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

Update prepared by
Climate Prediction Center / NCEP
December 29, 2014

Outline

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

Overview

- **The MJO remained active and strengthened during the past week. Other modes of variability are constructively interfering with the MJO.**

- **The upper-level fields are coherent with MJO activity, while the lower-level wind fields have some other factors influencing the pattern. The RMM and the CPC Velocity Potential Indices both indicate enhanced convection over the Maritime Continent.**

- **Dynamical model MJO index forecasts generally depict eastward propagation of an MJO signal by Week-2 to the West Pacific. Statistical models agree with the majority of the dynamical models.**

- **The MJO is forecast to remain active over the next two weeks, favoring enhanced convection shifting slowly from Maritime Continent the western Pacific.**

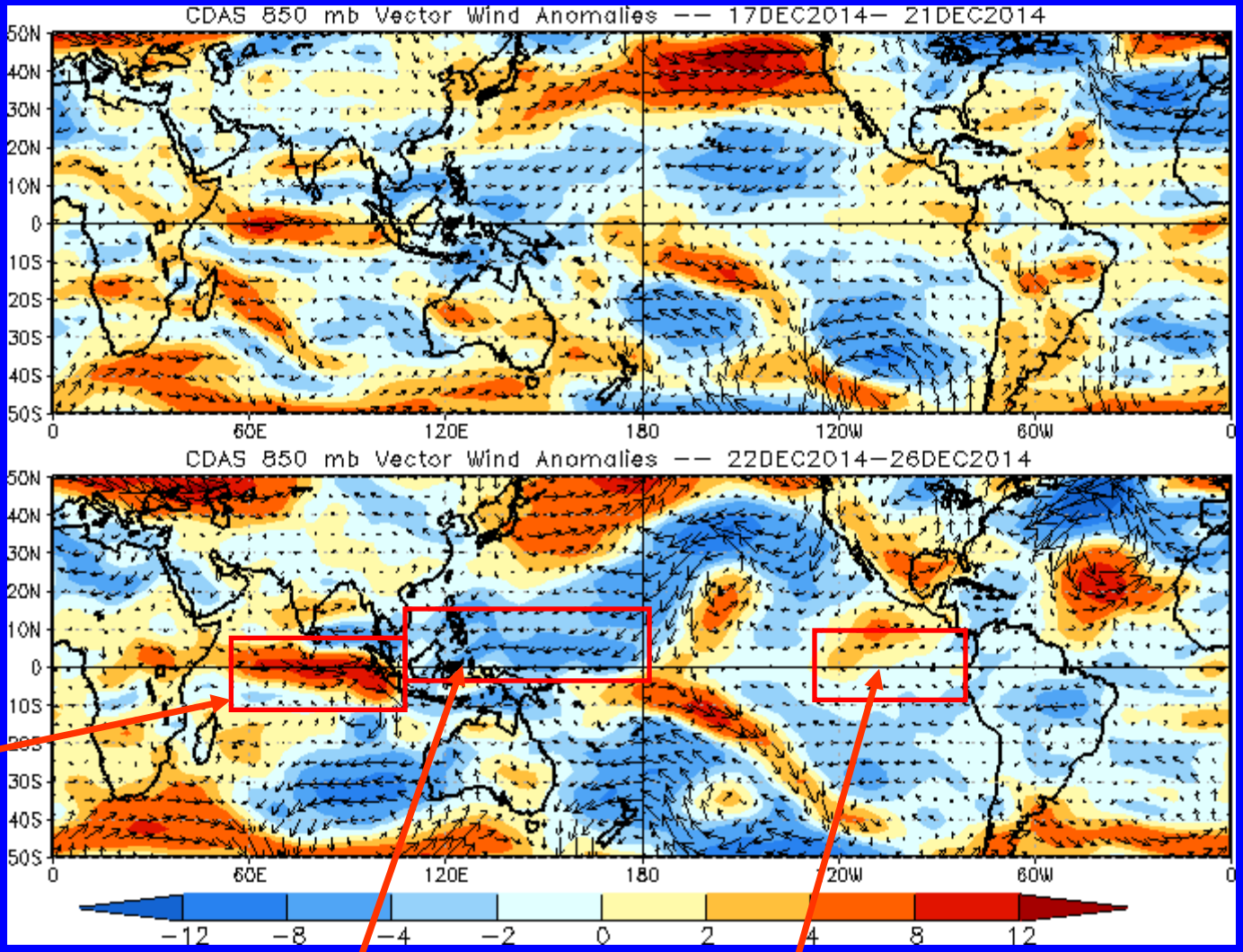
A forecast map of potential impacts across the global Tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 expanded eastward to the Maritime Continent.

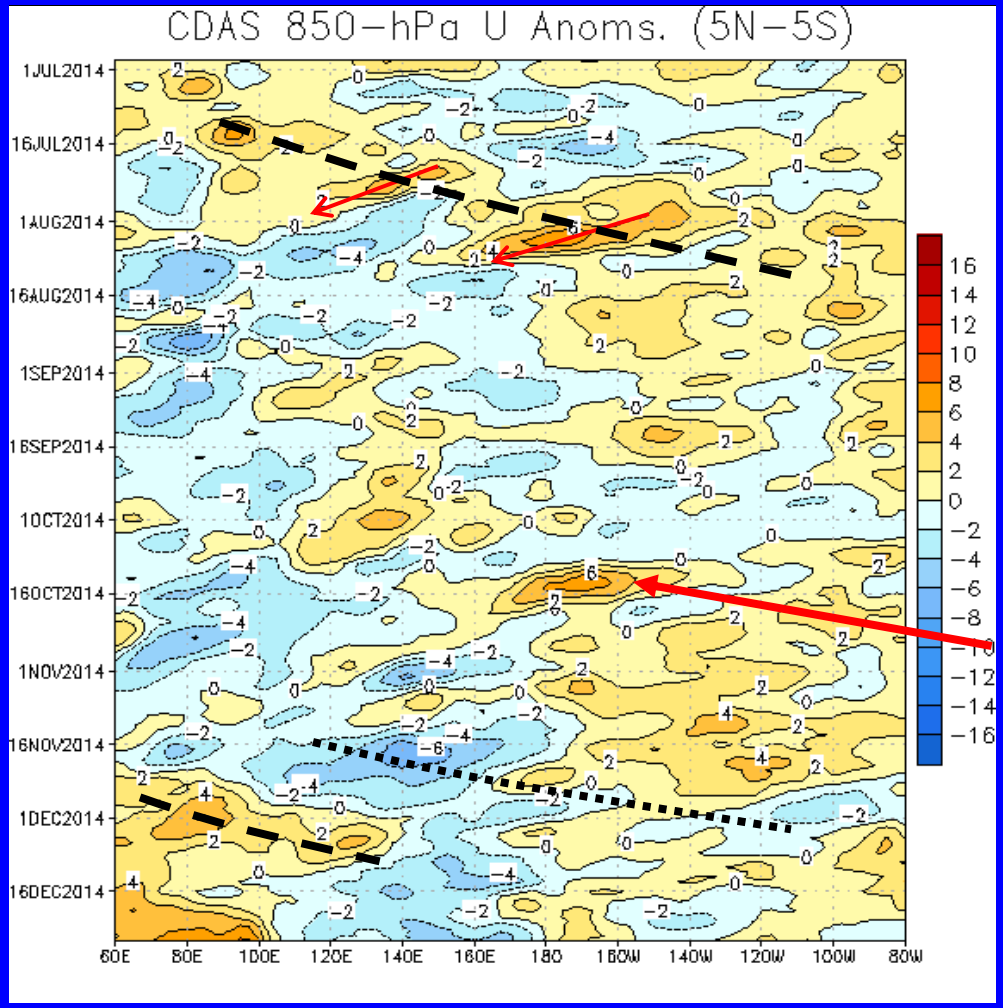
Easterly anomalies intensified slightly and expanded toward the Date Line.

Westerly anomalies over the eastern Pacific retreated west slightly.

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

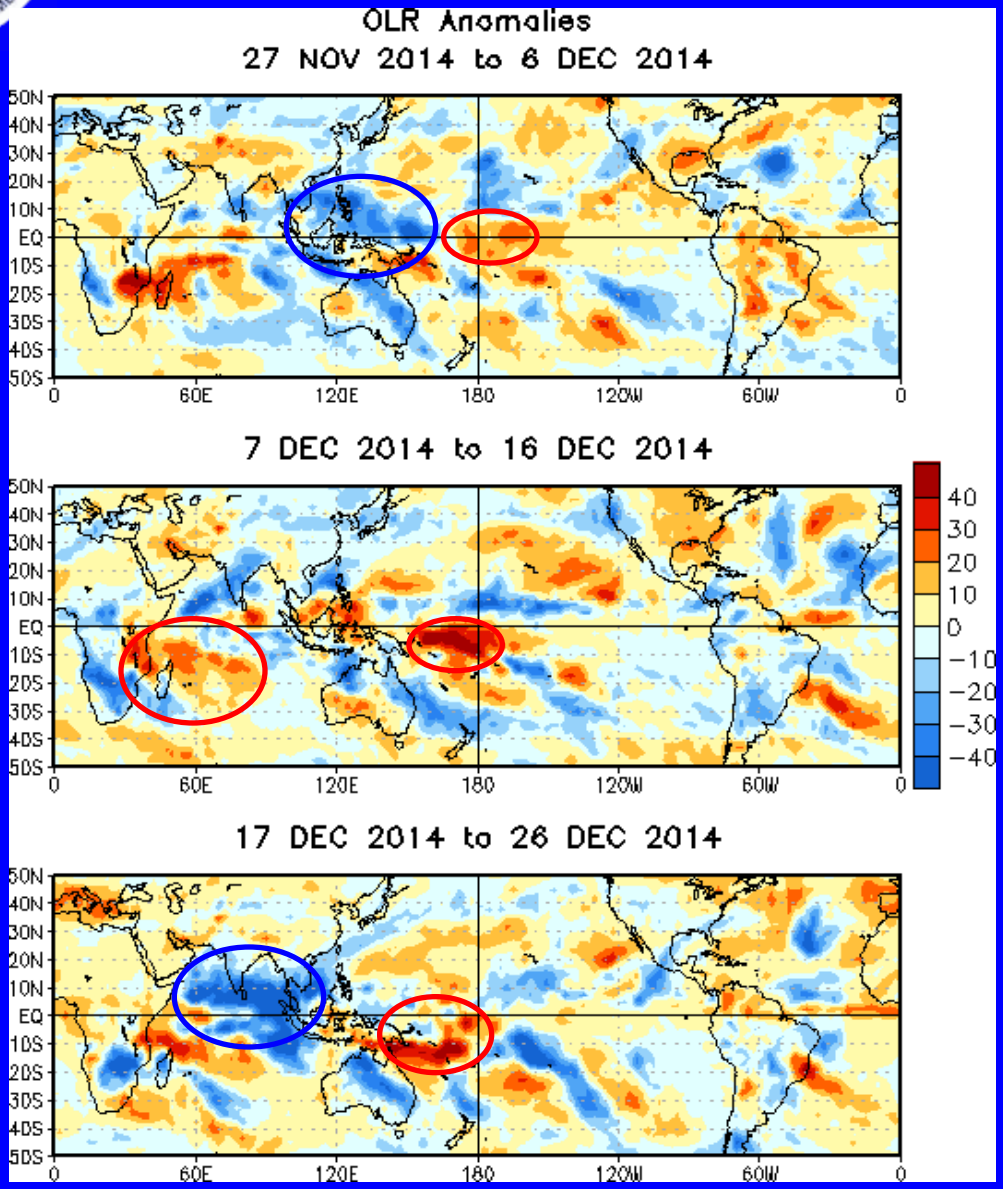
From late July to August, an envelope of westerly wind anomalies shifted eastward across the Pacific associated with weak MJO activity (dashed line). Embedded within this envelope were frequent and strong westward moving high frequency features (red arrows) over the eastern and central Pacific (western Pacific, Maritime Continent, and Indian Ocean).

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

Enhanced MJO activity was observed in late November into December.

Recently, westerly wind anomalies have intensified near 100E. Some weak, westward moving features are evident east of the Date Line.

OLR Anomalies – Past 30 days



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

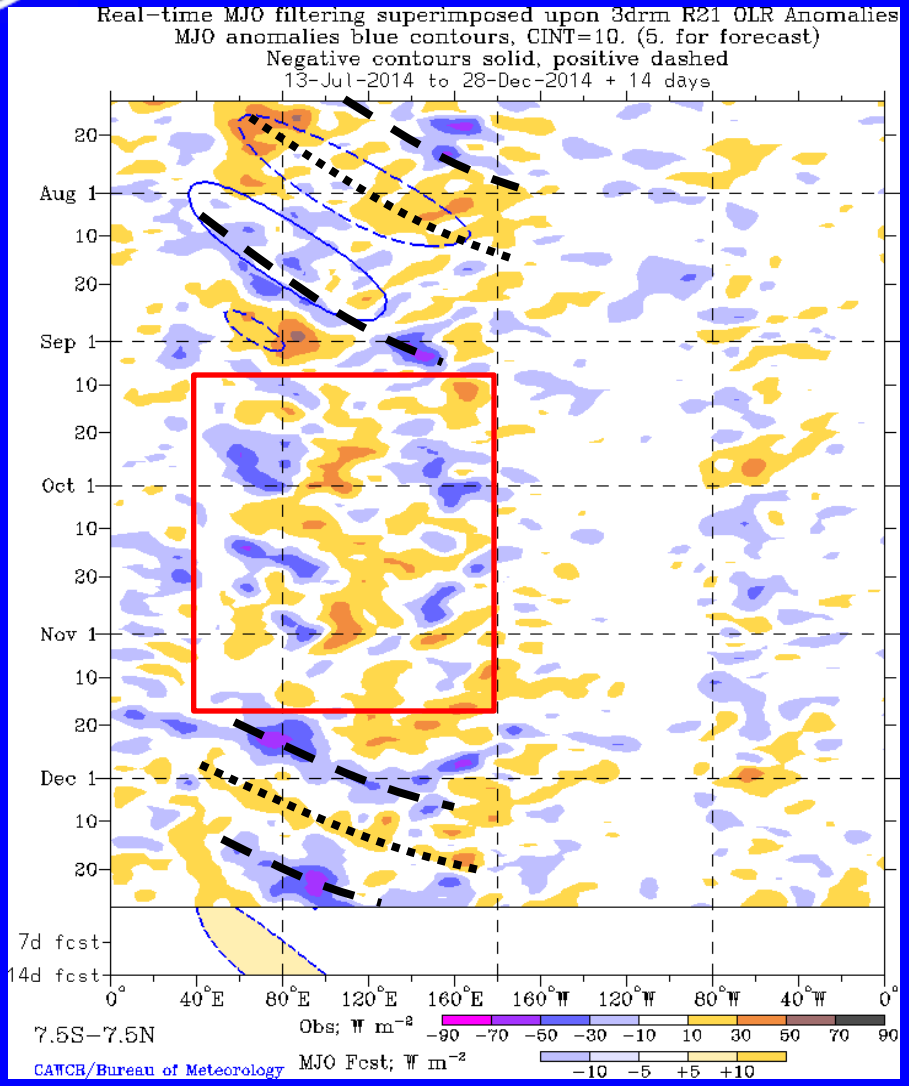
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

Widespread enhanced convection was observed during late November to early December over the Maritime Continent, with suppressed convection near the Date Line.

During early to mid-December, suppressed convection remained near the Date Line, shift westward slightly. Elsewhere, convective anomalies were disorganized.

During mid to late-December, the pattern showed some signs of reorganization, with enhanced convection developing over the Indian Ocean and suppressed convection centered over the West Pacific.

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).

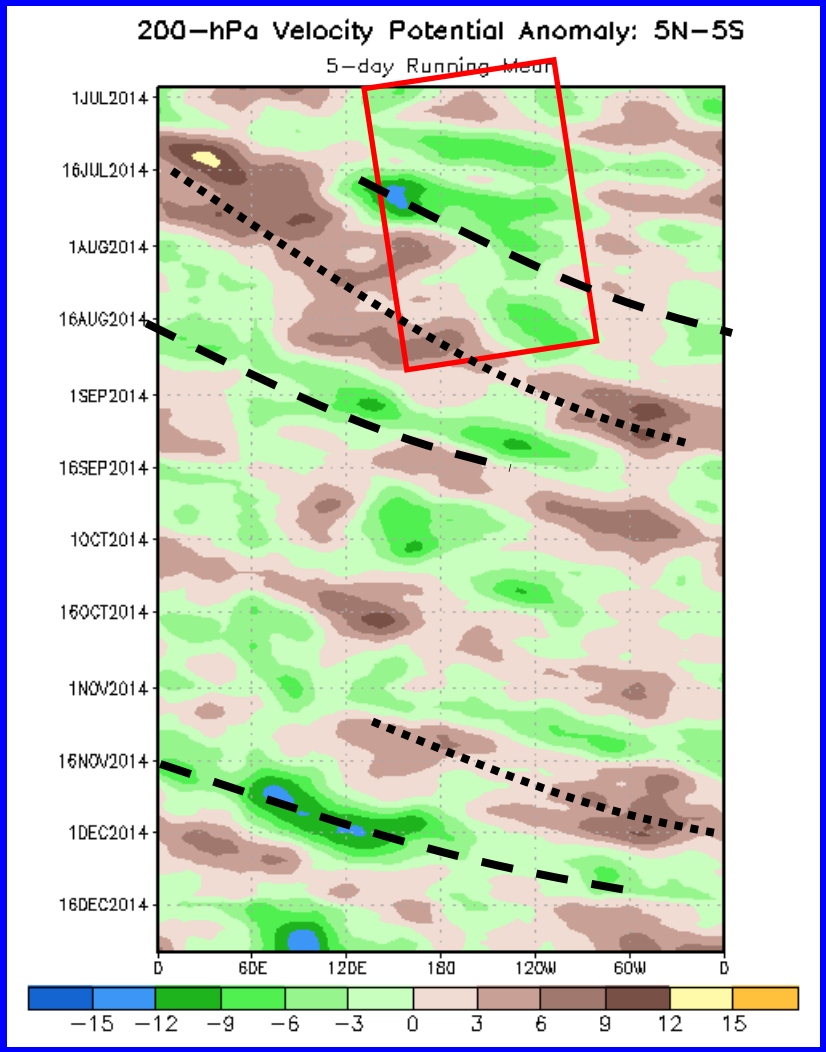
The pattern became less coherent with respect to canonical MJO activity by September and the MJO remained weak till late November (red box).

The MJO strengthened in late November with enhanced convection moving from the Indian Ocean to the Date Line. Recently, enhanced convection has resumed over the Indian Ocean. There is some evidence of westward moving modes.

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 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.

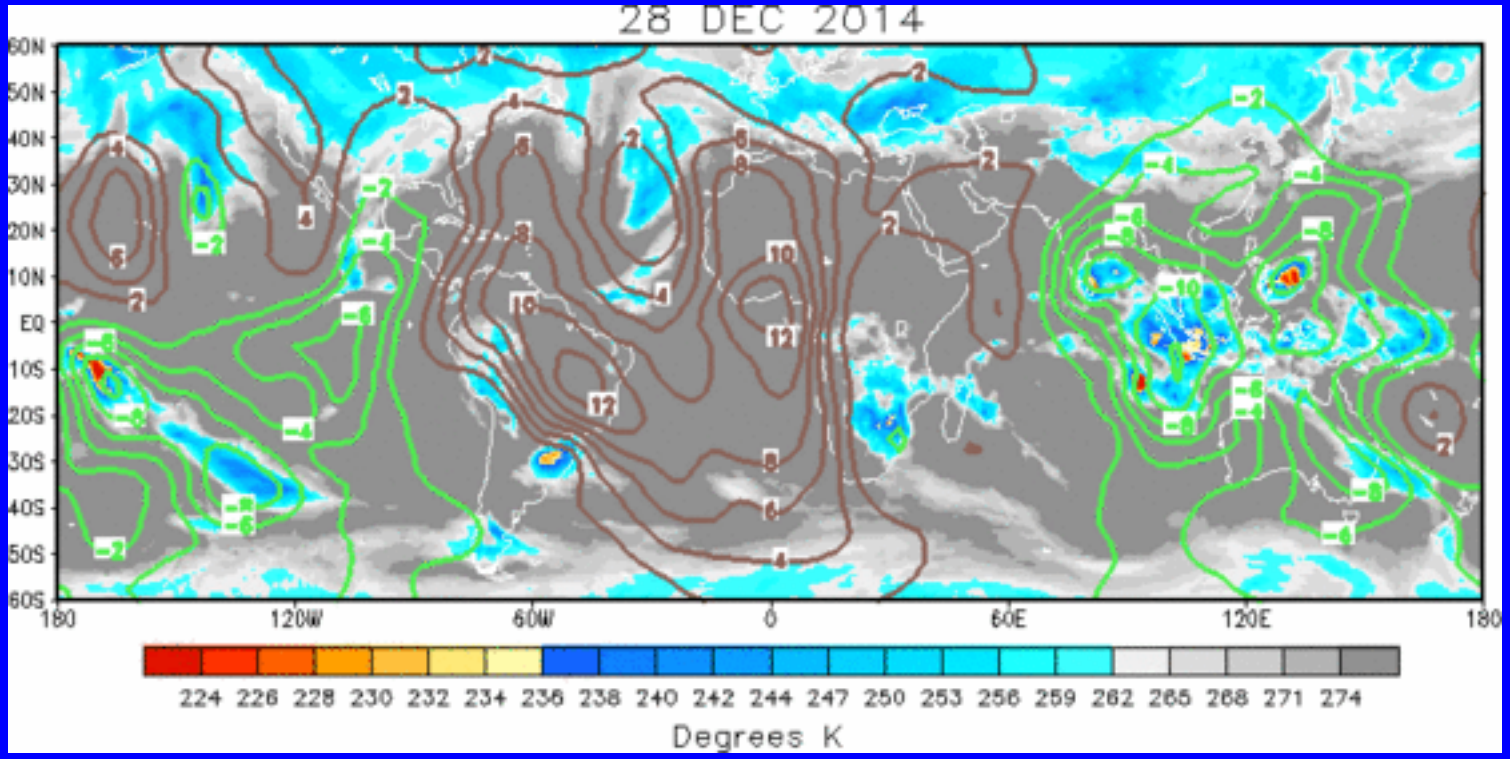
During November the MJO strengthened as indicated by eastward propagation of anomalies with the enhanced phase entering the west-central Pacific by early December. Rapid eastward propagation has continued, likely due to Kelvin wave activity.

Recently, upper level divergence developed over the Indian Ocean.

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

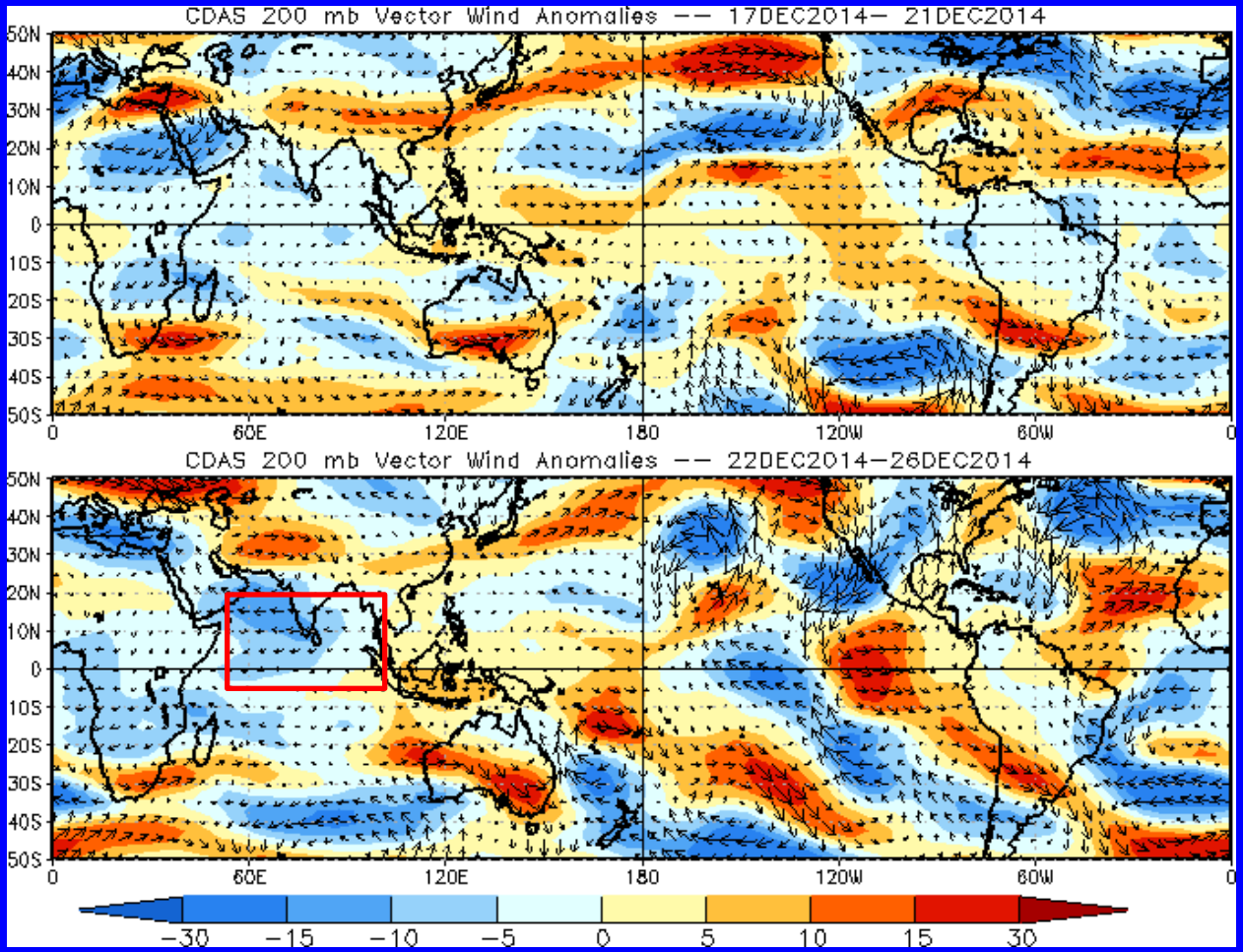
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The upper-level anomalous velocity potential spatial pattern is coherent with an active MJO. Upper-level divergence is now centered over the Maritime Continent with upper-level convergence convection spanning the Atlantic.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

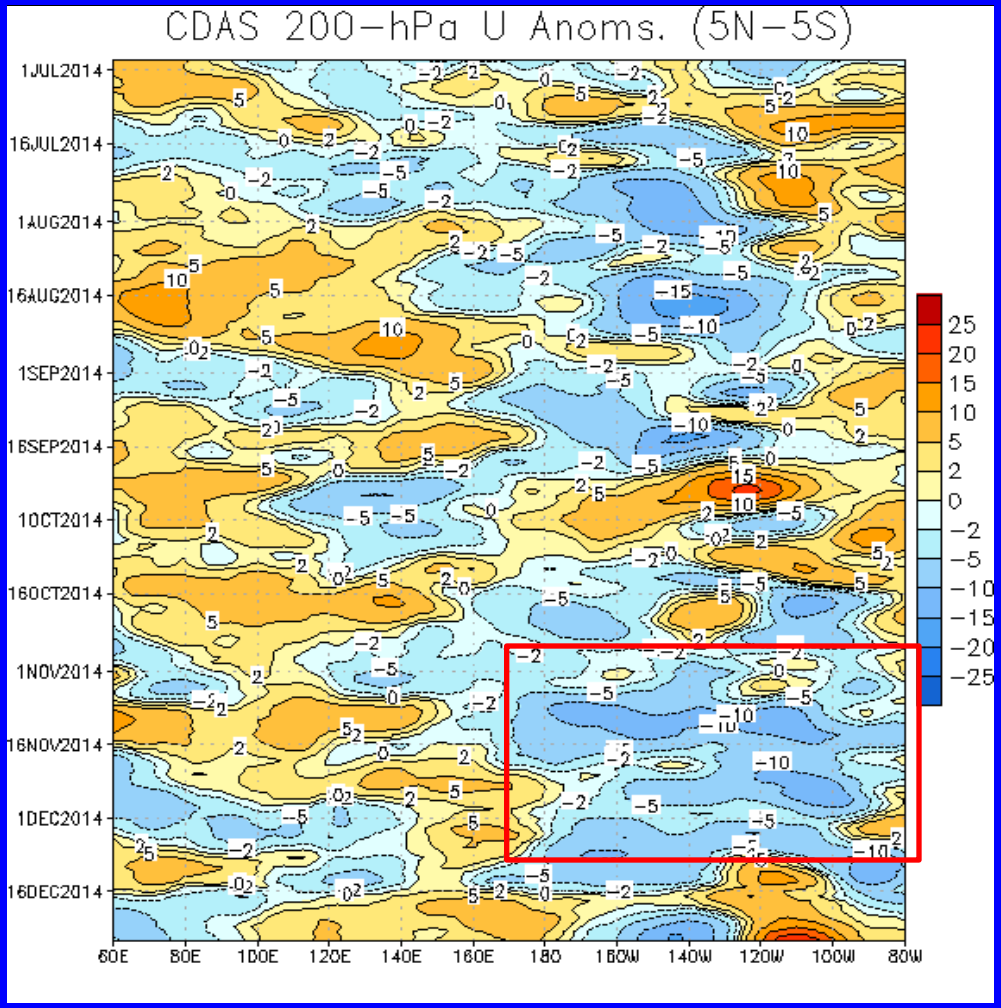
Red shades: Westerly anomalies

Easterly anomalies intensified over the Indian Ocean, while strong mid-latitude interactions are evident over the eastern 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

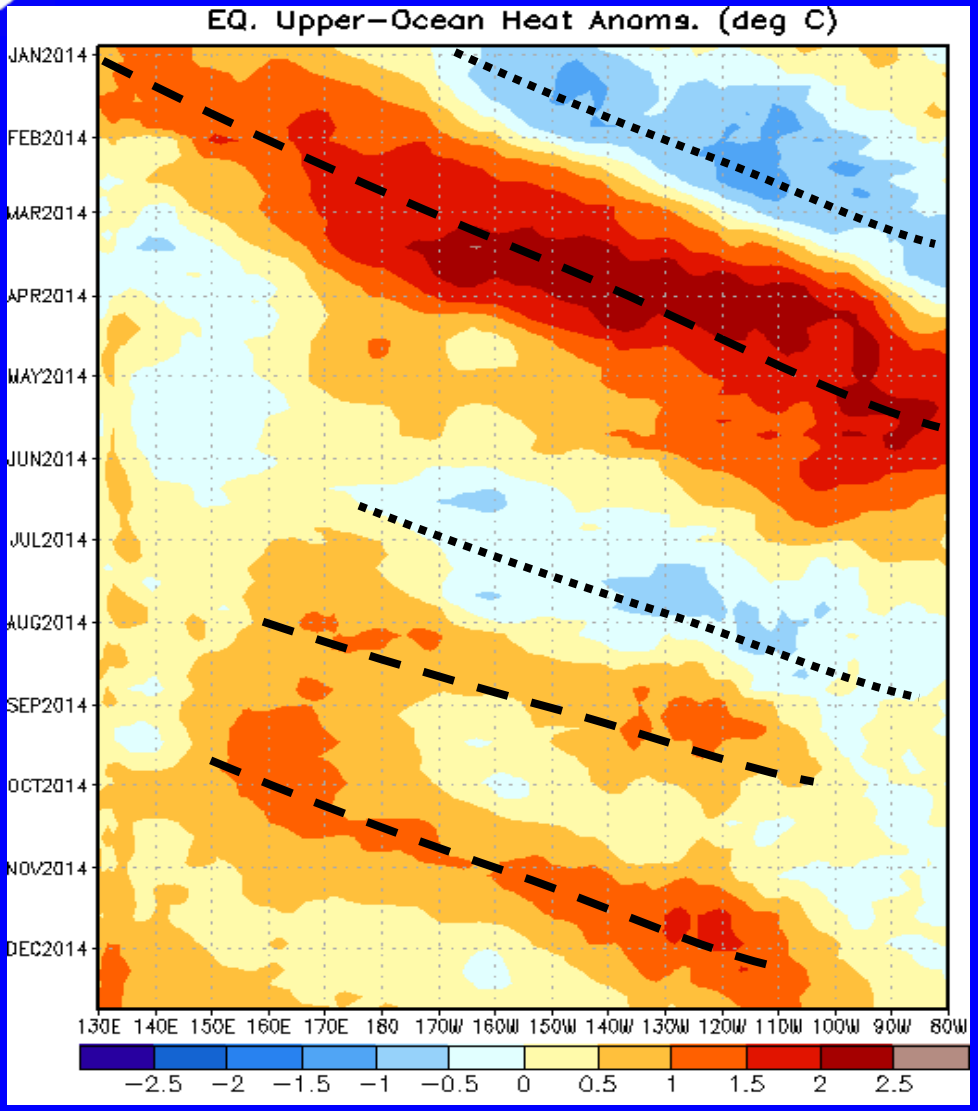
Westward propagation of westerly anomalies is evident over the east-central Pacific during June. In July, easterly anomalies intensified over the central and eastern Pacific.

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.

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

Recently, westerly anomalies have overspread the Maritime Continent and much of the western Pacific. A dipole of strong anomalies is evident over the eastern Pacific.

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 are again evident across much of the Pacific basin due to another moderate downwelling Kelvin wave traversing the Pacific during October and November 2014. The downwelling is moving slowly eastward, with some increasing anomalies near the Date Line.

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).

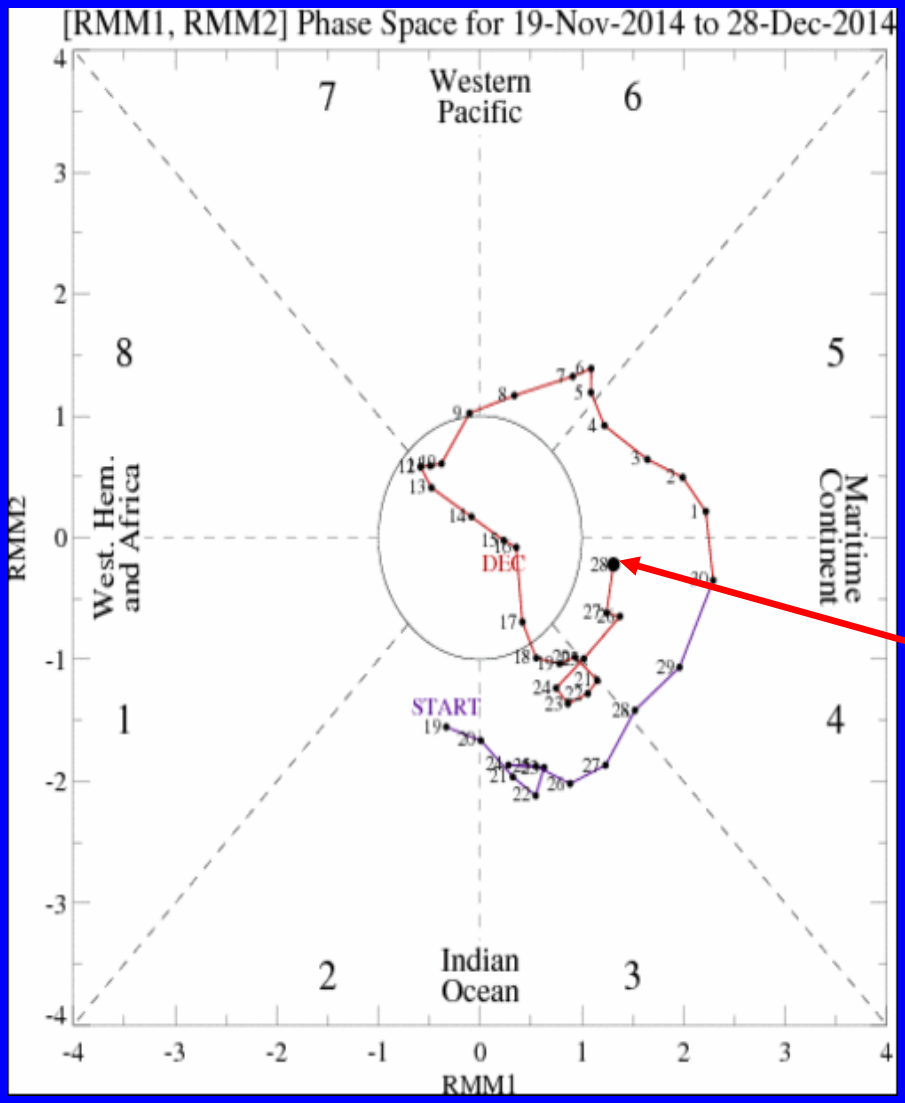
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

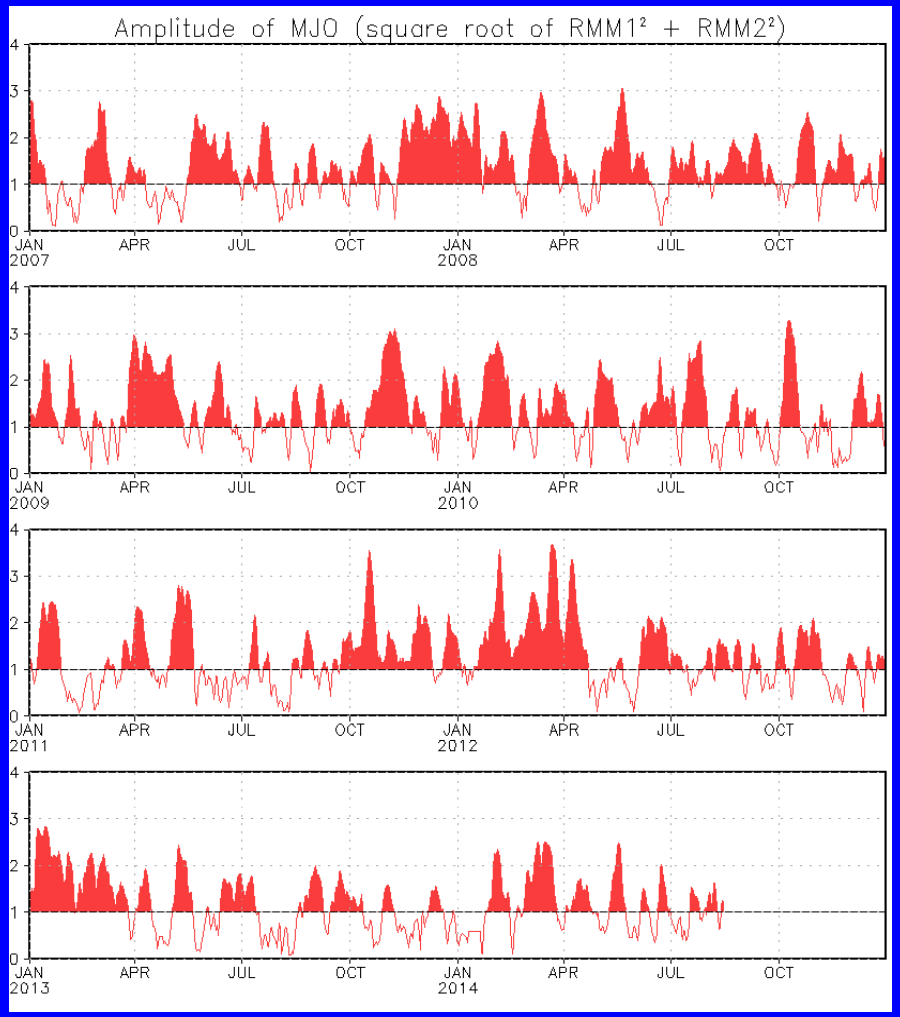
MJO Index -- Recent Evolution



- 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 a strengthening of the MJO during the past week, indicating enhanced convection shifting east to the Maritime Continent.

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.

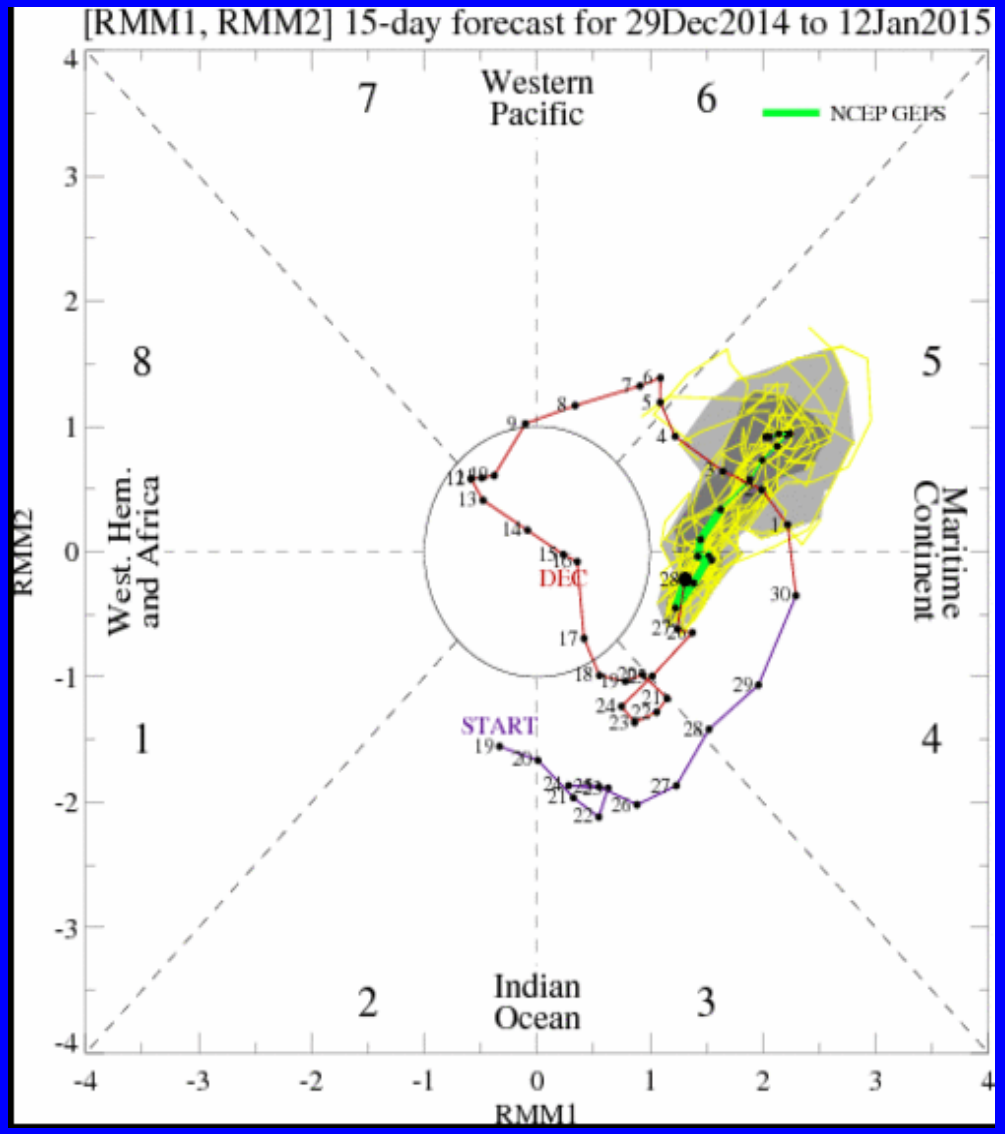
Ensemble GFS (GEFS) MJO Forecast

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

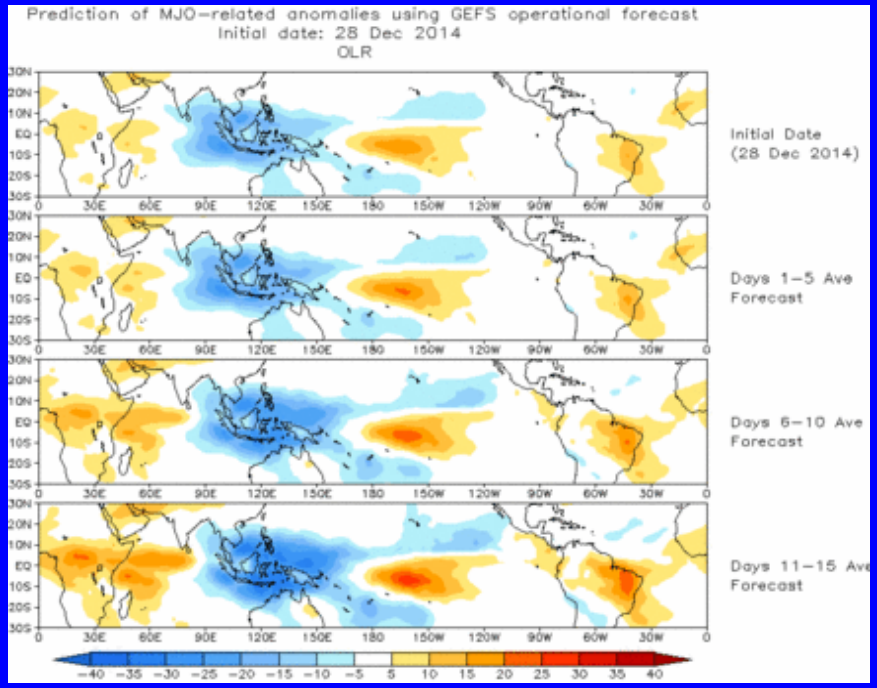
The ensemble GFS forecast indicates a slowly propagating signal with some intensification through Week-2.



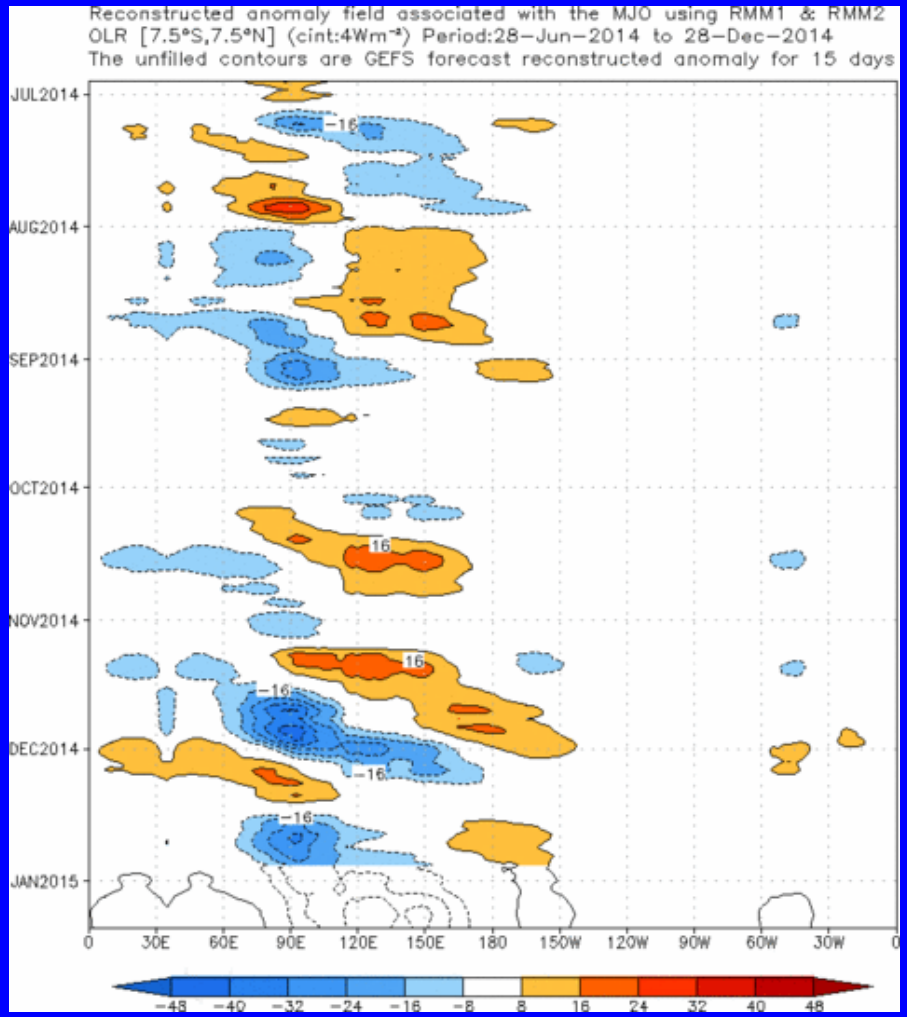
Ensemble Mean GFS MJO Forecast

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

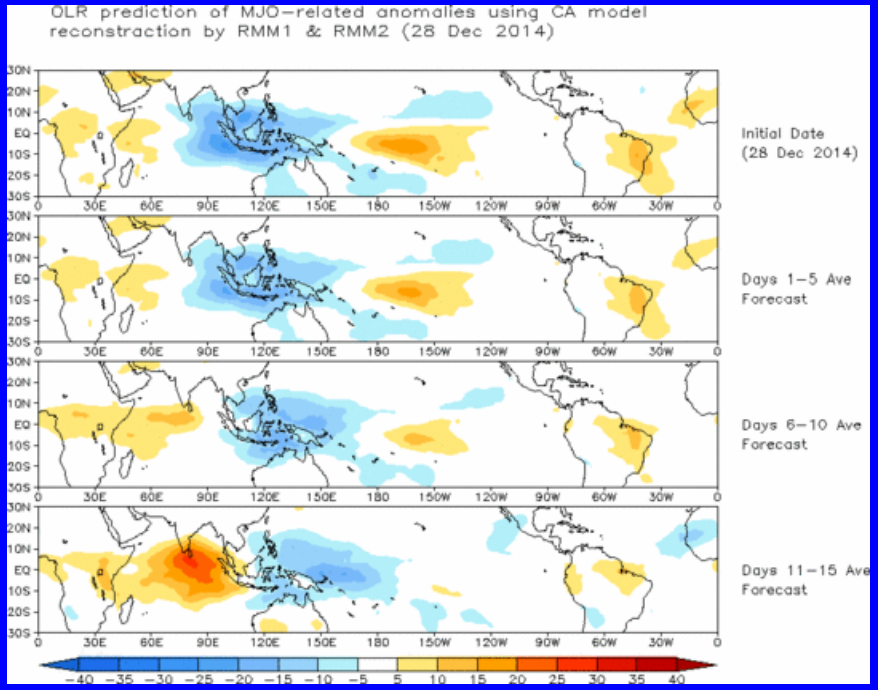


The GEFS mean MJO index based OLR anomaly forecast depicts enhanced convection during Week-1 over the Maritime Continent, with slow eastward propagation forecast by the end of Week-2.

Constructed Analog (CA) MJO Forecast

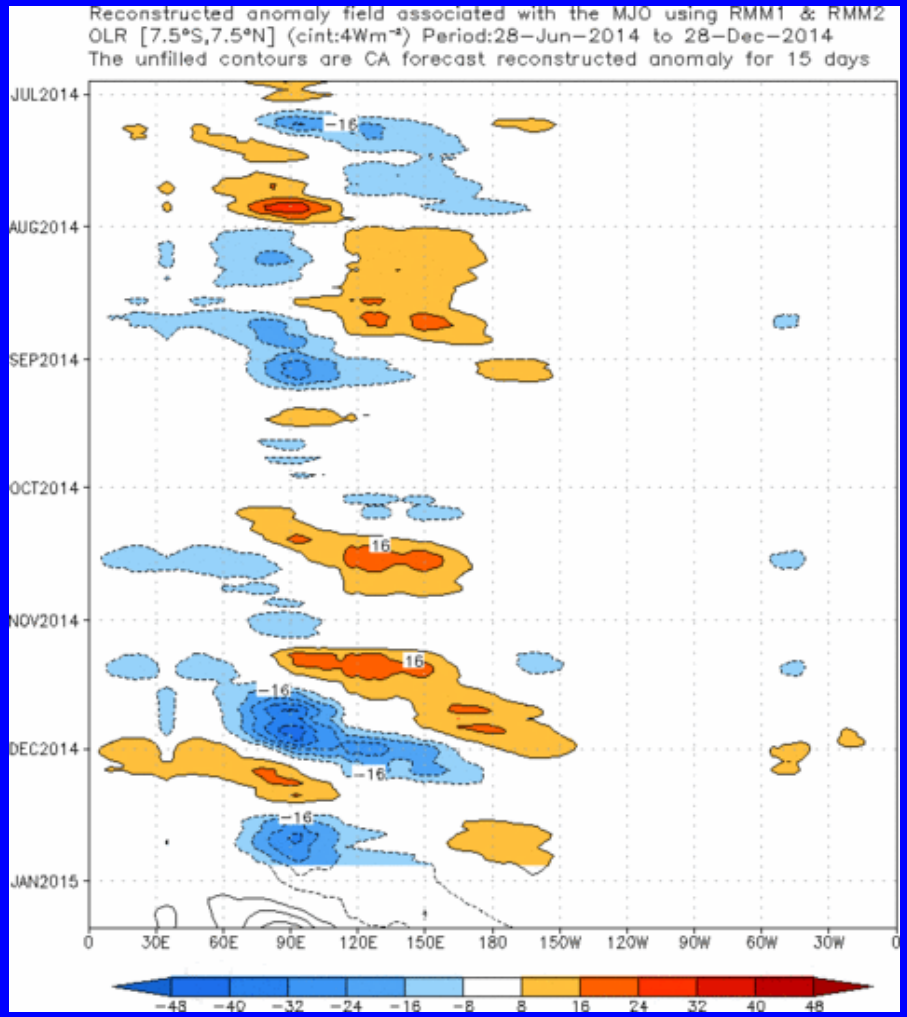
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



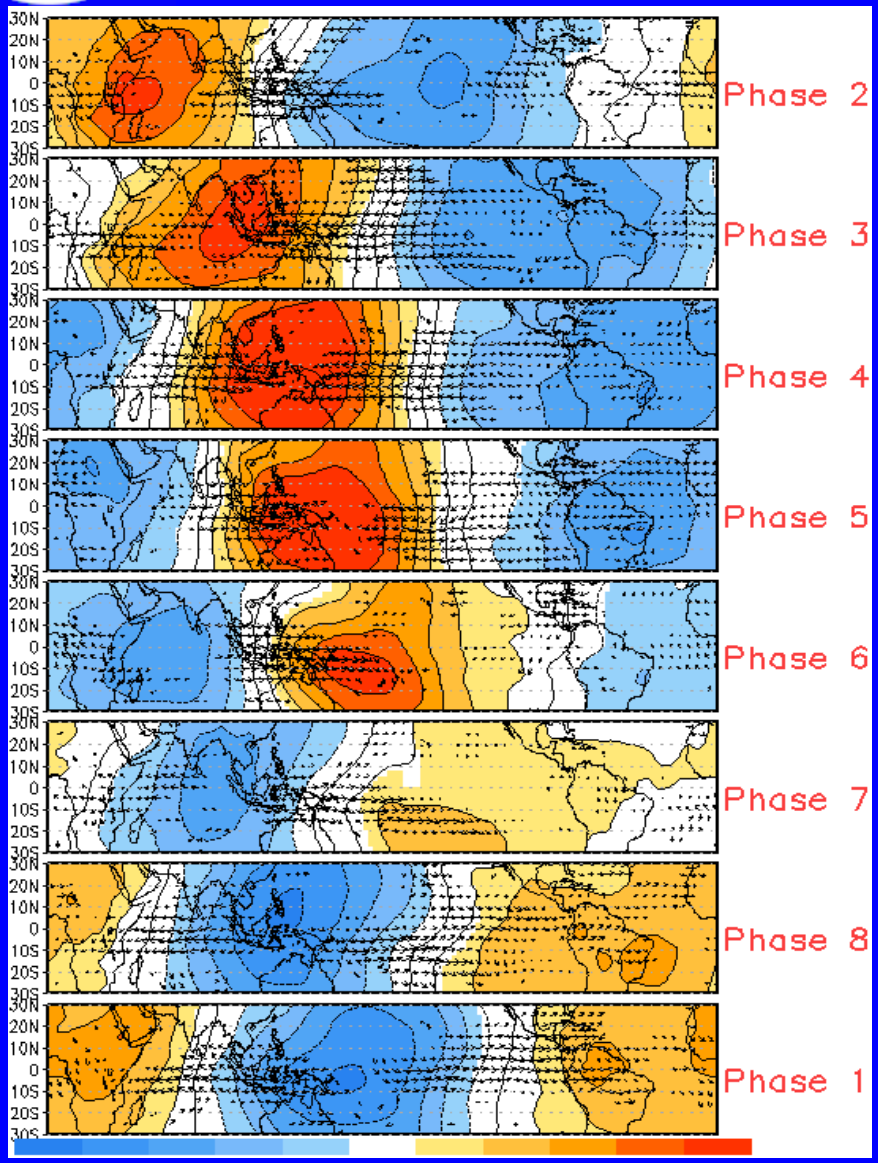
The constructed analog forecast depicts a faster eastward propagation than the GEFS, with a similar strength projection.

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

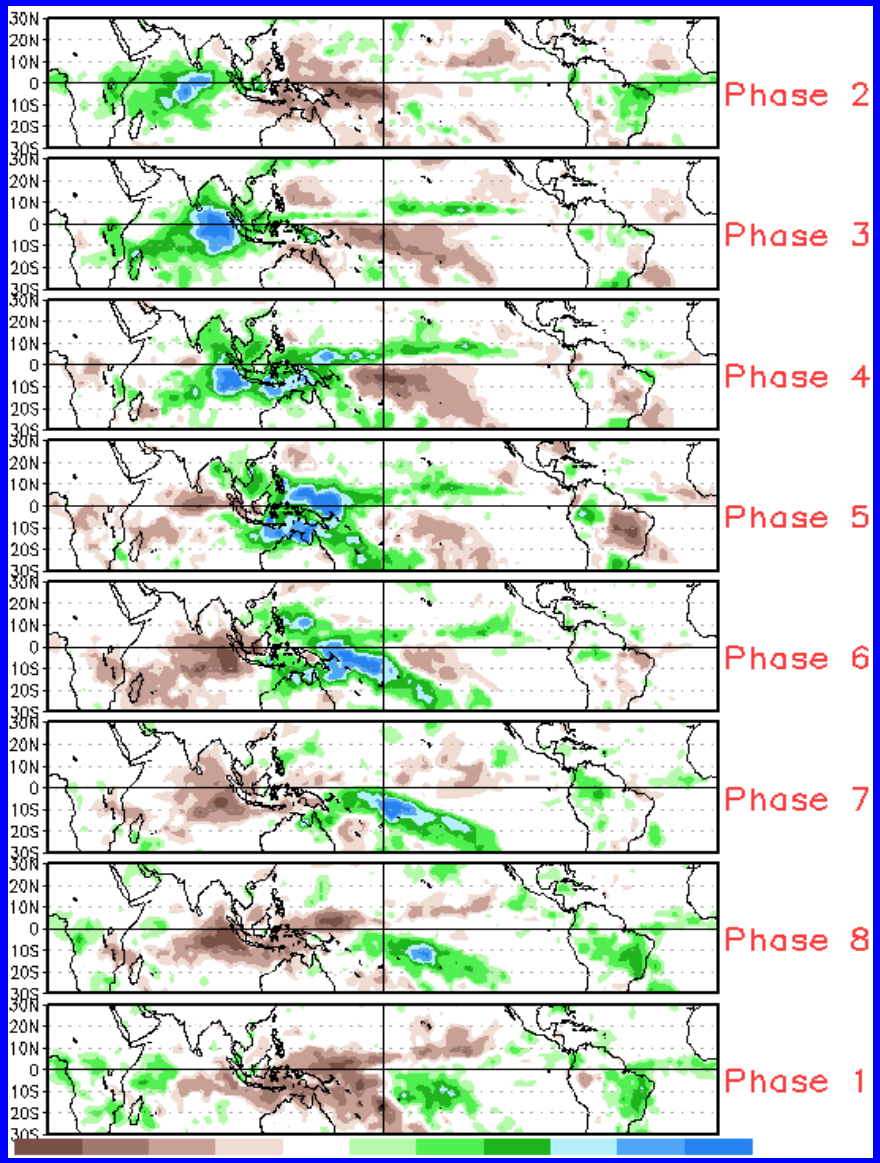


MJO Composites – Global Tropics

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

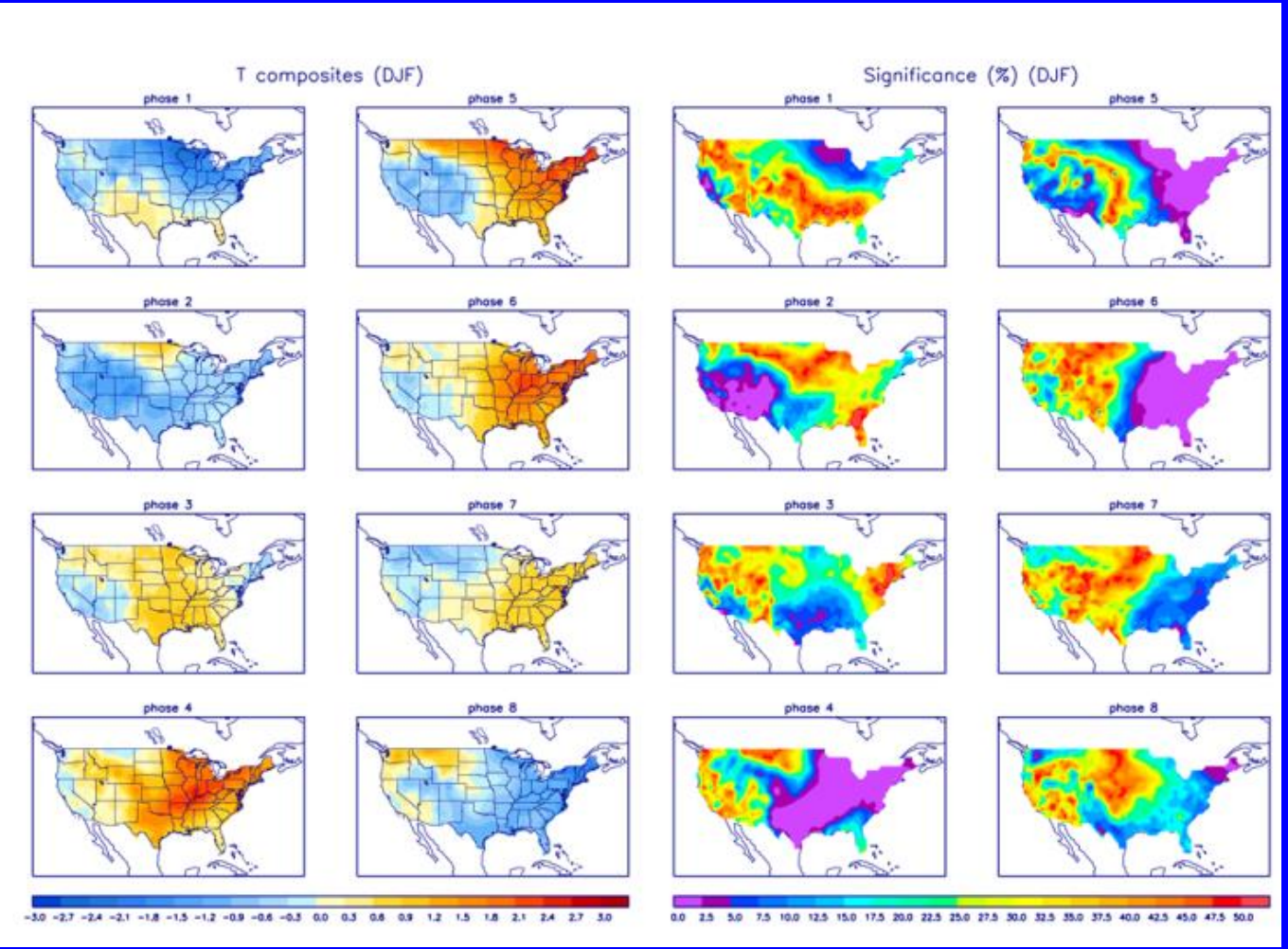


Precipitation Anomalies (Nov-Mar)



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.**

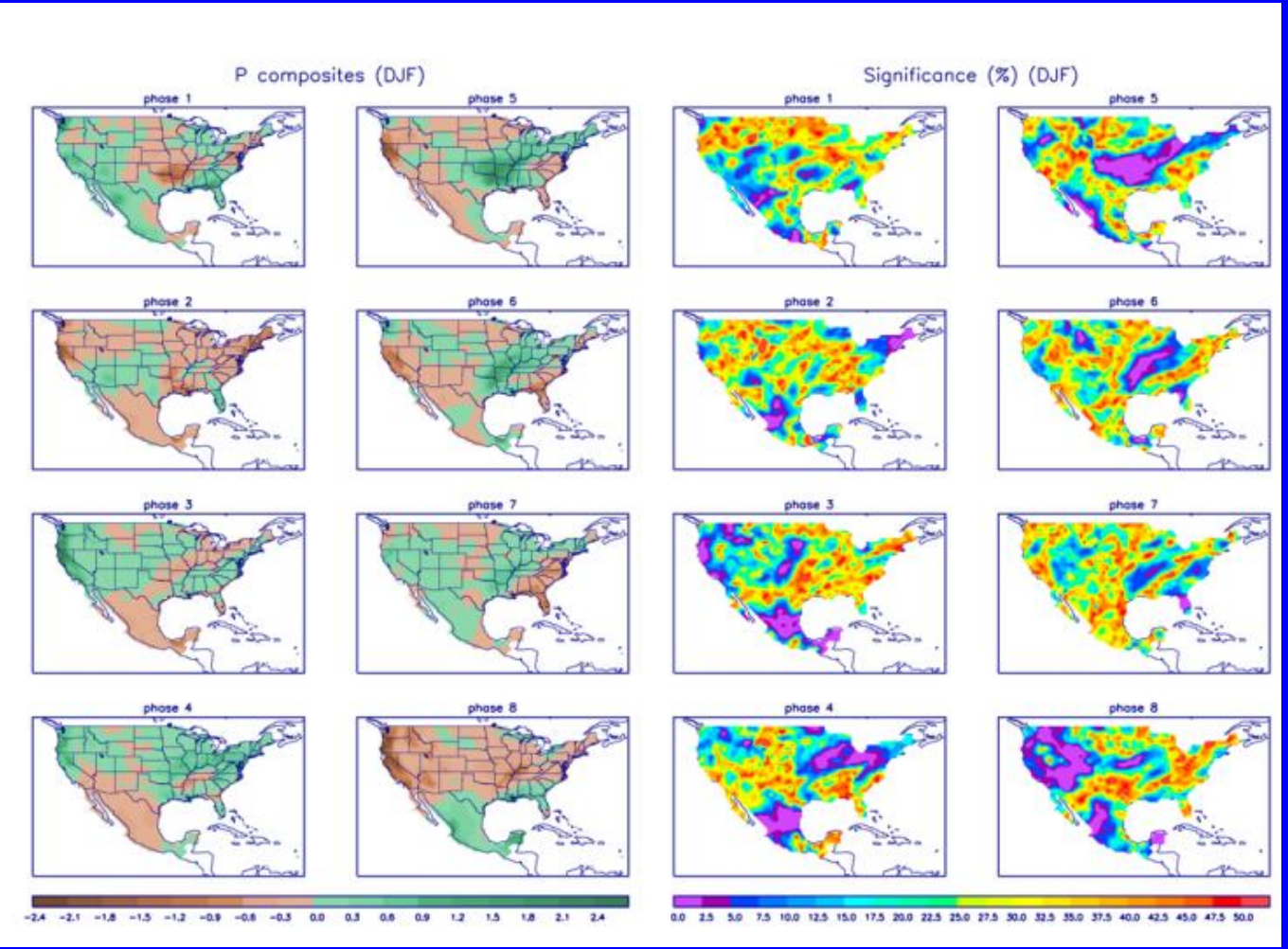


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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