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

Update prepared by
Climate Prediction Center / NCEP
July 29, 2013

Outline

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

Overview

- The MJO continued to weaken over the past week as most observational indicators indicate less coherent activity as compared to earlier in July.
- Most dynamical and statistical model MJO forecasts indicate weak or incoherent MJO activity during the upcoming two weeks.
- Based on both recent observations and model forecasts, the MJO is forecast to remain generally weak over the 1-2 weeks.
- Impacts directly attributable to the MJO are less clear than earlier in July although enhanced rainfall is likely to remain favored over parts of India, Southeast Asia, and the Maritime Continent during the period.

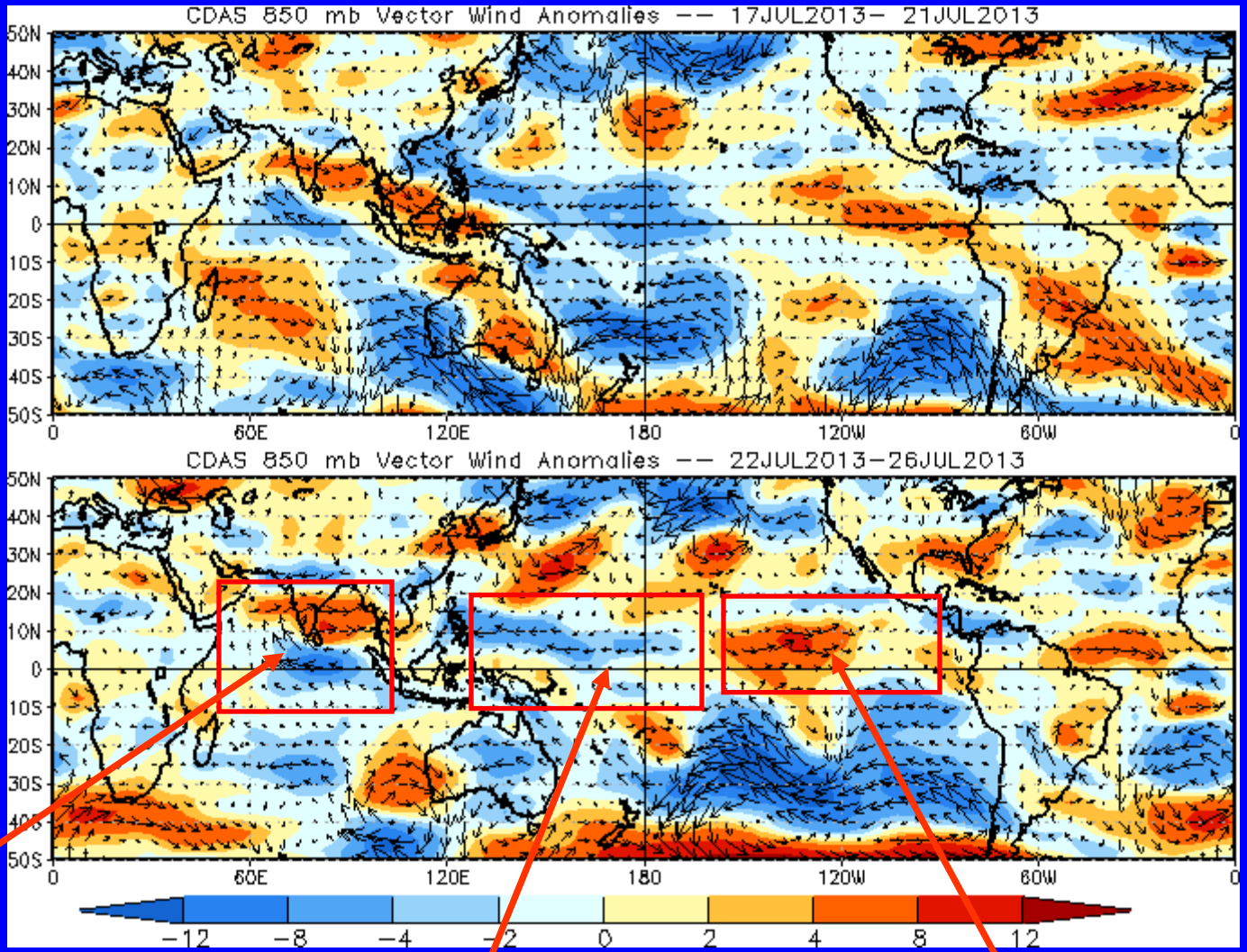
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 easterly (westerly) wind anomalies increased in magnitude over the equatorial Indian Ocean (India) indicating an enhanced monsoon circulation in this area.

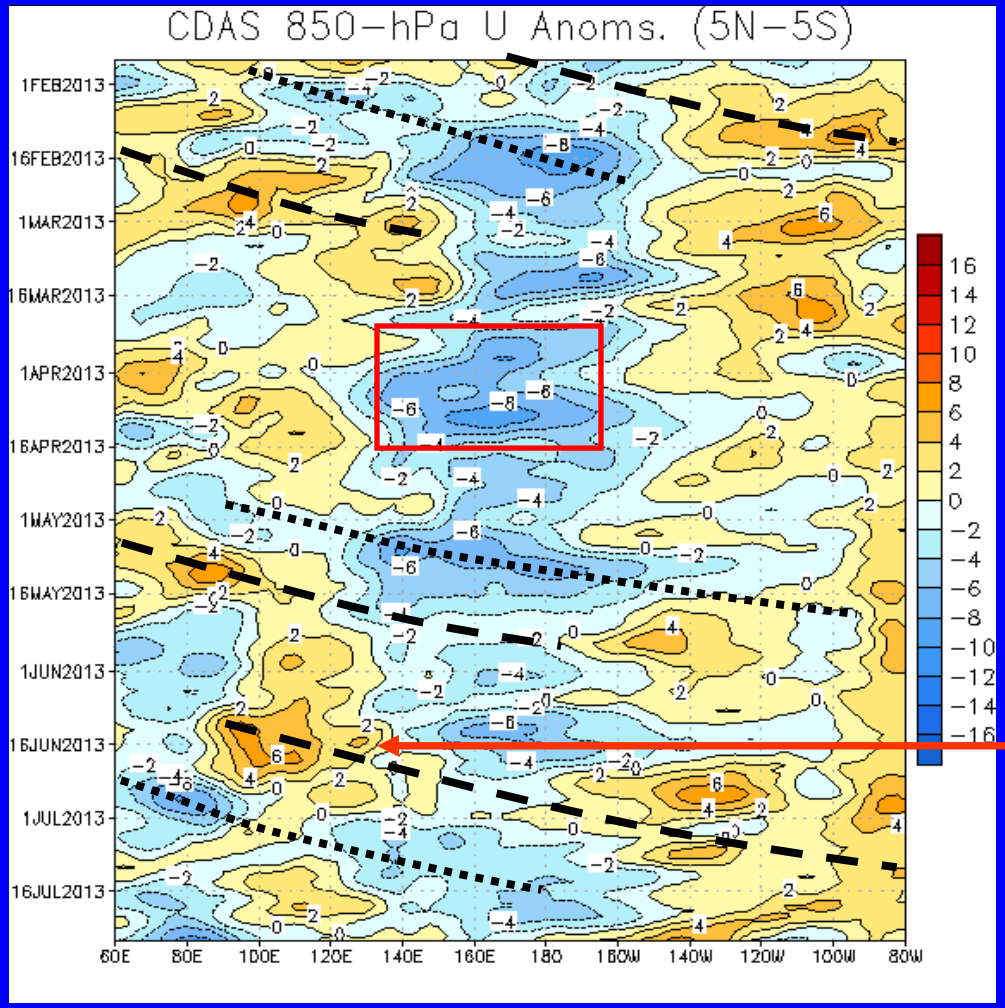
Easterly anomalies across the western Pacific have decreased during the past five days.

Westerly wind anomalies continued over parts of the east-central Pacific during the past five days.

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, the MJO was active as alternating westerly and easterly wind anomalies (dashed and dotted lines).

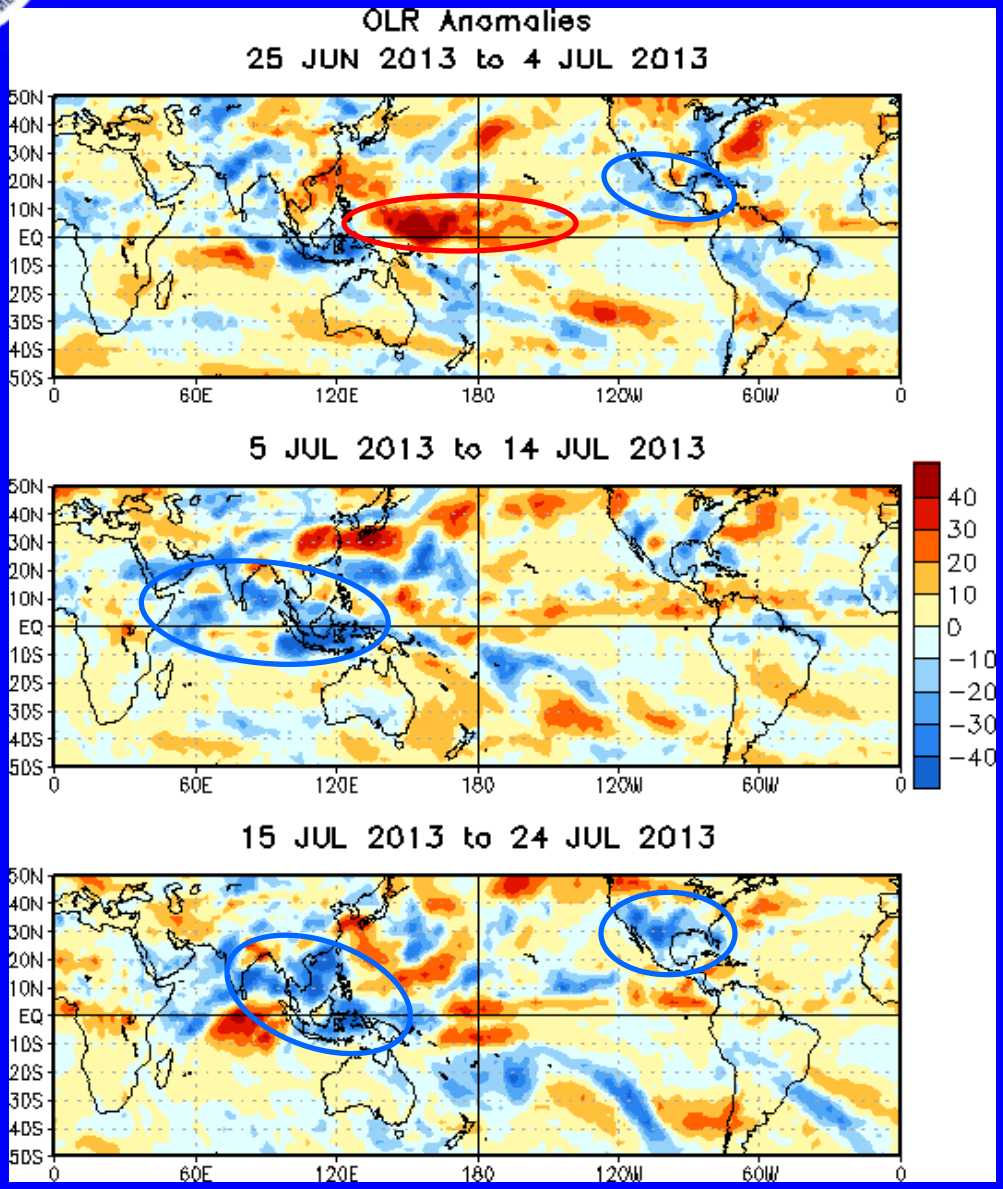
Easterly wind anomalies were evident near the Date Line during April (red box).

The MJO strengthened during early May, but was short-lived as the signal weakened later in the month.

The MJO strengthened in late June, with eastward propagation of low-level westerly wind anomalies noted from the Indian Ocean across the Pacific Ocean.

During late July, the MJO signal is less coherent with other types of intraseasonal variability more apparent (i.e., equatorial Rossby wave) across the eastern Pacific.

OLR Anomalies – Past 30 days



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

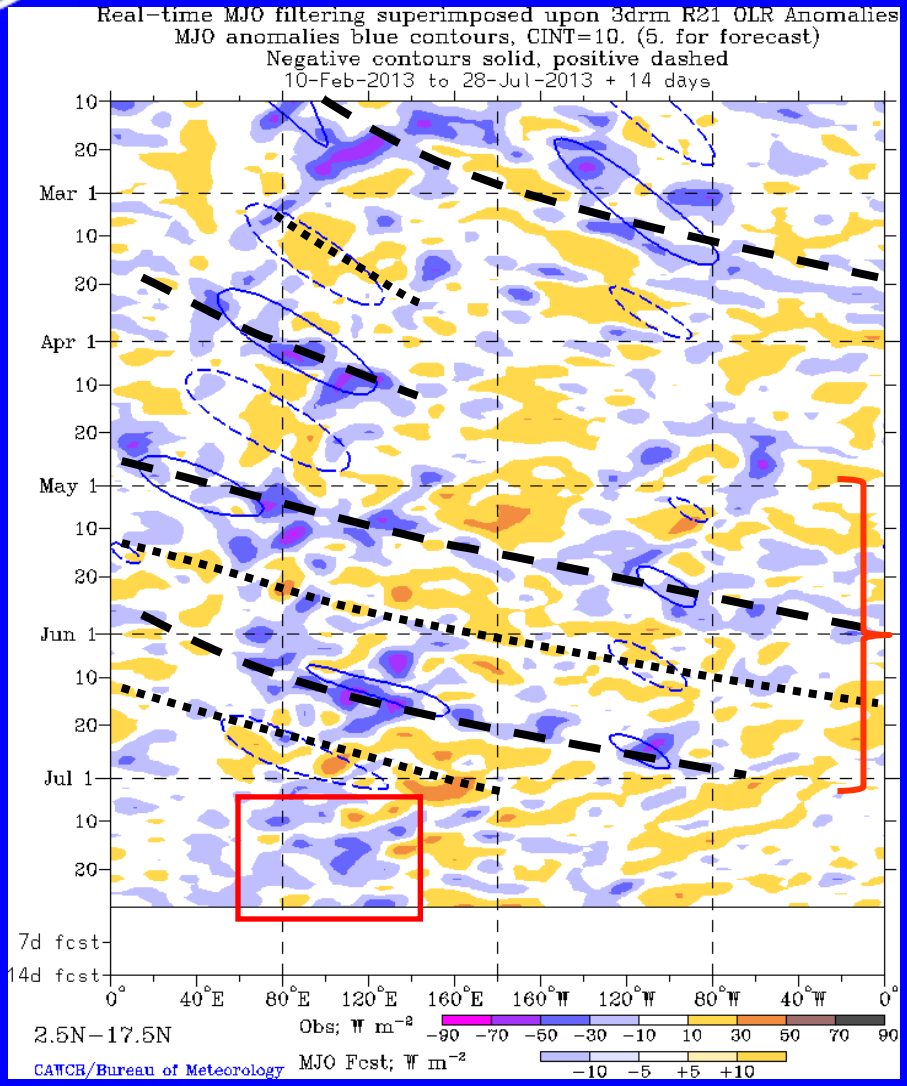
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

The MJO enhanced phase propagated eastward over the Western Hemisphere during late June and early July with enhanced convection (blue circle) apparent over the eastern Pacific. Suppressed convection is seen over much of the western Pacific (red circle).

During early to mid-July, the MJO enhanced phase propagated to the Indian Ocean and eastern Maritime Continent, increasing convection in these regions.

During mid-to-late July, enhanced convection continued over the Maritime Continent and Southeast Asia while intensifying across Mexico and southern sections of the CONUS.

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 active from February to April as indicated by alternating dashed and dotted lines representing the enhanced and suppressed phases respectively.

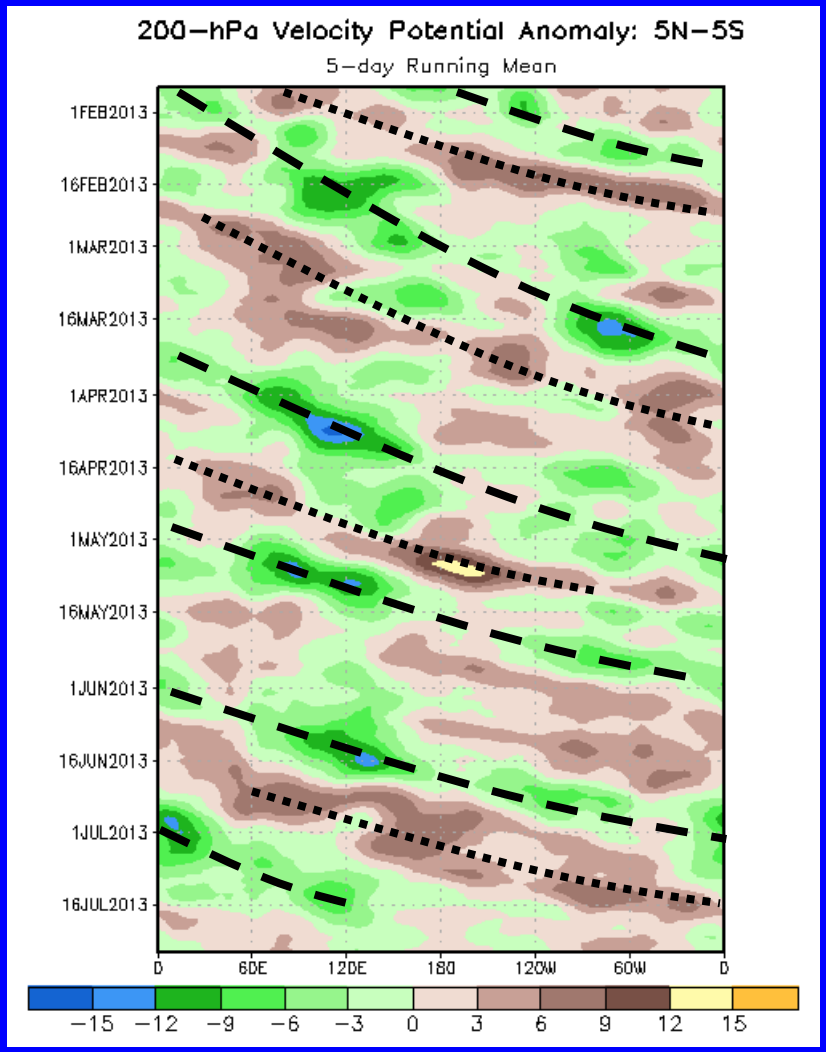
The MJO activity was more clear in OLR anomalies from May into July before weakening some later in July.

During mid-to-late July, enhanced convection is primarily observed over an area stretching from 70E to 130E (red box).

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 was active during much of the displayed period as shown by alternating dashed and dotted lines.

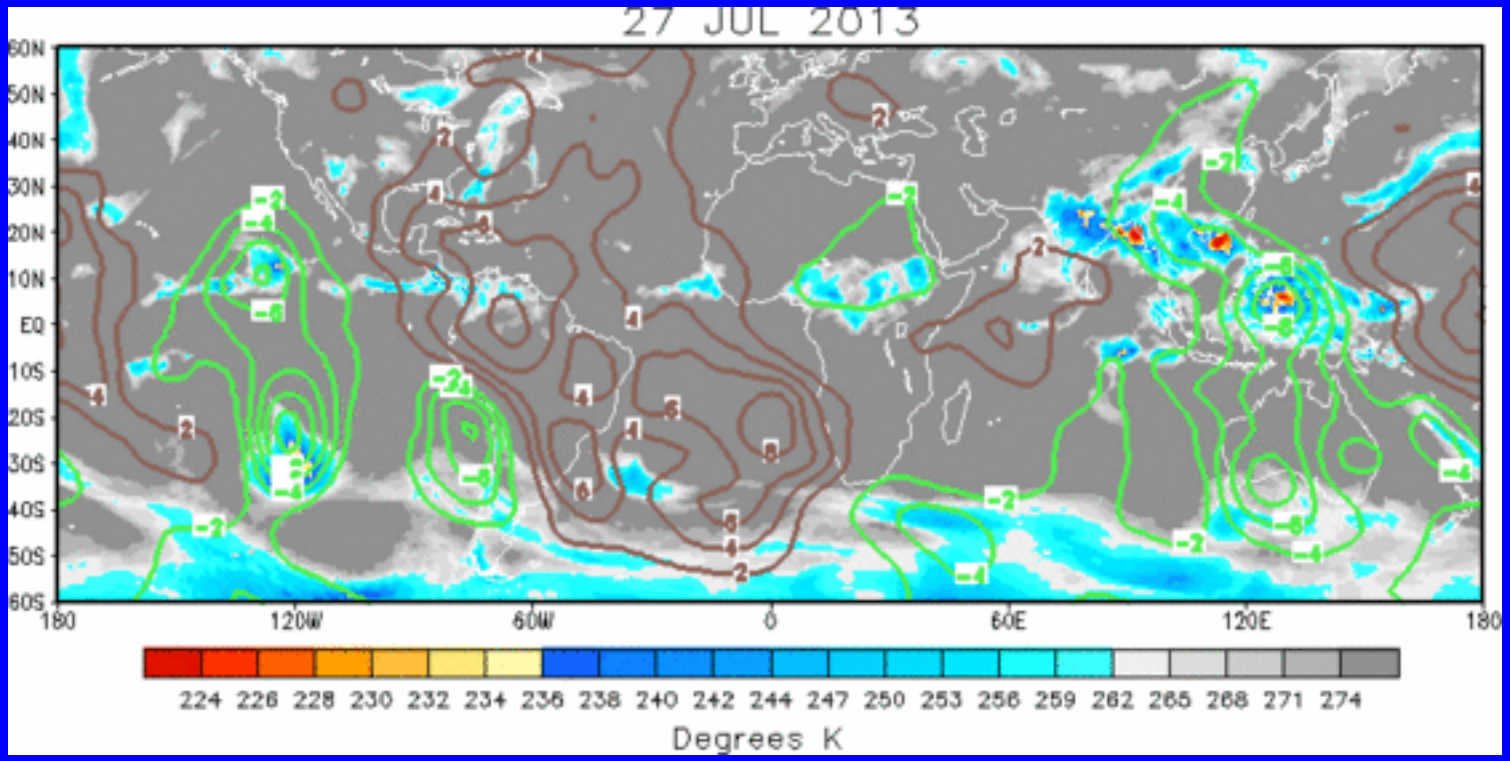
The MJO activity was strongest during the February into March, April to mid-May and from June to mid-July.

Most recently the MJO has weakened as indicated by lower magnitude anomalies and less clear eastward propagation.

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

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

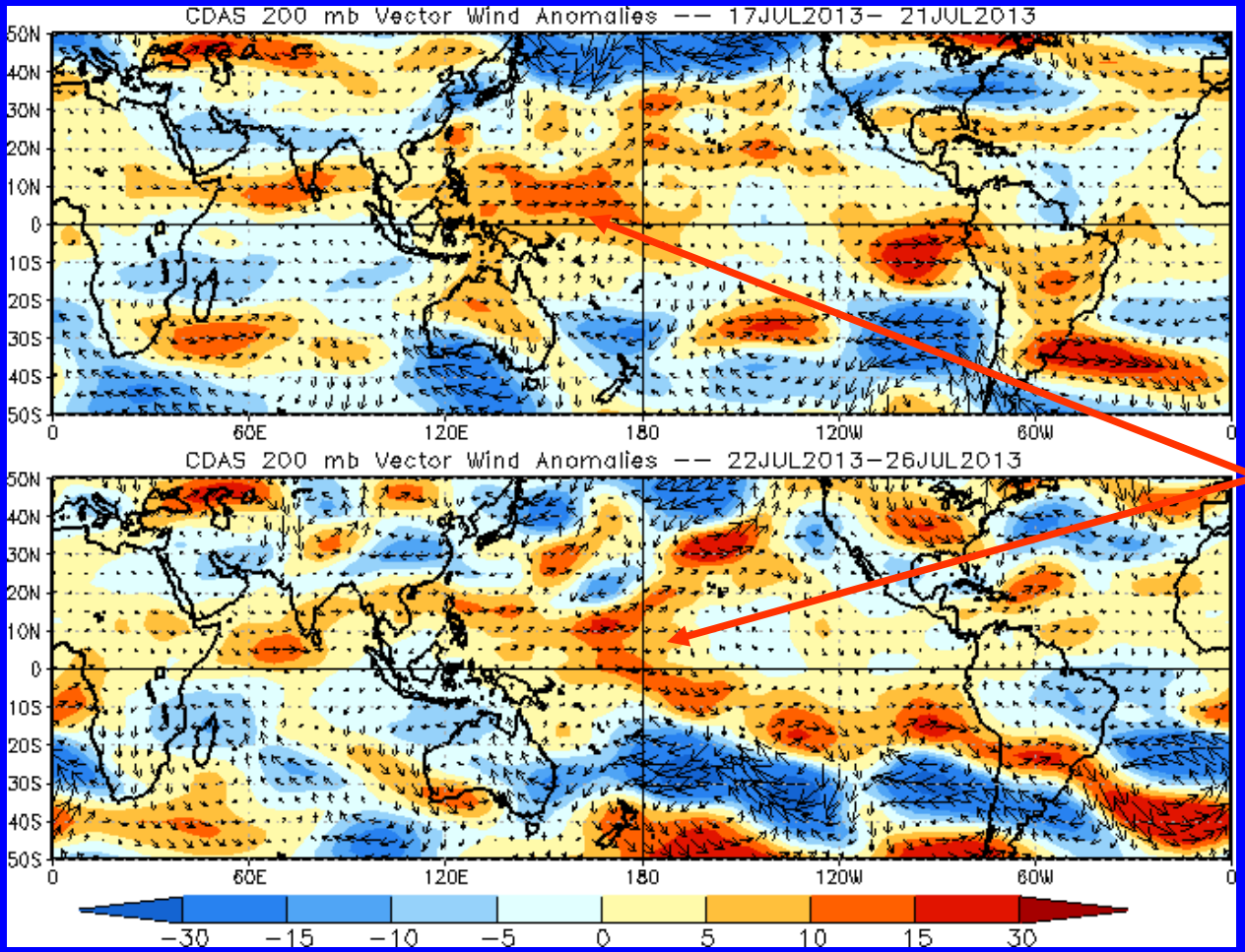
Negative anomalies (green contours) indicate favorable conditions for precipitation



The velocity potential map indicates a less coherent pattern than earlier in July with a wave-2 or wave-3 structure as other types of intraseasonal variability are impacting the upper-level circulation.

The strongest upper-level divergence is evident over Southeast Asia and the Maritime continent while upper-level convergence is indicated over the Atlantic Ocean.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

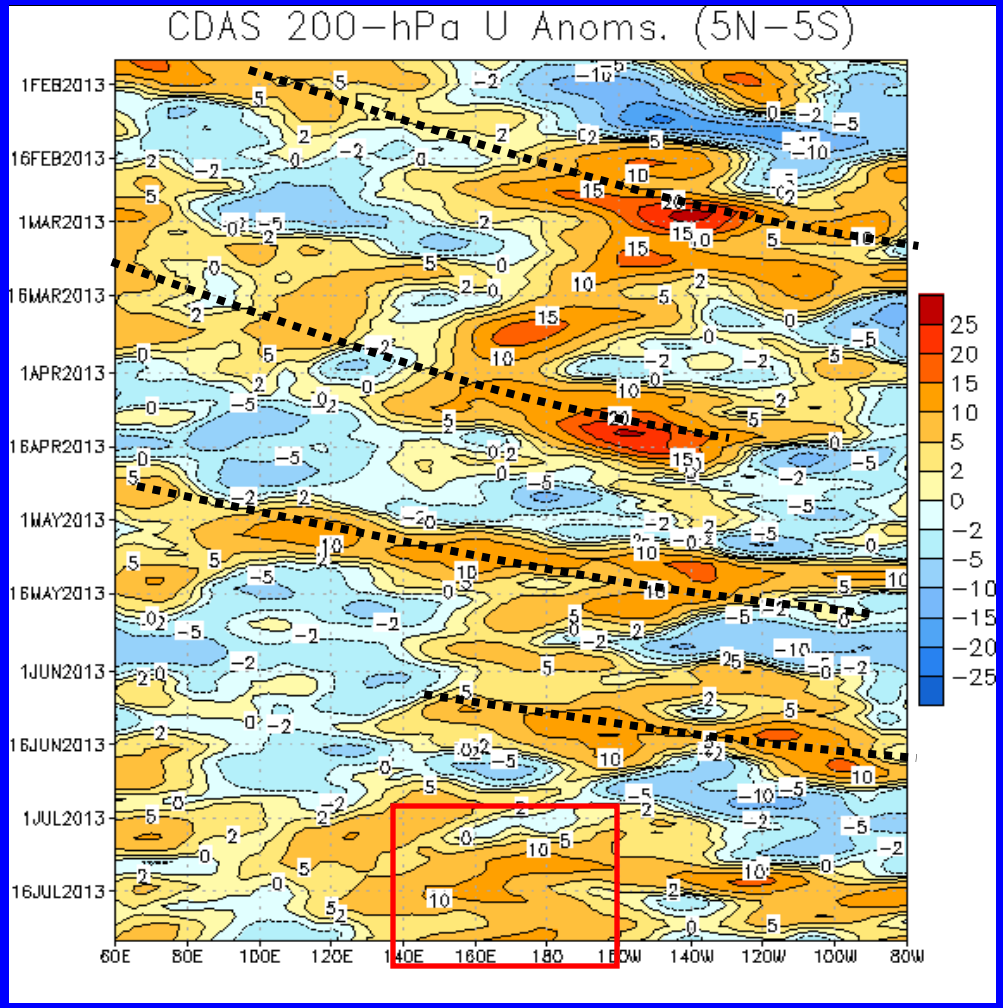
Red shades: Westerly anomalies

Westerly wind anomalies persisted across the western Pacific during the past five days, albeit with less magnitude.

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

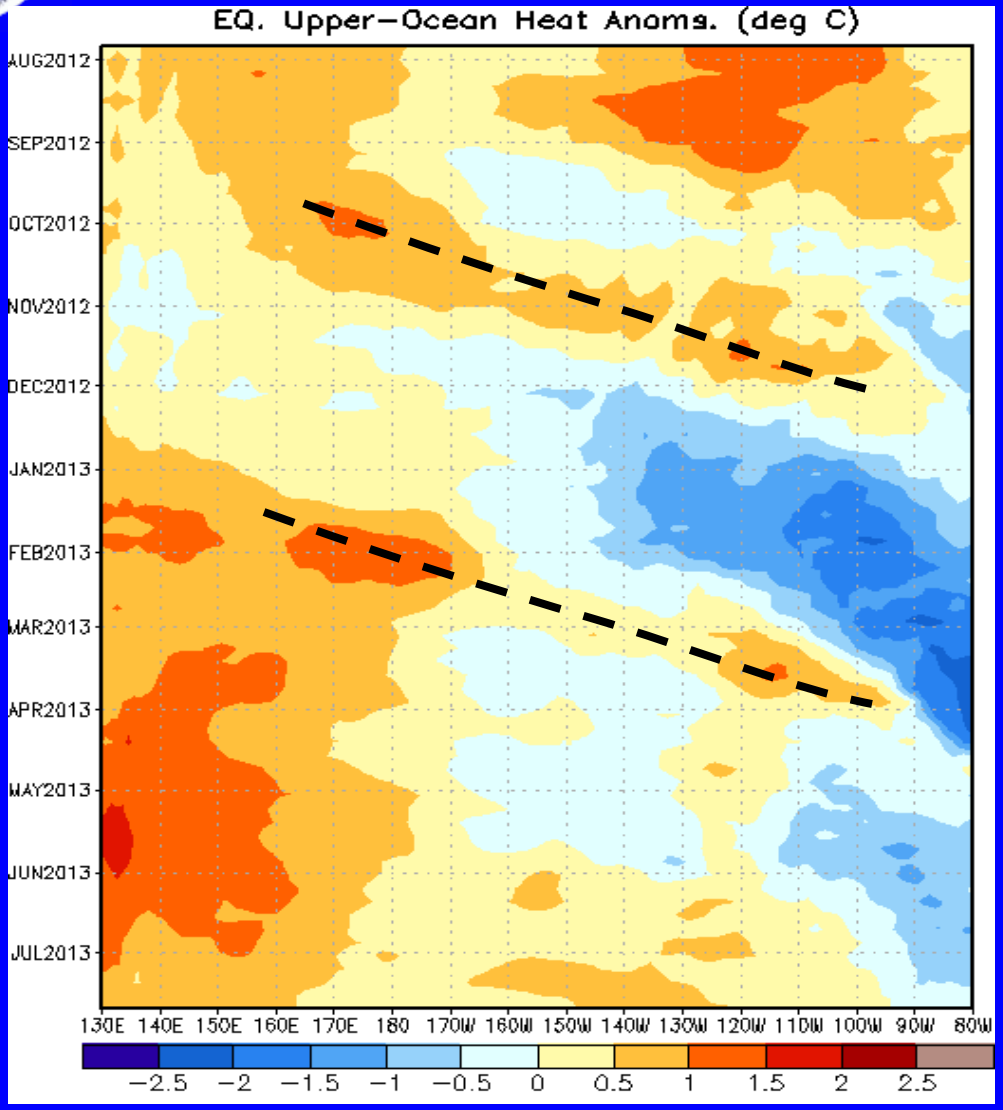
Longitude

Eastward propagation of westerly wind anomalies (dotted lines) were evident during much of the period and were often associated with the MJO.

The anomalous winds were especially strong across the central Pacific during late February and early March and once again in early-to-mid April.

Most recently during July, westerly anomalies are more persistent near and just west of the Date Line (red box).

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 (dashed line) 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 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).

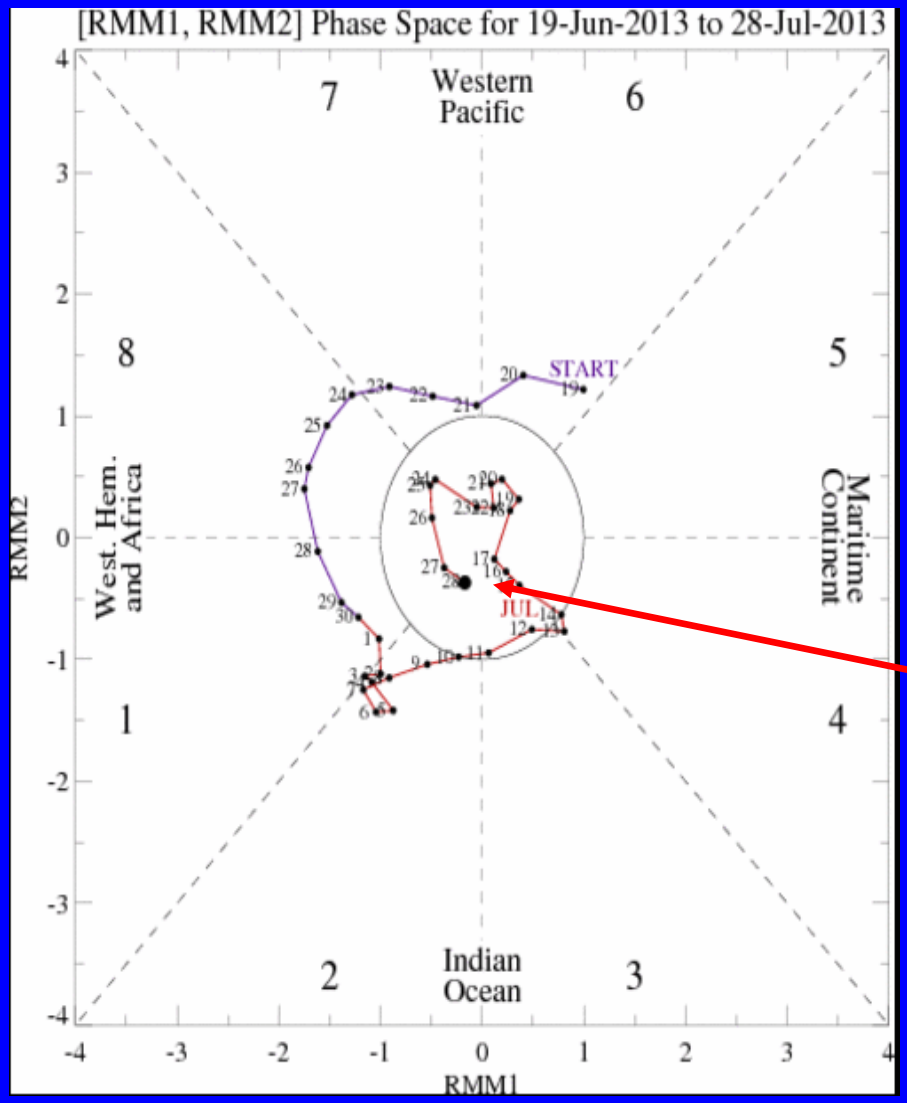
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

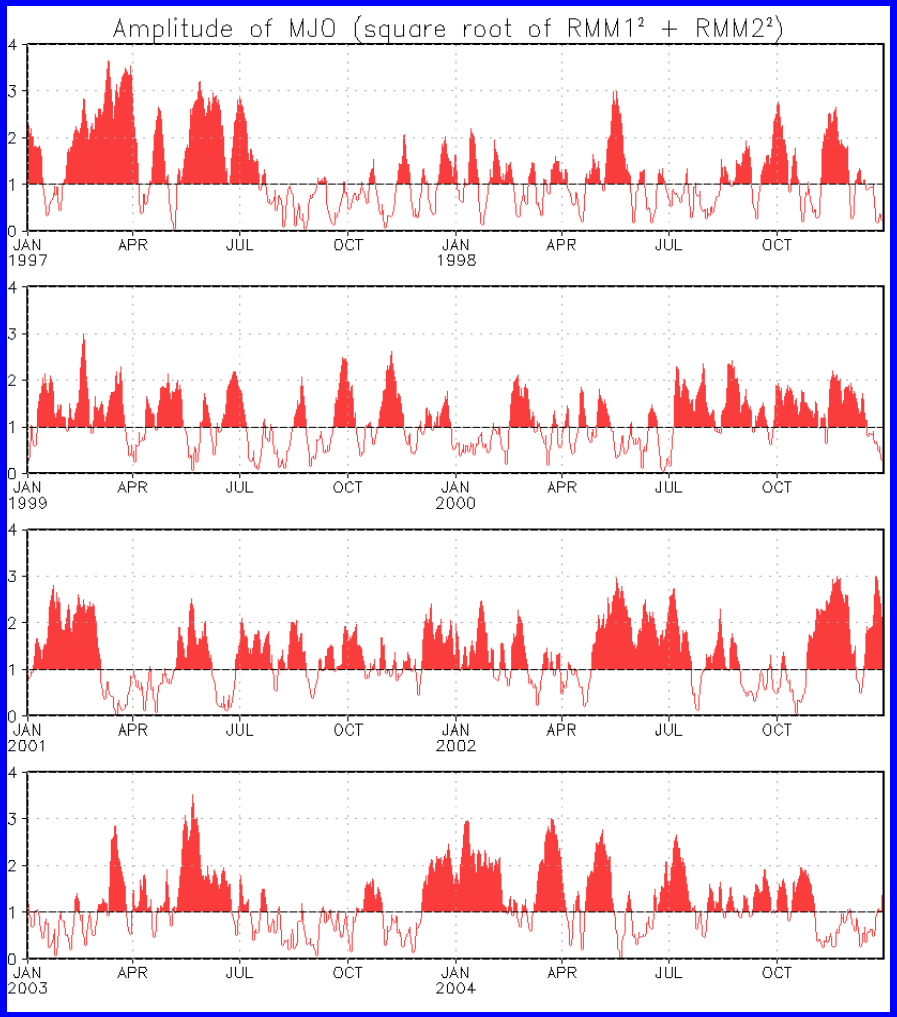
MJO Index -- Recent Evolution

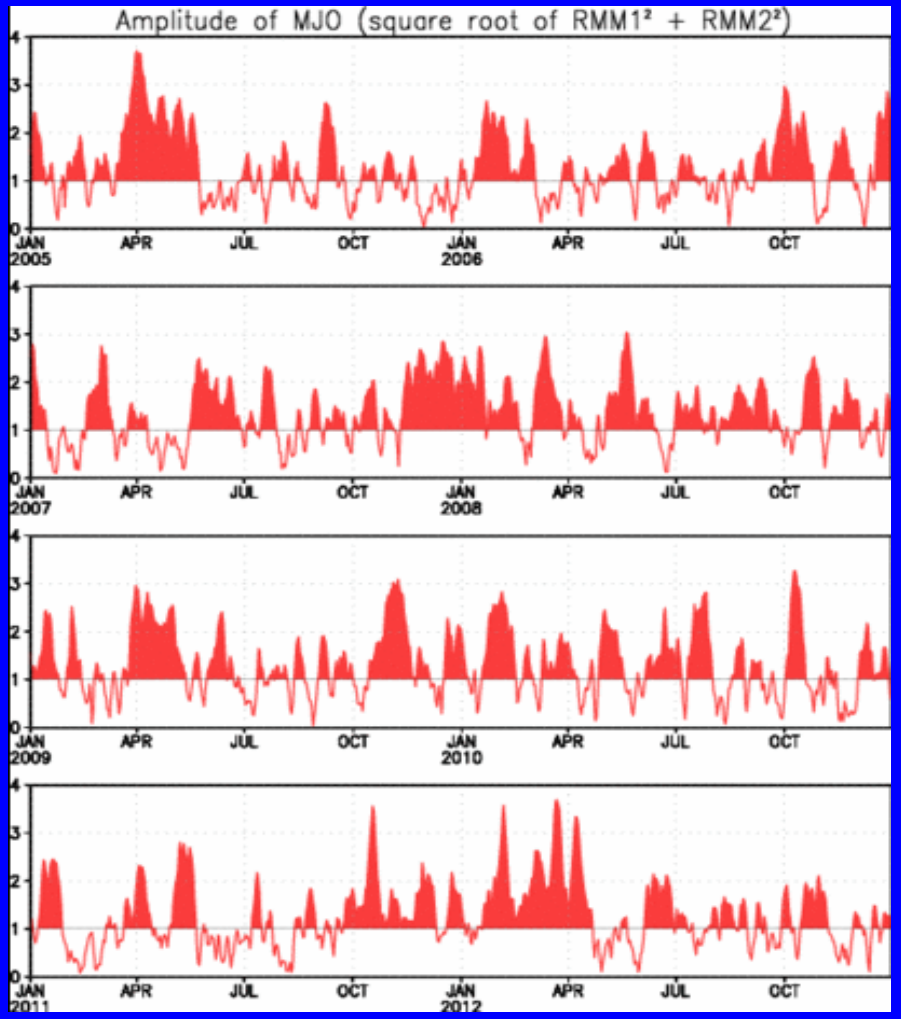


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index continues to indicate weak activity.

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.

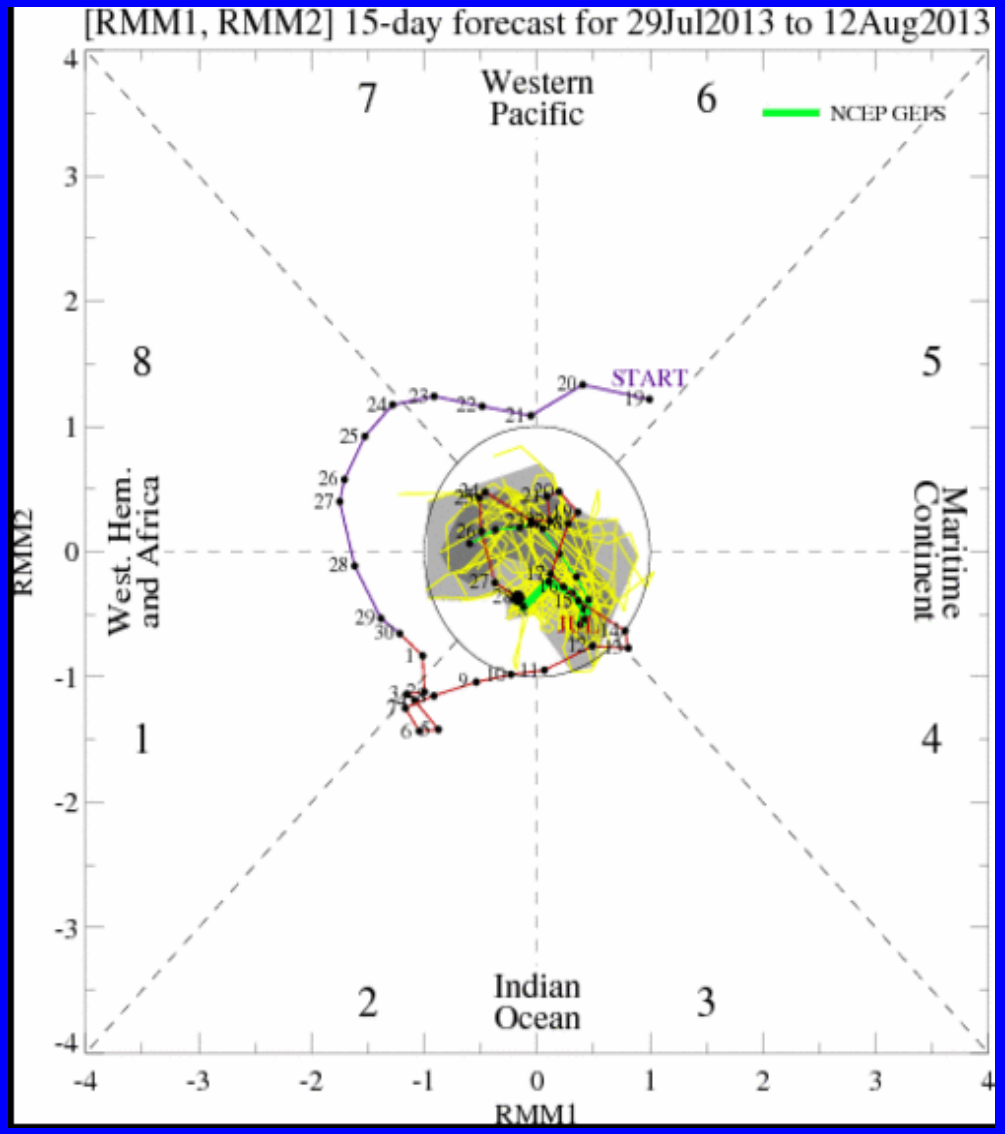
Ensemble GFS (GEFS) MJO Forecast

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

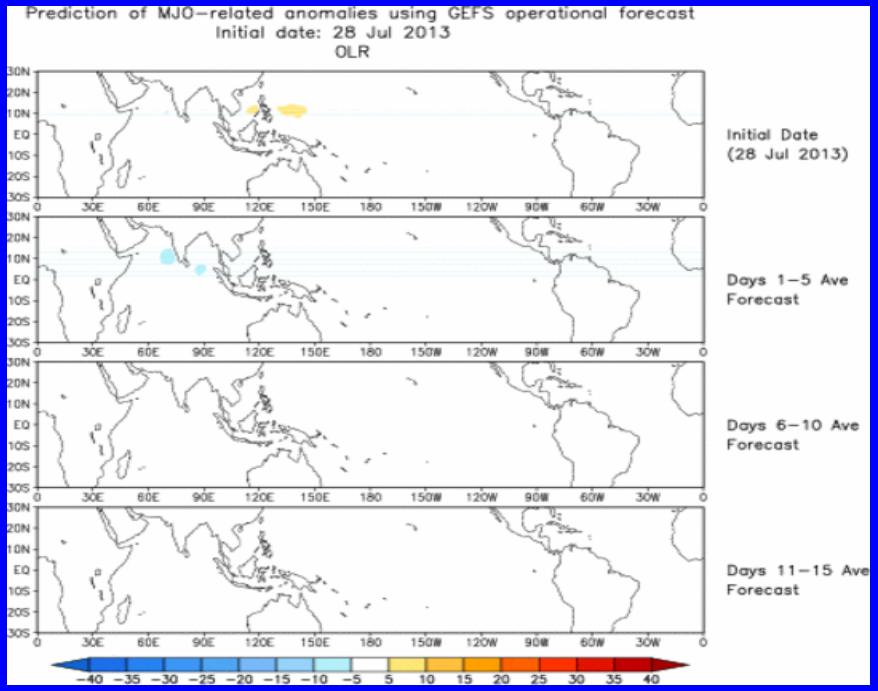
The ensemble GFS indicates a continuation of a weak or incoherent MJO signal during upcoming two weeks.



Ensemble Mean GFS MJO Forecast

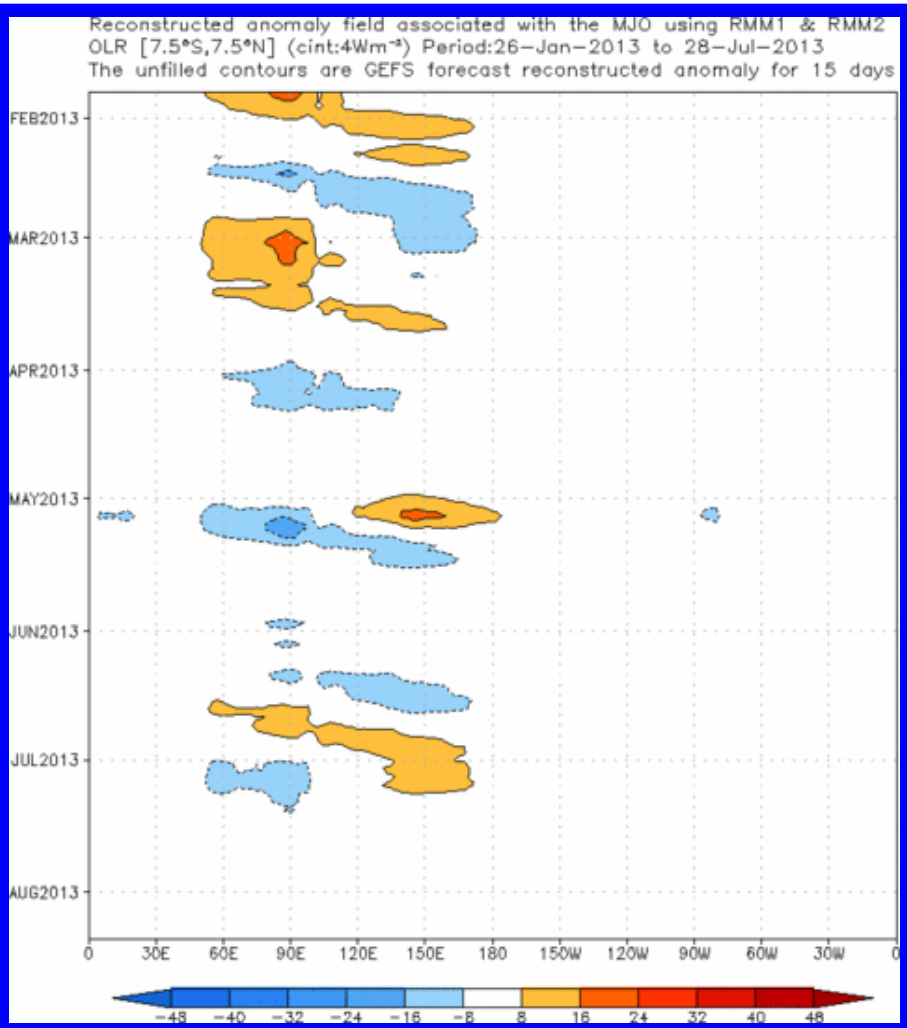
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecasts little or no anomalous convection associated specifically to the MJO.

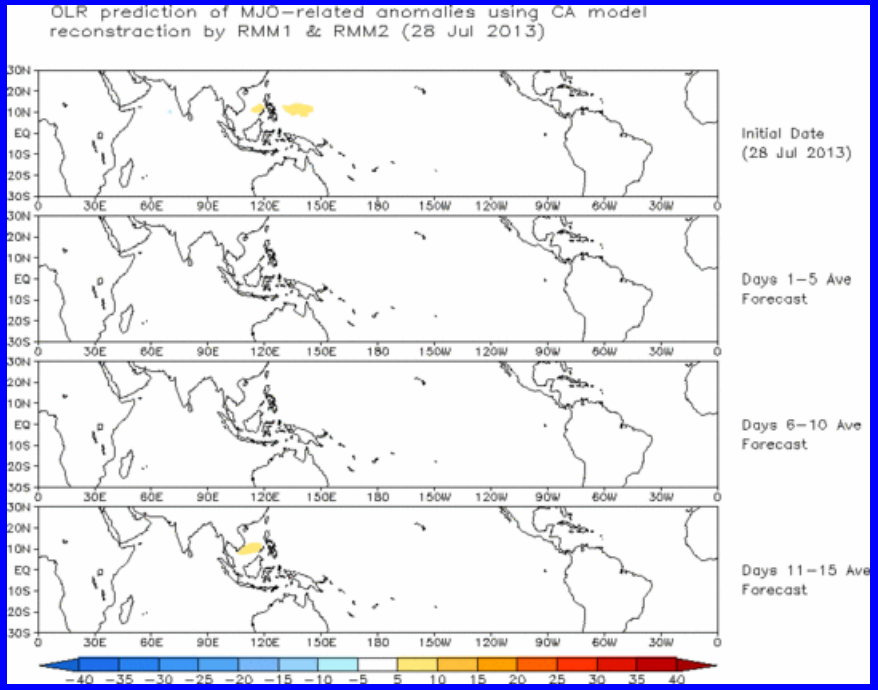
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

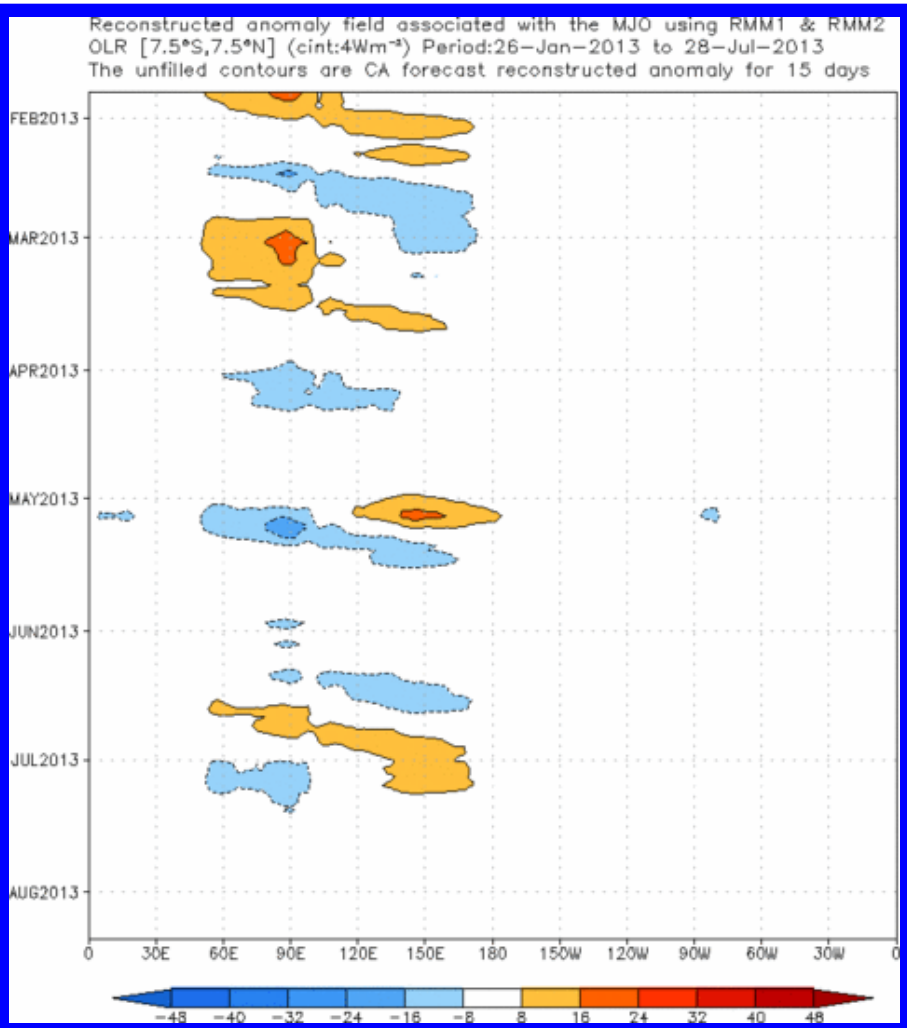
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



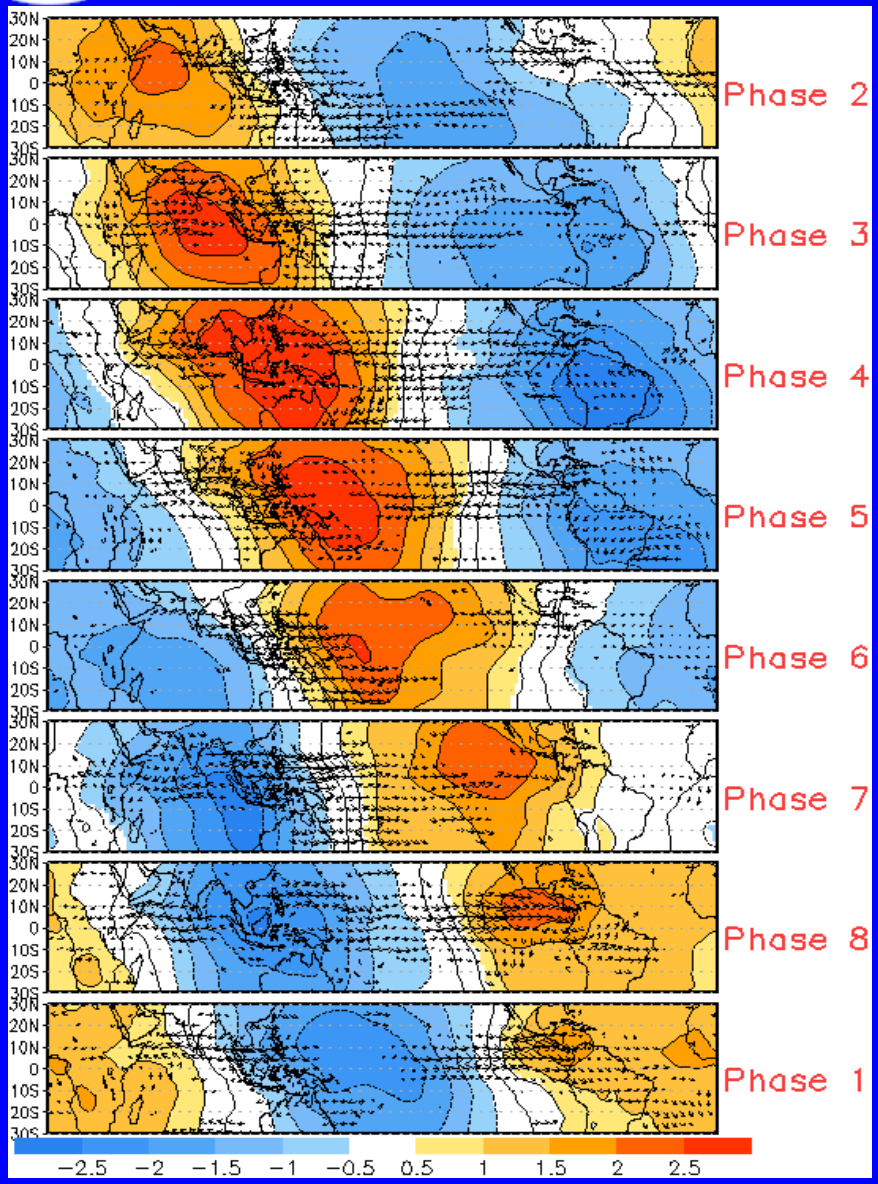
The statistical forecast indicates little or no anomalous convection associated specifically to the MJO.

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

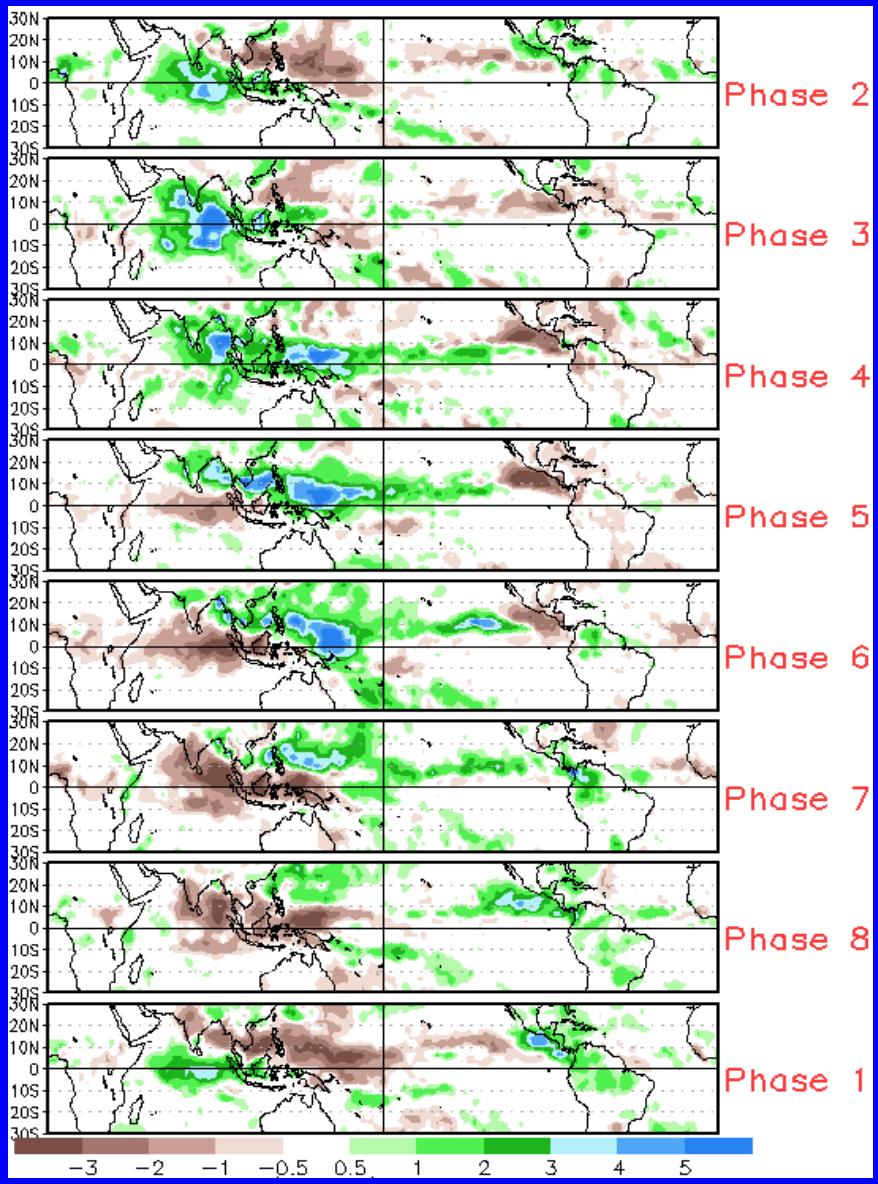


MJO Composites – Global Tropics

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

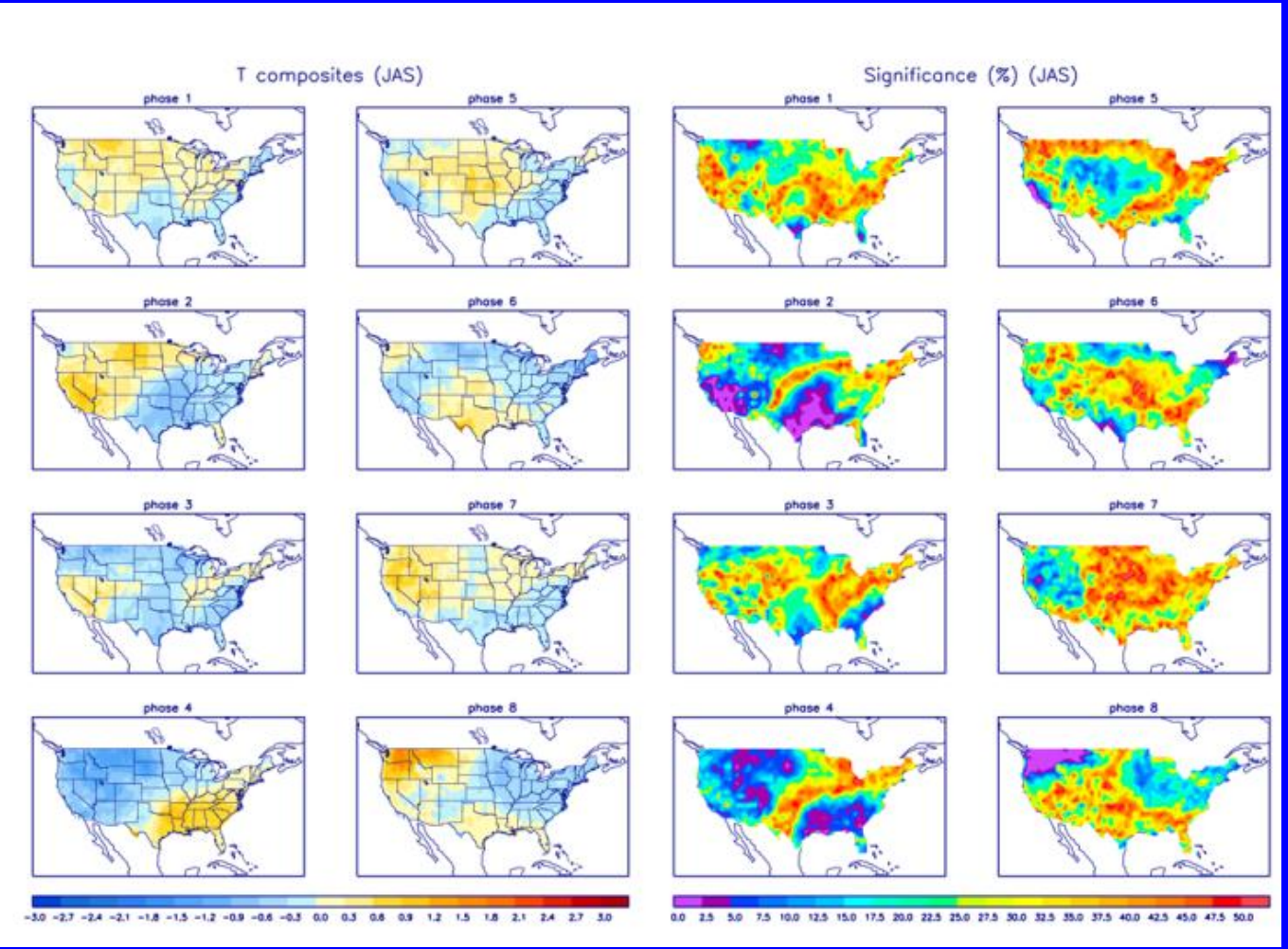


Precipitation Anomalies (May-Sep)



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.**

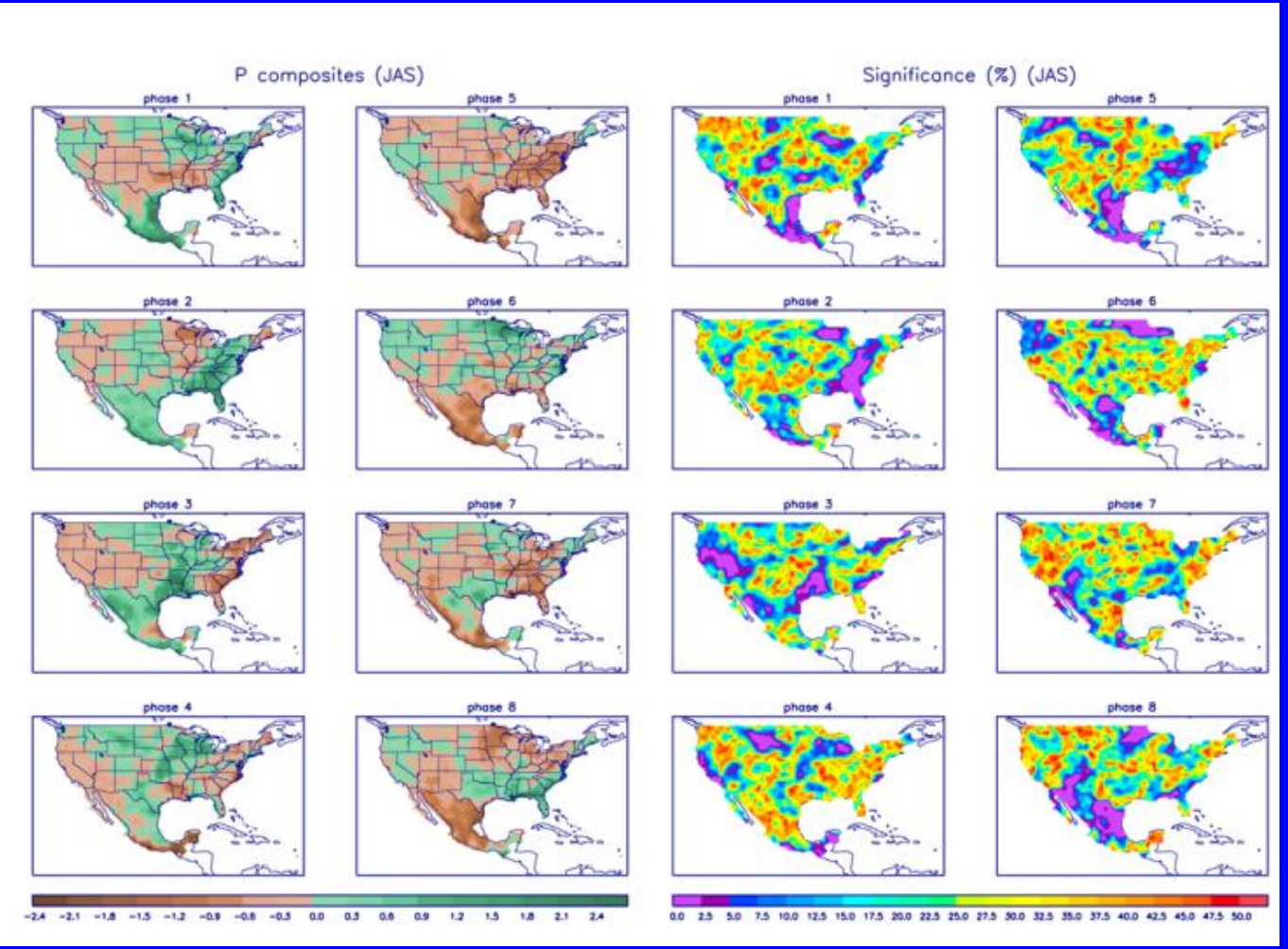


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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