

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



Update prepared by:
Climate Prediction Center / NCEP
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Outline

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Recent Evolution and Current Conditions

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MJO Composites

Overview

The MJO remained weak during the past week.

Other types of variability, including the ongoing El Niño and tropical cyclone activity over the western Pacific, are presently the primary drivers of the global tropical convective pattern.

Dynamical models are highly divergent due to the incoherent intraseasonal pattern, with most depicting little signal over the next two weeks.

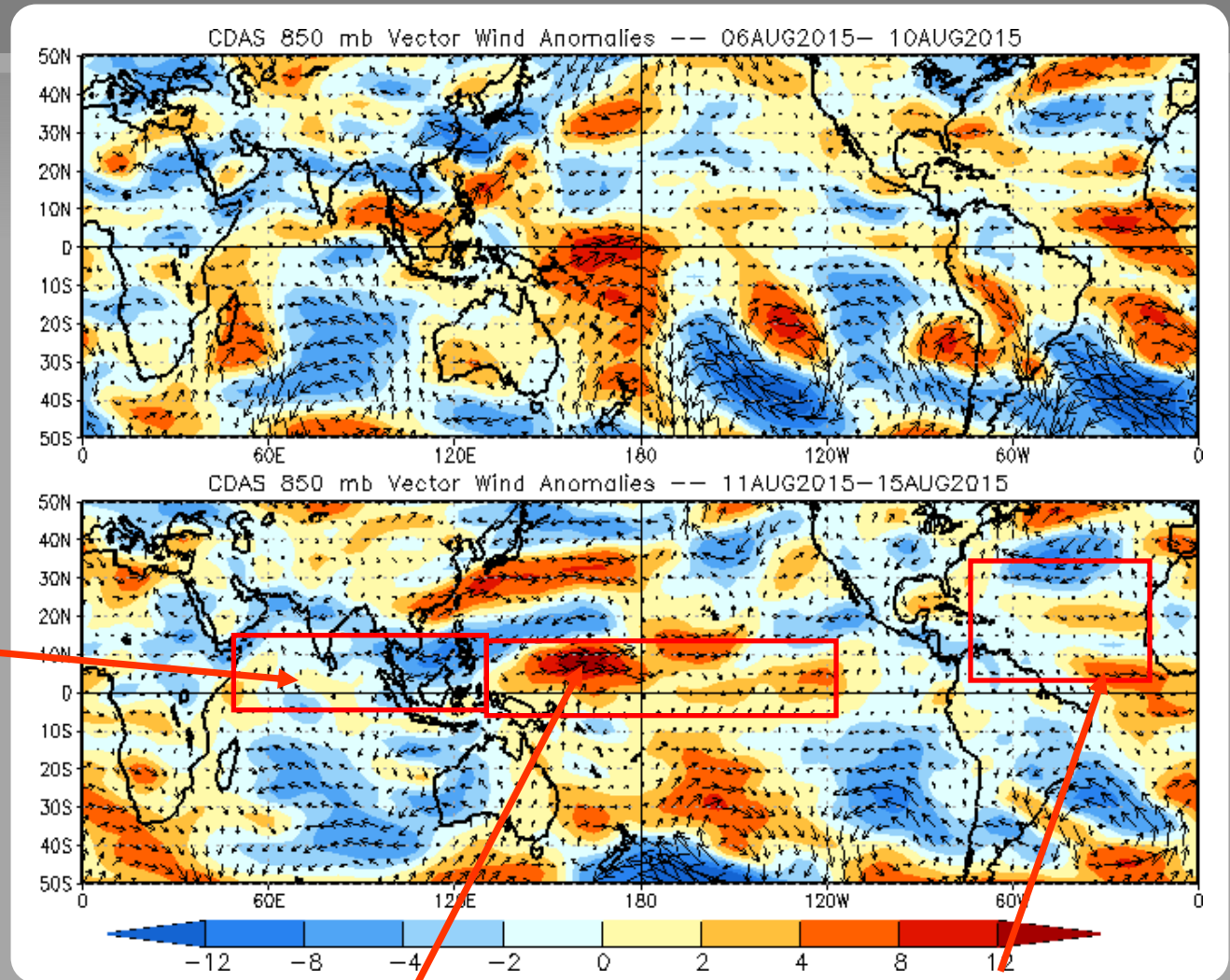
The MJO is not expected to play a role in the pattern of tropical convection during the next two weeks. The low frequency ENSO state and other modes, such as tropical cyclones and potentially the Indian Ocean Dipole pattern, are anticipated to have more influence.

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

Generally weak anomalies were observed over the northern Indian Ocean. Easterly anomalies overspread the western Maritime Continent.



Strong westerly wind anomalies, partly associated with tropical cyclone activity, persisted west of the Date Line.

Westerly wind anomalies persisted just north of the equator over the tropical Atlantic, with weak anomalies elsewhere.

850-hPa Zonal Wind Anomalies (m s⁻¹)

Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

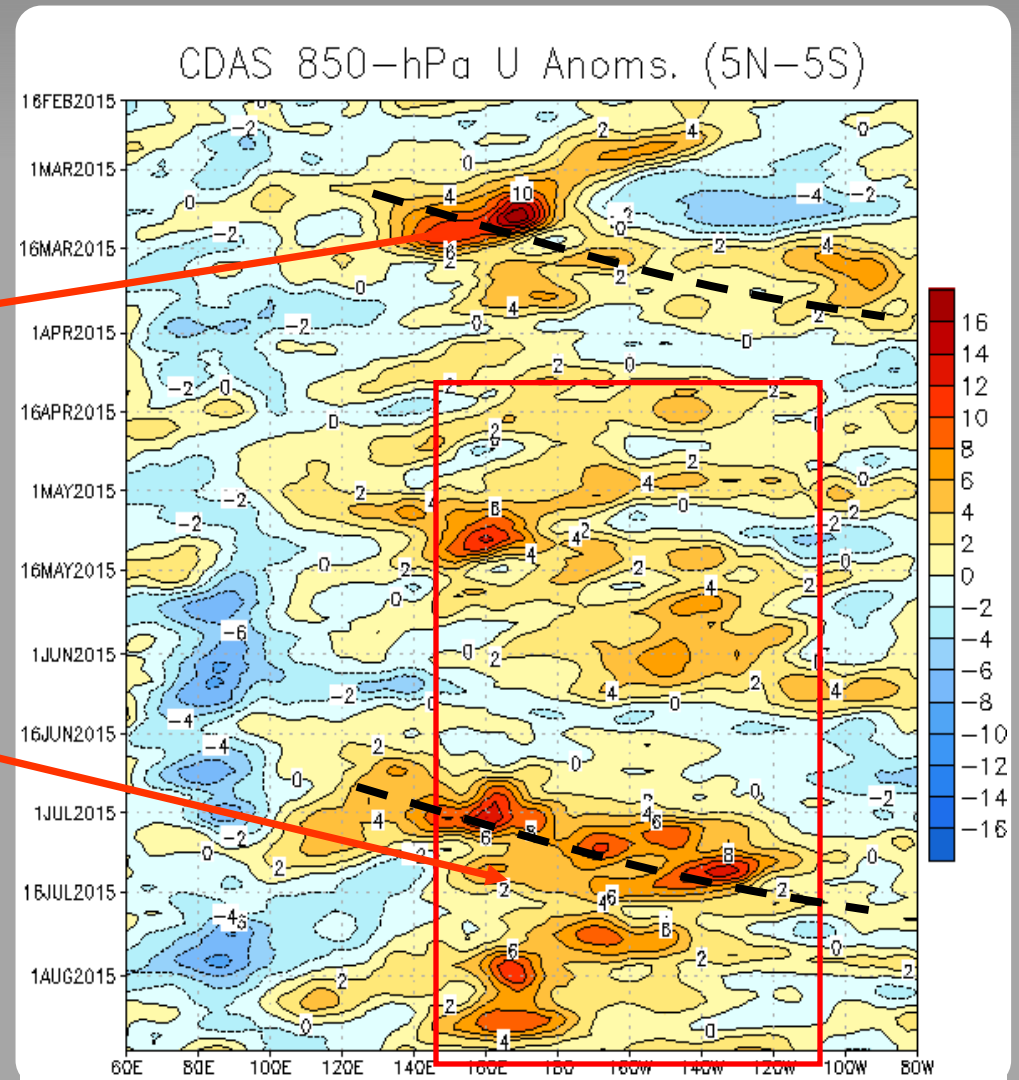
Easterly anomalies (blue shading) represent anomalous east-to-west flow

The MJO, Rossby wave activity, and El Niño conditions contributed to a strong westerly wind burst in early March.

The red box highlights the persistent low-frequency westerlies wind anomalies associated with ENSO. Some transient variability is observed as well.

A robust MJO event was observed in late June through mid-July, constructively interfering with the background state.

Recently, the background ENSO remains the primary signal, but other modes, including tropical cyclone activity west of the Date Line, continue to influence the pattern.



OLR Anomalies - Past 30 days

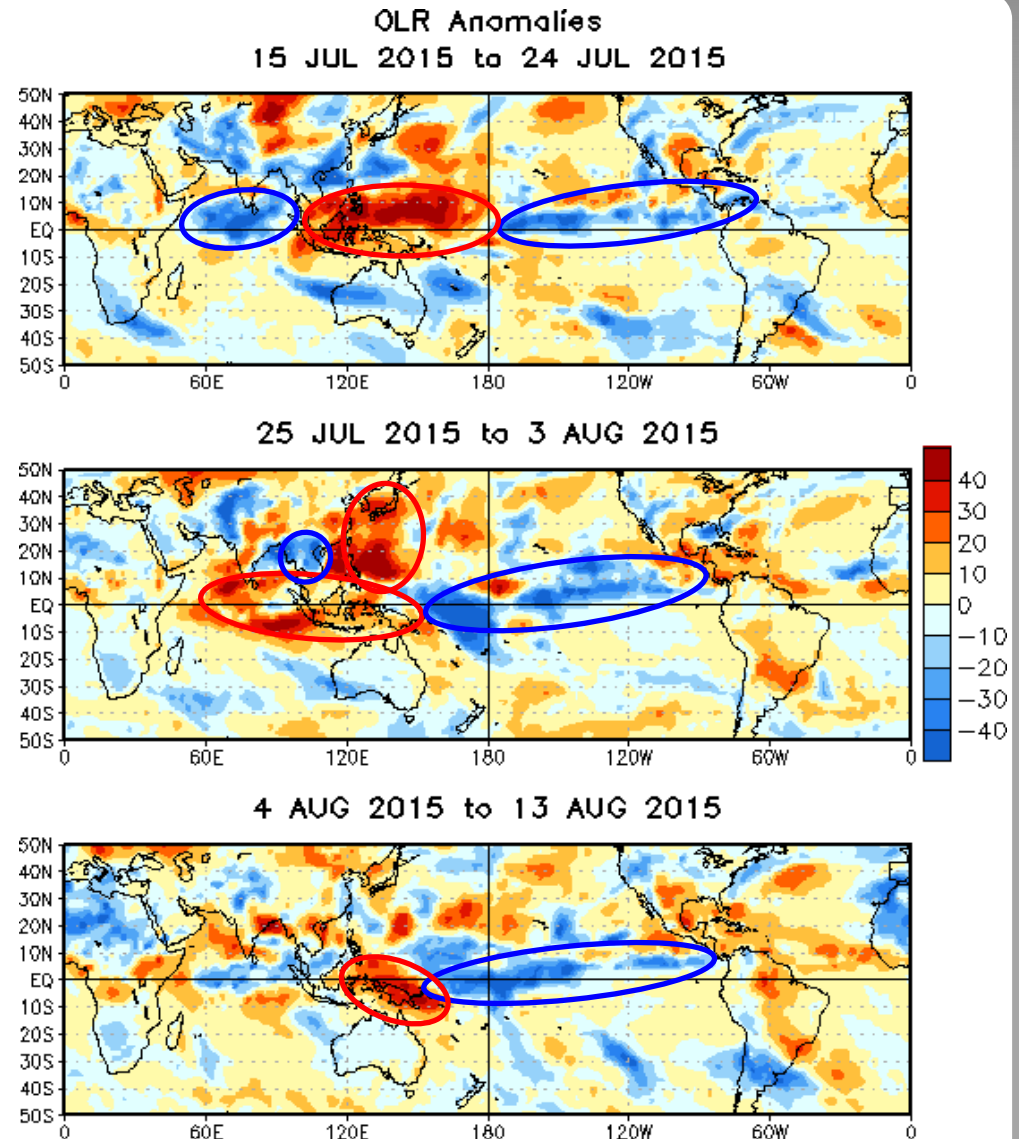
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid to late-July, the background ENSO pattern was evident with suppressed (enhanced) convection over the Maritime Continent and West Pacific (central and eastern Pacific and the central Indian Ocean).

Strong convection developed just west of the Date Line during late July and early August, while suppressed convection returned to the Indian Ocean and persisted over the Maritime Continent and northwestern Pacific.

During early August, enhanced (suppressed) convection persisted over the central Pacific (eastern Maritime Continent). A weaker anomaly field prevailed over the Indian Ocean Basin.



Outgoing Longwave Radiation (OLR) Anomalies (2.5°N-17.5°N)

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

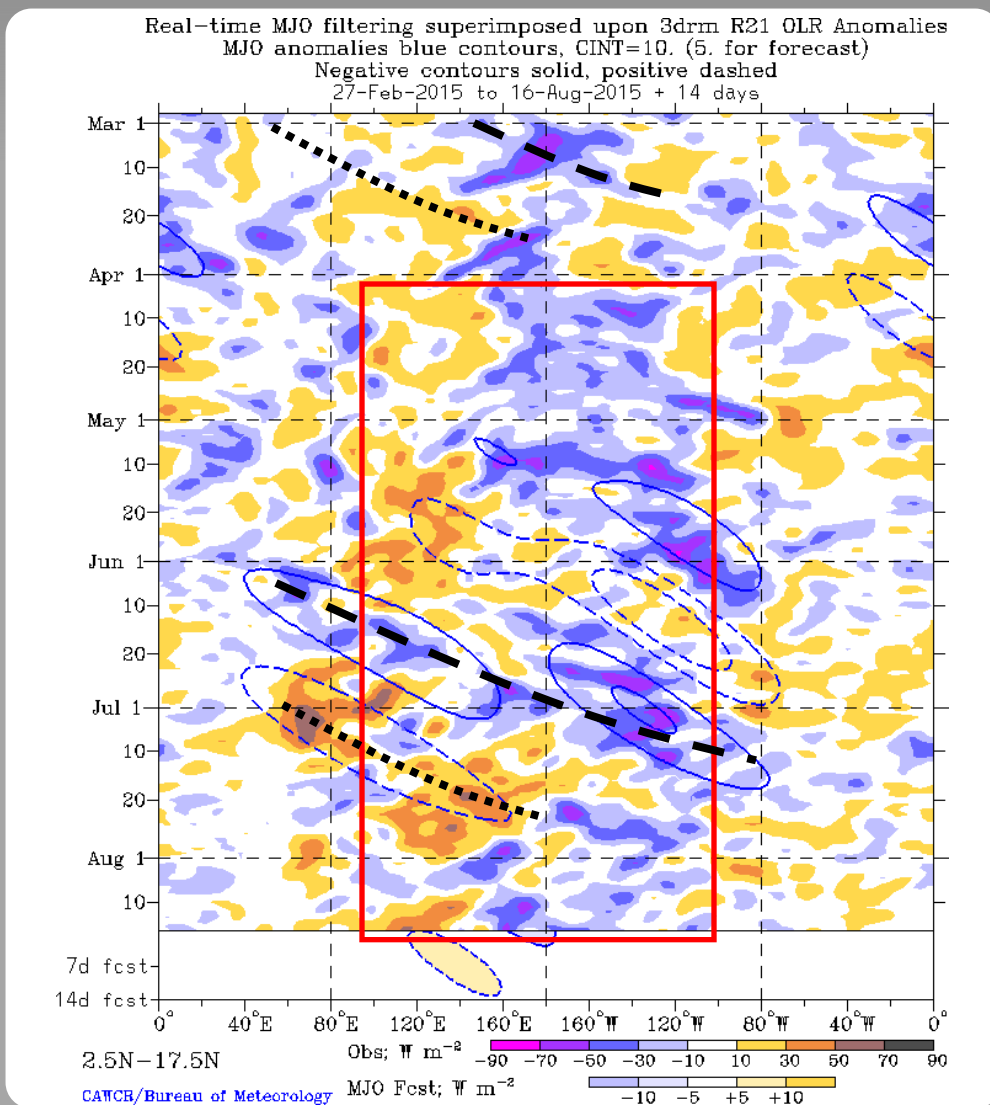
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

The MJO become active during March, with eastward propagating anomalies readily observed.

Since April, the ongoing El Niño is observed (red box) as a tendency toward a dipole of anomalous convection extending from the Maritime Continent (suppressed) to the East Pacific (enhanced).

During June and early July, the MJO become active, interfering with the ENSO signal at times.

Recently, the MJO signal has weakened and other modes, including El Niño and tropical cyclones, are more influential.



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

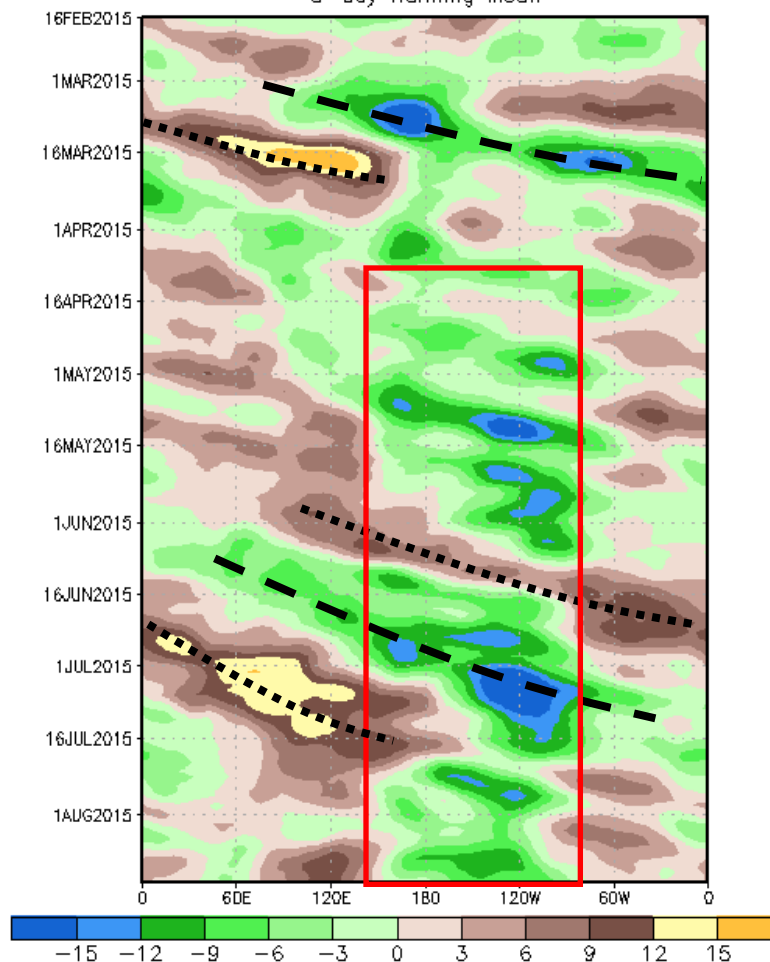
The MJO strengthened in early March as seen in the upper-level velocity potential anomalies.

The developing ENSO state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific. This pattern has only been temporarily interrupted by strong Kelvin wave/MJO activity at times.

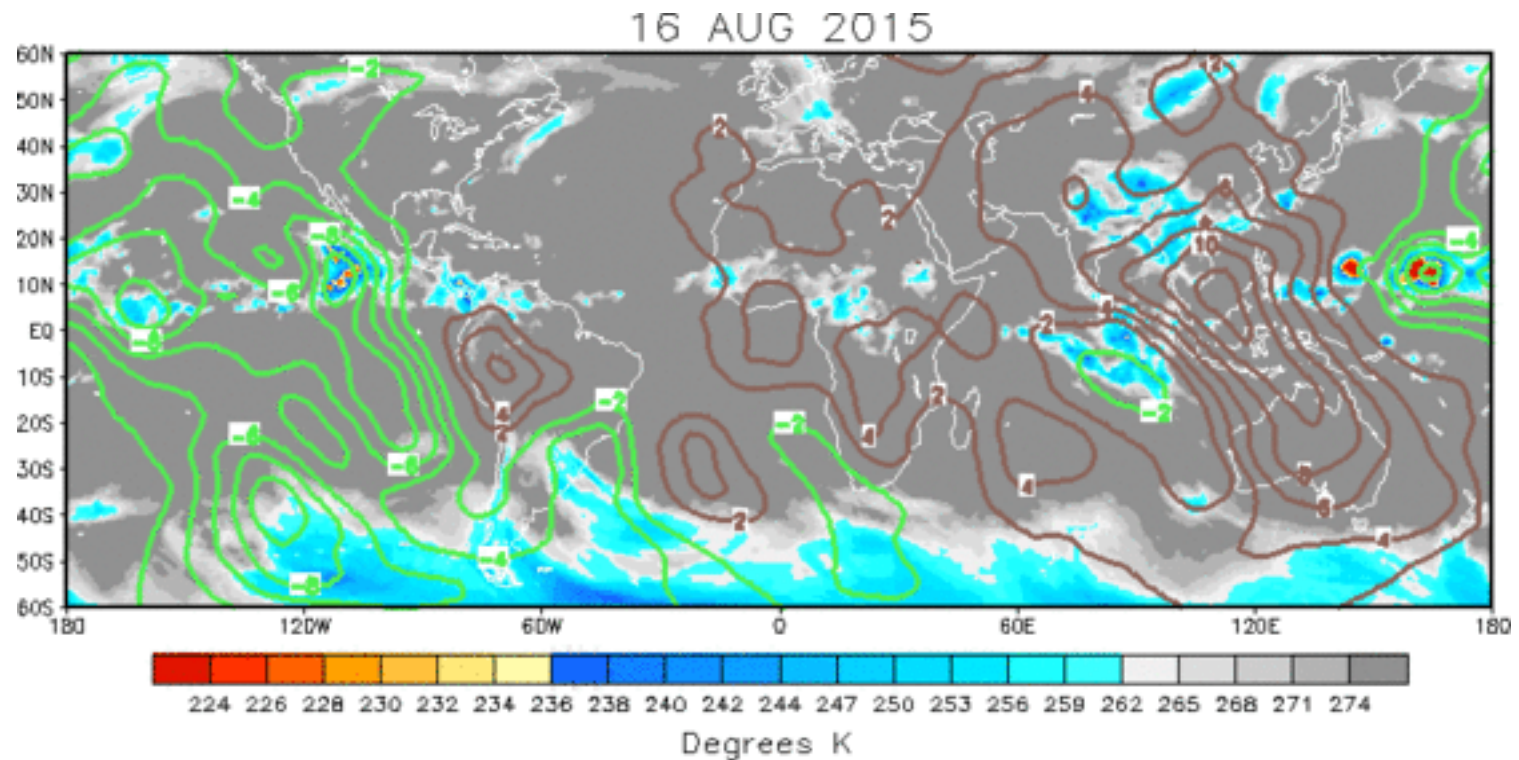
During June and early July, a high-amplitude MJO event was observed, constructively interfering with the El Niño signal in early July. By the end of July, the MJO weakened as the low-frequency state dominated the pattern of tropical variability.

More recently, a generally stationary pattern reflective of El Niño conditions was observed.

200-hPa Velocity Potential Anomaly: 5N-5S
5-day Running Mean



IR Temperatures (K) / 200-hPa Velocity Potential Anomalies



The upper-level velocity potential pattern continues to exhibit a generally wavenumber 1 pattern, with anomalous upper-level divergence (typically associated with enhanced convection) over the central and eastern Pacific, and convergence over Africa and the Maritime Continent.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation

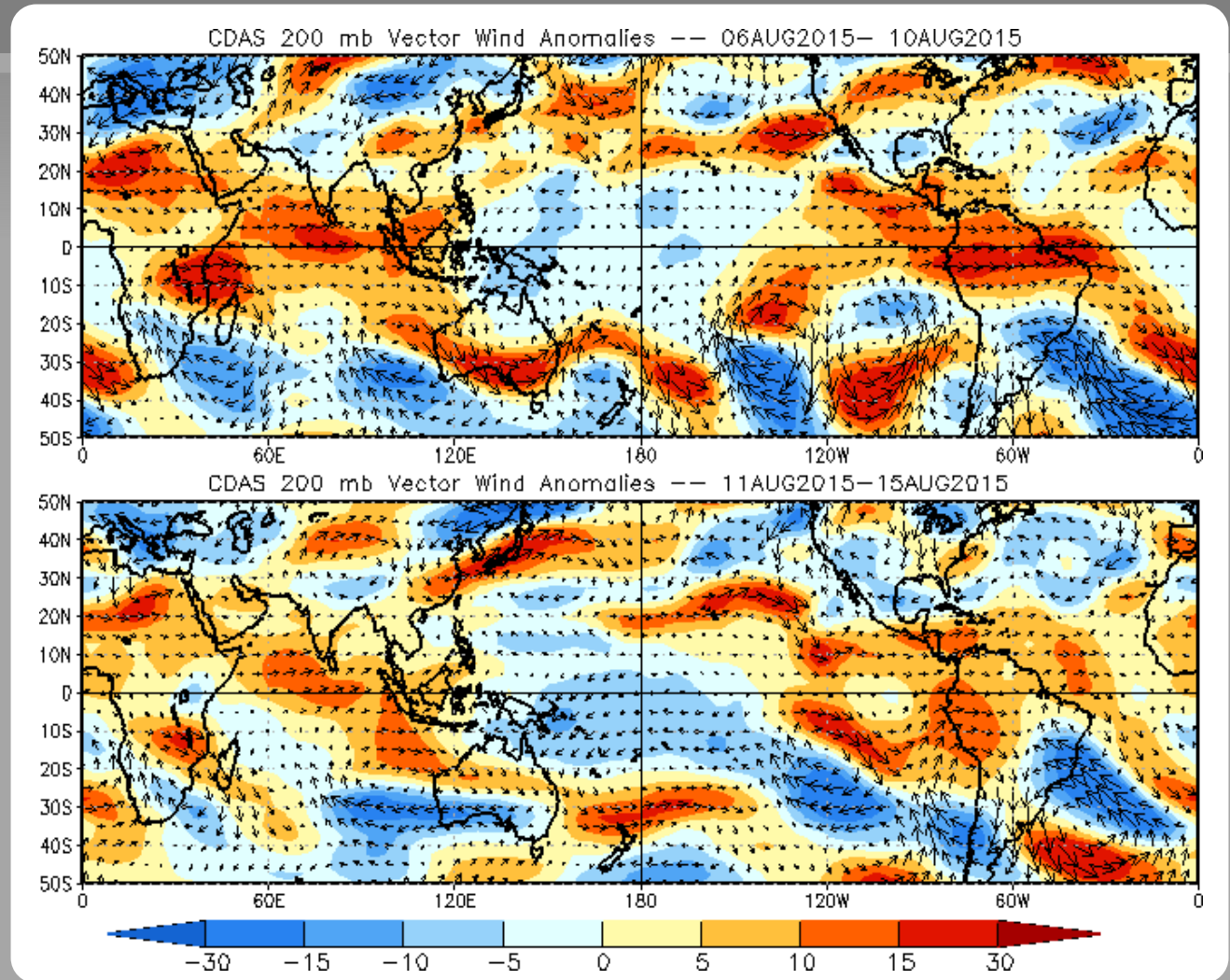
200-hPa Vector Wind Anomalies (m s⁻¹)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Westerly anomalies persisted over the eastern Pacific, Caribbean, and tropical Atlantic.



200-hPa Zonal Wind Anomalies (m s⁻¹)

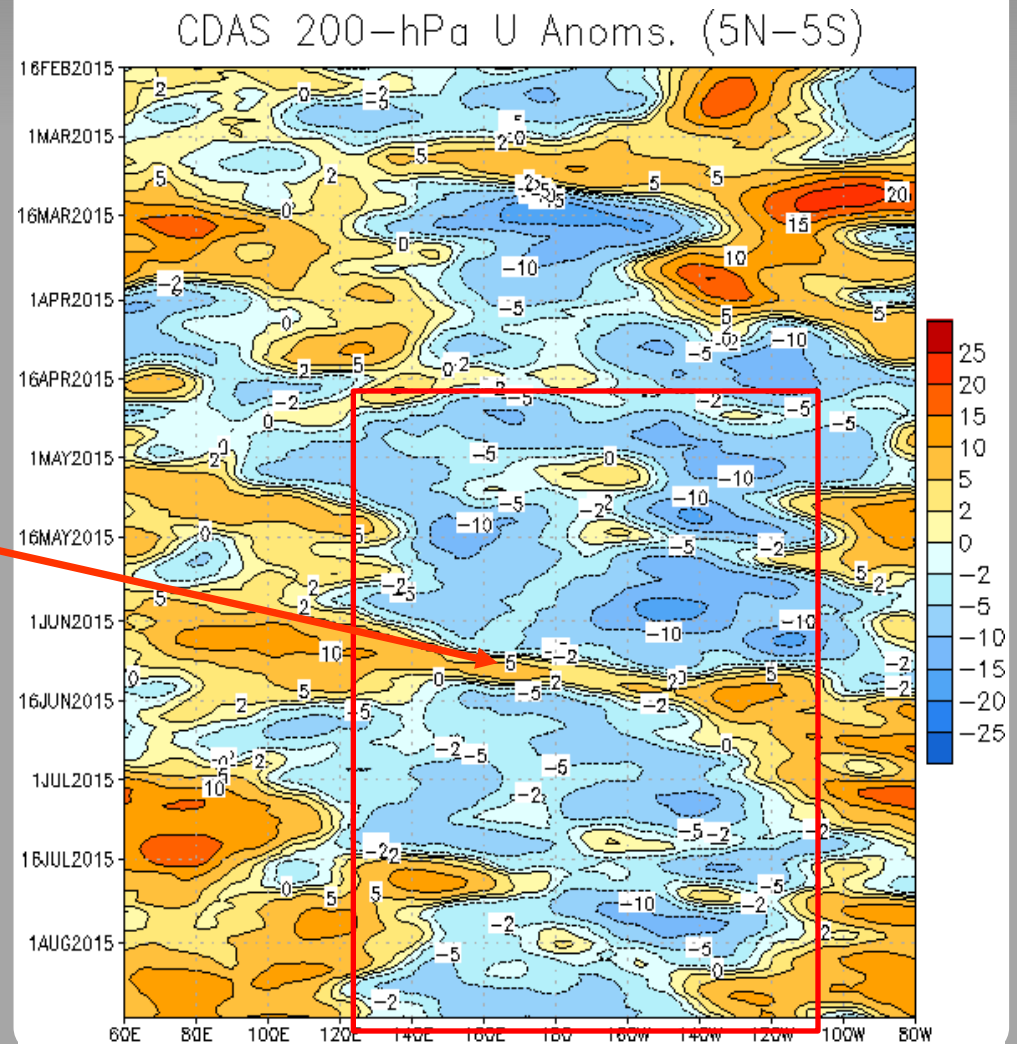
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

Easterly anomalies (blue shading) represent anomalous east-to-west flow

Easterly anomalies have persisted over the central and eastern Pacific associated with El Niño since mid-April (red box).

During June, these easterly anomalies were interrupted by a robust atmospheric Kelvin wave/MJO activity.

Recently, some westward propagation of westerly anomalies from the Maritime Continent to the Indian Ocean was evident.



Weekly Heat Content Evolution in the Equatorial Pacific

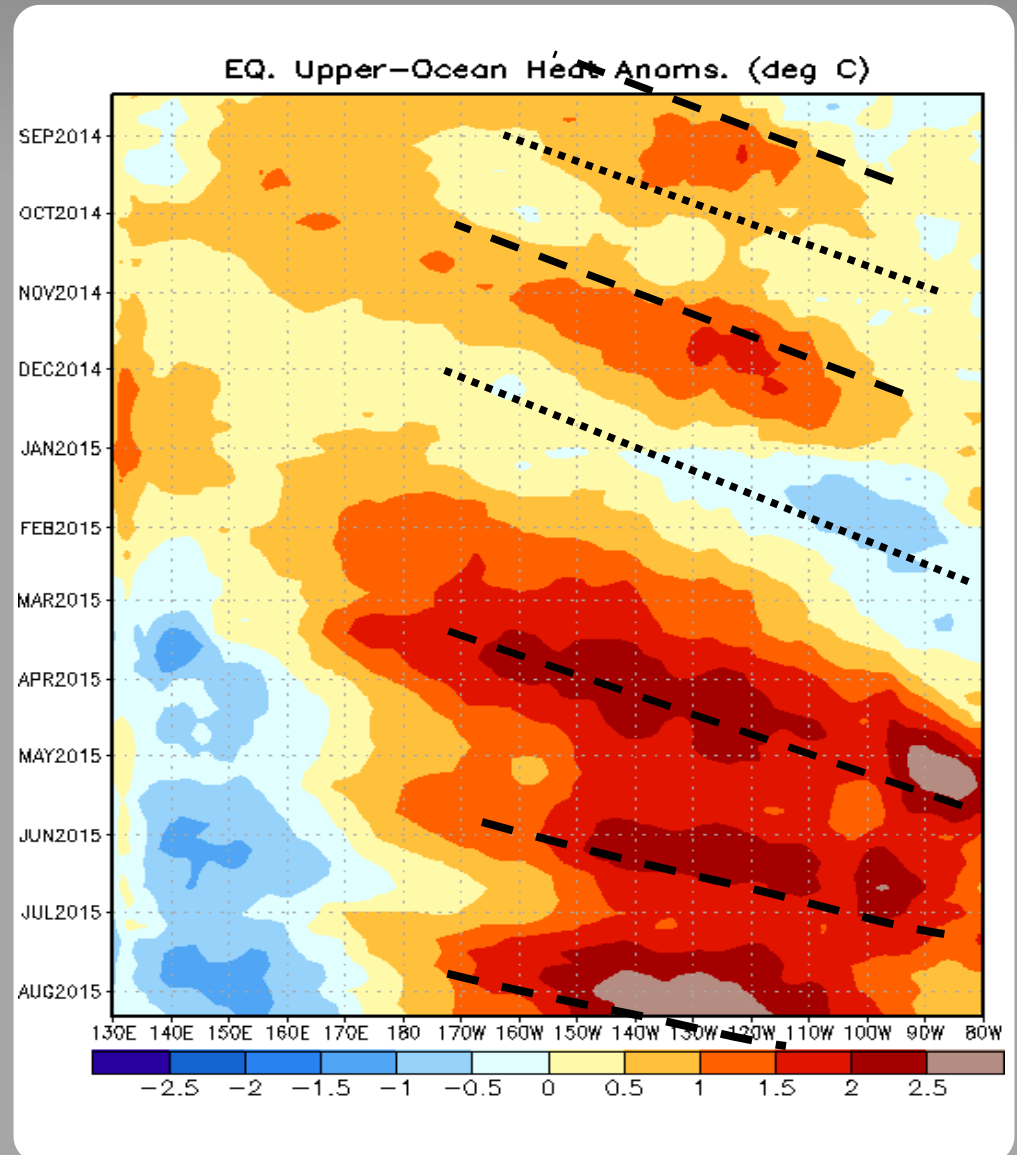
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

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.

Following a strong westerly wind burst in March, another downwelling phase of a Kelvin wave propagated eastward, reaching the South American coast during May.

Reinforcing downwelling events have followed, resulting in persistently above-normal heat content from the Date Line to 90W.

Heat content anomalies greater than 2.5° C were observed over the east-central Pacific with the latest oceanic 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

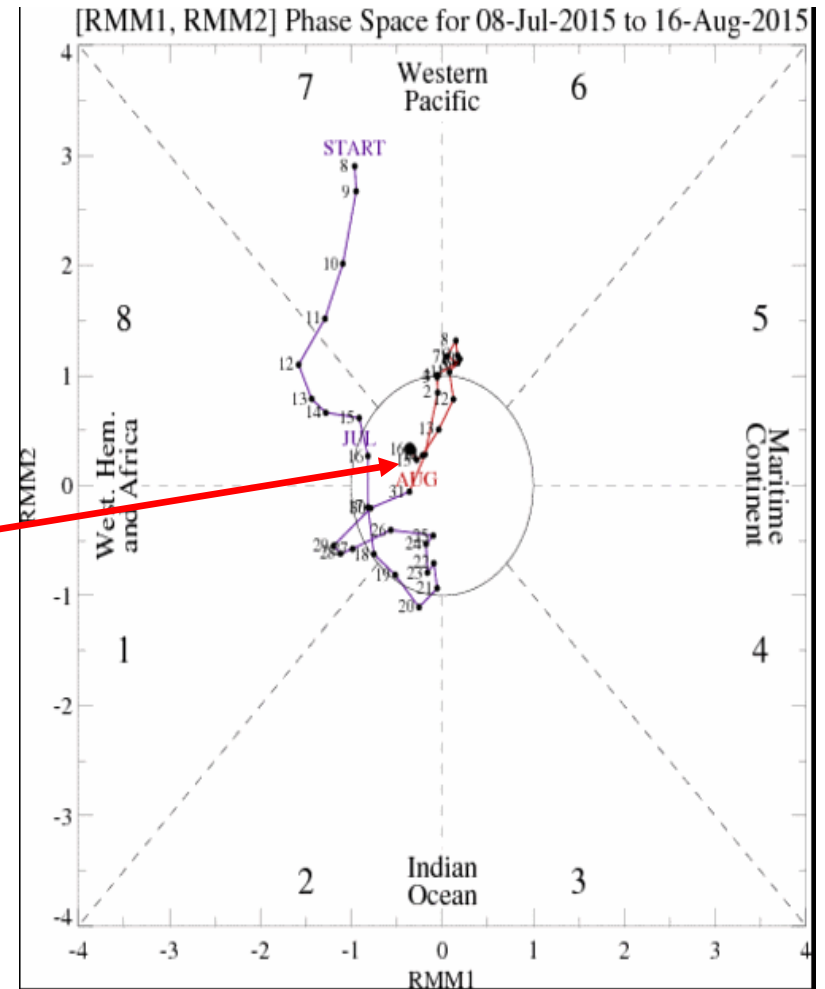
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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

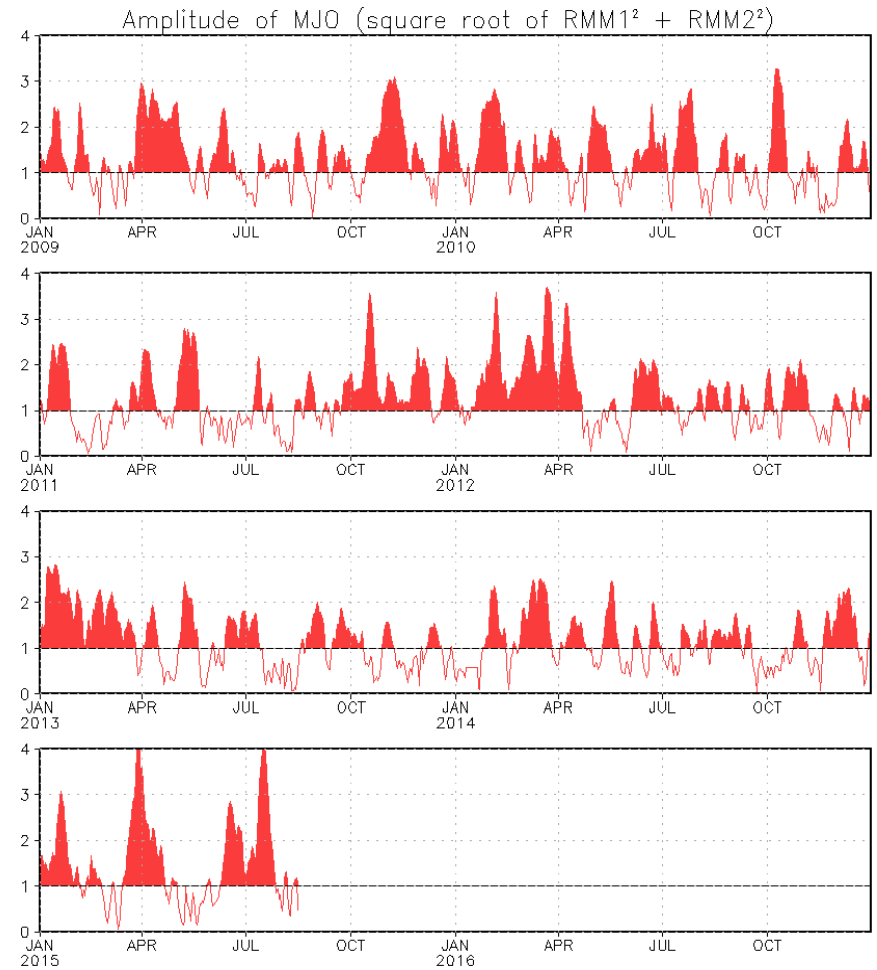


The RMM index indicated weak MJO activity.

MJO Index - Historical Daily Time Series

Time series of daily MJO index amplitude for the last few years.

Plot puts current MJO activity in recent historical context.



Ensemble GFS (GEFS) MJO Forecast

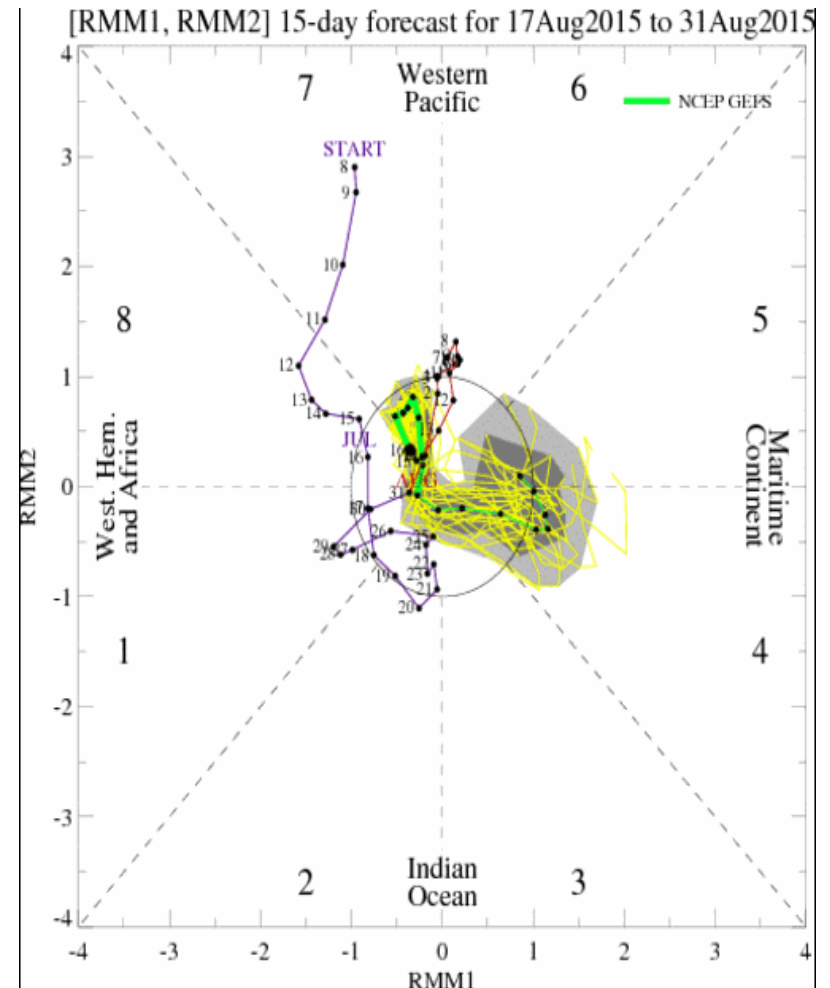
RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

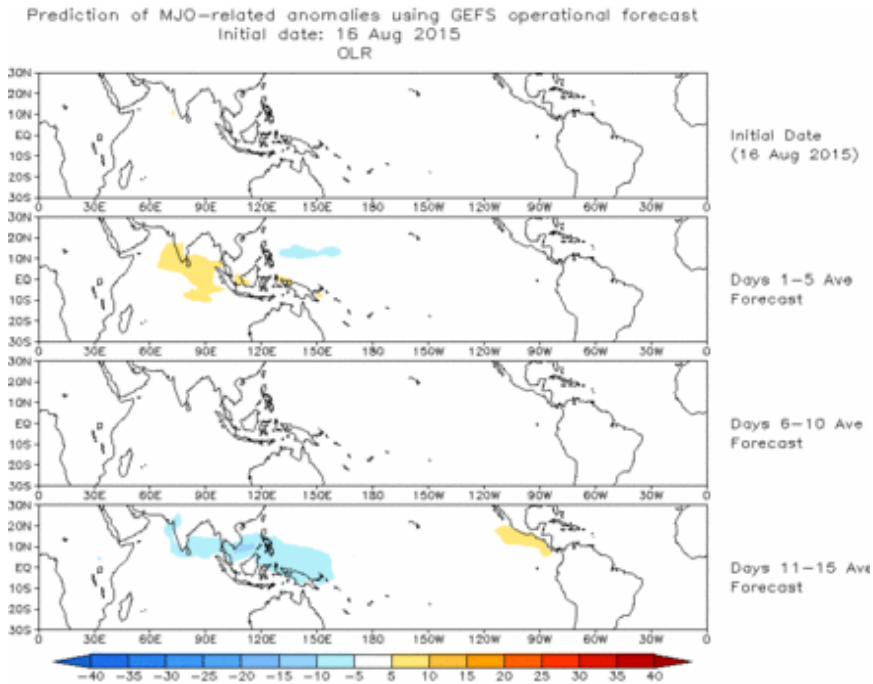
The GFS ensemble MJO index forecast depicts no coherent MJO signal during the next two weeks.

Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean



Ensemble GFS (GEFS) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

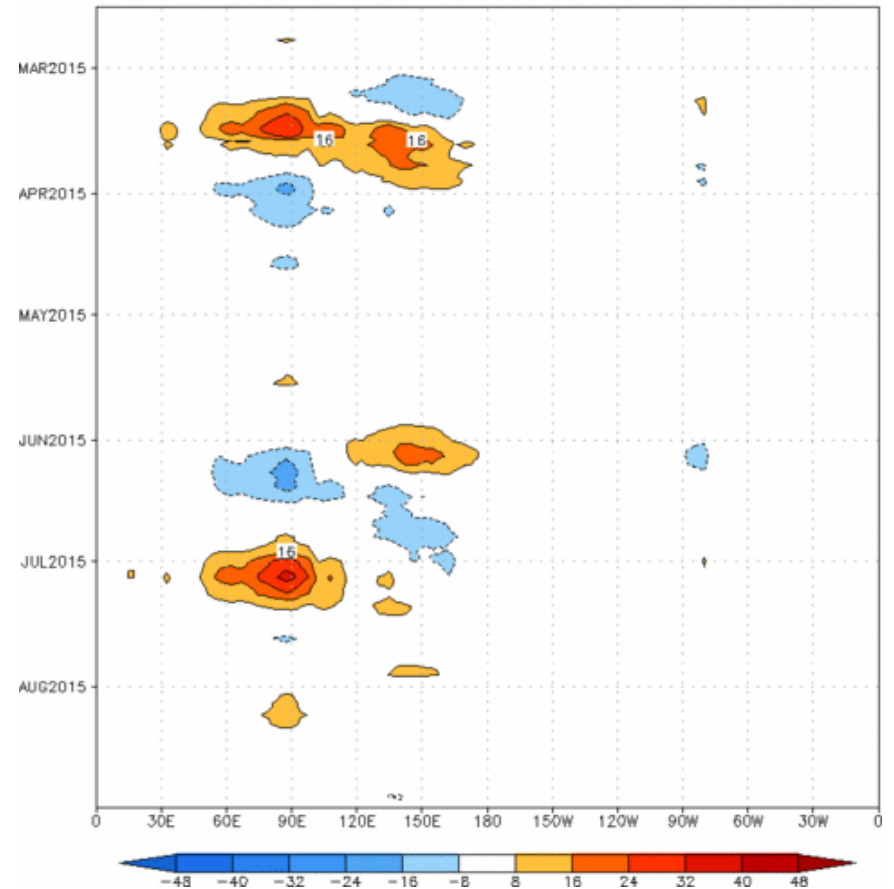


The GEFS MJO index-based OLR forecast depicts a weak anomaly pattern during the next two weeks, consistent with the weak MJO forecasts.

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.)

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

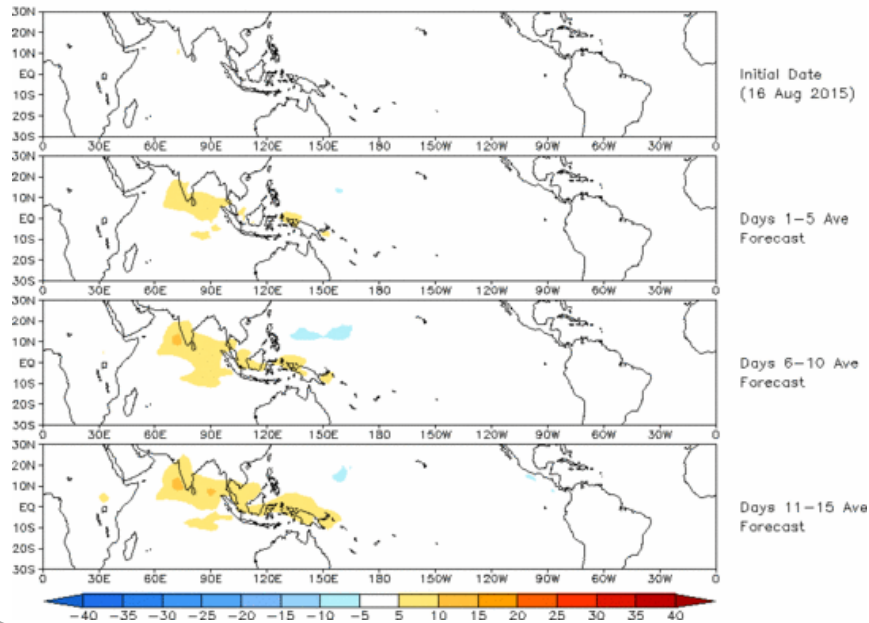
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2
OLR [7.5°S,7.5°N] (cont:4Wm⁻²) Period:14-Feb-2015 to 16-Aug-2015
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days



Constructed Analog (CA) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

OLR prediction of MJO-related anomalies using CA model reconstruction by RMM1 & RMM2 (16 Aug 2015)

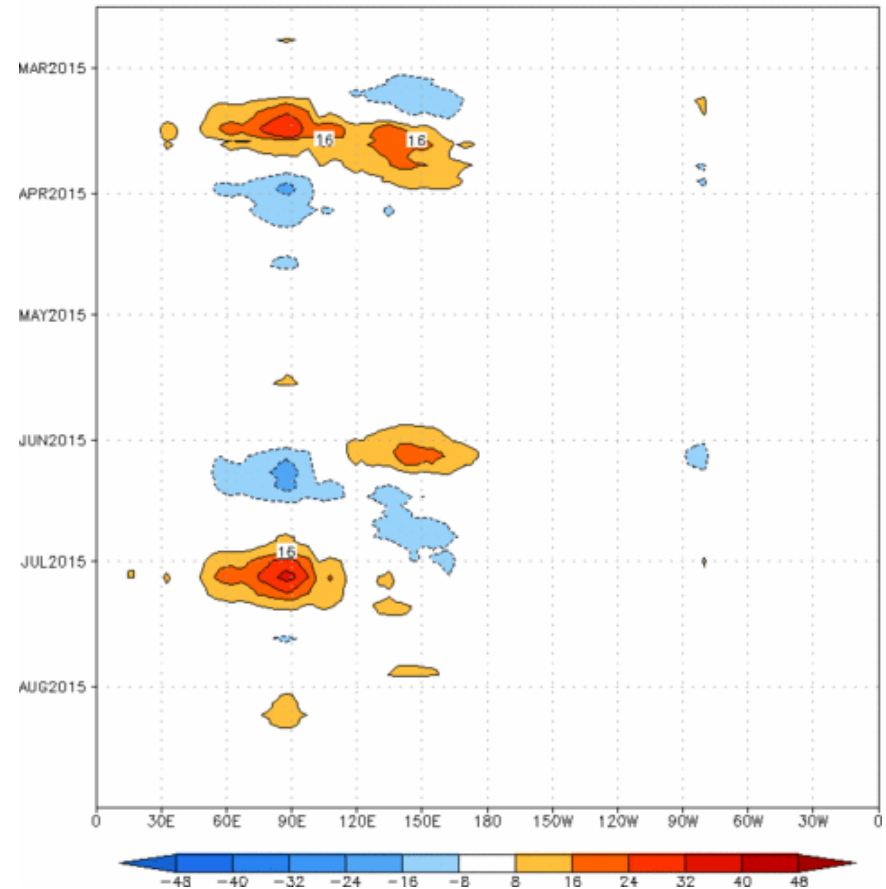


The constructed analog model also depicts a weak anomaly pattern, but shows eastward propagation of suppressed convection over the Maritime Continent during Week-2.

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.)

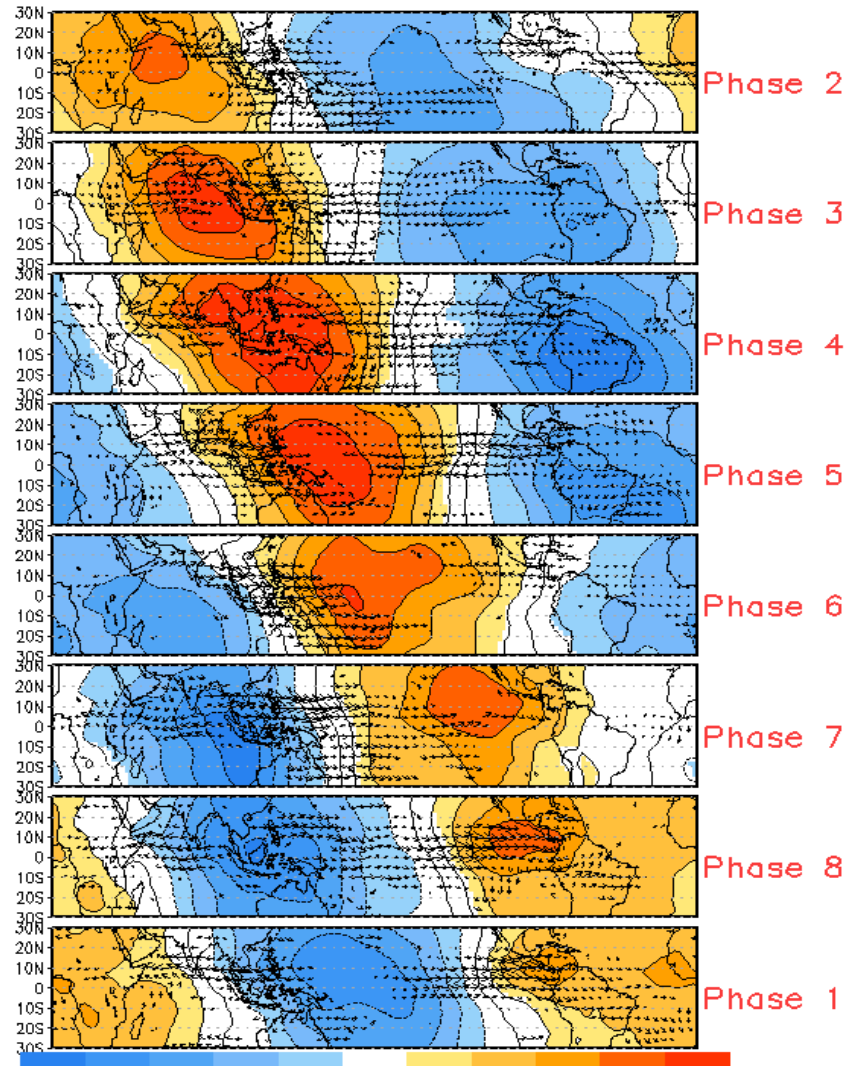
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [7.5°S,7.5°N] (cont:4Wm⁻²) Period:14-Feb-2015 to 16-Aug-2015
The unfilled contours are CA forecast reconstructed anomaly for 15 days

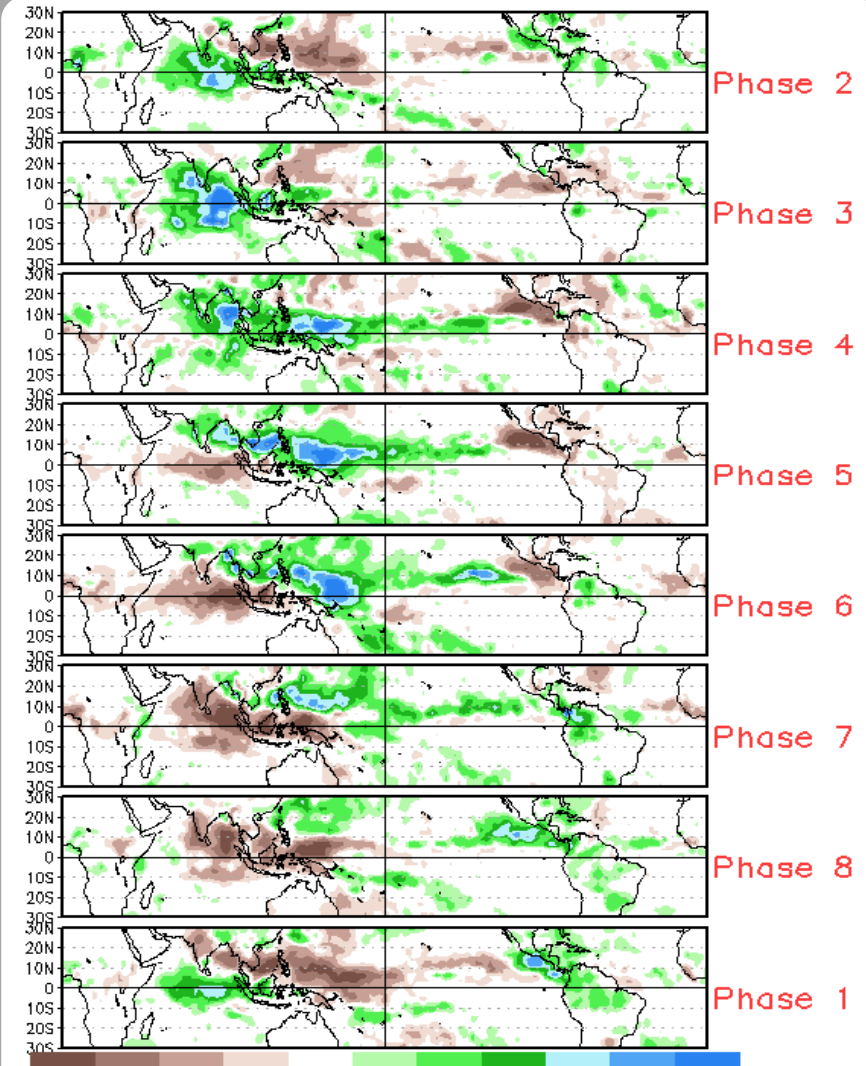


MJO Composites - Global Tropics

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



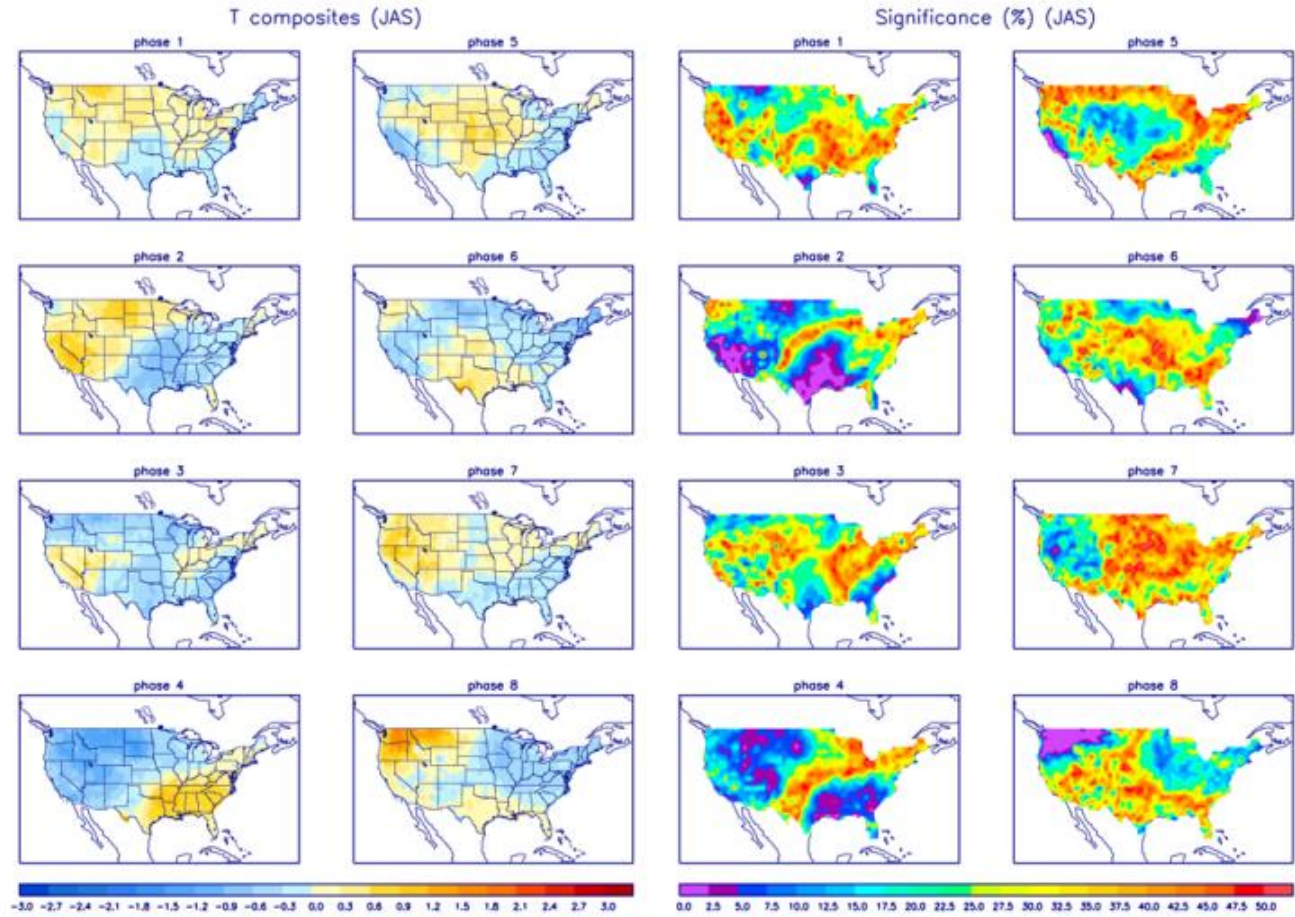
Precipitation Anomalies (May-Sep)



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.



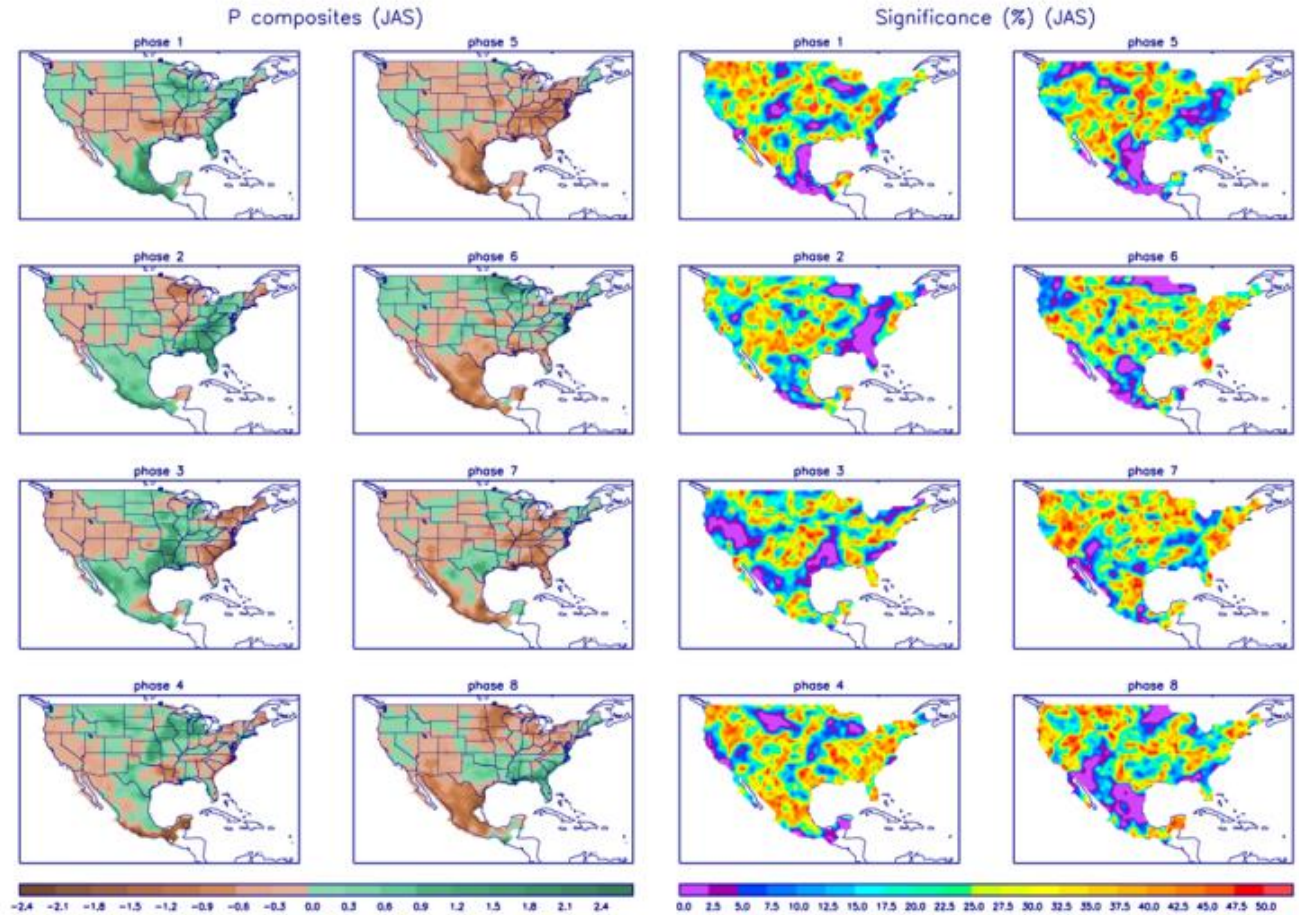
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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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