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

Update prepared by
Climate Prediction Center / NCEP
September 15, 2014

Outline

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

Overview

- The MJO remained weak with only the upper-levels consistent with robust MJO activity. MJO indices indicate the enhanced (suppressed) phase propagating over the Western Hemisphere (Maritime Continent).

- Other types of subseasonal variability, including tropical cyclones and Kelvin Waves, continue to play a large role in determining the pattern of anomalous tropical convection.

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

- Based on recent observations and model guidance, the MJO, although subject to considerable interference from other modes, may contribute to enhanced convection over the Americas and Africa.

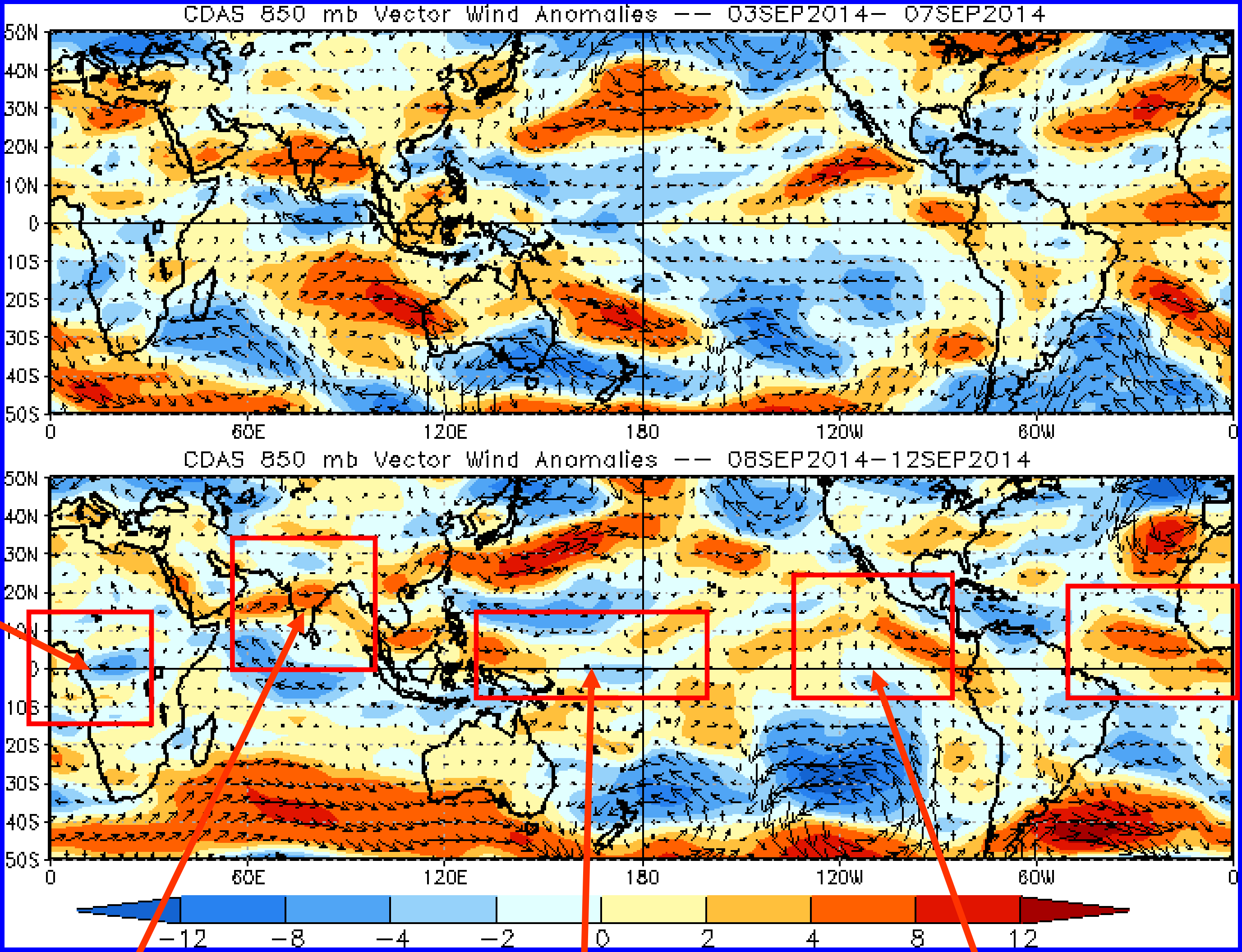
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 Africa.

Enhanced monsoon flow continued over South Asia.

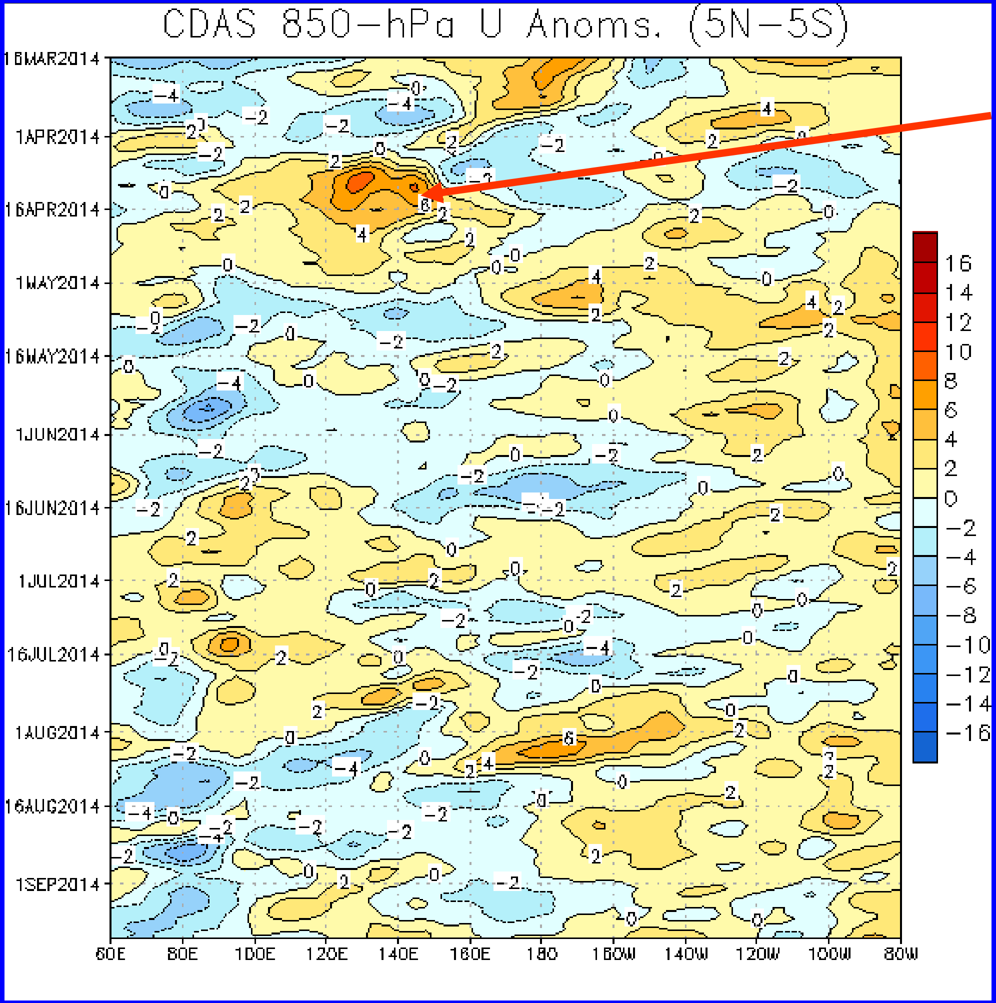
Easterly anomalies diminished near the Date Line, with westerly anomalies increasing near the Maritime Continent.

Off –equator westerly anomalies diminished slightly over the eastern Pacific, with weak anomalies on the equator.

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

A westerly wind burst was observed across the western Pacific in mid-April.

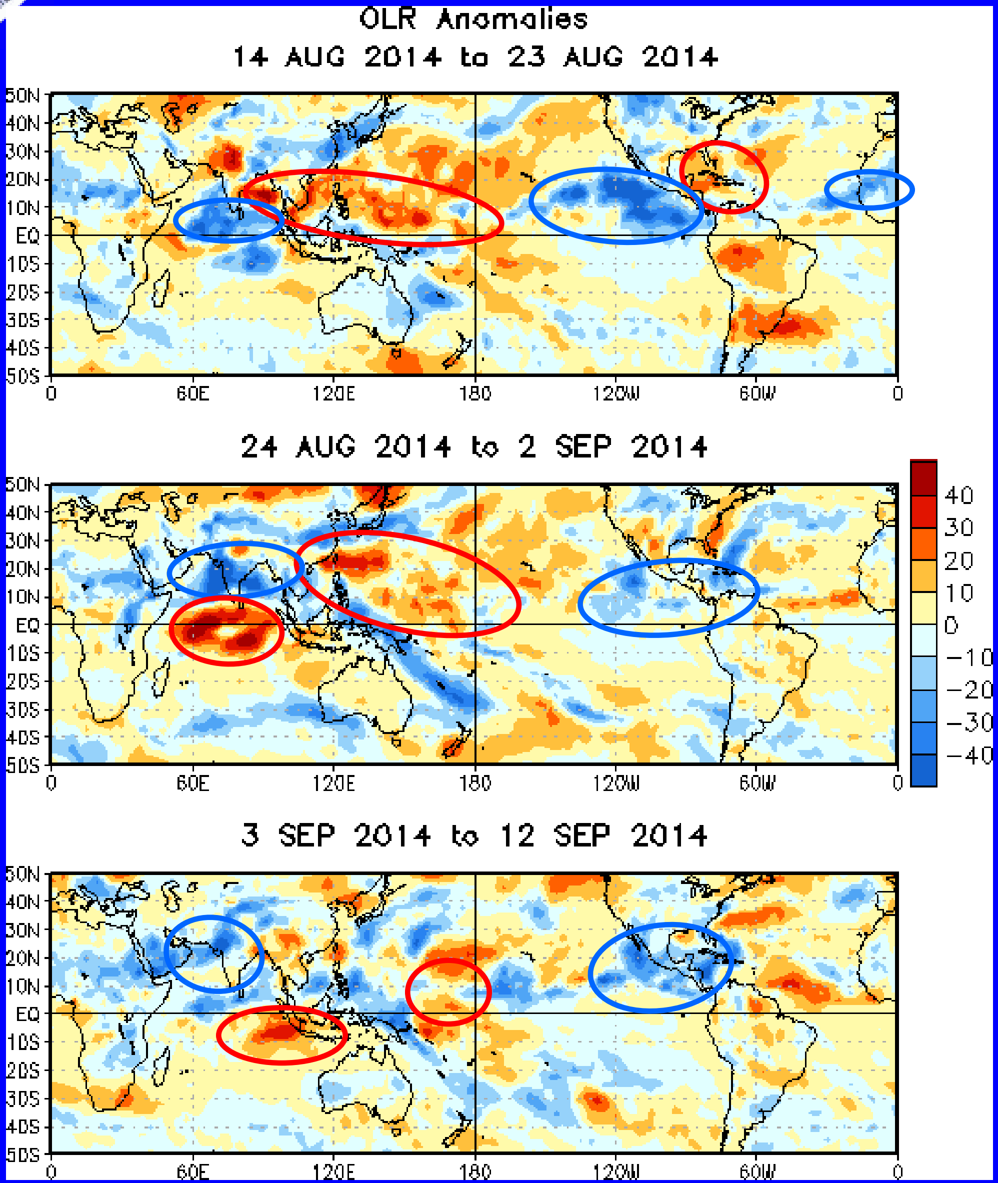
During April, westerly anomalies were generally persistent across the Maritime continent and far western Pacific.

During much of May and June, westerly anomalies were observed over the eastern Pacific. Westerly anomalies associated with an enhanced South Asian monsoon circulation 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).

Recently, westerly anomalies are present from 100 to 140E. A break in the westerly anomalies was measured near 110W, with westerly anomalies across the remainder of the Eastern 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)

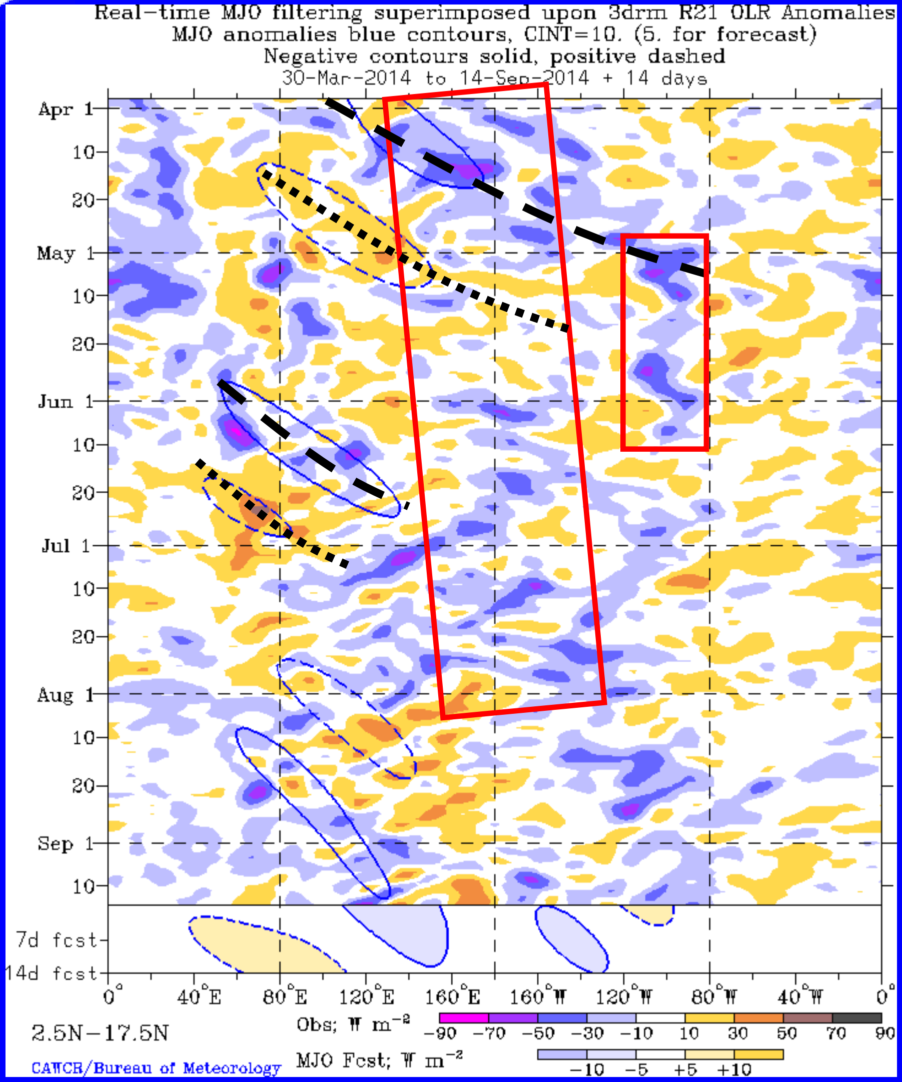
During mid August, enhanced (suppressed) convection was observed over the central Indian Ocean (northwestern and west-central Pacific). Tropical cyclone activity was evident over the eastern Pacific.

From late August to early September, enhanced (suppressed) convection shifted northward to India (northwestern Pacific). Enhanced convection, partly associated with tropical cyclone activity, spread across the eastern Pacific and western Atlantic.

During early September, enhanced convection propagated northward over South Asia, with suppressed convection overspreading the southwest Maritime Continent. Convective anomalies weakened across the central Pacific, with tropical cyclone activity evident over the eastern Pacific.

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

Time



Longitude

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 March, enhanced convection has propagated slowly eastward from the Maritime Continent to the central Pacific (red box).

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 the pattern became less coherent with respect to canonical MJO activity through August.

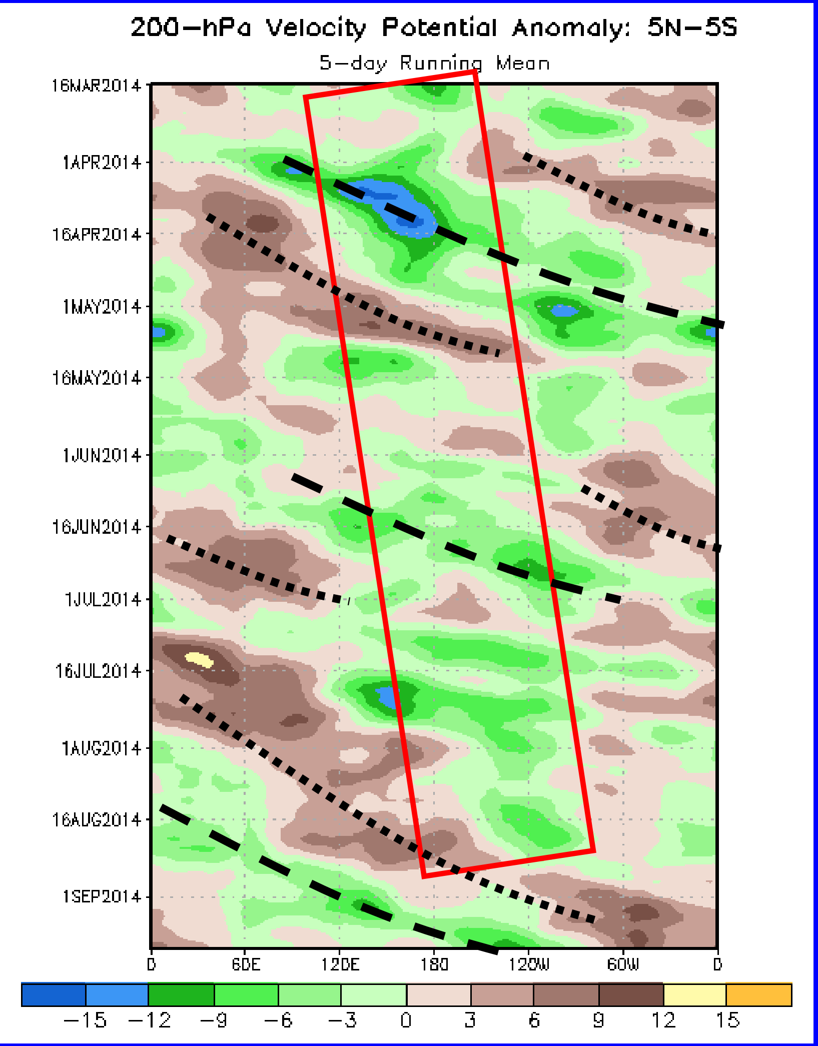
There is evidence of westward-moving subseasonal variability from mid-August and later, as well as an eastward-moving envelope of suppressed convection just west of the Date Line.

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 March 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.

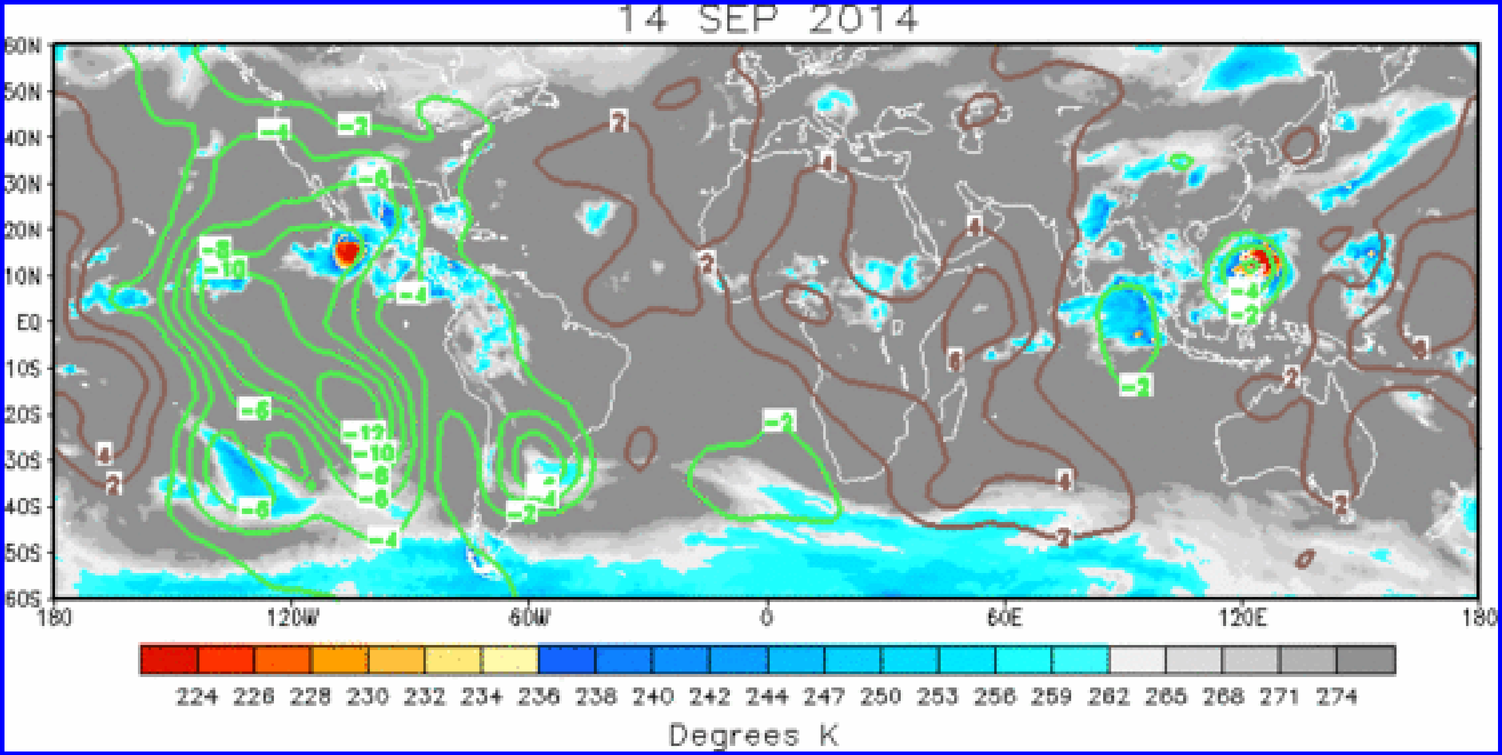
The pattern became less coherent during July and August as other modes of subseasonal tropical variability, e.g., equatorial Rossby and Kelvin wave activity, became the more dominant signals.

More recently, the signal strengthened with some eastward propagation over the Pacific.

IR Temperatures (K) / 200-hPa Velocity Potential Anomalies

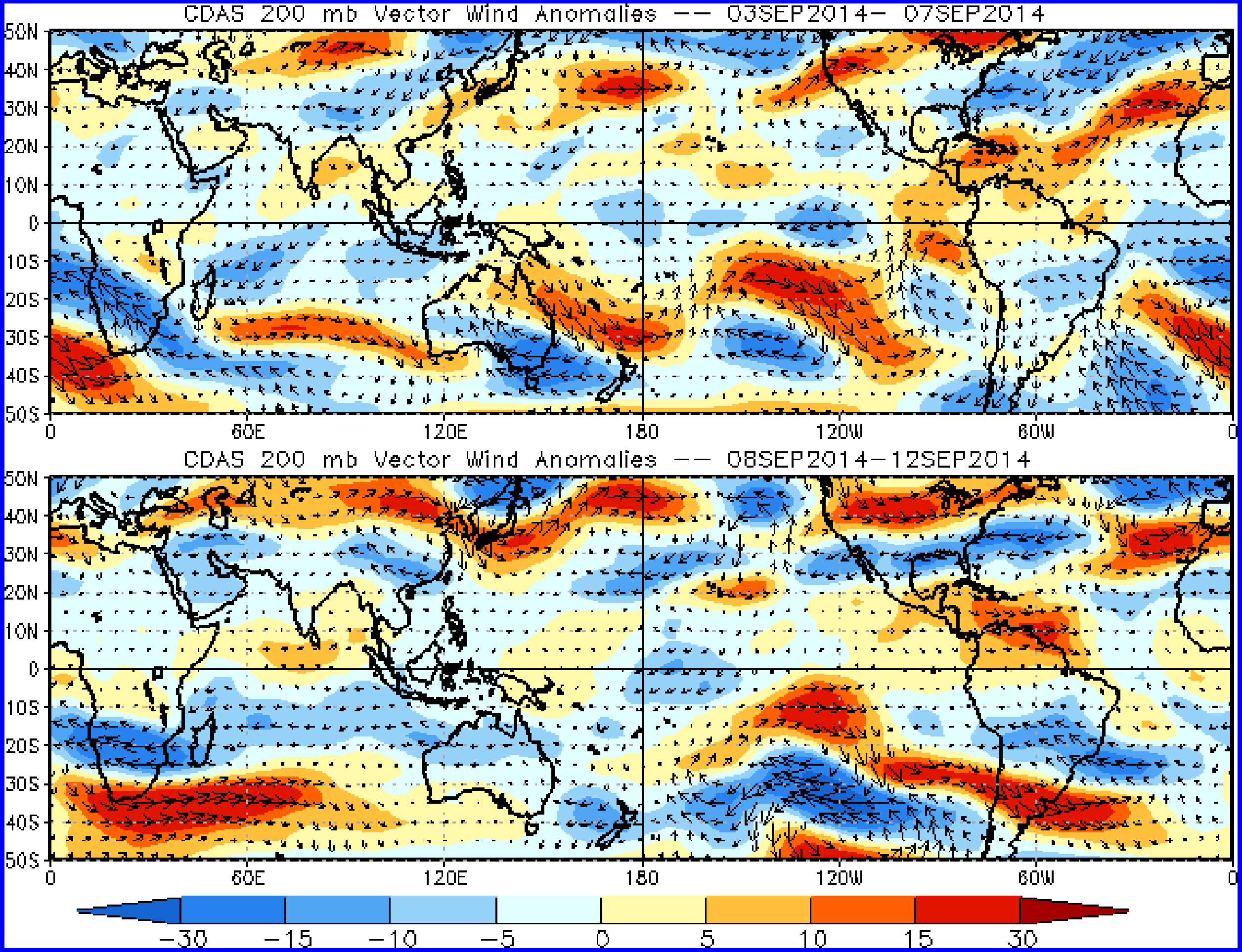
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The upper-level anomalous velocity potential spatial pattern exhibits a wave-1 structure, with large scale negative (positive) anomalies over the East Pacific (Africa). Smaller scale anomalies exist over the Indian Ocean and western North 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

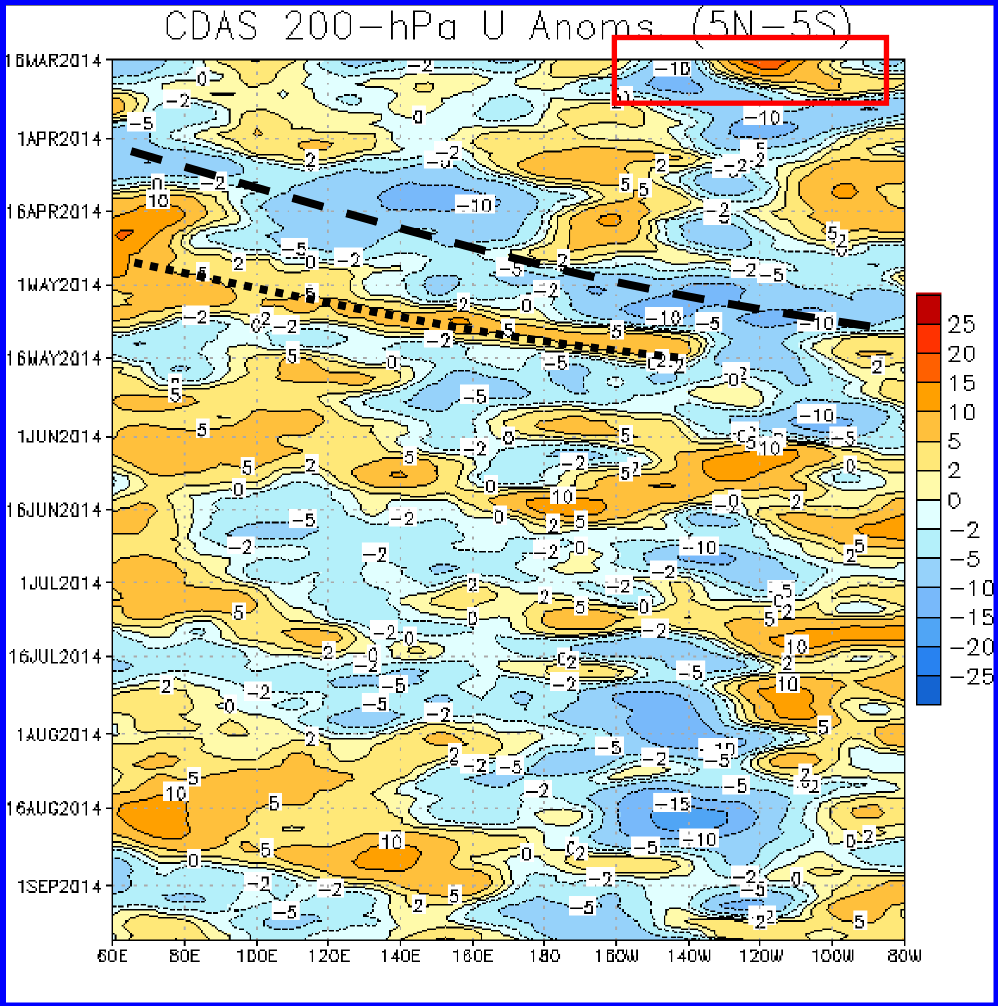
The upper level zonal wind anomalies remained generally weak along the equator, with weak easterly anomalies near the Date Line, and enhanced westerly anomalies over the Caribbean.

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

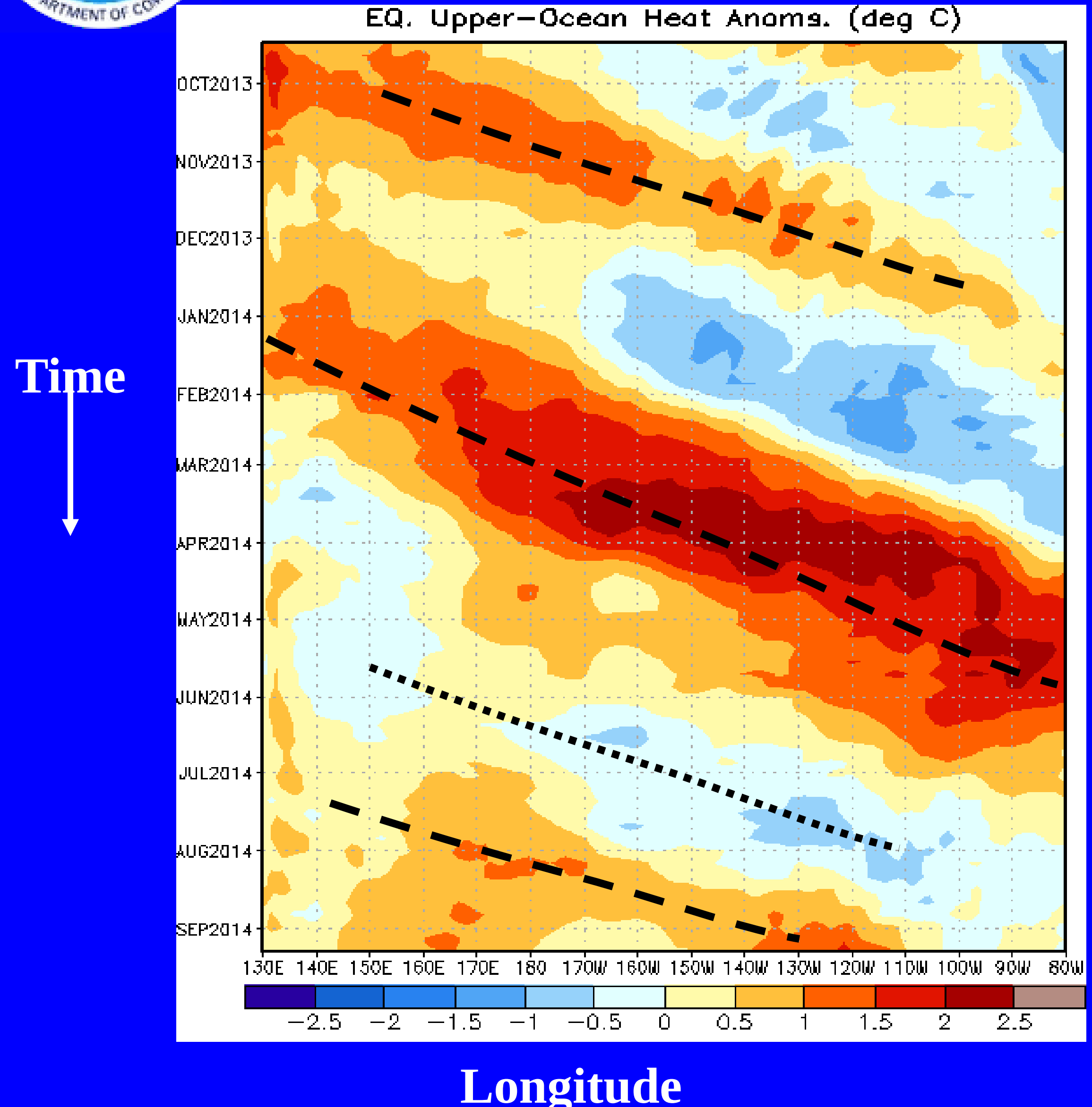
In March, westerly anomalies were most prevalent across the western Hemisphere (red box).

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.

A slow, eastward progression of westerly anomalies is evident over the Maritime Continent and western Pacific during August. More recently, easterly anomalies have developed near 170W, with westerly anomalies east of 135W.

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 across much of the Pacific due to another downwelling Kelvin wave.

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).

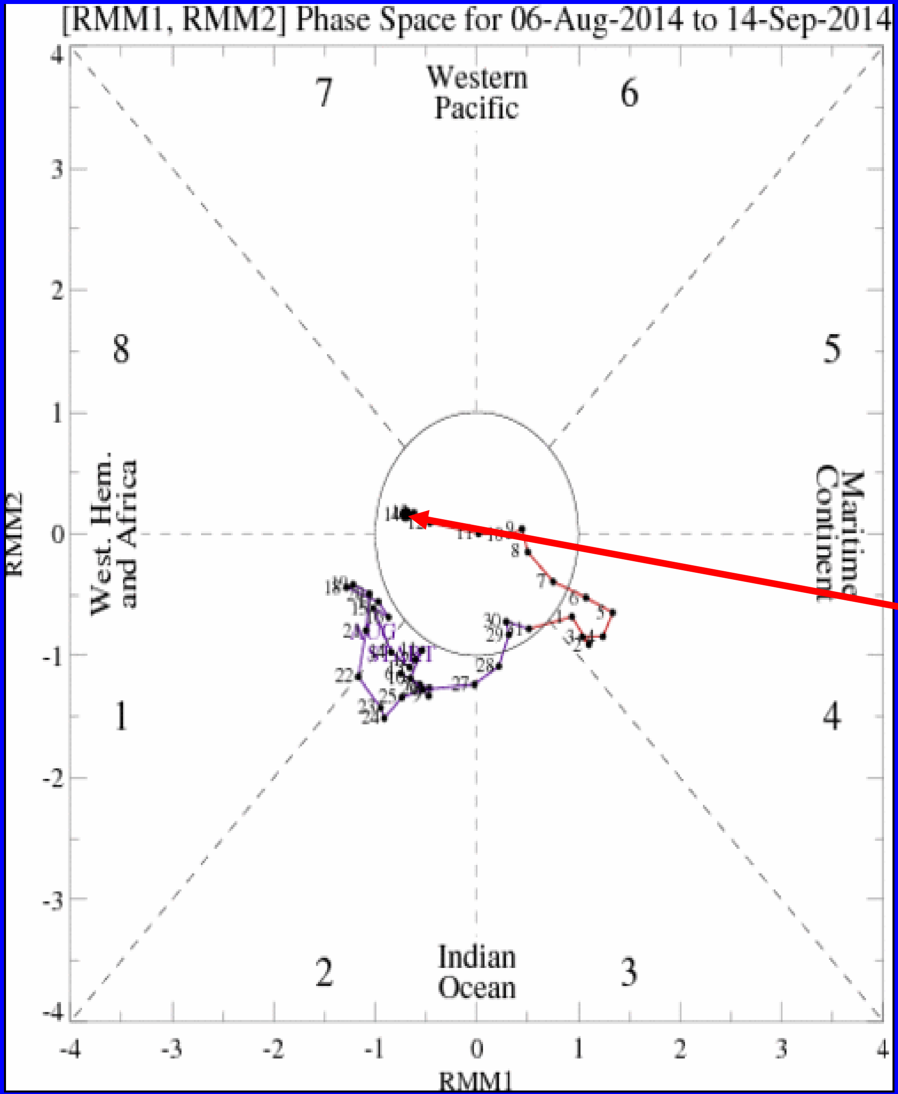
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

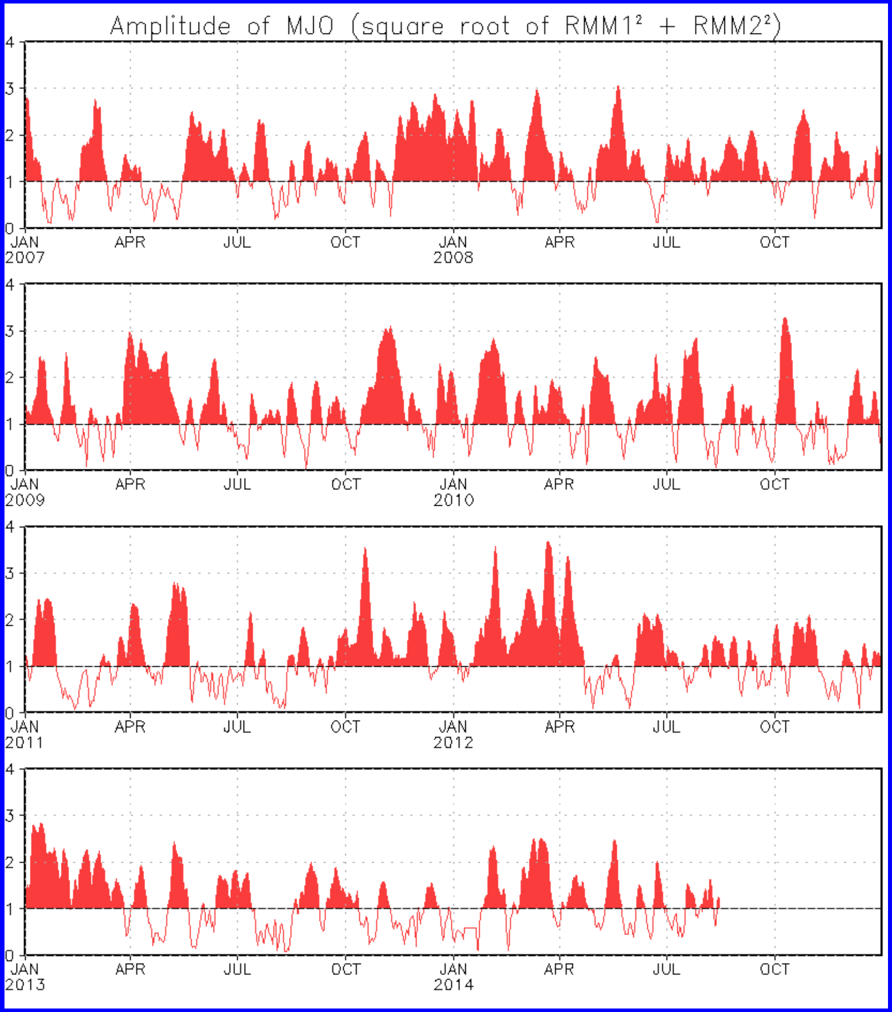
MJO Index -- Recent Evolution



- 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 MJO index indicates a shift in the center of convection from the Maritime Continent to the East Pacific. The signal is not consistent with robust 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.

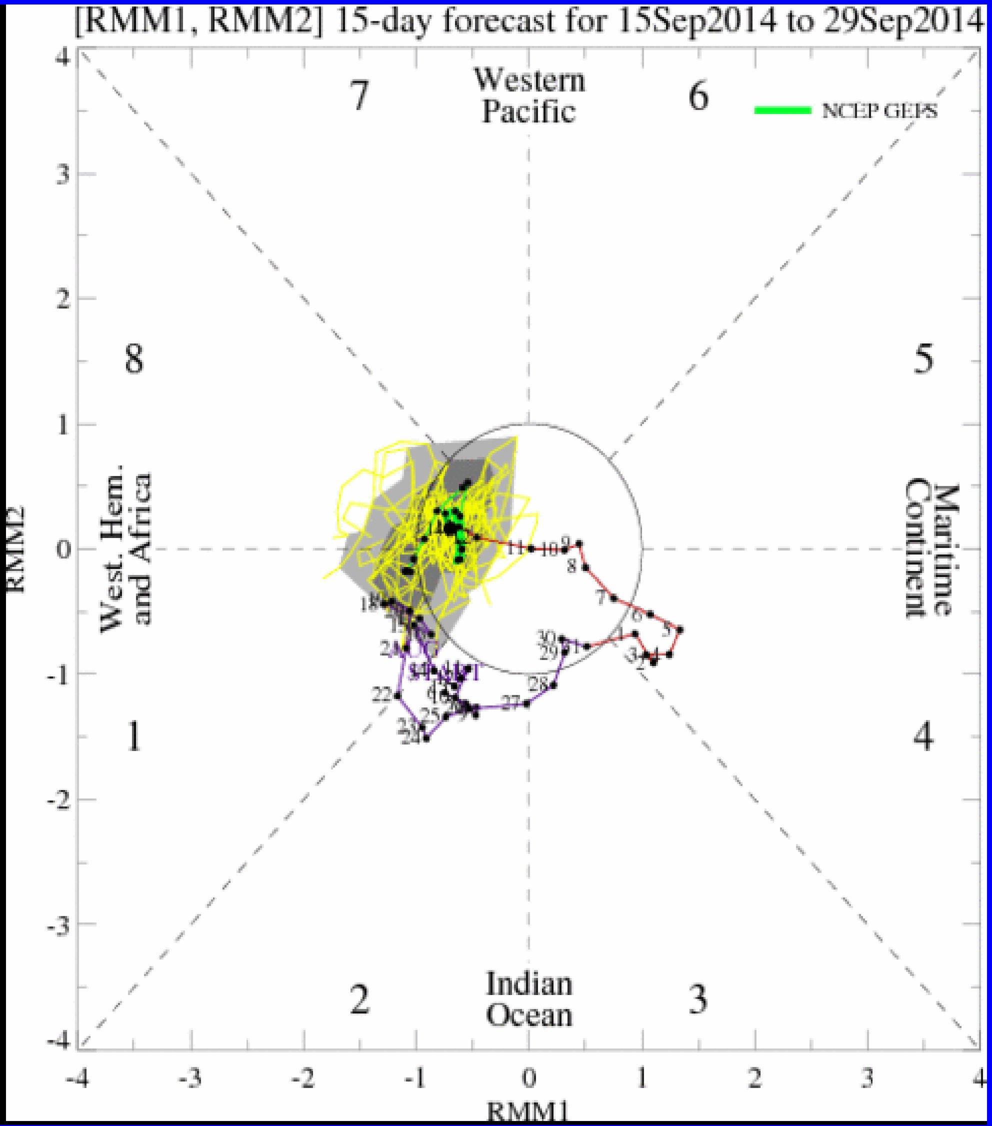
Ensemble GFS (GEFS) MJO Forecast

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

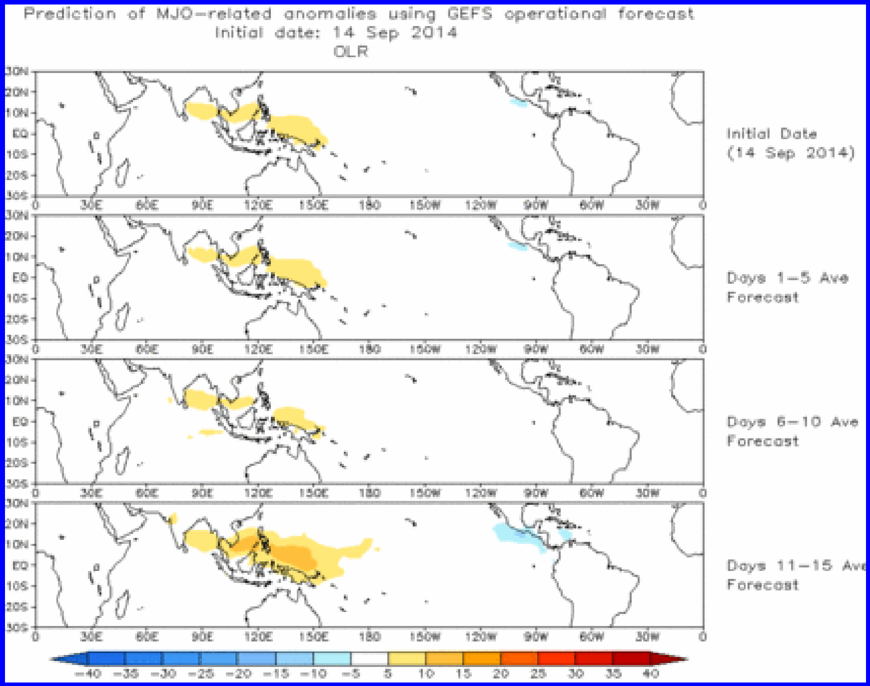
The ensemble GFS forecast indicates a weak MJO signal during the upcoming two weeks.



Ensemble Mean GFS MJO Forecast

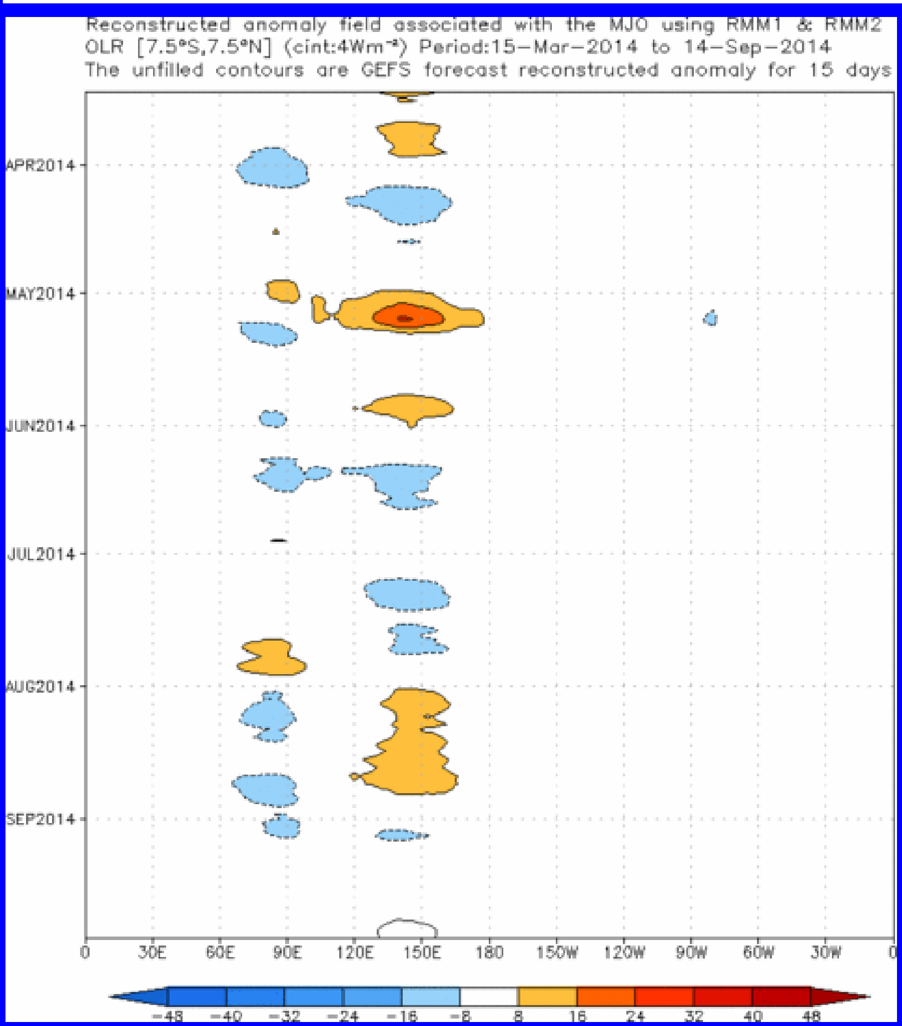
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecasts a weak and stagnant anomaly pattern during the upcoming two weeks.

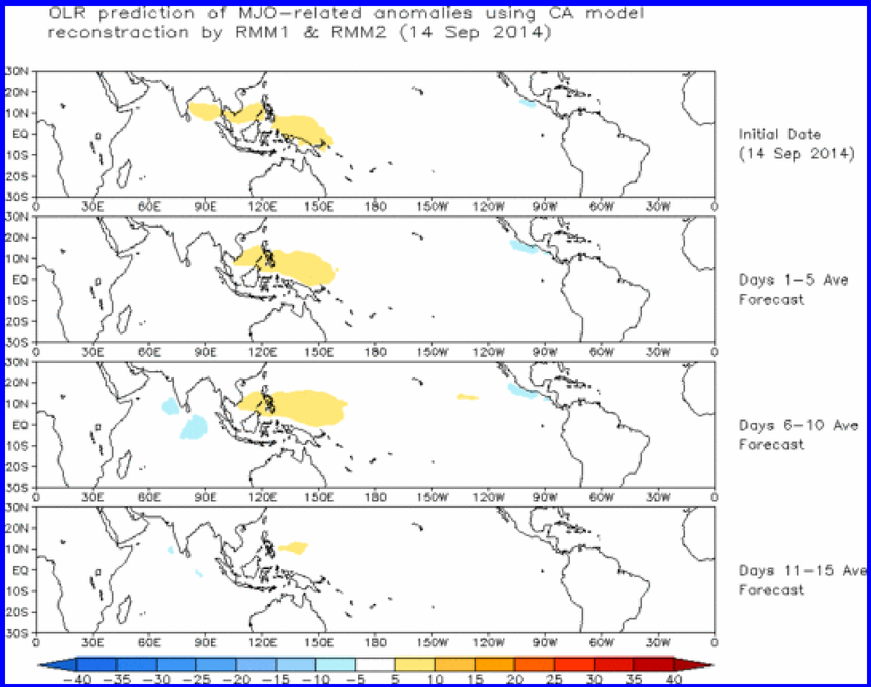
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



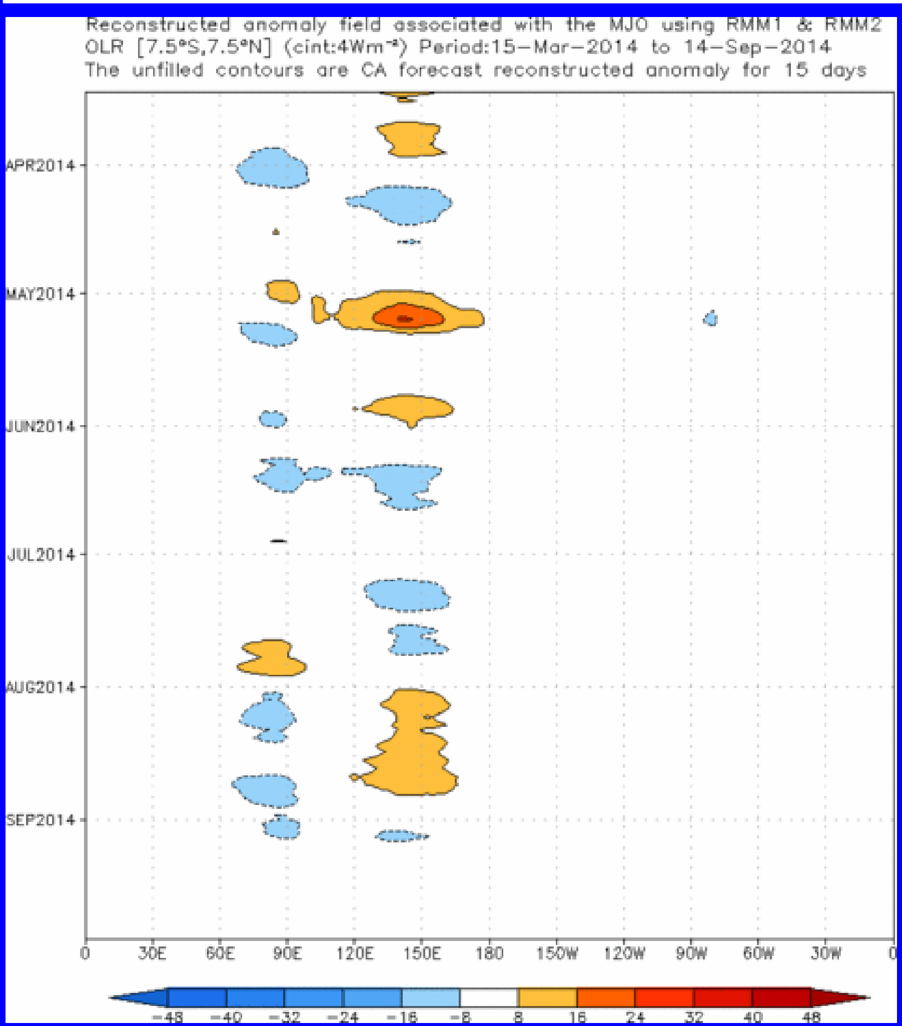
Constructed Analog (CA) MJO Forecast

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



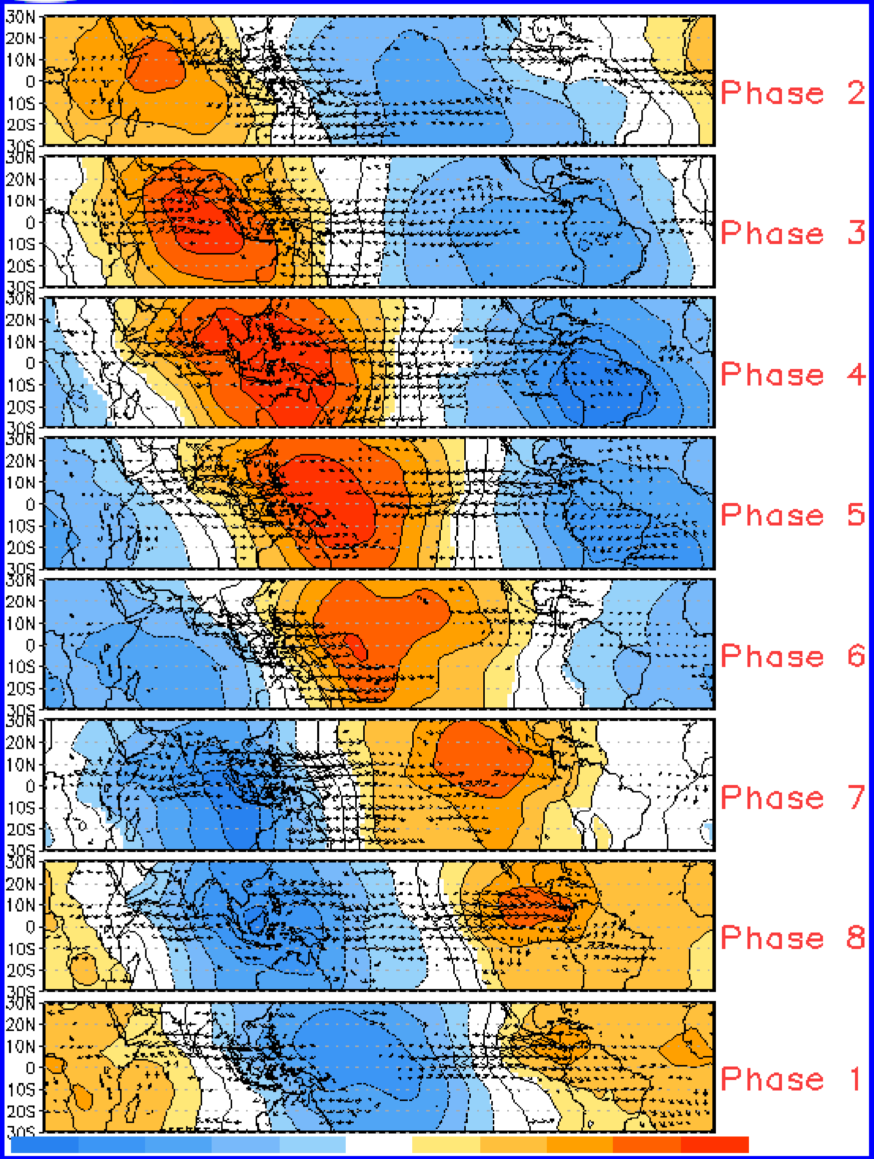
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



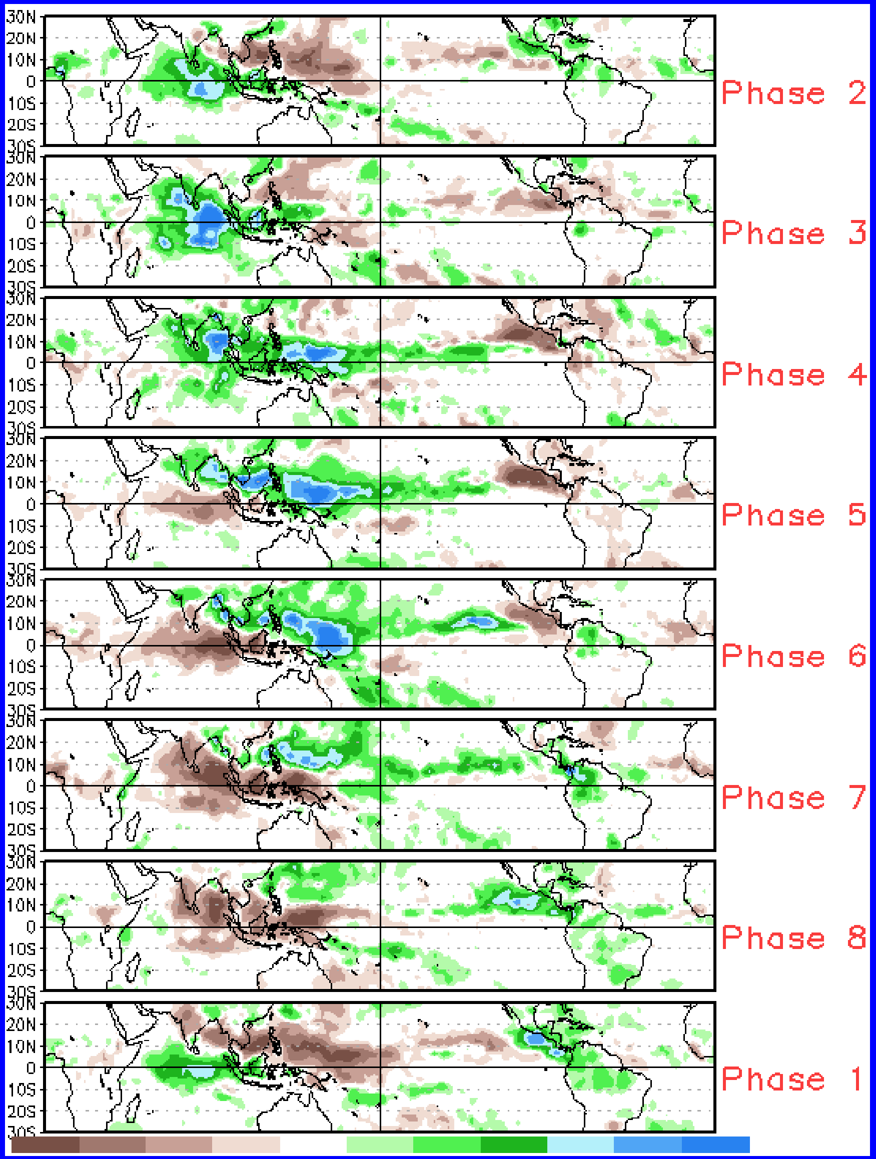
The constructed analog forecast depicts a weak pattern and some eastward propagation, with enhanced (suppressed) convection over the eastern Pacific (western Pacific). Anomalies dampen out by week-2.

MJO Composites – Global Tropics

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



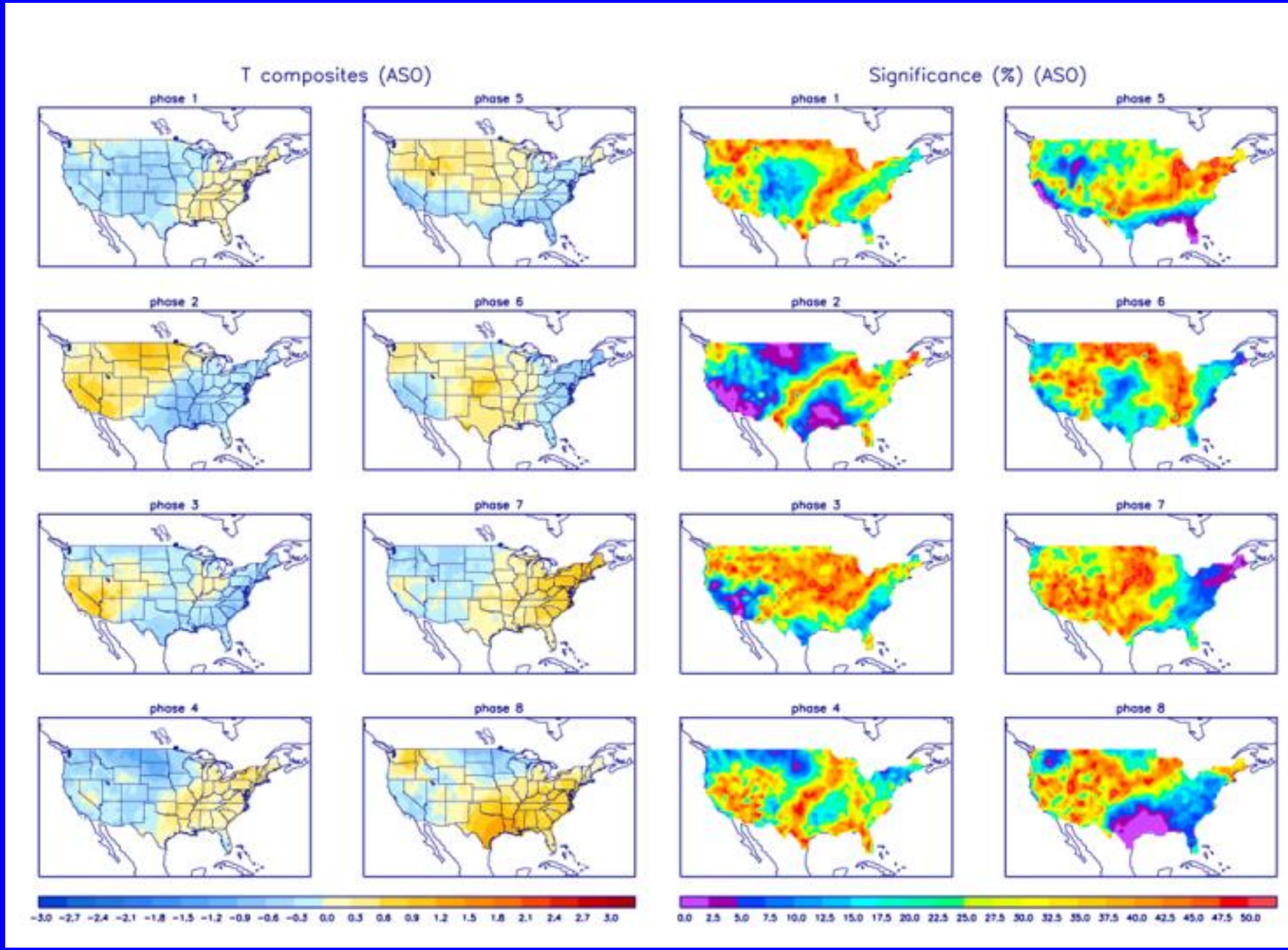
Precipitation Anomalies (May-Sep)



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.

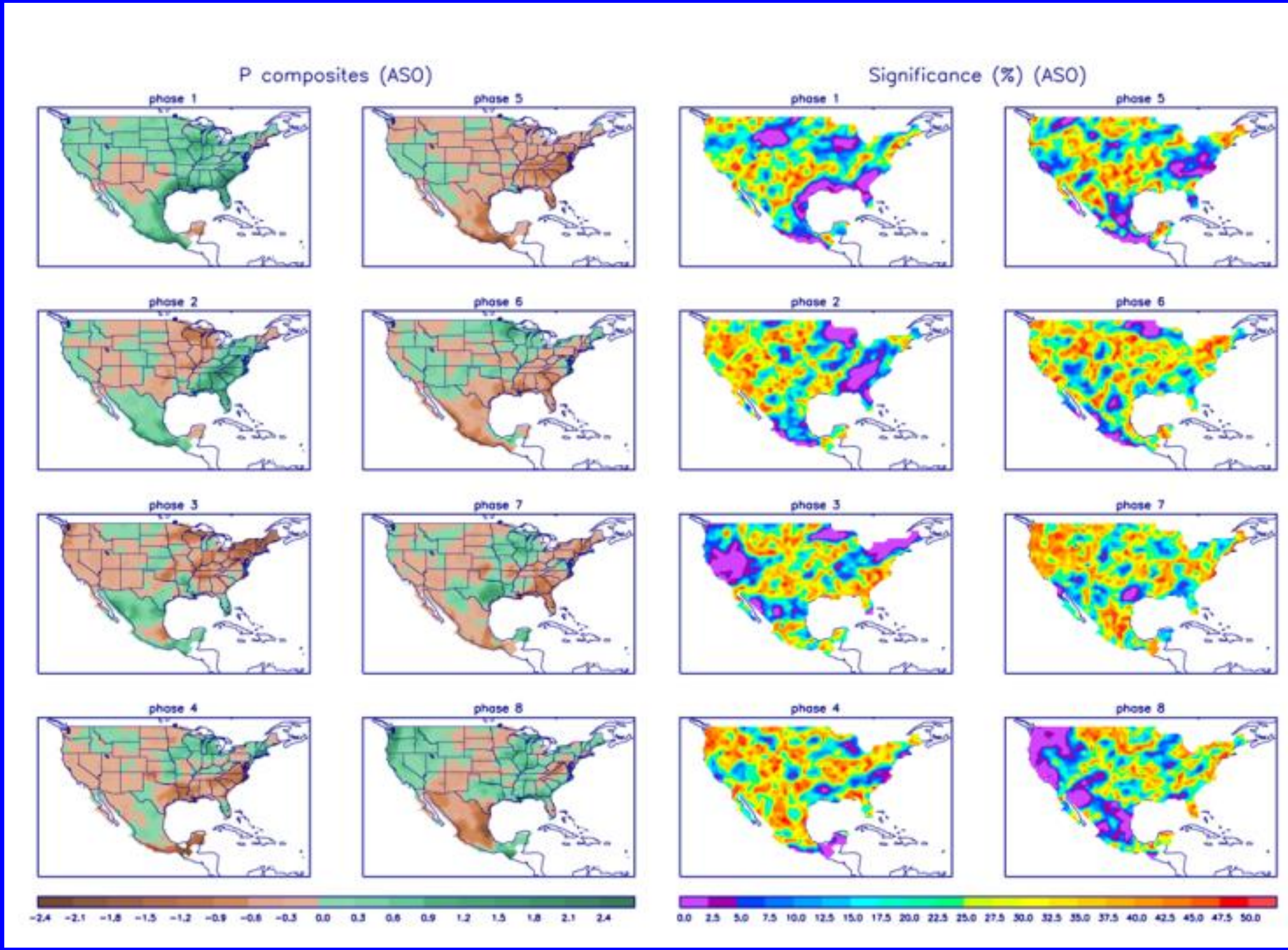


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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.



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