



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

**Update prepared by
Climate Prediction Center / NCEP
July 20, 2015**



Outline

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



Overview

- **The MJO remains active, although MJO indices indicate a somewhat weaker signal. The enhanced phase is currently over the Western Hemisphere.**
- **Destructive interference between the MJO and an El Niño base state that favors persistent low-level westerly wind anomalies over the central and eastern Pacific may be contributing to the lower amplitude of the MJO indices.**
- **Dynamical model MJO index forecasts depict varying solutions, with some favoring amplification of the signal over the Indian Ocean, and others showing no additional eastward propagation, with a signal favoring convection over the eastern Pacific.**
- **Based on the dynamical model forecasts, there is increasing uncertainty regarding the impacts of MJO activity on the global tropical convective pattern during the next several weeks; however, the MJO may continue to support suppressed convection over the western Pacific.**

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>

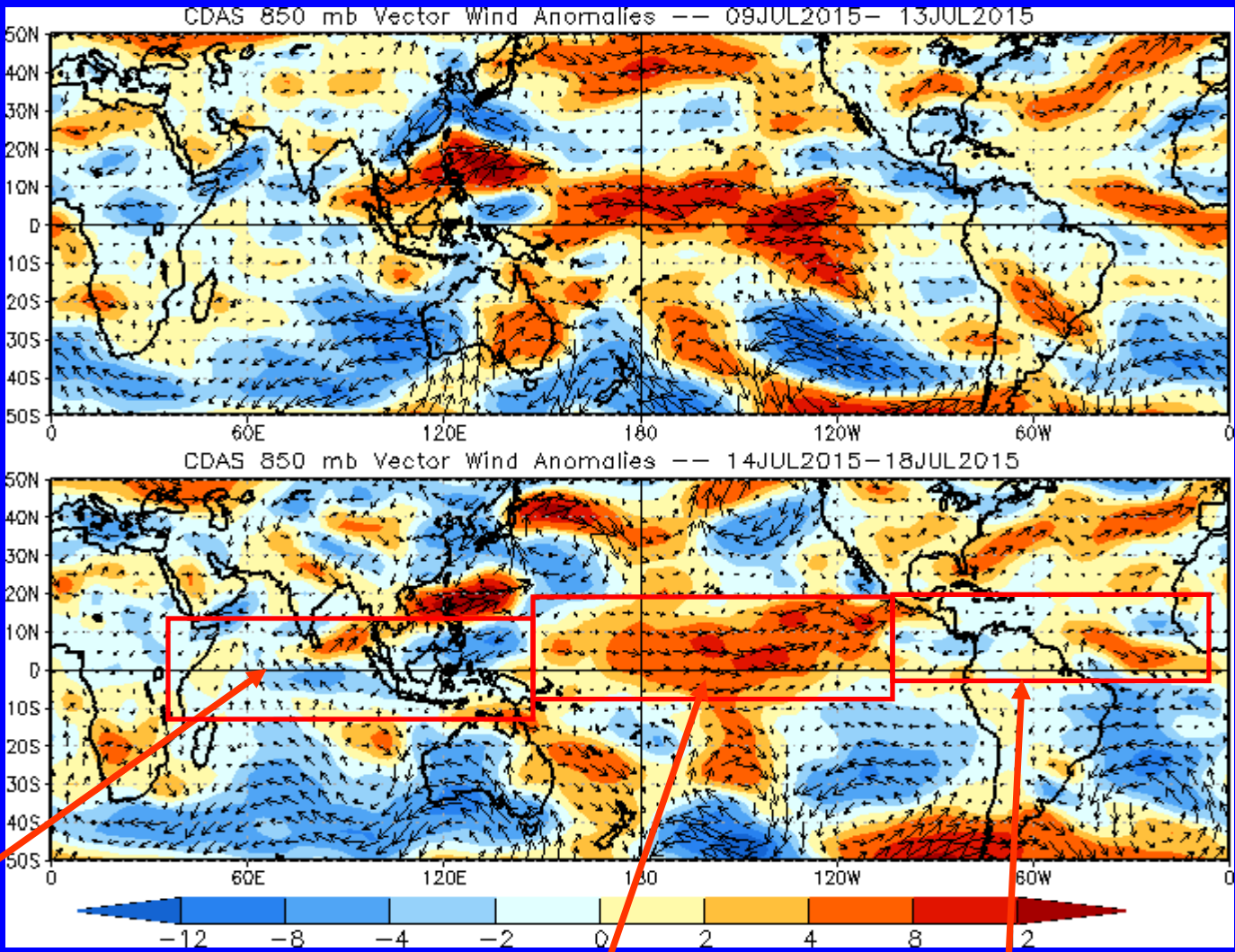


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Weak but generally easterly anomalies were observed over the Indian Ocean and Maritime Continent.

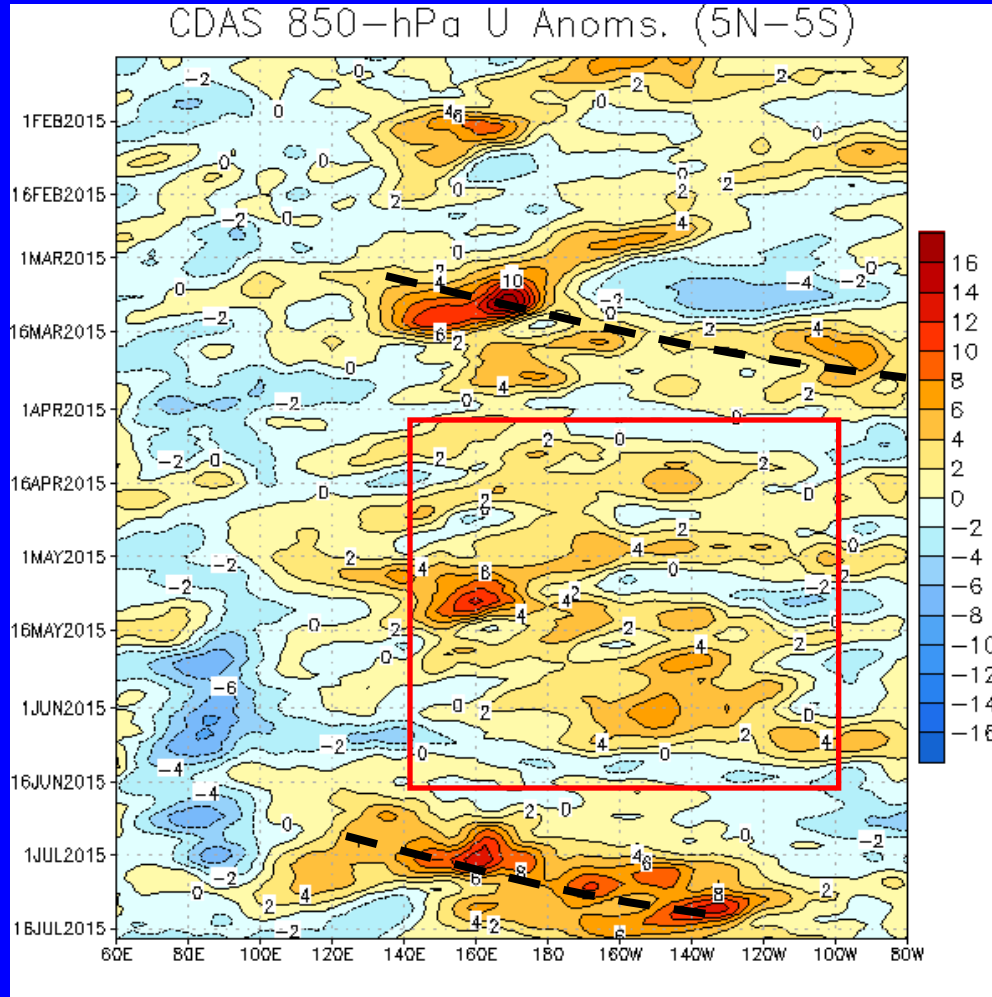
Westerly wind anomalies continued over much of the Pacific Basin.

Easterly (westerly) anomalies weakened over the far eastern Pacific (tropical North 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



Westerly anomalies returned to the Western Pacific during late January and early February.

The MJO, Rossby Wave activity, and El Niño conditions contributed to a strong westerly wind burst west of the Date Line during early March.

During April and May, westerly anomalies expanded over much of the central and eastern Pacific, consistent with El Niño (red box).

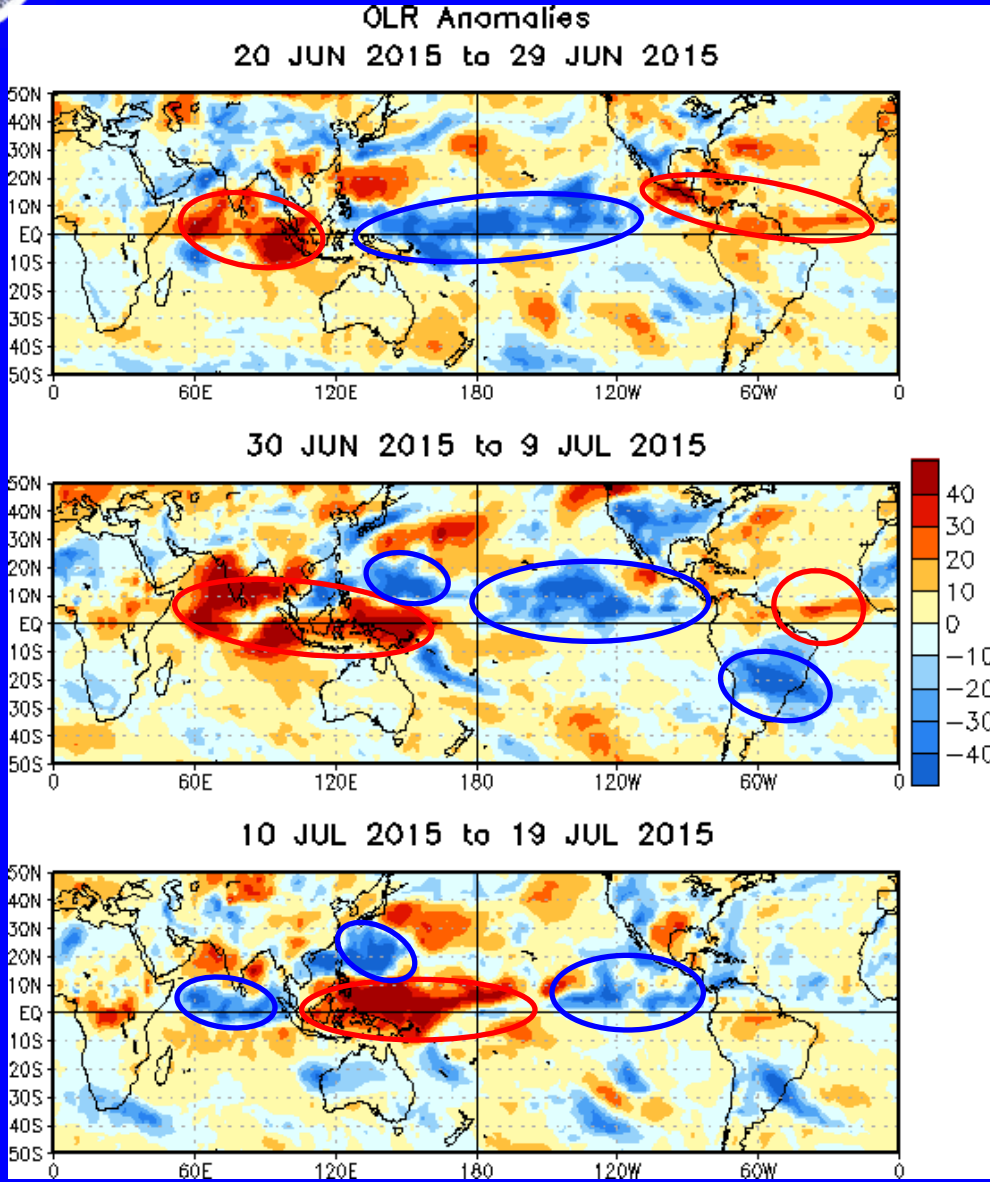
During June, a brief disruption of the westerly anomalies was observed, associated with a Kelvin wave.

More recently, westerly anomalies have strengthened over much of the Pacific, associated with both the base state and MJO activity.



OLR Anomalies – Past 30 days

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



Enhanced (suppressed) convection overspread much of the Pacific (Indian Ocean, western Maritime Continent, the far eastern Pacific, central America, and the tropical Atlantic) during late July.

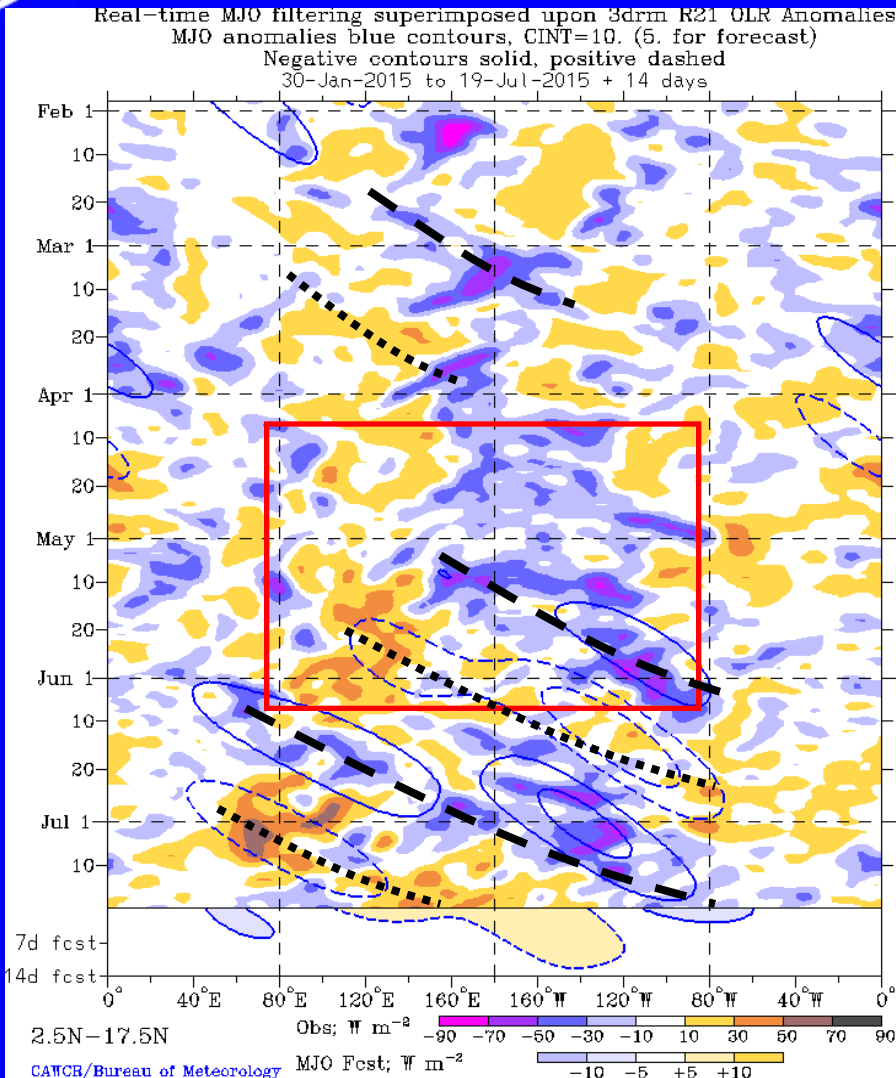
During the end of June and early July, suppressed convection shifted northward over South Asia and eastward across the Maritime Continent and the far western Pacific. Enhanced convection continued over the central and eastern Pacific. Tropical cyclone activity was observed east of the Philippines.

Suppressed convection continued across the Maritime Continent and shifted eastward across the western equatorial Pacific, while enhanced convection persisted over the eastern Pacific. Enhanced convection developed over the equatorial Indian Ocean, consistent with the MJO.



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) convective anomalies evident across the Pacific (Indian Ocean and Maritime Continent).

From late March to late May, enhanced (suppressed) convection has dominated at or east of the Date Line (Maritime Continent) (red box), consistent with El Niño conditions. Kelvin Waves were the most prominent subseasonal features during April and May.

During late May and June, slower, more robust eastward propagation was evident, consistent with MJO activity. Kelvin Wave activity over the east-central Pacific ahead of the MJO enhanced envelope constructively interfered with the El Niño signal.

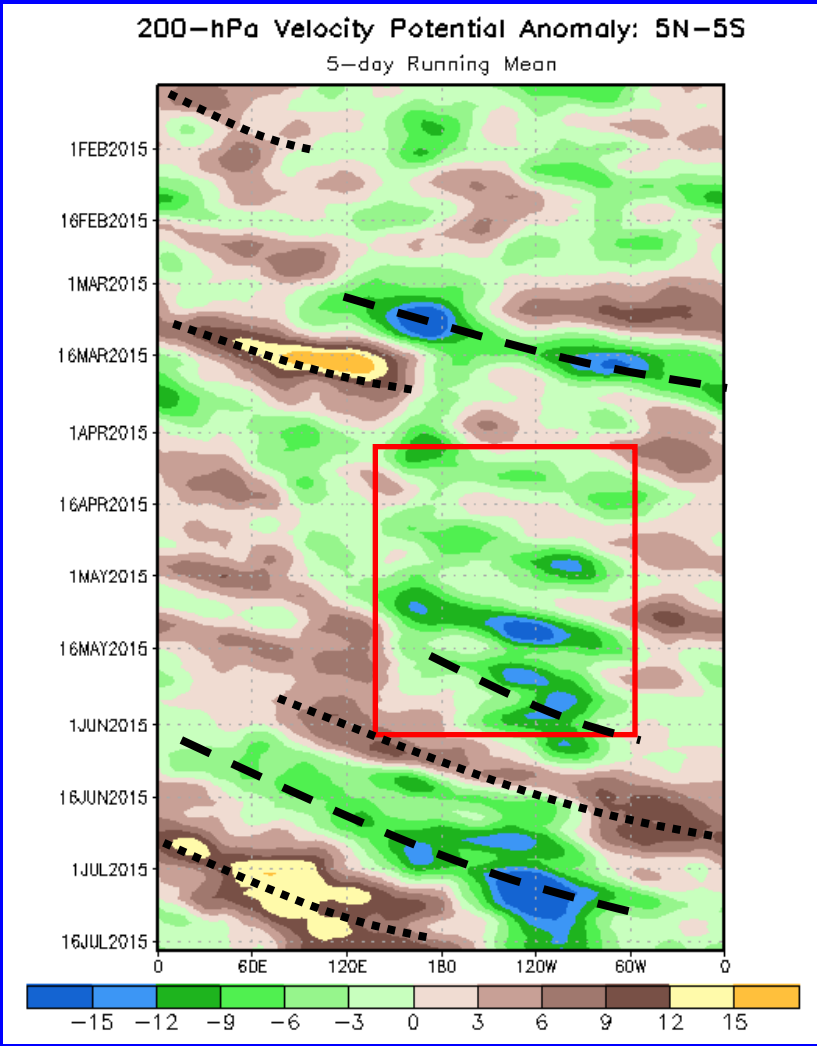


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time
↓



Longitude

An MJO signal at the start of the year weakened during late January and February, then strengthened again during March. The anomaly pattern became strong as they interacted with the developing low frequency state.

Negative anomalies persisted near the Date Line and to the east from early April through May due to the El Niño base state. During this time, Kelvin wave activity (fast eastward propagation) was the primary subseasonal mode of variability evident in this field.

During late May and June, slower eastward propagation of an anomaly couplet was observed, consistent with an MJO event. During early July, the amplitude of the anomaly field increased as the intraseasonal signal began constructively interfering with the El Niño base state.

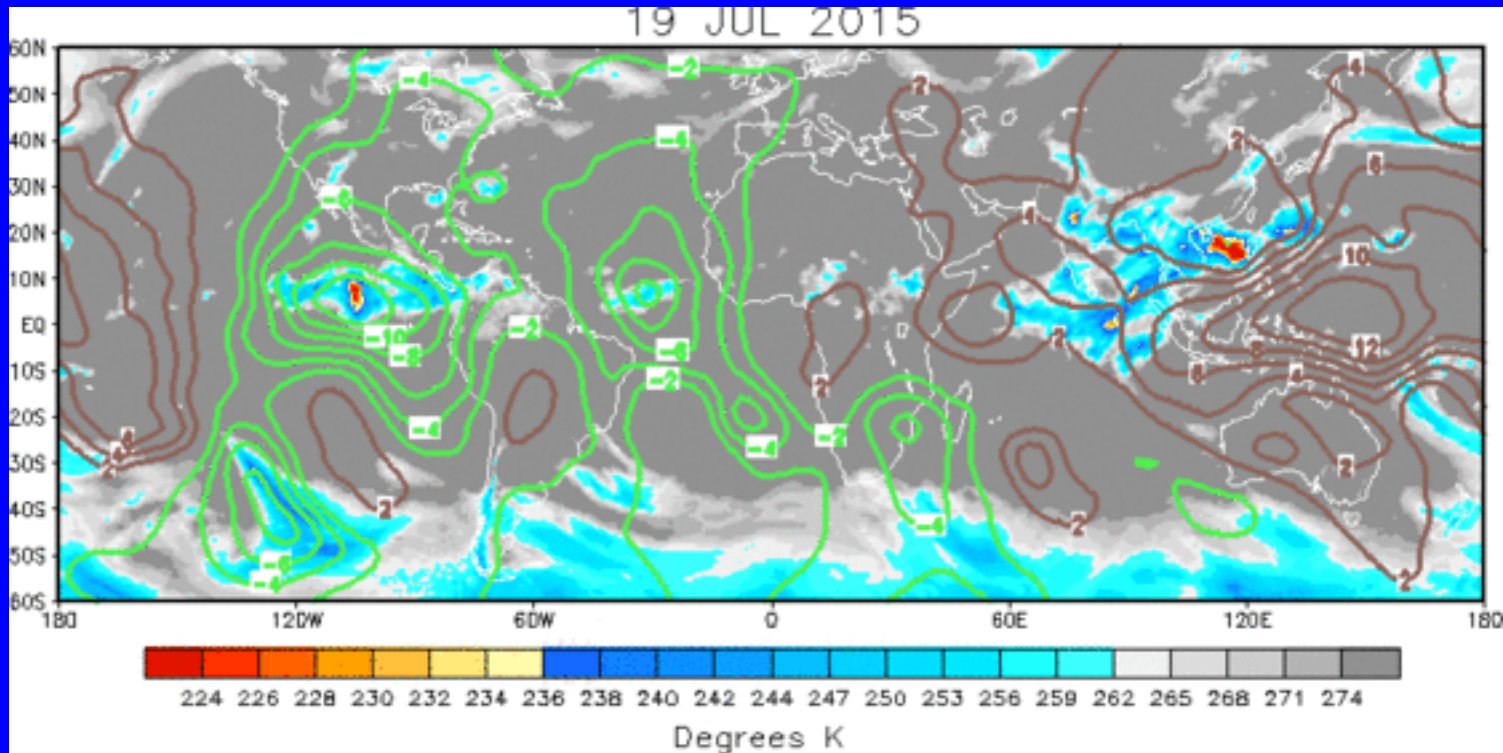
More recently, weak negative anomalies associated with the MJO emerged as far east as Africa.



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 velocity potential pattern continues to maintain a generally coherent Wave-1 structure, consistent with MJO activity. The suppressed phase is currently over the West Pacific, while negative VP anomalies associated with the enhanced phase are observed over the Western Hemisphere.

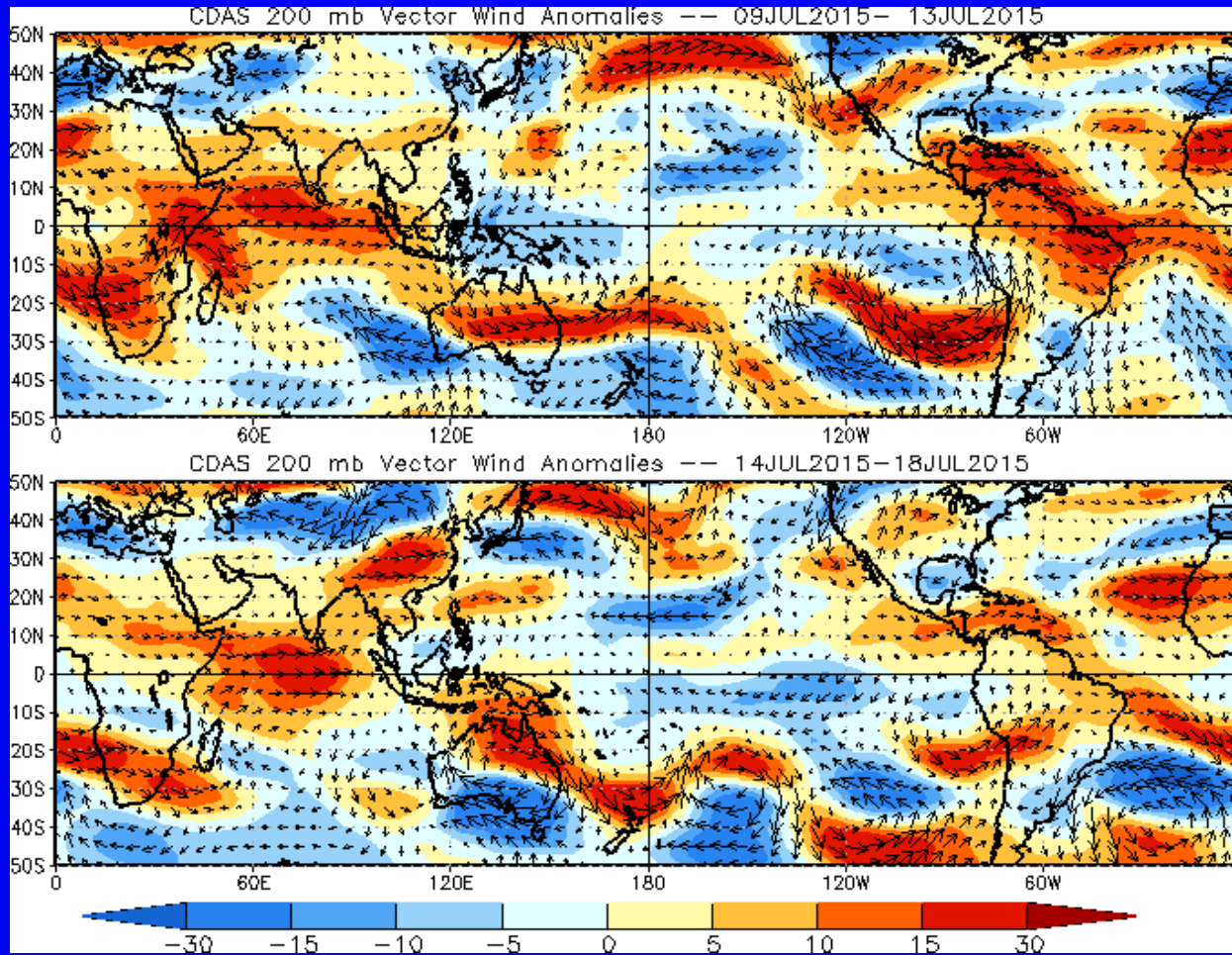


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



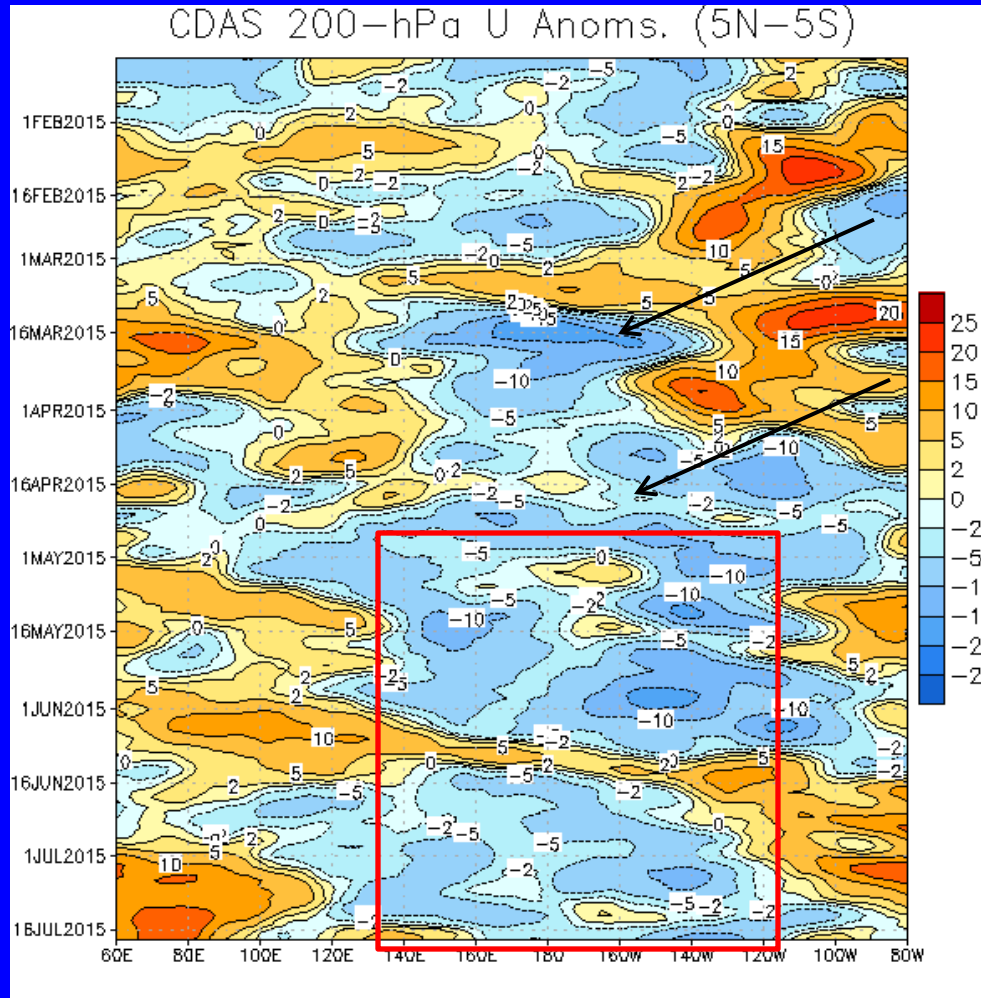
Easterly (westerly) upper level anomalies were observed over the equatorial central and eastern Pacific (Indian Ocean).



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

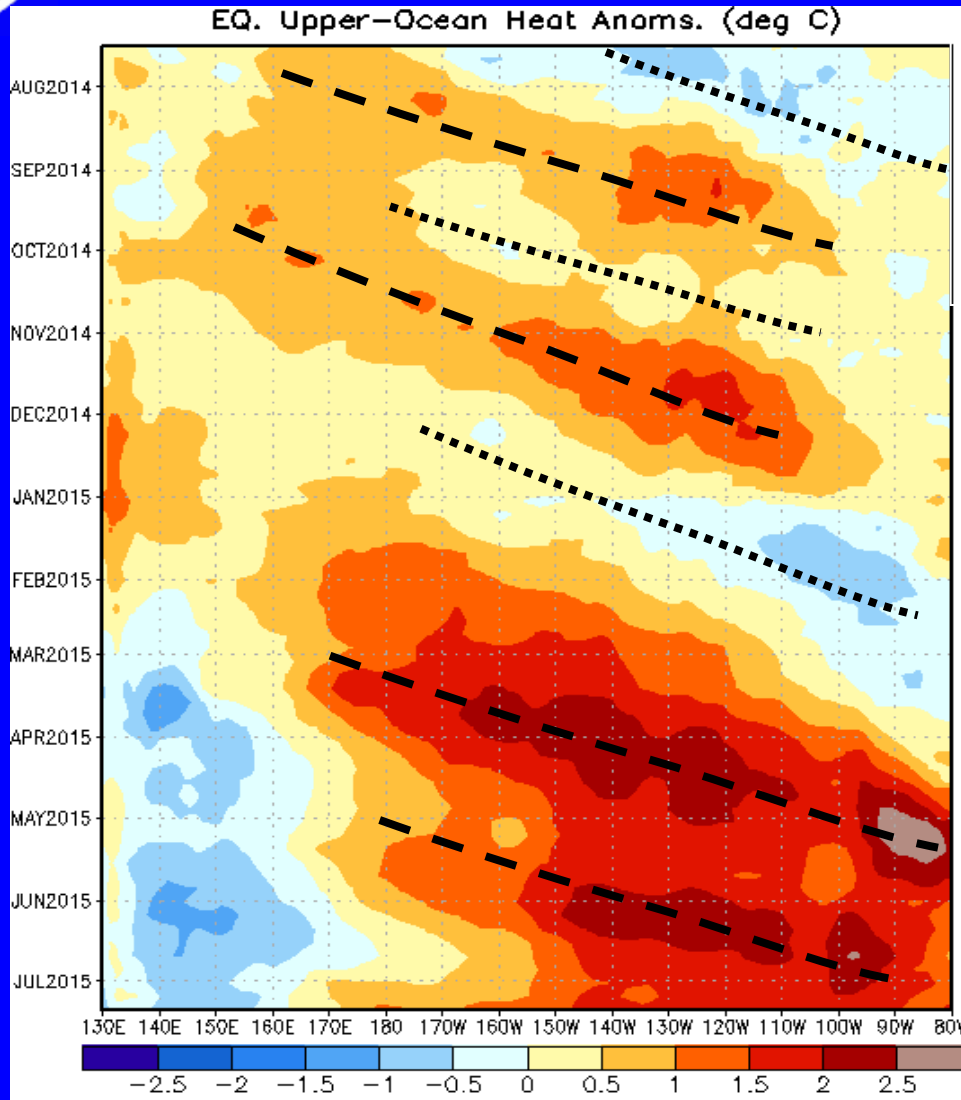
Westward propagation of westerly anomalies was evident over the eastern Pacific during late February and again in March (black arrows).

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

During June, westerly anomalies propagated eastward from the Maritime Continent to the western Hemisphere, consistent with MJO/Kelvin wave activity. Easterly anomalies developed near the Date Line and have expanded over most of the Pacific basin.



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 2014.

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, a very strong downwelling Kelvin Wave was observed.

Positive anomalies persisted over the central and Eastern Pacific, with a second downwelling Kelvin Wave evident during late May and early June.



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.

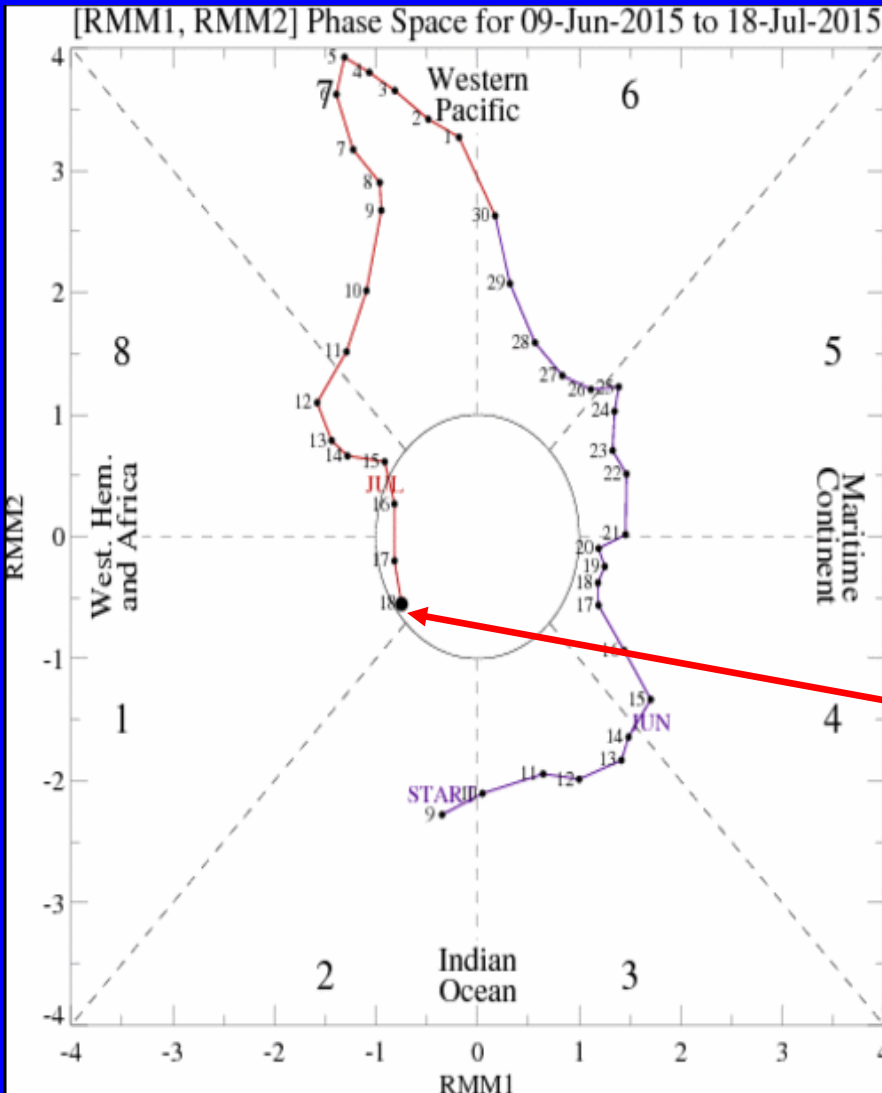
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

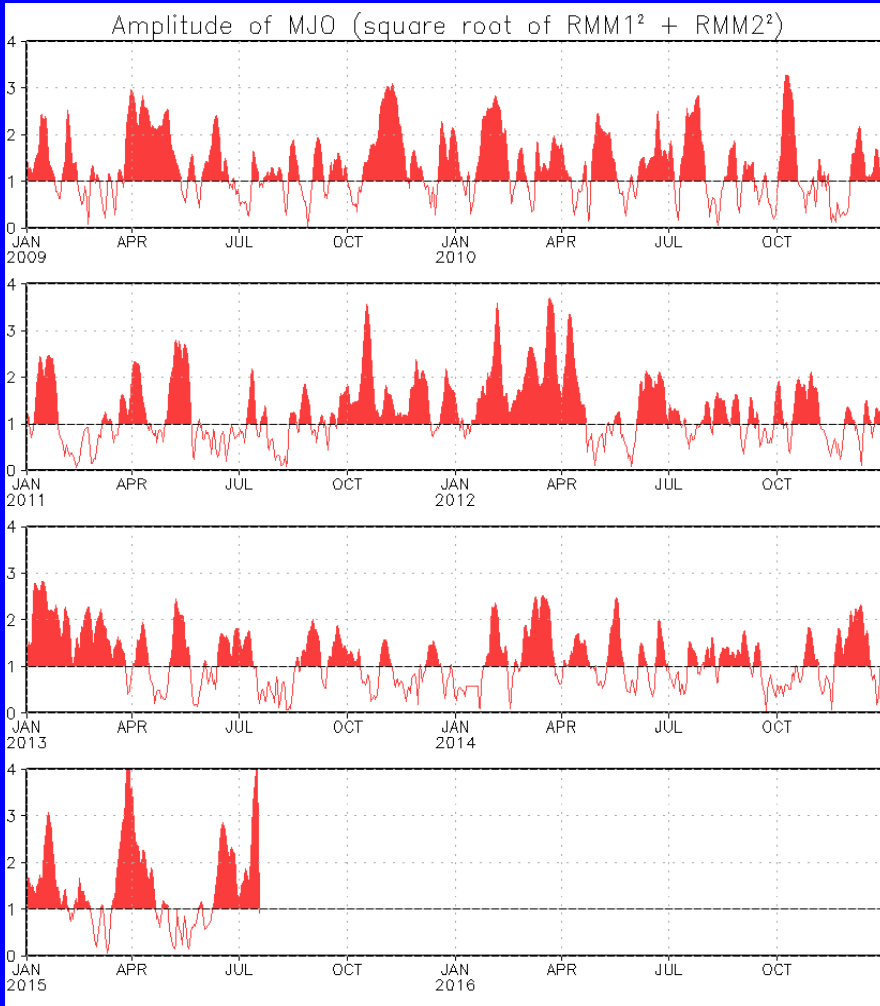


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The RMM based MJO index indicates a weak, fast moving signal over the Western Hemisphere.



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.



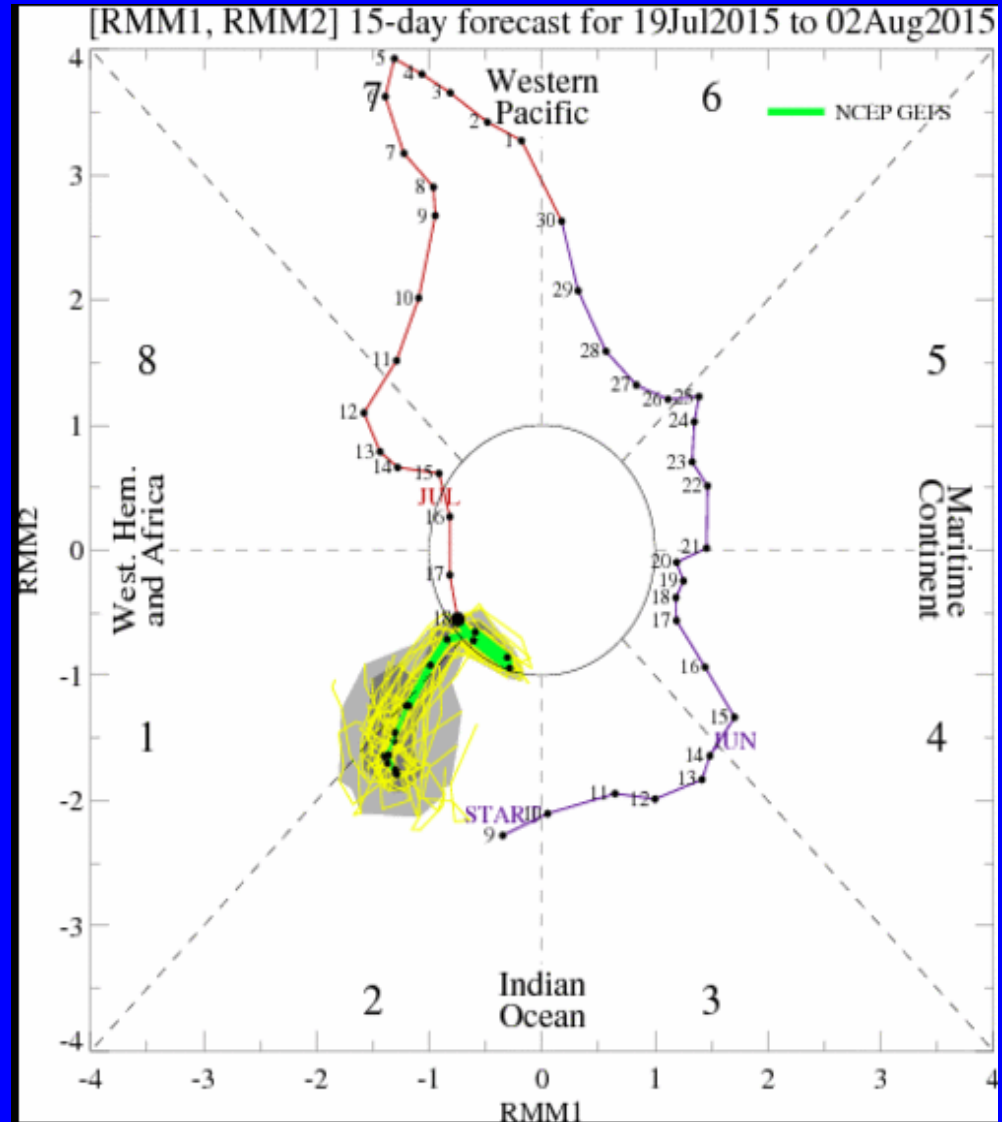
Ensemble GFS (GEFS) MJO Forecast

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 a strengthening signal over the western Indian Ocean during Week-2.

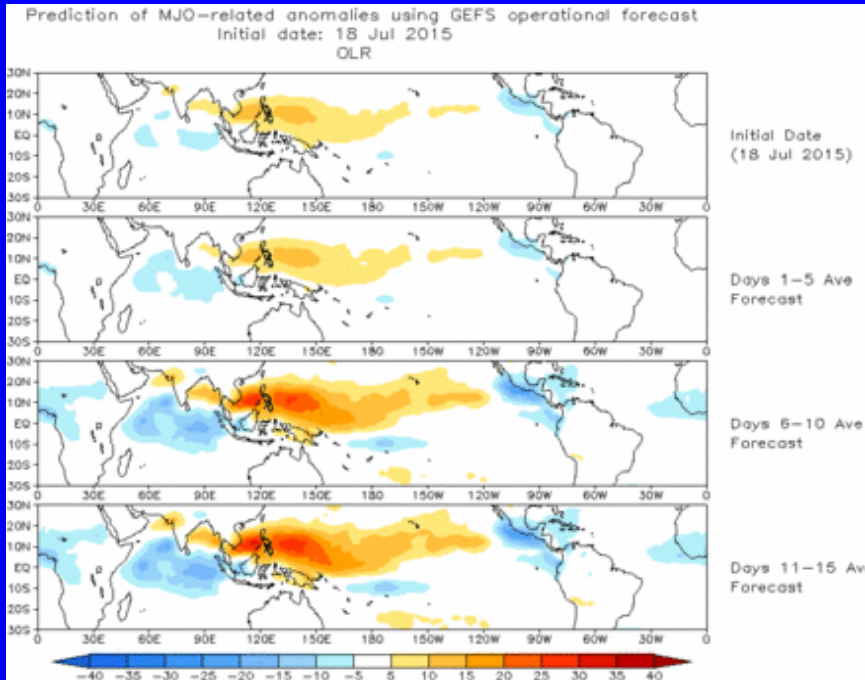




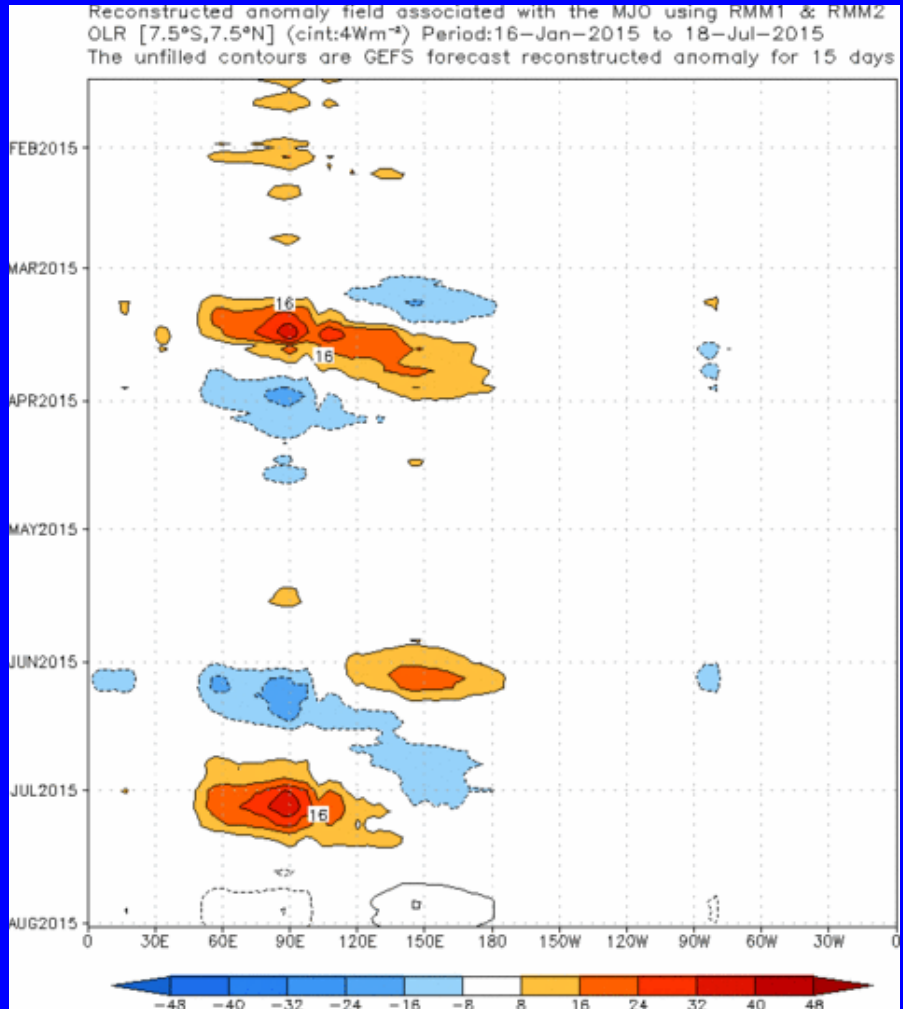
Ensemble Mean GFS MJO Forecast

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



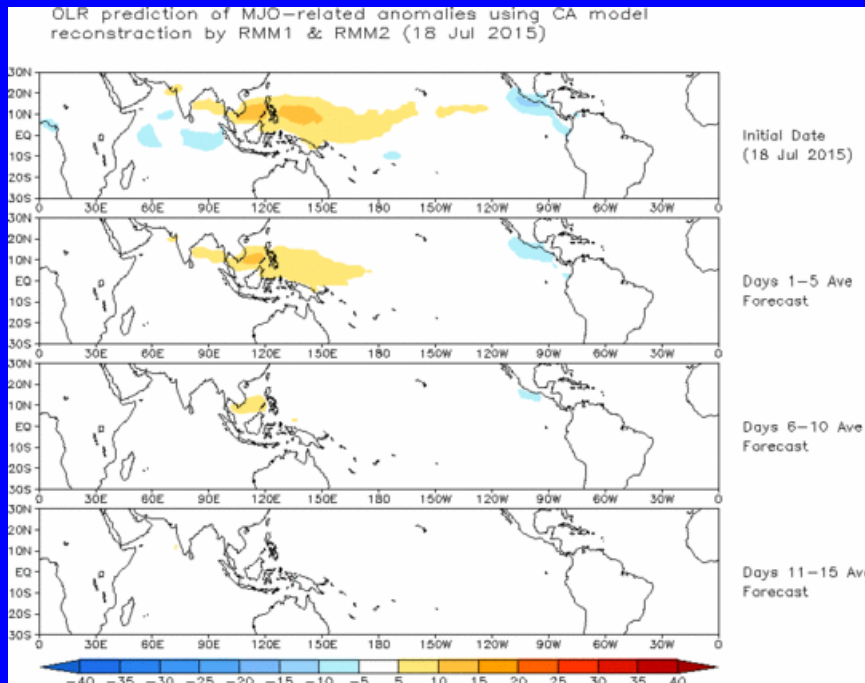
The ensemble GFS MJO index based forecast depicts a strengthening anomaly pattern with enhanced (suppressed) convection over the Indian Ocean (western Pacific) during the period.



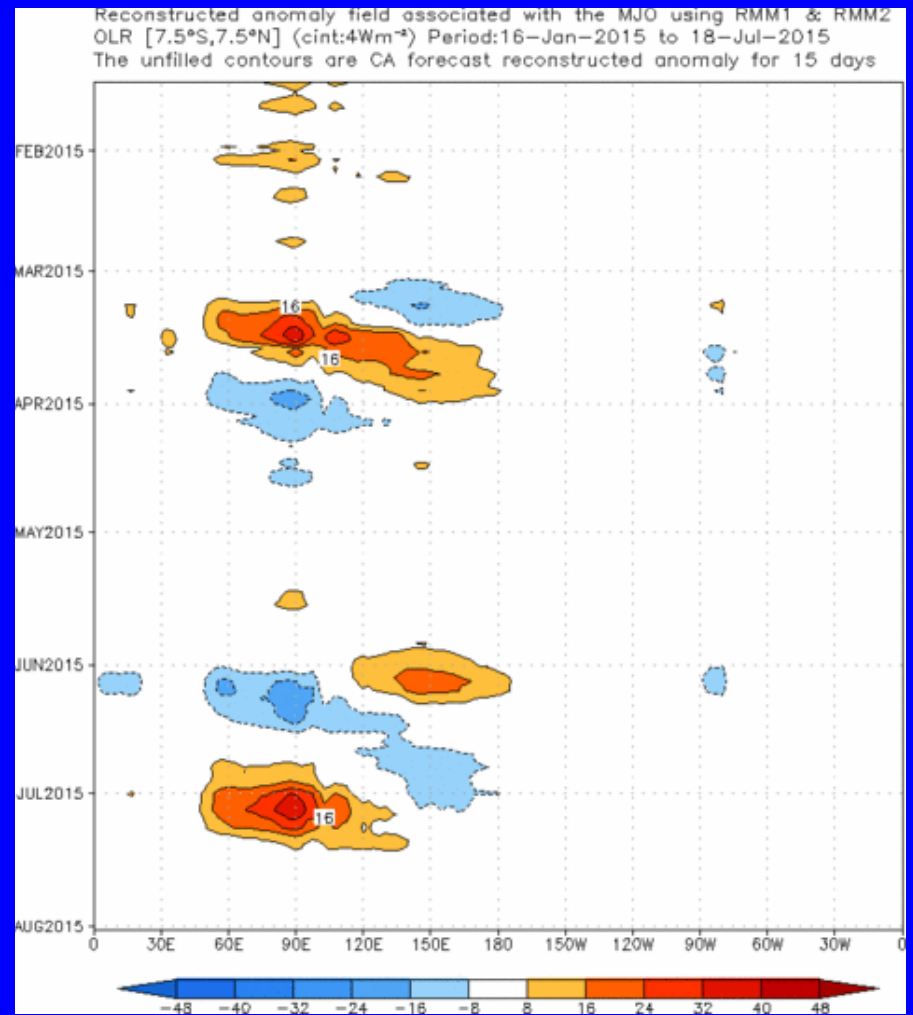
Constructed Analog (CA) MJO Forecast

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



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



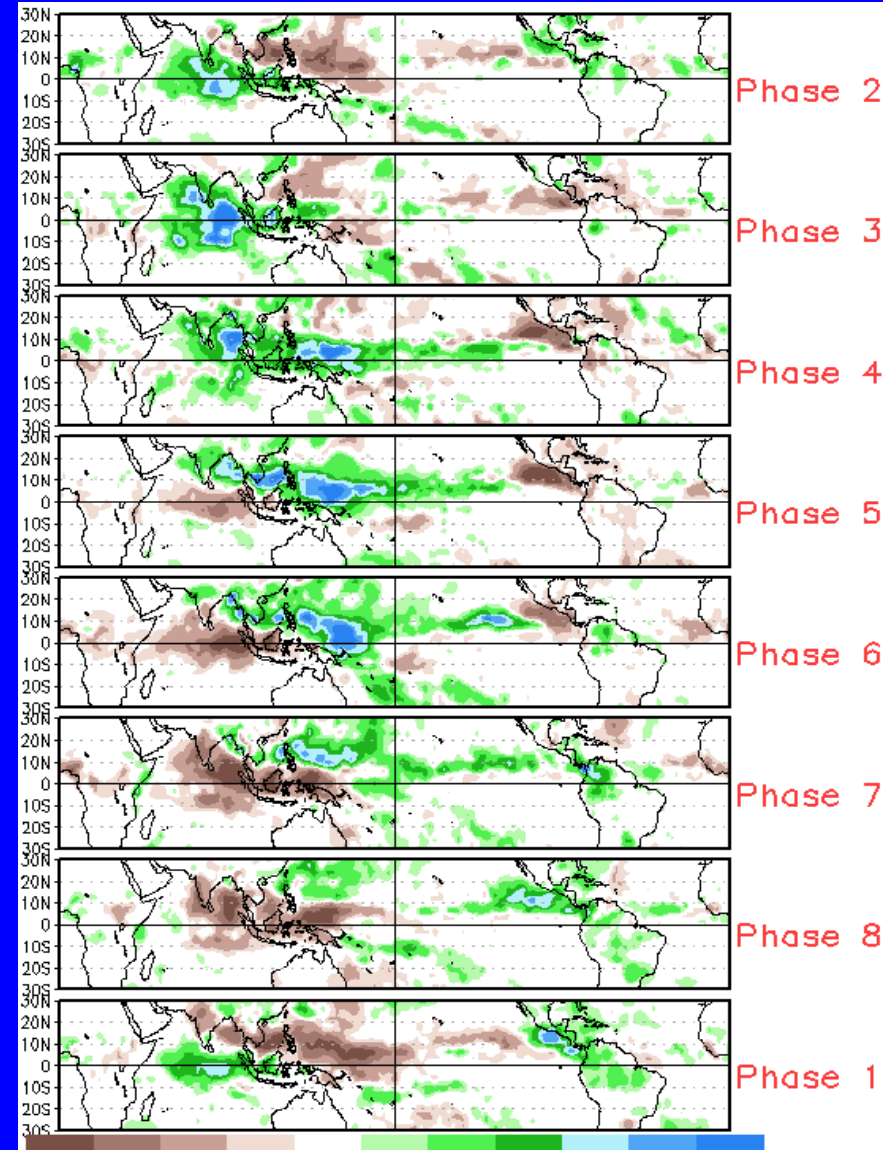
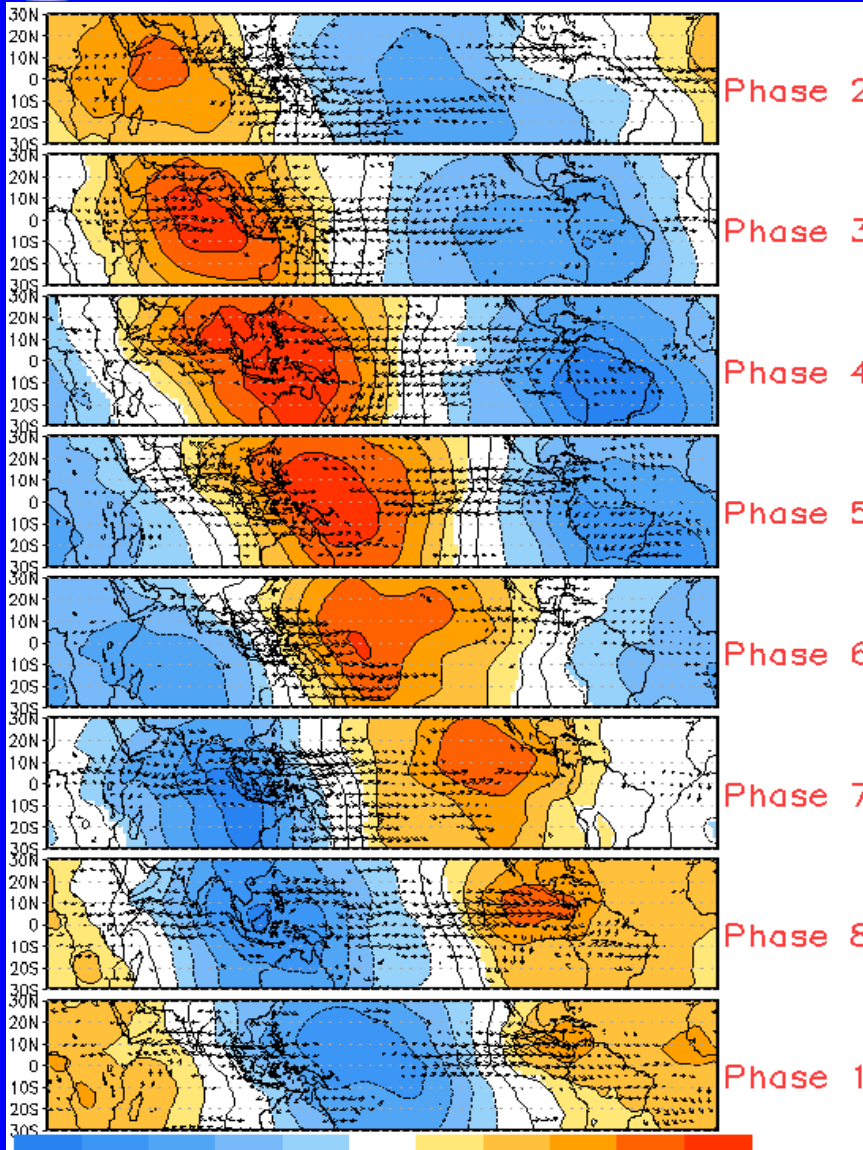
The statistical forecast weakens the anomaly field substantially by Week-2.



MJO Composites – Global Tropics

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

Precipitation Anomalies (May-Sep)

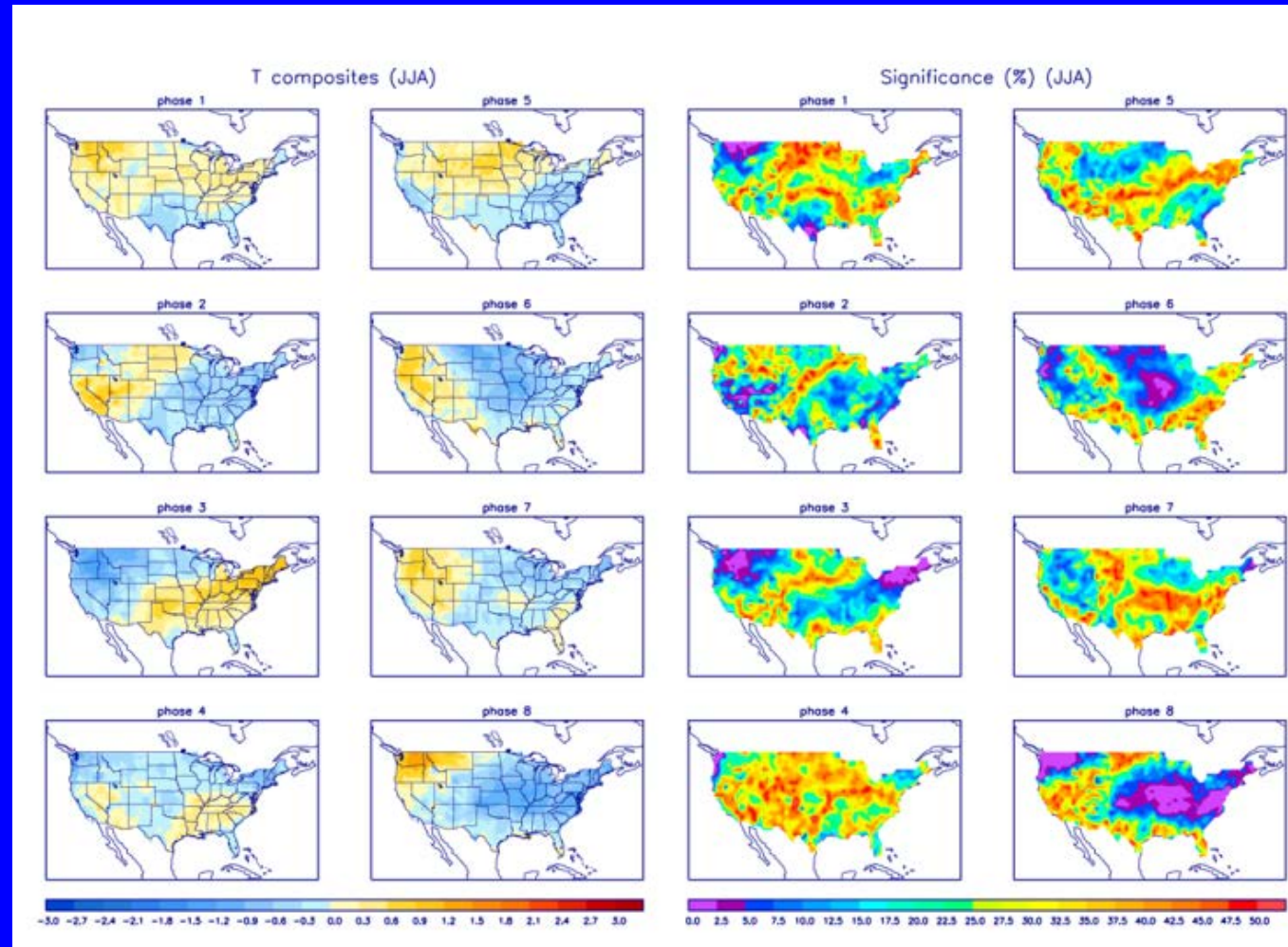




U.S. MJO Composites – Temperature

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.



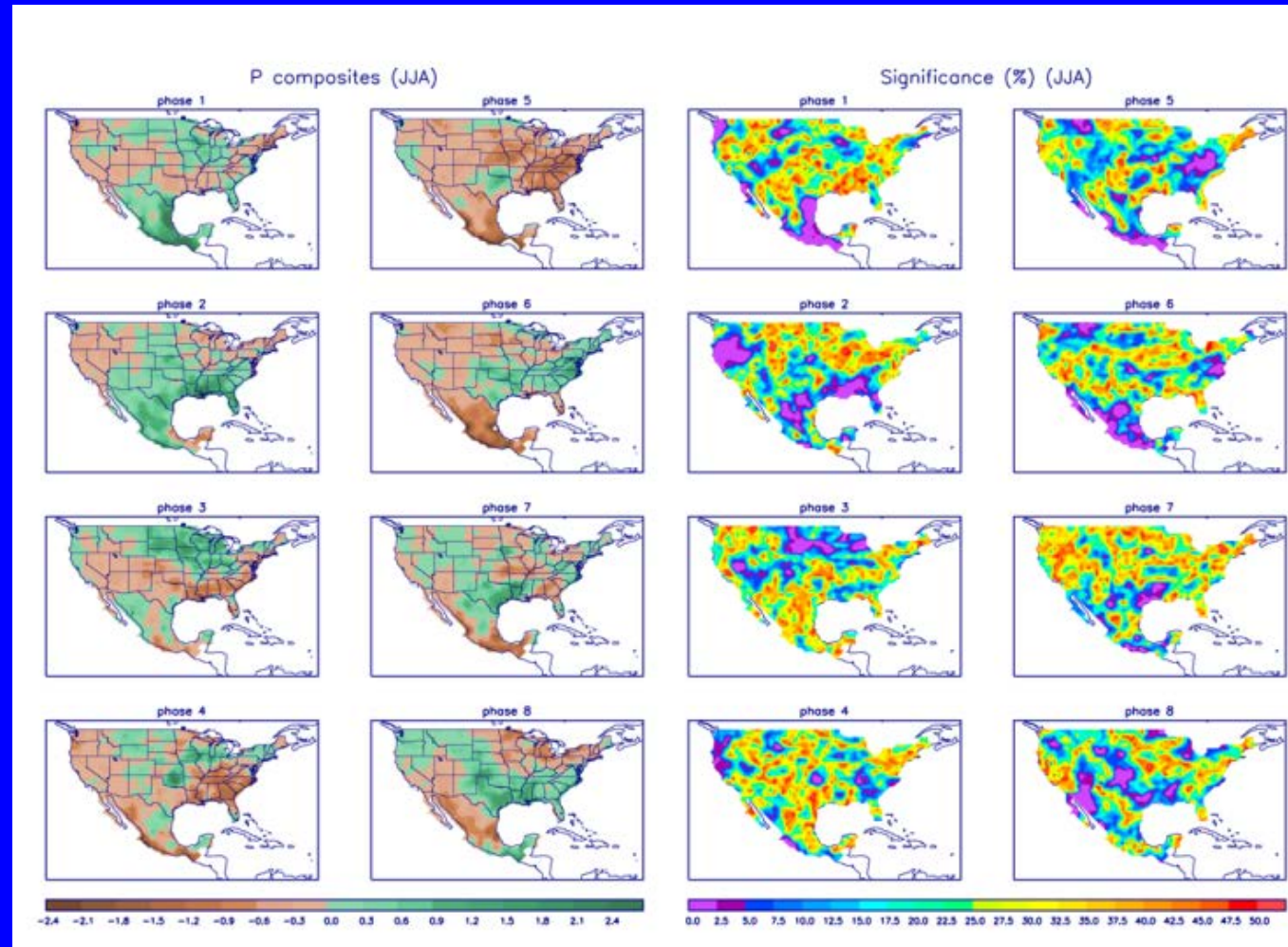
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>