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

Update prepared by
Climate Prediction Center / NCEP
November 17, 2014

Outline

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

Overview

- A more coherent MJO signal was evident during the previous week with the enhanced phase propagating across the Western Hemisphere. Upper-level atmospheric indicators are the most consistent with the MJO at the current time.

- Other types of tropical variability, including the low frequency background state, favor enhanced (suppressed) convection across the central Pacific (Maritime Continent) and continue to influence the pattern of anomalous convection.

- Several dynamical model MJO index forecasts depict eastward propagation of the MJO over the Indian Ocean, but model forecasts become more divergent during Week-2, and there is little model support for a robust Indian Ocean MJO event propagating to the Maritime Continent.

- Based on recent observations and model guidance, the MJO may contribute to enhanced (suppressed) convection over parts of South America, Africa, and the Indian Ocean basin (the Maritime Continent and western Pacific) during the period.

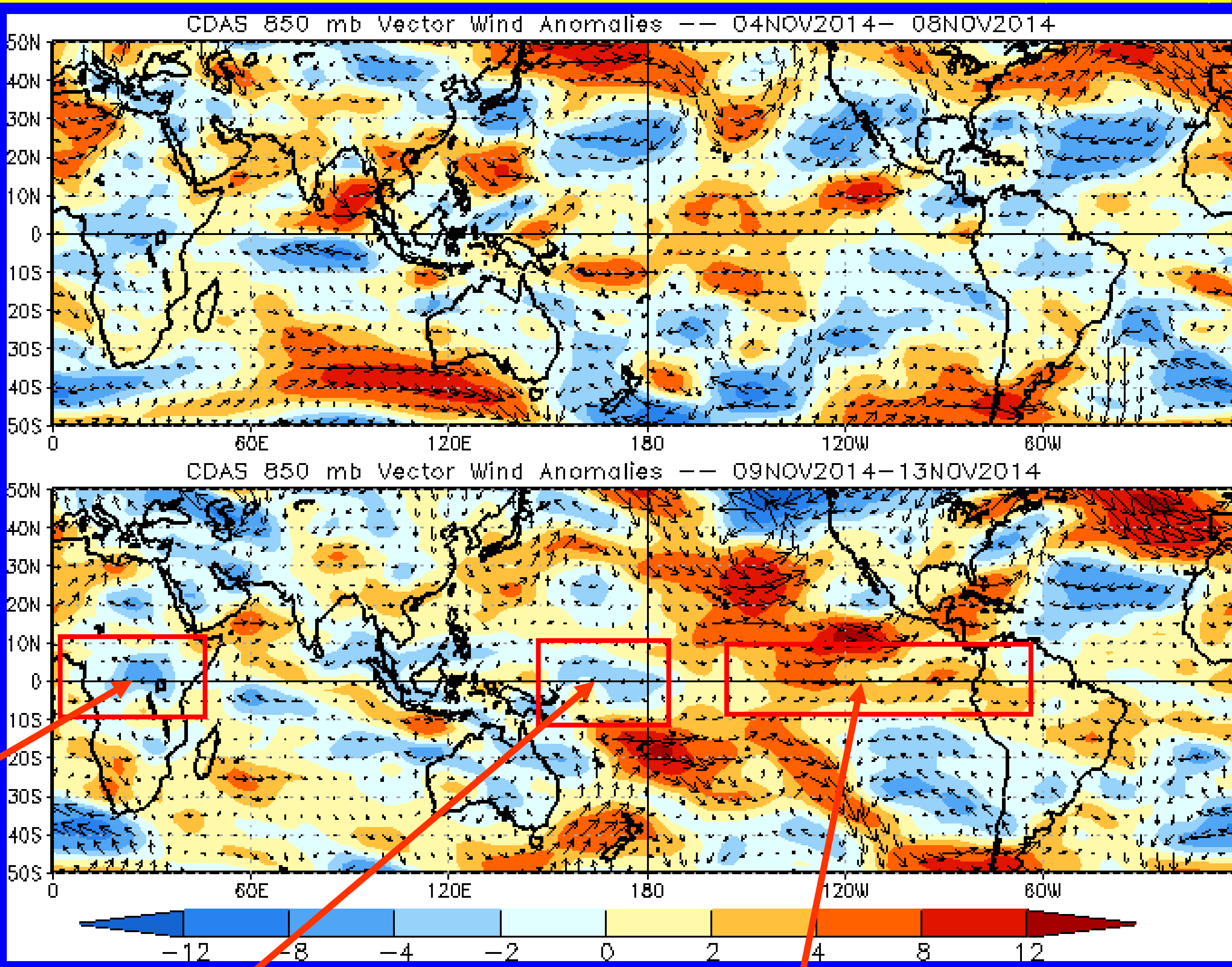
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies persisted over equatorial Africa.

Weak easterly anomalies developed along the equator near and west of the Date Line.

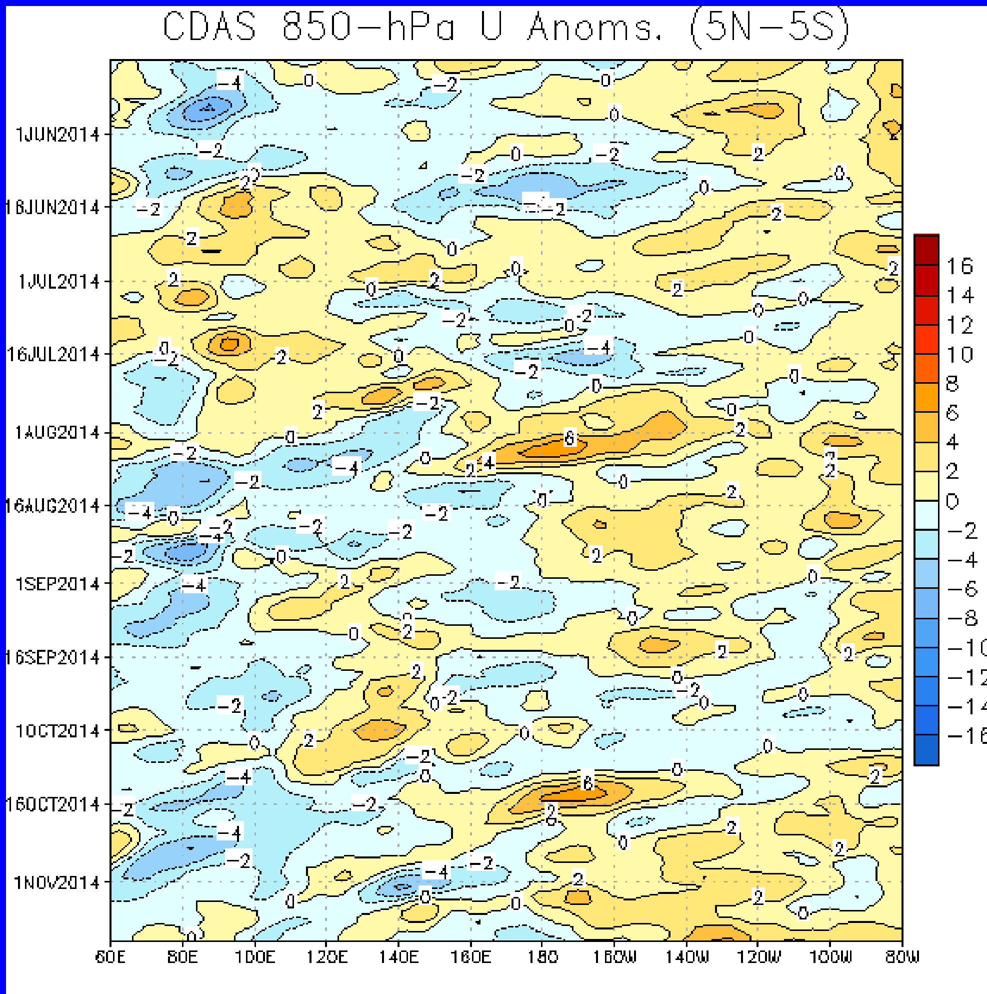
Westerly anomalies spread eastward across the eastern Pacific and South America.

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

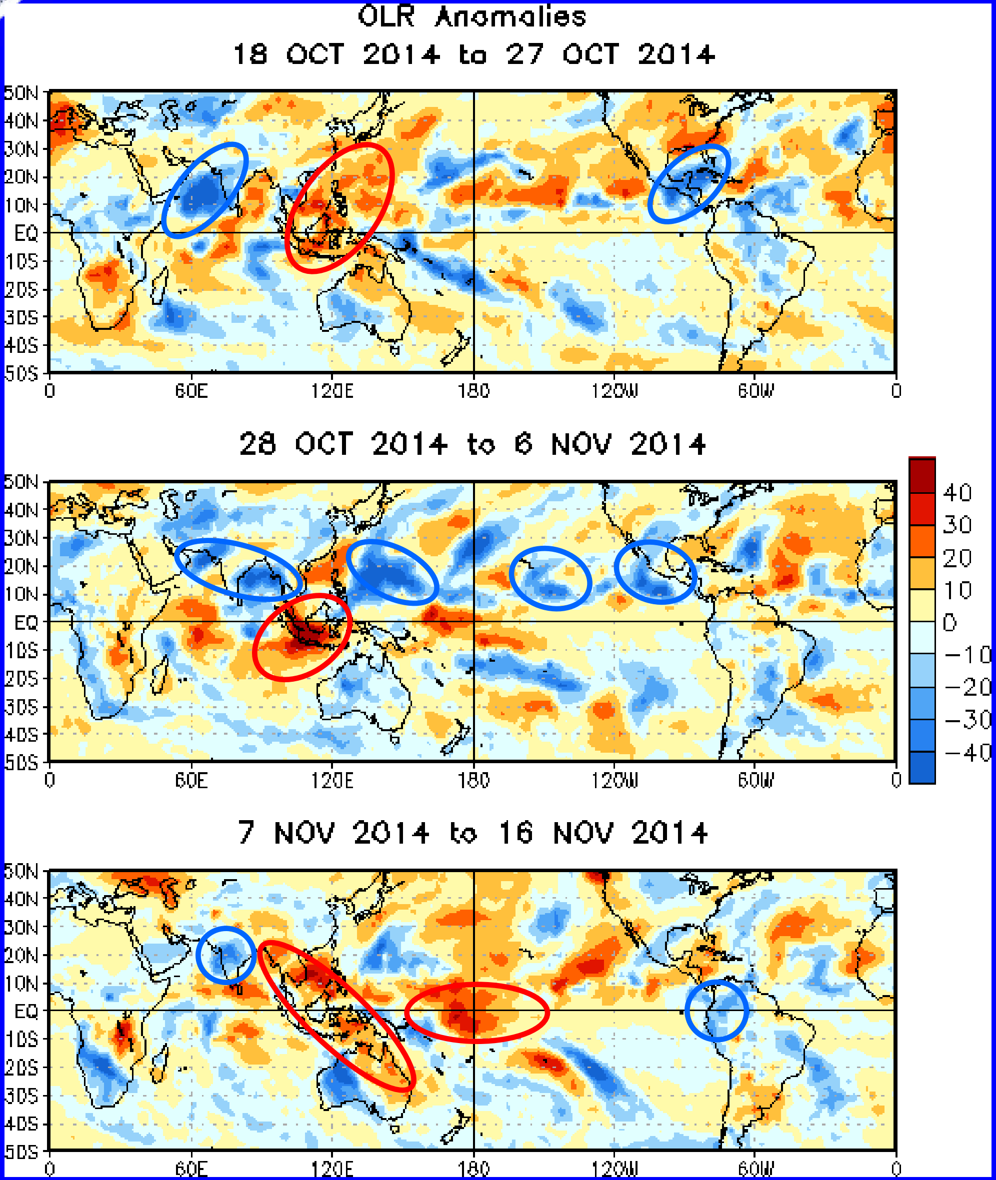
During much of May and June, westerly anomalies were observed over the eastern Pacific. An enhanced South Asian monsoon circulation developed during much of June and July.

From late July to August, westerly (easterly) anomalies shifted westward over the eastern and central Pacific (western Pacific, Maritime Continent, and Indian Ocean).

A westerly wind burst was observed near the Date Line during mid-October

More recently, westerly anomalies were observed over much of the Pacific basin, with a weaker and more incoherent anomaly field prevailing across the Indian Ocean and Maritime Continent.

OLR Anomalies – Past 30 days



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

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

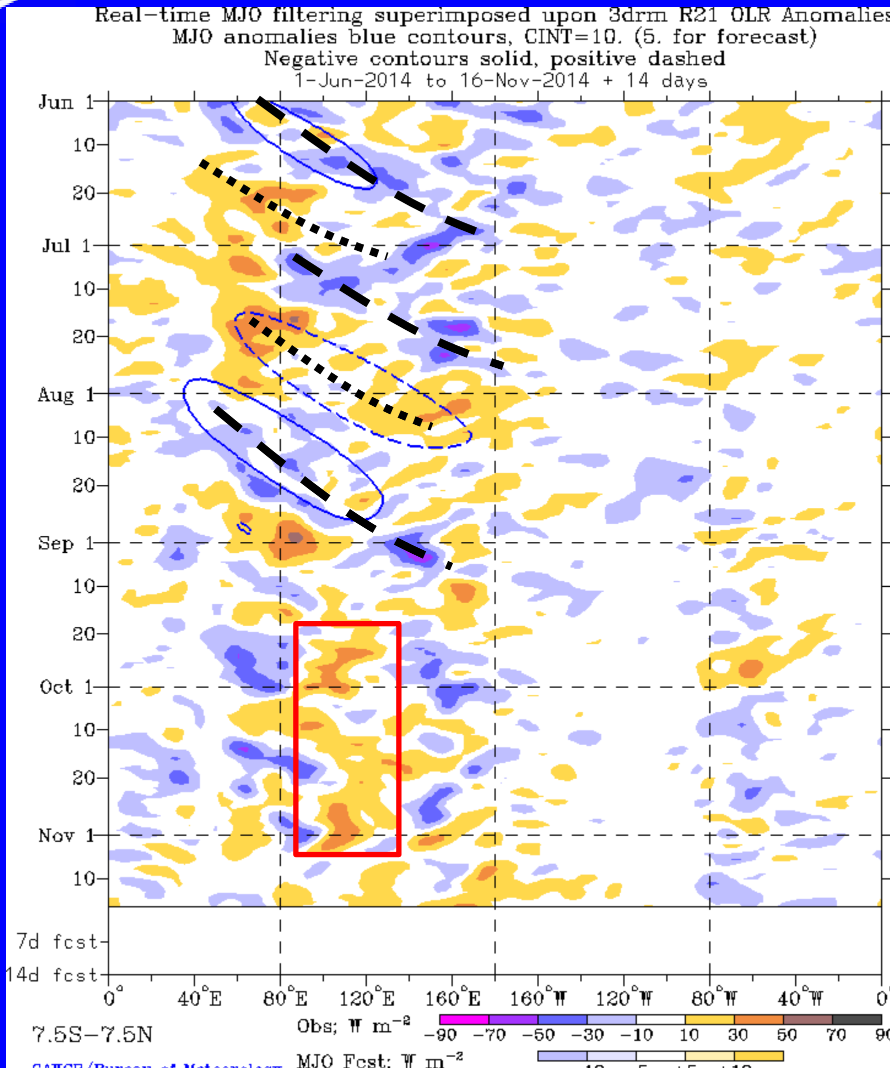
During late October, suppressed convection persisted from the western Maritime Continent through the northwestern Pacific, while enhanced convection associated with tropical cyclone activity was observed over the Arabian Sea and the Caribbean.

During late October and early November, suppressed convection persisted over the western Maritime Continent and developed over the central Pacific, while tropical cyclone related enhanced convection was observed over the Bay of Bengal, northwestern Pacific, and east Pacific.

During mid-November, suppressed convection persisted over the Maritime Continent and west-central Pacific, while weak enhanced convection was observed over South Asia and South America.

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)

The MJO became more organized during June and July, primarily over the Indian Ocean, but the pattern became less coherent with respect to canonical MJO activity by September.

Since mid-August, the pattern was dominated by interactions between westward moving features and eastward moving features that were more transient than canonical MJO-related activity.

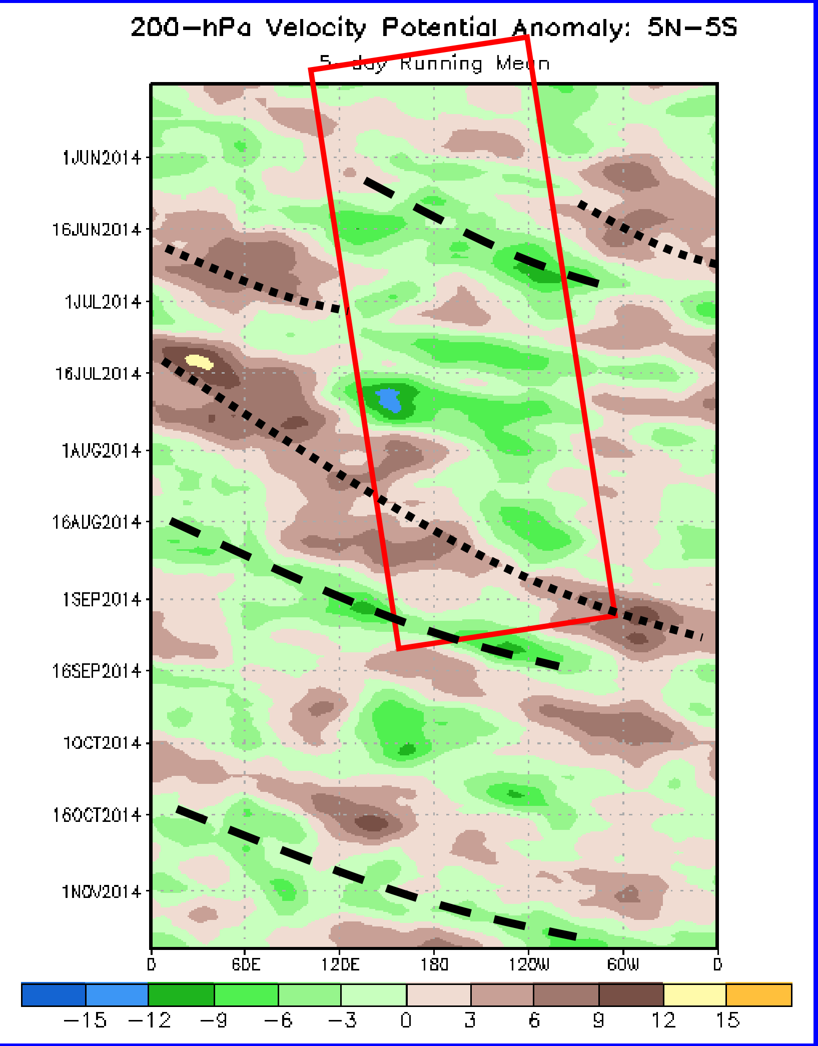
An area of persistent suppressed convection was observed over the western Maritime Continent since mid-September (red box), with pulses of enhanced convection observed both over the Indian Ocean and western Pacific. More recently, large scale convective anomalies have weakened.

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

A slow eastward progression of negative anomalies was observed during the late spring and summer across the Indo-Pacific warm pool and central-eastern Pacific (red box).

The pattern became more organized during June with a more coherent wave-1 MJO-like structure with eastward propagation.

The pattern became less coherent during early July, but then organized again in late July and August, with a wide area of suppressed convection moving around the planet.

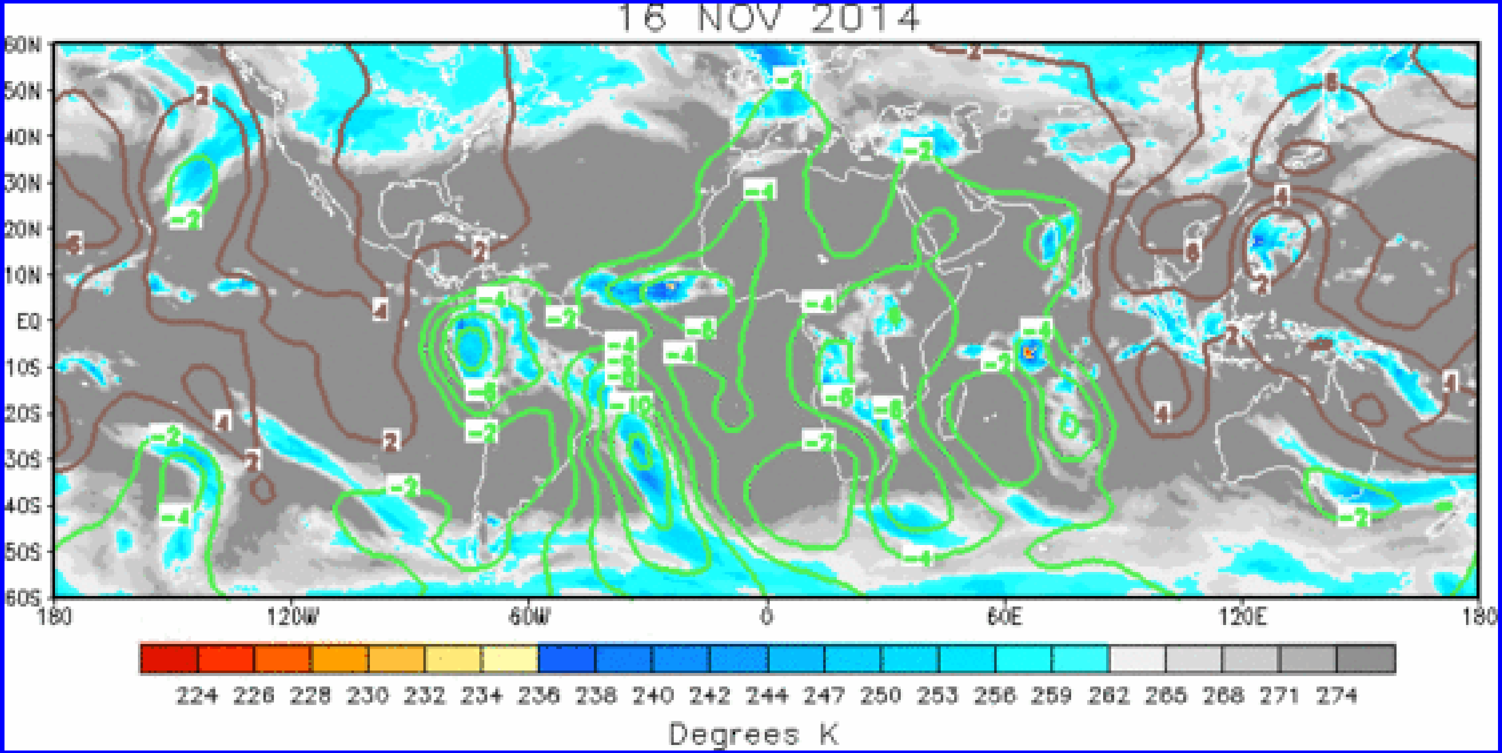
During early September, anomalies were consistent with rapid eastward propagation, before becoming stationary for the second half of the month.

During October and early November, some eastward propagation is evident, although other signals are interfering with the overall pattern.

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



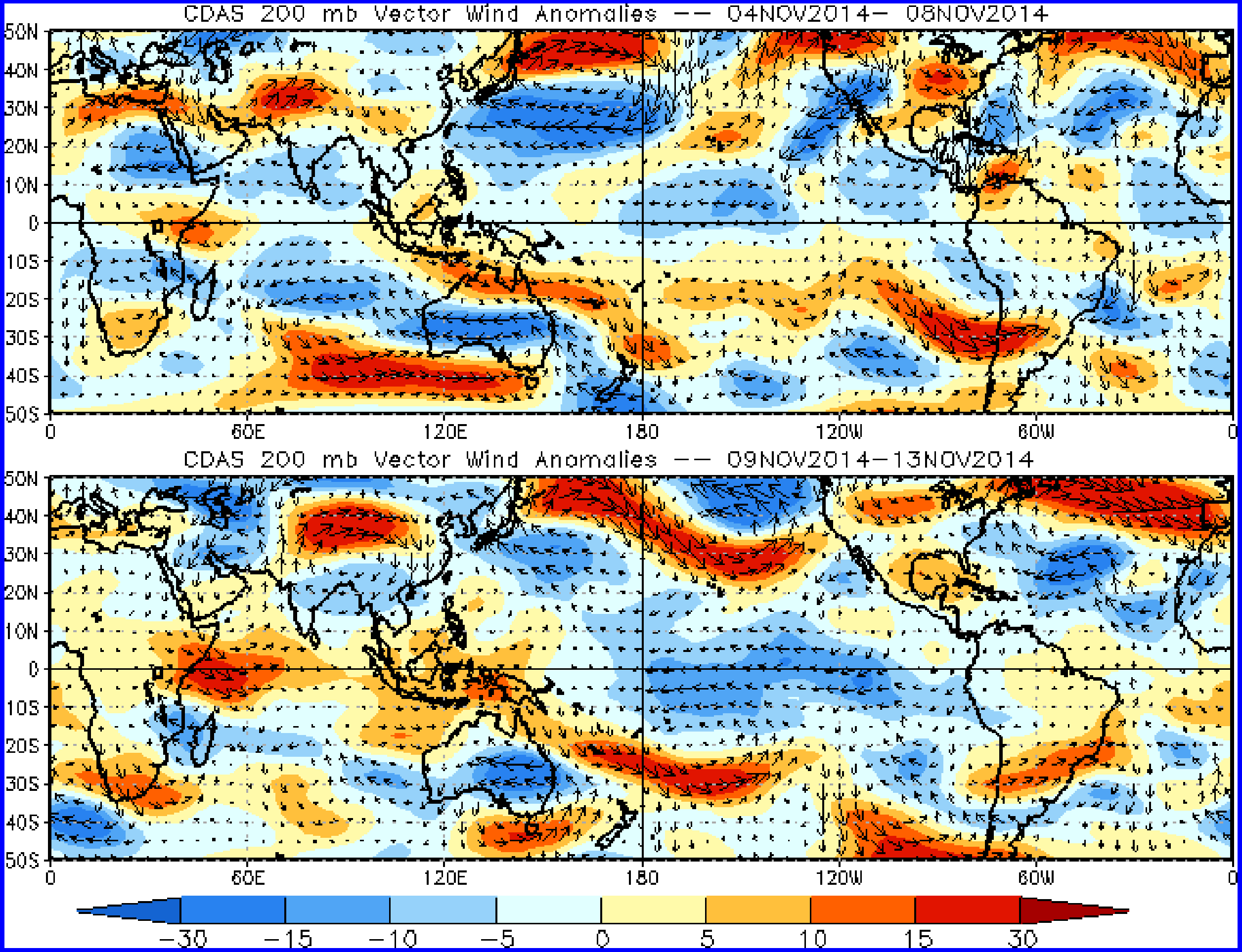
The upper-level anomalous velocity potential spatial pattern has become more coherent, with negative (generally positive) anomalies observed over the central and eastern Pacific (the Indian Ocean, and the Maritime Continent). A less coherent pattern remains over the Western Hemisphere.

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



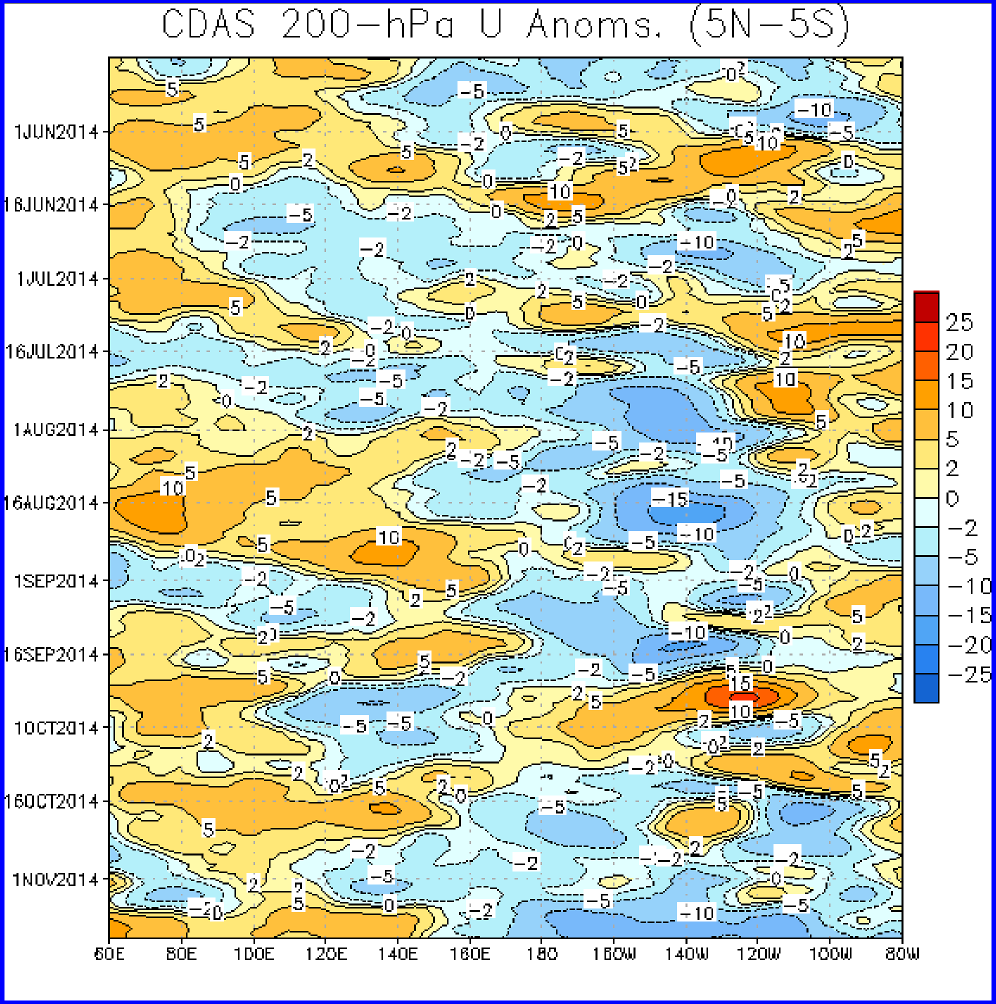
Westerly (easterly) anomalies were observed over the Western Hemisphere, Indian Ocean, and Maritime Continent (central and eastern Pacific).

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



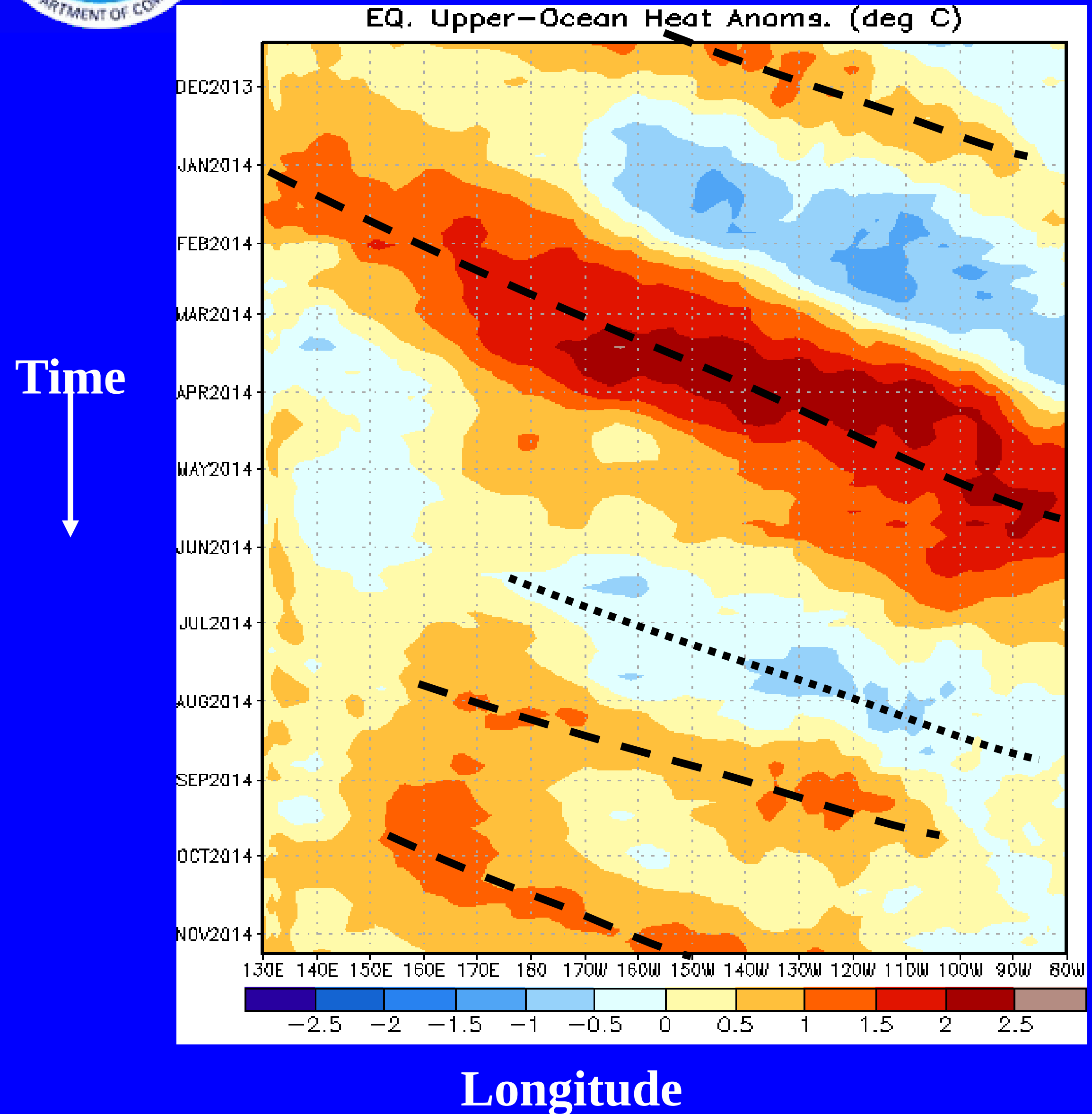
Longitude

Westward propagation of westerly anomalies is evident over the east-central Pacific during June. In July, easterly anomalies intensified over the central and eastern Pacific.

A slow, eastward progression of westerly anomalies is evident over the Maritime Continent and western Pacific during August. Some westward propagation is noticeable during September and early October.

More recently, a more coherent Wave-1 structure has emerged, with westerly (easterly) anomalies from Africa through the Maritime Continent (central and eastern Pacific).

Weekly Heat Content Evolution in the Equatorial Pacific



Oceanic downwelling Kelvin wave activity is evident during October through early December 2013.

A considerably stronger downwelling event began in January 2014 and propagated across the Pacific.

Warm anomalies persisted over much of the Pacific during April and May, though basin-averaged anomalies decreased during June associated with upwelling Kelvin wave activity (dotted line).

Warm anomalies are again evident across much of the Pacific due to another 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).

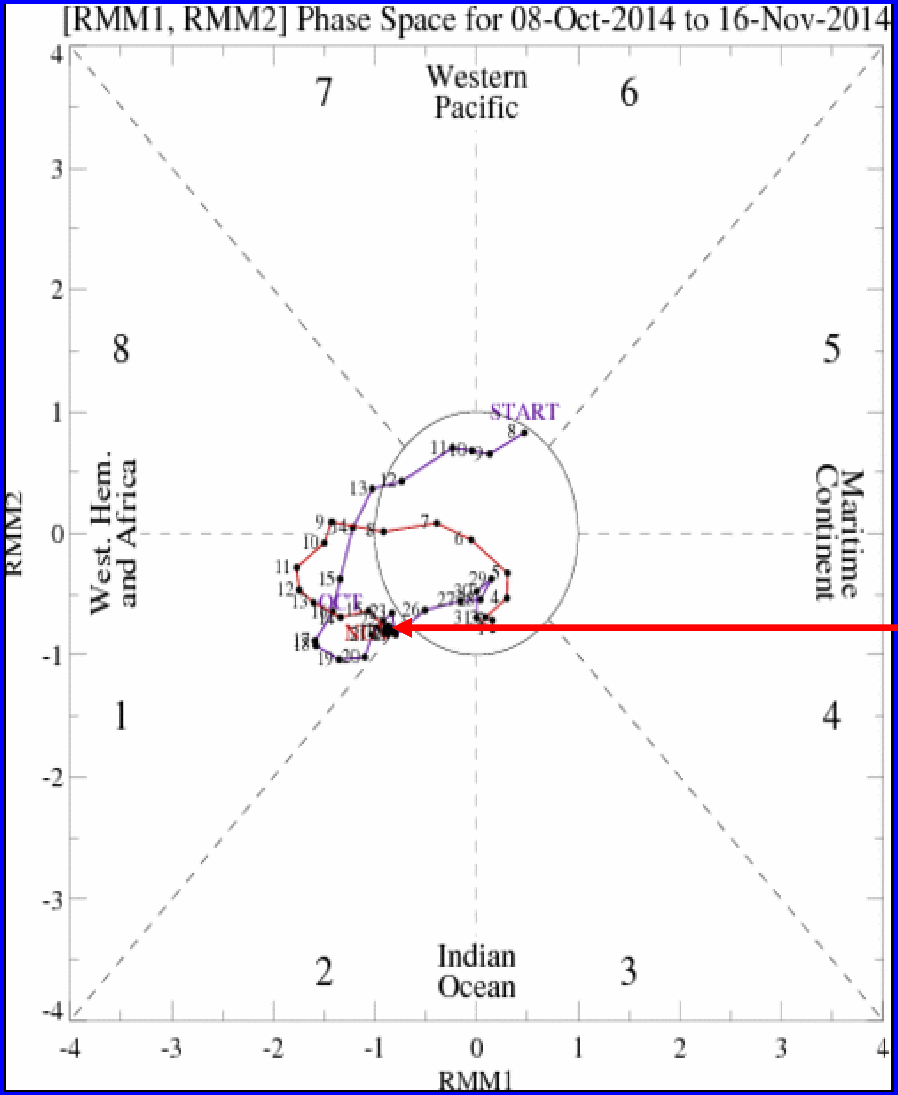
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

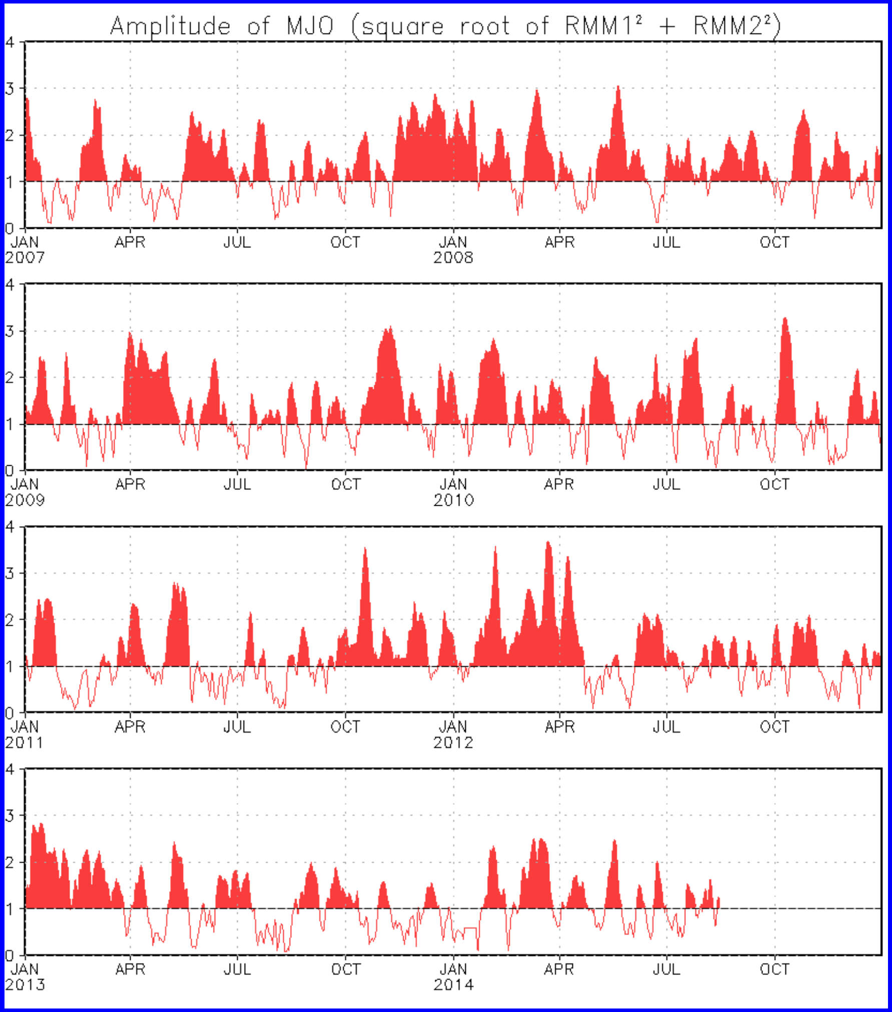
MJO Index -- Recent Evolution



- 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 RMM MJO index depicts eastward propagation of an MJO signal over the western Hemisphere and Africa during the past week.

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.

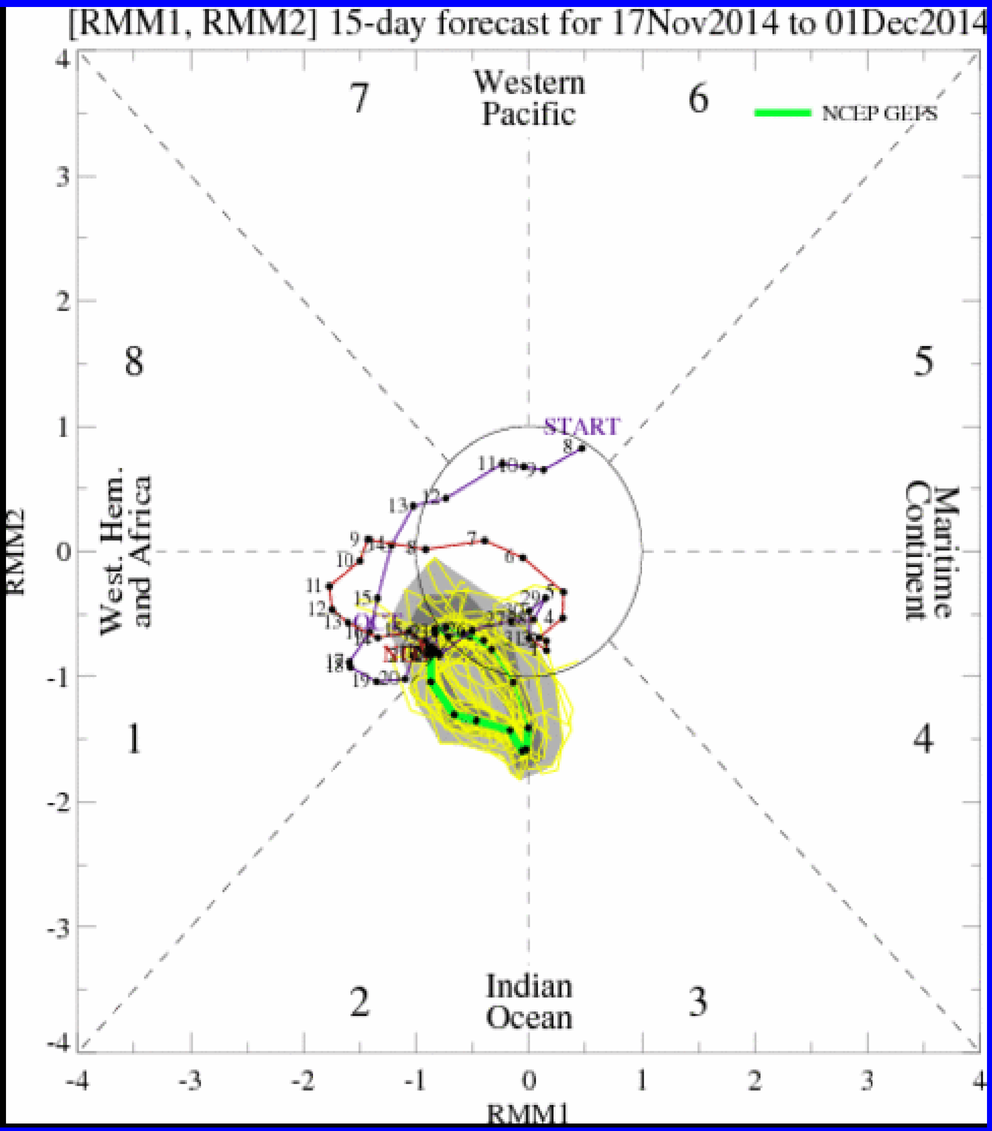
Ensemble GFS (GEFS) MJO Forecast

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

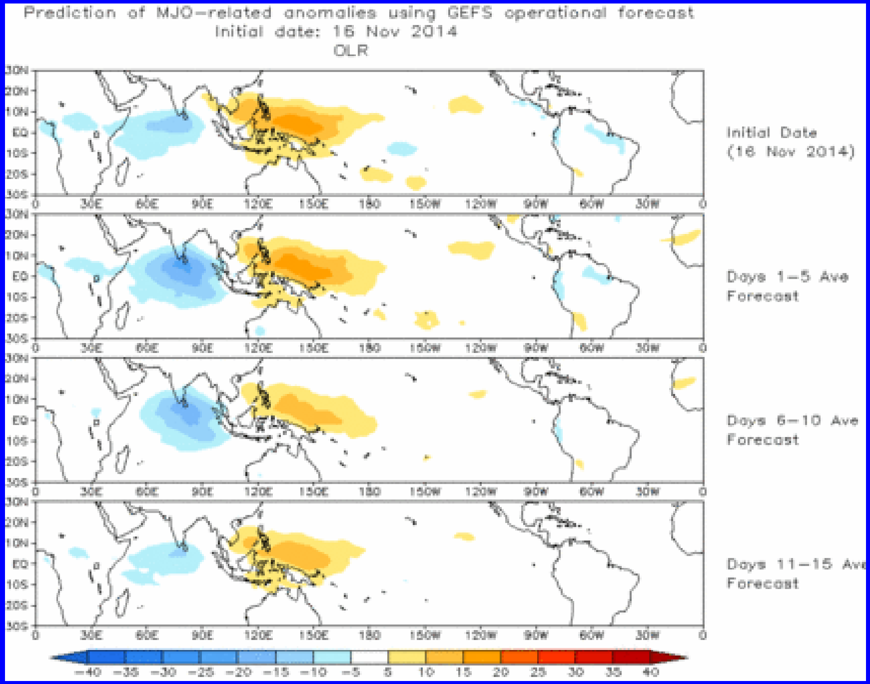
The ensemble GFS forecast indicates a continued eastward propagation of the MJO signal over the western Indian Ocean during Week-1, with weakening of the signal during Week-2.



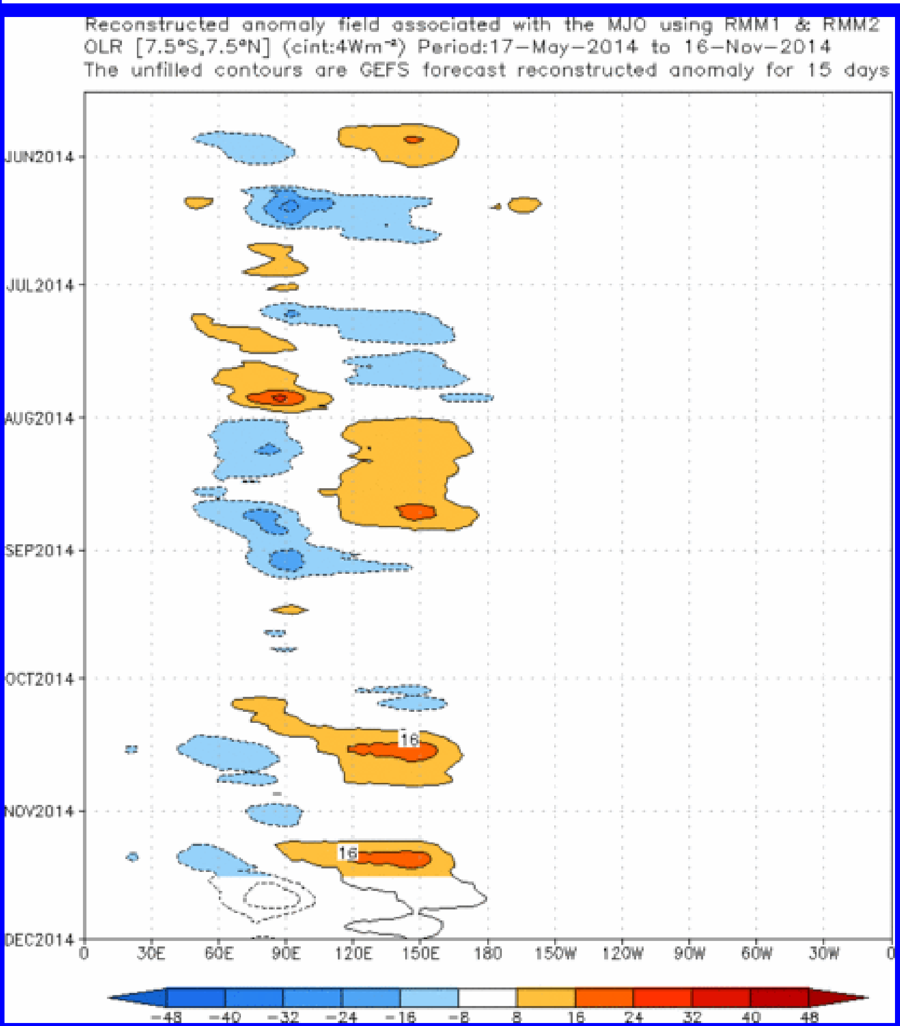
Ensemble Mean GFS MJO Forecast

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

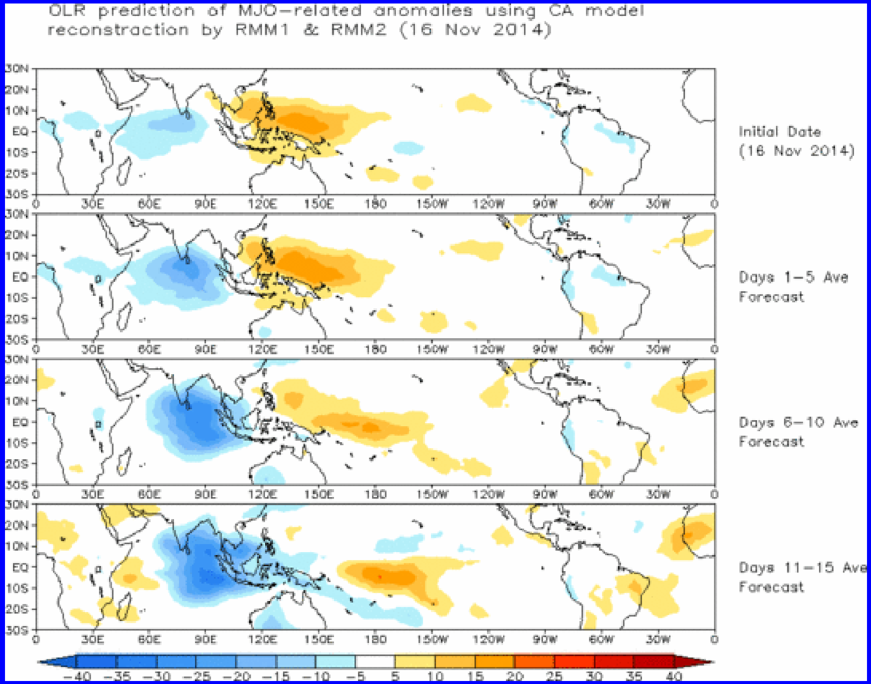


The ensemble mean GFS RMM Index based OLR anomaly forecast depicts robust anomalies over the Indian Ocean and western Pacific during Week-1, with a weakening signal and no eastward propagation by Week-2.

Constructed Analog (CA) MJO Forecast

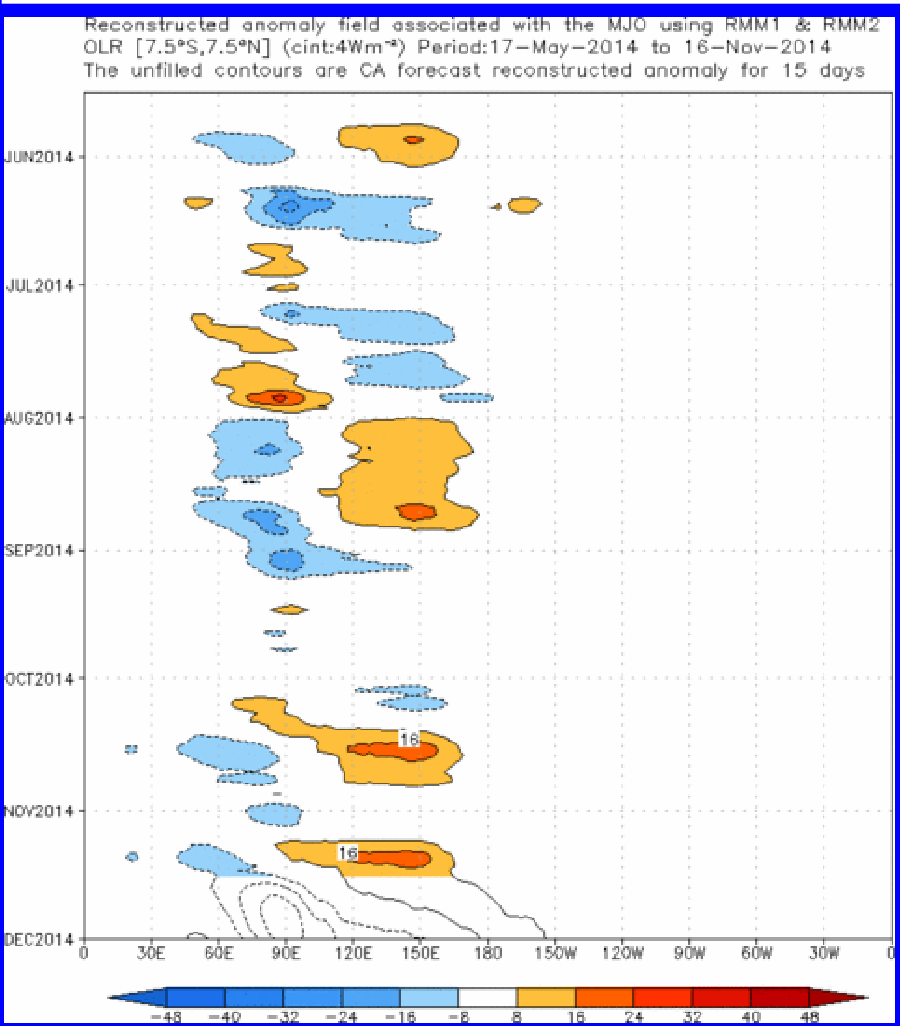
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



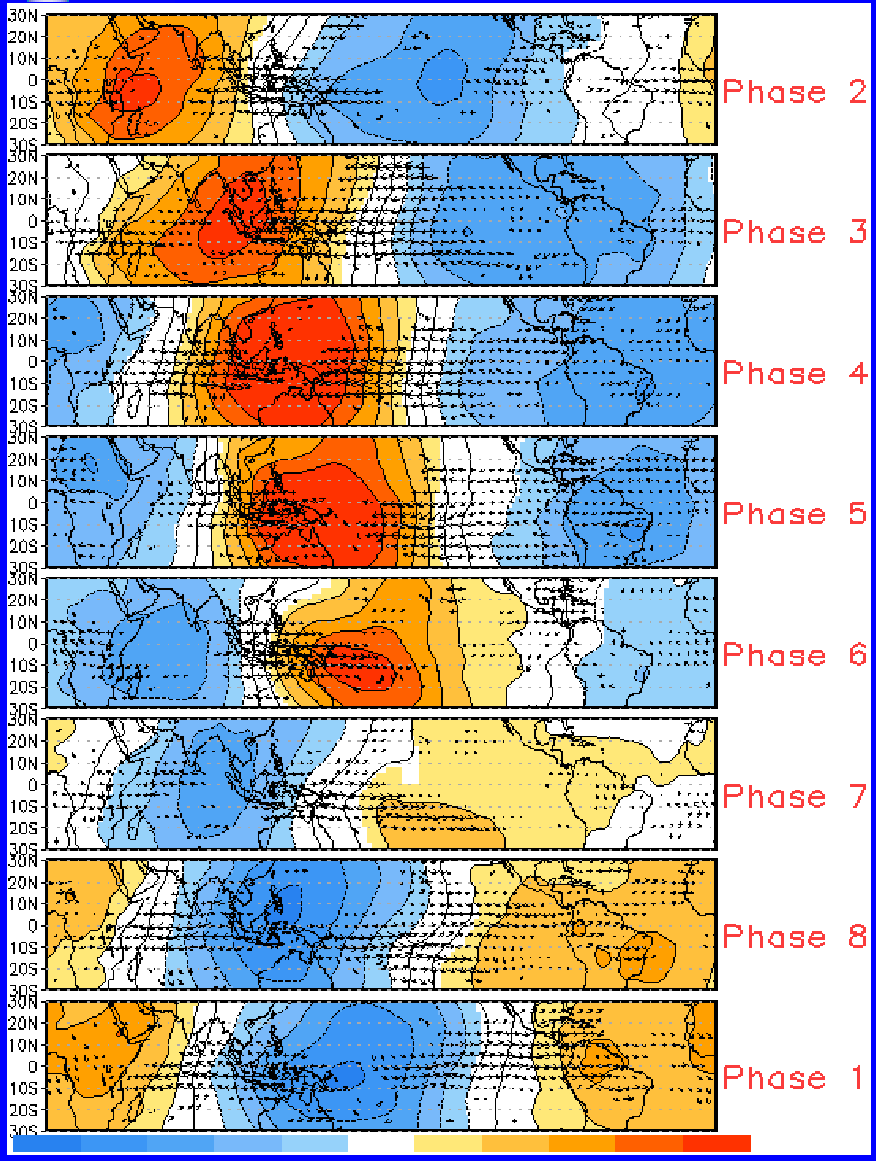
The constructed analog forecast depicts eastward propagation of an MJO signal over the Indian Ocean.

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

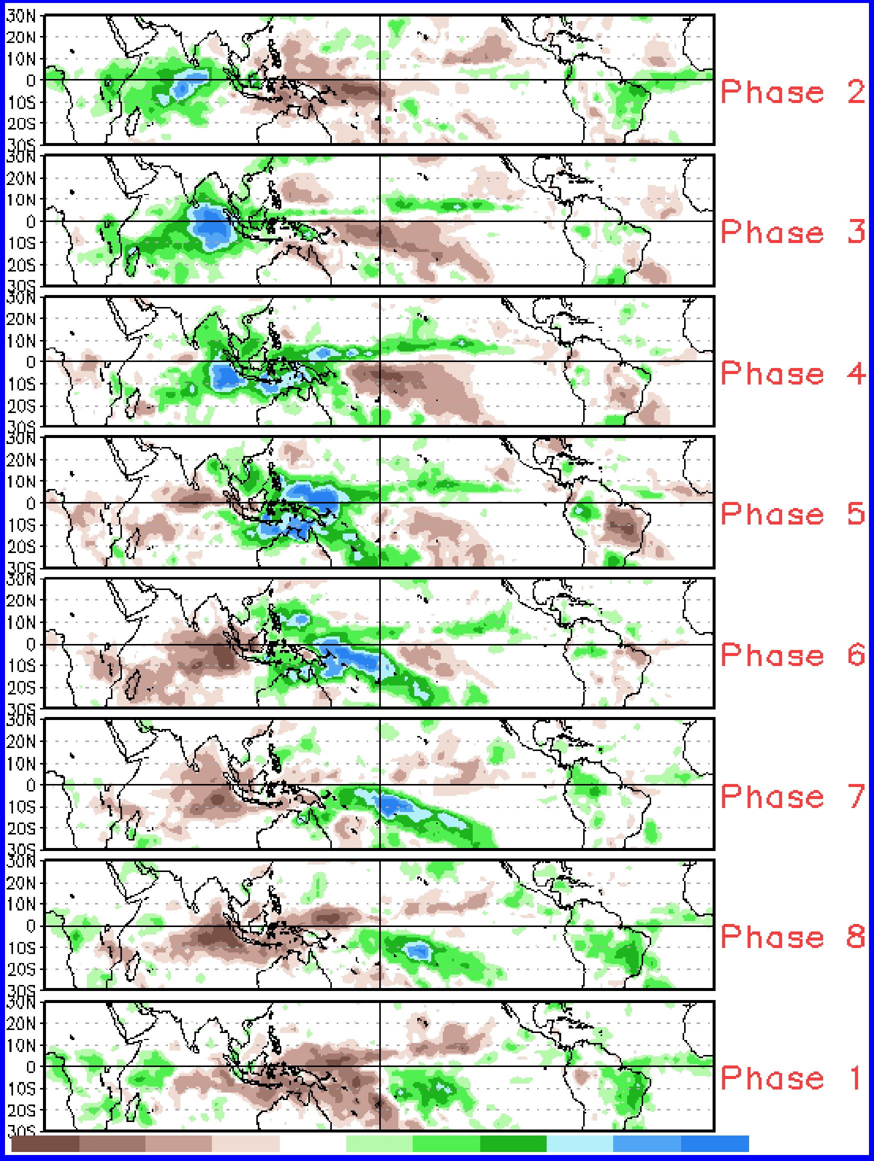


MJO Composites – Global Tropics

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

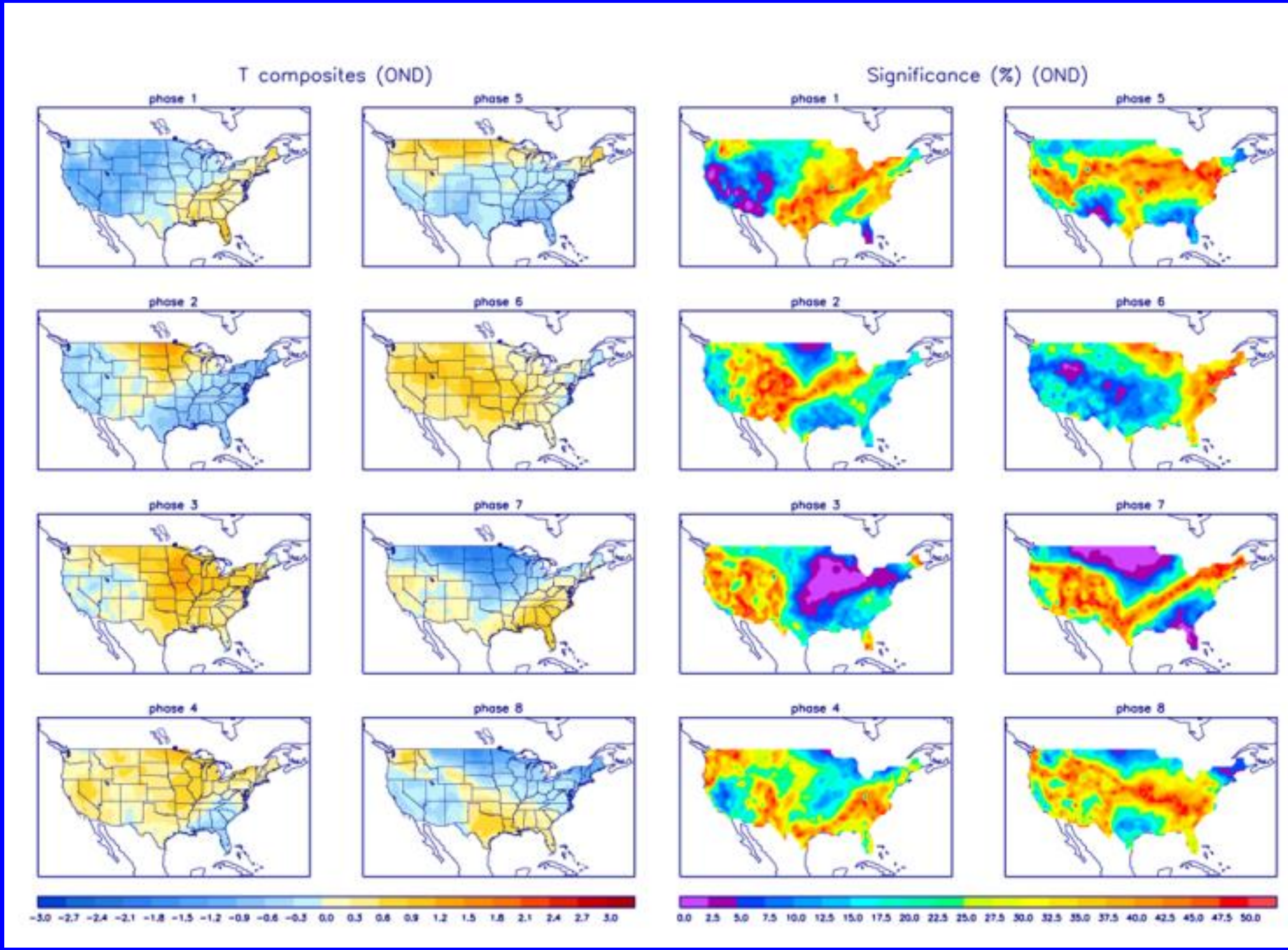


Precipitation Anomalies (May-Sep)



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.**

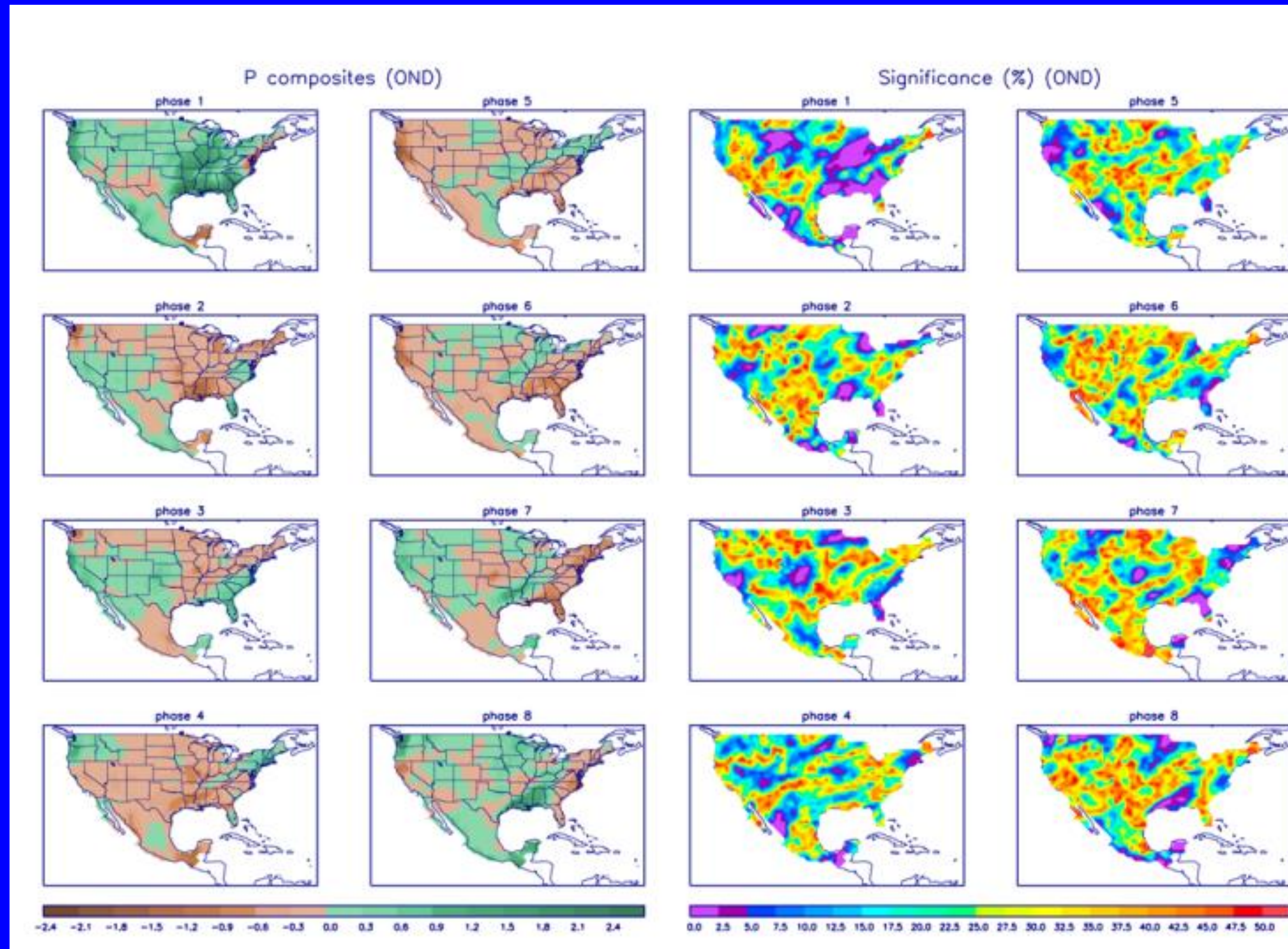


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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