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

Update prepared by:
Climate Prediction Center / NCEP
2 January 2017

Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- Both the CPC and RMM MJO indices indicate weak MJO activity at this time.
- Background La Niña conditions continue to strongly influence the pattern of anomalous tropical convection.
- Dynamical model forecasts of the RMM index generally maintain a weak MJO signal during the next two weeks. Dynamical model guidance diverges with the GEFS maintaining a weak signal over the Indian Ocean, while the ECMWF forecasts a more coherent signal developing over the West Pacific.

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)

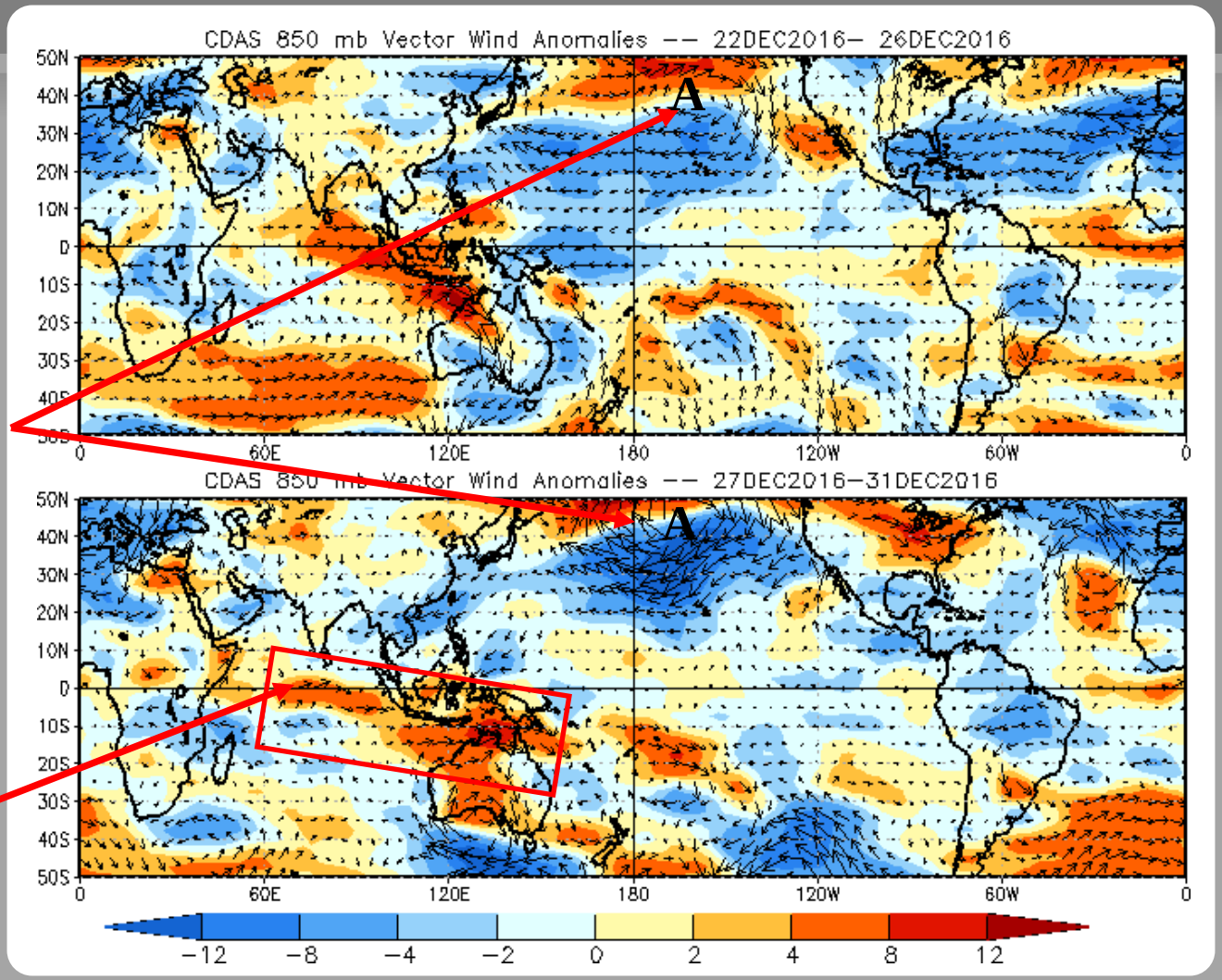
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

An anomalous anticyclone has persisted over the North Pacific.

Anomalous westerlies persisted over the Indian Ocean and Maritime Continent consistent with the low-frequency state.



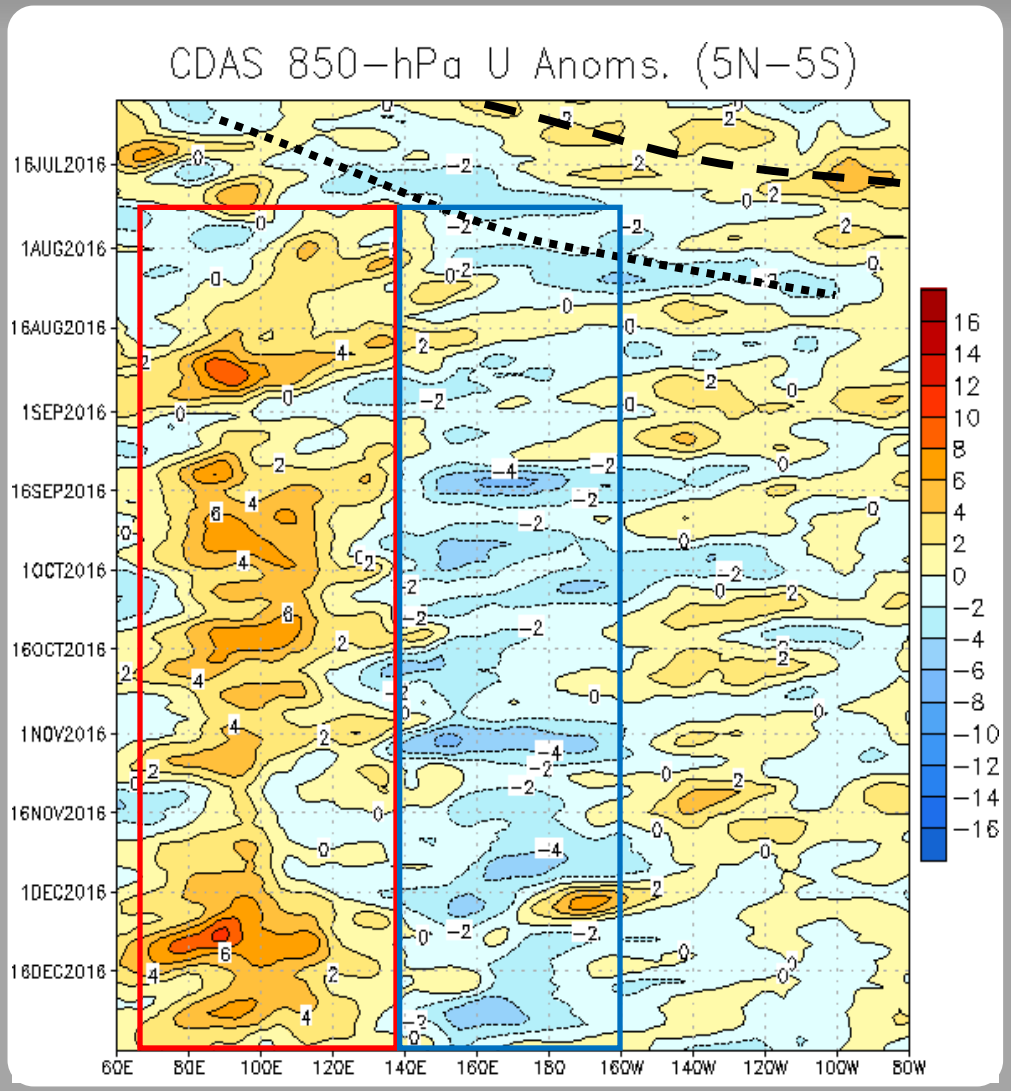
850-hPa Zonal Wind Anomalies (m s-1)

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

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

In July and early August, high frequency, eastward-propagating modes were observed crossing the Pacific.

Since late July, persistent westerly (easterly) anomalies were evident over the eastern Indian Ocean and western Maritime Continent (central and western Pacific) as shown by the red (blue) box at right. These anomalies are low frequency in nature, and reflect the La Niña base state as well as a negative phase of the Indian Ocean Dipole.



OLR Anomalies – Past 30 days

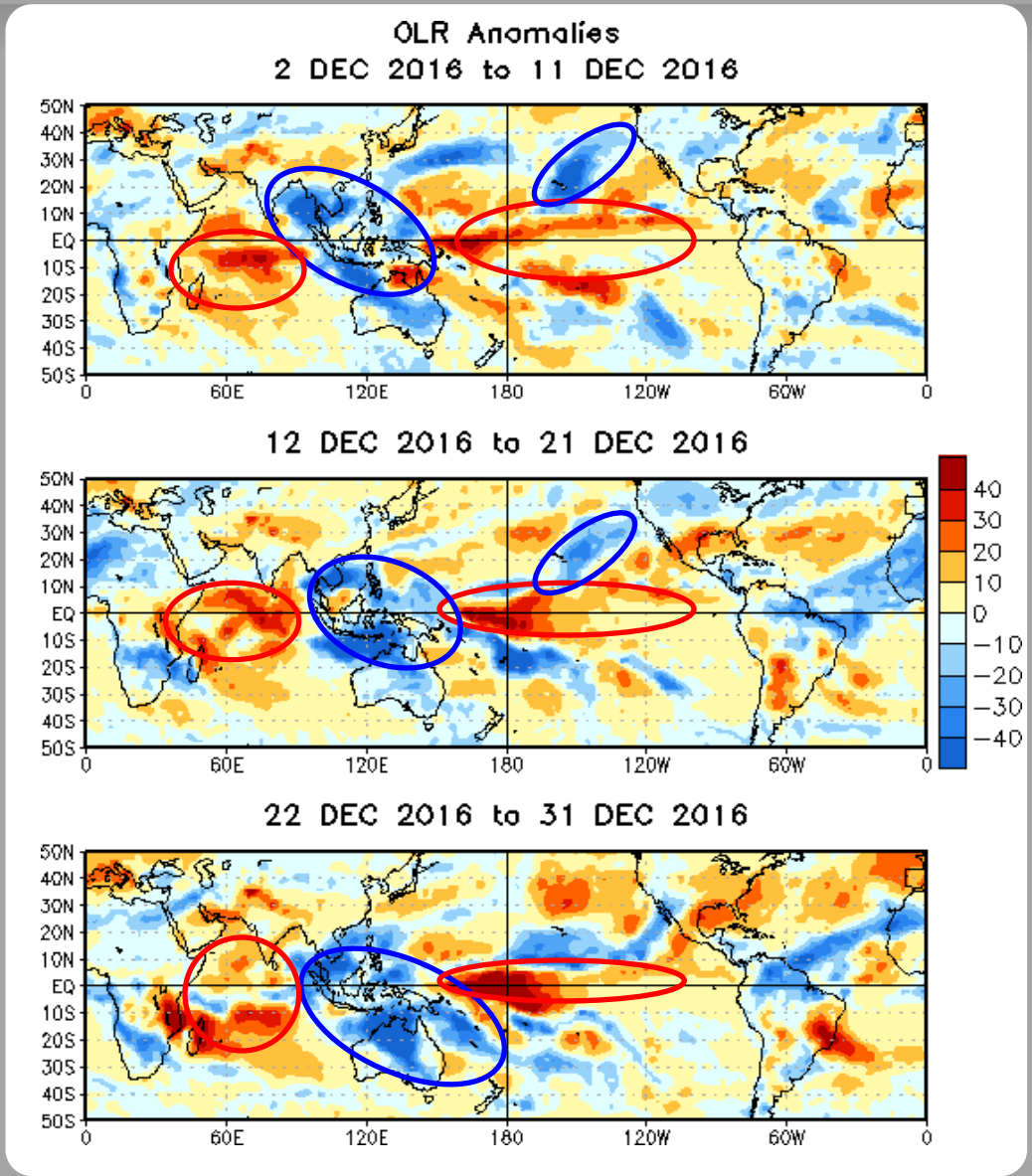
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During early December, the low-frequency signal dominated the pattern of anomalous tropical convection, with suppressed (enhanced) convection over the central and western Indian Ocean and much of the equatorial Pacific (Maritime Continent).

This low-frequency pattern persisted into mid-December, with enhanced rainfall continuing near and northeast of Hawaii to the U.S. West Coast.

During late December, the low-frequency state remained intact, with little evidence of coherent subseasonal variability.



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

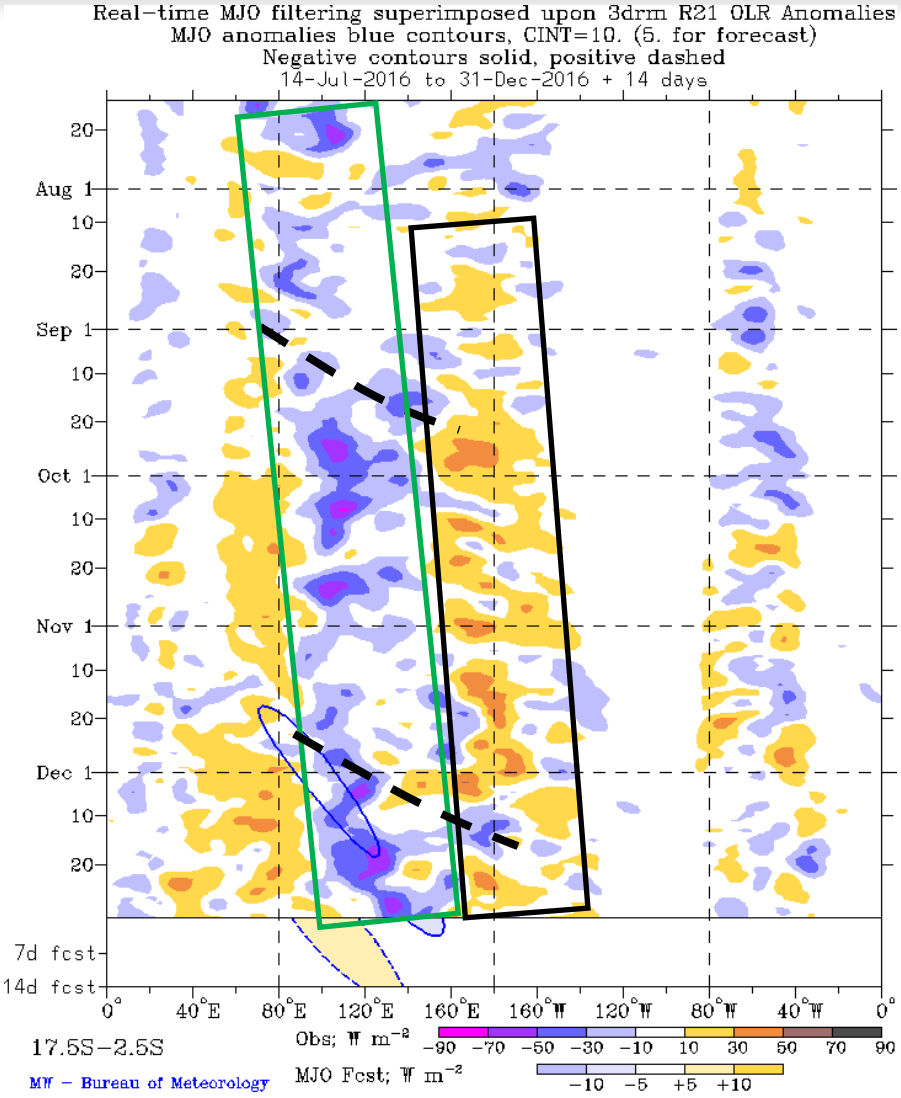
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

A low frequency state favoring enhanced convection shifted slowly east from the eastern Indian Ocean to the Maritime Continent has been evident since July (green box). Low-frequency suppressed convection, tied to building La Niña conditions, has been apparent near the Date Line since August (black box).

A fast eastward propagating convective envelope was evident during early September.

From late November into early December, an eastward propagating mode, on the fast end of the MJO phase speed envelope, was apparent across the Indian Ocean and West-Central Pacific.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

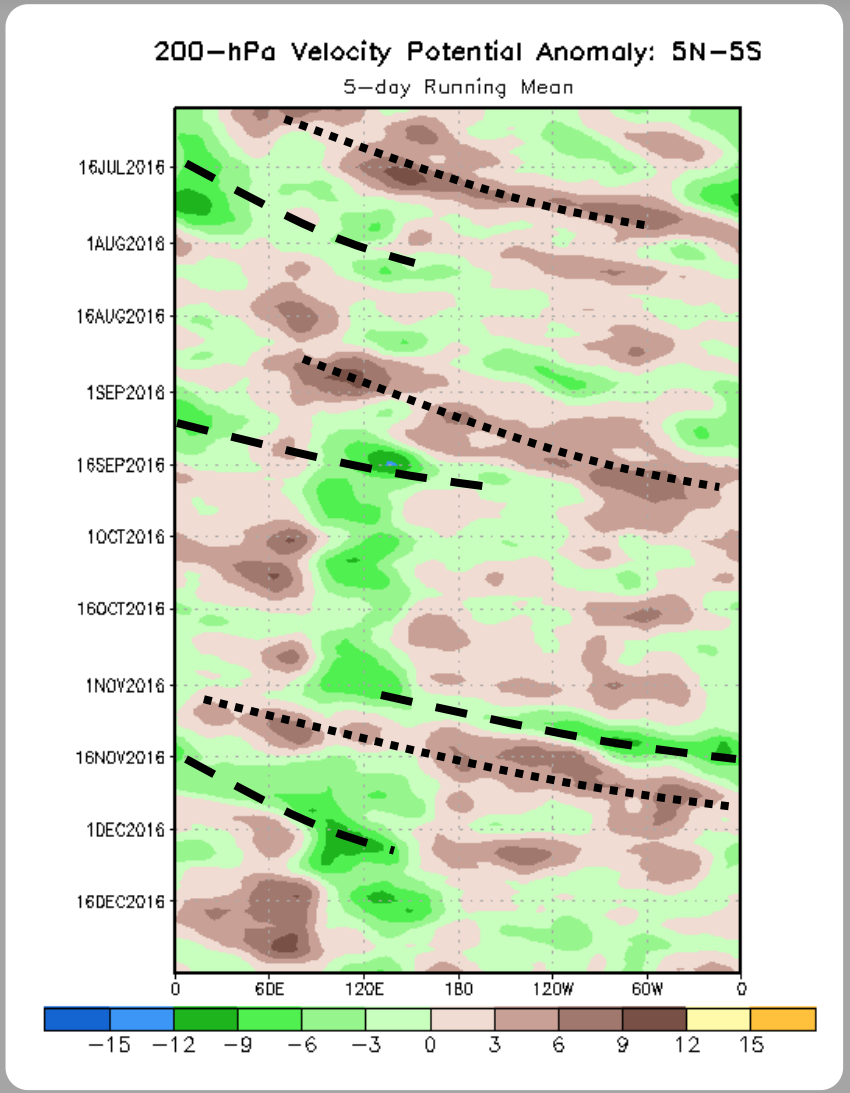
Negative anomalies (green shading) indicate favorable conditions for precipitation

Through early August, an eastward propagating signal was evident, with inactive and active periods of variability apparent.

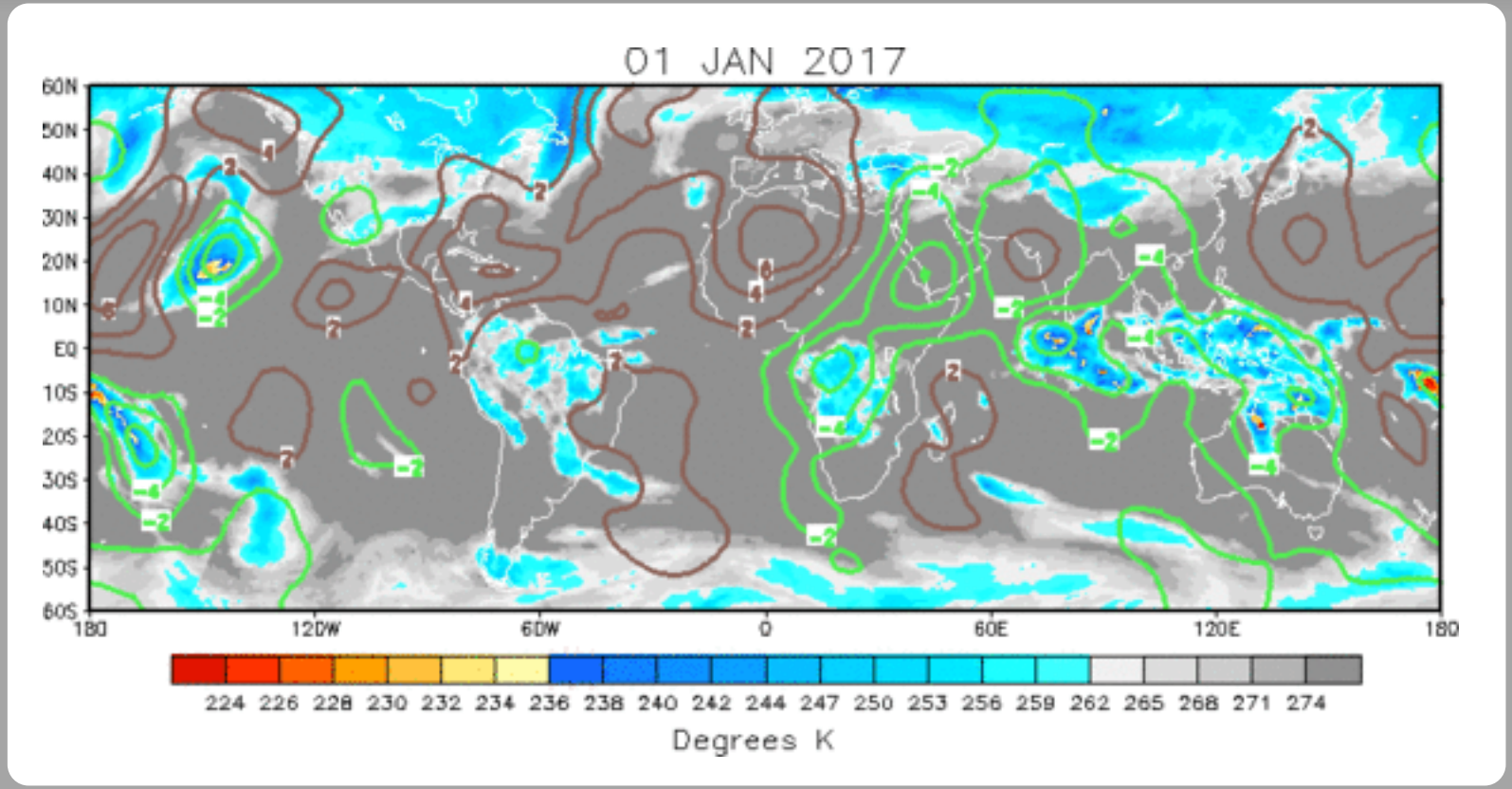
During August, the intraseasonal signal became less coherent, with a weaker and somewhat more stationary anomaly field in place. By late August and early September, there was renewed propagation of the intraseasonal signal.

From mid-September to late October, the low frequency signal dominated the pattern. During November, eastward propagation was observed consistent with MJO activity on the fast end of the intraseasonal spectrum.

During December, a more stationary pattern is evident with positive (negative) anomalies observed across the Indian Ocean (Maritime Continent and West Pacific). During the second half of the month, remnant weak MJO activity is inferred over the Western Hemisphere.



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



The pattern of upper-level velocity potential anomalies has become less coherent, with enhanced upper-level divergence over the Indian Ocean and Maritime Continent, and no organized structure over the Western Hemisphere.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

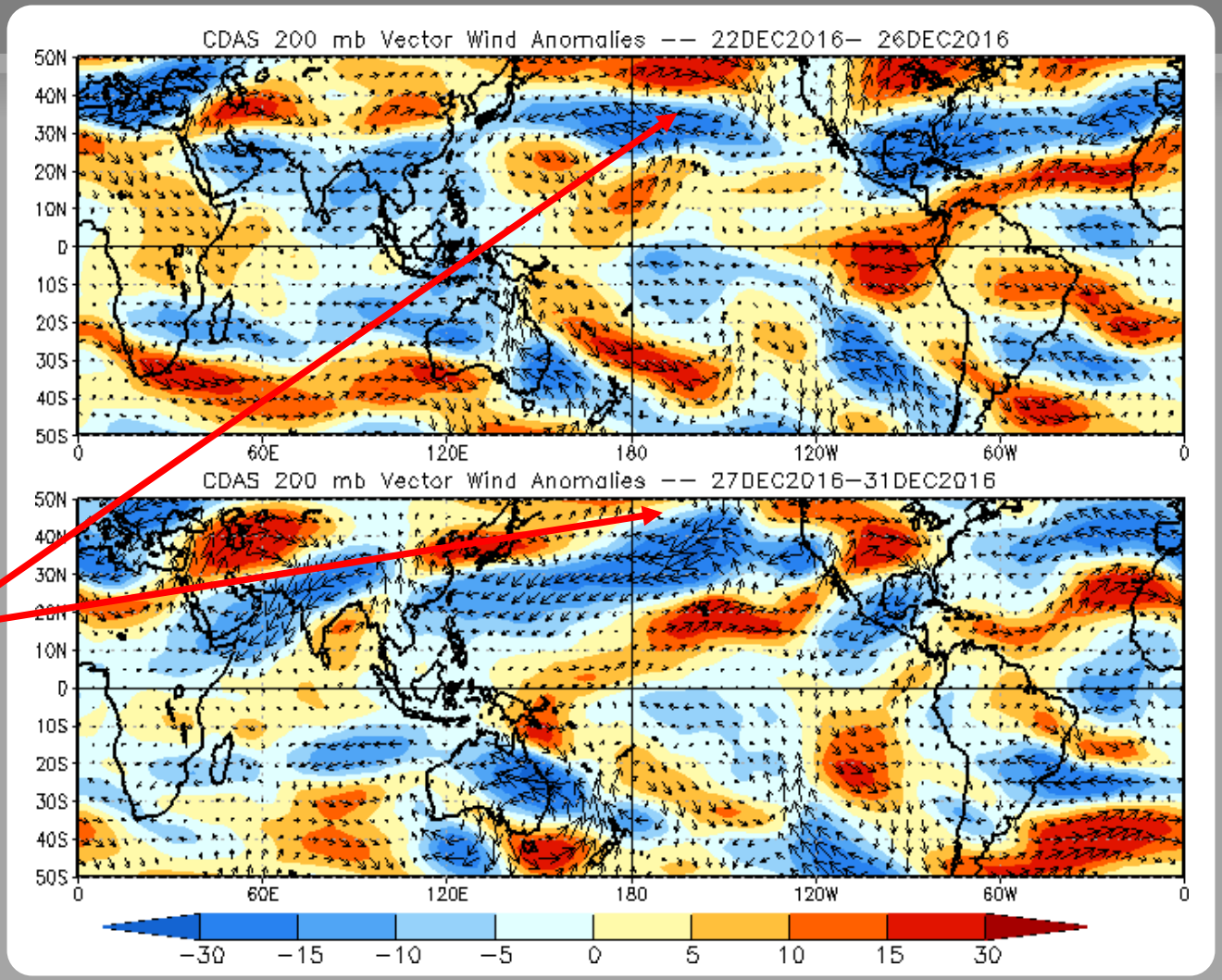
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



An upper-level anticyclone drifted northward over the North Pacific.

Recently, there have been generally low-amplitude anomalies over the global tropics.

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

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

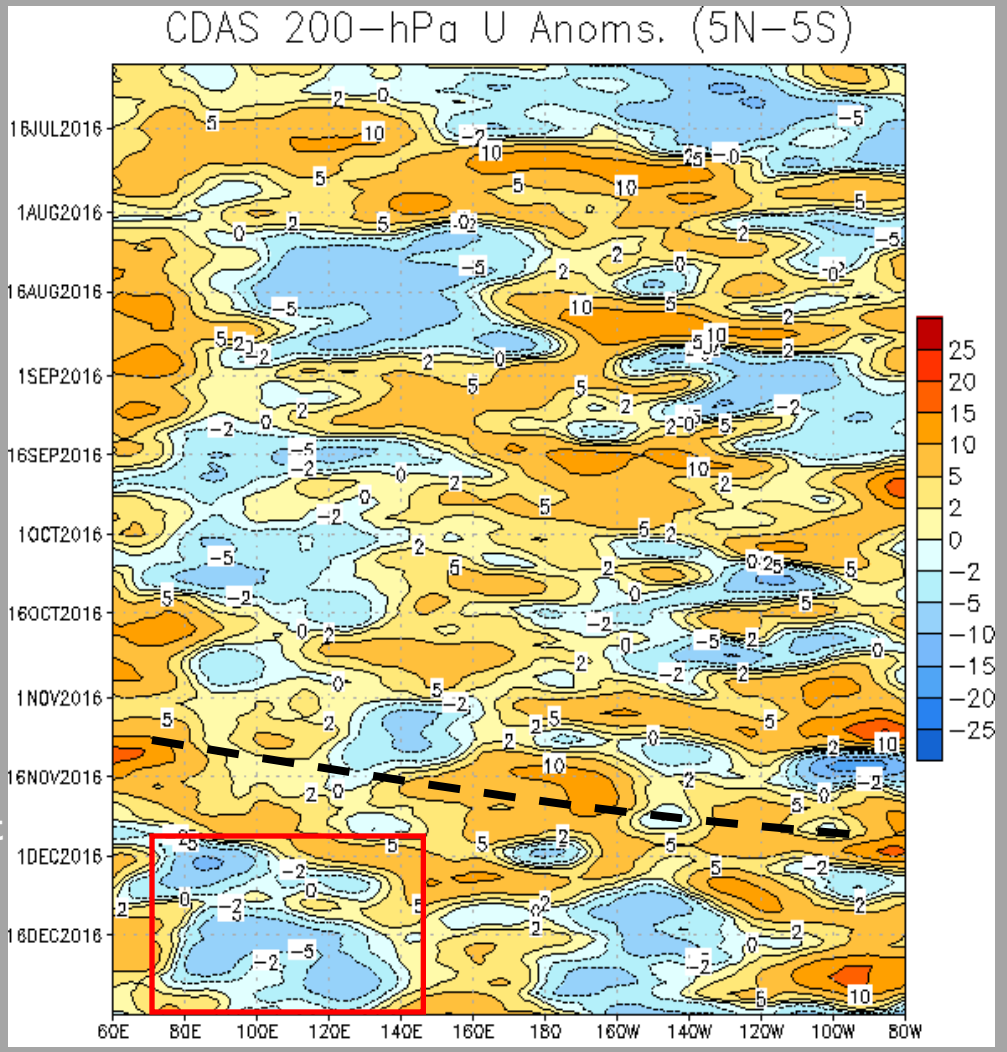
Easterly anomalies (blue shading) represent anomalous east-to-west flow

During July, some eastward propagation was evident, although the spatial consistency implies higher frequency variability than expected with the MJO.

During September, eastward propagation of westerly anomalies was broadly consistent with organized MJO activity.

During November, anomalous westerlies persisted near the Date Line, though intraseasonal variability associated with the MJO is evident.

Since late November, easterly anomalies have re-emerged across the Indian Ocean consistent with the passage of subseasonal activity and the re-alignment of the low frequency base state (red box).



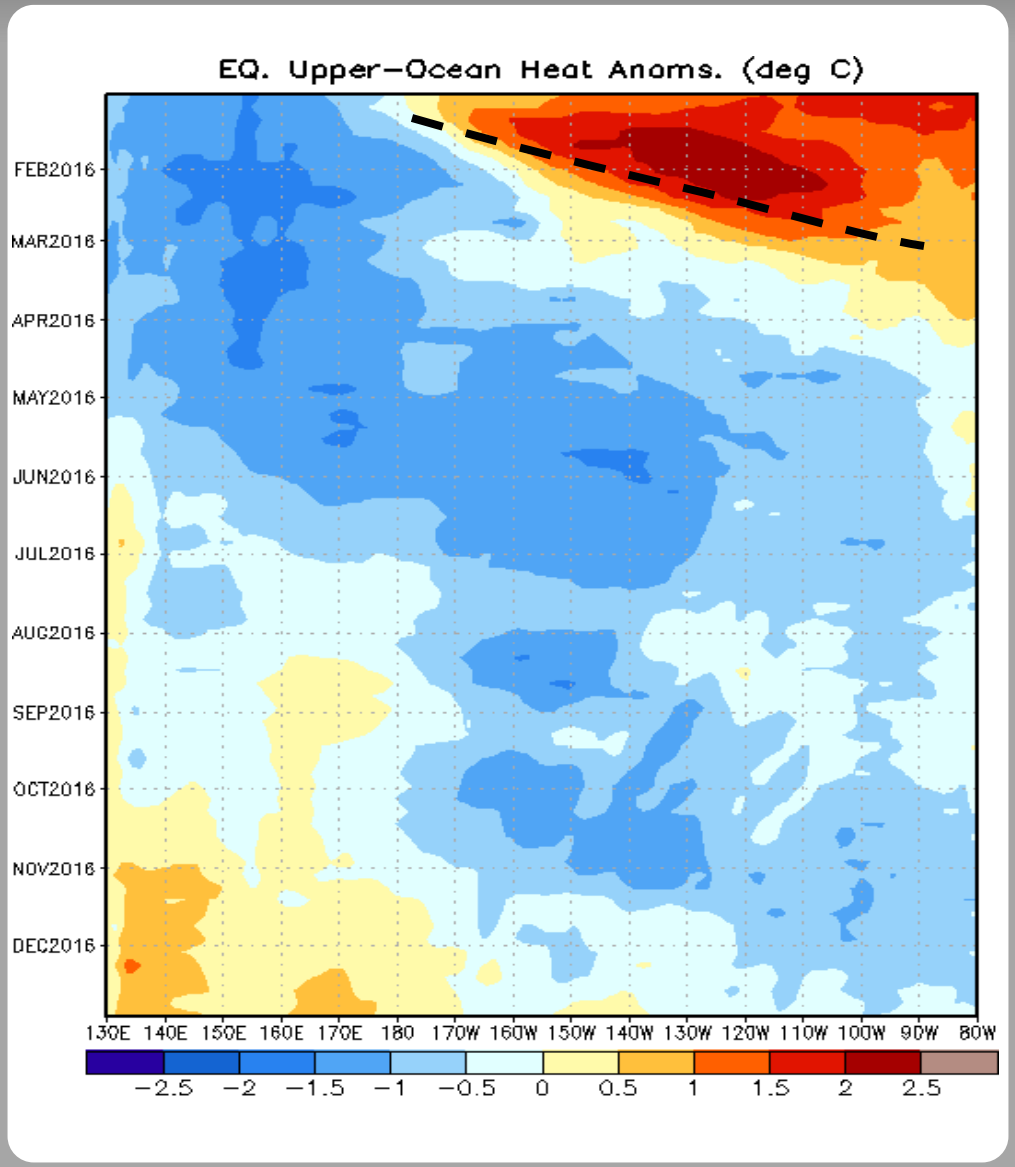
Weekly Heat Content Evolution in the Equatorial Pacific

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.

Downwelling events were observed through early February, resulting in persistently above-normal heat content from the Date Line to 80W over that period.

An eastward expansion of below average heat content over the western Pacific is evident through April, with widespread negative anomalies building across the Pacific over the course of the spring and summer months.

Most recently, upper-ocean heat content anomalies have been very low amplitude, consistent with the forecast transition to ENSO-neutral conditions over the coming months.



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

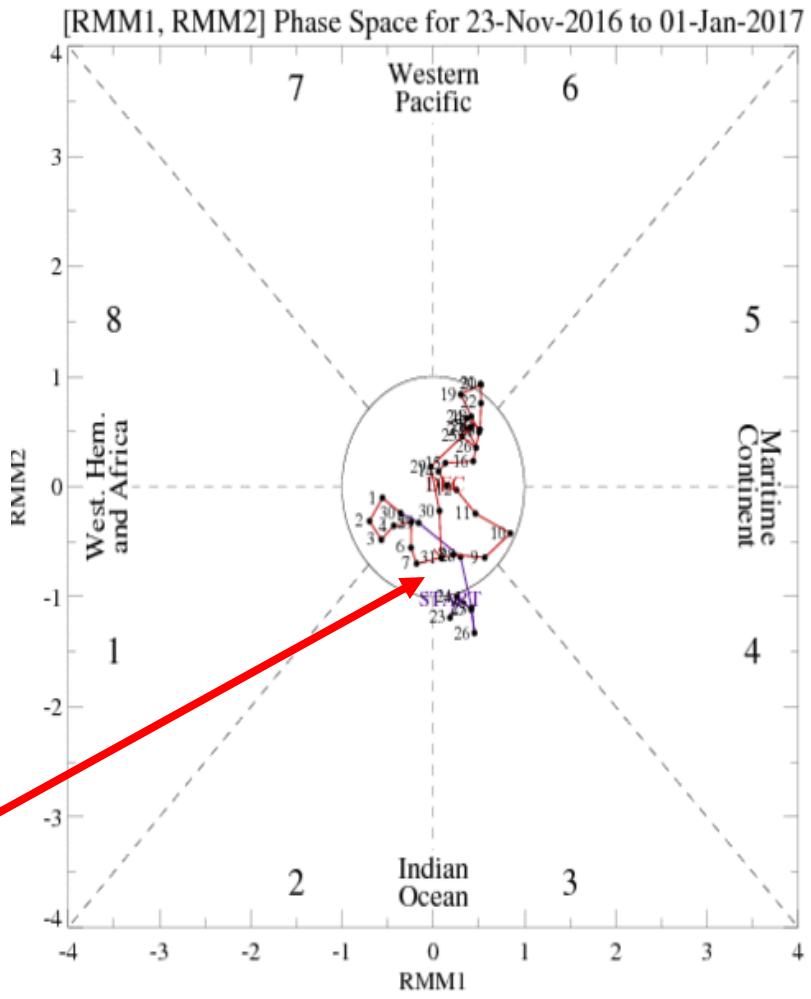
The triangular areas indicate the location of the enhanced phase of the MJO

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

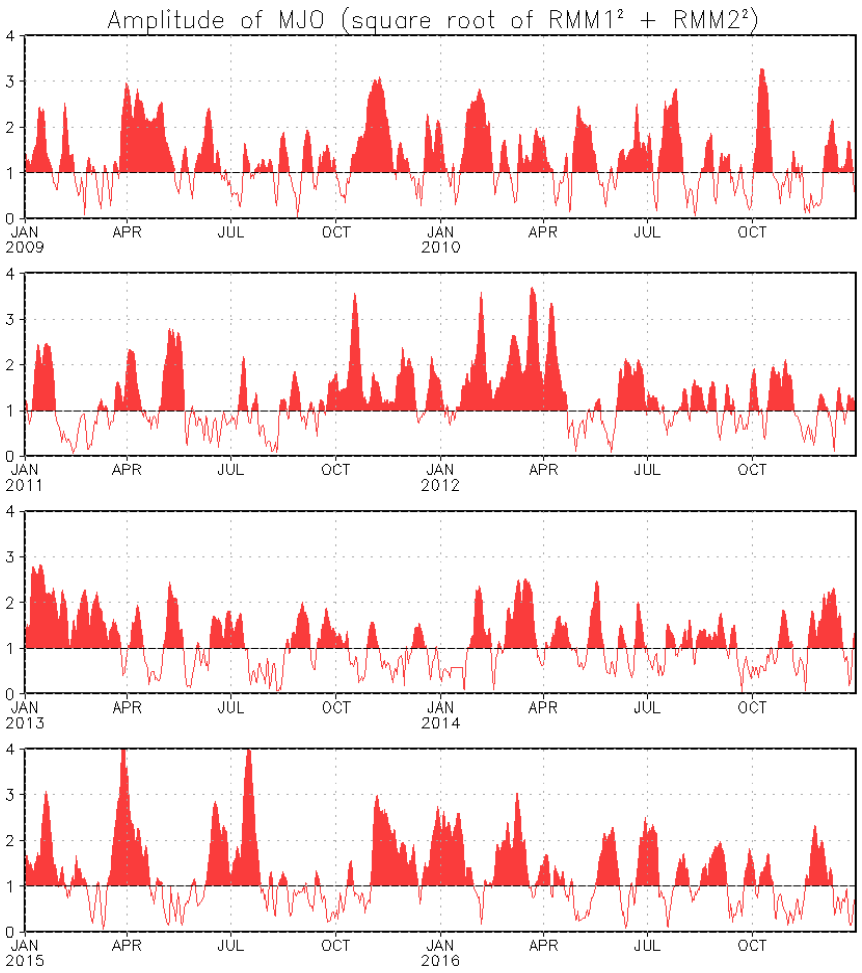
The MJO index remained low in amplitude since the end of November.



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.



Ensemble ECMWF MJO Forecast

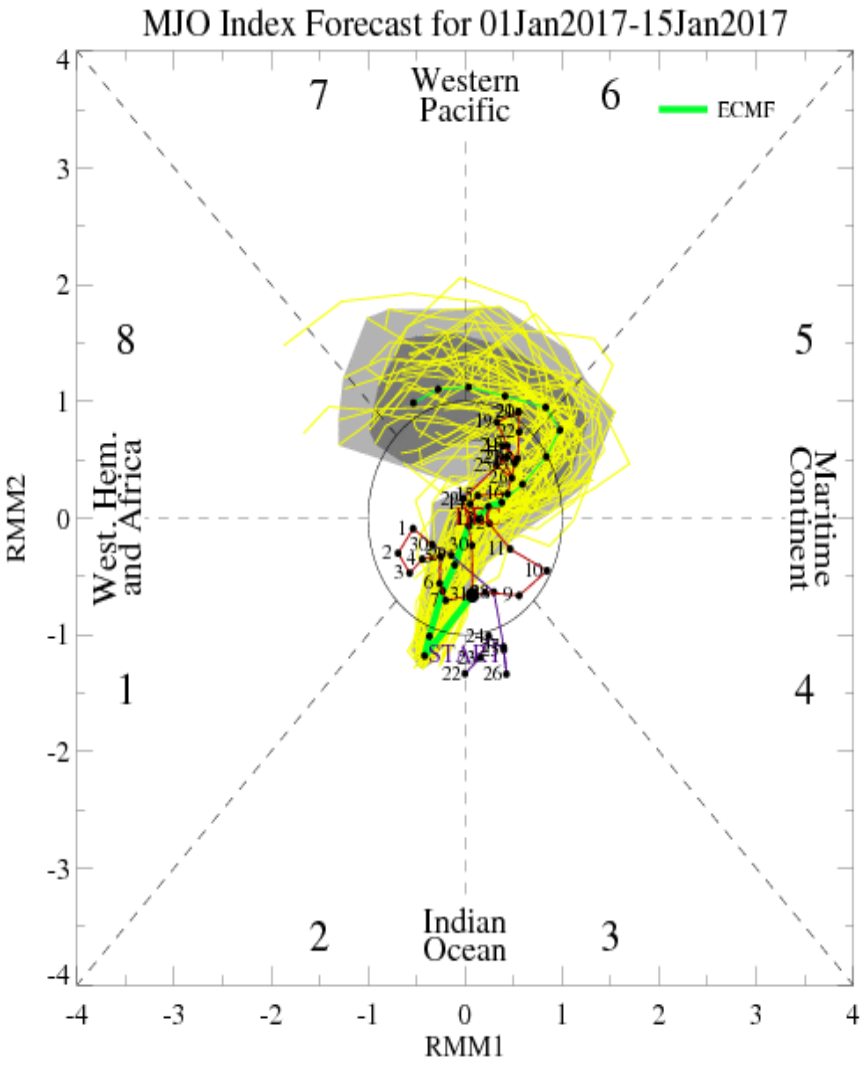
Yellow Lines - 51 Individual Members
Green Line - Ensemble Mean

RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble system from the European Center for Medium Range Weather Forecasts (ECMWF) for the next 15 days

light gray shading: 90% of forecasts

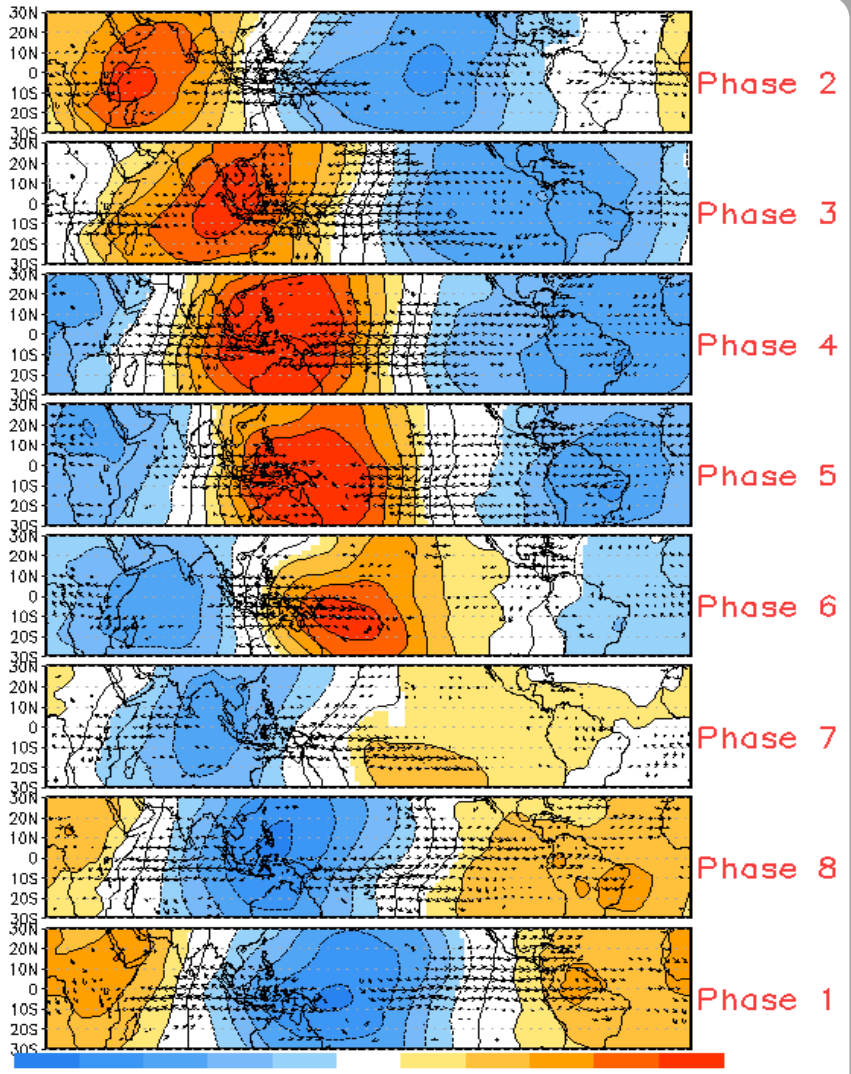
dark gray shading: 50% of forecasts

The ECMWF ensemble forecast depicts a weak signal early, giving way to a more coherent, fast eastward-propagating signal over the West Pacific during Week-2.

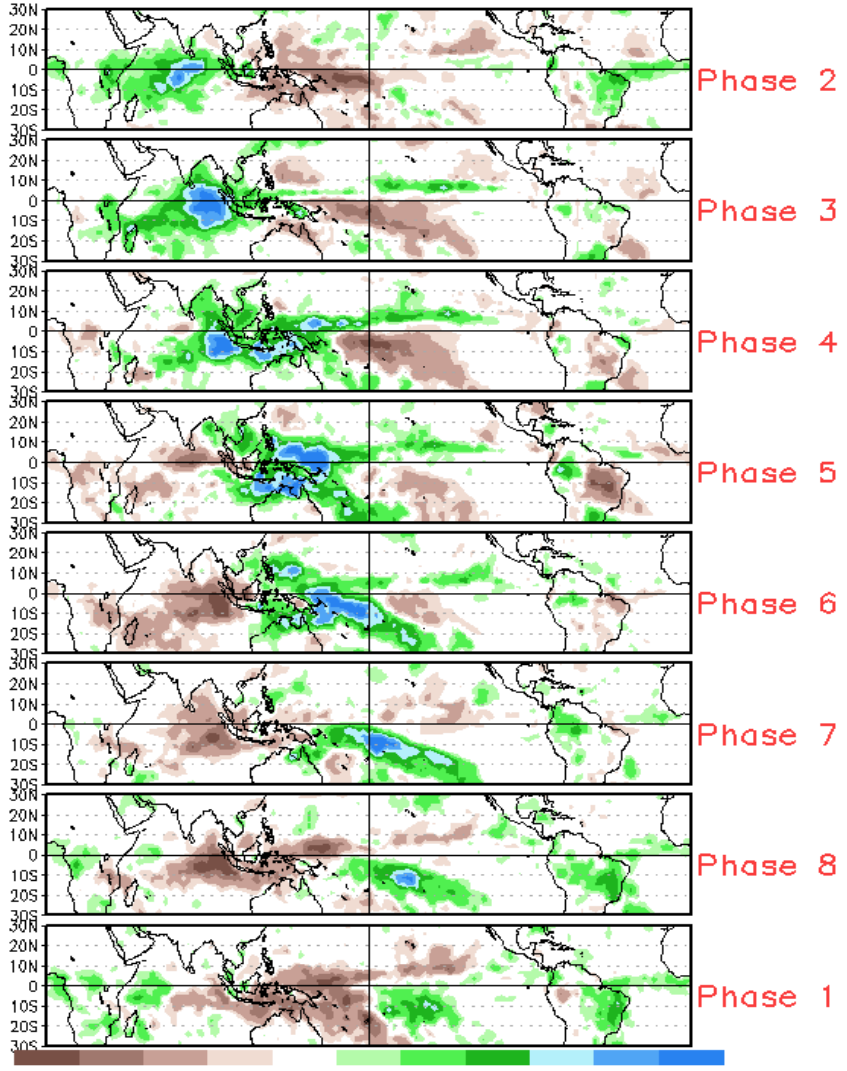


MJO Composites - Global Tropics

850-hPa Velocity Potential and Wind Anomalies (Nov - Mar)



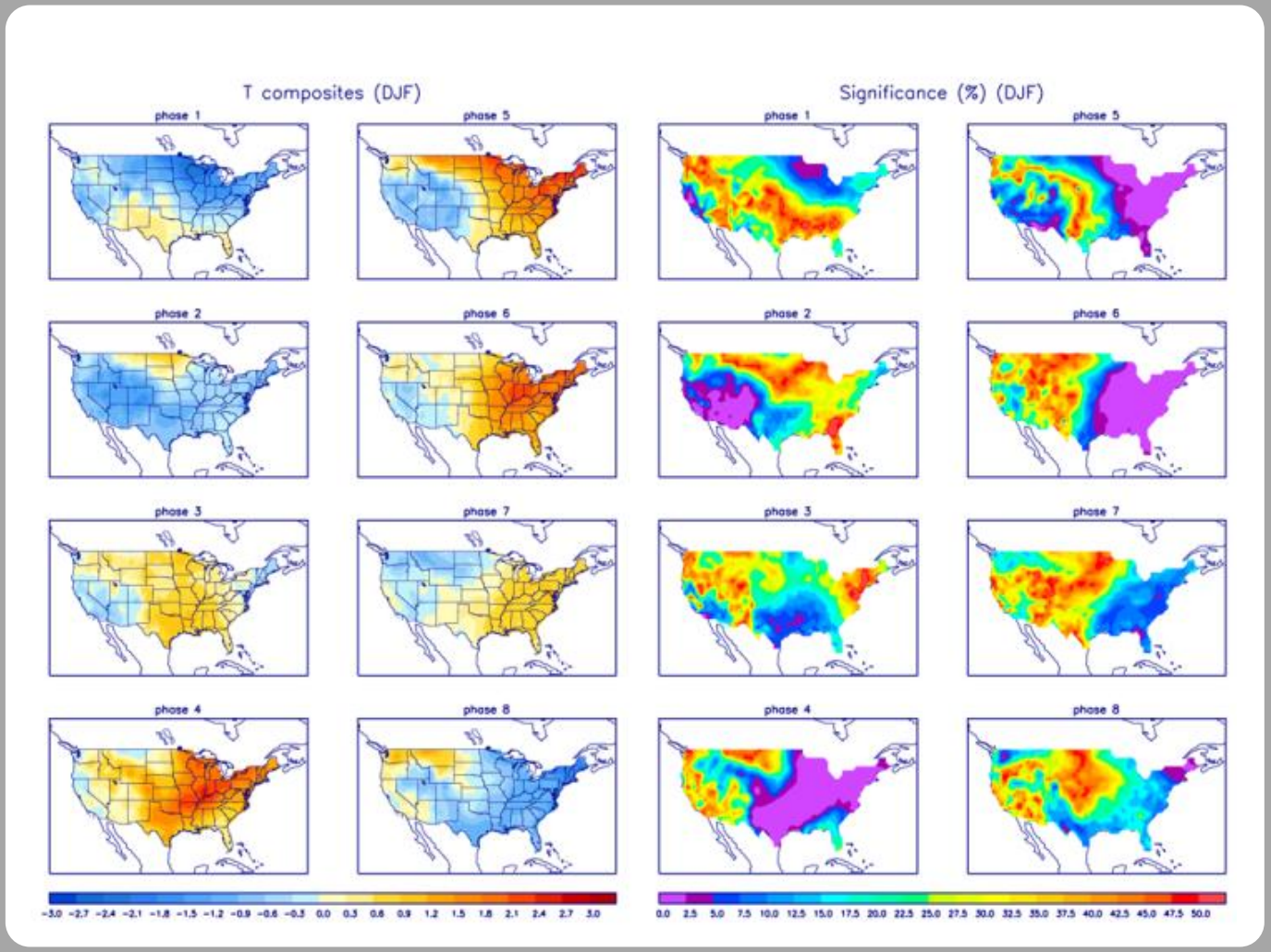
Precipitation Anomalies (Nov - Mar)



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.



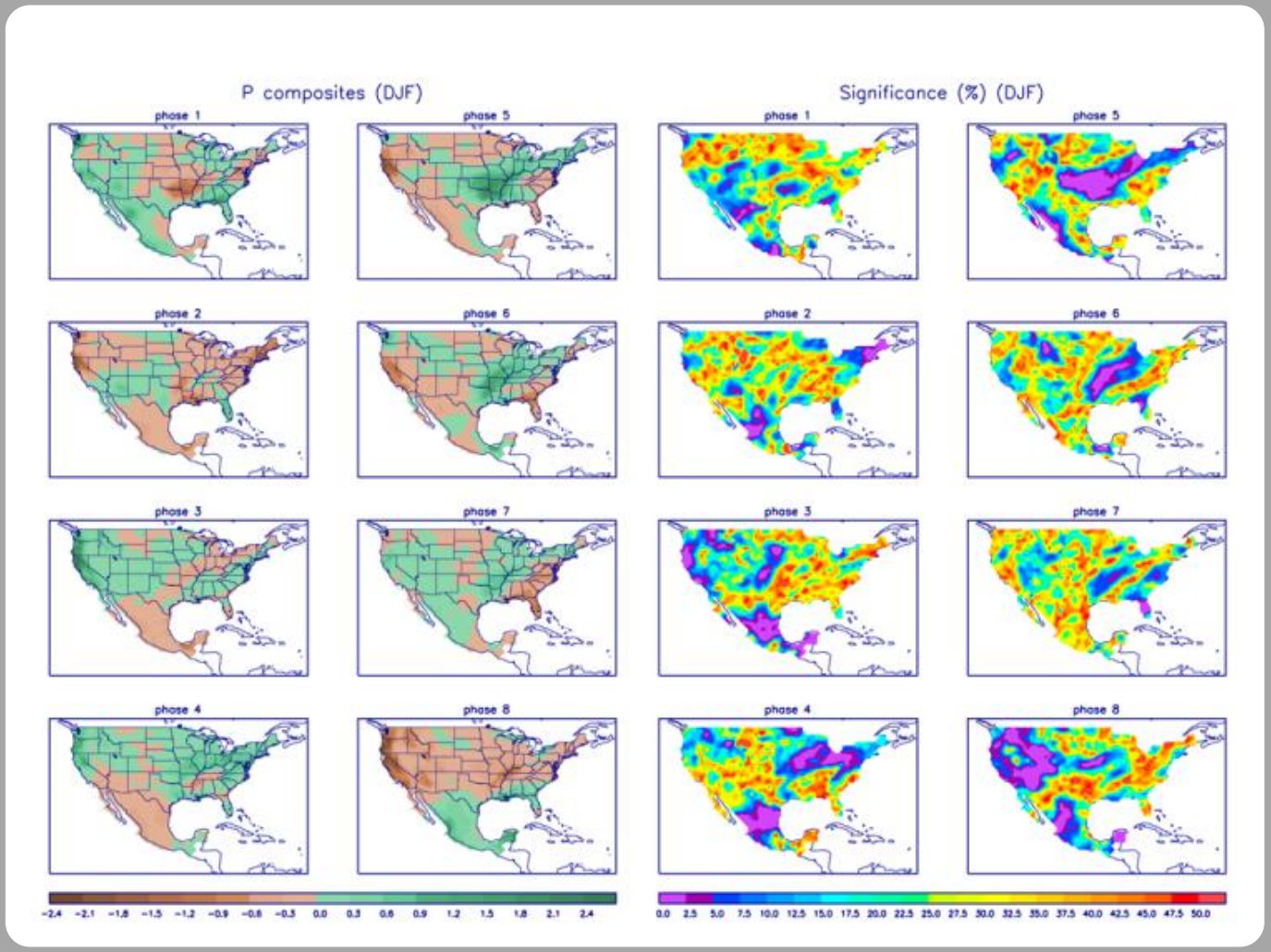
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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