



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

**Update prepared by
Climate Prediction Center / NCEP
November 11, 2013**



Outline

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



Overview

- **The MJO remained active over the past 7 to 10 days but was fairly weak. The enhanced phase propagated eastward to the Indian Ocean.**
- **There continues to be very high uncertainty whether a longer lived, robust MJO will cross the Maritime continent and emerge in the western Pacific over the next 1-2 weeks. Nearly all dynamical model MJO index forecasts indicate little clear MJO signal over the next two weeks. Statistical forecasts suggest a continued weak signal.**
- **Primarily based on recent observations, the MJO is forecast to remain generally weak over the next one to two weeks, with any enhanced phase shifting across the Maritime continent toward the western Pacific. Other subseasonal coherent tropical variability will continue to play a large role in anomalous tropical convection.**
- **The forecast evolution of the weak MJO could favor enhanced (suppressed) convection over parts of the Indian Ocean (southwestern Pacific) during Week-1. During Week-2, the MJO could contribute to enhanced (suppressed) convection across parts of the Maritime continent (Indian 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>

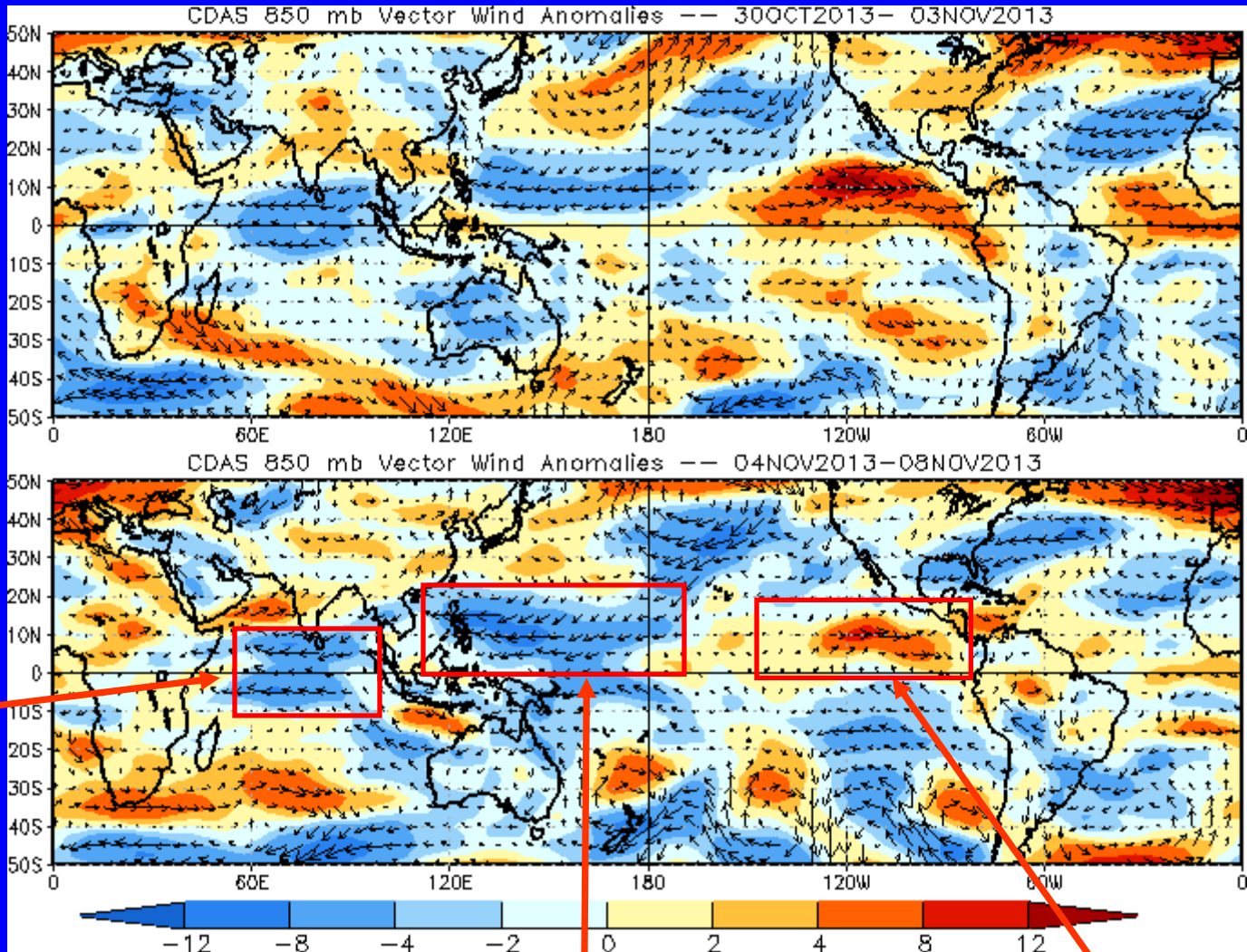


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies continued over the central Indian Ocean.

Easterly anomalies continued across the West Pacific, expanding westward with associated TC activity.

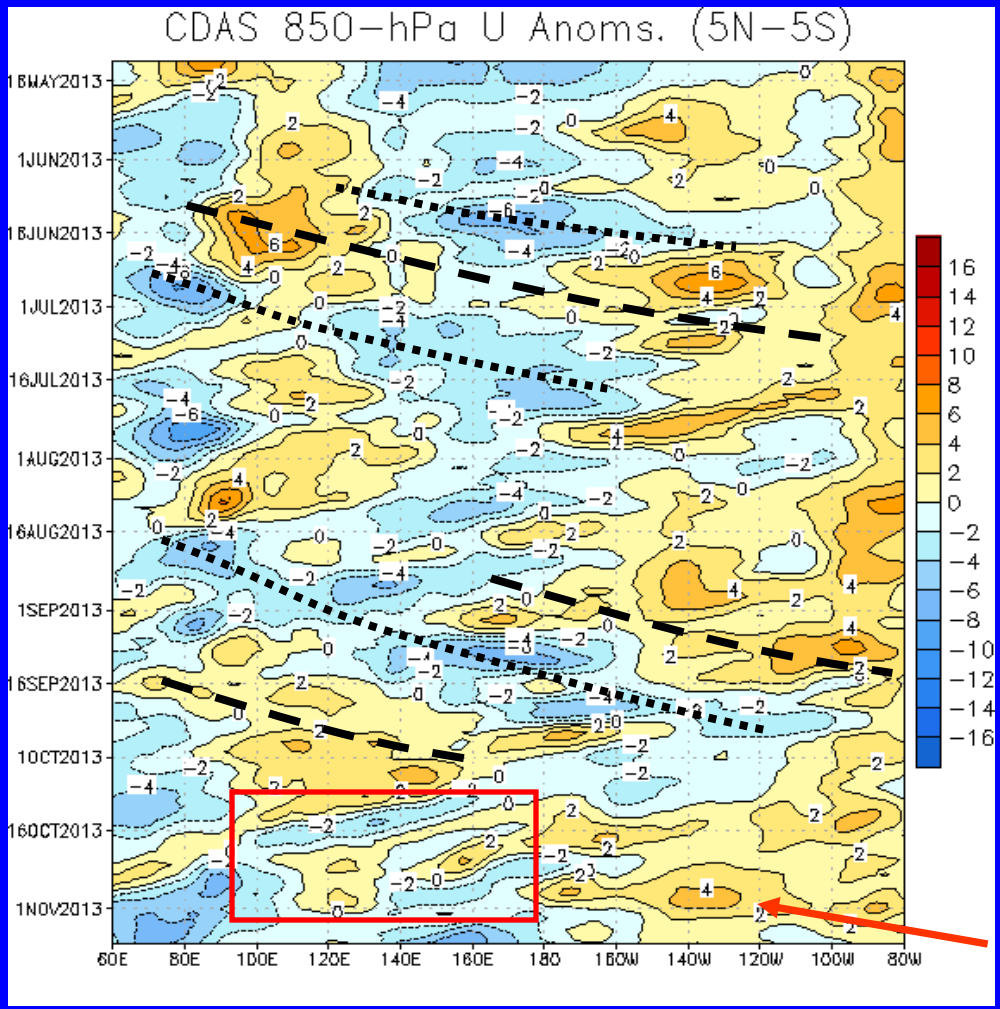
Westerly anomalies decreased over the eastern Pacific during the past five days.



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.

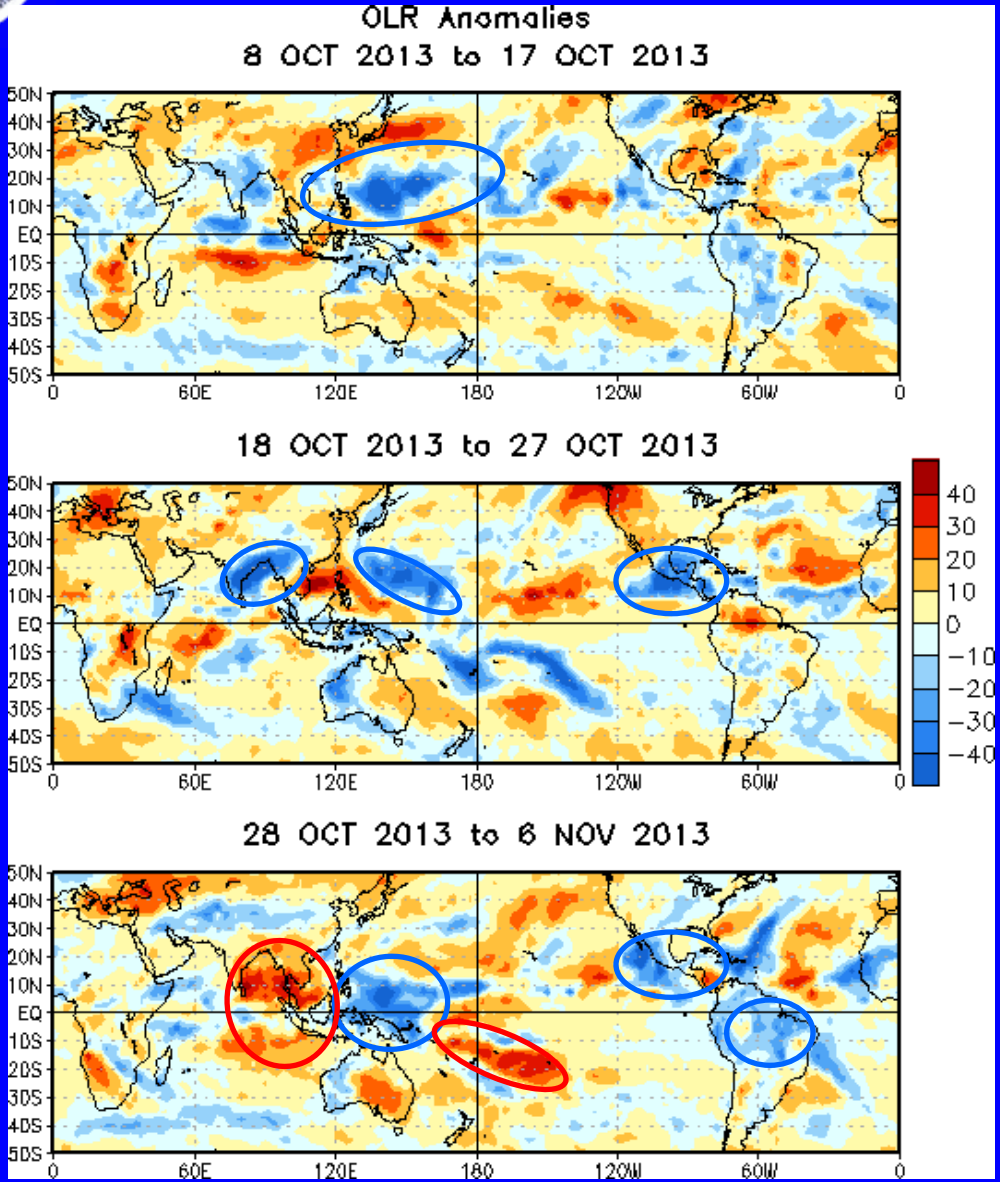
During October, equatorial Rossby wave activity was strong from 160E to 100E as westward movement features are evident (red box). MJO activity was less coherent during this period.

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 the middle of October, enhanced convection was centered north of the equator across the West Pacific where tropical cyclones were active. Convective signals were mixed over much of the Indian Ocean.

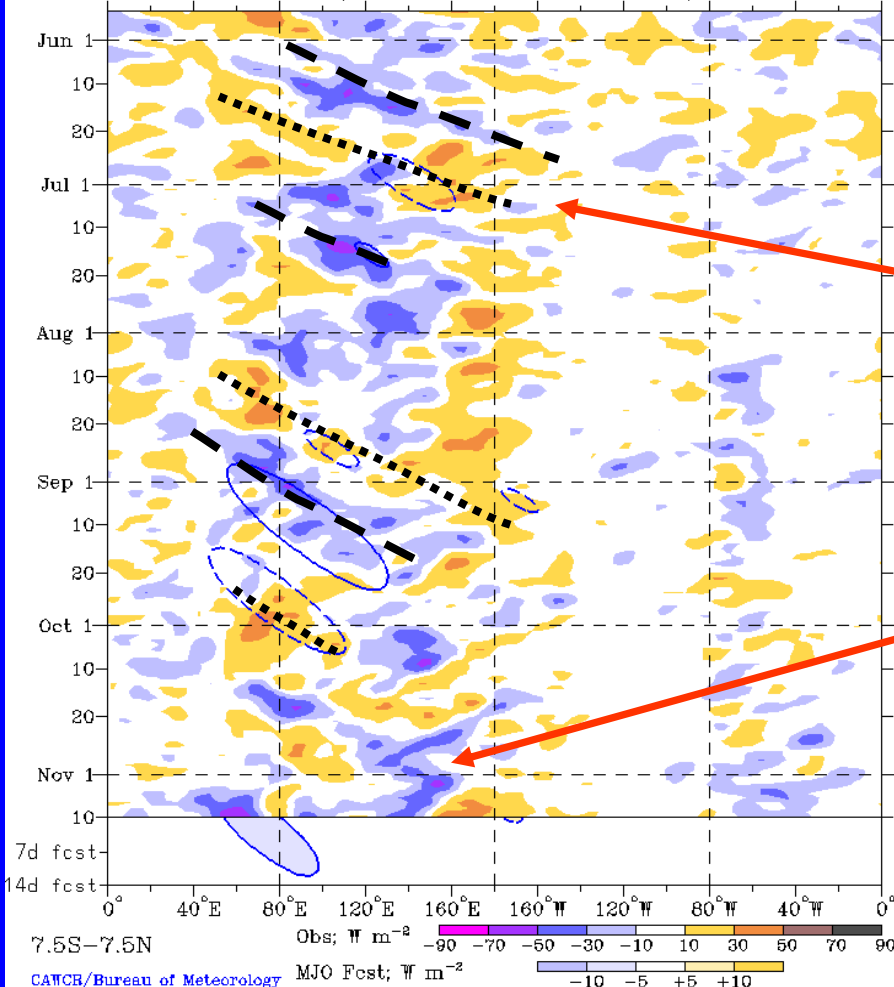
Late in the month, convective activity was strongest across parts of the West Pacific (again due, in part, to tropical disturbances). Convective activity also increased across parts of southern Asia and Central America.

During late October and early November, enhanced (suppressed) convection was observed across parts of the eastern Maritime Continent and West Pacific (eastern Indian Ocean and parts of the South Pacific). Anomalous convection continued across the east Pacific and Central America while developing across parts of South America.



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

Real-time MJO filtering superimposed upon 3drmm R21 OLR Anomalies
MJO anomalies blue contours, CINT=10. (5. for forecast)
Negative contours solid, positive dashed
26-May-2013 to 10-Nov-2013 + 14 days



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 strengthened 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. In addition, enhanced convection developed across the western Indian Ocean, consistent with the evolution of the MJO across Africa and tropical cyclone activity.

Time
↓

Longitude

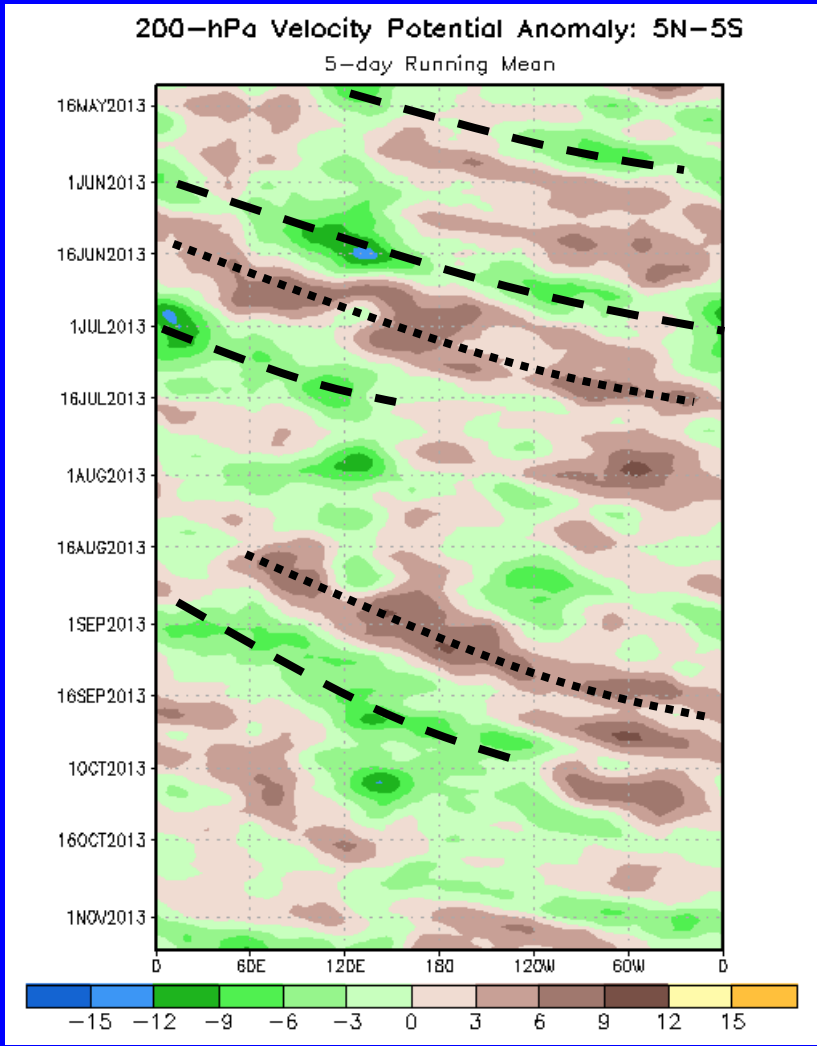


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time
↓



Longitude

The MJO was active (alternating dashed and dotted lines) during June and early July before weakening at 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.

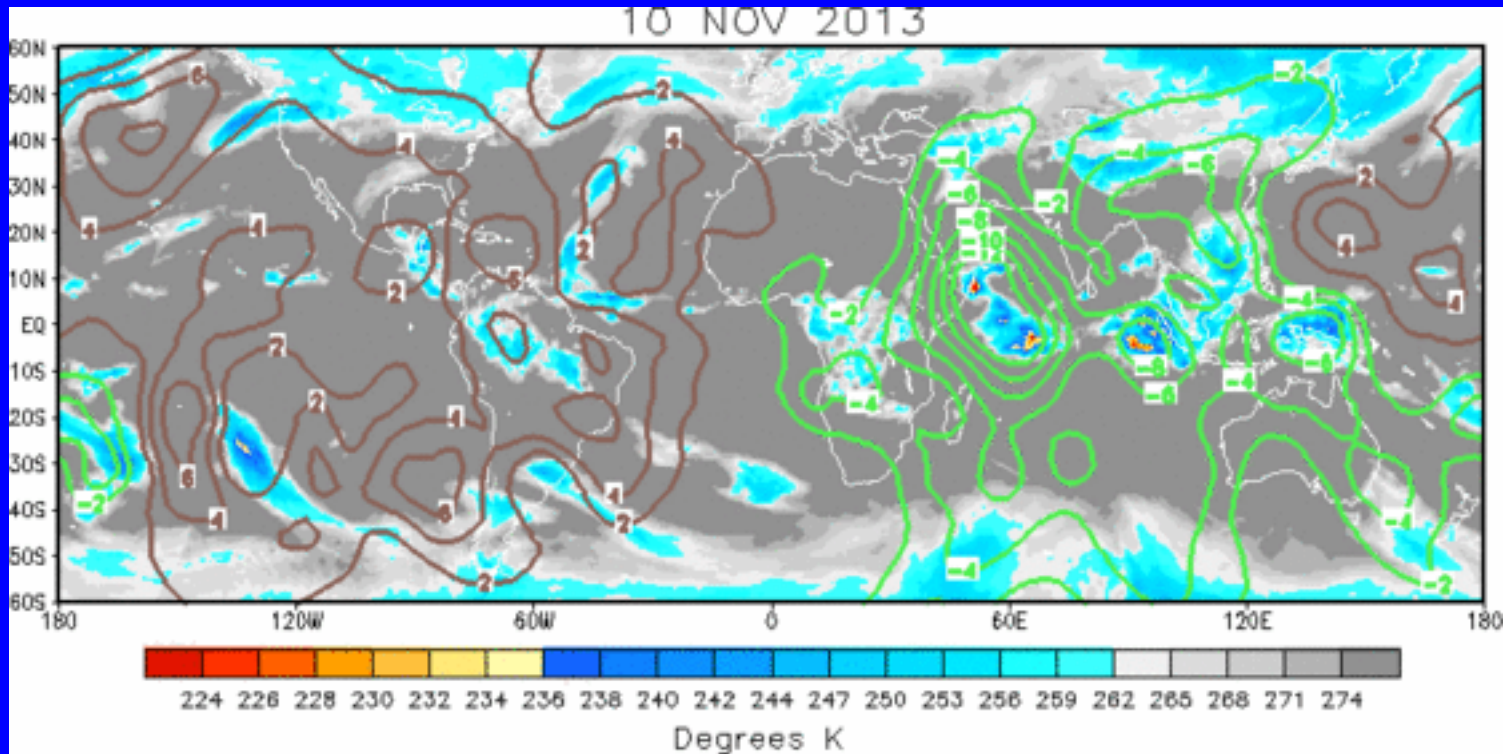
During the second half of October, upper-level velocity potential exhibited little MJO related variability. Recently, some coherent eastward propagation on the fast side of the MJO envelope of phase speeds has been observed.



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 remained organized during the past week, with a classic Wave-1 structure evident across the Tropics. It is consistent with an MJO enhanced phase propagating from the Western Hemisphere to the Indian Ocean.

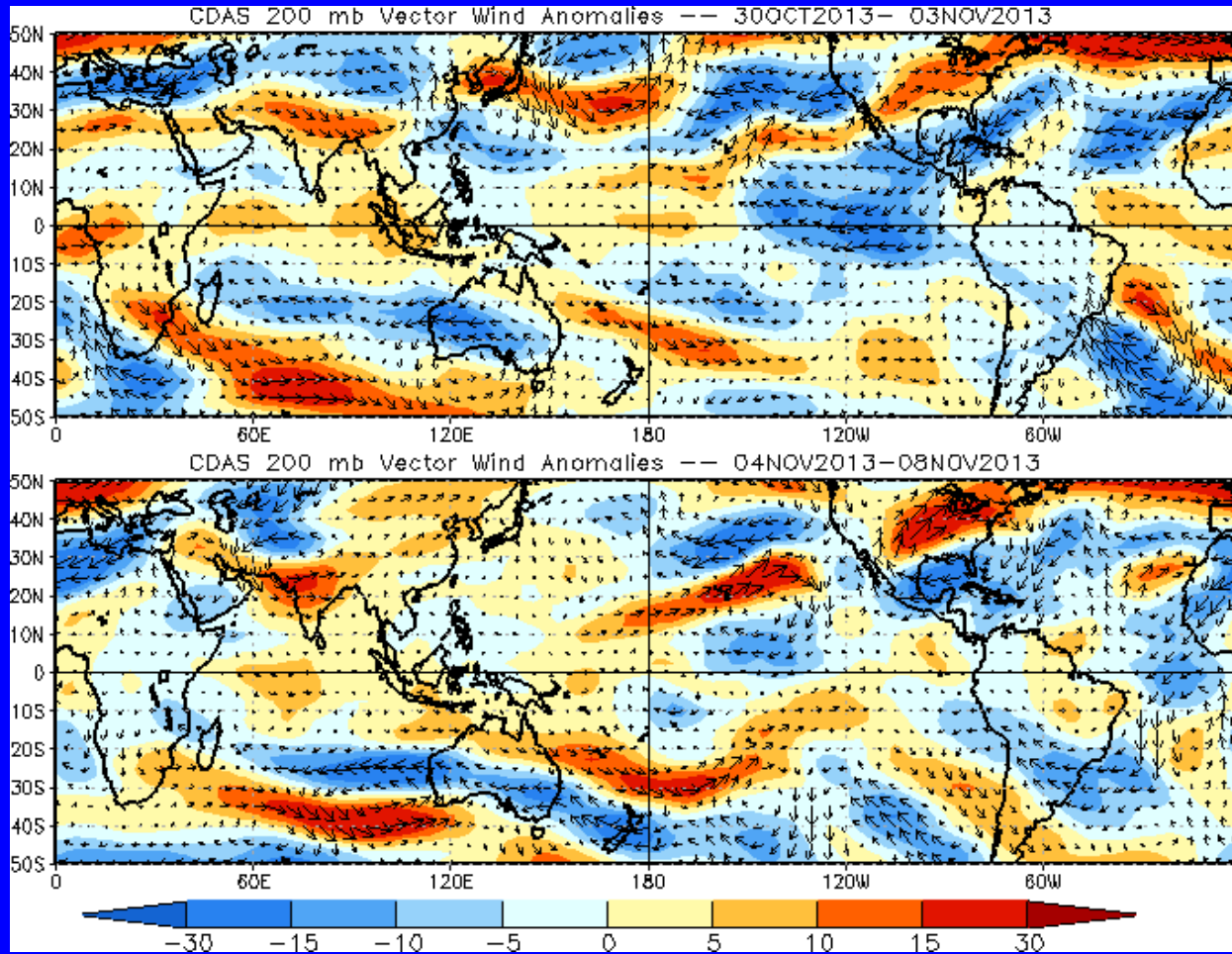


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



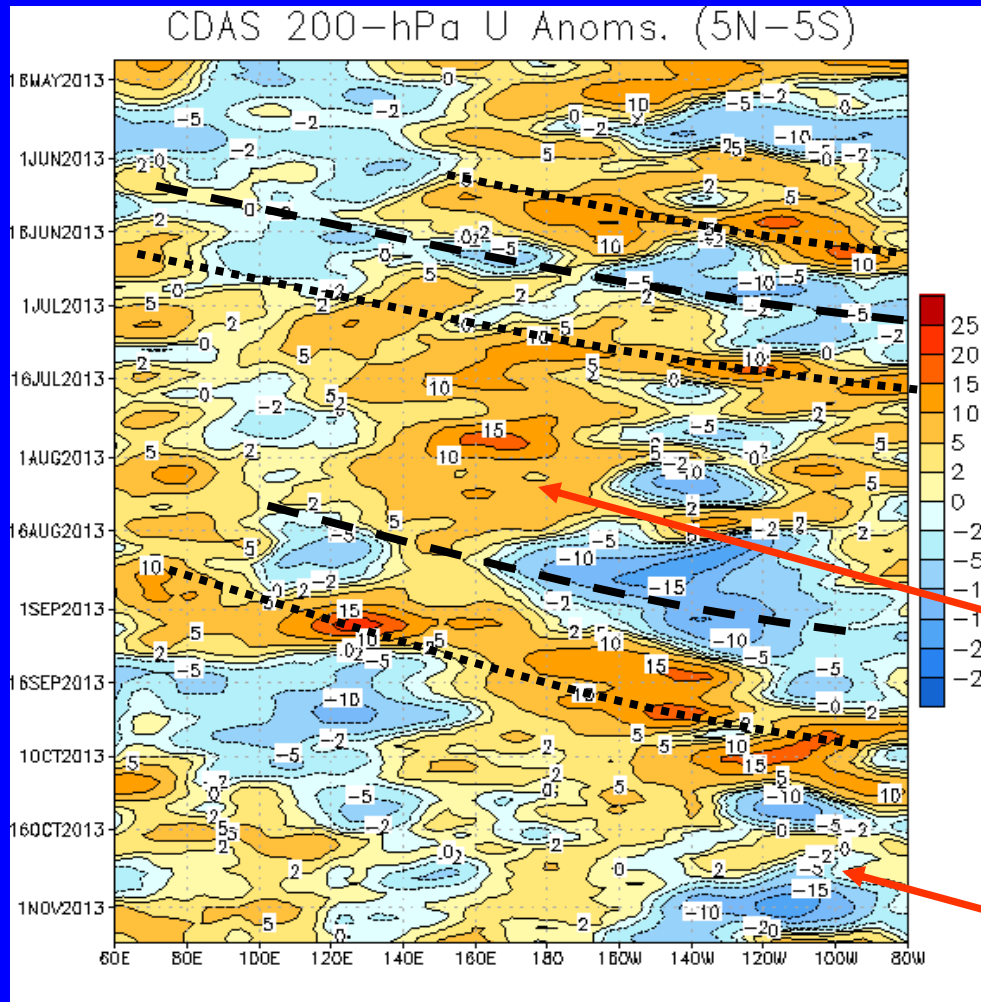
Upper-level zonal wind anomalies are generally weak across the Tropics.



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



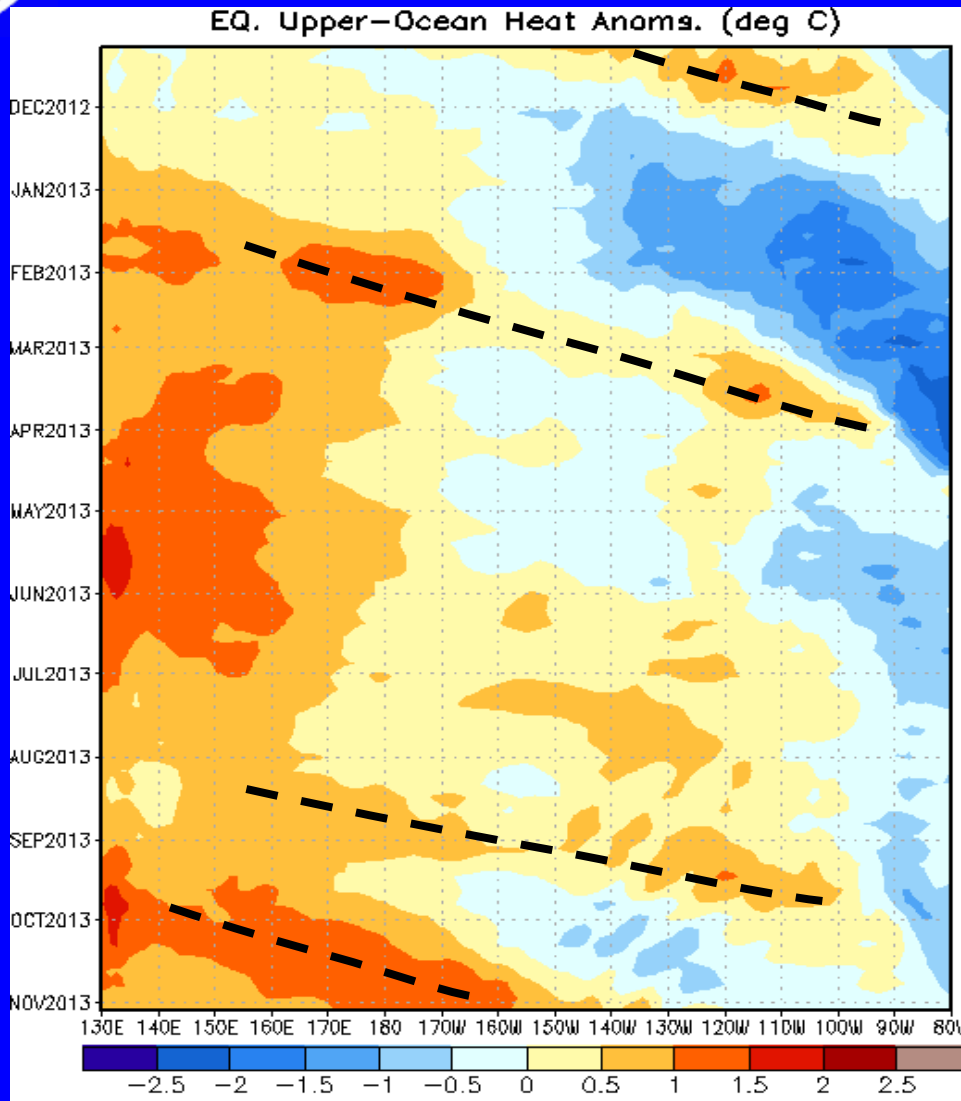
The MJO strengthened (alternating dotted and dashed lines) during June and its influence continued to mid-July, as eastward propagation of wind anomalies associated with the MJO were again observed.

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, anomalies of alternating sign have continued over the eastern Pacific, due in part to extratropical Rossby waves breaking into the Tropics.



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 oceanic downwelling Kelvin waves are seen in August and again in October into November.



MJO Index -- Information

- The MJO index illustrated on the next several slides is the CPC version of the Wheeler and Hendon MJO 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.

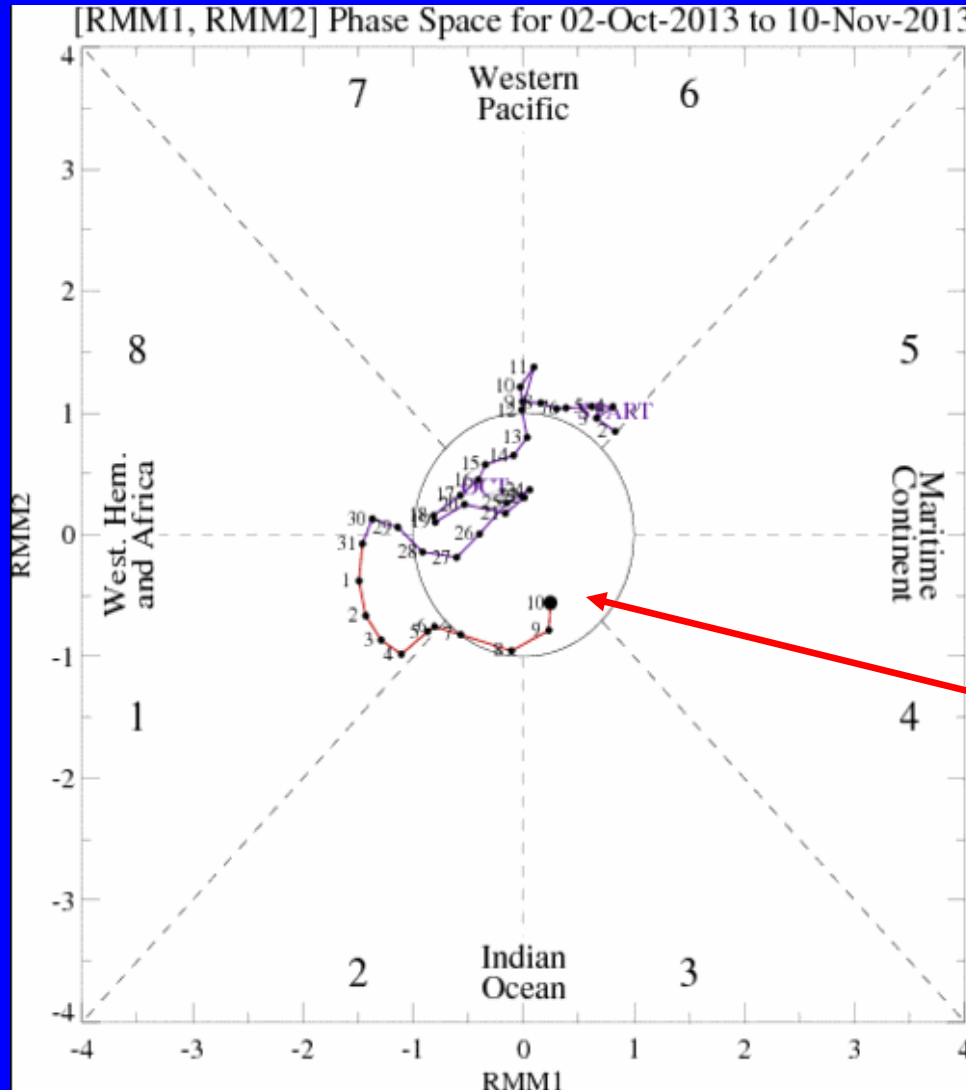
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

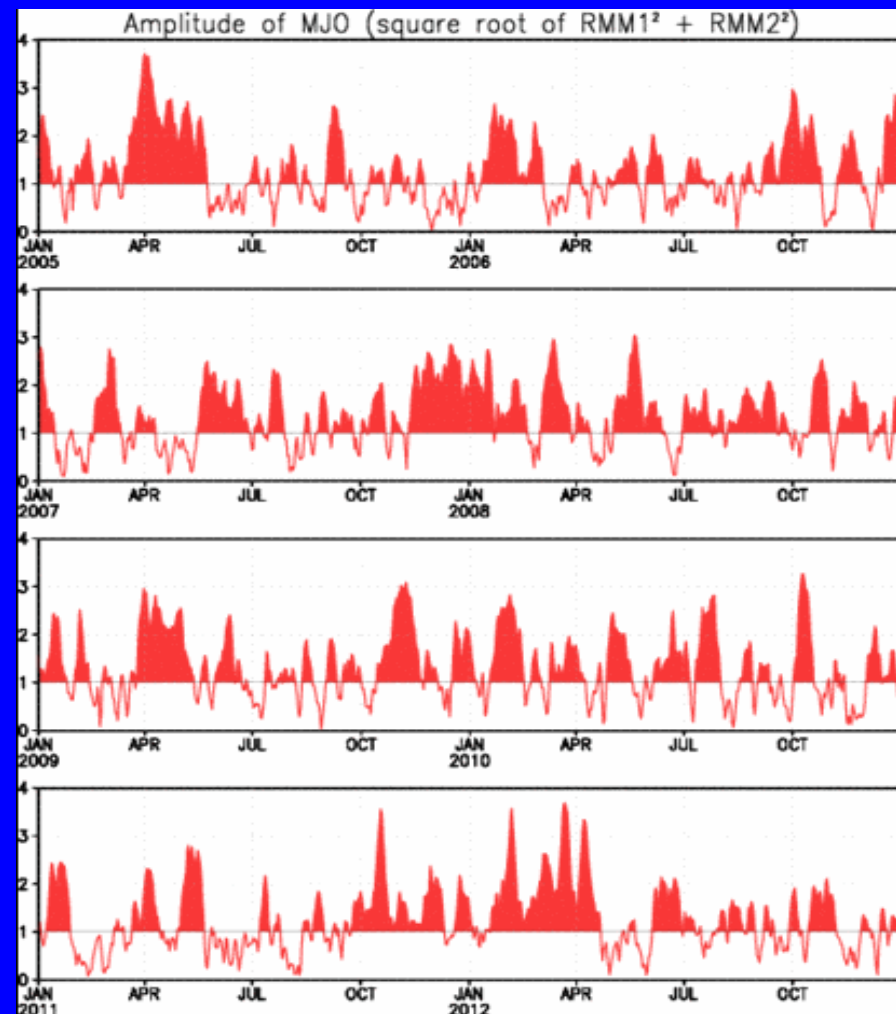
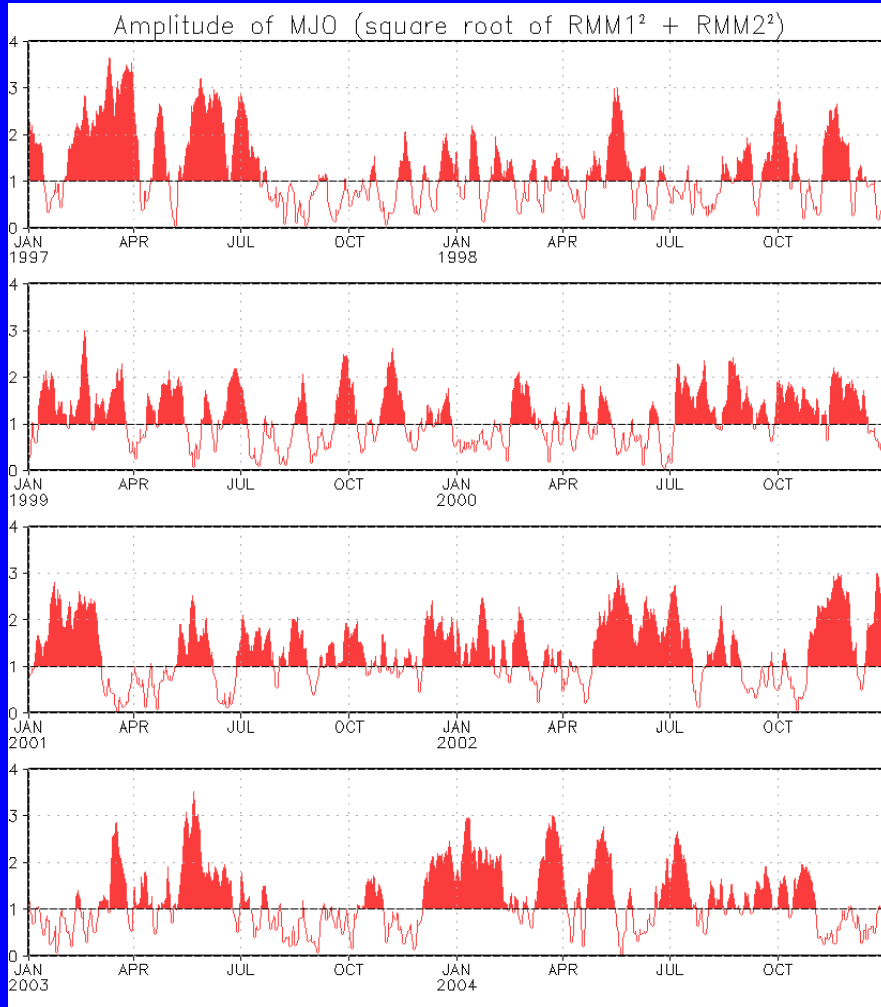


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index emerged in Phase 8 and exhibited a more canonical eastward propagation than predicted by the dynamical models over the last ten days. Most recently the MJO signal has decreased in amplitude.



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.



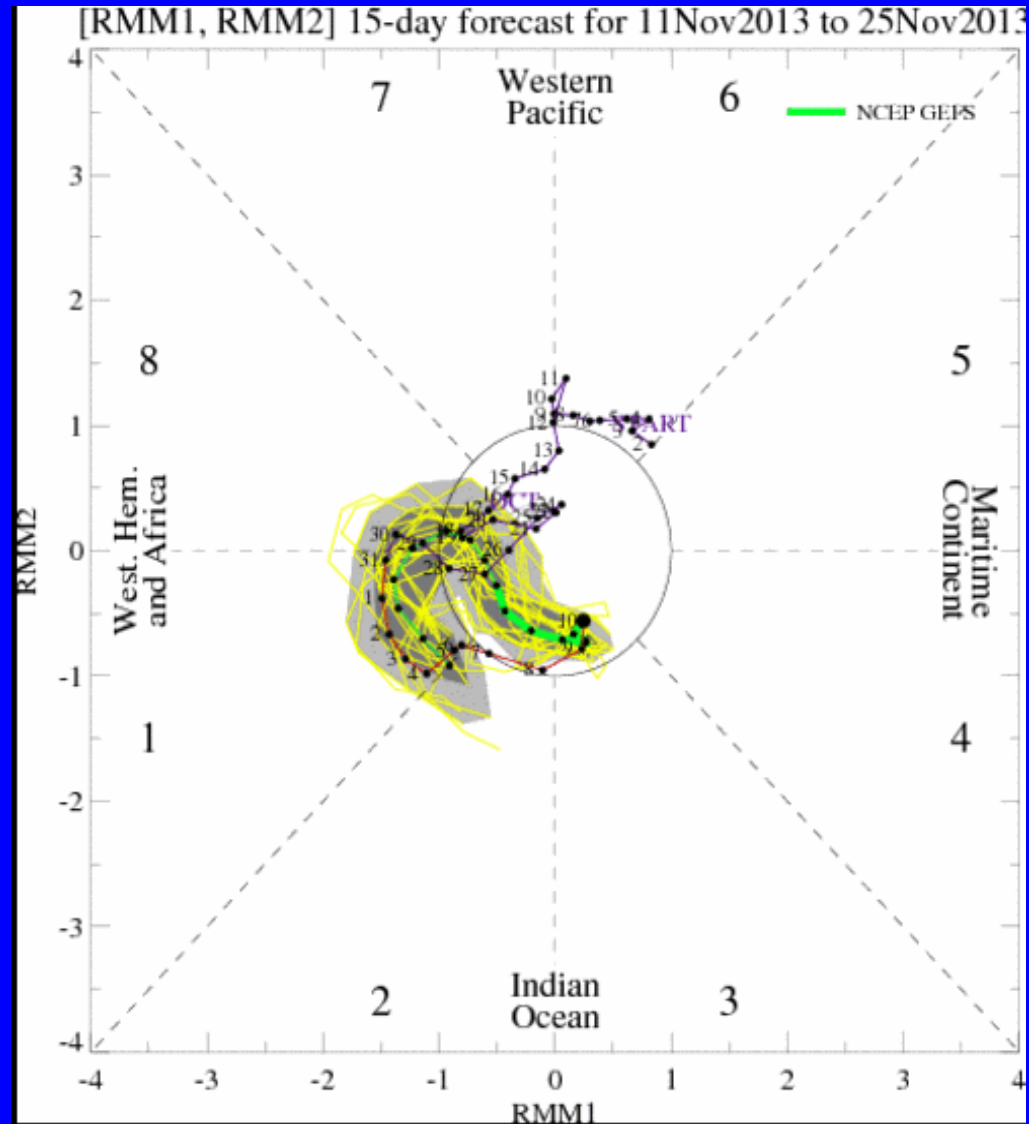
Ensemble GFS (GEFS) MJO Forecast

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 weak MJO signal potentially under the influence of other modes of variability during Week-1. A signal is forecast to emerge over the Western Hemisphere and Africa during Week-2.

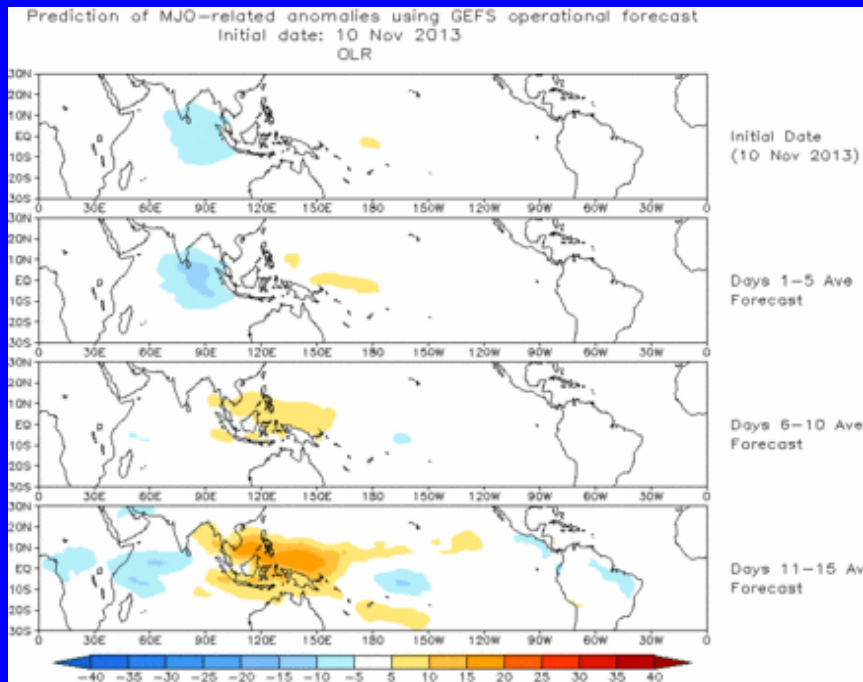




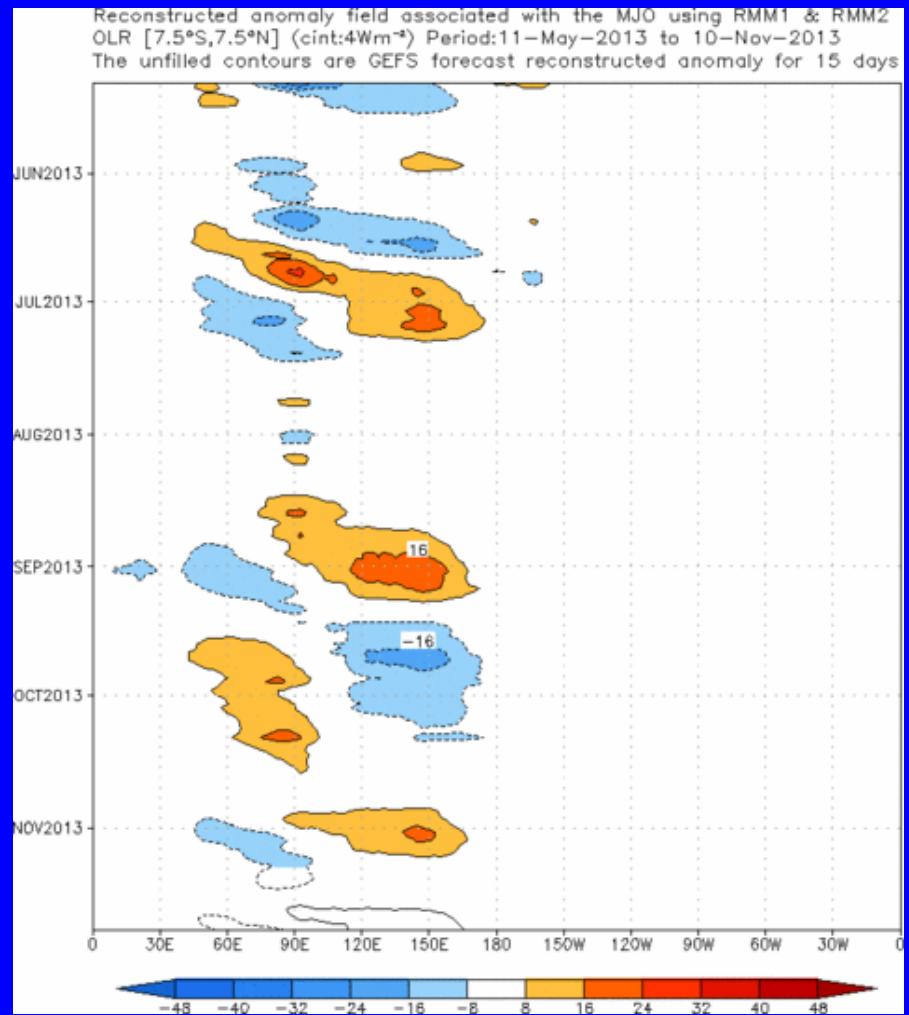
Ensemble Mean GFS MJO Forecast

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 forecasts suppressed convection developing over the Maritime Continent.

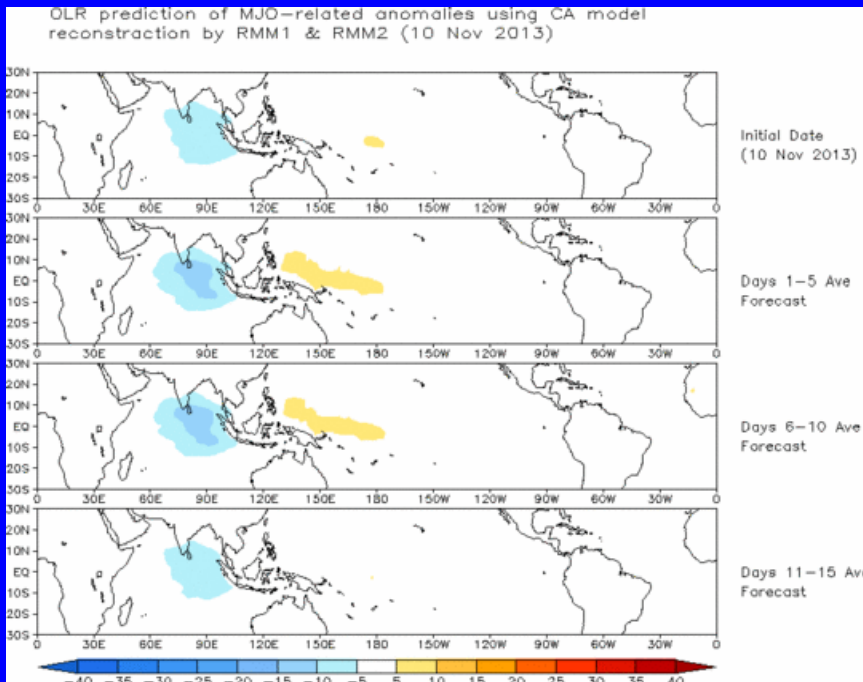


Constructed Analog (CA) MJO Forecast

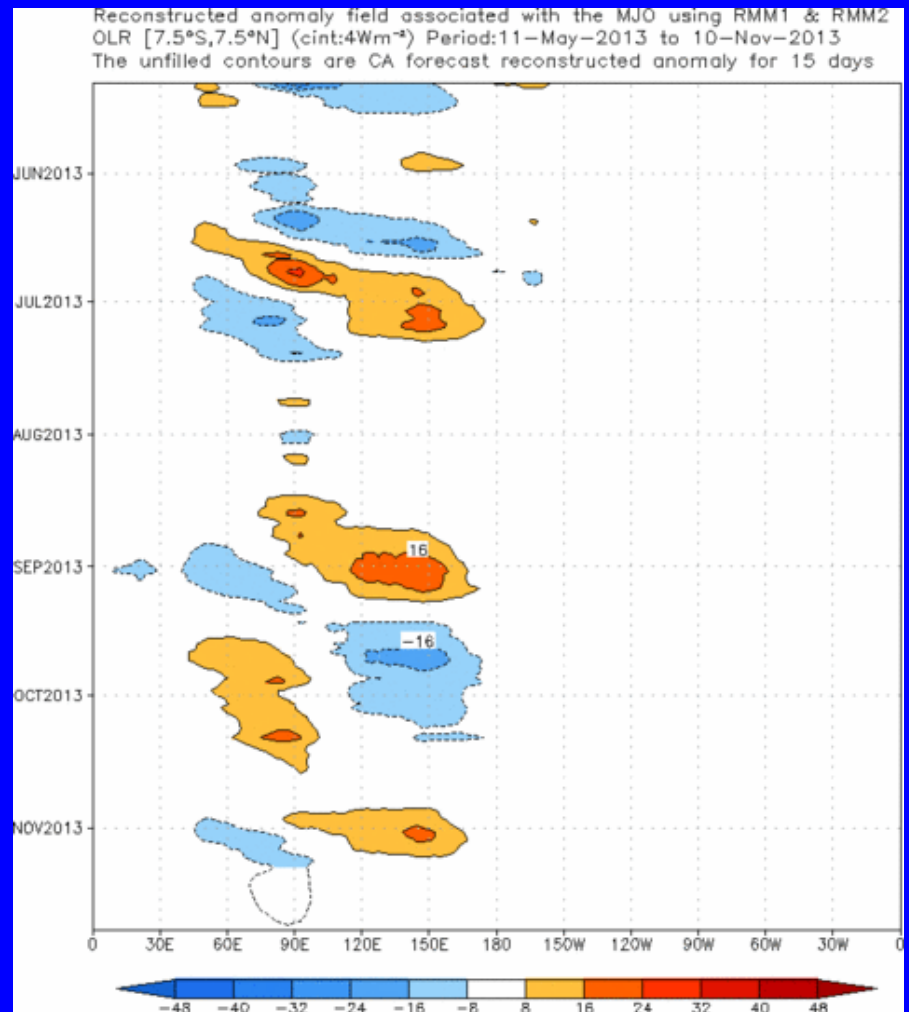
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days

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



The constructed analog MJO forecast indicates a weak, nearly stationary signal.

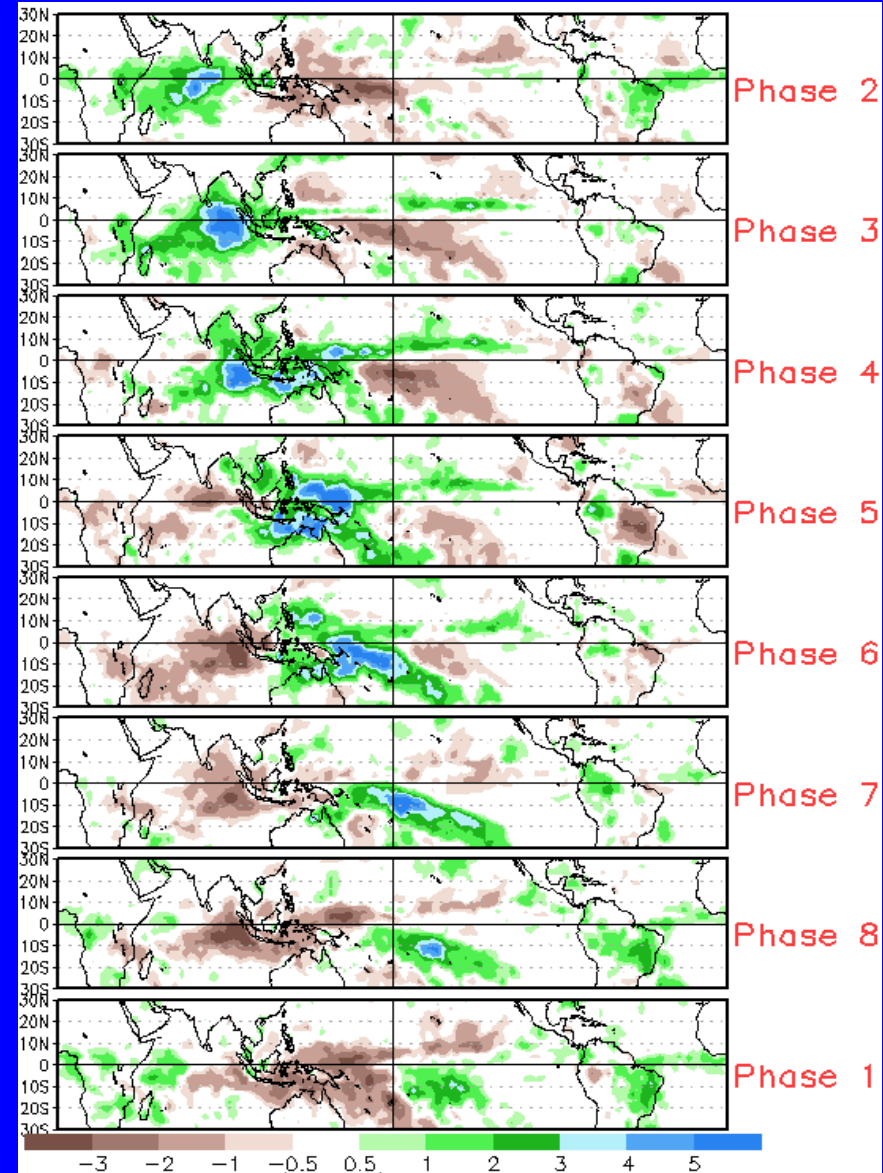
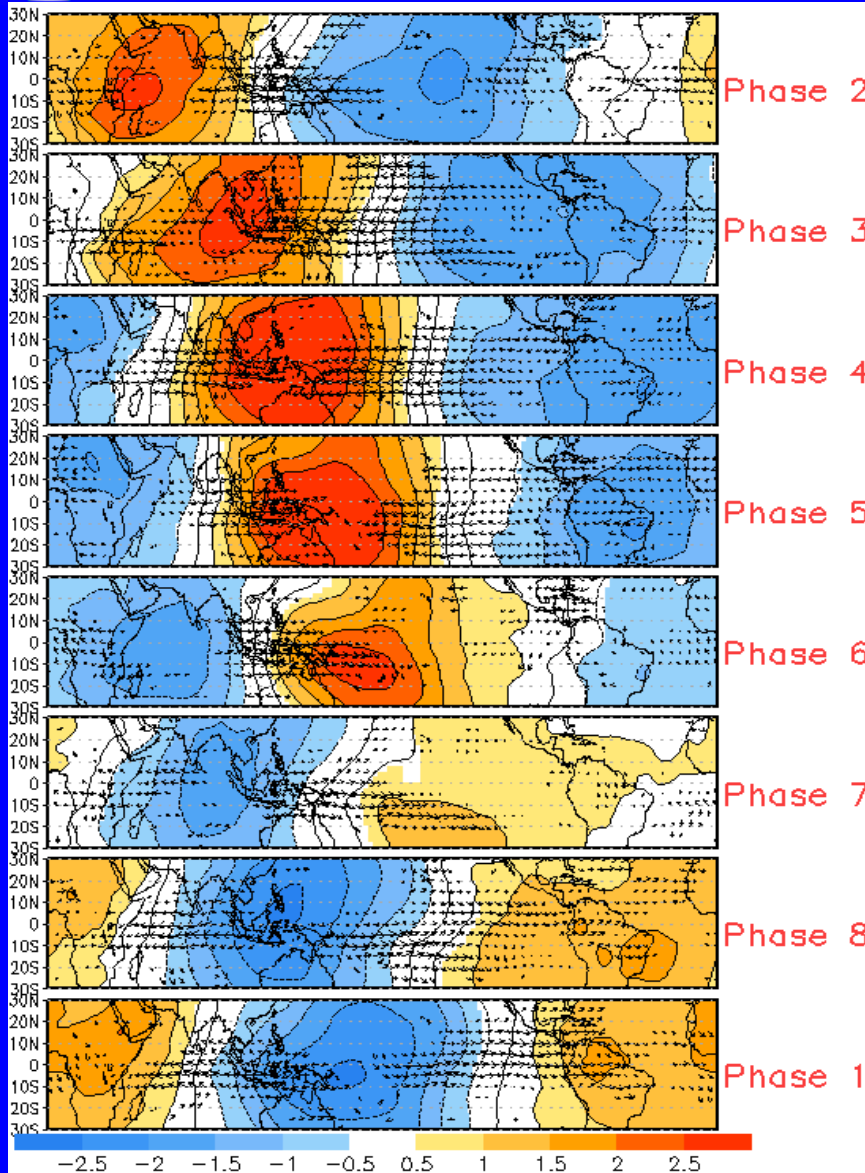




MJO Composites – Global Tropics

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

Precipitation Anomalies (Nov-Mar)

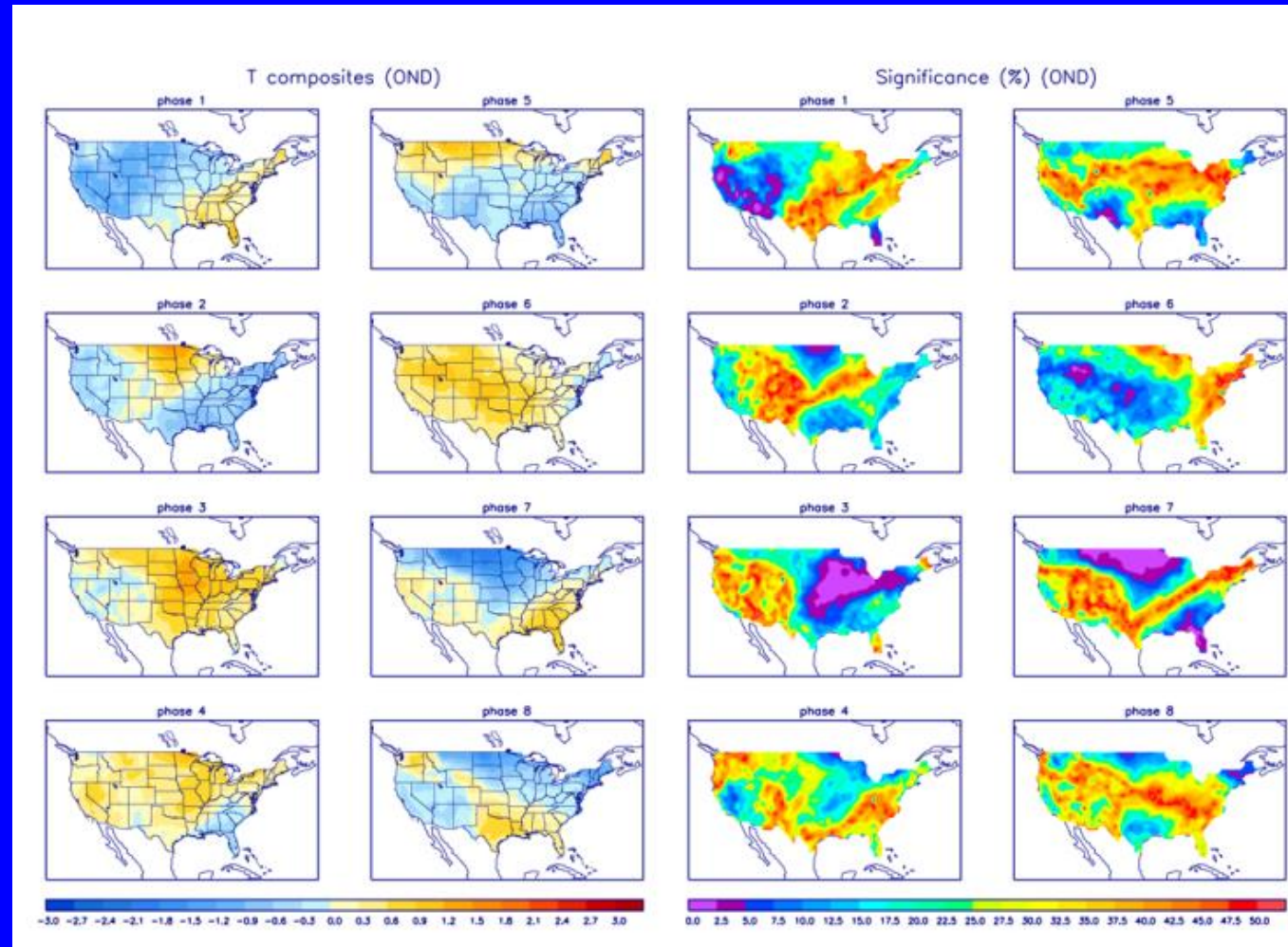




U.S. MJO Composites – Temperature

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.



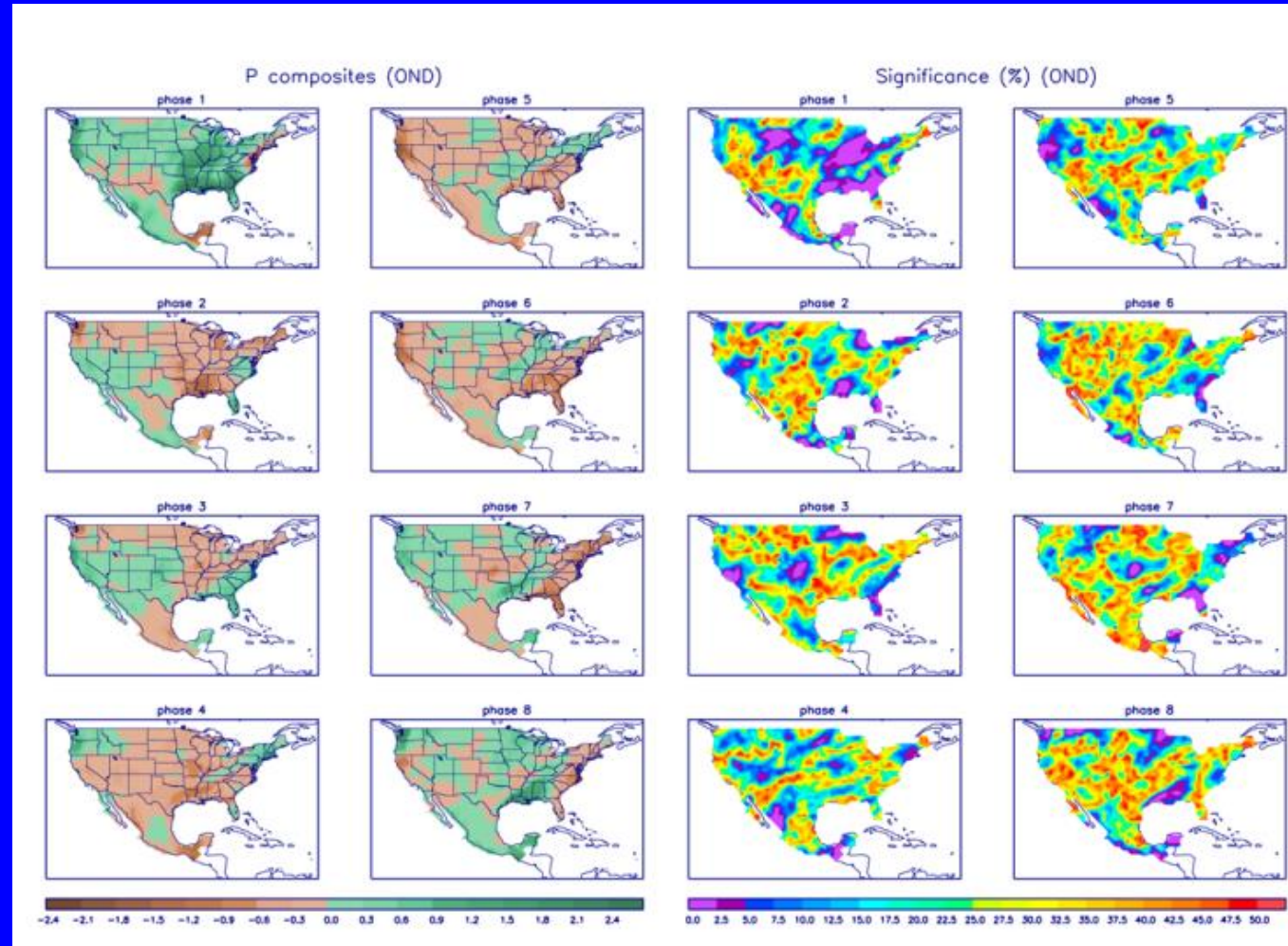
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>