



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

**Update prepared by
Climate Prediction Center / NCEP
December 3, 2012**



Outline

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



Overview

- **The MJO remained weak during the past week. Other subseasonal coherent tropical variability continue to play larger roles in anomalous convection.**
- **There remains large spread in dynamical model MJO index forecasts during the next 1-2 weeks and uncertainty is high for any potential MJO strengthening of the MJO by the end of the period.**
- **Based on the latest observations and model MJO index forecasts, the MJO is forecast to remain generally weak for the next two weeks.**
- **The MJO may weakly contribute to suppressed (enhanced) convection in the eastern Maritime continent and western Pacific (western Indian Ocean) during parts of the upcoming period.**

Additional potential impacts across the global tropics are available at:
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php>



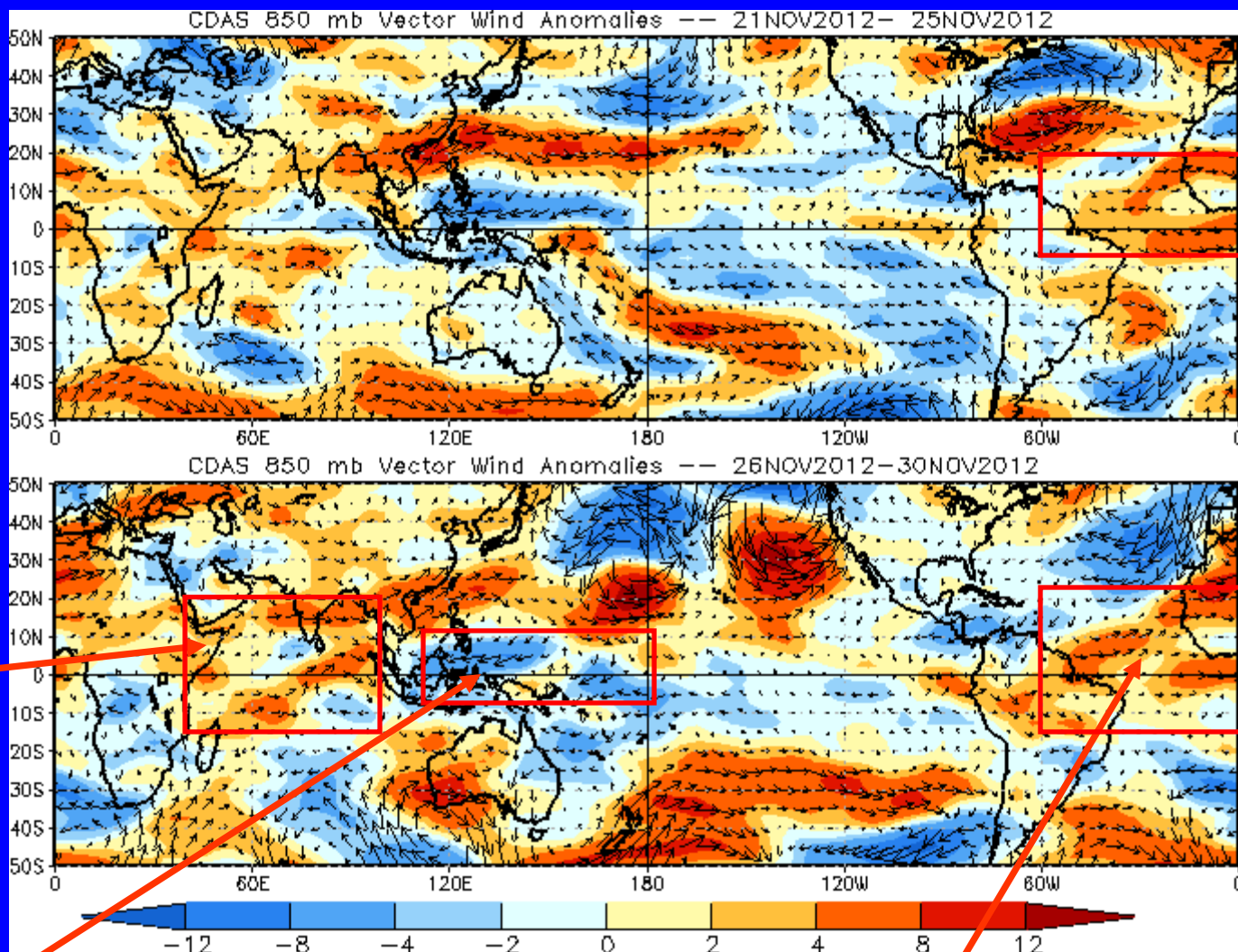
850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Westerly anomalies have intensified over the Indian Ocean.



Coverage of easterly anomalies is smaller than the previous five day period over the western Pacific.

Westerly anomalies continued over the tropical Atlantic during the past five days.

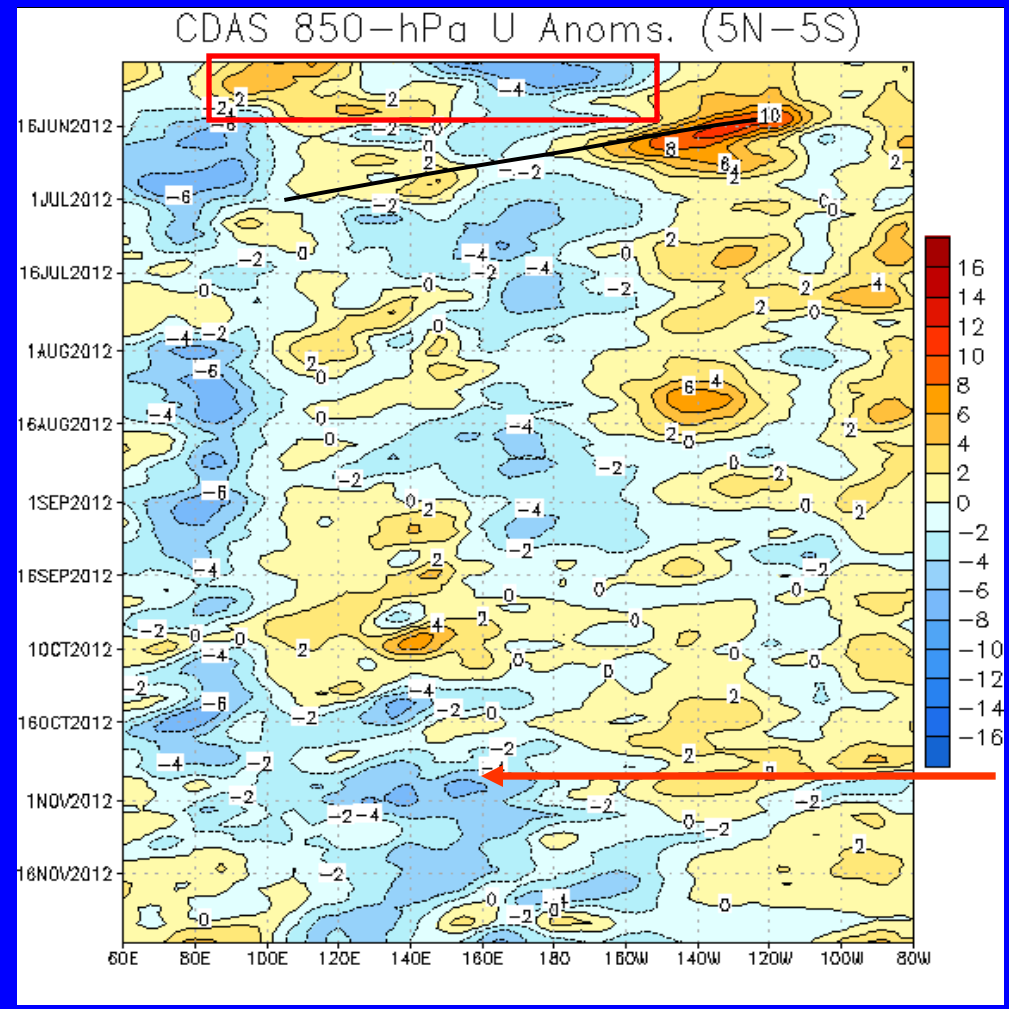


850-hPa Zonal Wind Anomalies (m s^{-1})

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

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

Time
↓



Longitude

Anomalies were generally persistent in most areas during early June (red box). Strong westerly anomalies developed across the eastern Pacific in mid-June and shifted westward (black solid line) and contributed to weakening the trade winds.

Easterly anomalies persisted near 80E for much of August and September.

During September, westerly anomalies developed near 140E and persisted into October.

In mid to late October, easterly anomalies developed west of the Date Line in the west Pacific and have persisted.

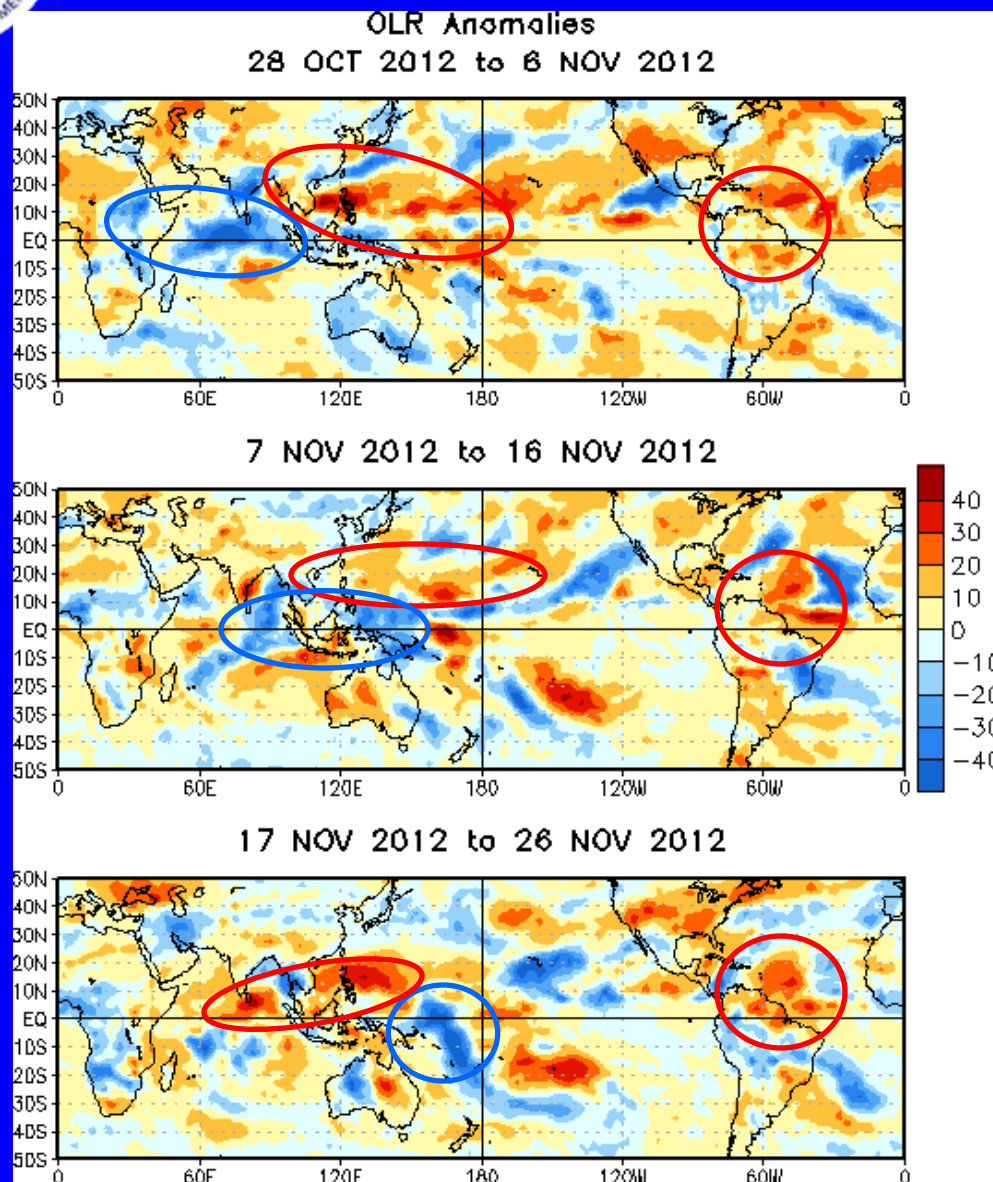
Westward propagation due to equatorial Rossby wave activity is evident during much of November.



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 and early November, suppressed convection expanded across the western Pacific with enhanced convection developing across the Indian Ocean.

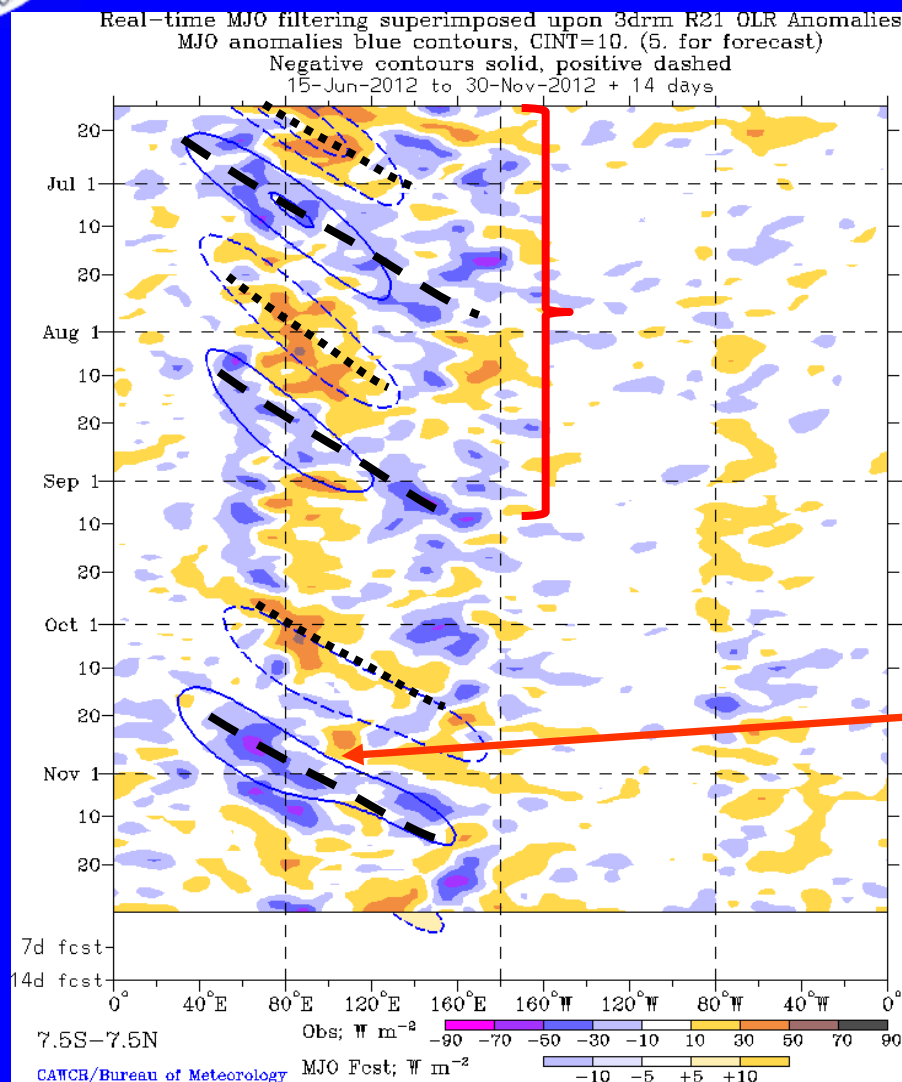
Entering mid-November, suppressed convection shifted north across the western Pacific and continued over northern South America. Enhanced convection shifted east into the western Pacific.

In mid-to-late November, some enhanced convection was evident in the western Pacific in response to an equatorial Rossby wave, while suppressed convection developed in the central Indian Ocean and extended to parts of the South China Sea and northwestern tropical Pacific.



Outgoing Longwave Radiation (OLR)

Anomalies (7.5°S-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)

From late May into September, eastward propagation of both enhanced and suppressed convection is evident across the eastern hemisphere (alternating dashed and dotted lines).

The MJO was active during October into November with enhanced convection developing over Africa during mid-October and shifting eastward to the western Pacific by mid-November.

The recent convection near 160°E is due, at least in part, to a strong equatorial Rossby (ER) wave while enhanced convection near 80°E is most likely a superposition of a ER wave and eastward moving Kelvin wave.

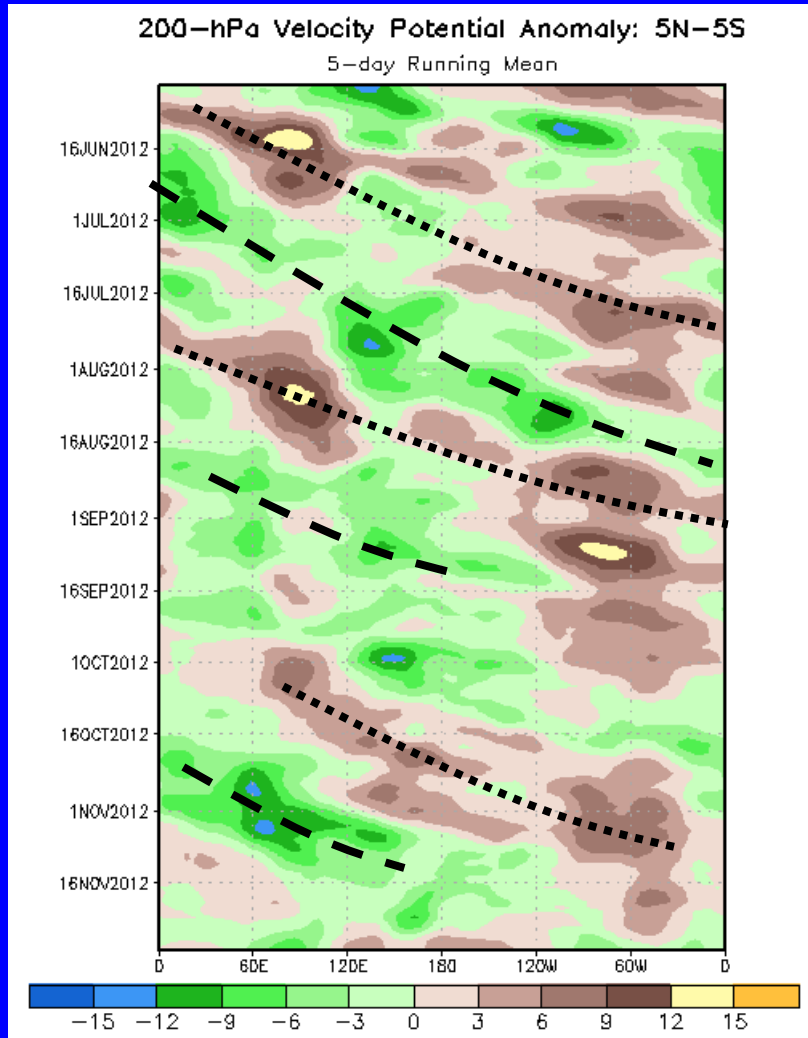


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time



Longitude

Eastward propagation was evident from late May into September associated with the MJO (alternating dashed and dotted lines), as well as atmospheric Kelvin wave activity, which at times resulted in fast eastward propagation of observed anomalies.

In mid-September, anomalies decreased and eastward propagation became less clear.

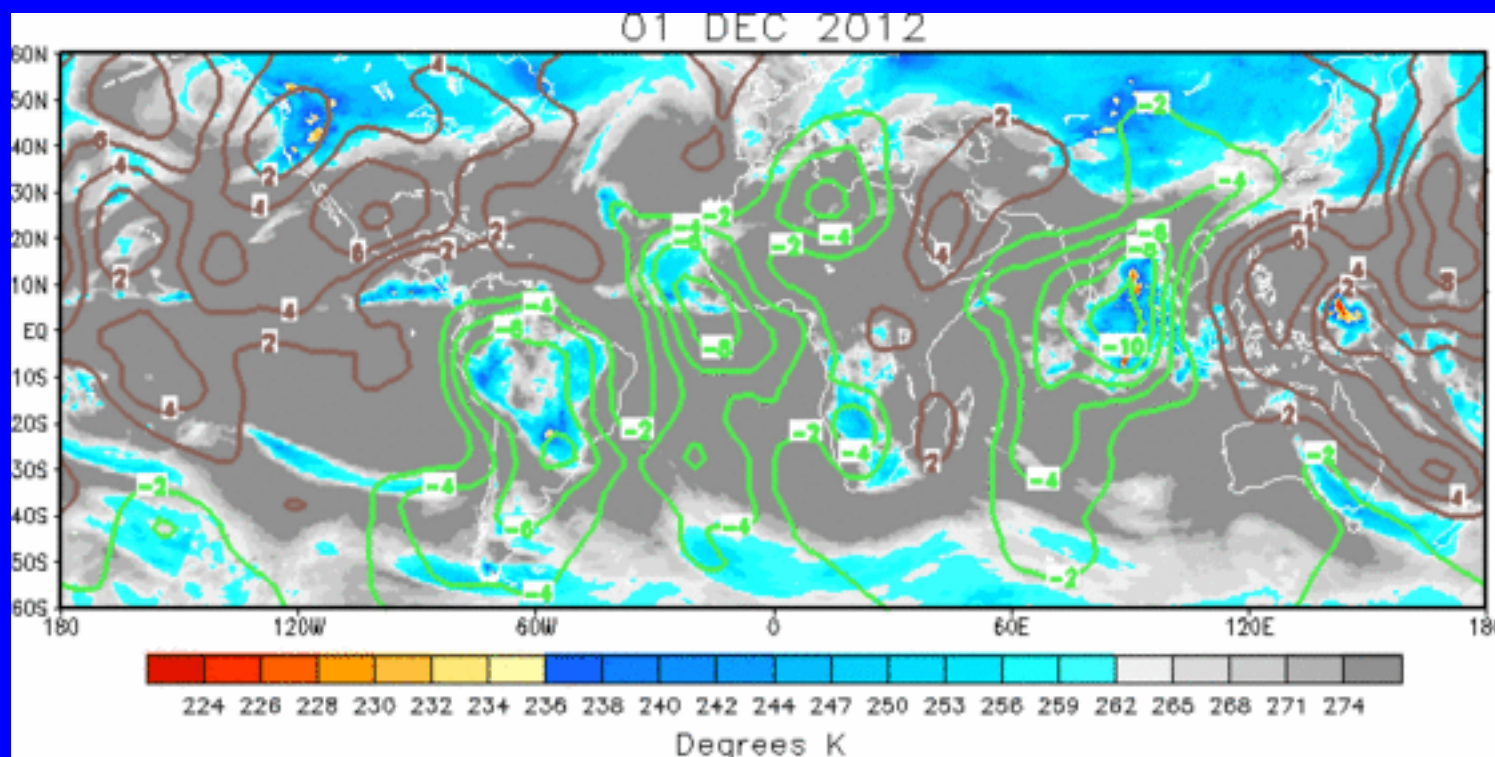
In early October, upper-level divergence (convergence) increased over the Pacific (Indian Ocean) and has shifted eastward throughout October and early November. Anomalies decreased from mid to late November and propagation became less clear.



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 large scale velocity potential pattern is more coherent in recent days and shows strong upper-level divergence across the Indian Ocean and parts of South America and the Atlantic. Upper-level convergence has emerged over most of the tropical Pacific basin.

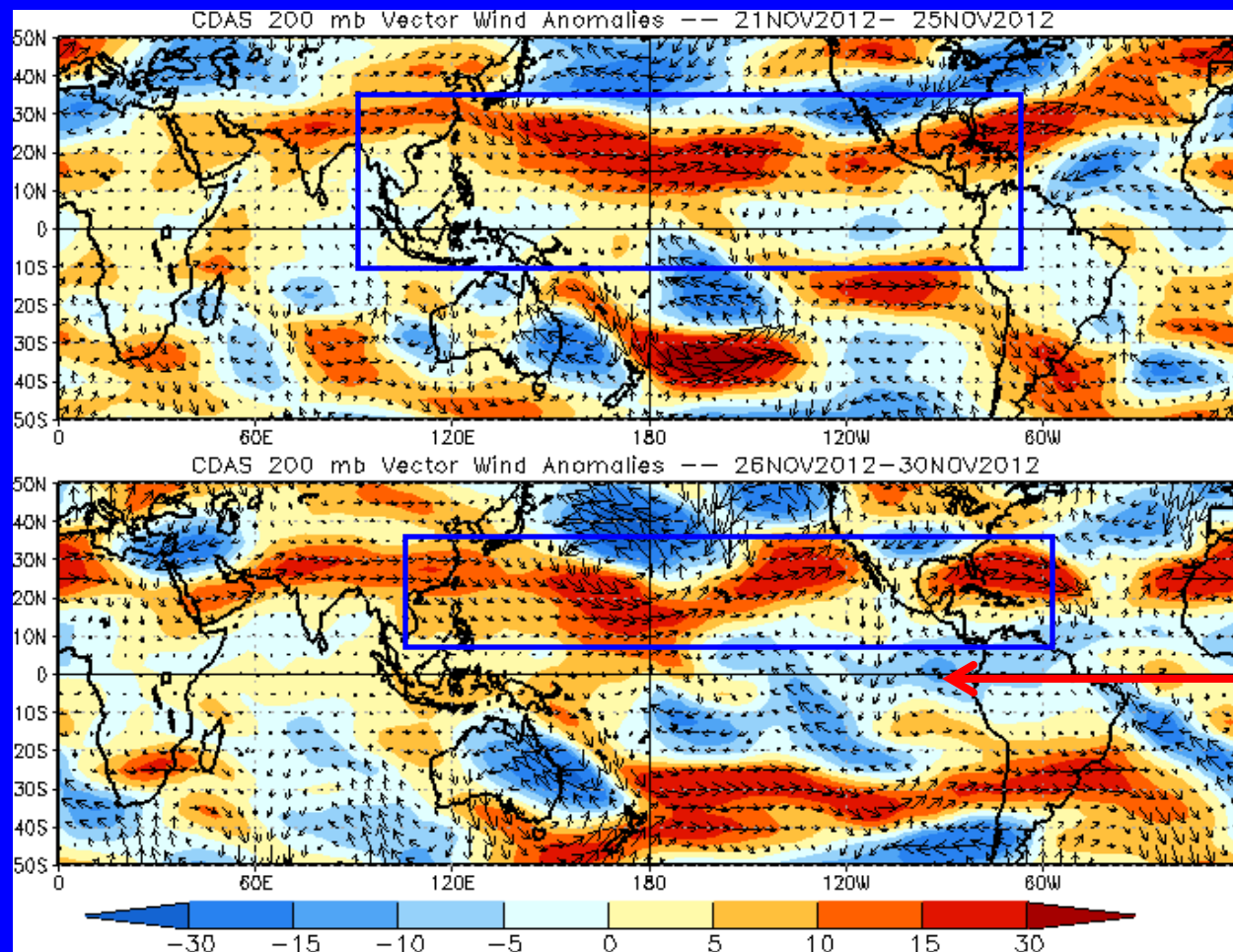


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies (blue boxes) have been generally persistent over the tropical and sub-tropical Pacific into the Americas during the last five to ten days.

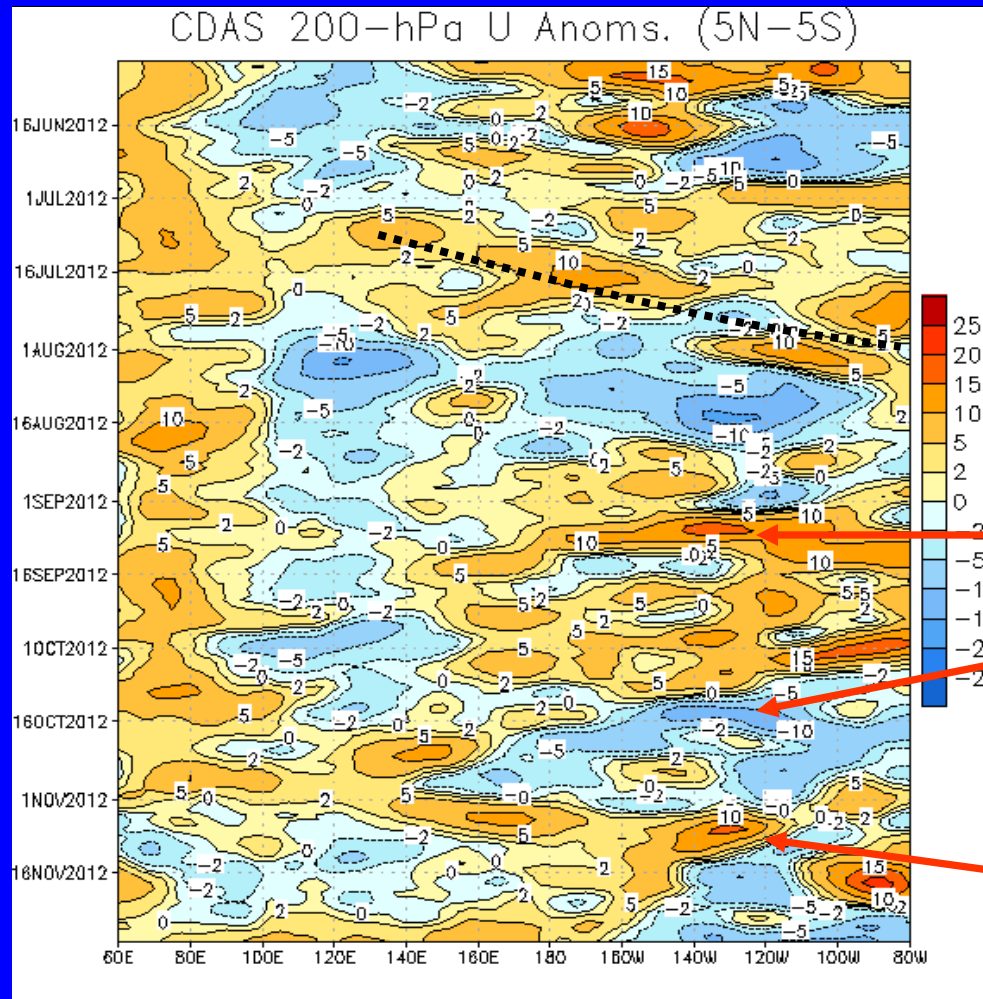
However, more easterly anomalies have emerged along the equator in the central and eastern Pacific.



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

Anomalies were not very coherent during late May and June.

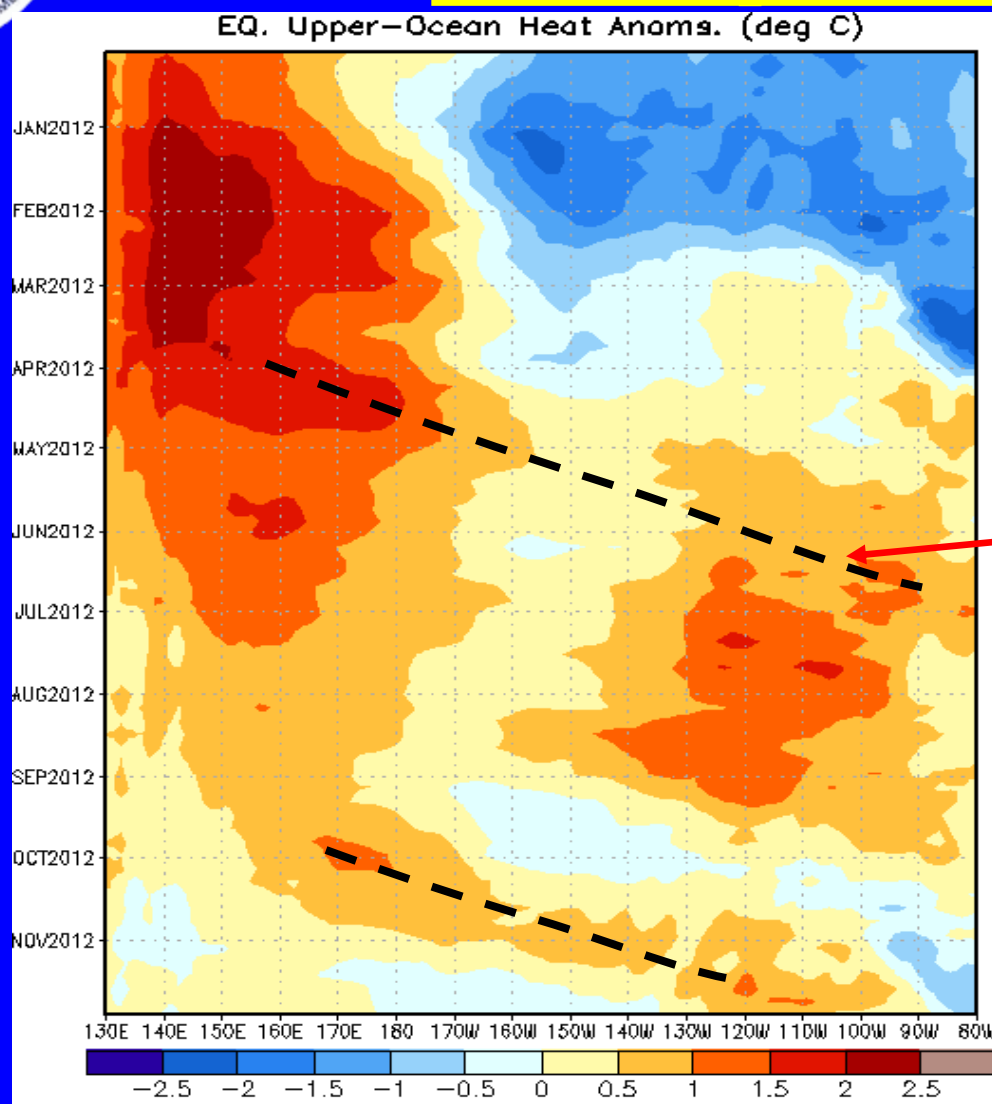
Westerly anomalies shifted eastward across the Pacific during July and early August.

Westerly anomalies prevailed across the eastern Pacific and Americas for much of September and October, but were replaced by easterly anomalies during mid-October.

Westerly anomalies shifted east to the eastern Pacific in early November, but have recently weakened and, in some places, been replaced by easterly anomalies.



Weekly Heat Content Evolution in the Equatorial Pacific



From July 2011 through February 2012, heat content was below average in the central and eastern equatorial Pacific.

From March into July 2012, heat content anomalies became positive and increased in magnitude across eastern equatorial Pacific, partly in association with a downwelling Kelvin wave.

Positive anomalies decreased across the eastern Pacific during late August and September.

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



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.

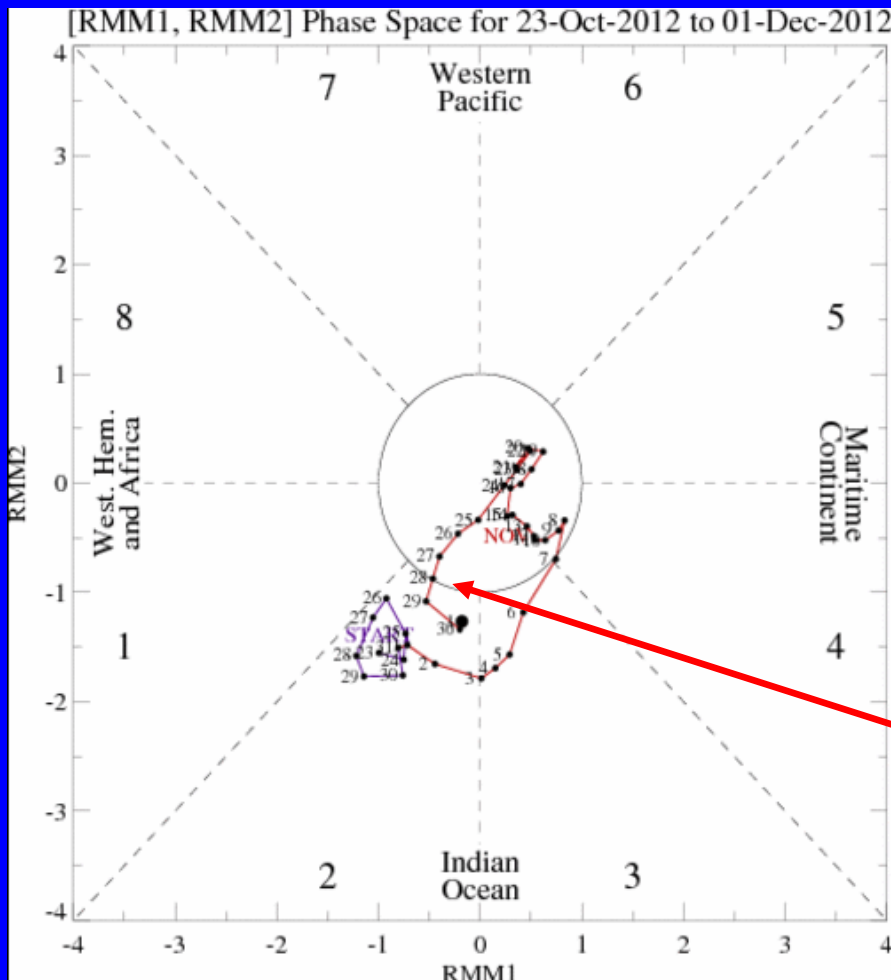
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

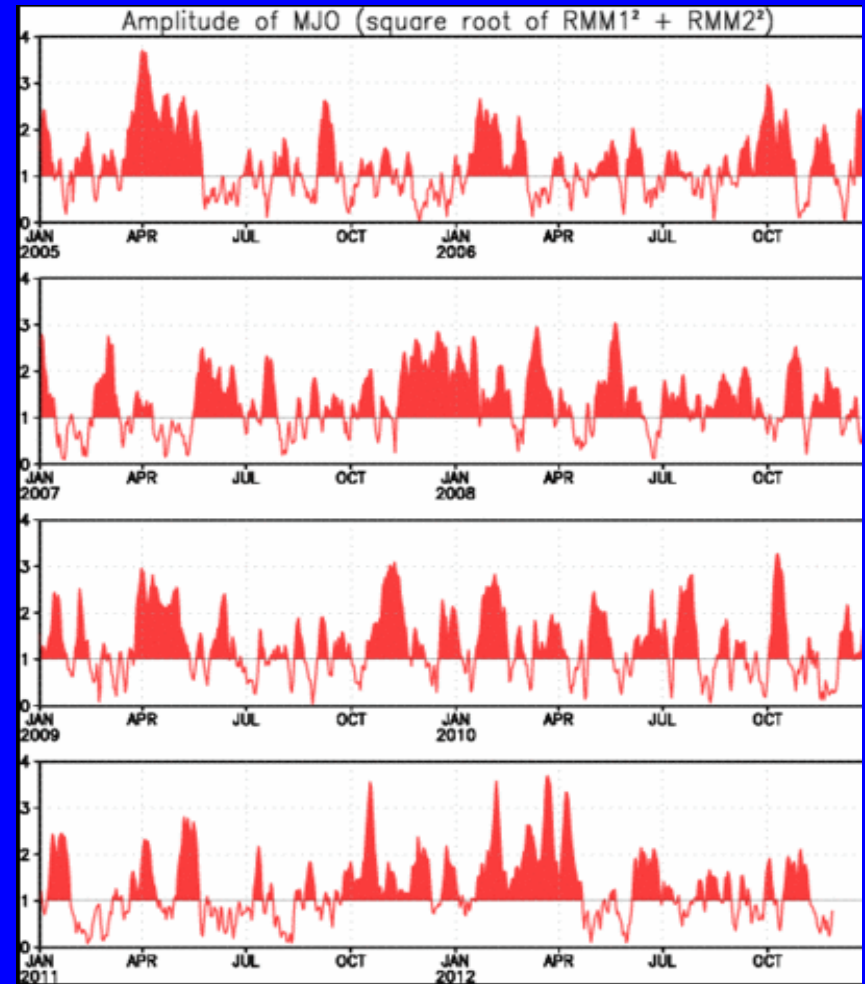
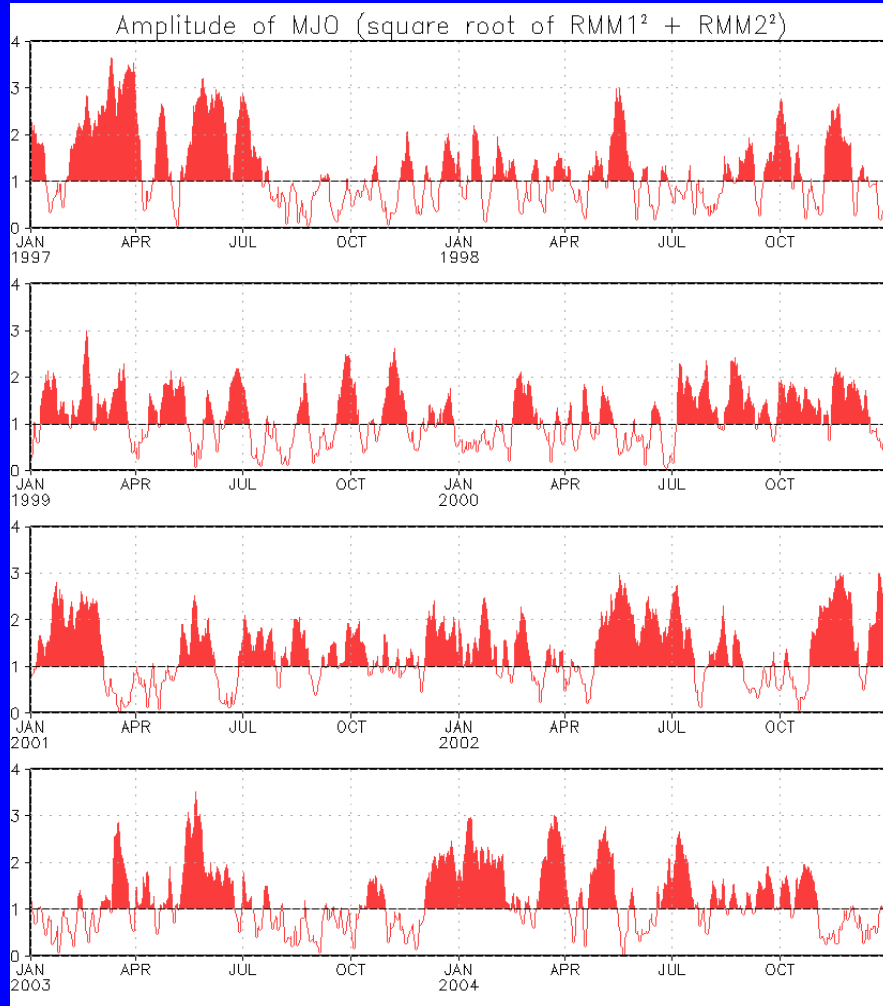


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index has increased in amplitude during the past week, but the apparent strengthening is most likely due to both equatorial Rossby wave and atmospheric Kelvin wave activity.



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

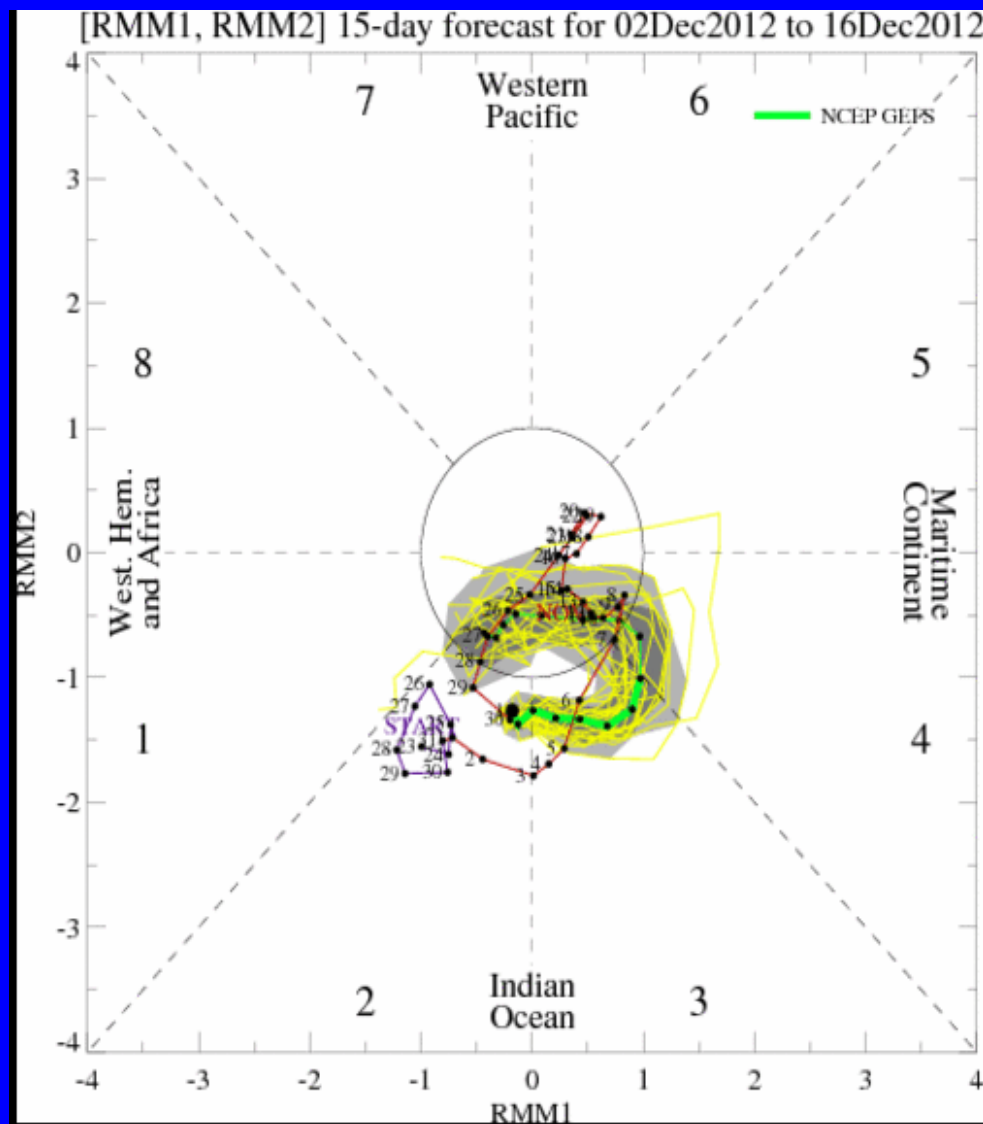
Green Line – Ensemble Mean

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 bias-corrected ensemble GFS forecasts propagation through Phase 3 during Week-1 with a weakening in the signal during Week-2.

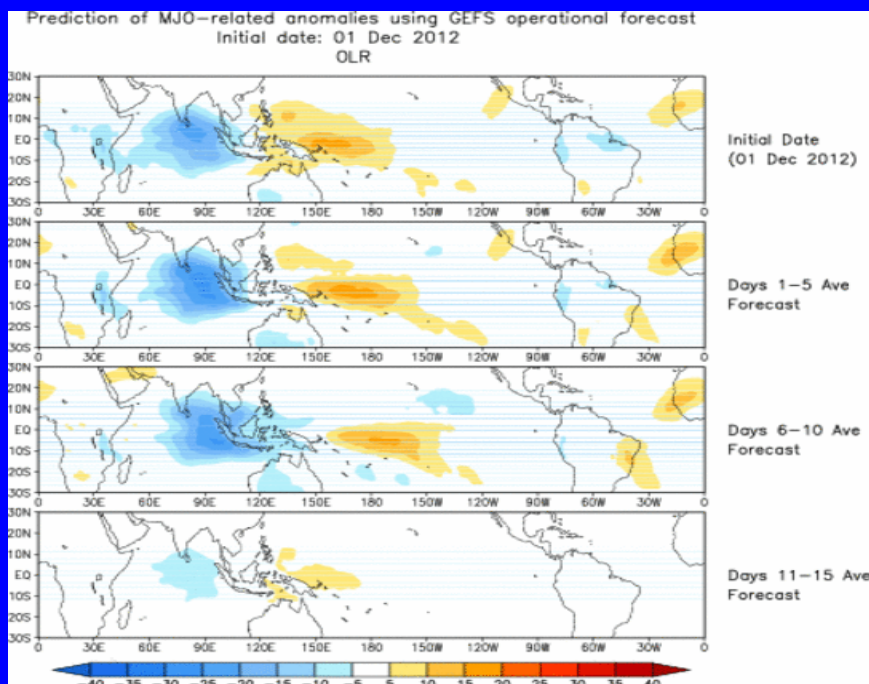




Ensemble Mean GFS MJO Forecast

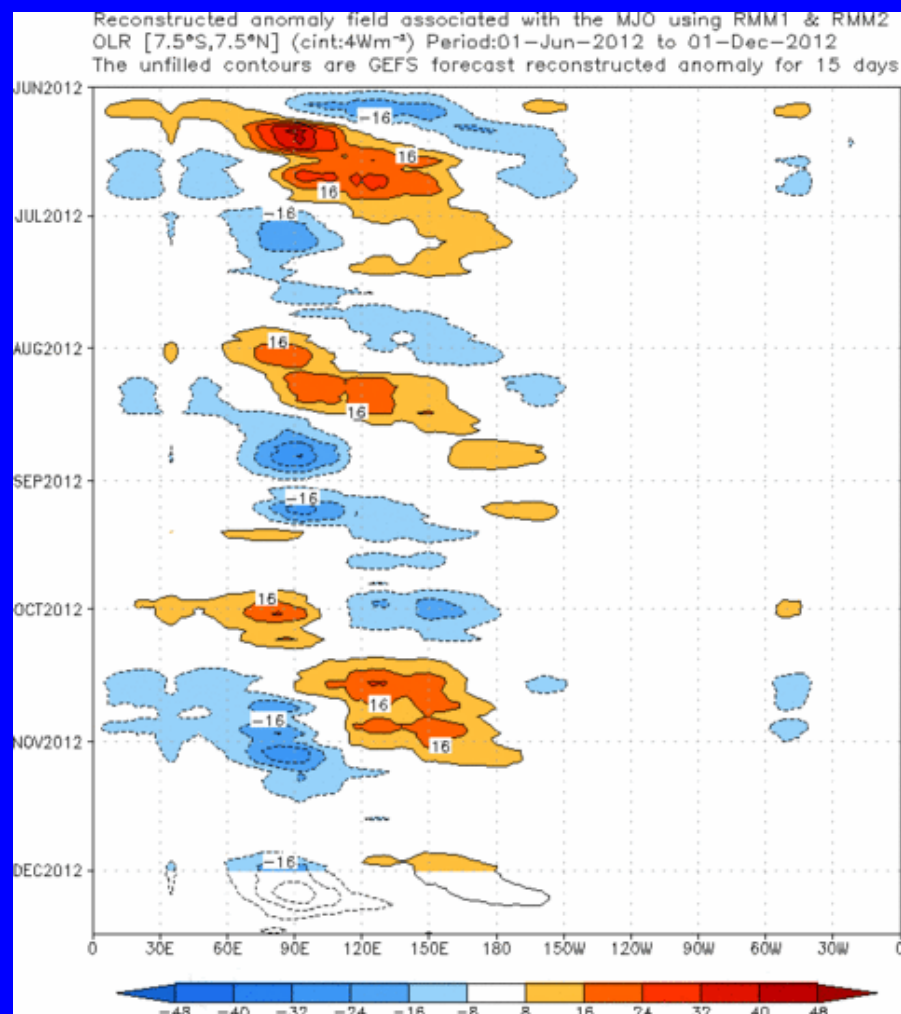
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecast indicates enhanced (suppressed) convection across the eastern Indian Ocean (western Pacific) primarily during Week-1.

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

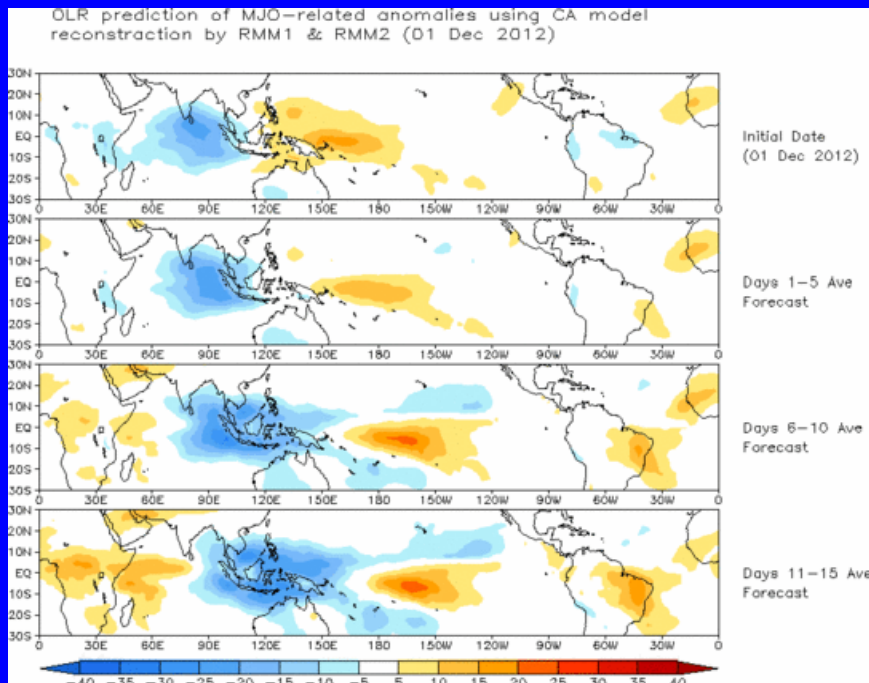




Constructed Analog (CA) MJO Forecast

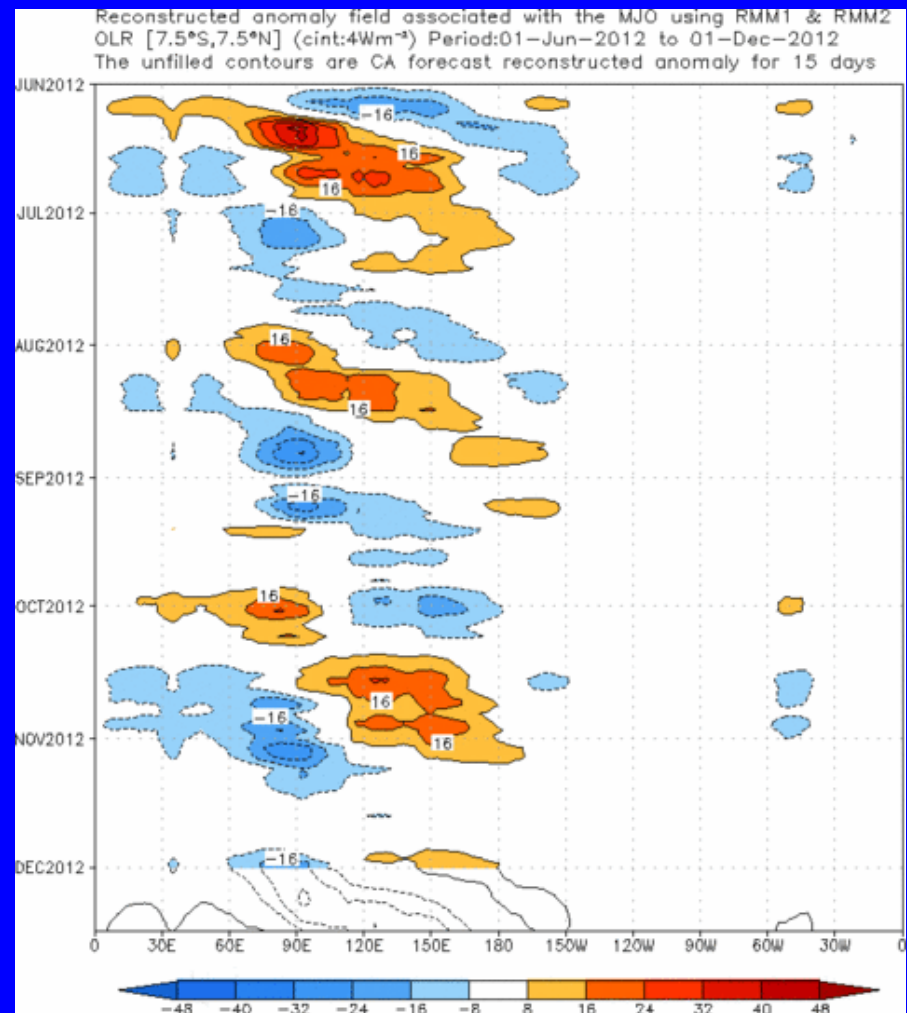
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



This forecast indicates a more progressive signal with enhanced convection shifting to and across the Maritime Continent during the period.

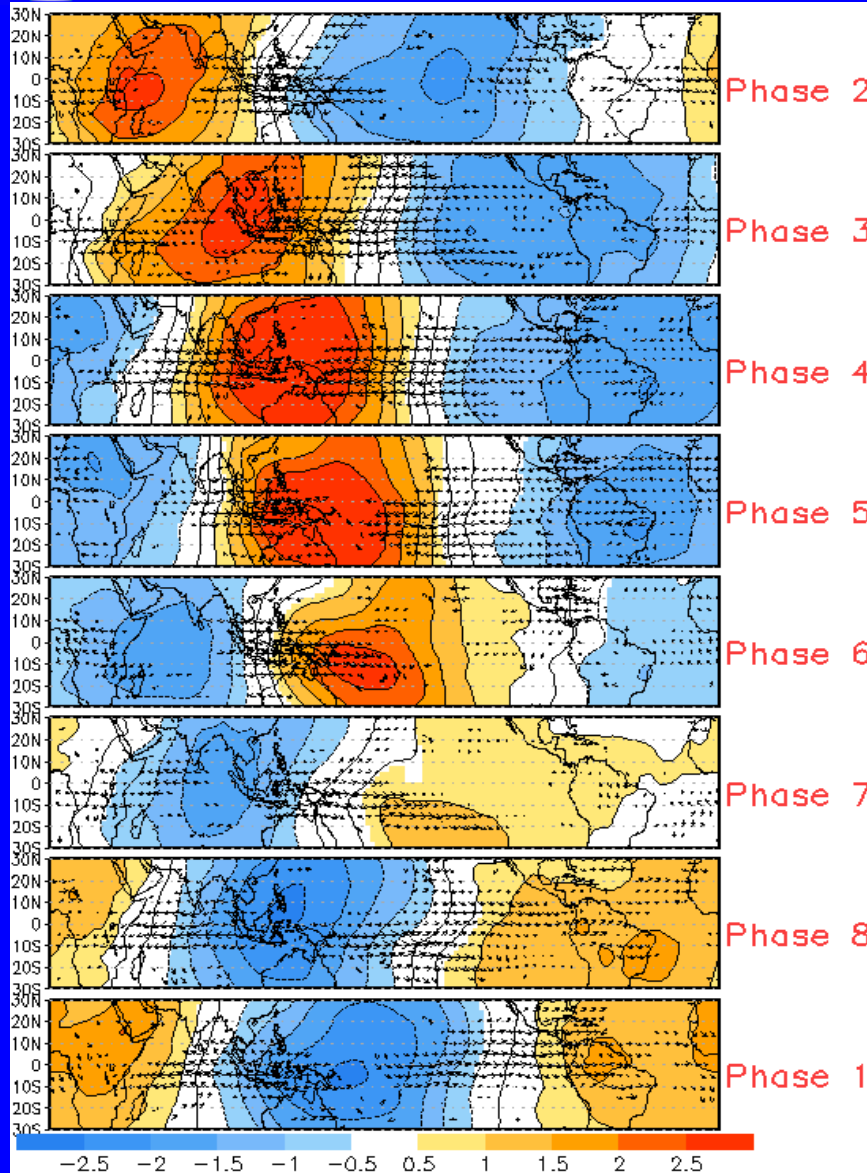
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



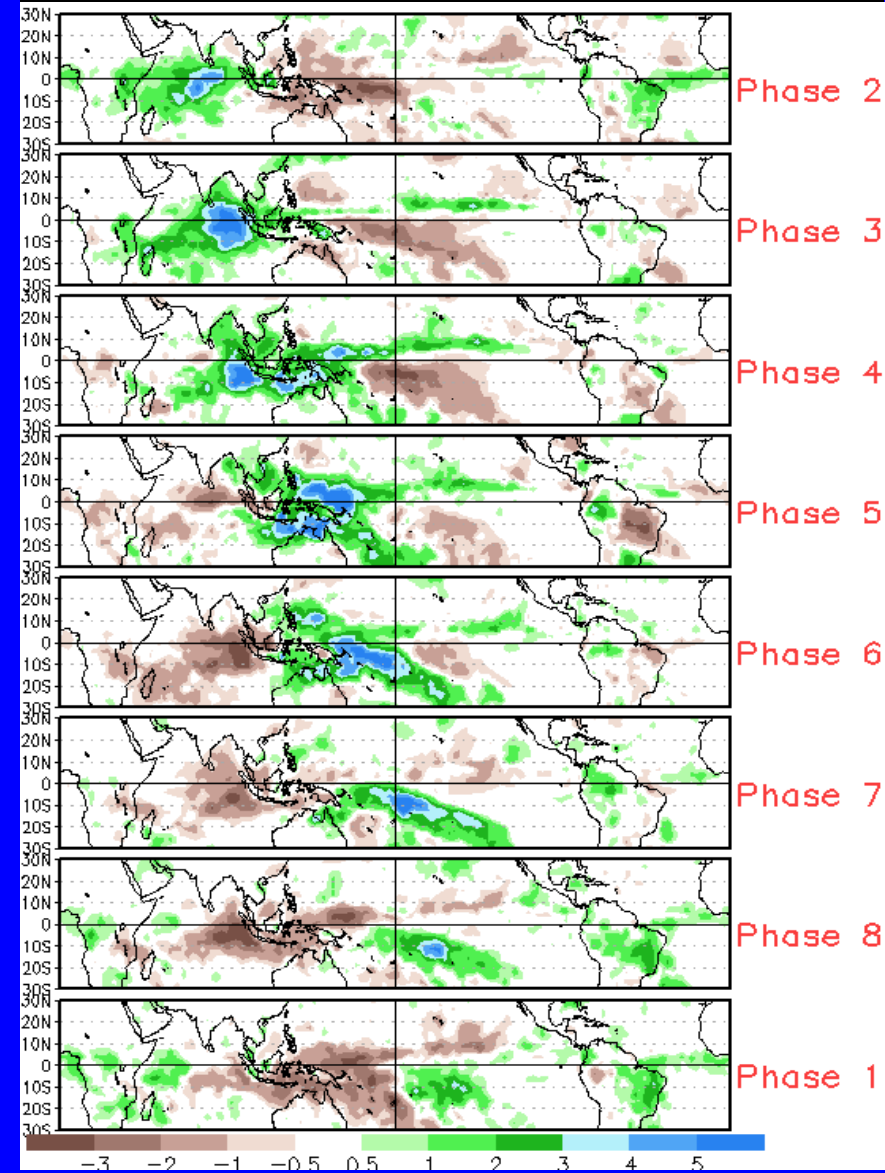


MJO Composites – Global Tropics

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



Precipitation Anomalies (Nov-Mar)

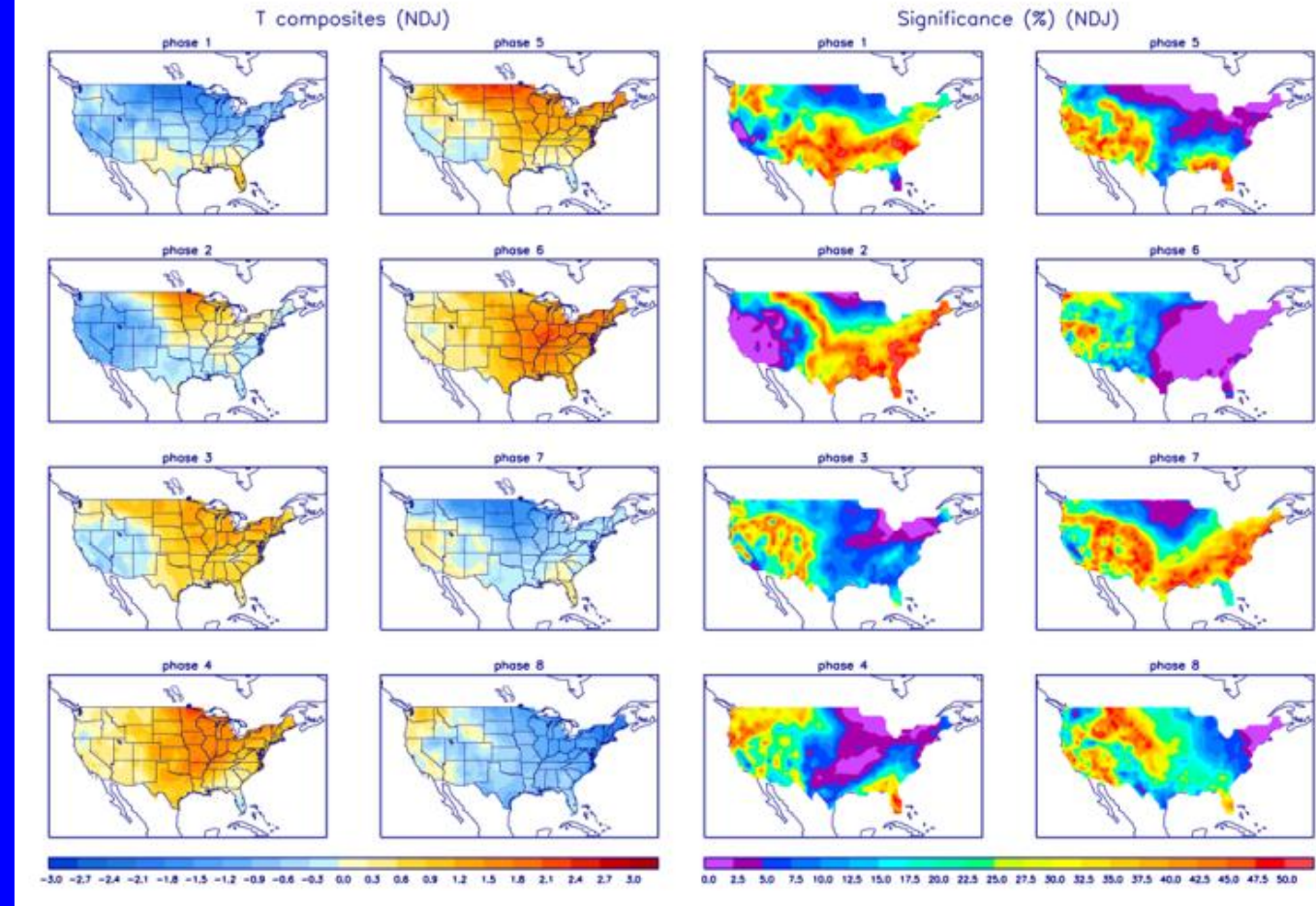




U.S. MJO Composites – Temperature

- 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.



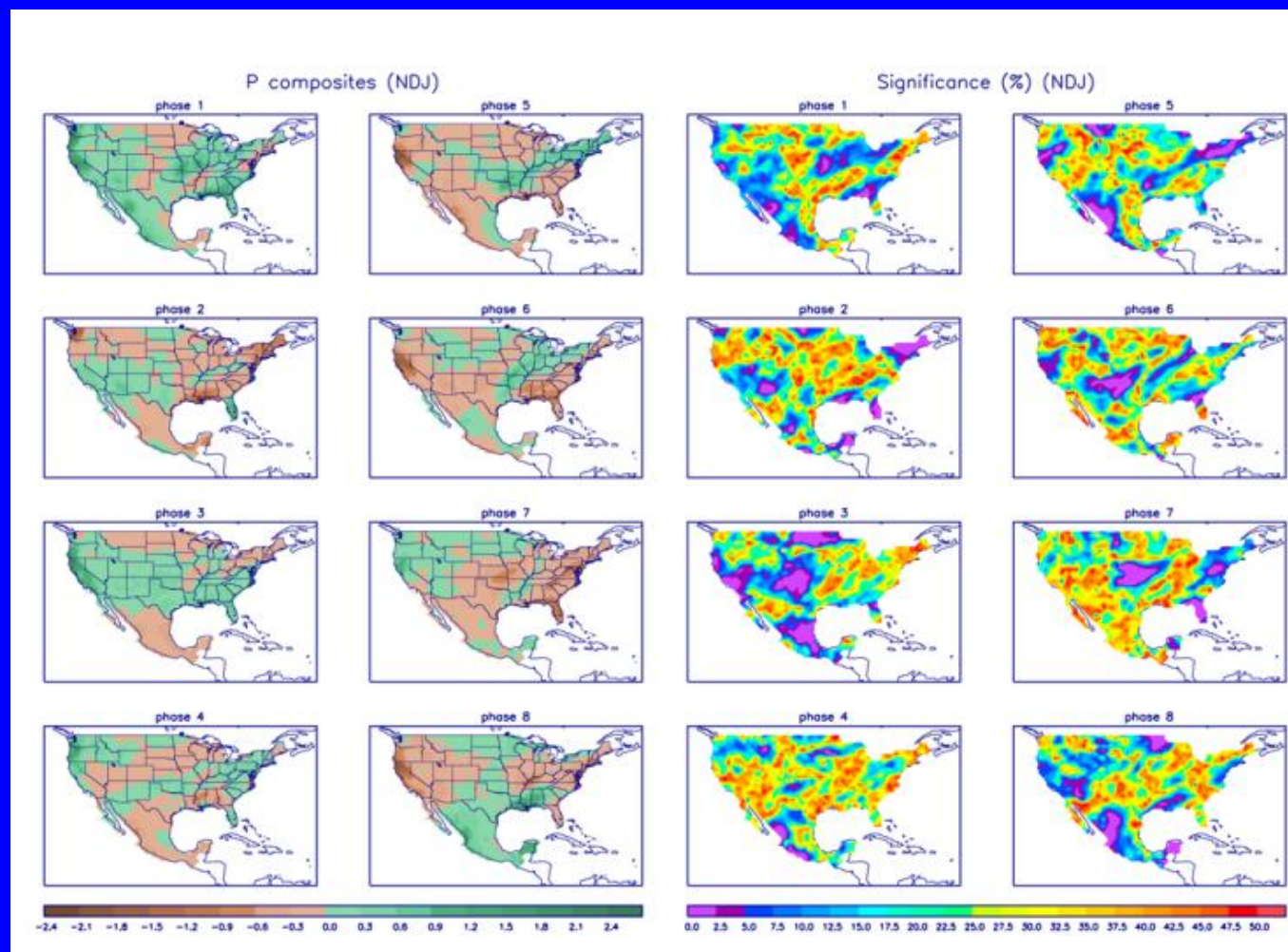
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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

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