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

Update prepared by
Climate Prediction Center / NCEP
January 14, 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 rapid propagation from the Maritime continent into the western Pacific.

- Dynamical and statistical model MJO index forecasts are only in fair agreement this week, with some dynamical forecasts, namely the GFS and Canadian ensemble means, limiting eastward propagation during the period. The statistical tools and other dynamical model forecasts maintain eastward propagation into the western Hemisphere.

- Based on the latest observations and MJO index forecasts, the MJO is forecast to remain active and propagate across the western Pacific over the next two weeks.

- The MJO is expected to contribute to enhanced (suppressed) convection across the western and central equatorial Pacific (Indian Ocean and western Maritime Continent) during the period. Tropical cyclogenesis remains favored for portions of the southwest Pacific.

- The MJO favors an increased likelihood for below-normal temperatures for parts of the central and eastern U.S. during the last 7-10 days of January into early February. Drier-than-average conditions are also favored for portions of the western U.S.

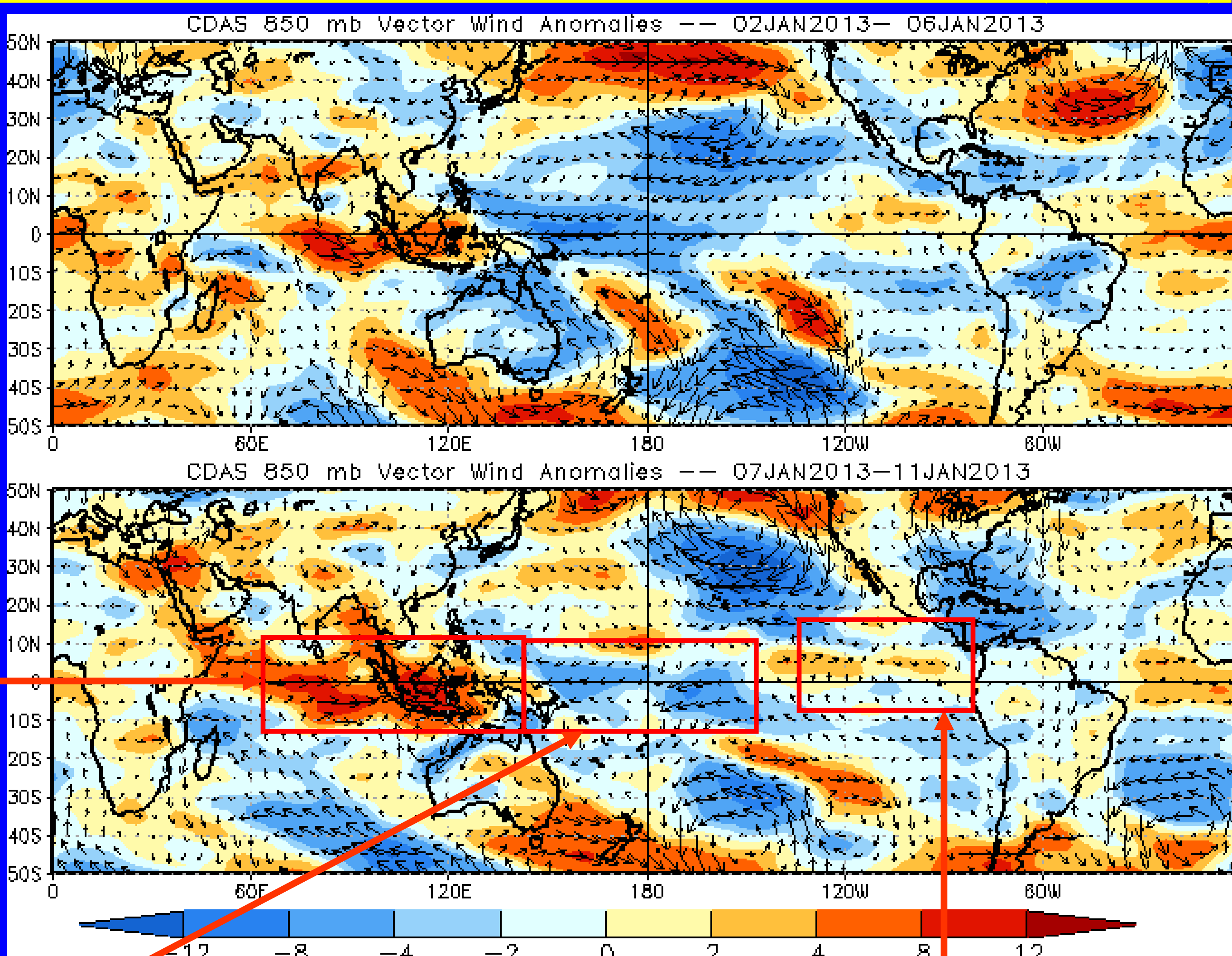
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 shifted slightly east over the Maritime Continent, consistent with MJO propagation.

Easterly anomalies also shifted east and weakened over the past several days.

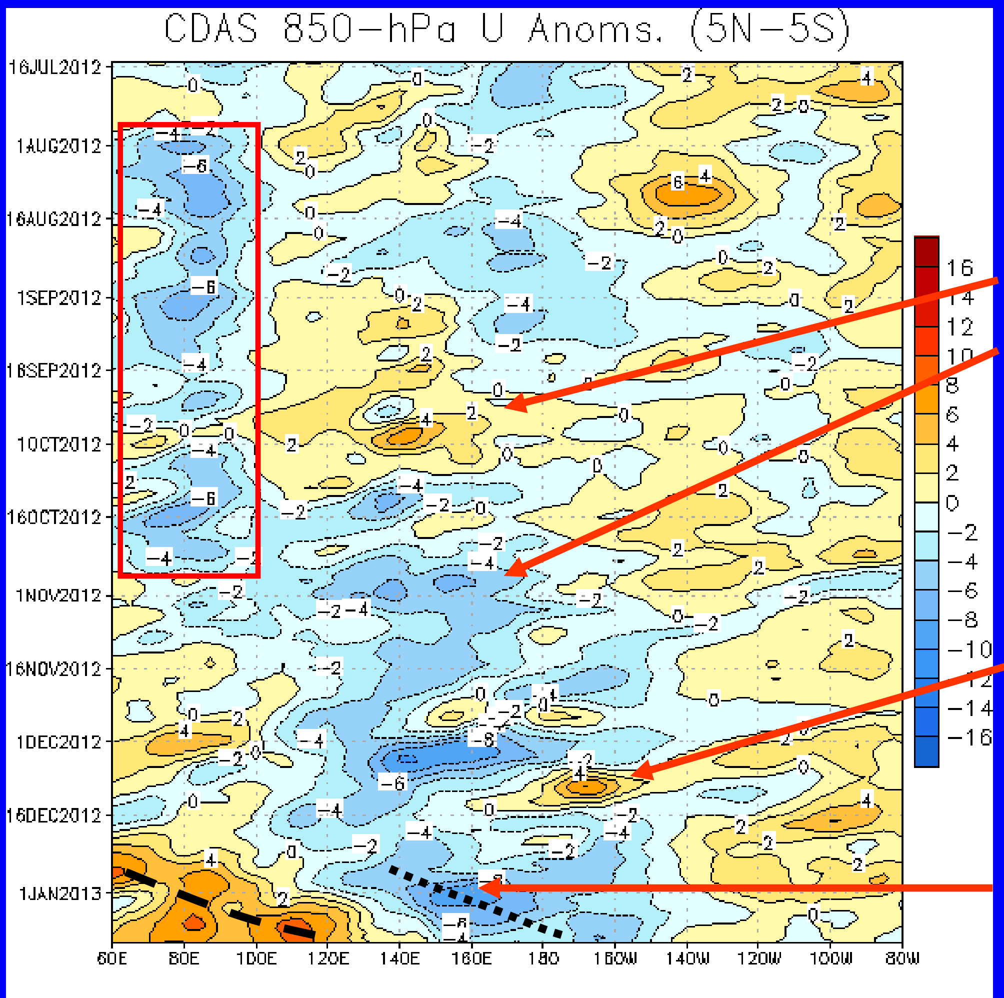
Weak westerly anomalies continued over the eastern tropical Pacific during the past five days.

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

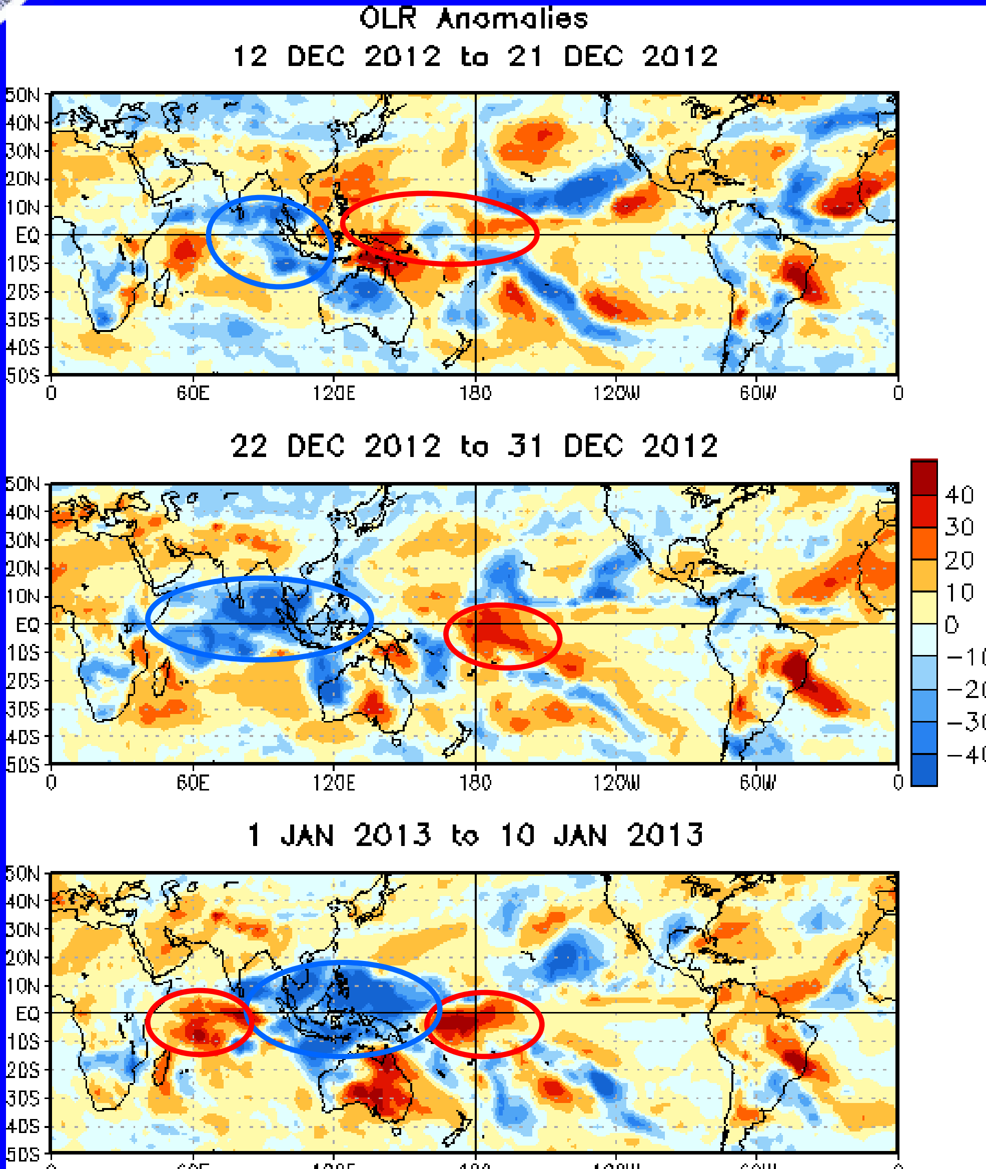
Easterly anomalies persisted near 80E for much of August to October (red box).

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.

Recently, there has been 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)

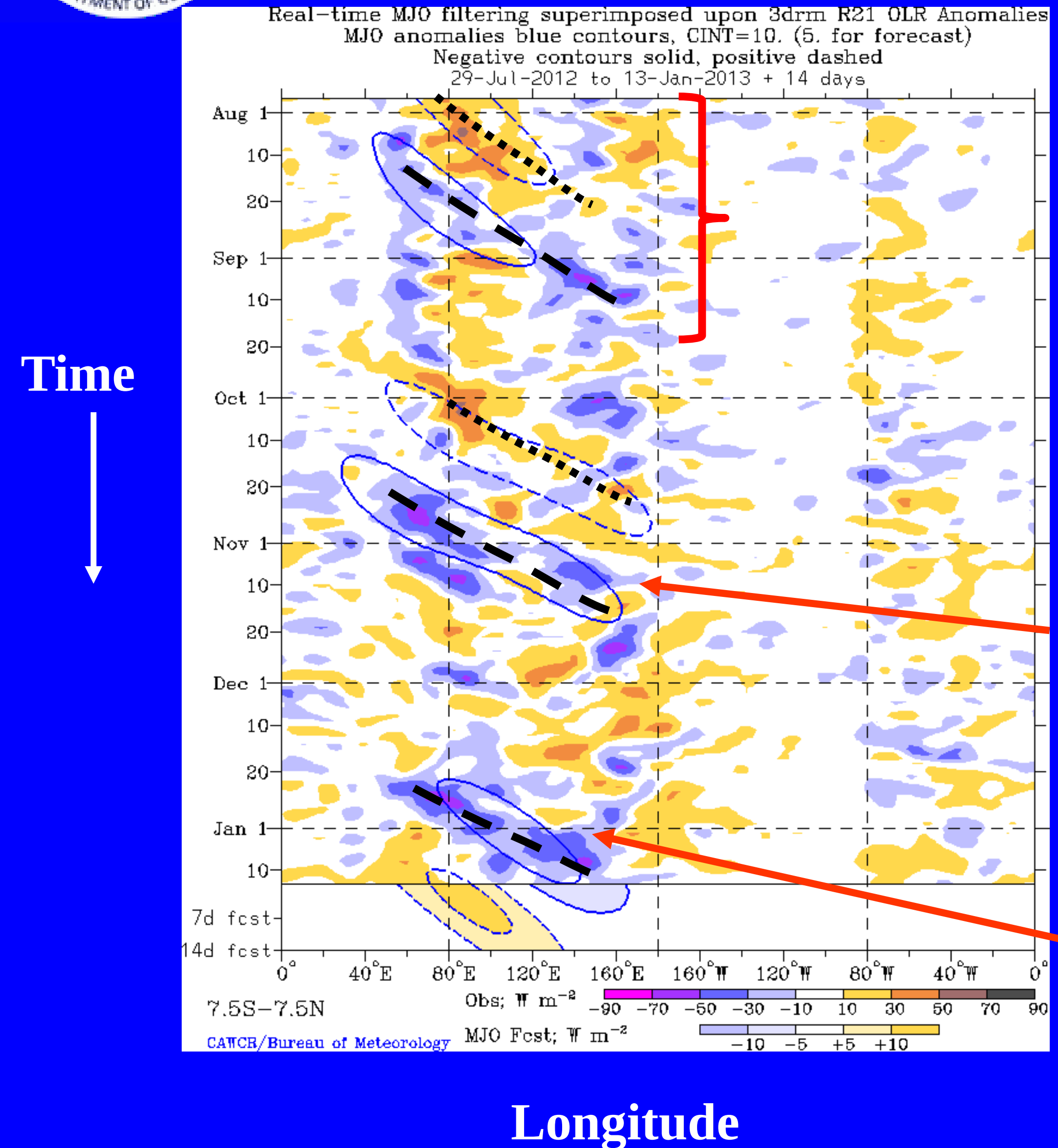
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

Mid-December featured slowly organizing convection over the Indian Ocean and a disorganized area of suppressed convection over the western and central Pacific.

During late December, convection was well-organized over the Indian Ocean and western Maritime Continent, consistent with MJO activity. Suppressed convection shifted eastward, centered along and east of the Date Line.

In early January convection shifted east across the Maritime Continent toward the West Pacific, while suppressed convection remained near the Date Line. At the same time, suppressed convection developed over the western and central Indian Ocean.

Outgoing Longwave Radiation (OLR) Anomalies (7.5°S-7.5°N)



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.

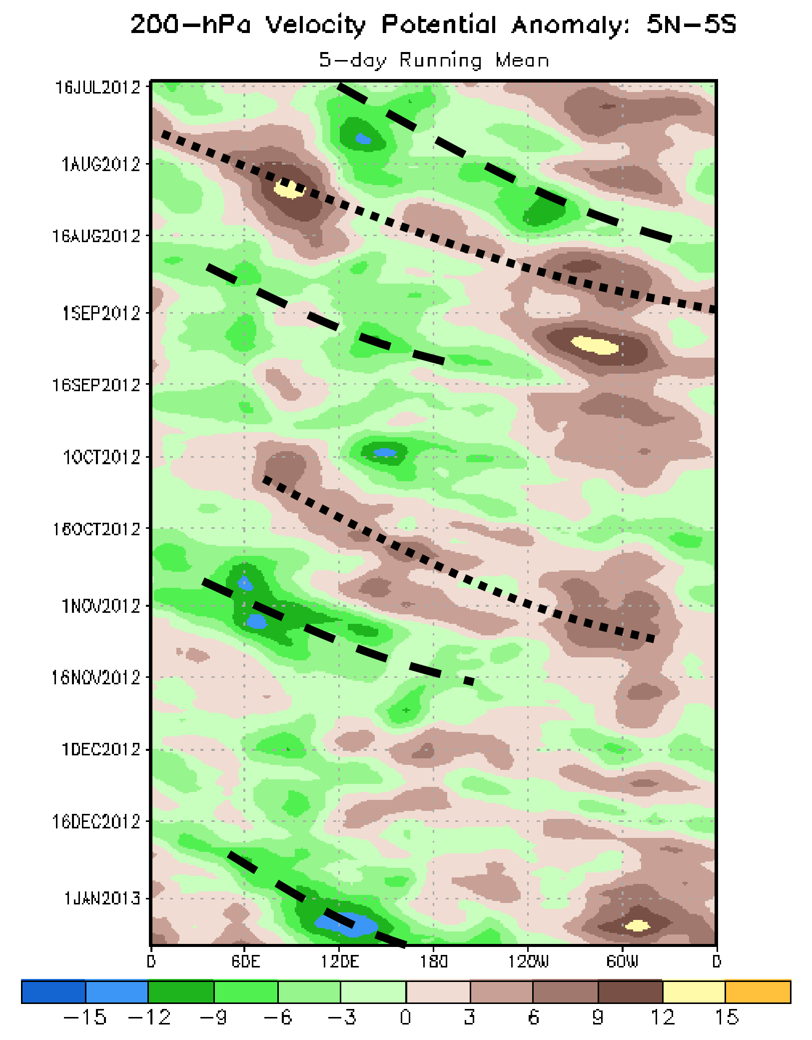
During late November and much of December, convective anomalies were disorganized. However, during late December enhanced convection developed across the Indian Ocean and shifted eastward into January 2013 (dashed line) as the MJO strengthened.

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 July 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 shifted eastward until early November.

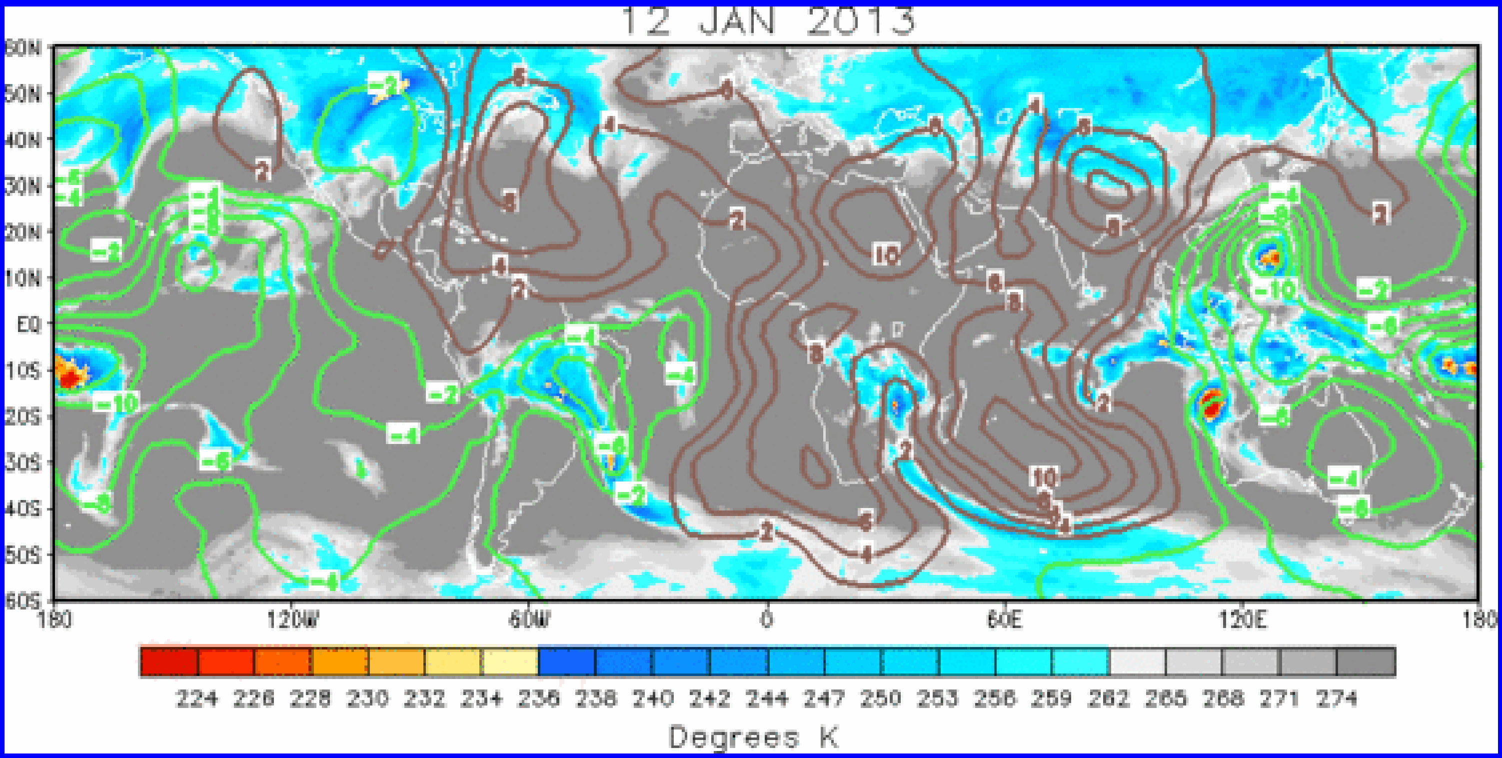
During most of December, anomalies were weaker, with less coherent eastward propagation. Other subseasonal variability were most prevalent during this period.

As the MJO strengthened, negative anomalies increased in magnitude with more robust eastward propagation (dashed line) 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



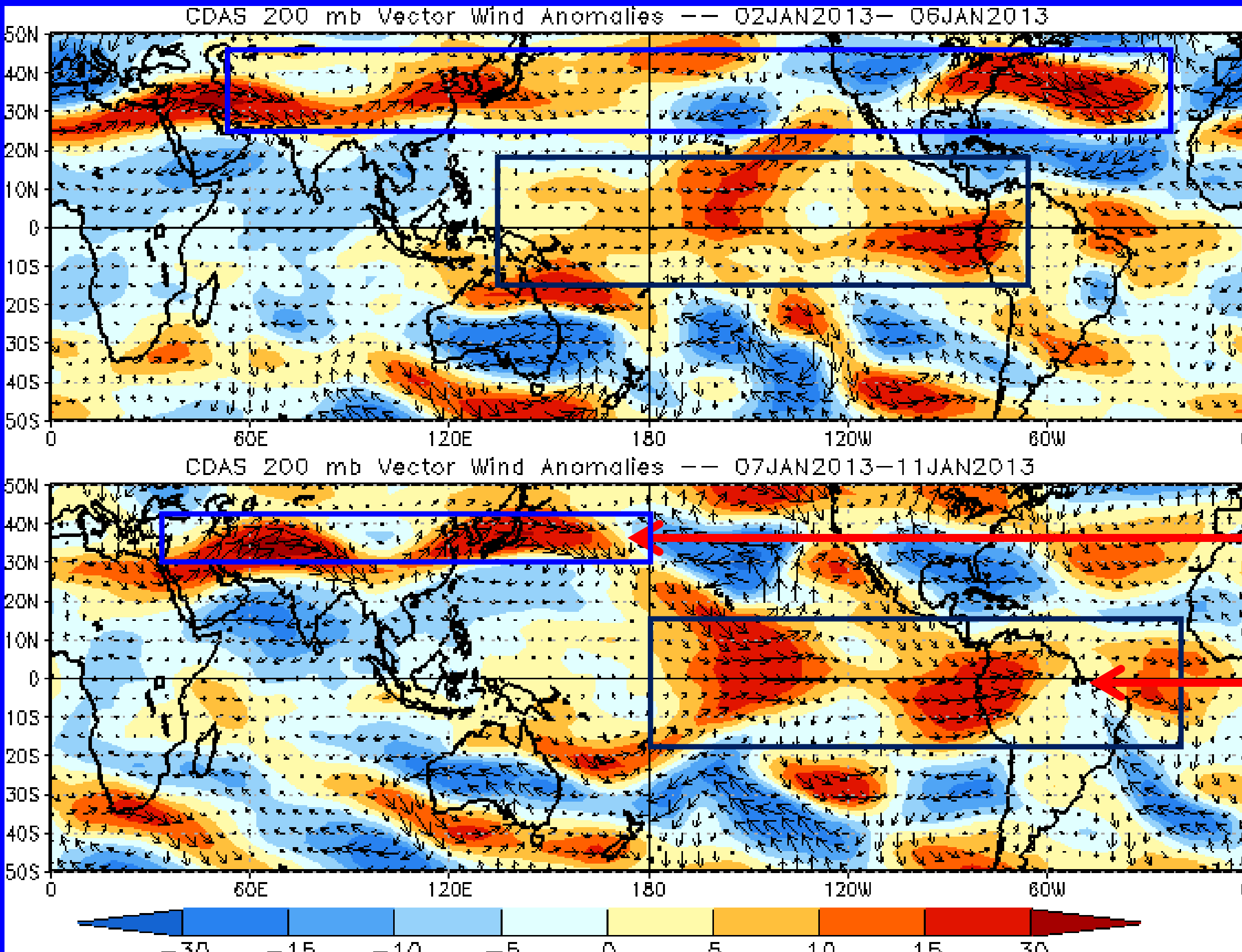
The large scale velocity potential pattern closely resembles a wave-1 structure, indicative of organized MJO activity. Upper-level convergence is strongest over the Africa and the western Indian Ocean. Upper-level divergence is evident over most of the Maritime Continent and the Pacific. The signal over the Atlantic sector is less coherent than in previous days.

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 located farther north across the Northern mid-latitudes. The eastward extension of westerly anomalies near Japan is consistent with the MJO moving into the Pacific.

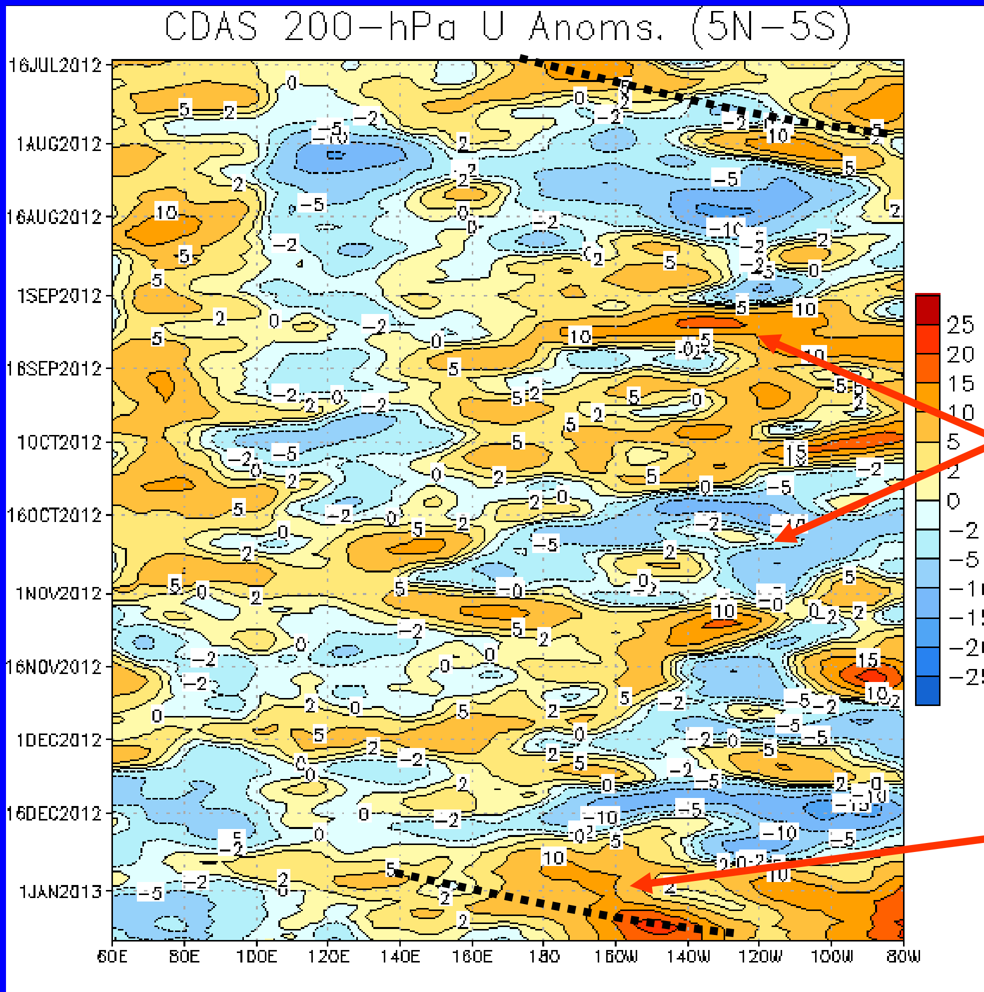
Recently, strong westerly anomalies (black boxes) have shifted eastward over the eastern equatorial Pacific, also consistent with MJO.

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

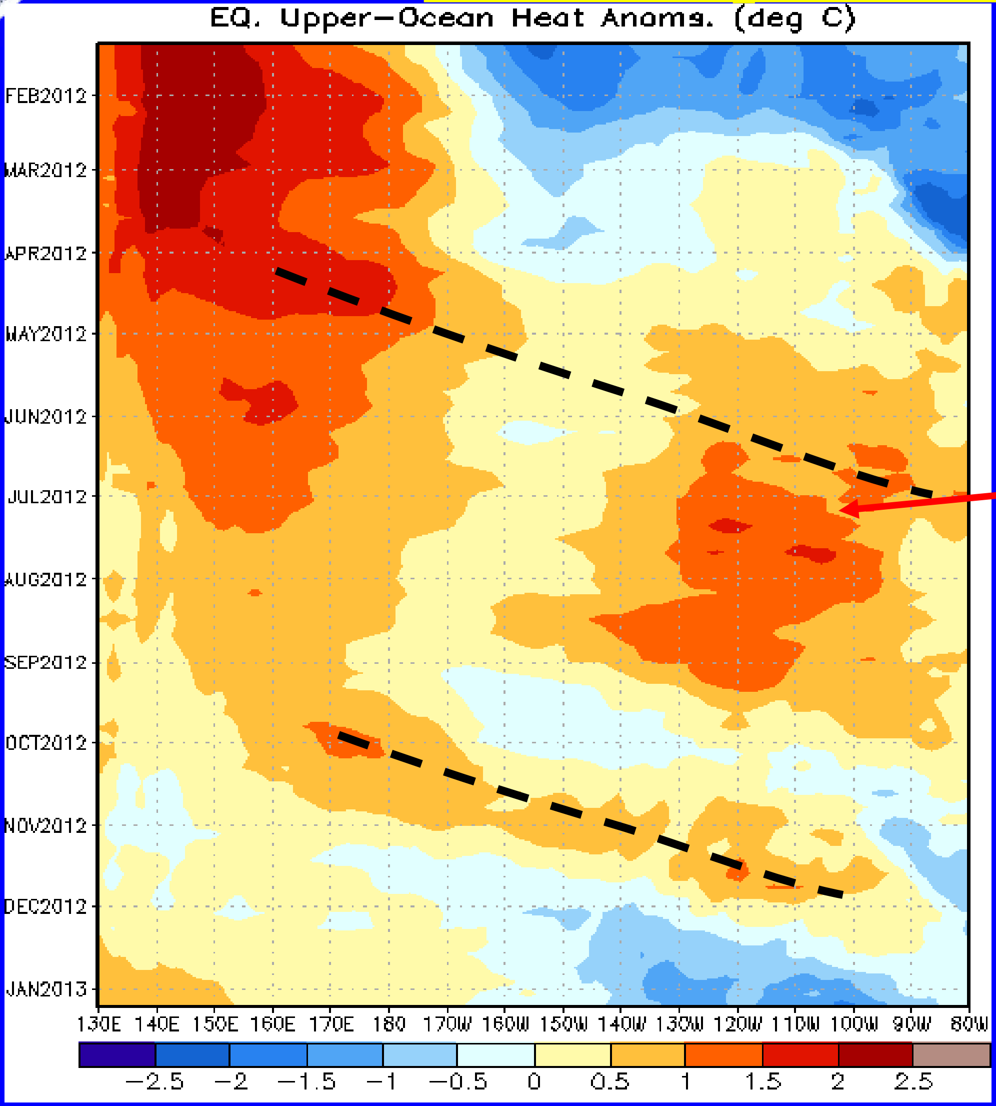
Westerly anomalies shifted eastward across the Pacific during July and early August.

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

There is now some eastward propagation evident in late December and early January associated with the strengthening 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 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).

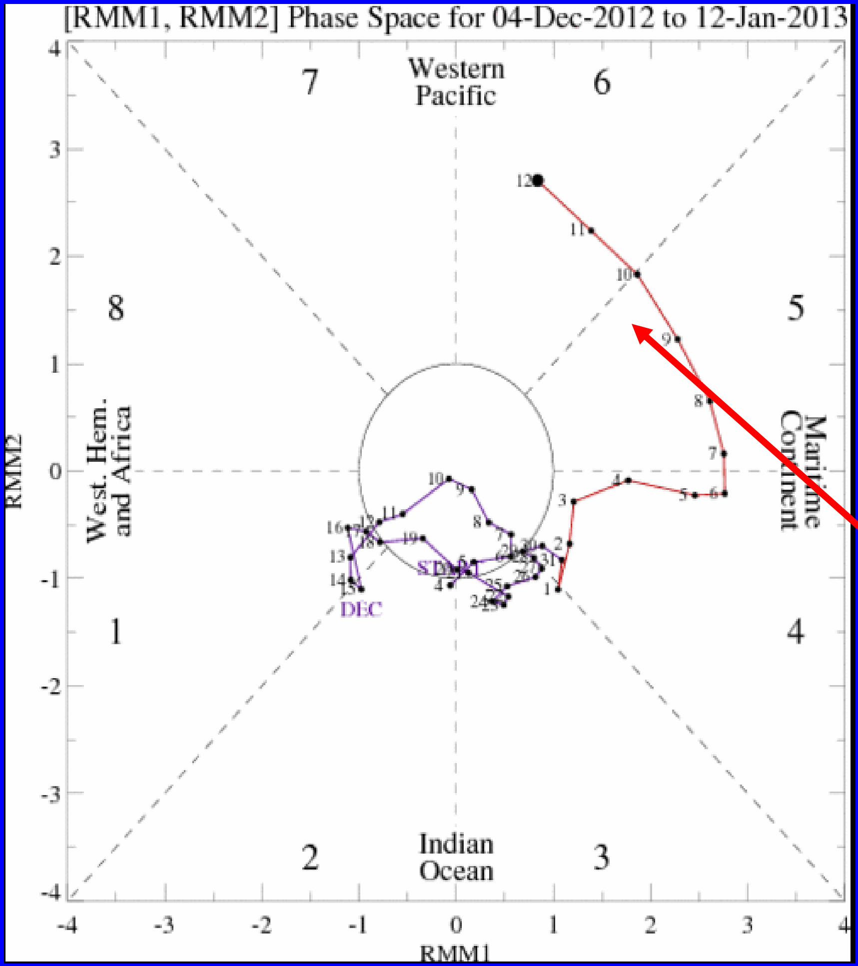
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

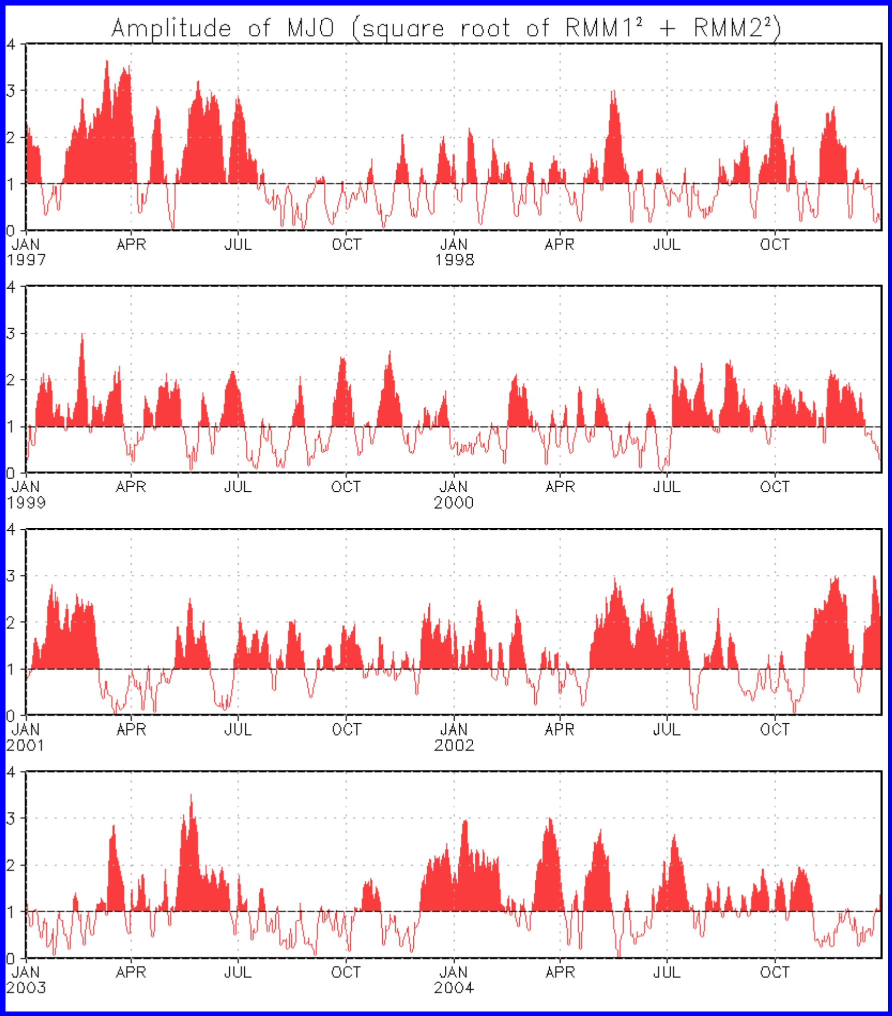
MJO Index -- Recent Evolution

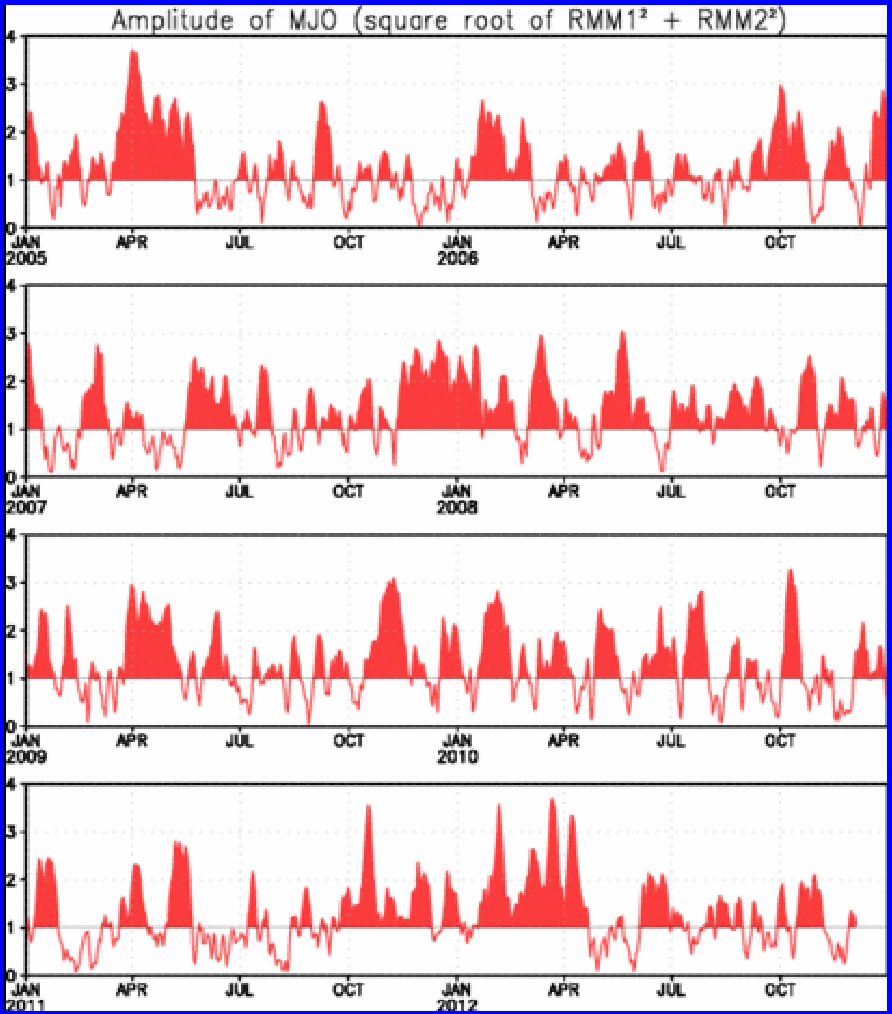


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index shows rapid strengthening and eastward propagation of the MJO signal over the past two weeks. The rapid propagation captured by this index suggests atmospheric Kelvin wave activity is also contributing to this signal.

MJO Index – Historical Daily Time Series





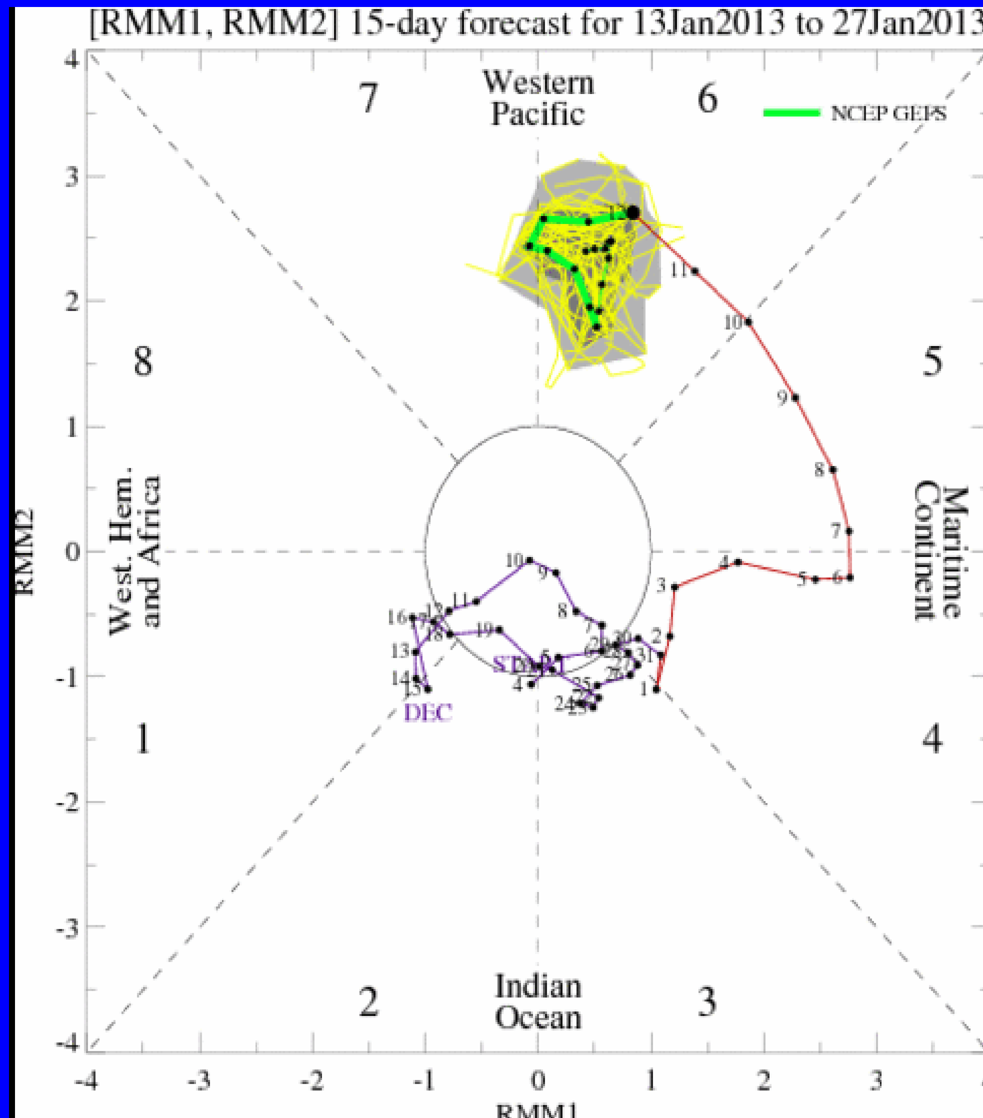
Time series of daily MJO index amplitude from 1997 to present. Plots put current MJO activity in historical context.

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

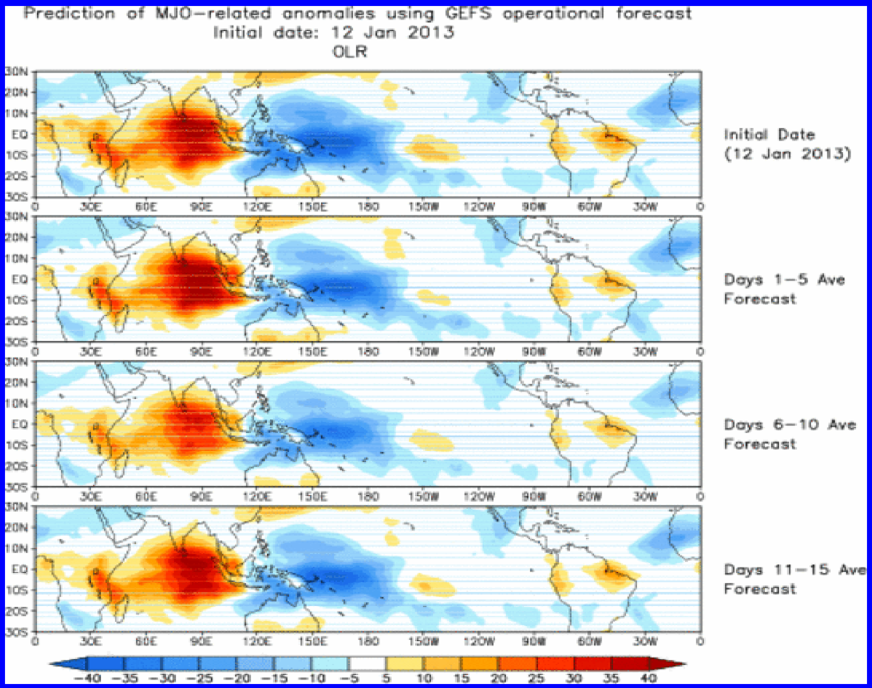


The bias-corrected ensemble GFS forecasts indicate a decrease in amplitude and eastward propagation during the next two weeks. Other model forecasts, however, indicate less decrease in the MJO signal. Other modes of subseasonal variability are impacting the GFS forecast.

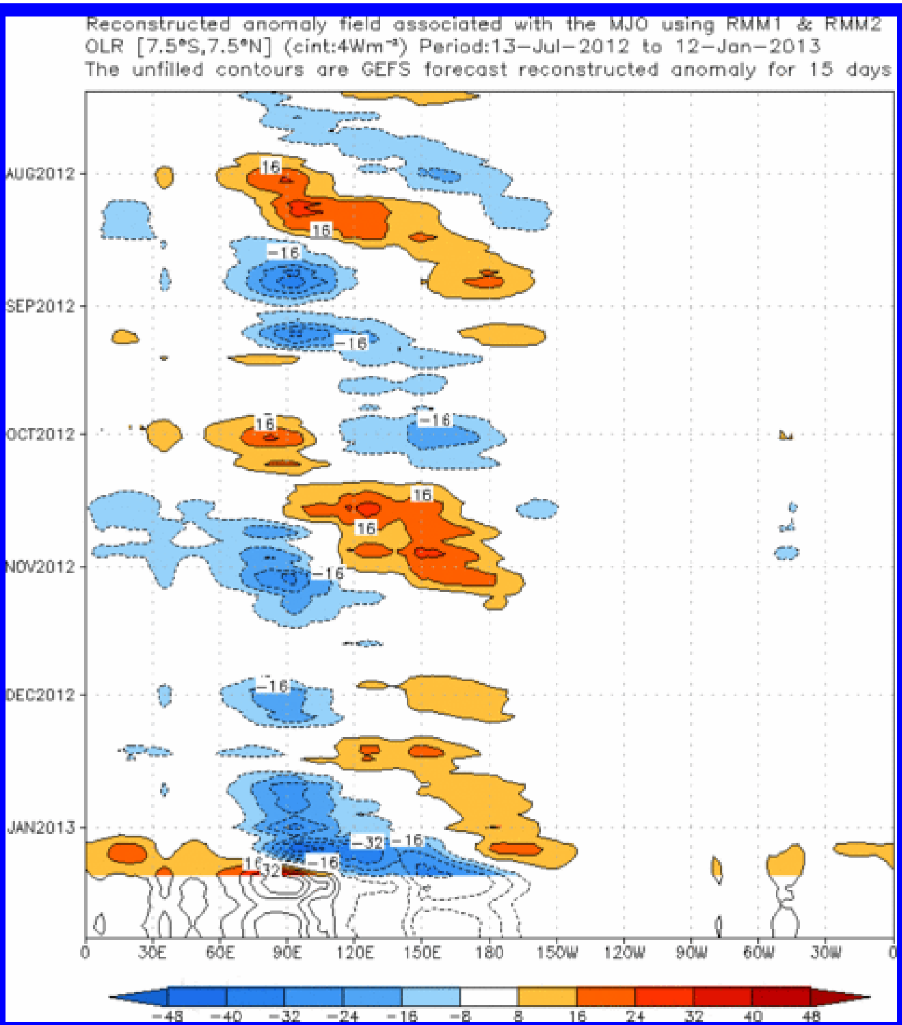
Ensemble Mean GFS MJO Forecast

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

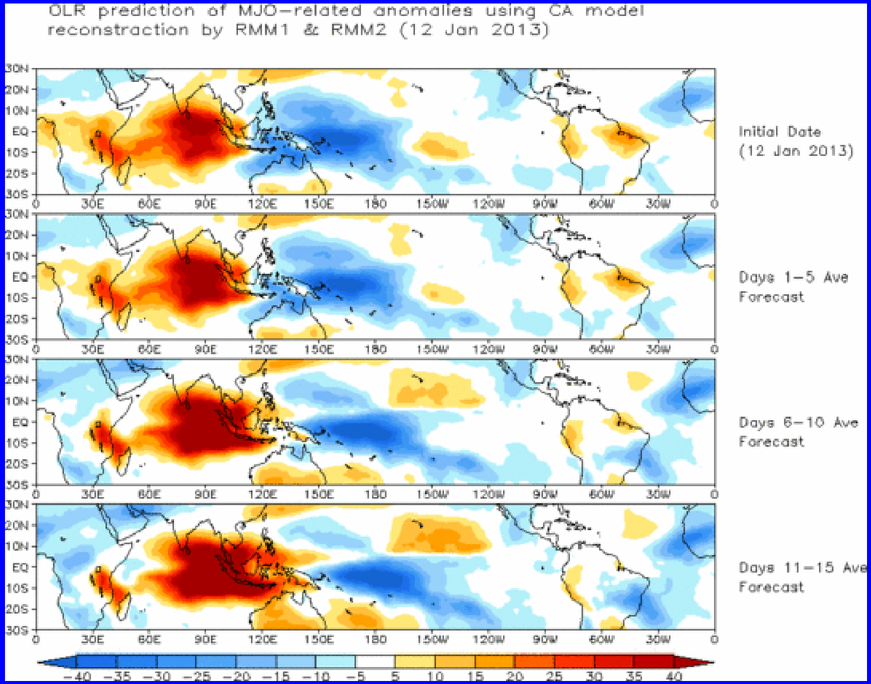


The ensemble mean GFS forecast indicates very little eastward propagation toward the central Pacific. Drier-than-average conditions are forecast for the Indian Ocean, parts of Africa and South America.

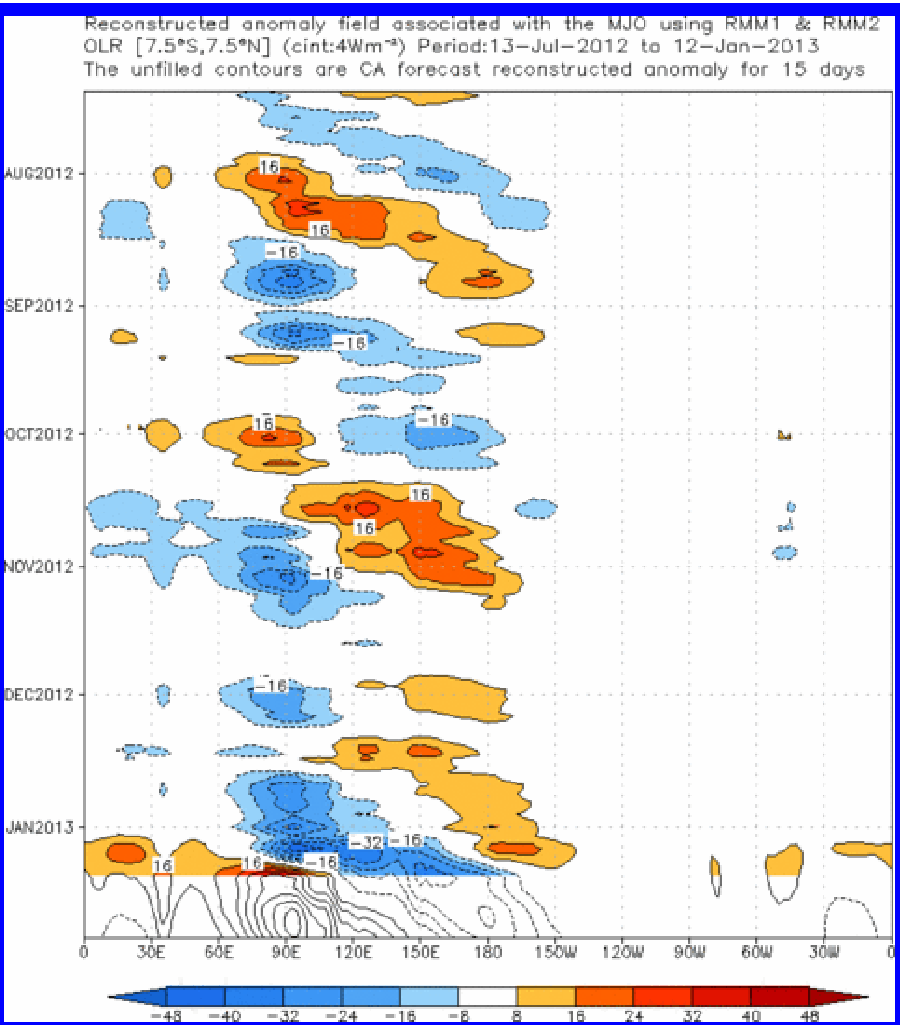
Constructed Analog (CA) MJO Forecast

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



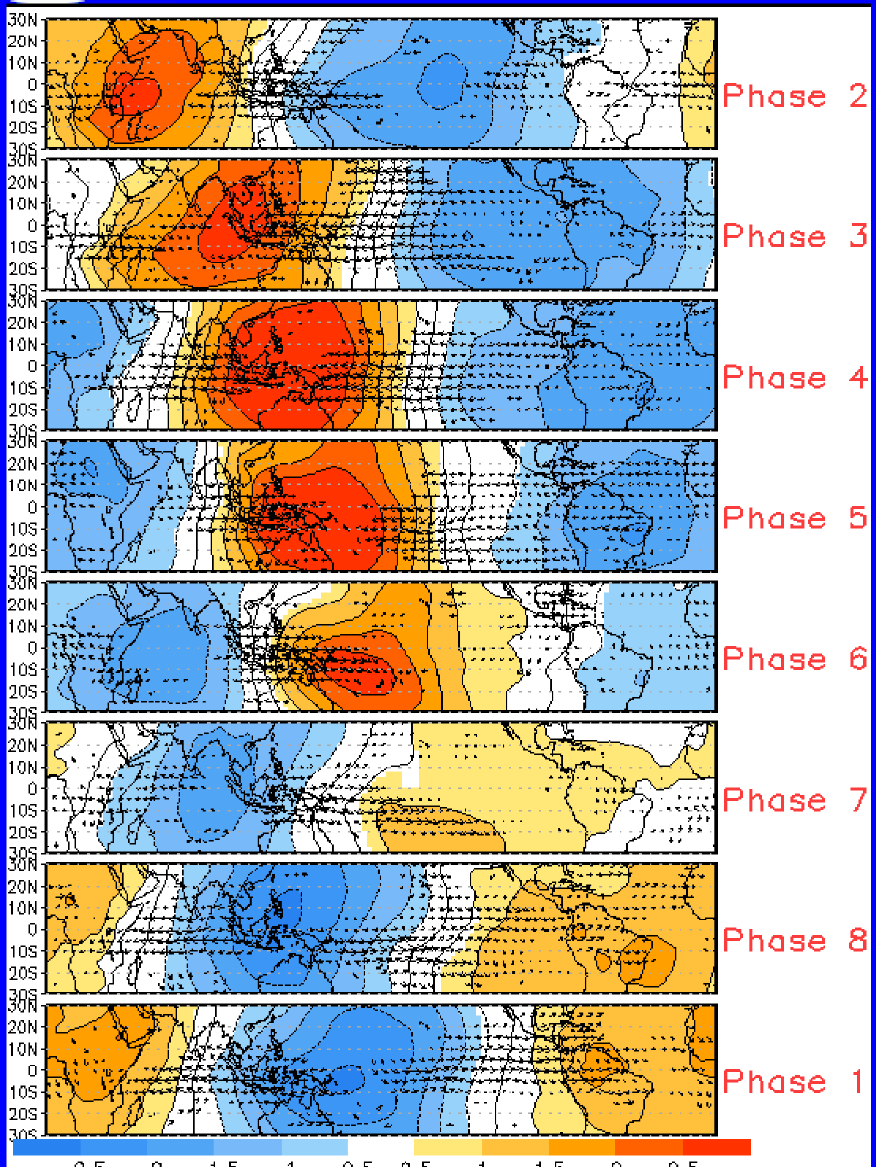
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



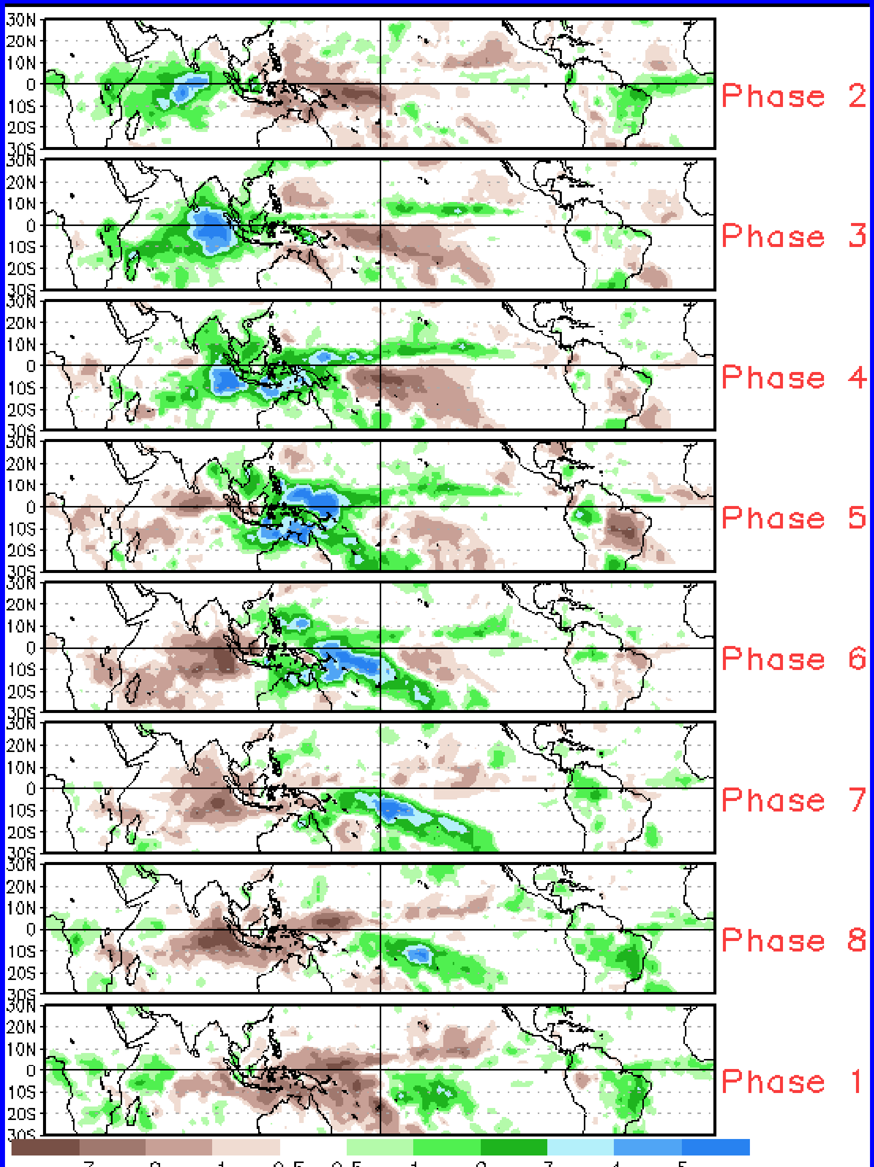
This statistical forecast maintains eastward propagation unlike the GFS based forecast, with enhanced convection moving into the central Pacific and suppressed convection shifting over the Maritime Continent.

MJO Composites – Global Tropics

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

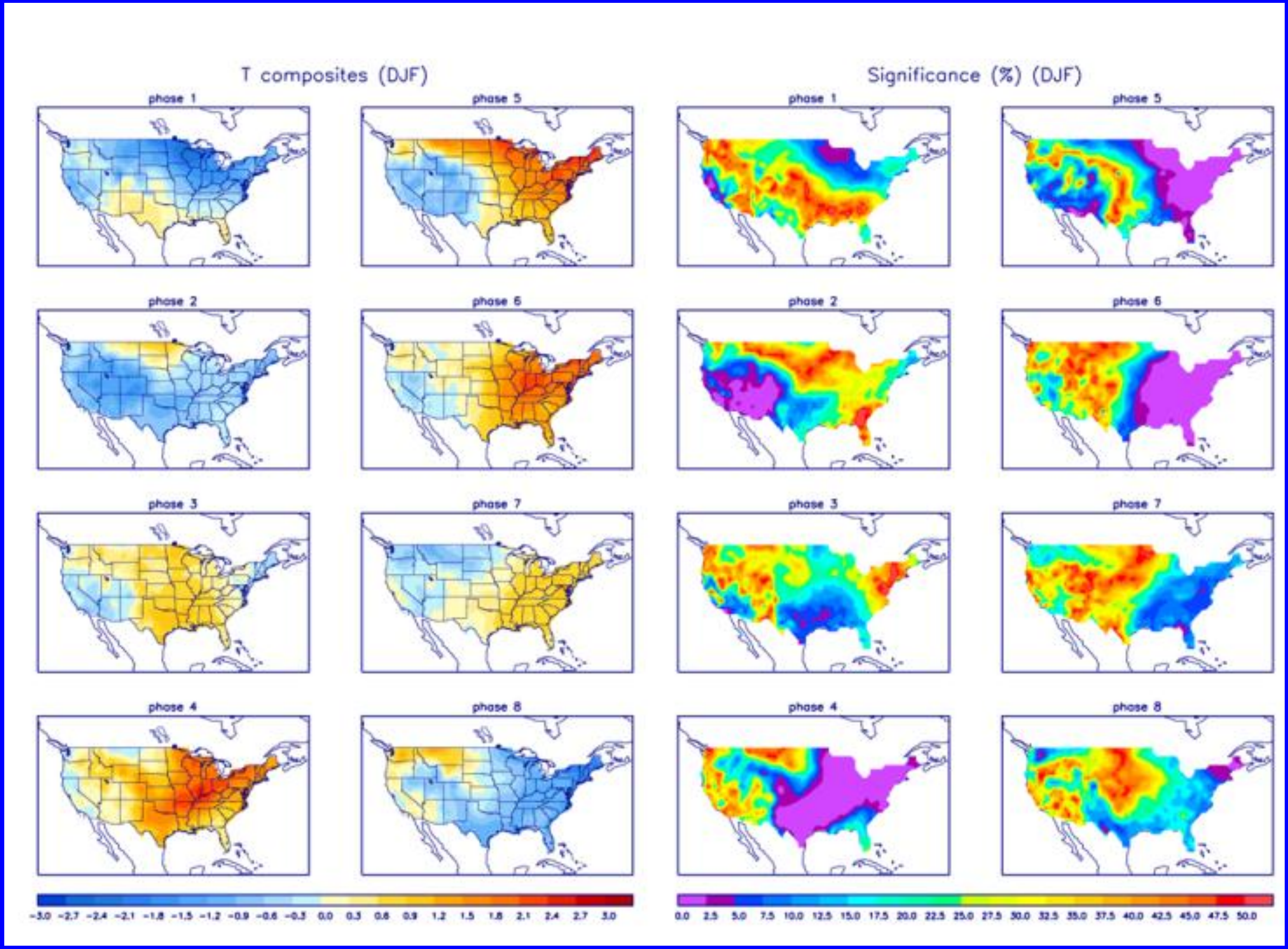


Precipitation Anomalies (Nov-Mar)



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.

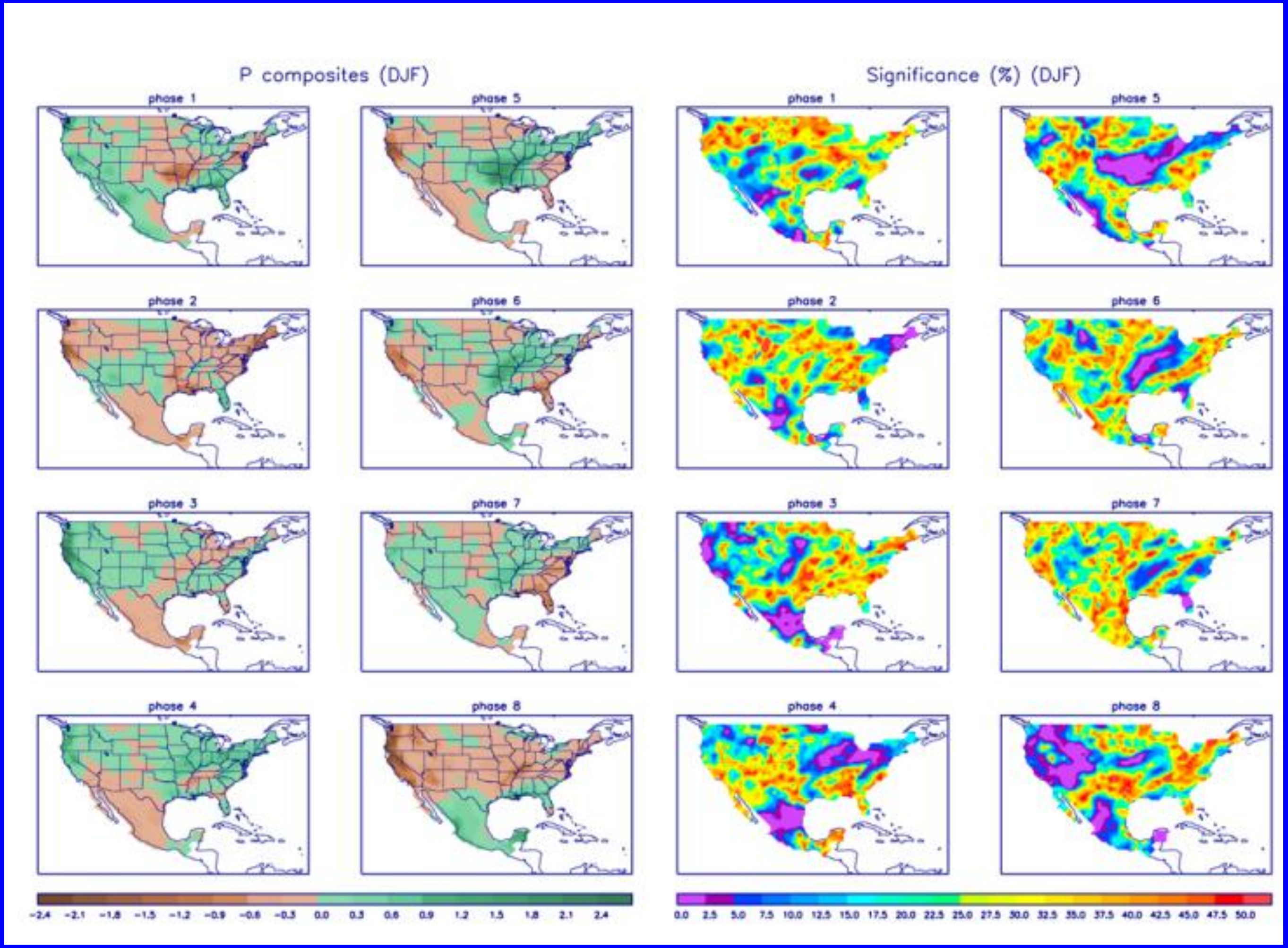


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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