



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

**Update prepared by
Climate Prediction Center / NCEP
June 8, 2015**



Outline

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



Overview

- **The MJO became more coherent during 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 models differ on the eastward propagation of the MJO signal during Week-2 with some models indicating the enhanced phase of the MJO progressing eastward across the Maritime Continent and other models weakening the signal.**
- **The MJO is expected to play at least a minor role in the pattern of tropical convection during the next two weeks. However, 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>

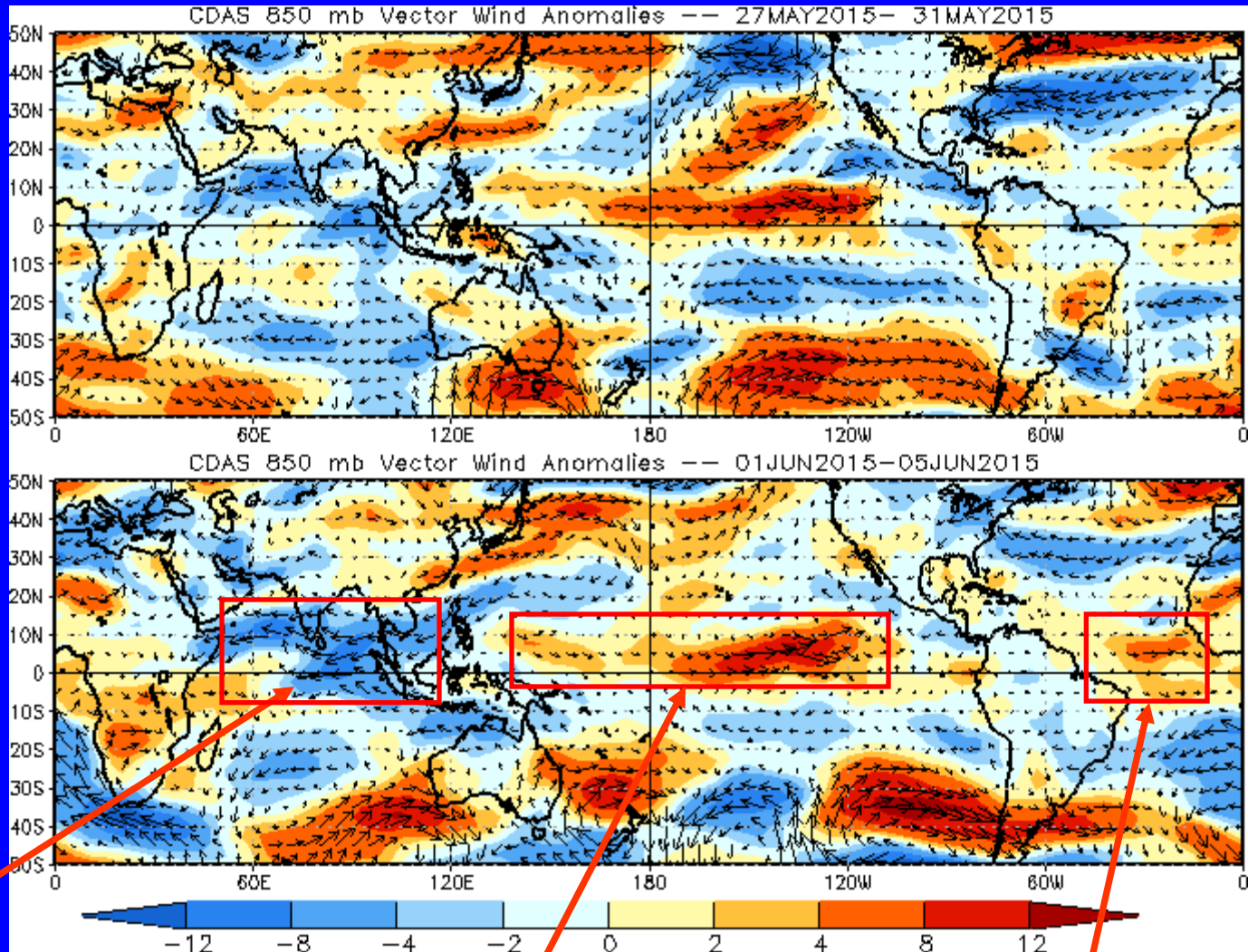


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies persisted over the Indian Ocean.

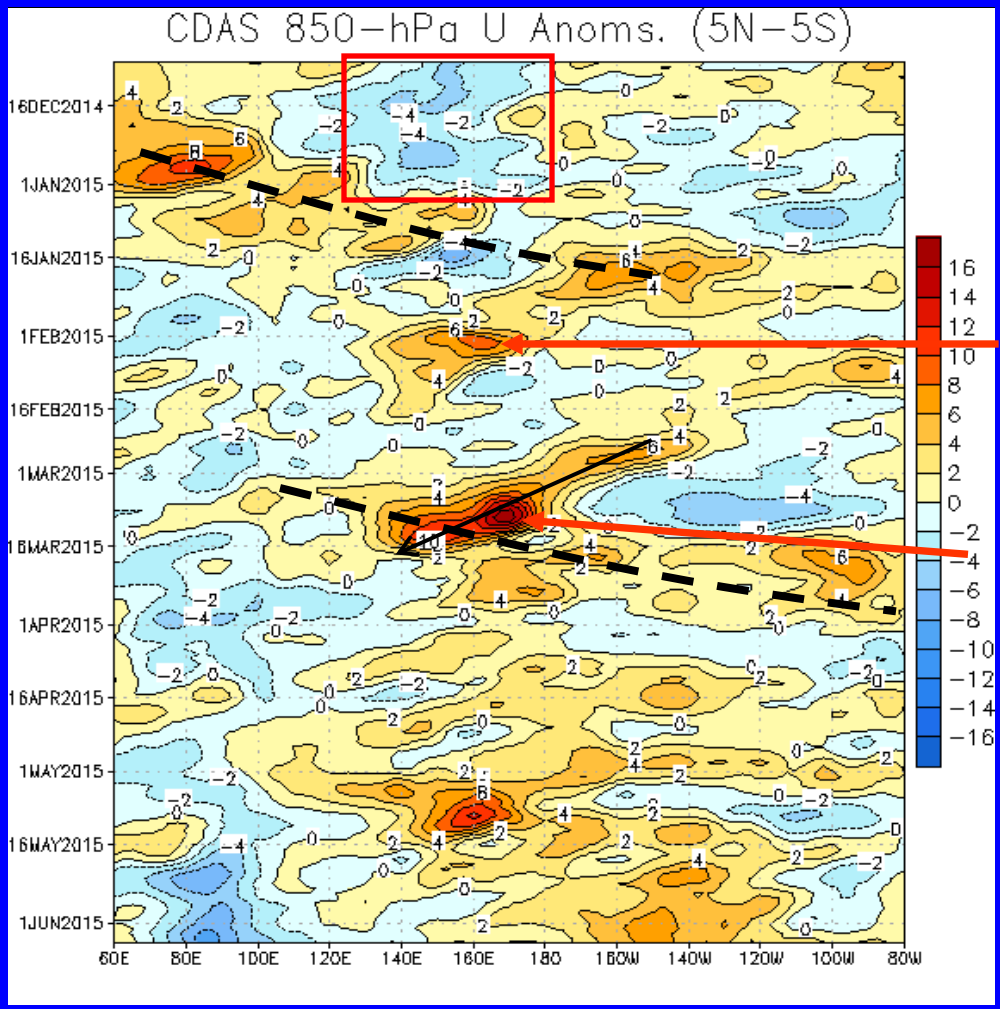
Westerly anomalies persisted across most of the equatorial Pacific and the eastern Pacific.

Westerly anomalies strengthened over the eastern tropical Atlantic.



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



During December, easterly anomalies persisted from 120E to 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.

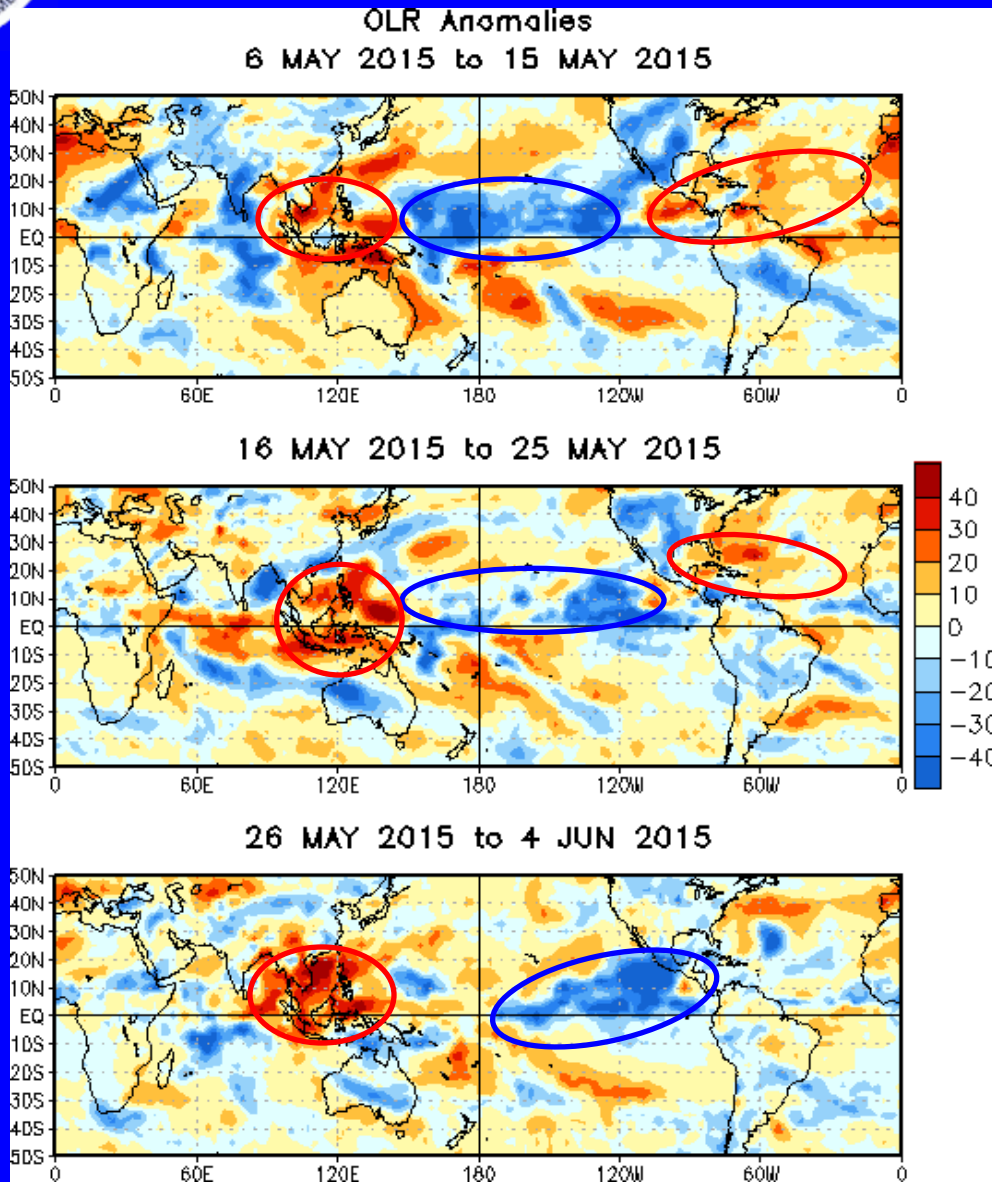
Strong westerly anomalies associated with the MJO, an equatorial Rossby wave (ERW) and El Niño base state conditions resulted in strong westerly anomalies propagating west of the Date Line during early March.

During April and May, westerly anomalies expanded over much of the central and eastern Pacific. That pattern has migrated slightly eastward.



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 May enhanced (suppressed) convection was noted over the central Pacific (Southeast Asia, East Pacific to the tropical Atlantic).

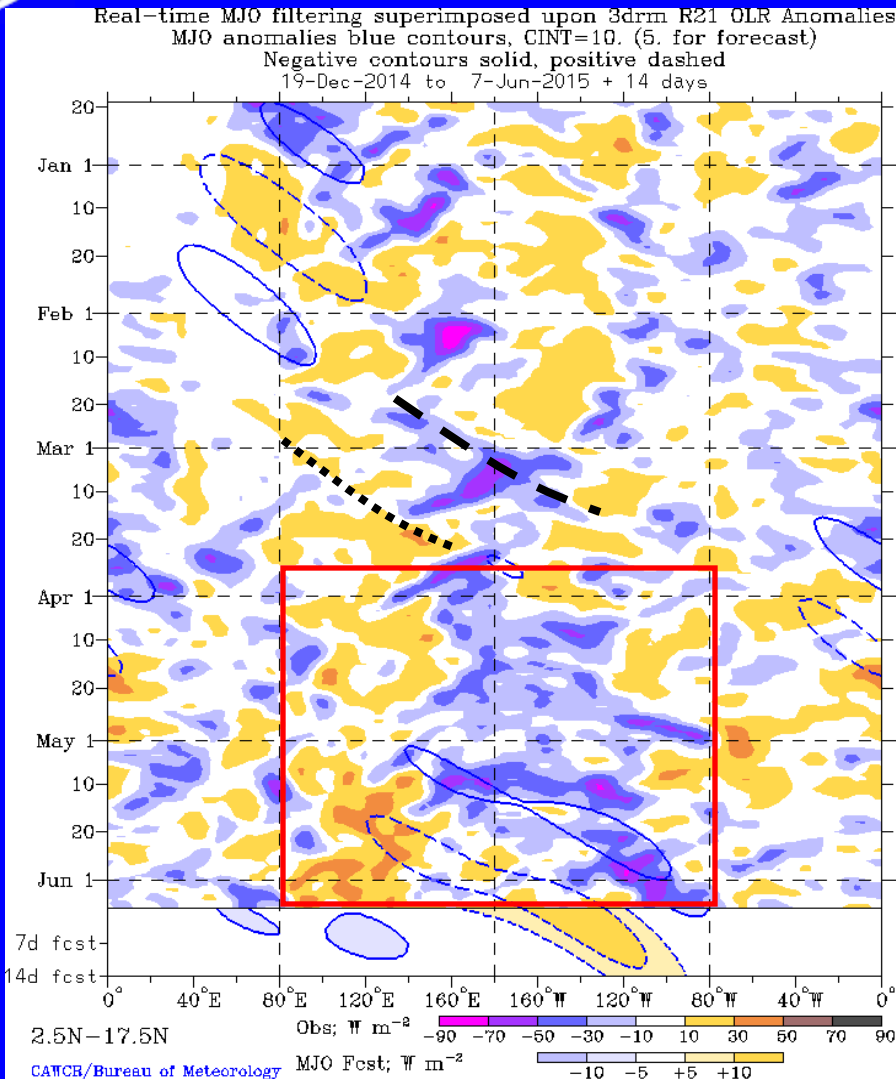
Enhanced convection continued across the central Pacific during mid-May while suppressed convection was observed across the Caribbean Sea and Tropical Atlantic, as well as the Maritime Continent and western North Pacific. Some extratropical connections are evident.

Enhanced convection across the East Pacific intensified and expanded during late May with extratropical connections evident. Strongly suppressed convection was observed over the Maritime Continent.



Outgoing Longwave Radiation (OLR)

Anomalies (2.5°N-17.5°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 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 at or east of the Date Line (Maritime Continent) (red box), consistent with El Niño conditions. Kelvin wave activity has been prominent across global Tropics at the same time.

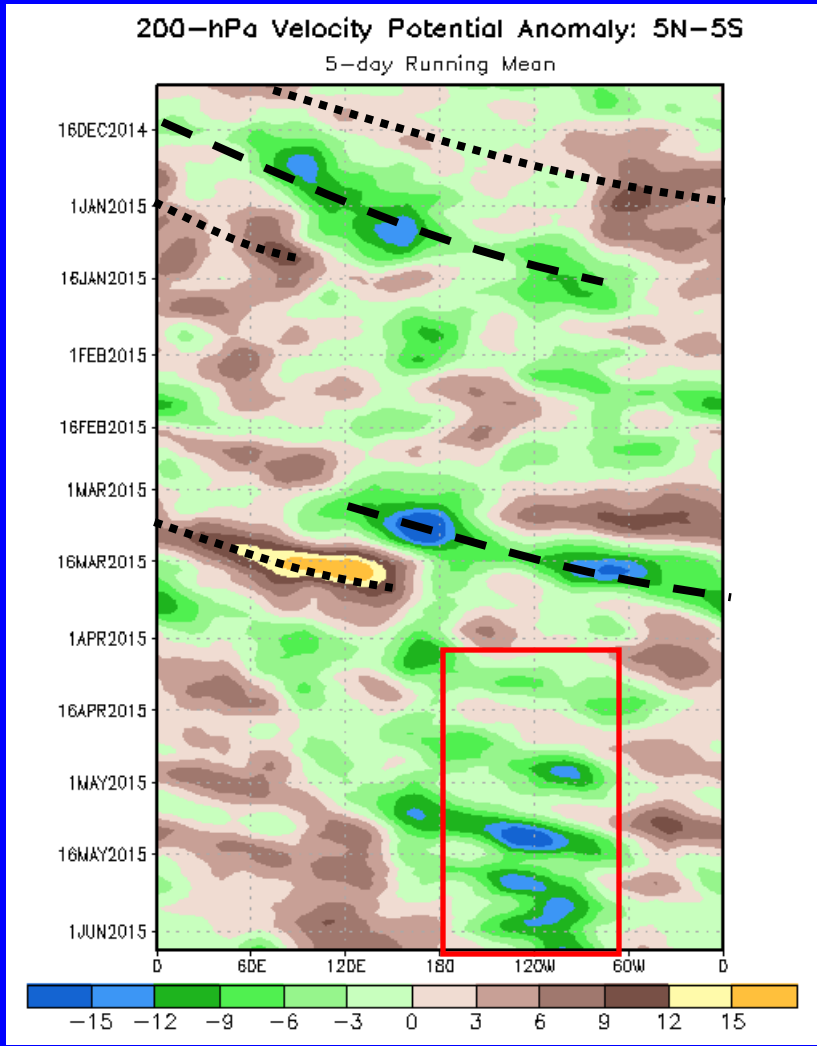


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time
↓



Longitude

From December 2014 though January 2015, the MJO was active, 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).

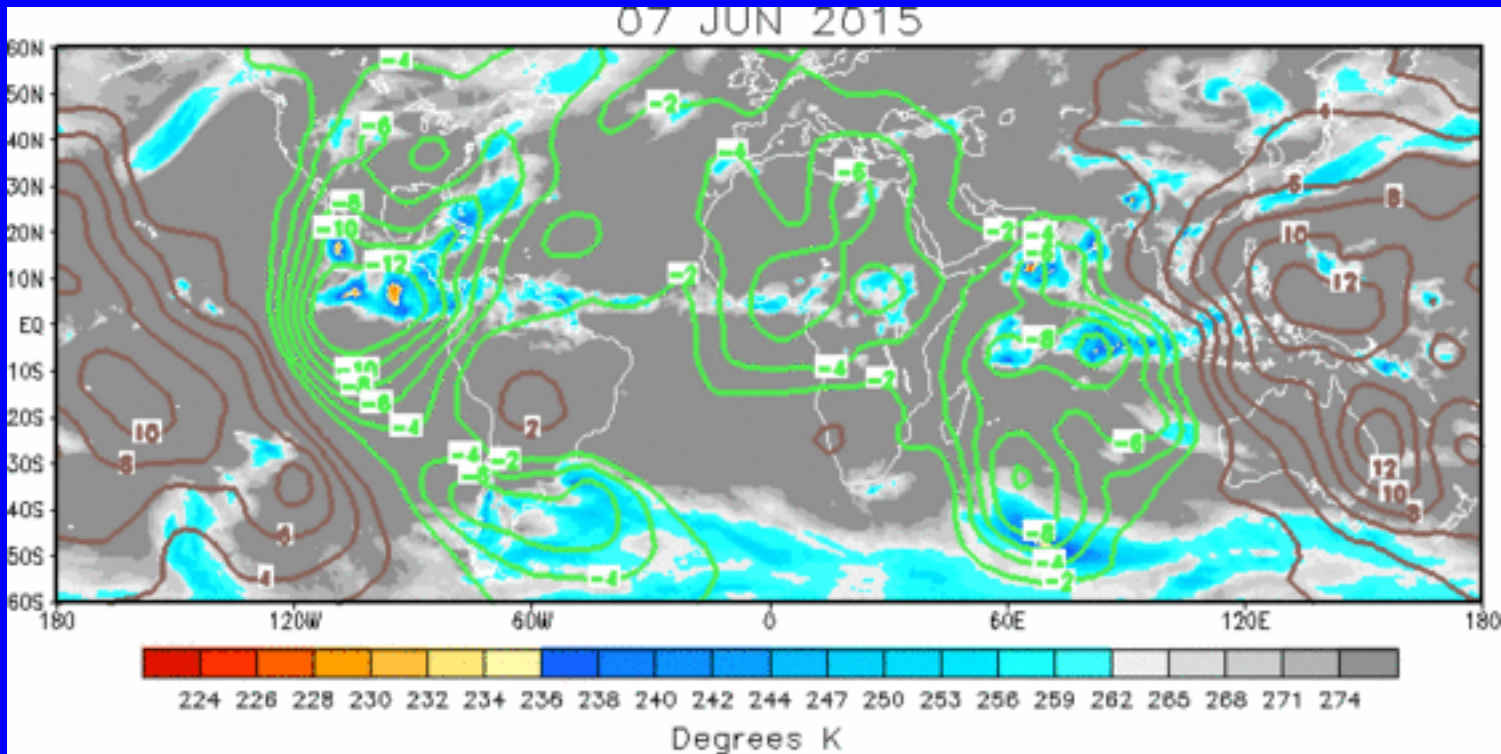
Negative anomalies persisted near the Date Line and to the east since early April due to the low-frequency base state. During this time, Kelvin wave activity (fast eastward propagation) has been the primary subseasonal mode of variability evident in this field.



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 Niño conditions and a more coherent MJO signal. Enhanced upper-level divergence is observed over the East Pacific, and extending east to Africa and the western Indian Ocean. Suppressed convection persists across the Maritime Continent and recently shifted east across the West Pacific.

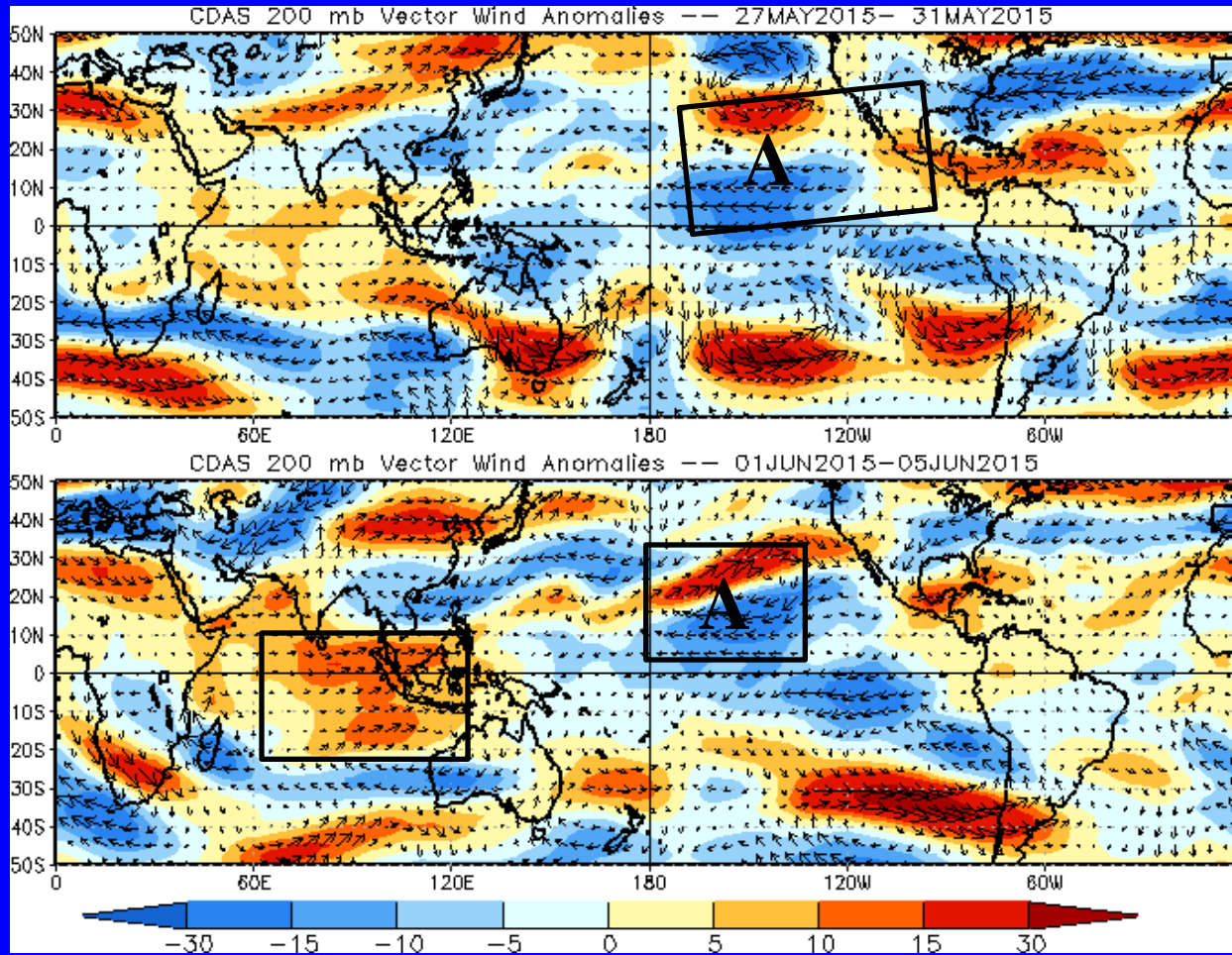


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



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.

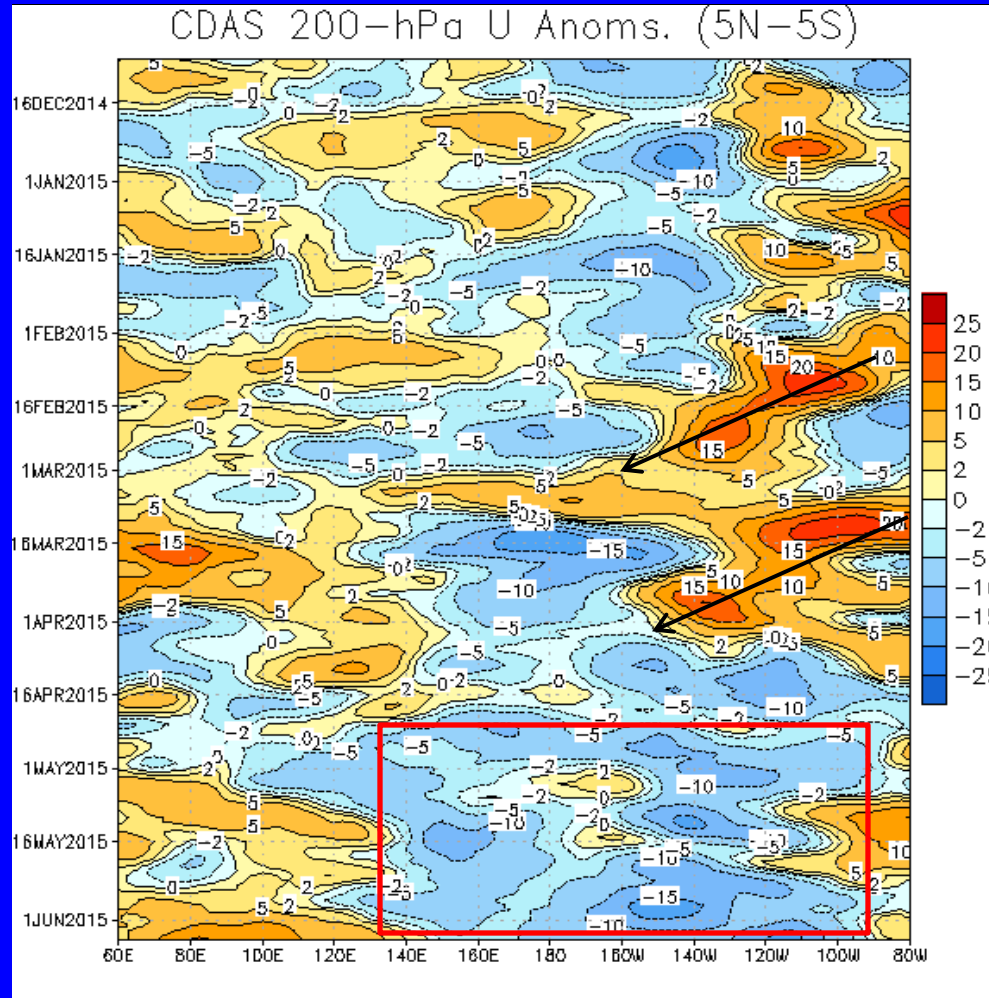
Westerly anomalies strengthened across the Indian Ocean and Maritime Continent at the beginning of June.



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



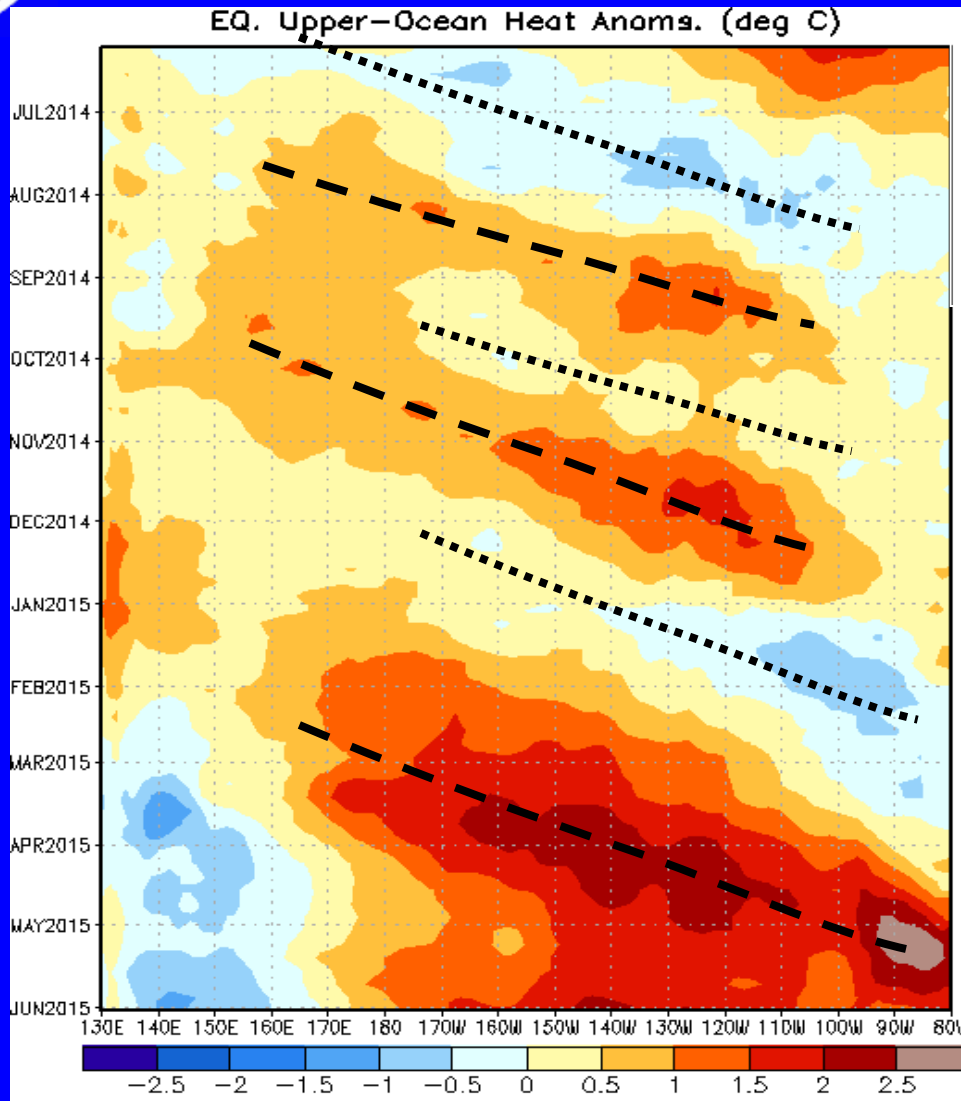
During late December through the mid-April, westerly anomalies increased in coverage and intensity from 120W to 80W.

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

Easterly anomalies have generally persisted over the central and eastern Pacific (red box) consistent with El Niño since early May.



Weekly Heat Content Evolution in the Equatorial Pacific



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.

Positive anomalies have increased in magnitude recently near the Date Line, possibly associated with another downwelling Kelvin wave.



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.

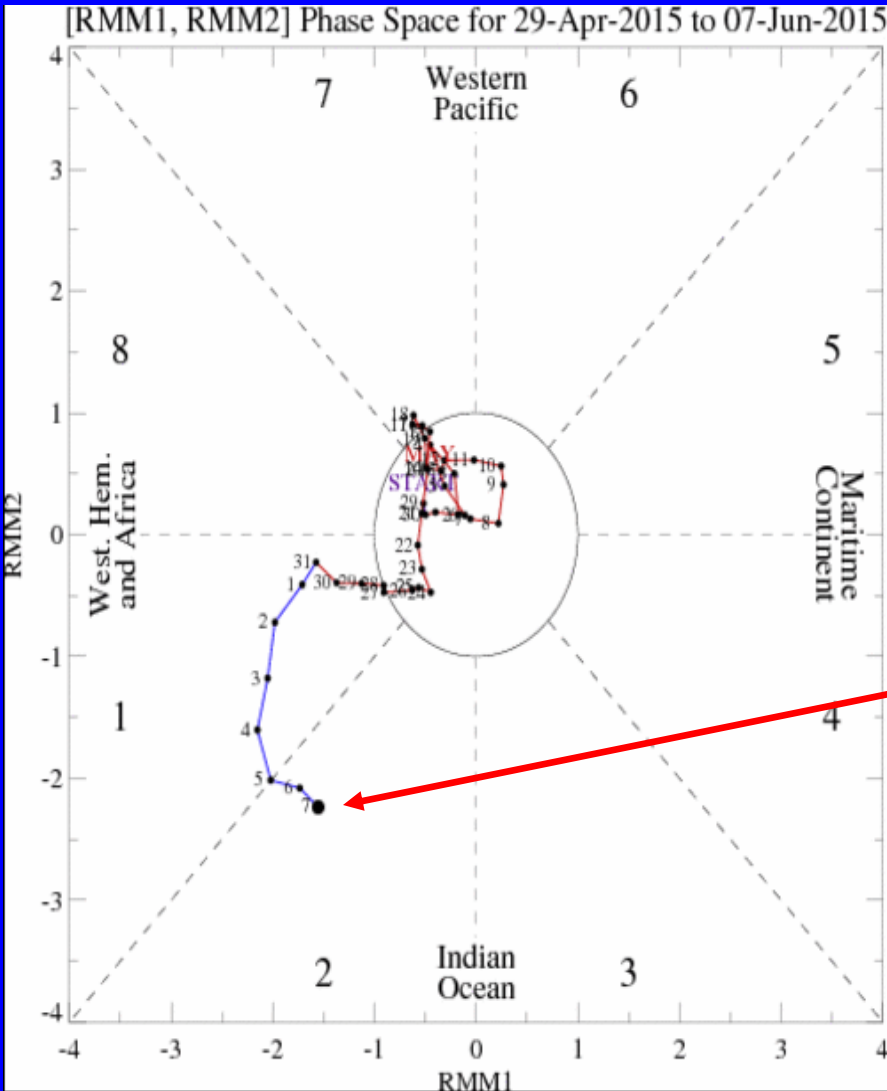
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

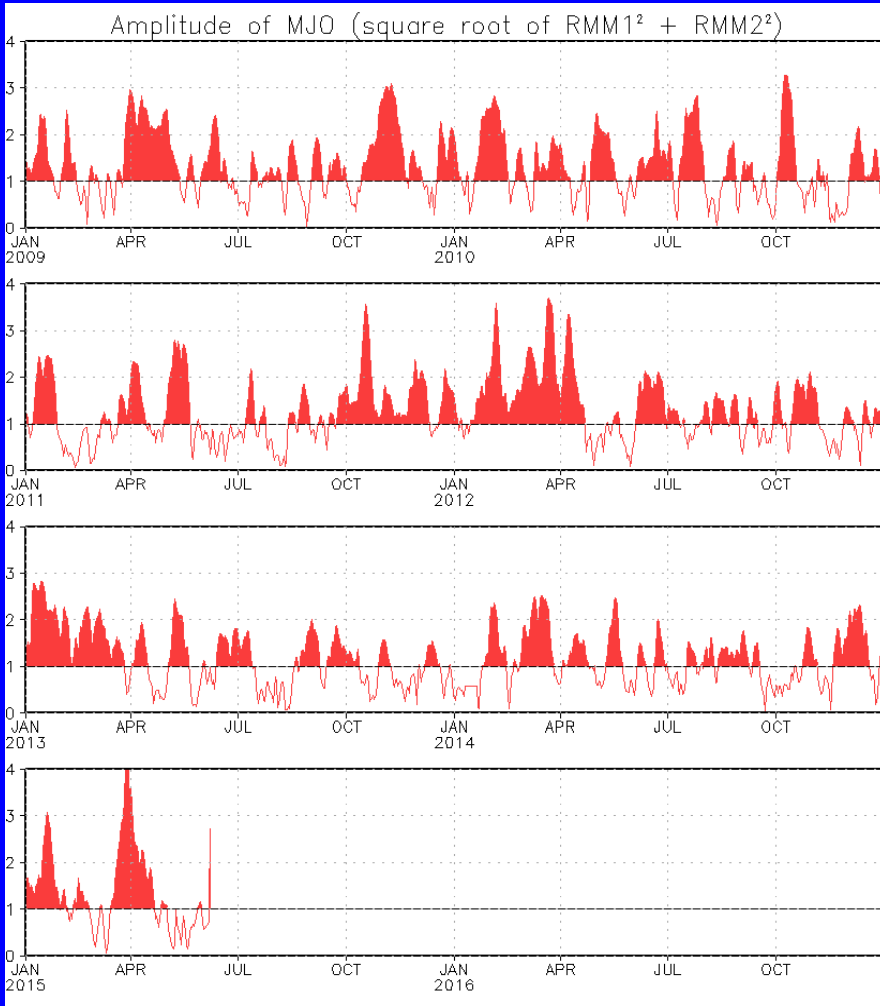


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The amplitude of the MJO index increased during the first week of June with eastward propagation.



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.



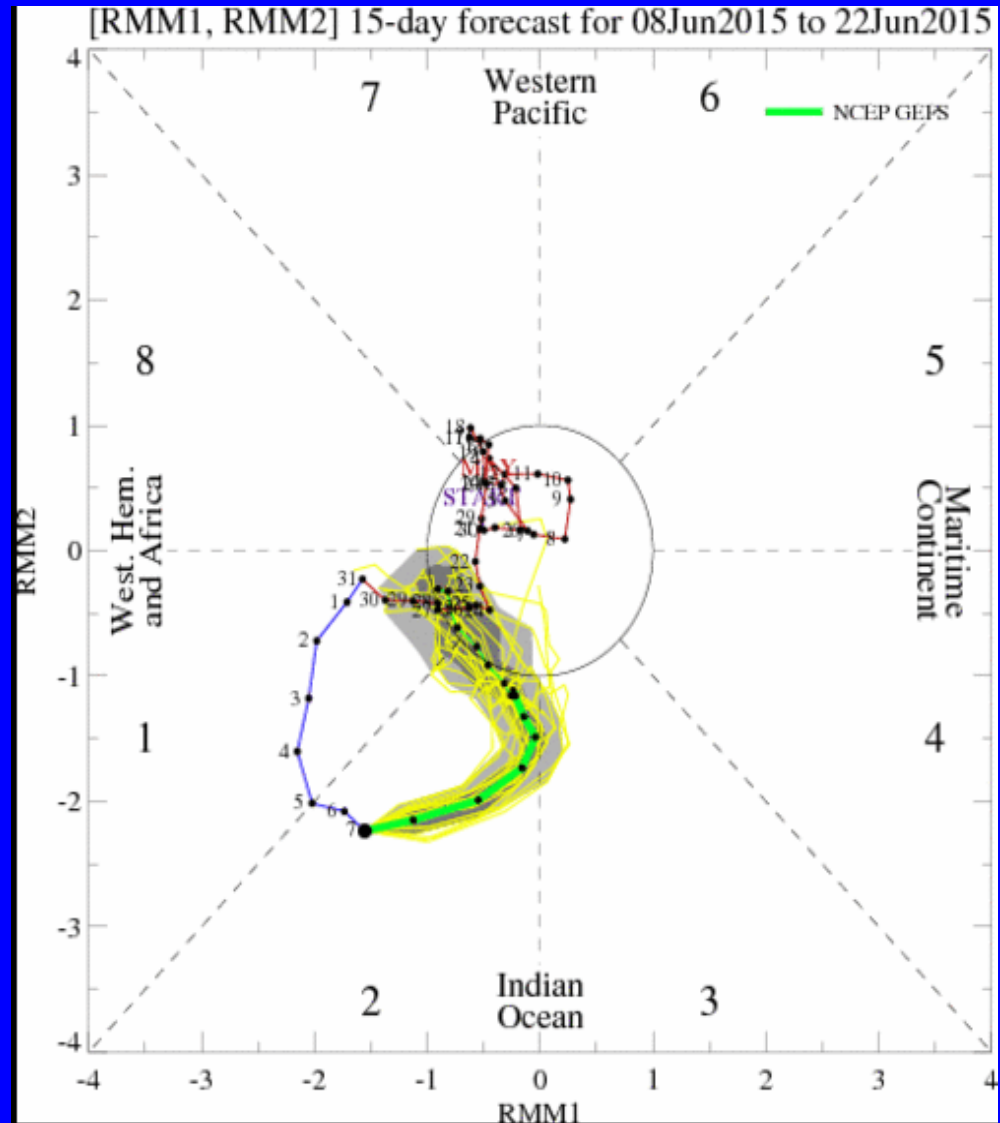
Ensemble GFS (GEFS) MJO Forecast

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 an eastward propagation during the next week followed by a weakening signal during Week-2.

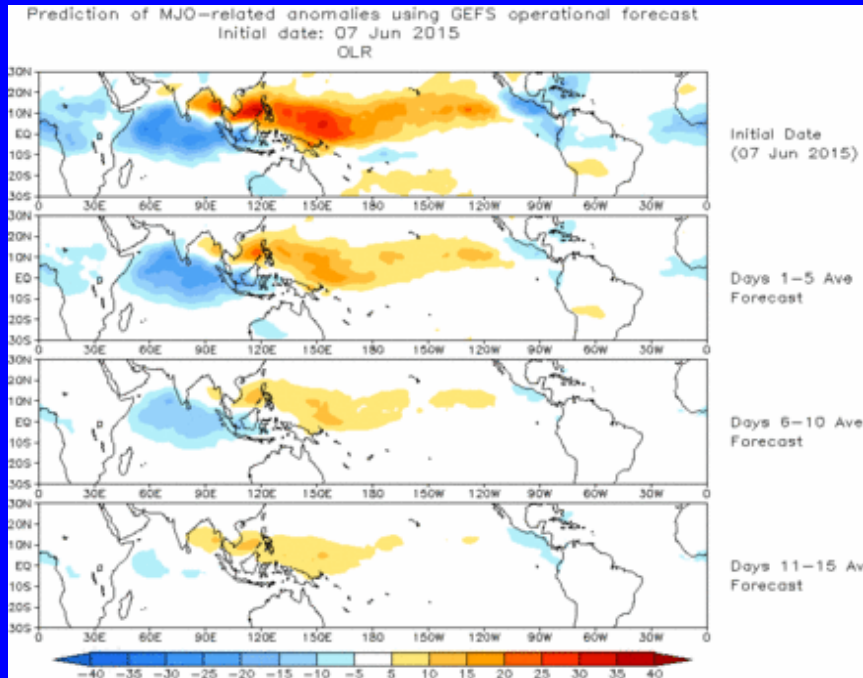




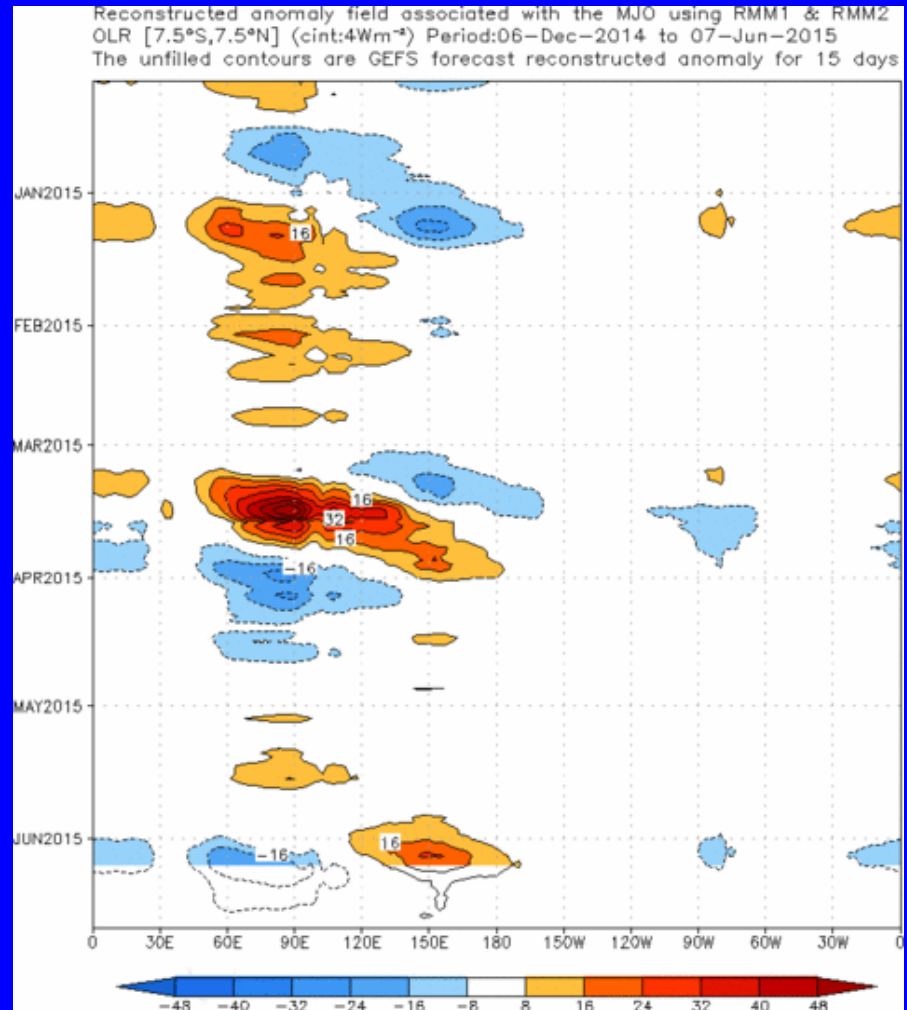
Ensemble Mean GFS MJO Forecast

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



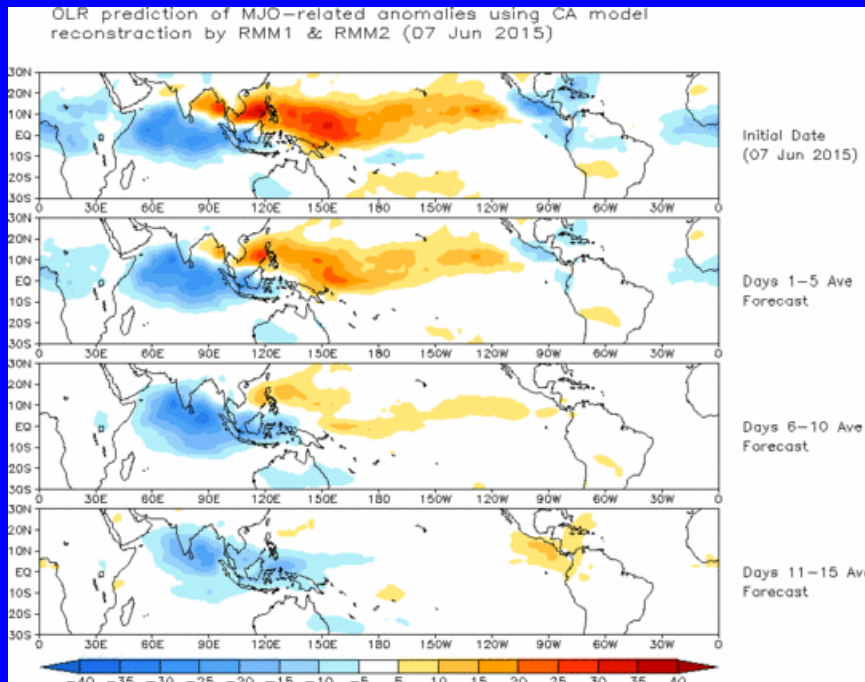
The GEFS MJO index based OLR anomalies forecast depicts enhanced (suppressed) convection over the Indian (Pacific) Ocean during Week-1. Likely destructive interference with the ongoing El Nino is evident with the smaller anomalies during Week-2.



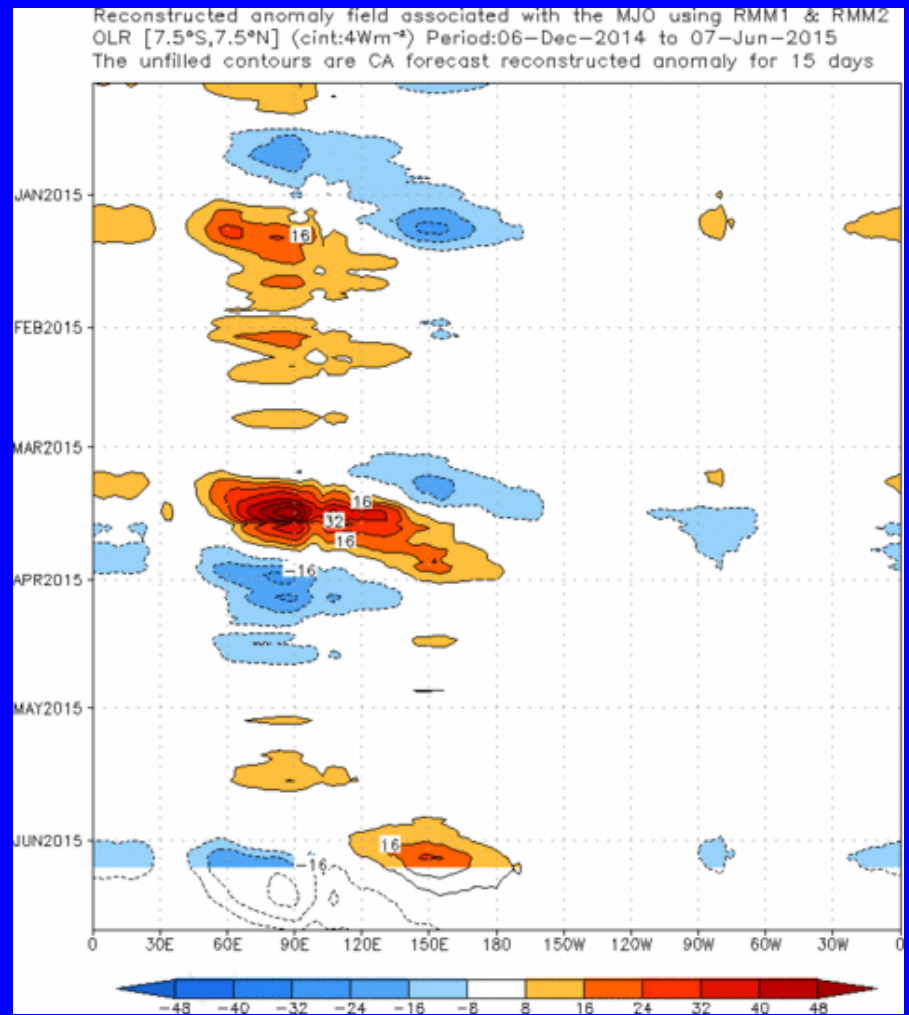
Constructed Analog (CA) MJO Forecast

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



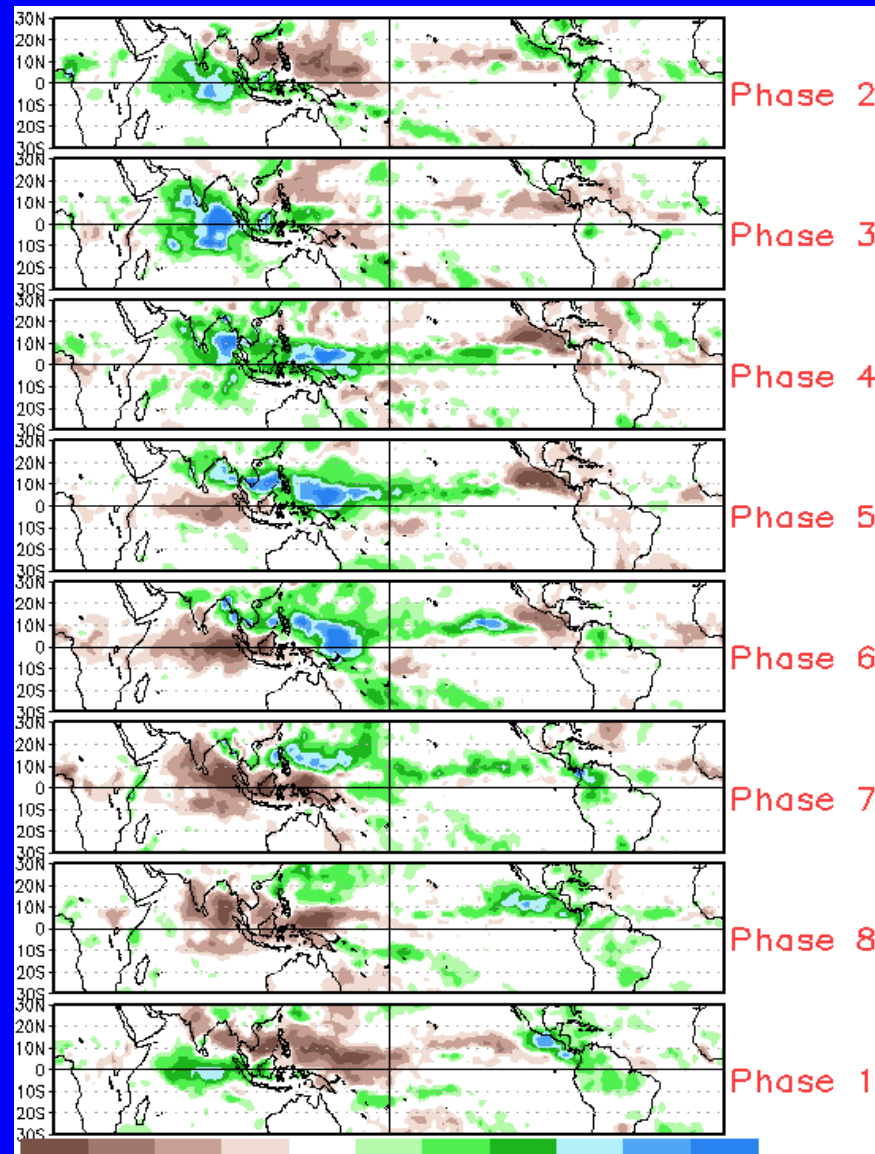
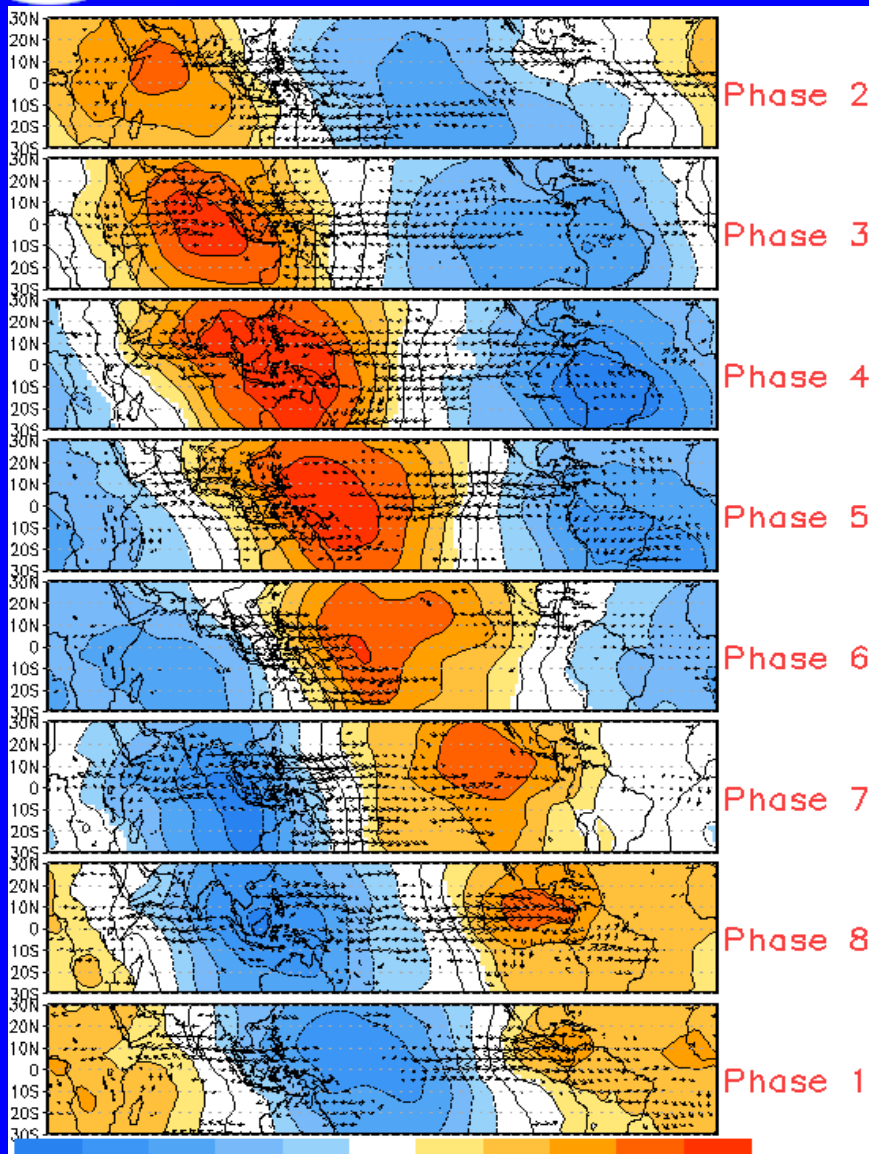
The statistical forecast depicts eastward propagation of the enhanced convection across the Maritime Continent during the next ten days.



MJO Composites – Global Tropics

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

Precipitation Anomalies (May-Sep)

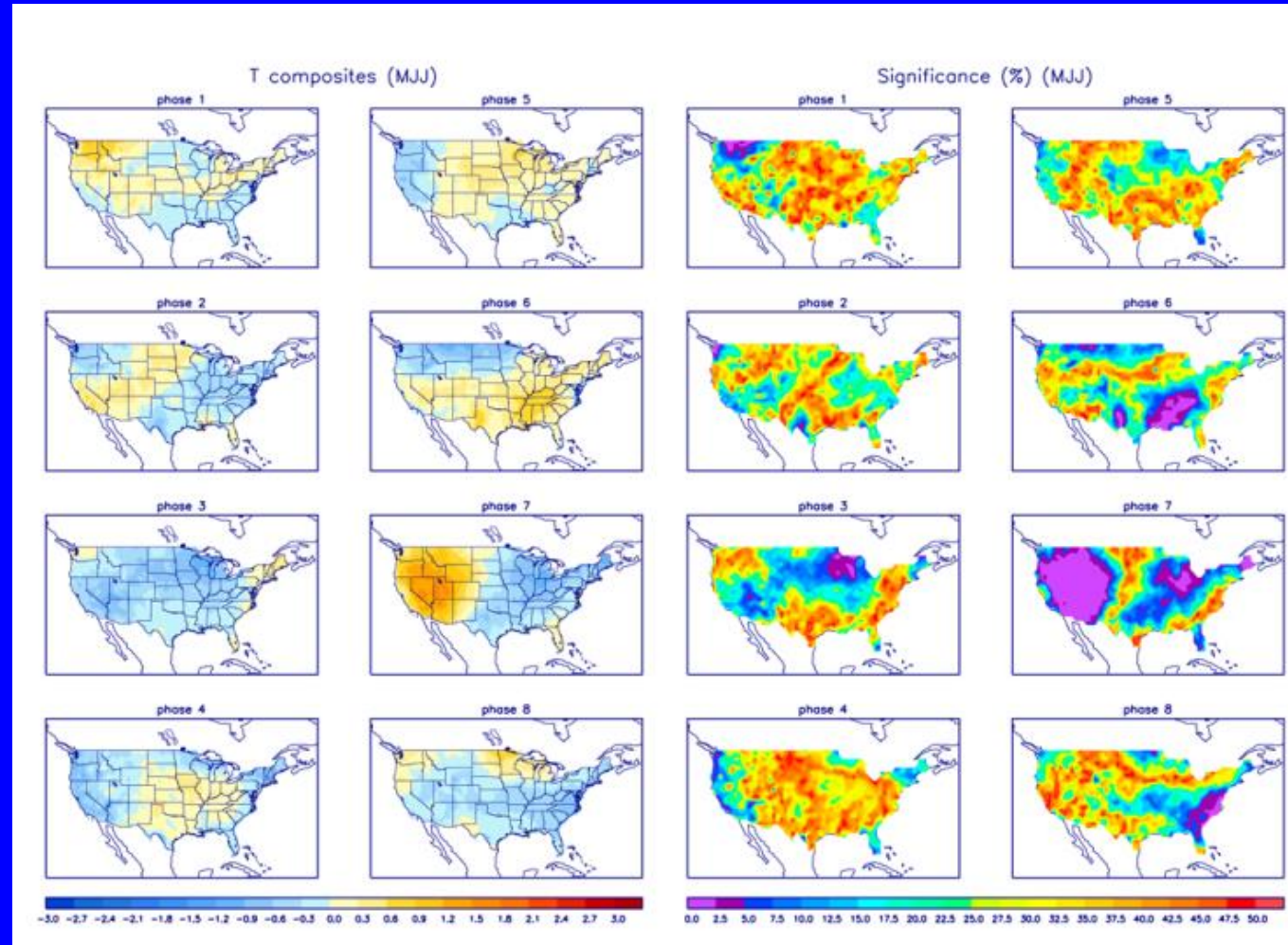




U.S. MJO Composites – Temperature

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.



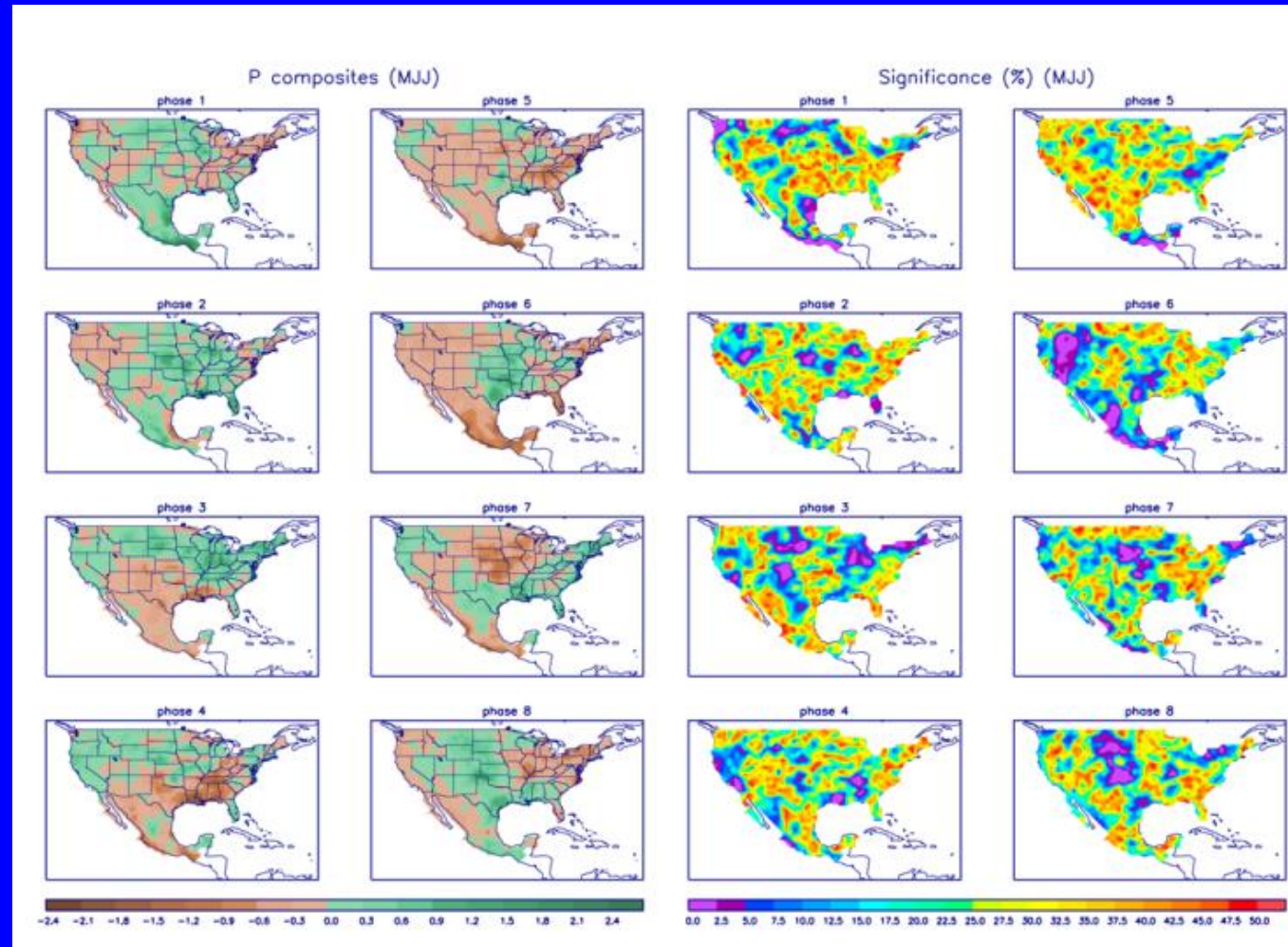
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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

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