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

Update prepared by
Climate Prediction Center / NCEP
May 5, 2014

Outline

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

Overview

- The MJO remains active although the evolving background climate state remains a major contributor to anomalous convection across the global tropics.

- Dynamical model MJO index forecasts indicate eastward propagation of a moderate MJO signal during the next two weeks. Statistical models also forecast MJO activity with a weakening signal later in Week-2.

- Based on the latest observations and primarily dynamical model forecasts, the MJO is forecast to remain active with the enhanced phase shifting from the Western Hemisphere to the Indian Ocean.

- The enhanced phase of the MJO signal is likely to result in above-average rainfall across the eastern Pacific and Gulf of Guinea during Week-1 with the suppressed phase continuing to bring below-average rainfall to the Maritime Continent and western Pacific. During Week-2, the highest confidence in MJO-related impacts is the persistence of above-average rainfall across the Gulf of Guinea.

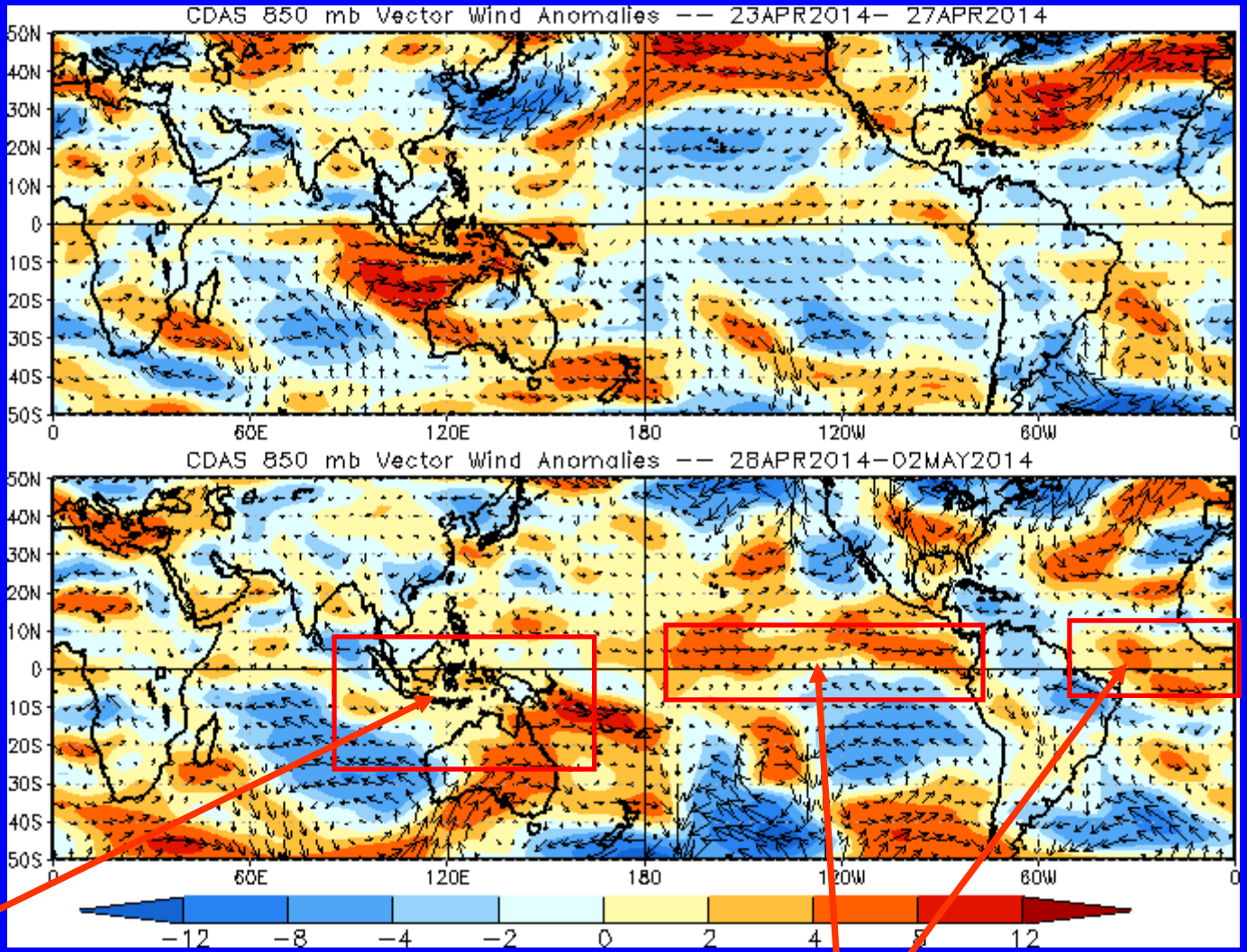
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



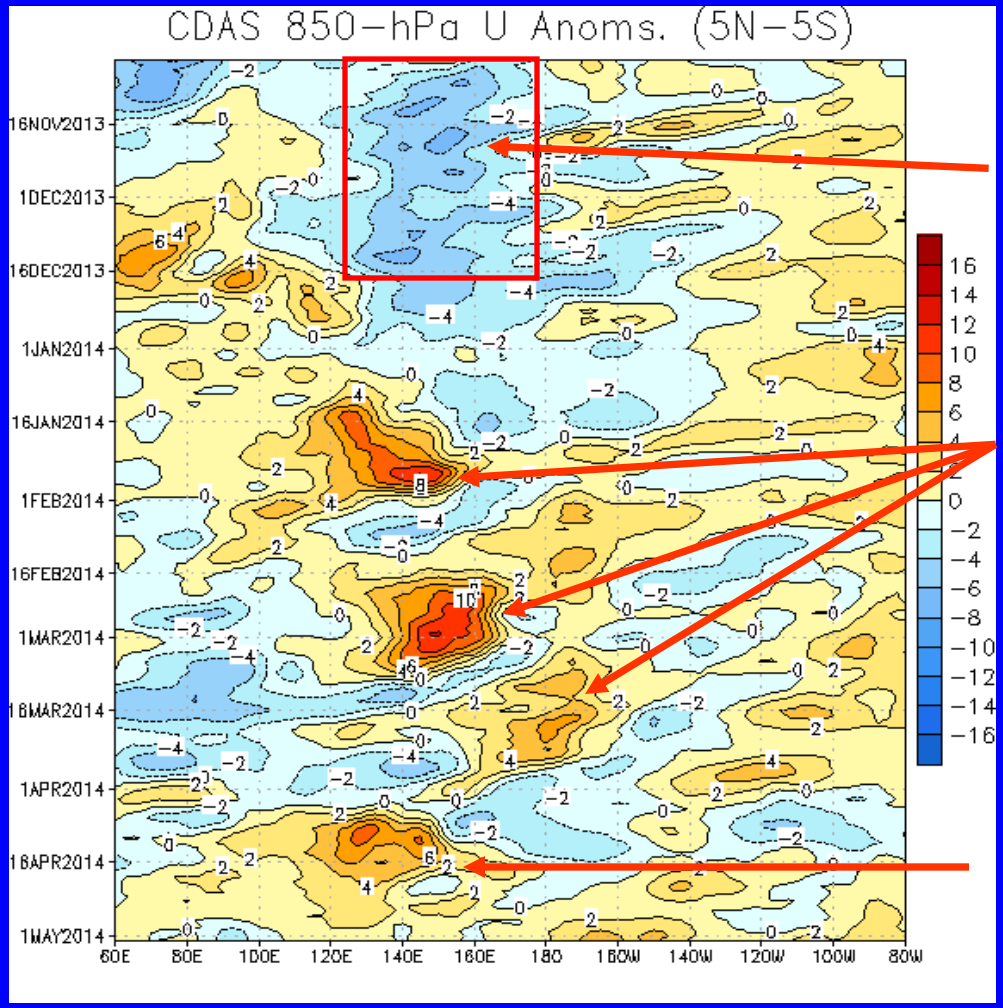
Westerly anomalies diminished across the southeast Indian Ocean and southern Maritime continent during the most recent five days.

Westerly anomalies increased in magnitude during the past five days over the east-central Pacific and eastern 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



Time

Longitude

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

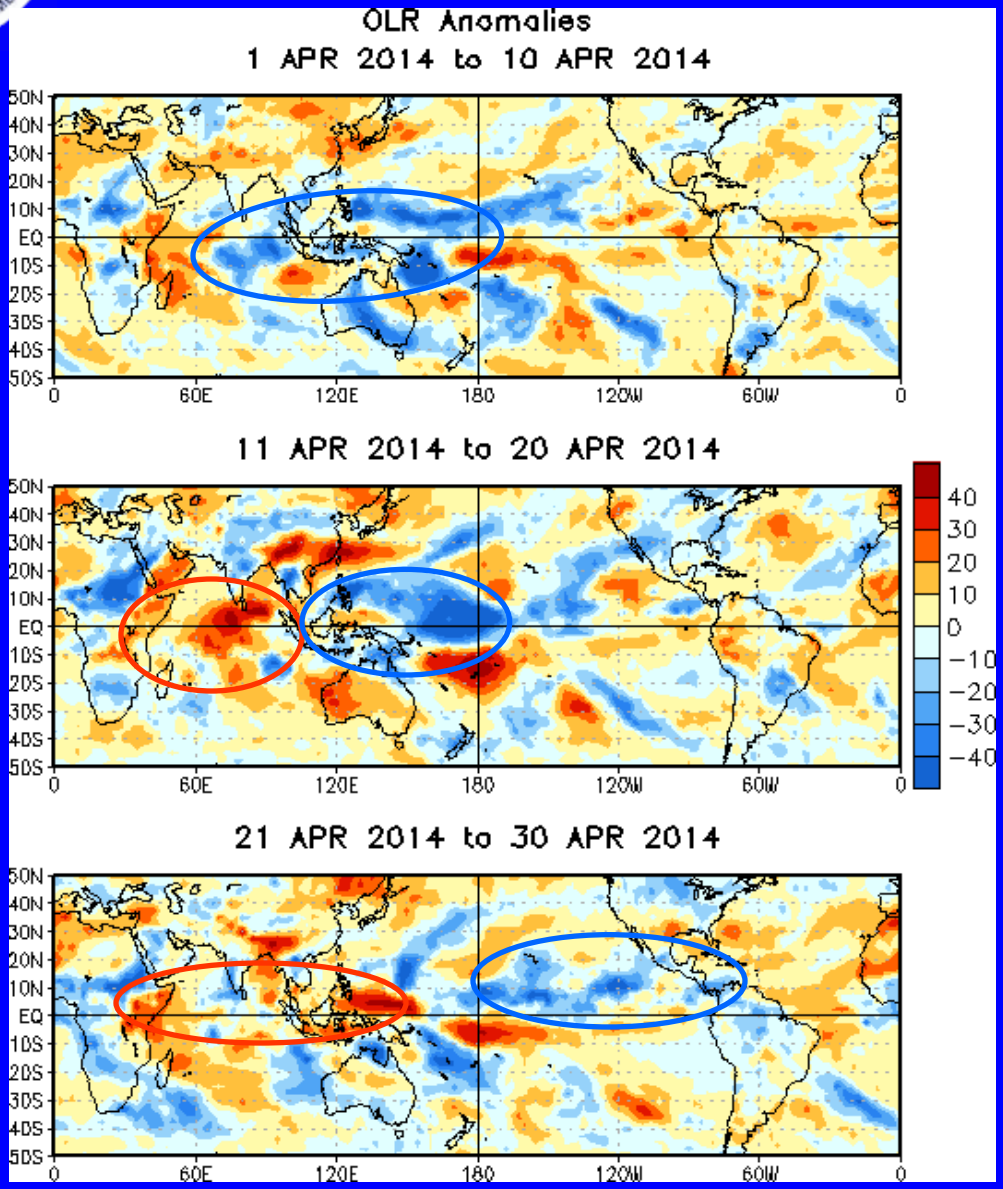
Multiple westerly wind bursts were observed across the western Pacific between January and mid-March. Each westerly wind burst shifted slightly further east.

During April, winds near the Date Line have been close to average while westerly anomalies have been generally persistent across the Maritime continent and far western Pacific.

OLR Anomalies – Past 30 days

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

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

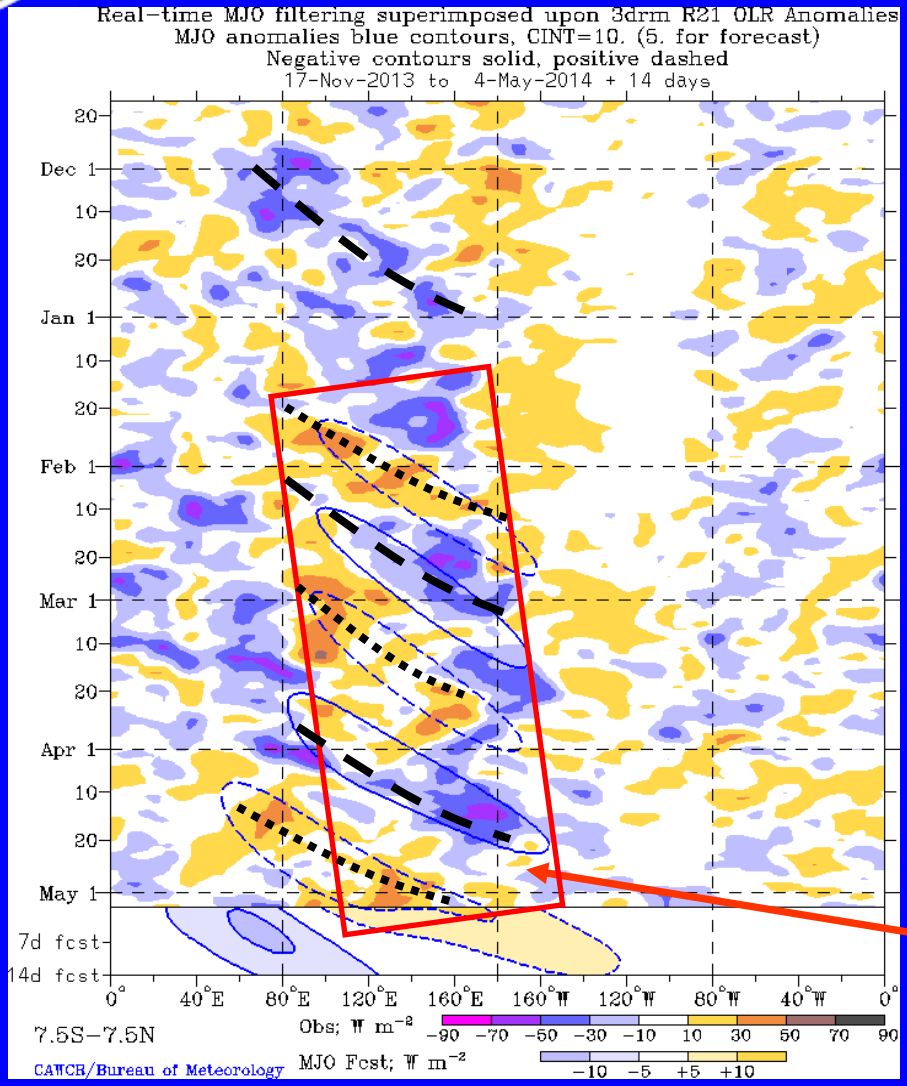


During early April, enhanced convection continued over the Indian Ocean and near the Date Line, while convection began to increase across the Maritime Continent.

During mid-April, enhanced (suppressed) convection prevailed over the western North Pacific and portions of the Maritime Continent (Indian Ocean and eastern Arica) associated with MJO activity.

Suppressed convection expanded east to the Maritime Continent during late April, while enhanced convection expanded east across the Western Hemisphere.

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



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)

Enhanced convection associated with the MJO developed over the Indian Ocean during November and propagated eastward to the Pacific by January. A clear suppressed phase was not evident before weakening.

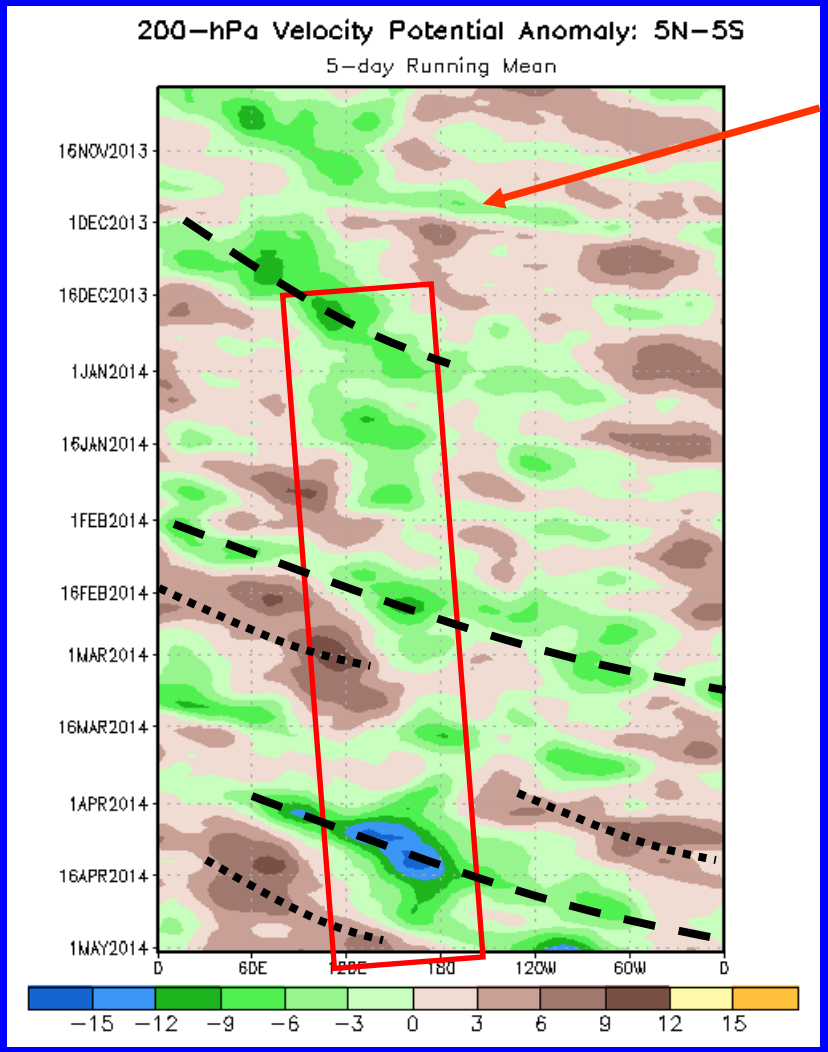
From January through April, enhanced convection propagated slowly eastward from the Maritime Continent to the western Pacific (red box), interrupted by positive OLR anomalies during late January and early February and again in March associated with the MJO.

In mid April, strong enhanced convection was evident near the Date Line as the MJO and low frequency background state combined. Most recently enhanced convection diminished near the Date Line as the suppressed phase of a MJO signal shifted towards this region.

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).

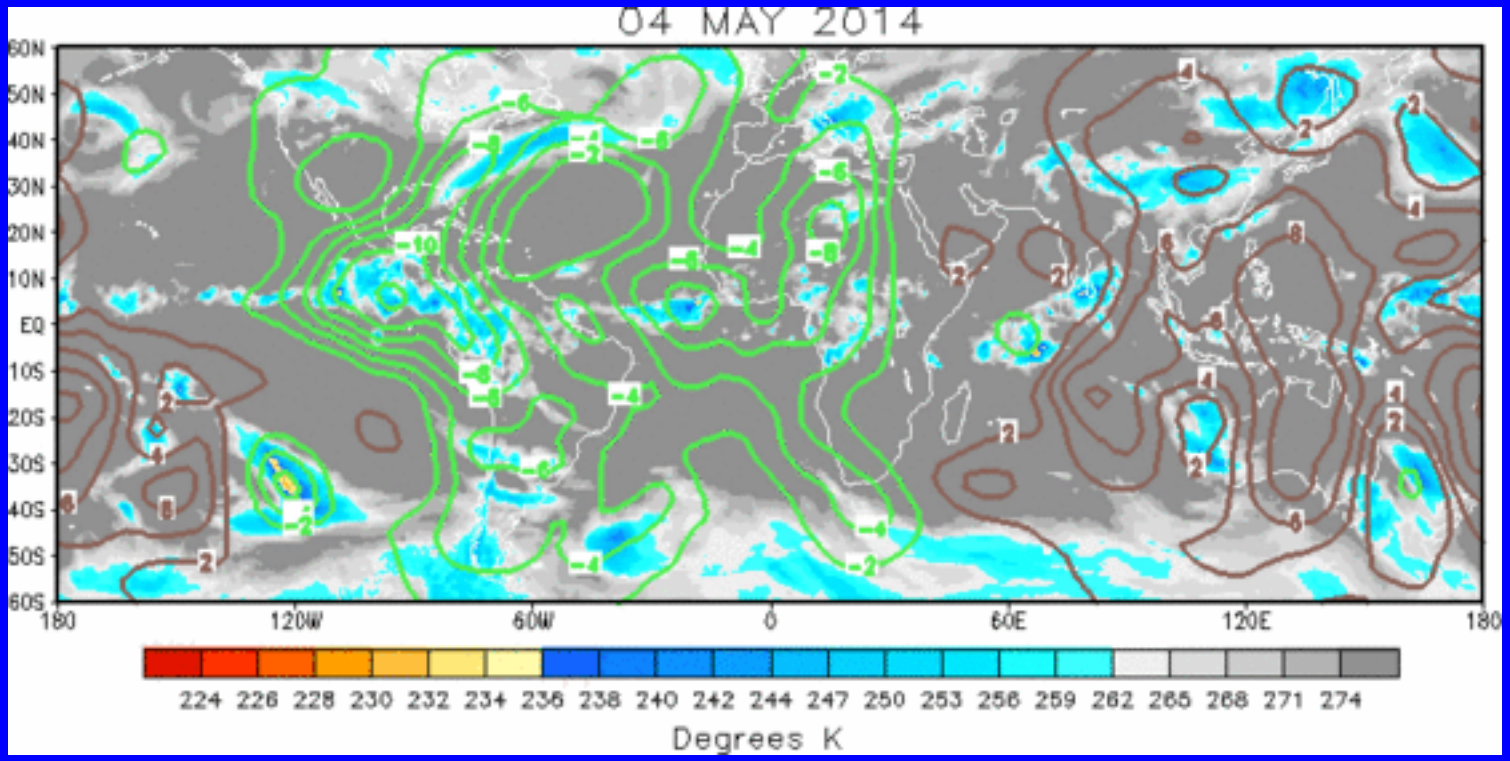
During February into early March, anomalies propagated eastward with time associated with the MJO before weakening.

The MJO strengthened once again during April as eastward propagation of both positive and negative anomalies are indicated. This signal continues to interact with the more slowly evolving background state.

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

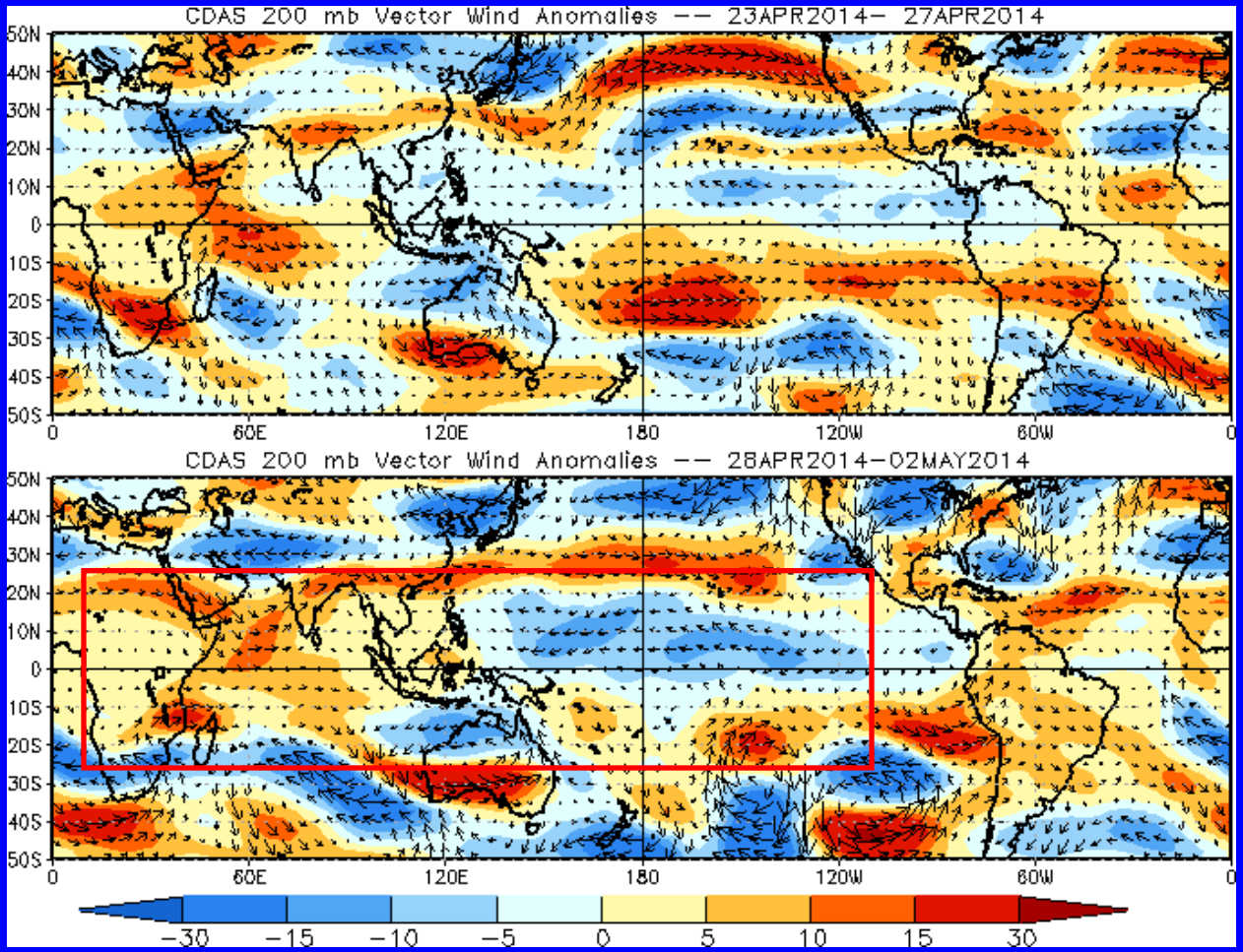
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The current spatial distribution of velocity potential anomalies is a combination of the low frequency background state and the ongoing MJO activity. Anomalous upper-level divergence (convergence) associated with the MJO is generally shown from the eastern Pacific across Africa (Indian Ocean to the central Pacific).

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

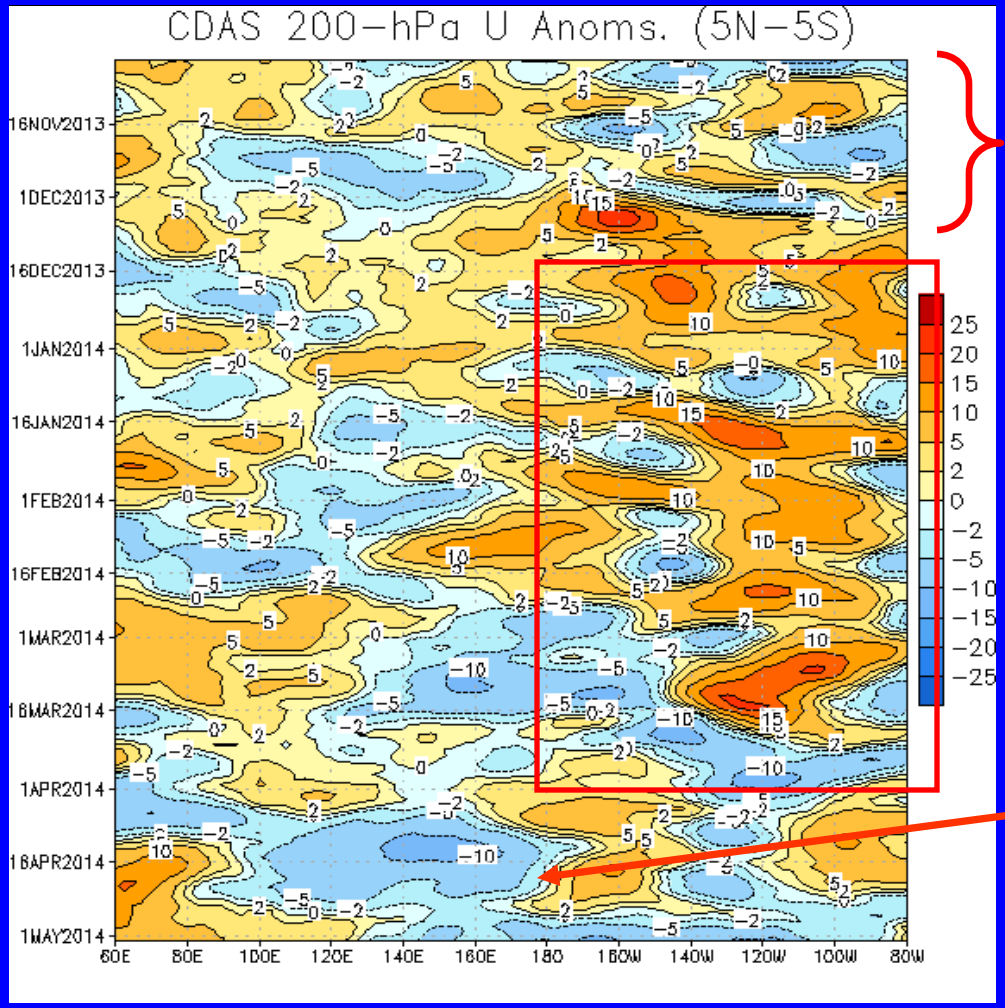
Red shades: Westerly anomalies

Easterly anomalies continued over the central Pacific, while westerly anomalies expanded east to the Maritime Continent during the last five days (red box).

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

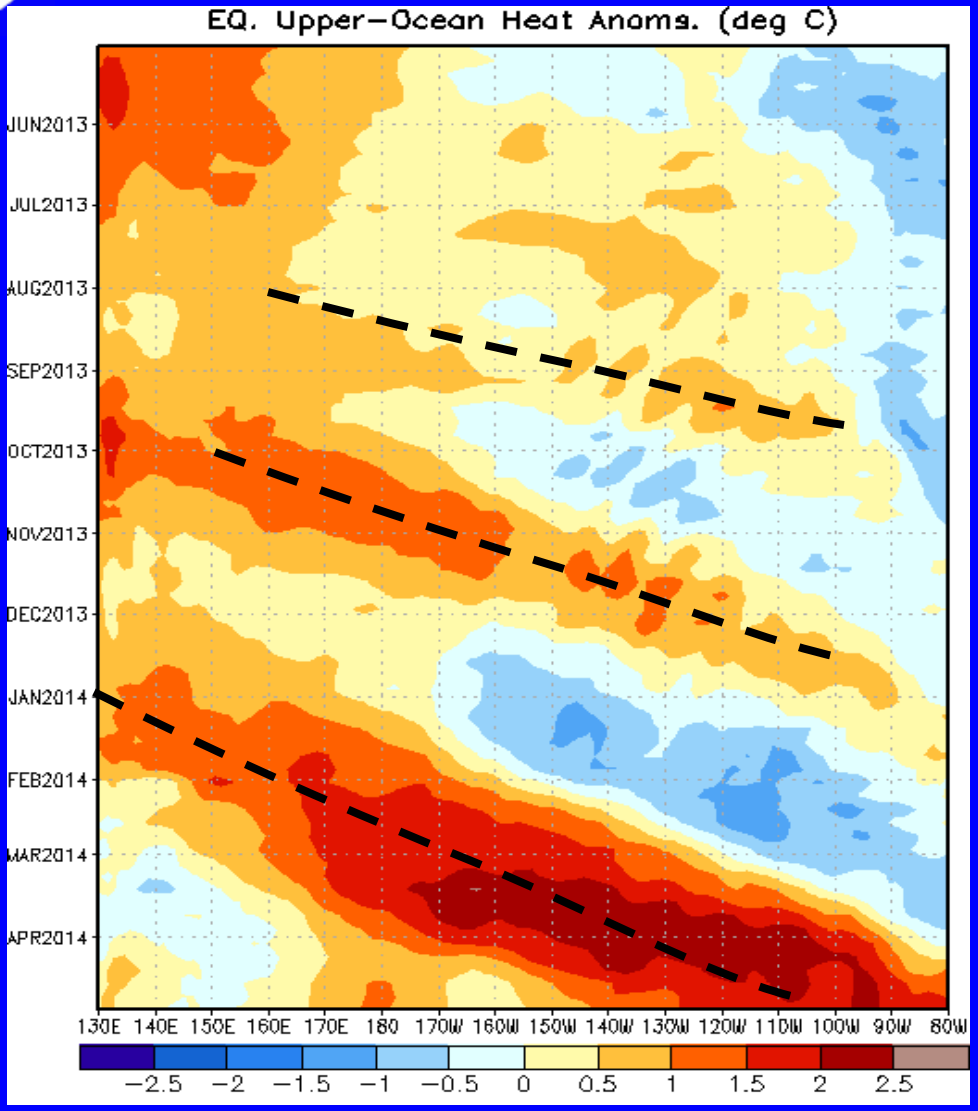
Longitude

Anomalies of alternating sign were evident over the eastern Pacific, due in part to extratropical Rossby waves breaking into the Tropics (red bracket).

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.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

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 continues to propagate across the 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).

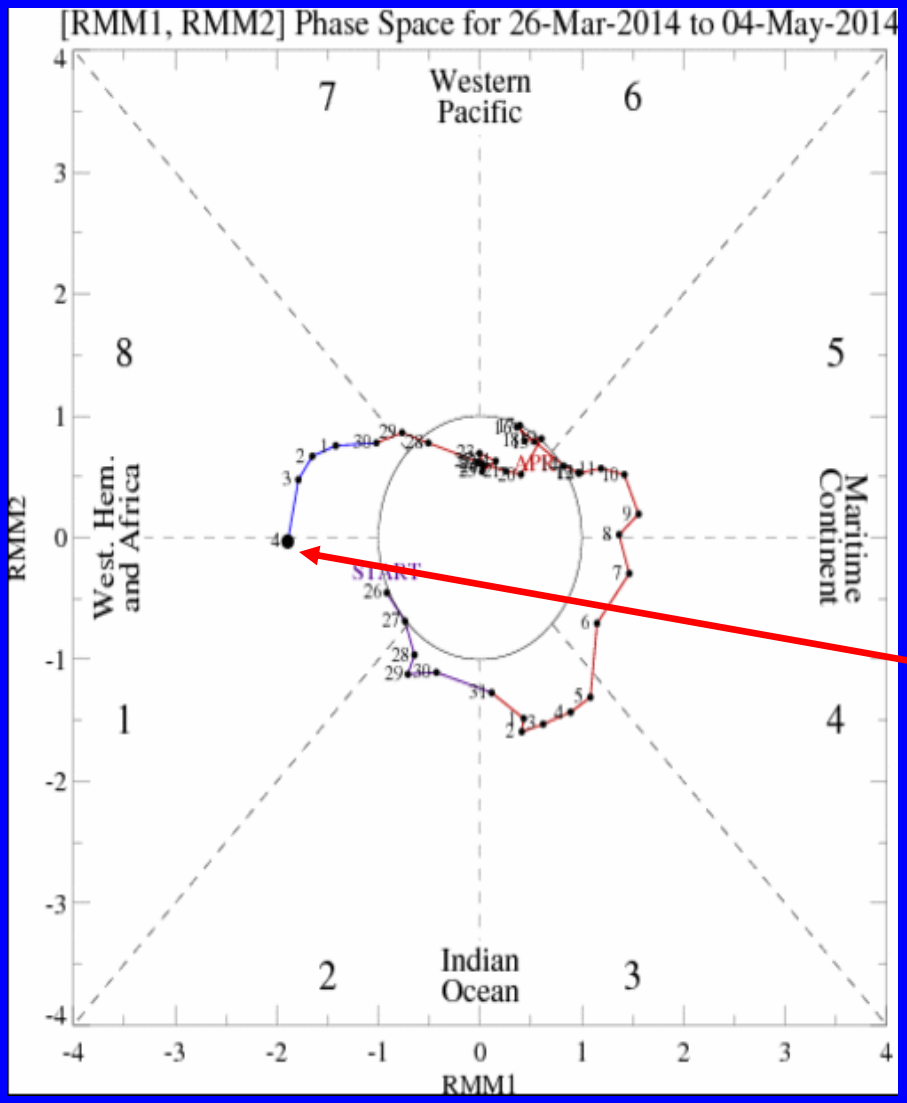
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

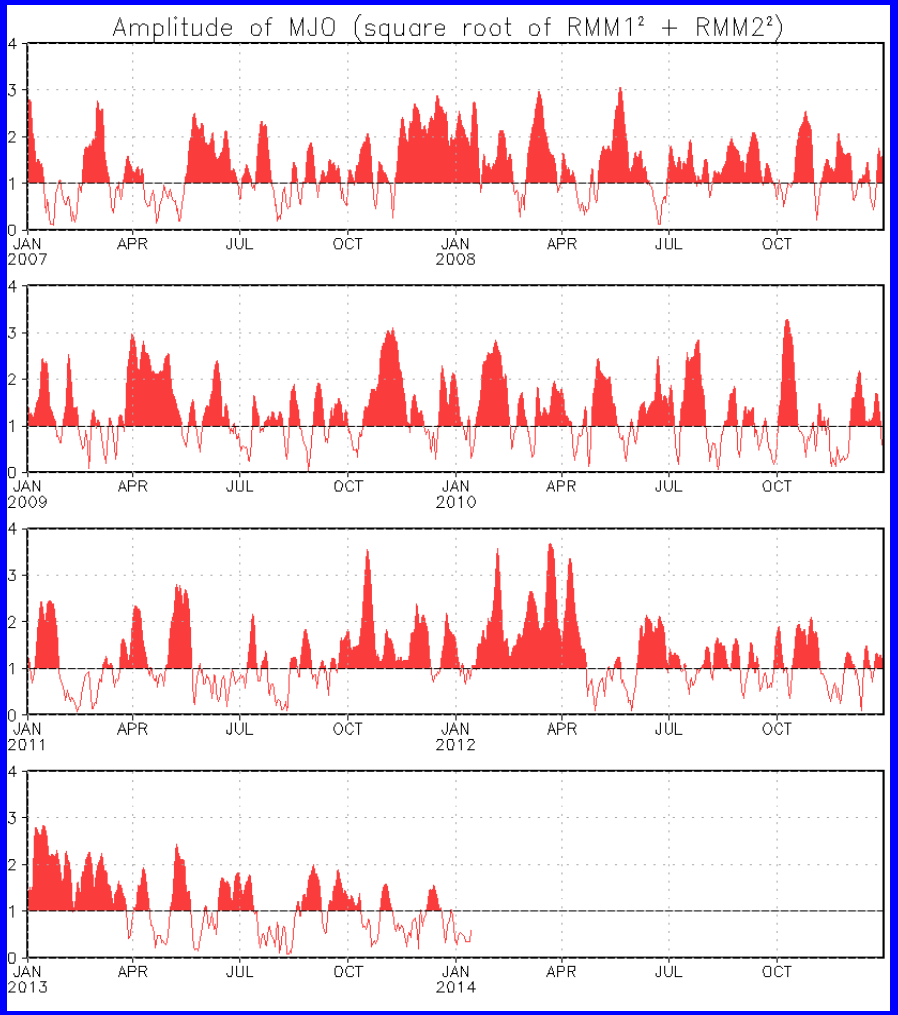
MJO Index -- Recent Evolution



- 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

The MJO index shows an increase in amplitude with renewed eastward propagation with the enhanced phase into the western Hemisphere during 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.

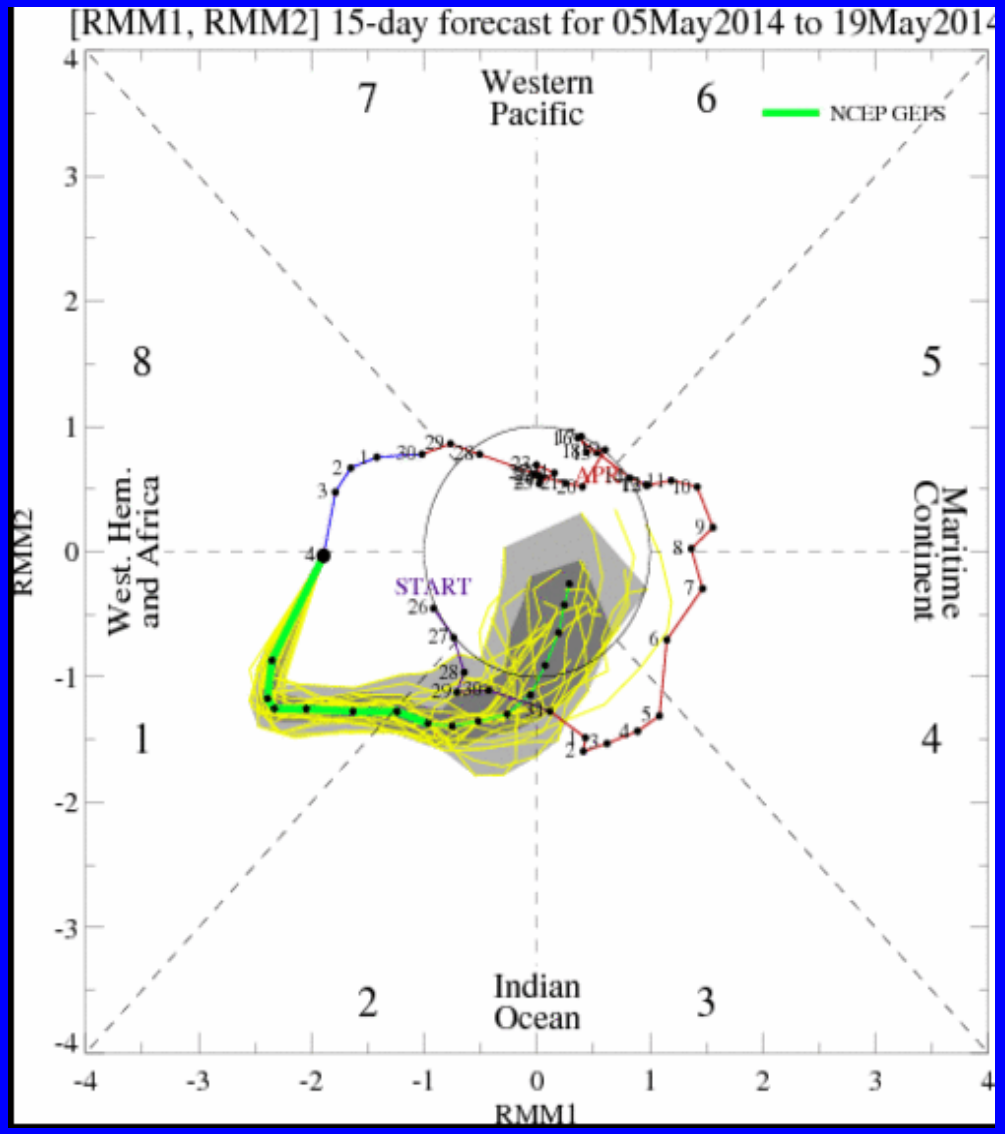
Ensemble GFS (GEFS) MJO Forecast

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

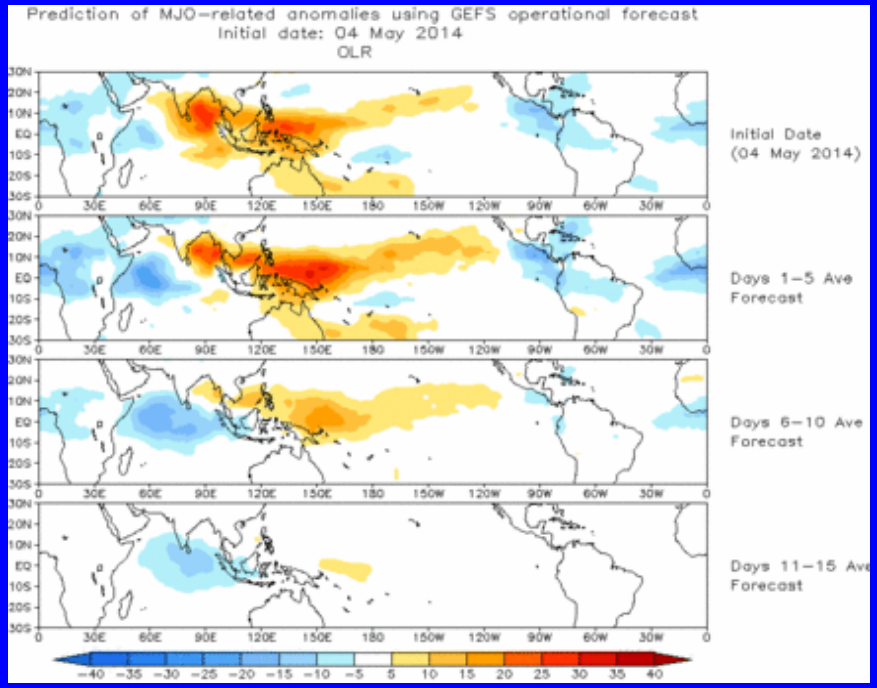
The ensemble GFS forecast indicates eastward propagation of a MJO signal during the next two weeks.



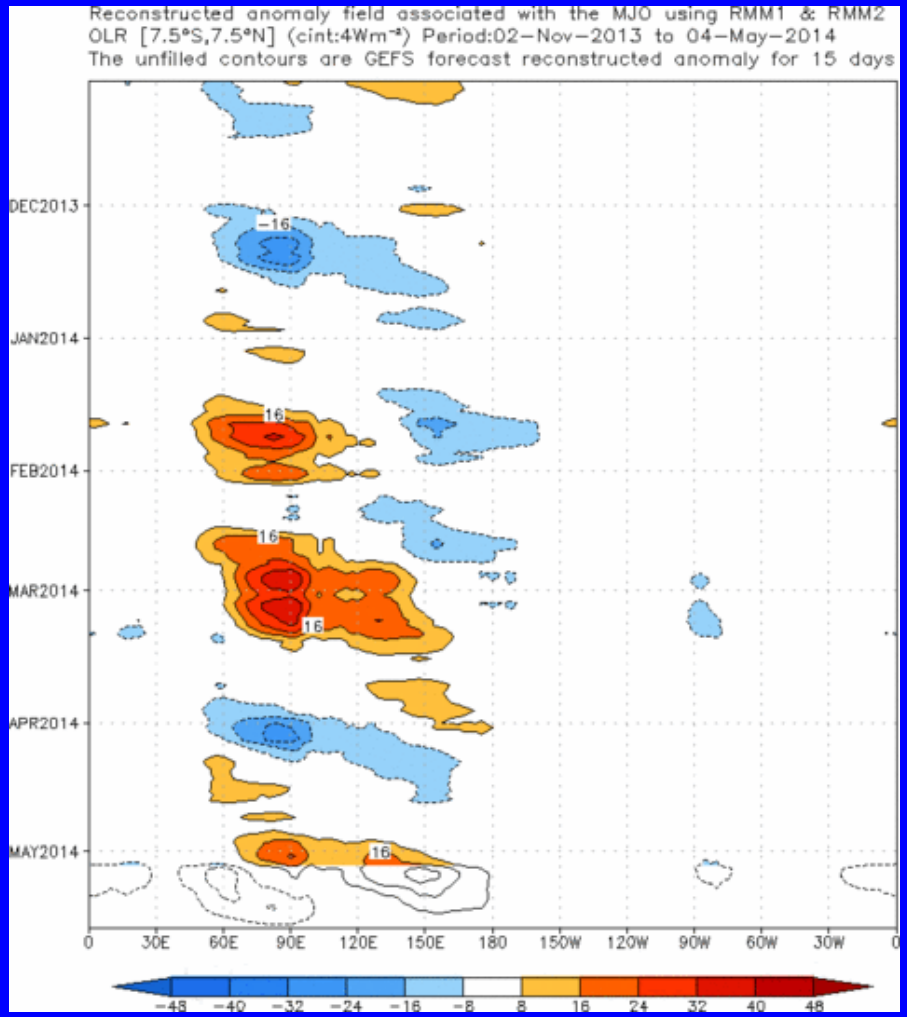
Ensemble Mean GFS MJO Forecast

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

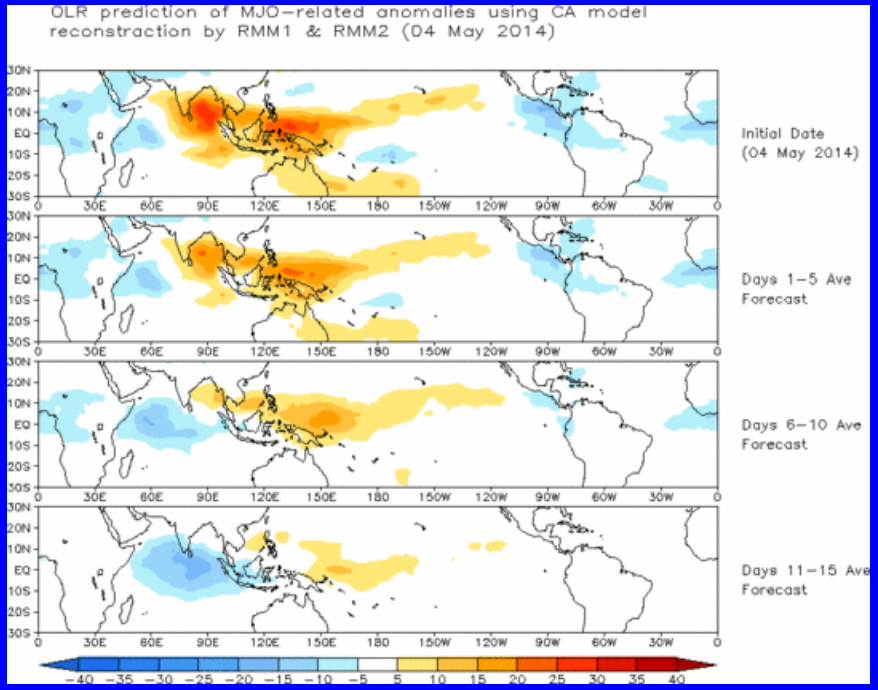


The ensemble mean GFS forecasts suppressed convection from the eastern Indian Ocean to the western Pacific, while enhanced convection is shown over the Americas during Week-1 and shifting east across the Indian Ocean during Week-2.

Constructed Analog (CA) MJO Forecast

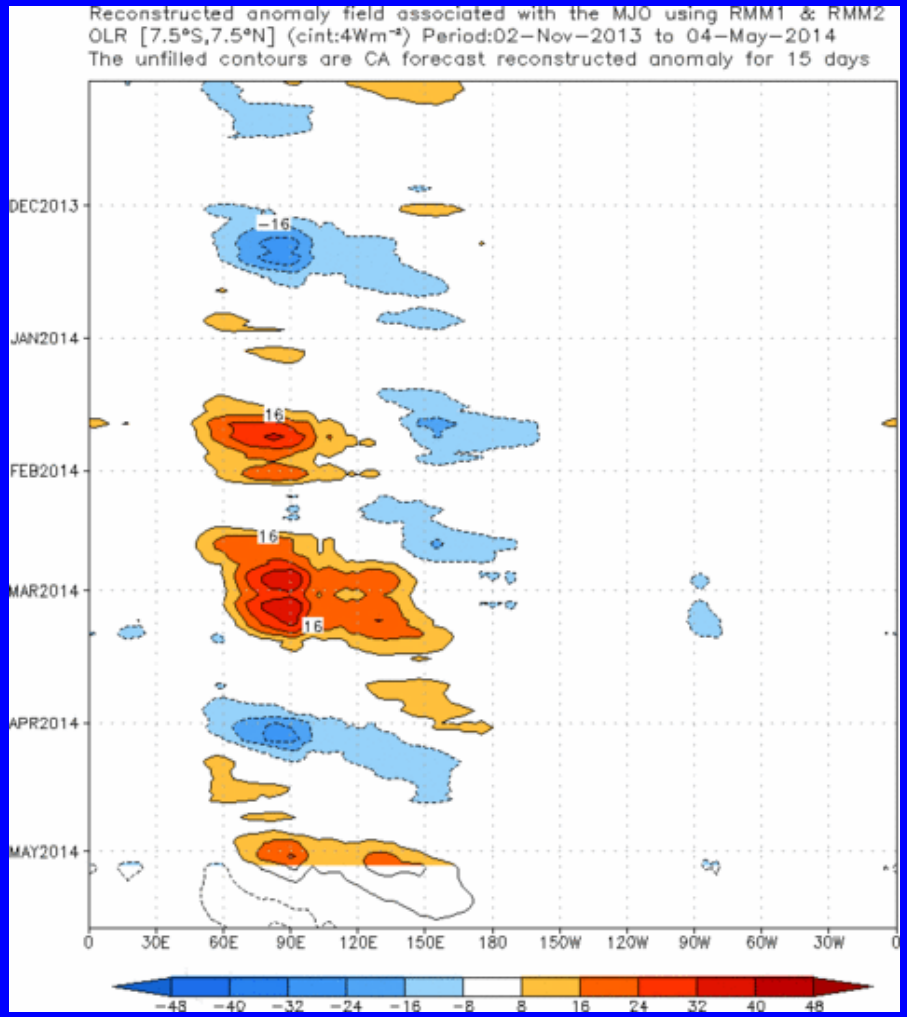
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



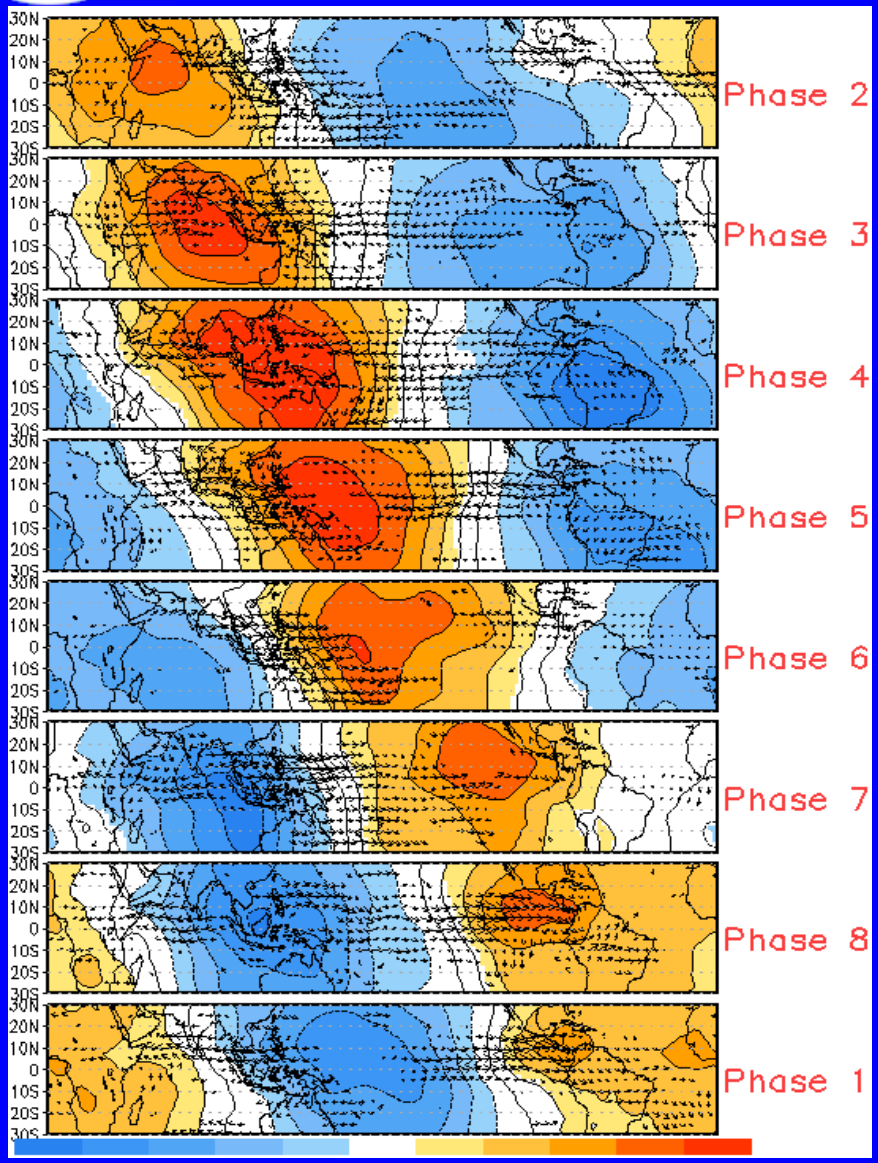
The constructed analog MJO forecast is quite similar to the ensemble GFS forecasts.

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

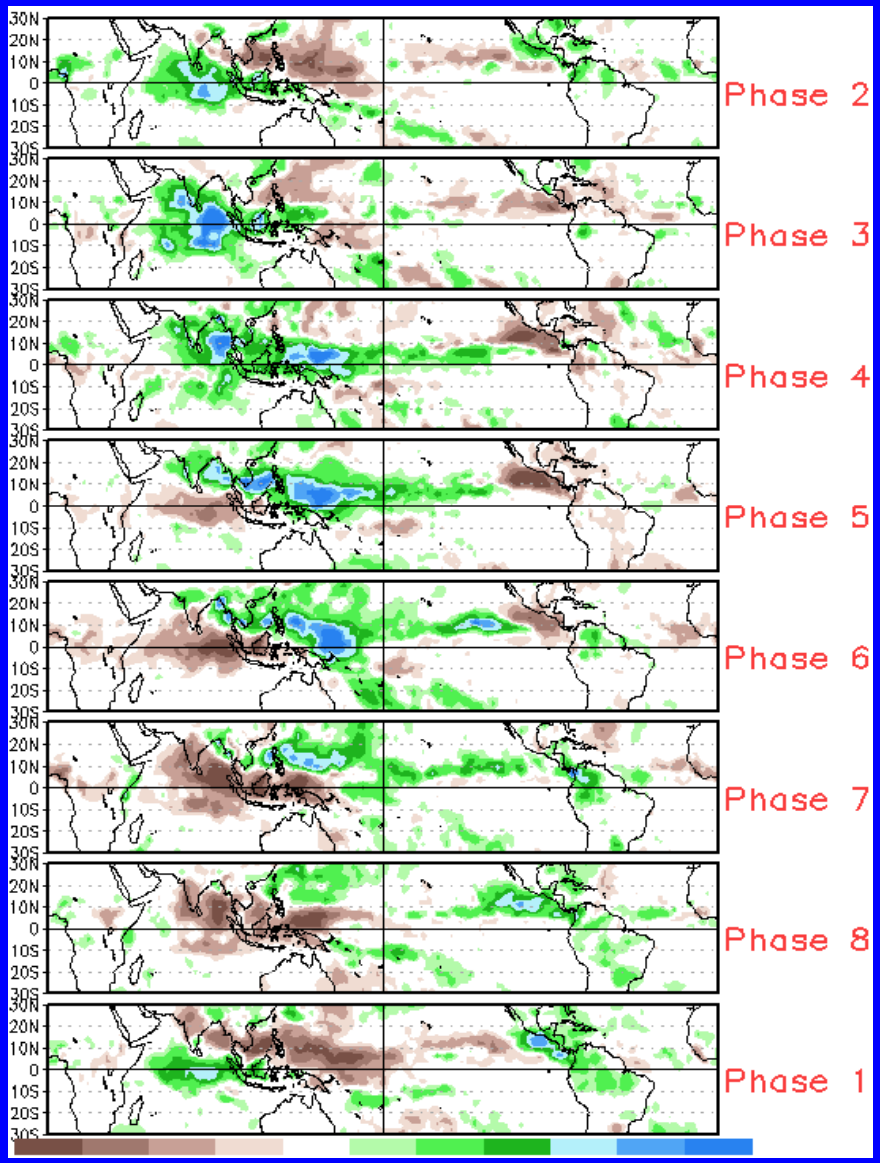


MJO Composites – Global Tropics

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

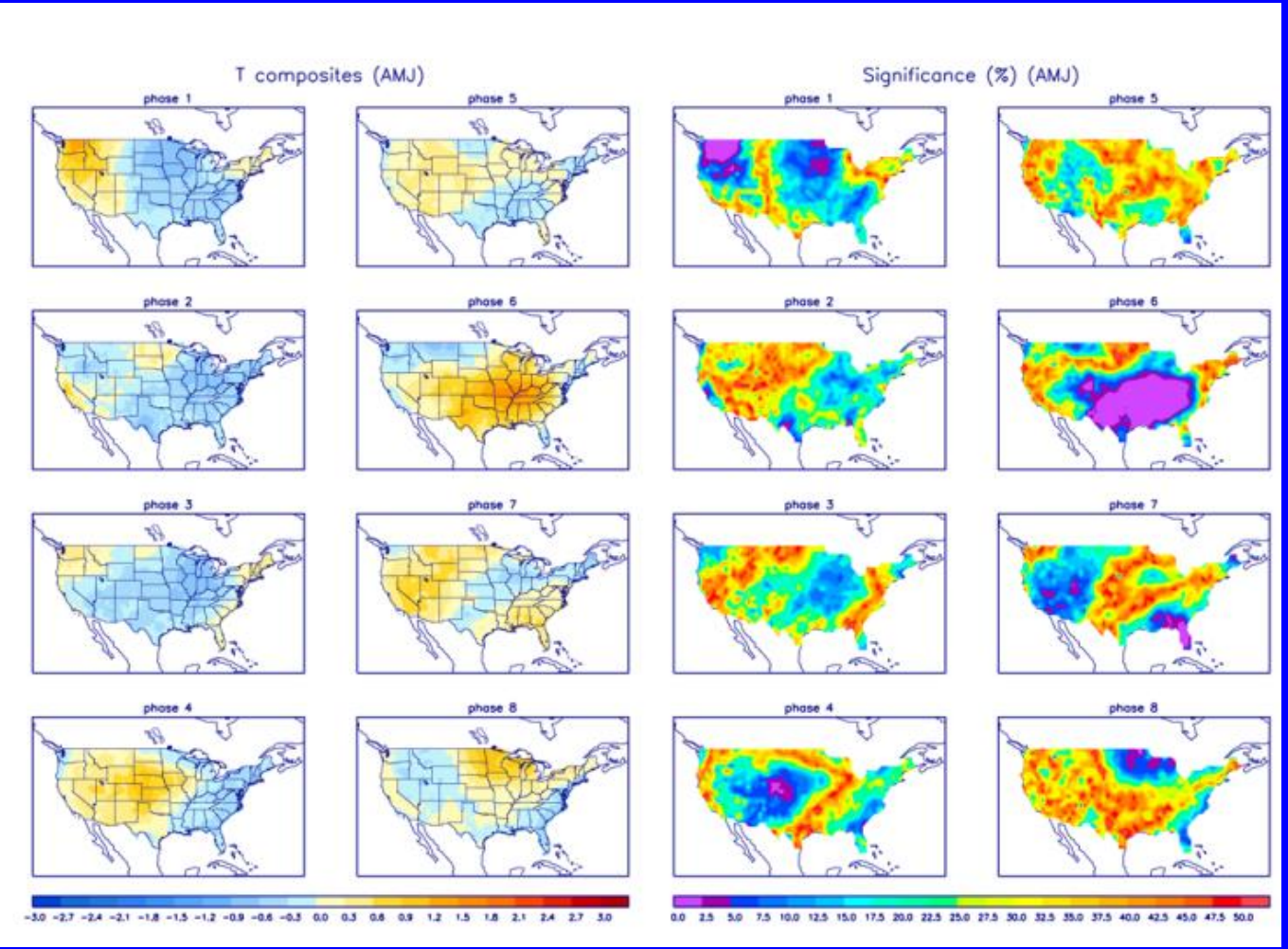


Precipitation Anomalies (May-Sep)



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.**

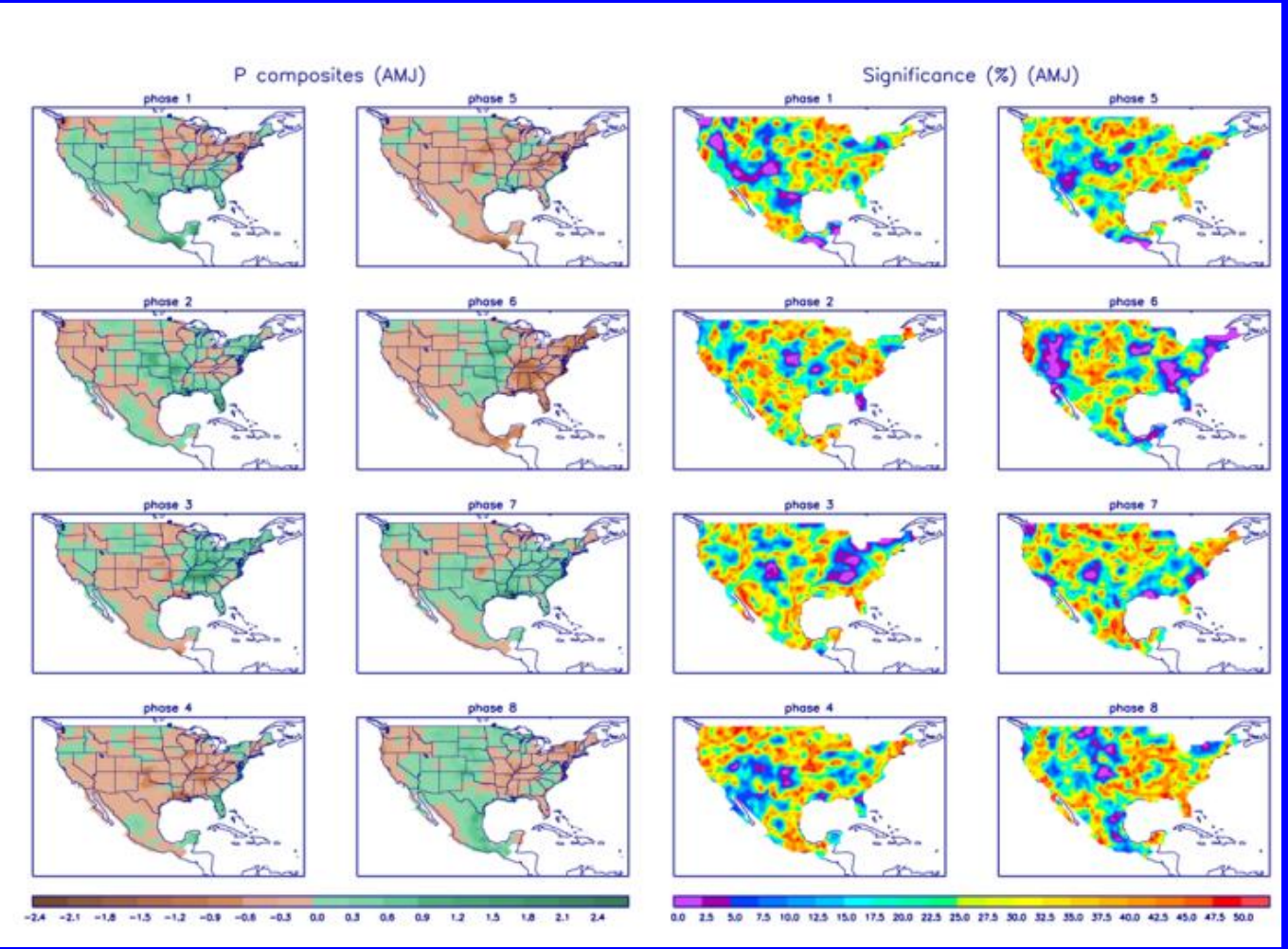


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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.**



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