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

Update prepared by:
Climate Prediction Center / NCEP
24 July 2017

Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The atmosphere remained largely consistent with an active MJO, with the enhanced phase over the Maritime Continent.
- The various dynamical models exhibit good agreement through Week-1 on a continued eastward propagation of a convective signal, but then disagree on the Week-2 evolution, likely due to differences in strength of an equatorial Rossby wave.
- The MJO is expected to propagate eastward across the Maritime Continent and Western Pacific over the next week, with typical warm-season precipitation impacts expected from the Indian Ocean to the West Pacific, including parts of Southeast Asia.
- The forecast MJO evolution would support reduced tropical cyclone (TC) activity over the East Pacific basin and Atlantic Ocean.

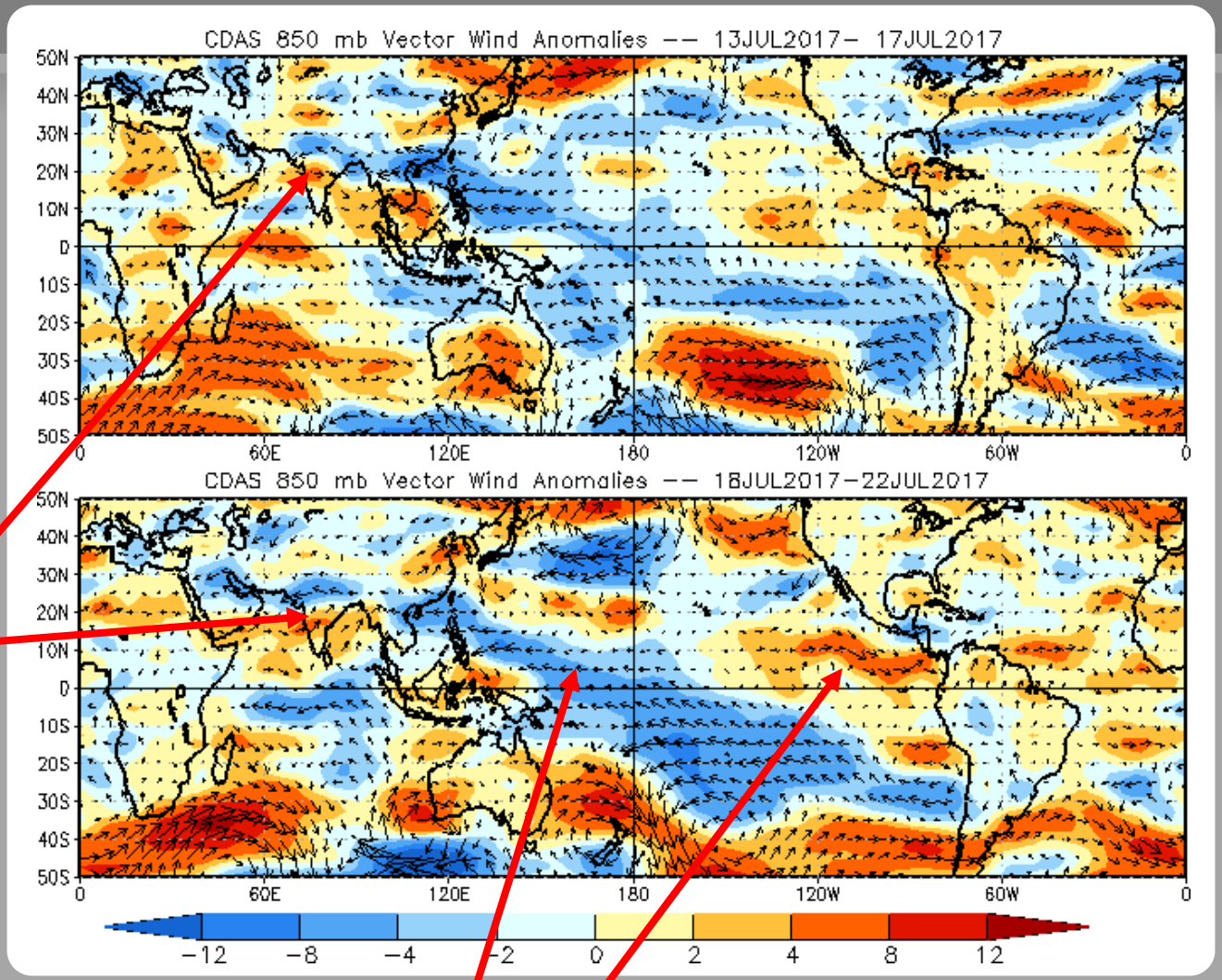
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 persisted over India with an anomalous cyclone over northwest India. Additionally, a couplet of westerly/easterly anomalies moved northward from the equator over the Indian Ocean.

Easterly (Westerly) anomalies increased over the western (eastern) Pacific

850-hPa Zonal Wind Anomalies (m s-1)

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

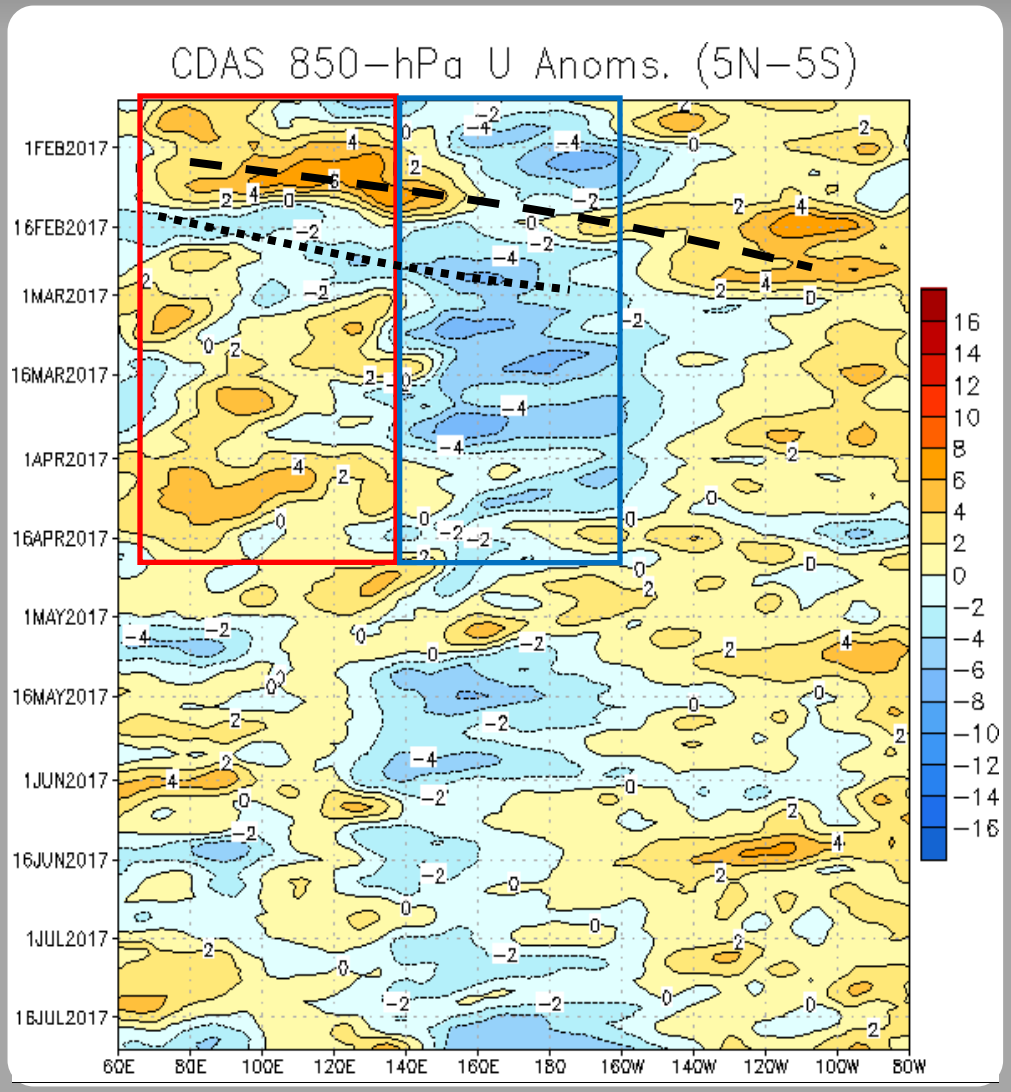
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Persistent westerly (easterly) anomalies, shown by the red (blue) box at right, were associated with the negative phase of the Indian Ocean Dipole (IOD), and later, La Niña.

In February, MJO activity destructively interfered with the base state. During mid-March and early April, the low frequency state reemerged, with some intraseasonal variability evident in late March.

Equatorial flow was fairly weak throughout June, with easterlies favored between 120E and the Date Line and also emerging across the western Indian Ocean.

Recently, the pattern has shifted eastward and intensified, with westerly anomalies now over the Maritime Continent. The lower-level wind pattern is still exhibiting a wave-2 structure.



OLR Anomalies – Past 30 days

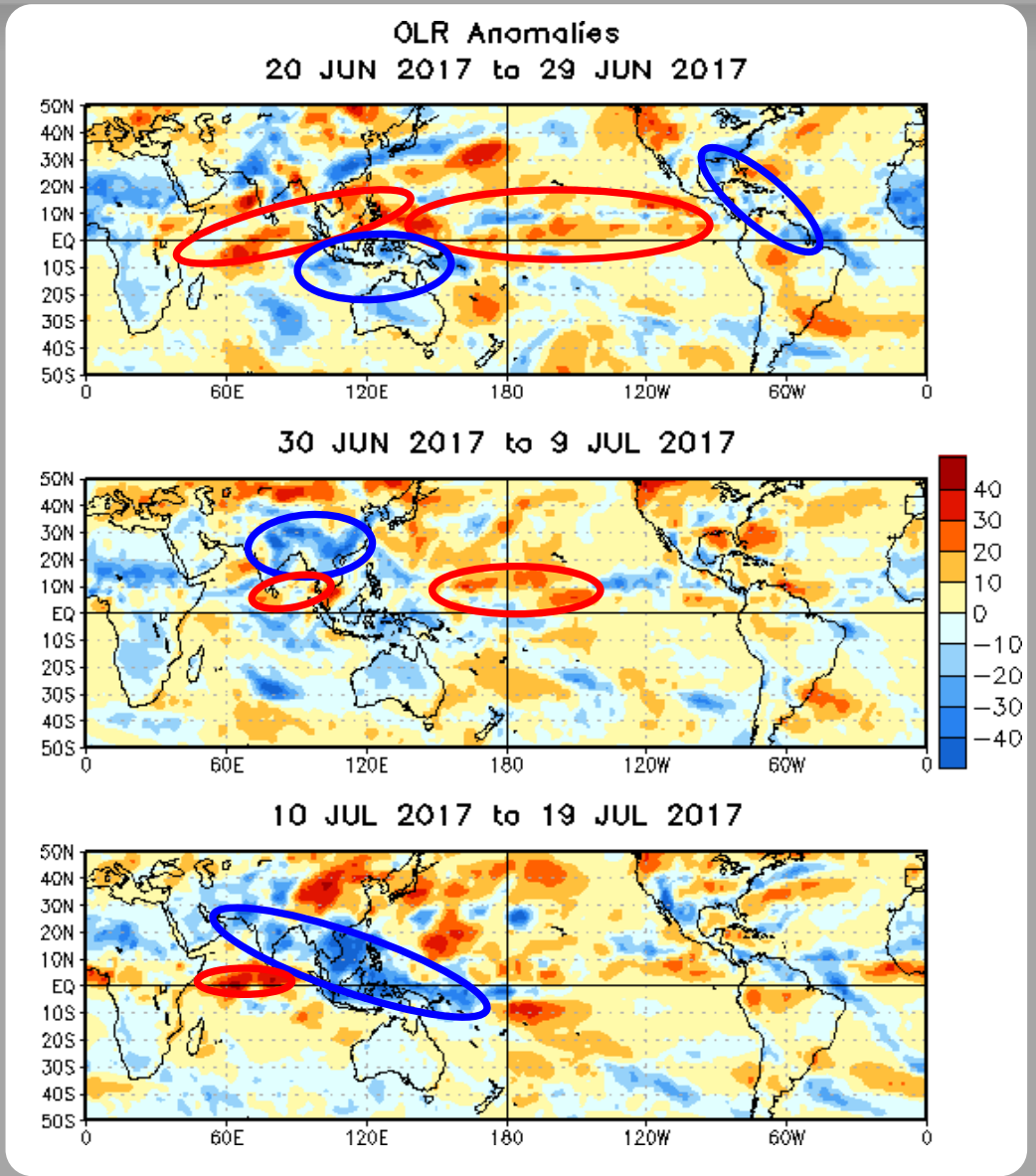
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid- to late June, suppressed convection was observed over much of the Indian and Pacific Ocean basins. A surge of tropical moisture into southeastern North America is also evident.

In late June and early July, enhanced convection was observed over parts of Southeast Asia, with suppression over the central Pacific. Thin areas of enhanced convection are evident over the East Pacific, likely tropical cyclone related.

By early to mid-July, the enhanced convective pattern became more organized over Southeast Asia and the Maritime Continent. Some low-frequency tendency is noted over the latter during the past month.



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

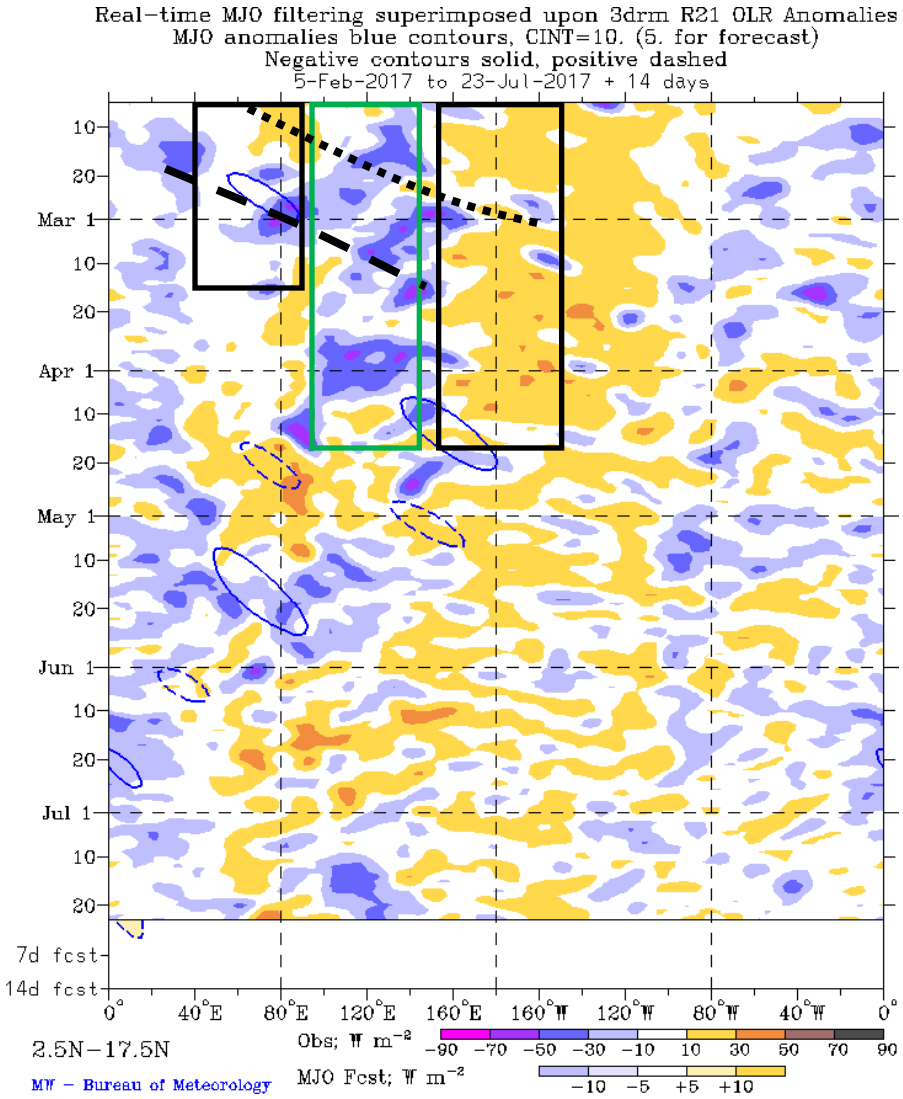
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

A low frequency state favoring enhanced convection over the eastern IO and the Maritime Continent was evident from July 2016 through early April 2017 (green box), with suppressed convection near the Date Line (right black box). The remainder of the IO generally had suppressed convection during this period (left black box), with the exception of an MJO-related wet period from mid-Feb to early March.

From mid-April through present, convective anomalies were generally weak. In mid-May, enhanced convection was noted over the Indian Ocean with some eastward propagation.

During the past week convective signals increased in amplitude over the Maritime Continent, with some notable eastward propagation.



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

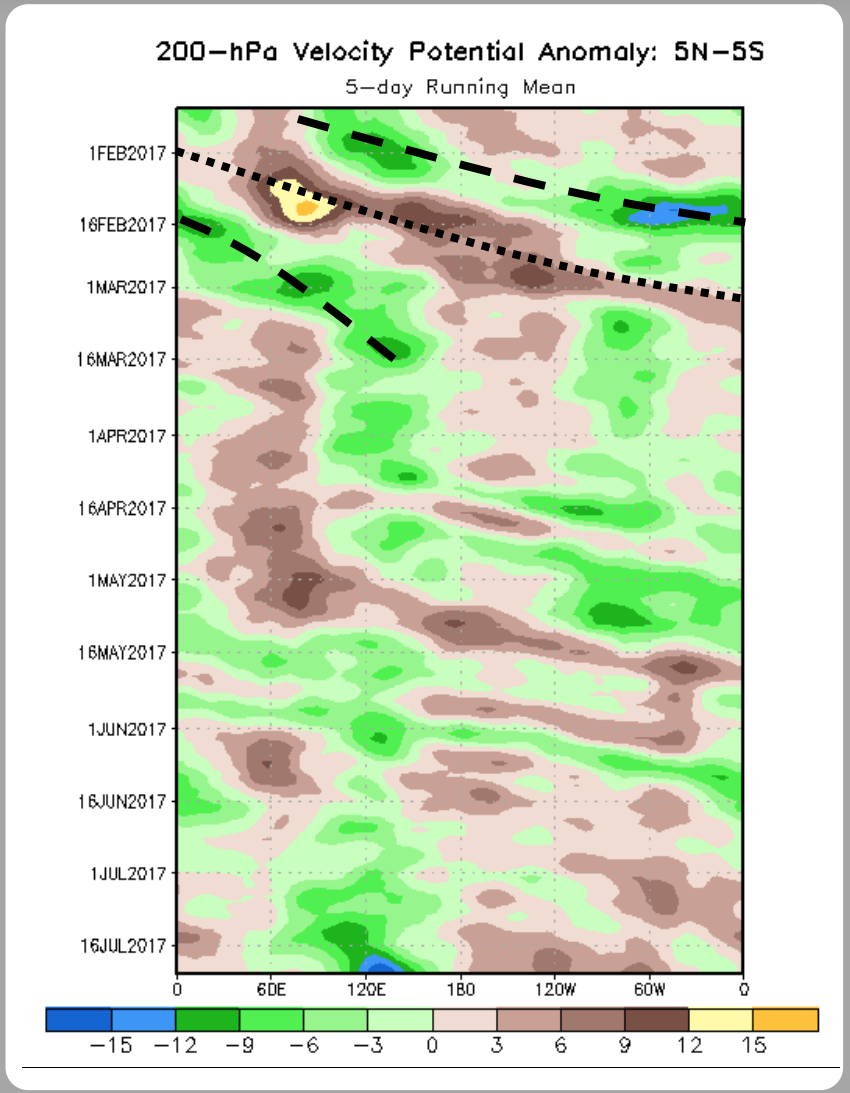
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

A signal emerged over the Maritime Continent and continued propagating through early March, creating alternating periods of constructive and destructive interference with the base state.

During March, a low frequency signal favoring enhanced (suppressed) convection over the Maritime Continent (Indian Ocean) once again became the primary component of the anomaly field.

Kelvin wave activity was apparent from April through early June, as seen in the rapidly propagating eastward signals. Over the past month anomalies have been somewhat stationary with enhanced (suppressed) convection over the Maritime Continent (East Pacific). The recent maximum observed near 100E is among the strongest signals observed over that region during the past six months.



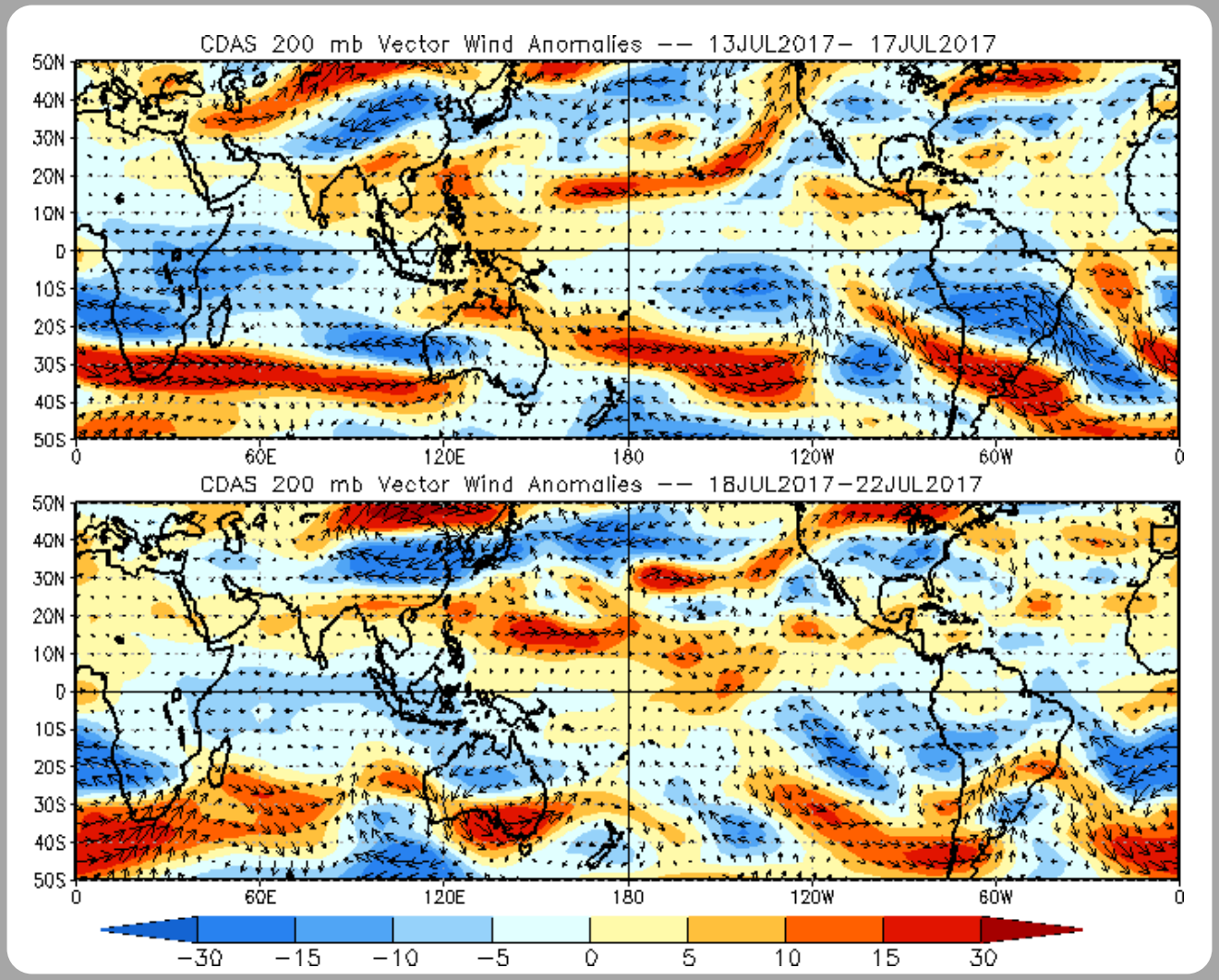
200-hPa Vector Wind Anomalies (m s-1)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Upper-level wind anomalies indicated some mid-latitude influence over the tropics near 140W, and east of South America.



200-hPa Zonal Wind Anomalies (m s-1)

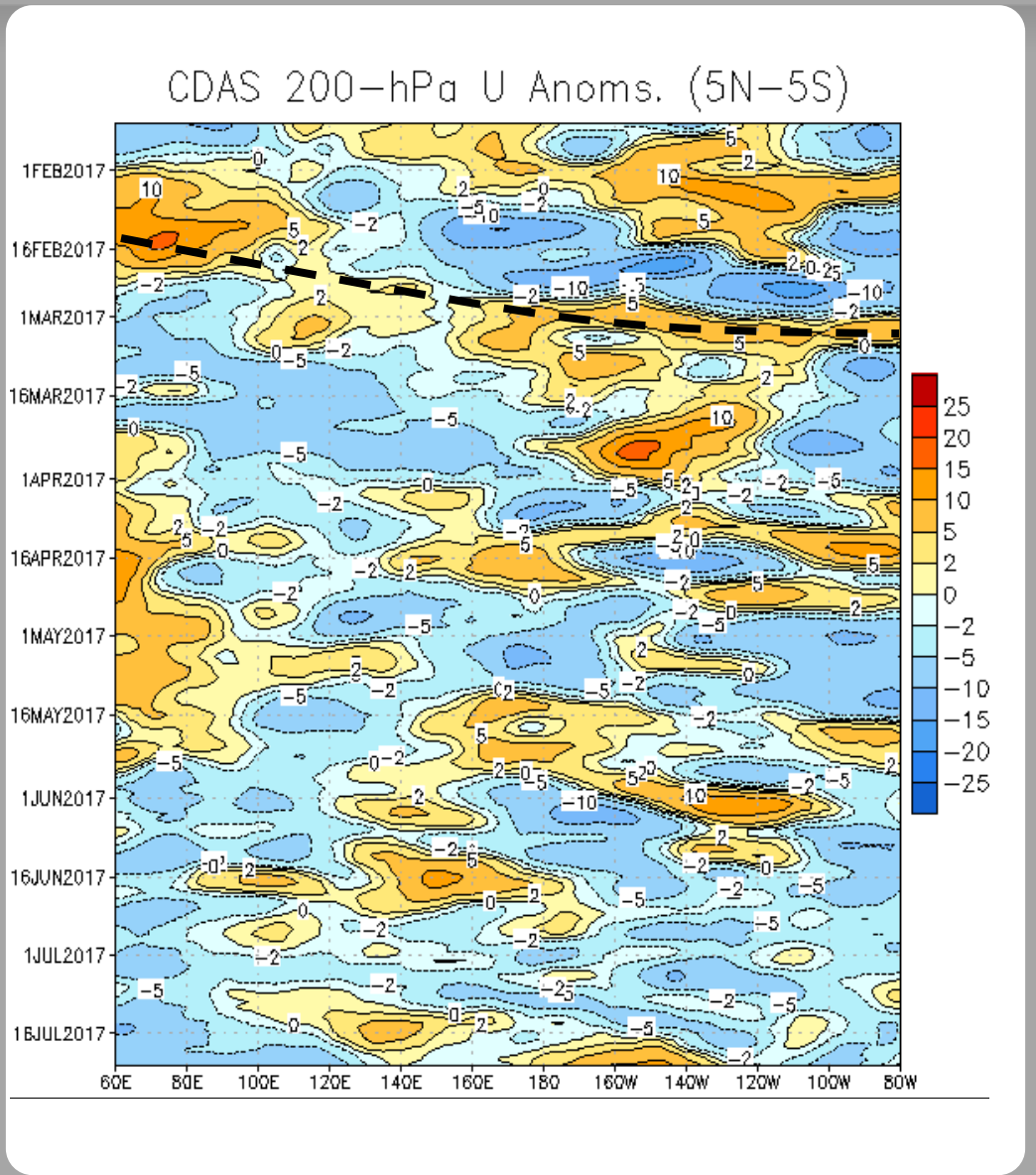
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

Easterly anomalies returned to the East Pacific during late April and persisted with some period of high-frequency interference.

During early to mid-June, easterly anomalies were most prominent across the global tropics, in part due to mid-latitude influences.

Recently, westerly anomalies were observed over the West Pacific, consistent with the organized enhanced convection ongoing west and northwest of that region. Anomalies near 140W appear to be linked to mid-latitude influences.

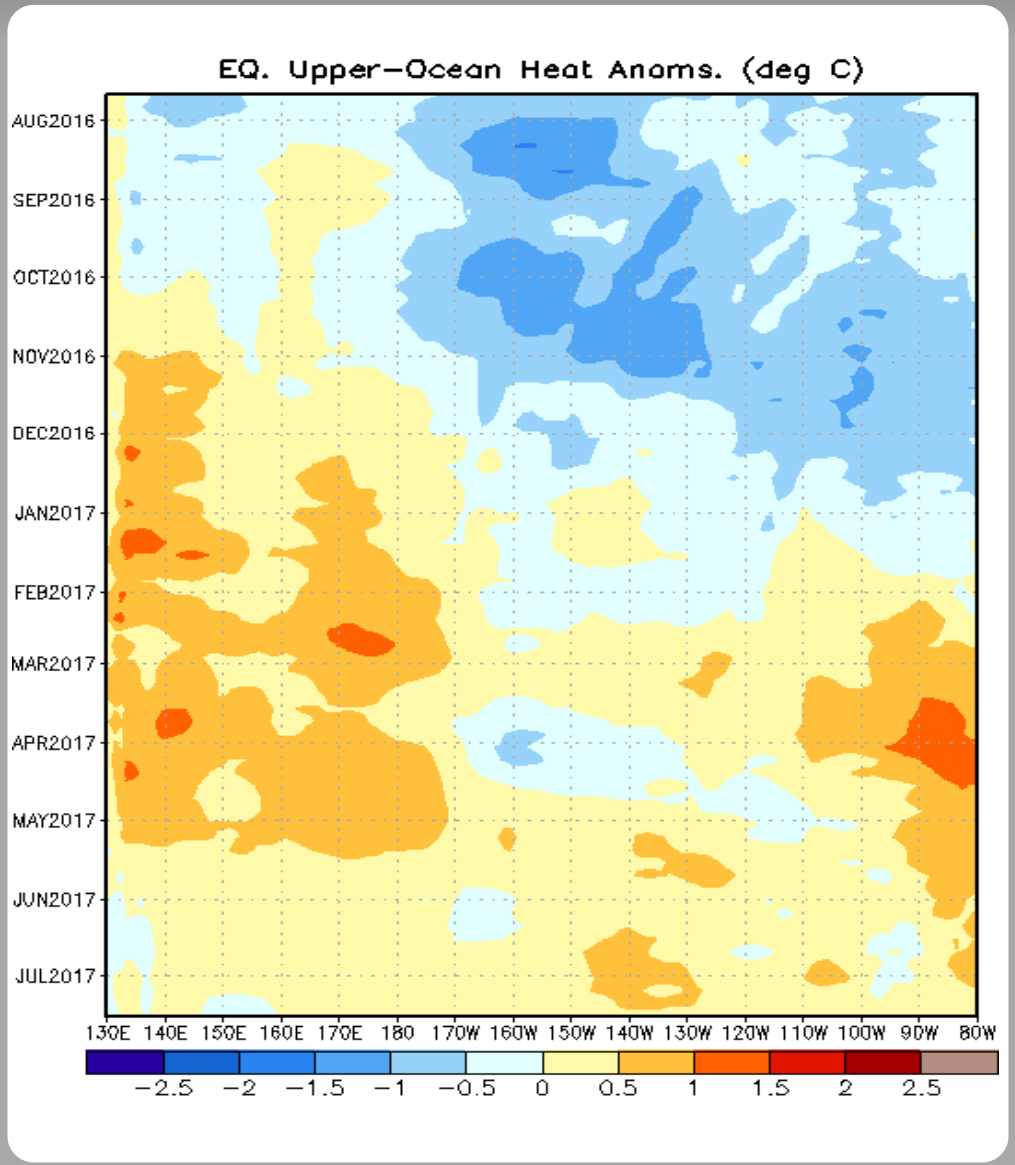


Weekly Heat Content Evolution in the Equatorial Pacific

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.

An eastward expansion of below average heat content over the western Pacific is evident through June 2016, with negative upper-ocean heat content anomalies persisting through the end of 2016.

During the current year, positive anomalies have developed and generally persist over the entire basin. The anomalies are generally weak. A small pocket of warmer than normal heat content developed between 150-140W. Much of this heat was in the uppermost 100 meters, with anomalously cool water below this, and more recent observations indicate a moderation in this area.



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

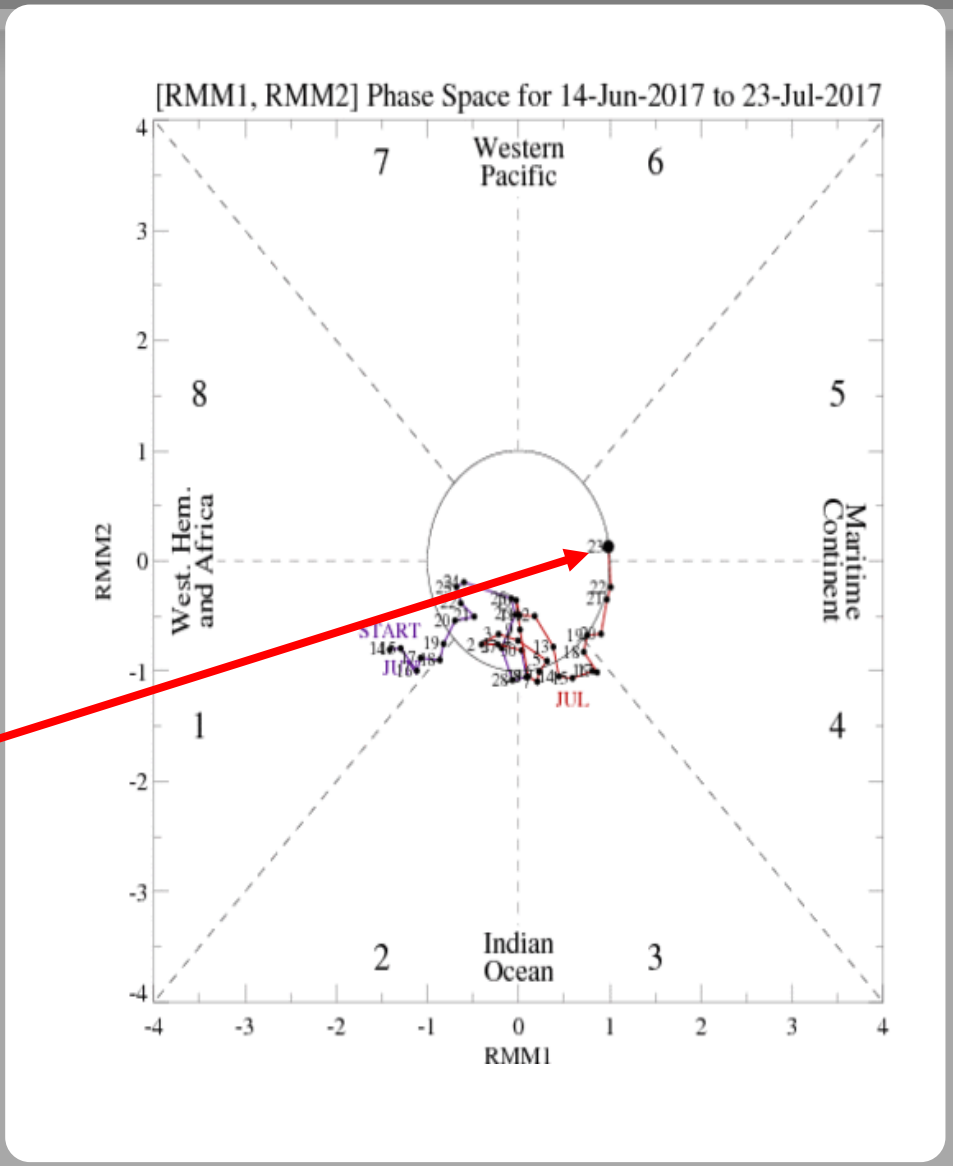
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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

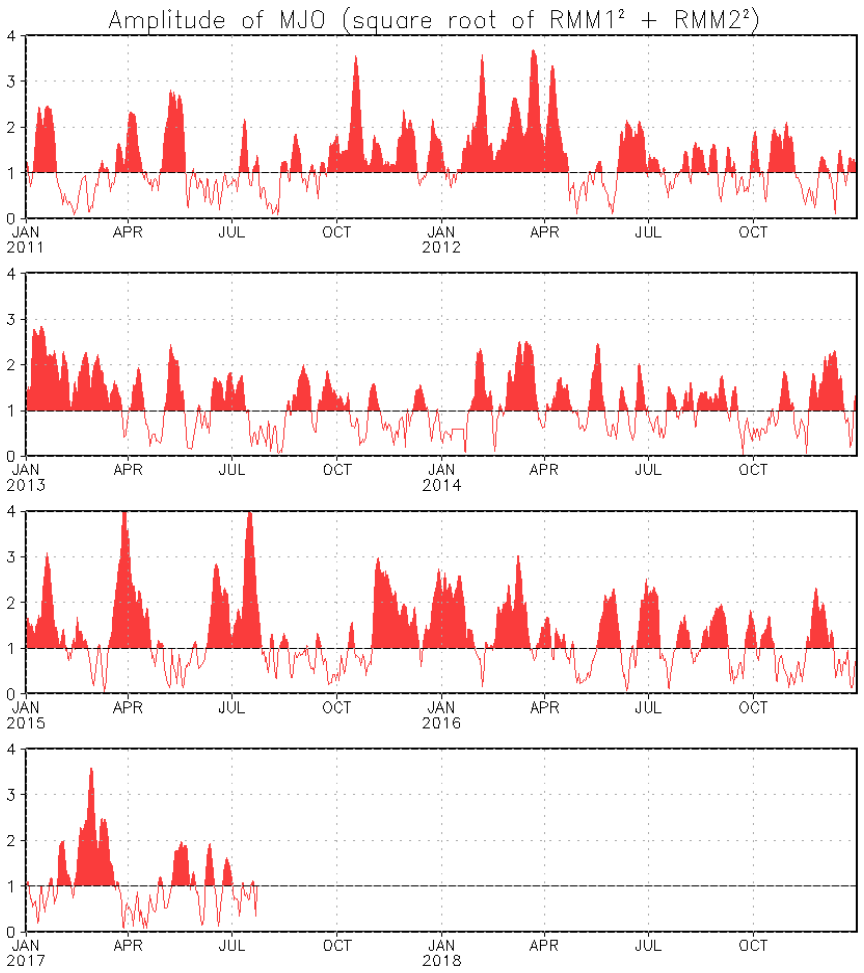


During the past week, the RMM index showed eastward propagation across the Maritime Continent with little change in amplitude.

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.



GFS Ensemble (GEFS) MJO Forecast

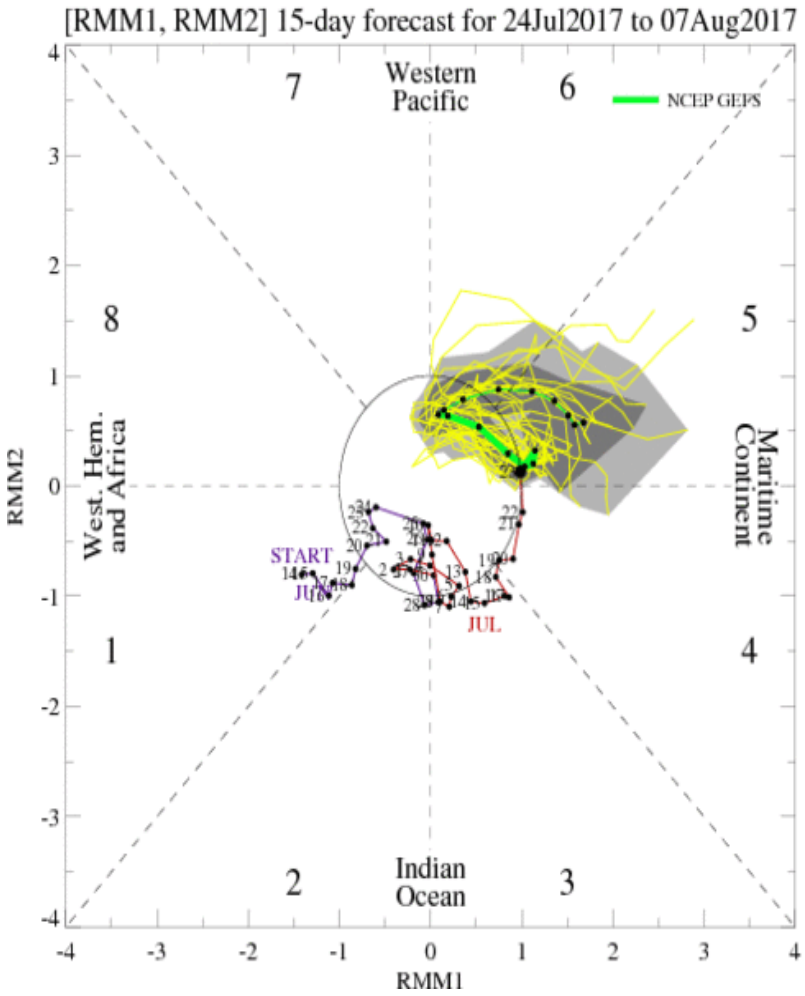
Yellow Lines – 20 Individual Members
Green Line – Ensemble Mean

RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

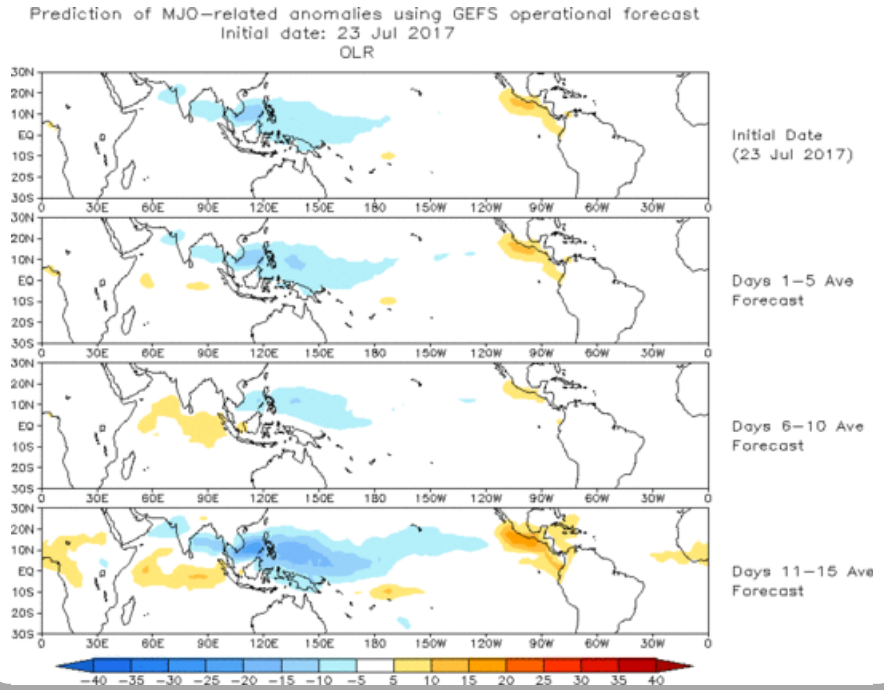
The GEFS forecast indicates an eastward propagation during Week-1, with a retrograding signal during Week-2.



Ensemble GFS (GEFS) MJO Forecast

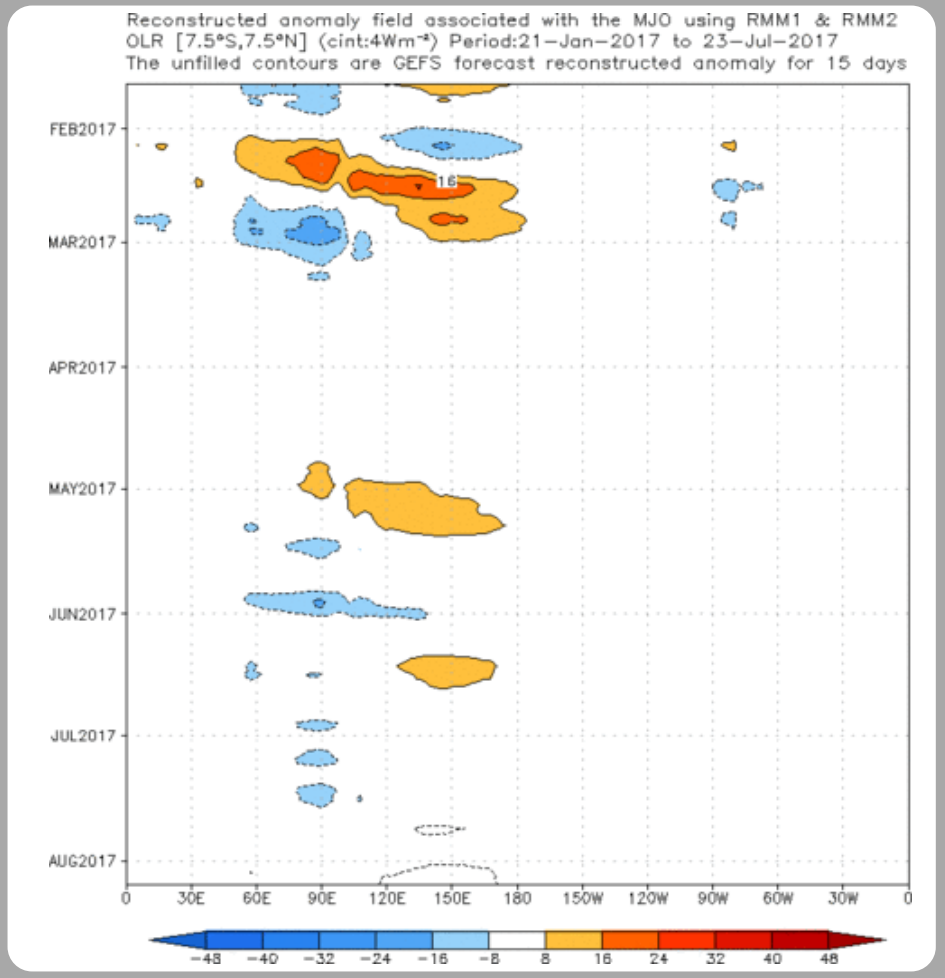
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS RMM-based OLR anomaly indicates an eastward propagation early, then an amplifying stationary pattern.

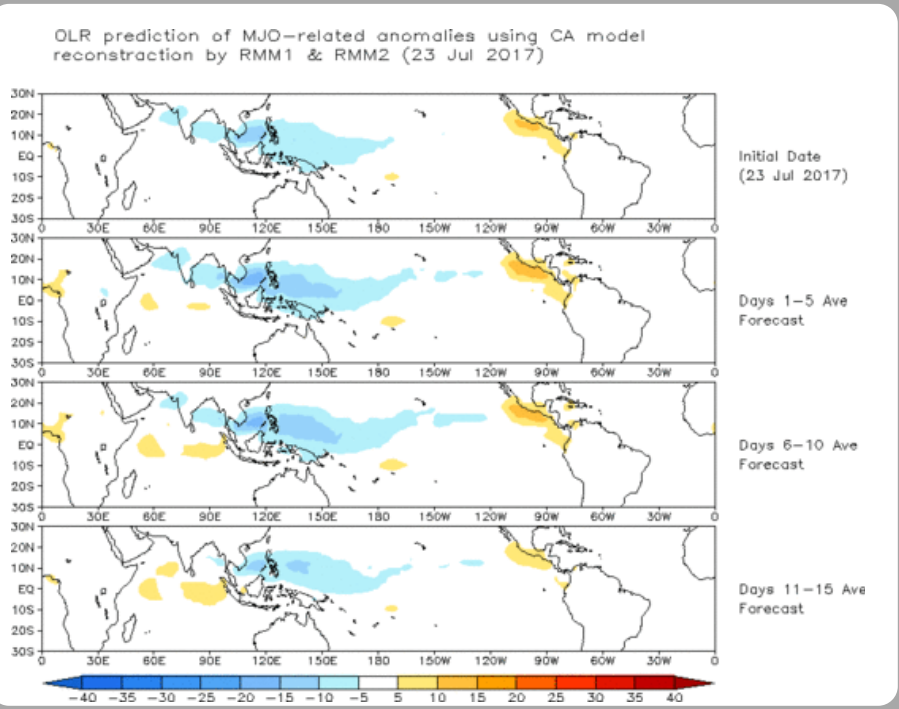
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

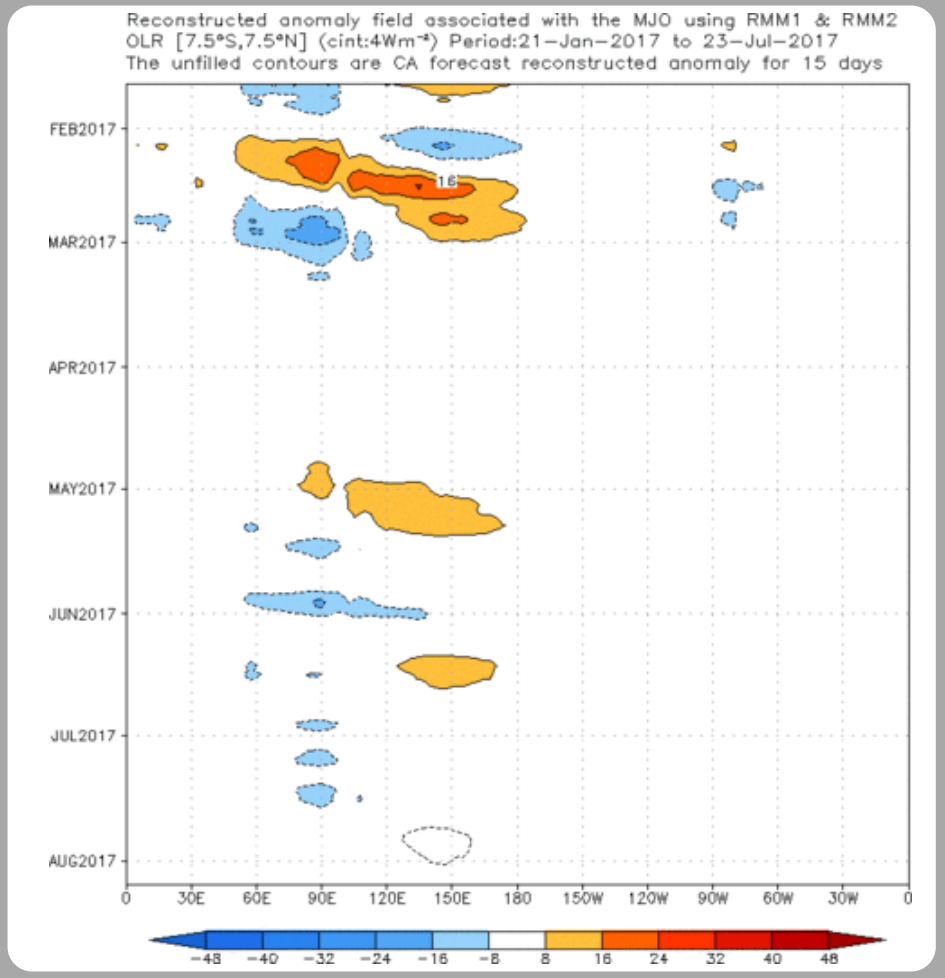
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



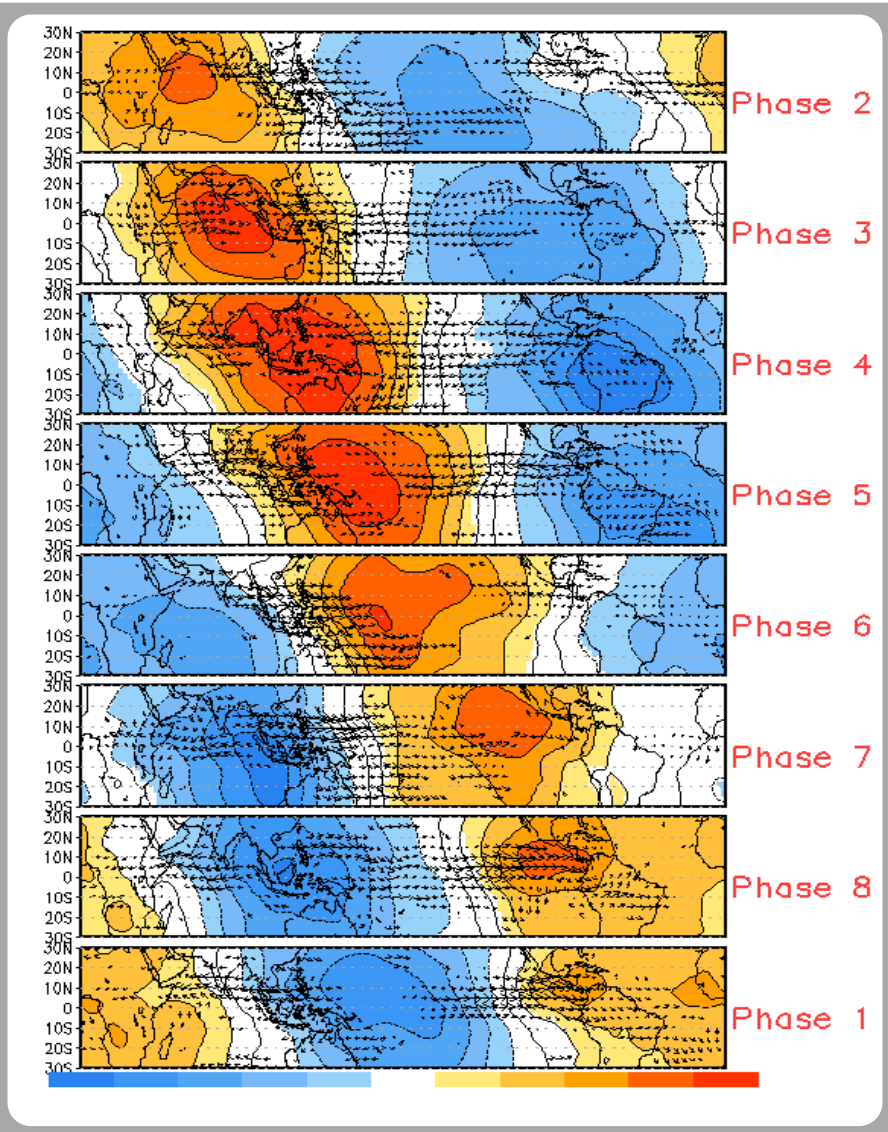
The constructed analog RMM-based OLR anomaly is fairly similar to the GEFS today, but with a slightly lower amplitude in Week-2.

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

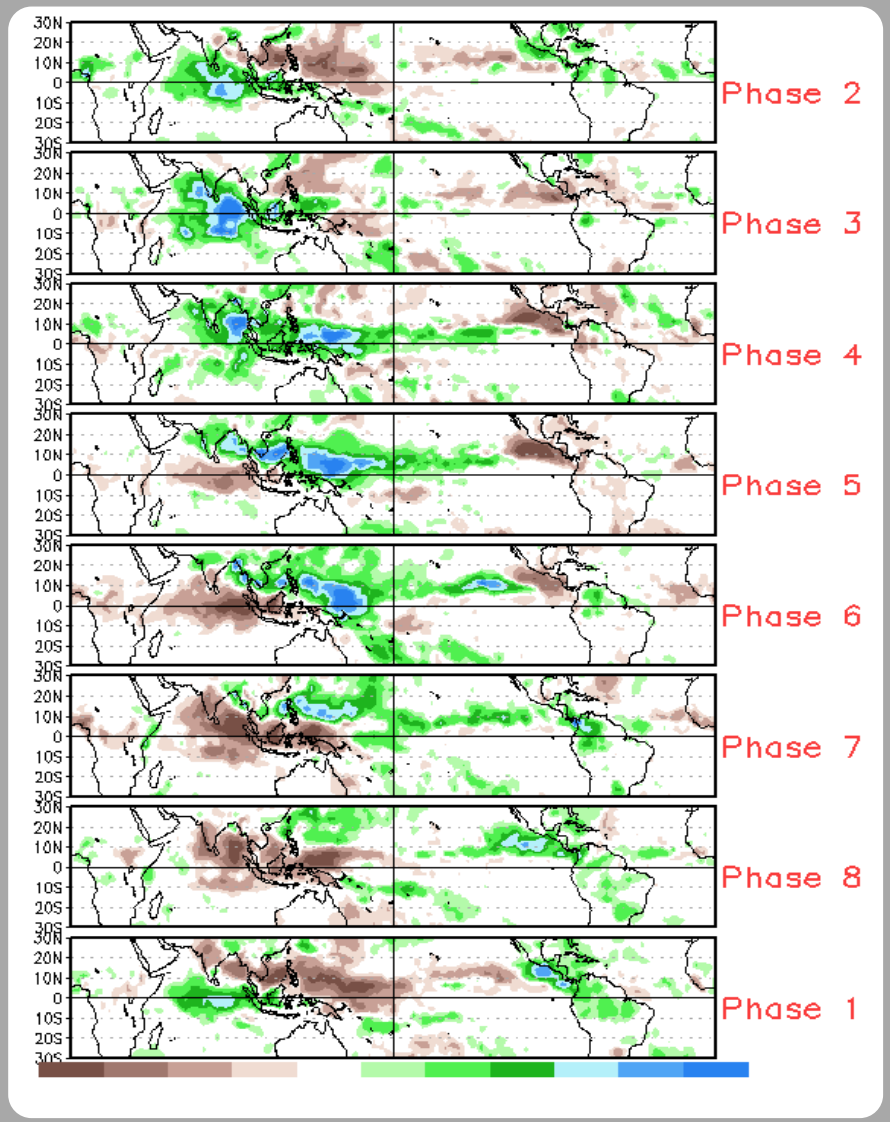


MJO Composites – Global Tropics

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



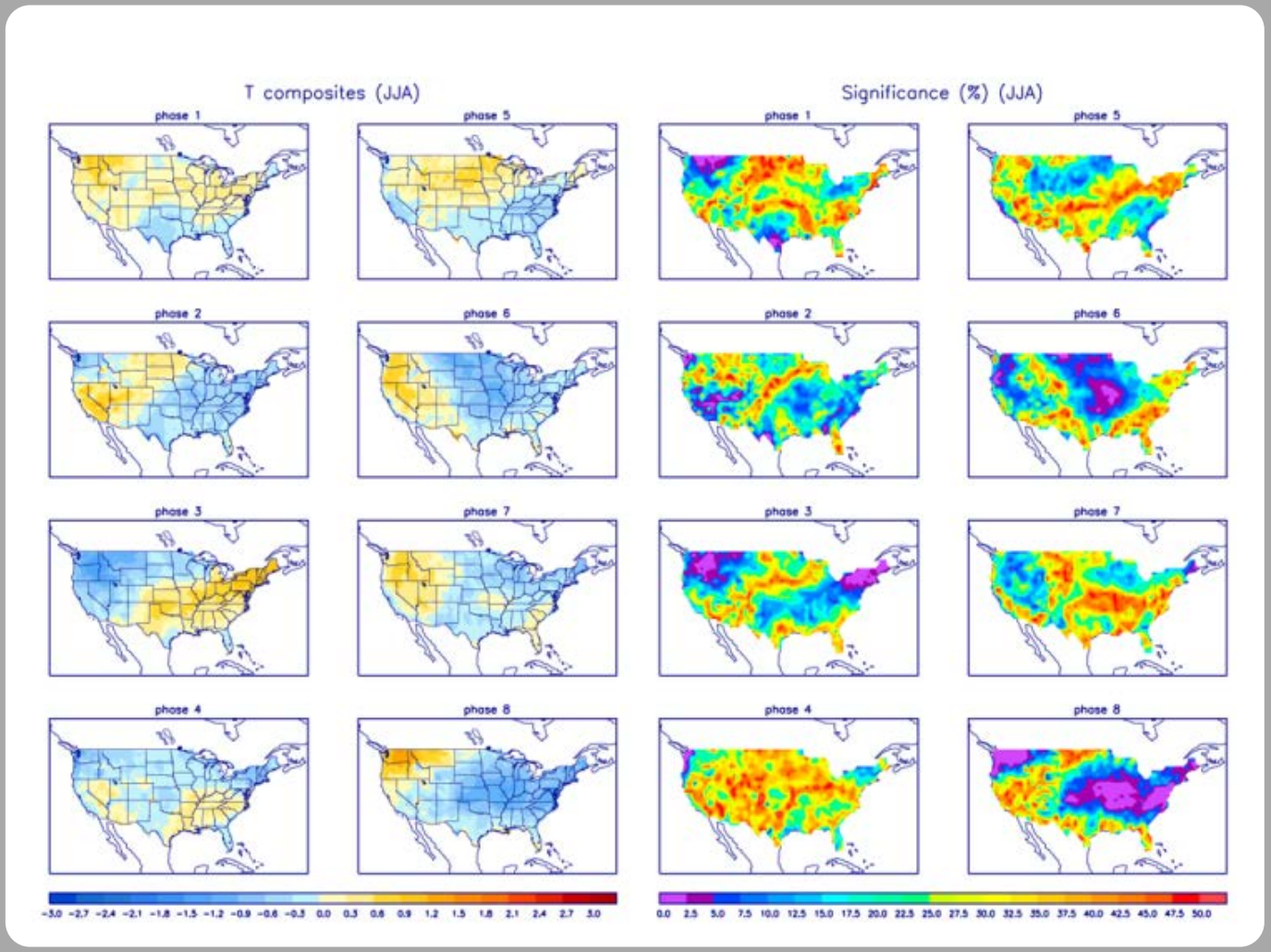
Precipitation Anomalies (May - Sep)



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.



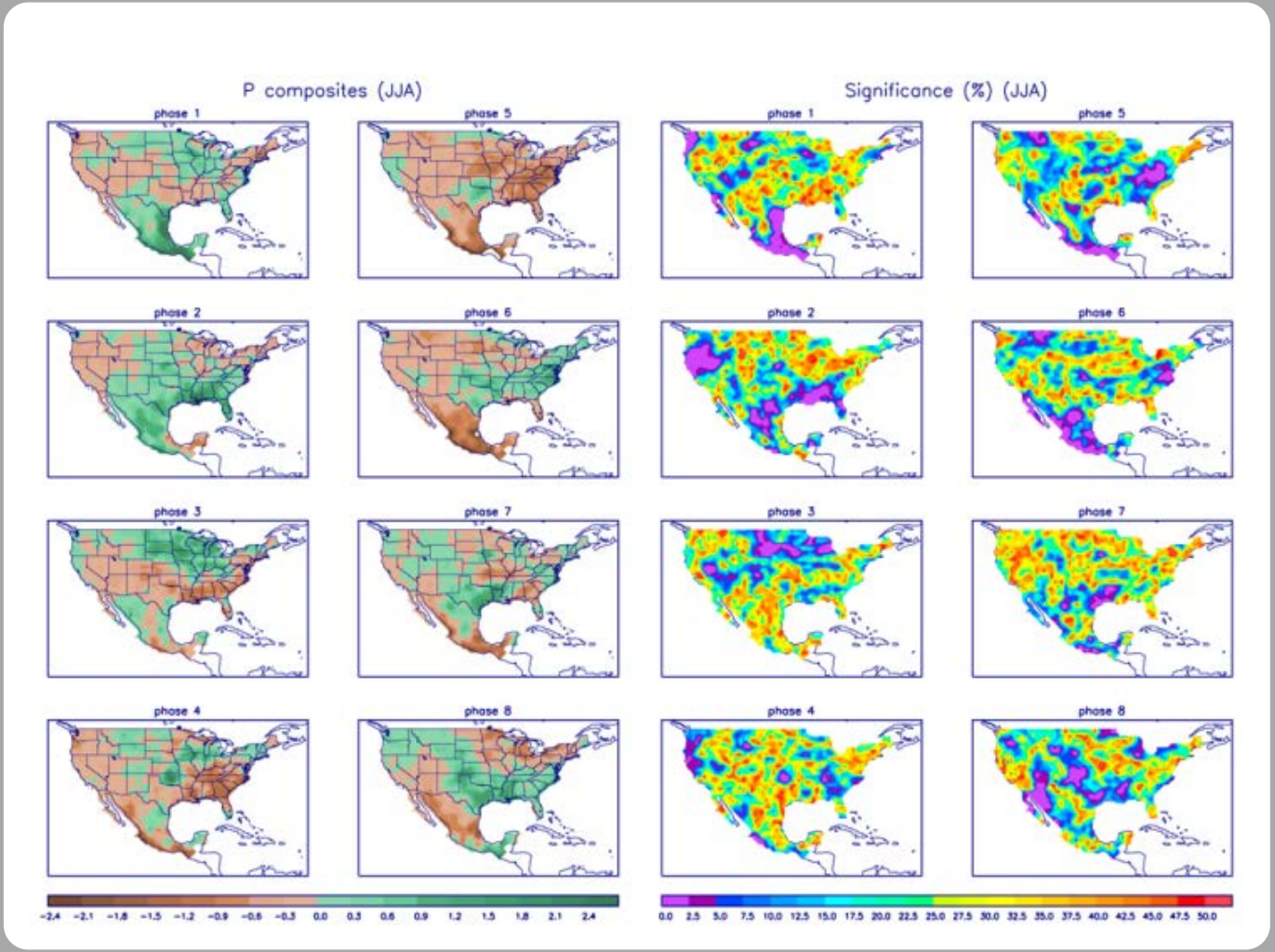
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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