



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

**Update prepared by
Climate Prediction Center / NCEP
March 31, 2014**



Outline

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



Overview

- Recent observations indicate that MJO activity has remained weak, with the atmospheric circulation inconsistent with robust MJO activity.
- The dynamical model MJO index forecasts indicate a strengthening MJO signal but propagation consistent with other modes of tropical variability during Week-1. During Week-2, most models indicate a dramatically weakened signal.
- Statistical models generally favor slow eastward propagation of a weak signal.
- The MJO favors enhanced (suppressed) convection over the central Indian Ocean (Maritime Continent and western Pacific) during the Week-1, with a tendency toward the emerging background state during Week-2.

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>

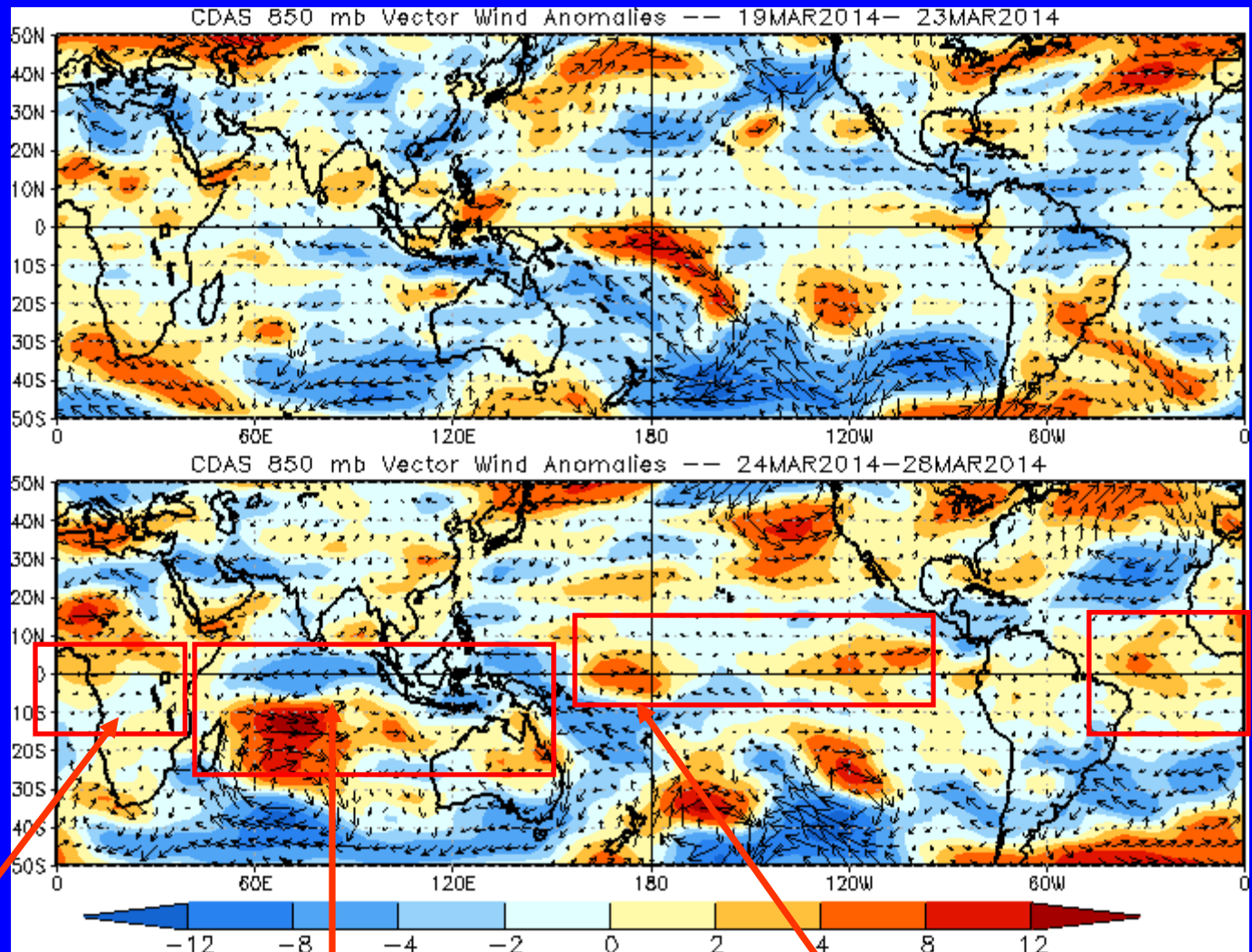


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Weak westerly anomalies persisted over equatorial Africa.

Easterly anomalies expanded to cover the equatorial Indian Ocean and Maritime Continent, while strong westerly anomalies developed over the southern Indian Ocean.

Westerly anomalies diminished in coverage and magnitude near the Date Line, with a slight strengthening over the eastern Pacific

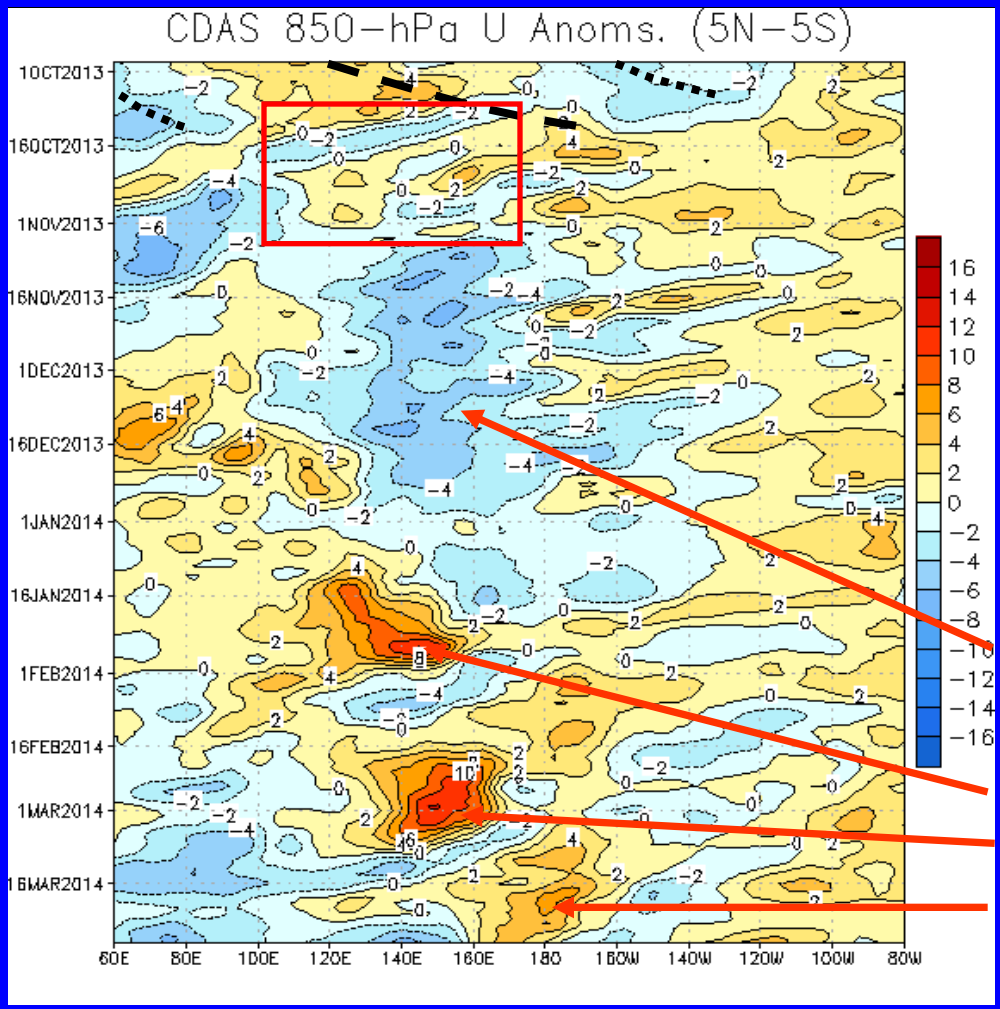


850-hPa Zonal Wind Anomalies (m s^{-1})

Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

Easterly anomalies (blue shading) represent anomalous east-to-west flow

Time
↓



Longitude

During September and into early October, 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.

Easterly anomalies dominated from 120E to near the Date Line during November and December.

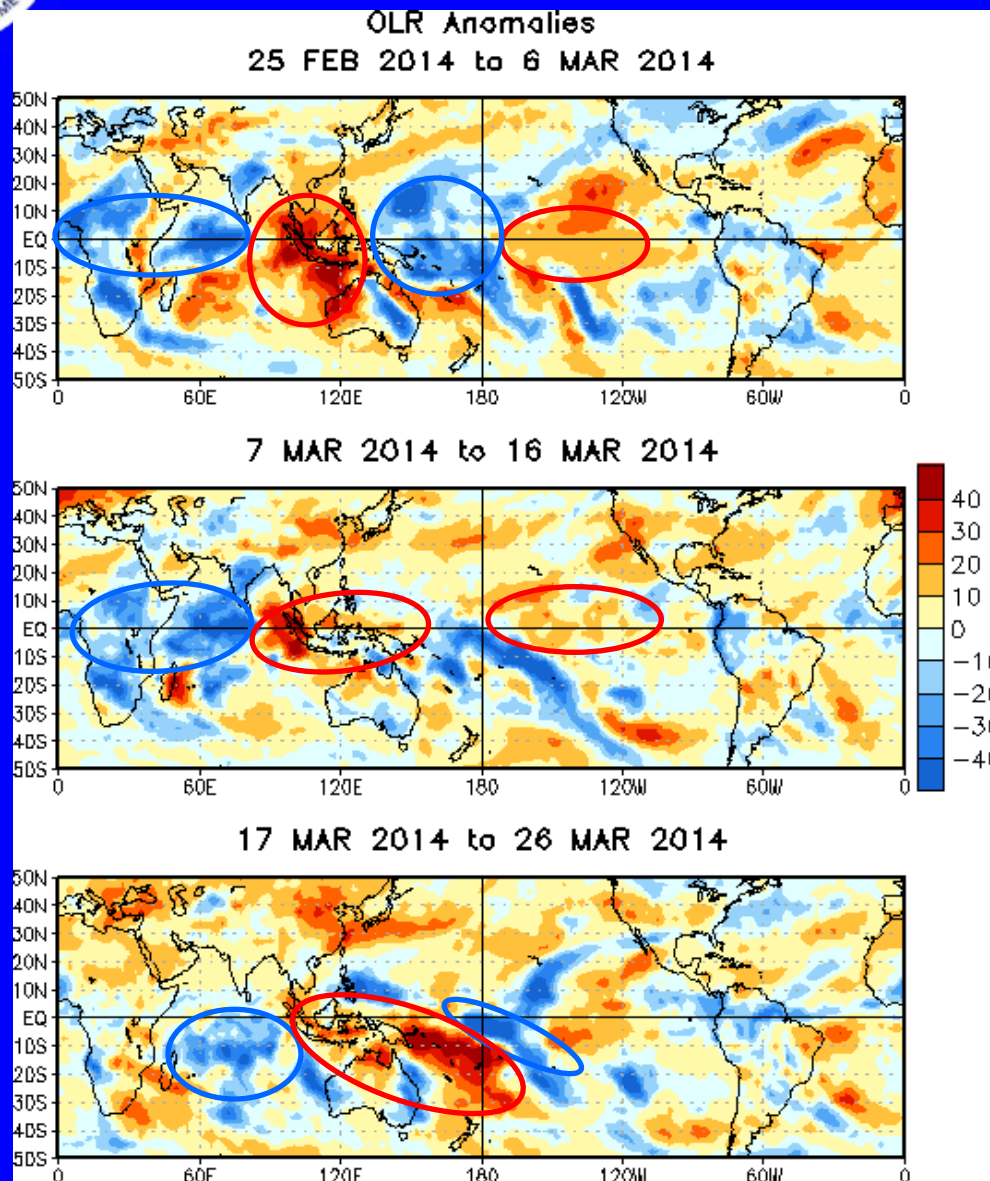
Multiple westerly wind bursts have been observed across the western Pacific between January and mid-March. Each westerly wind burst has shifted slightly further east.

Recently, easterly anomalies have developed from 60E to 150E.



OLR Anomalies – Past 30 days

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



From late February into early Mar, enhanced (suppressed) convection was observed over parts of Africa, the western Indian Ocean, and the western Pacific Ocean (the Maritime Continent, and Central Pacific).

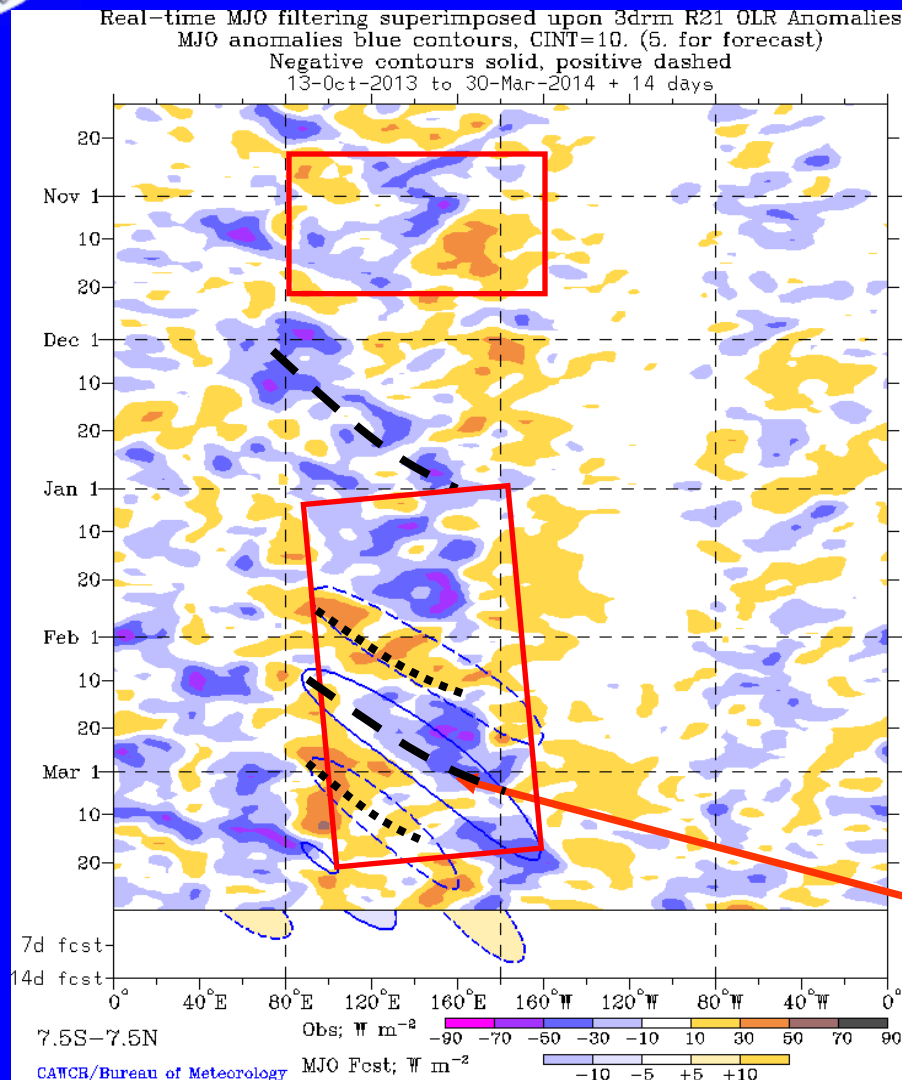
During mid-March, enhanced (suppressed) convection persisted over Africa and the western Indian Ocean, (the eastern Indian Ocean and western Maritime Continent), and convection flared over the southwest Pacific.

Enhanced convection over the Indian Ocean shifted southward. Suppressed convection shifted eastward to the Southwest Pacific during mid- to late March as convection along the SPCZ waned.



Outgoing Longwave Radiation (OLR)

Anomalies (7.5°N-7.5°S)



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.

Most recently, other modes of variability (Kelvin and Equatorial Rossby waves) appear to be dominating the OLR pattern.

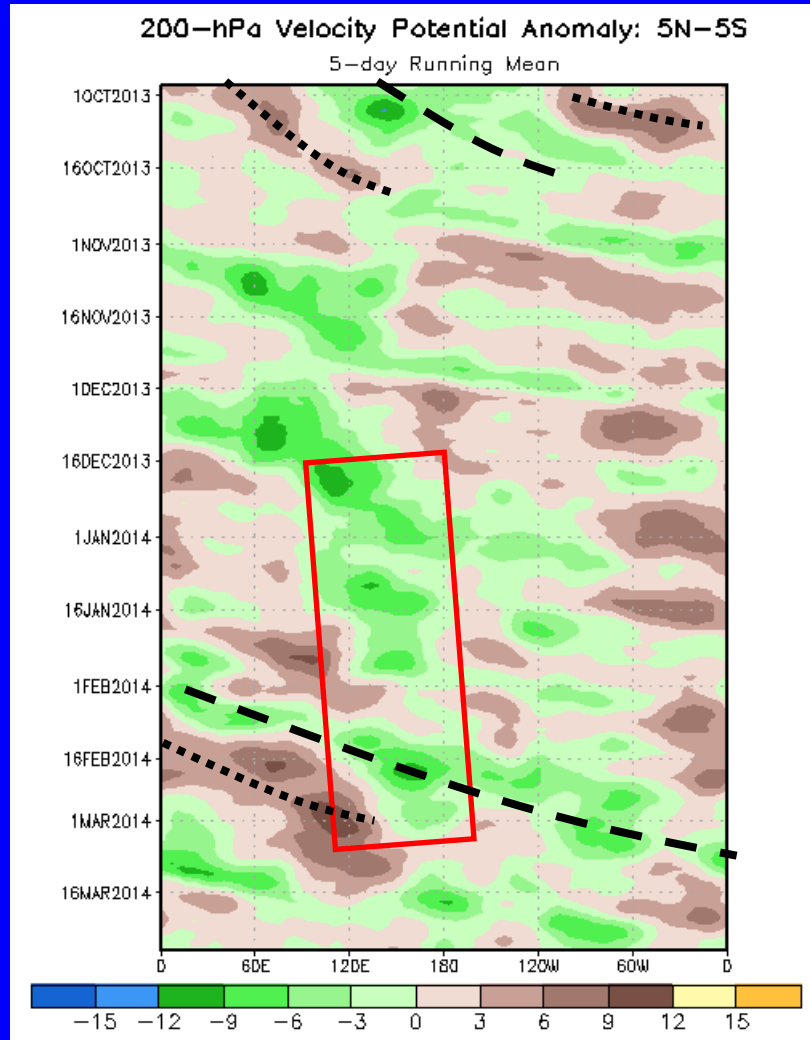


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time



Longitude

The MJO was active through early October, 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 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).

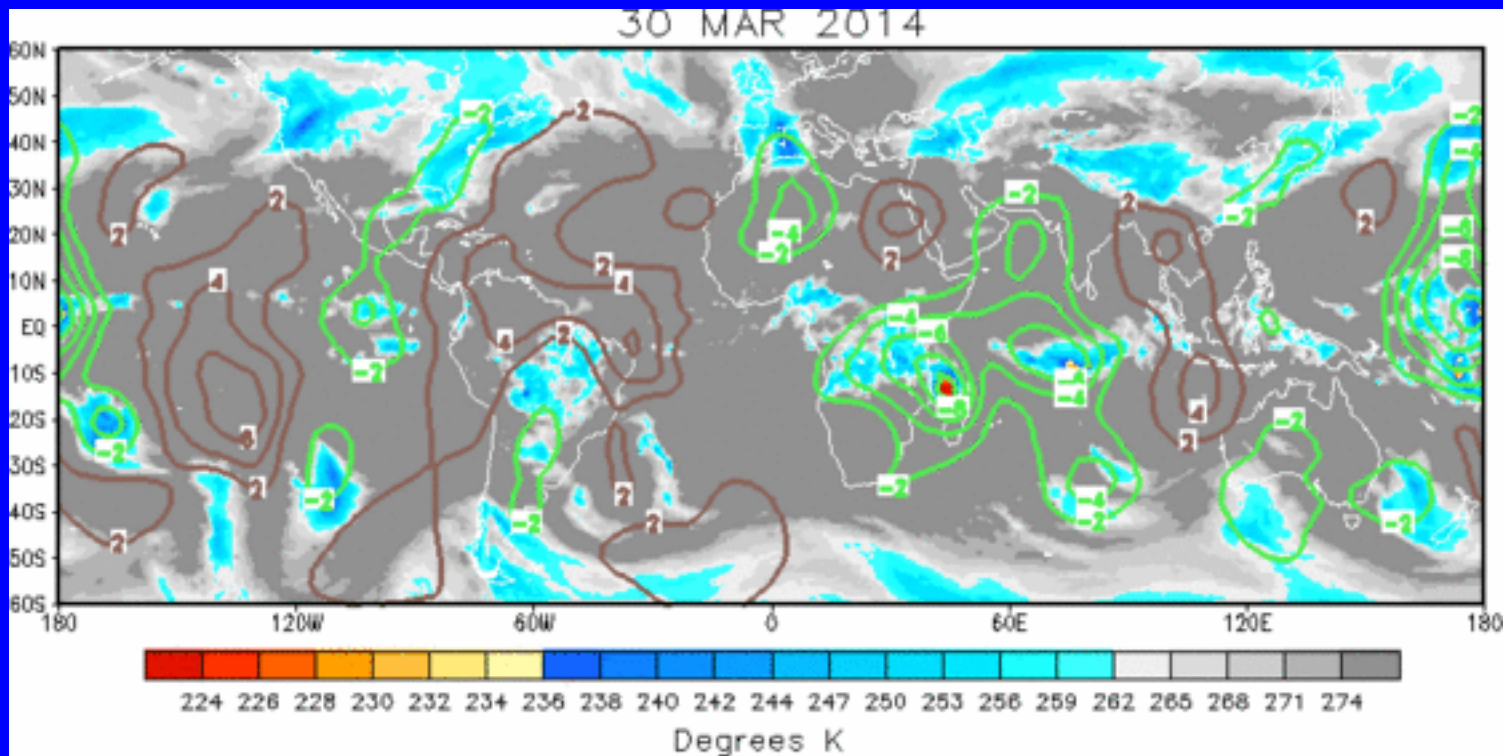
During February into early March, anomalies propagated eastward with time associated with the MJO. More recently the signal has broken down and seems consistent with atmospheric Kelvin waves and a slowly evolving background state.



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 Africa, the Indian Ocean, and the Central Pacific (Maritime Continent, East-central Pacific, and the Atlantic).

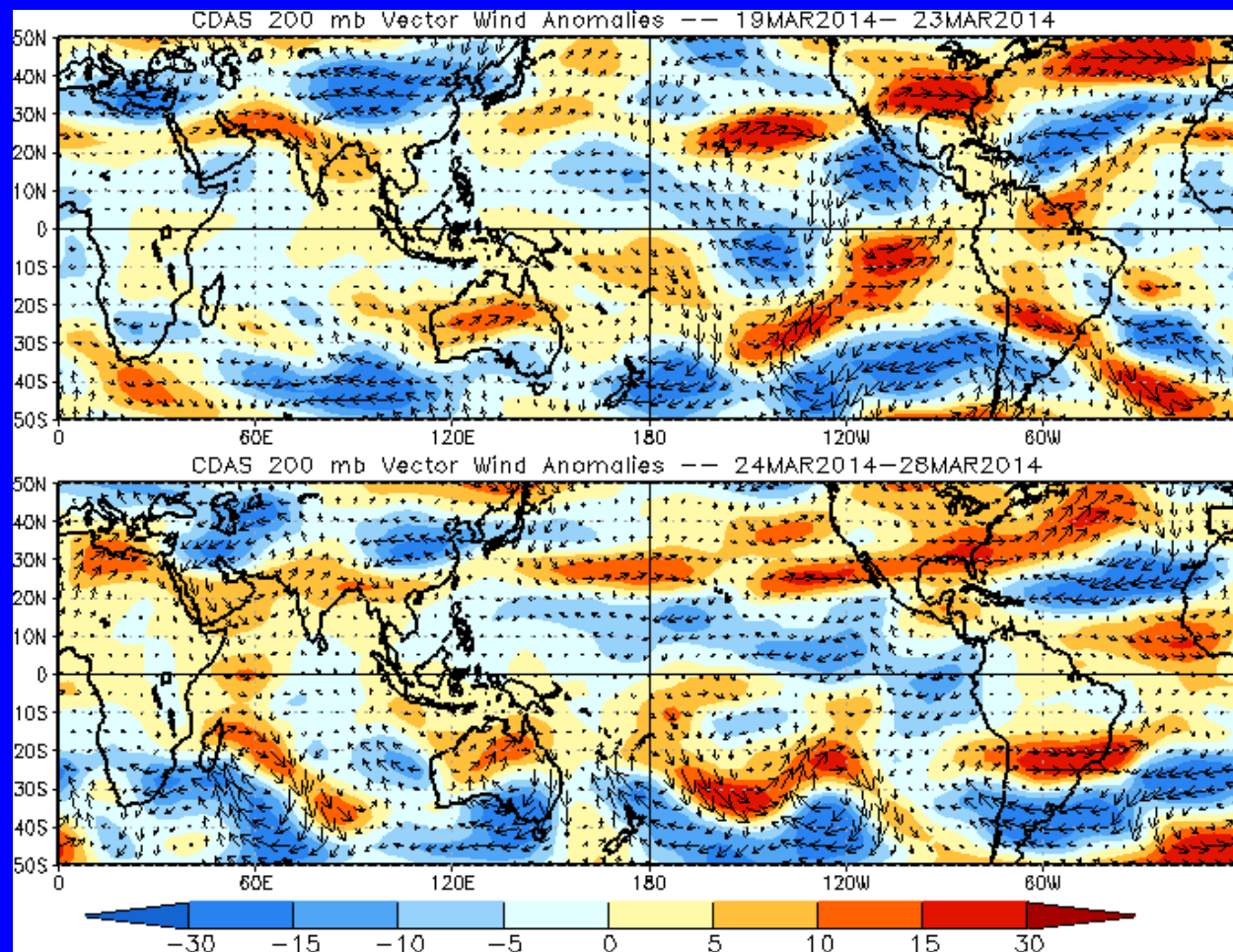


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



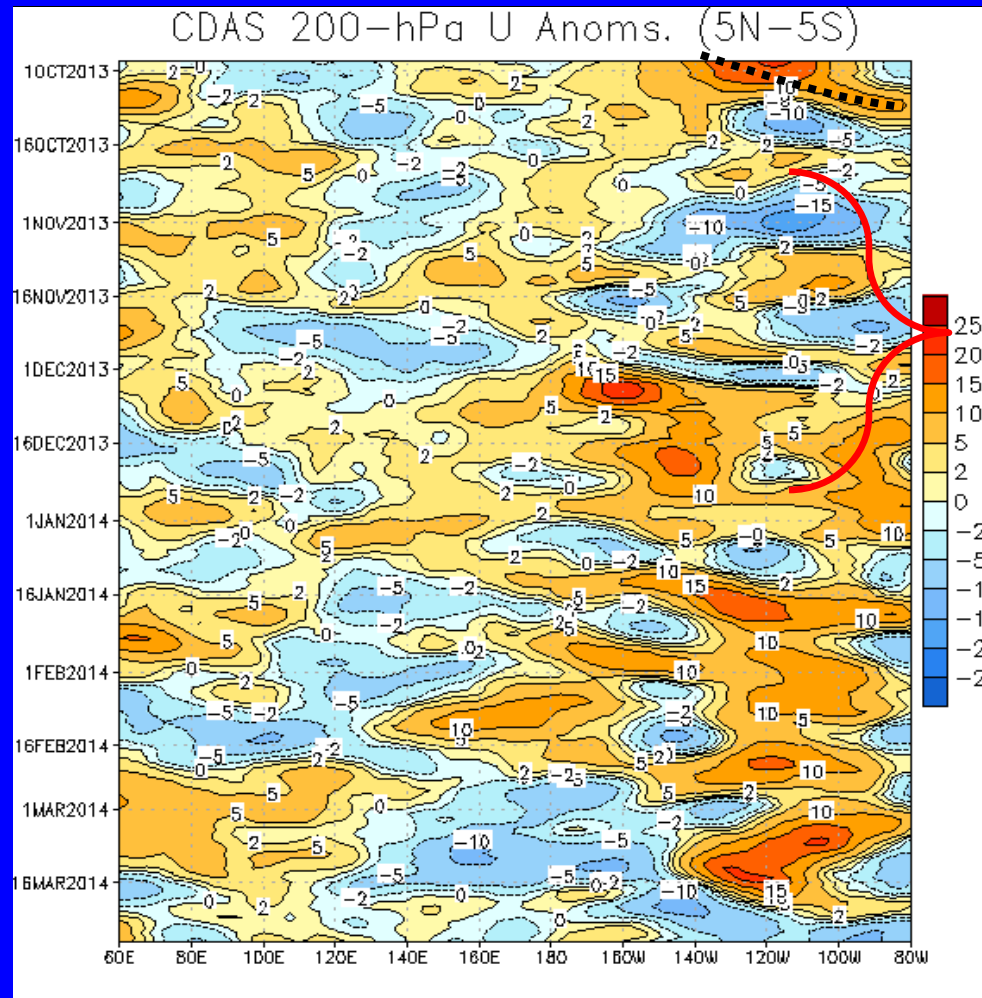
During the middle of March, generally weak anomalies were observed in the Tropics west of the Date Line. Mid-latitude influence is apparent over the Southwest Indian Ocean, and Southwest Pacific.



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



MJO activity (dotted line) occurred from late August to early October with westerly wind anomalies shifting east to the eastern Pacific.

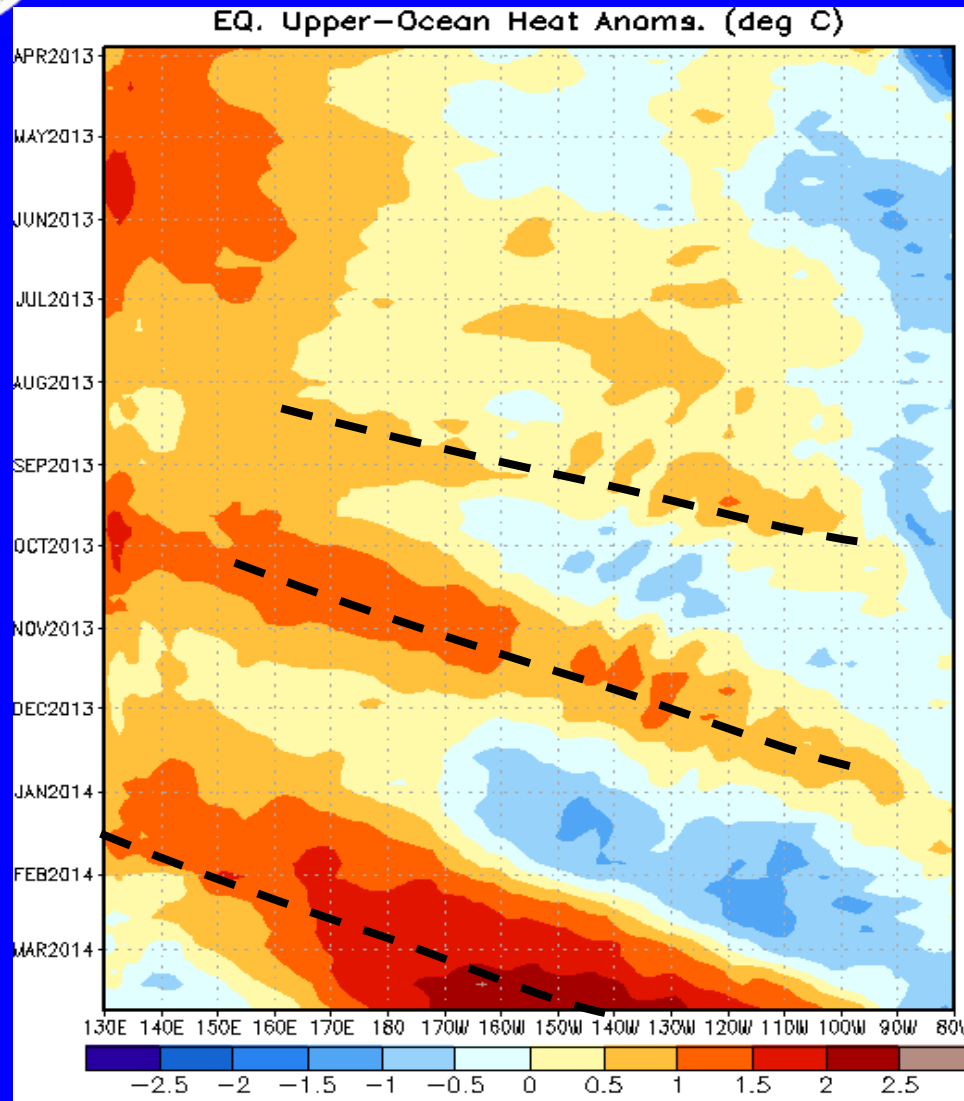
Anomalies of alternating sign were evident over the eastern Pacific, due in part to extratropical Rossby waves breaking into the Tropics (red bracket).

Westerly anomalies across the western Hemisphere persisted from December to early January. During January, anomalies were dominated by Kelvin wave activity and interaction with the extratropics.

During early March, westerly anomalies persisted over the eastern Pacific, before being replaced by easterly anomalies. Elsewhere, anomalies were generally weak during the most recent period.



Weekly Heat Content Evolution in the Equatorial Pacific



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.

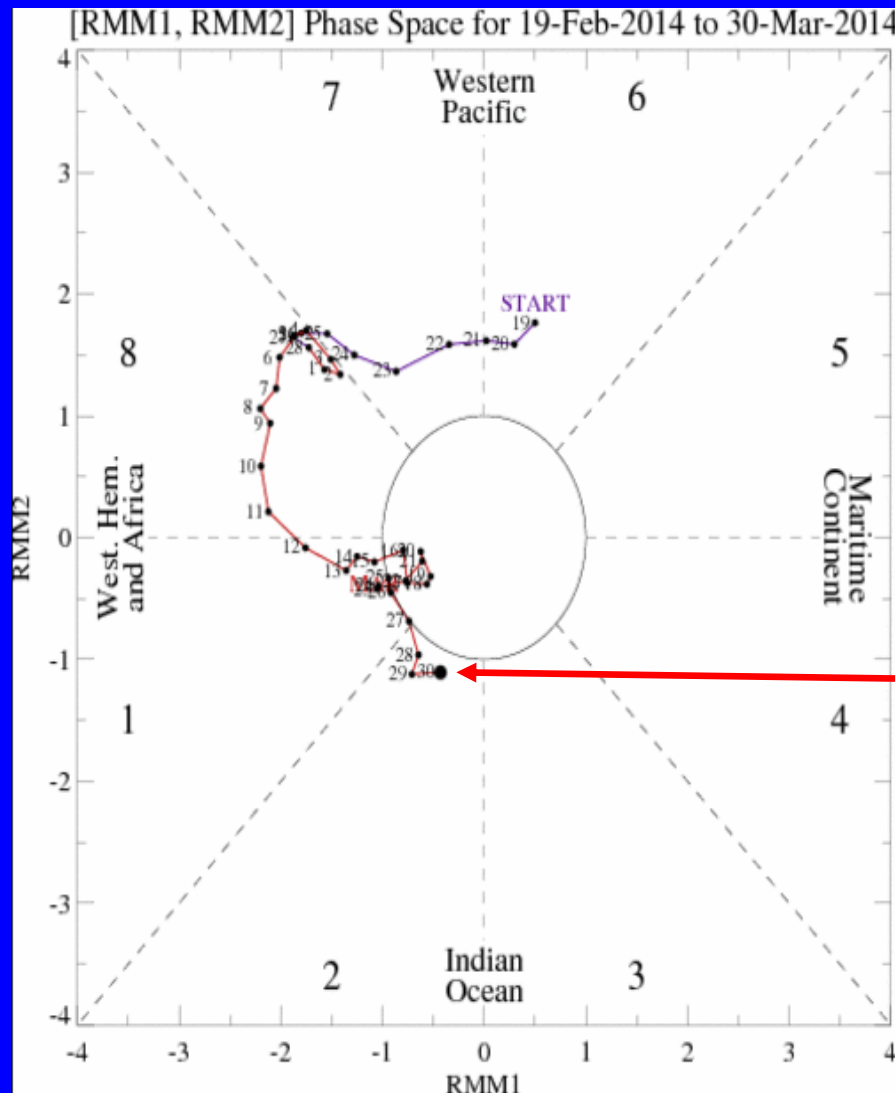
Gottschalck et al. 2010: A Framework for Assessing Operational Madden-Julian Oscillation Forecasts: A CLIVAR MJO Working Group Project, *Bull. Amer. Met. Soc.*, 91, 1247-1258.

- 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

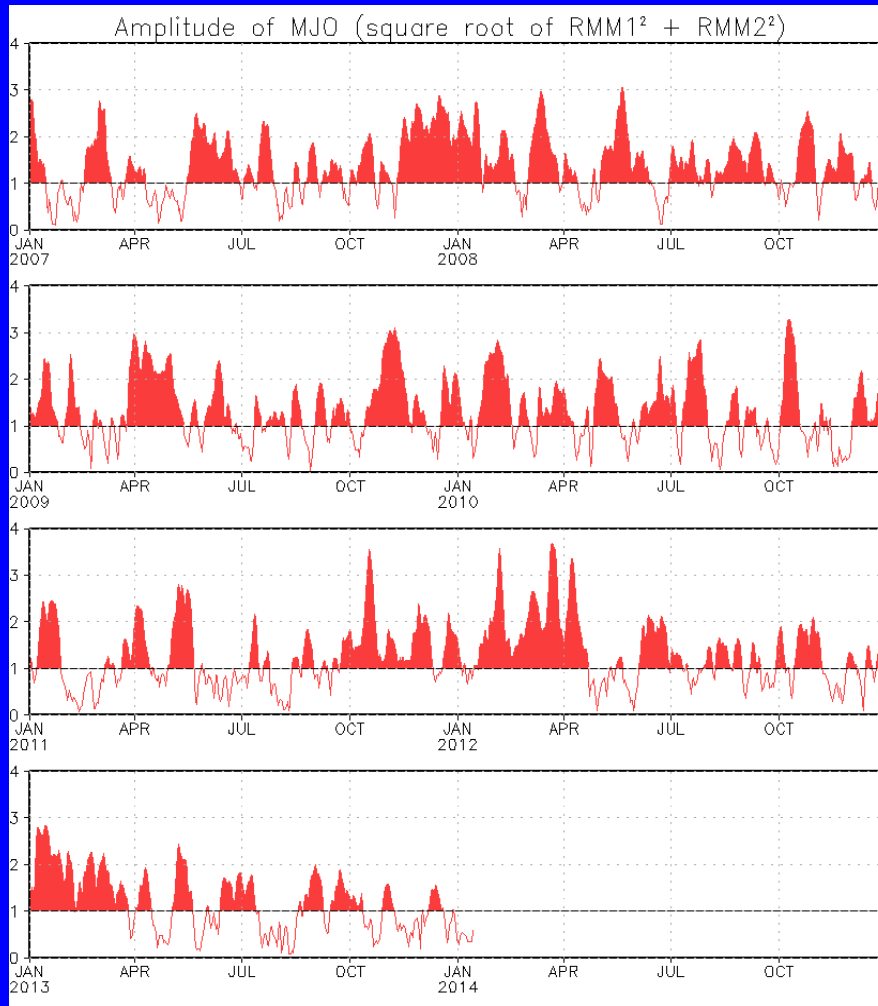
- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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



The MJO index indicates eastward propagation of the MJO-related signal during the past week, with some increase in magnitude of the MJO.



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

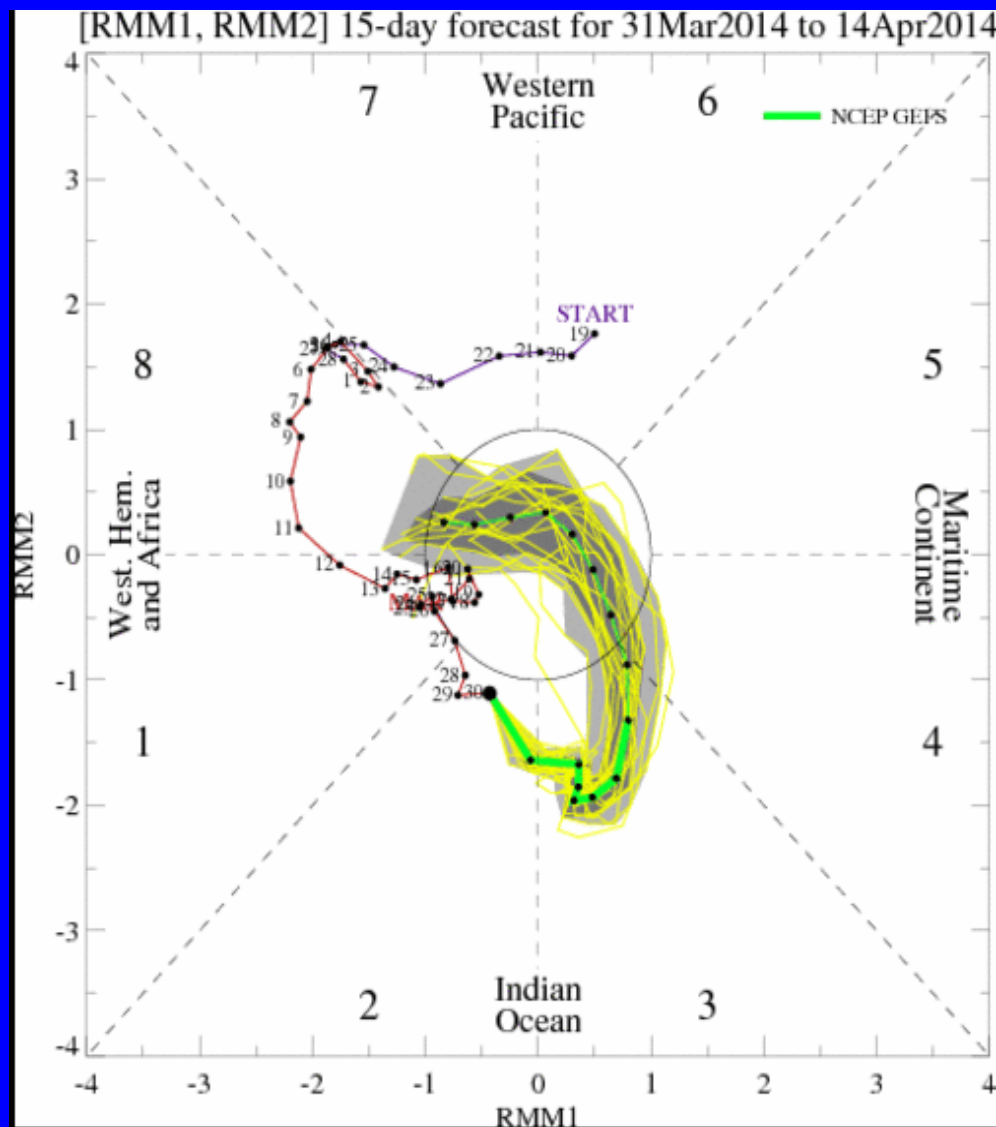
Green Line – Ensemble Mean

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 eastward propagation and strengthening of the MJO signal during Week-1. During Week-2, the model indicates a rapidly weakening MJO signal.

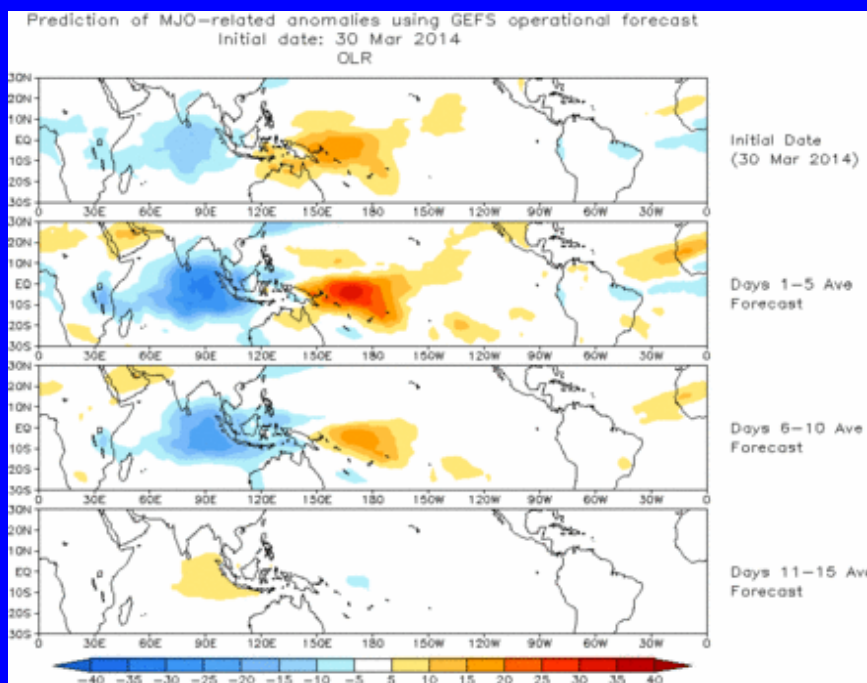




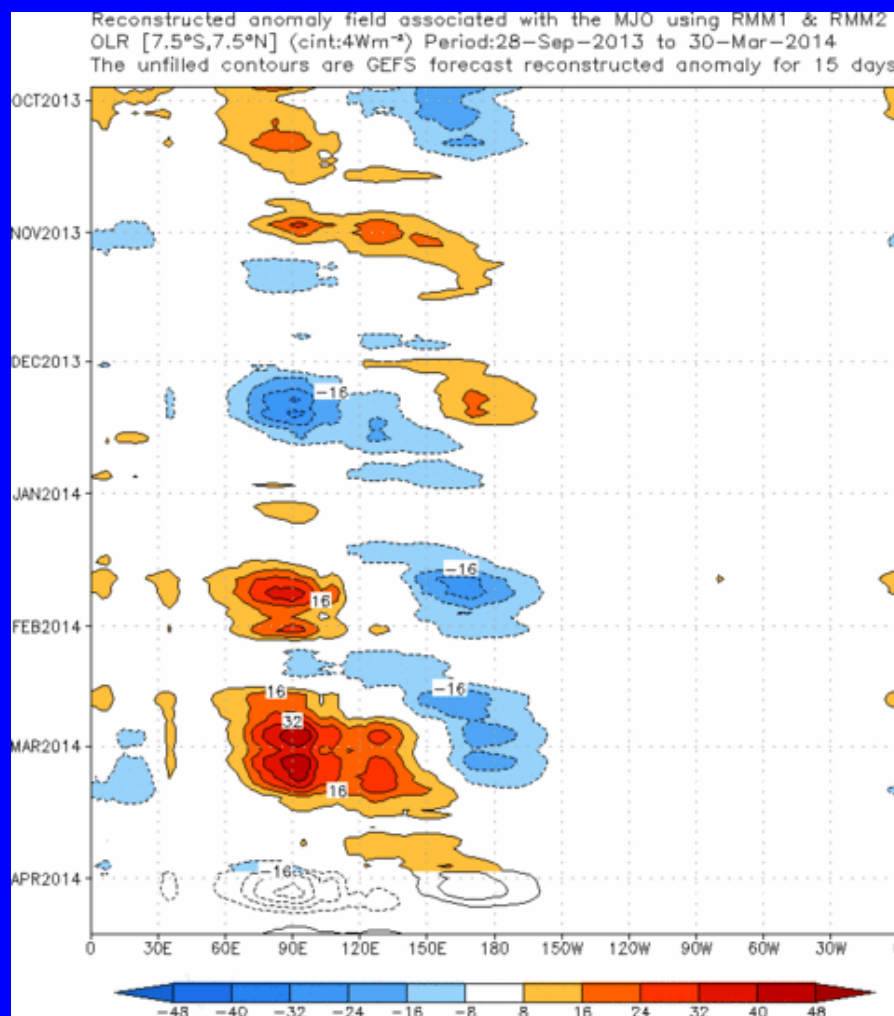
Ensemble Mean GFS MJO Forecast

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



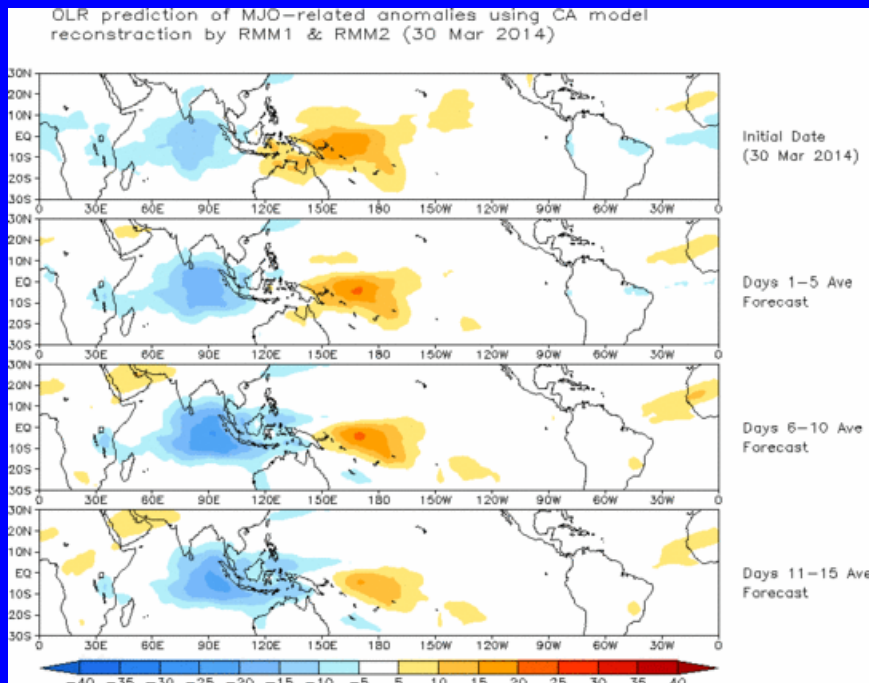
The ensemble mean GFS forecasts eastward propagation of a strengthening of the signal during Week-1, with enhanced (suppressed) convection shifting from the Indian Ocean to the Maritime Continent (Western Pacific). During Week-2, the signal breaks down almost completely.



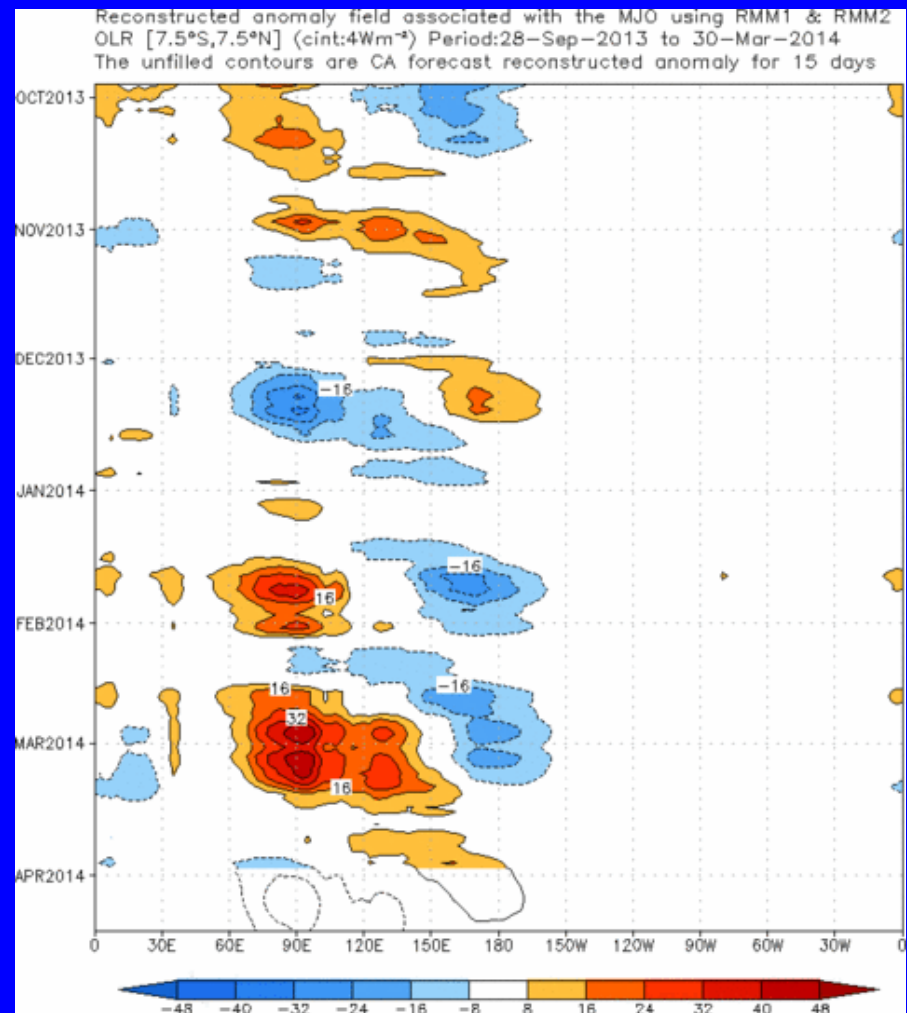
Constructed Analog (CA) MJO Forecast

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

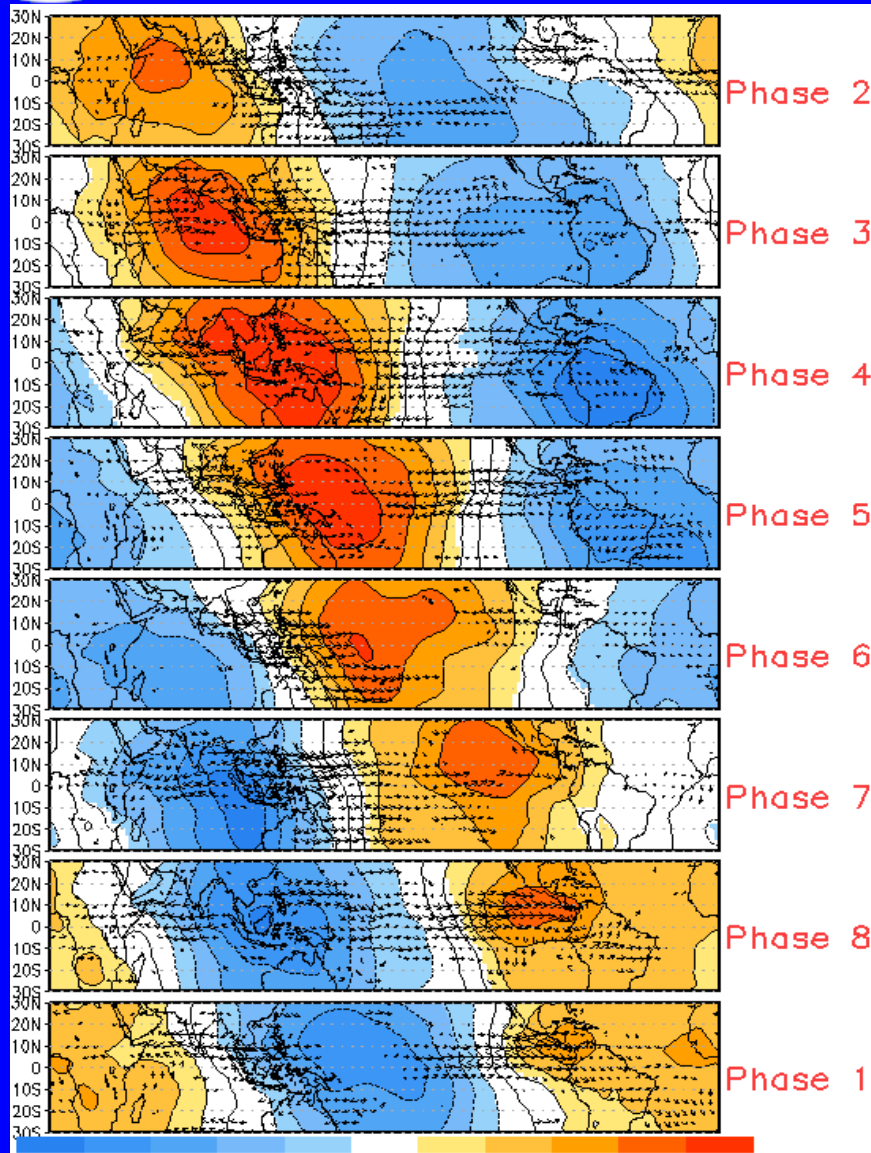


The constructed analog MJO forecast indicates eastward propagation and a strengthening signal of the MJO with enhanced (suppressed) convection shifting from the Indian Ocean to the Maritime Continent (western Pacific to Central Pacific and the Americas).

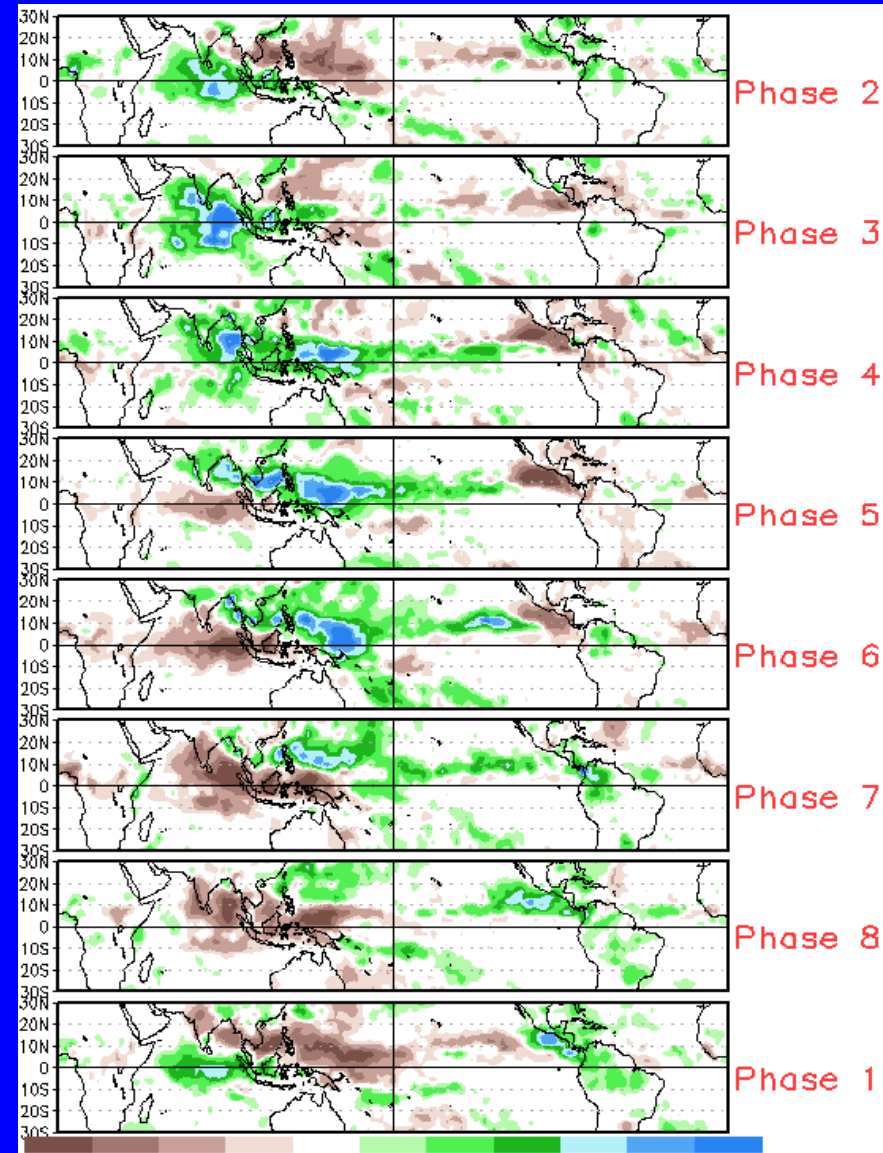


MJO Composites – Global Tropics

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



Precipitation Anomalies (Nov-Mar)

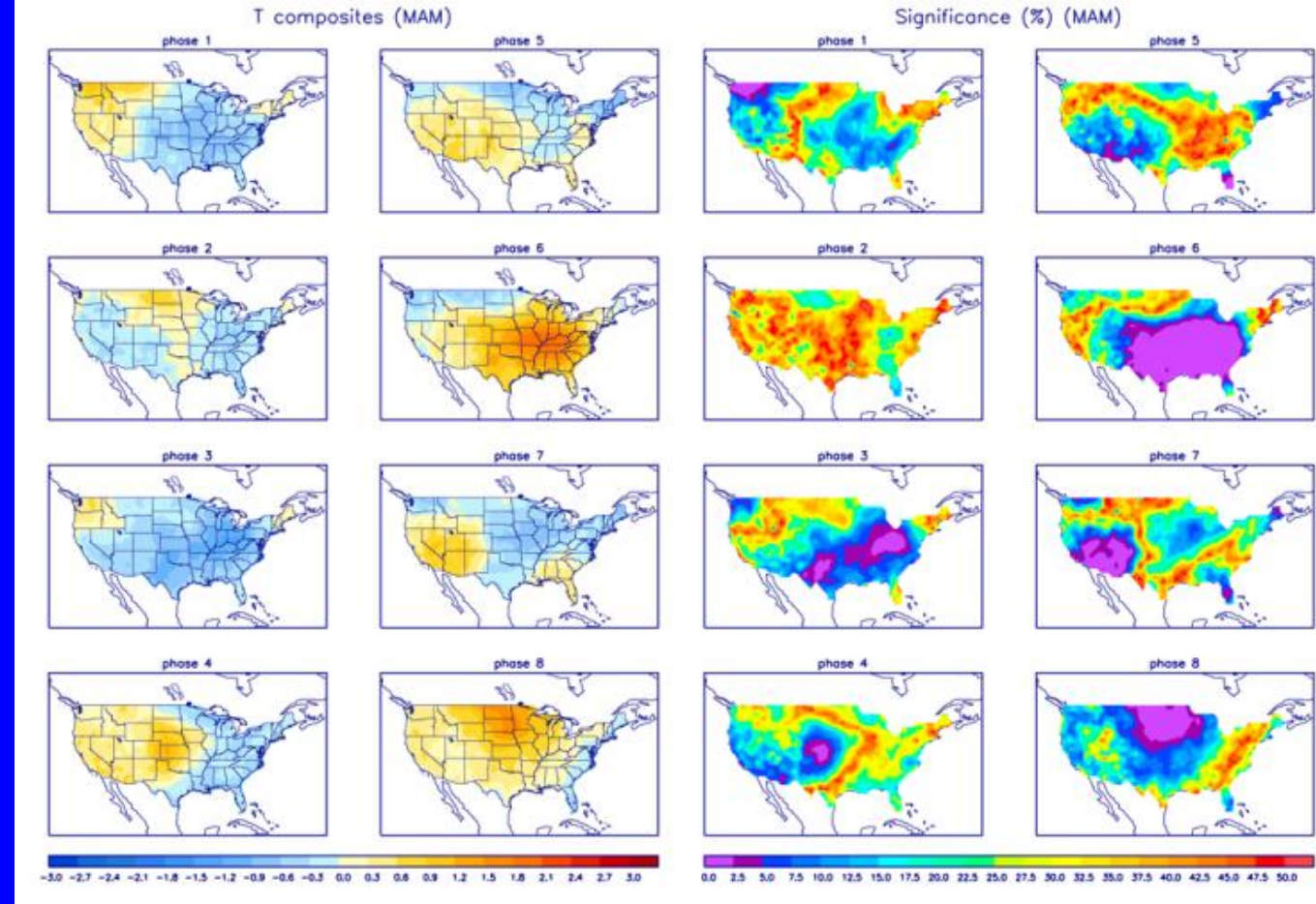




U.S. MJO Composites – Temperature

- 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

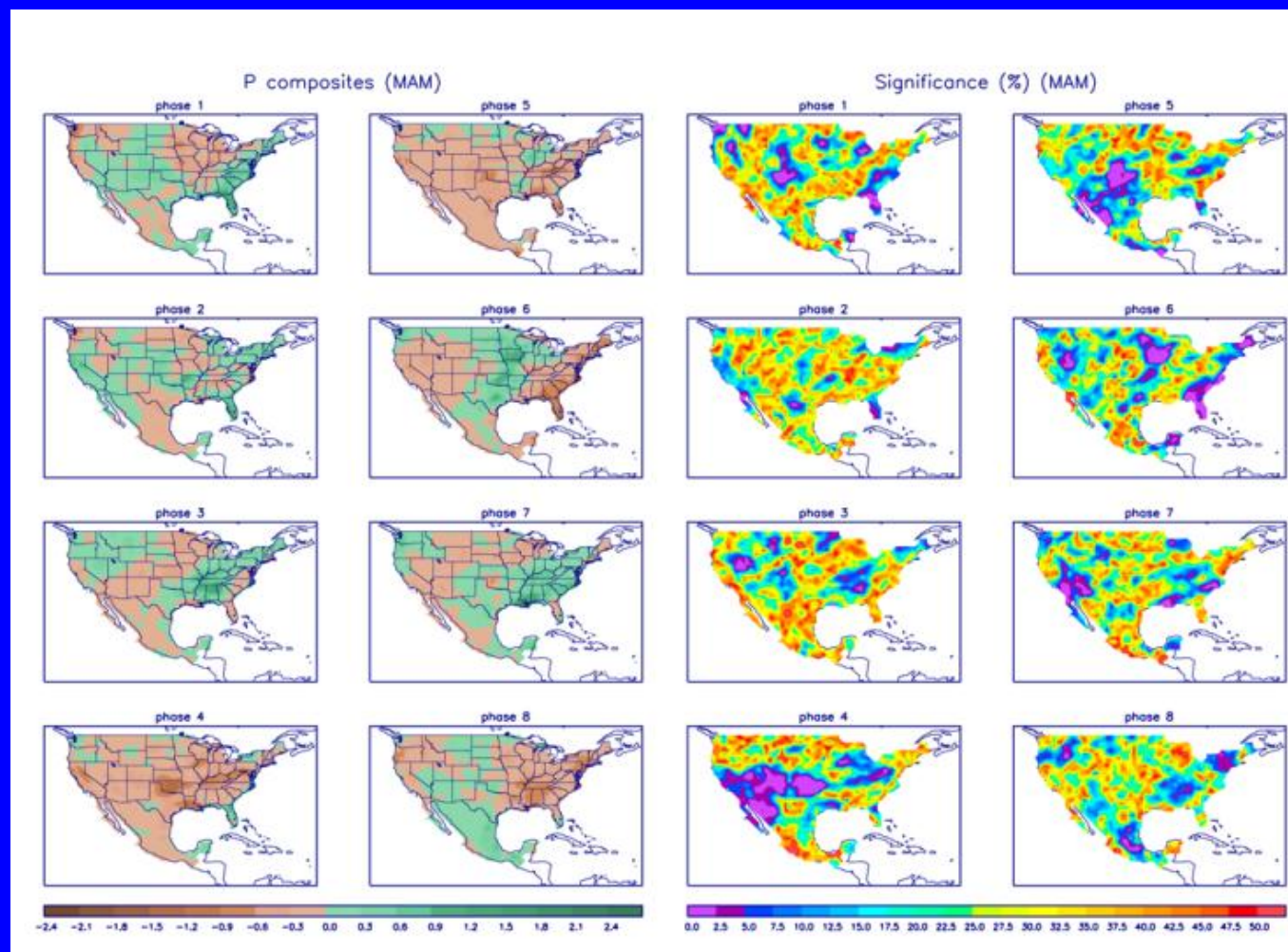
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml>



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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