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

Update prepared by
Climate Prediction Center / NCEP
July 15, 2013

Outline

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

Overview

- A coherent MJO signal propagated eastward over the eastern Indian Ocean during the previous week.

- Dynamical model MJO forecasts indicate an incoherent MJO pattern during the upcoming two weeks. A few statistical models forecast eastward propagation of a weak MJO signal.

- Based on recent observations and statistical forecasts, in contrast with the dynamical guidance, the MJO is forecast to retain coherence and propagate eastward over the Maritime Continent during the upcoming two weeks.

- Consistent with the observed state of the MJO, enhanced convection is favored over India, the Bay of Bengal, and the Maritime Continent during Week-1, with suppressed convection forecast over the eastern Pacific. During Week-2, enhanced convection is forecast over Southeast Asia and the Maritime Continent, contrasting with suppressed convection over the Caribbean.

- Based on the current and forecasted MJO state, tropical cyclone development is not favored over the Atlantic basin. Enhanced probabilities of tropical cyclogenesis extend over the western Pacific, with odds of tropical cyclone formation increasing over the eastern Pacific during Week-2.

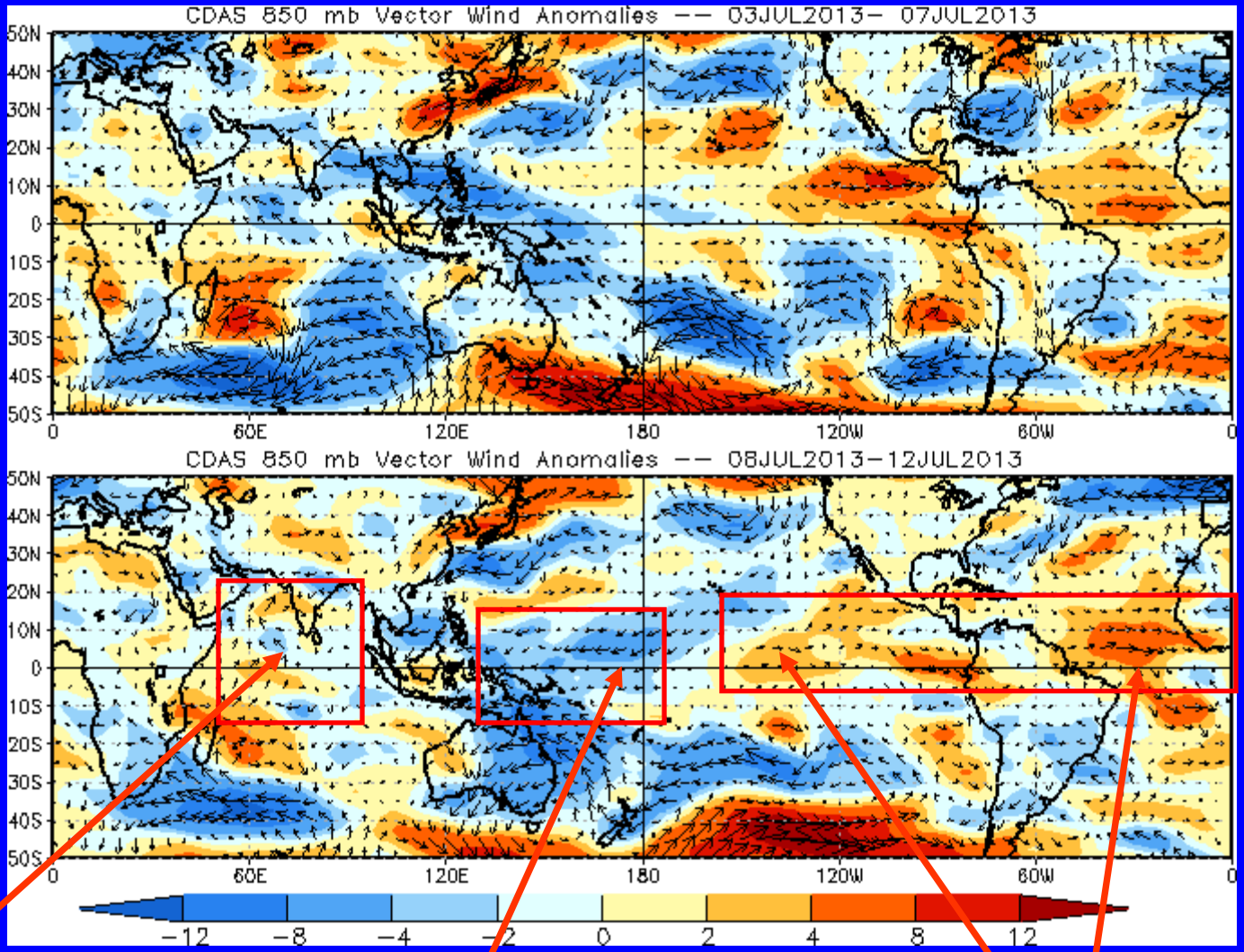
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Low level zonal wind anomalies weakened over the Indian Ocean.

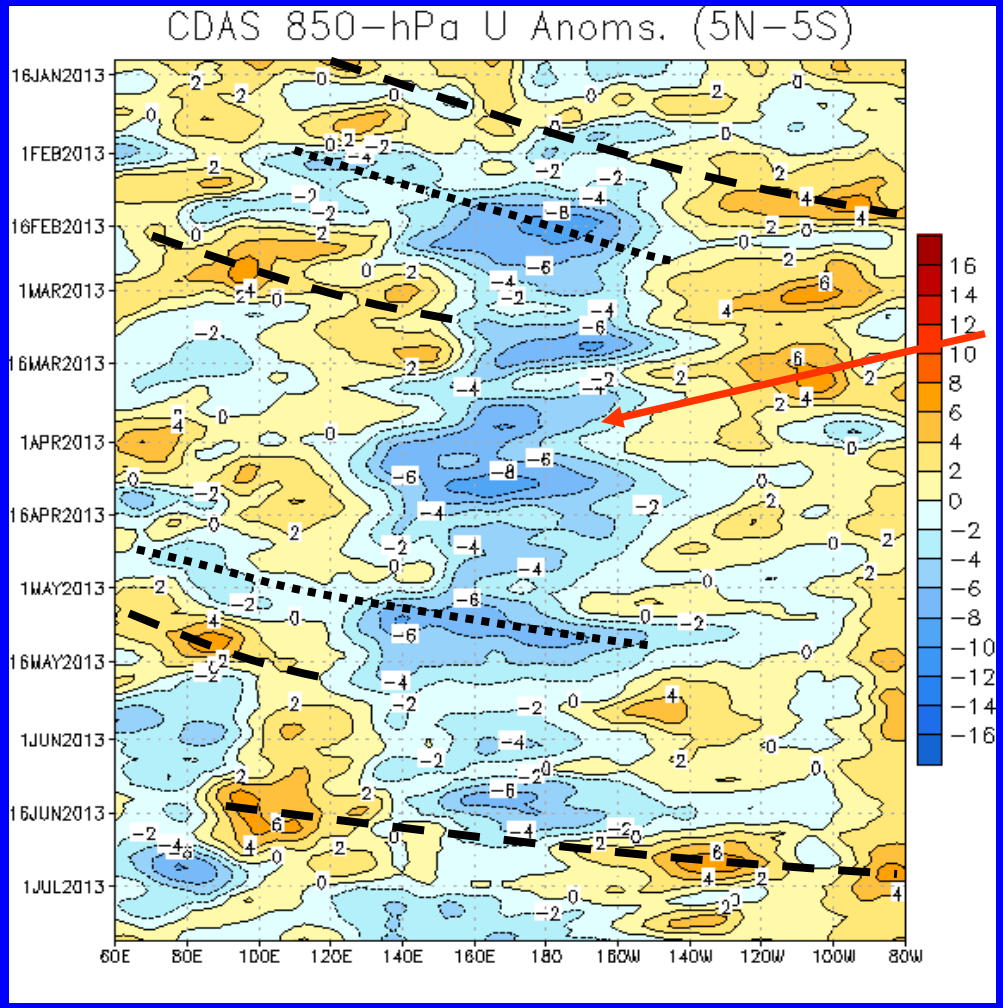
Easterly anomalies increased near the Date Line over the central Pacific.

Westerly anomalies weakened over the eastern Pacific and persisted over the tropical Atlantic.

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

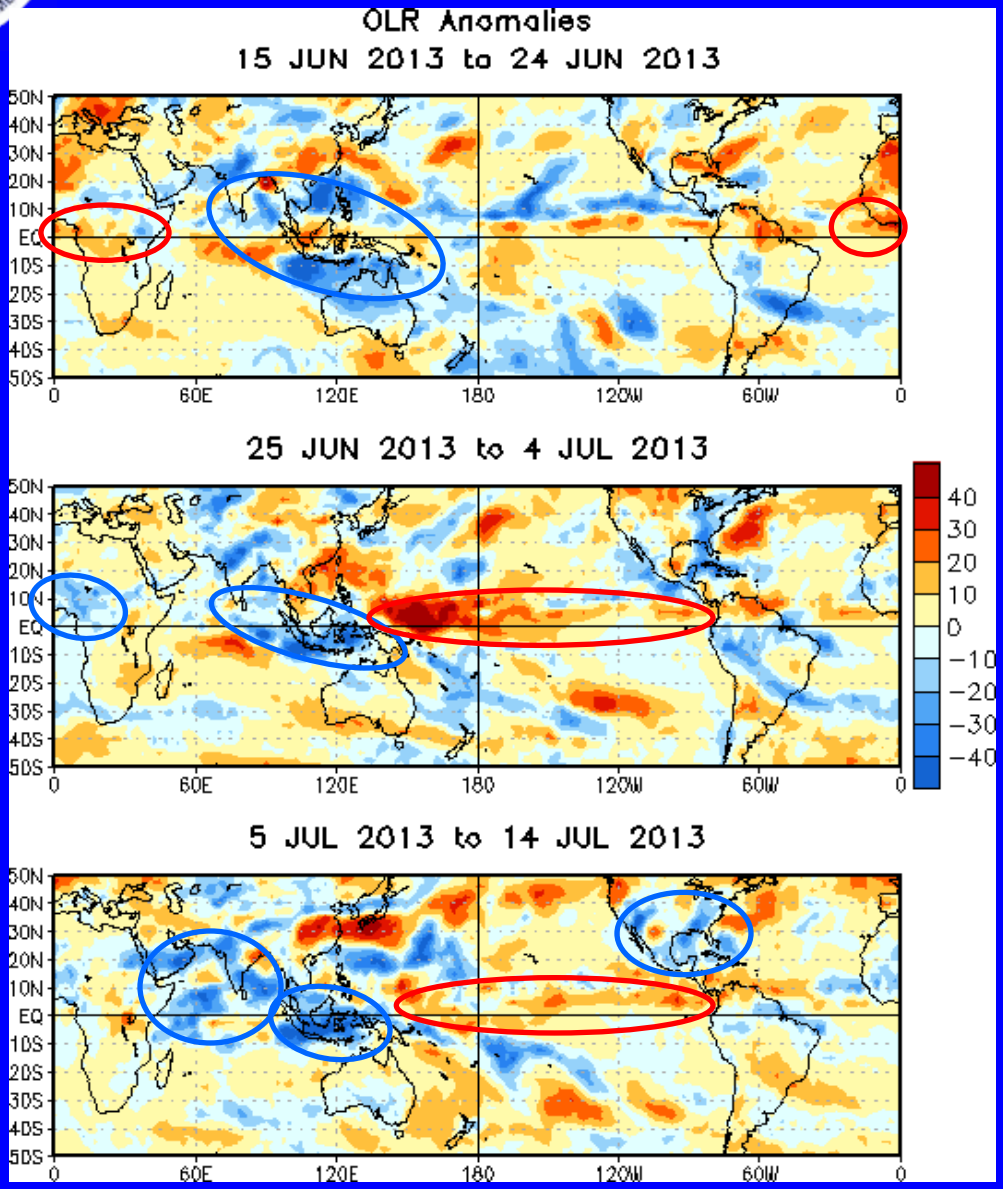
During early January the MJO strengthened (alternating dotted/dashed lines).

During March and early 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. Recently, westerly (easterly) anomalies have persisted over the eastern (western) Pacific.

OLR Anomalies – Past 30 days



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

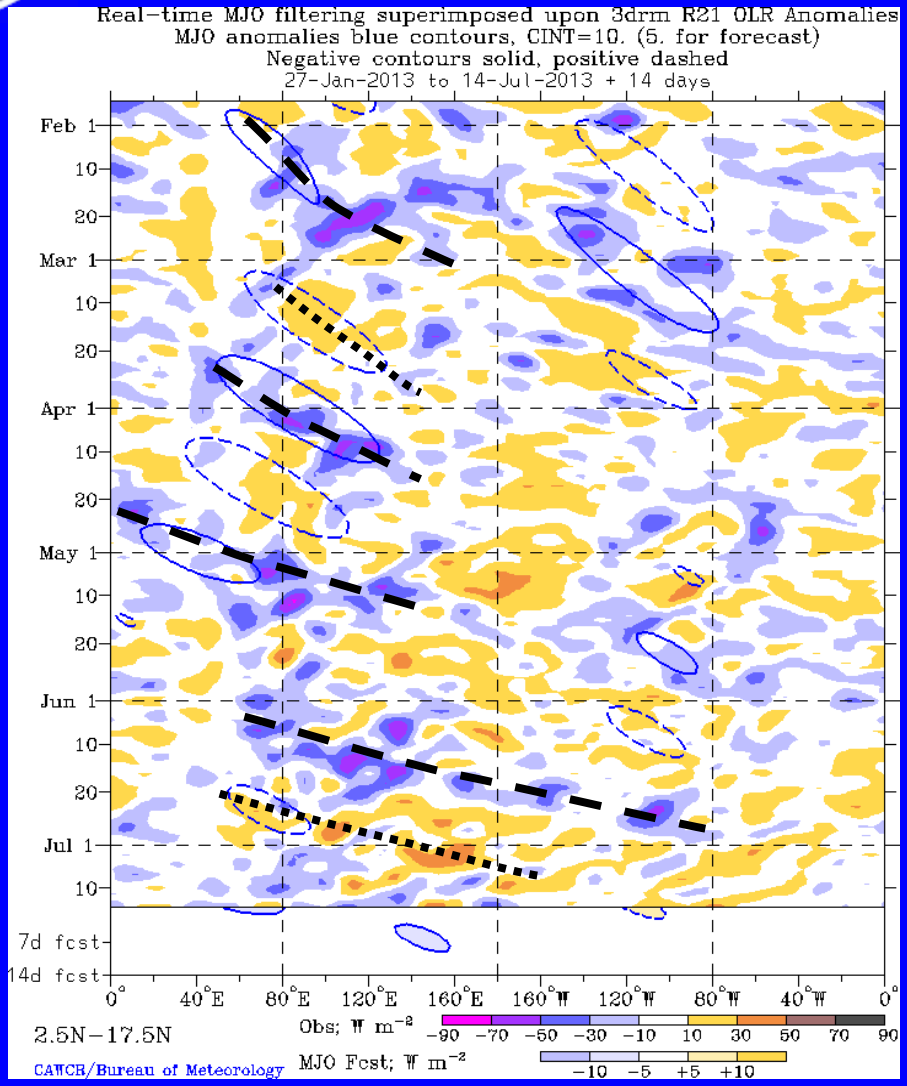
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During mid to late June, enhanced (suppressed) convection associated with the MJO was apparent over the Maritime Continent and western Pacific (Western Hemisphere).

The MJO enhanced phase propagated eastward into the Western Hemisphere during late June and early July. Anomalous convection persisted over the Maritime Continent.

During the first two weeks of July, the MJO enhanced phase propagated eastward into the Indian Ocean. Other modes of tropical intraseasonal variability were apparent in the OLR pattern.

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)

The MJO was a dominant mode of variability across the Tropics from January into 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.

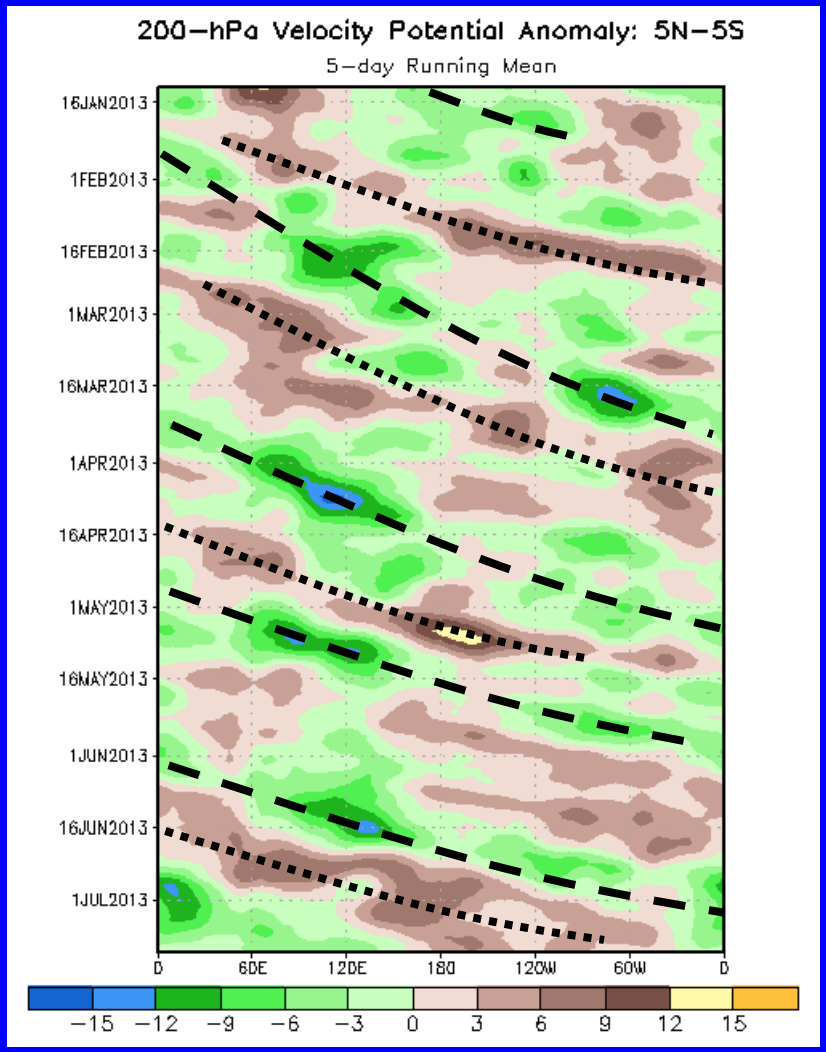
During early May, OLR decreased significantly (stronger negative anomalies) across the Indian Ocean. The MJO signal quickly broke down.

The MJO signal emerged during June and early July, as indicated by the alternating dashed and dotted lines. Other modes of variability are apparent as well, such as a westward propagating Rossby wave over the Maritime continent.

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

The MJO strengthened in late December, (alternating dashed and dotted lines) and anomalies increased in magnitude with more robust eastward propagation indicated during late 2012 to April 2013.

Anomalies became less coherent at times during late January and early February as the influence from other modes of variability are evident in the depicted anomalies. Some reorganization is evident in late February and early March.

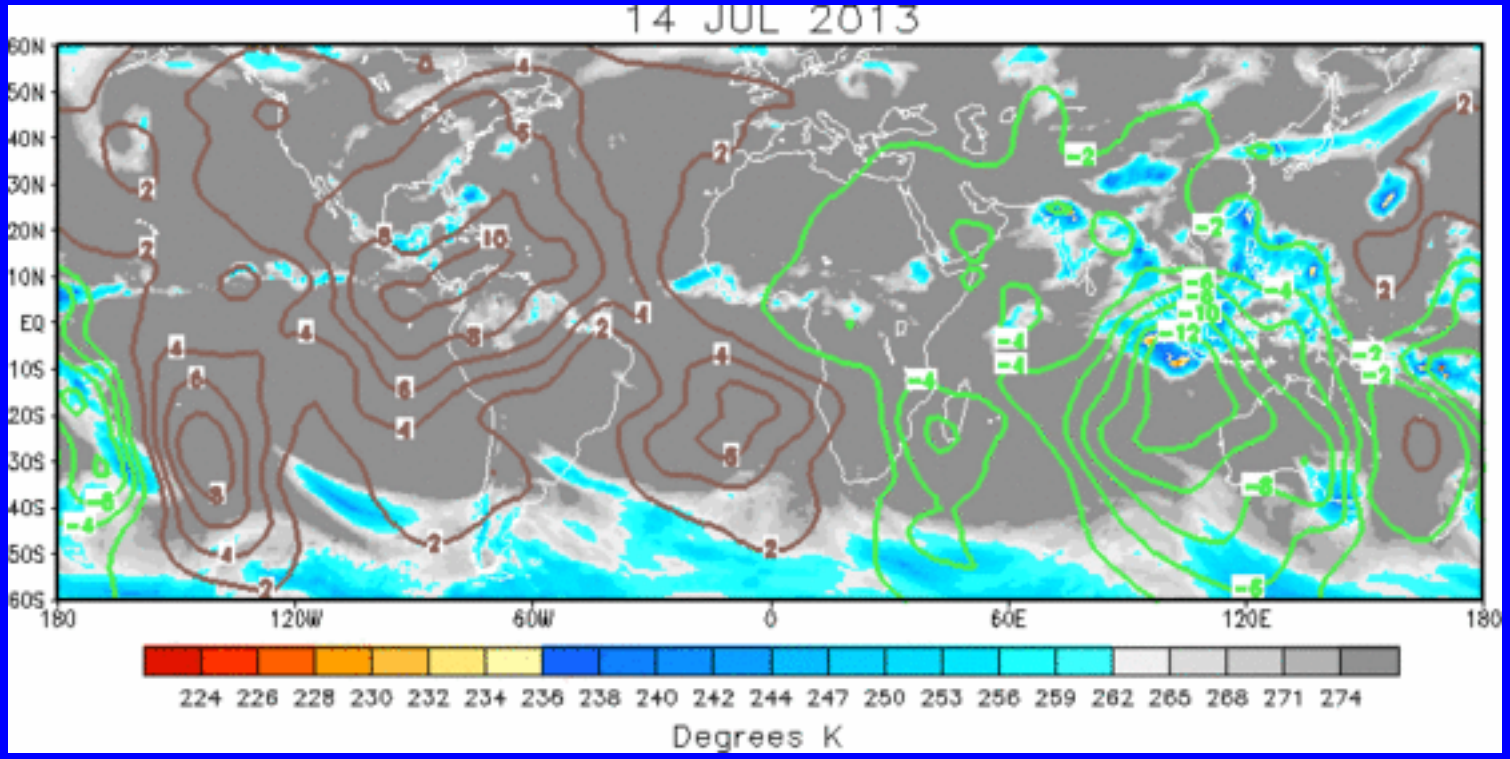
The velocity potential anomalies were more coherent only briefly during early to mid-May.

Recently, the signal is more coherent and consistent with a canonical MJO footprint, although other modes are still apparent.

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

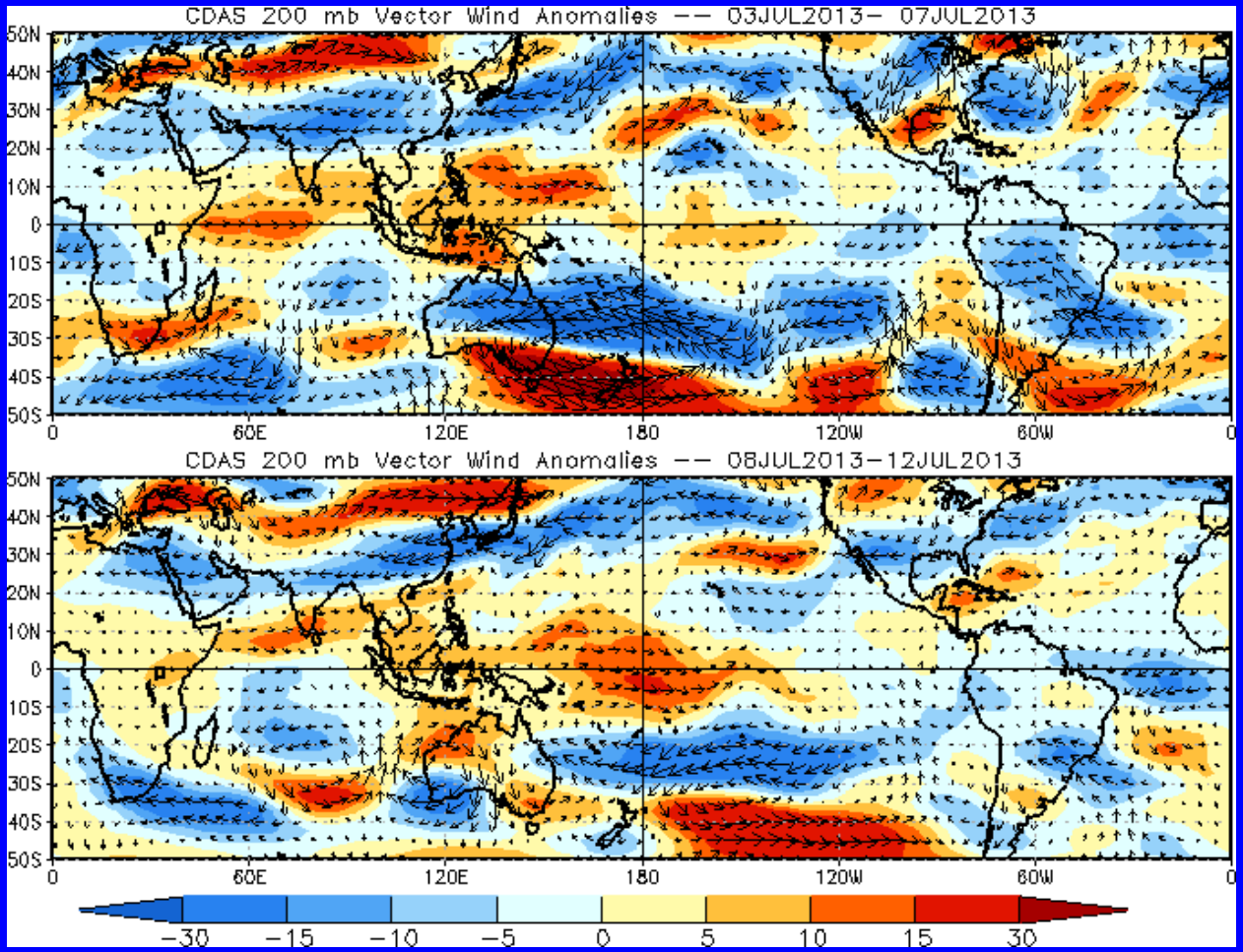
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The velocity potential pattern is consistent with the MJO convectively-active phase over the Indian Ocean, surrounded by regions of large scale suppressed convection over the central and eastern Pacific and the Atlantic basins.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

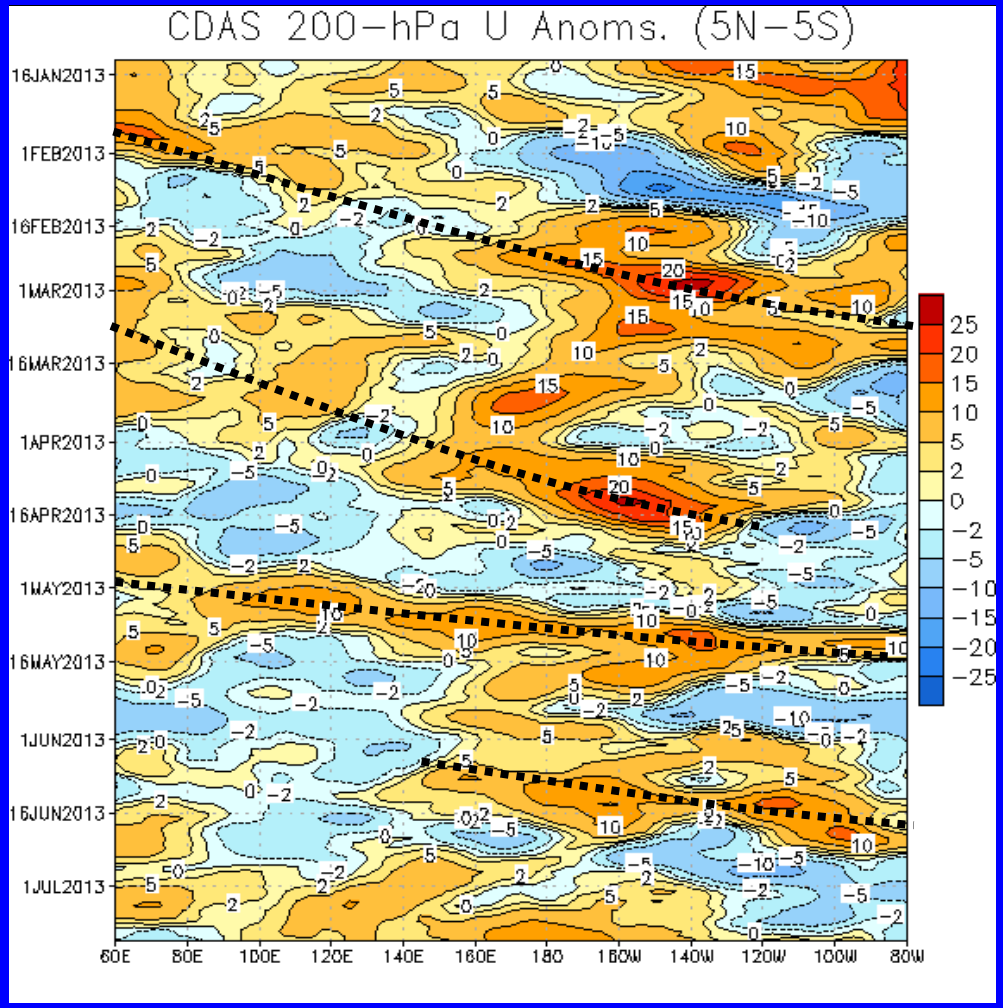
Red shades: Westerly anomalies

Westerly upper-level wind anomalies increased near the date line and shifted northward in the Indian Ocean. Easterly anomalies persisted over the equatorial Atlantic.

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

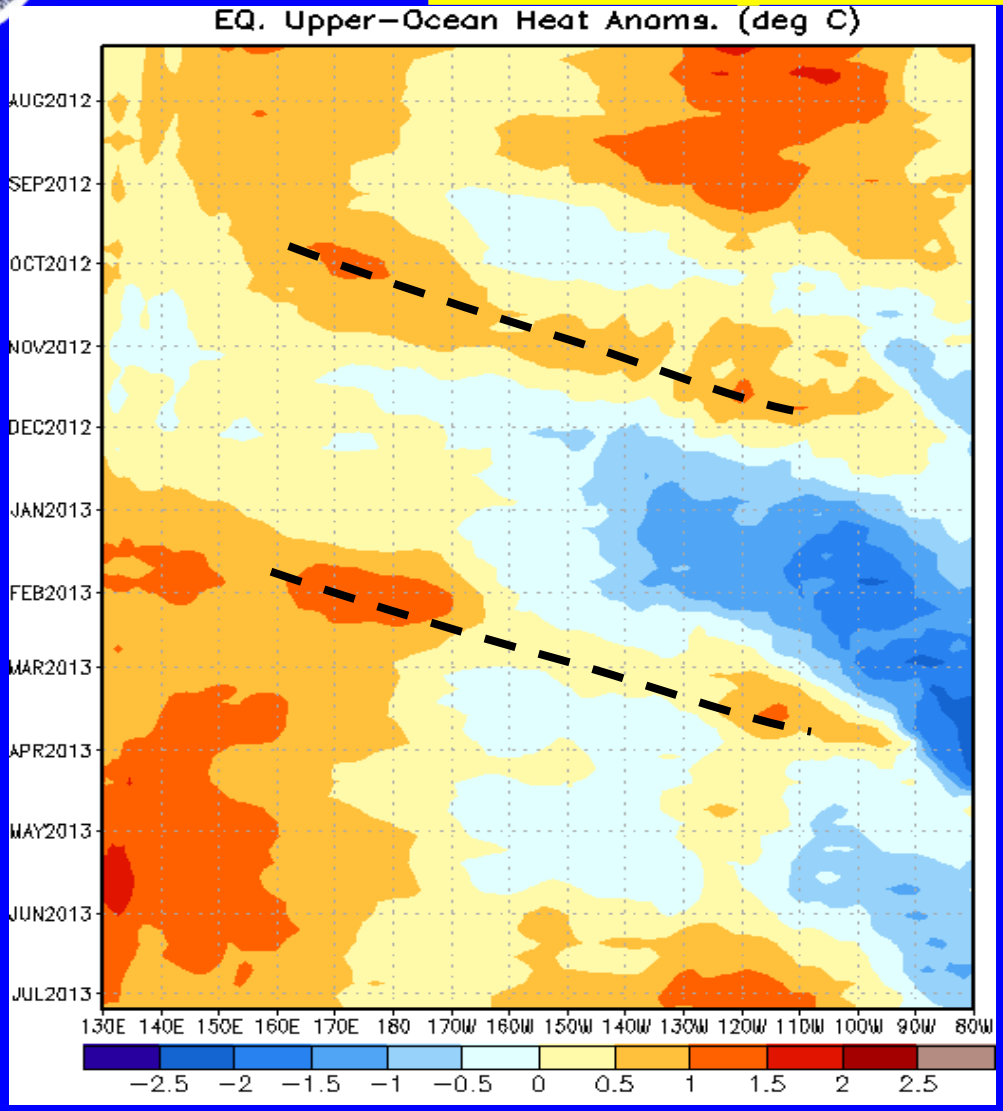
Longitude

Eastward propagation of westerly wind anomalies associated with the MJO continued into April 2013. 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 were observed. More recently, influence from westward propagating features over the Maritime Continent and eastern Pacific are apparent.

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 eastern and central Pacific during June and early 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).

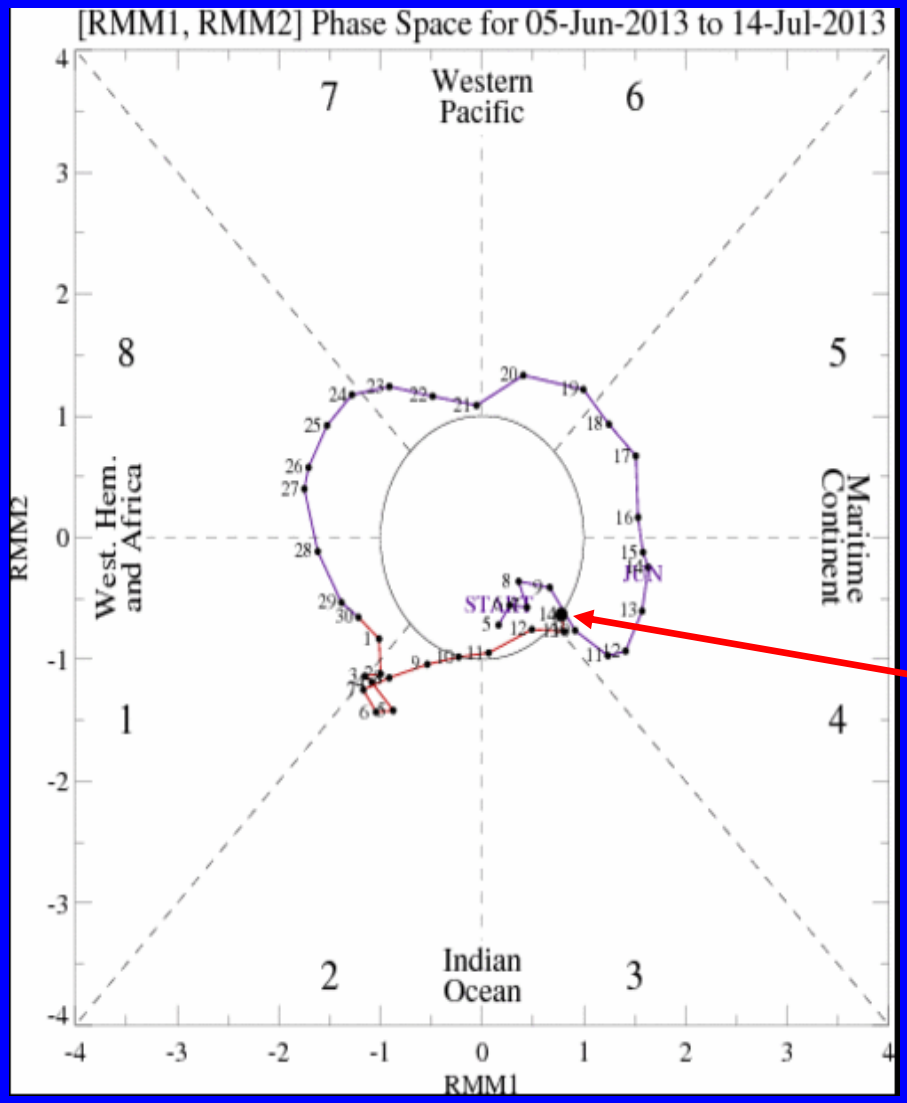
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

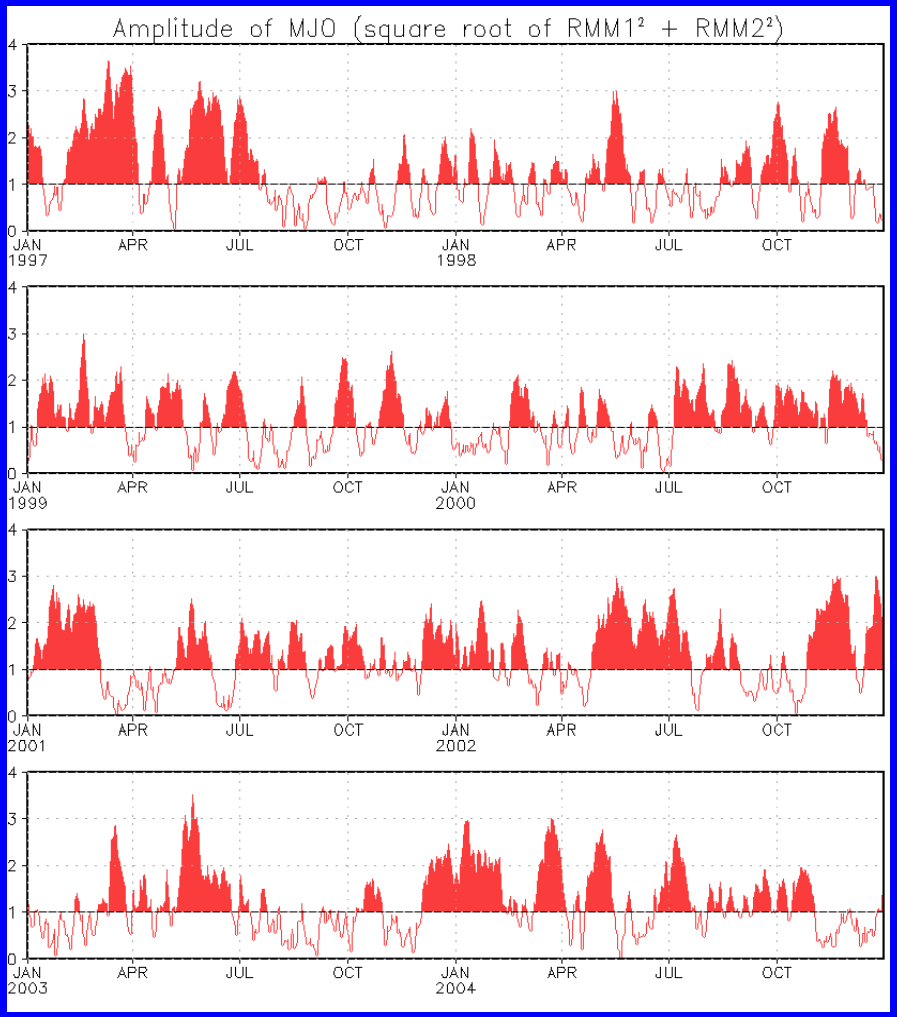
MJO Index -- Recent Evolution

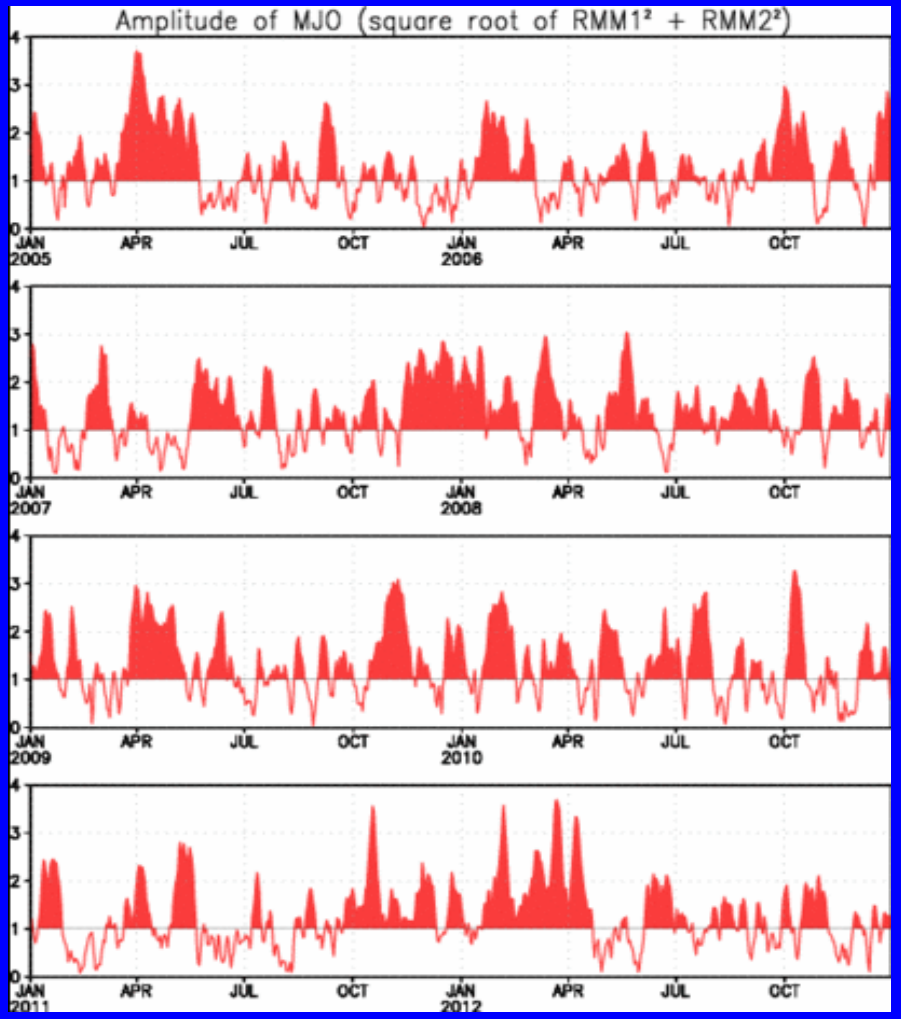


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

During the previous week, the MJO signal propagated eastward over the Indian Ocean with a decreasing amplitude.

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.

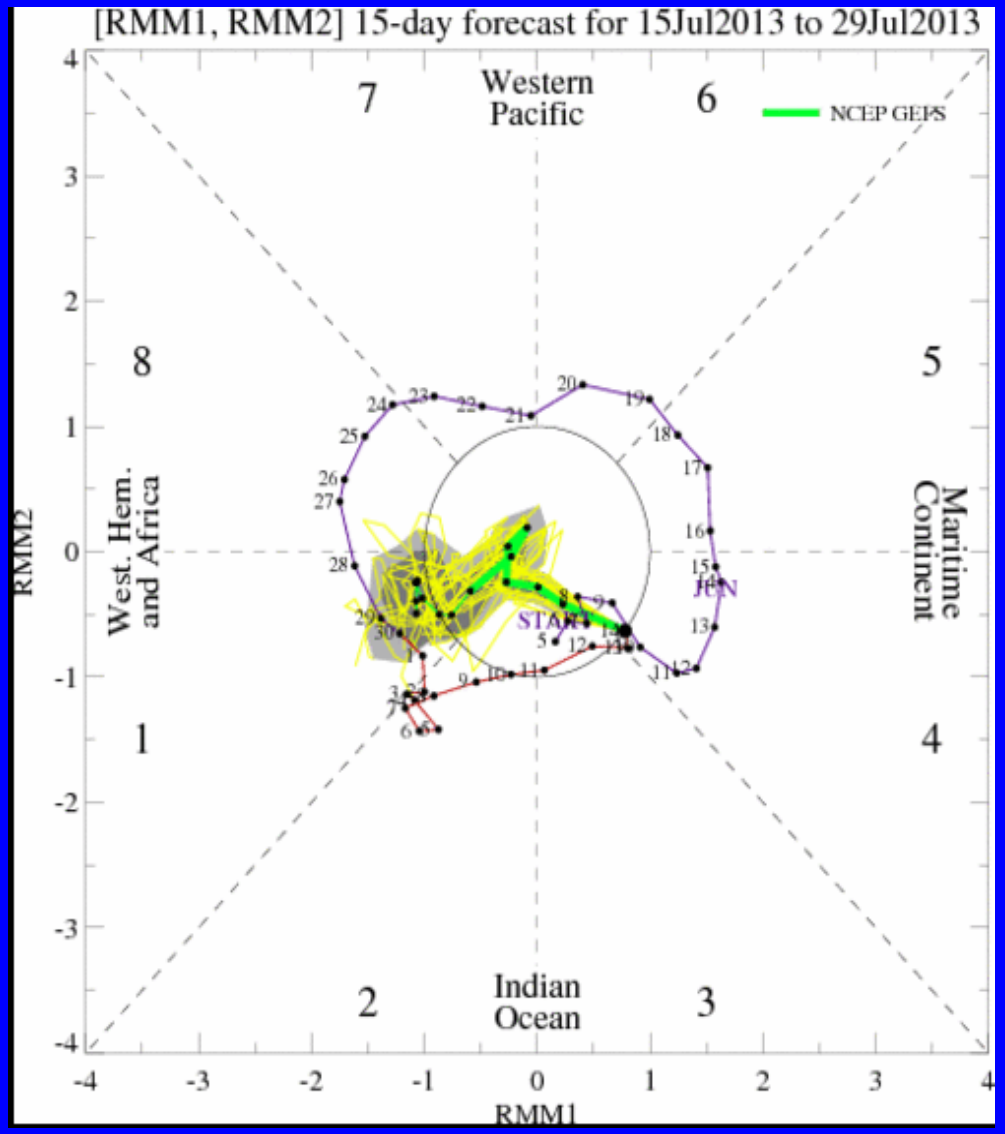
Ensemble GFS (GEFS) MJO Forecast

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

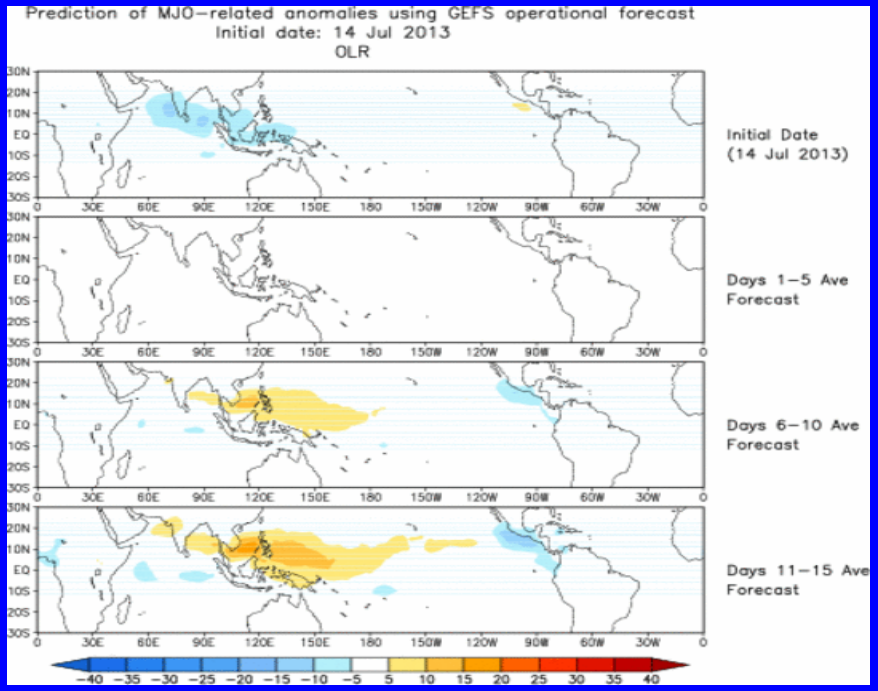
The ensemble GFS indicates an incoherent MJO signal during the upcoming two week period.



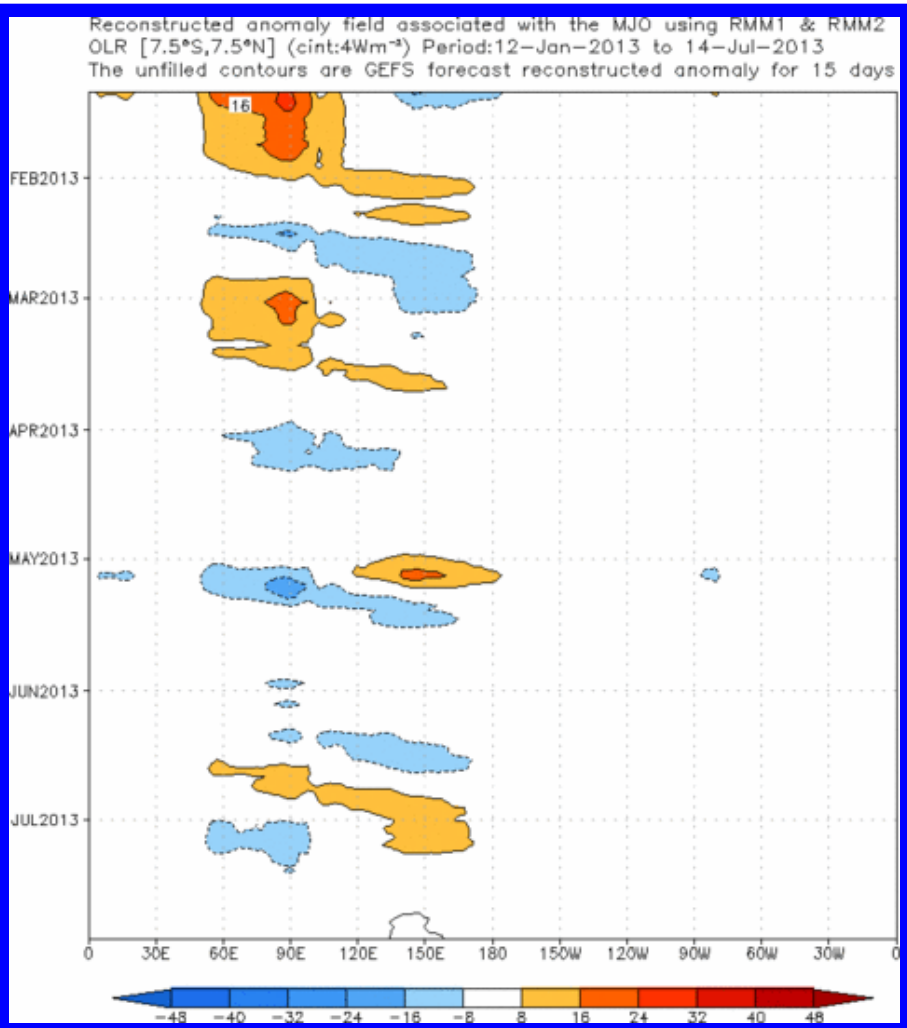
Ensemble Mean GFS MJO Forecast

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

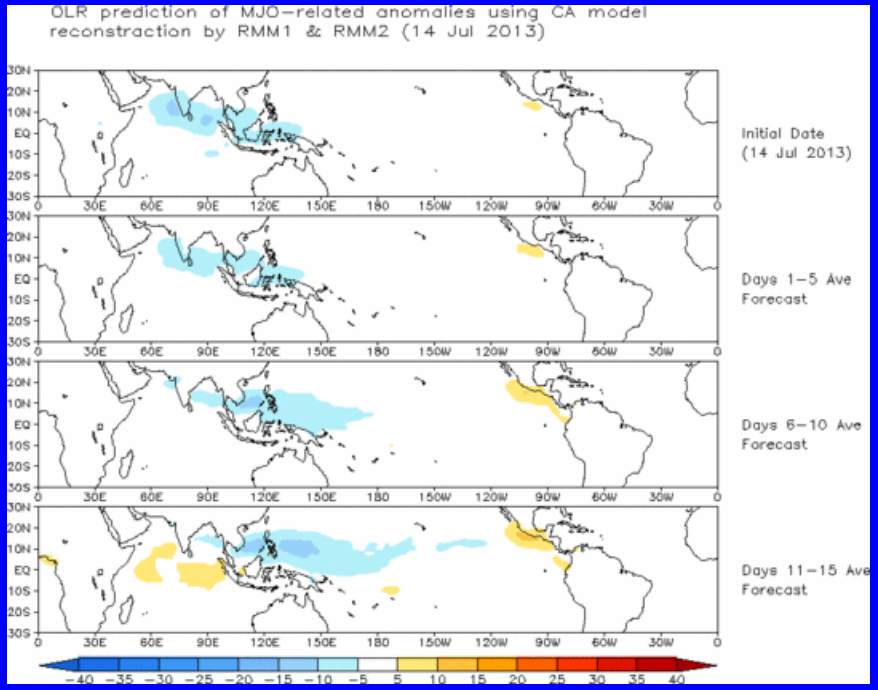


The ensemble mean GFS forecasts little or no anomalous convection. Suppressed (enhanced) convection is forecast over the western (eastern) Pacific during Week-2.

Constructed Analog (CA) MJO Forecast

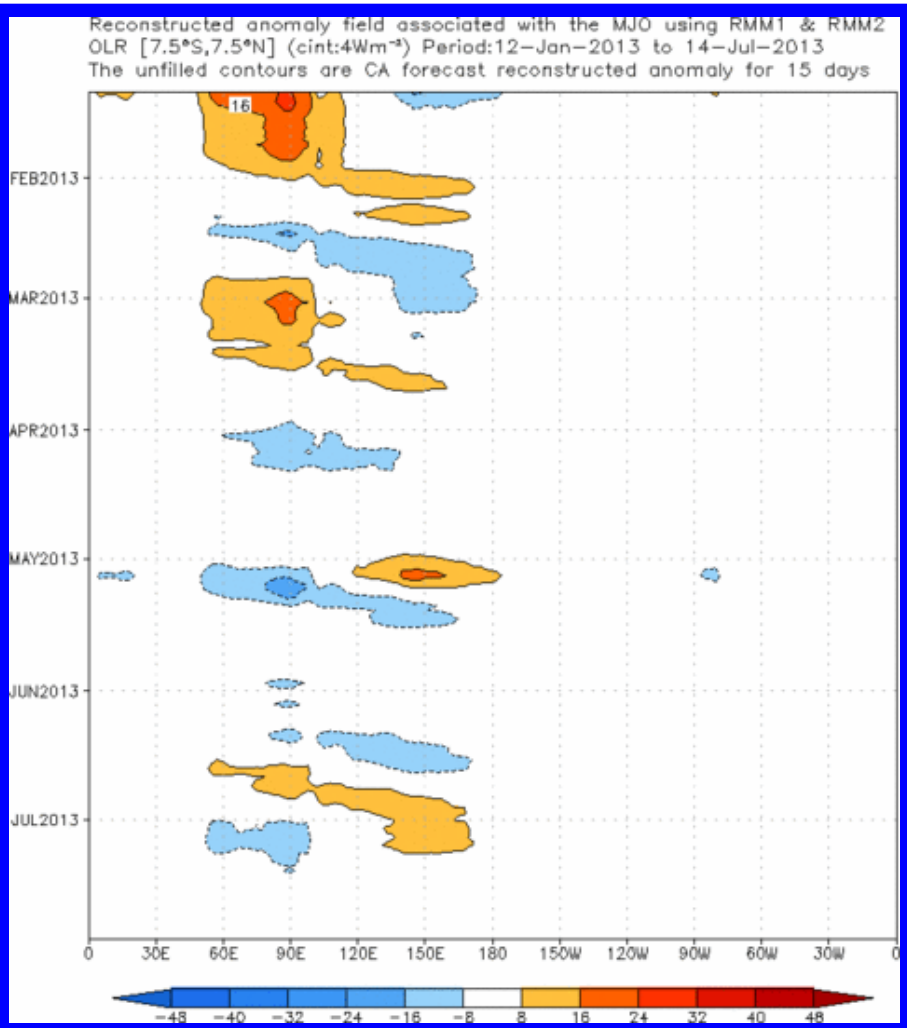
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



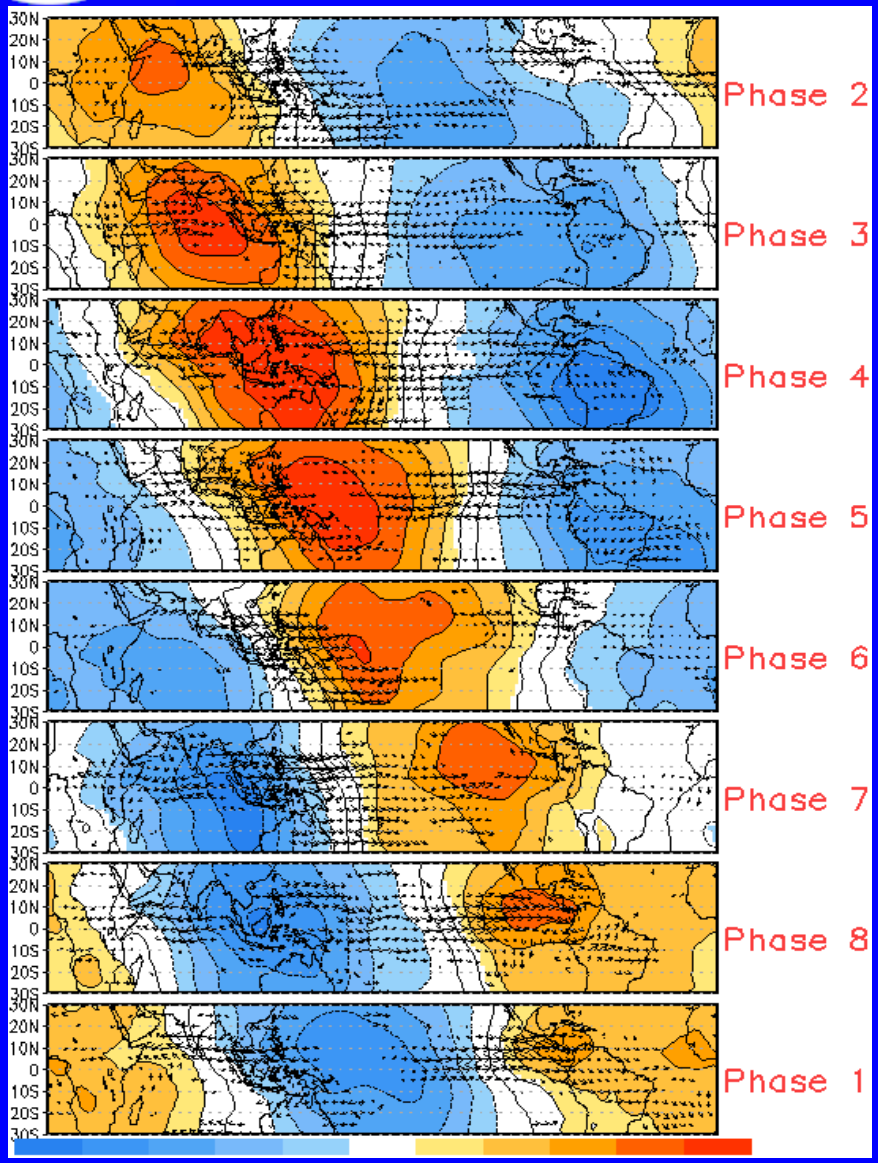
This statistical forecast indicates a more coherent MJO signal, with eastward propagation of the convectively active phase over the Maritime Continent and western Pacific during the upcoming two weeks.

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

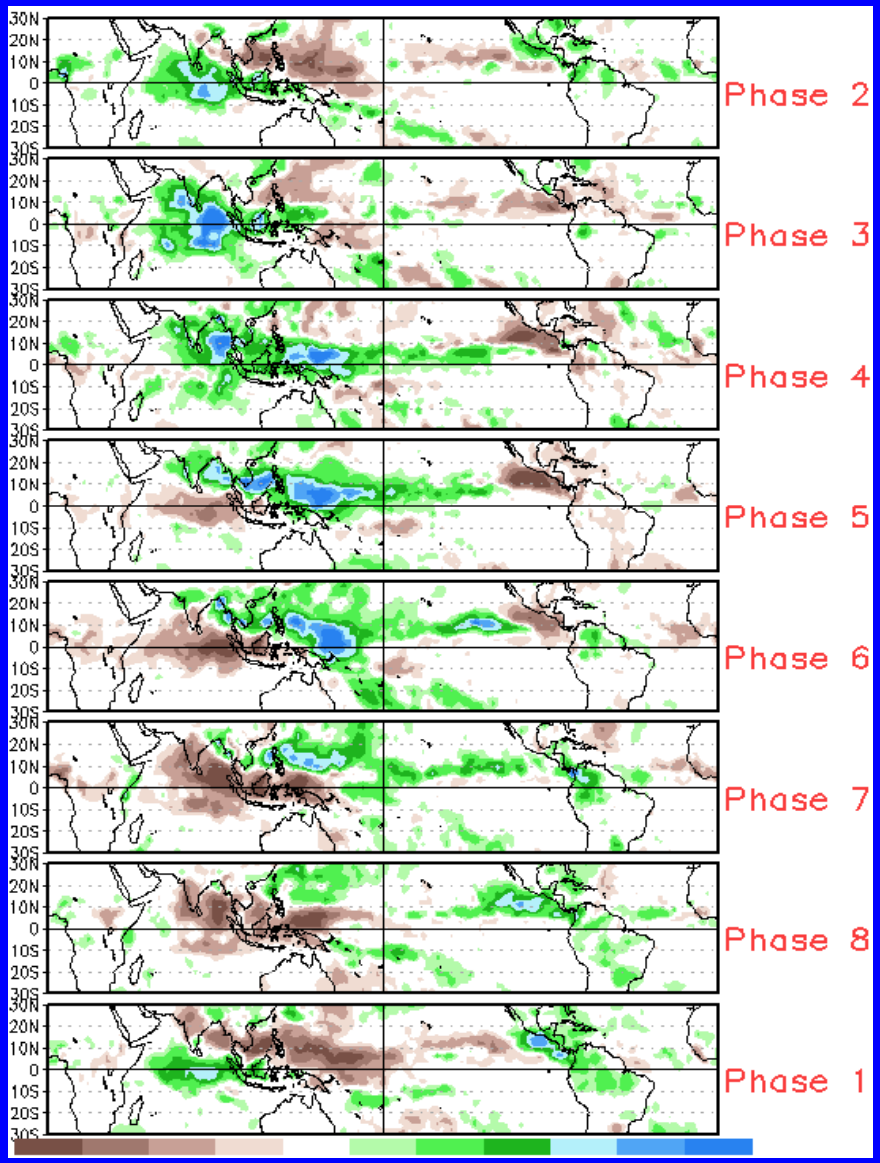


MJO Composites – Global Tropics

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

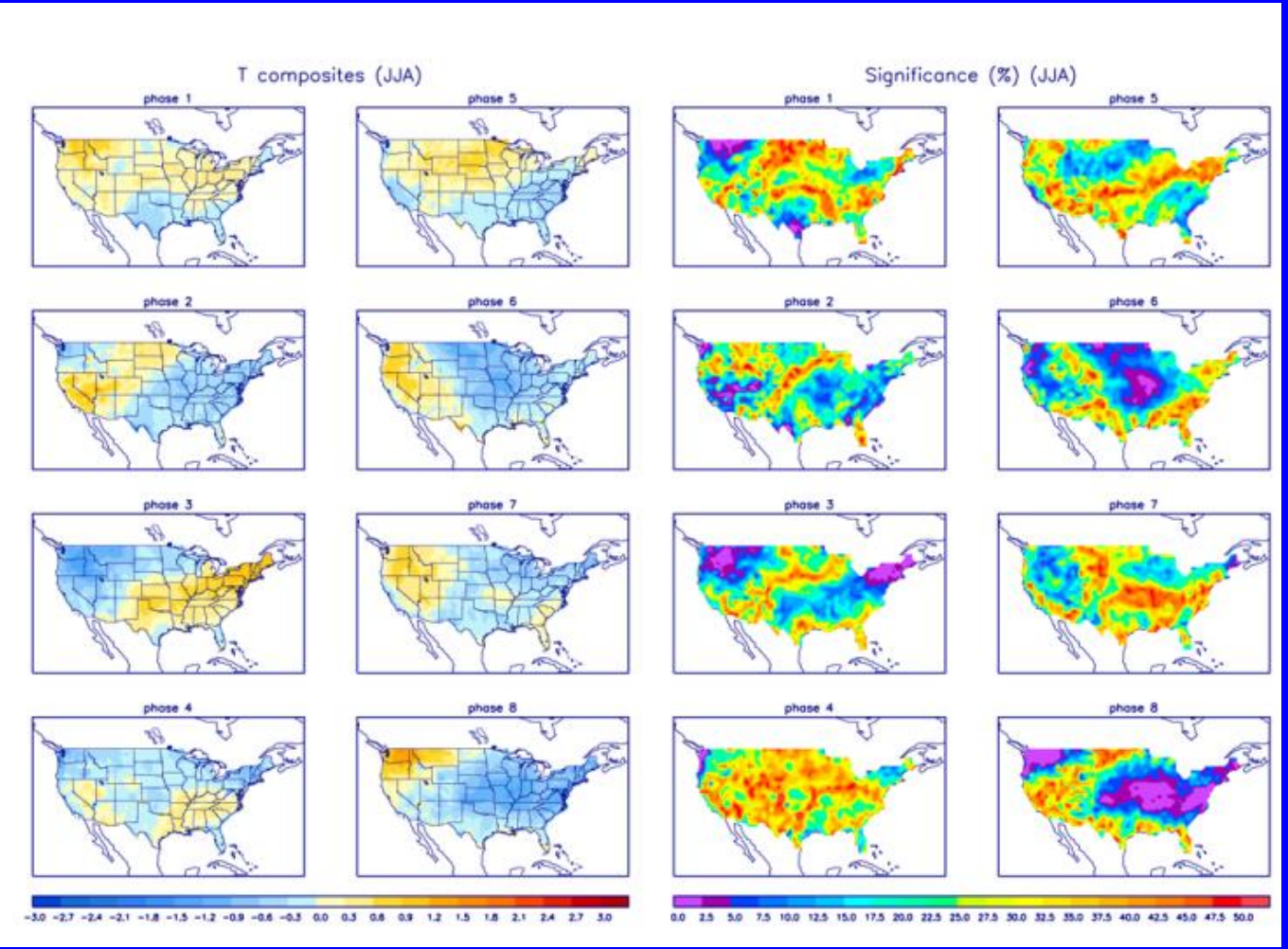


Precipitation Anomalies (May-Sep)



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.**

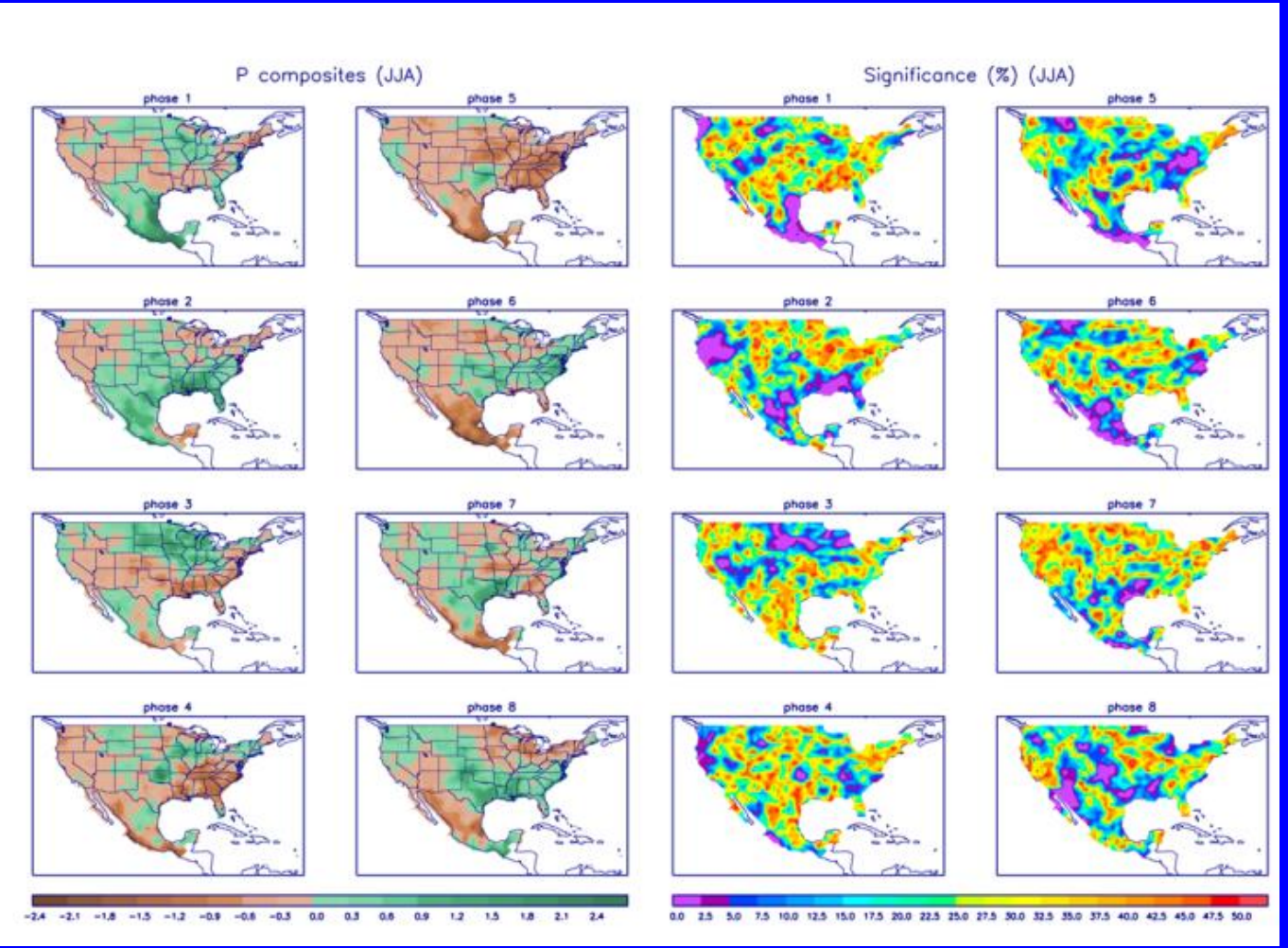


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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