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

Update prepared by
Climate Prediction Center / NCEP
February 9, 2015

Outline

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

Overview

- Some indicators, including the RMM and CPC MJO indices and the spatial pattern of upper-level velocity potential, indicated an increasingly coherent MJO-like signal during the previous week with the enhanced phase propagating over the Western Hemisphere.

- The OLR anomaly spatial pattern was not consistent with a MJO signal over the Western Hemisphere, however, as other signals including tropical cyclone activity and equatorial Rossby Waves continue to strongly influence the pattern.

- Dynamical model MJO index forecasts do not depict the continued evolution of a coherent MJO pattern during the upcoming two weeks.

- Based on the latest observations and several forecast tools, the MJO is not forecast to contribute significantly to the overall pattern of tropical convection.

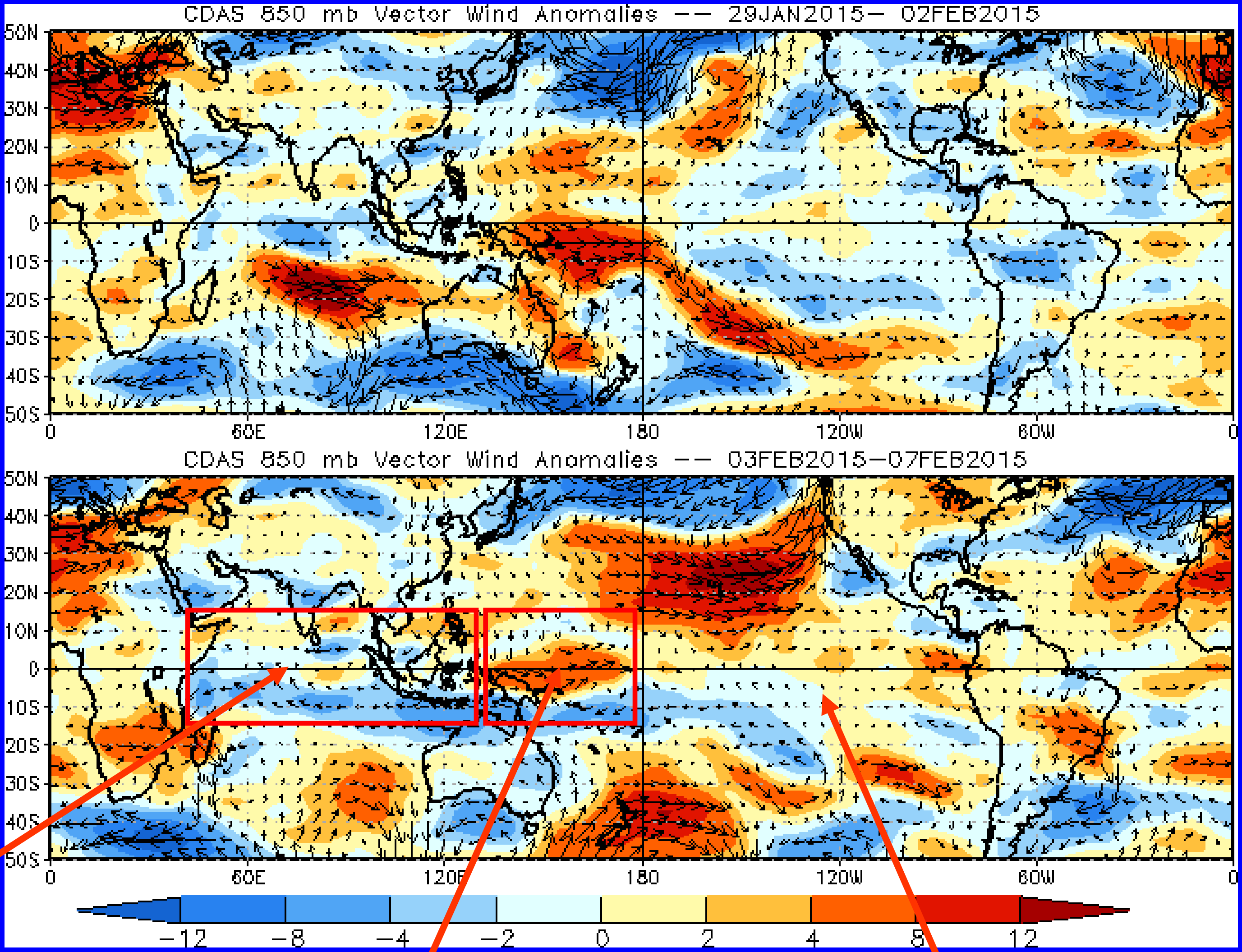
A forecast map of potential impacts across the global Tropics and a discussion for the U.S. are available at: http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 weakened across the Indian Ocean and western Maritime Continent.

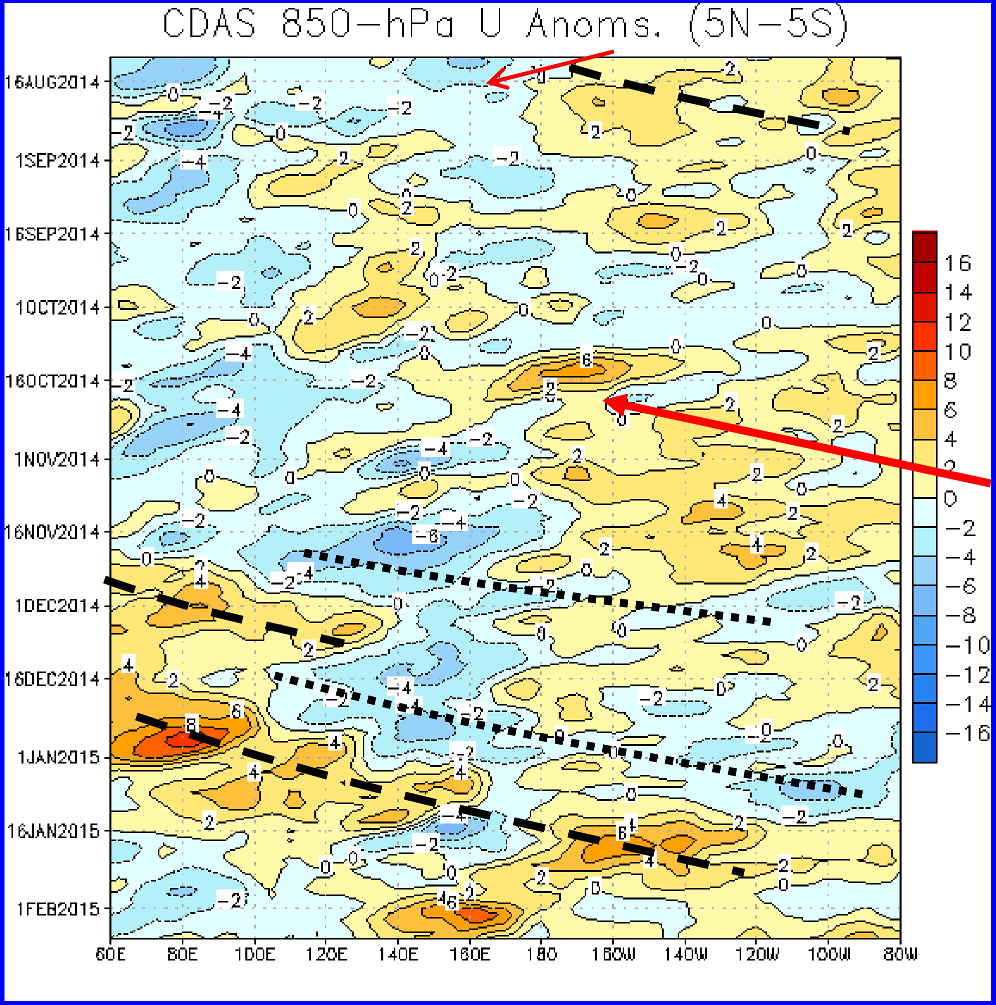
Westerly anomalies persisted over the equatorial Pacific west of the Date Line.

Generally weak westerly anomalies were observed across the remainder of the Pacific and Atlantic basins.

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

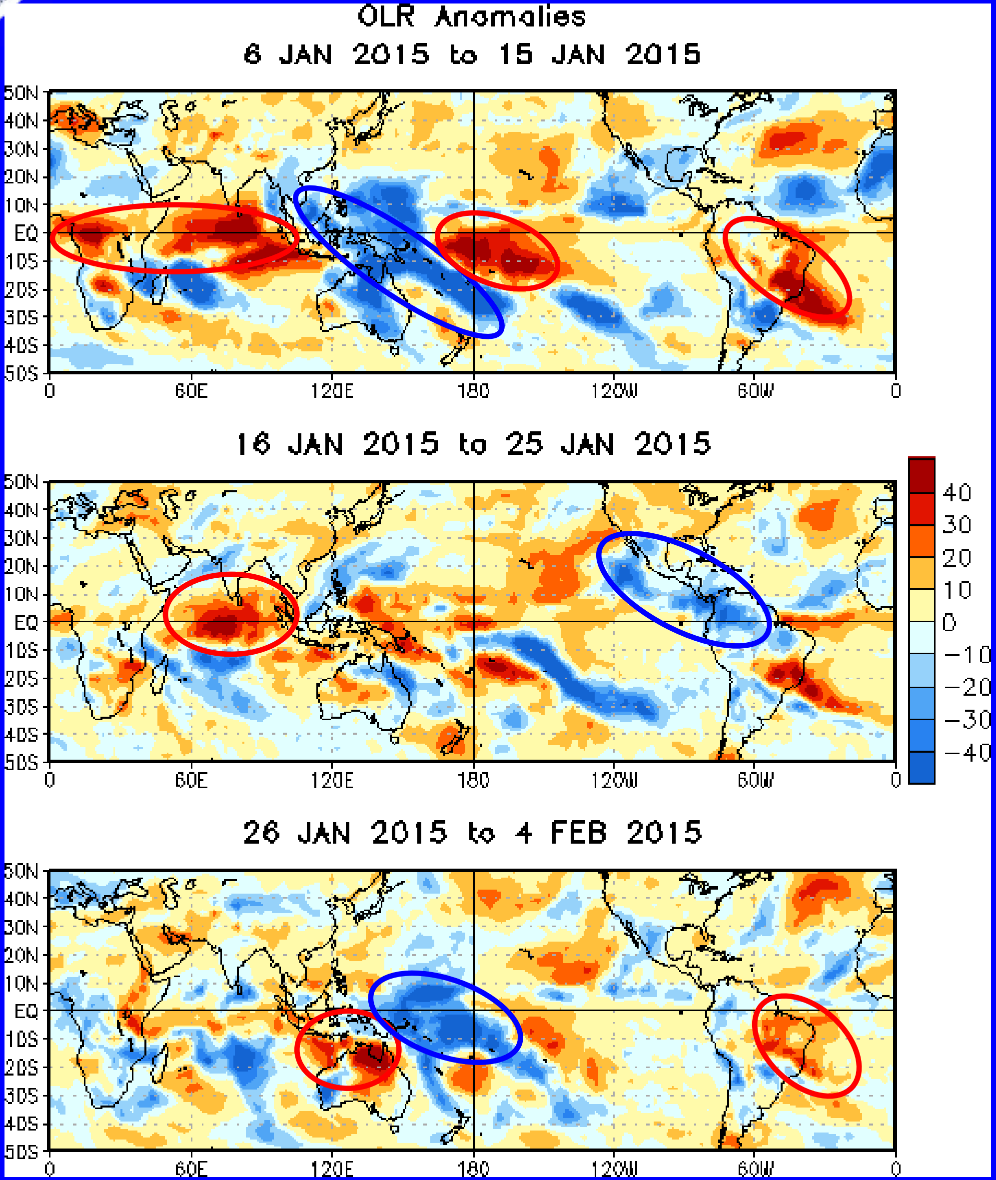
Longitude

During early August, an envelope of westerly wind anomalies shifted eastward across the Pacific associated with weak MJO activity (dashed line). Embedded within this envelope at times were strong westward moving high frequency features (red arrow) over the east/central Pacific.

A westerly wind burst was observed near the Date Line during mid-October

MJO activity was observed beginning in late November into December and a second stronger event has evolved during late December and January 2015, with westerly anomalies shifting eastward to the western hemisphere by mid-January. Recently, anomalies have been weak, with westerly anomalies just west 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)

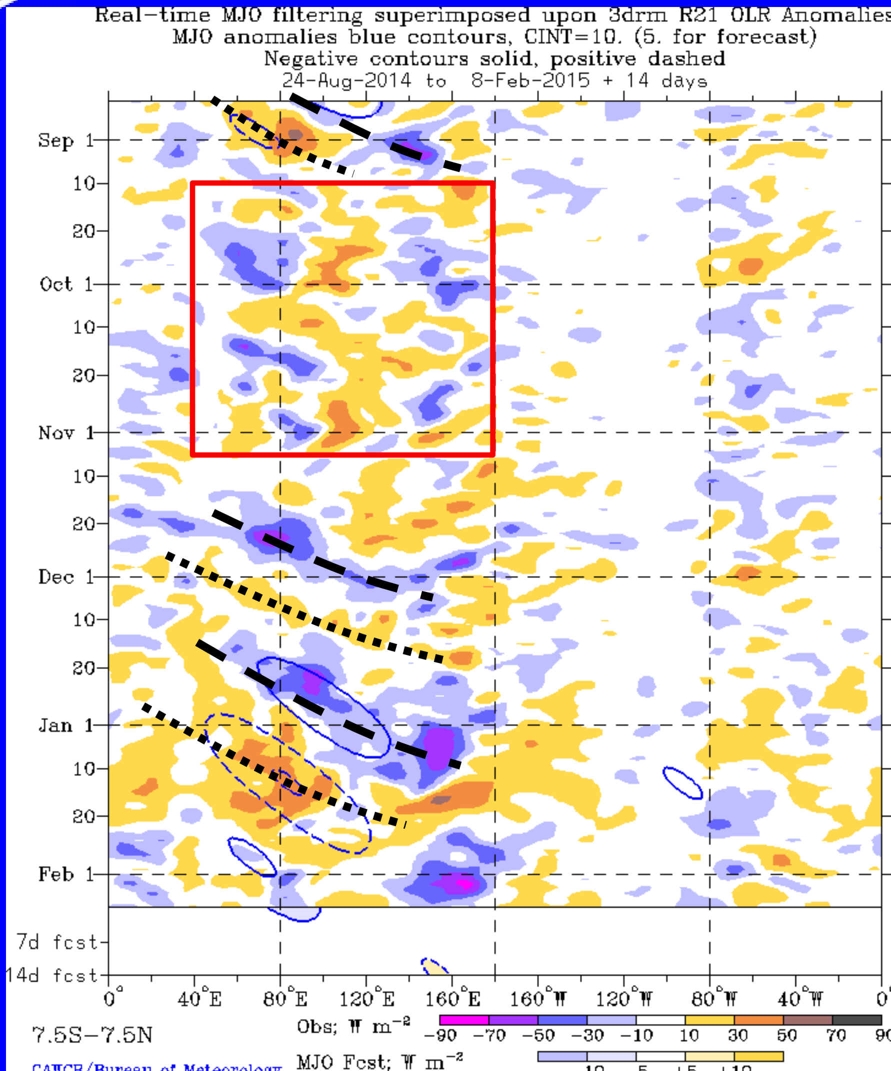
During mid-January, robust MJO-related convective anomalies were observed, with enhanced (suppressed) convection emerging over the far western Pacific (Africa, Indian Ocean , central Pacific, and northeastern Brazil).

During mid to late January, the enhanced convective anomaly signal dissipated across the western Pacific, while suppressed convection persisted over the Indian Ocean. Enhanced convection was observed over the eastern Pacific.

During late January and early February, enhanced convection returned to the western Pacific, while enhanced (suppressed) anomalies weakened across the eastern Pacific (Indian Ocean). Suppressed convection was observed across northeastern Brazil and northern Australia.

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

Some MJO activity was evident during August, as enhanced and suppressed convection phases shifted eastward from the Indian Ocean to the Pacific Ocean during this period (dashed/dotted lines).

The pattern became less coherent with respect to canonical MJO activity by September and the MJO remained weak till late November (red box).

The MJO strengthened in late November with alternating areas of enhanced and suppressed convection moving from the Indian Ocean to the Date Line through January.

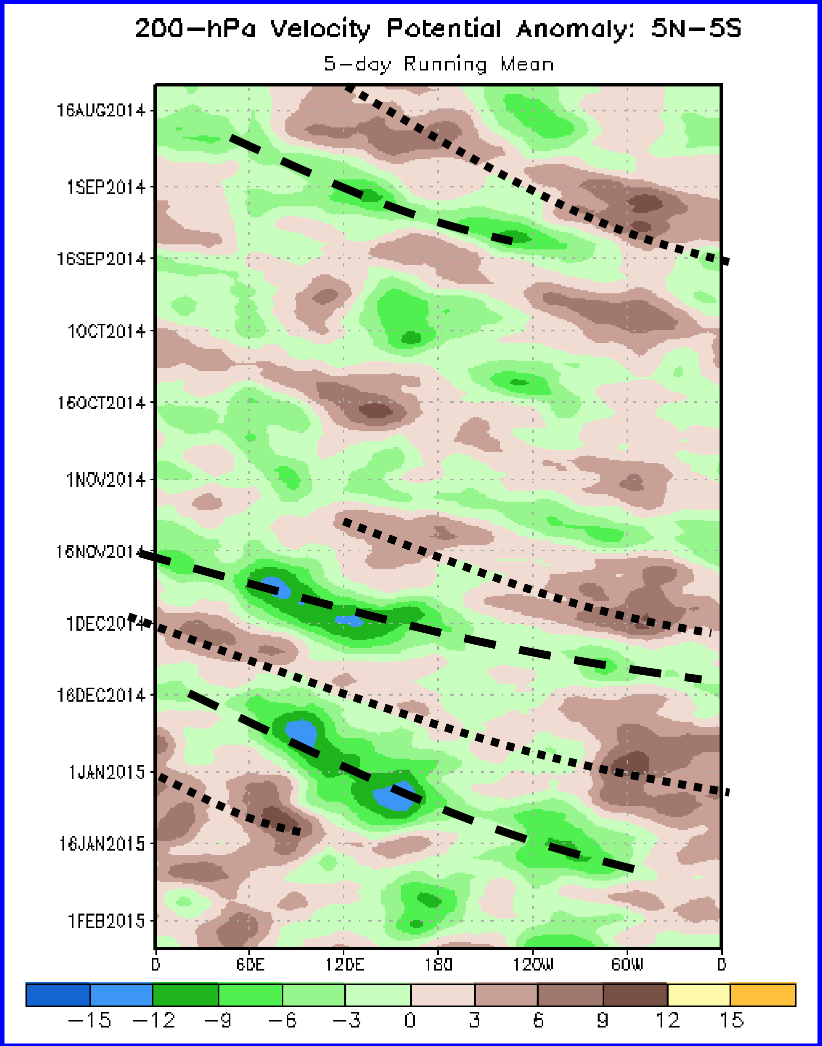
Since mid-January, the signal began to become less coherent as other variability interfered.

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 pattern became more organized during late July as the MJO strengthened. This is observed as a coherent "Wave-1" canonical MJO-like structure that developed and shifted eastward with time.

The MJO weakened and remained incoherent through September and October.

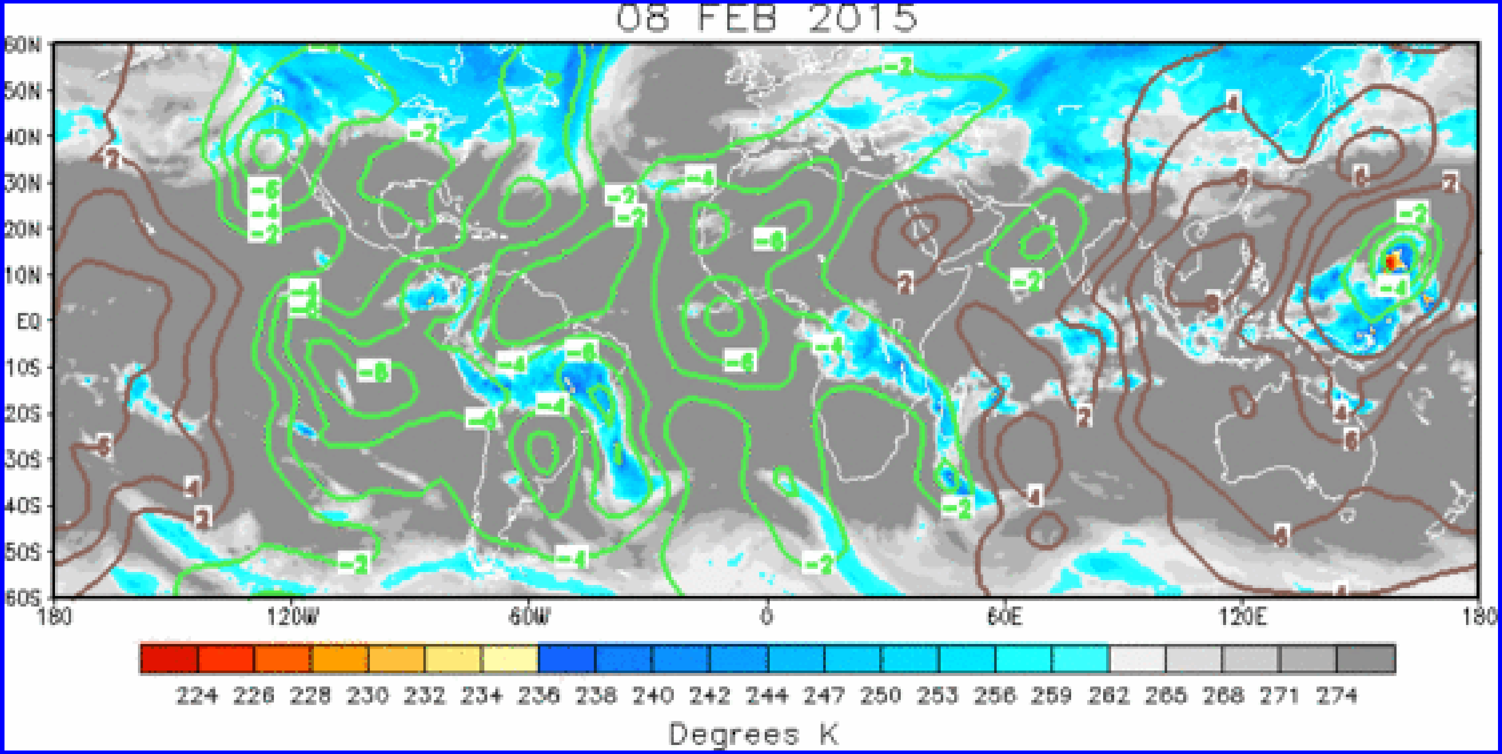
Beginning in November the MJO strengthened as indicated by eastward propagation of alternating anomalies into January 2015. At times, the signal has been dominated by faster-moving Kelvin wave variability, but from late December through mid-January the signal has been more consistent with canonical MJO activity.

Since mid-January, the signal has broken down, with other modes of variability dominating the upper-level velocity potential anomaly pattern.

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



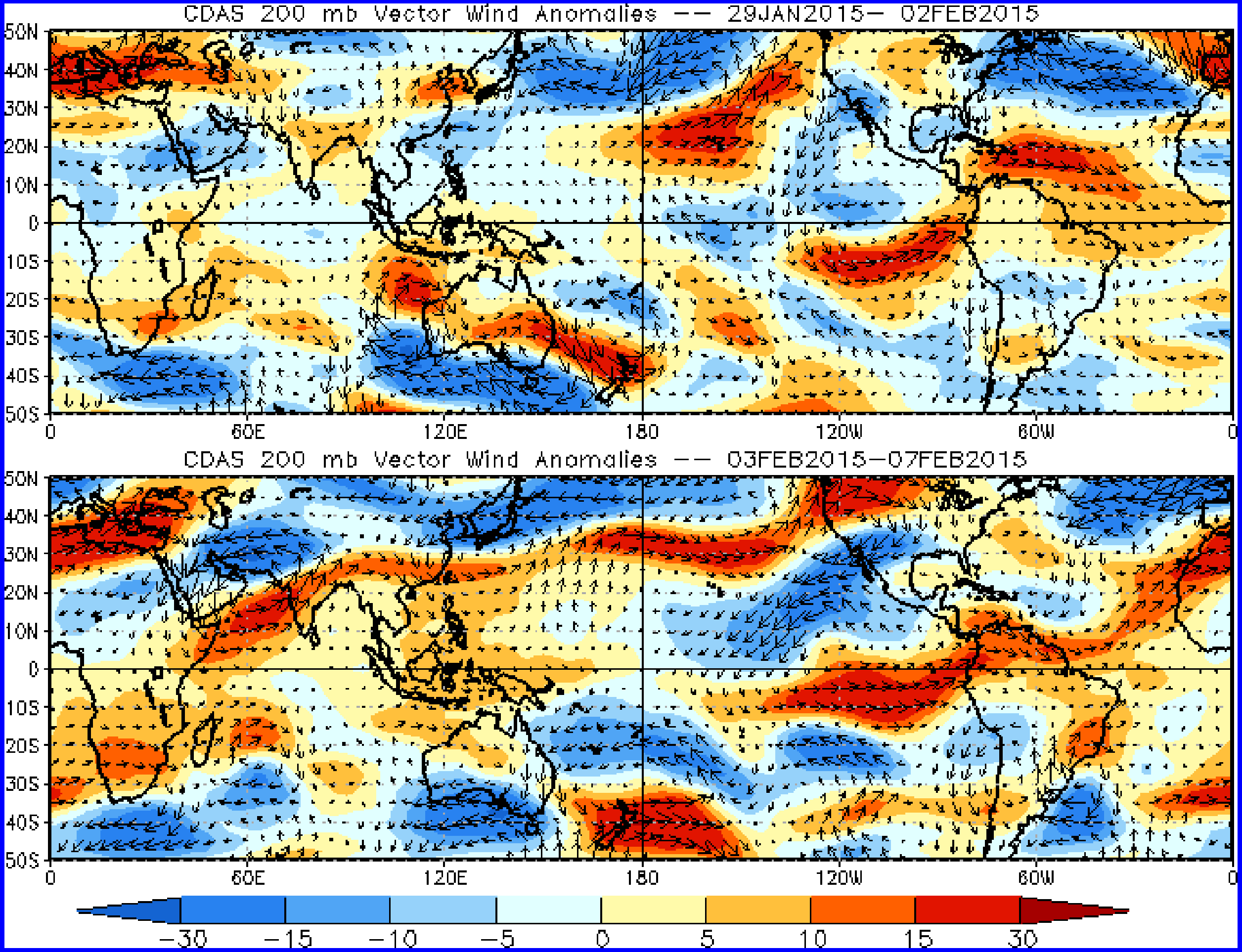
The spatial pattern of upper-level velocity potential anomalies has become more coherent, with large-scale negative (positive) anomalies over the Western Hemisphere (Maritime Continent and west-central Pacific). Negative anomalies persisted over the northwestern Pacific, associated in part with tropical cyclone activity.

200-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 returned to the equatorial eastern Pacific.

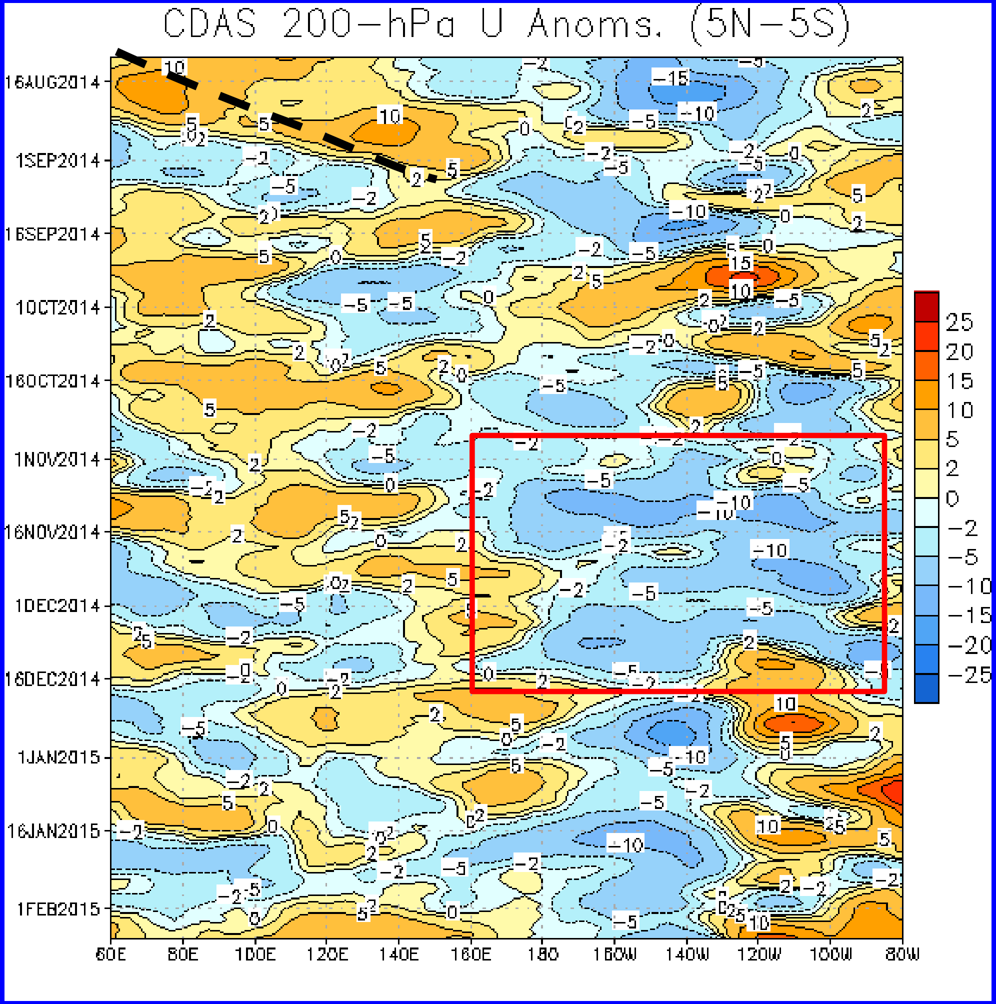
Weak westerly anomalies were observed over the Indian Ocean, Maritime Continent, and western Pacific.

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

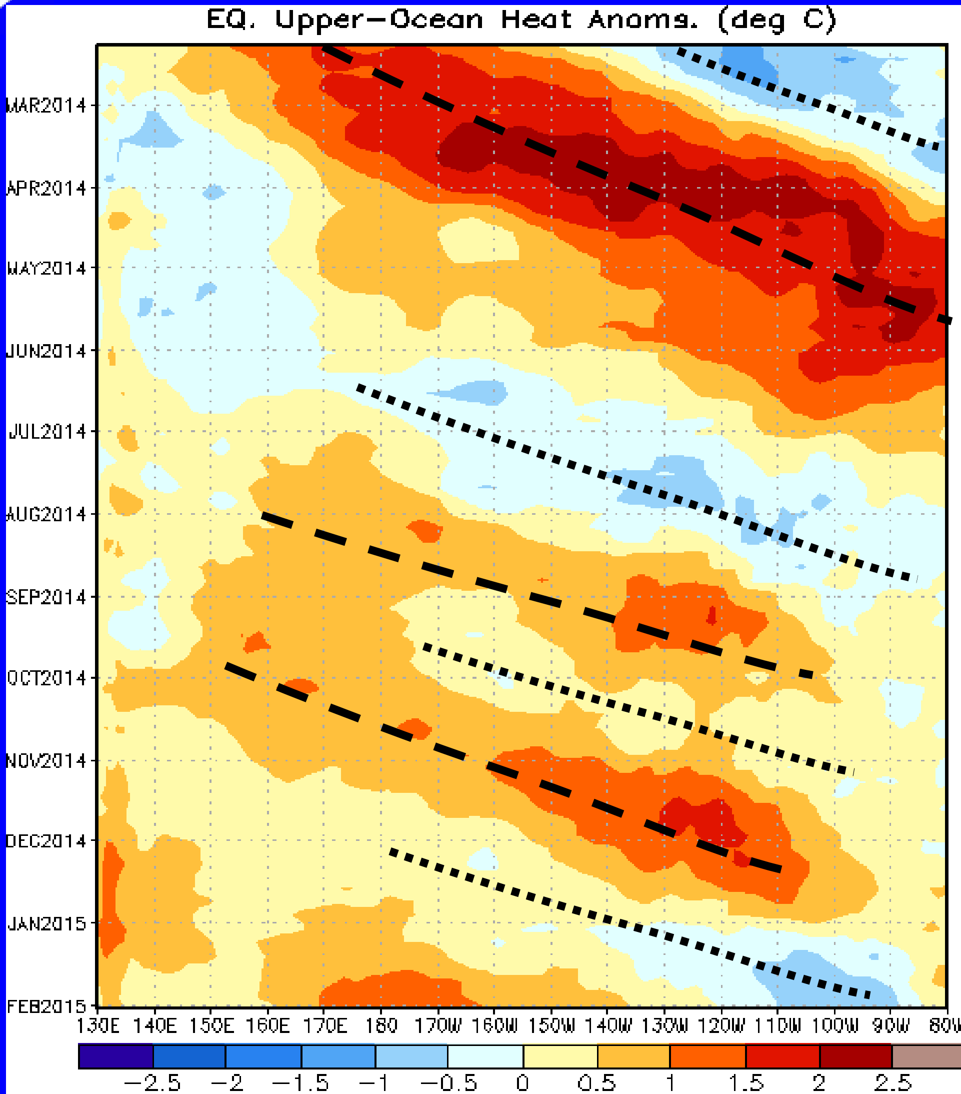
A slow, eastward progression of westerly anomalies is evident over the Maritime Continent and western Pacific during August (black dashed line). Some westward propagation is noticeable during September and early October over the eastern Pacific.

Easterly wind anomalies persisted east of the Date Line from late October through early December (red box).

During late December and January, westerly anomalies once again increased in coverage and intensity from 120W to 80W similar to September and October 2014.

Weekly Heat Content Evolution in the Equatorial Pacific

Time



Longitude

A strong downwelling event began in January 2014 and propagated across the Pacific reaching the South American coast by May 2014.

Warm anomalies persisted over much of the Pacific during April and May, though basin-averaged anomalies decreased during June and July associated with an upwelling Kelvin wave (dotted line).

Warm anomalies increased across much of the Pacific basin due to another moderate downwelling Kelvin wave traversing the Pacific during October and November 2014. The upwelling phase is now evident in the central and eastern Pacific.

Warm anomalies began increasing again near the Date Line during late January and early February.

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).

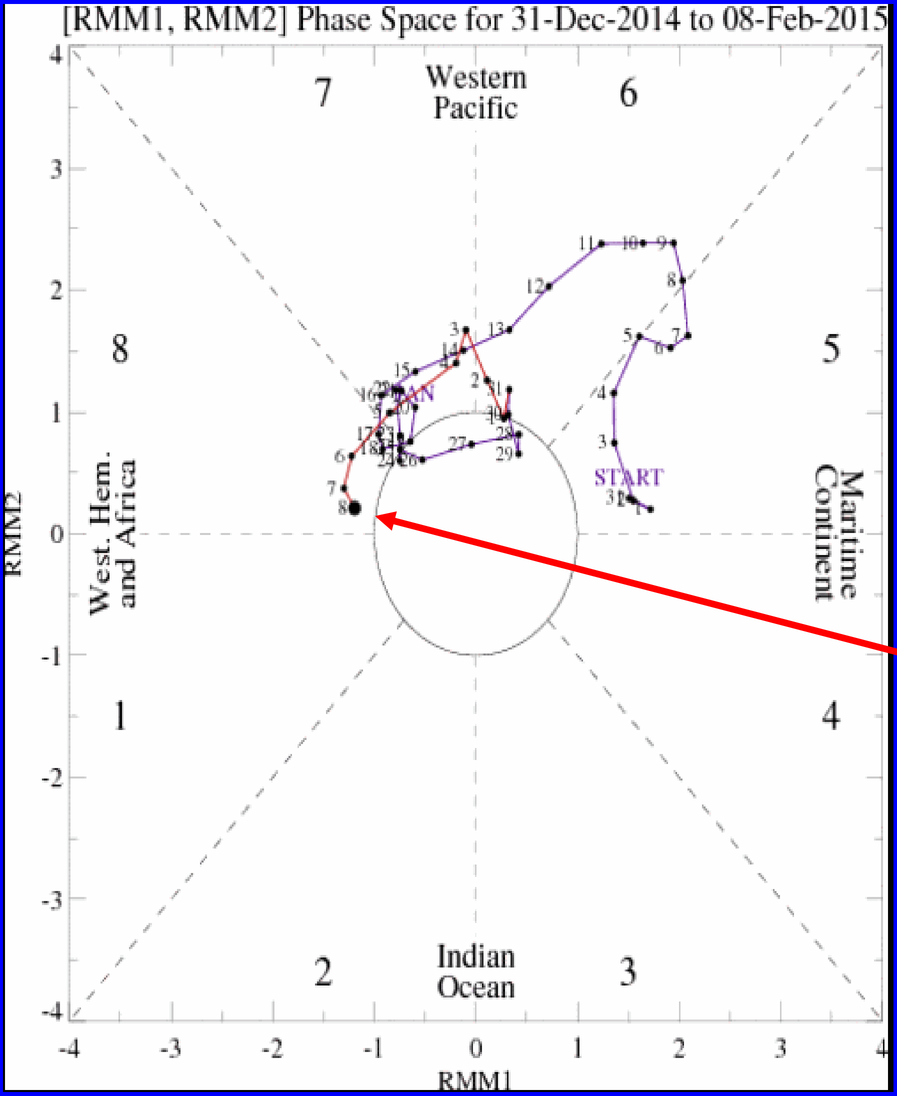
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

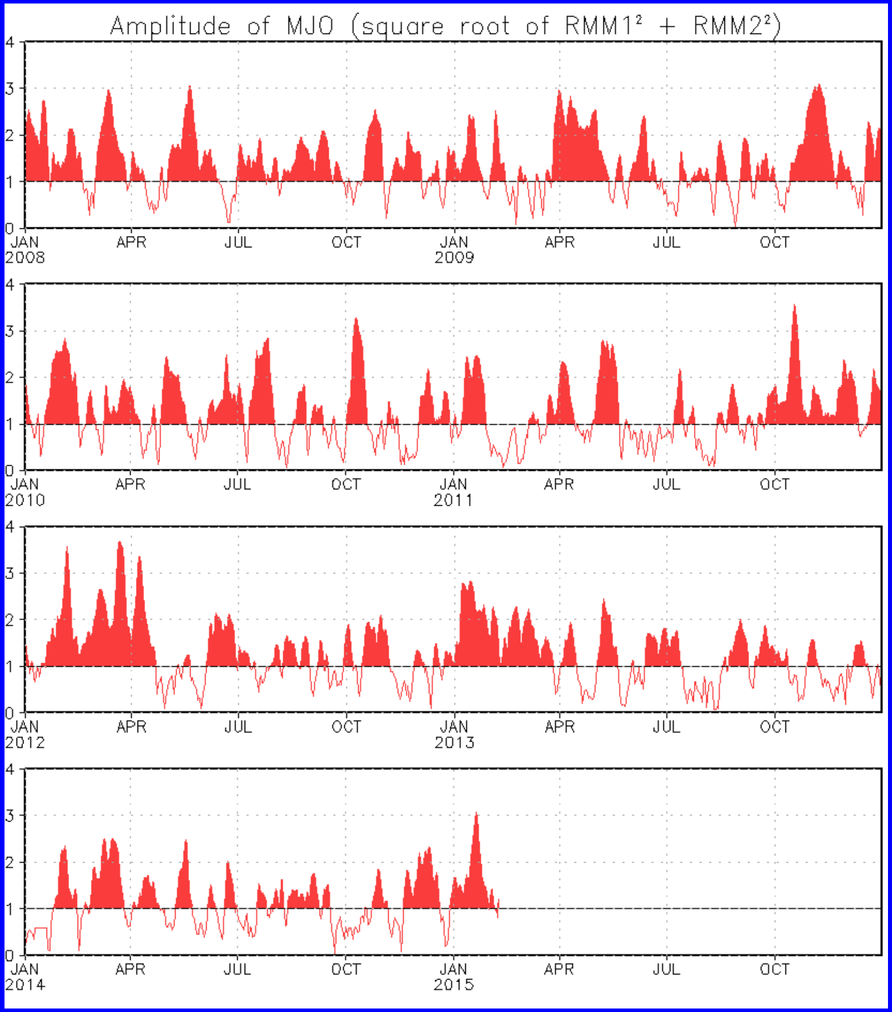
MJO Index -- Recent Evolution



- 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 over the past week has shown eastward propagation to the Western Hemisphere.

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.

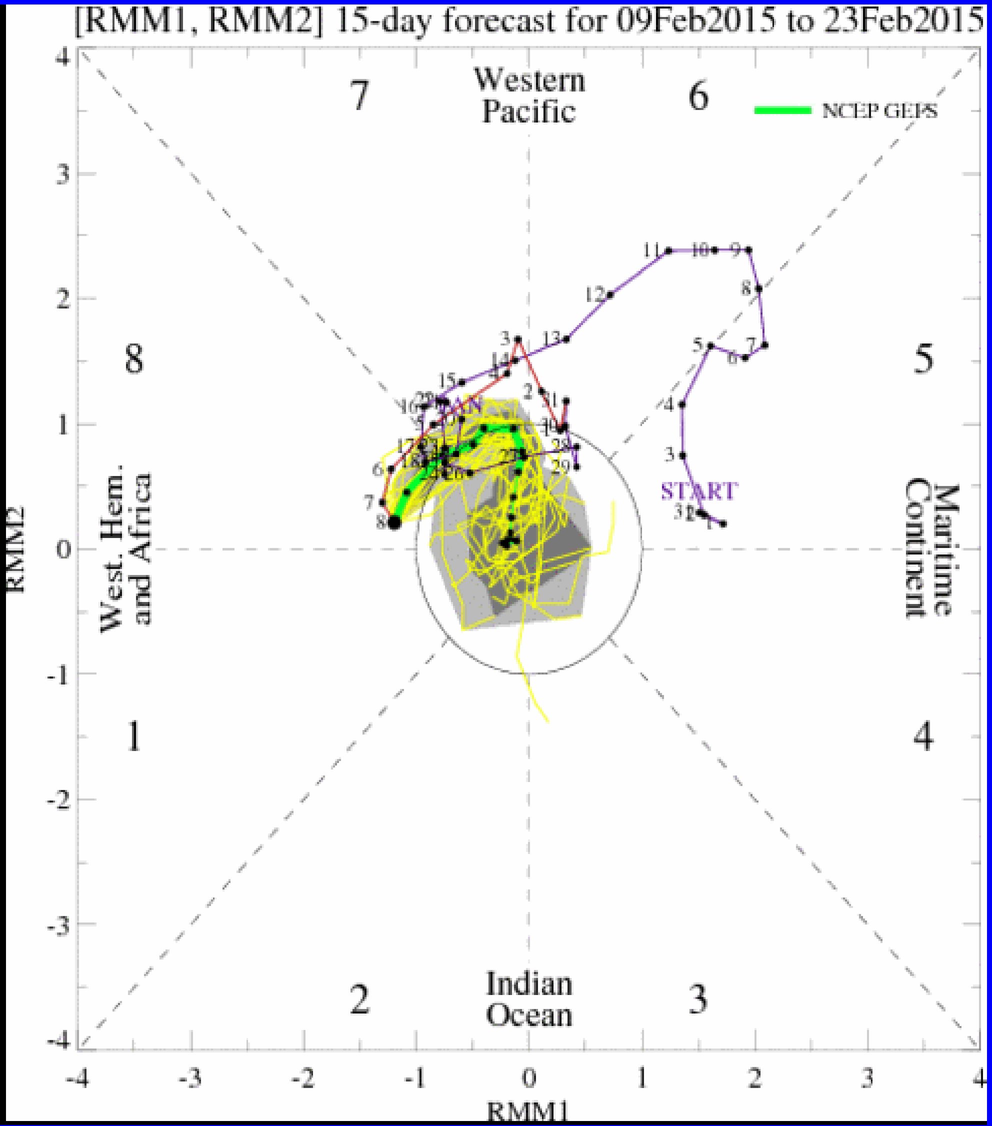
Ensemble GFS (GEFS) MJO Forecast

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

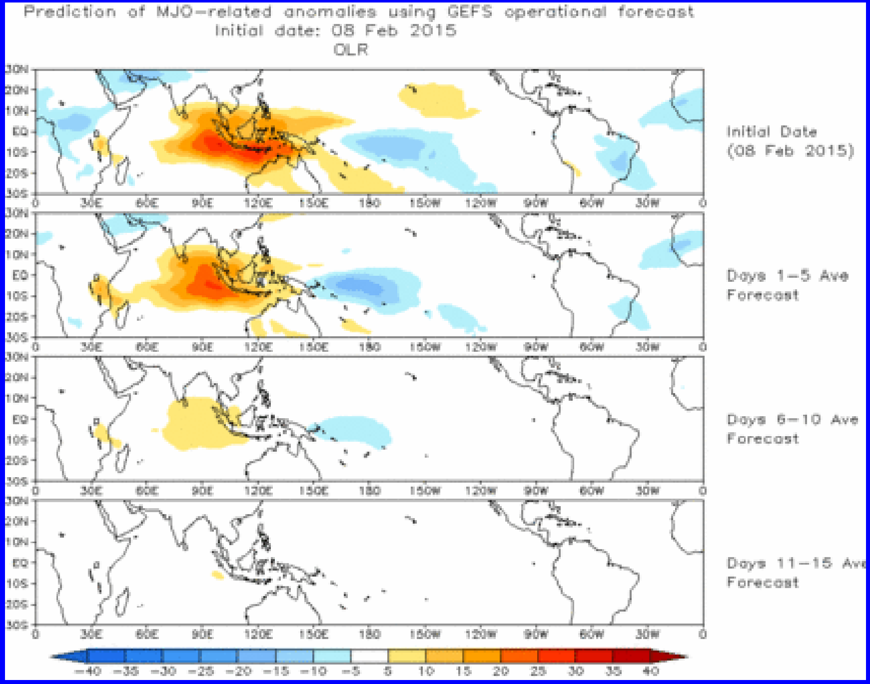
The GFS ensemble RMM Index forecasts do not depict a signal consistent with MJO activity.



Ensemble Mean GFS MJO Forecast

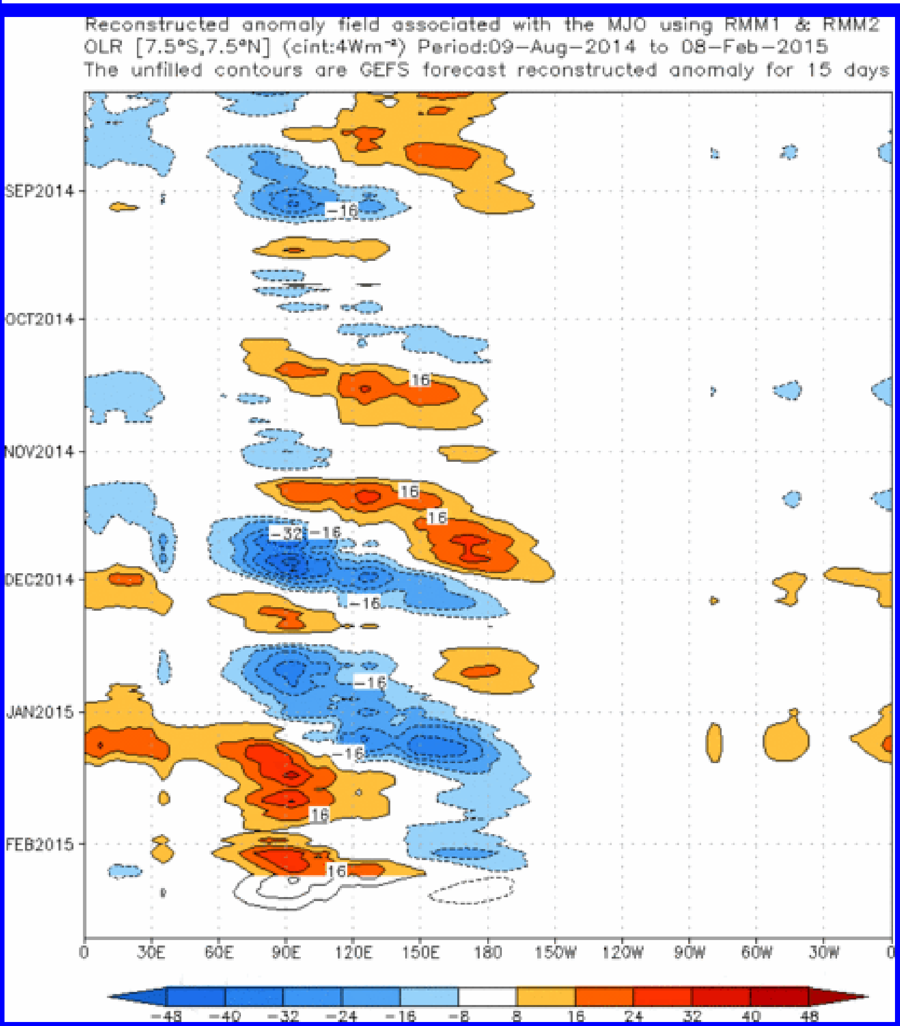
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS RMM Index based OLR anomalies forecast depicts no eastward propagation of the signal during Week-1, with a weakening signal during Week-2.

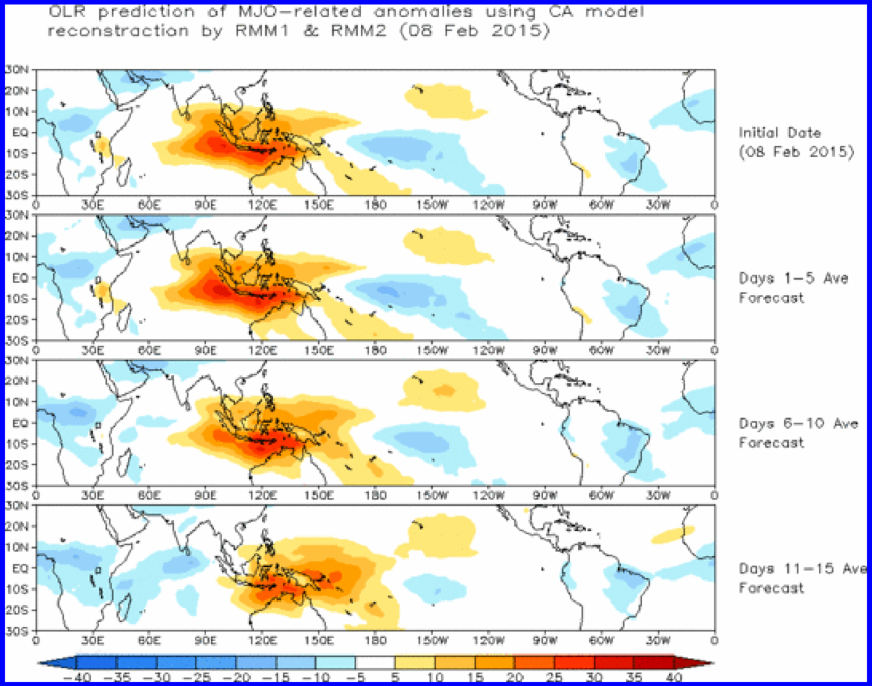
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



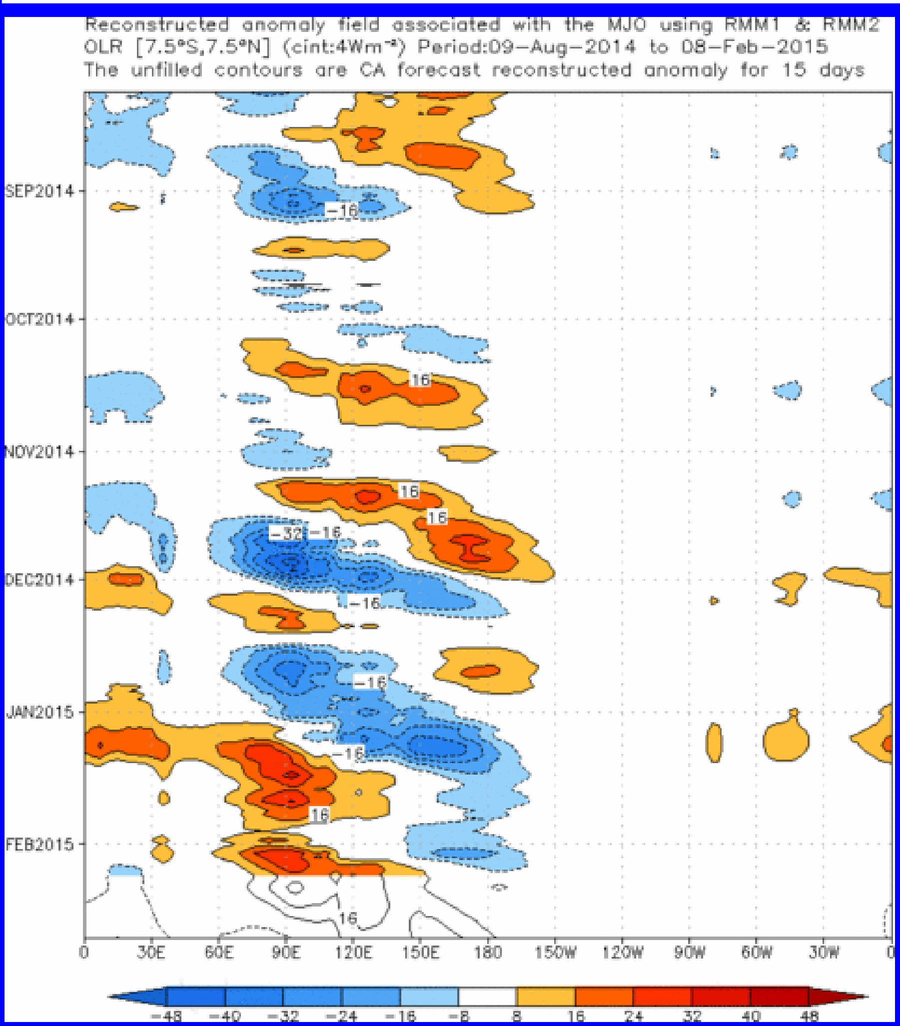
Constructed Analog (CA) MJO Forecast

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



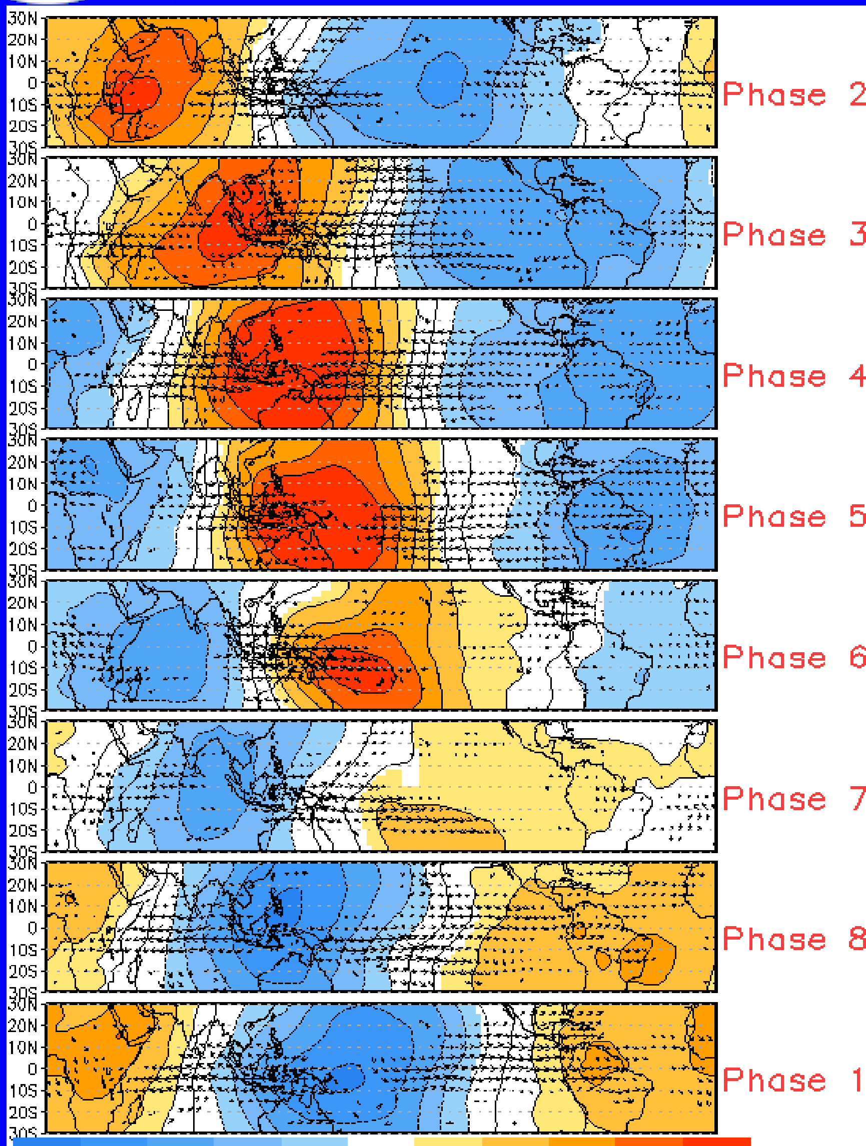
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



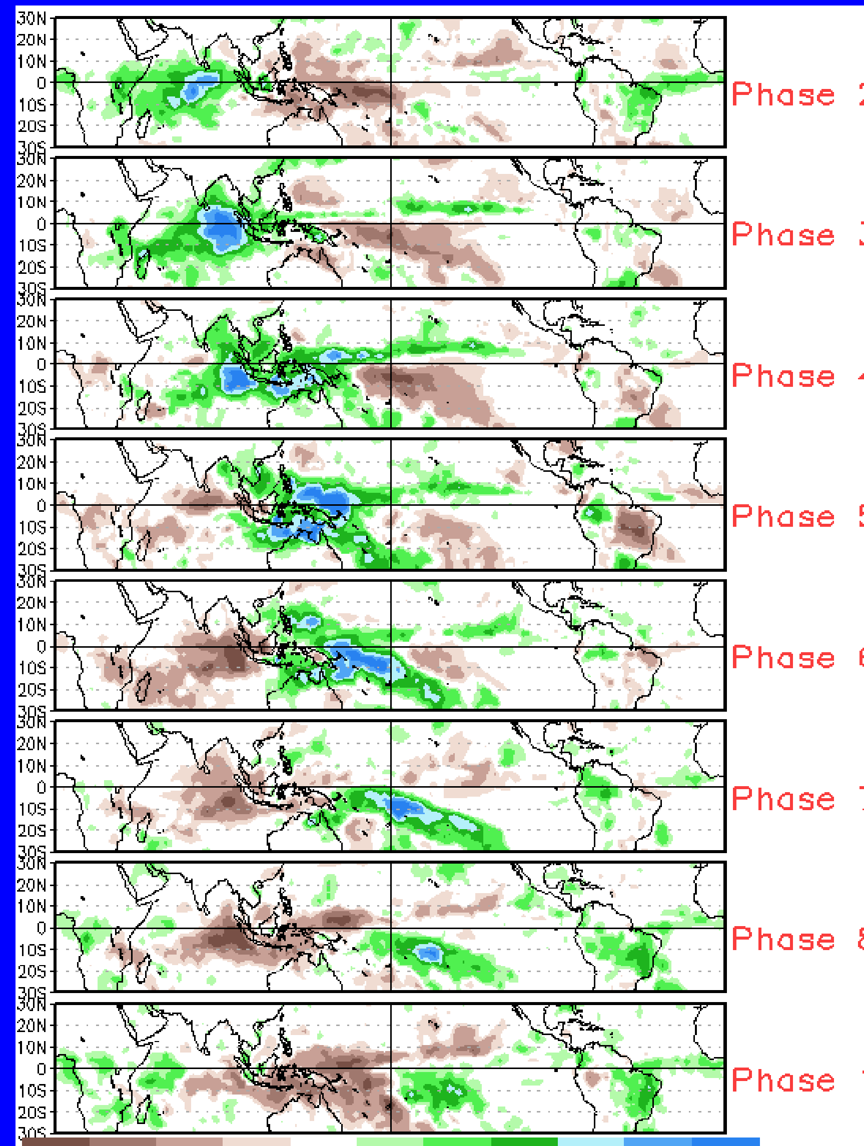
The statistical forecast depicts some eastward propagation of an MJO signal during the upcoming two week period.

MJO Composites – Global Tropics

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

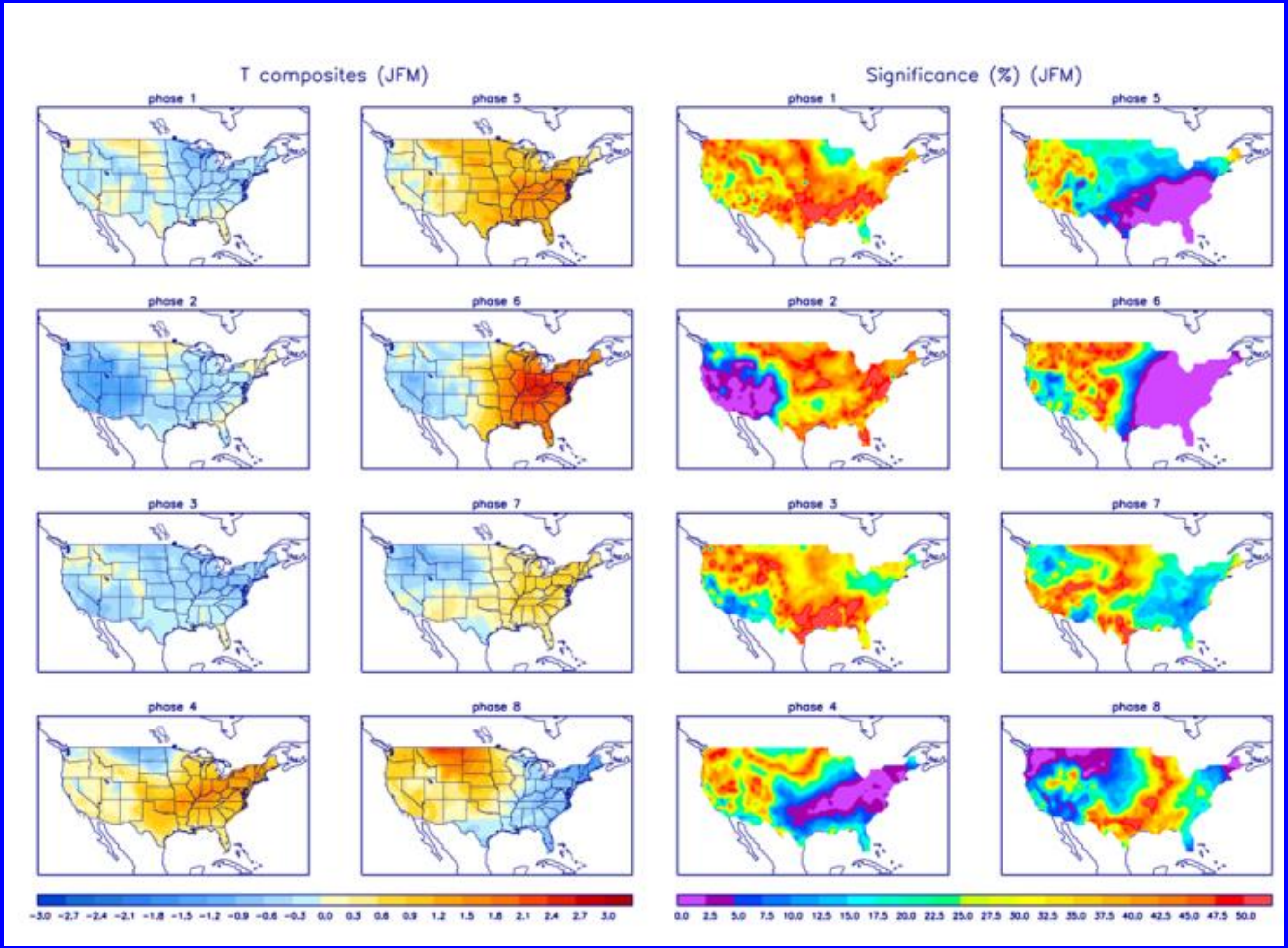


Precipitation Anomalies (Nov-Mar)



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.

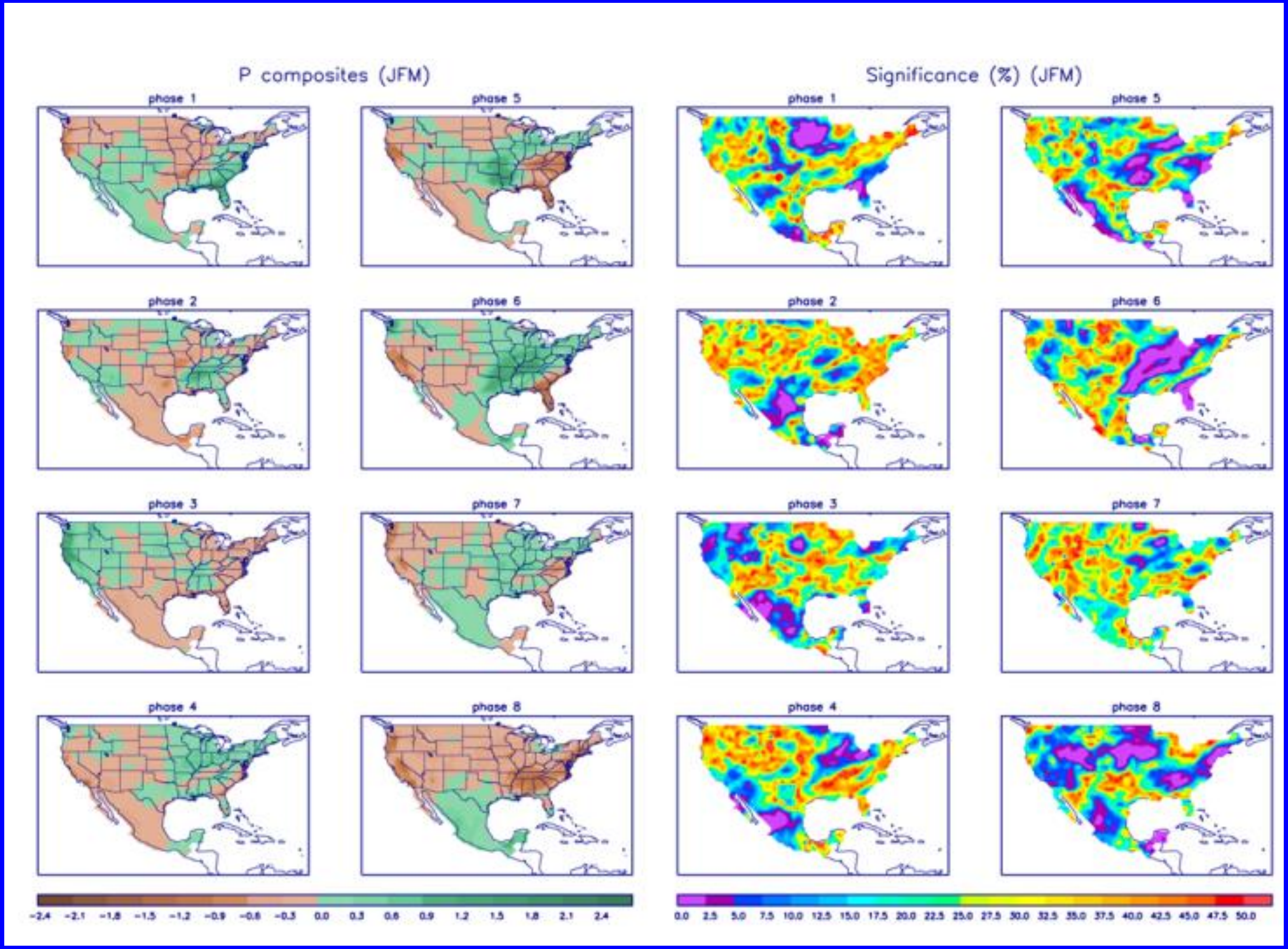


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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