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

Update prepared by
Climate Prediction Center / NCEP
June 23, 2014

Outline

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

Overview

- The MJO strengthened some during the past week, with the upper-level signal much more spatially coherent. Most indices indicate the convectively enhanced phase over the Central Pacific.

- There is considerable spread among dynamical MJO index model forecasts, with some showing a stationary signal over the Western Pacific and others propagating a signal to the Western Hemisphere. The statistical models favor some propagation.

- Based on recent observations and considerable range illustrated by dynamical model forecasts, the MJO is forecast to remain active, but it is unclear whether the current signal persists as a longer lived robust MJO.

- The MJO may contribute some to enhanced (suppressed) rainfall across parts of the Central and Eastern Pacific (Indian Ocean) during the period.

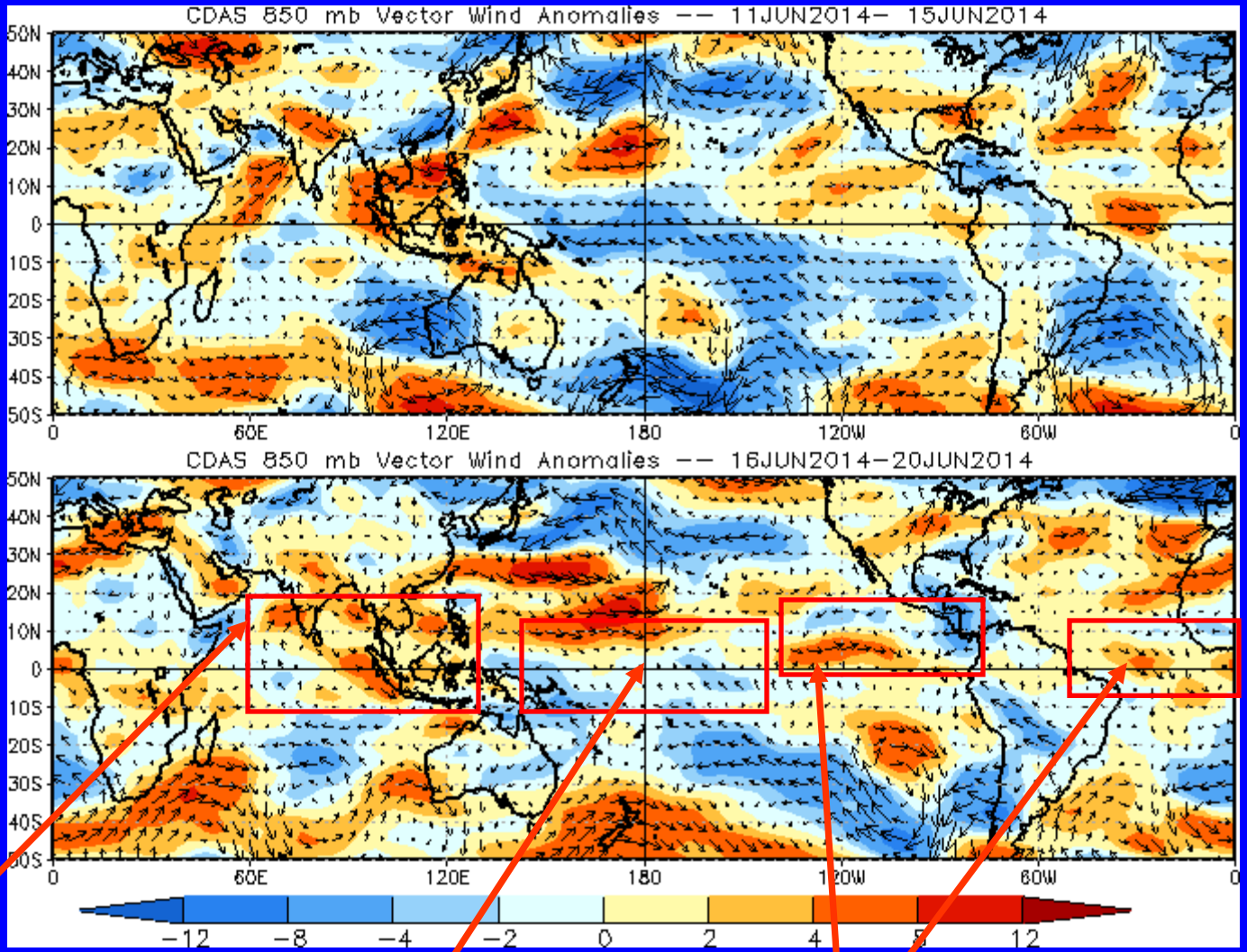
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies persisted over the Northern Indian Ocean and the western Maritime Continent.

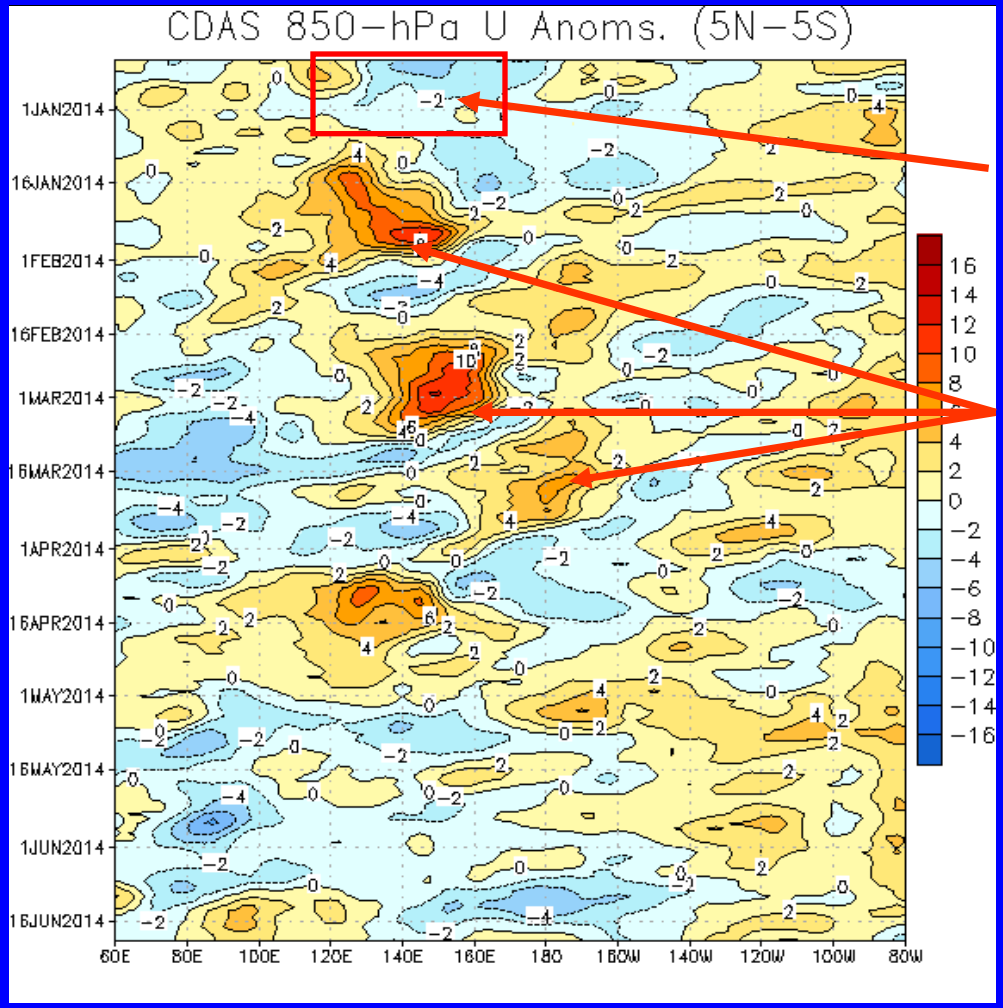
Easterly anomalies diminished to near zero close the Date Line along the equator, while westerly anomalies built in off the equator.

Westerly anomalies intensified over the eastern Pacific and diminished over the Atlantic 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.

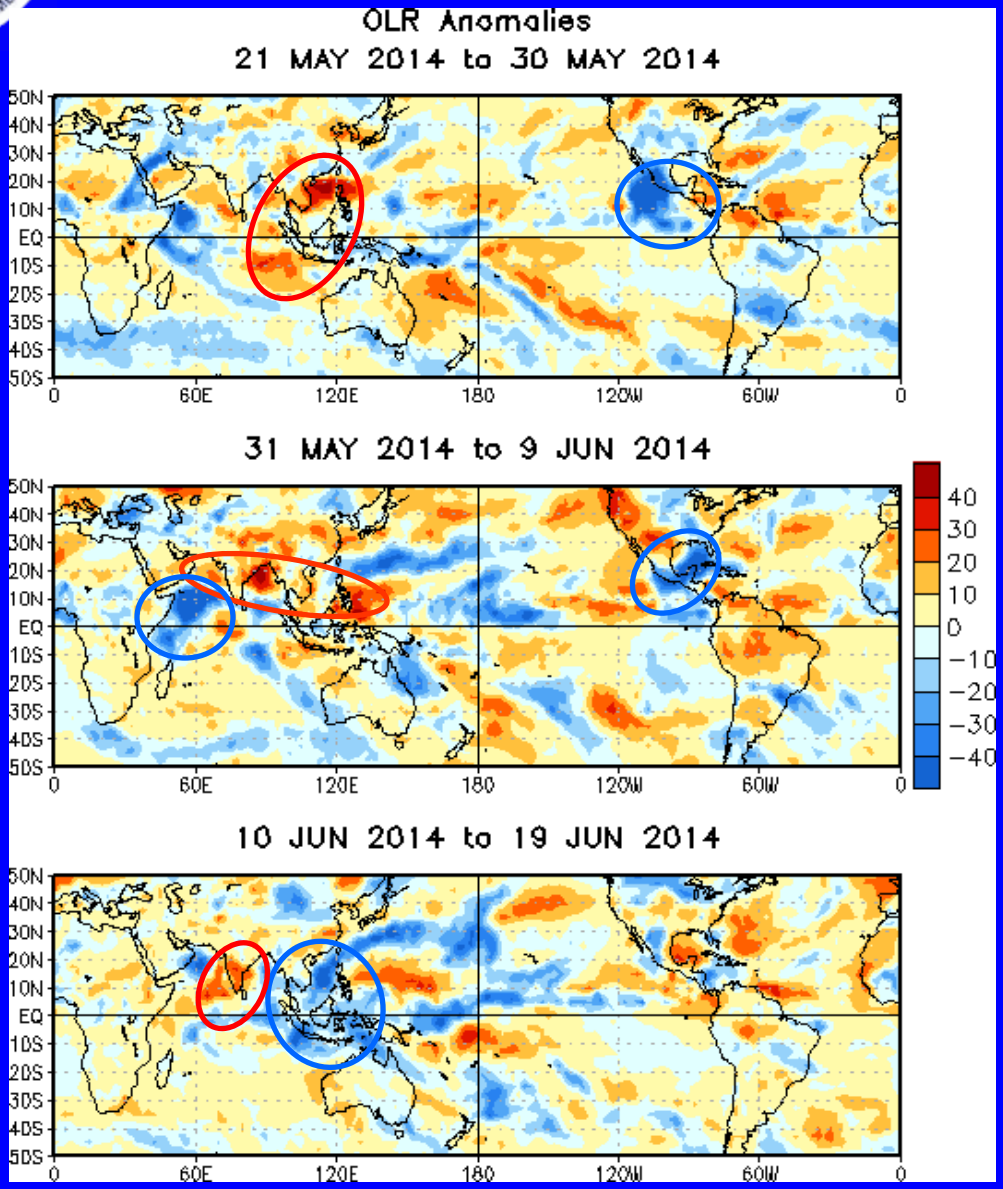
Multiple westerly wind bursts were observed across the western Pacific between January and mid-March. Each westerly wind burst shifted slightly further east.

During April, westerly anomalies were generally persistent across the Maritime continent and far western Pacific.

During much of May and early June, westerly anomalies were observed over the eastern Pacific and Atlantic.

Westerly anomalies associated with the South Asian monsoon are evident. Other anomalies are generally weak.

OLR Anomalies – Past 30 days



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

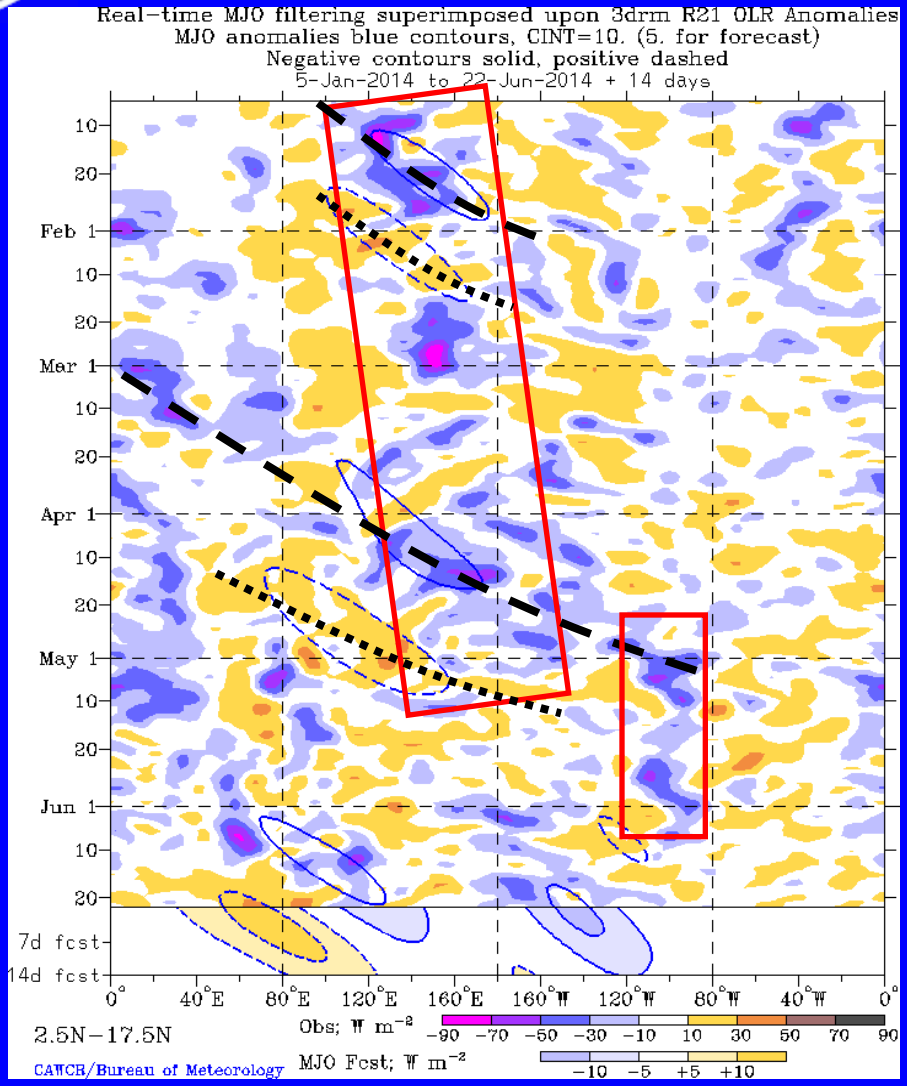
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During late May, tropical cyclone activitiy is evident over the eastern Pacific while a weak monsoon is evident across southern Asia.

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).

During mid-June, enhanced convection was observed over the Arabian Sea, Maritime Continent, and South China Sea. Suppressed convection over India is associated with a delayed monsoon.

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.

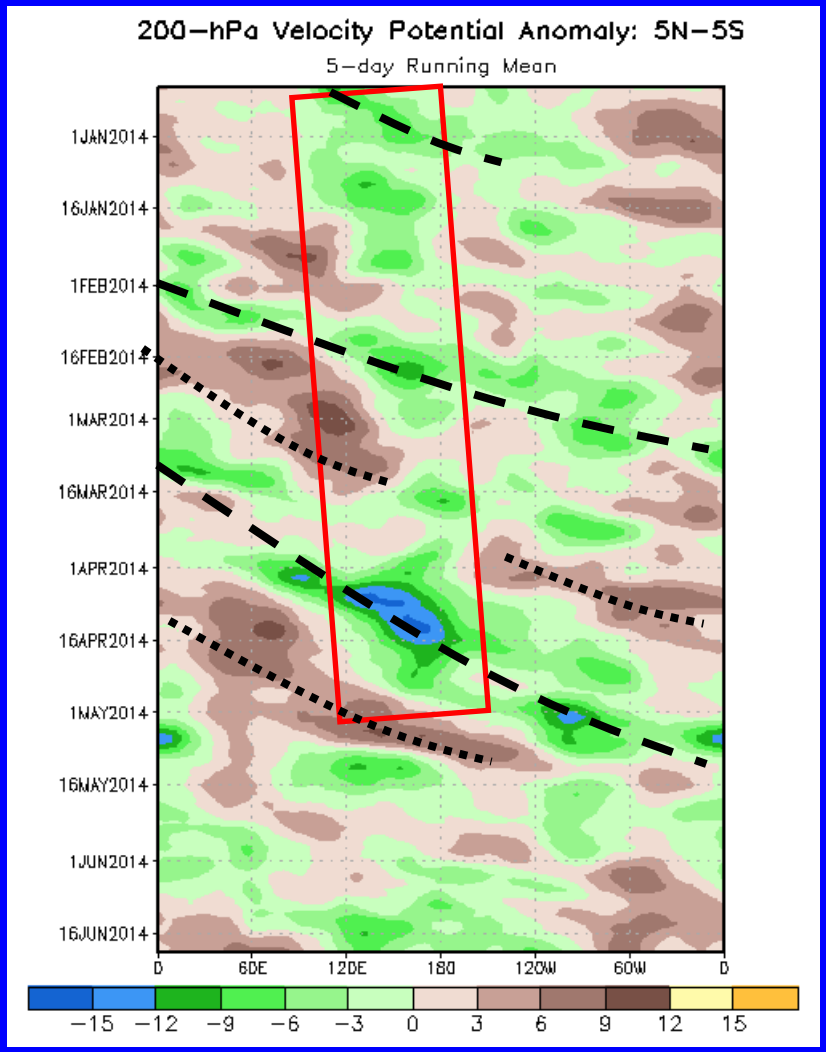
The MJO became more coherent during April, with the subseasonal envelopes of enhanced and suppressed convection modulating the strength of the low frequency signal. The anomalous tropical convection pattern became largely incoherent during mid-May, with convection over the eastern Pacific (red box).

More recently, areas of enhanced convection were observed over parts of the Indian Ocean and Central 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



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.

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

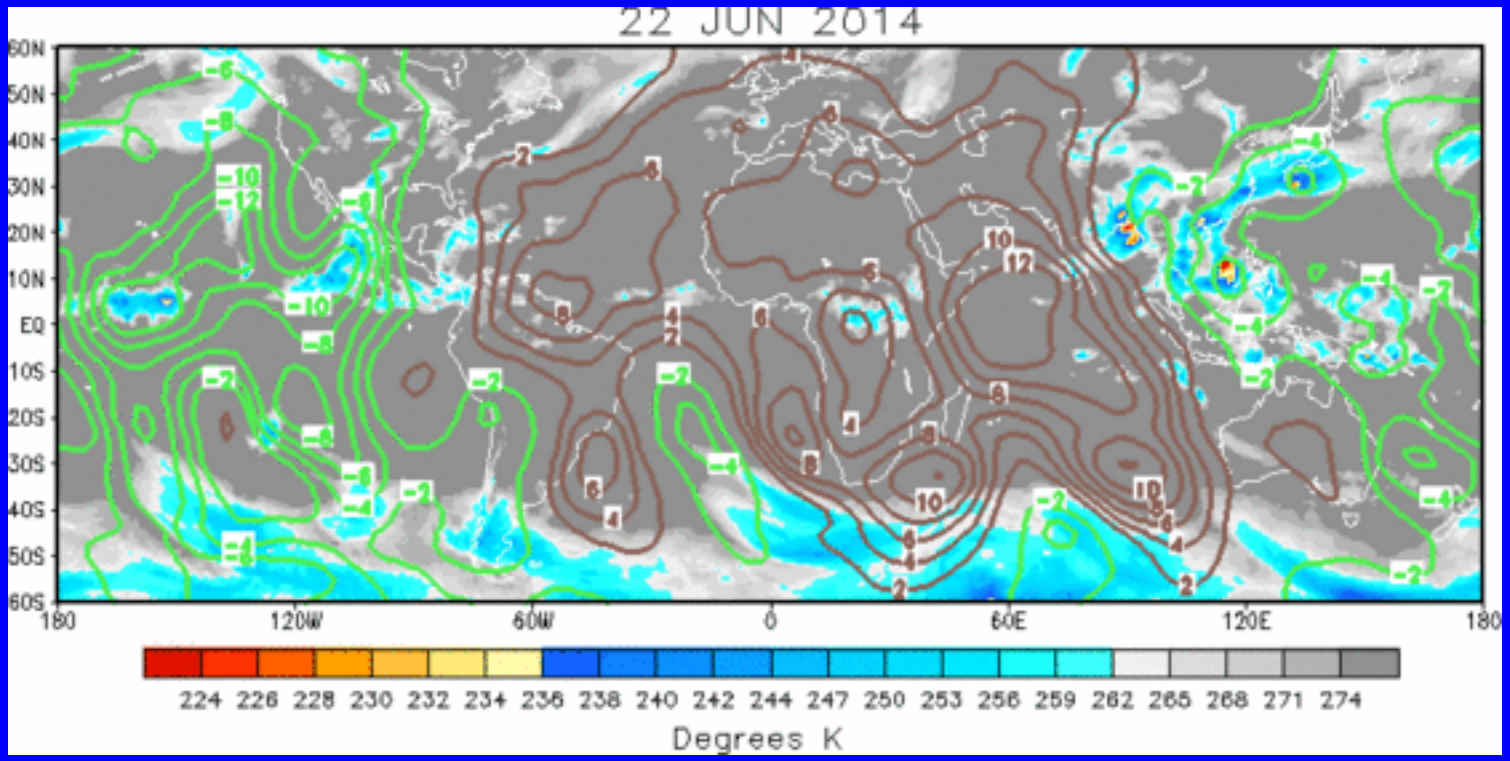
During February through April, anomalies propagated eastward with time associated with the MJO before weakening.

Recently the pattern indicates a mixture of faster modes of variability superposed with the evolving background state, not consistent with MJO activity.

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

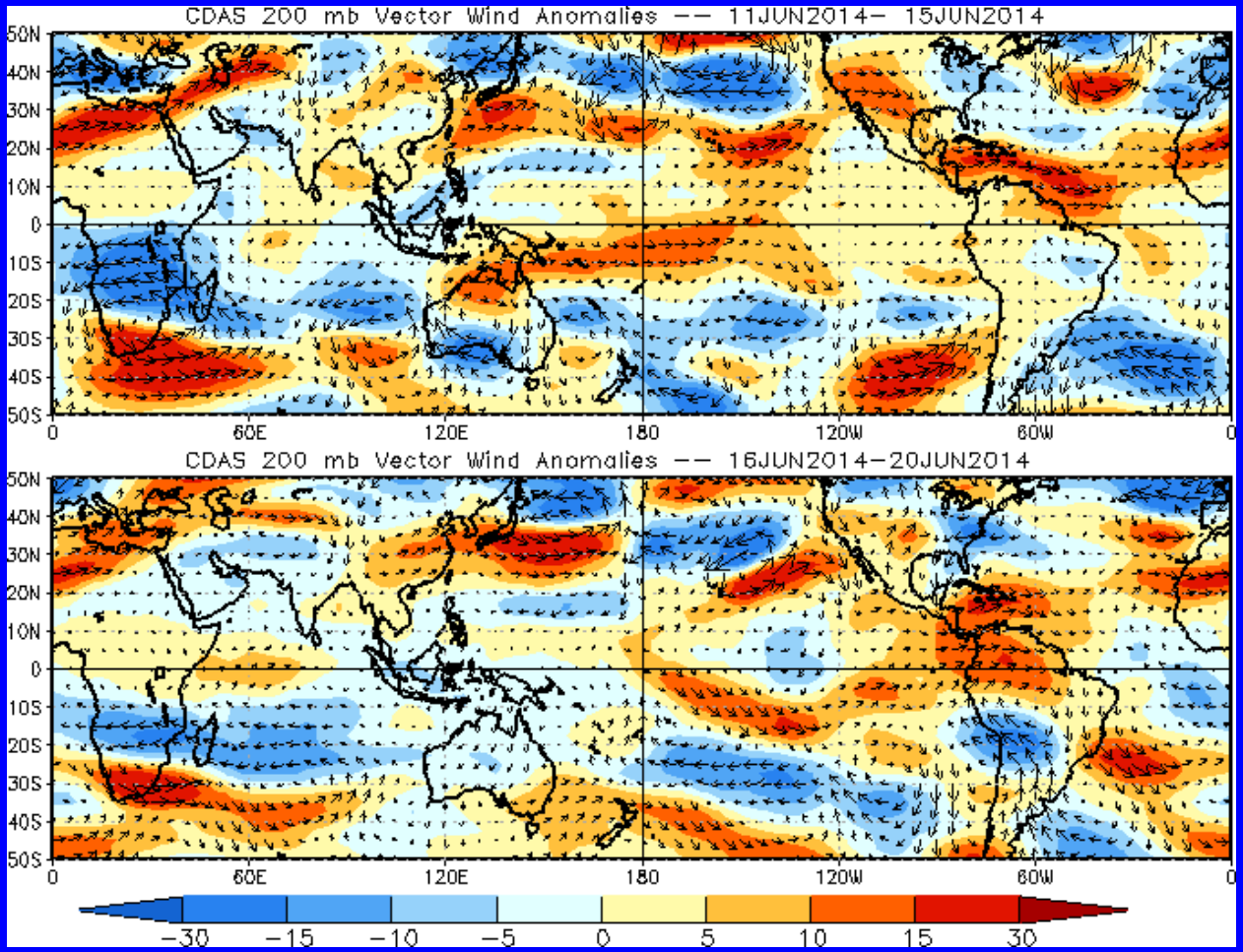
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The upper-level anomalous velocity potential spatial pattern exhibits a wave-1 structure with divergence (convergence) across the Pacific (Americas to Africa). The pattern is consistent with the evolving background state and potentially an strengthening MJO.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

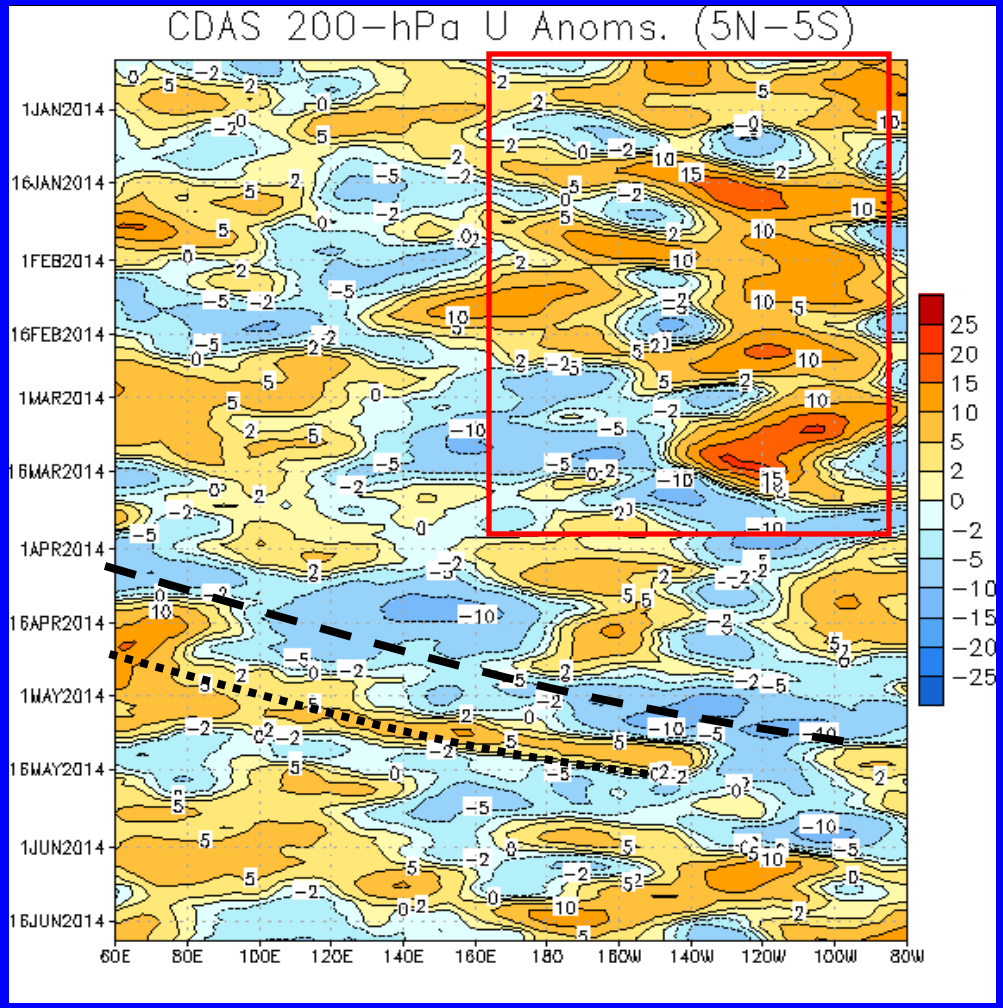
Red shades: Westerly anomalies

Easterly anomalies associated with the Tropical Easterly Jet over southern Asia strengthened. Westerly anomalies over the Americas and Africa expanded.

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

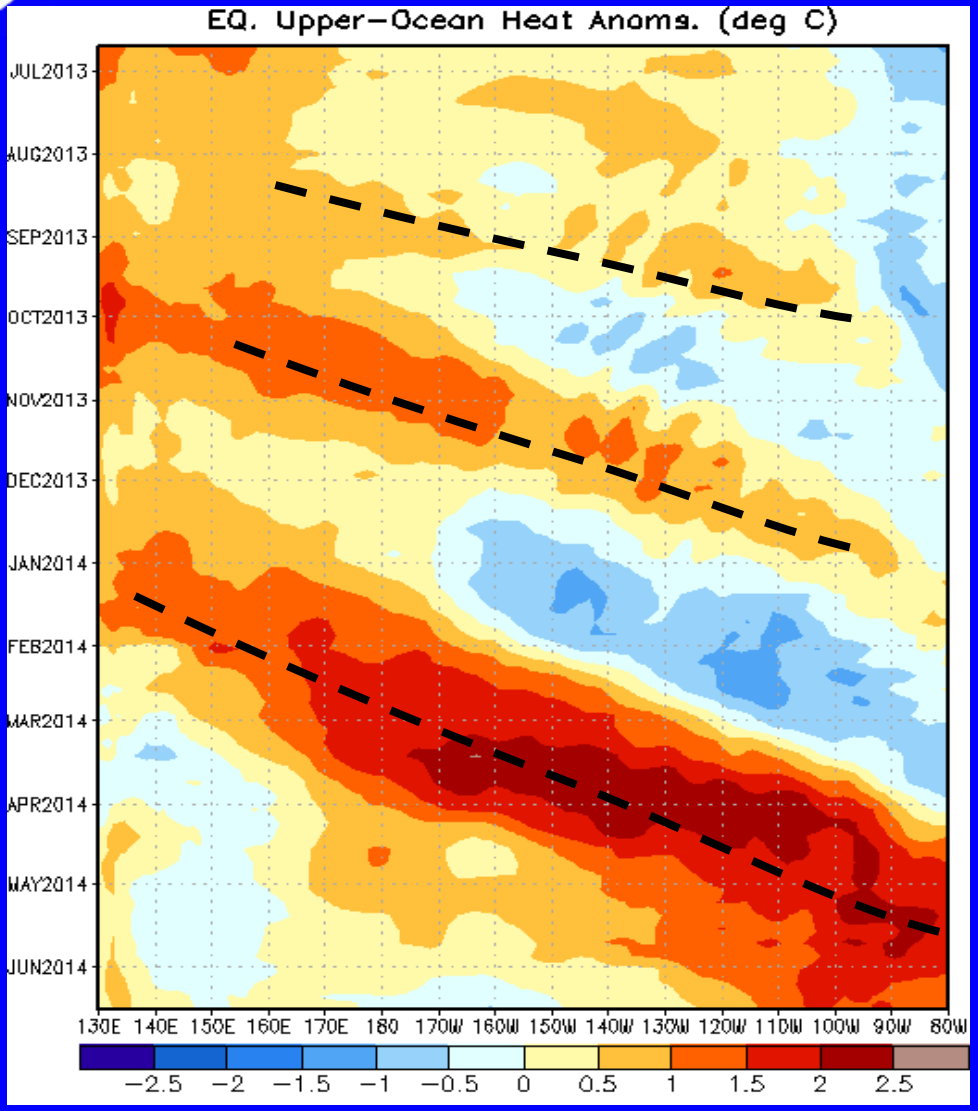
From December into March, westerly anomalies were most prevalent across the western Hemisphere (red box).

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.

Westward propagation of westerly anomalies is evident over the east central Pacific during June. The development of easterly anomalies is evident over the Indian Ocean during recent days.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

Oceanic downwelling Kelvin wave activity is evident in late August 2013 and once again during October through early December 2013.

A considerably stronger downwelling event began in January 2014 and propagated across the Pacific.

Warm anomalies persisted over much of the Pacific from April through early June.

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).

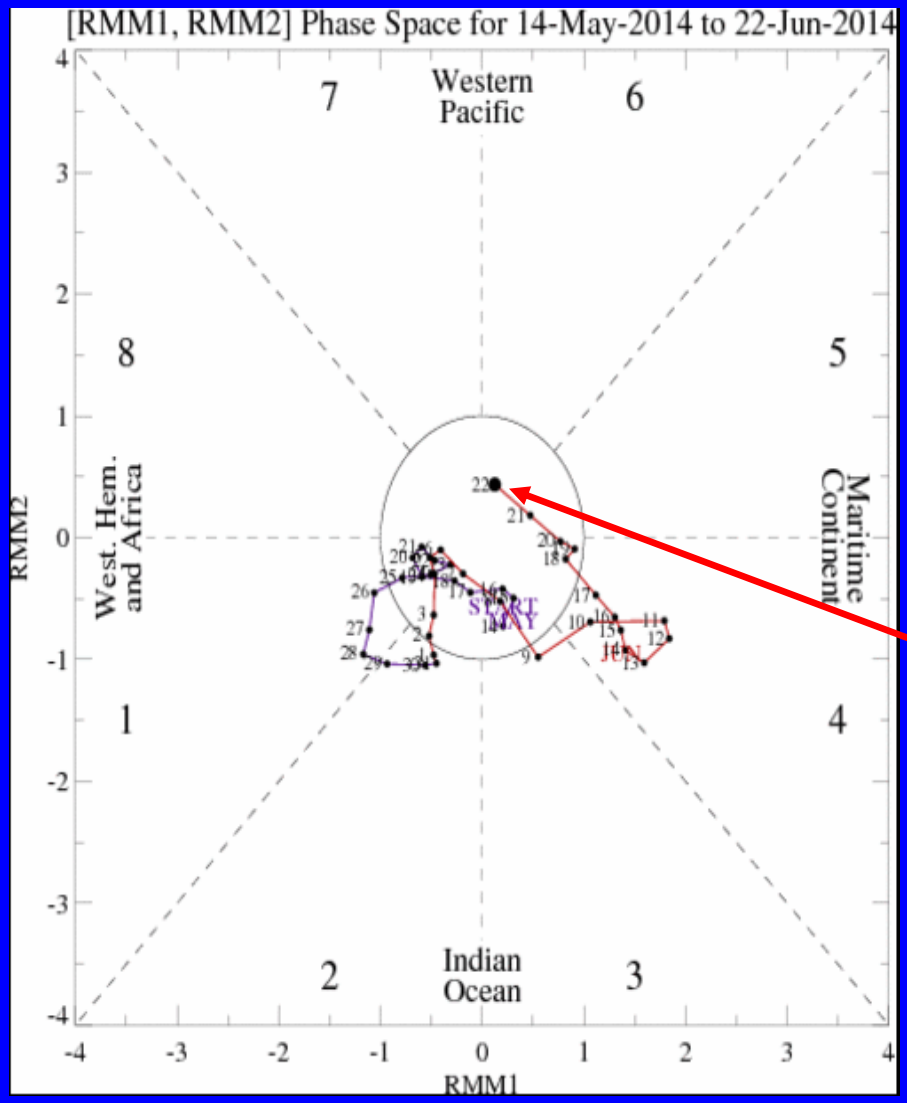
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

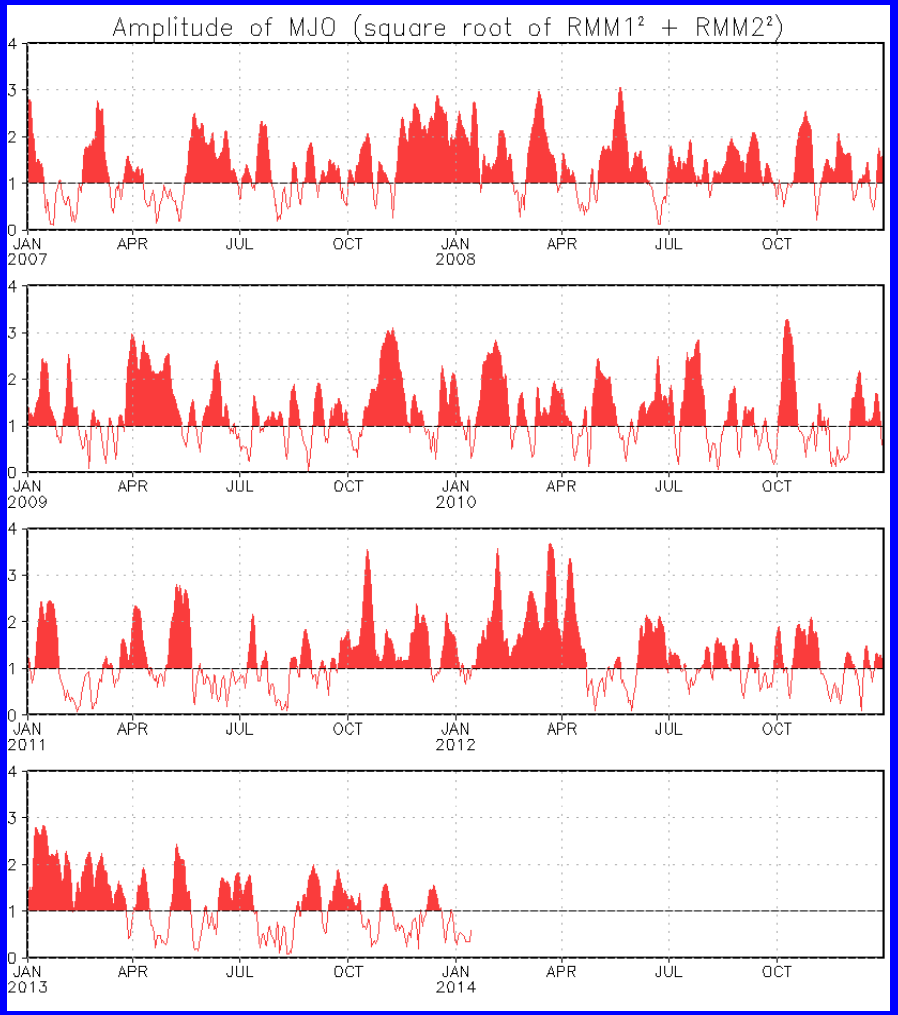
MJO Index -- Recent Evolution



- 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 a weak signal over the Maritime Continent during the past 5 days.

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.

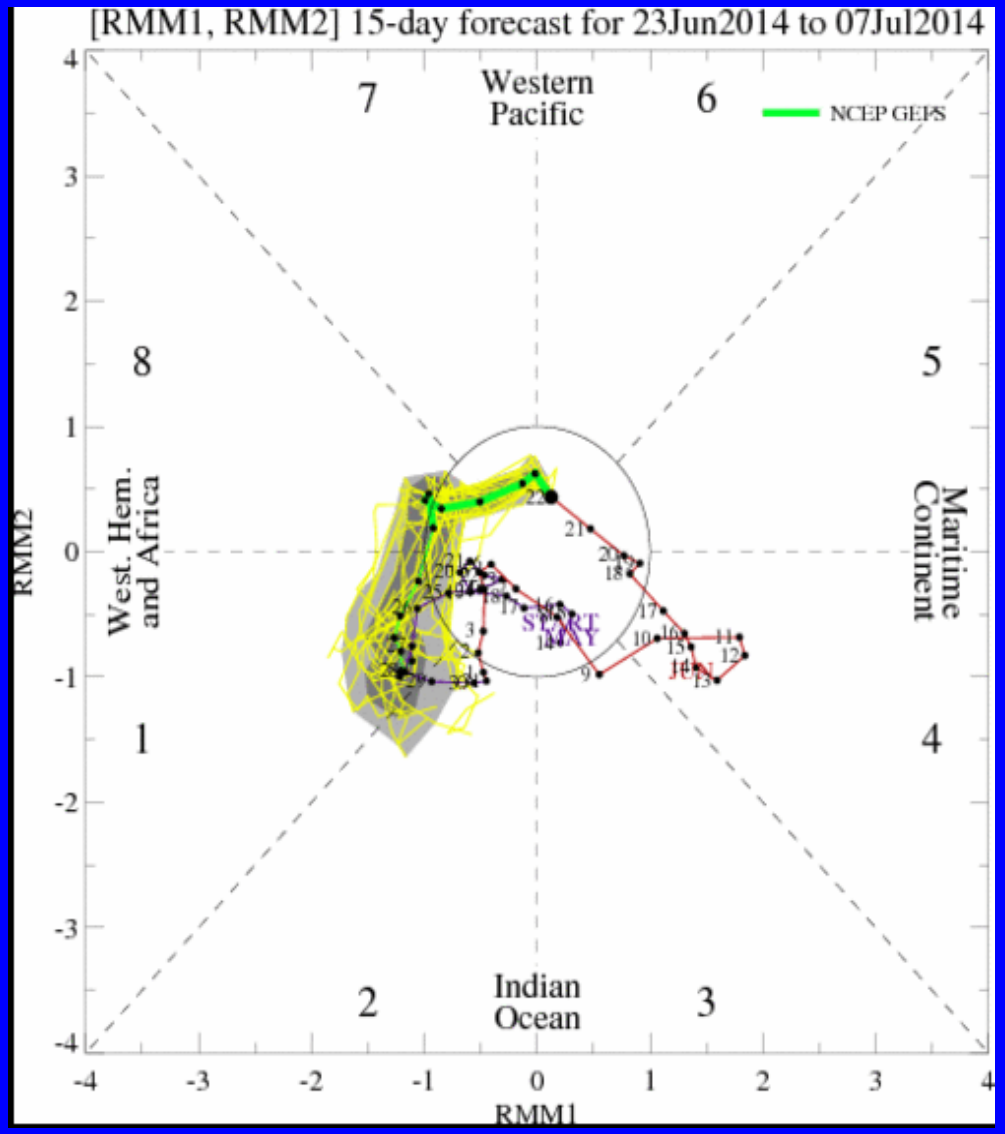
Ensemble GFS (GEFS) MJO Forecast

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

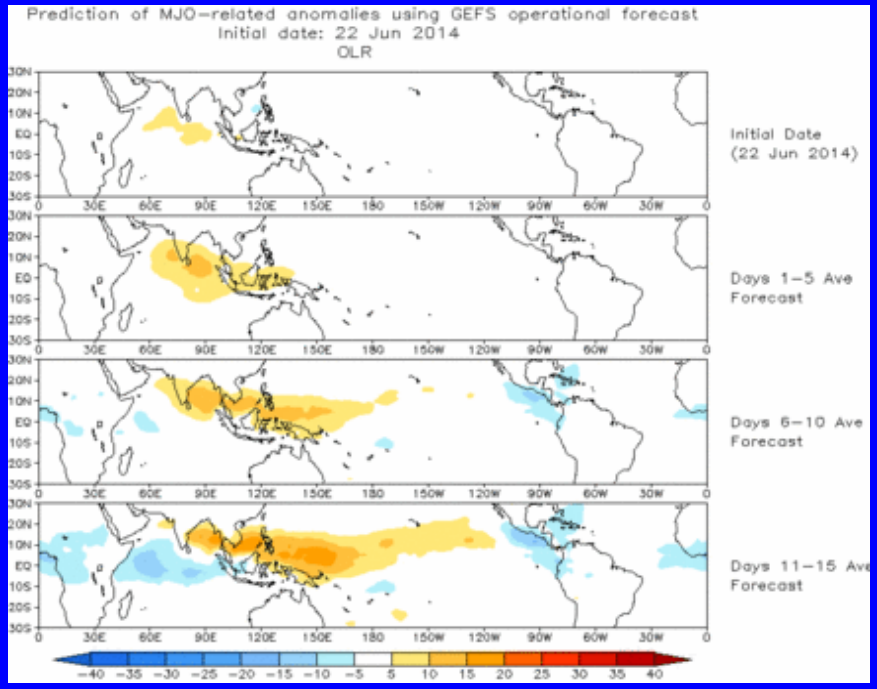
The ensemble GFS forecast indicates a weak signal with eastward propagation of the MJO RMM Index during the next week. During Week-2, the signal emerges over Africa and the Western Indian Ocean.



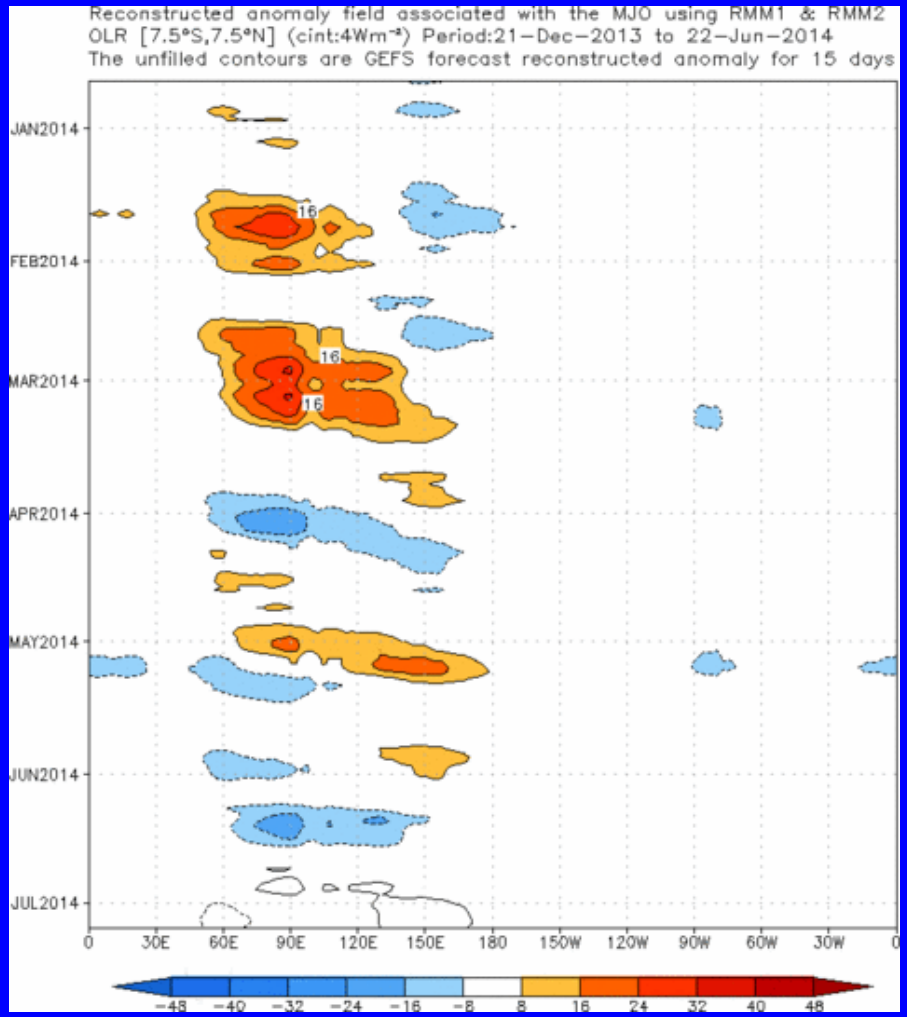
Ensemble Mean GFS MJO Forecast

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

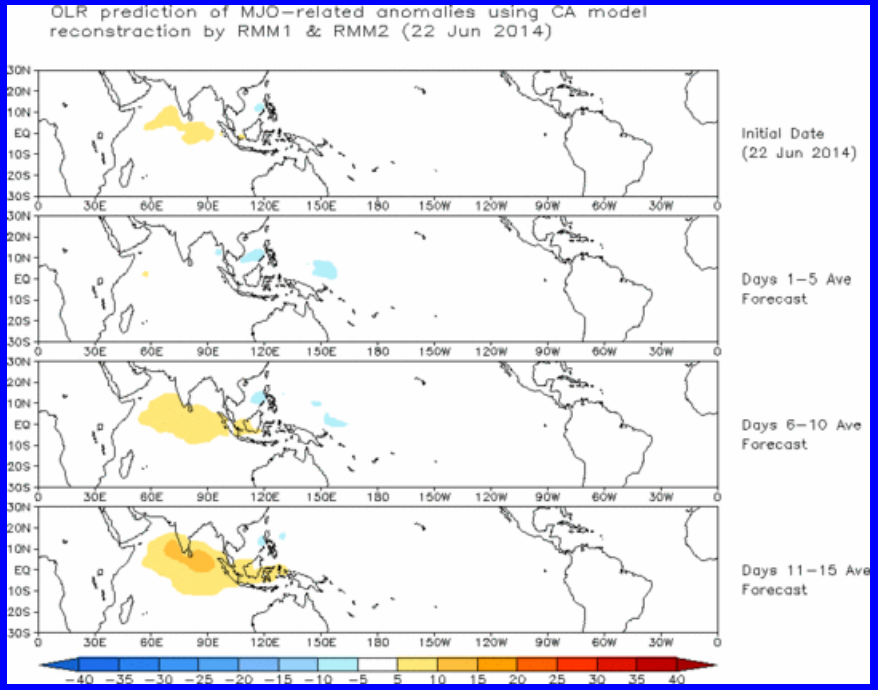


The ensemble mean GFS forecasts enhanced (suppressed) convection persisting over the Americas (Indian Ocean and Maritime Continent) during Week-1. Later, the signal propagates eastward with convection returning to the western Indian Ocean.

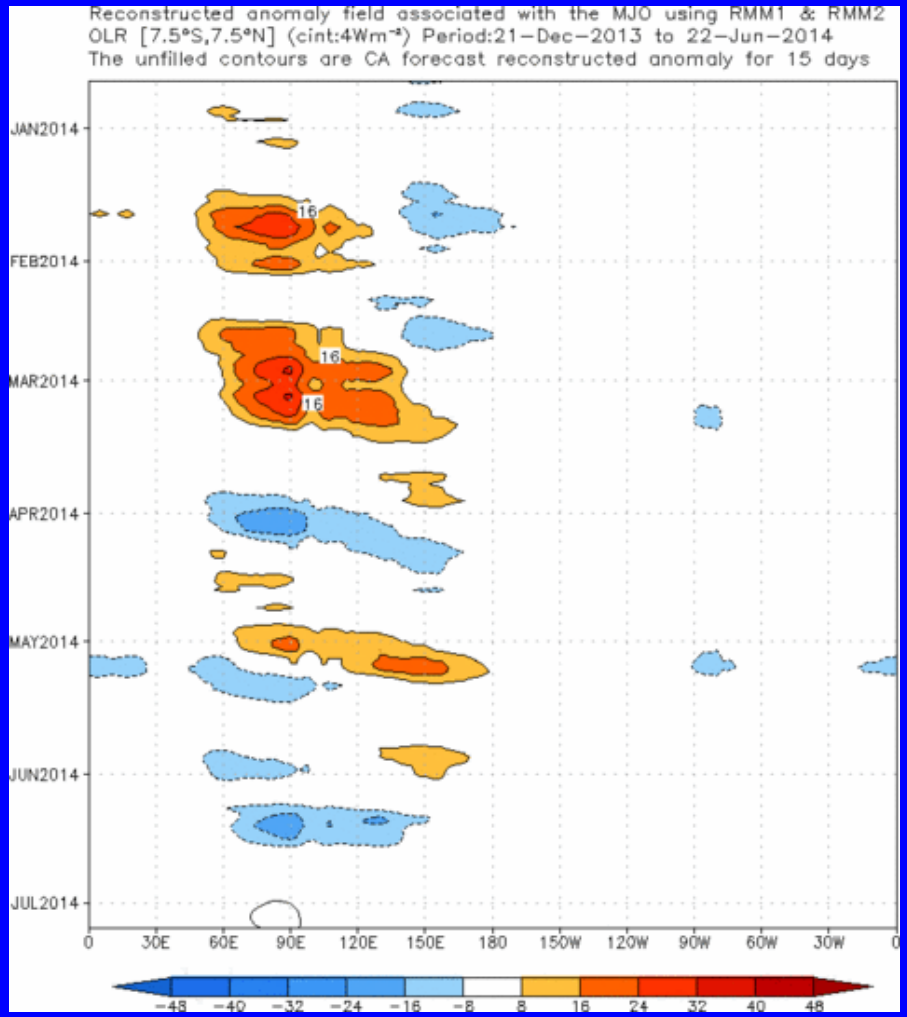
Constructed Analog (CA) MJO Forecast

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



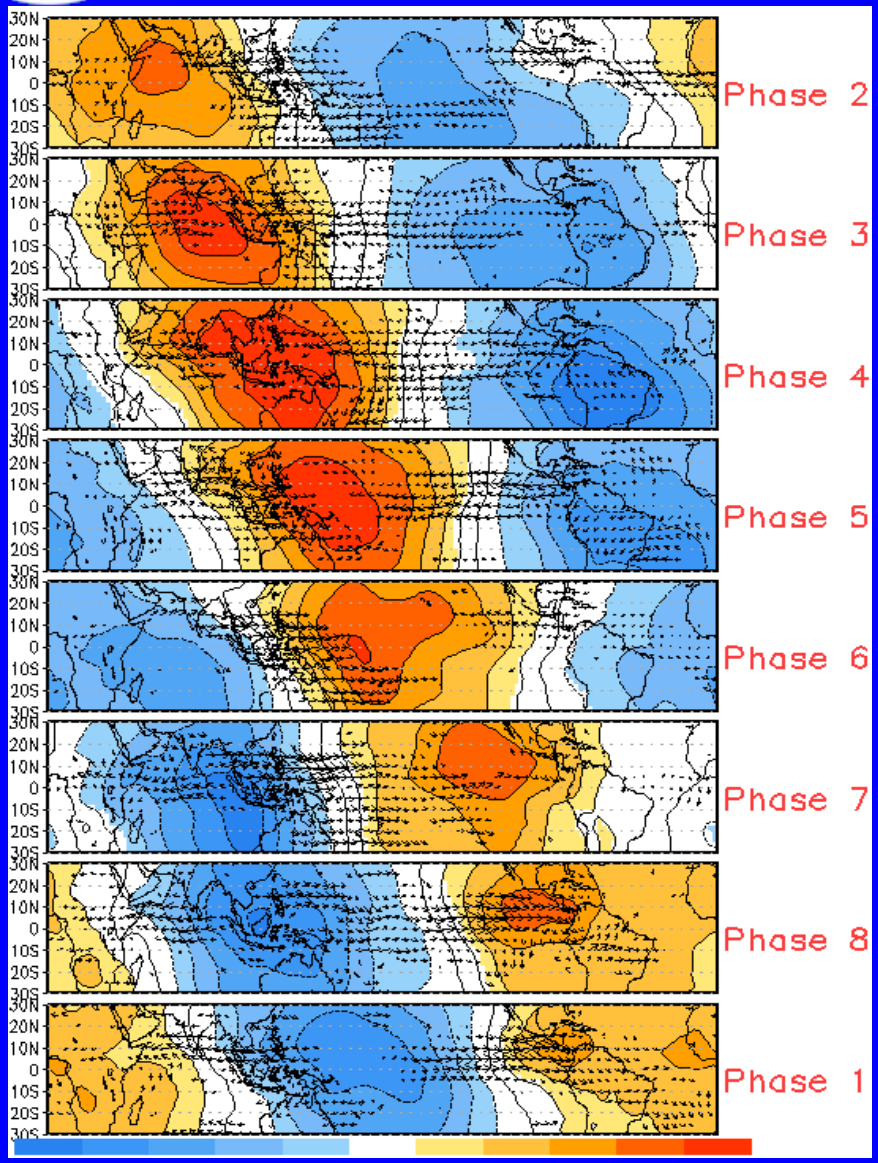
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



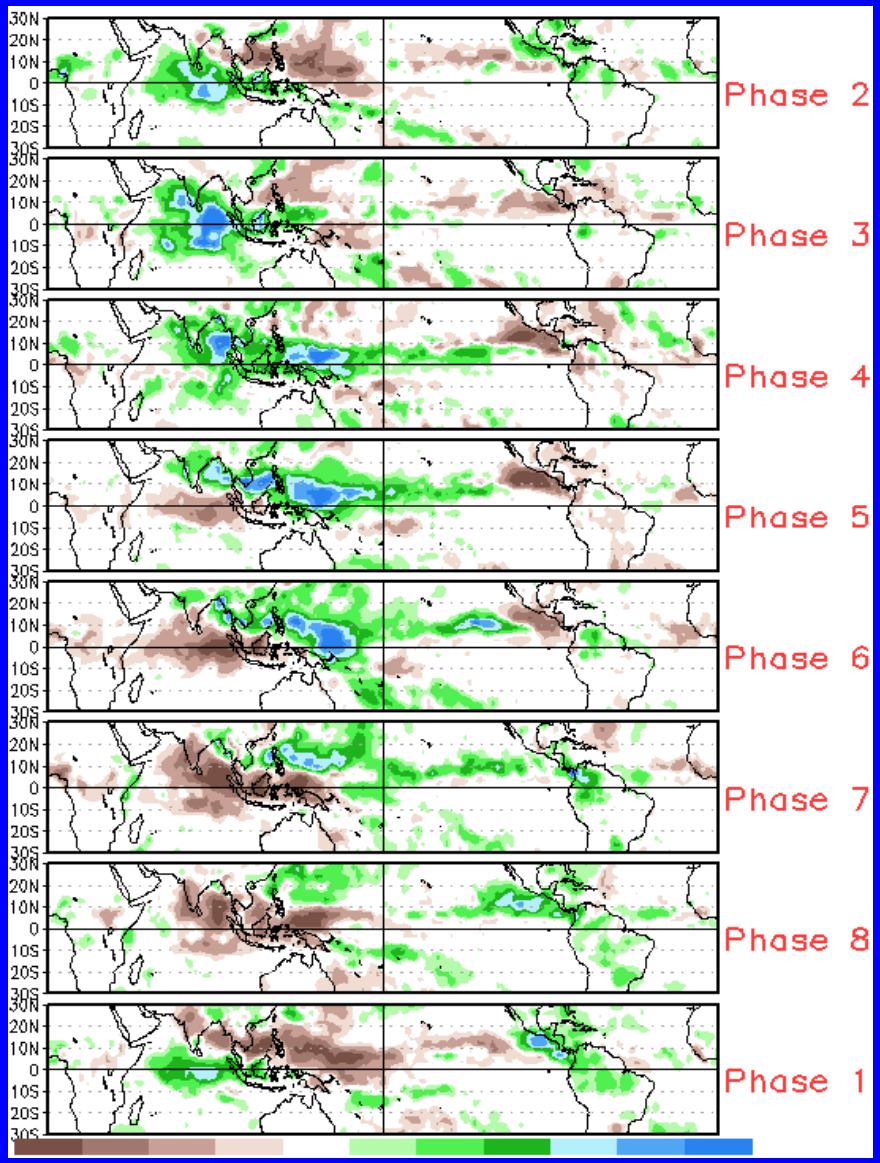
The constructed analog MJO forecast depicts a slower eastward propagation of convective anomalies with suppressed convection remaining over the Indian Ocean.

MJO Composites – Global Tropics

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

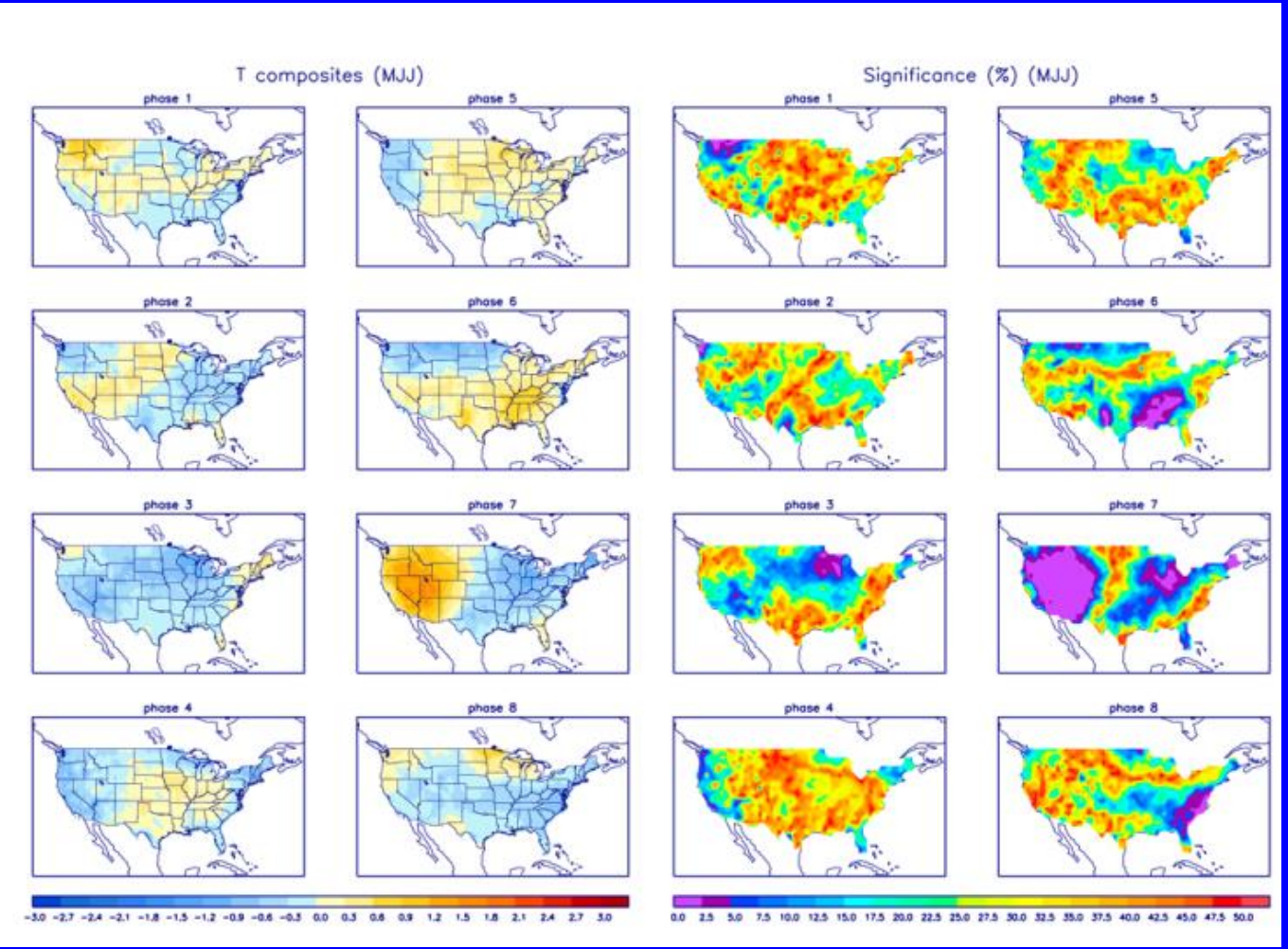


Precipitation Anomalies (May-Sep)



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.**

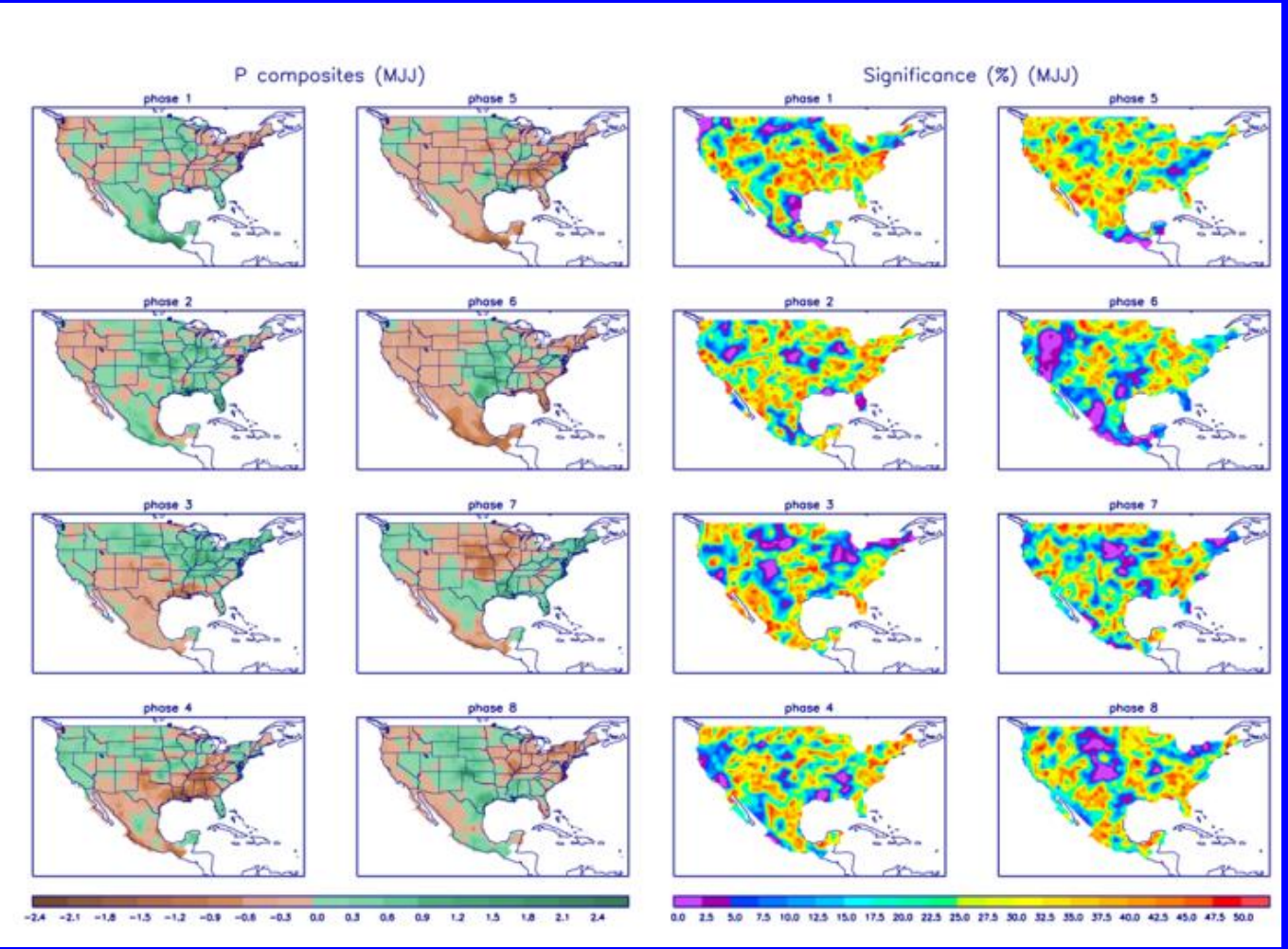


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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