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

Update prepared by
Climate Prediction Center / NCEP
May 3, 2010

Outline

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

Overview

- The MJO has become coherent and strengthened during the past week.

- Dynamical model MJO index forecasts indicate MJO activity will continue with eastward propagation during the next two weeks. Statistical forecasts also indicate MJO activity but forecast slower propagation.

- Based on the latest model MJO observations and forecasts, the MJO is expected to remain active, with the enhanced convective phase located over Africa and the Indian Ocean during Week-1, shifting to the Maritime Continent during Week-2.

- The MJO is expected to contribute to enhanced rainfall across the Indian Ocean during Week-1 and the Maritime Continent in Week-2. Drier-than-average conditions are favored across Central America in Week-1 and Week-2 and east-central Africa in Week-2.

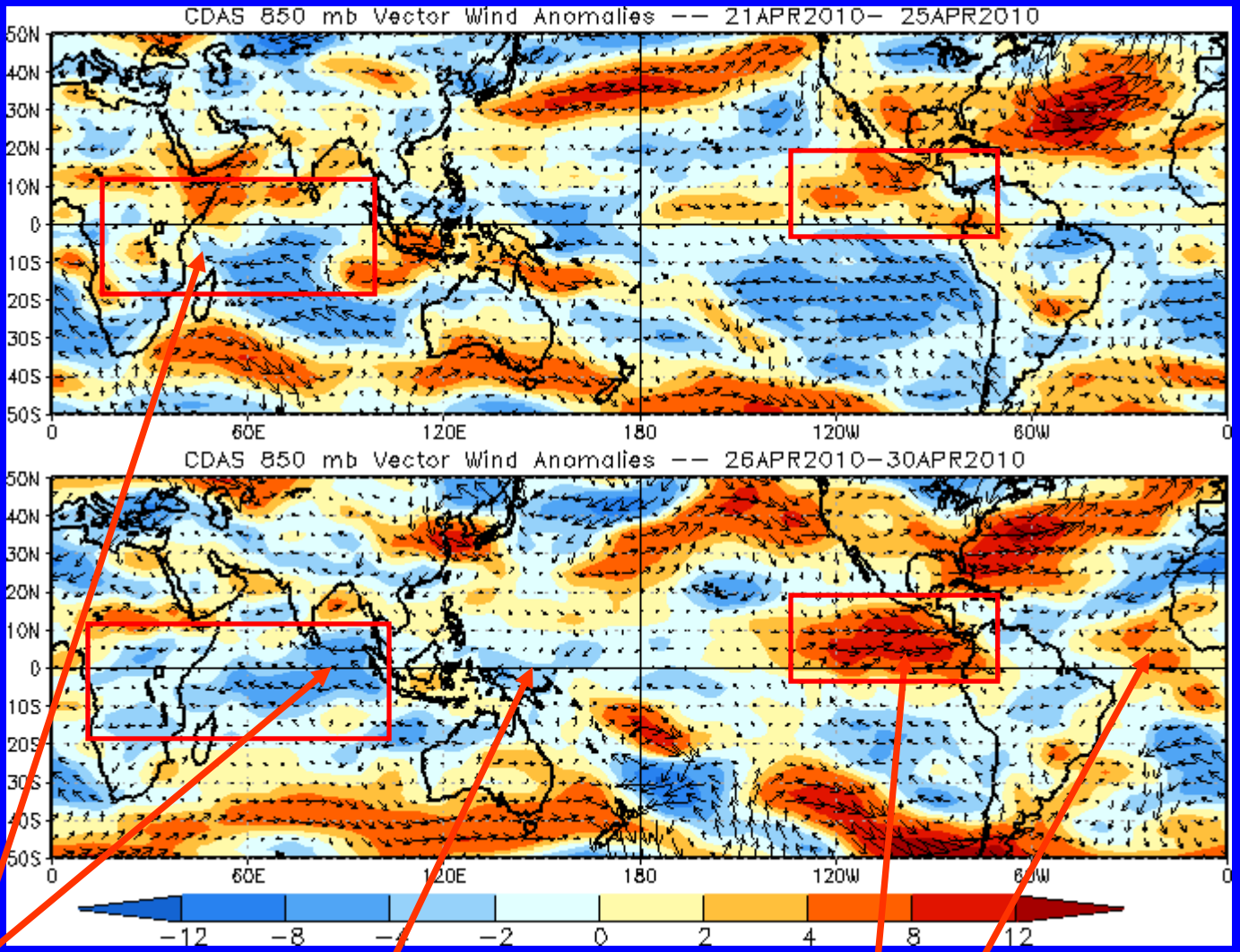
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/ghaz.shtml

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 expanded across the Indian Ocean.

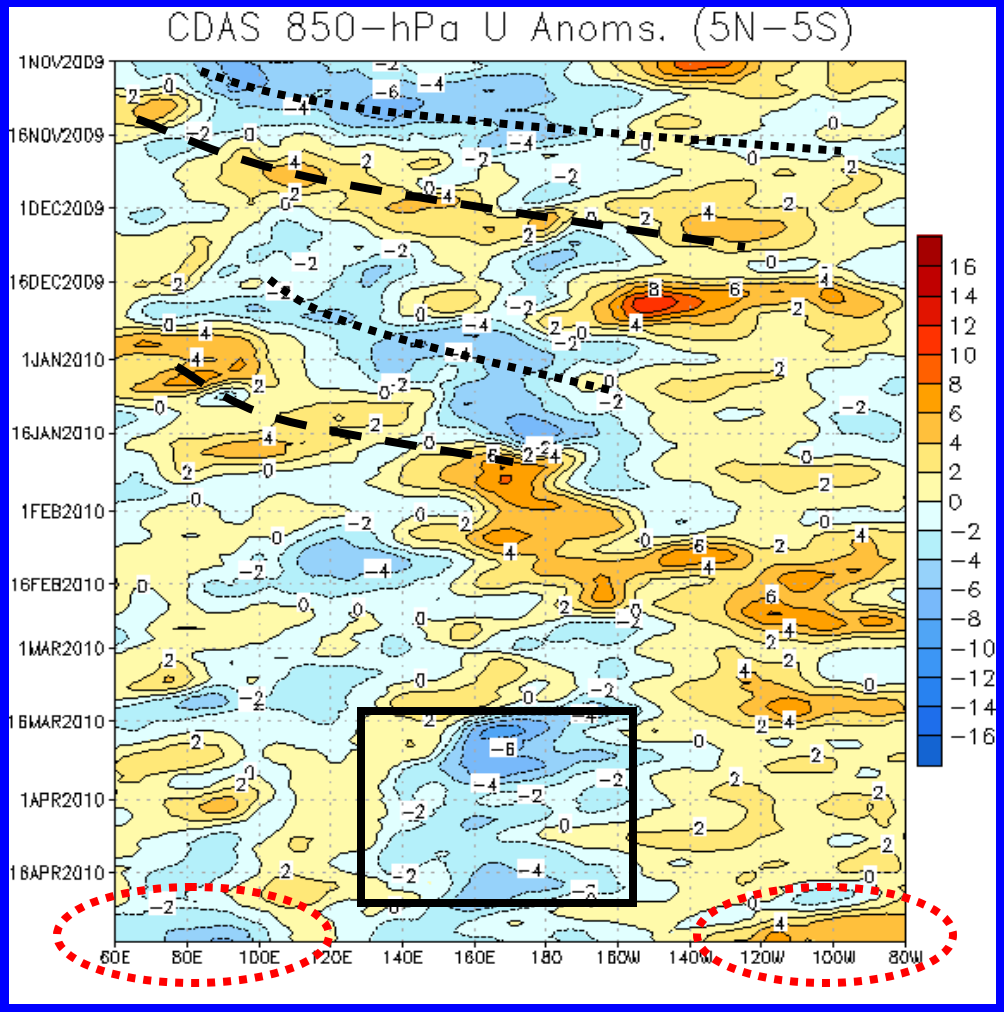
Easterly anomalies weakened in the western Pacific.

During the last five days, westerly anomalies strengthened in the eastern Pacific north of the equator and developed to the west of Africa.

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 (dotted line) and westerly (dashed line) anomalies developed across the Indian Ocean and shifted eastward across the Date Line during November associated with the MJO.

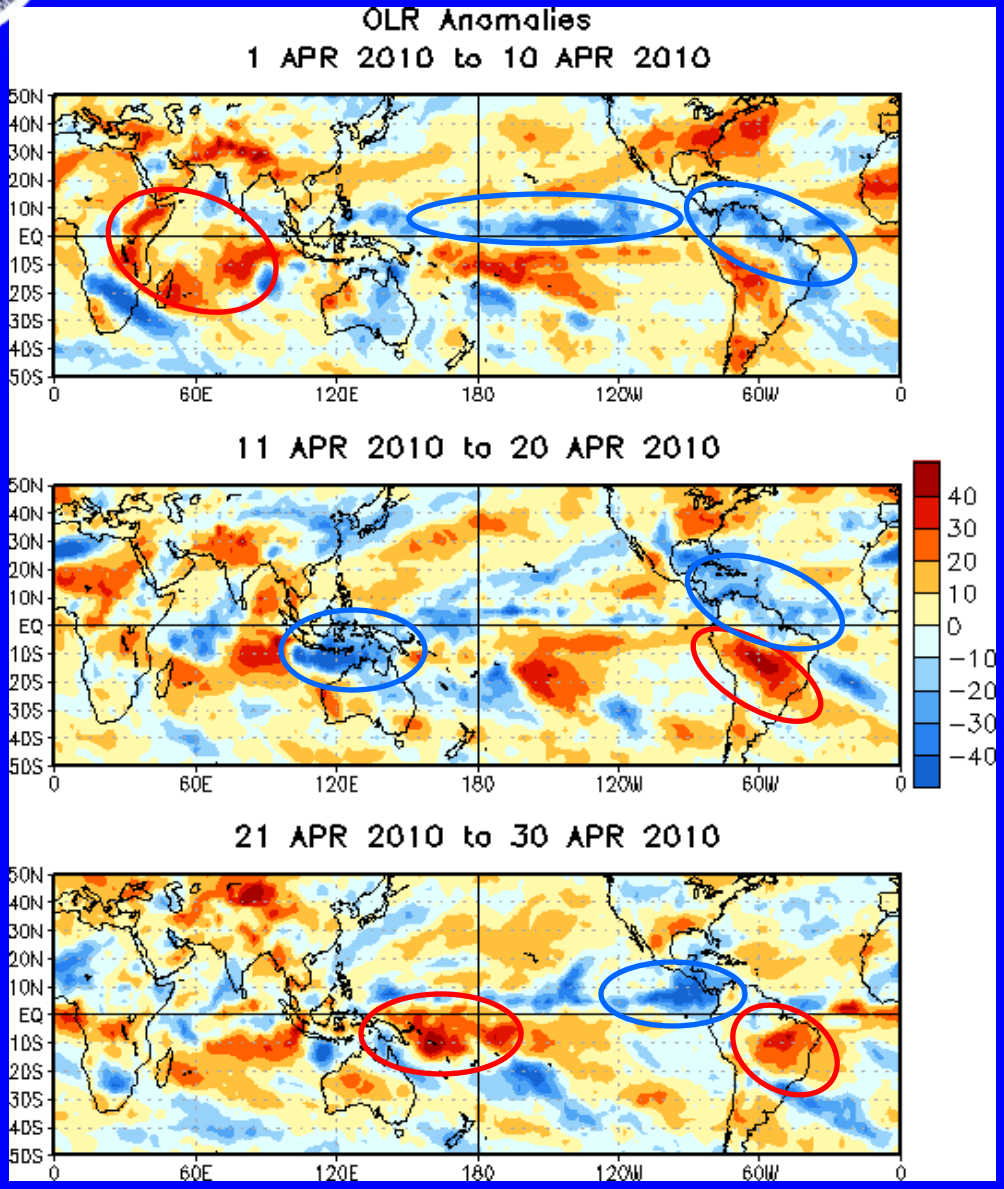
Weaker and shorter-lived MJO activity was evident during January.

Easterly anomalies have persisted in the west-central Pacific since mid-March (black box). Recently, easterly (westerly) anomalies have developed in the Indian Ocean (eastern Pacific) associated with the developing MJO (red ovals).

OLR Anomalies: Last 30 days

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

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

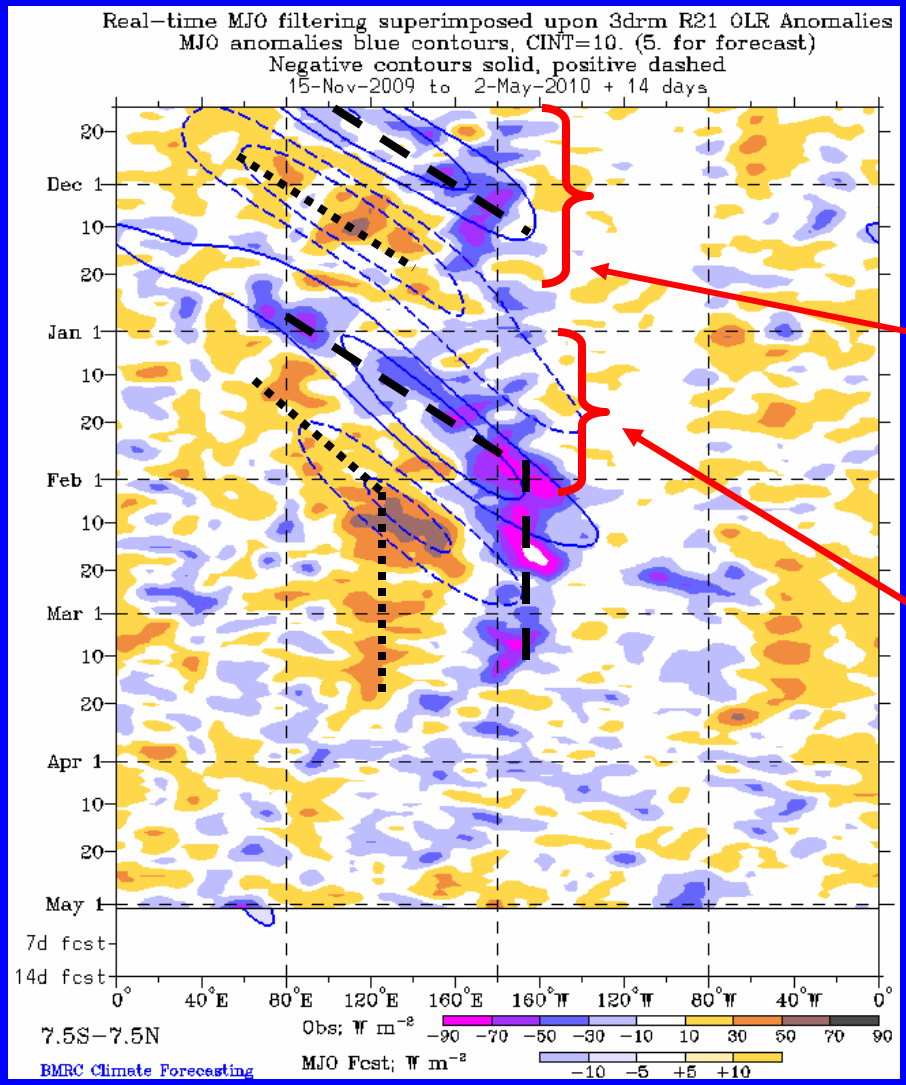


During early April, enhanced convection was evident over much of the equatorial Pacific and northern South America. Suppressed convection was evident over east-central Africa and parts of the Indian Ocean.

In mid-April enhanced convection developed over the Maritime Continent. Enhanced convection continued across northern South America, while suppressed convection developed in central South America.

During late April, suppressed convection developed over the western Pacific and continued over parts of Brazil. Enhanced convection developed over the eastern Pacific and Central America.

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 the Bureau of Meteorology (BOM) - Australia)

During November to early December 2009, enhanced convection shifted eastward from the Indian Ocean into the western Pacific (dashed line) followed by an episode of enhanced convection (dotted line).

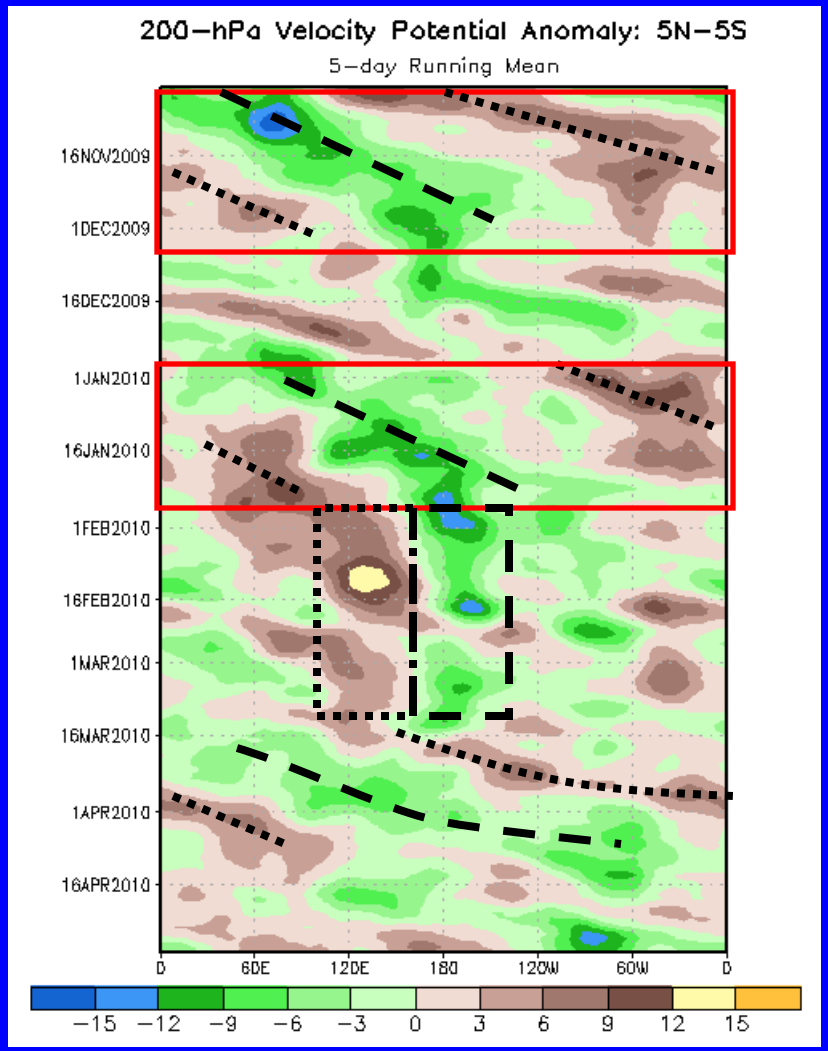
After a brief break during mid-late December, enhanced convection developed in the Indian Ocean and shifted eastward to the western and central Pacific during mid to late January. An area of suppressed convection across the Indian Ocean and Maritime Continent followed.

Since mid-March anomalies have been weak.

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 associated with the MJO was evident during November and during early-mid January (red boxes).

During February and early March, the MJO weakened and anomalies became more stationary and incoherent on the intraseasonal time scale (black boxes).

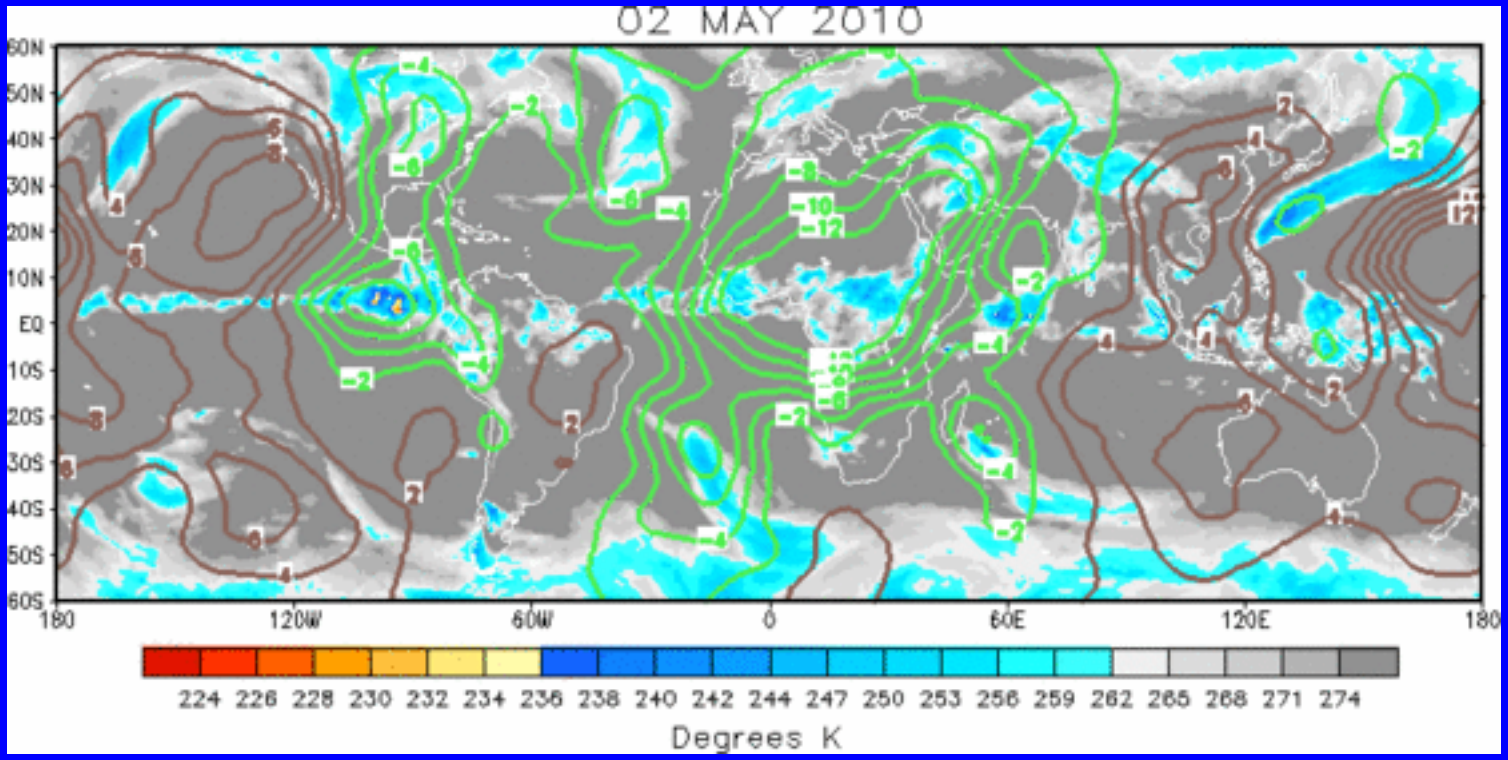
In mid-March, weak upper-level divergence (convergence) developed over Africa and the Indian Ocean (Maritime continent) and these anomalies propagated eastward.

Since mid-April anomalies have been weak with signals from other coherent modes of tropical variability.

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

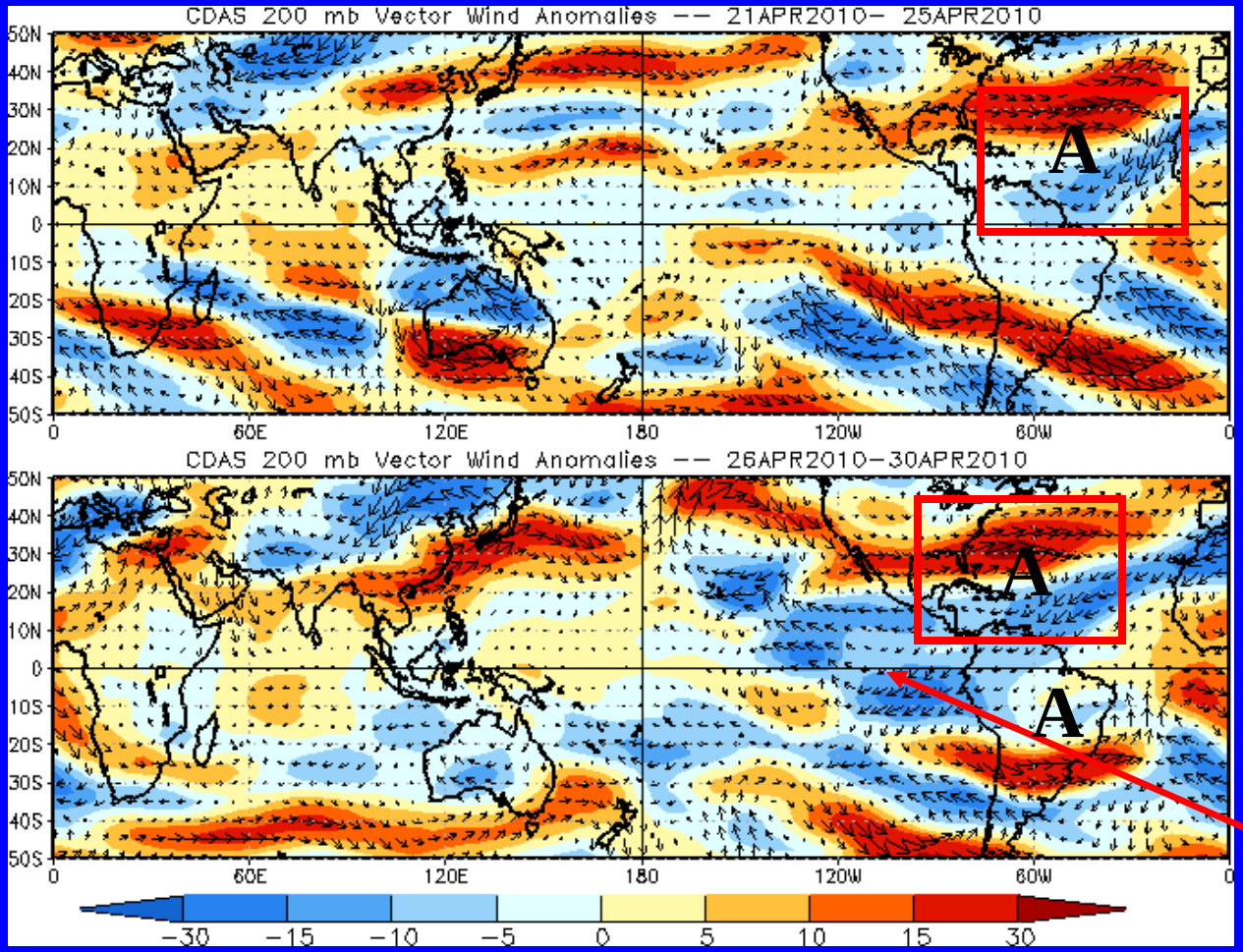
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The current anomalous velocity potential pattern is more coherent than in recent weeks. Upper level divergence is apparent over the western hemisphere, and upper level convergence is apparent over the eastern hemisphere.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

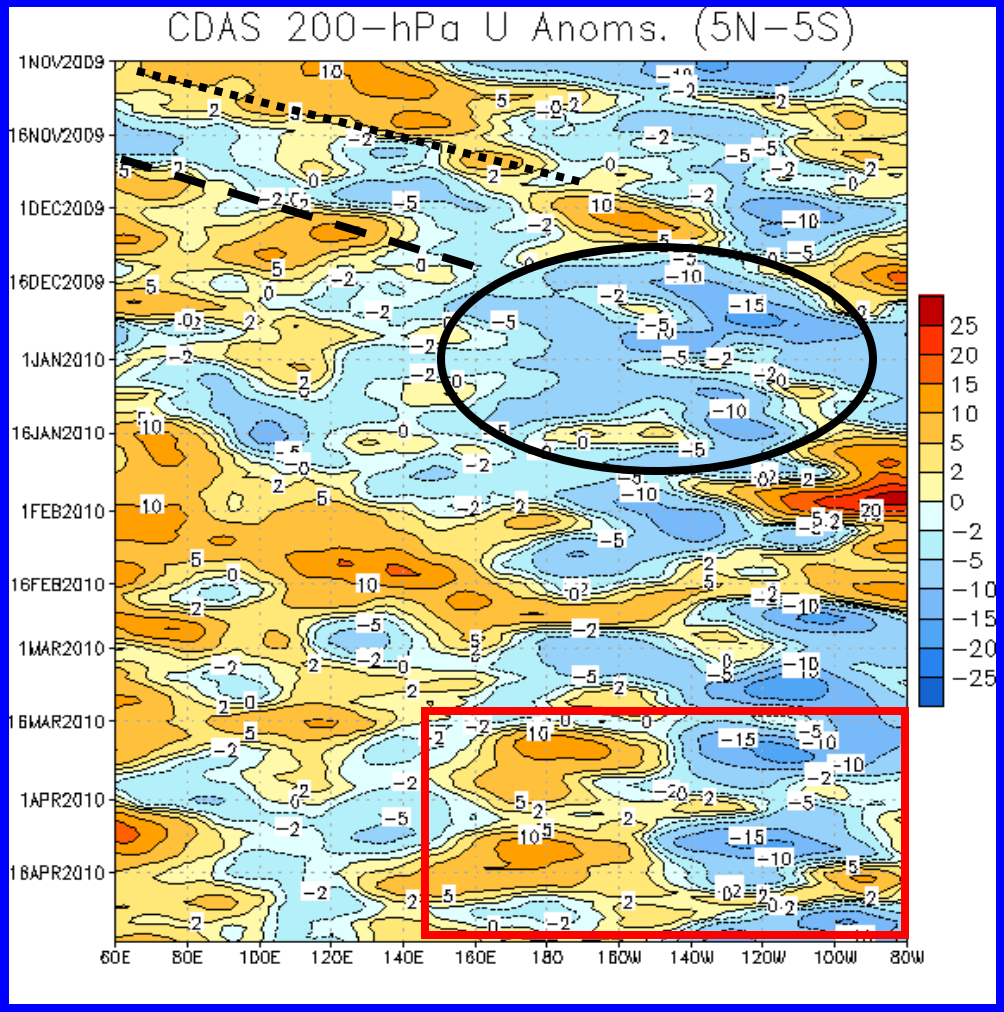
During the last ten days, an anti-cyclonic circulation (red box, A) is evident across the western North Atlantic. A paired anti-cyclone is also evident across northern South America. This pattern is most likely related to the persistent enhanced tropical convection across South and Central America.

Easterly anomalies have strengthened in the eastern Pacific.

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

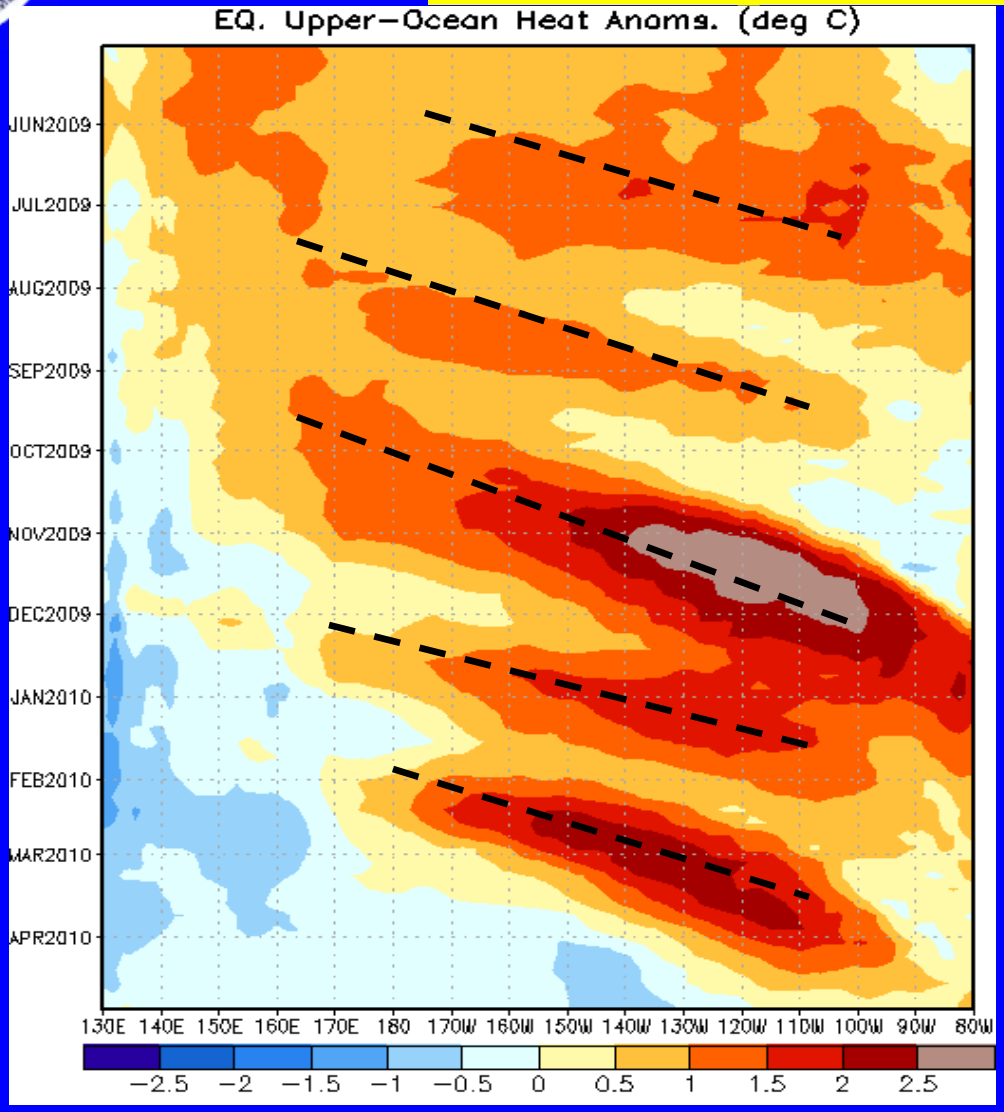
Longitude

Westerly (easterly) anomalies (dotted and dashed lines) shifted eastward across the Maritime Continent during November associated with the MJO.

Easterly anomalies dominated much of the central and eastern Pacific during the second half of December and most of January (black oval).

For several weeks, westerly anomalies have been in place in the central Pacific while easterlies have dominated the eastern Pacific (red box). Over the past two weeks this pattern has become less coherent.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

In April 2009, the combined effects of an oceanic Kelvin wave and weaker easterly trade winds contributed to an increase in the upper-ocean heat content anomalies across the Pacific Ocean. Since April 2009, heat content anomalies have remained above-average.

From November 2009 – February 2010 three ocean Kelvin waves contributed to the change in heat content across the eastern Pacific (last three dashed black lines).

During April 2010 heat content anomalies have decreased across the Pacific in association with the upwelling phase of a Kelvin wave. Currently, negative heat content anomalies extend across the central and east-central 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).**

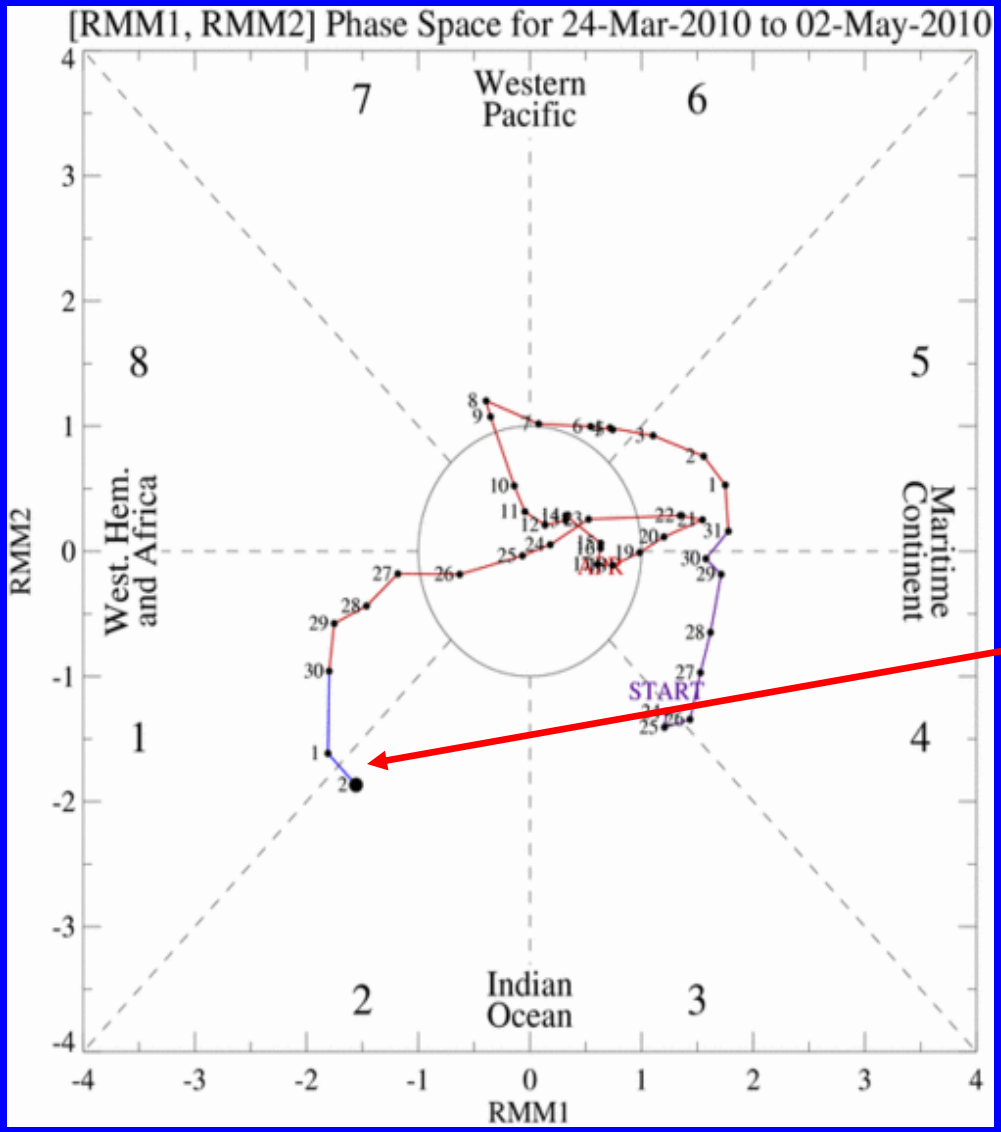
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review*, 132, 1917-1932.

- **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 Model MJO Forecasts: A Project of the CLIVAR Madden-Julian Oscillation Working Group, *Bull. Amer. Met. Soc.*, Accepted.

- **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).**

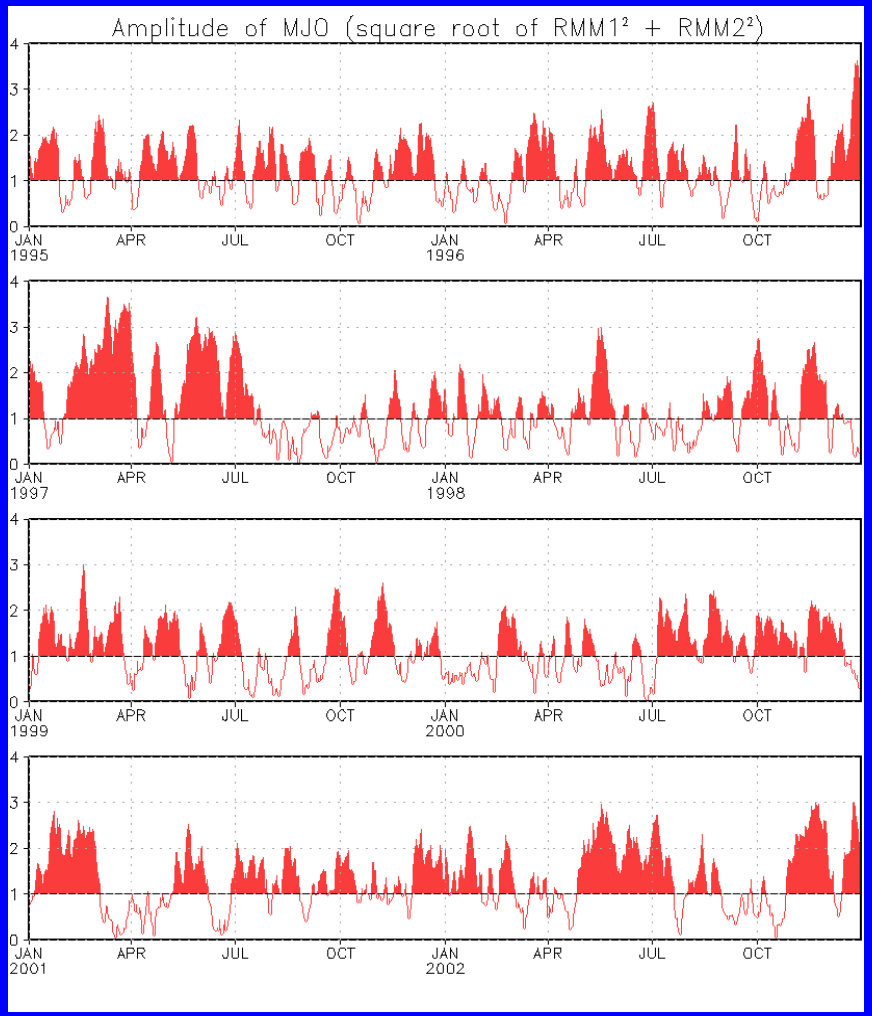
MJO Index -- Recent Evolution

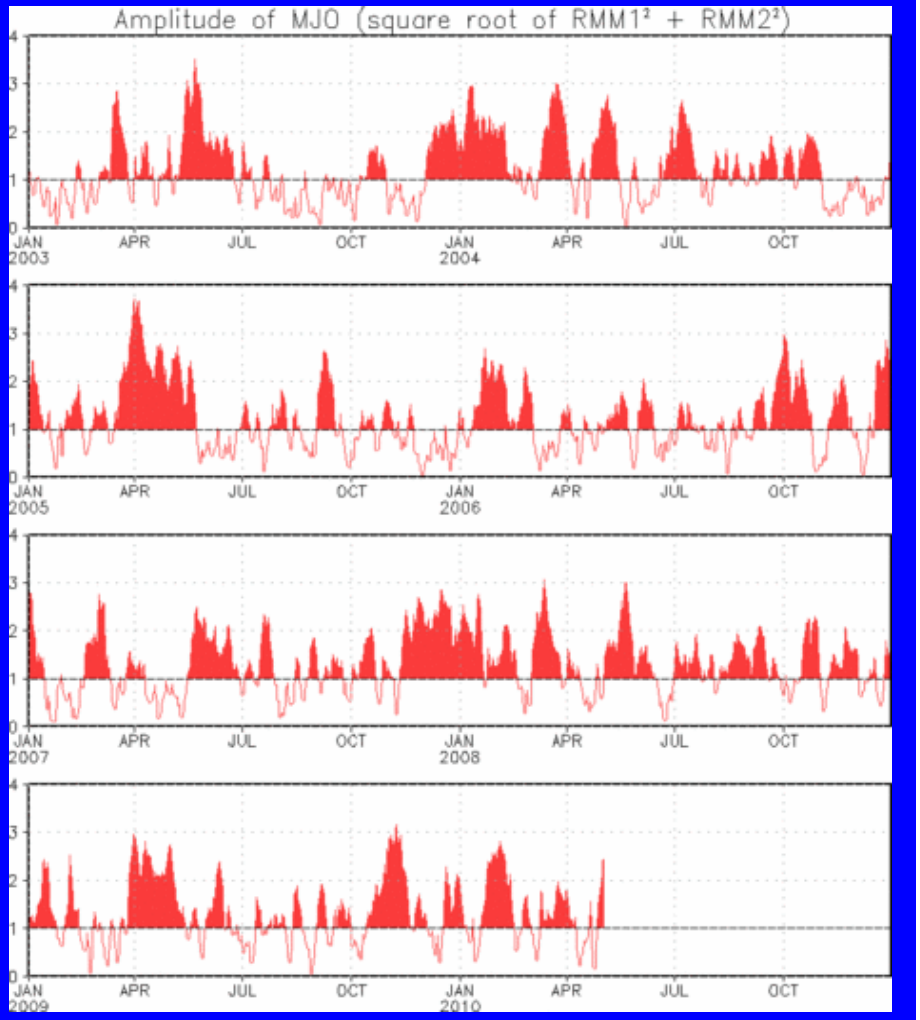


- **The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes**
- **The triangular areas indicate the location of the enhanced phase of the MJO**
- **Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.**
- **Distance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

During the past week, the MJO index indicated a strengthening MJO signal which has moved eastward over the past few days.

MJO Index – Historical Daily Time Series





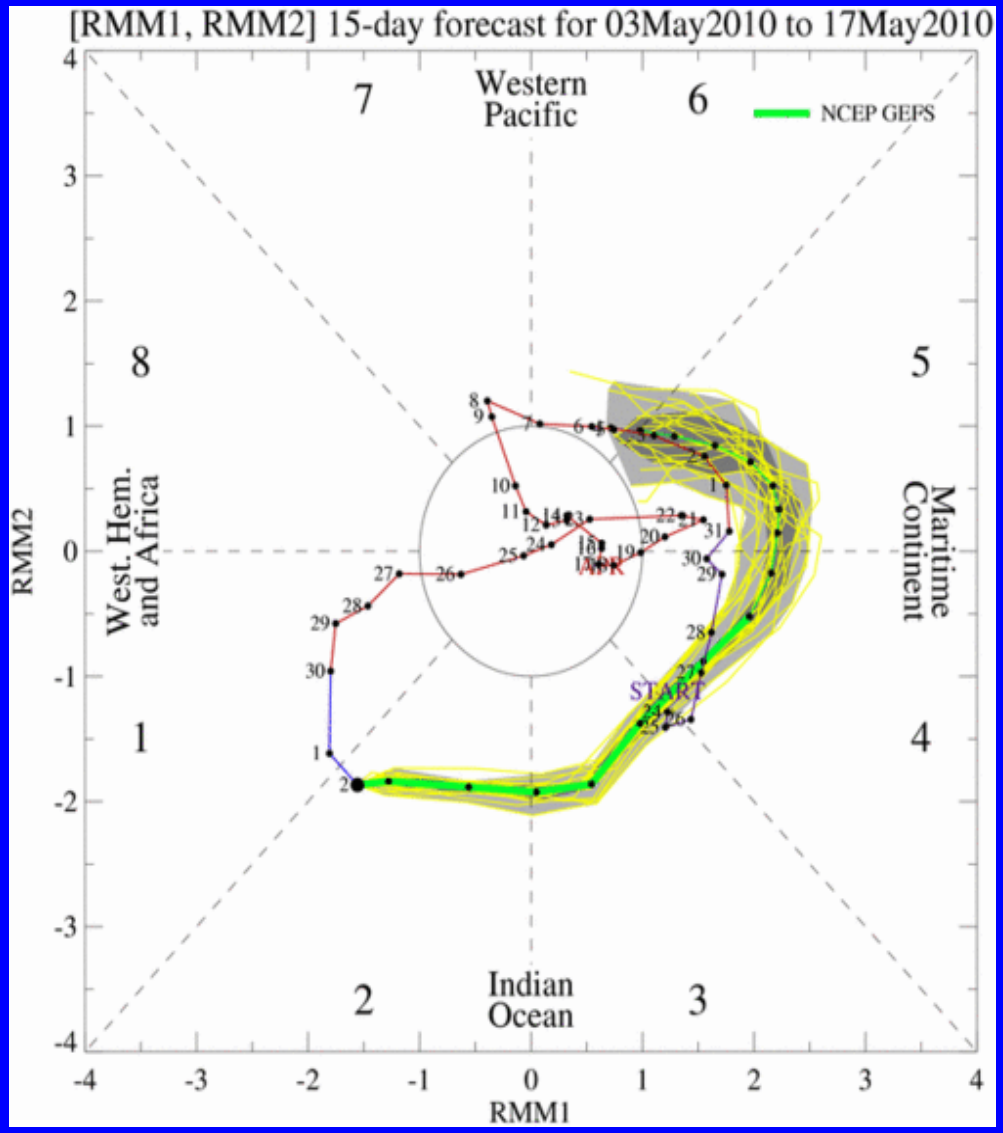
Time series of daily MJO index amplitude from 1995 to present.
Plots put current MJO activity in historical context.

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



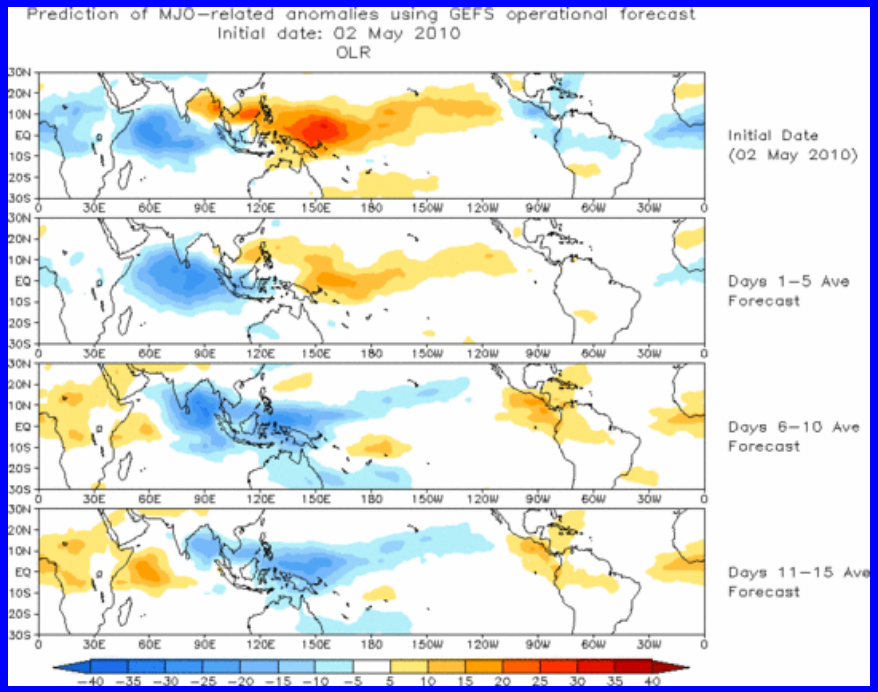
The GFS forecasts indicate a strong signal and fast eastward propagation during the next two weeks.

There is low spread in the ensemble forecast especially during Week-1 increasing confidence in the future evolution of the MJO.

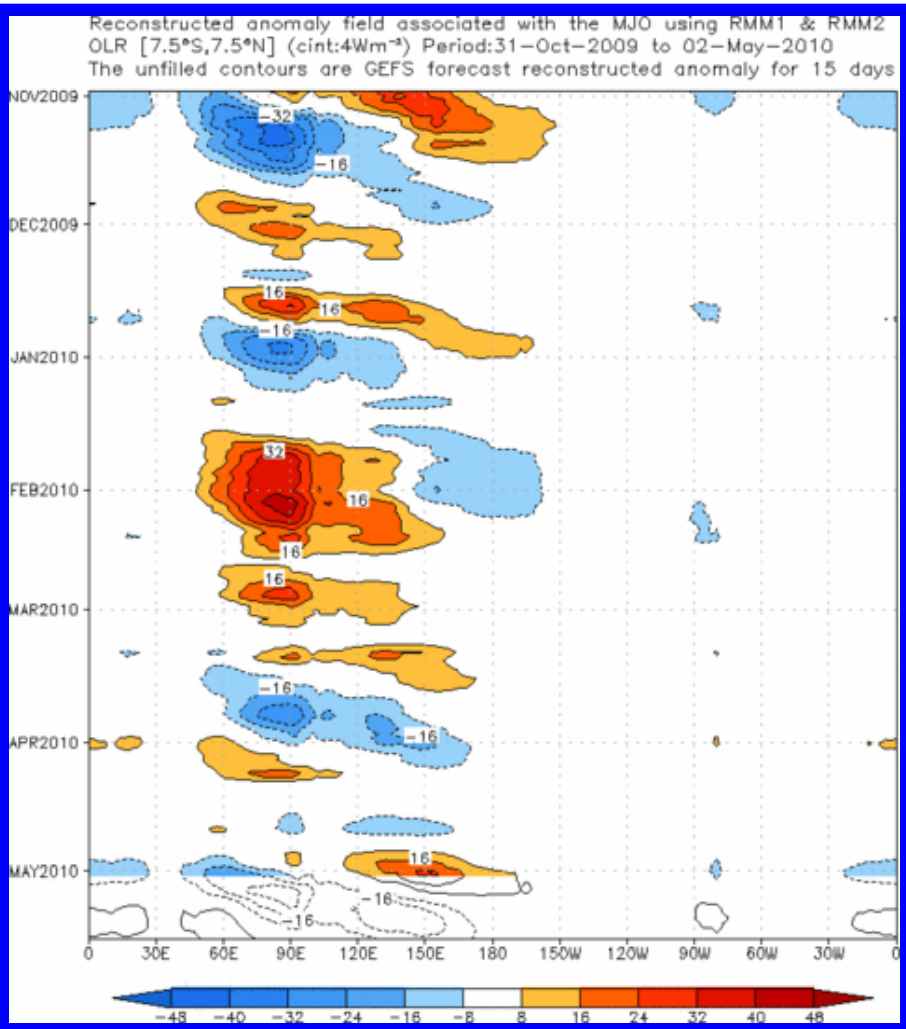
Ensemble Mean GFS MJO Forecast

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)

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 GEFS ensemble mean forecast indicates enhanced (suppressed) convection over Africa and the Indian Ocean (west-central Pacific) during Week-1, and enhanced (suppressed) convection over the Maritime Continent (eastern Pacific and Central America) during Week-2.

Statistical MJO Forecast

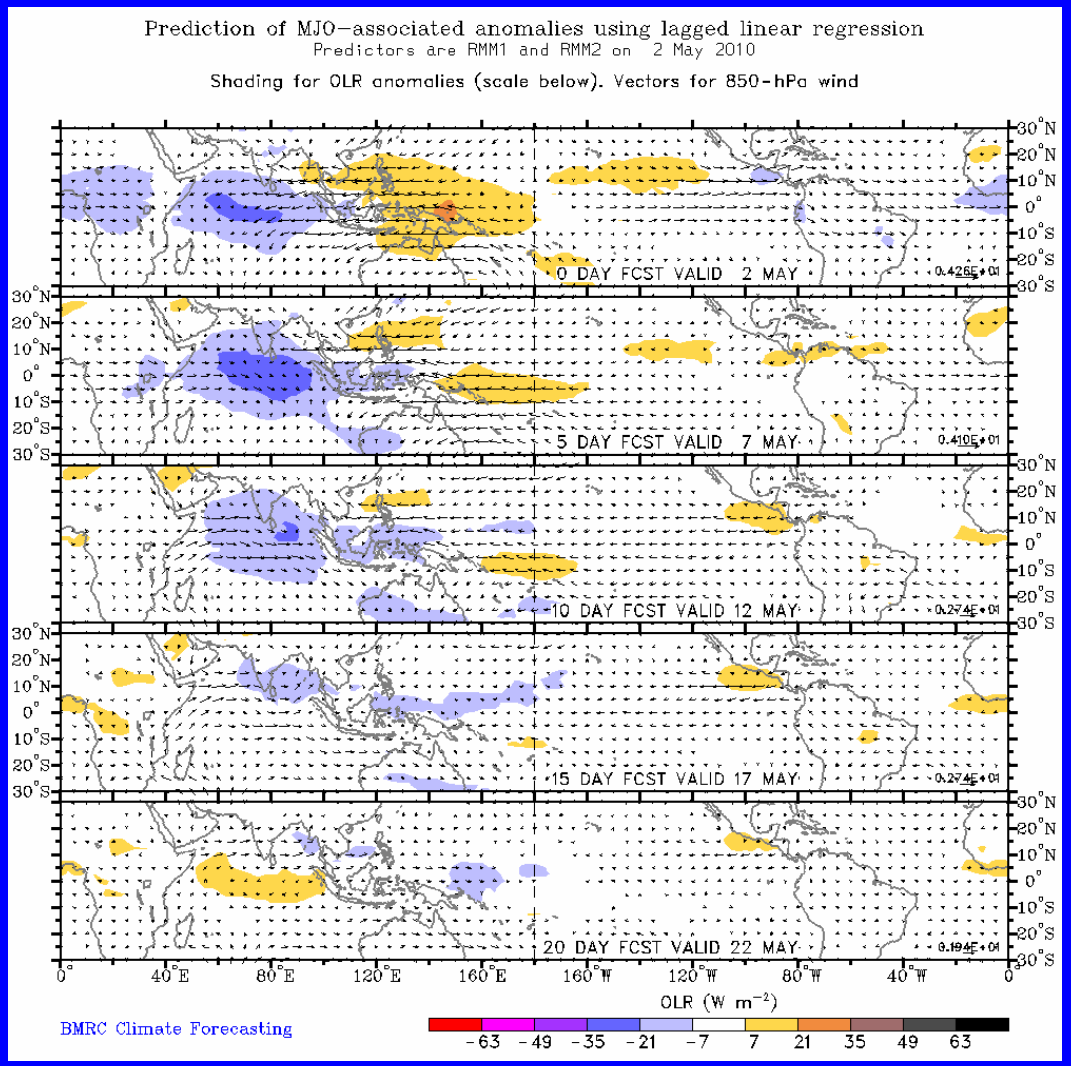
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons)

Spatial map of OLR anomalies and 850-hPa vectors for the next 20 days

(Courtesy of the Bureau of Meteorology Research Centre - Australia)

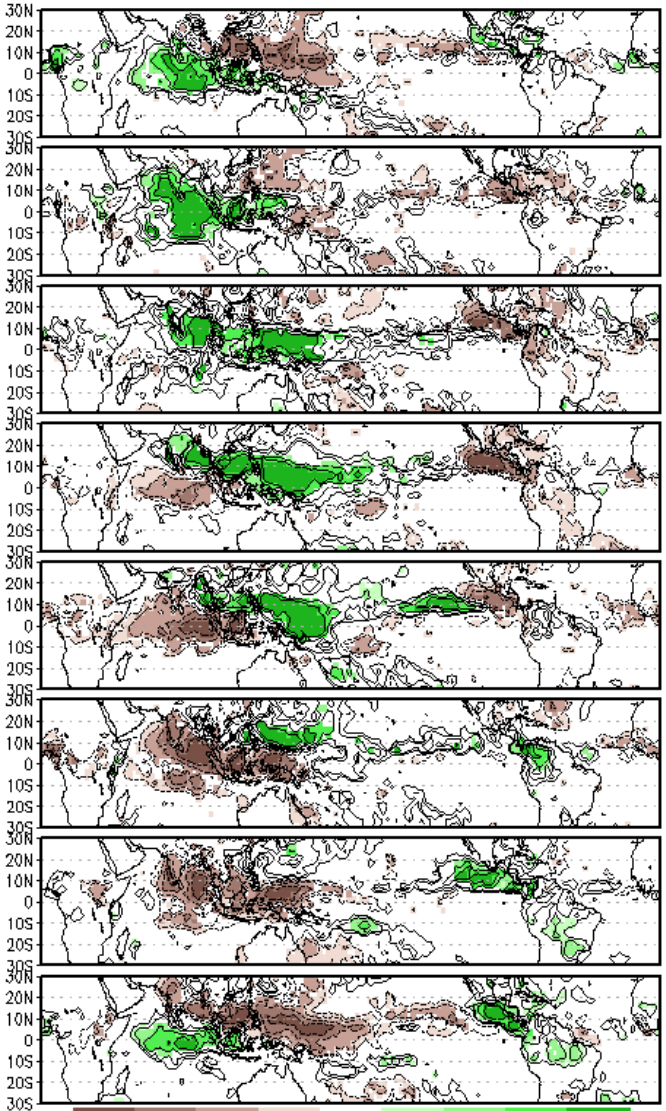
The statistical forecast is consistent with the GFS in Week-1 and weakens the signal in Week-2.

This forecasts indicates enhanced convection over Africa and the Indian Ocean and suppressed convection over the western Pacific over the next 1-2 weeks.



MJO Composites – Global Tropics

Precipitation Anomalies (May-Sep)



850-hPa Wind Anomalies (May-Sep)