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

Update prepared by
Climate Prediction Center / NCEP
November 4, 2013

Outline

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

Overview

- The MJO remained generally weak during the past week, though there has been some reorganization of late with enhanced convection centered across parts of the Americas and the Atlantic.
- Dynamical model MJO index forecasts generally indicate little propagation of a coherent signal. However, statistical tools support a more robust MJO signal propagating into the Indian Ocean over the next two weeks.
- Based on recent observations, statistical tools, and some dynamical MJO index forecasts, the MJO is forecast to remain fairly weak but coherent, with the enhanced phase moving into the Indian Ocean. Other types of subseasonal tropical variability are likely to influence the pattern of tropical convection and potentially interfere with any emerging MJO signal.
- The forecast evolution of the MJO favors enhanced convection from the Americas to parts of the Indian Ocean over the next two weeks. Likewise, the MJO would favor subsidence over parts of the central Pacific.

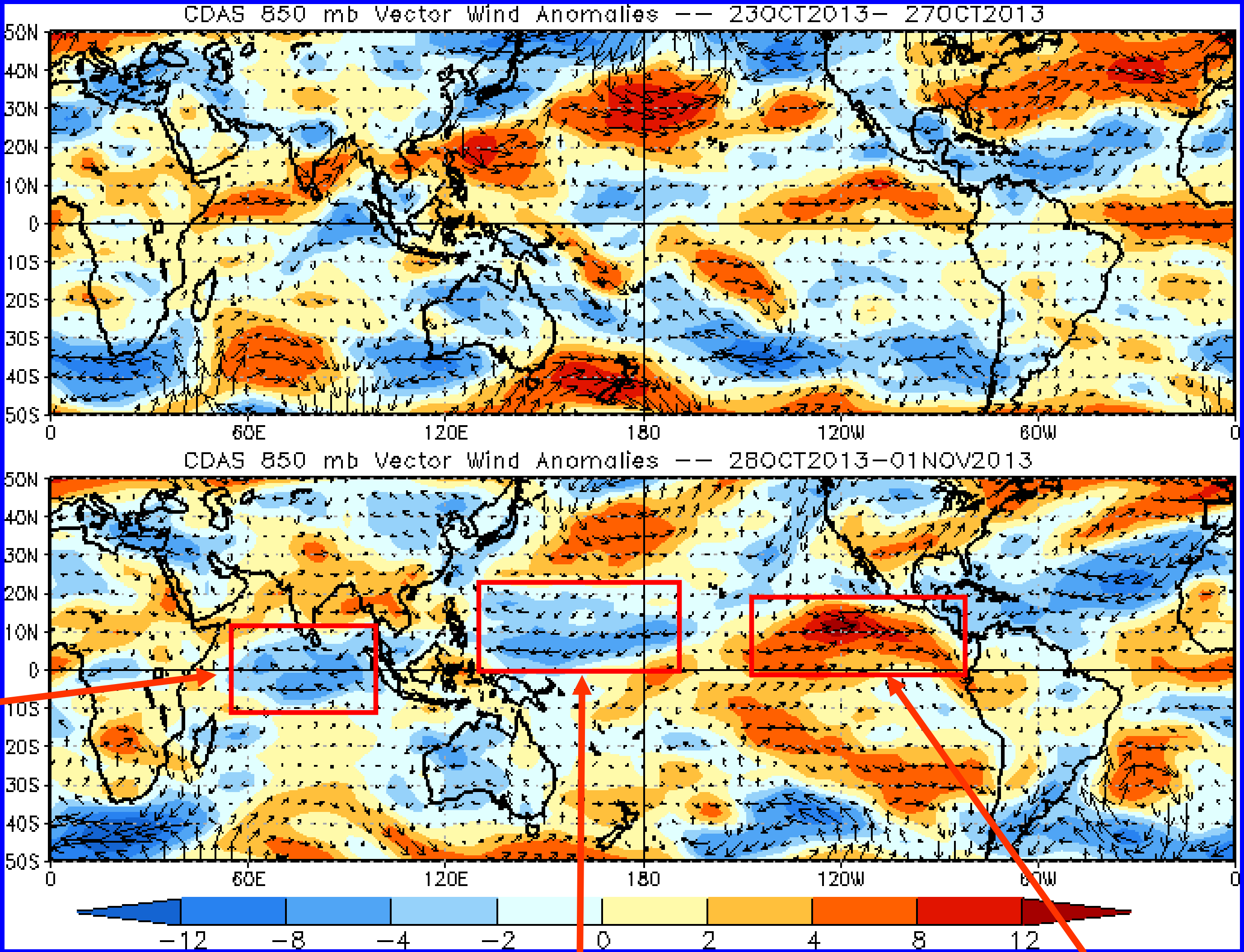
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies developed over the central Indian Ocean.

Easterly anomalies expanded westward across the West Pacific.

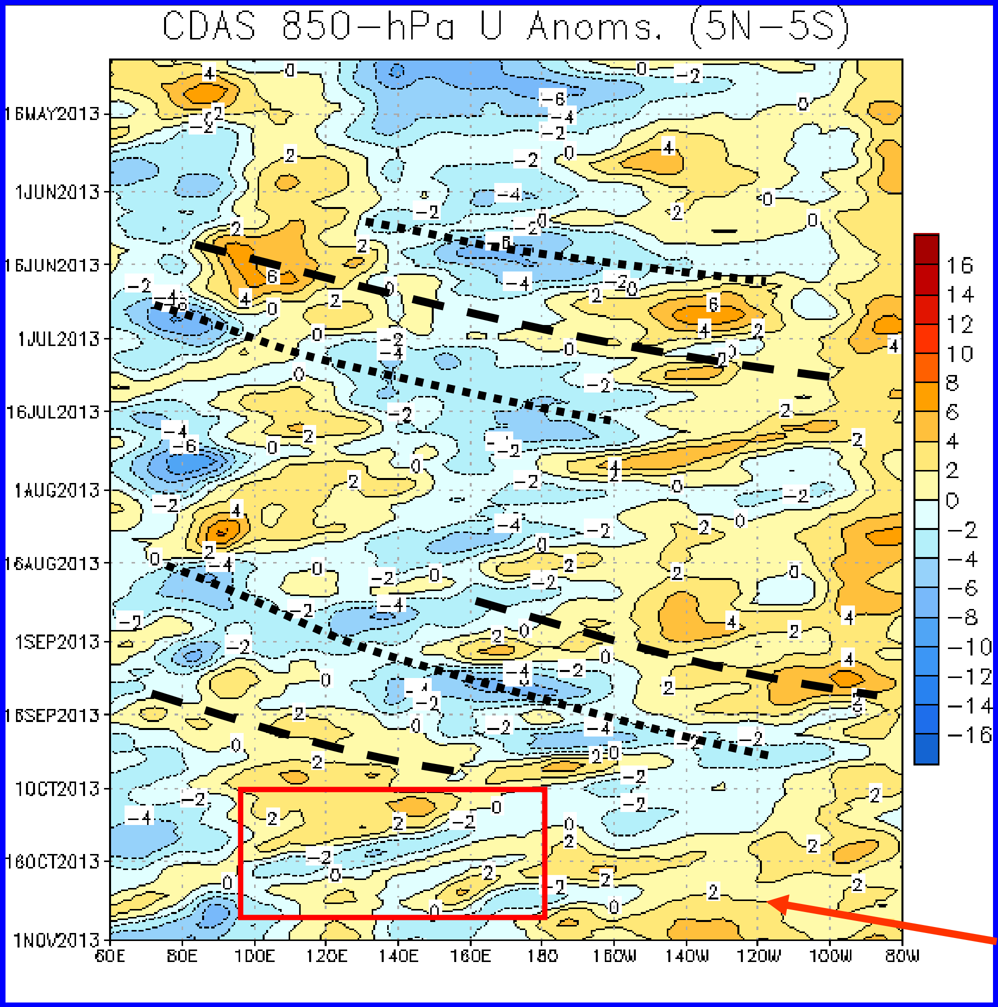
Westerly anomalies increased over the eastern Pacific during the past five days.

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

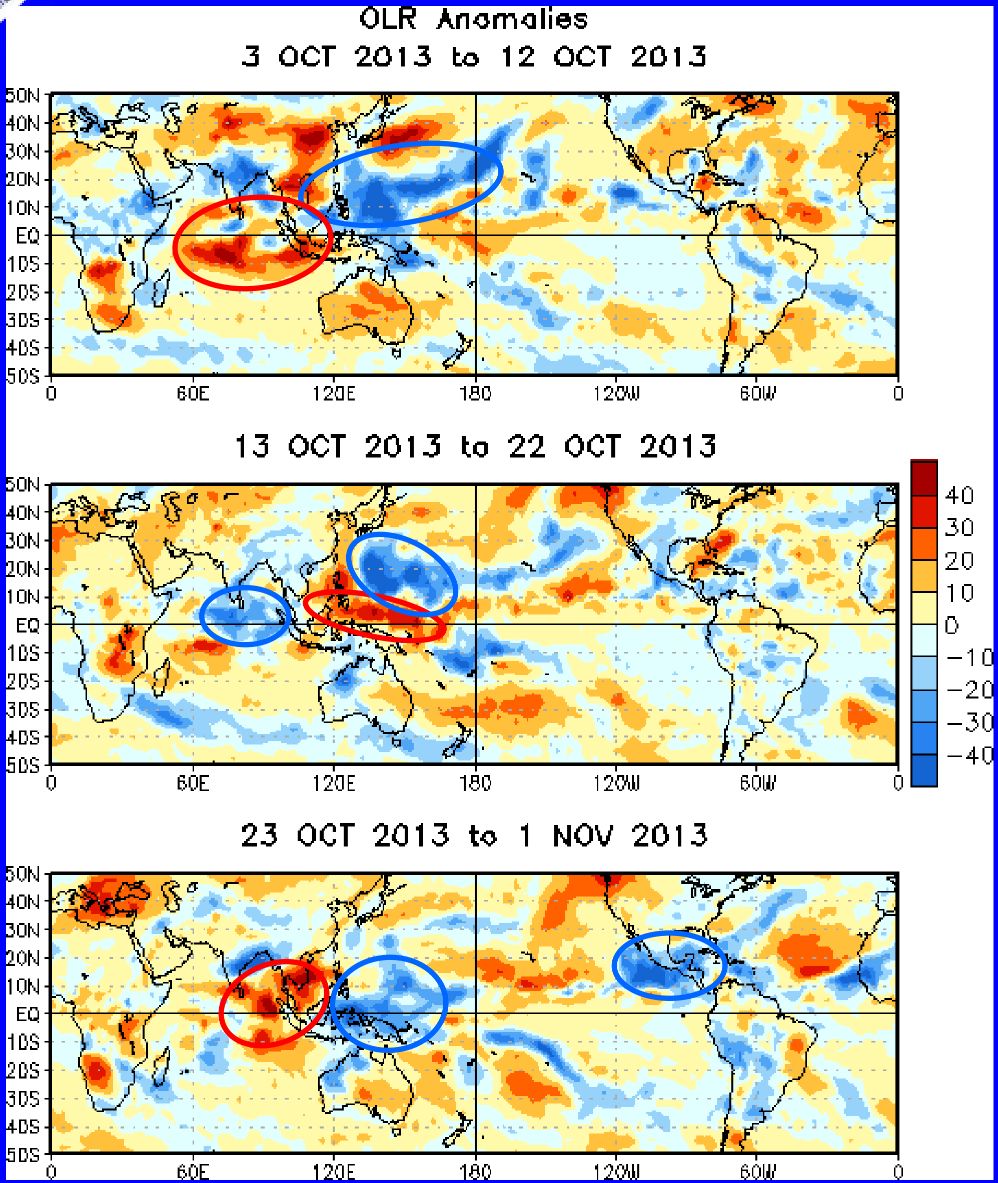
The MJO strengthened during June and continued until mid-July with fast eastward propagation.

During late July through mid-August, other types of subseasonal variability strongly contributed to the observed anomalies as the MJO was weak. In late August and early September, westerly (easterly) anomalies increased over the eastern (western) Pacific in associated with renewed MJO activity.

During October, equatorial Rossby wave activity was strong from 160E to 100E as westward movement features are evident (red box). MJO activity was less coherent during this period.

Westerly anomalies persisted across the Western Hemisphere during the second half of October.

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 October, suppressed convection expanded over the Indian Ocean while enhanced convection was evident across the West Pacific, largely associated with tropical cyclone activity.

Suppressed convection shifted eastward across the equatorial Maritime Continent during mid-October, while the tropical cyclones remained active across parts of the West Pacific. Convection also increased the Indian Ocean.

During late October, enhanced (suppressed) convection was observed across parts of the eastern Maritime Continent and West Pacific (eastern Indian Ocean and parts of the western Maritime Continent). Anomalous convection developed across the east Pacific and Central America.

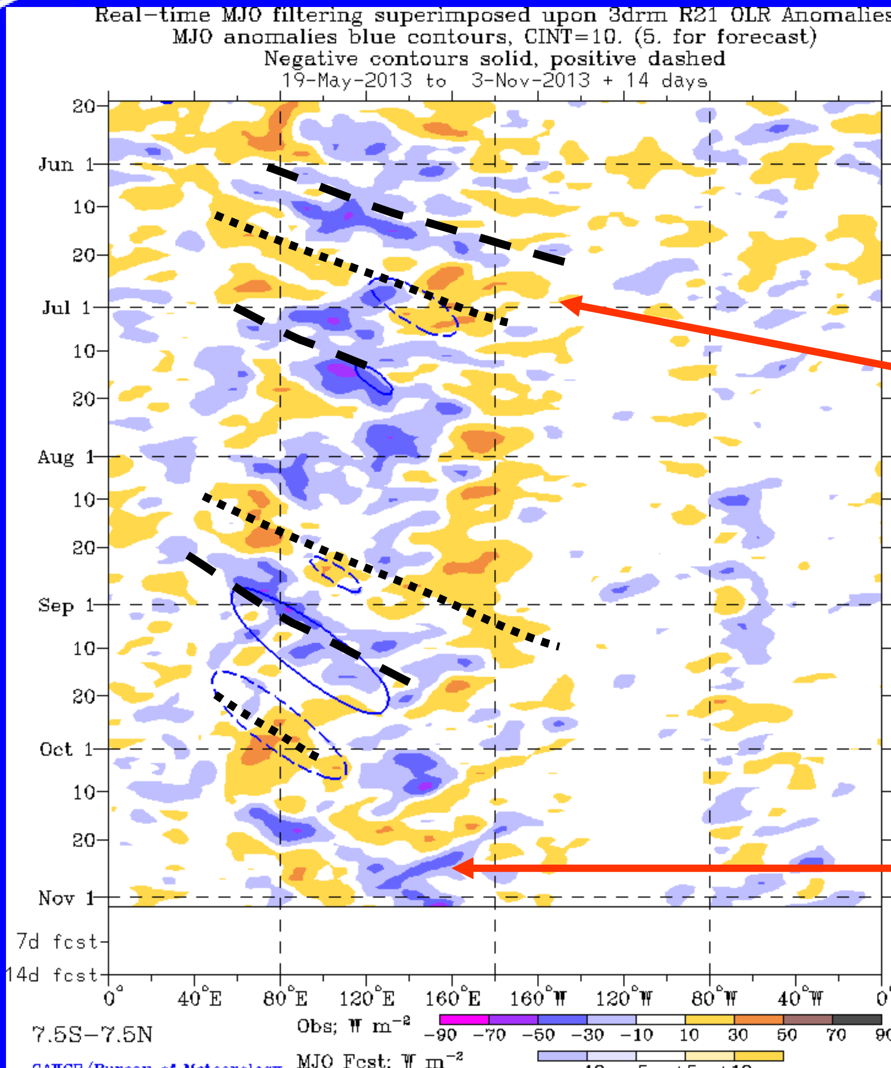
Outgoing Longwave Radiation (OLR) Anomalies (7.5°N-7.5°N)

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)

Time



Longitude

The MJO strengthened once again during June and continued into early July.

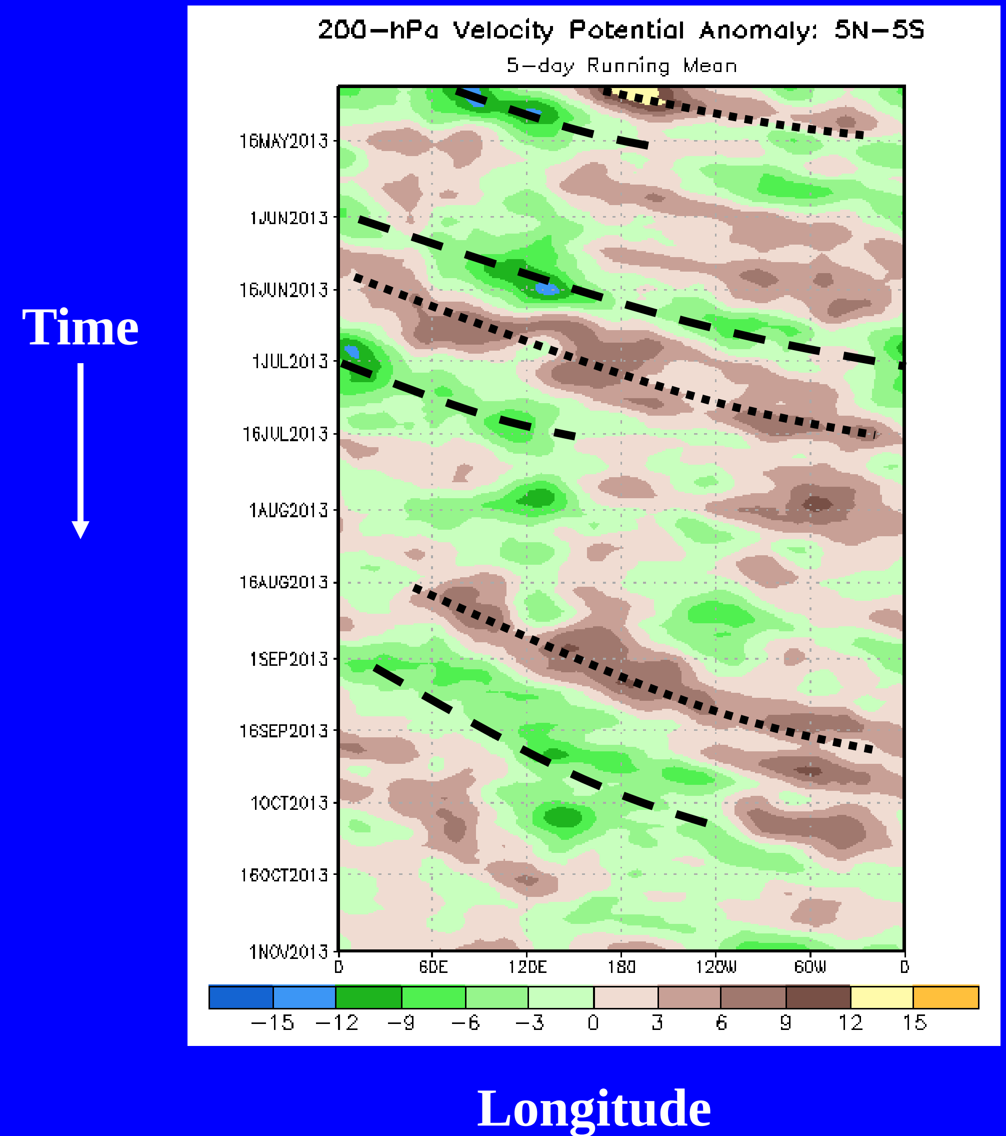
MJO was active during late August and September with the enhanced phase propagating eastward over the western Pacific Ocean, while the suppressed phase strengthened over the Indian Ocean.

Tropical cyclone activity contributed to the persistence of enhanced convection across the West Pacific as well as a weakened suppressed phase further west.

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



The MJO was active during the early May 2013 period as shown by generally alternating positive (brown) and negative (green) anomalies with clear eastward propagation.

The MJO was less coherent during late May, then strengthened once again during June and the first half of July before weakening by the end of the month.

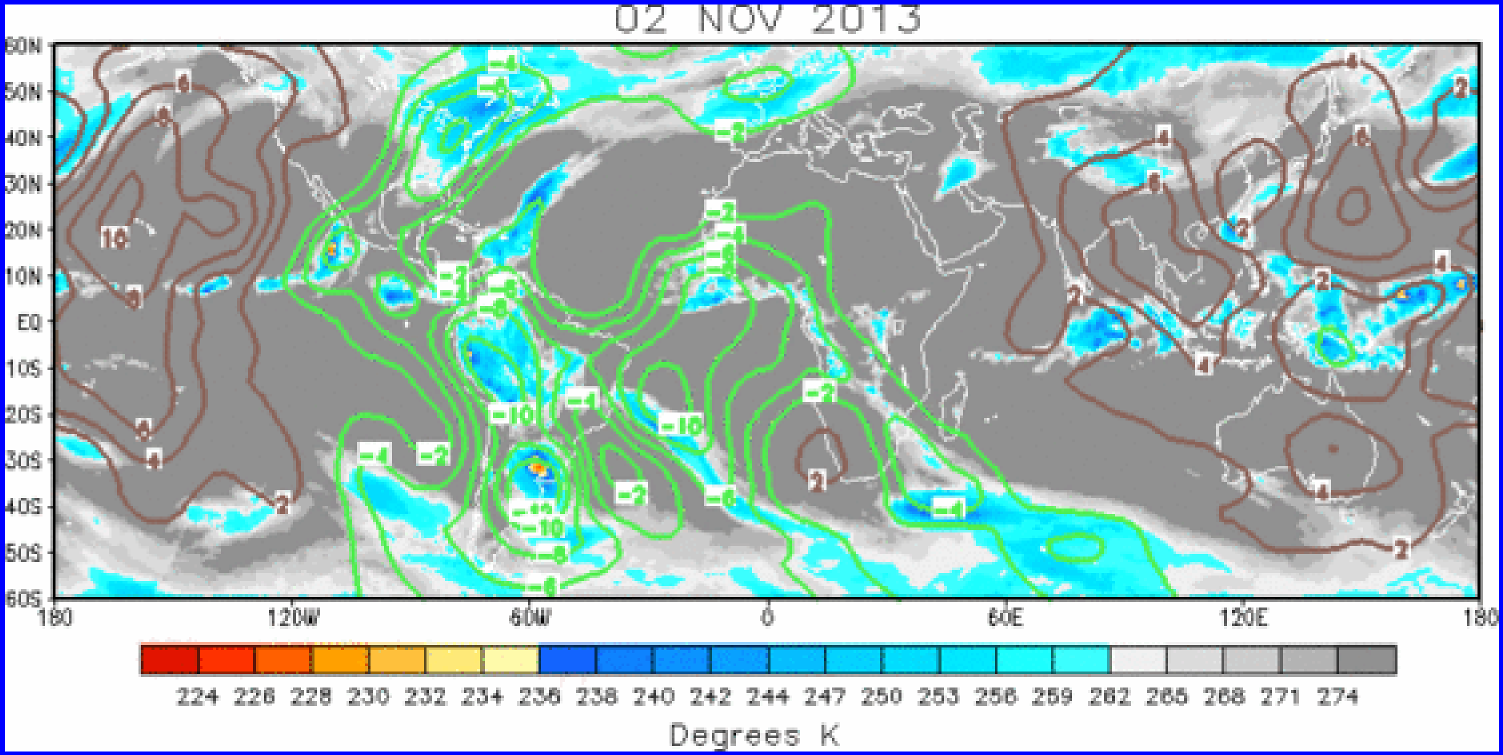
The MJO was not active during late July and much of August, but strengthened during late August and September, with eastward propagation of robust upper-level velocity potential anomalies. Other modes of tropical intraseasonal variability are also evident.

During the second half of October, upper-level velocity potential has exhibited little MJO related variability.

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

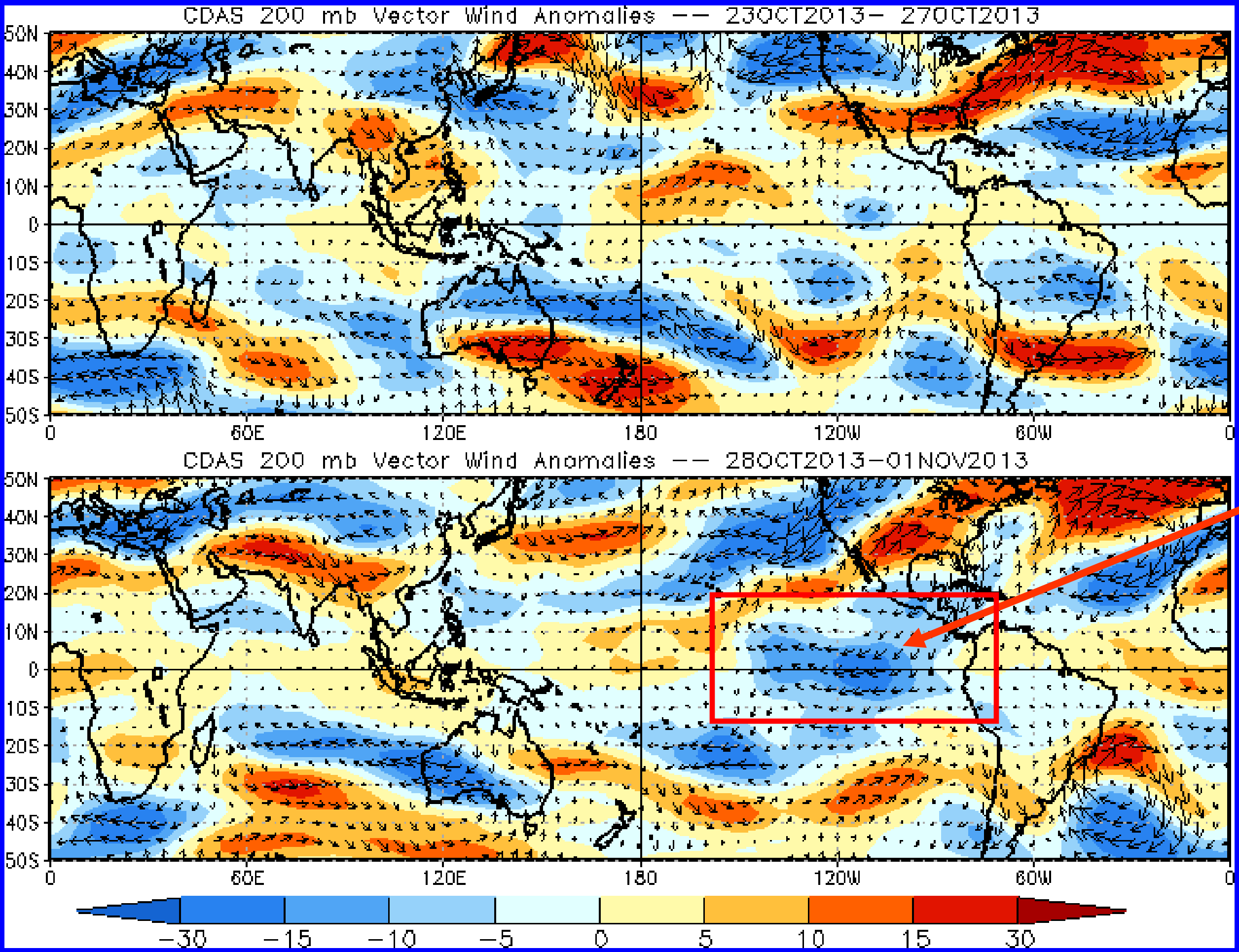
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The velocity potential pattern has reorganized in the past week, with a classic Wave-1 structure evident across the Tropics. It is unclear whether this pattern of upper-level convergence/divergence signals a reorganization of the MJO.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

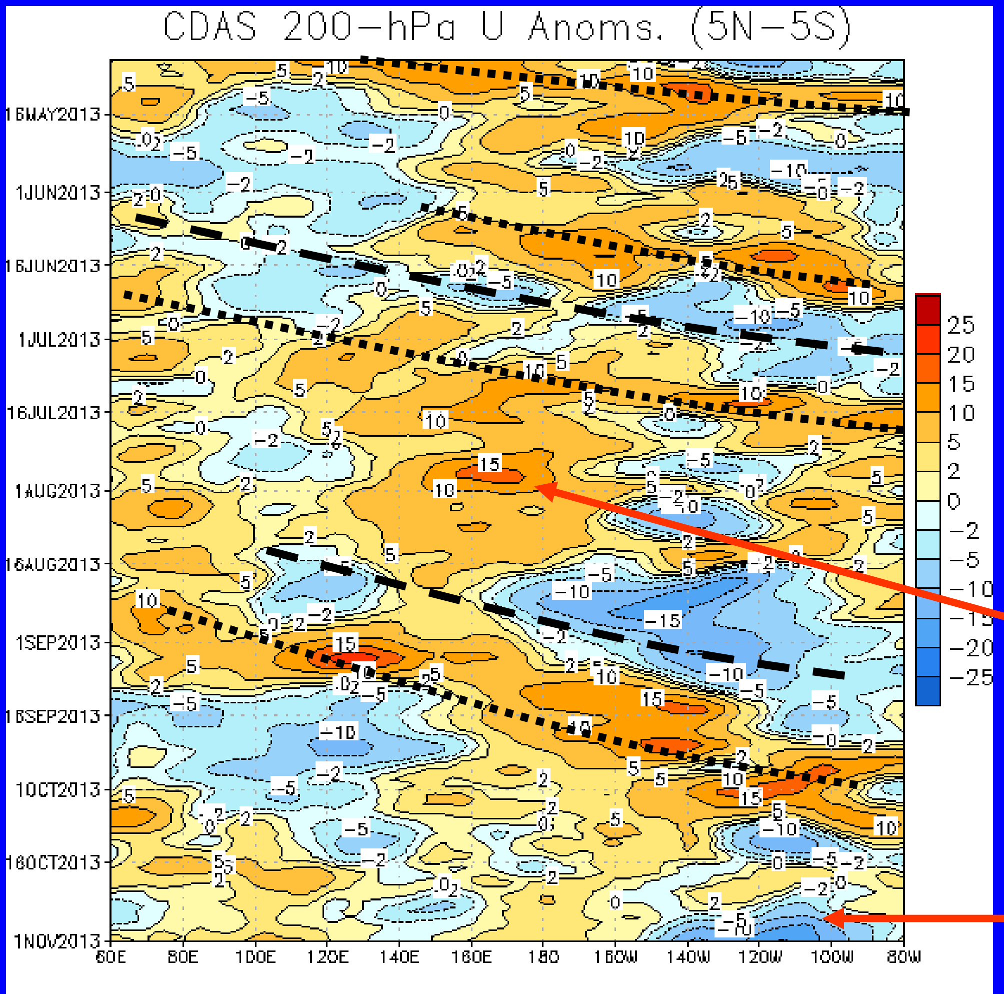
Easterly upper-level zonal wind anomalies have developed across the east Pacific during the past five days.

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

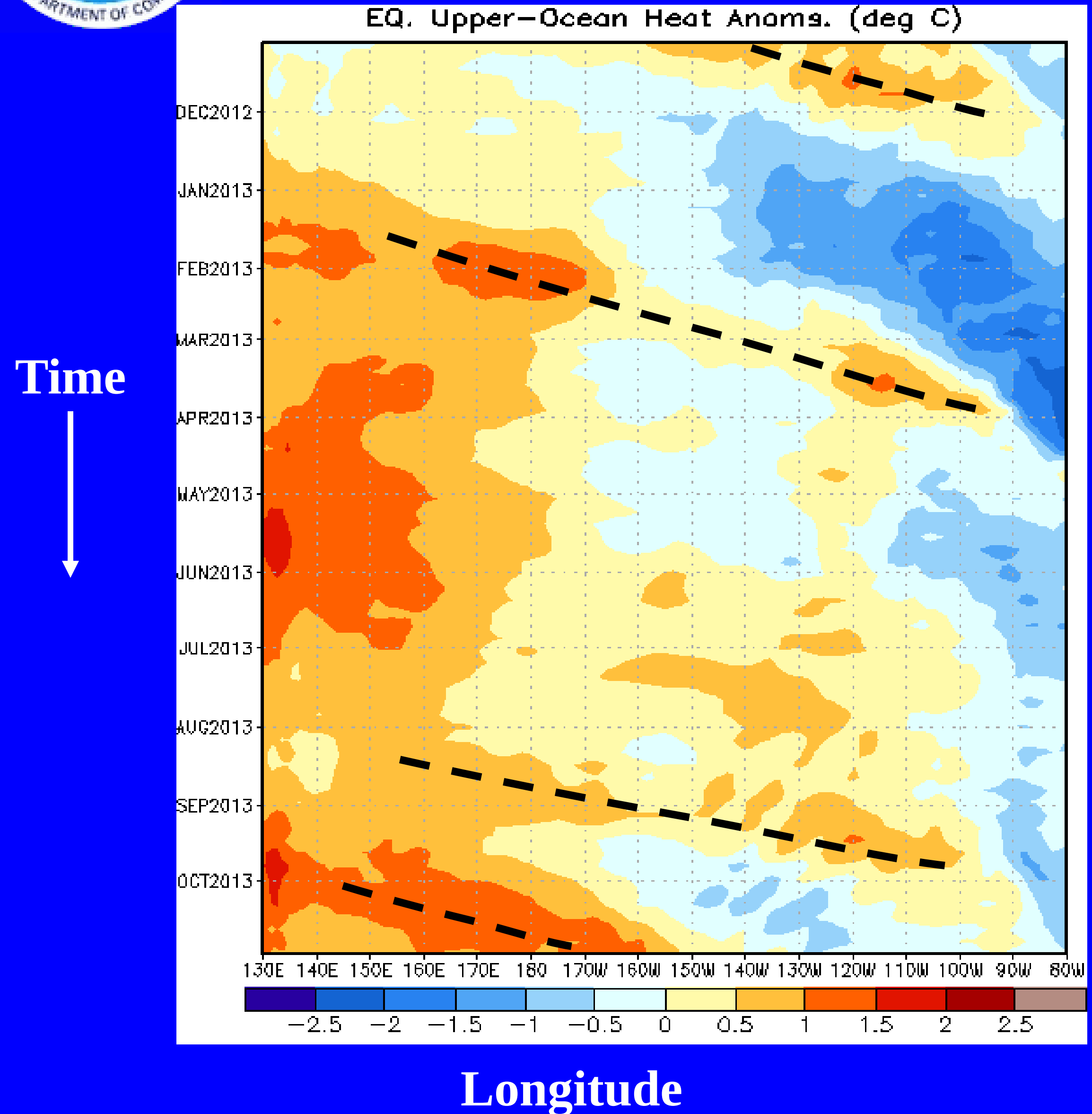
Eastward propagation of wind anomalies associated with the MJO (dotted and dashed lines) continued into May 2013.

The MJO strengthened during June and its influence continued to mid-July, as eastward propagation of wind anomalies associated with the MJO were again observed.

During August, westerly wind anomalies were generally persistent just west of the Date Line. Renewed MJO activity occurred during late August and September with westerly wind anomalies shifting east to the eastern Pacific.

Most recently, easterly anomalies have developed over the eastern Pacific.

Weekly Heat Content Evolution in the Equatorial Pacific



An oceanic downwelling Kelvin wave was initiated at the end of September and increased heat content across the central and eastern Pacific during October and November 2012.

Positive (negative) anomalies developed in the western (eastern) Pacific during January 2013 and persisted into early March. The influence of a downwelling oceanic Kelvin wave can be seen during late February and March as anomalies became positive in the east-central Pacific.

Evidence of an oceanic downwelling Kelvin waves are seen in late August and October.

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).

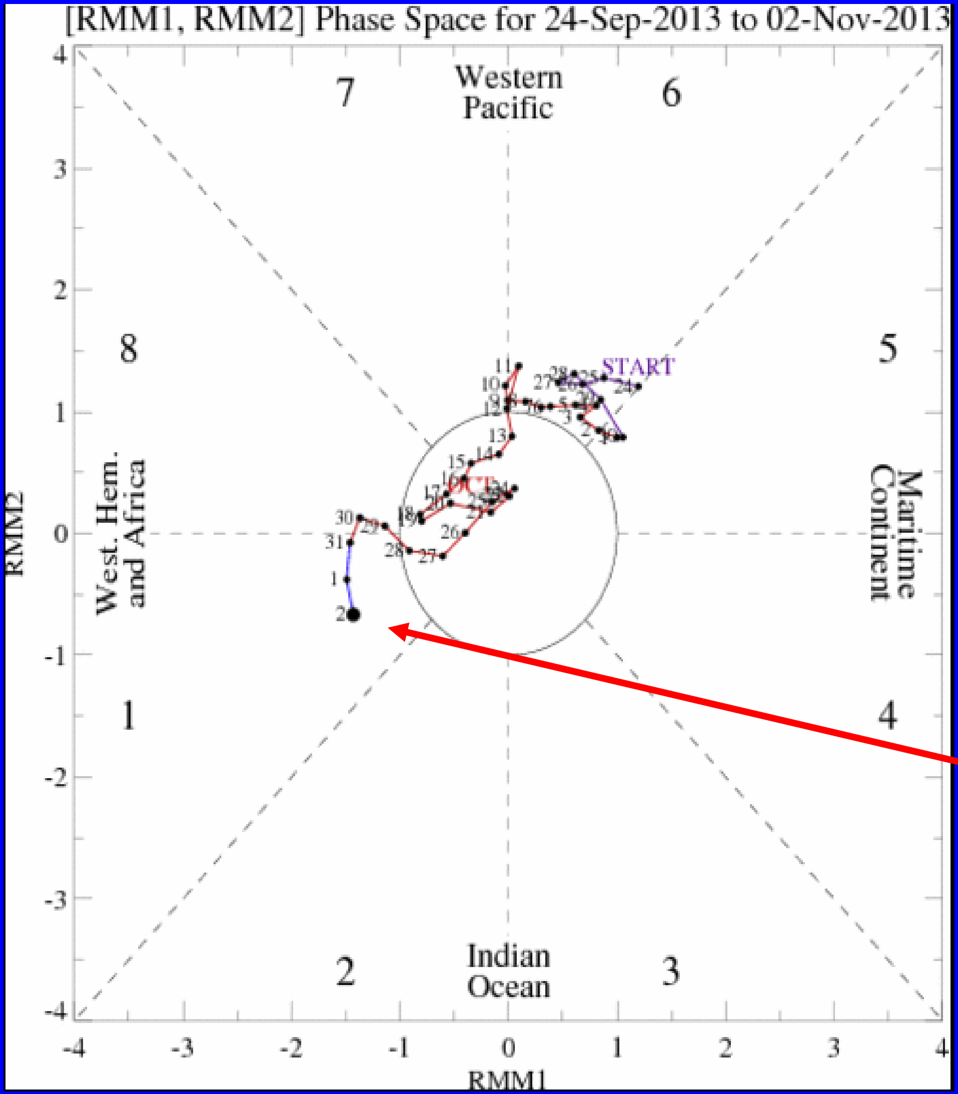
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

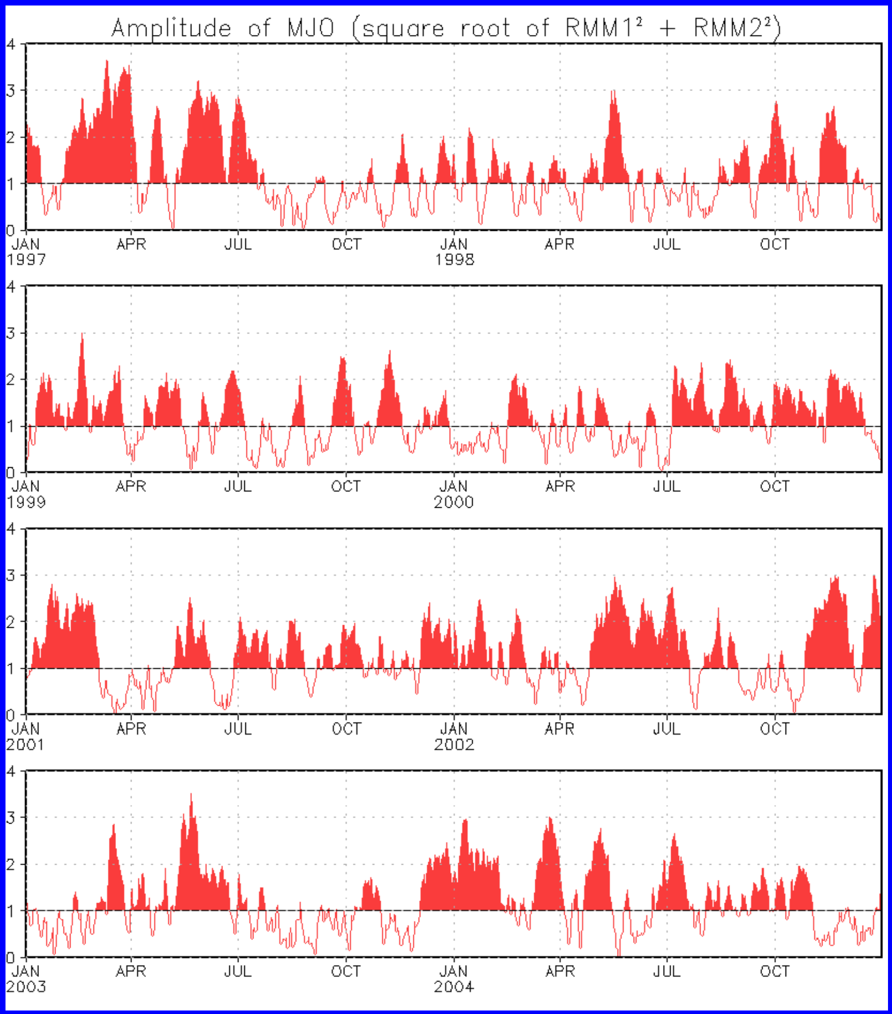
MJO Index -- Recent Evolution

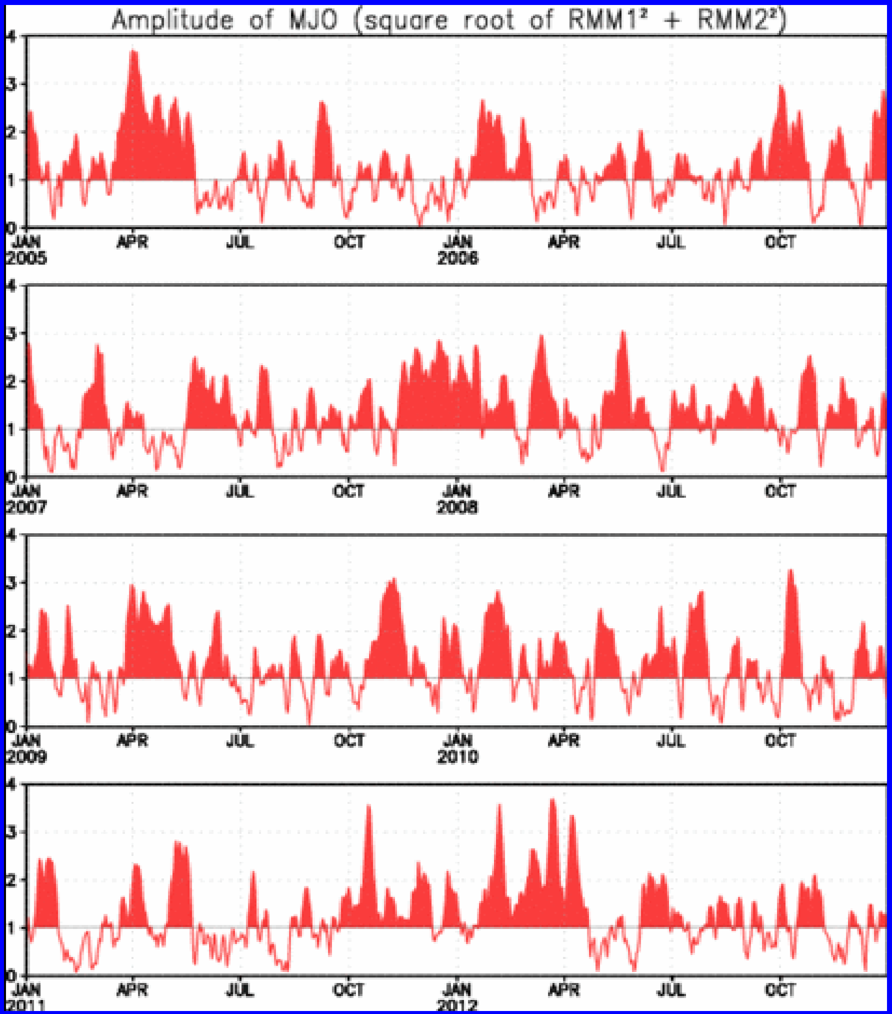


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index emerged in Phase 8 and has exhibited a more canonical eastward propagation than predicted by the dynamical models over the last few days.

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.

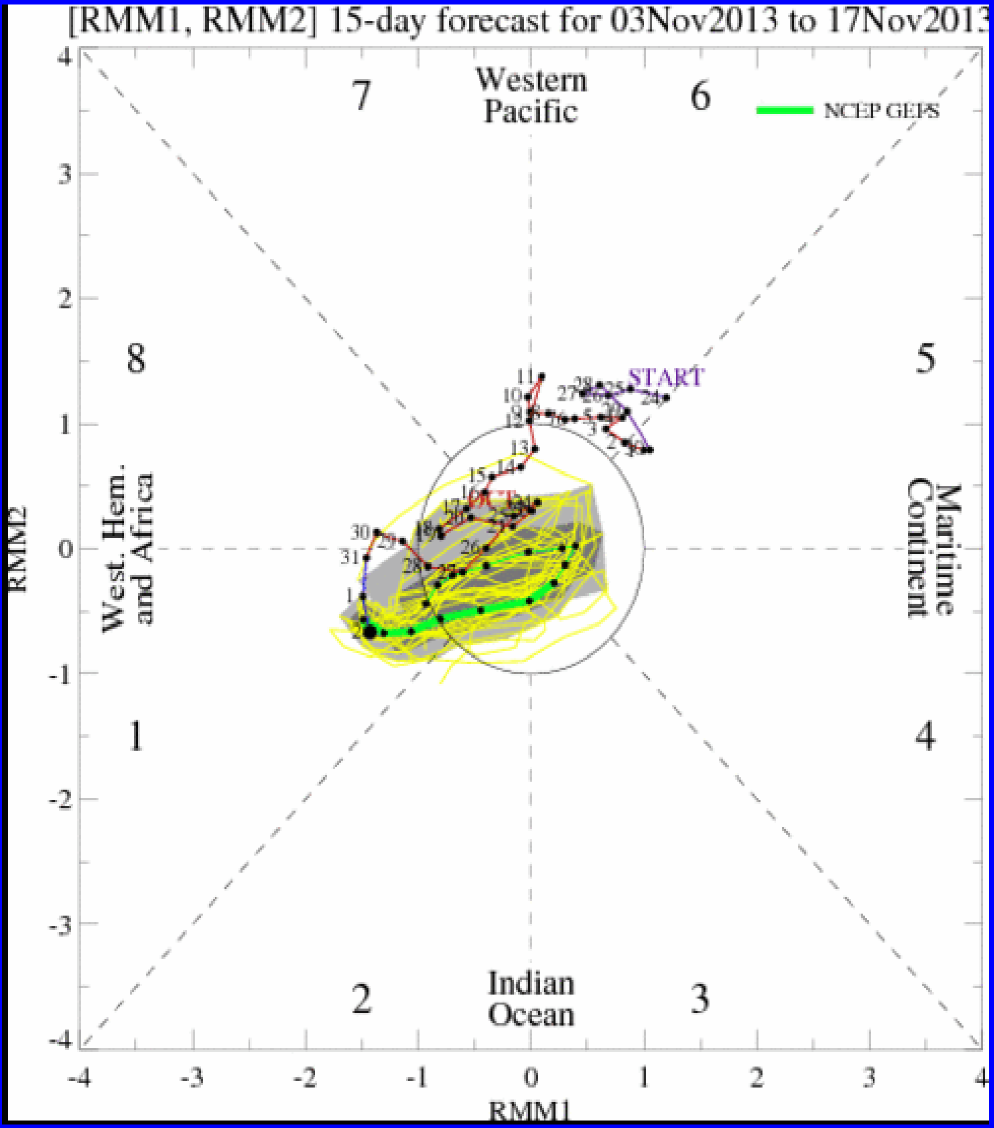
Ensemble GFS (GEFS) MJO Forecast

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

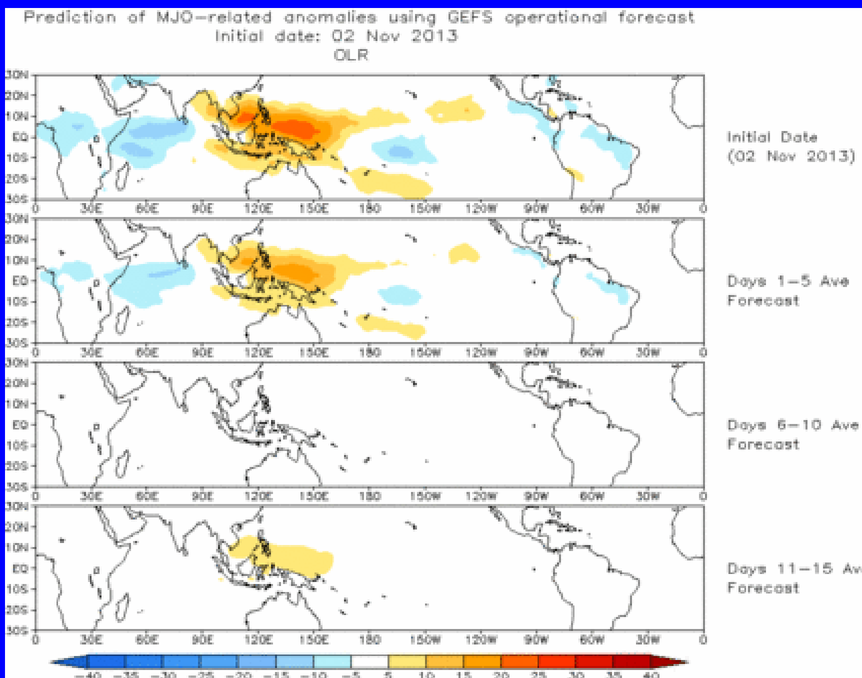
The ensemble GFS indicates a weakening MJO signal as eastward propagation continues over the next week. The forecast indicates a continued weak signal during Week-2.



Ensemble Mean GFS MJO Forecast

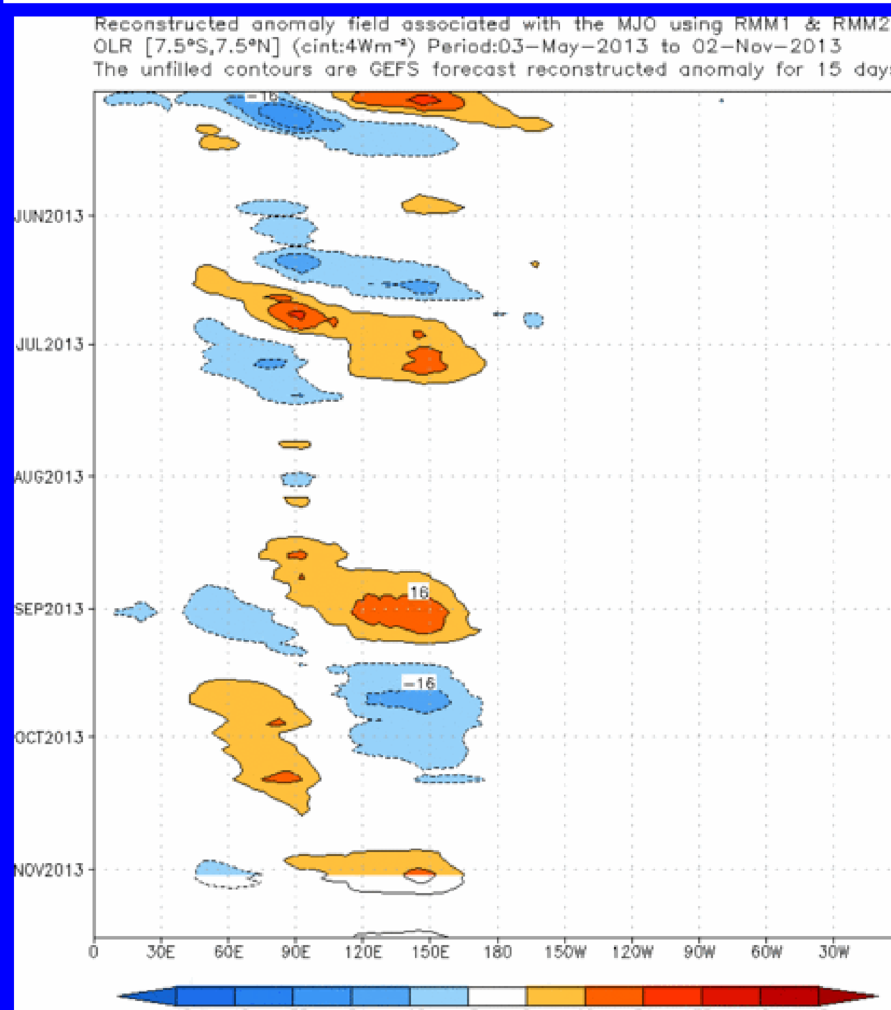
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecasts suppressed convection across the Maritime Continent slowly weakening over time with little overall propagation.

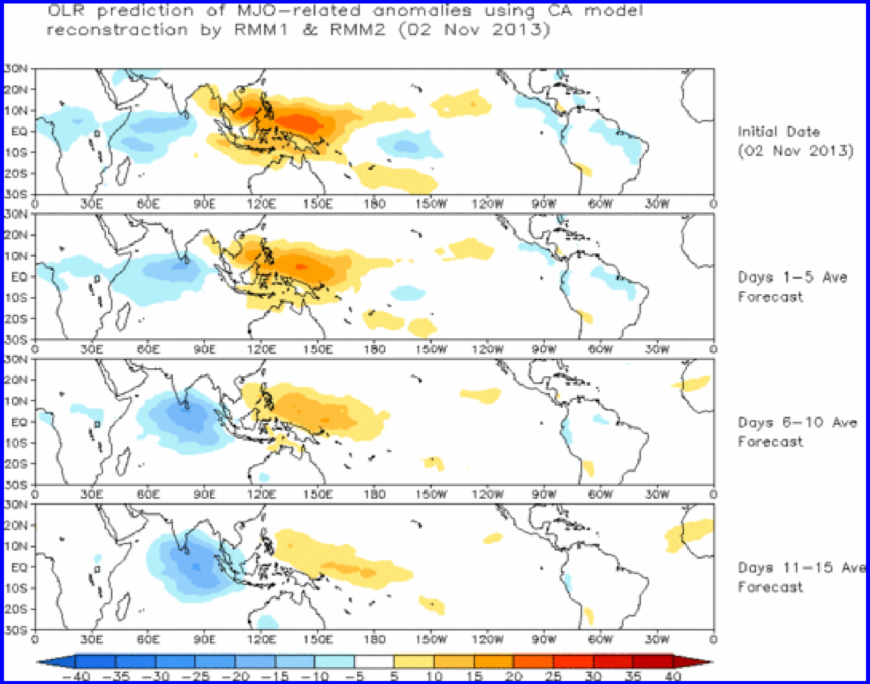
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

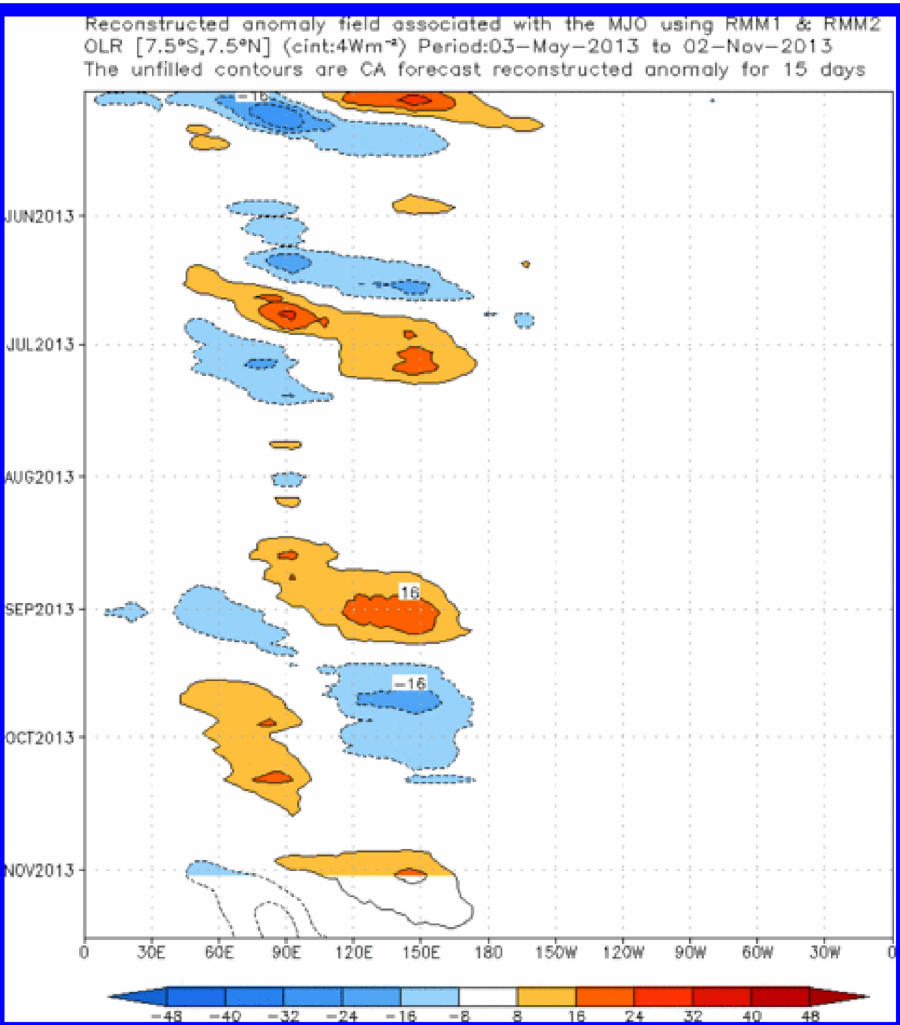
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



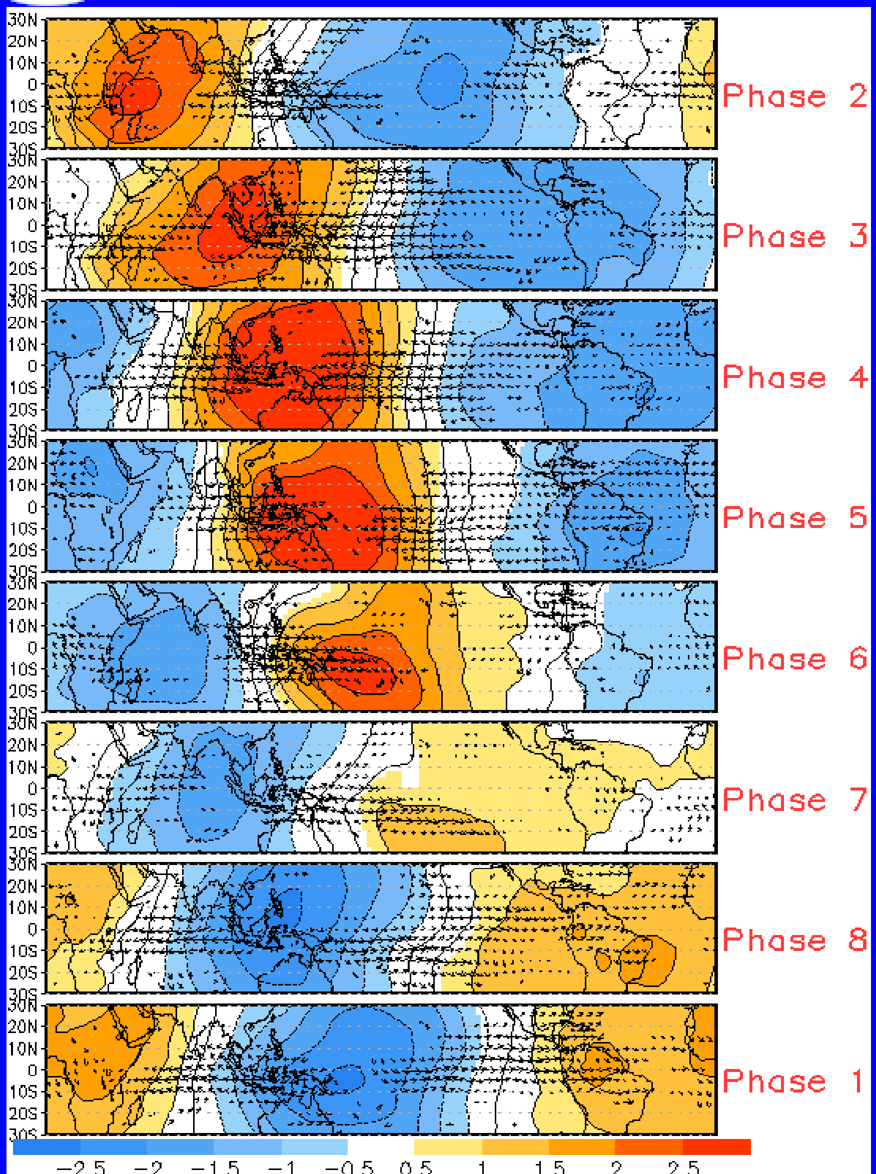
The constructed analog MJO forecast propagates an MJO signal eastward to the eastern Indian Ocean over the next two weeks.

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

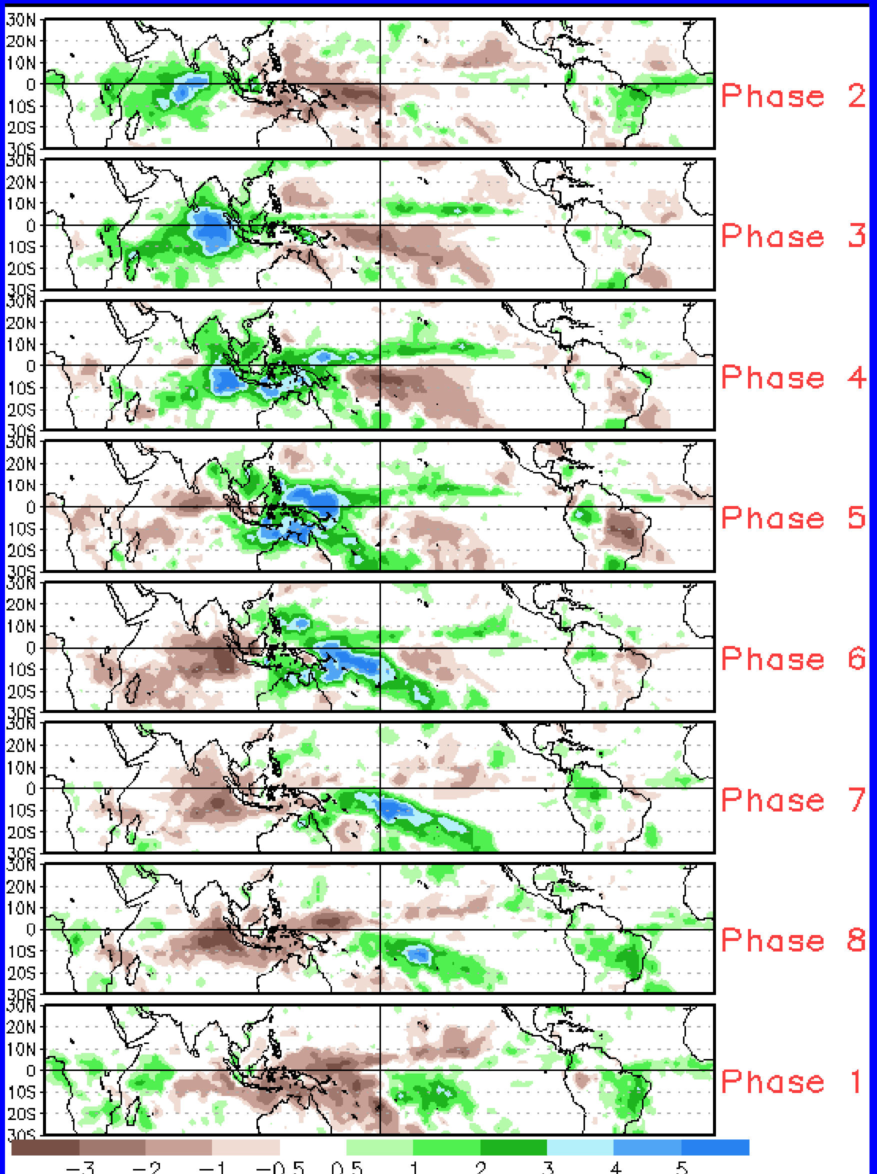


MJO Composites – Global Tropics

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

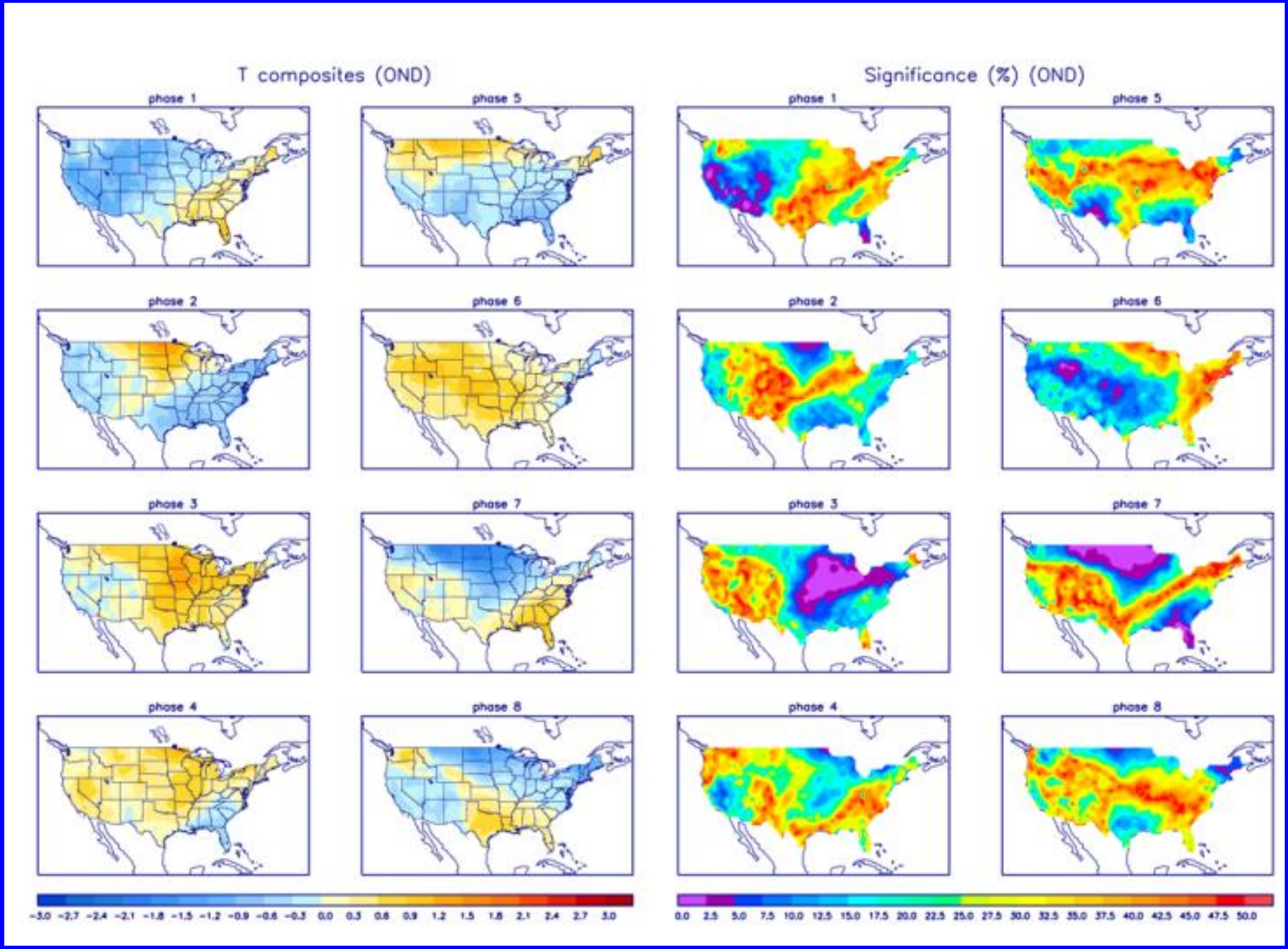


Precipitation Anomalies (Nov-Mar)



U.S. MJO Composites – Temperature

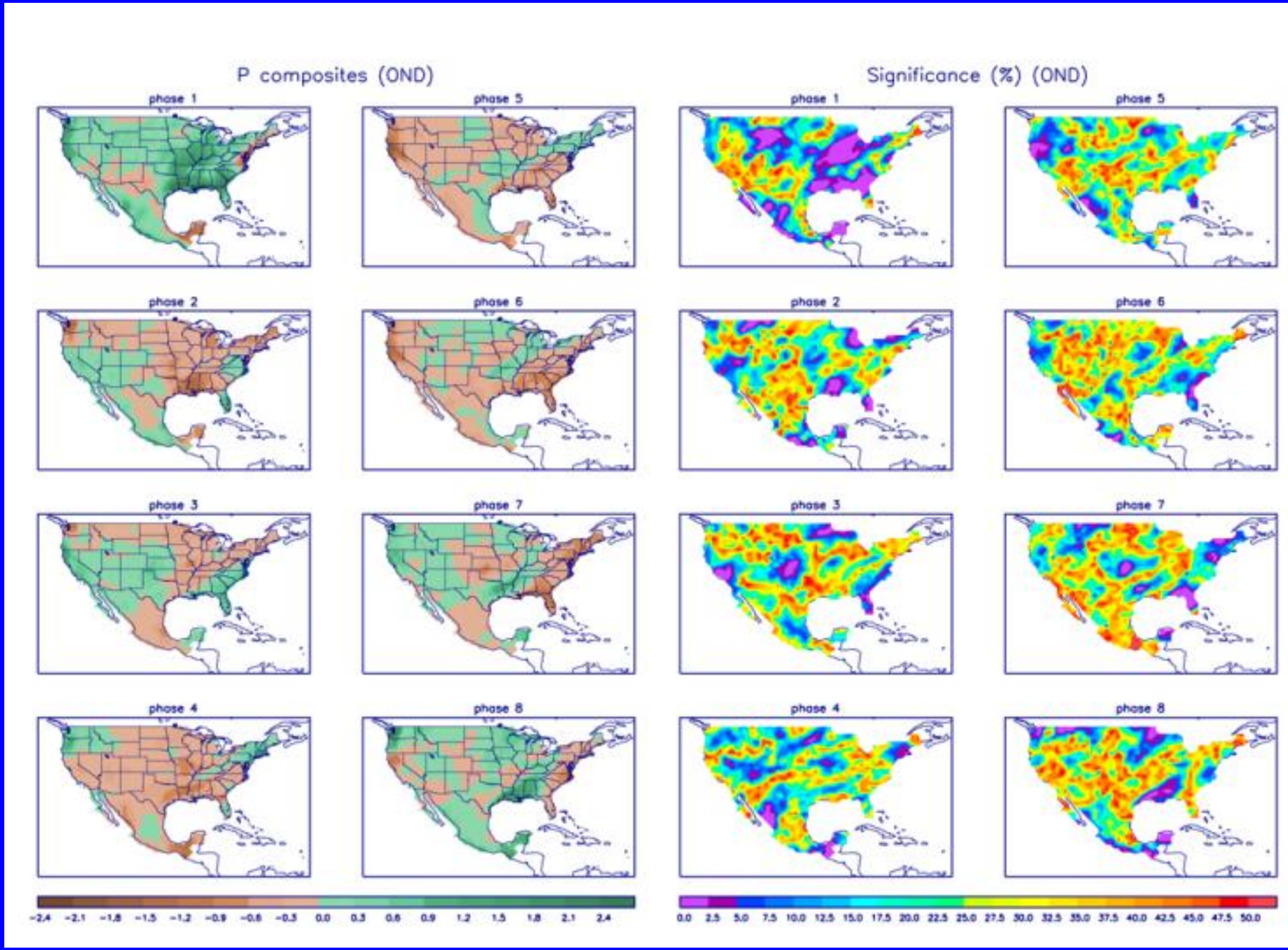
- Left hand side plots show temperature anomalies by MJO phase for MJO events that have occurred over the three month period in the historical record. Blue (orange) shades show negative (positive) anomalies respectively.
- Right hand side plots show a measure of significance for the left hand side anomalies. 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

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