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

Update prepared by
Climate Prediction Center / NCEP
December 31, 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, though some eastward propagation was evident. The MJO continues to show signs of strengthening with the enhanced phase centered across the eastern Indian Ocean and western Maritime Continent.

- Dynamical and statistical model MJO index forecasts contain moderate amounts of spread, though they generally agree on eastward propagation of a weak to moderate MJO signal.

- Based on the latest observations and MJO index forecasts, the MJO is forecast to strengthen slightly and propagate through phases 4 and 5 over the next two weeks.

- The MJO may contribute to enhanced (suppressed) convection across the Maritime Continent (western and central Indian Ocean) during the period.

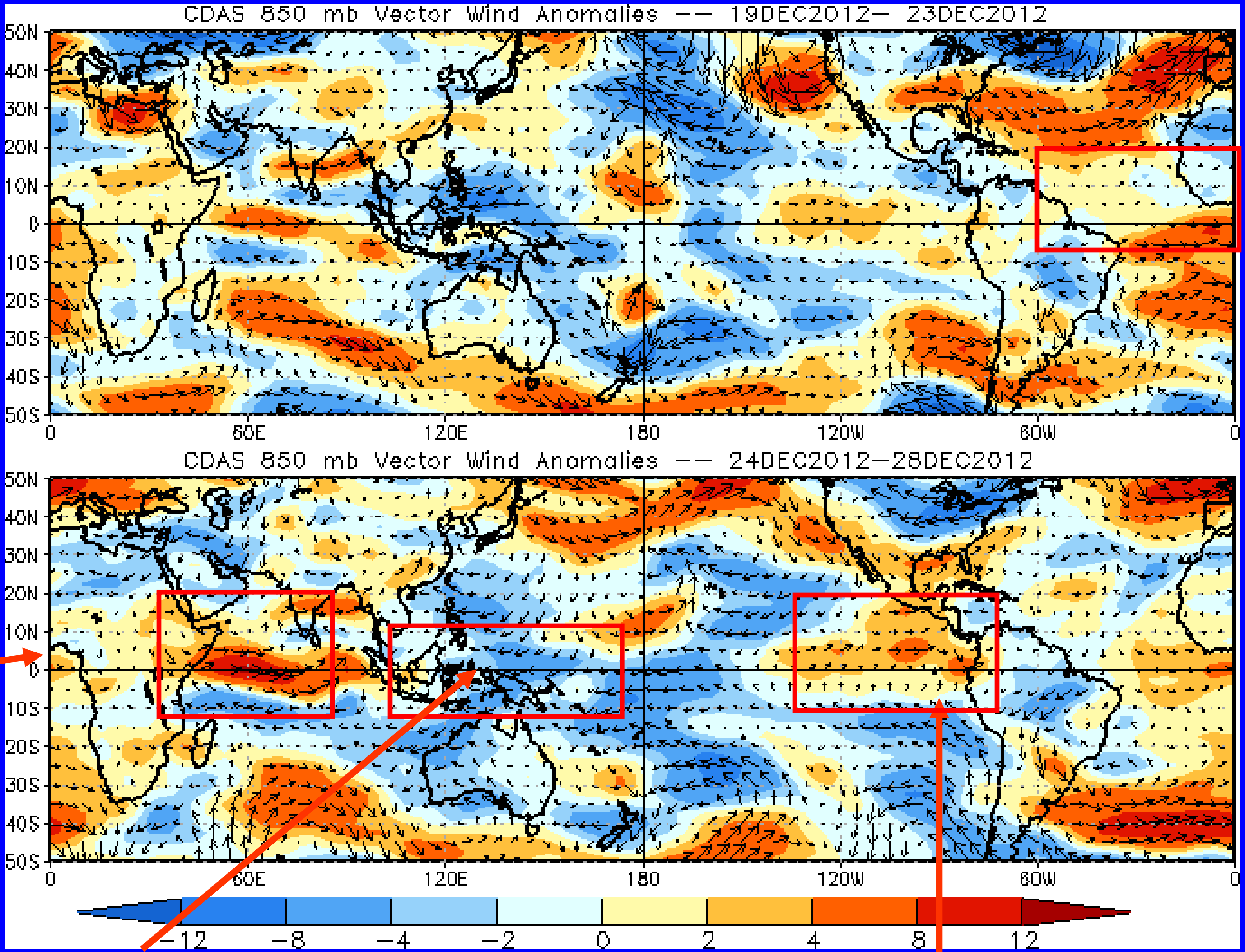
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 strengthened along the equator over parts of the Indian Ocean.

Easterly anomalies continued over the western Pacific, while some mid-latitude influence remains evident.

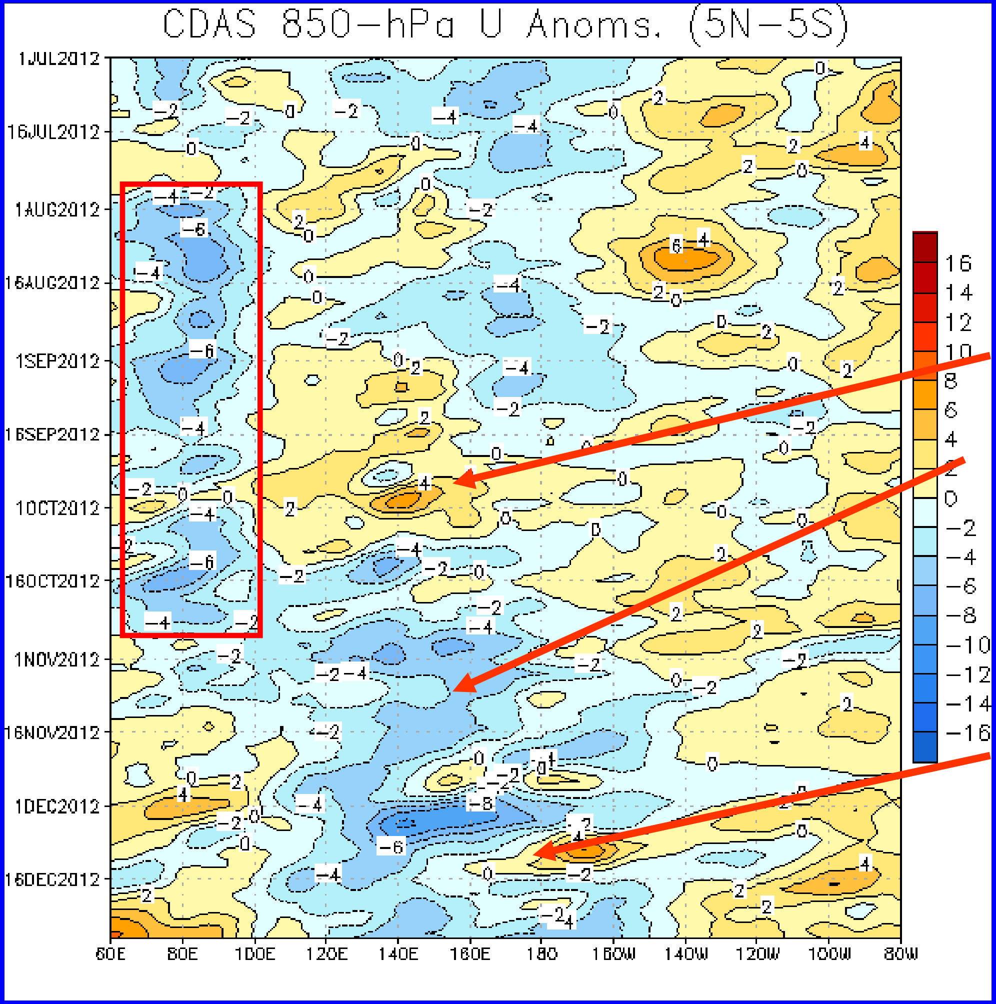
Westerly anomalies strengthened over the eastern tropical Pacific during the past five days.

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

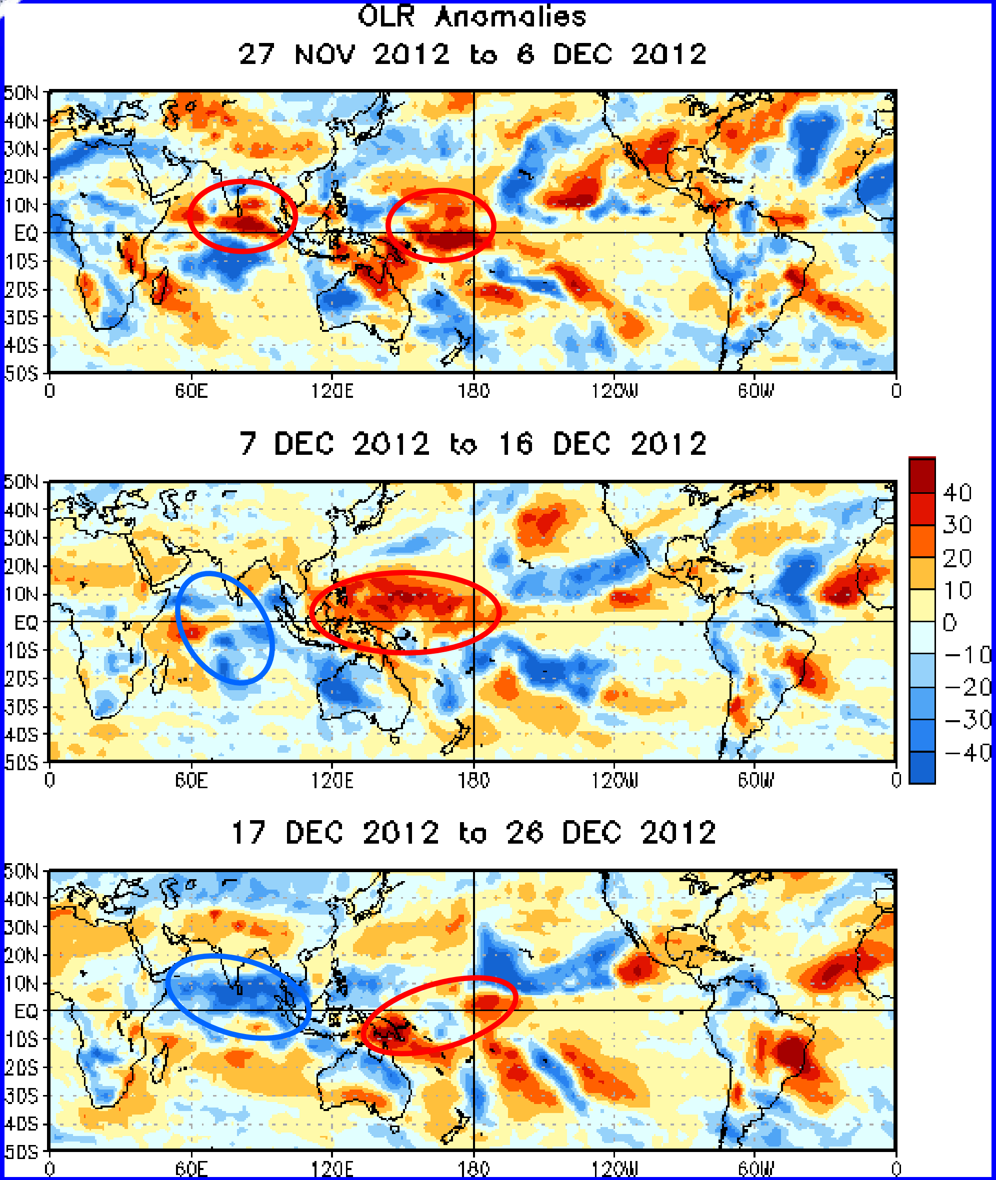


Longitude

Easterly anomalies persisted near 80E for much of August to October (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 (shaded areas, 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)

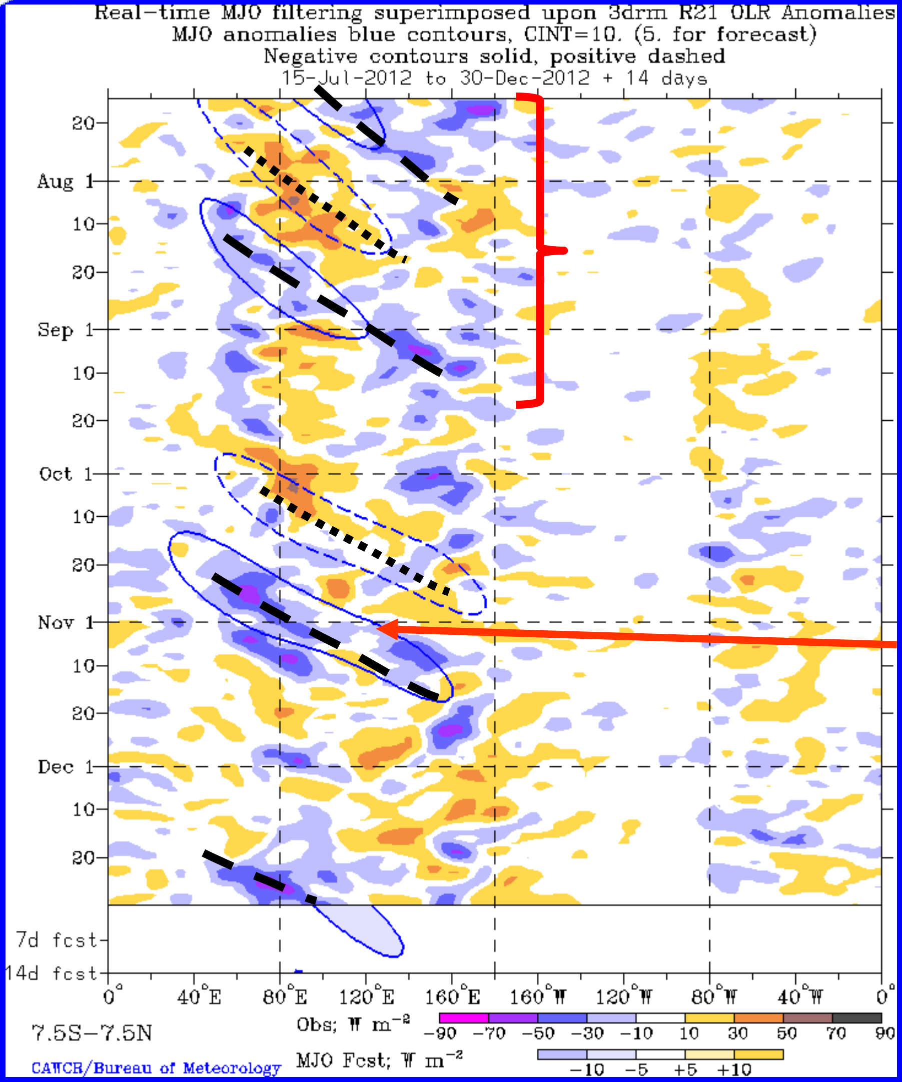
From late-November to the beginning of December, suppressed convection (red circles) was evident across the northern Indian Ocean and near the Date Line.

During early to mid-December, most of the western Pacific Ocean experienced suppressed convection, while enhanced convection over the Indian Ocean was disorganized, partly due to tropical cyclone activity.

Enhanced convection organized and strengthened over the northern Indian Ocean later in December while shifting eastward. Suppressed convection weakened in magnitude over the western and central Pacific basin.

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 July 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.

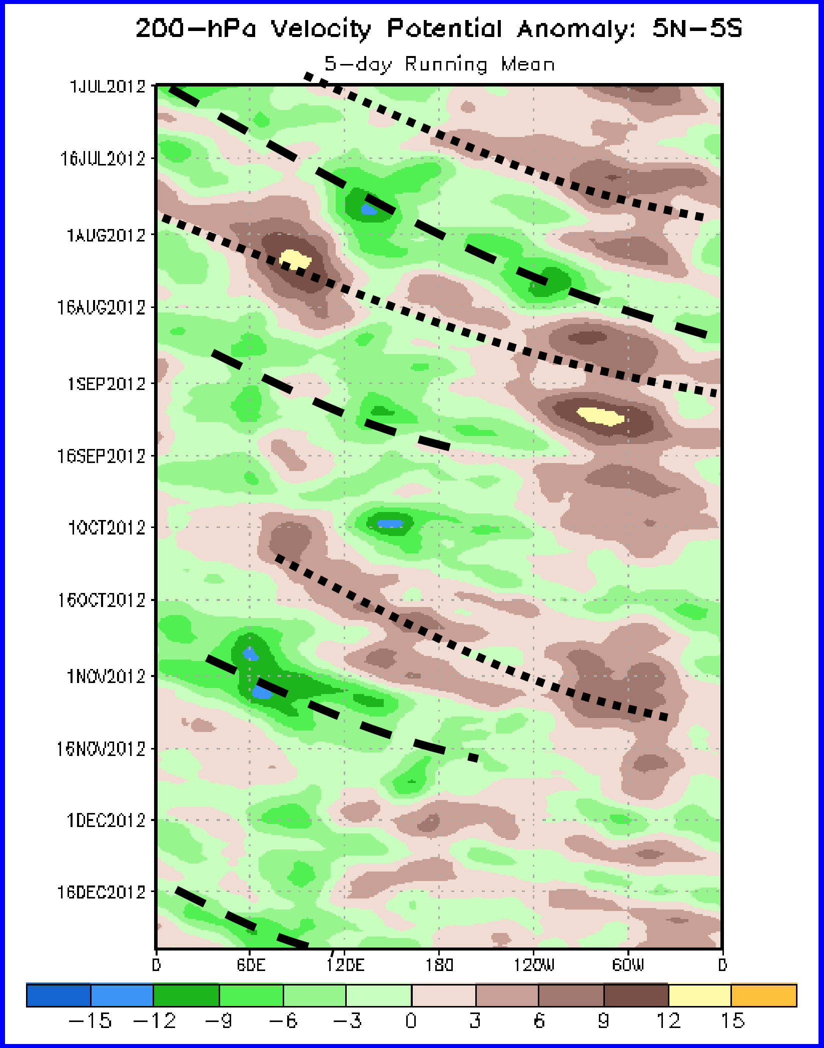
During late November and much of December, convective anomalies have been disorganized, in part a consequence of continued weak MJO activity. Suppressed convection persisted near the Date Line during early December, along with some westward propagation of these anomalies. During late-December, enhanced convection increased over the Indian Ocean, with some eastward propagation.

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.

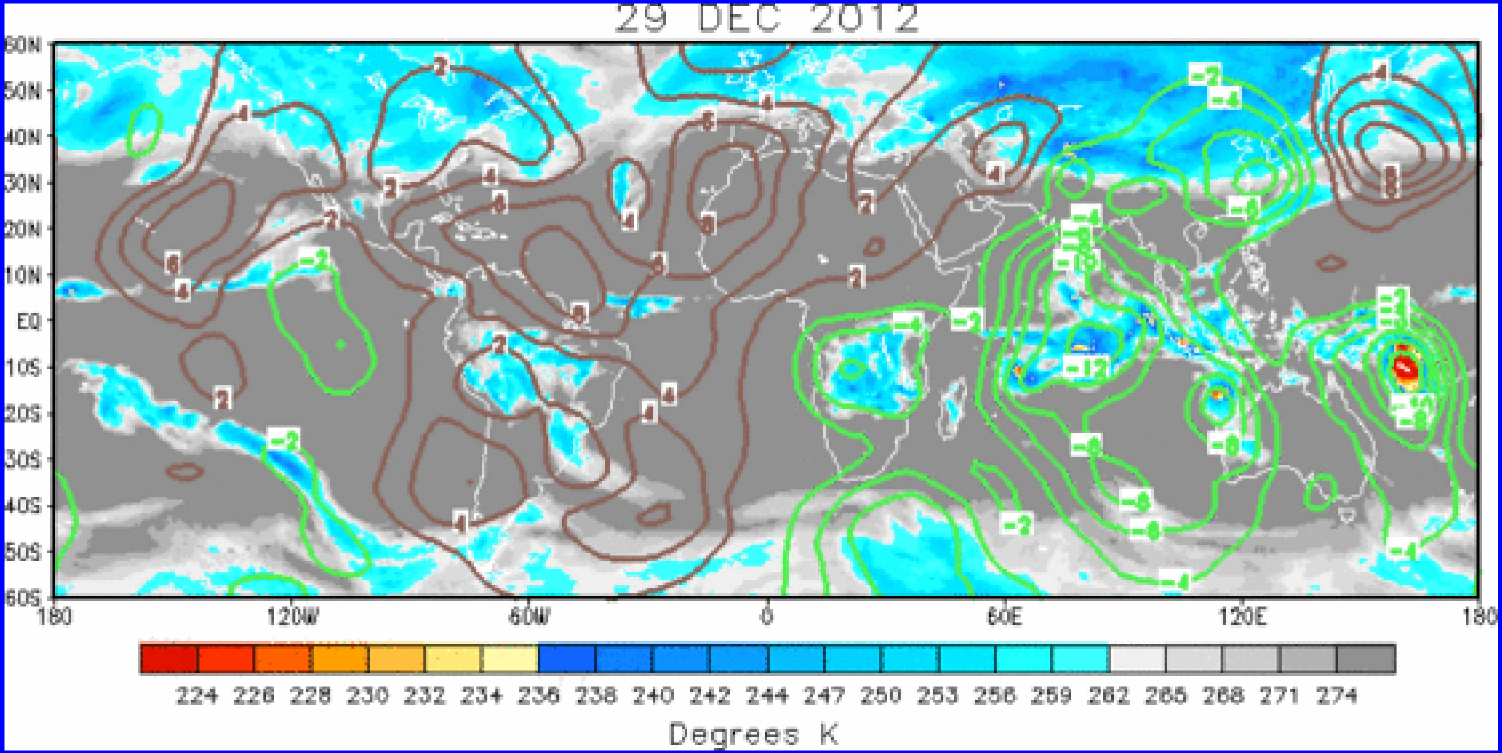
In early October, upper-level divergence (convergence) increased over the Pacific (Indian Ocean) and has shifted eastward throughout October and early November.

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. Recently, however, more robust eastward propagating upper-level divergent anomalies are evident, likely associated with MJO.

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



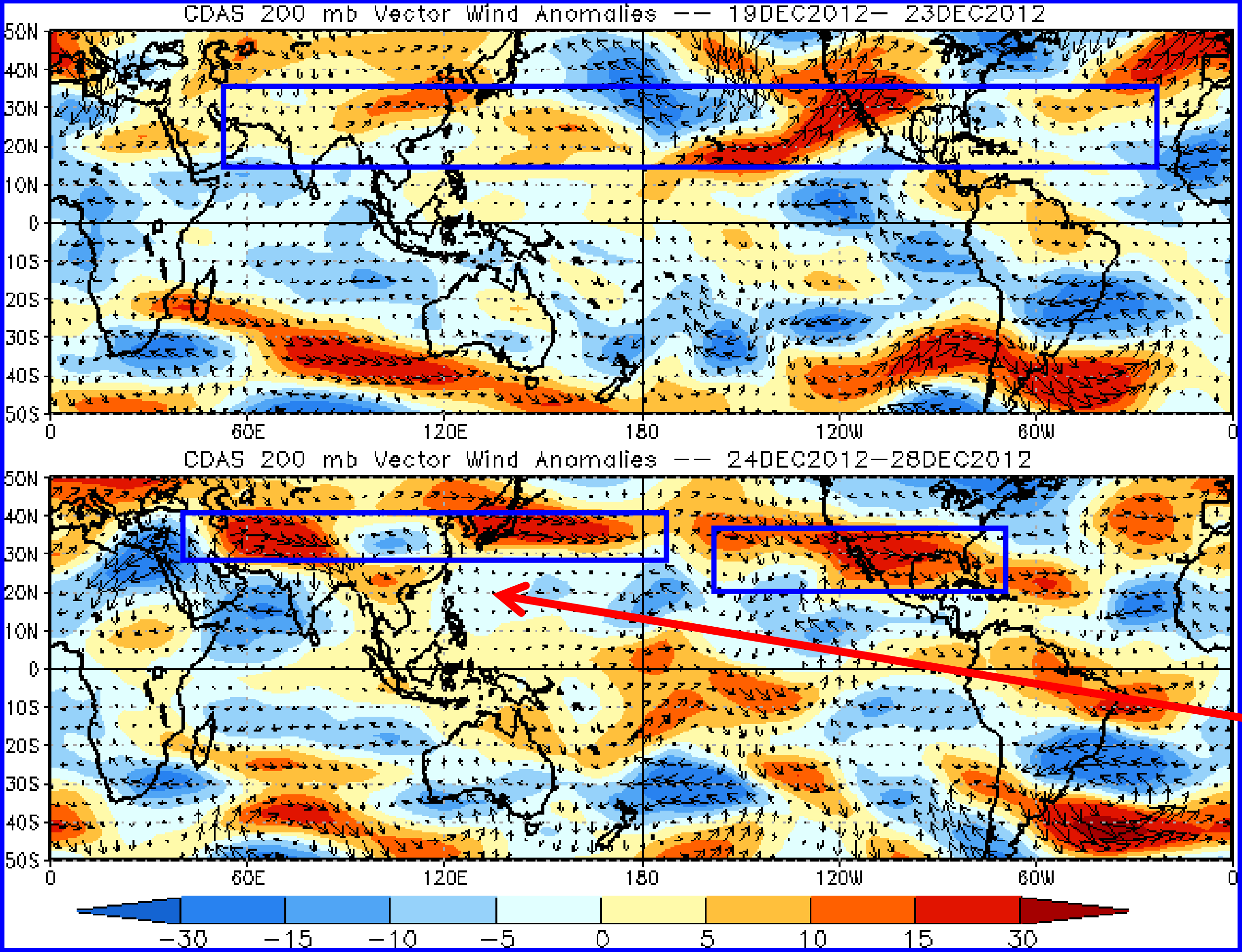
The large scale velocity potential pattern closely resembles a wave-1 structure, indicative of organized MJO activity. Upper-level convergence is strongest over the Americas, Atlantic Ocean, and Africa. Upper-level divergence is evident over parts of eastern Africa, Indian Ocean, and Maritime Continent.

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. There is noticeable mid-latitude influence near the Date Line.

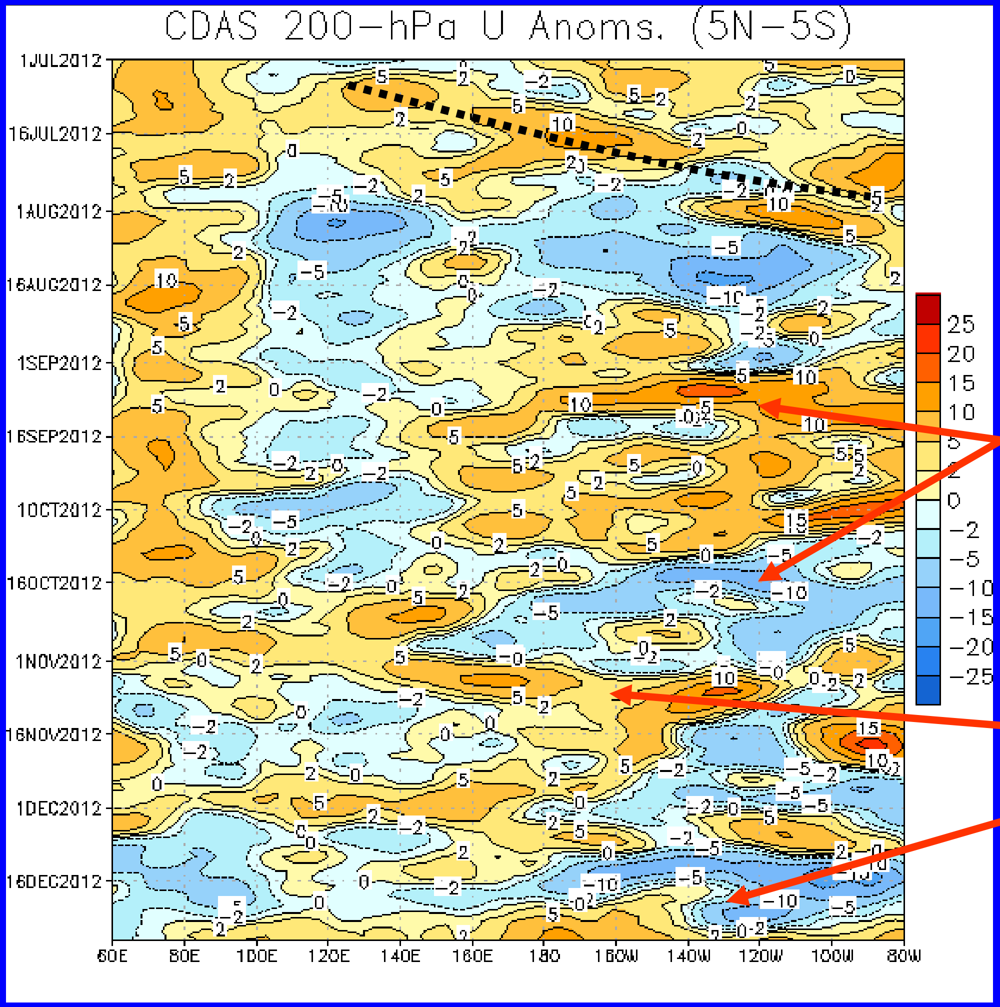
Recently, the strongest westerly anomalies appear farther north than in recent weeks.

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

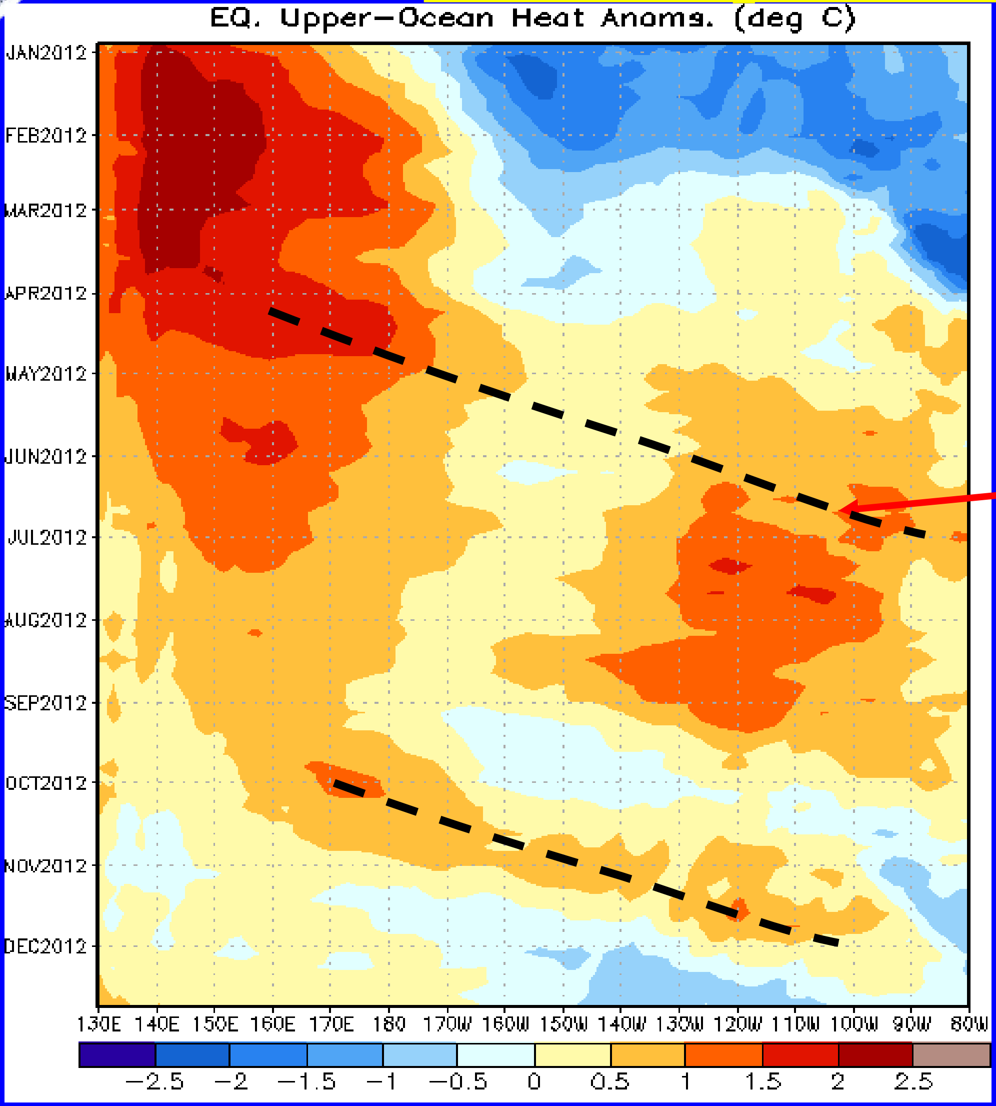
Westerly anomalies shifted eastward across the Pacific during July and early August.

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 was located over the equatorial eastern Pacific, but has now reversed.

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, negative anomalies, in the central Pacific, east of the Date Line, have increased in magnitude.

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).

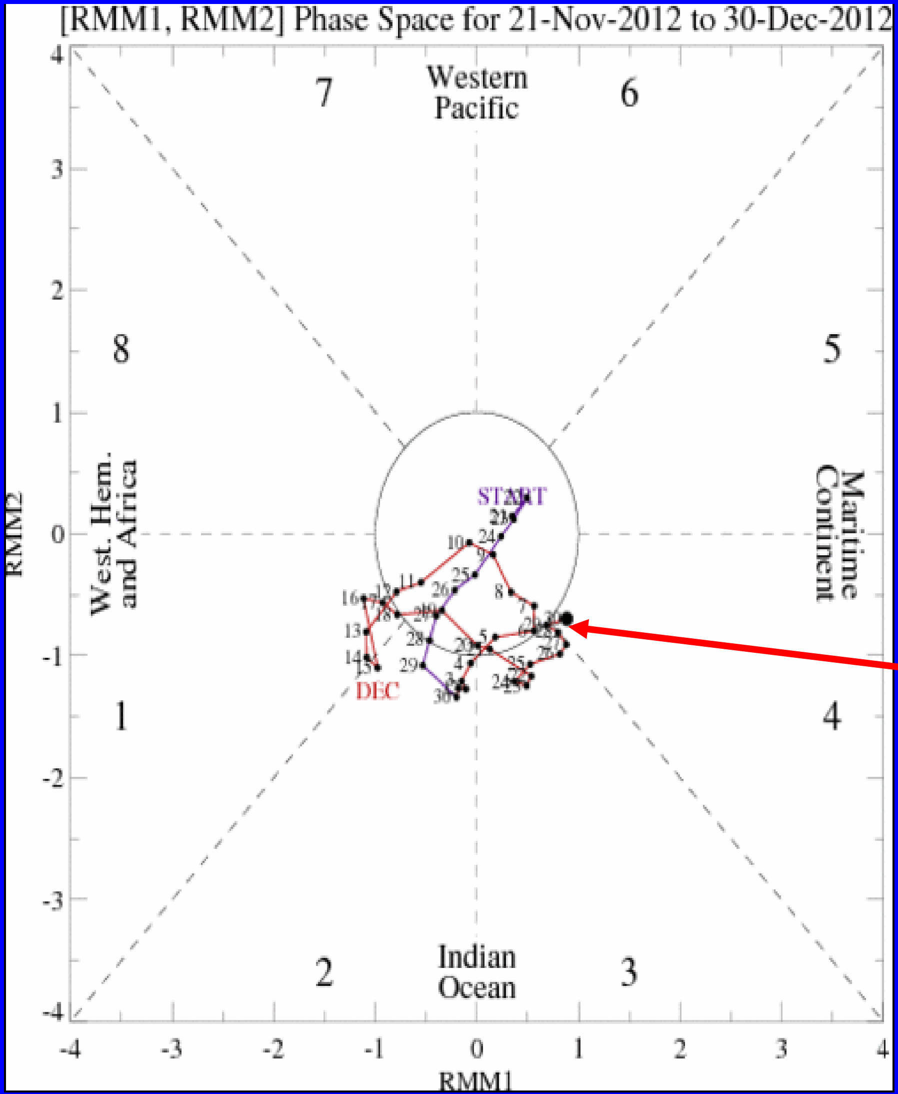
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

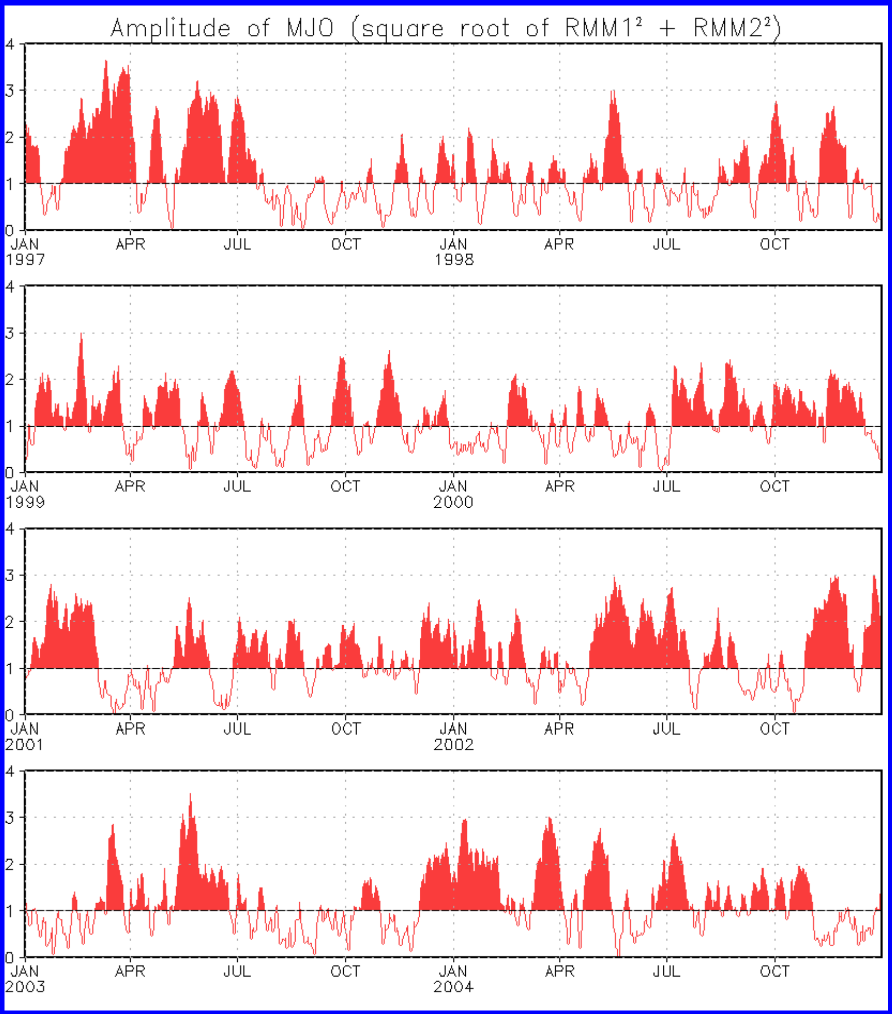
MJO Index -- Recent Evolution

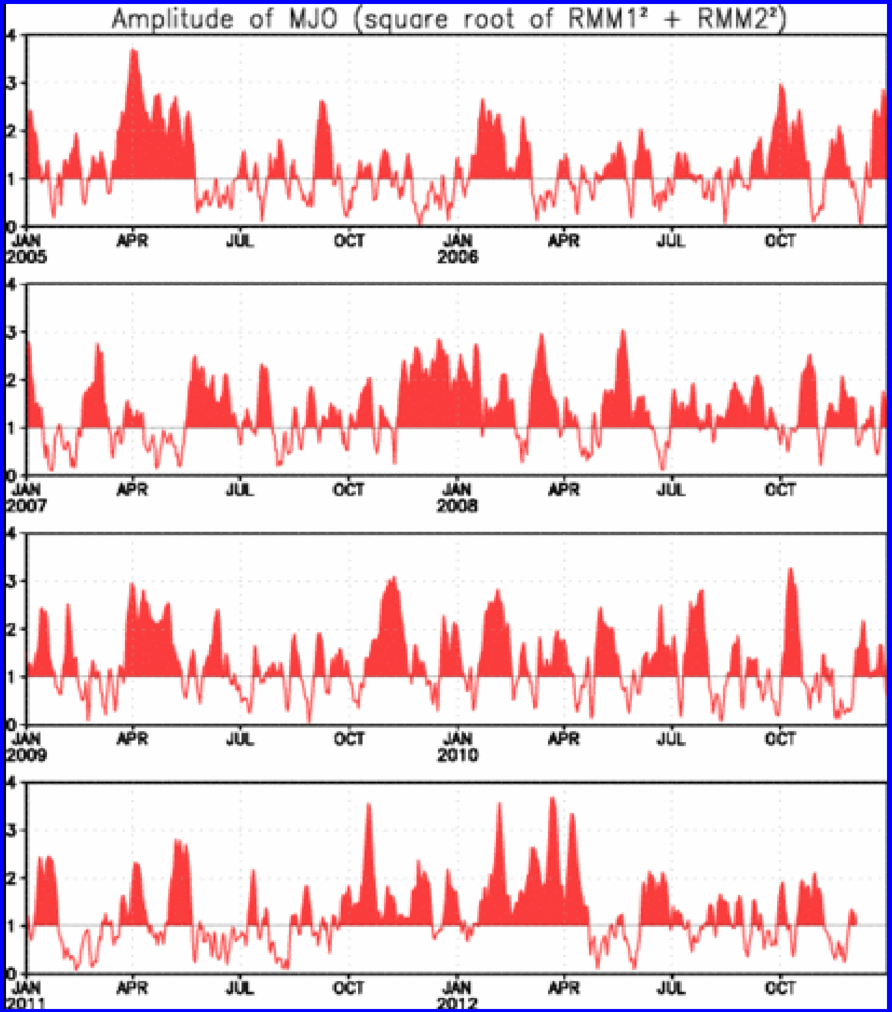


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates some eastward propagation over the past two weeks, while remaining weak in amplitude. Projection of other modes onto the index in also evident.

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.

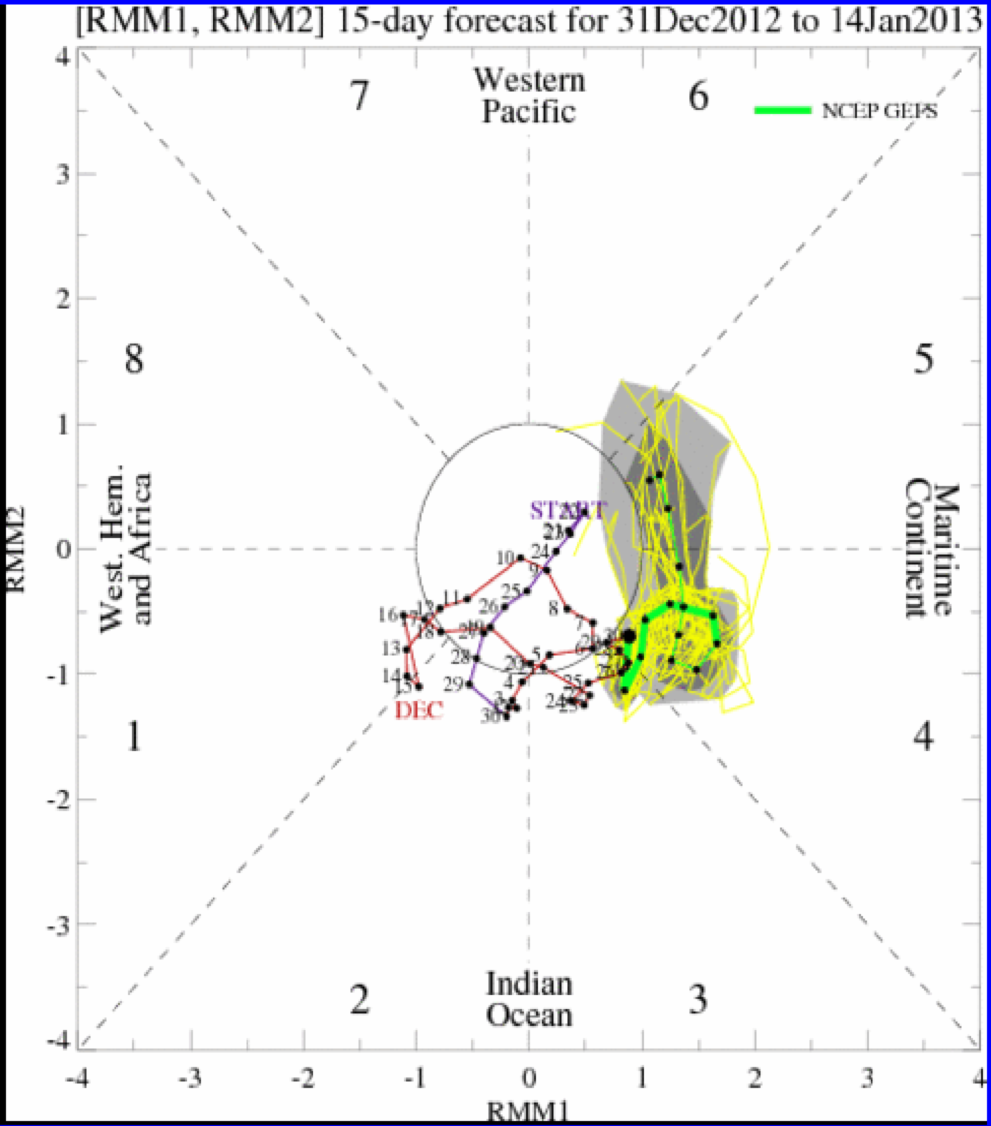
Ensemble GFS (GEFS) MJO Forecast

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 a slow strengthening of the MJO signal while propagating toward the Maritime Continent, with continued eastward propagation through Week-2.

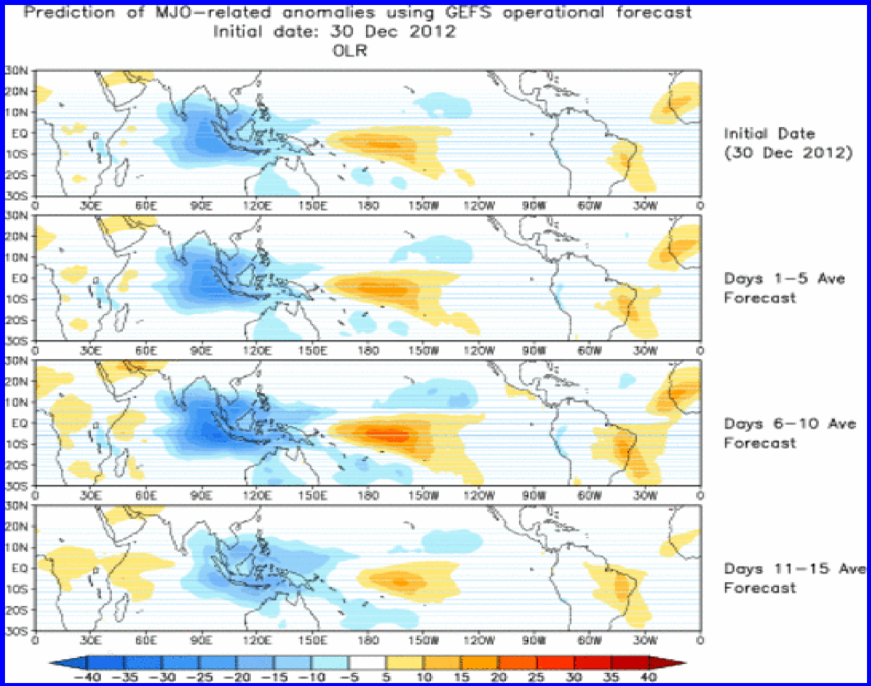


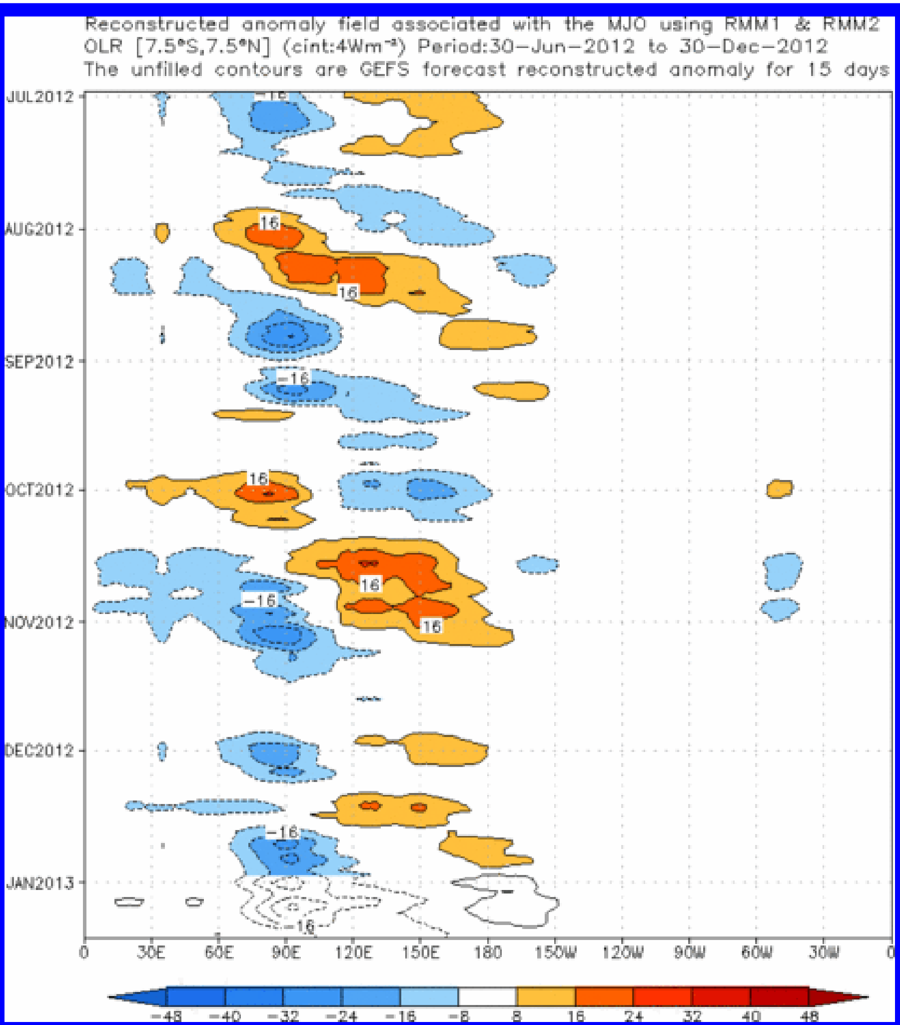
Ensemble Mean GFS MJO Forecast

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



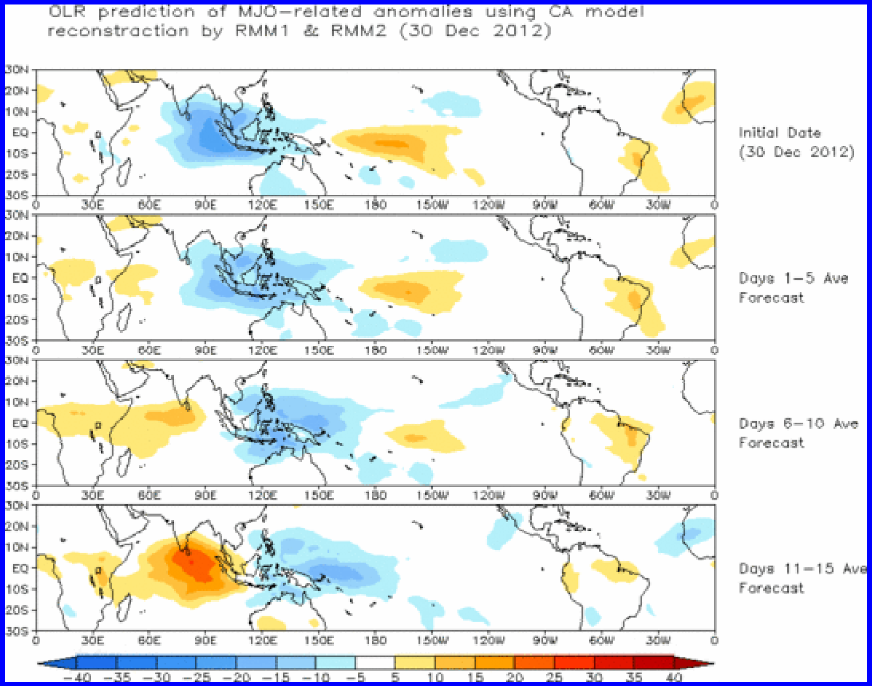


The ensemble mean GFS forecast indicates eastward propagation toward the Maritime Continent, consistent with MJO. Drier-than-average conditions are forecast for the central Pacific, parts of Africa and South America.

Constructed Analog (CA) MJO Forecast

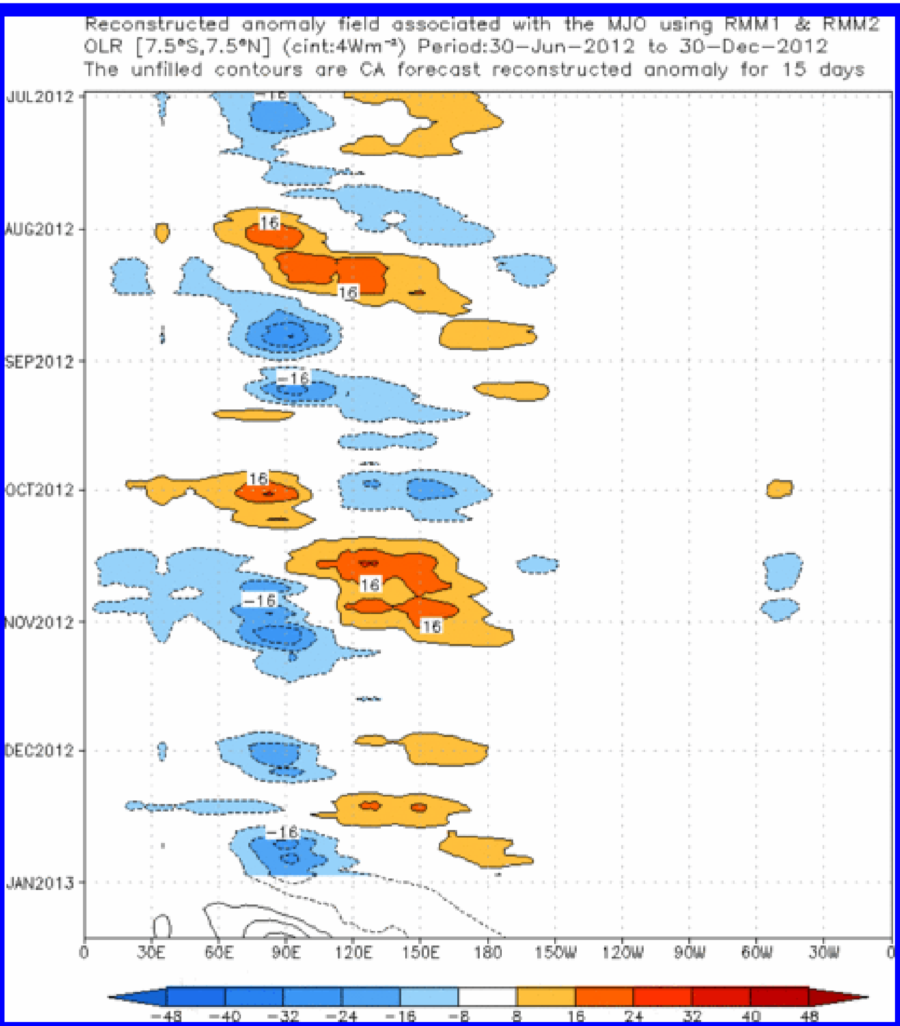
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



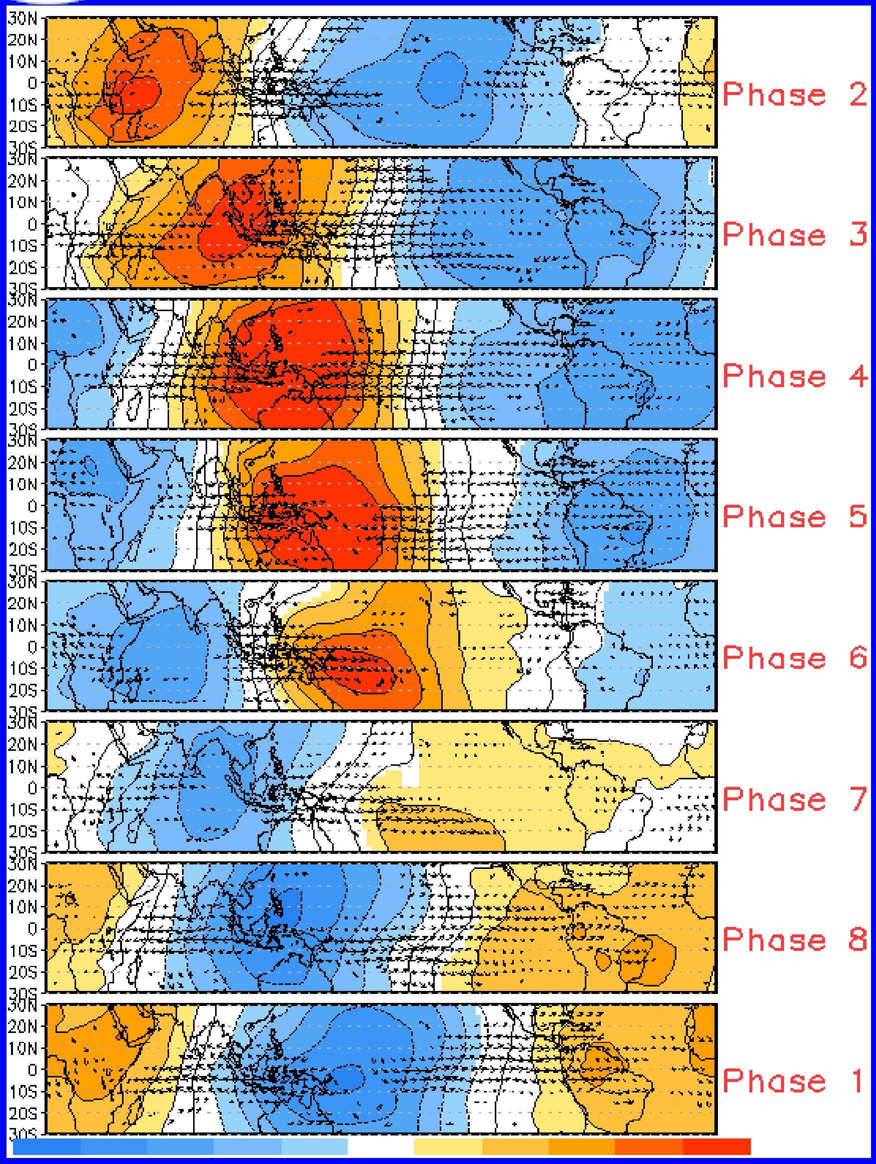
This statistical forecast indicates faster eastward propagation than the GFS based forecast, with enhanced convection moving into the western Pacific during Week-2. Suppressed convection is forecast for northeast South America. In this scenario, suppressed convection develops in the Indian Ocean late in Week-2.

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

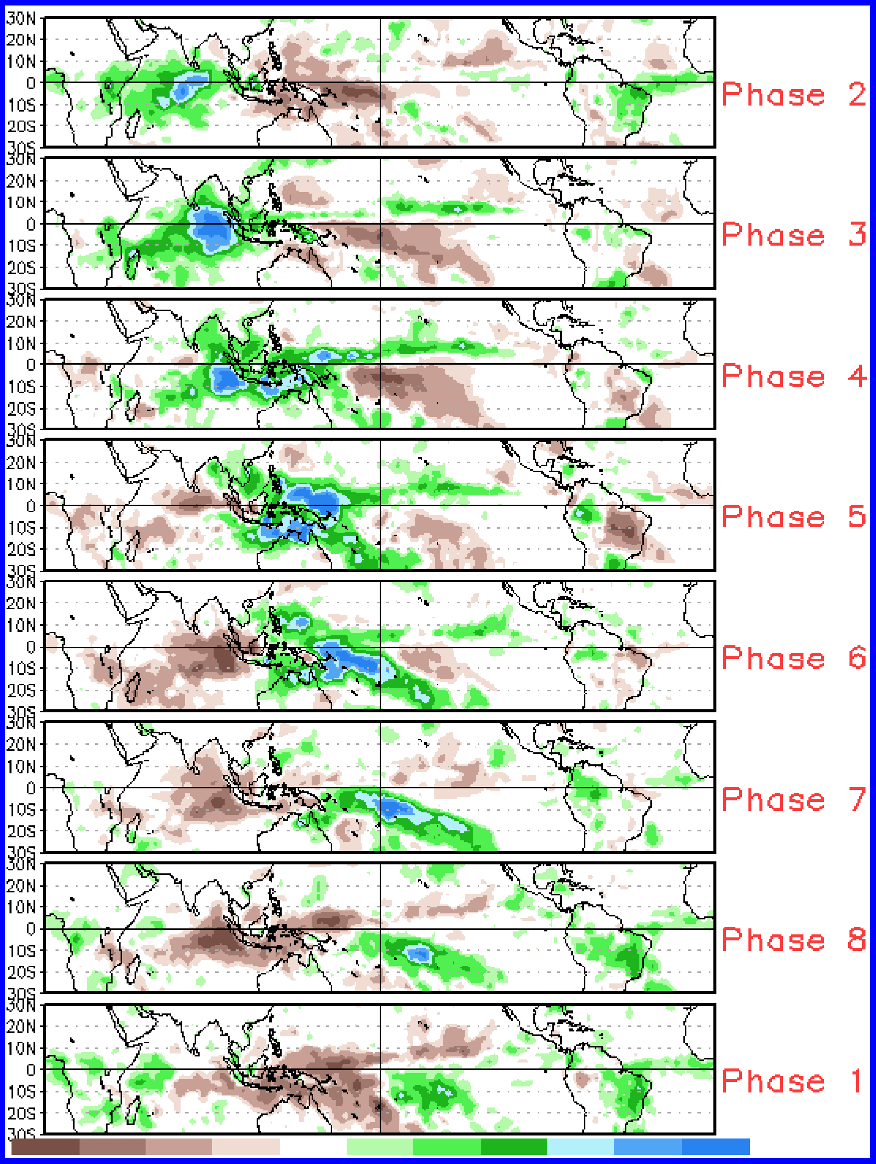


MJO Composites – Global Tropics

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

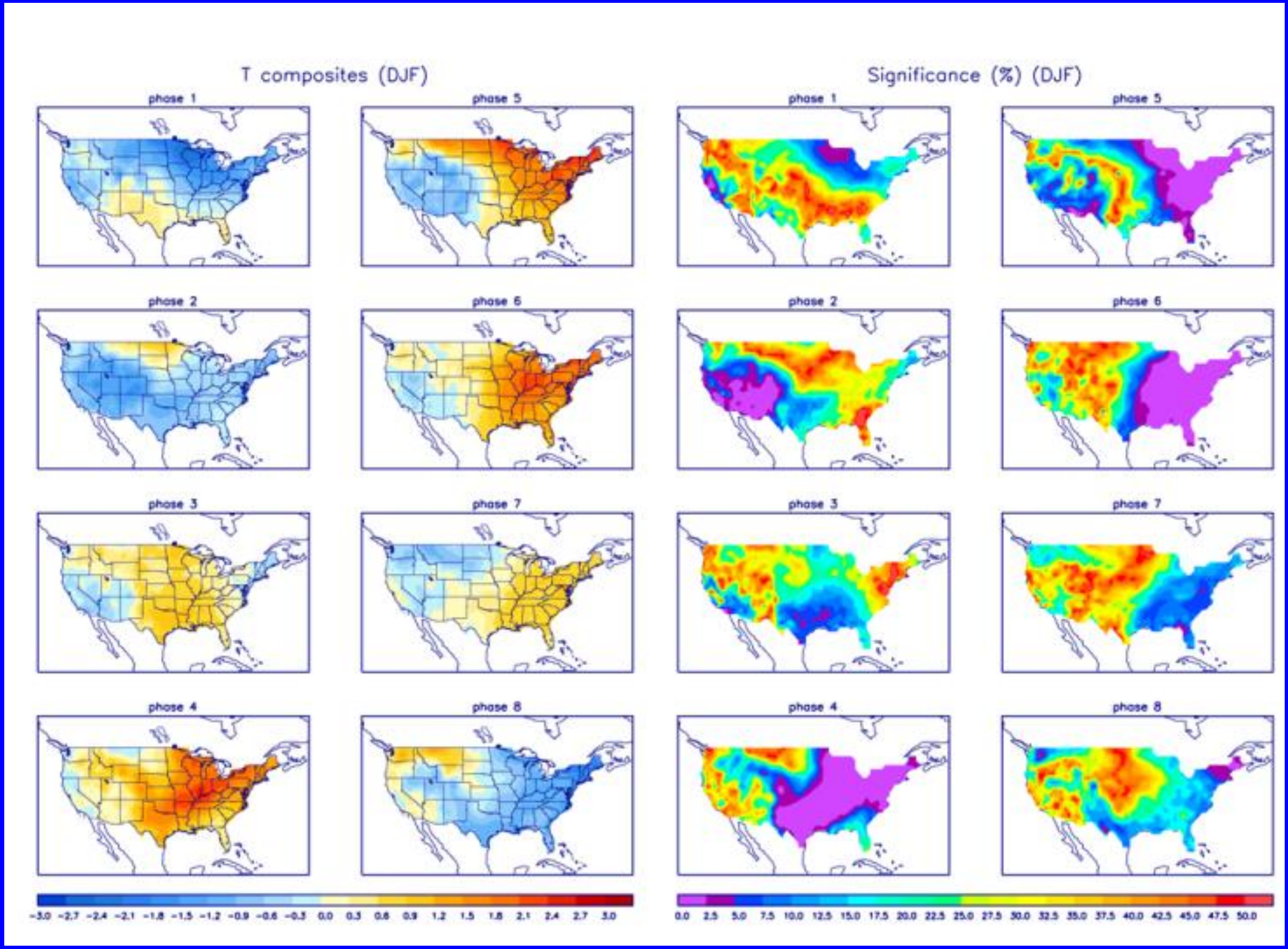


Precipitation Anomalies (Nov-Mar)



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.**



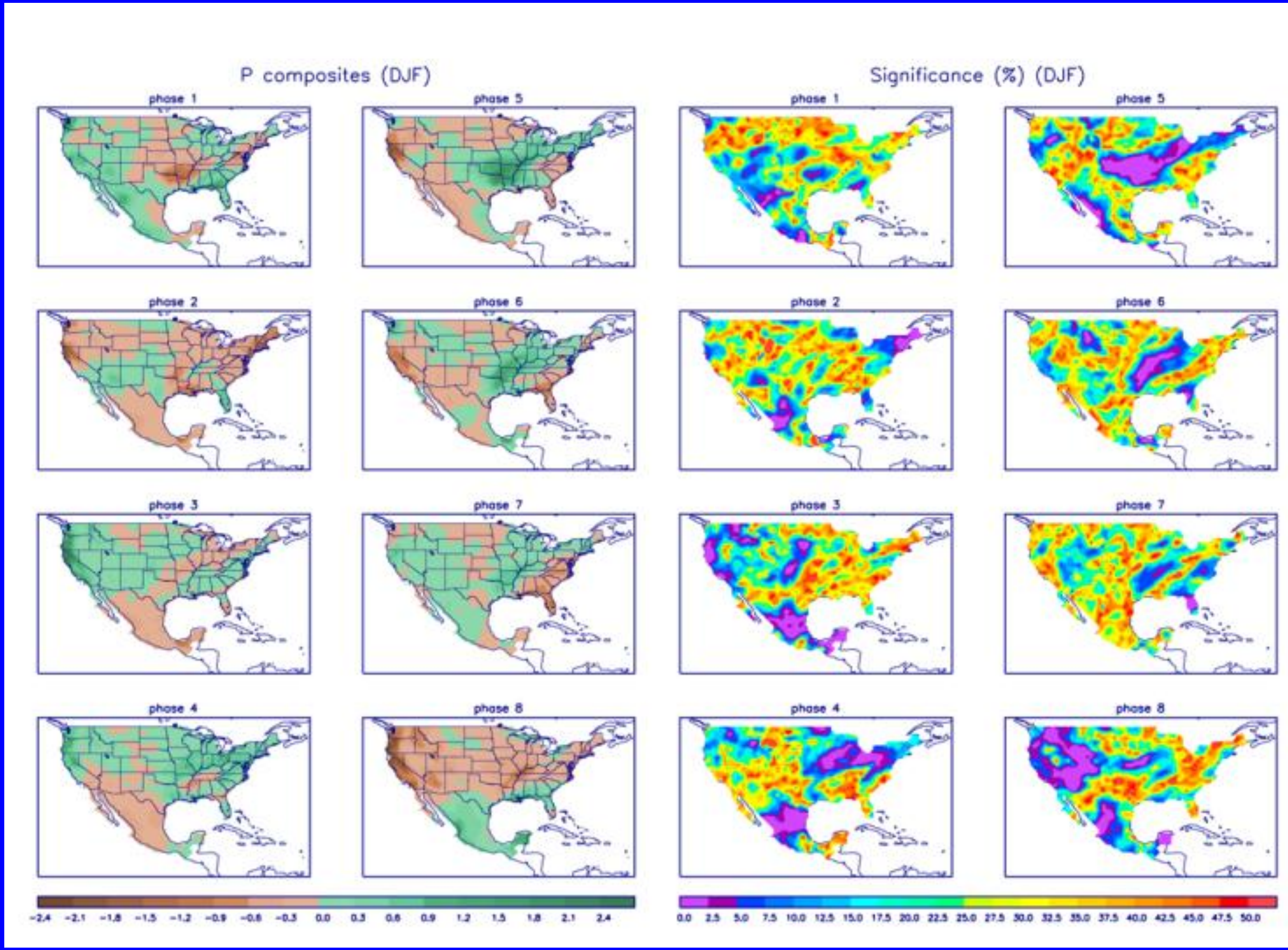
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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