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

Update prepared by
Climate Prediction Center / NCEP
June 29, 2015

Outline

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

Overview

- The MJO remains active with the enhanced convective phase currently emerging over the West Pacific.

- Constructive interference among the MJO, Kelvin Waves ahead of the MJO convective envelope, and the El Niño base state are resulting in renewed widespread Pacific convection. Destructive interference between the intraseasonal signal and El Niño continues over the eastern Pacific, with suppressed convection and increased vertical shear as a result.

- Dynamical model MJO index forecasts favor a substantial increase in amplitude over the western and central Pacific, with differing solutions regarding further eastward propagation.

- The MJO is expected to continue influencing the global tropical convective pattern, especially during Week-1, favoring enhanced convection and likely tropical cyclogenesis over the western Pacific, and suppressed convection over the Indian Ocean and parts of South Asia.

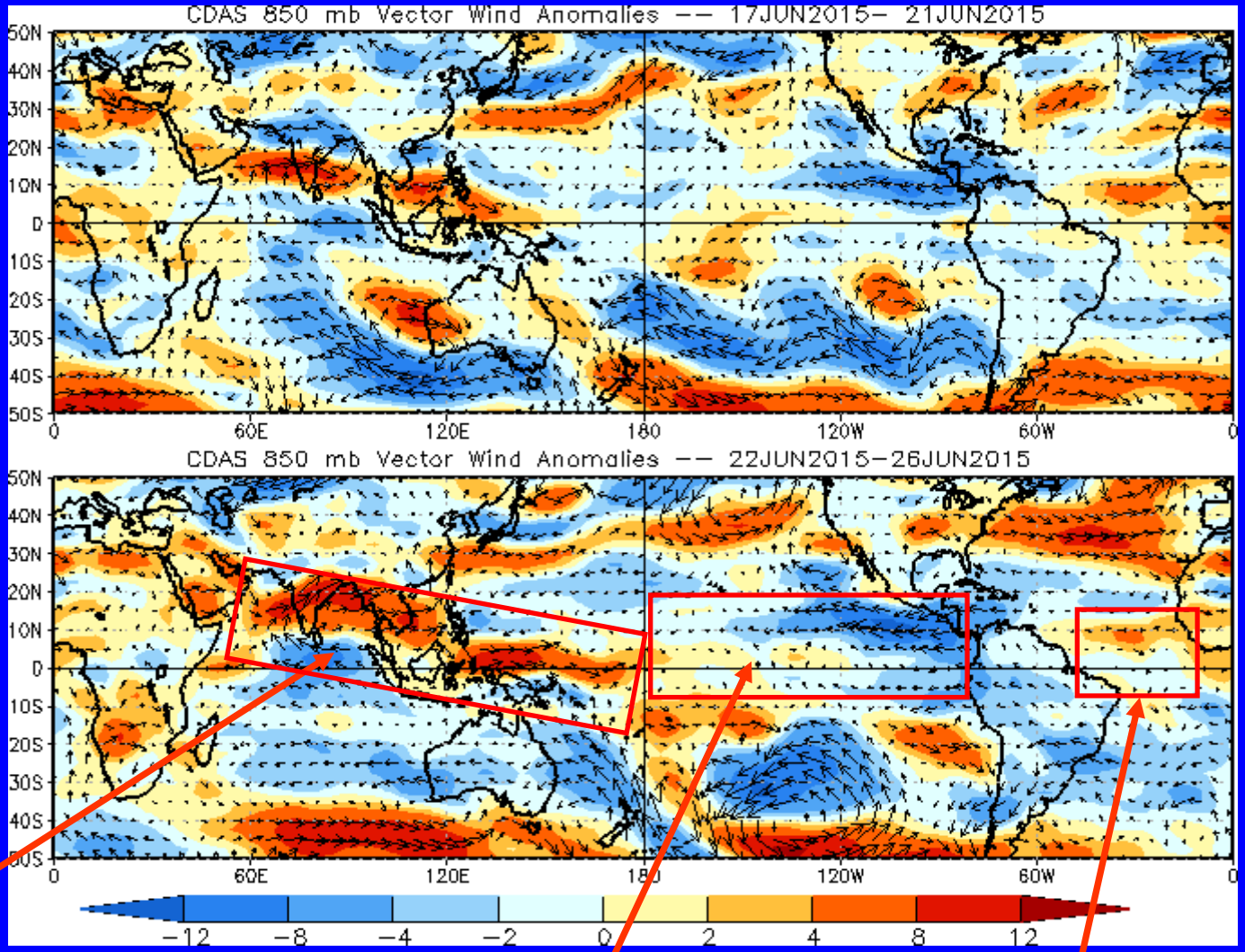
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies shifted northward (eastward) over South and Southeast Asia (the western Pacific), while easterlies developed over the equatorial Indian Ocean.

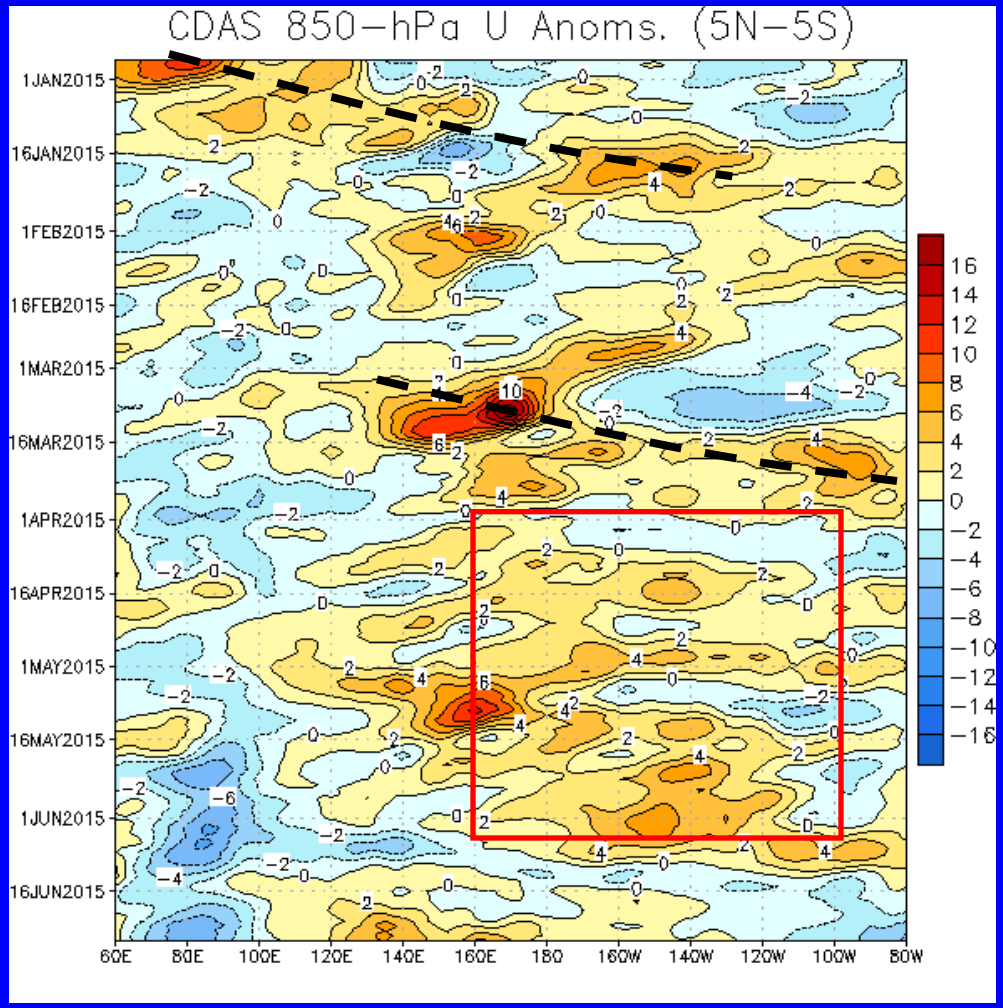
Generally weak zonal wind anomalies continued over the east-central Pacific, while easterlies strengthened over the far eastern Pacific..

Westerly anomalies weakened over the 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



Time

Longitude

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.

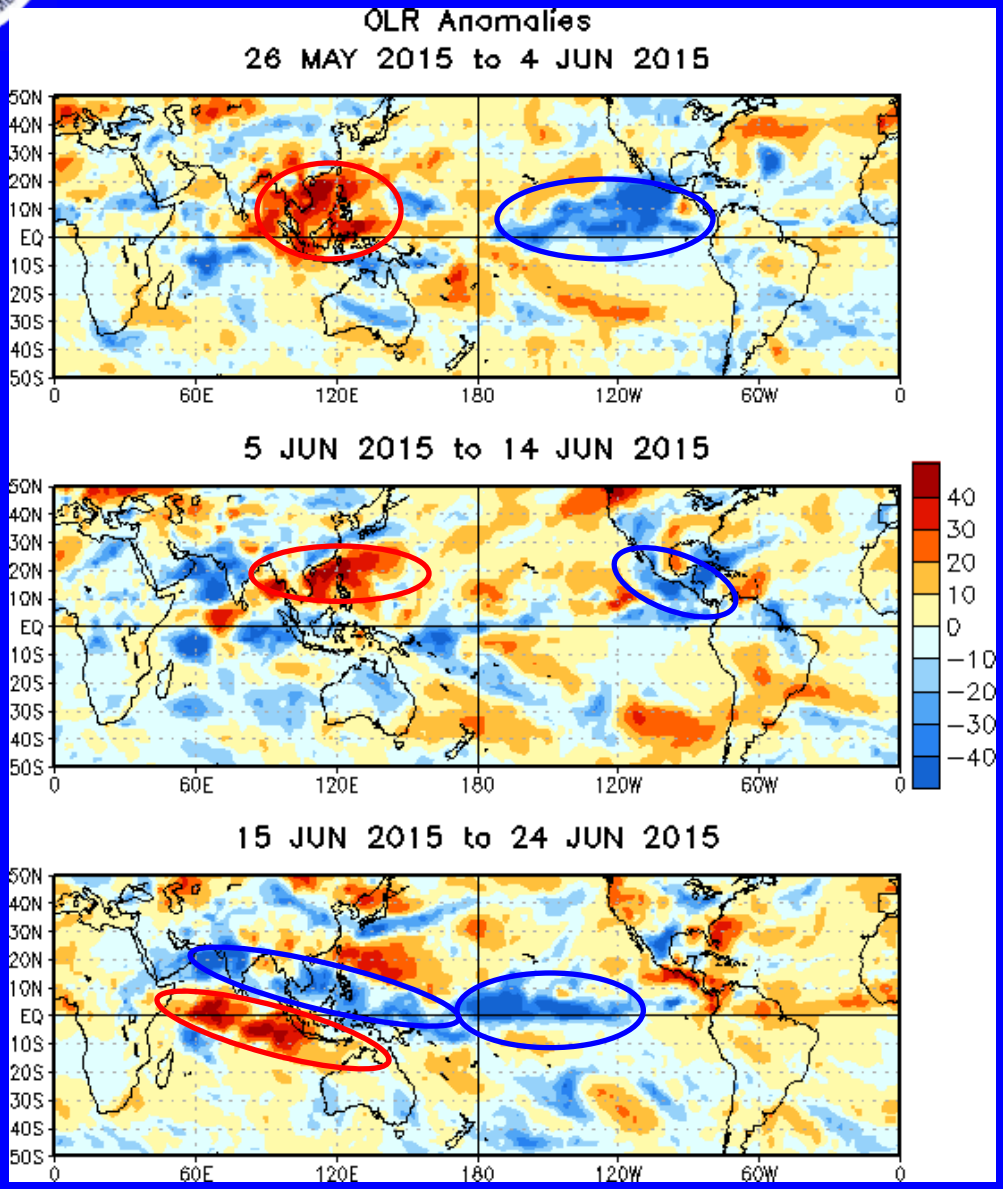
During April and May, westerly anomalies expanded over much of the central and eastern Pacific, consistent with El Nino (red box).

During June, eastward propagation on the intraseasonal time scale was observed, with a brief disruption of the westerly anomalies across the Pacific. More recently, westerly anomalies returned to the west-central 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)

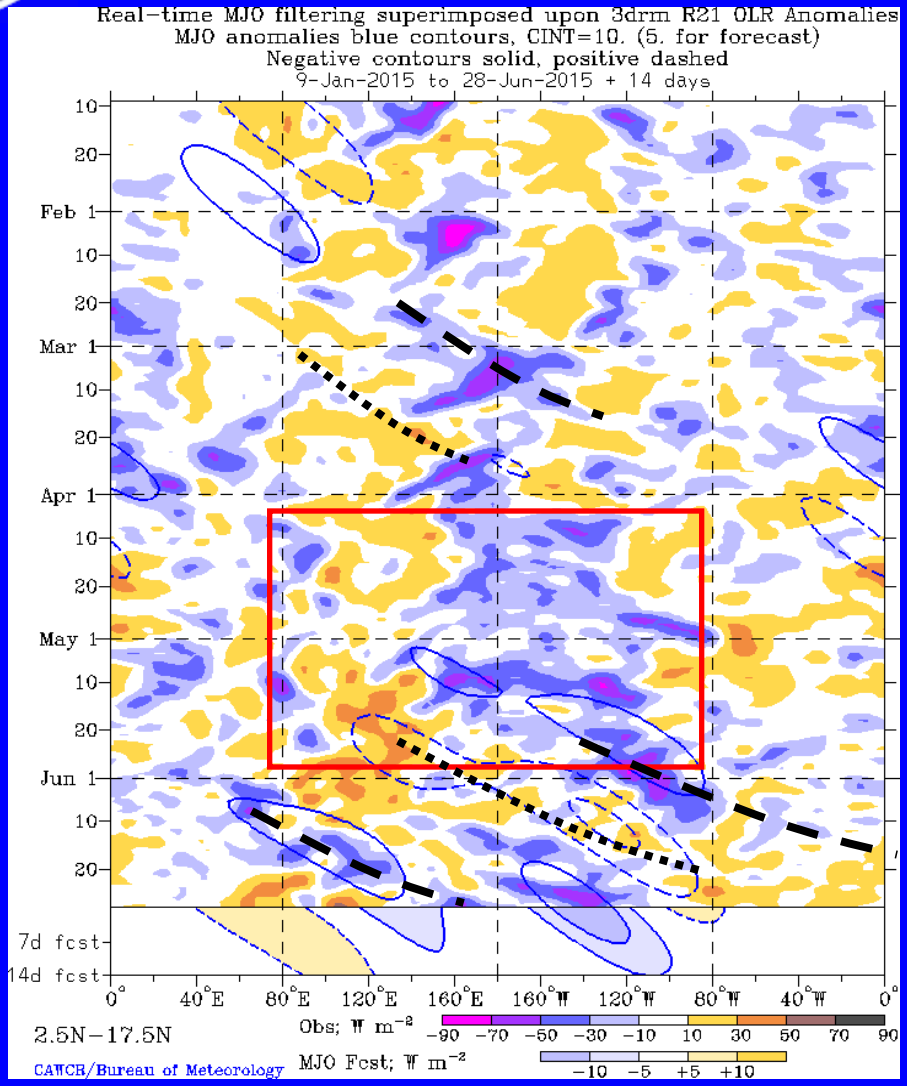


Enhanced (suppressed) convection persisted over the eastern Pacific (Southeast Asia, Maritime Continent, and the far western Pacific) during late May and early June, consistent with El Niño.

The OLR spatial pattern became less consistent with the base state during early to mid-June, as the MJO enhanced phase propagated from the Indian Ocean to the Maritime Continent, destructively interfering with El Niño. Enhanced convection over the far eastern Pacific was associated with tropical cyclone activity.

During mid to late June, enhanced convection extended from South and Southeast Asia to the western Pacific, consistent with MJO influence on the Monsoon, while suppressed convection overspread the equatorial Indian Ocean. Widespread enhanced convection returned to the central Pacific.

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).

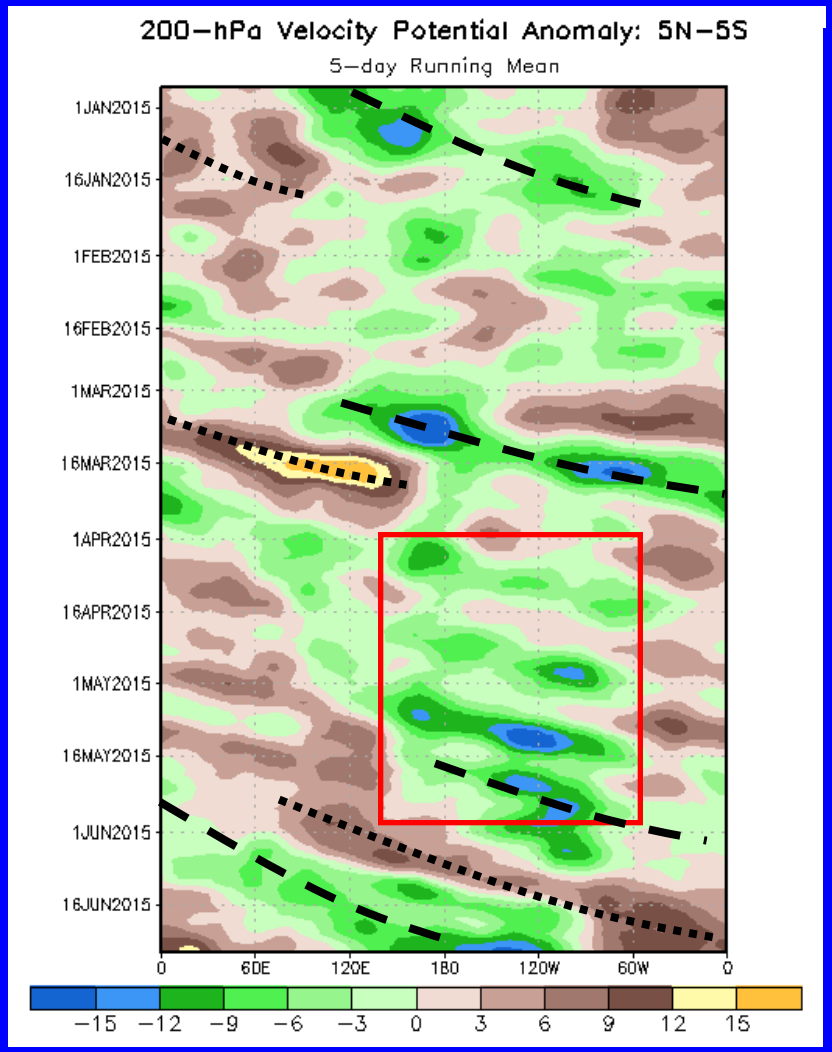
Since late March, enhanced (suppressed) convection has dominated at or east of the Date Line (Maritime Continent) (red box), consistent with El Niño conditions. Kelvin Waves were the most prominent subseasonal features during April and May.

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

The MJO was active at the start of 2015, indicated by eastward propagation of alternating anomalies. At times, the signal was dominated by faster-moving variability (likely Kelvin Wave activity).

The signal became weak during late January and February.

During March, MJO activity was observed, with anomalies becoming strong as they interacted with the developing low frequency state.

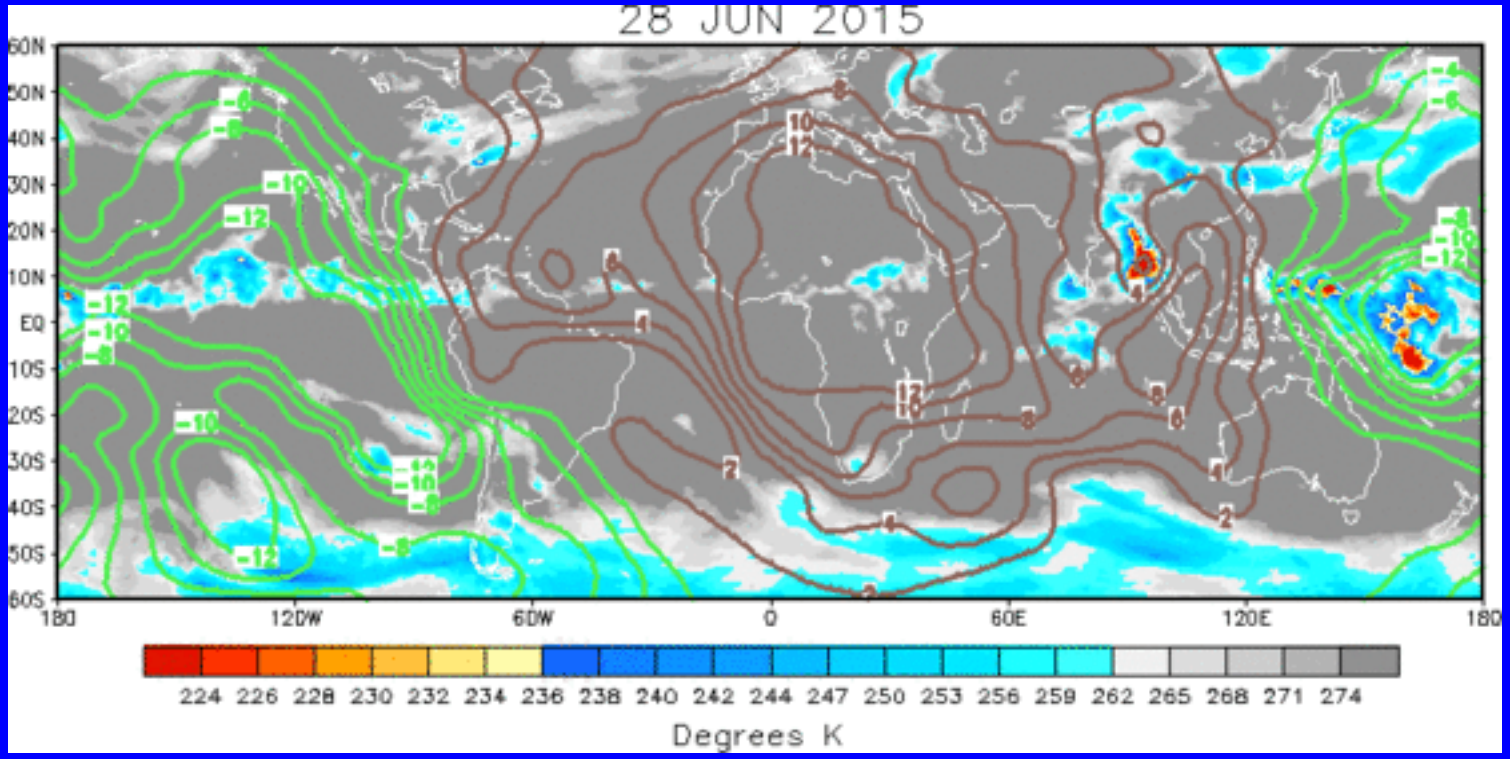
Negative anomalies persisted near the Date Line and to the east from early April through May due to the El Niño base state. During this time, Kelvin wave activity (fast eastward propagation) has been the primary subseasonal mode of variability evident in this field.

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

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

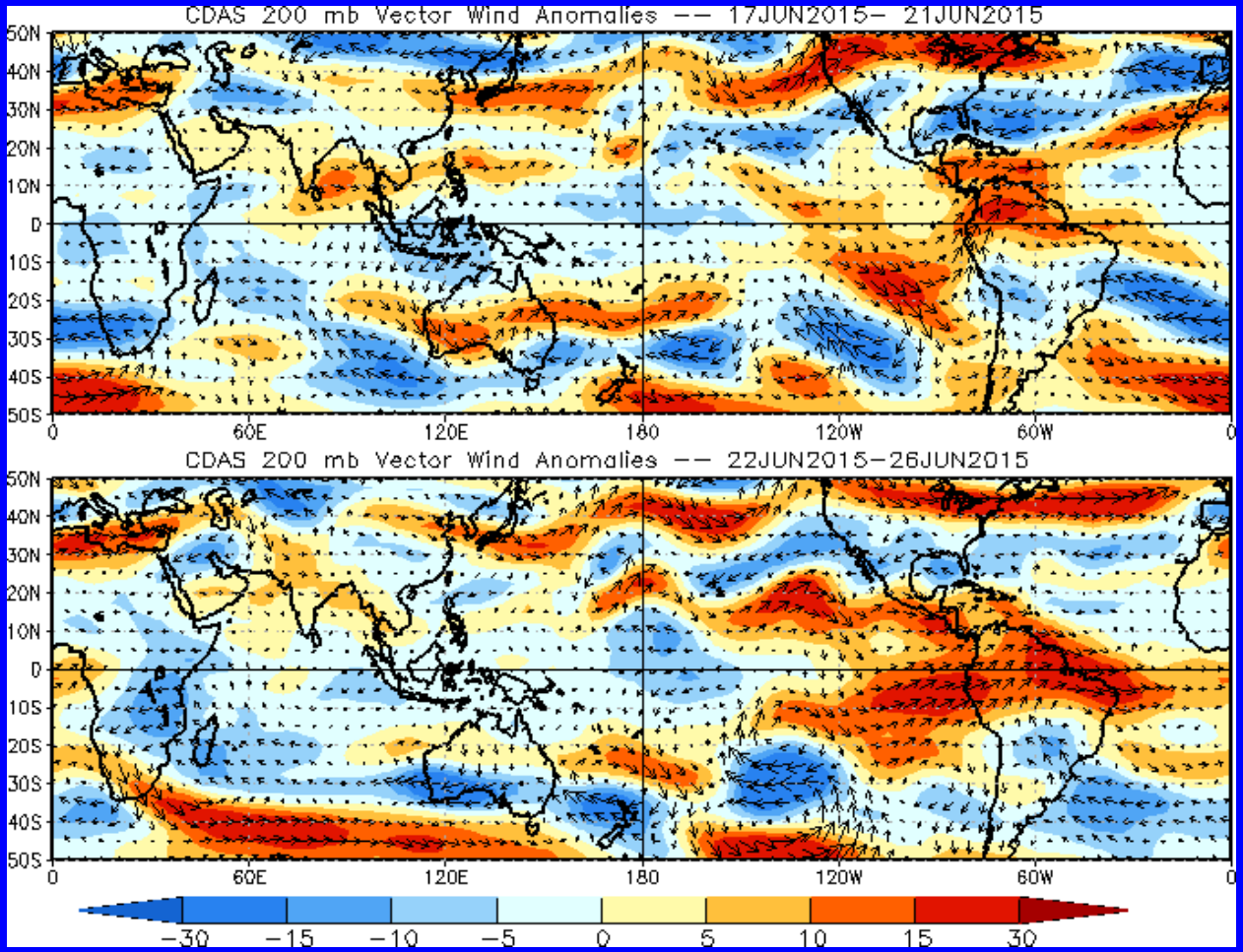
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The spatial velocity potential pattern continues to maintain a robust and coherent Wave-1 structure, consistent with MJO activity. The suppressed phase is currently over the Atlantic, Africa, and the Indian Ocean, while negative VP anomalies associated with the enhanced phase overspread the entire Pacific basin.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

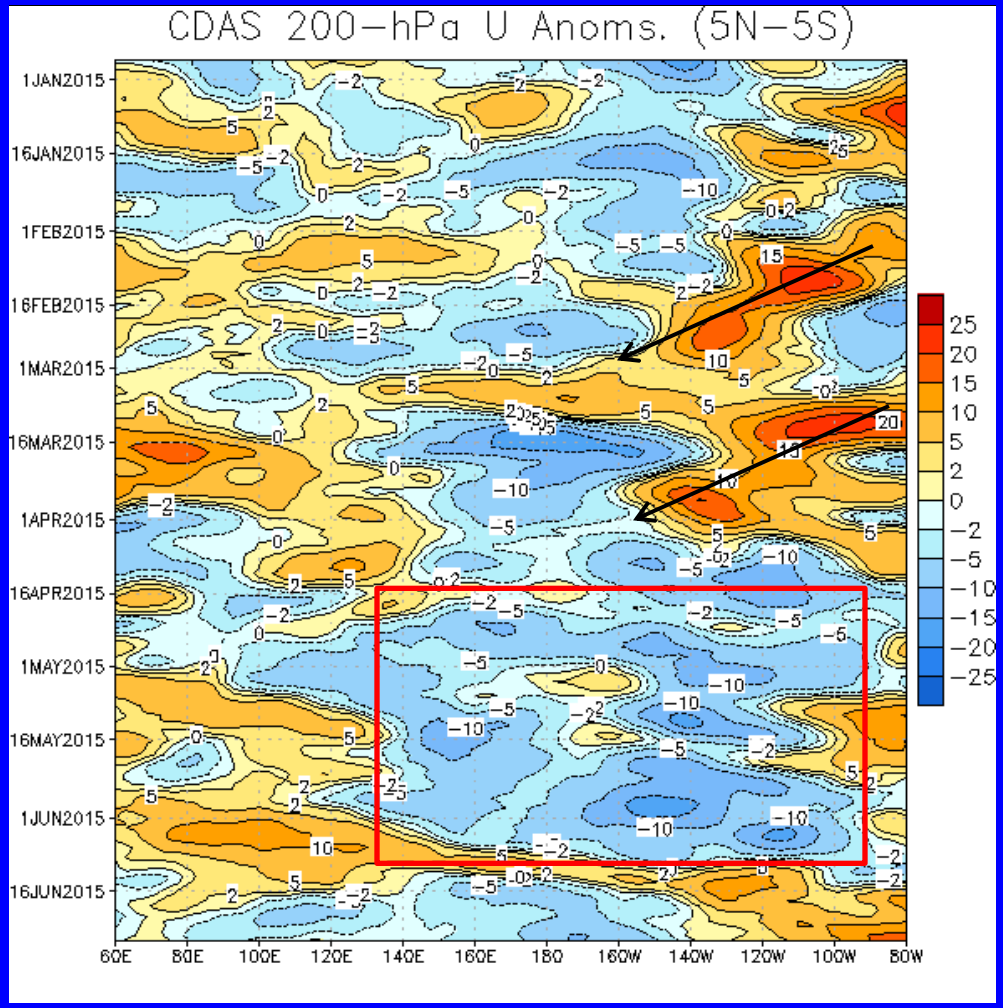
Red shades: Westerly anomalies

Westerly anomalies strengthened over the Americas during the ten days, while easterly anomalies developed near the Date Line.

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

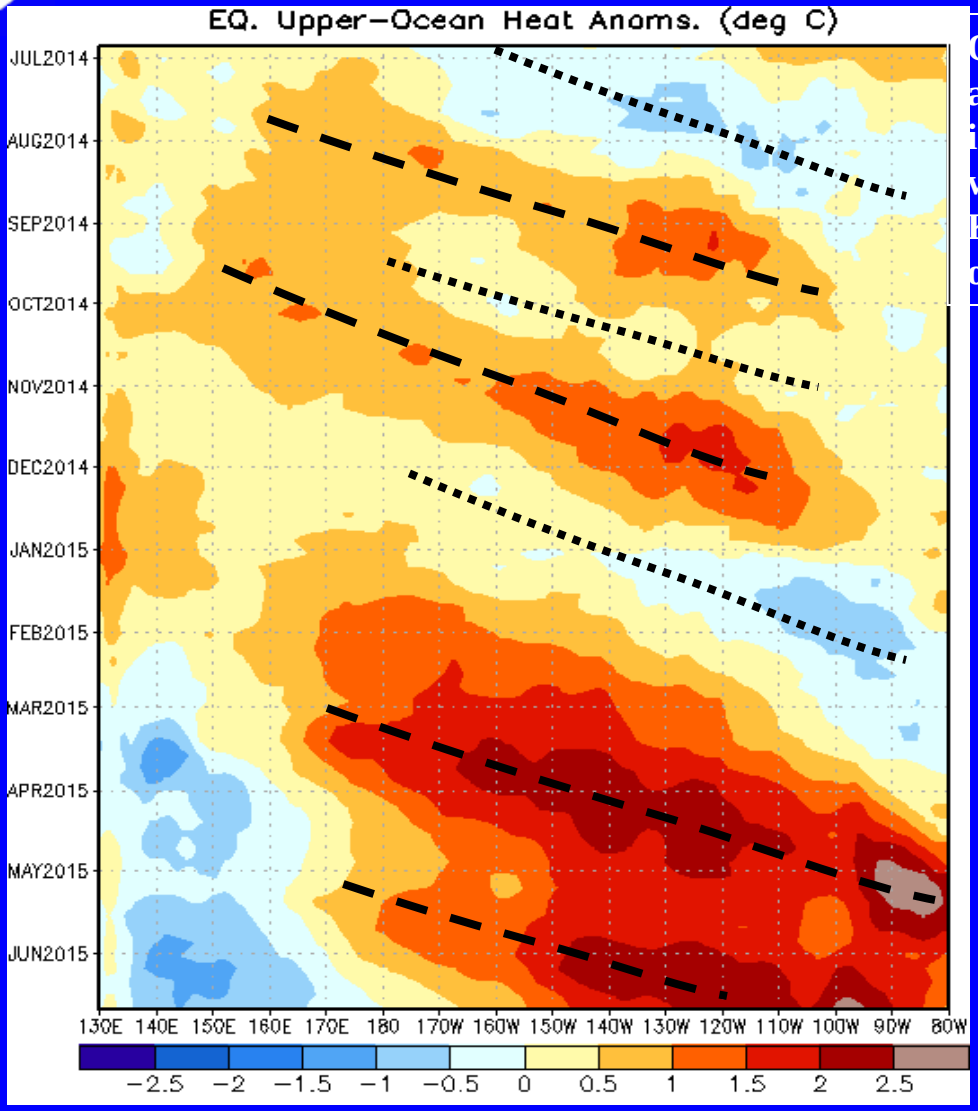
During late December through the mid-April, westerly anomalies increased in coverage and intensity from 120W to 80W.

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 Nino since early May.

During June, westerly anomalies propagated eastward from the Maritime Continent to the western Hemisphere, consistent with MJO activity. Easterly anomalies developed near the Date Line.

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 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 evidence of a potential 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).

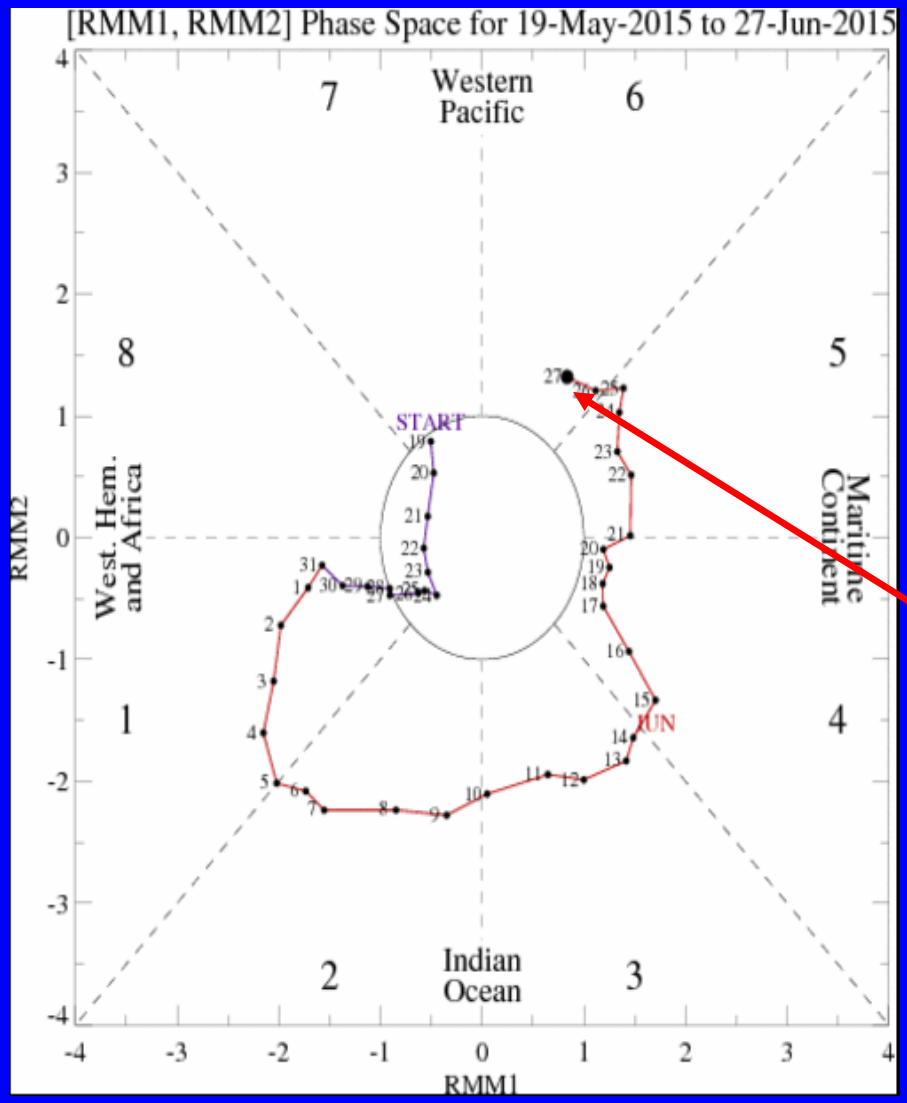
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

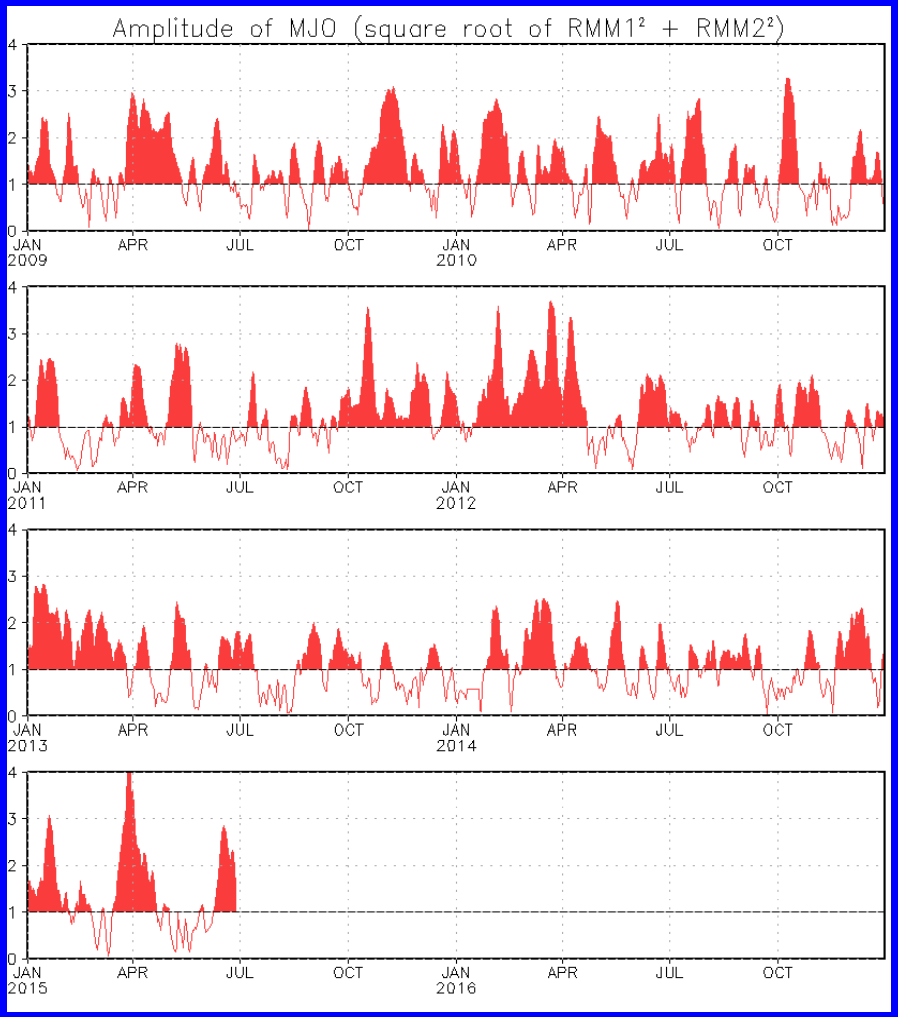
MJO Index -- Recent Evolution



- 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

Eastward propagation of a MJO signal was evident during the past month, with the enhanced phase emerging over the western Pacific.

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.

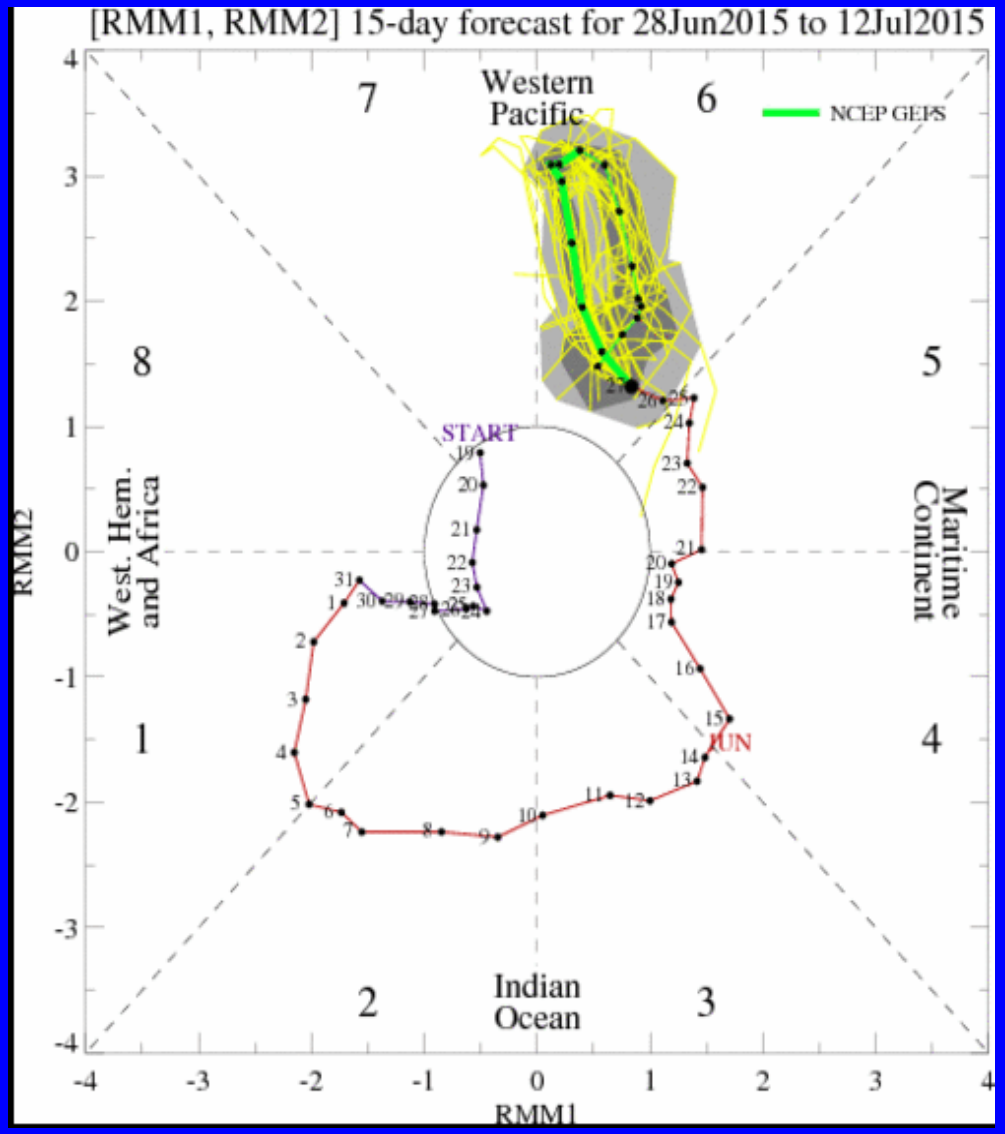
Ensemble GFS (GEFS) MJO Forecast

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

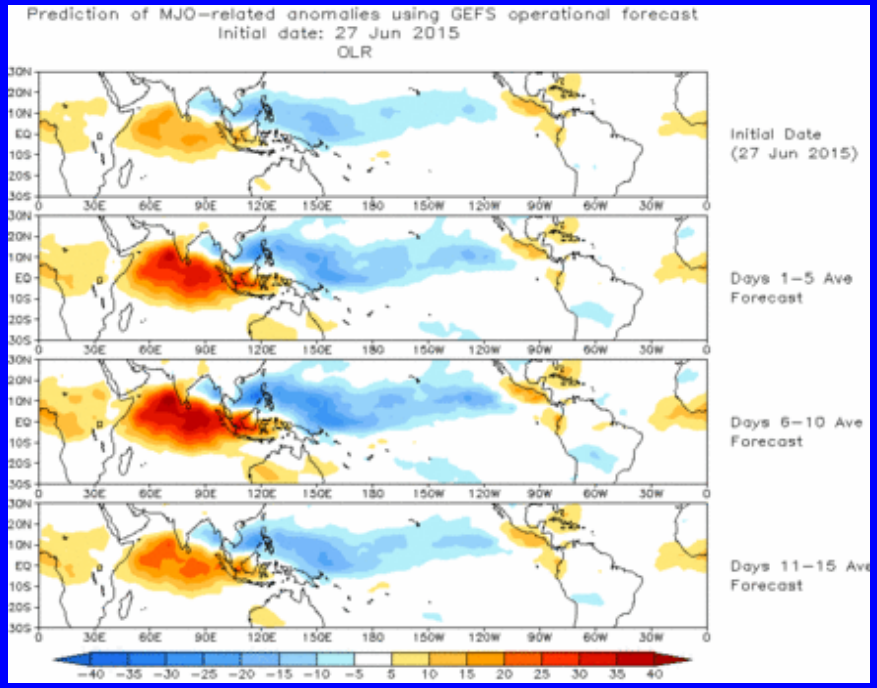
The GFS ensemble MJO index forecast depicts a substantial increase in amplitude of the index over the western Pacific, with little additional eastward propagation. Some of this amplitude is likely due to forecasted tropical cyclone development over both the northwestern and southwestern Pacific.



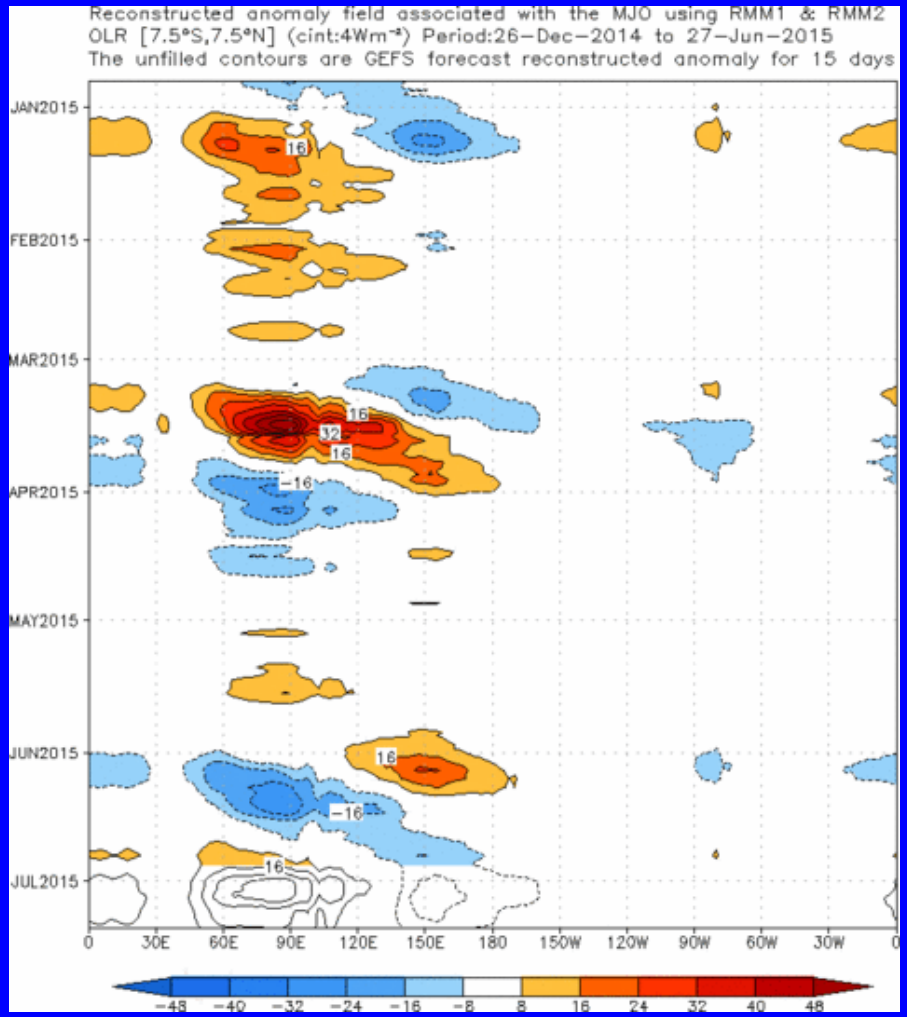
Ensemble Mean GFS MJO Forecast

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

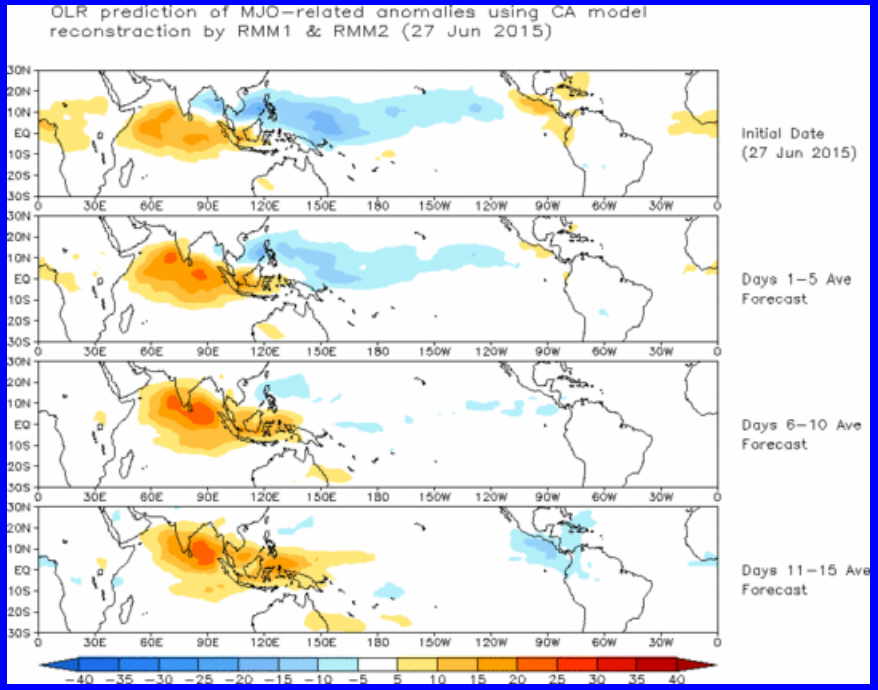


The ensemble GFS MJO index based forecast depicts robust enhanced (suppressed) convective anomalies over the western Pacific (Indian Ocean and far southern Asia), with little to no additional eastward propagation.

Constructed Analog (CA) MJO Forecast

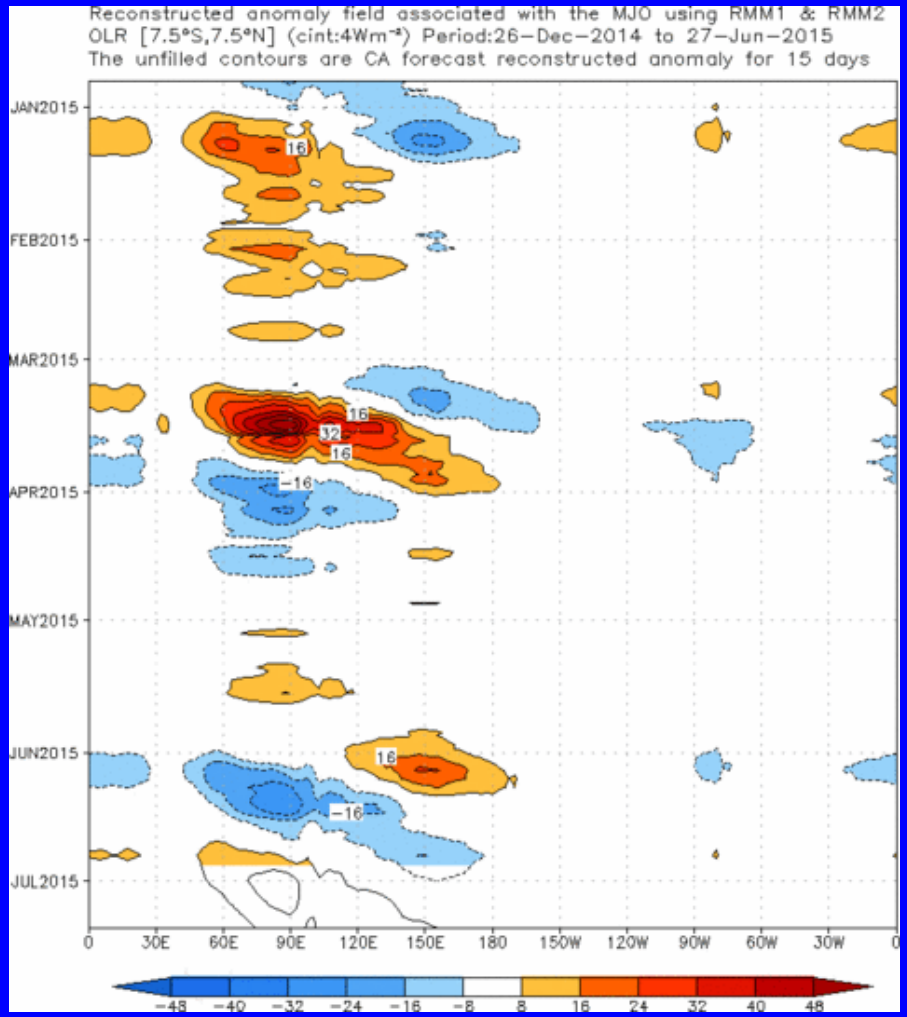
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



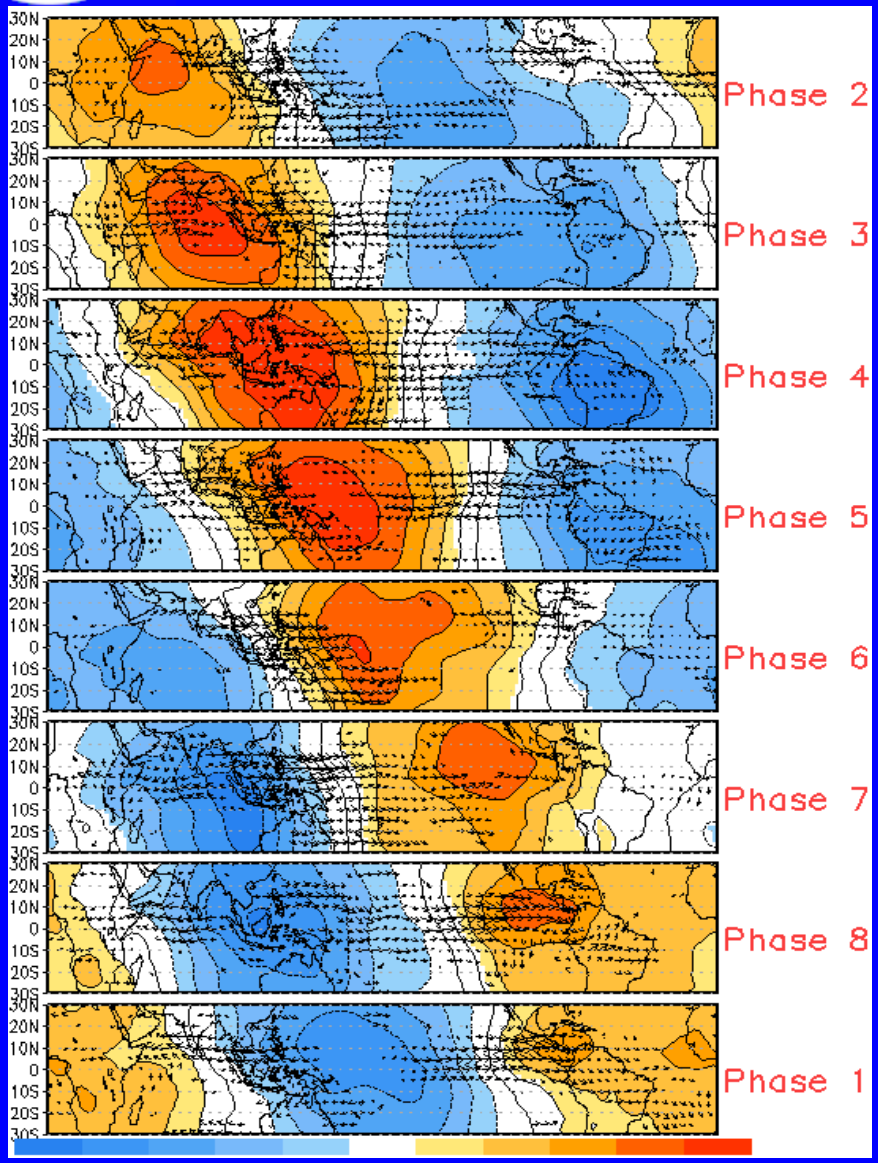
The statistical forecast depicts continued eastward propagation of a weaker signal during the next two weeks.

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

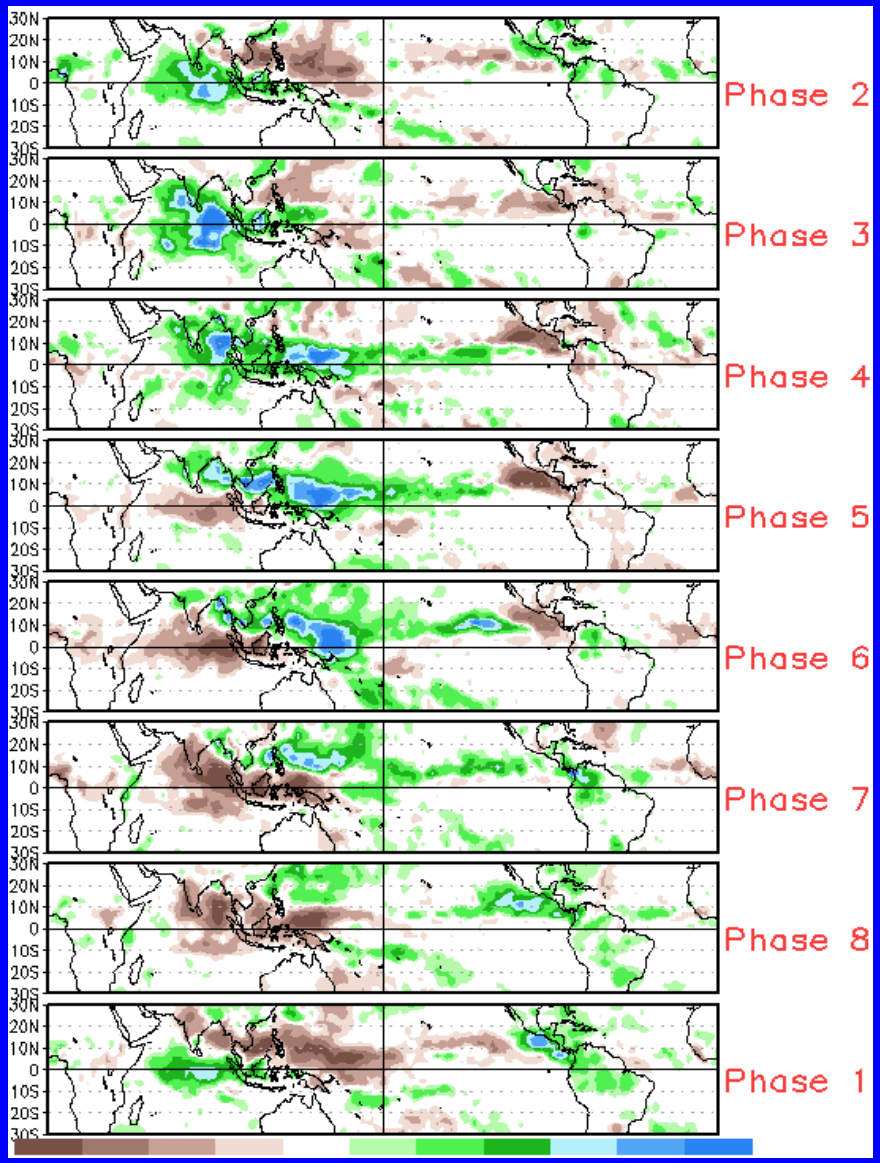


MJO Composites – Global Tropics

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

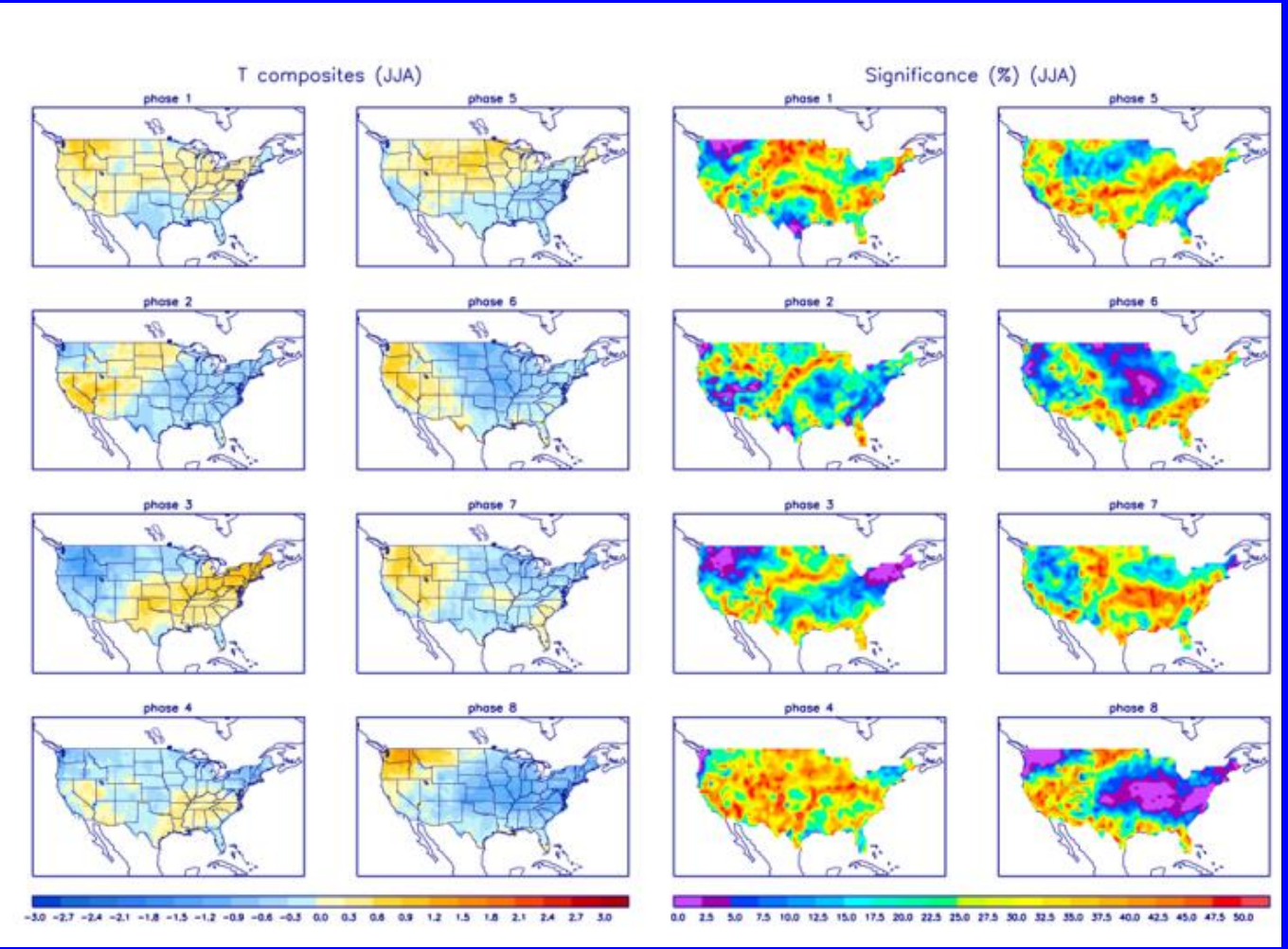


Precipitation Anomalies (May-Sep)



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.**

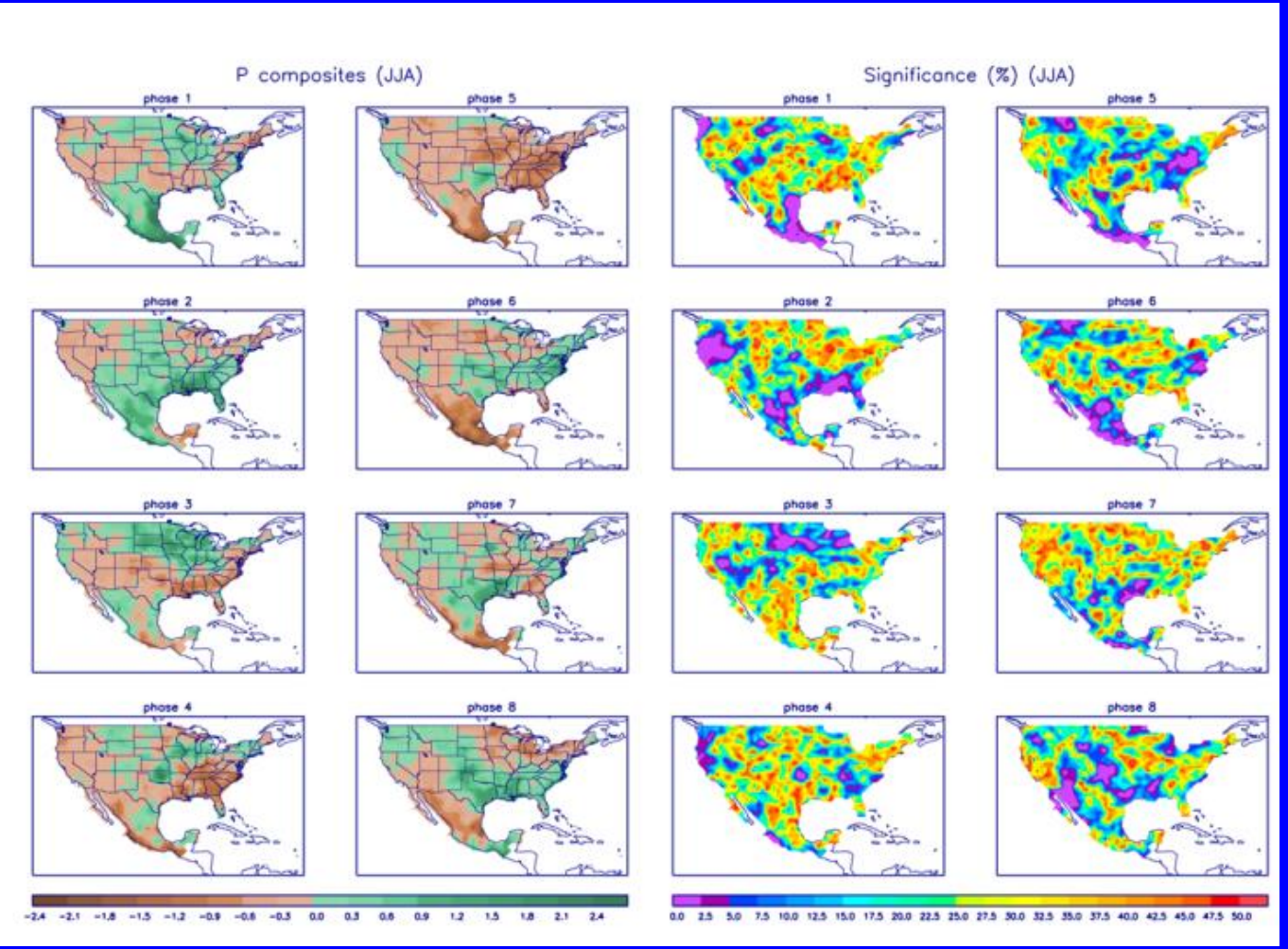


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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