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

Update prepared by
Climate Prediction Center / NCEP
February 4, 2013

Outline

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

Overview

- The MJO remained active over the past week with the enhanced convective phase now nearing Africa. Eastward propagation is now more clear than over the last two weeks.

- Although there is considerable spread in the dynamical model MJO index forecasts, some of the most skillful models historically indicate a continuation of the MJO signal into the western Indian Ocean over the next two weeks.

- Based on recent observations and some MJO index forecasts, the MJO is forecast to remain active during the next two weeks with the enhanced phase entering the western Indian Ocean.

- The MJO favors enhanced rainfall across parts of the south central Pacific Ocean (Week-1), interior South America (Week-1) and southeast Africa and the Indian Ocean (Week 2). Suppressed convection is favored for the Maritime continent and parts of the western Pacific.

- For the U.S., the MJO favors, on average, the development of a mean trough across the western U.S. during mid-February suggesting elevated chances for below normal temperatures. As we approach the end of February, the MJO would favor troughing near or along the west coast and a tendency toward a mean ridge across the eastern U.S..

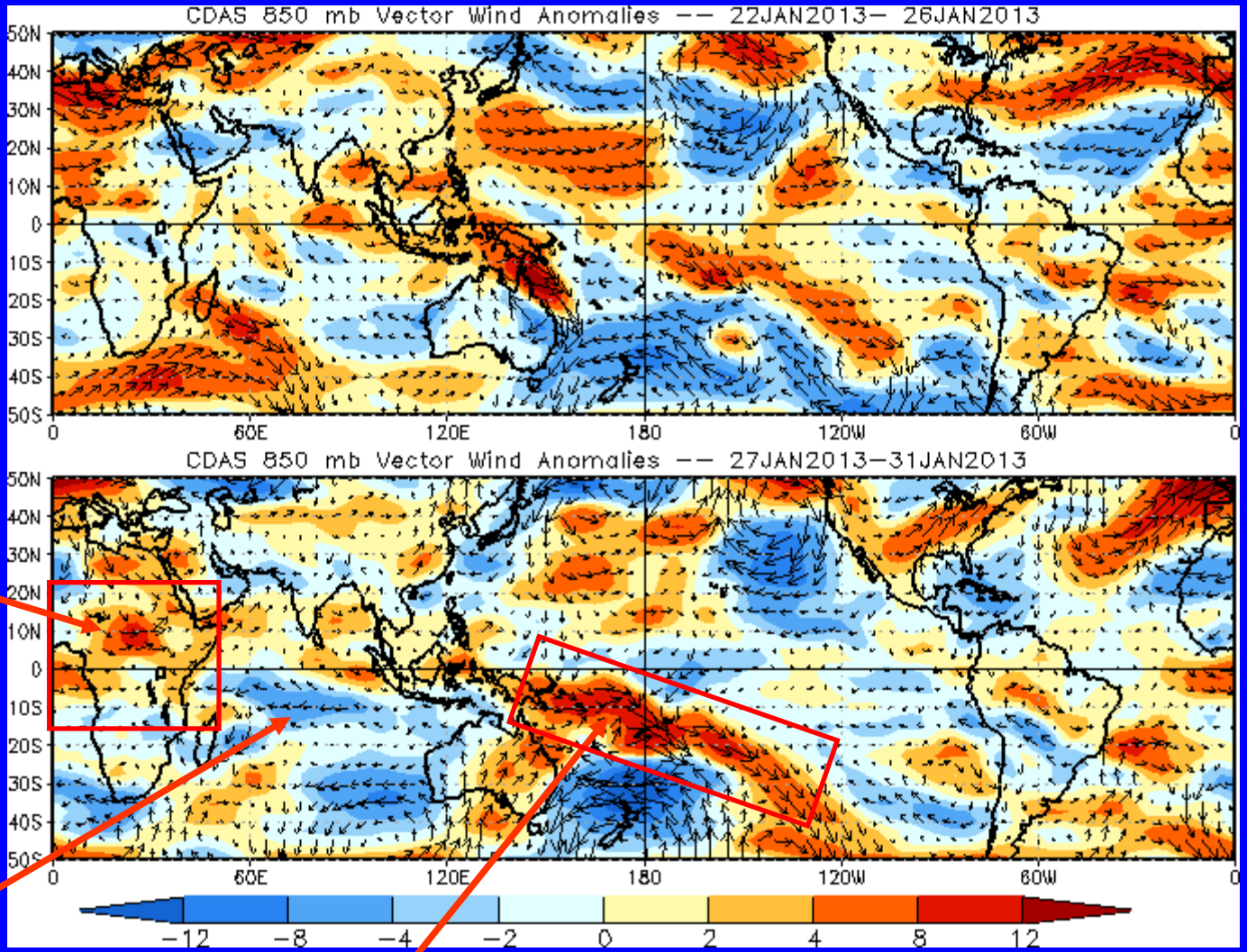
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 increased across parts of central Africa during the past five days.

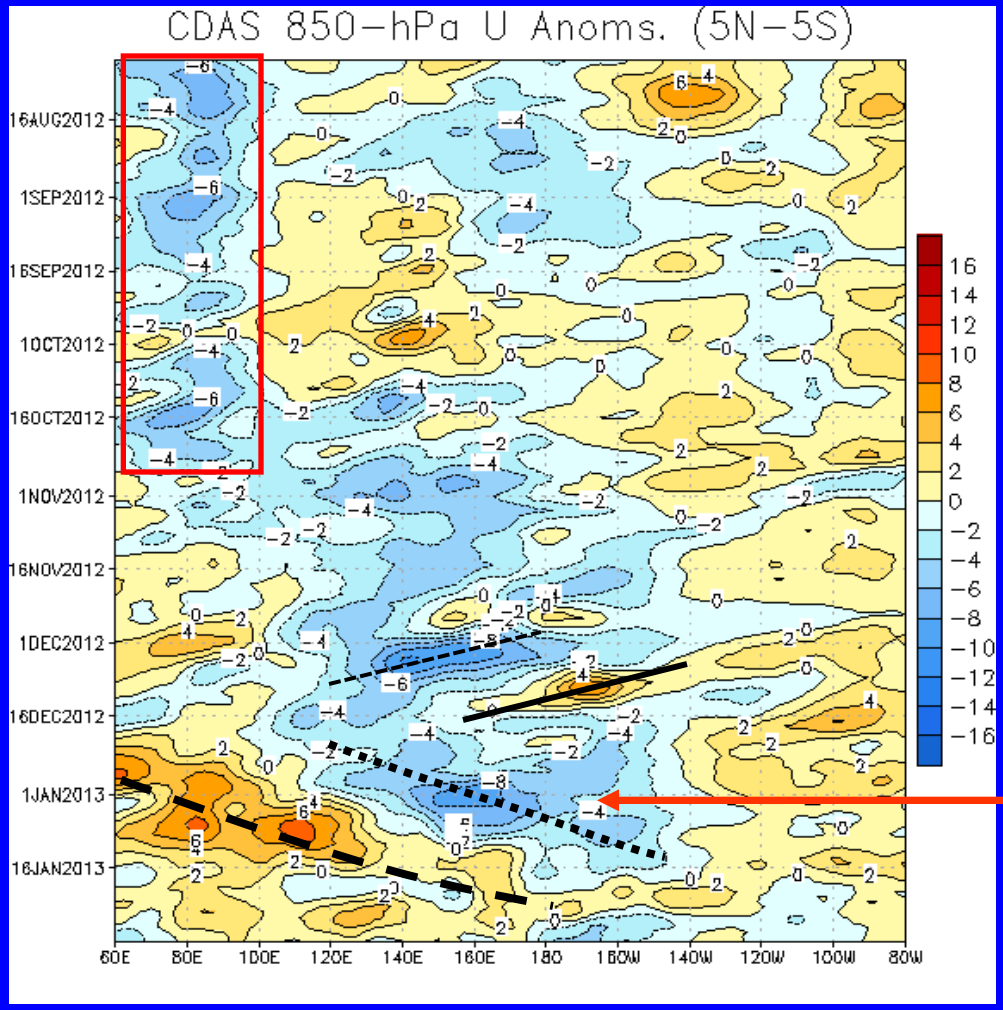
Some easterly anomalies have developed south of the equator in the Indian Ocean during the past five days.

Westerly anomalies continued across the south central 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

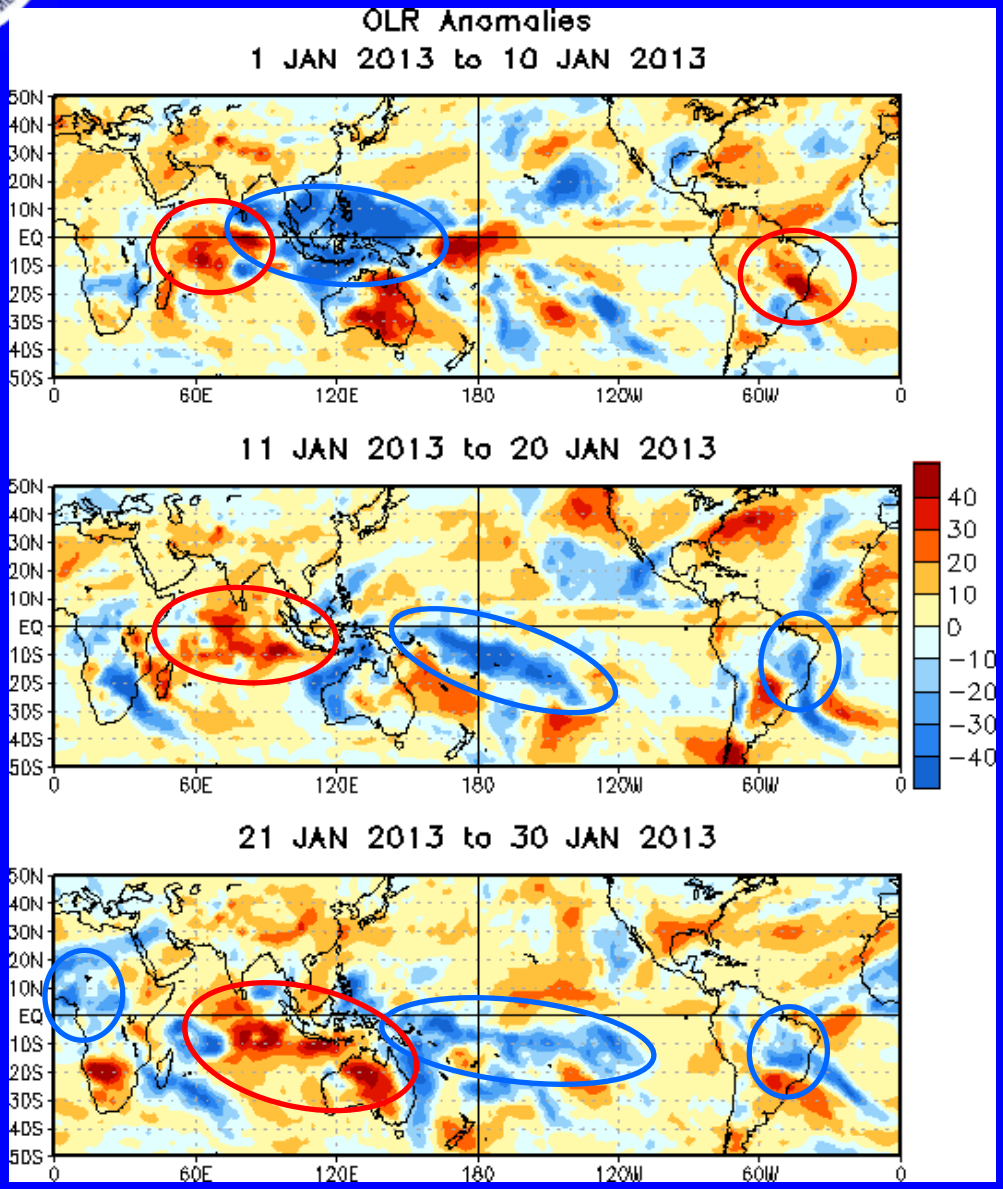
Longitude

Easterly anomalies persisted near 80E for much of August to October (red box).

Westward propagation (dashed/solid lines sloping down and to the left) during much of November and early December are primarily due to equatorial Rossby wave activity as the MJO was generally weak throughout much of this period.

During January, there was a substantial increase and eastward propagation of anomalies (dashed and dotted lines) in association with strengthening of the MJO.

OLR Anomalies – Past 30 days



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

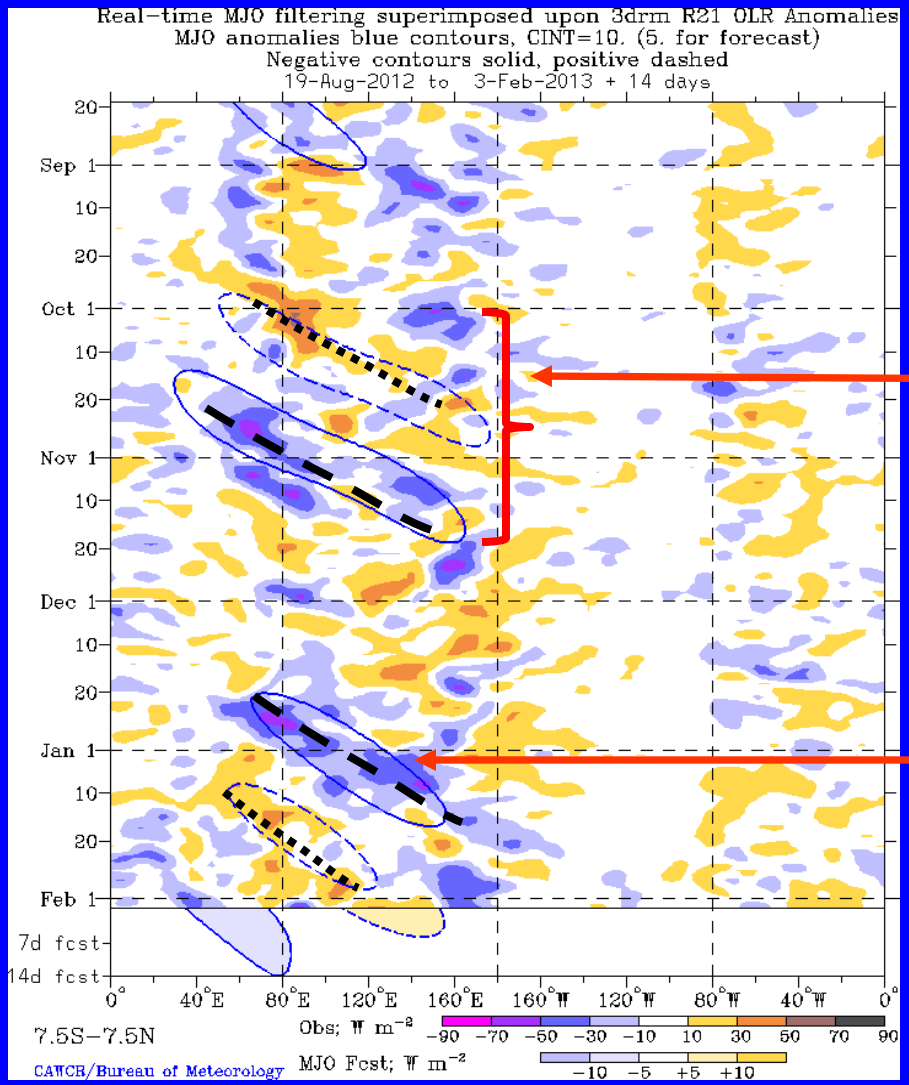
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During early January, enhanced convection remained centered across the Maritime Continent while suppressed convection remained across parts of South America and developed over the Indian Ocean.

Enhanced convection shifted eastward to the SPCZ and east of the Date Line during mid-January and began to increase across parts of Africa and South America. Suppressed convection increased in coverage over the Indian Ocean.

During late January, enhanced convection continued across the south Pacific, northeast Brazil and parts of Africa. Suppressed convection began to shift eastward to include Australia.

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 (alternating dashed and dotted lines) 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.

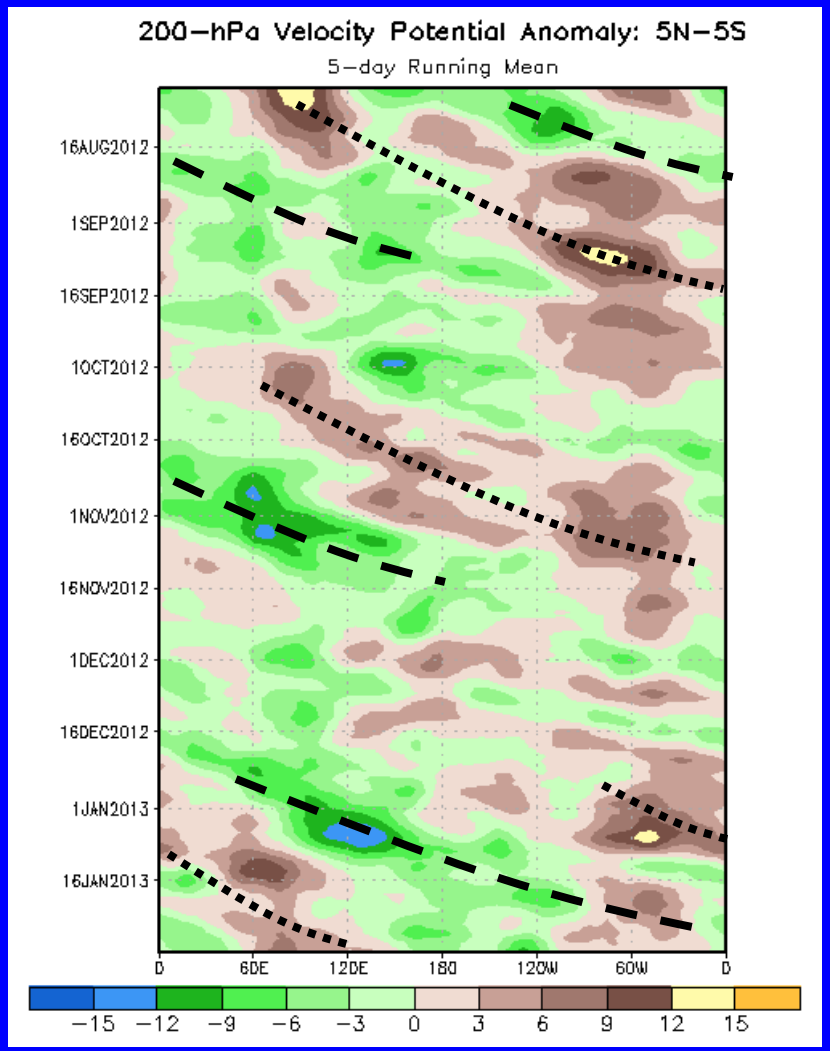
During late November and much of December, convective anomalies were disorganized.

Enhanced convection developed across the Indian Ocean in late December and shifted eastward into January 2013 as the MJO strengthened. Suppressed convection followed in the Indian Ocean during January, but anomalies have become less organized over the last couple of weeks.

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



Eastward propagation was evident from August into September associated with the MJO (alternating dashed and dotted lines).

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 shifted eastward until early November.

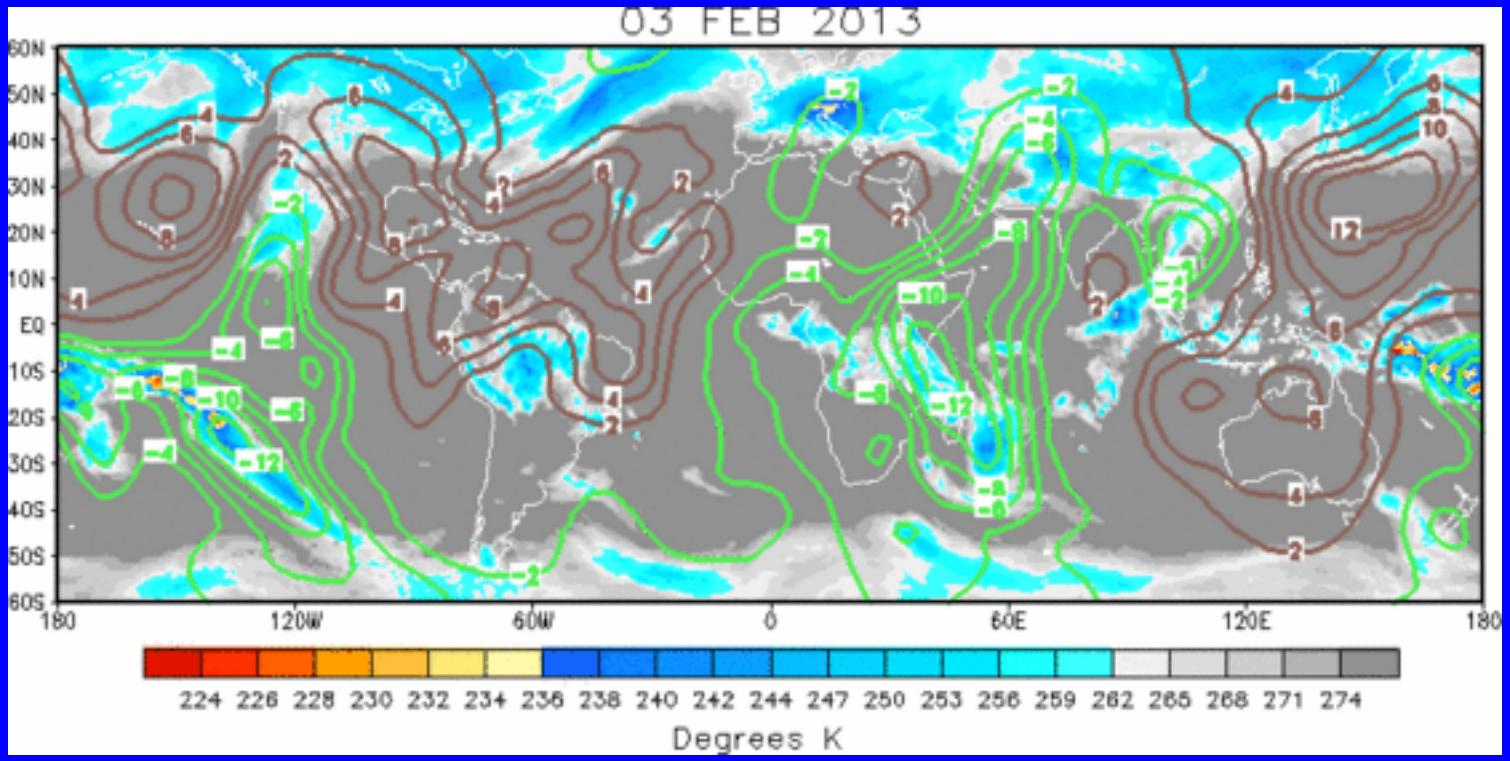
During most of December, anomalies were weak with less coherent eastward propagation. Other subseasonal variability was more prevalent during this period.

As the MJO strengthened in late December, anomalies increased in magnitude with more robust eastward propagation indicated during late 2012 and early 2013.

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

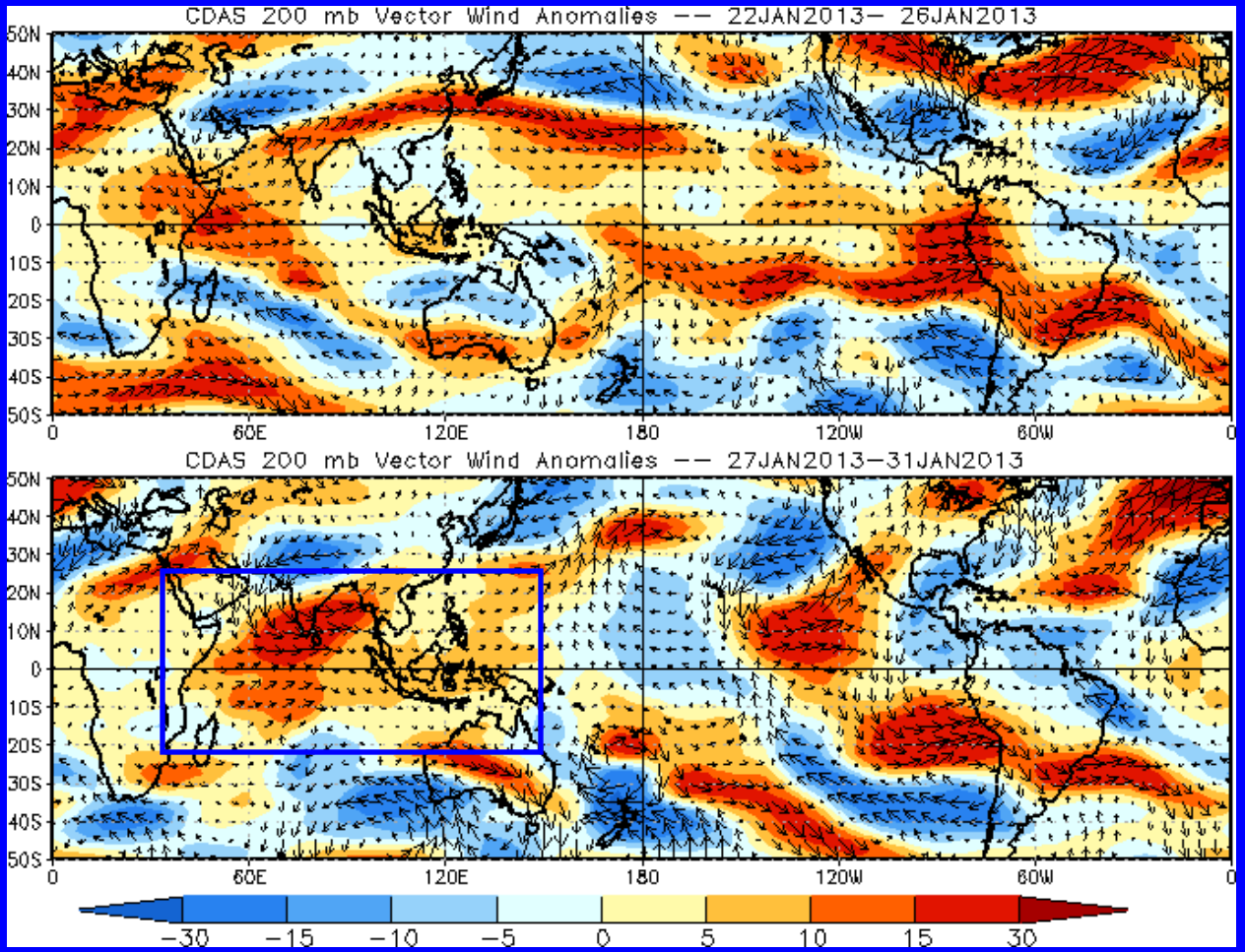
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The large scale velocity potential pattern remained less coherent than that displayed during mid-January and exhibits a 'Wave 2' pattern. Upper-level divergence is strongest over parts of the Pacific and Africa, while upper-level convergence is evident over northern South America and parts of the Indian and western Pacific Oceans.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

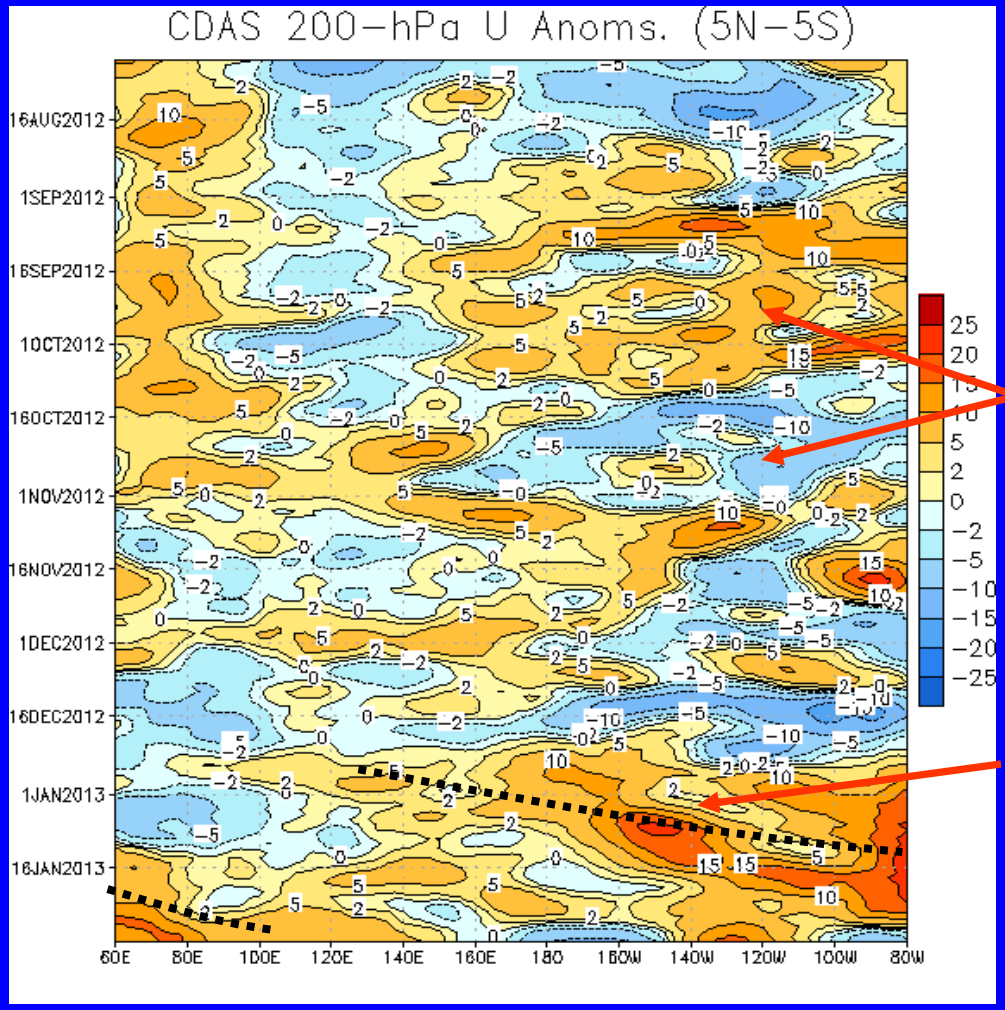
Red shades: Westerly anomalies

Westerly anomalies (blue box) continued to slowly shift eastward and encompass the Indian Ocean and now parts of the Maritime continent during the past five days.

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



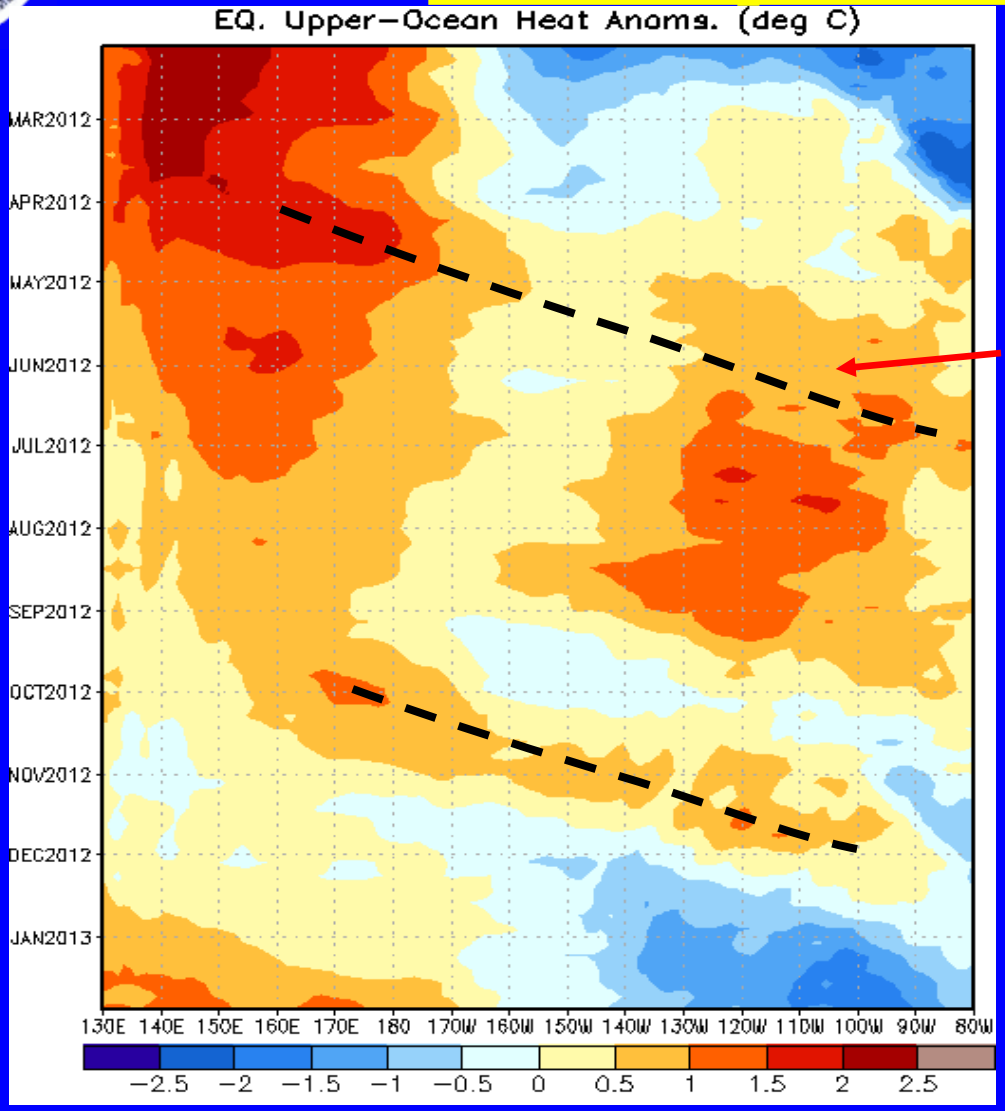
Time

Longitude

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

Eastward propagation of westerly wind anomalies is evident beginning in late December and continuing into January 2013 associated with the MJO.

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 the 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 and eastern 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).

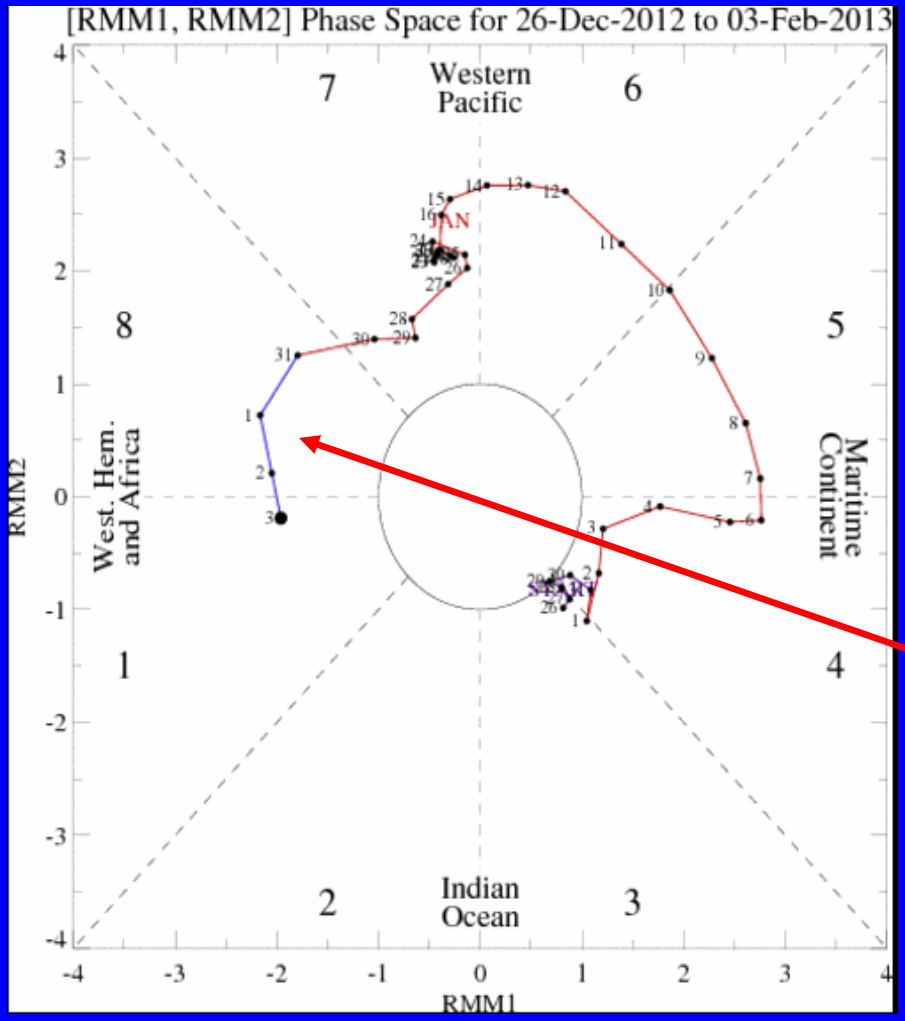
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

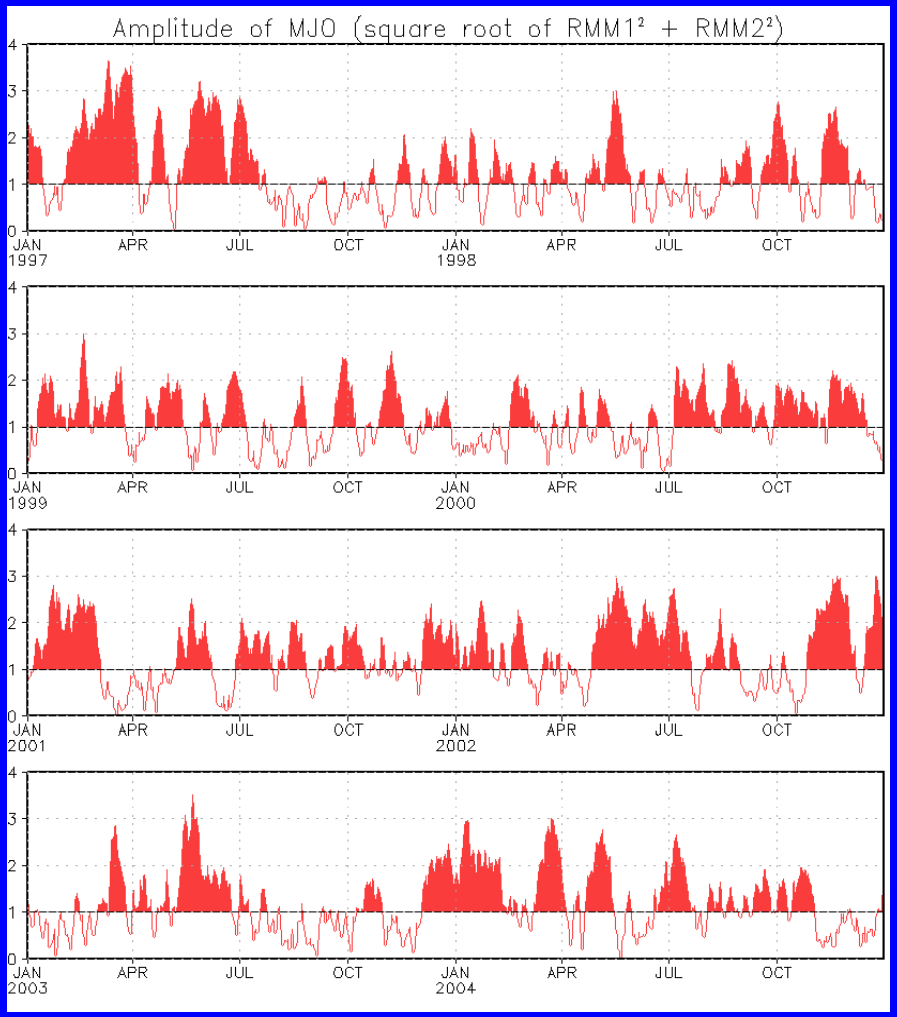
MJO Index -- Recent Evolution

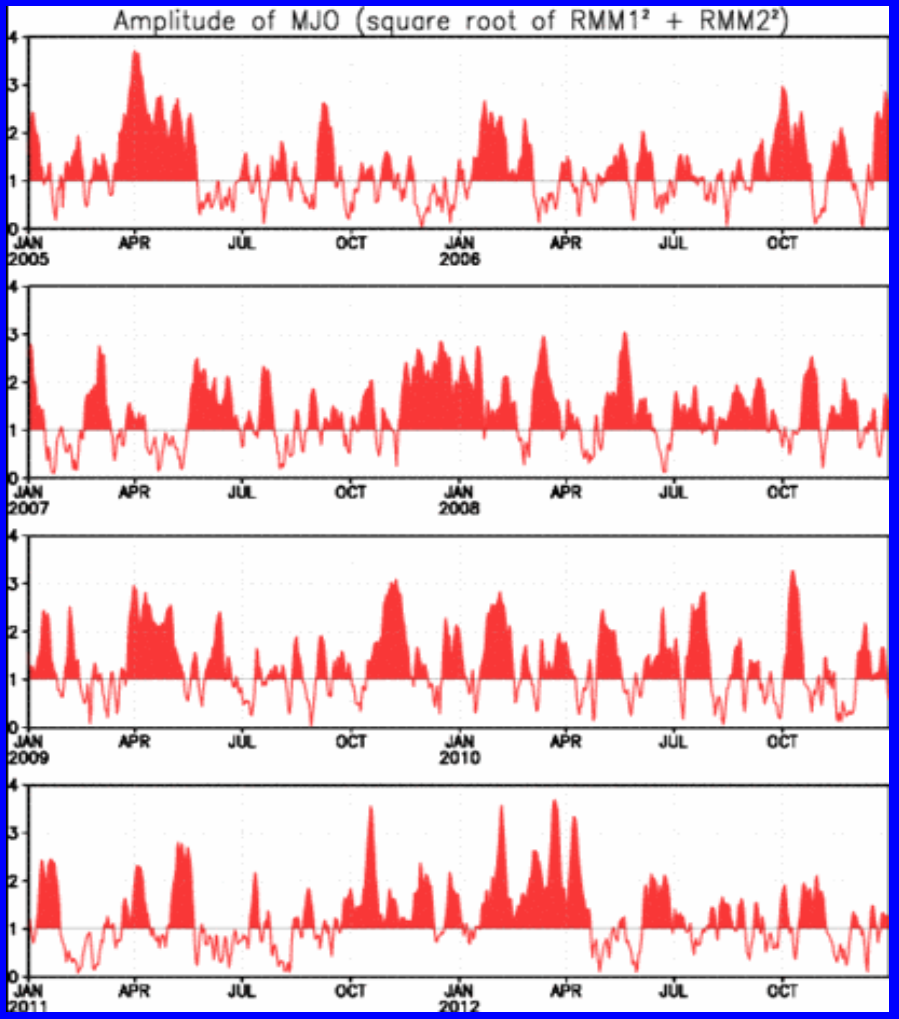


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates renewed eastward propagation during the past week, with the enhanced convective phase nearing Africa.

MJO Index – Historical Daily Time Series





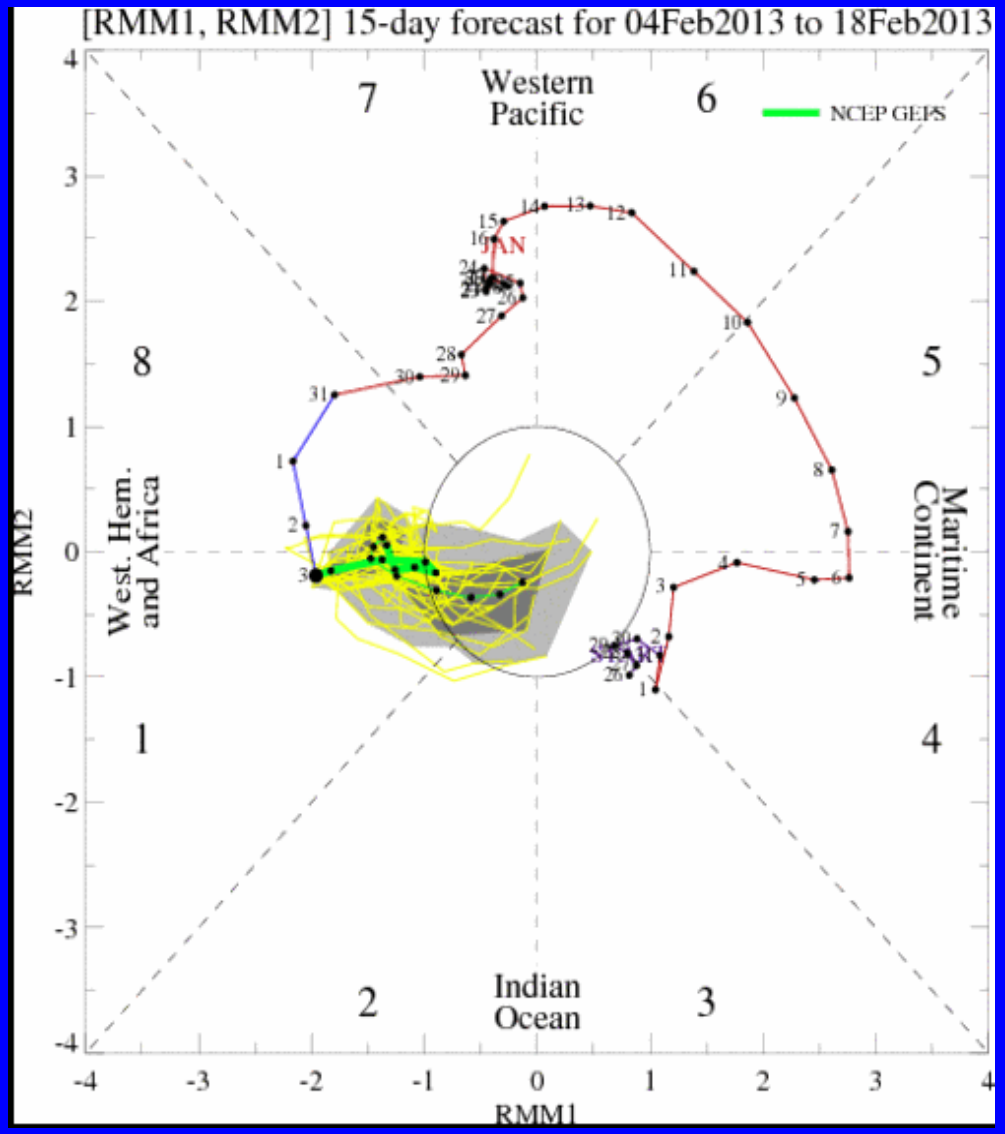
Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

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



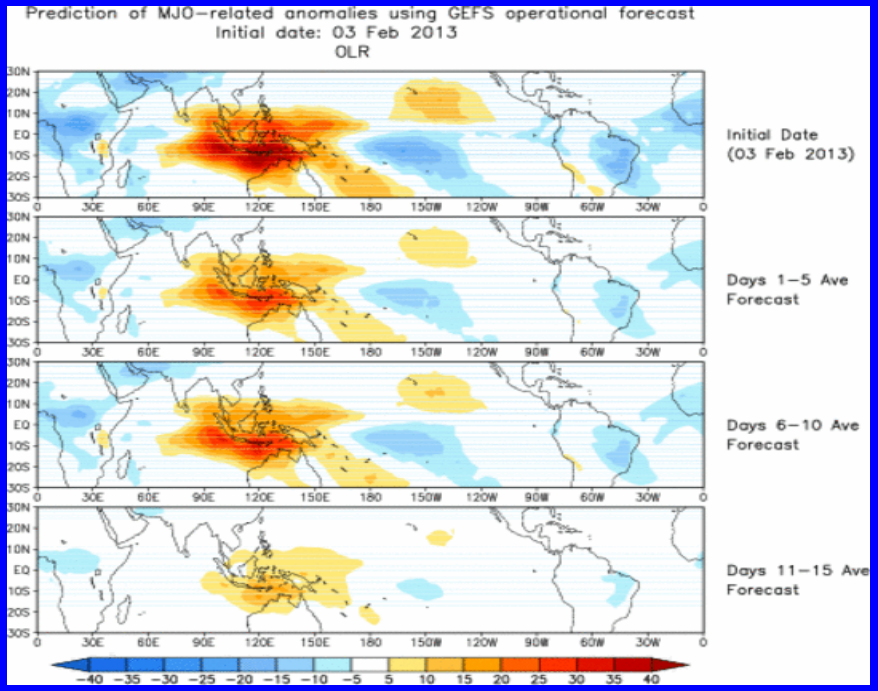
The bias-corrected ensemble GFS forecasts indicate a weakening MJO signal as both amplitude decreases and eastward propagation ceases.

Other model forecasts, however, predict a more robust MJO signal continuing over the next two weeks and entering the western Indian Ocean during Week-2.

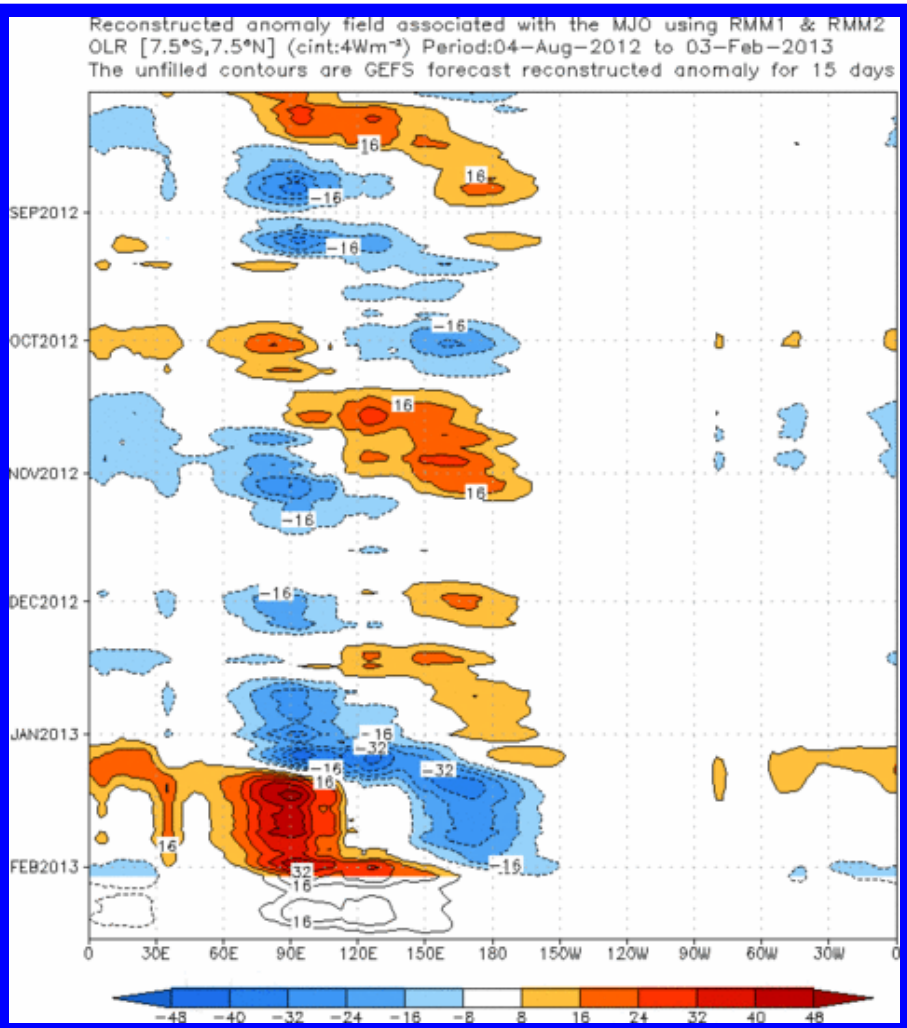
Ensemble Mean GFS MJO Forecast

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

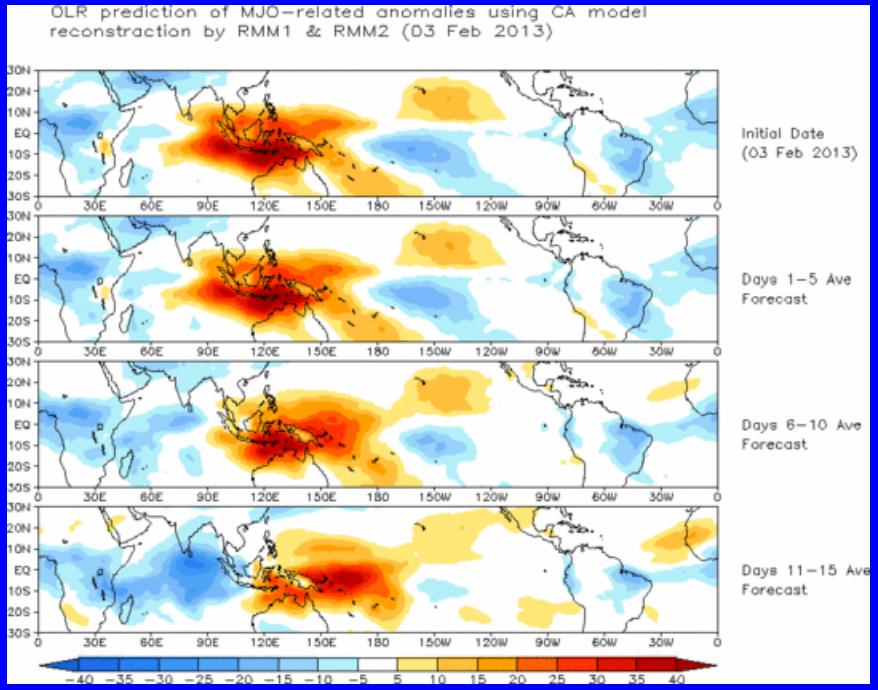


The ensemble mean GFS forecast indicates little change in anomalous tropical convection during the period, although a weakening is shown by the end of Week-2.

Constructed Analog (CA) MJO Forecast

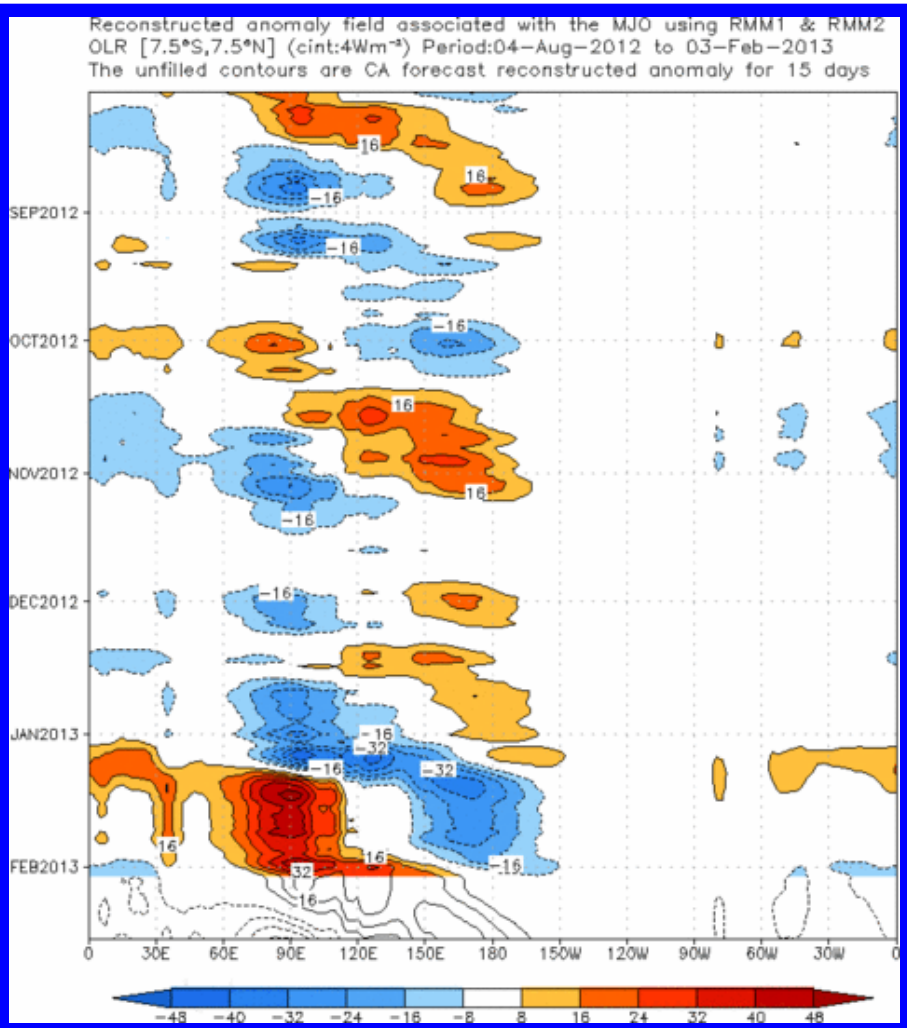
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



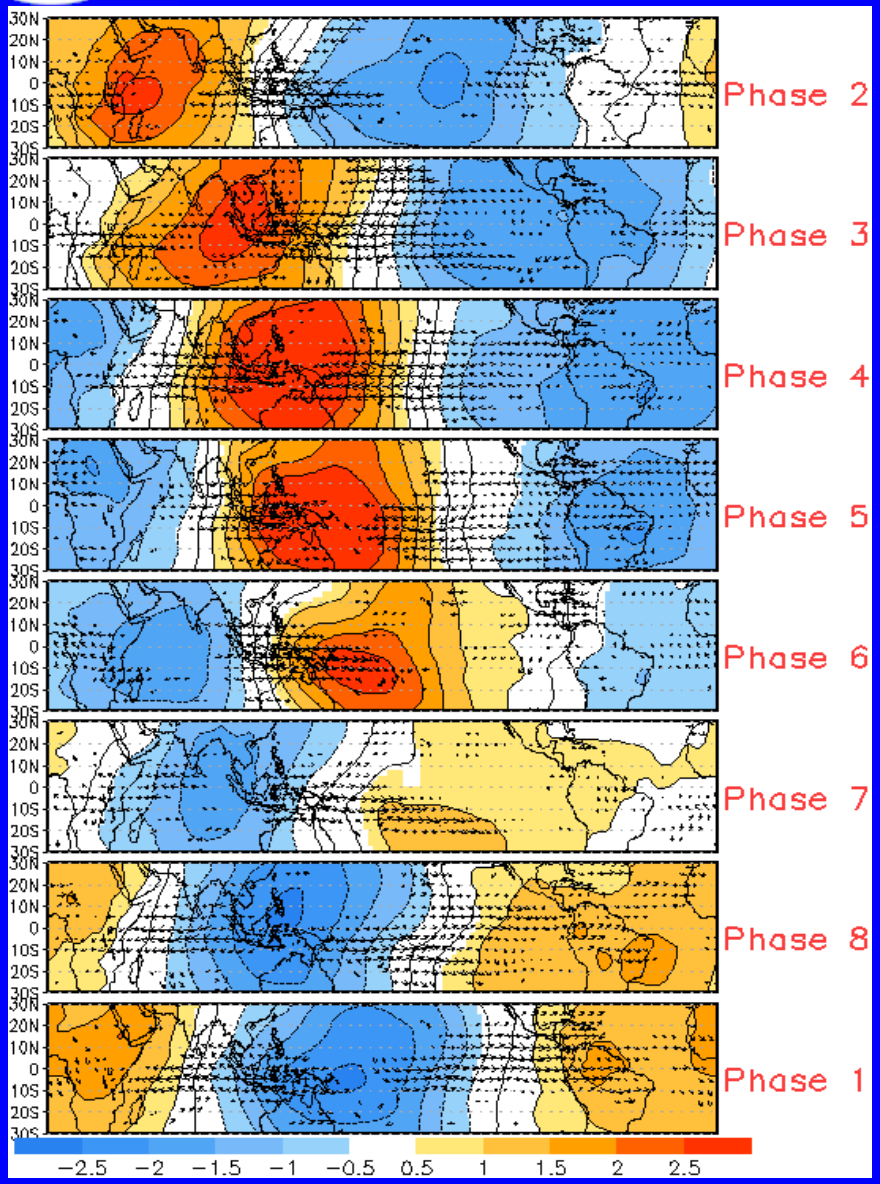
This forecast shows some eastward progression with enhanced convection slowly shifting eastward as indicated by a decrease in convection in the South Pacific and an increase in convection across the Indian Ocean by the end of Week-2. Suppressed convection slowly shifts from the eastern Indian Ocean to the western Pacific.

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

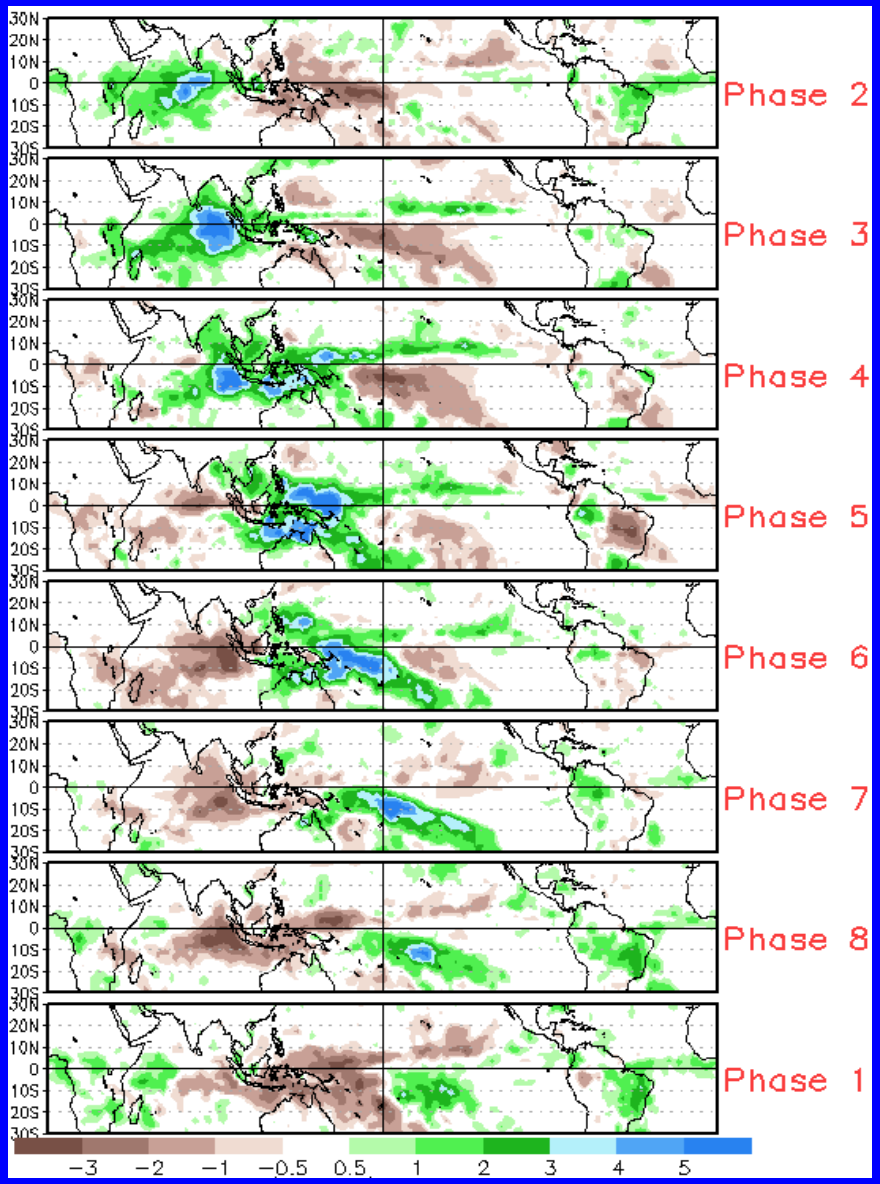


MJO Composites – Global Tropics

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

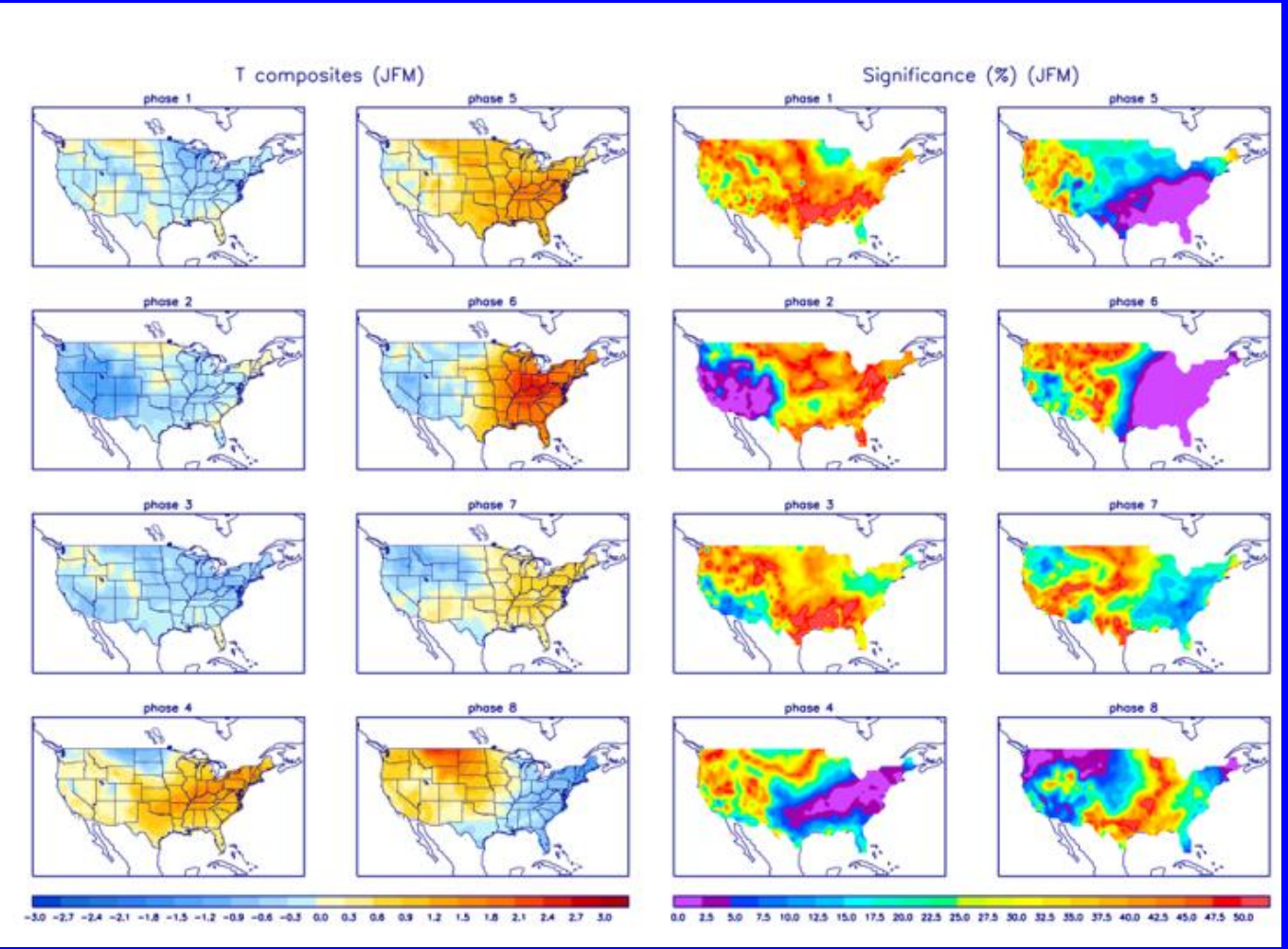


Precipitation Anomalies (Nov-Mar)



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.**

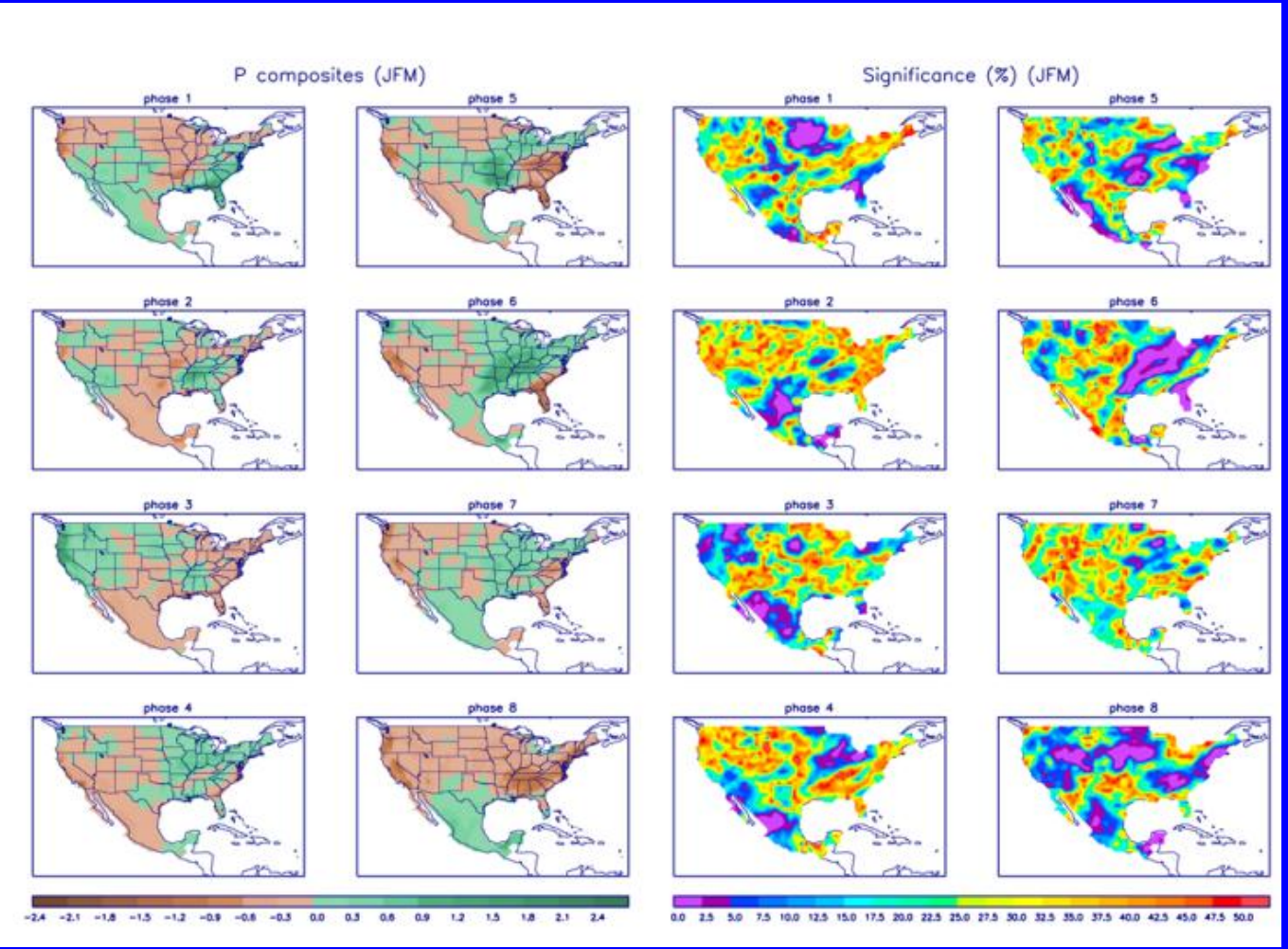


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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