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

Update prepared by
Climate Prediction Center / NCEP
February 25, 2013

Outline

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

Overview

- The MJO remained active with the enhanced phase centered across the Maritime continent over the past week.

- There is large spread in the dynamical model forecasts for the predicted evolution of the MJO index. Some models persist the signal over the Maritime continent while others show some eastward propagation into the western Pacific. Statistical forecasts are more in line with the latter, however, westward moving subseasonal tropical variability supports a more slow eastward evolution of large-scale convection.

- Based on recent observations and consideration of both empirical and dynamical model MJO forecasts, the MJO is forecast to remain active during the next two weeks with a slow eastward propagation of the enhanced phase into the western Pacific by the end of Week-2.

- The MJO favors enhanced rainfall across the Maritime continent and the western Pacific during the period with odds of suppressed rainfall elevated across parts of South America (Week-1), Africa and the Indian Ocean. The chances for tropical cyclogenesis remain elevated for the waters near Australia.

- Higher latitude variability is expected to be the primary driver across most of the U.S. over the next few weeks. Typical impacts associated with the MJO are not likely.

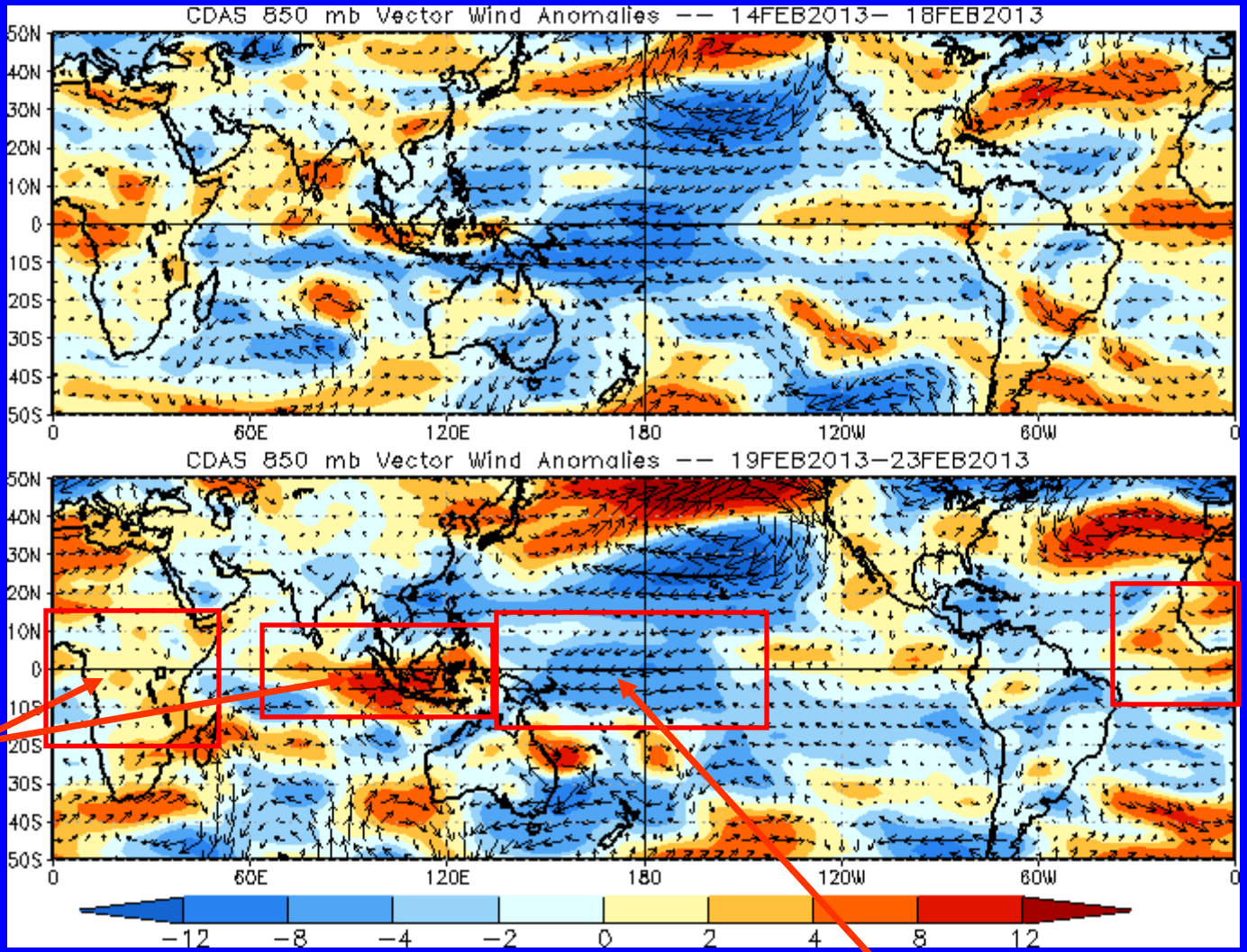
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



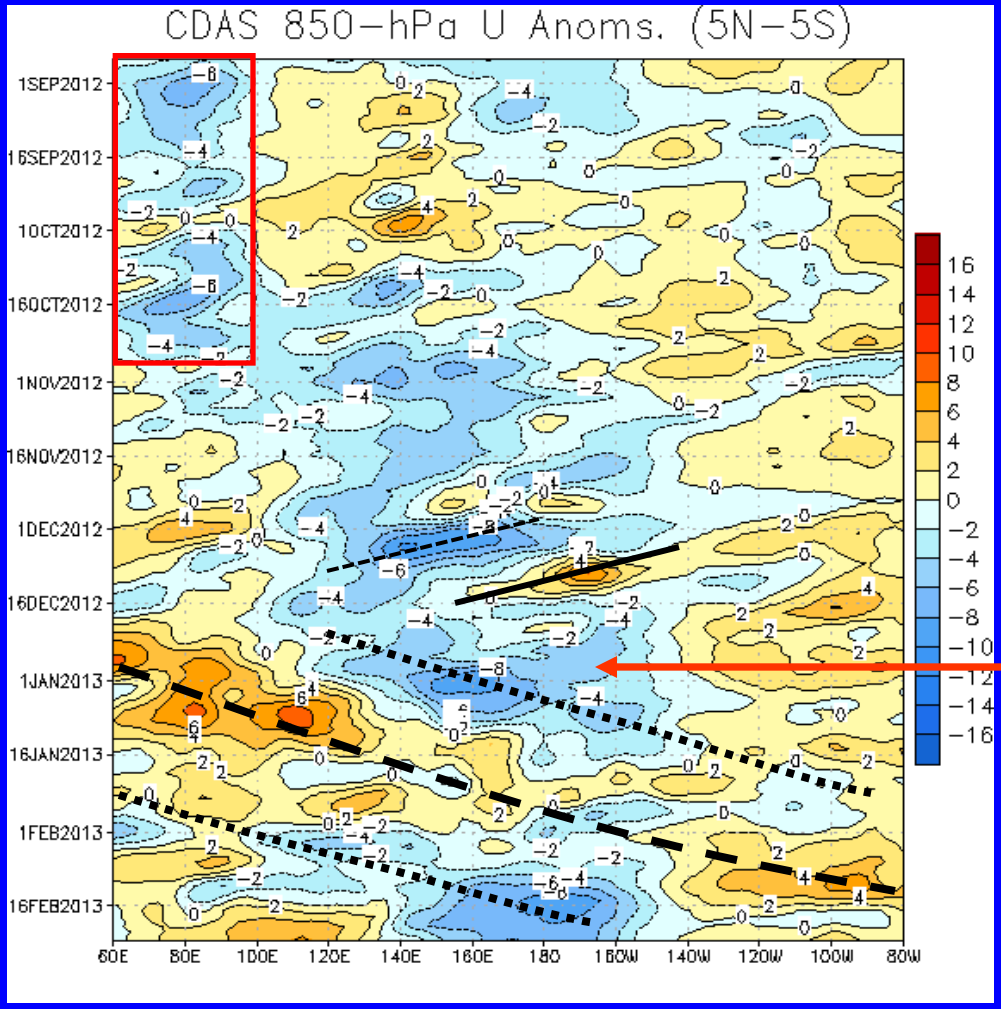
Westerly anomalies continued across the eastern Atlantic and Africa and increased over the eastern Indian Ocean and Maritime continent during the last five days.

Easterly anomalies focused across the western 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

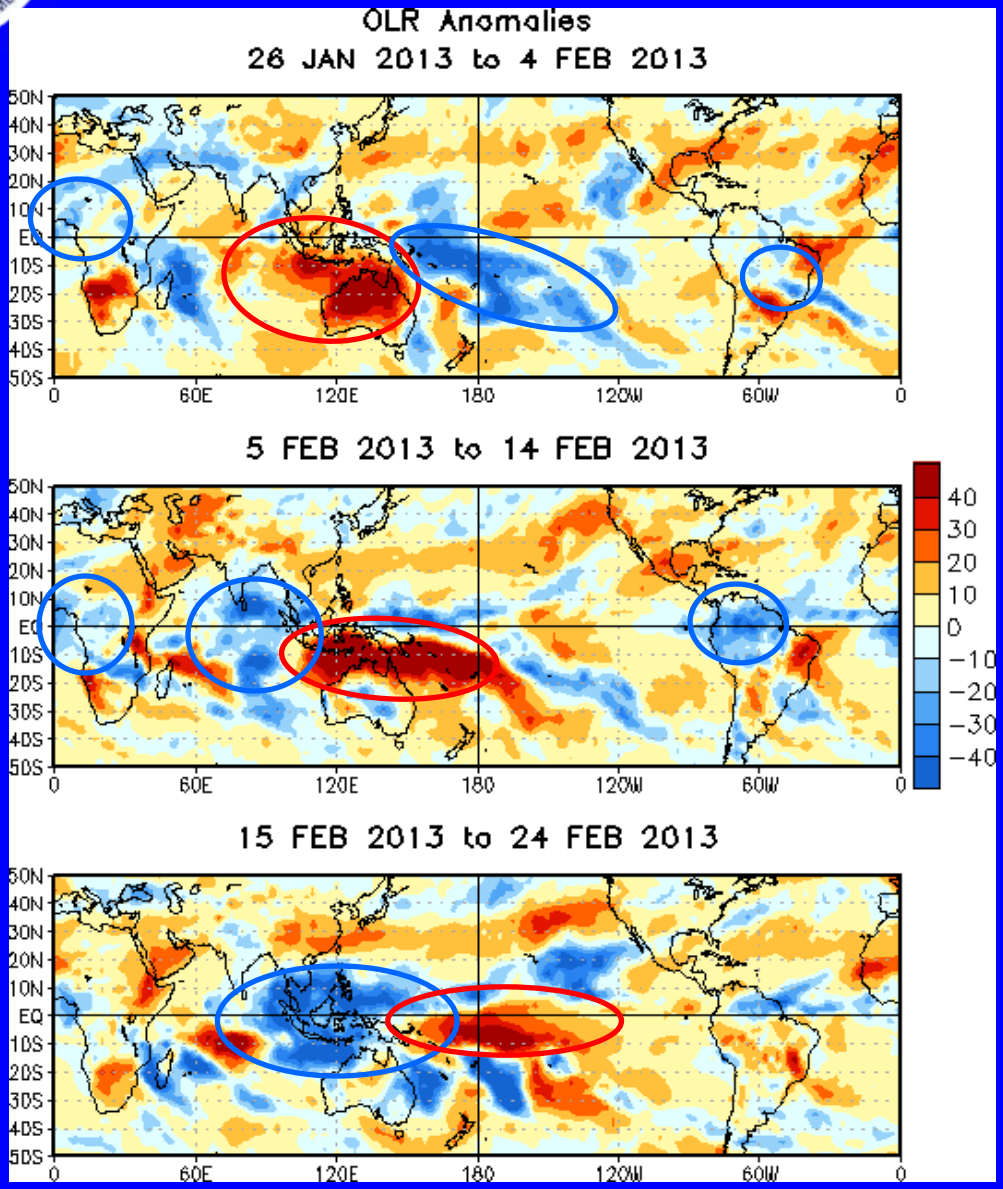
Longitude

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 late December the MJO strengthened as indicated by an increase in magnitude of anomalies along with eastward propagation (alternating dotted/dashed lines). The MJO has remained active into February, although the signal was less clear at times during late January and early February.

OLR Anomalies – Past 30 days



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

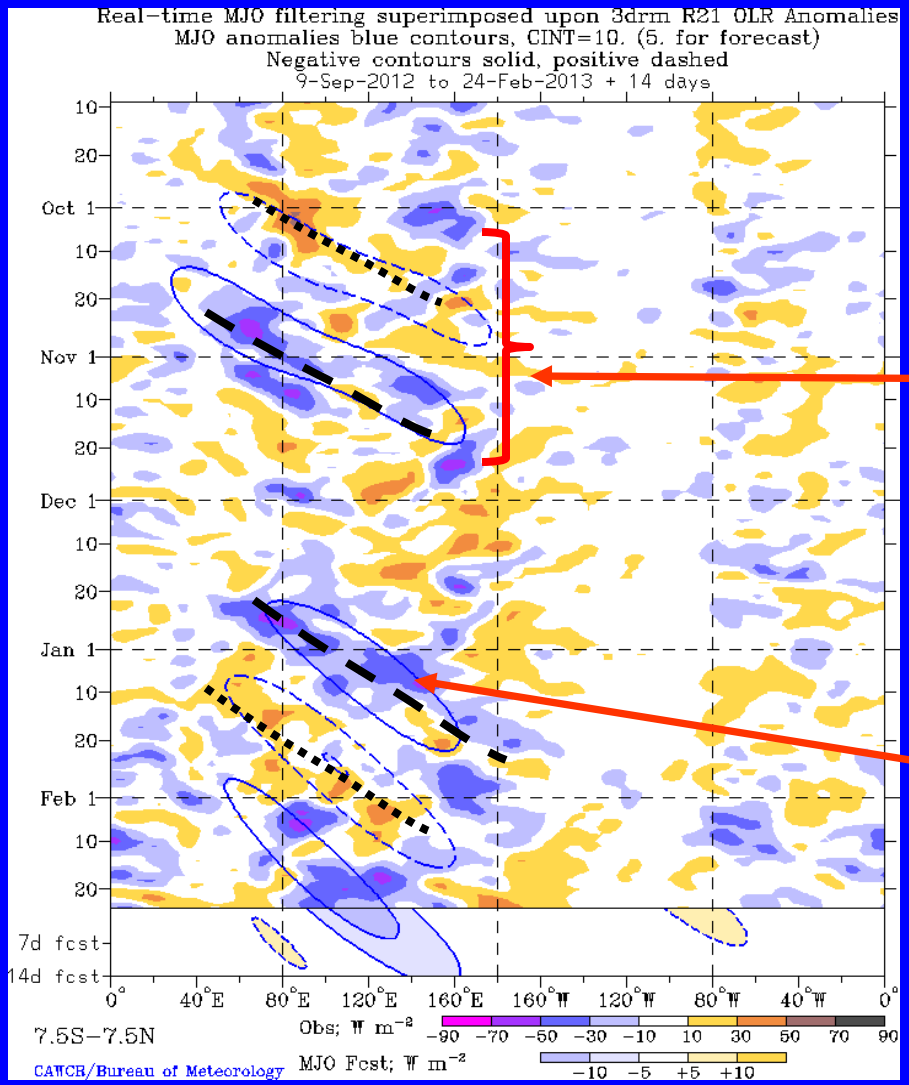
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

Enhanced convection shifted eastward to the western Pacific during late January into early February and continued across parts of Africa and South America. Suppressed convection increased over parts of the Maritime continent and Australia.

Suppressed convection was very strong across northern Australia and the southern Maritime continent during early-to-mid February. Enhanced convection shifted northwest in South America and developed over the eastern Indian Ocean.

By mid-to-late February, enhanced convection developed over a large region stretching from the eastern Indian Ocean into the western Pacific with suppressed convection shifted eastward to the central Pacific.

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.

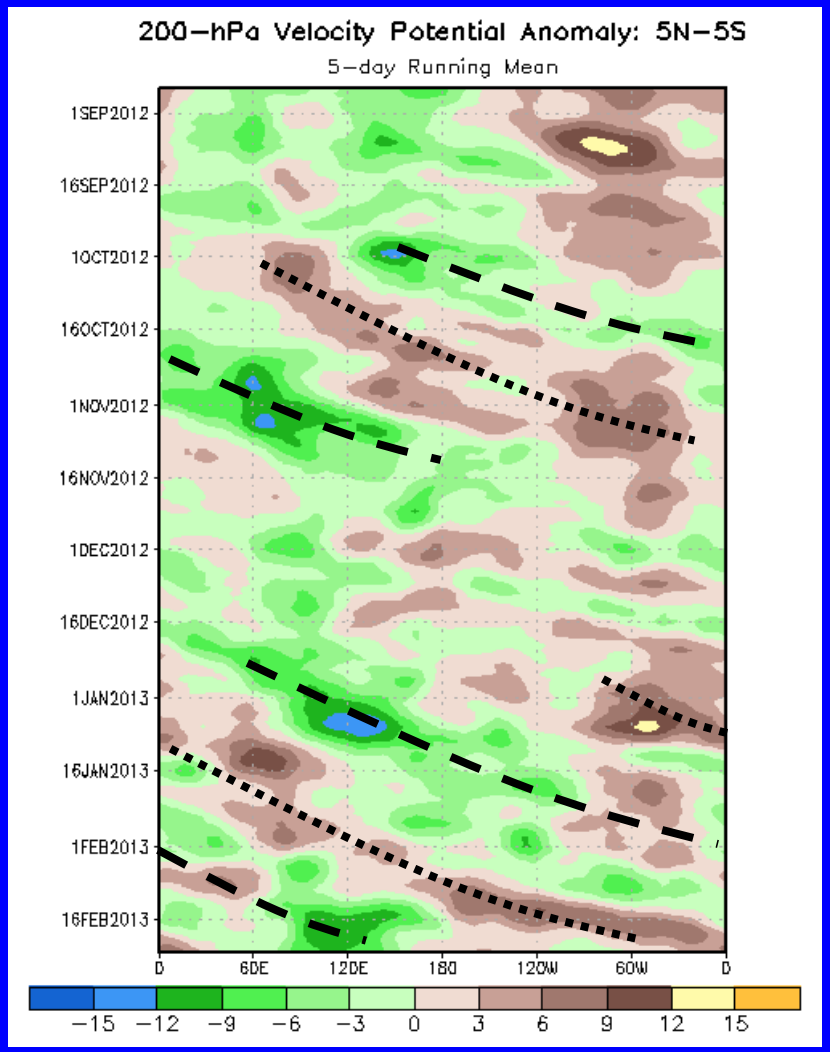
During late November and much of December, convective anomalies were disorganized.

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 and most recently during late February, strong enhanced convection has redeveloped across the eastern Indian ocean and the Maritime continent.

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

In mid-September, anomalies were small with little eastward propagation as the MJO was weak.

In early October, upper-level divergence (convergence) increased over the Pacific (Indian Ocean) and shifted eastward until mid November (alternating dashed and dotted lines).

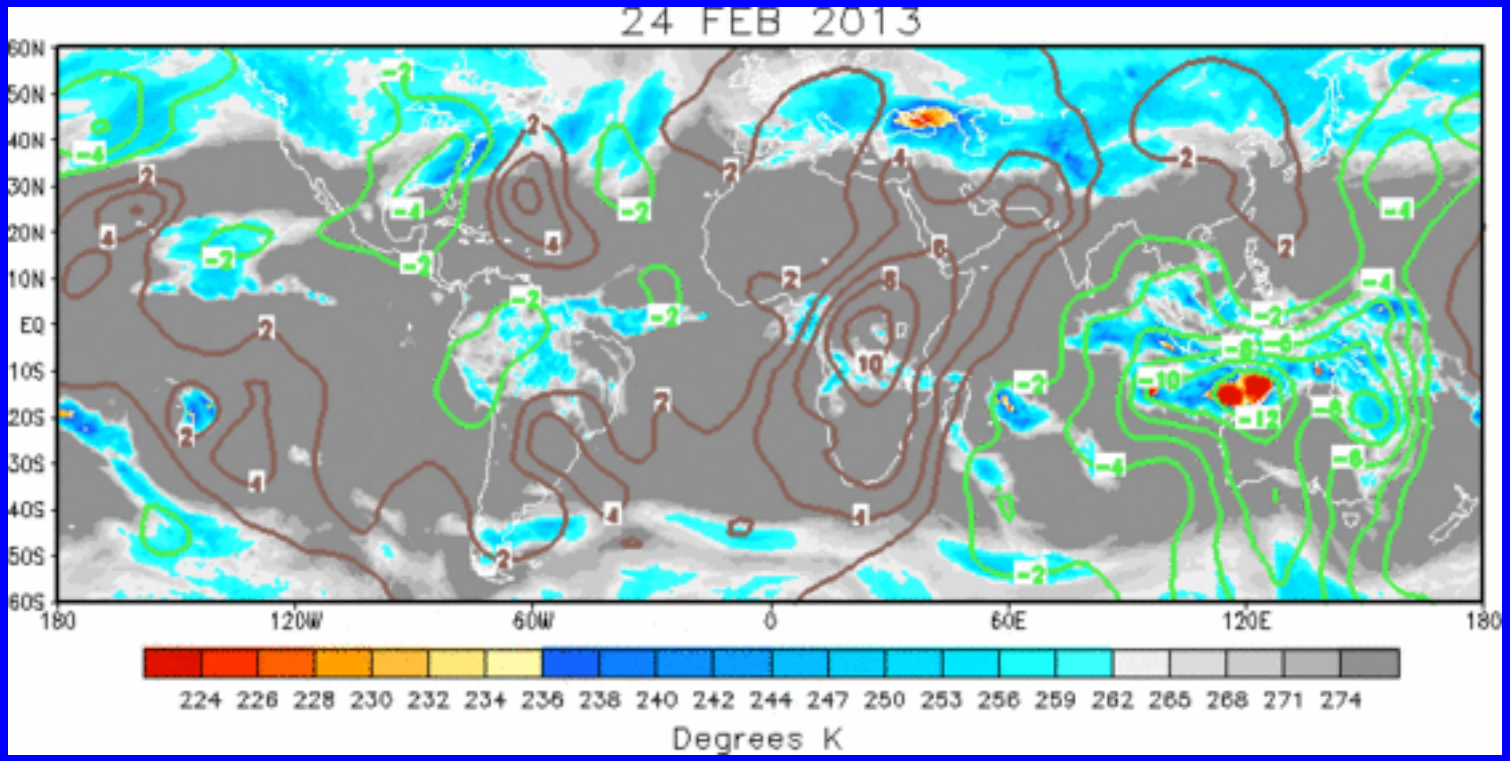
During most of December, anomalies were weak with less coherent eastward propagation. Other subseasonal variability was more prevalent during this period.

As the MJO strengthened in late December, anomalies increased in magnitude with more robust eastward propagation indicated during late 2012 and early 2013. Anomalies became less coherent during late January into early February, but the MJO remains active.

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

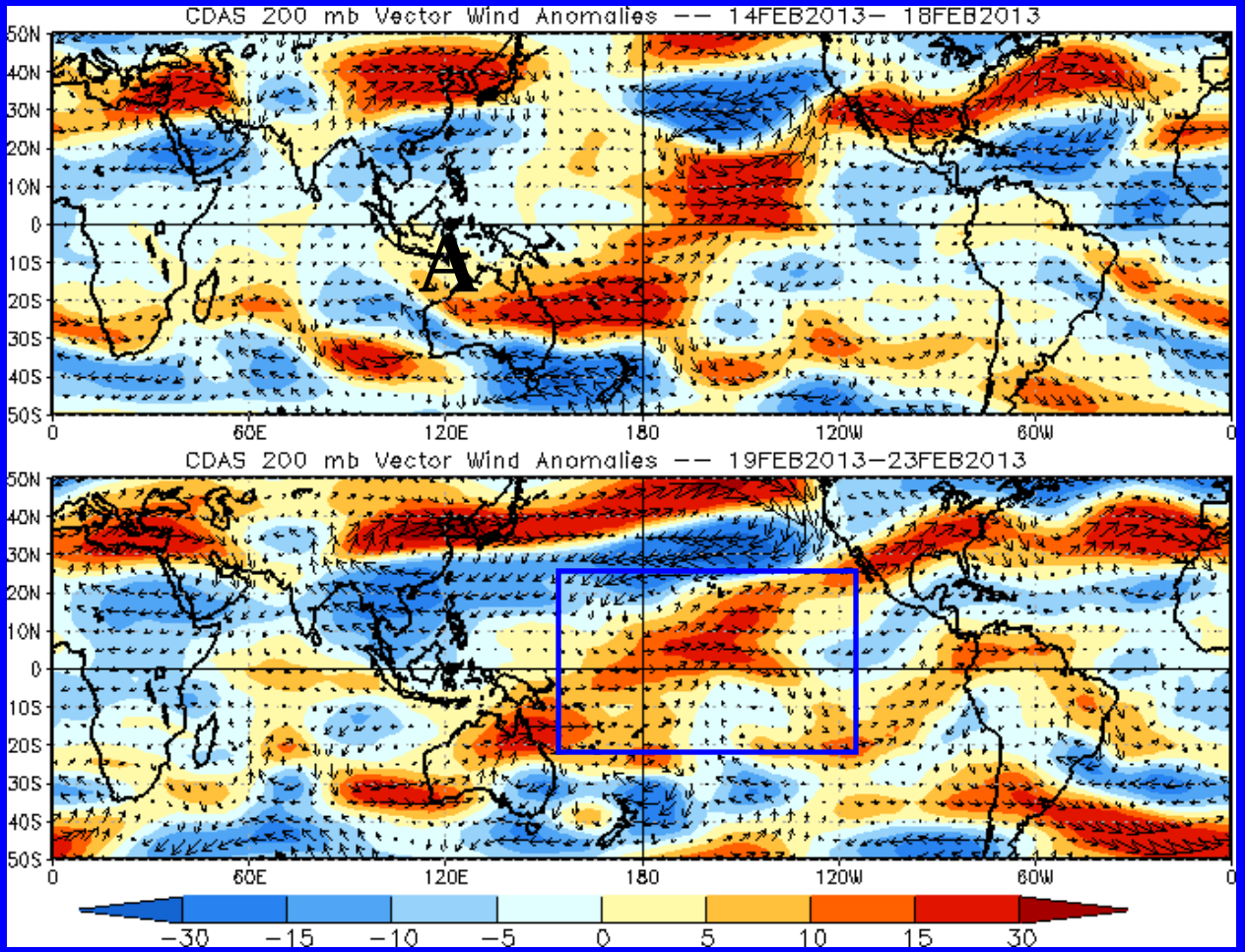
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The velocity potential pattern shows strong upper-level divergence across the Maritime continent with upper-level convergence centered across Africa.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

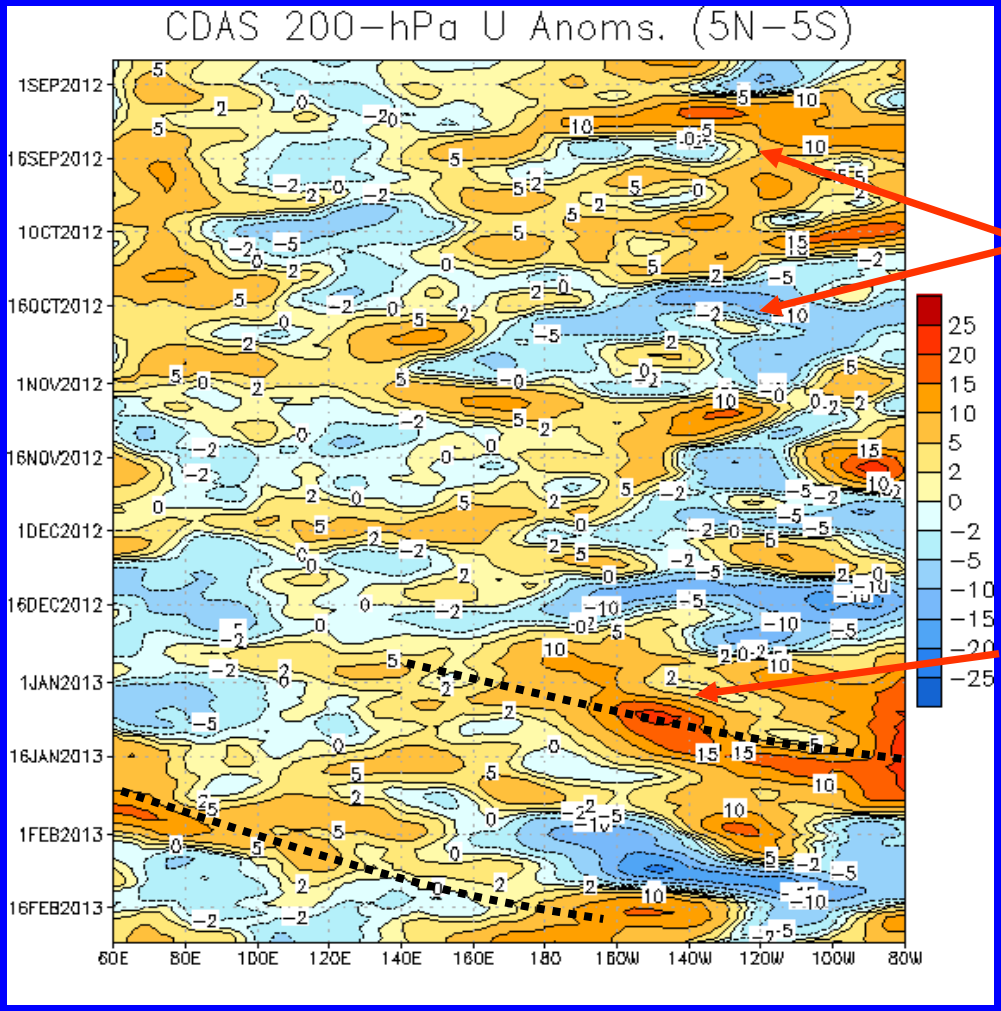
Red shades: Westerly anomalies

Westerly anomalies (blue box) remain across the central equatorial Pacific during the last 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



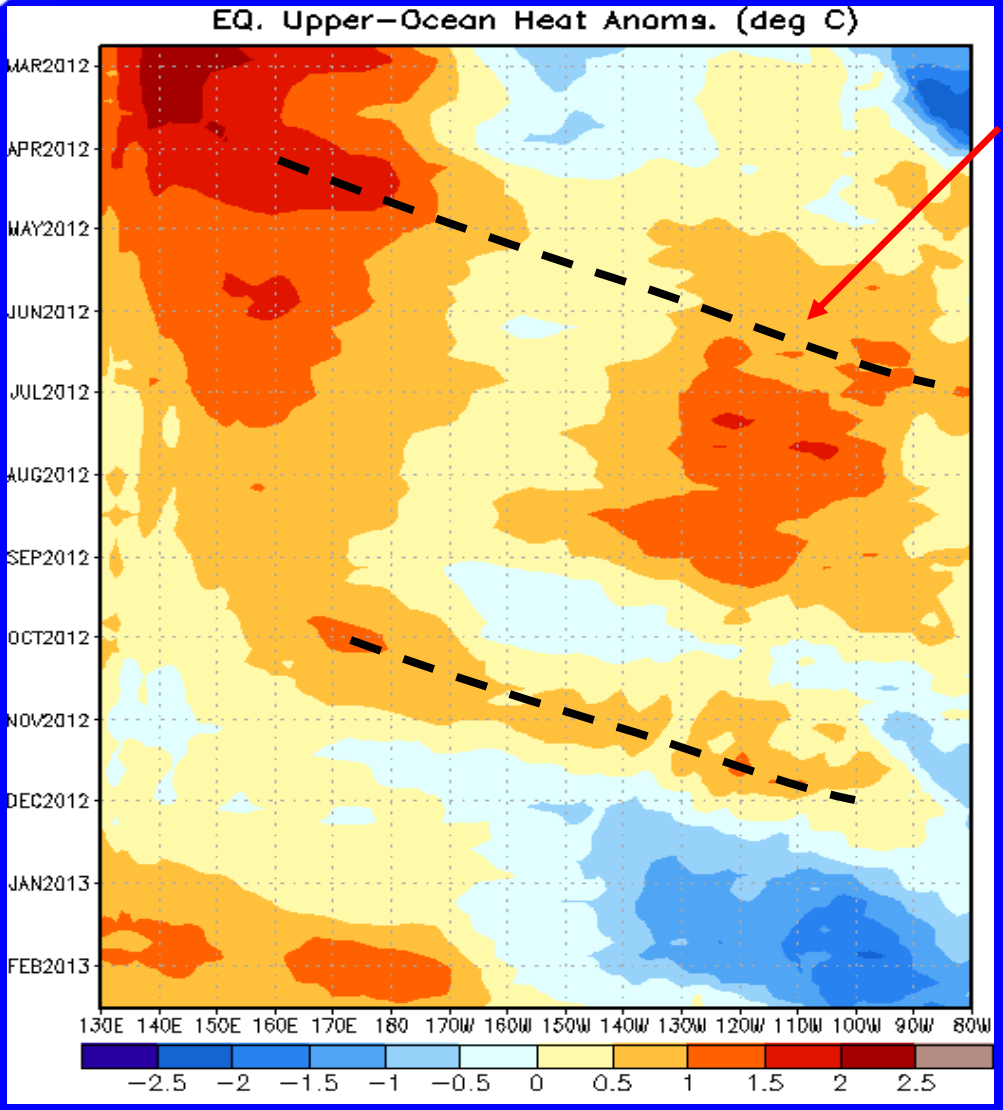
Time

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 associated with the MJO is evident beginning in late December and continuing into February 2013.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

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.

Positive (negative) anomalies have developed in the western (eastern) Pacific respectively during January 2013.

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).

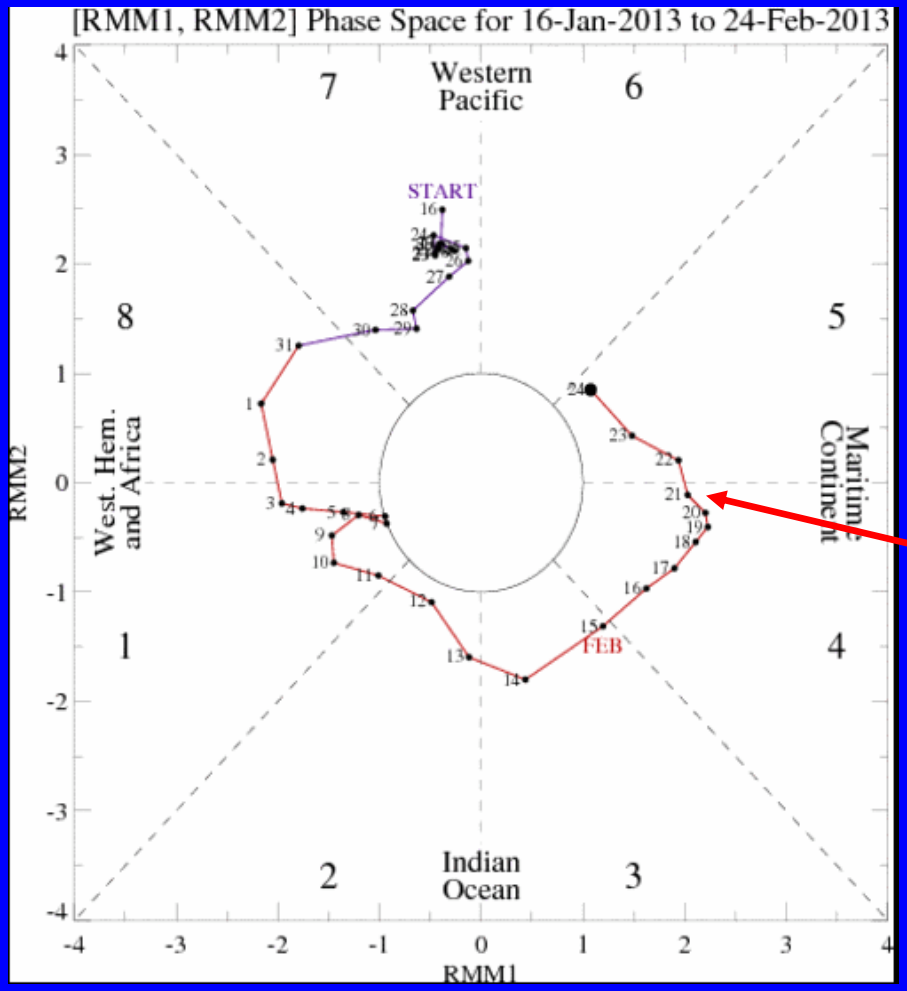
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

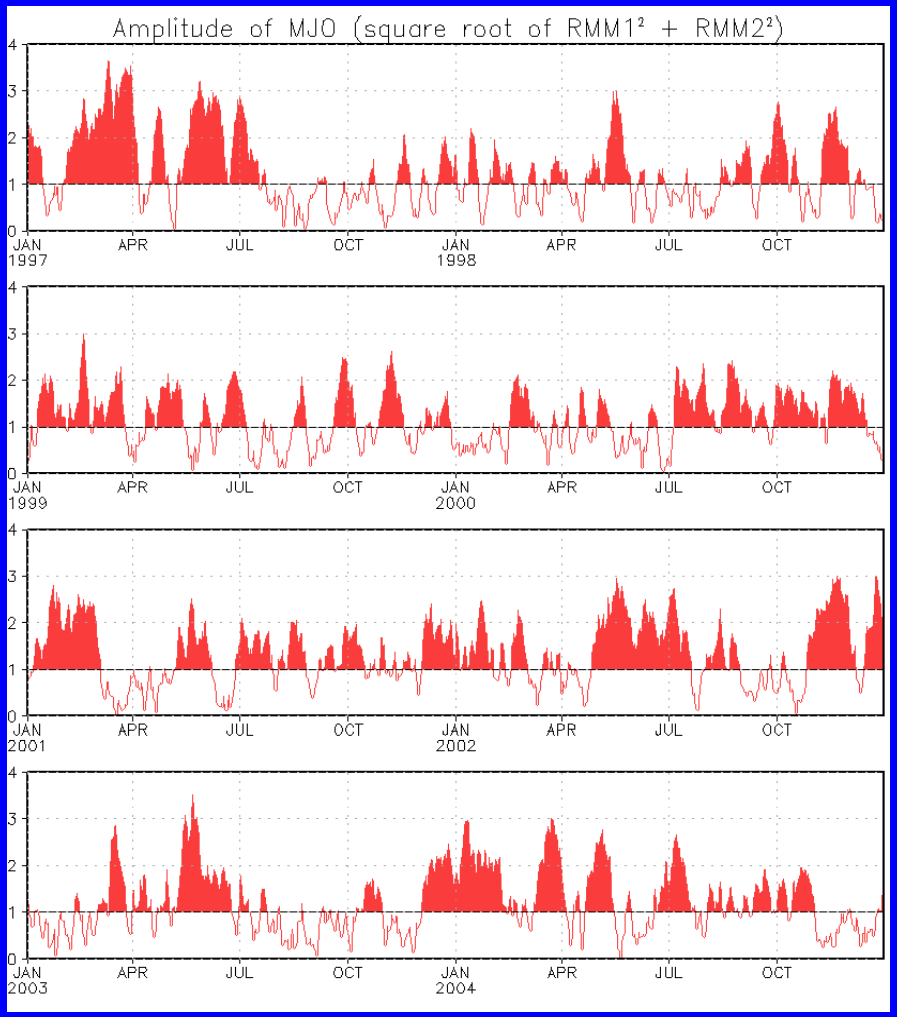
MJO Index -- Recent Evolution

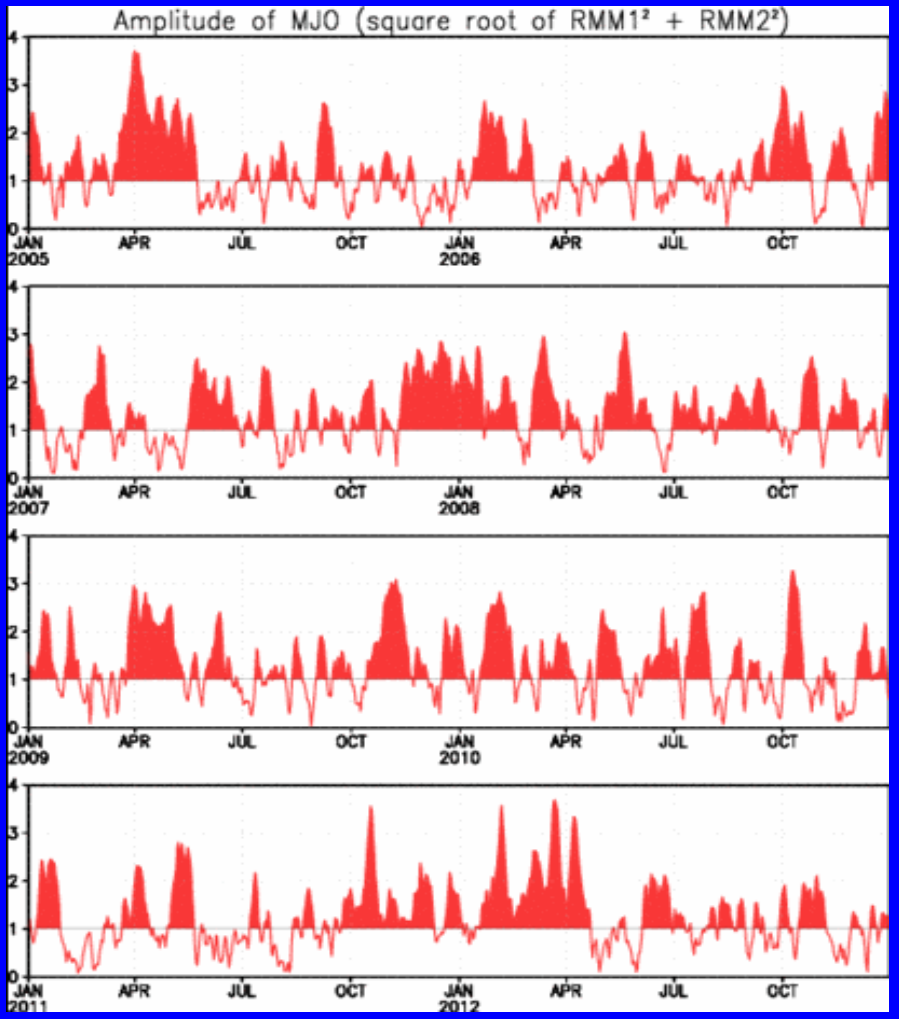


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates continued eastward propagation of the MJO over the past week with the enhanced convective phase crossing the Maritime continent.

MJO Index – Historical Daily Time Series





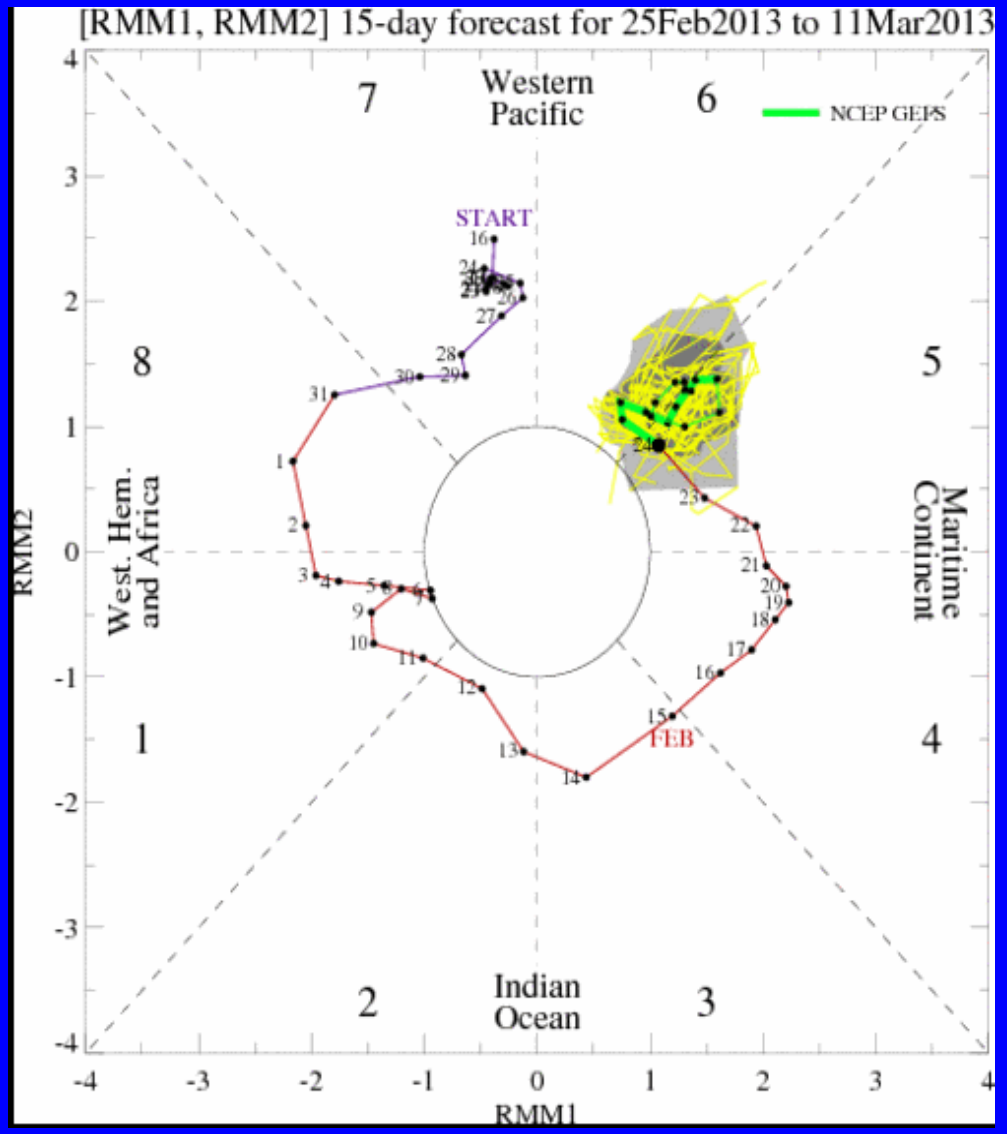
Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

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



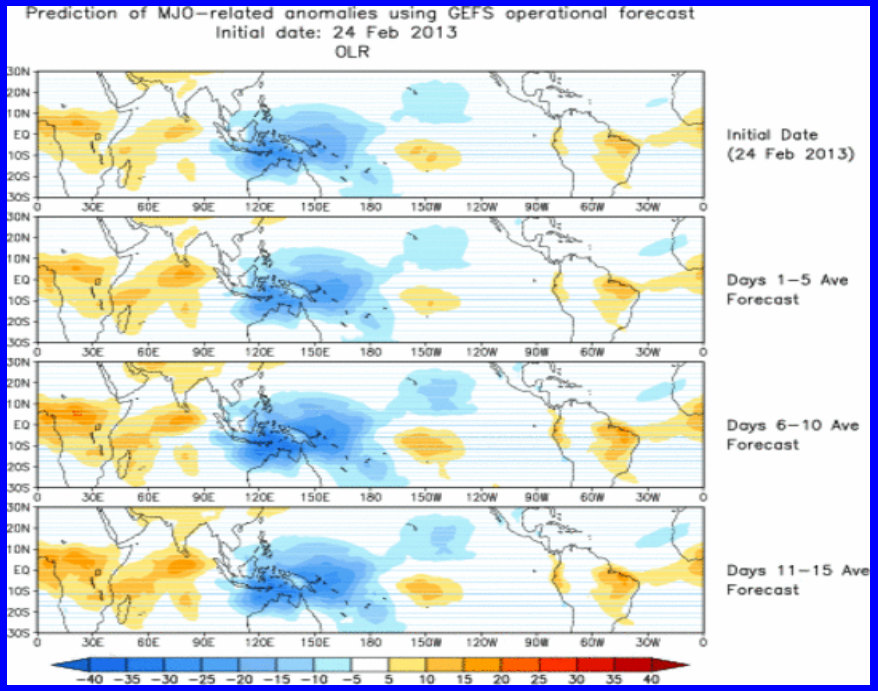
The bias-corrected ensemble GFS forecasts a weakening of the MJO signal as eastward propagation ceases early during the period.

However, other tropical subseasonal variability is most likely impacting the forecast at this time and the MJO signal is favored to continue.

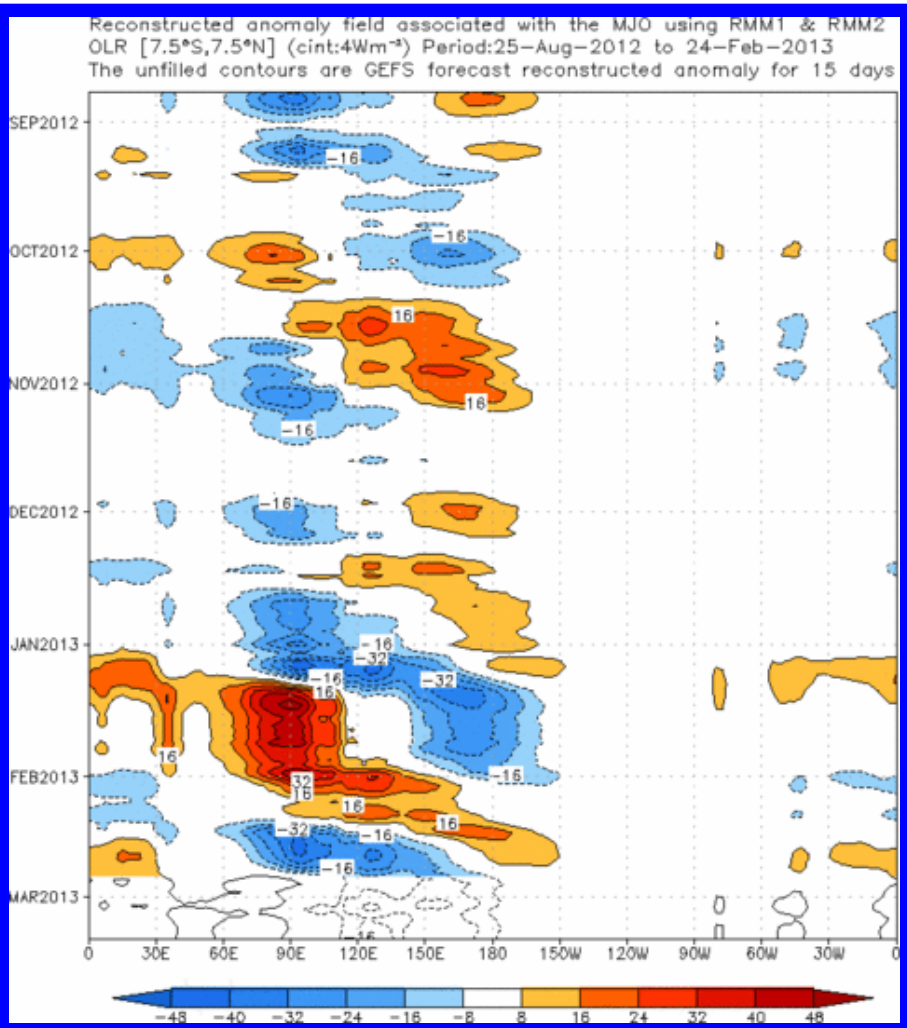
Ensemble Mean GFS MJO Forecast

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

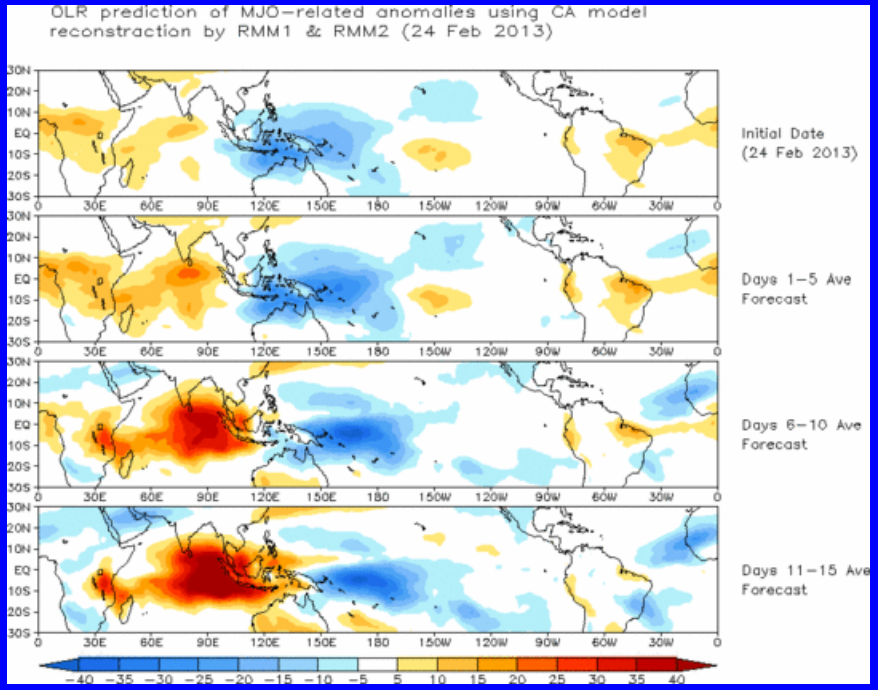


The ensemble mean GFS forecasts enhanced (suppressed) convection to persist across the Maritime continent and western Pacific (Brazil/Africa) during the period.

Constructed Analog (CA) MJO Forecast

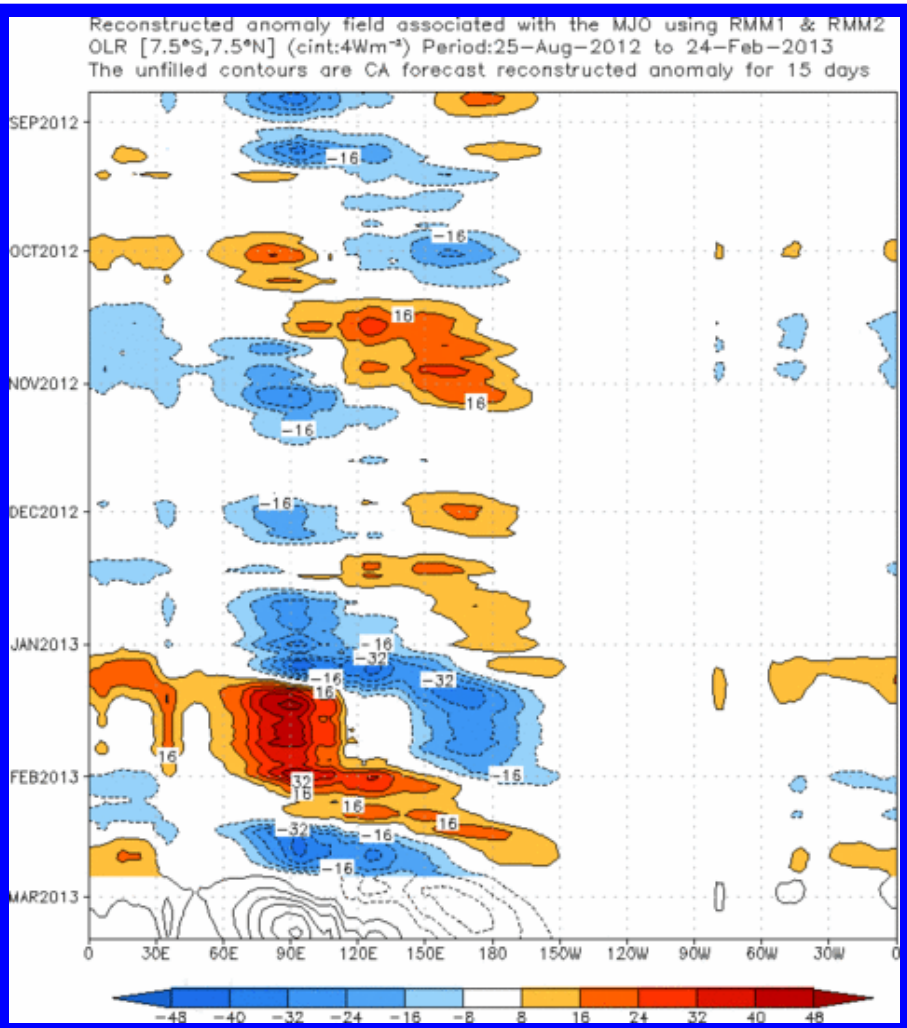
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



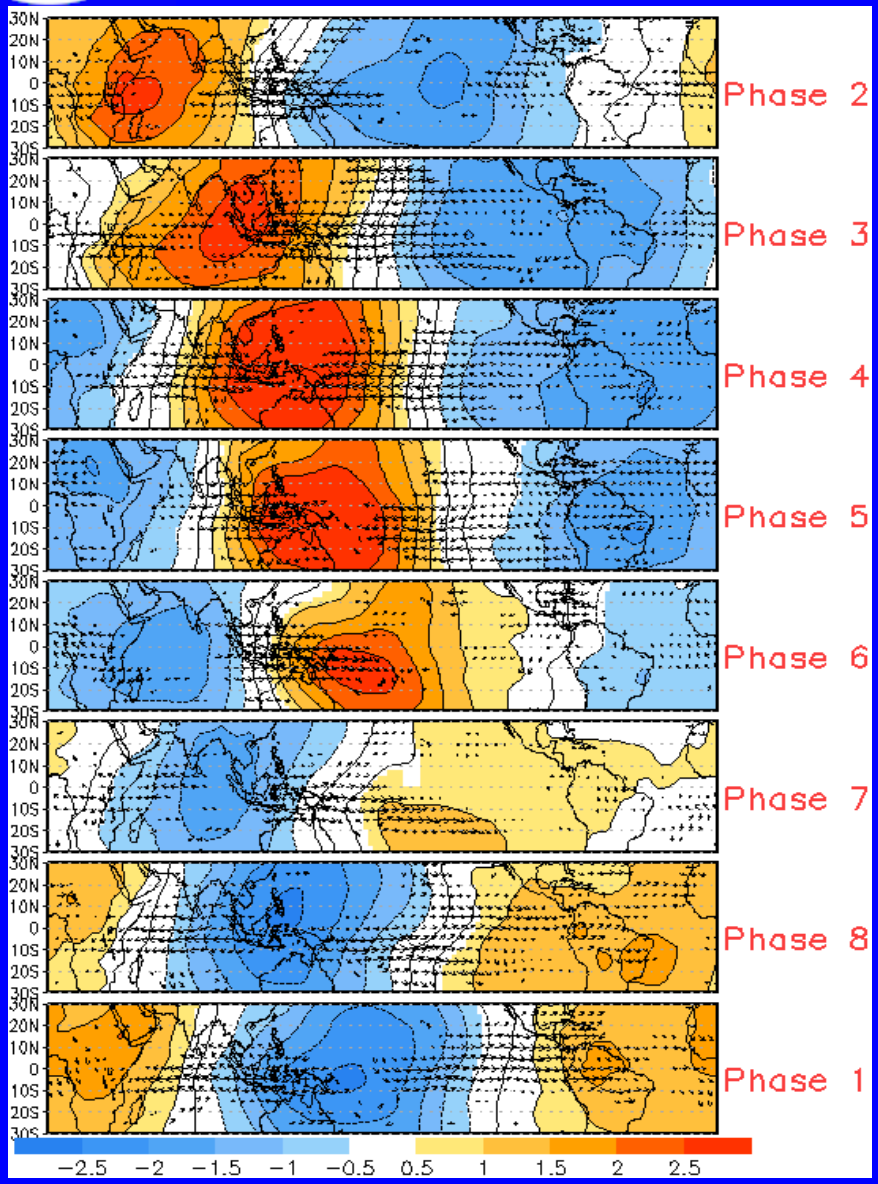
This forecast shows more clear eastward progression with enhanced convection shifting from the Maritime continent well into the Pacific during the period. Suppressed convection is forecast to become very strong across the Indian Ocean by Week-2.

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

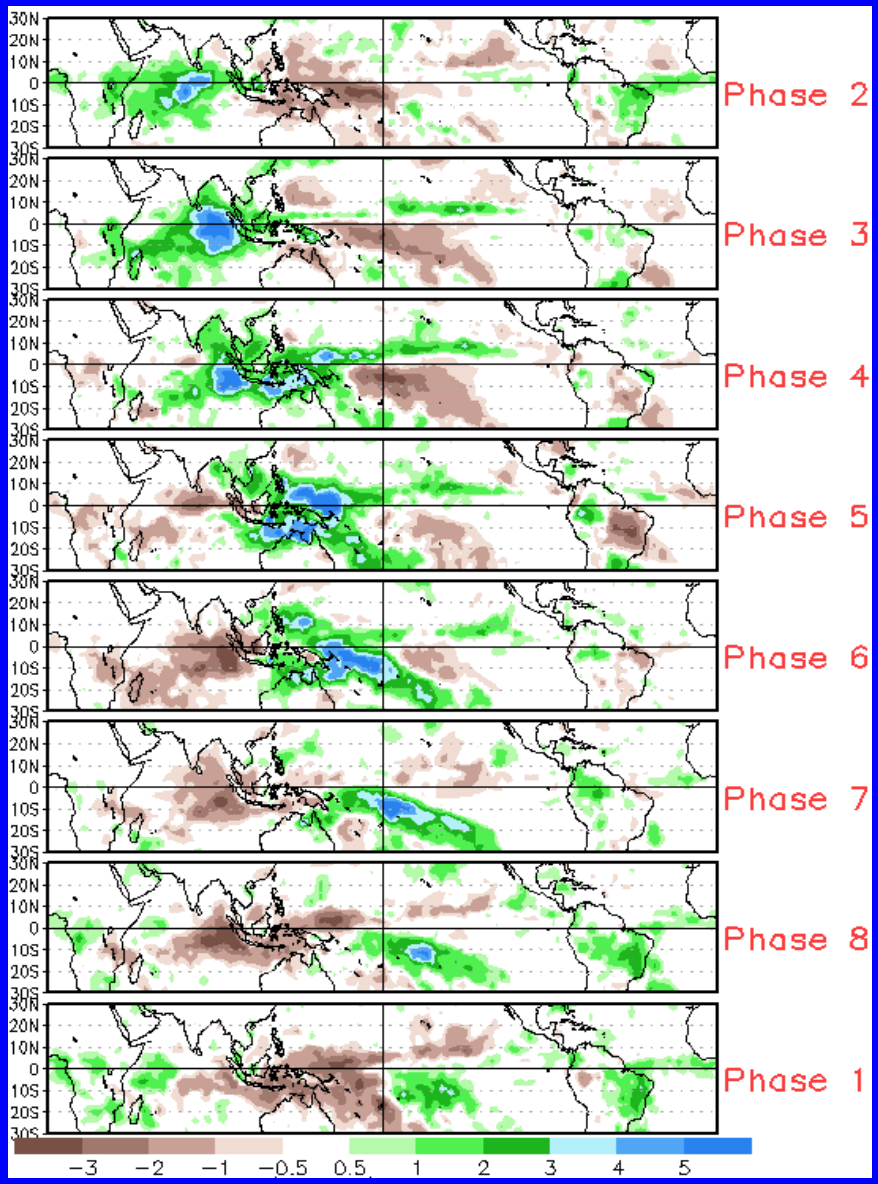


MJO Composites – Global Tropics

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

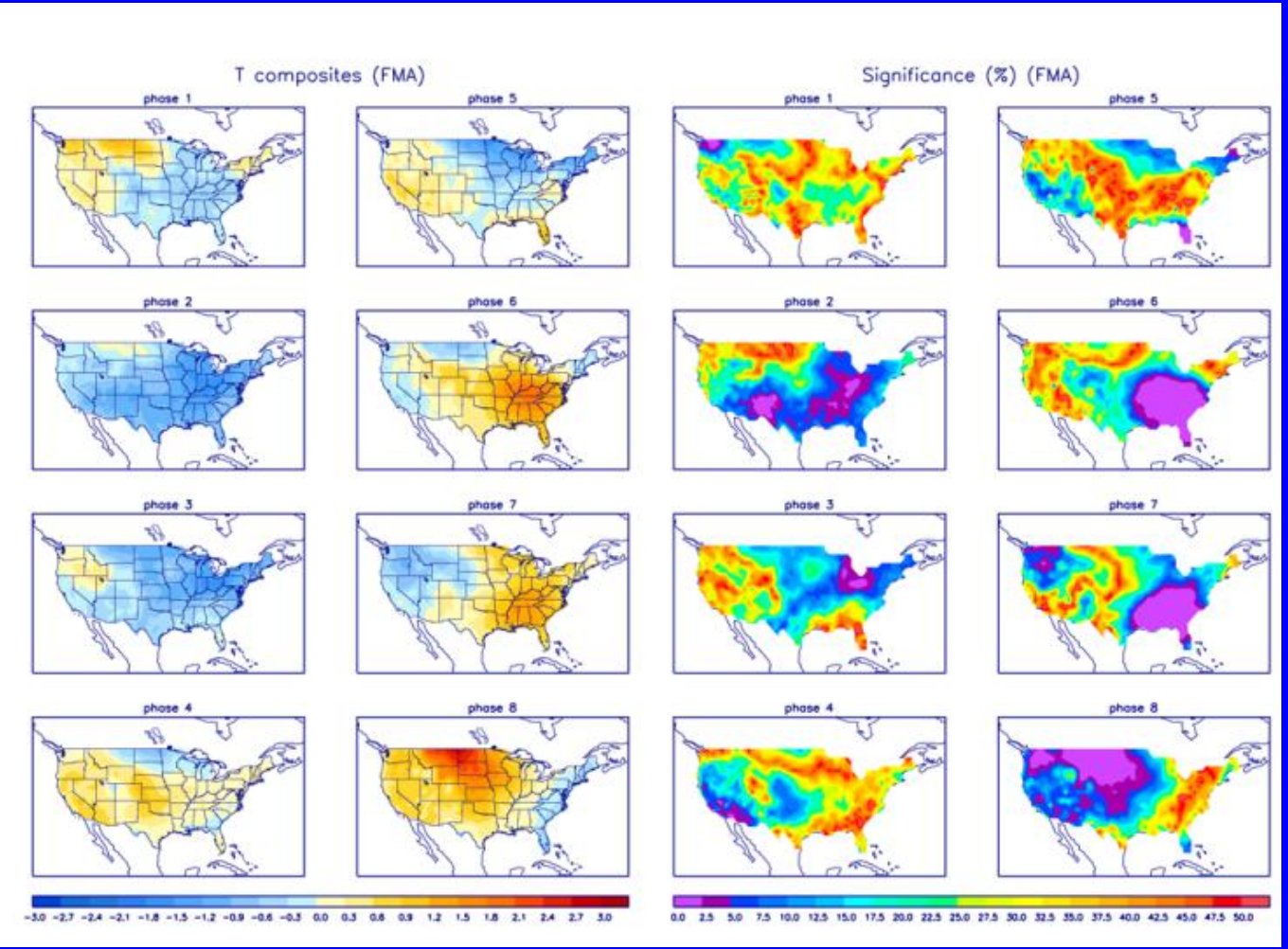


Precipitation Anomalies (Nov-Mar)



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.**

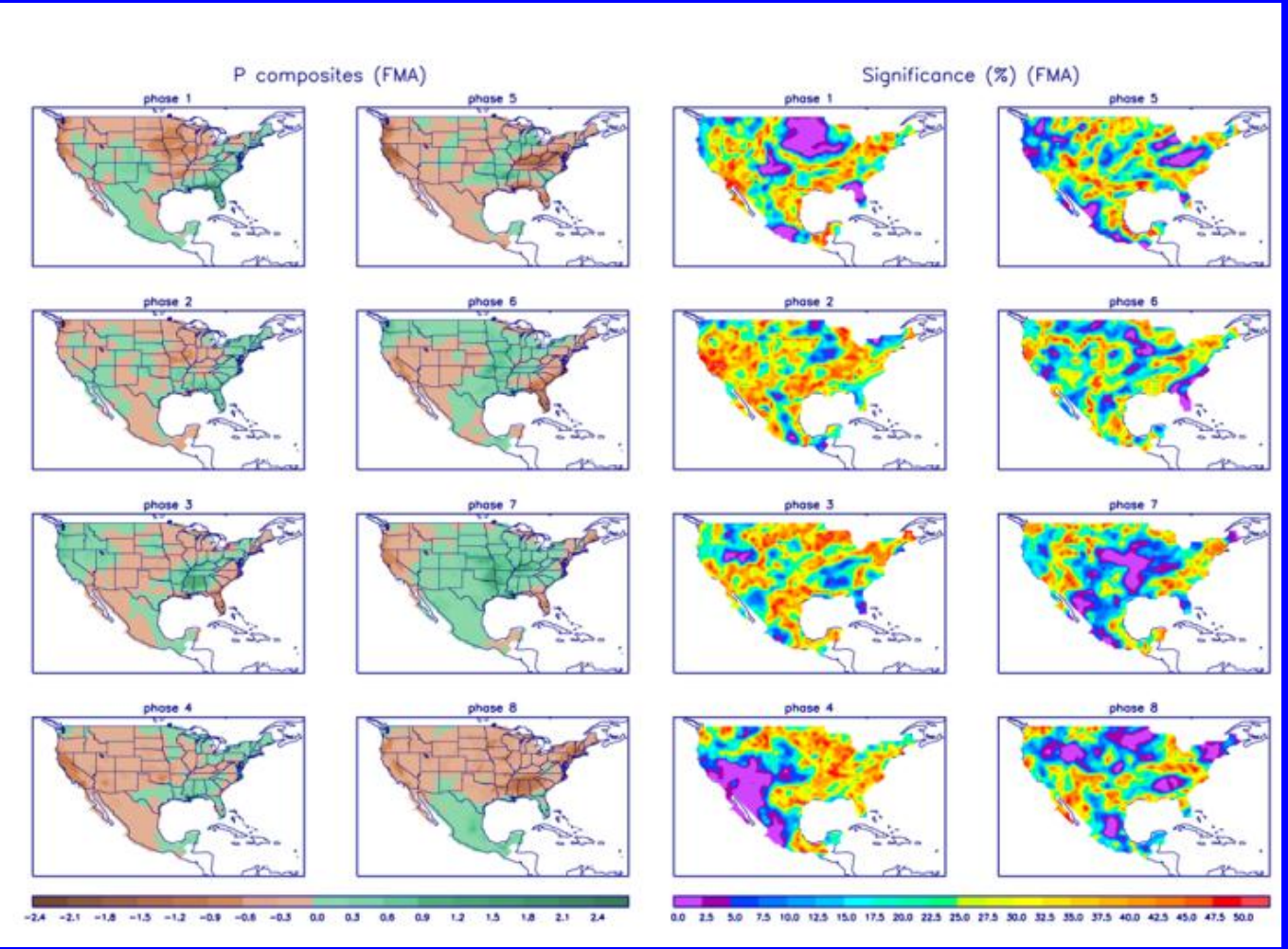


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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