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

Update prepared by
Climate Prediction Center / NCEP
January 28, 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 but observational indicators continued to become less coherent. The enhanced convective phase is centered across the western Hemisphere.

- Other forms of subseasonal variability remain active and have contributed to making the MJO signal less clear. This is expected to be temporary and dynamical model MJO index forecasts are in good agreement of renewed eastward propagation during the period.

- Primarily based on dynamical model MJO index forecasts, the MJO is forecast to remain active with the enhanced convective phase shifting to Africa over the next 2 weeks.

- The MJO favors enhanced rainfall across parts of the south central Pacific Ocean and suppressed convection for the eastern Indian Ocean (Week-1), the Maritime continent (Weeks 1-2) and the western Pacific (Week-2).

- For the U.S., the MJO favors, on average, split flow and ridging across the western U.S. and a mean trough across the east until about mid-February. The MJO would also favor an active southern jet during this similar period. Thereafter, the MJO would support a tendency for a mean trough to develop across the western U.S. near the last week of February.

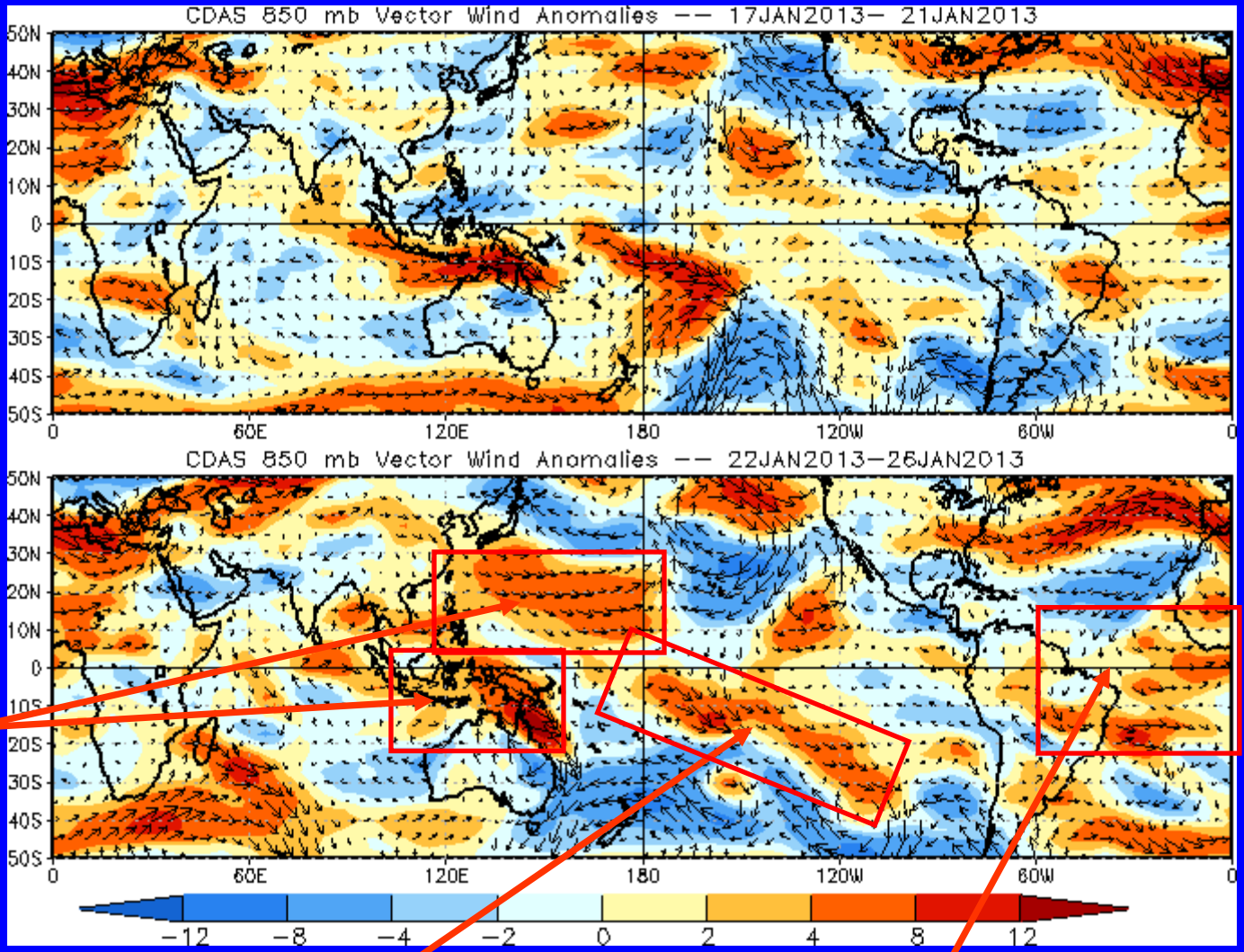
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 continued across the Maritime continent and northern Australia and increased across the northwest Pacific during the past five days.

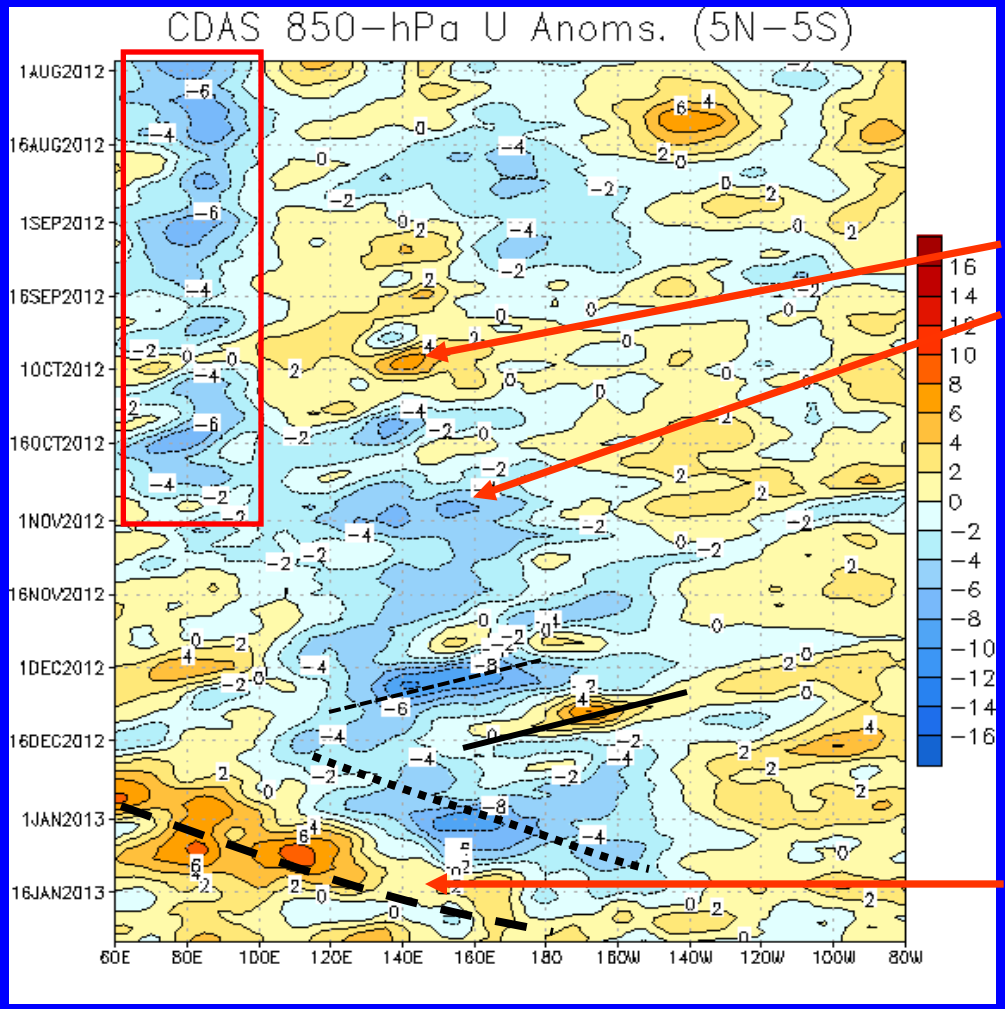
Westerly anomalies shifted far east and south during the past five days and extended into the southeast Pacific subtropics.

Westerly anomalies increased 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

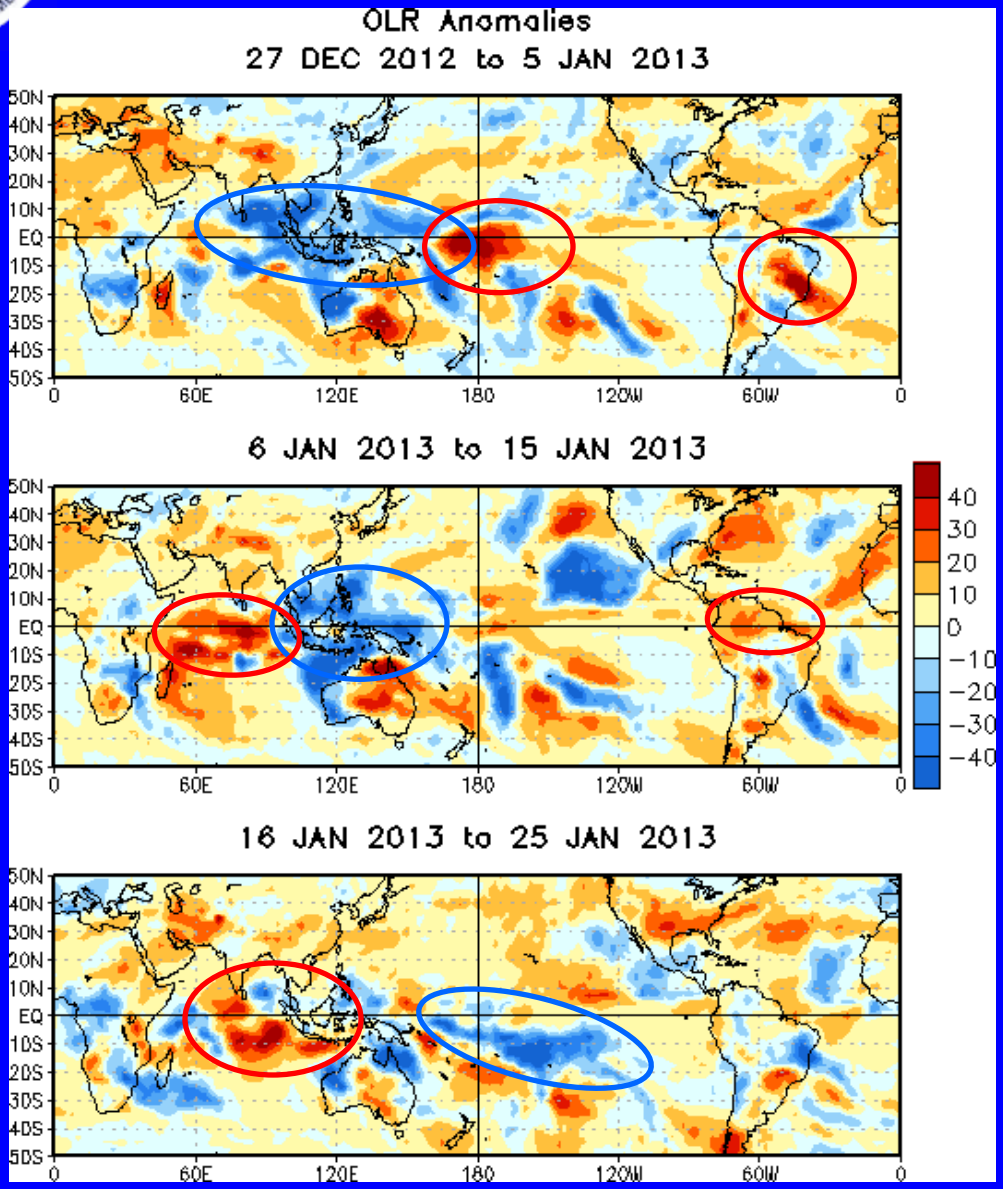
Easterly anomalies persisted near 80E for much of August to October (red box).

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 persisted into December.

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.

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)

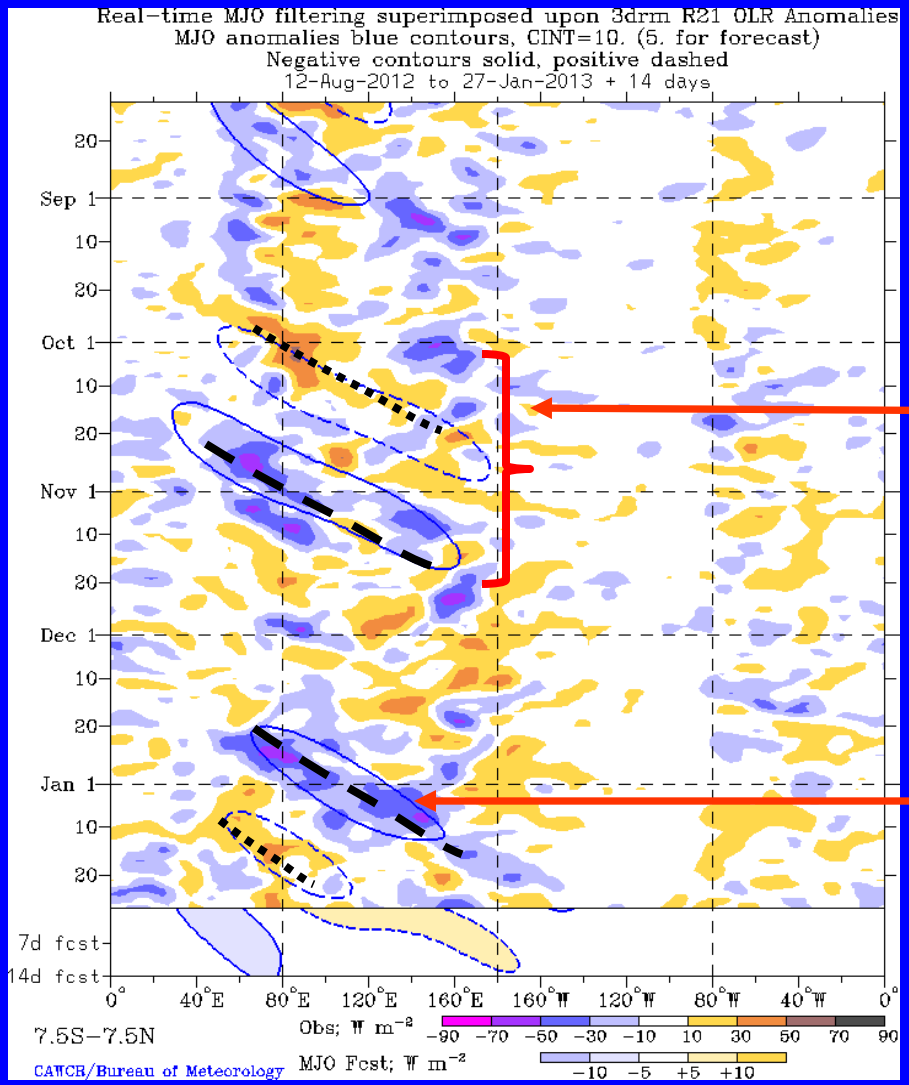
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During late December and early January, enhanced convection was centered over the Maritime Continent. Suppressed convection was evident near the Date Line and eastern Brazil.

During early-to-mid 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 by late mid-to-late January and began to increase across parts of Africa. Suppressed convection continued over 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)

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.

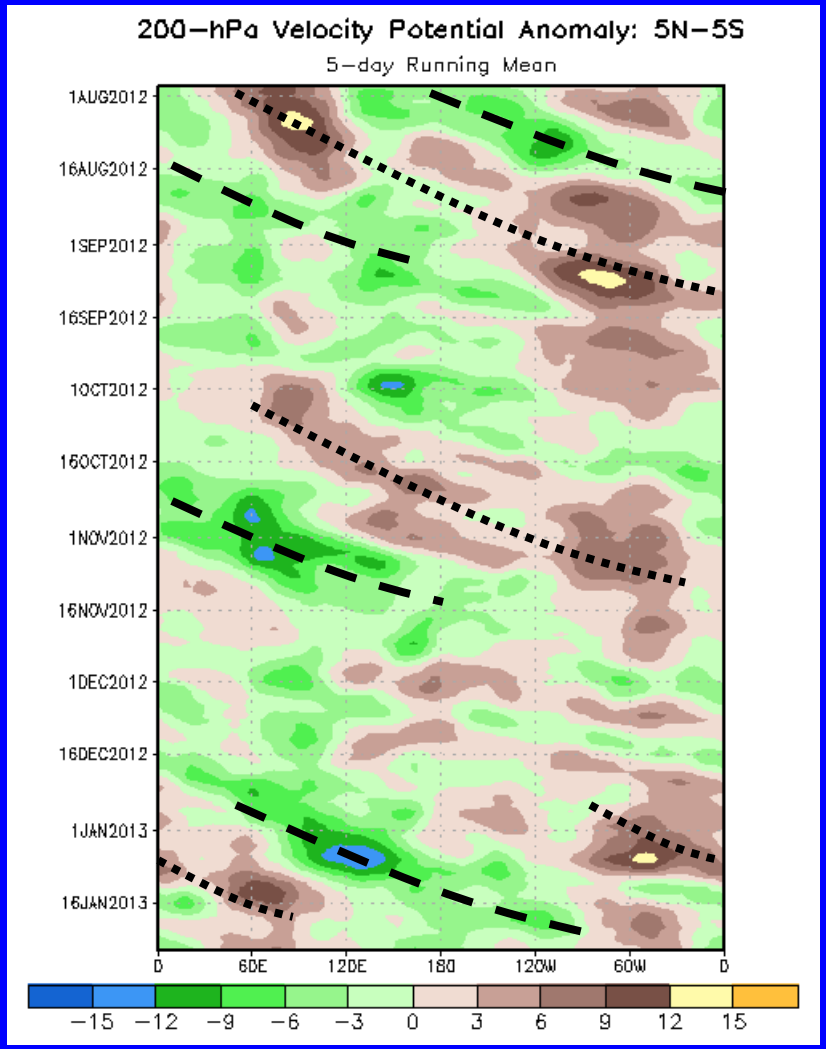
During late November and much of December, convective anomalies were disorganized.

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. In recent days, the anomalies have become less organized.

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 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.

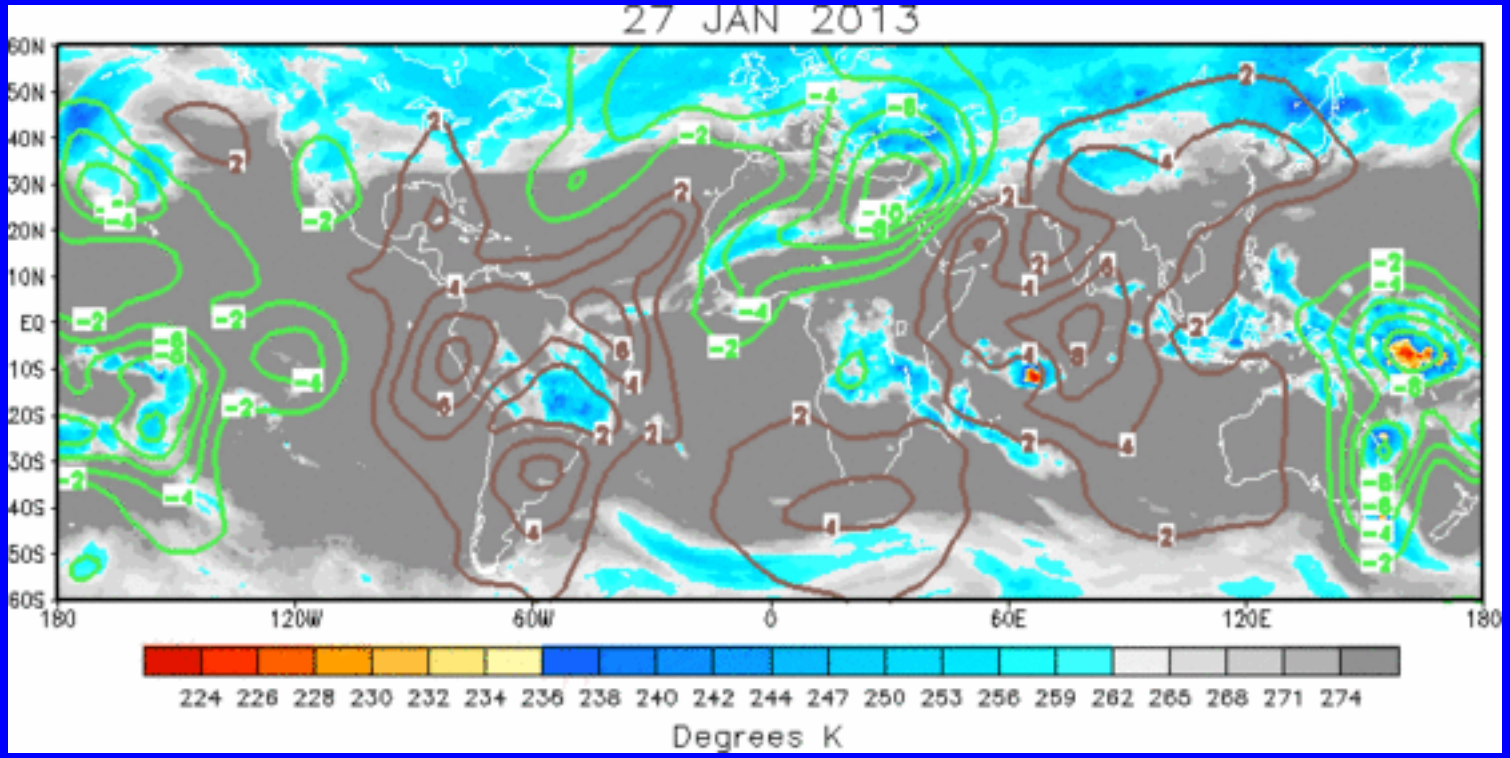
During most of December, anomalies were weak with less coherent eastward propagation. Other subseasonal variability was more prevalent during this period.

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

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

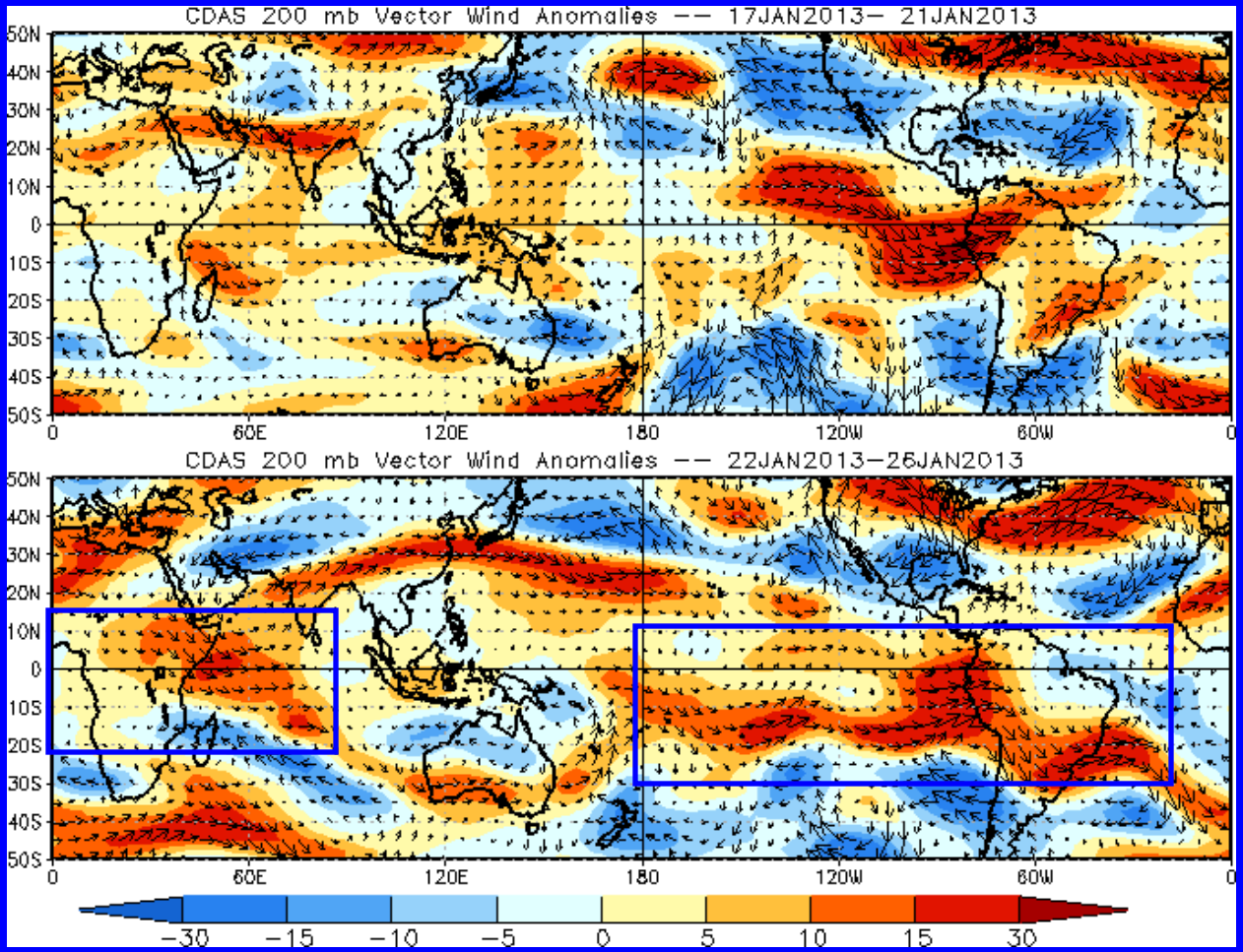
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The large scale velocity potential pattern remained less coherent than that displayed earlier in January, in part because of interference from other modes subseasonal tropical variability and tropical cyclone activity. Upper-level divergence is strongest over parts of the Pacific while upper-level convergence is evident over 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

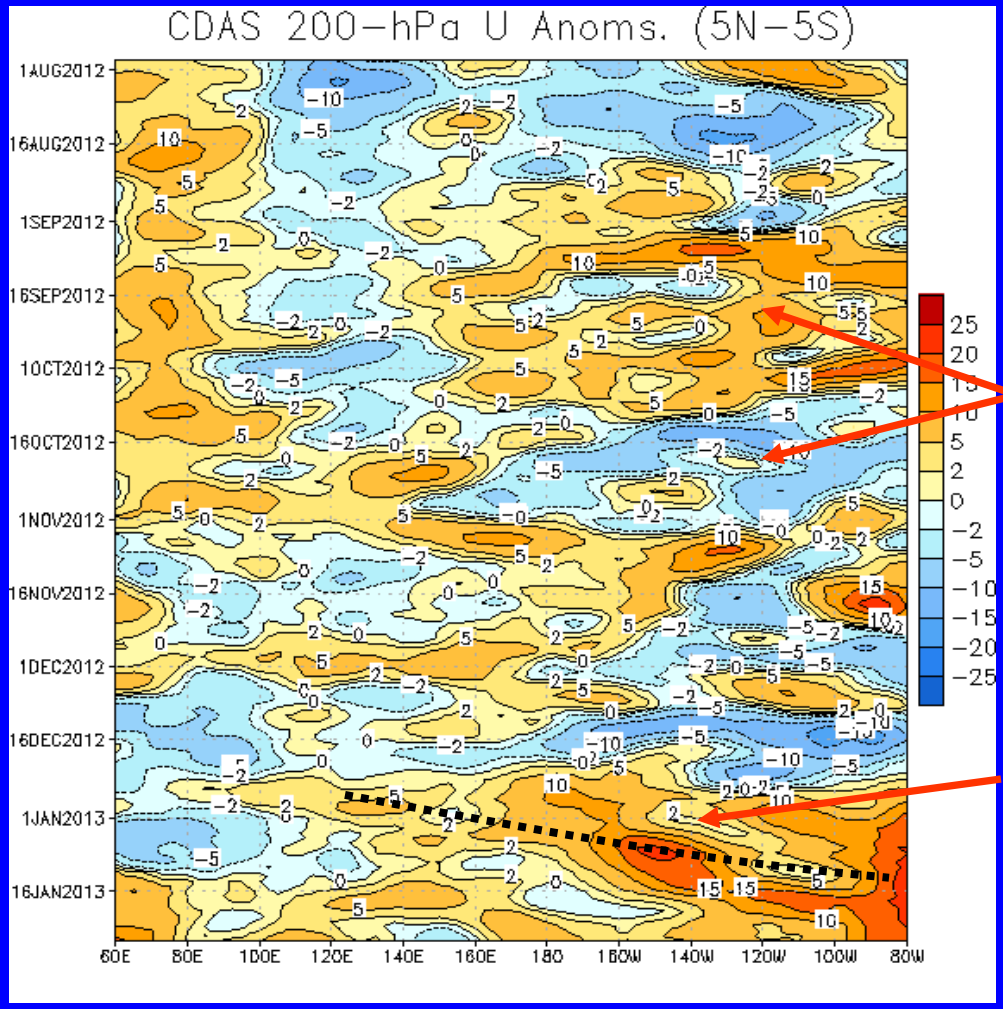
Red shades: Westerly anomalies

Westerly anomalies (blue boxes) continued across the eastern Pacific and South America as well as across Africa and the western Indian Ocean 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



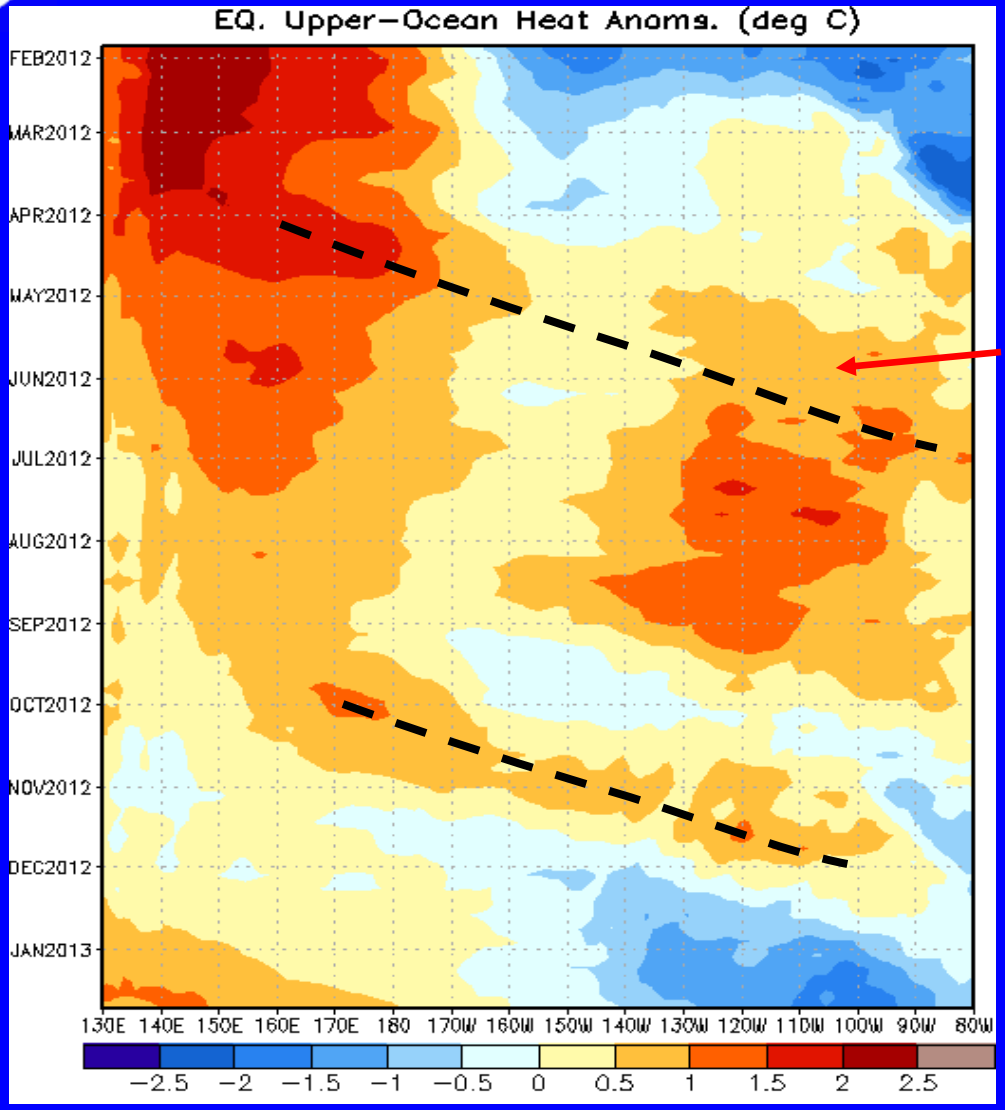
Time

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).

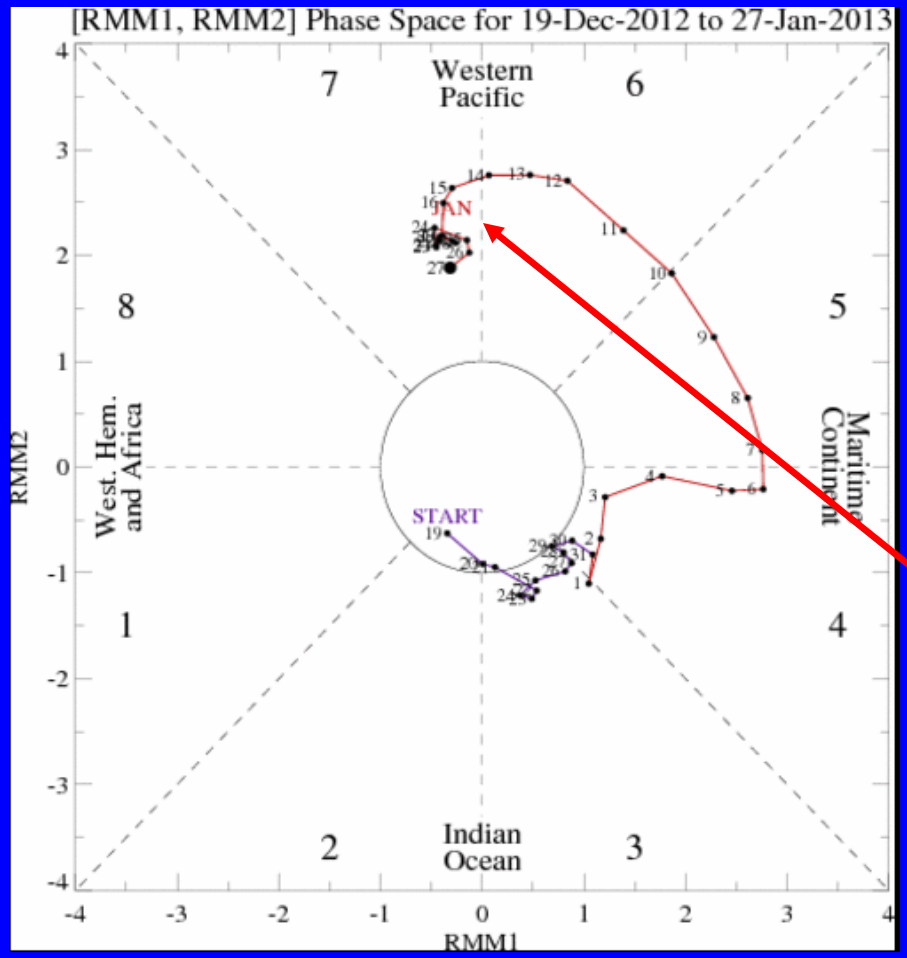
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

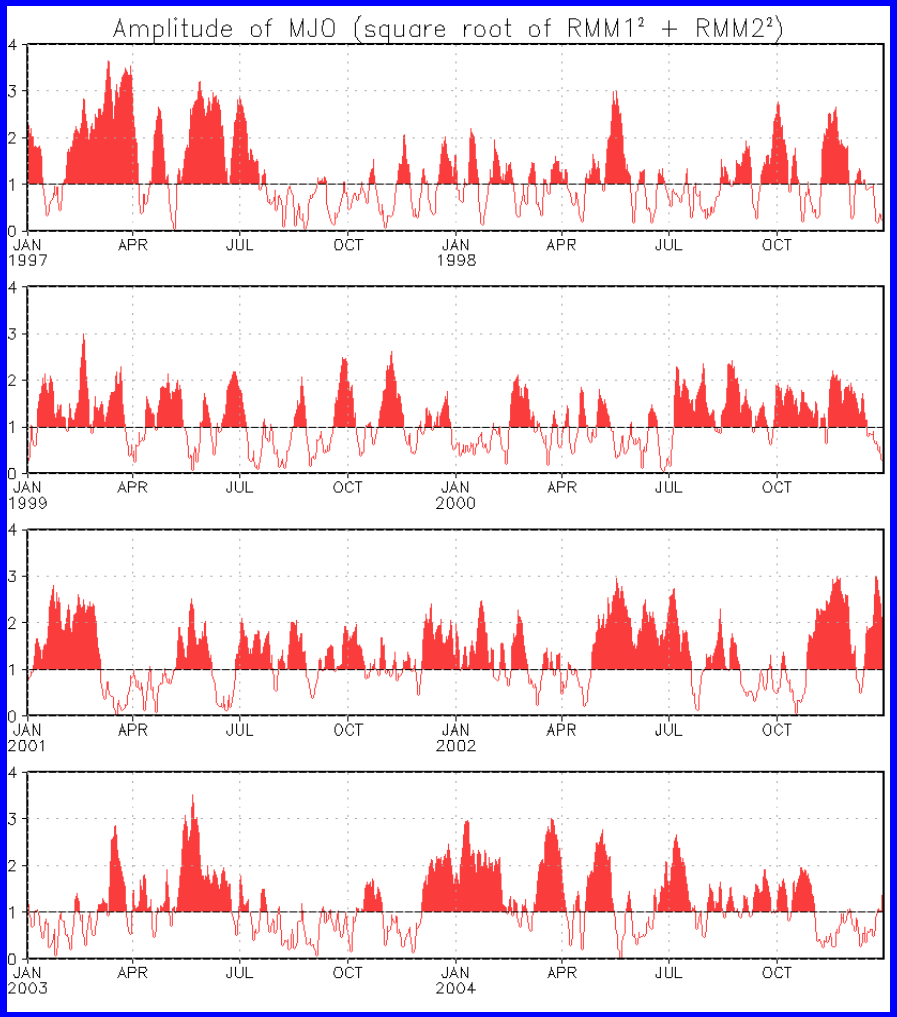
MJO Index -- Recent Evolution

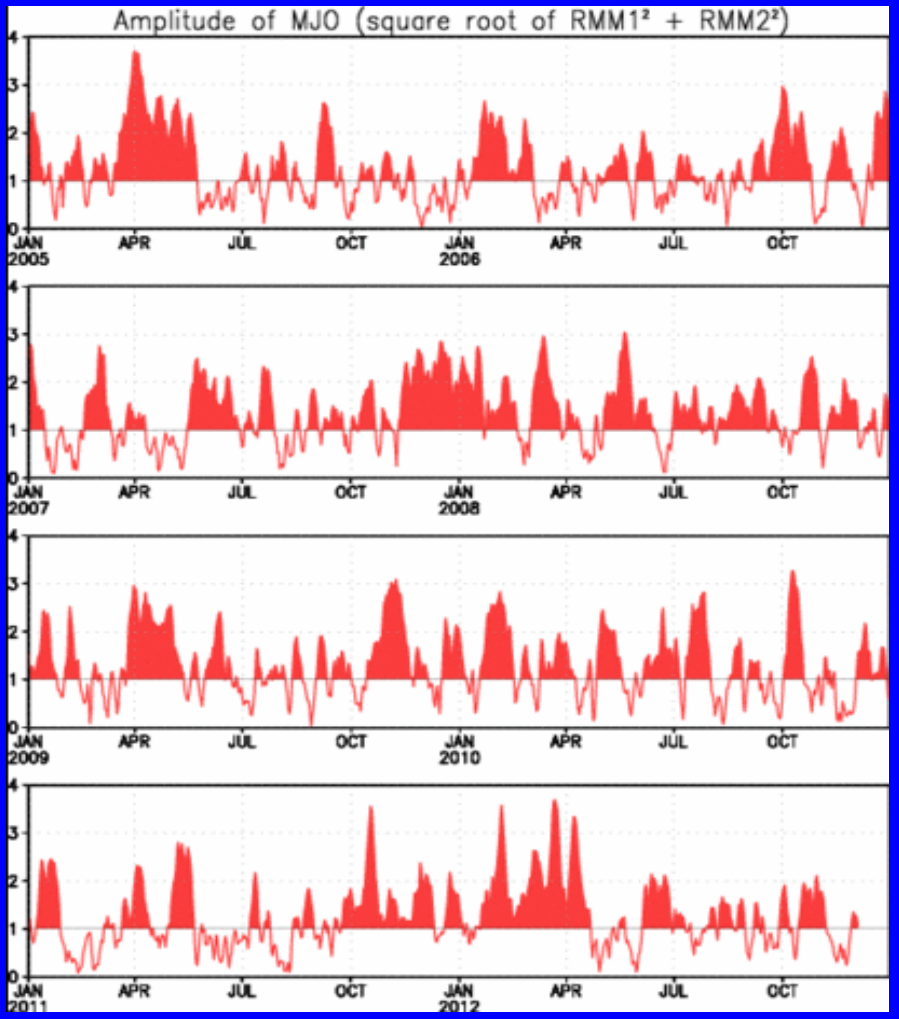


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

Eastward propagation of the MJO index has slowed during the past couple of weeks, in part as a result of interference with other types of subseasonal tropical variability.

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.

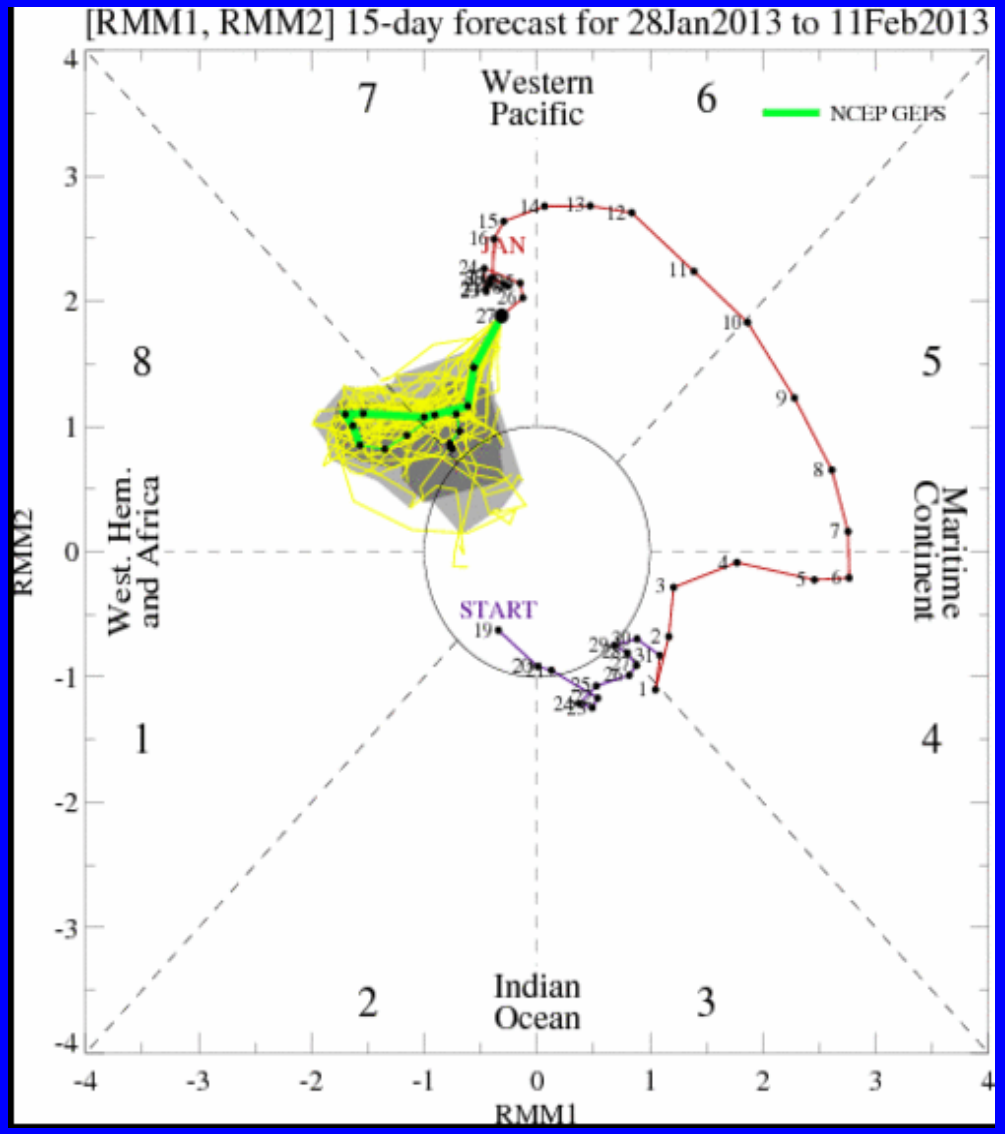
Ensemble GFS (GEFS) MJO Forecast

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

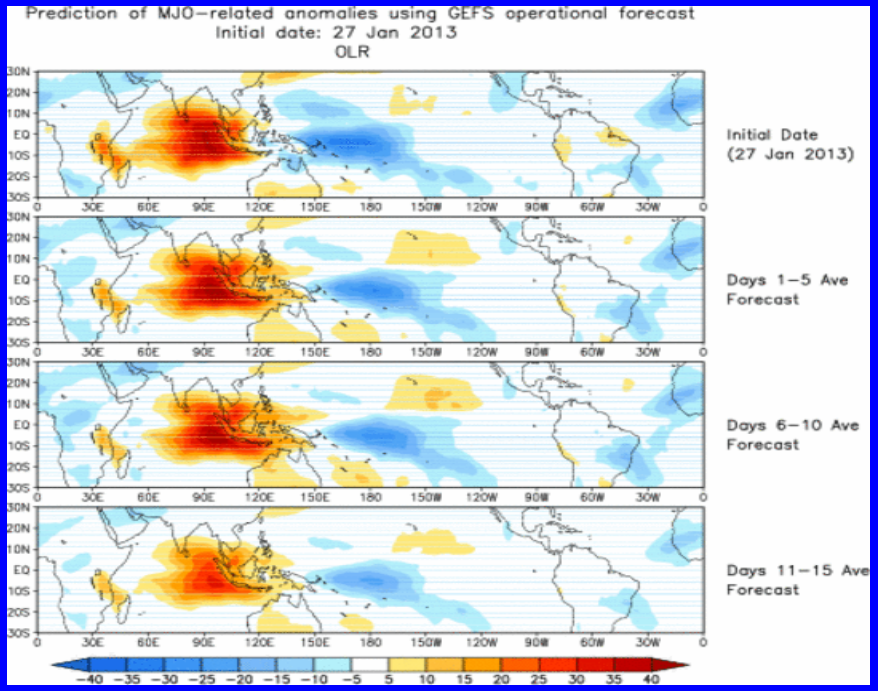
The bias-corrected ensemble GFS forecasts indicate a continuation of eastward propagation during Week-1, but a weakening of the MJO index thereafter.



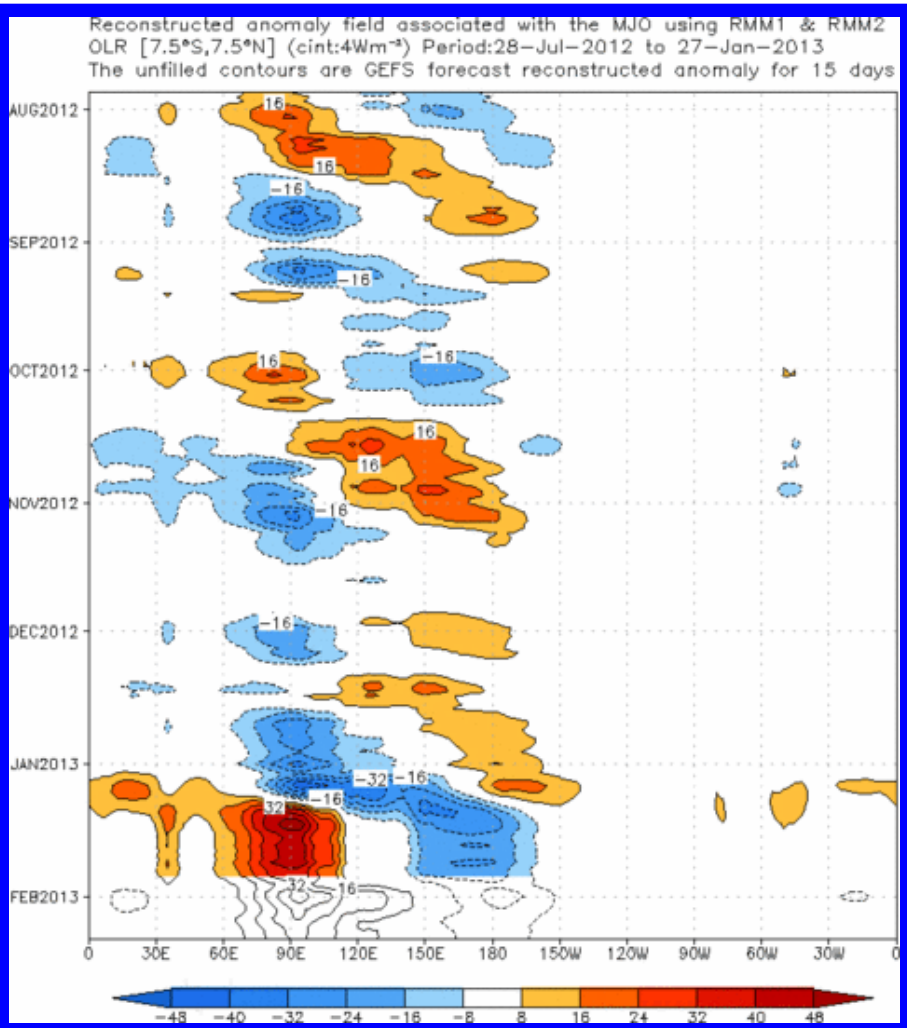
Ensemble Mean GFS MJO Forecast

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

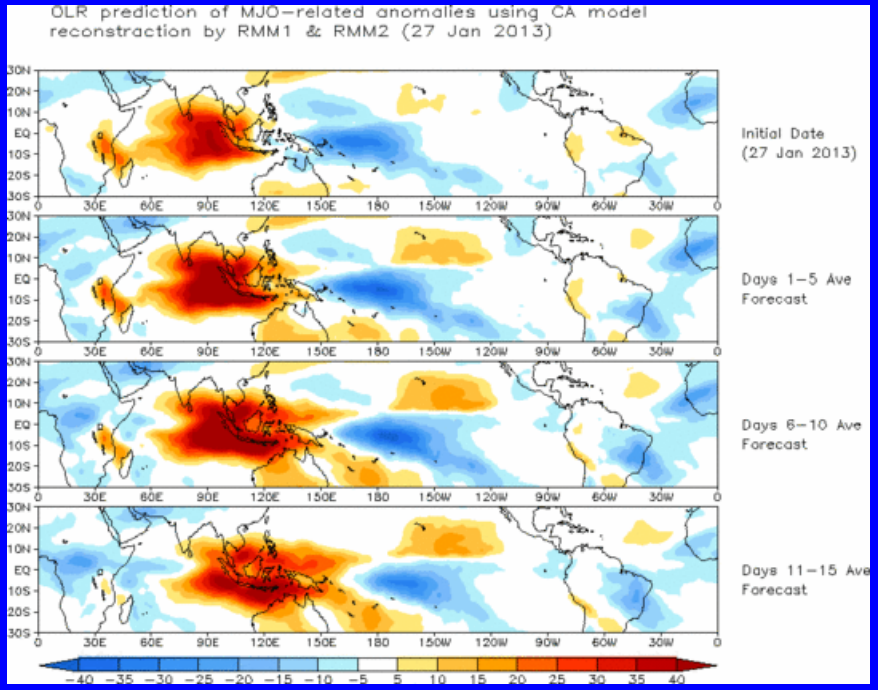


The ensemble mean GFS forecast indicates enhanced convection across parts of the central Pacific as well as South America and Africa. Suppressed convection is forecast to shift slightly eastward to include the western Maritime continent prior to Week-2.

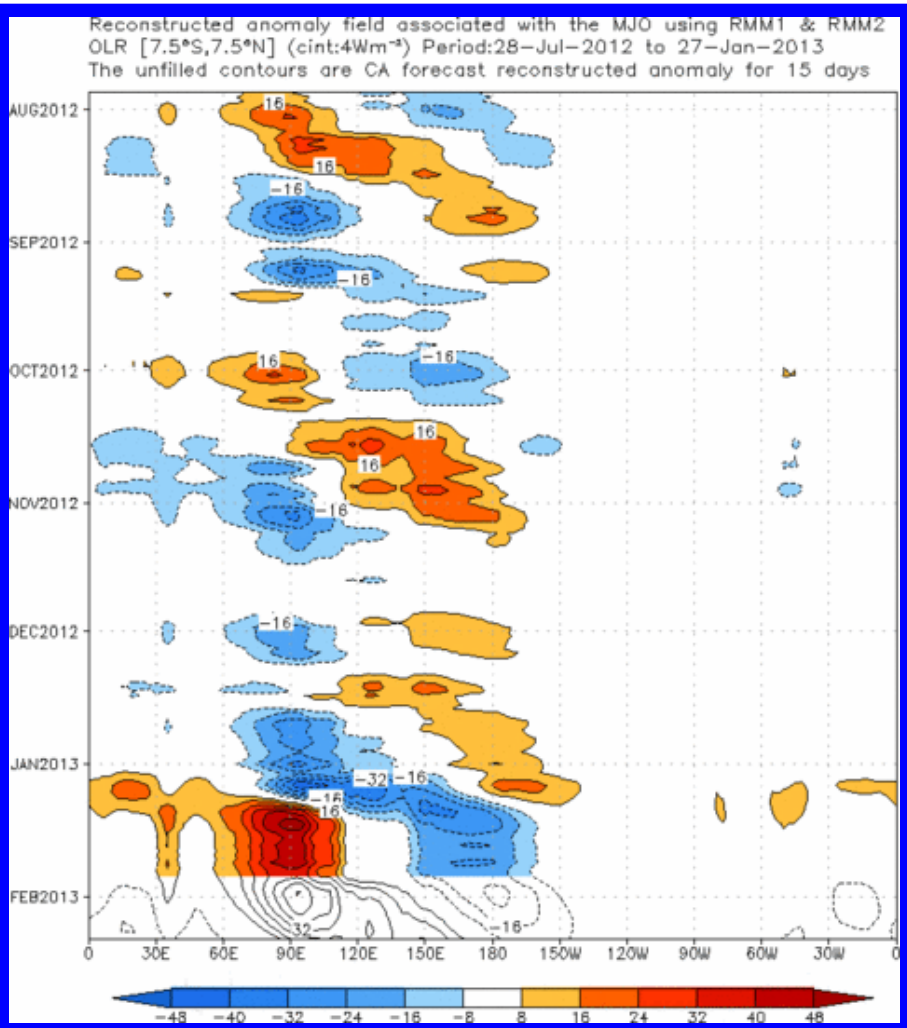
Constructed Analog (CA) MJO Forecast

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



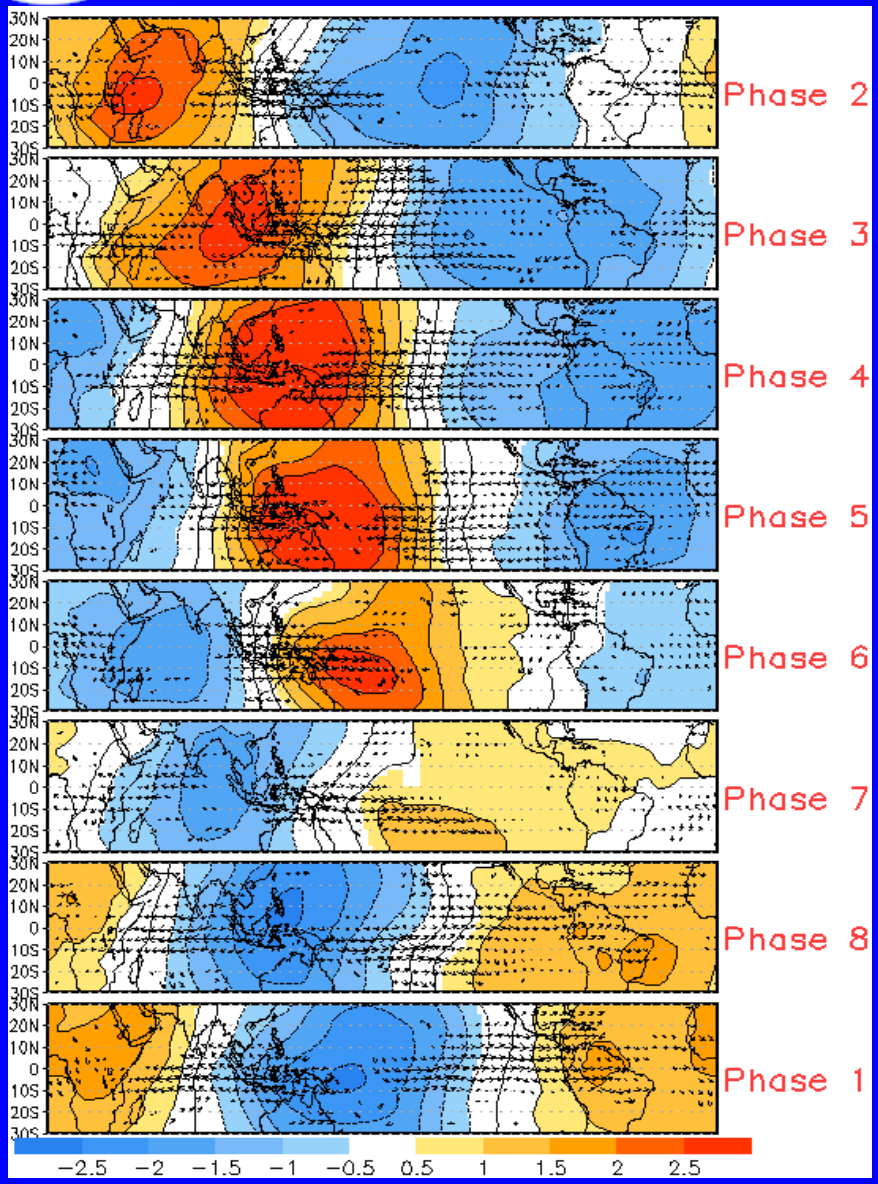
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



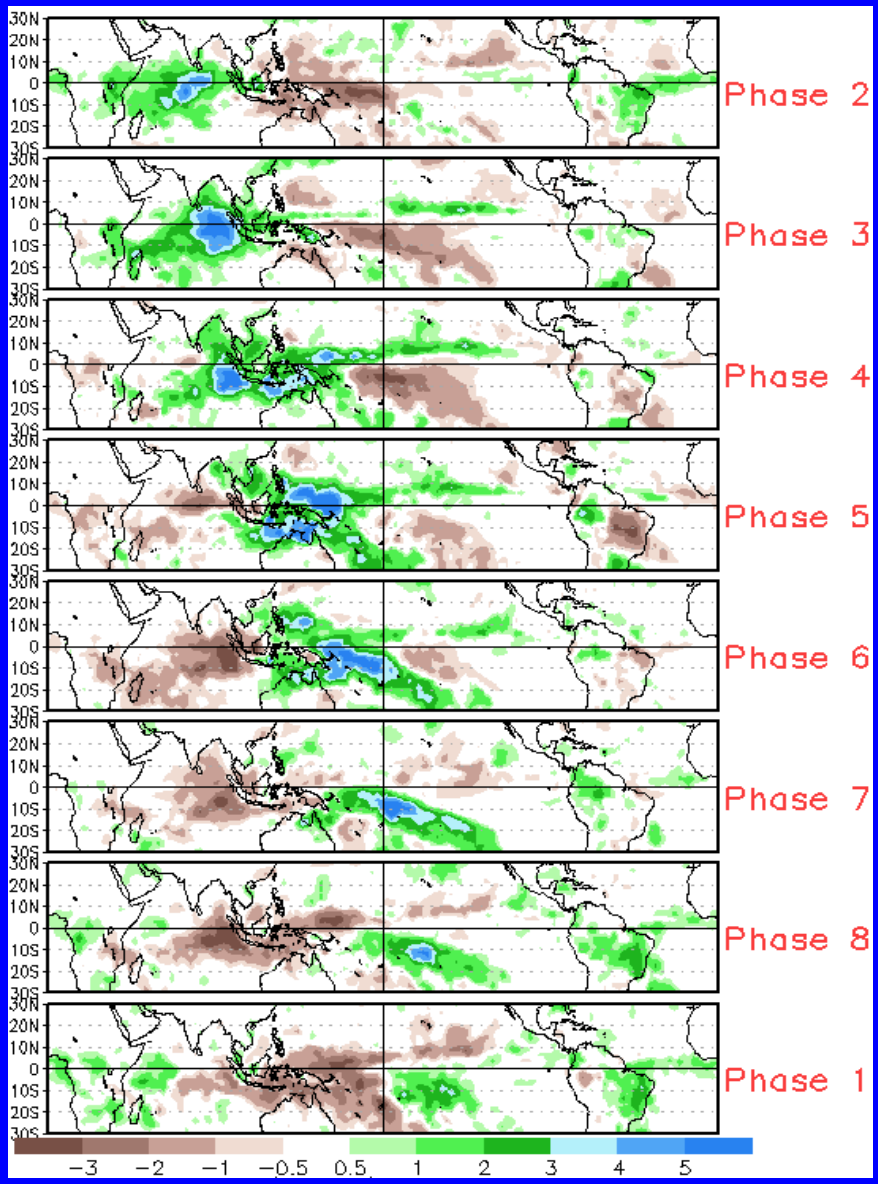
This statistical forecast shows slow eastward propagation during the period with enhanced convection increasing across South America and Africa over the period and suppressed convection shifting to the Maritime Continent by the end of Week-2.

MJO Composites – Global Tropics

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

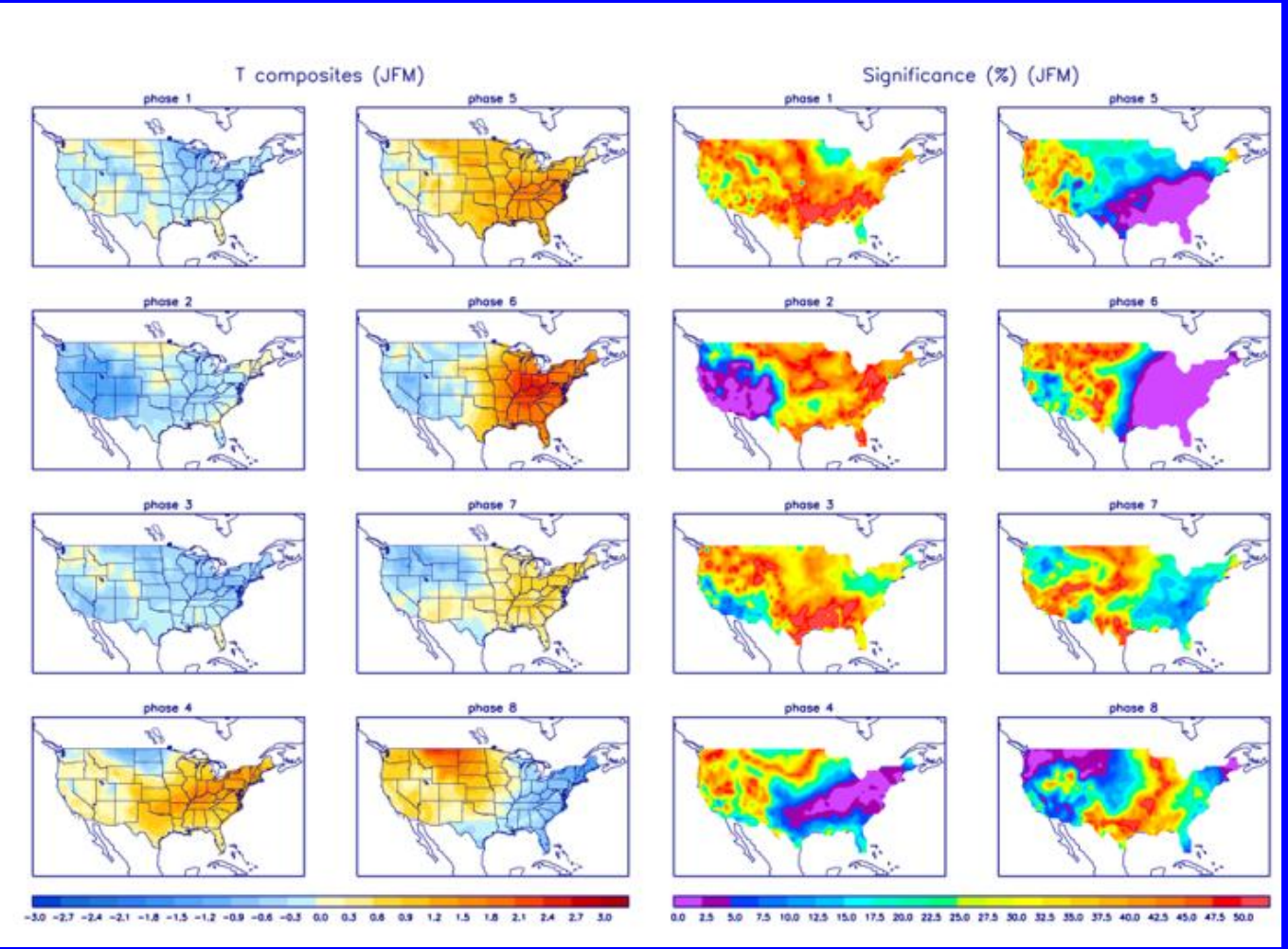


Precipitation Anomalies (Nov-Mar)



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.**

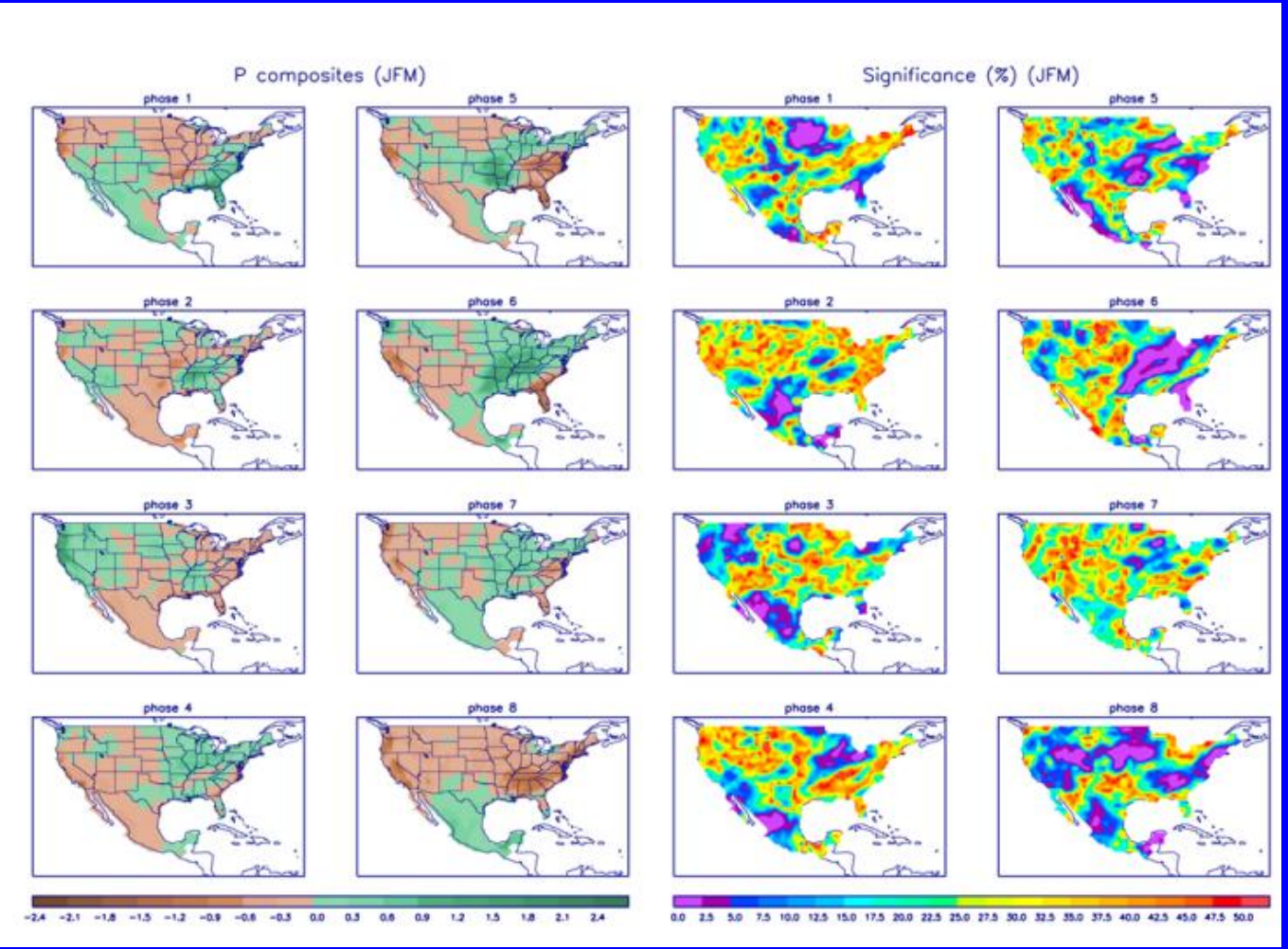


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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