



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

**Update prepared by
Climate Prediction Center / NCEP
April 22, 2013**



Outline

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



Overview

- **The MJO remained fairly weak over the past several days, as many observational indicators are less coherent than in previous weeks while other subseasonal modes of variability are playing a role in the tropical convection pattern. The velocity potential field is more consistent with MJO activity than other indicators, and suggests a weakly enhanced phase centered between the western Pacific and South America.**
- **Dynamical model MJO index forecasts indicate a weak signal through Week-1, with some guidance suggesting reorganization somewhere in phases 1 through 3 later in Week-2.**
- **Based on recent observations and model MJO forecasts, the MJO is forecast to remain weak during Week-1, with some strengthening possible during Week-2.**
- **The MJO weakly favors enhanced (suppressed) rainfall across parts of South America and western Pacific (Indian Ocean) during Week-1 with enhanced convection emerging over parts of Africa and the Indian Ocean during Week-2. No specific areas are favored for tropical cyclogenesis at this time.**

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>

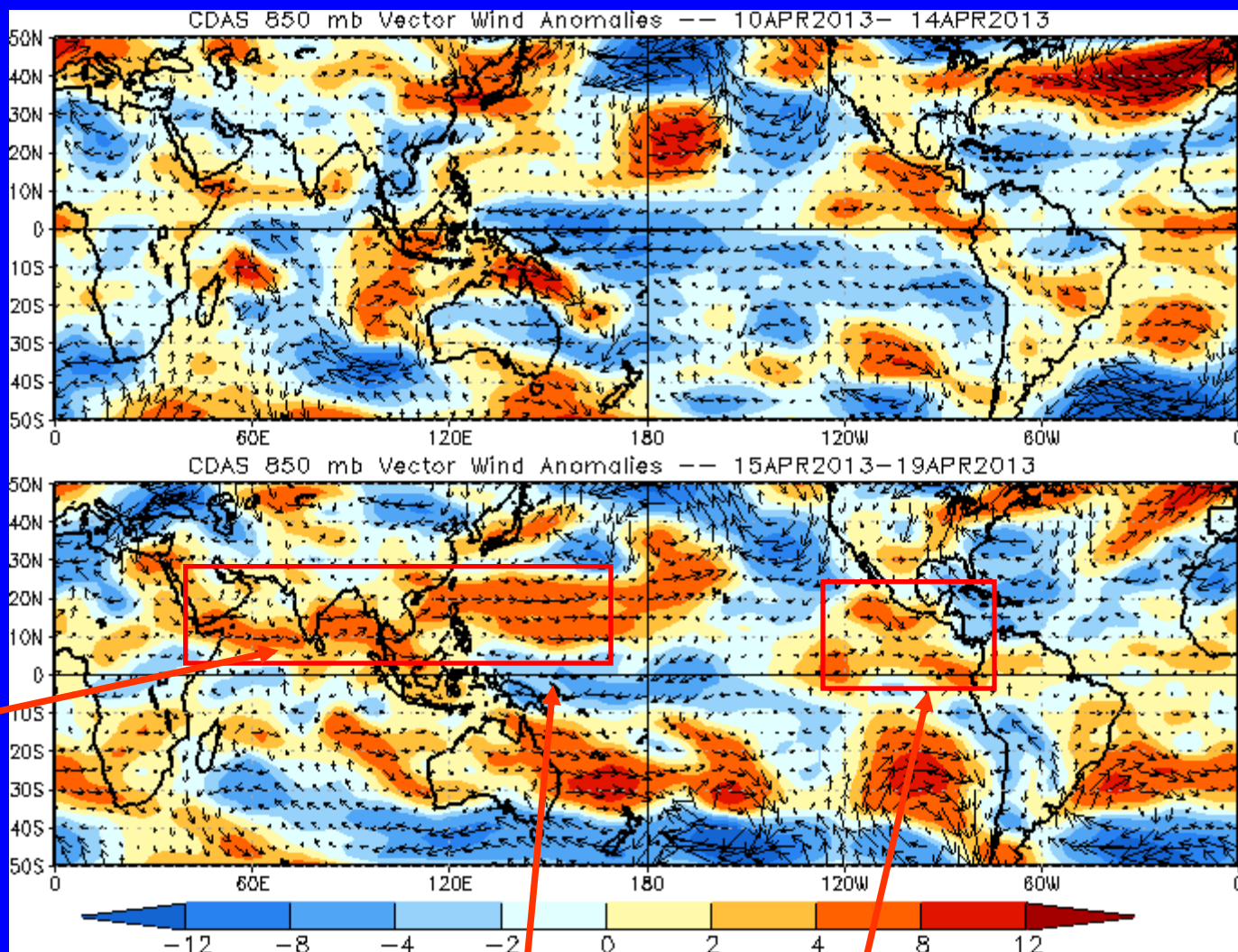


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies persisted over the Indian Ocean and strengthened north of the Equator in the western Pacific.

Easterly anomalies weakened slightly over the equatorial, western Pacific during the past ten days.

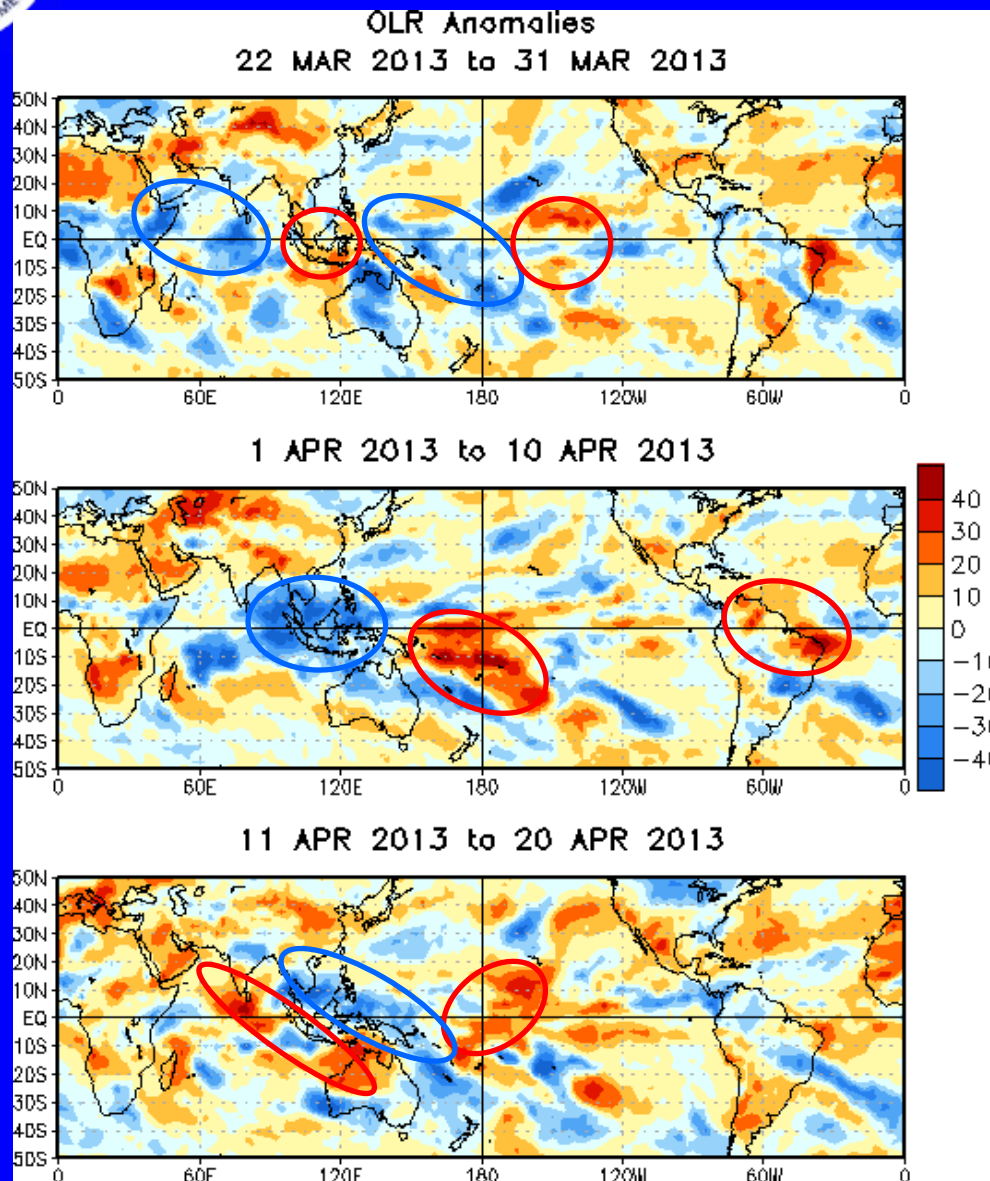
Westerly anomalies continued across the eastern Pacific.



OLR Anomalies – Past 30 days

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

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



During late March, enhanced convection lingered in the southwest Pacific, while convection also increased across eastern Africa and parts of the Indian Ocean.

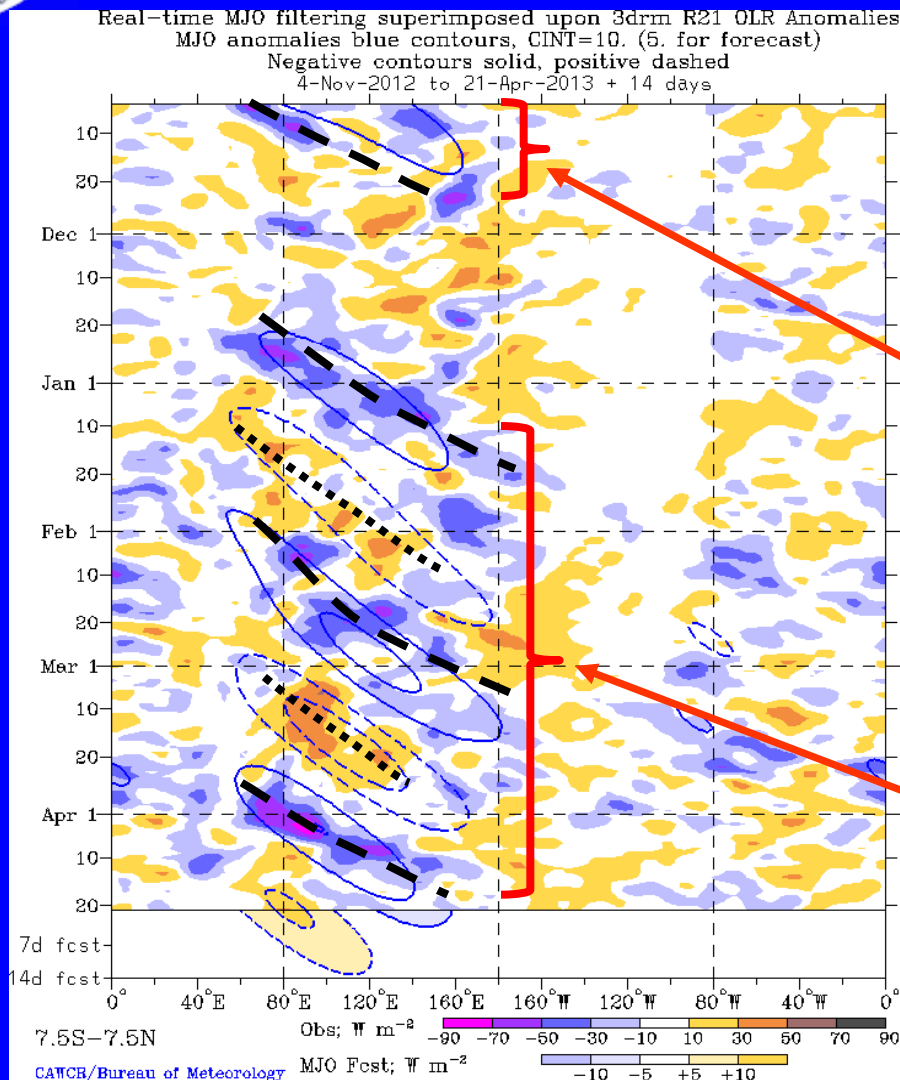
During early April, enhanced convection shifted east to the Maritime Continent and Suppressed convection returned to the central Pacific and northern South America.

During mid-April, the OLR pattern became less coherent as the MJO signal weakened. Suppressed convection increased in parts of the Indian Ocean while enhanced convection shifted subtly eastward into the western 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 (alternating dashed and dotted lines) was active during October into November with enhanced convection developing over Africa during mid-October and shifting eastward to the western Pacific by mid-November.

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 April, the OLR signal weakened substantially.

Longitude

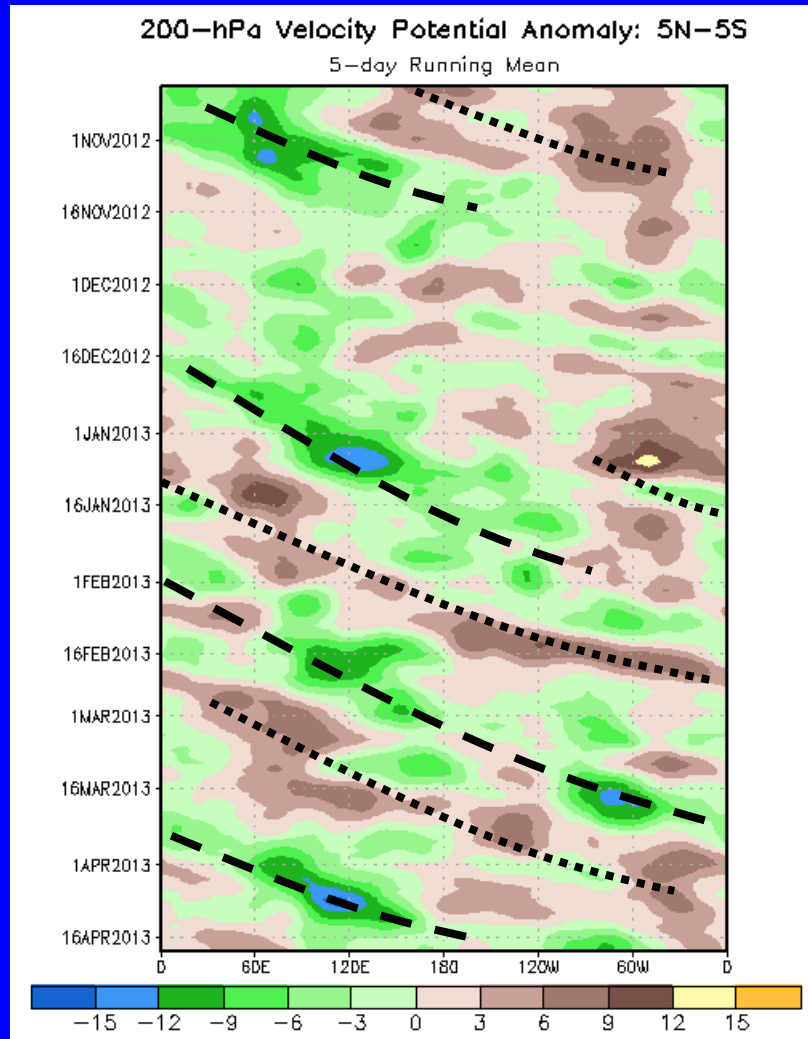


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time



In early October, upper-level divergence (convergence) increased over the Pacific (Indian Ocean) and shifted eastward until mid November (alternating dashed and dotted lines).

During most of November and December, anomalies were weak with less coherent eastward propagation. Other modes of subseasonal variability were more prevalent during this period.

As the MJO strengthened in late December, anomalies increased in magnitude with more robust eastward propagation indicated during late 2012 and early 2013. Anomalies became less coherent during late January into early February, but reorganized in late February and early March. Influence from other modes of variability are evident in the anomaly field.

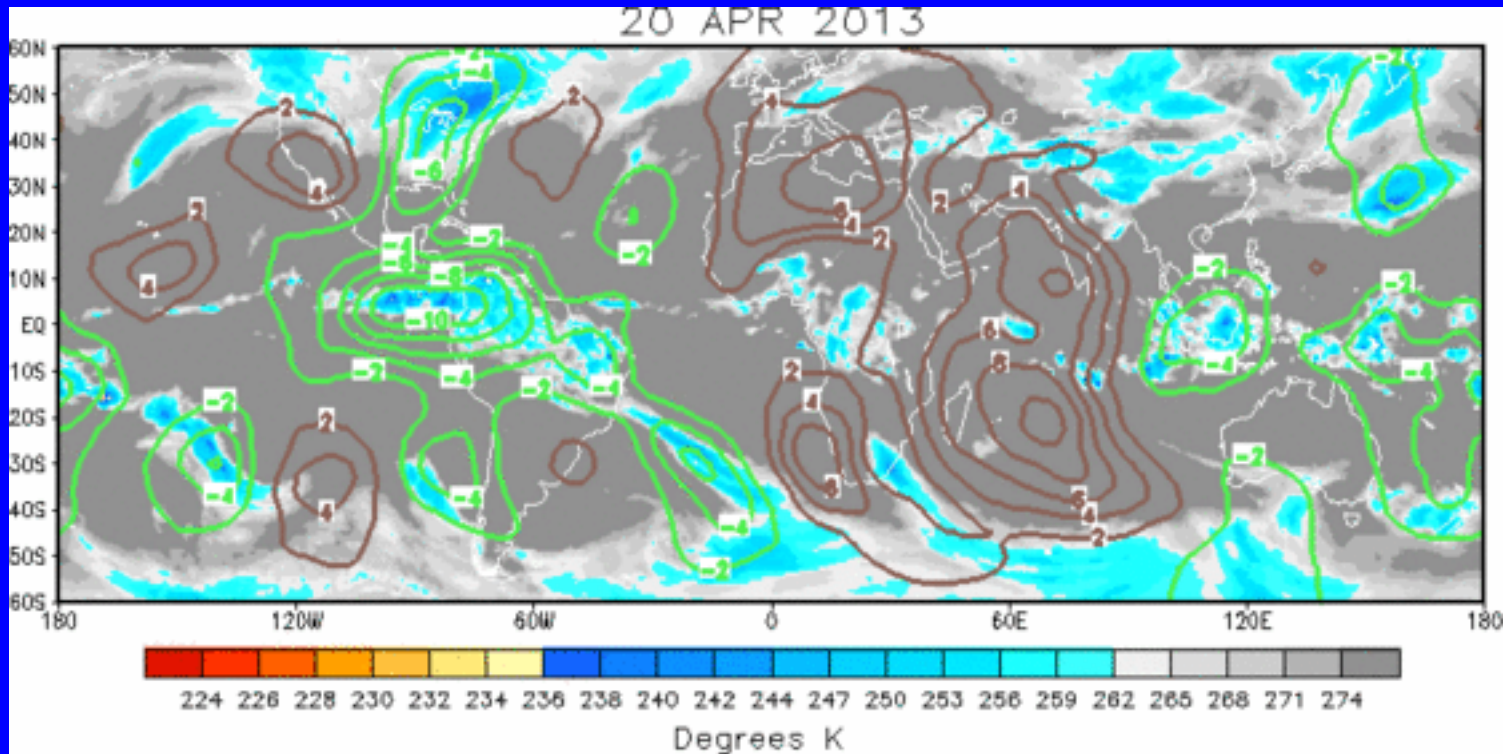
Recently, the velocity potential field has been more consistent with MJO propagation than other observational indicators.



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 shows strong upper-level divergence across the eastern Pacific and northern South America. The strongest upper-level convergence is centered across Africa and the western Indian Ocean. Influence from higher frequency modes of variability can be seen, especially over the Pacific-North America domain.

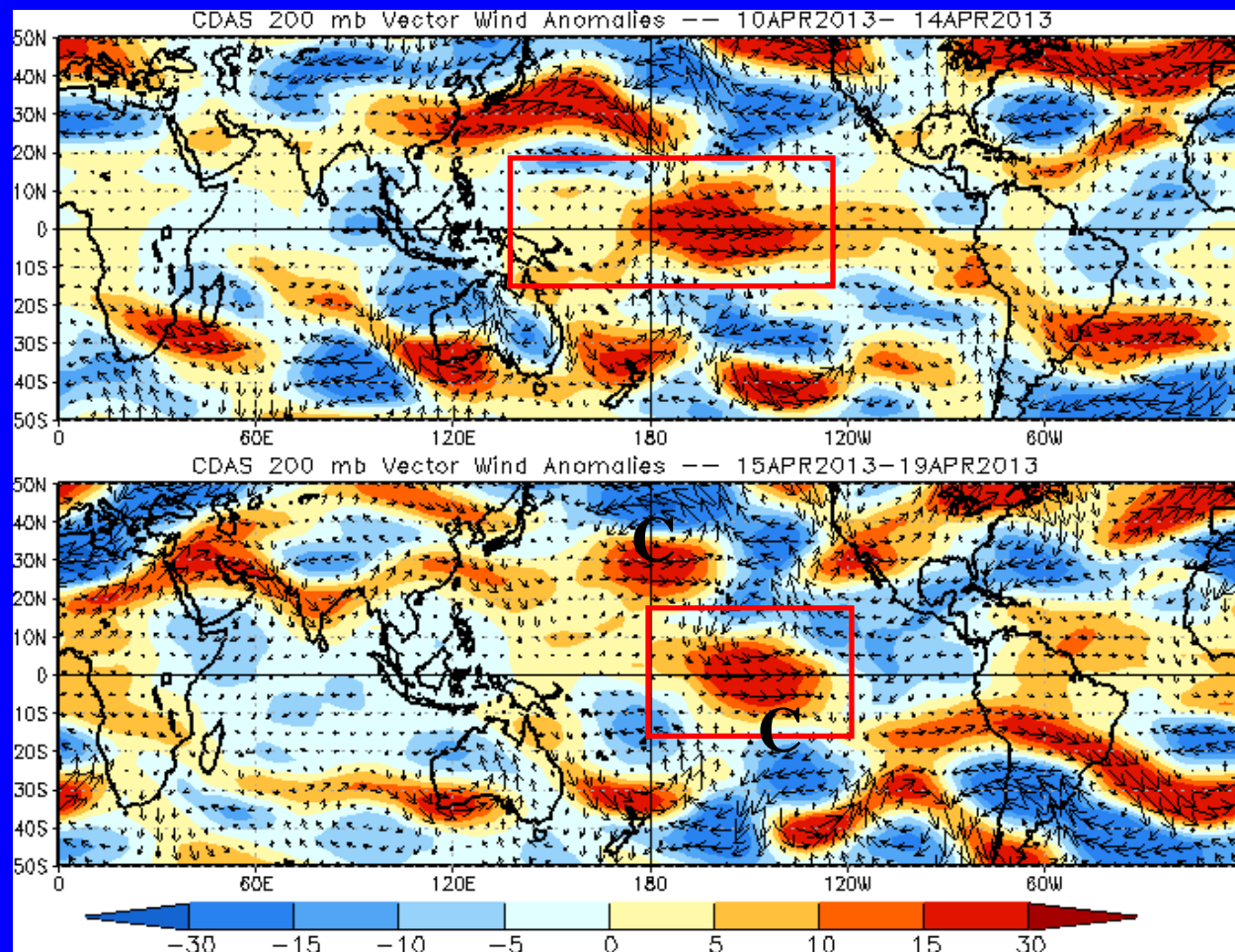


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies (red box) remain across the central equatorial Pacific during the last ten days, while weak anomalies were evident elsewhere along the Equator.

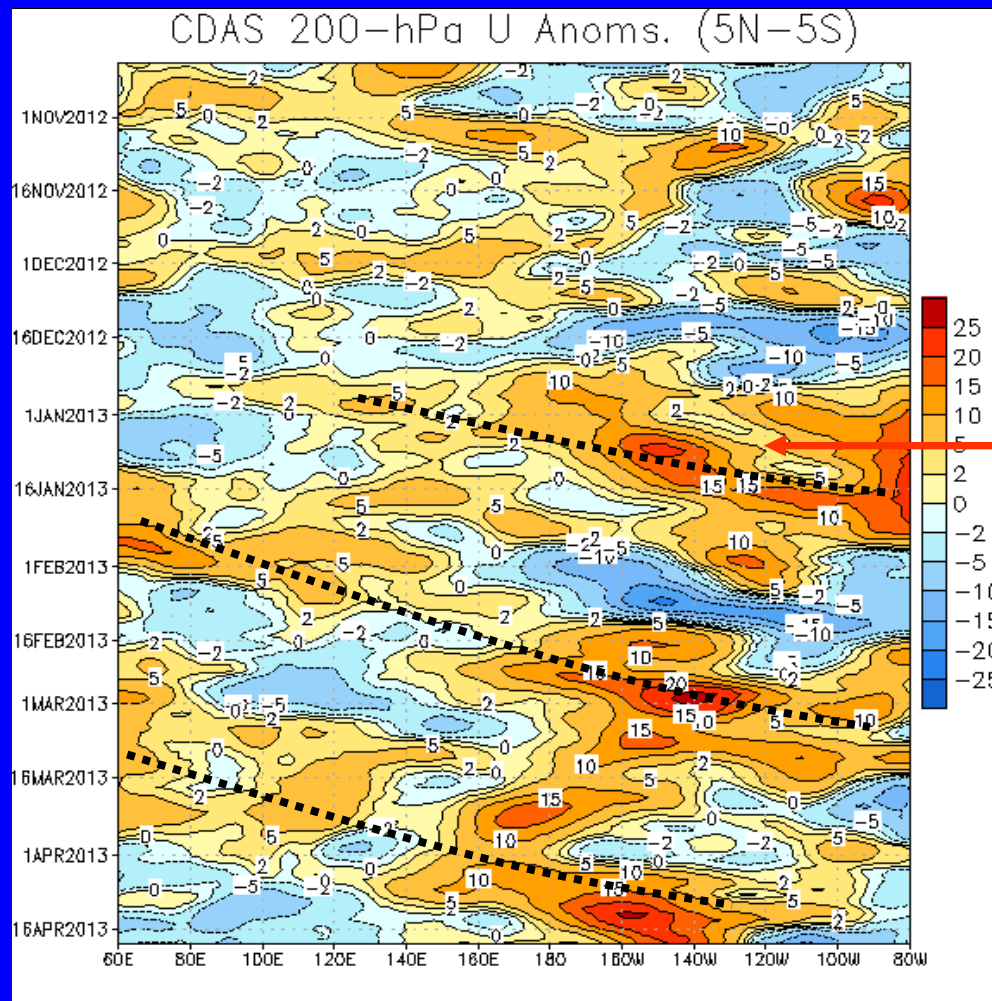
Two cyclonic circulation centers (indicated by 'C') are also evident over the central Pacific. There remains evidence of a jet extension across eastern Asia and the Pacific near 30N.



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

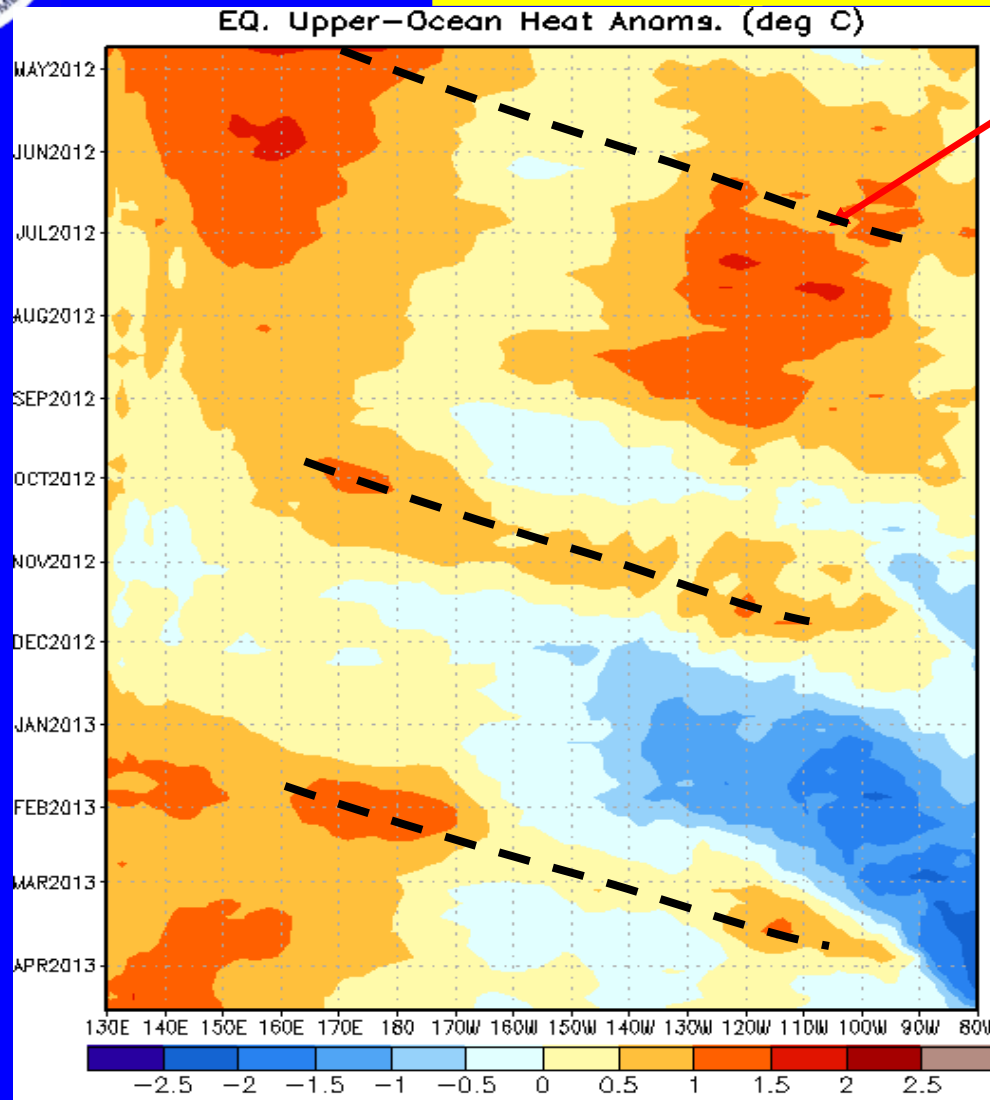


Eastward propagation of westerly wind anomalies associated with the MJO is evident beginning in late December and continuing into March 2013. Some propagation of easterly anomalies is evident during late January and early February.

The anomalies continue to be influenced by westward moving features over the central and western Pacific.



Weekly Heat Content Evolution in the Equatorial Pacific



From March into July 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 have generally persisted through 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.

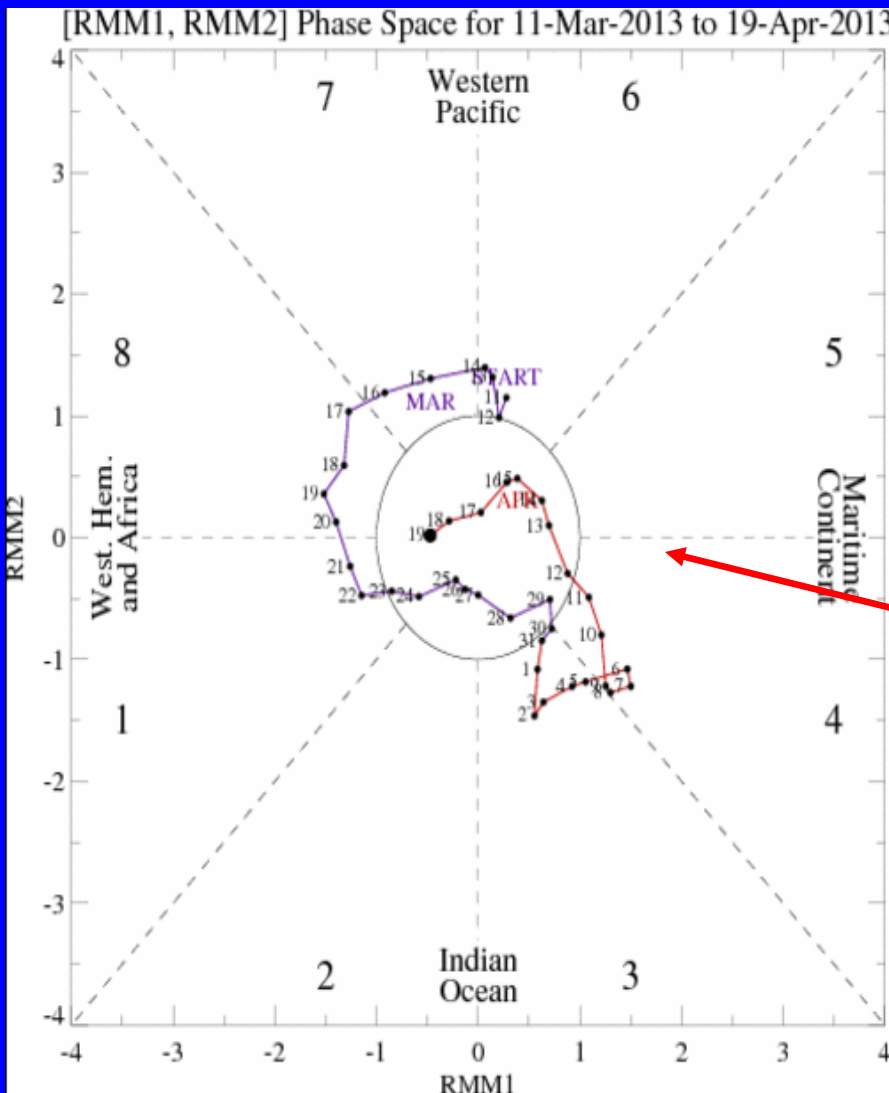
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

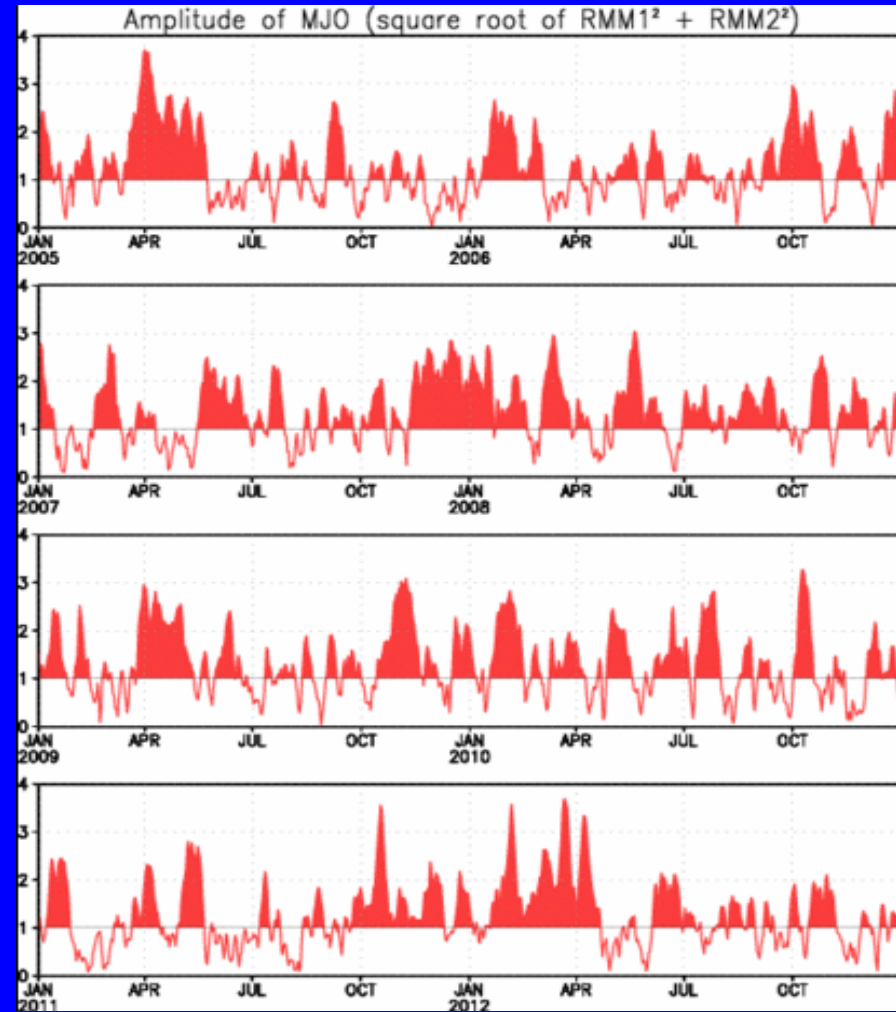
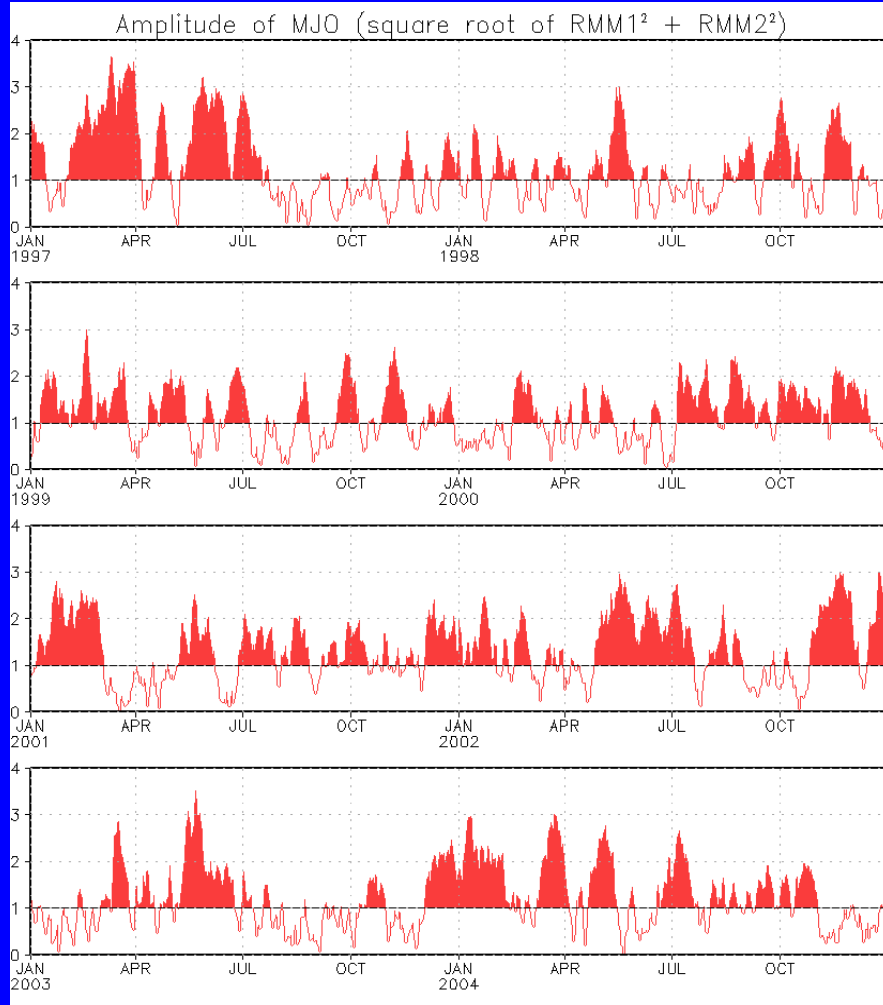


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates rapid eastward propagation of a weak MJO signal during the past week, now centered over the eastern Pacific and South America.



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

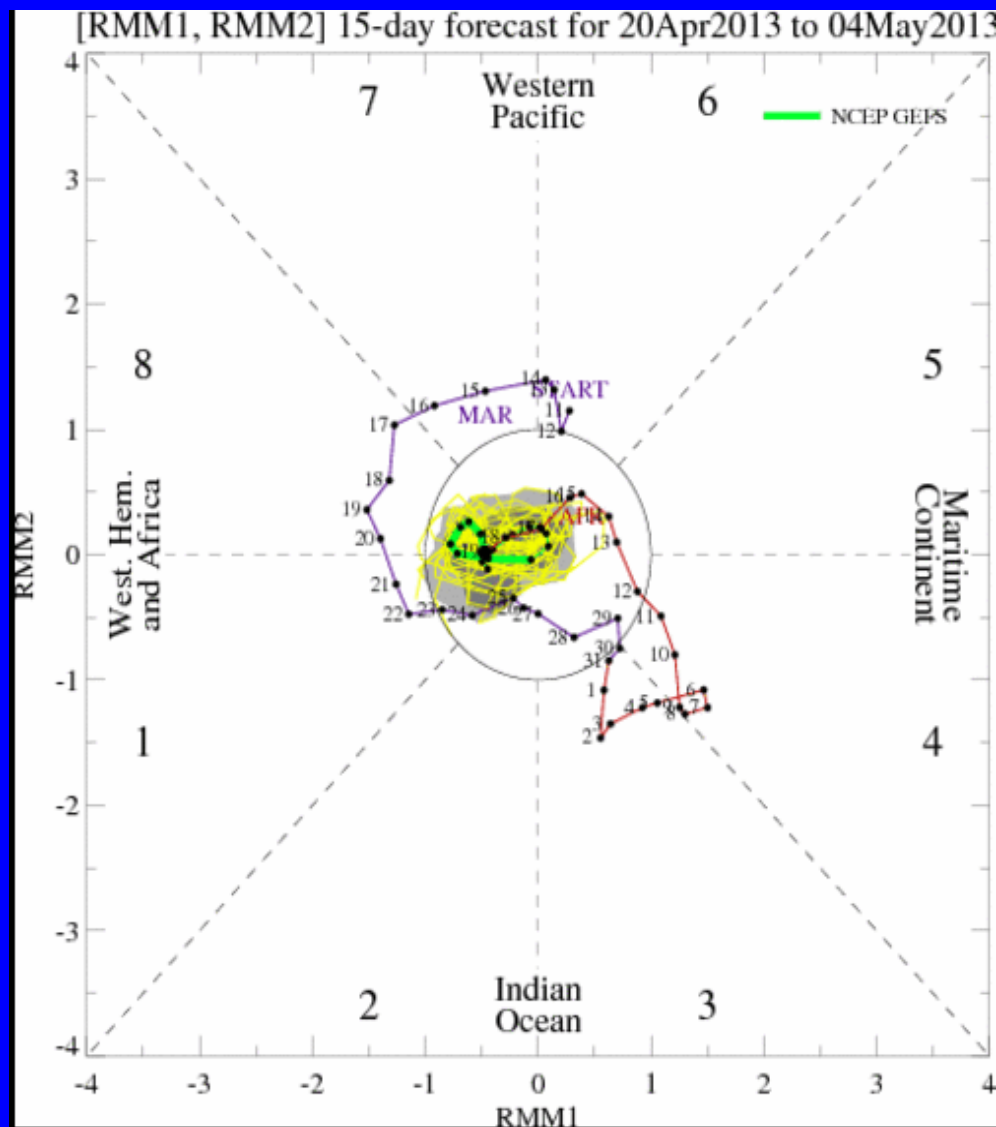
Green Line – Ensemble Mean

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 nearly stationary signal for the next two weeks.

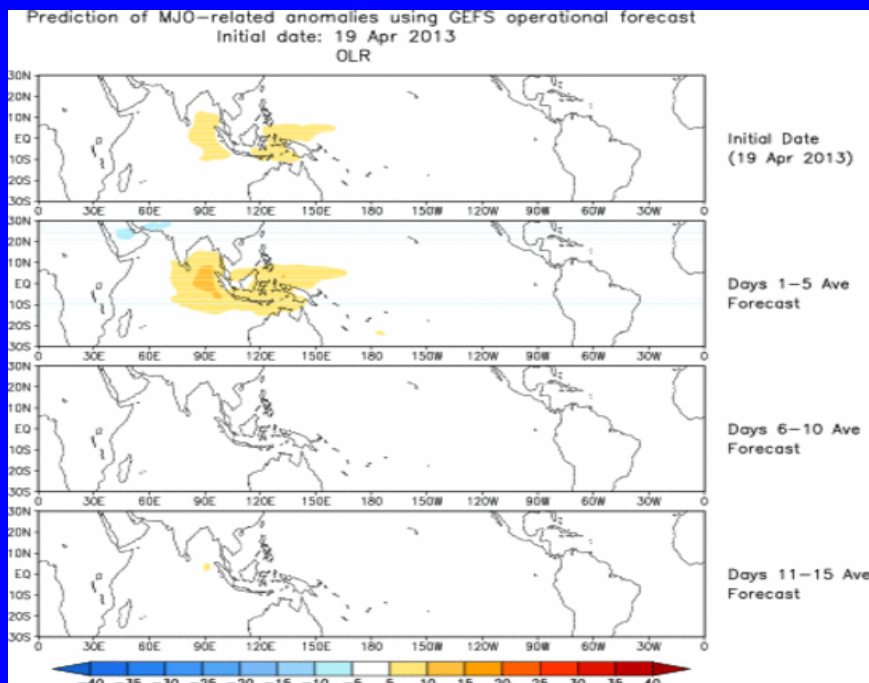




Ensemble Mean GFS MJO Forecast

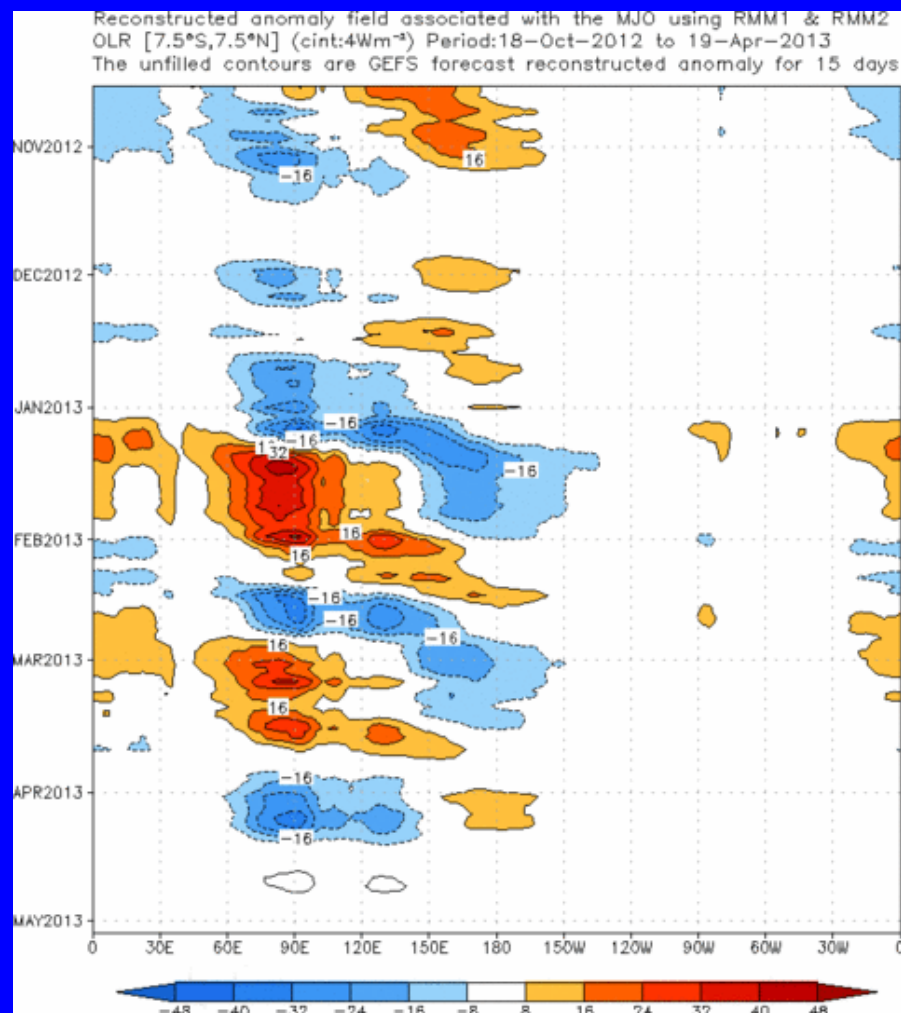
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecasts little to no anomalous convection associated with MJO over the next two weeks.

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

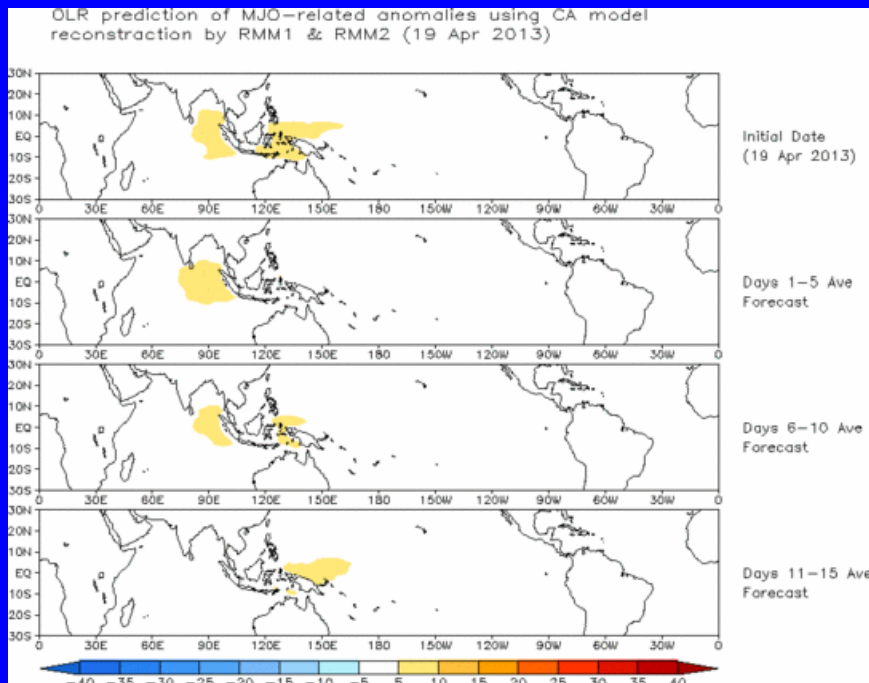




Constructed Analog (CA) MJO Forecast

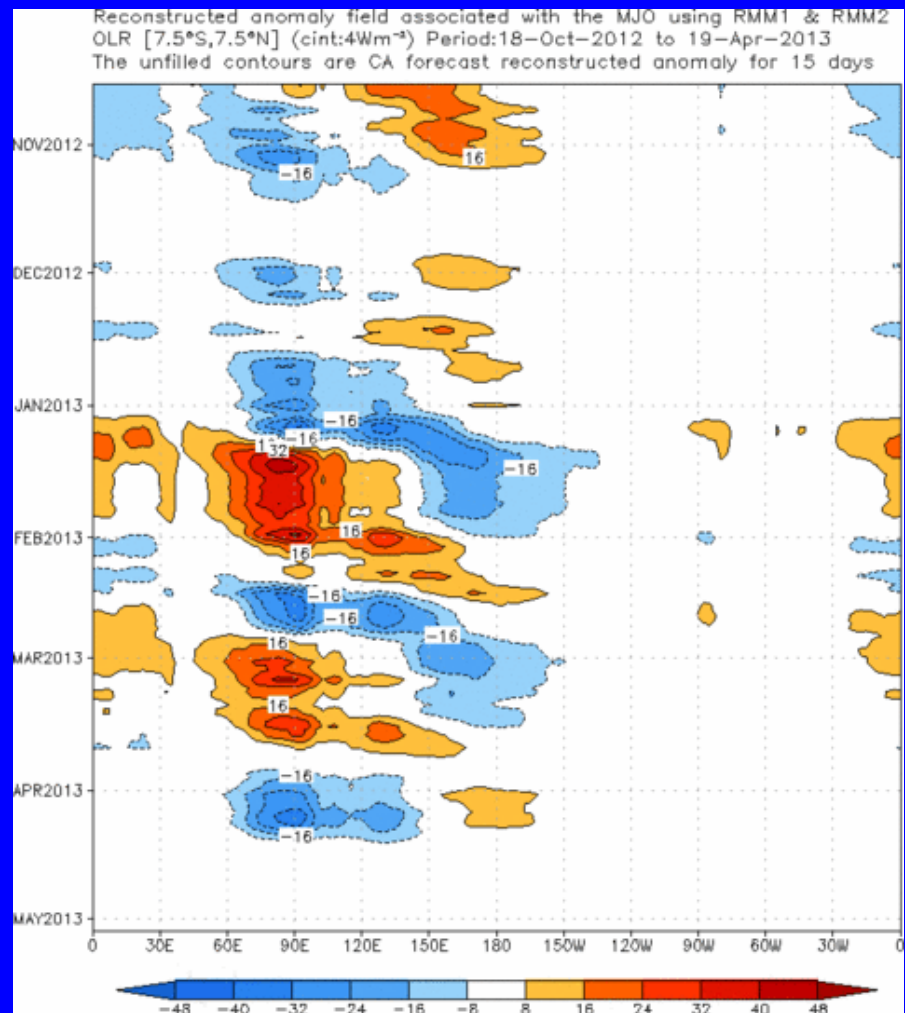
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



This statistical forecast shows some eastward propagation of weakly suppressed convection across the Maritime Continent.

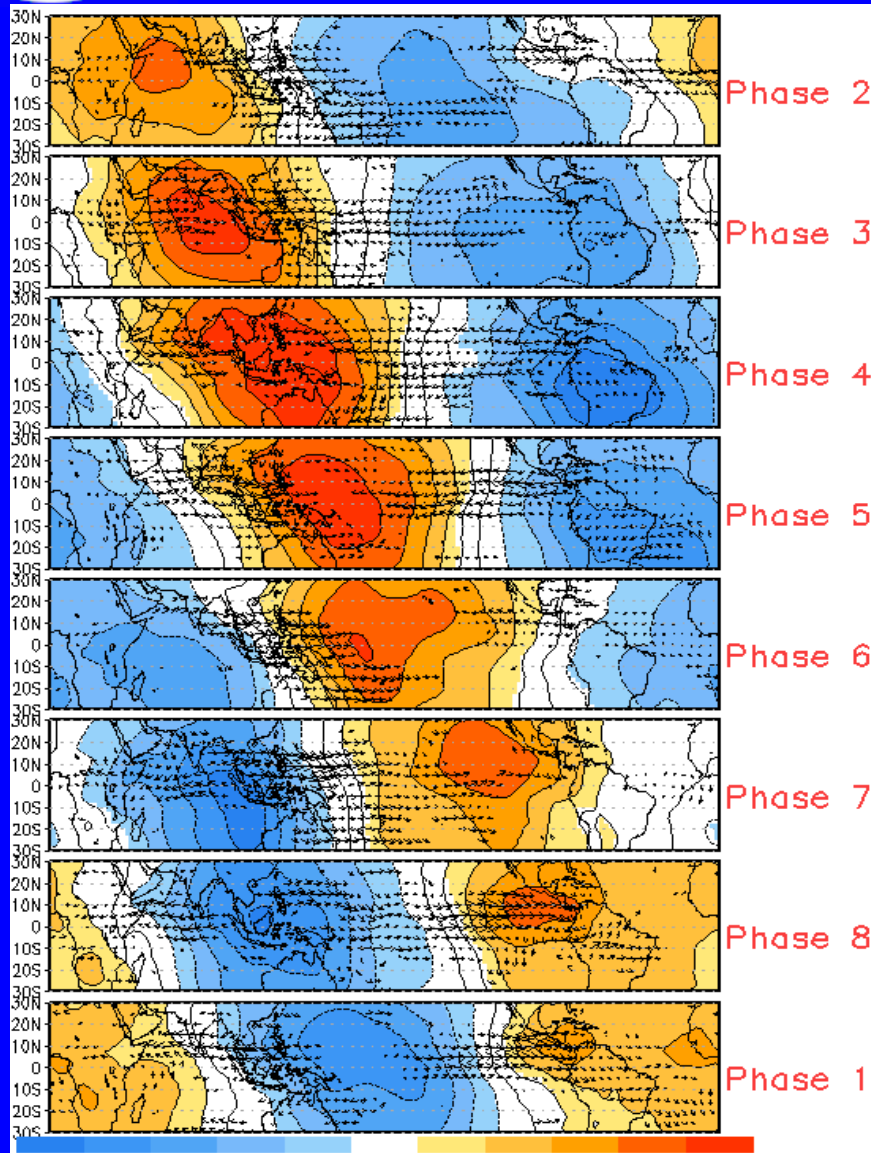
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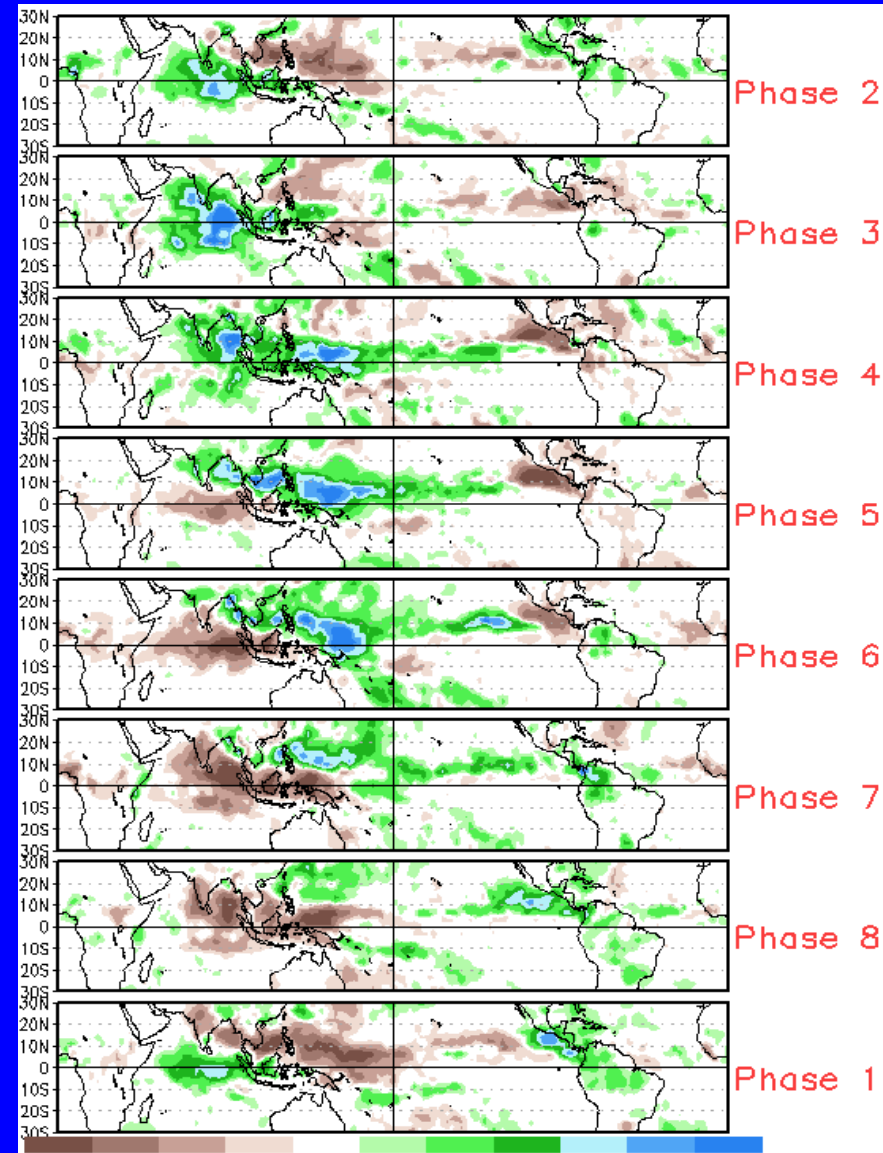


MJO Composites – Global Tropics

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



Precipitation Anomalies (May-Sep)

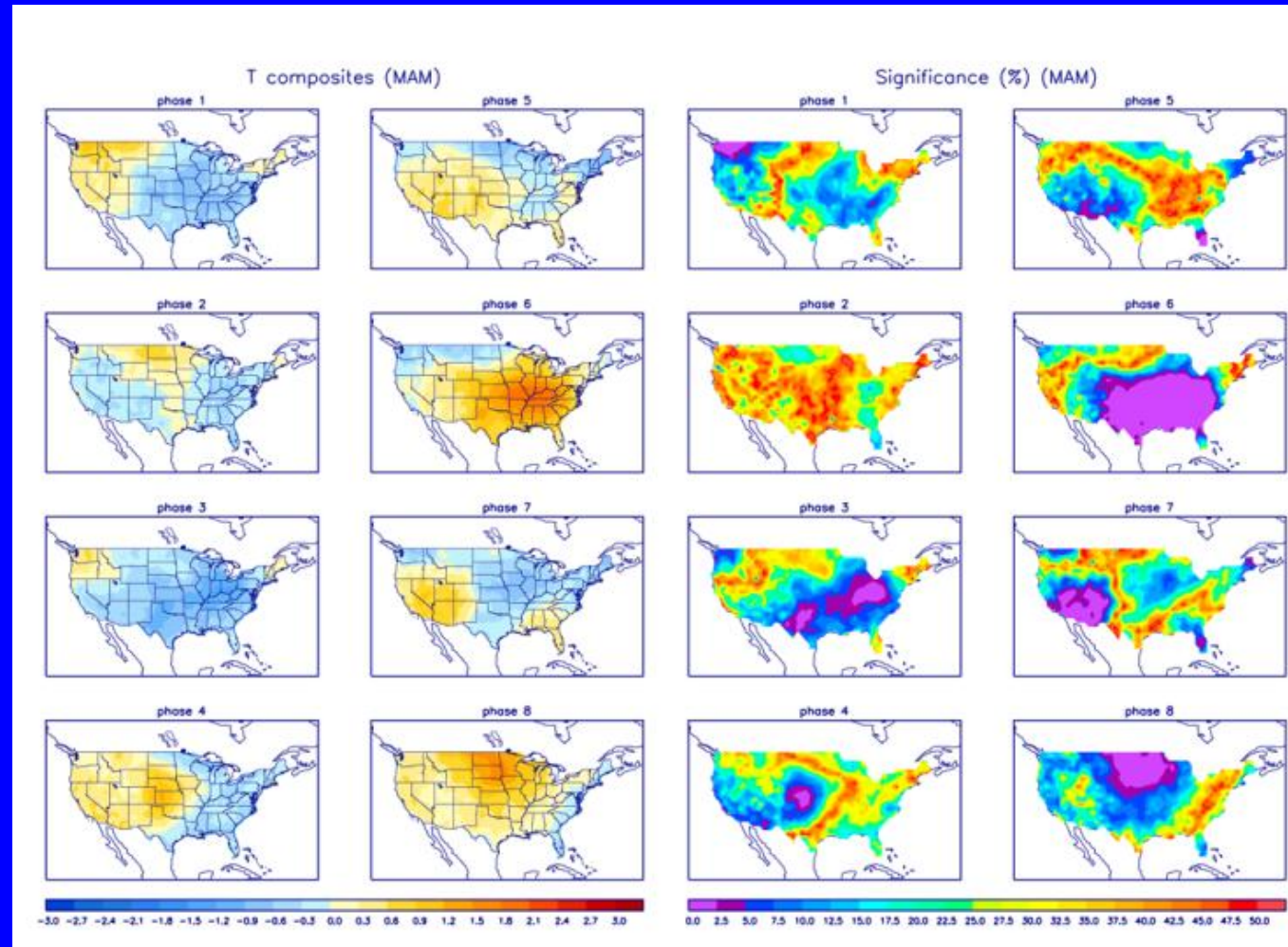




U.S. MJO Composites – Temperature

- 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.



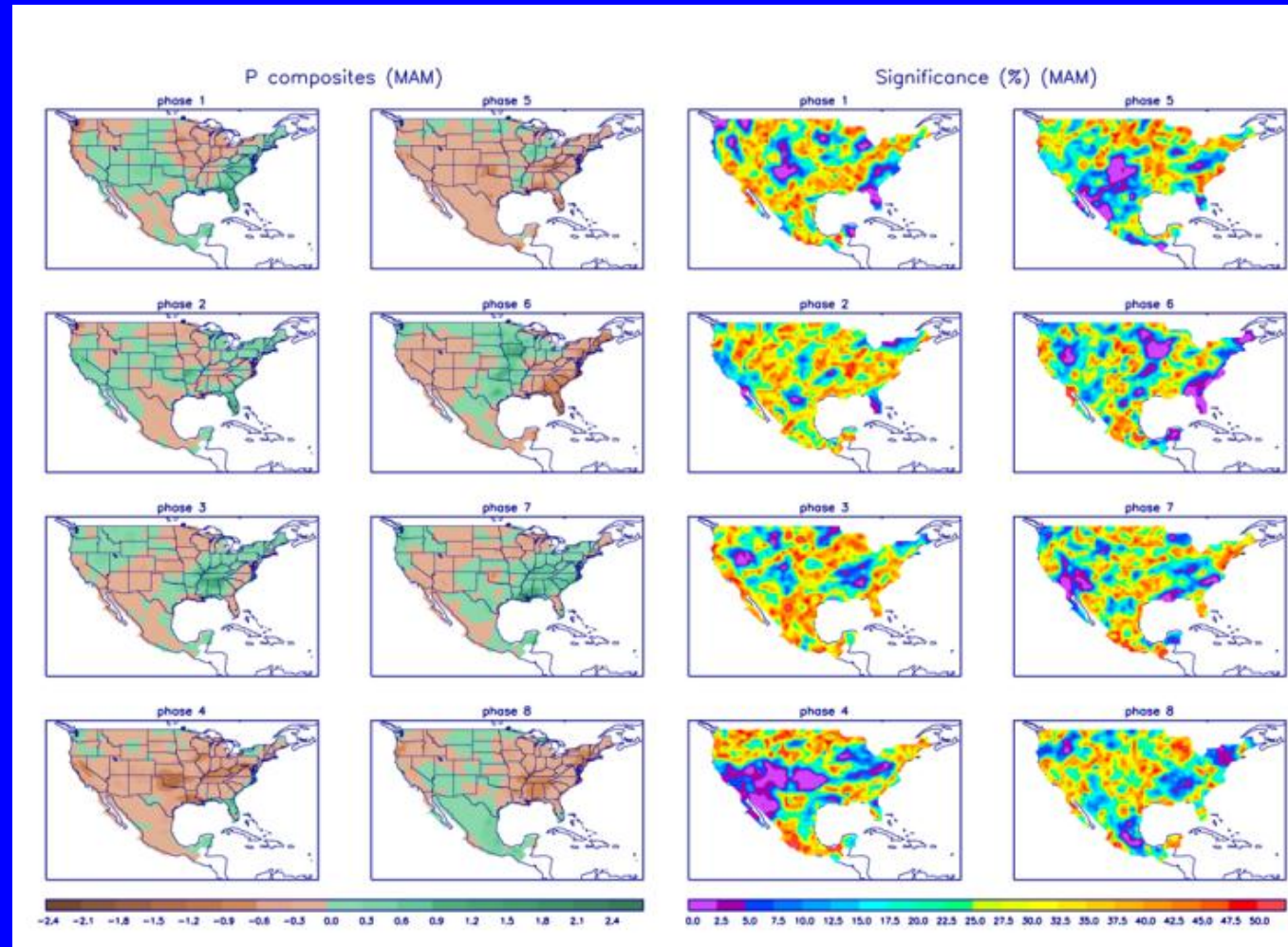
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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

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