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

Update prepared by
Climate Prediction Center / NCEP
January 26, 2015

Outline

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

Overview

- The MJO remained active during the past week though several observational indicators depict a notable less coherent and considerably weaker signature than previous weeks. The enhanced phase is generally located across the Americas.

- In addition to a weaker MJO signal, other coherent subseasonal tropical variability is interfering with the current MJO signal. This further contributes to the less clear MJO signature and high uncertainty during Week-2 for main centers of action for anomalous tropical convection.

- Dynamical model MJO index forecasts show continued weakening of the MJO signal in Week-1 with high spread in the guidance for Week-2.

- Based on the latest observations and several forecast tools, the MJO is forecast to be weak over the next 1-2 weeks with high uncertainty for the main areas of anomalous convection.

- The MJO may contribute to suppressed (enhanced) rainfall for portions of northern Australia, the southern Maritime continent and areas near the Philippines (Southwest Pacific Ocean).

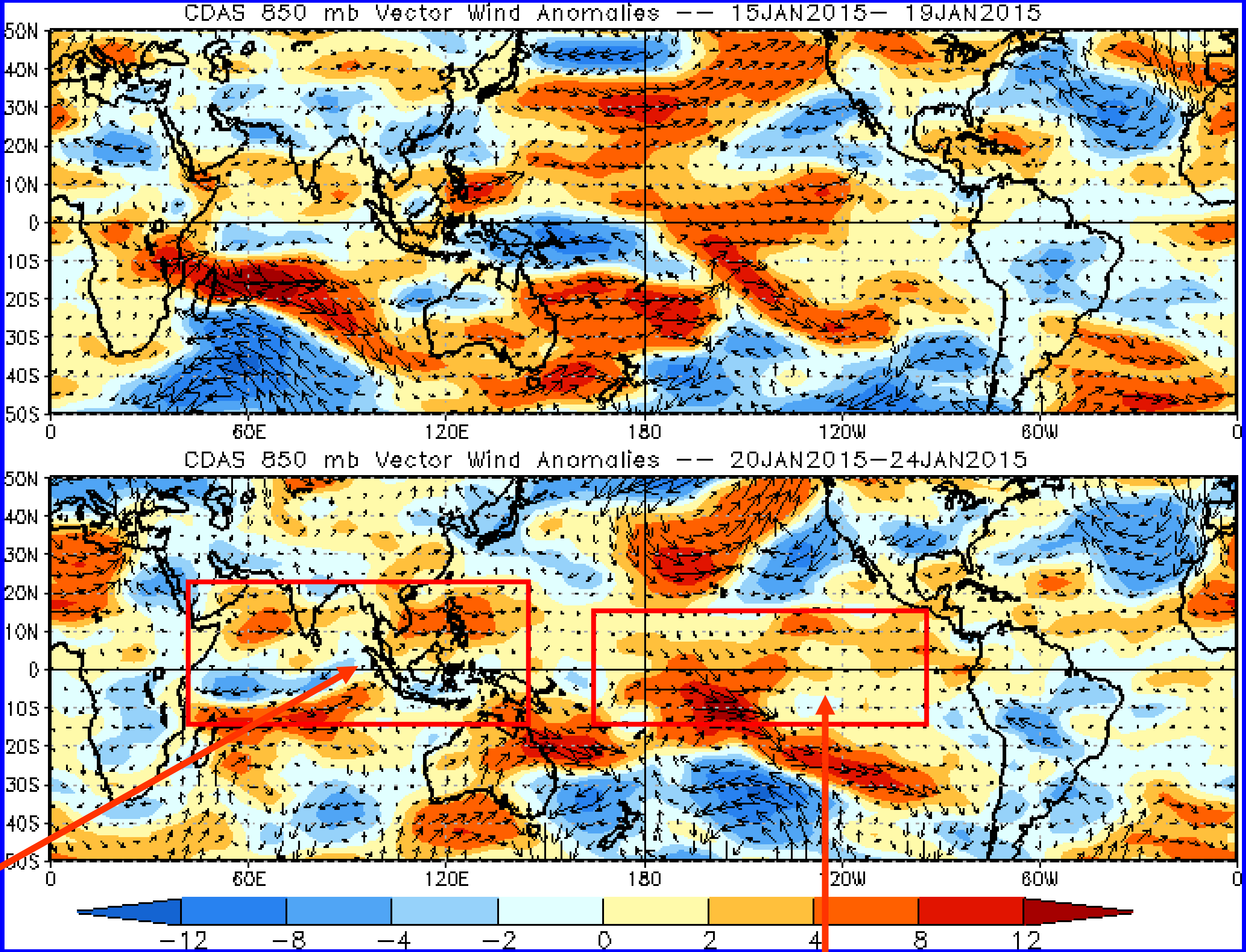
A forecast map of potential impacts across the global Tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



During the more recent five days, equatorial winds have been generally close to average across the Indian Ocean and Maritime continent. Westerly anomalies were more apparent in areas off of the equator, for instance near the Philippines.

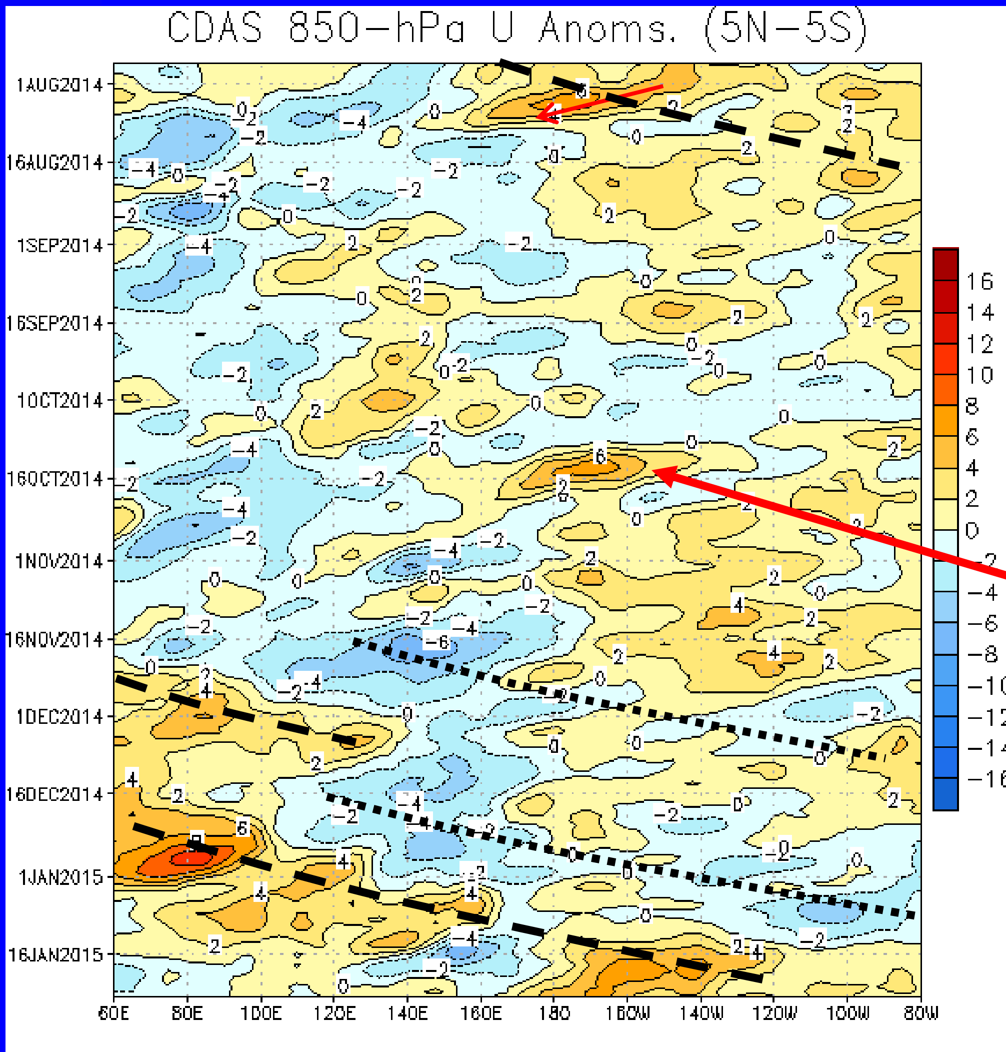
Westerly anomalies continued over portions of the east-central Pacific.

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



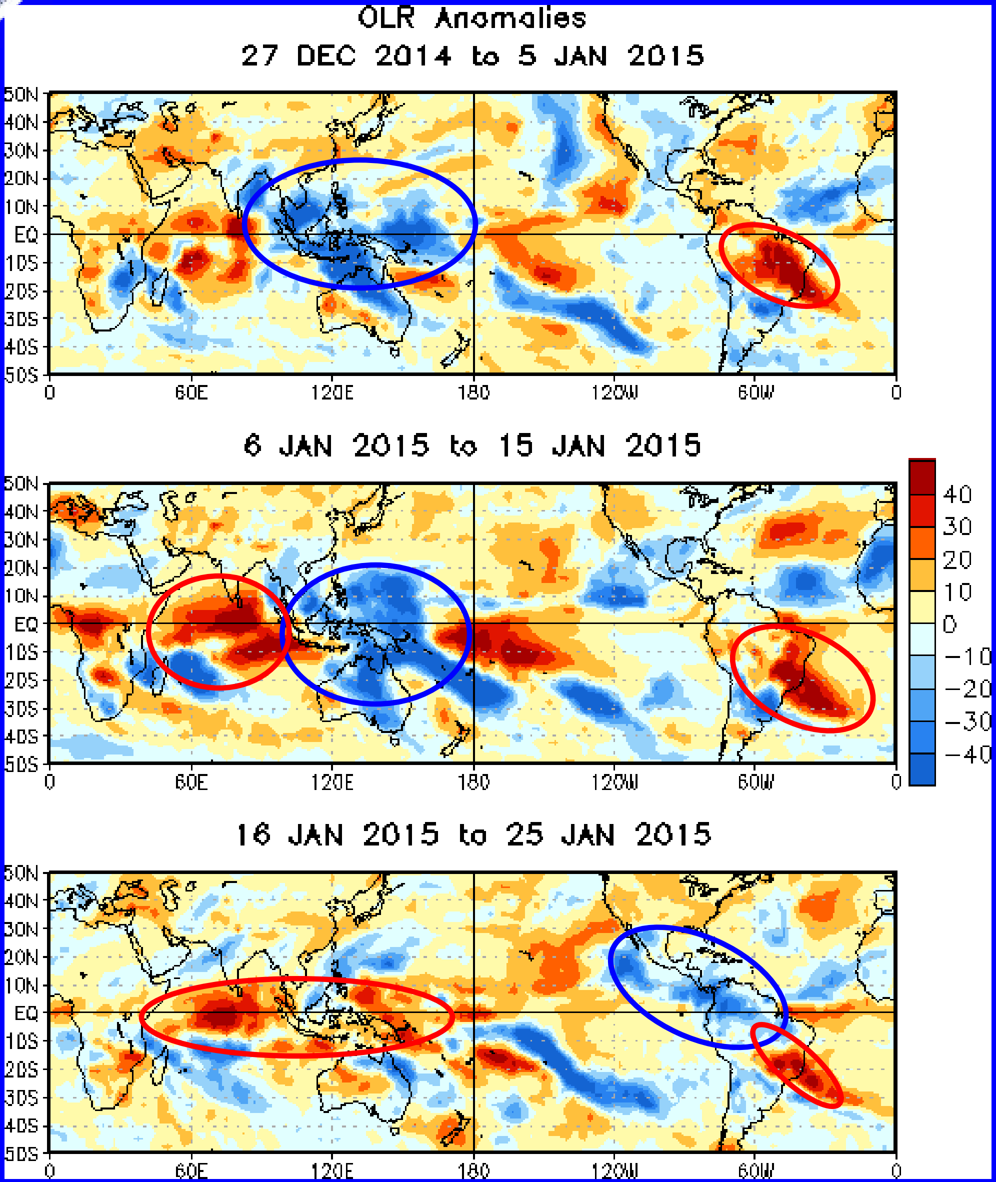
Longitude

From late July to 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 arrows) over the eastern and 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 best illustrated by westerly anomalies shifting eastward from the Indian Ocean to the western hemisphere by mid-to-late January.

OLR Anomalies – Past 30 days



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

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

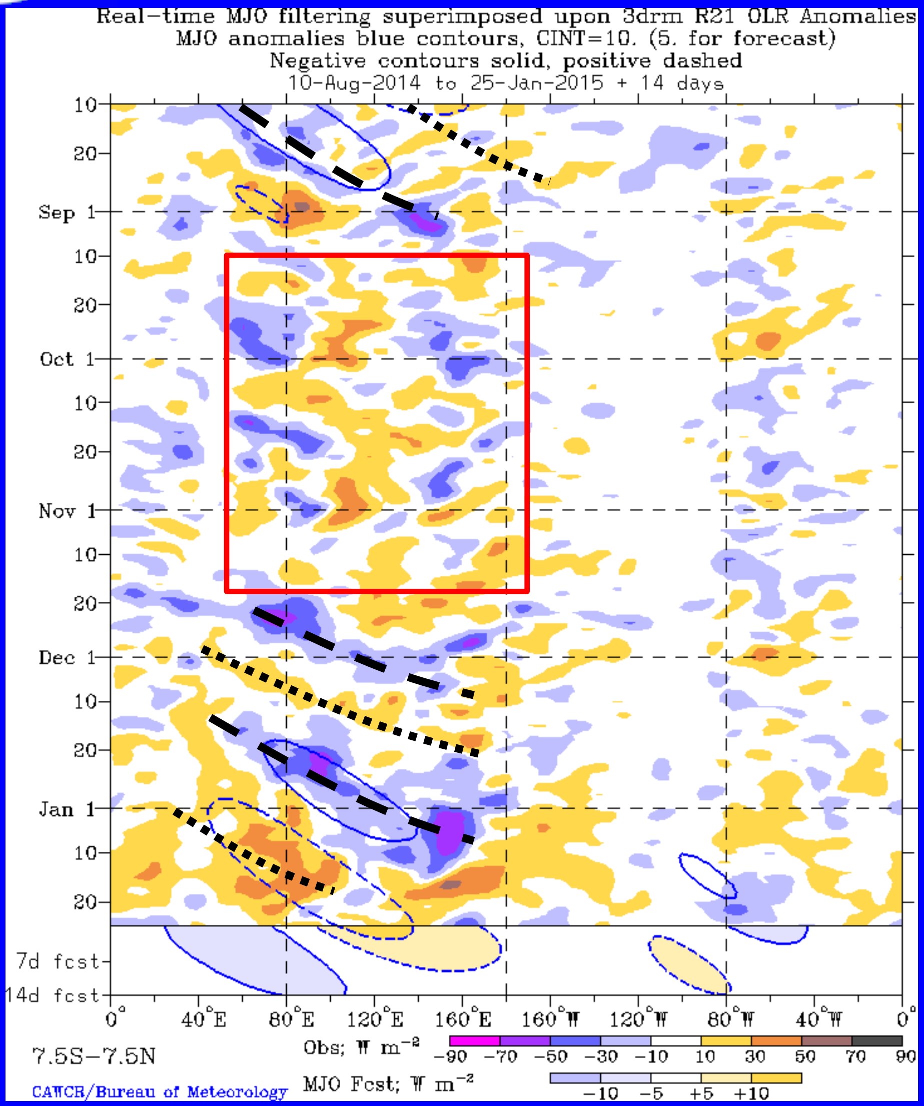
During late December into early January, enhanced convection shifted eastward to the Maritime Continent and far western Pacific, consistent with MJO activity. Suppressed convection was observed over Brazil.

In early-to-mid January, a coherent pattern continued with eastward propagation of enhanced convection continuing. Suppressed convection intensified over the Indian Ocean as well as near and east of the Date Line. Suppressed convection persisted over Brazil.

By mid-January, suppressed convection somewhat expanded across the Maritime continent while enhanced convection developed near the Americas.

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).

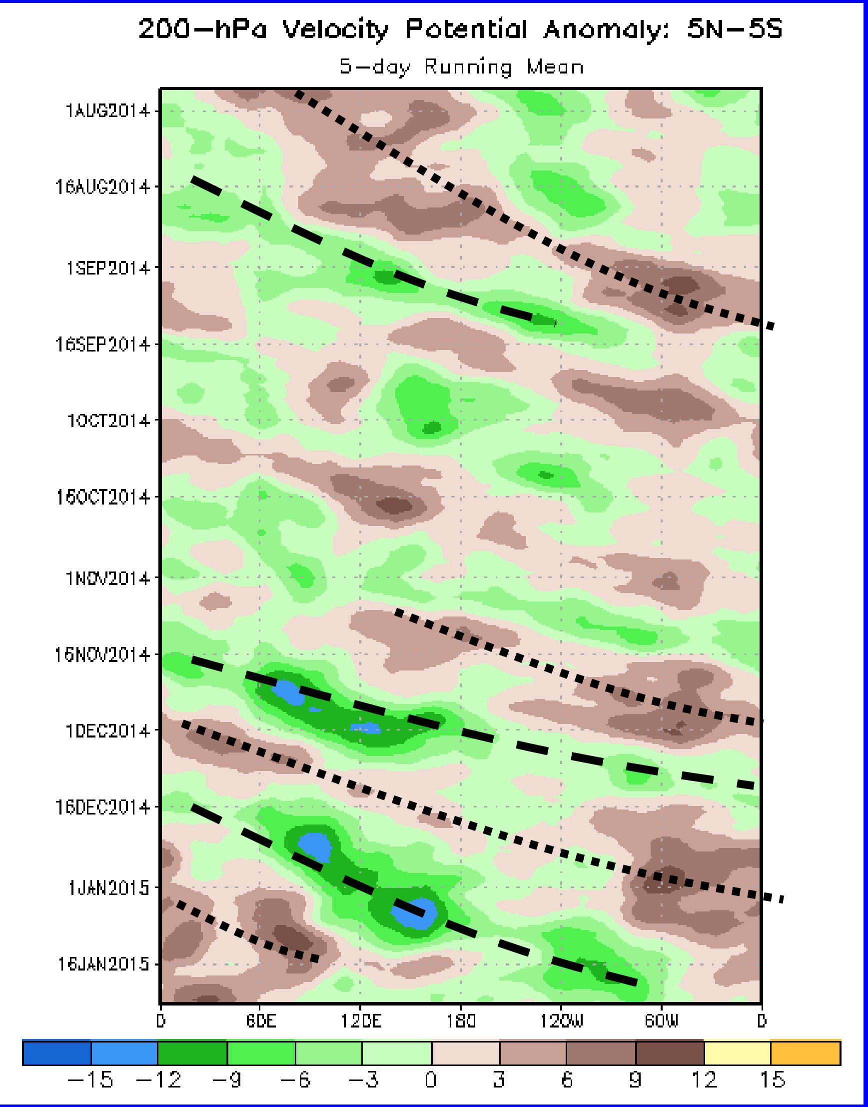
The MJO strengthened in late November with alternating areas of enhanced and suppressed convection moving from the Indian Ocean to the Date Line through January. Recently, the signal began to become less coherent as other variability interfered.

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.

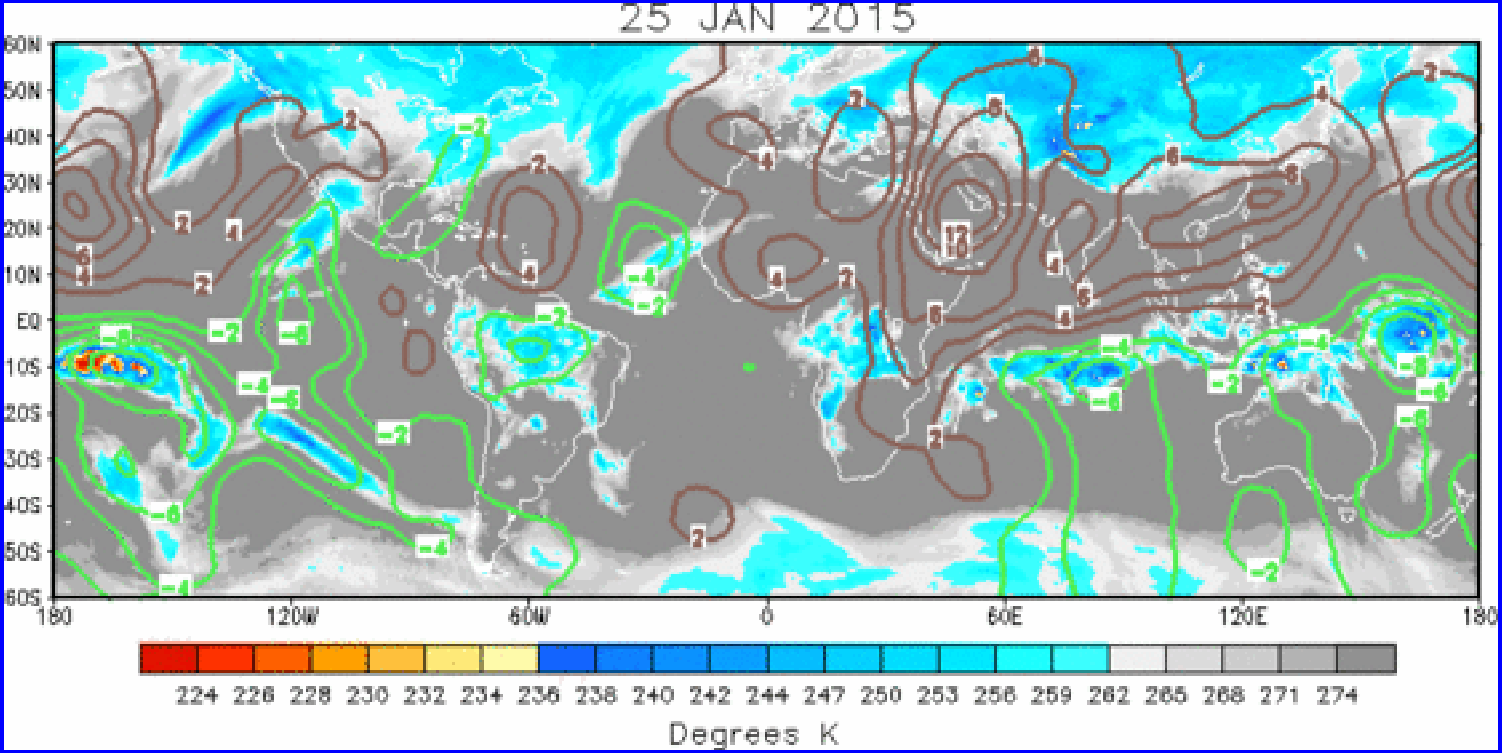
Beginning in November the MJO strengthened as indicated by eastward propagation of alternating anomalies into January 2015. At times, the signal has been dominated by faster-moving Kelvin wave variability, but from late December through mid-January the signal has been more consistent with canonical MJO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

Most recently, the pattern has become somewhat less coherent, however.

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



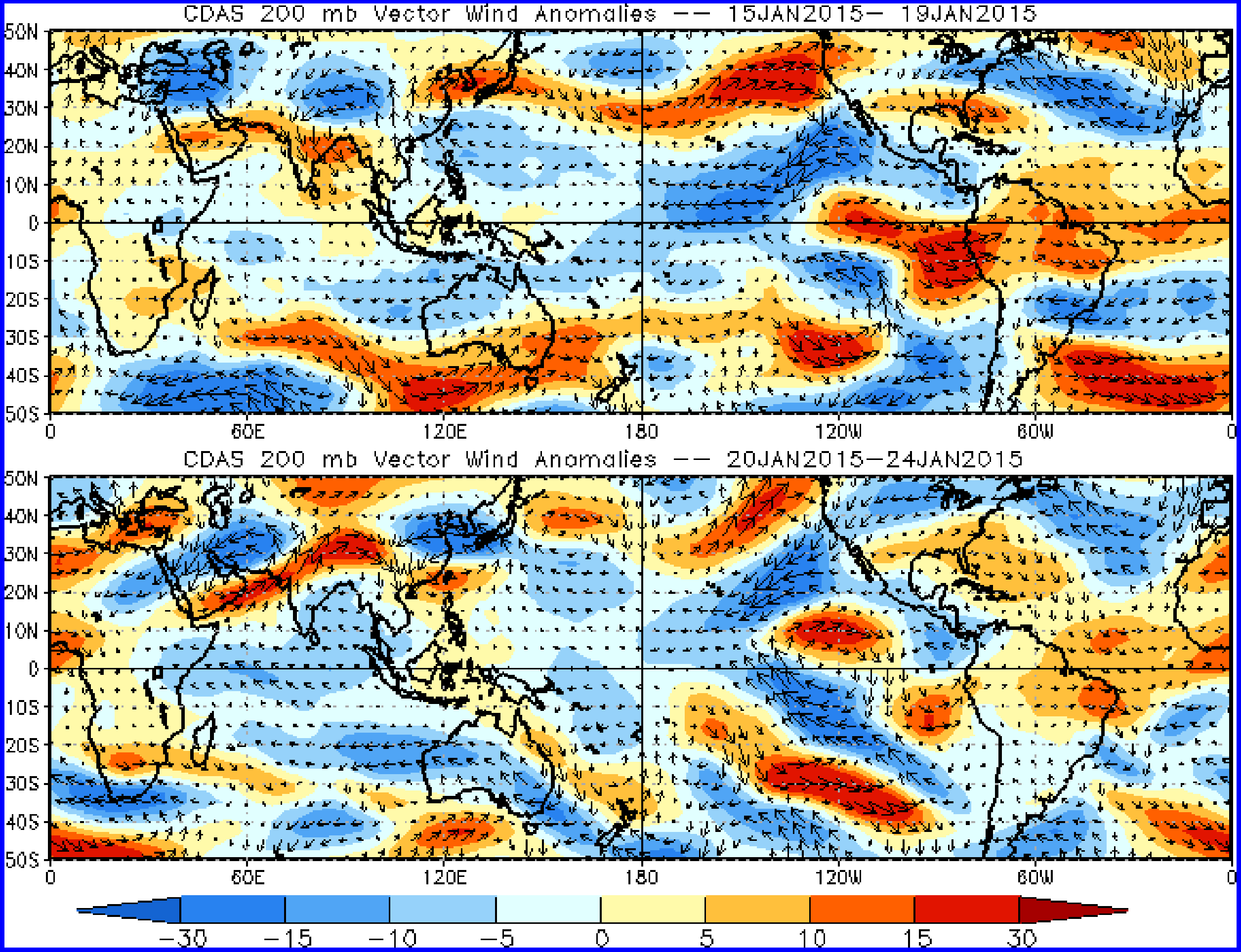
The upper-level anomalous velocity potential spatial pattern has become less coherent than past recent weeks suggesting the MJO may be showing signs of weakening.

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



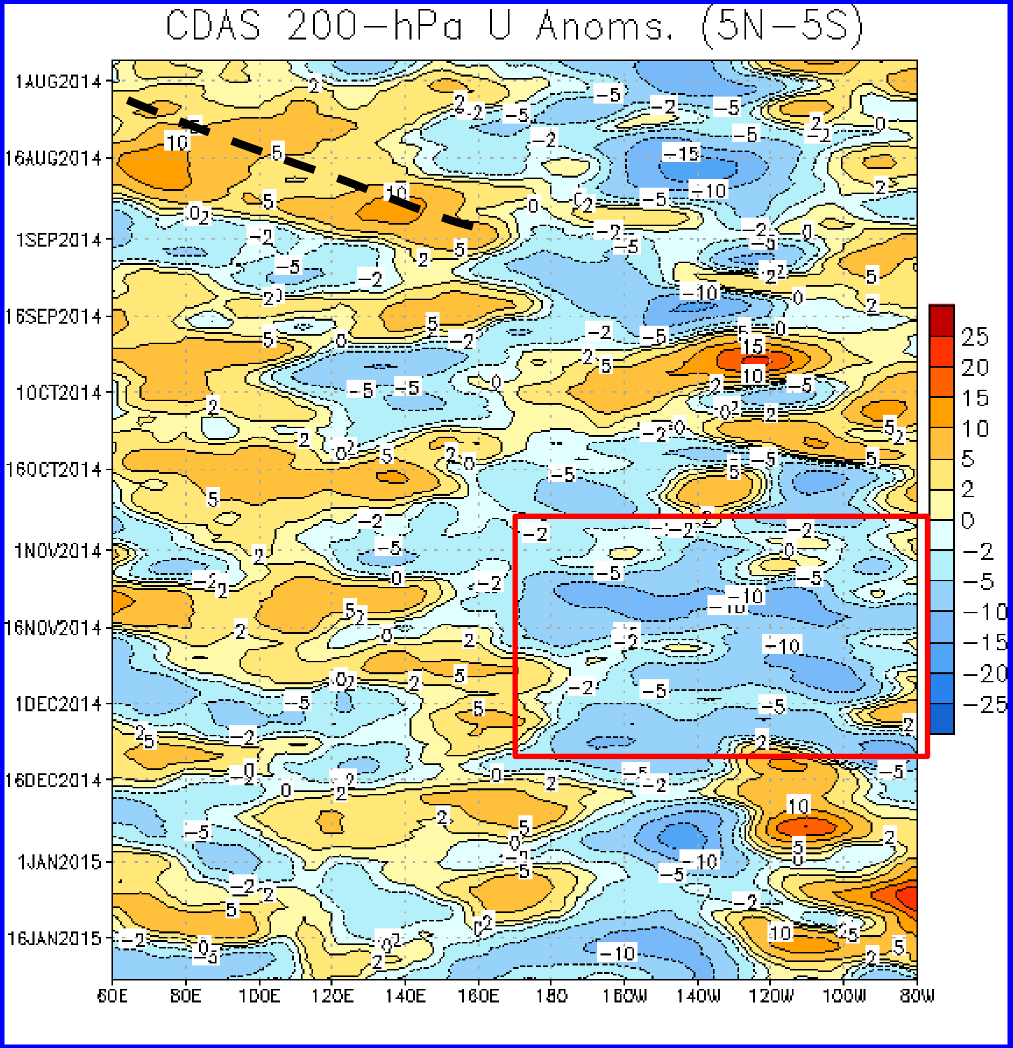
Little coherent variability of upper-level zonal wind anomalies is observed over the global Tropics. One exception is the persistent westerly anomalies from South America to western Africa.

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

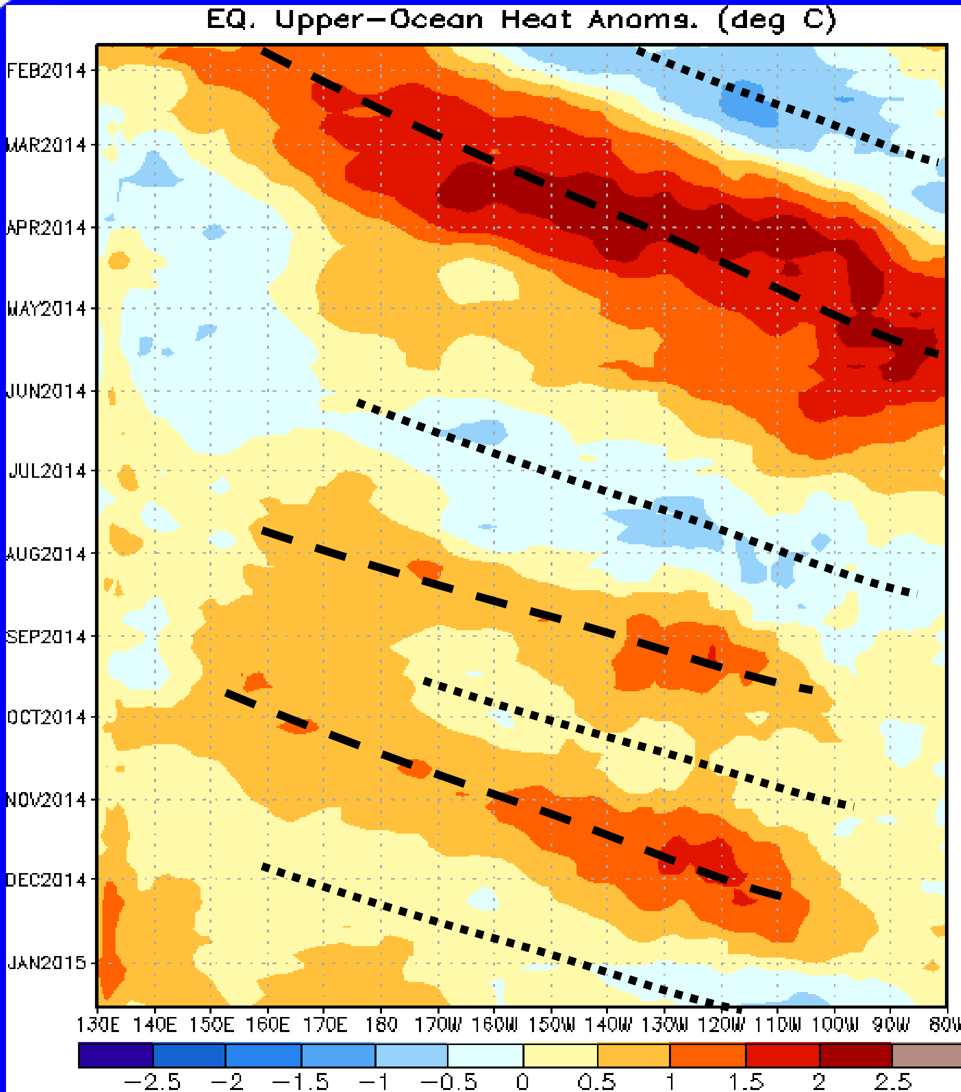
A slow, eastward progression of westerly anomalies is evident over the Maritime Continent and western Pacific during August (black dashed line). Some westward propagation is noticeable during September and early October over the eastern Pacific.

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

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.

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).

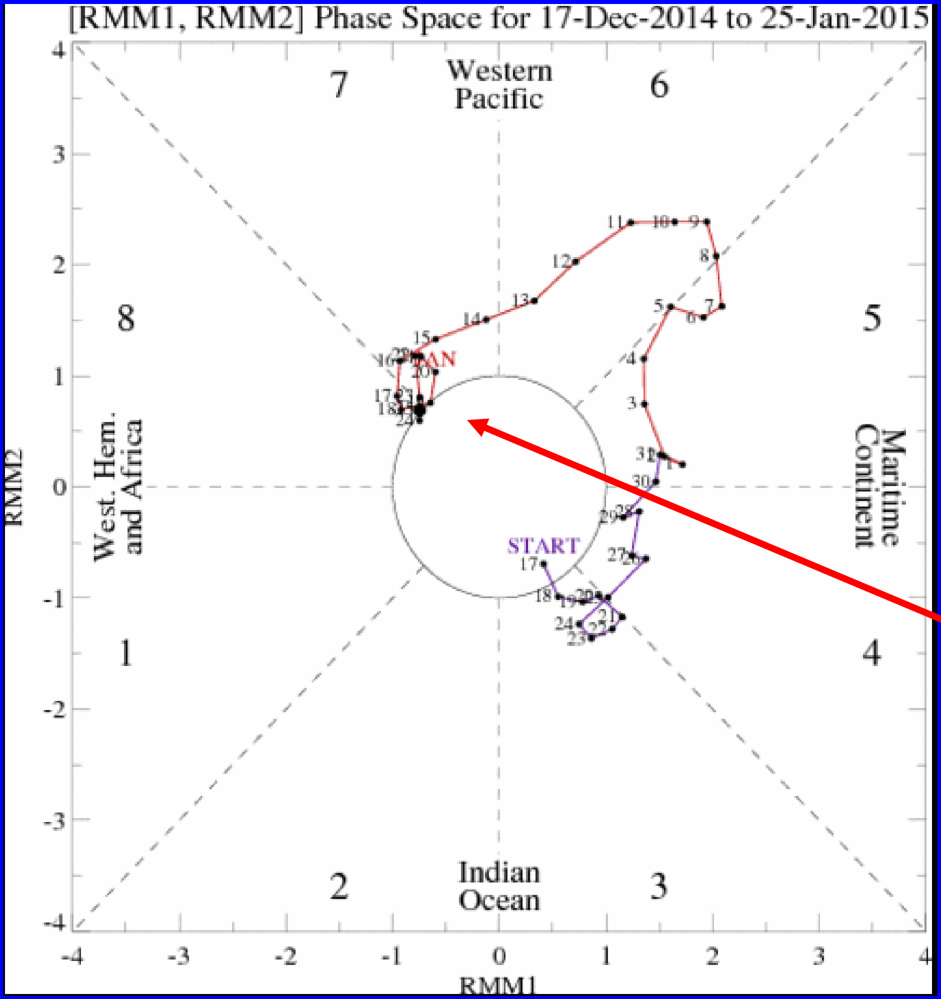
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

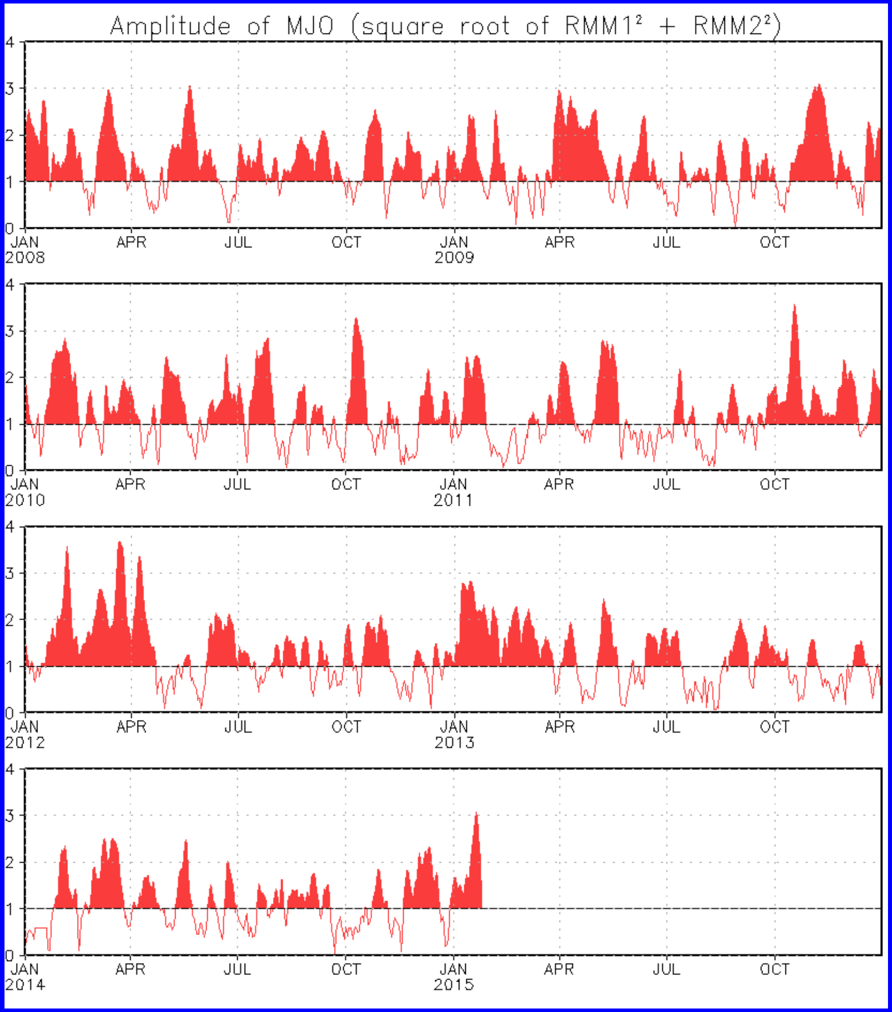
MJO Index -- Recent Evolution



- 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 little eastward propagation while maintaining the same amplitude and location generally across the east-central Pacific.

MJO Index – Historical Daily Time Series



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

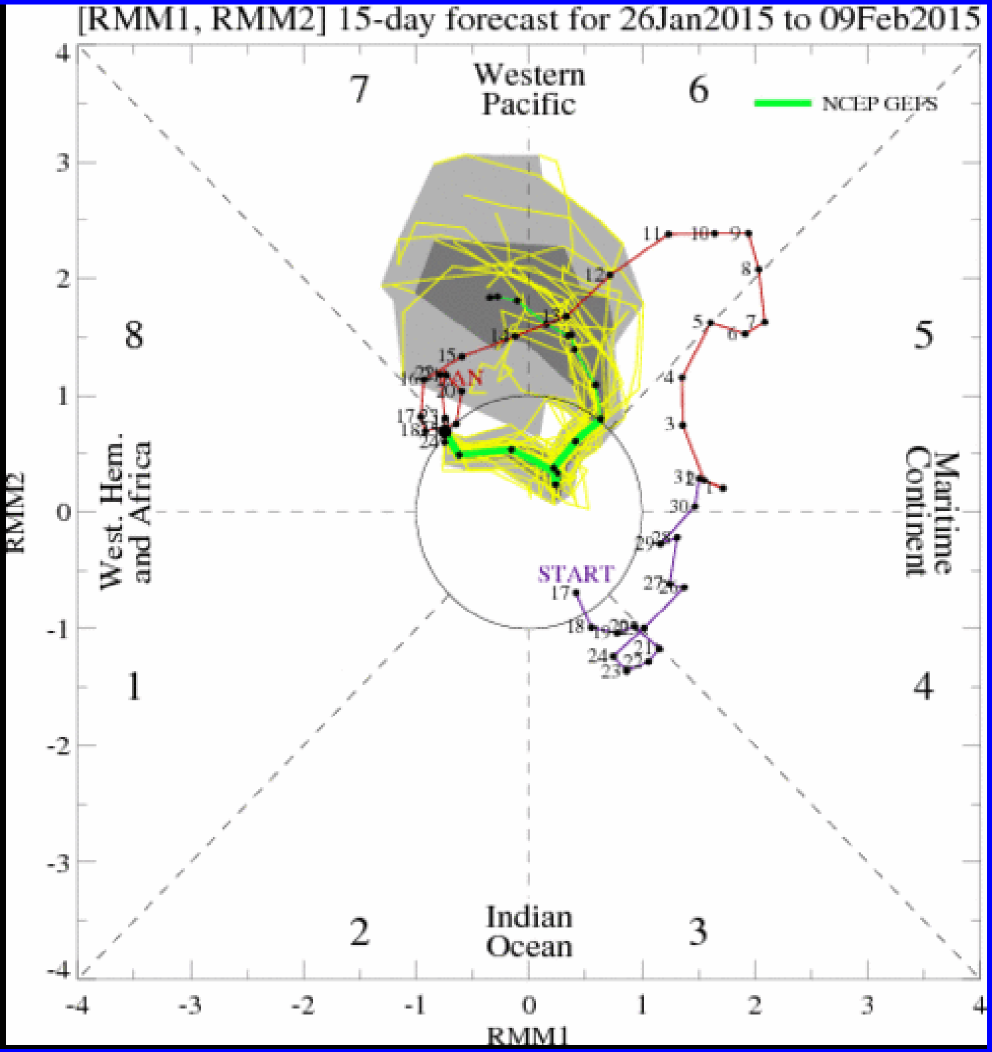
Plot puts current MJO activity in recent historical context.

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

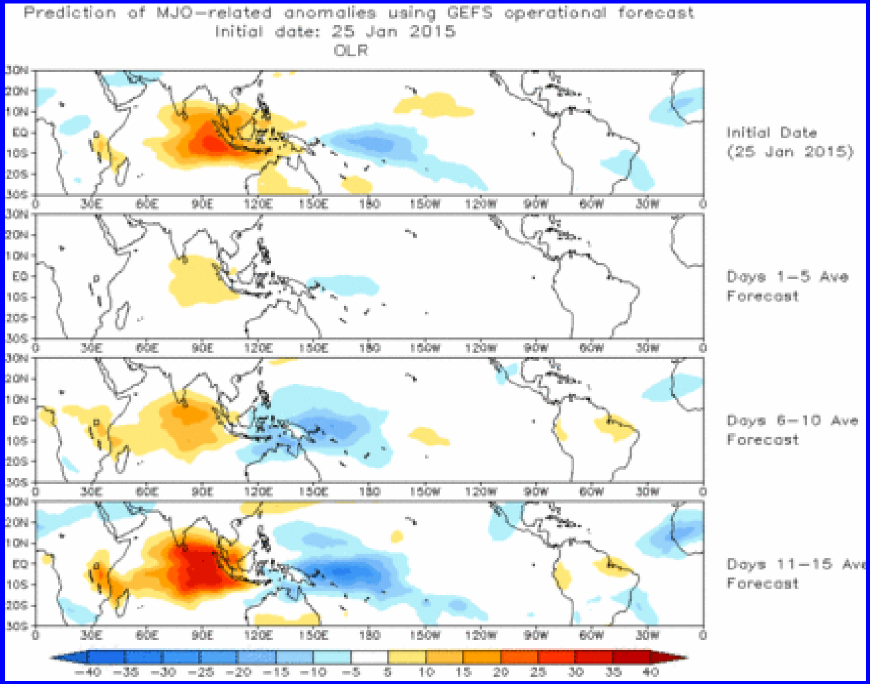


The ensemble GFS forecast indicates an incoherent westward moving signal during the next several days. The forecast does depict, however, an increase in amplitude in Week-2 centered once again across the western Pacific.

Ensemble Mean GFS MJO Forecast

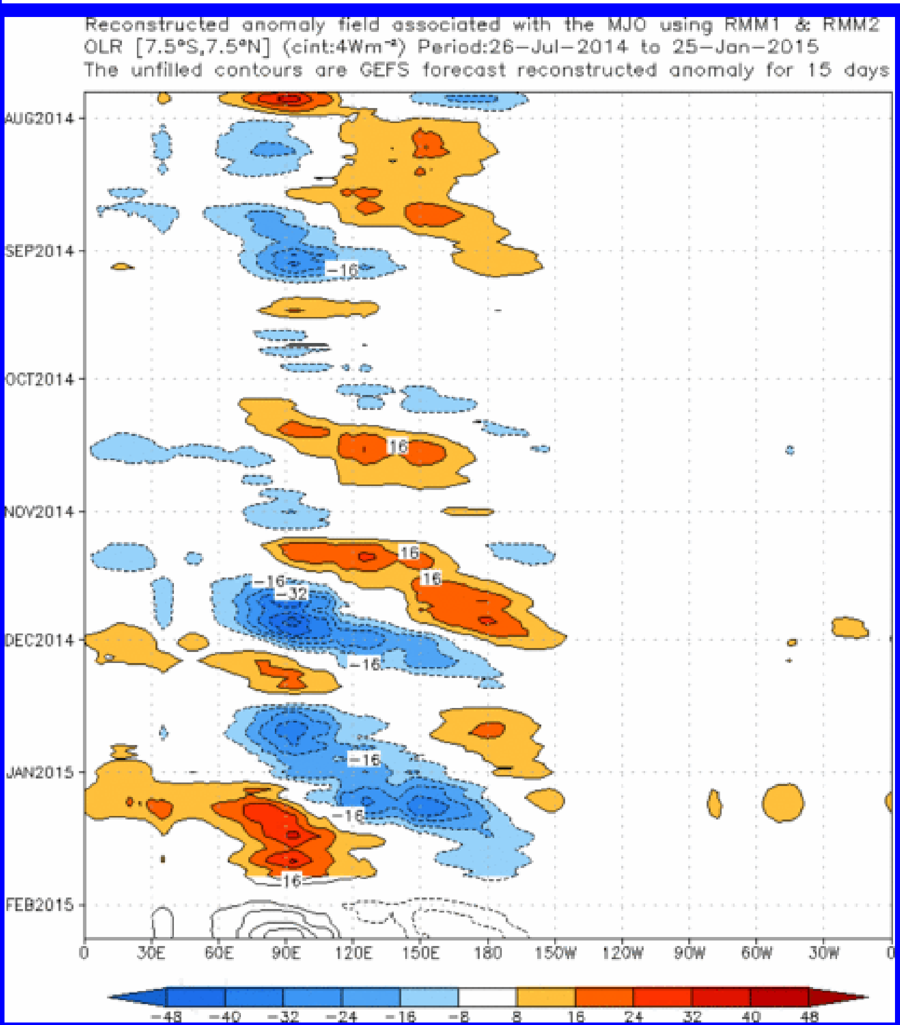
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS mean MJO index based OLR anomaly forecast depicts a weak anomalous convection during Week-1 with a dipole of suppressed (enhanced) convection developing across the Indian Ocean (far western Pacific) by Week-2.

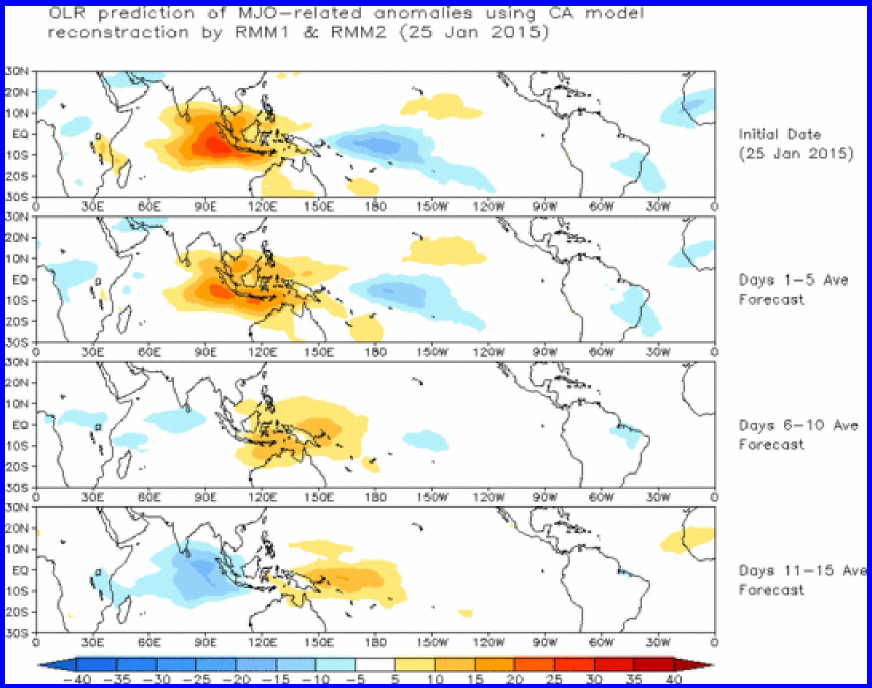
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



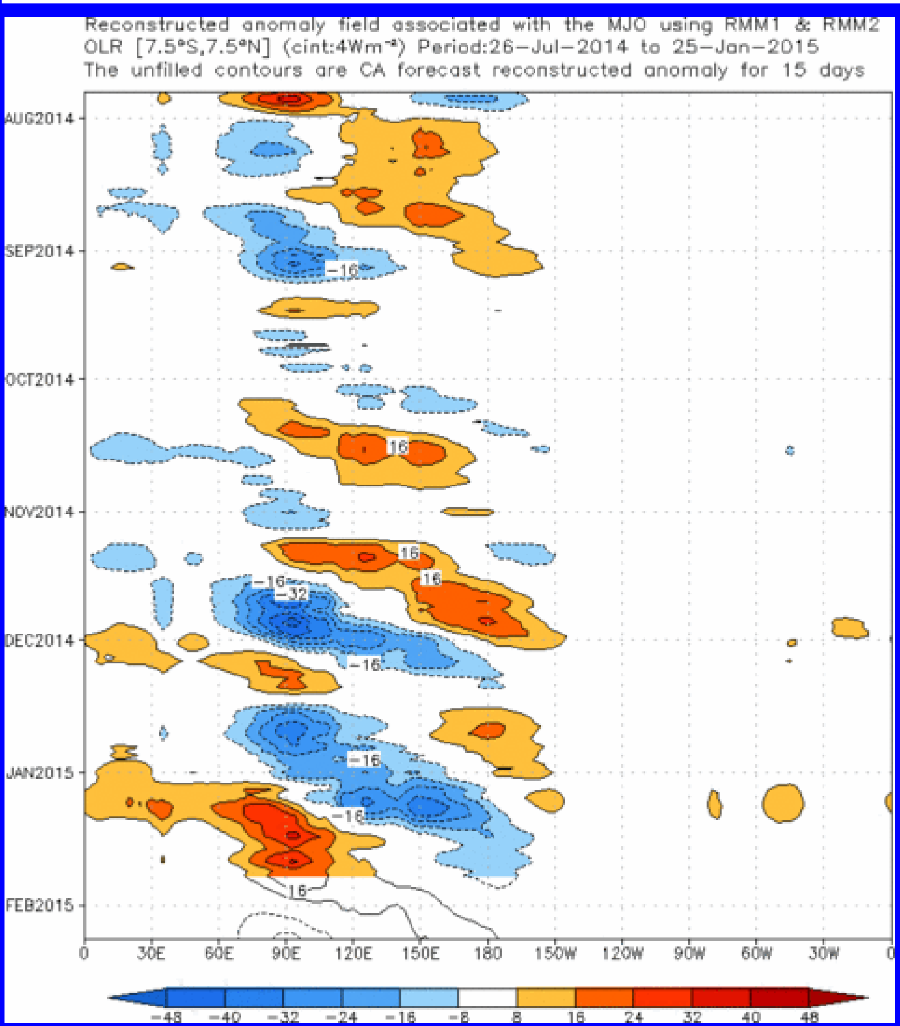
Constructed Analog (CA) MJO Forecast

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



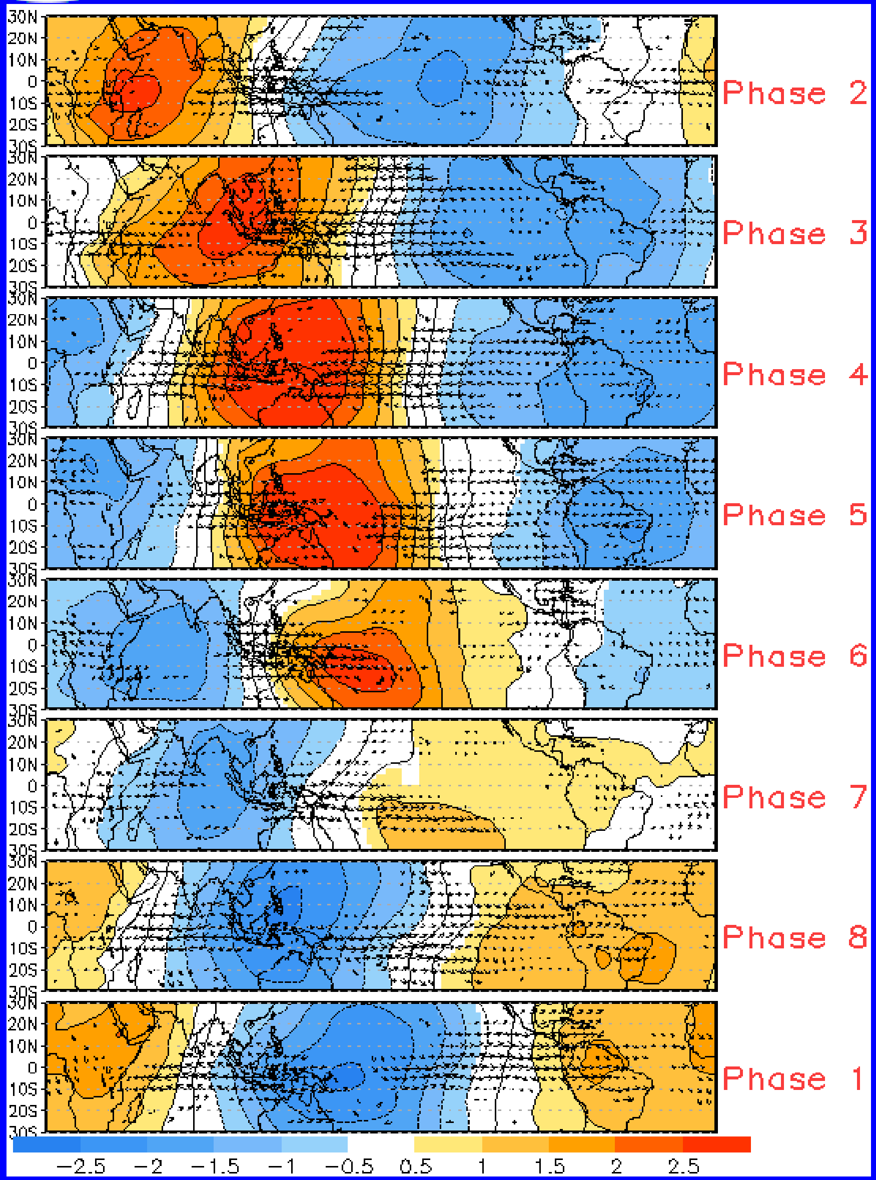
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



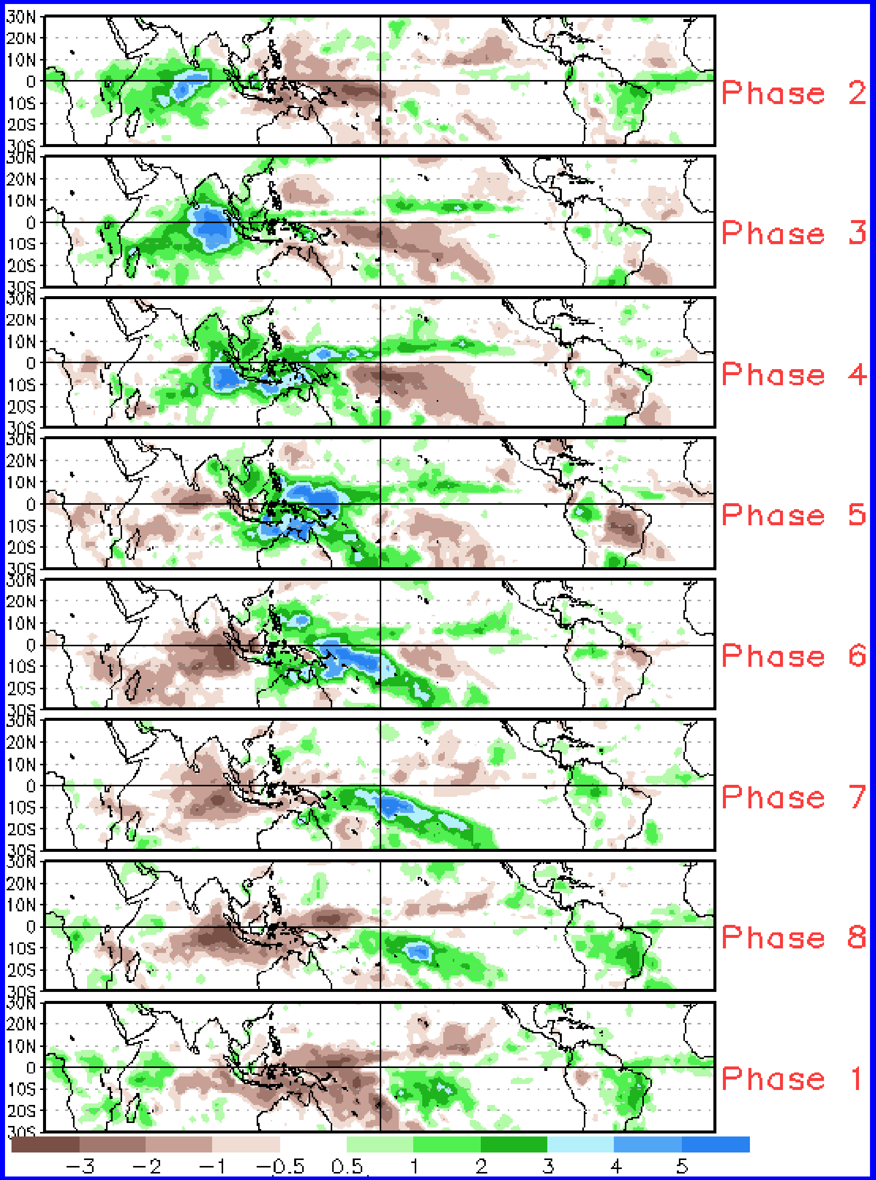
The constructed analog forecast depicts eastward propagation of weak suppressed convection from the Indian Ocean to the far western Pacific Ocean during the period. Enhanced convection is forecast to develop in the Indian Ocean by Week-2.

MJO Composites – Global Tropics

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

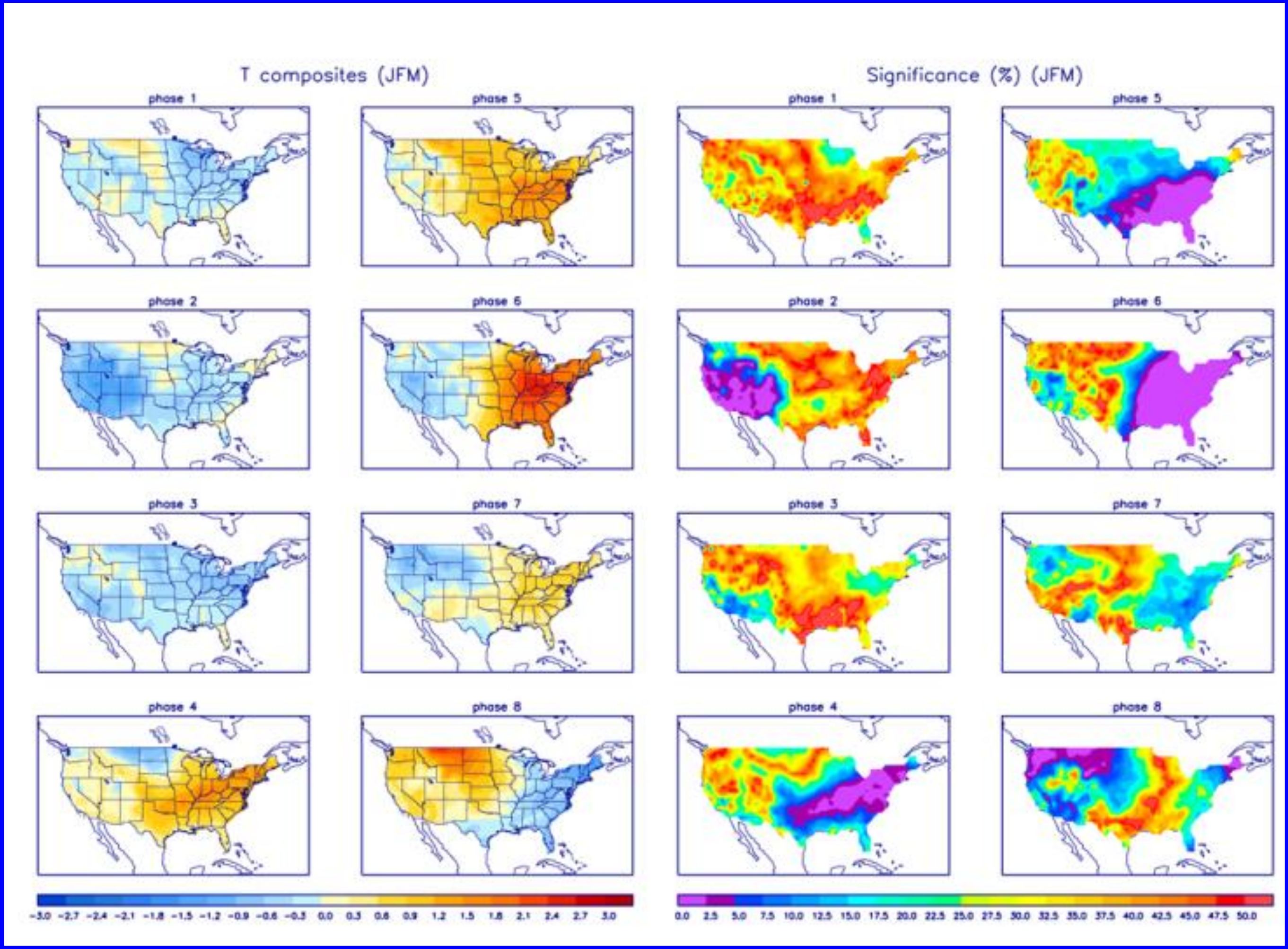


Precipitation Anomalies (Nov-Mar)



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.

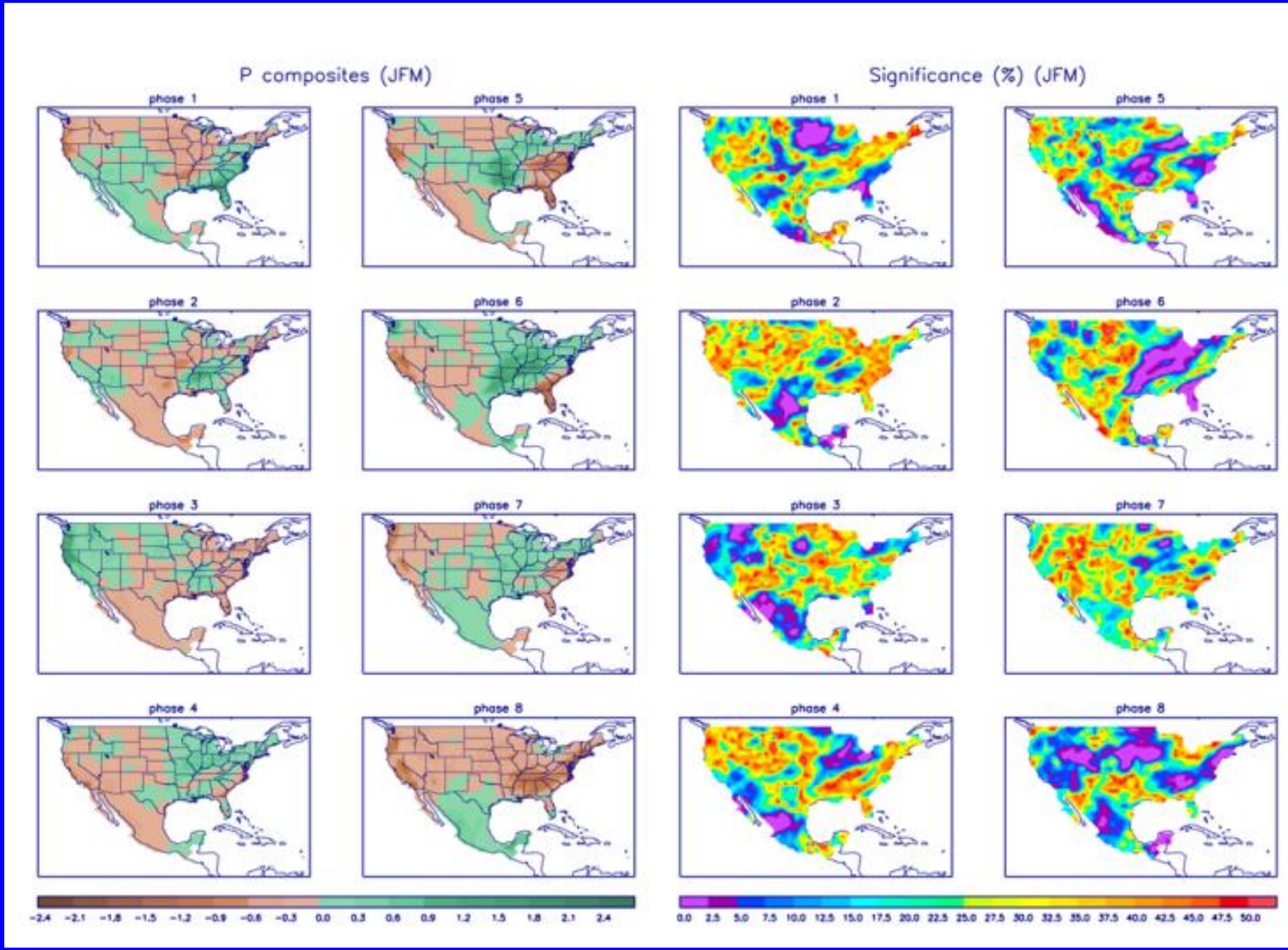


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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