



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

**Update prepared by
Climate Prediction Center / NCEP
March 3, 2014**



Outline

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



Overview

- **Observations and MJO monitoring indices, such as the CPC MJO index based on upper-level velocity potential, indicate a fast-moving MJO signal with the enhanced phase centered over the Western Hemisphere.**
- **The dynamical forecast models generally indicate a fast-moving MJO signal with the enhanced phase over the Indian Ocean during Week-2. A low-frequency base state continues to influence the global tropics.**
- **The low-frequency base state favors enhanced (suppressed) convection over the west-central Pacific (Maritime Continent) during the next two weeks with increased chances for tropical cyclone development continuing across the southwest Pacific Ocean.**

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>

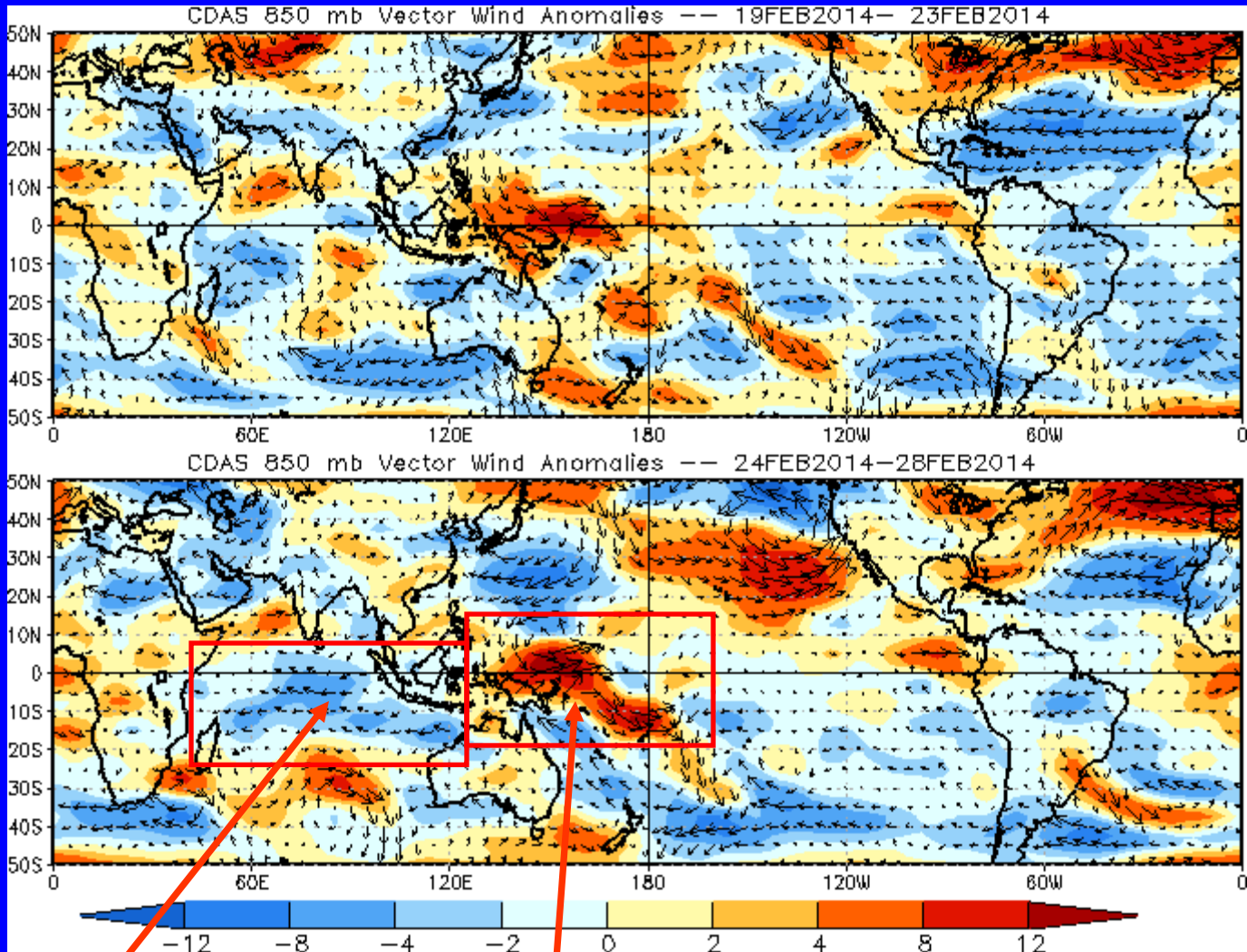


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



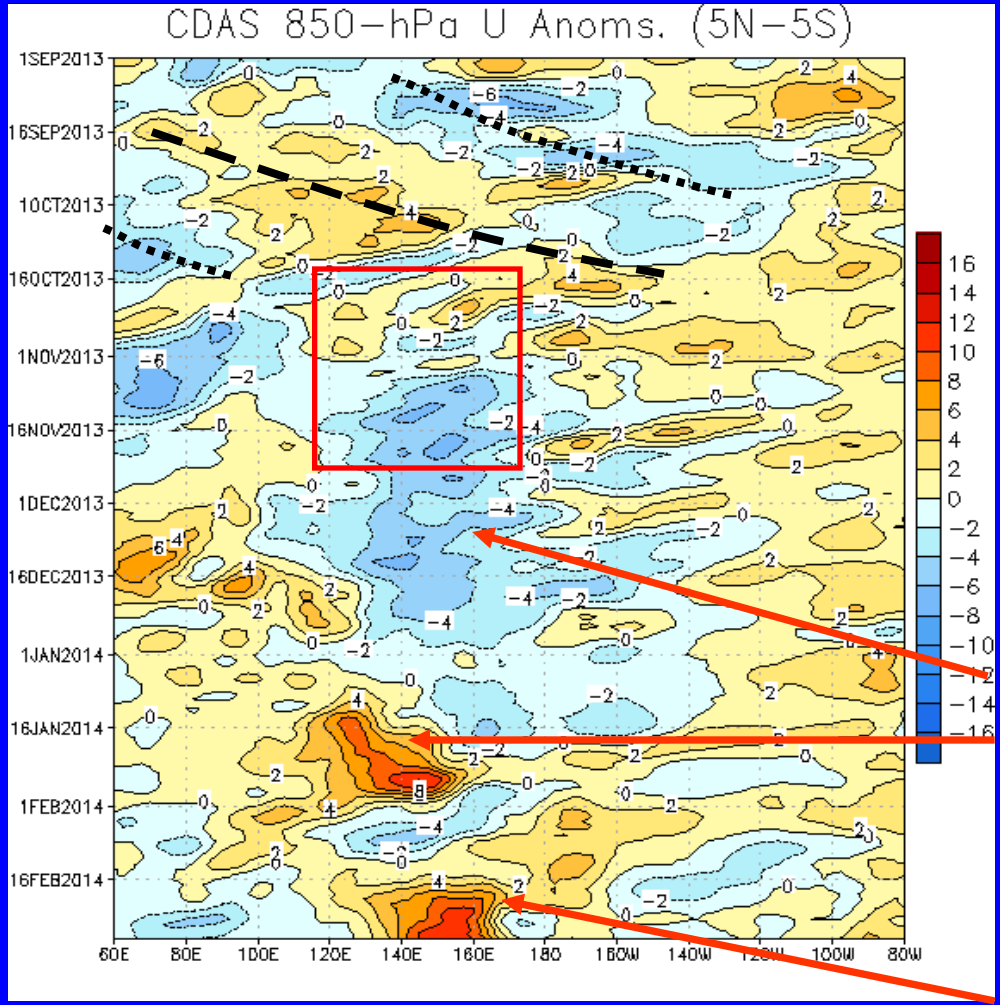
Easterly anomalies expanded east across the Indian Ocean to include the western Maritime Continent.

Westerly anomalies persisted over the western 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



Time
↓

Longitude

In early September, westerly (easterly) anomalies increased over the eastern (western) Pacific in associated with renewed MJO activity.

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.

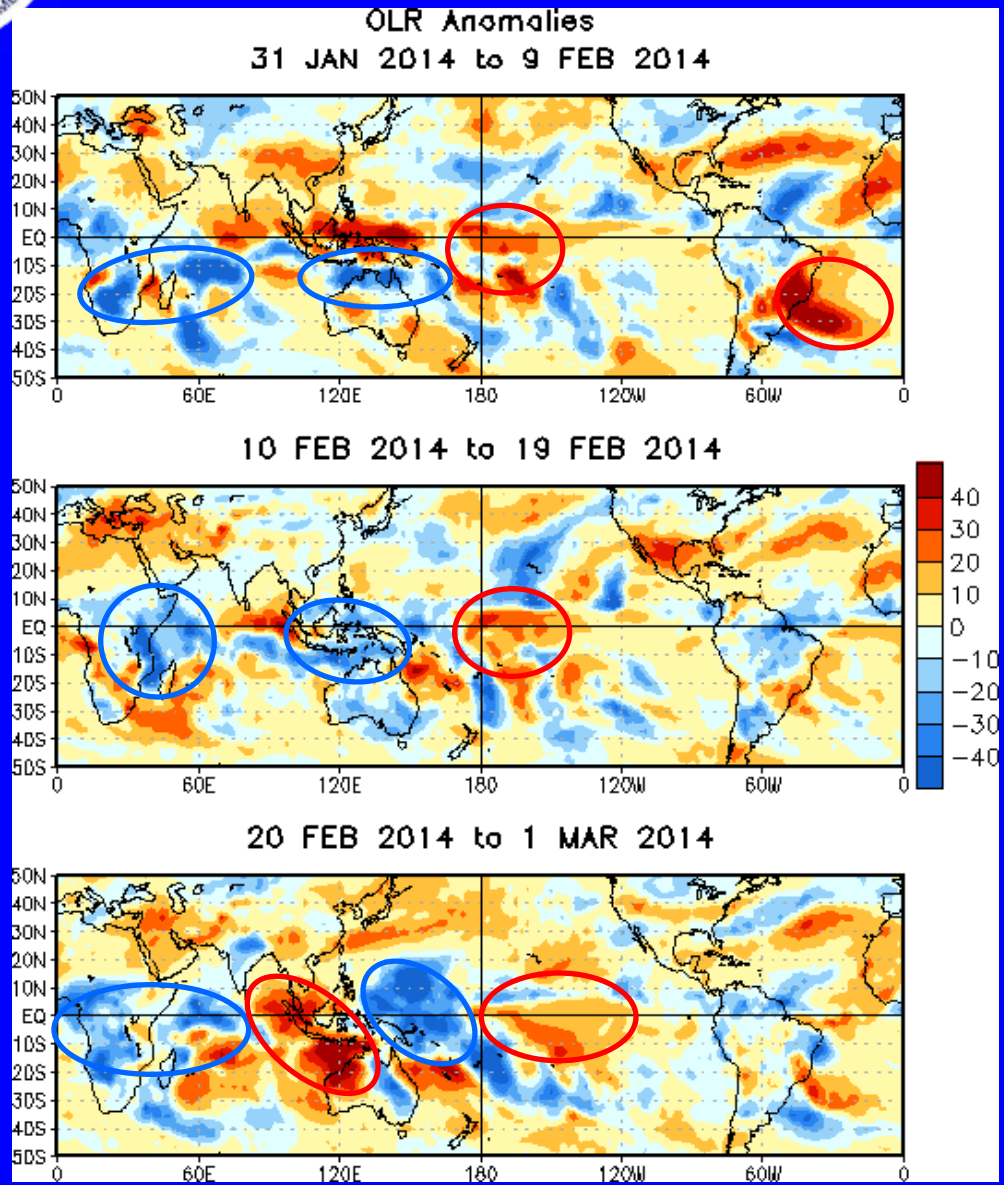
During November and December, easterly anomalies were persistent from 120E to near the Date Line. Westerly anomalies replace those easterly anomalies during January, east of the Maritime Continent over the West Pacific. Easterly anomalies disrupted the signal during early February.

Westerly anomalies returned to the Western Pacific during late 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 February, enhanced convection shifted south to northern Australia and developed across southern Africa and the southwest Indian Ocean. Suppressed convection persisted at the Date Line and over southeast Brazil.

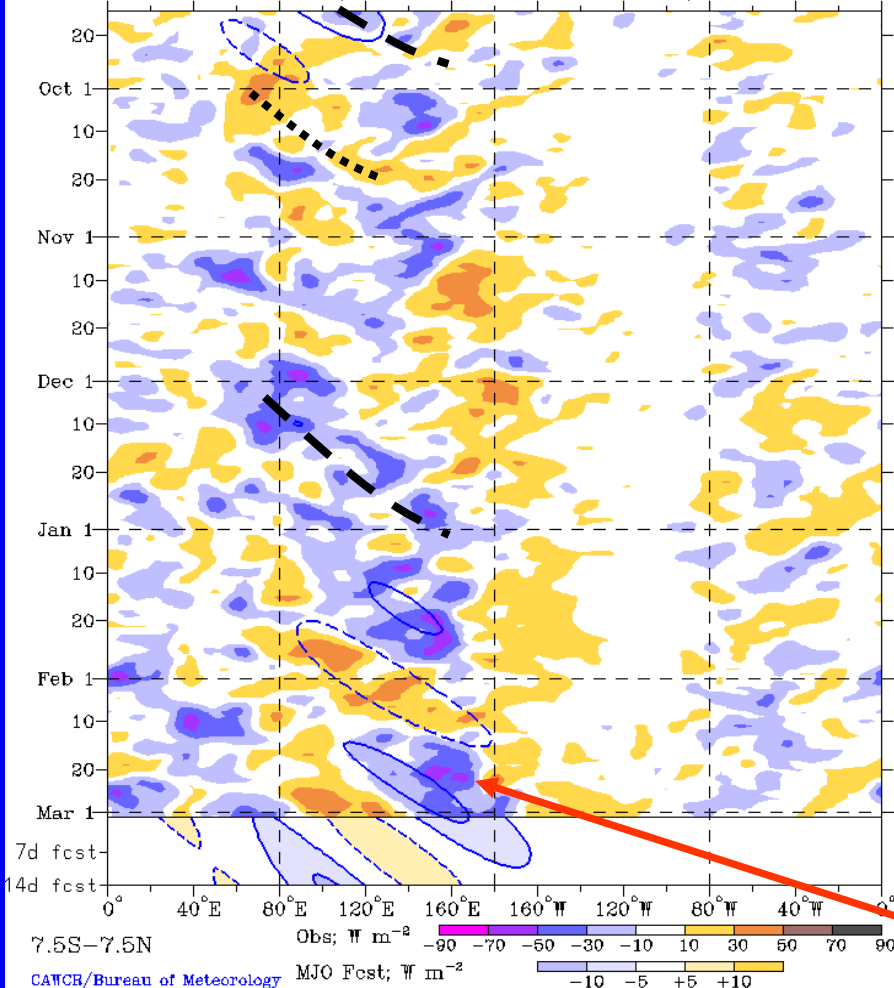
During mid-February, enhanced convection was observed over eastern Africa, the western Indian Ocean and parts of the Maritime Continent, while suppressed convection remained over the Central Pacific.

Enhanced convection shifted east to the west-central Pacific during late February with suppressed convection across much of the Maritime Continent and northern Australia. Enhanced (suppressed) convection prevailed across Africa and the western Indian Ocean (east-central Pacific).



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
15-Sep-2013 to 2-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)

The MJO was active from late August through early October with the enhanced phase propagating eastward from the Indian Ocean to the western Pacific Ocean over this period.

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 late January. During early February suppressed convection propagated rapidly from the Indian Ocean to the Pacific.

Convection returned to the Western Pacific during late February and shifted east to the Date Line at the beginning of March.

Longitude

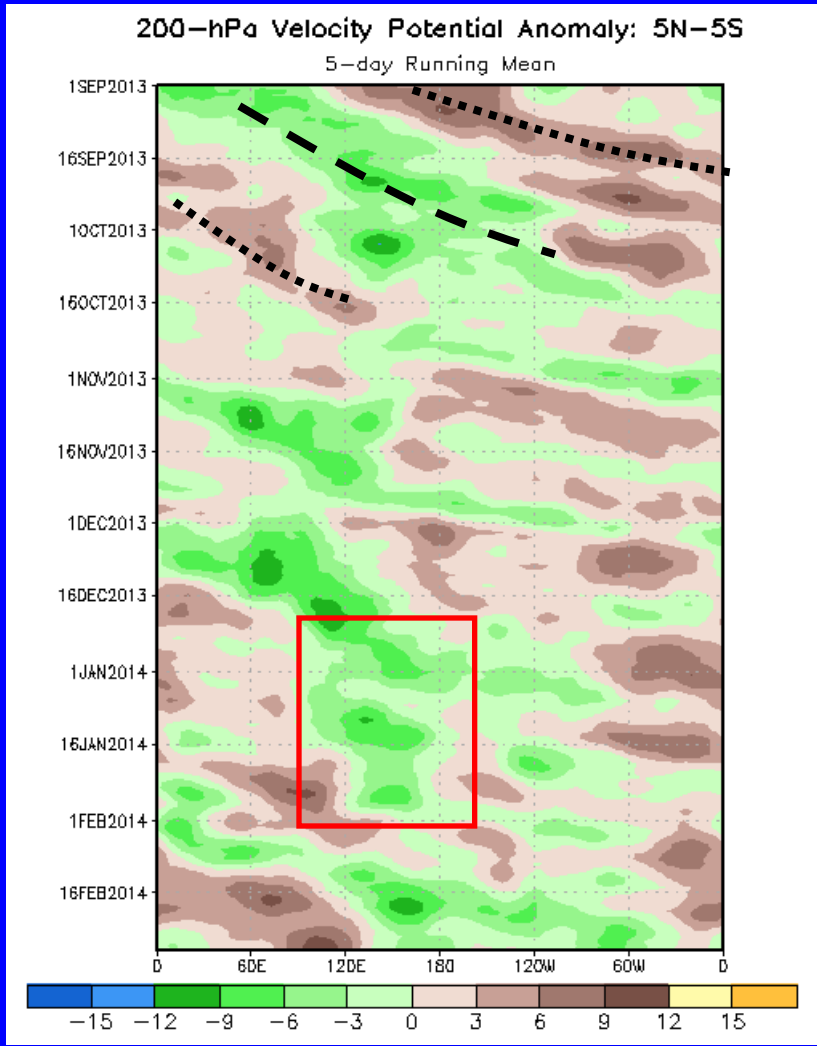


200-hPa Velocity Potential Anomalies (5°S-5°N)

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). Other modes of tropical intraseasonal variability are also evident.

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.

A slower eastward propagation of 200-hPa velocity potential anomalies was observed from mid-December to mid-January across the Indo-Pacific warm pool region (red box).

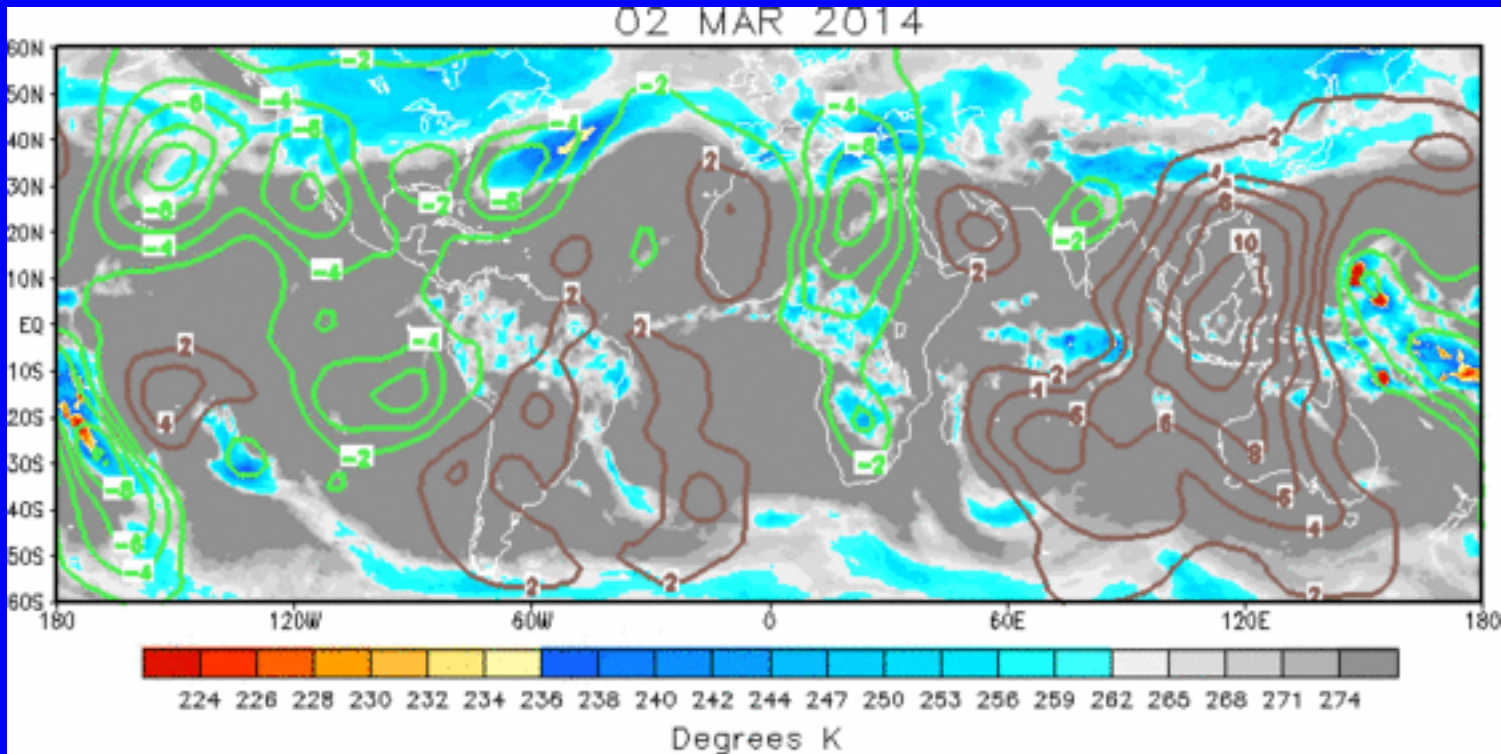
During early February, negative anomalies propagated east to the Maritime Continent and western Pacific. Negative anomalies shifted east across the western Hemisphere during late February while the eastward propagation of the positive anomalies slowing at the end of February.



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 data recently became less coherent with a more stationary pattern of strong upper-level divergence (convergence) observed over the central Pacific Ocean (southern Indian Ocean and Maritime Continent).

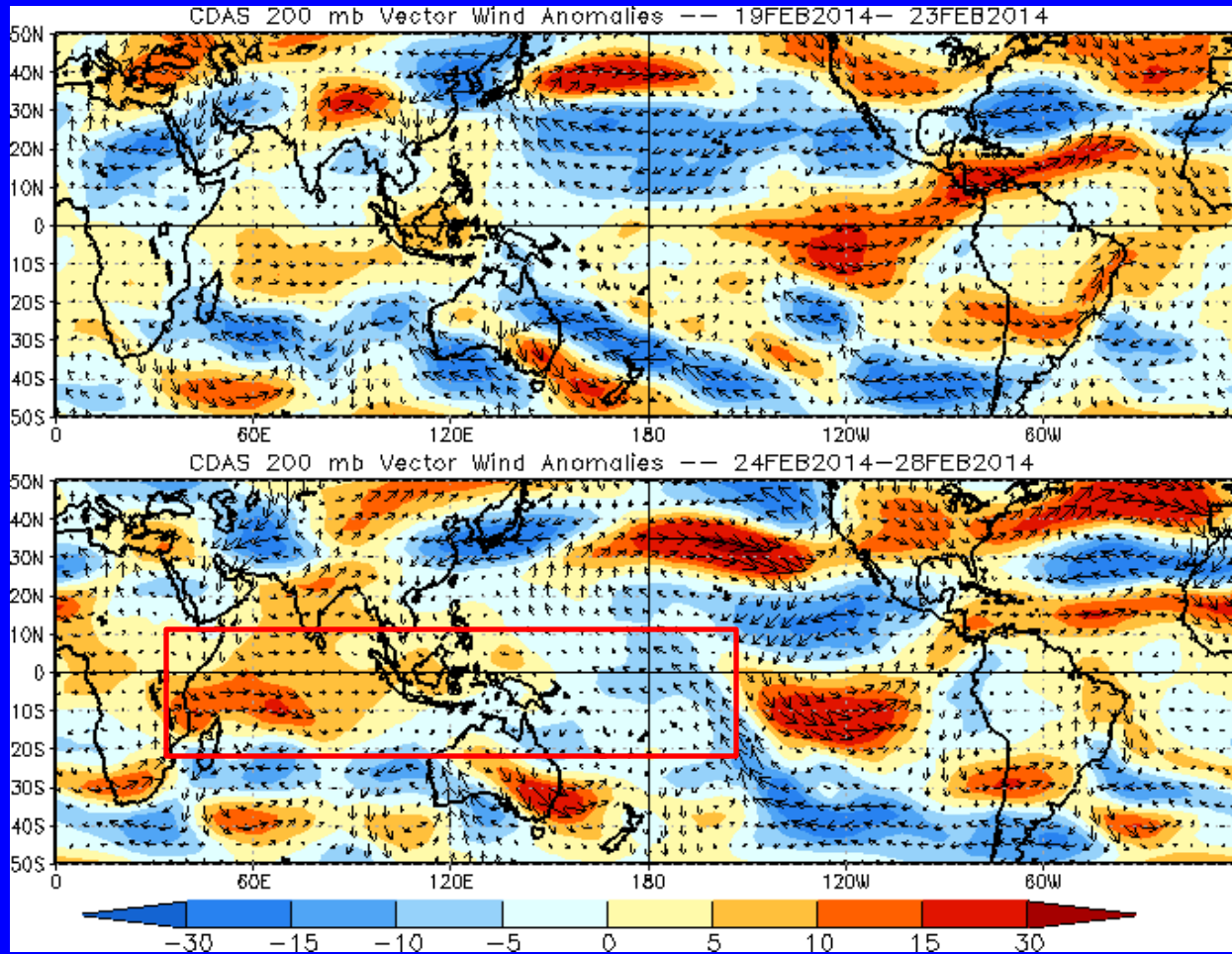


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



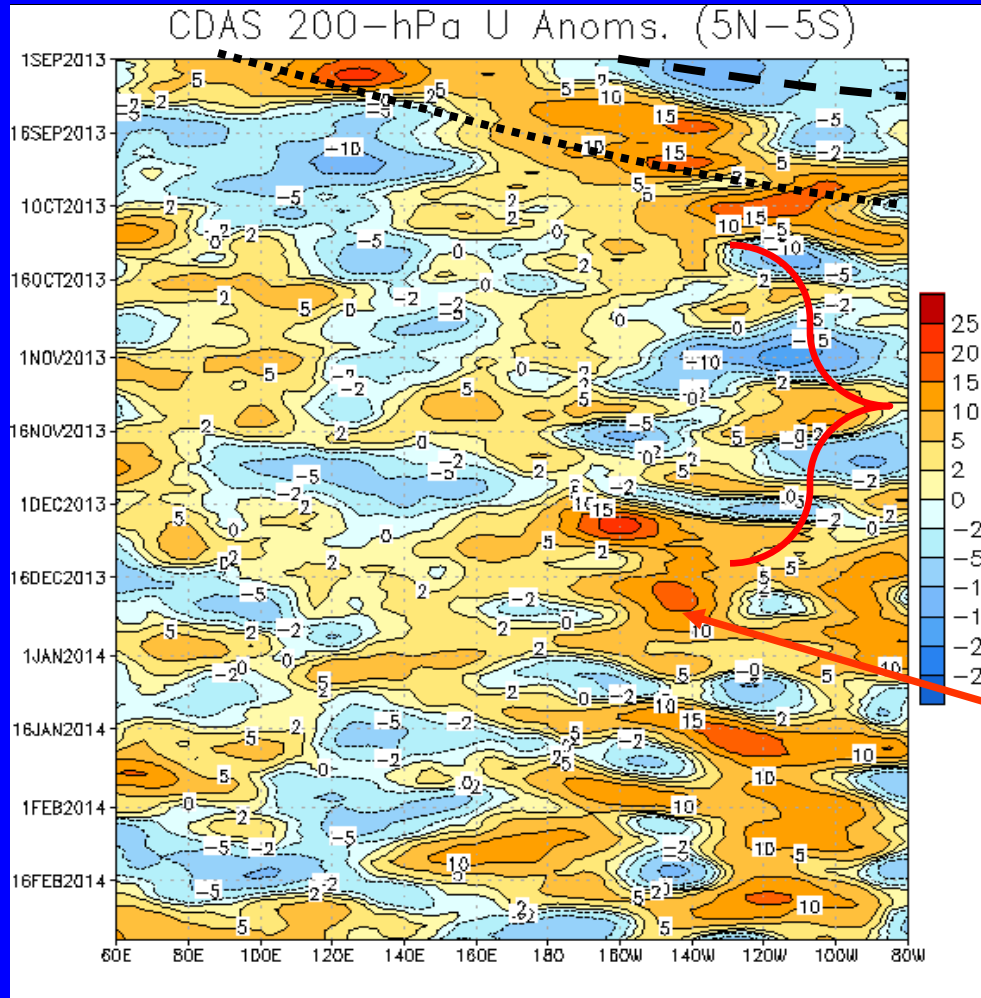
During last five days of February, westerly anomalies intensified over the Indian Ocean while easterly anomalies developed at the Date Line (red box).



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



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

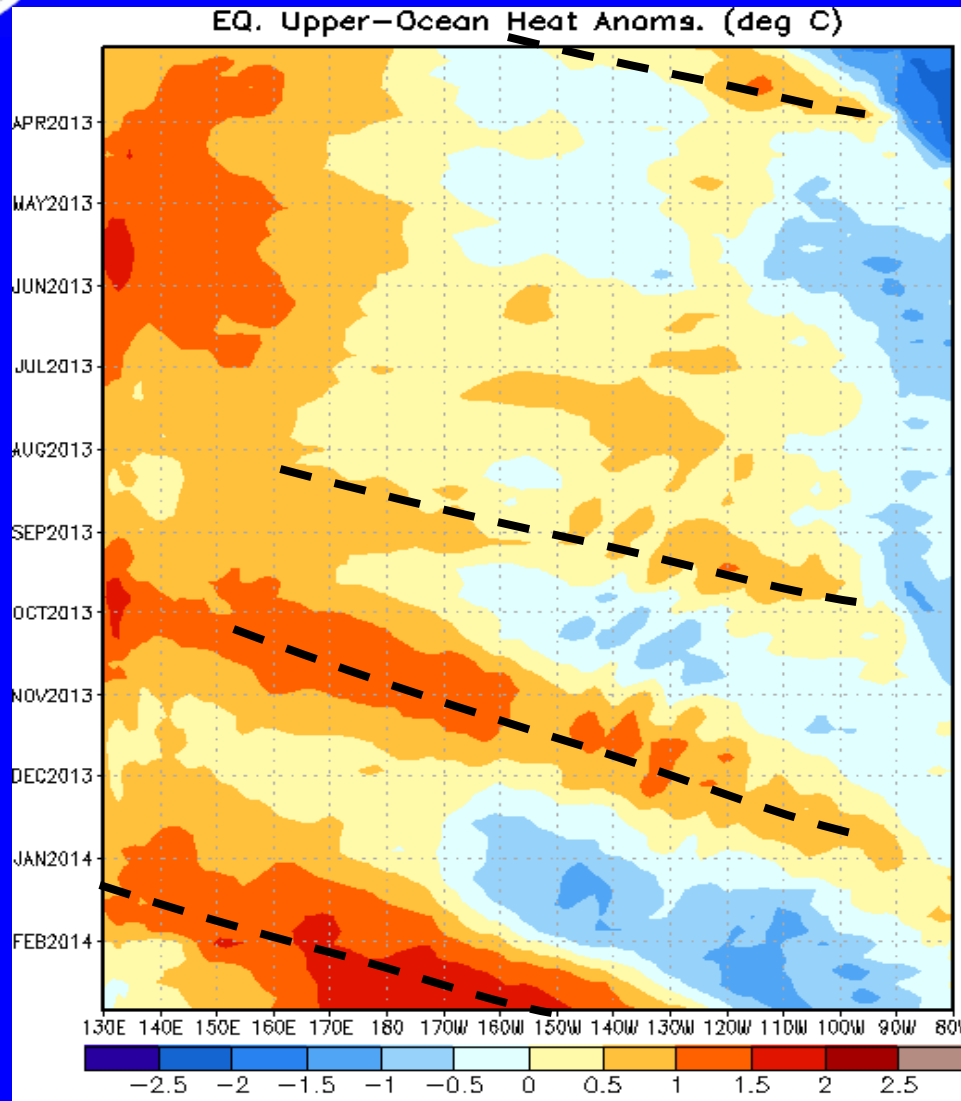
Anomalies of alternating sign are evident over the eastern Pacific, due in part to extratropical Rossby waves breaking into the Tropics (red bracket).

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, 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, the latter being the strongest wave during 2013.

A strong downwelling event began in January and is propagating 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.

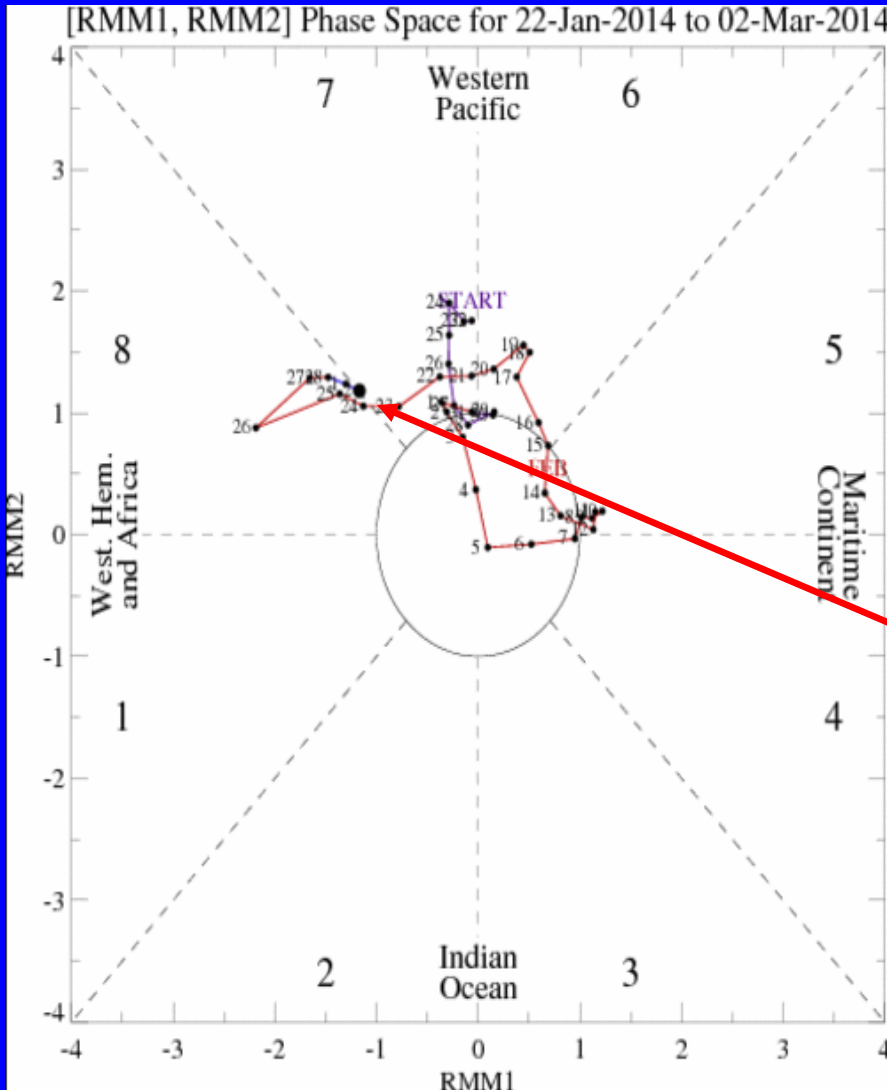
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

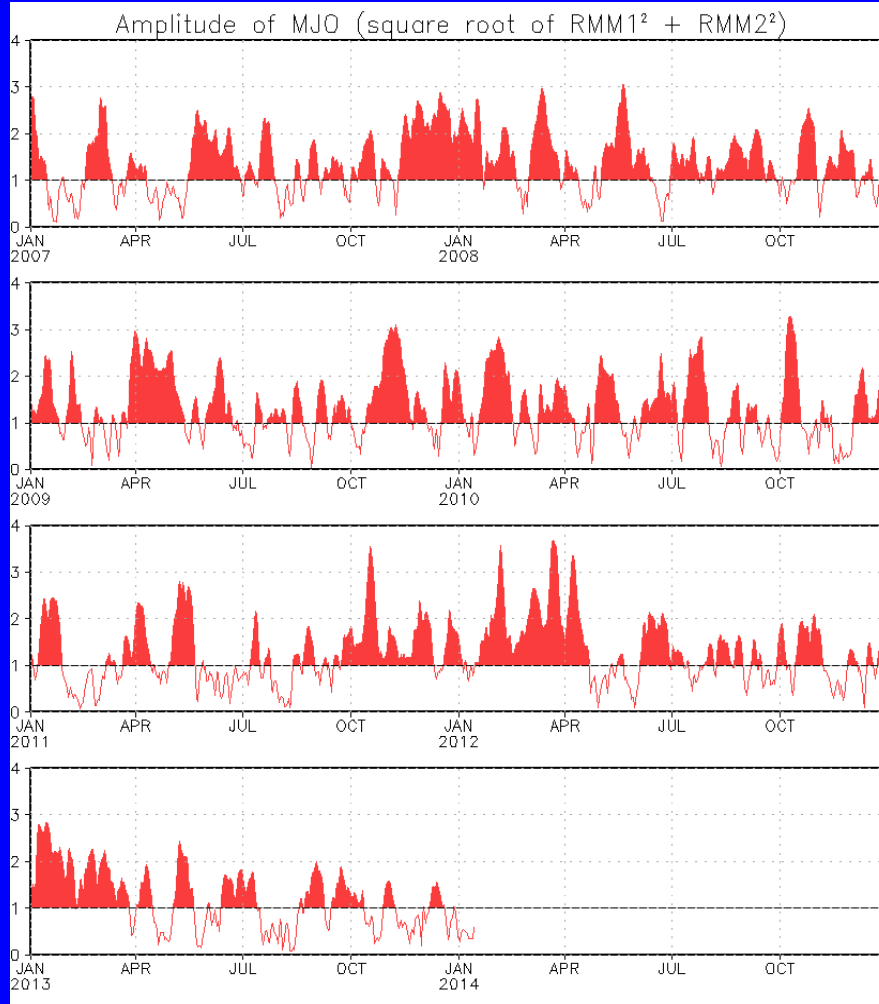


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The RMM index indicates eastward propagation of a MJO signal ending during the final week of February.



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.



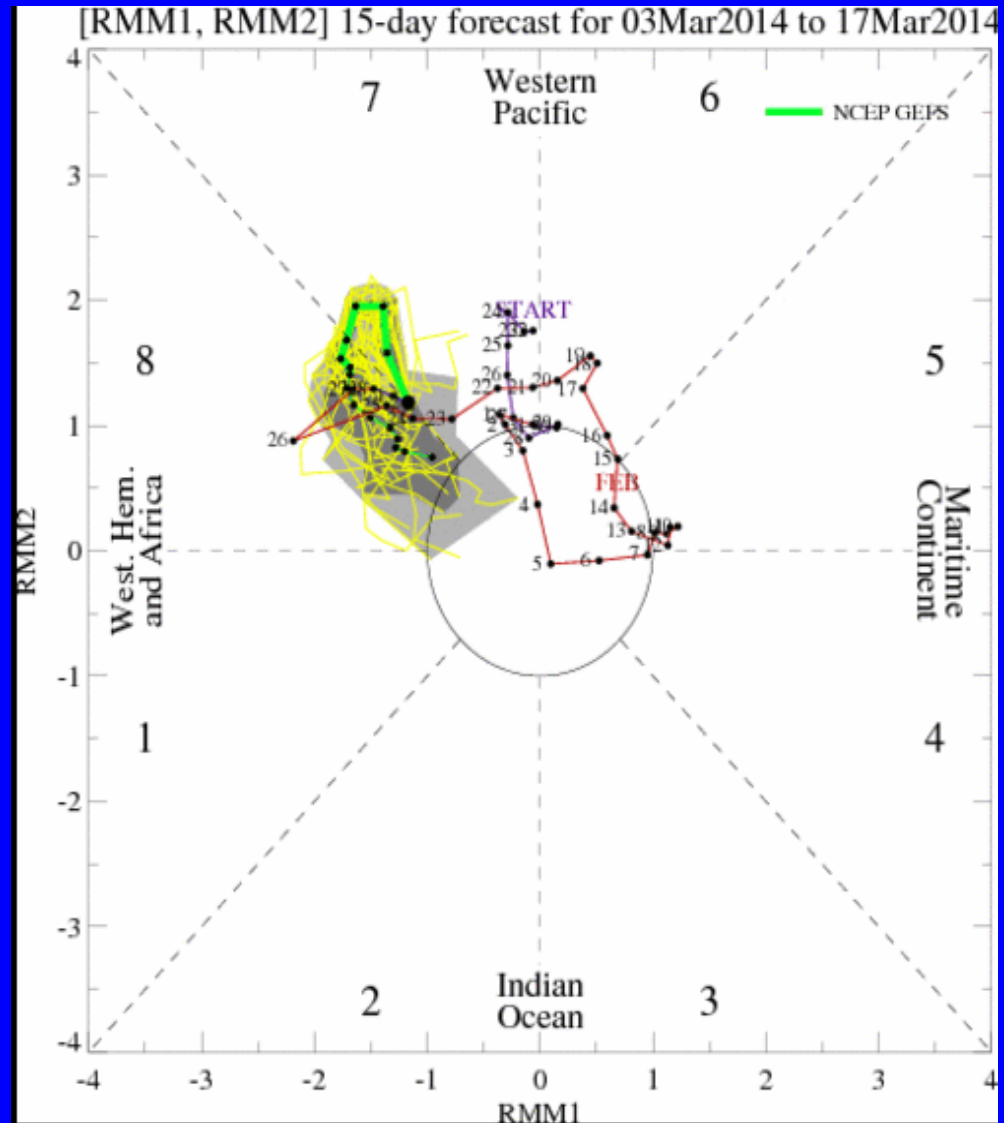
Ensemble GFS (GEFS) MJO Forecast

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 eastward propagation of a MJO signal with the low-frequency base state contributing to the amplitude.



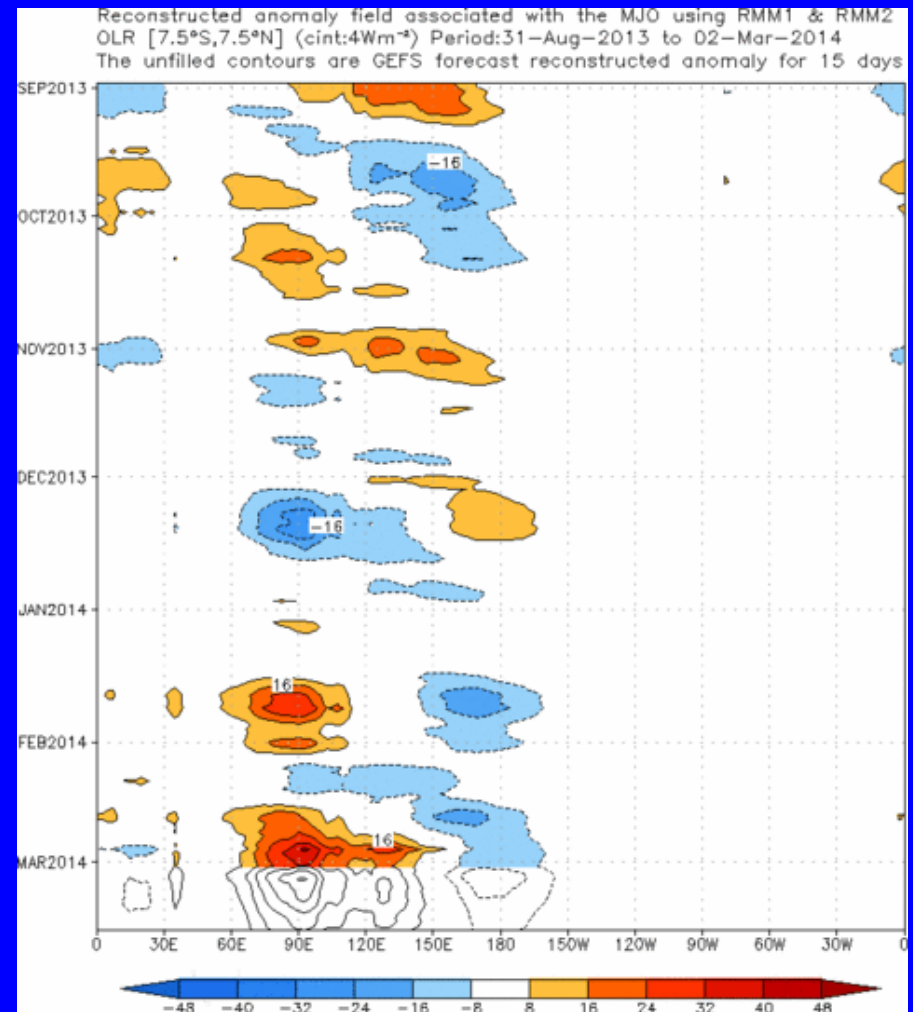
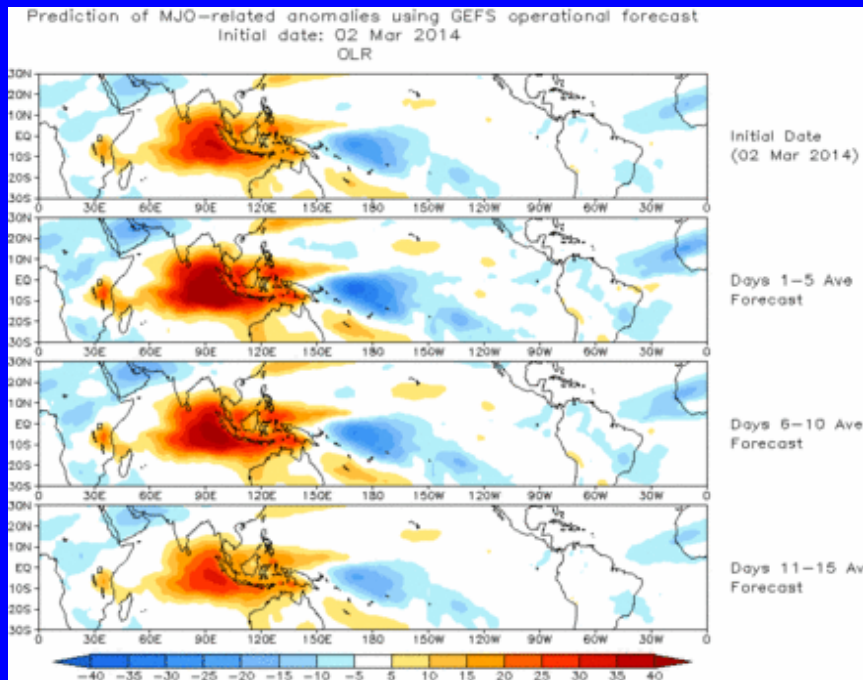


Ensemble Mean GFS MJO Forecast

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 enhanced (suppressed) convection persisting across the central Pacific Ocean (eastern Indian Ocean, Maritime Continent, and Australia).

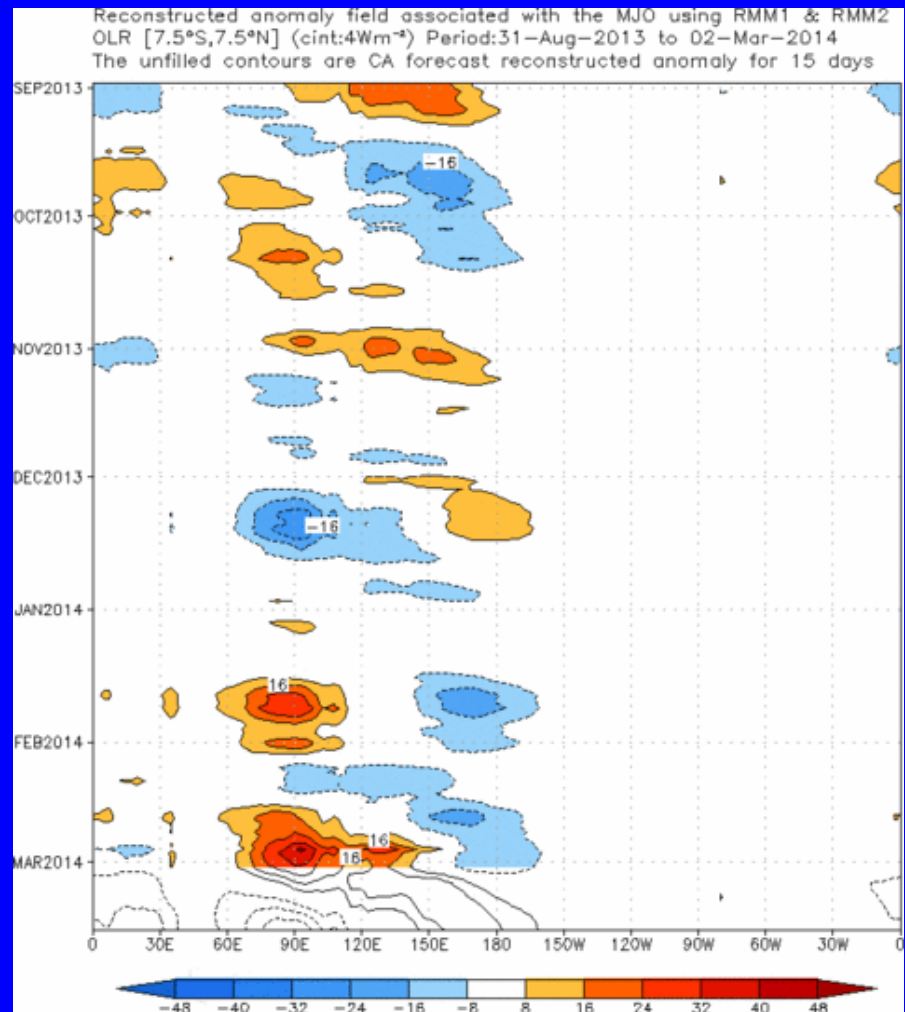
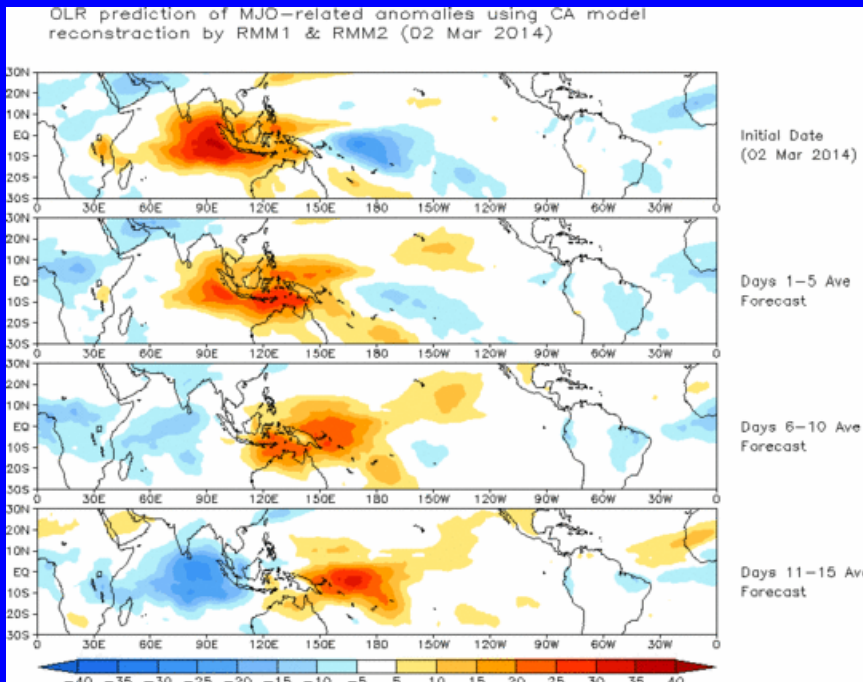


Constructed Analog (CA) MJO Forecast

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



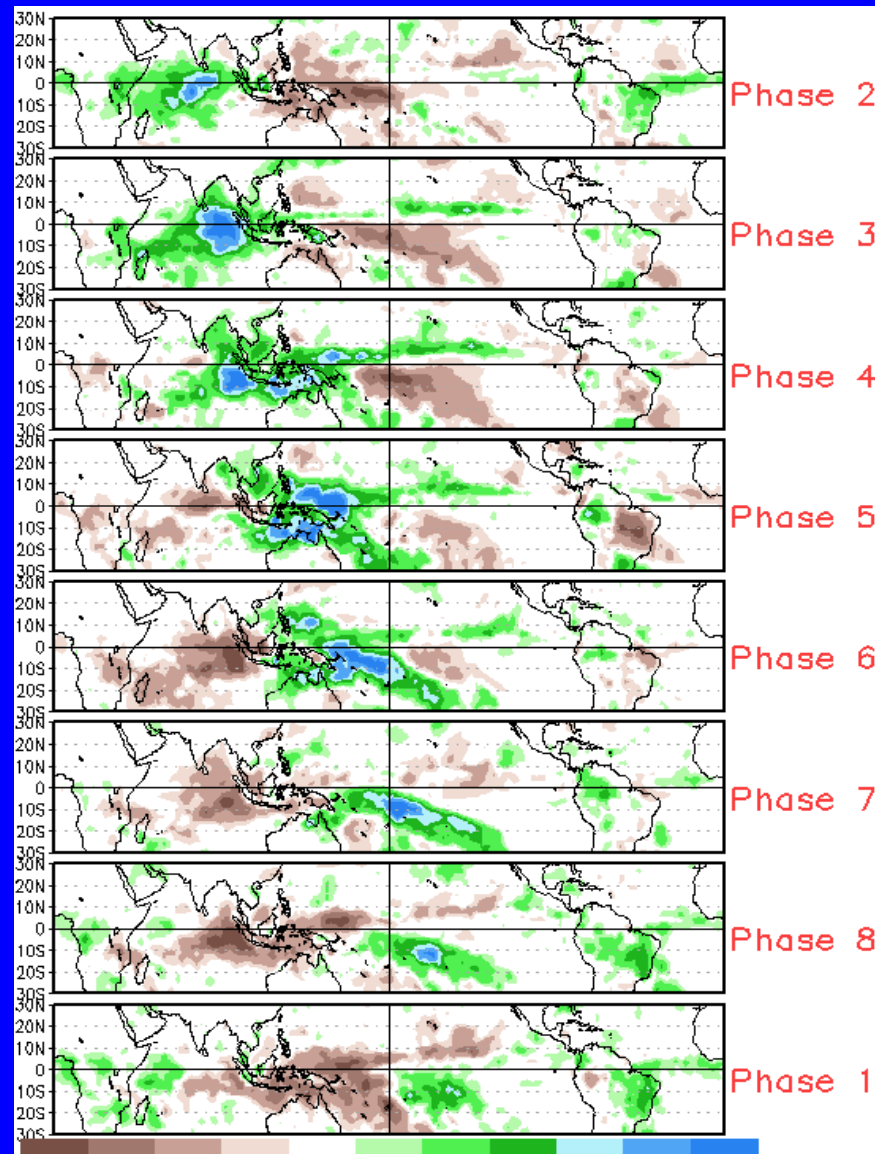
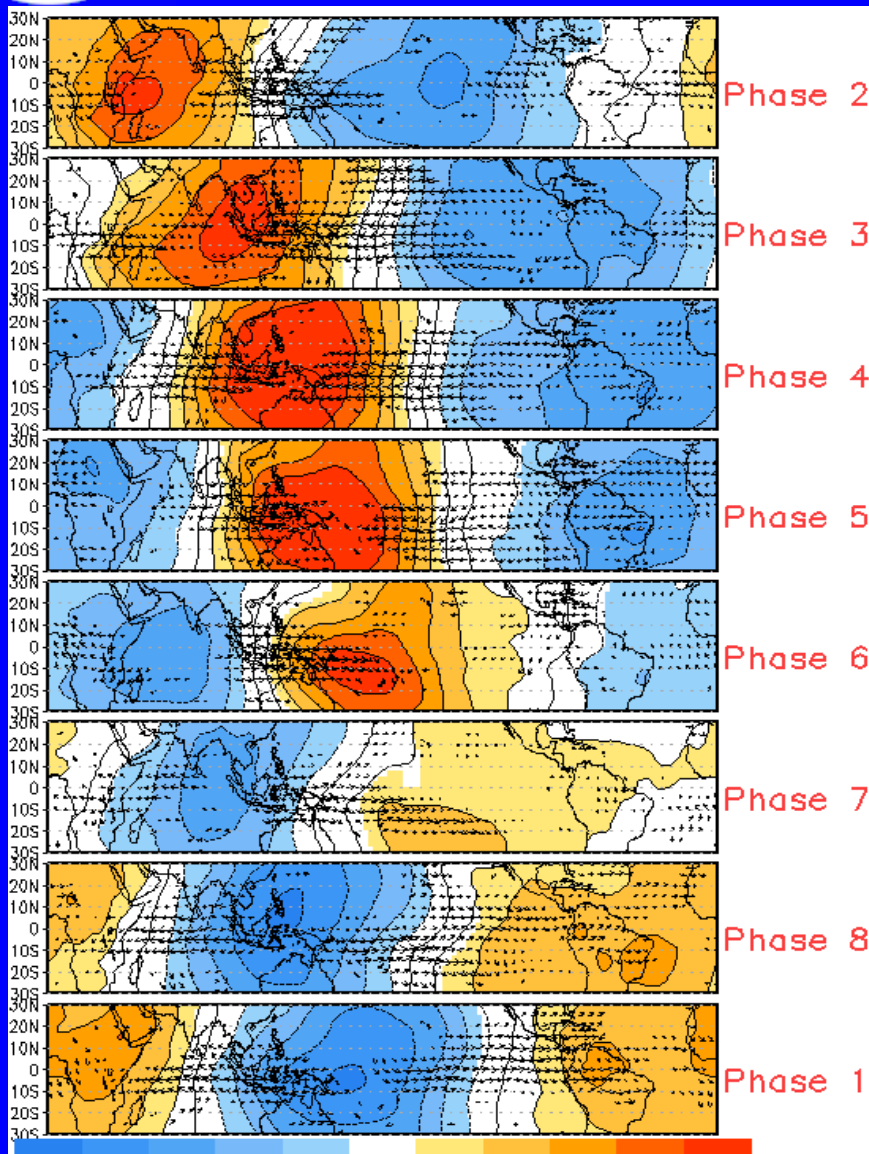
The constructed analog MJO forecast indicates a eastward shift of anomalous convection throughout the global tropics.



MJO Composites – Global Tropics

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

Precipitation Anomalies (Nov-Mar)

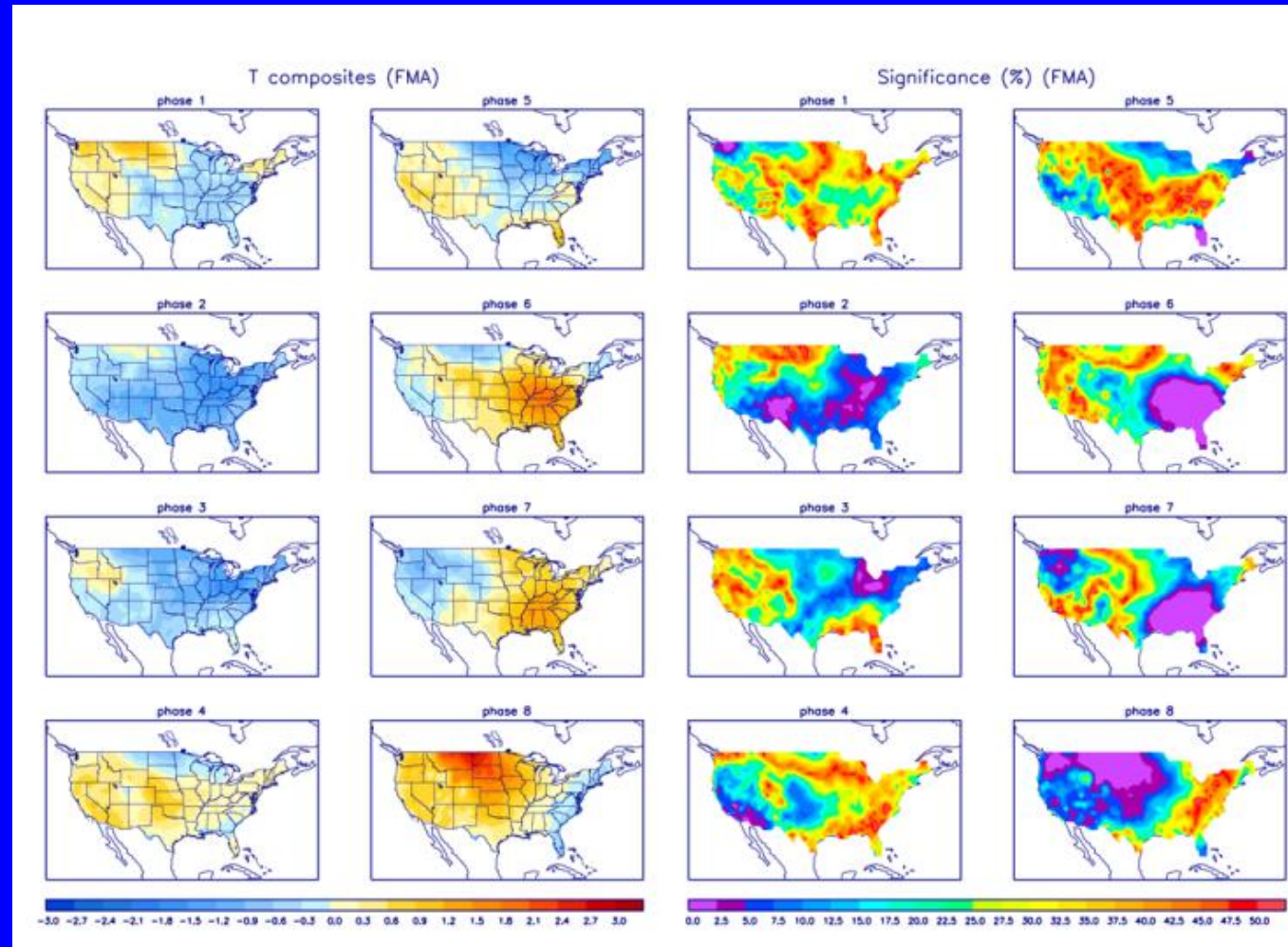




U.S. MJO Composites – Temperature

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.



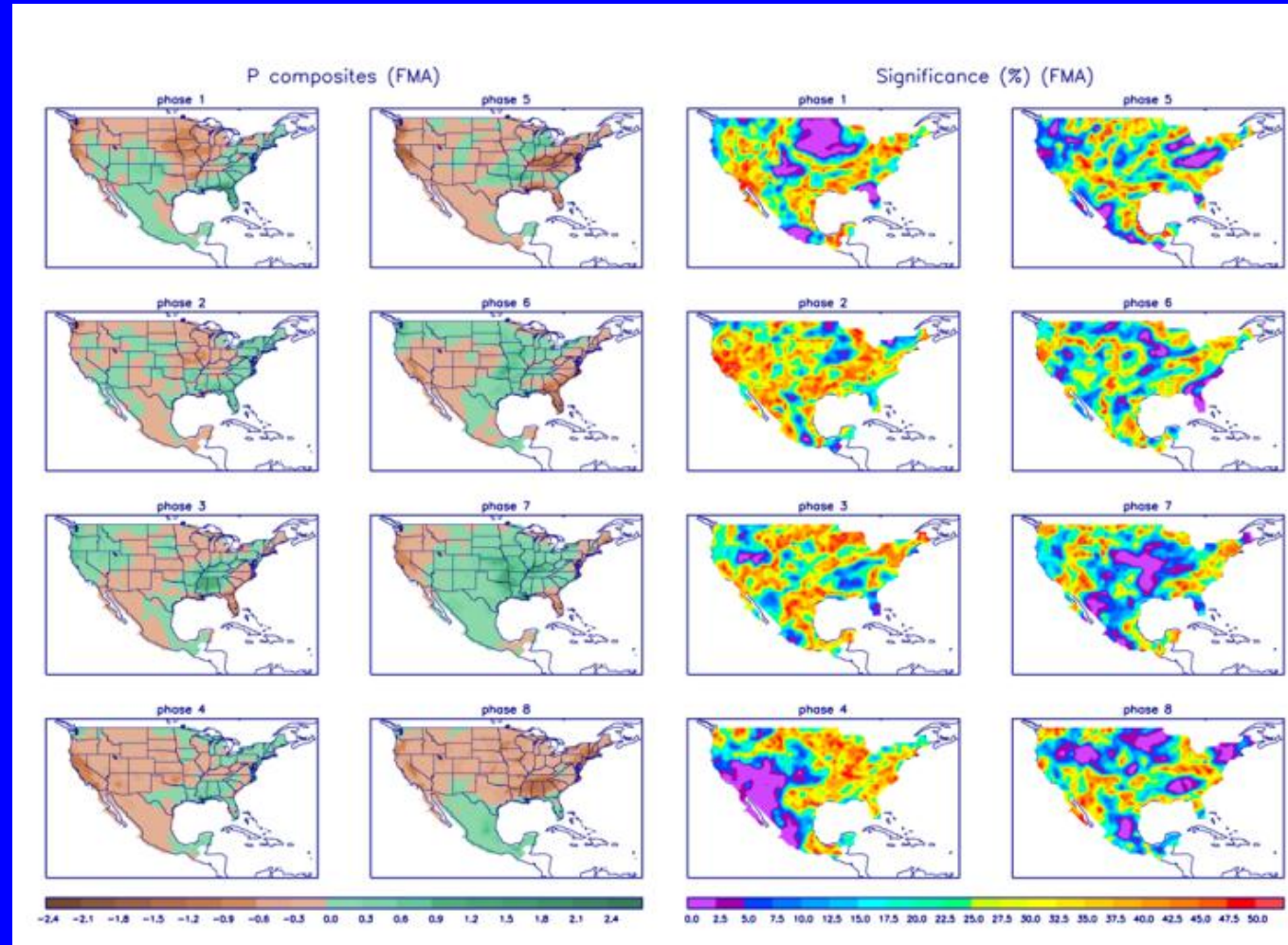
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>