



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

**Update prepared by
Climate Prediction Center / NCEP
May 20, 2013**



Outline

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



Overview

- **The MJO became less coherent during the past week as the enhanced phase advanced east of the Maritime Continent.**
- **Dynamical model MJO index forecasts are in good agreement for a generally weak MJO signal during Week-1, in part related to interference from other tropical subseasonal variability, but also from a weakened MJO. The models indicate potential renewed organization of an enhanced phase across the Western Hemisphere and Africa during Week-2.**
- **Based on recent observations and model MJO forecasts, the MJO is forecast to become better organized during Week-2 with the enhanced phase centered across the Western Hemisphere and Africa.**
- **Enhanced (suppressed) rainfall is favored across the east Pacific / Central America (west Africa / Indian Ocean / Philippines) primarily associated with other subseasonal variability. Elevated chances for tropical cyclone development exist across the eastern Pacific Ocean.**
- **A more organized MJO favors enhanced rainfall across central America and the western Caribbean Sea during Week-2 where tropical cyclogenesis chances are also elevated. Above average rainfall is also favored for west Africa, the Indian Ocean and southern India while below average rainfall is most likely for the Philippines and parts of the western Pacific Ocean.**

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>

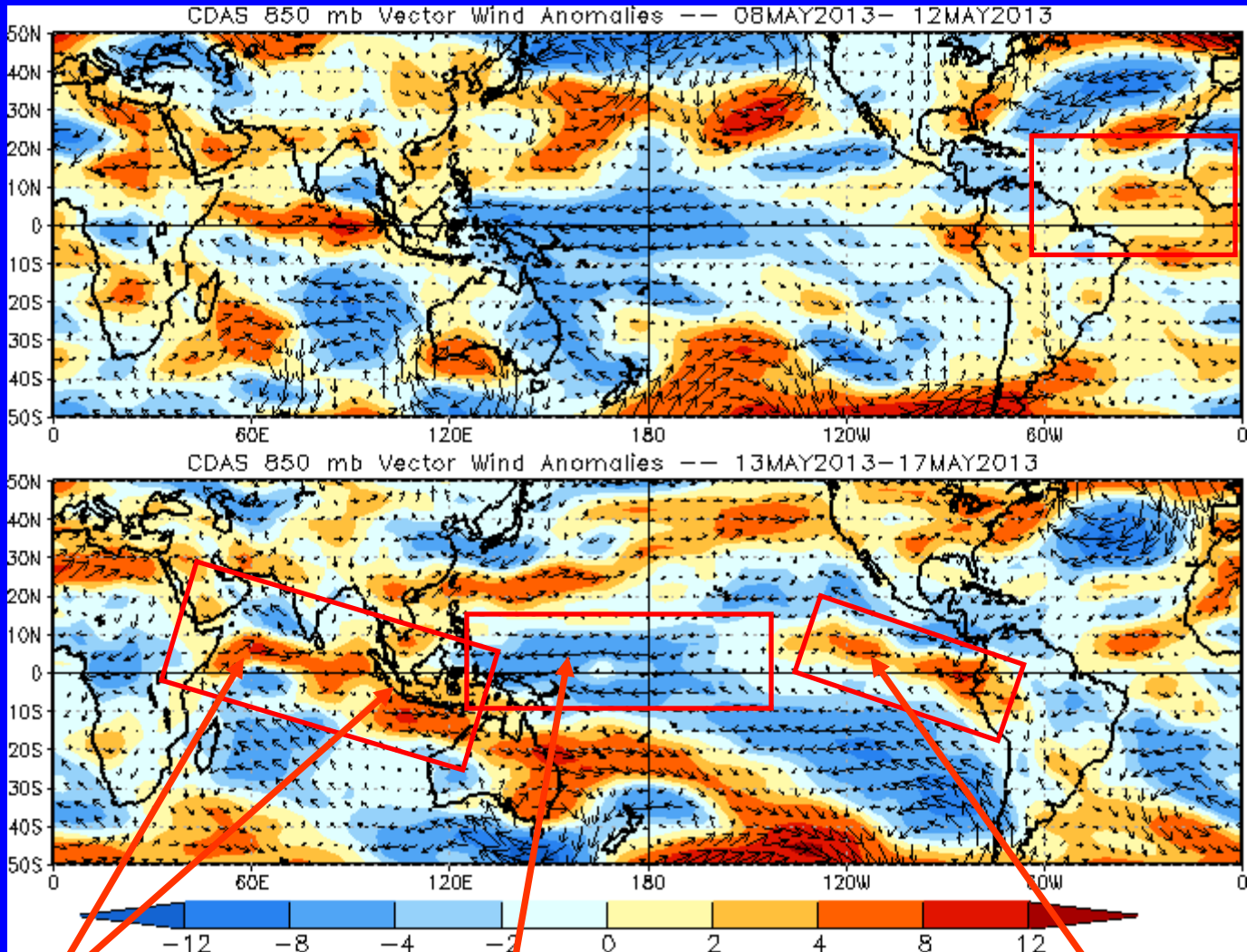


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies continued the Indian Ocean and strengthened across the Maritime Continent during the past five days.

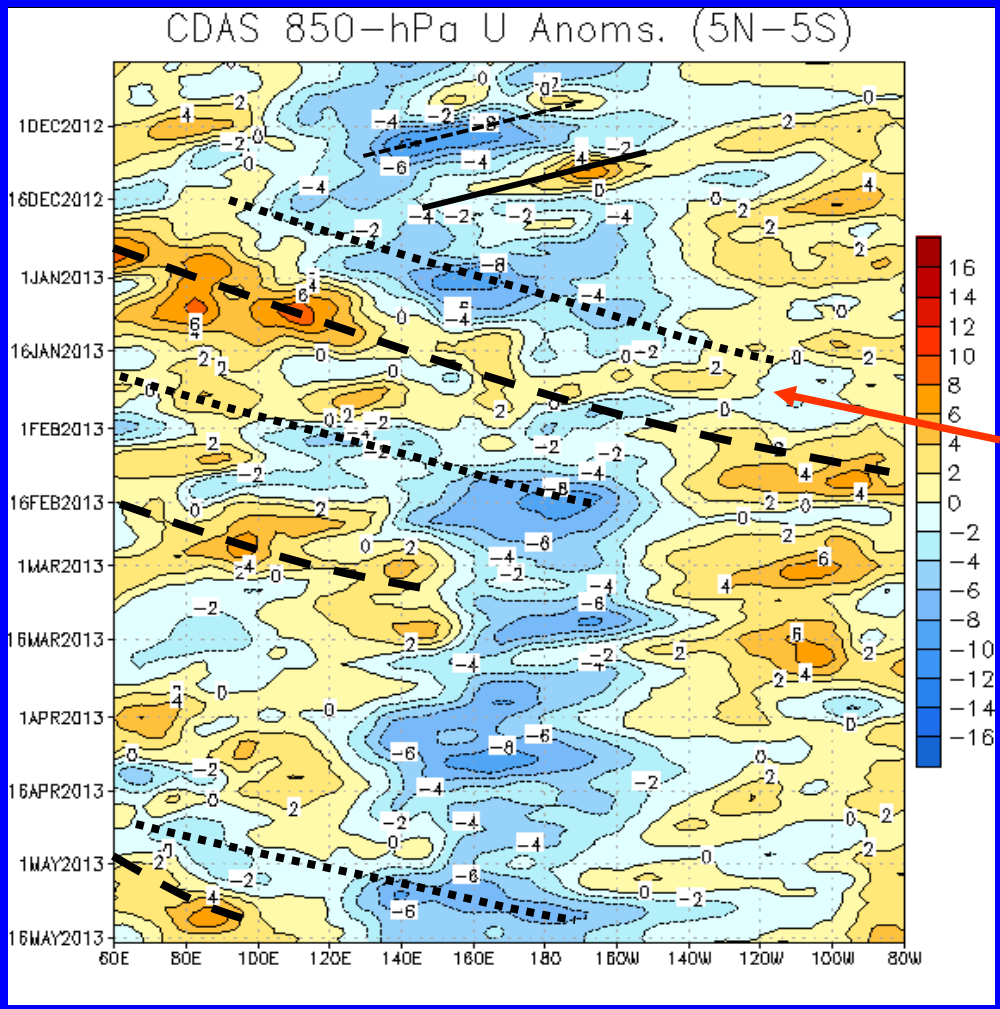
Easterly anomalies remained in place across the western Pacific, contributing to a decay in the MJO index.

Westerly anomalies were larger 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



Westward propagation (dashed/solid lines sloping down and to the left) of anomalies during much of November and early December were primarily due to equatorial Rossby wave activity as the MJO was then generally weak.

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

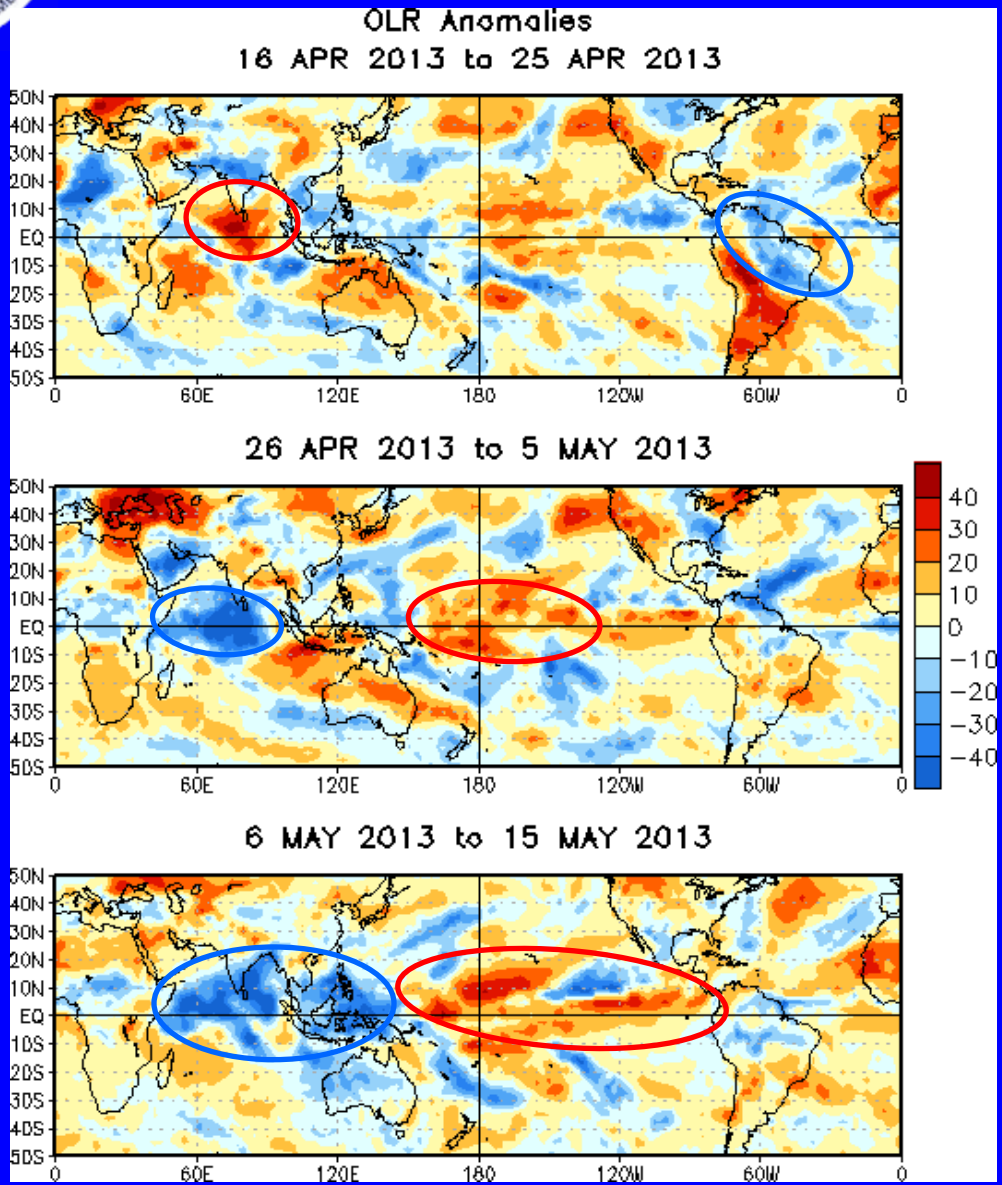
During March and early April, anomalies indicate signs of being influenced by equatorial Rossby wave activity with less eastward propagation evident.

The MJO strengthened during early May with eastward propagation of low-level wind anomalies noted. Recently anomalies have been more stationary as the MJO signal became less coherent.



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-April, suppressed convection was located across the Indian Ocean, while convection became enhanced northeast South America.

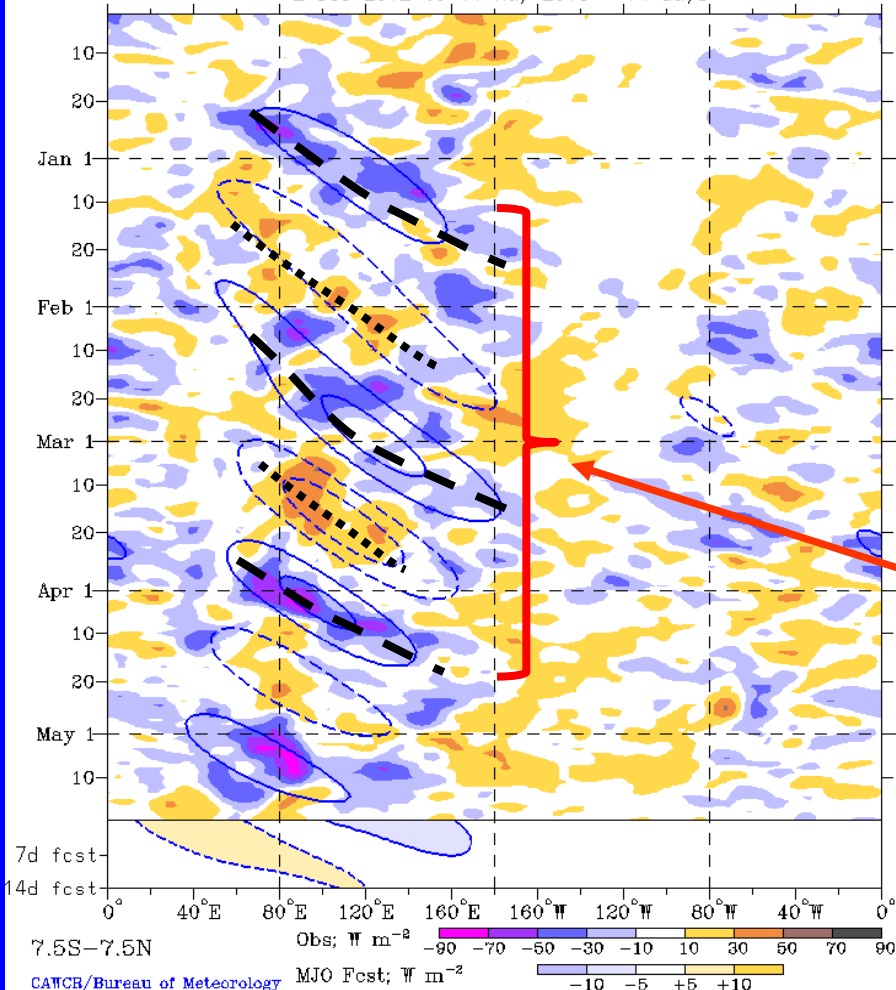
During late April and the beginning of May, convection rapidly developed across the Indian Ocean, while the west-central Pacific experienced suppressed convection.

During early to mid-May, enhanced (suppressed) convection prevailed across the Indian Ocean and Maritime Continent (central/eastern Pacific Ocean).



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

Real-time MJO filtering superimposed upon 3drmm R21 OLR Anomalies
MJO anomalies blue contours, CINT=10. (5. for forecast)
Negative contours solid, positive dashed
2-Dec-2012 to 19-May-2013 + 14 days



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)

During late November and much of December, convective anomalies were disorganized.

The MJO was again 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.

During early May, anomalous OLR increased significantly across the Indian Ocean.

Longitude

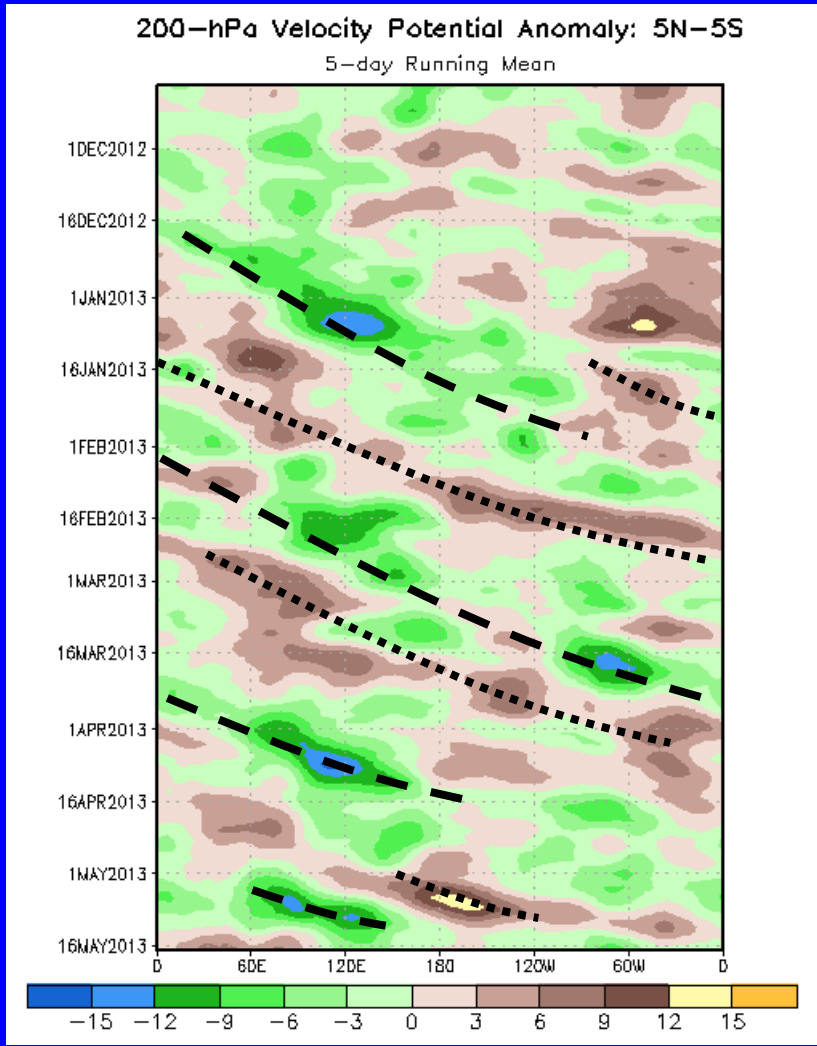


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time
↓



After some MJO activity at the start of November, anomalies decreased with less coherent eastward propagation during most of November and December. Other modes of subseasonal variability were more prevalent during this period.

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

Anomalies became less coherent at times during this period as the influence from other modes of variability are evident in the depicted anomalies, namely during late January into early February, before reorganizing in late February and early March.

The velocity potential anomalies were more coherent briefly during early May.

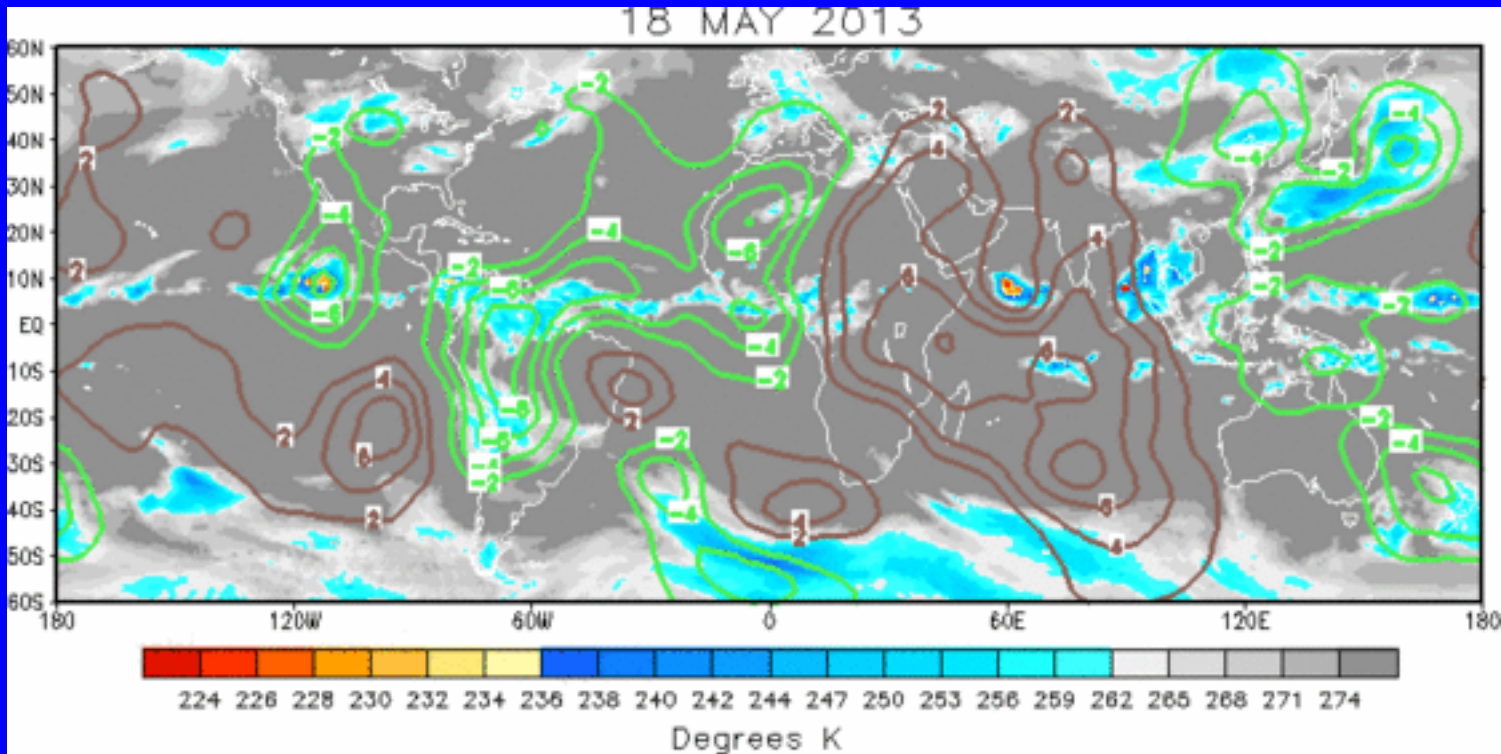
Longitude



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 has become less coherent recently. Upper-level divergence is observed across the Americas and west Africa, while positive anomalies (upper-level convergence) cover the Indian Ocean.

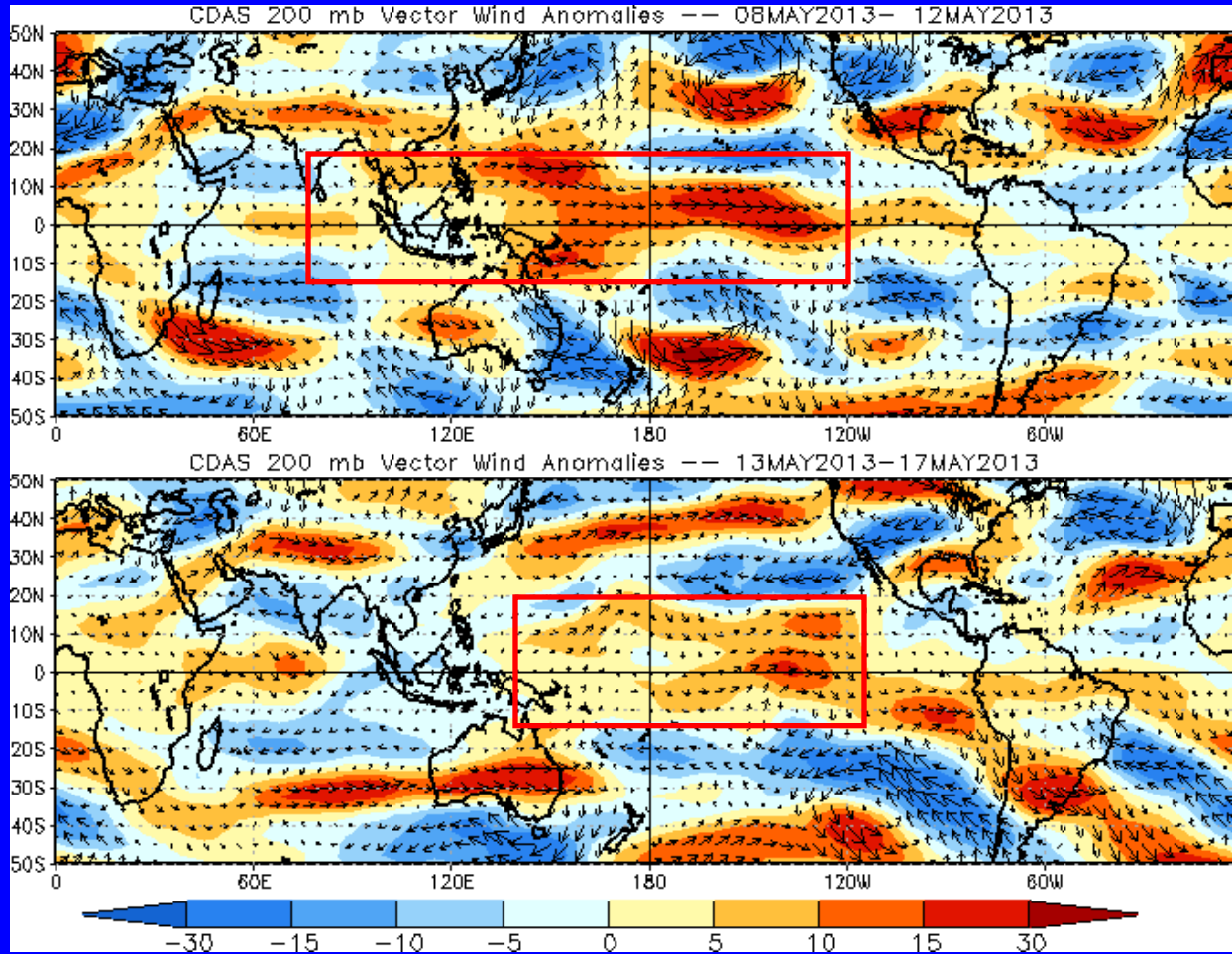


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



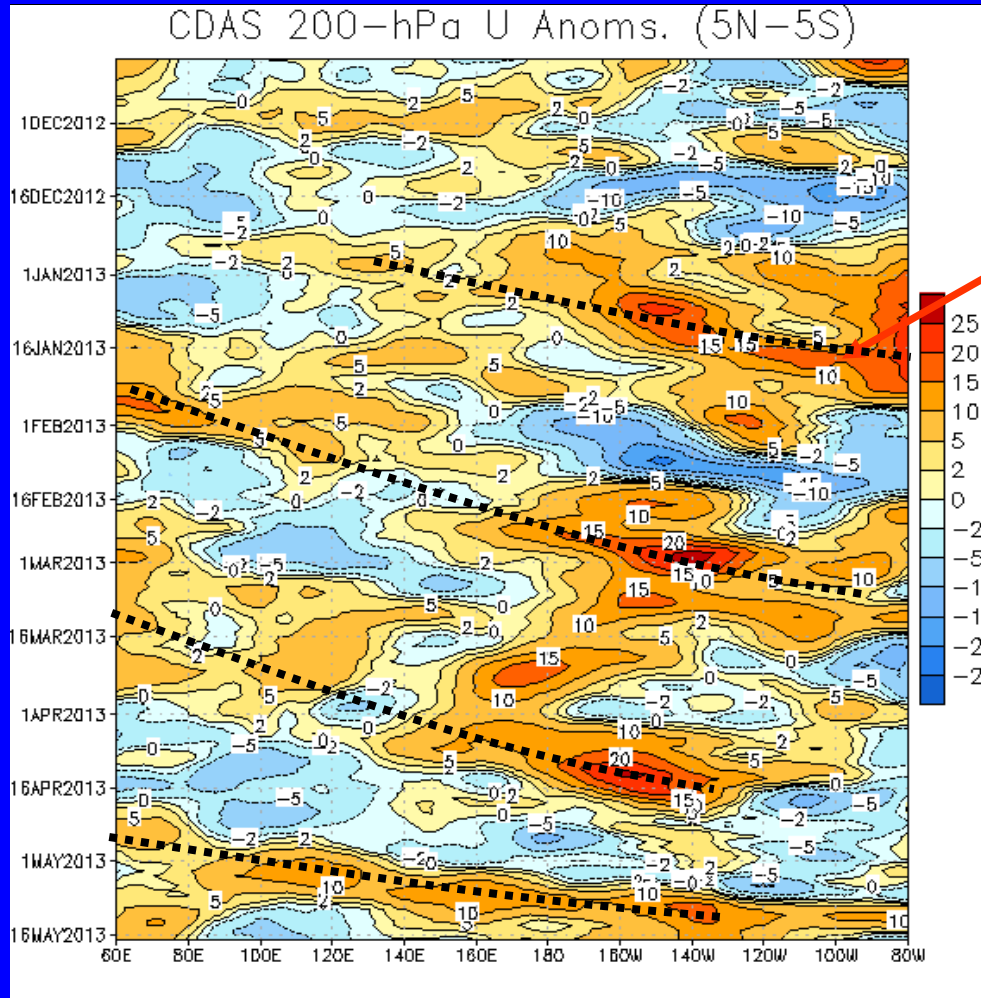
Westerly anomalies (red box) weakened during the past five days along the Equator.



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.

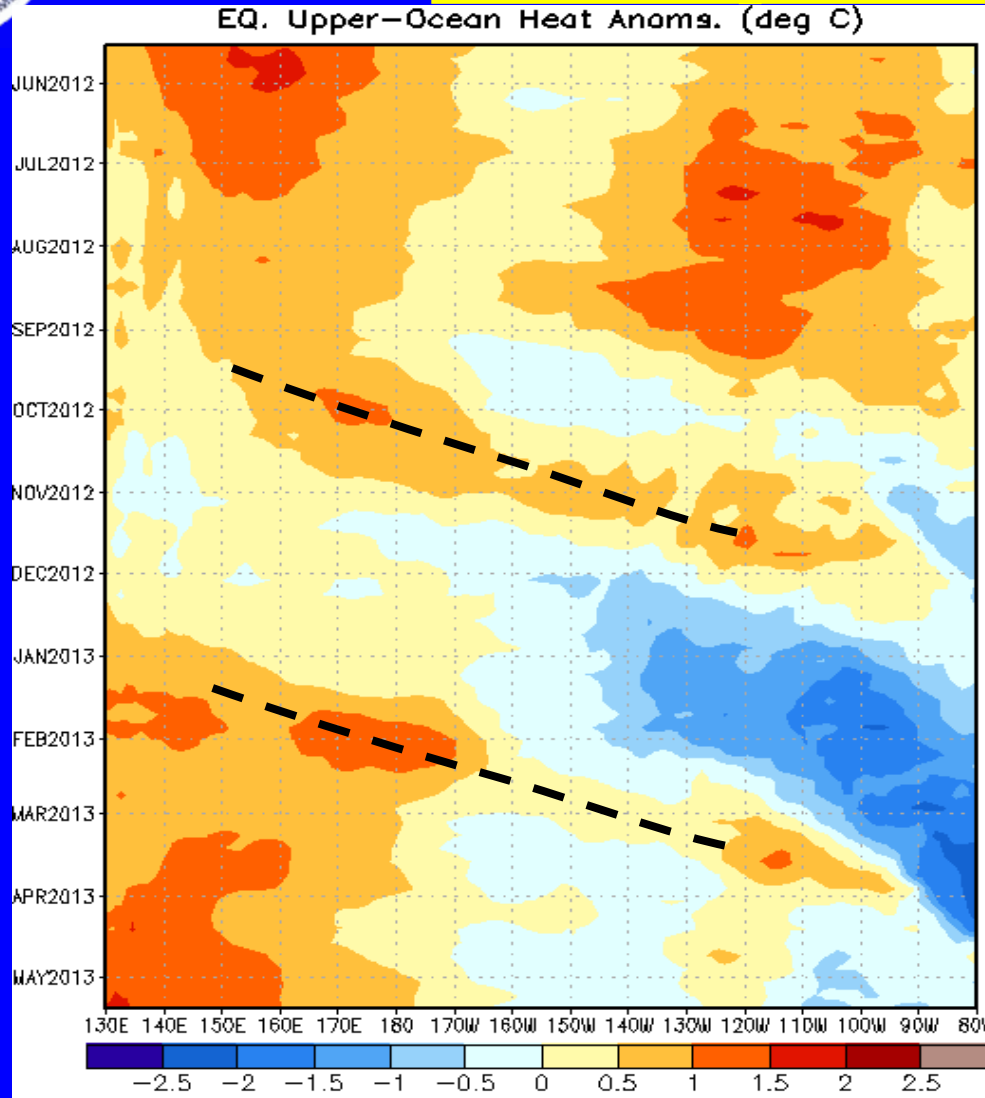
During March and early April, anomalies were influenced by westward moving features over the central and western Pacific.

Westerly anomalies shifted east of the Date Line during early May.



Weekly Heat Content Evolution in the Equatorial Pacific

Time
↓



Longitude

From March into 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.



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.

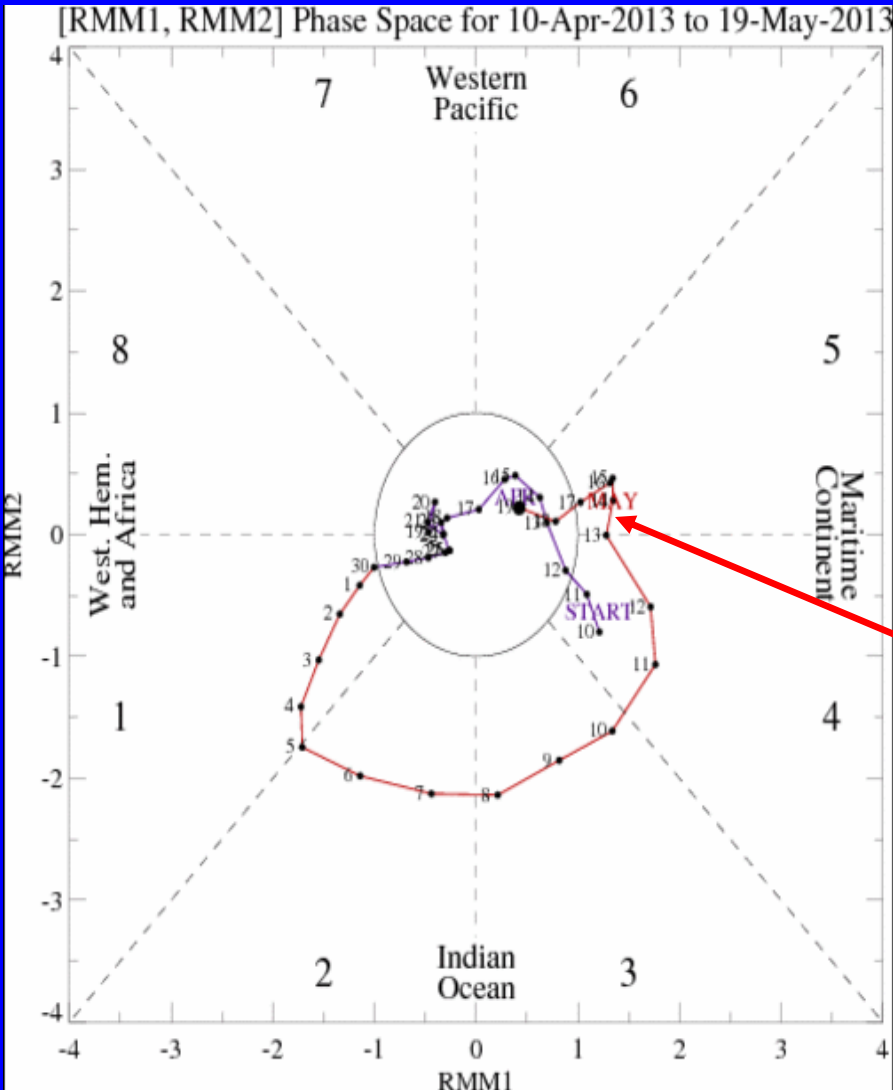
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

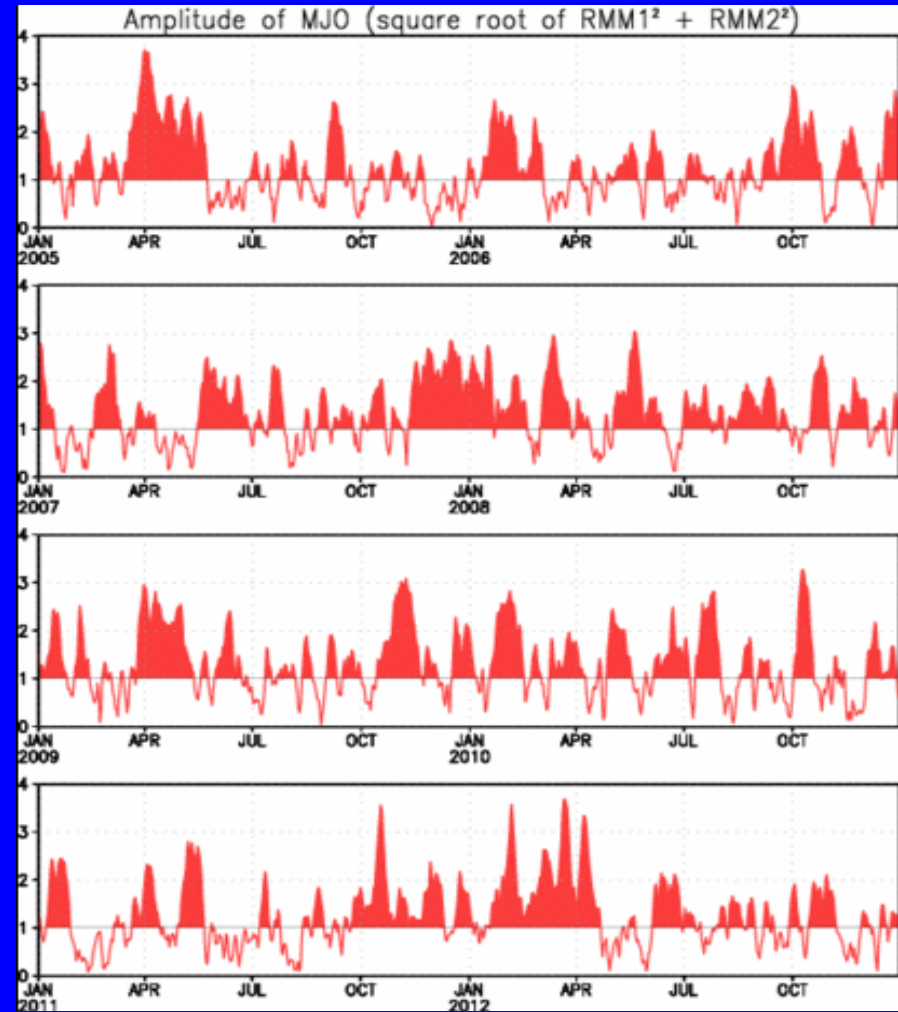
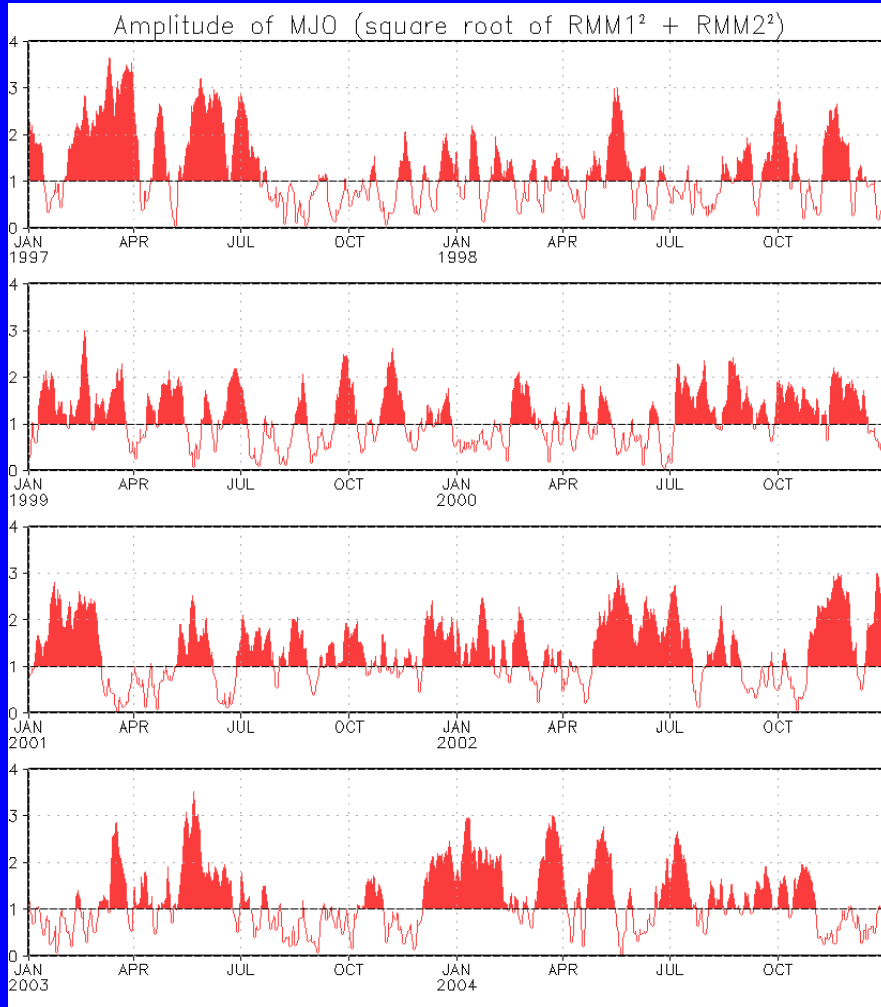


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates a weaker signal during the past few 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.



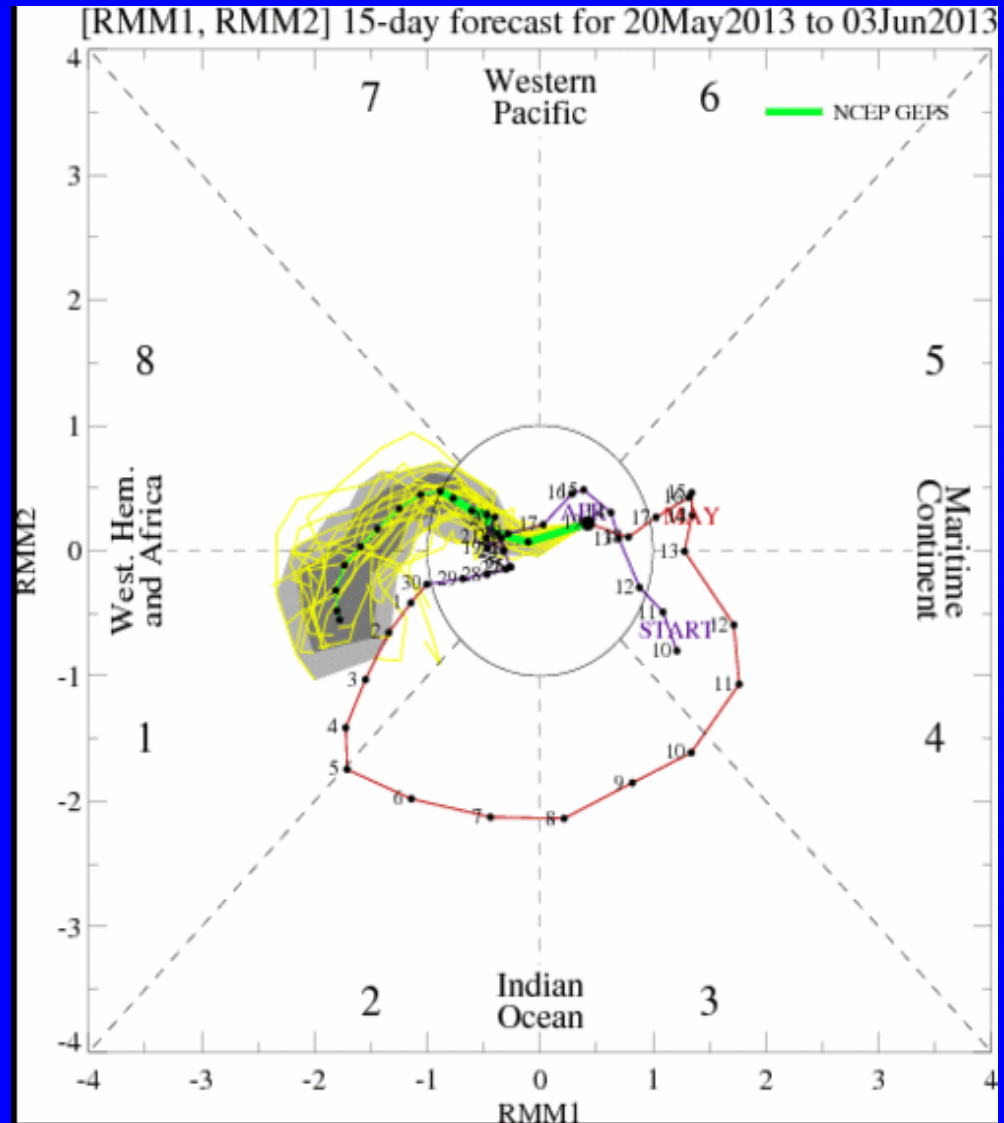
Ensemble GFS (GEFS) MJO Forecast

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 bias-corrected ensemble GFS indicates a weak signal until week-2 when it reemerges in Phase 8.



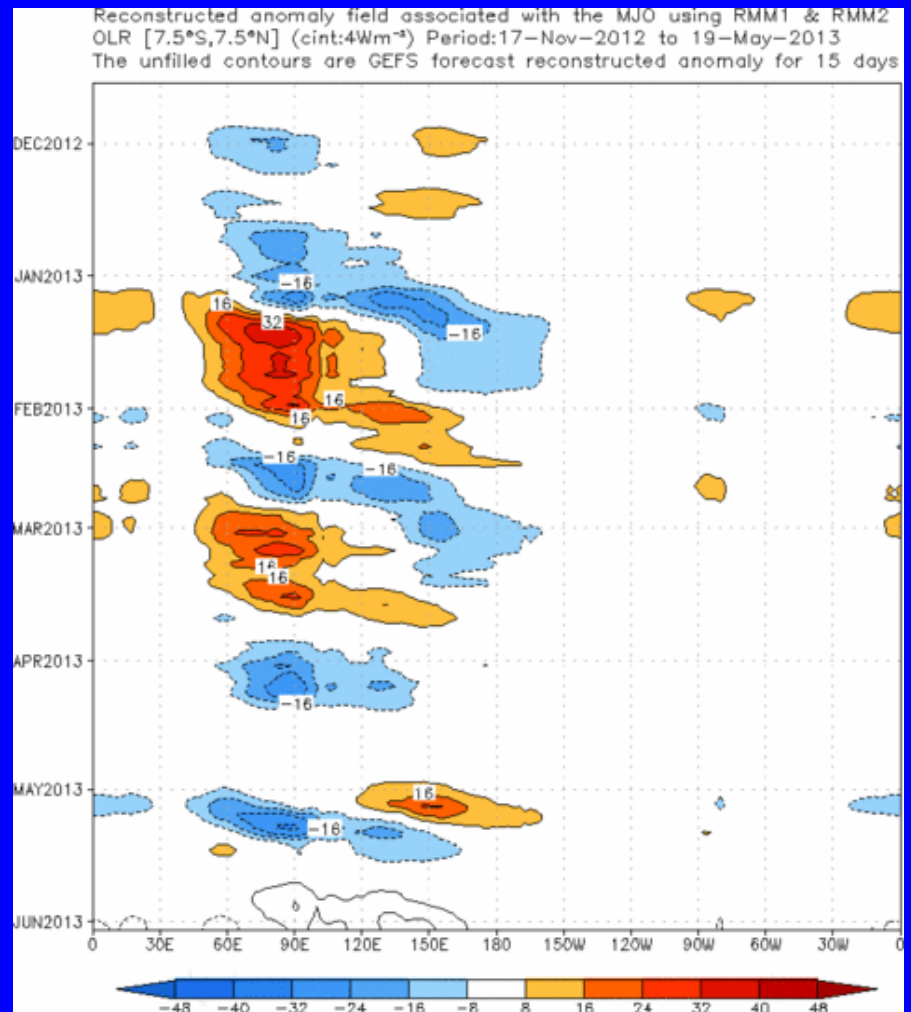
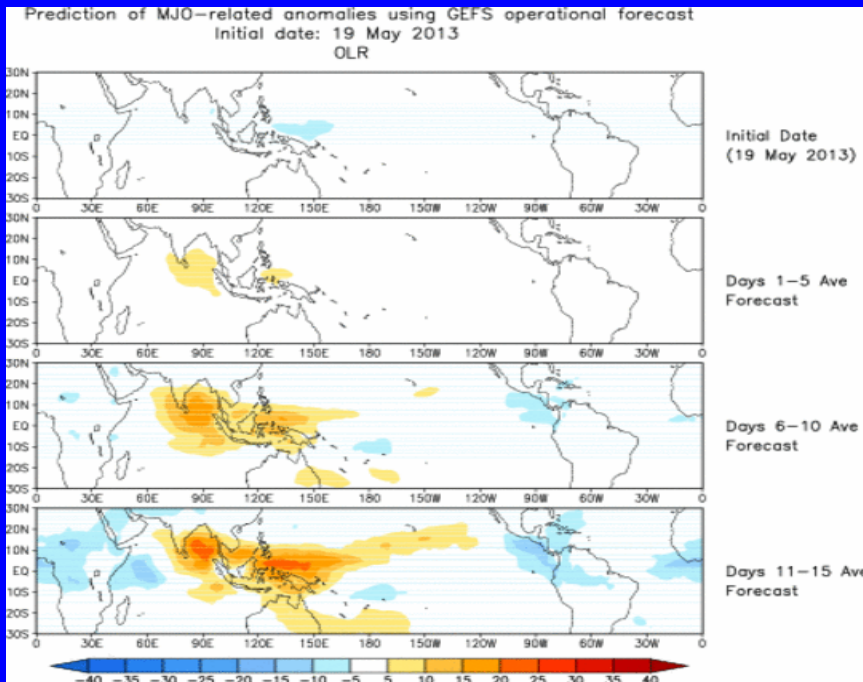


Ensemble Mean GFS MJO Forecast

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 suppressed (enhanced) convection developing across the Indian Ocean and Maritime Continent (east Pacific, central America, and western Caribbean Sea) during the next two weeks.

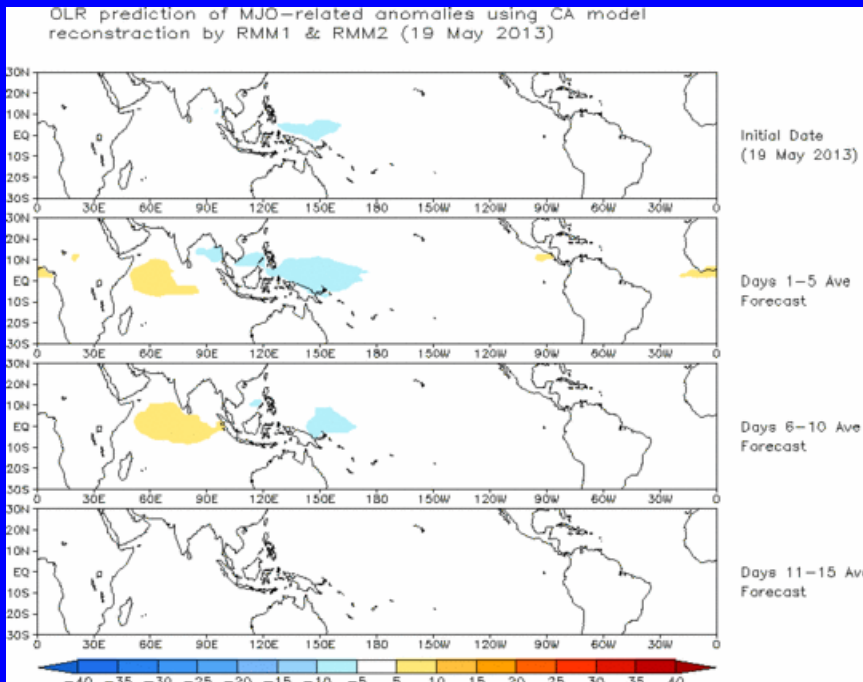


Constructed Analog (CA) MJO Forecast

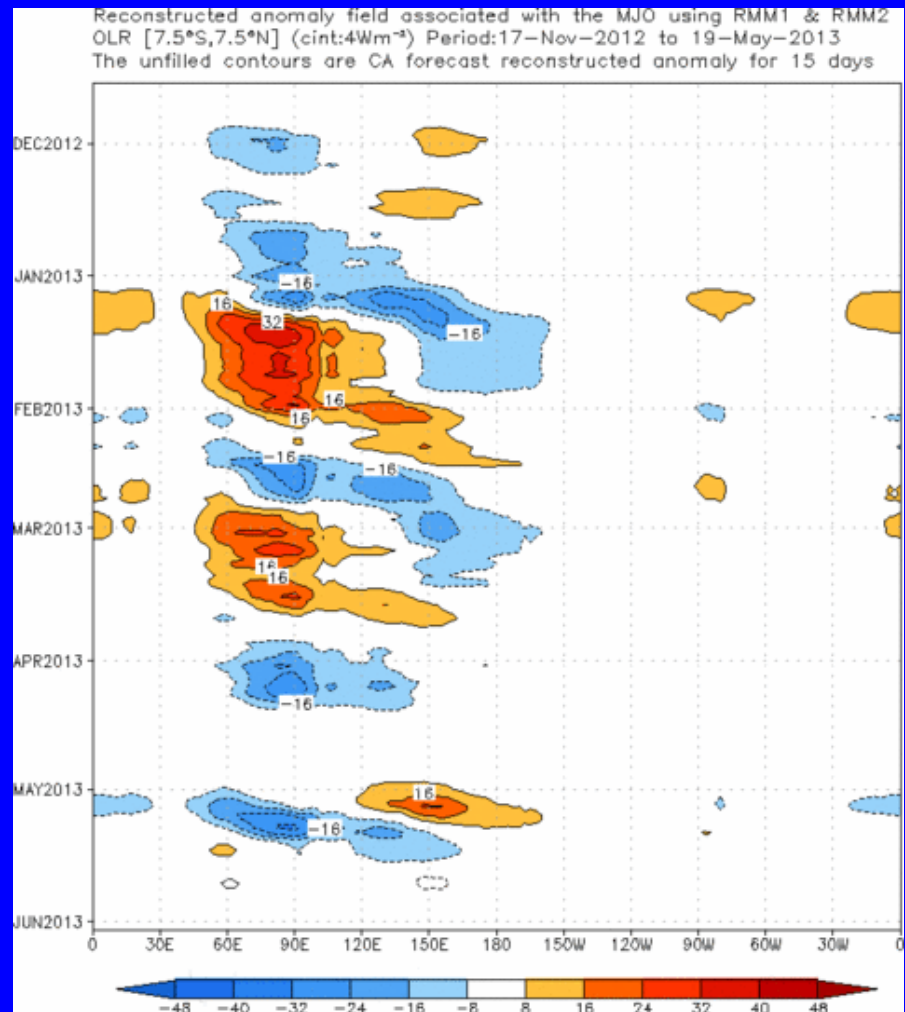
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

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 small anomalies across the global tropics.

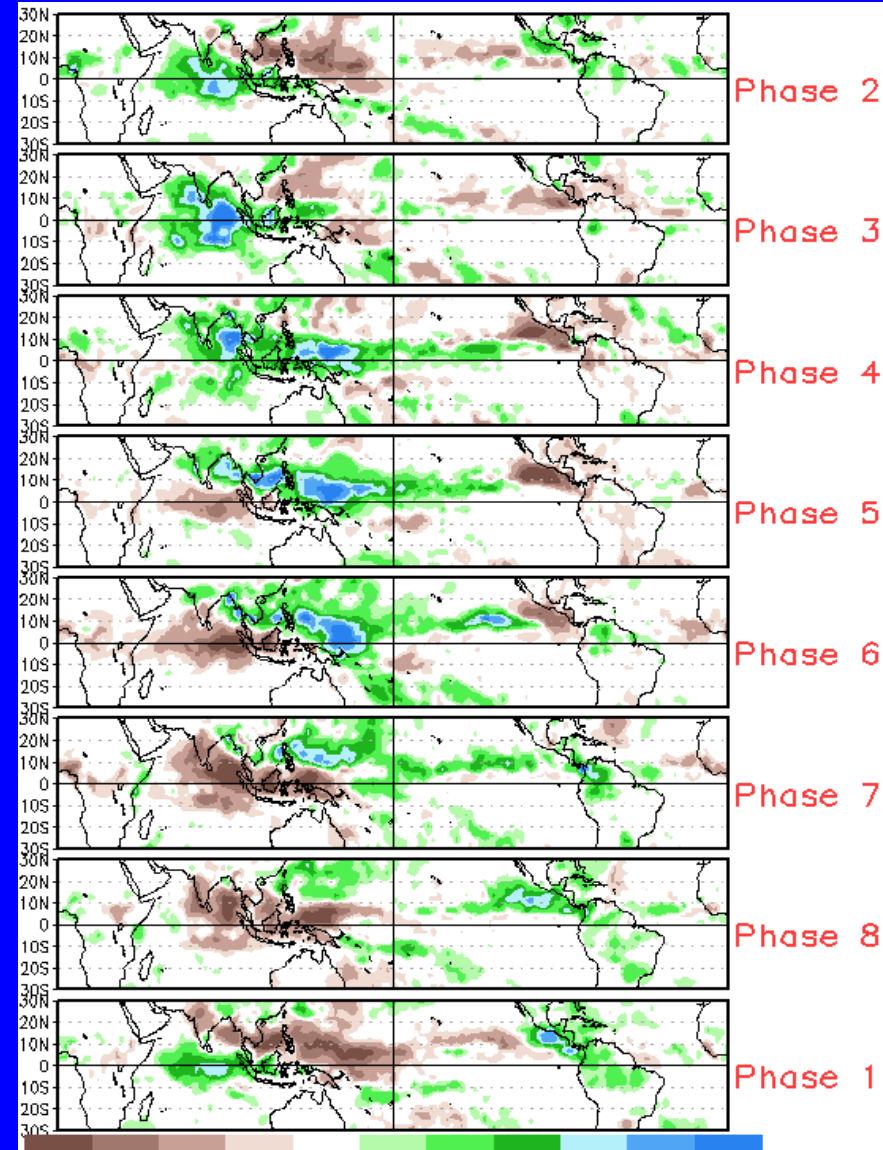
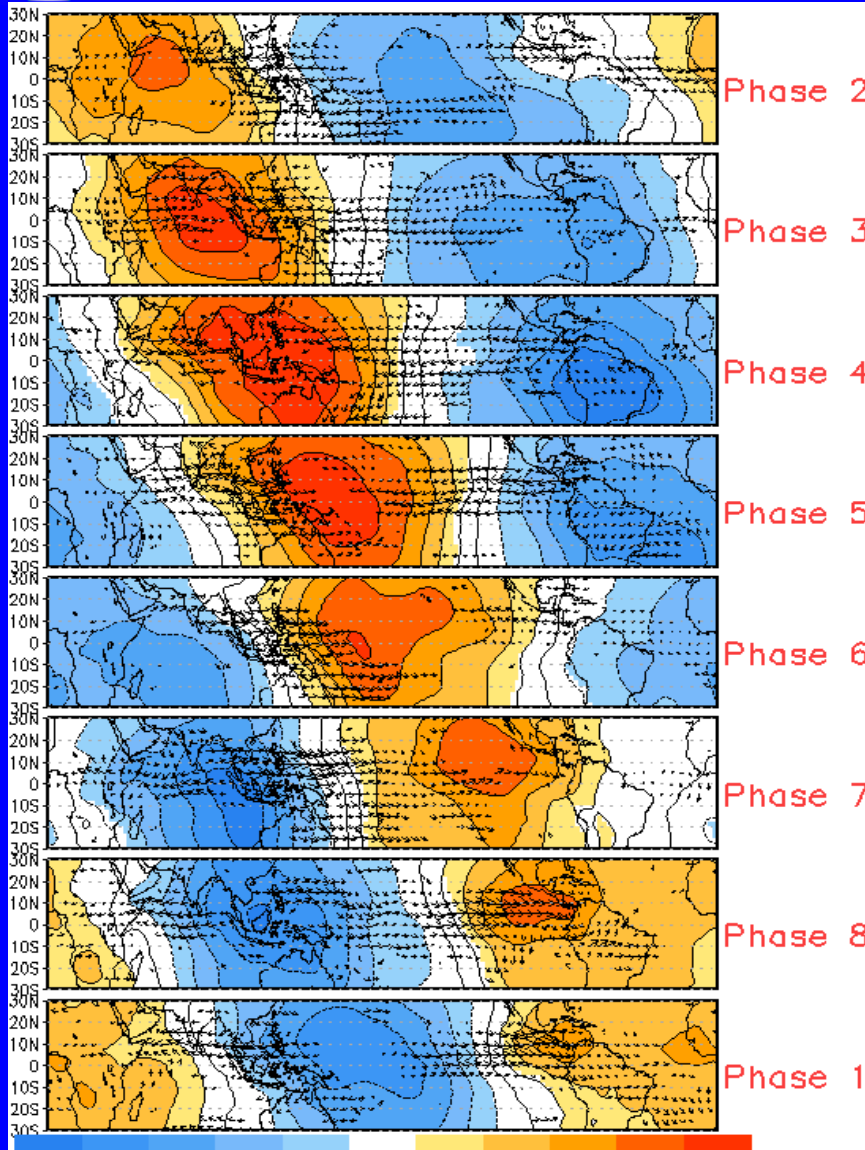




MJO Composites – Global Tropics

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

Precipitation Anomalies (May-Sep)

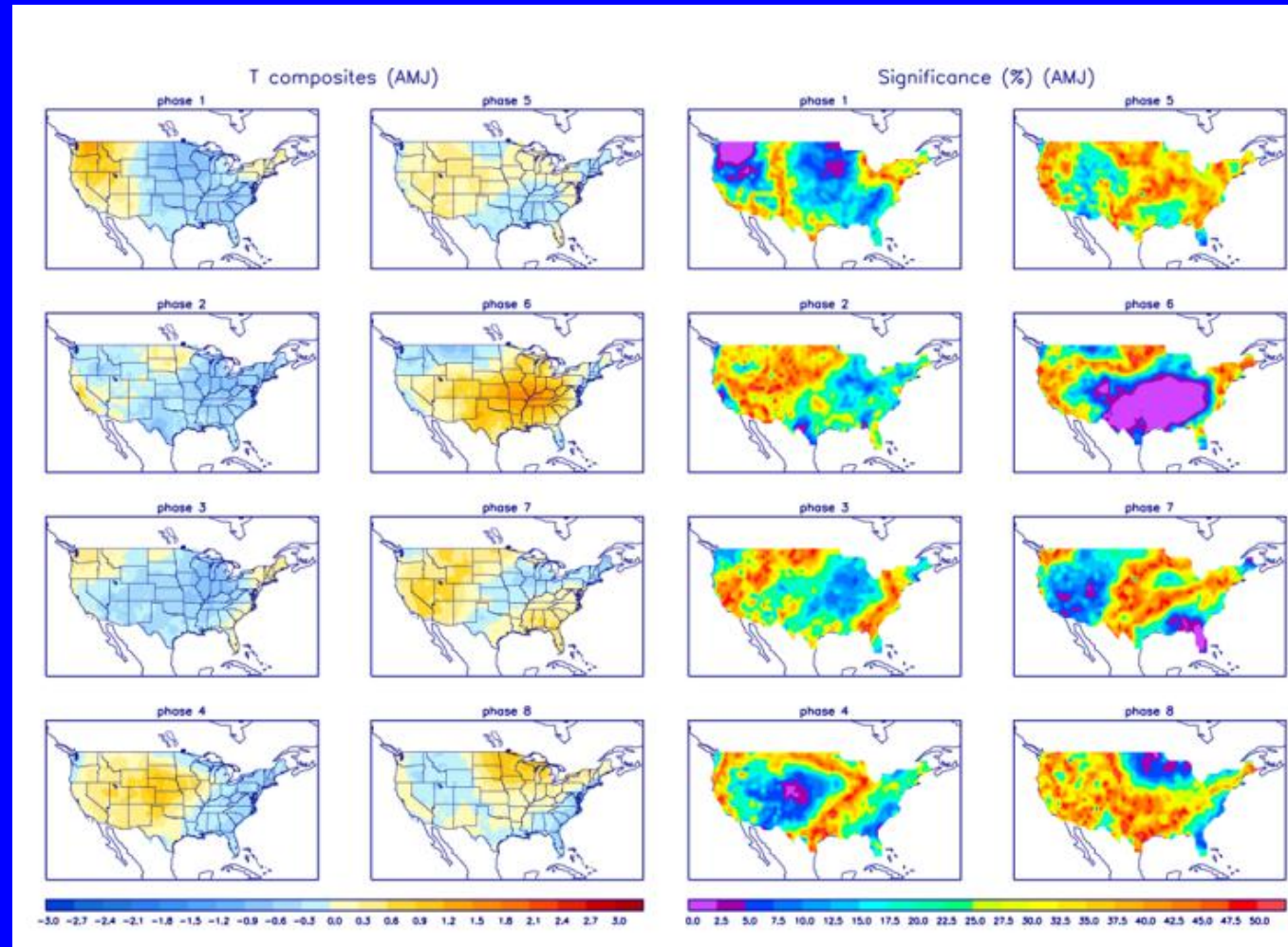




U.S. MJO Composites – Temperature

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.



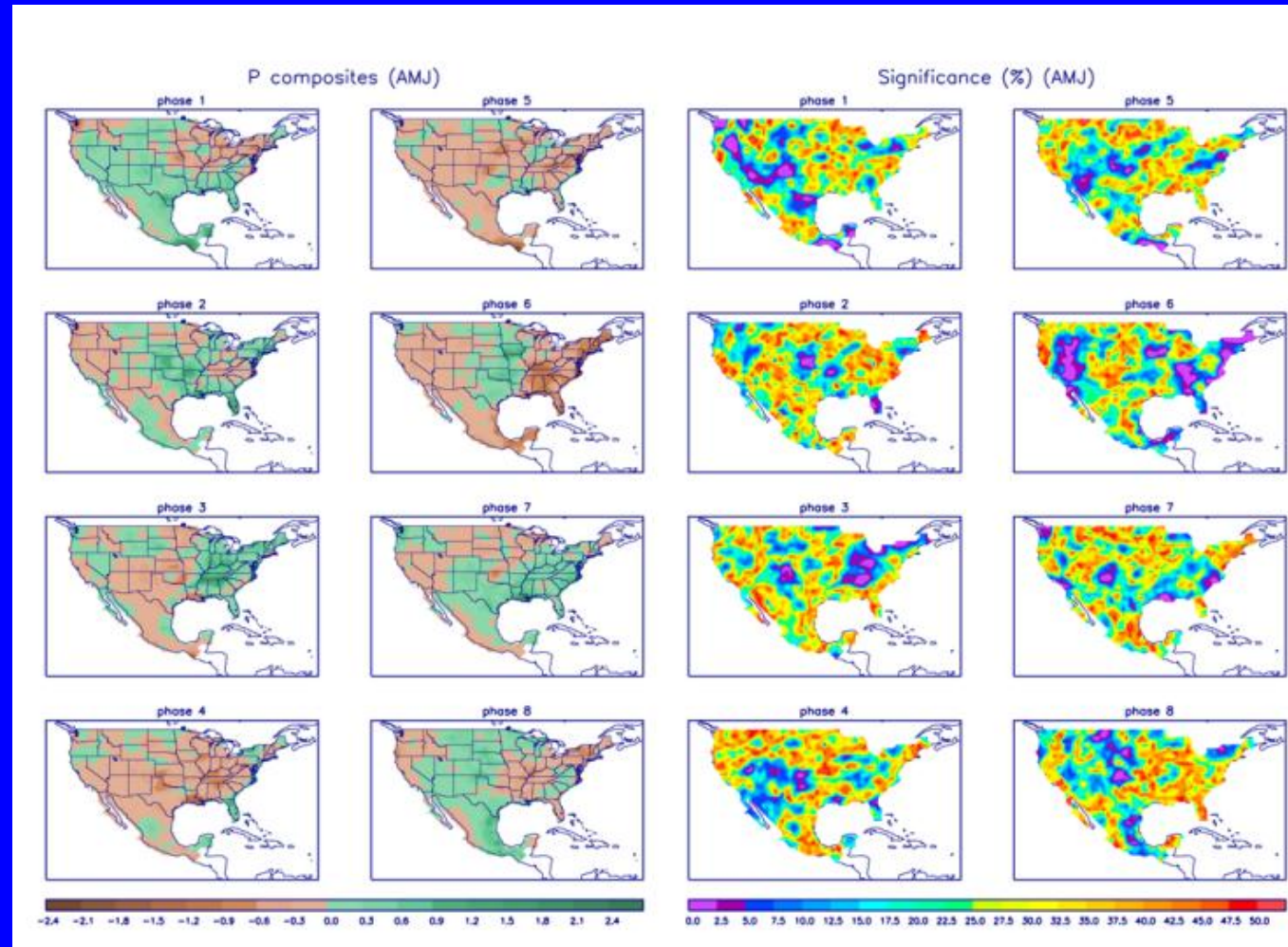
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>