



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

**Update prepared by
Climate Prediction Center / NCEP
April 14, 2014**



Outline

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



Overview

- Recent observations of tropical convective anomalies and other variables have been more consistent with MJO activity; however, some aspects of the variability link the changes to other coherent subseasonal modes.
- Dynamical model MJO forecasts indicate continued eastward propagation of an MJO signal during Week-1, with a significant weakening of the signal during Week-2. This appears to be related to other coherent modes becoming less aligned.
- Statistical models favor a more robust eastward propagation of the MJO over the West Pacific.
- The currently active coherent subseasonal modes favor enhanced (suppressed) convection over the West and Central Pacific (Maritime Continent) during Week-1, with a tendency toward the emerging background state throughout the period.

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>

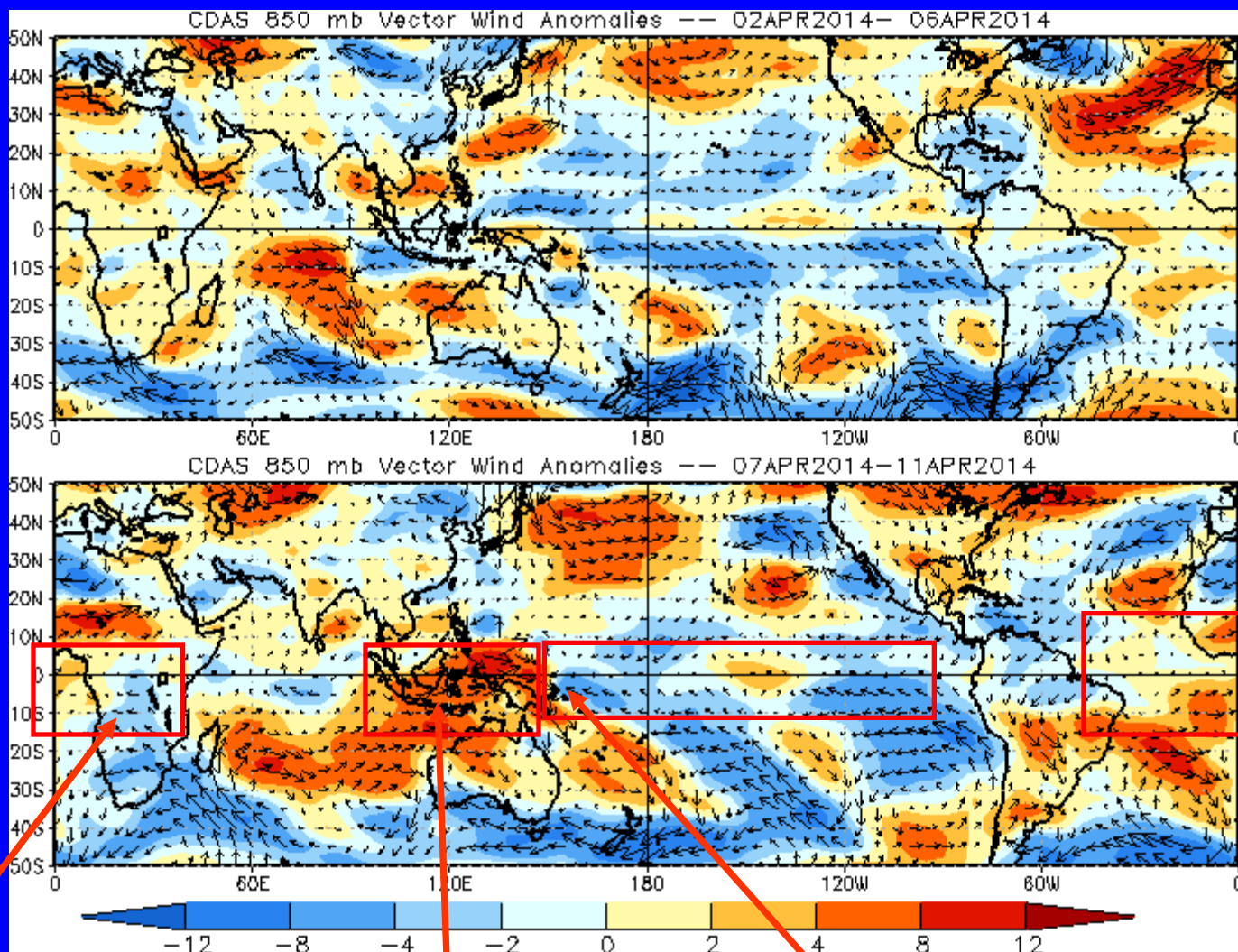


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies developed over equatorial Africa, but remained weak.

Westerly anomalies developed over the Maritime Continent.

Easterly anomalies decreased slightly in coverage over the Central Pacific.

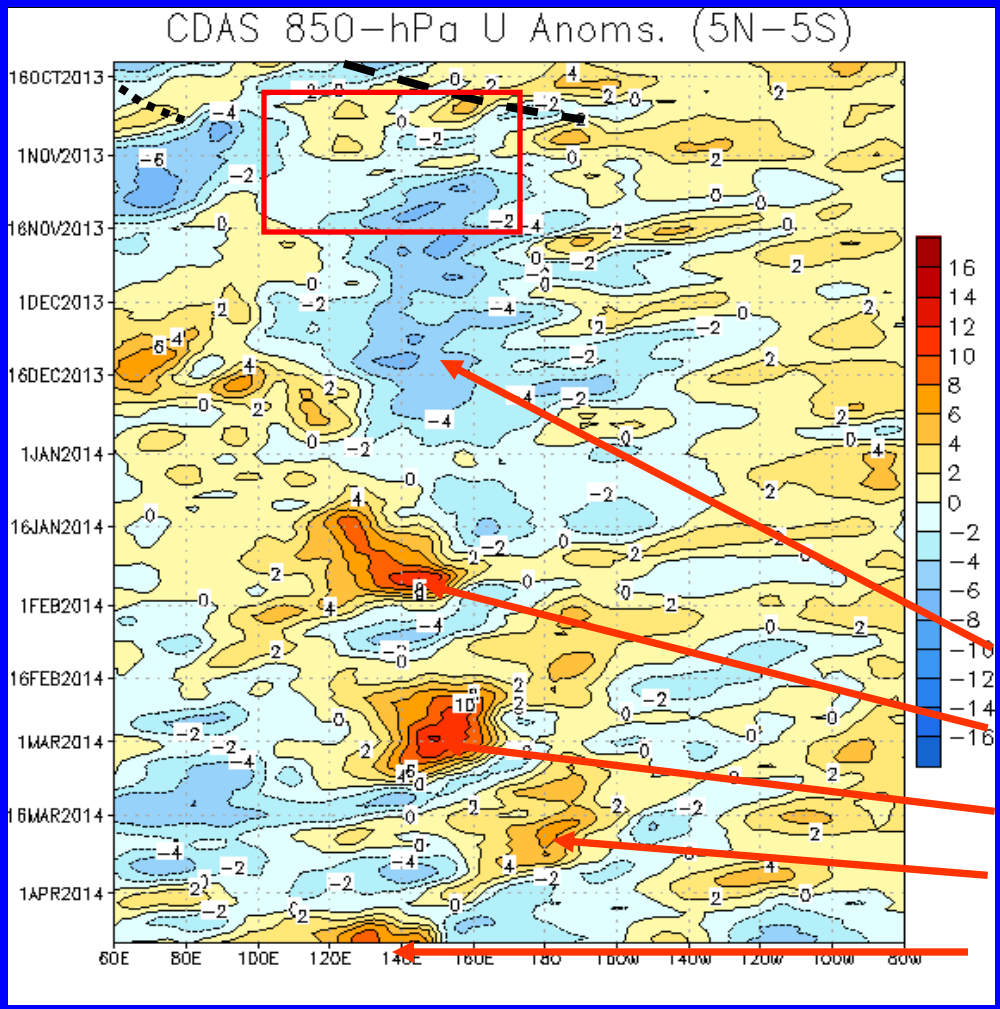


850-hPa Zonal Wind Anomalies (m s^{-1})

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.

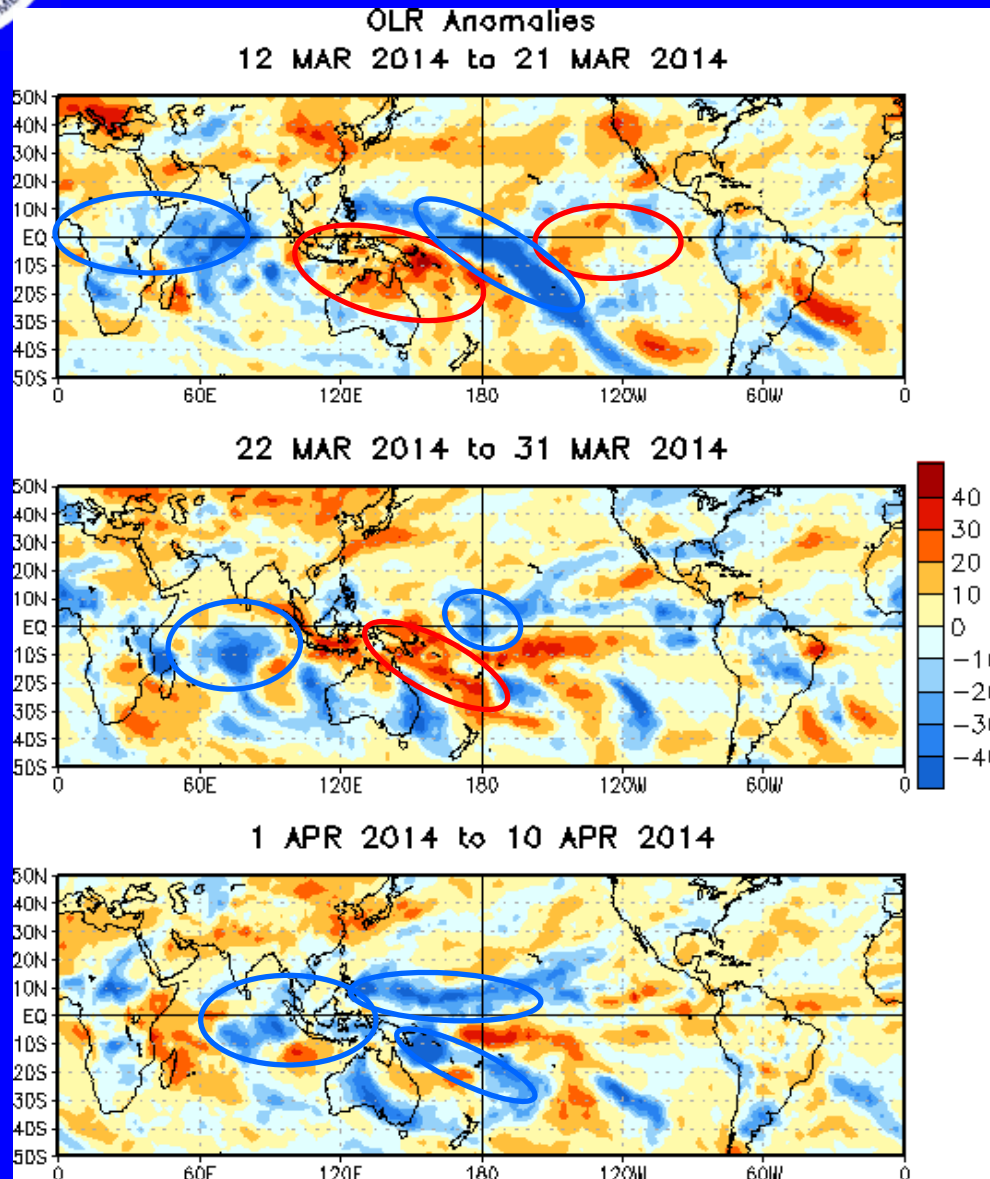
Recently, westerly anomalies have spread from the Indian Ocean to the Western Pacific.



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 South Pacific (Maritime Continent).

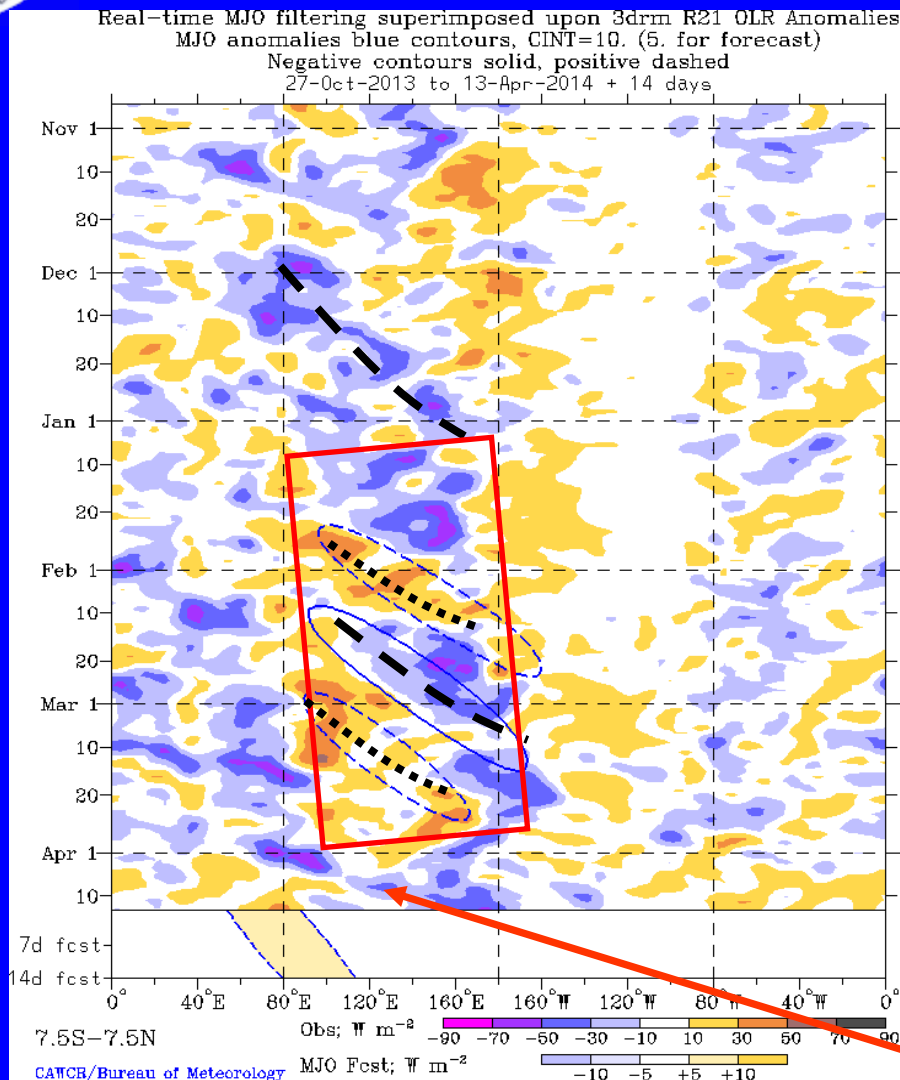
During late March, enhanced convection shifted into the Central Indian Ocean, while the enhanced convection near the Date Line diminished. Suppressed convection developed over the southwestern Pacific.

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



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.

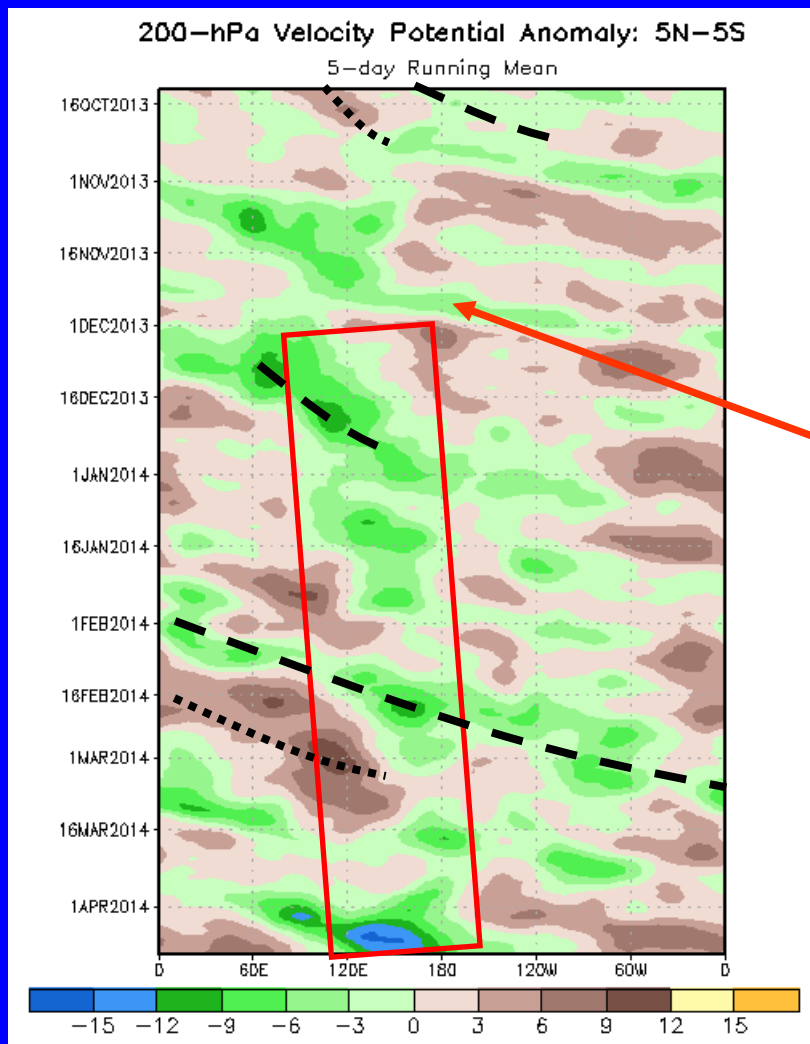


200-hPa Velocity Potential Anomalies (5°S-5°N)

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).

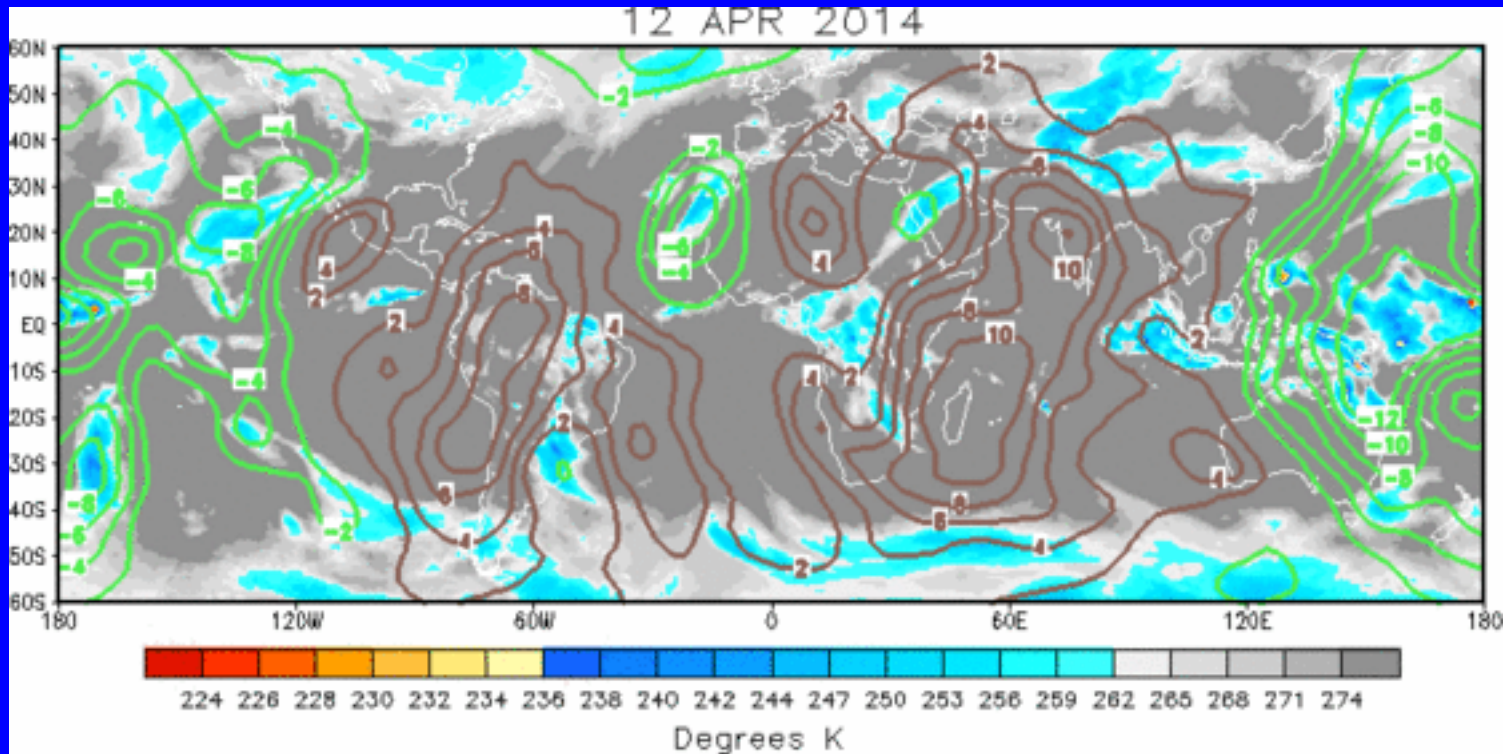
During February into early March, anomalies propagated eastward with time associated with the MJO. More recently the signal has broken down and seems consistent with atmospheric Kelvin waves and a slowly evolving background state.



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 more coherent, with areas of anomalous upper-level divergence (convergence) over the West and Central Pacific, and western Africa (Americas and western Indian Ocean).

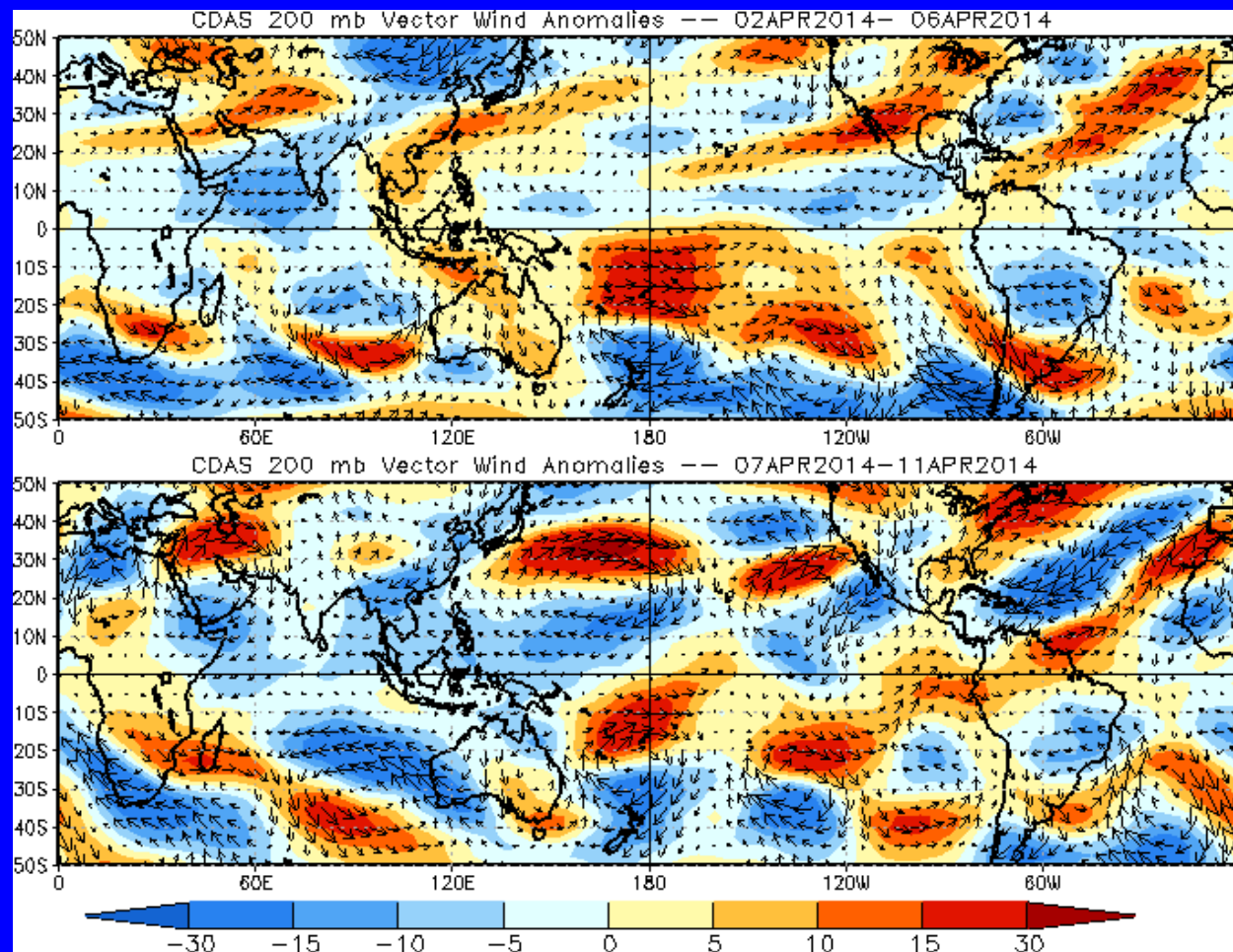


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



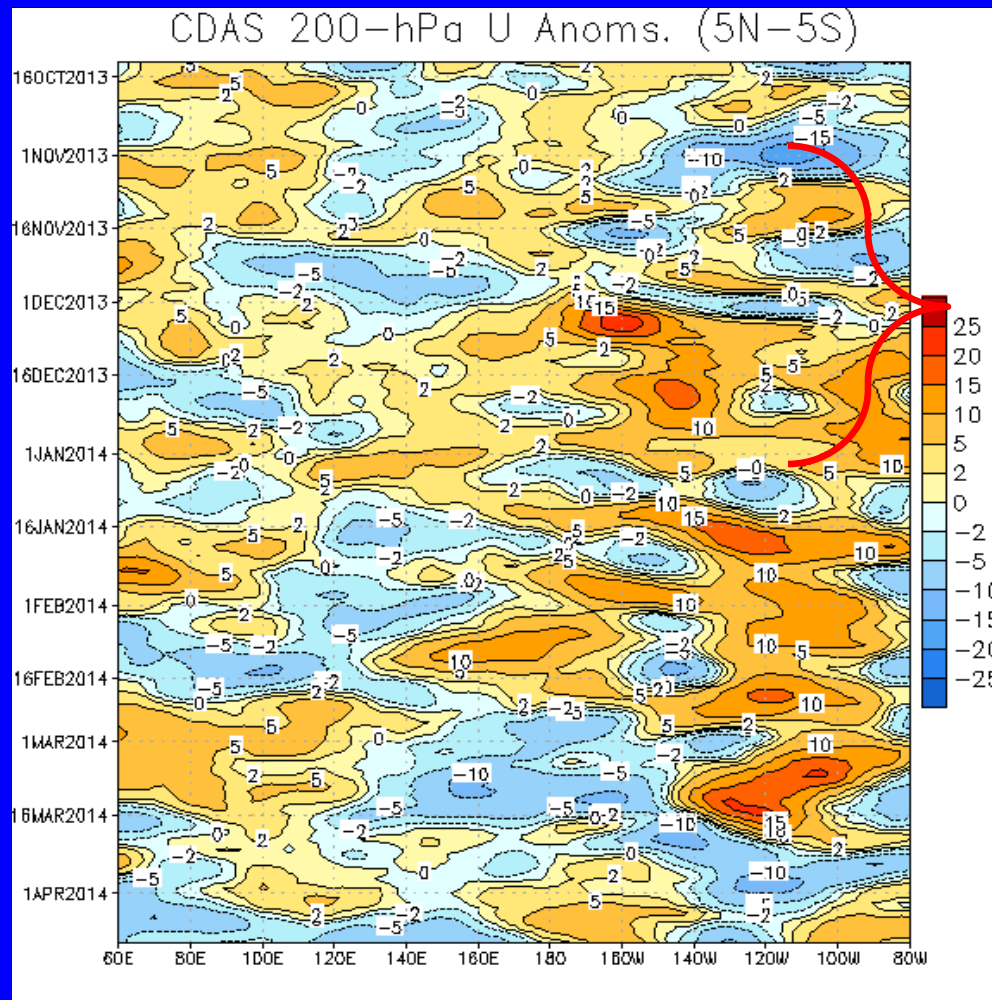
During mid April, easterly (westerly) anomalies strengthened over the West Pacific (Central Pacific and northern South America).



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



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

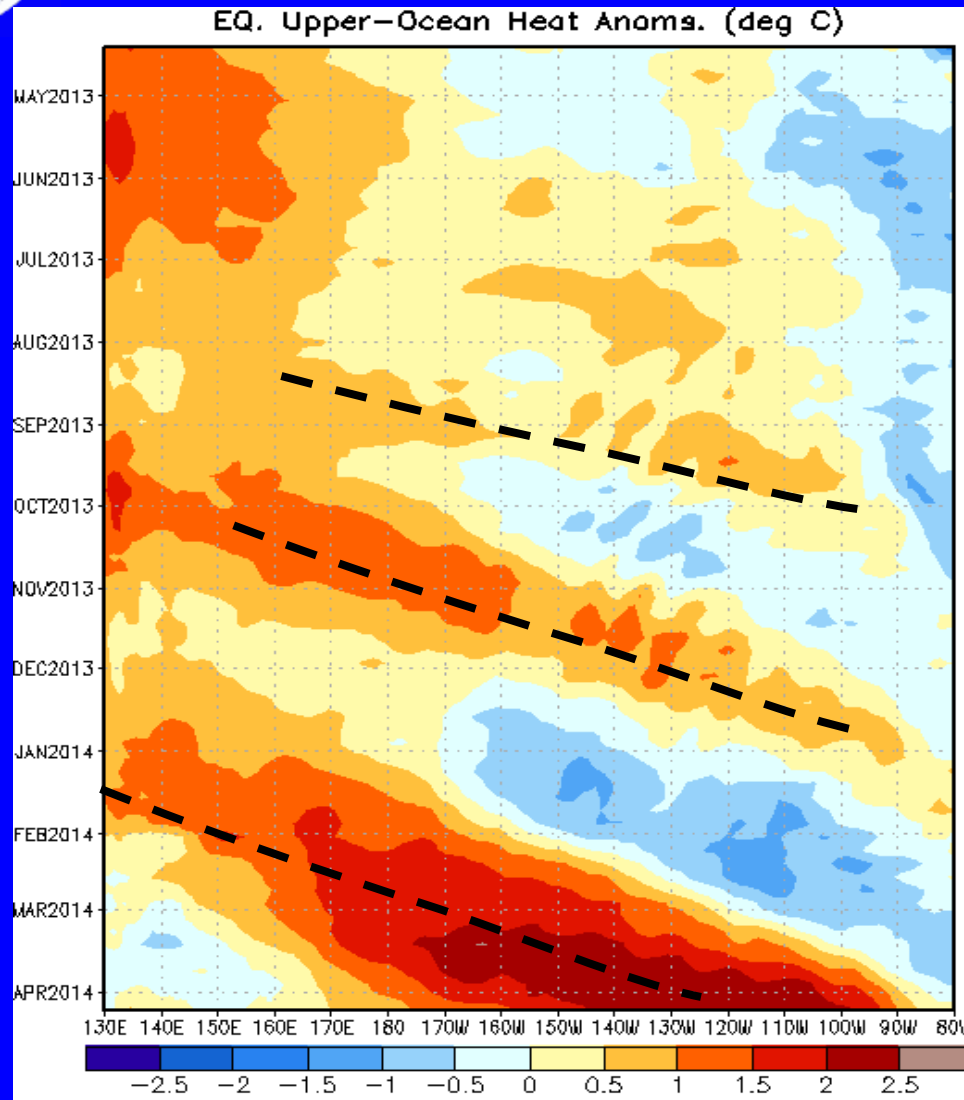
Westerly anomalies across the western Hemisphere persisted from December to early January. During January, anomalies were dominated by Kelvin wave activity and interaction with the extratropics.

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.

Recently, the slow evolving background state has contributed to easterly anomalies expanding to the Date Line, with westerly anomalies from 180-150W.



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.

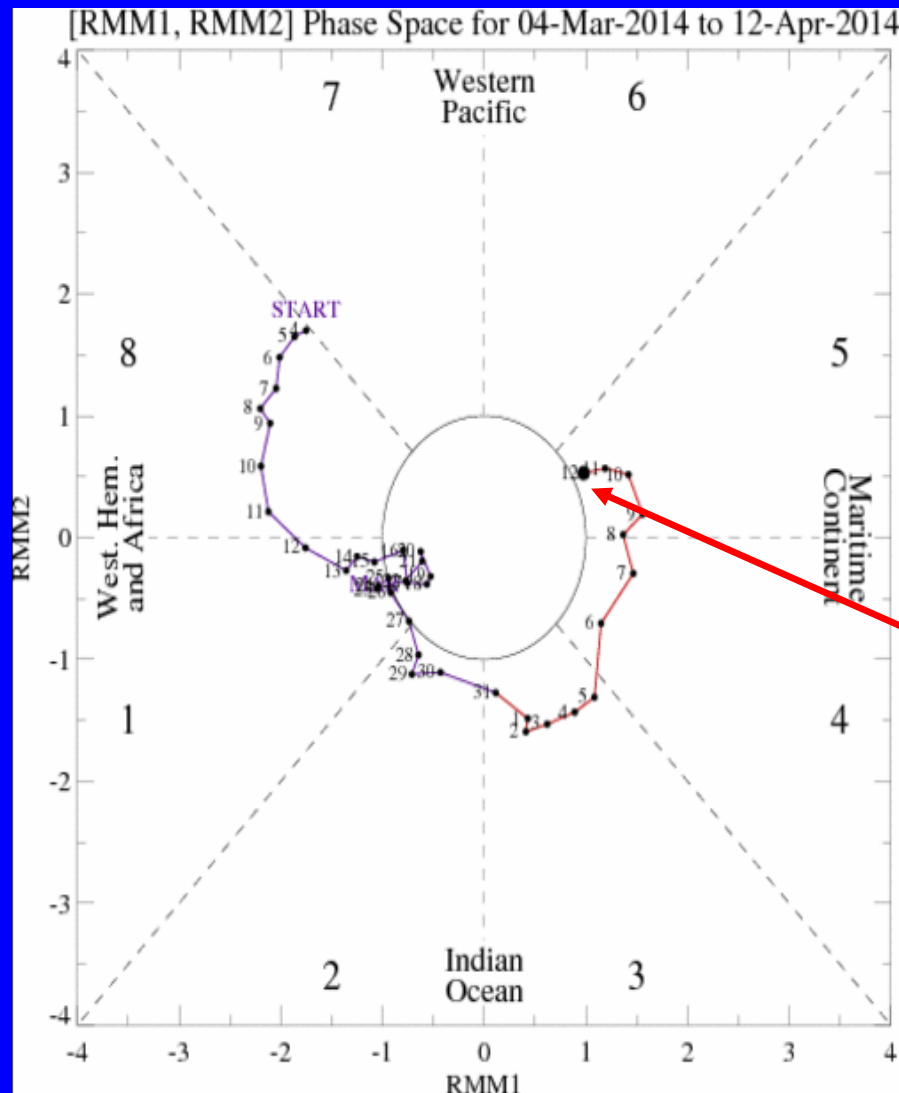
Gottschalck et al. 2010: A Framework for Assessing Operational Madden-Julian Oscillation Forecasts: A CLIVAR MJO Working Group Project, *Bull. Amer. Met. Soc.*, 91, 1247-1258.

- 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

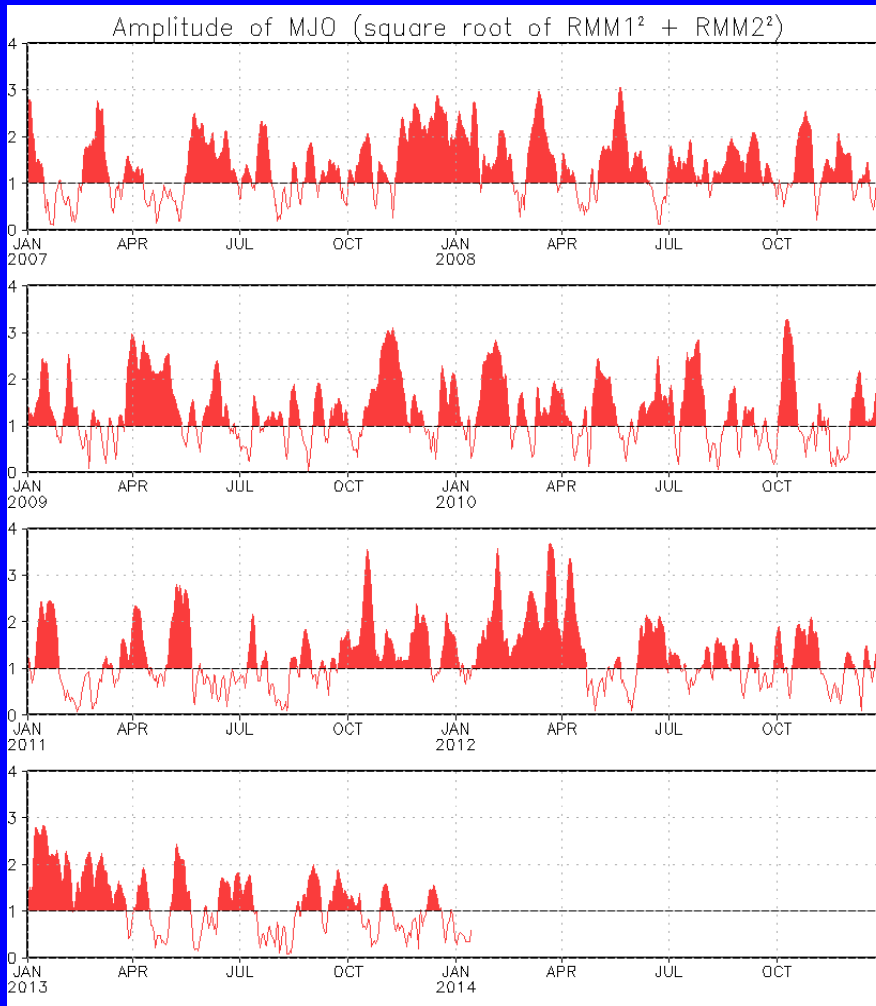
- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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



The MJO index indicates continued eastward propagation of a signal that maps to the MJO index. The propagation speed is too fast for MJO activity, so this signal is likely aliased in from other modes.



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

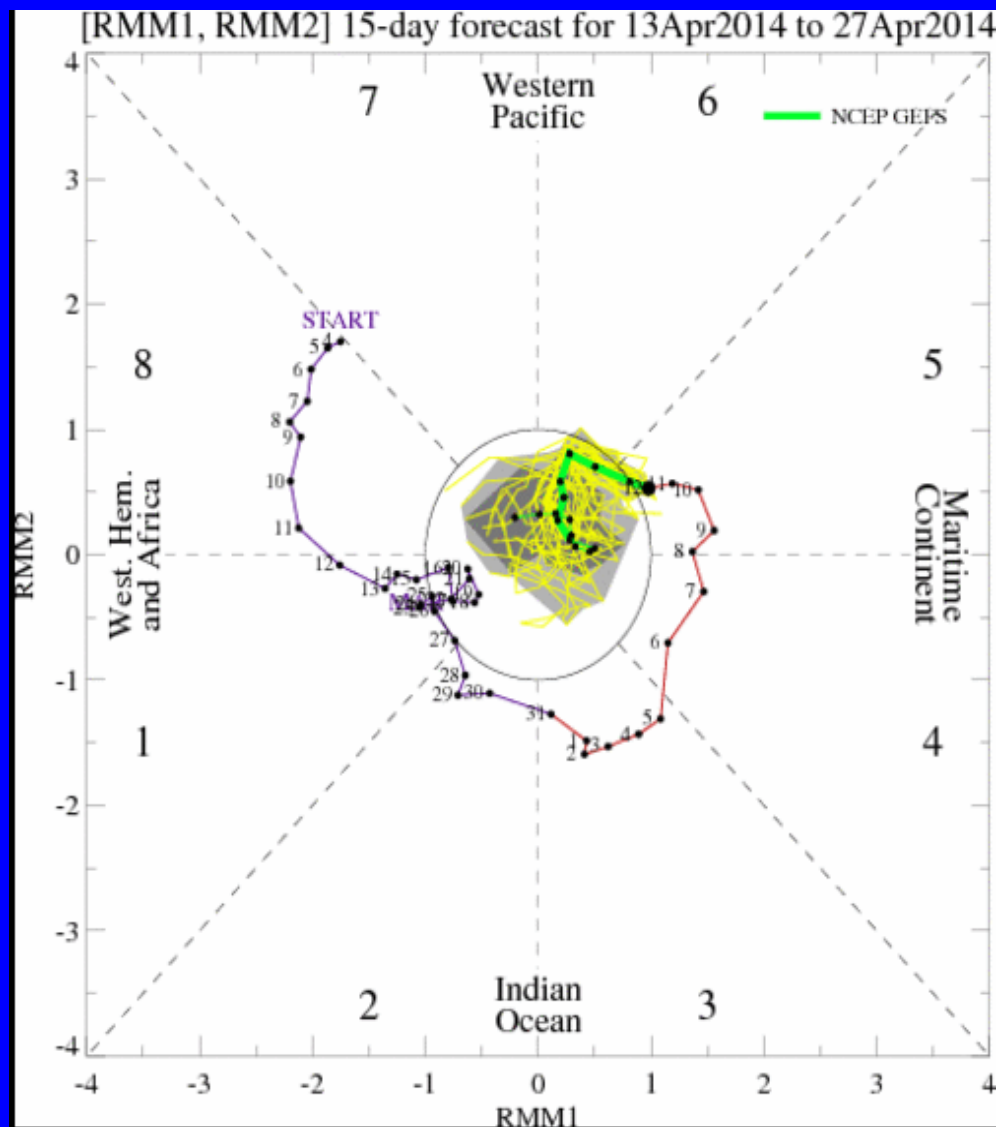
Green Line – Ensemble Mean

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 some eastward propagation of the signal during Week-1, with significant weakening of the signal throughout the period.

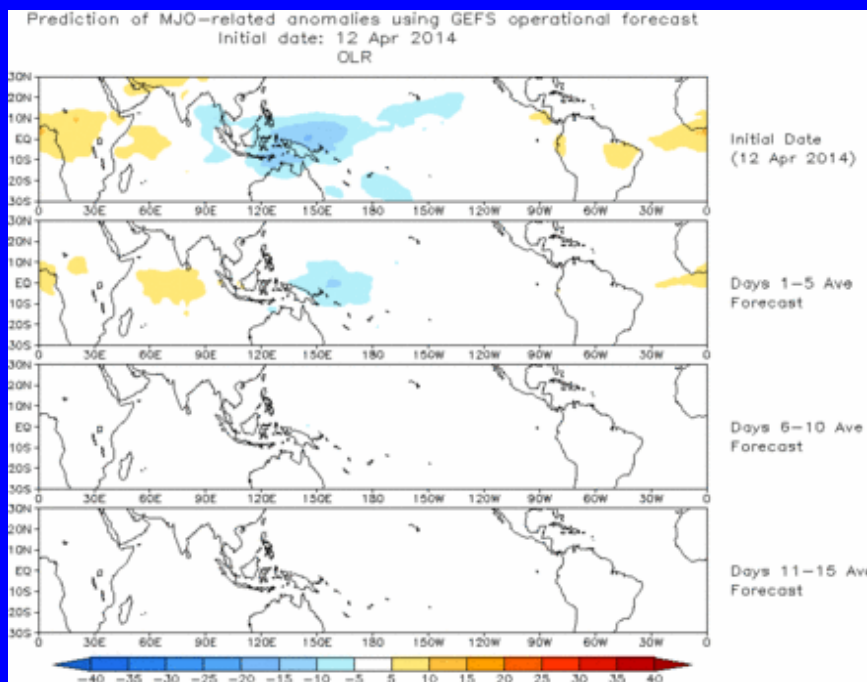




Ensemble Mean GFS MJO Forecast

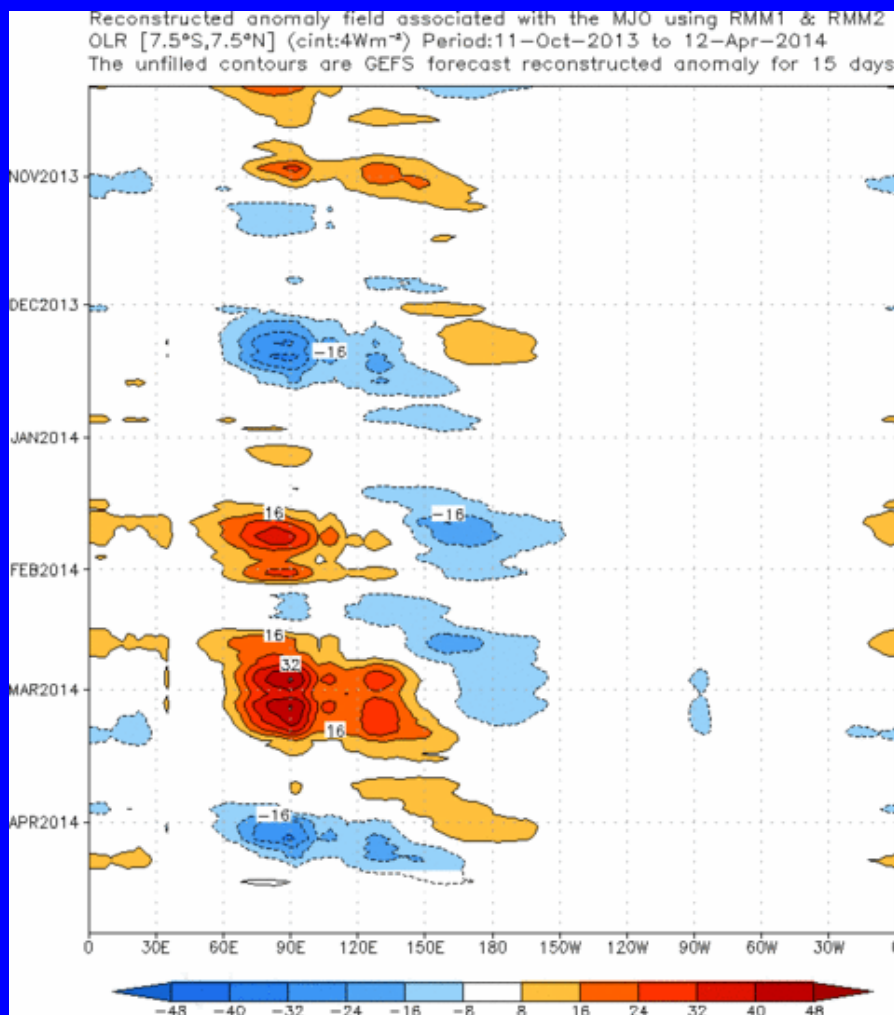
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecasts eastward propagation of an MJO signal during Week-1, with a weakening signal 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

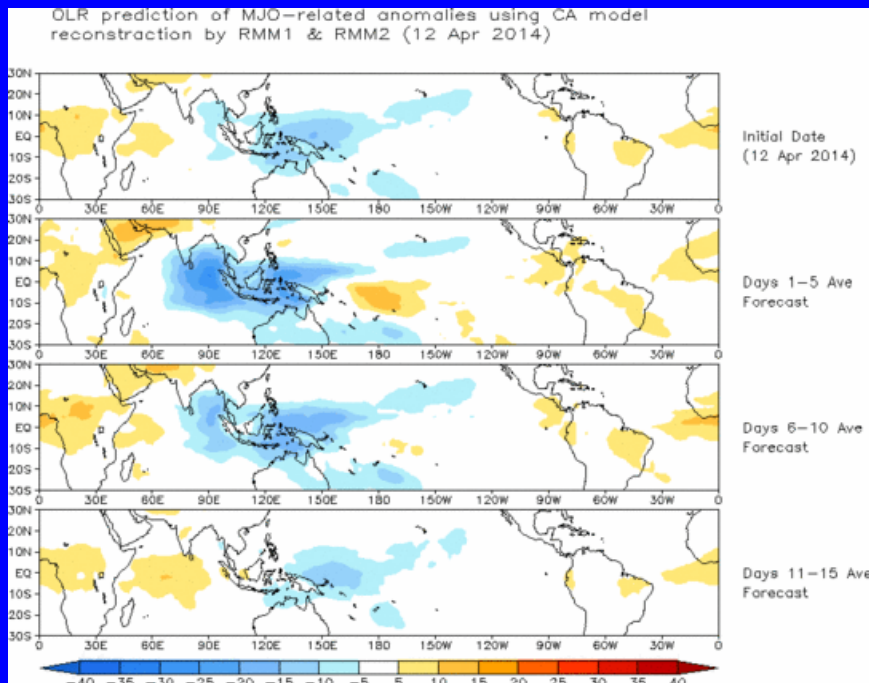




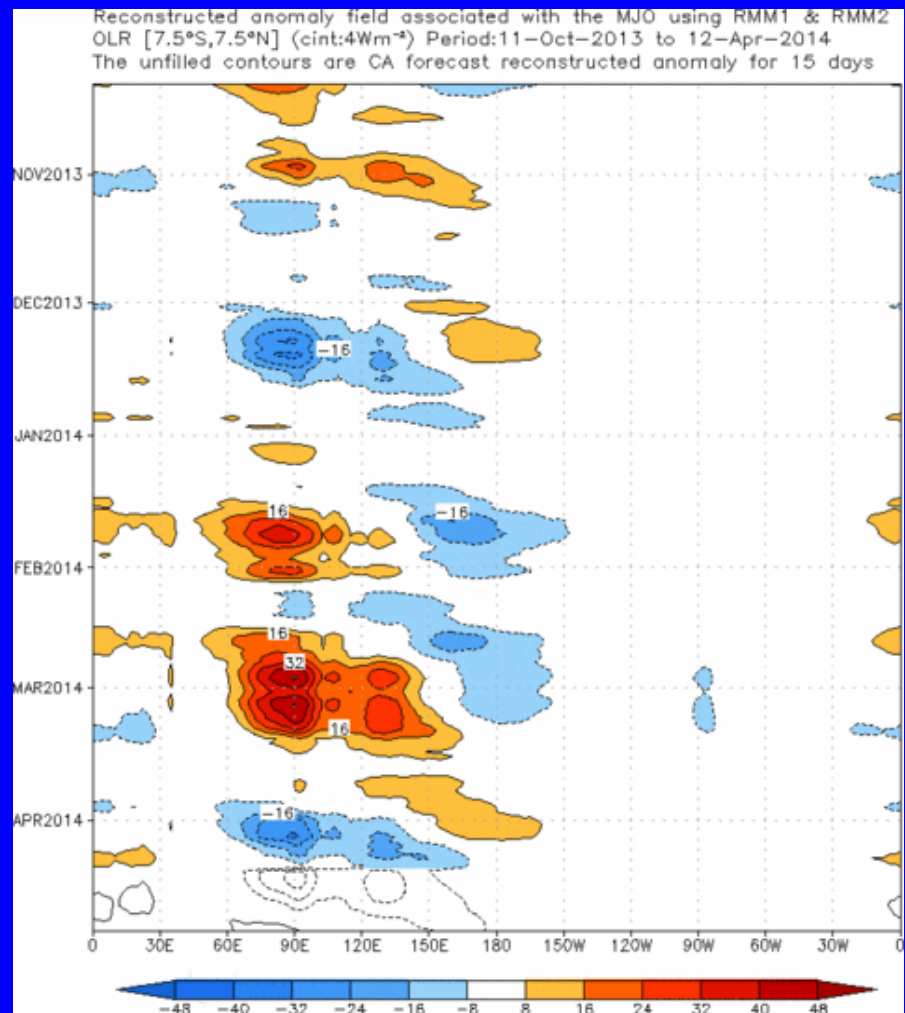
Constructed Analog (CA) MJO Forecast

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

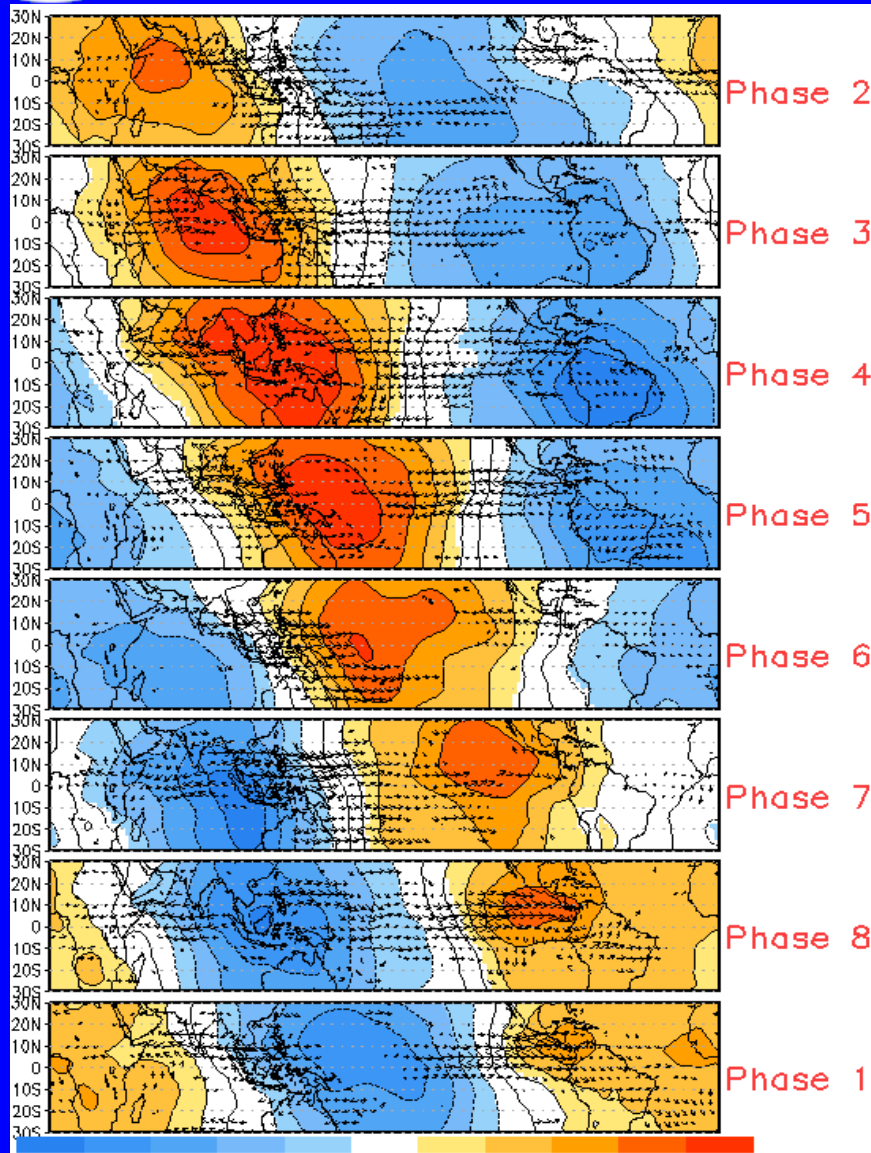


The constructed analog MJO forecast indicates robust MJO propagation, with enhanced (suppressed) convection shifting from the eastern Indian Ocean to the western Pacific (Americas to the western Indian Ocean).

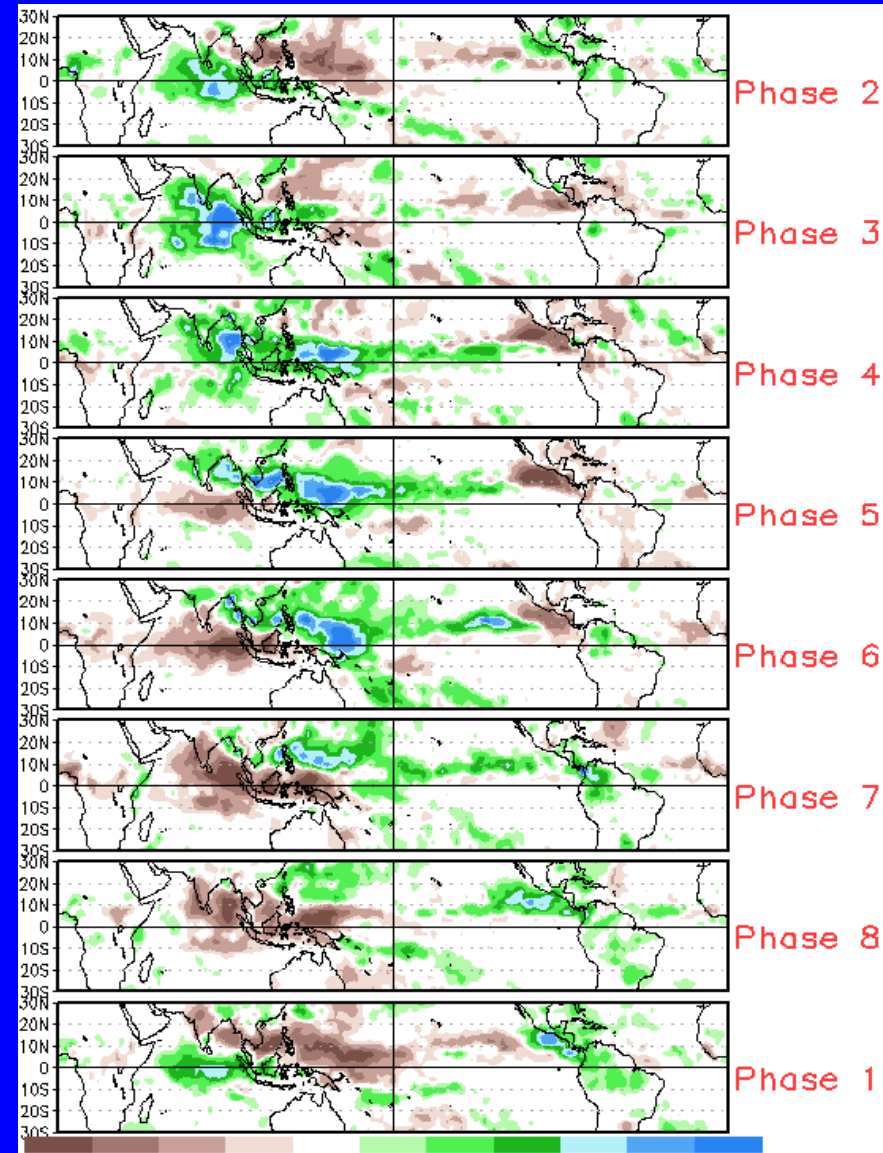


MJO Composites – Global Tropics

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



Precipitation Anomalies (May-Sep)

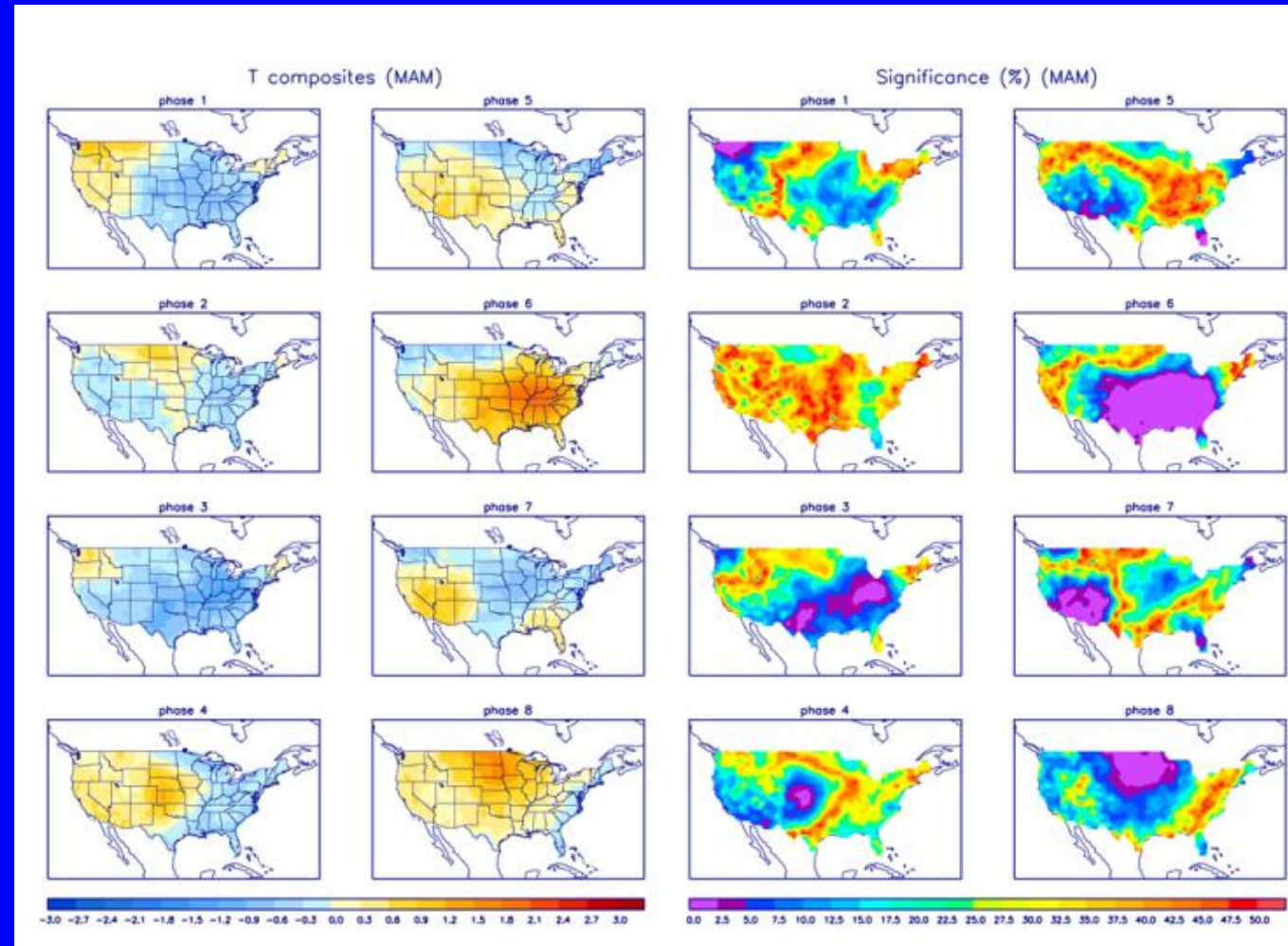




U.S. MJO Composites – Temperature

- 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.



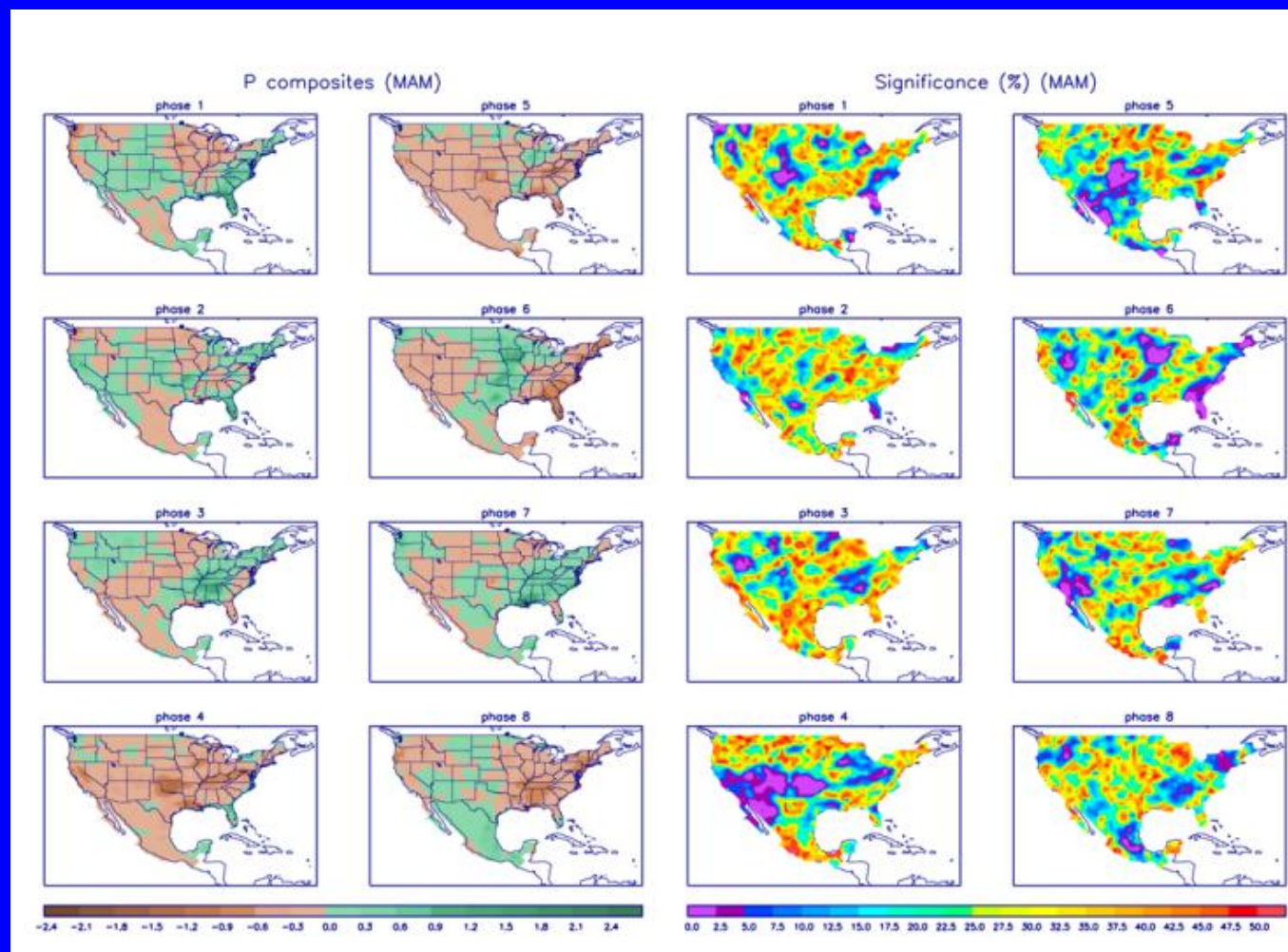
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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.



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

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