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

Update prepared by
Climate Prediction Center / NCEP
July 1, 2013

Outline

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

Overview

- The MJO signal has persisted during the past week, with the convectively active phase now located over the Western Hemisphere.

- Dynamical and statistical model MJO index forecasts exhibit considerably less agreement than last week. The models differ considerably on the strength of the forecast MJO signal over the Indian Ocean.

- Based on recent observations and model MJO forecasts, the MJO is forecast to weaken over the Indian Ocean as the signal becomes less coherent.

- Enhanced convection is favored across the North American Monsoon regions, the Gulf of Mexico, and the African monsoon regions during week 1, while suppressed convection is expected over southeastern Asia and the western Pacific. Tropical cyclogenesis is possible over the eastern Pacific basin.

- During week 2, enhanced convection is forecasted to continue across western Mexico, central America, the western Caribbean, and western Africa, with increasing convection possible over the eastern Indian Ocean. Suppressed convection is favored over the western north Pacific.

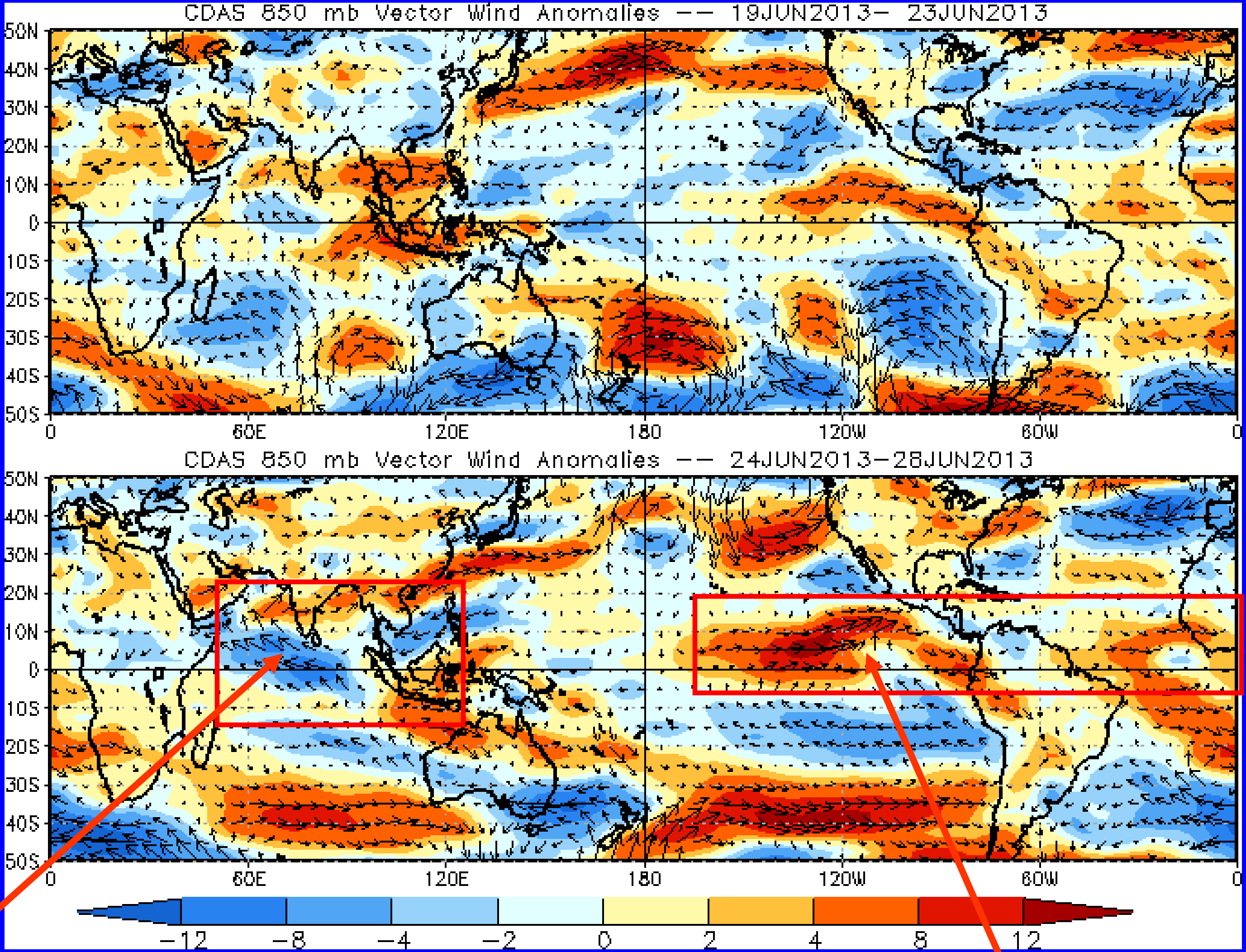
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 increased over the equatorial and northern Indian Ocean and the South China Sea.

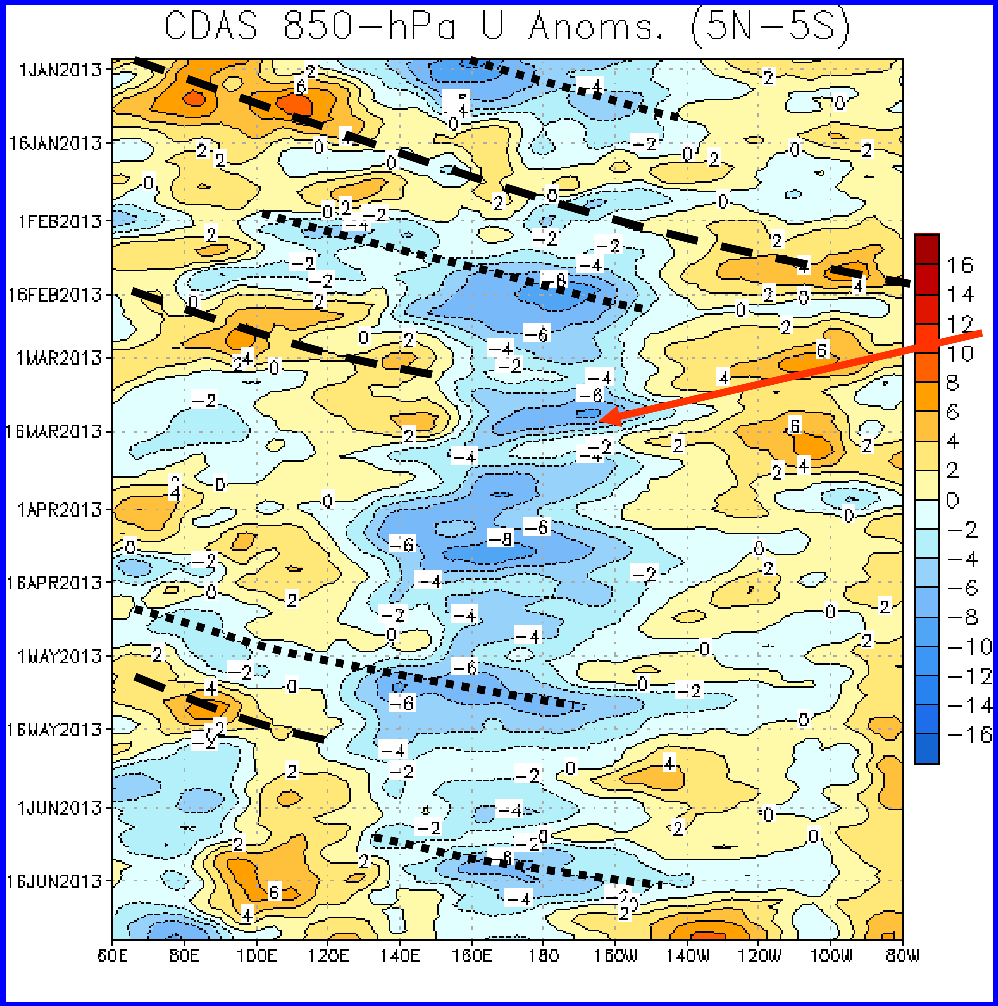
Westerly anomalies increased over the eastern Pacific and Atlantic Basins.

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

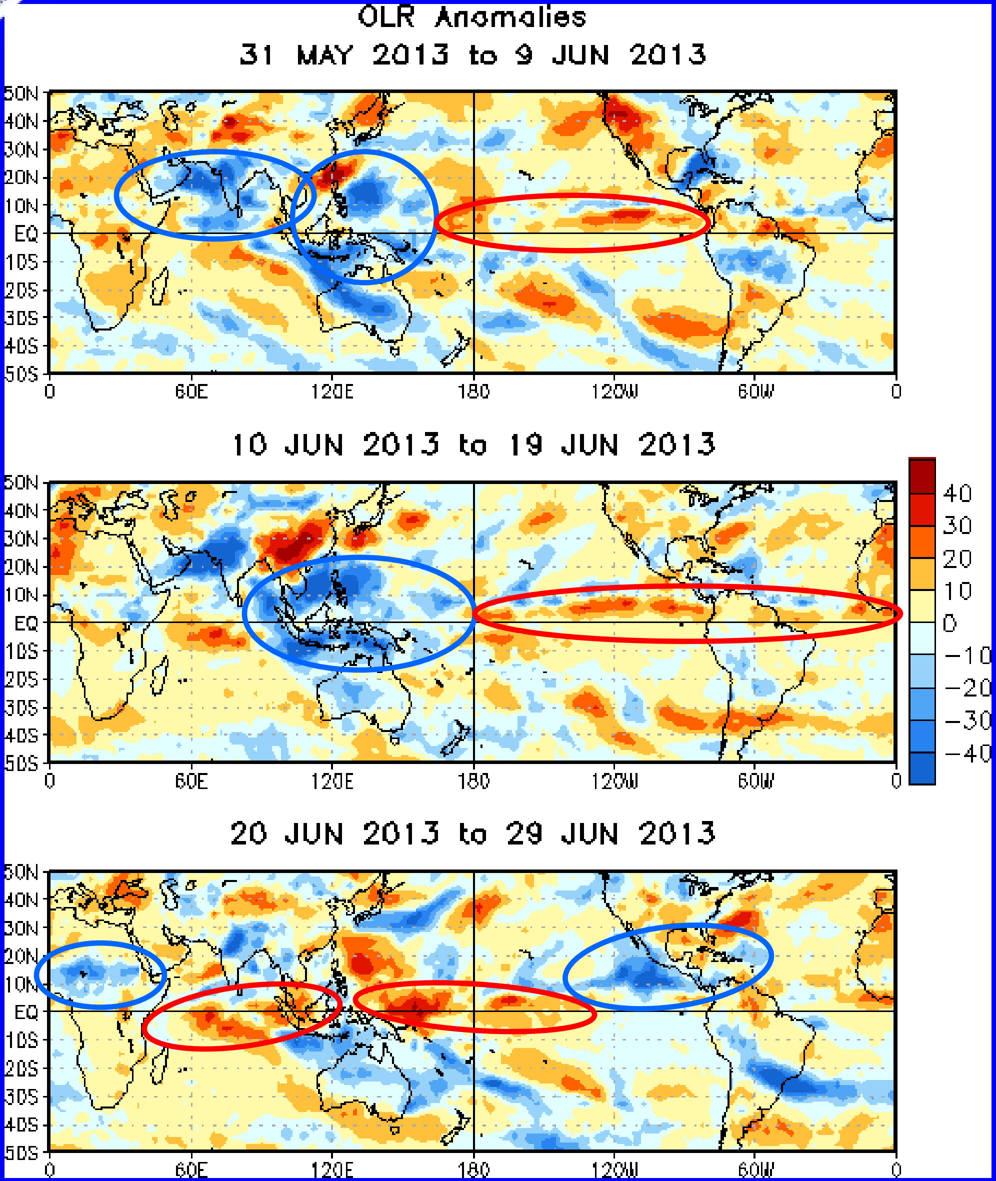
During early January the MJO strengthened (alternating dotted/dashed lines).

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

Recently, easterly (westerly) anomalies increased over the Indian Ocean (eastern Pacific and Atlantic Oceans).

OLR Anomalies – Past 30 days



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

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

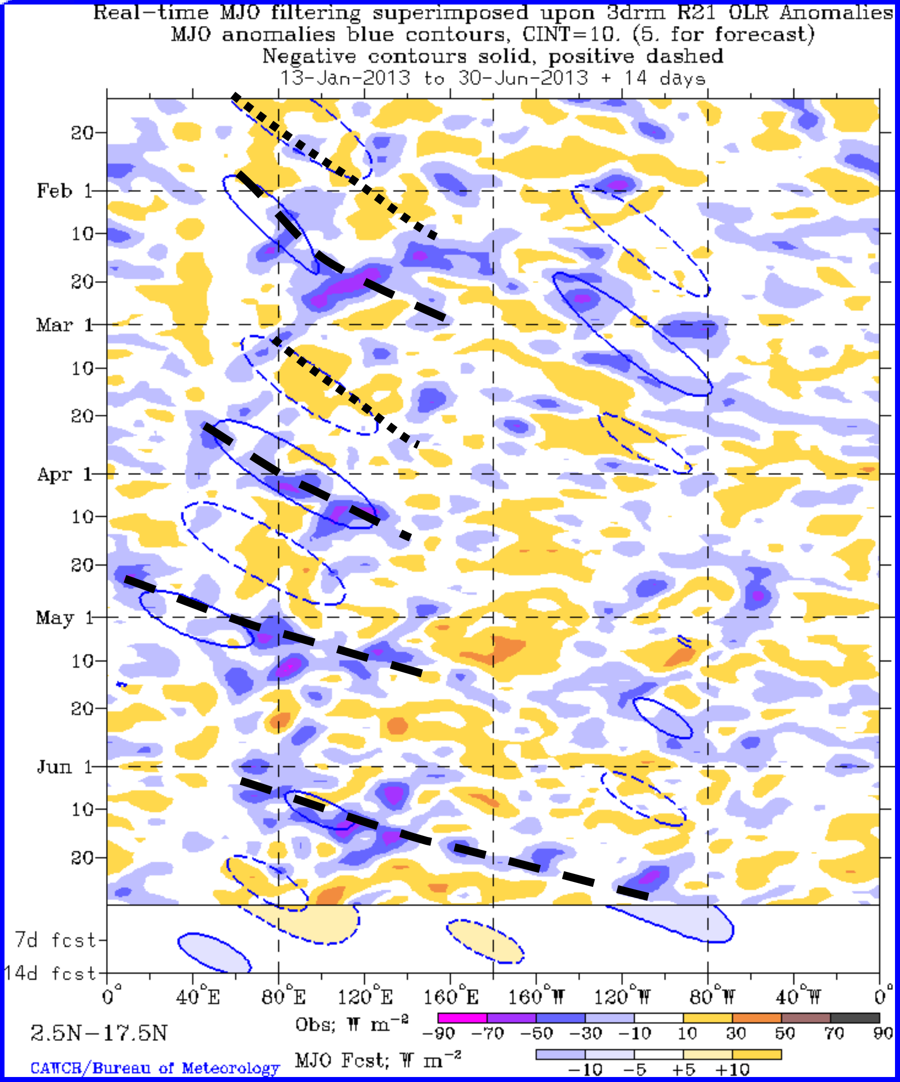
During early June, a more coherent pattern of enhanced (suppressed) convection developed over the Indian Ocean, Maritime Continent, and Australia (central and eastern Pacific and Africa). An area of enhanced convection continued to shift eastward to the Gulf of Mexico and Caribbean.

The enhanced convective anomalies propagated eastward over the Maritime Continent into the western Pacific during mid-June.

During late June, enhanced (suppressed) convective anomalies continued an eastward propagation into the eastern Pacific, western Atlantic, and Africa (Indian Ocean, Maritime Continent, and western Pacific).

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.

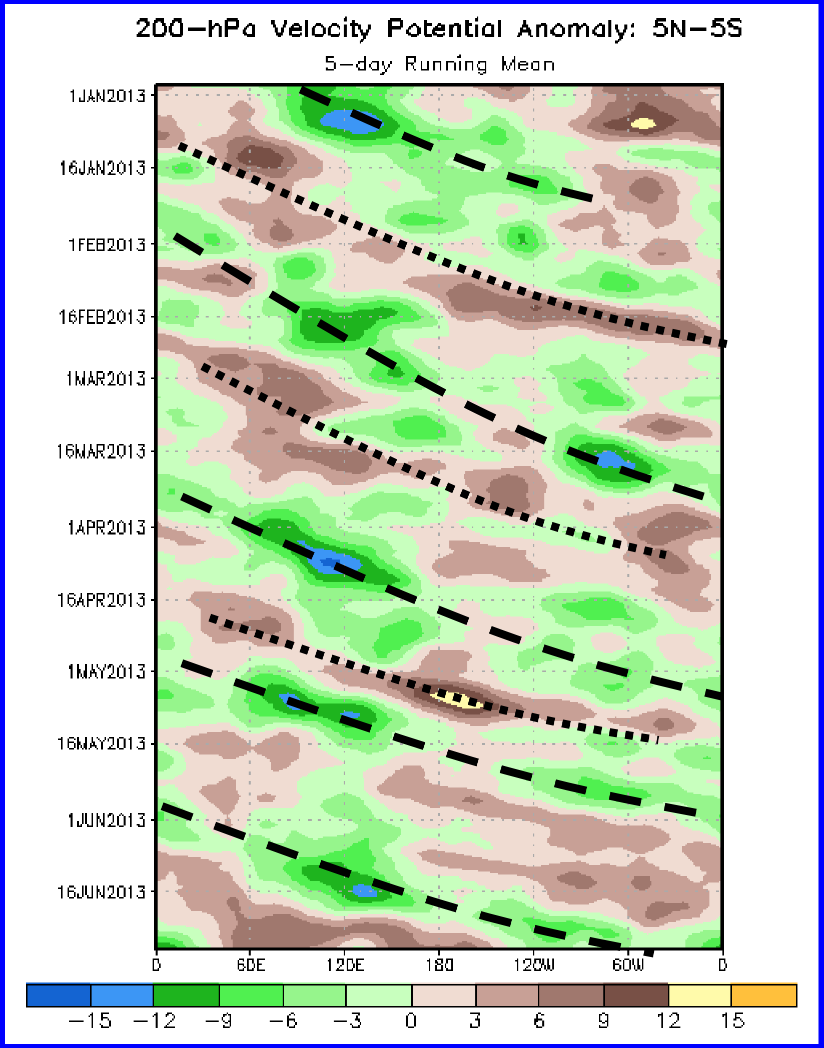
Recently, enhanced convection propagated eastward from the Maritime Continent and western Pacific into the eastern Pacific and Caribbean. Suppressed convection increased over the Indian Ocean.

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.

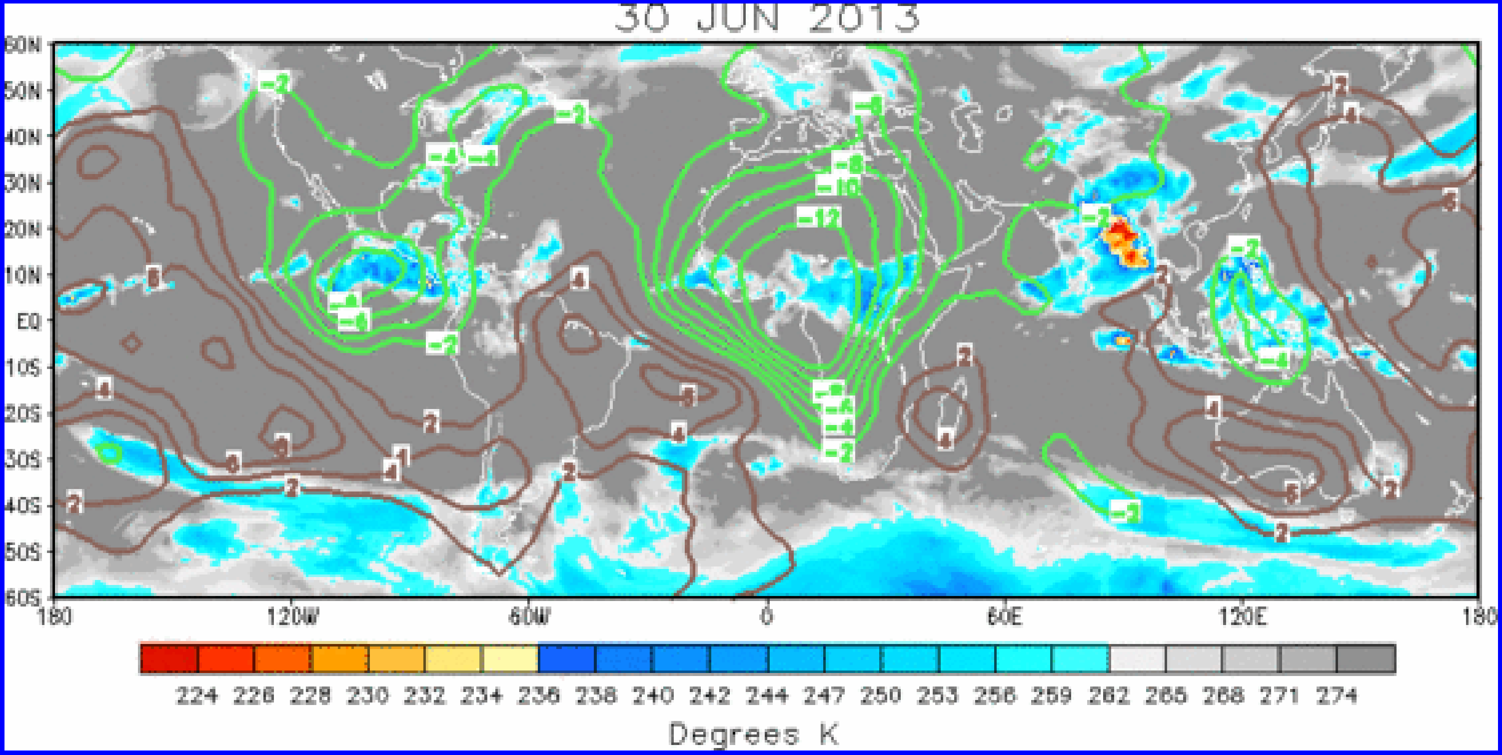
The velocity potential anomalies were more coherent only briefly during early to mid-May.

Recently, the signal is more coherent and consistent with classical MJO influence, although other modes are still apparent.

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

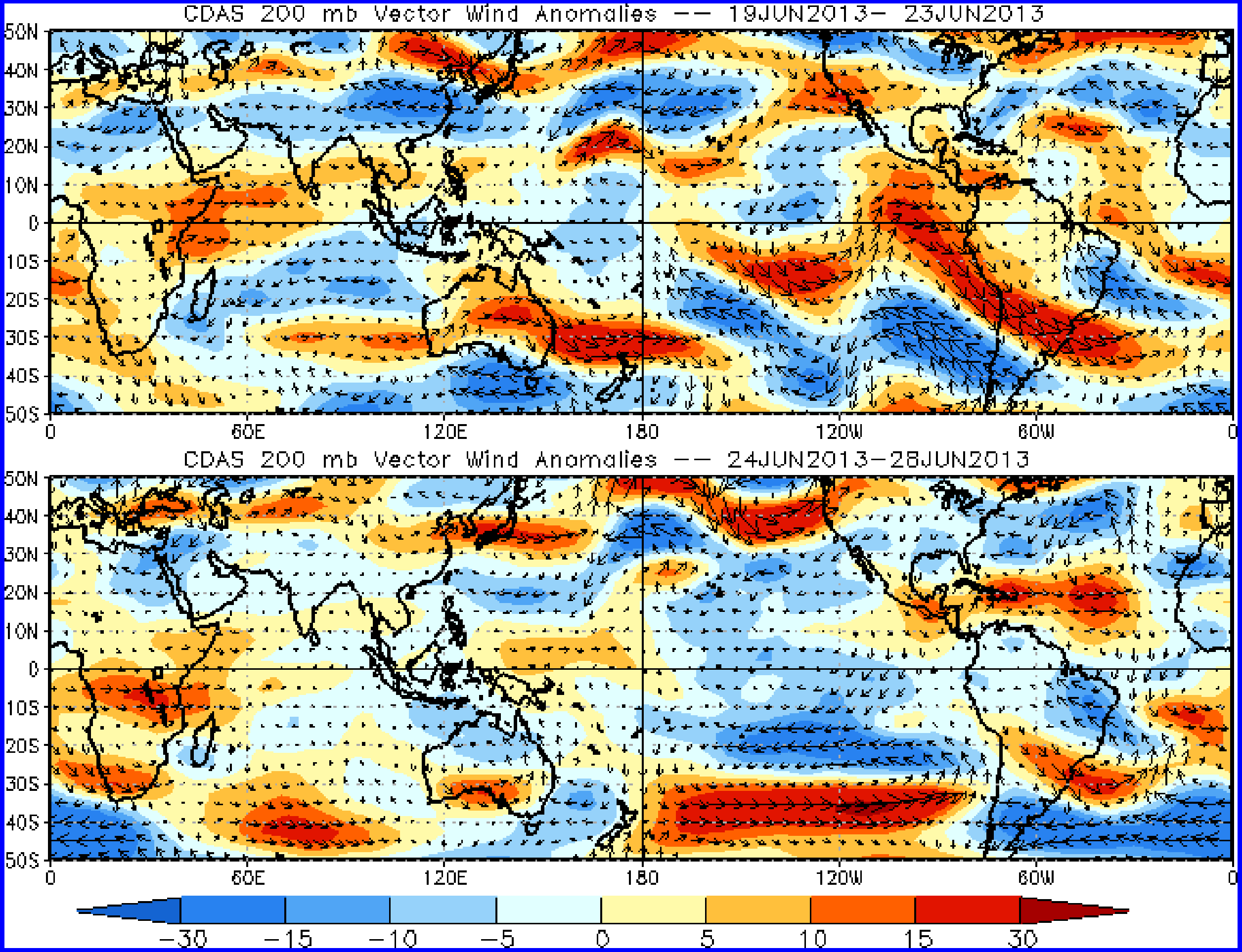
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The velocity potential pattern is consistent with a MJO convectively active phase over the Western Hemisphere (eastern Pacific, Africa), surrounded by regions of large scale suppressed convection over the Indian Ocean and western and central Pacific. Other modes of tropical variability are evident as well, including a tropical cyclone in the South China Sea.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

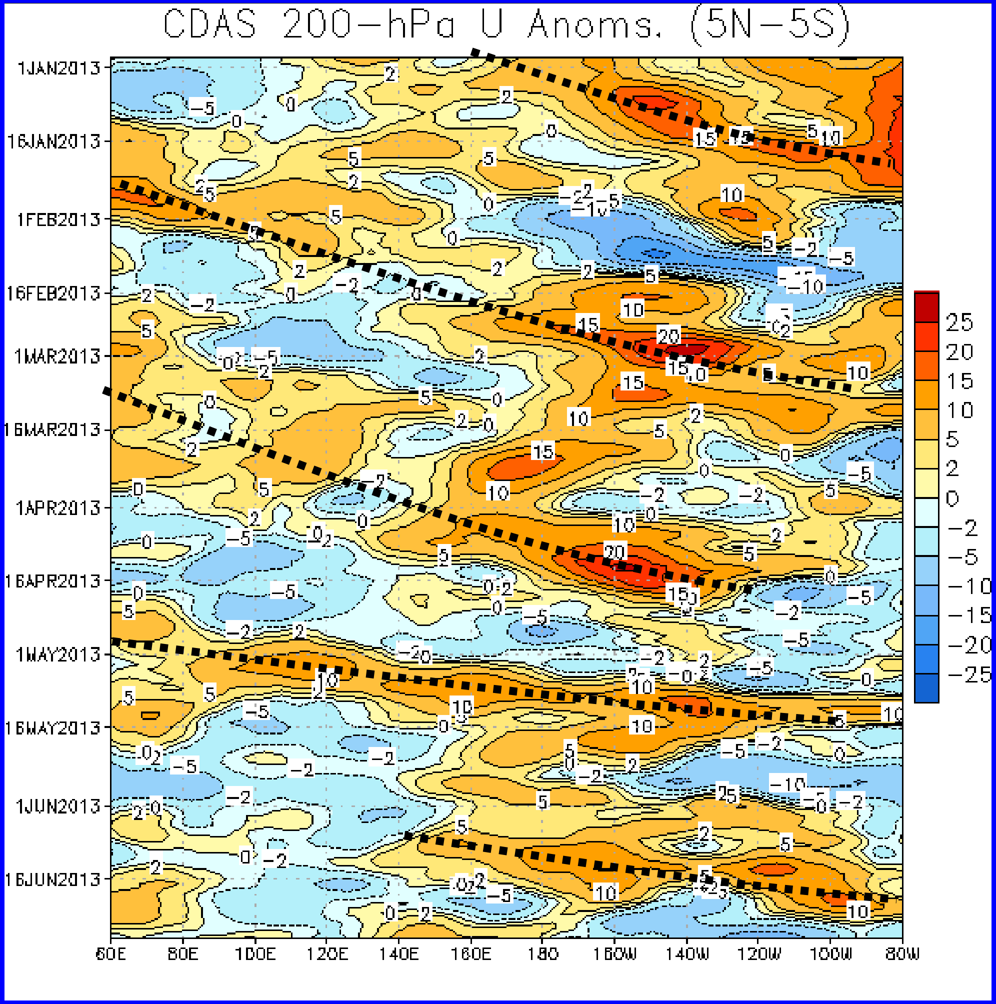
Anomalies remained weak throughout most of the tropics, with easterly (westerly) anomalies increasing over the eastern (western) Pacific.

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



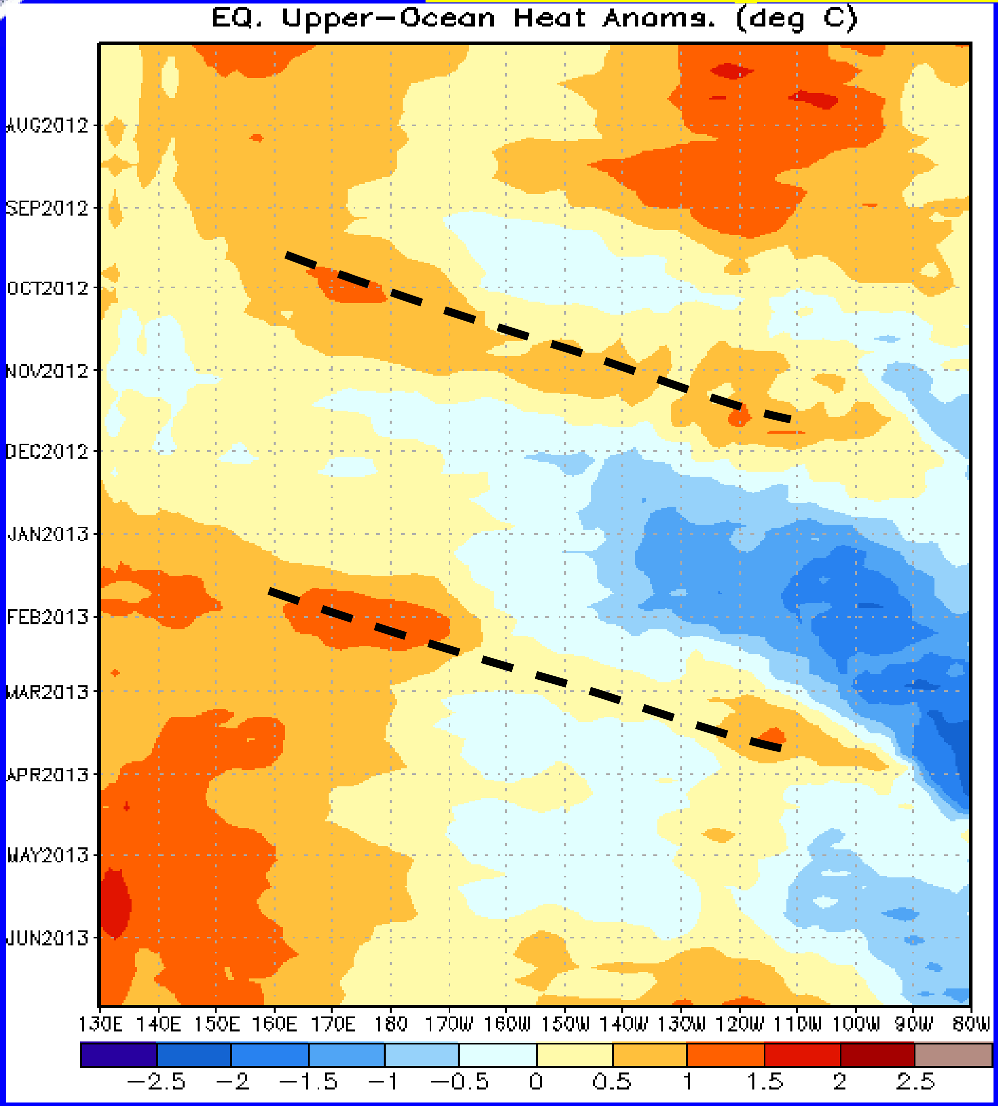
Longitude

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 both early May and early June. The rapid phase speed suggests the influence of higher-frequency Kelvin waves. Recently, westerly (easterly) anomalies have increased over the western (eastern) Pacific.

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, warming has occurred across the eastern Pacific west of 90°W.

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).

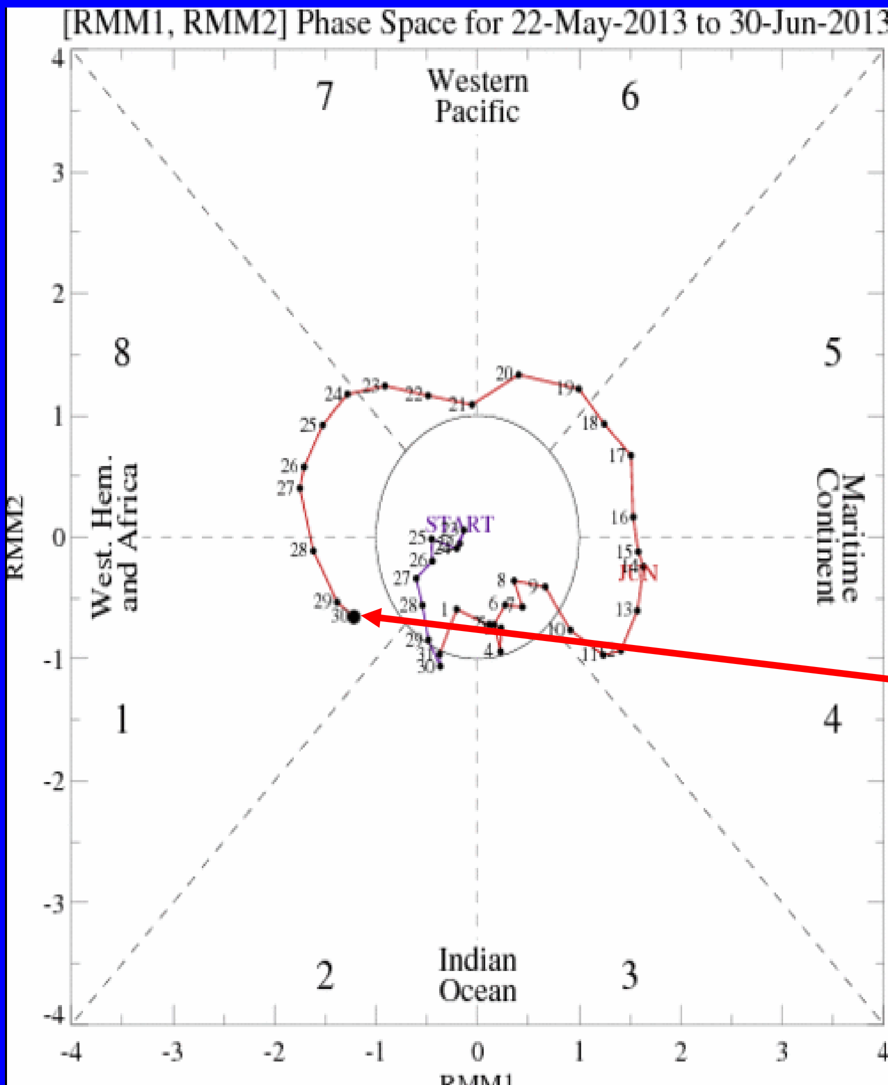
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

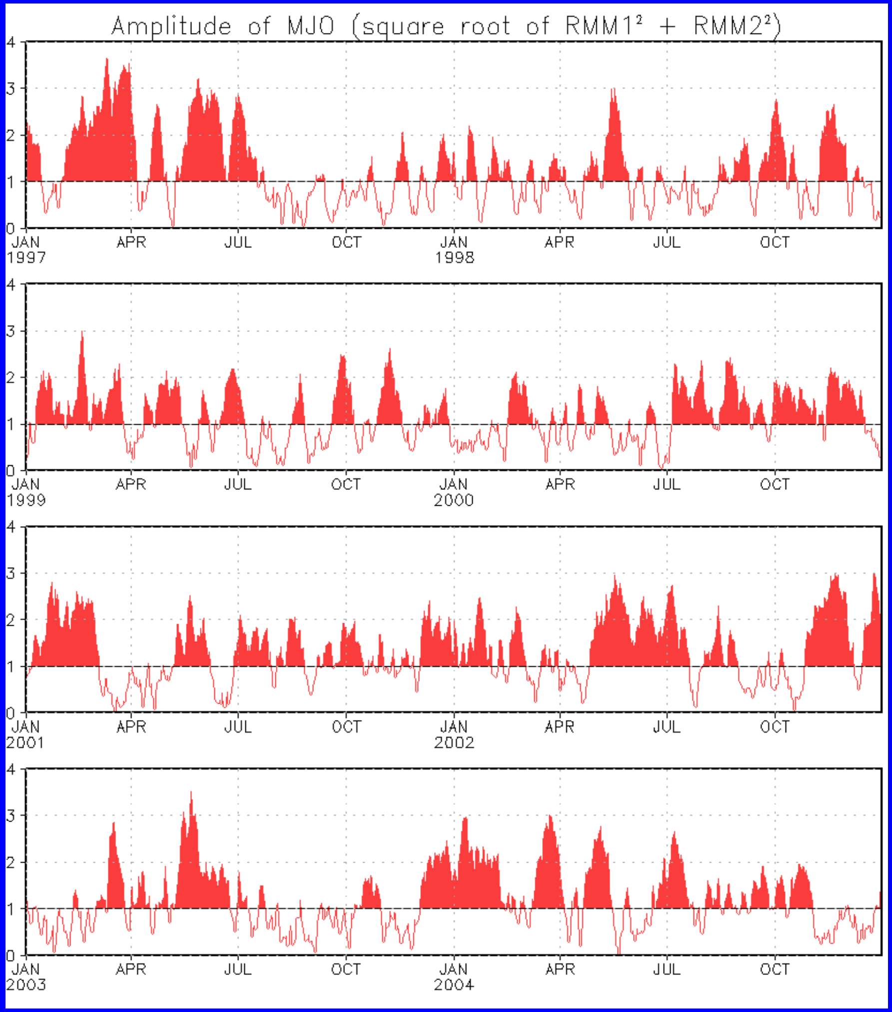
MJO Index -- Recent Evolution

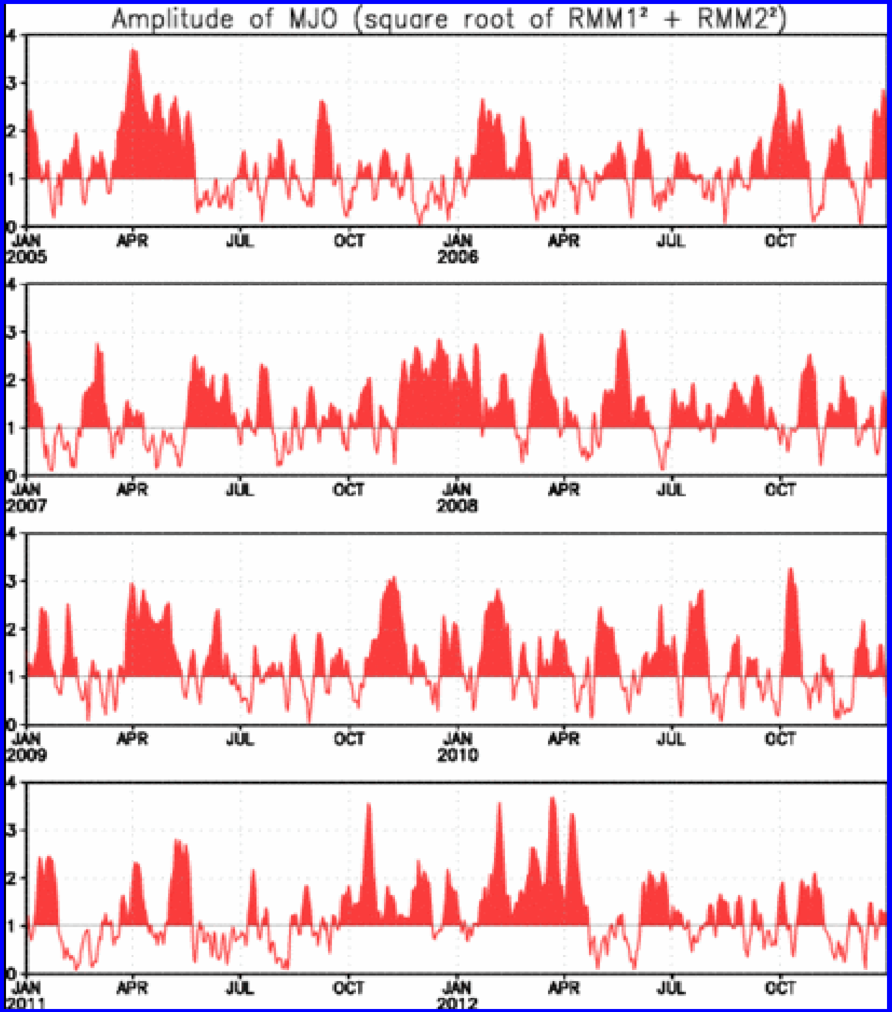


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index maintained a steady eastward propagation into phase 1 (Western Hemisphere and Africa) during the previous week.

MJO Index – Historical Daily Time Series





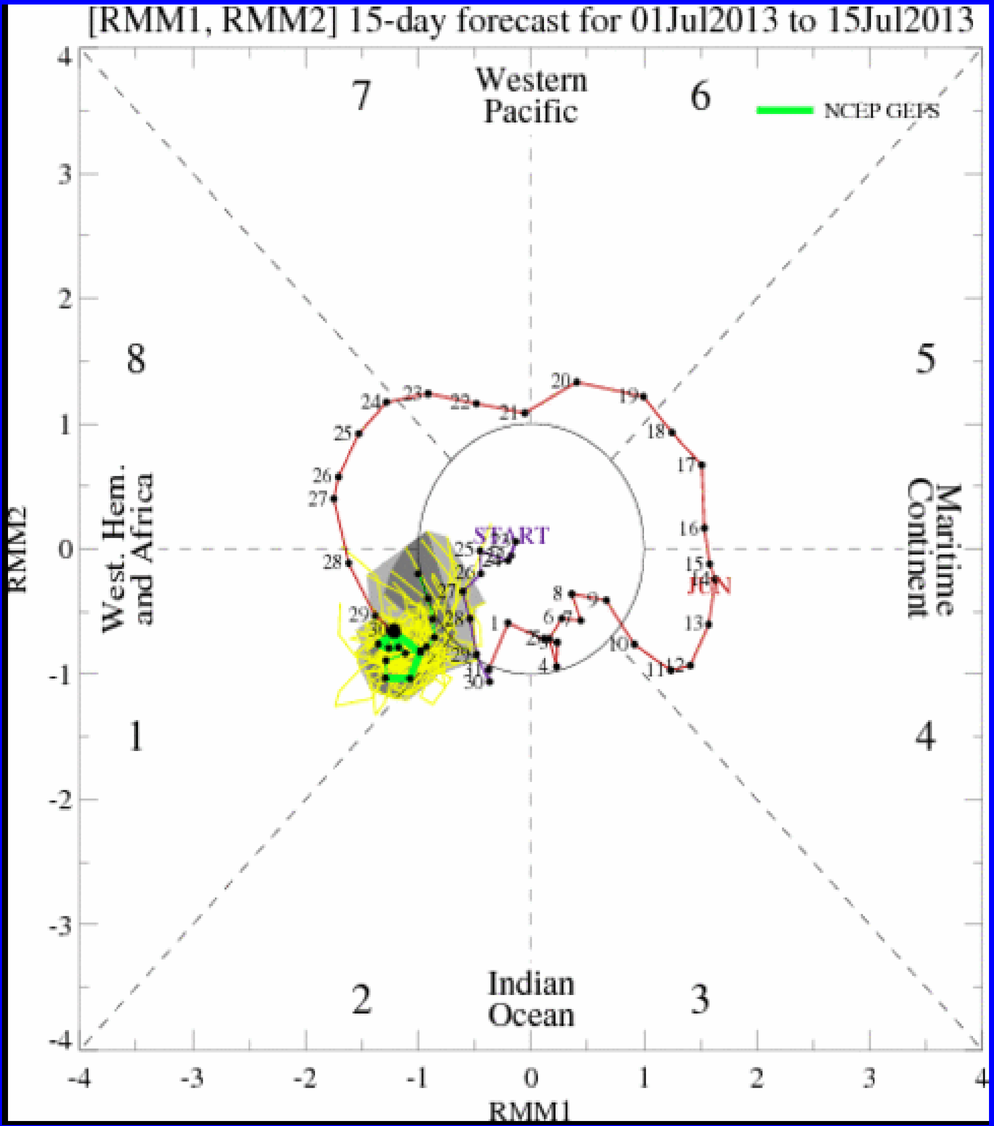
Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

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

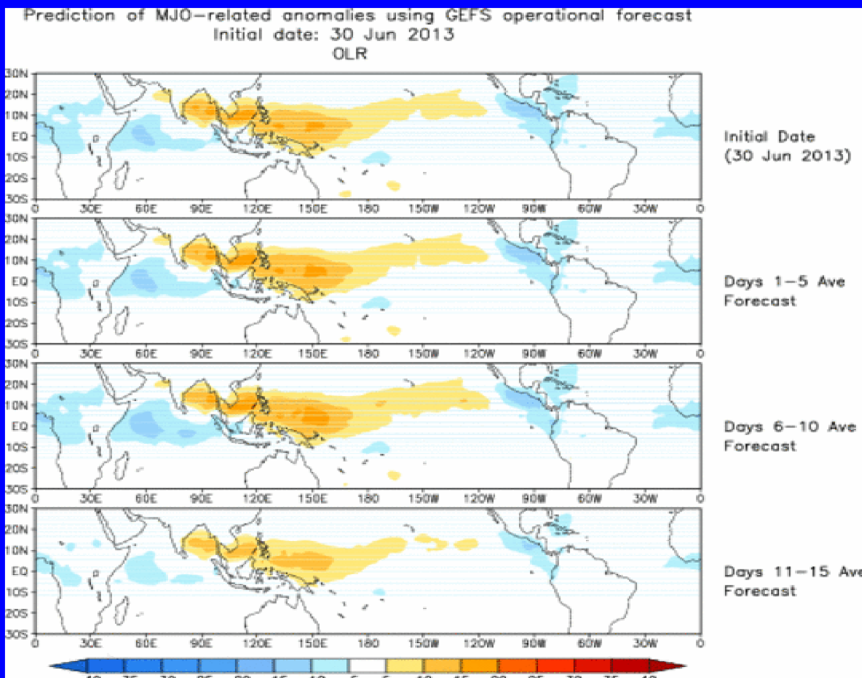


The ensemble GFS indicates little additional eastward propagation of the MJO signal.

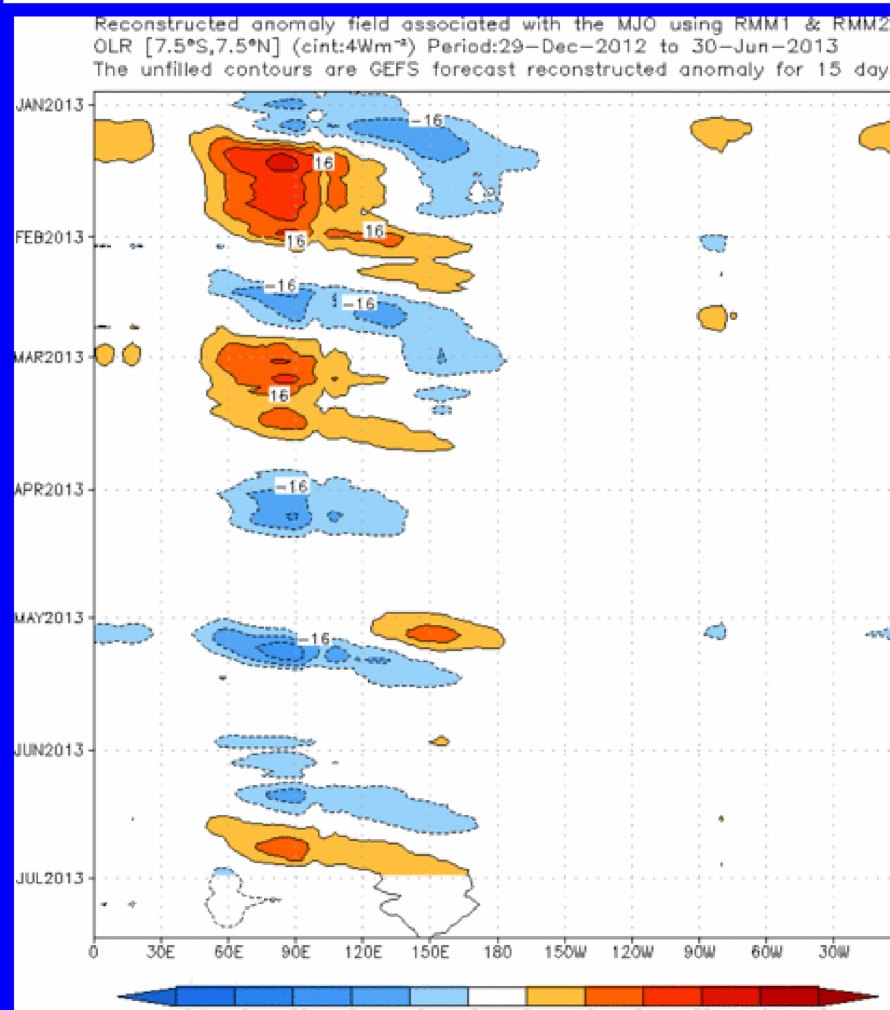
Ensemble Mean GFS MJO Forecast

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

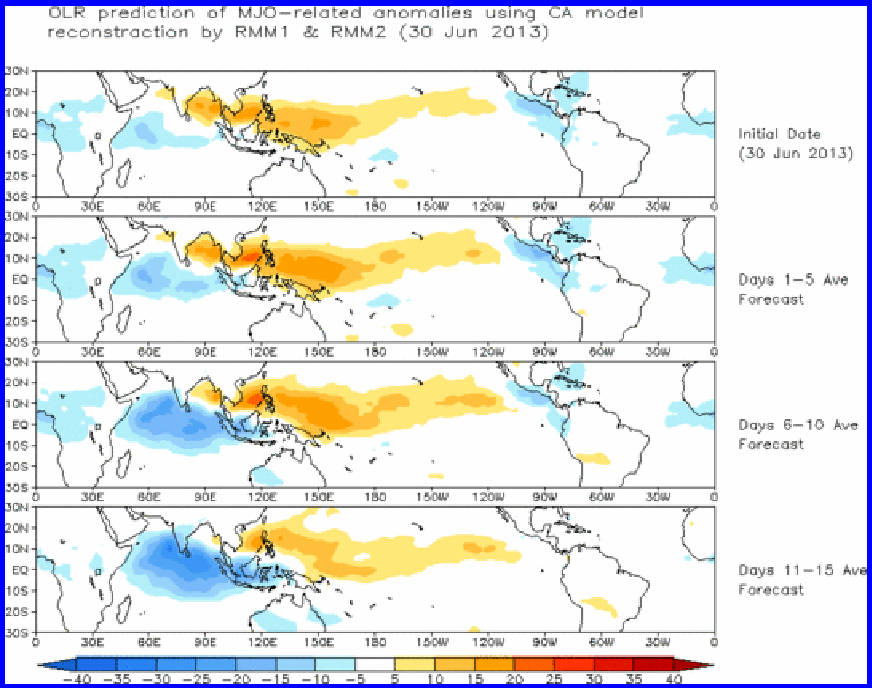


The ensemble mean GFS forecasts enhanced convection persisting across the eastern Pacific, western Atlantic, Africa, and the eastern Indian Ocean. Suppressed convection is forecasted to persist over the Bay of Bengal, Maritime Continent, and the western and central Pacific.

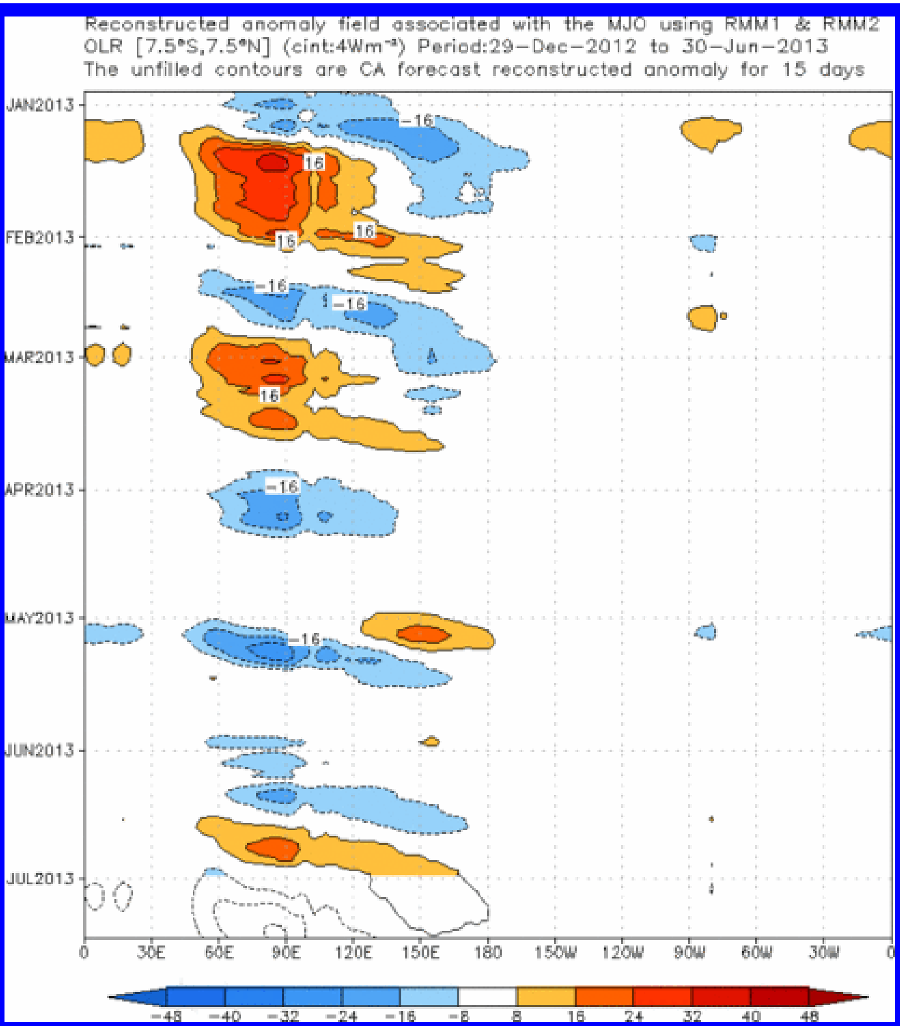
Constructed Analog (CA) MJO Forecast

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



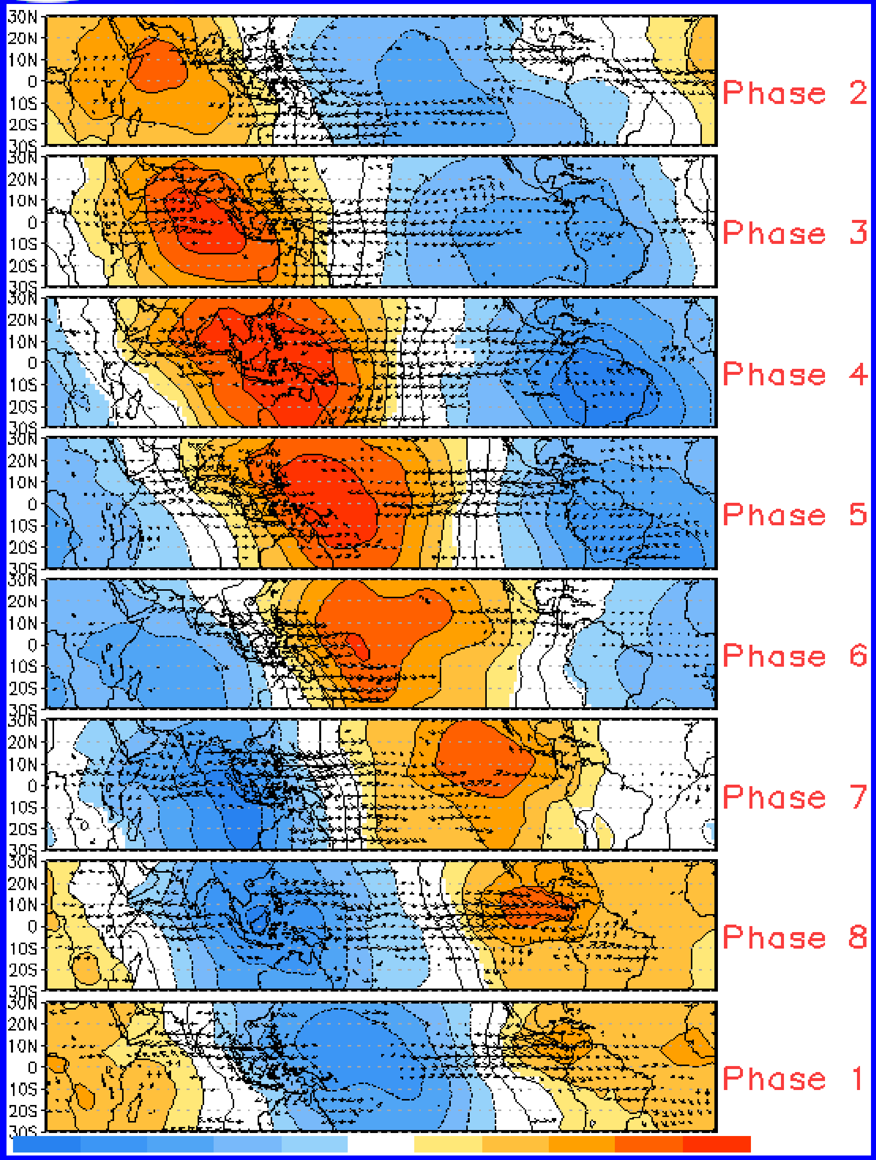
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



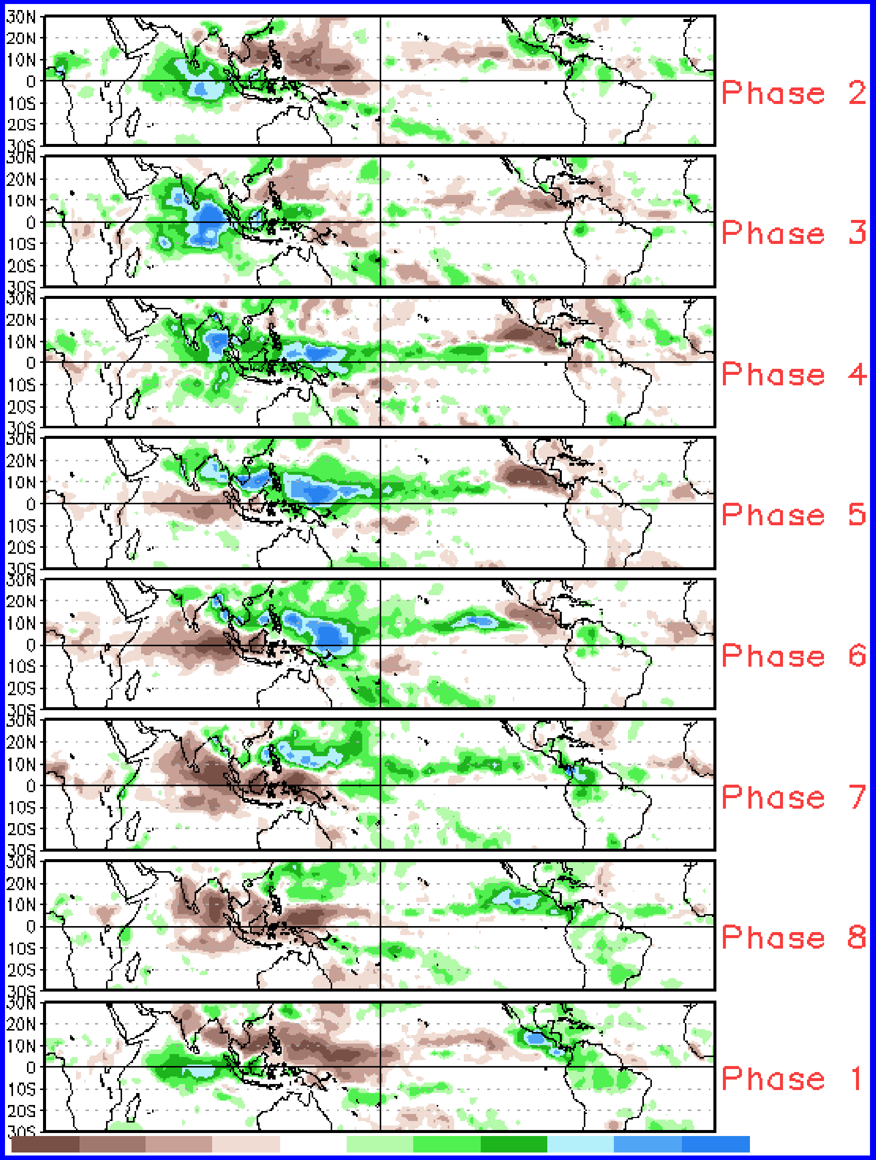
This statistical forecast indicates more eastward propagation of the MJO signal, with enhanced convective anomalies propagating into the Indian Ocean during week-2.

MJO Composites – Global Tropics

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

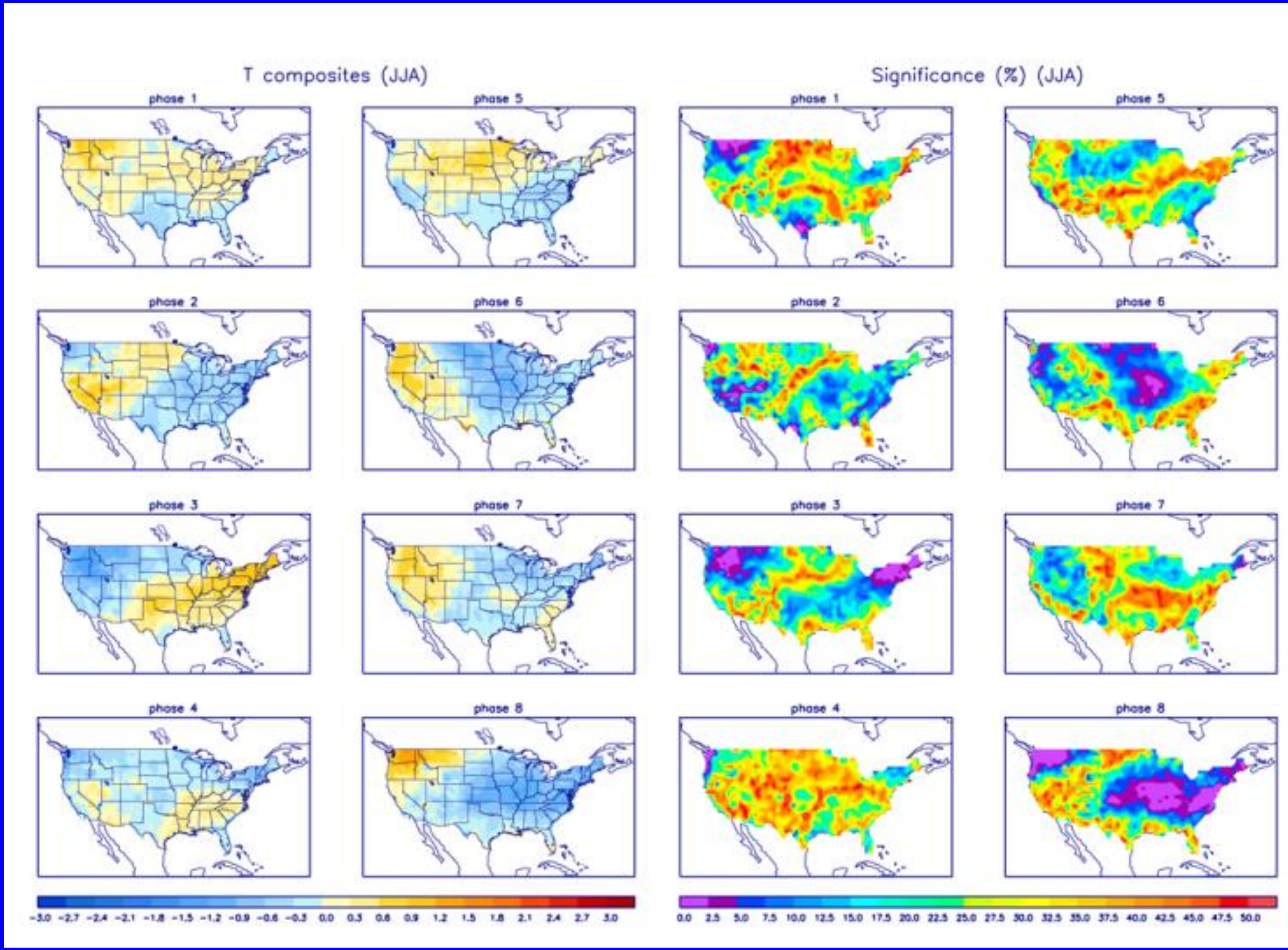


Precipitation Anomalies (May-Sep)



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.

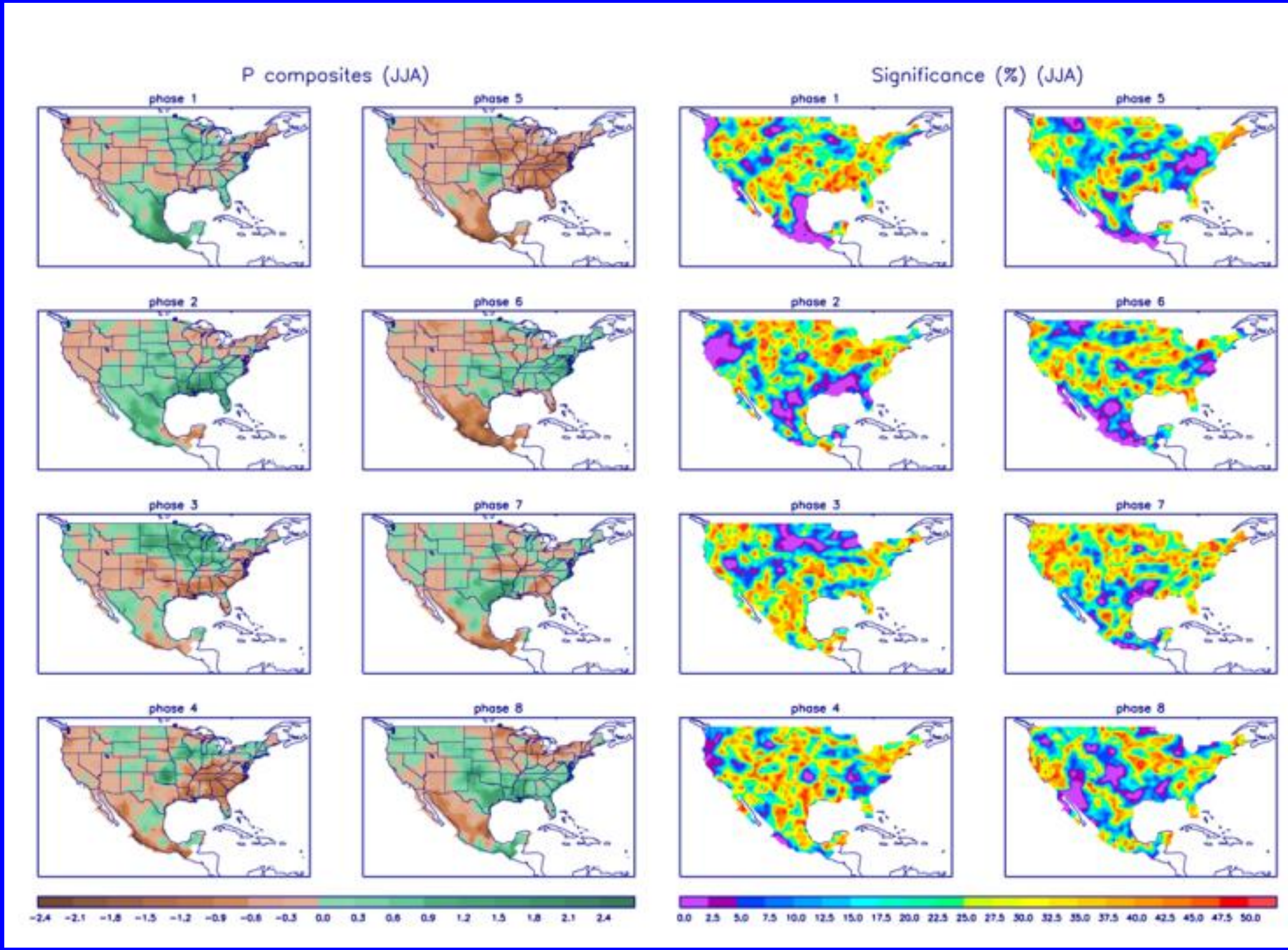


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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