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

Update prepared by
Climate Prediction Center / NCEP
December 17, 2012

Outline

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

Overview

- The MJO remained weak during the past week and other subseasonal coherent tropical variability continued to impact anomalous tropical convection.
- The majority of dynamical model MJO index forecasts indicate generally low spread for some strengthening and eastward propagation of an MJO signal during the upcoming period.
- Based on the latest observations and dynamical model MJO index forecasts, the MJO is forecast to become somewhat better organized and propagate eastward across the Indian Ocean through the end of Week-2.
- The MJO may contribute to suppressed (enhanced) convection across the western and central Pacific (Indian Ocean) during the period.

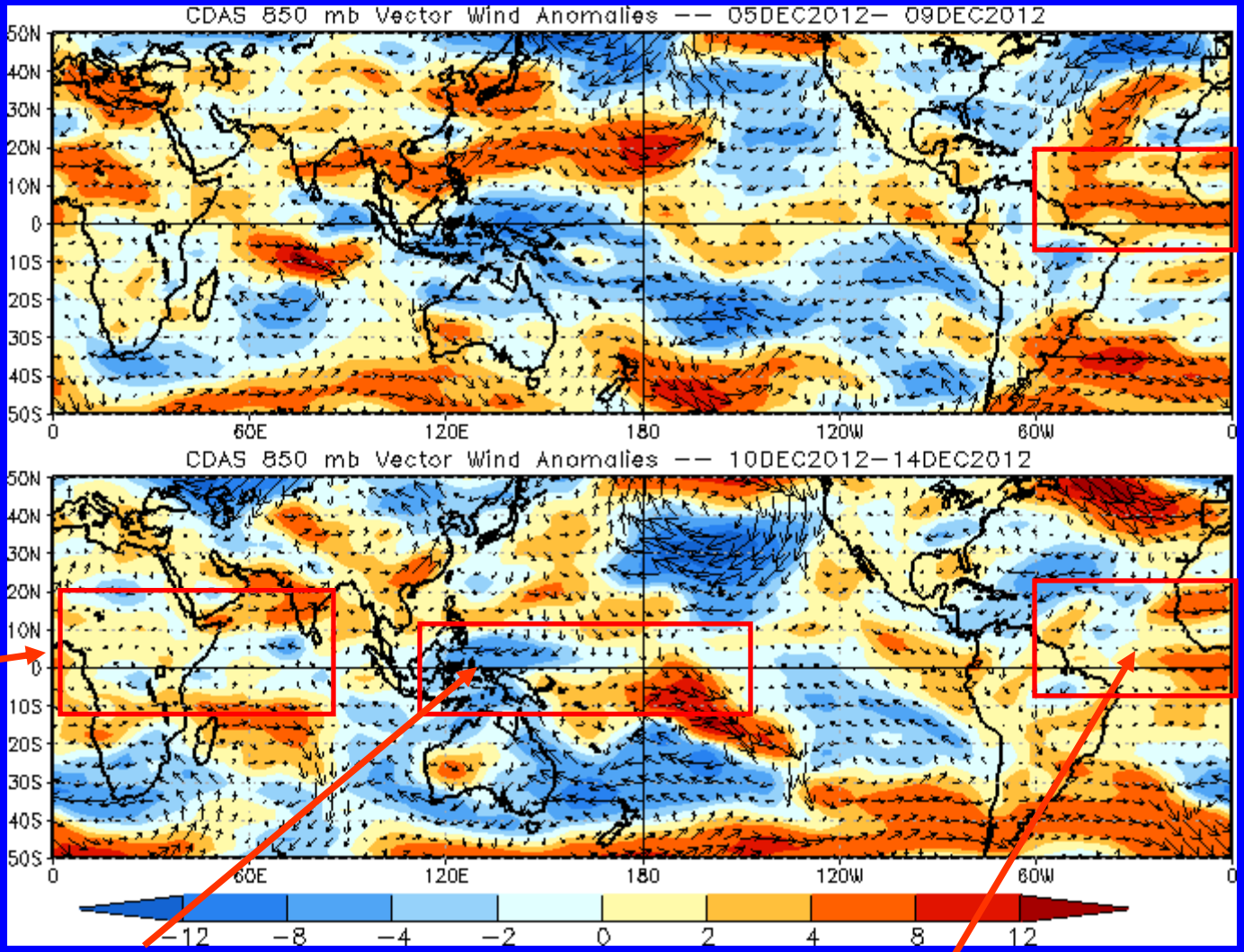
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 have weakened over parts of Africa the Indian Ocean.

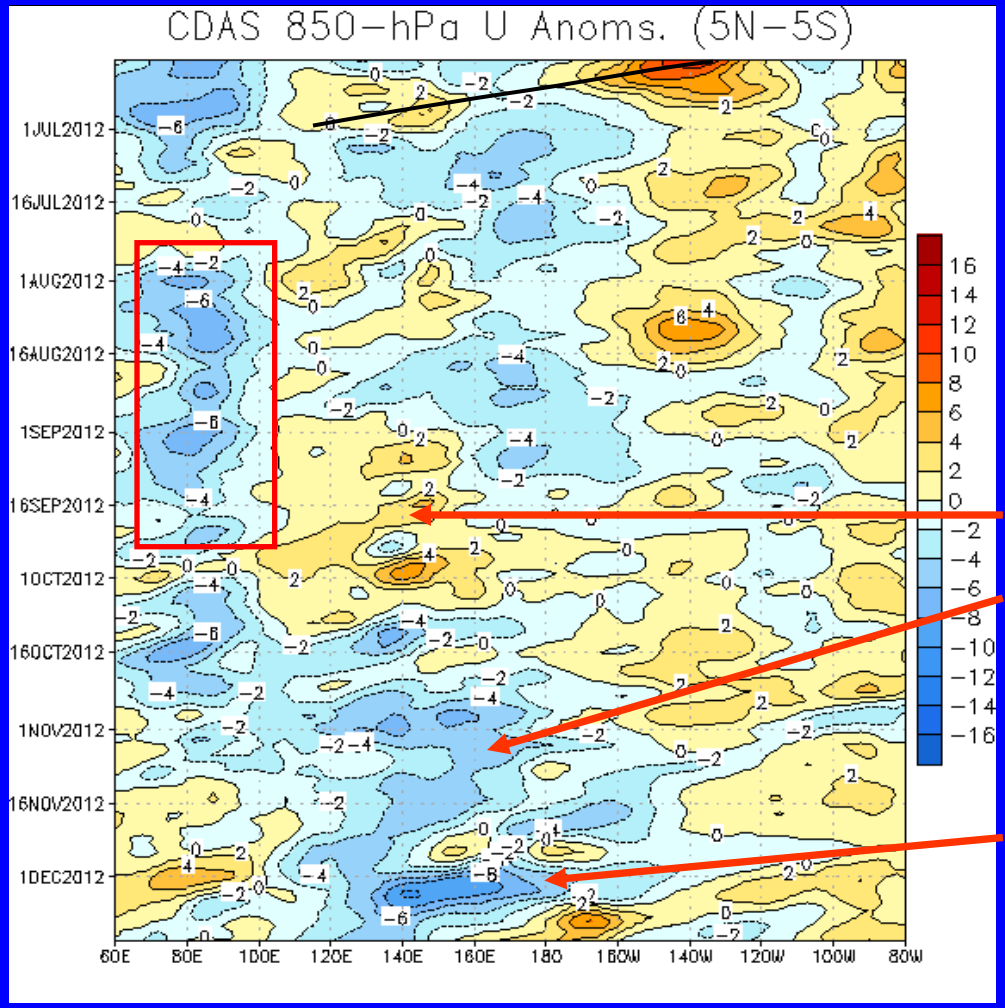
Easterly anomalies over the western Pacific weakened while strong westerly anomalies developed near the South Pacific Convergence Zone (SPCZ) during the past five days.

Westerly anomalies also weakened over the tropical Atlantic during the past 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



Time

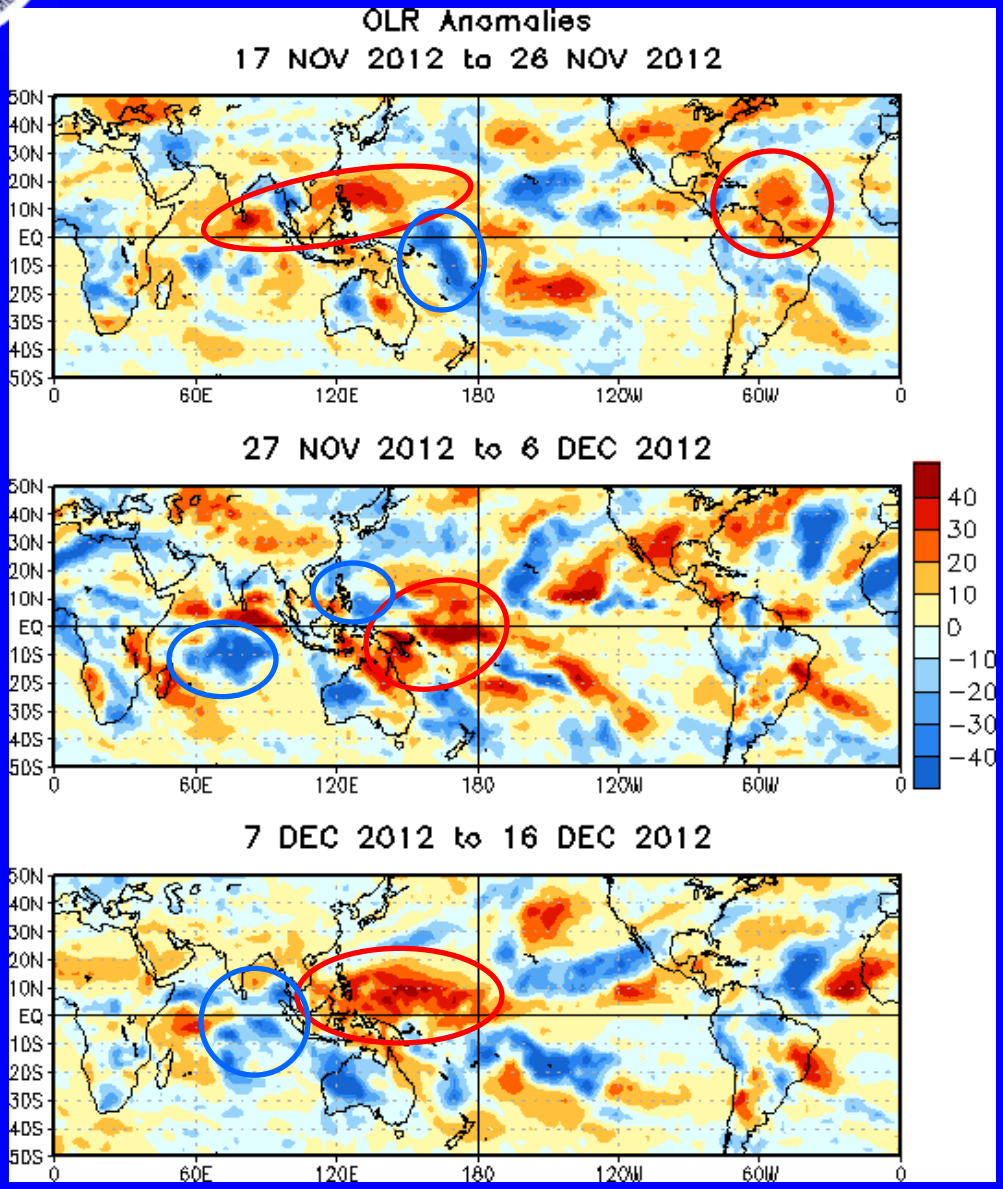
Longitude

Strong westerly anomalies developed across the eastern Pacific in mid-June and shifted westward (black solid line) and contributed to weakening the trade winds.

Easterly anomalies persisted near 80E for much of August and September (red box). During September, westerly anomalies developed near 140E and persisted into October. Easterly anomalies developed west of the Date Line during late October in the west Pacific and have persisted.

Westward propagation (shading sloping down and to the left) during much of November and early December are primarily due to equatorial Rossby wave activity.

OLR Anomalies – Past 30 days



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

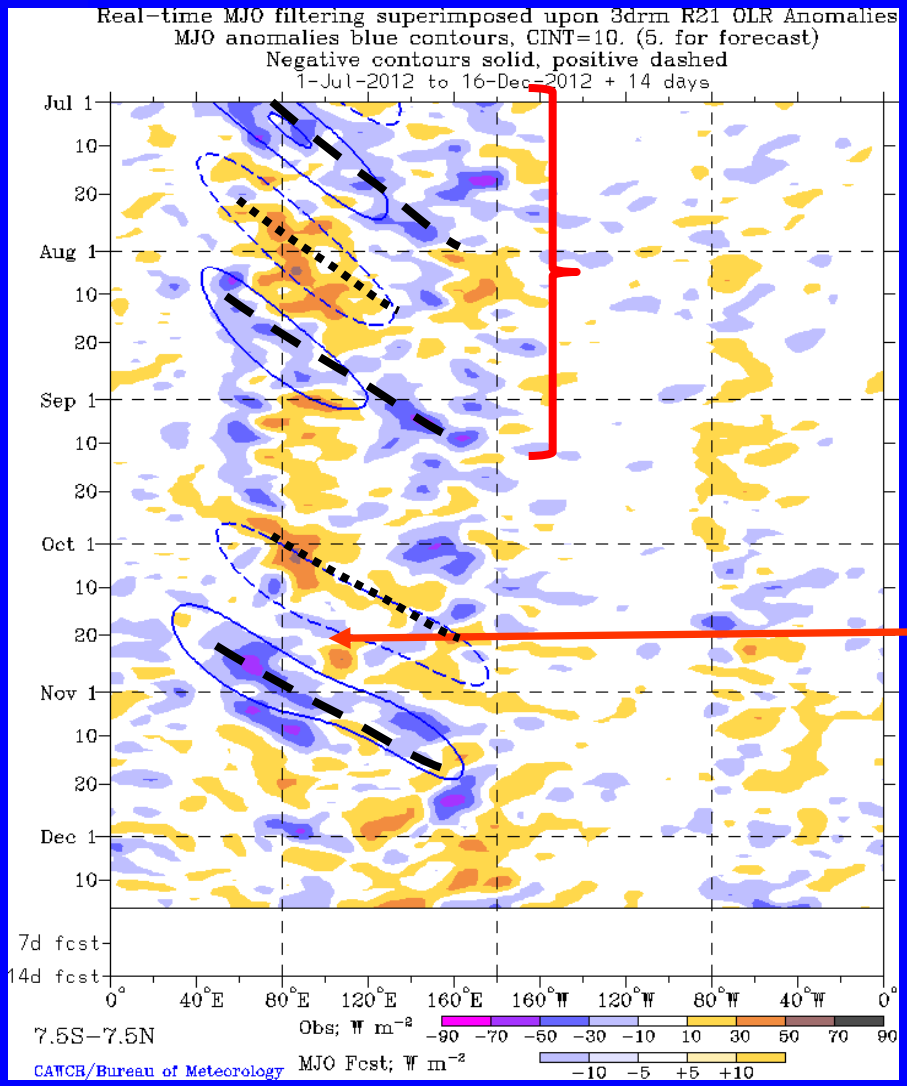
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

From mid-to-late-November, suppressed convection (red circles) was evident across the eastern Indian Ocean and western North Pacific, and continued over parts of the tropical Atlantic. Enhanced convection (blue circle) strengthened in the western South Pacific.

Entering early December, most of the equatorial Indian and western Pacific Oceans experienced suppressed convection, interrupted by tropical cyclone activity at times near the Philippines and in the southern Indian Ocean.

Suppressed convection organized on a broad scale across the western Pacific while enhanced convection has slowly increased across the 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)

From late June into September, eastward propagation of both enhanced and suppressed convection is evident across the eastern hemisphere (alternating dashed and dotted lines).

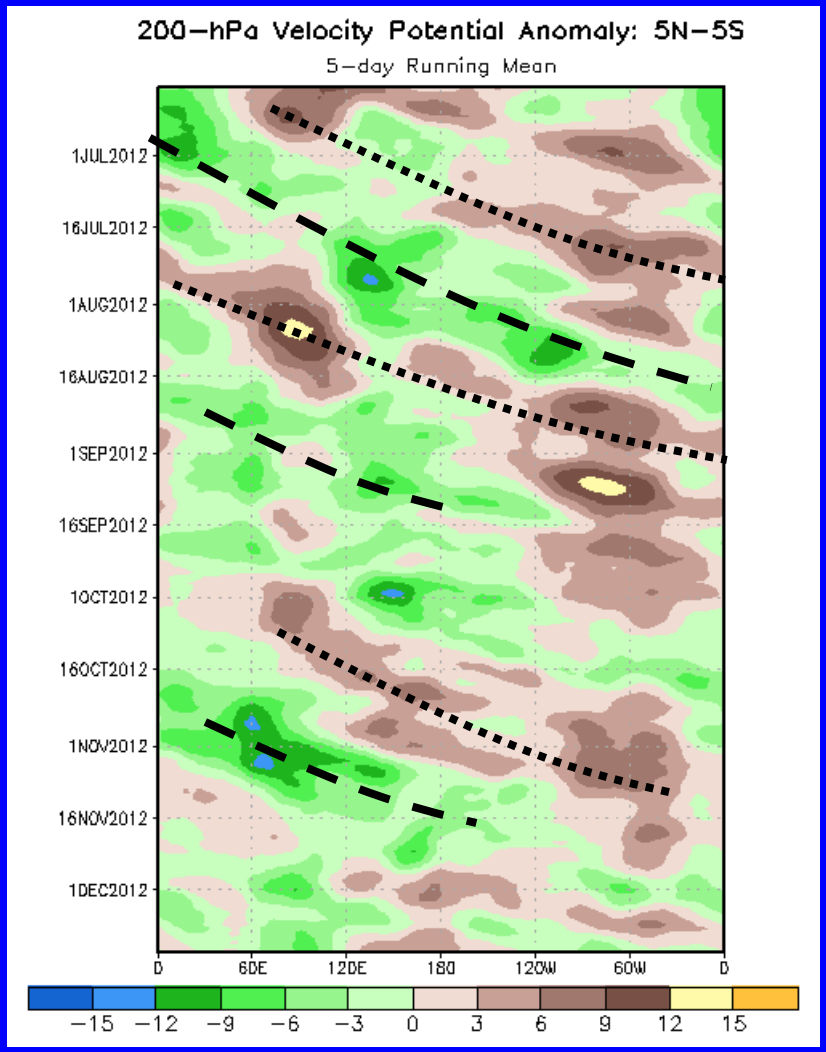
The MJO was active during October into November with enhanced convection developing over Africa during mid-October and shifting eastward to the western Pacific by mid-November.

The recent convective anomalies have been disorganized, in part a consequence of continued weak MJO activity. There has been some persistence of suppressed convection near the Date Line during early December along with some westward propagation of these anomalies.

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

Eastward propagation was evident from June into September associated with the MJO (alternating dashed and dotted lines), as well as atmospheric Kelvin wave activity, which at times resulted in fast eastward propagation of observed anomalies.

In mid-September, anomalies decreased and eastward propagation became less clear.

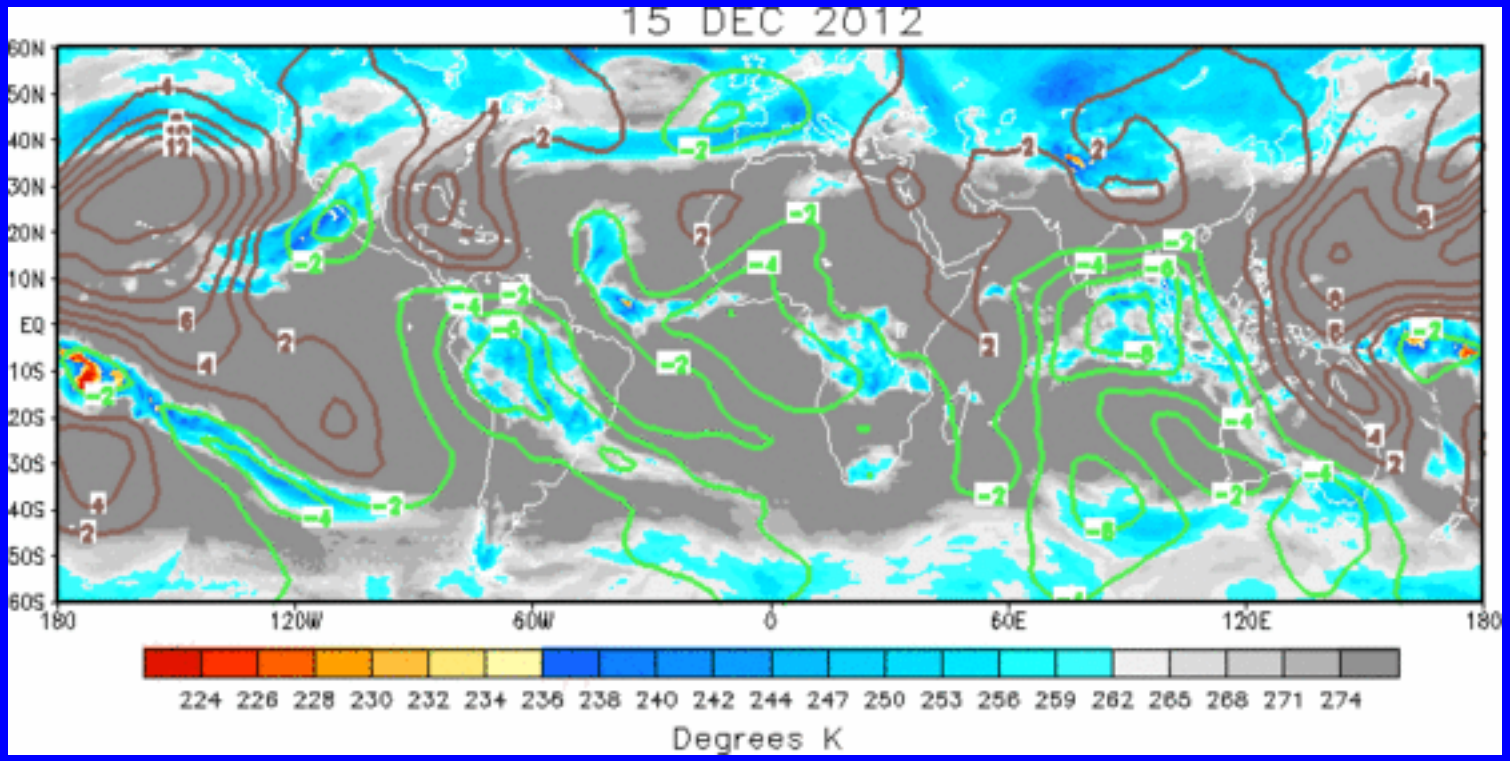
In early October, upper-level divergence (convergence) increased over the Pacific (Indian Ocean) and has shifted eastward throughout October and early November.

During December, anomalies have been weaker with less coherent eastward propagation. Other subseasonal variability (atmospheric Kelvin and equatorial Rossby waves) are also evident during December.

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

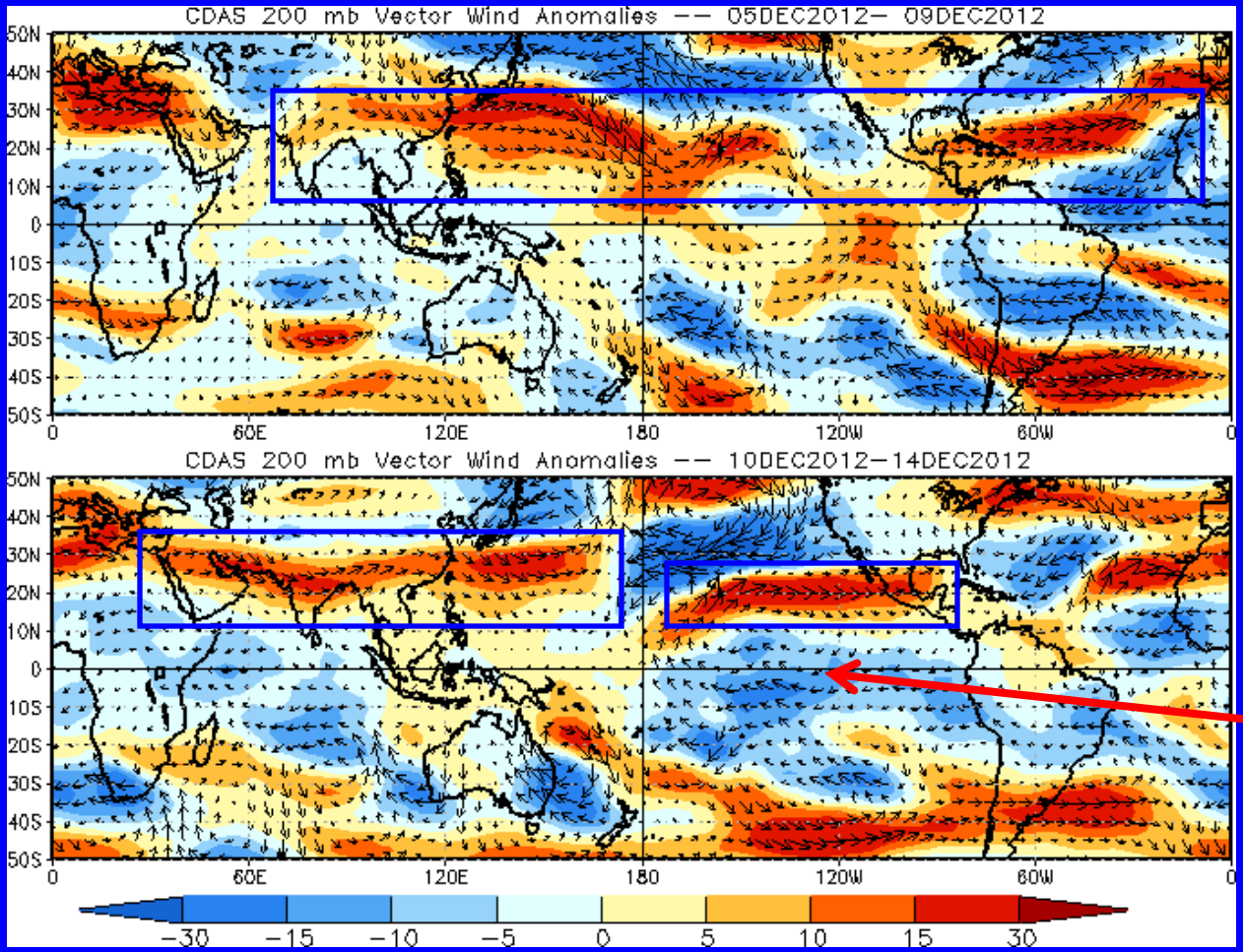
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The large scale velocity potential pattern is not organized in a manner consistent with a coherent robust MJO. Upper-level convergence is strongest over the Northern Pacific and upper-level divergence evident over parts of northern South America and 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

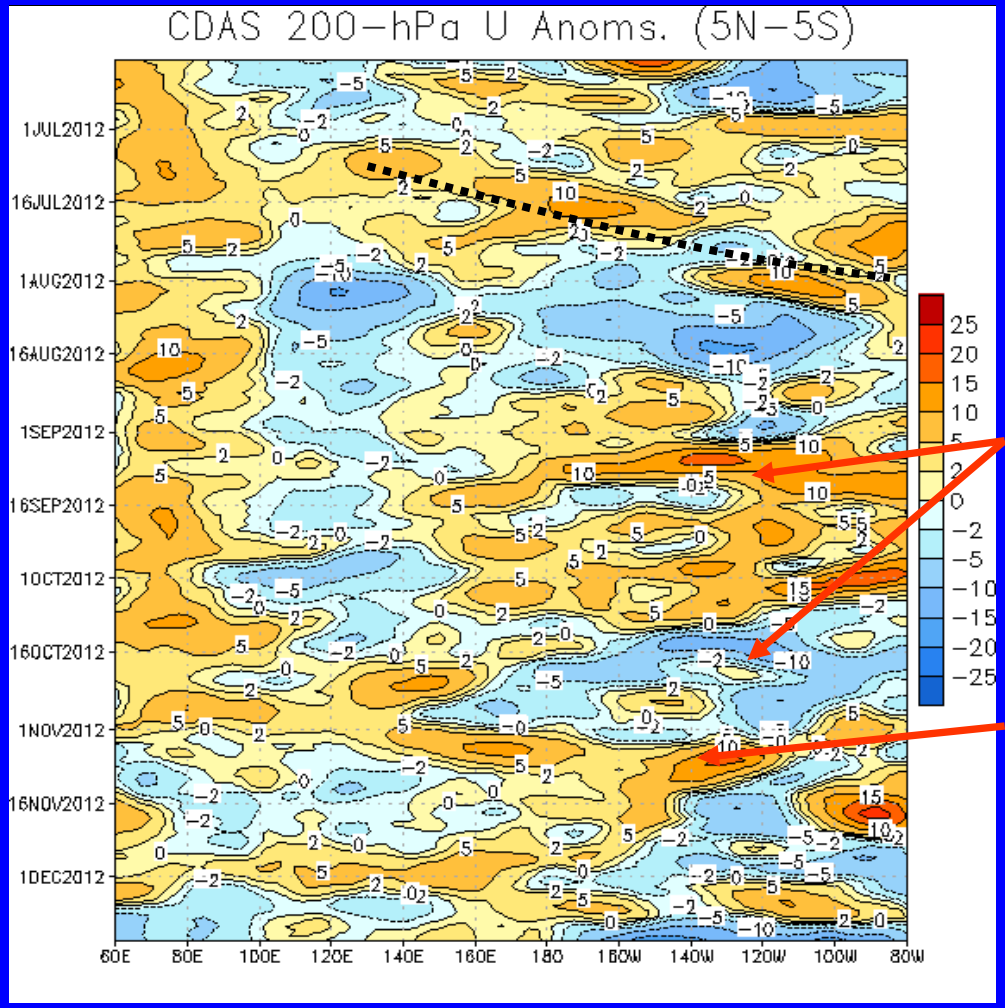
Westerly anomalies (blue boxes) have been generally persistent over the tropical and sub-tropical Pacific to the Americas during the last five to ten days. Although, recently, a deep trough has extended southward, near the Date Line.

Easterly anomalies have developed over the equatorial, 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

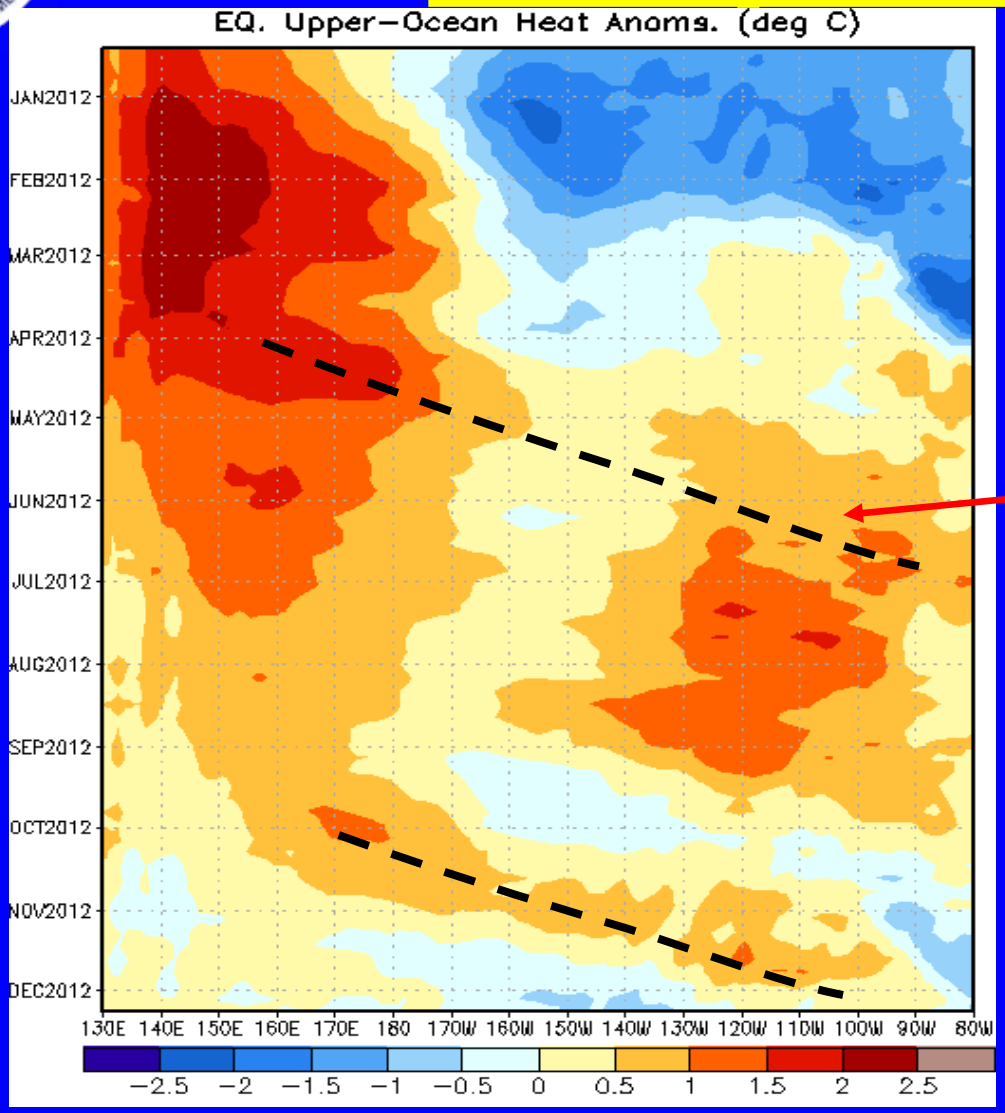
Longitude

Westerly anomalies shifted eastward across the Pacific during July and early August.

Westerly anomalies prevailed across the eastern Pacific and Americas for much of September and October, but were replaced by easterly anomalies during mid-October.

Westerly anomalies shifted east to the eastern Pacific in early November, but have alternated between easterly and westerly anomalies since this period. An area of stronger, easterly anomalies is now evident just east of the Date Line.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

From December 2011 through February 2012, heat content was below average in the central and eastern equatorial Pacific.

From March into July 2012, heat content anomalies became positive and increased in magnitude across eastern equatorial Pacific, partly in association with a downwelling Kelvin wave.

Positive anomalies decreased across the eastern Pacific during late August and September.

An oceanic Kelvin wave was initiated at the end of September and increased heat content across the central and eastern Pacific during October and November. Recently, some small negative anomalies, are indicated in the central Pacific, east of 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).

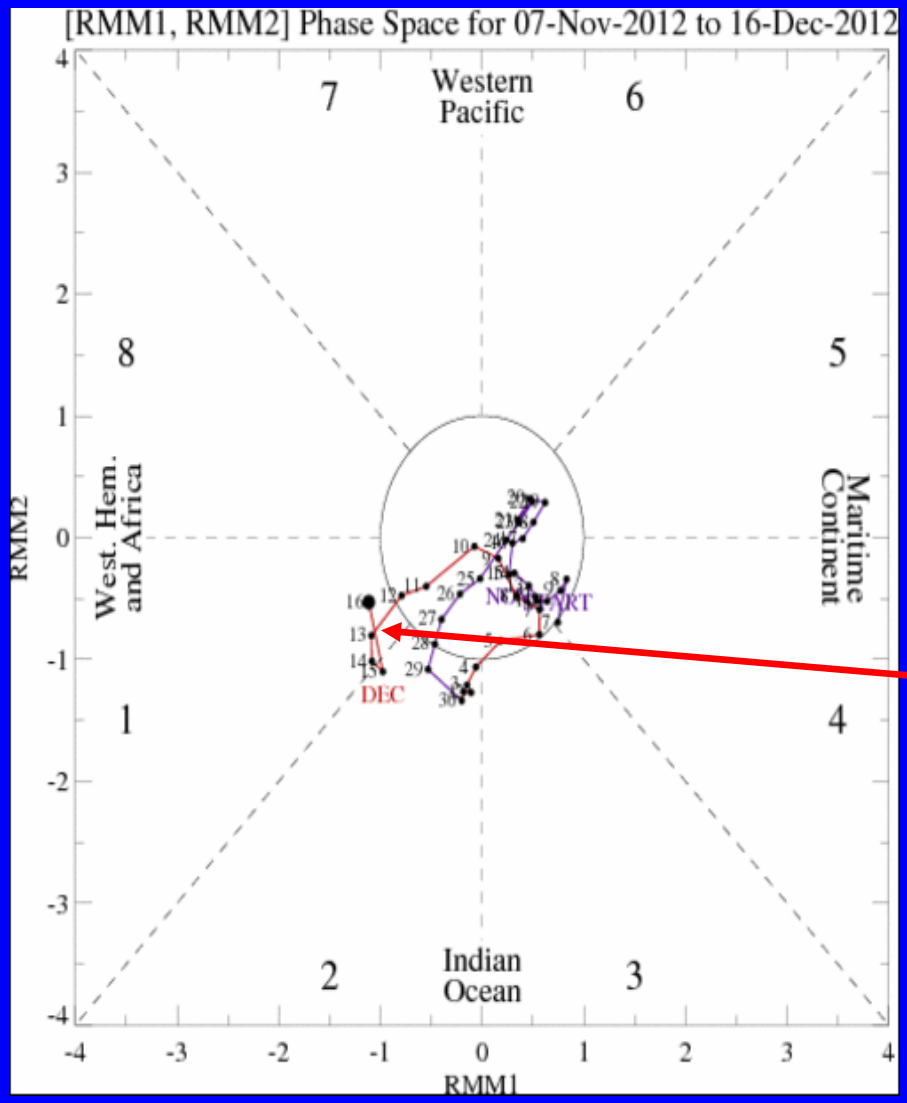
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

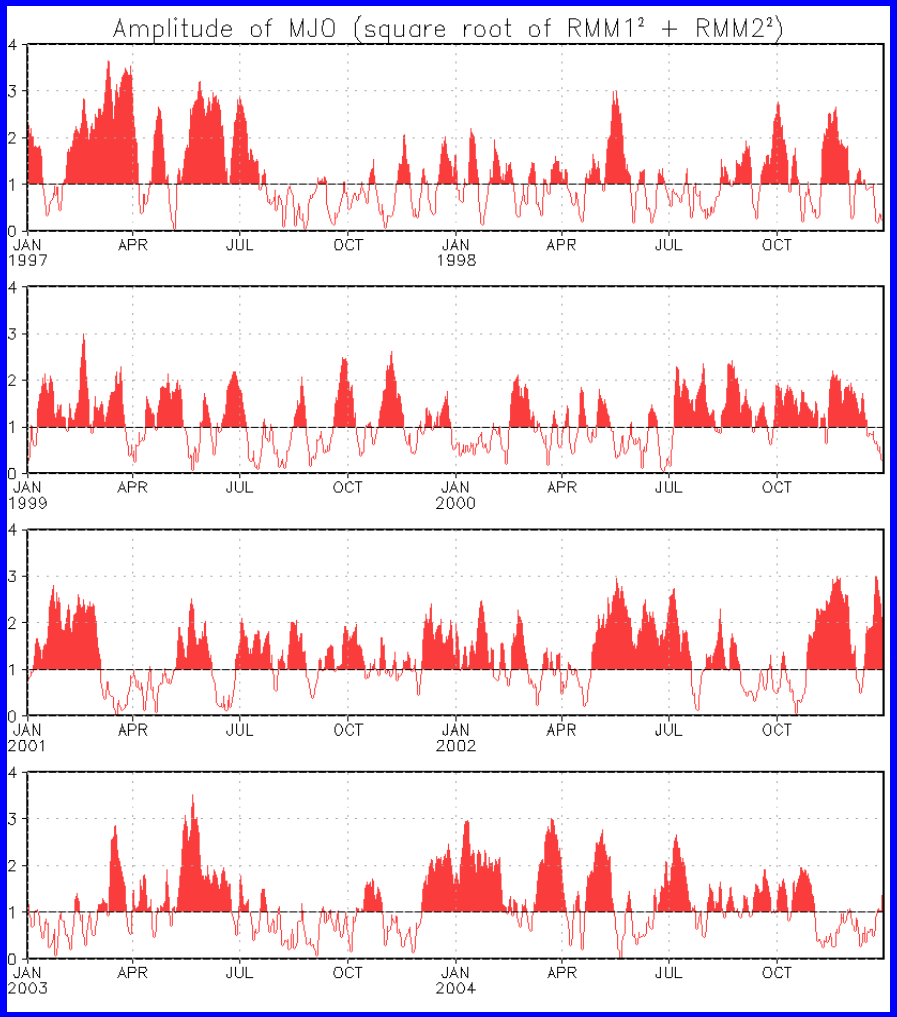
MJO Index -- Recent Evolution

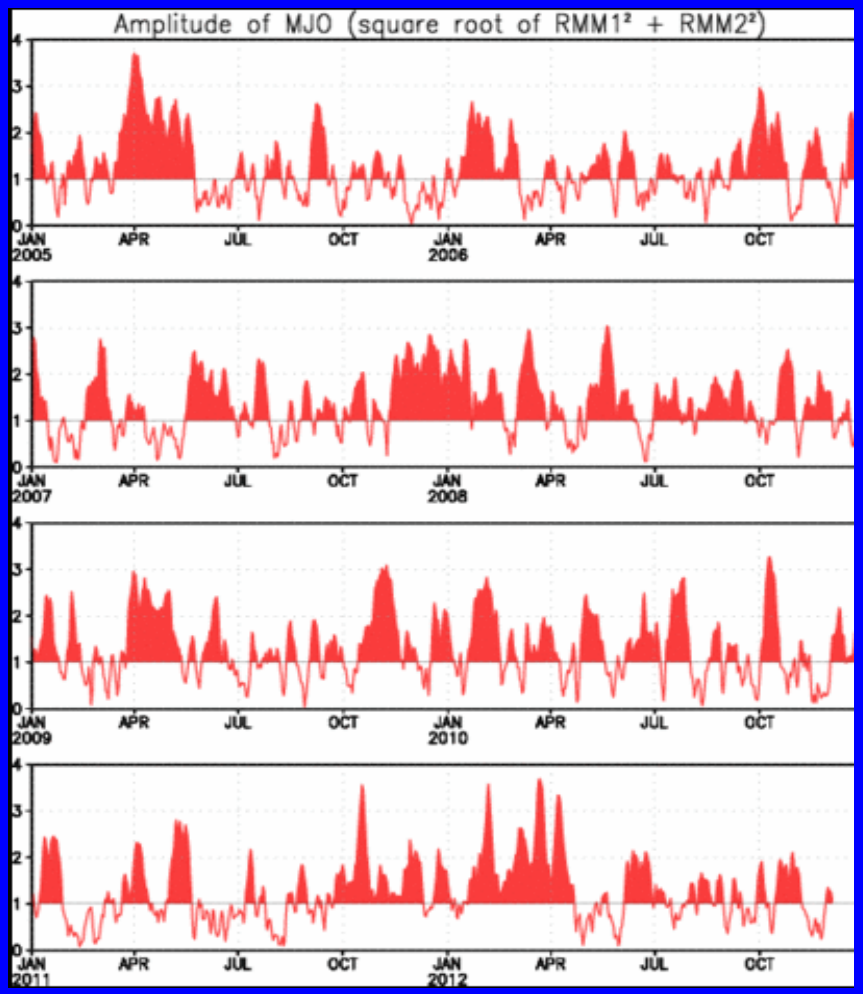


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates an increase in amplitude over Africa during the past 5 days.

MJO Index – Historical Daily Time Series





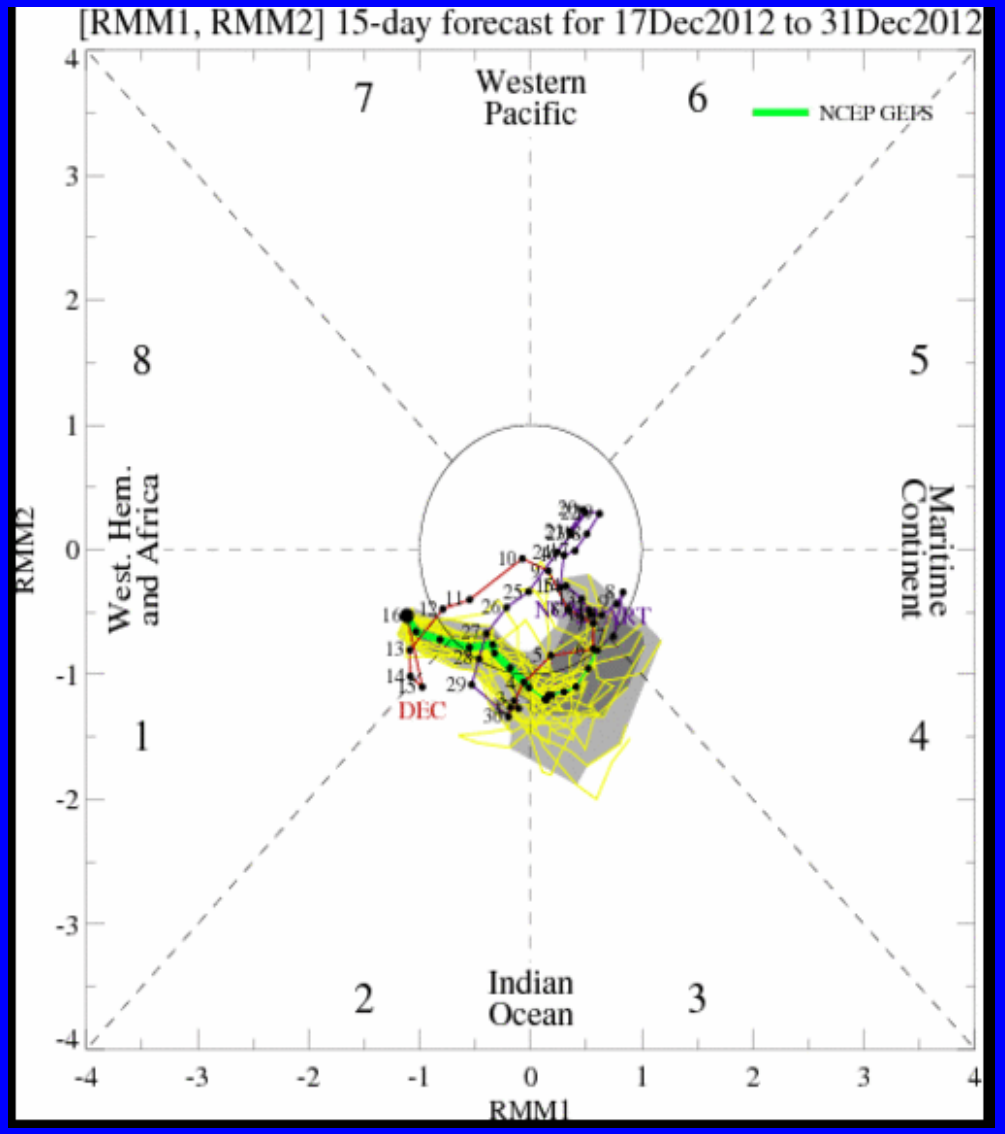
Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

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

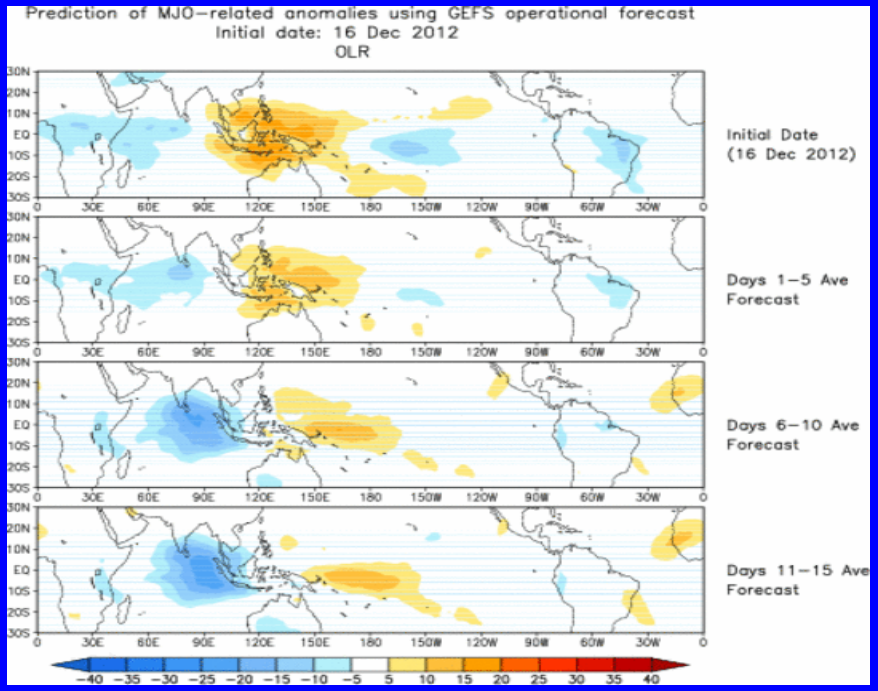


The bias-corrected ensemble GFS forecasts indicate the emergence of a weak MJO signal that persists through Week-2. Initial values of the forecast index are consistent with a continued westward propagating equatorial Rossby Wave.

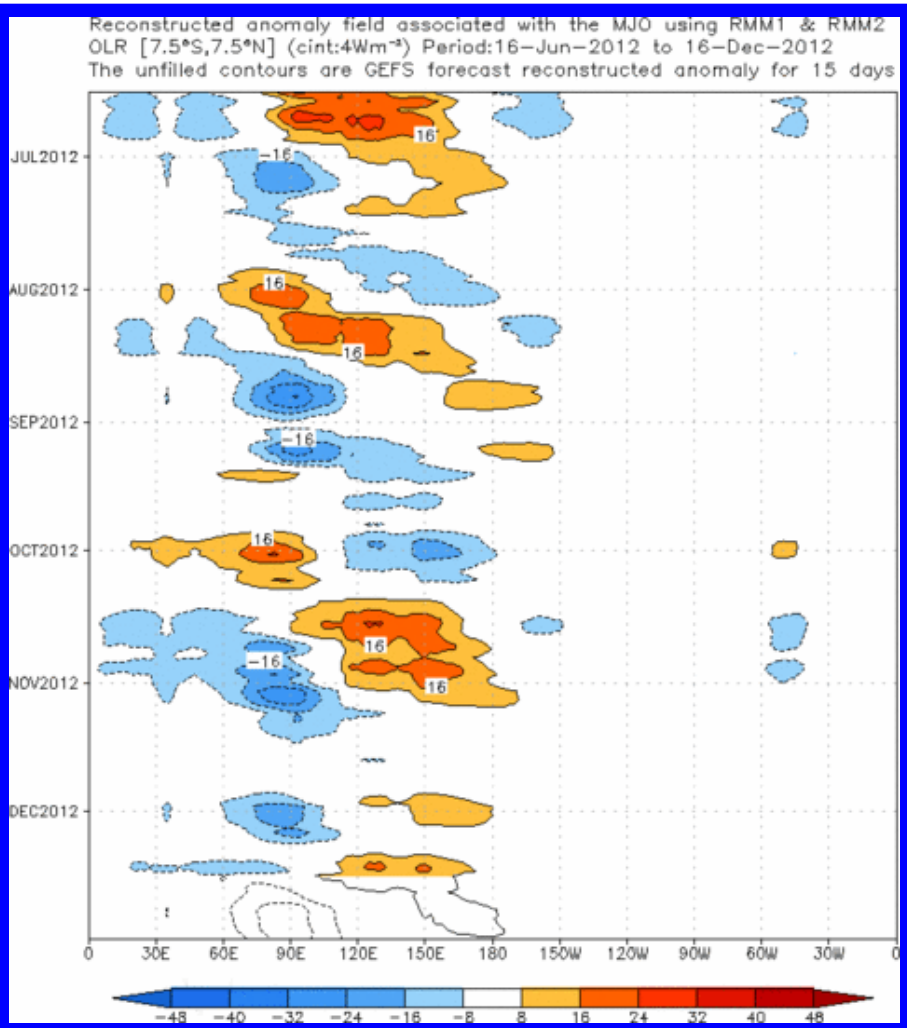
Ensemble Mean GFS MJO Forecast

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

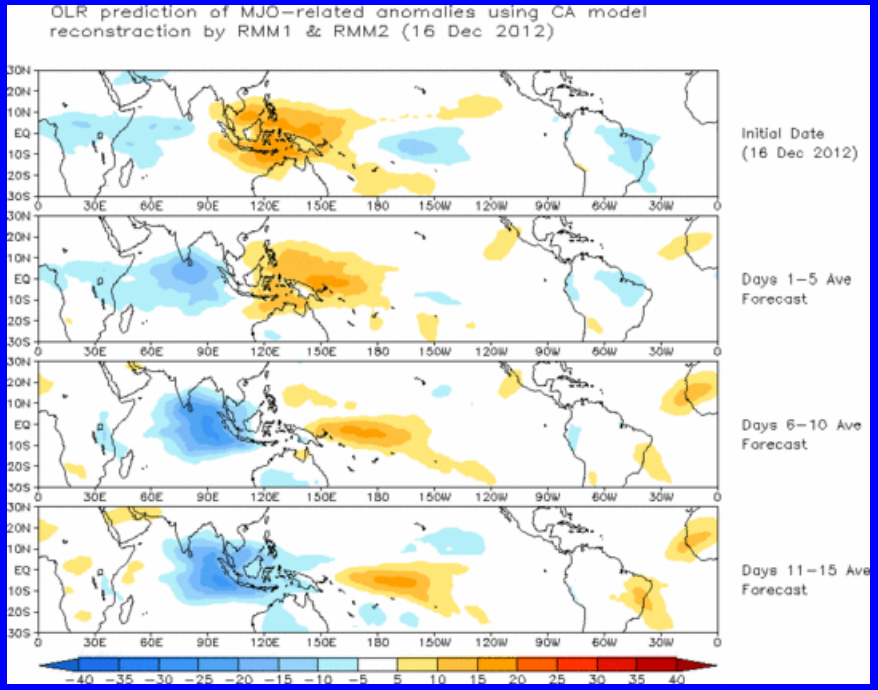


The ensemble mean GFS forecast indicates the development of enhanced convection across Africa, South America, and the Indian Ocean over the next 10 days. Drier-than-average conditions are forecast for the western Pacific, with some eastward propagation by the end of Week-2.

Constructed Analog (CA) MJO Forecast

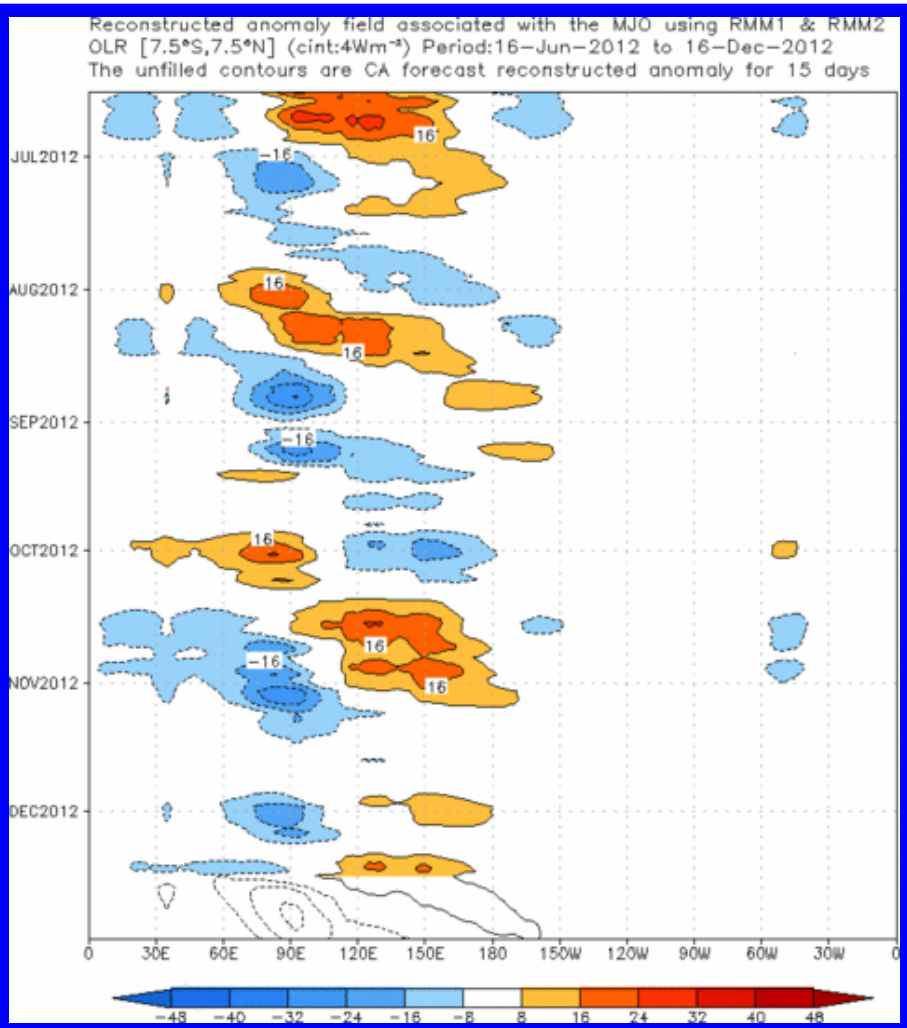
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



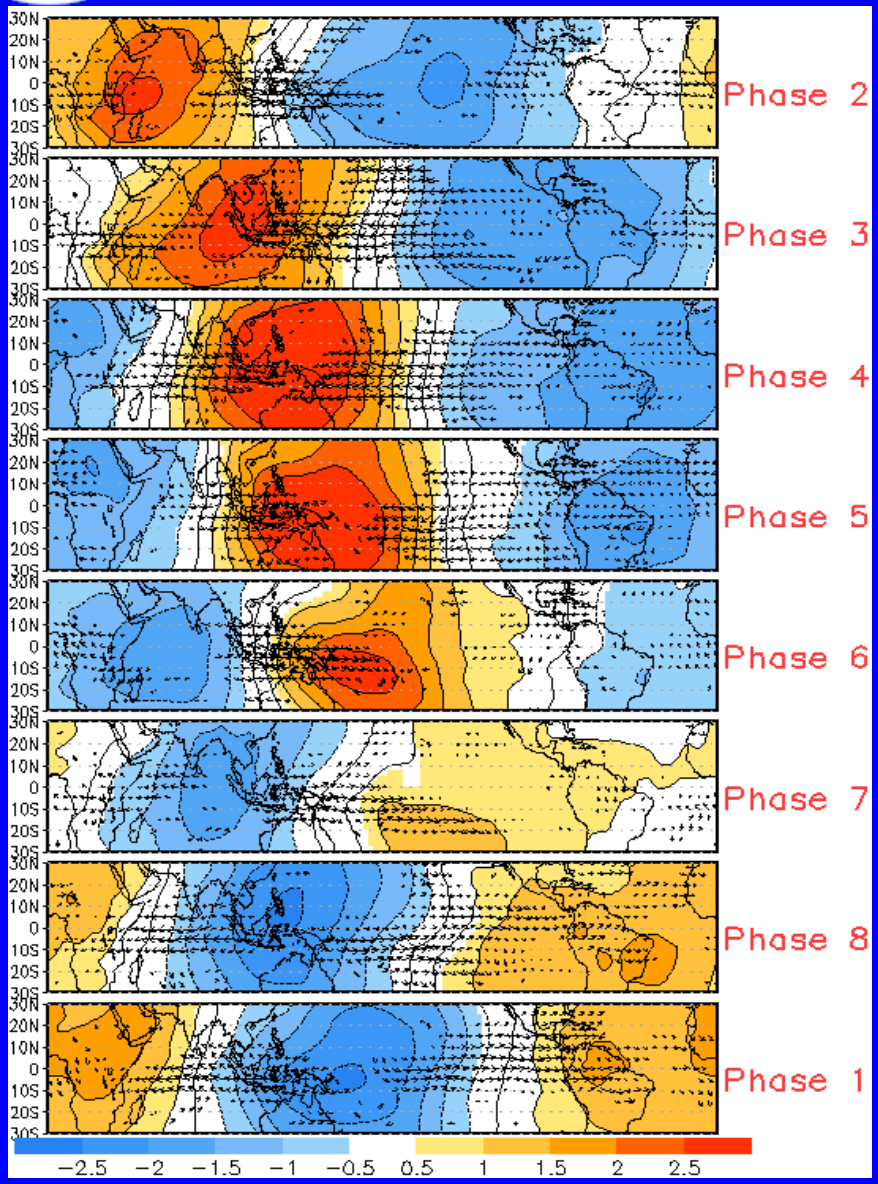
This forecast indicates more eastward propagation than the GFS based forecast, with enhanced convection across the Maritime continent by the end of Week-2. Suppressed convection is forecast for northeast South America and parts of Africa by the end of the period.

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

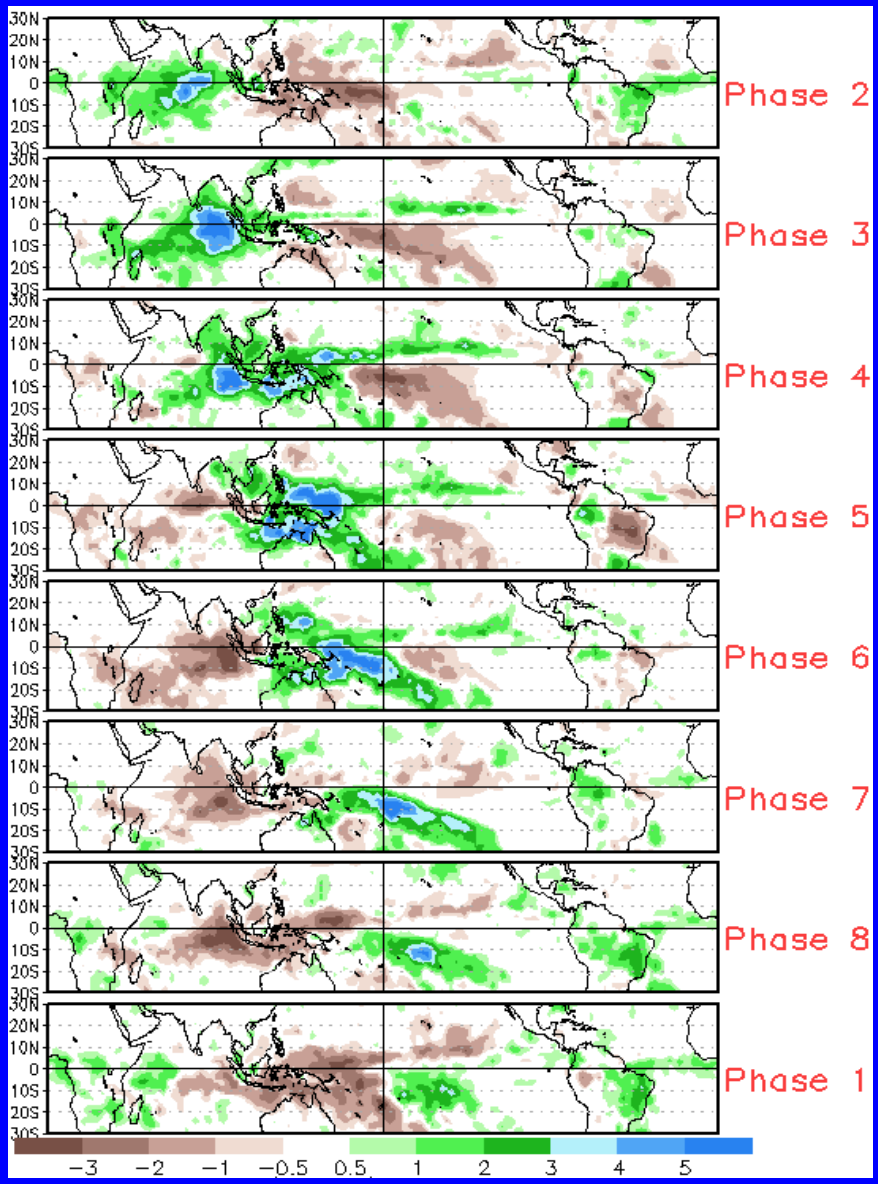


MJO Composites – Global Tropics

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

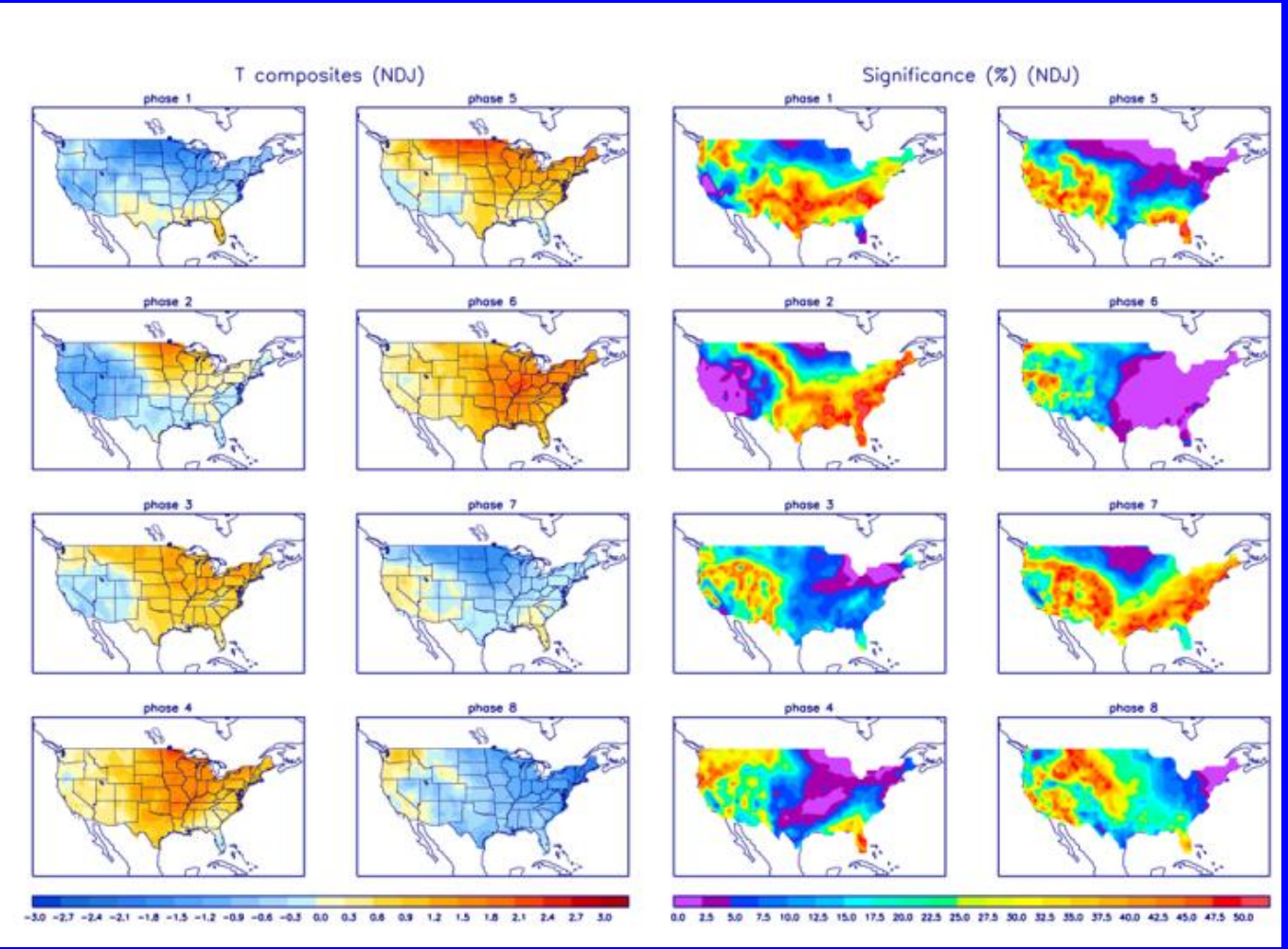


Precipitation Anomalies (Nov-Mar)



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.**

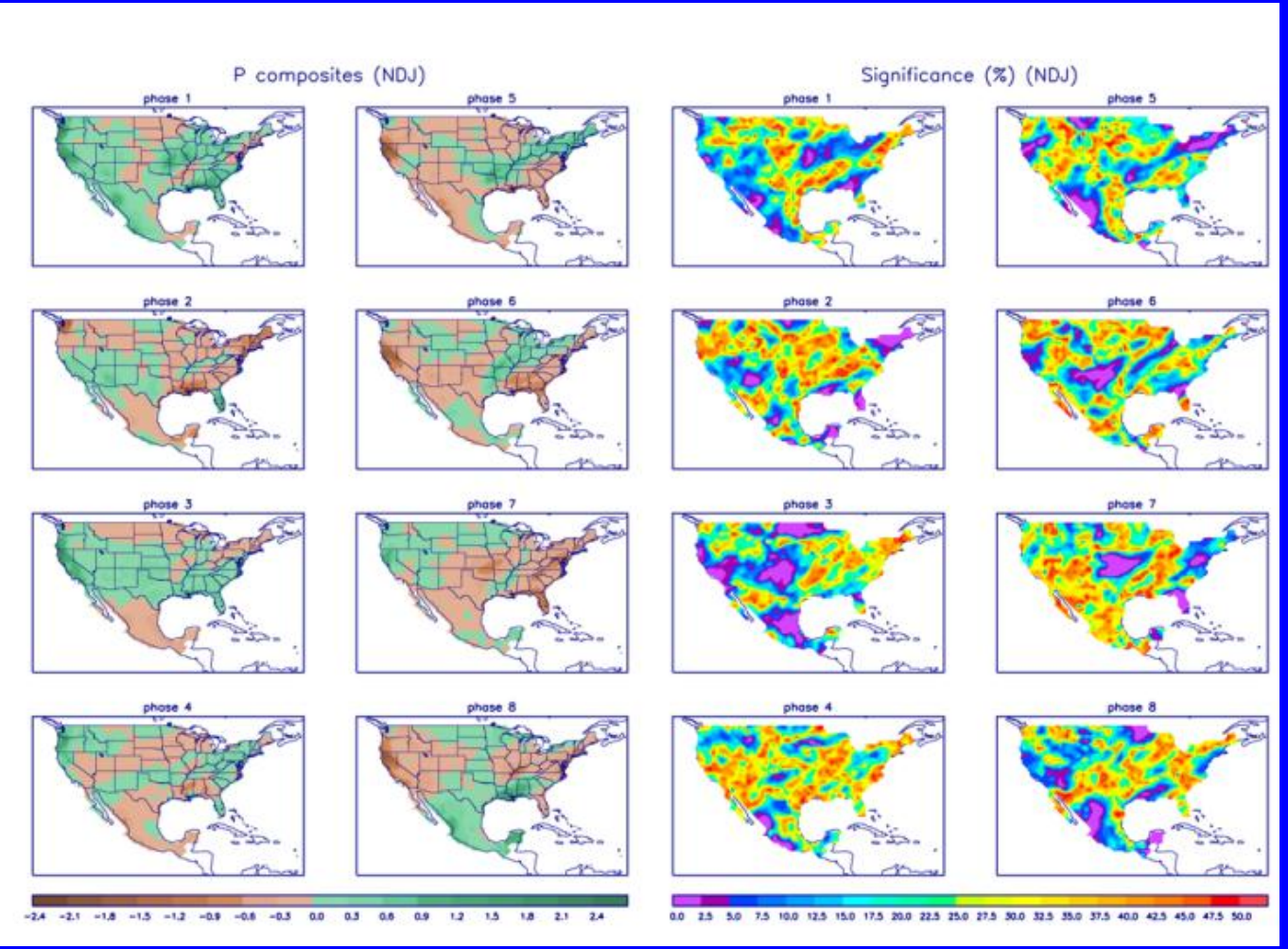


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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