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

Update prepared by
Climate Prediction Center / NCEP
August 18, 2014

Outline

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

Overview

- The MJO remains weak as indicated by various MJO indices, although some evidence of an intraseasonal signal is present, primarily noted as an envelope of suppressed convection that has propagated eastward from the Indian Ocean to the Pacific during the past few weeks.

- Other types of subseasonal variability, including tropical cyclones and westward moving features interacting with the intraseasonal signal, are playing large roles in the pattern of anomalous tropical convection.

- Dynamical and statistical models do not support the evolution of a canonical MJO signal during the upcoming two weeks.

- Based on recent observations and model guidance, the MJO, although weak, may contribute to enhanced (suppressed) convection over the Western Hemisphere and Indian Ocean (western and central Pacific).

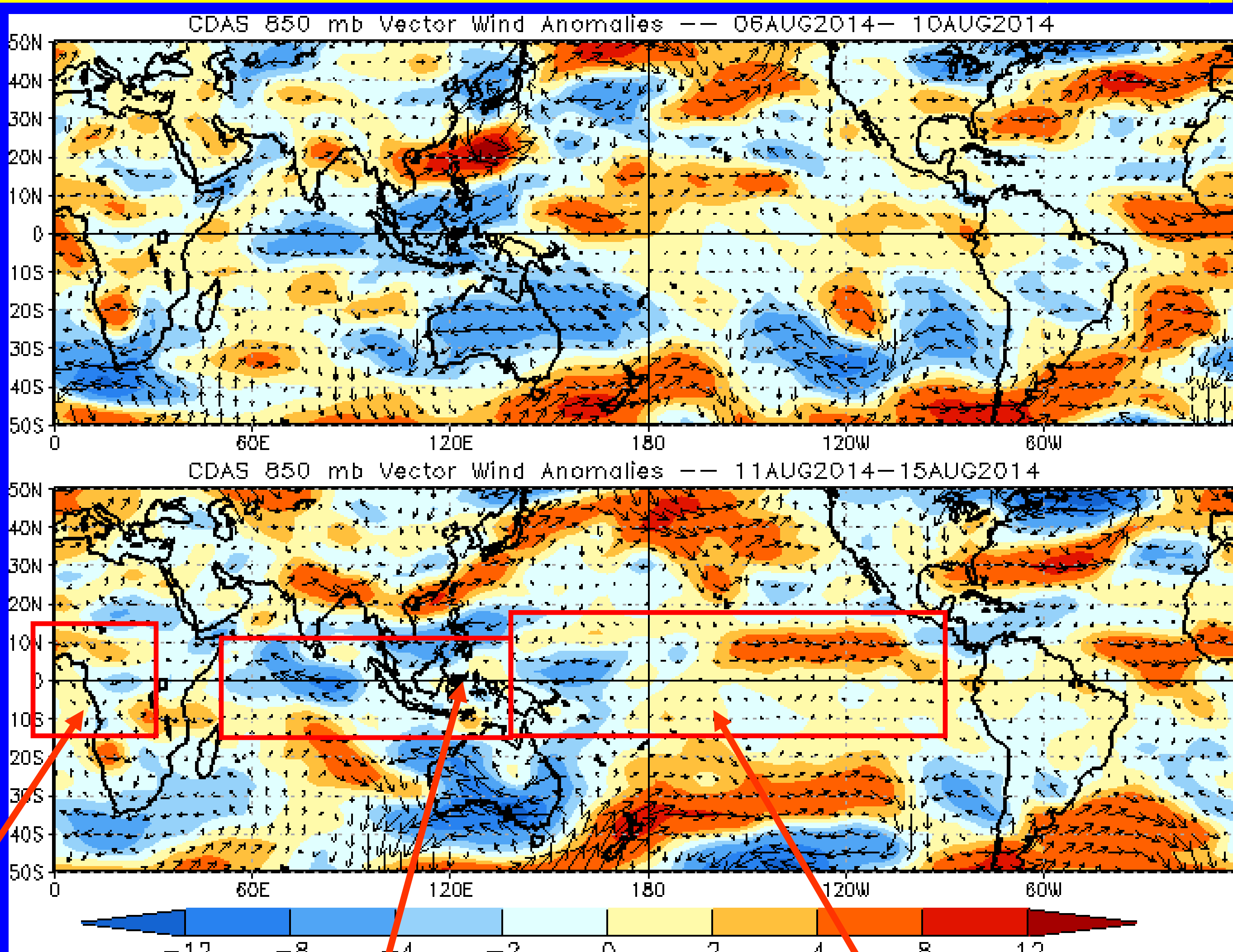
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 weakened over Africa while persisting over the west-central Atlantic.

Easterly anomalies persisted over the central Indian Ocean and weakened over the Maritime Continent.

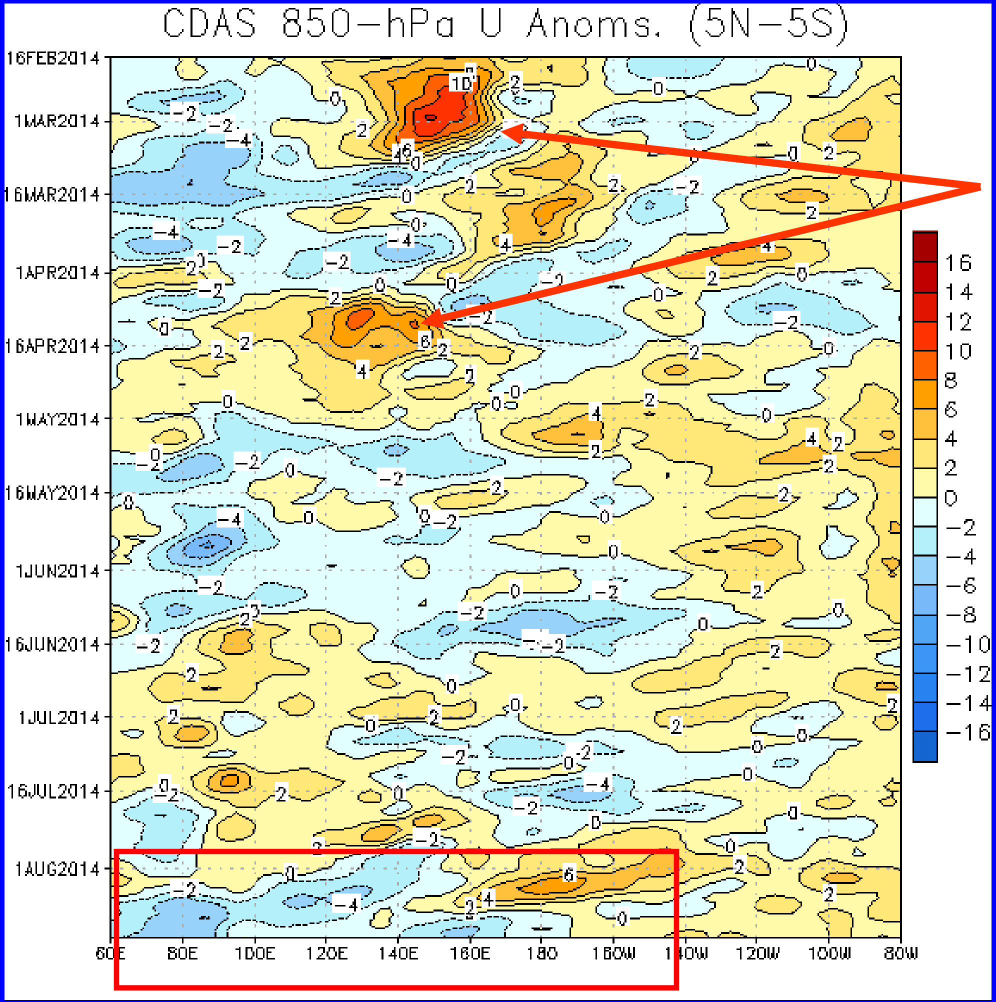
Westerly anomalies shifted to the eastern Pacific, while easterly anomalies developed west of the Date Line.

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

Two westerly wind bursts were observed across the western Pacific between February and mid-April.

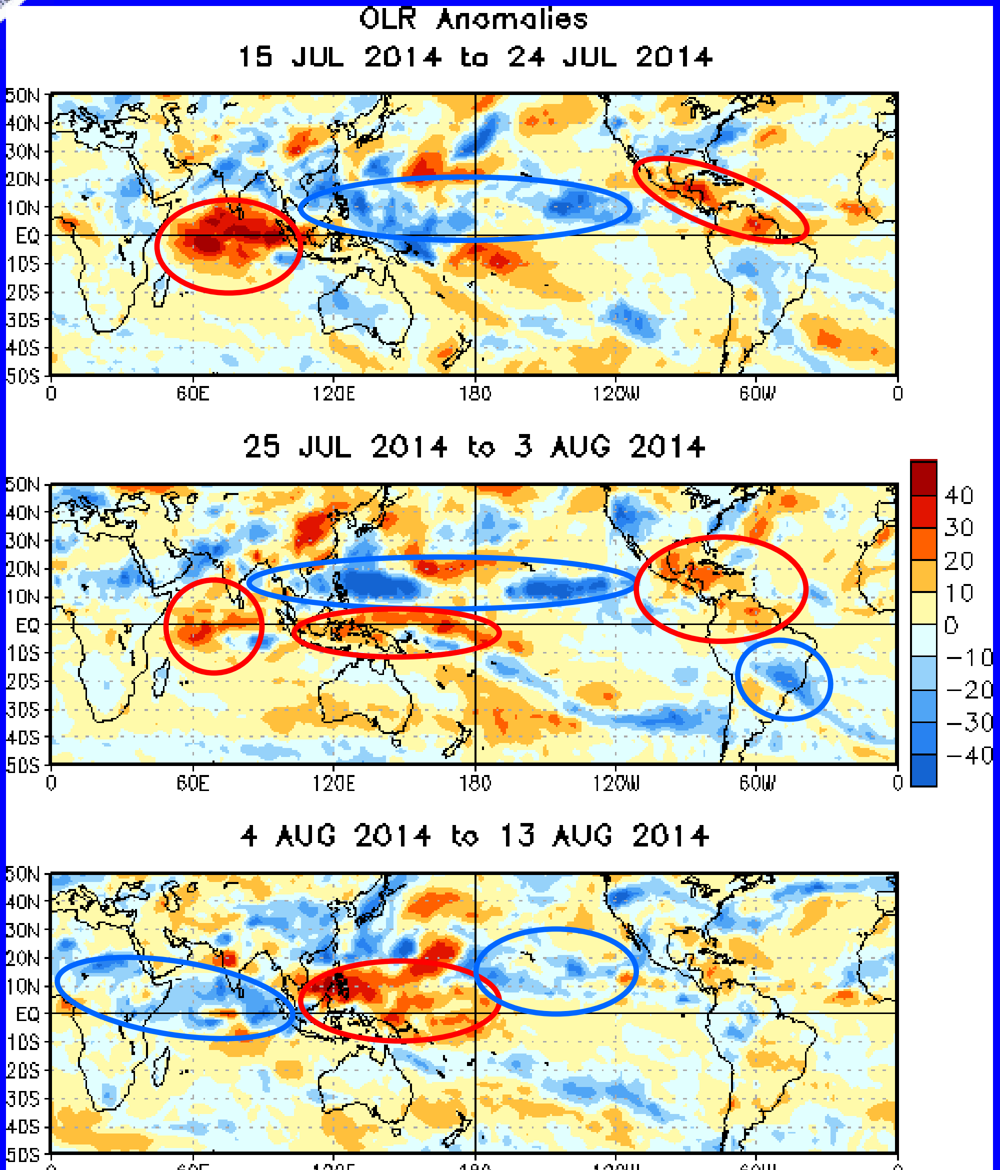
During April, westerly anomalies were generally persistent across the Maritime continent and far western Pacific.

During much of May and June, westerly anomalies were observed over the eastern Pacific.

Westerly anomalies associated with an enhanced Southeast Asian monsoon circulation are evident from 80E to 120E during much of June and July.

Beginning in late July into August, westerly (easterly) anomalies shifted westward over the eastern and central Pacific (western Pacific, Maritime Continent, and Indian Ocean). More recently, easterly anomalies developed near and west of the Date Line.

OLR Anomalies – Past 30 days



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

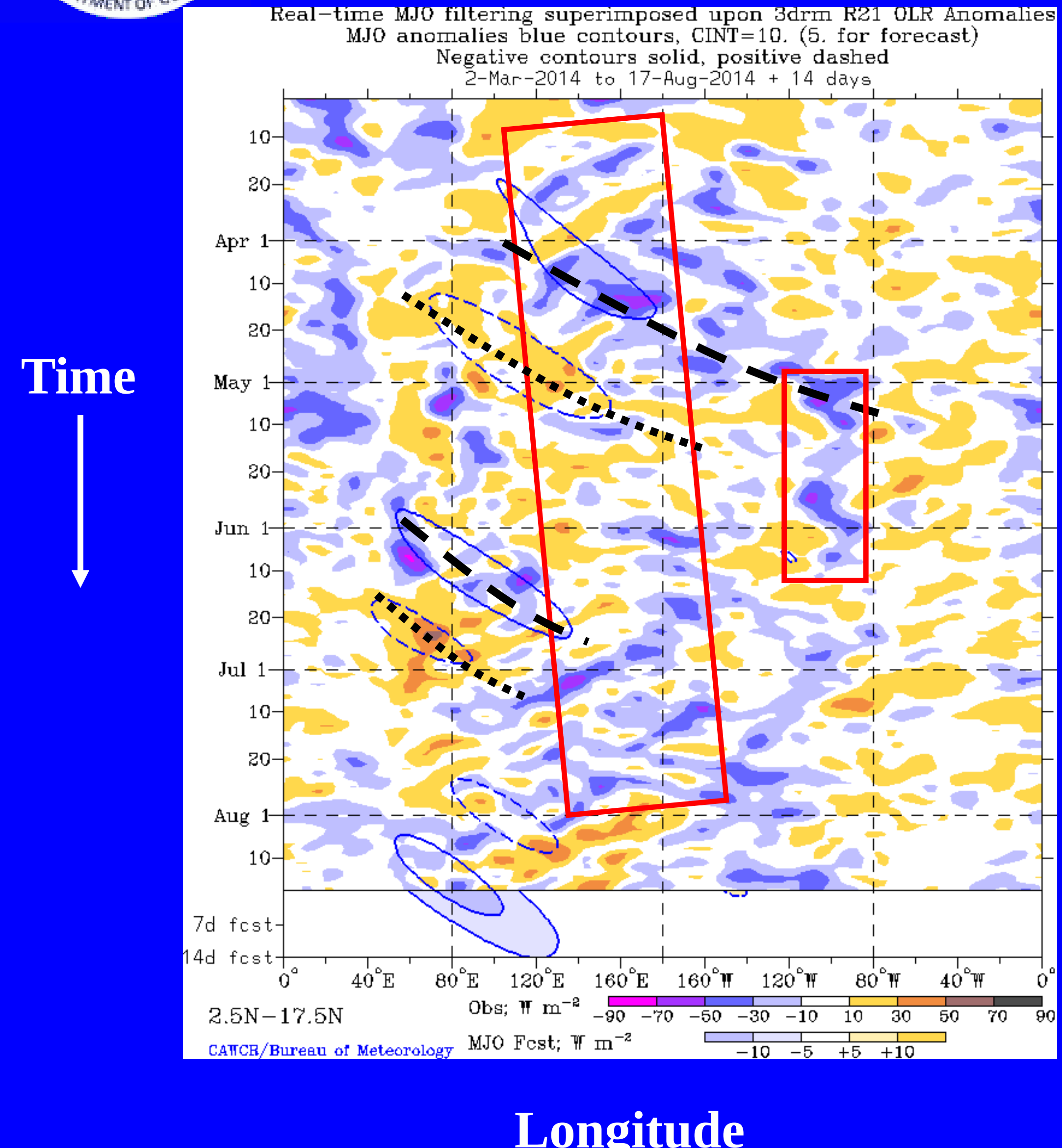
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During mid-July, enhanced convection (blue ovals) was evident over much of the Pacific basin, while suppressed convection (red ovals) was evident across the equatorial Indian Ocean, central America, and northern South America.

An active Pacific basin north of the equator continued during late July and early August, while suppressed convection developed along the equatorial Maritime Continent and western Pacific. Suppressed convection continued over the western Indian Ocean and the Americas.

During early August, suppressed convection overspread much of the West Pacific, while areas of enhanced convection (associated with TC activity) continued over the east-central Pacific. Enhanced convection developed across much of the northern Indian Ocean basin.

Outgoing Longwave Radiation (OLR) Anomalies (2.5°N-17.5°N)



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)

Since January, enhanced convection has propagated slowly eastward from the Maritime Continent to the central Pacific (red box), interrupted periodically by subseasonal variability.

The MJO became more coherent during April, with the subseasonal envelopes of enhanced and suppressed convection modulating the strength of the low frequency signal. The anomalous tropical convection pattern became largely incoherent during mid-May, with enhanced convection centered over the eastern Pacific (red box).

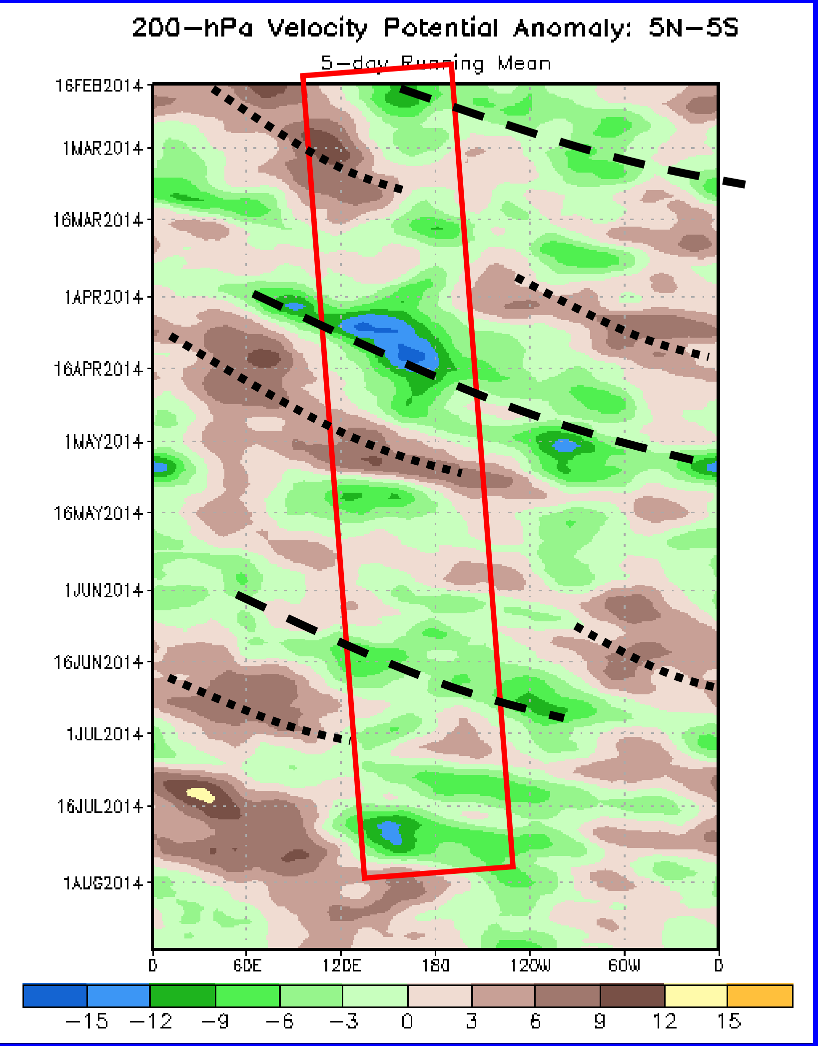
During June, the MJO became more organized, primarily over the Indian Ocean, but during July and into early August the pattern became less coherent with respect to canonical MJO activity.

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

A slow eastward progression of negative anomalies was observed from January to present across the Indo-Pacific warm pool and central Pacific (red box).

During February through April, anomalies propagated eastward with time associated with the MJO before weakening for much of May.

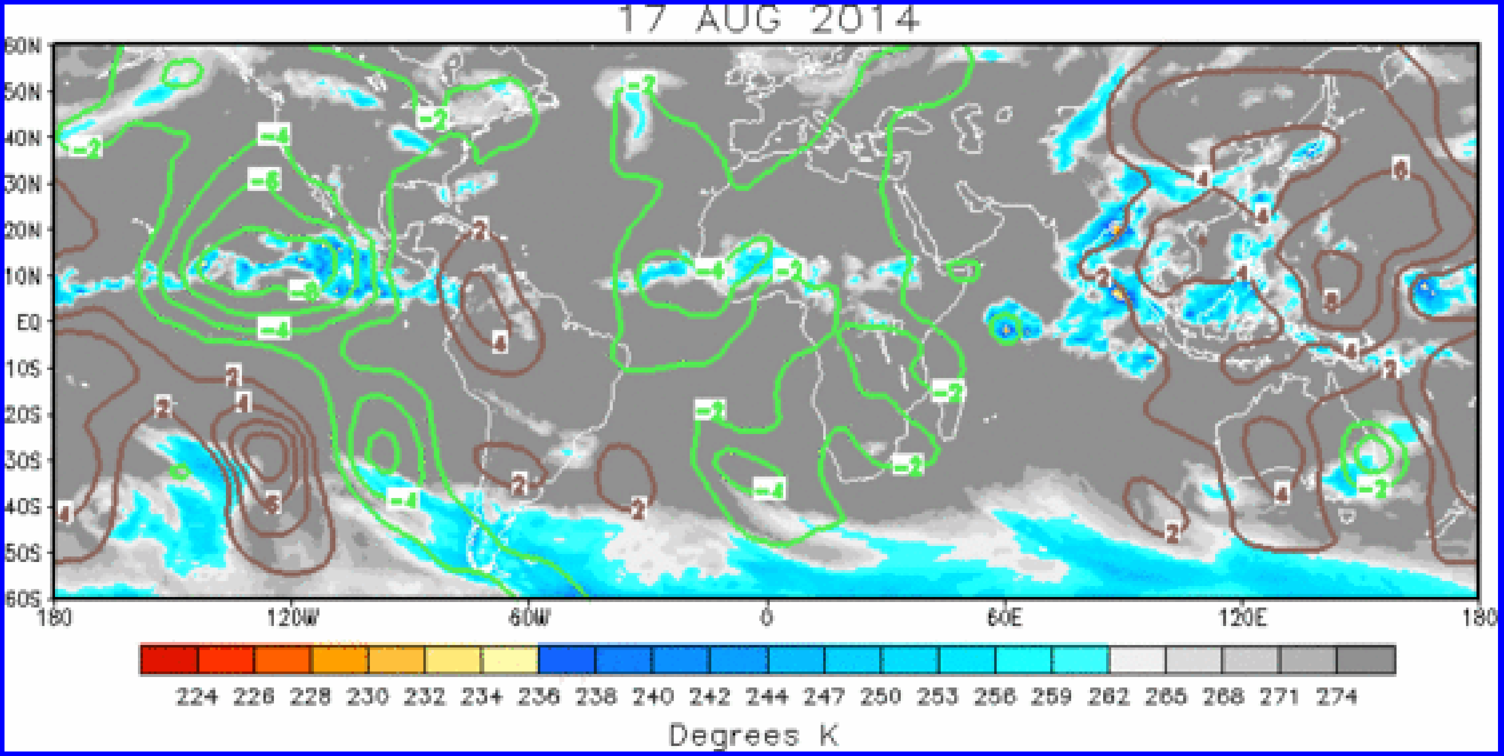
The pattern became more organized during June with a more coherent wave-1 MJO like structure with eastward propagation.

More recently, the pattern became less coherent as other modes of subseasonal tropical variability (e.g., equatorial Rossby and Kelvin wave activity) appear to have become the more dominant signals.

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



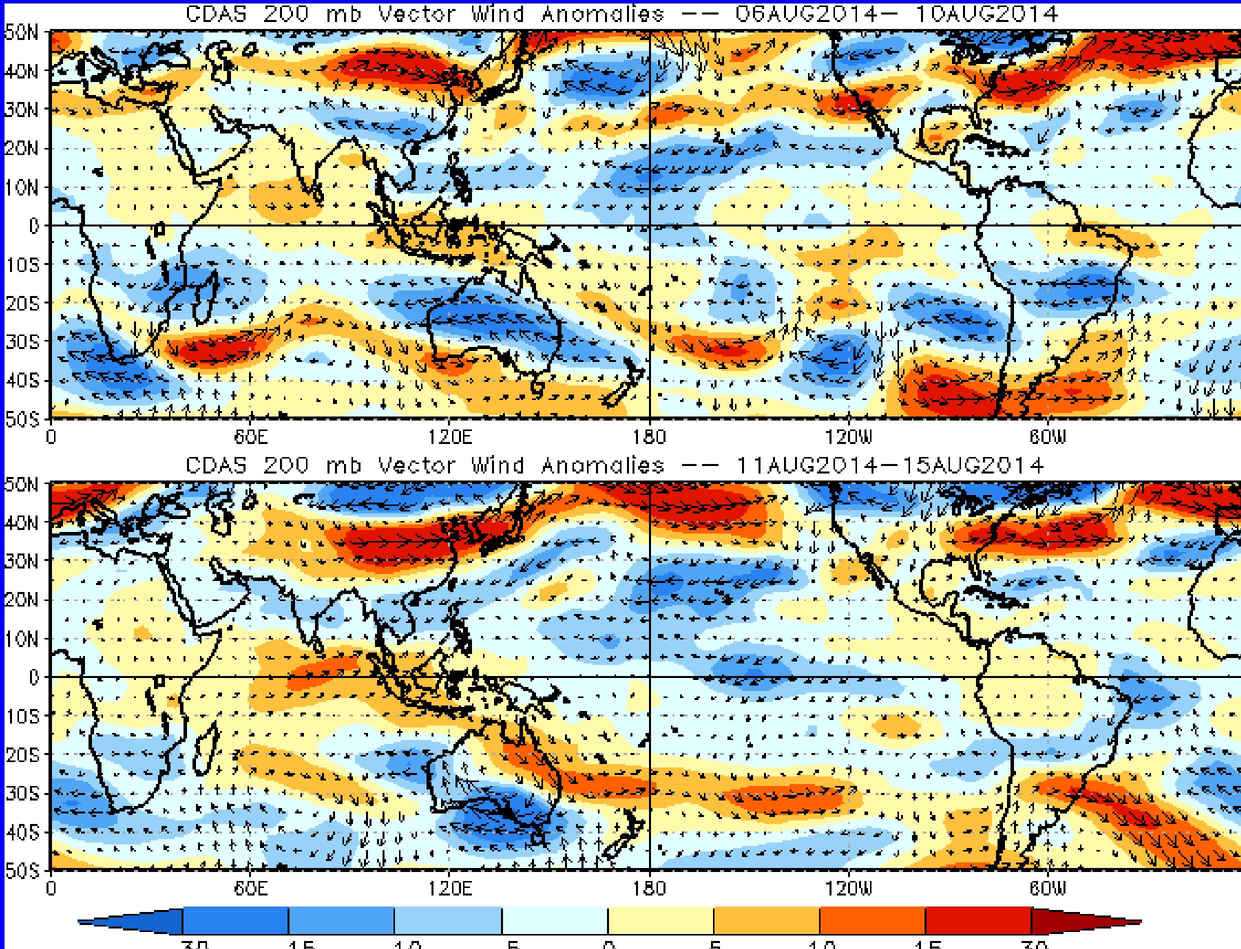
The upper-level anomalous velocity potential spatial pattern indicates broad but discontinuous negative anomalies (green contours) over the eastern Pacific, eastern Atlantic, and Africa, while positive anomalies (brown contours) overspread much of the western and central Pacific.

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



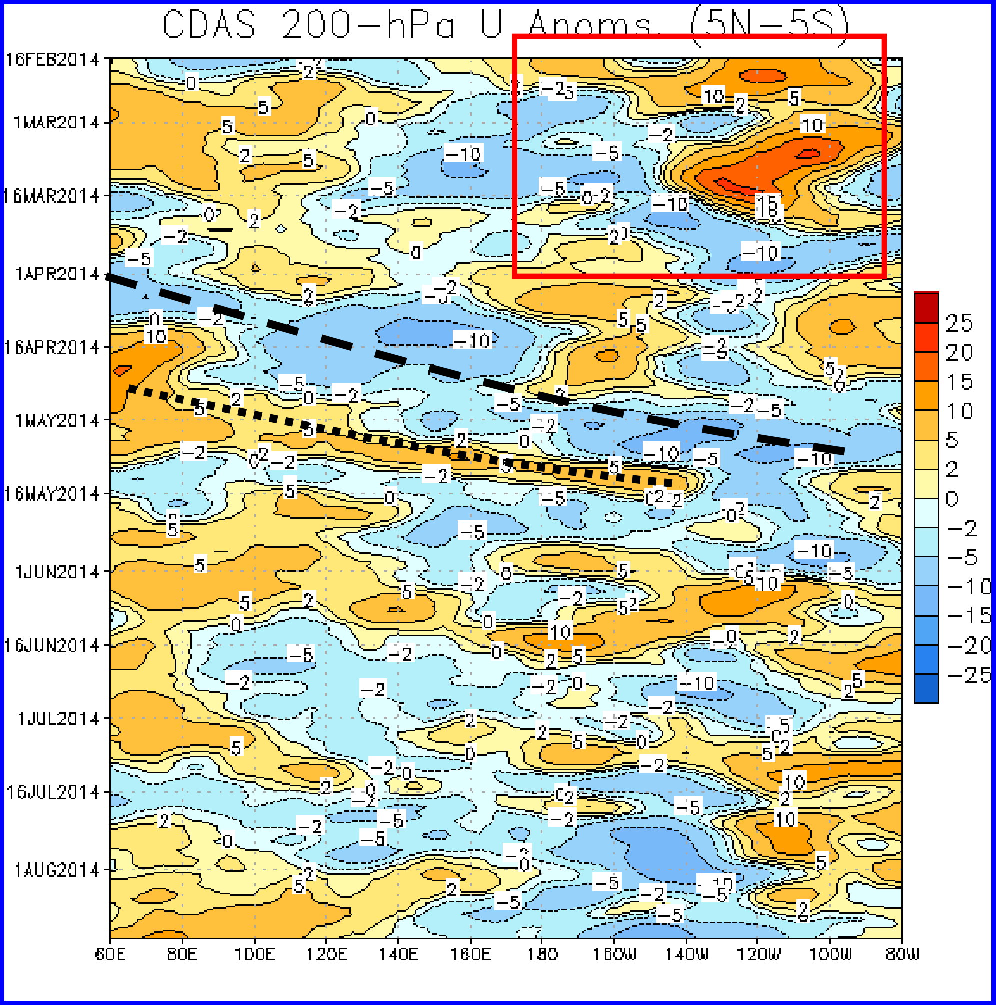
Upper-level westerly (easterly) anomalies over the Indian Ocean (central and eastern Pacific) support large scale suppressed convection over the western Pacific.

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

Time



Longitude

From January into March, westerly anomalies were most prevalent across the western Hemisphere (red box).

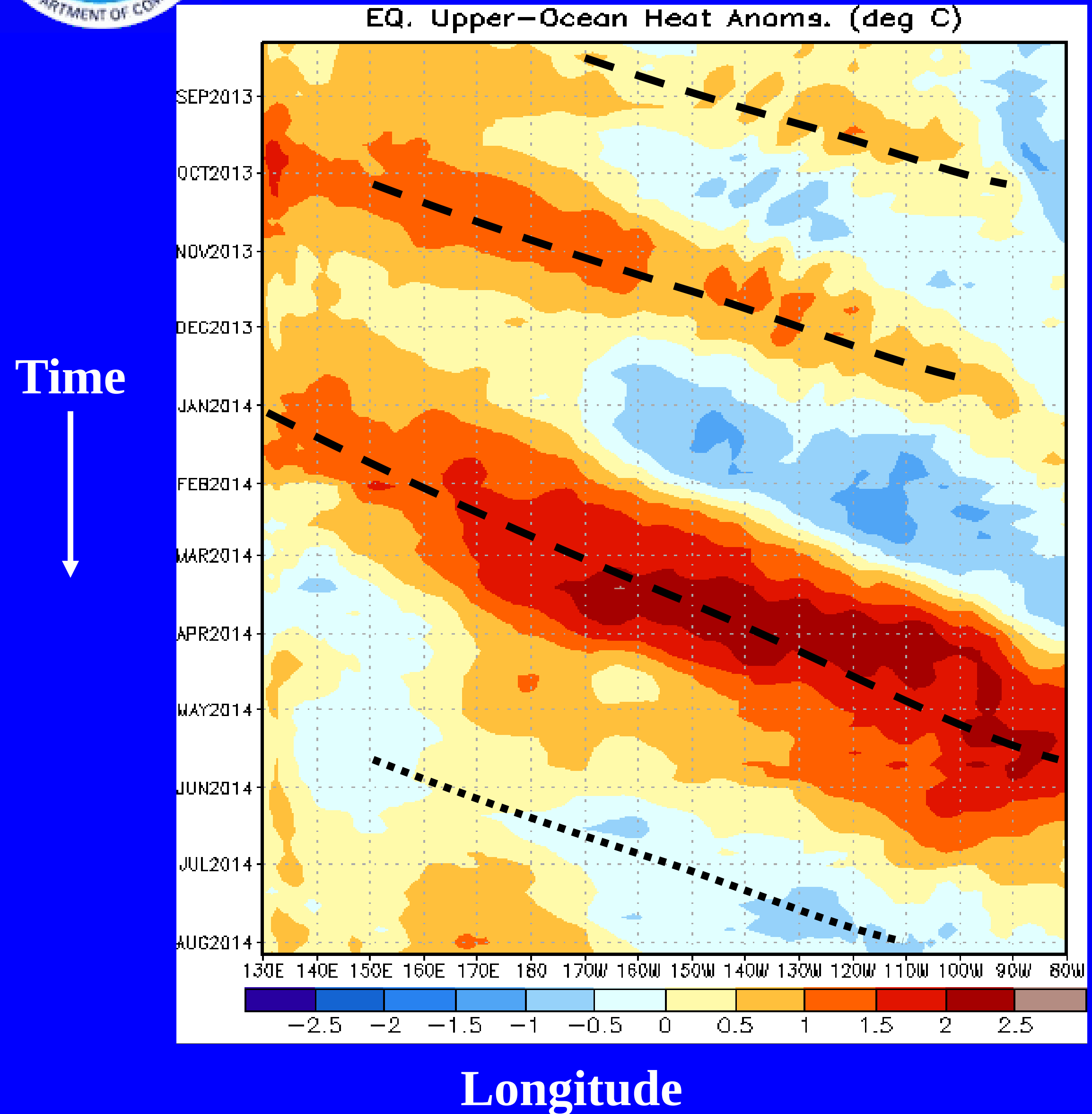
During mid-April, the slowly evolving background state contributed to easterly anomalies expanding to the Date Line.

MJO activity is evident in the eastward propagation of both easterly and westerly anomalies during April and early May. This signal weakened during late May.

Westward propagation of westerly anomalies is evident over the east-central Pacific during June. In July, easterly anomalies intensified over the central and eastern Pacific.

Westward propagation of westerly anomalies was present over the western Pacific and Maritime Continent during early August.

Weekly Heat Content Evolution in the Equatorial Pacific



Oceanic downwelling Kelvin wave activity is evident in late August 2013 and once again during October through early December 2013.

A considerably stronger downwelling event began in January 2014 and propagated across the Pacific.

Warm anomalies persisted over much of the Pacific during April and May, though basin-averaged anomalies decreased during June associated with upwelling Kelvin wave activity (dotted line).

Warm anomalies are again evident near and west of the Date Line.

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).

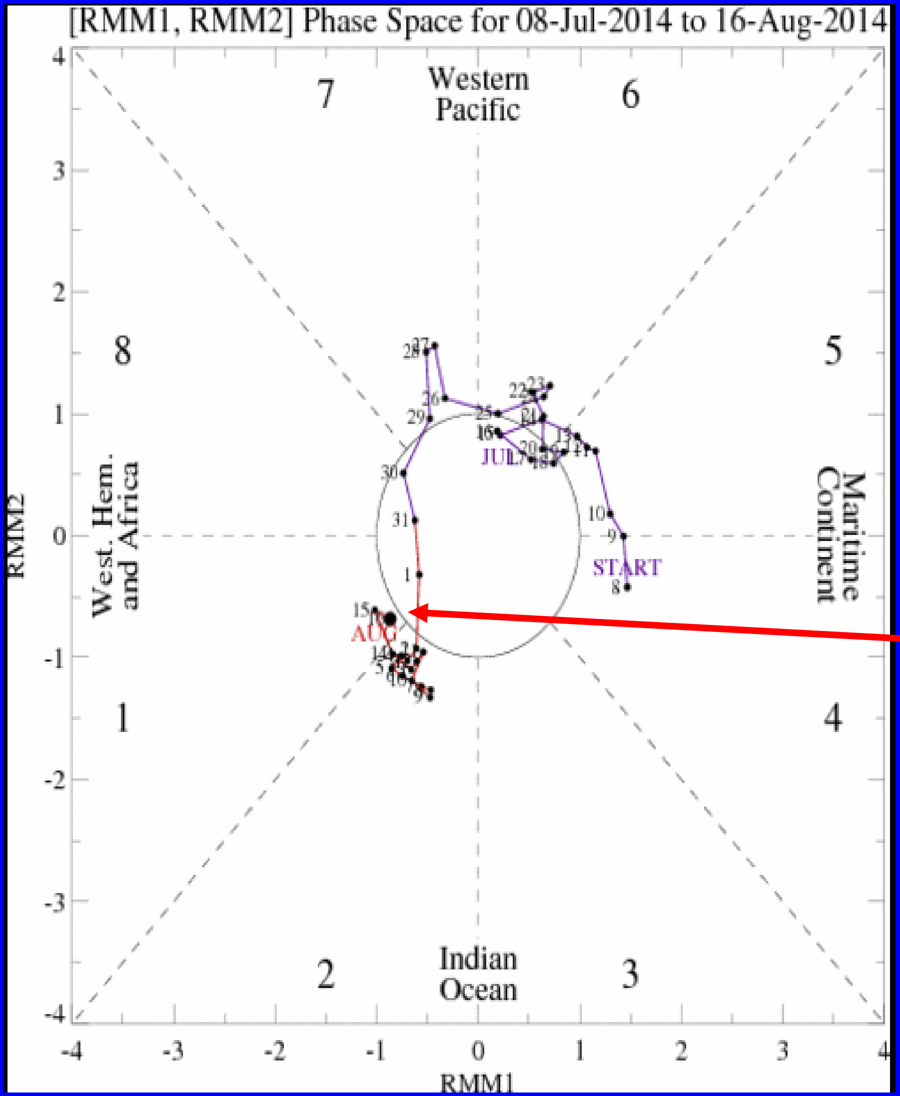
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

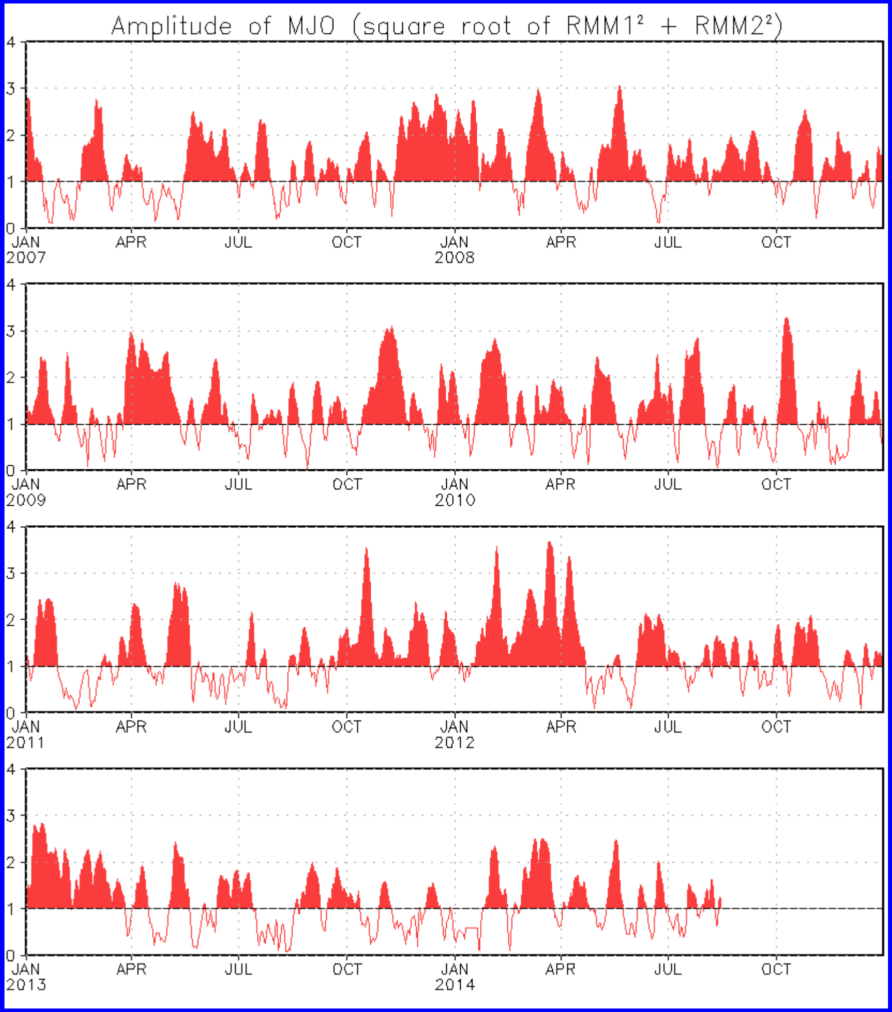
MJO Index -- Recent Evolution



- 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 little coherent MJO activity during the past several weeks. Although values continue to have some amplitude, there has been no clear eastward propagation during August.

MJO Index – Historical Daily Time Series



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

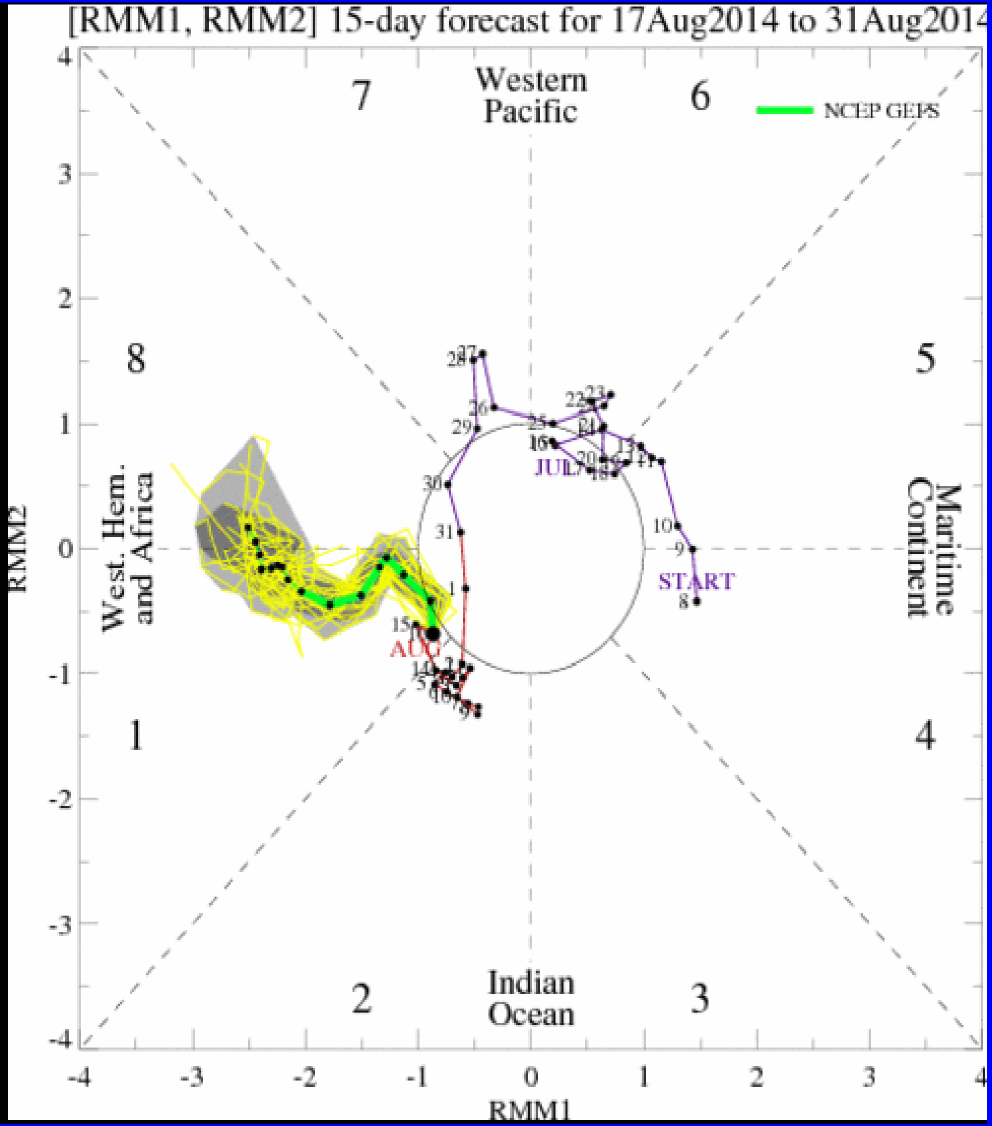
Plot puts current MJO activity in recent historical context.

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

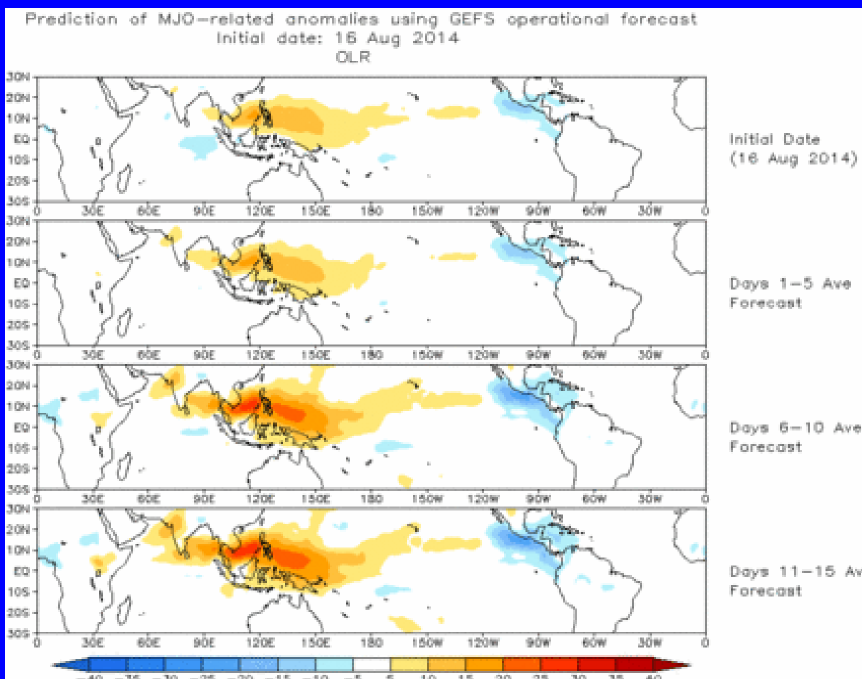


The ensemble GFS forecast indicates increasing amplitude over the Western Hemisphere during the upcoming two weeks, with no eastward propagation of the signal.

Ensemble Mean GFS MJO Forecast

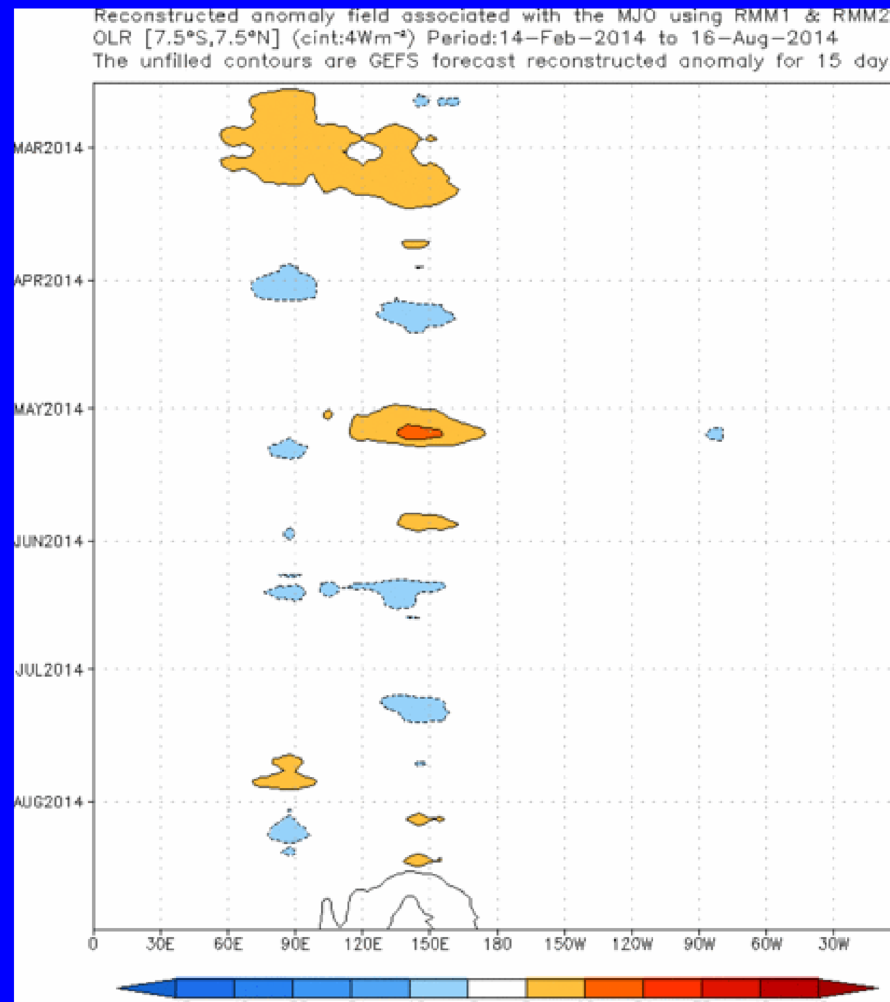
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecasts persistently enhanced (suppressed) convection over the eastern Pacific and western Caribbean (northeastern Indian Ocean, Maritime Continent, and the western Pacific).

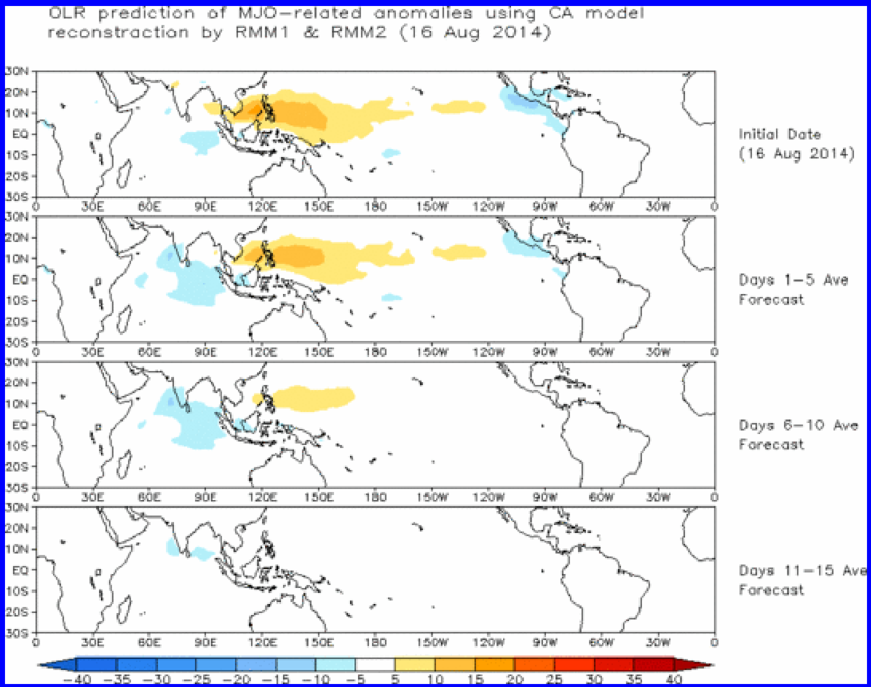
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



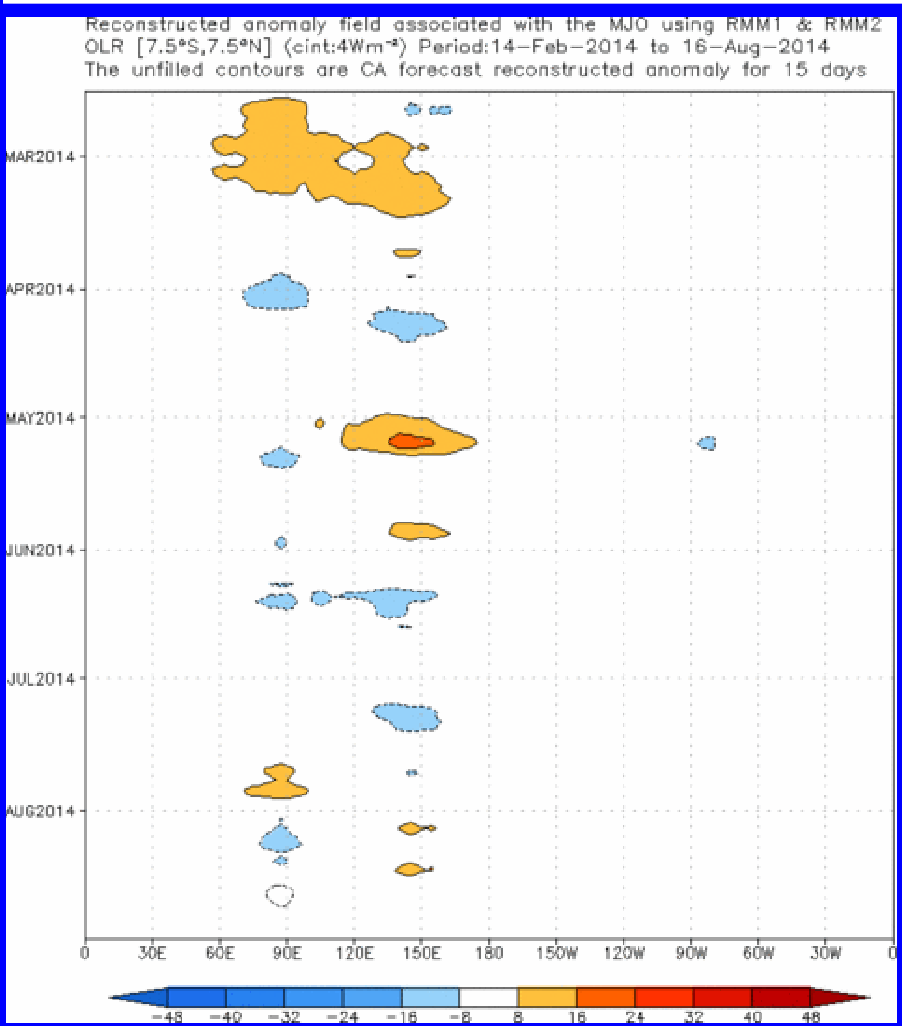
Constructed Analog (CA) MJO Forecast

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



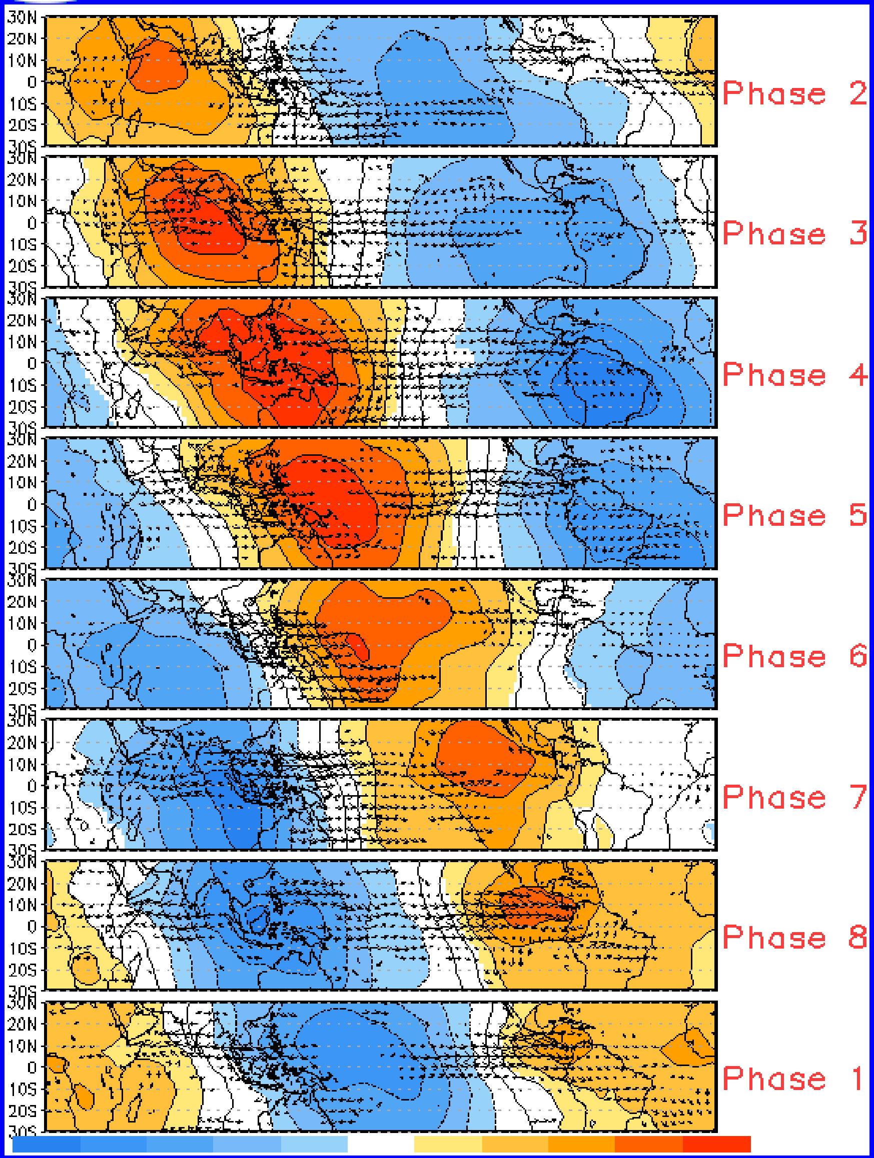
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



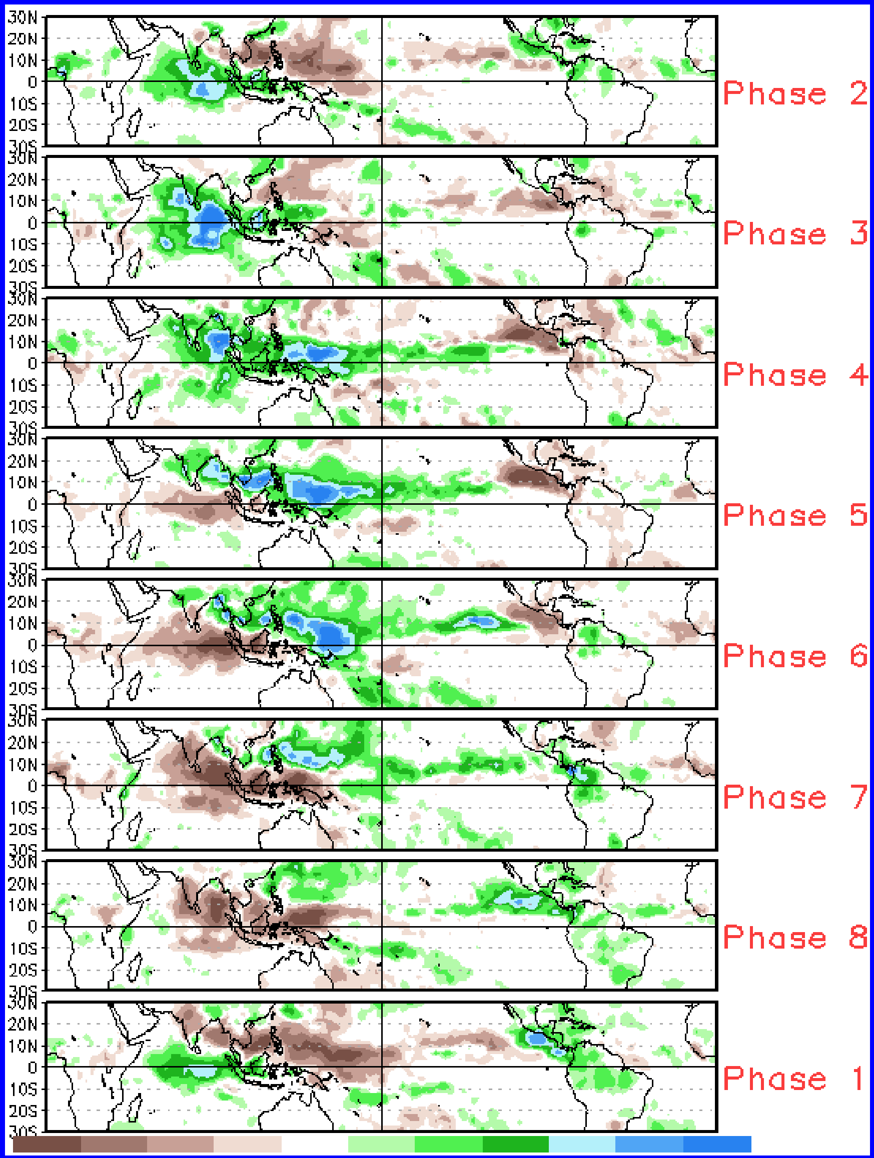
The constructed analog forecast depicts anomalous convection over the Indian Ocean and Americas and suppressed convection over the western Pacific, with a decaying signal in all areas by Week-2.

MJO Composites – Global Tropics

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



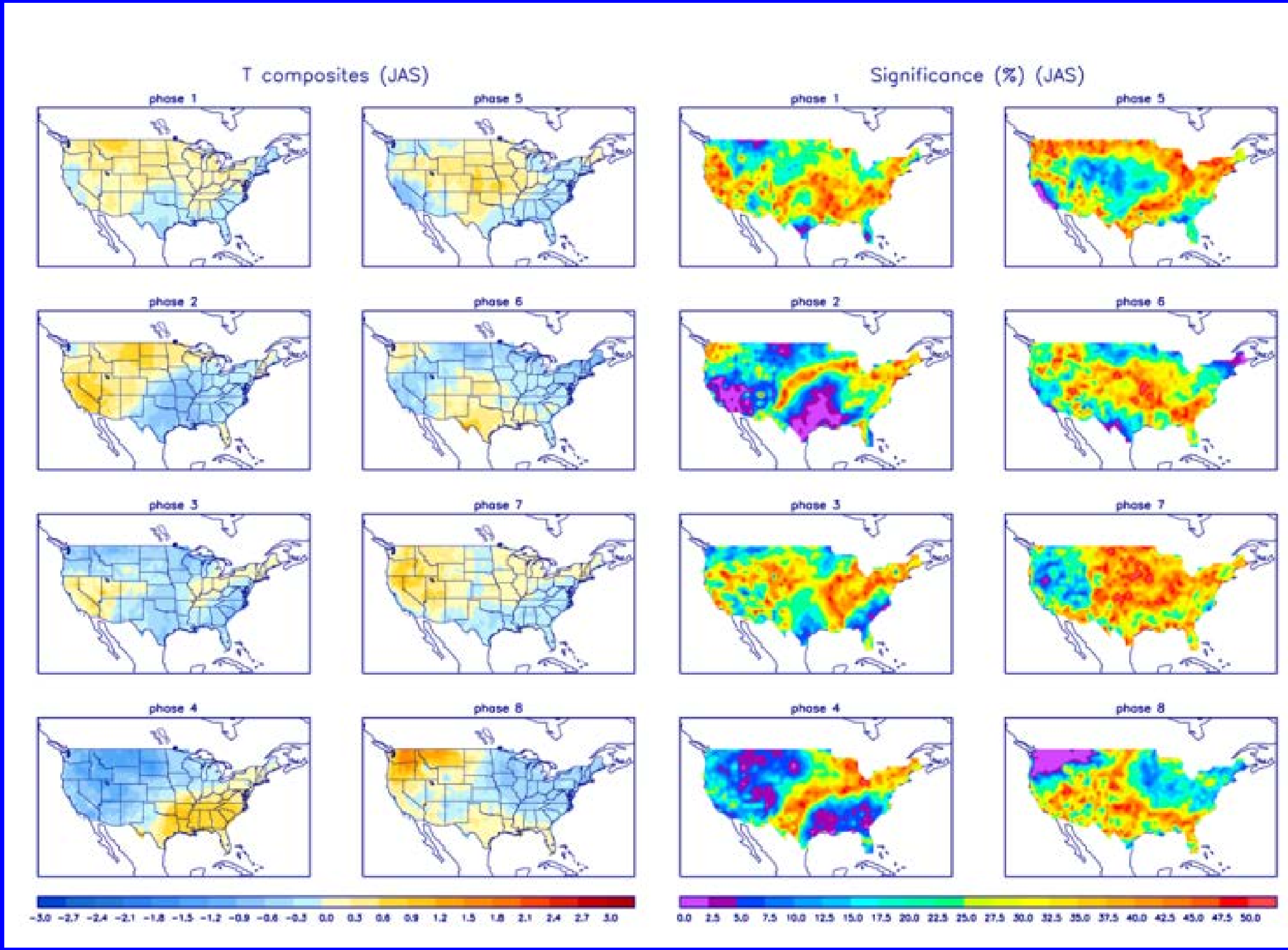
Precipitation Anomalies (May-Sep)



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.

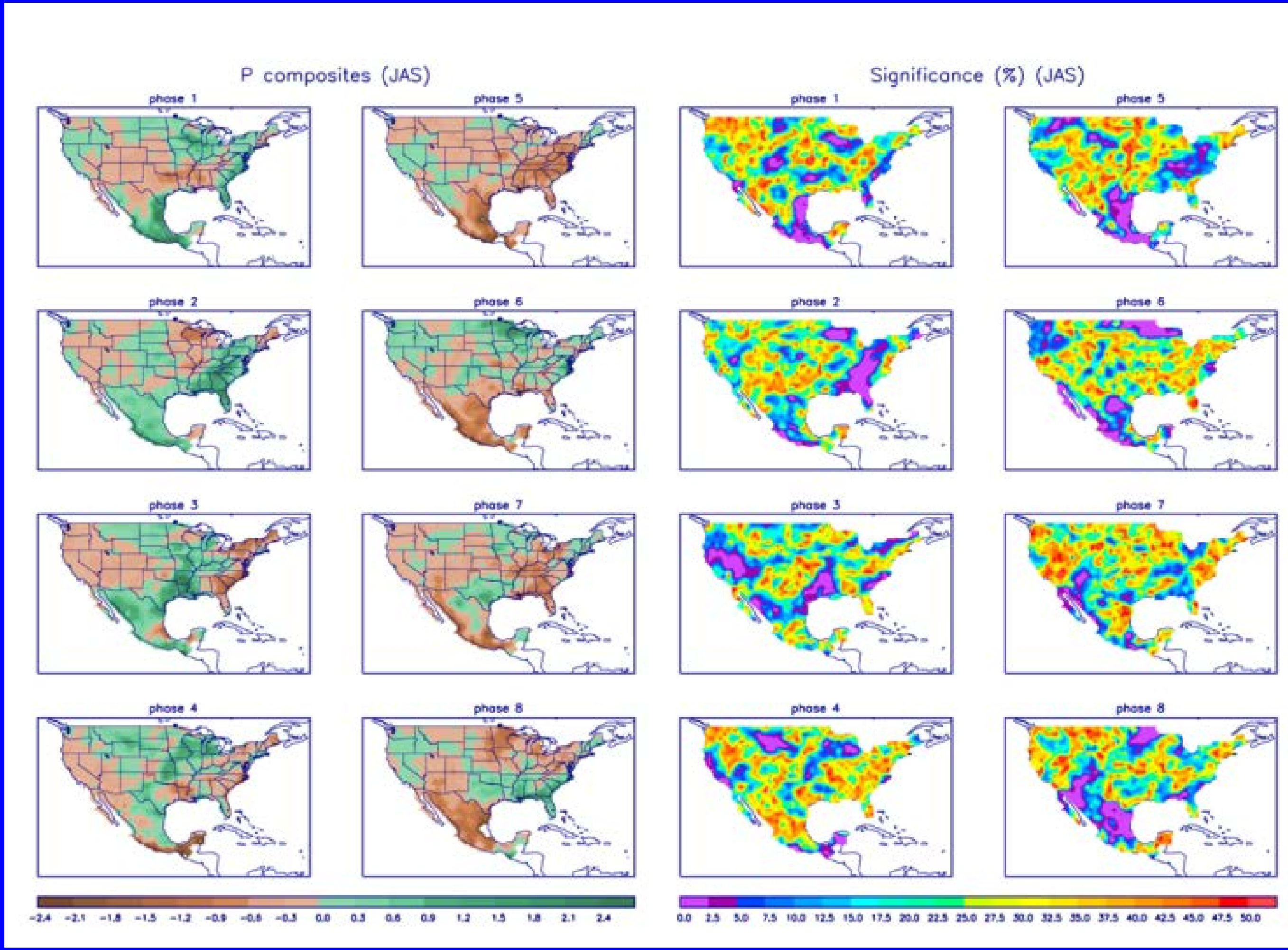


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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