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

Update prepared by:
Climate Prediction Center / NCEP
31 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/western Pacific.
- Most dynamical models predict any subseasonal signals will be largely affected by westward modes of variability through Week-1, with a few models suggesting possible development of a weak subseasonal signal in Week-2 over the Indian Ocean.
- Although the MJO is expected to propagate somewhat to the east during the next two weeks, most of the associated enhanced convection (due in part to a low-frequency signal) is anticipated to remain over the Maritime Continent and western Pacific.
- The forecast MJO evolution would support tropical cyclone (TC) activity over the Pacific basin (Week-1) and possibly the Atlantic basin (Week-2).

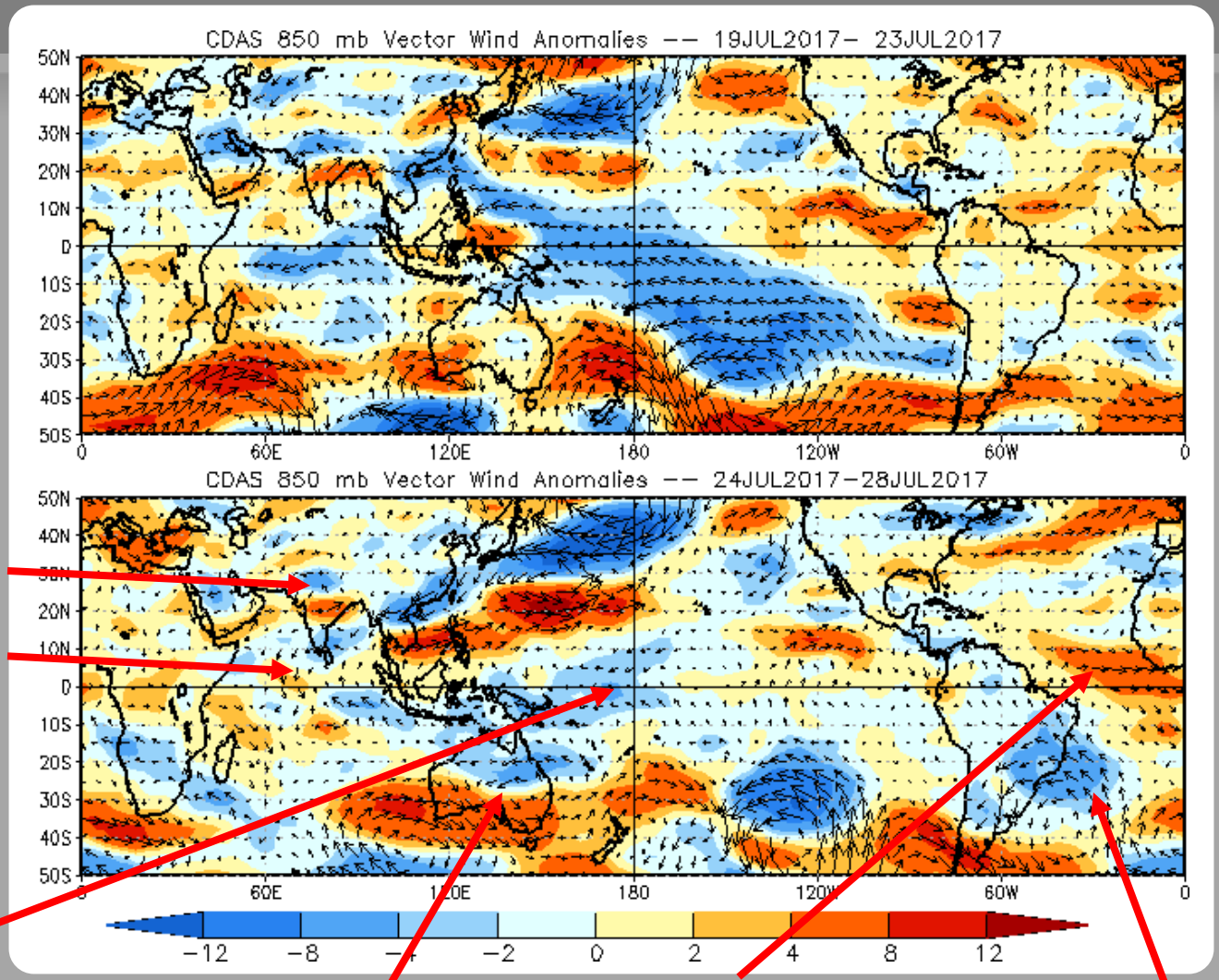
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



An anomalous cyclone over Northwest India weakened during the past week. Another anomalous cyclone is depicted just south of the first cyclone.

Easterly anomalies decreased across the western and central Pacific. A zonal pattern of low-level wind anomalies developed over Australia, with easterlies across the north and westerlies across the south.

Westerly anomalies increased over the eastern Atlantic, and southeasterly anomalies strengthened across southern Brazil.

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

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

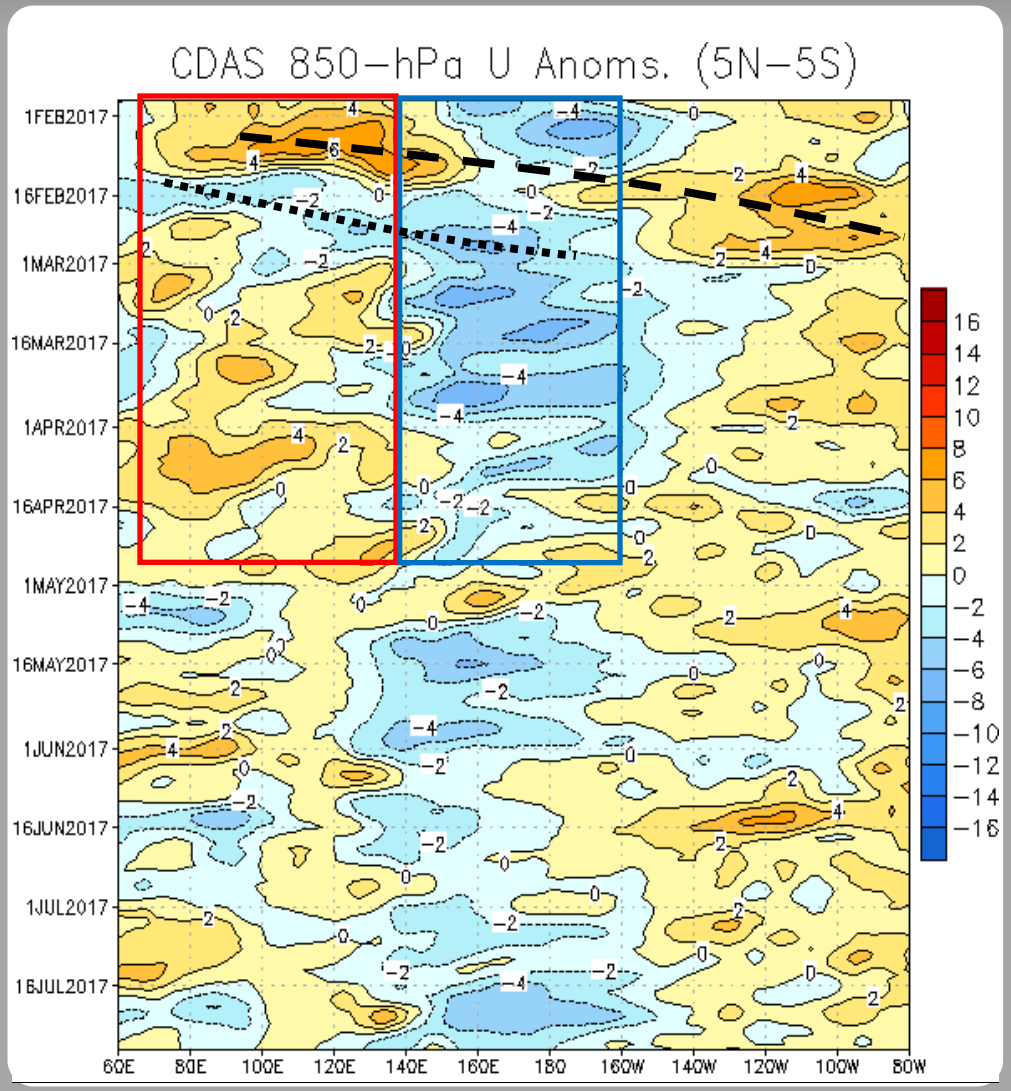
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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 shifted eastward, and easterly anomalies strengthened over the western and central Pacific. The lower-level wind pattern is still exhibiting a wave-2 structure.



OLR Anomalies – Past 30 days

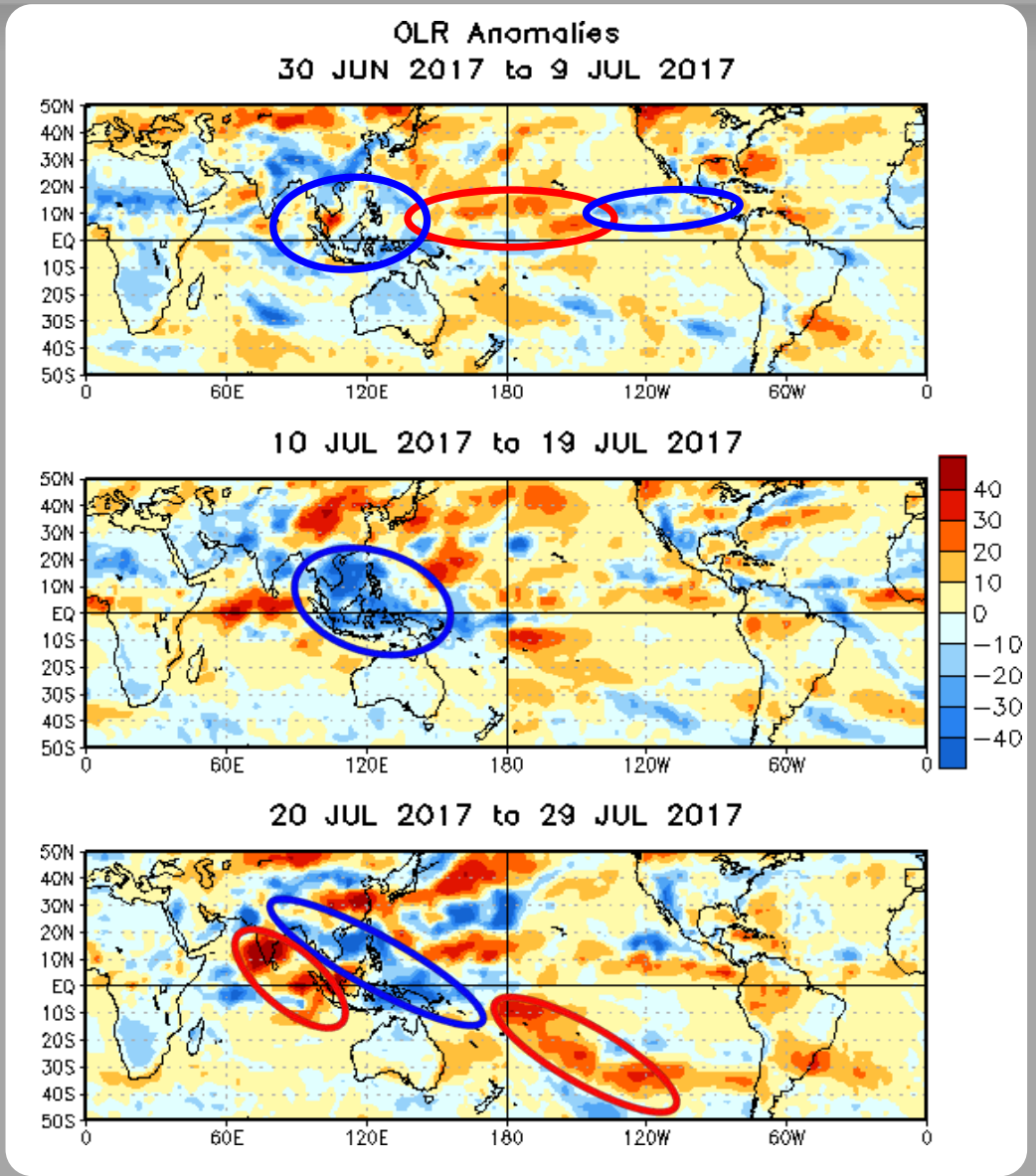
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

In late June and early July, enhanced convection was observed over parts of Southeast Asia, with suppression over the central Pacific (mostly off the equator). Thin areas of enhanced convection are evident over the East Pacific, related to tropical cyclone activity.

By early to mid-July, the enhanced convective pattern became more organized over Southeast Asia and the Maritime Continent (MC).

In late July, enhanced convection continued over Southeast Asia and the MC, with suppressed convection stretching from India to Malaysia, and over central portions of the South Pacific.



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

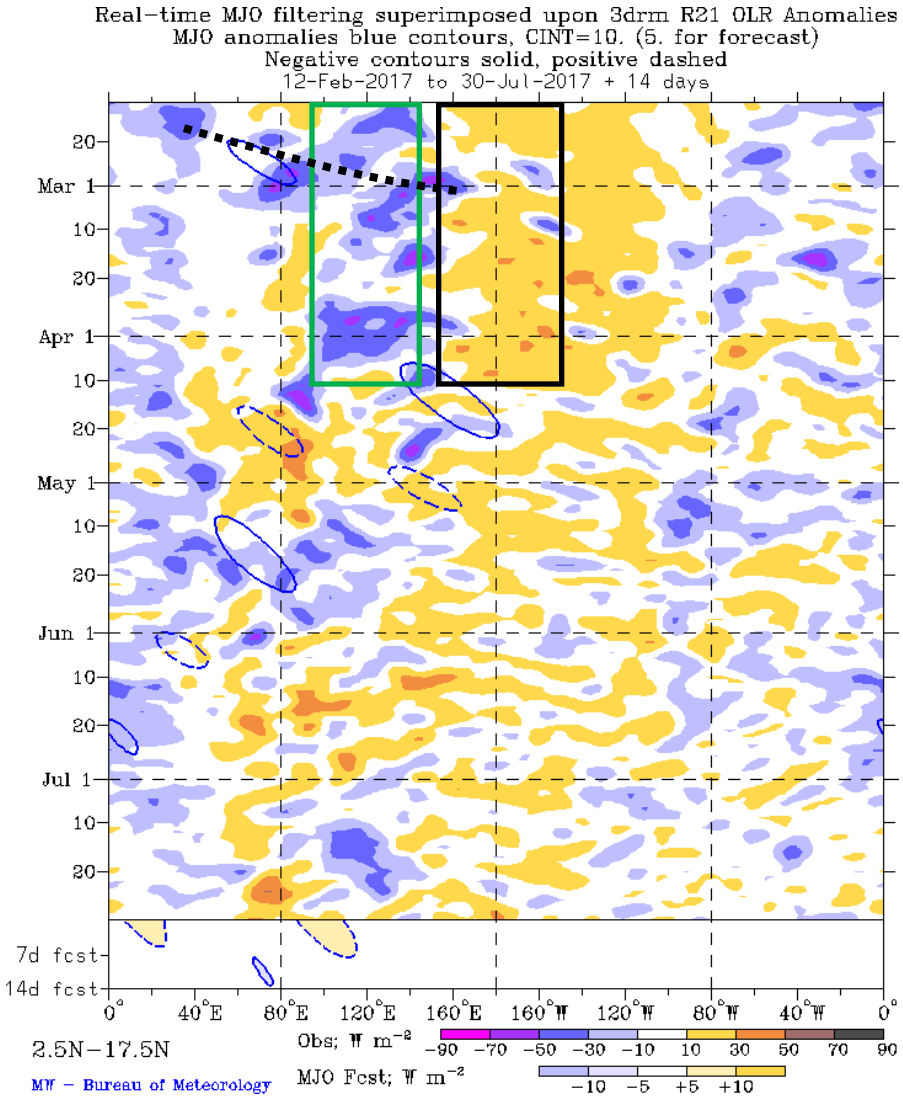
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

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).

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.

Some eastward propagation of enhanced convective anomalies is evident during mid- to late July. Recently the convective pattern became a bit noisier.



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

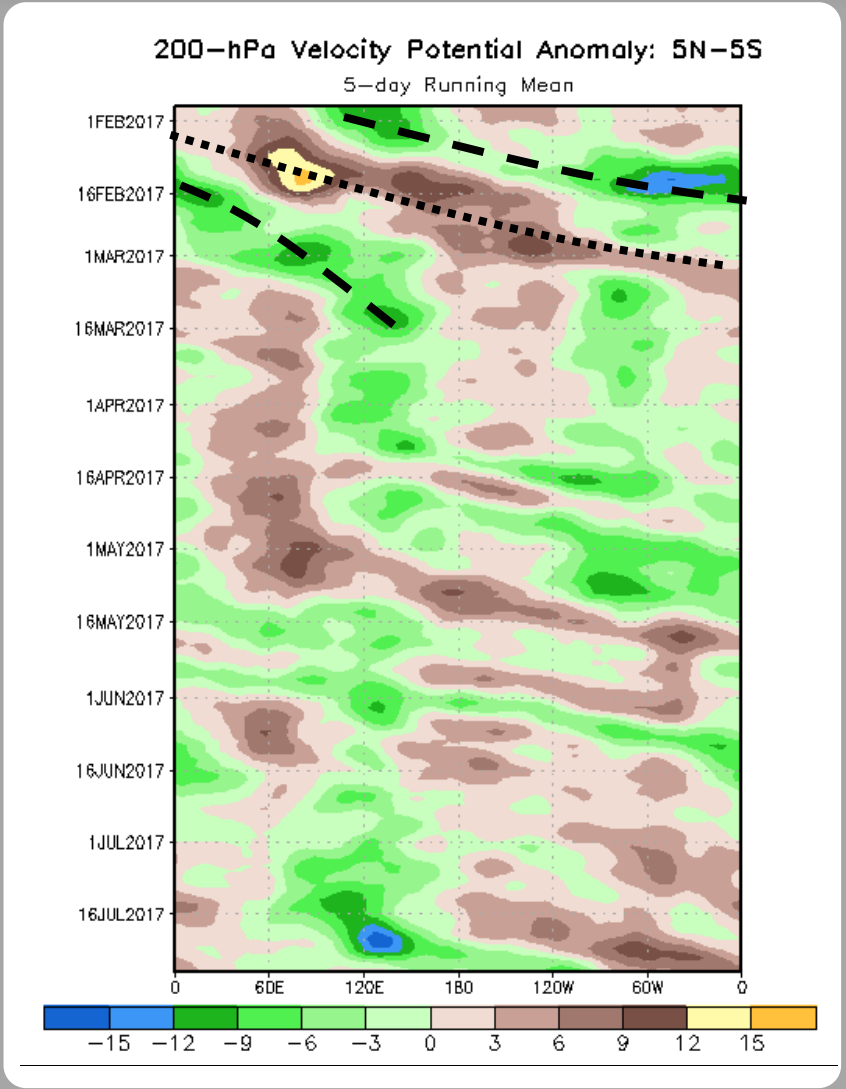
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

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 110E is among the strongest signals observed over that region during the past 4-5 months. A combination of MJO and Kelvin wave activity appears evident over the past couple of weeks.

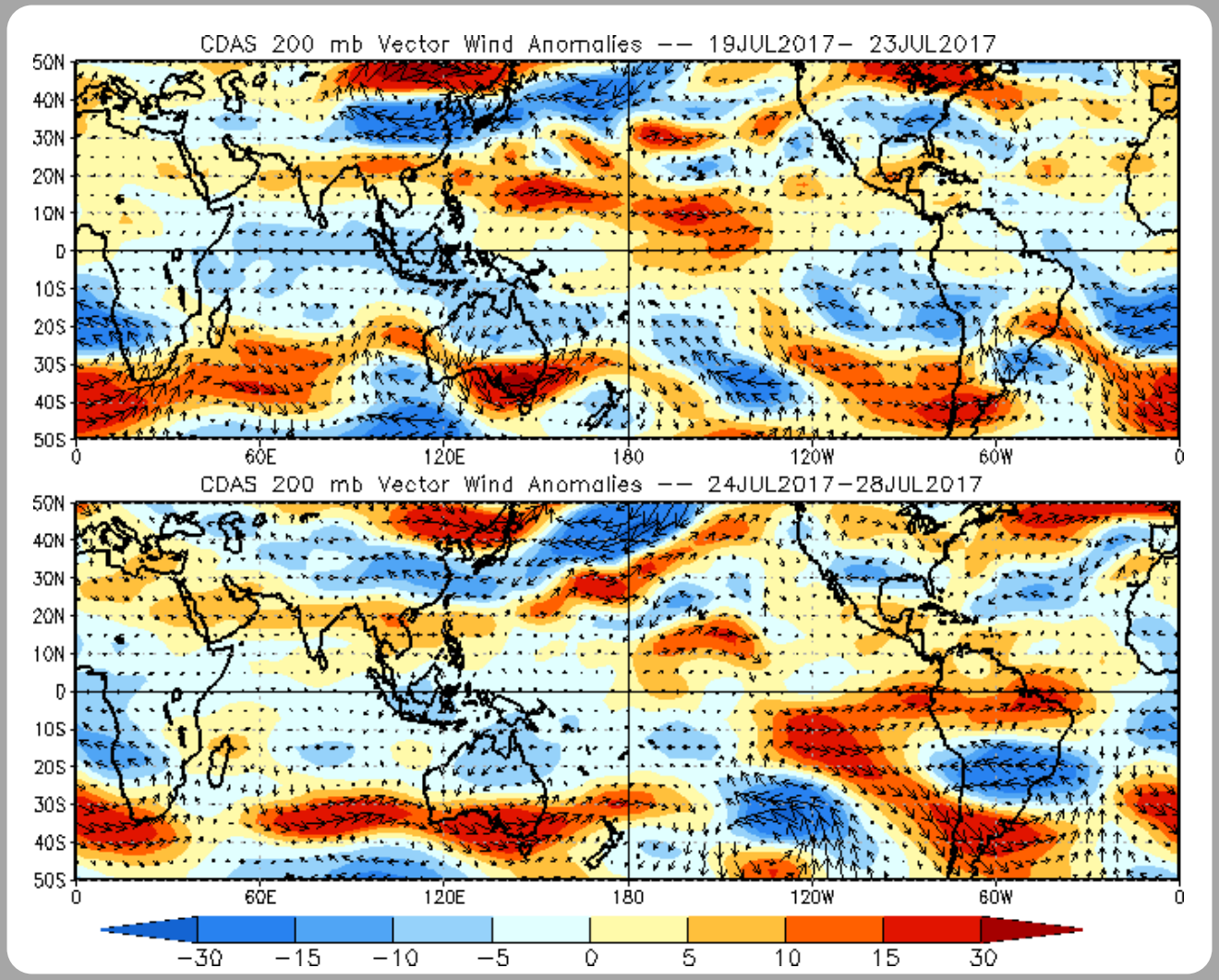


200-hPa Vector Wind Anomalies (m s-1)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Upper-level wind anomalies indicated extratropical-tropical interaction in the Southern Hemisphere over the eastern Pacific and southern South America.

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

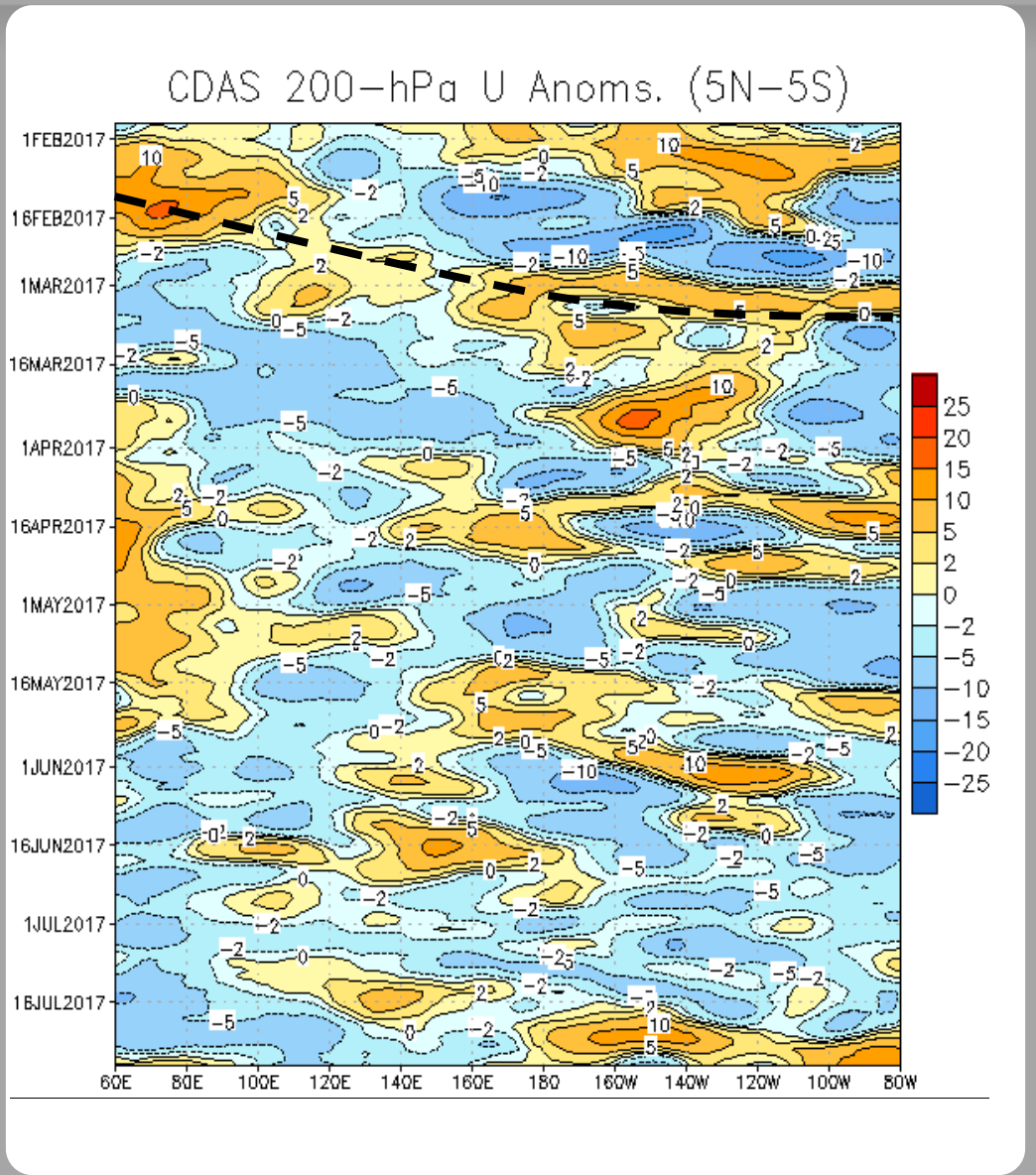
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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.

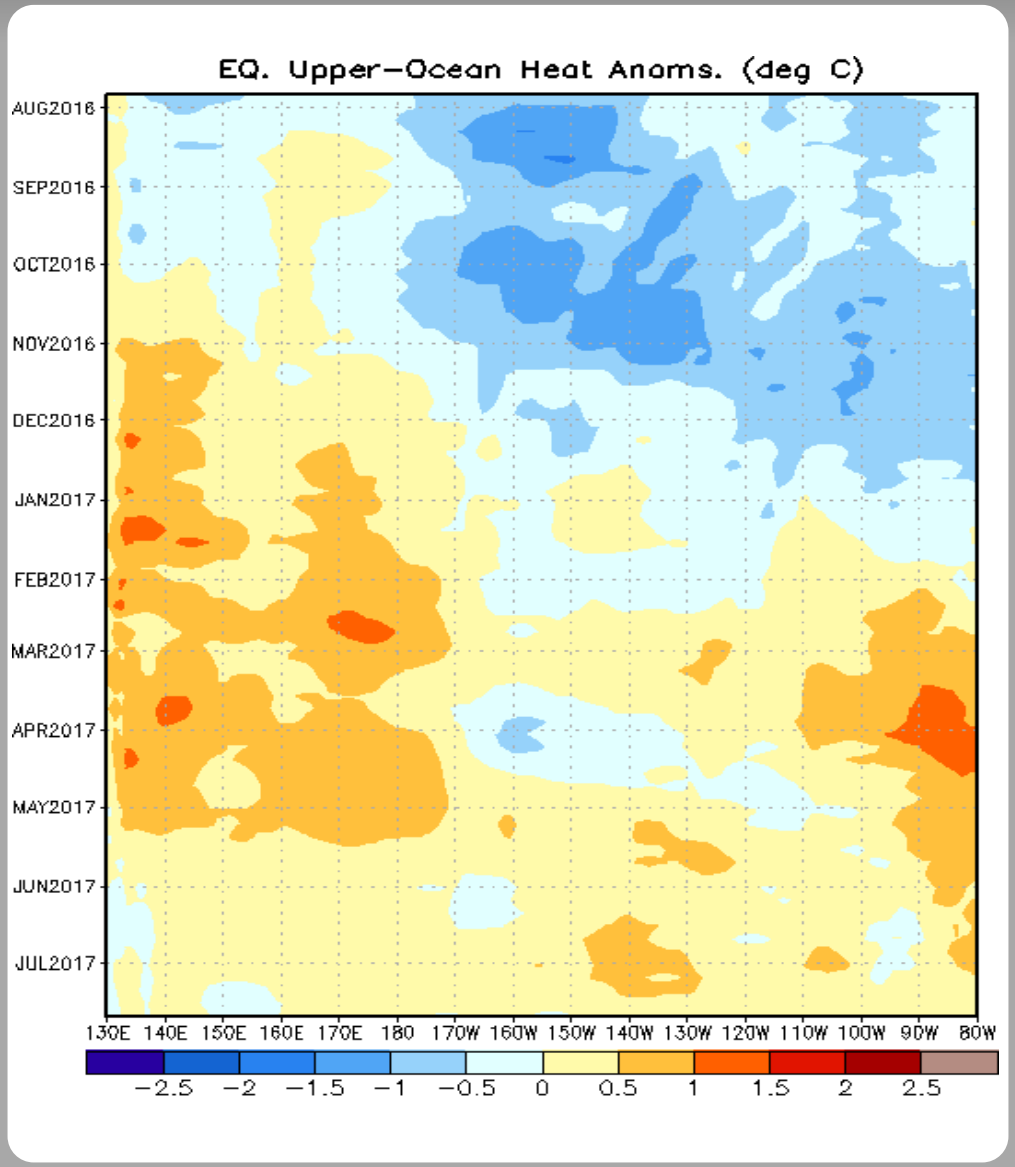
During July, westerly anomalies traversed the Maritime Continent, the Pacific Ocean, Central America, and the Gulf of Mexico. These westerly anomalies were subsequently replaced by easterly anomalies from the Indian Ocean eastward to near the Date Line. Some coherent eastward propagation is evident.



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.

Negative upper-ocean heat content (UOHC) anomalies persisted primarily east of the Date Line from August through the remainder of 2016. Positive UOHC anomalies developed near and west of the Date Line in November and December 2016, and continued through March 2017. Positive UOHC anomalies also developed over the far eastern Pacific (110W-80W) in February 2017, and have persisted into July 2017. Elsewhere, UOHC anomalies have remained within a half degree (C) of normal.



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

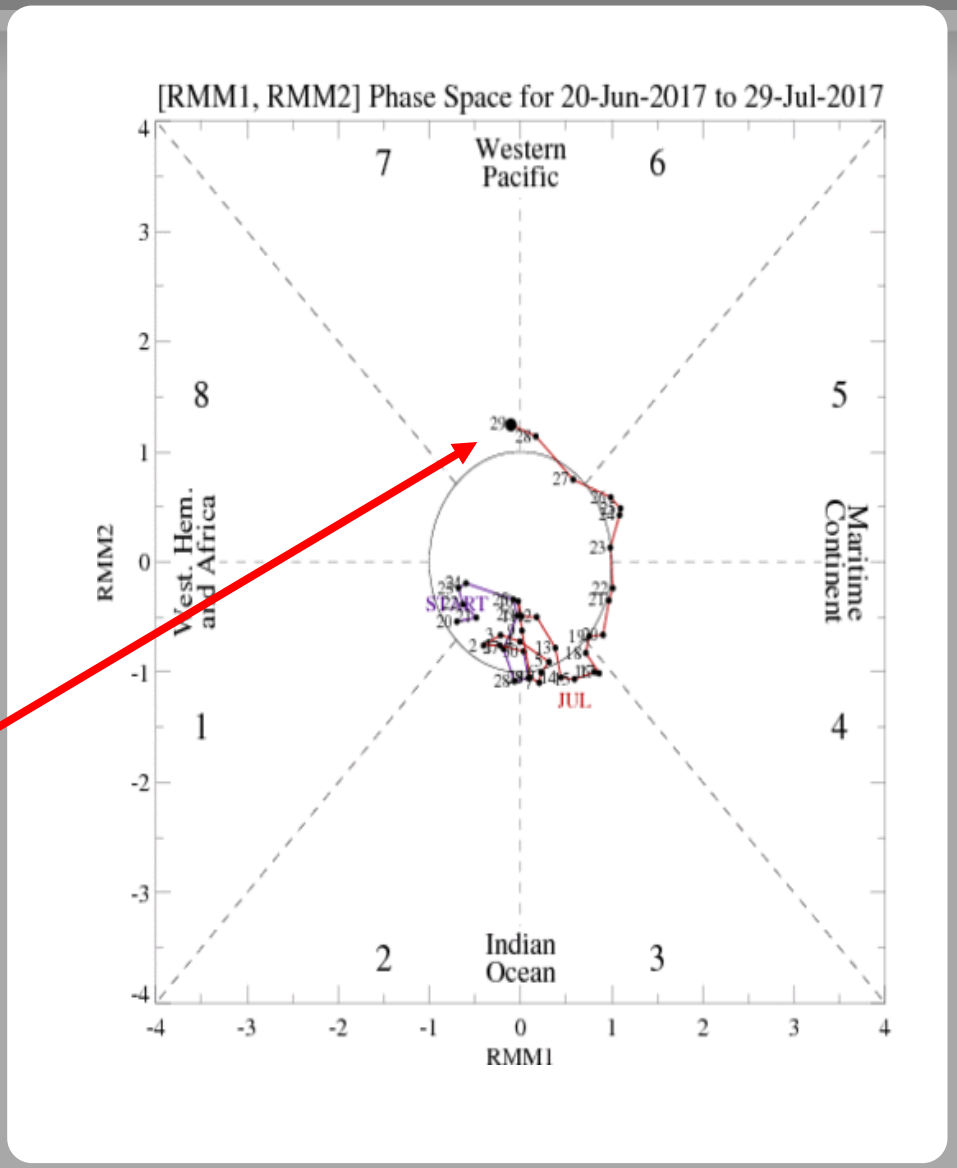
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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

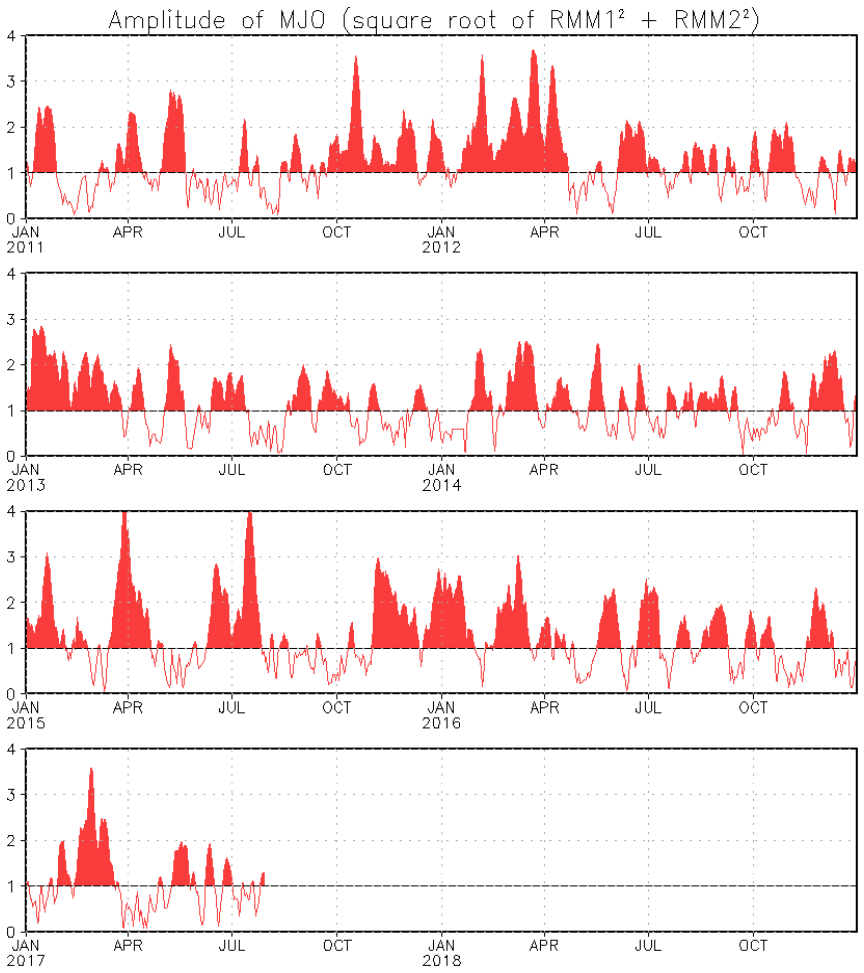


During the past week, the RMM index showed eastward propagation of the center of enhanced convection across the Maritime Continent and into the western North Pacific, with little change in amplitude.

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

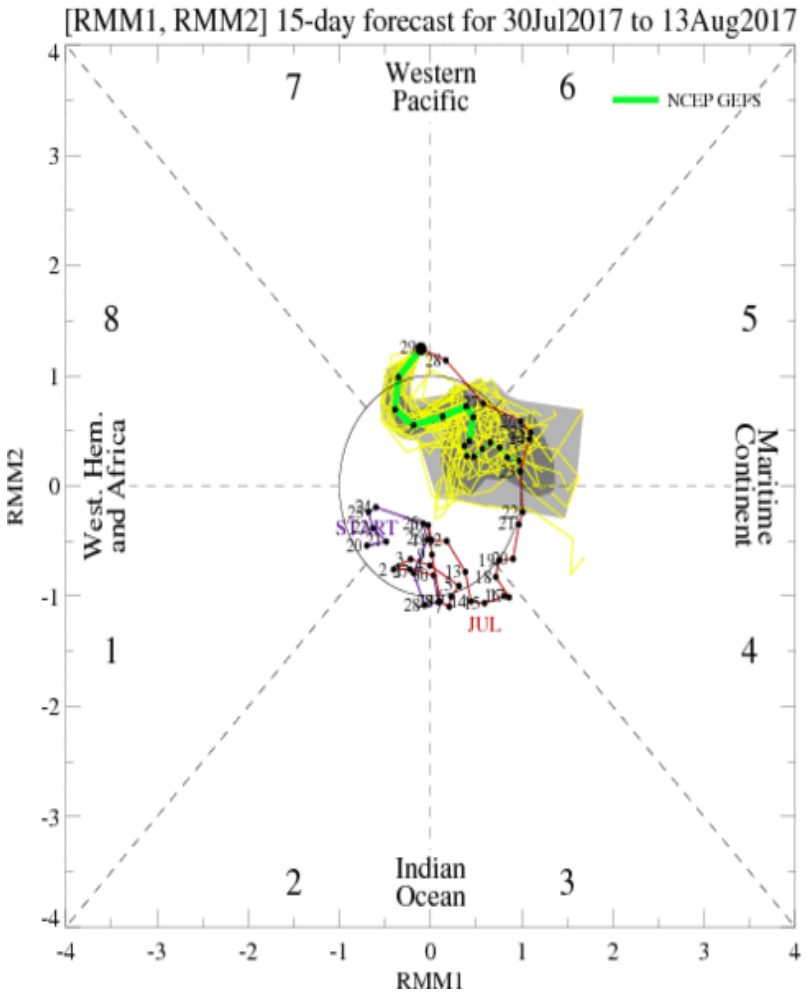
Yellow Lines – 20 Individual Members
Green Line – Ensemble Mean

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

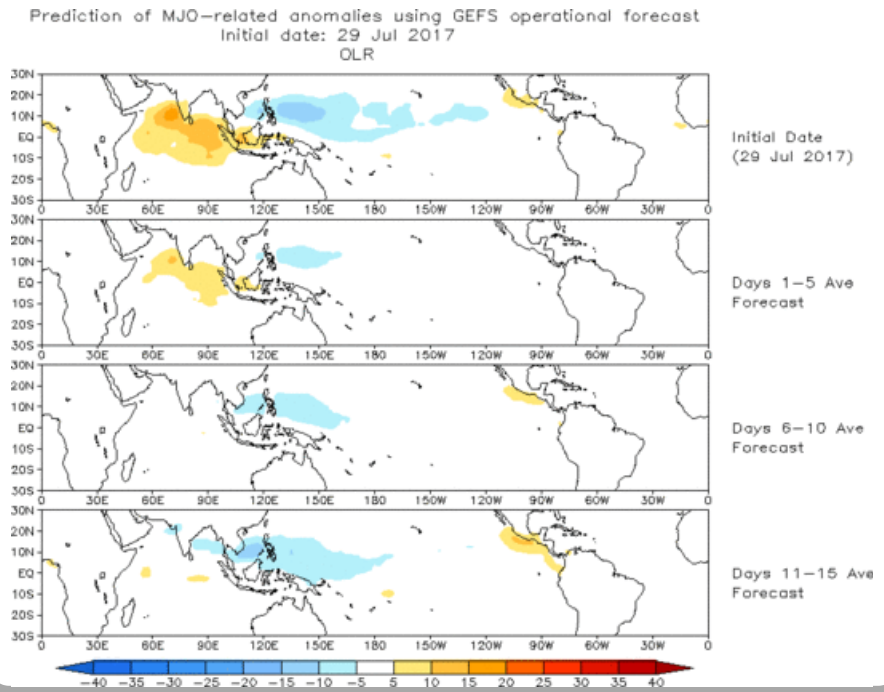
The GEFS forecast indicates a retrograding, weakening signal during the next two weeks, associated with westward moving modes of variability such as Equatorial Rossby Waves (ERWs).



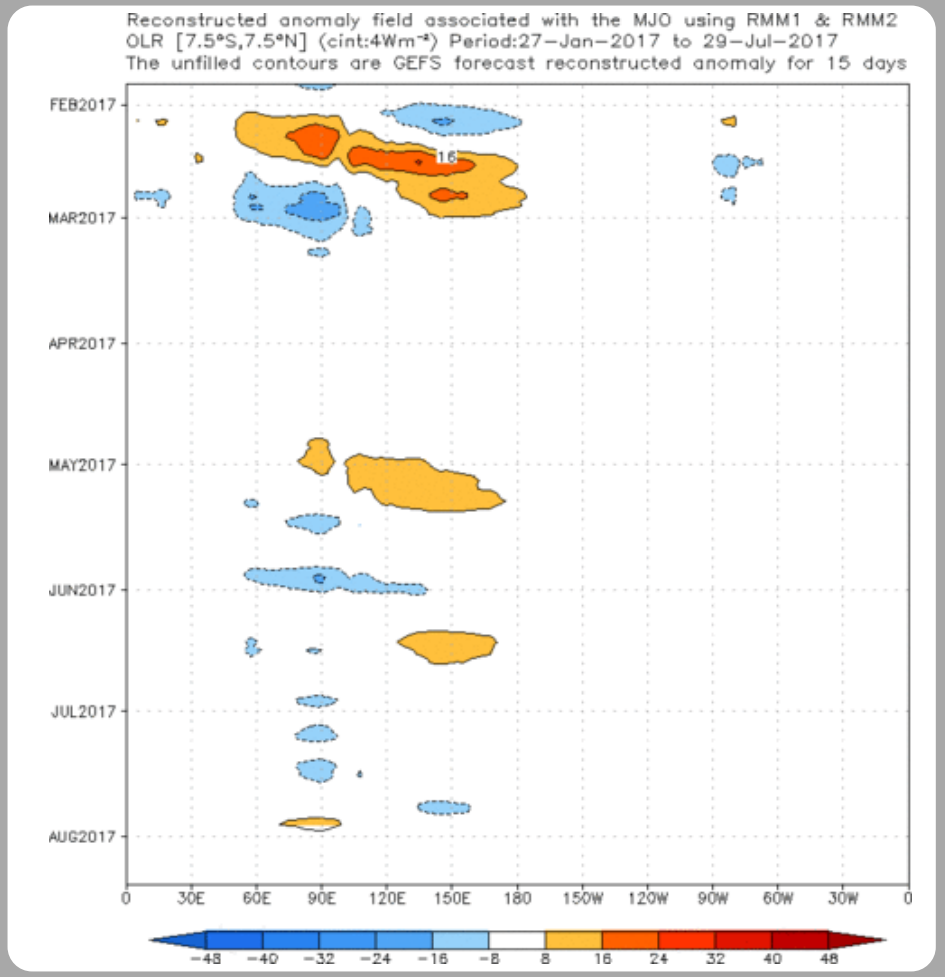
Ensemble GFS (GEFS) MJO Forecast

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



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

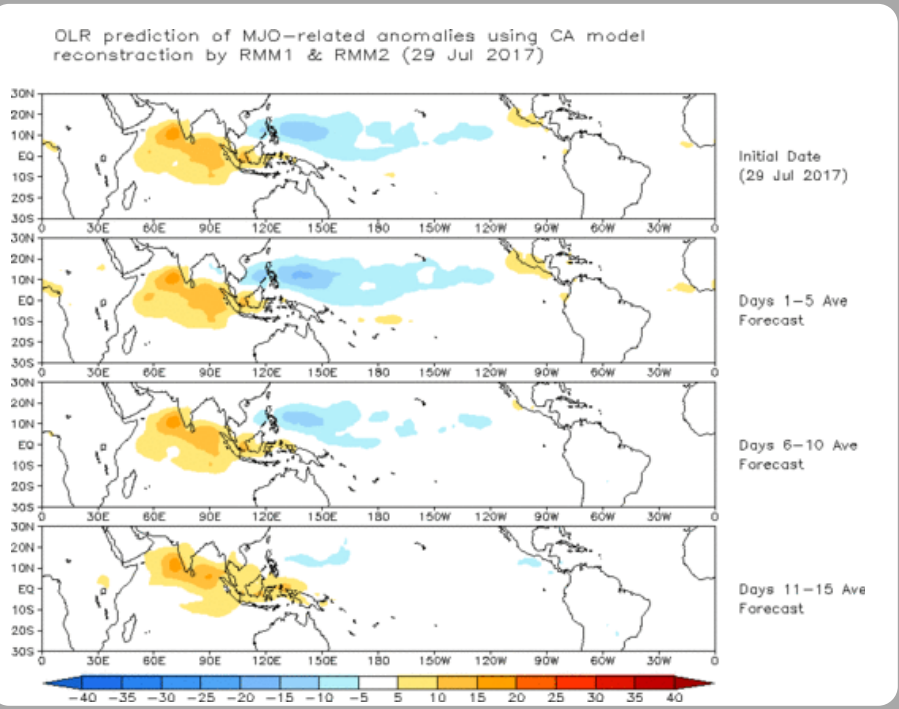


The GEFS RMM-based OLR anomaly indicates a weakening, stationary pattern for the next two weeks, with enhanced convection predicted over the MC/western North Pacific.

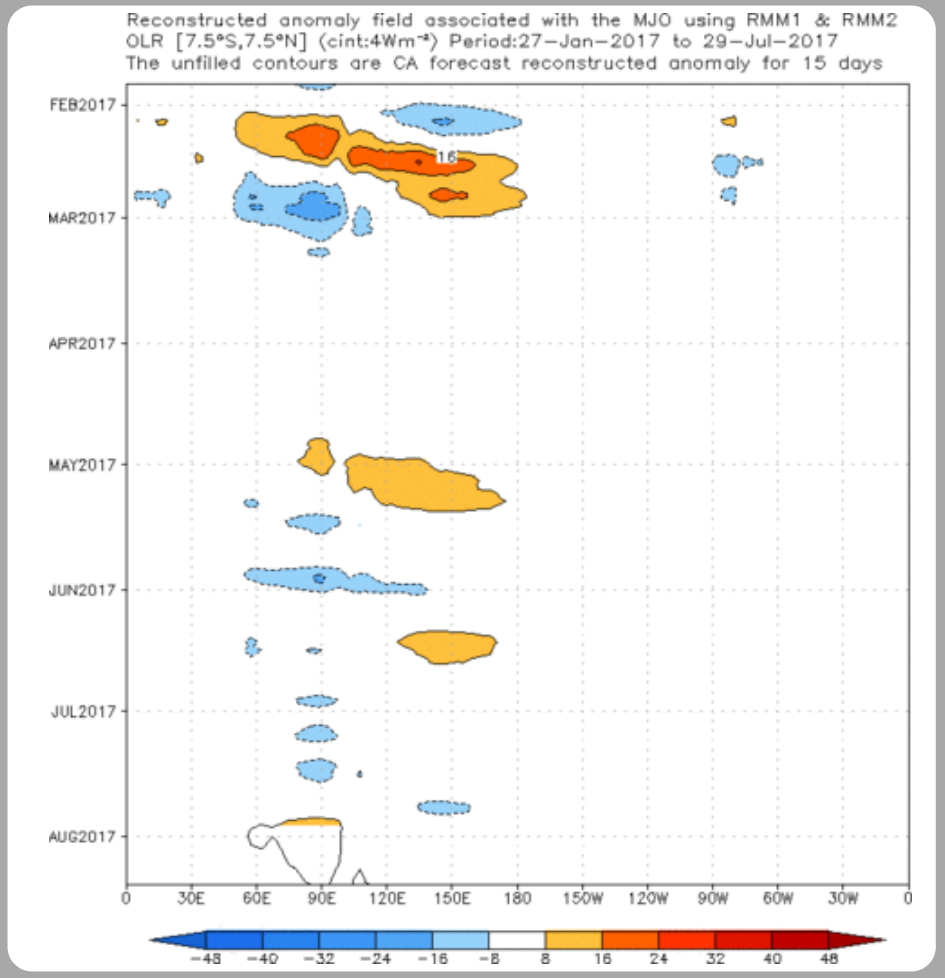
Constructed Analog (CA) MJO Forecast

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



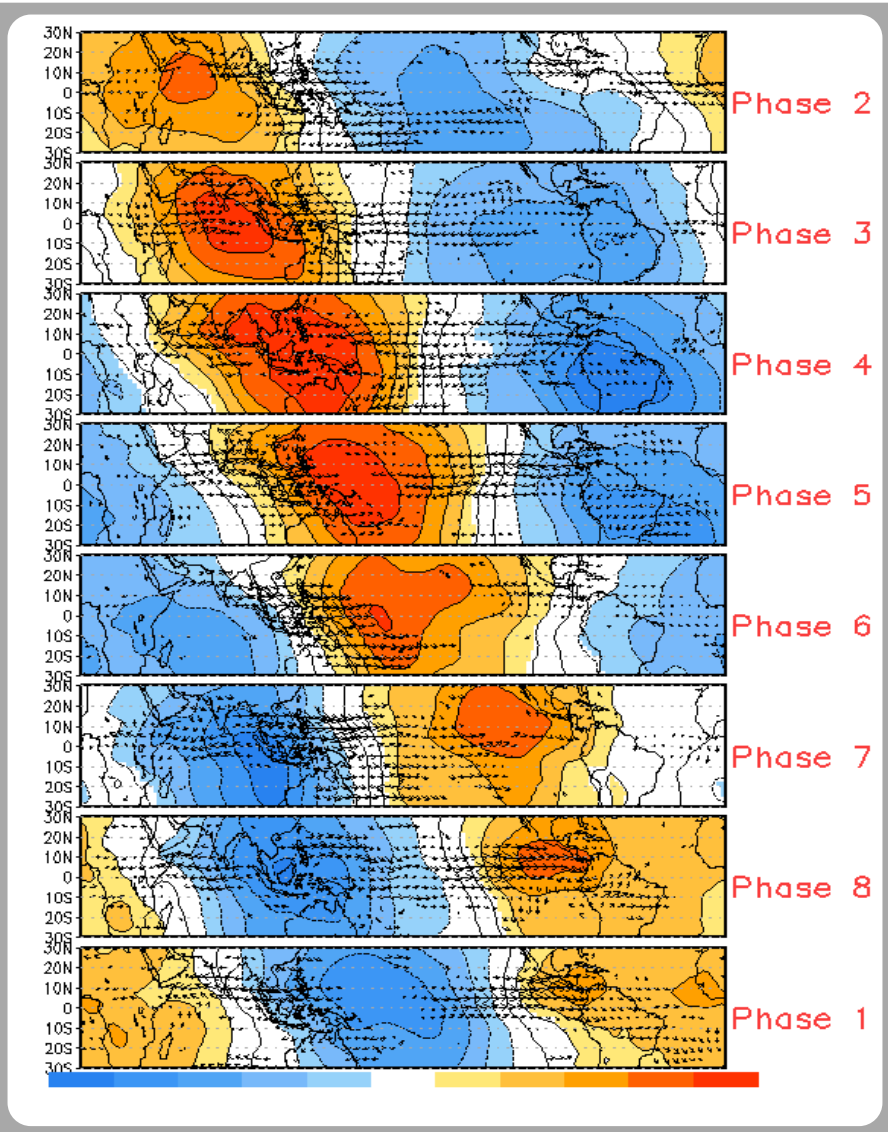
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



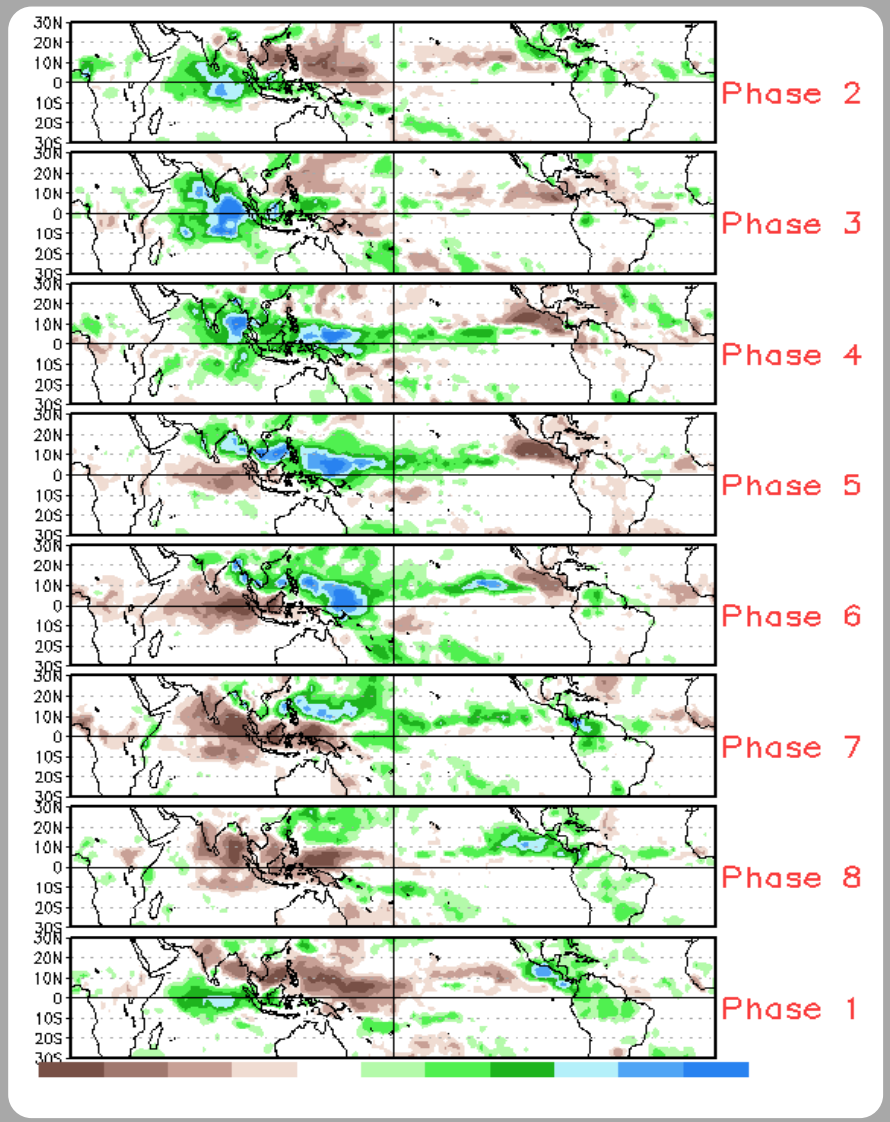
Compared to the GEFS MJO Forecast (previous slide), the constructed analog RMM-based OLR anomaly predicts a more robust, stationary signal during the next ten days, followed by a tapering off of the enhanced convective signal across the MC/far western Pacific later in Week-2.

MJO Composites – Global Tropics

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



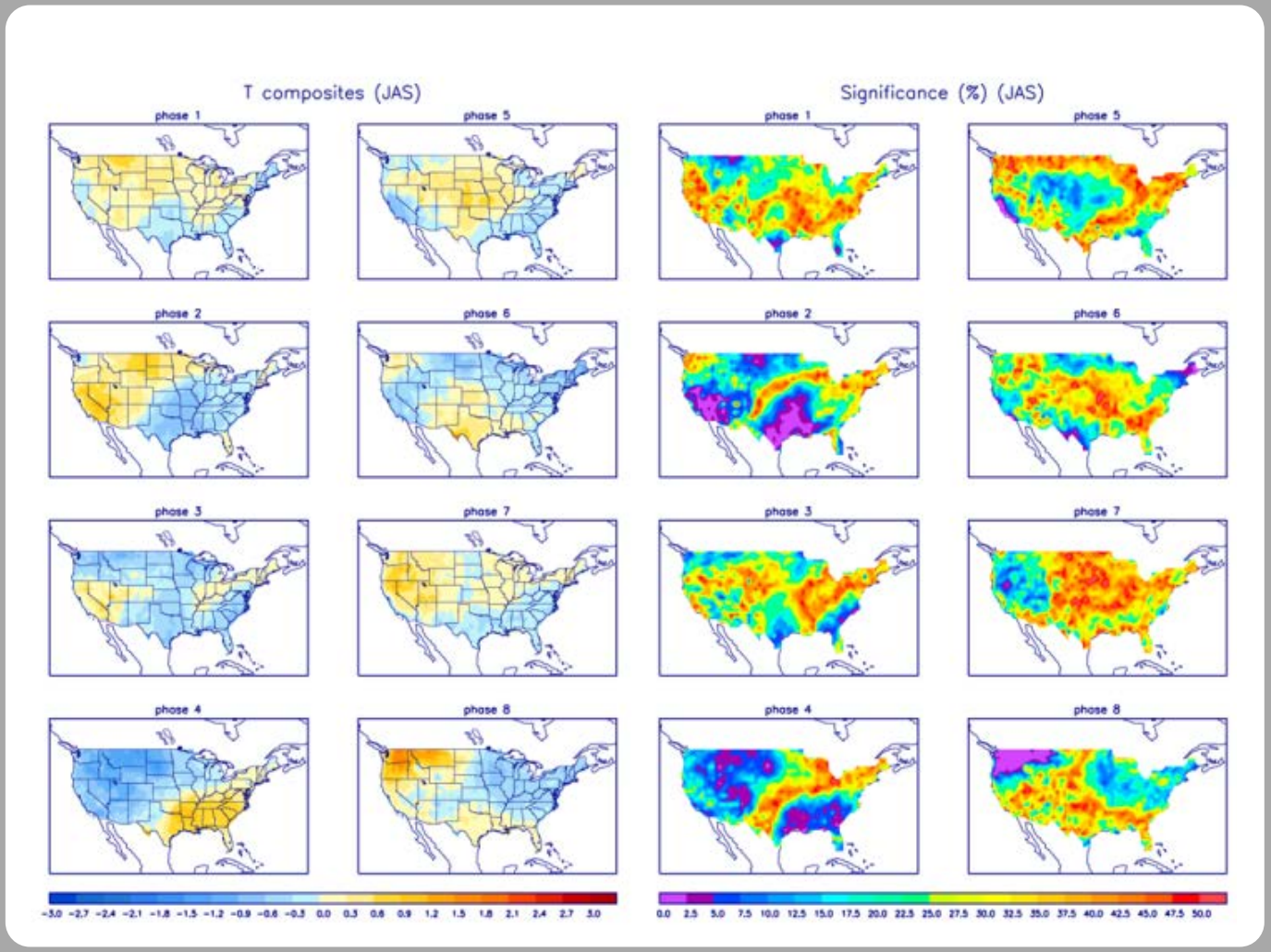
Precipitation Anomalies (May - Sep)



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.



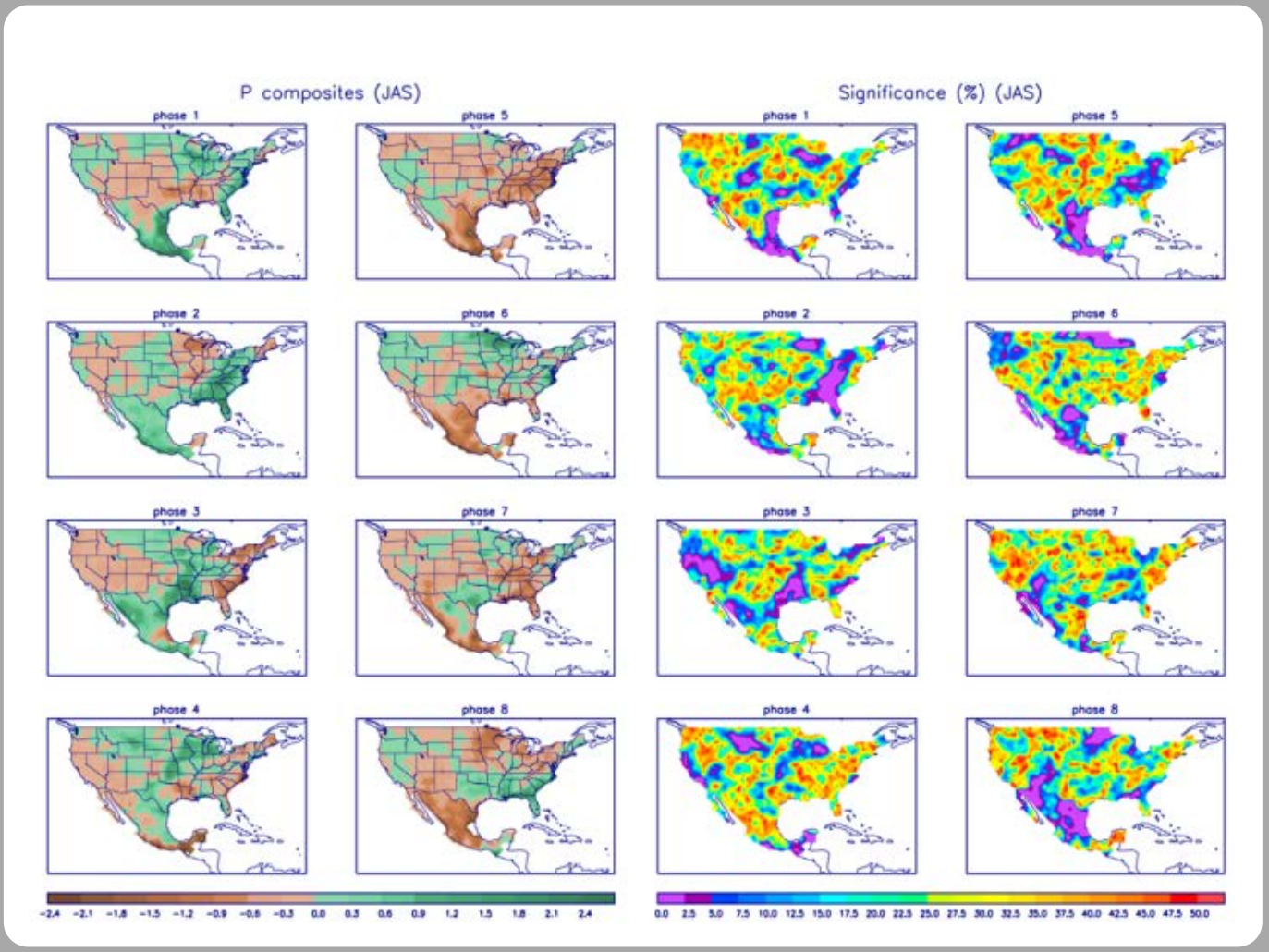
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml