



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

**Update prepared by
Climate Prediction Center / NCEP
March 10, 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 convective phase now propagating across the Western Hemisphere.**
- **MJO indices continue to be strongly influenced by slowly evolving atmospheric and oceanic conditions in the western Pacific that are producing somewhat less clear or coherent indicators for the ongoing MJO activity.**
- **Along those lines, the dynamical model MJO index forecasts show varying depictions as they try to reconcile the MJO activity and the current tropical base state, with most indicating a weakening MJO signal due to destructive interference of these two signals. Statistical models show a more robust MJO signal over the next two weeks.**
- **The MJO favors enhanced (suppressed) convection over the western Indian Ocean (Maritime Continent) during the period while also tending to oppose ongoing convection across the western 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>

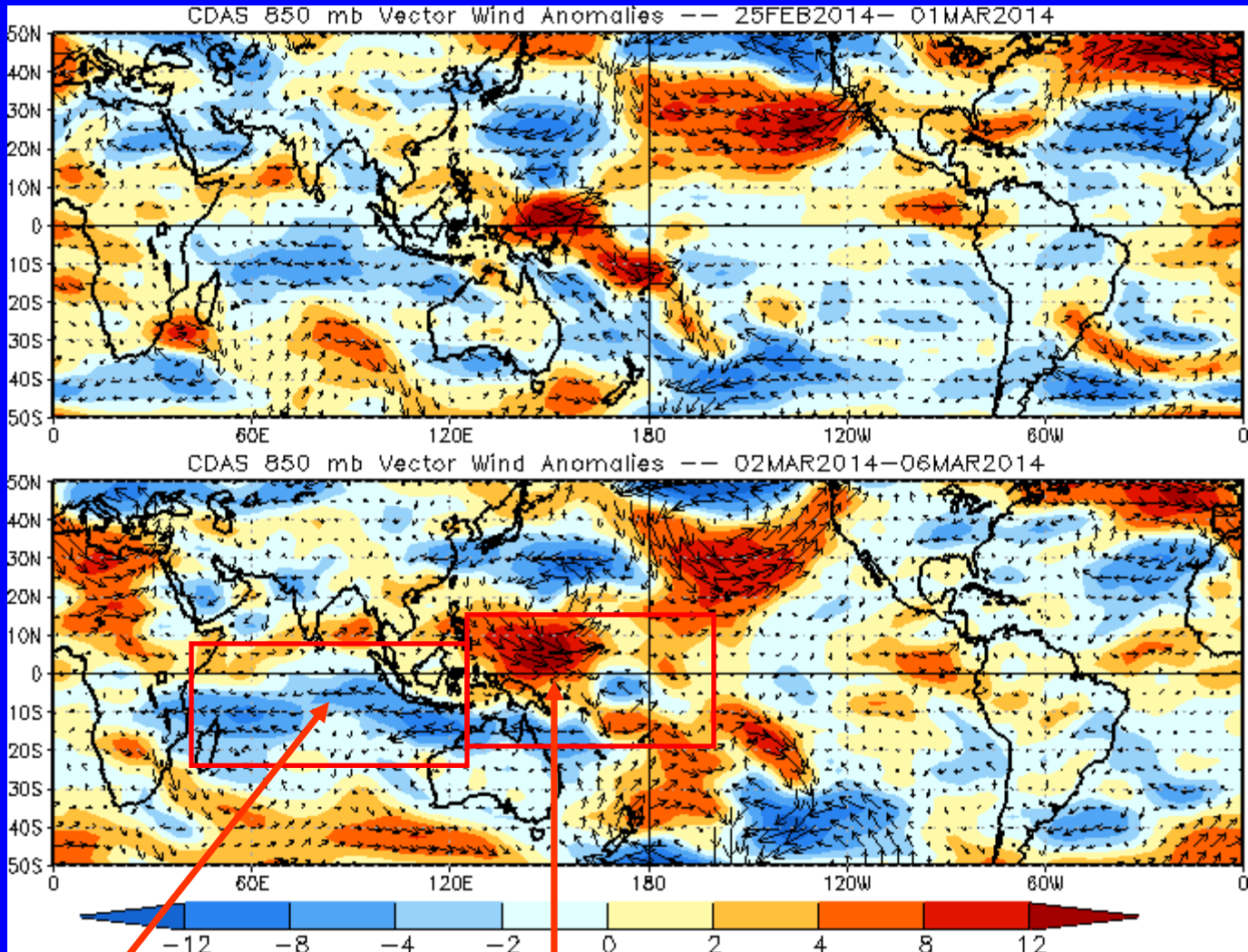


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies persisted across much of the southern Indian Ocean and south of the Maritime Continent.

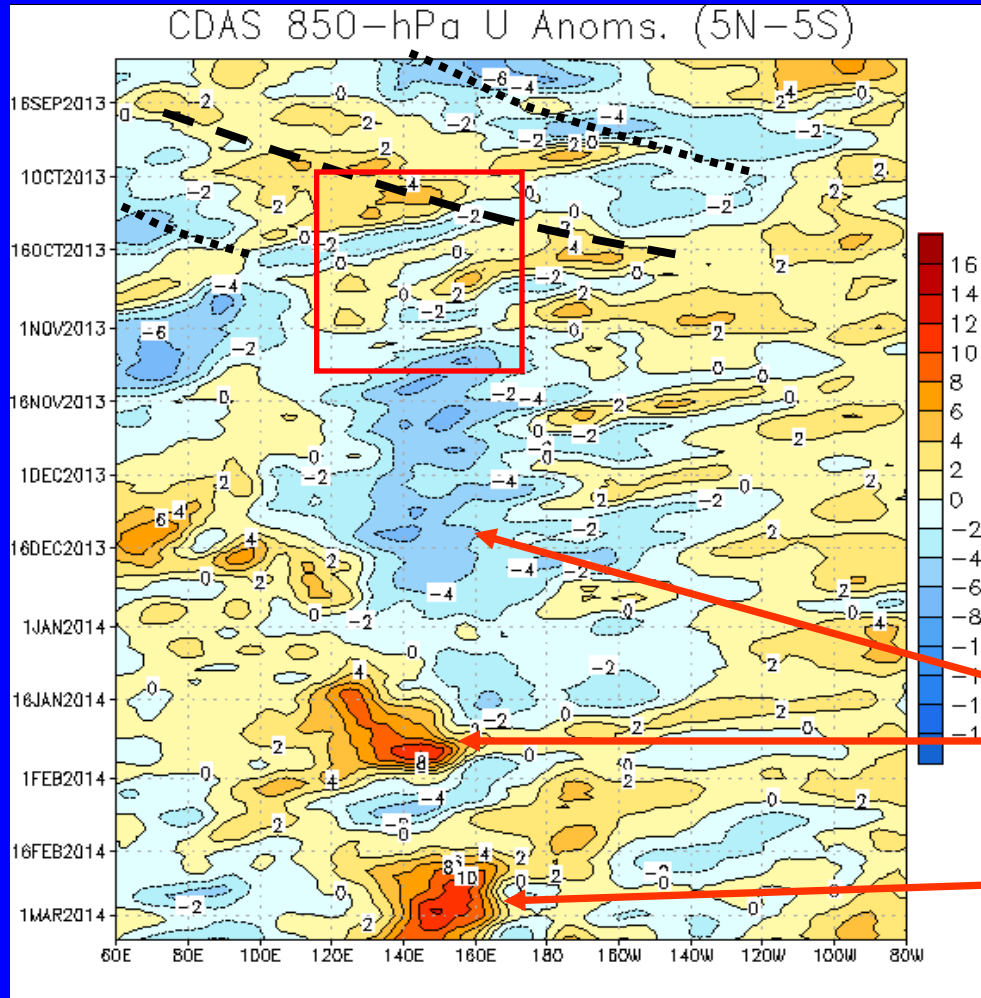
Westerly anomalies persisted over the equatorial and northern West Pacific and central equatorial Pacific.



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



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.

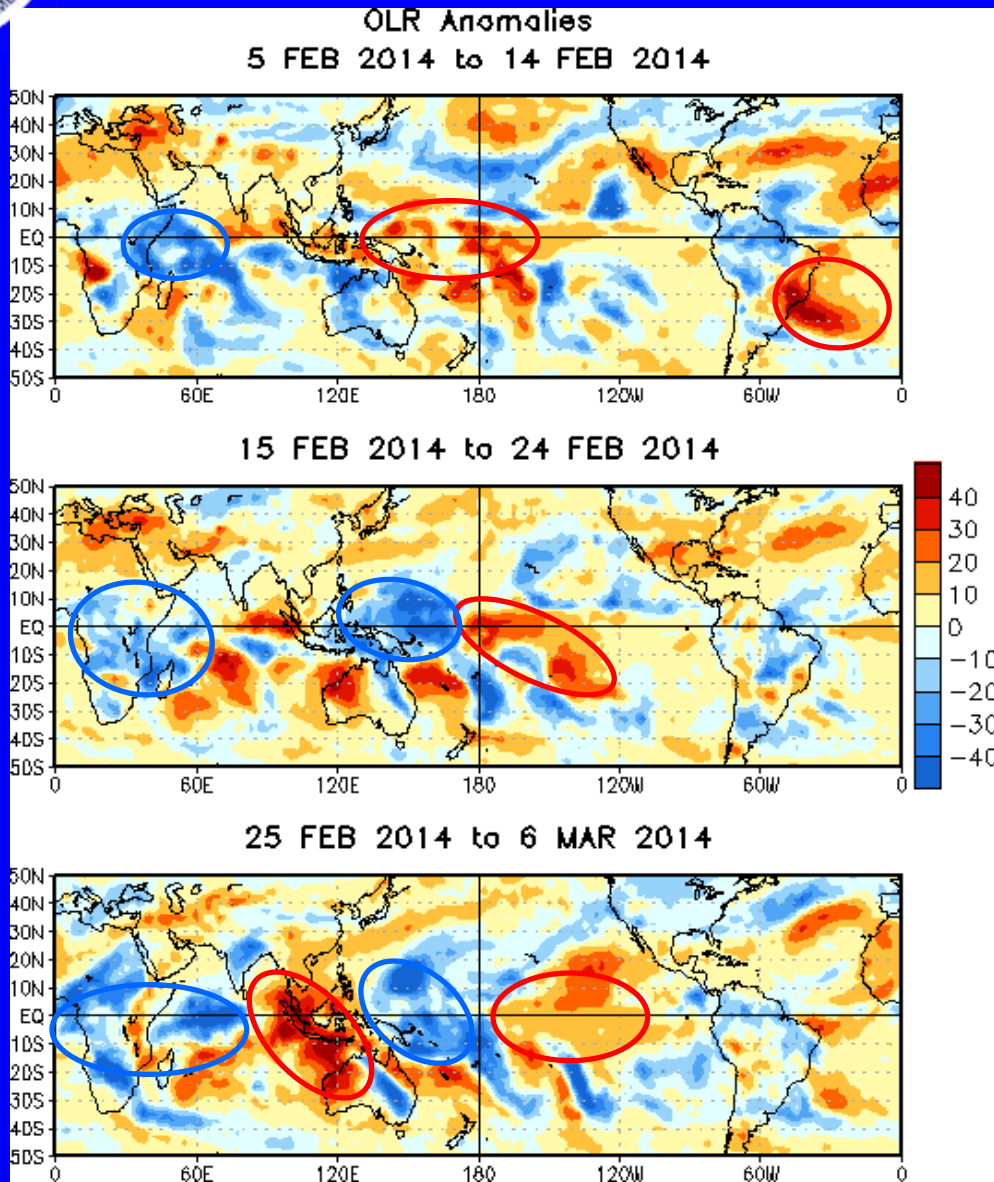
Persistent easterly anomalies from 120E to near the Date Line during November and December were replaced by westerly anomalies east of the Maritime Continent during January.

Westerly anomalies returned to the Western Pacific during late February and early March following a brief disruption by easterly anomalies in early February.



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 early to mid-February, enhanced (suppressed) convection was observed over parts of Africa and the western Indian Ocean (the western and central Pacific and eastern Brazil).

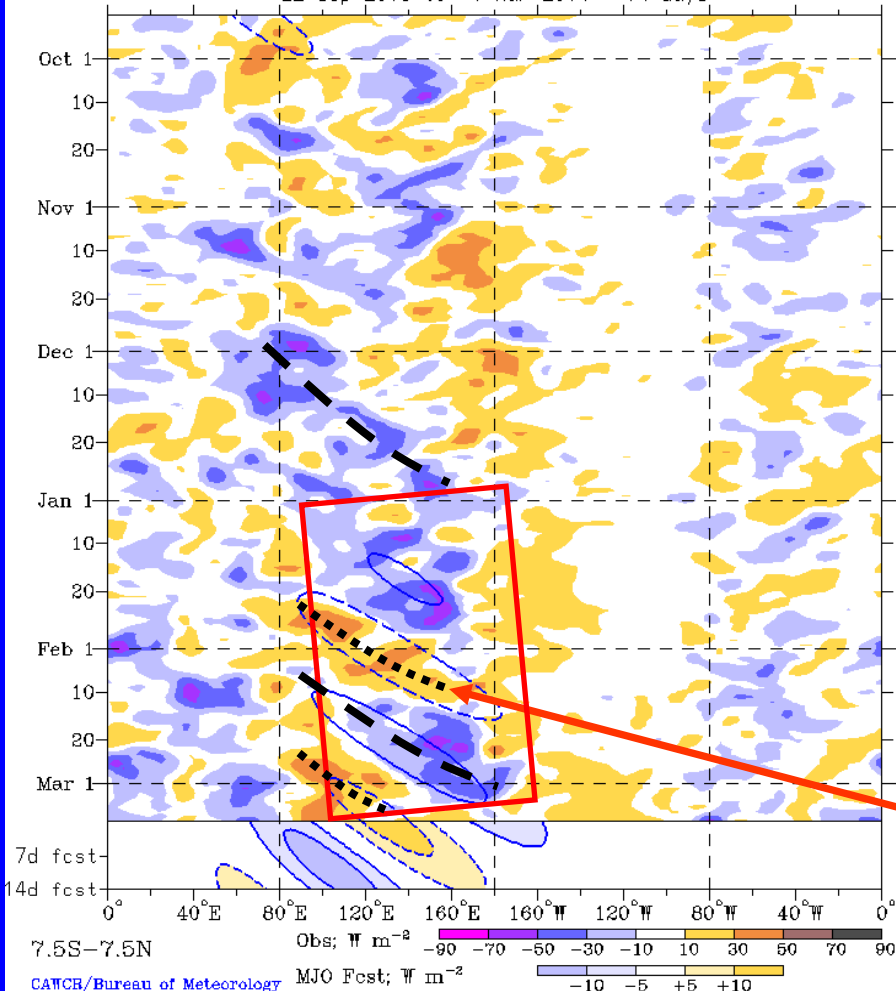
During mid to late February, enhanced convection returned to the equatorial western Pacific while persisting over southern Africa and the far western Indian Ocean. Suppressed convection was observed over the central Pacific.

Enhanced (suppressed) convection was observed over the western Pacific (Maritime Continent and east-central Pacific) during late February and early March, while enhanced convection returned to the equatorial western Indian Ocean.



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

Real-time MJO filtering superimposed upon 3drmm R21 OLR Anomalies
MJO anomalies blue contours, CINT=10. (5. for forecast)
Negative contours solid, positive dashed
22-Sep-2013 to 9-Mar-2014 + 14 days



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.

Longitude

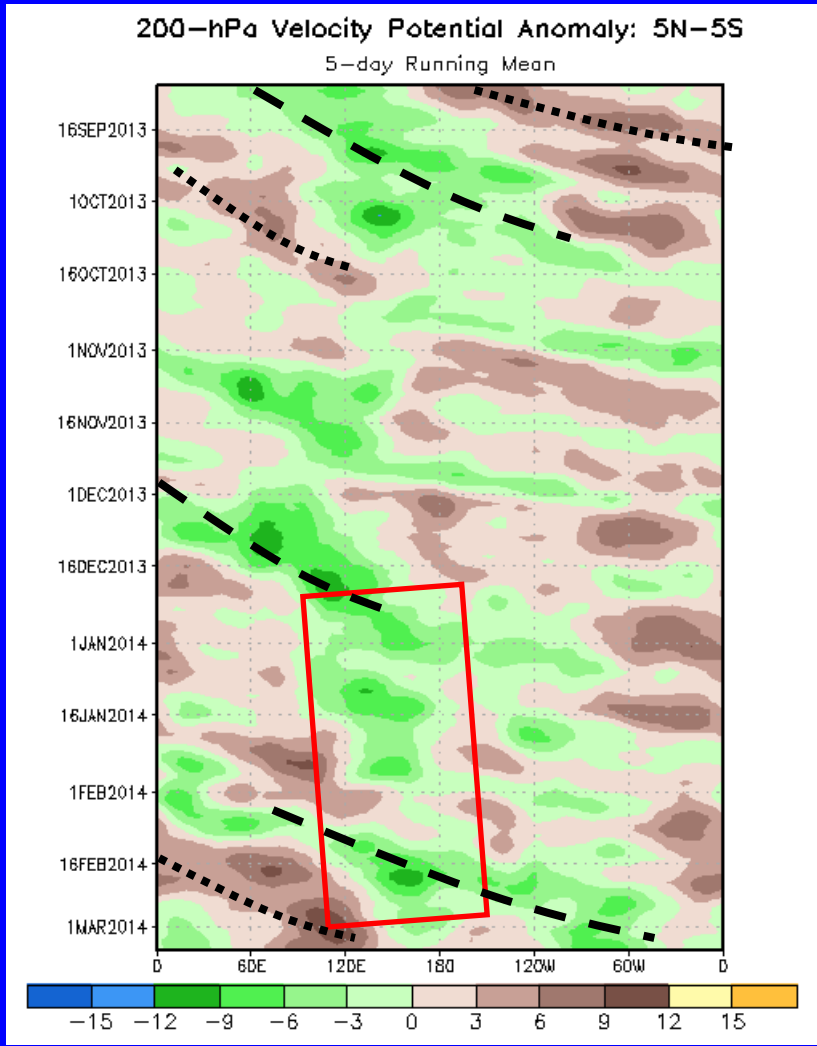


200-hPa Velocity Potential Anomalies (5°S-5°N)

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).

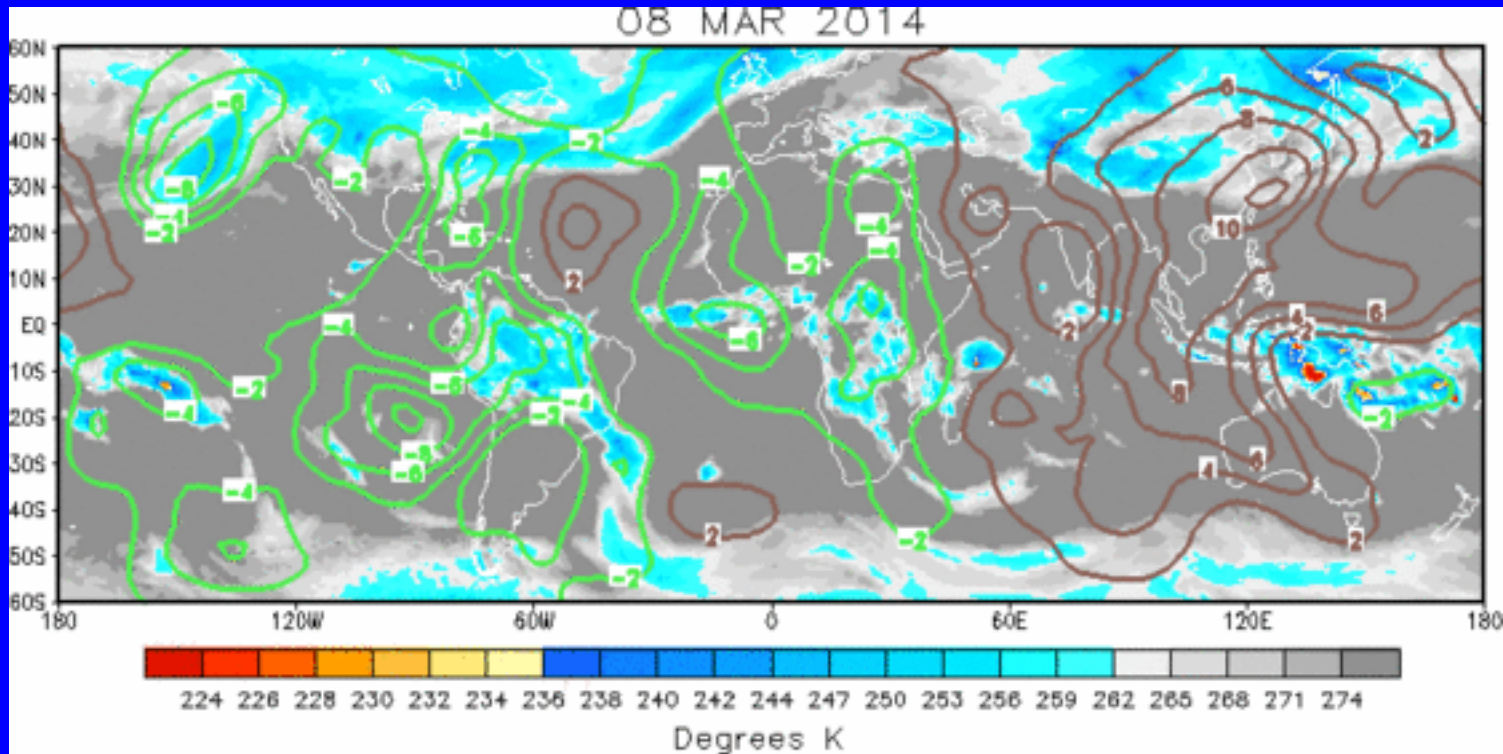
During February into early March, anomalies propagated eastward with time associated with the MJO.



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 more coherent, with large areas of anomalous divergence (convergence) over the Western Hemisphere (Indian Ocean and western Maritime Continent). Influence from other modes remains apparent, with areas of anomalous divergence persisting over parts of the southwestern and south-central Pacific.

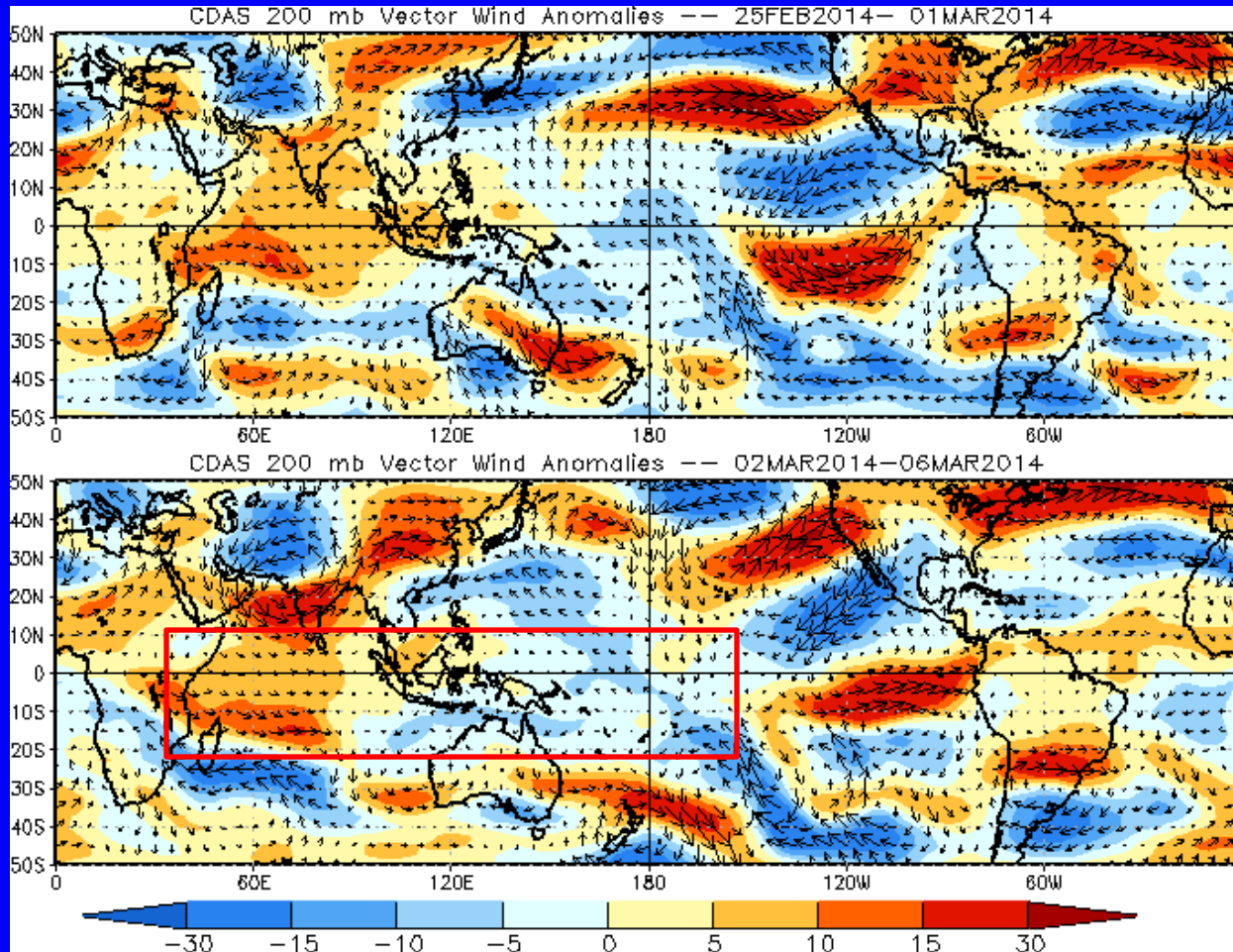


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



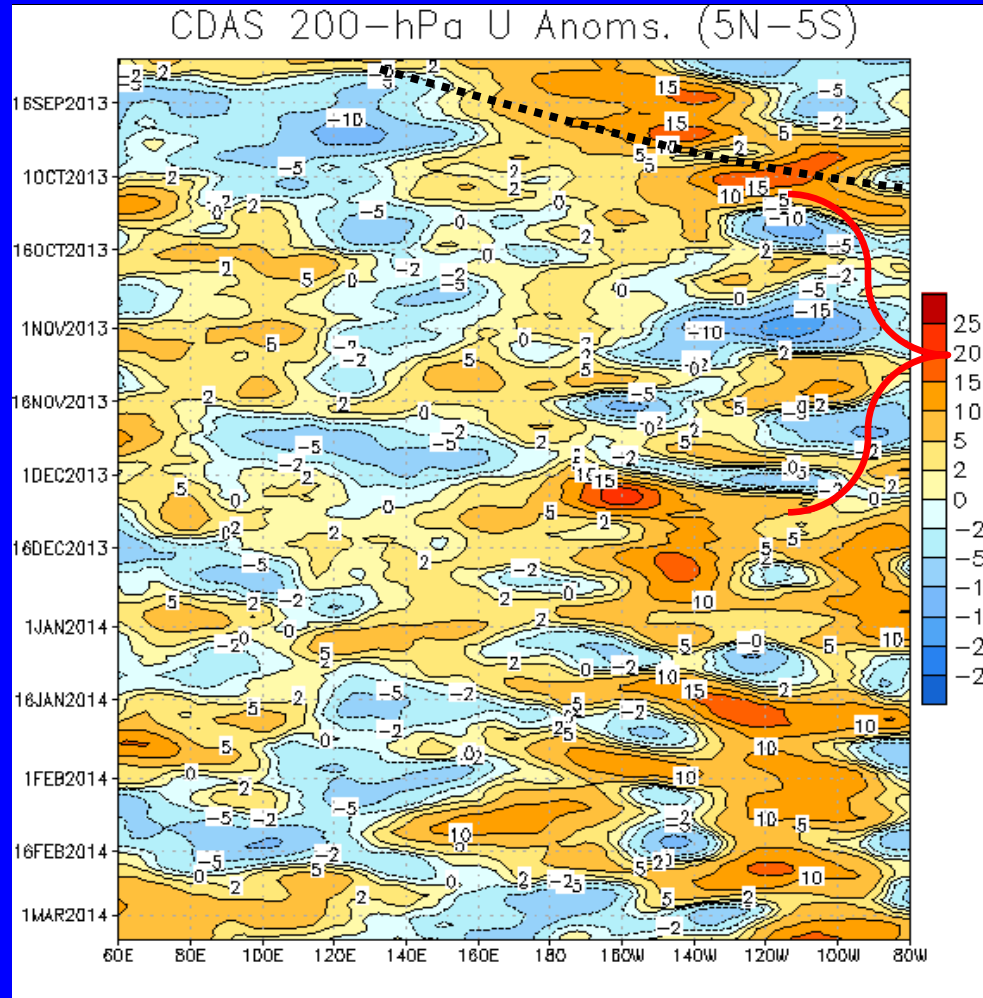
During early March, westerly (easterly) anomalies persisted over the western Indian Ocean (west-central Pacific). Westerly anomalies increased over the equatorial eastern Pacific.



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



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

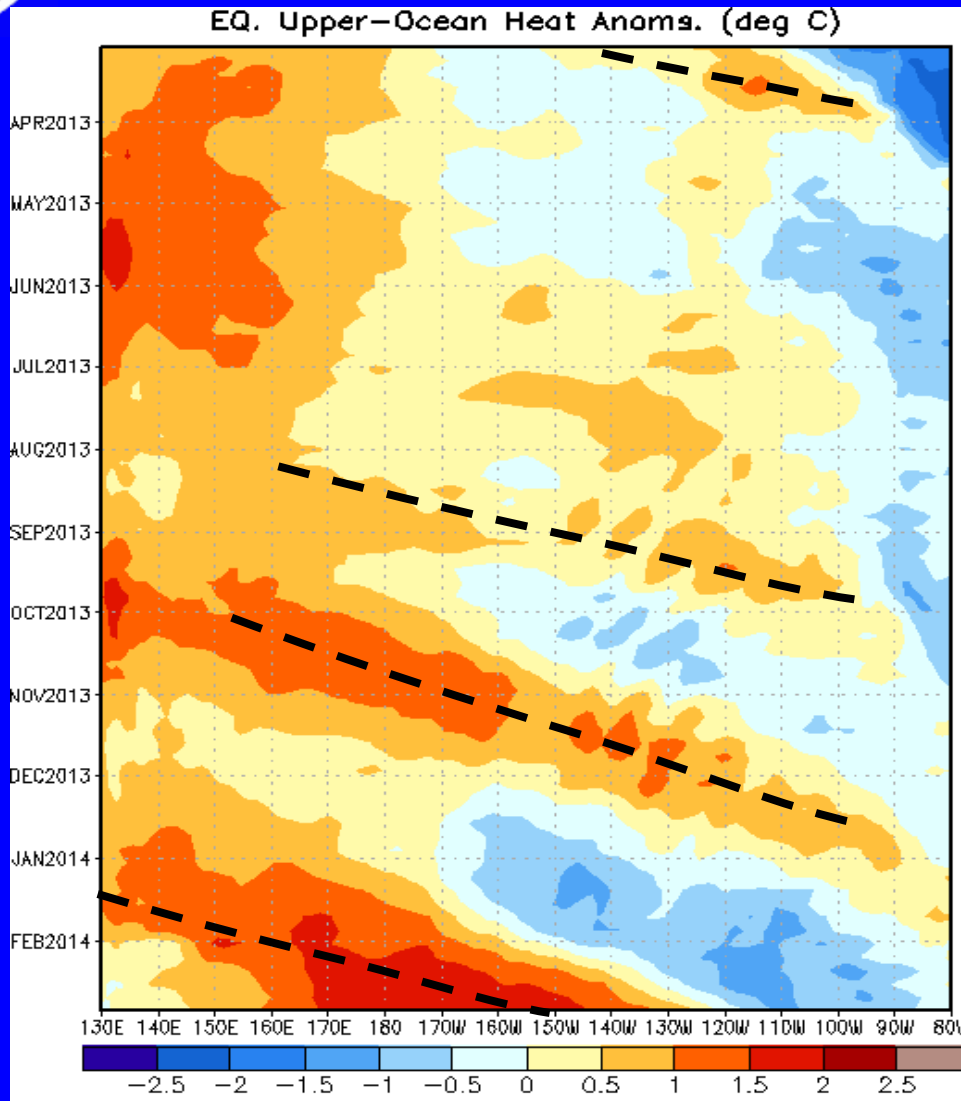
Anomalies of alternating sign were evident over the eastern Pacific, due in part to extratropical Rossby waves breaking into the Tropics (red bracket).

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 February and early March, westward moving features were evident over the central and western Pacific.



Weekly Heat Content Evolution in the Equatorial Pacific



The influence of a downwelling oceanic Kelvin wave (dashed line) can be seen during late February and 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.

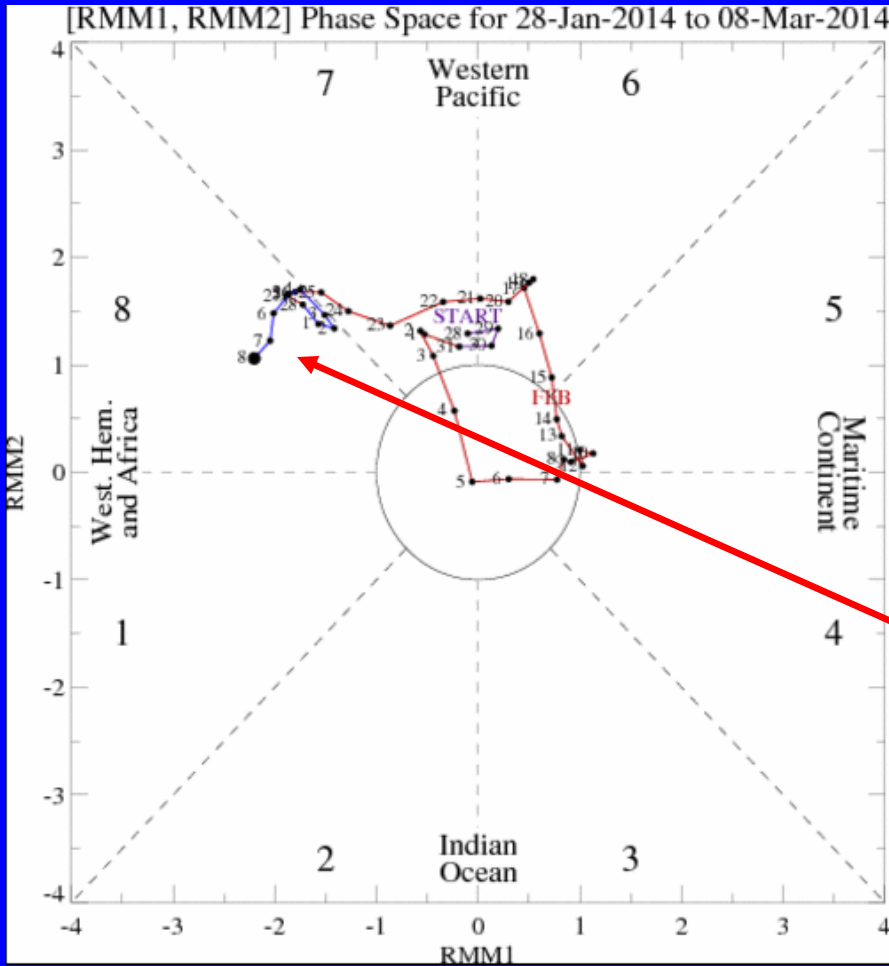
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

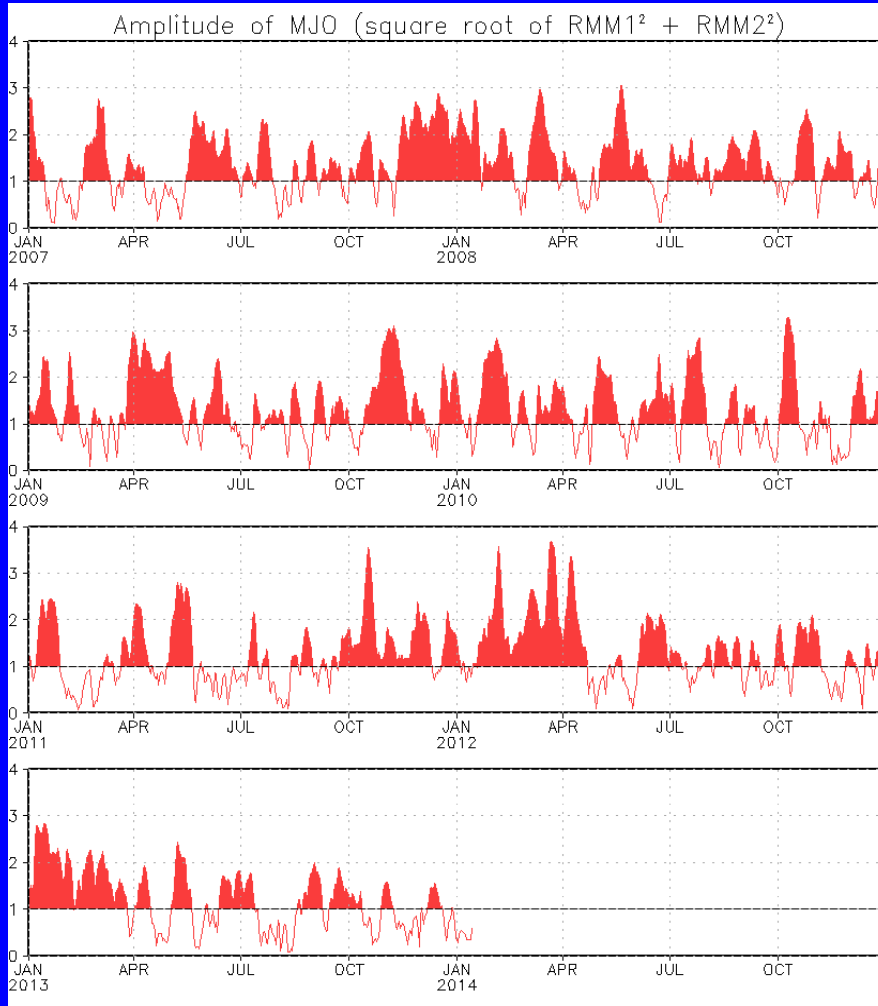


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates slow eastward propagation of a MJO signal over the Western Hemisphere during early March.



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.



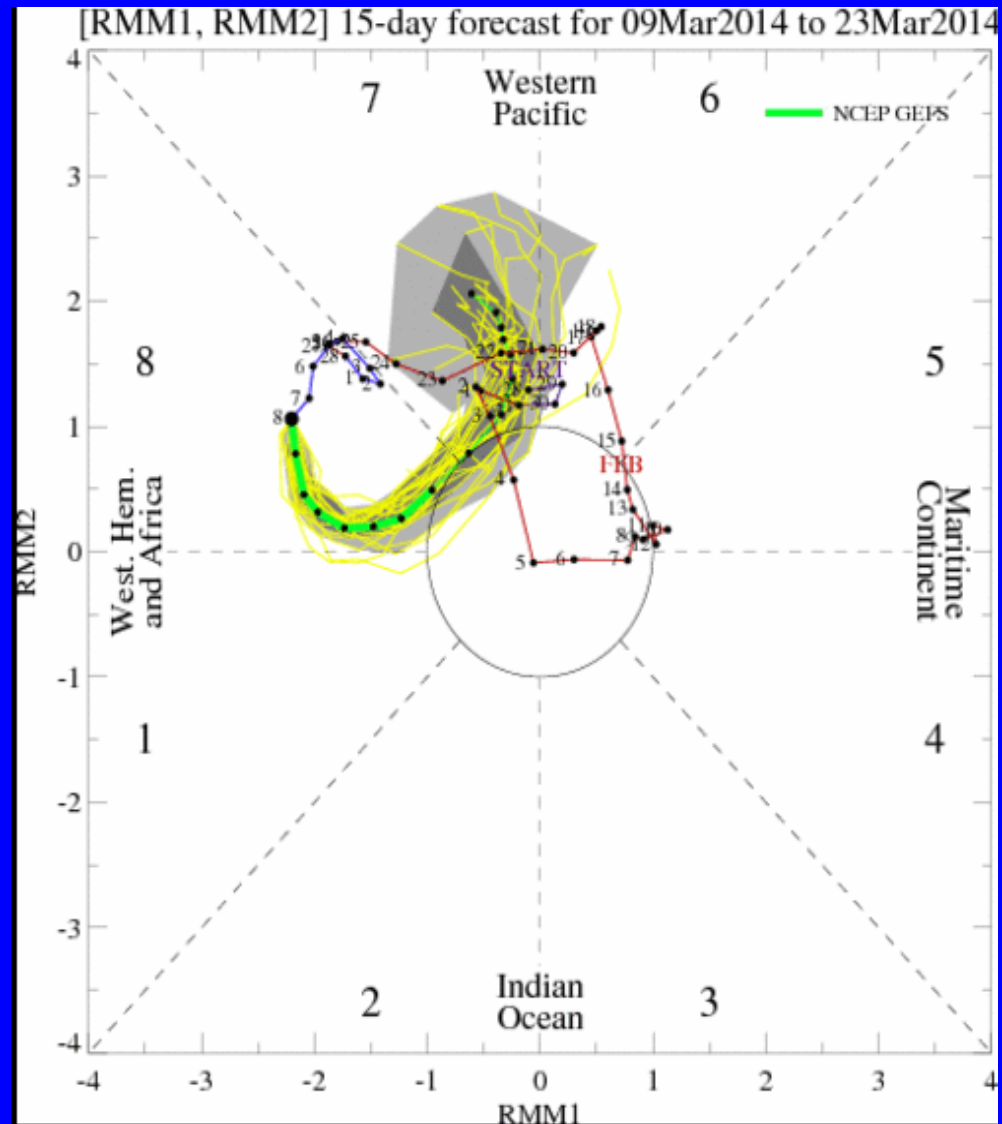
Ensemble GFS (GEFS) MJO Forecast

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 minor eastward propagation of the MJO signal early in Week-1. Thereafter, the influence of the low-frequency base state increasing contributes to the forecast signal over the western Pacific.

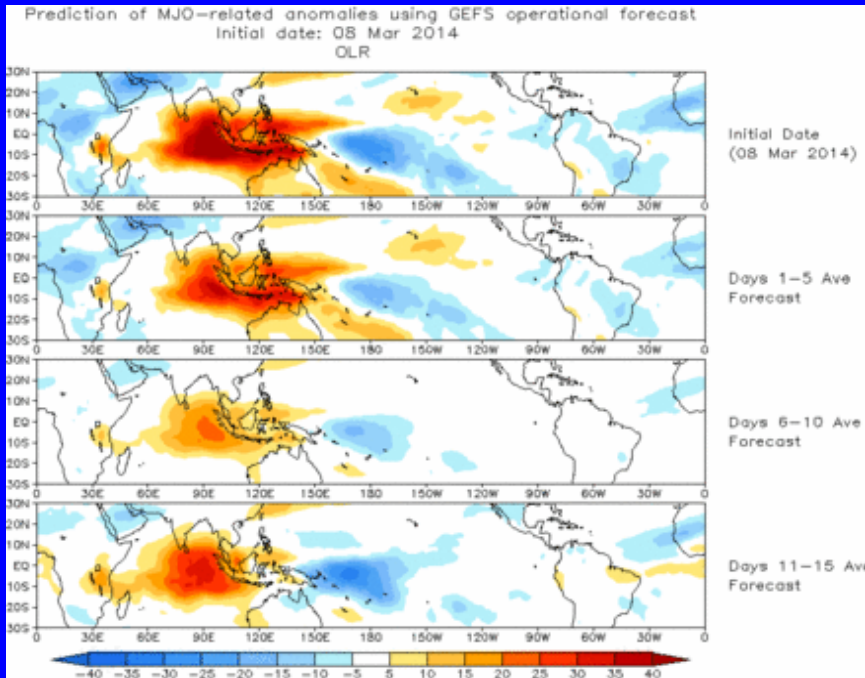




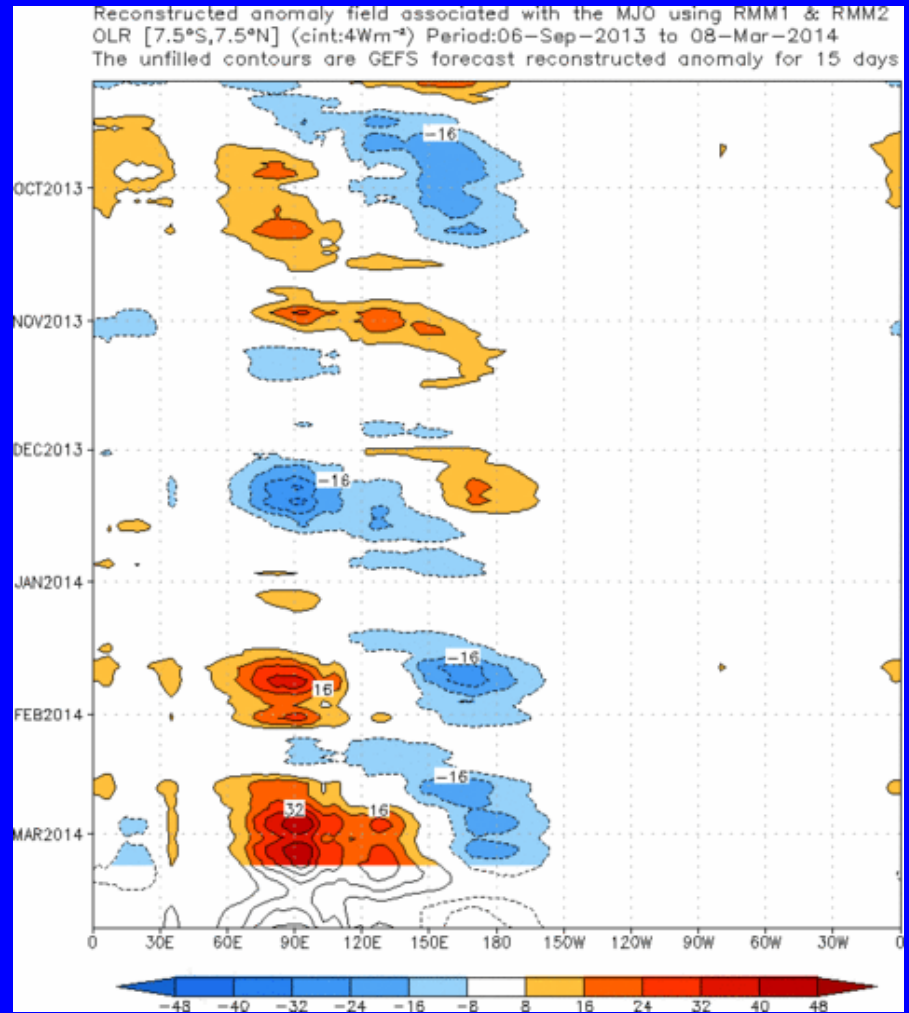
Ensemble Mean GFS MJO Forecast

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 weakening signal over the Western Hemisphere, with enhanced (suppressed) convection persisting over the western and central Pacific (eastern Indian Ocean and western Maritime Continent).

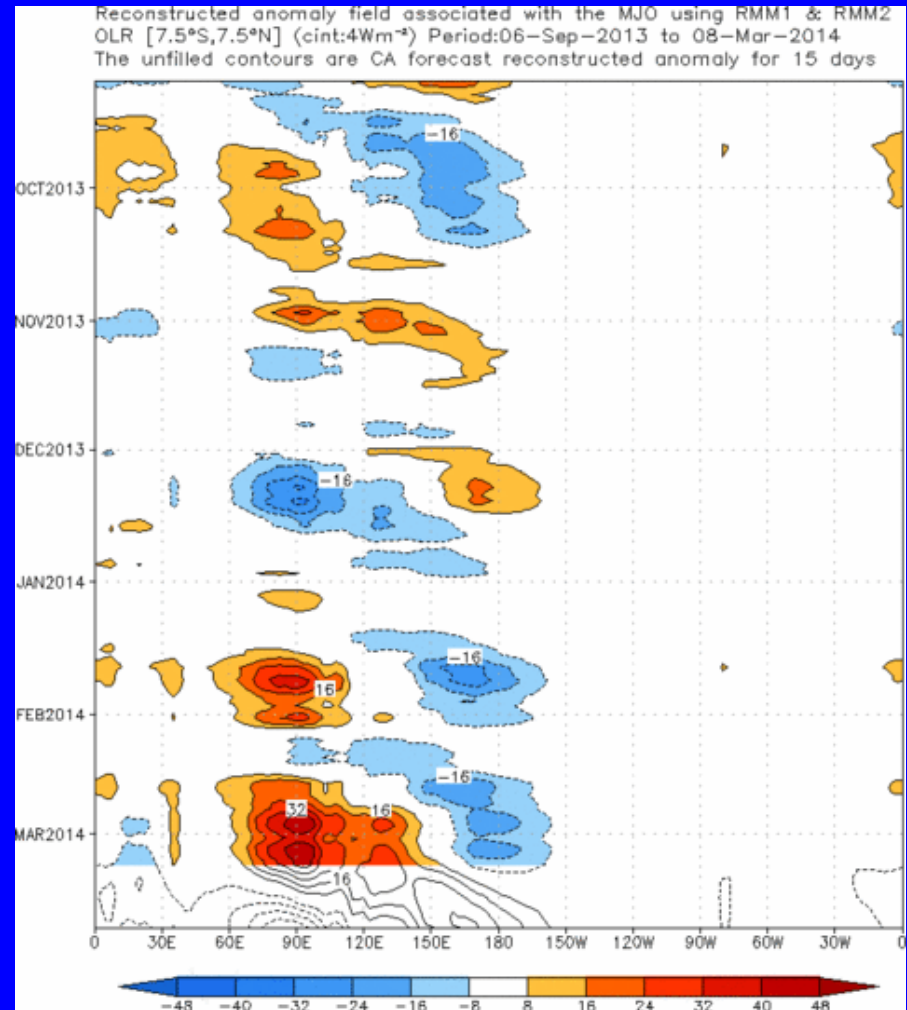
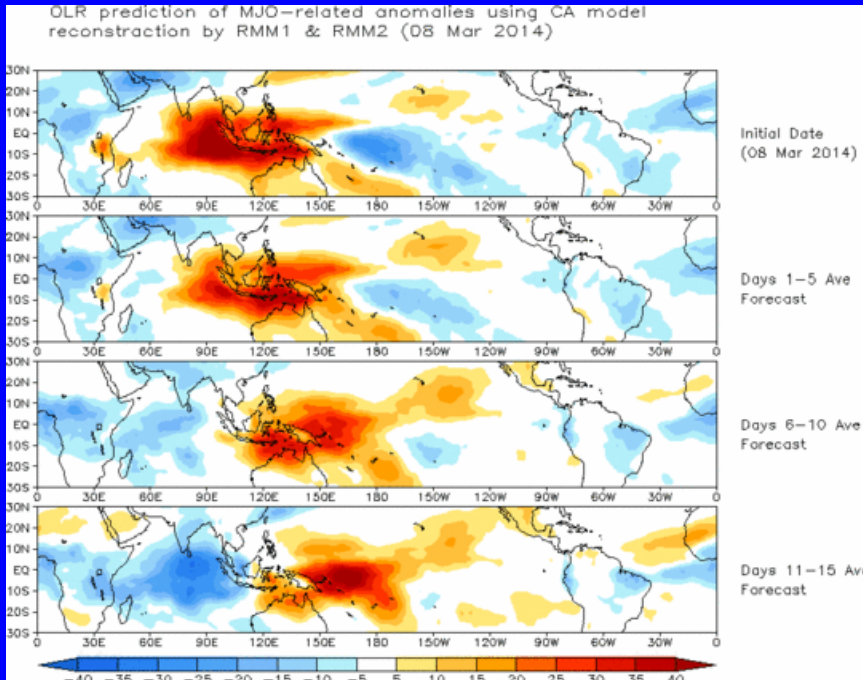


Constructed Analog (CA) MJO Forecast

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



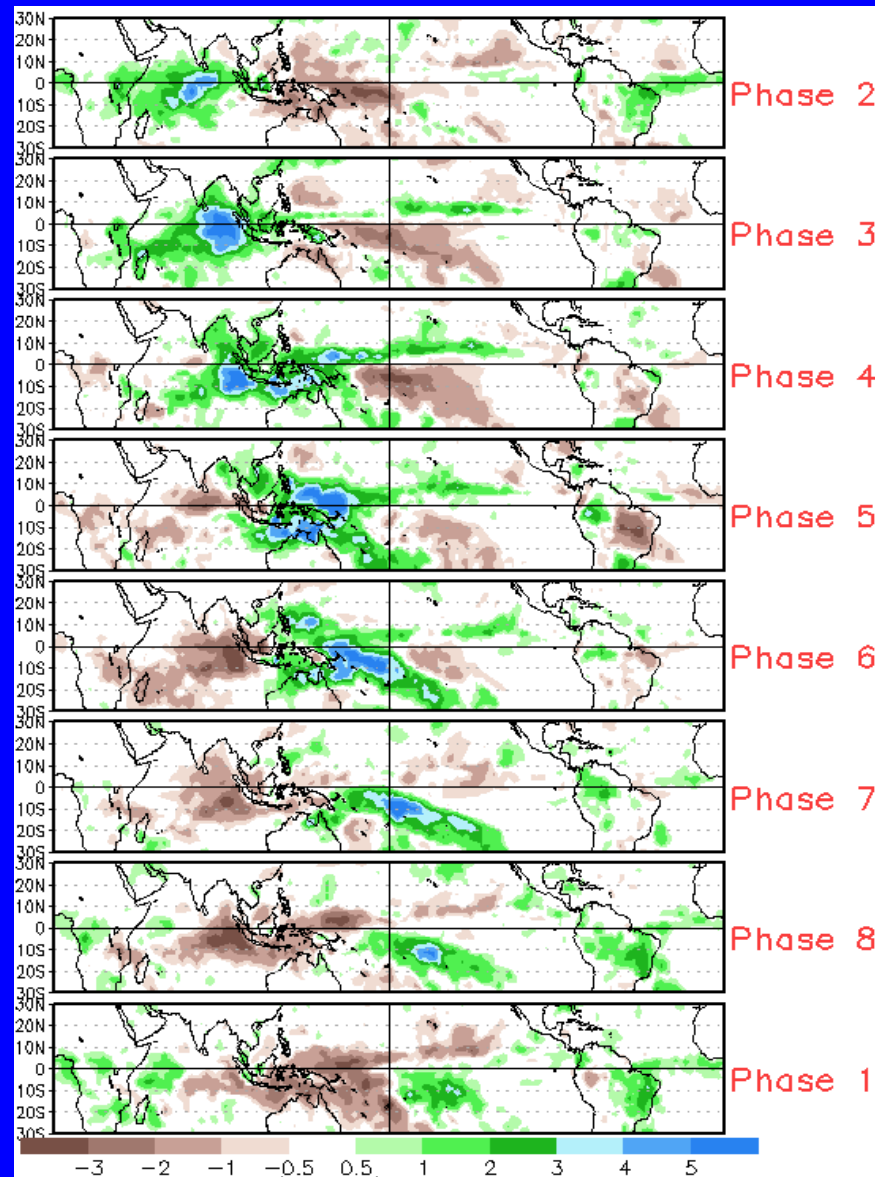
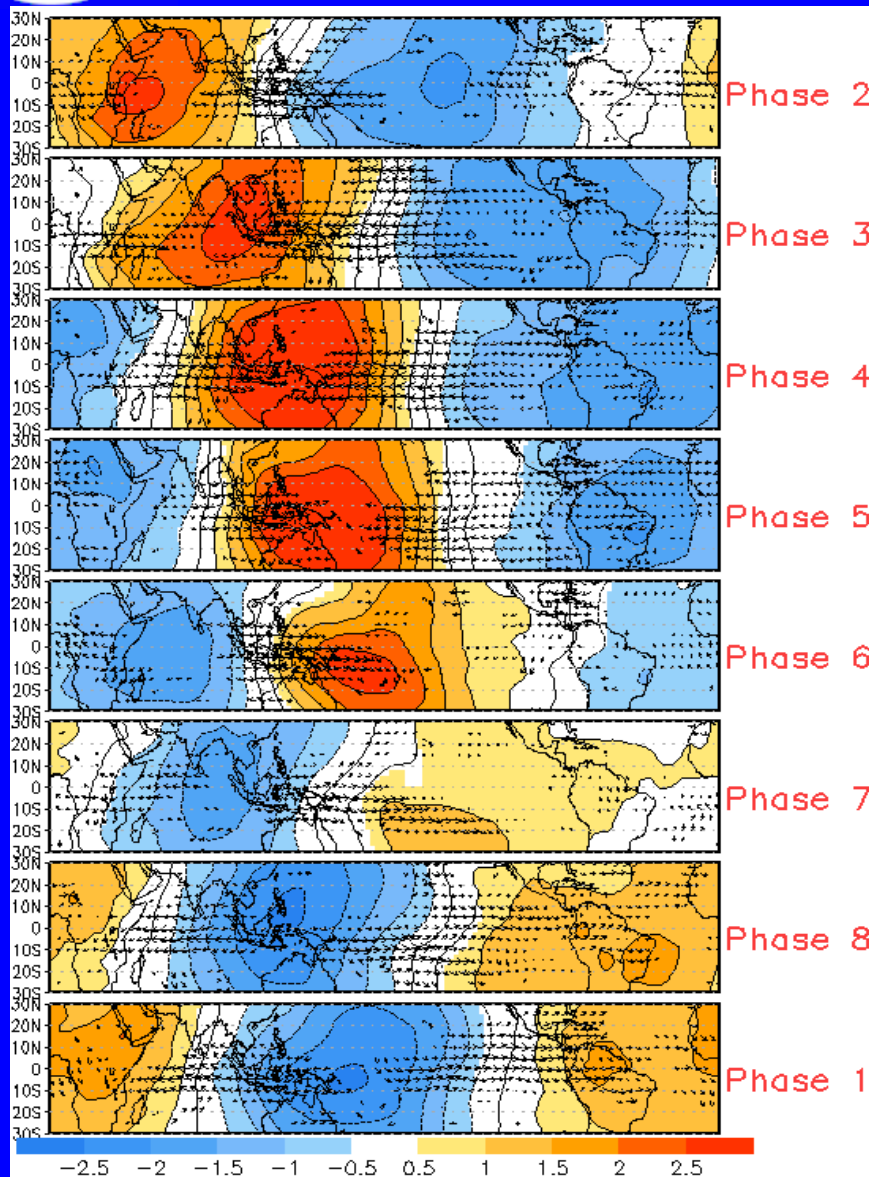
The constructed analog MJO forecast indicates eastward propagation of the MJO with enhanced convection increasing over the Indian Ocean by Week-2.



MJO Composites – Global Tropics

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

Precipitation Anomalies (Nov-Mar)

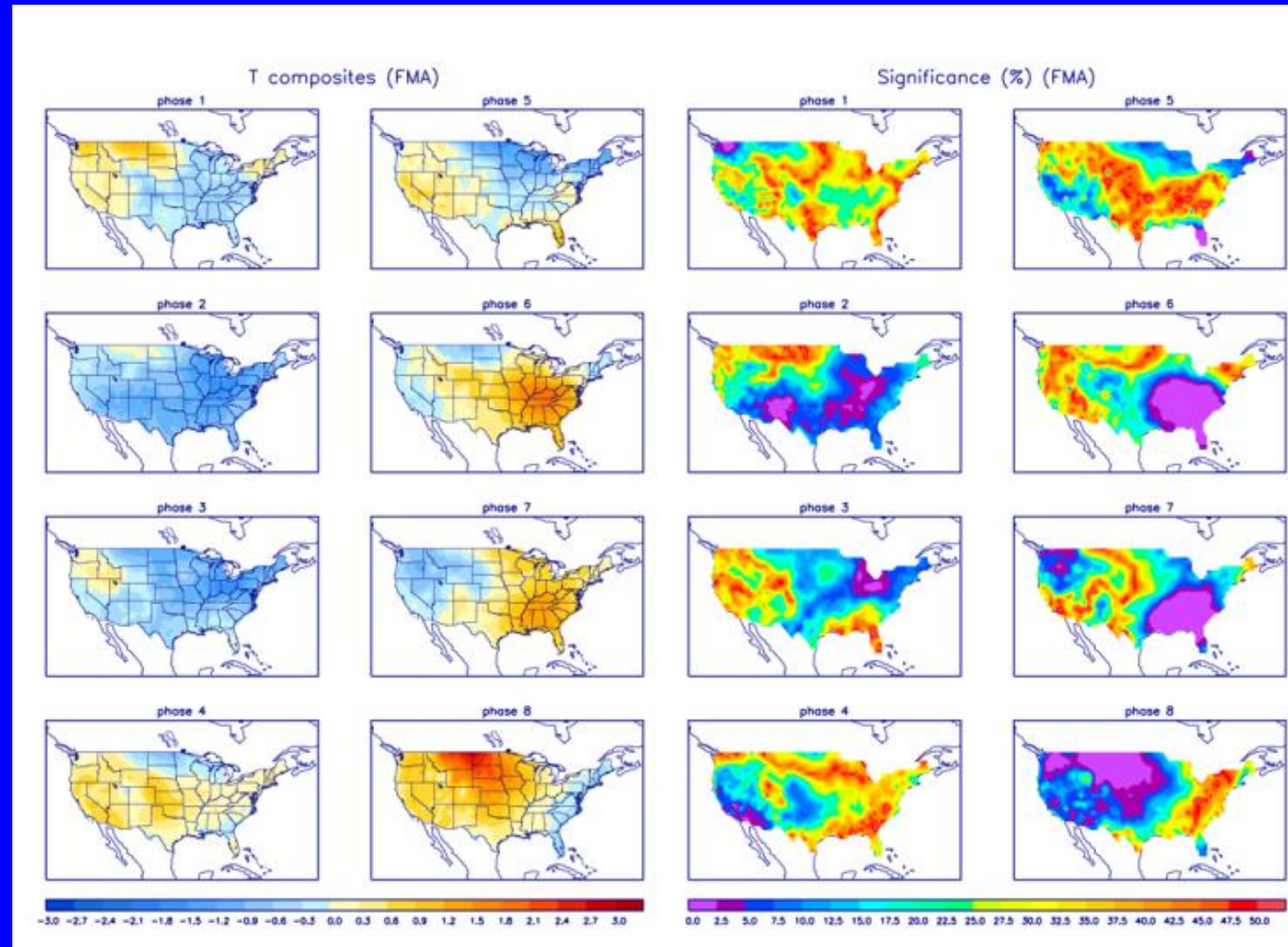




U.S. MJO Composites – Temperature

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.



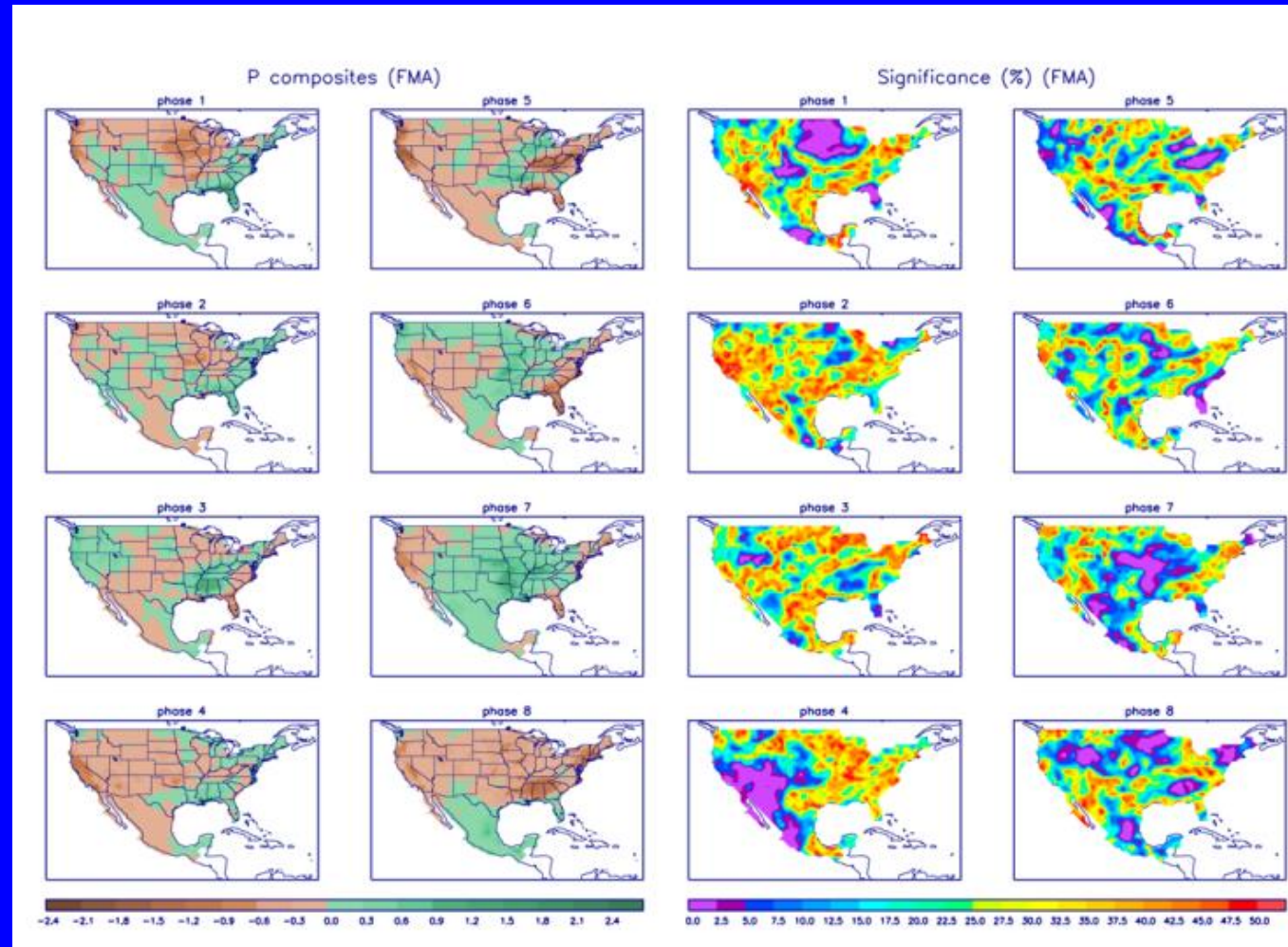
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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.



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>