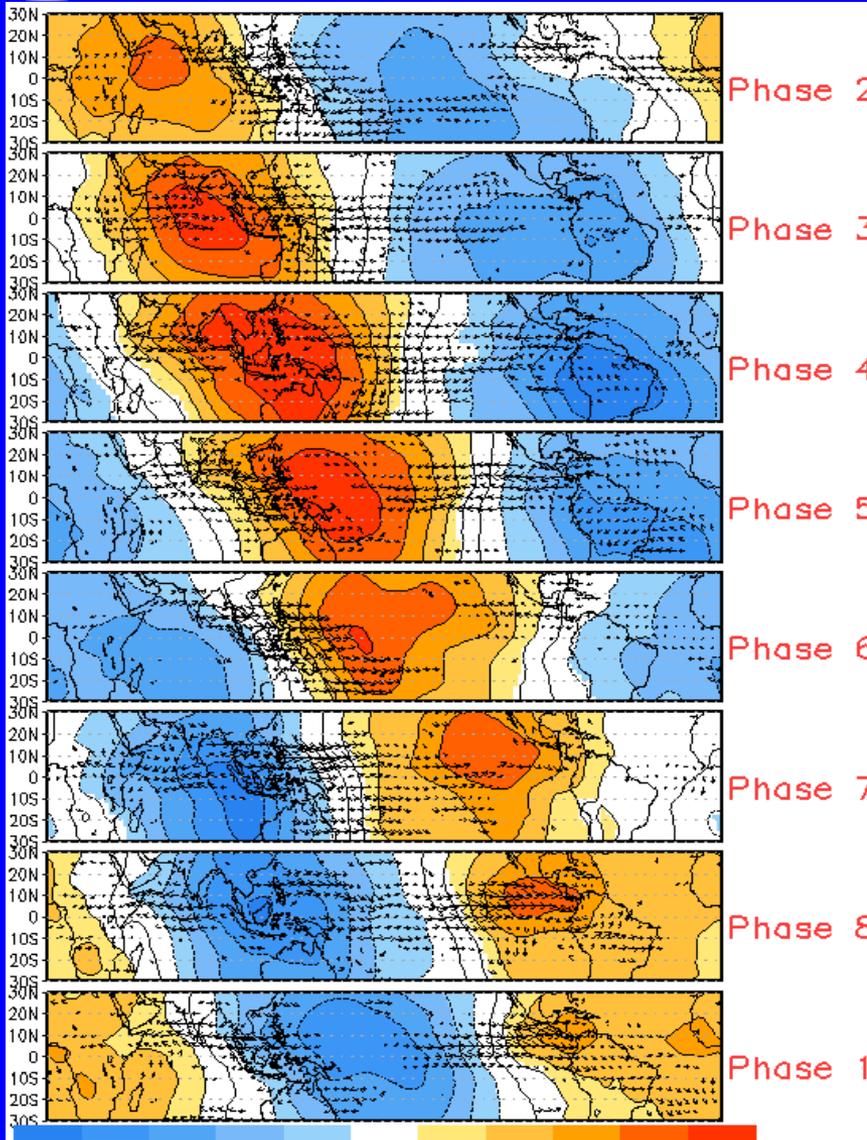
The constructed analog MJO forecast shows a more robust eastward propagation of large scale convective anomalies.



MJO Composites – Global Tropics

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

Precipitation Anomalies (May-Sep)

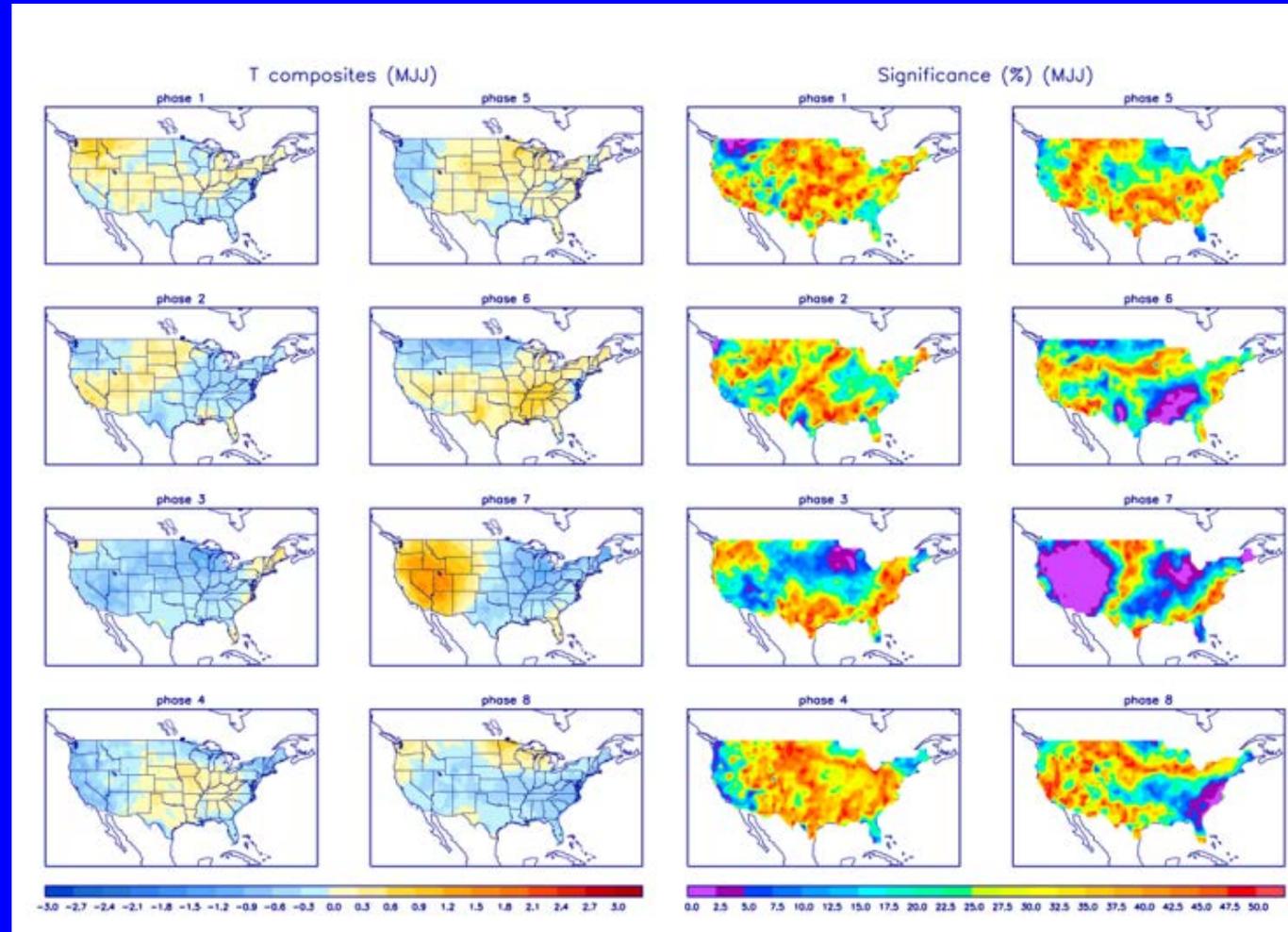




U.S. MJO Composites – Temperature

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.



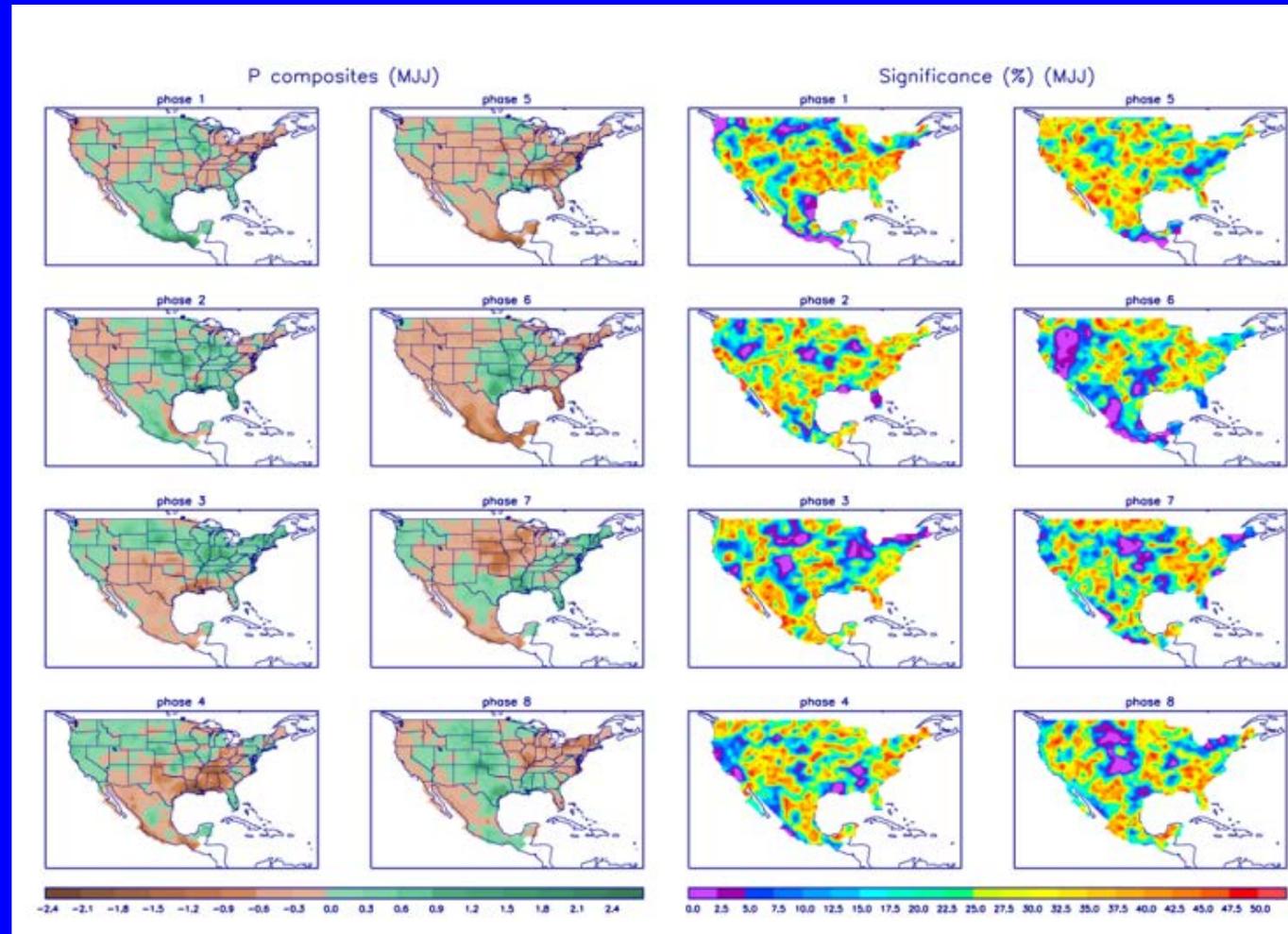
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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

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