



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

**Update prepared by
Climate Prediction Center / NCEP
August 12, 2013**



Outline

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



Overview

- The MJO signal remained weak during the past week. The influence of other modes of variability is dominating the global tropical circulation.
- Most dynamical and statistical model MJO forecasts indicate a weak or incoherent MJO pattern during Week-1, with some indication of a weak MJO signal emerging over the Western Hemisphere during Week-2.
- Based on recent observations and statistical forecasts, the MJO is not forecast to play a major role in the atmospheric circulation during the next two weeks, though some impacts are possible during Week-2.
- Enhanced convection is favored over the Maritime Continent and Southeast Asia during the next one to two weeks, while suppressed convection is expected over parts of India, the equatorial Indian Ocean, and the western Pacific.
- Odds of tropical cyclone formation are enhanced across parts of the western North Pacific during Week-1, mainly north of 20N. Elevated odds for tropical cyclone development are expected across parts of the East Pacific and Atlantic Basins during Week-2.

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>

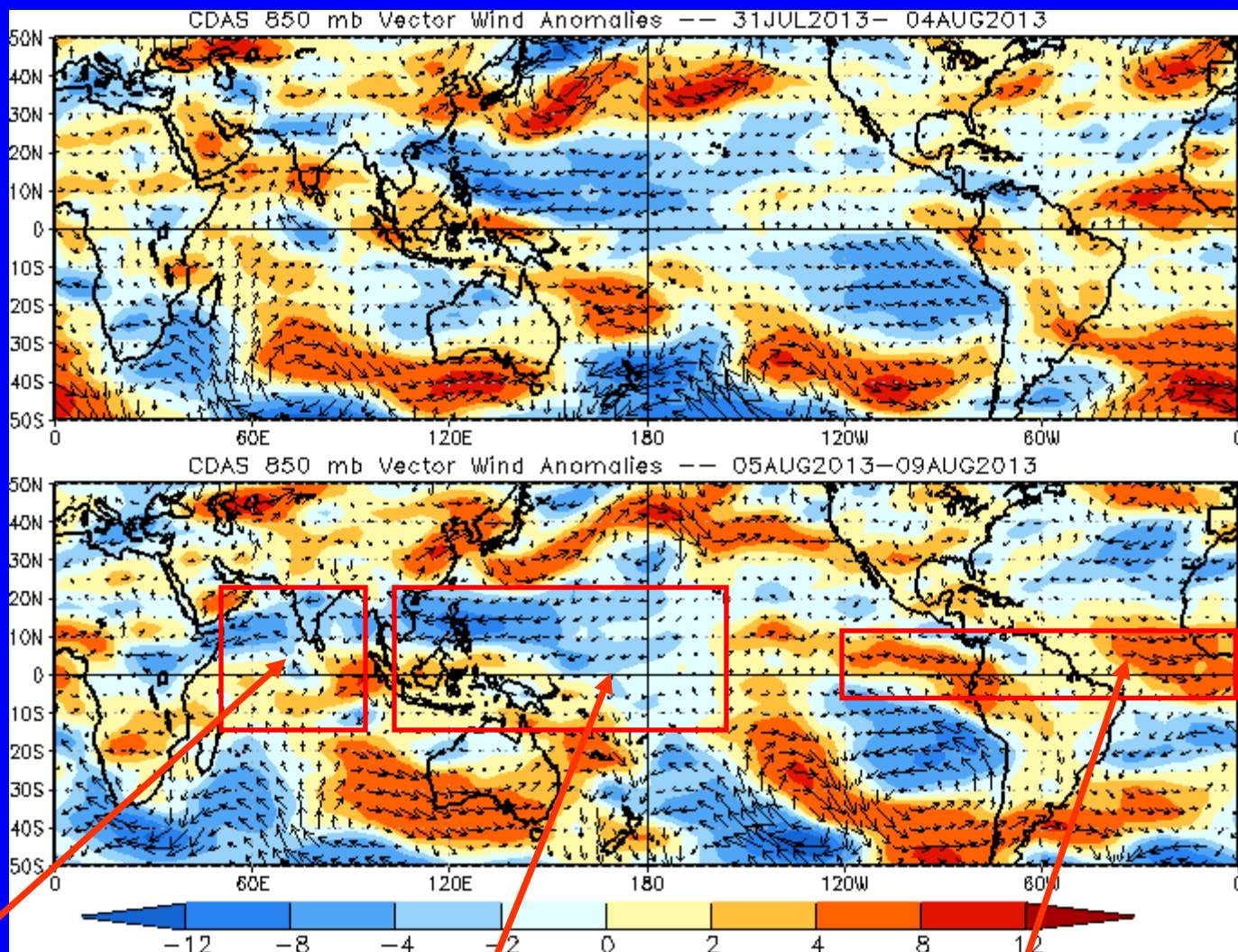


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



The Indian monsoonal circulation weakened over the past several days.

Westerly (easterly) anomalies have persisted over the Maritime Continent (western Pacific).

Westerly anomalies persisted (strengthened) across the eastern Atlantic Ocean (East Pacific).

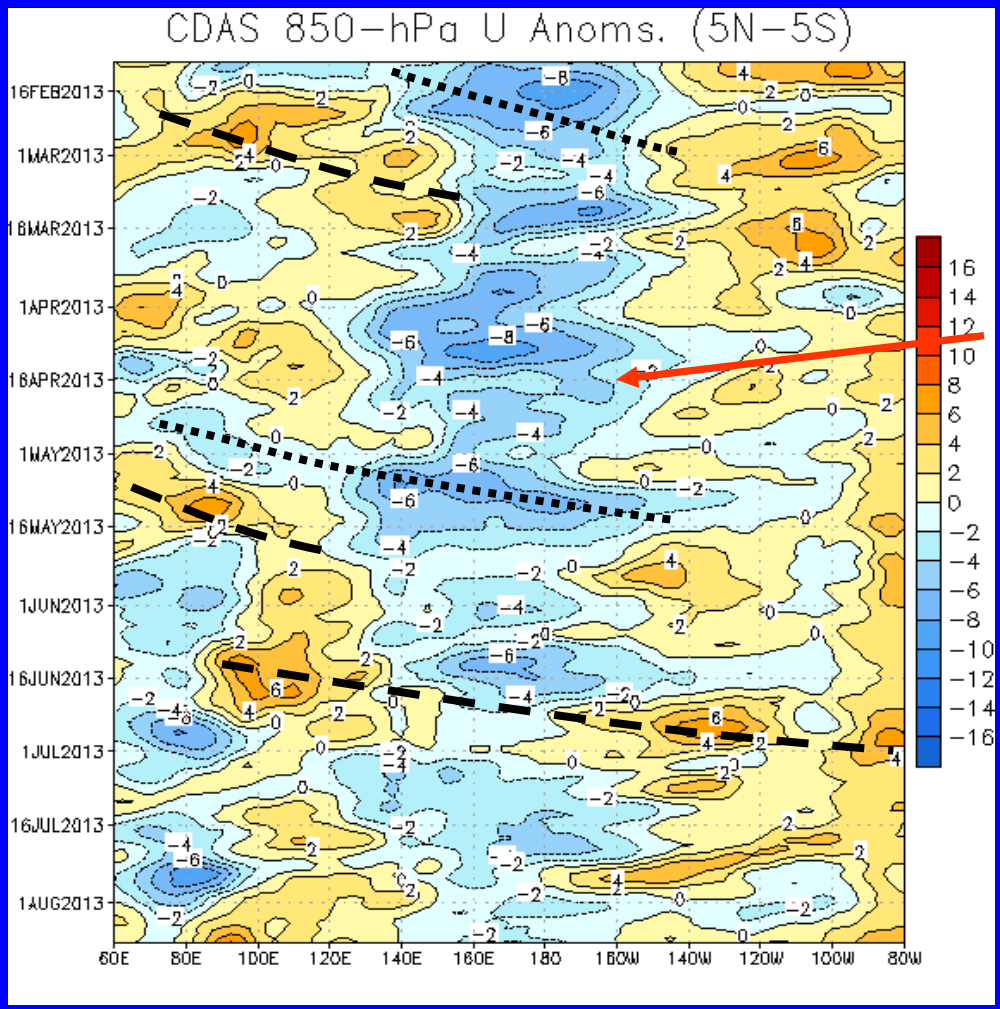


850-hPa Zonal Wind Anomalies (m s^{-1})

Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

Easterly anomalies (blue shading) represent anomalous east-to-west flow

Time
↓



Longitude

During February, MJO activity was apparent in the low-level wind pattern (alternating dashed and dotted lines).

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.

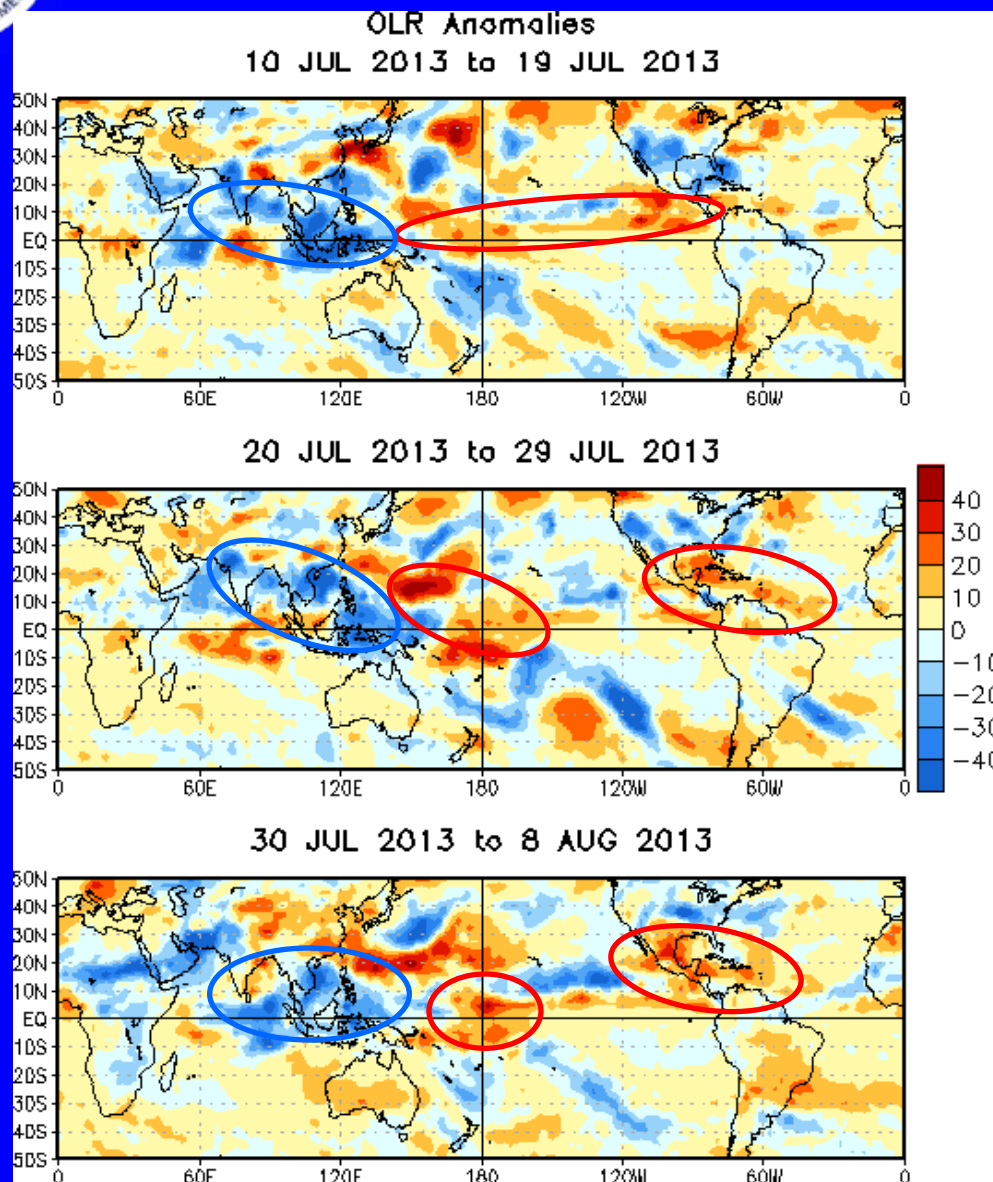
During late July and early August, other modes contributed to the tropical circulation, with some westward moving modes and faster Kelvin waves evident.



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, the MJO enhanced phase propagated over the Indian Ocean to the Maritime Continent, promoting increased convection.

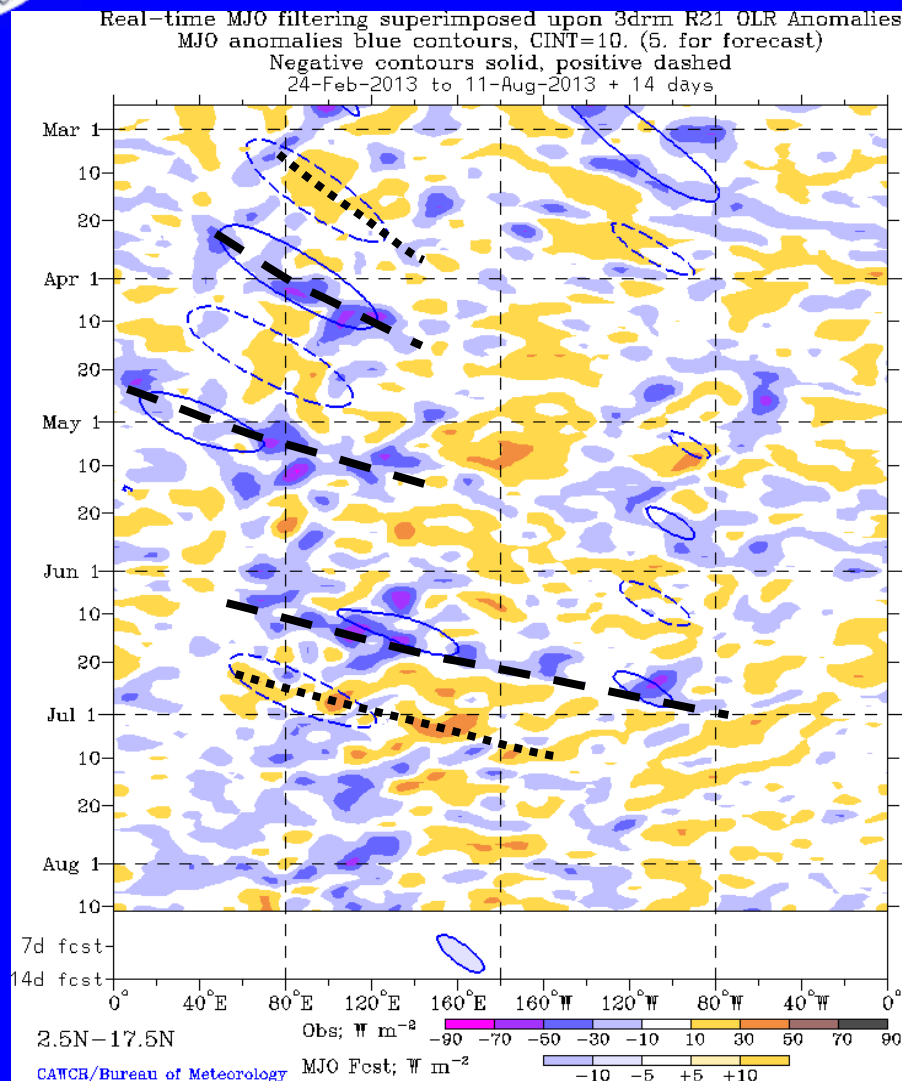
The MJO signal weakened toward the end of the month. Enhanced convection shifted northeast across Southeast Asia and the Maritime Continent. Enhanced (suppressed) convection continued across the North American monsoon region (central Pacific).

During late July and early August, other modes of variability influenced anomalous convection with enhanced convection persisting across Southeast Asia and the Maritime Continent. Drier conditions are noted across Mexico and the Caribbean region.



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)

The MJO was a dominant mode of variability across the Tropics from February to March as indicated by the alternating dashed and dotted lines.

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. Other modes of variability have dominated more recently, such as a Rossby wave over the Maritime continent and a Kelvin Wave over the eastern Pacific.

Longitude

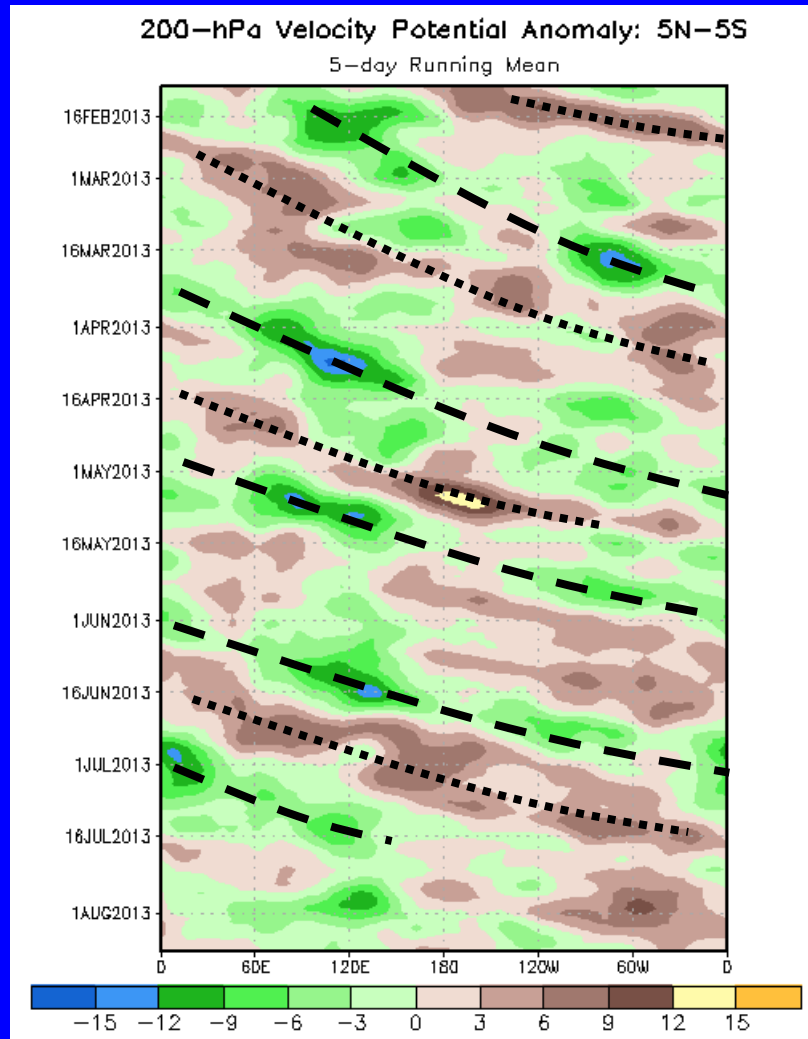


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time



A MJO signal is evident in late February and 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.

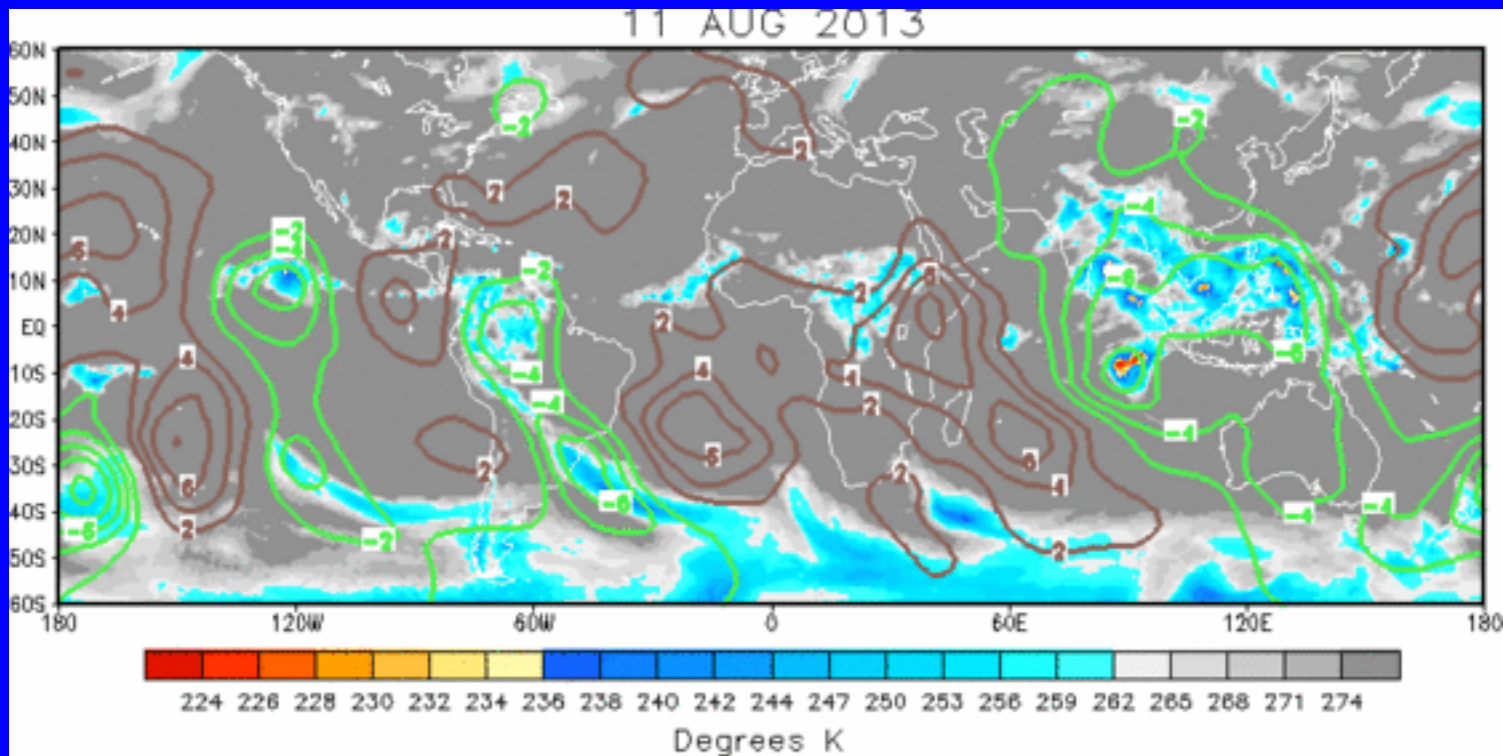
During late June and the first half of July, the signal was more coherent and consistent with a canonical MJO footprint. More recently, a more stationary pattern is noted along with evidence of atmospheric Kelvin waves.



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 indicates upper-level divergence persisting across the Maritime Continent while upper-level convergence dominates across Africa and parts of the central Pacific. Tropical activity is noted across the east Pacific.

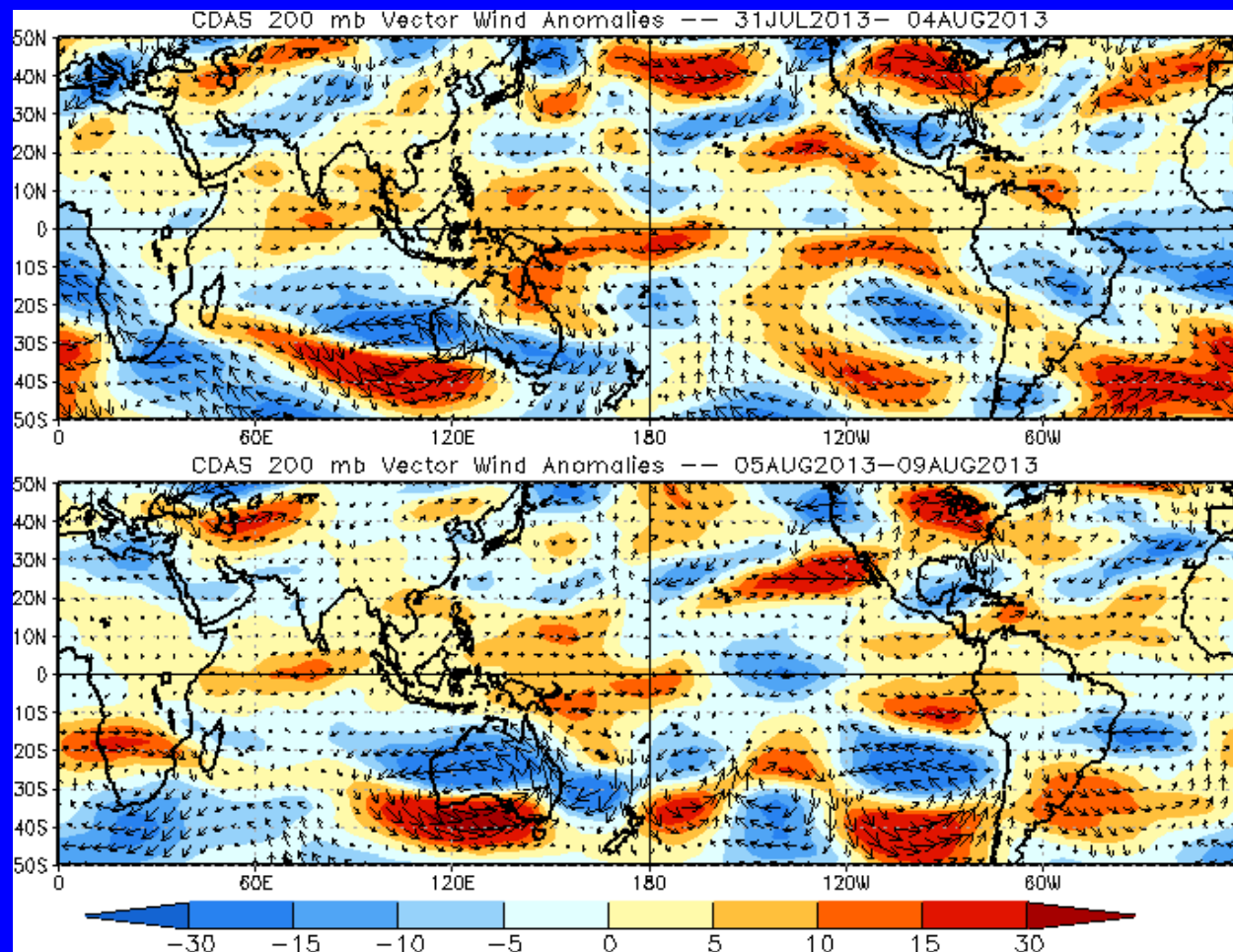


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



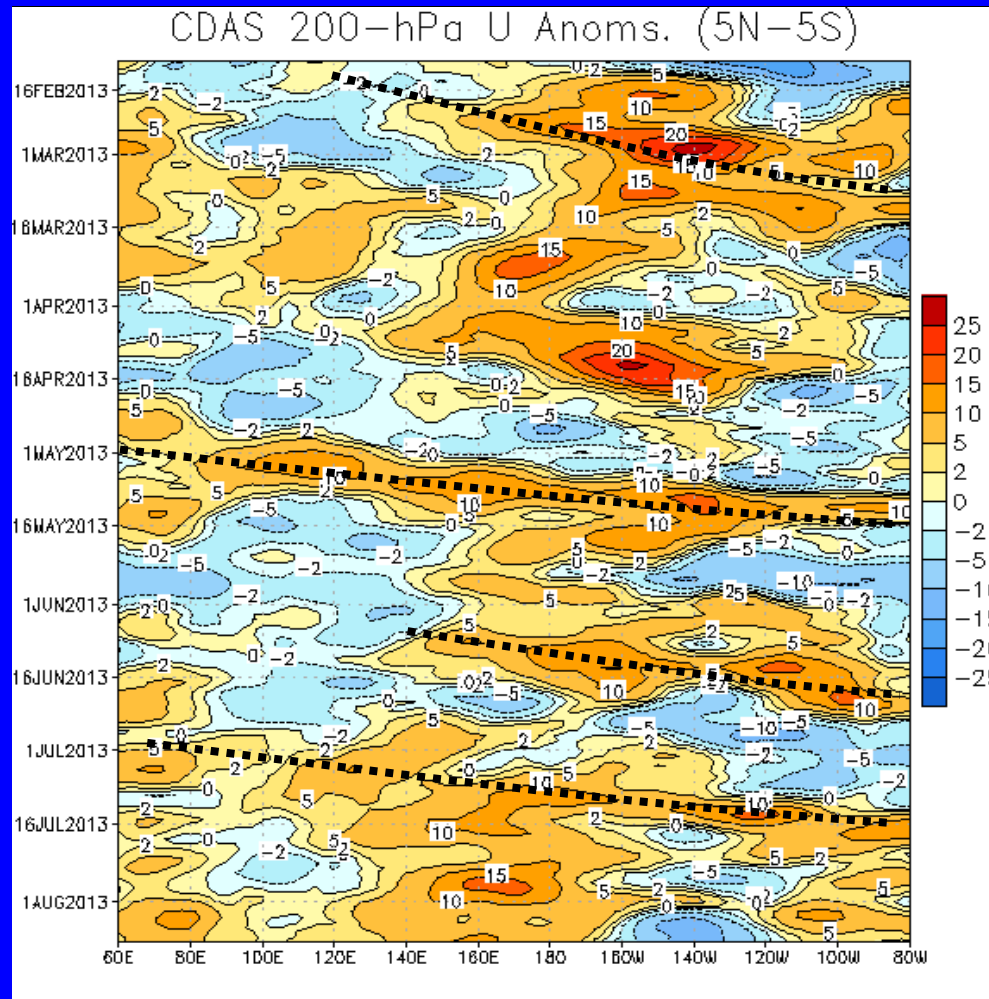
Westerly wind anomalies continue across much of the Tropics.



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



Eastward propagation of westerly wind anomalies associated with the MJO continued into April 2013. Some propagation of easterly anomalies is evident during late January and early February.

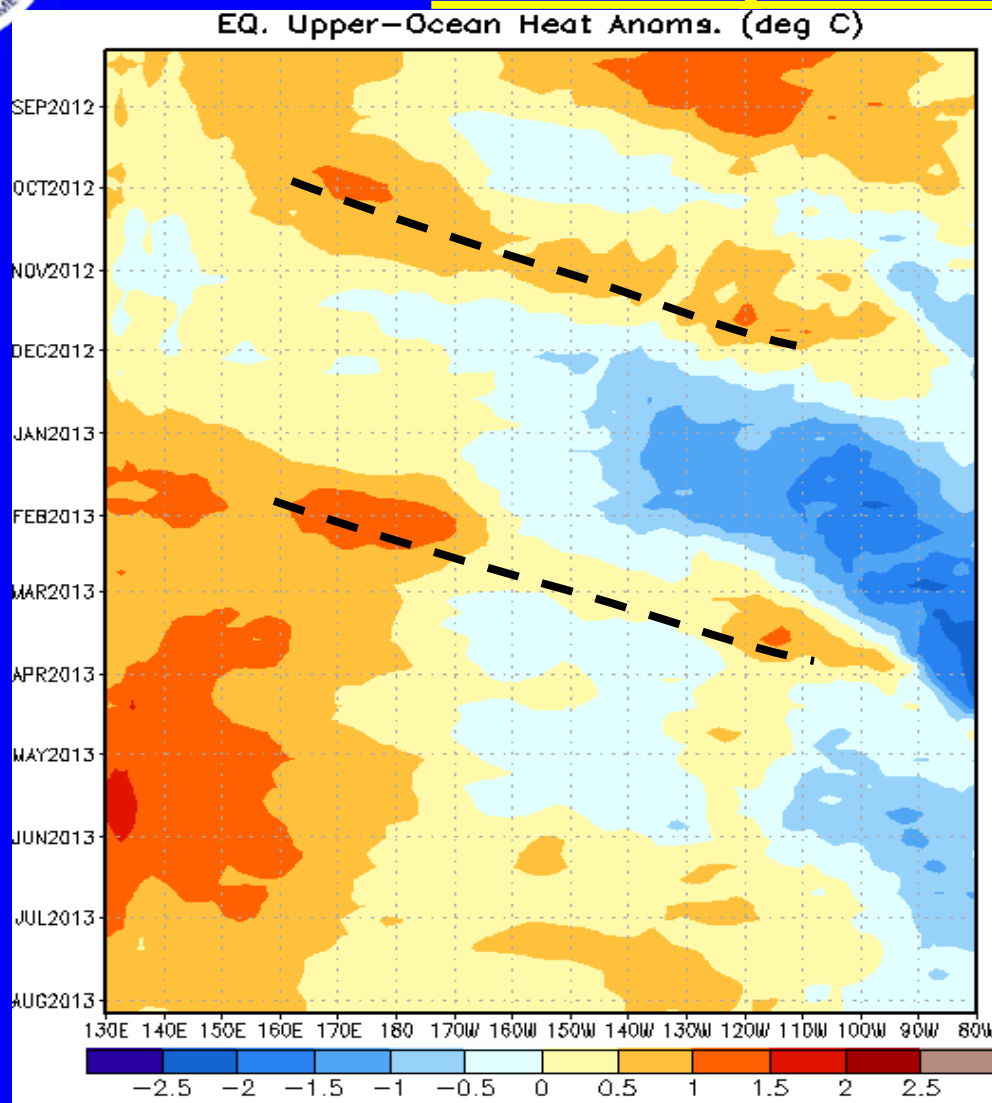
During March and early April, anomalies were influenced by westward moving features over the central and western Pacific.

During June and early July, eastward propagation of upper-level zonal wind anomalies was observed. More recently, 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

Time



Longitude

Through August 2012, heat content anomalies became positive and increased in magnitude across the eastern equatorial Pacific, partly in association with a downwelling Kelvin wave.

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.

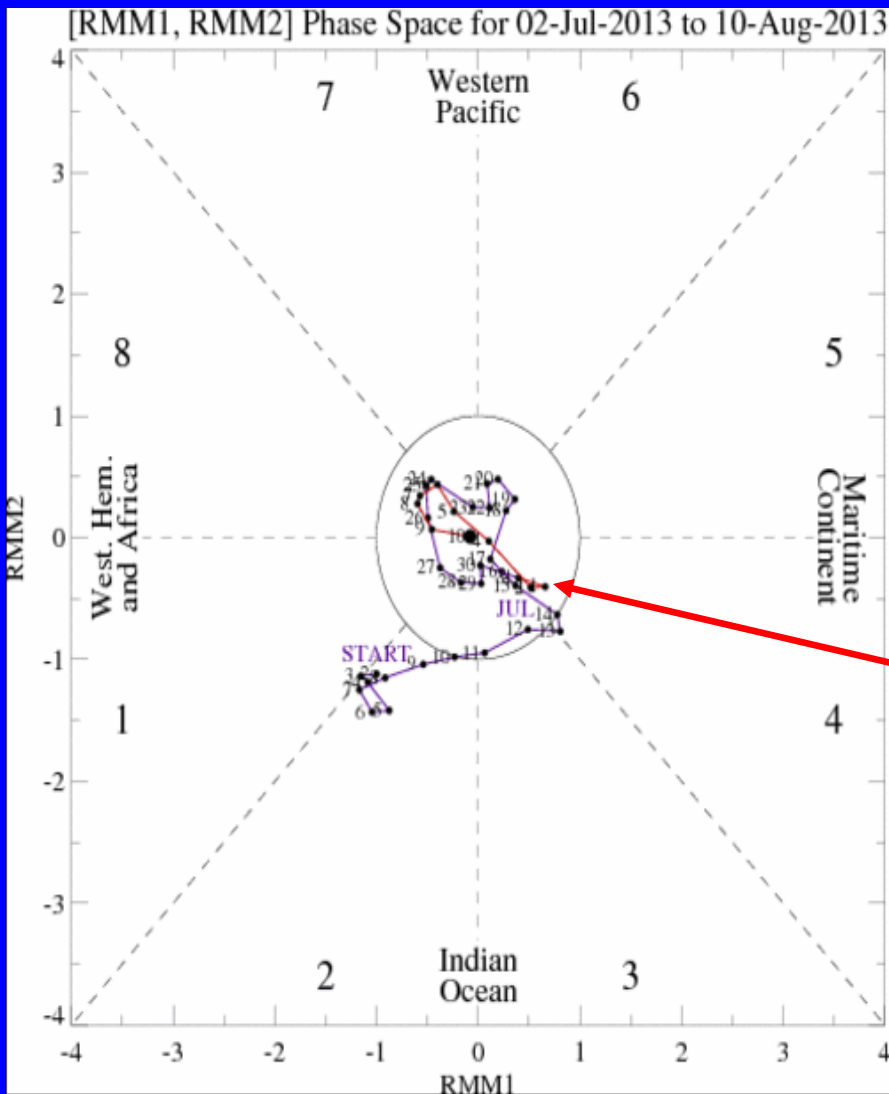
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

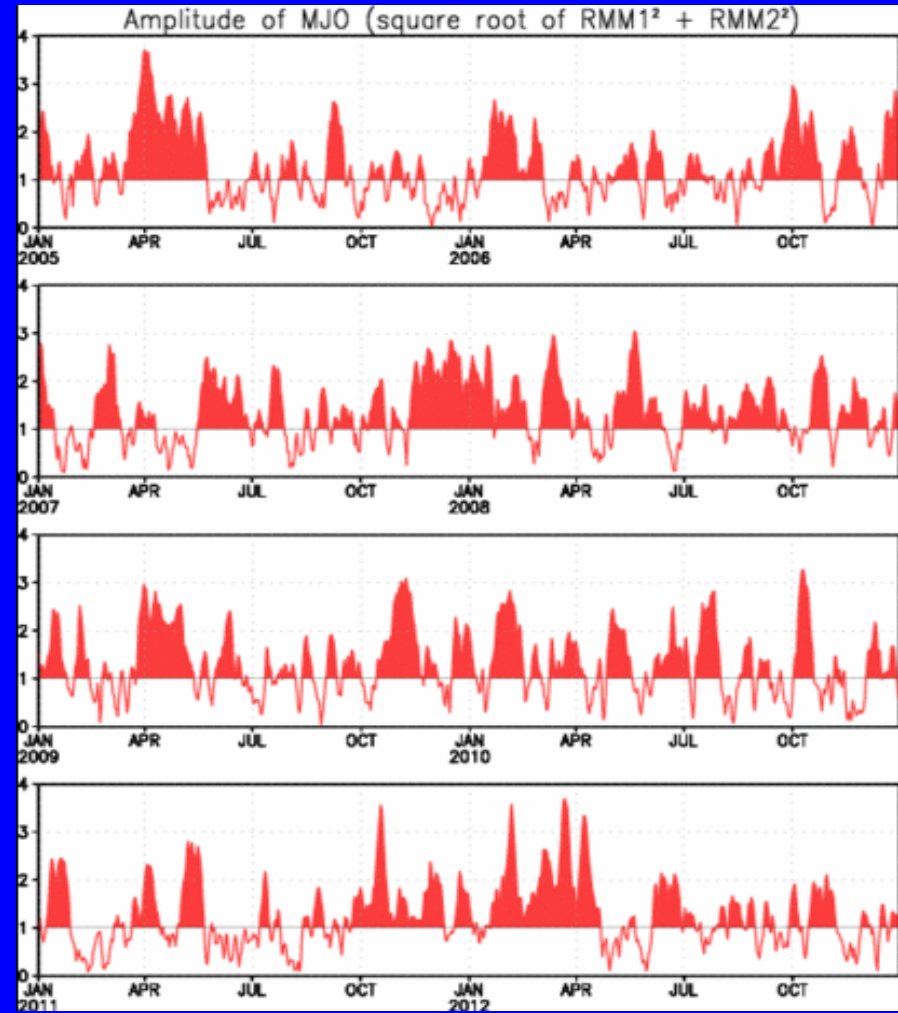
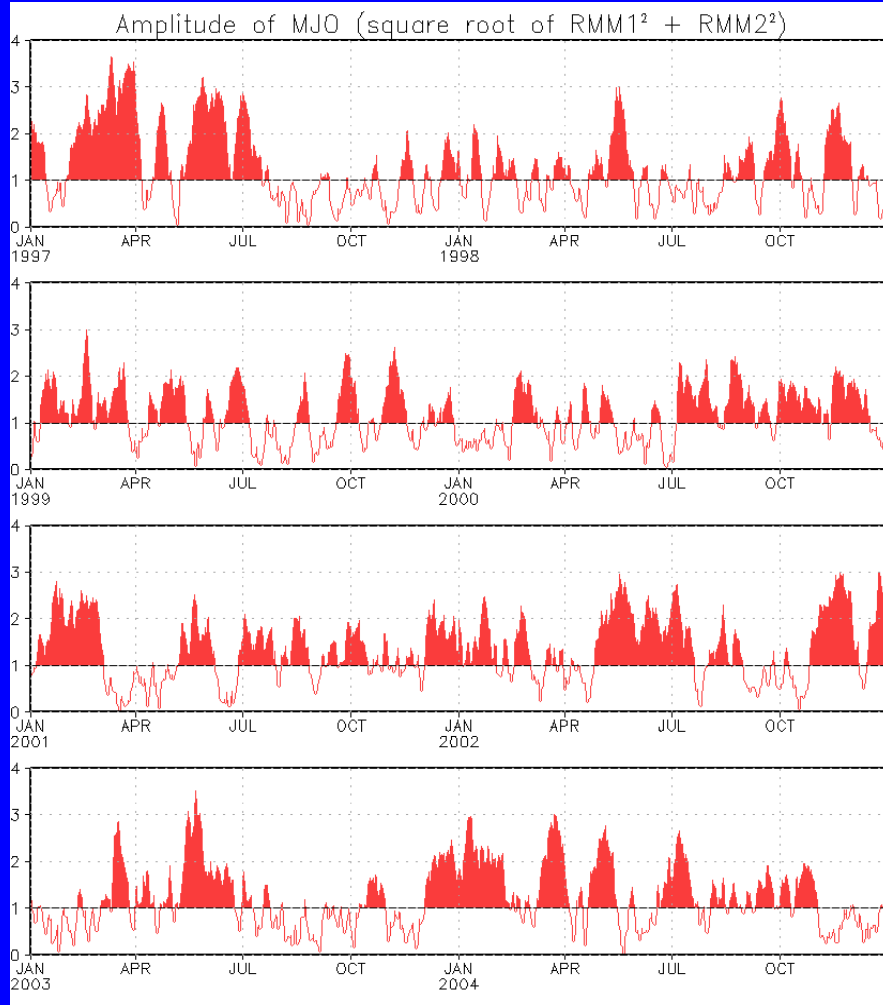


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

During the previous week, the Wheeler-Hendon Index indicated a weak MJO signal.



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

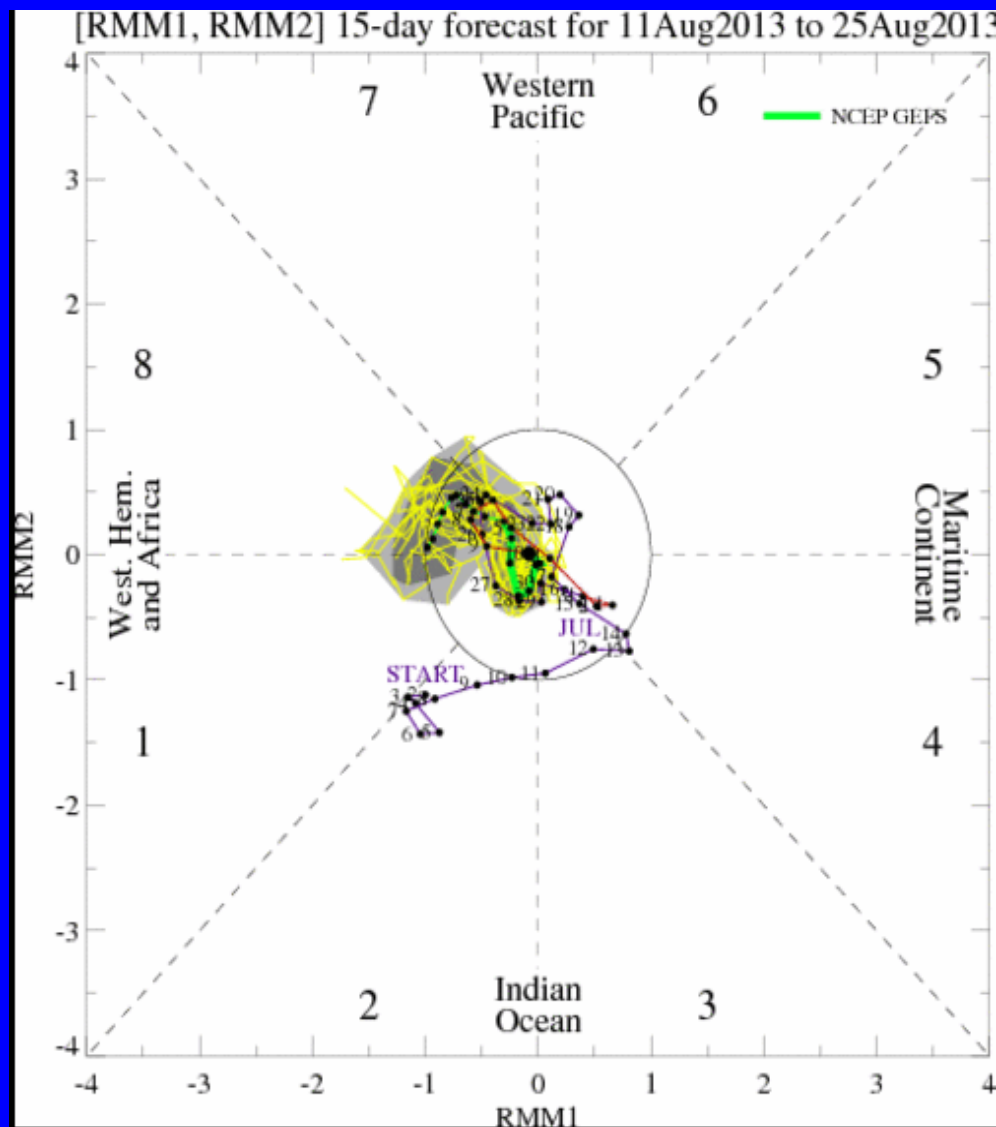
Green Line – Ensemble Mean

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 an incoherent MJO signal during Week-1, with a weak signal emerging near Phase 8 in Week-2.





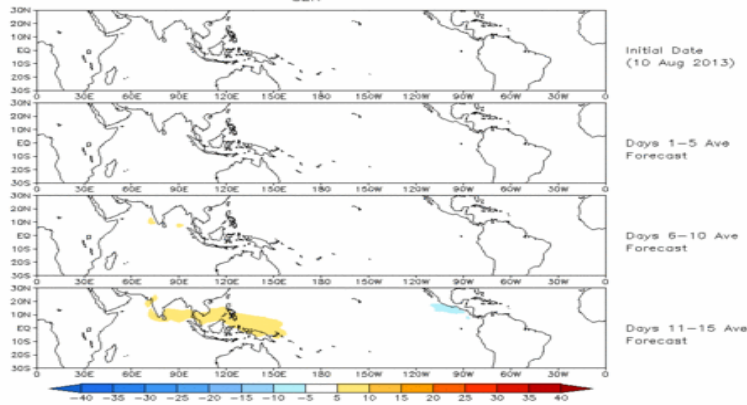
Ensemble Mean GFS MJO Forecast

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

Prediction of MJO-related anomalies using GEFS operational forecast
Initial date: 10 Aug 2013
OLR



Initial Date
(10 Aug 2013)

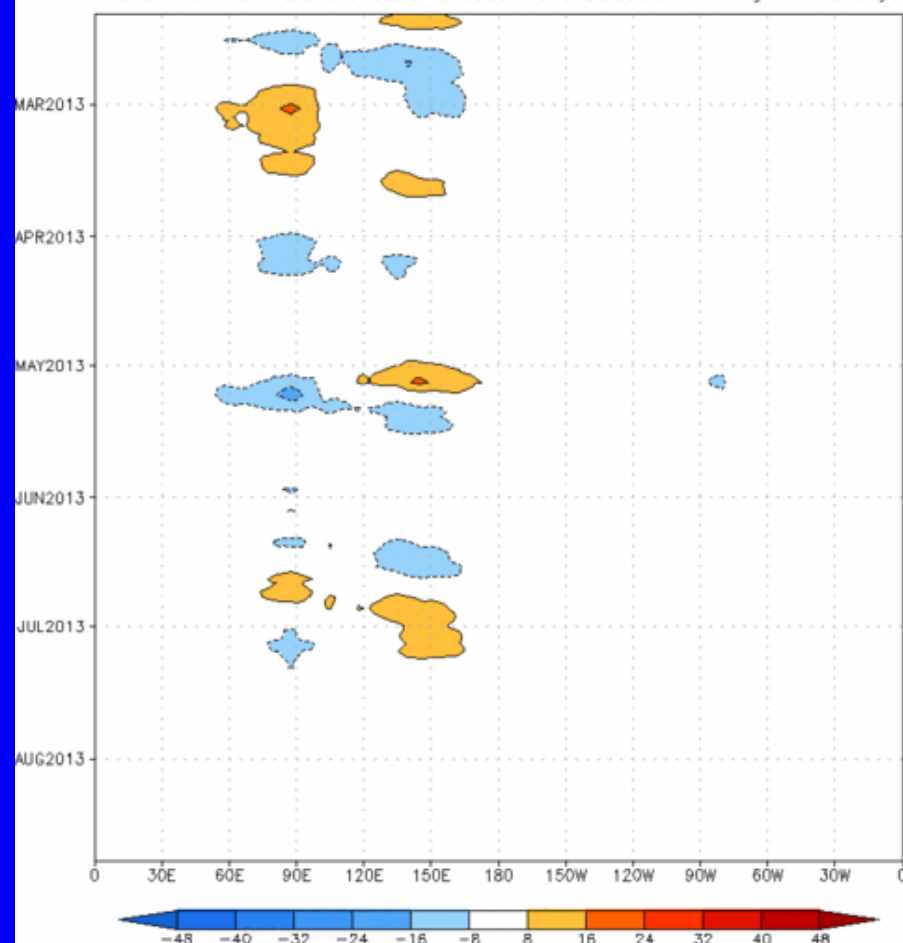
Days 1-5 Ave
Forecast

Days 6-10 Ave
Forecast

Days 11-15 Ave
Forecast

The ensemble mean GFS forecasts little to no anomalous convection during the next 10 days.

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2
OLR [7.5°S,7.5°N] (cont:4Wm⁻²) Period:08-Feb-2013 to 10-Aug-2013
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days

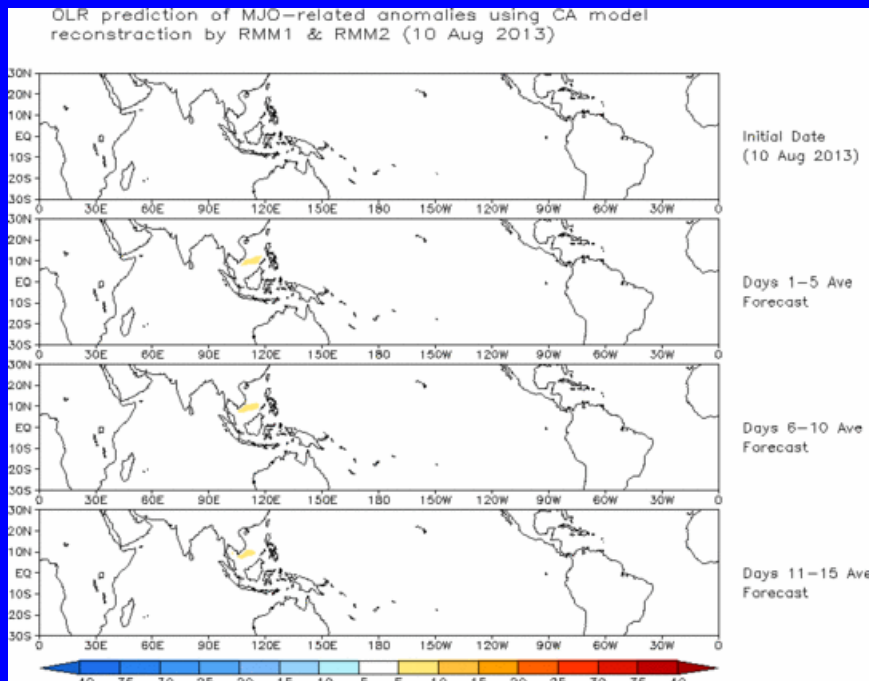




Constructed Analog (CA) MJO Forecast

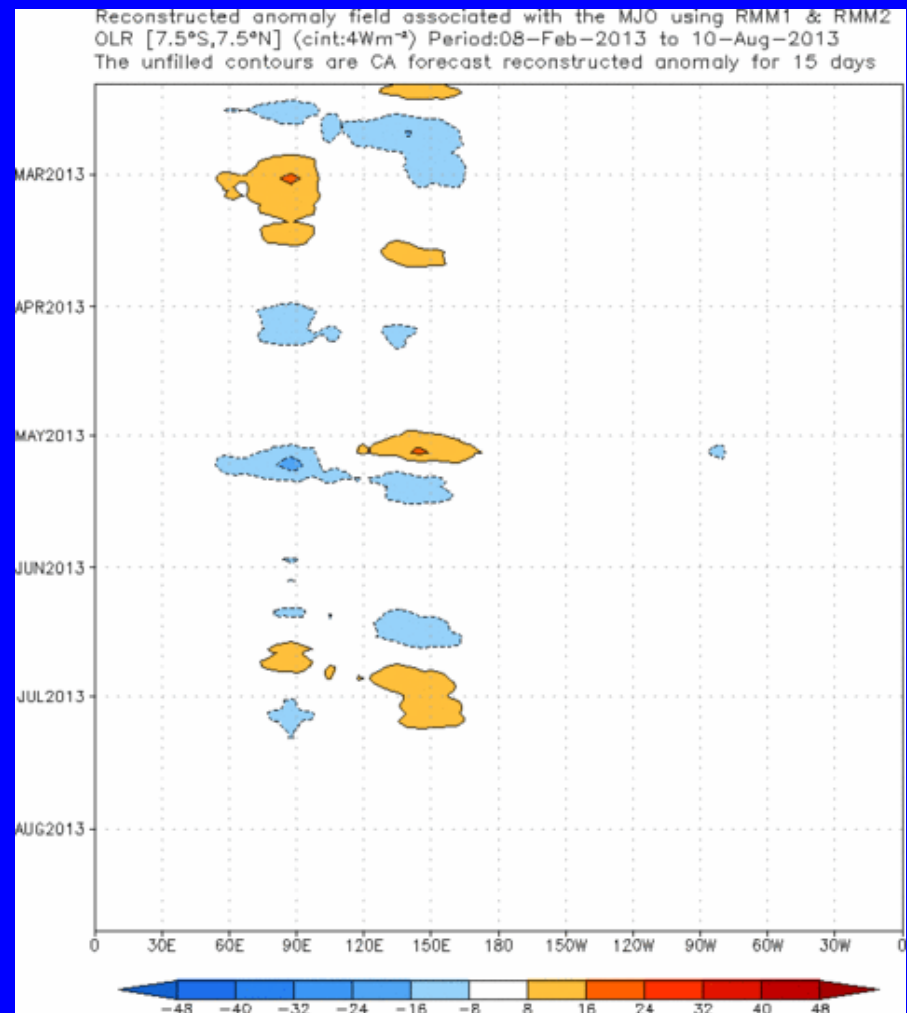
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



This statistical forecast indicates little to no anomalous convection during the next two weeks.

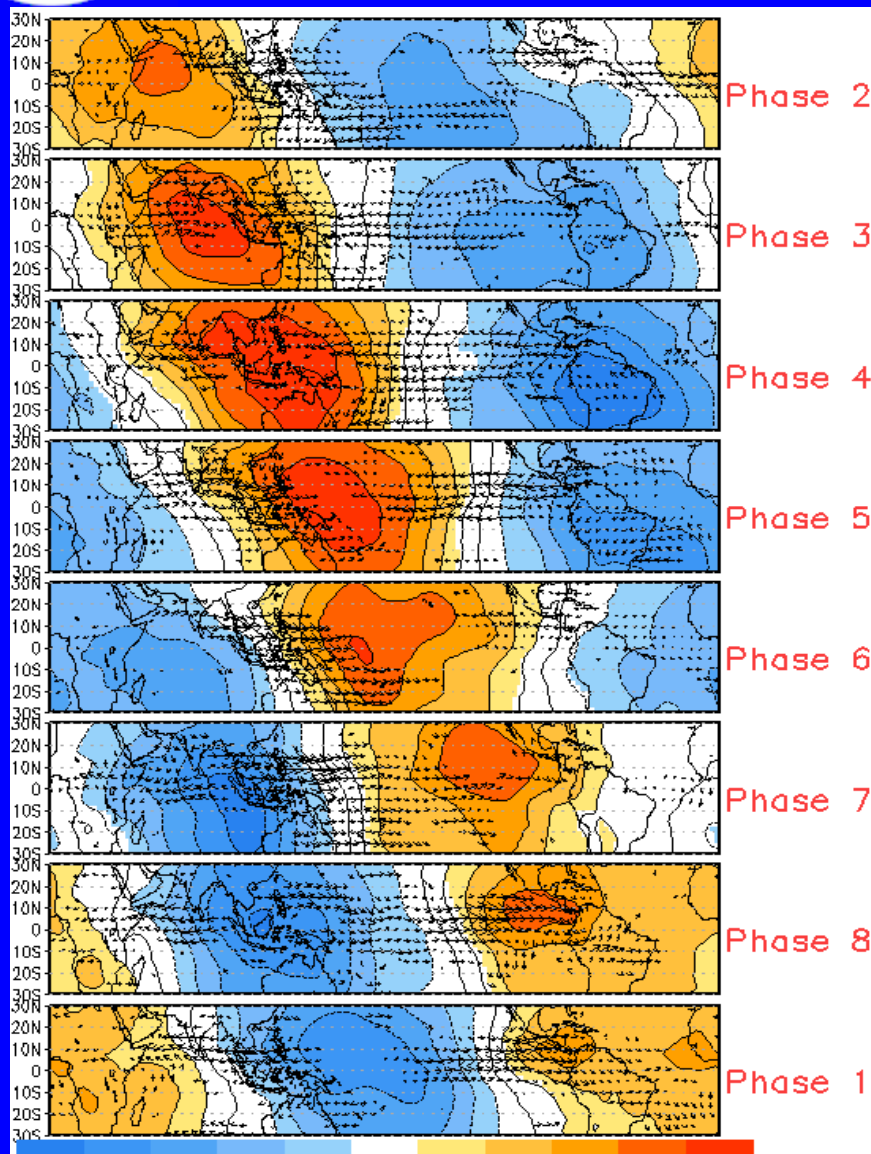
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



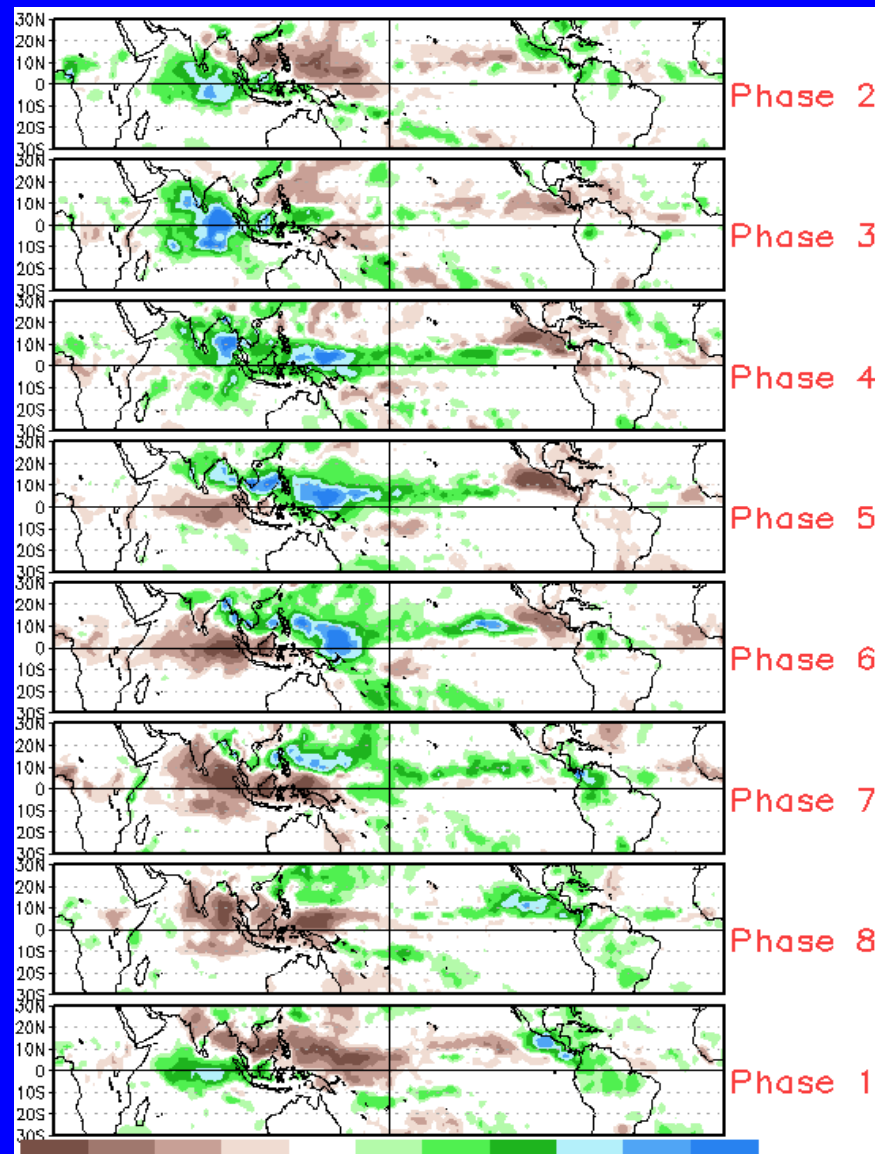


MJO Composites – Global Tropics

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



Precipitation Anomalies (May-Sep)

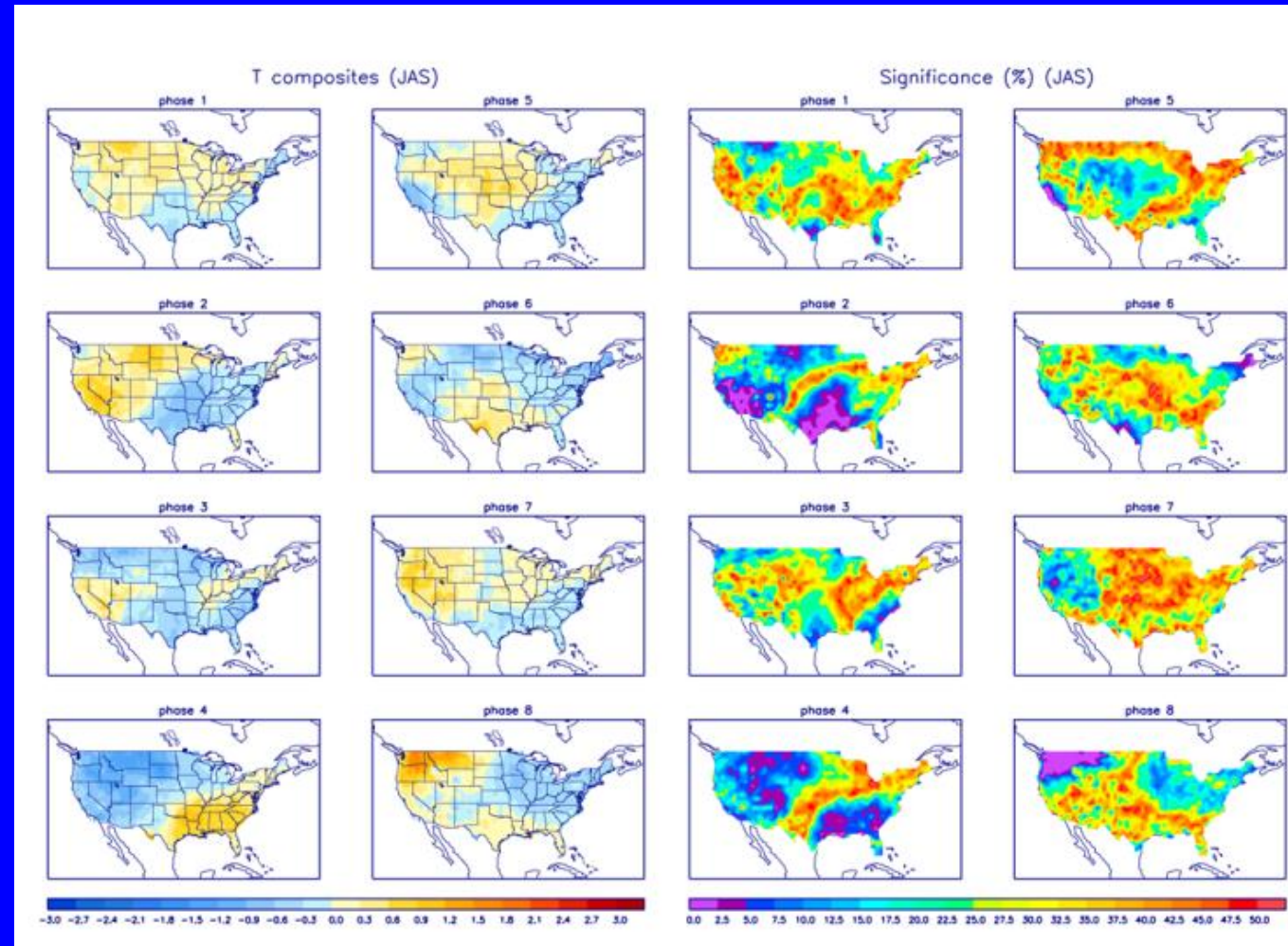




U.S. MJO Composites – Temperature

- 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.



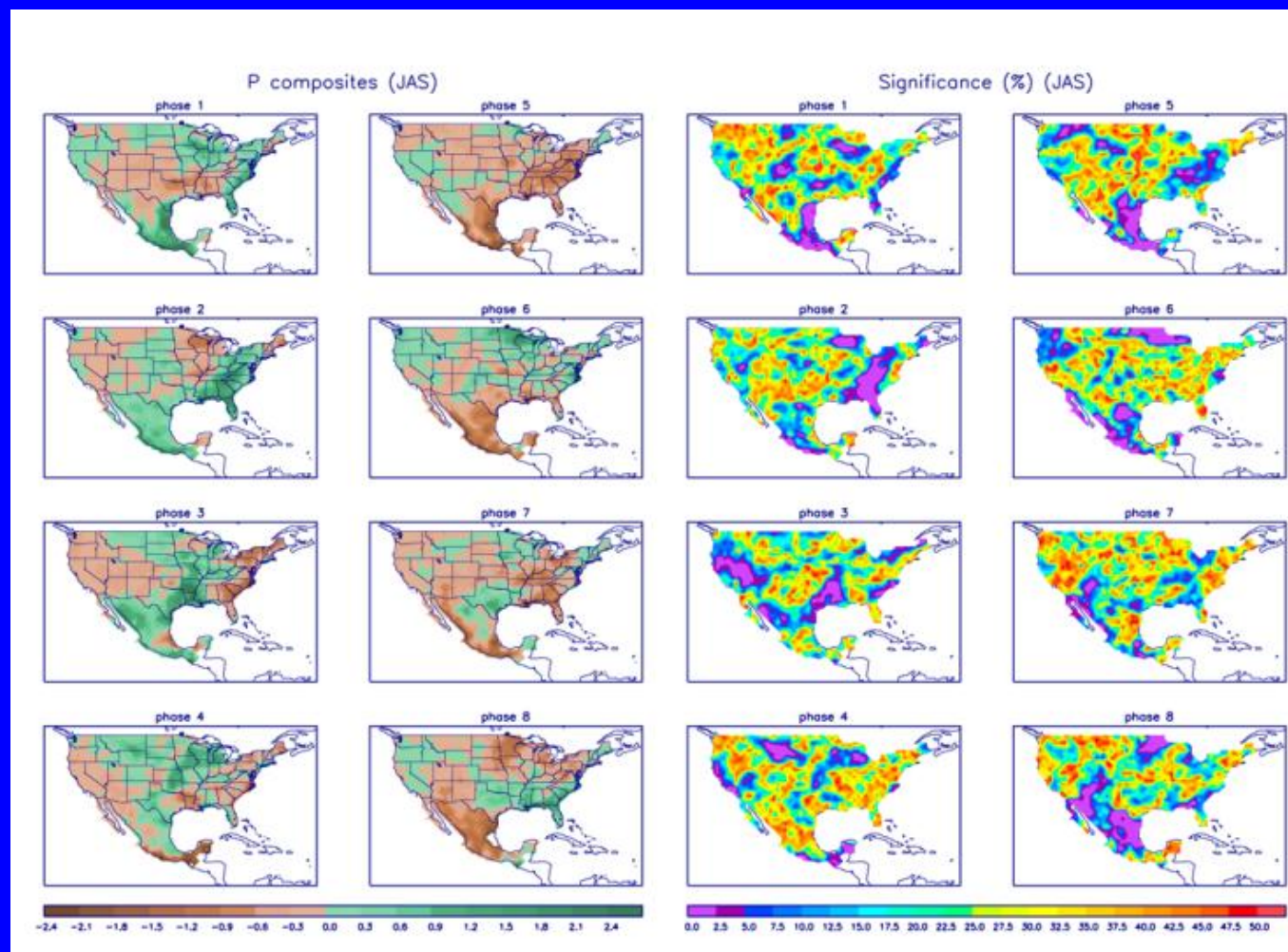
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>