



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

**Update prepared by
Climate Prediction Center / NCEP
June 24, 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 Pacific.
- 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 Pacific Ocean to the Western Hemisphere during the upcoming two weeks.
- Suppressed rainfall is favored during week 1 across the Indian Ocean, including southern Asia, spreading to the Maritime Continent by week 2.
- During week 2, the MJO forecast favors increased convection across the tropical Americas and Africa, with an enhanced probability of tropical cyclogenesis in the eastern Pacific and Atlantic basins.

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>

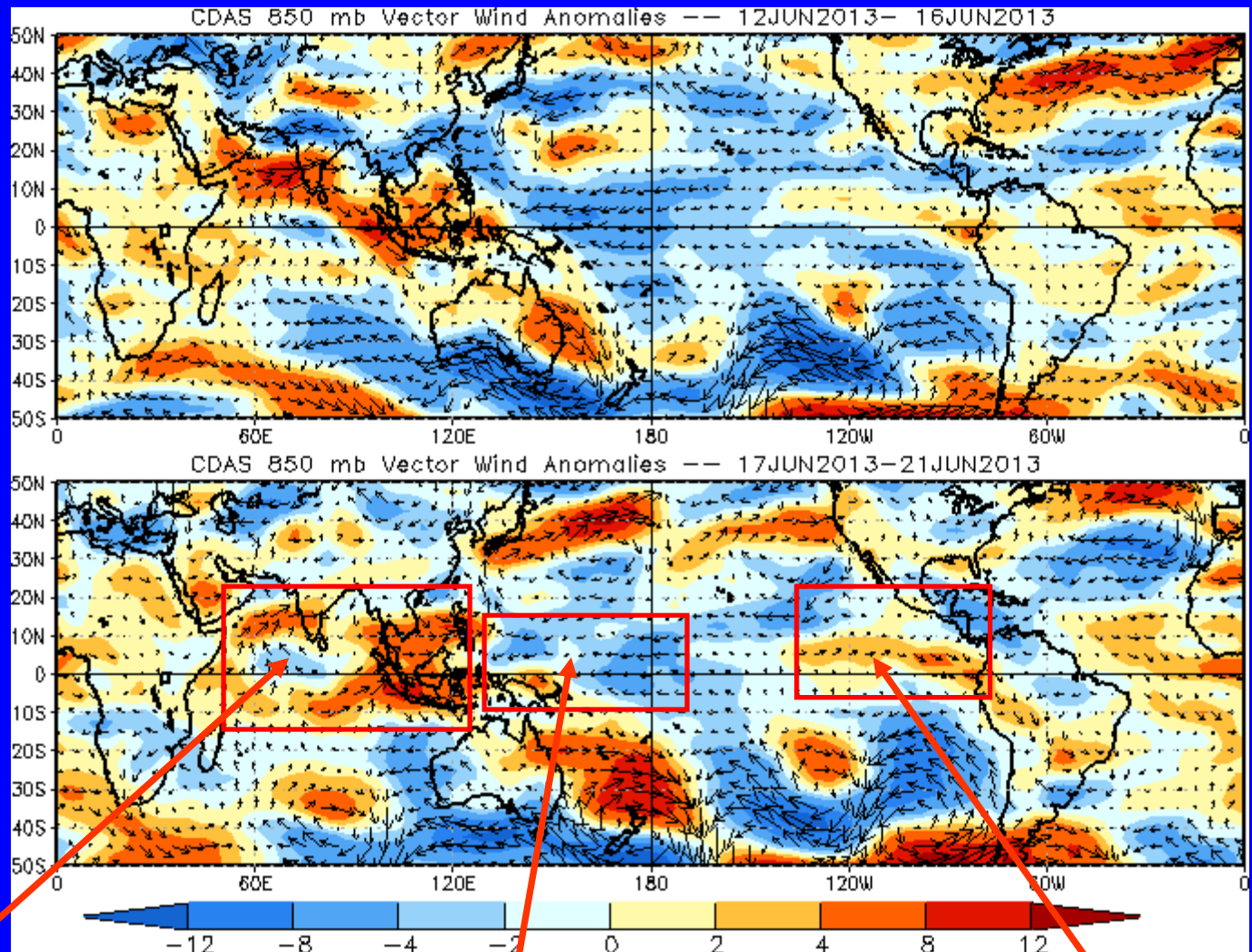


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies diminished over the northern Indian Ocean while strengthening over the South China Sea and the Maritime Continent.

Easterly anomalies diminished over the western and central Pacific.

Westerly anomalies increased over the eastern Pacific just north of the equator.

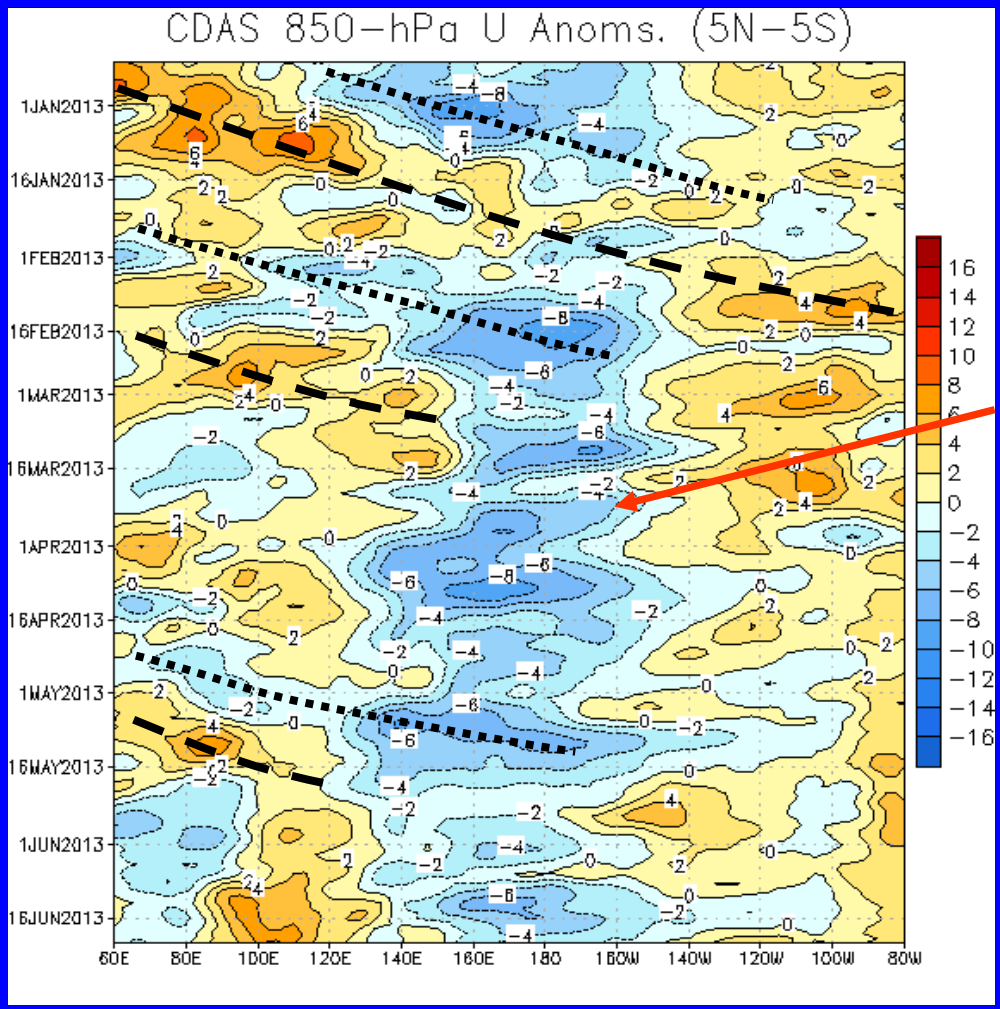


850-hPa Zonal Wind Anomalies (m s^{-1})

Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

Easterly anomalies (blue shading) represent anomalous east-to-west flow

Time
↓



During late December and 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, westerly (easterly) anomalies increased over the Indian Ocean and Maritime Continent (western Pacific), with some eastward propagation observed.

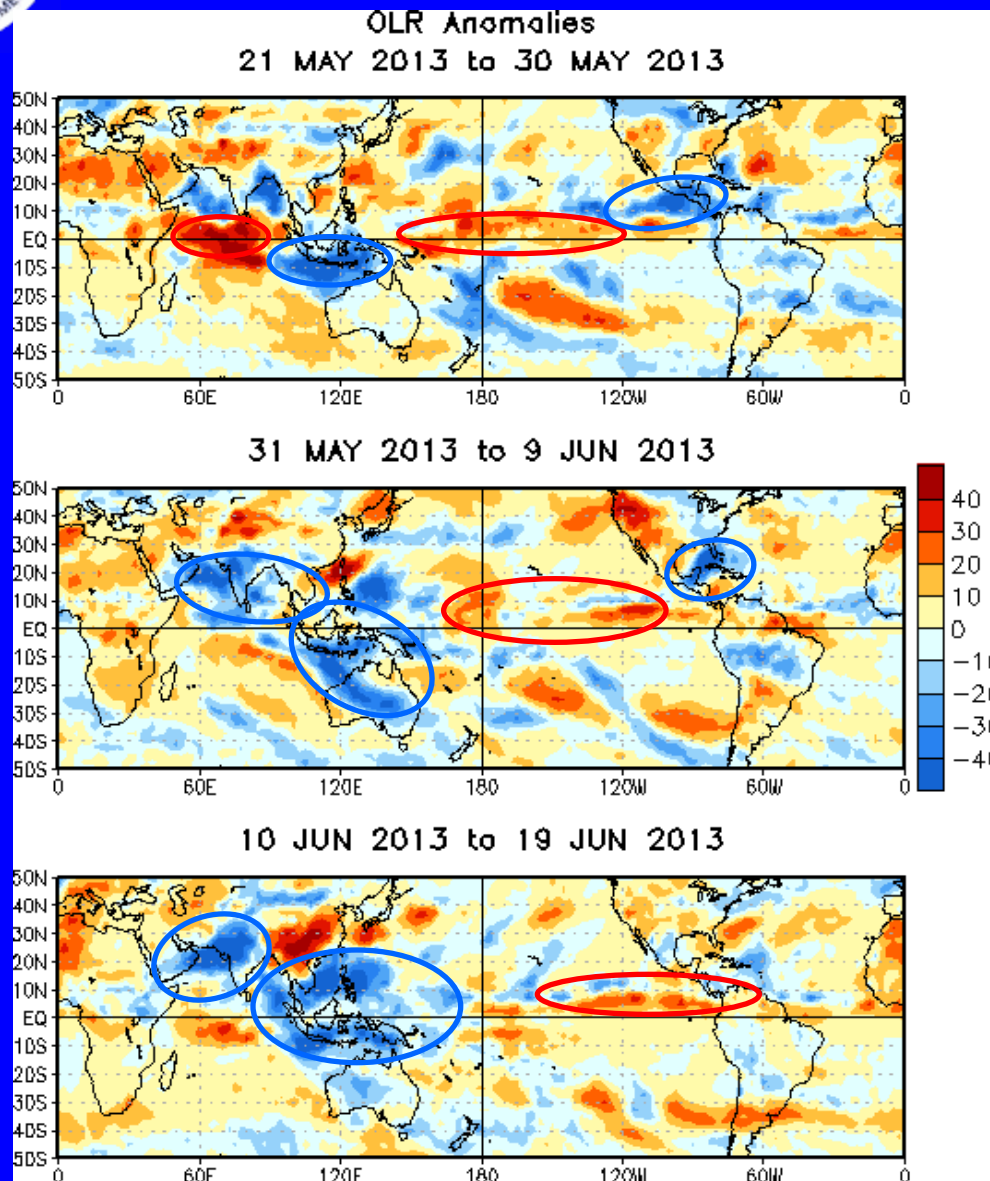
Longitude



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 May, an incoherent OLR field was apparent, with generally suppressed convection along the equator, and enhanced convection over the Maritime Continent and eastern Pacific.

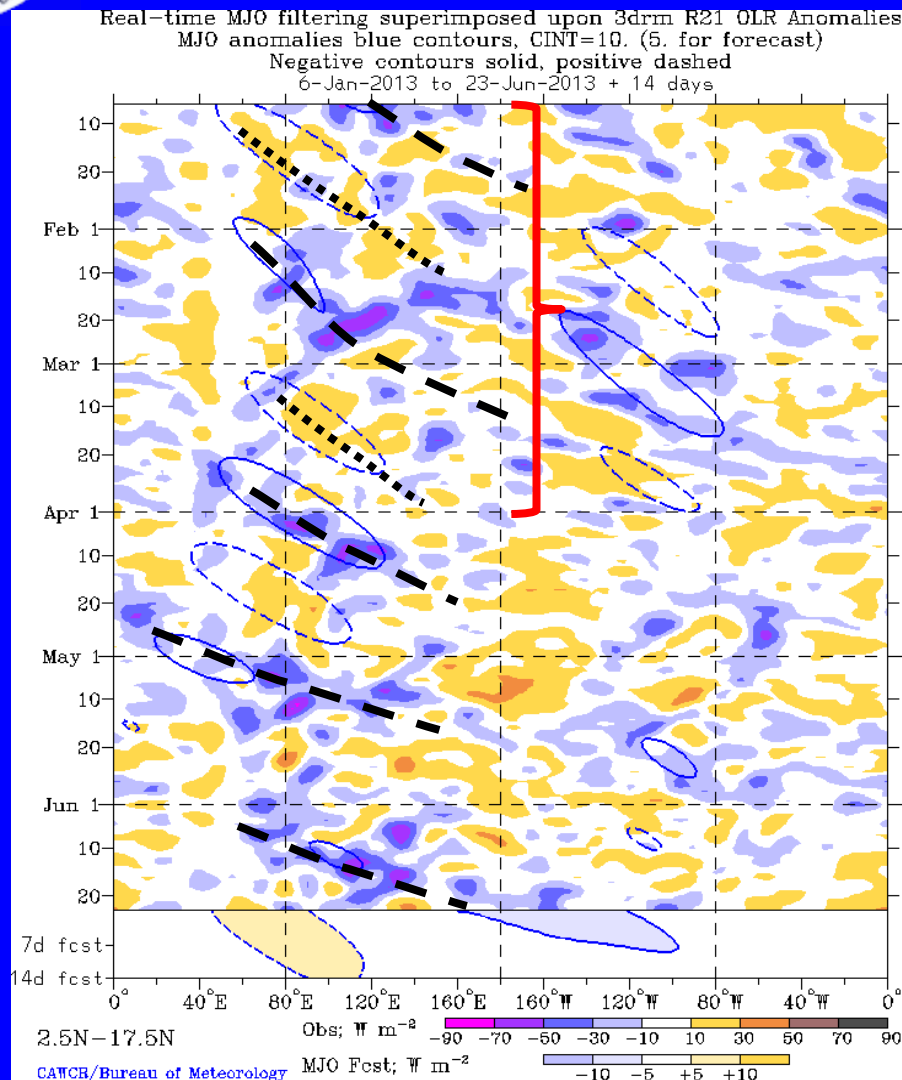
During early June, a more coherent pattern of enhanced (suppressed) convection developed over the Indian Ocean, Maritime Continent, and Australia (central and eastern Pacific and Africa). An area of enhanced convection continued to shift eastward to the Gulf of Mexico and Caribbean.

Most recently, enhanced convection anomalies shifted eastward over the Maritime Continent and western Pacific, while suppressed convection anomalies continued over the eastern Pacific.



Outgoing Longwave Radiation (OLR)

Anomalies (7.5°S-7.5°N)



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 organized over the Indian Ocean, with a fast eastward propagation to the western Pacific observed. Other modes of tropical variability are likely influencing the pattern.

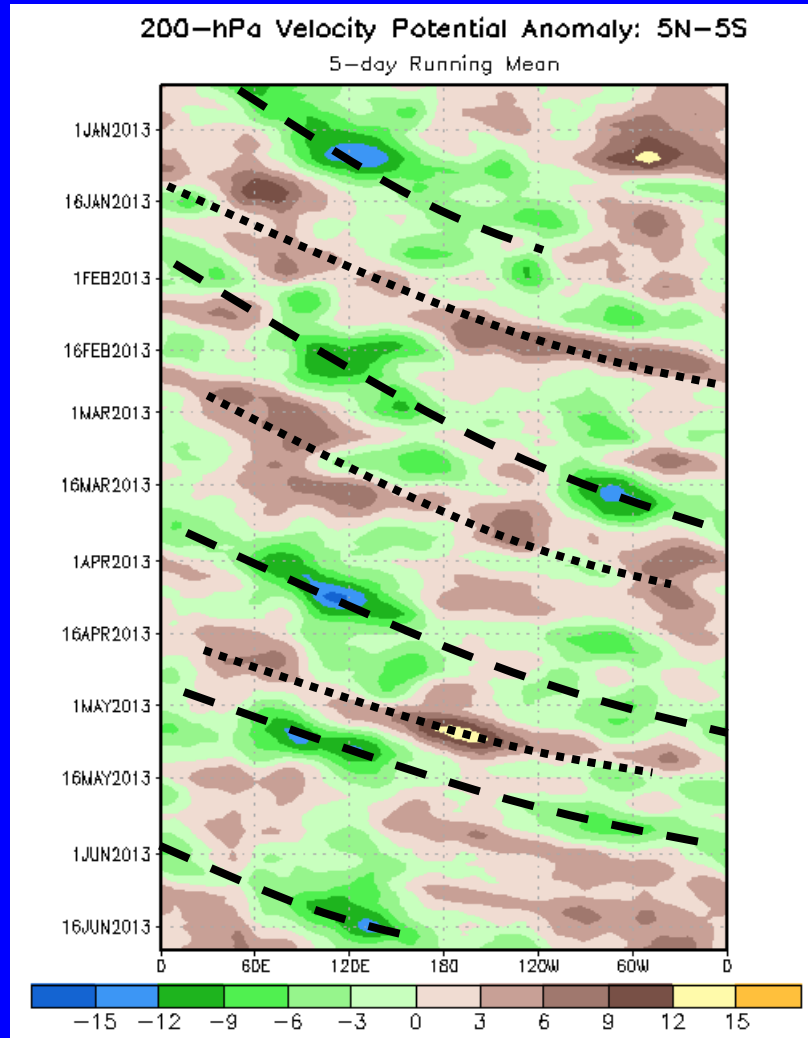


200-hPa Velocity Potential Anomalies (5°S-5°N)

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.

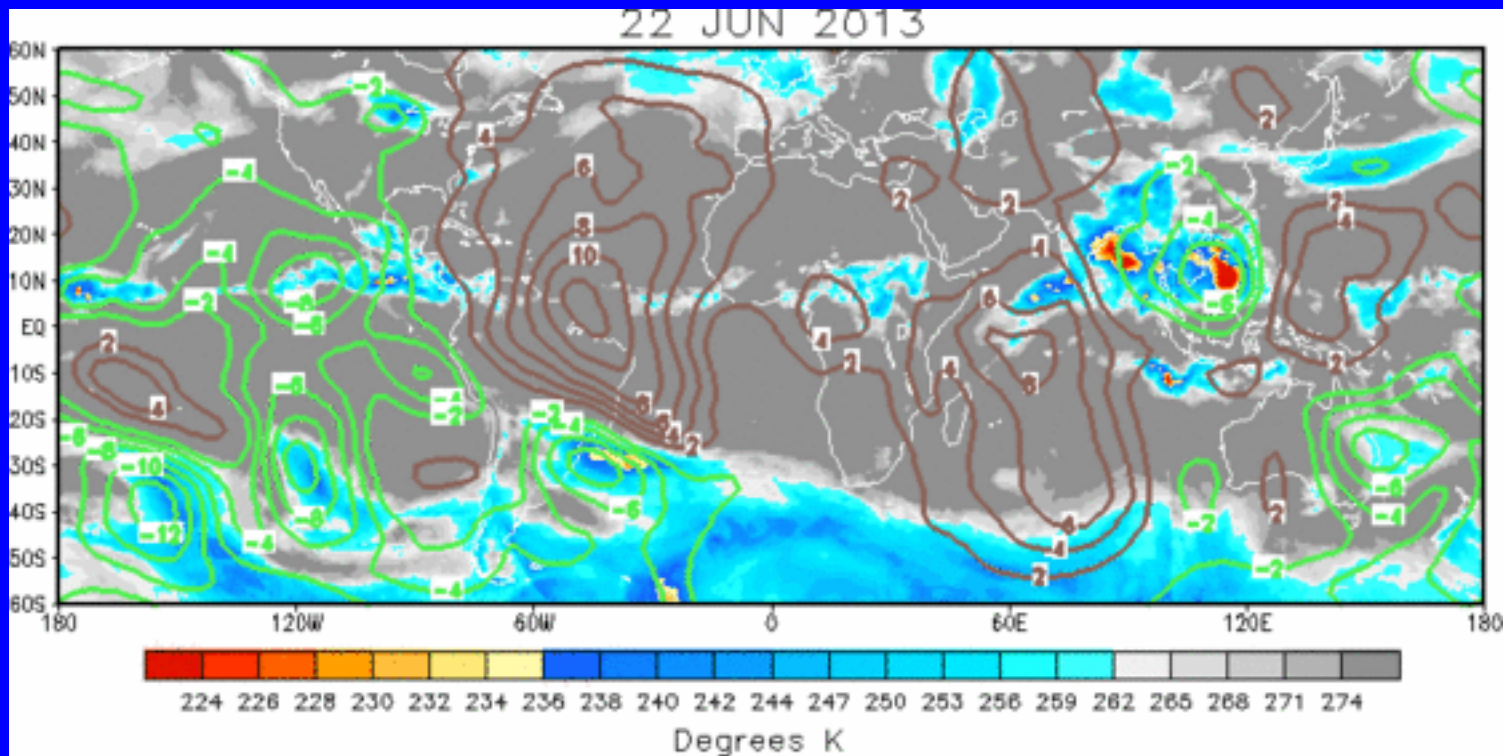
Recently, the signal is slightly more coherent and consistent with classical MJO influence, although other modes are still apparent.



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 signal over the Western Pacific, surrounded by areas of suppressed convection in the central Pacific, Africa, and the tropical Atlantic. Other modes, including tropical cyclones, remain influential in the global tropical circulation, however, with another region of upper-level diffidence over the eastern Pacific.

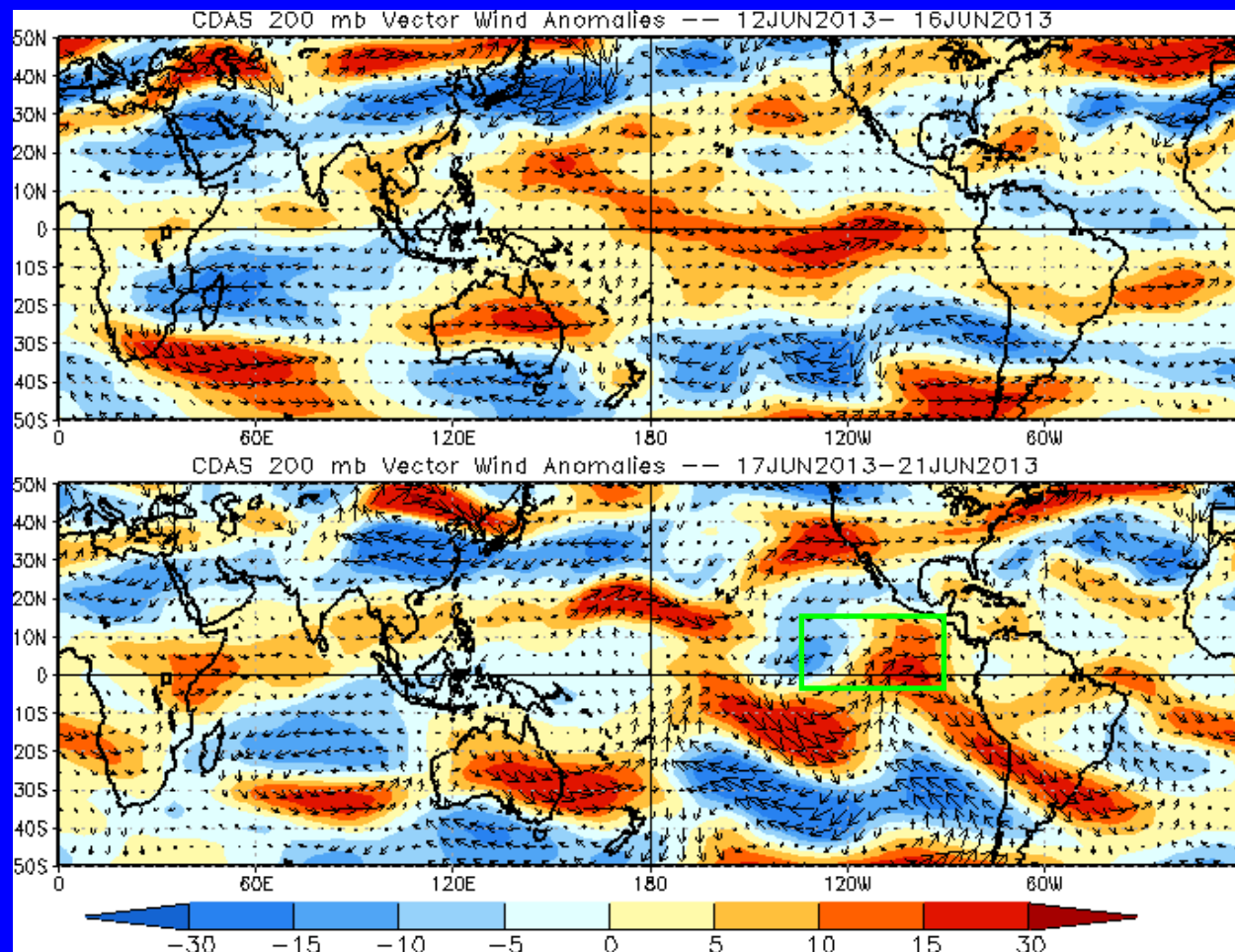


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



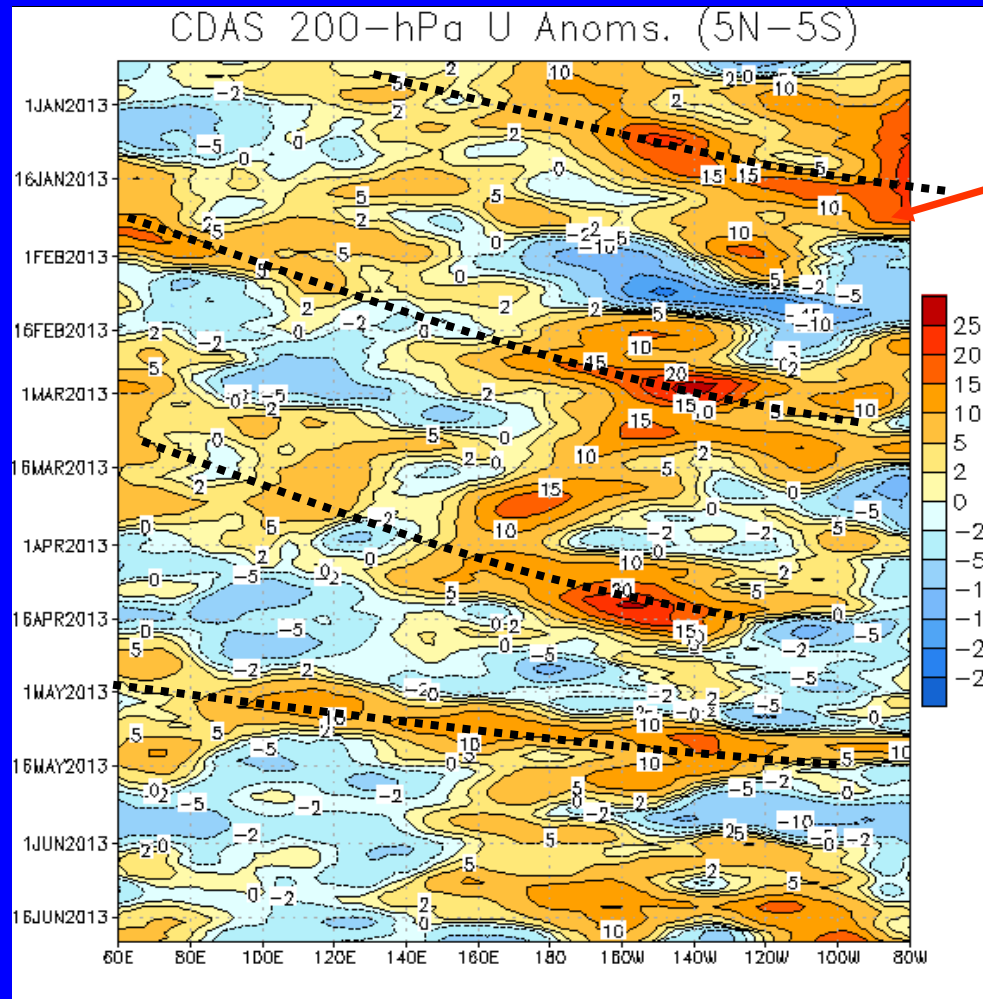
200-hPa wind anomalies remained weak throughout most of the tropics; however, an area of upper level divergence has become more apparent over the eastern Pacific.



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



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.

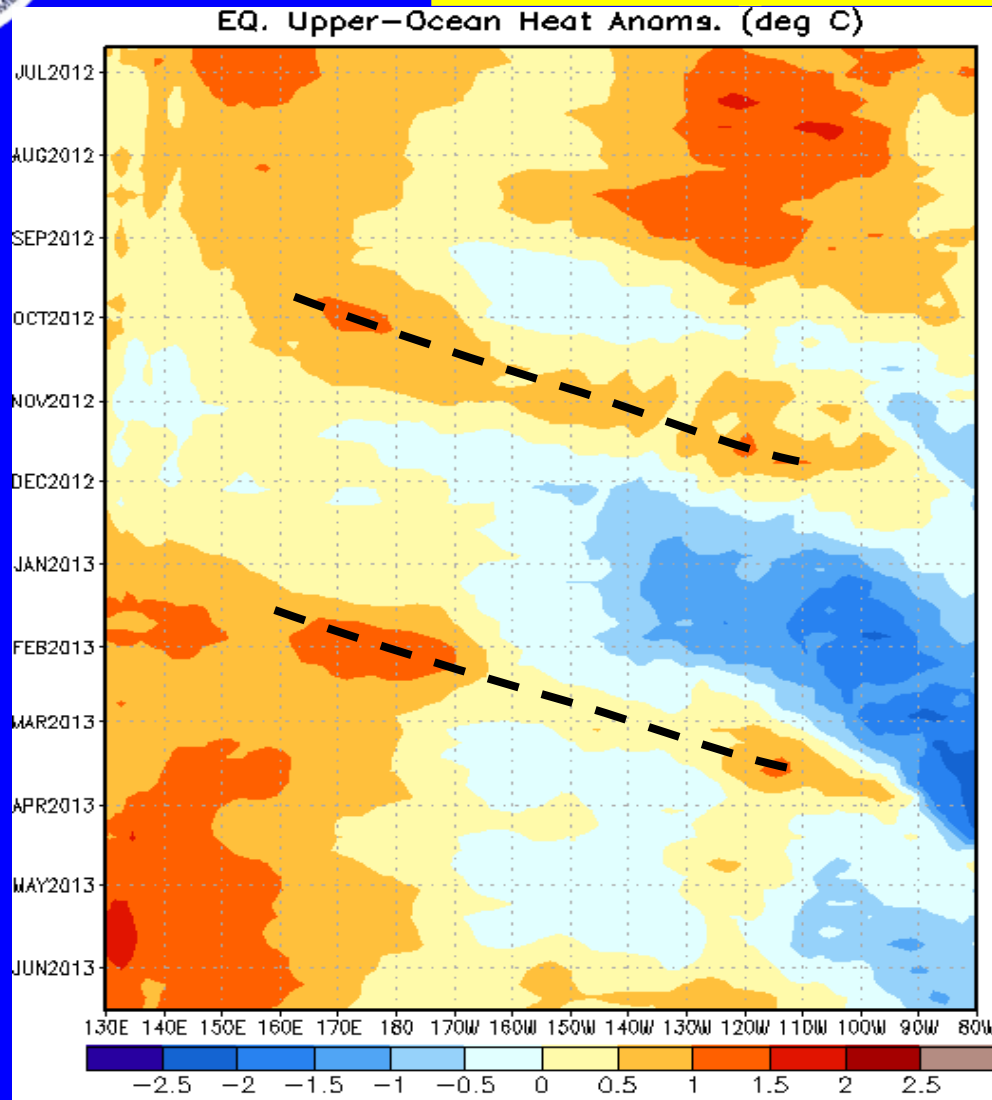
During March and early April, anomalies were influenced by westward moving features over the central and western Pacific.

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 again translated rapidly eastward across the Pacific, suggesting another Kelvin Wave.



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.

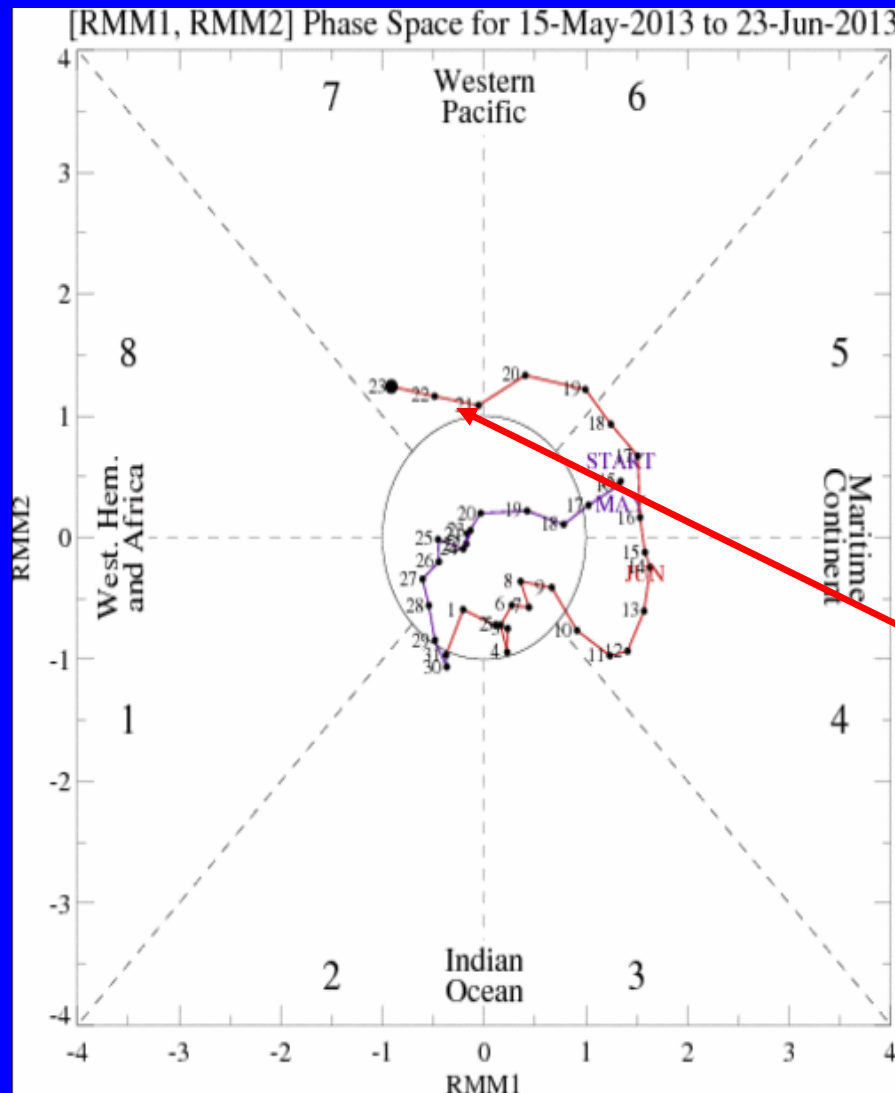
Gottschalck et al. 2010: A Framework for Assessing Operational Madden-Julian Oscillation Forecasts: A CLIVAR MJO Working Group Project, *Bull. Amer. Met. Soc.*, 91, 1247-1258.

- 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

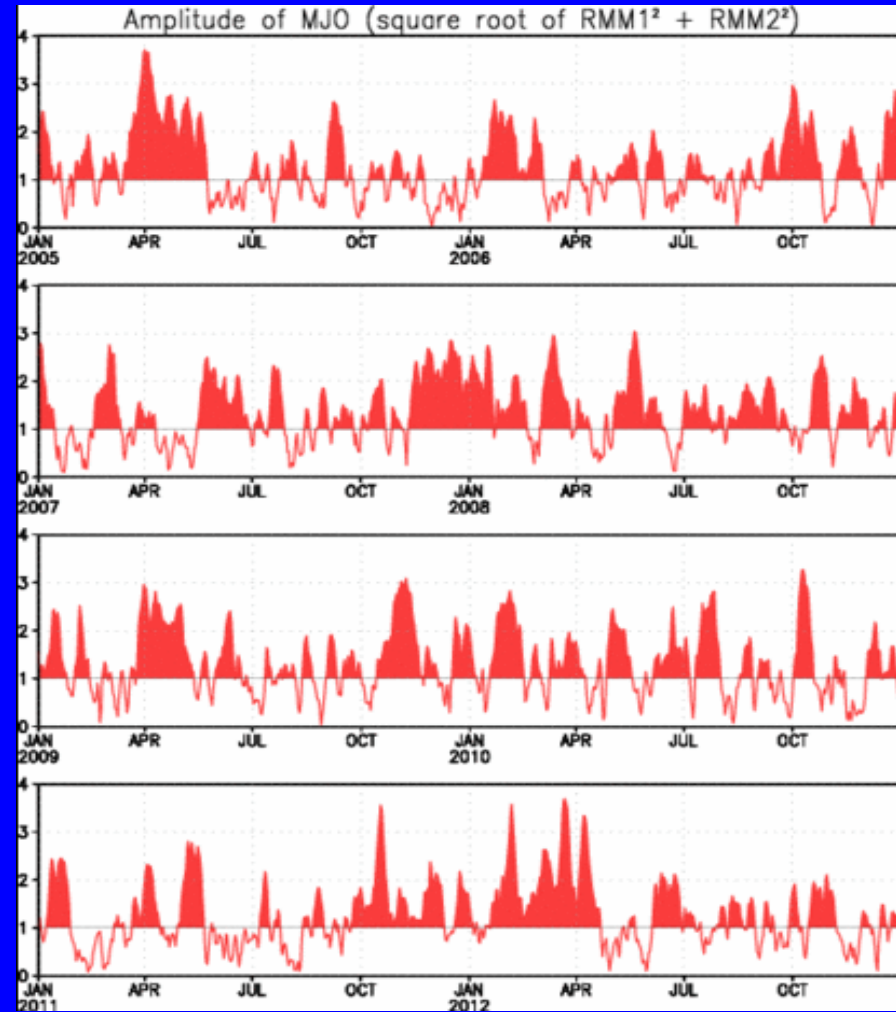
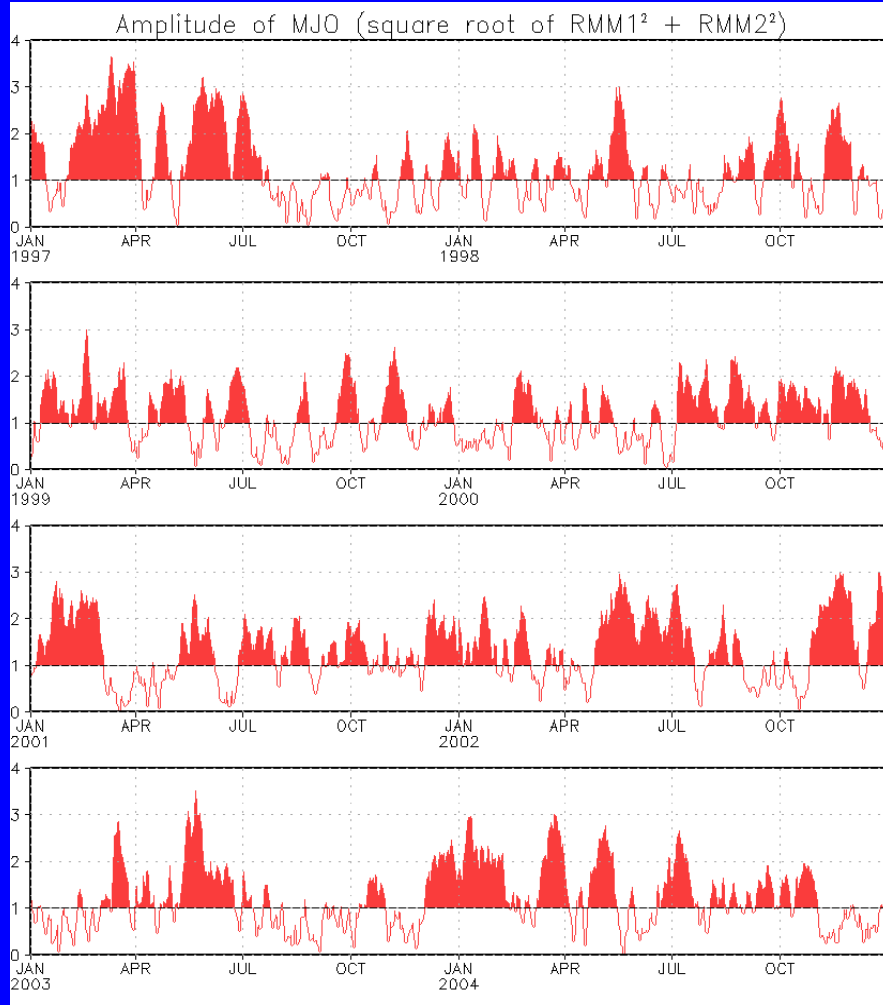
- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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



The MJO index decreased slightly in amplitude while continuing an easterly progression across the western Pacific basin.



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

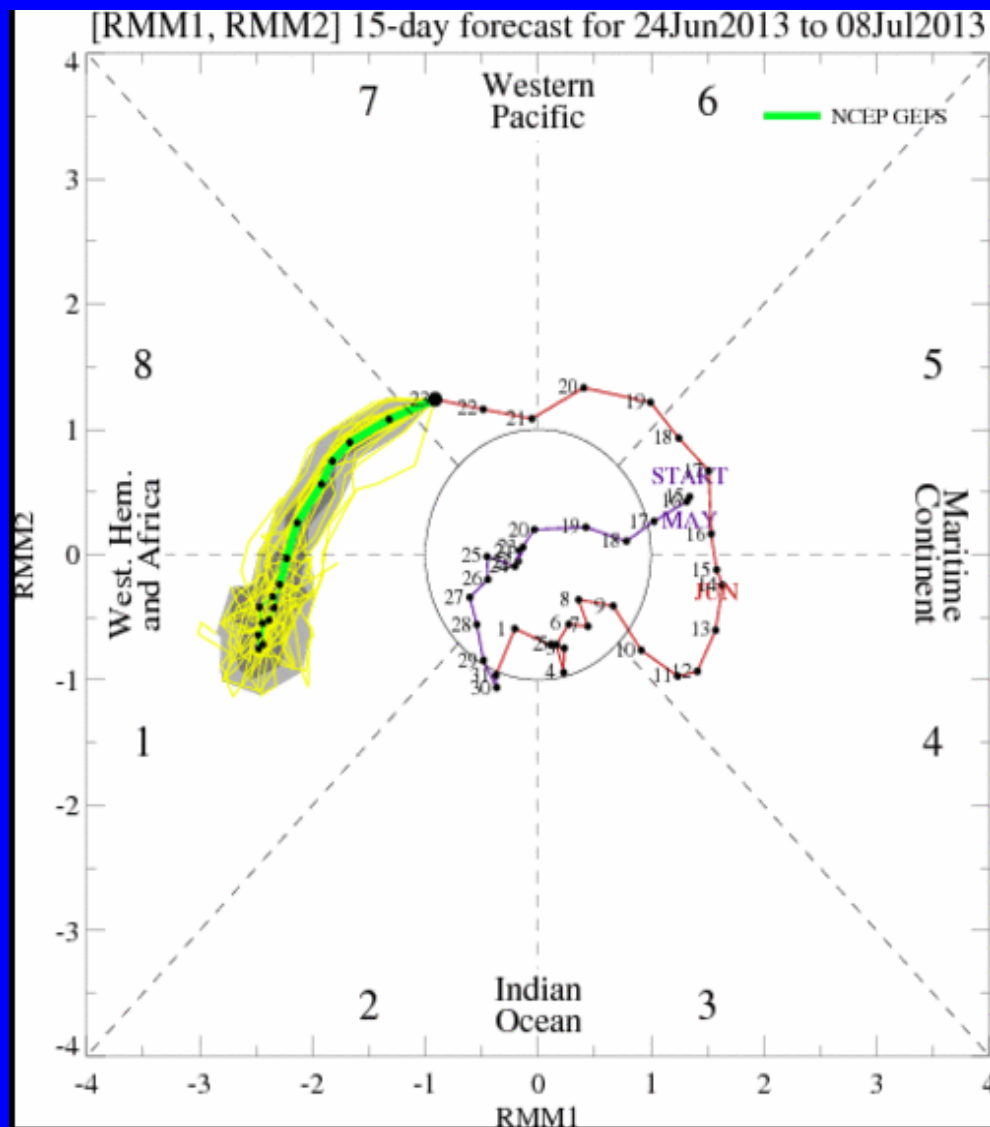
Green Line – Ensemble Mean

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 7 into phase 8 (Western Hemisphere) during week 1. The ensemble members are in good agreement for an emergence into phase 1 by week 2, although with slackening eastward propagation.

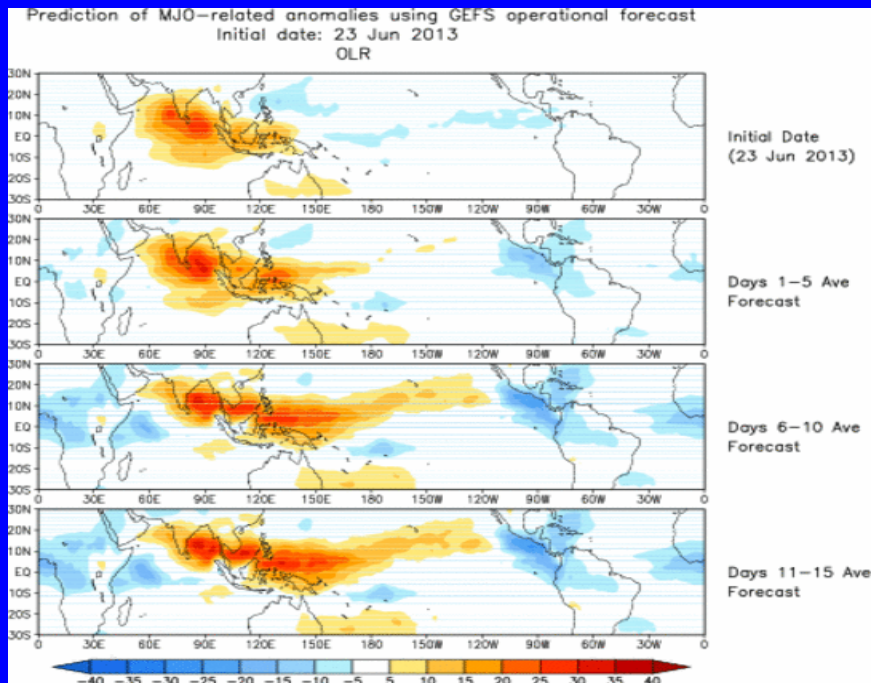




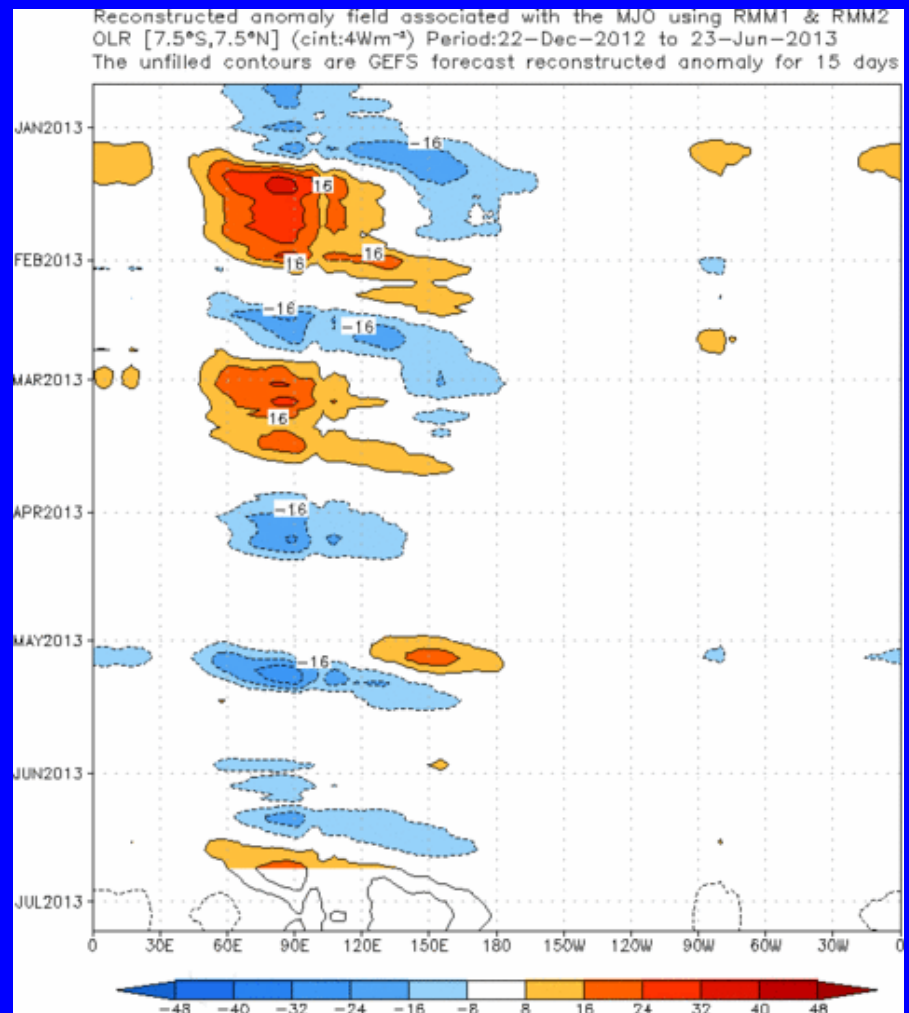
Ensemble Mean GFS MJO Forecast

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



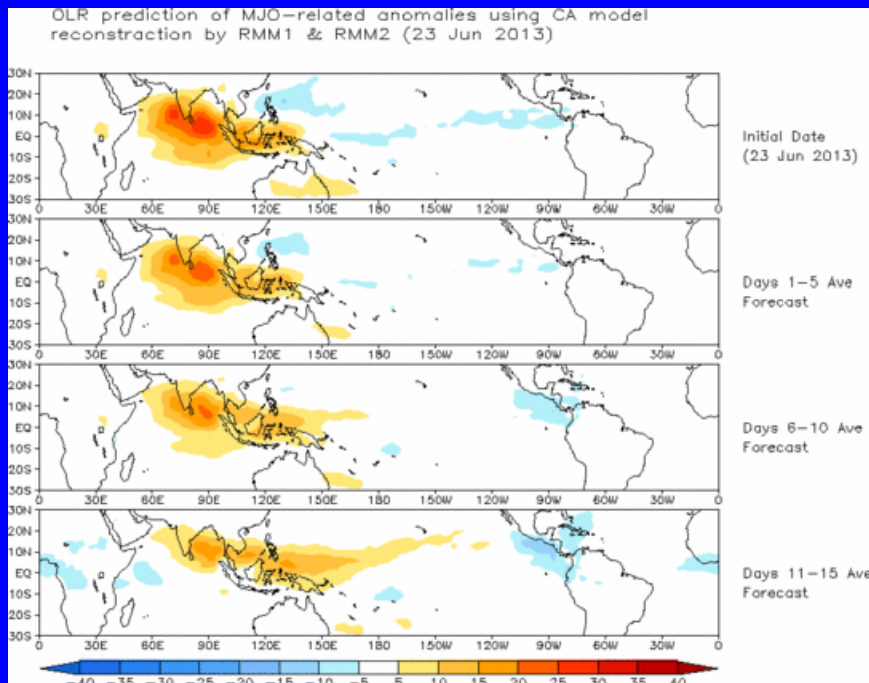
The ensemble mean GFS forecasts enhanced convection developing across the eastern Pacific and western Atlantic during week 1, with enhanced convection building over the African monsoon regions by week 2. In contrast, suppressed convection over the Indian Ocean is forecasted to shift eastward to the Pacific basin during the period.



Constructed Analog (CA) MJO Forecast

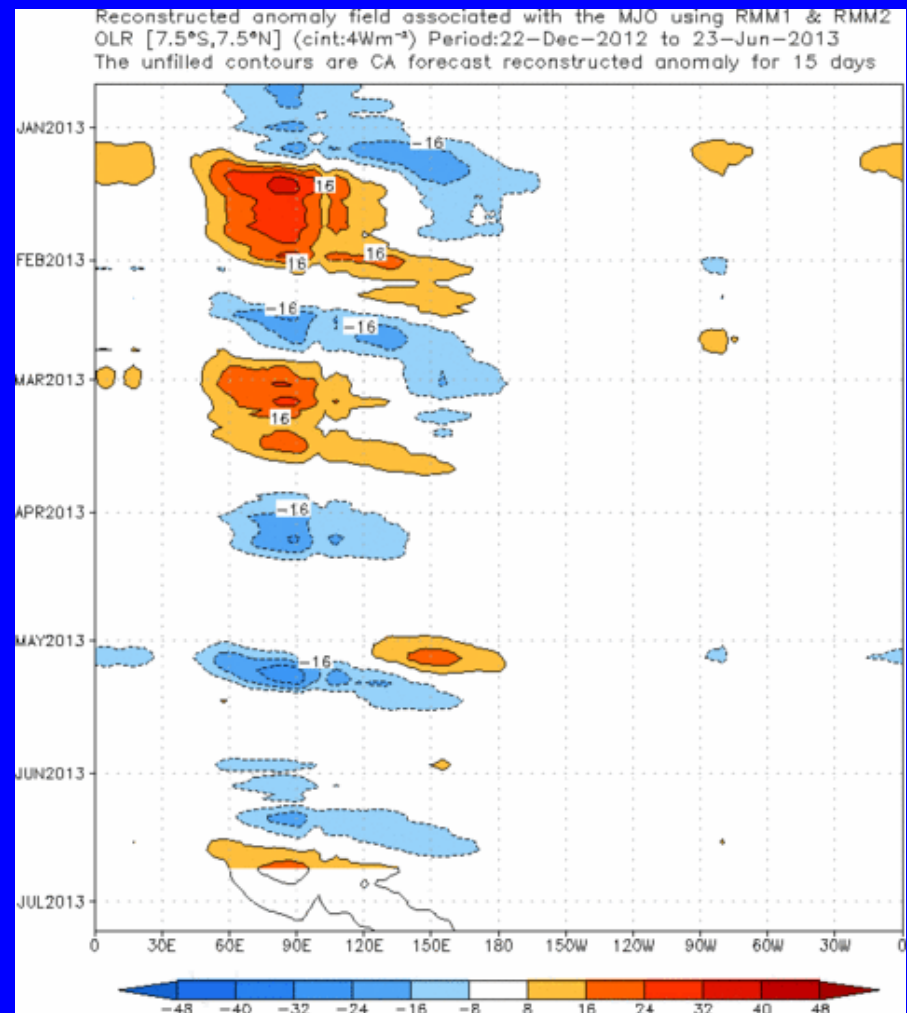
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



This statistical forecast indicates a continued active MJO with enhanced convection over the north Pacific during week 1 shifting eastward into the western hemisphere during week 2. Suppressed convection over the Indian Ocean is forecast to translate eastward into the western Pacific.

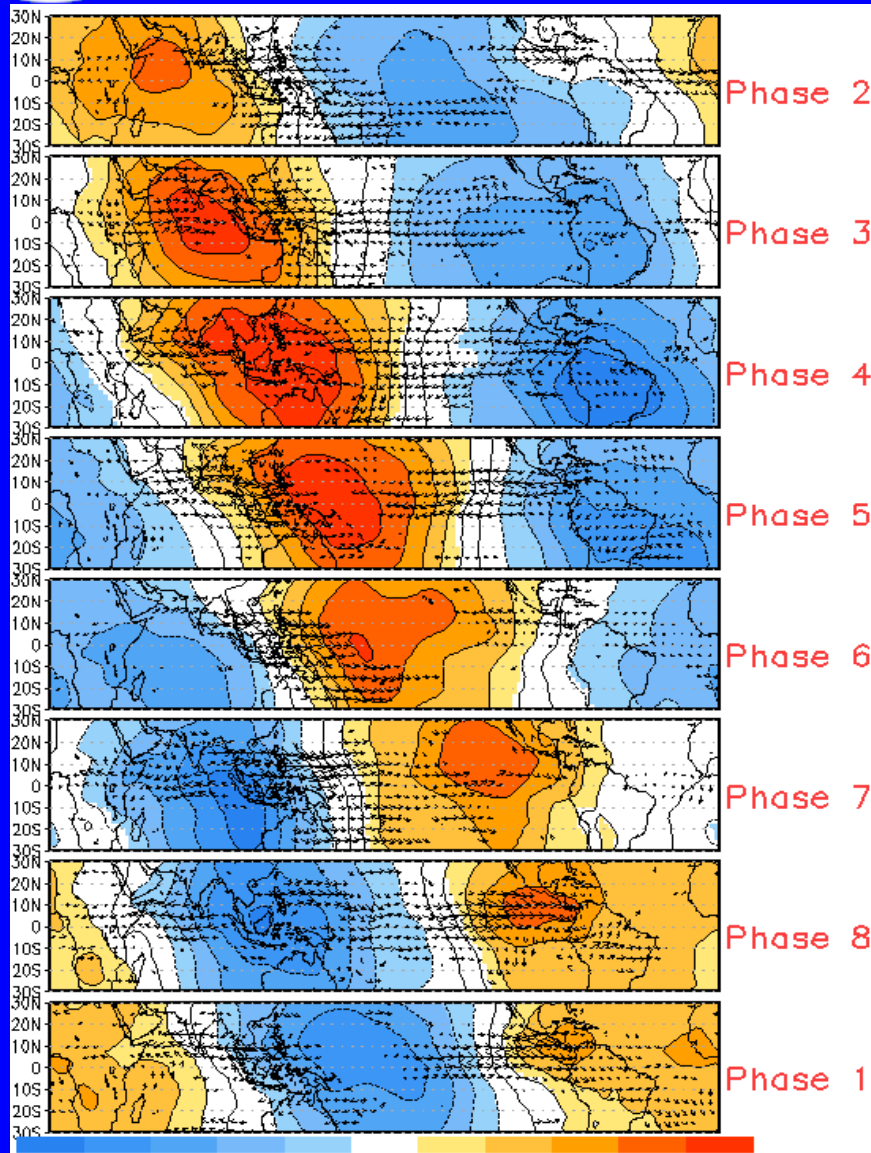
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



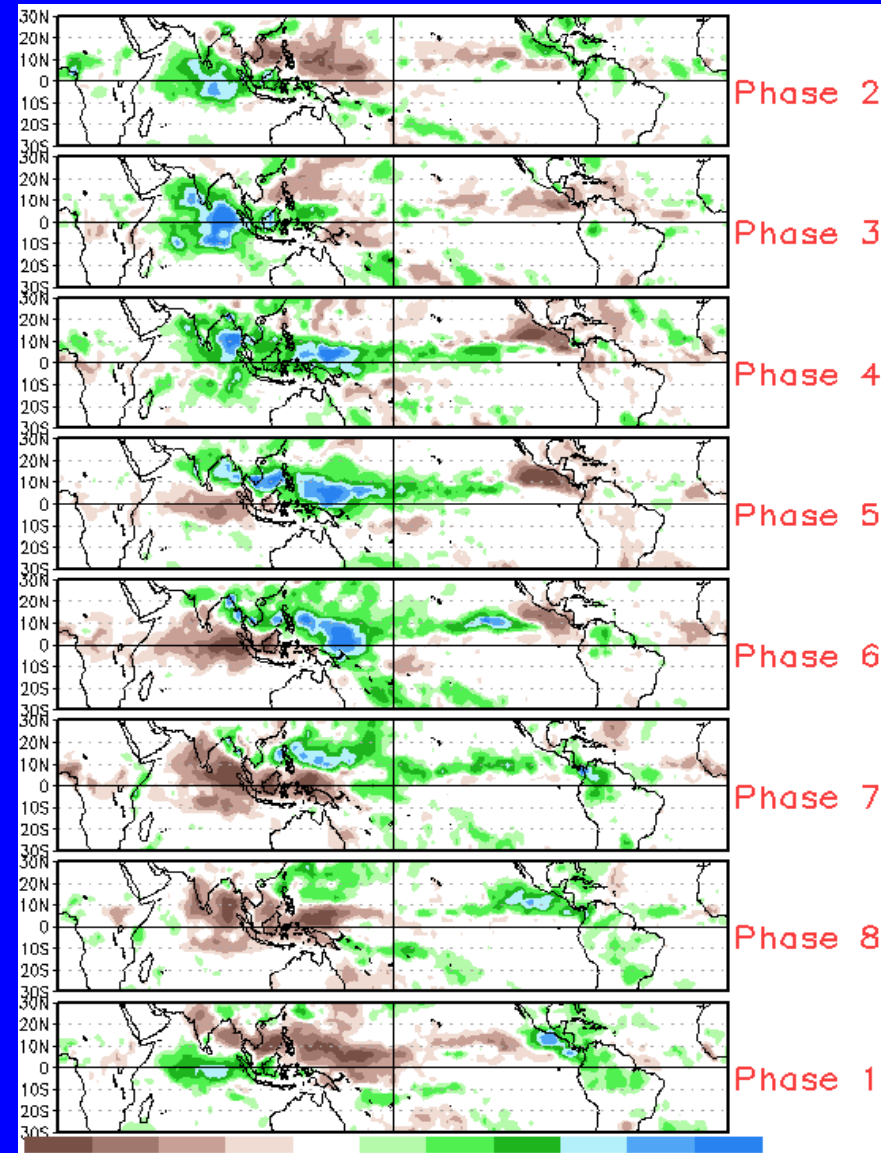


MJO Composites – Global Tropics

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



Precipitation Anomalies (May-Sep)

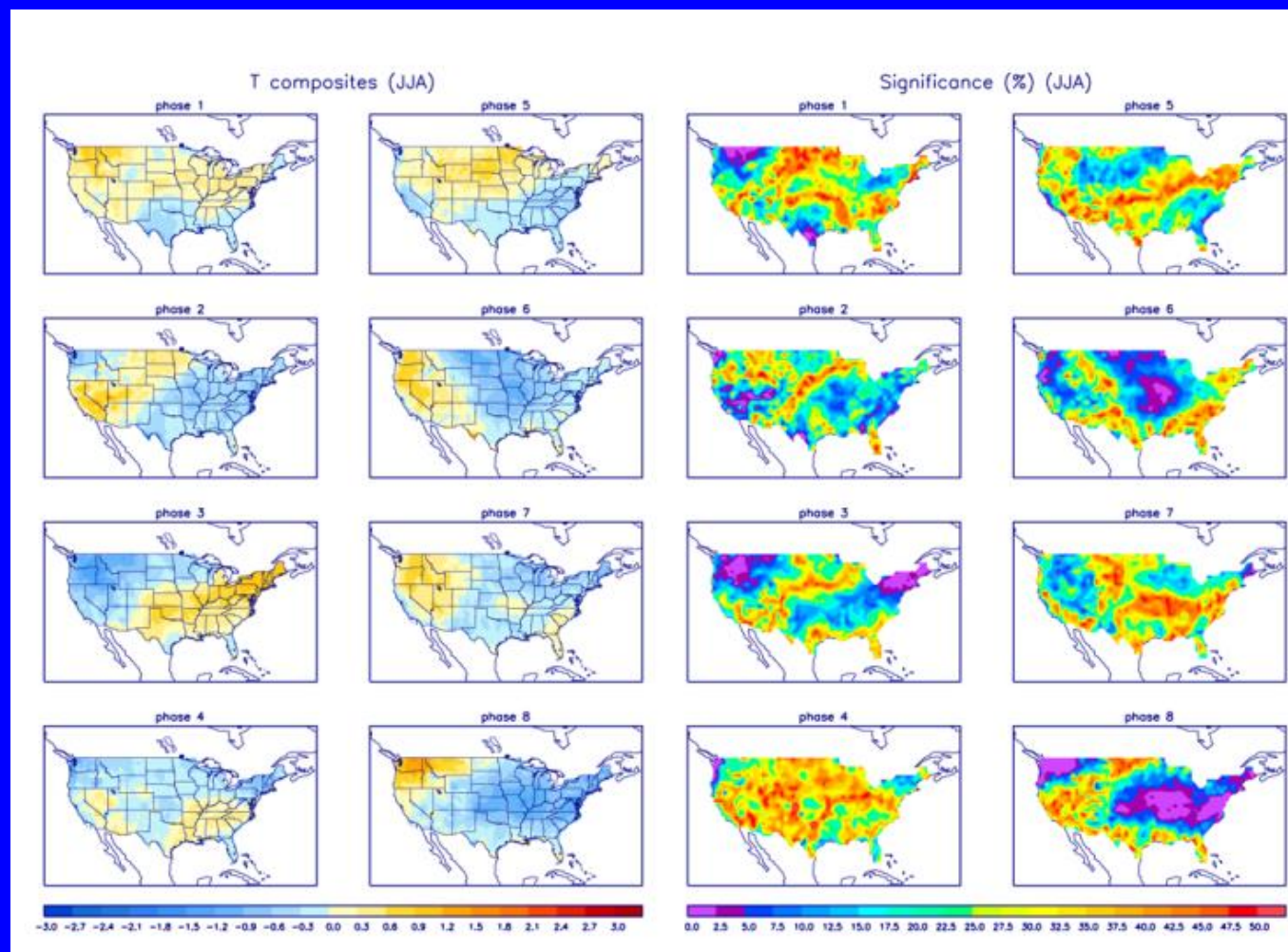




U.S. MJO Composites – Temperature

- 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.



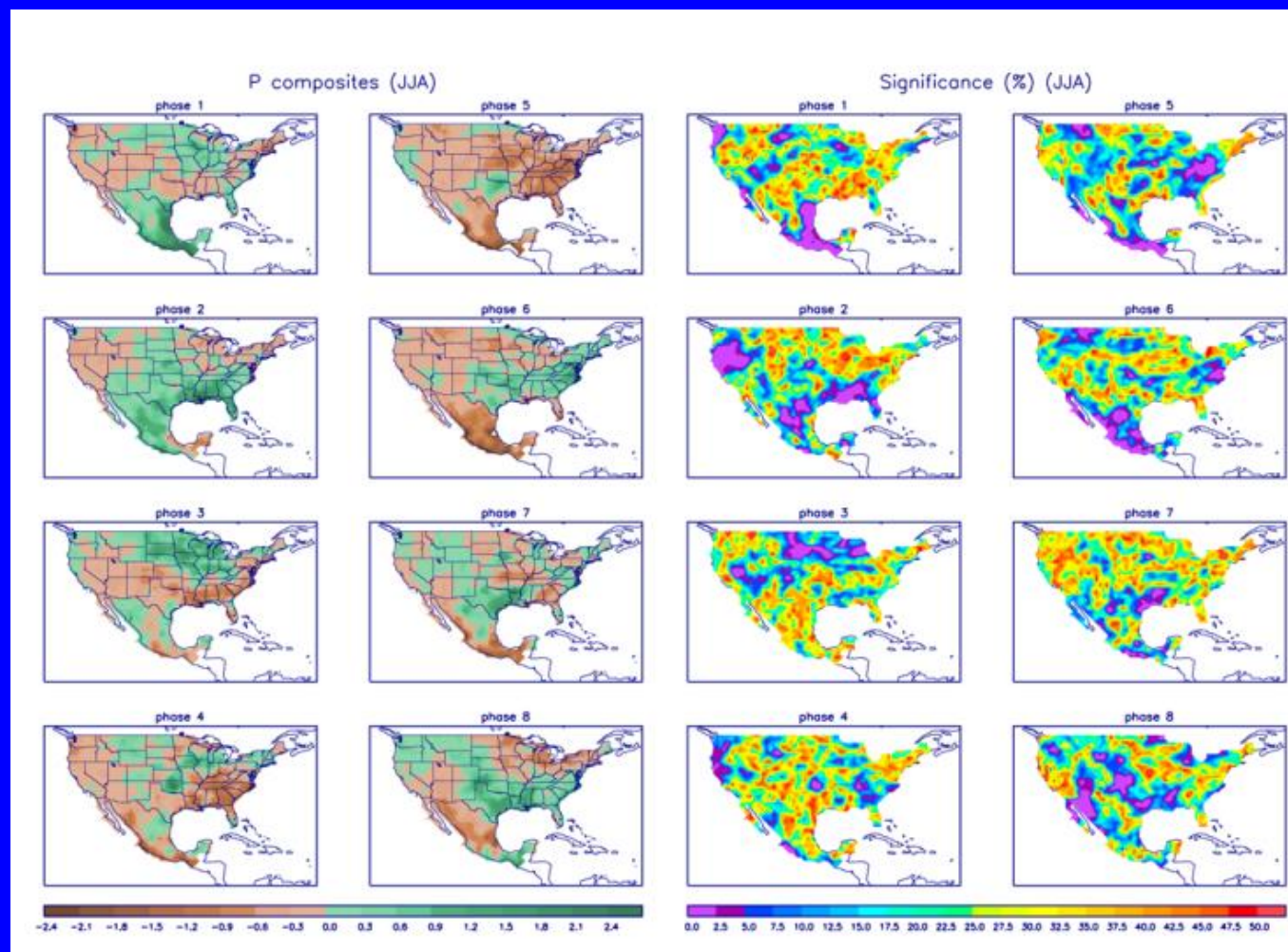
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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.



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>