



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

**Update prepared by
Climate Prediction Center / NCEP
June 30, 2014**



Outline

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



Overview

- **The MJO remained active during the past week with the enhanced phase centered over the eastern Pacific and the Americas.**
- **There is some spread among dynamical MJO index model forecasts, though most suggest the MJO will become less coherent over the next couple of weeks due to interaction with the low-frequency base state and other subseasonal variability.**
- **Based on recent observations and considerable range illustrated by dynamical model forecasts, the MJO is forecast to gradually become less discernible over the next two weeks.**
- **The MJO may contribute some to enhanced (suppressed) rainfall across parts of the Americas and Africa (Maritime Continent) during the period. The current and forecast state of the MJO may support tropical cyclone activity across the eastern Pacific basin.**

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>

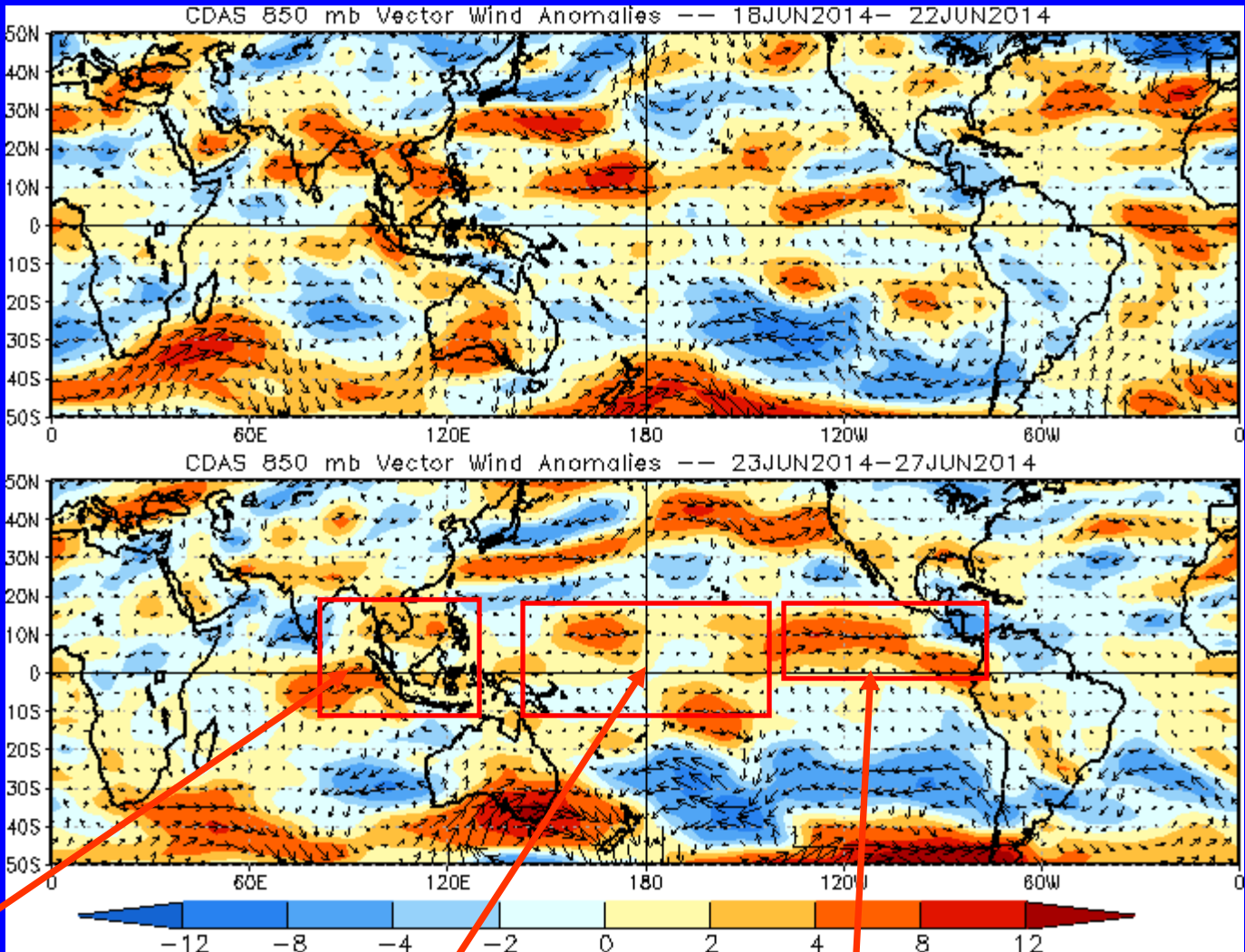


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies persisted over the eastern Indian Ocean and the western Maritime Continent.

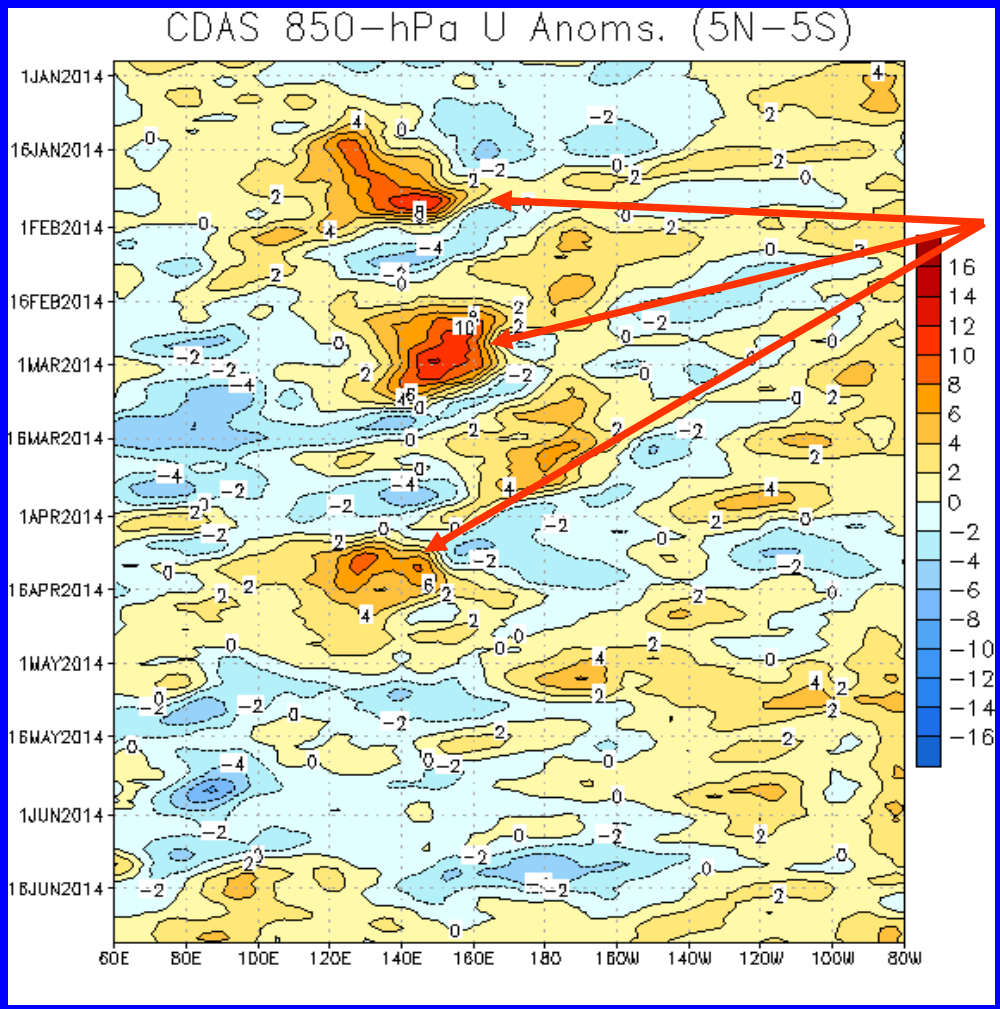
Weak westerly anomalies persisted across parts of the central Pacific.

Westerly anomalies continued over the eastern Pacific and diminished over the Atlantic during the most recent 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
↓

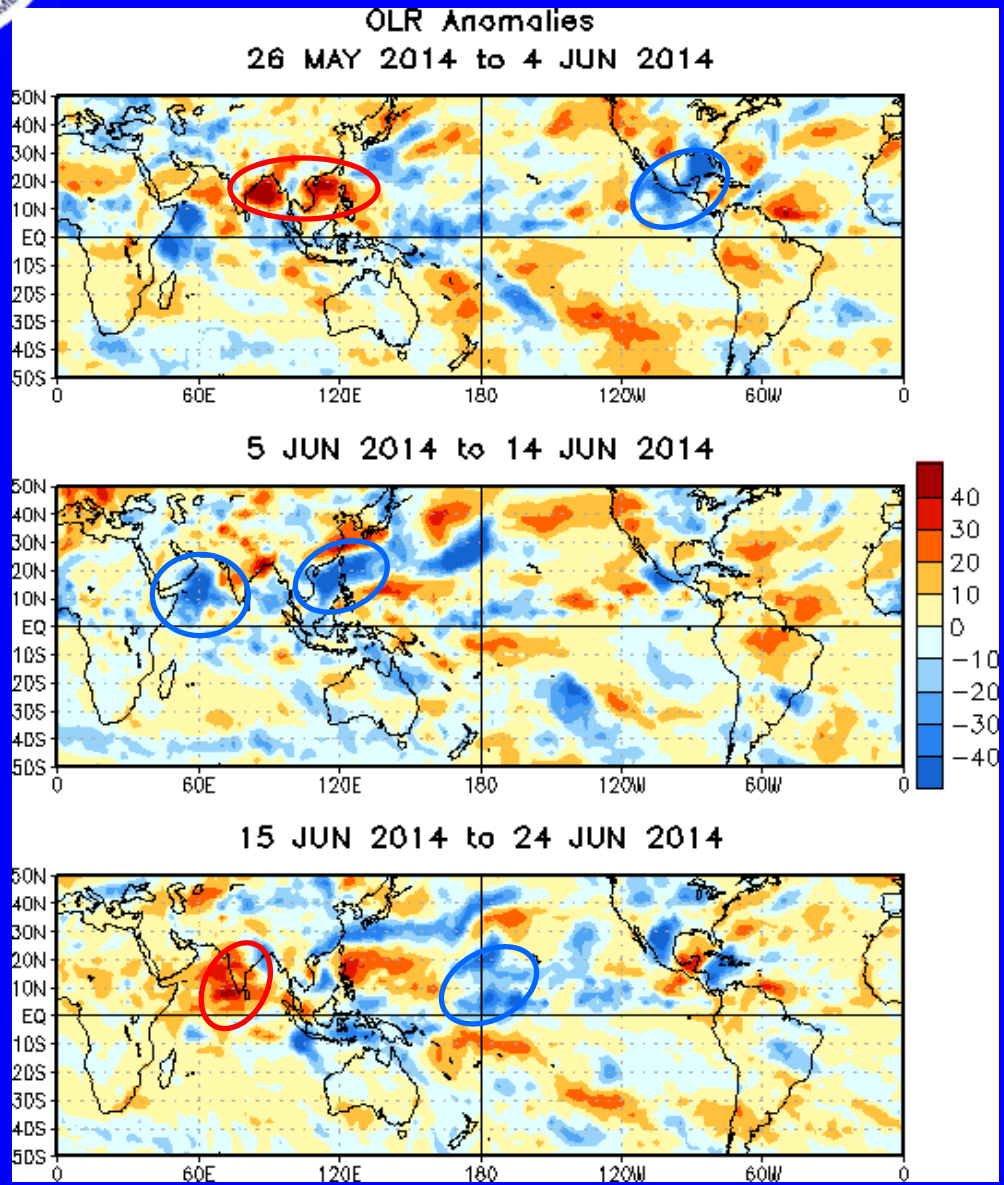
Longitude

- Multiple westerly wind bursts were observed across the western Pacific between January and mid-April.
- During April, westerly anomalies were generally persistent across the Maritime continent and far western Pacific.
- During much of May and June, westerly anomalies were observed over the eastern Pacific and Atlantic.
- Westerly anomalies associated with the South Asian monsoon are evident. Other anomalies are generally weak, though westerly, across the Pacific basin.



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 May and early June, tropical cyclone activity was evident over the eastern Pacific while a weak monsoon was evident across parts of southern Asia.

During early to mid-June, tropical convective anomalies were generally weak, though enhanced convection was observed across the western Indian Ocean and along the mei-yu front.

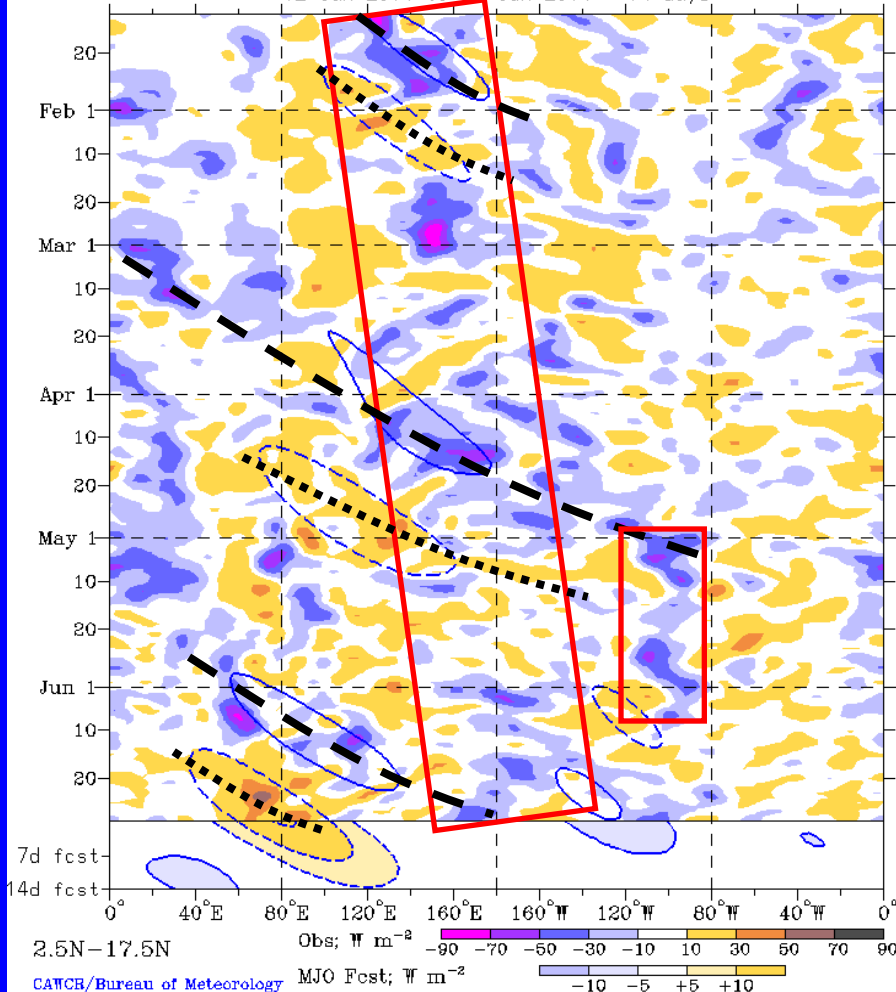
During mid- to late June, more organized enhanced convection was observed near the Date Line. Suppressed convection over India is associated with a delayed monsoon.



Outgoing Longwave Radiation (OLR)

Anomalies (2.5°N-17.5°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
12-Jan-2014 to 29-Jun-2014 + 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)

Since early January, enhanced convection has propagated slowly eastward from the Maritime Continent to the central Pacific (red box), interrupted periodically by subseasonal variability.

The MJO became more coherent during April, with the subseasonal envelopes of enhanced and suppressed convection modulating the strength of the low frequency signal. The anomalous tropical convection pattern became largely incoherent during mid-May, with convection over the eastern Pacific (red box).

During June, the MJO became more organized as eastward propagation of a coherent large-scale convective pattern was observed.

Longitude

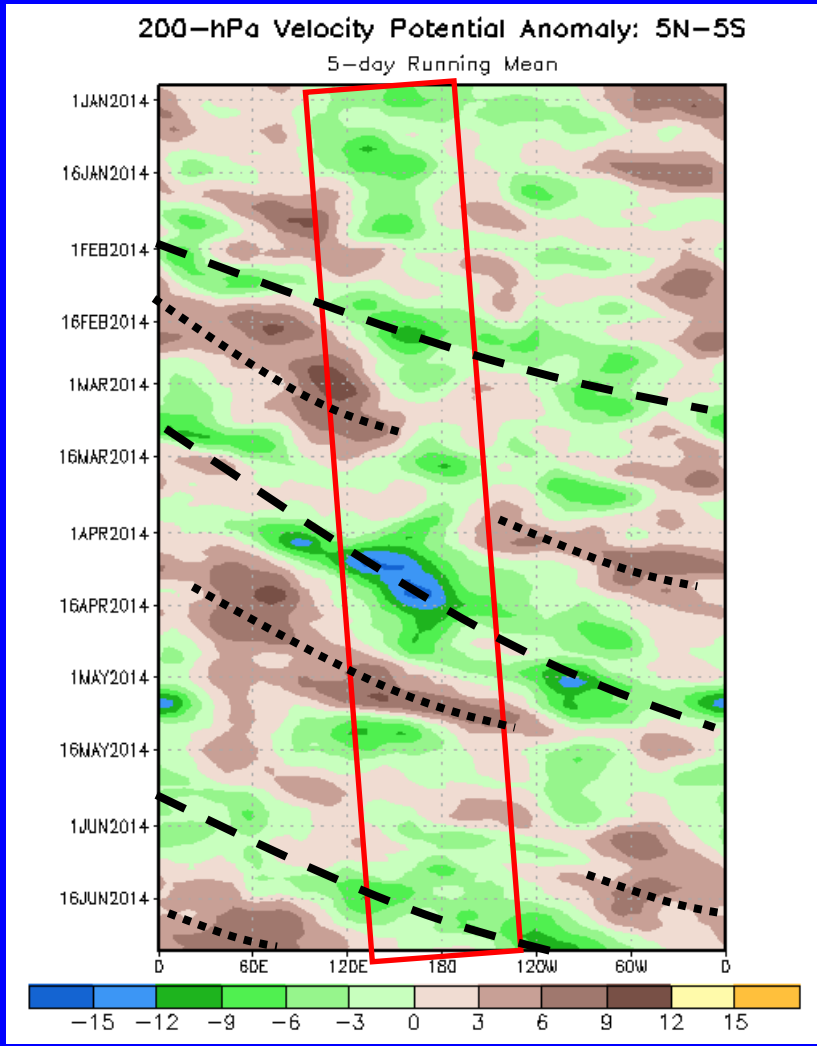


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time
↓



A slow eastward progression of negative anomalies was observed from late December to the present across the Indo-Pacific warm pool region (red box).

During February through April, anomalies propagated eastward with time associated with the MJO before weakening for much of May.

Recently the pattern has become more organized with a coherent wave-1 structure propagating eastward during most of June.

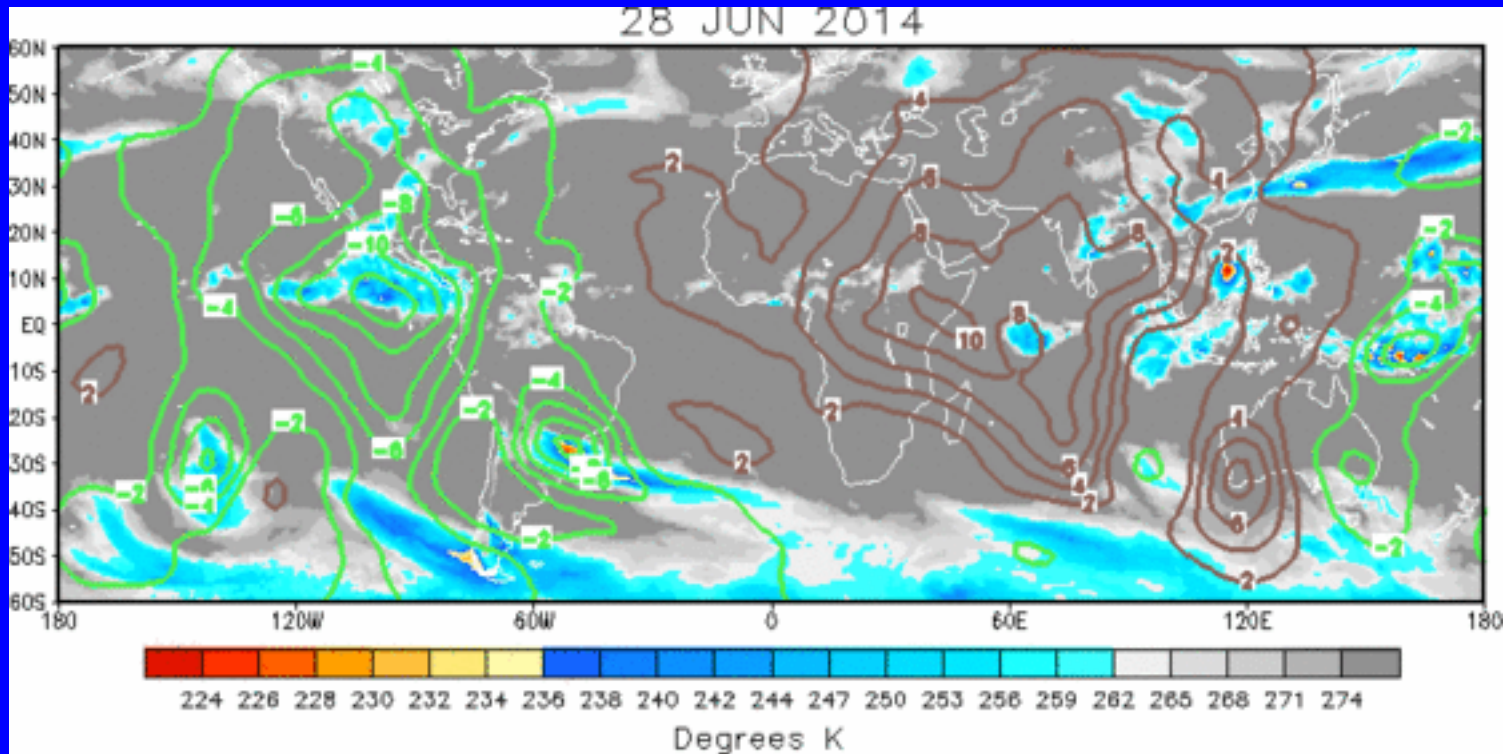
Longitude



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 exhibits a wave-1 structure with divergence (convergence) across the eastern Pacific and Americas (Africa and the Indian Ocean). The pattern is consistent with the evolving background state and ongoing MJO activity.

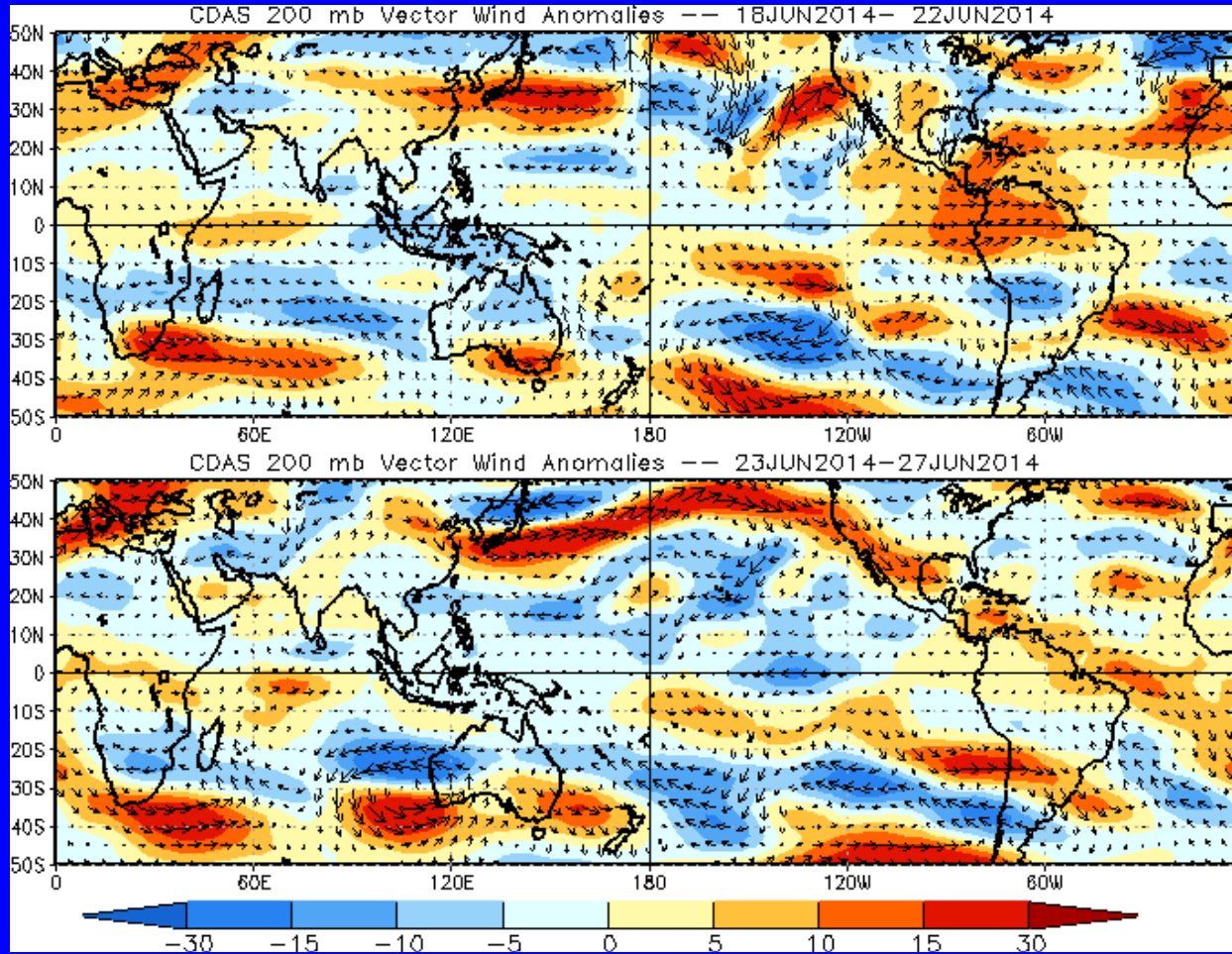


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



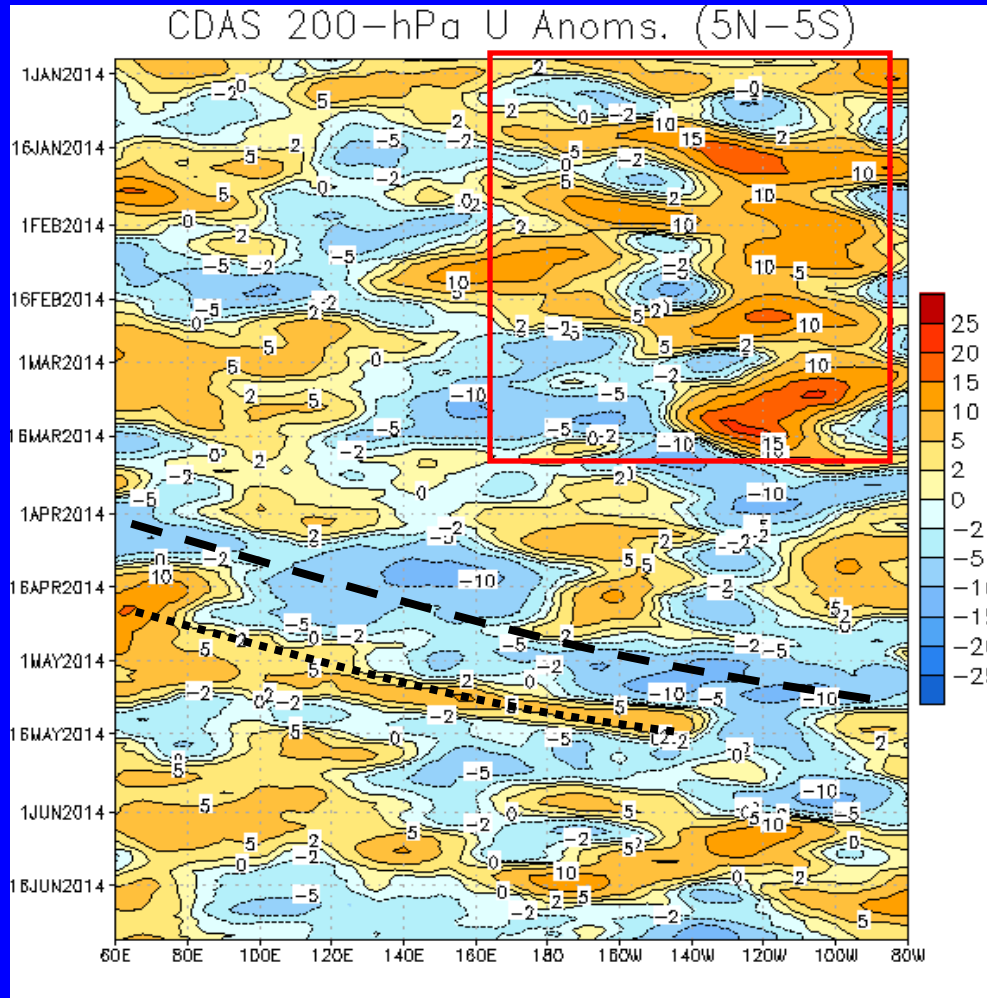
Upper-level zonal wind anomalies are generally weak and disorganized.



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

From December into March, westerly anomalies were most prevalent across the western Hemisphere (red box).

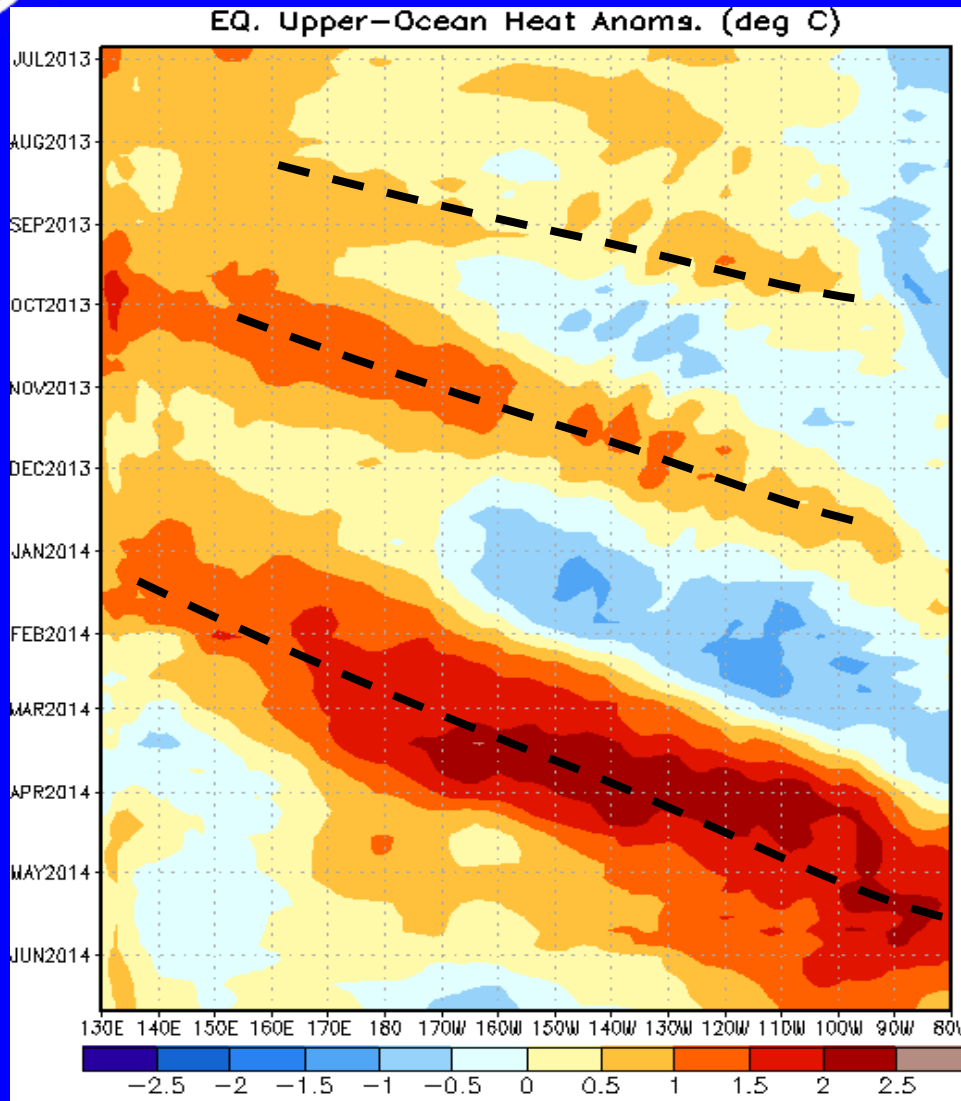
During mid-April, the slowly evolving background state has contributed to easterly anomalies expanding to the Date Line.

MJO activity is evident in the eastward propagation of both easterly and westerly anomalies during April and early May. This signal weakened during late May.

Westward propagation of westerly anomalies is evident over the east central Pacific during June, as is the eastward propagation of a larger scale signal.



Weekly Heat Content Evolution in the Equatorial Pacific



Oceanic downwelling Kelvin wave activity is evident in late August 2013 and once again 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 from April through early June, though basin-averaged anomalies are low-amplitude recently.



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.

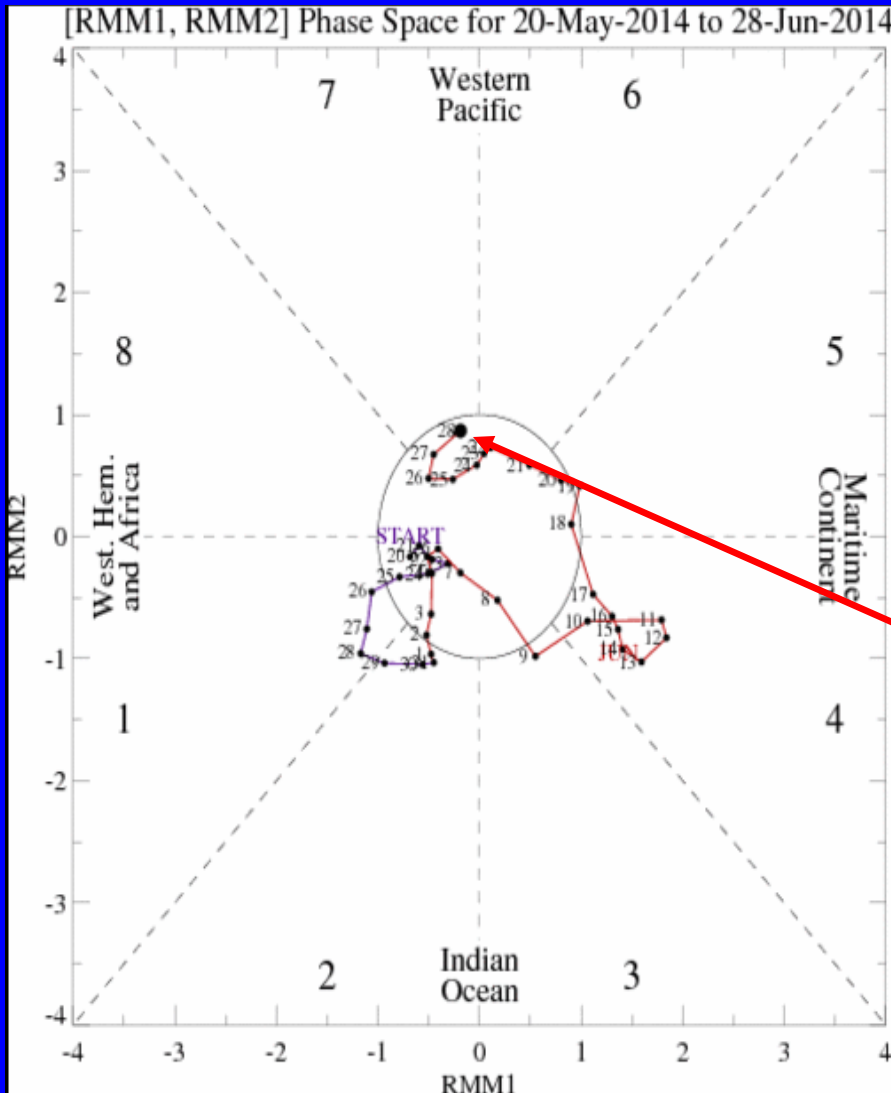
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

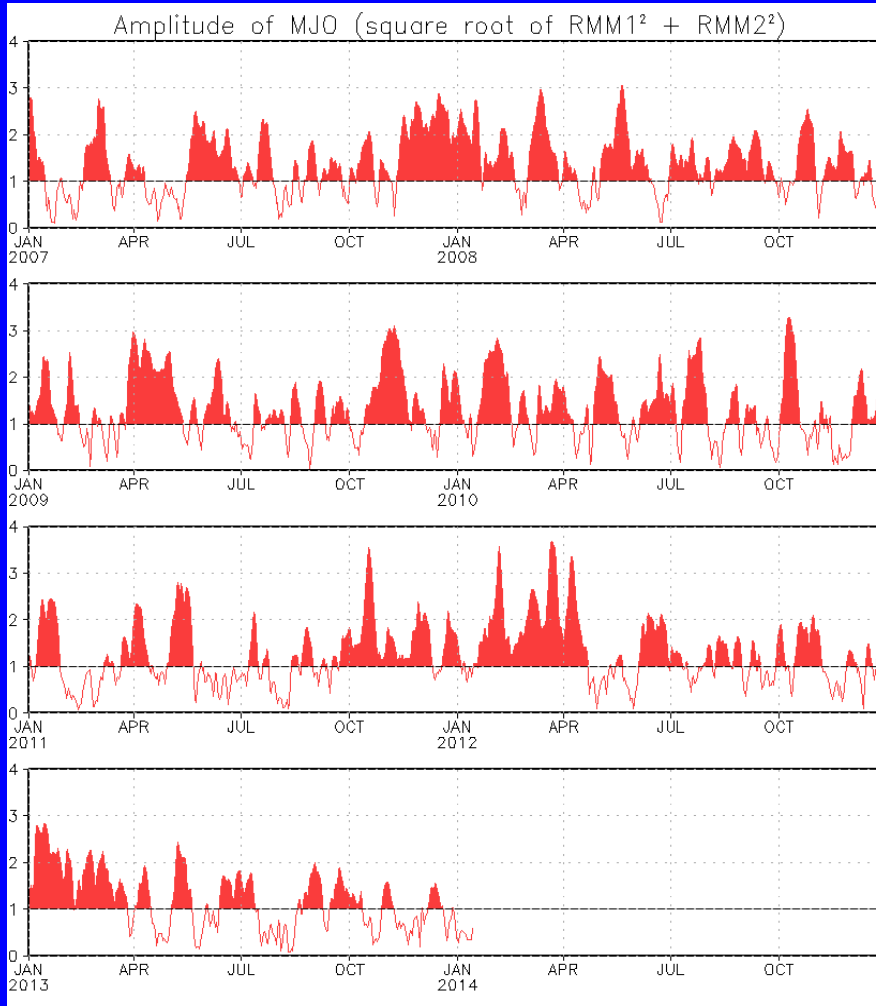


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index shows a weak signal over the western Pacific during the past 5 days.



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.



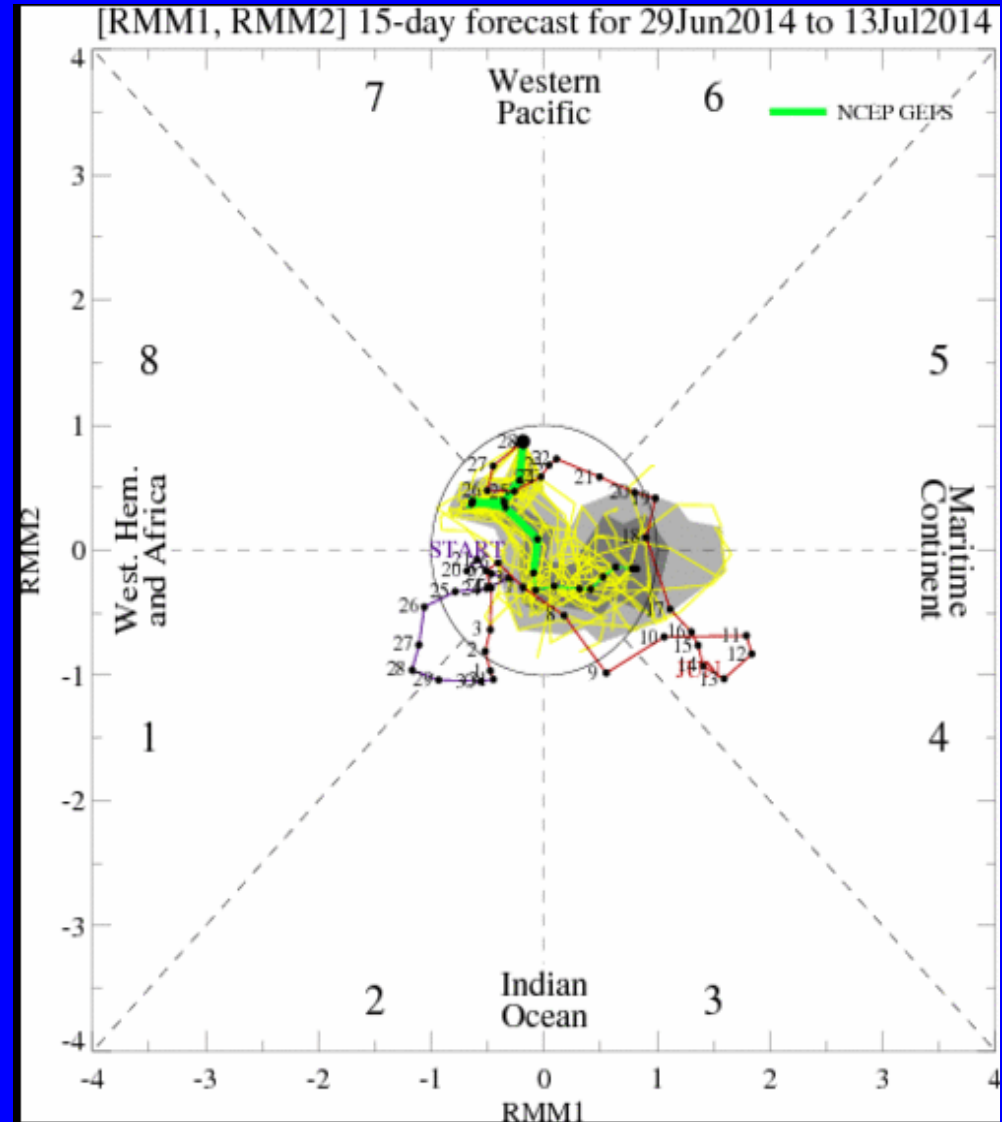
Ensemble GFS (GEFS) MJO Forecast

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 weak signal with rapid eastward propagation of the MJO RMM Index during the next two weeks.

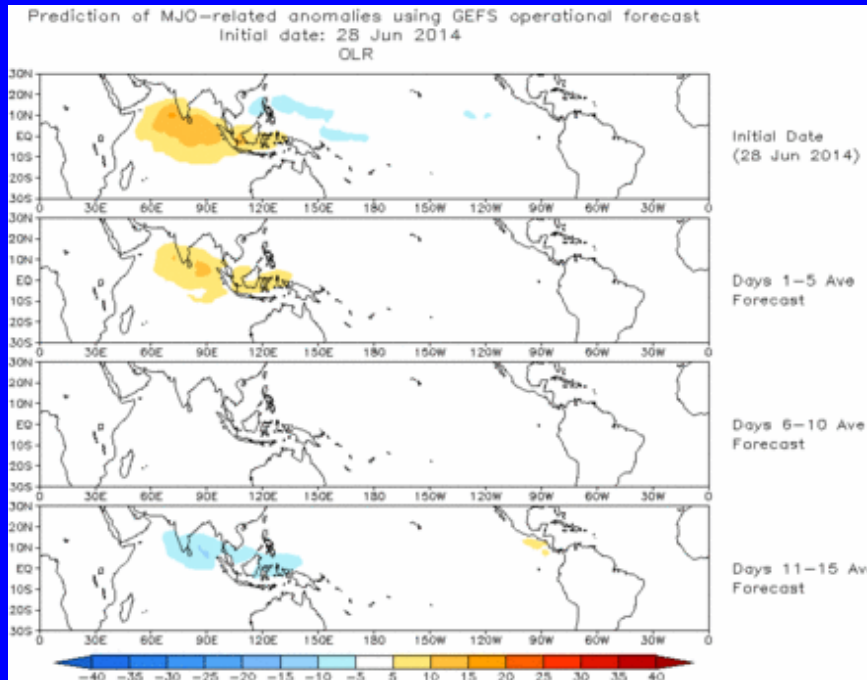




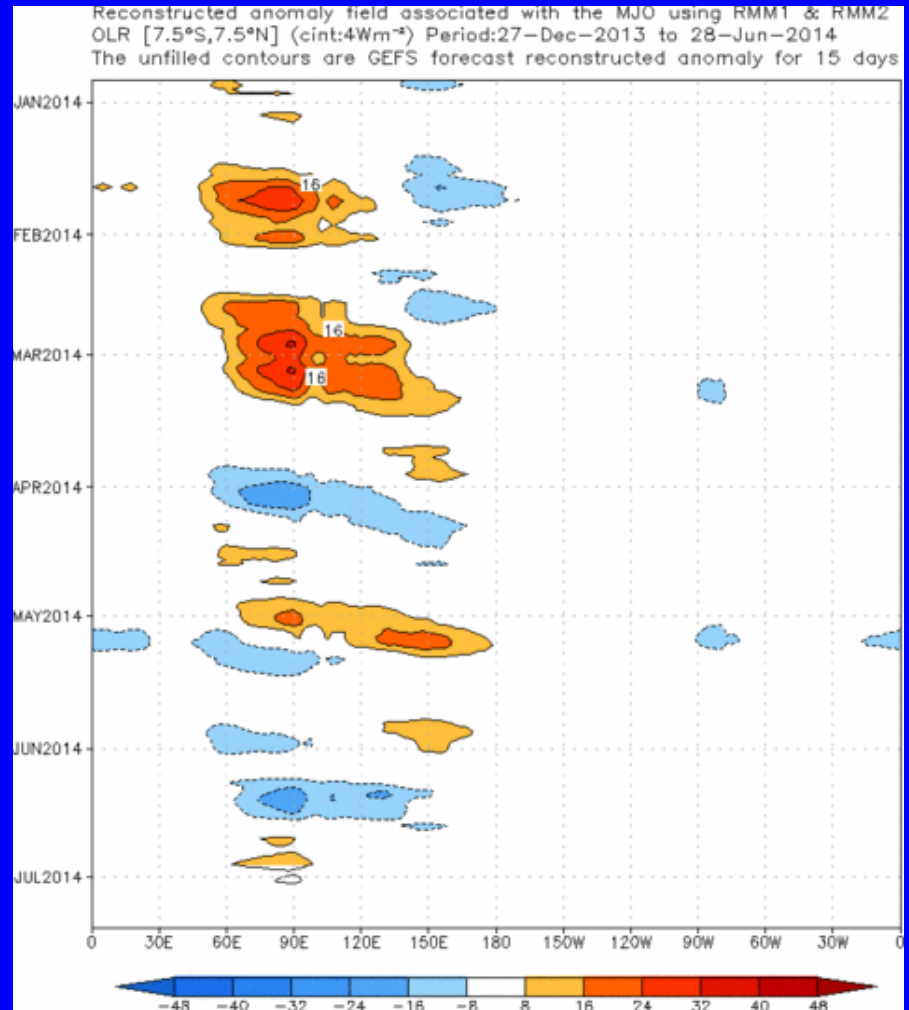
Ensemble Mean GFS MJO Forecast

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



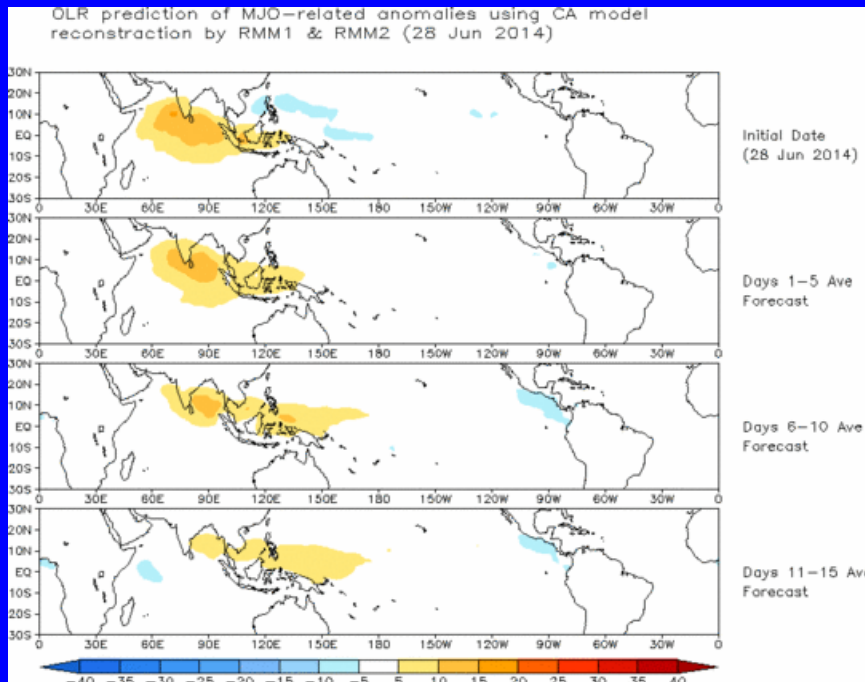
The ensemble mean GFS forecasts rapid eastward propagation of convection back toward the Indian Ocean and Maritime Continent by late in Week-2. This phase speed is more consistent with Kelvin wave activity.



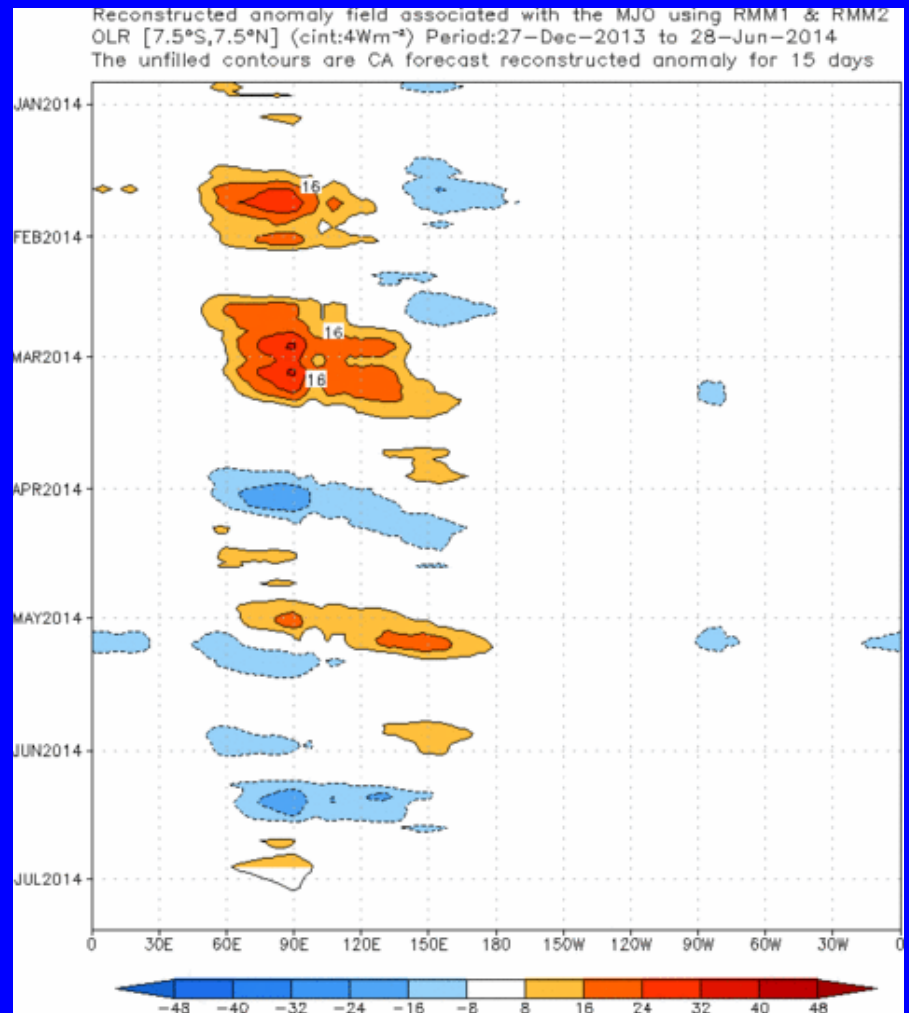
Constructed Analog (CA) MJO Forecast

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.)

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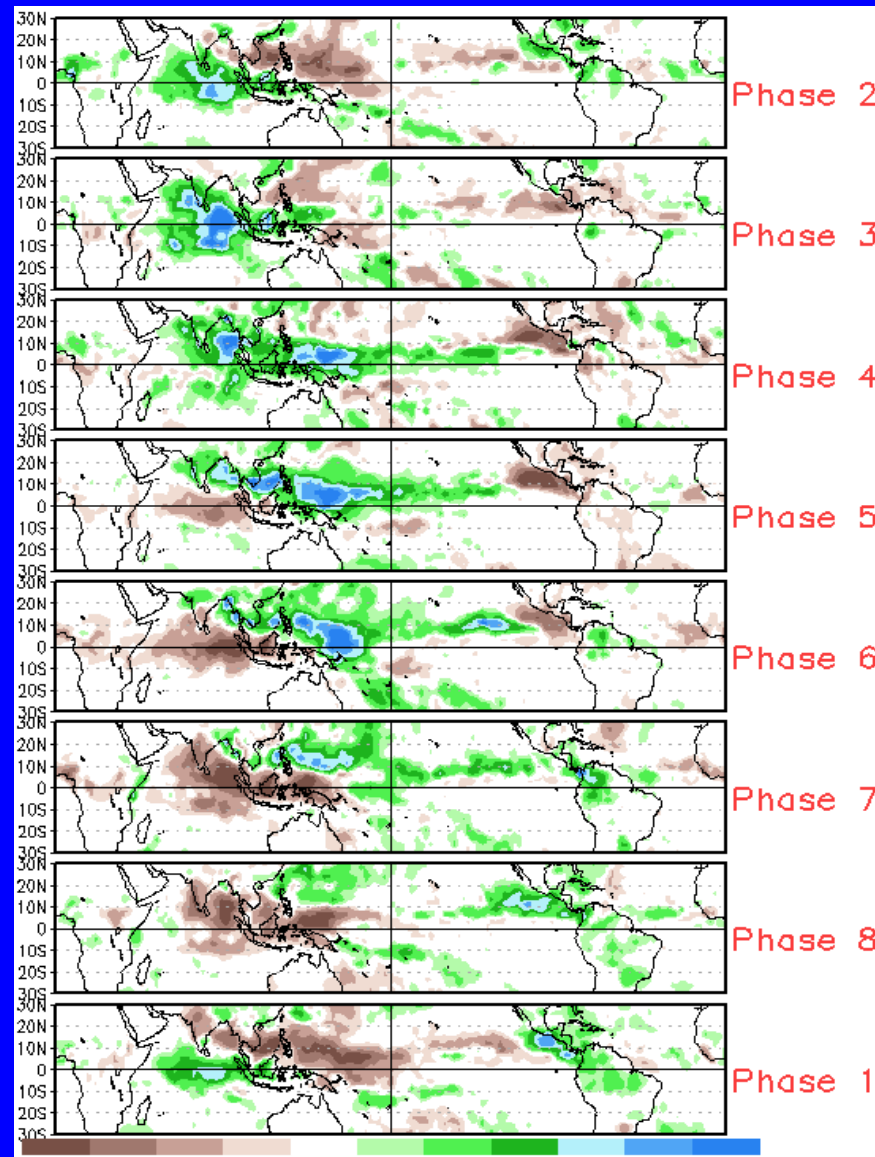
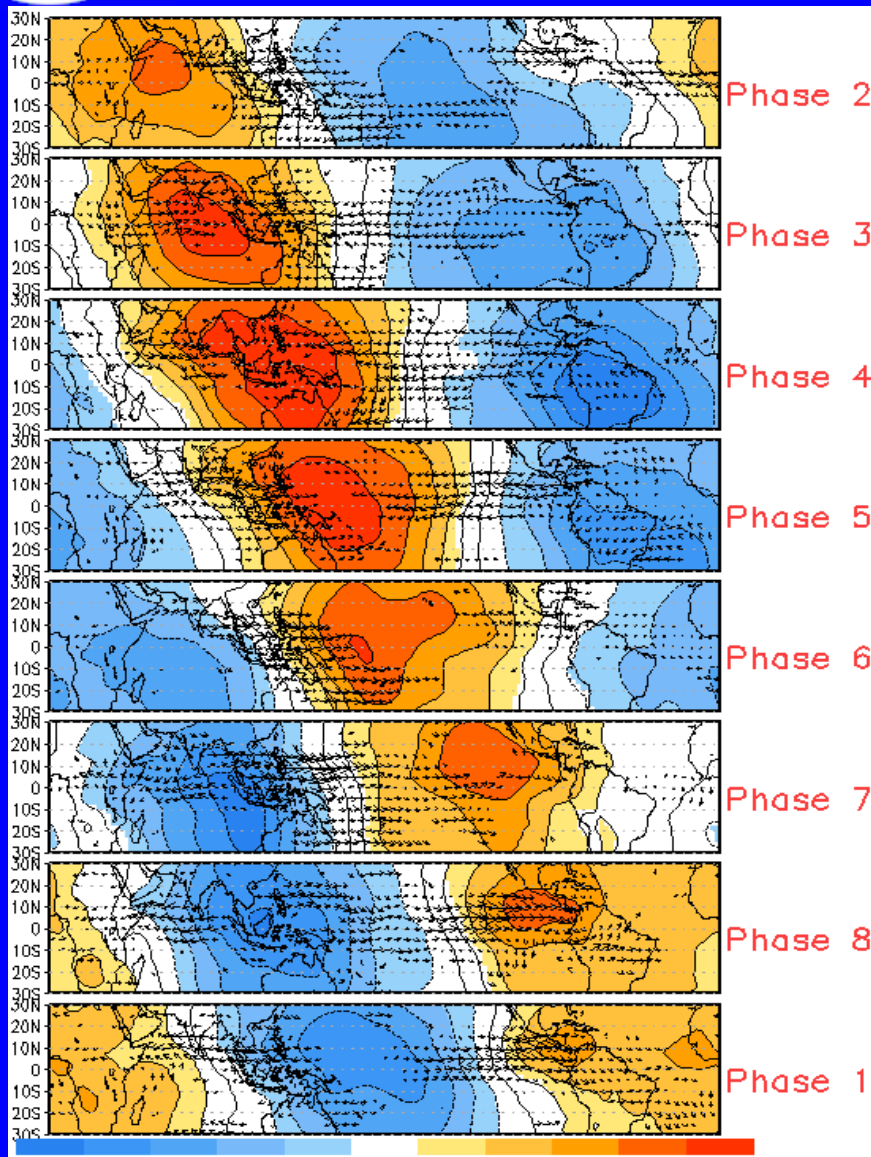
The constructed analog MJO forecast depicts a slower eastward propagation of convective anomalies with suppressed propagating slowly over the Maritime Continent.



MJO Composites – Global Tropics

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

Precipitation Anomalies (May-Sep)

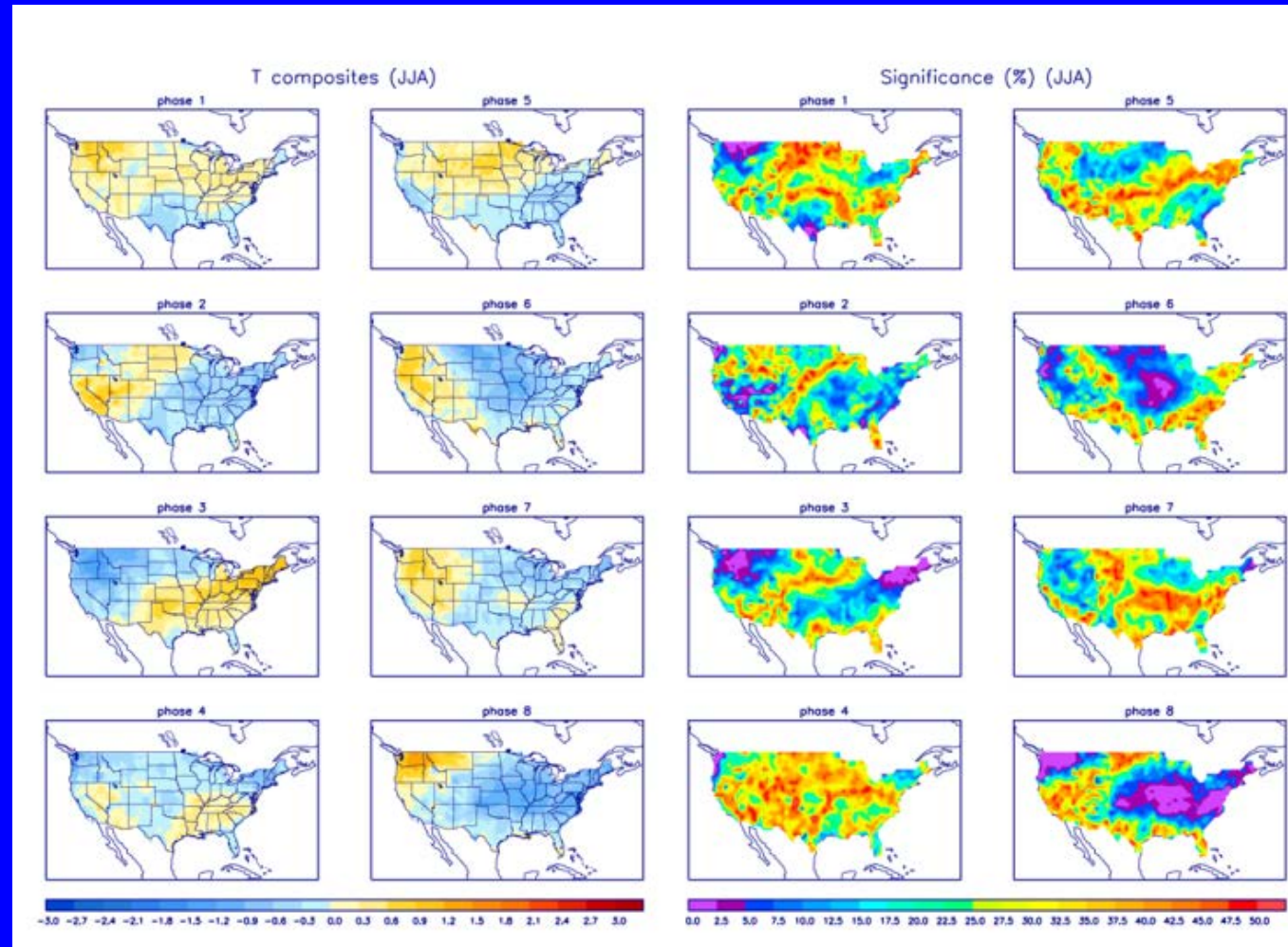




U.S. MJO Composites – Temperature

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.



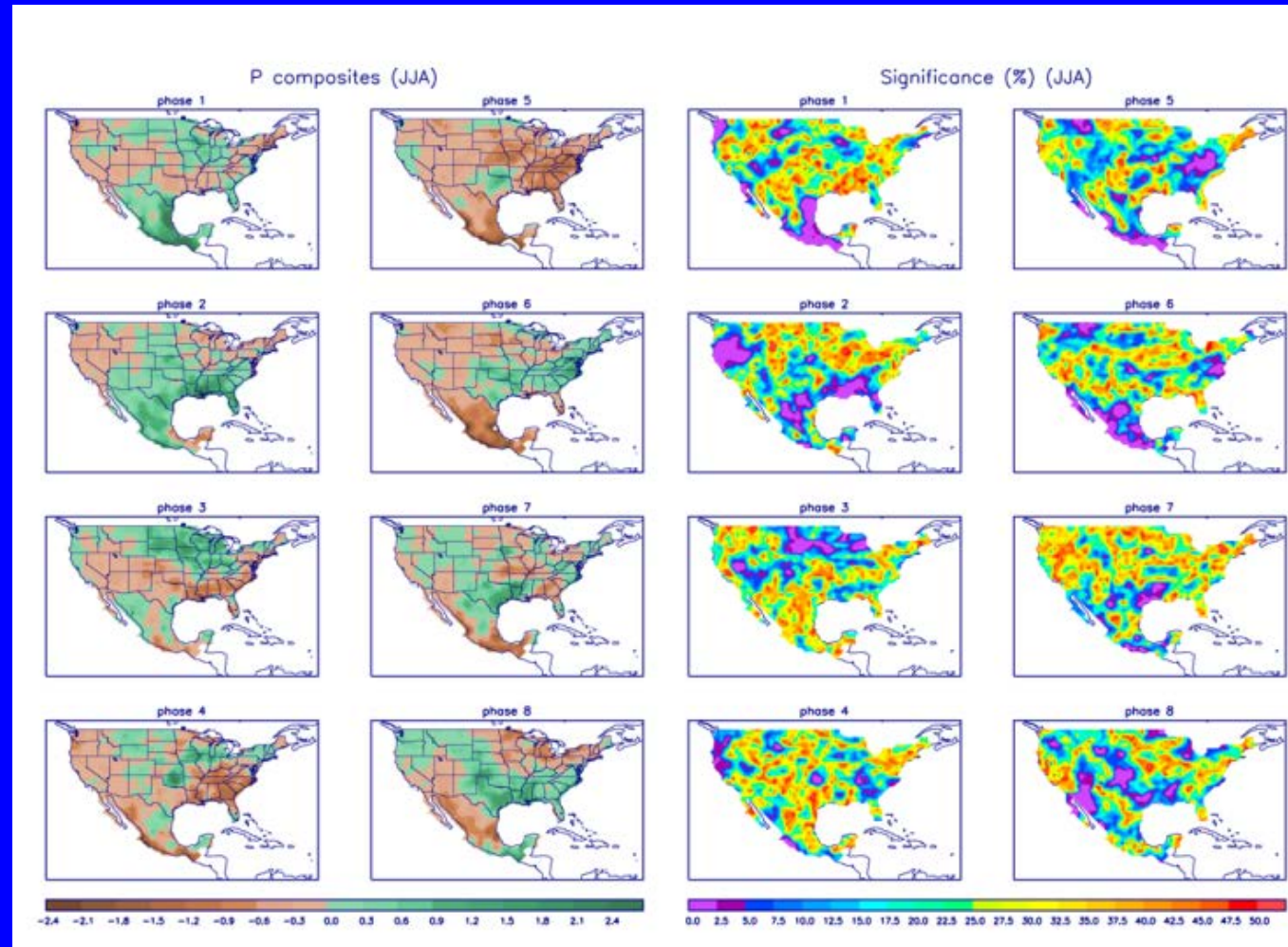
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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.



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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