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

Update prepared by
Climate Prediction Center / NCEP
September 2, 2013

Outline

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

Overview

- The MJO signal strengthened during the previous week, with the convectively active phase over the Western Hemisphere.

- Dynamical model MJO forecasts indicate a weakening MJO signal during the upcoming week, with some strengthening of the convective signal over the Maritime Continent or western Pacific possible late in the Week-2 period.

- Based on recent observations and statistical forecasts, the MJO is forecast to have a continuing impact on the global tropical convective pattern, with increasing influence from other modes of tropical intraseasonal variability.

- Tropical cyclone formation is possible over the central Atlantic and the Bay of Campeche during Week-1, with increasing odds for cyclogenesis over the Atlantic main development region (MDR) later in the week and during Week-2. Tropical cyclone formation is likely over the eastern Pacific during Week-1, with additional cyclone development possible in Week-2.

- Enhanced convection is favored over the eastern Indian Ocean and the North American Monsoon region during Week-1, while suppressed convection is possible over the western Pacific. Enhanced convection is anticipated over the Maritime Continent during Week-2, with a continued active North American Monsoon pattern.

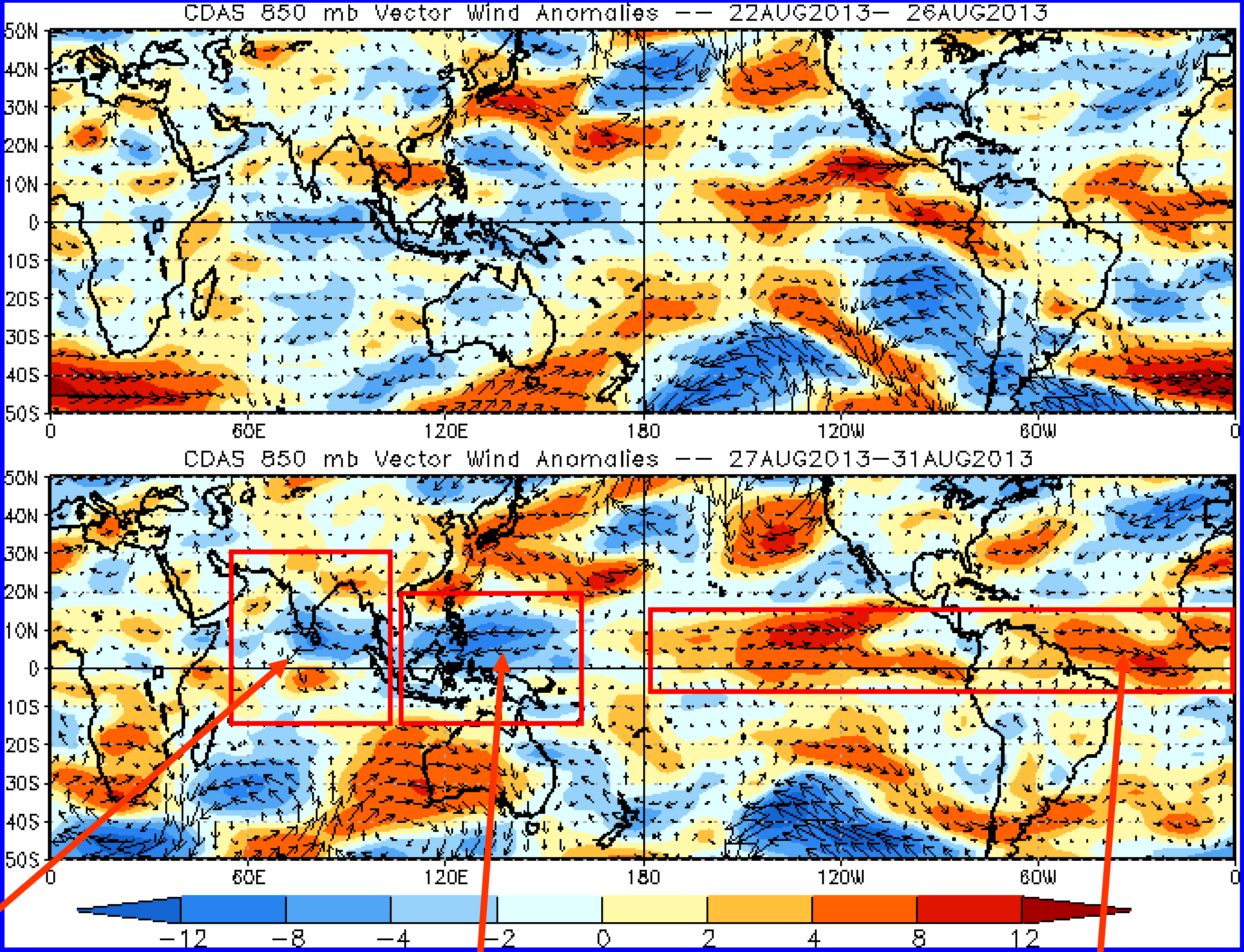
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Low level zonal easterly wind anomalies shifted northward from the equatorial Indian Ocean to southern Asia and the Bay of Bengal.

Easterly anomalies increased over the western North Pacific and the Maritime Continent.

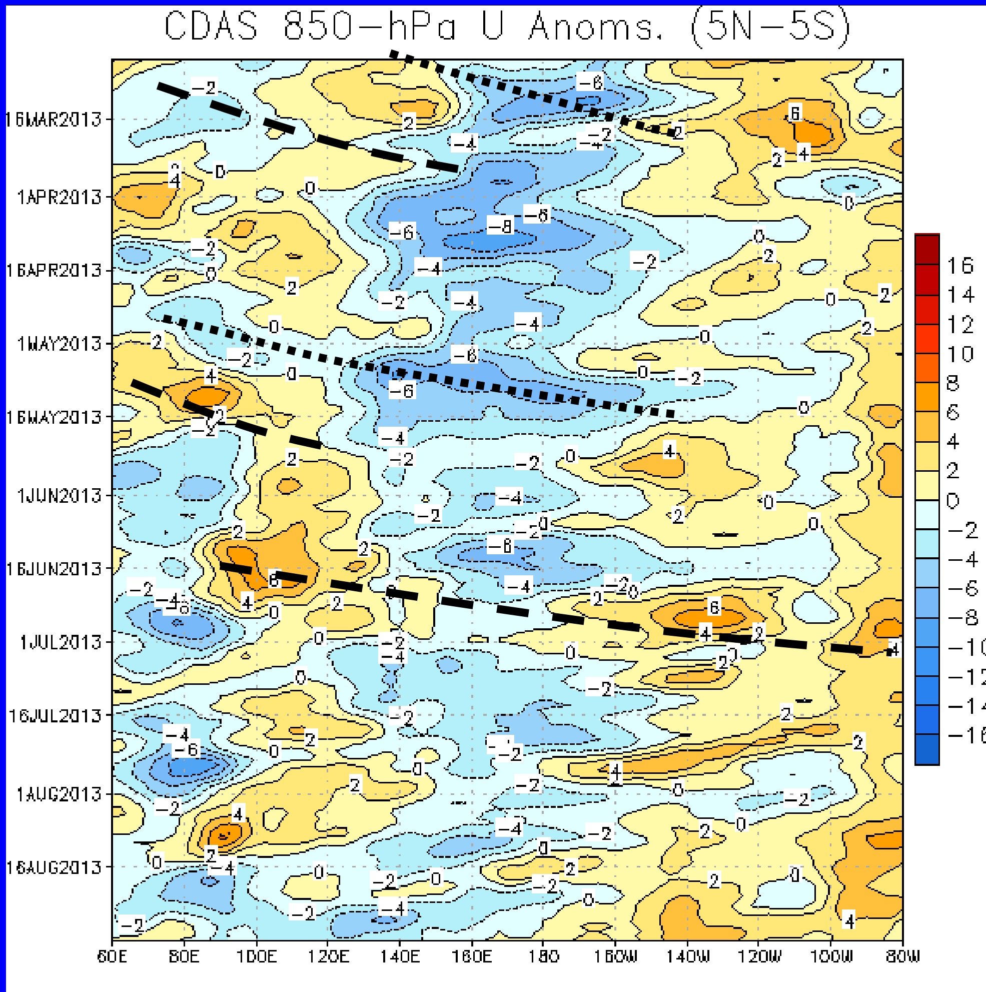
Westerly anomalies expanded over the eastern Pacific and the Atlantic basins.

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

During April, anomalies indicate signs of being influenced by equatorial Rossby wave activity with less eastward propagation evident.

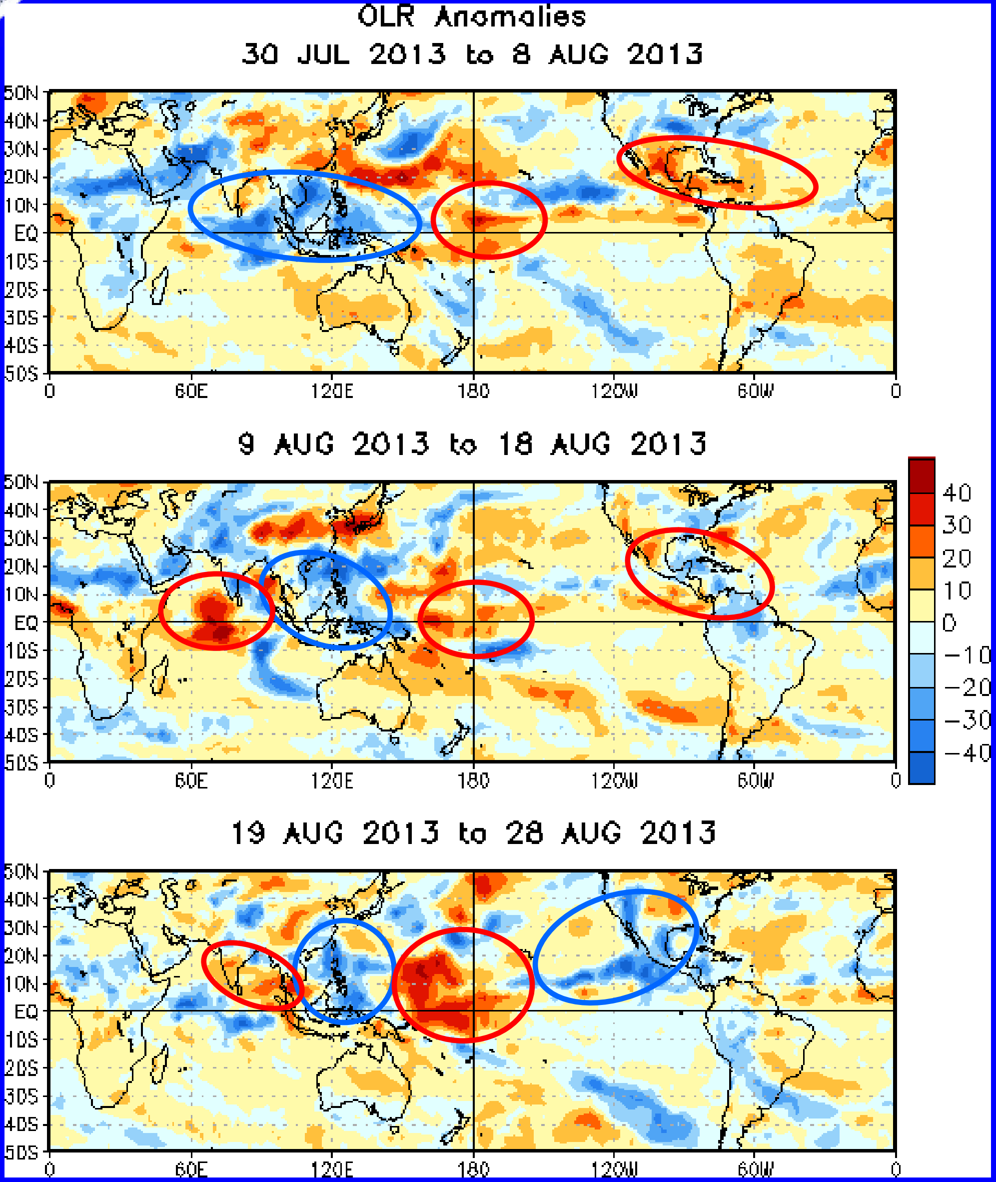
The MJO strengthened during early May, with the signal becoming more incoherent later in the month.

The MJO strengthened again in late June, with eastward propagation of low-level westerly wind anomalies noted. The propagation speed was at the faster end of the spectrum.

During late July through mid-August, other modes contributed to the tropical circulation, with some westward moving modes and faster Kelvin waves evident.

During late August, westerly (easterly) anomalies increased over the eastern (western) 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)

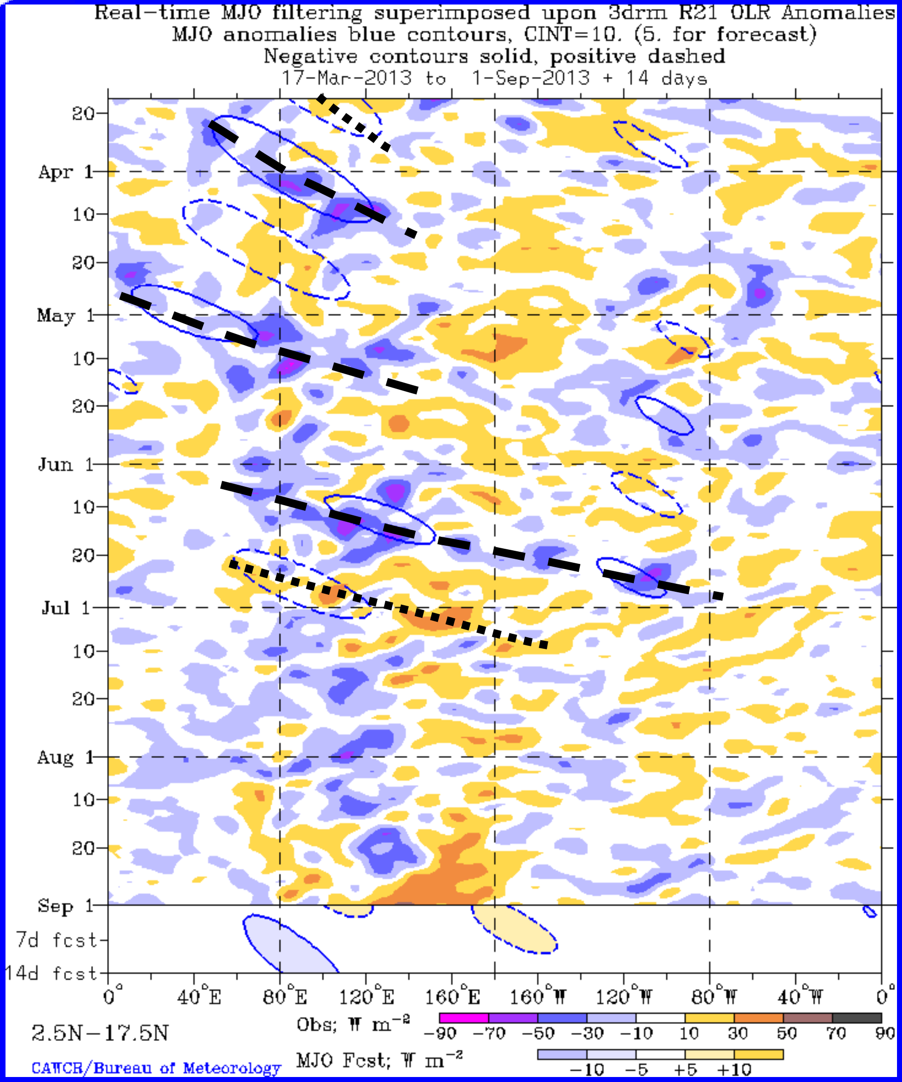
Although the MJO signal weakened at the end of July, enhanced convection persisted across the Maritime Continent during early August. Suppressed convection expanded across the North American monsoon region.

During mid-August, enhanced (suppressed) convection persisted over parts of the Maritime Continent (the Date Line). Suppressed convection also developed across the central Indian Ocean.

During late August, the couplet of enhanced (suppressed) convection persisted over parts of the Maritime Continent (Date Line), while suppressed convective anomalies shifted northward into southern Asia. Enhanced convective anomalies developed over the eastern Pacific and North American Monsoon regions.

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)

Near the end of March, the anomalies show signs of influence from other modes of tropical variability. However, MJO activity reemerged in early April across the Indian Ocean, then again in early May. Each time, the MJO signal quickly broke down.

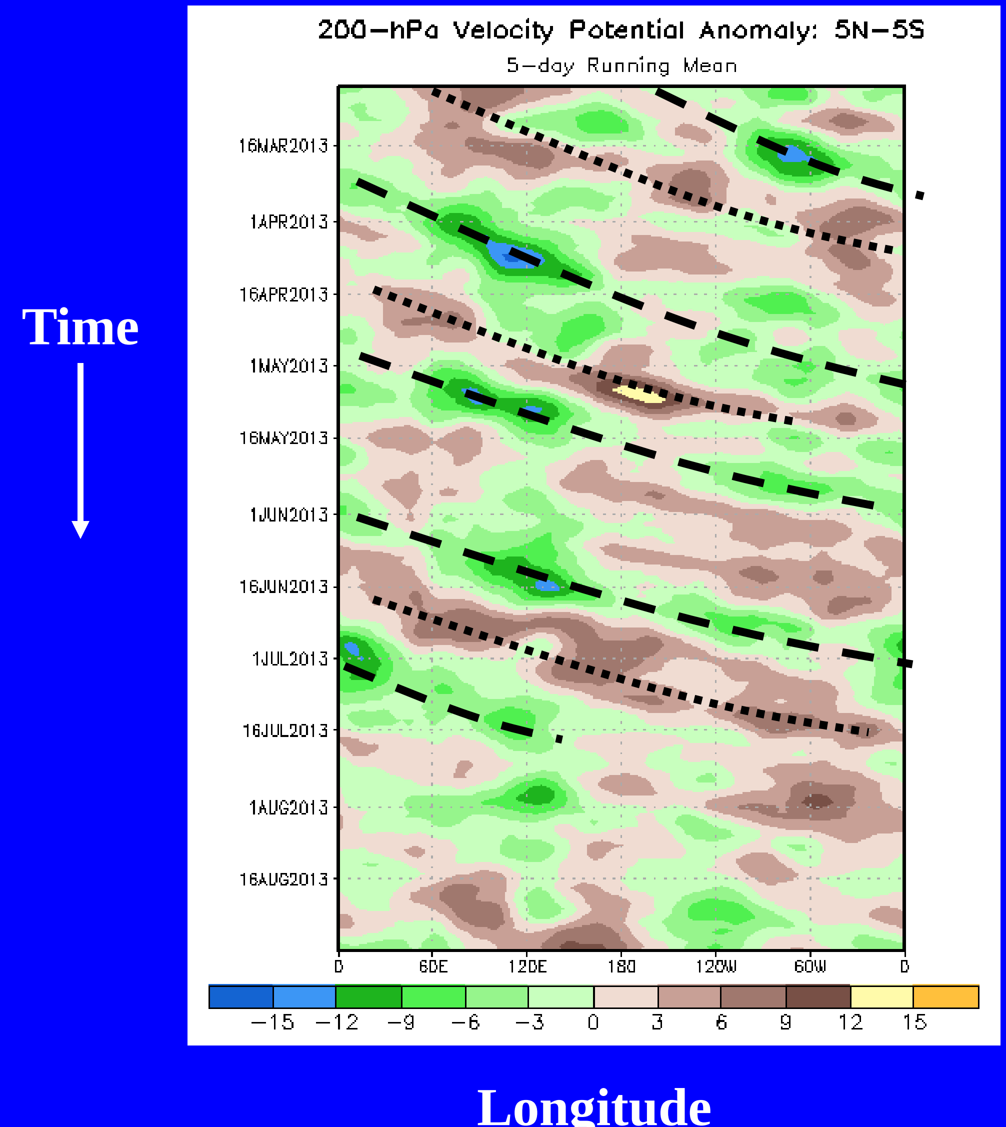
The MJO signal emerged during June and continued to July, as indicated by the alternating dashed and dotted lines.

Recently, other modes of variability have dominated the global convective pattern, with a low frequency enhanced (suppressed) convective signal over the Maritime Continent (west-central Pacific). Influence from Rossby Waves and Kelvin Waves are also apparent.

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



A MJO signal is evident in early March. Anomalies increased in magnitude with more robust eastward propagation indicated during April 2013.

The velocity potential anomalies were more coherent only briefly during early to mid-May.

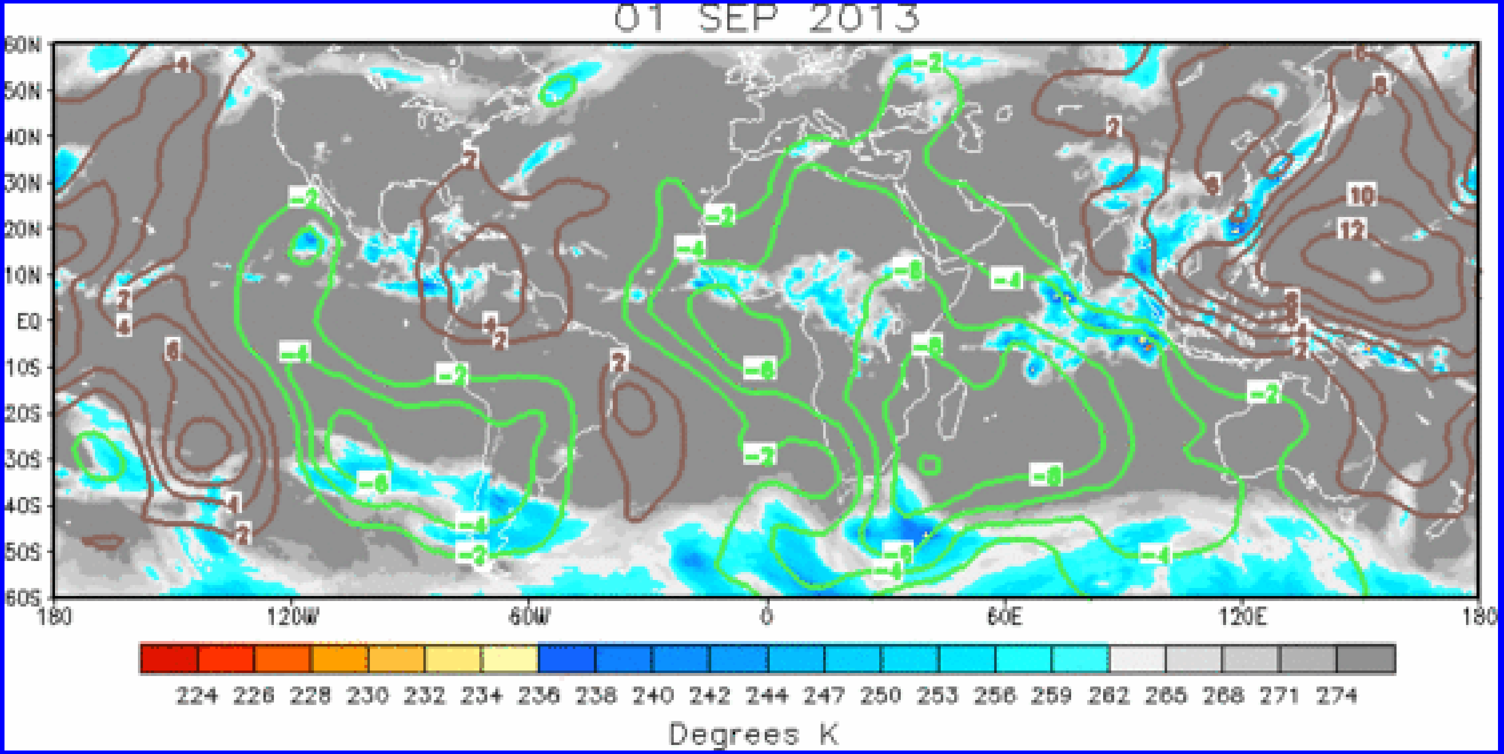
During late June and the first half of July, the signal was more coherent and consistent with a canonical MJO footprint.

More recently, the upper-level velocity potential pattern was incoherent, with influence from multiple modes of variability apparent.

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



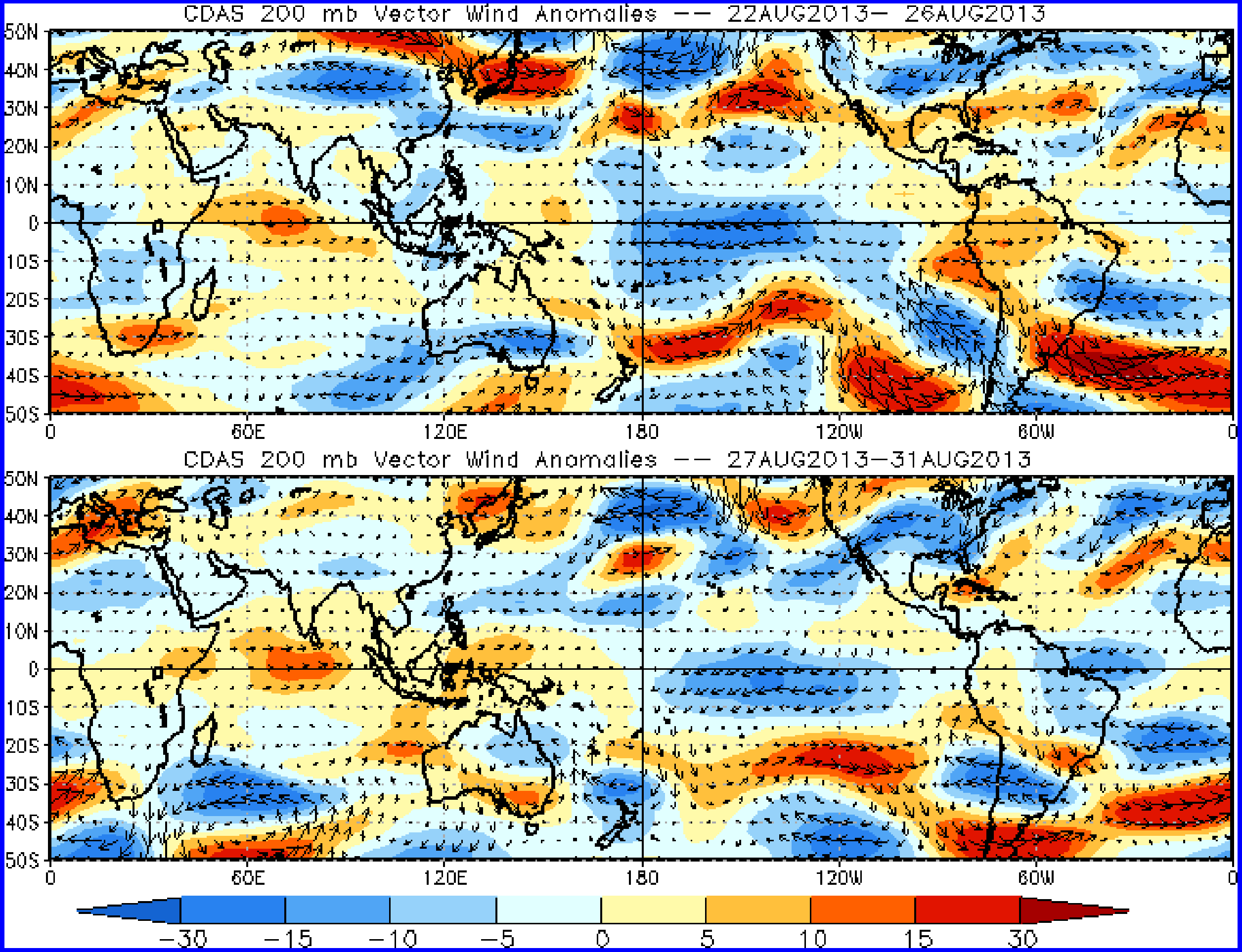
The velocity potential pattern has become slightly more coherent, but exhibits a wavenumber-2 structure along the equator, with areas of large scale upper level divergence over the eastern Pacific, Africa, and the Indian Ocean contrasting with large scale upper-level convergence over the western Pacific and western Atlantic.

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



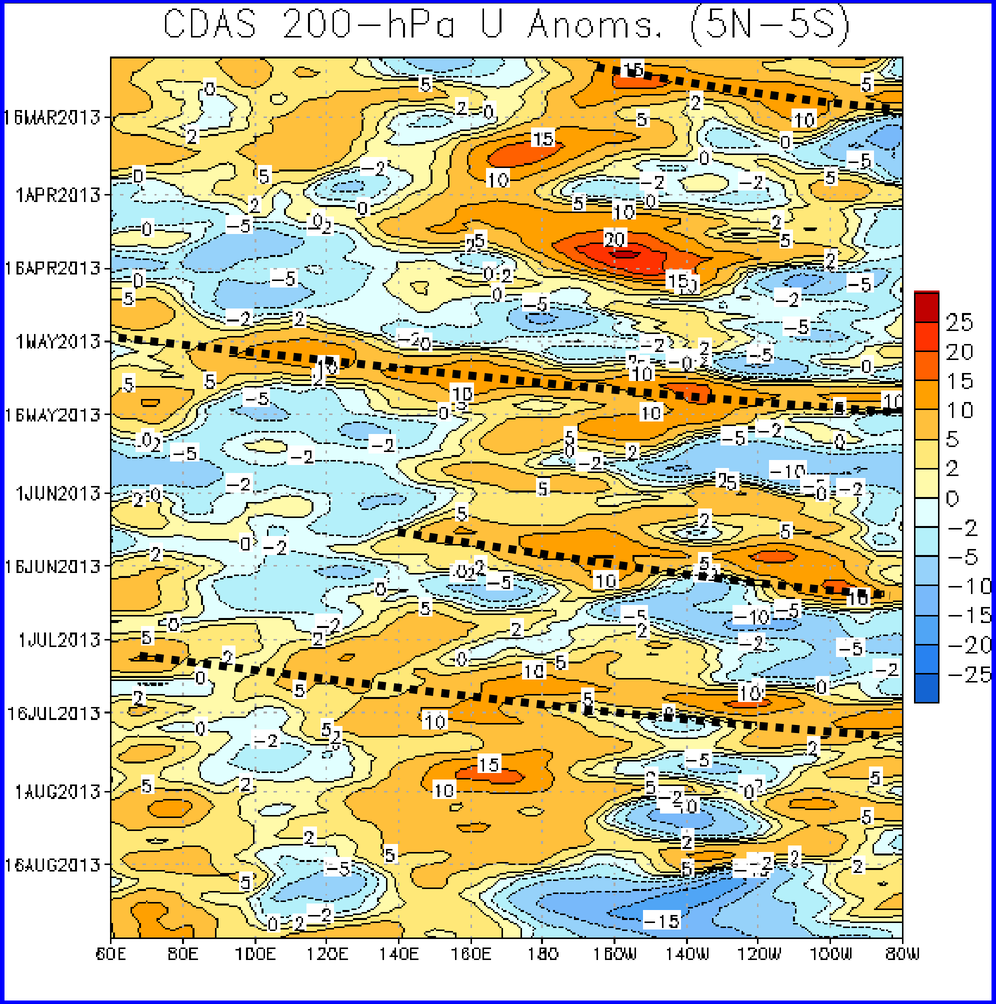
Easterly anomalies persisted over the central Pacific, while westerly anomalies expanded over the central Indian Ocean.

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

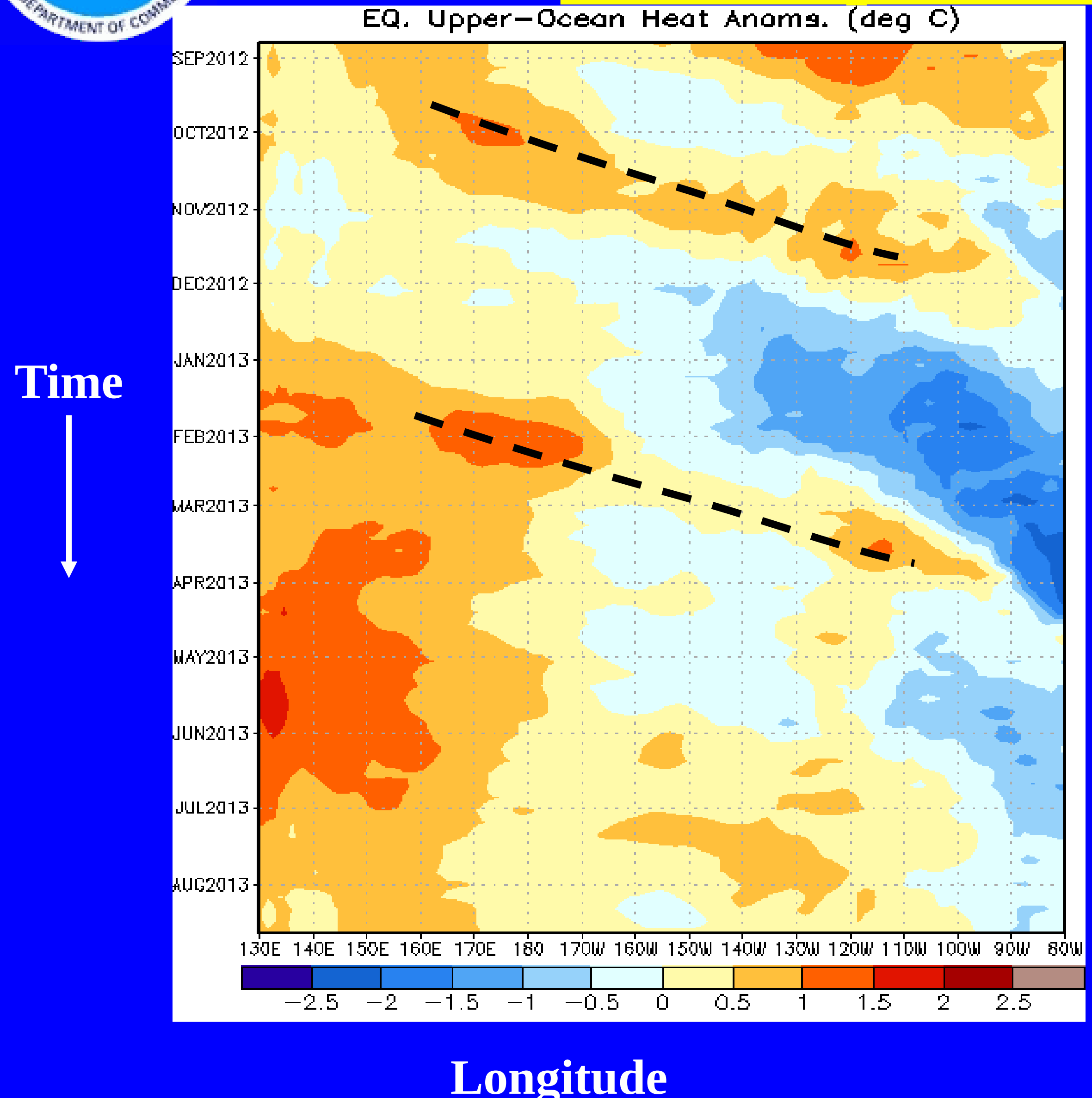
Eastward propagation of westerly wind anomalies associated with the MJO continued into April 2013.

During March and early April, anomalies were influenced by westward moving features over the central and western Pacific.

During June and early July, eastward propagation of upper-level zonal wind anomalies associated with the MJO was observed.

During August, influence from other modes of tropical intraseasonal variability produced a less coherent upper-level zonal wind anomaly pattern.

Weekly Heat Content Evolution in the Equatorial Pacific



An oceanic Kelvin wave was initiated at the end of September and increased heat content across the central and eastern Pacific during October and November.

Positive (negative) anomalies developed in the western (eastern) Pacific during January 2013 and persisted into early March. The influence of a downwelling oceanic Kelvin wave can be seen during late February and March as anomalies became positive in the east-central Pacific.

Positive anomalies increased over the central Pacific during June and July 2013.

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).

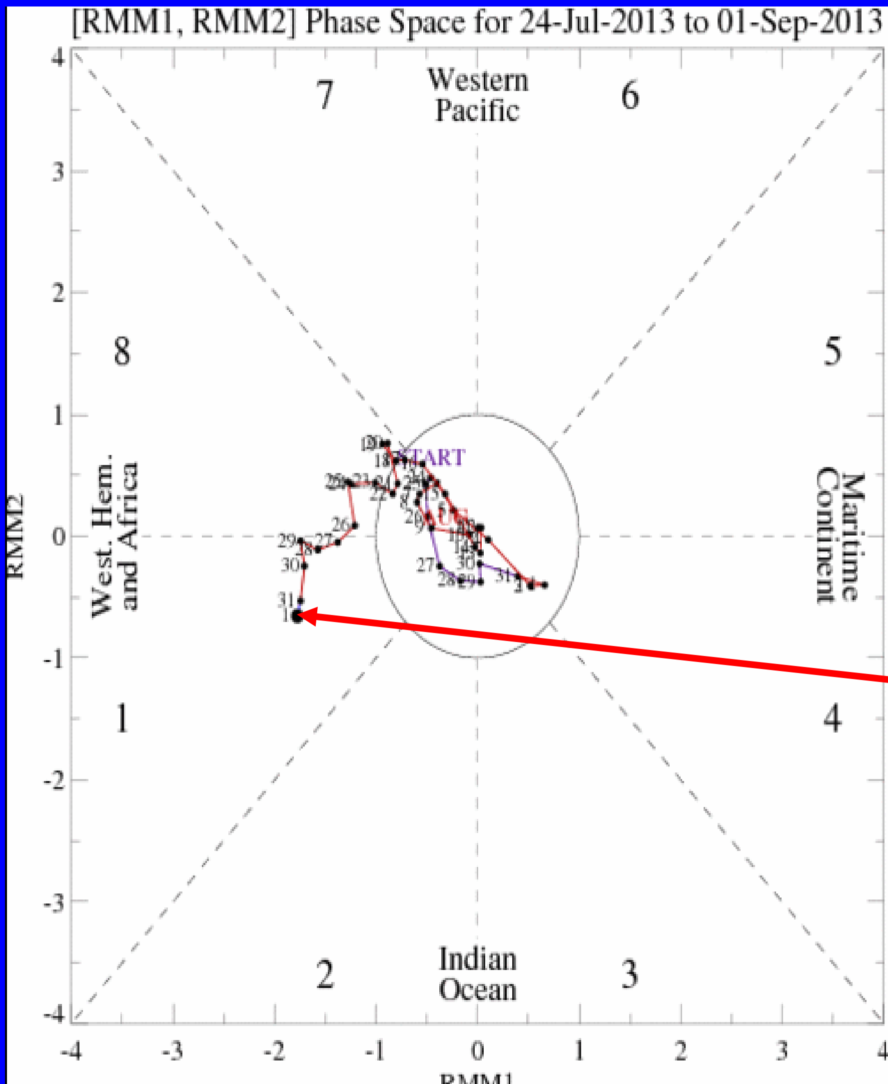
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

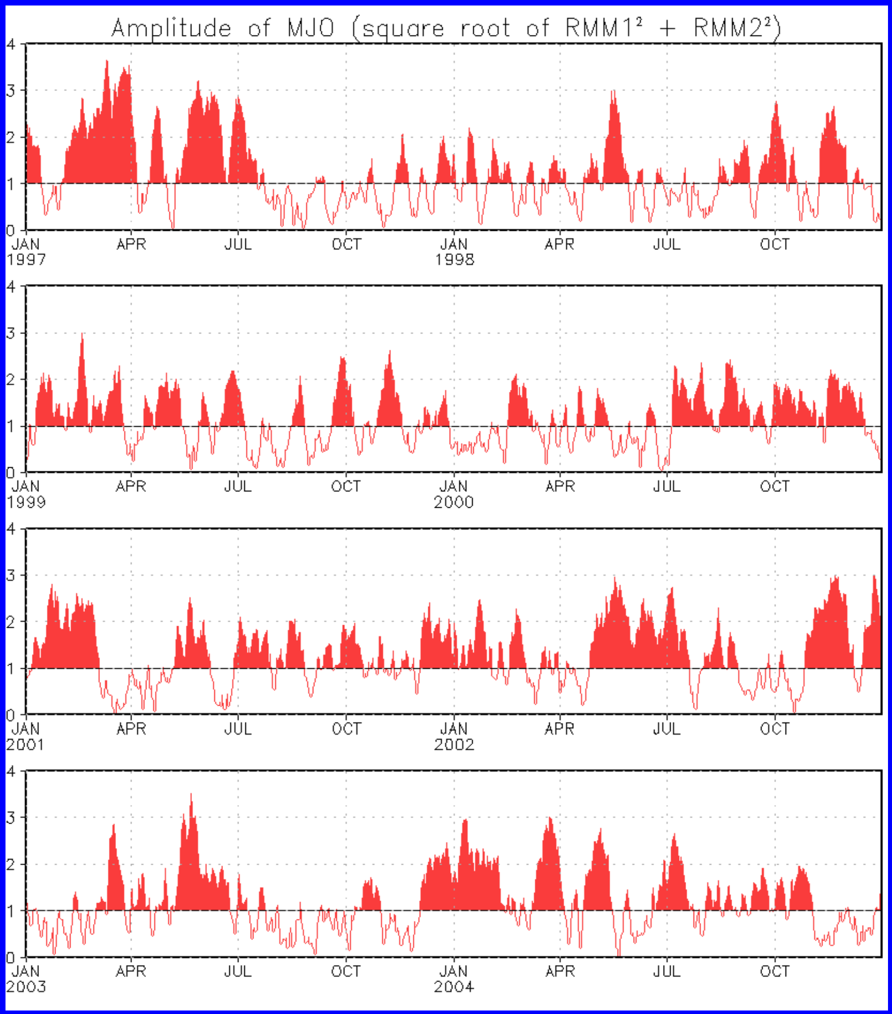
MJO Index -- Recent Evolution

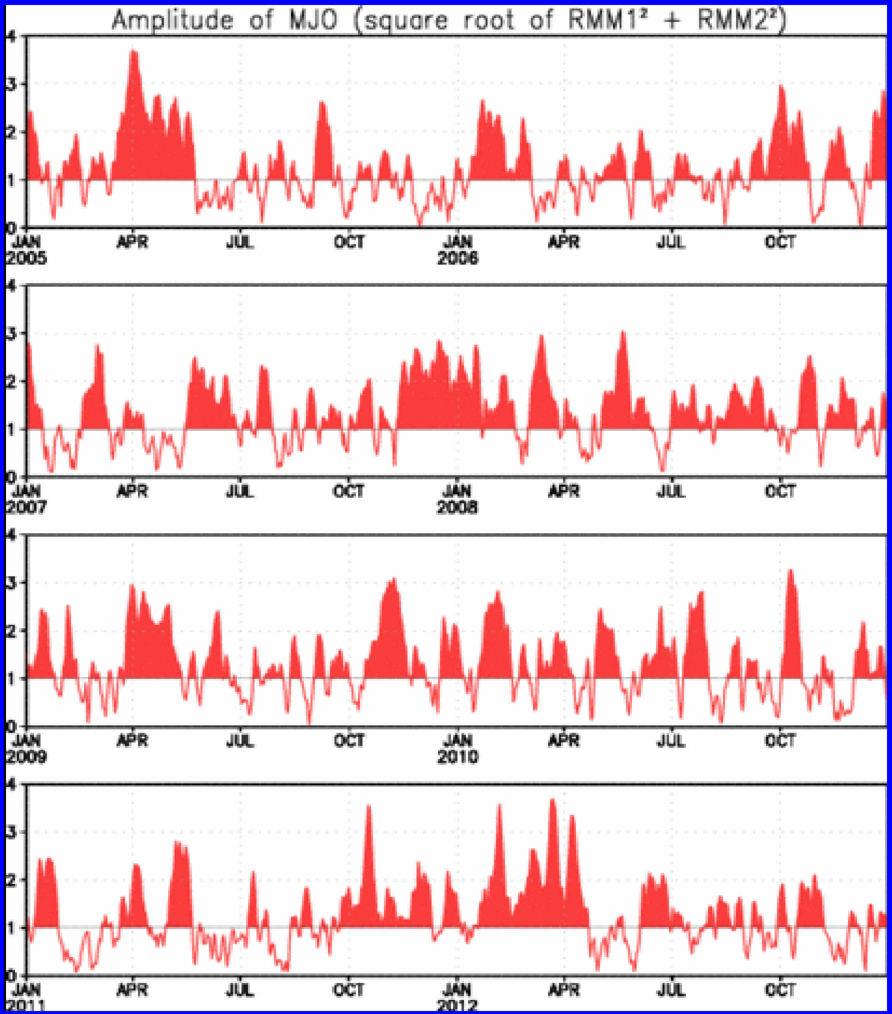


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

During the past two weeks, the Wheeler-Hendon Index indicates a strengthening MJO signal with eastward propagation over the Western Hemisphere.

MJO Index – Historical Daily Time Series





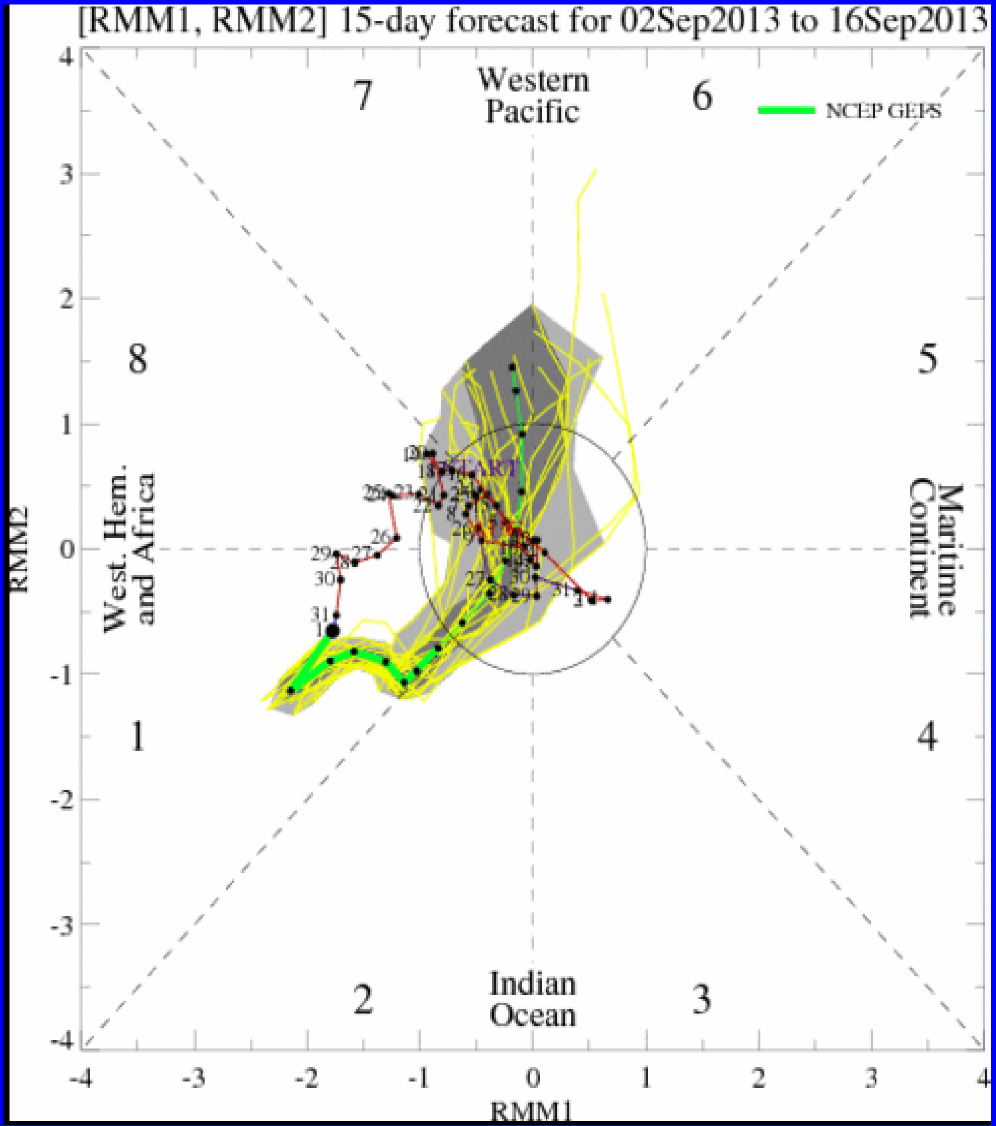
Time series of daily MJO index amplitude from 1997 to present. Plots put current MJO activity in historical context.

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



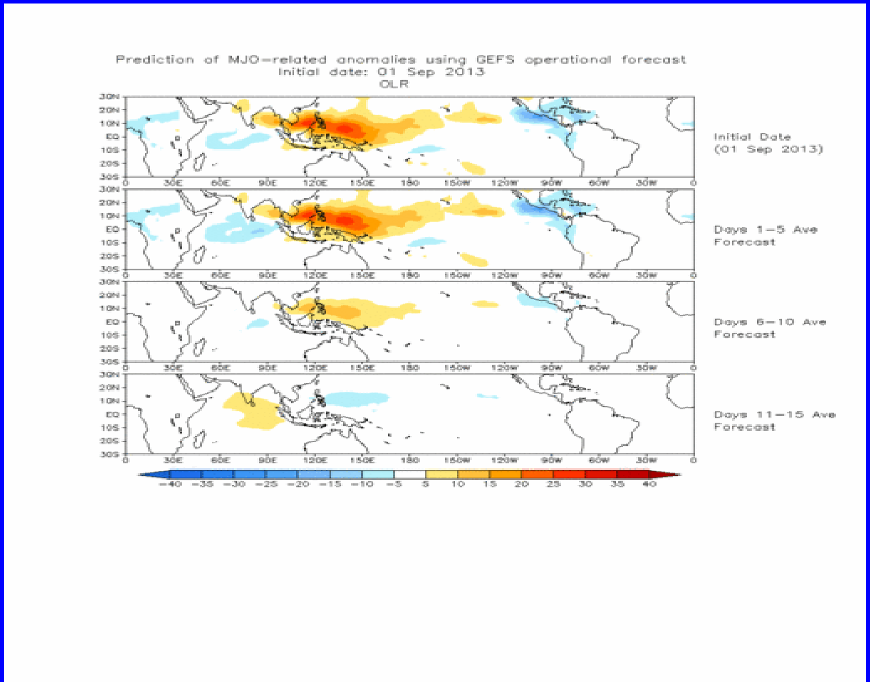
The ensemble GFS indicates a weakening MJO signal during the upcoming week, with a strengthening convectively active signal over the western Pacific at the end of Week-2.

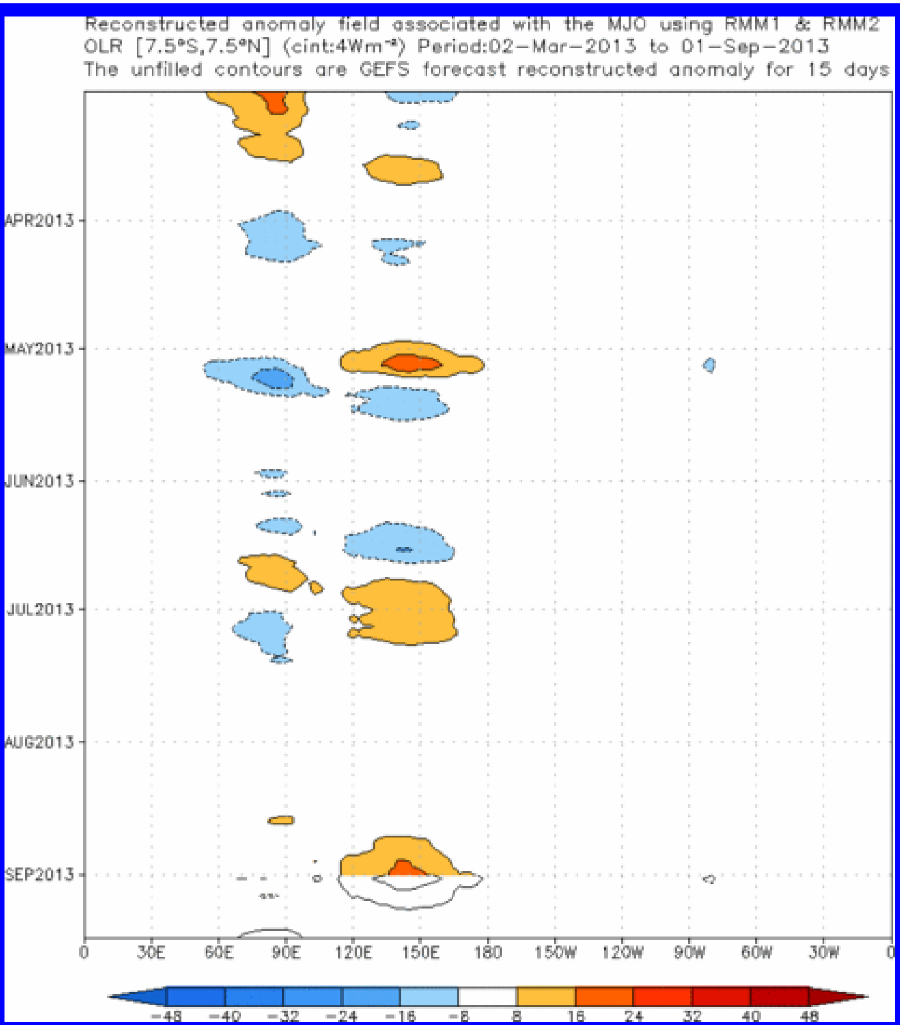
Ensemble Mean GFS MJO Forecast

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



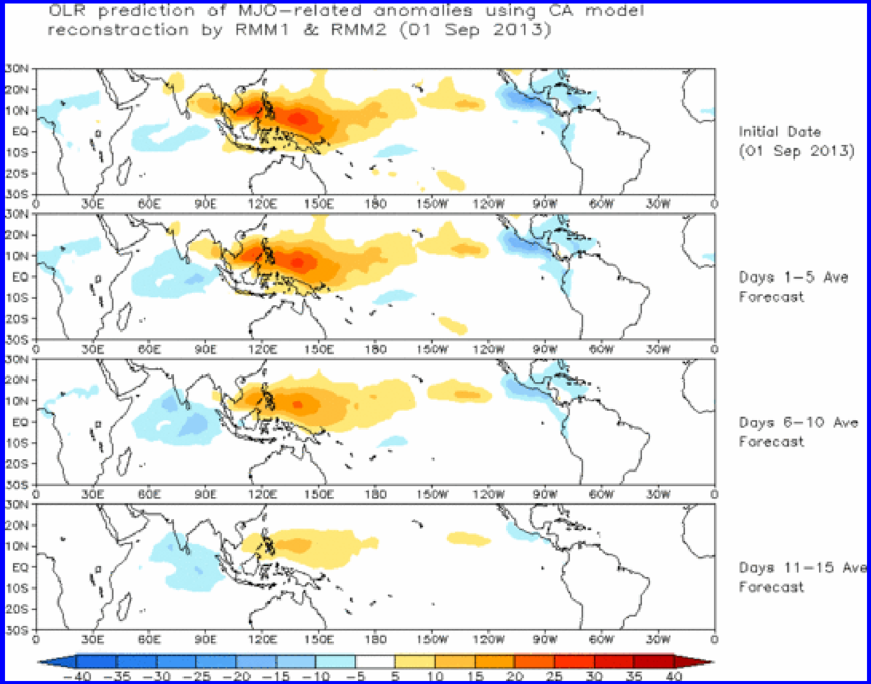


The ensemble mean GFS forecasts enhanced (suppressed) convection persisting over the Western Hemisphere (western Pacific) during Week-1, with increasing convective anomalies over the western Pacific at the end of the Week-2 period.

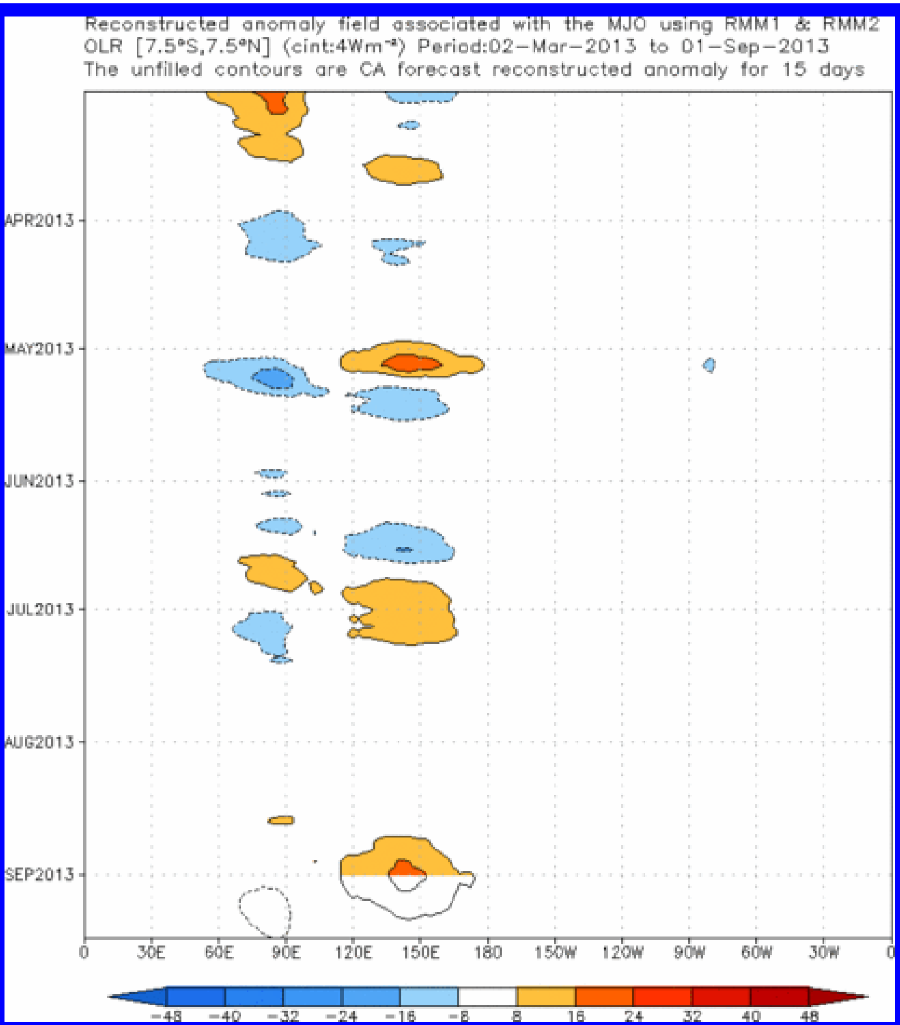
Constructed Analog (CA) MJO Forecast

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



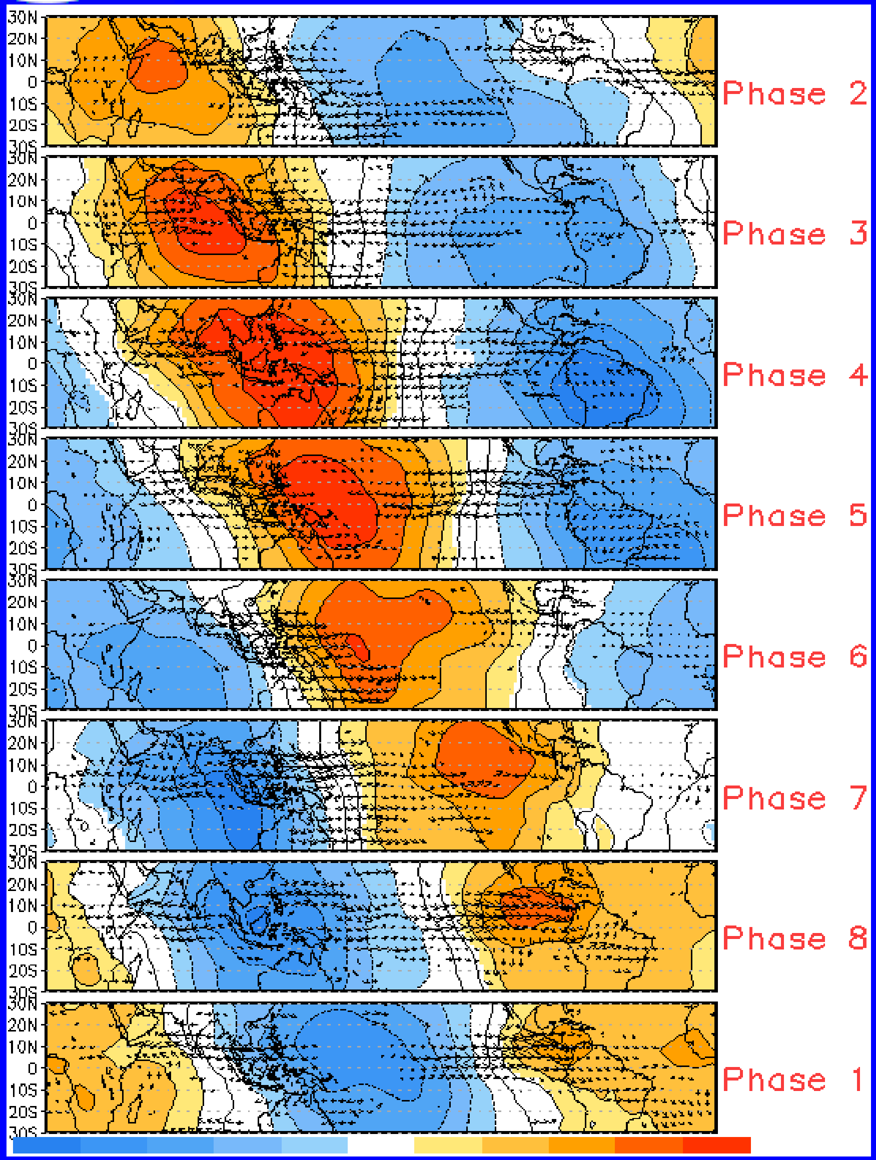
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



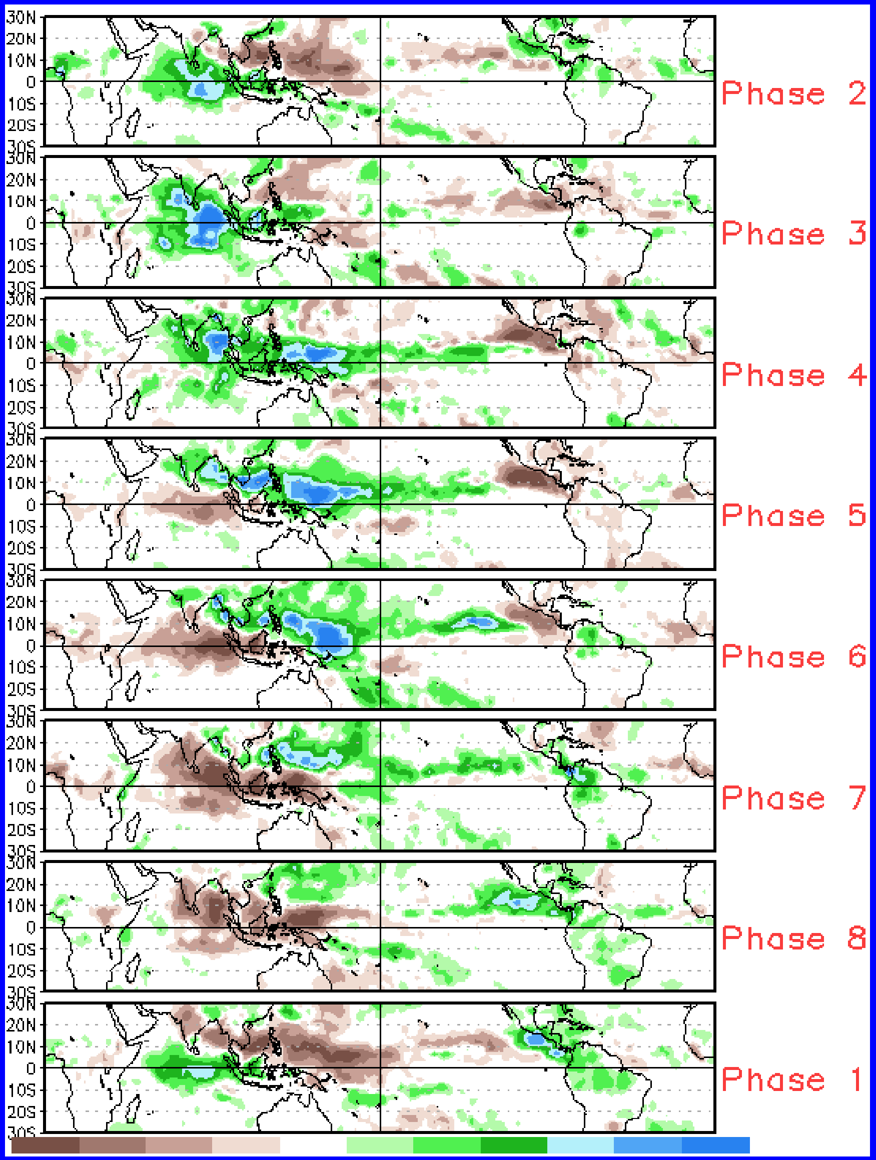
This statistical forecast indicates persistent suppressed convective anomalies over the western Pacific, with enhanced convection developing over the Indian Ocean during Week-2. Weakening enhanced convective anomalies are forecast over the western Hemisphere.

MJO Composites – Global Tropics

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

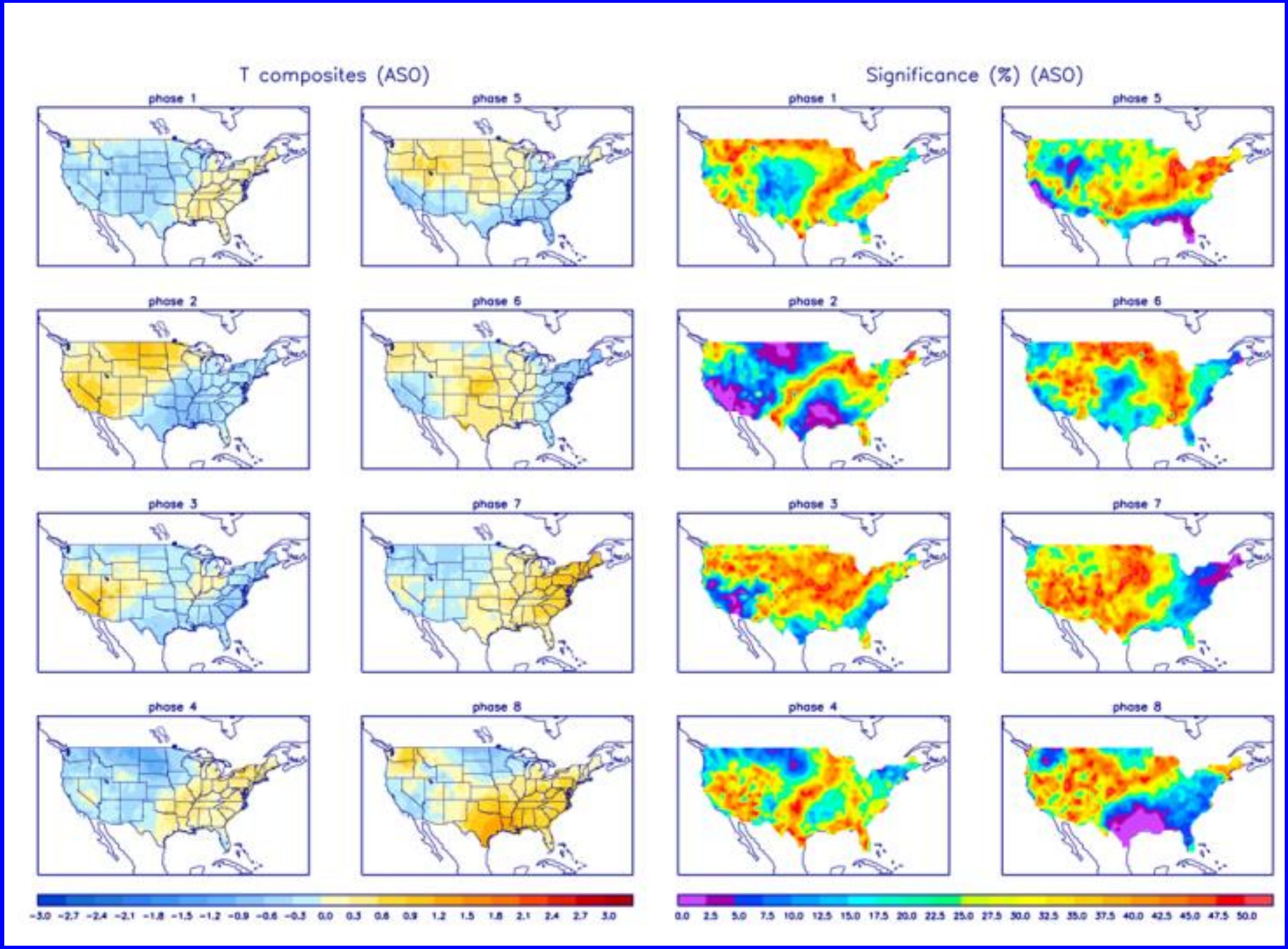


Precipitation Anomalies (May-Sep)



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.

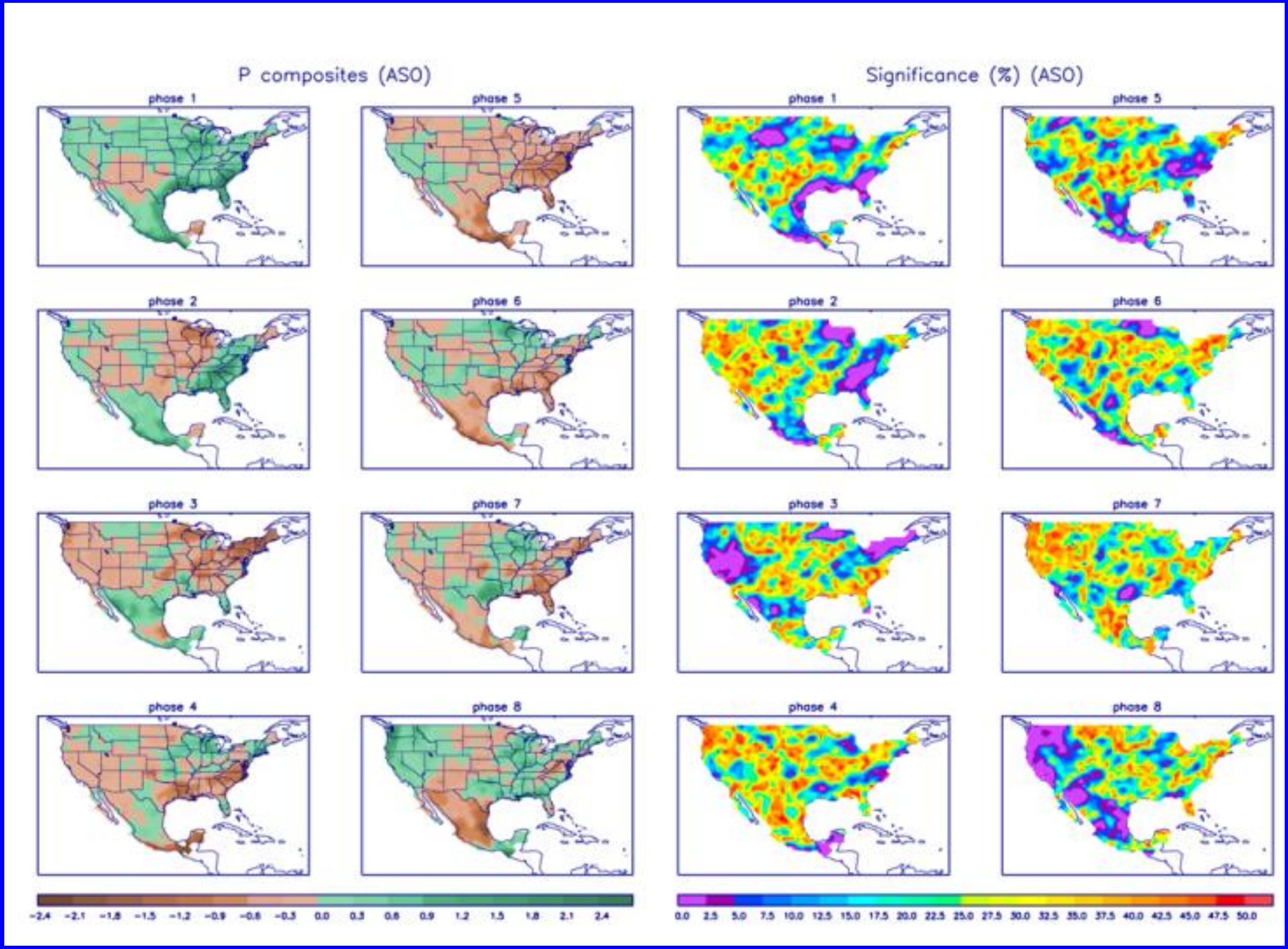


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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