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

Update prepared by
Climate Prediction Center / NCEP
December 15, 2014

Outline

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

Overview

- Although the MJO remained active during the past week, a number of observational indicators show a weakened and somewhat less coherent signal.

- The upper atmosphere portion of the signal remains the most coherent with the enhanced phase shifting quickly eastward and is now centered over the Atlantic Ocean.

- Dynamical model MJO index forecasts depict continued fast eastward propagation of a weak signal with a potential more robust signal emerging across the Indian Ocean during Week-2.

- The MJO is forecast to remain active with any potential impacts primarily during the later portion of the outlook period and include favored enhanced (suppressed) convection for the Indian Ocean (western Pacific) during Week-2.

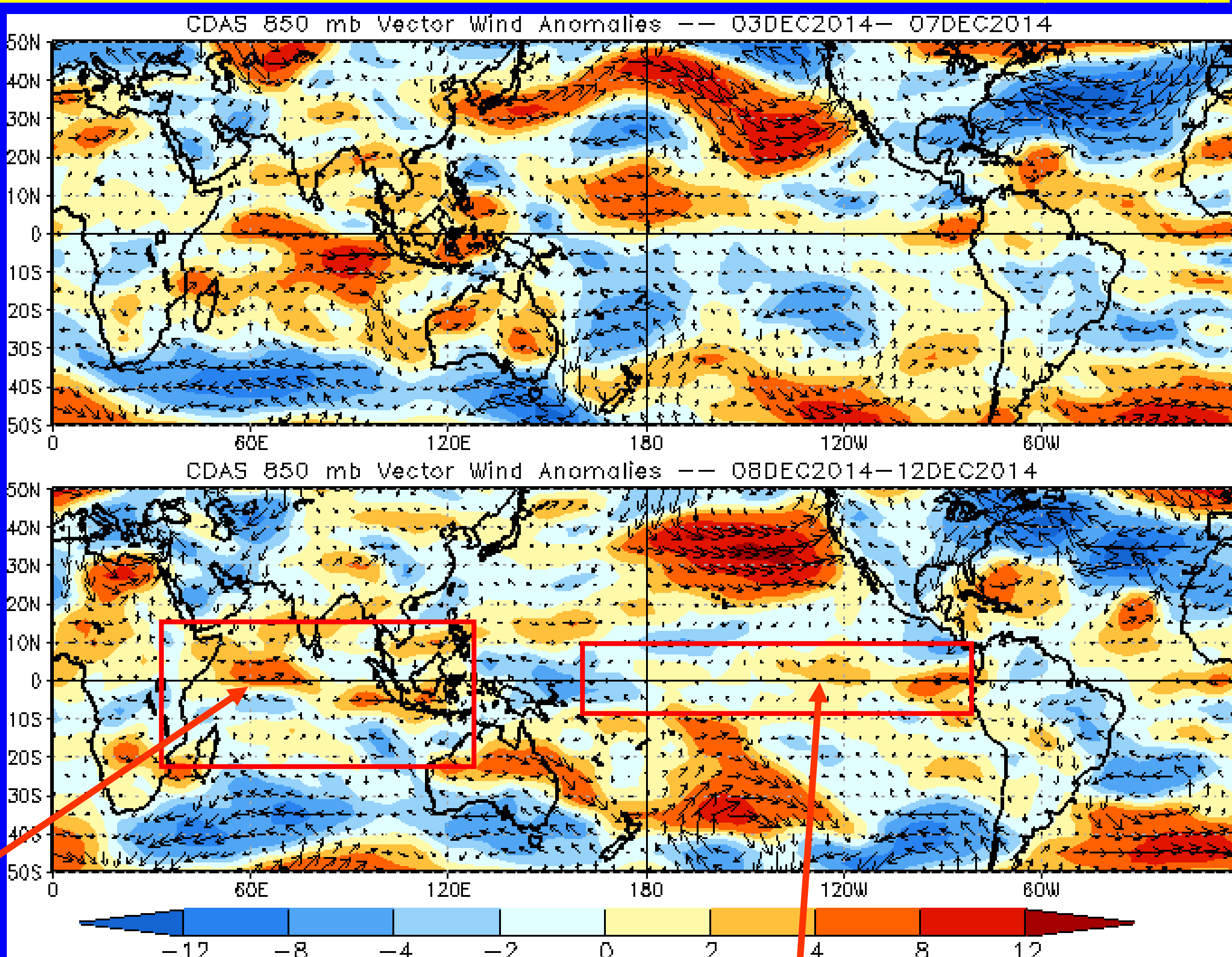
A forecast map of potential impacts across the global Tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies across the Indian Ocean and western Maritime continent decreased in strength and coverage with no eastward propagation during the most recent five day average.

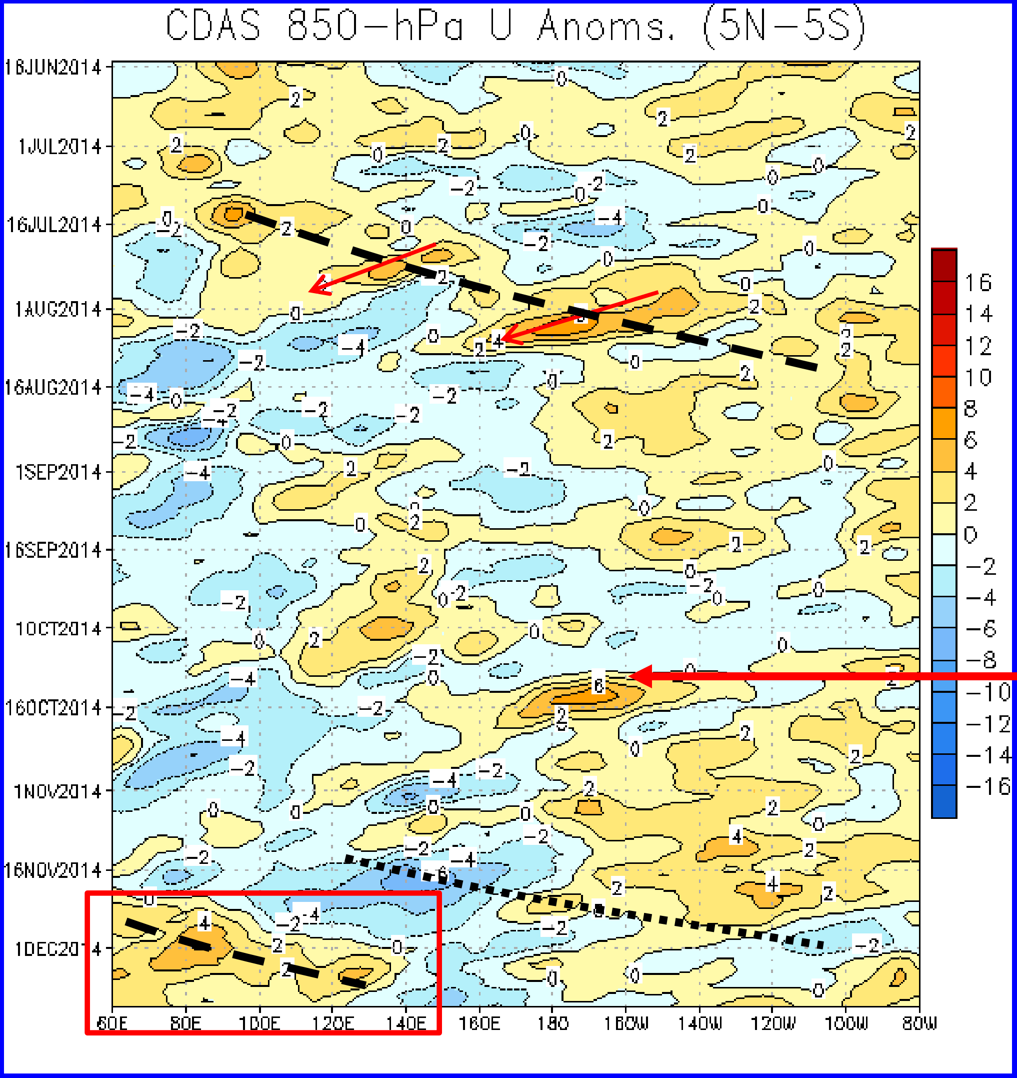
Winds across the equatorial Pacific did not change over the most recent five days.

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



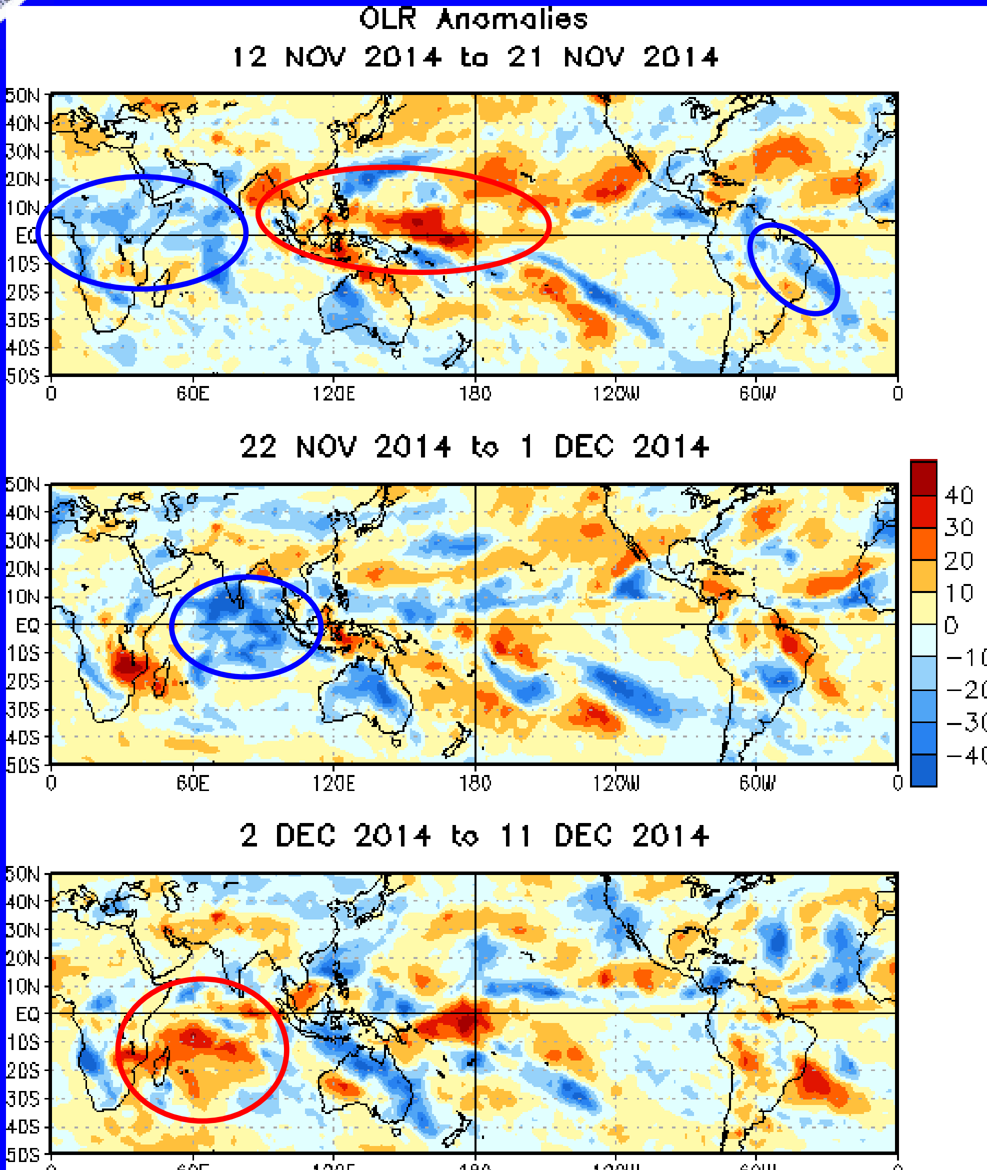
Longitude

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 were frequent and strong westward moving high frequency features (red lines). over the eastern and central Pacific (western Pacific, Maritime Continent, and Indian Ocean).

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

Recently, moderate westerly anomalies have entered the Indian Ocean and have slowly propagated eastward (red box). MJO activity has contributed to a shift from westerly to easterly anomalies in the east Pacific (dashed 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)

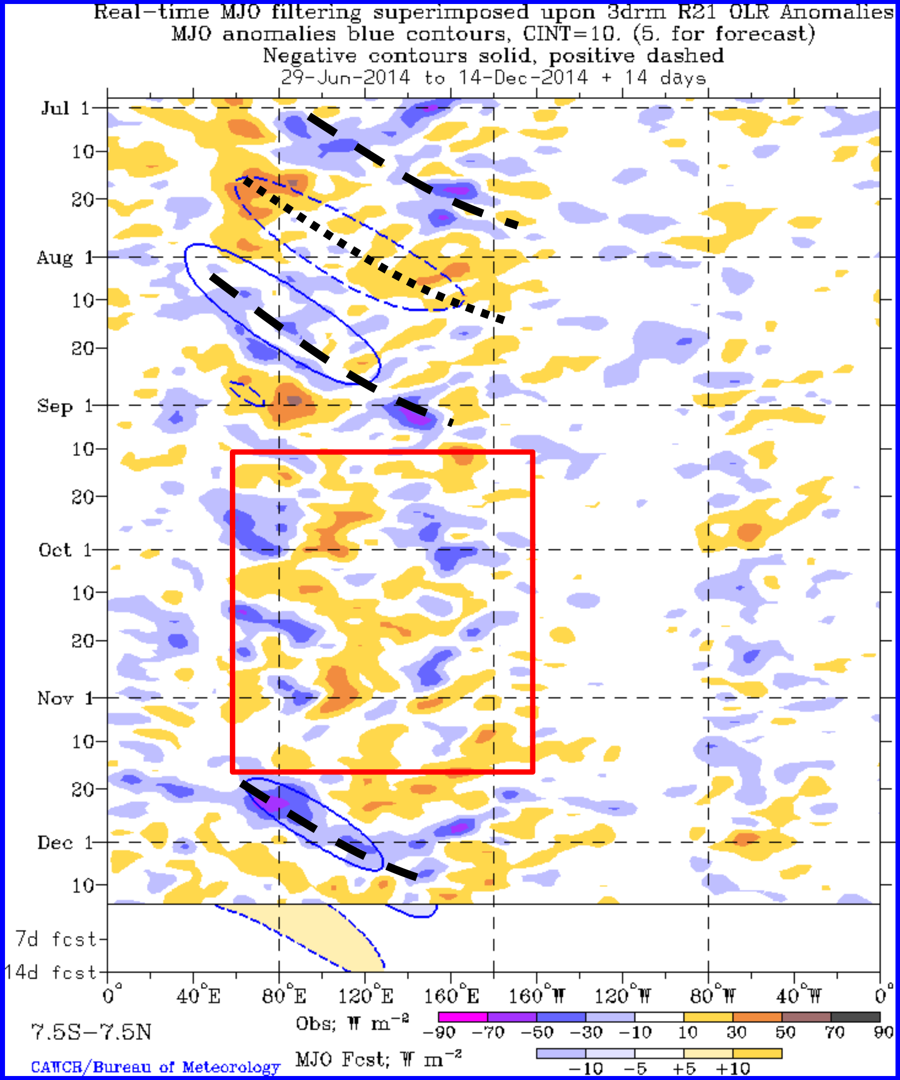
Widespread enhanced convection developed from Africa to the western Indian Ocean, while suppressed convection stretched from the Maritime Continent to the west-central Pacific, resulting in a more coherent pattern as the MJO strengthened.

By early December, the MJO shifted eastward so that enhanced convection was centered over the Indian Ocean. Anomalous convection was generally weak across the central Pacific as the MJO and El Nino like base state destructively interfered.

During early-to-mid December, the pattern of anomalous convection became considerably less organized as the MJO strength has decreased. Some suppressed convection was observed over portions of the Indian Ocean.

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)

The MJO became more organized during July and 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).

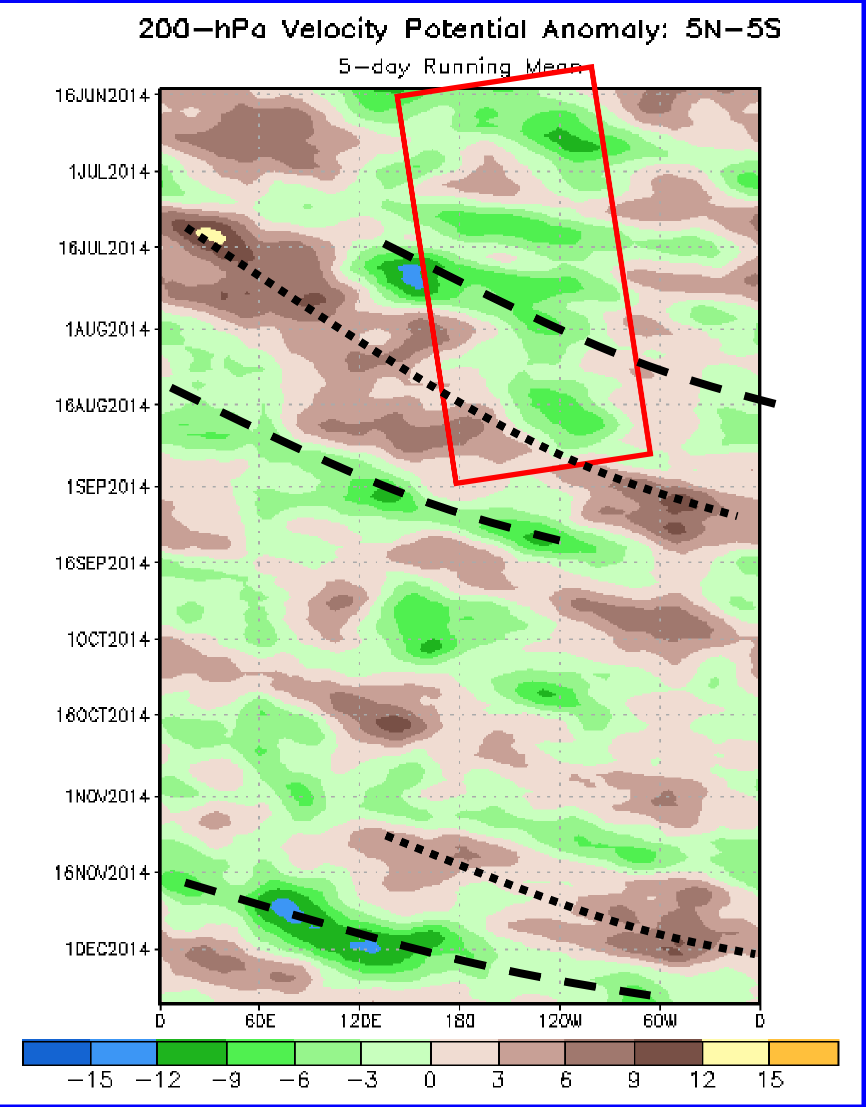
The MJO strengthened in late November as shown by enhanced convection shifting from the Indian Ocean to near 160E by early December (dashed line) and weakly suppressed convection entering the Indian Ocean.

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

A slow eastward progression of negative anomalies was observed during the late spring and summer across the Indo-Pacific warm pool and central-eastern Pacific (red box).

The pattern became more organized during July as the MJO strengthened at this time (dashed and dotted lines) as a more coherent "Wave-1" canonical MJO-like structure developed and shifted eastward with time.

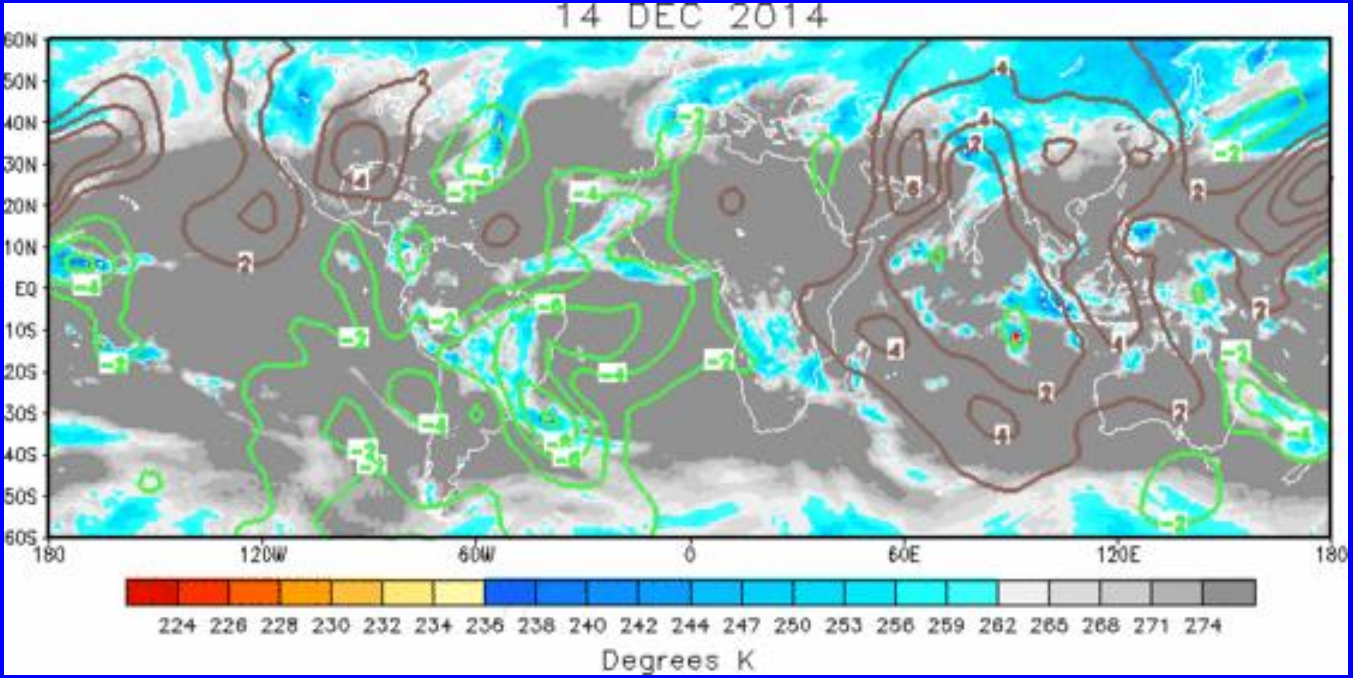
The MJO weakened and remained incoherent through September and October.

During November the MJO strengthened as indicated by eastward propagation of anomalies with the enhanced phase entering the west-central Pacific by early December.

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



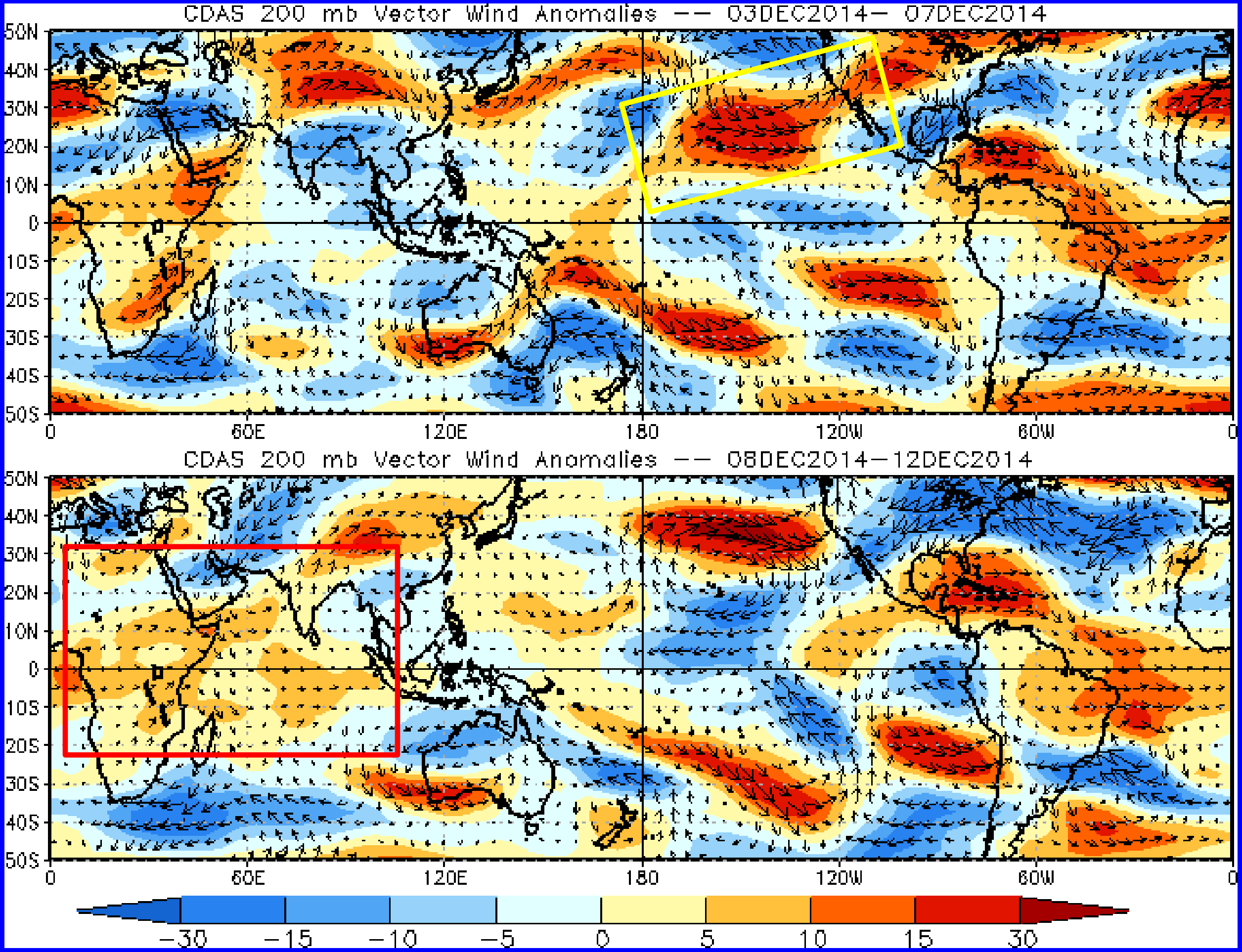
The upper-level anomalous velocity potential spatial pattern continues to remain somewhat coherent but has shifted eastward extremely quickly during the past week. Anomalous divergence is now located over the Americas, the Atlantic and Africa while anomalous convergence is now already centered over the Maritime Continent.

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 have shifted eastward to include Africa and the Indian ocean during the most recent five days (red box).

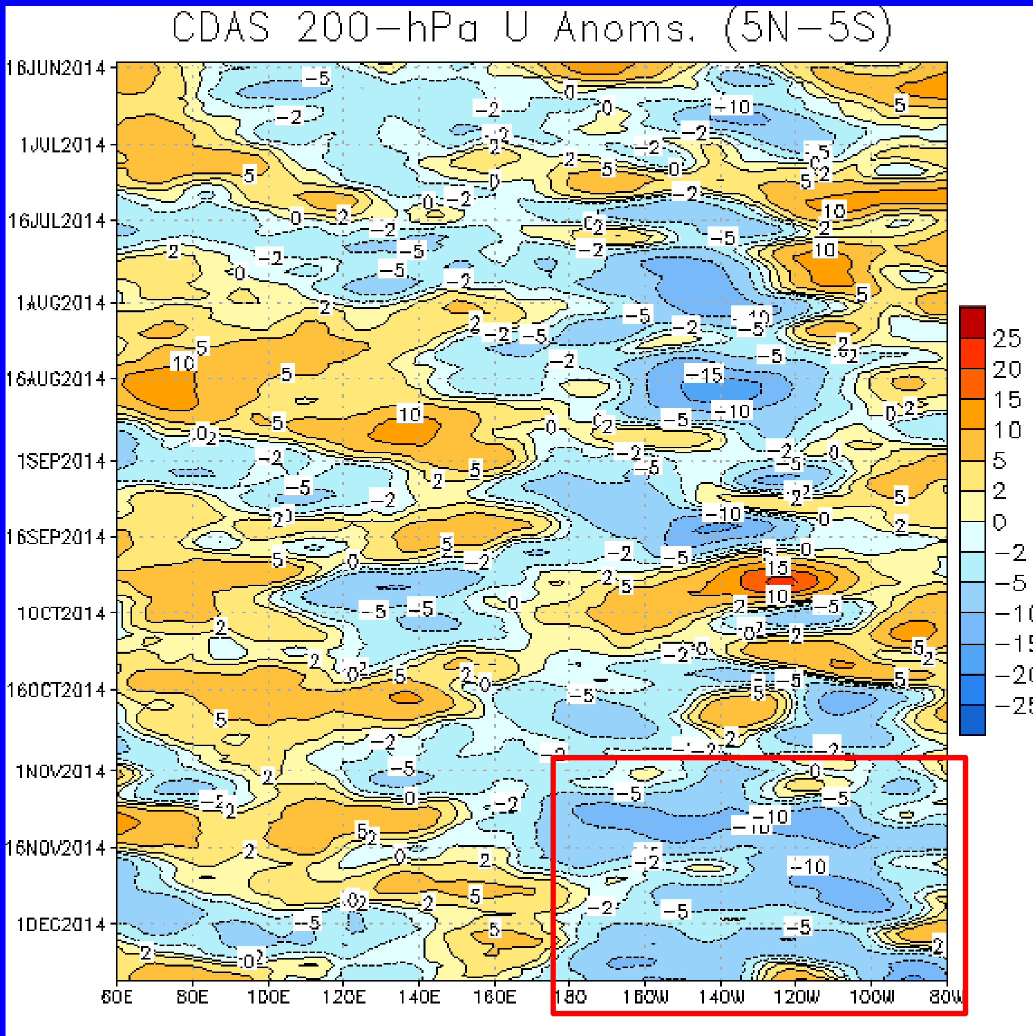
A strong anomalous trough is also noted from the central Pacific sub-Tropics to the southwest U.S. (yellow box) during the previous five days.

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

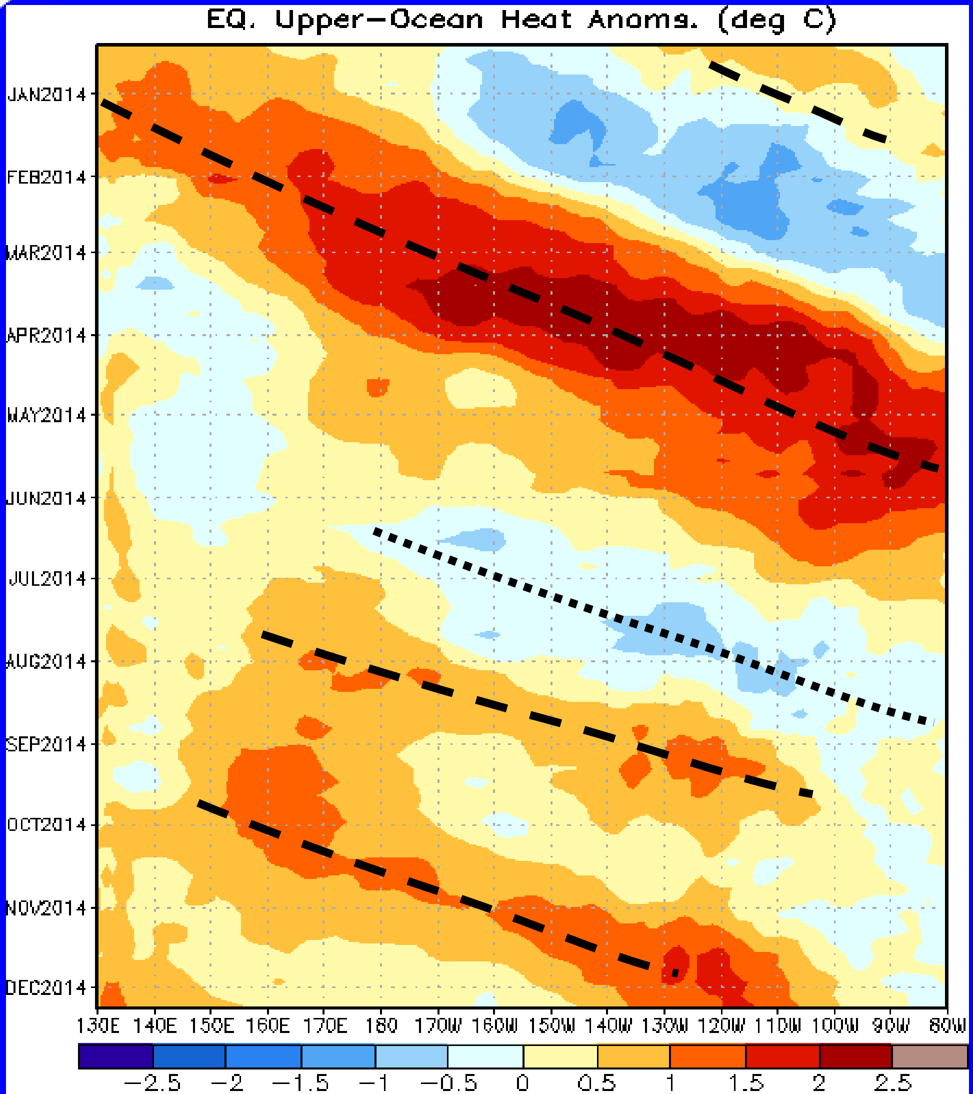
Westward propagation of westerly anomalies is evident over the east-central Pacific during June. In July, easterly anomalies intensified over the central and eastern Pacific.

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

Most recently, easterly wind anomalies persisted east of the Date Line (red box).

Weekly Heat Content Evolution in the Equatorial Pacific

Time



Longitude

Oceanic downwelling Kelvin wave activity is evident during October through December 2013 across the east Pacific Ocean (dashed line).

A considerably stronger 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 are again evident across much of the Pacific basin due to another moderate downwelling Kelvin wave traversing the Pacific during October and November 2014.

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).

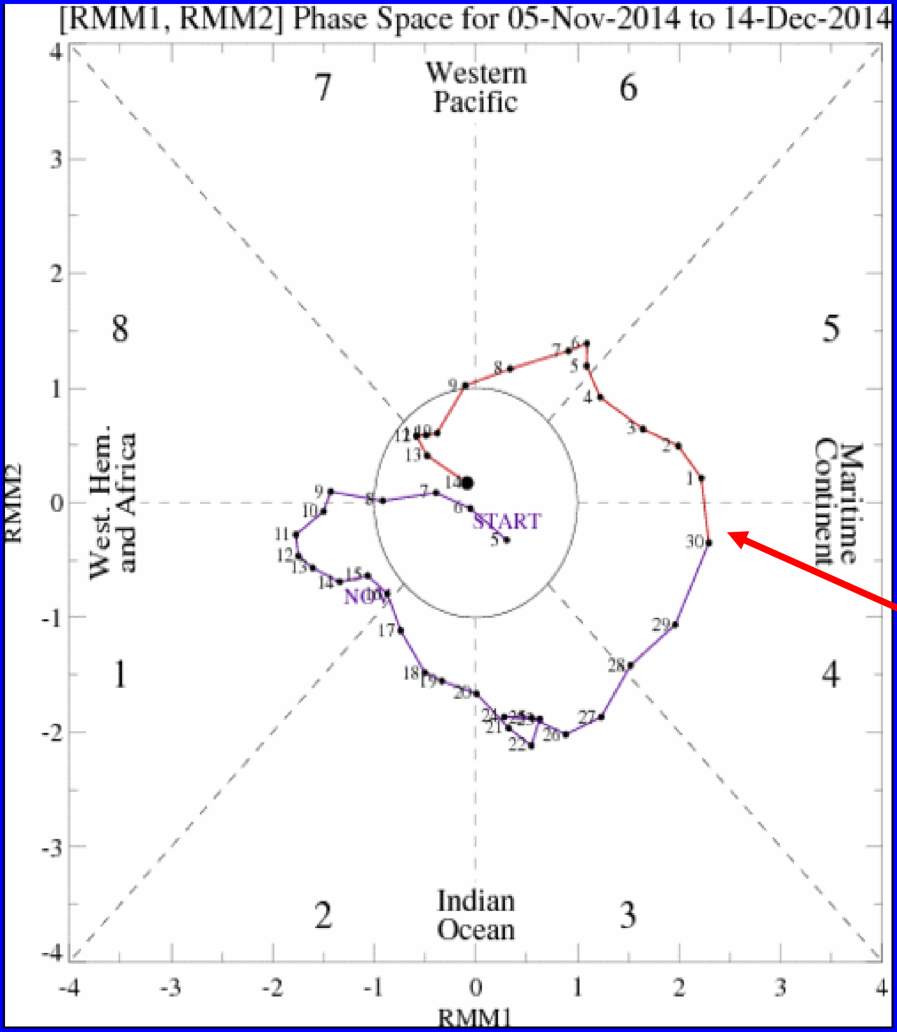
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

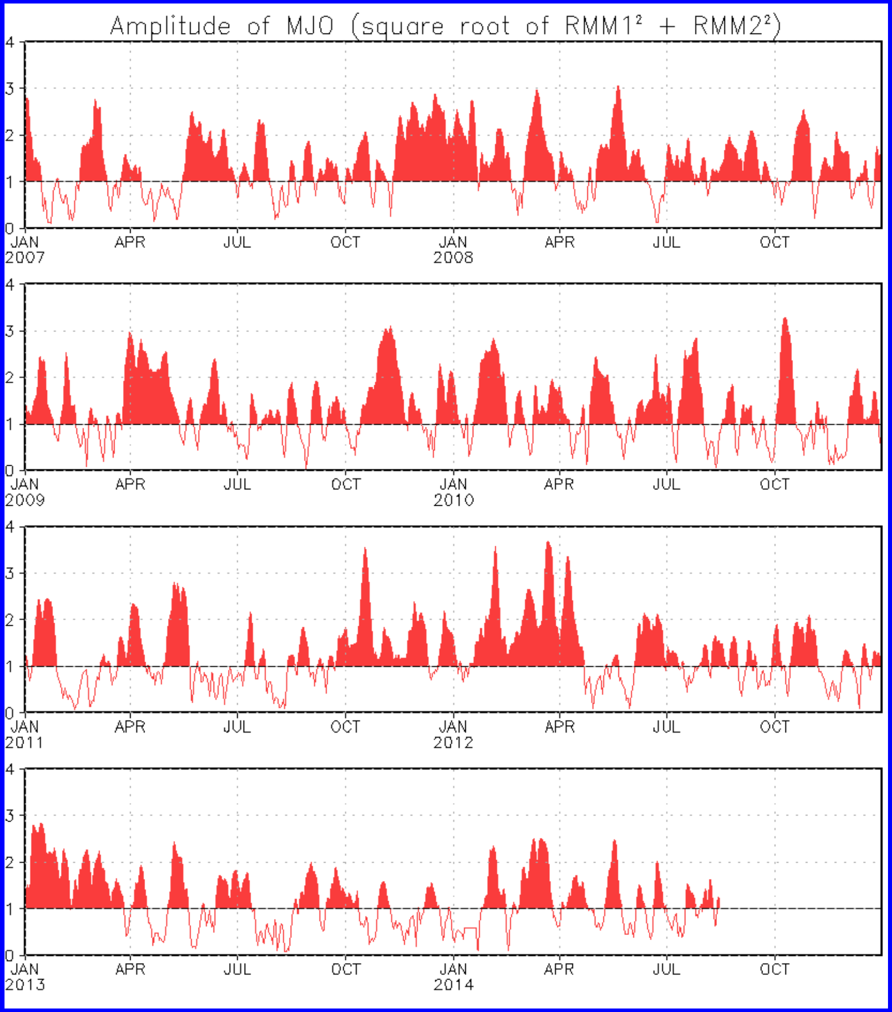
MJO Index -- Recent Evolution



- 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 depicts MJO activity during November into December. The amplitude has decreased over the past several days with any enhanced phase now centered over the Atlantic Ocean.

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.

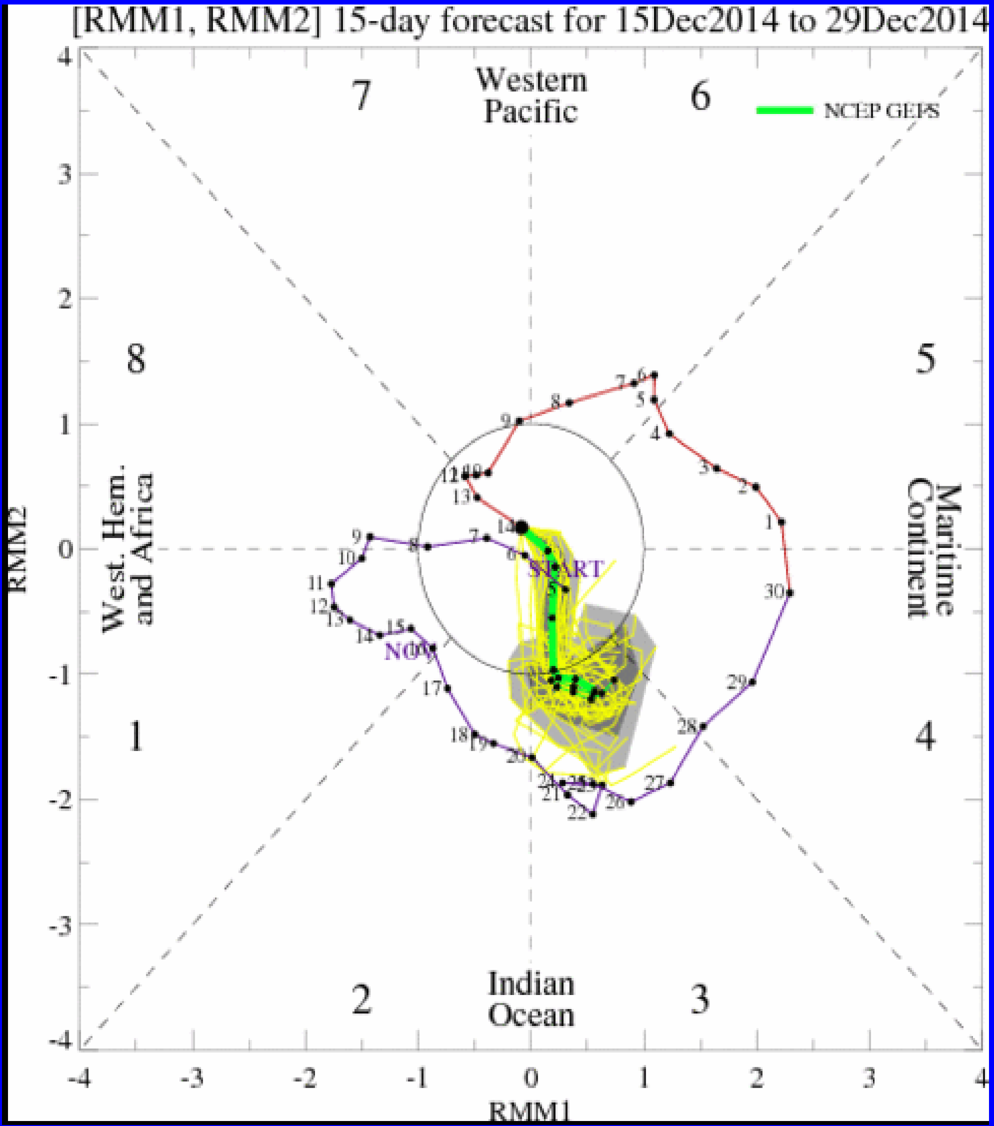
Ensemble GFS (GEFS) MJO Forecast

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

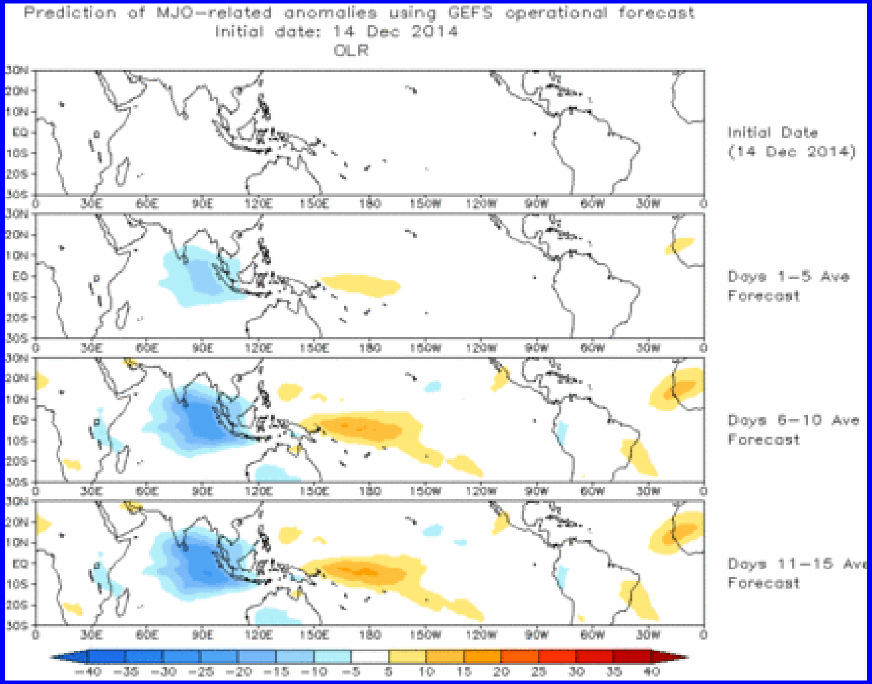
The ensemble GFS forecast indicates weak amplitude over the next week with an increase in the signal during Week-2 over the Indian Ocean.



Ensemble Mean GFS MJO Forecast

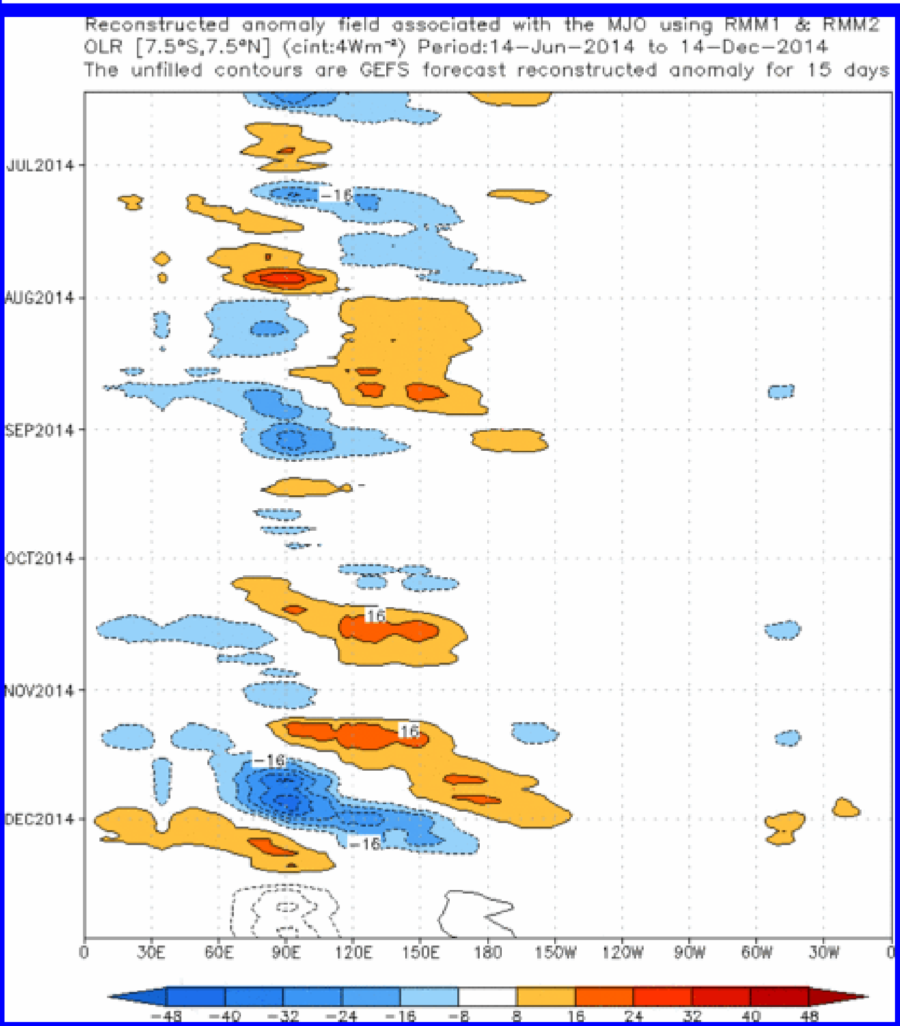
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS mean MJO index based OLR anomaly forecast depicts an increase in convection over the Indian Ocean entering Week-2. Suppressed convection increases over the western Pacific at the same time.

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

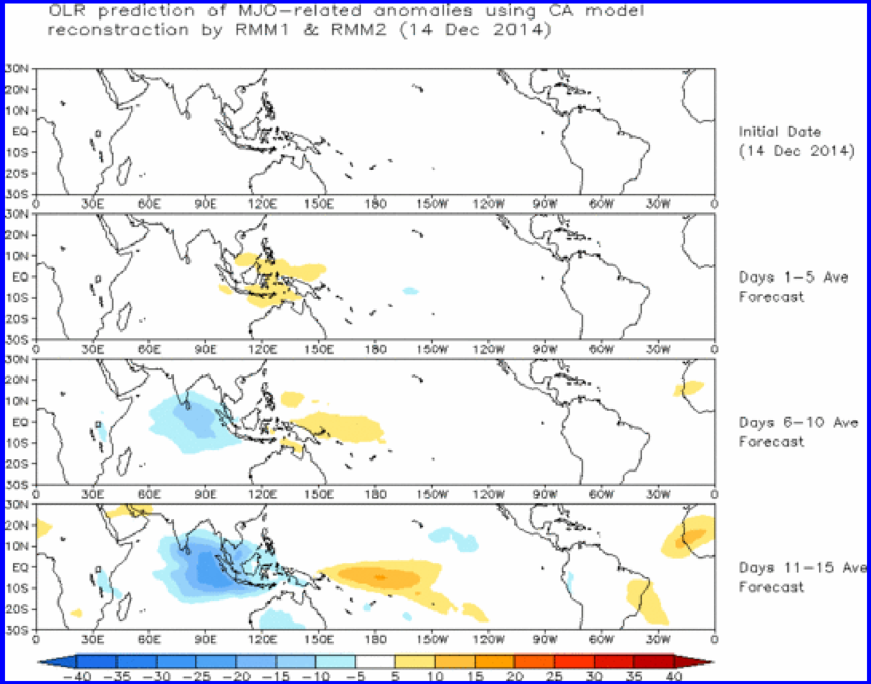


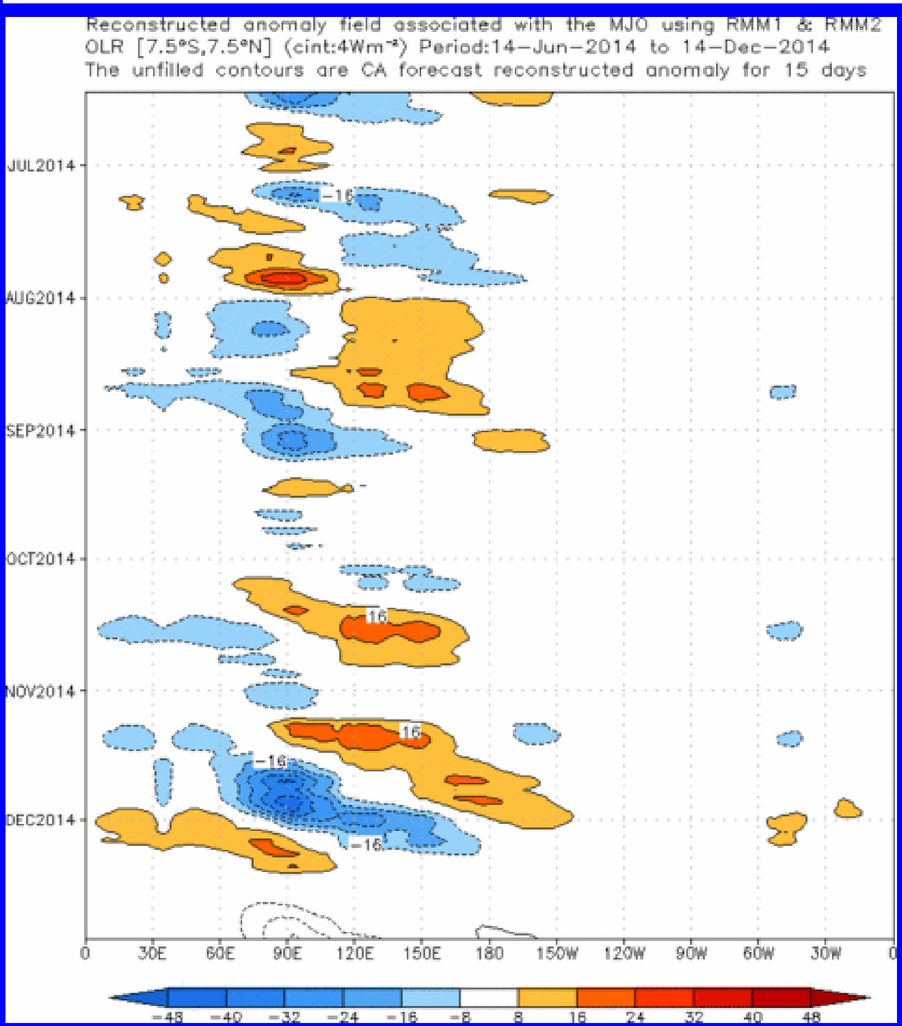
Constructed Analog (CA) MJO Forecast

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



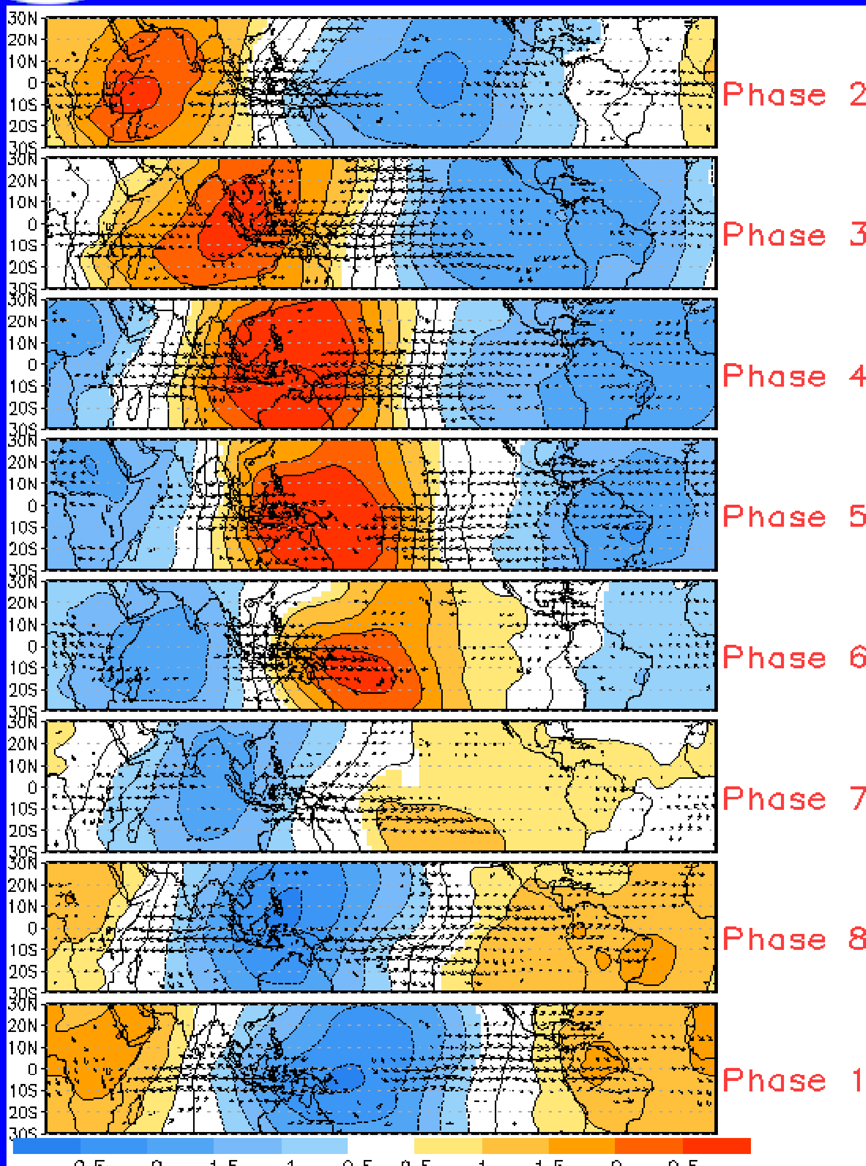


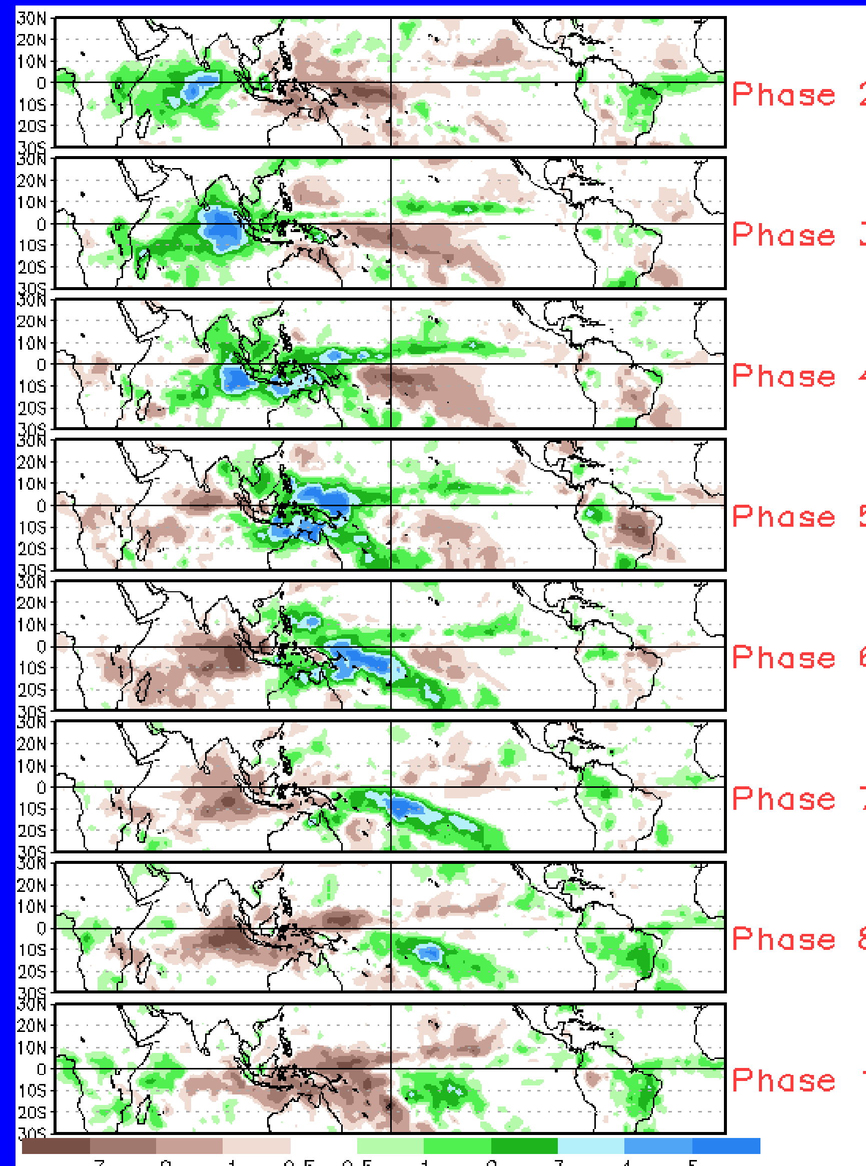
The constructed analog forecast depicts a weak eastward propagating signal over the period with enhanced convection developing in the Indian Ocean during Week-2.

MJO Composites – Global Tropics

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

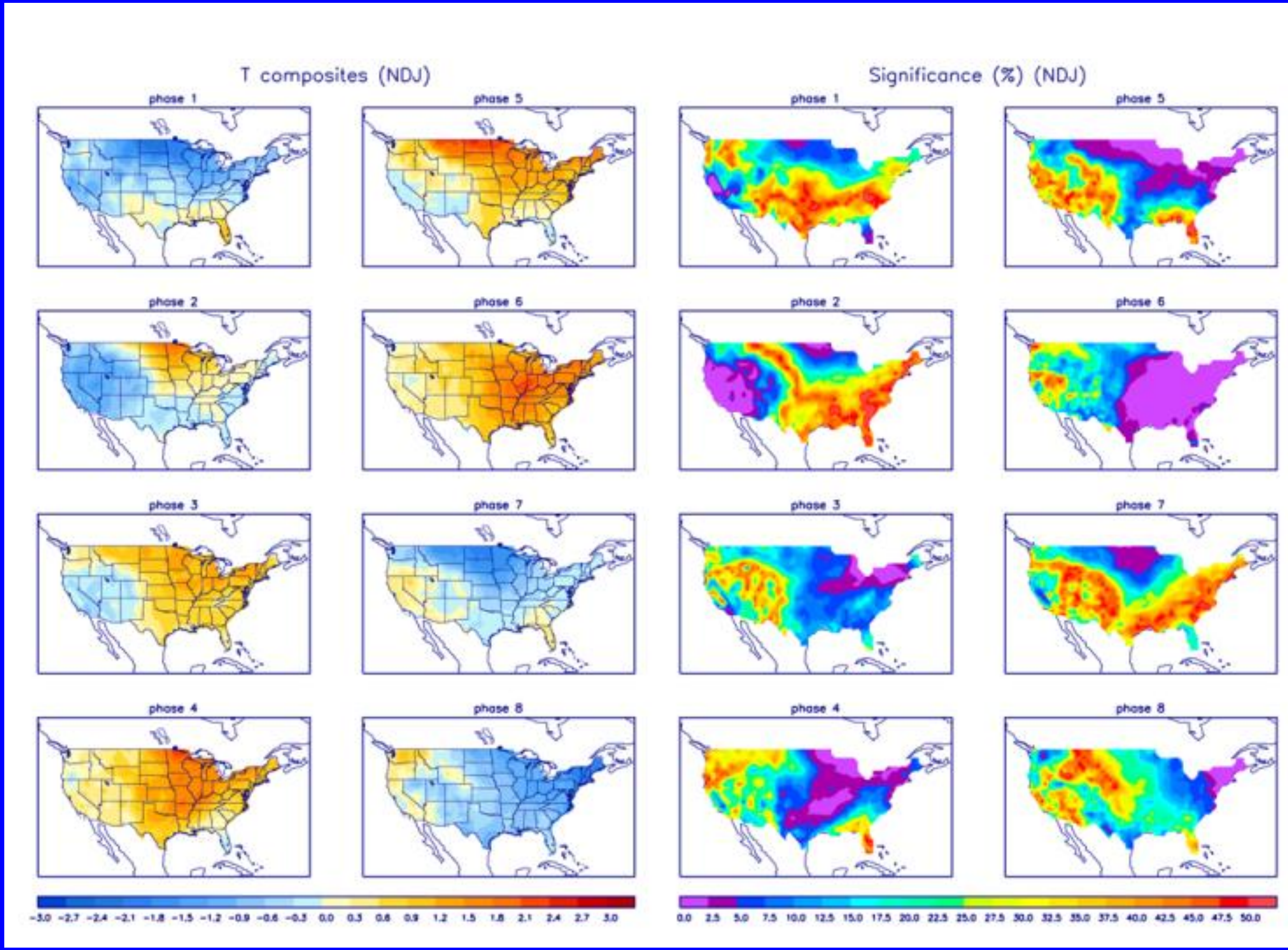
Precipitation Anomalies (Nov-Mar)





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.**

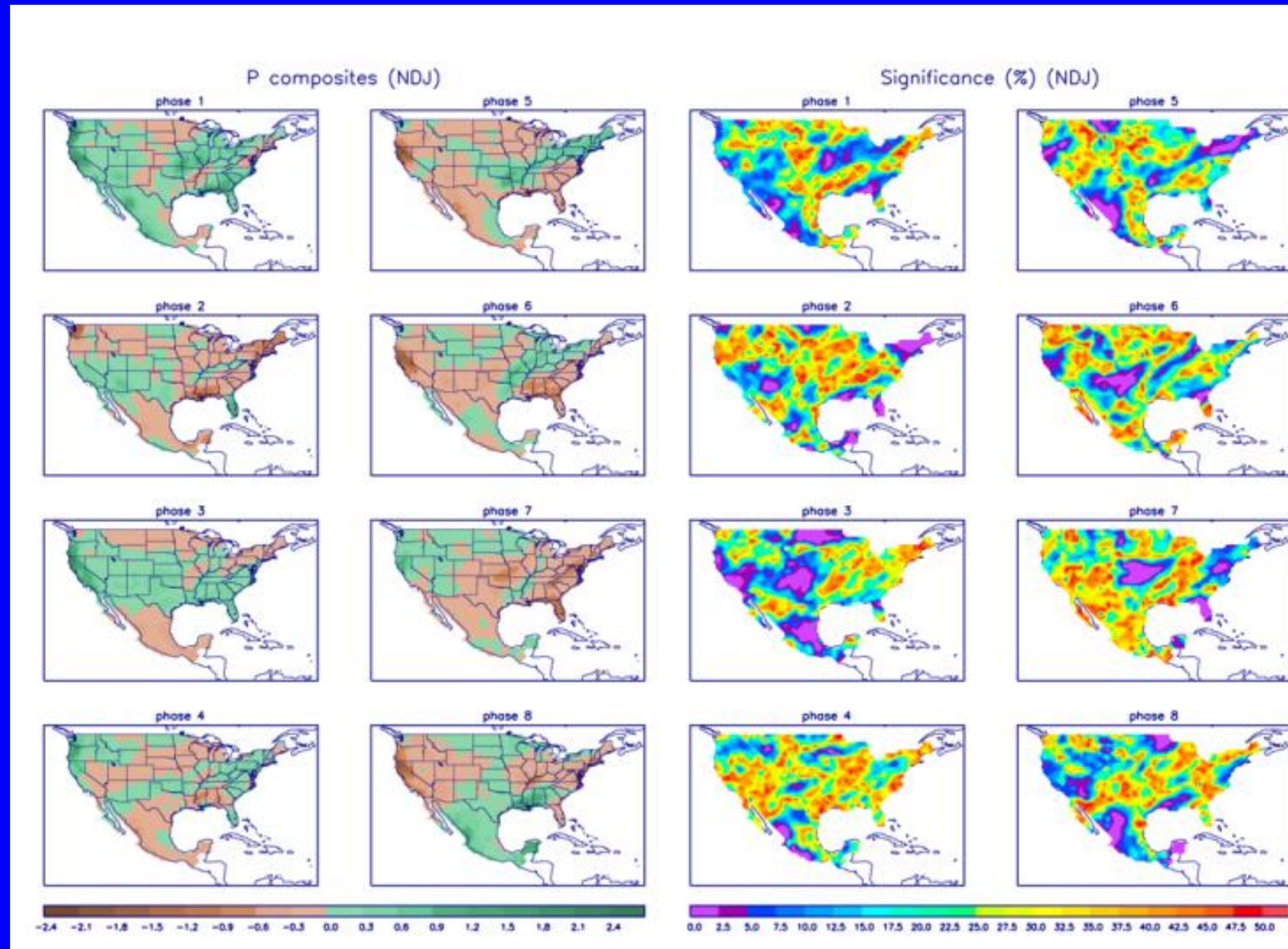


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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