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

Update prepared by
Climate Prediction Center / NCEP
July 23, 2012

Outline

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

Overview

- The MJO remained active during the past week, albeit generally weak, with the enhanced phase now centered over the Maritime Continent. Other types of tropical subseasonal variability continue to strongly impact the patterns of anomalous tropical convection.

- Dynamical model MJO index forecasts indicate large spread with most showing generally incoherent behavior over the next two weeks. Contributions from other forms of tropical subseasonal variability continue to impact these forecasts.

- Based on the latest observations, the MJO is forecast to remain active with the enhanced phase impacting the western Pacific during the period.

- The MJO signal is expected to contribute to enhanced convection across the western Pacific along with elevated chances for tropical cyclone development. Suppressed convection is favored across the Indian Ocean during the next two weeks.

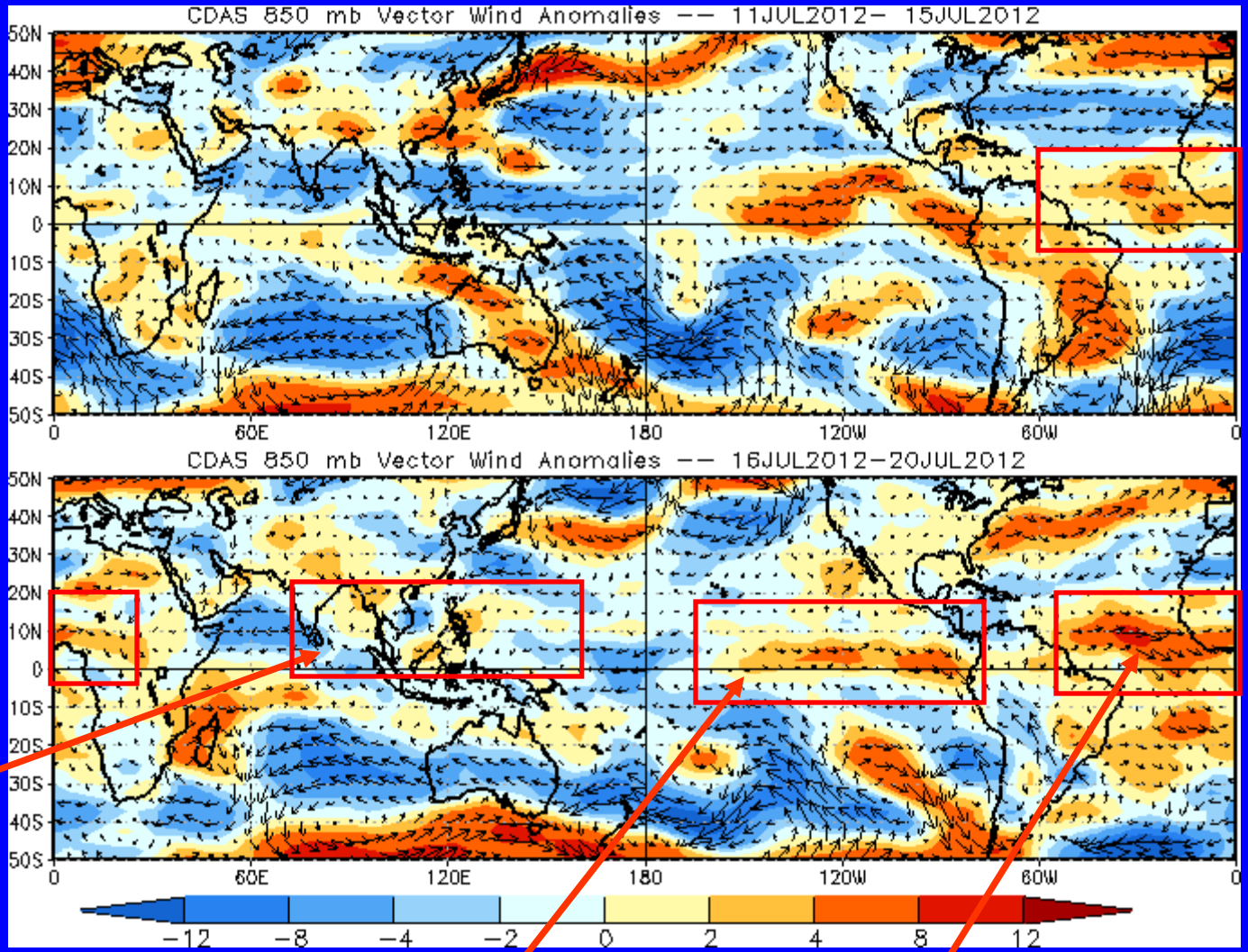
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 decreased in coverage across southeast Asia and the western North Pacific during the past five days.

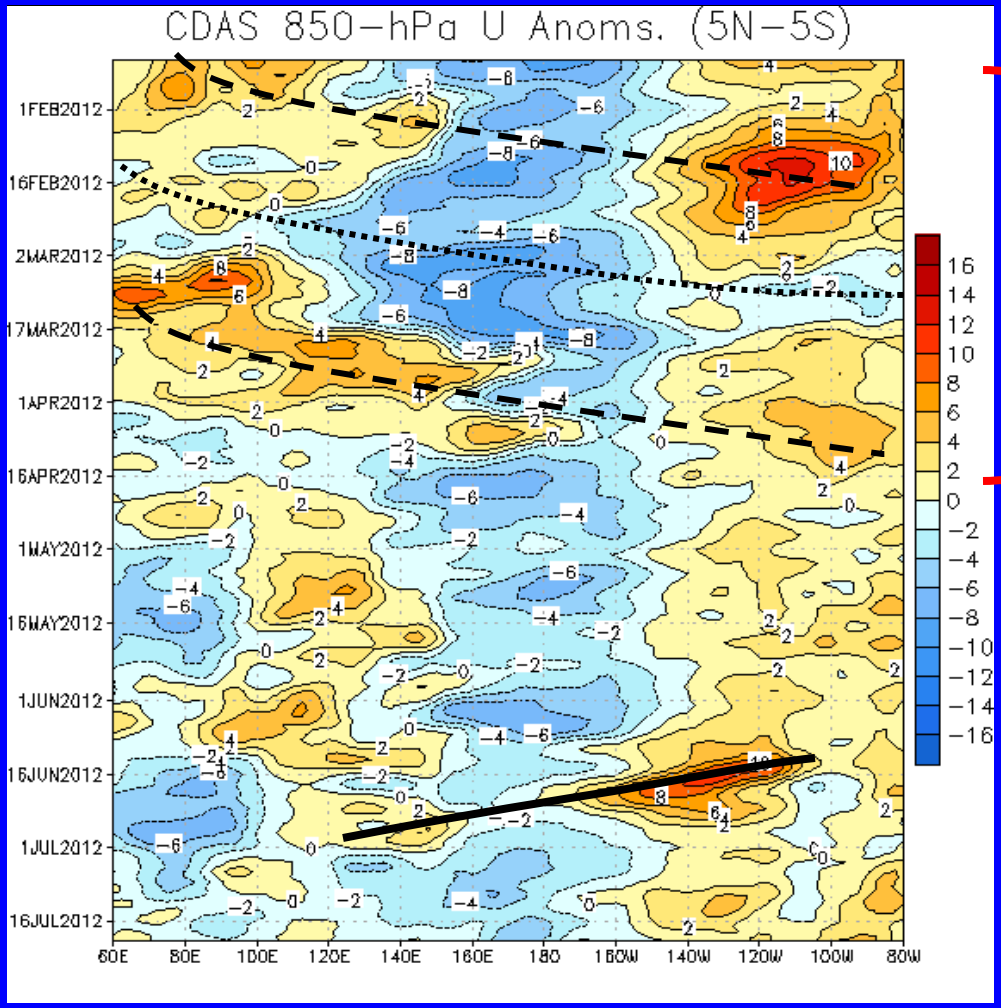
Westerly wind anomalies persisted across the eastern Pacific.

Westerly wind anomalies strengthened across the eastern tropical Atlantic and western Africa during the past five days.

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

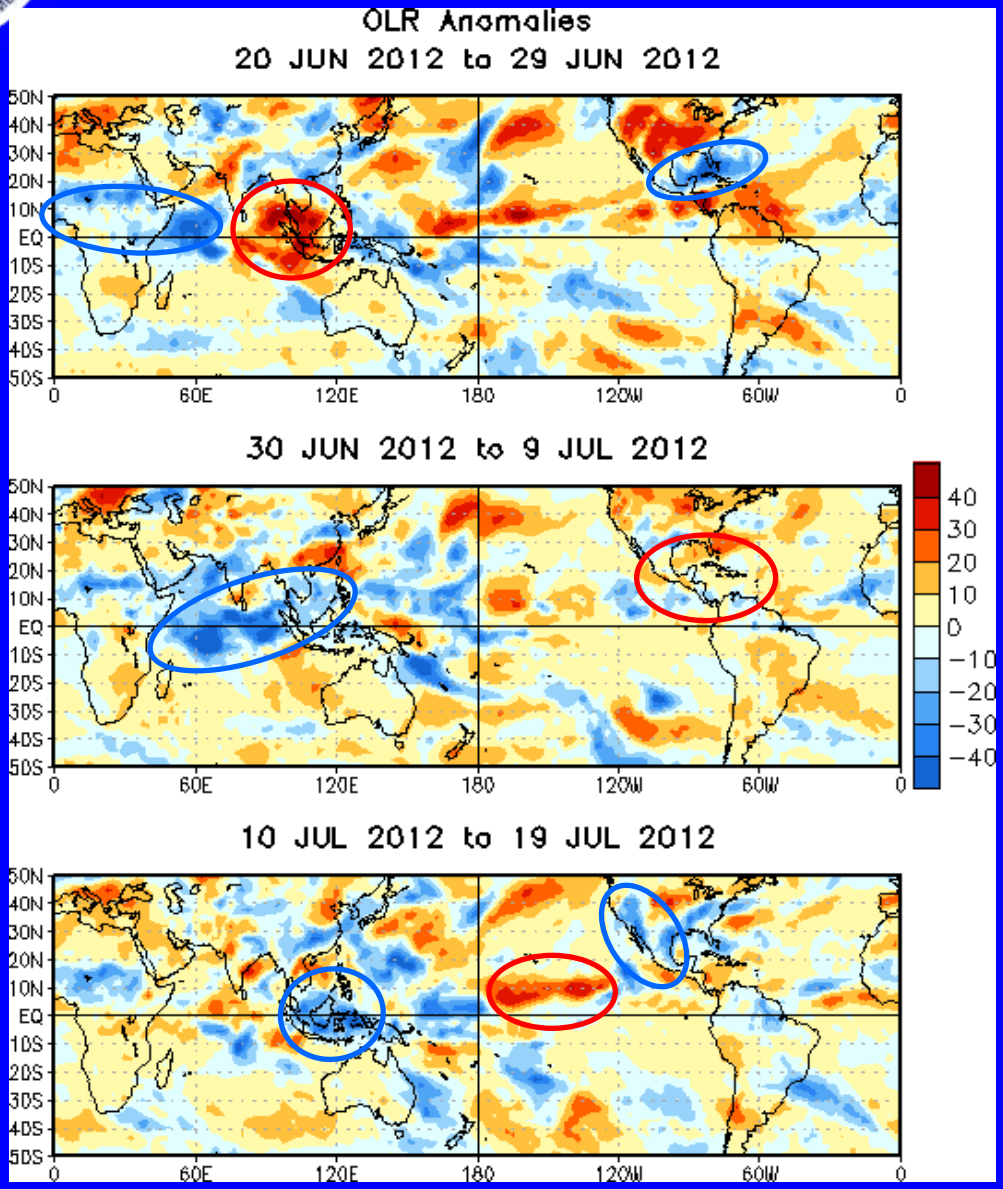
Longitude

During the first half of February, the MJO (alternating black dashed and dotted lines) contributed to increased westerly anomalies near 140E and across the eastern Pacific while decreasing easterly anomalies in the central Pacific. MJO activity continued into April, with westerly anomalies associated with the MJO located near the Date Line and western hemisphere early in the month.

Anomalies were generally persistent across much of the global tropics during April and May.

Strong westerly anomalies developed across the eastern Pacific in mid-June and shifted westward (black solid line) and likely were associated with a robust equatorial Rossby wave as it progressed west across the Pacific.

OLR Anomalies – Past 30 days



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

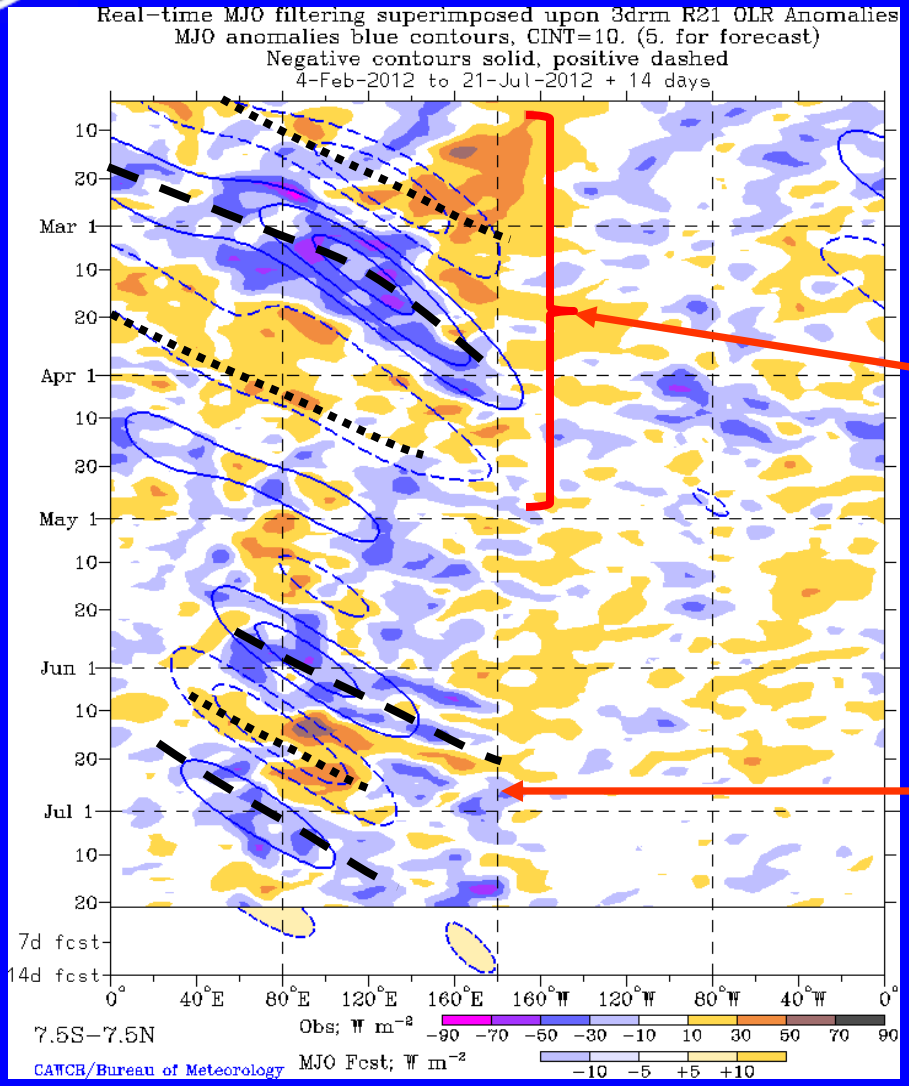
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

Enhanced convection was observed over Central America and the Caribbean, as well as Africa, with drier than average conditions evident for the Maritime Continent and eastern Indian Ocean.

From late June to early July anomalous convection shifted east across the Indian Ocean, while drier conditions were observed over the Caribbean and Central America.

During mid-July, anomalous convection was somewhat unorganized. Enhanced convection spread to the Maritime Continent with a small area of below-average convection noted over the central Pacific. The North American monsoon became quite active.

Outgoing Longwave Radiation (OLR) Anomalies (7.5°S-7.5°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)

Strong MJO activity (alternating dashed and dotted lines) was evident during February and continued into mid-April.

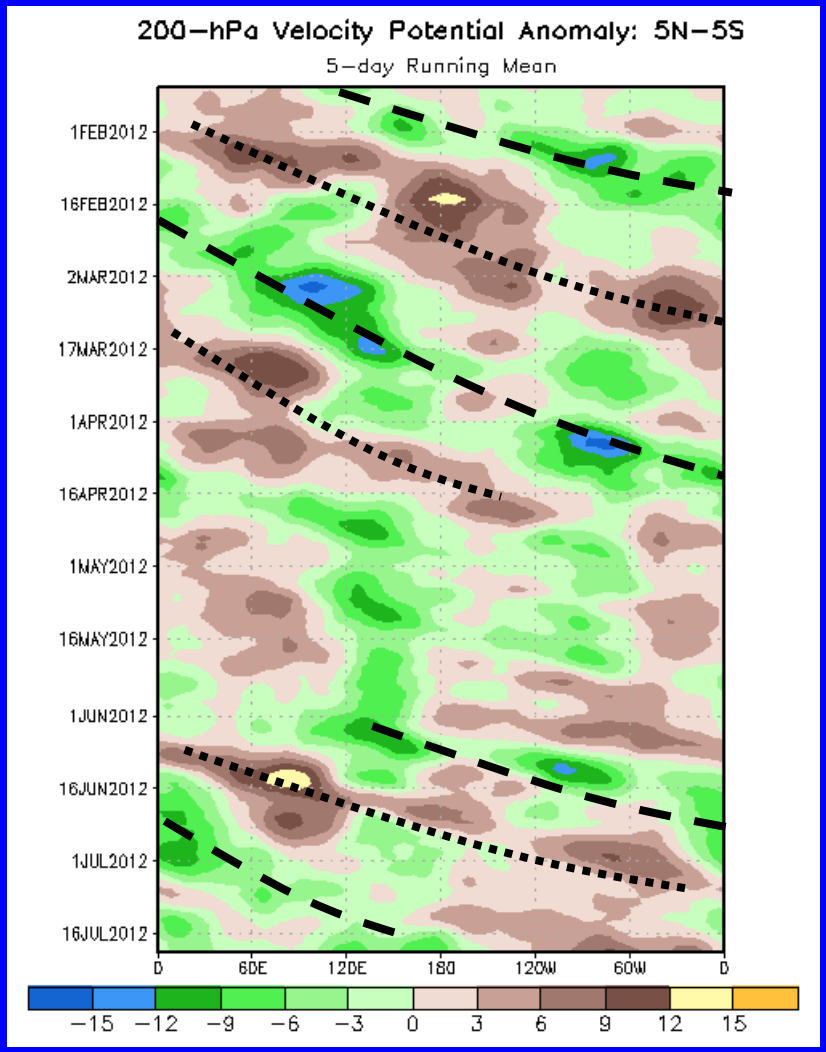
Anomalies became less coherent during most of April and May.

In late May into July, eastward propagation of both enhanced and suppressed convection is evident across the eastern hemisphere. Atmospheric Kelvin wave activity also played a large role in the pattern of anomalous convection across the Pacific and western Hemisphere during this period.

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 strengthened in late January as indicated by alternating negative (dashed lines) and positive (dotted lines) anomalies with eastward propagation. The activity continued into mid-April.

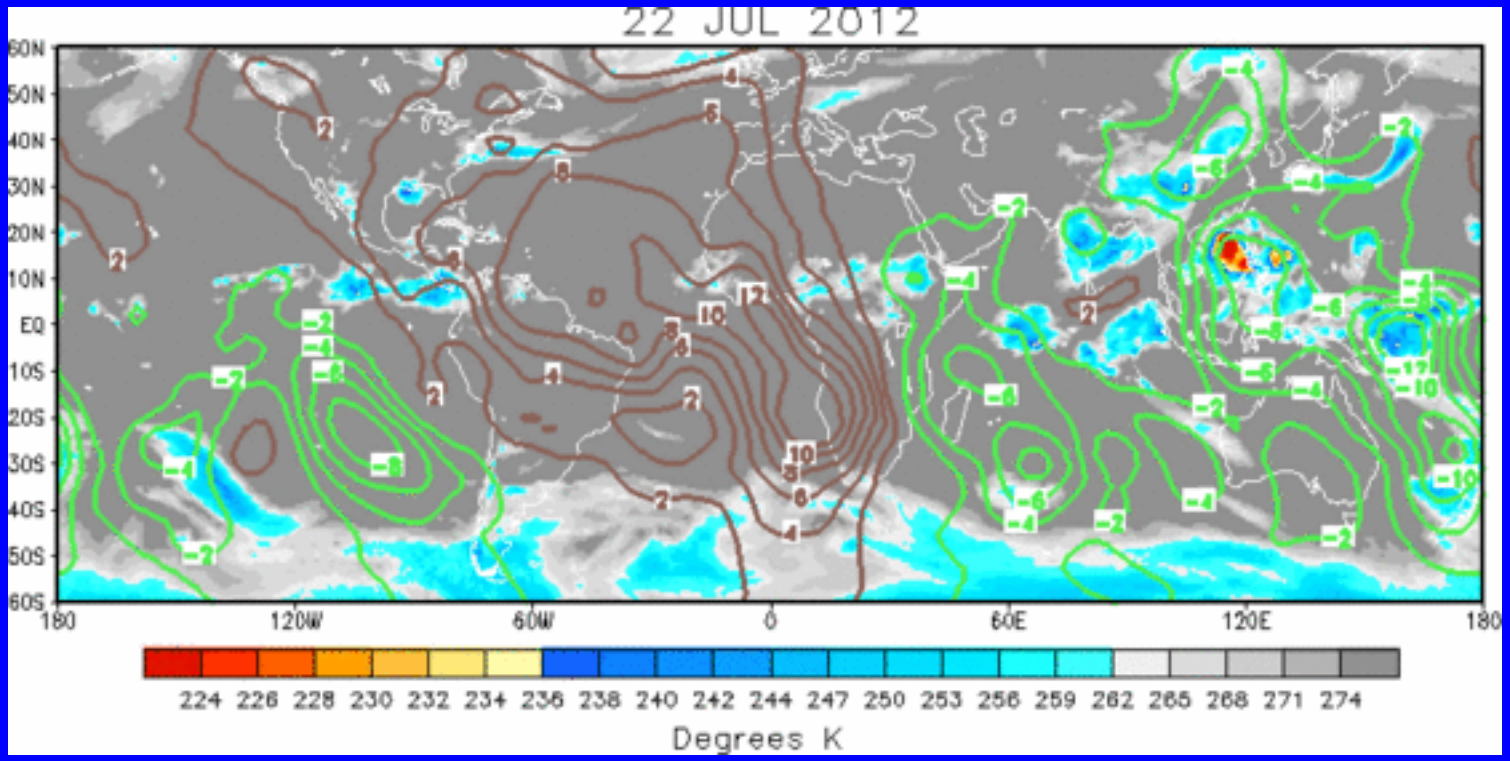
Beginning in late April, anomalies became weaker and less coherent than earlier in the year.

Eastward propagation was once again evident from late May into July associated with the MJO as well as atmospheric Kelvin wave activity, which at times resulted in fast eastward propagation of observed anomalies.

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

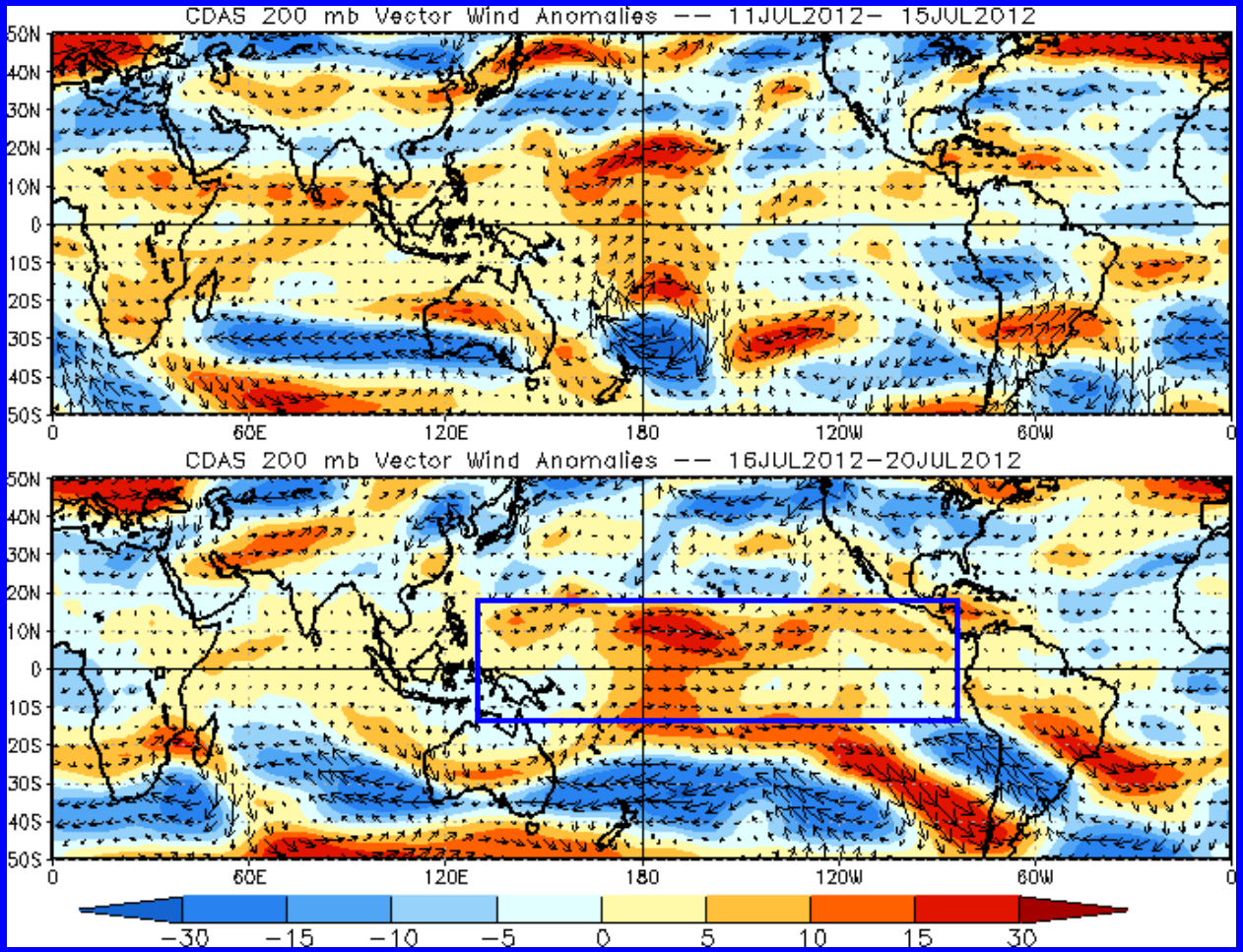
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The large scale velocity potential pattern reflects anomalous upper-level divergence across the Indian Ocean, Maritime continent, and west Pacific with anomalous upper-level convergence across the Americas, the Atlantic and western Africa.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

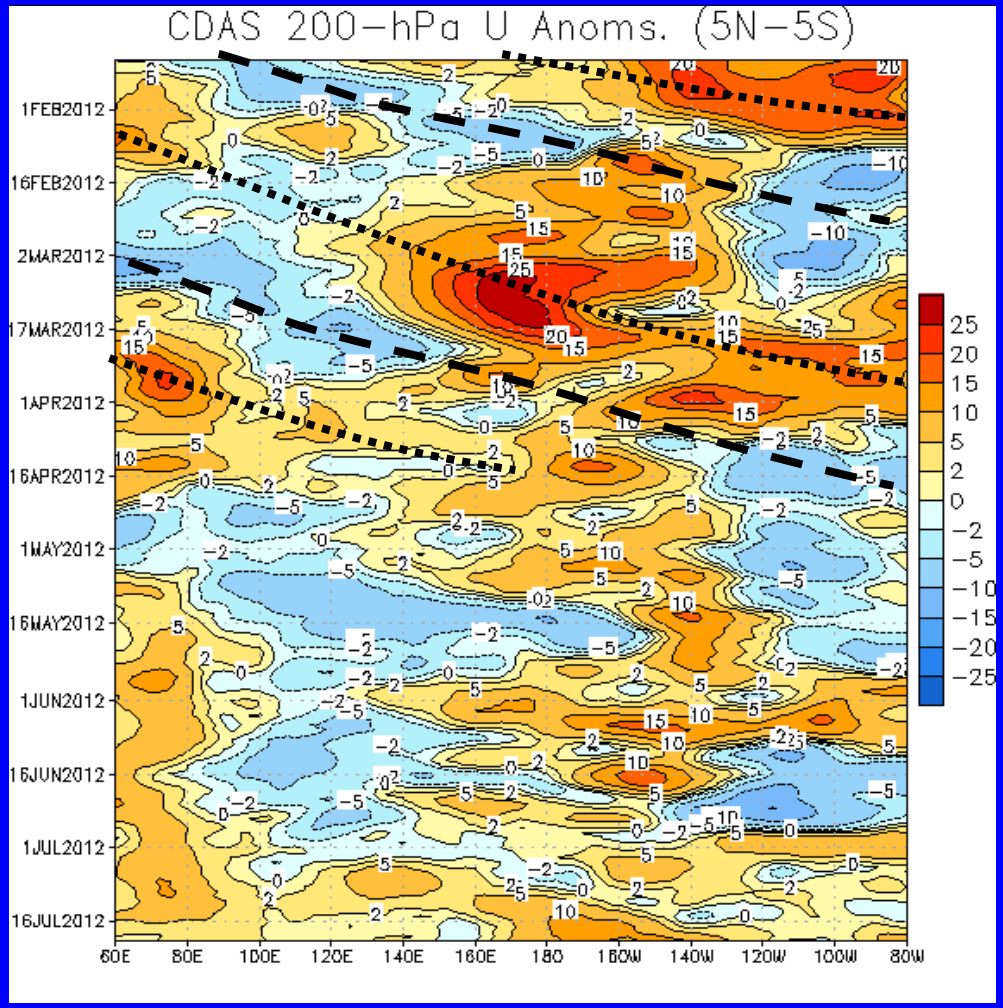
Red shades: Westerly anomalies

Westerly anomalies are now evident across much of the Pacific Ocean (blue box).

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



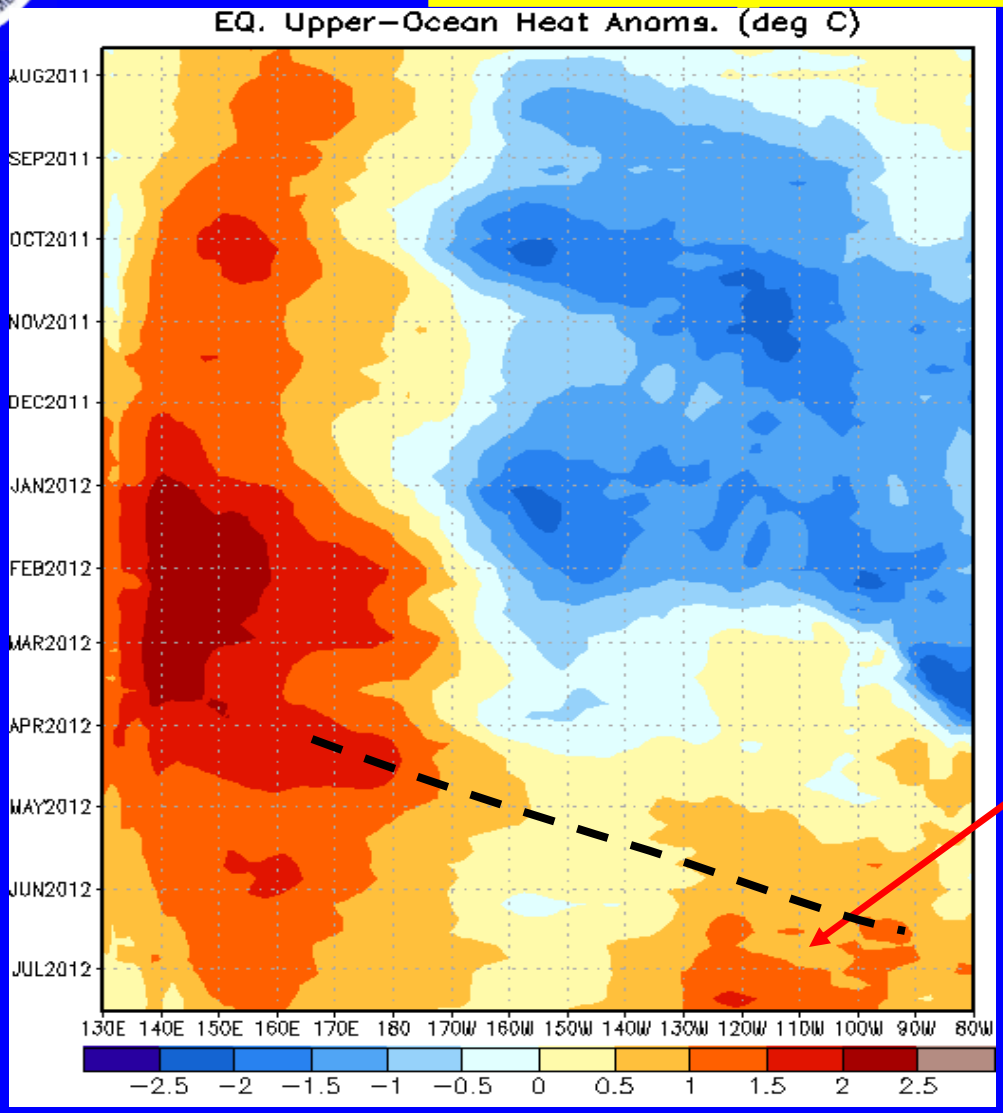
Time

Longitude

The MJO strengthened once again in late January as indicated by alternating westerly (dotted lines) and easterly (dashed lines) anomalies. This activity continued to mid-April.

Anomalies were less coherent during much of April and May. Some evidence of faster moving, subseasonal variability can be seen during parts of June and July.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

From July 2011 through February 2012, heat content was below average in the central and eastern equatorial Pacific.

From March- May 2012, heat content anomalies were positive across much of the equatorial Pacific, partly in association with a 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).

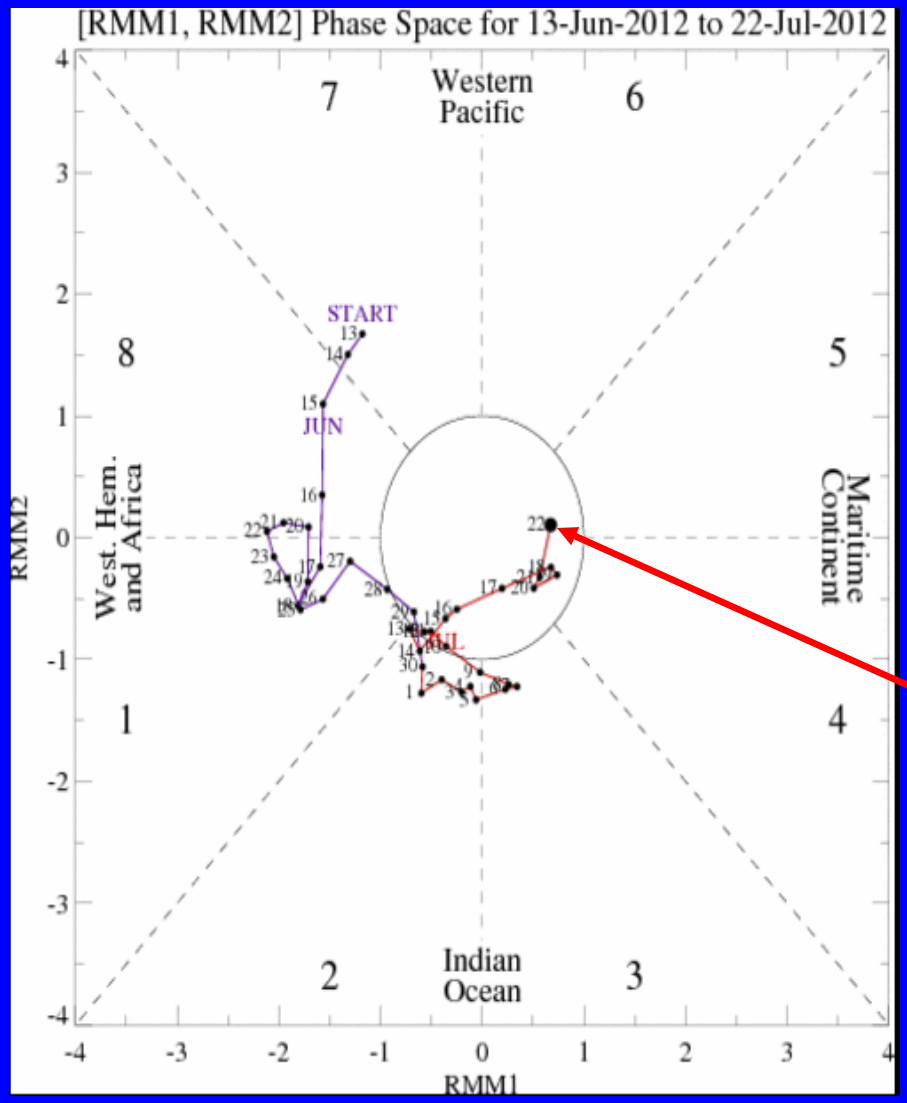
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

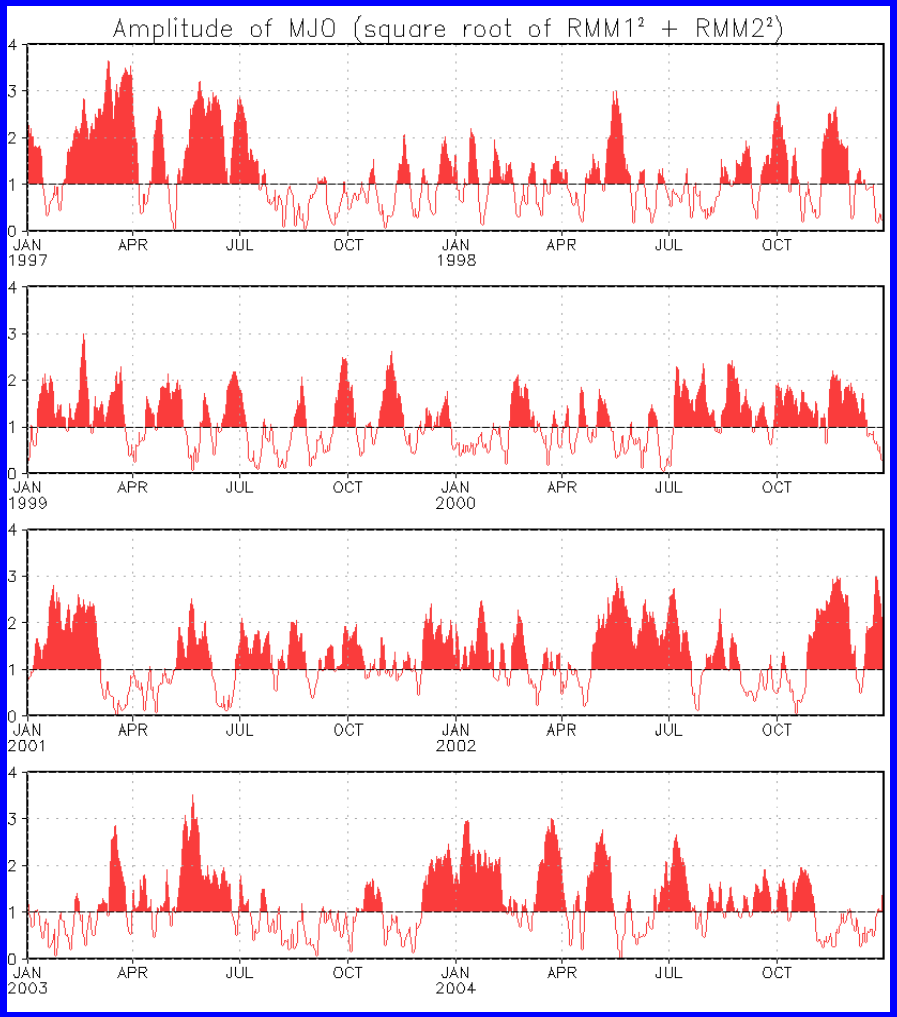
MJO Index -- Recent Evolution

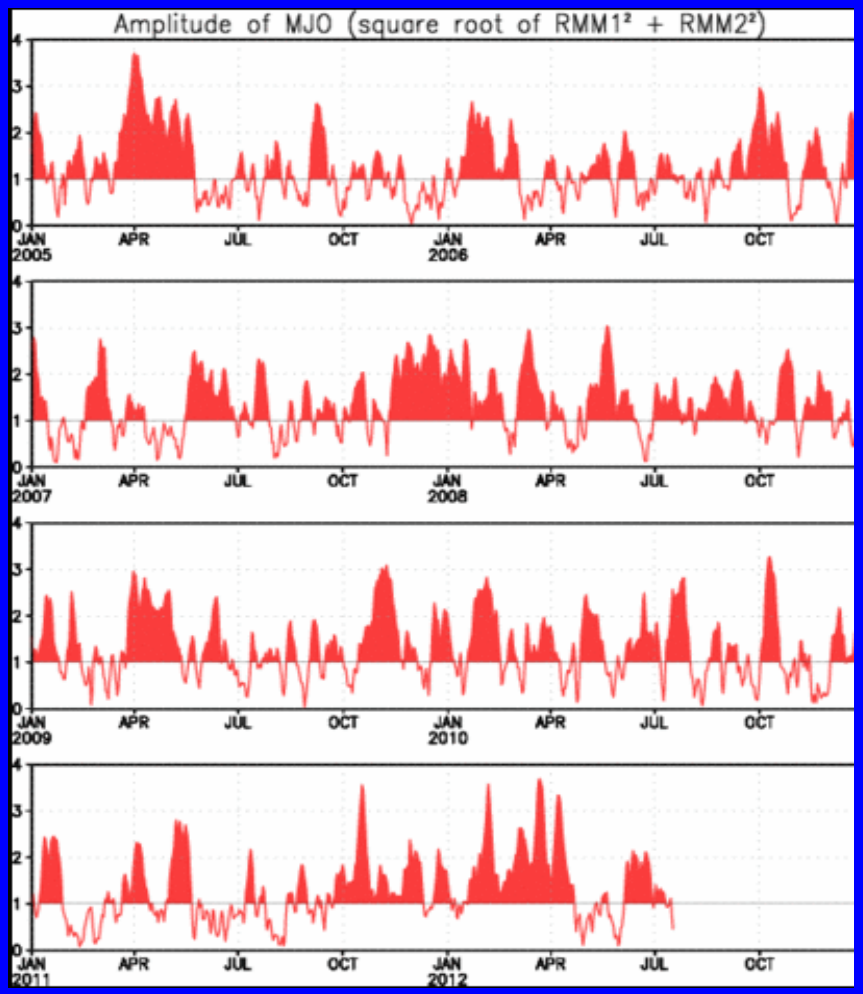


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index shifted to the Maritime Continent during the past week. Other tropical subseasonal variability and tropical cyclone activity continue to contribute to the evolution of the index over the past couple of weeks.

MJO Index – Historical Daily Time Series





Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

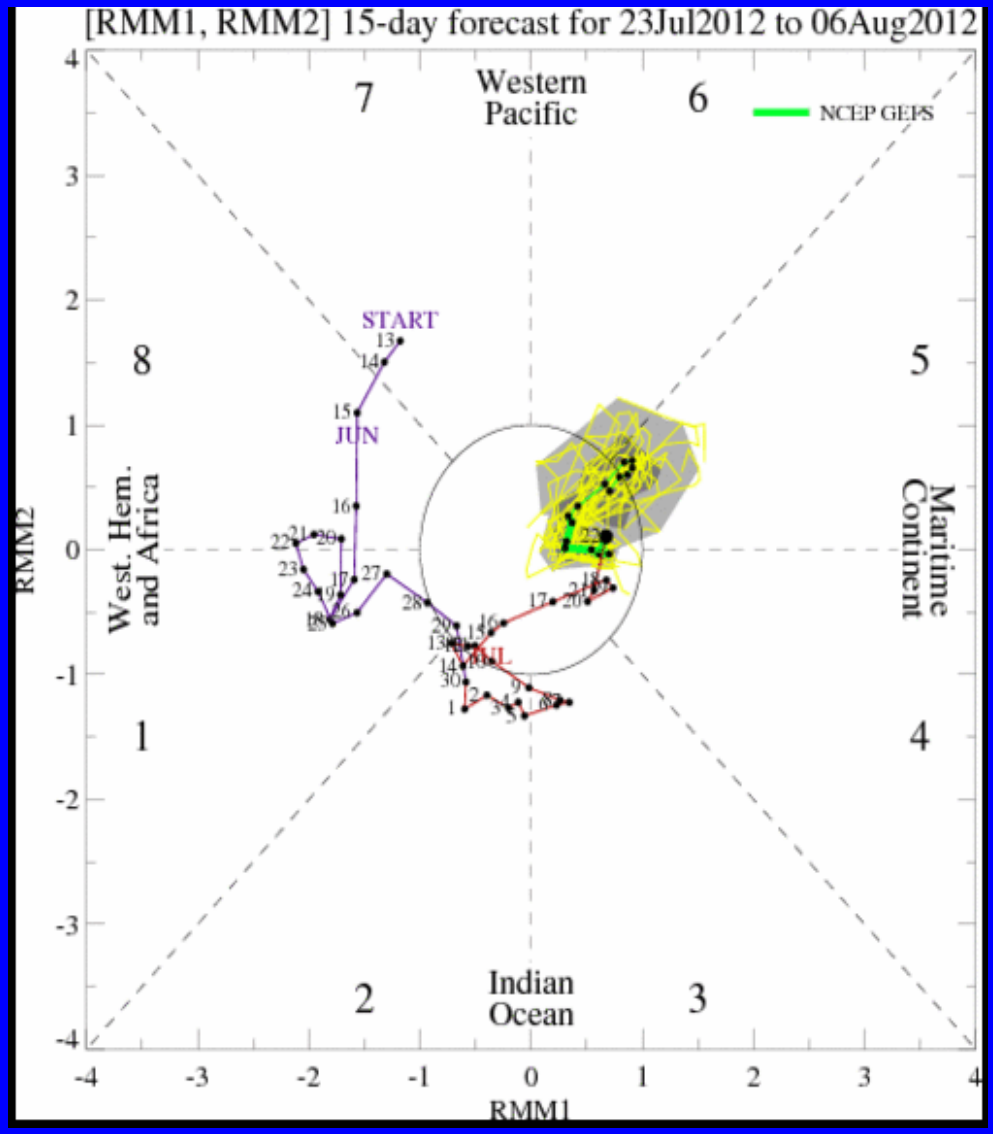
Ensemble GFS (GEFS) MJO Forecast

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

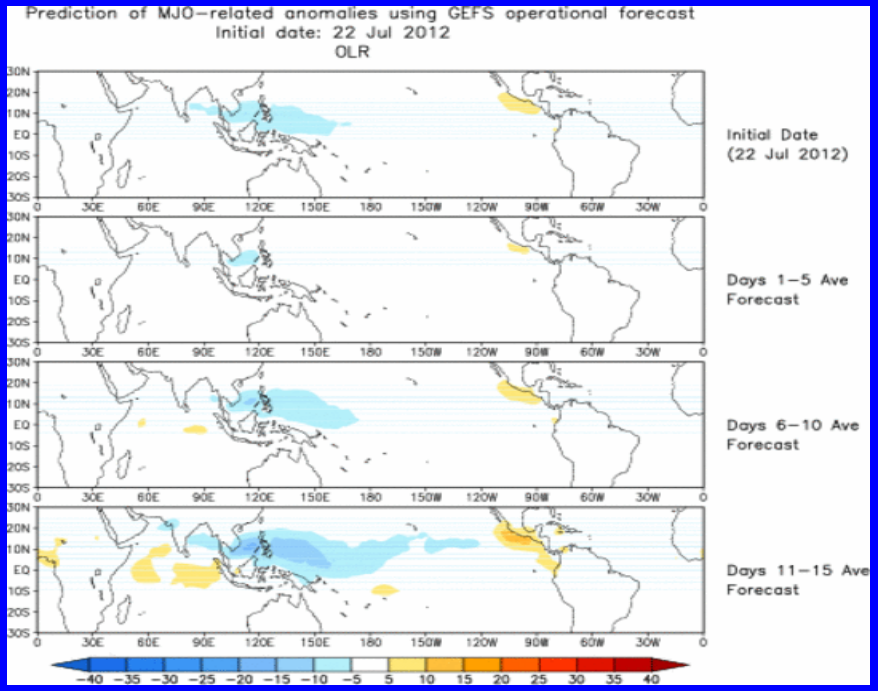
The ensemble GFS forecasts show a generally weak signal with little eastward propagation during the next two weeks.



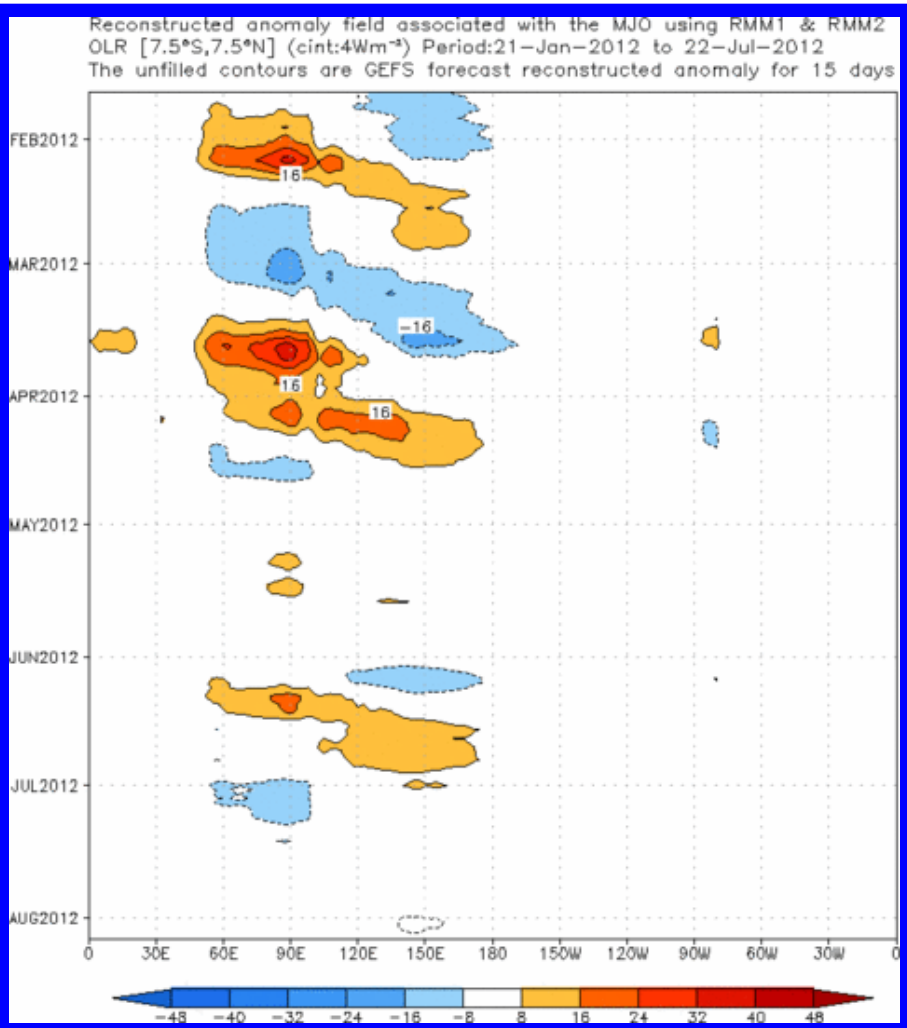
Ensemble Mean GFS MJO Forecast

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

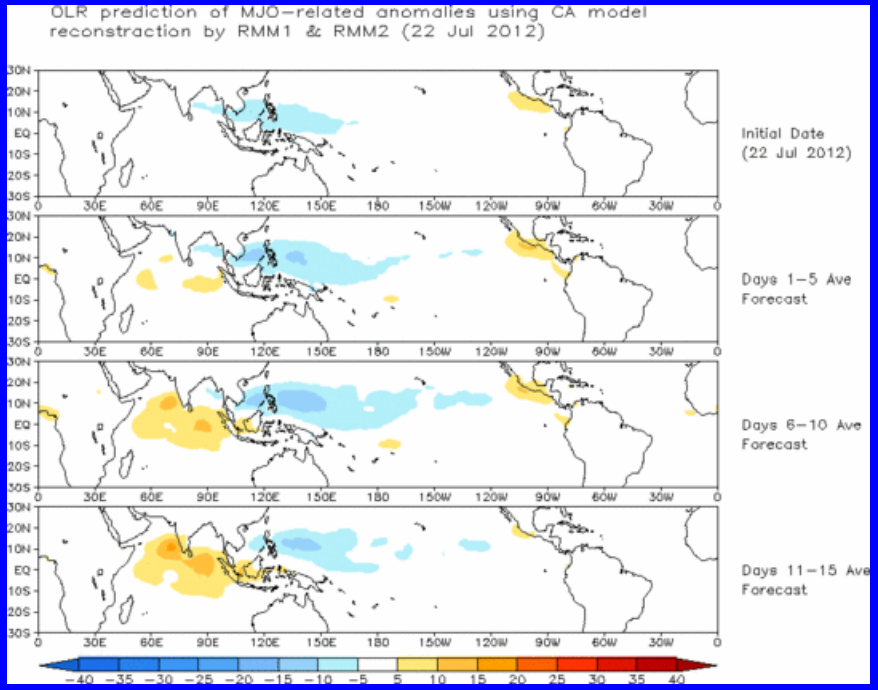


The ensemble mean GFS forecast indicates small negative anomalies (enhanced convection) over the Maritime Continent and west Pacific (primarily Week-2).

Constructed Analog (CA) MJO Forecast

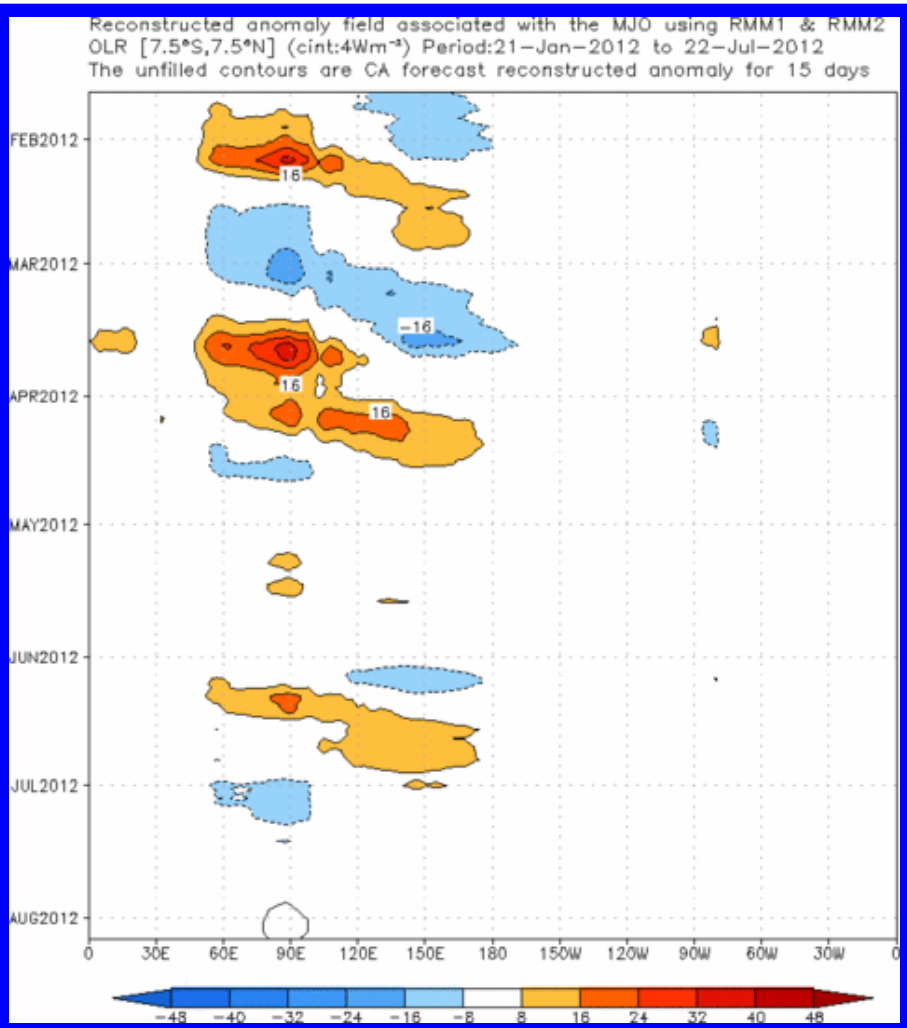
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



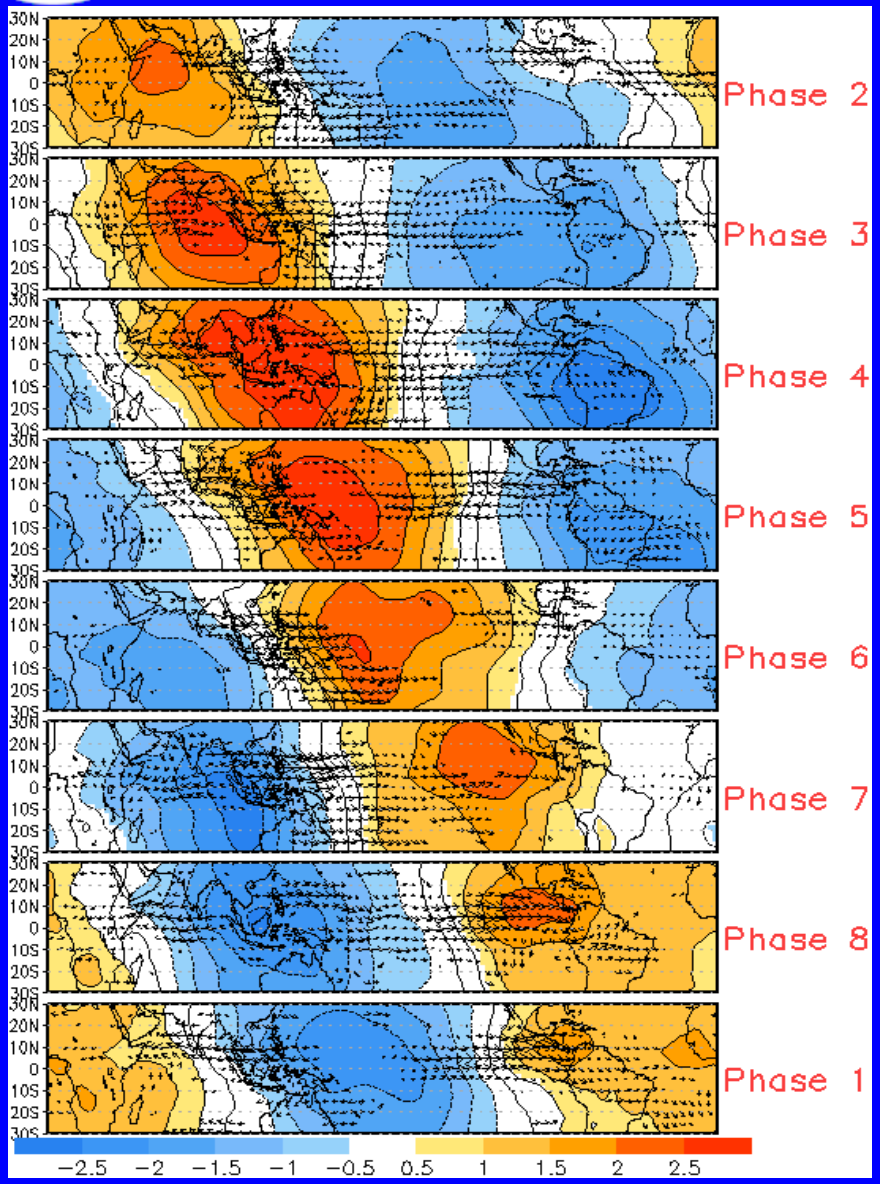
This forecast indicates weak enhanced convection persisting across the western Pacific during the period. Suppressed convection is forecast to develop over the Indian Ocean.

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

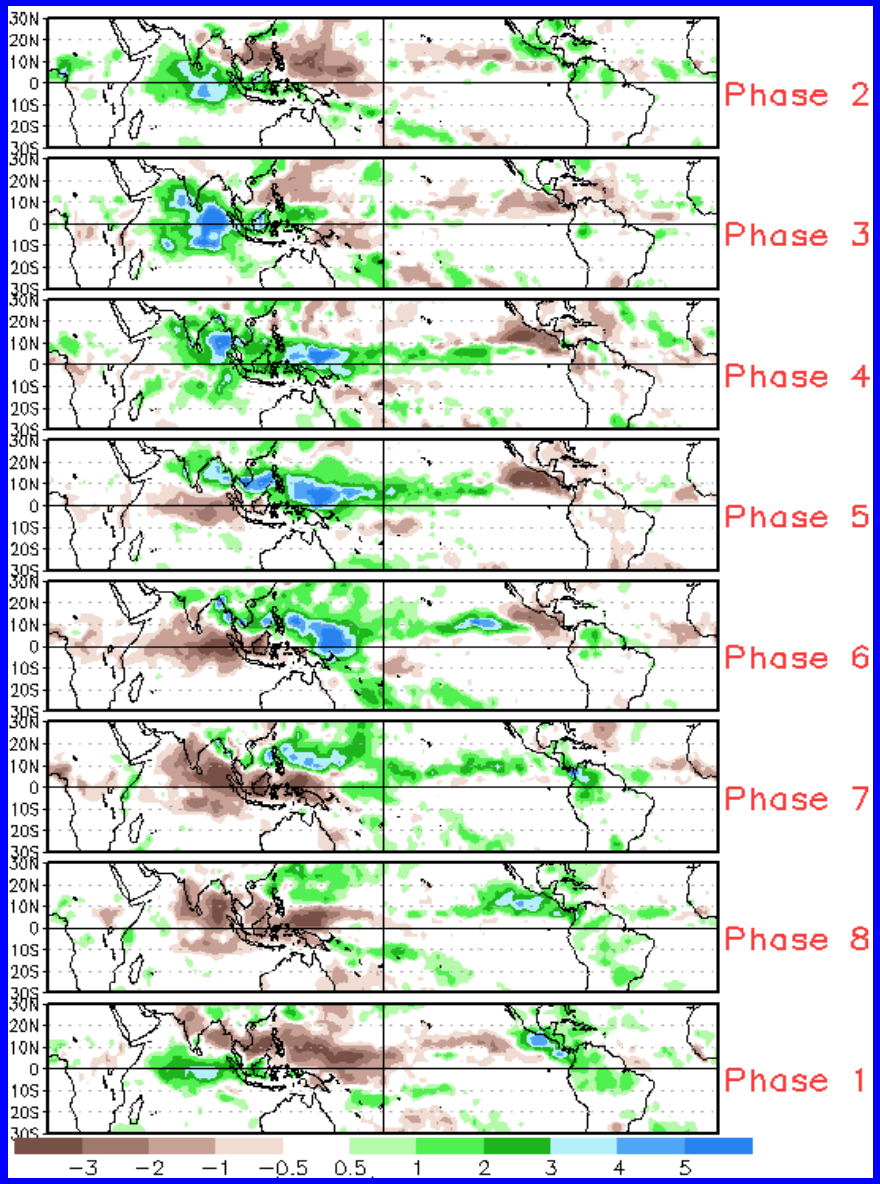


MJO Composites – Global Tropics

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

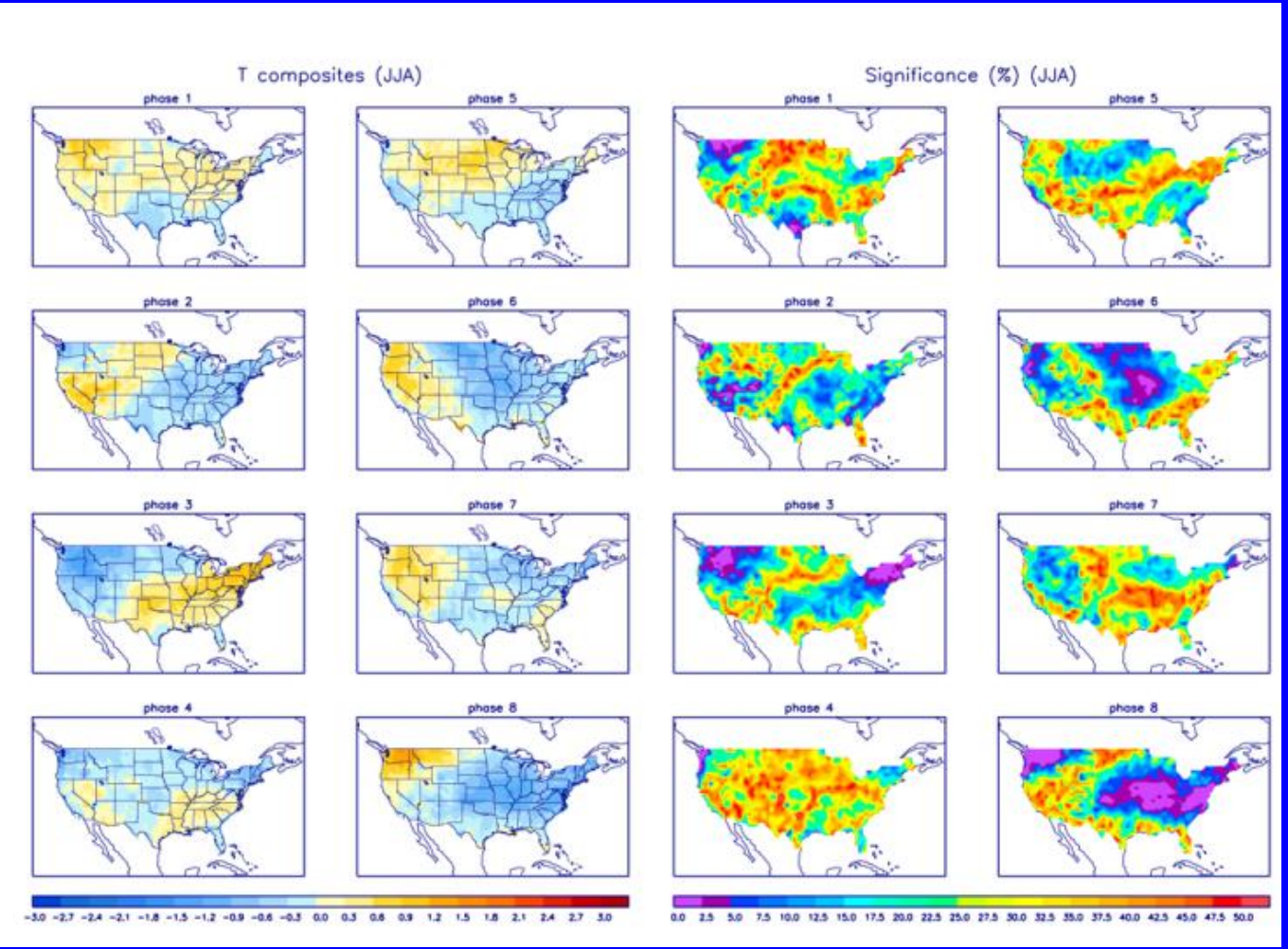


Precipitation Anomalies (May-Sep)



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.**

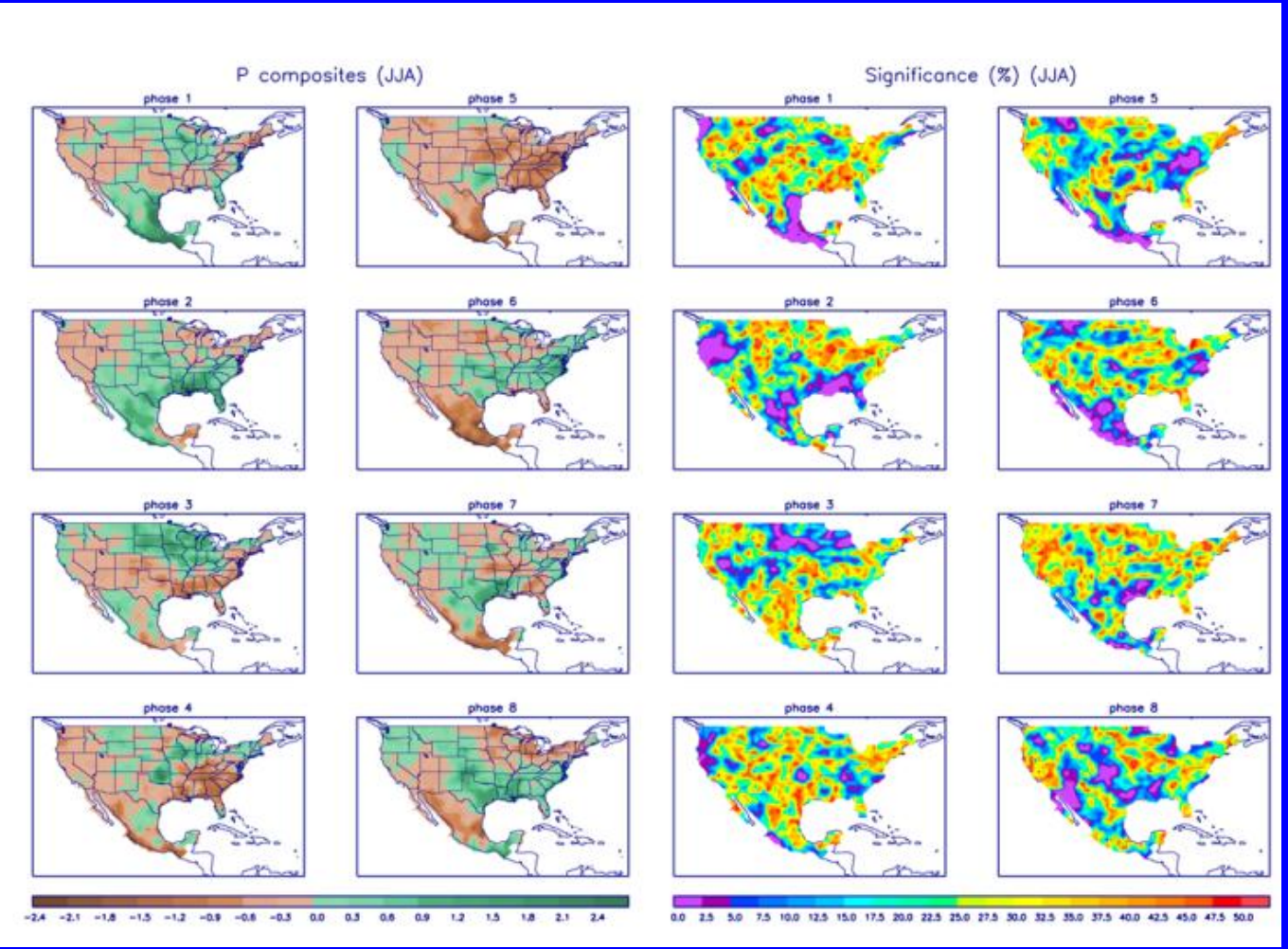


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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