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

Update prepared by
Climate Prediction Center / NCEP
December 8, 2014

Outline

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

Overview

- The MJO remained active during the past week with the enhanced convective phase now nearing the west-central Pacific Ocean. Other subseasonal tropical variability continues to modulate this MJO activity.

- Most statistical and dynamical model MJO index forecasts depict continued eastward propagation of the MJO to the central Pacific during Week-1. Considerable uncertainty exists in the guidance for the Week-2 period, where the majority of forecasts decrease the amplitude of the MJO signal.

- The MJO is forecast to remain active during the outlook period with the MJO favoring enhanced (suppressed) convection for the western and central Pacific (Indian Ocean and western Maritime Continent). Confidence in these impacts is less during the Week-2 period.

- There is an elevated risk for tropical cyclogenesis for areas in the western Pacific and southern Indian Ocean during the period as well.

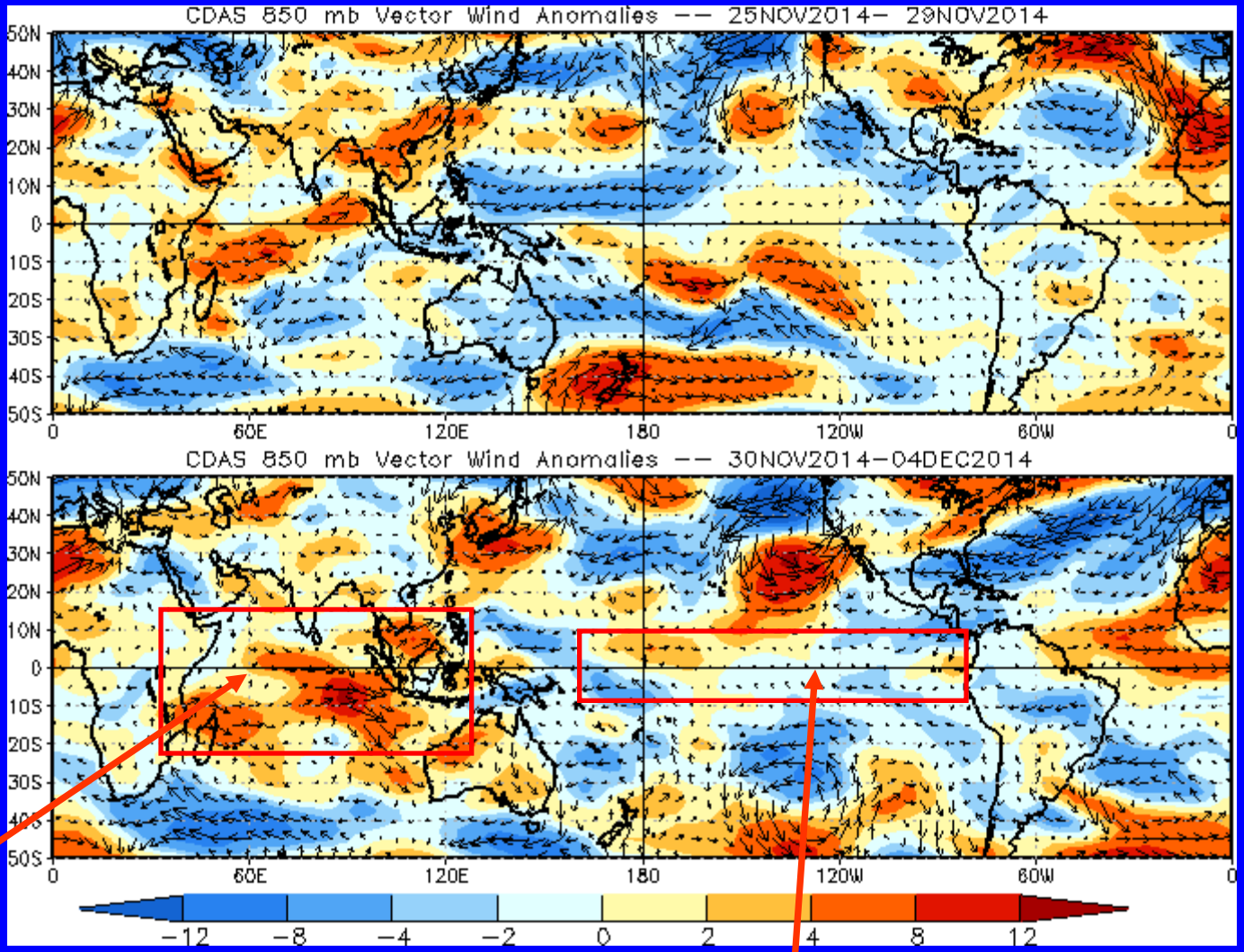
A forecast map of potential impacts across the global Tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



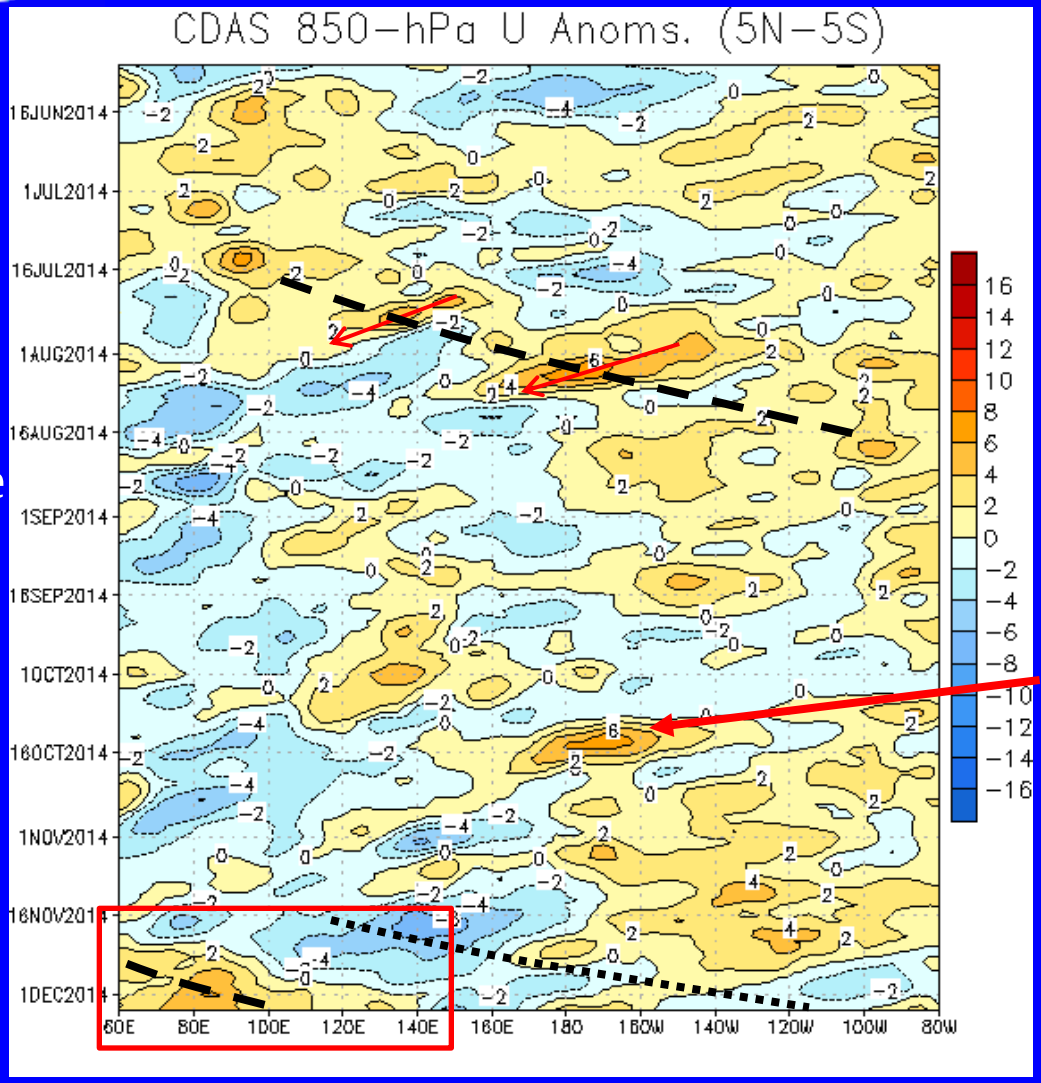
Westerly anomalies increased in strength and coverage during the most recent five day average for areas of the Indian Ocean and western Maritime continent.

Winds over the most recent five days are near average across most of the equatorial 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

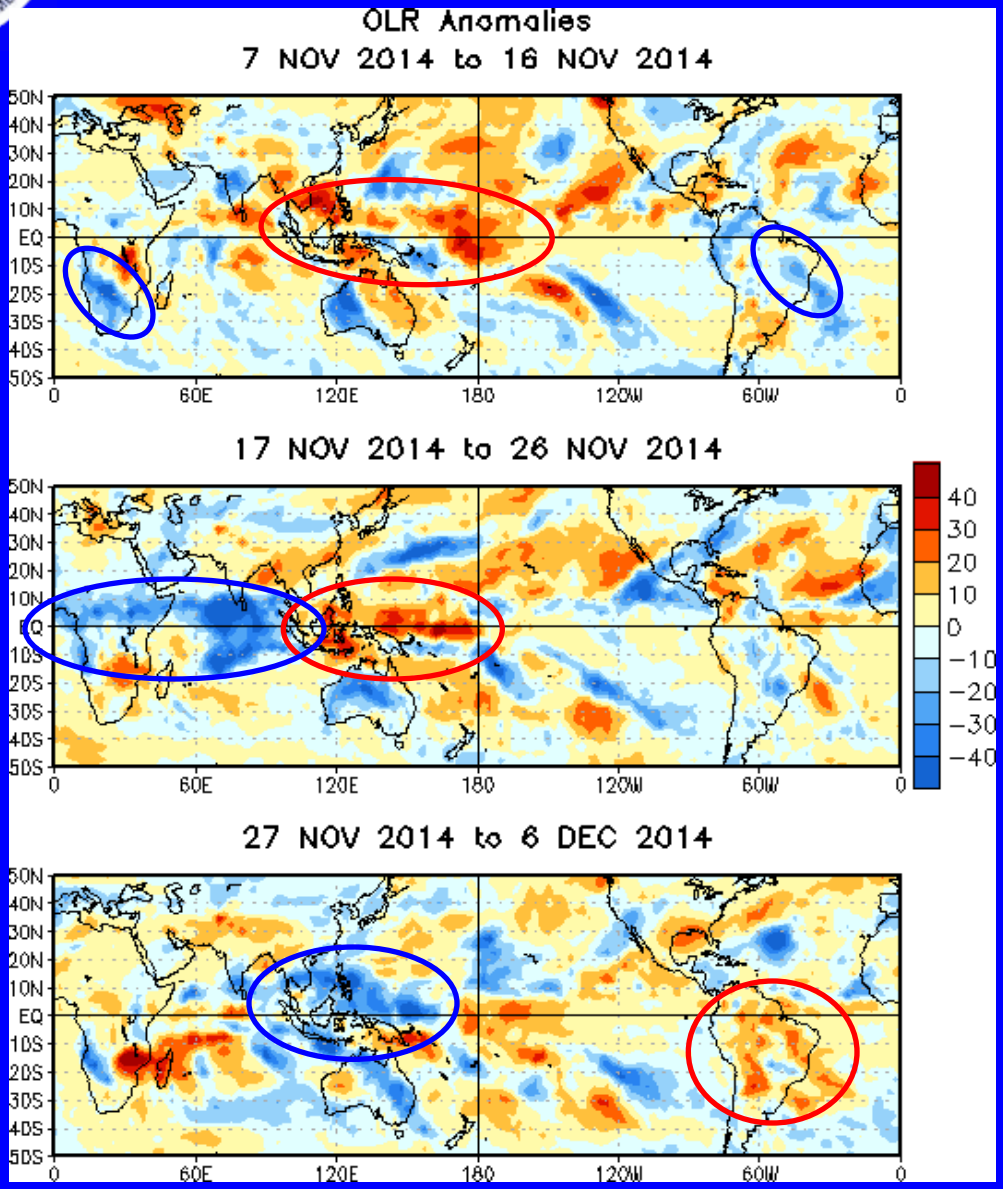
Longitude

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 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)

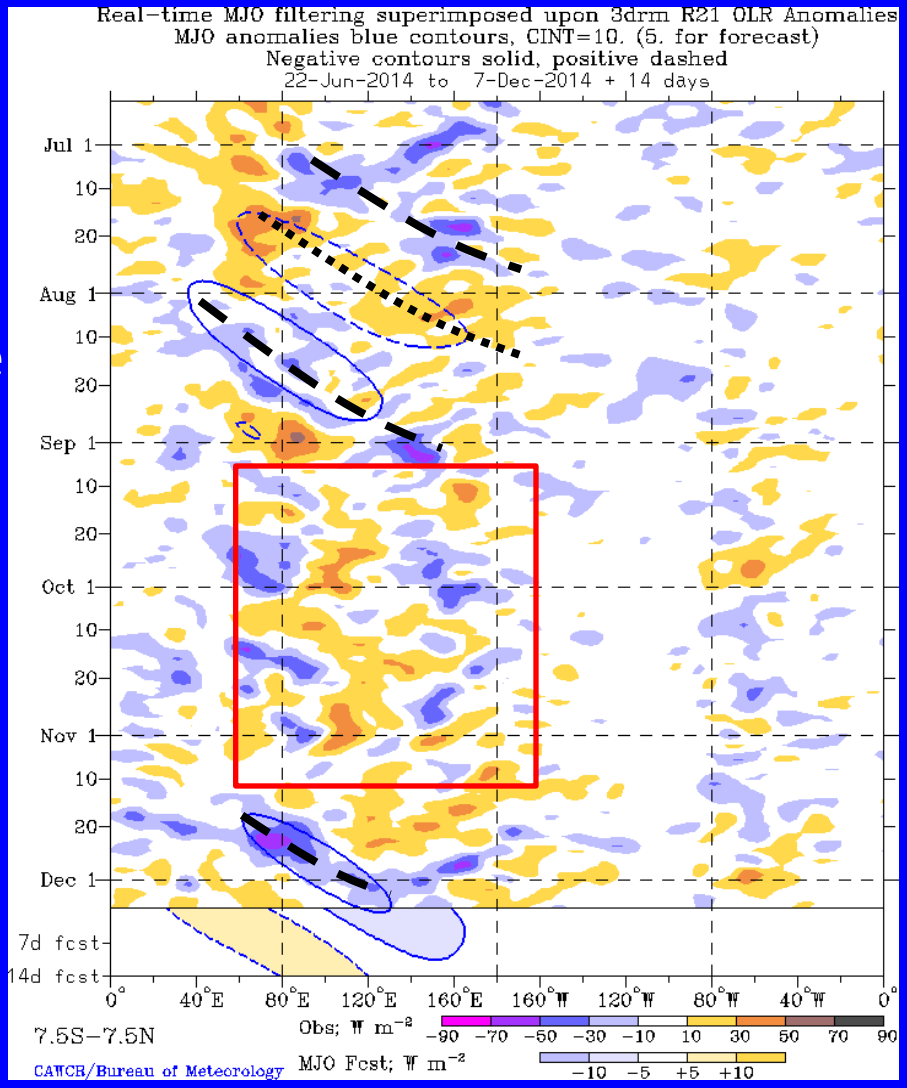
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During early to mid November, suppressed convection prevailed across most of the Maritime Continent and Pacific basin. Enhanced convection was confined to smaller regions in southern Africa and South America.

Widespread enhanced convection developed from Africa to the 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 Maritime continent. Anomalous convection was generally weak across the central Pacific as the MJO and El Nino like base state constructively interfered.

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).

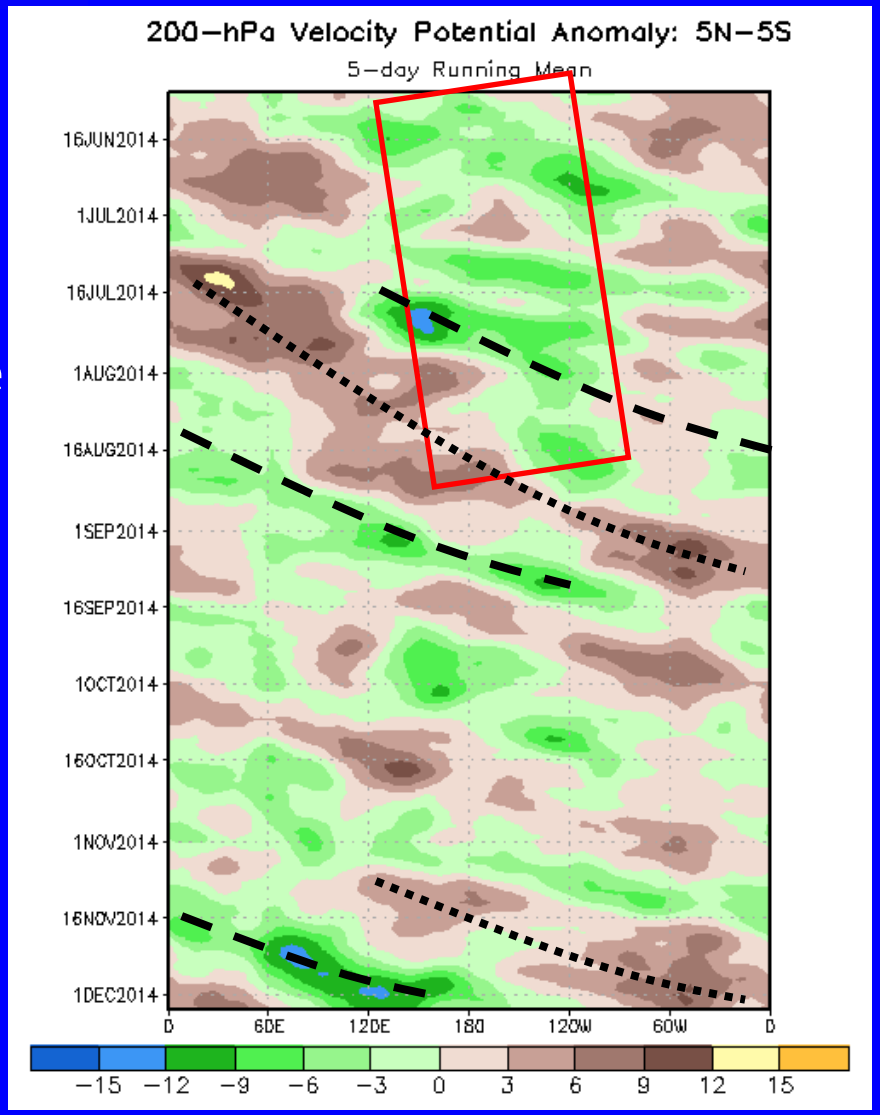
The pattern became less coherent with respect to canonical MJO activity by September and the MJO remained weak till late November (red box).

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.

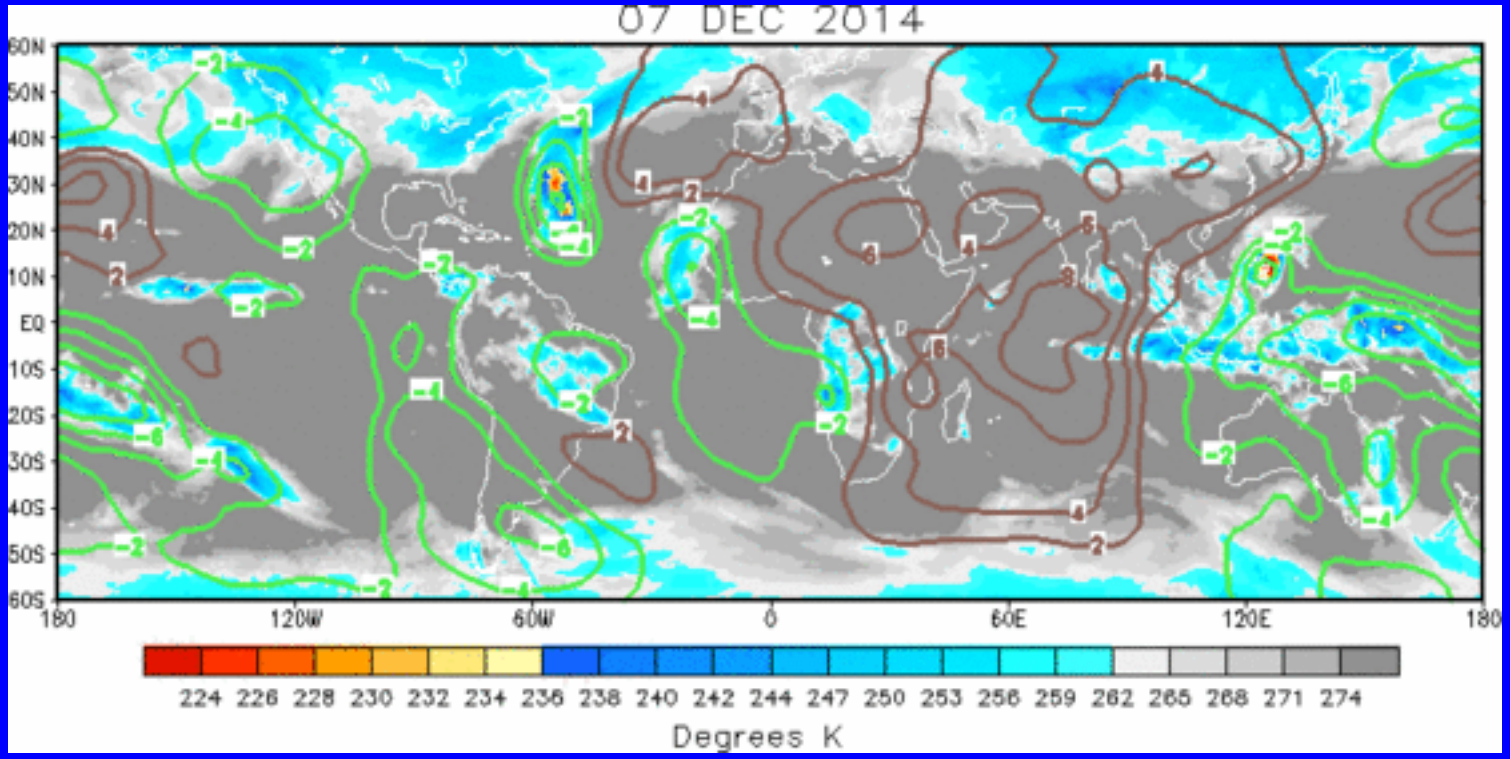
The MJO weakened and remained incoherent through September and October.

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

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

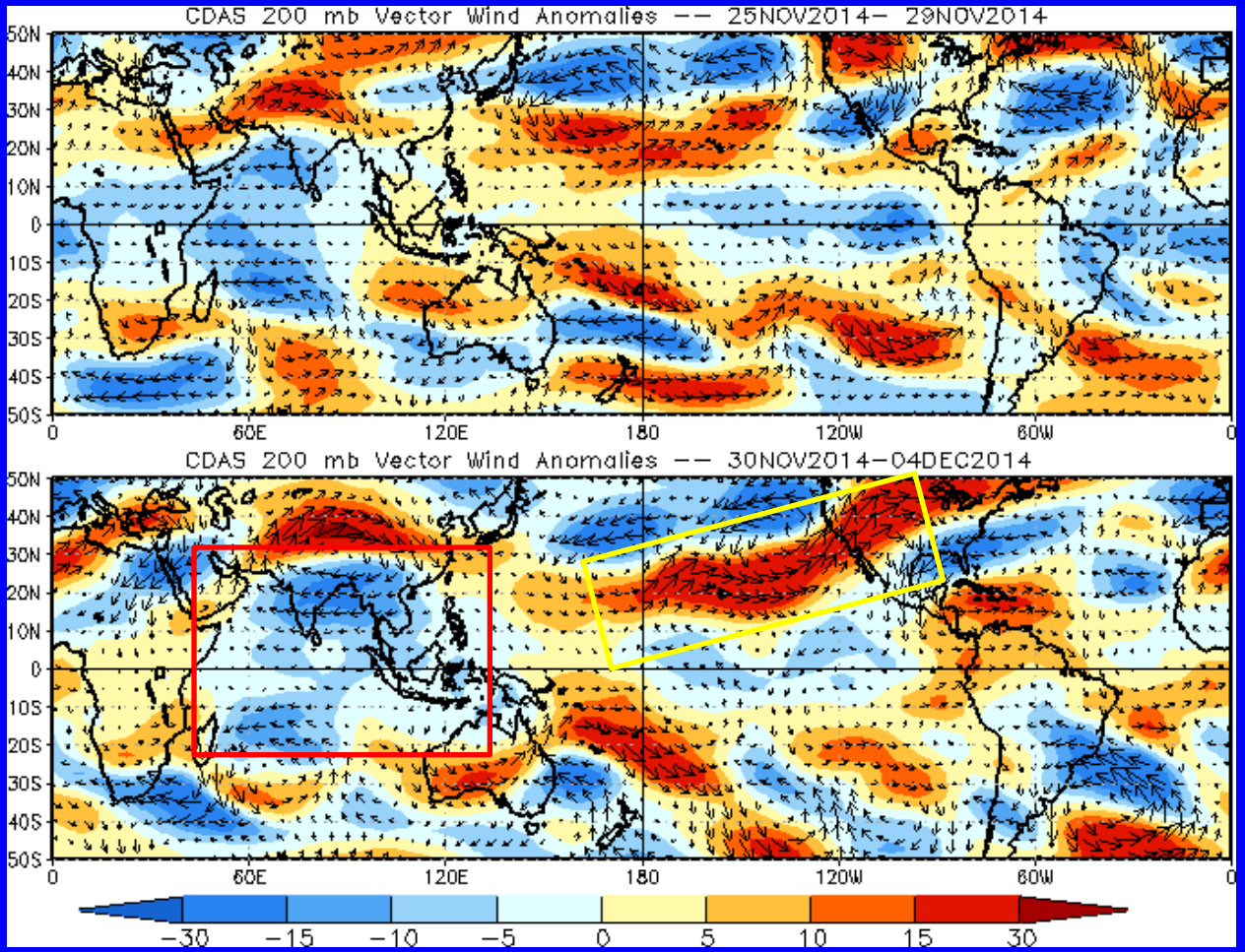
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The upper-level anomalous velocity potential spatial pattern remains is less coherent as compared to the previous 1-2 weeks. Anomalous divergence is located over the Pacific Basin entering the Americas, while anomalous convergence stretches from Africa across the Indian Ocean.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

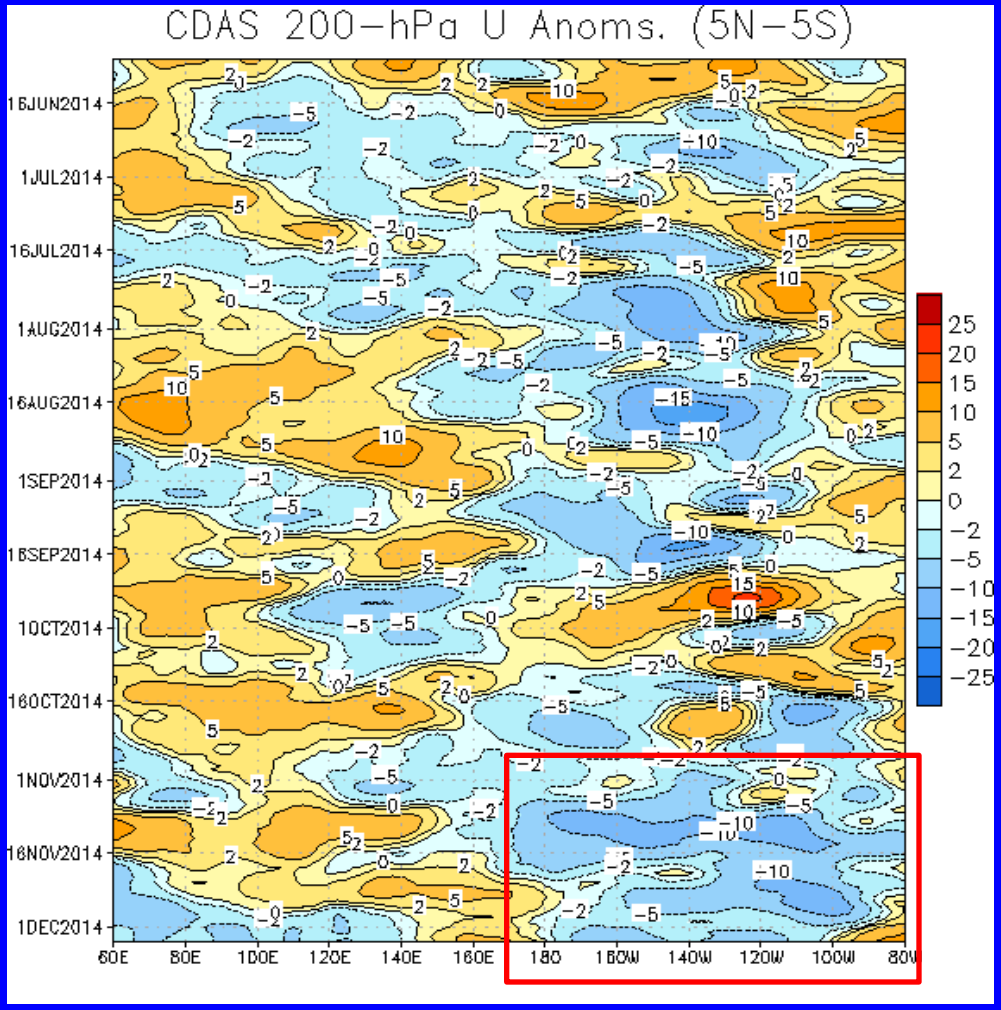
Easterly anomalies shifted eastward to the Indian ocean during the most recent five days (red box).

A strong subtropical jet is also noted from the central Pacific sub-Tropics to the southwest U.S. (yellow 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

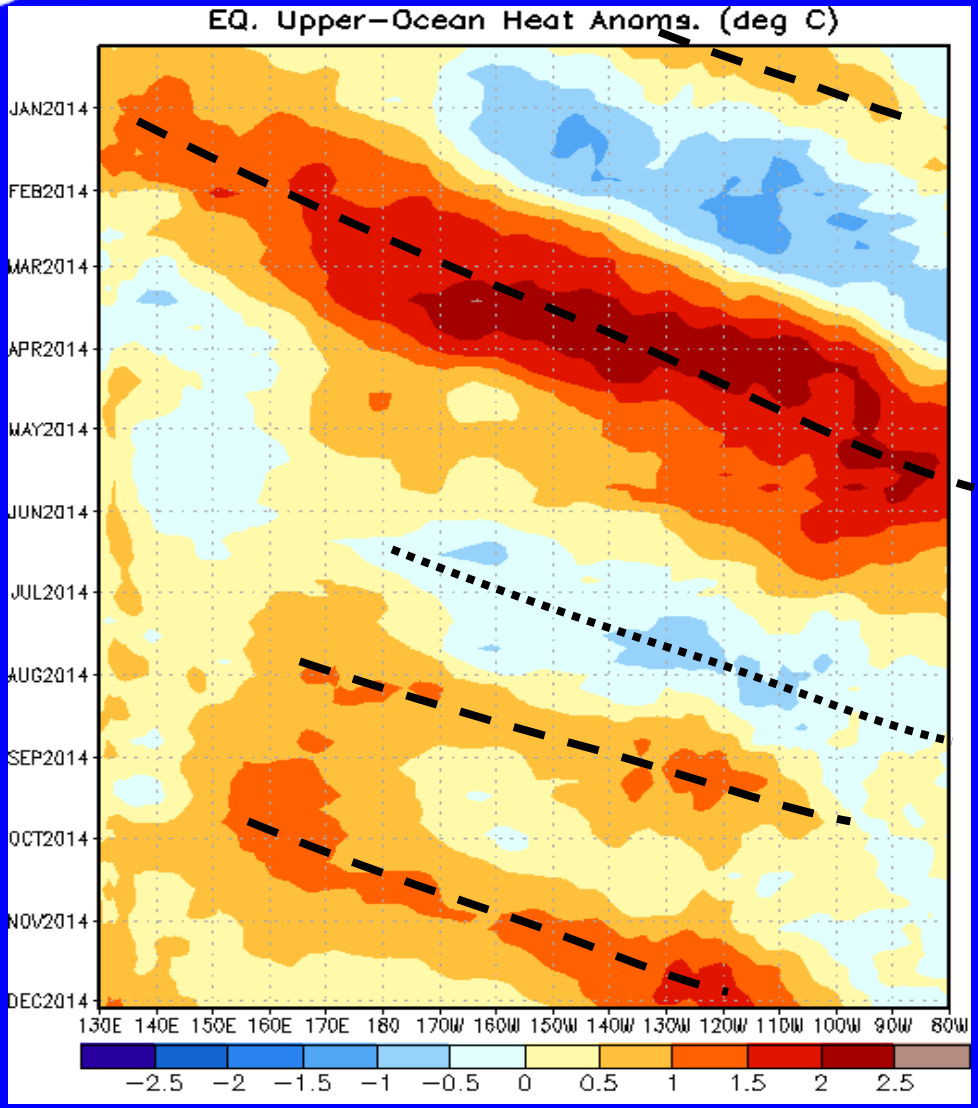
Longitude

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).

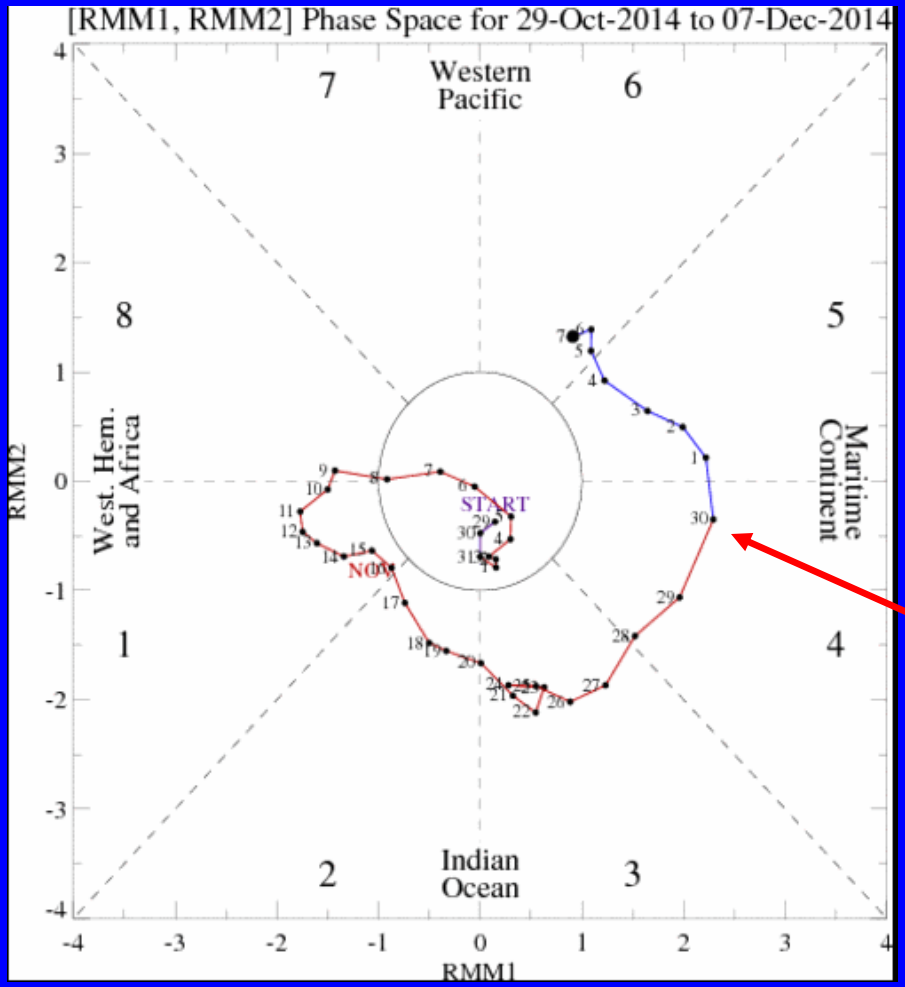
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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

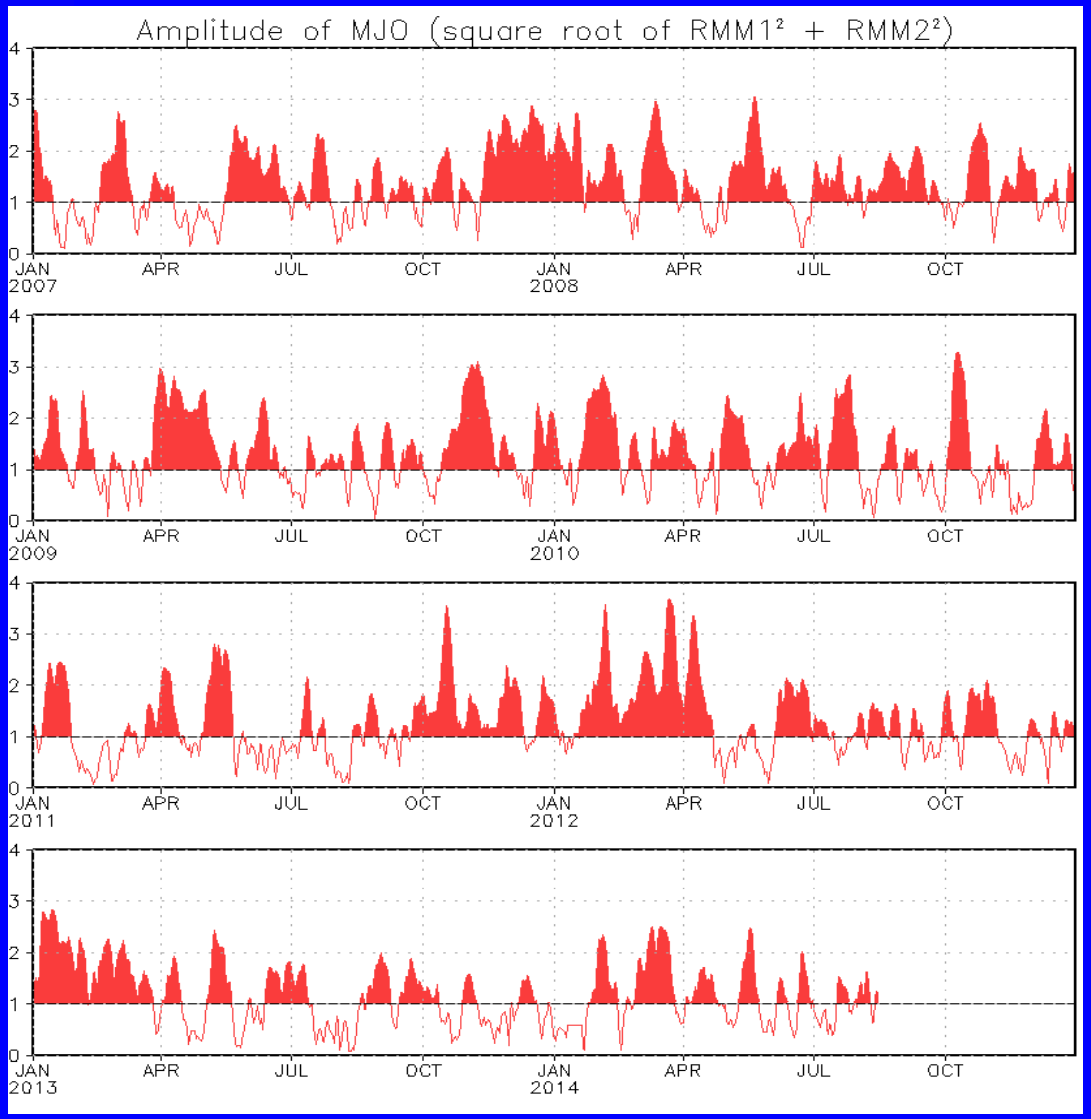


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the origin is proportional to MJO strength
- Line colors distinguish different months

The MJO index depicts ongoing MJO activity with the enhanced phase now located over the western Pacific Ocean.

Variations in phase speed are due in part to interaction with other modes of subseasonal variability such as atmospheric Kelvin and equatorial Rossby waves.

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.

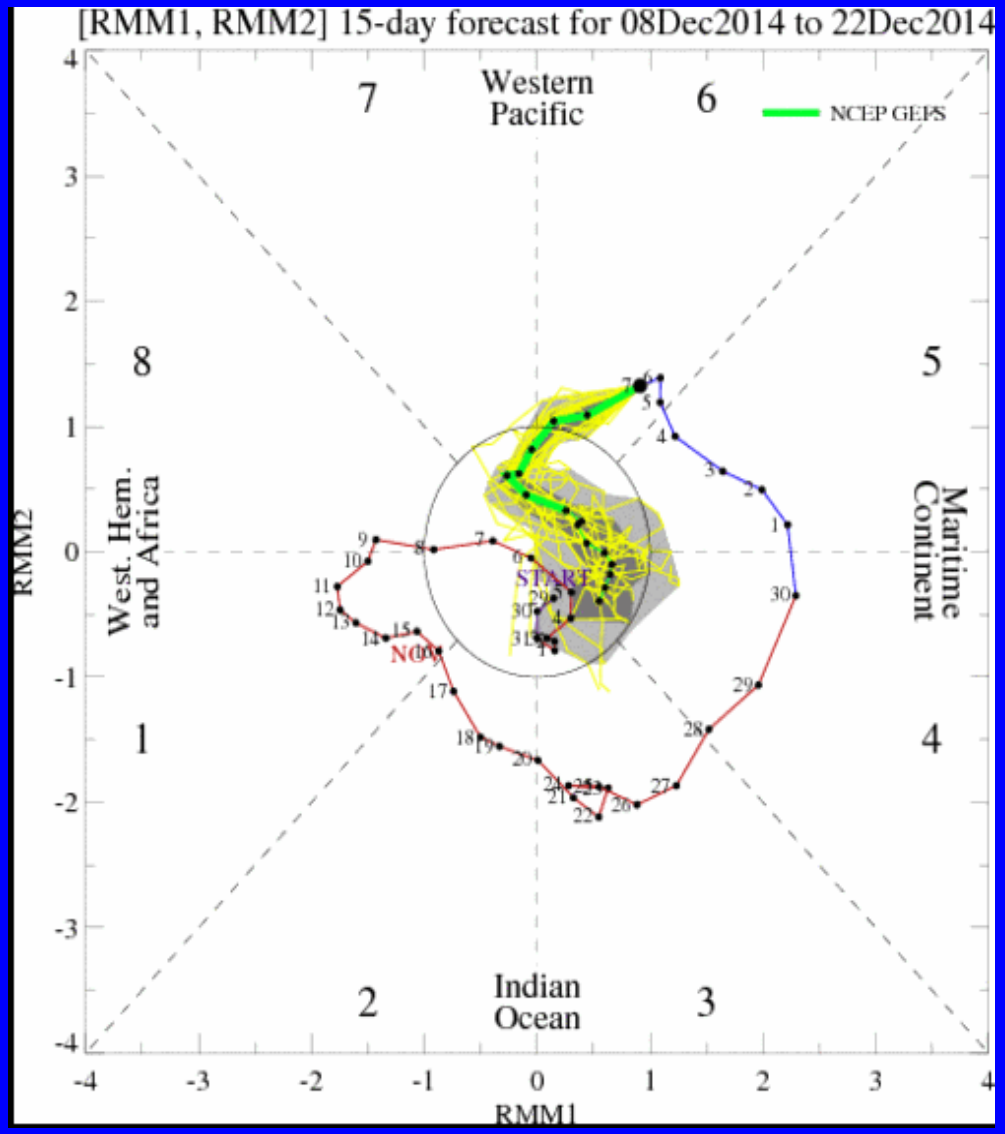
Ensemble GFS (GEFS) MJO Forecast

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

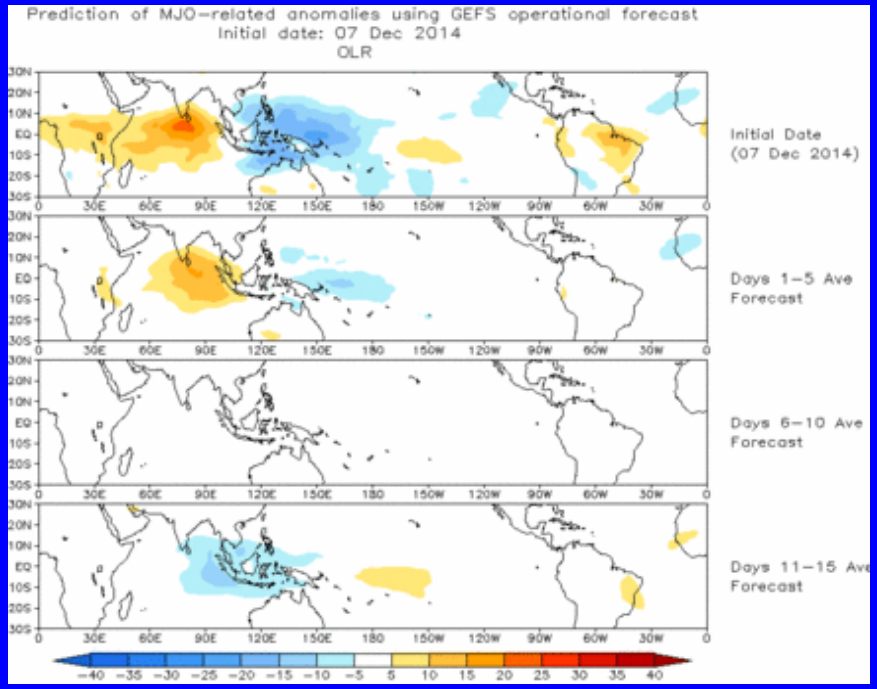
The ensemble GFS forecast indicates a continued eastward propagation of the MJO signal further into the Pacific Ocean during Week-1, but weakens the signal during Week-2.



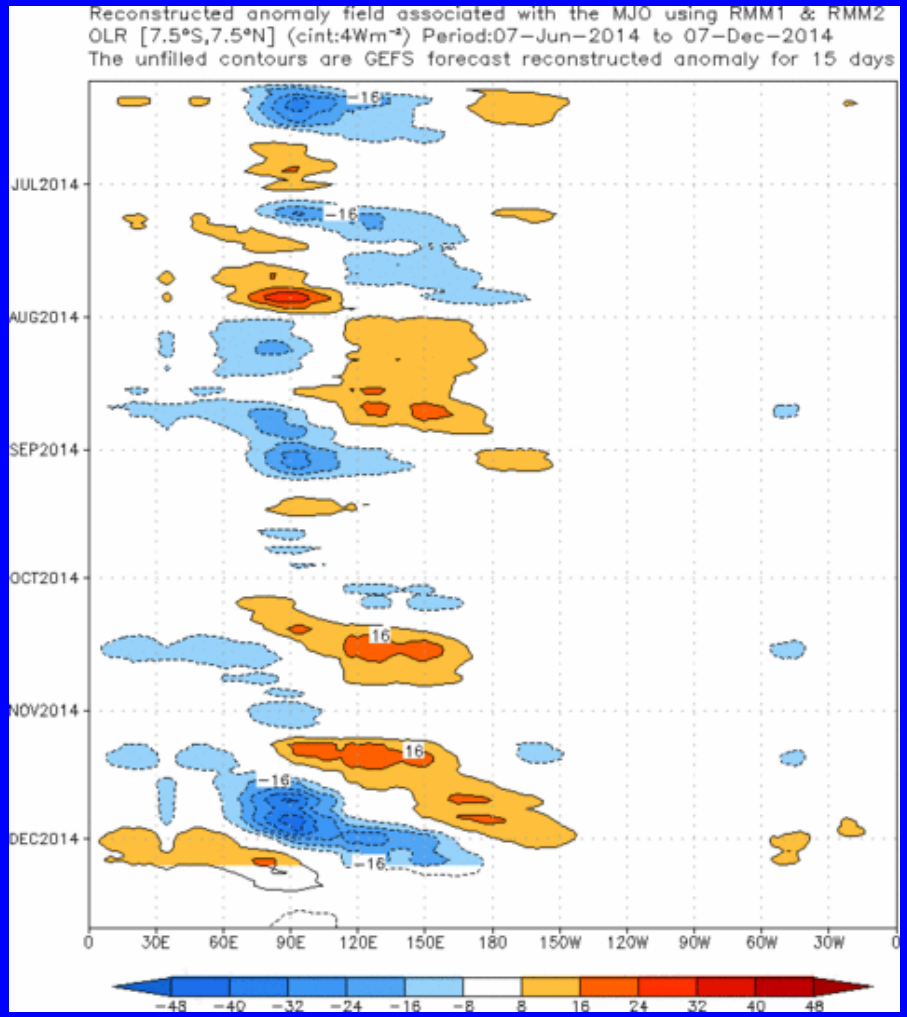
Ensemble Mean GFS MJO Forecast

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

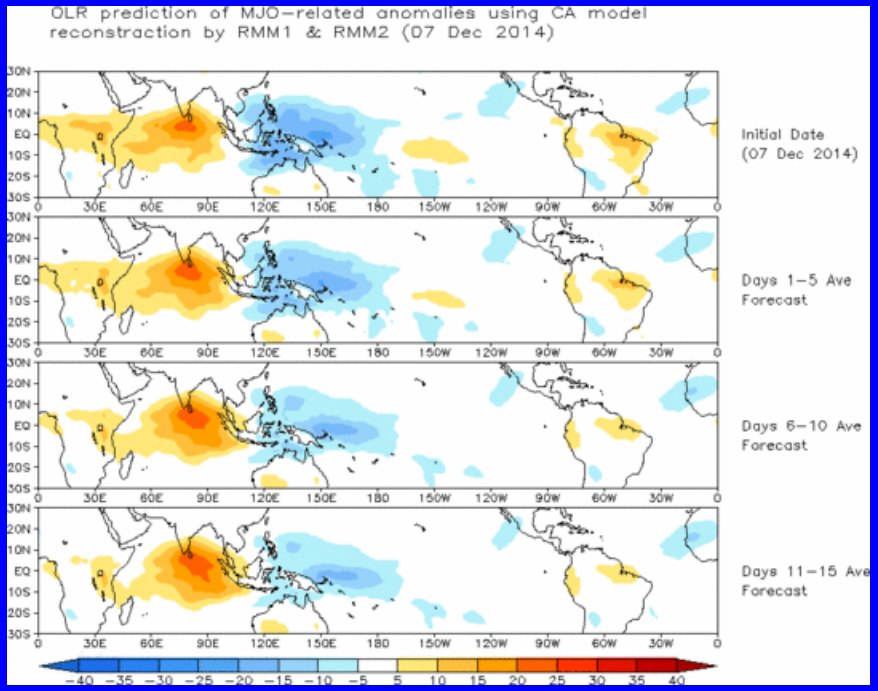


The GEFS mean MJO index based OLR anomaly forecast depicts suppressed (enhanced) convection for the Indian Ocean (Maritime Continent) early in the forecast period before weakening.

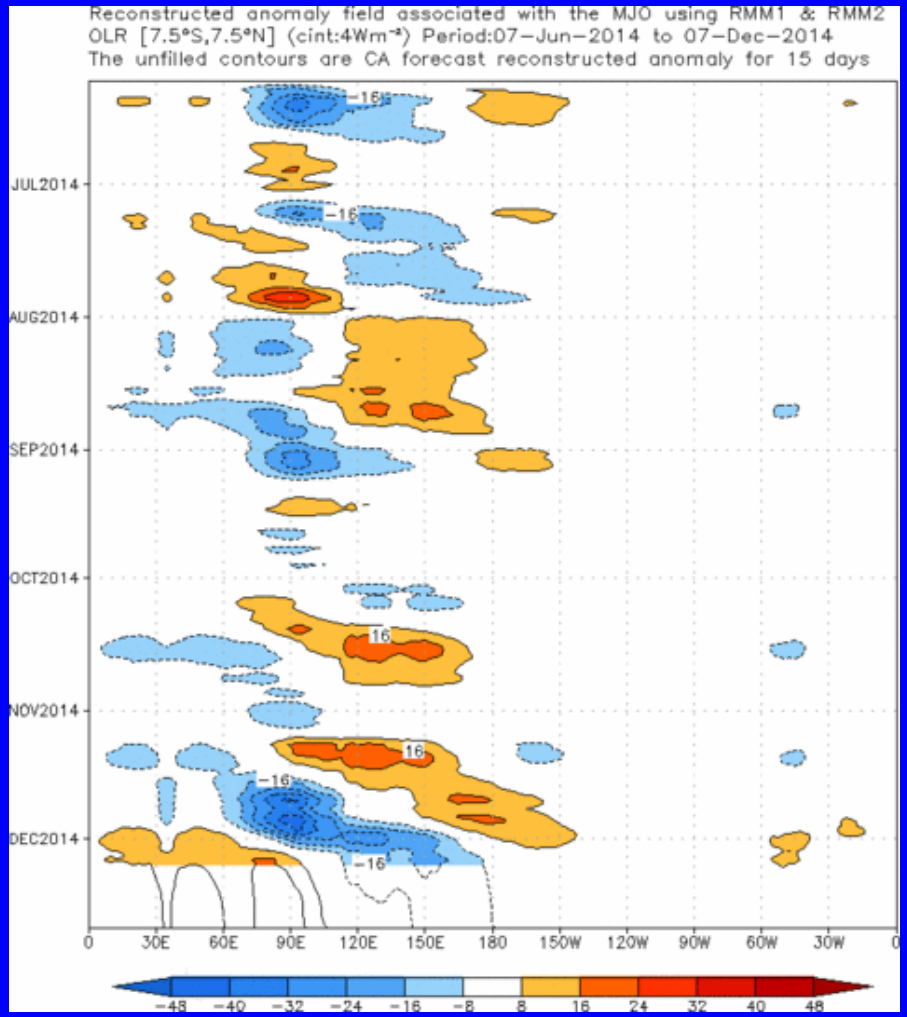
Constructed Analog (CA) MJO Forecast

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



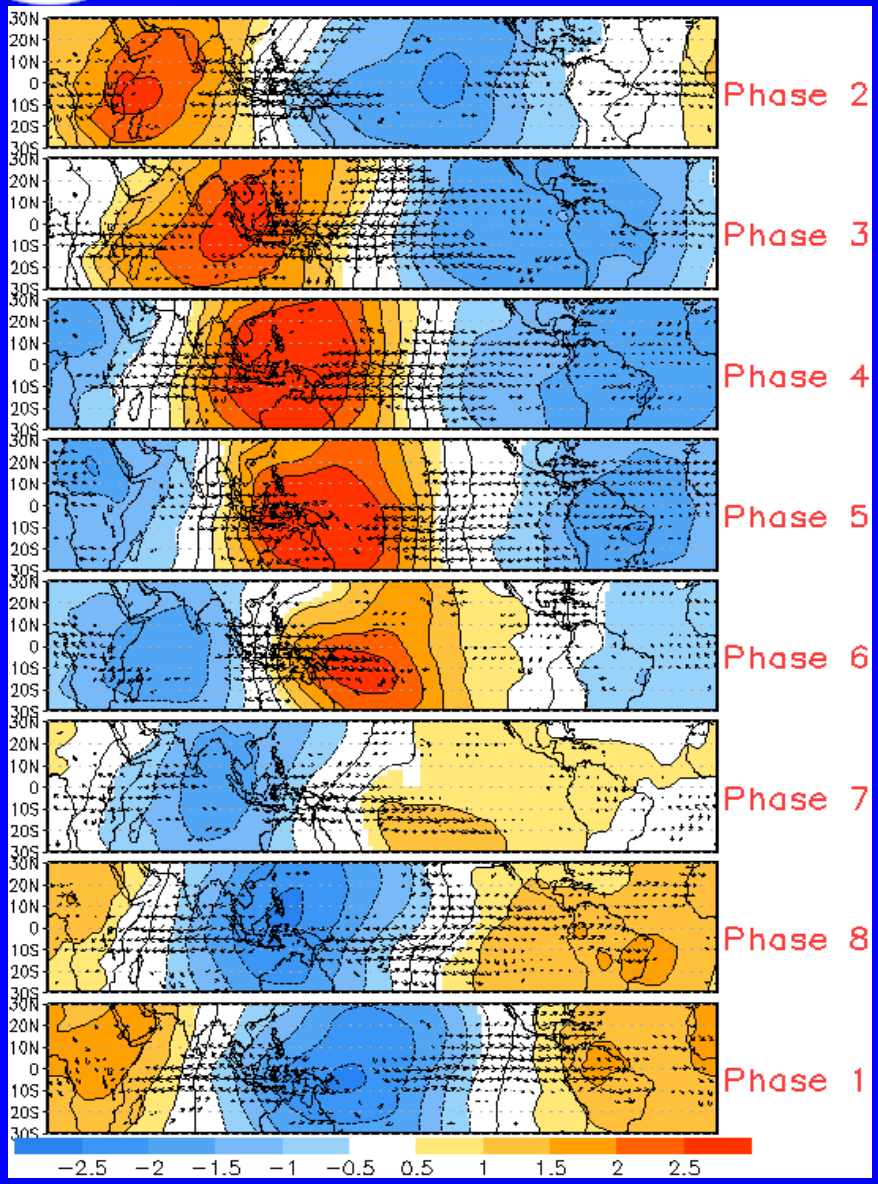
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



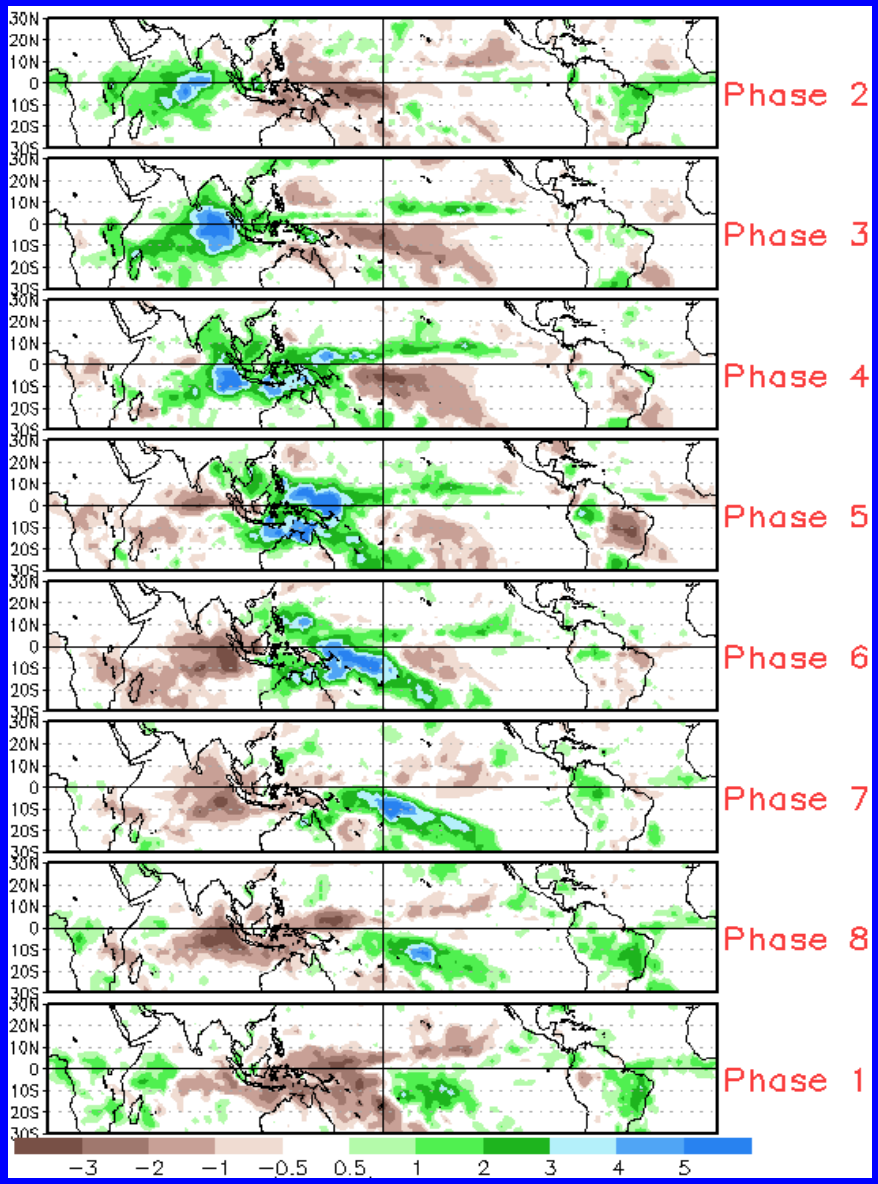
The constructed analog forecast depicts a similar pattern as that of the GEFS forecast although shifted slightly to the east. Another difference is this forecast maintains the amplitude of the MJO signal throughout the period, but with no propagation.

MJO Composites – Global Tropics

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

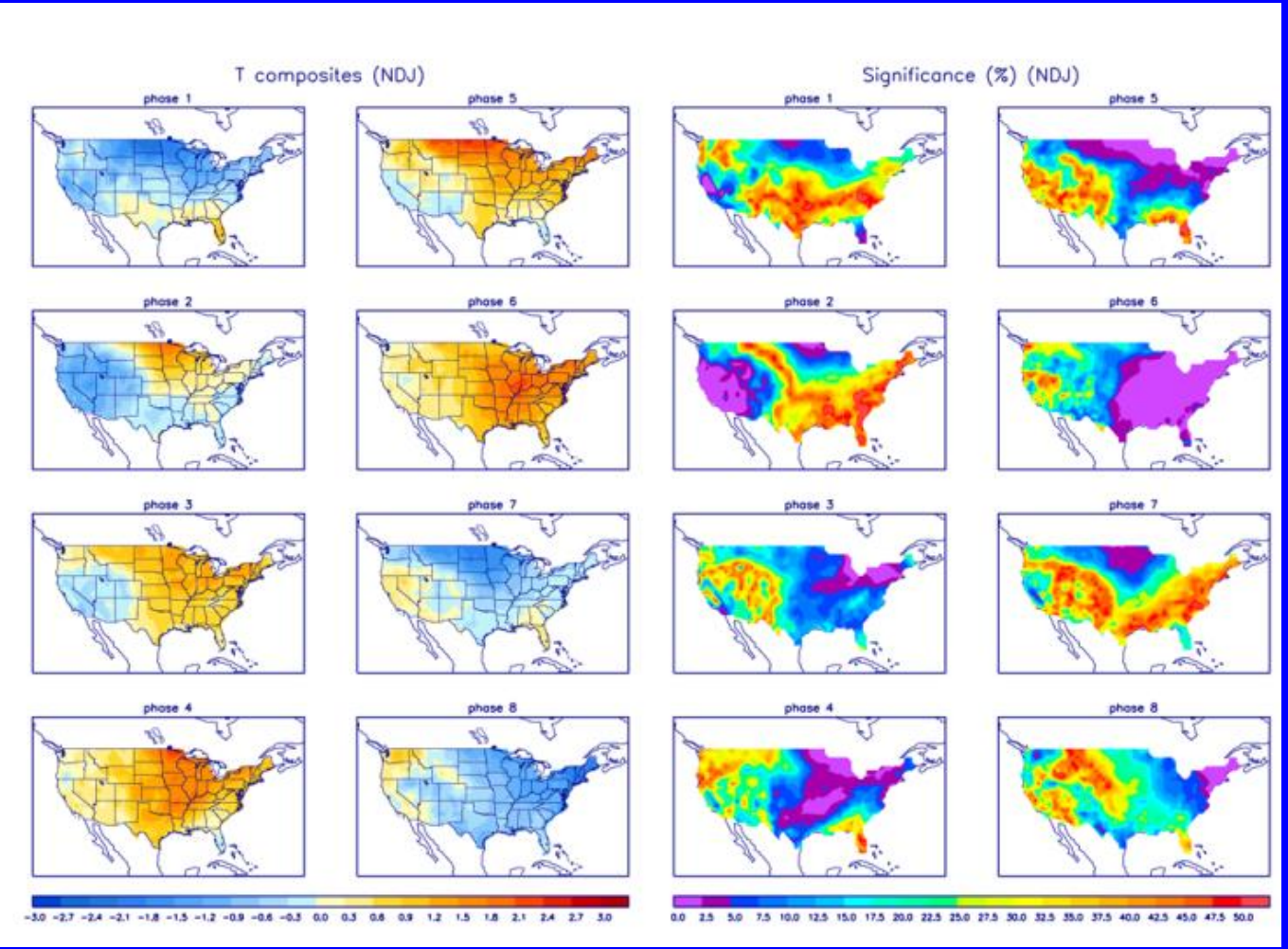


Precipitation Anomalies (Nov-Mar)



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.**

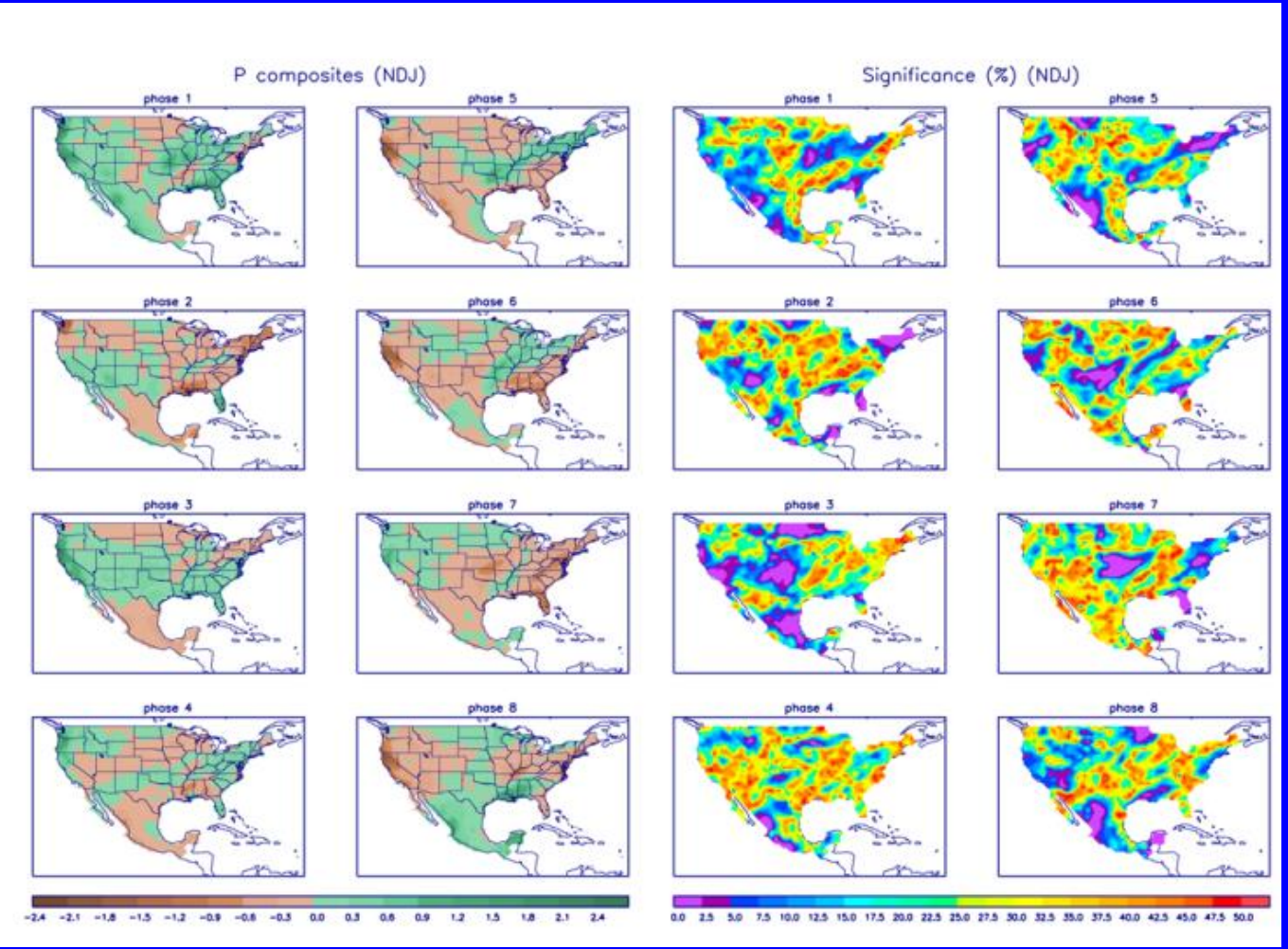


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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