



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

**Update prepared by
Climate Prediction Center / NCEP
August 19, 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.**
- **Dynamical model MJO forecasts indicate an organizing MJO signal during Week-1 with an eastward propagation across the Western Hemisphere.**
- **Based on recent observations and statistical forecasts, the MJO is forecast to have an increasing impact on anomalous convection across the global tropics and also influence tropical cyclone activity.**
- **Odds for tropical cyclone (TC) formation are expected to increase during Week-2 across the main development region of the Atlantic. The North American monsoon is forecast to become more active during the next two weeks with elevated chances for TC development continuing across the East Pacific.**
- **While a general enhancement of convection is favored across the Western Hemisphere during the next two weeks, suppressed convection is more likely from southern India to Southeast Asia.**

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>

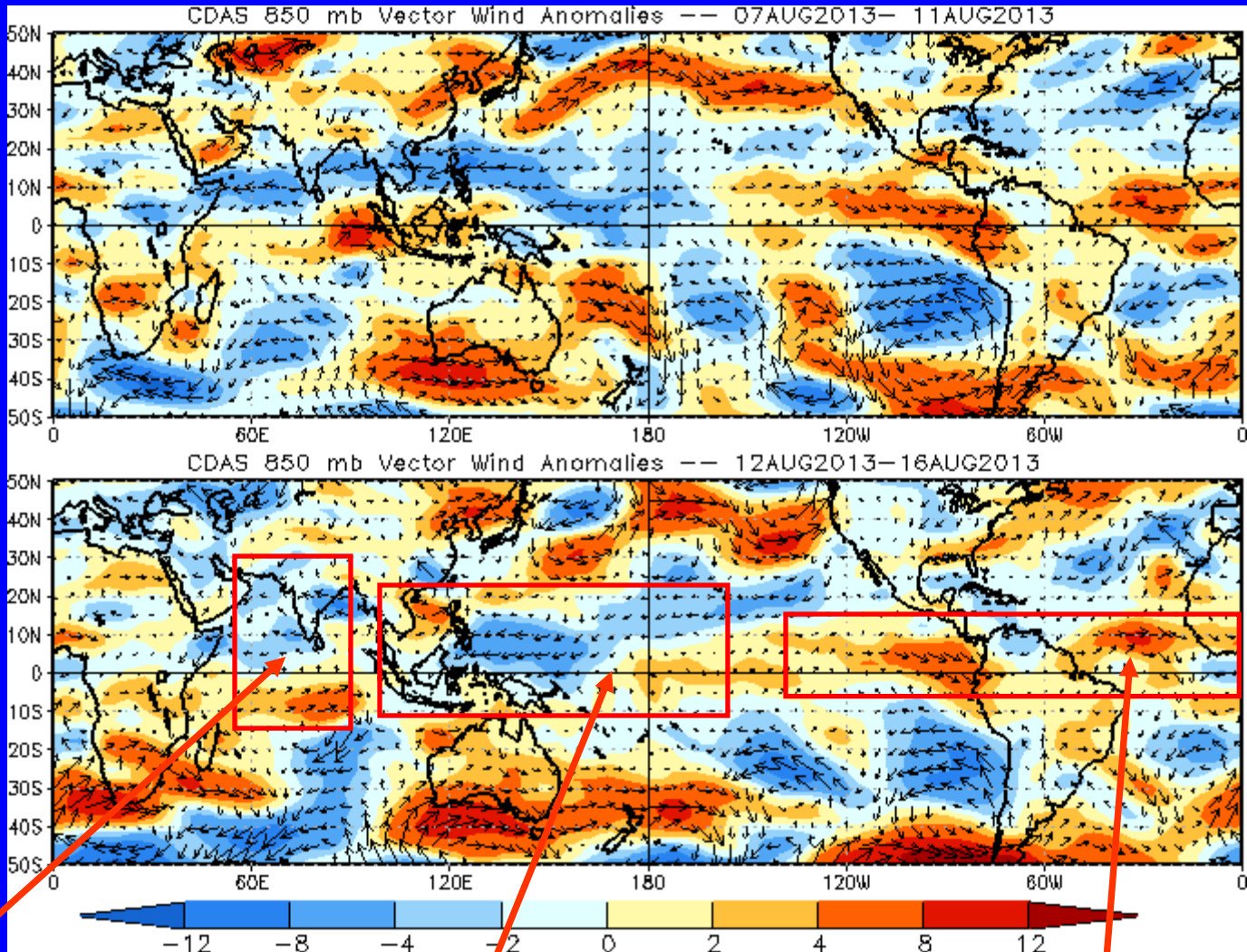


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies persisted across the north Indian Ocean during the past ten days.

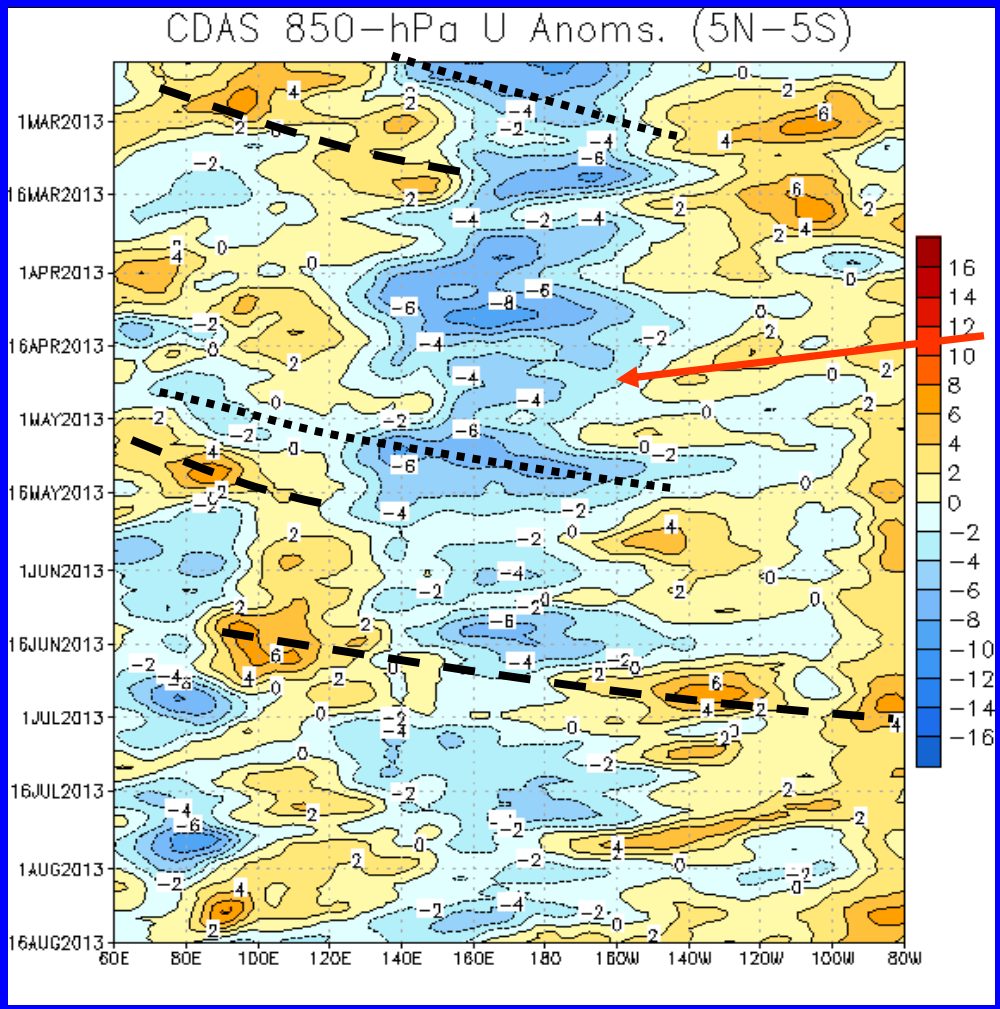
Westerly anomalies diminished across the Maritime Continent, while easterly anomalies persisted over the West Pacific. Some westerly anomalies developed near the Date Line

Westerly anomalies persisted across the East Pacific, tropical Atlantic, and West Africa.



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.

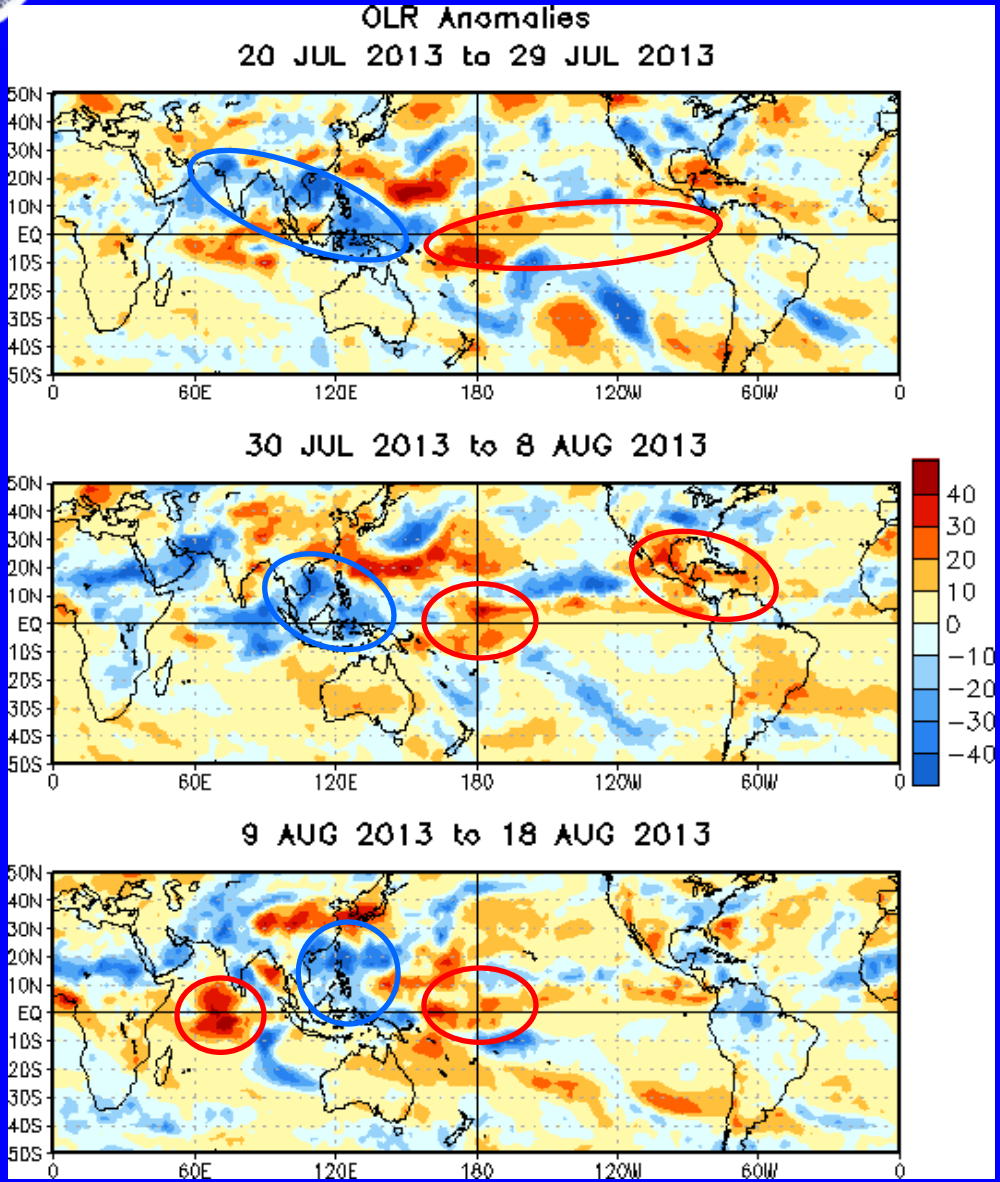
The MJO strengthened again in late June, with eastward propagation of low-level westerly wind anomalies noted. The propagation speed was at the faster end of the spectrum.

During late July through mid-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 late July, the MJO enhanced phase propagated over the Indian Ocean to the Maritime Continent with enhanced convection shifting northeast across South Asia and the Maritime Continent.

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

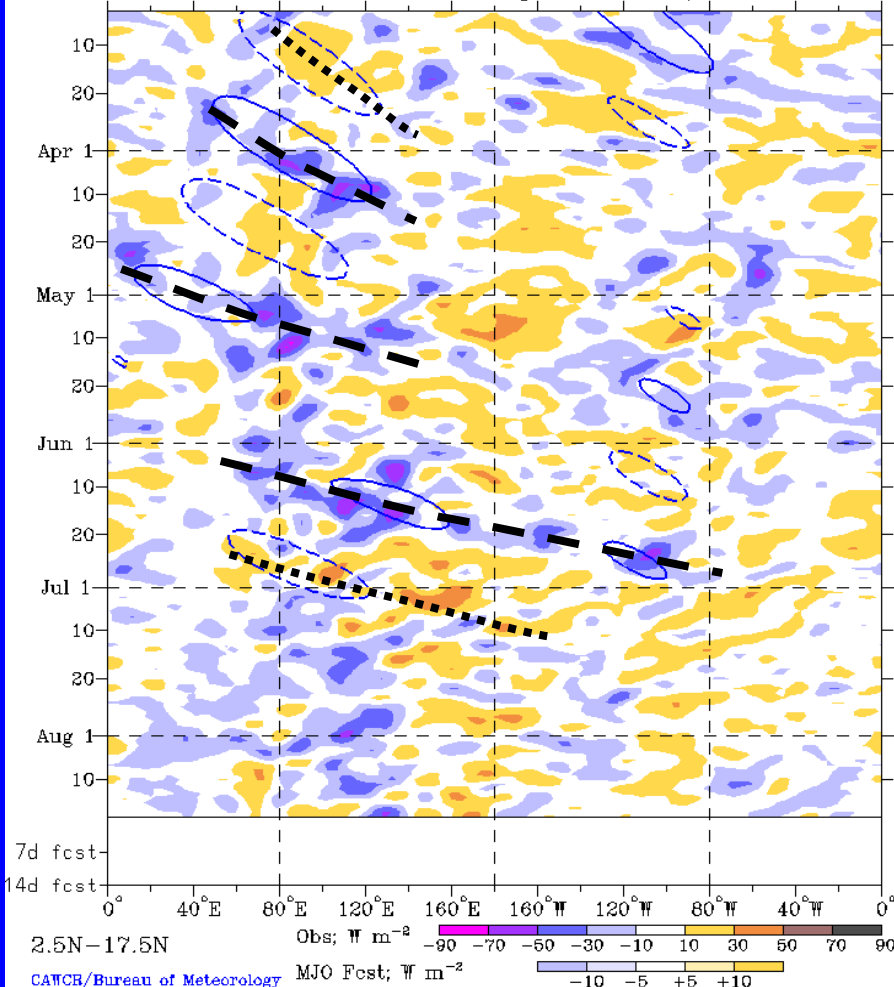
During early to mid-August, other modes of variability influenced anomalous convection with enhanced convection persisting across parts of the Maritime Continent. Suppressed convection developed across the central Indian Ocean.



Outgoing Longwave Radiation (OLR)

Anomalies (2.5°N-17.5°N)

Real-time MJO filtering superimposed upon 3drmm R21 OLR Anomalies
MJO anomalies blue contours, CINT=10. (5. for forecast)
Negative contours solid, positive dashed
3-Mar-2013 to 18-Aug-2013 + 14 days



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 during 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

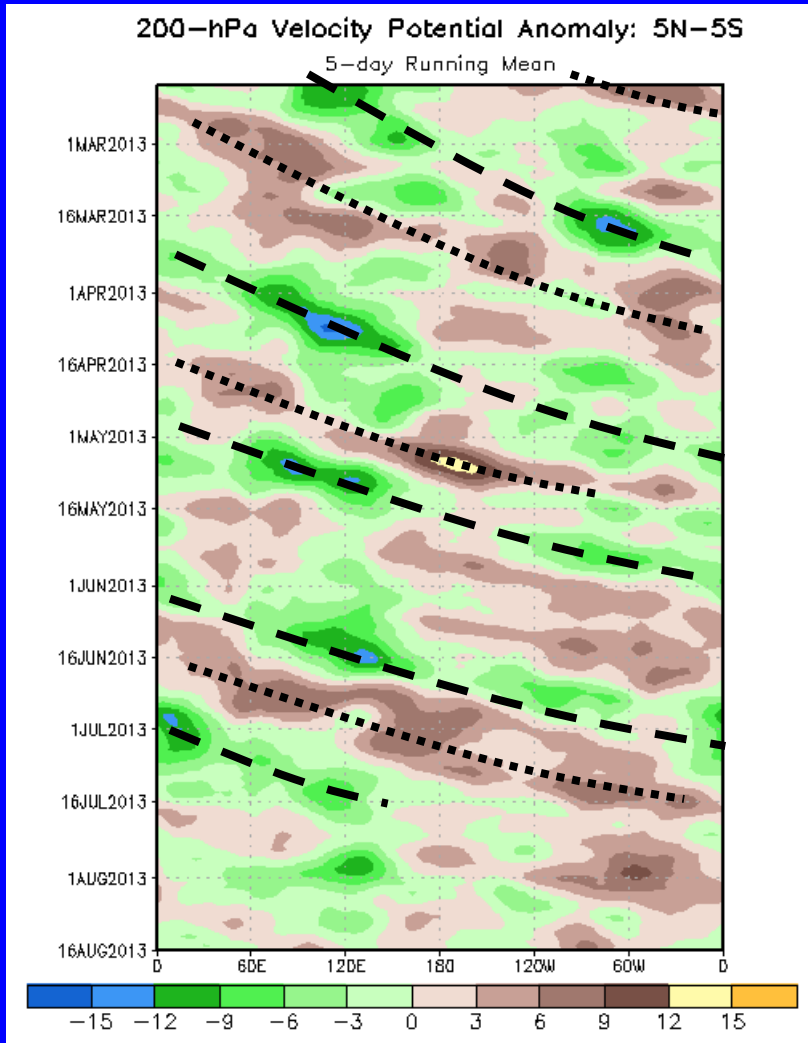


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time
↓



Longitude

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.

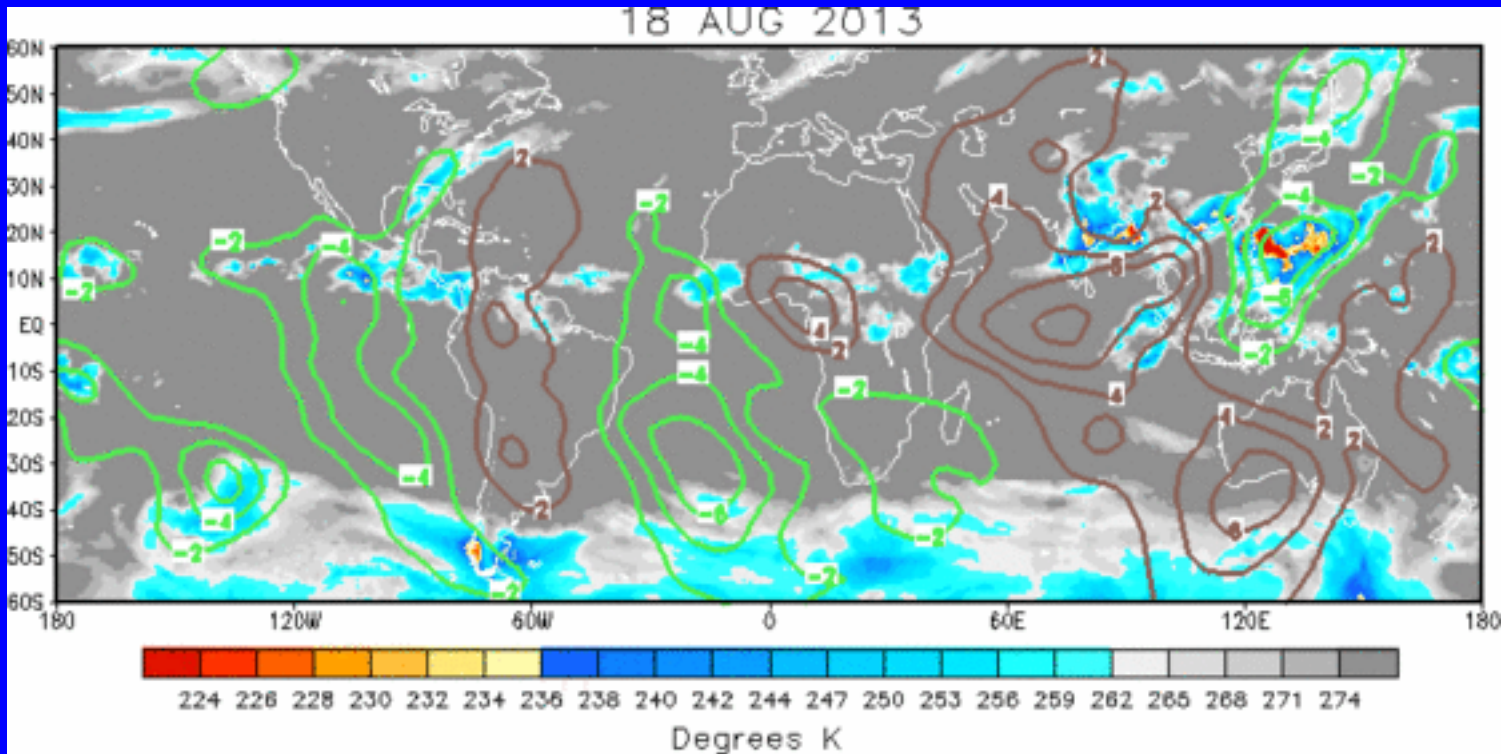
During late June and the first half of July, the signal was more coherent and consistent with a canonical MJO footprint. More recently, a more stationary pattern is noted along with evidence of atmospheric Kelvin waves.



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 is incoherent with small anomalies observed across most of the global tropics. Upper-level convergence recently increased across the eastern Indian Ocean and western Maritime Continent.

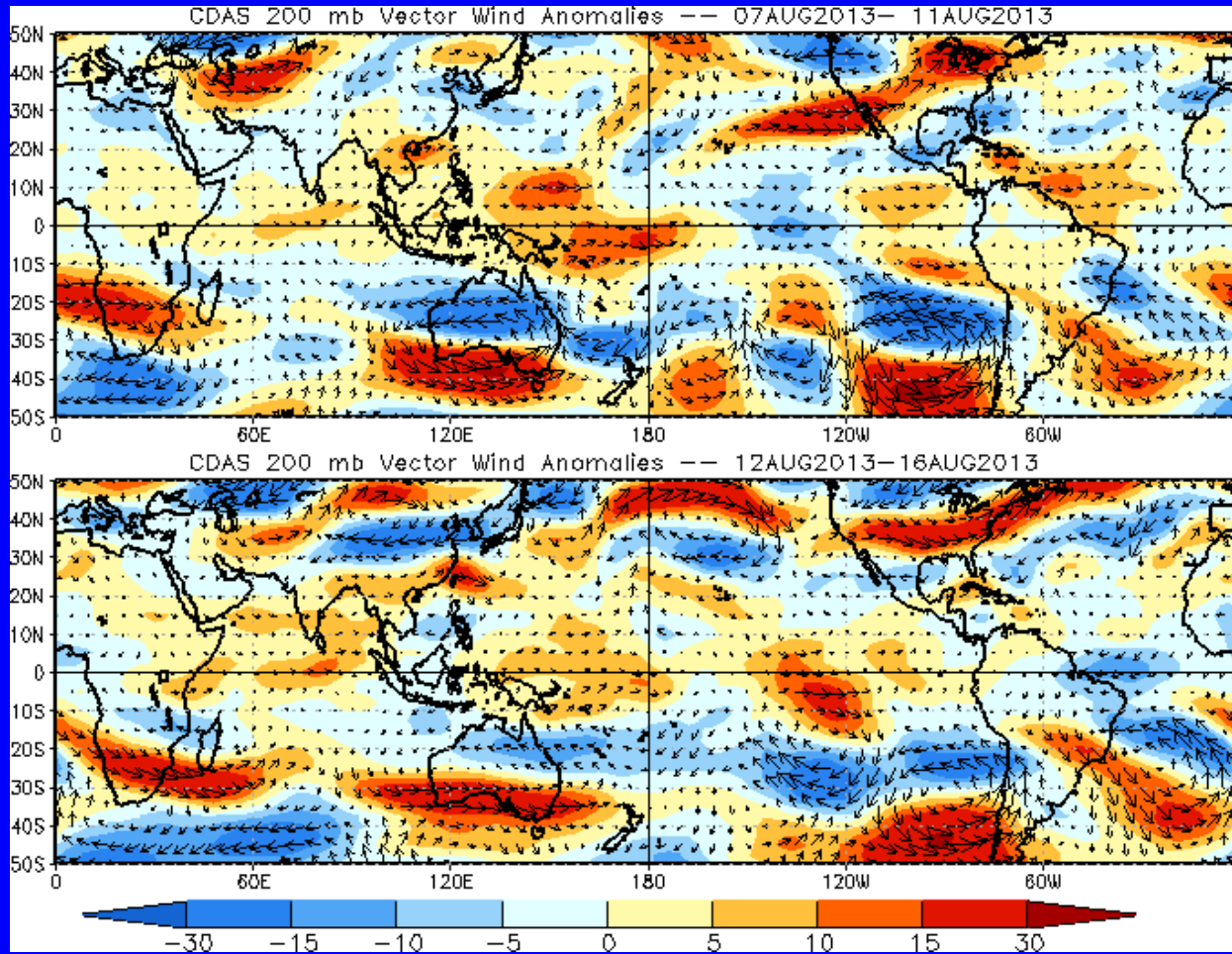


200-hPa Vector Wind Anomalies ($m s^{-1}$)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



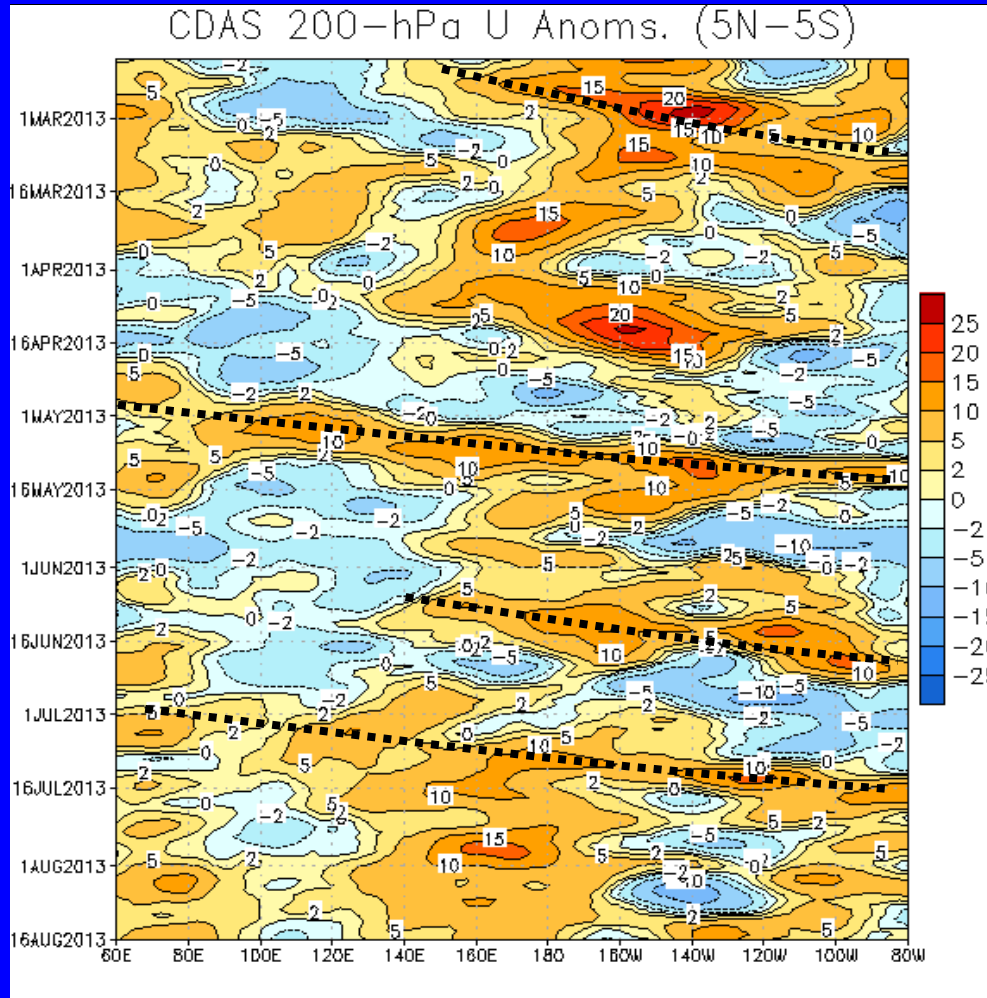
Westerly wind anomalies continue across much of the Tropics.



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



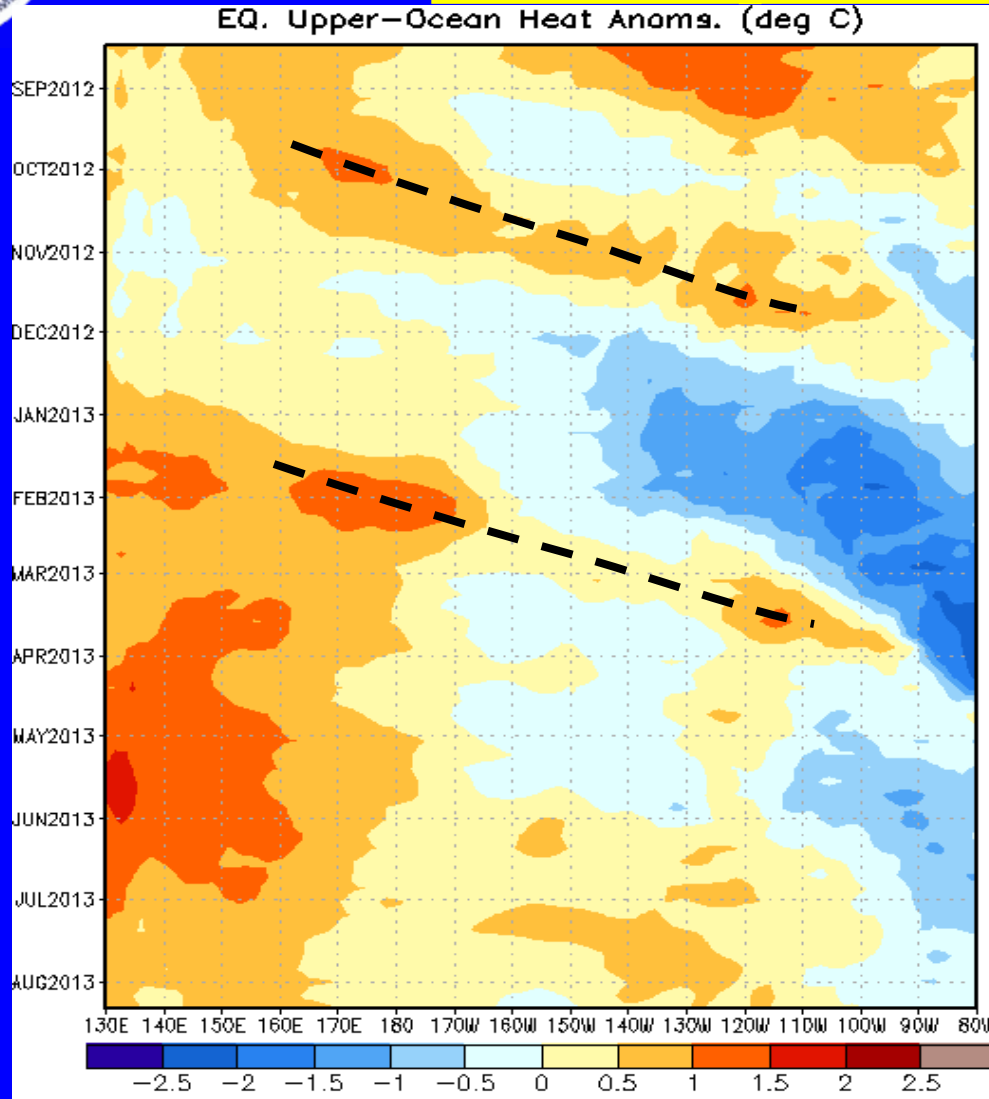
Eastward propagation of westerly wind anomalies associated with the MJO continued into April 2013. Some propagation of easterly anomalies is evident during late January and early February.

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



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.

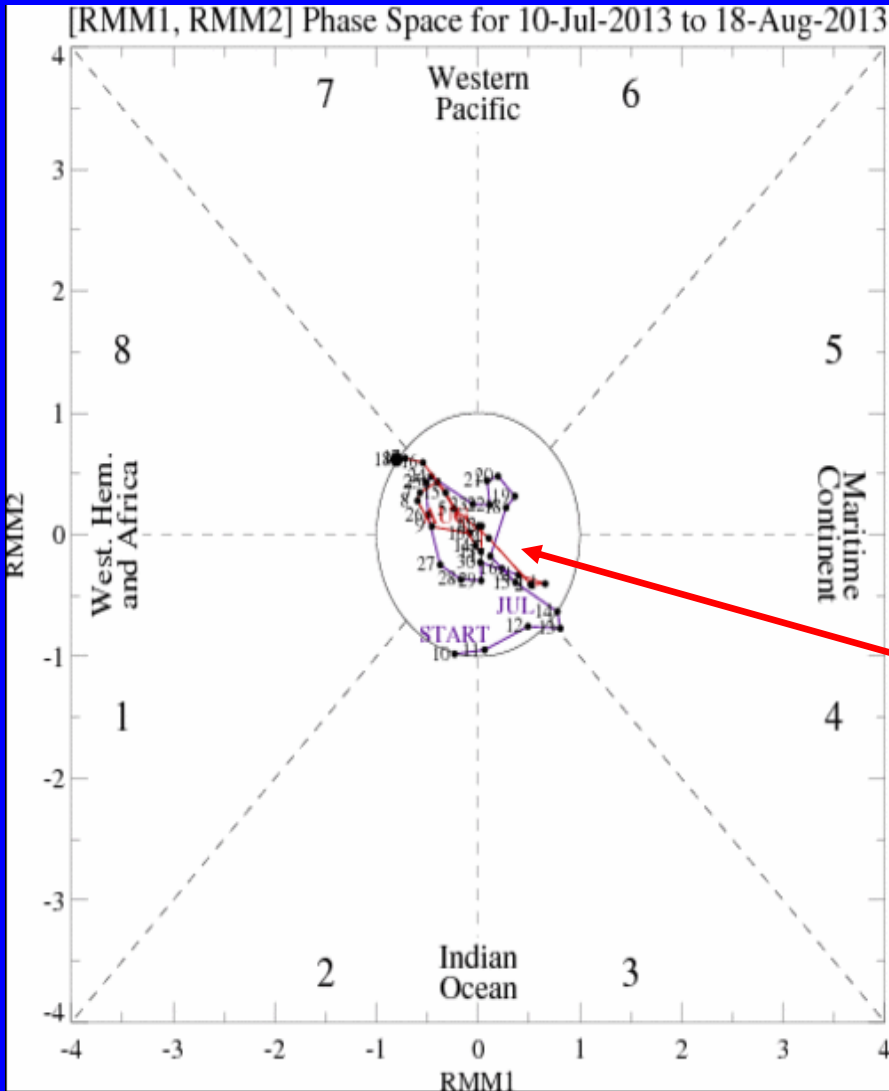
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

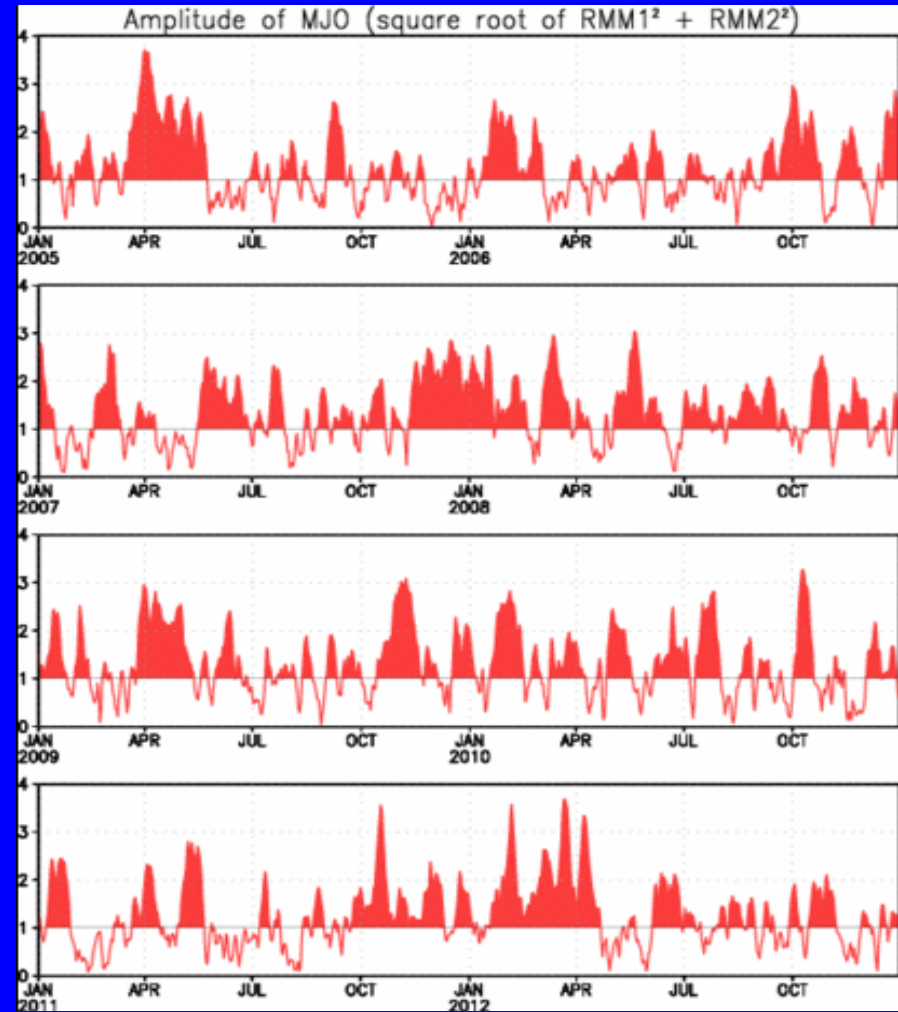
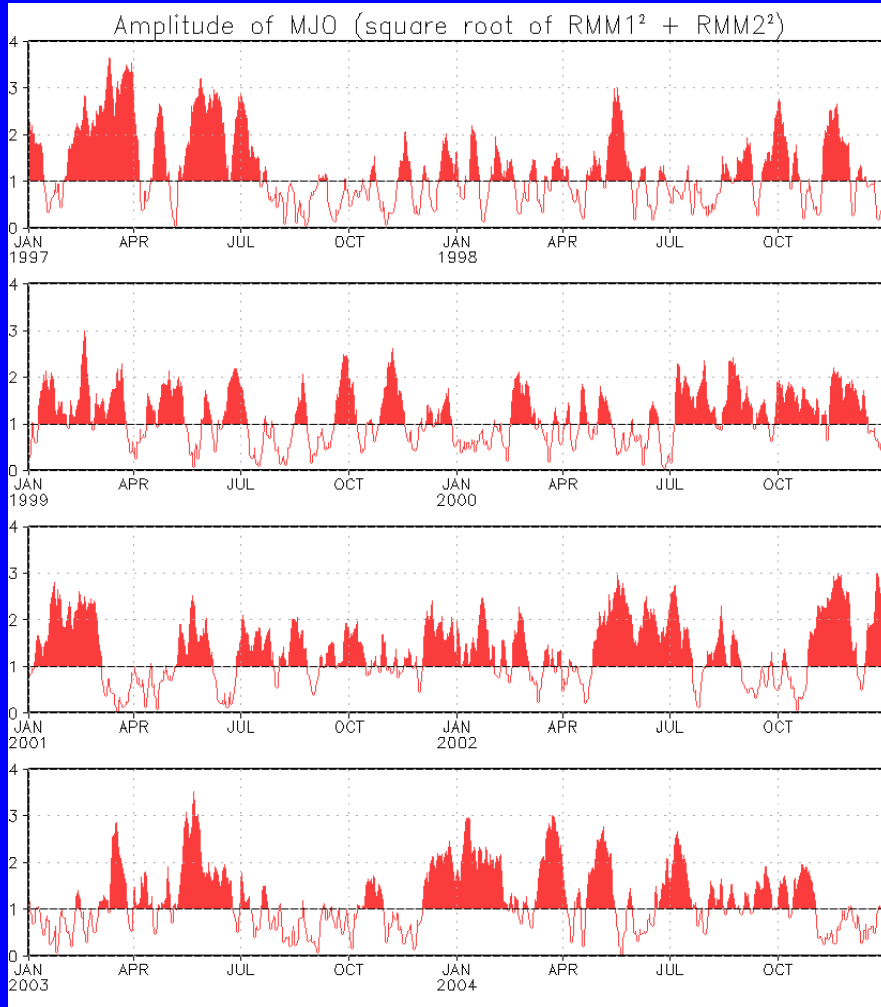


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

During the past several weeks, the Wheeler-Hendon Index indicates 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.



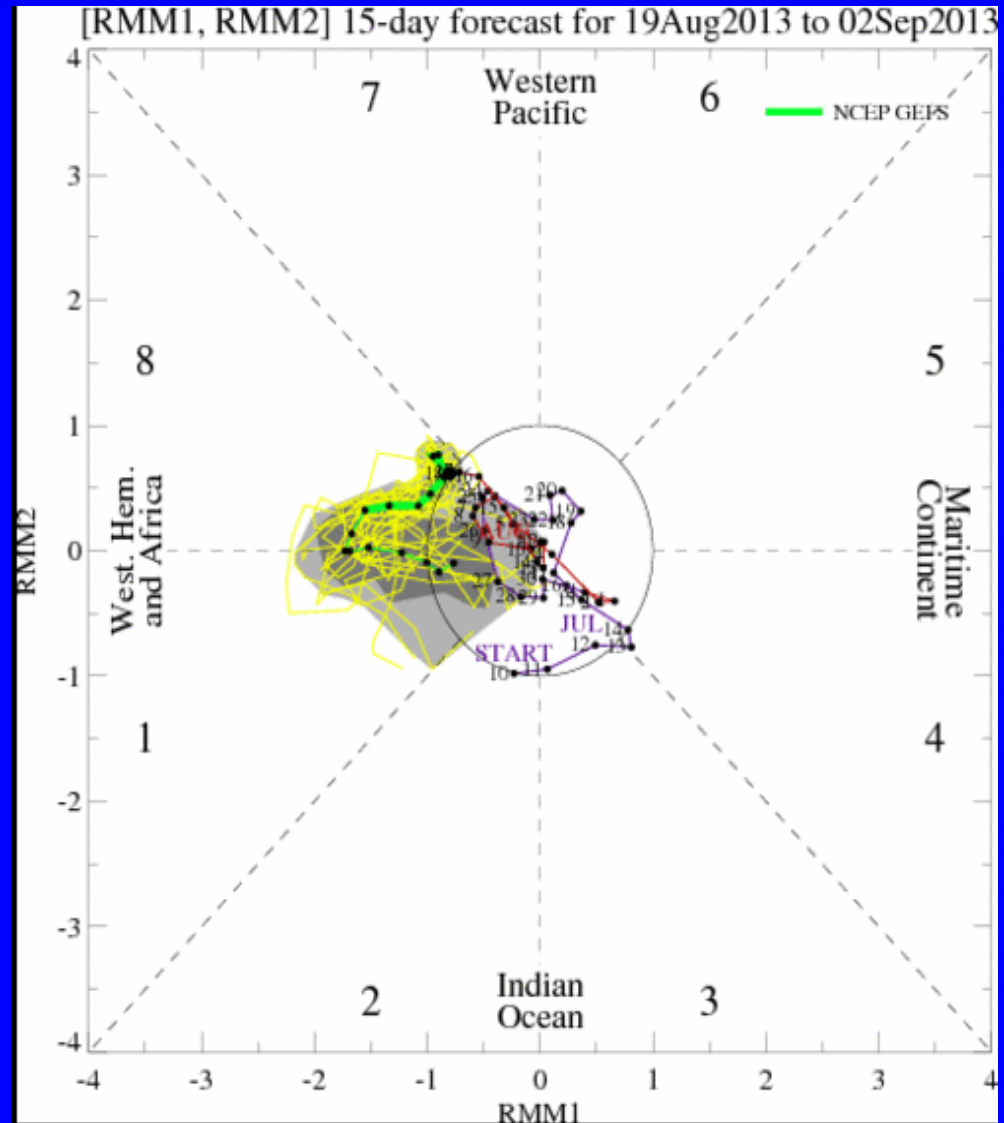
Ensemble GFS (GEFS) MJO Forecast

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 a weak signal emerging in Phase 8 early in Week-1 with some eastward propagation.



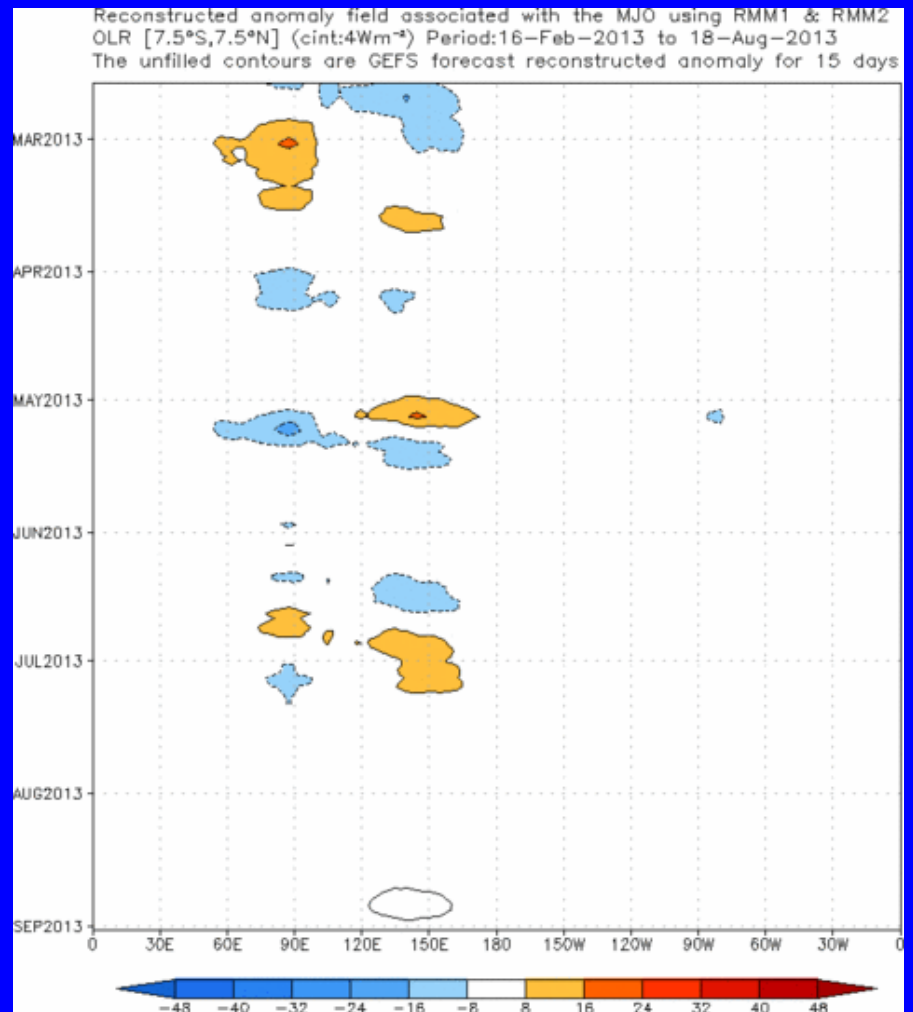
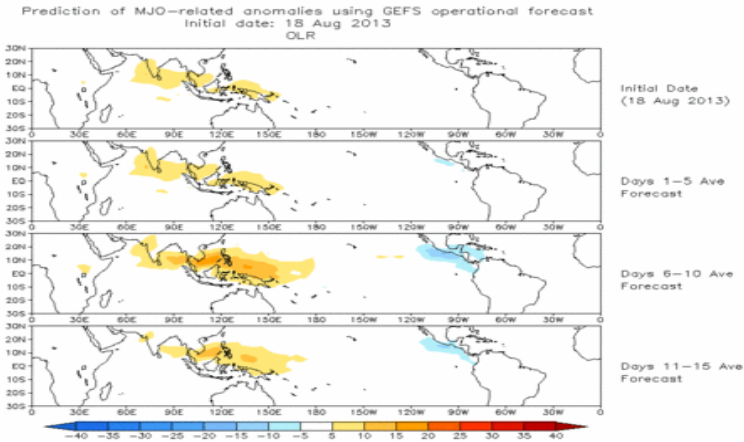


Ensemble Mean GFS MJO Forecast

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 across the Maritime Continent to the West Pacific during the next two weeks. Enhanced convection is forecast to develop across the East Pacific, southern Mexico, and central America later in Week-1.

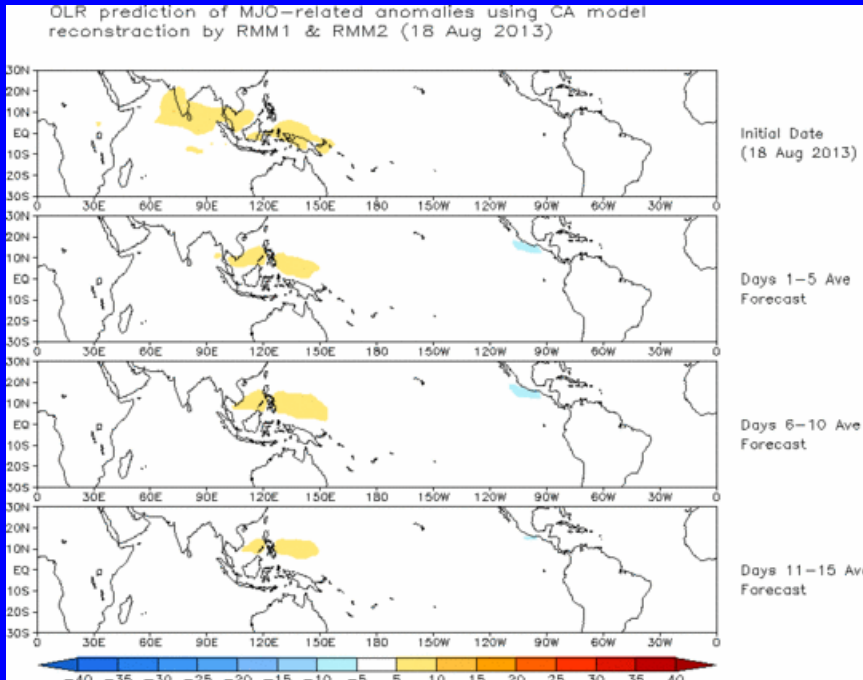


Constructed Analog (CA) MJO Forecast

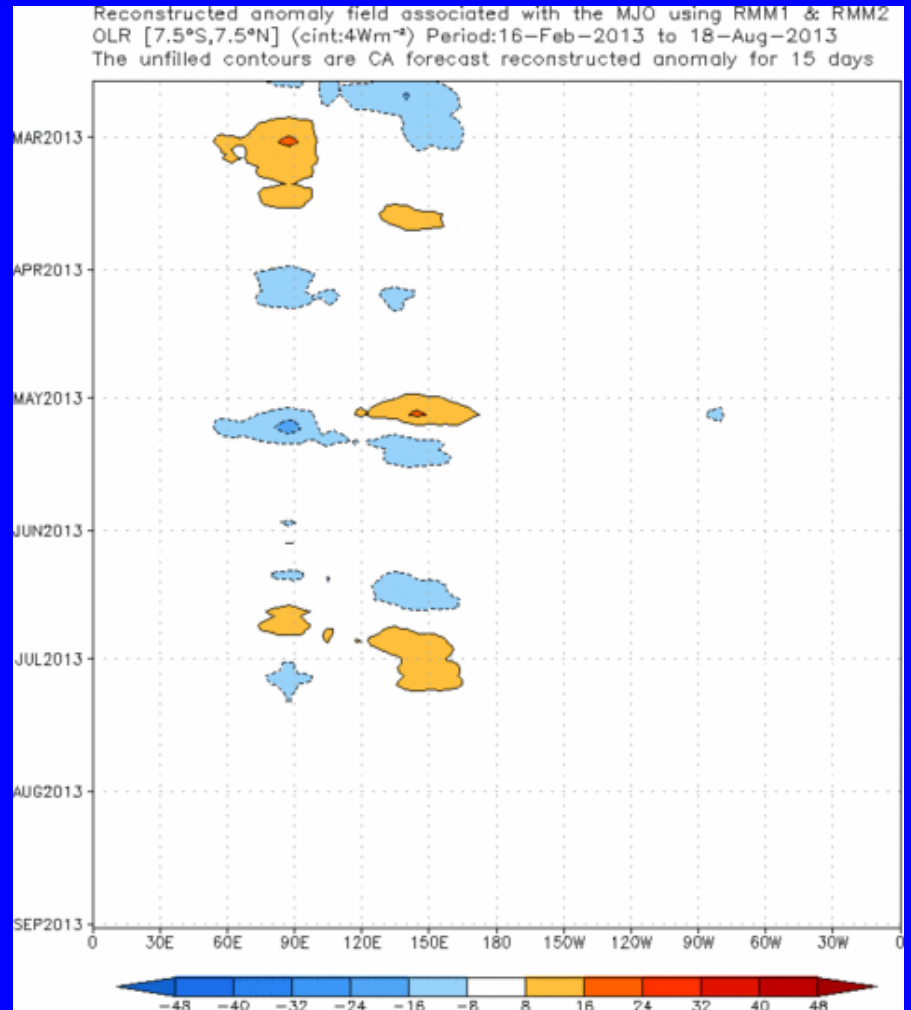
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

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 little anomalous convection during the next two weeks.

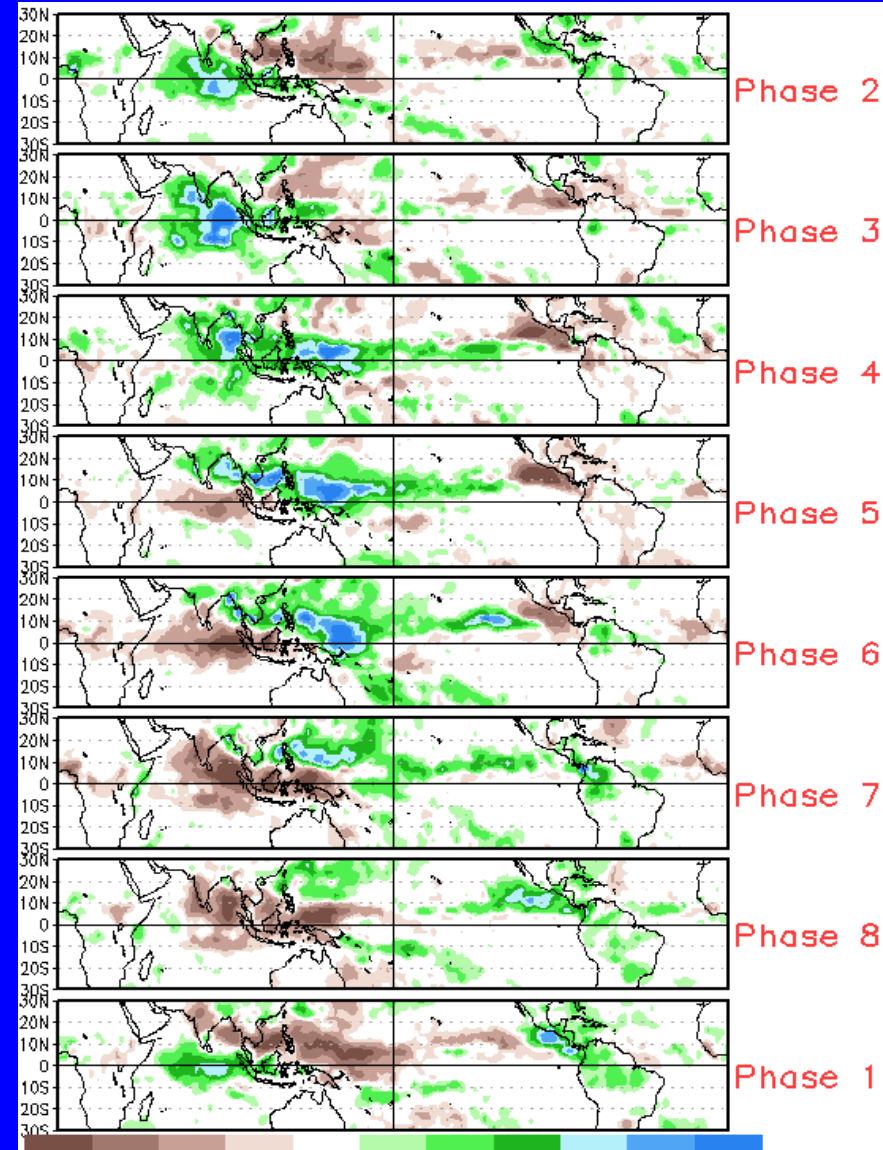
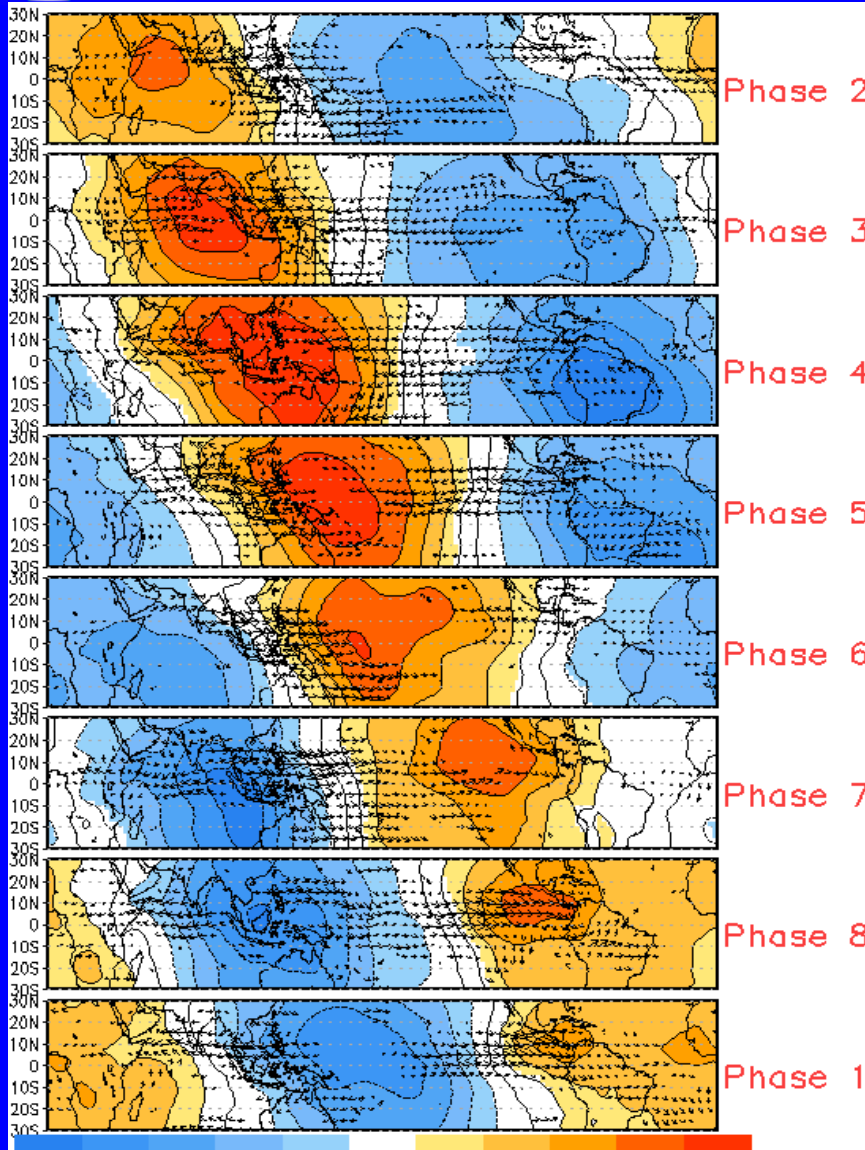




MJO Composites – Global Tropics

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

Precipitation Anomalies (May-Sep)

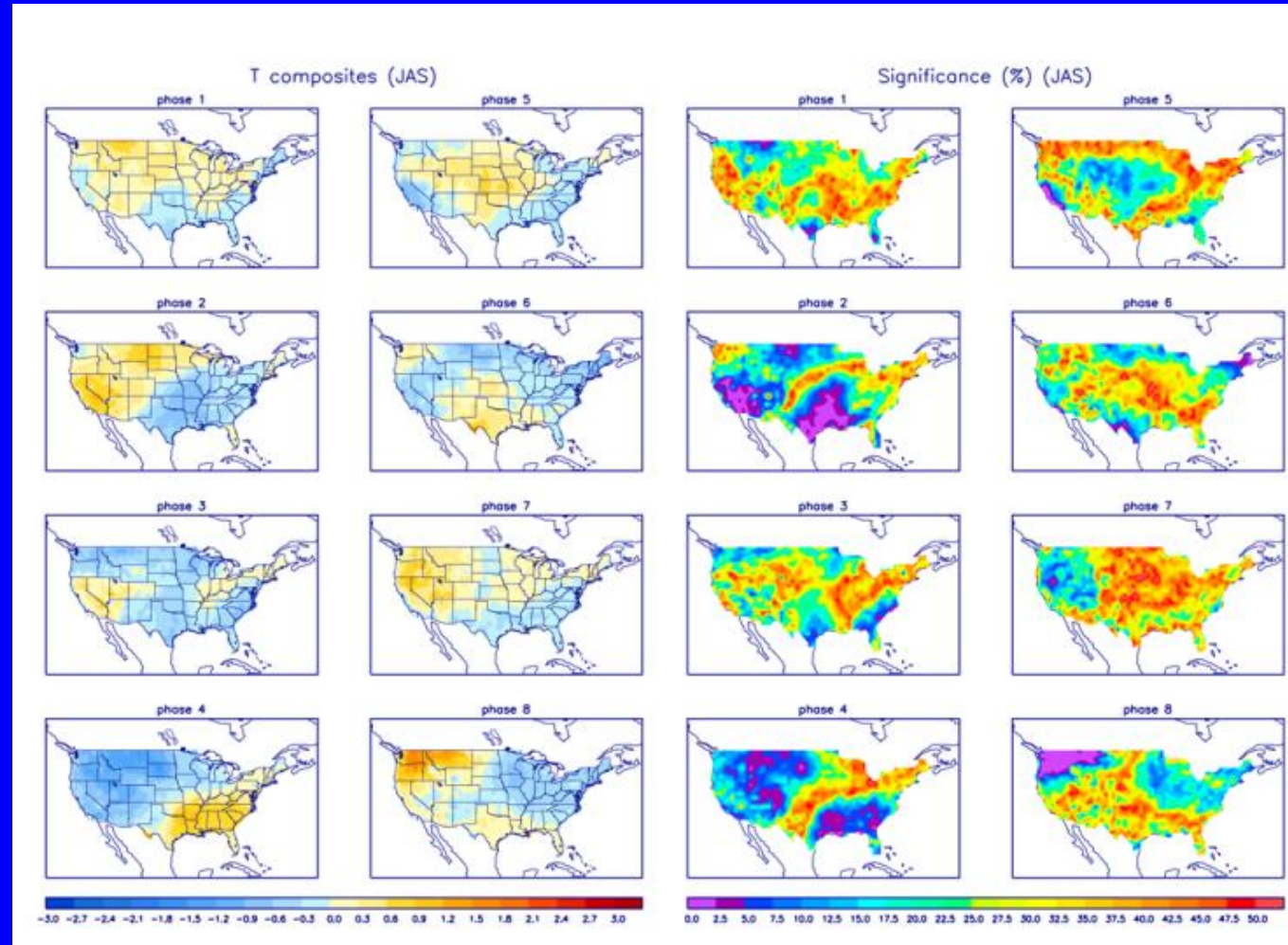




U.S. MJO Composites – Temperature

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.



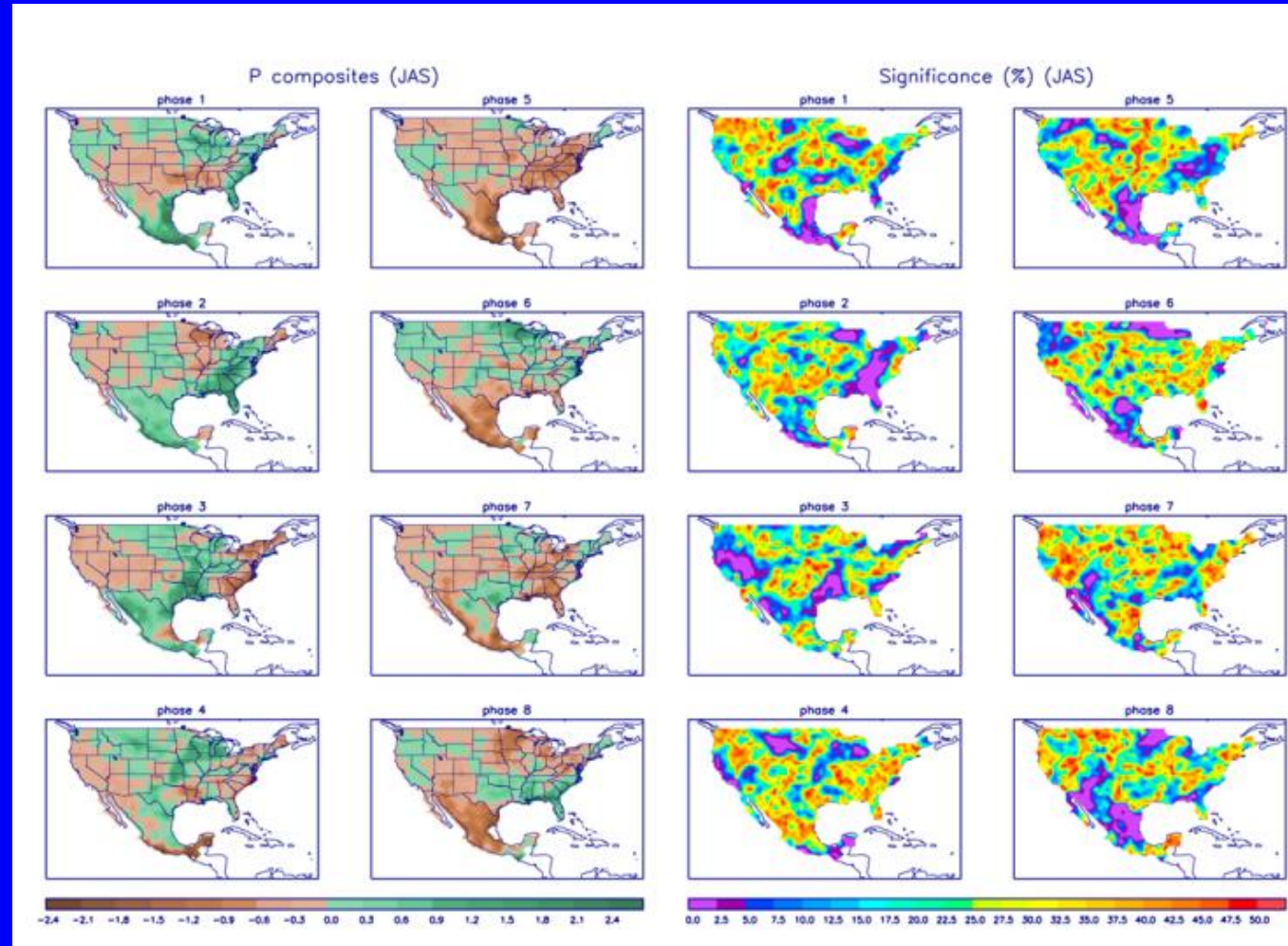
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>