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

Update prepared by
Climate Prediction Center / NCEP
April 7, 2014

Outline

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

Overview

- Recent observations of tropical convective anomalies have been more consistent with MJO activity; however, other coherent subseasonal modes continue to strongly influence the pattern.

- Dynamical model MJO forecasts indicate continued eastward propagation of an MJO signal, with significant differences in the strength and propagation speed of the signal. Many models weaken the signal during Week-2 as a low frequency base state favoring enhanced convection over anomalously warm sea surface temperatures across the western and central Pacific re-emerges as a dominant feature of the global tropical pattern.

- Statistical models favor a more robust eastward propagation of the MJO over the Maritime Continent and West Pacific.

- Ongoing tropical cyclone activity and the MJO favor enhanced convection over parts of the Maritime Continent and western Pacific during Week-1, with a tendency toward the emerging background state during Week-2.

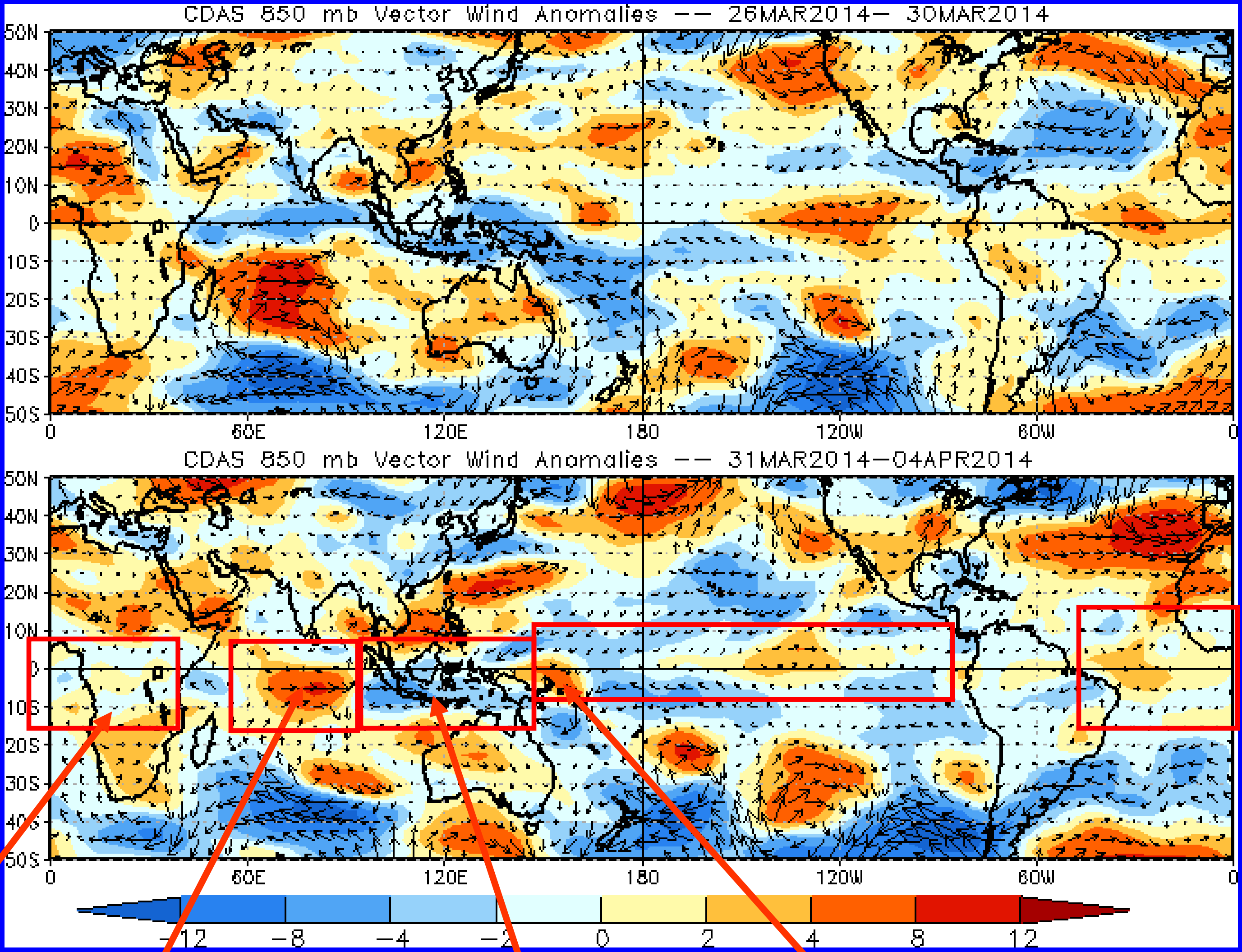
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies diminished across Africa and the tropical Atlantic.

Westerly anomalies developed along and just south of the equator over the central Indian Ocean.

Easterly anomalies persisted over the Maritime Continent.

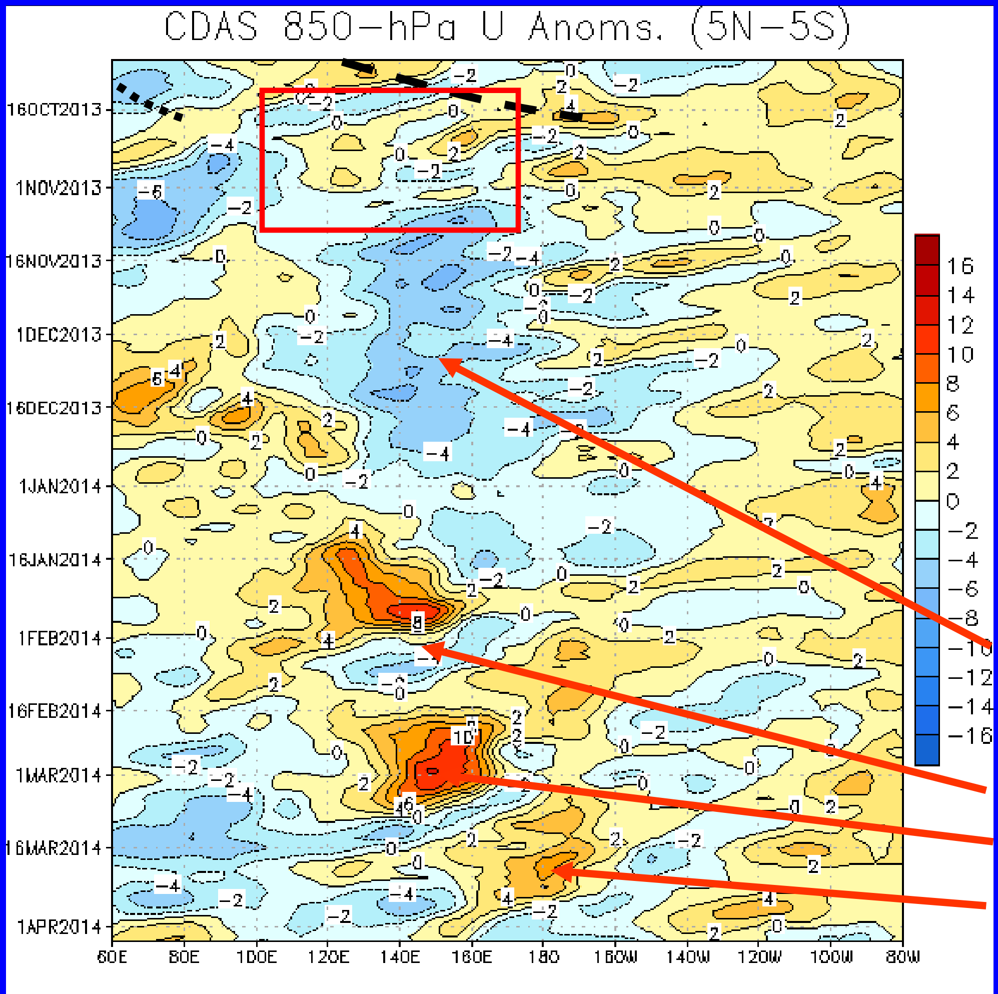
Westerly anomalies weakened across the eastern Pacific, and a small pocket of westerly anomalies shifted westward east of New Guinea.

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).

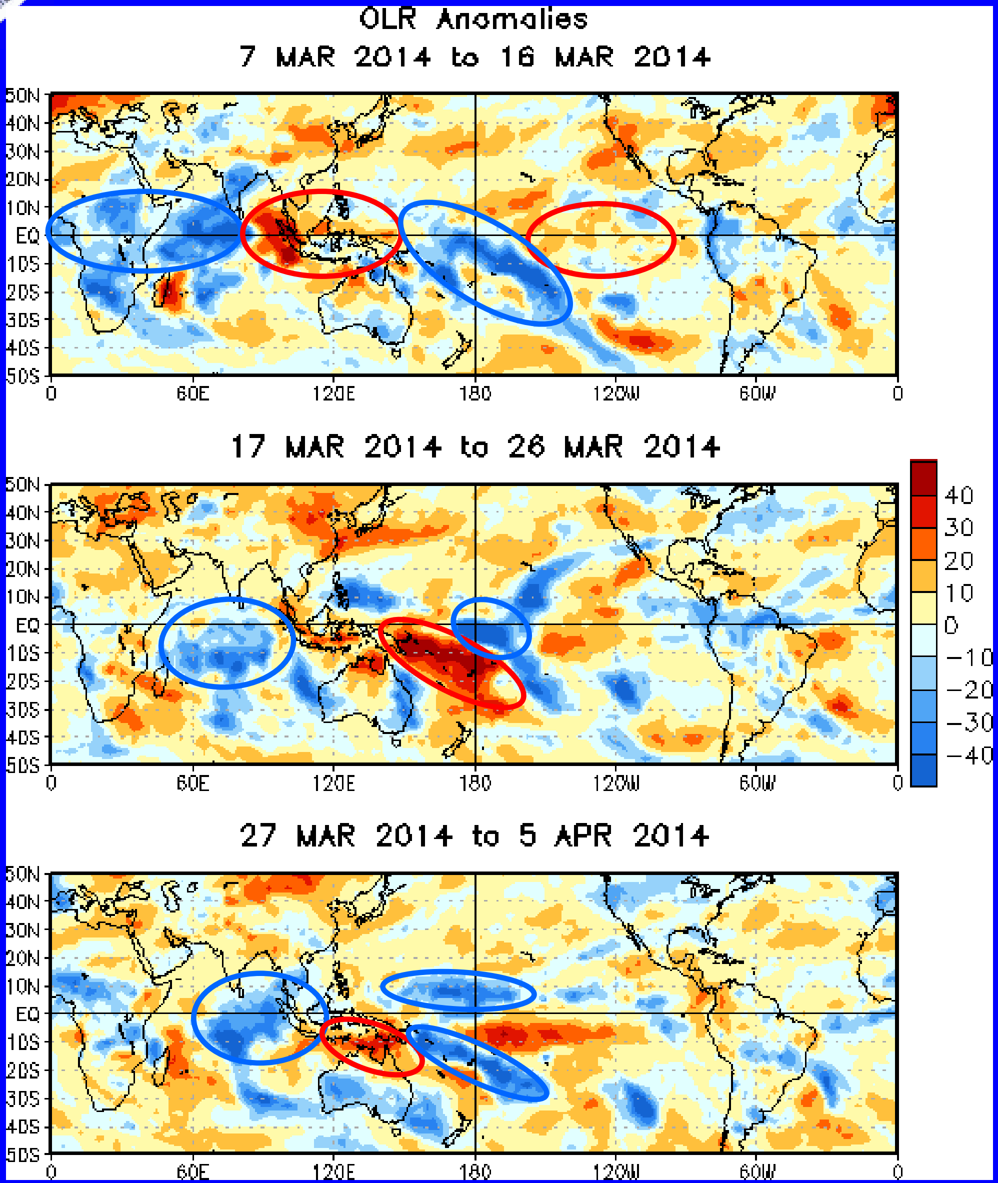
During October, equatorial Rossby wave activity was strong from 160E to 100E as westward movement features are evident (red box). MJO activity was less coherent during this period.

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, westerly anomalies have developed over the central Indian Ocean.

OLR Anomalies – Past 30 days



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

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

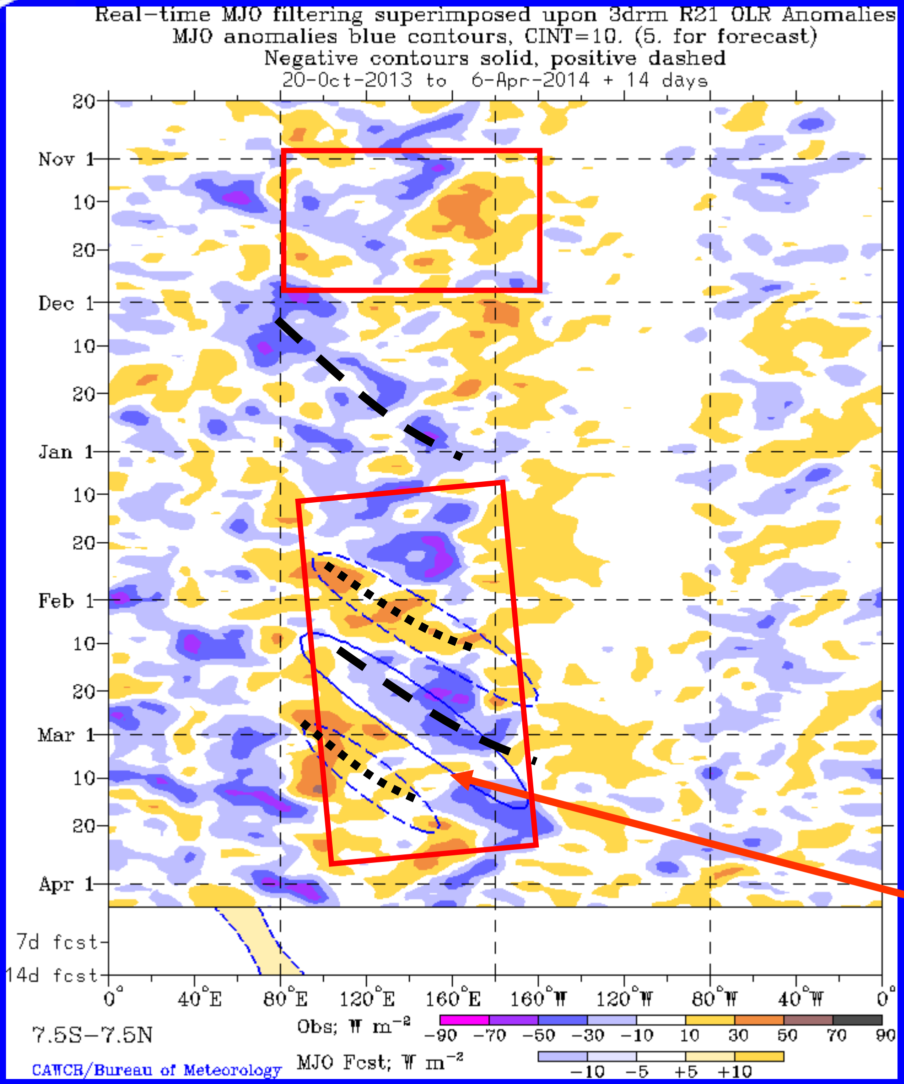
During mid-March, enhanced (suppressed) convection persisted over Africa, the western Indian Ocean, and the central and southwestern Pacific (eastern Indian Ocean and the western Maritime Continent).

During mid to late March, enhanced convection shifted into the southern Indian Ocean and persisted near the equatorial Date Line, while suppressed convection developed over the southwestern Pacific.

During late March and early April, enhanced (suppressed) convection developed over the eastern Indian Ocean and the northwestern and southwestern Pacific (eastern Maritime Continent and just south of the equator across the central 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.

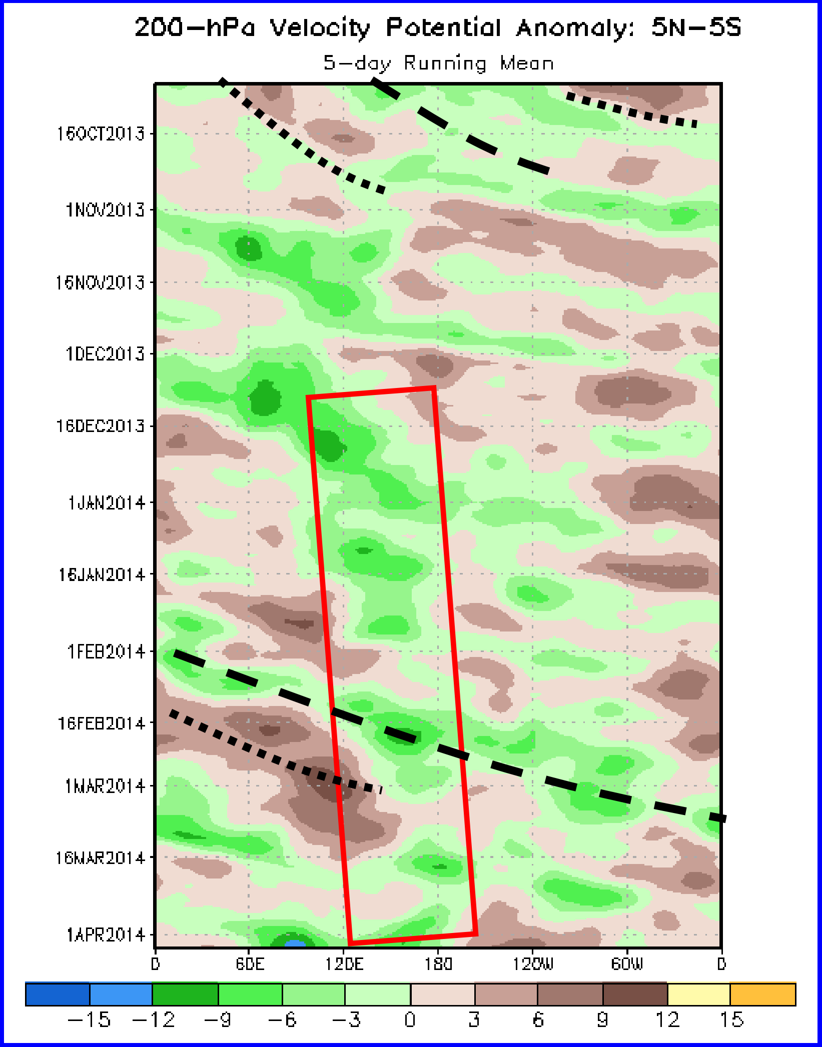
Most recently, other modes of variability (Kelvin and Equatorial Rossby waves) appear to be dominating the OLR pattern.

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.

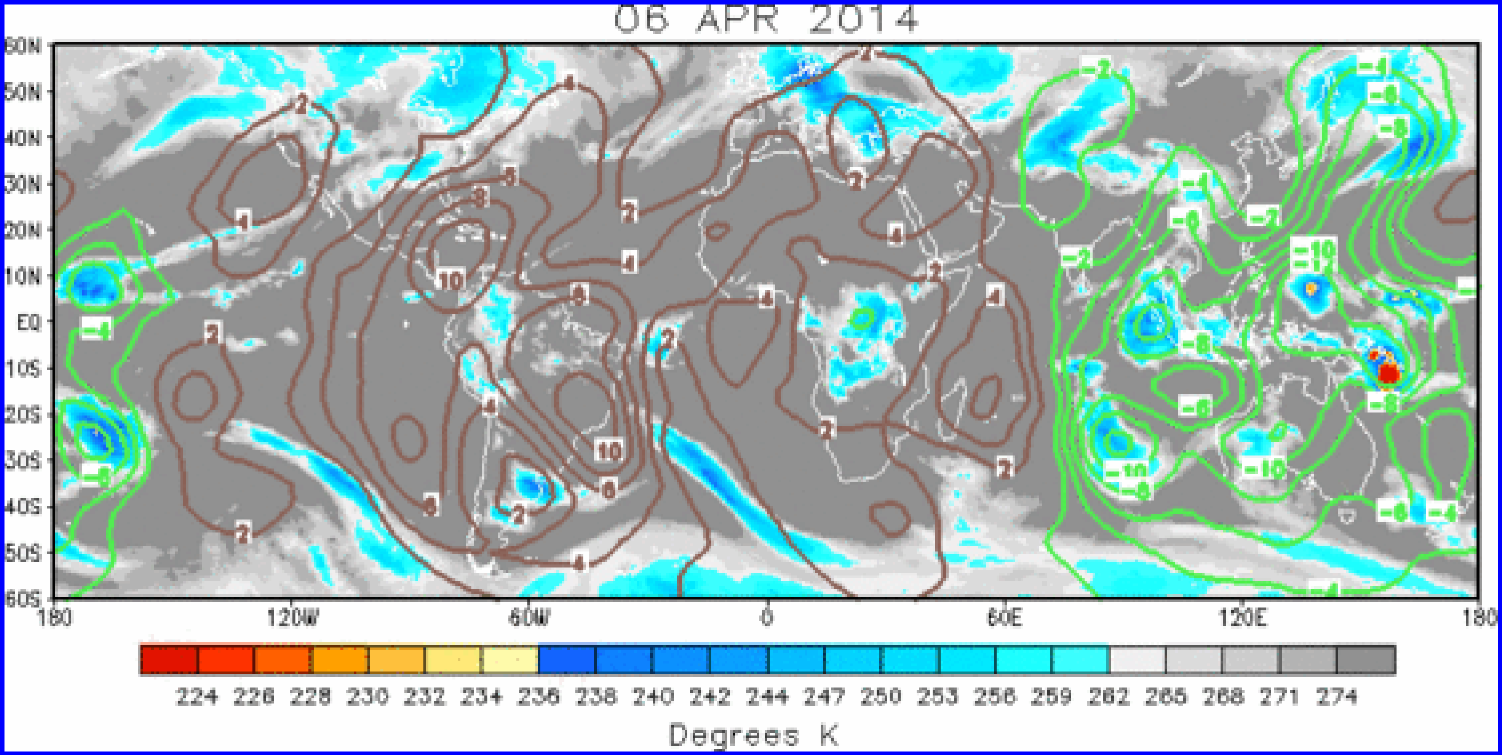
Slower eastward propagation was observed from mid-December to late February across the Indo-Pacific warm pool region (red box).

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



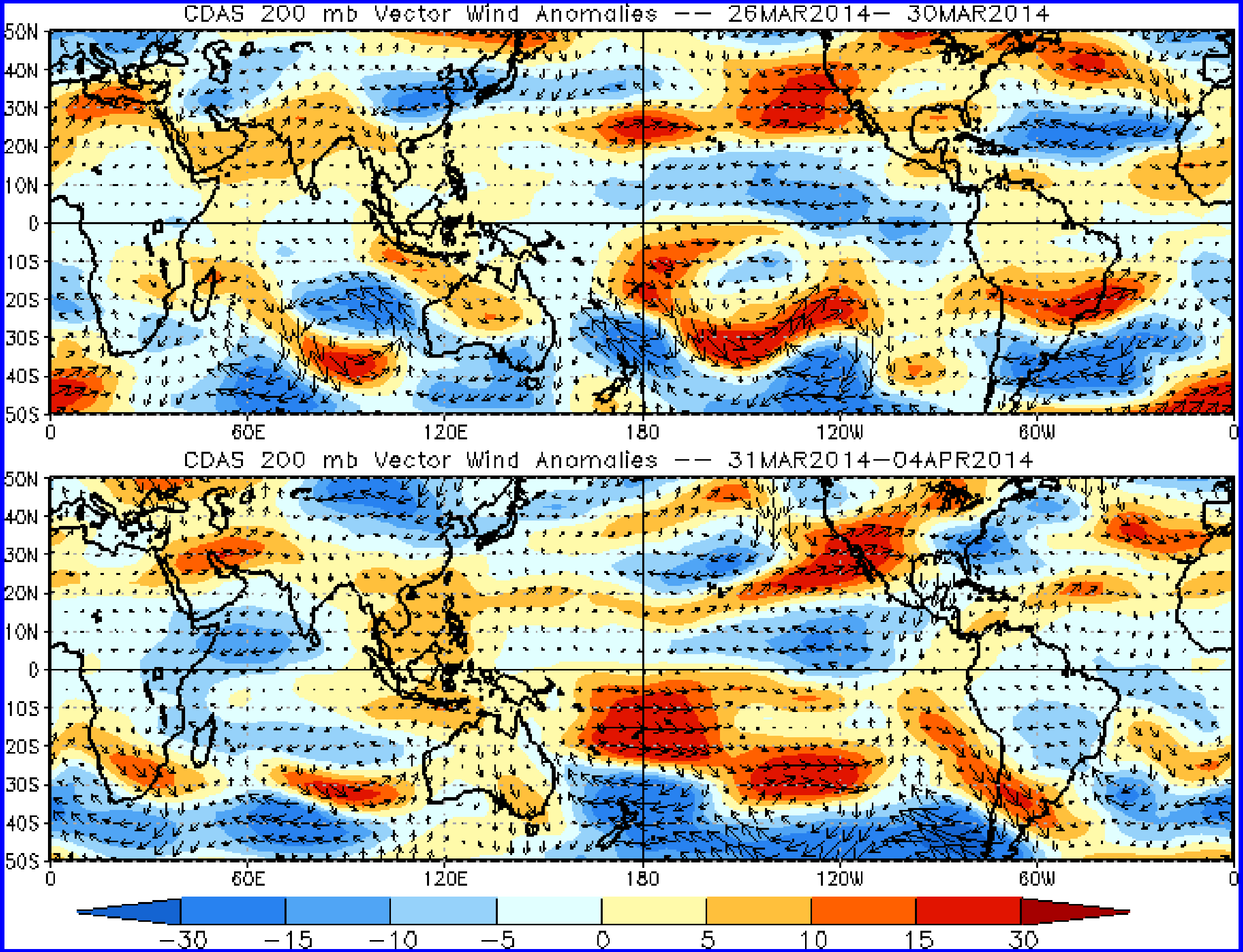
The current velocity potential spatial anomaly pattern has become more coherent, with areas of anomalous upper-level divergence (convergence) over the eastern Indian Ocean, Maritime Continent, and western Pacific (eastern Pacific and Western Hemisphere).

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



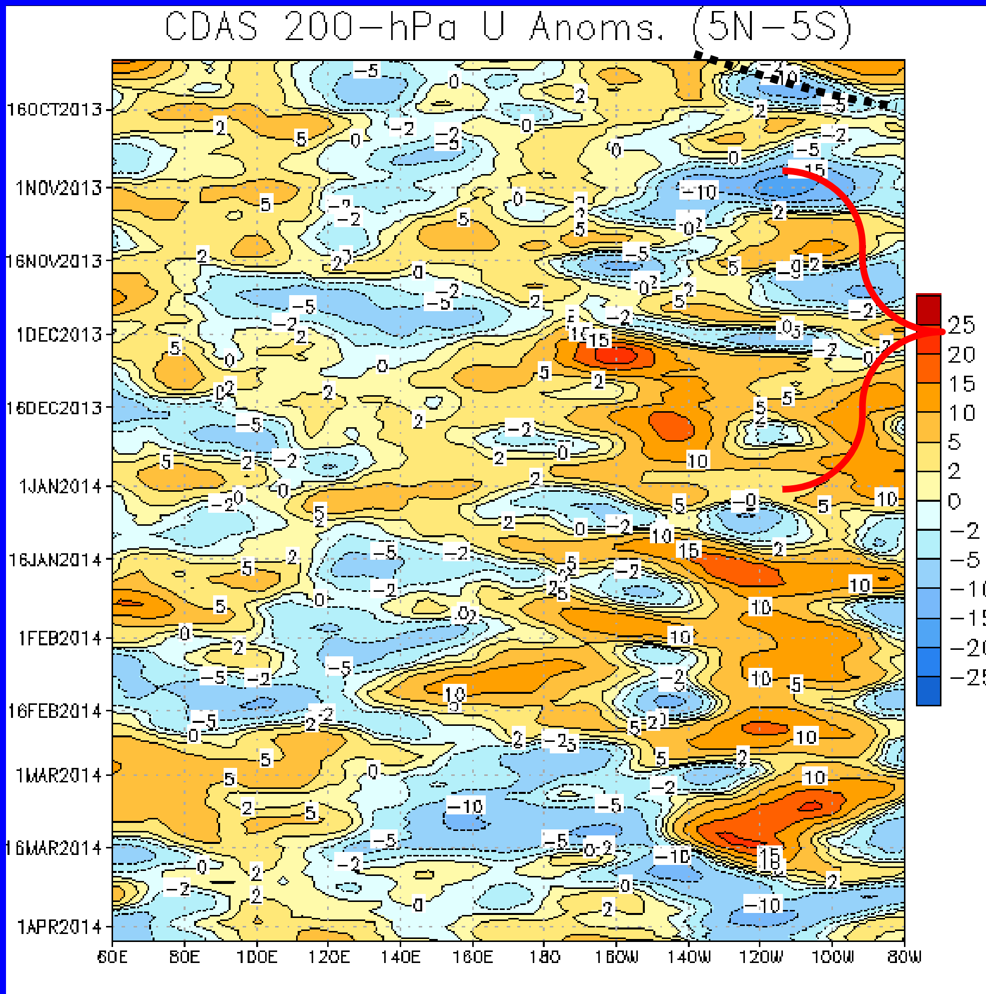
During early April, easterly (westerly) anomalies were observed over the western Indian Ocean (Maritime Continent).

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

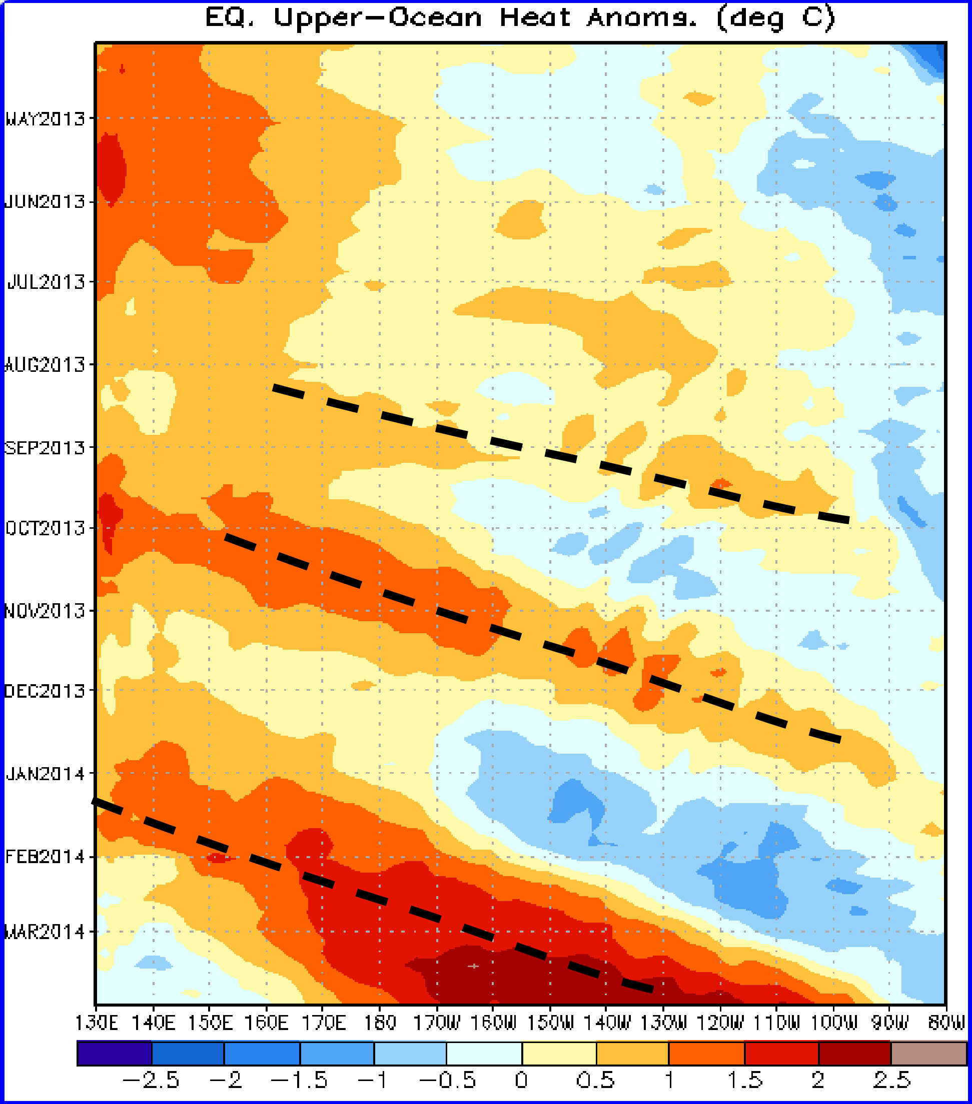
Anomalies of alternating sign were evident over the eastern Pacific, due in part to extratropical Rossby waves breaking into the Tropics (red bracket).

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. Westerly anomalies strengthened over parts of the Maritime Continent and east-central 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).

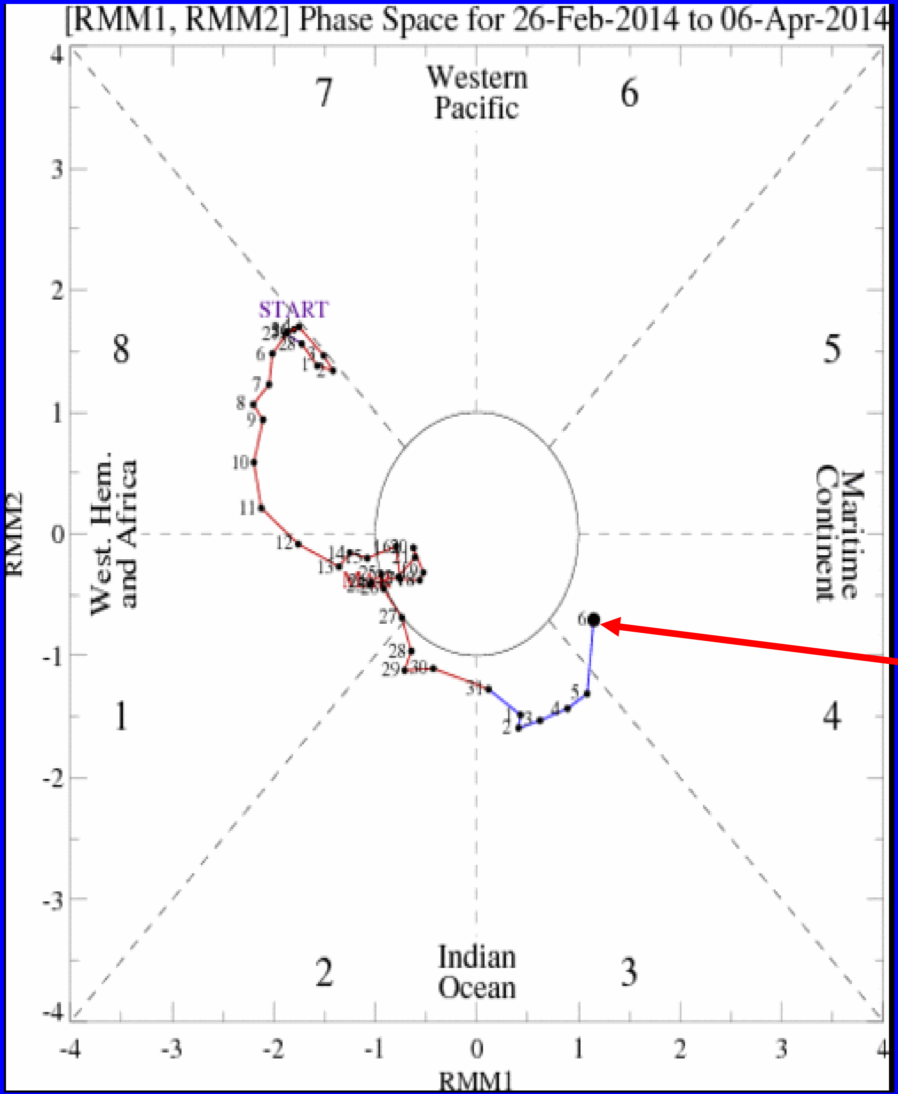
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

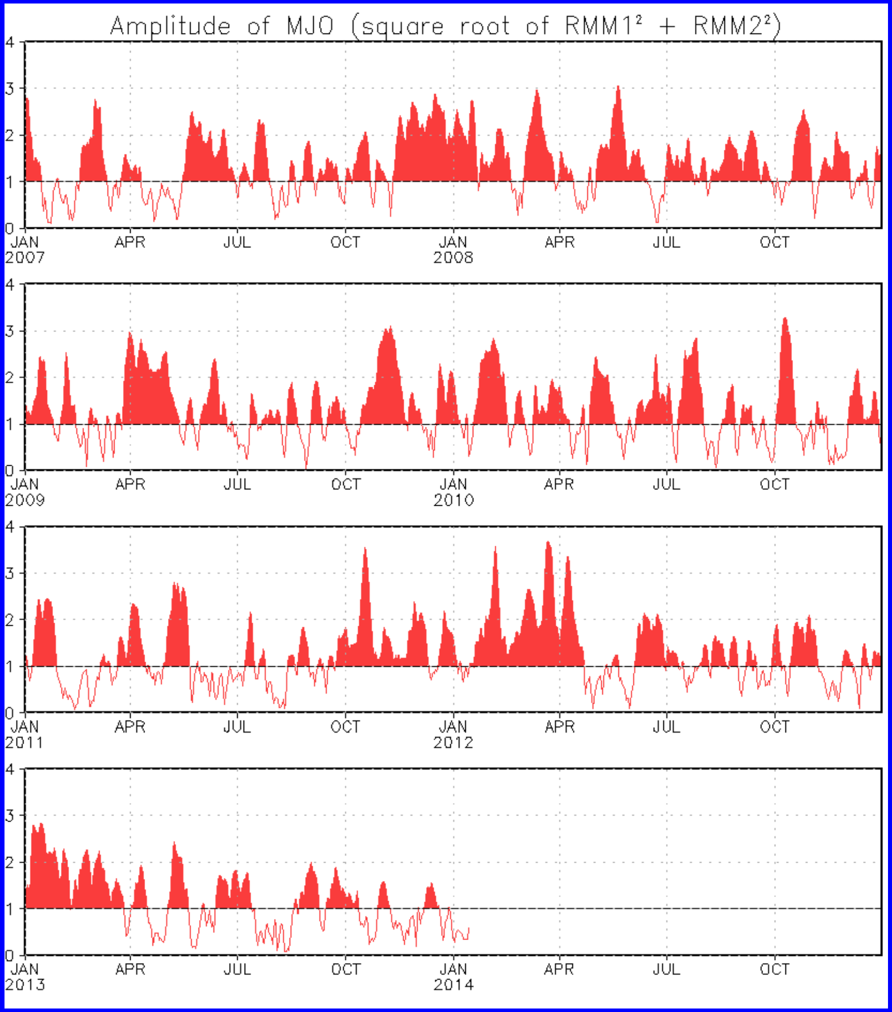
MJO Index -- Recent Evolution



- 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 continued eastward propagation of the MJO-related signal during the past week, with the convectively enhanced phase over the western Maritime Continent.

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.

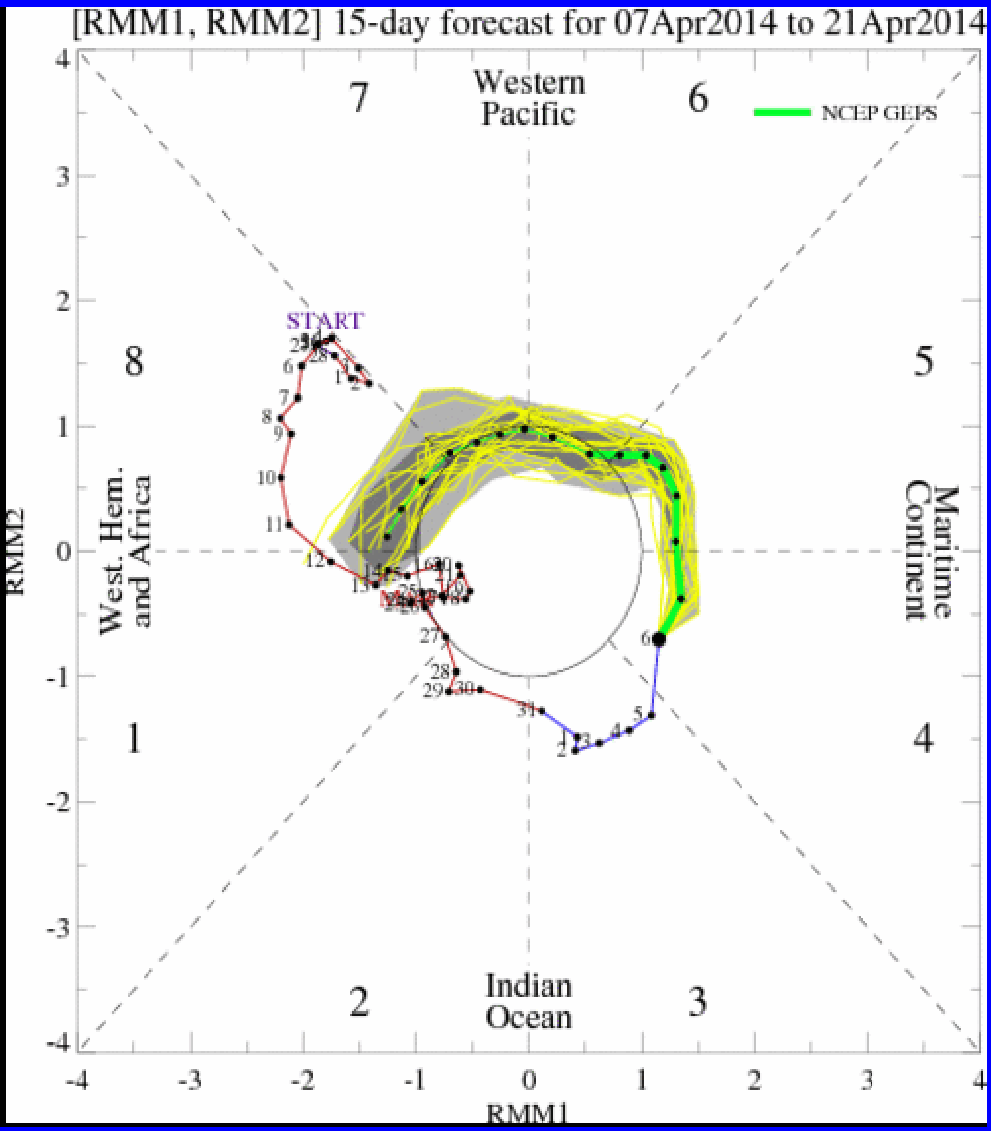
Ensemble GFS (GEFS) MJO Forecast

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

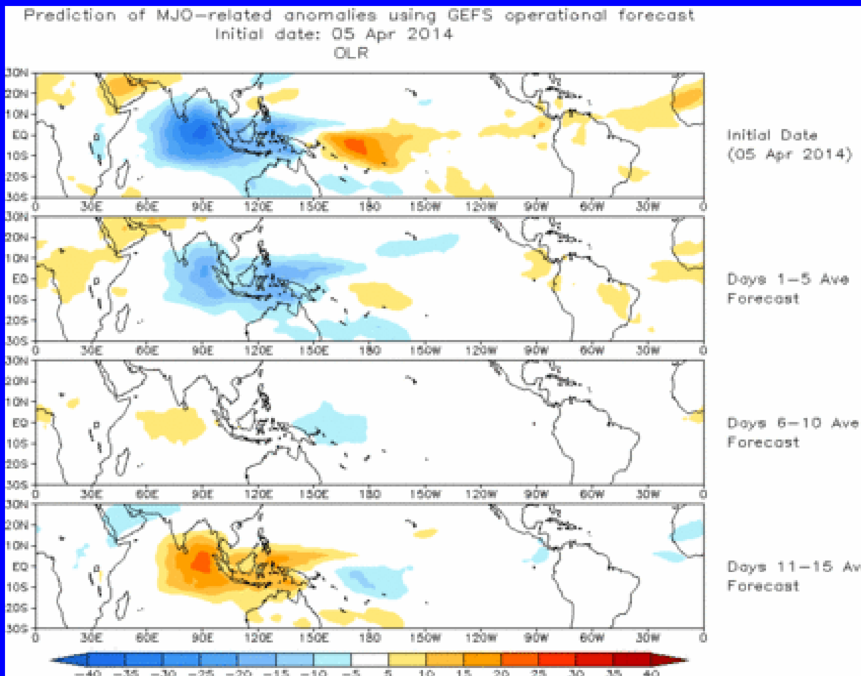
The ensemble GFS forecast indicates eastward propagation of a weak MJO signal during Week-1 with a phase speed more suggestive of KW activity over the Maritime Continent. Enhanced (suppressed) convection is forecast to return to the Pacific basin (eastern Indian Ocean and Maritime Continent) during Week-2.



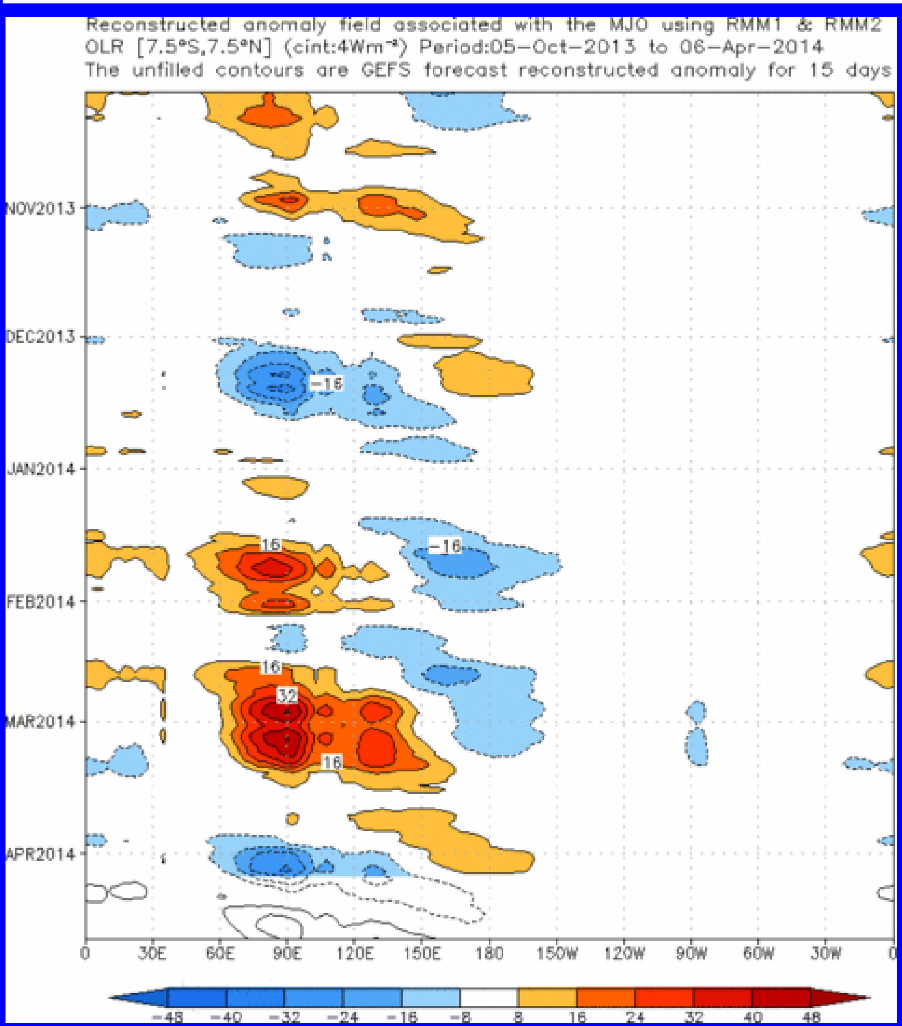
Ensemble Mean GFS MJO Forecast

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

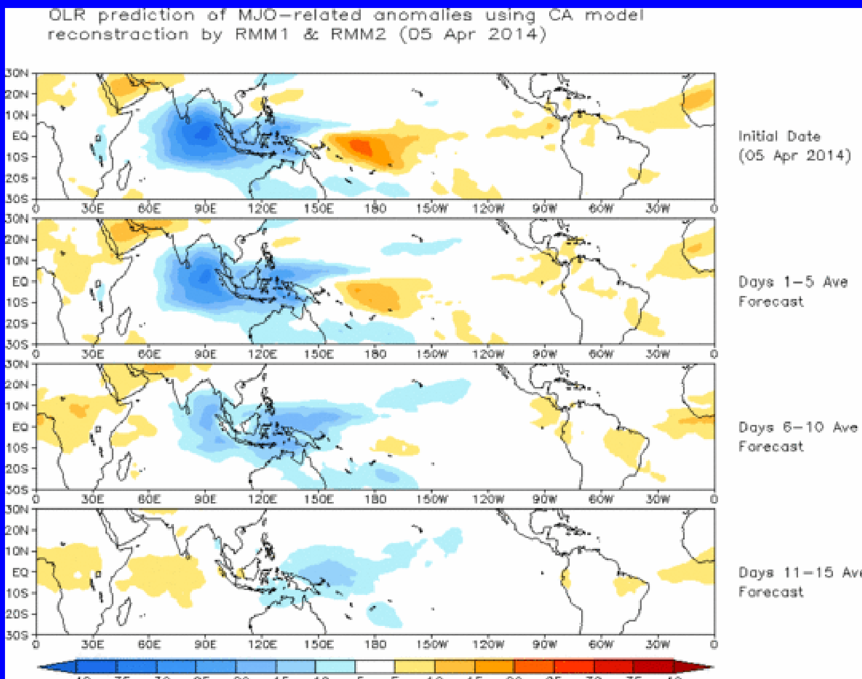


The ensemble mean GFS forecasts eastward propagation of an MJO signal during Week-1, with a weakening signal during Week-2 as the low frequency base state re-emerges.

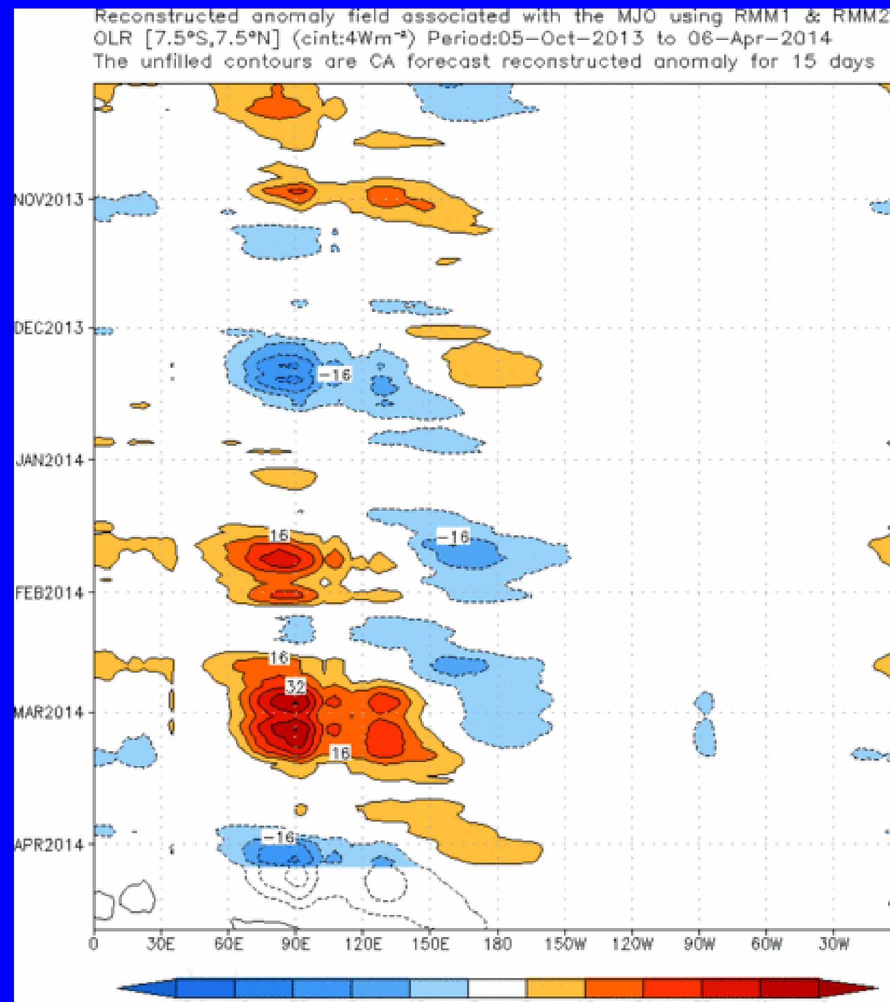
Constructed Analog (CA) MJO Forecast

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



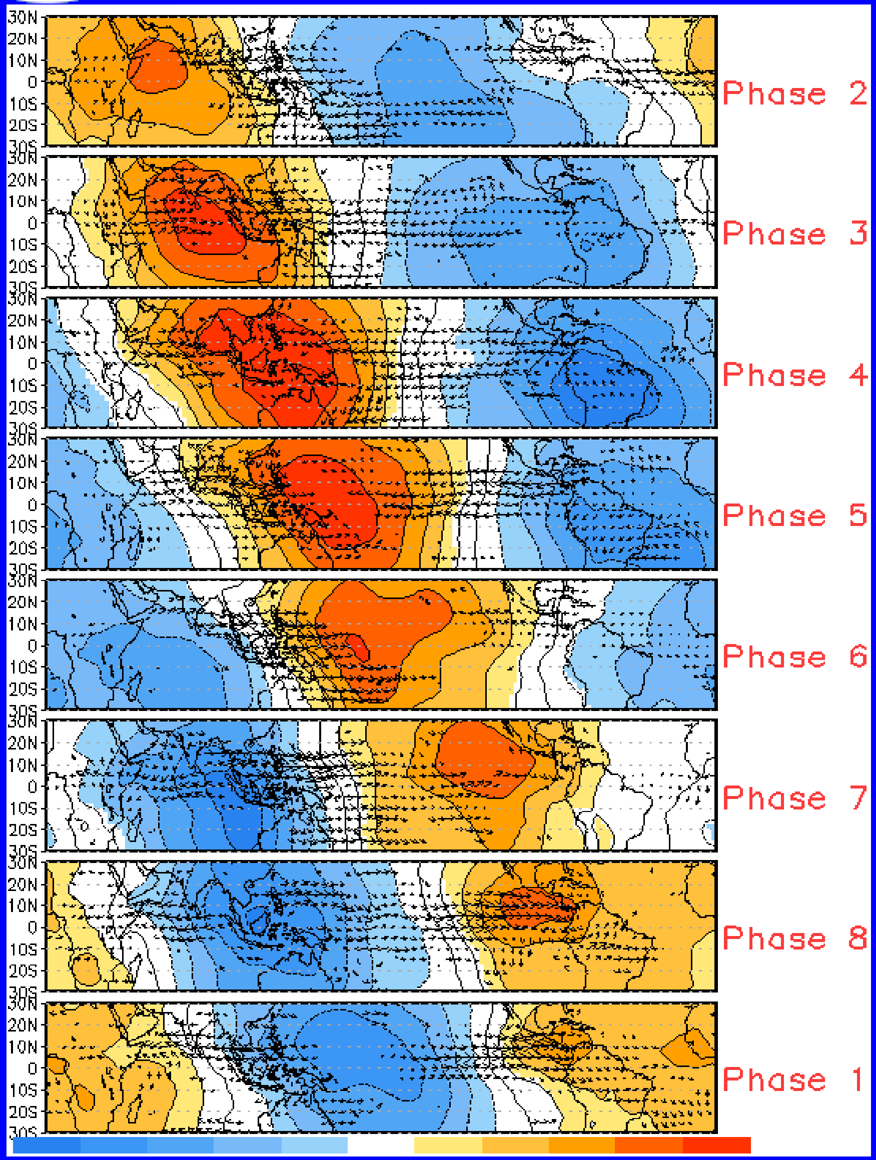
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



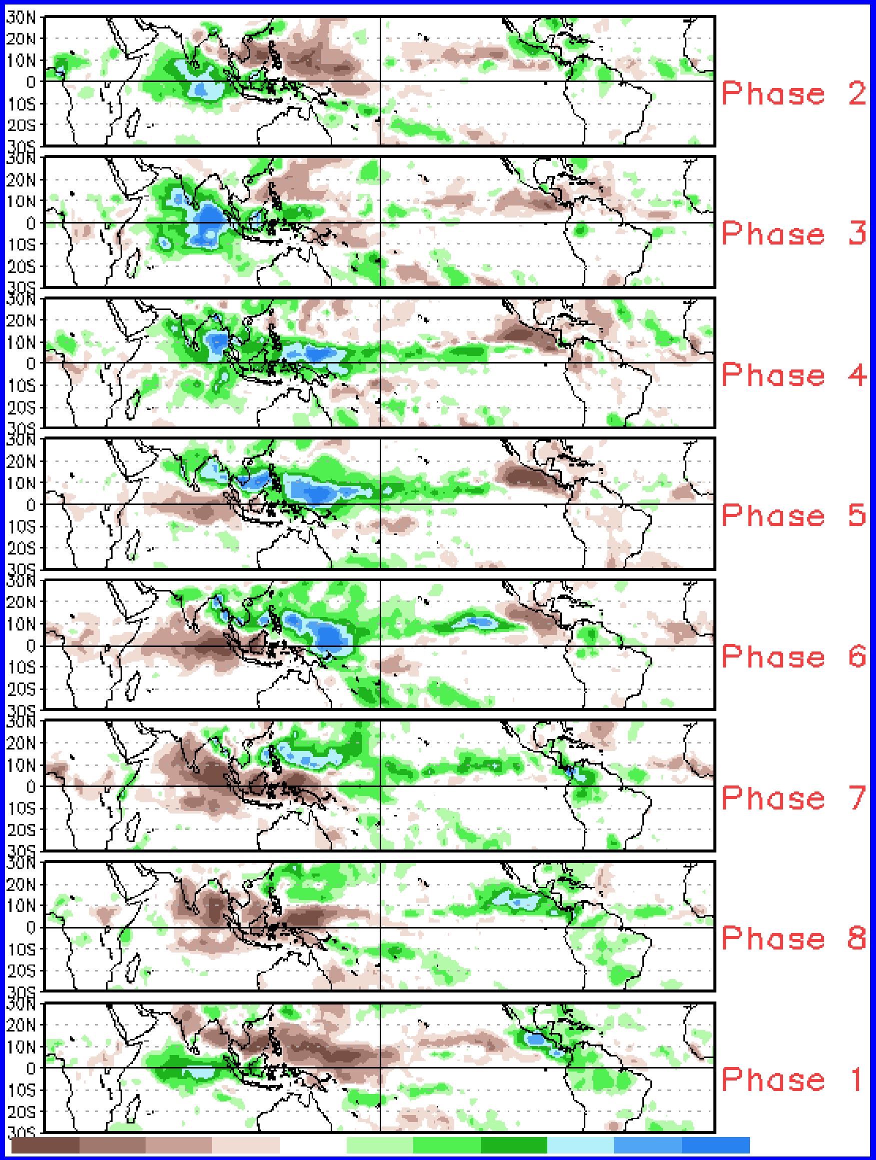
The constructed analog MJO forecast indicates robust MJO propagation, with enhanced (suppressed) convection shifting from the eastern Indian Ocean and Maritime Continent to the western Pacific (west-central Pacific to the western Hemisphere).

MJO Composites – Global Tropics

850-hPa Velocity Potential and Wind Anomalies (May-Sep)

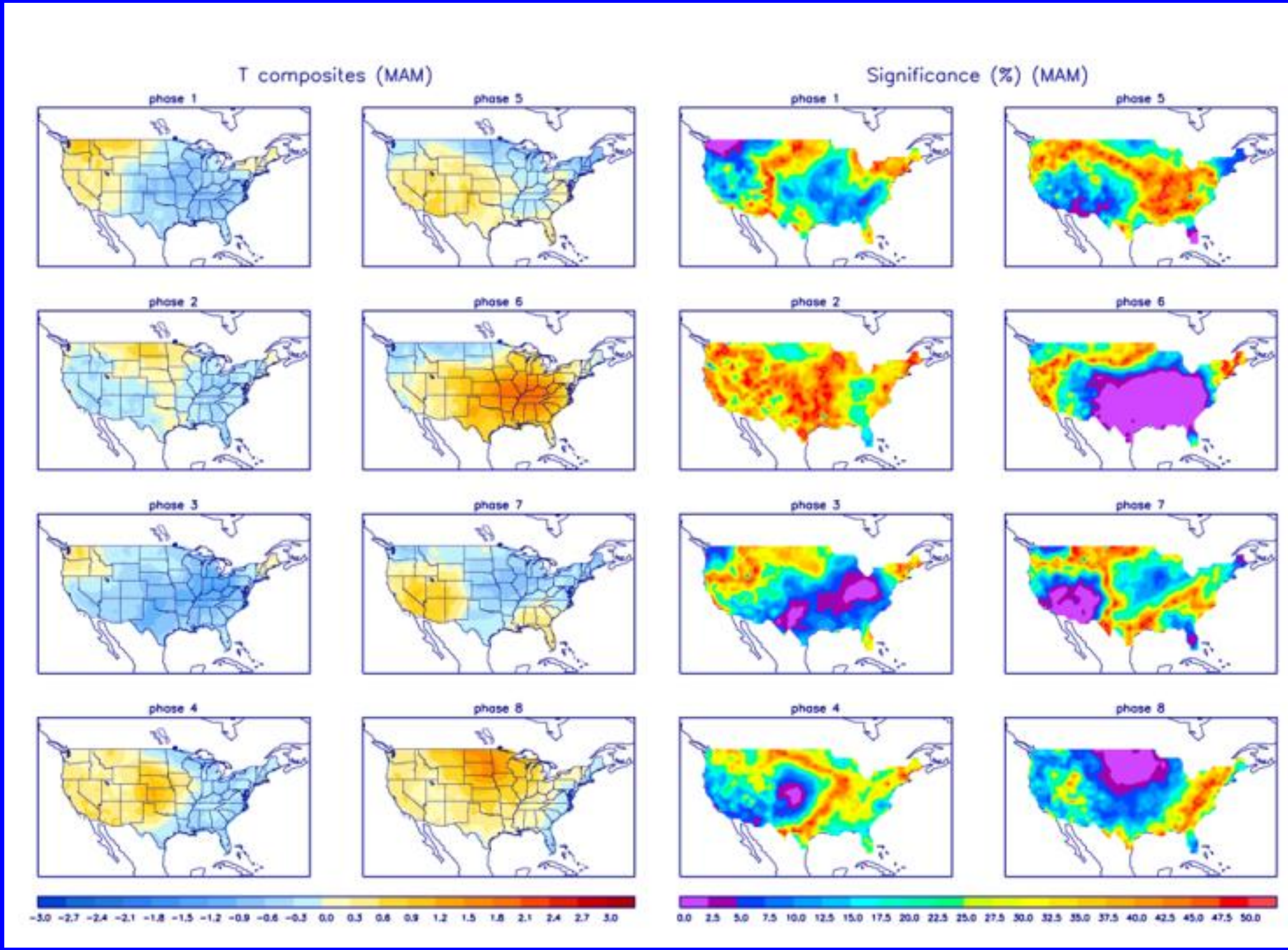


Precipitation Anomalies (May-Sep)



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.



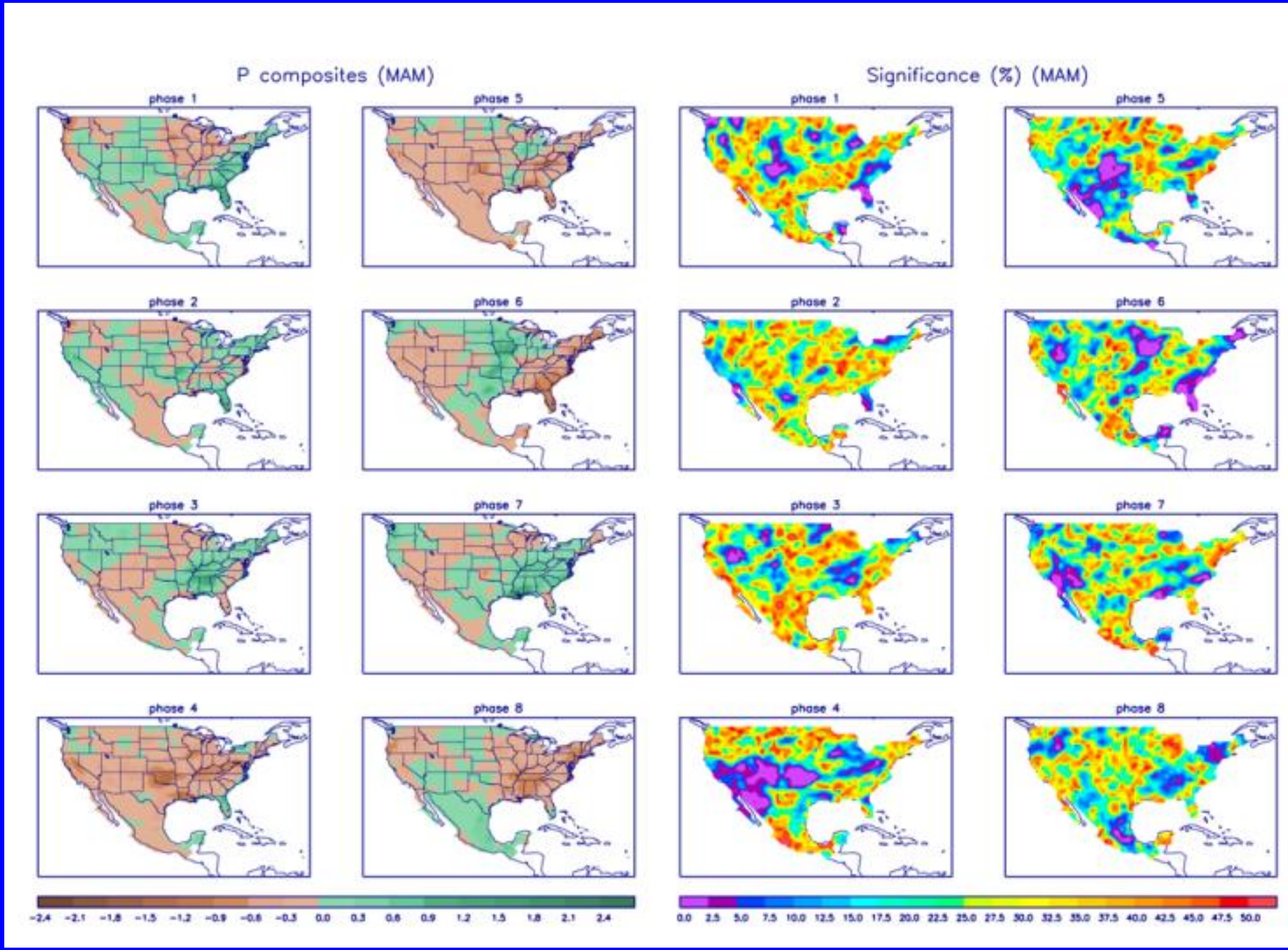
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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