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

Update prepared by
Climate Prediction Center / NCEP
March 17, 2014

Outline

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

Overview

- **Recent observations indicate that the MJO remains active with the enhanced phase entering the Indian Ocean, although indicators are increasingly incoherent due to destructive interference with slowly evolving atmospheric and oceanic conditions in the western Pacific.**

- **The dynamical model MJO index forecasts diverge considerably in their depictions of the evolution of the MJO during the upcoming two weeks. Several models weaken the MJO as it interacts with the low frequency base state, while others indicate a more robust Indian Ocean MJO event.**

- **Statistical models generally favor continued MJO activity.**

- **The MJO favors enhanced (suppressed) convection over the western and central Indian Ocean (Maritime Continent and western Pacific) during the period while also tending to oppose ongoing convection across the west-central Pacific associated with increasing ocean temperatures.**

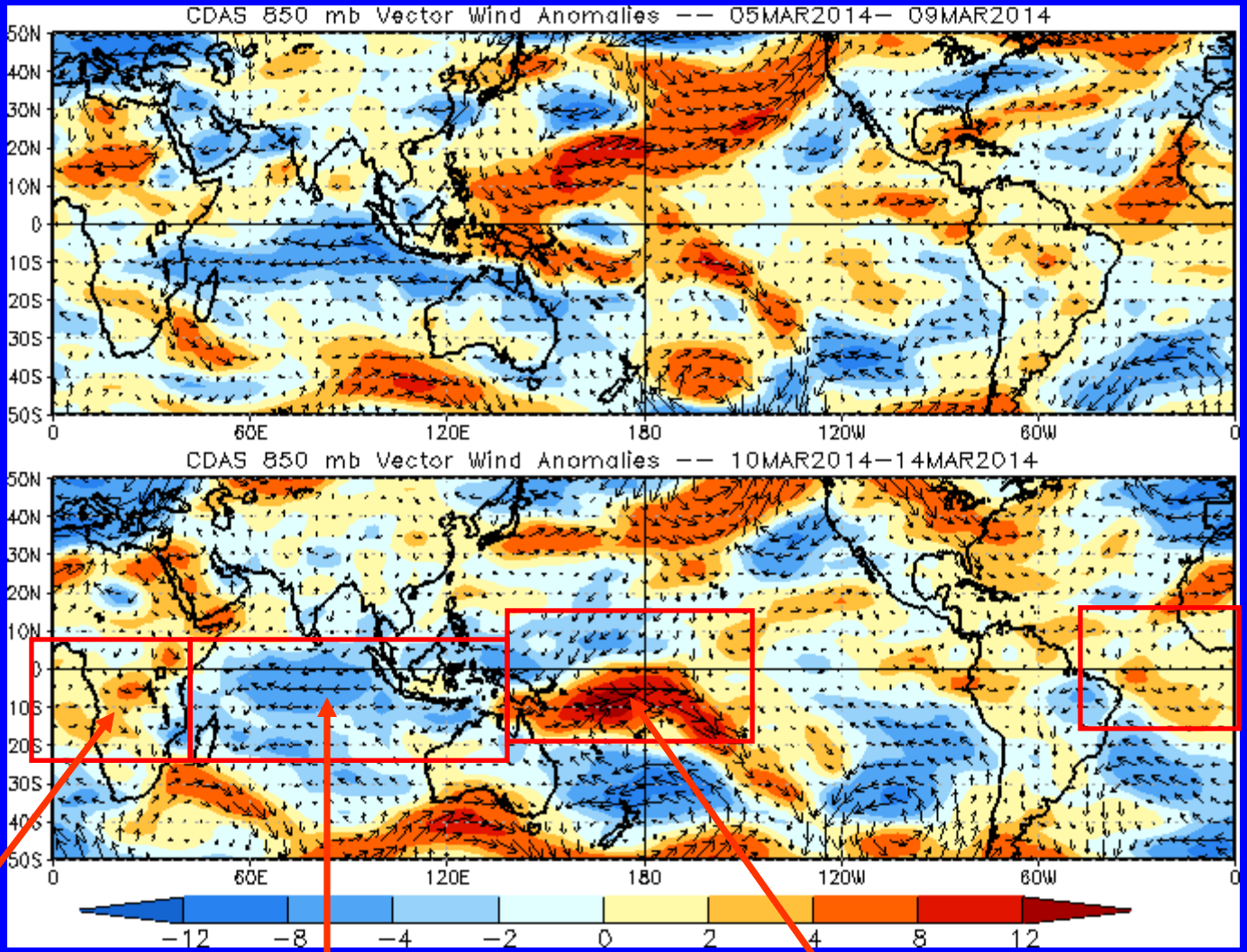
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 persisted over the tropical Atlantic and increased over Africa.

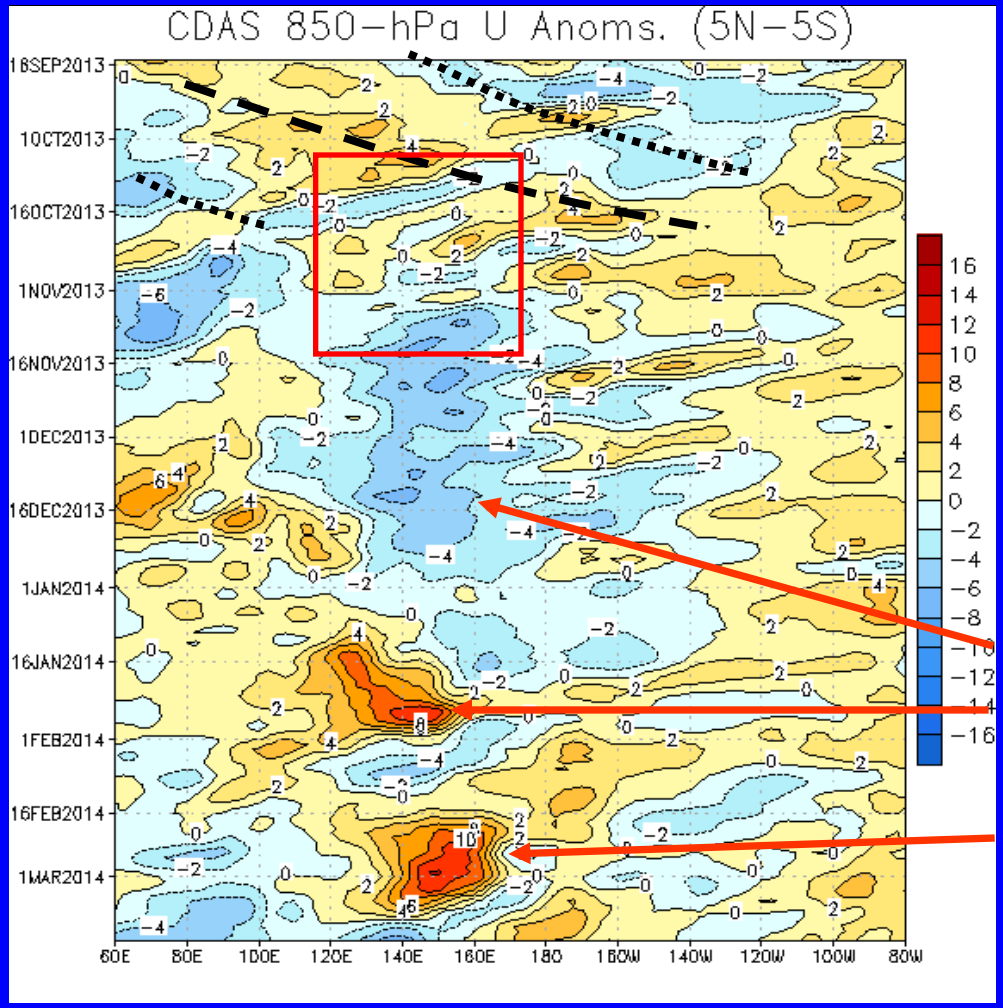
Easterly anomalies persisted but weakened slightly over the Indian Ocean and expanded eastward over the Maritime Continent.

Westerly anomalies intensified south of the equator near the Date Line.

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 September, MJO activity was apparent in the low-level wind anomaly field (alternating dotted and dashed lines).

During October, equatorial Rossby wave activity was strong from 160E to 100E as westward movement features are evident (red box). MJO activity was less coherent during this period.

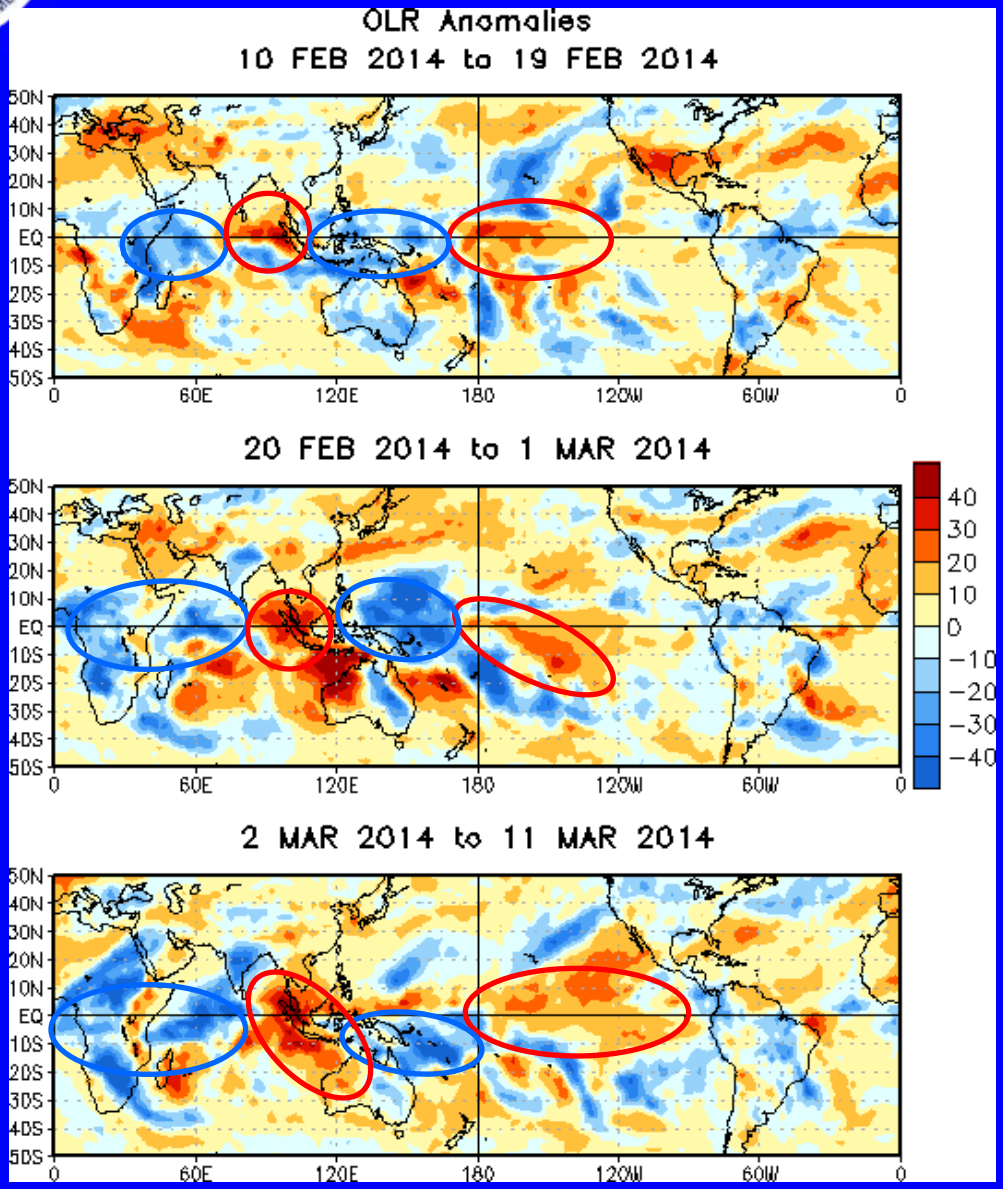
Persistent easterly anomalies from 120E to near the Date Line during November and December were replaced by westerly anomalies east of the Maritime Continent during January.

Westerly anomalies returned to the Western Pacific during late February and early March, with disruptions by easterly anomalies in early February and mid-March.

OLR Anomalies – Past 30 days

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

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

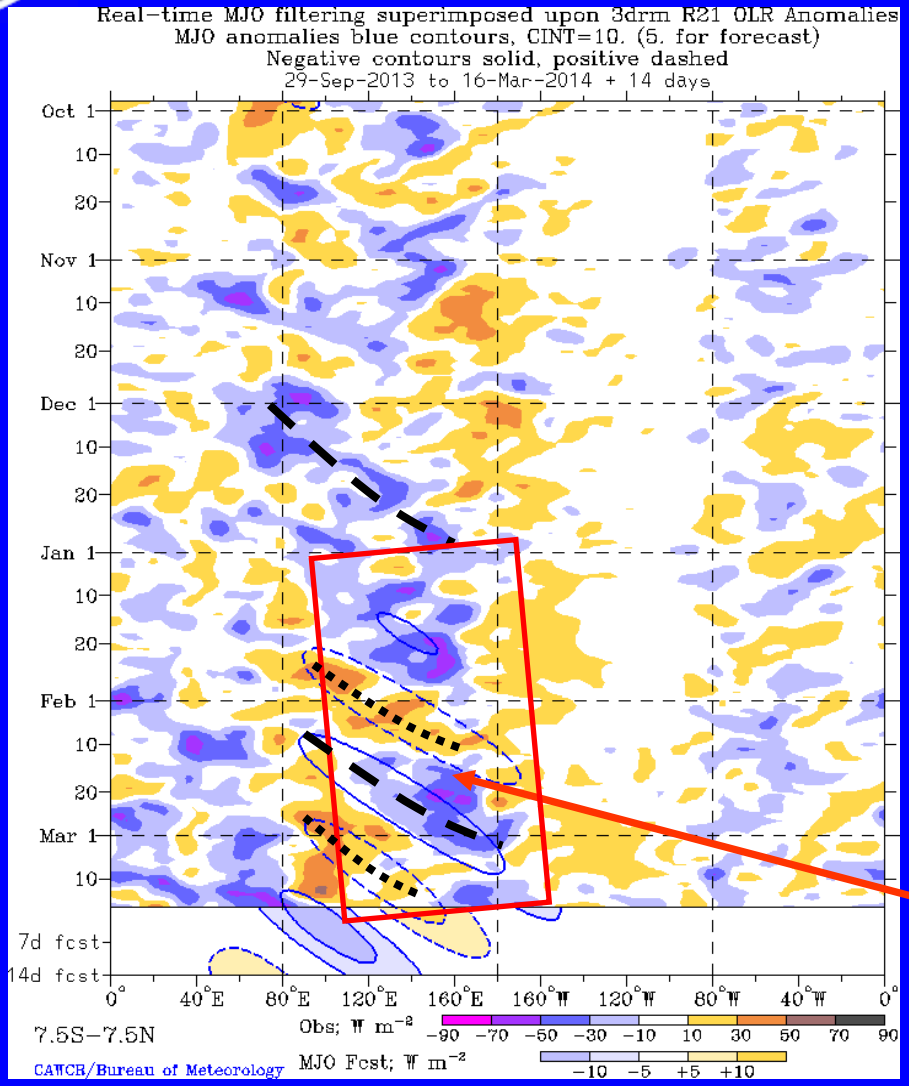


During mid-February, enhanced (suppressed) convection was observed over parts of Africa, the western Indian Ocean, the Maritime Continent, and West Pacific (eastern equatorial Indian Ocean and central Pacific).

During late February, enhanced convection persisted over the western Indian Ocean and intensified over the West Pacific, while suppressed convection persisted over the eastern Indian Ocean and western Maritime Continent.

Enhanced (suppressed) convection persisted over the western Indian Ocean and southwestern Pacific (eastern Indian Ocean and western Maritime Continent) during early March, while suppressed convection spread eastward across the central and eastern Pacific.

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



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)

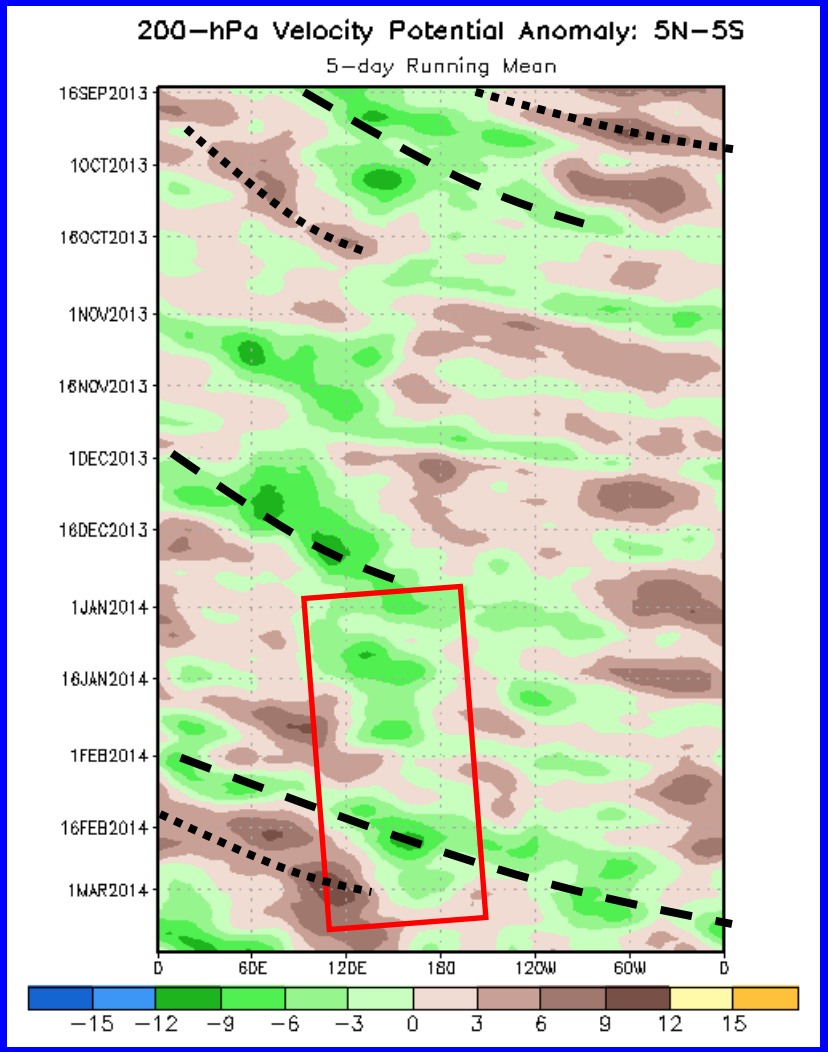
Until late November, the MJO was generally weak or incoherent, then a large area of enhanced convection developed over the Indian Ocean during late November and propagated slowly eastward to the west Pacific Ocean by early January.

From January through early March, enhanced convection propagated slowly from the Maritime Continent to the western Pacific (red box), interrupted by positive OLR anomalies during late January and early February and again in early March associated with the MJO.

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

The MJO strengthened during late August and September, with eastward propagation of robust upper-level velocity potential anomalies (alternating dashed and dotted lines).

From late October to early December, the MJO was not very strong or coherent. There was evidence of coherent eastward propagation at times during this period, but much of this activity exhibited fast propagation speeds more consistent with atmospheric Kelvin waves.

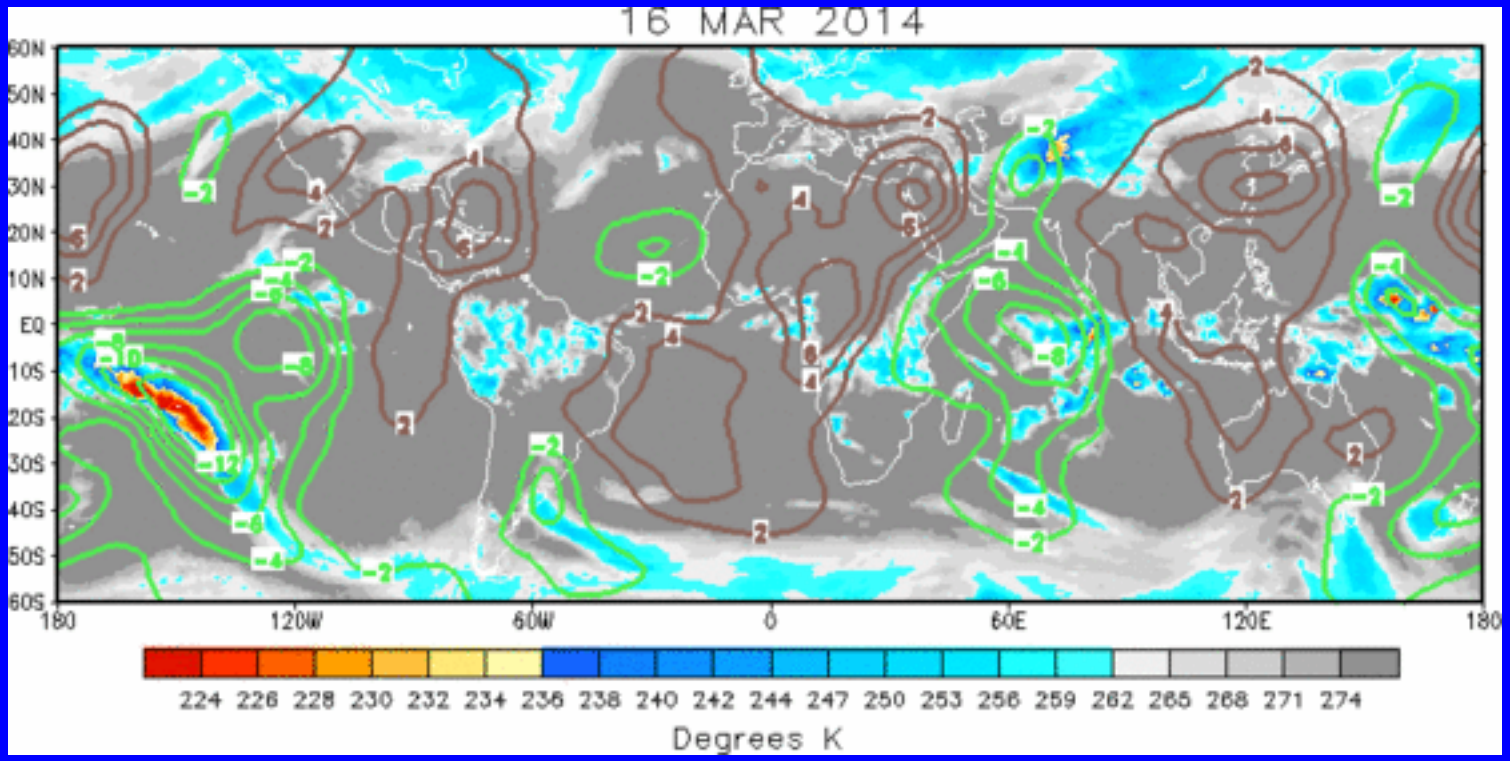
Slower eastward propagation was observed from mid-December to late February across the Indo-Pacific warm pool region (red box).

During February into early March, anomalies propagated eastward with time associated with the MJO.

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

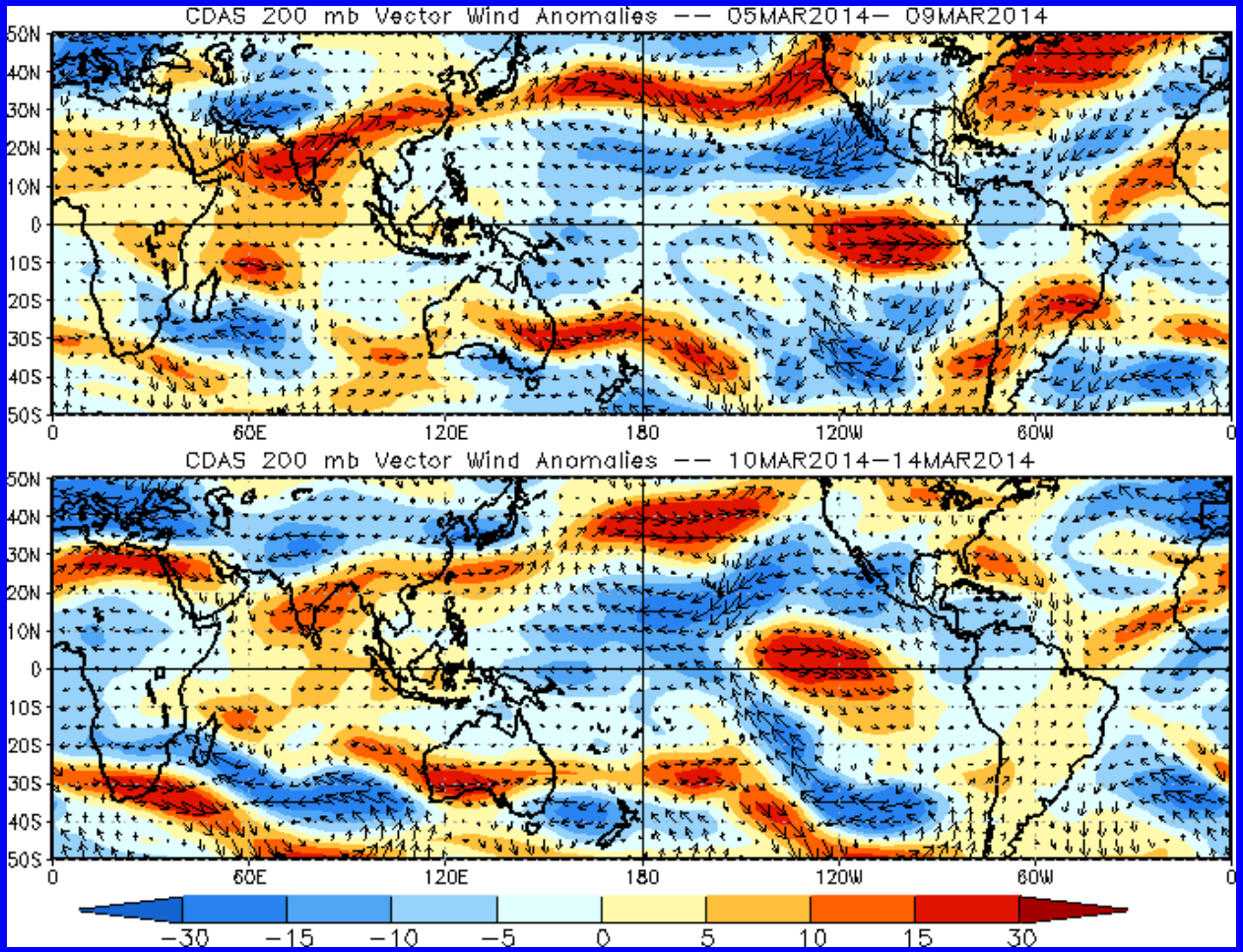
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The current velocity potential spatial anomaly pattern has become less coherent, with areas of anomalous upper-level divergence (convergence) over the west-central Pacific and western Indian Ocean (Maritime Continent and parts of the Western Hemisphere).

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

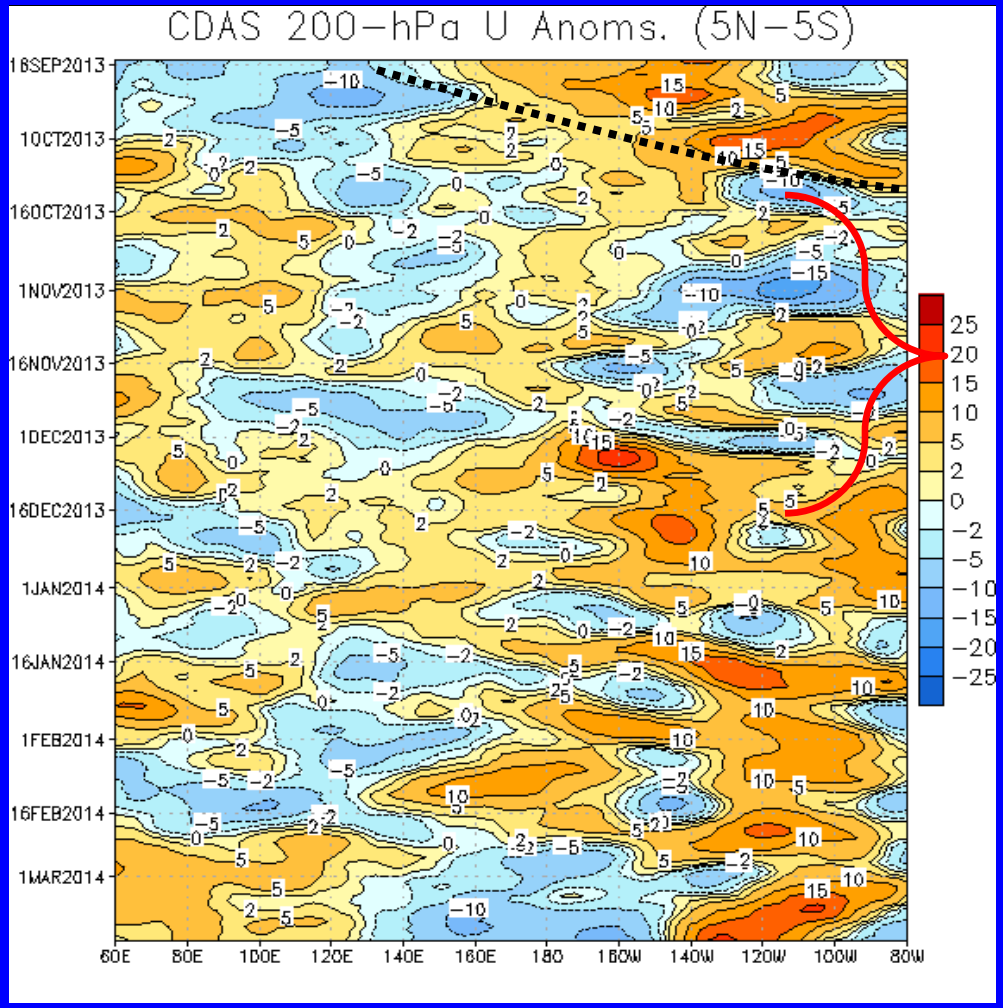
Red shades: Westerly anomalies

During early to mid-March, westerly (easterly) anomalies persisted over the Indian Ocean (central Pacific). A band of strong westerly anomalies shifted westward over 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

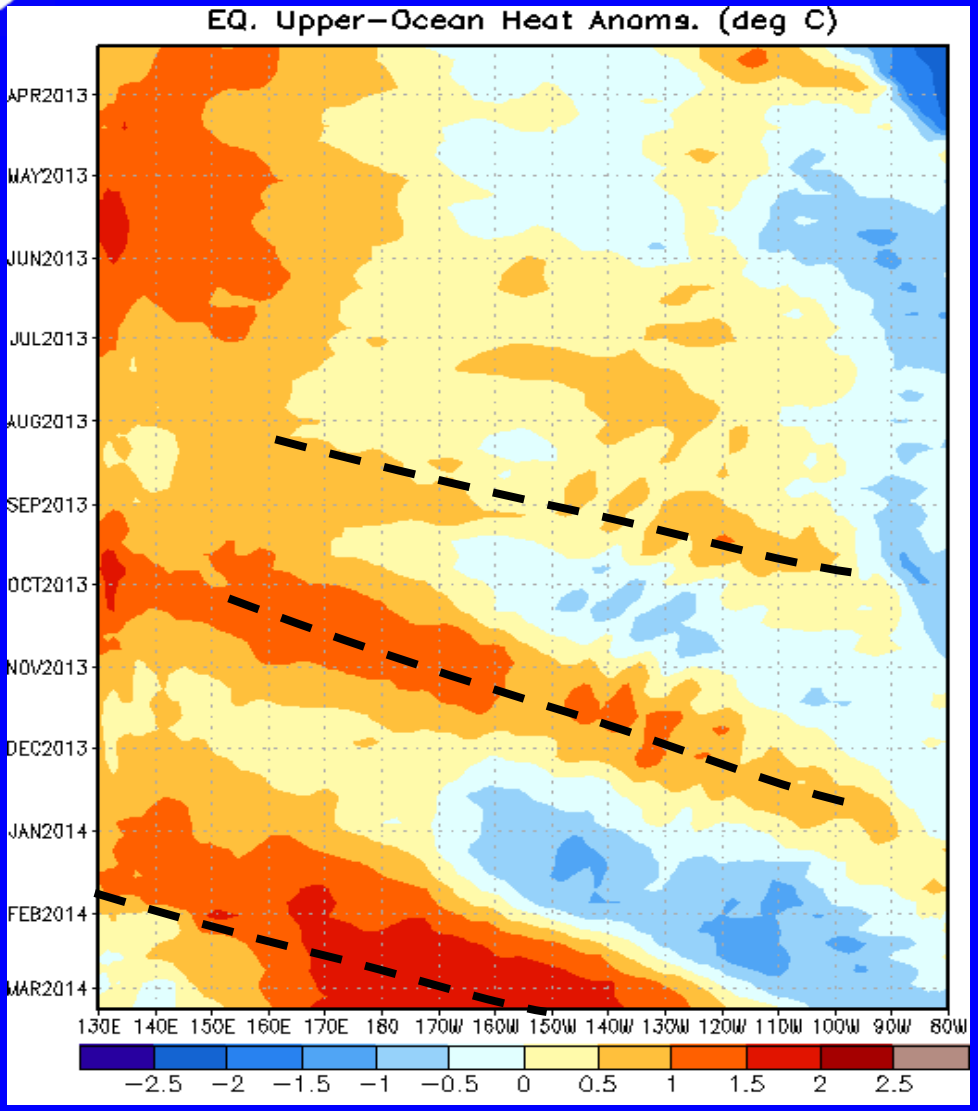
MJO activity (alternating dotted and dashed lines) occurred during late August and September with westerly wind anomalies shifting east to the eastern Pacific.

Anomalies of alternating sign were evident over the eastern Pacific, due in part to extratropical Rossby waves breaking into the Tropics (red bracket).

Westerly anomalies increased in December across the western Hemisphere and persisted into early January. During January, anomalies were dominated by Kelvin wave activity and interaction with the extratropics over the Western Hemisphere.

During early March, a westward moving feature is evident over the eastern Pacific.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

The influence of a downwelling oceanic Kelvin wave can be seen through late March 2013 as anomalies became positive in the east-central Pacific.

Oceanic downwelling Kelvin wave activity is evident in late August and once again during October through early December.

A considerably stronger downwelling event began in January and continues to propagate across the 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).

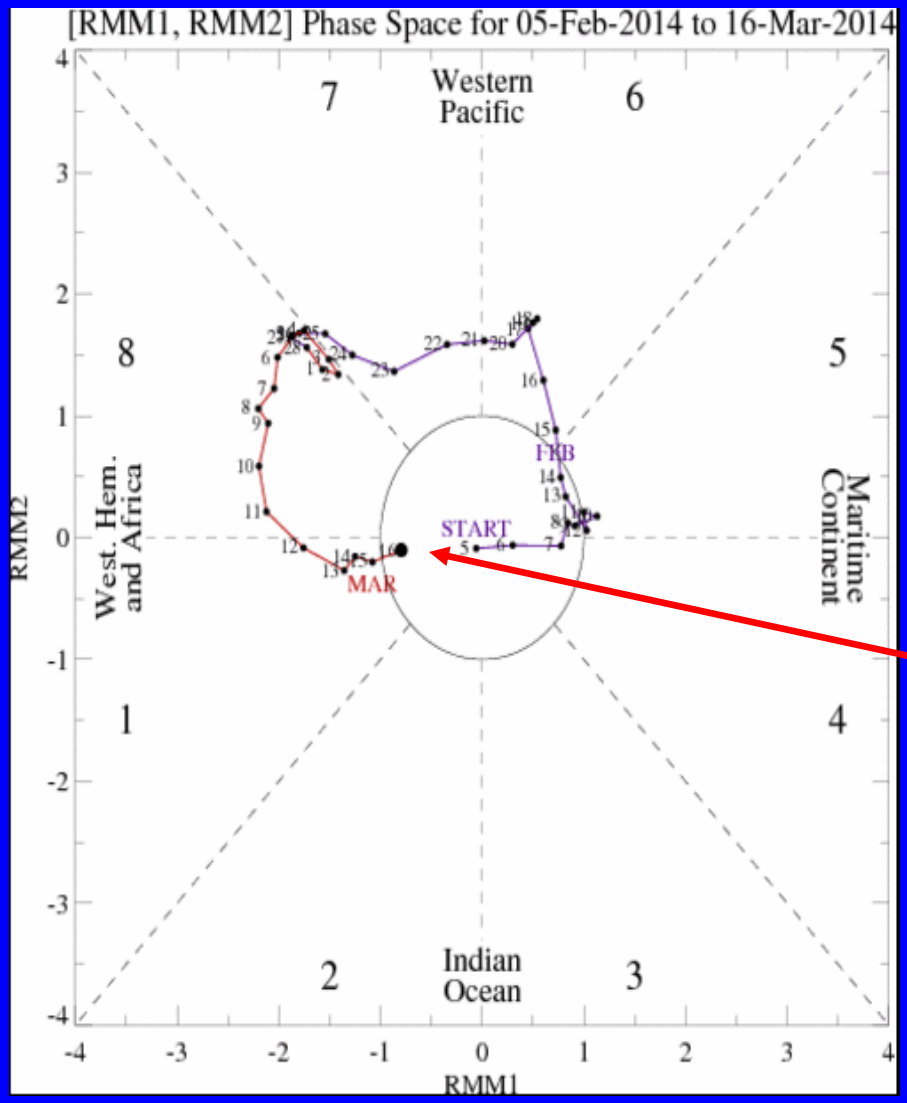
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

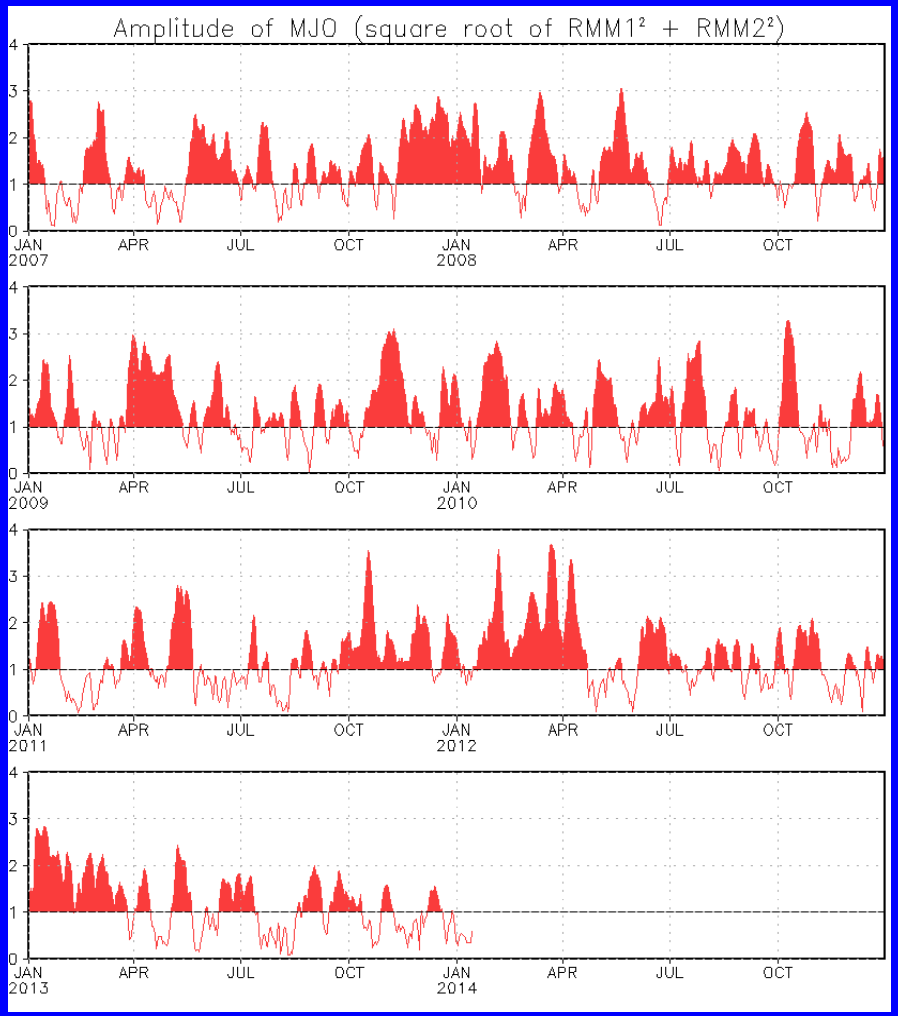
MJO Index -- Recent Evolution



- 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

The MJO index indicates slow eastward MJO propagation over the Western Hemisphere during early March, with a weakening signal towards the middle of the month.

MJO Index – Historical Daily Time Series



Time series of daily MJO index amplitude from 2007 to present.

Plot puts current MJO activity in recent historical context.

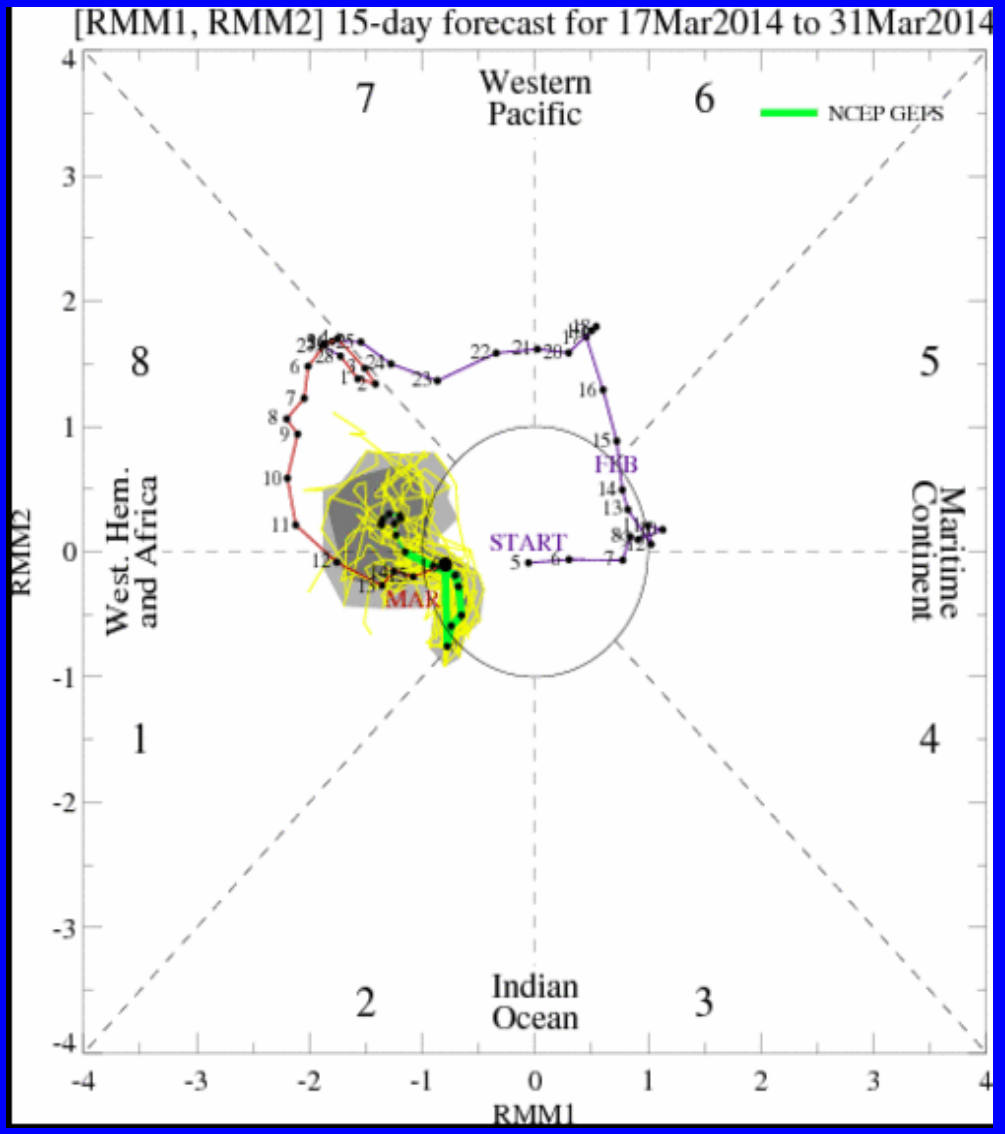
Ensemble GFS (GEFS) MJO Forecast

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

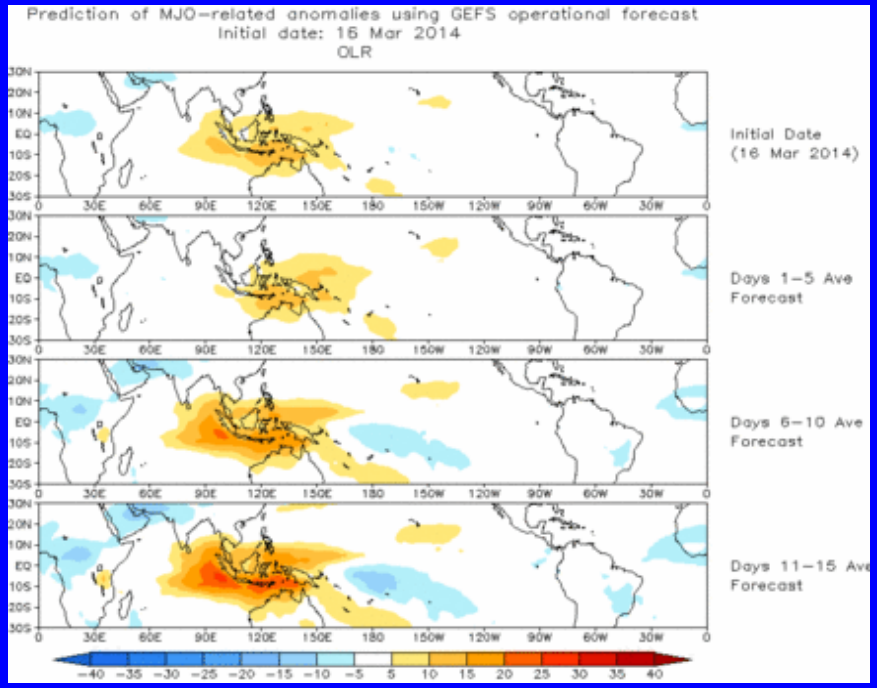
The ensemble GFS forecast indicates no additional eastward propagation of the MJO signal.



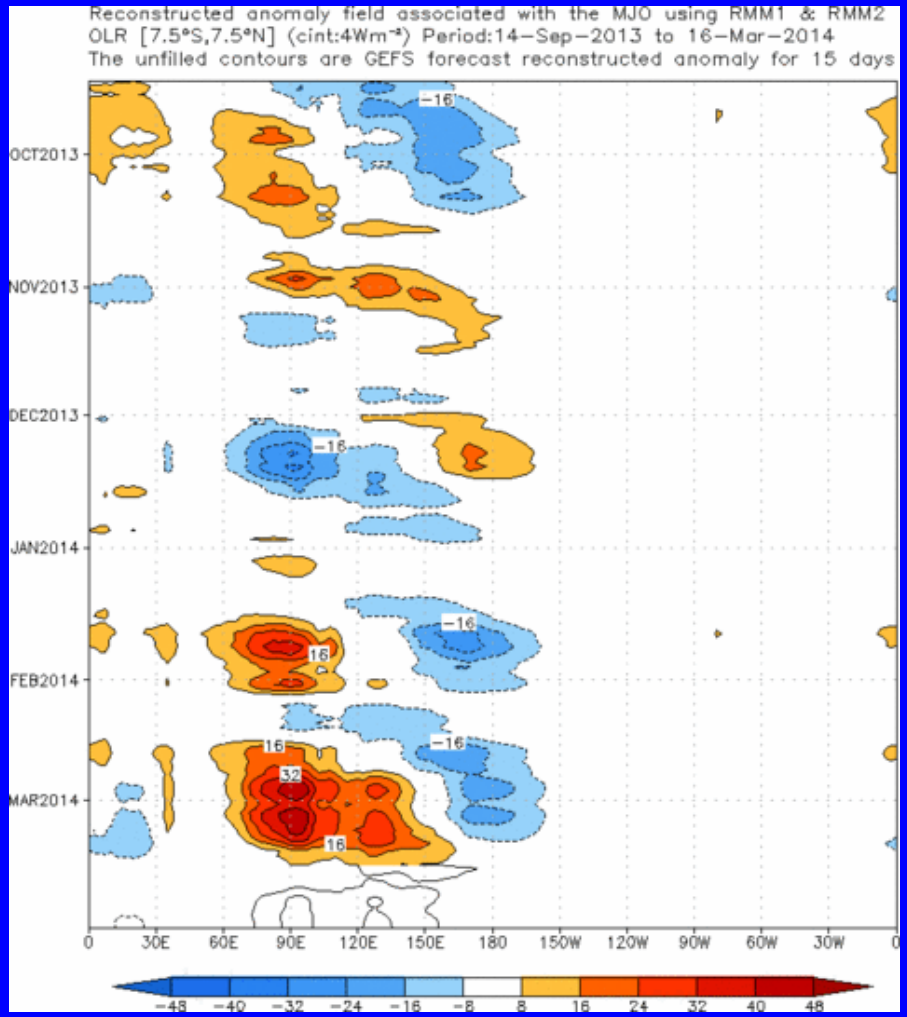
Ensemble Mean GFS MJO Forecast

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

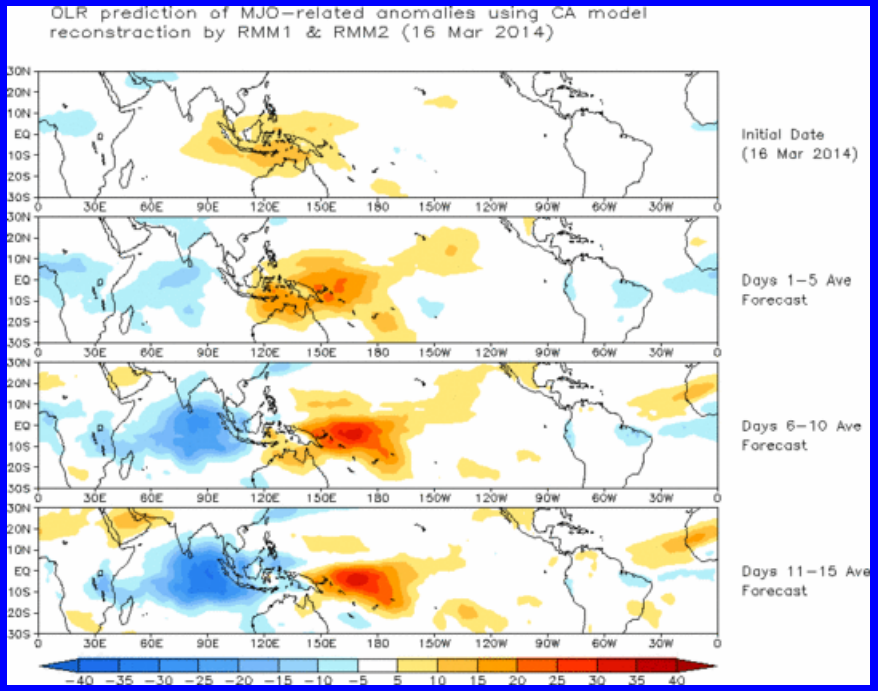


The ensemble mean GFS forecasts a stationary pattern during the upcoming two weeks, with suppressed convection persisting over the Maritime Continent and West Pacific while expanding over the eastern Indian Ocean. Enhanced convection is forecast to persist over parts of equatorial Africa.

Constructed Analog (CA) MJO Forecast

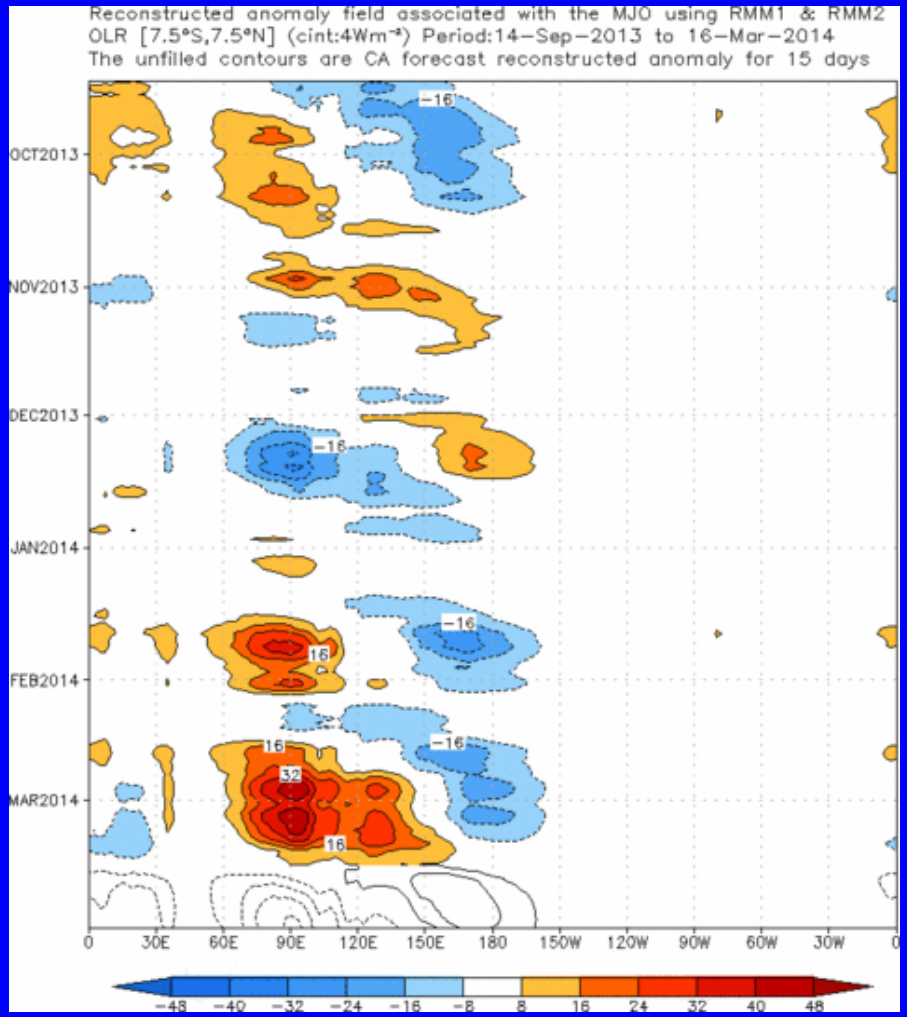
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



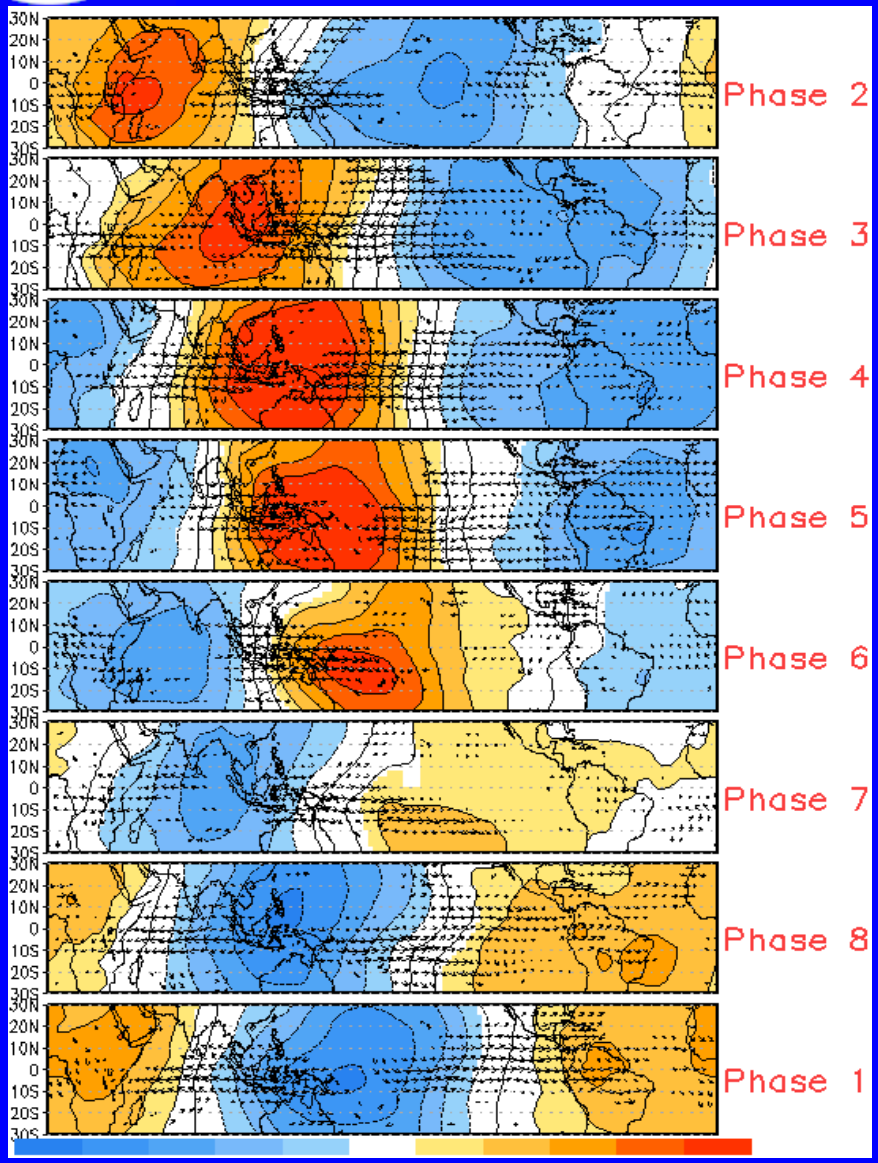
The constructed analog MJO forecast indicates eastward propagation of the MJO with enhanced convection increasing over the Indian Ocean and western Maritime Continent during Week-2.

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

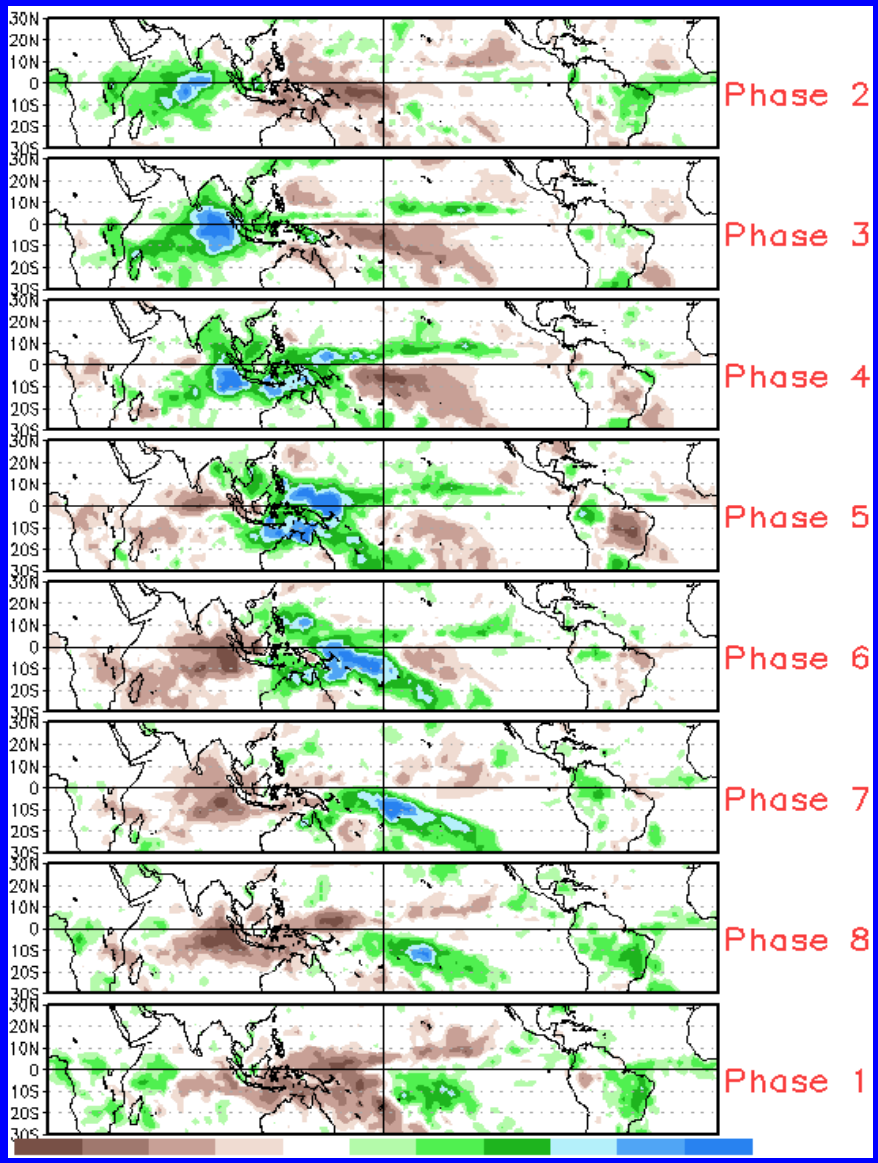


MJO Composites – Global Tropics

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

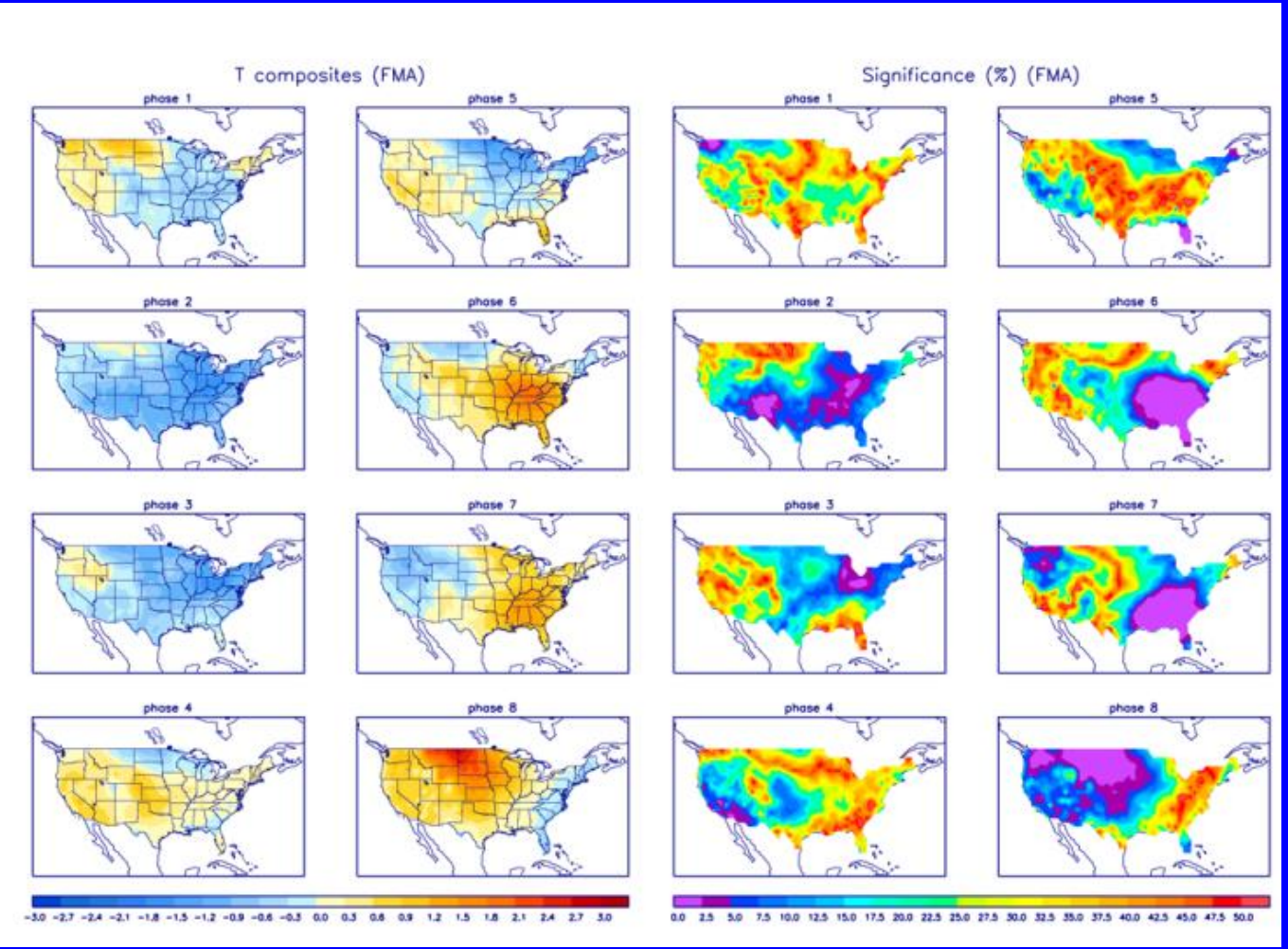


Precipitation Anomalies (Nov-Mar)



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.**

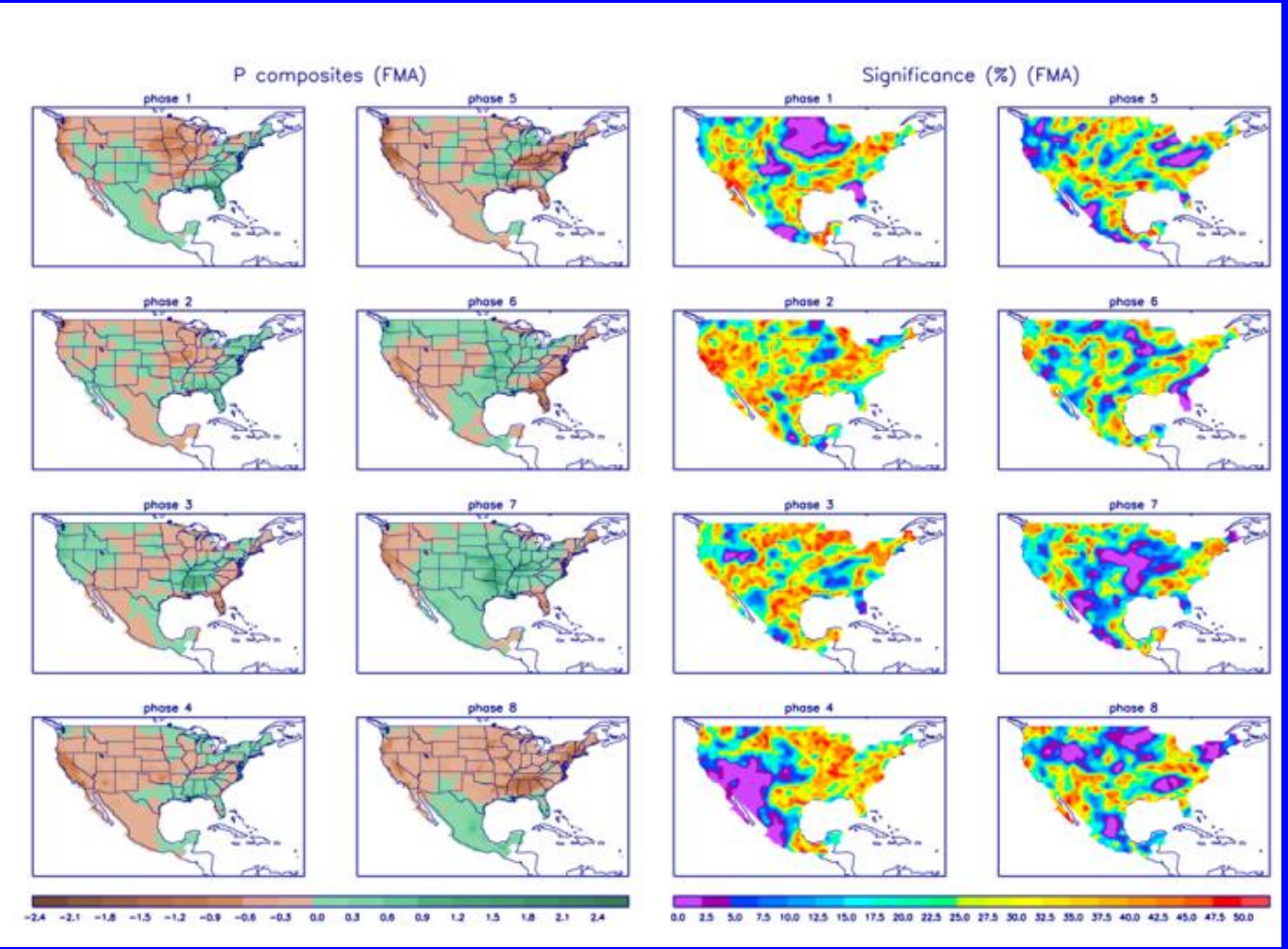


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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