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

Update prepared by
Climate Prediction Center / NCEP
July 27, 2015

Outline

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

Overview

- **The MJO has weakened during the past week.**
- **With a weak MJO, with the low-frequency state now more dominant in the tropical circulation pattern.**
- **Dynamical model MJO index forecasts depict varying solutions, all depicting a westward moving signal in convection, with some amplification of the signal over the Americas during Week-1, followed by amplificiation over the West Pacific.**
- **Based on the dynamical model forecasts, the MJO is not likely to play a direct role in the distribution of tropical convection during the next 2 weeks.**

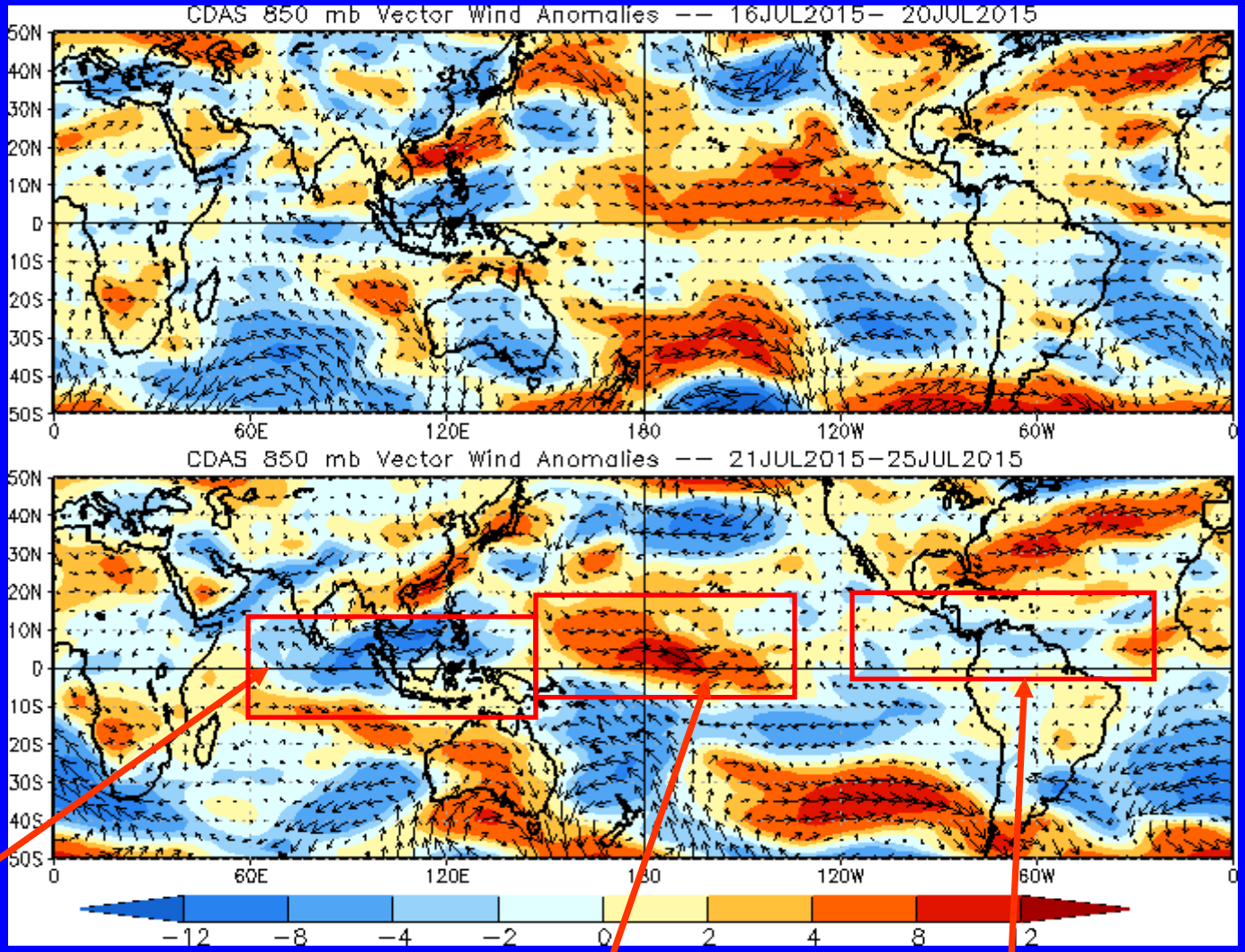
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 strengthened over the eastern Indian Ocean and Southeast Asia.

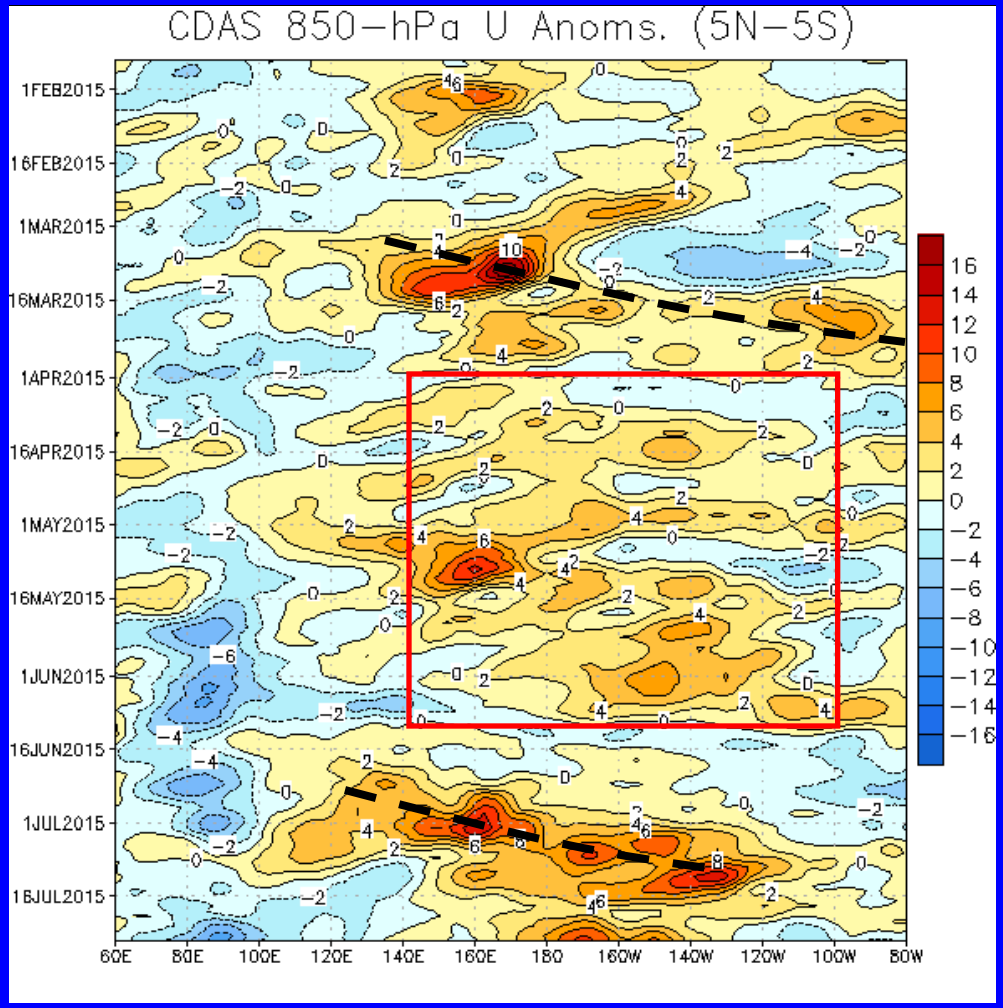
Westerly wind anomalies intensified over the central Pacific.

Easterly anomalies replaced westerly anomalies over the East Pacific, while intensifying slightly over the Atlantic Basin.

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

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.

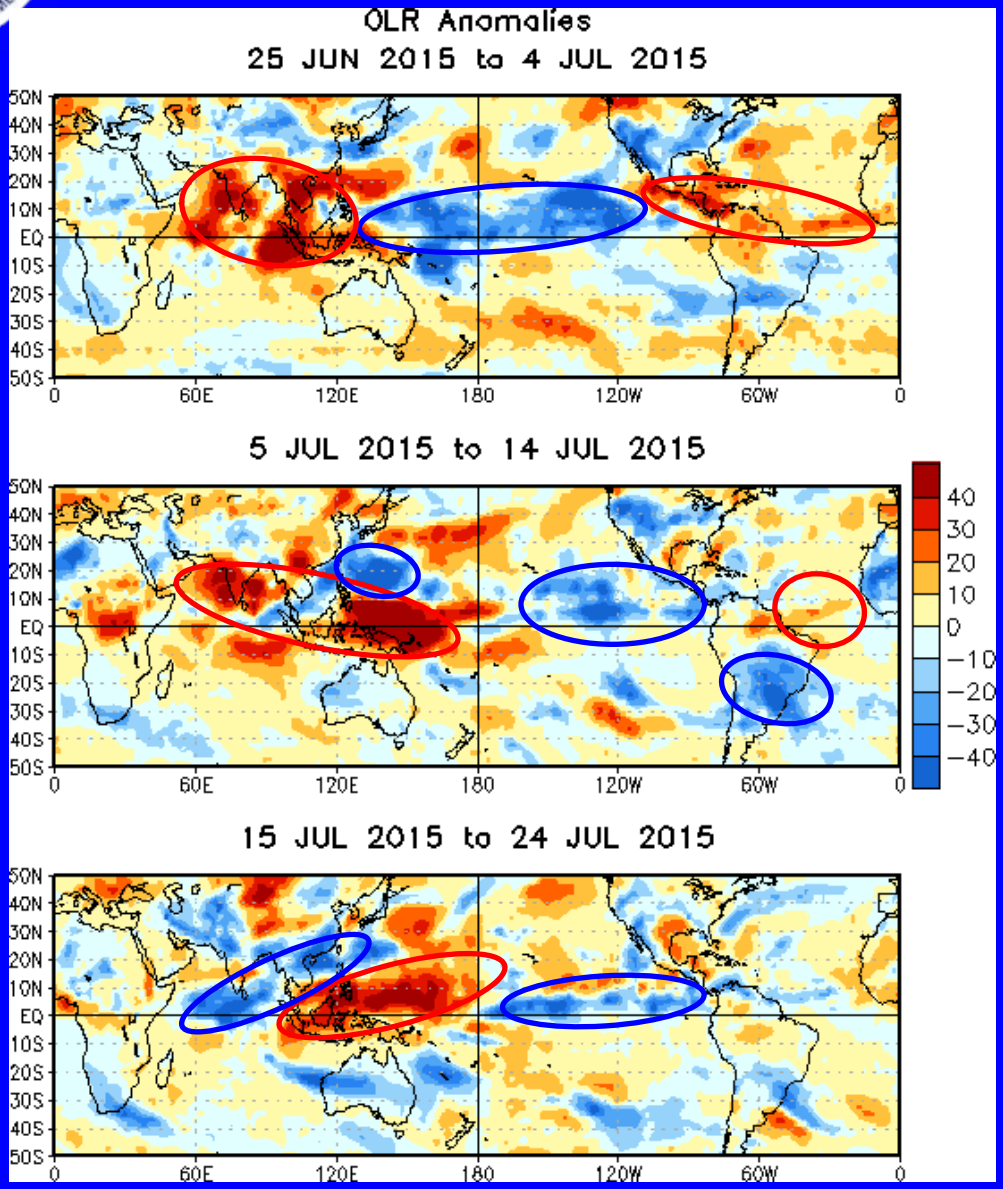
During April and May, westerly anomalies expanded over much of the central and eastern Pacific, consistent with El Niño (red box). There was a brief disruption of the westerly anomalies during early June, associated with a Kelvin wave.

Westerly anomalies, associated with MJO activity, strengthened over the western Pacific during early July. Westerly wind anomalies have remained over the Central Pacific, with some relaxation over 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)

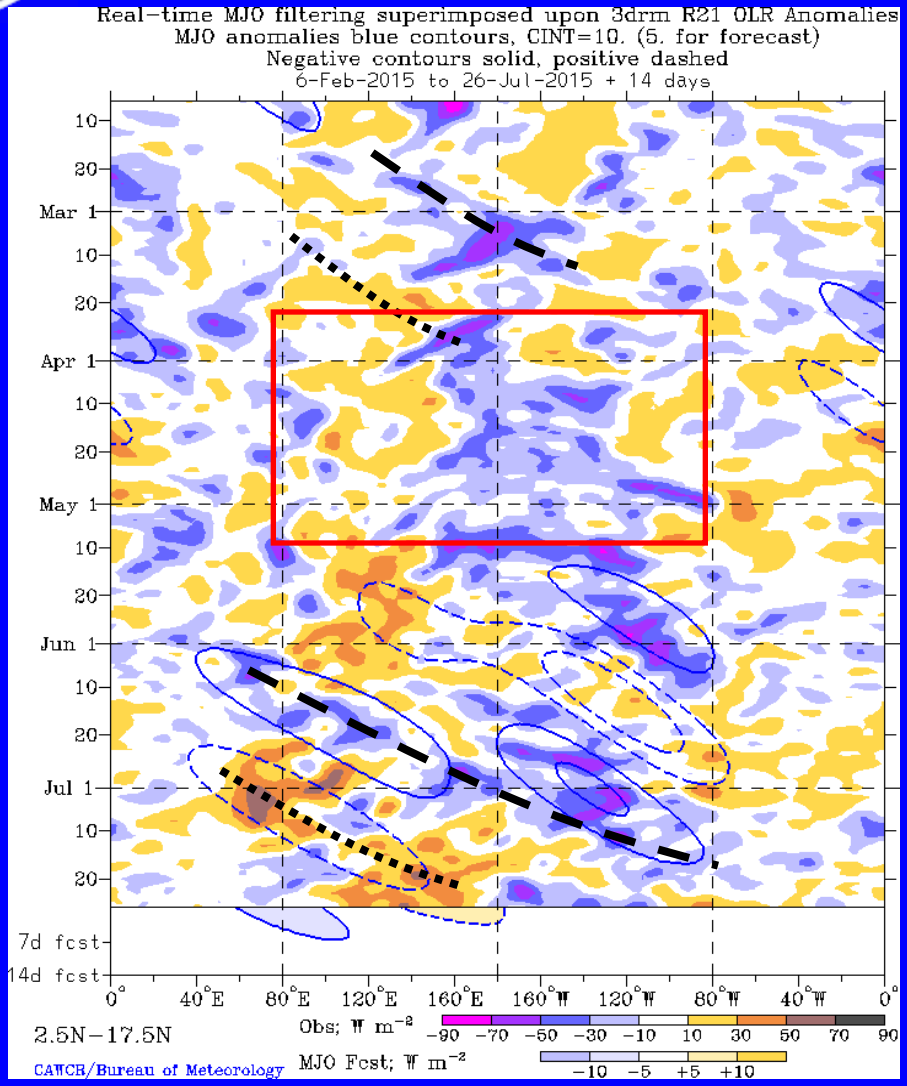


Enhanced (suppressed) convection overspread much of the Pacific (Indian Ocean, western Maritime Continent, Central America, and the tropical Atlantic) during late June to early July.

During early to mid-July, suppressed convection remained over South Asia, while another area of suppressed convection moved to the western Pacific, in the wake of a cluster of tropical cyclones. Enhanced convection remained over the central and eastern Pacific.

Enhanced convection redeveloped over the Indian Ocean and Southeast Asia, while suppressed convection shifted slightly eastward to spread from the Maritime Continent toward the Date Line. Enhanced convection over the central Pacific waned slightly.

Outgoing Longwave Radiation (OLR) Anomalies (2.5°N-17.5°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 became active and strong during March, with eastward propagation of enhanced (suppressed) convective anomalies evident across the Pacific (Indian Ocean and Maritime Continent).

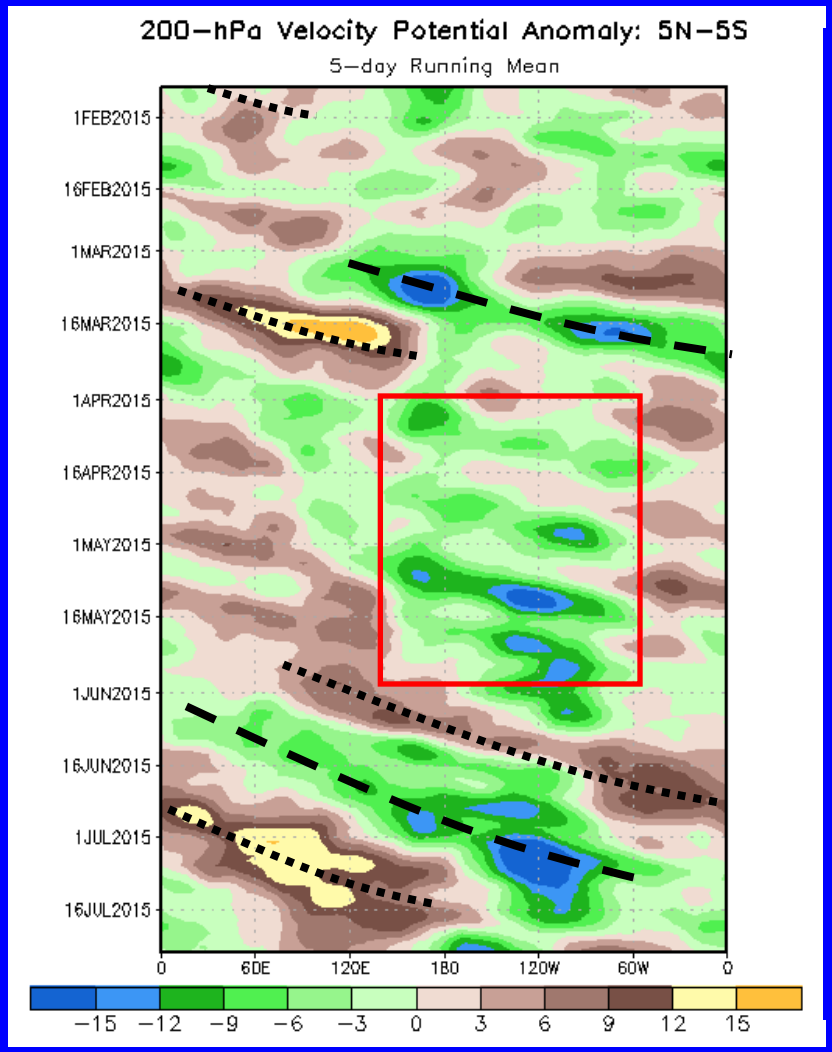
From late March to late May, enhanced (suppressed) convection has dominated at or east of the Date Line (Maritime Continent) (red box), consistent with El Niño conditions. Kelvin Waves were the most prominent subseasonal features during April and May.

During June and July, slower, more robust eastward propagation was evident, consistent with MJO activity. Recently the ENSO related signal has dominated as the MJO related signals have waned.

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, 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.

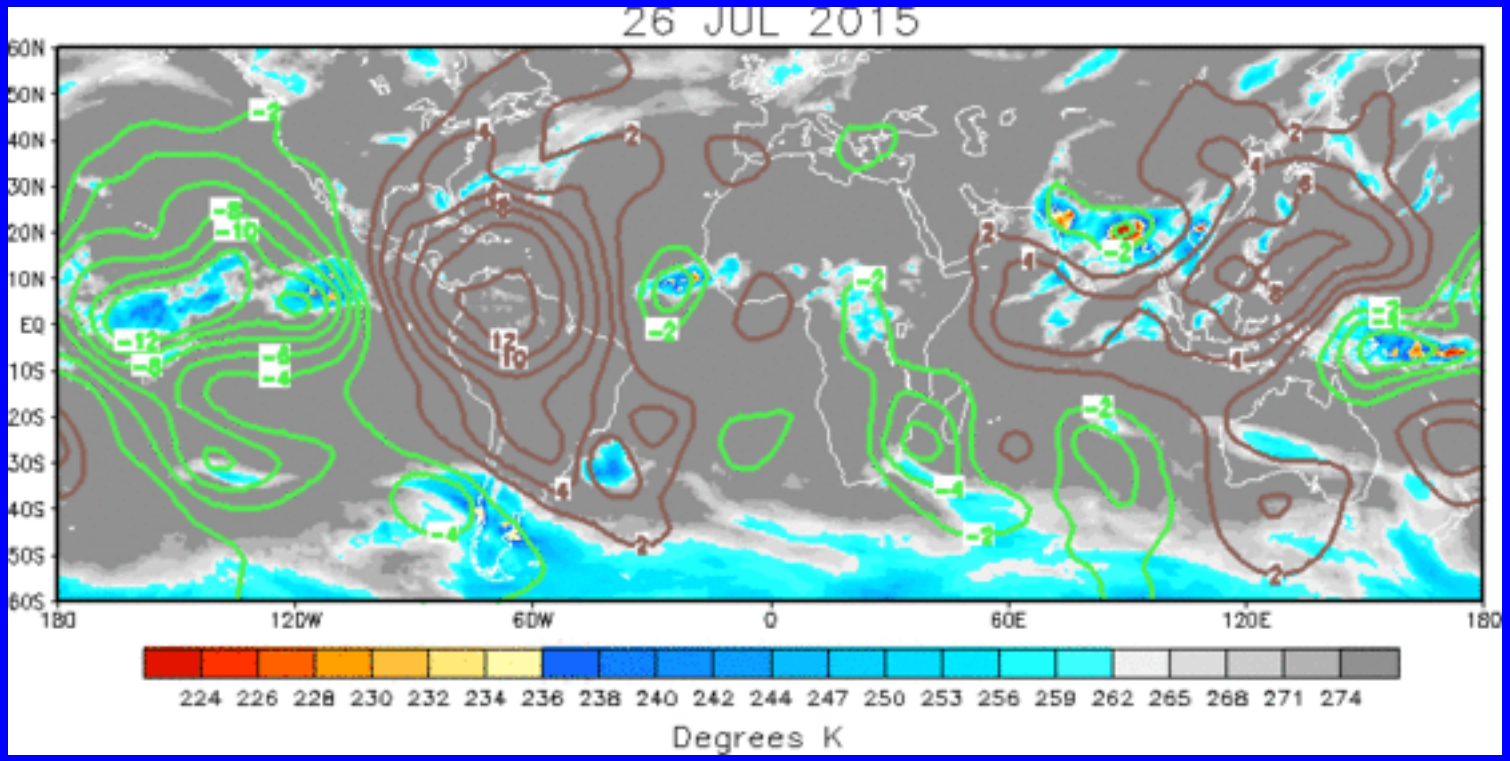
During late May and June, slower eastward propagation of an anomaly couplet was observed, consistent with an MJO event. During early July, the amplitude of the anomaly field increased as the intraseasonal signal began constructively interfering with the El Niño base state.

More recently, MJO related anomalies have weakened and the low-frequency state is more evident in measurements.

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

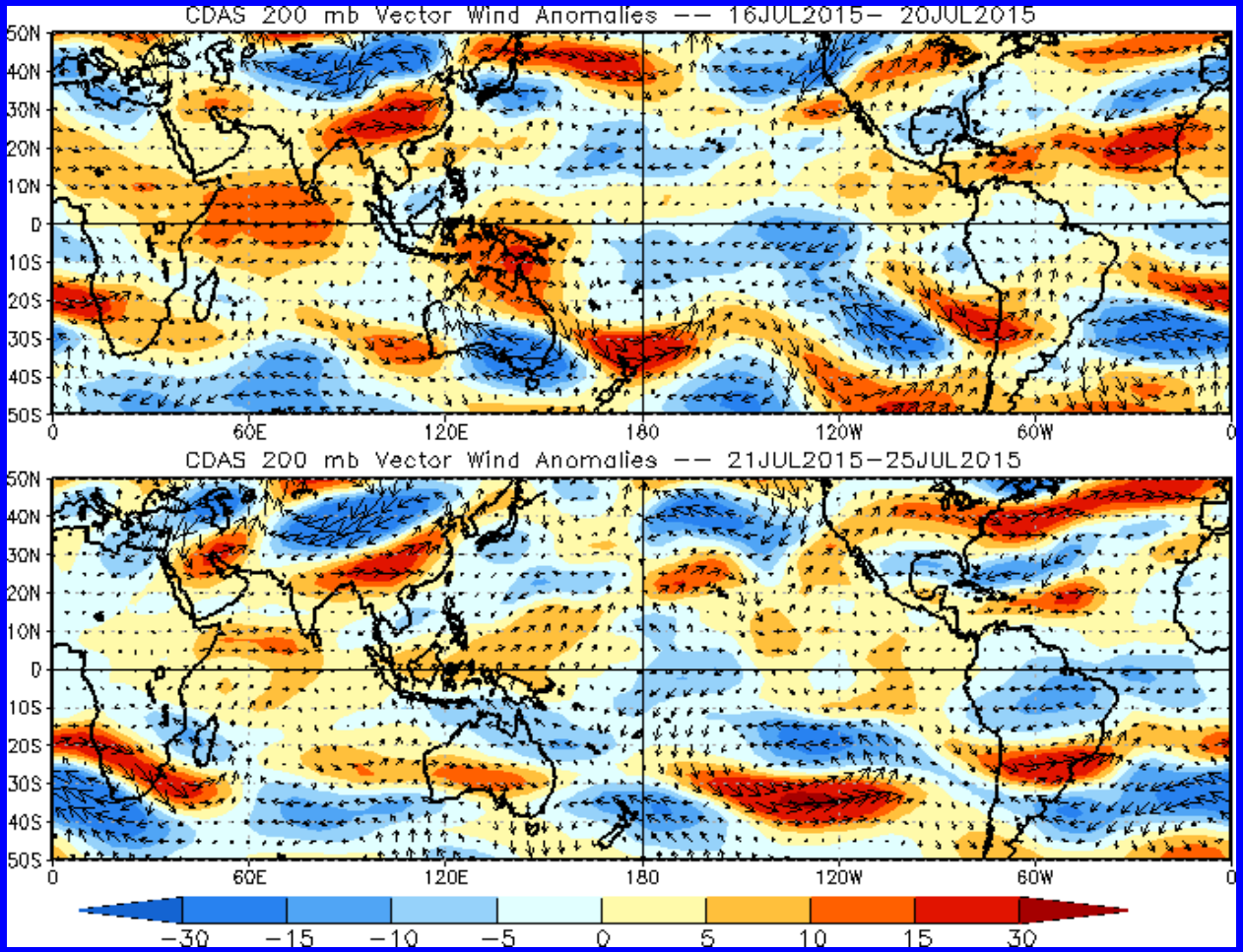
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The spatial velocity potential pattern has broken down from a Wave-1 structure to reflect the low-frequency state and other modes of variability. Enhanced upper-level divergence remains over the central Pacific with enhanced convergence over the Americas and the Maritime Continent.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

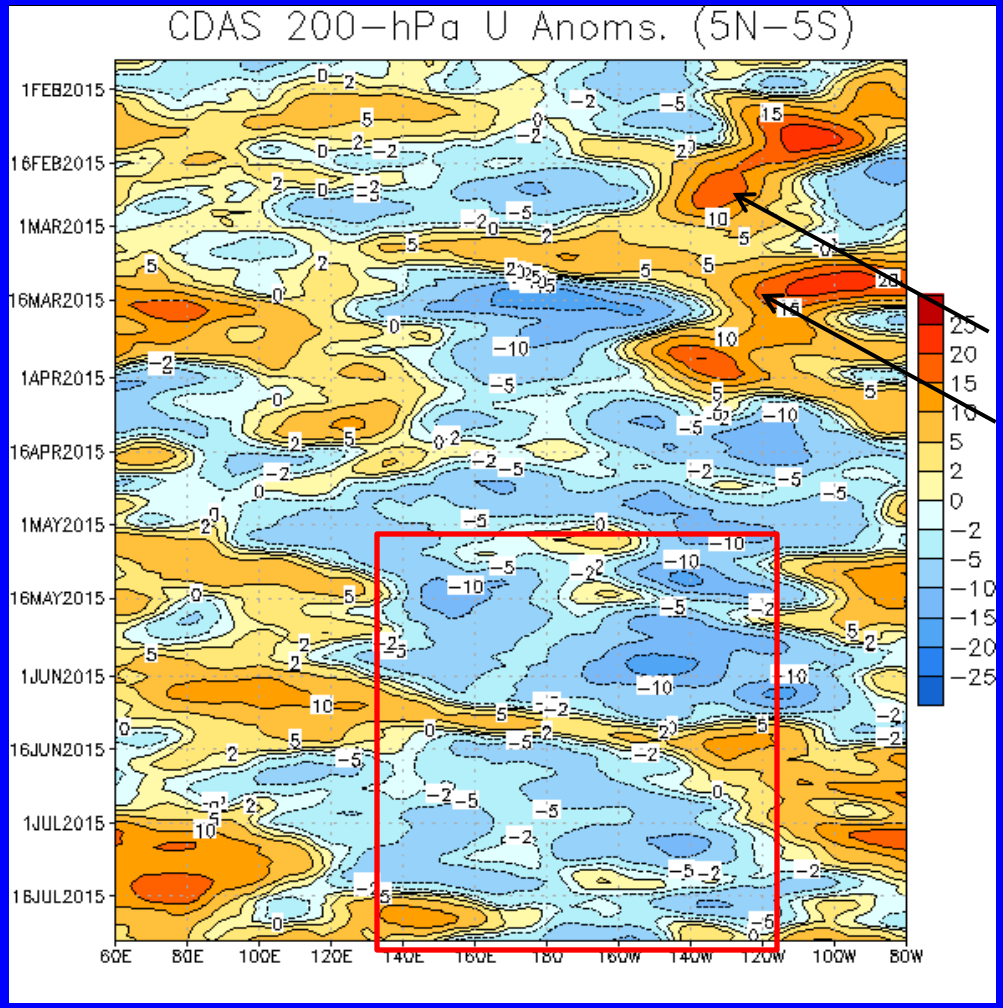
Red shades: Westerly anomalies

Easterly (westerly) upper level anomalies were observed over the equatorial central 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



Time

Longitude

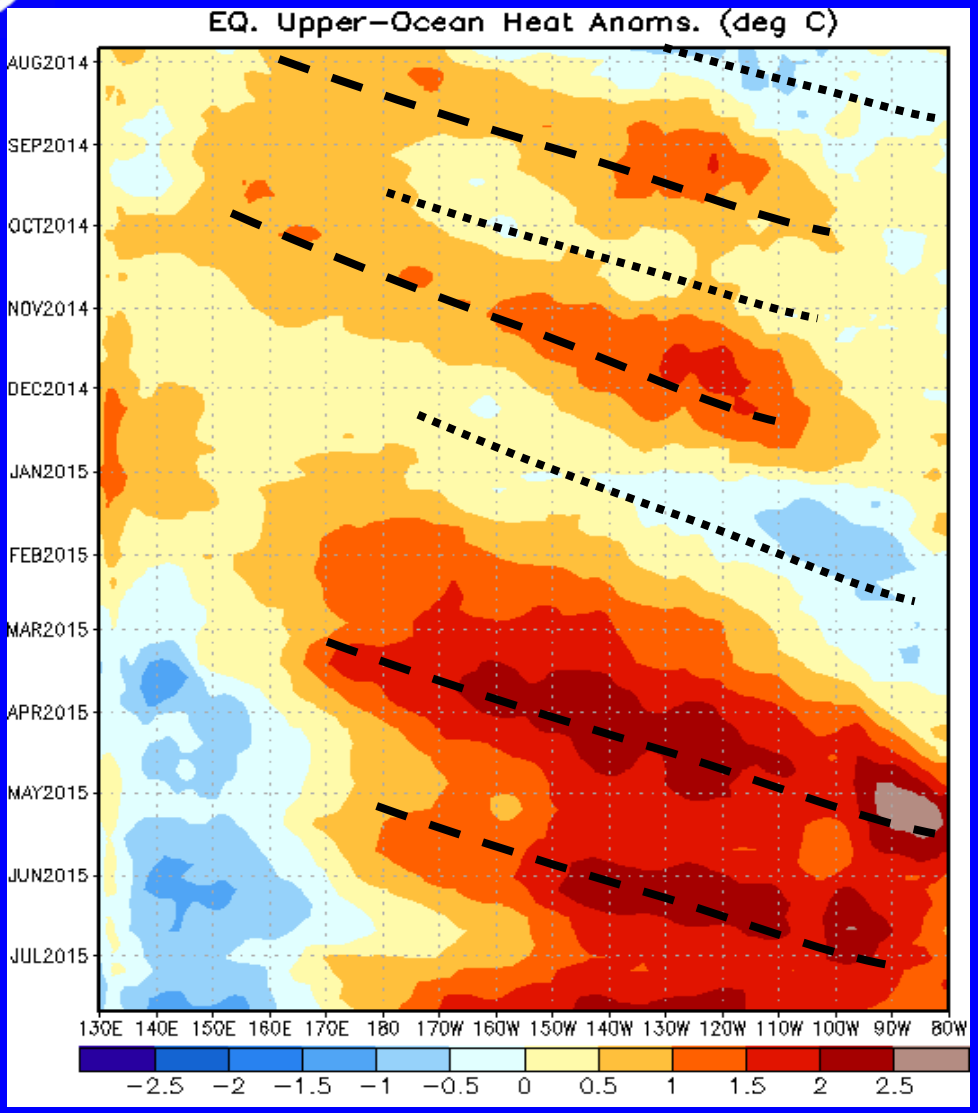
During January through the mid-April, westerly anomalies increased in coverage and intensity from 120W to 80W.

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



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 August 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. Reinforcing downwelling events that followed are evident as well.

Recently, some increased heat content was measured from 150W to 120W.

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).

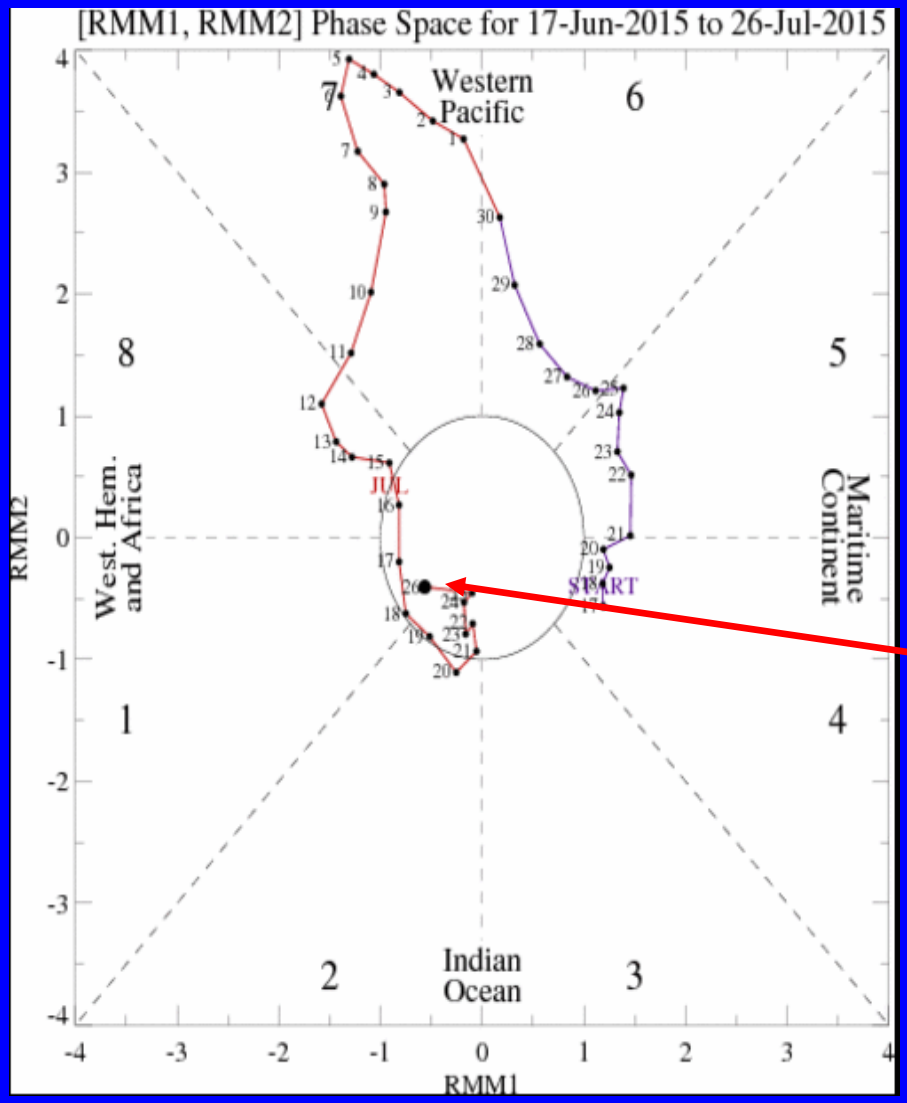
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

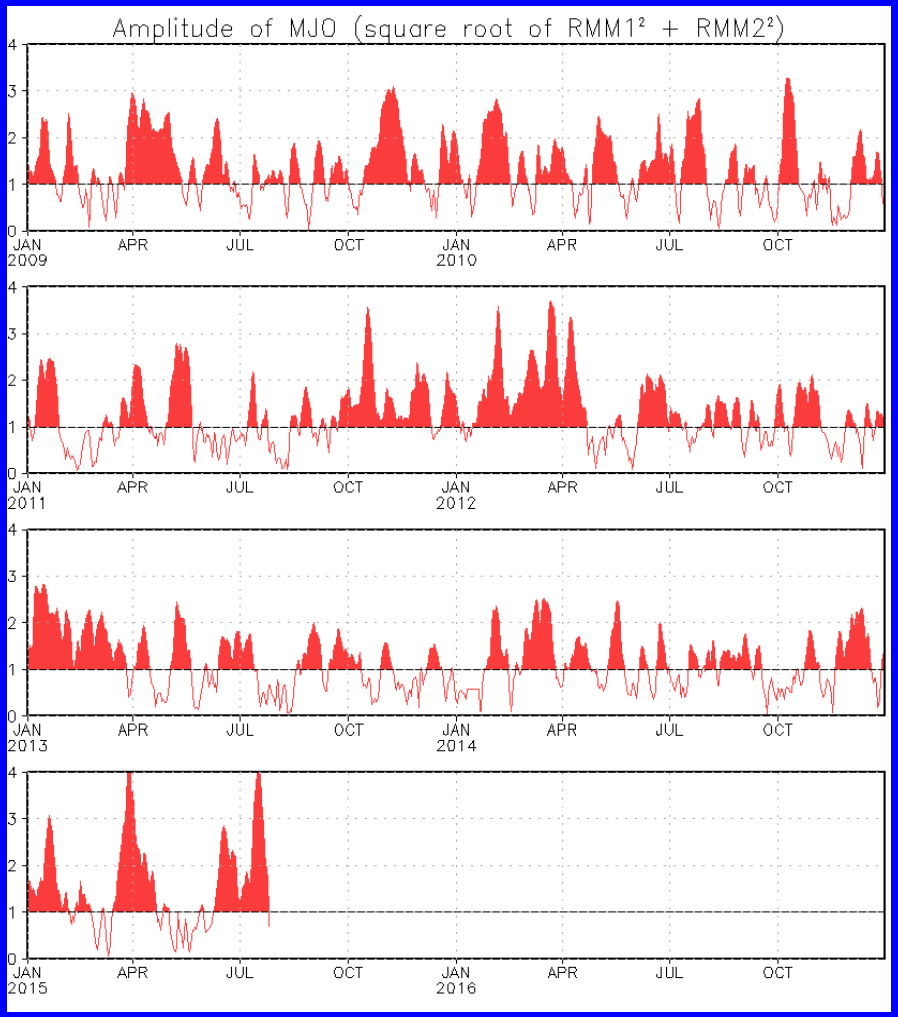
MJO Index -- Recent Evolution



- 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 signal.

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.

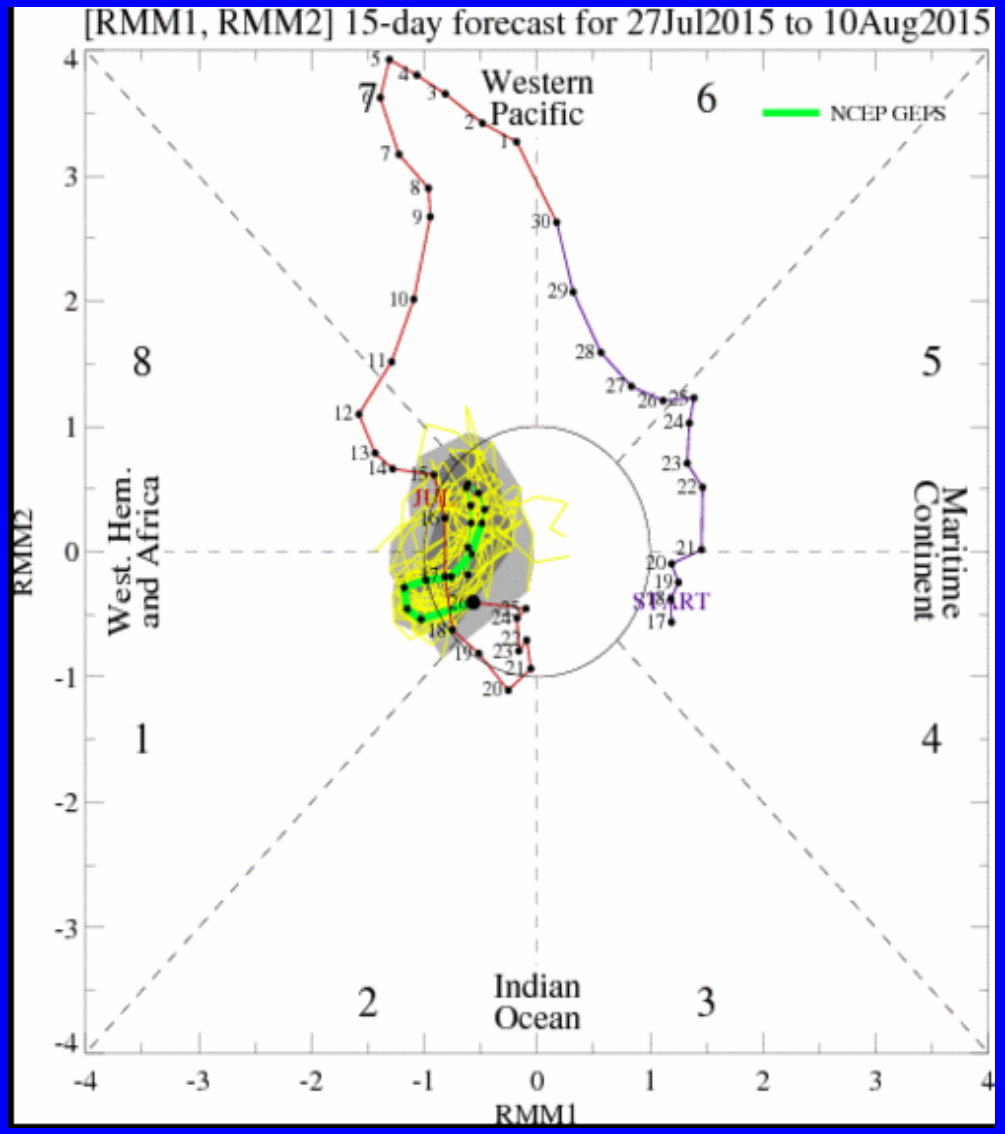
Ensemble GFS (GEFS) MJO Forecast

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

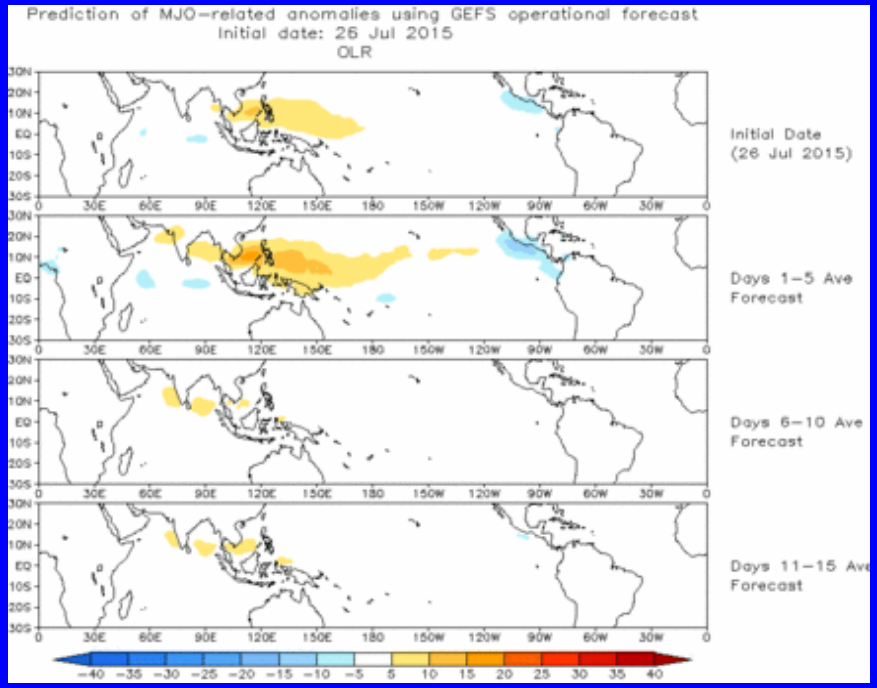
The GFS ensemble MJO index forecast depicts a weak signal over the Atlantic basin, with a signal likely linked to other modes of variability.



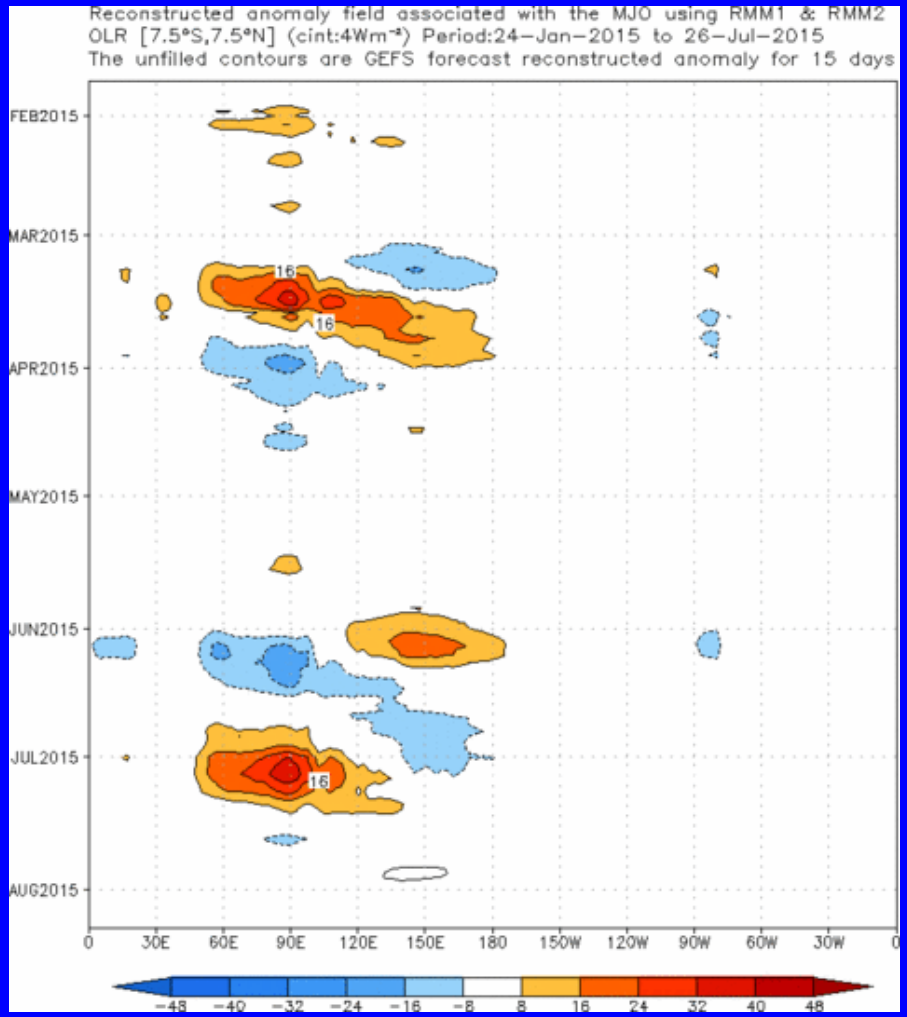
Ensemble Mean GFS MJO Forecast

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

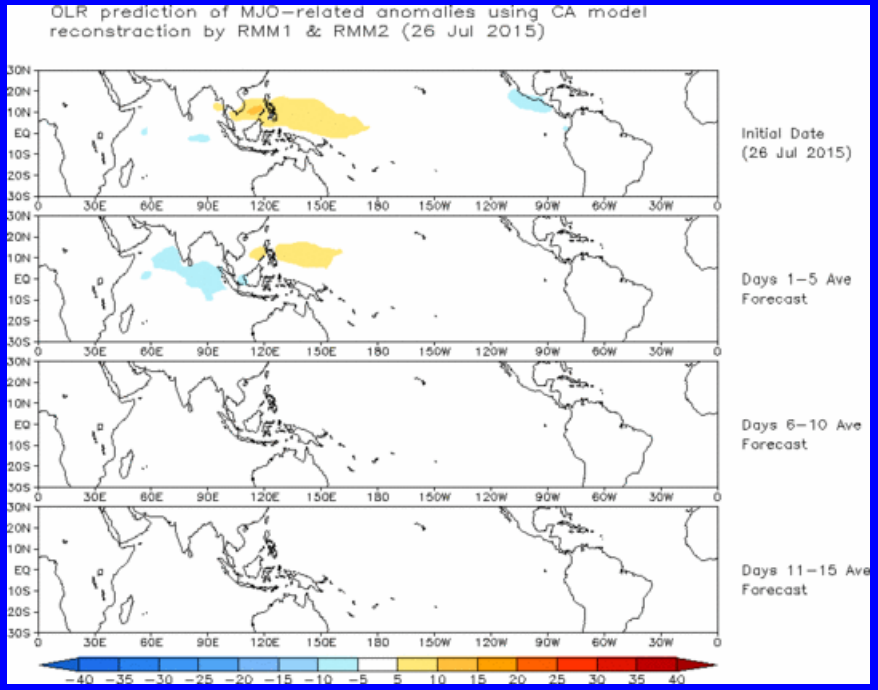


The ensemble GFS MJO index based forecast depicts a strengthening anomaly pattern with enhanced (suppressed) convection over the East Pacific (western Pacific) during Week-1, followed by a weak and stationary signal during Week-2.

Constructed Analog (CA) MJO Forecast

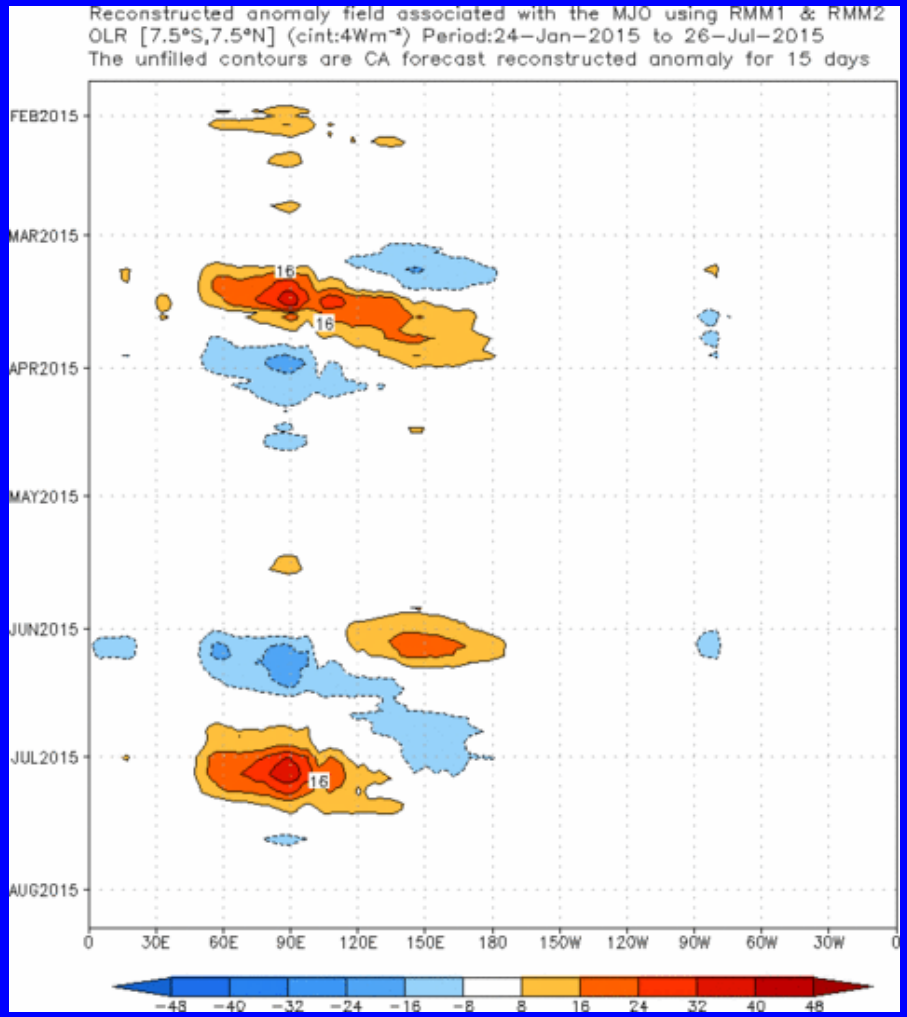
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



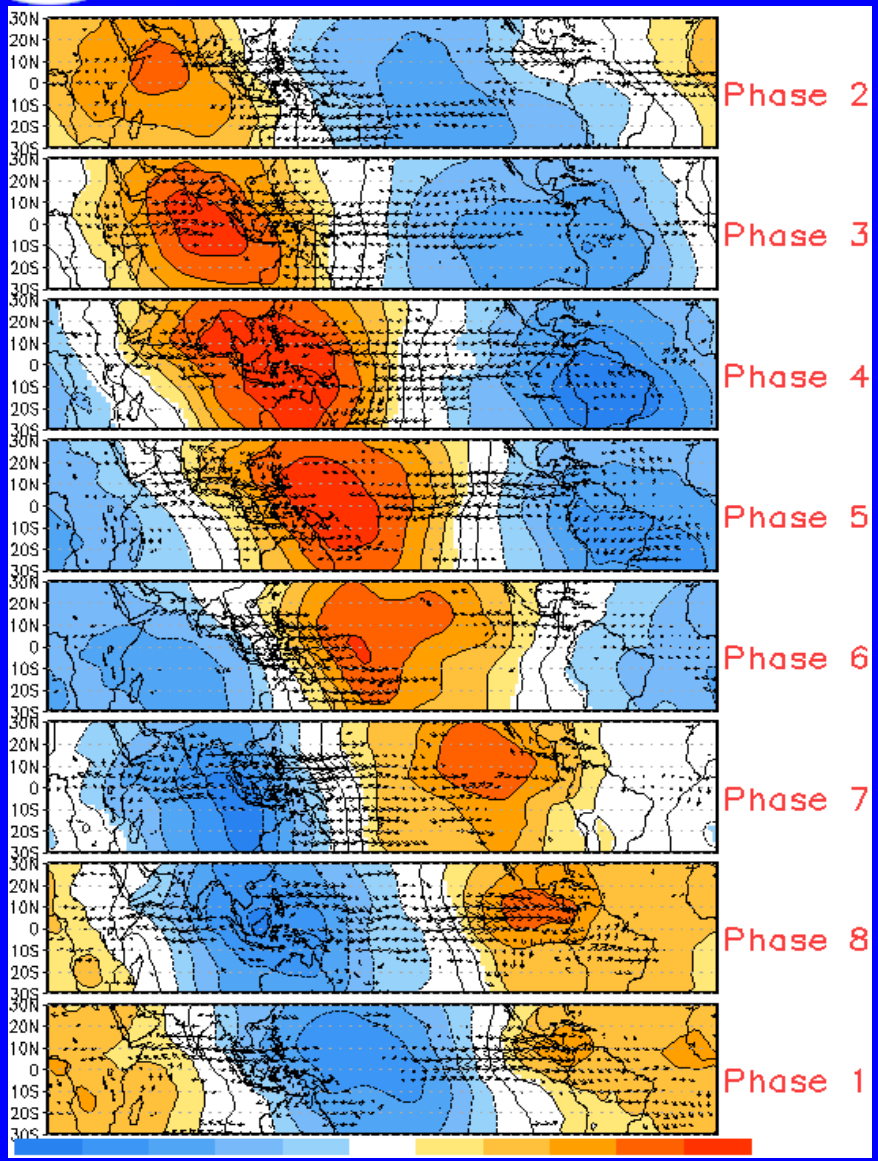
The statistical forecast weakens the anomaly field substantially by Week-2.

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

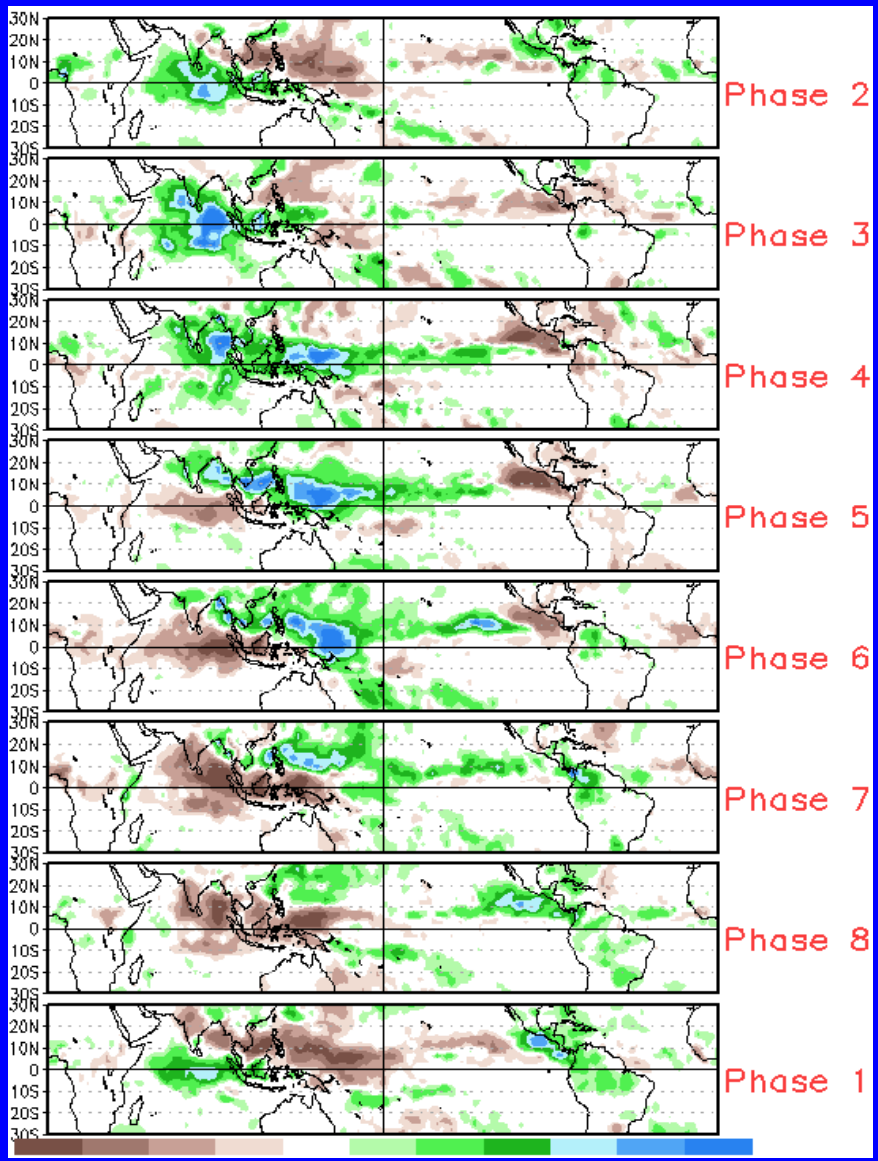


MJO Composites – Global Tropics

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

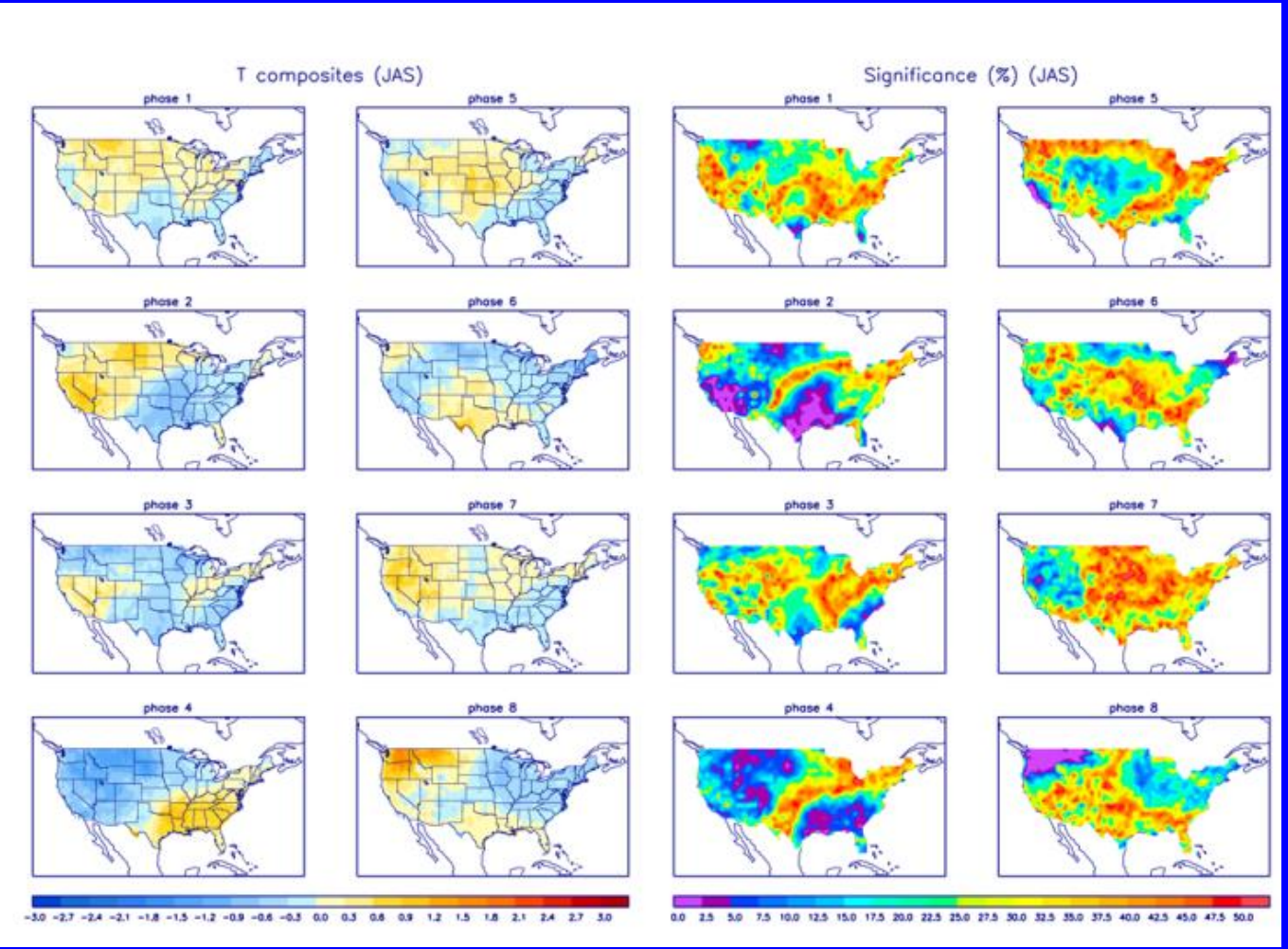


Precipitation Anomalies (May-Sep)



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.**

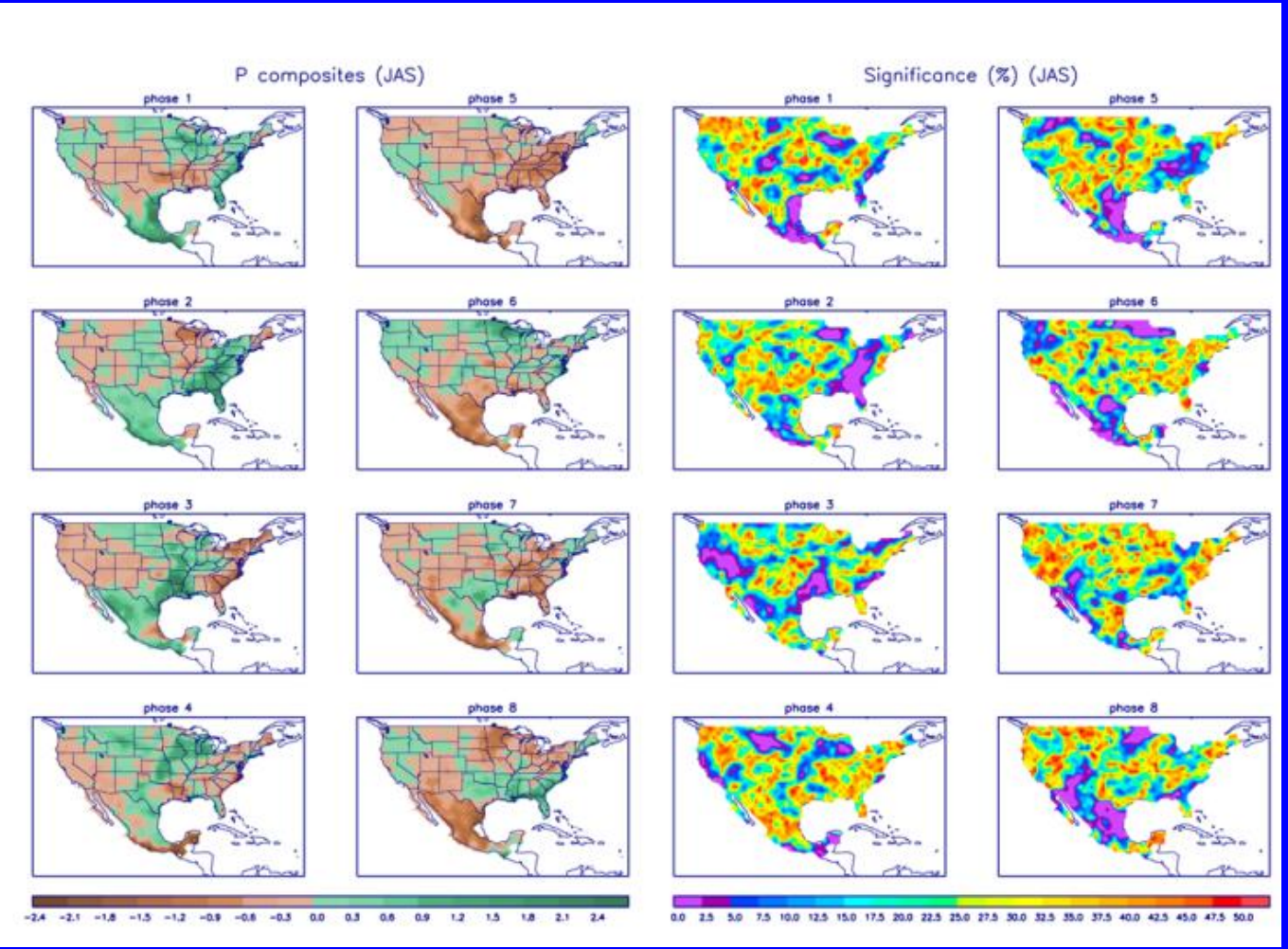


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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.**



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