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

Update prepared by
Climate Prediction Center / NCEP
February 24, 2014

Outline

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

Overview

- Indices used to monitor the MJO indicate a strengthening and more coherent signal.
- This subseasonal variability is in phase with the slowly-evolving low frequency base state that favors convection across the western Pacific. The future evolution of a MJO signal is uncertain.
- Some dynamic forecast models indicate propagation across the entire Pacific Basin while others are much slower with propagation barely crossing the Date Line. The statistical tools favor the faster solutions.
- The combination of subseasonal variability and the low-frequency base state favors enhanced (suppressed) convection over the West Pacific (Indian Ocean and Maritime Continent) during the next one to two weeks. Additionally, extratropical impacts are likely as the pattern of tropical convection favors an extension of the East Asian jet stream.

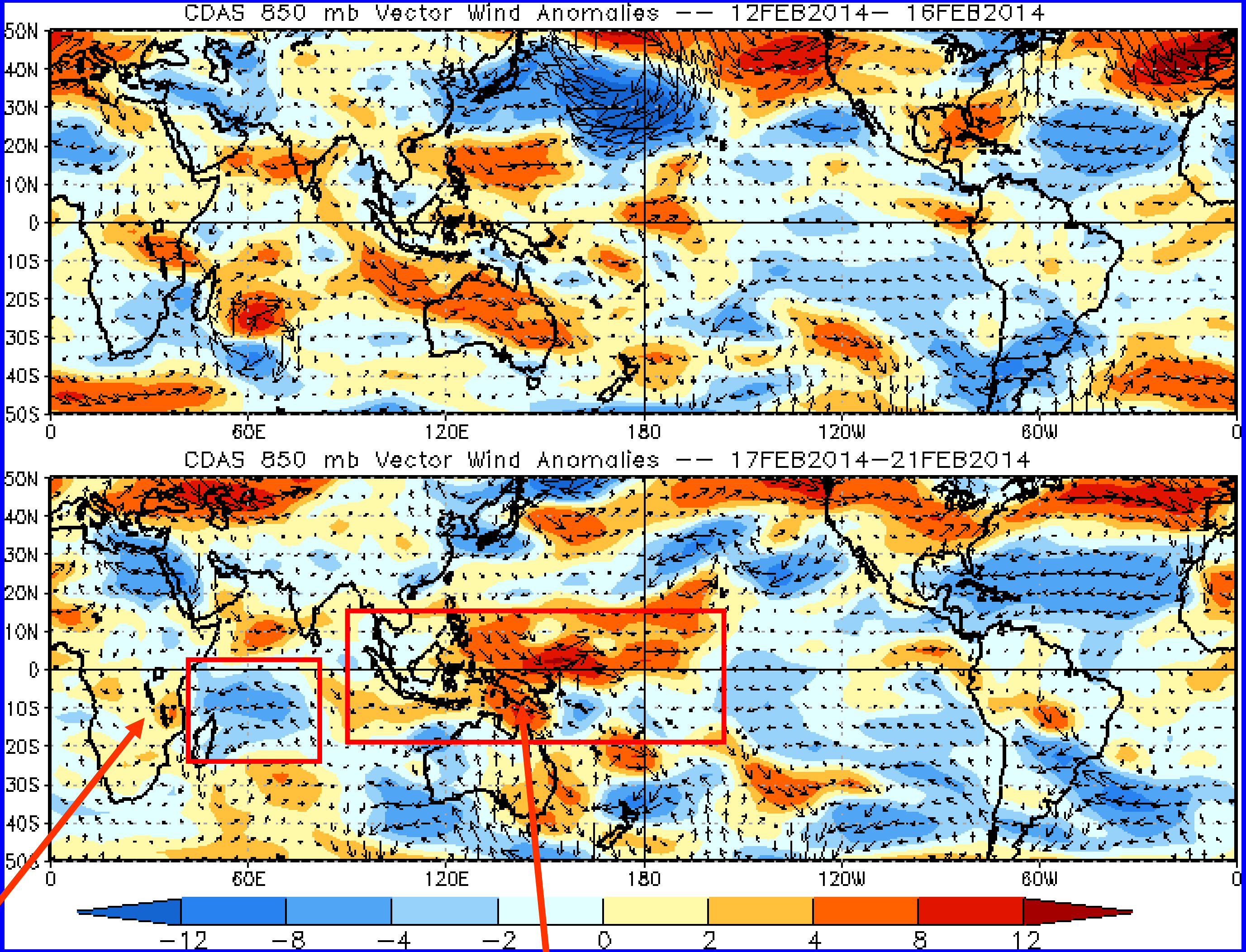
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 replaced westerly anomalies over the Southwest Indian Ocean.

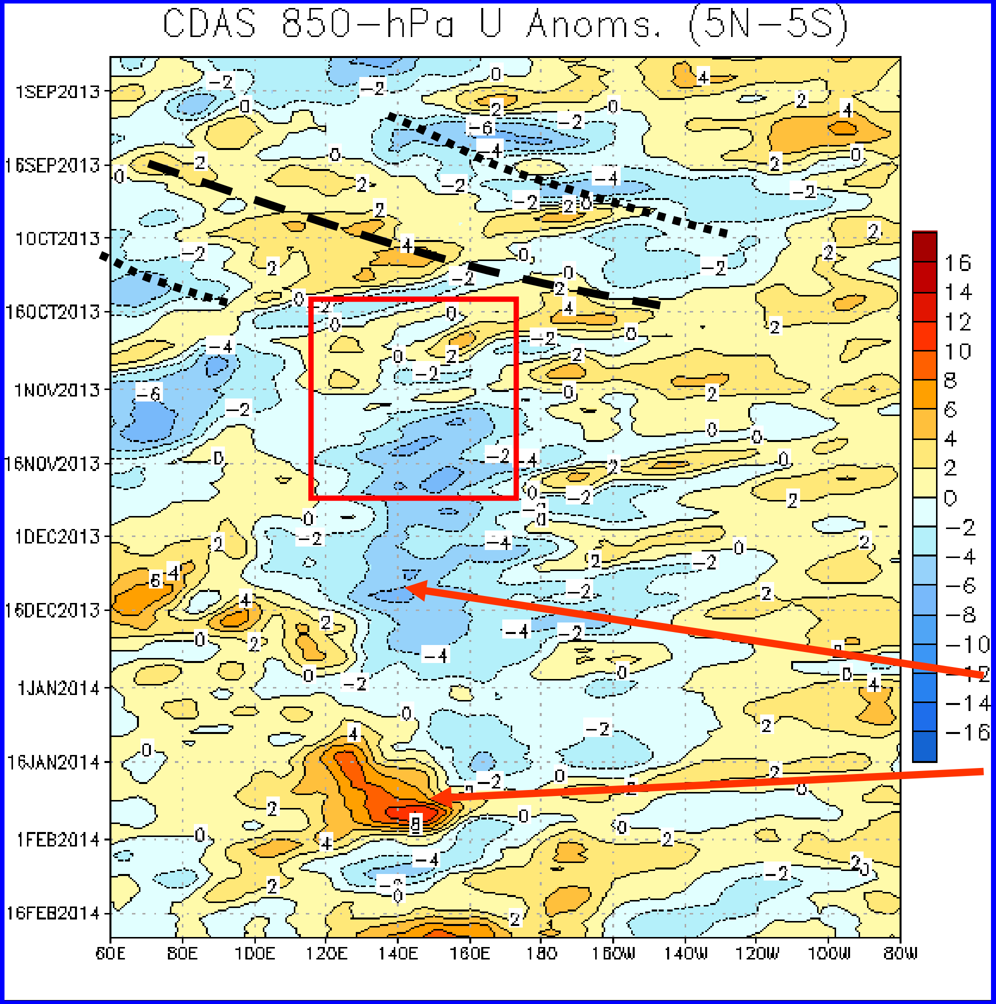
Westerly anomalies consolidated and intensified over the western equatorial Pacific, retreating from Australia.

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

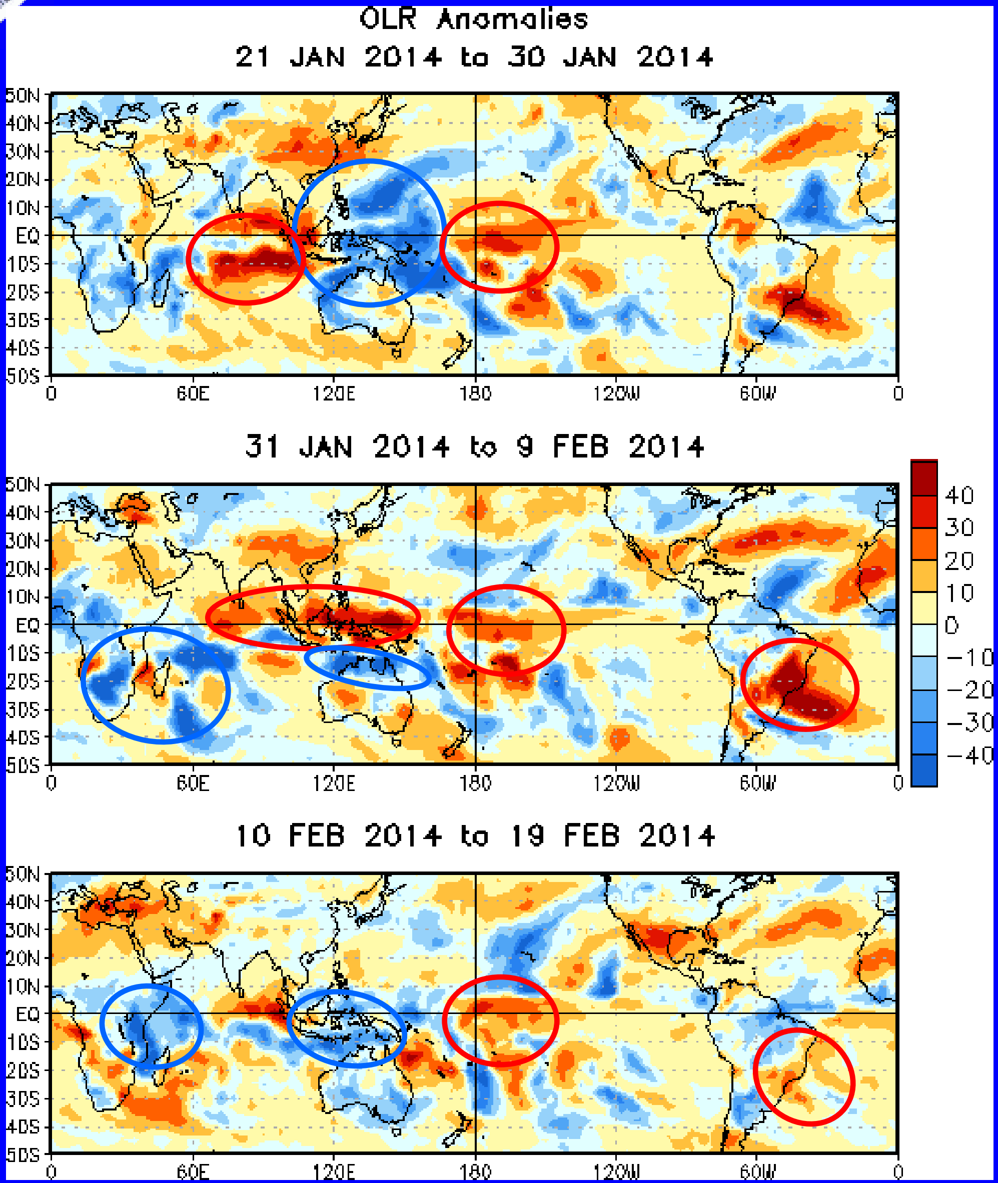
In early September, westerly (easterly) anomalies increased over the eastern (western) Pacific in associated with renewed MJO activity.

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.

Recently, westerly anomalies have returned to the Western Pacific, slightly farther east of the previous local maximum.

OLR Anomalies – Past 30 days



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

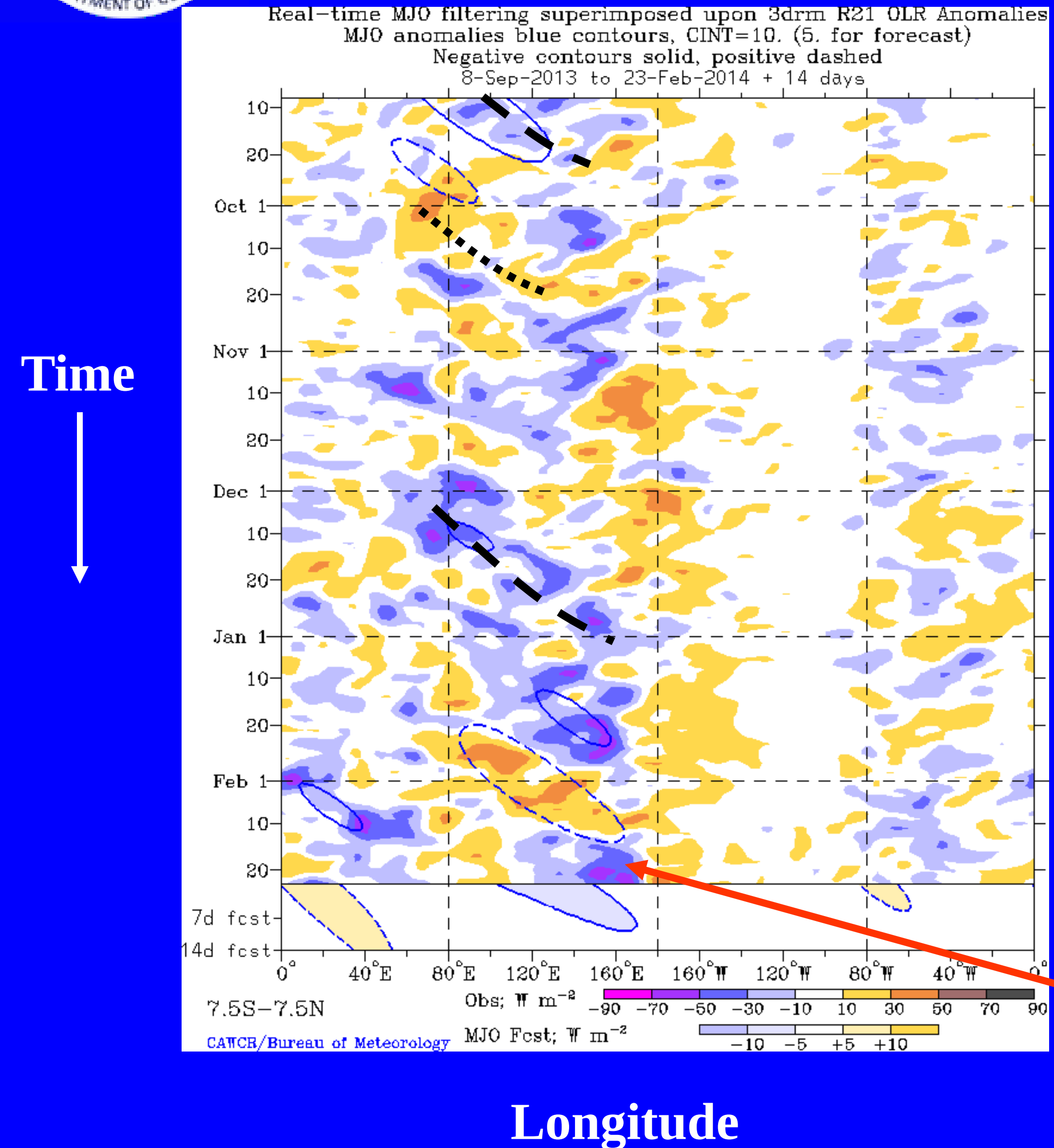
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During mid- to late January, enhanced (suppressed) convection was observed across the Maritime Continent, West Pacific, and north central Australia (south central Indian Ocean, and central Pacific).

Enhanced (suppressed) convection persisted across much of the western Pacific (eastern Indian Ocean) during late January and early February. Enhanced convection was also observed across southern Africa and the southwest Indian Ocean, while suppressed convection intensified across southeastern Brazil.

During mid-February, enhanced convection shifted to eastern Africa, the western Indian Ocean and portions of the Maritime Continent, while suppressed convection remained over the Central Pacific and southeastern Brazil.

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)

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.

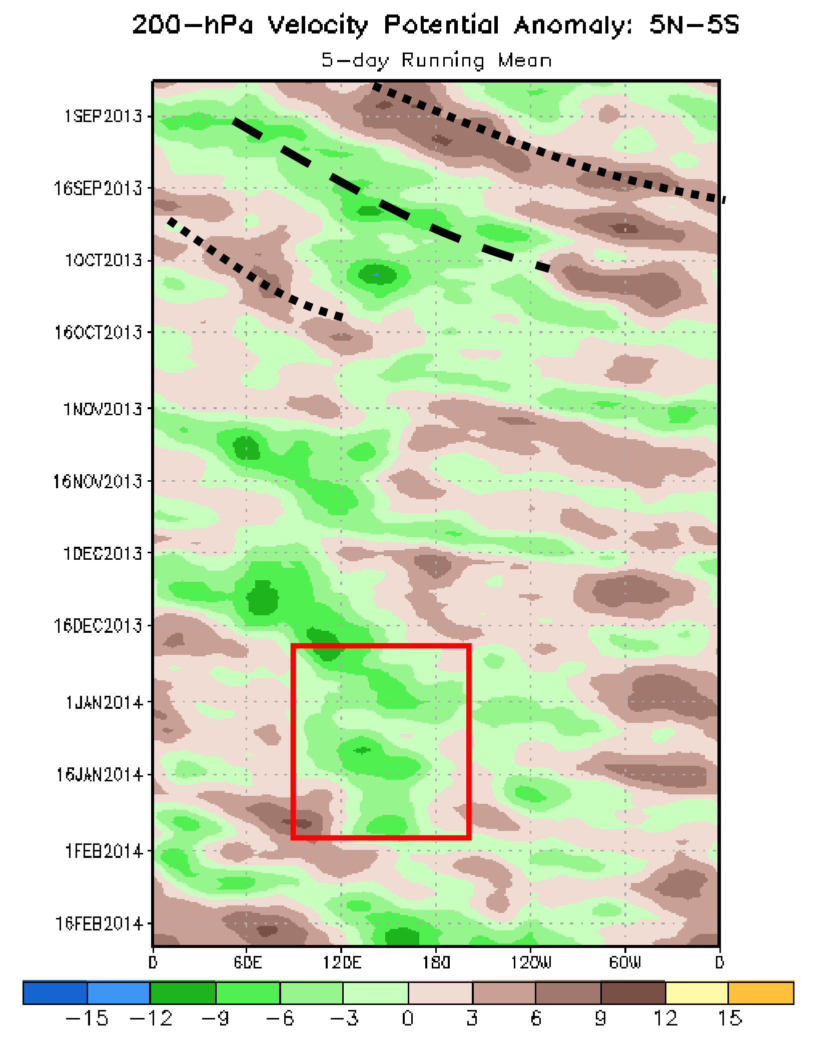
Convection as returned to Western Pacific during the past week.

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.

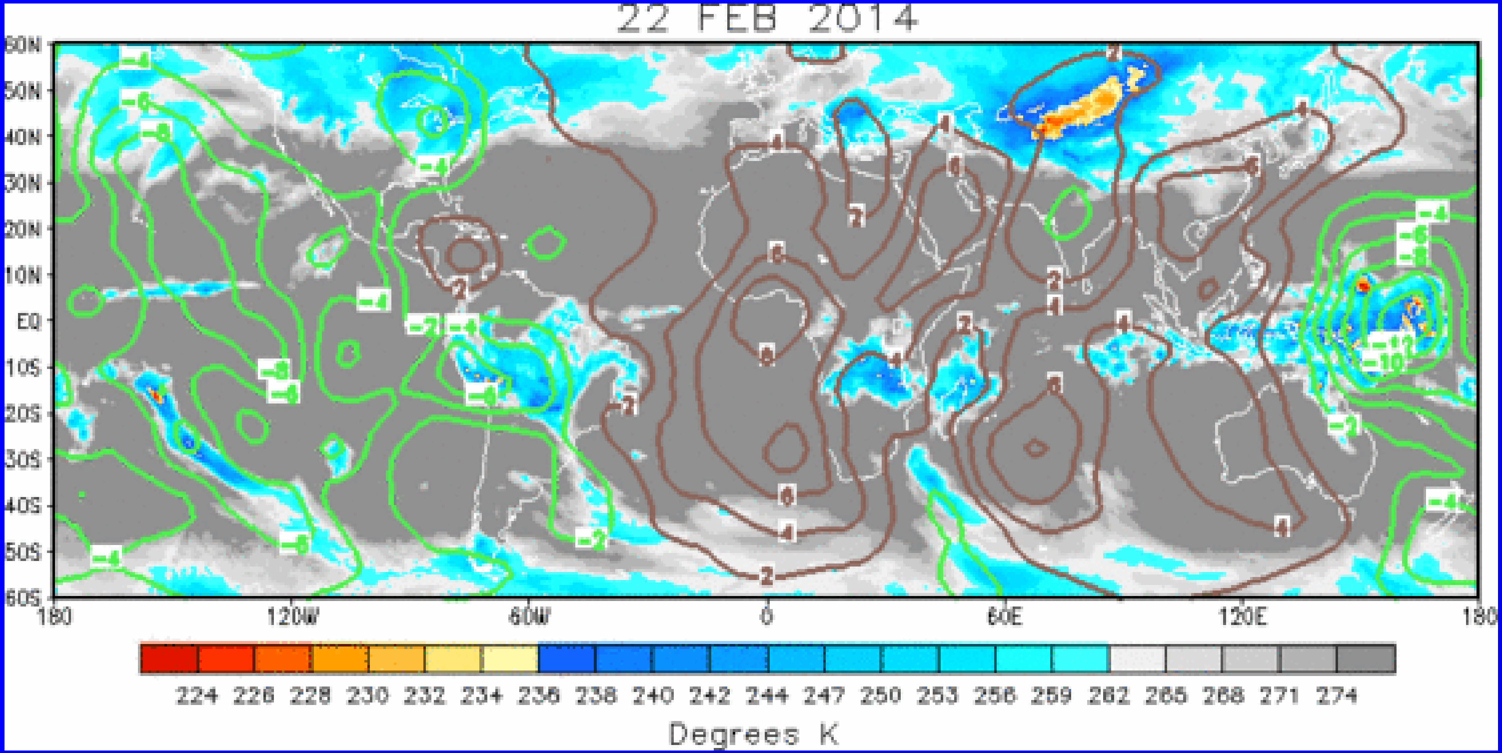
A slower eastward propagation of 200-hPa velocity potential anomalies was observed from mid-December to mid-January across the Indo-Pacific warm pool region (red box).

During early February, negative anomalies propagated east to the Maritime Continent and western Pacific. Most recently, negative (positive) anomalies have returned to the western Pacific (Indian Ocean), consistent with a potentially strengthening 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



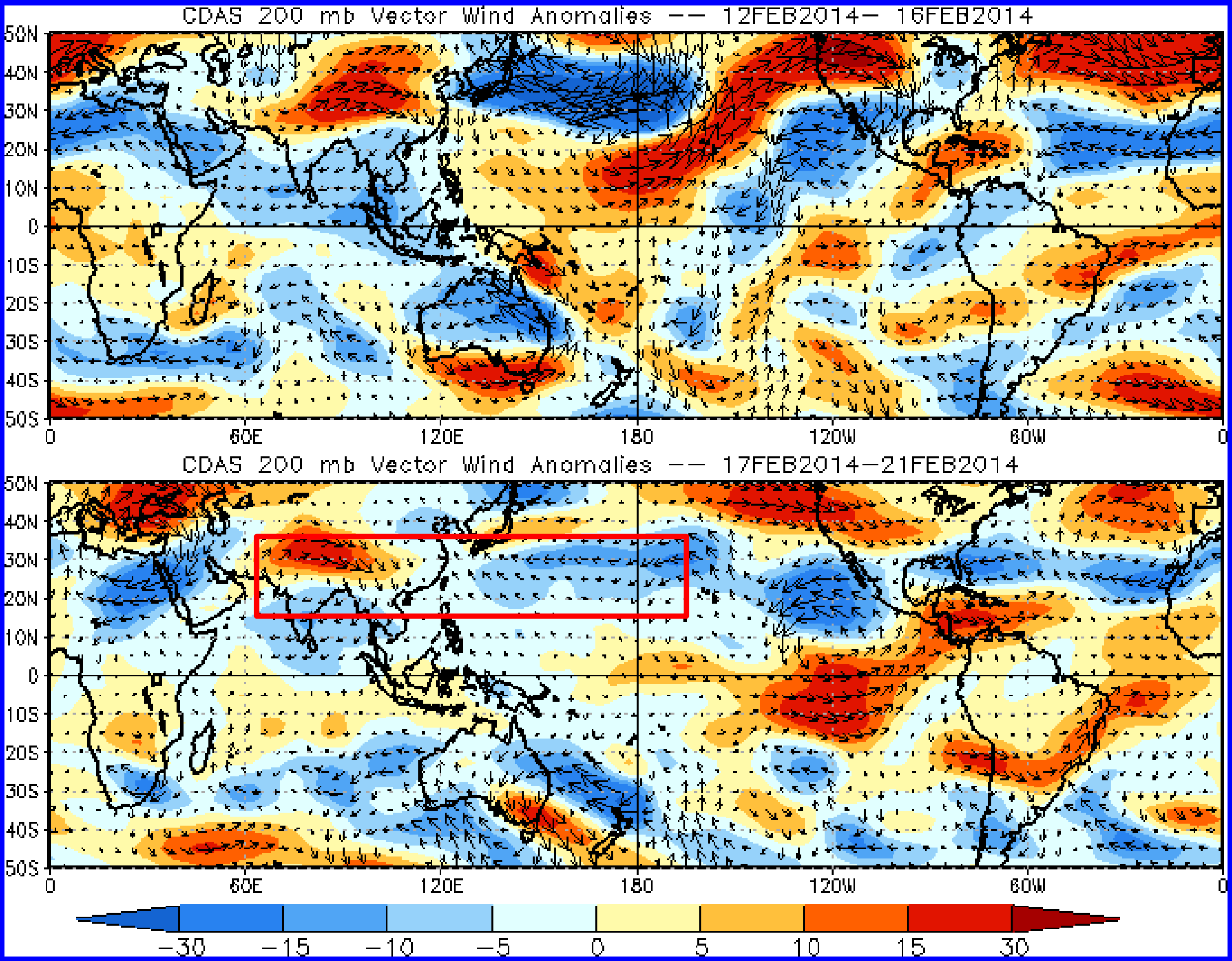
The current velocity potential data indicates a wave-1 pattern consisting of upper-level convergence (divergence) centered over the Indian Ocean (west-central Pacific).

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



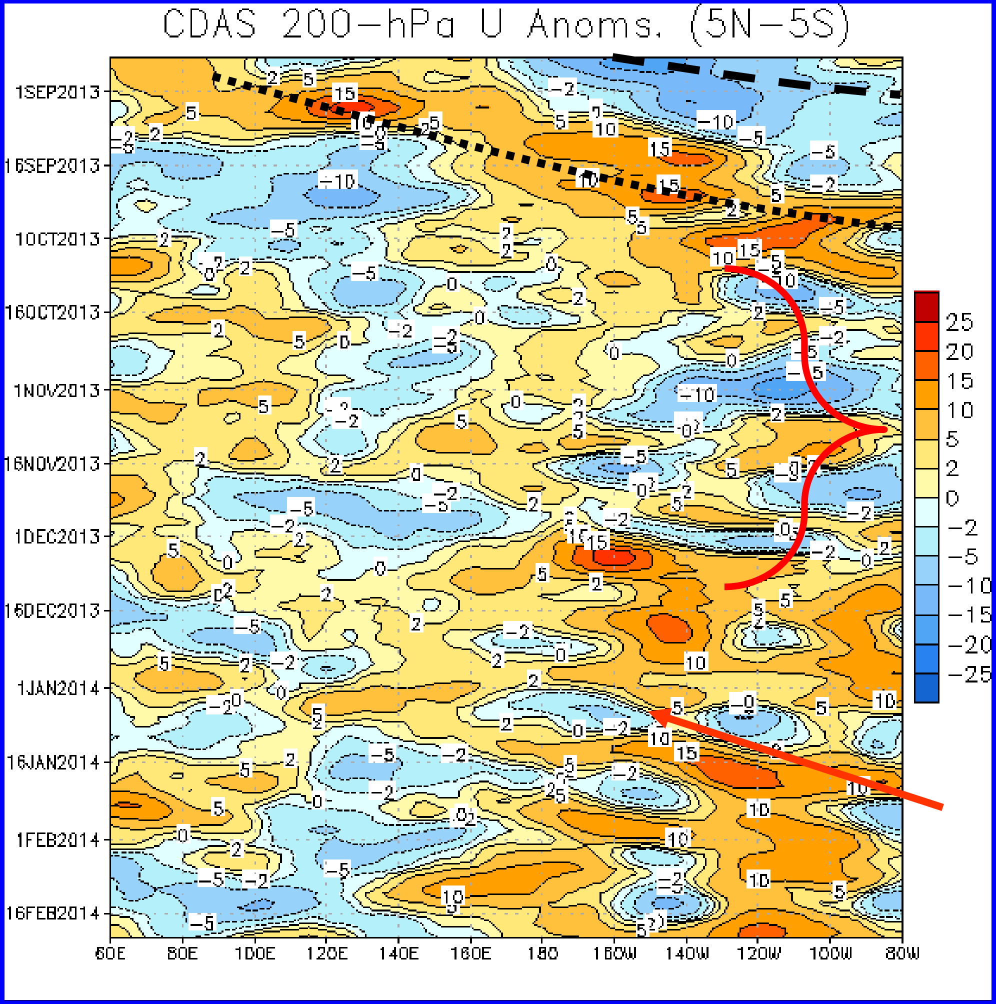
The most prominent feature at 200 hPa is the coherent retraction of the East Asian jet stream (red box).

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

Time



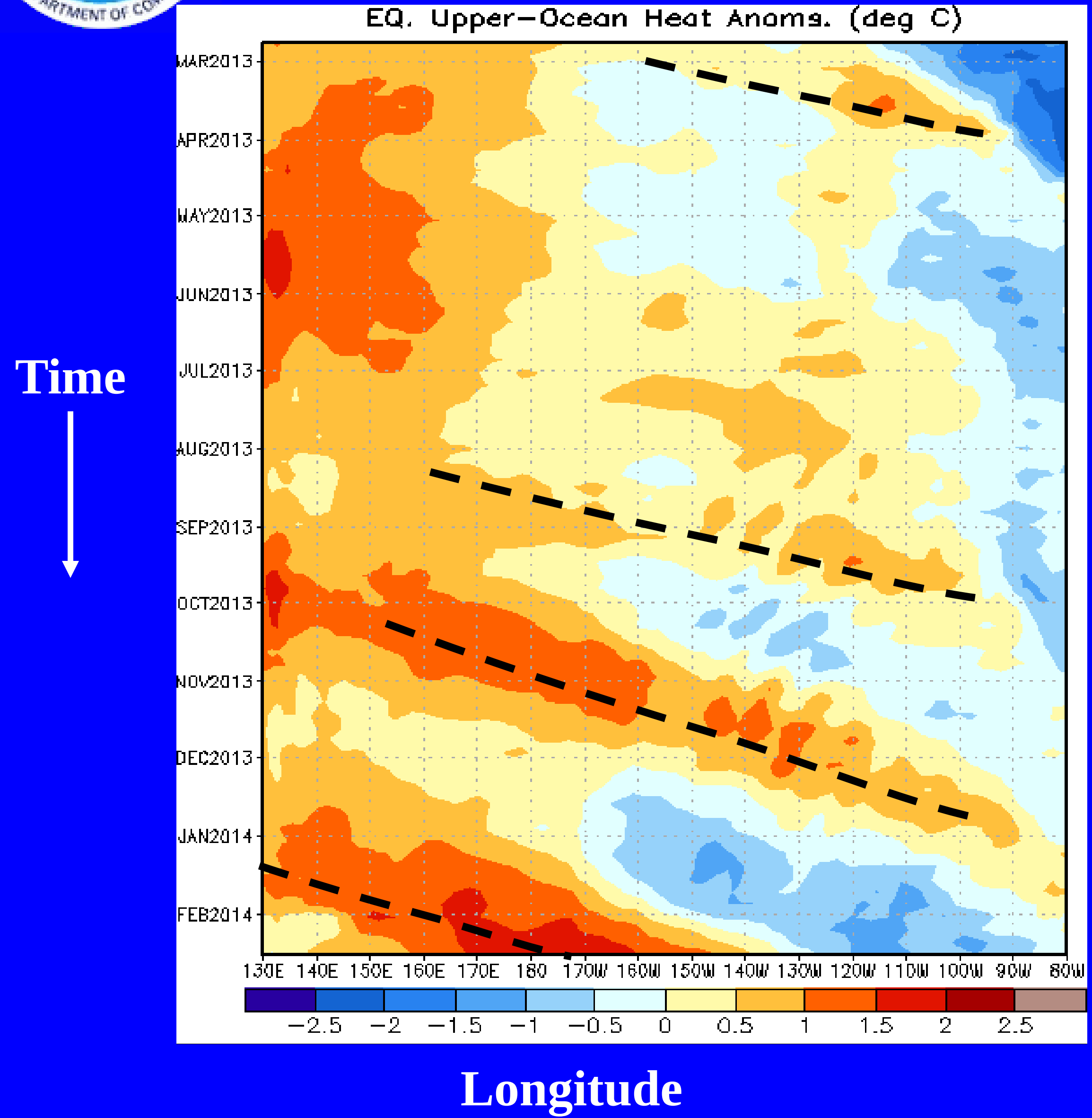
Longitude

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).

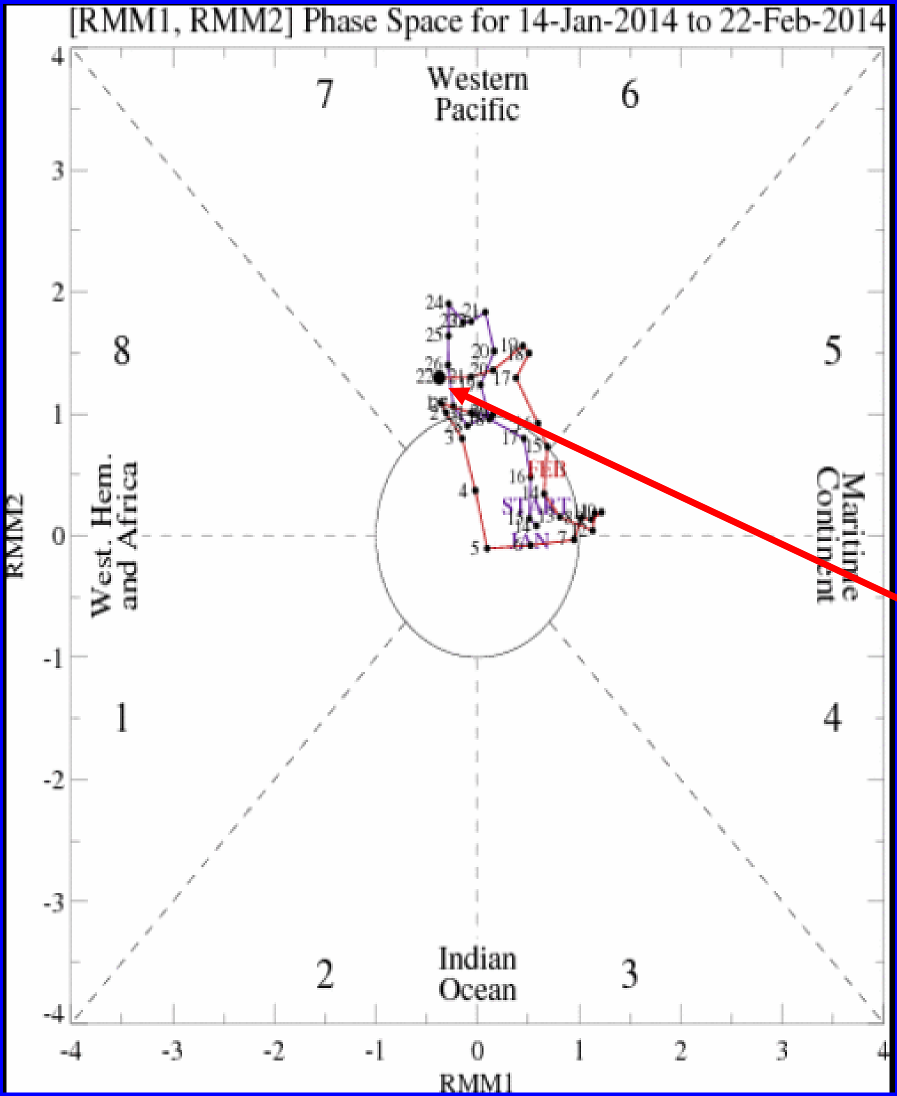
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

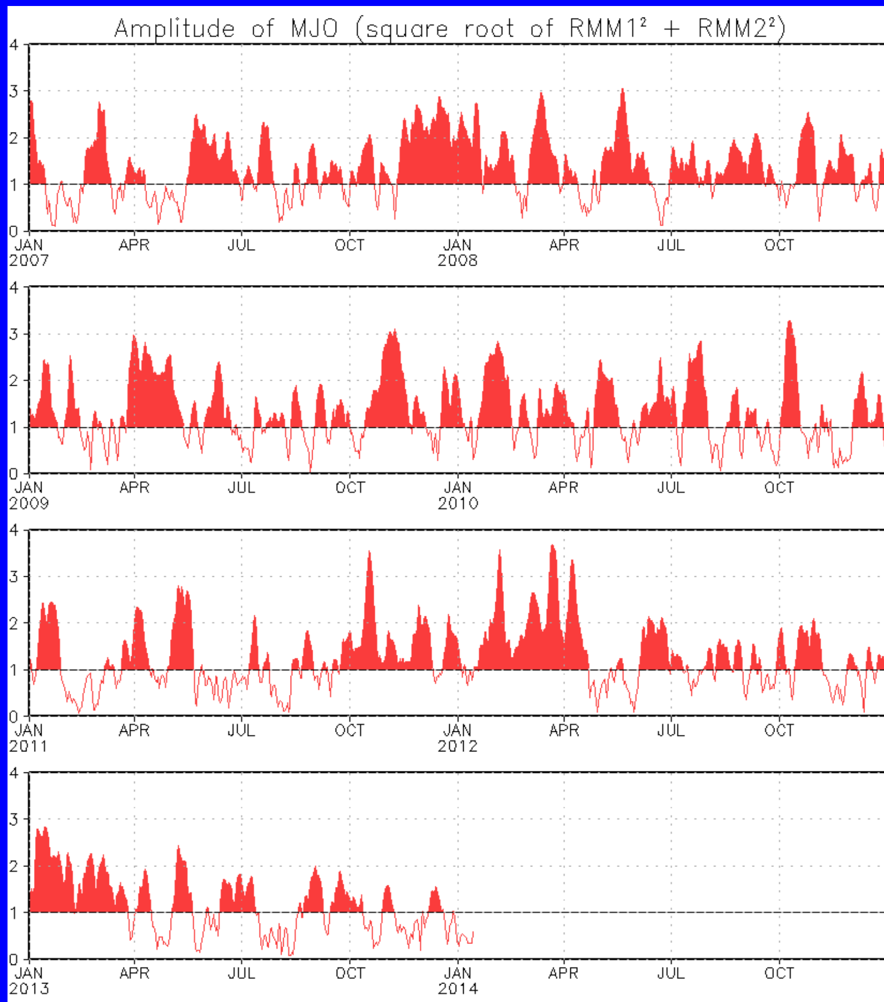
MJO Index -- Recent Evolution



- 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 to the western Pacific, consistent with the other measures of MJO activity.

MJO Index – Historical Daily Time Series



Time series of daily MJO index amplitude from 2007 to present.

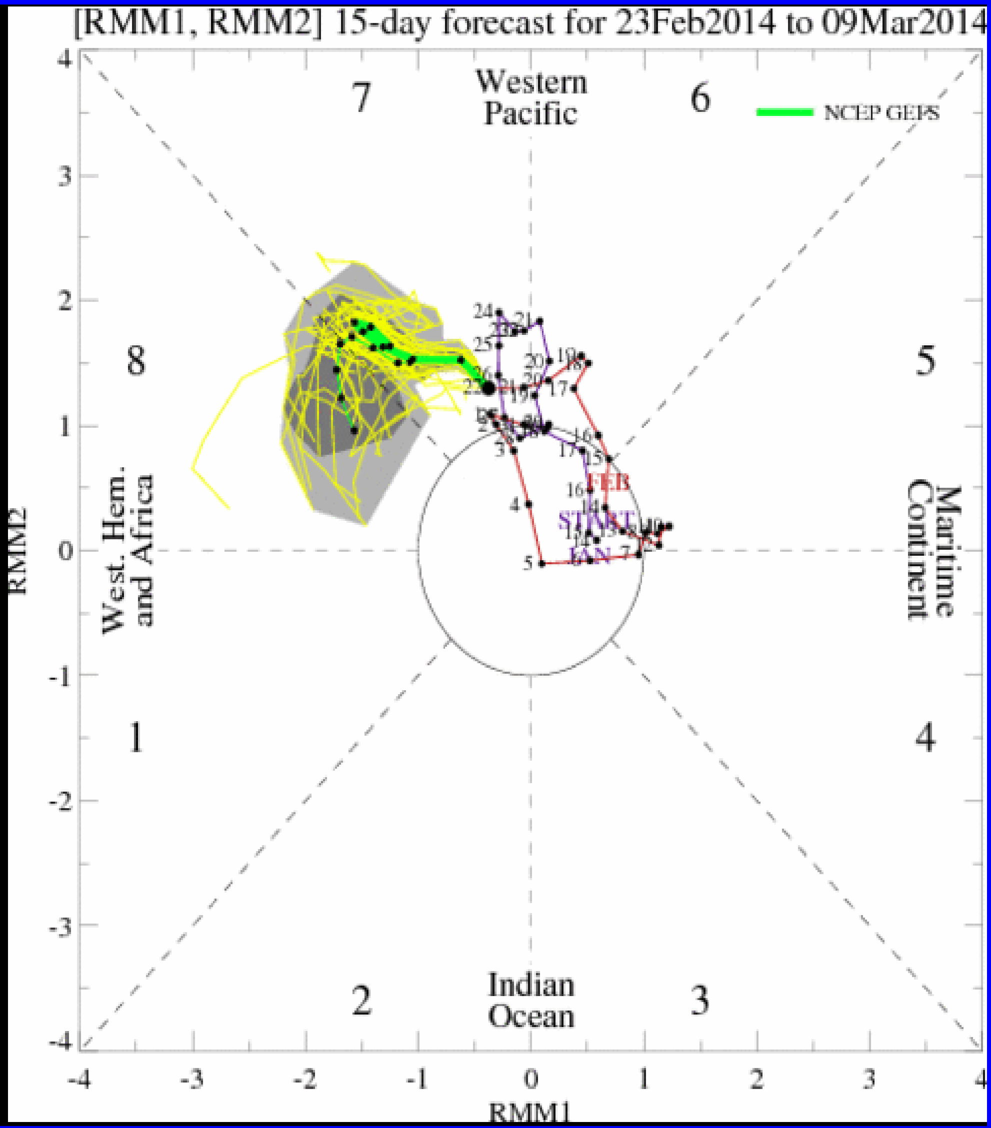
Plot puts current MJO activity in recent historical context.

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



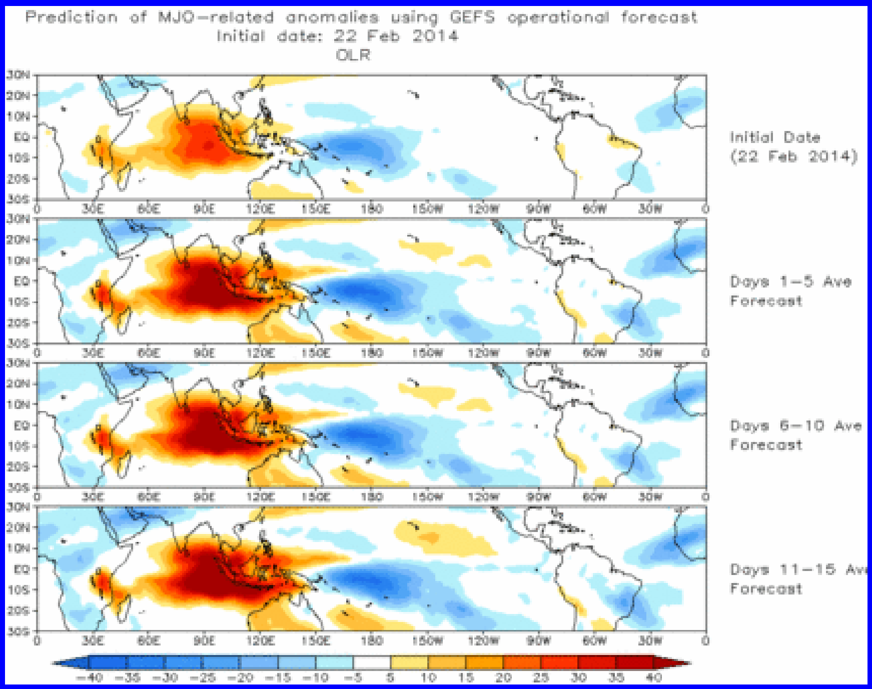
The ensemble GFS forecast indicates a fairly strong convective signal propagating across the Pacific during Week-1, with some interference from other modes. The model continues a robust event into Week-2.

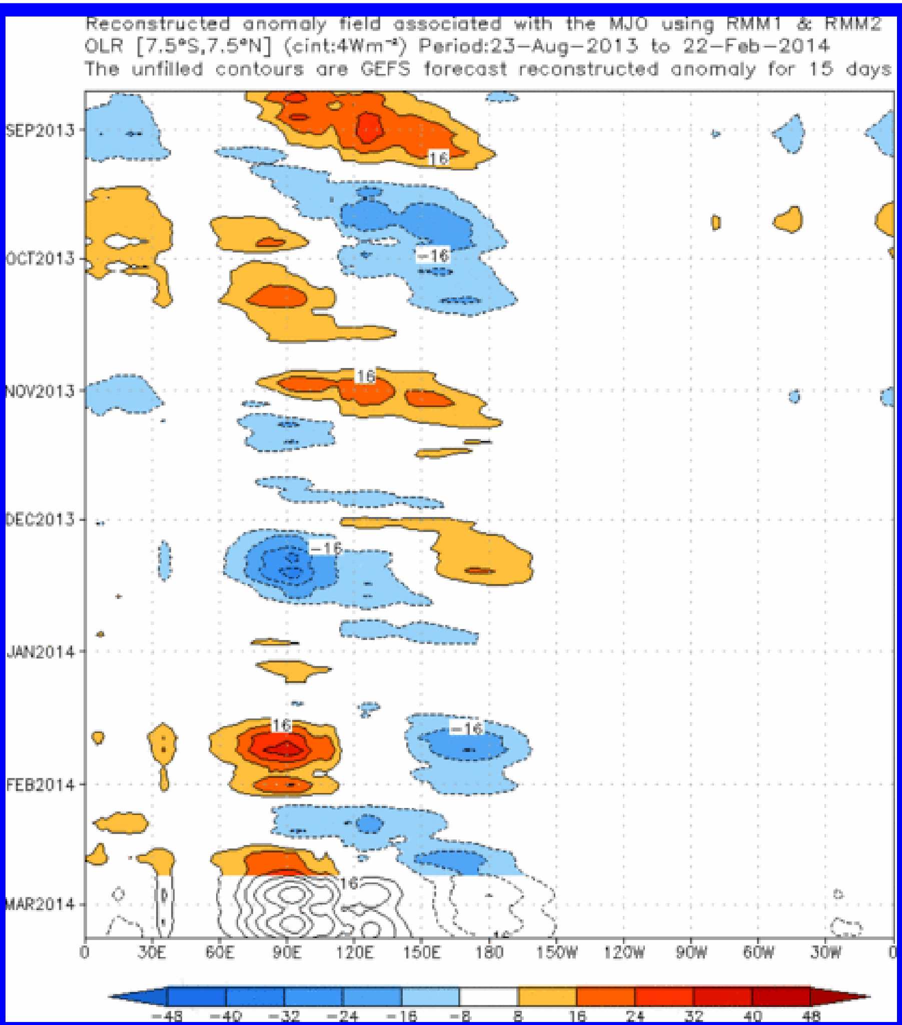
Ensemble Mean GFS MJO Forecast

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



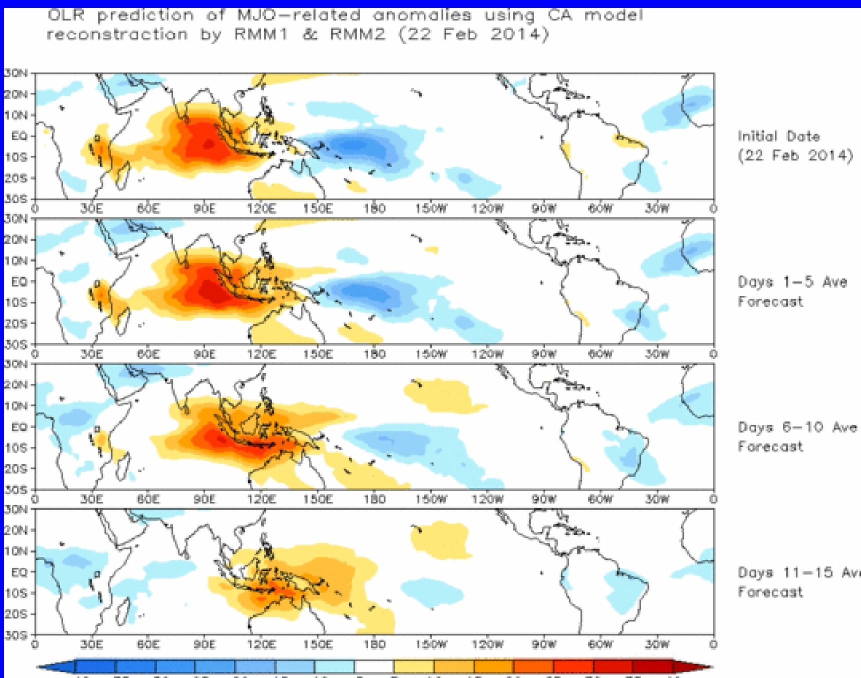


The ensemble mean GFS forecasts suppressed convection shifting east from Indian Ocean to the Maritime Continent while enhanced convection slowly expands east across the Western Hemisphere. The propagation is at the slow end of the MJO spectrum through Week-2.

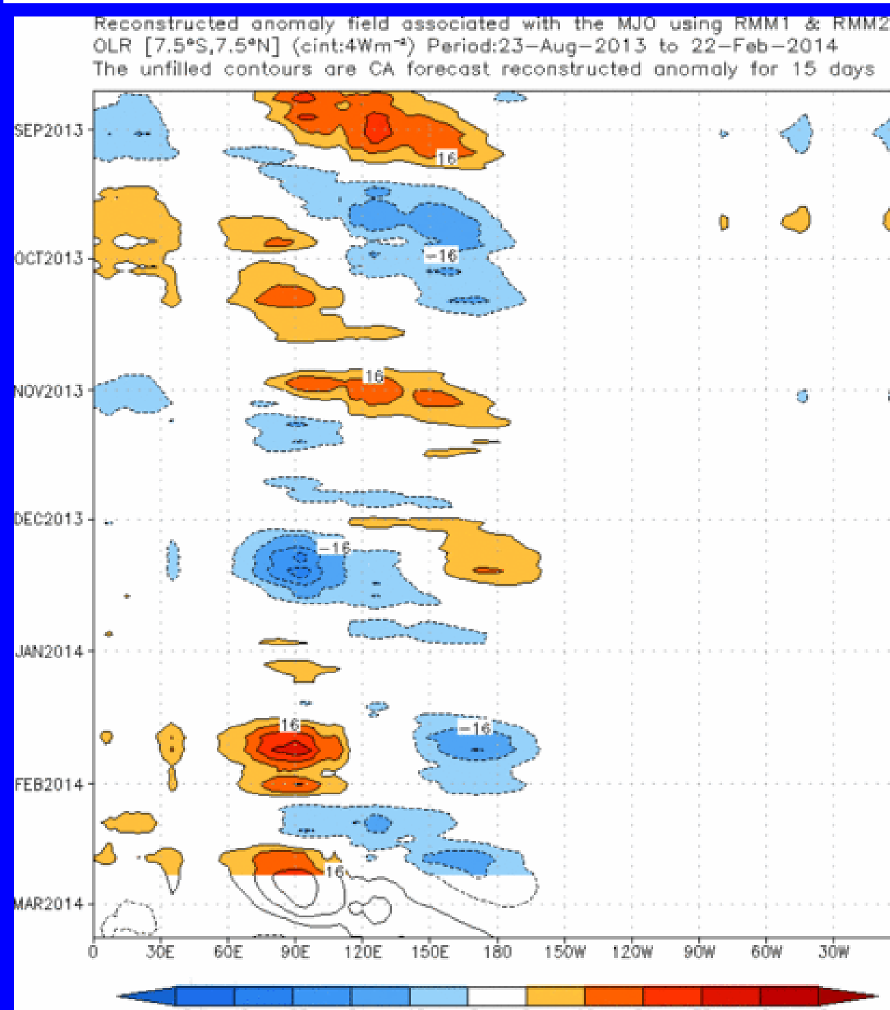
Constructed Analog (CA) MJO Forecast

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



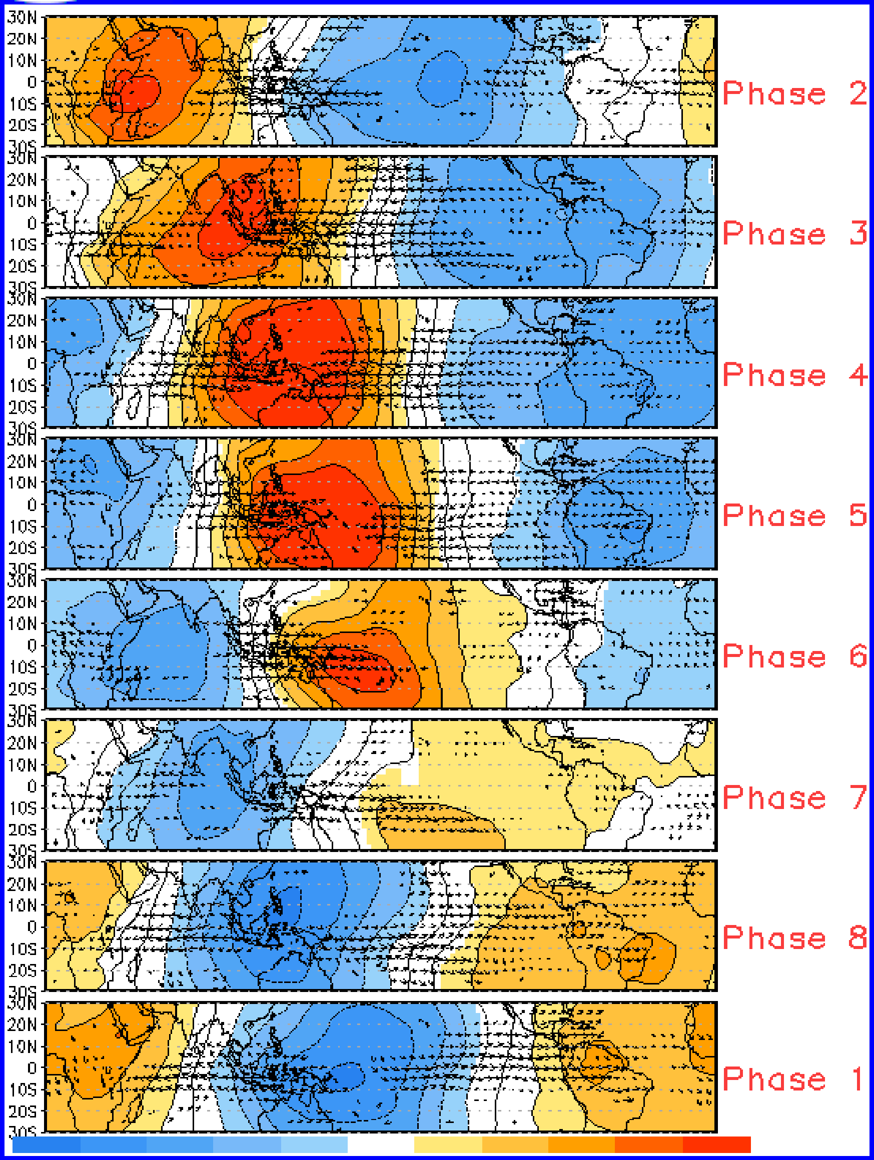
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



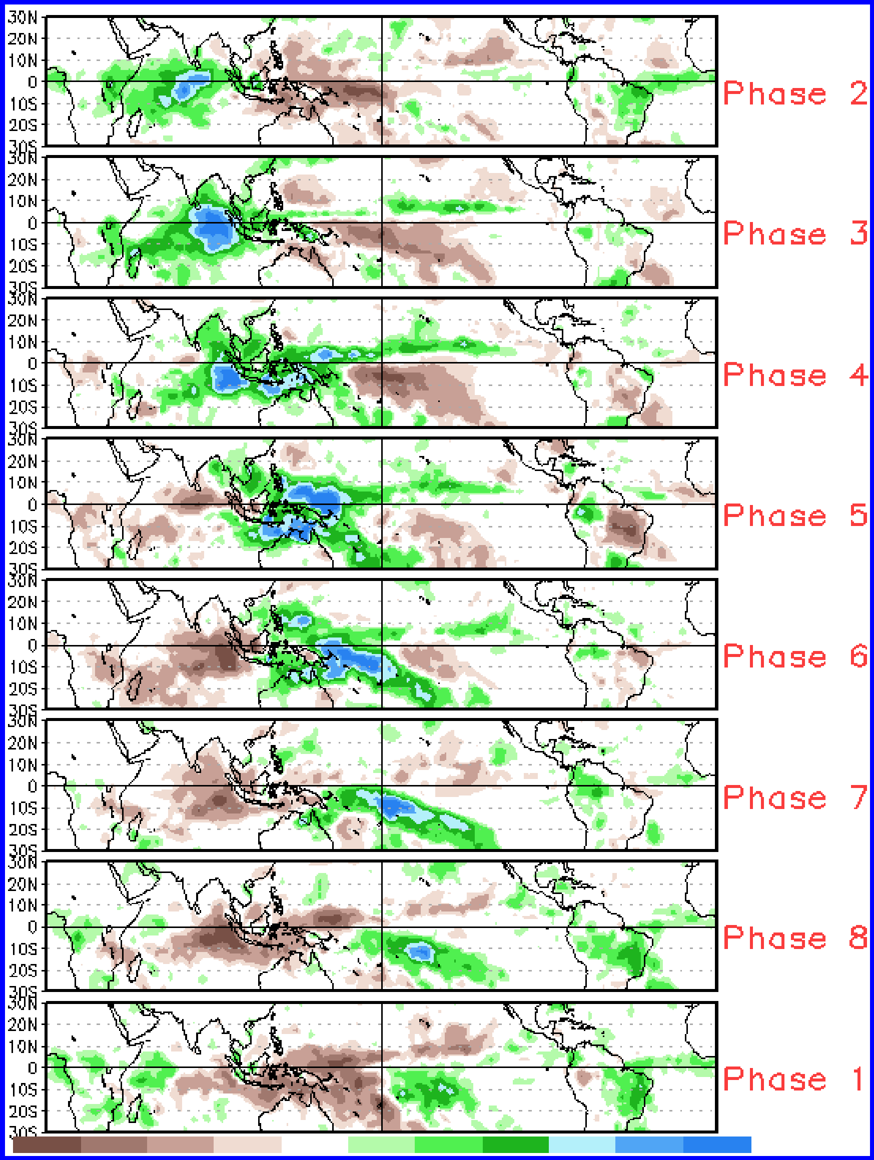
The constructed analog MJO forecast indicates suppressed (increased) convection over the Indian Ocean (Western Pacific) that moves to the eastern Maritime Continent (Americas) during Week-2, slightly faster than the GFS forecasts.

MJO Composites – Global Tropics

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

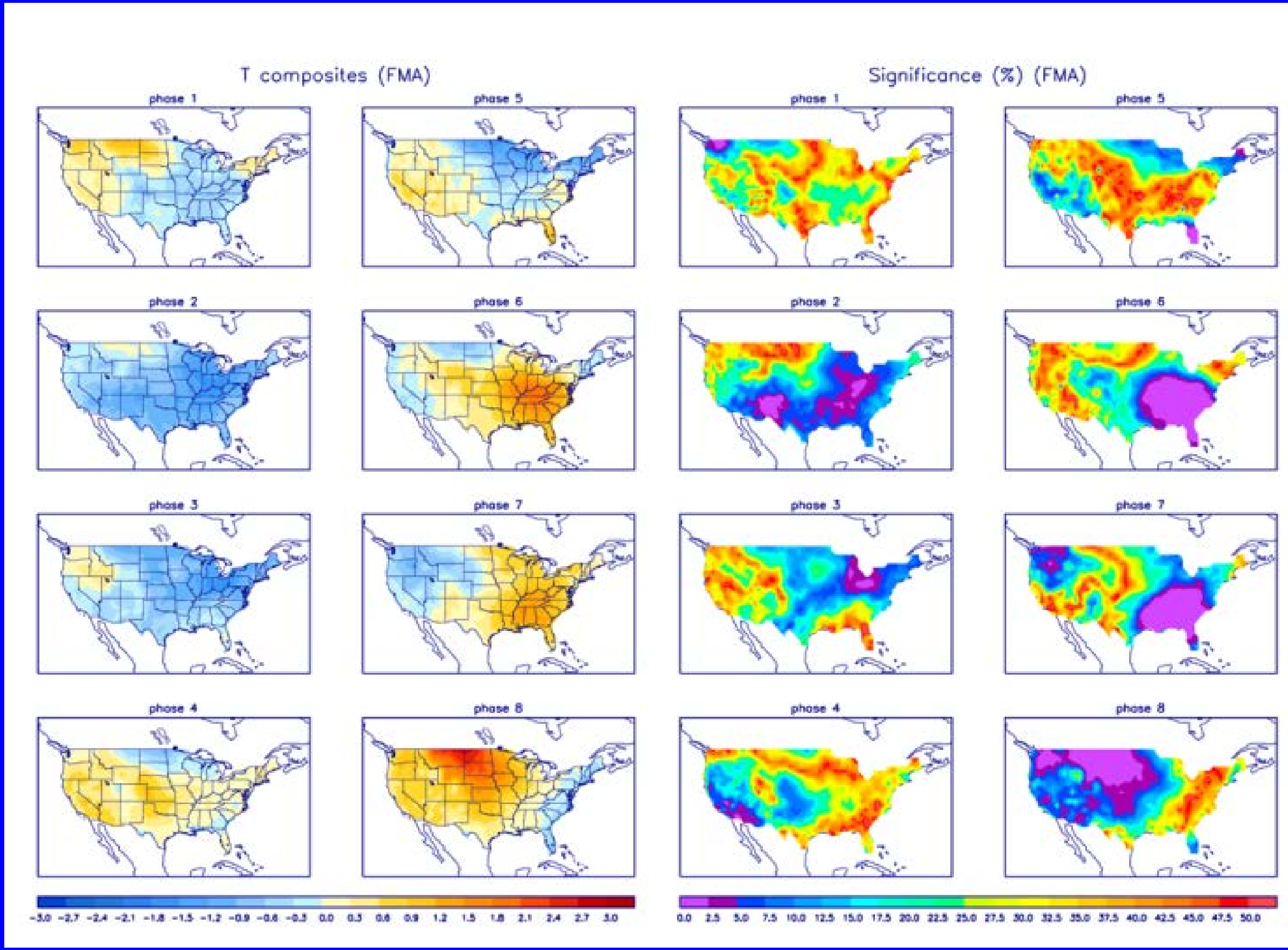


Precipitation Anomalies (Nov-Mar)



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.**



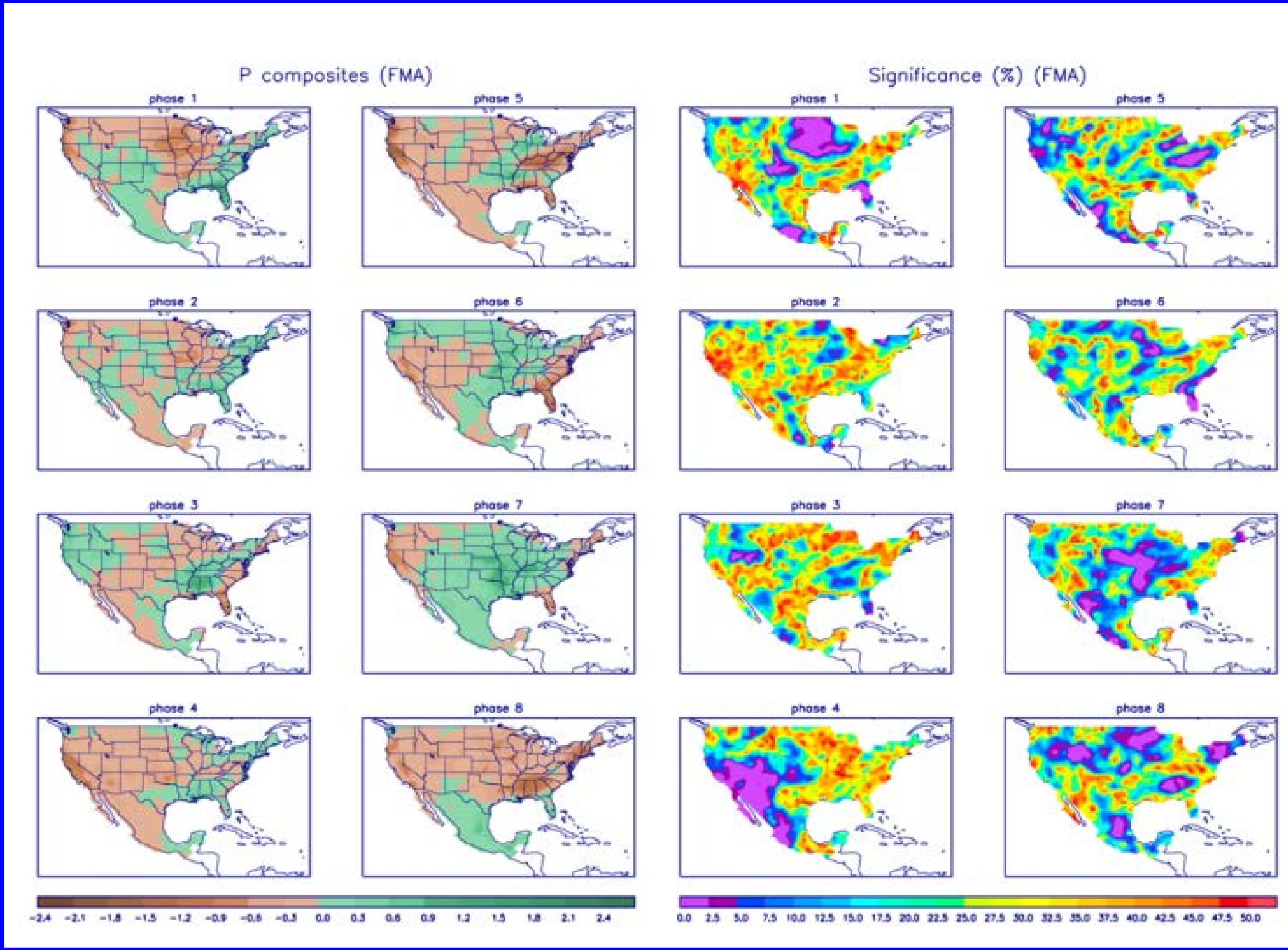
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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