



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

**Update prepared by
Climate Prediction Center / NCEP
December 22, 2014**



Outline

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



Overview

- Although the MJO may still be considered active, the enhanced phase has propagated rapidly to the Indian Ocean due to atmospheric Kelvin wave activity. The signal could be constructively interfering there with westward moving variability.
- The upper atmosphere portion of the signal is increasing aligned with the convection and low-level wind fields, yielding a more coherent signal between the RMM and CPC Velocity Potential indices.
- Dynamical model MJO index forecasts generally depict eastward propagation of an MJO signal by Week-2 to the Maritime Continent/West Pacific.
- The MJO is forecast to remain active over the next two weeks, favoring enhanced convection shifting slowly from the Indian Ocean to the Maritime Continent and far 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>

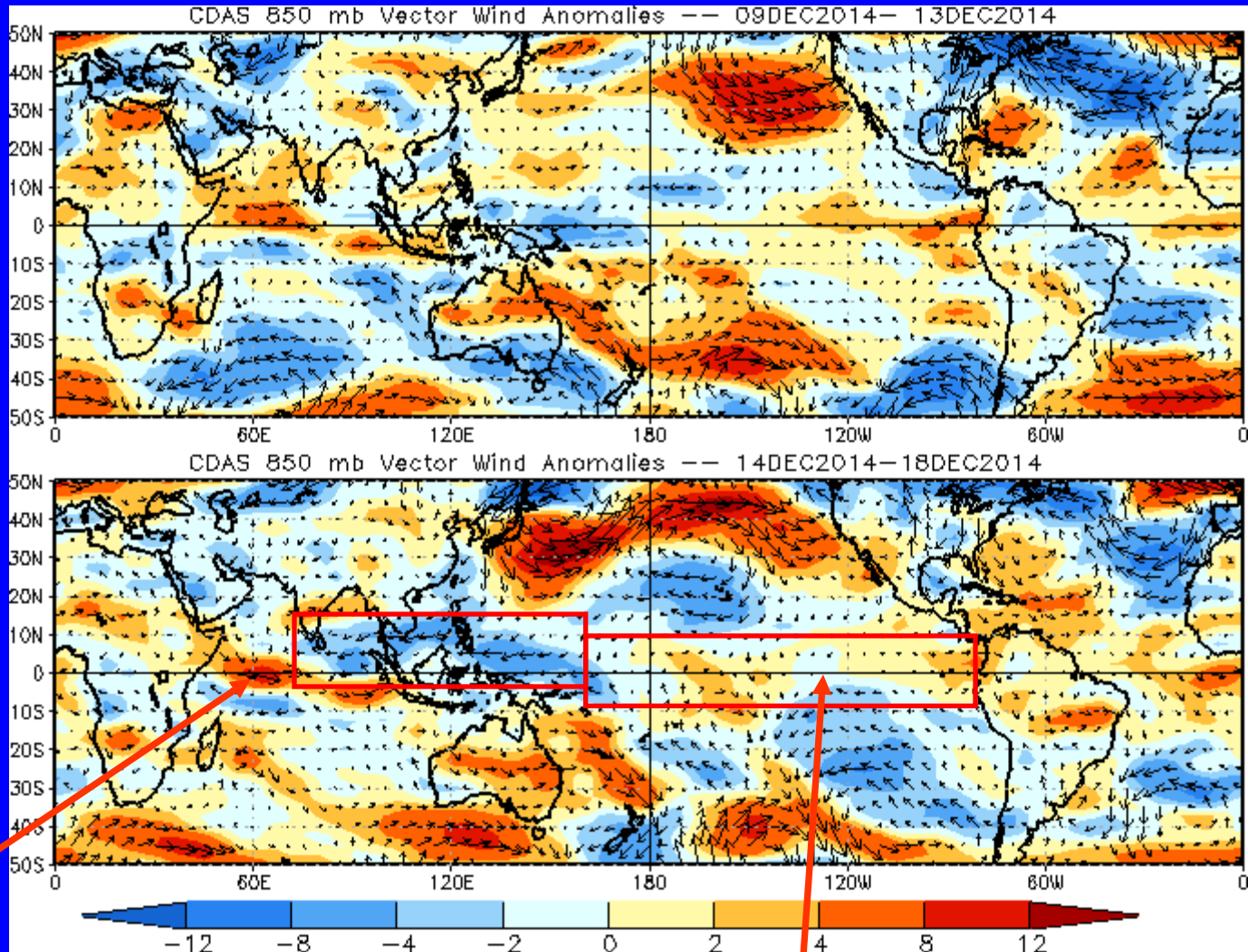


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



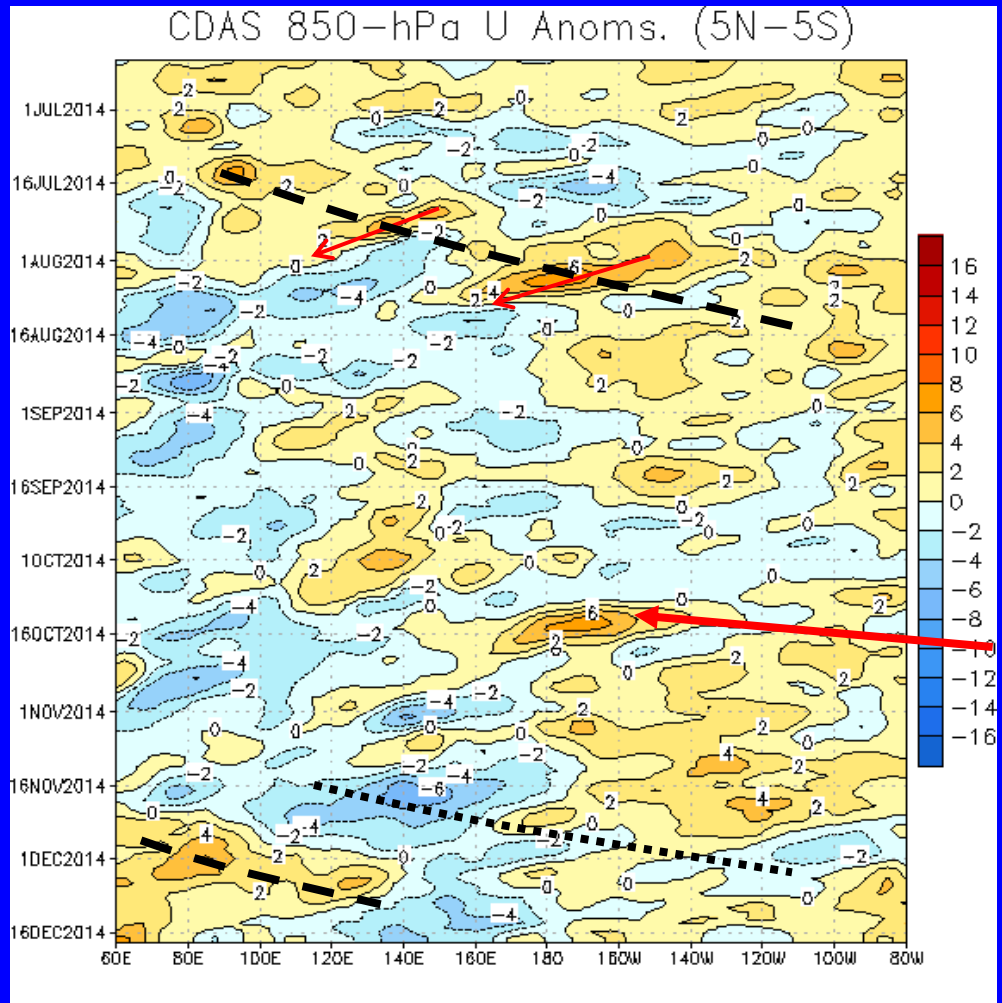
Easterly anomalies became more organized over parts of the eastern Indian Ocean, Maritime Continent, and West Pacific.

Winds across the equatorial Pacific did not change substantially 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



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).

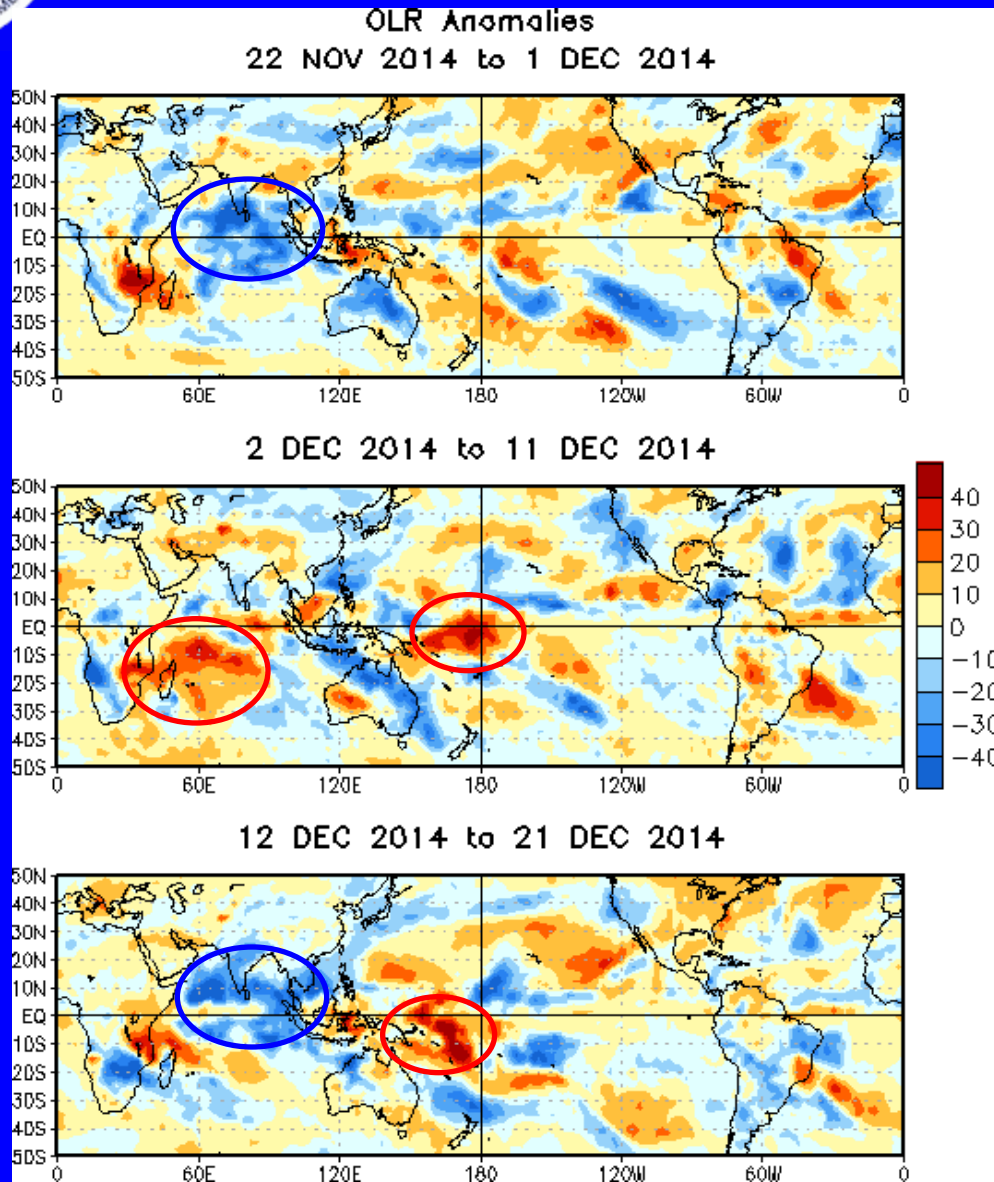
A westerly wind burst was observed near the Date Line during mid-October

Recently, enhanced MJO activity was observed in late November into December. However, eastward propagation of a coherent signal broke down over the past week.



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 over the Indian Ocean, with little coherent signal over the remainder of the Pacific, where there may have been some destructive interference between the MJO and low-frequency patterns.

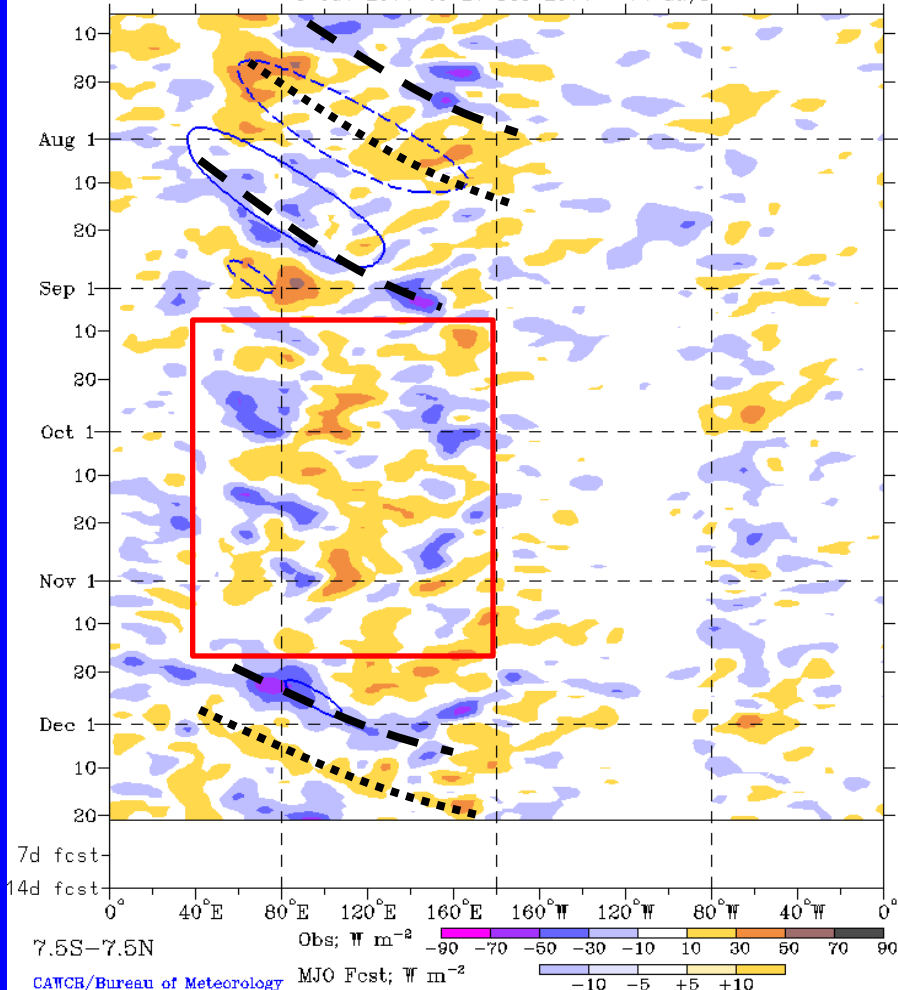
During early December, there was some evidence of enhanced convection over the Maritime Continent, though the only robust signals were suppressed convection at the Date Line and over the southwestern Indian Ocean.

During mid-December, the pattern showed some signs of reorganization, with enhanced convection developing over the Indian Ocean and suppressed convection centered over the West Pacific. This is due in part to westward moving equatorial Rossby waves.



Outgoing Longwave Radiation (OLR) Anomalies (7.5°S-7.5°N)

Real-time MJO filtering superimposed upon 3drmm R21 OLR Anomalies
MJO anomalies blue contours, CINT=10. (5. for forecast)
Negative contours solid, positive dashed
6-Jul-2014 to 21-Dec-2014 + 14 days



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 160°E by early December (dashed line) and weakly suppressed convection entering the Indian Ocean. Recently, convection has reemerged in the Indian Ocean.

Longitude

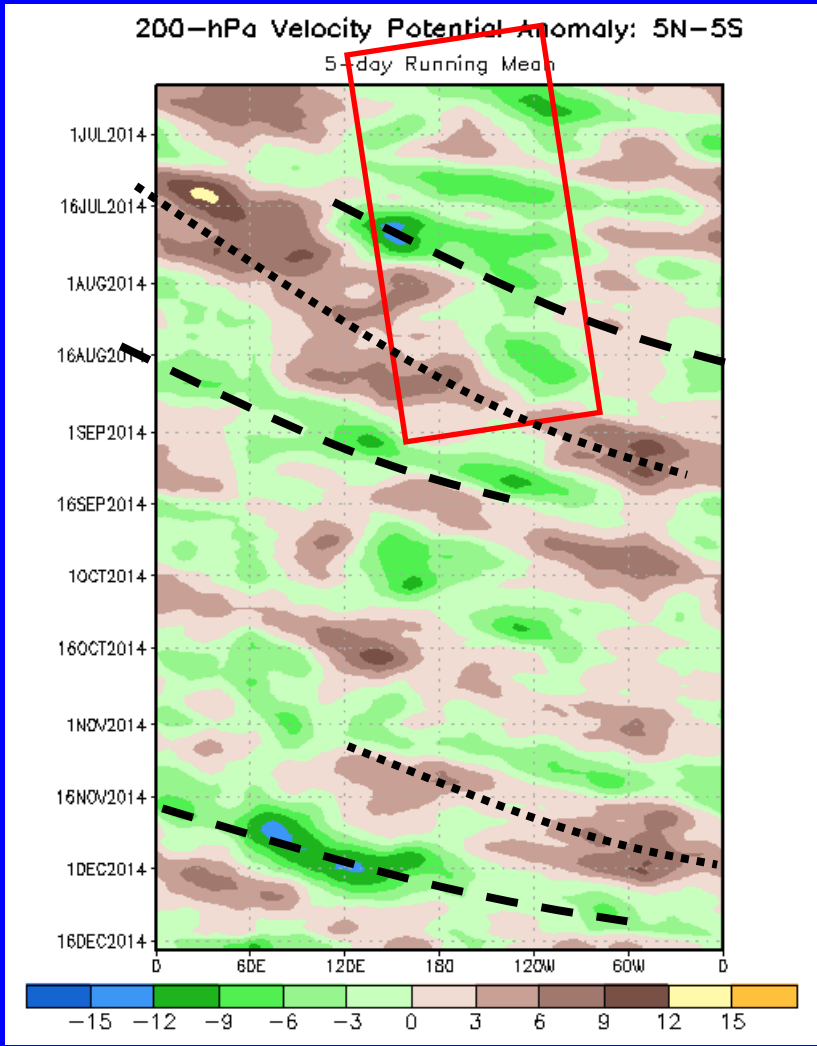
Time
↓



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.

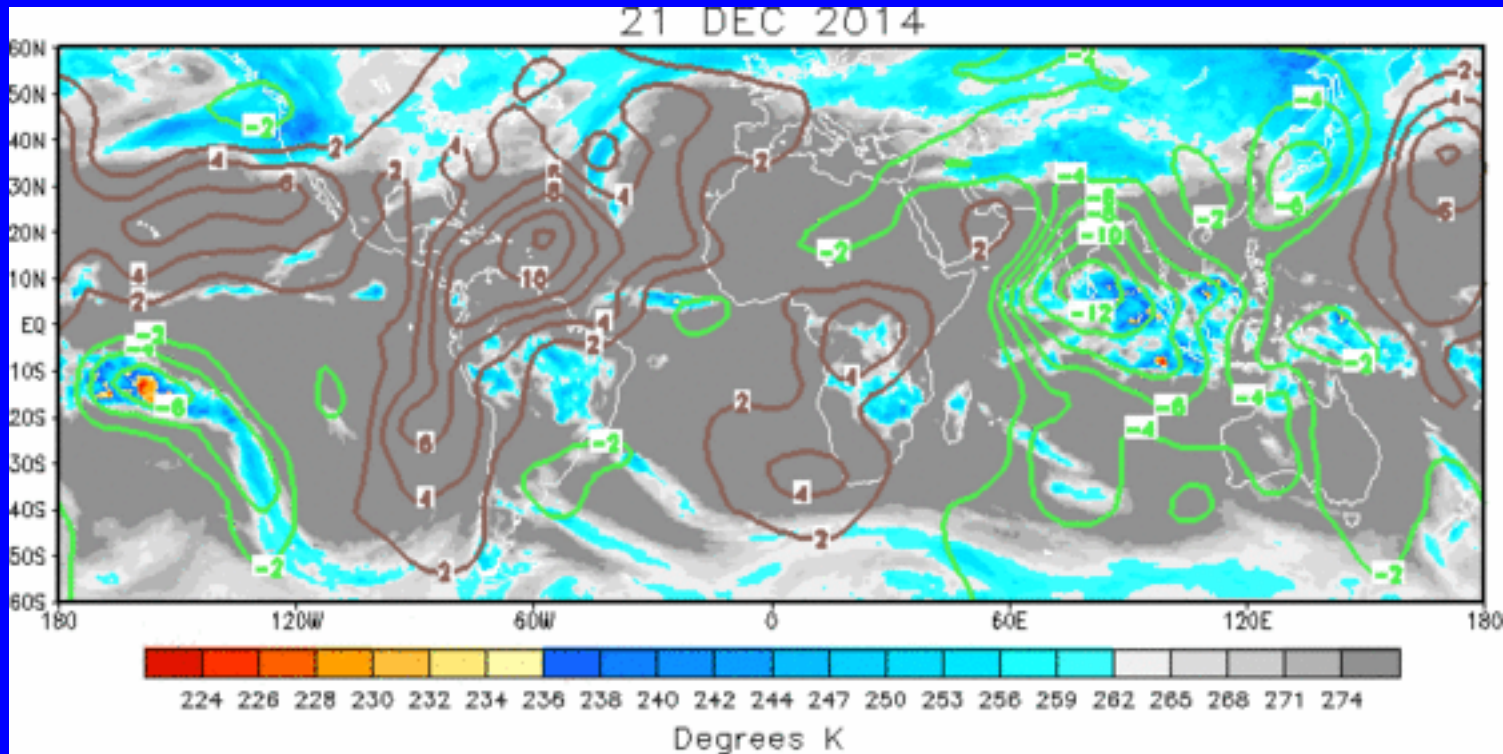
During November the MJO strengthened as indicated by eastward propagation of anomalies with the enhanced phase entering the west-central Pacific by early December. Rapid eastward propagation has continued, likely due to Kelvin wave activity. Enhanced convection has recently developed over the Indian 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 continued its rapid eastward propagation over the past week, with upper-level divergence now centered over the eastern Indian Ocean and suppressed convection centered over the Americas.

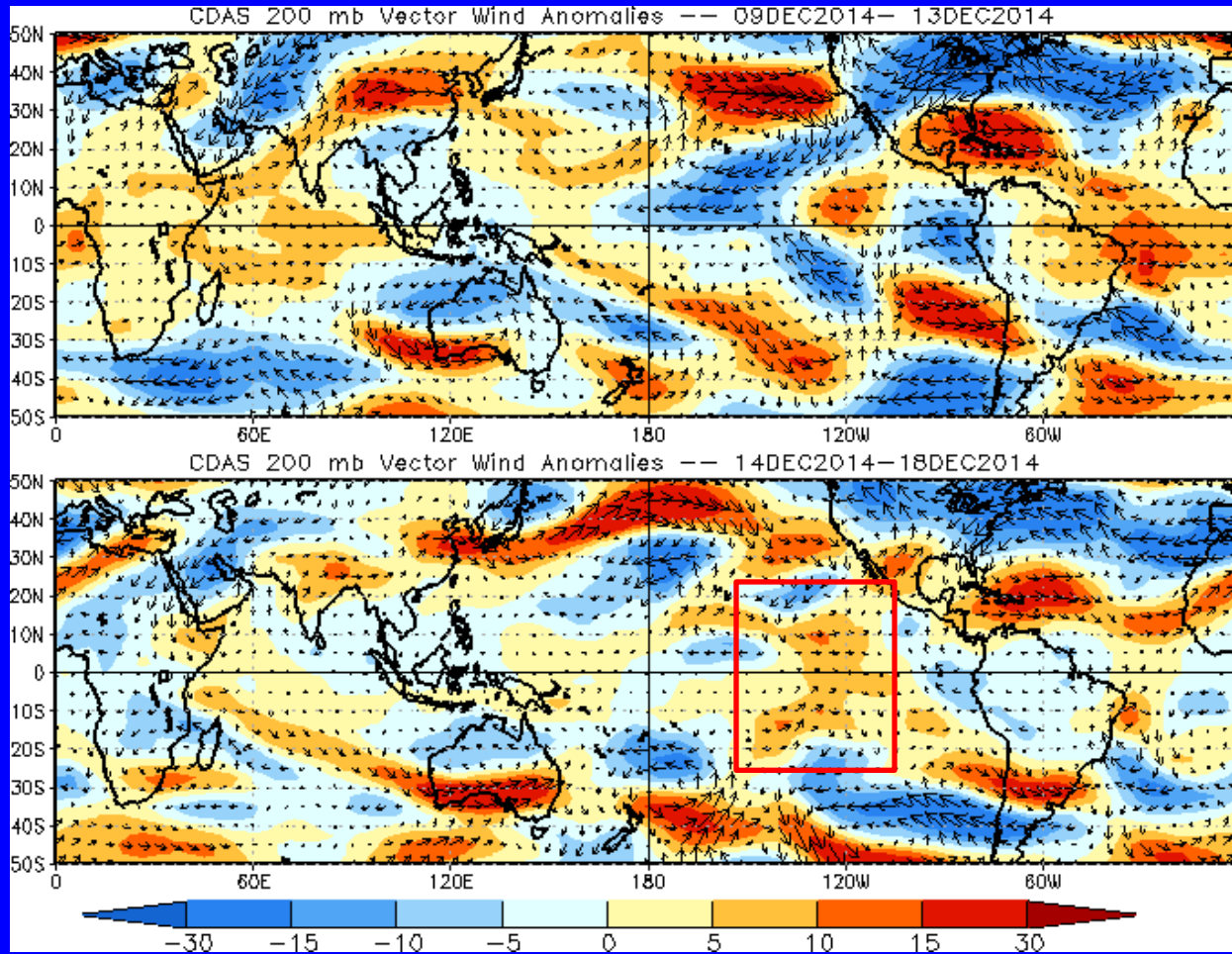


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



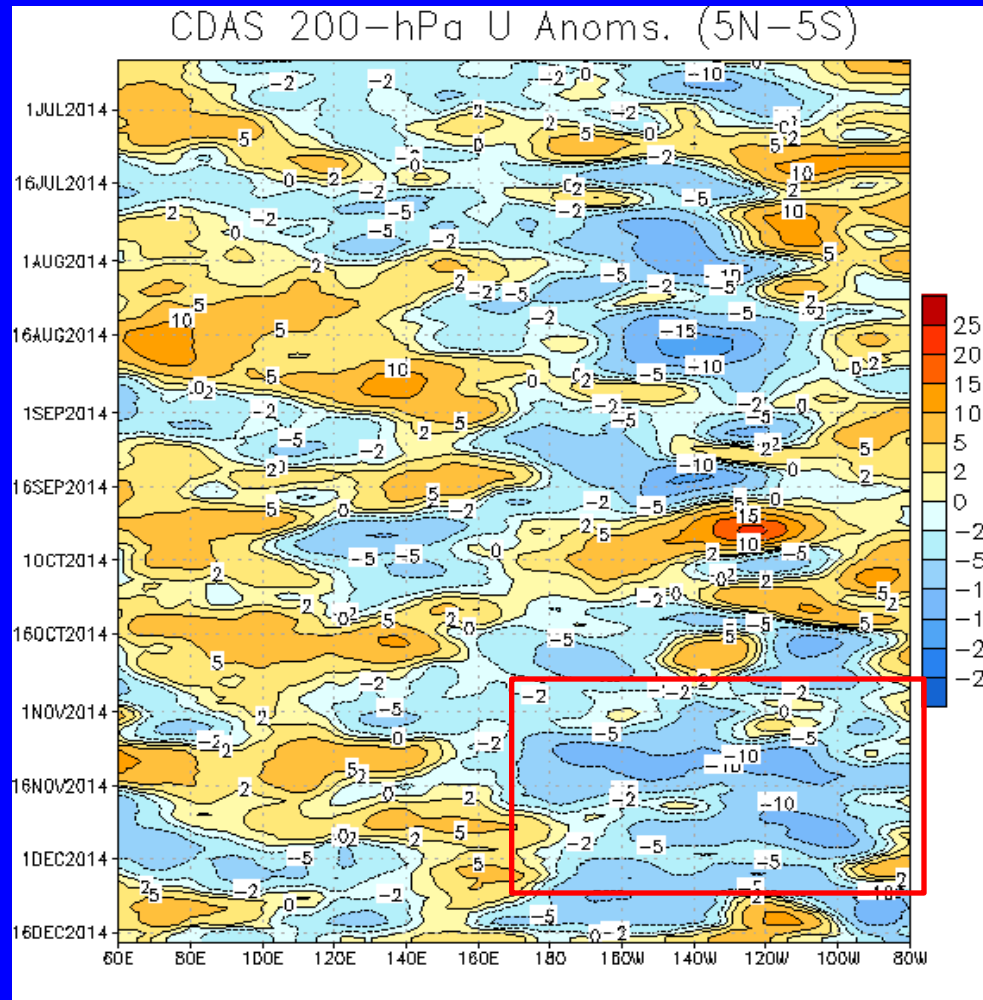
Westerly anomalies have developed over the eastern Pacific during the most recent pentad (red box).



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



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.

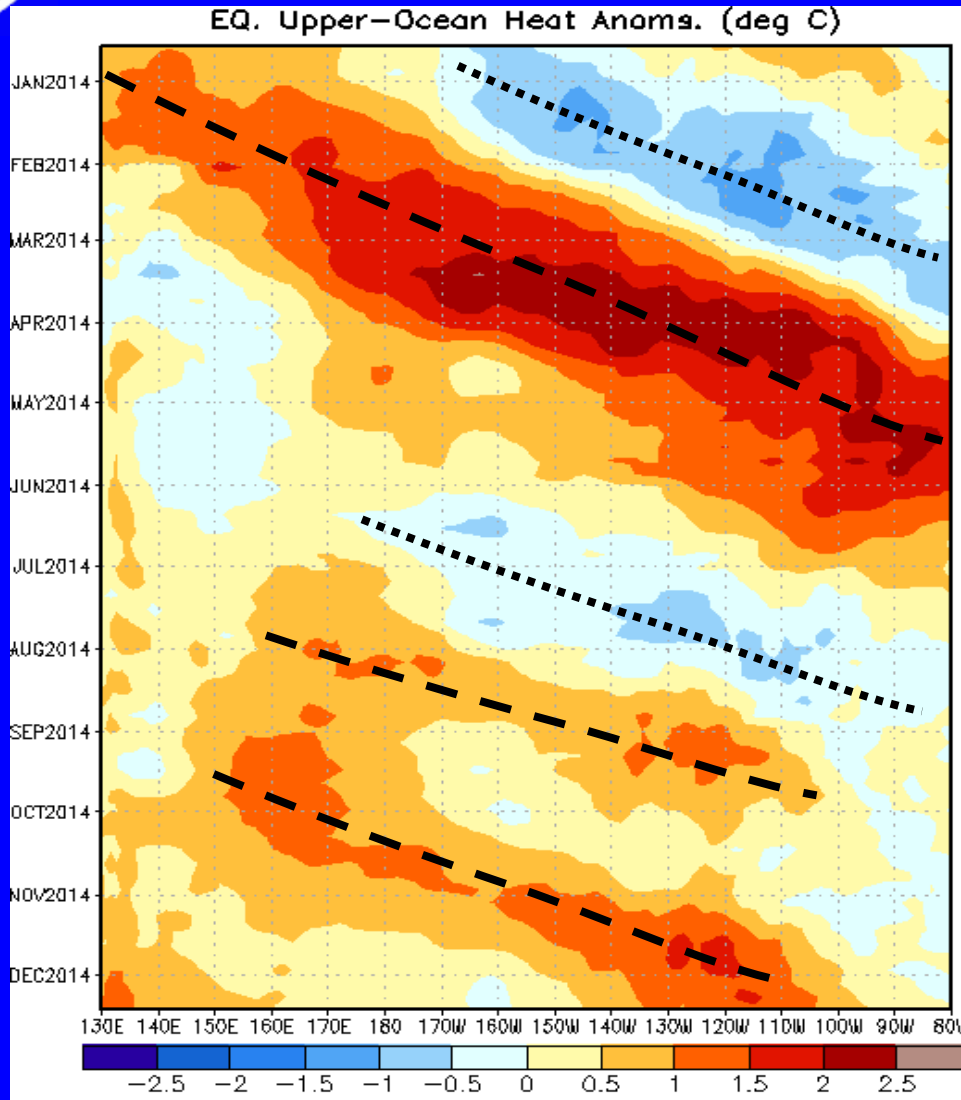
A slow, eastward progression of westerly anomalies is evident over the Maritime Continent and western Pacific during August. Some westward propagation is noticeable during September and early October.

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

Recently, westerly anomalies have developed in that region.



Weekly Heat Content Evolution in the Equatorial Pacific



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.



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.

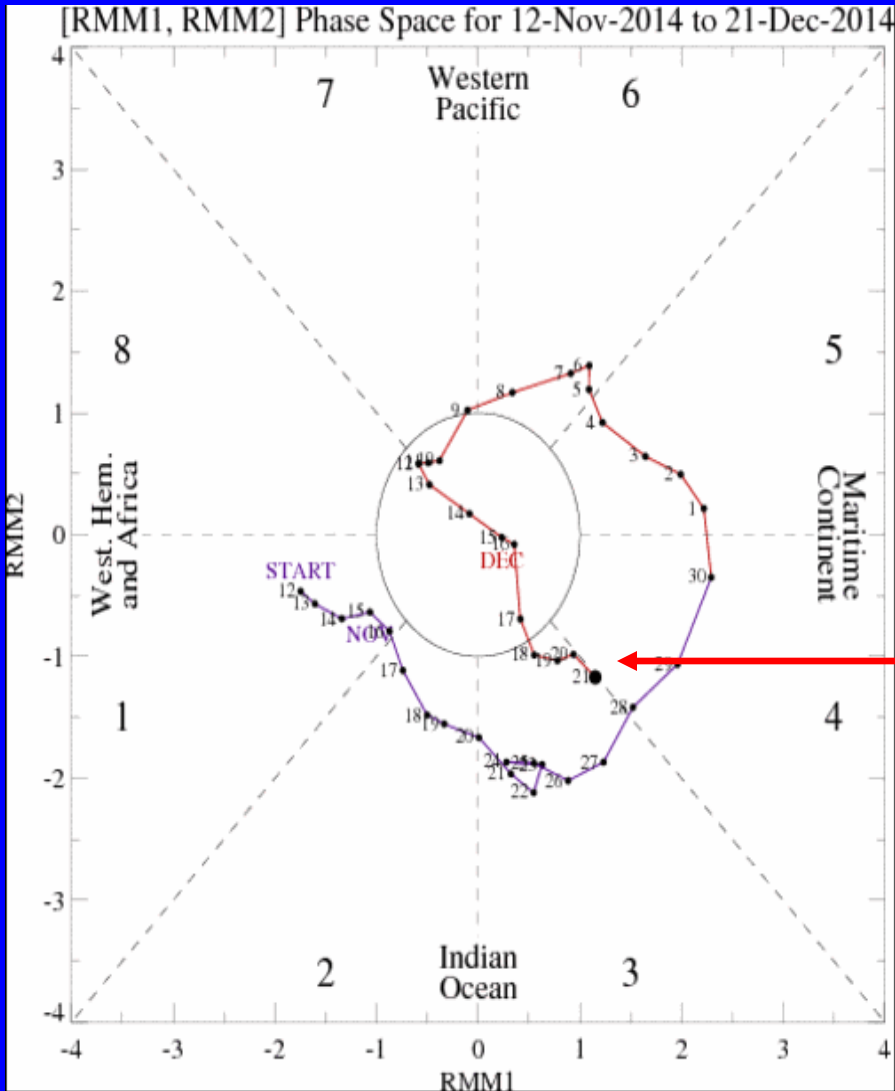
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

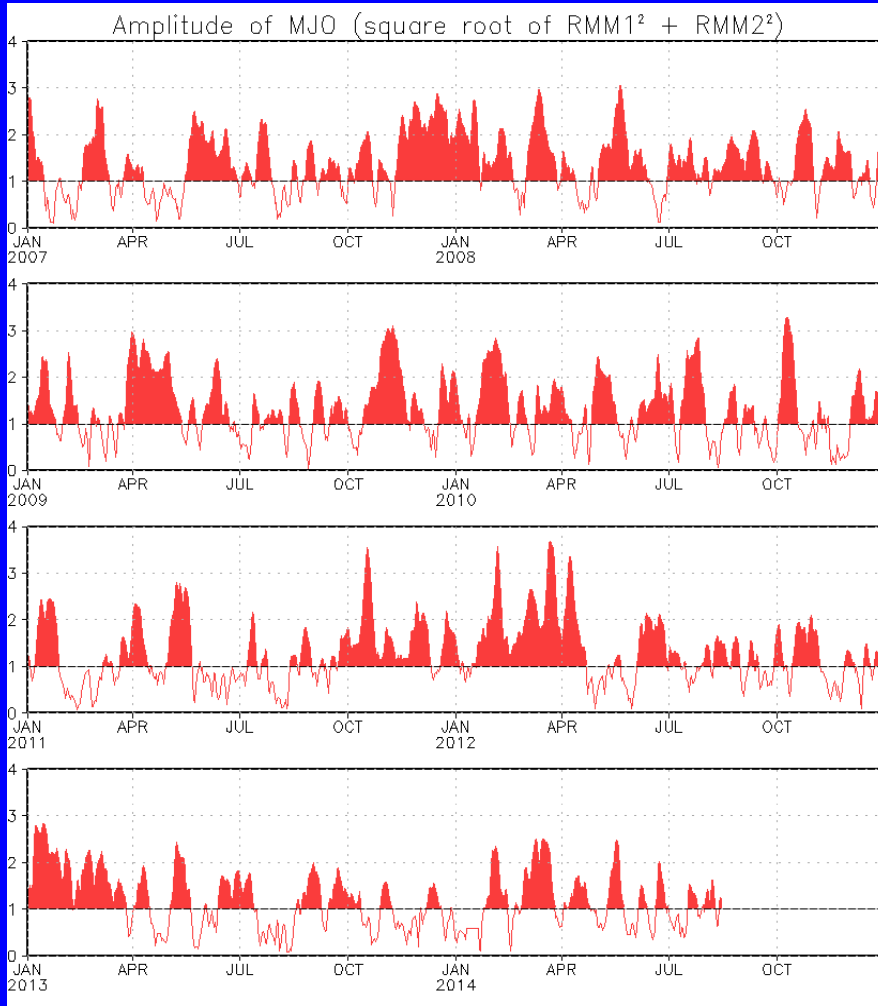


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index depicts MJO activity during November into December before weakening in mid-December. The MJO signal, at least in this index, has reemerged in phase 3 over the eastern Indian 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.



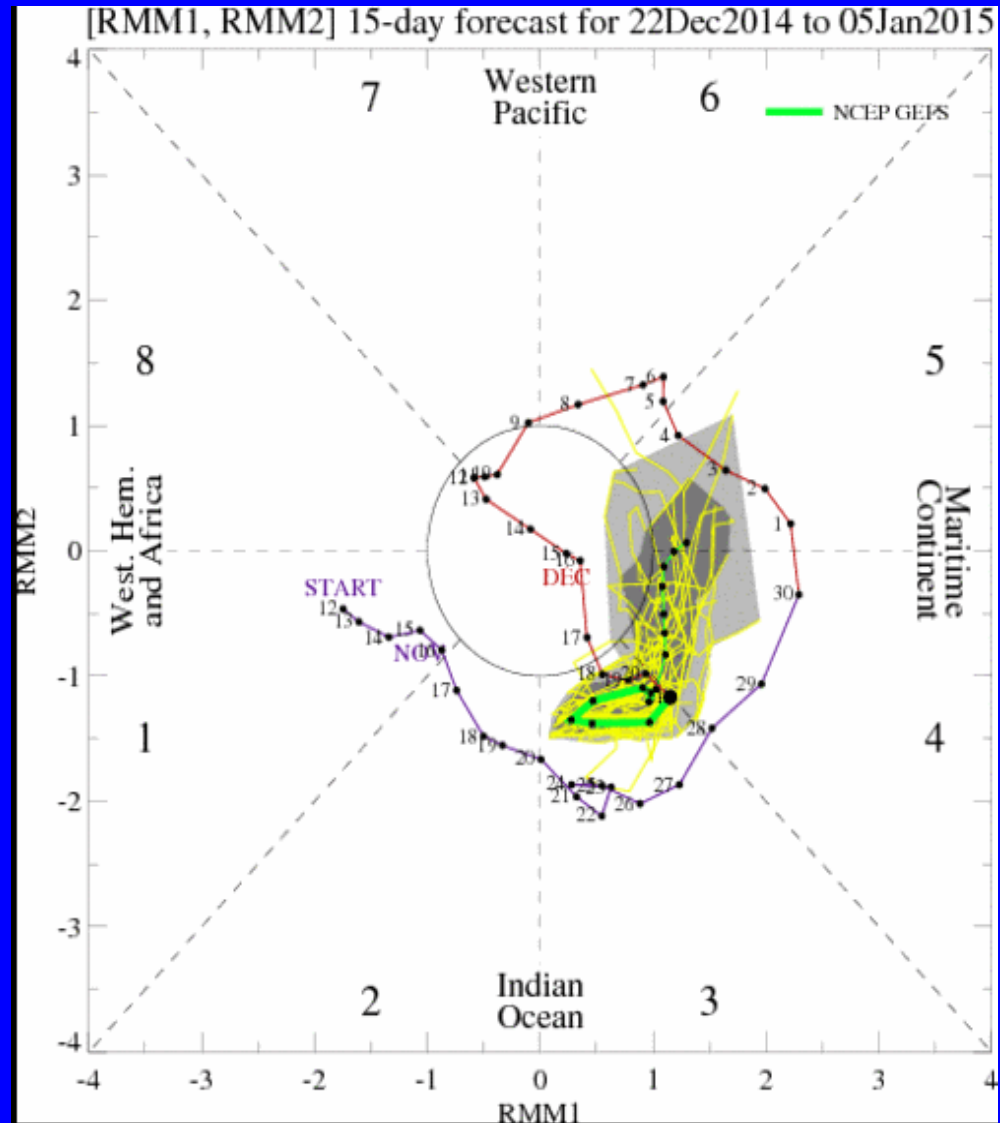
Ensemble GFS (GEFS) MJO Forecast

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 a stationary signal during Week-1, possibly due to interference with westward moving variability. Eastward propagation of the signal across the Maritime Continent is forecast during Week-2.

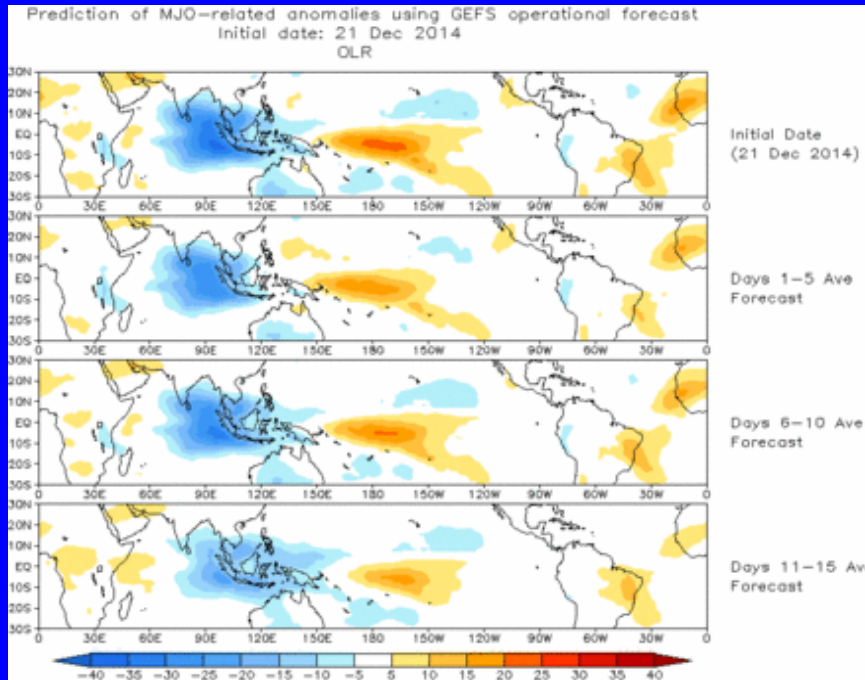




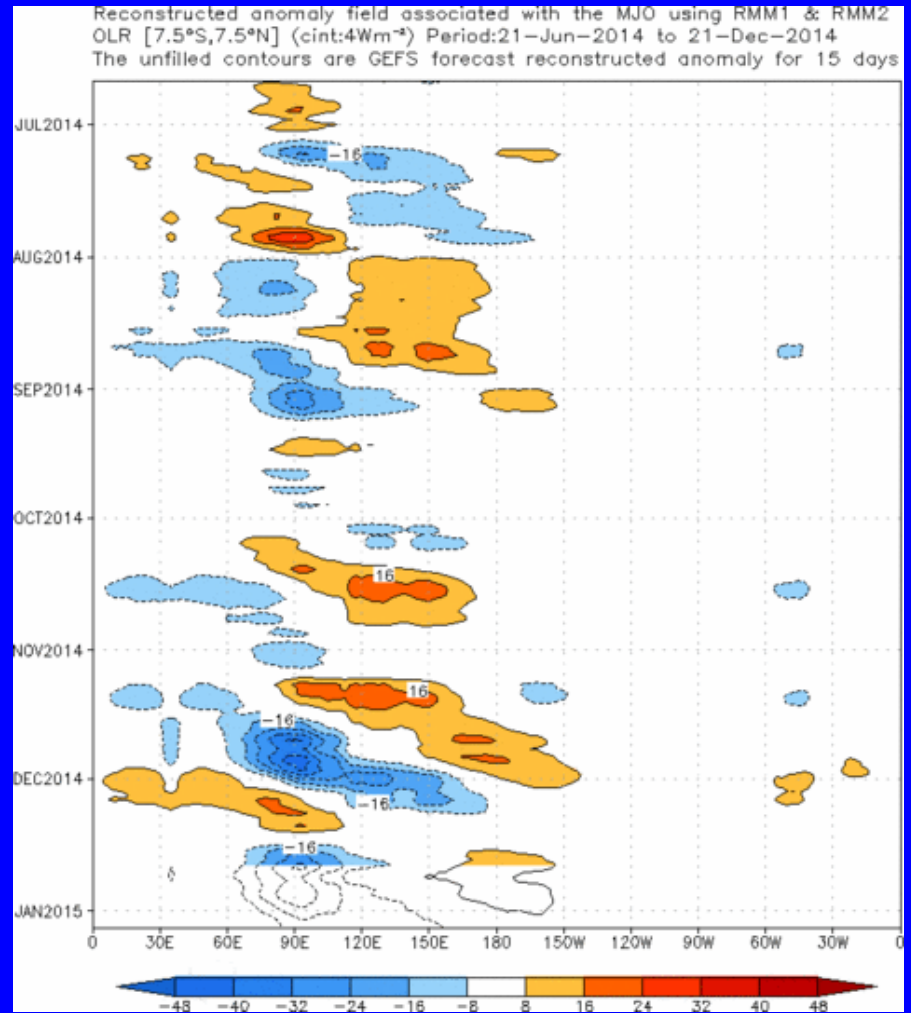
Ensemble Mean GFS MJO Forecast

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



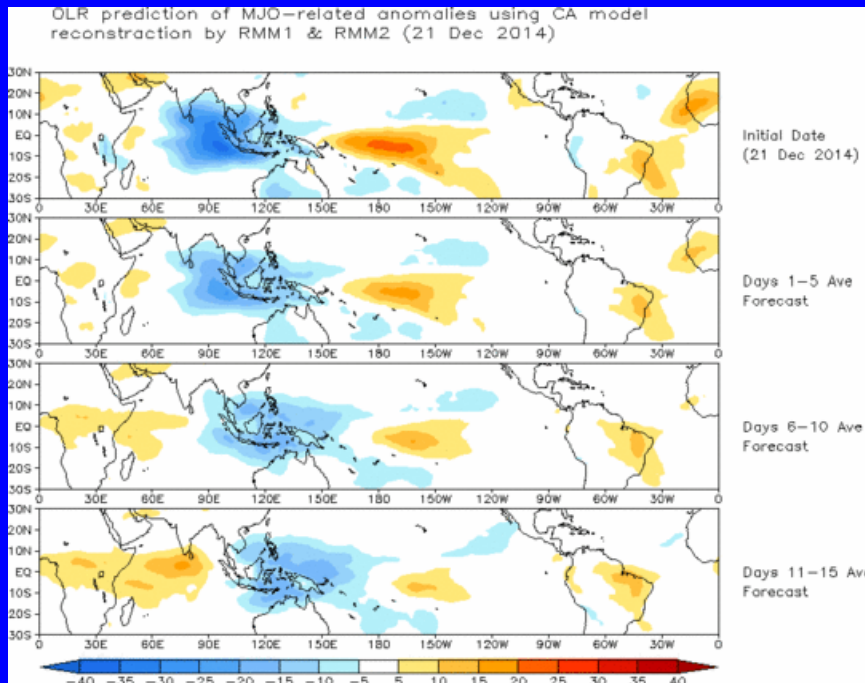
The GEFS mean MJO index based OLR anomaly forecast depicts enhanced convection during Week-1 over the Indian Ocean, with eastward propagation forecast by the end of Week-2.



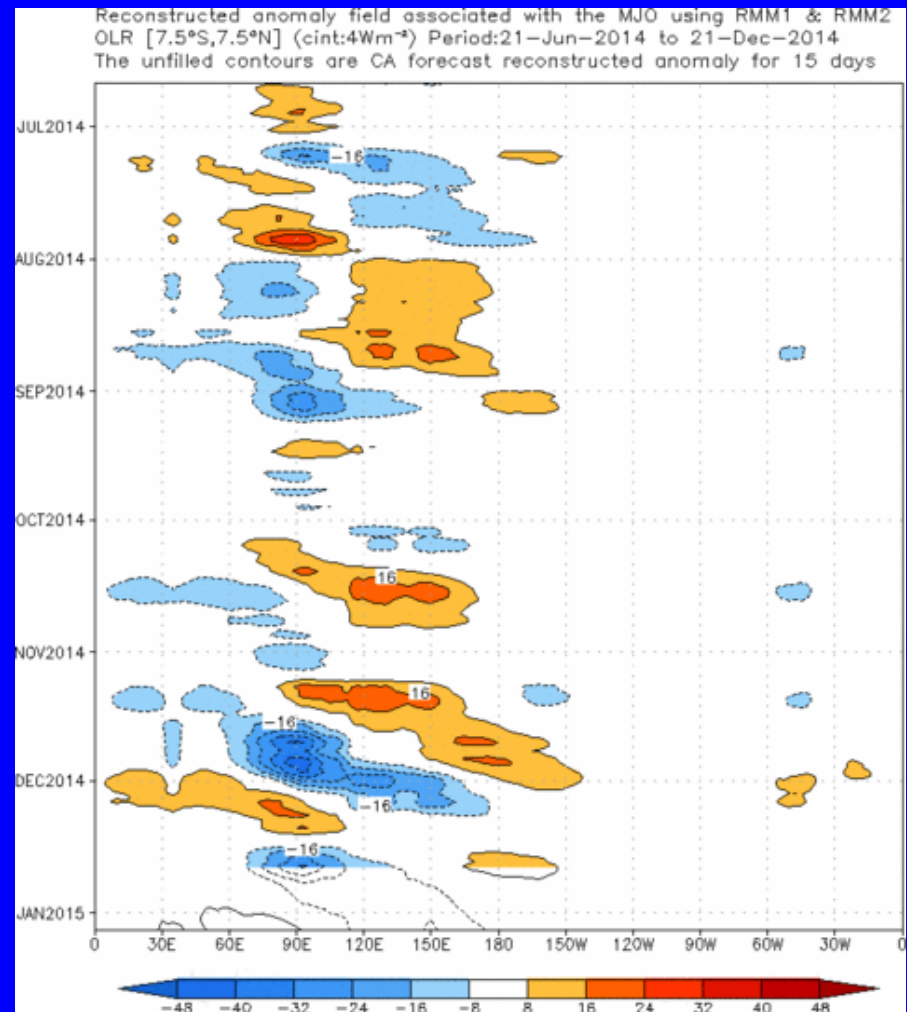
Constructed Analog (CA) MJO Forecast

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



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



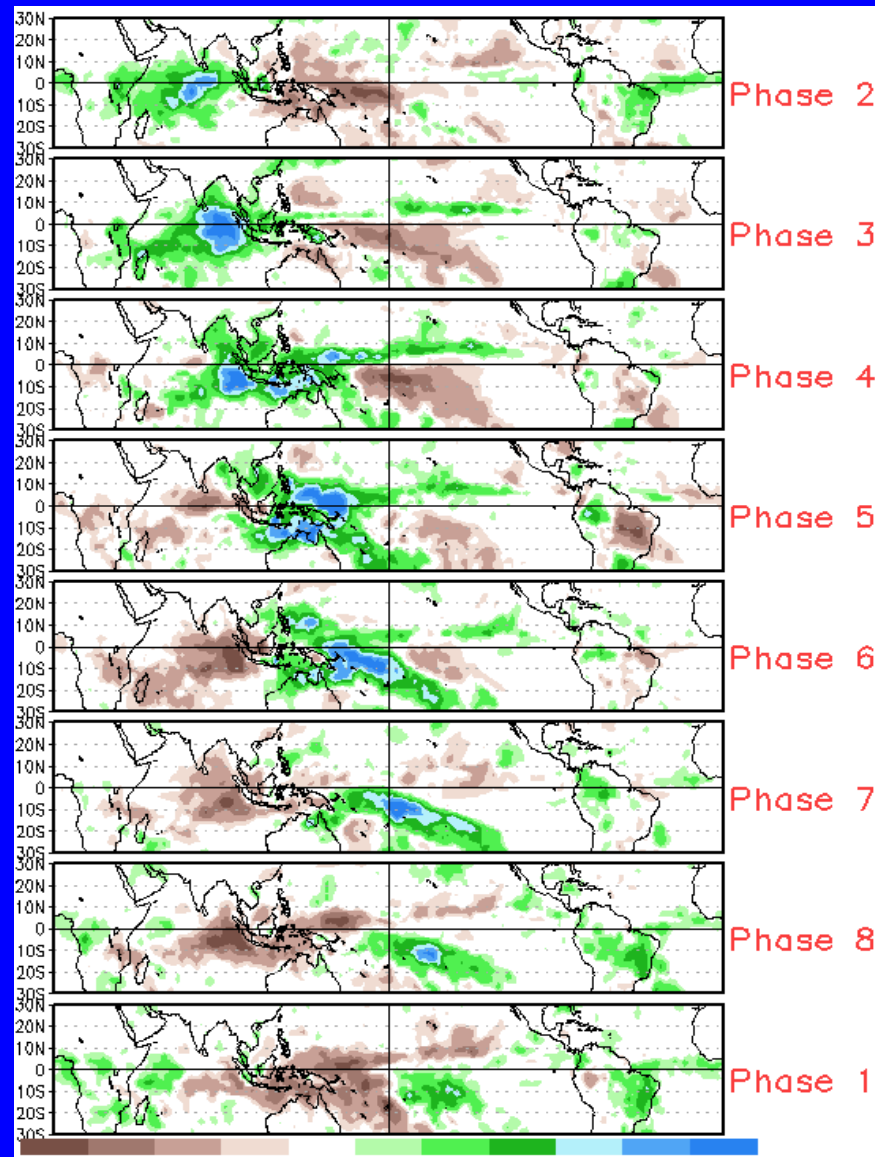
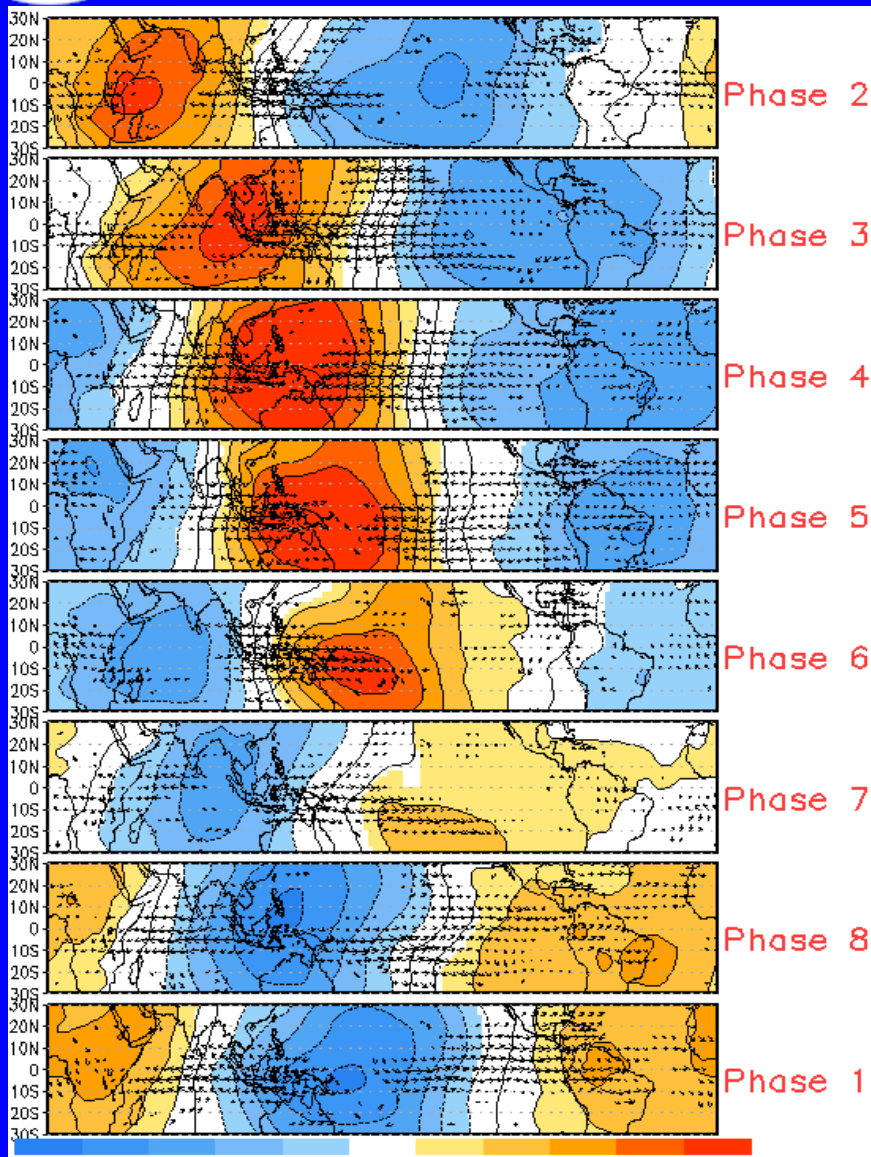
The constructed analog forecast depicts a more canonical eastward propagation from the initial time through Week-2.



MJO Composites – Global Tropics

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

Precipitation Anomalies (Nov-Mar)

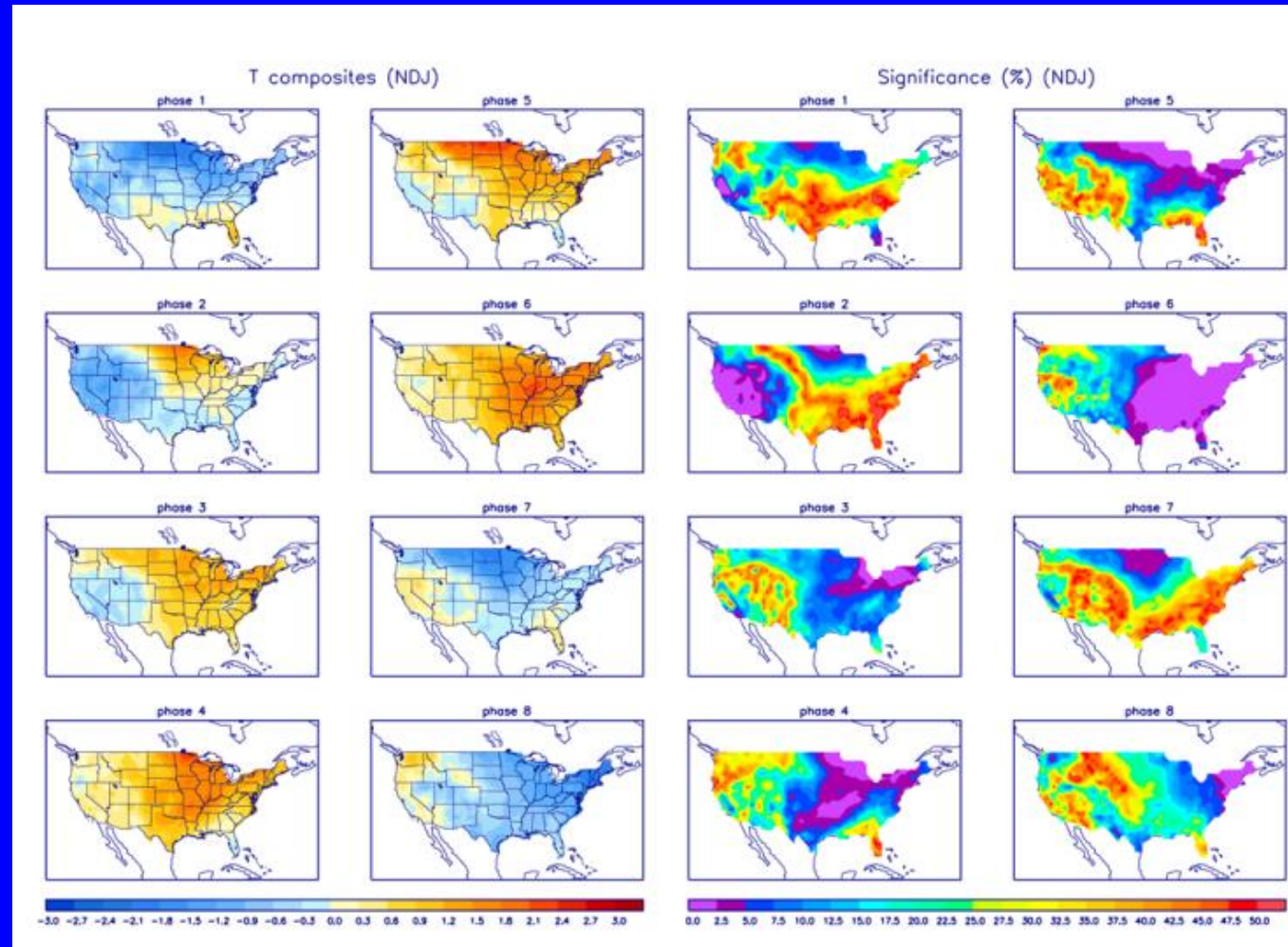




U.S. MJO Composites – Temperature

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.



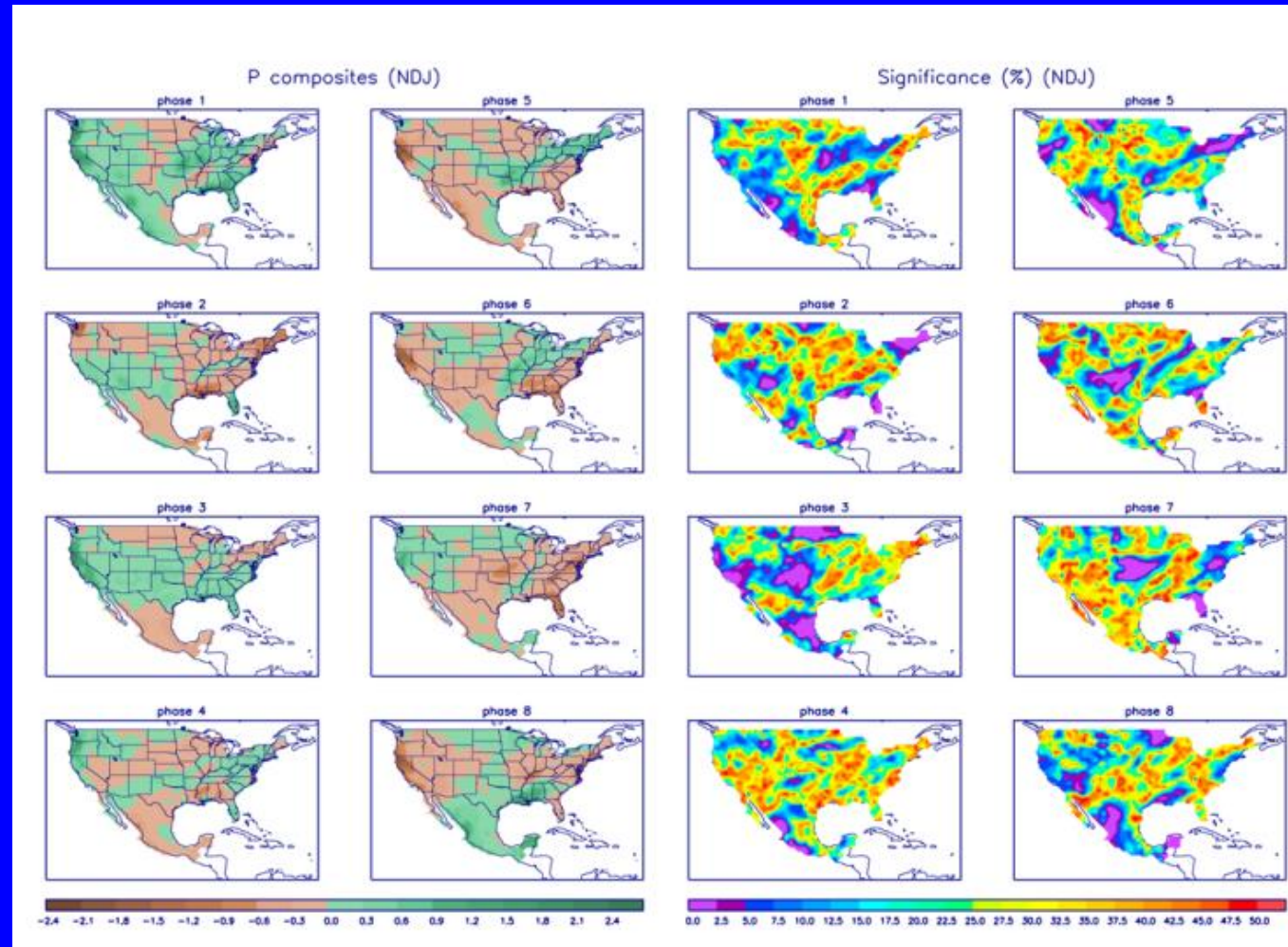
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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.



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

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