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

Update prepared by
Climate Prediction Center / NCEP
June 17, 2013

Outline

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

Overview

- The MJO has strengthened during the past week, with the convectively active phase now located over the Maritime Continent.

- Dynamical and statistical model MJO index forecasts are in reasonable agreement for continued propagation of the signal. The dynamical models indicate a slightly stronger signal.

- Based on recent observations and model MJO forecasts, the MJO is forecast to propagate across the Maritime Continent to the Western Pacific during the next two weeks.

- Enhanced rainfall is favored during Week-1 across parts of Southeast Asia, the Maritime Continent, and the western North Pacific. Tropical cyclogenesis is more likely than normal over the South China Sea and Western North Pacific.

- During Week-2 the MJO favors increased convection across parts of the western and central Pacific, with some potential for increased rainfall along the eastern Pacific ITCZ.

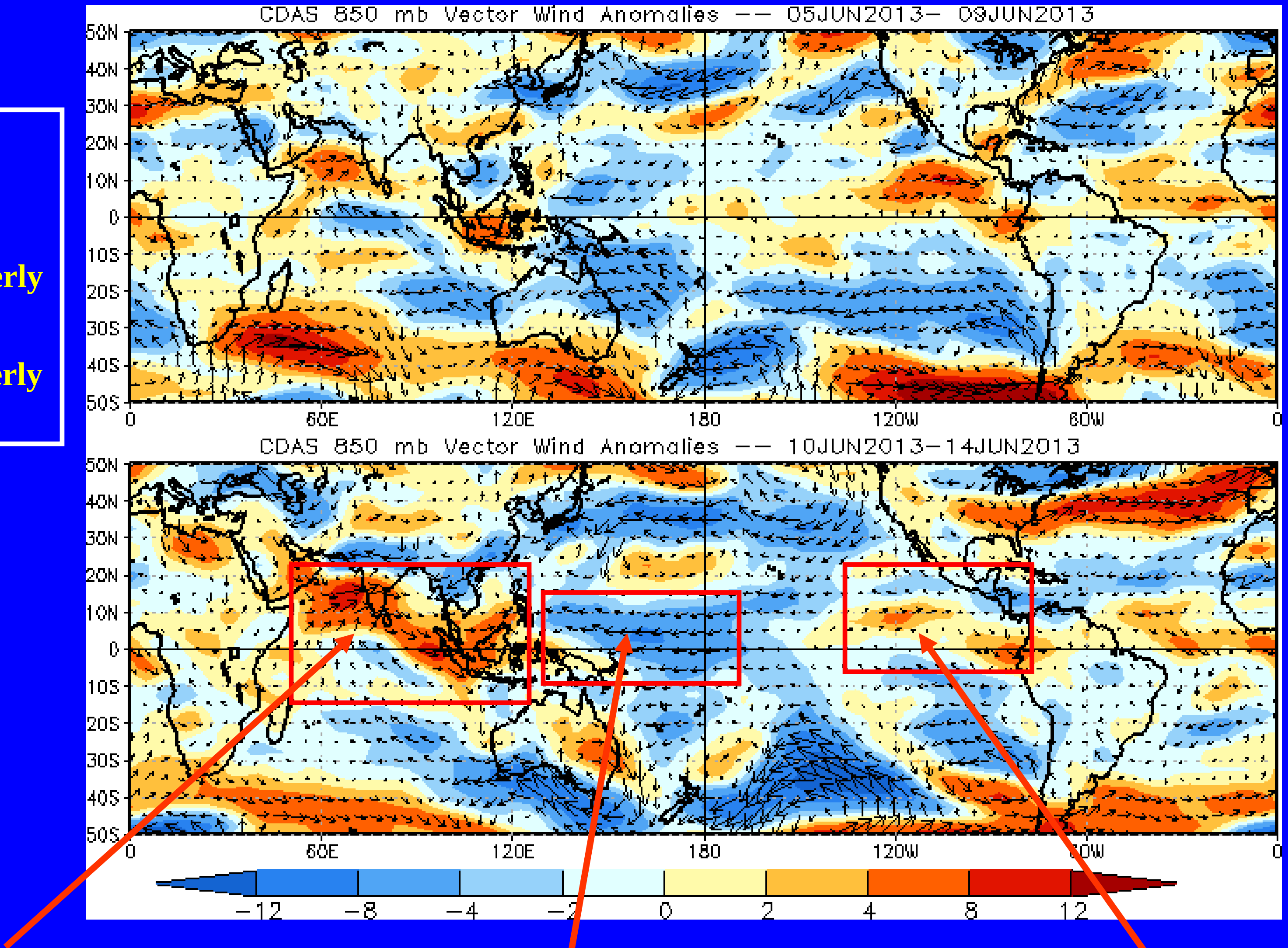
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies have become more organized and intensified over the Indian Ocean.

Easterly anomalies expanded and intensified over most of the western and central Pacific.

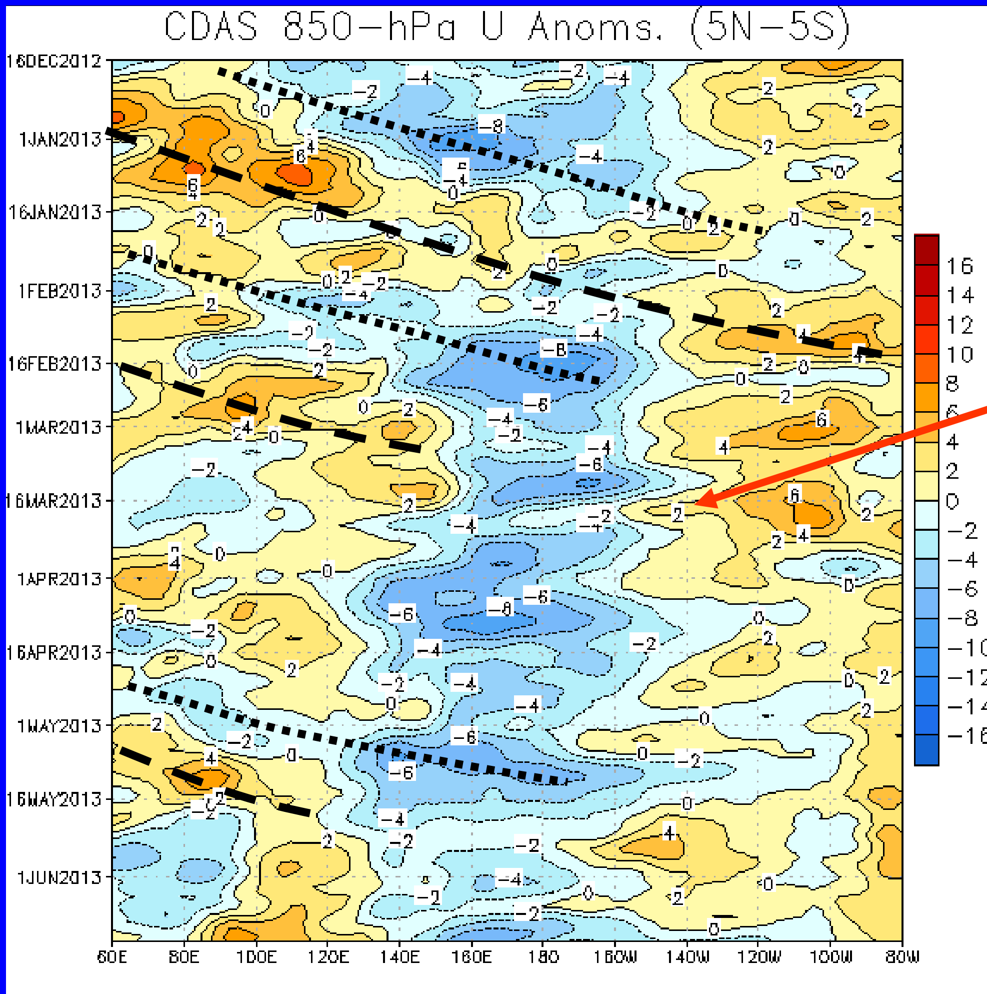
Westerly anomalies diminished over the East Pacific during the past five days.

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

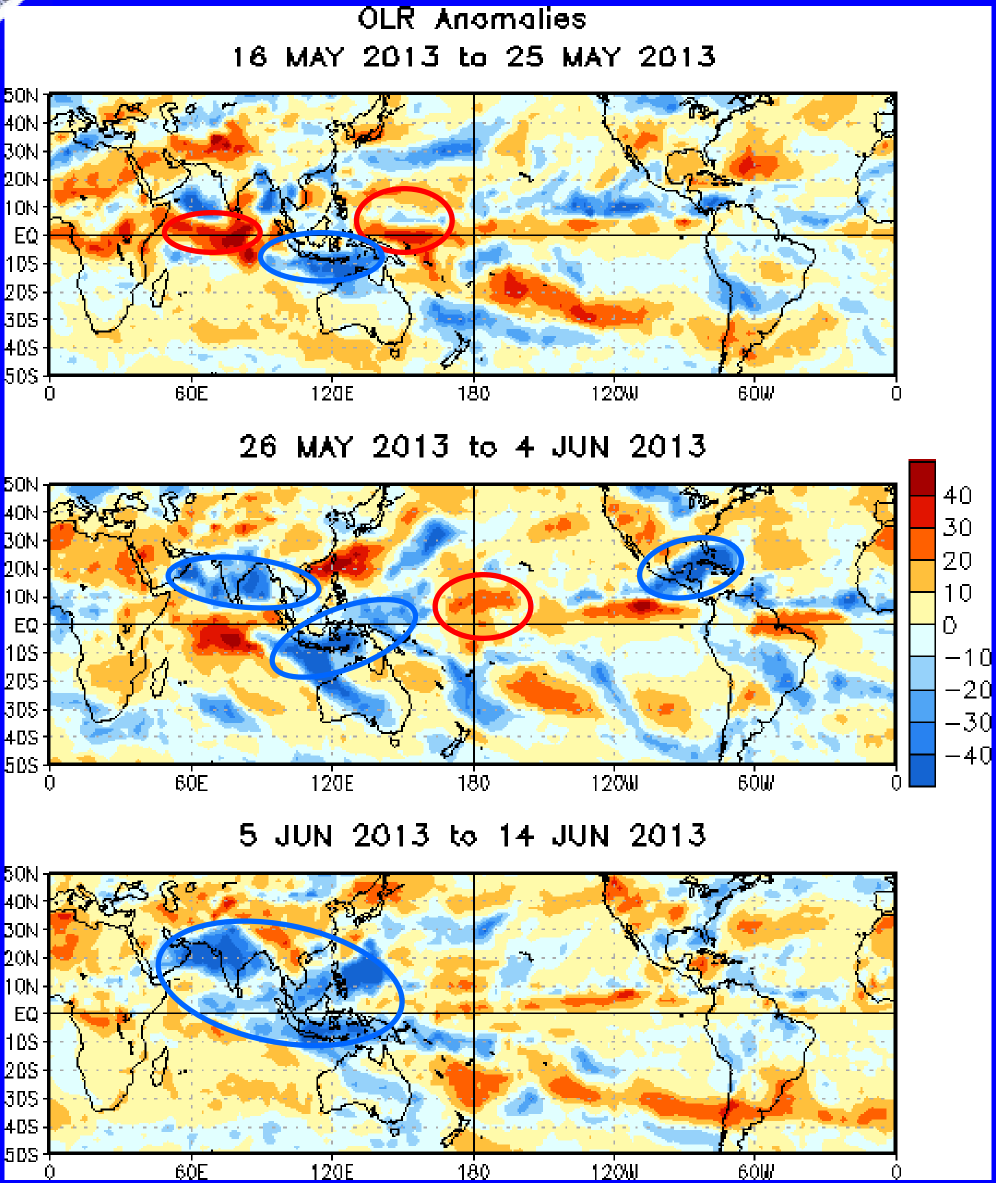
During late December the MJO strengthened (alternating dotted/dashed lines).

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 eastward propagation of low-level wind anomalies noted. More recently, other sub-seasonal modes have limited eastward propagation.

Recently, westerly (easterly) anomalies have increased over the Indian Ocean (western Pacific). These intensifications are attributed only in part to the MJO.

OLR Anomalies – Past 30 days



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

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

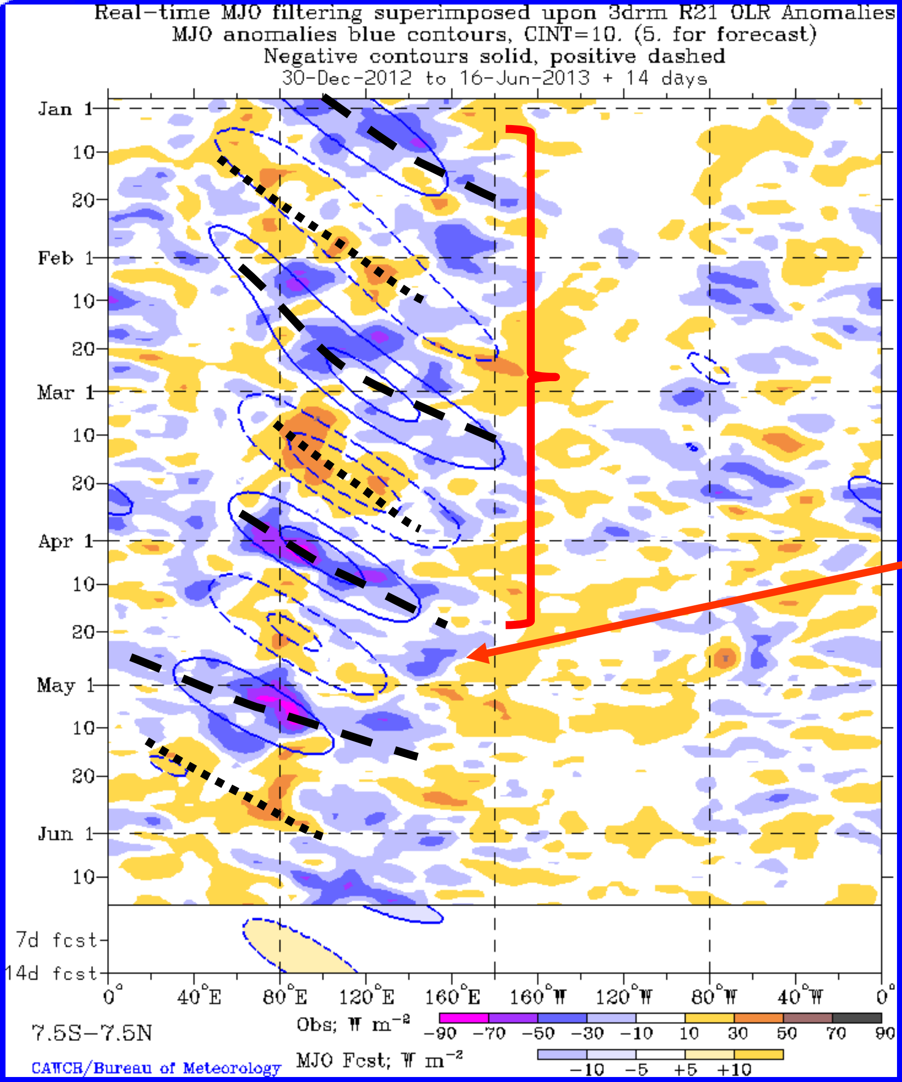
During mid-May, the OLR field became less coherent with generally suppressed convection near the Equator across the Indian Ocean and portions of the Western Pacific. Convection increased over parts of the East Pacific due to a northward displaced ITCZ.

During late May, the OLR field remained incoherent with respect to the MJO. Convection flared up over southern Asia, the Maritime Continent, and western Atlantic.

Most recently, the convective anomalies have become more organized, with enhanced convection over south Asia and the Maritime Continent, with generally suppressed convection across most of the Pacific and Africa.

Outgoing Longwave Radiation (OLR) Anomalies (7.5°S-7.5°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.

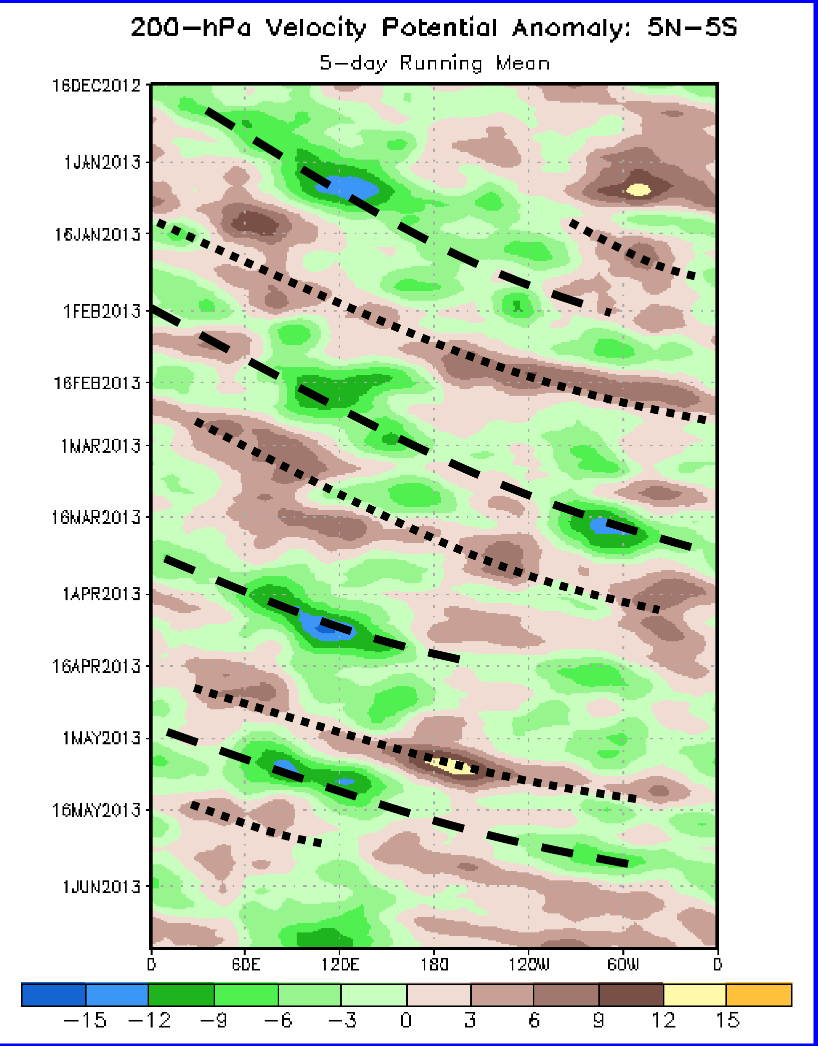
Recently, enhanced convection was noted across much of the Indian Ocean, influenced by the MJO and other modes of subseasonal variability (Kelvin waves and equatorial Rossby waves).

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.

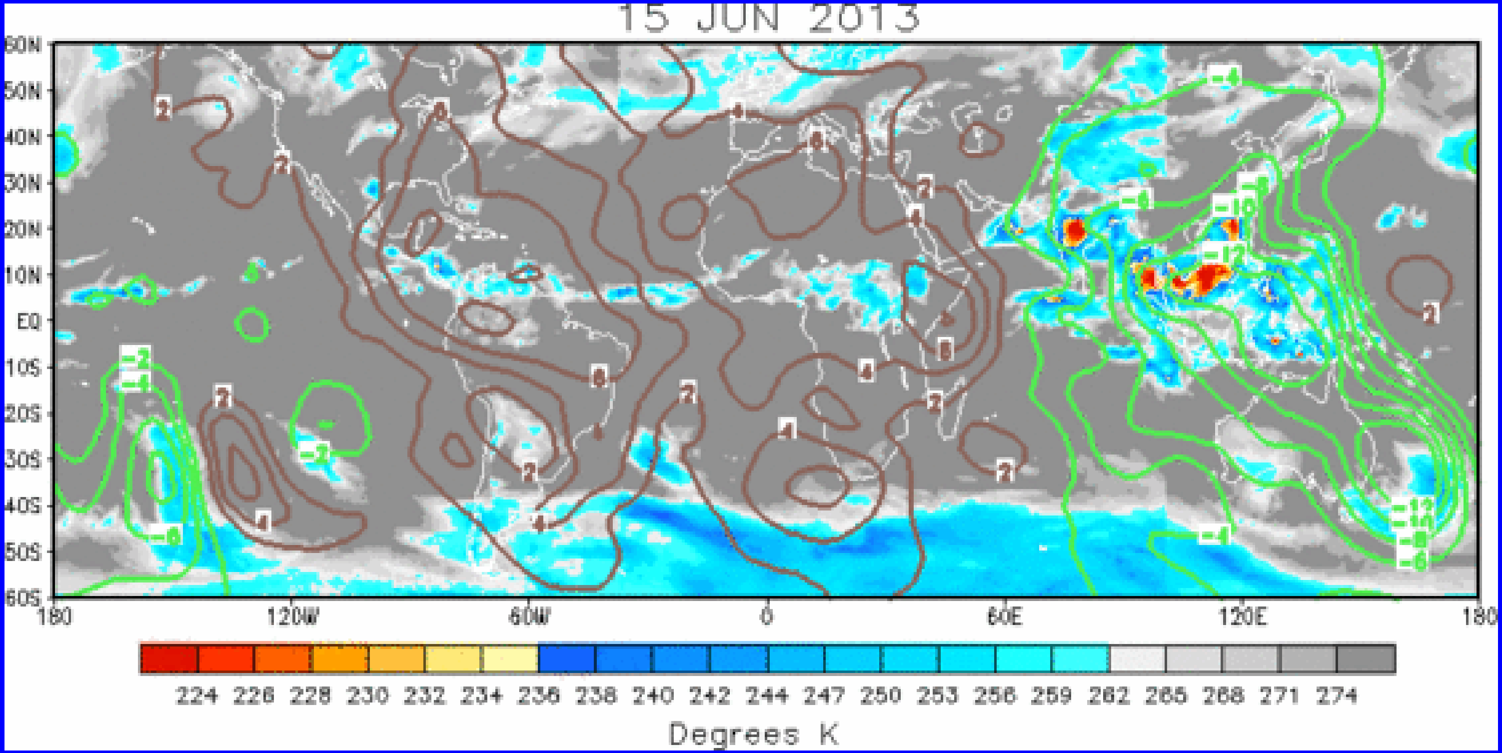
The velocity potential anomalies were more coherent only briefly during early to mid-May.

Recently, the signal is slightly more coherent and consistent with classical MJO influence, although other modes of variability are evident in the pattern.

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

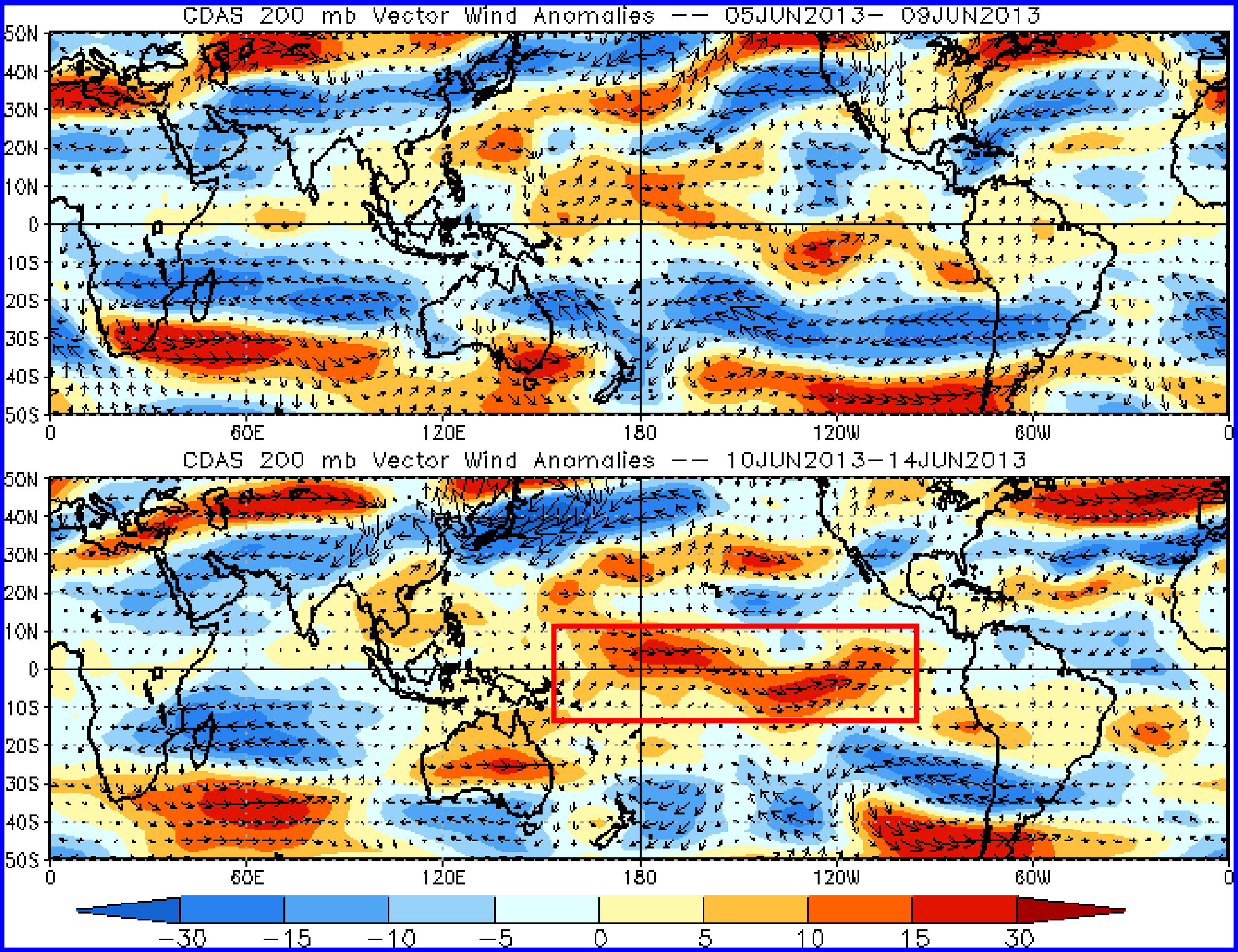
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The velocity potential pattern suggests some reorganization of the MJO with the convectively active phase across the Maritime Continent. However, other modes remain influential and are impacting the circulation, as the pattern is not a pure wave-1 structure.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

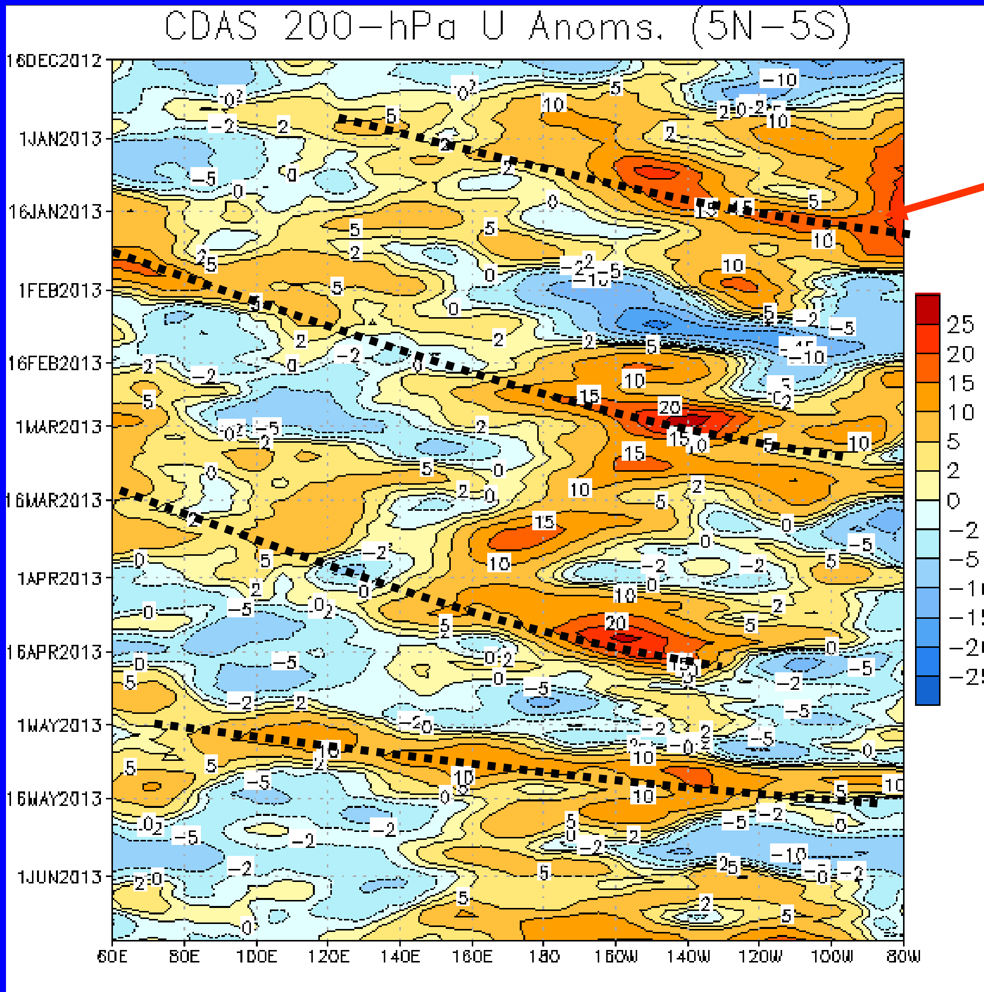
Large-scale tropical anomalies remain fairly weak, with westerly anomalies over much of the central Pacific. Those westerly anomalies have shifted slightly eastward during the past 5 days.

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

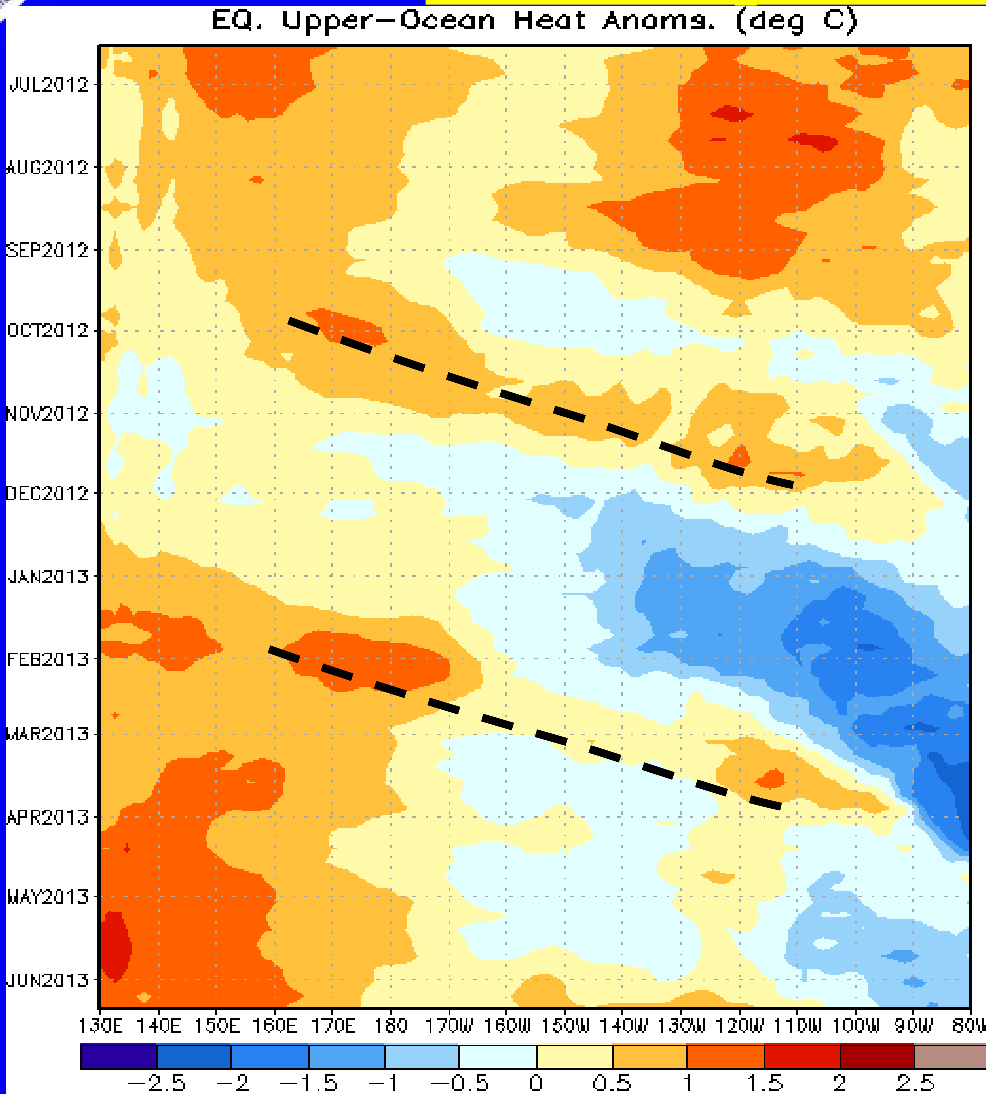
Eastward propagation of westerly wind anomalies associated with the MJO is evident beginning in late December and continuing into April 2013. Some propagation of easterly anomalies is evident during late January and early February.

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

Westerly anomalies shifted east of the Date Line during early May. The rapid phase speed suggests the influence of a higher-frequency Kelvin wave. Recently, westerly anomalies have become persistent over the central and eastern equatorial Pacific, with some eastward movement evident.

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.

Recently, the pattern is persistent, with some cooling east of 115W.

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).

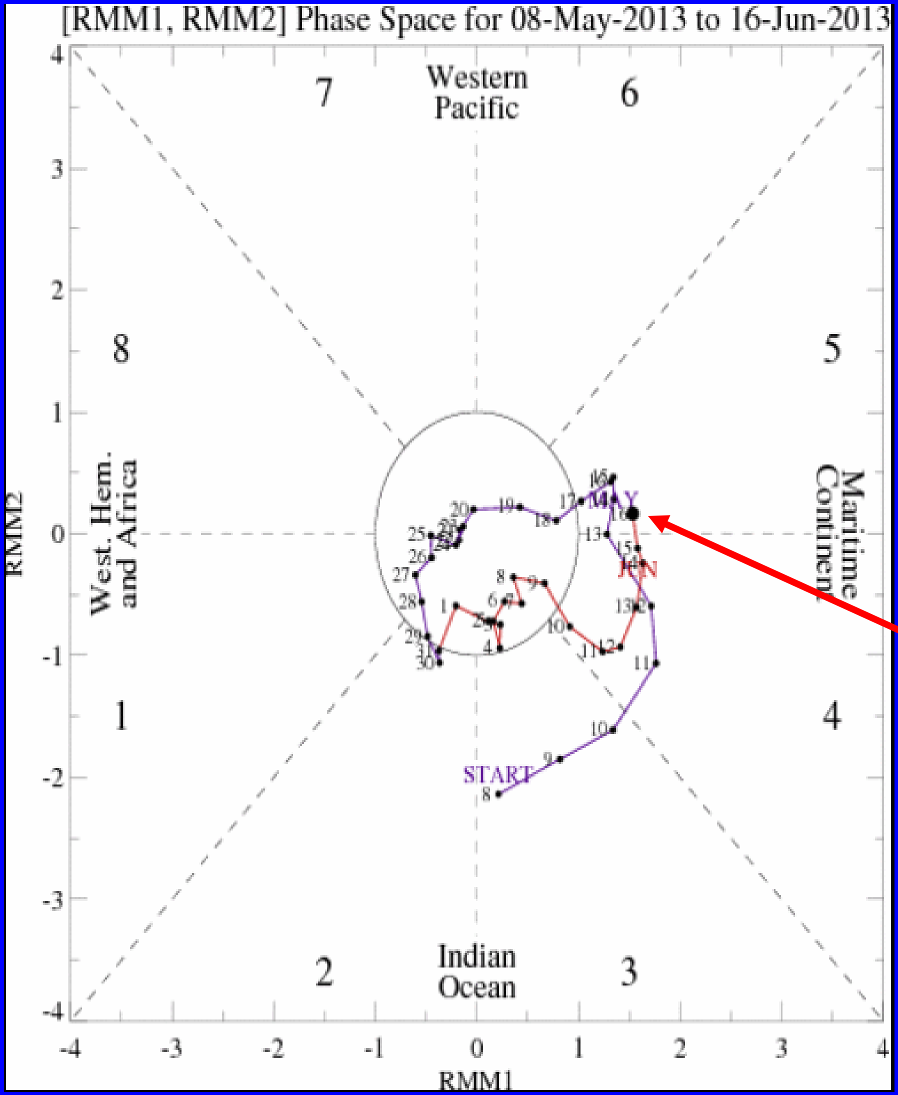
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

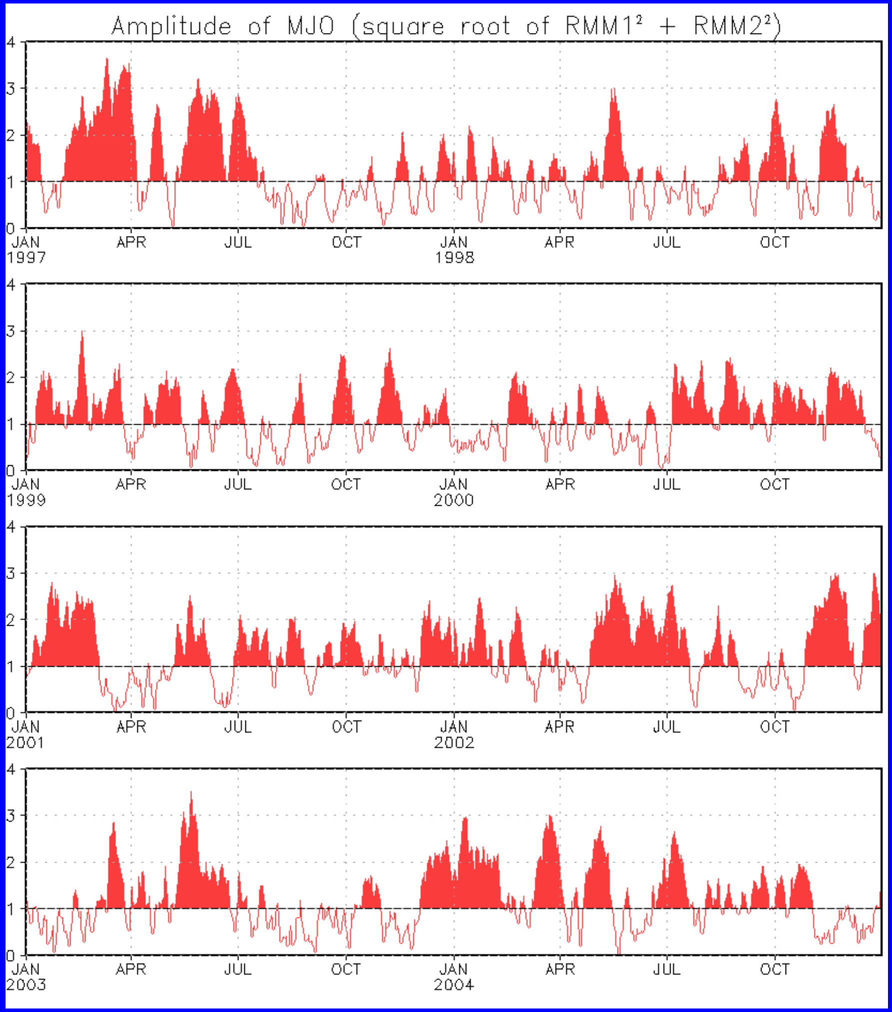
MJO Index -- Recent Evolution

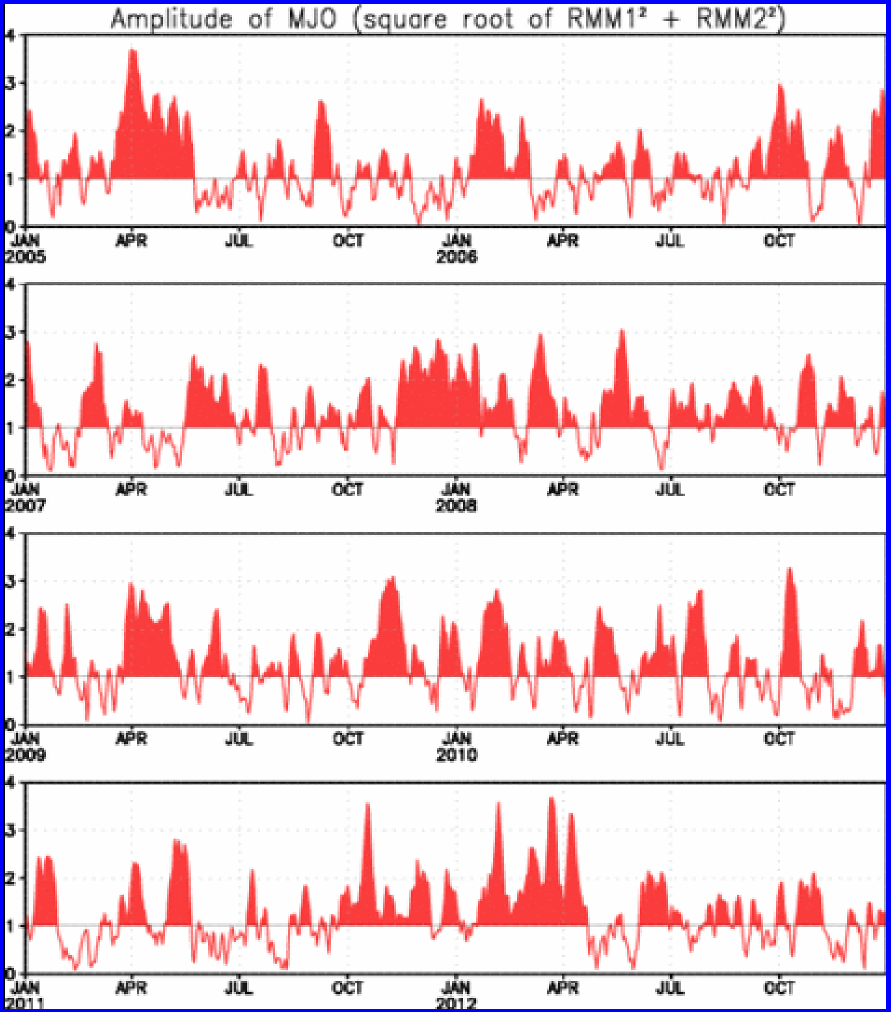


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates a stronger MJO signal in Phases 4 and 5 during the past several days.

MJO Index – Historical Daily Time Series





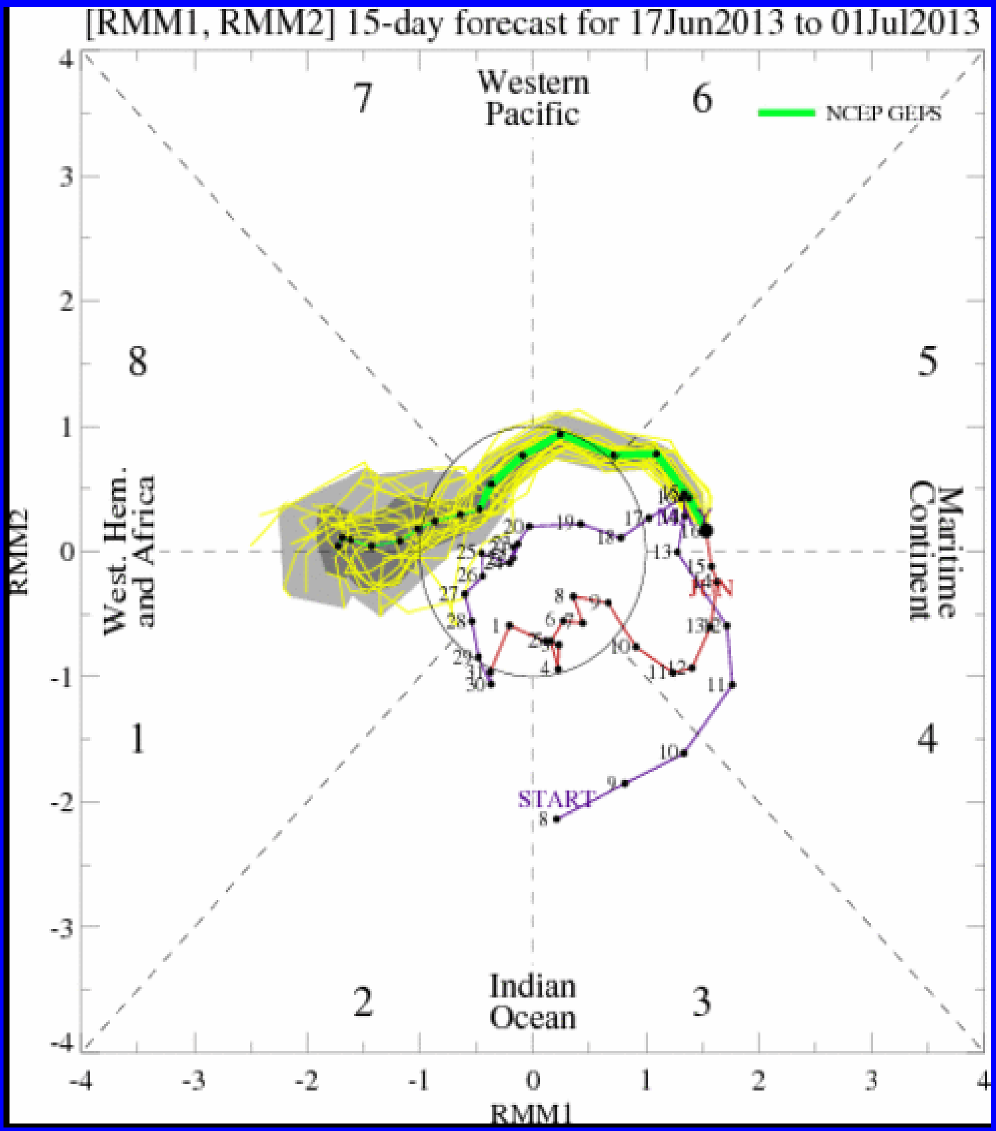
Time series of daily MJO index amplitude from 1997 to present. Plots put current MJO activity in historical context.

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



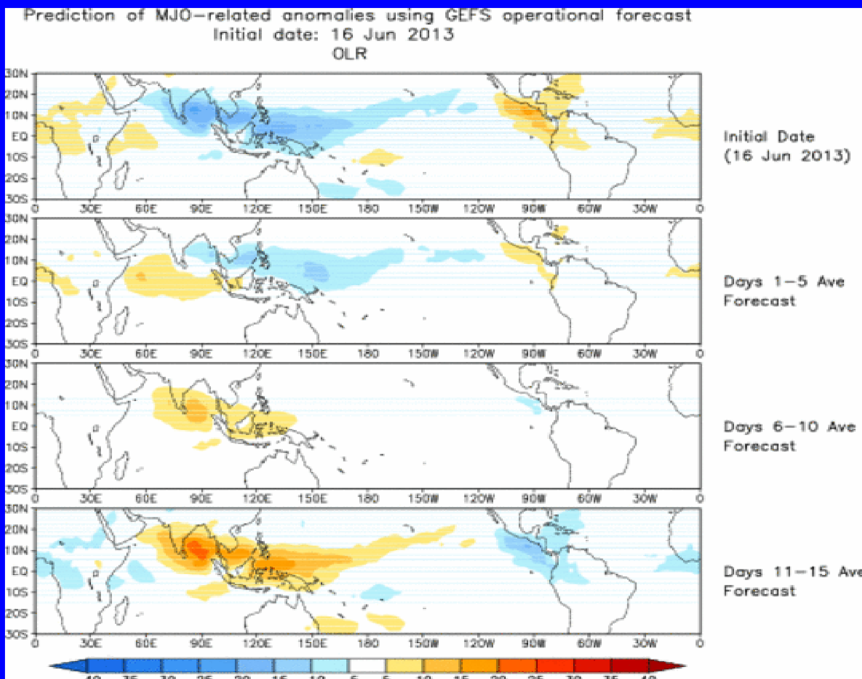
The ensemble GFS indicates MJO propagation through Phase 6 to Phase 7 during Week-1. the signal then becomes weaker, with more uncertainty for Week-2.

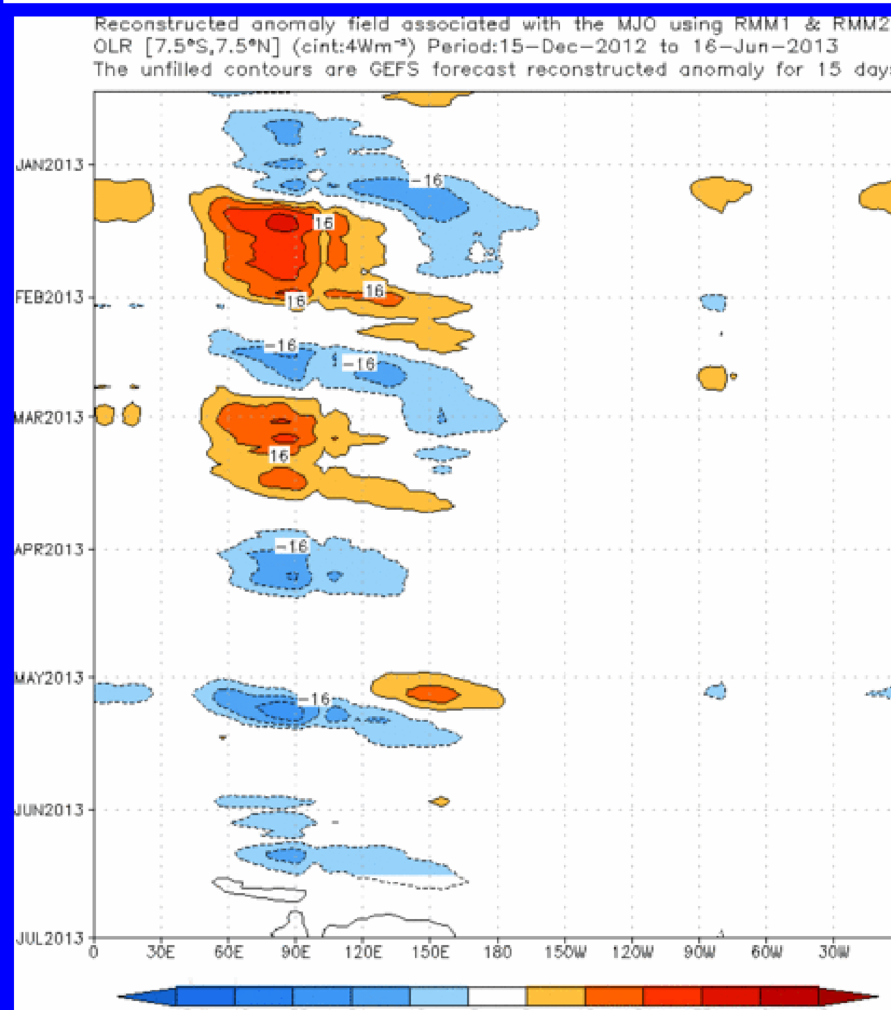
Ensemble Mean GFS MJO Forecast

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



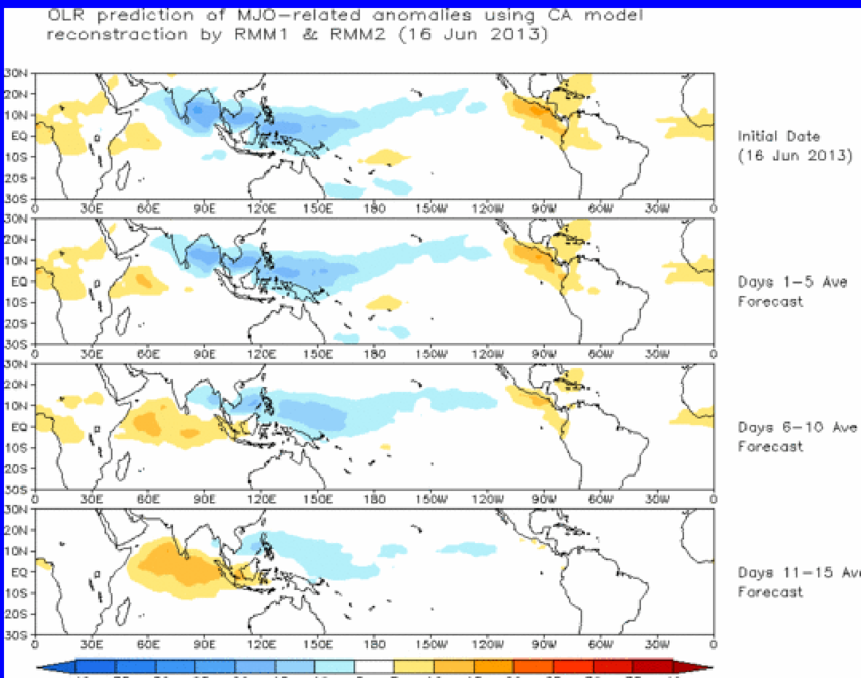


The ensemble mean GFS forecasts enhanced convection across the Maritime Continent and western North Pacific with some suppressed convection across the East Pacific during Week-1. Rapid eastward propagation of the signal results in wet conditions returning to Central America with drying over the Indian Ocean during Week-2.

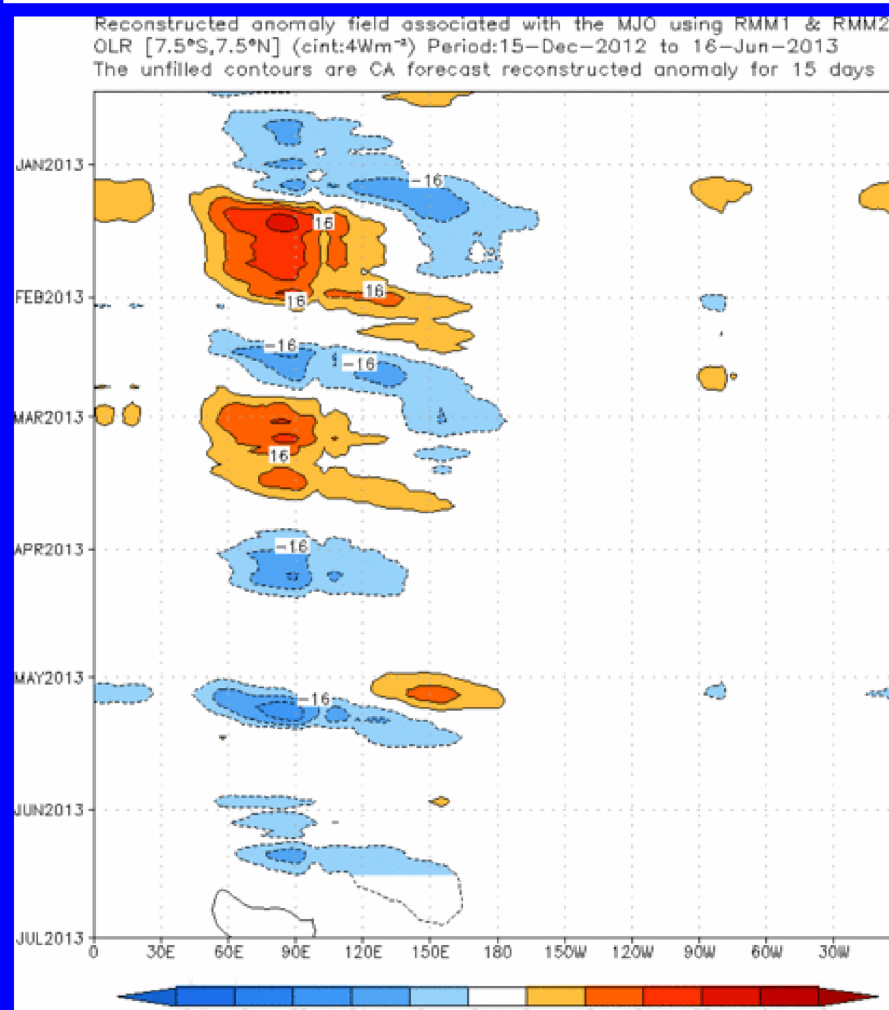
Constructed Analog (CA) MJO Forecast

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



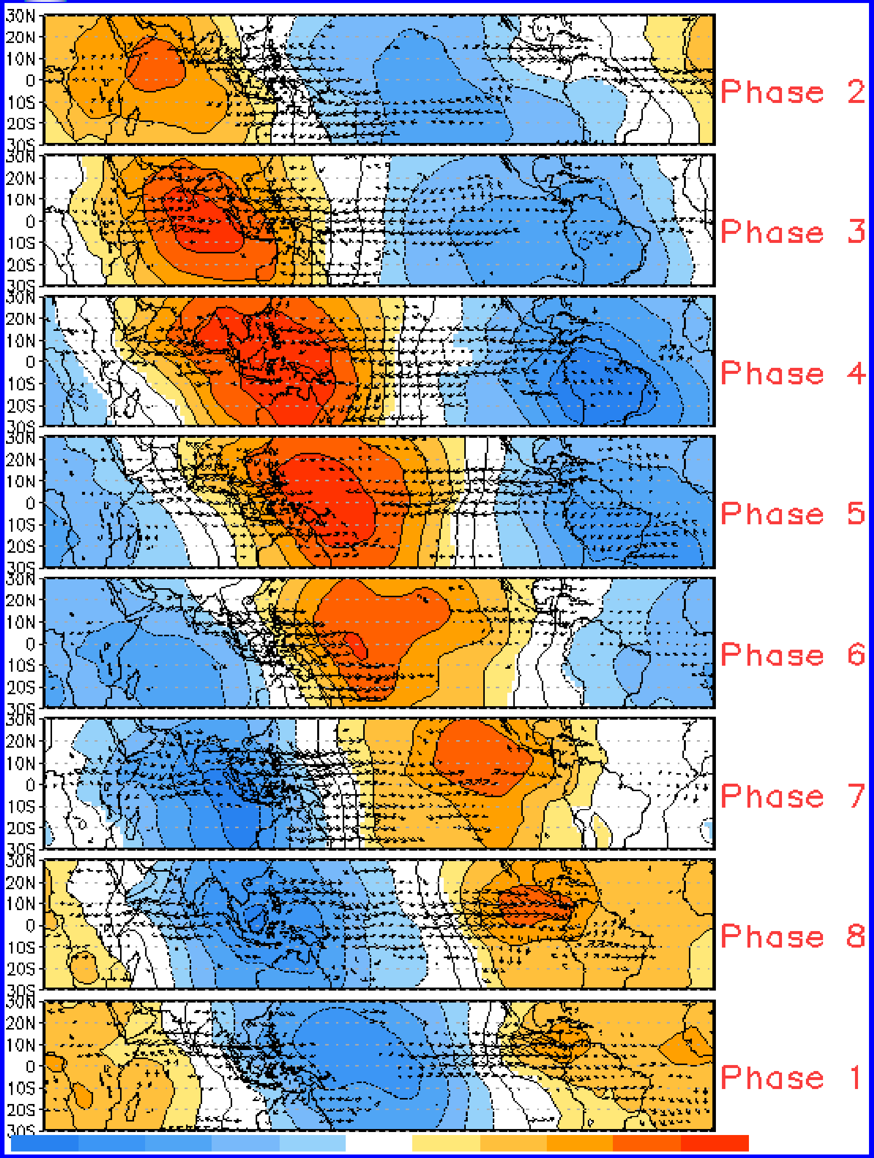
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



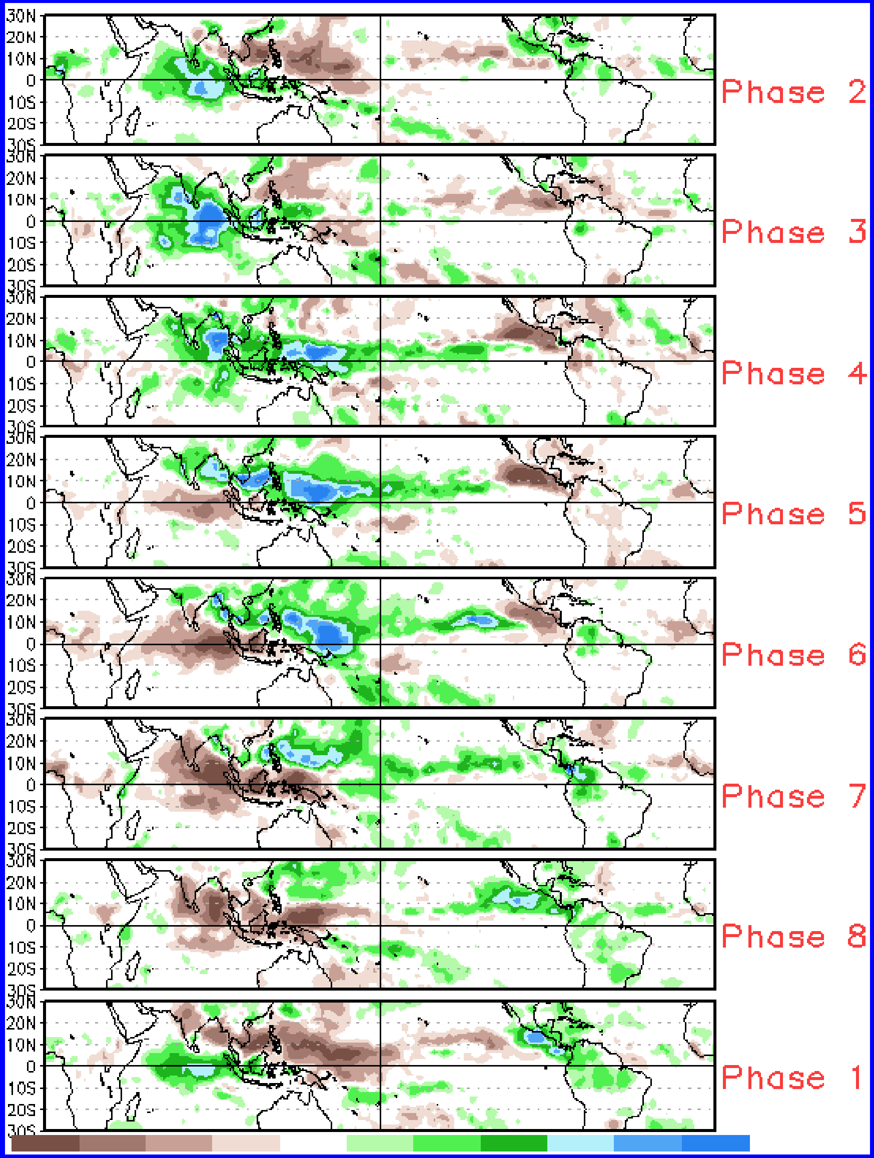
This statistical forecast indicates a continued active MJO with enhanced convection over the western North Pacific during Week-1. The continued propagation would result in dry conditions developing across Africa and the western Indian Ocean by Week-2.

MJO Composites – Global Tropics

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

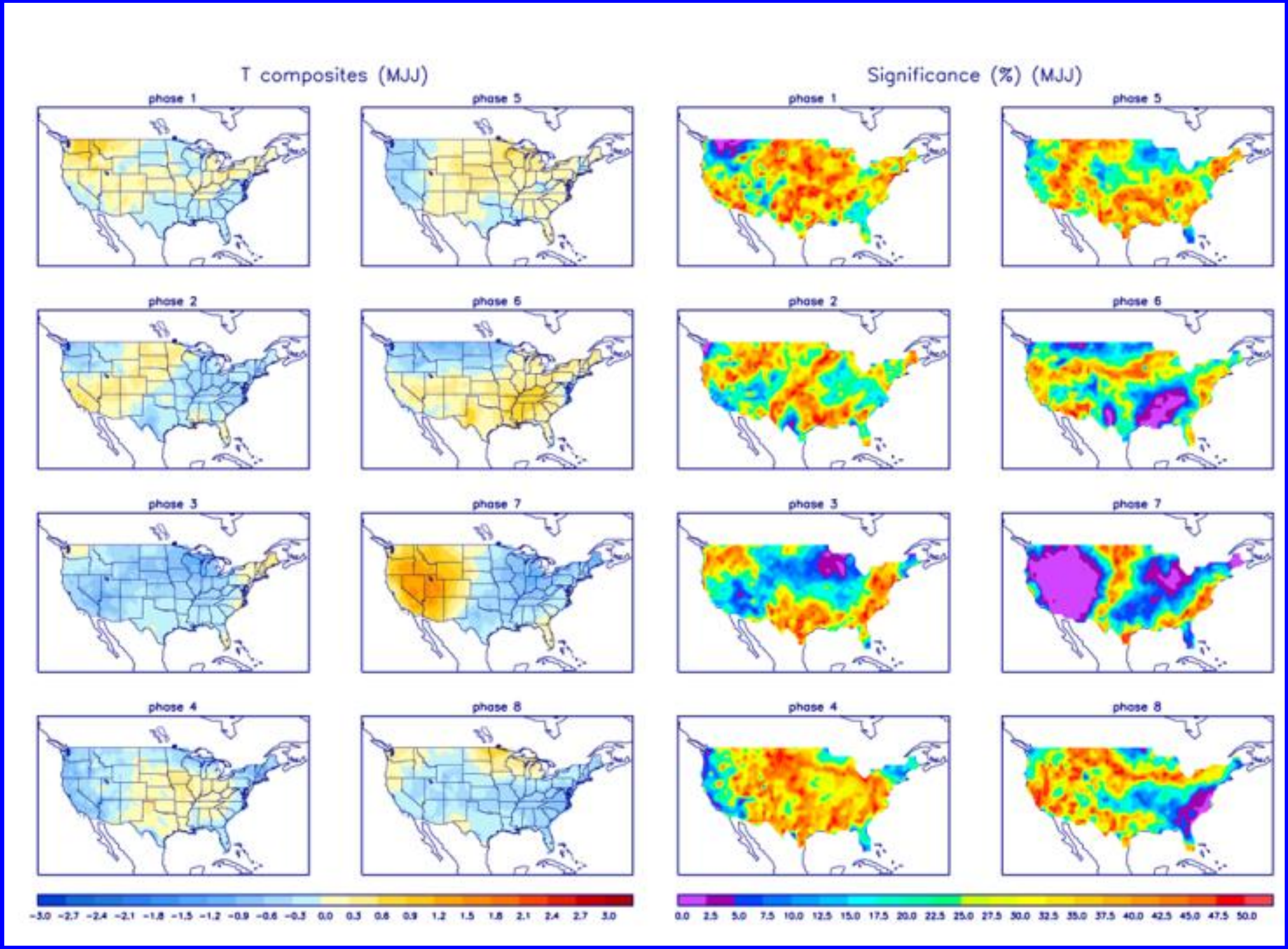


Precipitation Anomalies (May-Sep)



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.

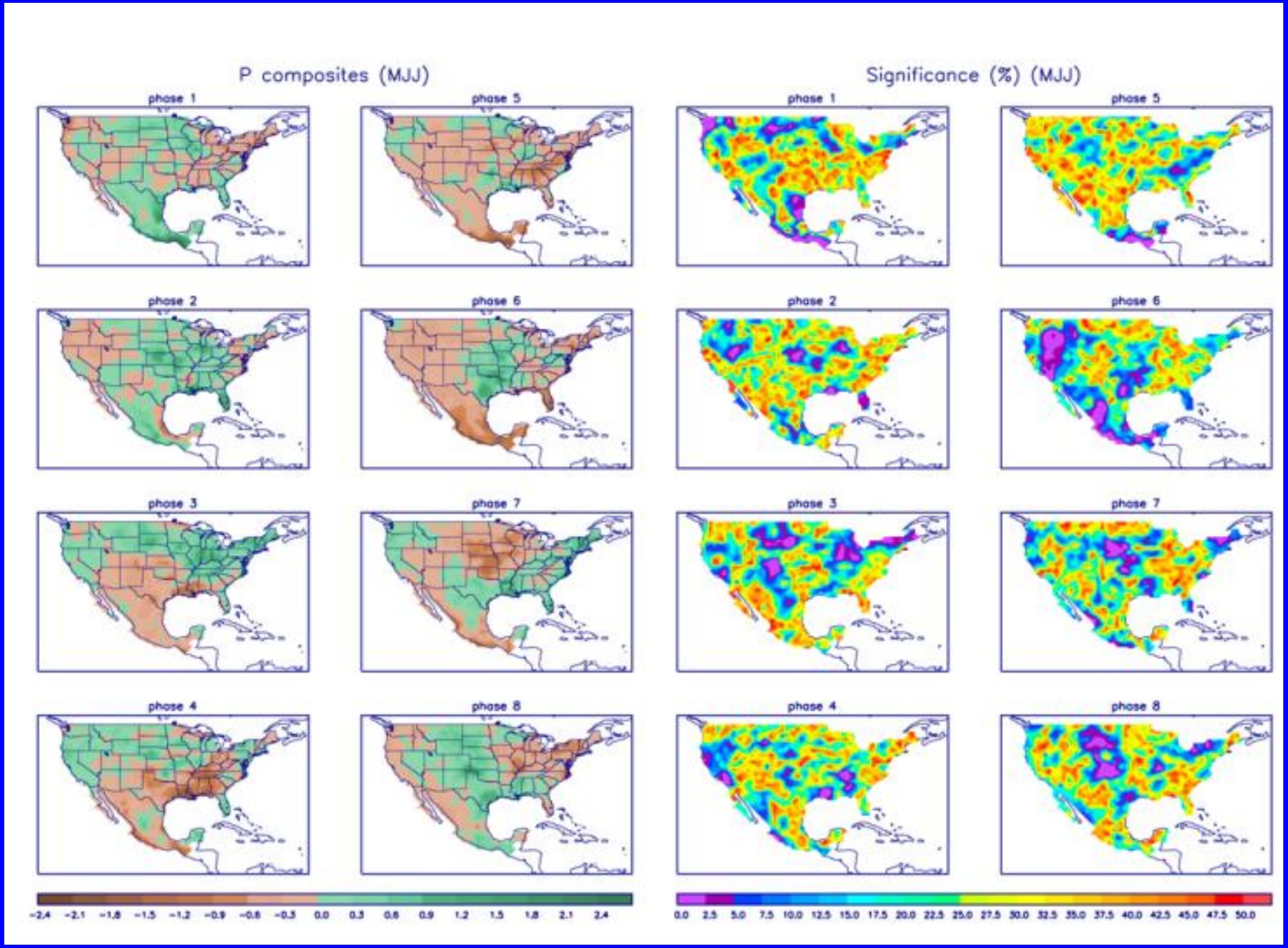


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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