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

Update prepared by
Climate Prediction Center / NCEP
January 5, 2015

Outline

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

Overview

- The MJO remained active at moderate strength during the past week with the enhanced phase centered over the eastern Maritime Continent and far West Pacific.

- Both dynamical model MJO index forecasts as well as statistical forecasts indicate a continued MJO signal during the next two weeks shifting eastward at varying speeds.

- Based on the latest observations and several forecast tools, the MJO is forecast to remain active during the next two weeks with the enhanced convective phase shifting into the western and central Pacific.

- The MJO is expected to contribute to enhanced rainfall for areas of the eastern Maritime continent, northern Australia and the western Pacific over the period and suppressed rainfall for parts of Brazil (Week-1) and the Indian Ocean. An elevated threat for tropical cyclone development exists for some areas across the West Pacific and waters near northern Australia.

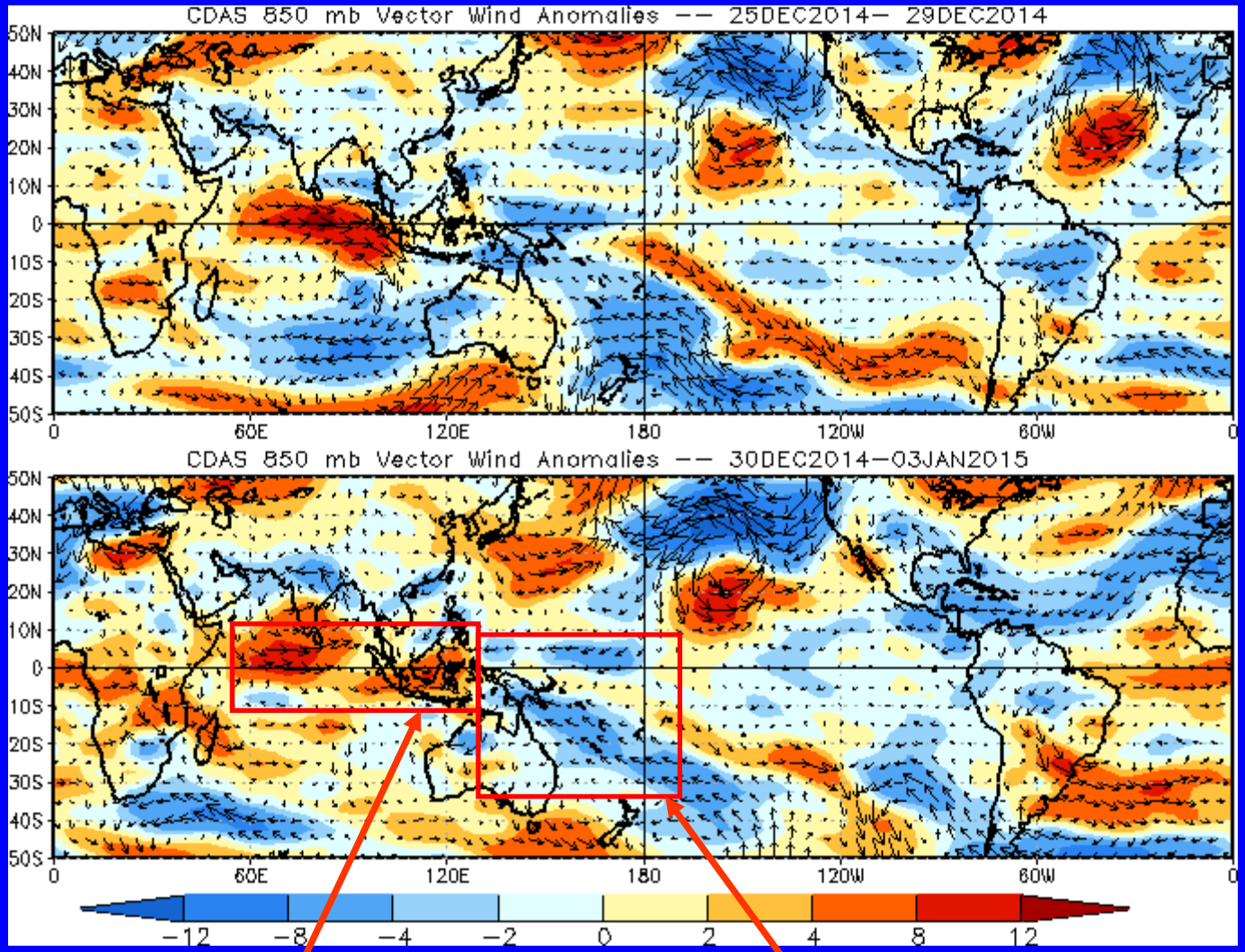
A forecast map of potential impacts across the global Tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



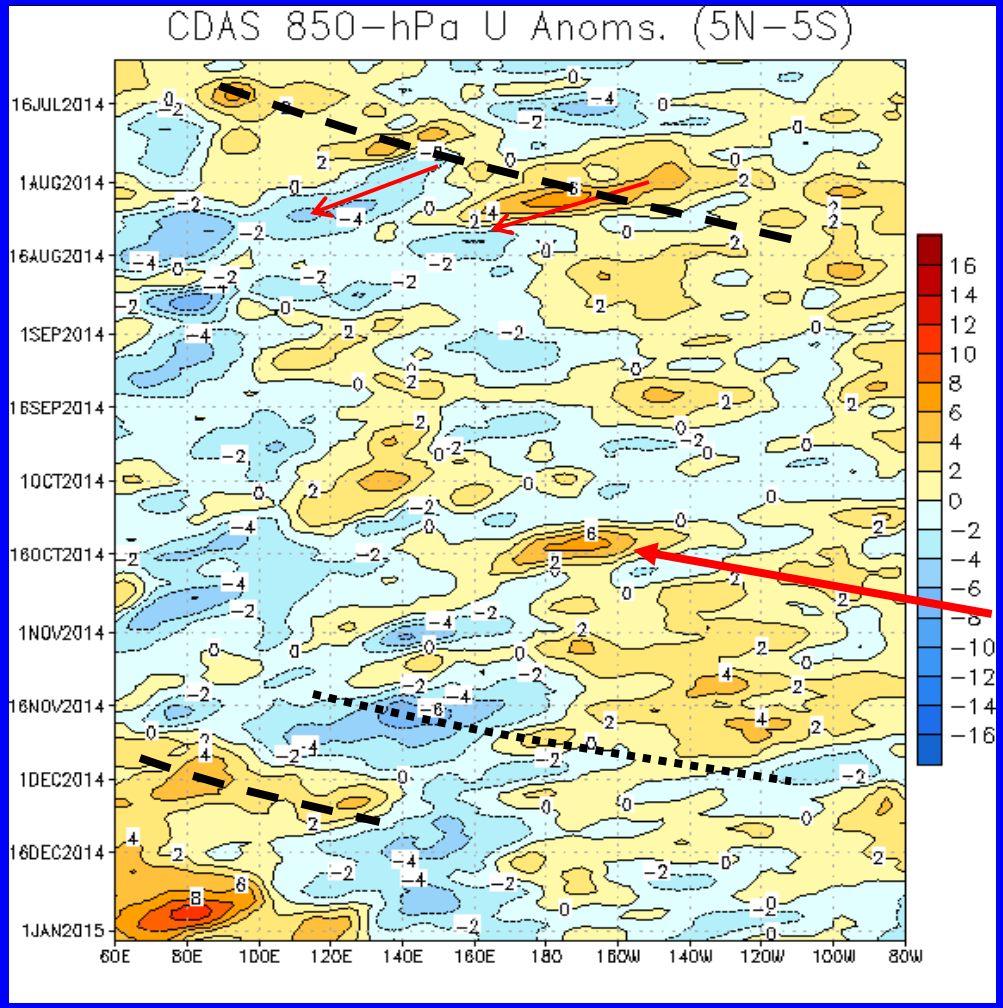
Westerly anomalies expanded east across the Maritime Continent during the past five days.

Easterly anomalies persisted near the Date Line and across the southwest 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 arrows) over the eastern and central Pacific (western Pacific, Maritime Continent, and Indian Ocean).

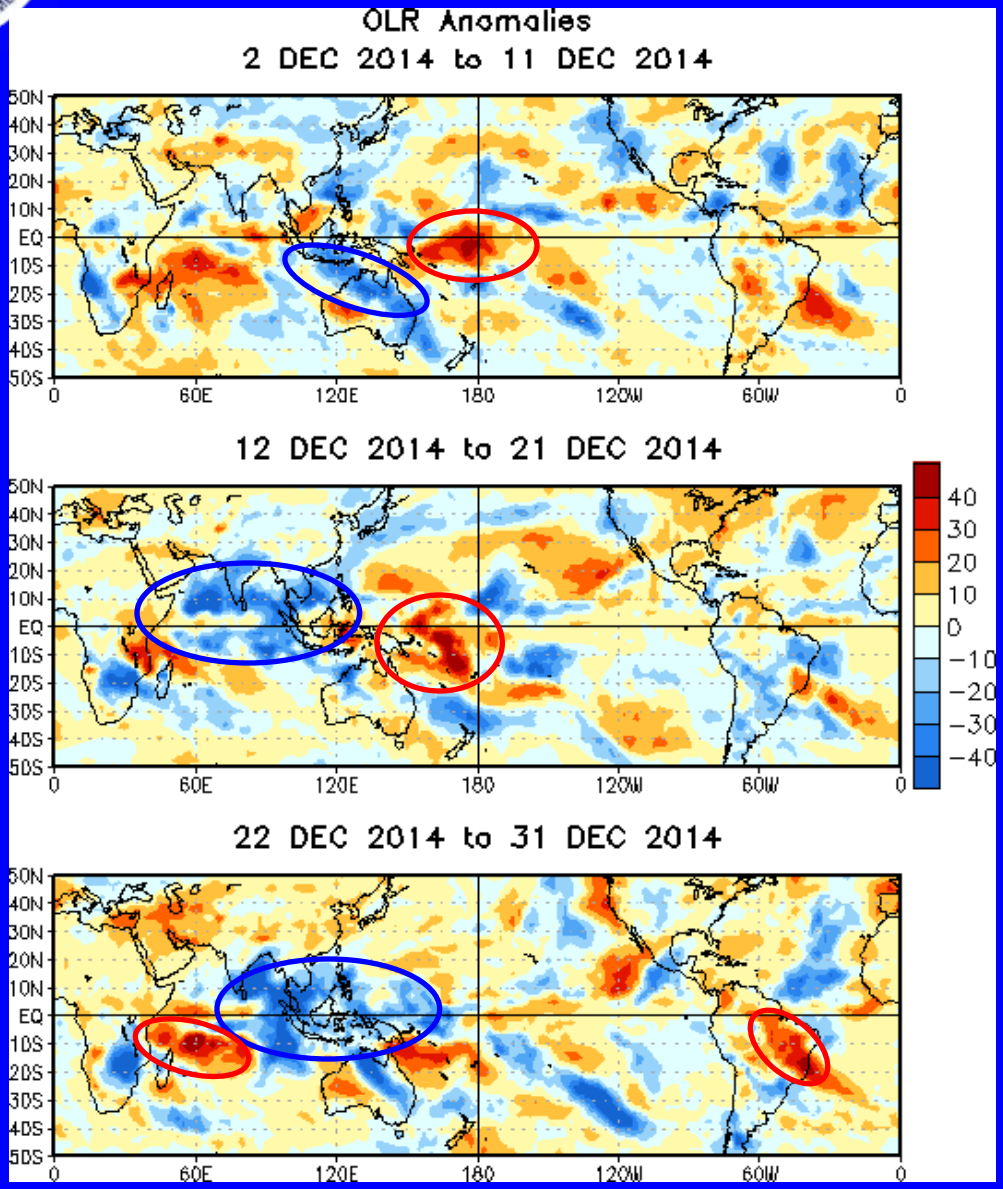
A westerly wind burst was observed near the Date Line during mid-October

Enhanced MJO activity was observed in late November into December and most recently in late December, strong westerly anomalies are evident between 60-100E.

OLR Anomalies – Past 30 days

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

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

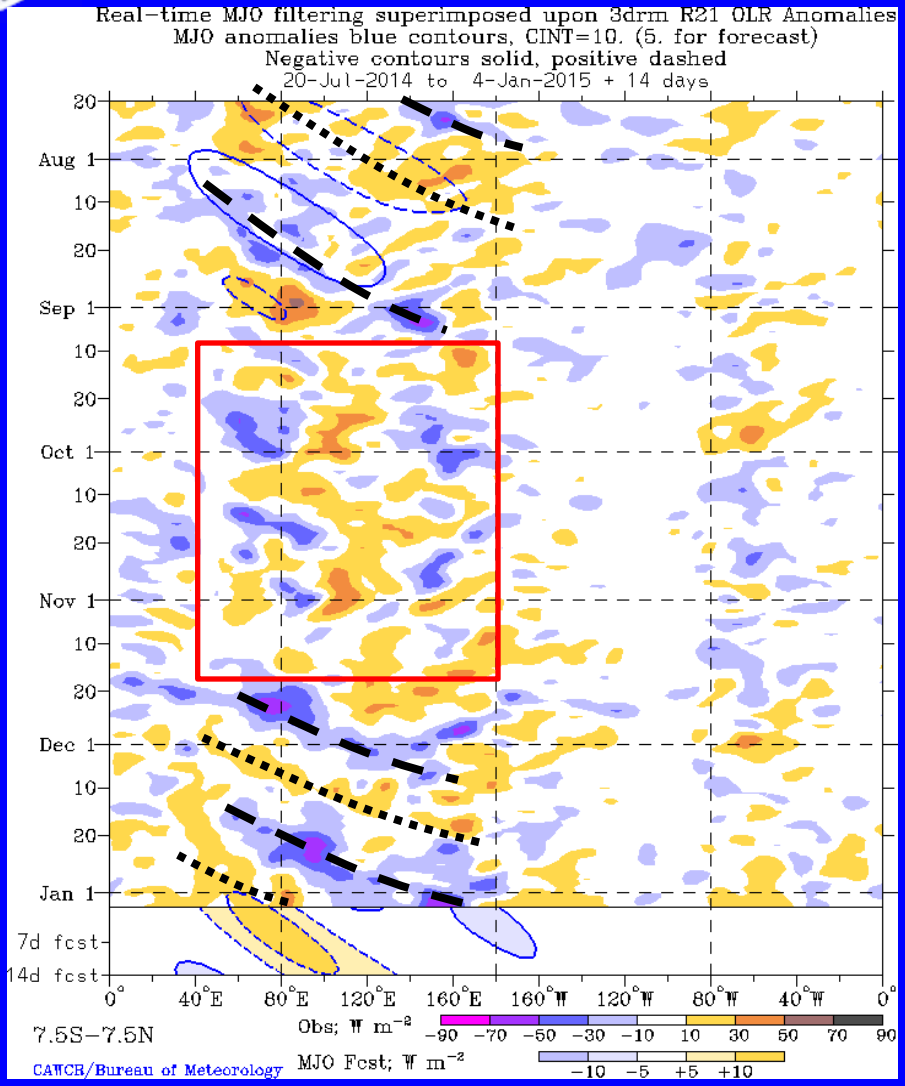


Enhanced convection was observed during early December over the southern Maritime Continent and northern Australia, with suppressed convection near the Date Line.

During mid-December, suppressed convection remained near the Date Line, while convection became enhanced over the Indian Ocean.

During late December, the pattern was more coherent, with enhanced convection shifting east from the Indian Ocean to the Maritime Content. Suppressed convection was observed over Brazil and the southwest 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).

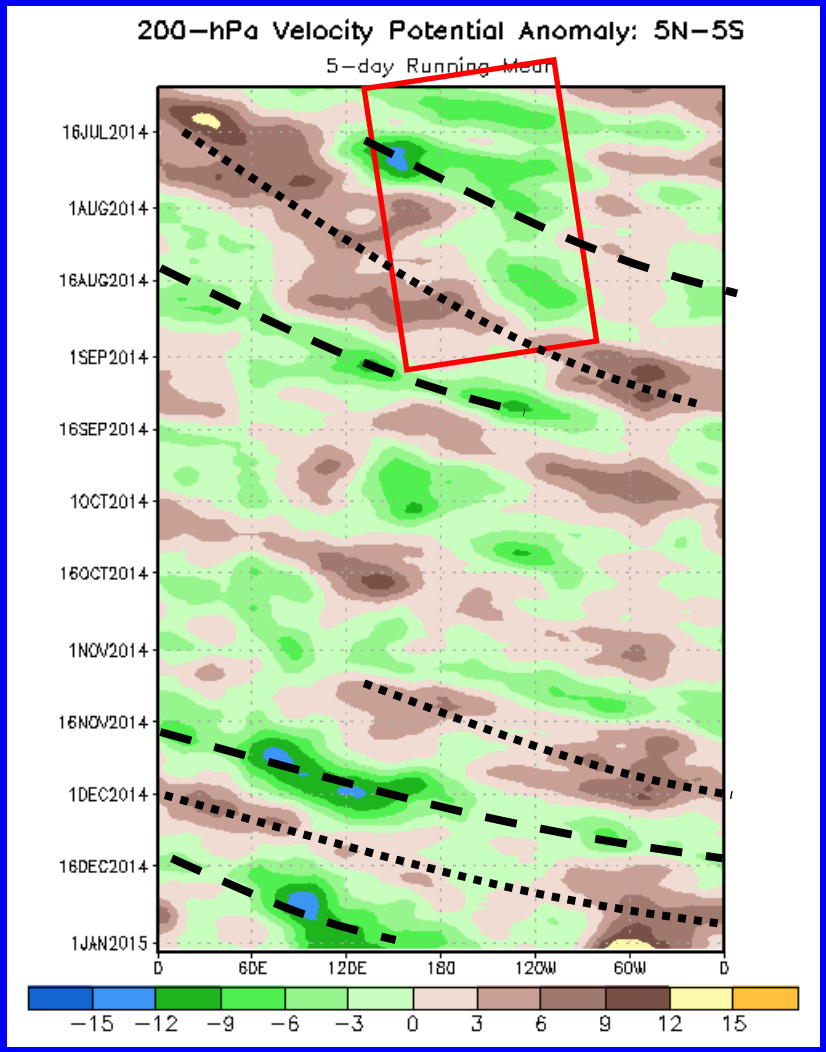
The pattern became less coherent with respect to canonical MJO activity by September and the MJO remained weak till late November (red box).

The MJO strengthened in late November with alternating areas of enhanced and suppressed convection moving from the Indian Ocean to the Date Line through early January.

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.

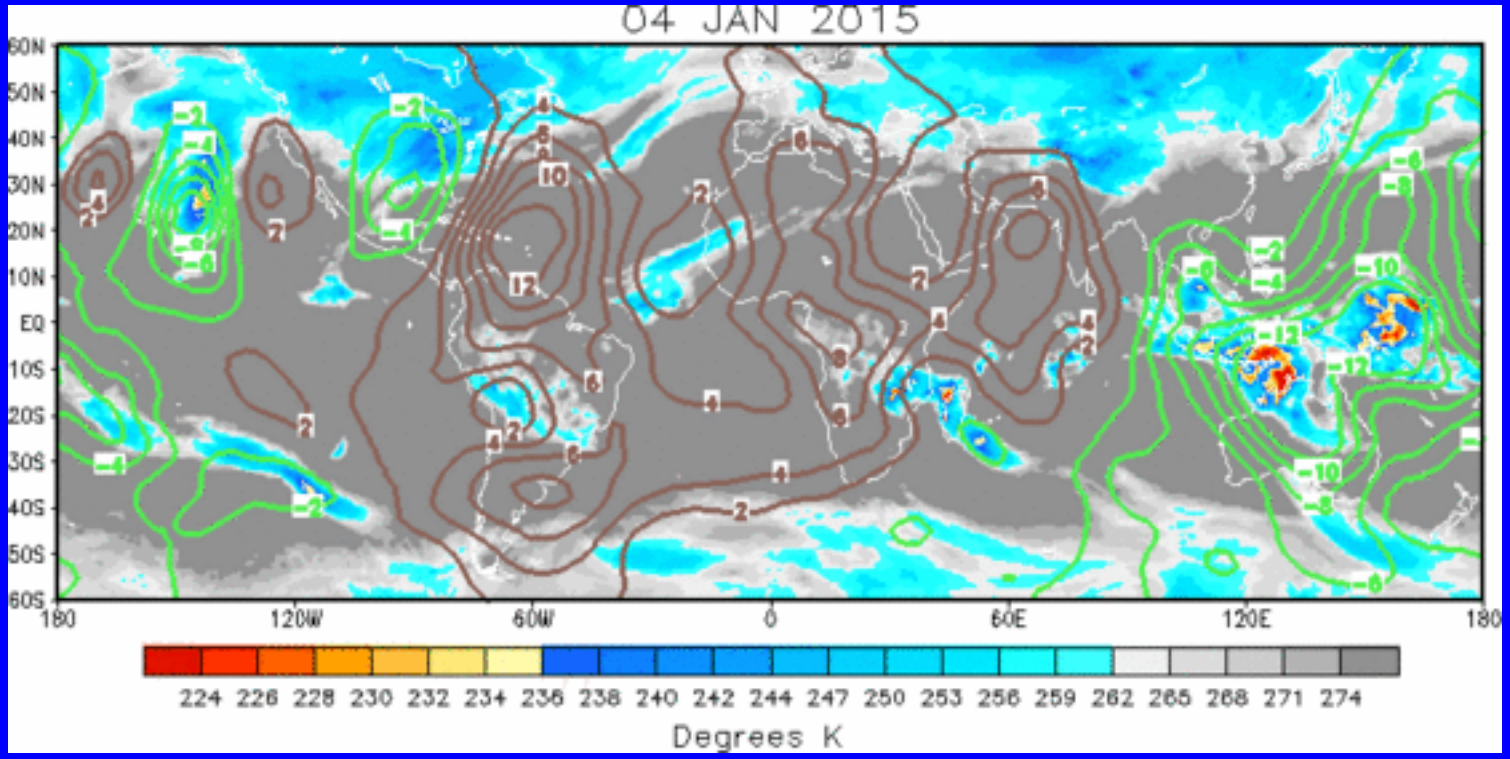
The MJO weakened and remained incoherent through September and October.

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, and strong upper level divergence is once again indicated from the eastern Indian Ocean to the West Pacific.

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

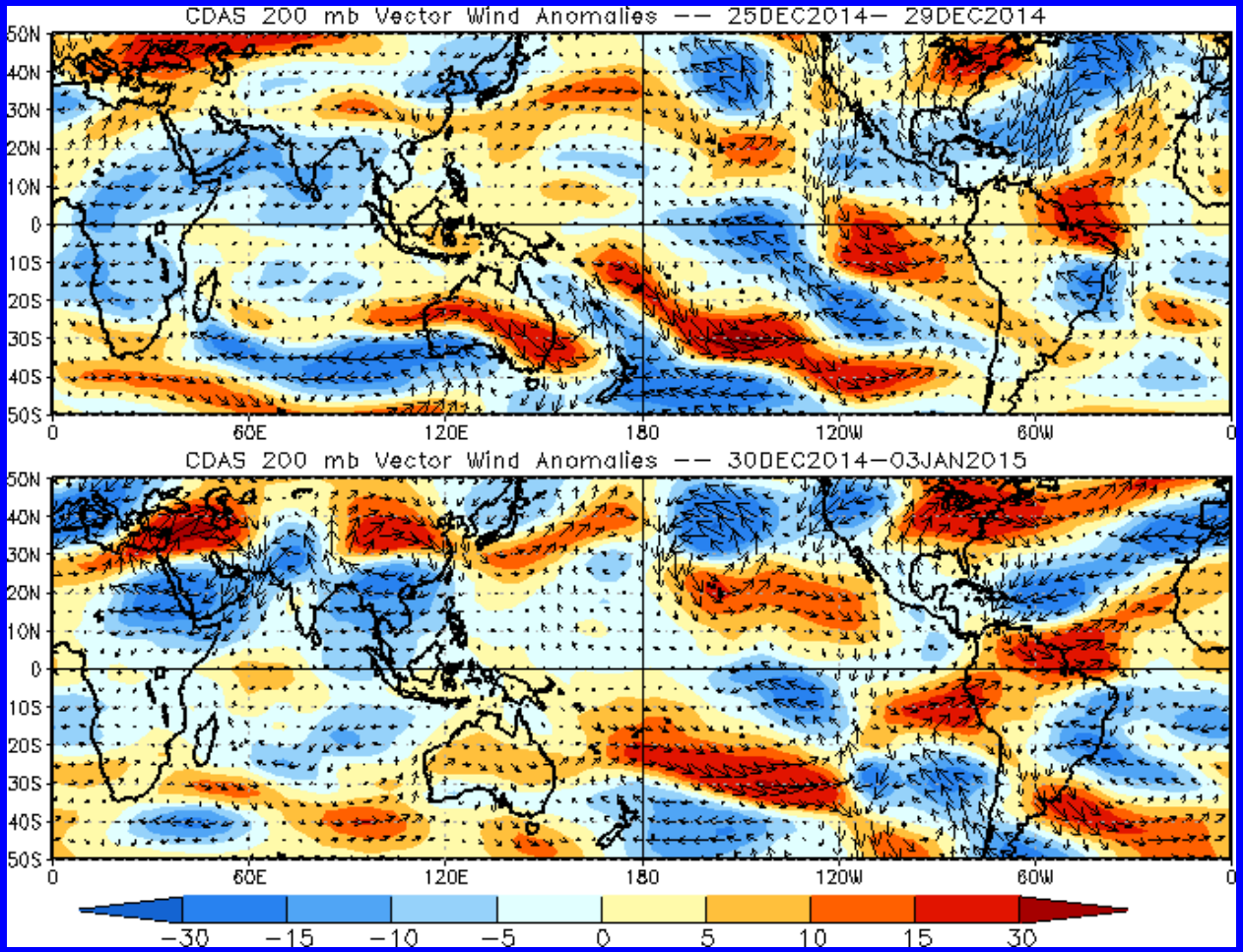
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The upper-level anomalous velocity potential spatial pattern is coherent with an active MJO. Upper-level divergence is now centered over the eastern Maritime Continent and West Pacific with upper-level convergence stretching from South America to the western Indian Ocean.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

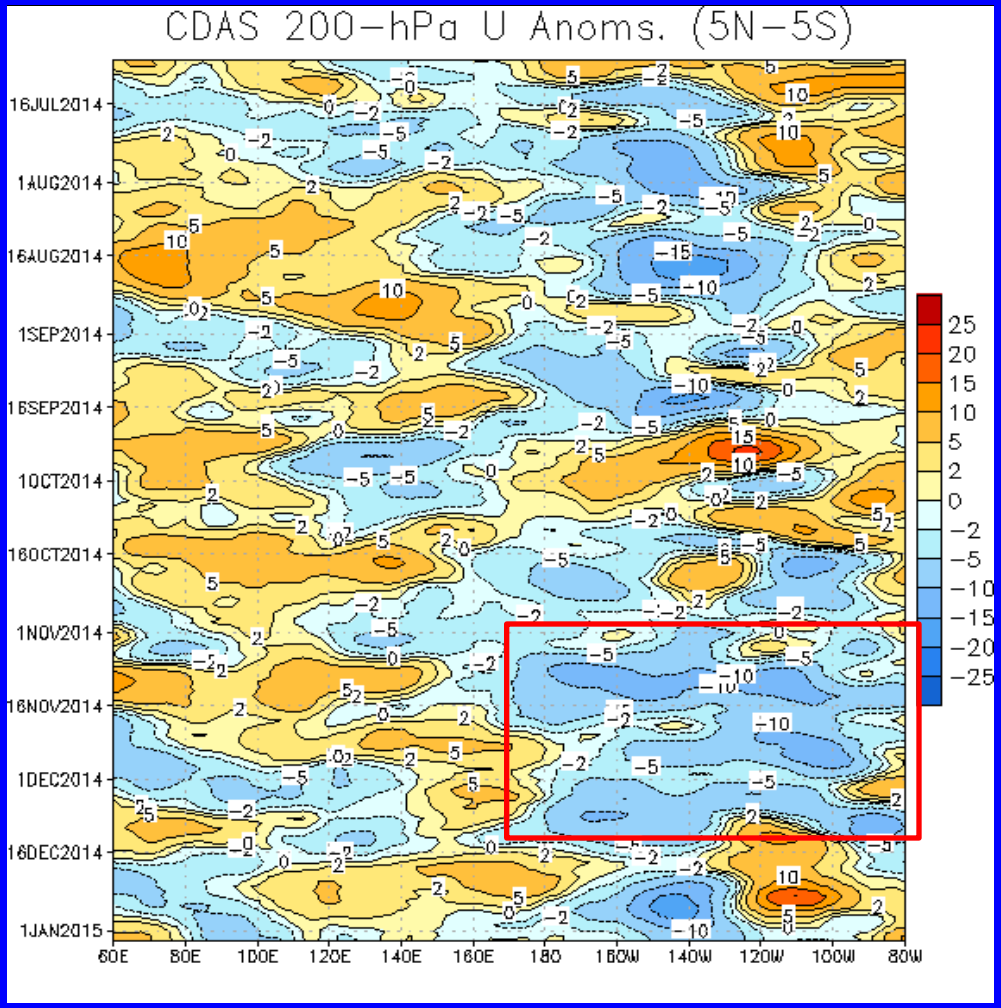
Red shades: Westerly anomalies

Easterly anomalies diminished 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

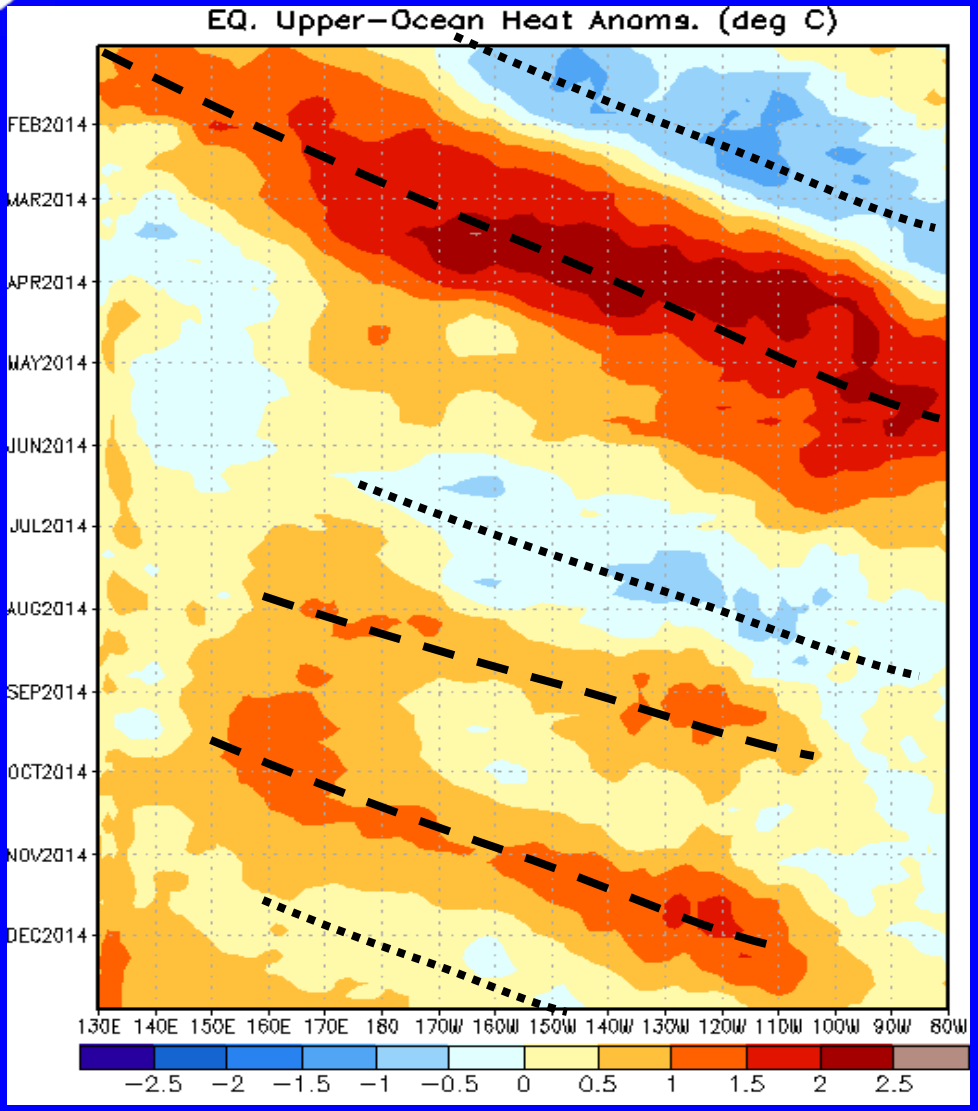
Longitude

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, the dipole evident over the East Pacific during December has ended.

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 increased across much of the Pacific basin due to another moderate downwelling Kelvin wave traversing the Pacific during October and November 2014. The upwelling phase is now evident in the central Pacific.

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).

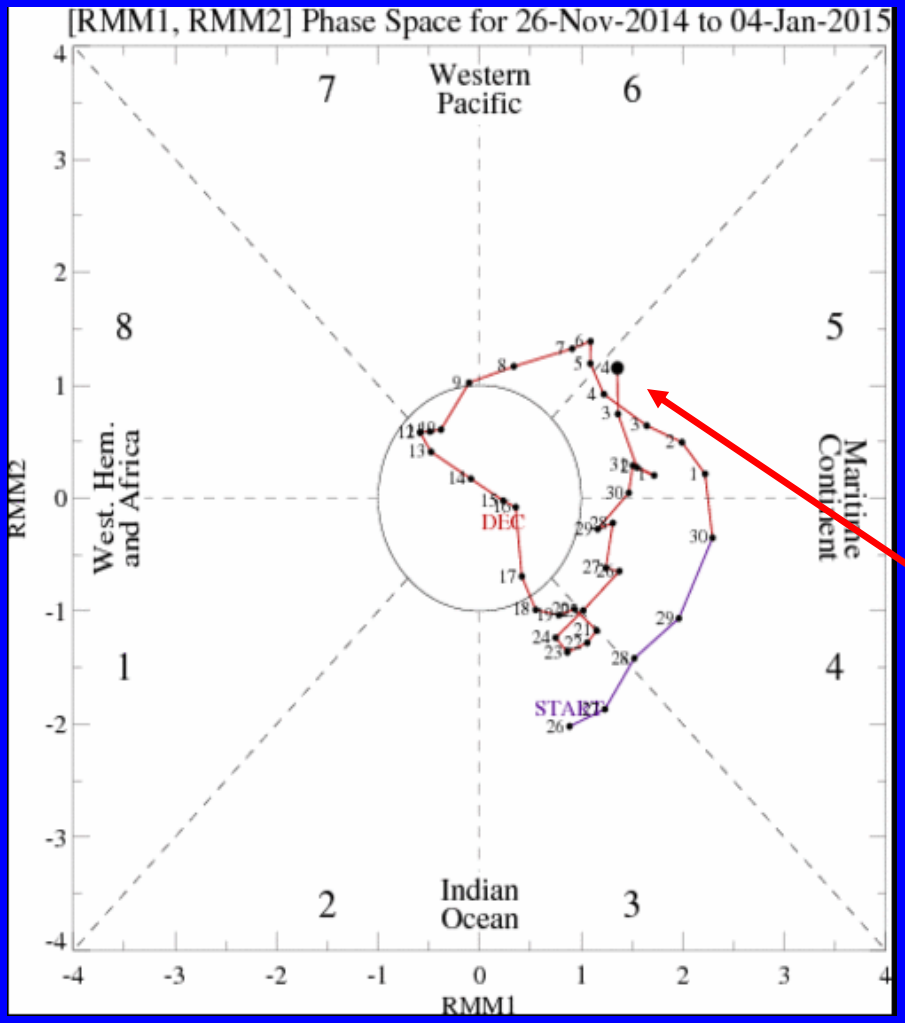
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

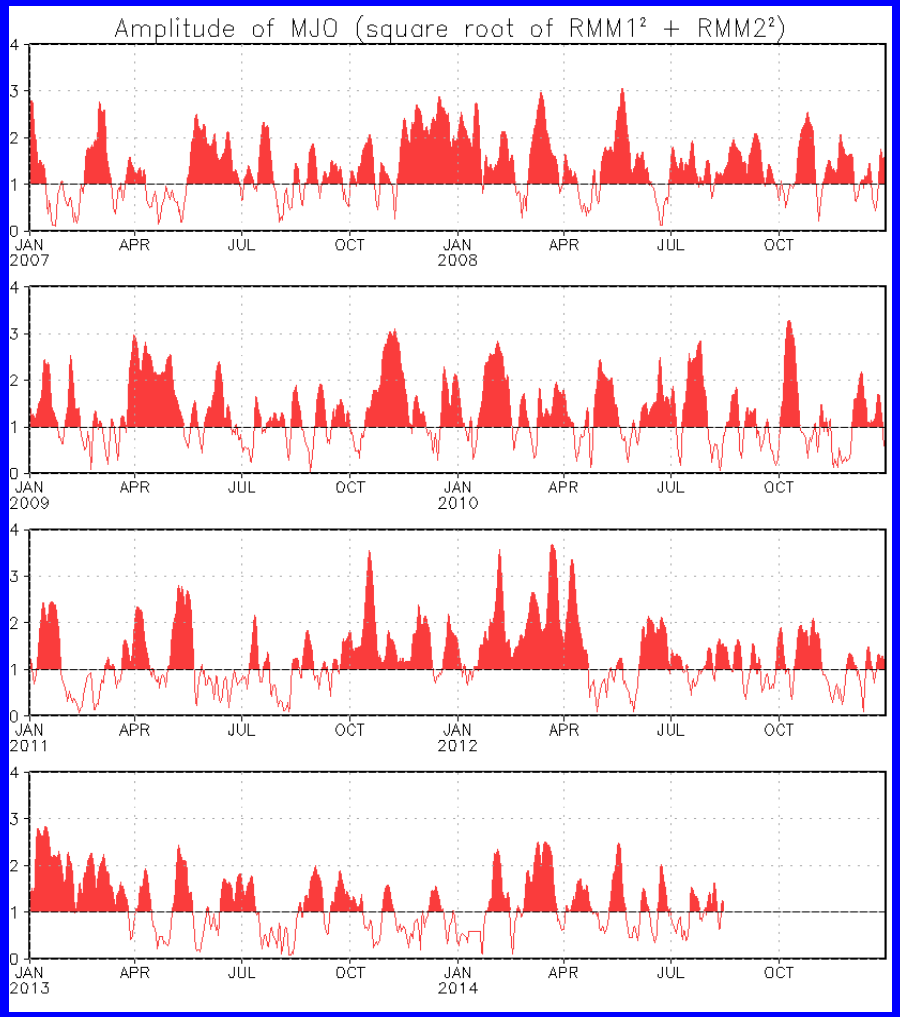
MJO Index -- Recent Evolution



- 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 an eastward propagating MJO moderate amplitude signal during the past week.

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.

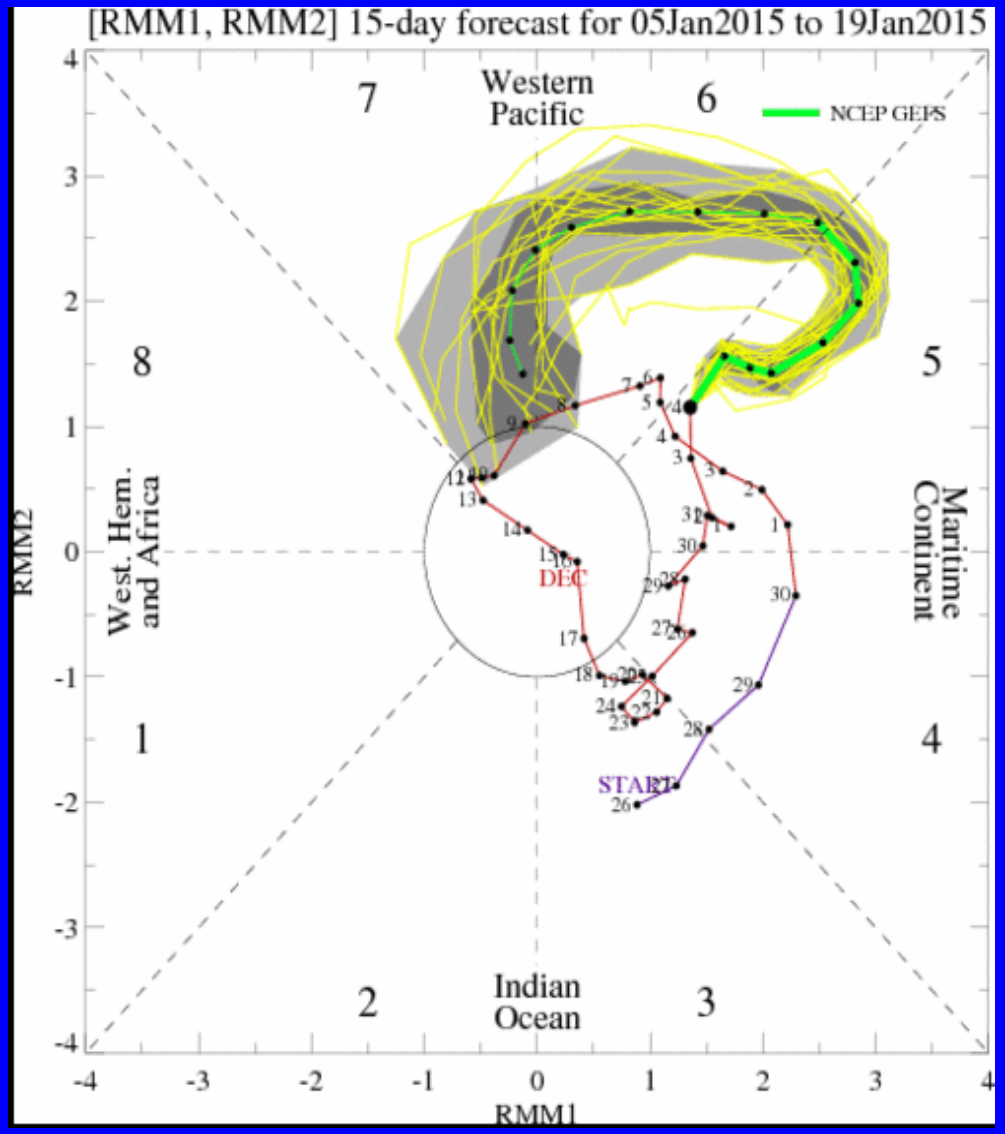
Ensemble GFS (GEFS) MJO Forecast

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

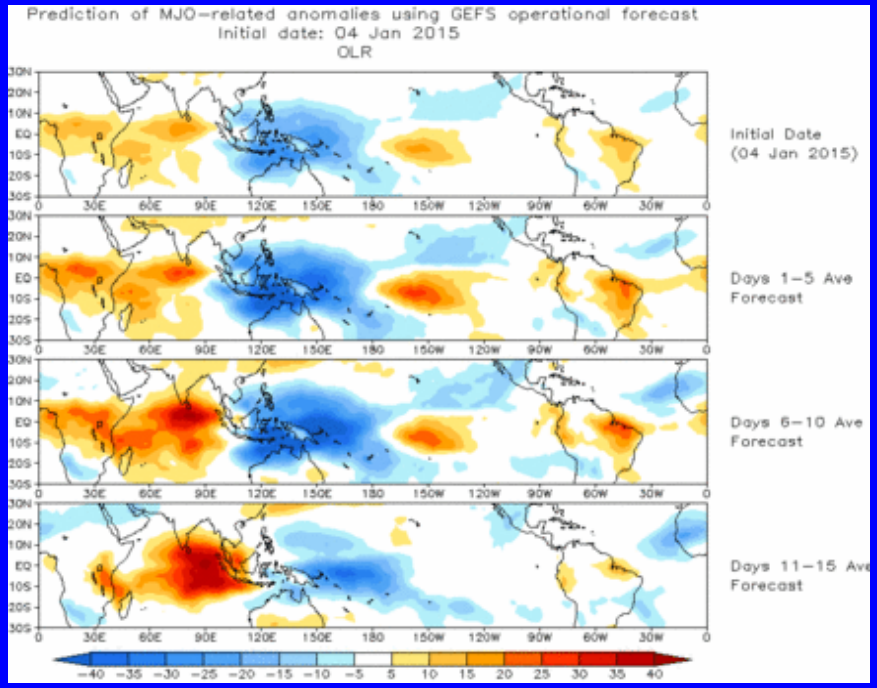
The ensemble GFS forecast indicates a continued MJO signal shifting east across the Pacific Ocean, primarily during Week-2.



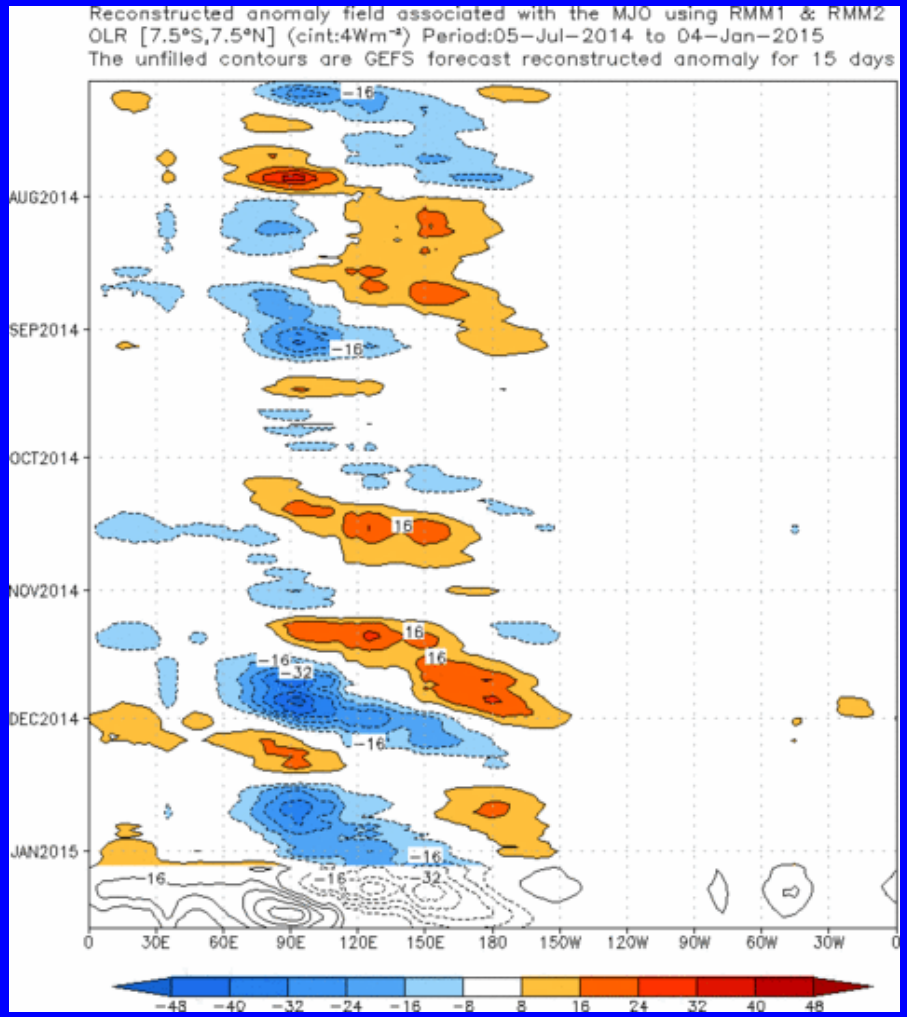
Ensemble Mean GFS MJO Forecast

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

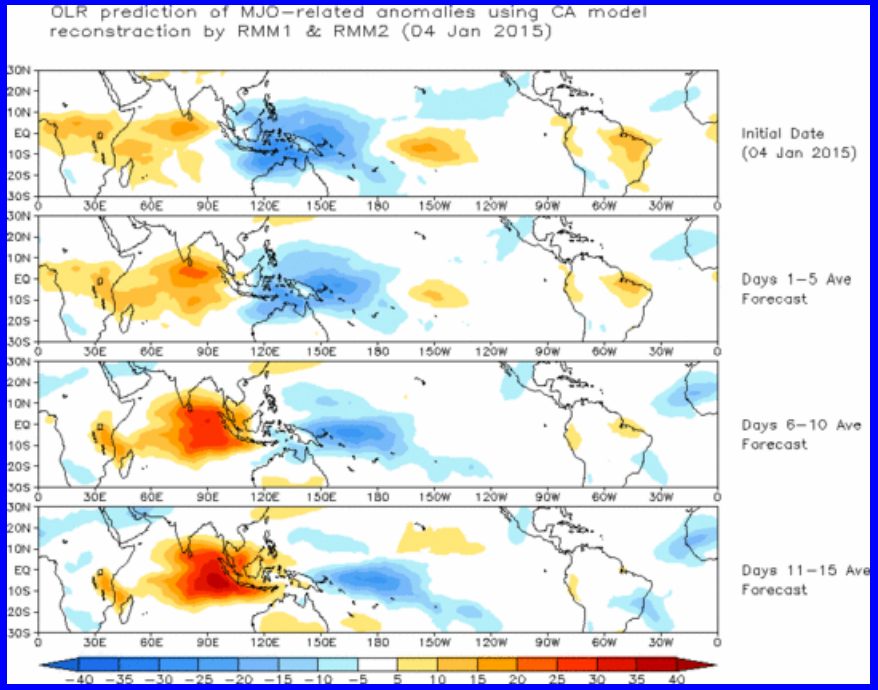


The GEFS mean MJO index based OLR anomaly forecast depicts enhanced convection over the eastern Maritime Continent and West Pacific, with suppressed convection shifting east across the Indian Ocean during the next two weeks.

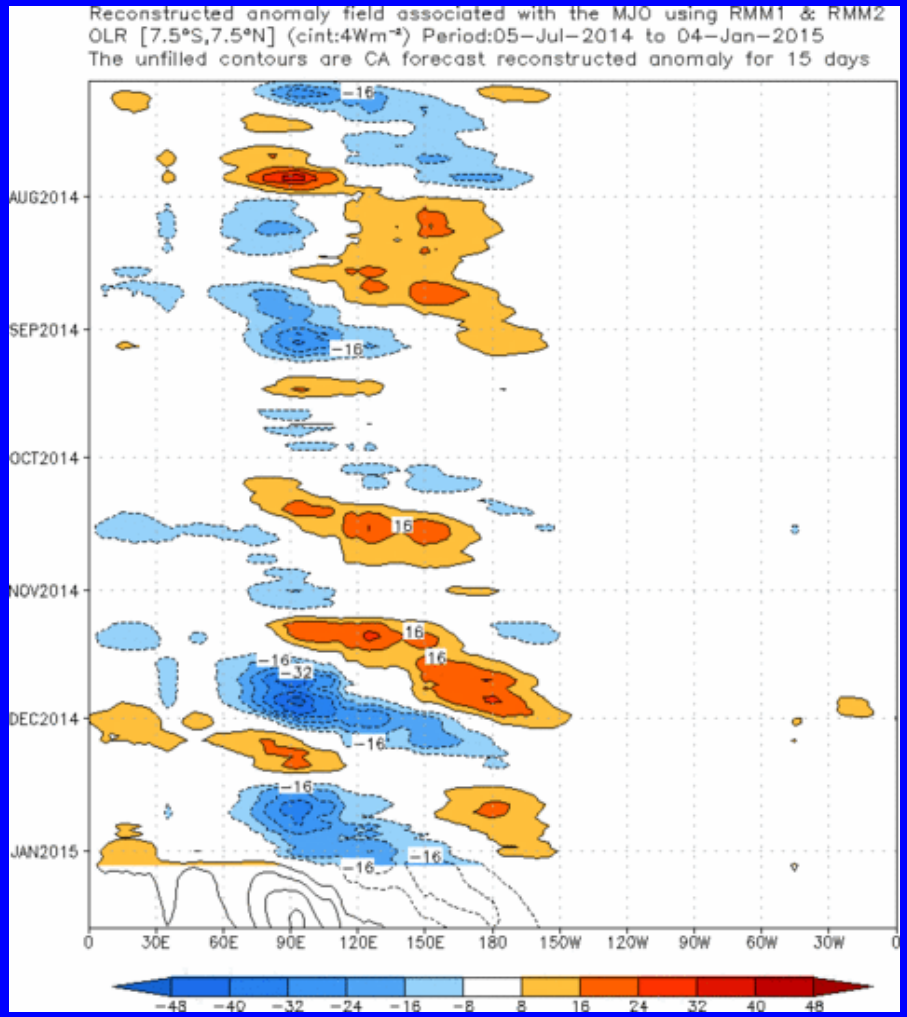
Constructed Analog (CA) MJO Forecast

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



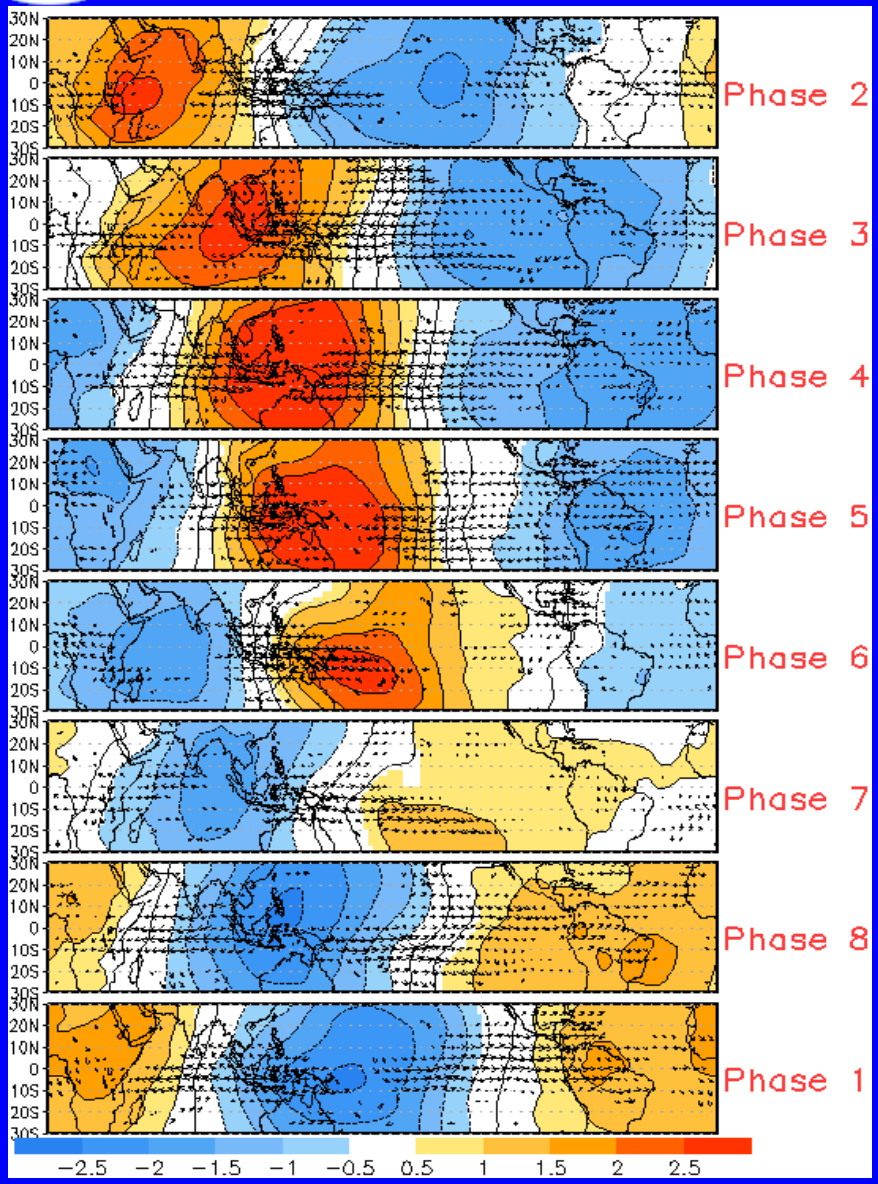
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



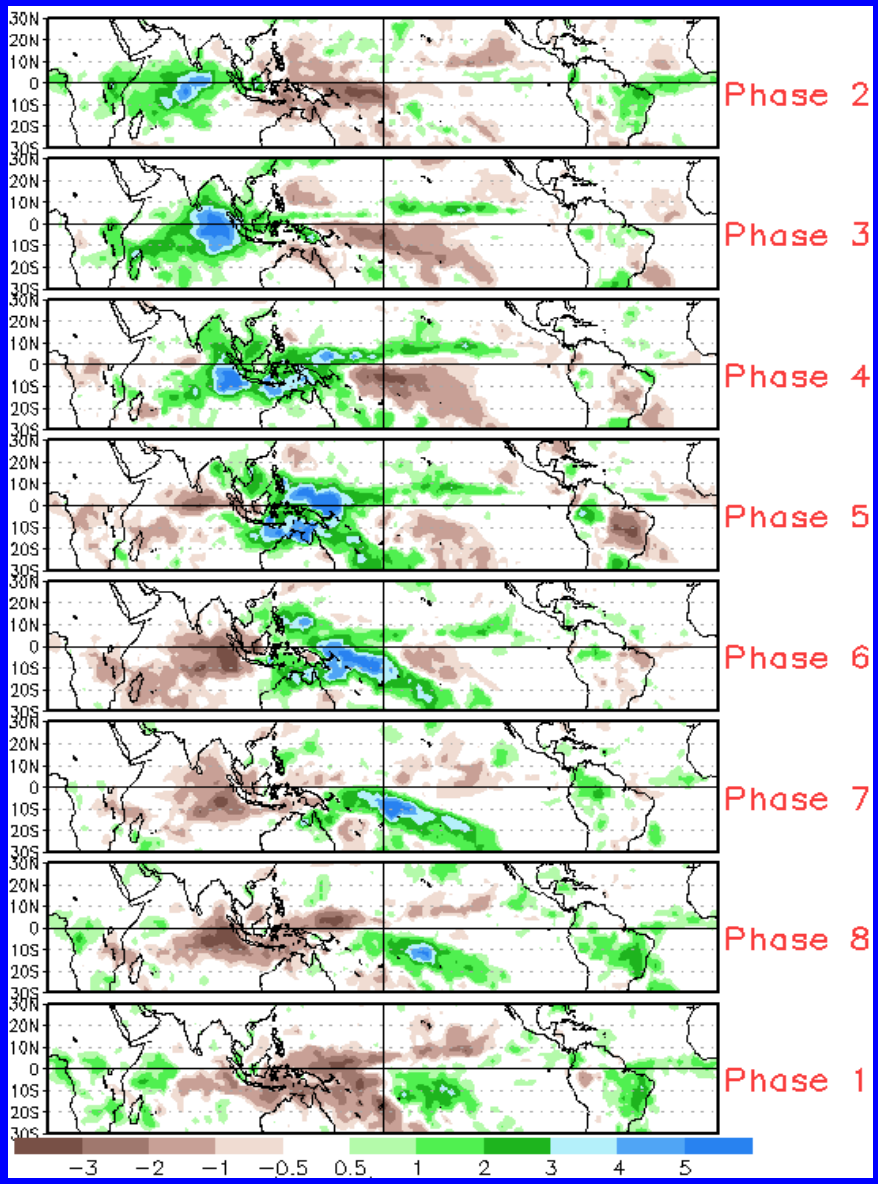
The constructed analog forecast depicts a similar pattern of anomalous convection as the Ensemble Mean GFS forecast, although perhaps with a slightly faster speed.

MJO Composites – Global Tropics

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

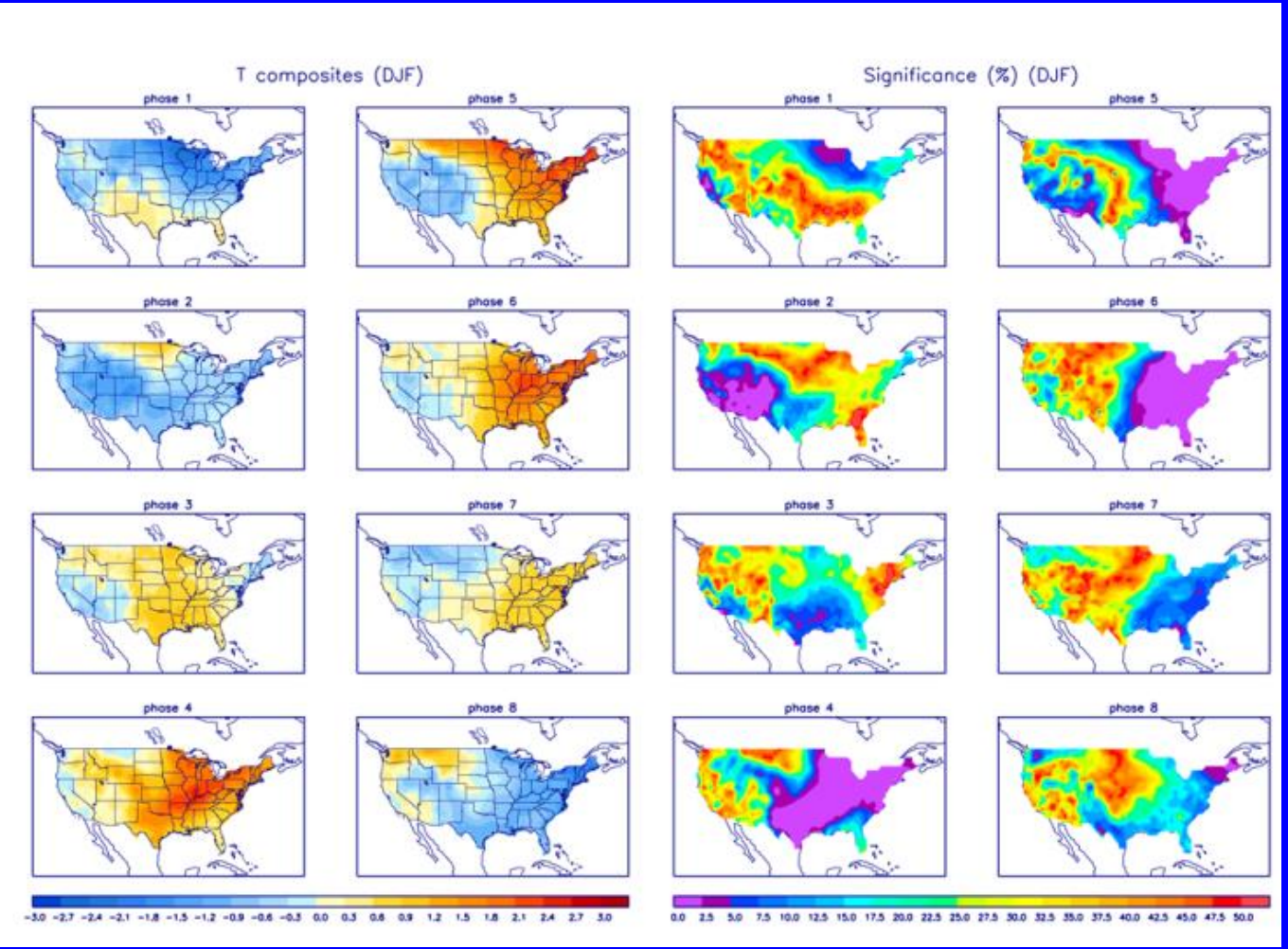


Precipitation Anomalies (Nov-Mar)



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.**

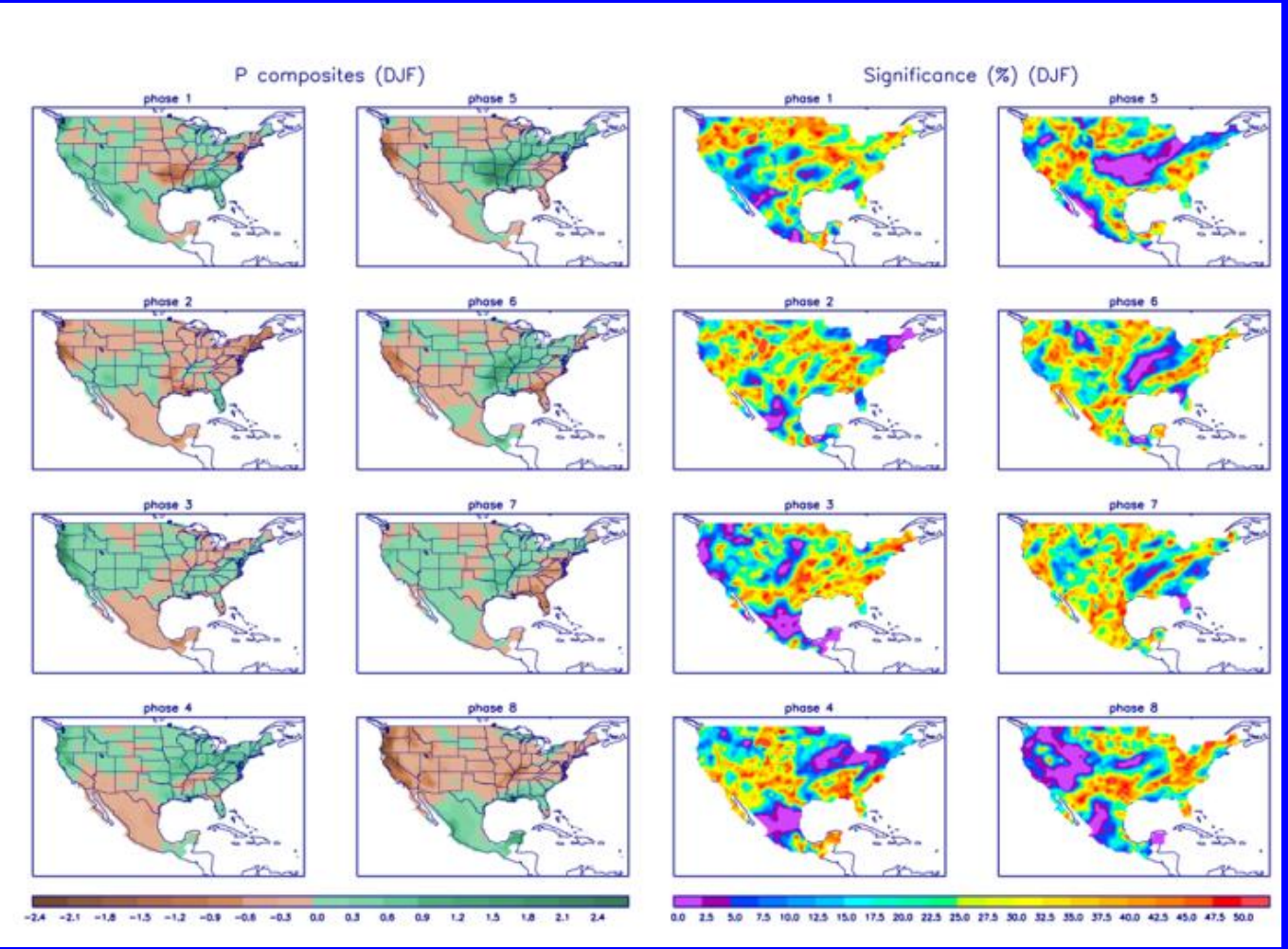


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml