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

Update prepared by
Climate Prediction Center / NCEP
February 20, 2012

Outline

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

Overview

- The MJO continued to propagate eastward during the past week and the enhanced phase is now entering the Indian Ocean.

- Dynamical model MJO index outlooks forecast continued MJO activity over the next two weeks with slow eastward propagation across the Indian Ocean over the period. Based on the latest observations and model forecasts, the MJO is forecast to be active during the upcoming 1-2 weeks.

- The MJO is forecast to contribute to enhanced convection across parts of Brazil, eastern Africa, and the Indian Ocean during the next two weeks. Suppressed convection is favored for portions of the western Pacific and northern Australia during Week-1.

- Upcoming phases of the MJO during the next 1-2 weeks favor below-normal temperatures for the western U.S. with some potential for more troughs and above-average precipitation for parts of the northwest U.S..

- Moving into March, potential upcoming phases of the MJO would favor above average temperatures for much of the eastern half of the country and above-average precipitation for areas of the lower Mississippi, Tennessee and Ohio valleys and Great Lakes.

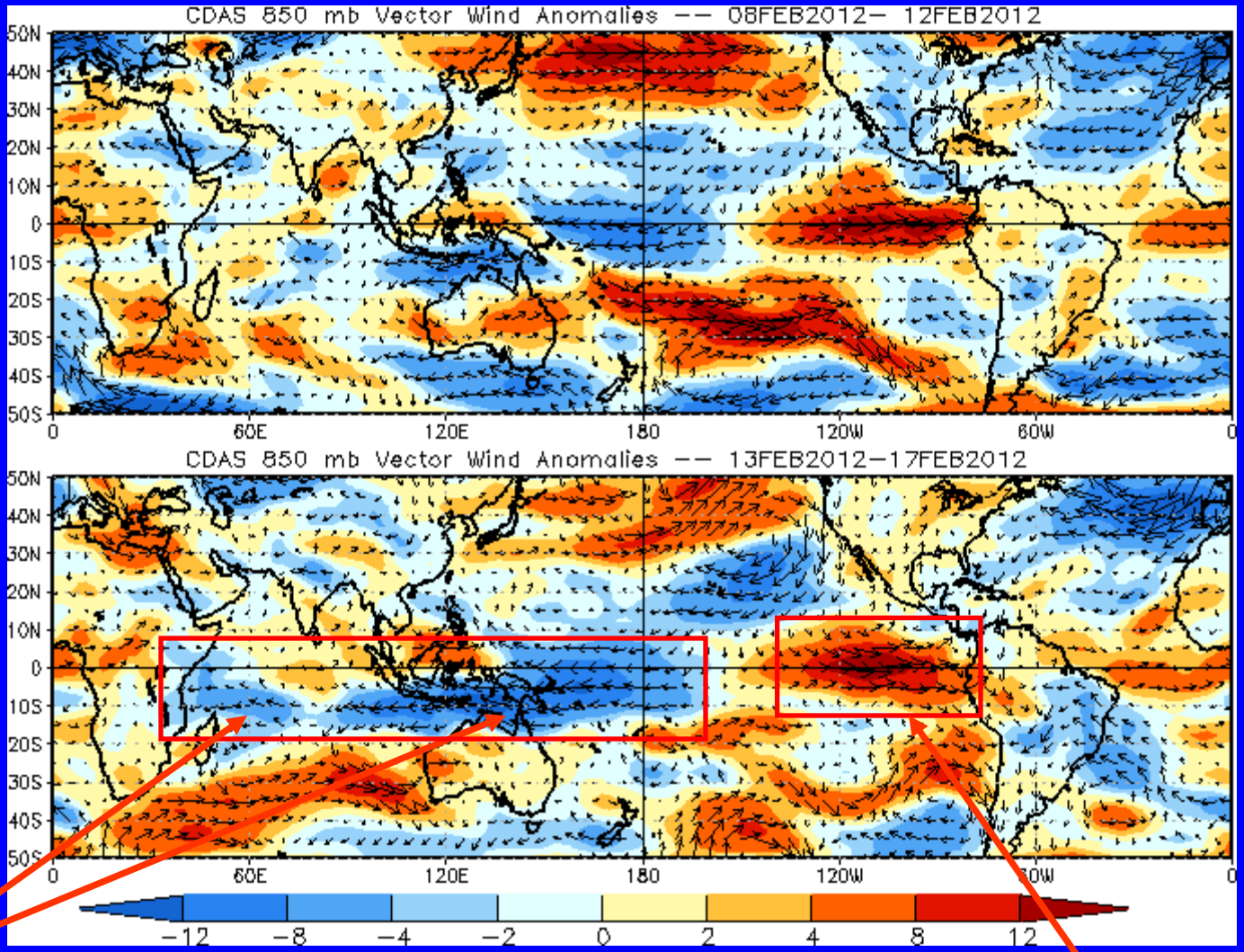
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



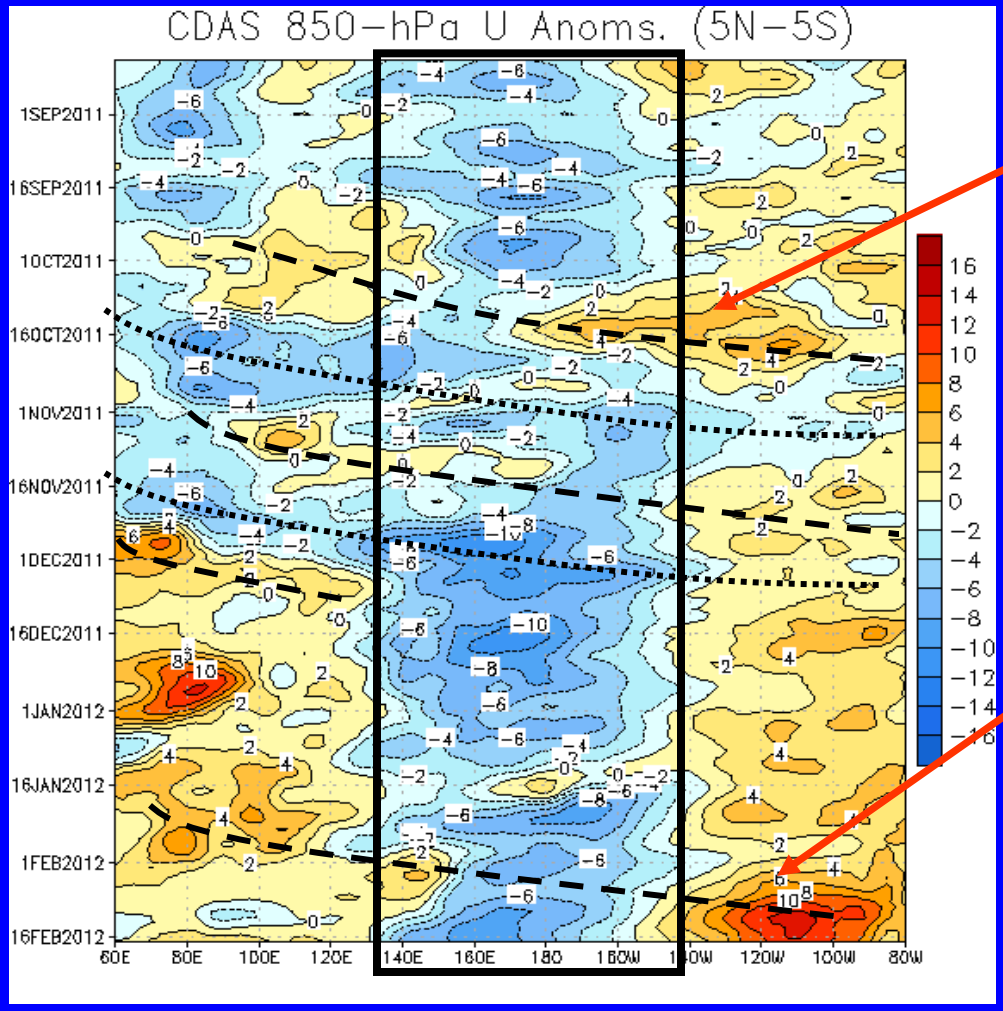
Easterly anomalies developed over portions of the Indian Ocean and strengthened across the Maritime continent and western Pacific during the past five days.

Westerly wind anomalies continued over the eastern Pacific Ocean.

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

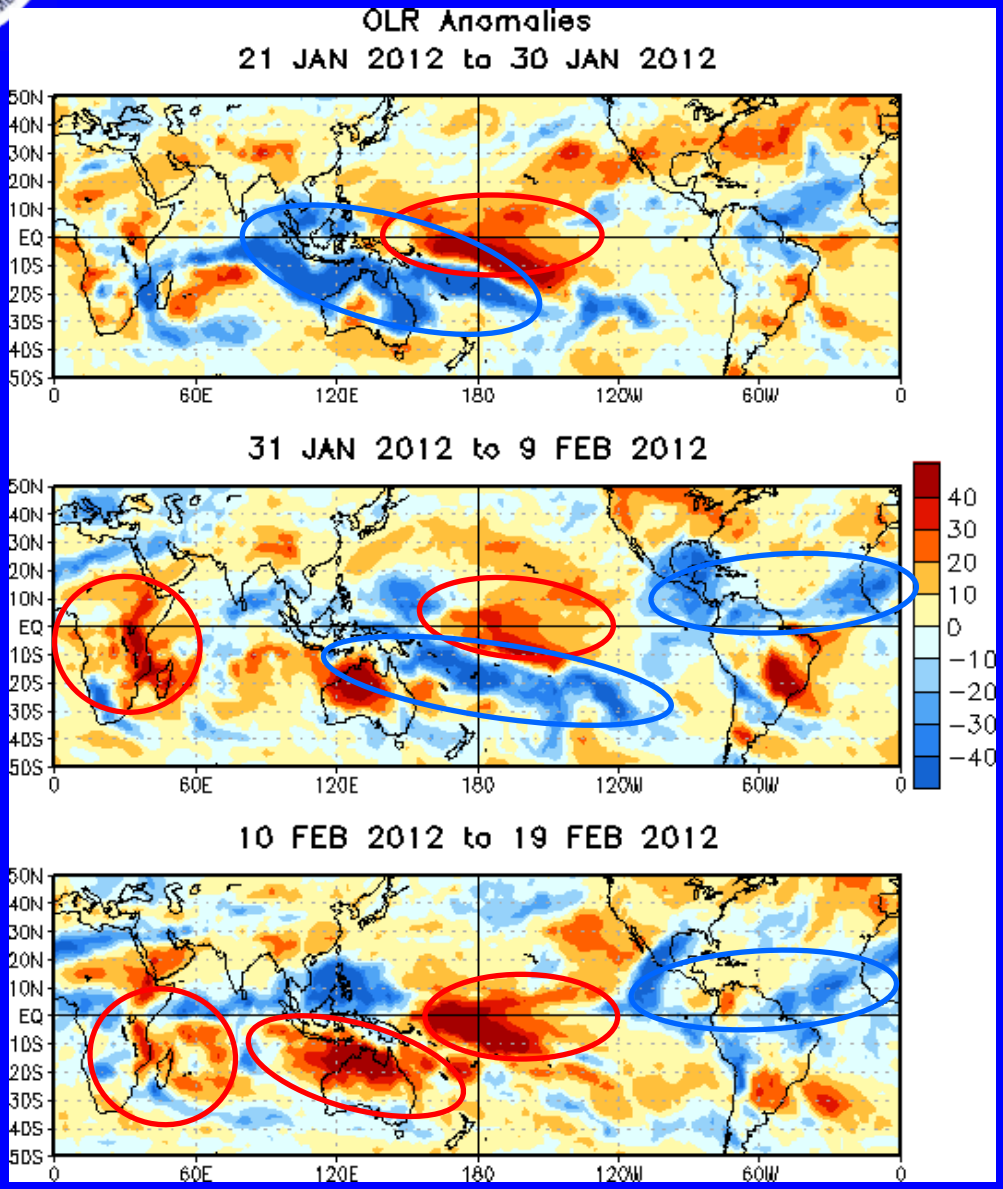
Longitude

In early October, MJO activity weakened the persistent easterly anomalies across the central Pacific (first dashed line).

MJO activity continued into December (altering dashed and dotted lines), but then westerly (easterly) wind anomalies across the Indian Ocean (western Pacific) became more stationary.

The MJO contributed to an eastward shift of westerly anomalies in the western Pacific during late January and early February, weakened easterlies near the Date Line in early February and strong westerly anomalies over the eastern Pacific in mid-February.

OLR Anomalies – Past 30 days



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

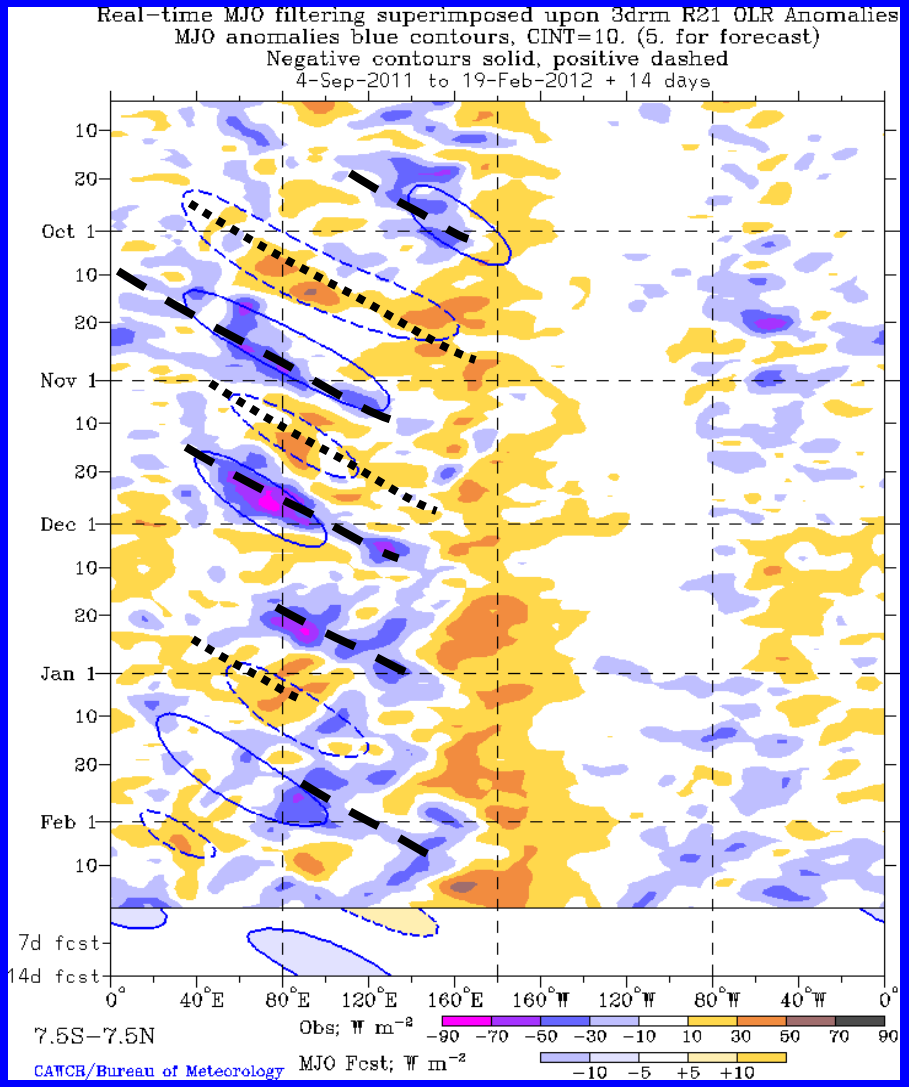
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

The MJO contributed to enhanced convection (blue circle) across the eastern Indian Ocean, Maritime Continent, and SPCZ in late January. Suppressed convection (red circle) continued across the central equatorial Pacific throughout the 30 day period.

By early February the MJO contributed to enhanced convection further east across the southern Pacific while suppressed convection prevailed across much of Africa.

In early-to-mid February, enhanced (suppressed) convection was observed across Central America, northern South America, and the equatorial Atlantic Ocean (eastern Africa, southern Indian Ocean and 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)

Beginning in mid-September, enhanced convection shifted from southern Asia to the western Pacific while suppressed convection developed during late September across India and also shifted eastward to the western Pacific.

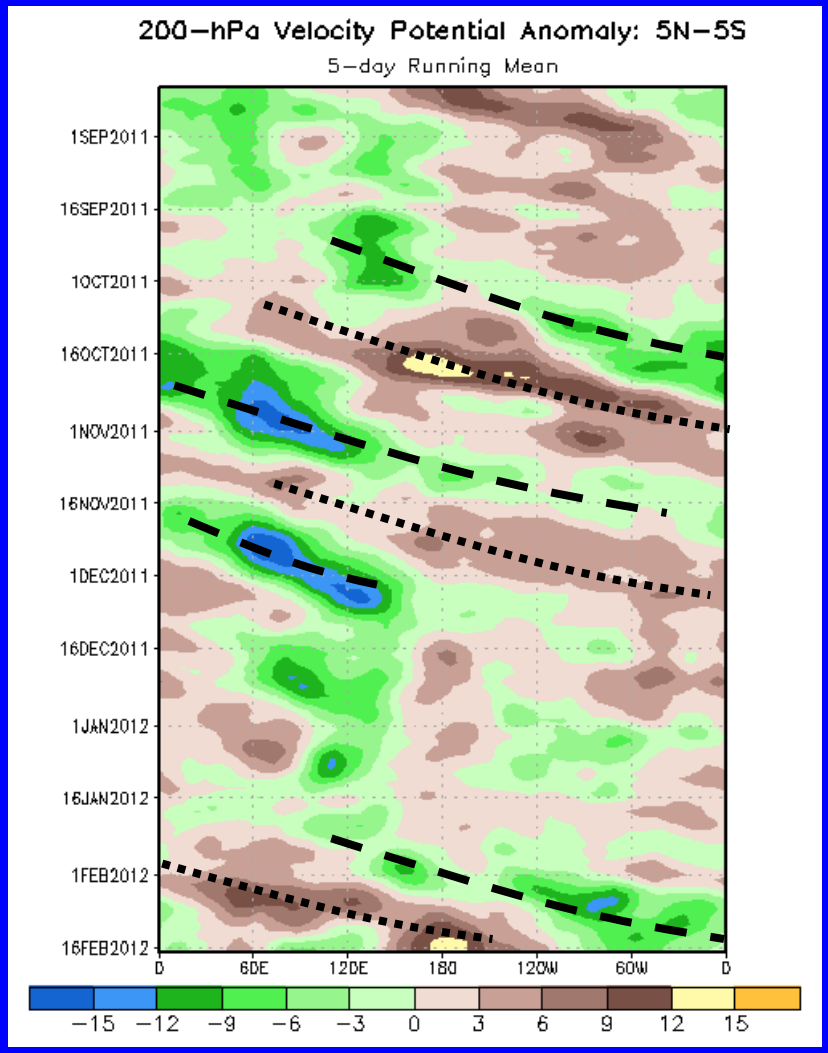
MJO activity continued into early December, then OLR anomalies decreased and eastward propagation was not clear. However, during late December, eastward propagation of OLR anomalies was again observed.

Strong enhanced convection developed across the Indian Ocean during late January. In early February enhanced convection shifted eastward into the western Pacific and parts of the western Hemisphere.

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

Beginning in the second half of September into December, alternating negative (dashed lines) and positive (dotted lines) anomalies were evident and associated with MJO activity during the period.

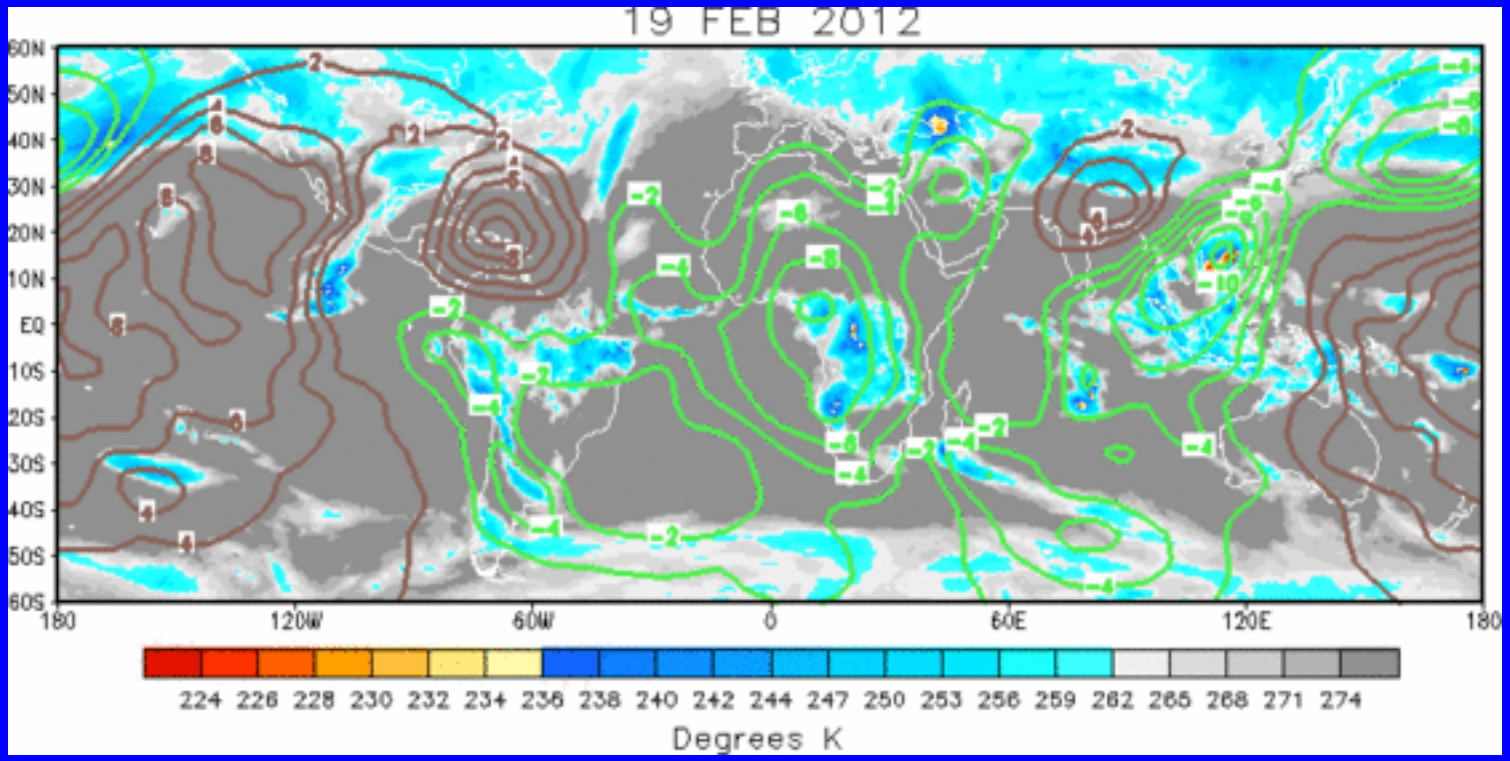
Eastward propagation of anomalies became less coherent during late December and early January and anomalies weakened.

The MJO strengthened once again in late January as eastward propagation of larger anomalies was observed with anomalous upper-level divergence strongest over areas of the western hemisphere during the past week.

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

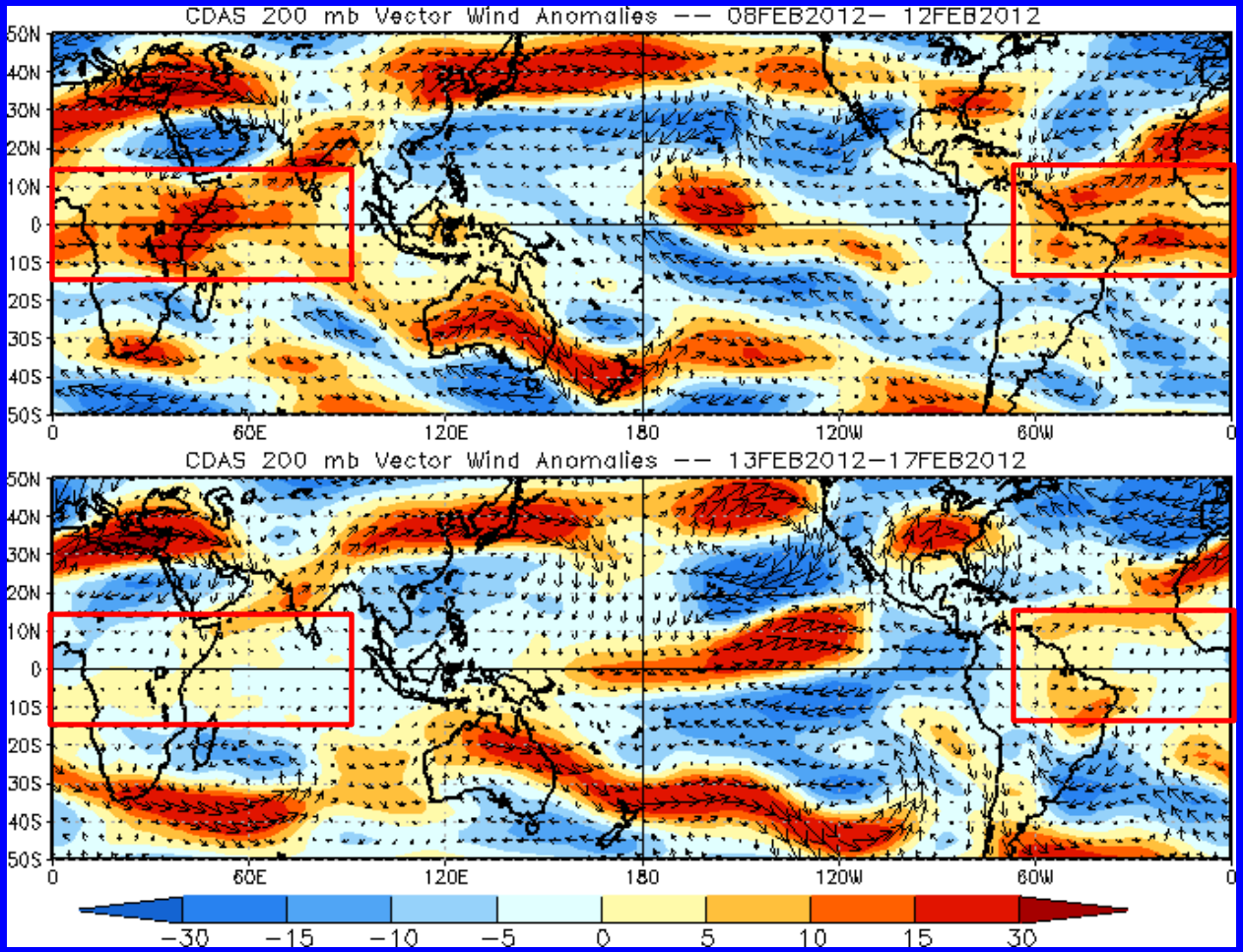
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The large scale velocity potential pattern shows upper-level divergence across areas of South America, Africa and the Indian Ocean/Maritime continent with upper-level convergence mainly across the Pacific.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

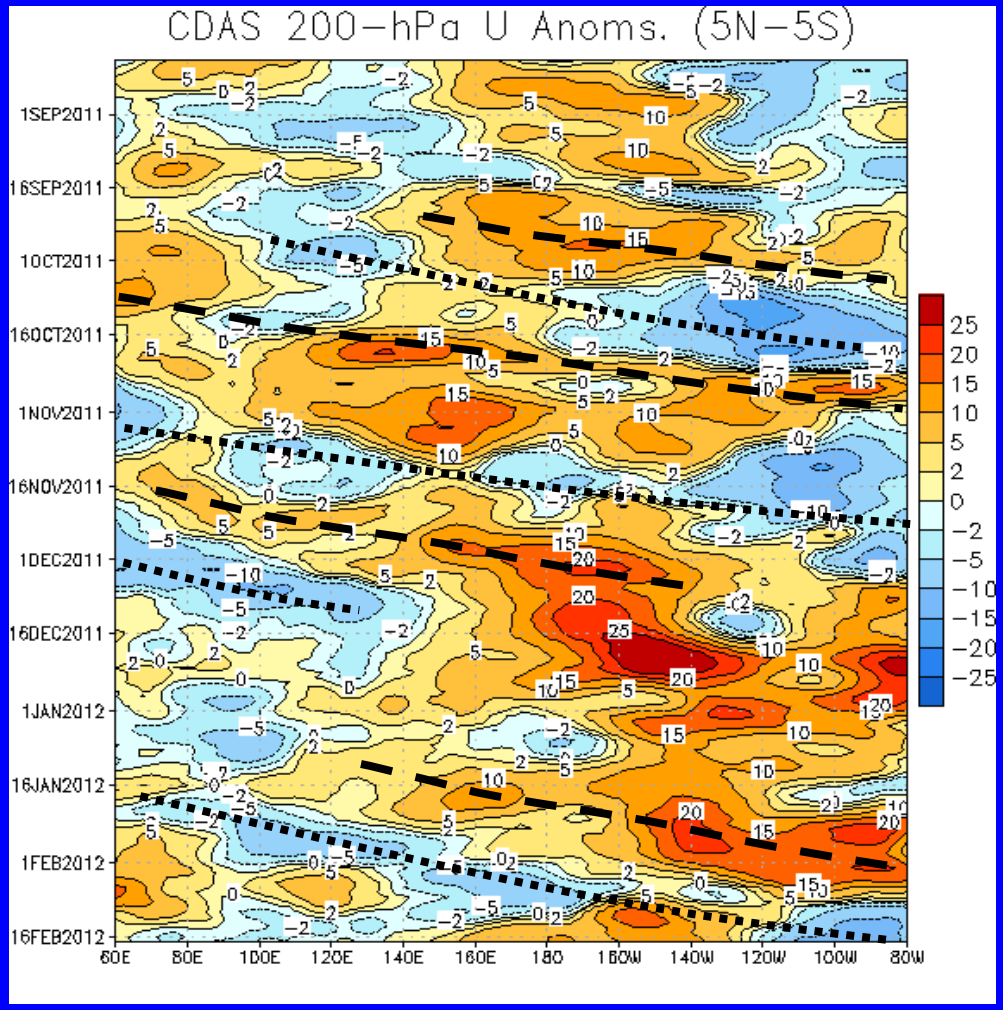
Red shades: Westerly anomalies

During the past five days, strong westerly anomalies over the Atlantic, Africa and the western Indian Ocean have substantially decreased.

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

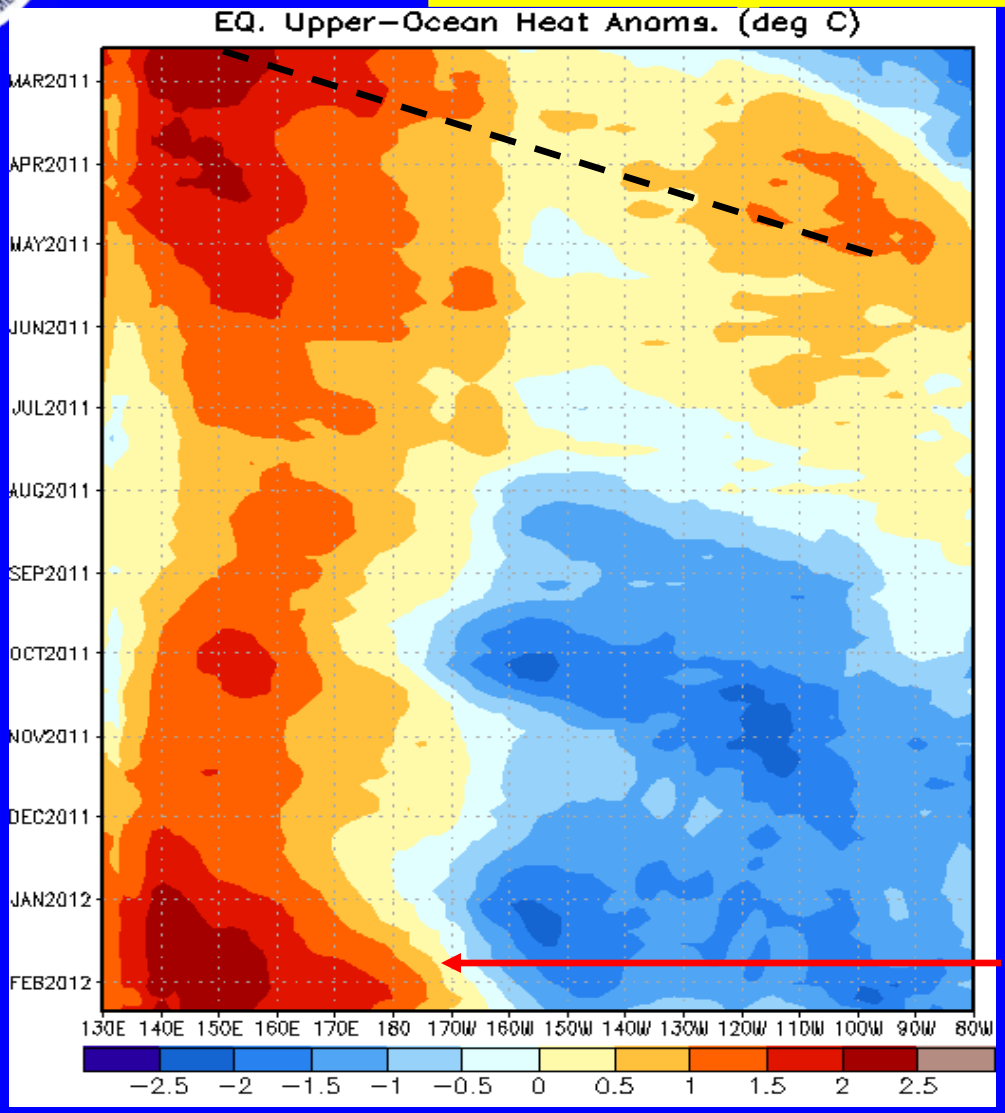
Longitude

Alternating westerly (dashed lines) and easterly (dotted lines) anomalies are evident from mid-September into December associated with the MJO.

In December, westerly anomalies strengthened over the Pacific.

During the second half of January, westerly anomalies in the Pacific propagated eastward associated with the MJO activity. These were followed, somewhat less clearly, by easterly anomalies.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

An oceanic Kelvin wave (dashed line) shifted eastward during February and March 2011.

Since late July, negative heat content anomalies are evident across the equatorial central and eastern Pacific.

In January 2012, positive heat content anomalies have increased and shifted slightly eastward in the central equatorial Pacific.

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).

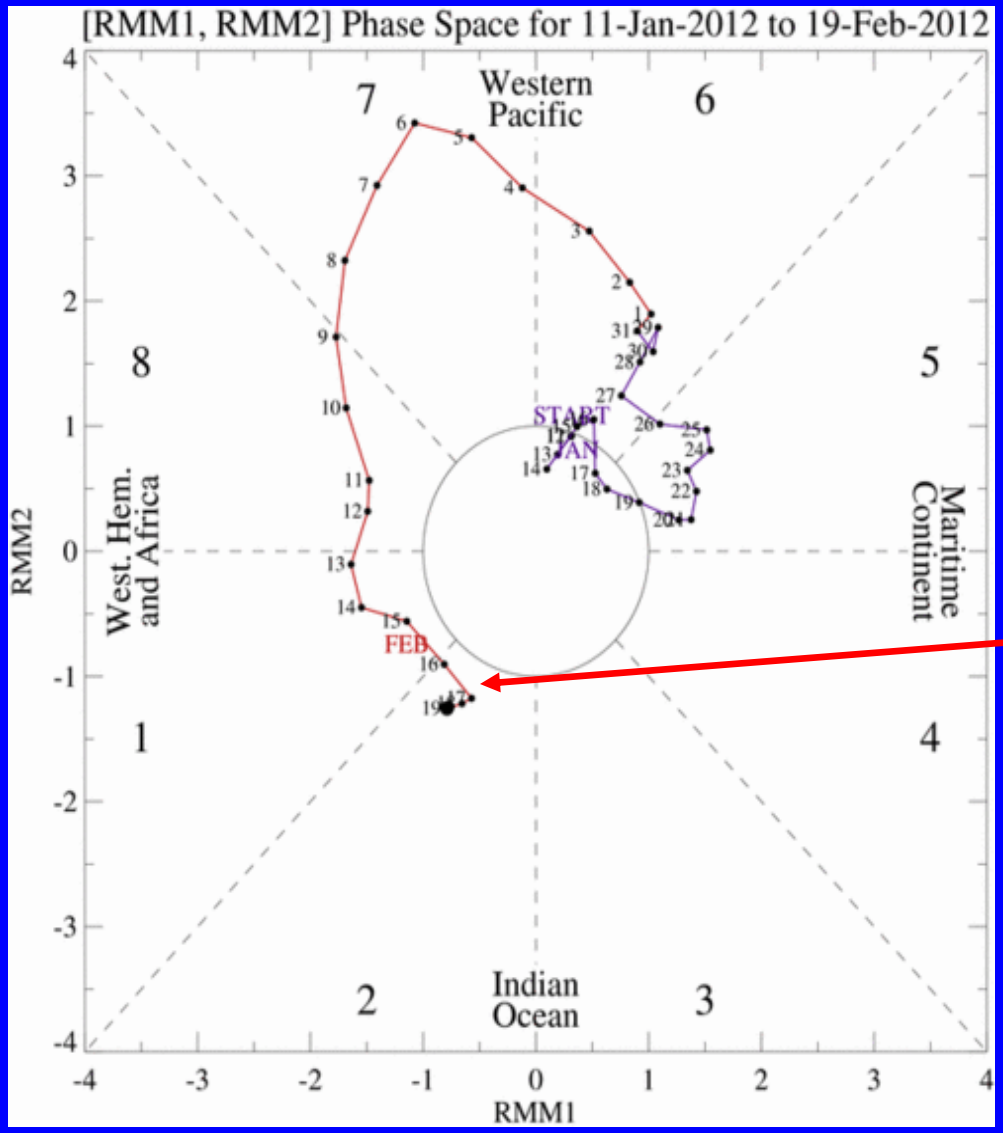
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

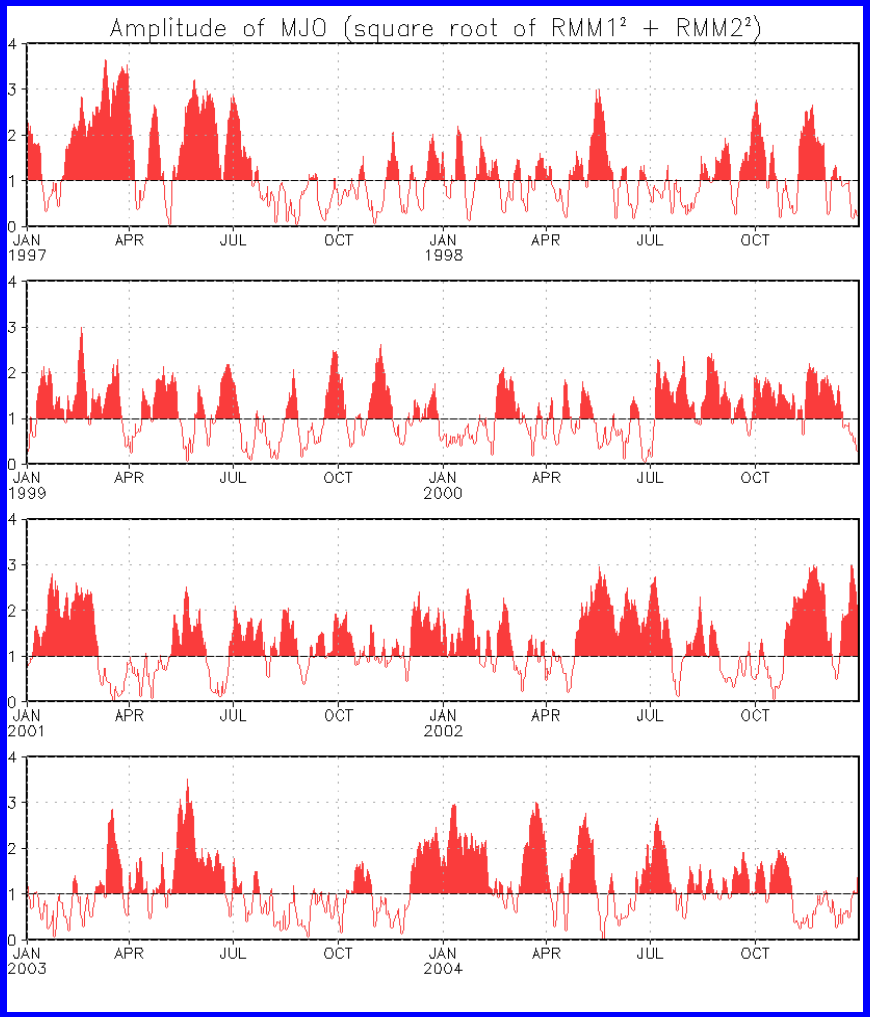
MJO Index -- Recent Evolution

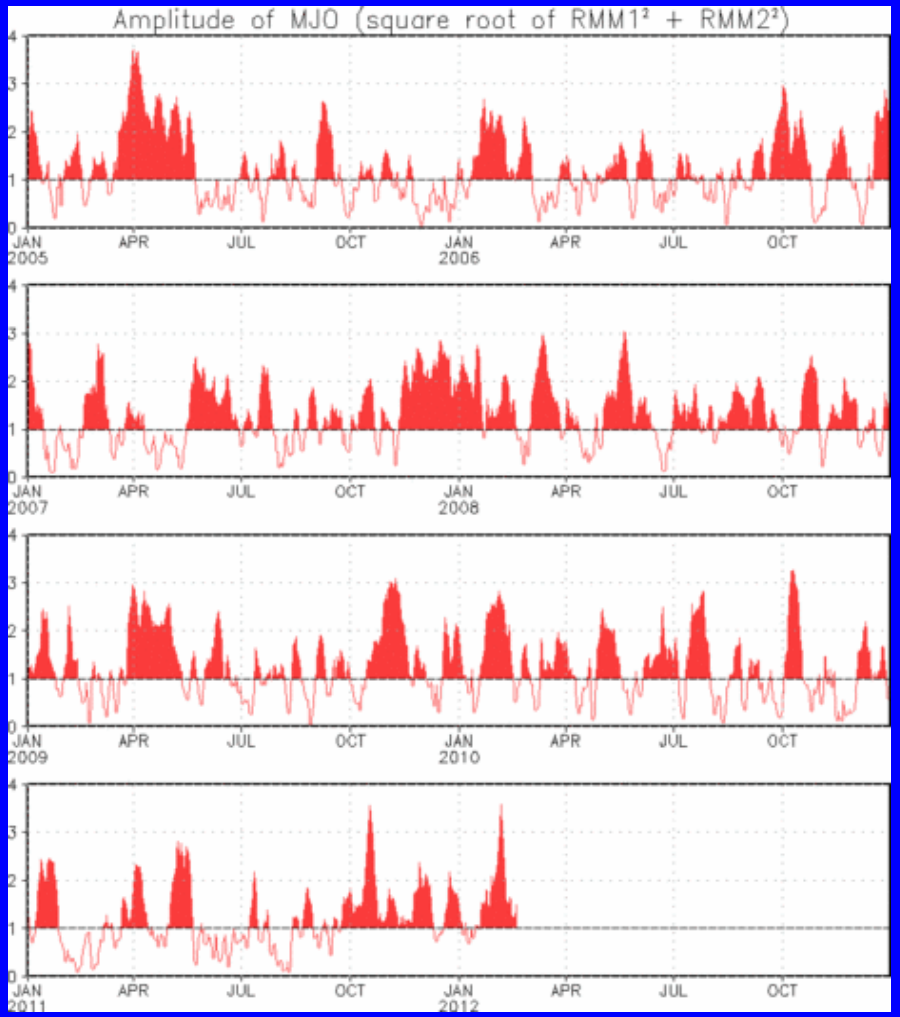


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

During the past week, the MJO index continued to indicate MJO activity with the enhanced phase now centered across the western Indian Ocean.

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.

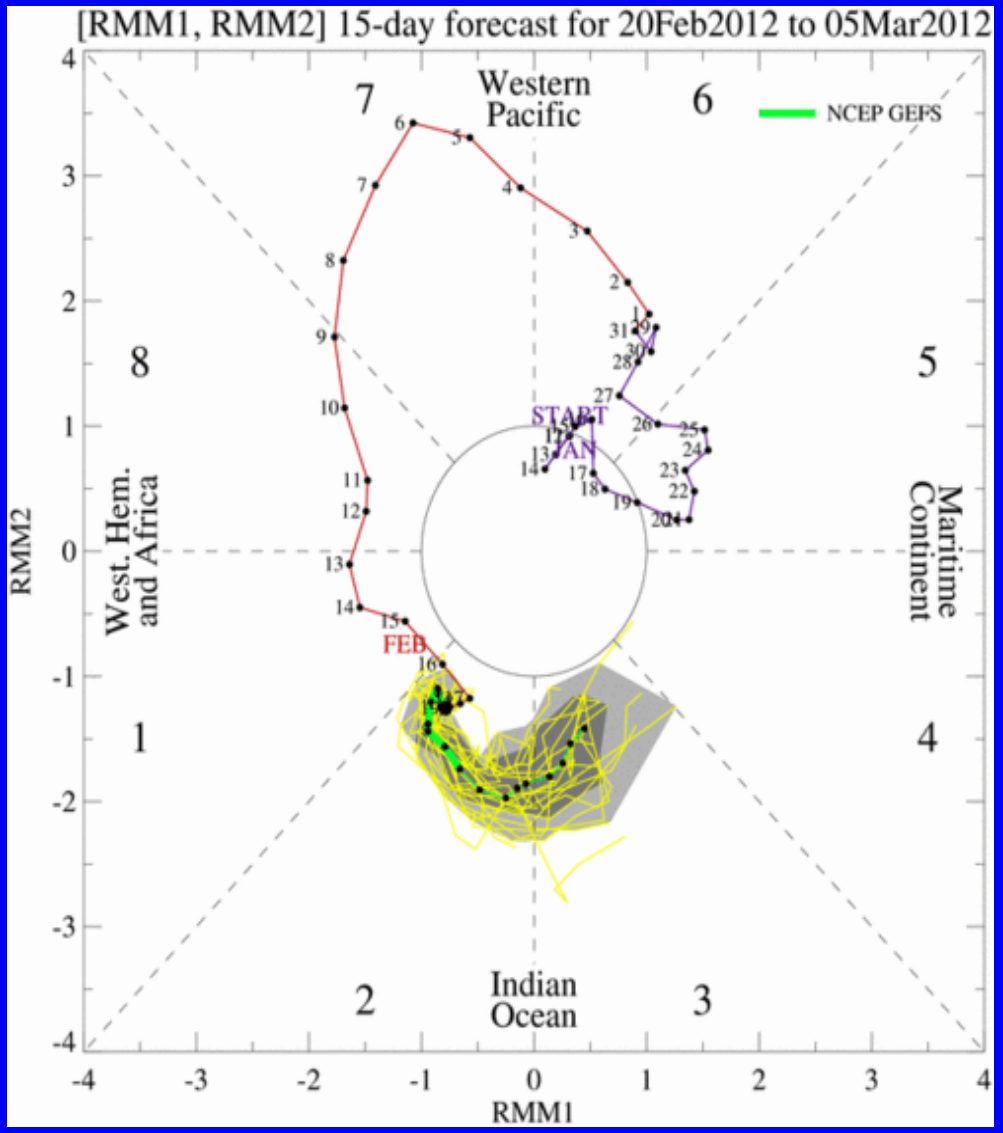
Ensemble GFS (GEFS) MJO Forecast

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

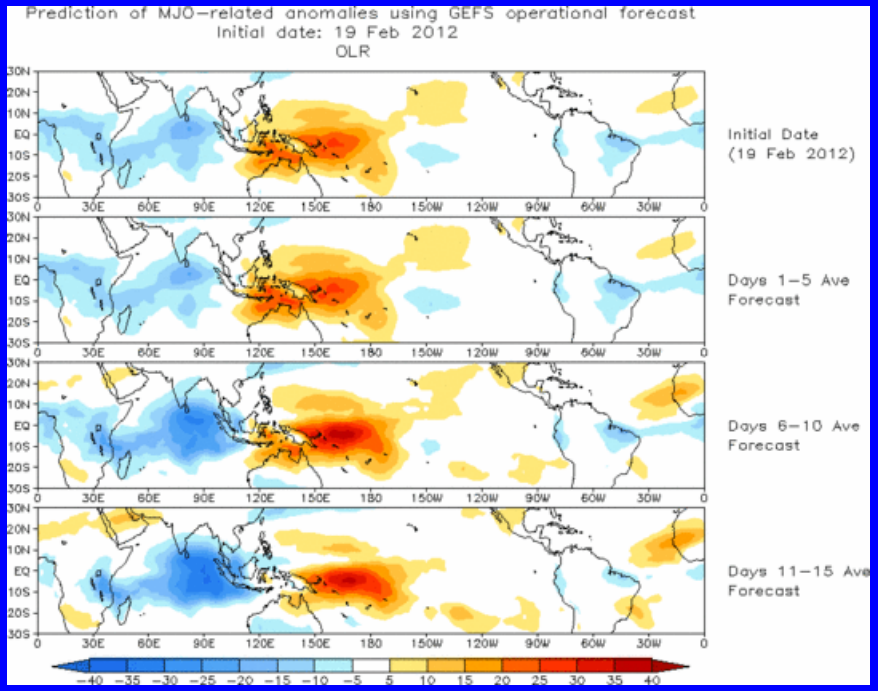
The ensemble GFS forecasts the MJO to continue with slow eastward propagation across the Indian Ocean over the next 1-2 weeks.



Ensemble Mean GFS MJO Forecast

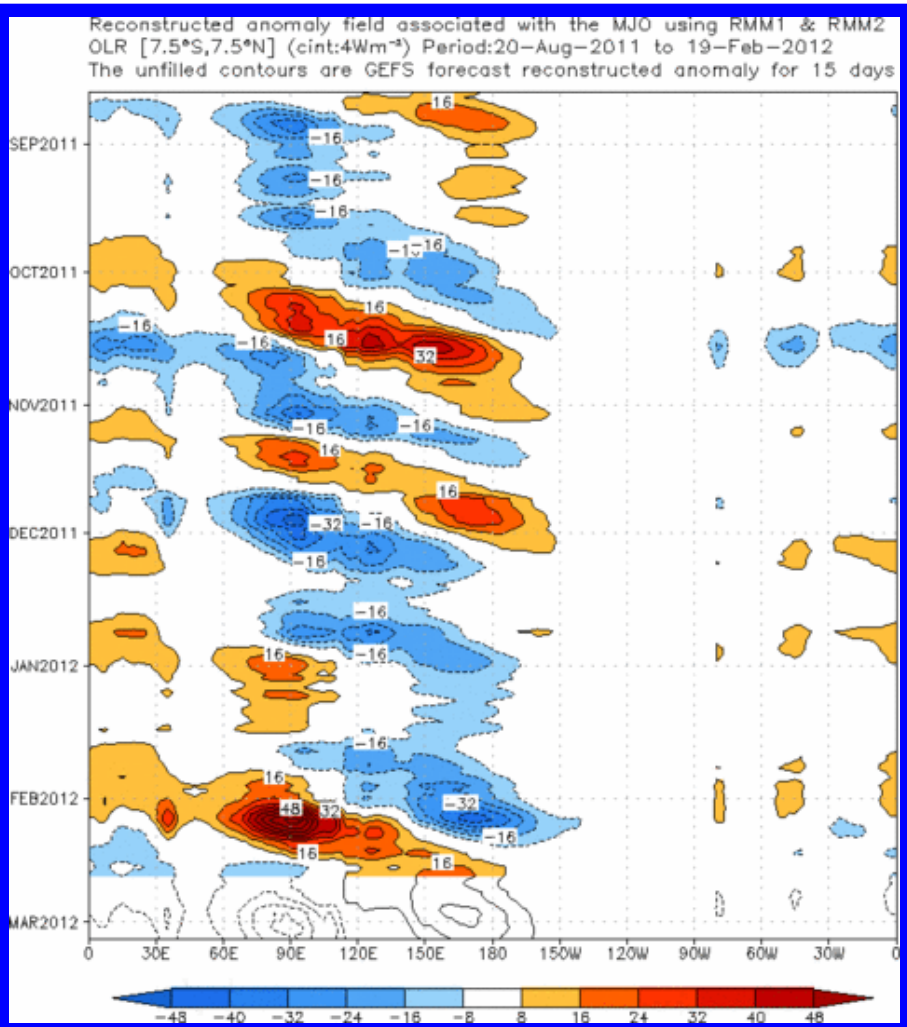
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecast indicates enhanced convection across the Indian Ocean during the period with suppressed convection across parts of the western Pacific.

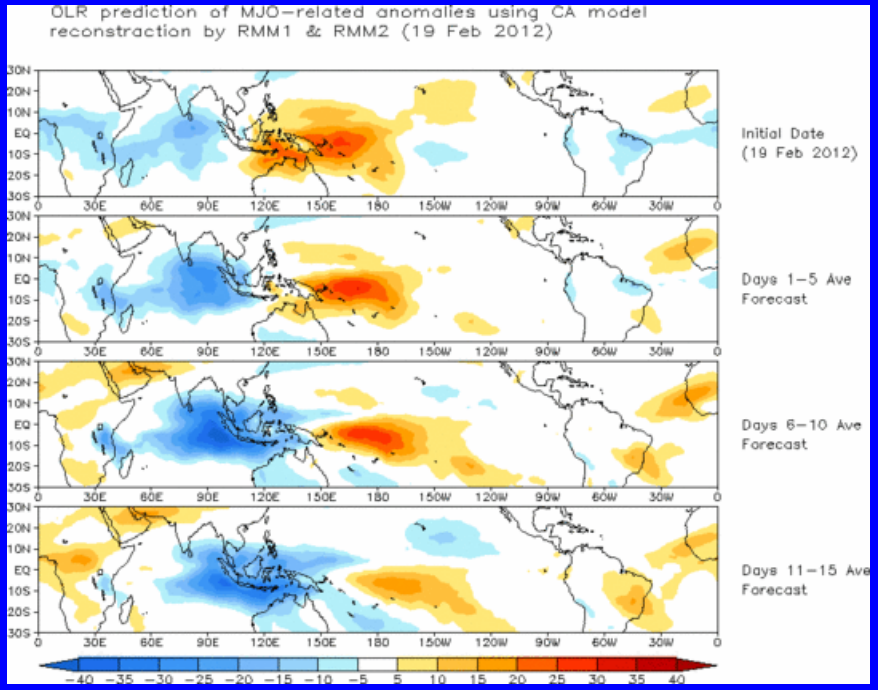
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



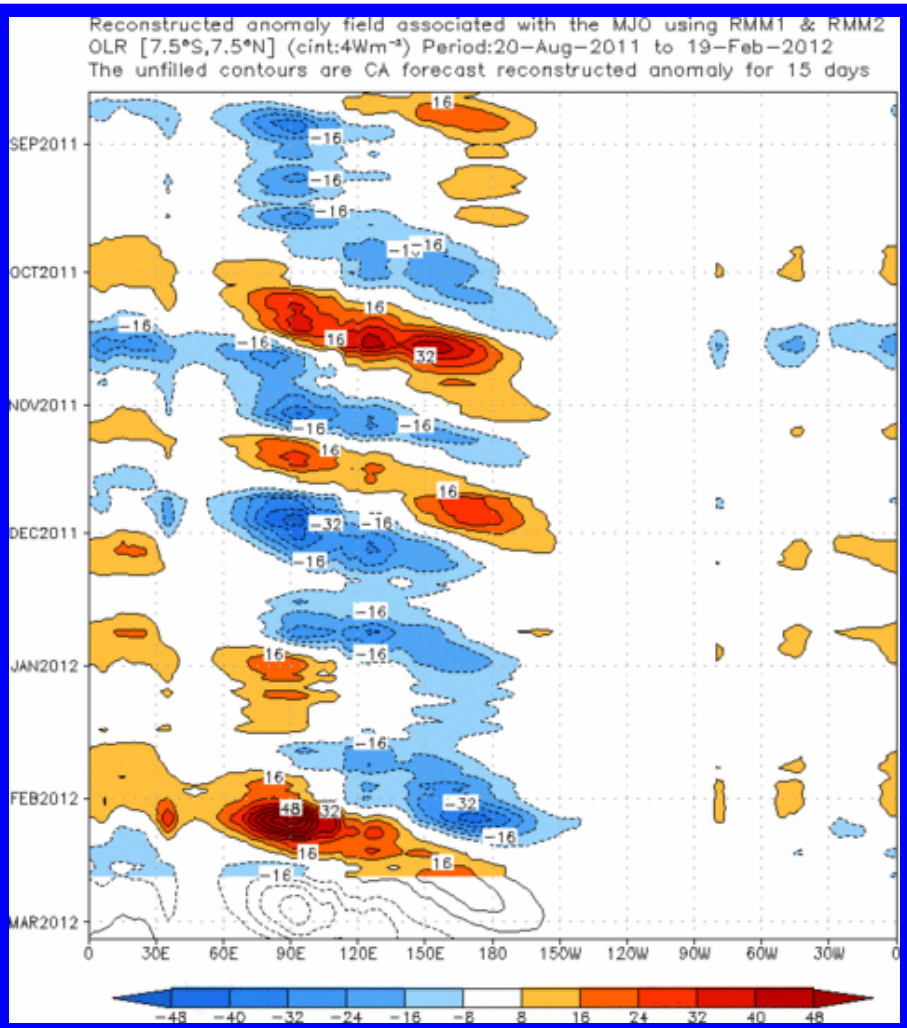
Constructed Analog (CA) MJO Forecast

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



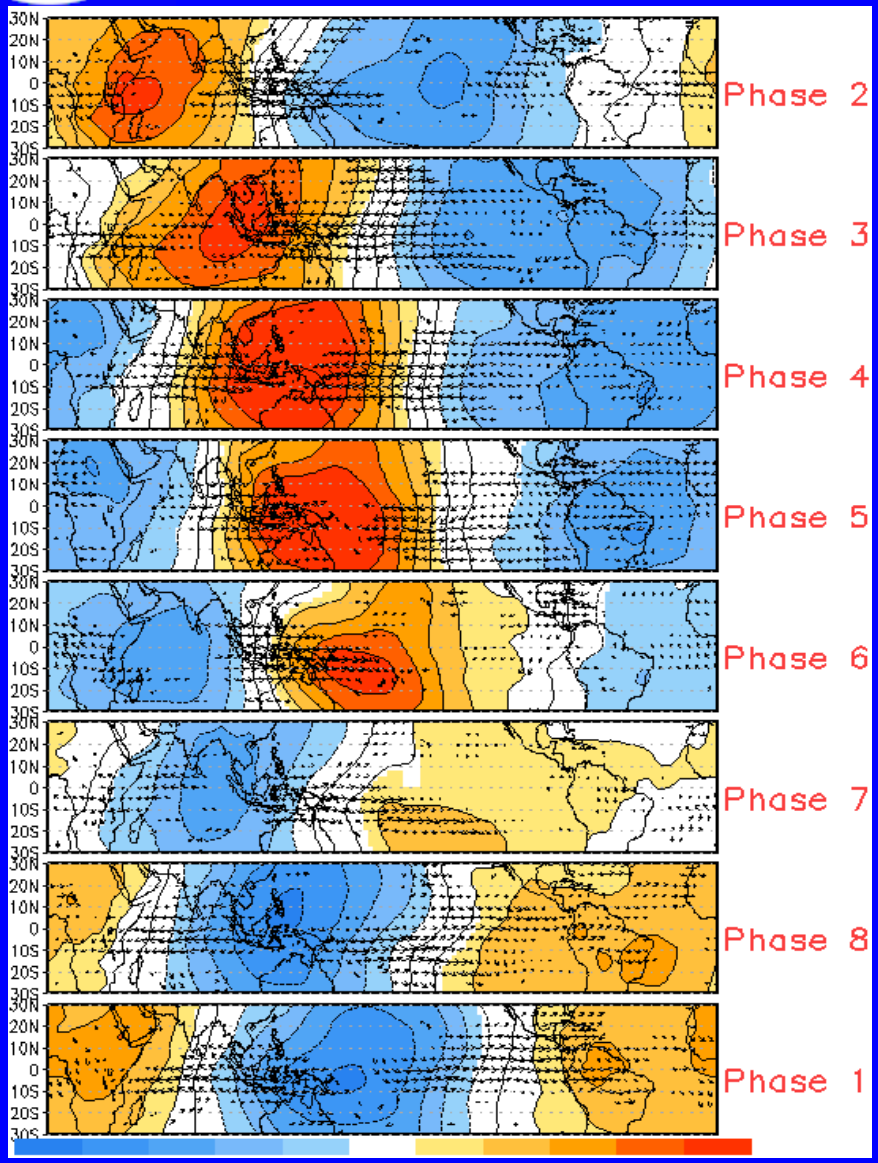
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



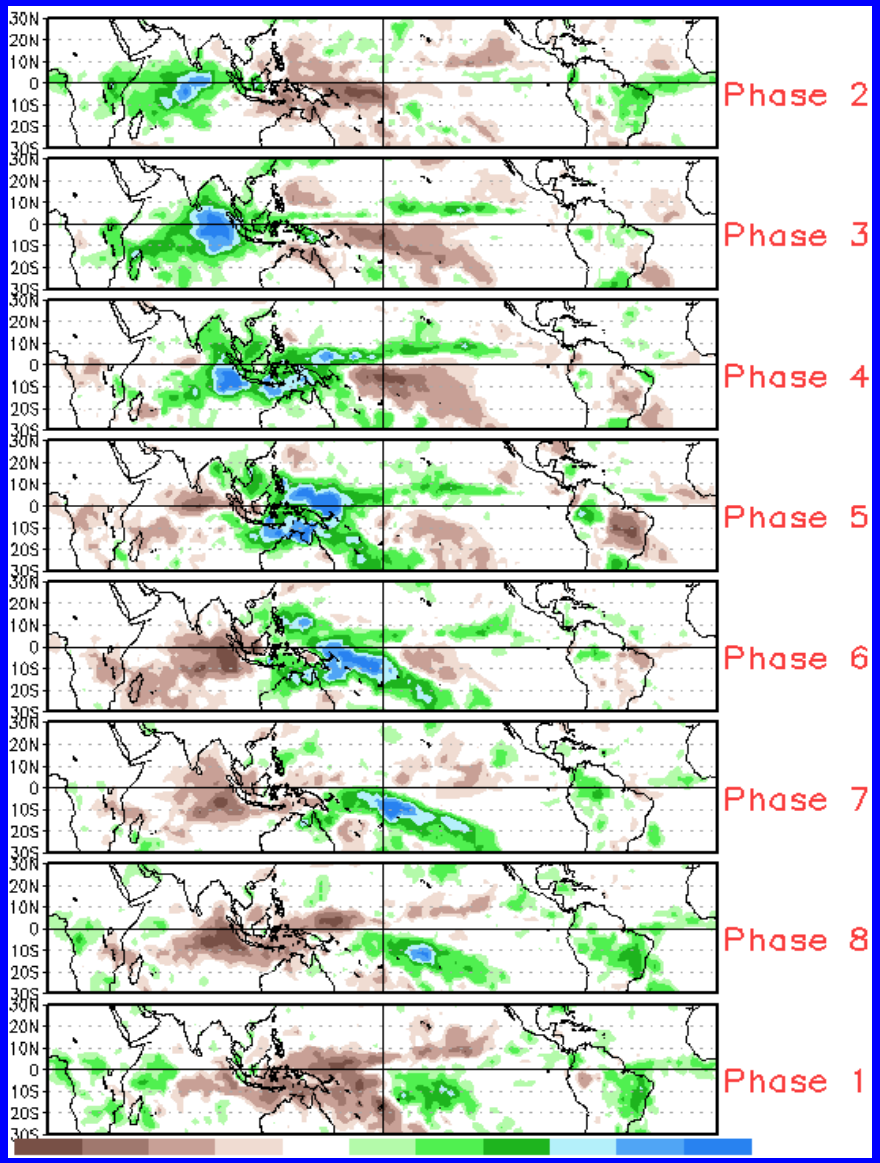
The CA forecast is a little more progressive and shows enhanced convection across the Indian Ocean slowly shifting to the western Maritime continent. Suppressed convection is favored over parts of the western Pacific early and later for Brazil.

MJO Composites – Global Tropics

850-hPa Wind Anomalies (Nov-Mar)

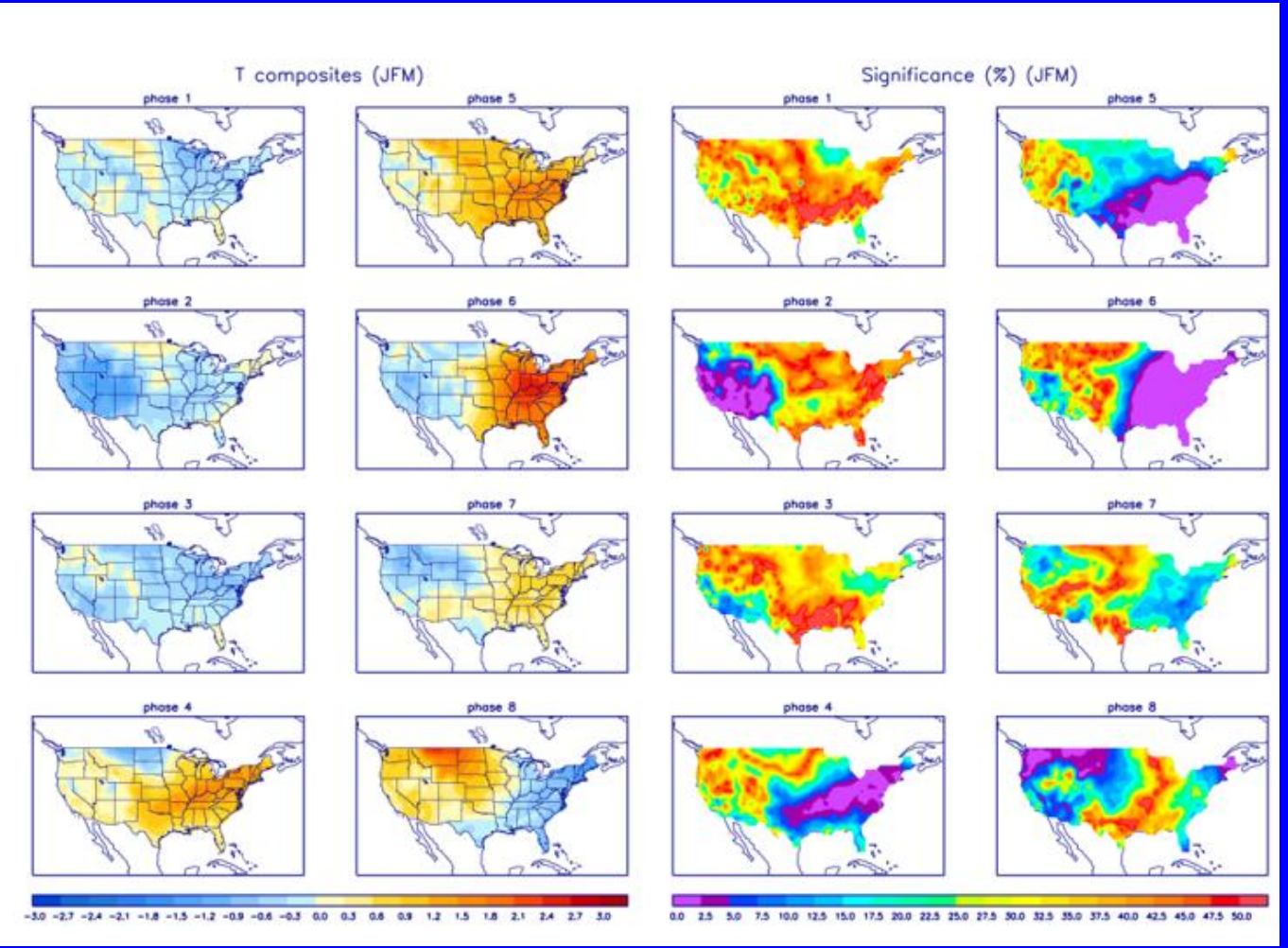


Precipitation Anomalies (Nov-Mar)



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. Dark blue and purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.**

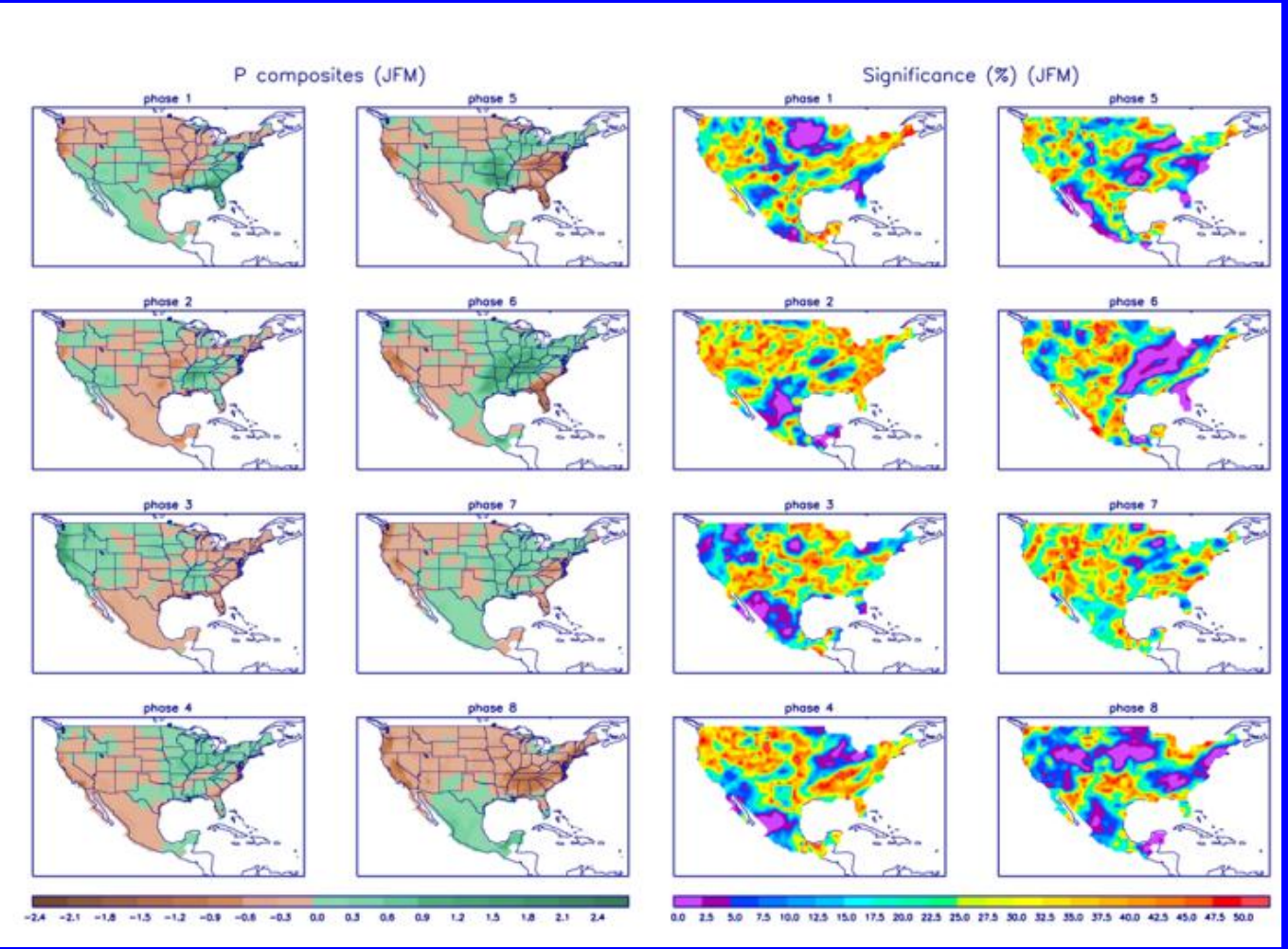


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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. Dark blue and purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.**



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