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

**Update prepared by**
**Climate Prediction Center / NCEP**
**December 1, 2014**

# Outline

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

# Overview

- A coherent MJO signal was evident during the previous week with the enhanced phase propagating from the Indian Ocean to the Maritime Continent. Upper-level atmospheric indicators are the most consistent with the MJO at the current time.

- There continues to be some interference with other modes of variability from the eastern Indian Ocean to the West Pacific.

- Several dynamical model MJO index forecasts depict eastward propagation of the MJO to the West Pacific over the next several days.

- Based on recent observations and model guidance, the MJO may contribute to enhanced (suppressed) convection over the Maritime Continent and West Pacific (Africa and the central Indian Ocean) during the period.

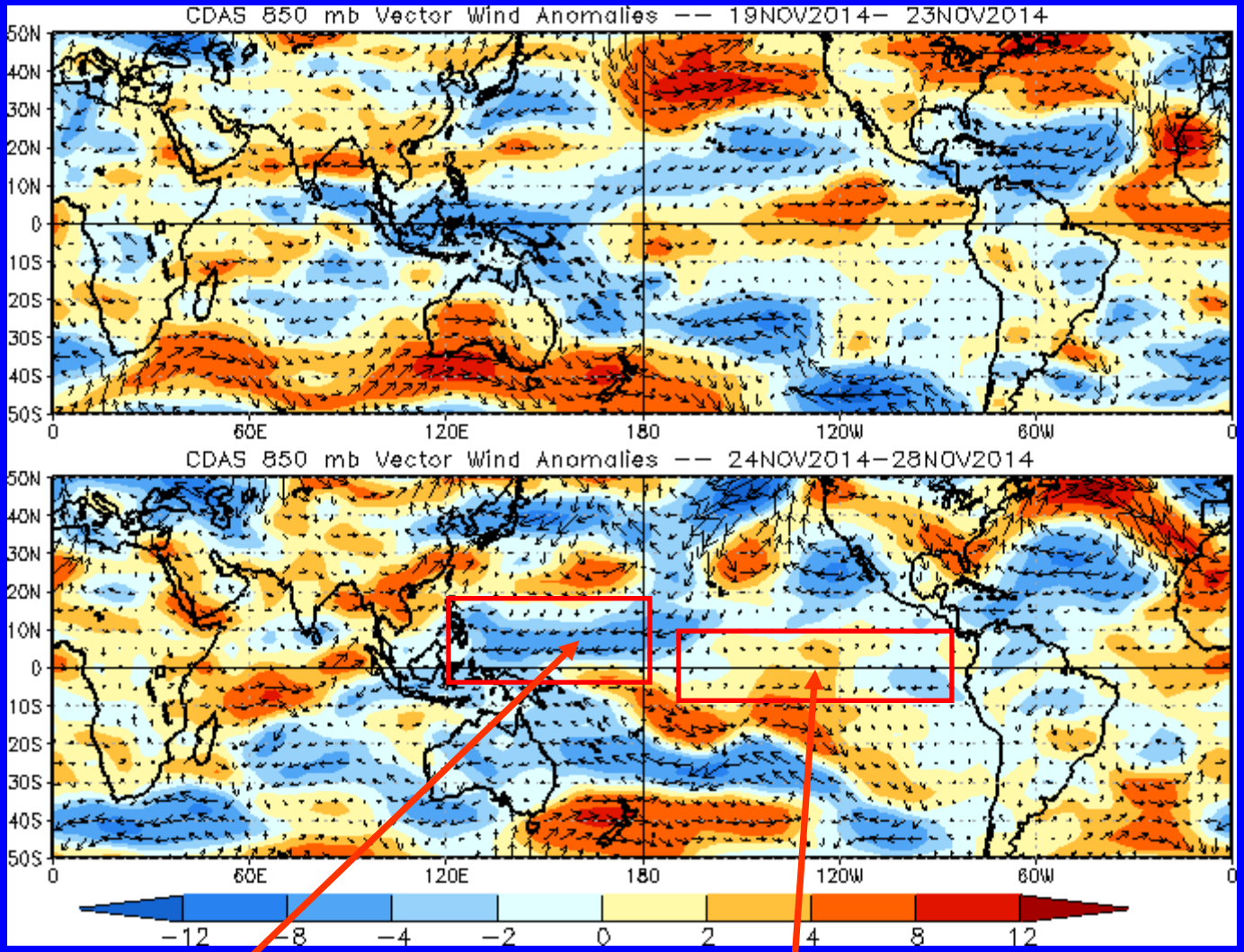
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

**Blue shades**: Easterly anomalies

**Red shades**: Westerly anomalies



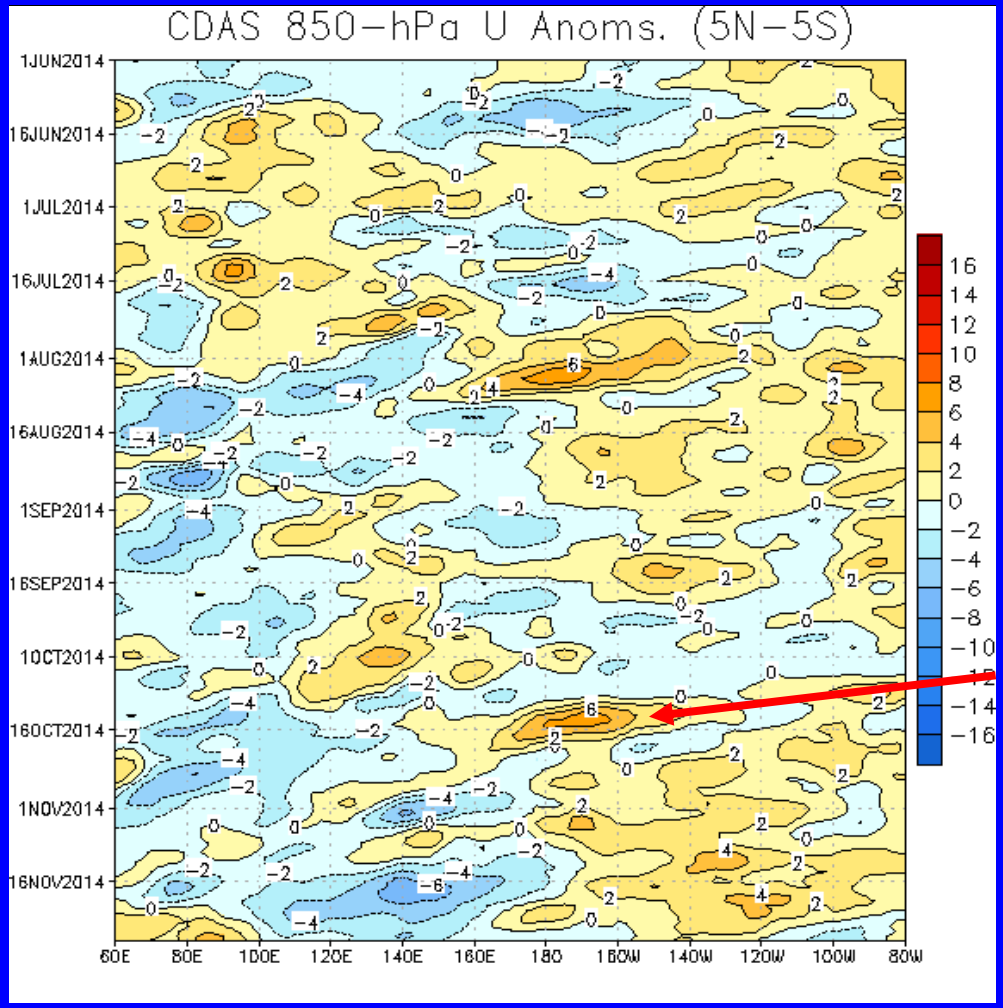

Easterly anomalies shifted eastward just north of the equator.

Westerly anomalies weakened across the eastern 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

During much of May and June, westerly anomalies were observed over the eastern Pacific. An enhanced South Asian monsoon circulation developed during much of June and July.

From late July to August, westerly (easterly) anomalies shifted westward over the eastern and central Pacific (western Pacific, Maritime Continent, and Indian Ocean).

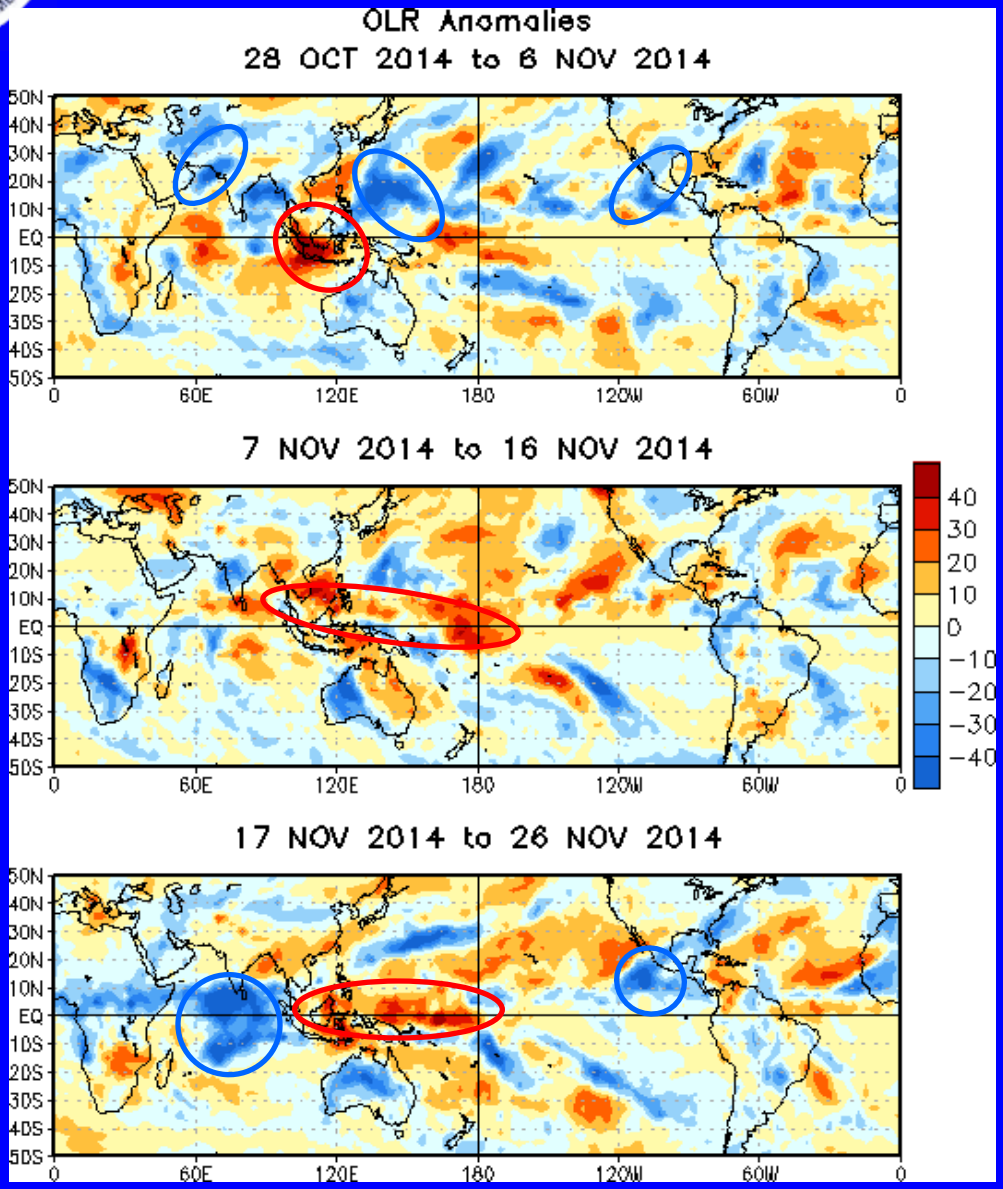
A westerly wind burst was observed near the Date Line during mid-October

Recently, westerly (easterly) anomalies persisted east (west) of the Date Line. Easterly anomalies also persisted over the Indian Ocean until recently.

# OLR Anomalies – Past 30 days

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

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

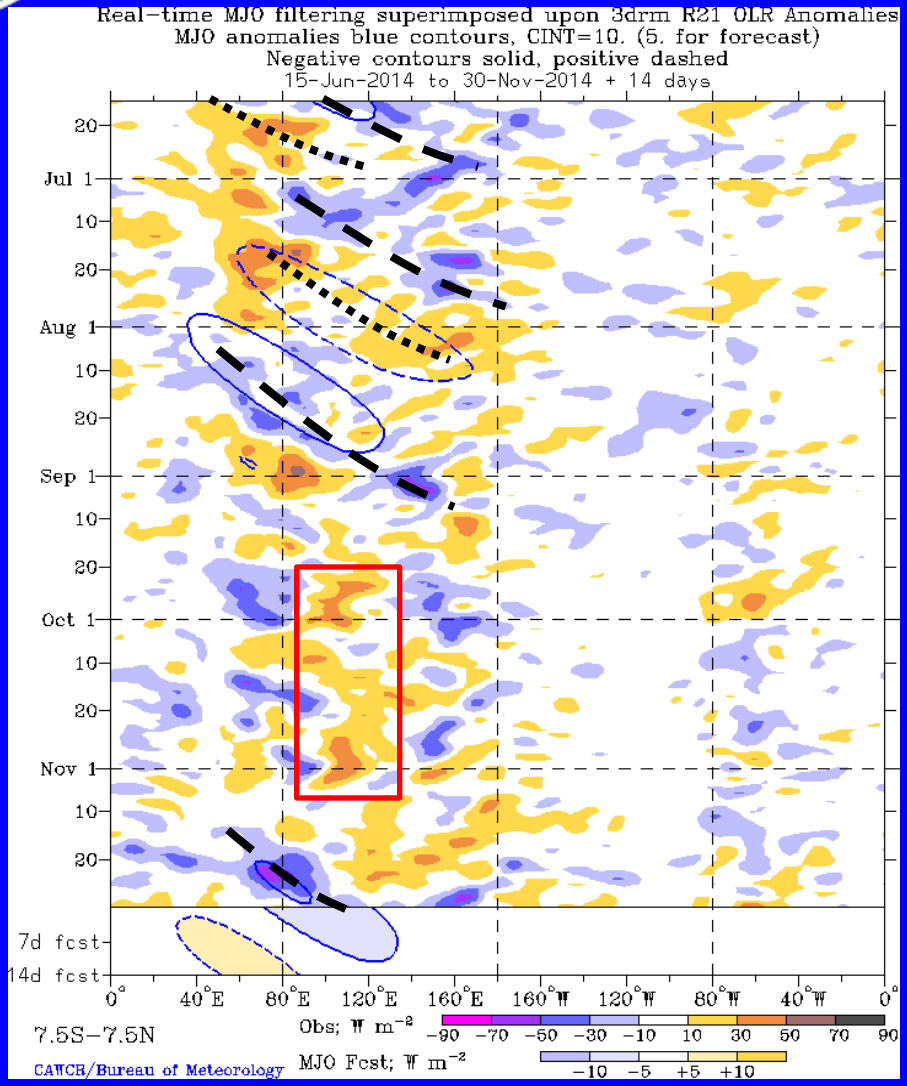



During late October to early November, enhanced (suppressed) convection was present over the Western North Pacific (Maritime Continent), along with an enhanced Pacific ITCZ.

Convection became less organized during early to mid-November, with suppressed convection extending from the South China Sea to the central Pacific.

During mid to late November, 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.

# 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 June and July, primarily over the Indian Ocean, but the pattern became less coherent with respect to canonical MJO activity by September.**

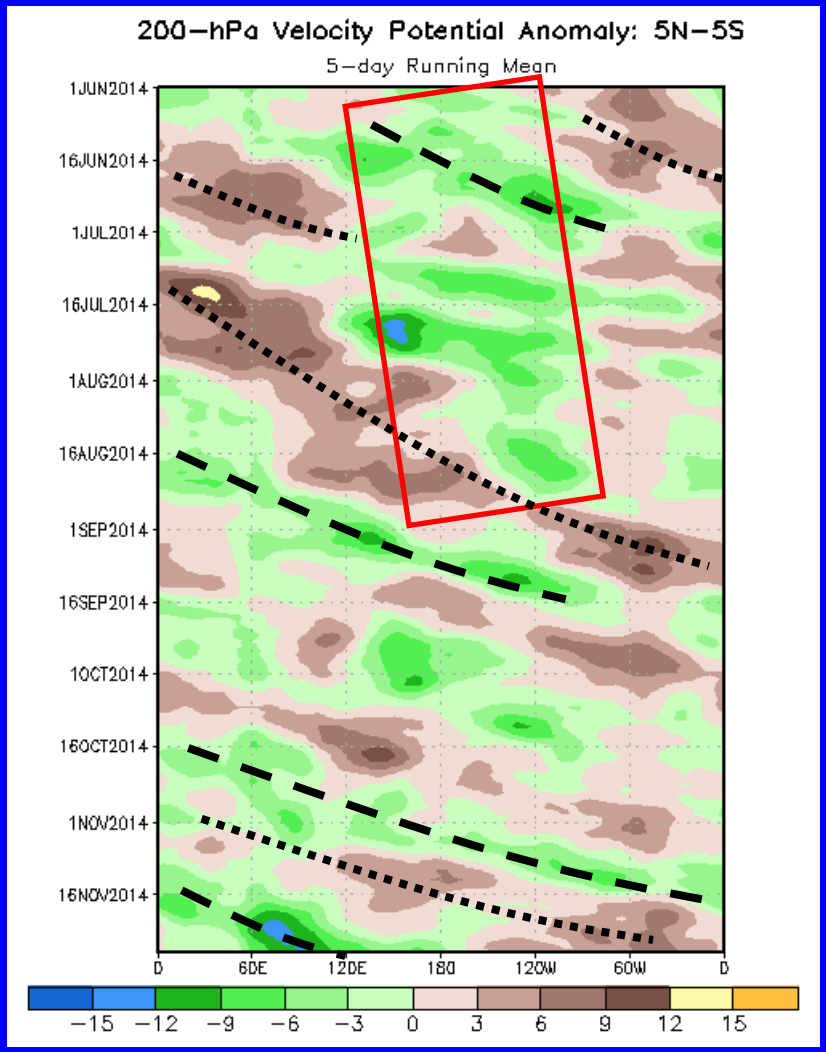
**Since mid-August, the pattern was dominated by interactions between westward moving features and eastward moving features that were more transient than canonical MJO-related activity.**

**Enhanced convection is now present over the Maritime Continent. Westward moving equatorial Rossby waves are evident as well over the West Pacific.**

# 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 June with a more coherent wave-1 MJO-like structure with eastward propagation.

The pattern became less coherent during early July, but then organized again in late July and August, with a wide area of suppressed convection moving around the planet.

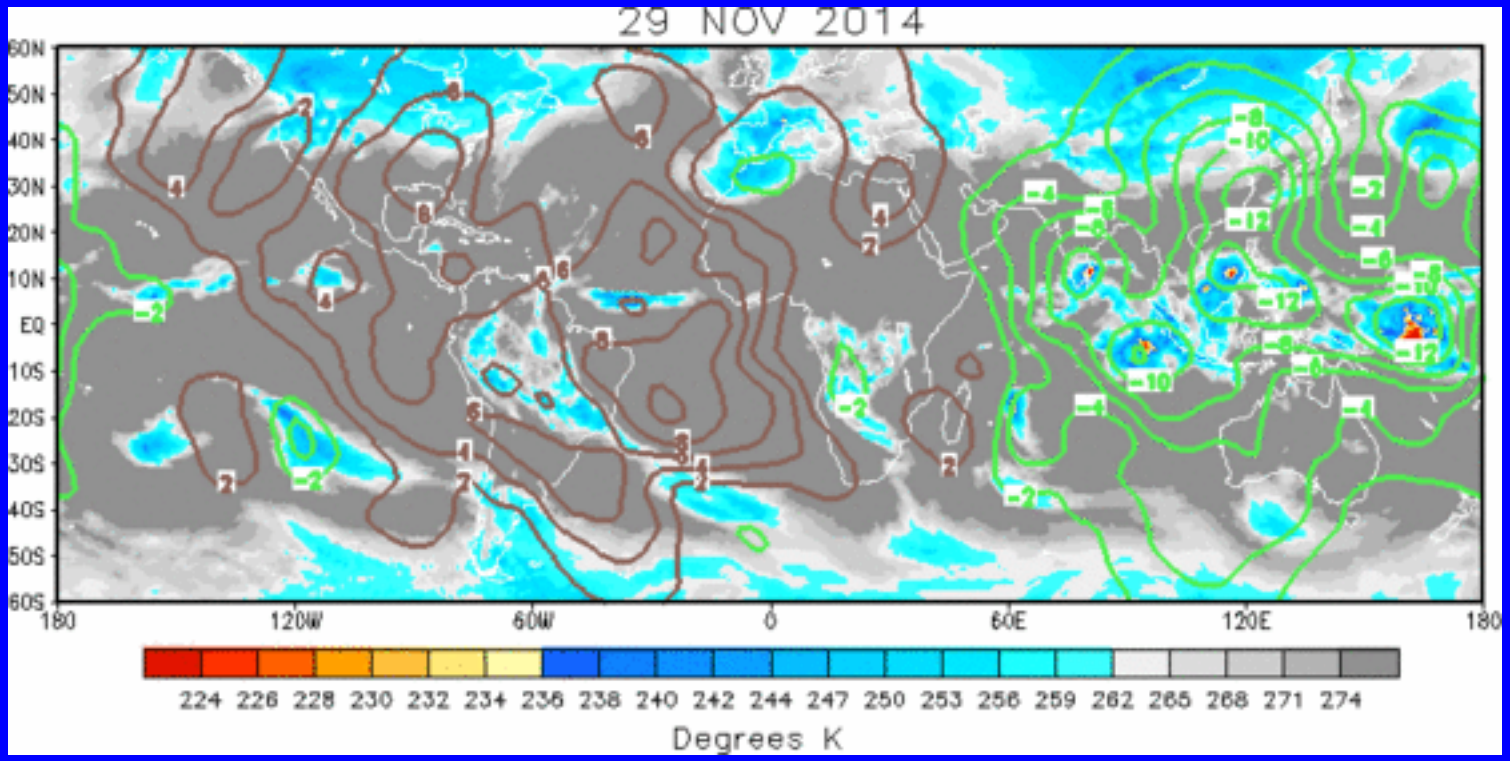
During early September, anomalies were consistent with rapid eastward propagation, before becoming stationary for the second half of the month.

During October and early November, some eastward propagation is evident. Recently, the pattern has been consistent with MJO activity.

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

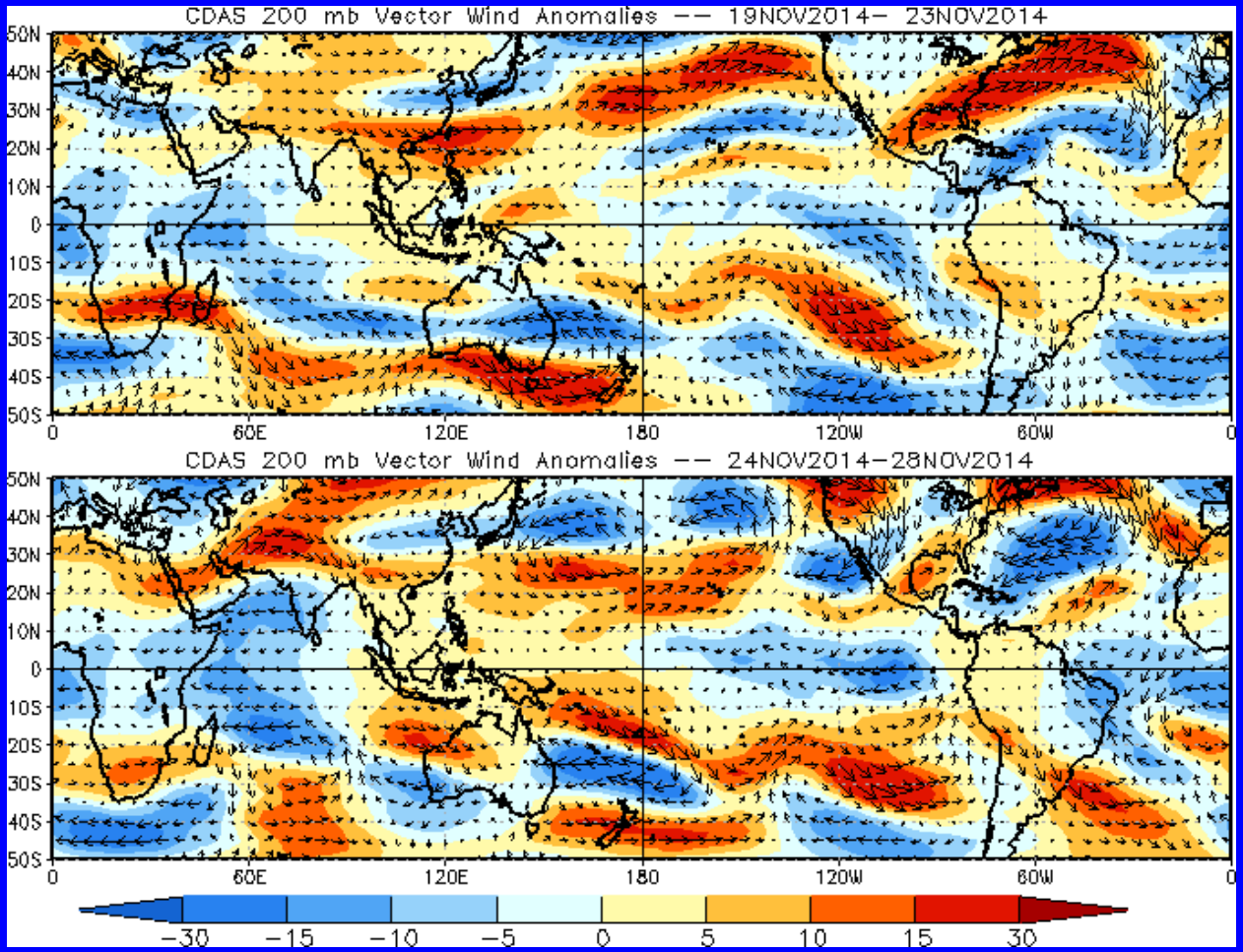
**Positive** anomalies (brown contours) indicate unfavorable conditions for precipitation

**Negative** anomalies (green contours) indicate favorable conditions for precipitation




**The upper-level anomalous velocity potential spatial pattern is very coherent, exhibiting a Wave-1 structure with anomalous upper-level divergence (convergence) over the Maritime Continent and West Pacific (Americas and Atlantic basin).**

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




**Note that shading denotes the zonal wind anomaly**

**Blue shades: Easterly anomalies**

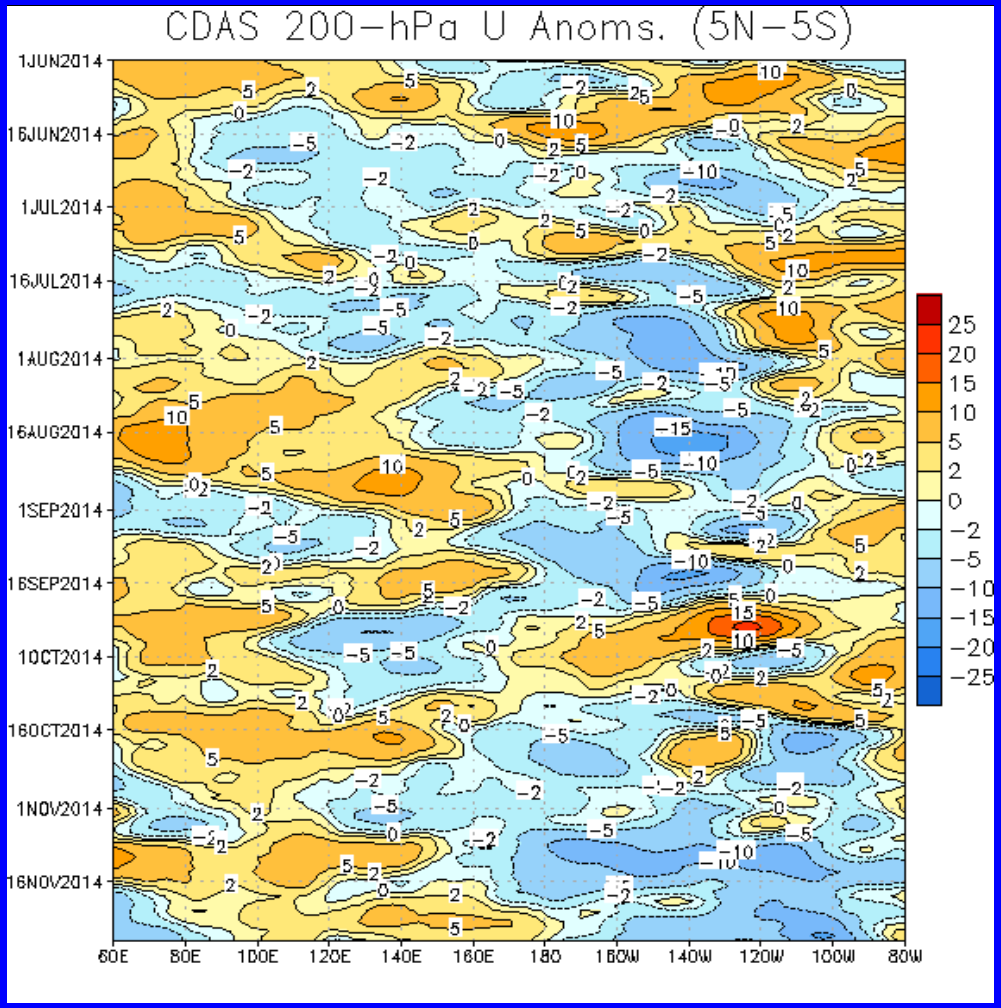
**Red shades: Westerly anomalies**

**Easterly anomalies persisted over the Pacific, east of the Date Line, while intensifying over the equatorial Atlantic. Easterly anomalies have intensified over the Indian Ocean.**

# 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

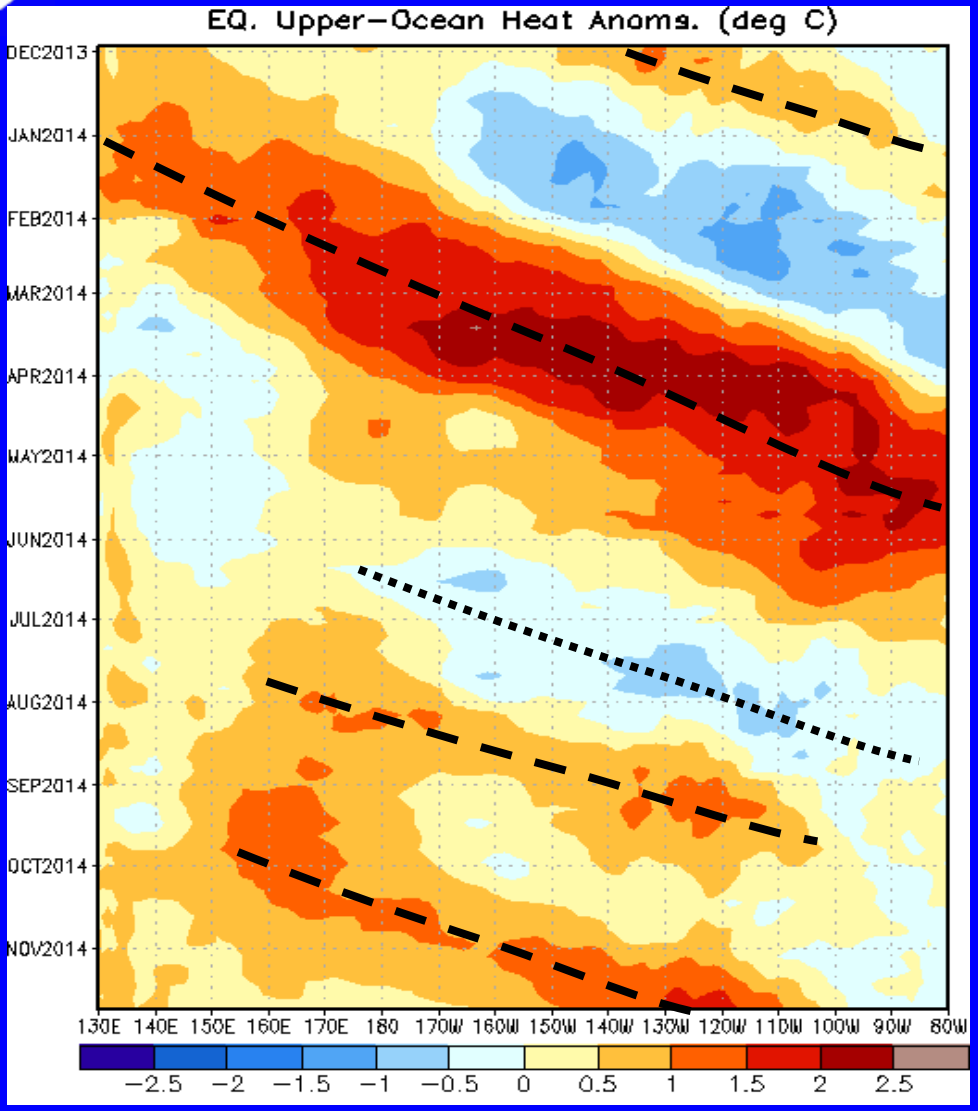
Longitude

**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.**

**Recently, easterly (westerly) anomalies persisted east (west) of the Date Line.**

# Weekly Heat Content Evolution in the Equatorial Pacific




Time

Longitude

Oceanic downwelling Kelvin wave activity is evident during October through early December 2013.

A considerably stronger downwelling event began in January 2014 and propagated across the Pacific.

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

Warm anomalies are again evident across much of the Pacific due to another downwelling Kelvin wave.

# 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).

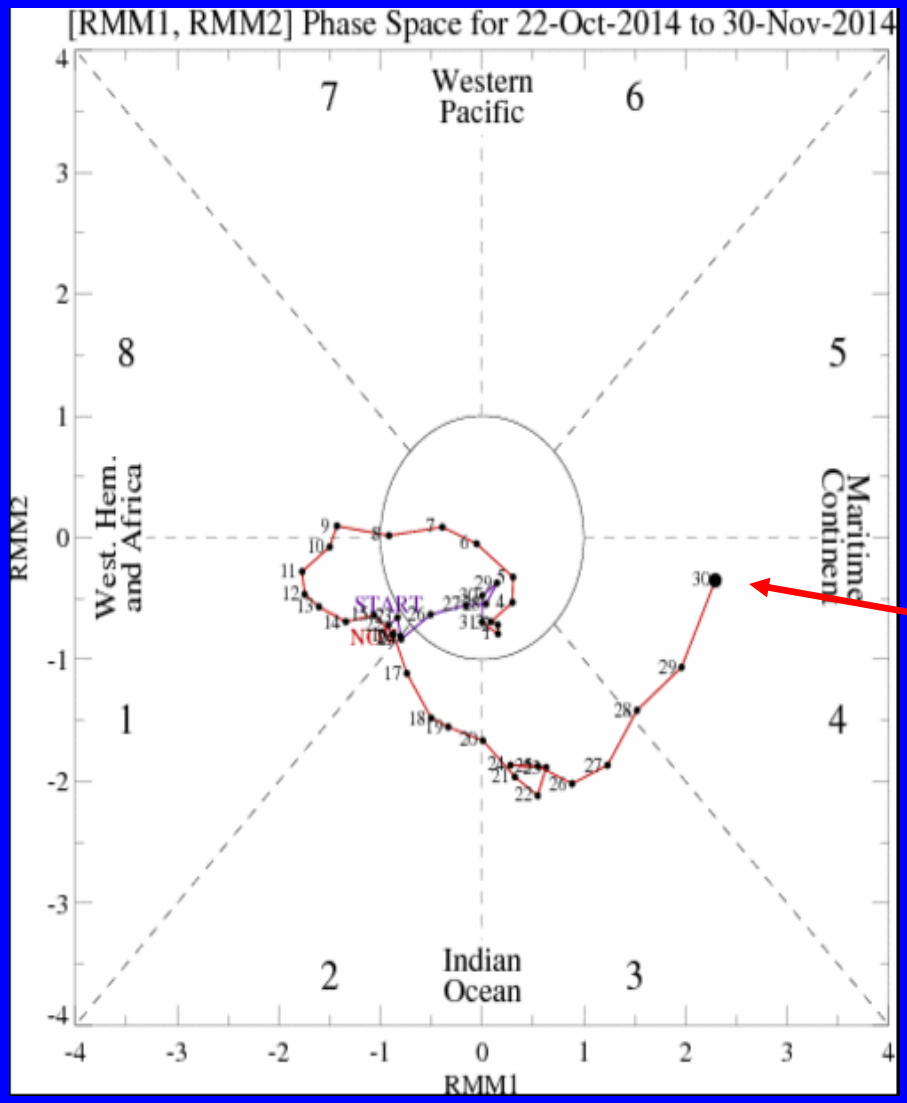
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

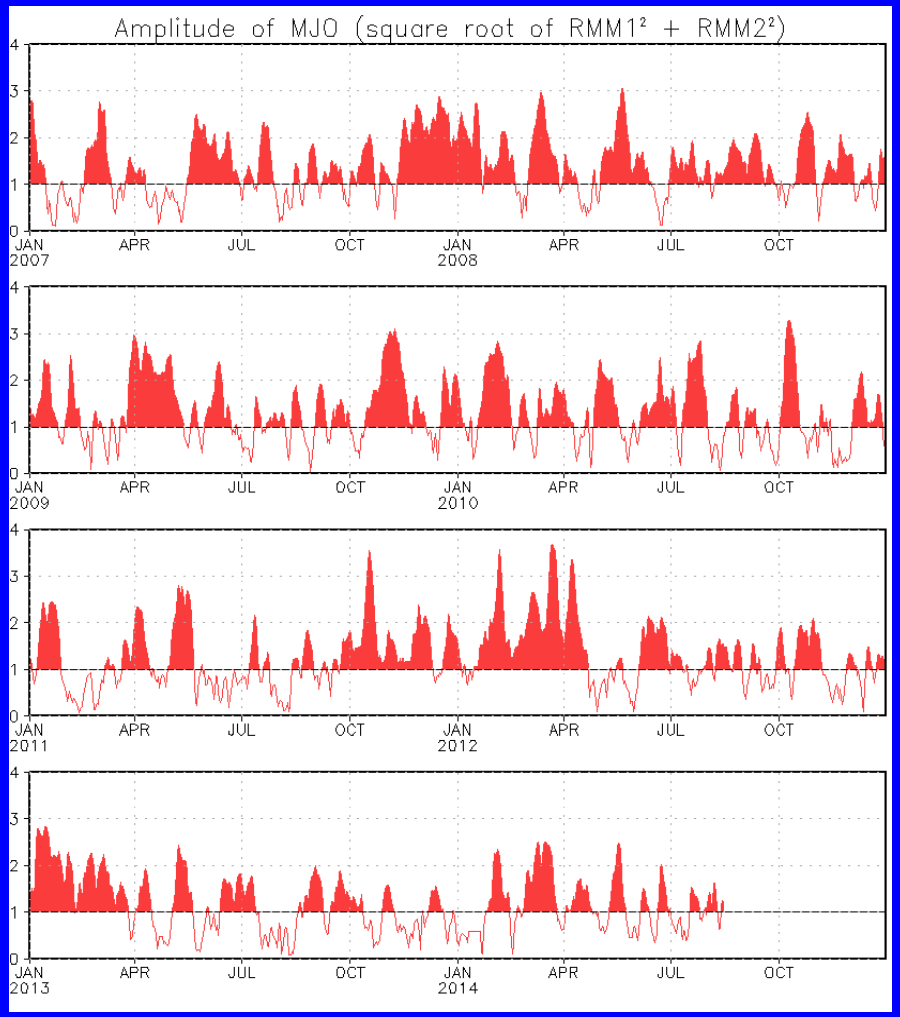
# MJO Index -- Recent Evolution




- 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 RMM MJO index depicts rapid eastward propagation of a signal from the Indian Ocean to the Maritime Continent over the past week. The apparent change in phase speed is due in part to interaction with other modes of variability, including 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.

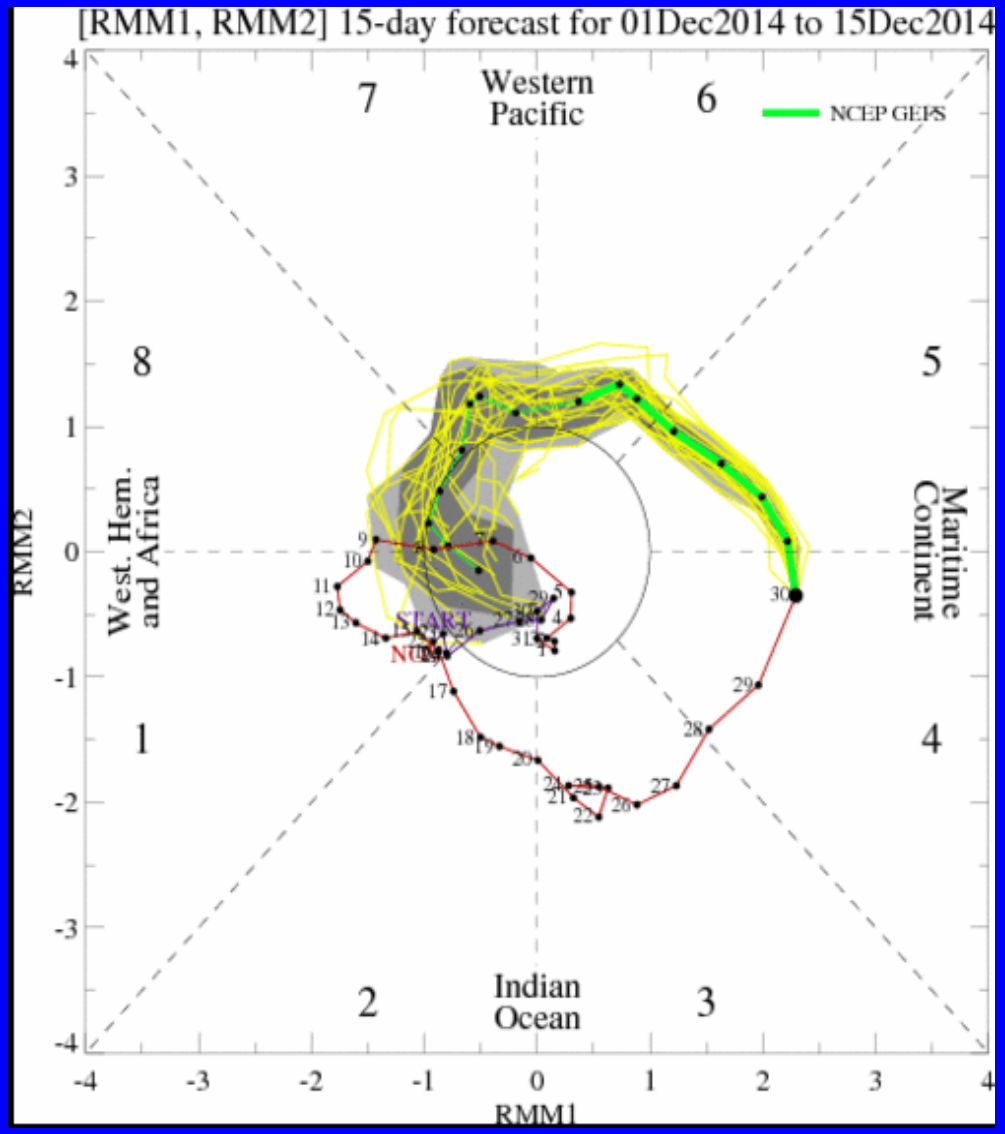
# Ensemble GFS (GEFS) MJO Forecast

**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**

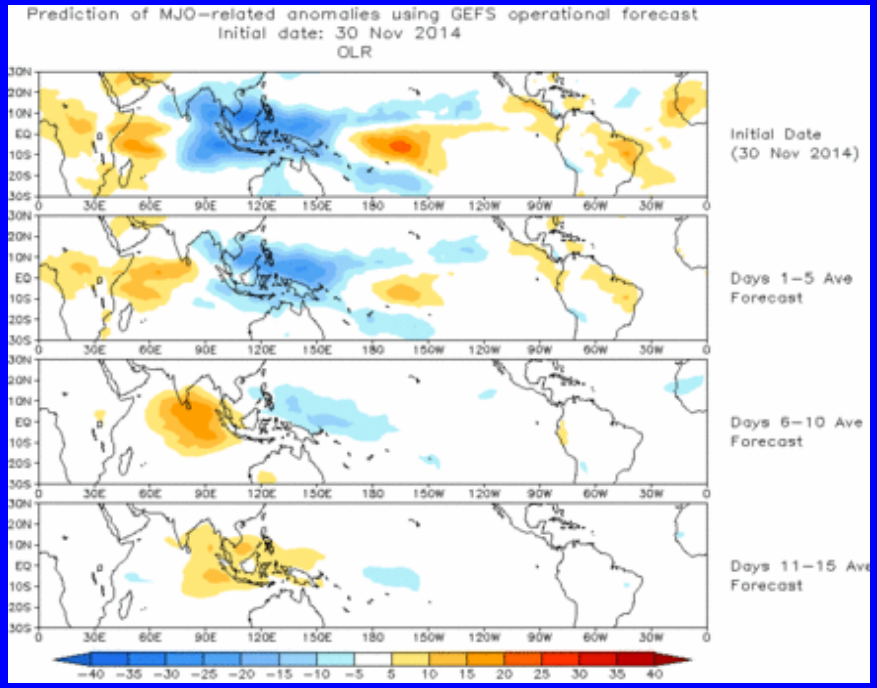
**The ensemble GFS forecast indicates a continued eastward propagation of the MJO signal to the West Pacific over the next week, with a weakening of the signal during Week-2.**



# Ensemble Mean GFS MJO Forecast

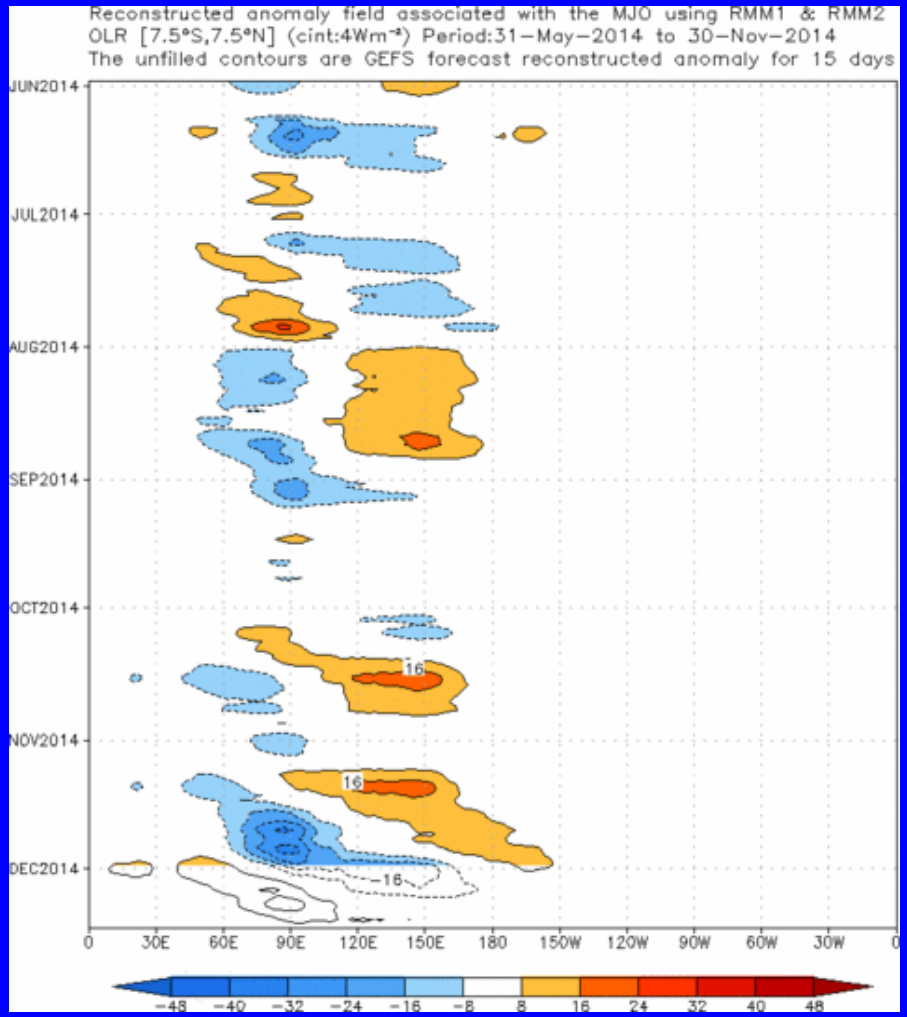
**Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)**

**Spatial map of OLR anomalies for the next 15 days**




**The GEFS mean RMM Index based OLR anomaly forecast depicts robust anomalies over the Maritime Continent early, shifting to the West Pacific before weakening later in the period.**

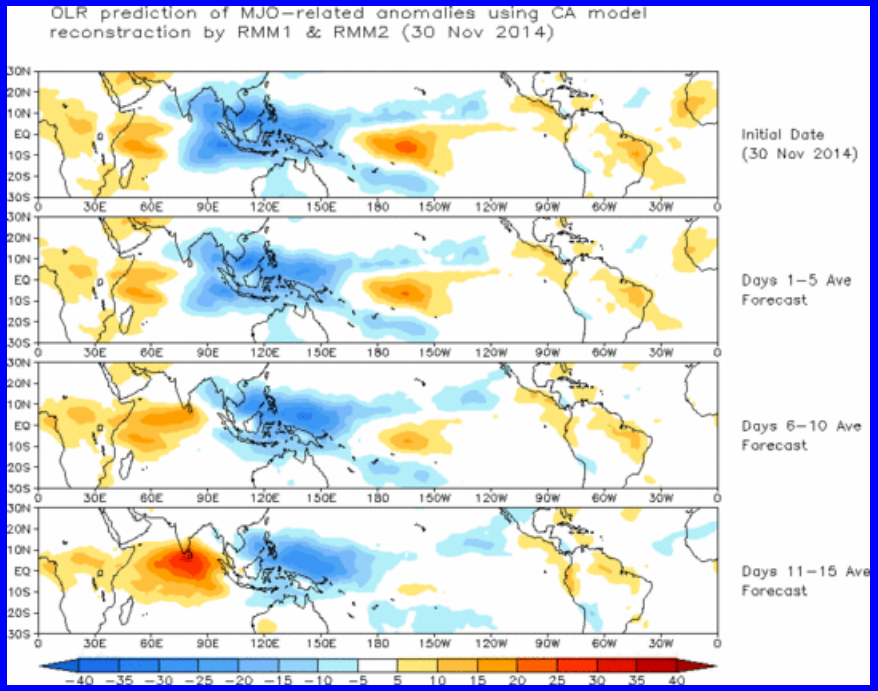
**Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days**



# Constructed Analog (CA) MJO Forecast

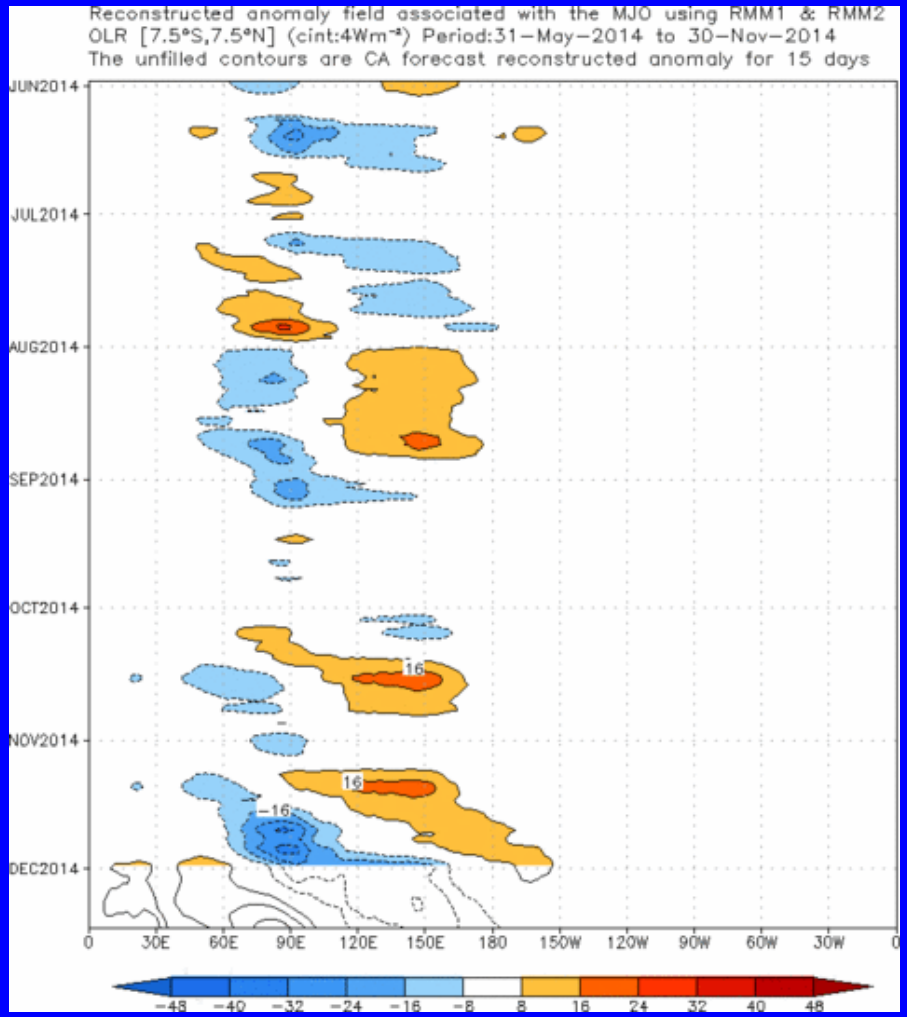
**Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)**

**Spatial map of OLR anomalies for the next 15 days**



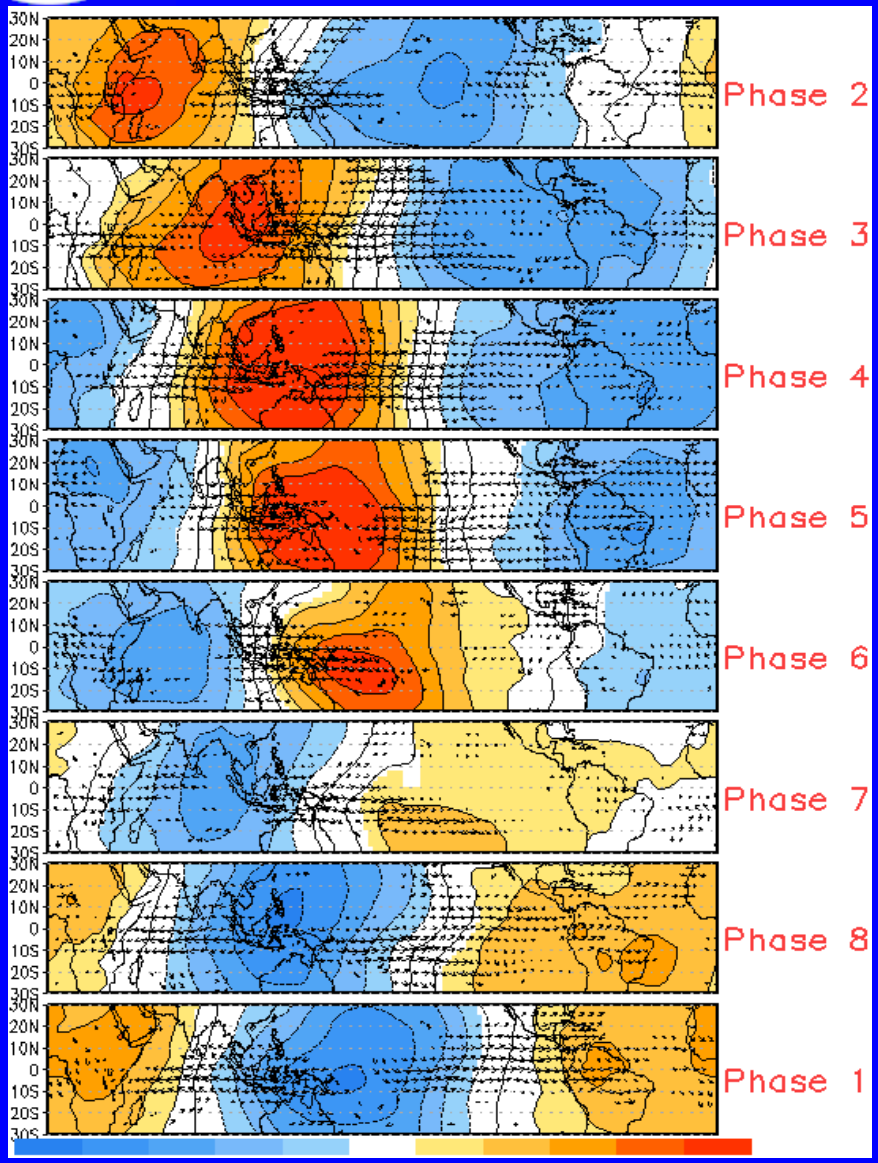

**The constructed analog forecast depicts eastward propagation of a robust MJO signal from the Maritime Continent to the West Pacific over the next two weeks.**

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

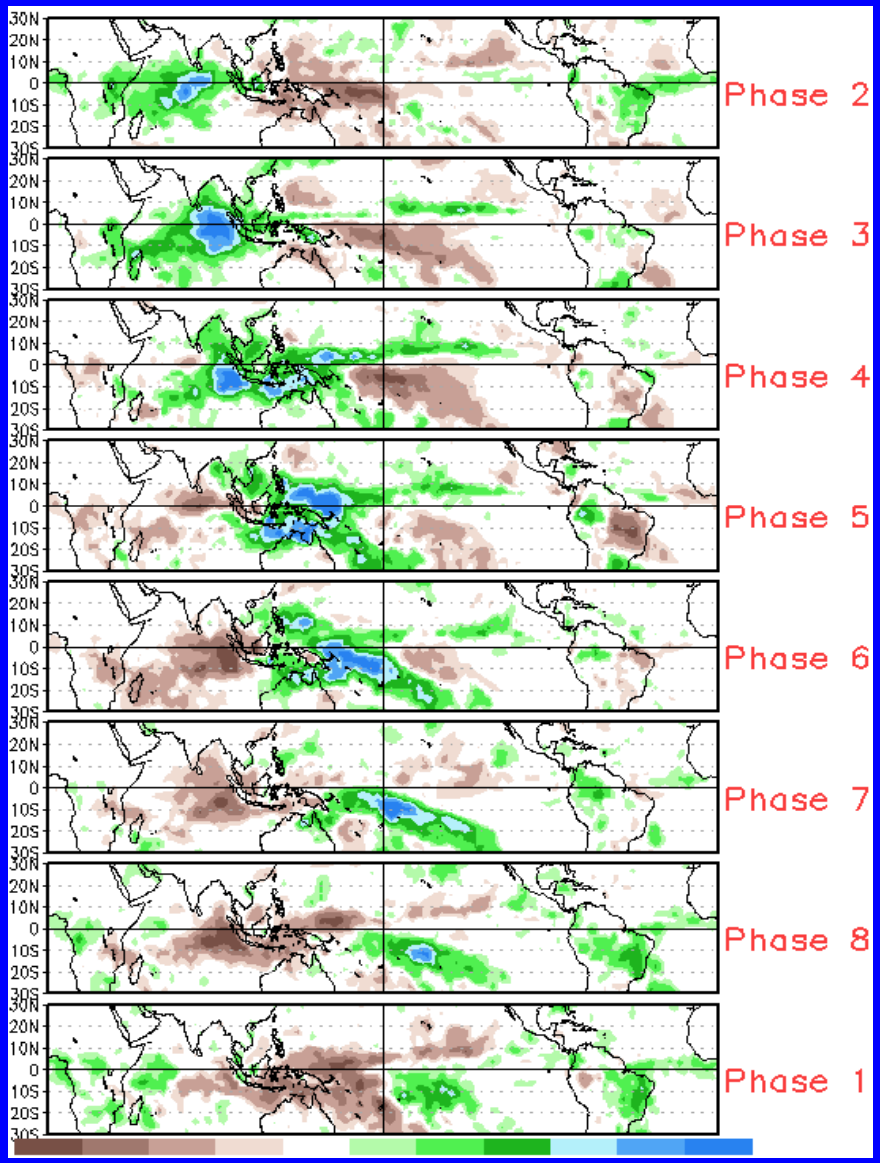


# MJO Composites – Global Tropics

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

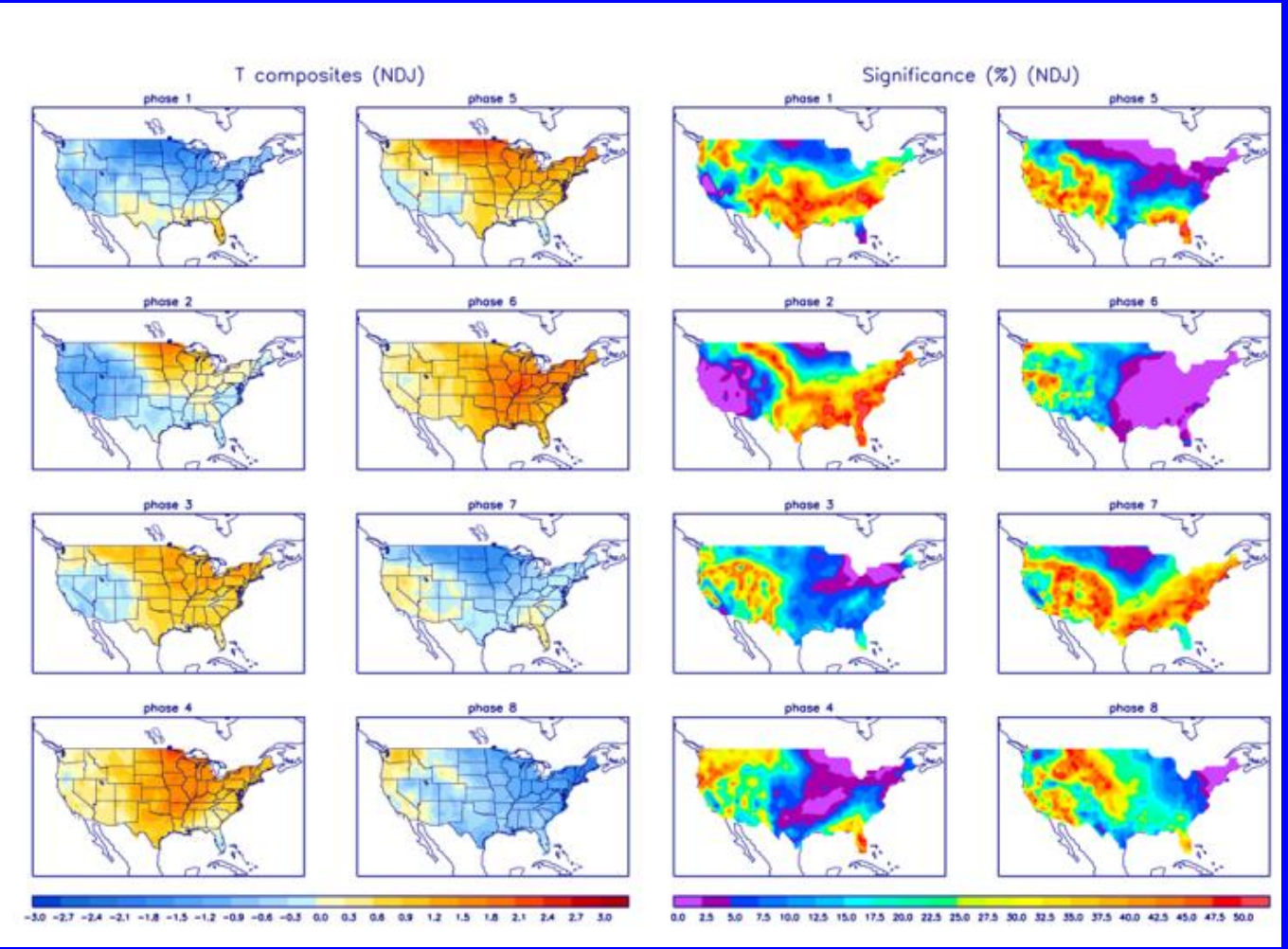



Precipitation Anomalies (Nov-Mar)



# 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.**

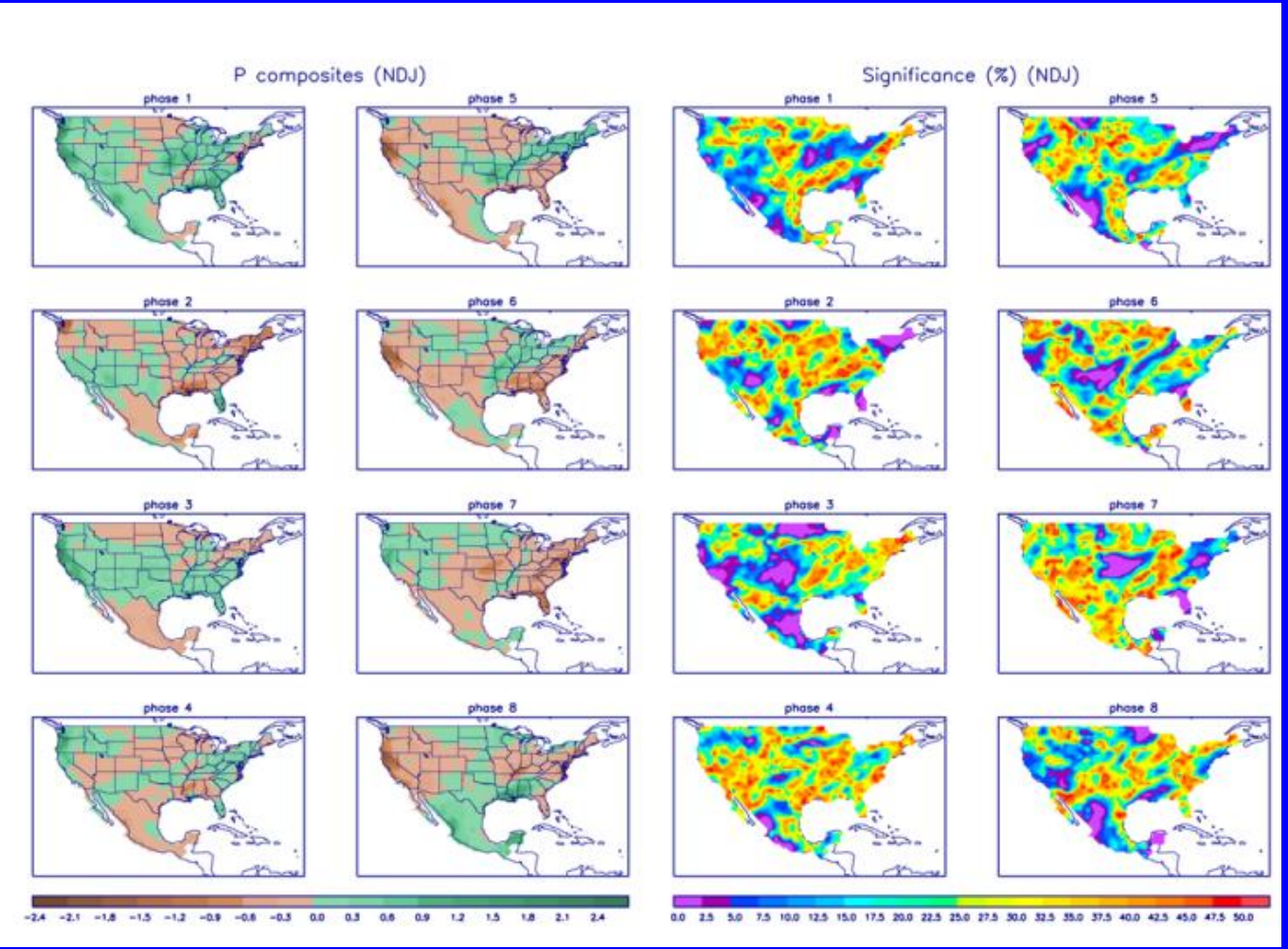



Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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