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

Update prepared by
Climate Prediction Center / NCEP
May 18, 2015

Outline

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

Overview

- The MJO remained weak over the past week.

- Other types of subseasonal coherent tropical convective variability, primarily atmospheric Kelvin waves continue to be the dominant intraseasonal variability. This along with El Niño conditions continue to influence the pattern of tropical convection.

- Dynamical and statistical models generally predict weak MJO activity over the next two weeks.

- The MJO is not expected to play a substantial role in the pattern of tropical convection during the next two weeks. The low frequency ENSO state, modulated by more transient features such as atmospheric Kelvin wave activity, is anticipated to remain the dominant factor in the global tropical convective pattern.

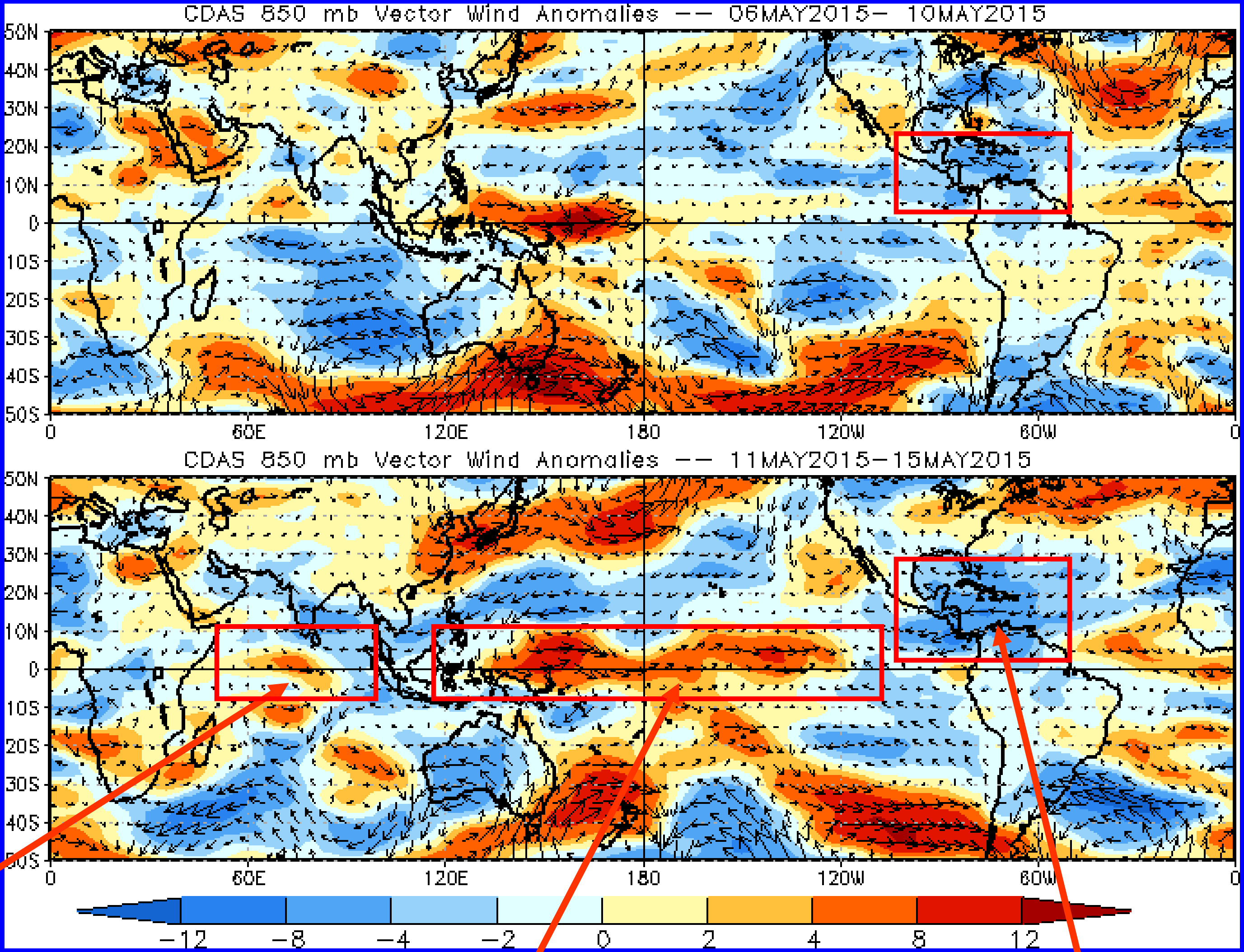
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Weak anomalies were observed on the equator over the Indian Ocean.

Westerly anomalies increased in strength across the central Pacific and continued over the far western Pacific.

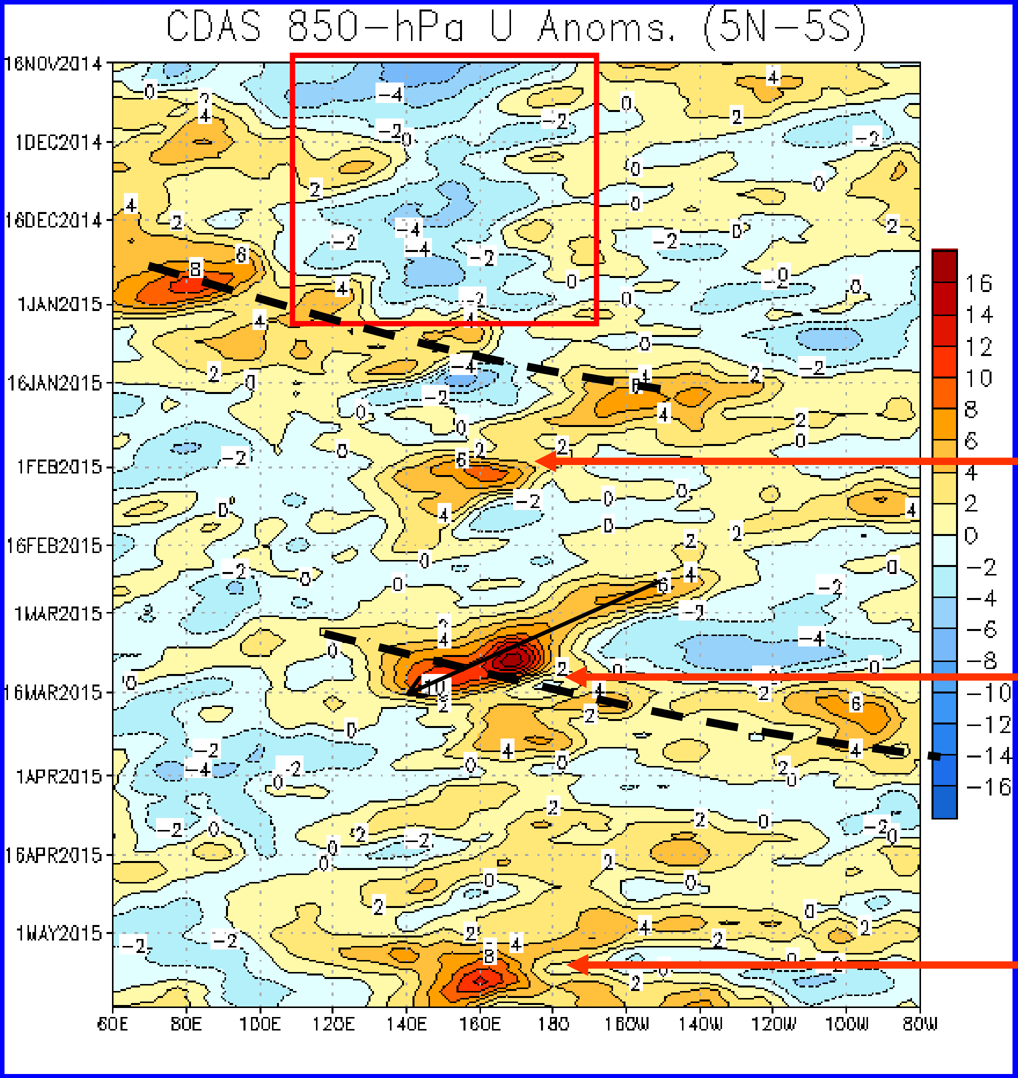
Strong easterly anomalies continued across the Caribbean and central America.

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 November and December, easterly anomalies were persistent from 120E to near the Date Line (red box).

Westerly anomalies associated with the MJO propagated eastward (dashed line) during the first half of January. Westerly anomalies returned to the Western Pacific during late January and early February.

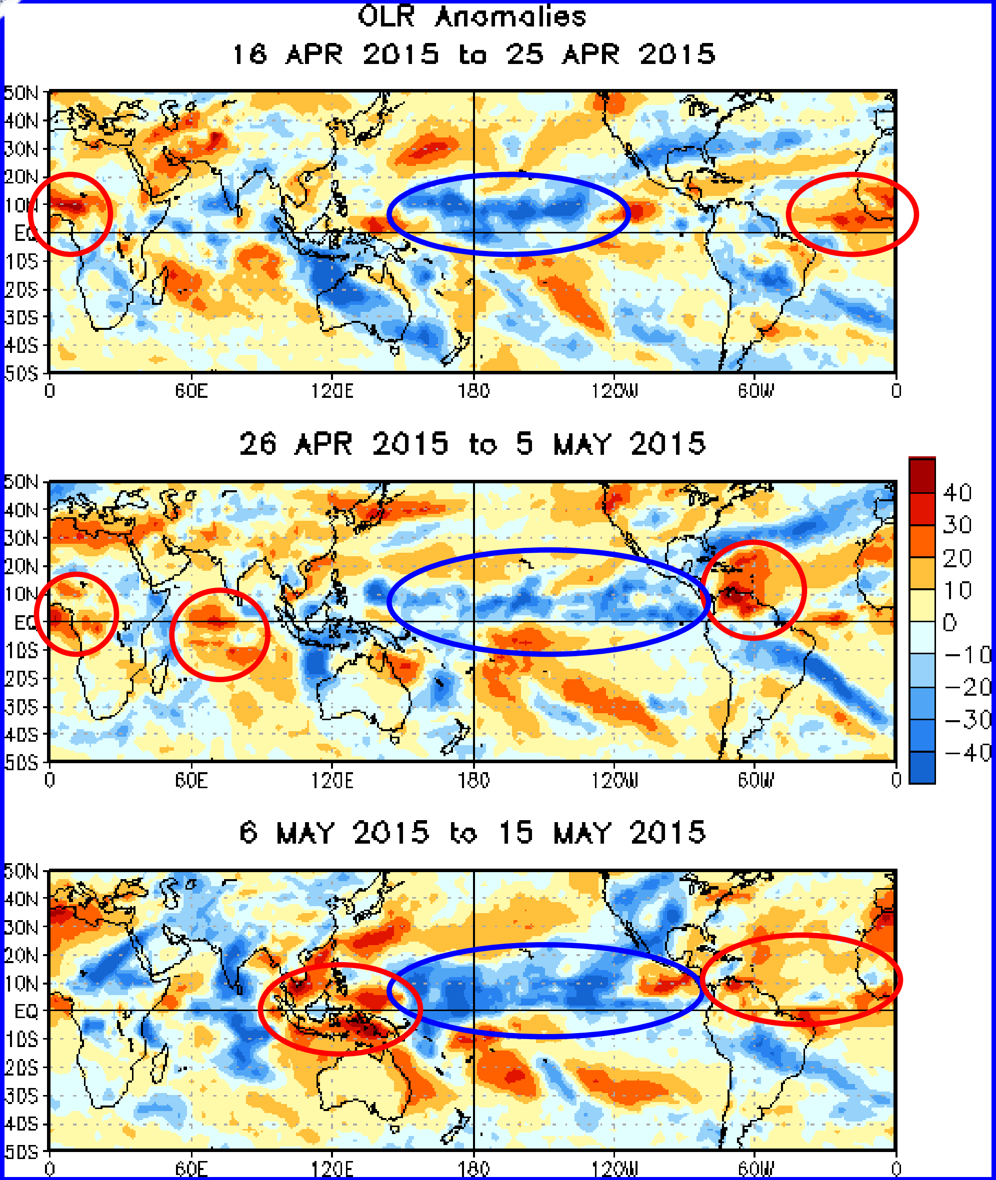
Strong westerly anomalies associated with the MJO, an equatorial Rossby wave (ERW) and El Nino base conditions resulted in strong westerly anomalies propagated west of the Date Line during early March.

During April and May, westerly anomalies expanded over much of the central and 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)



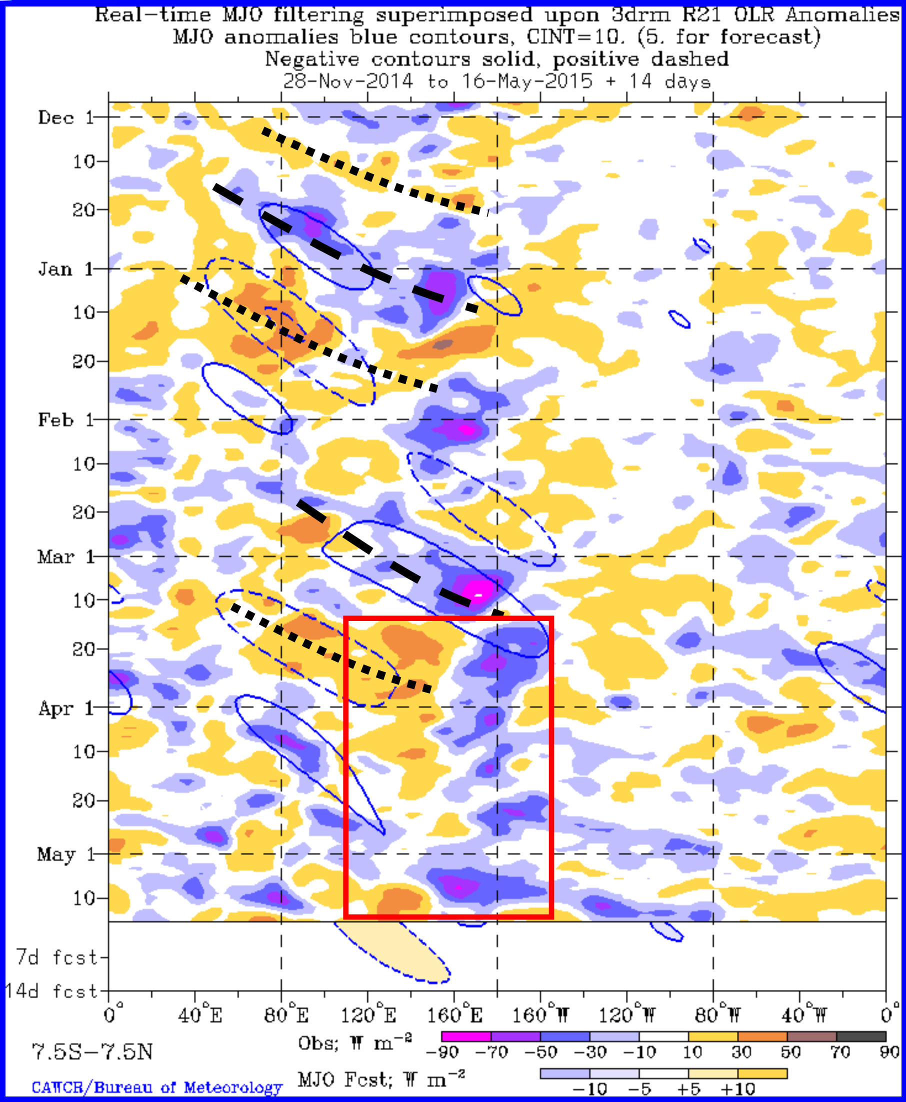
From mid- to late April, enhanced convection (blue oval) was observed across the western and central Pacific associated with El Nino. Suppressed convection (red oval) was observed over western Africa.

Enhanced convection continued across the central Pacific during late April and early May while suppressed convection was observed across the tropical Atlantic, western Africa, and the Indian Ocean.

Enhanced convection across the Pacific basin increased in coverage and strength during the first half of May with extratropical connections evident. Suppressed convection was observed across the Maritime continent, tropical Atlantic and northern South America.

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 strengthened in late November with alternating areas of enhanced/suppressed convection moving from the Indian Ocean to the Date Line through mid-January.

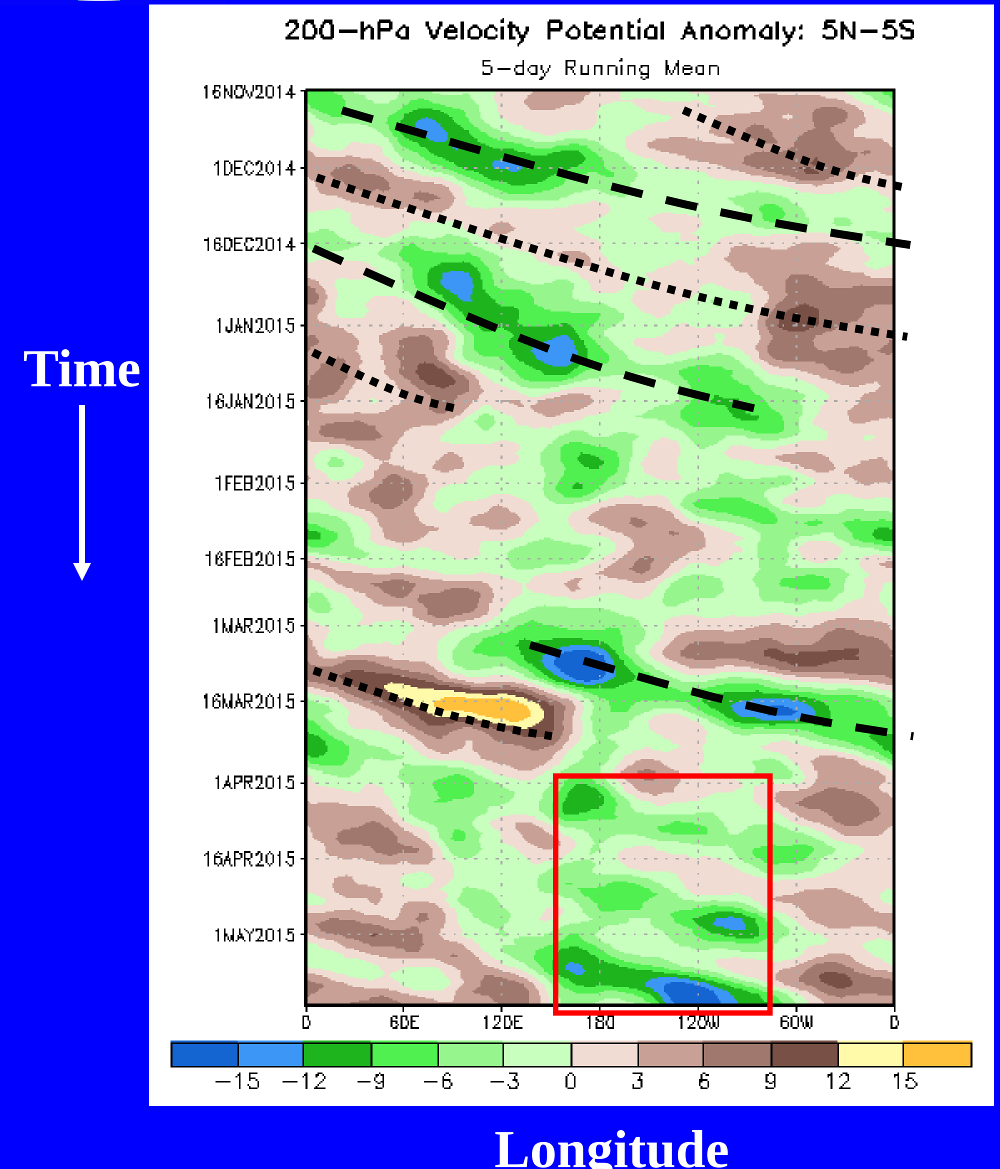
The MJO became active and strong during March, with eastward propagation of enhanced (suppressed) anomalies evident across the Pacific (Indian Ocean and Maritime Continent).

Since late March enhanced (suppressed) convection has dominated near the Date Line (Maritime Continent) (red box), consistent with El Niño conditions. Kelvin wave activity has impacted the area east of 140W.

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



Beginning in November and continuing into January 2015, the MJO strengthened as indicated by eastward propagation of alternating anomalies. At times, the signal was dominated by faster-moving variability (likely Kelvin Wave activity).

The signal was weak much of January and during February.

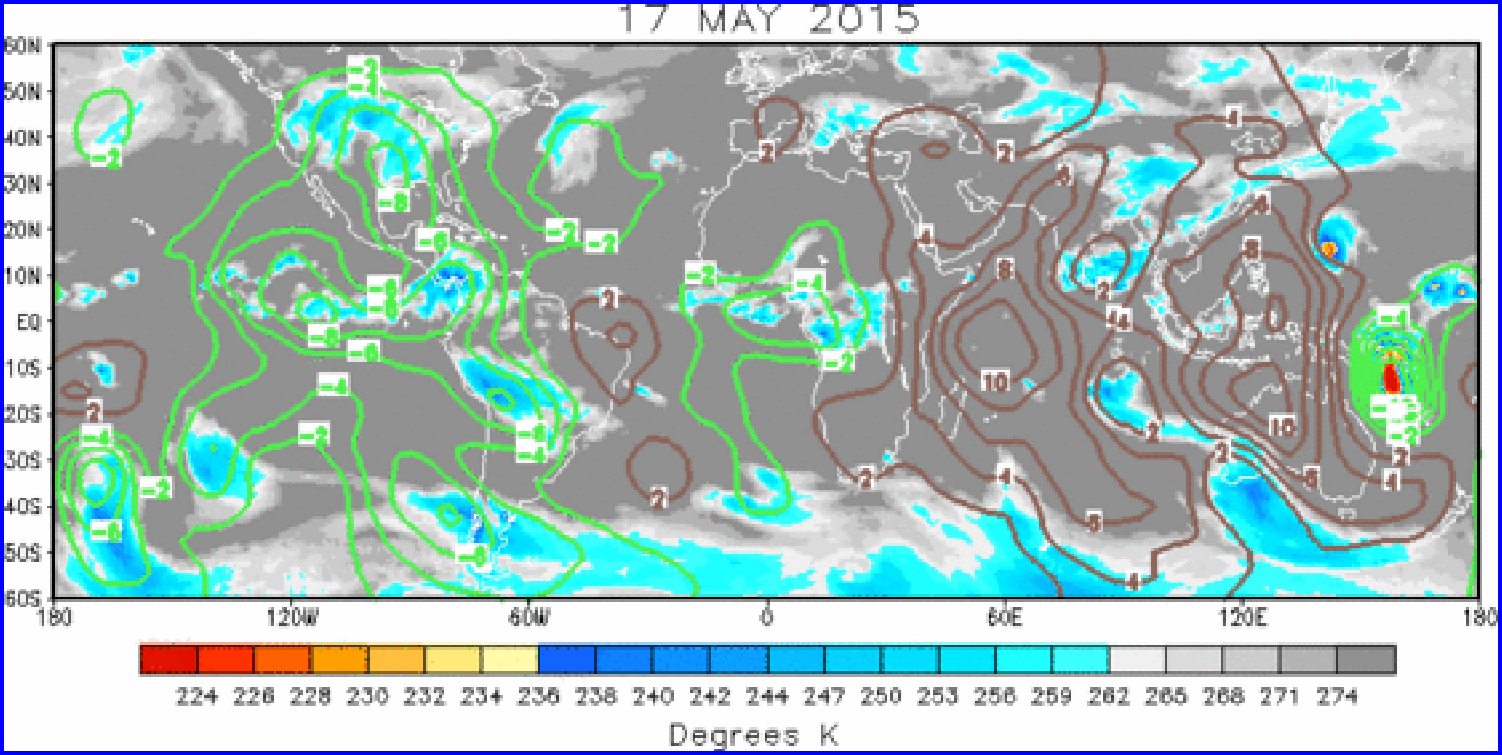
During March, eastward propagation of a strong anomaly couplet was observed, with negative (positive) anomalies propagating over the Western Hemisphere (Maritime Continent and far West Pacific).

Negative anomalies persisted near the Date Line and to the east since early April due to the low-frequency base state. During this time, Kelvin wave activity (fast eastward propagation) has been the primary subseasonal variability evident.

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 spatial pattern of velocity potential anomalies reflects the combination of El Nino conditions and a strong atmospheric Kelvin wave. Upper-level divergence is evident across the eastern Pacific and Americas associated with the enhanced phase of the Kelvin wave. located across the Americas.

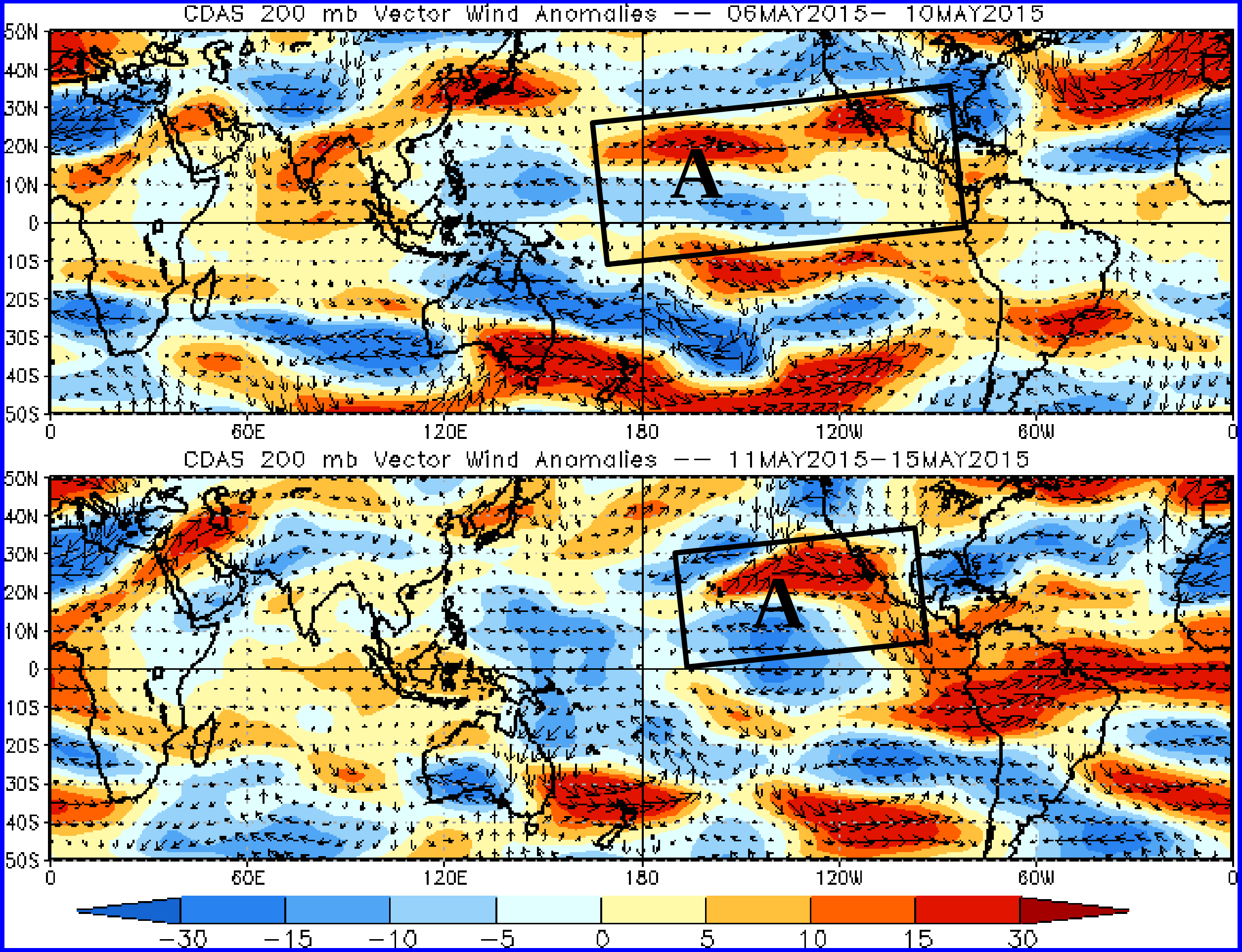
Upper-level convergence is shown across the Indian Ocean and Maritime continent.

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



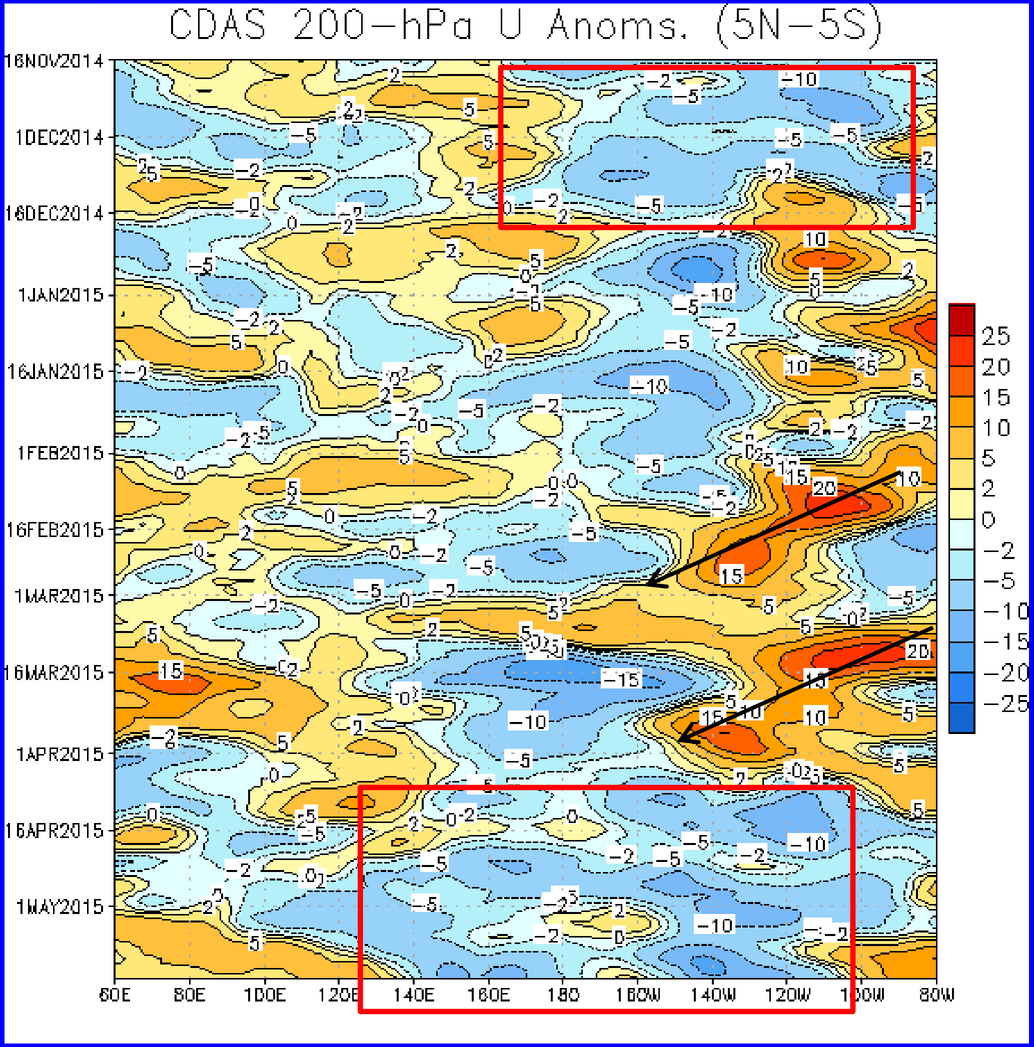
Anomalous ridging continues over the subtropical central and eastern Pacific, consistent with El Niño conditions. This anomalous circulation has allowed moisture to impact the continental U.S. at times during the period.

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

Easterly wind anomalies persisted east of the Date Line from late October through early December (red box).

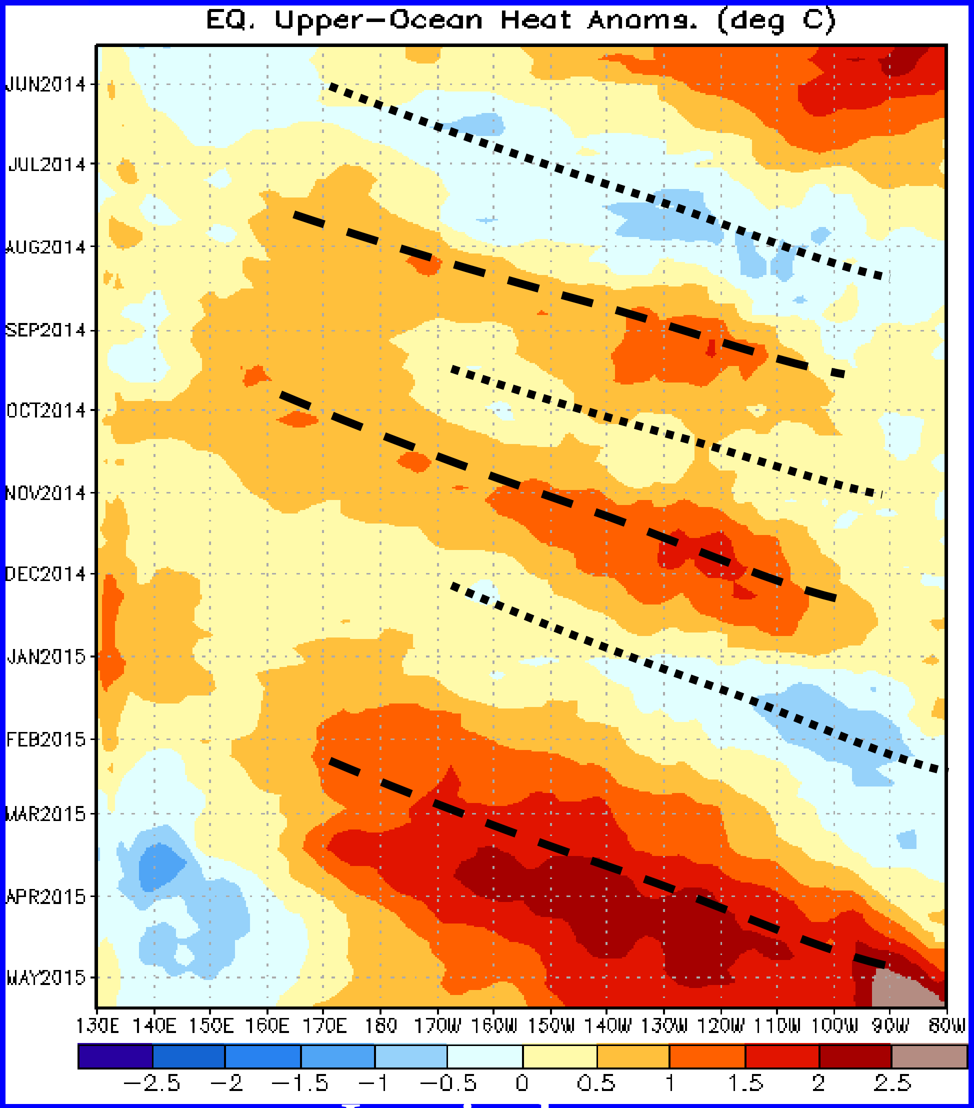
During late December through the mid-April, westerly anomalies increased in coverage and intensity from 120W to 80W.

Westward propagation of westerly anomalies was evident over the eastern Pacific during late February and again in March (black arrows).

Recently, easterly anomalies have generally persisted over the central and eastern Pacific (red box) consistent with El Nino.

Weekly Heat Content Evolution in the Equatorial Pacific

Time



Longitude

Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

The upwelling phase of a Kelvin wave went through during May-July.

During October-November, positive subsurface temperature anomalies increased and shifted eastward in association with the downwelling phase of a Kelvin wave.

During November - January, the upwelling phase of a Kelvin wave shifted eastward.

During January through April, another downwelling phase of a Kelvin wave pushed eastward.

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).

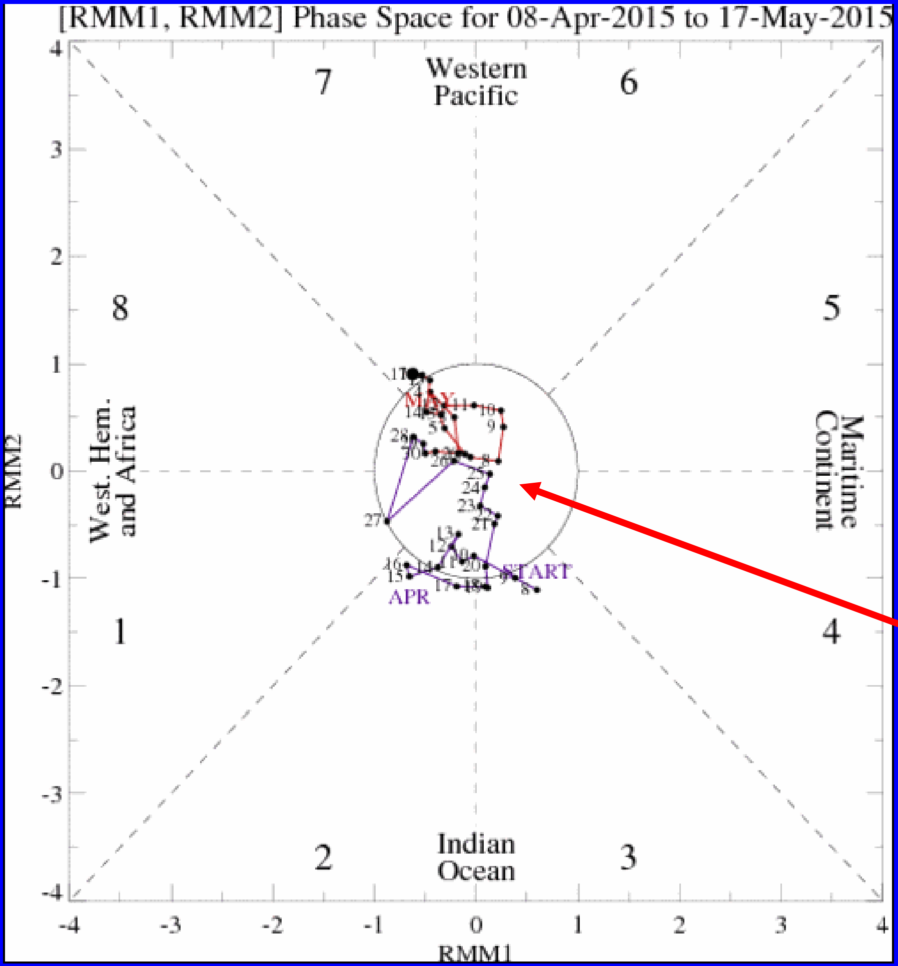
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

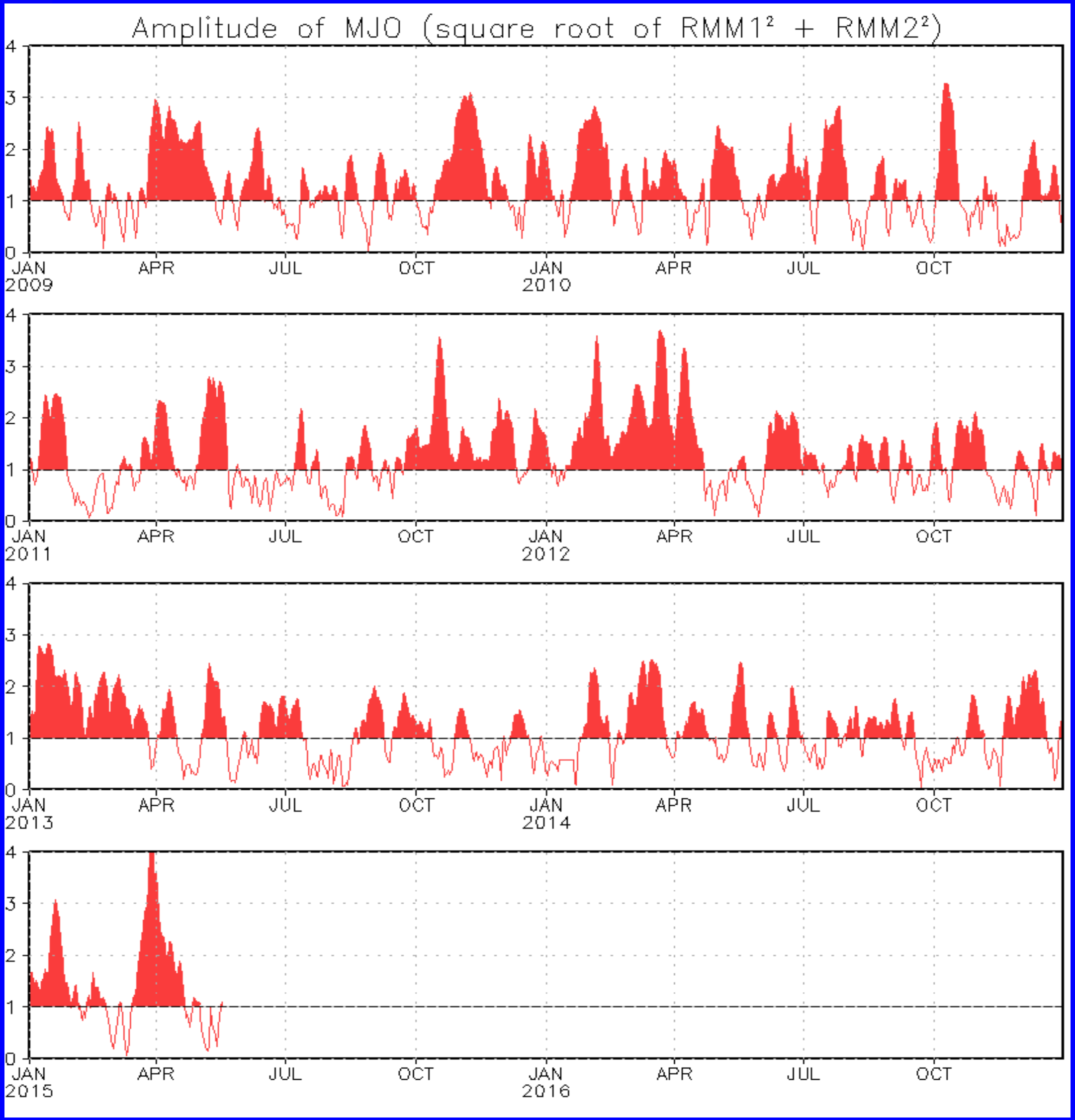
MJO Index -- Recent Evolution



- 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 continued to indicate weak or incoherent MJO activity.

MJO Index – Historical Daily Time Series



Time series of daily MJO index amplitude from 2007 to present.

Plot puts current MJO activity in recent historical context.

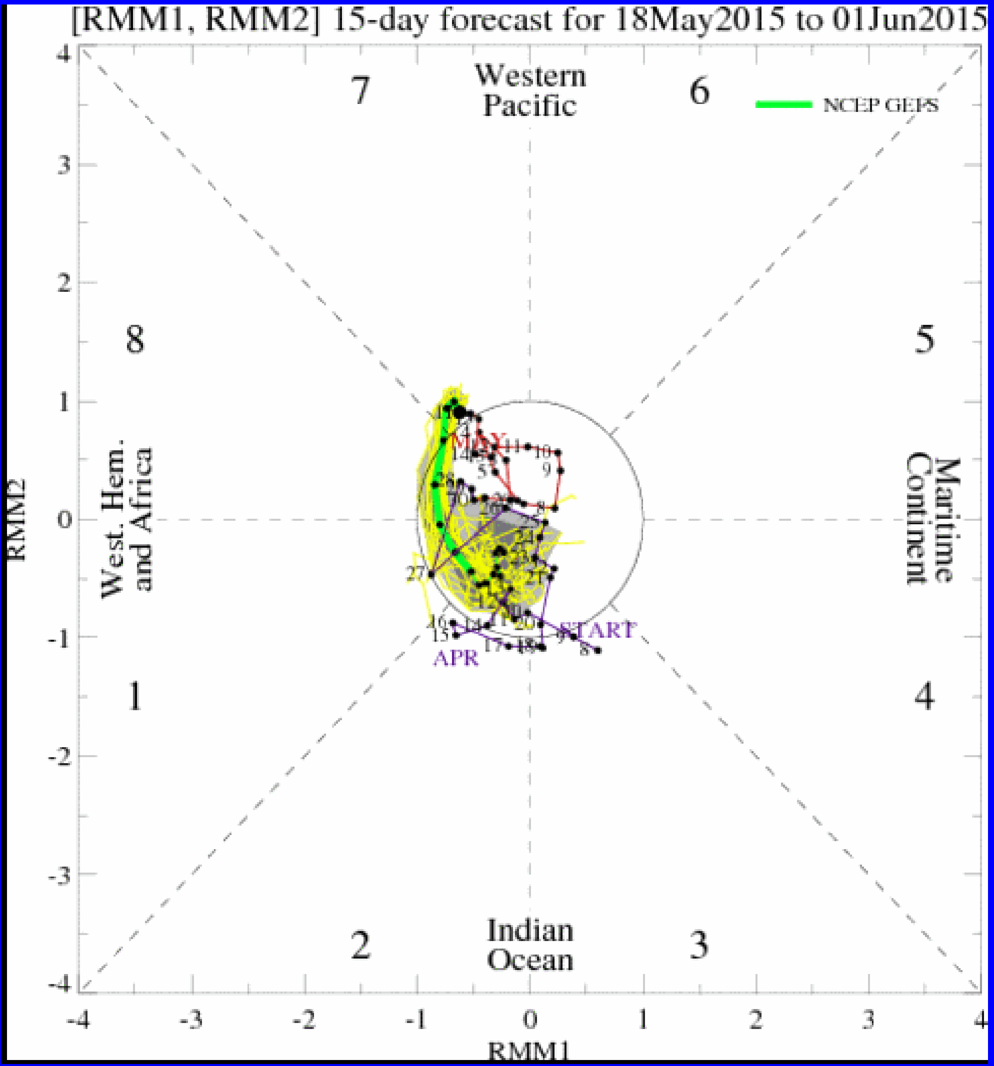
Ensemble GFS (GEFS) MJO Forecast

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

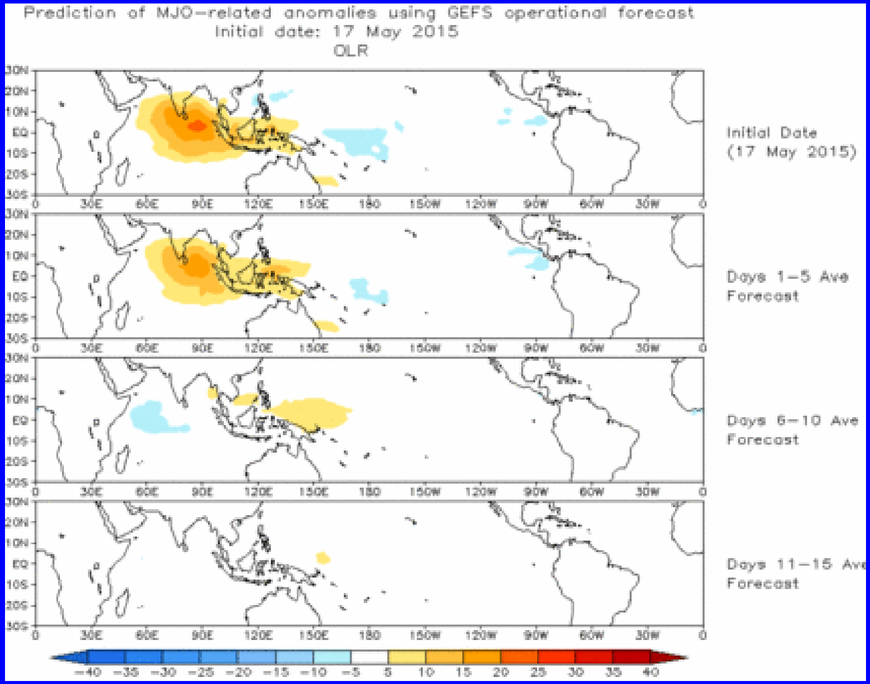
The GFS ensemble MJO index forecast depicts continued weak activity during the next two weeks.



Ensemble Mean GFS MJO Forecast

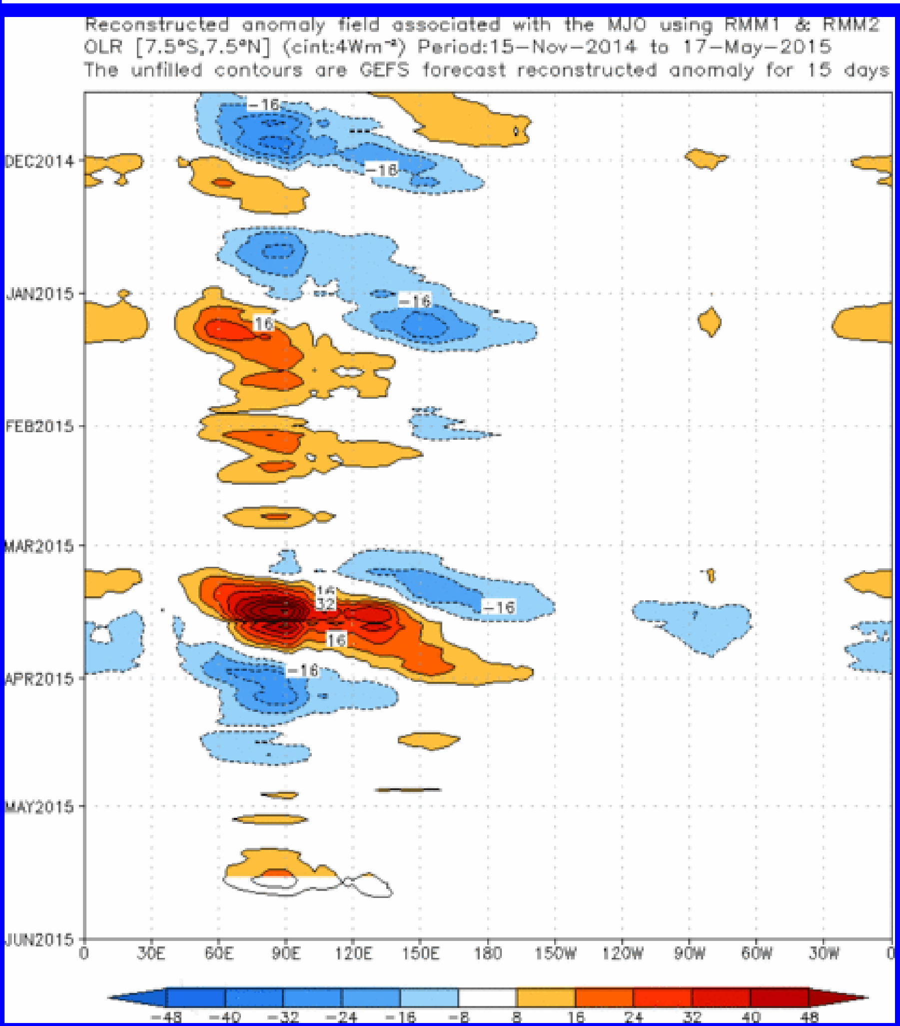
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS MJO index based OLR anomalies forecast shows weak anomalies over the next two weeks.

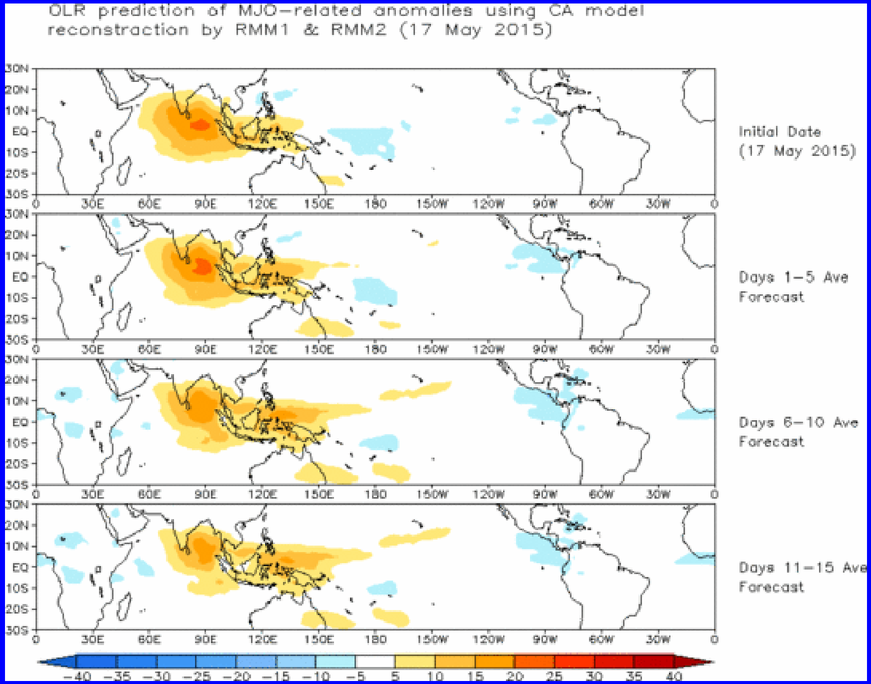
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



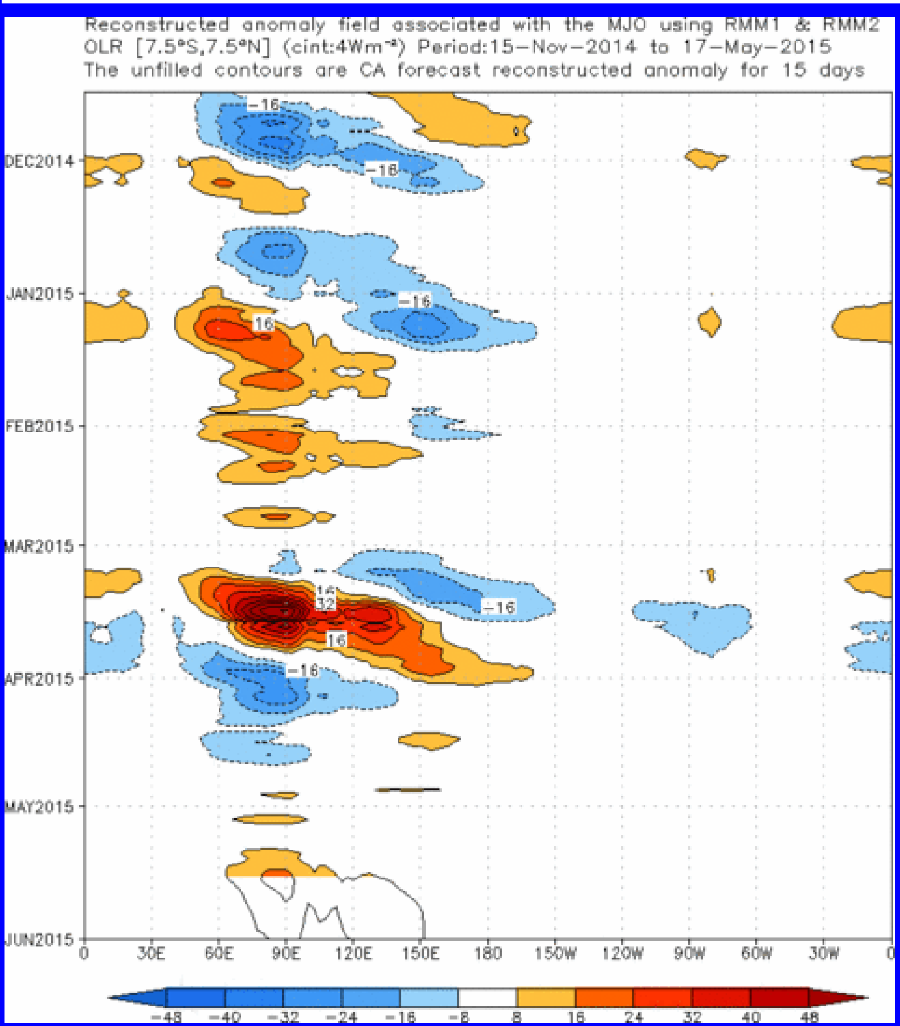
Constructed Analog (CA) MJO Forecast

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



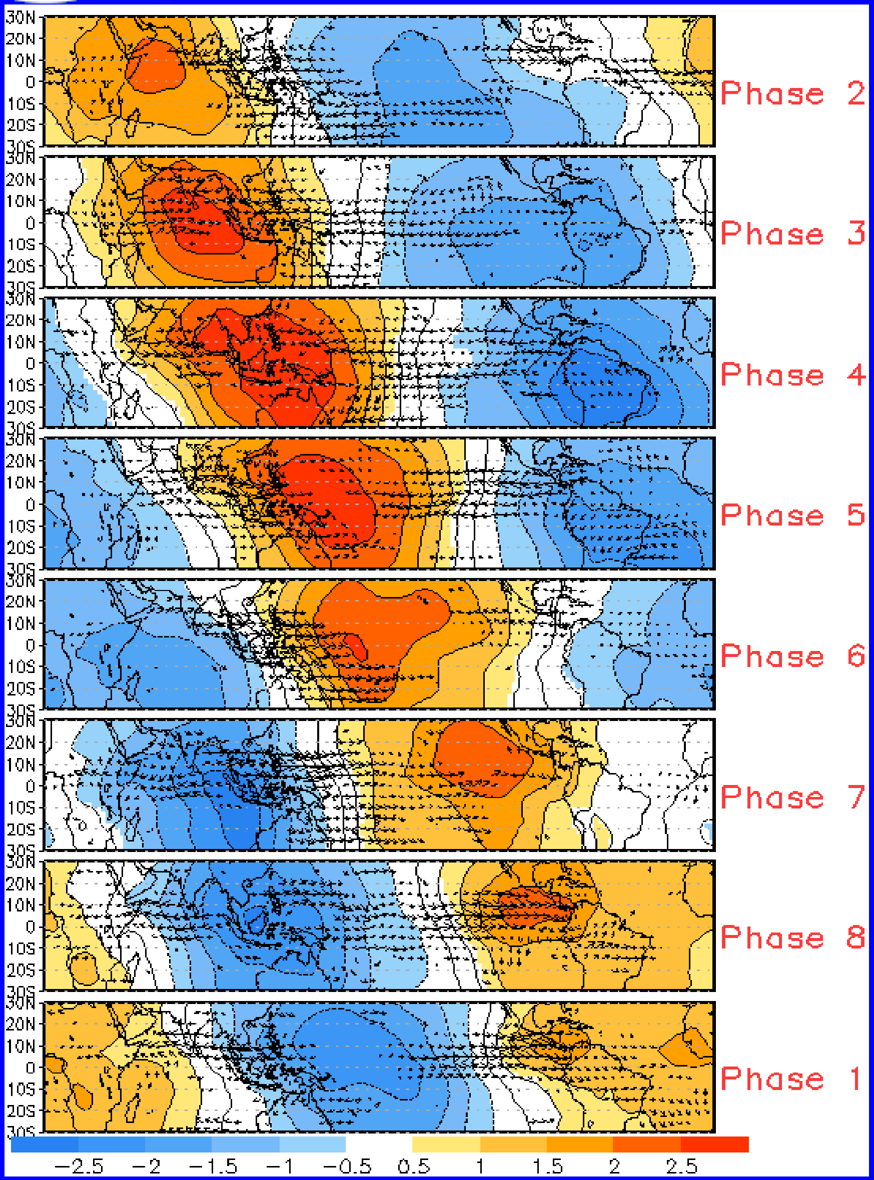
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



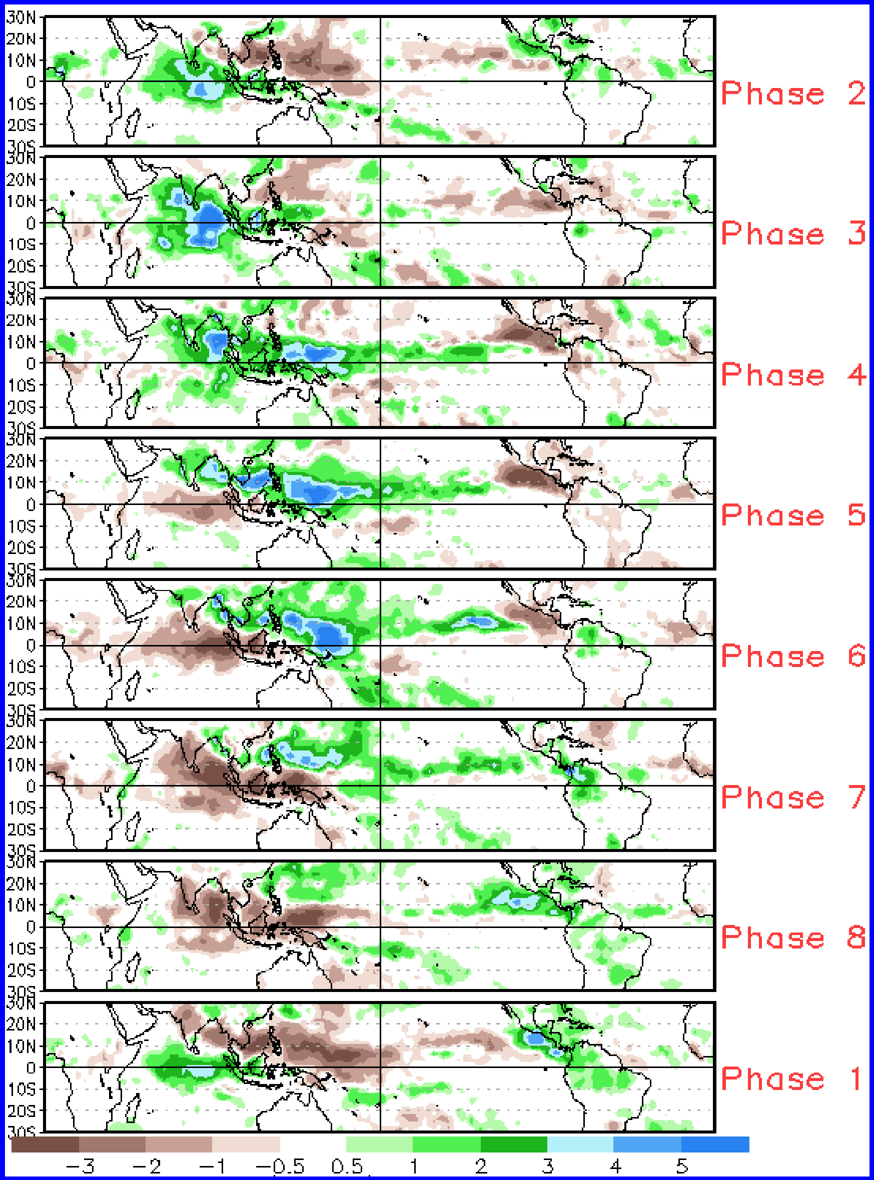
The statistical forecast generally depicts a persistent weak signal during the next two weeks with suppressed (enhanced) convection over the Indian Ocean and Maritime continent (eastern Pacific and Americas).

MJO Composites – Global Tropics

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

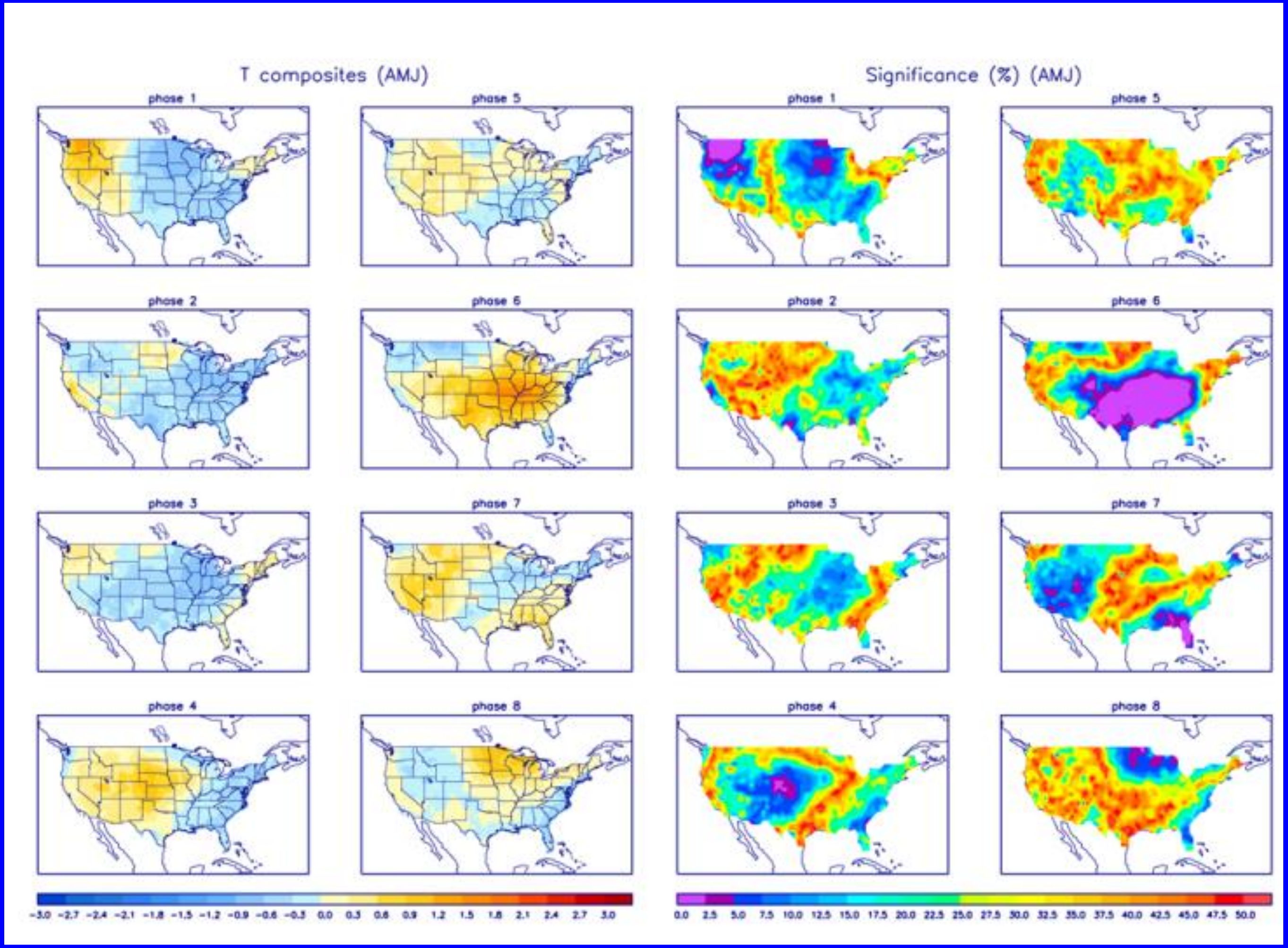


Precipitation Anomalies (May-Sep)



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.**

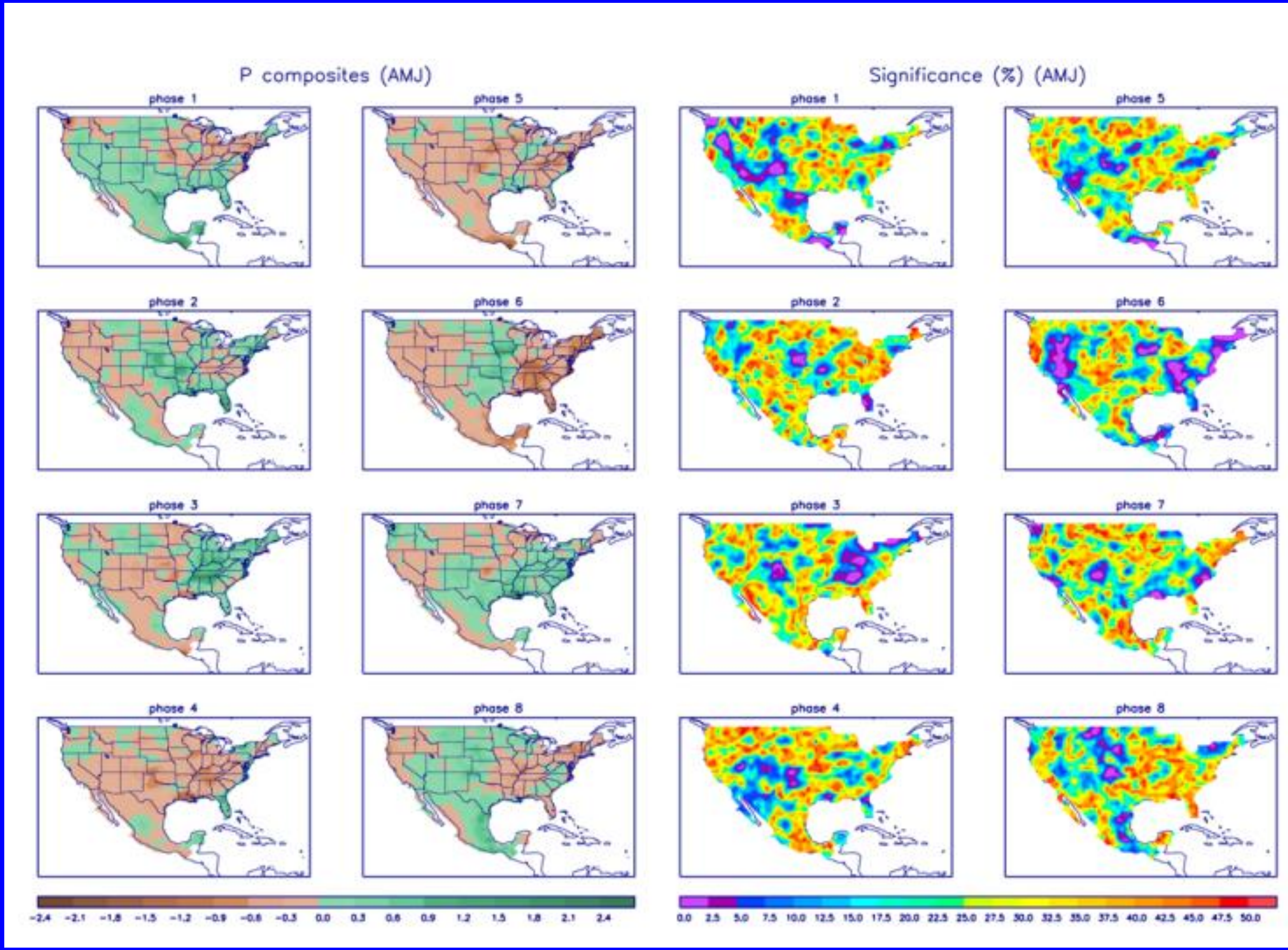


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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