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

Update prepared by the Climate Prediction Center
NWS / NCEP / CPC
11 December 2023

Overview

- Since early December, an active MJO has continued to propagate eastward across the Indian Ocean and Maritime Continent and has recently begun to constructively interfere with the low frequency El Nino base state over the equatorial Pacific.

- Continued eastward propagation of the MJO signal into Western Hemisphere is favored in the RMM forecasts towards the end of December, however dynamical models generally point to some disorganization and loss of amplitude likely tied to competing tropical variability as it crosses the Pacific during the next two weeks.

- The favored return of strongly anomalous lower-level westerlies throughout the equatorial Pacific is likely to further reinforce the El Nino conditions, while the responses associated with the positive Indian Ocean Dipole (+IOD) look to gradually weaken.

- Models show an uptick in Tropical Cyclone (TC) genesis potential in the Indian Ocean, while the large-scale environment appears favorable for development in the Western and South Pacific basins.

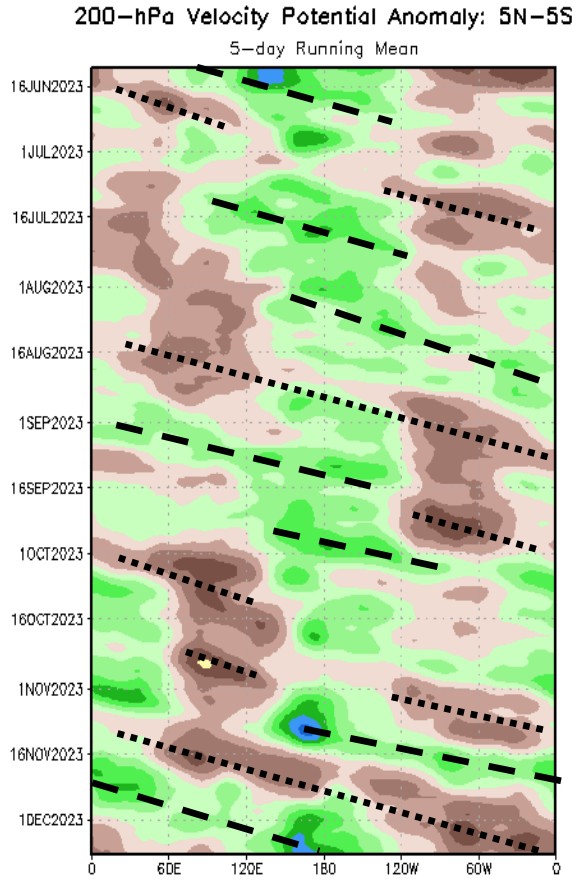
- Eastward propagating MJO events over the western Pacific typically favor the development of anomalous mid-level troughing over the CONUS, though models depict more of El Nino response over North America (namely a +PNA pattern emerging).

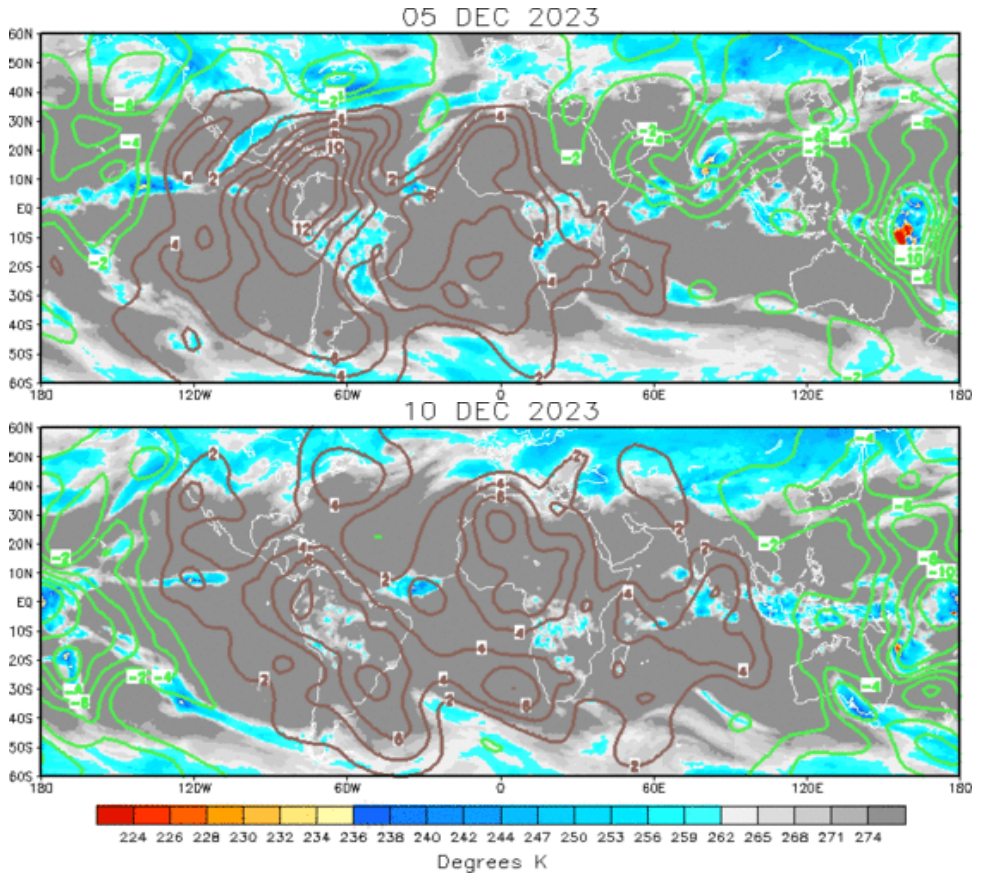
A discussion of potential impacts for the global tropics and those related to the U.S. are updated on Tuesday at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

200-hPa Velocity Potential Anomalies

Green shades: Anomalous divergence (favorable for precipitation)

Brown shades: Anomalous convergence (unfavorable for precipitation)

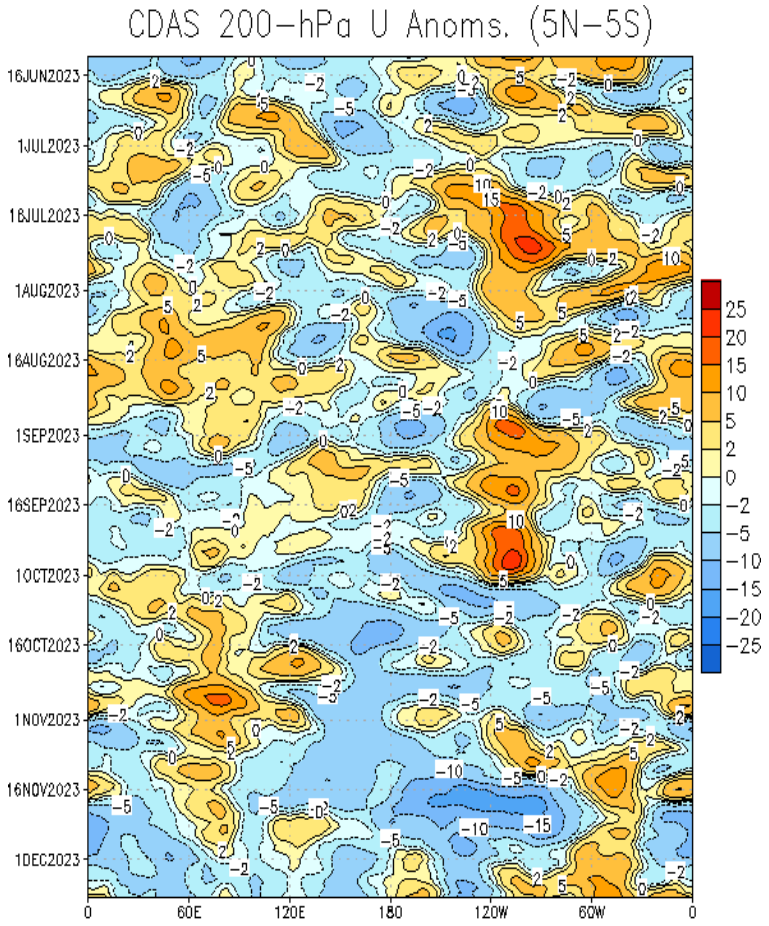


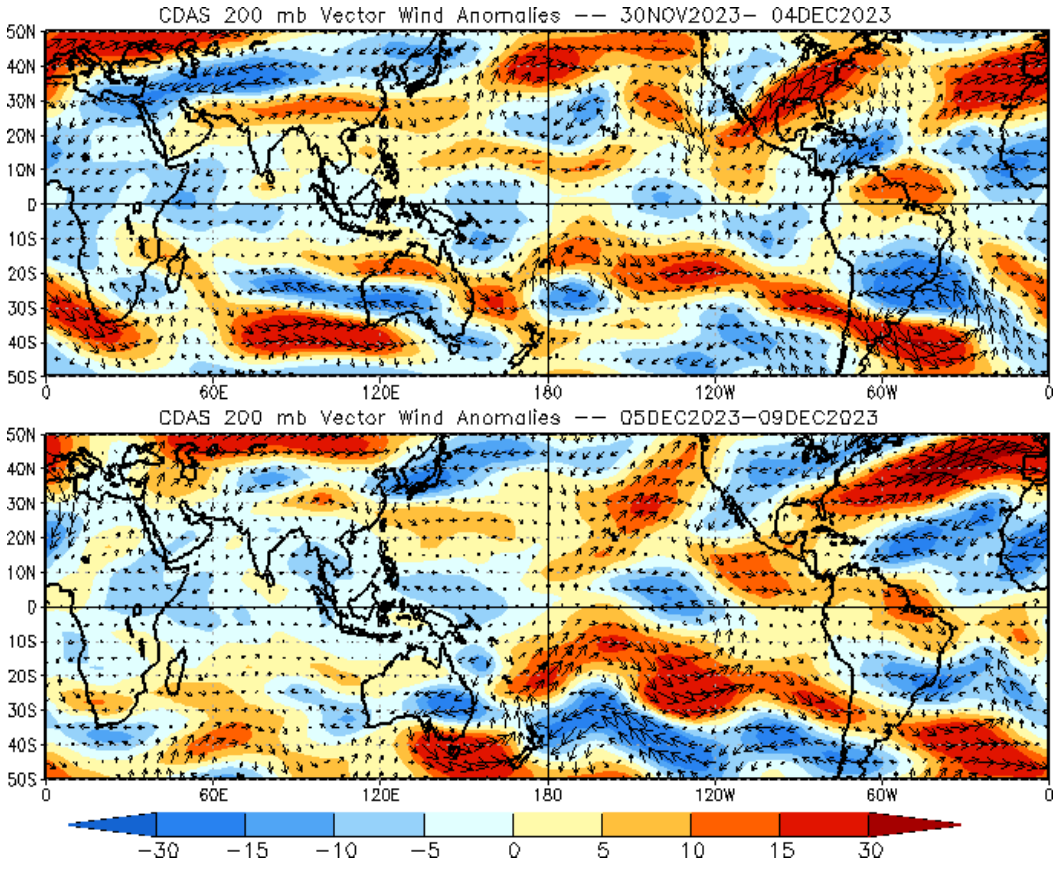


- Organized MJO activity continues in the upper-level velocity potential anomalies fields with a well-defined wave-1 pattern during the past week.
- Both the suppressed and enhanced phases show a canonical eastward propagation, where the latter is constructively interfering with the low frequency El Nino base state in the equatorial Pacific.

200-hPa Wind Anomalies

Shading denotes the zonal wind anomaly. Blue shades: Anomalous easterlies. Red shades: Anomalous westerlies.

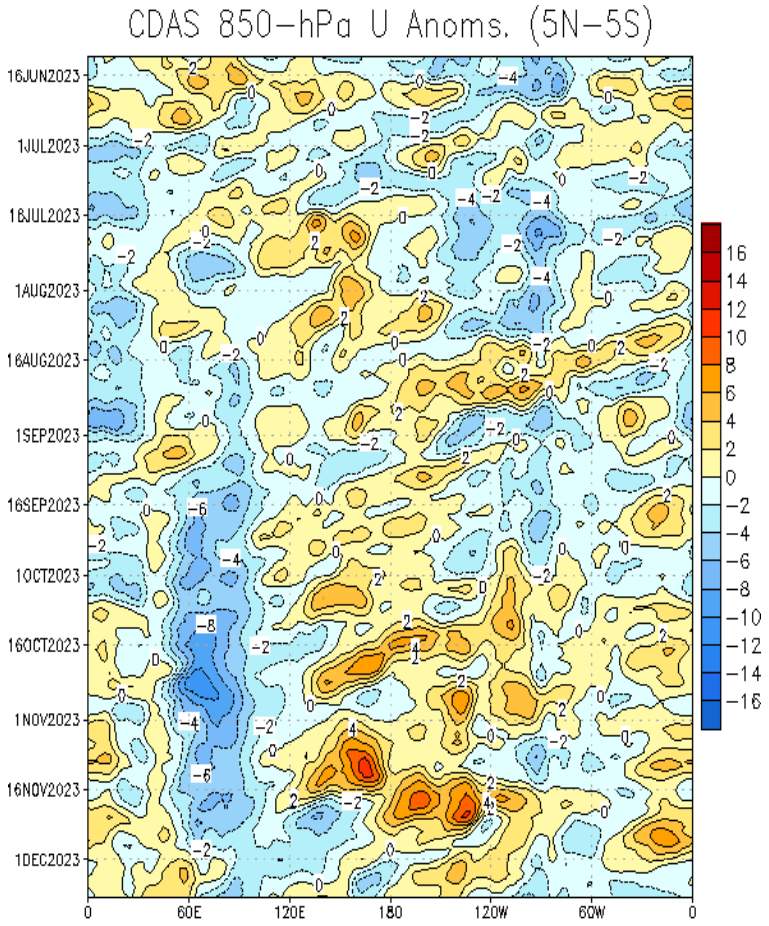


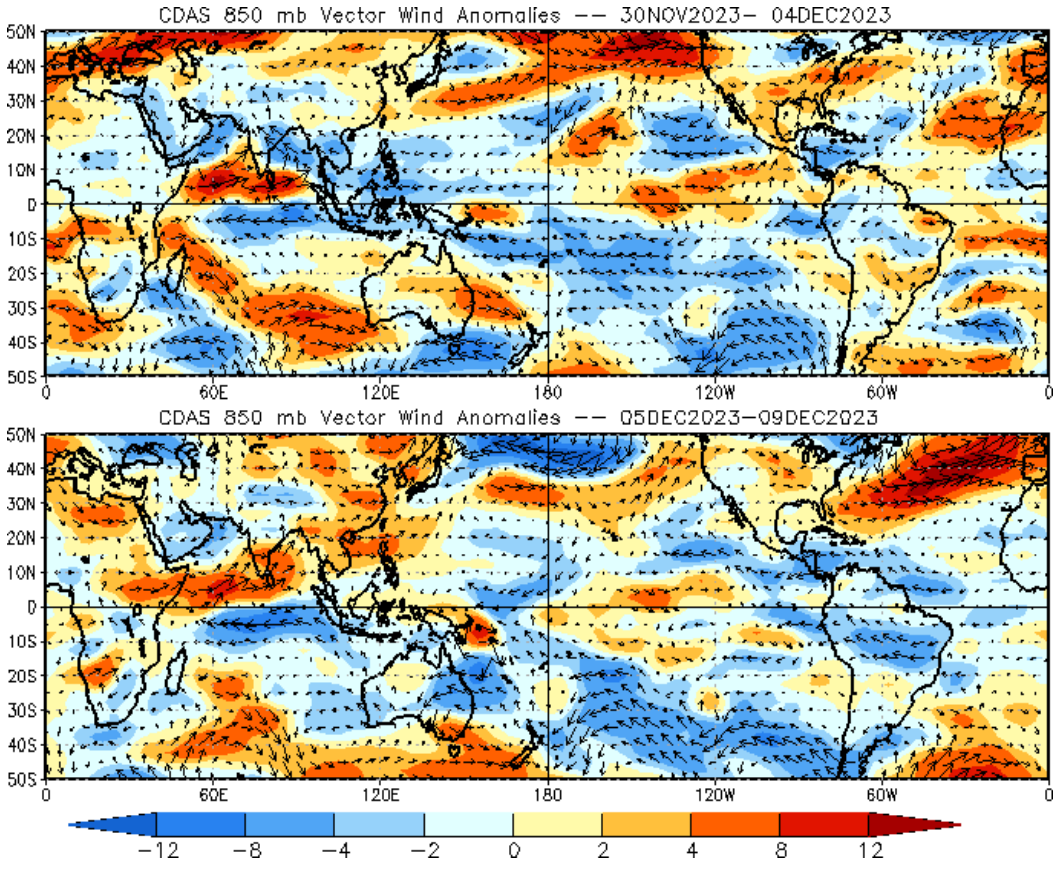


- A more uniform distribution of anomalous easterlies are evident (albeit weak) from the Indian Ocean to the western Pacific, consistent with an eastward propagating MJO that also relaxed the response of the positive Indian Ocean Dipole (+IOD) aloft.
- More coherent intraseasonal activity is also supported by the emergence of anomalous westerlies over the equatorial eastern Pacific and tropical Americas, though wave train activity in the southern hemisphere has injected a band of easterlies along the equator to the west of 120W.

850-hPa Wind Anomalies

Shading denotes the zonal wind anomaly. Blue shades: Anomalous easterlies. Red shades: Anomalous westerlies.

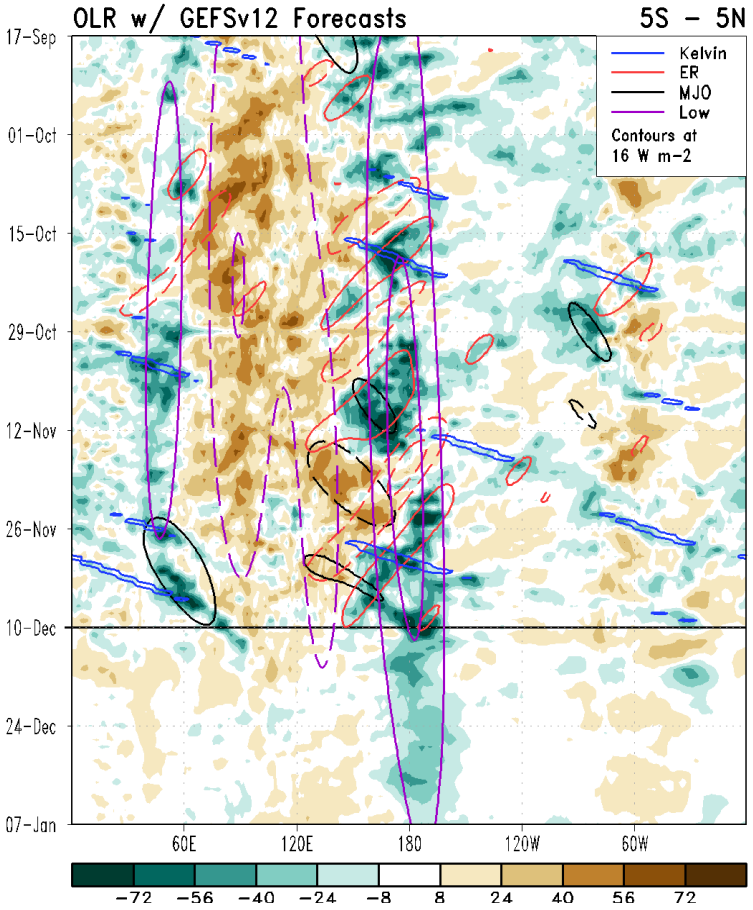


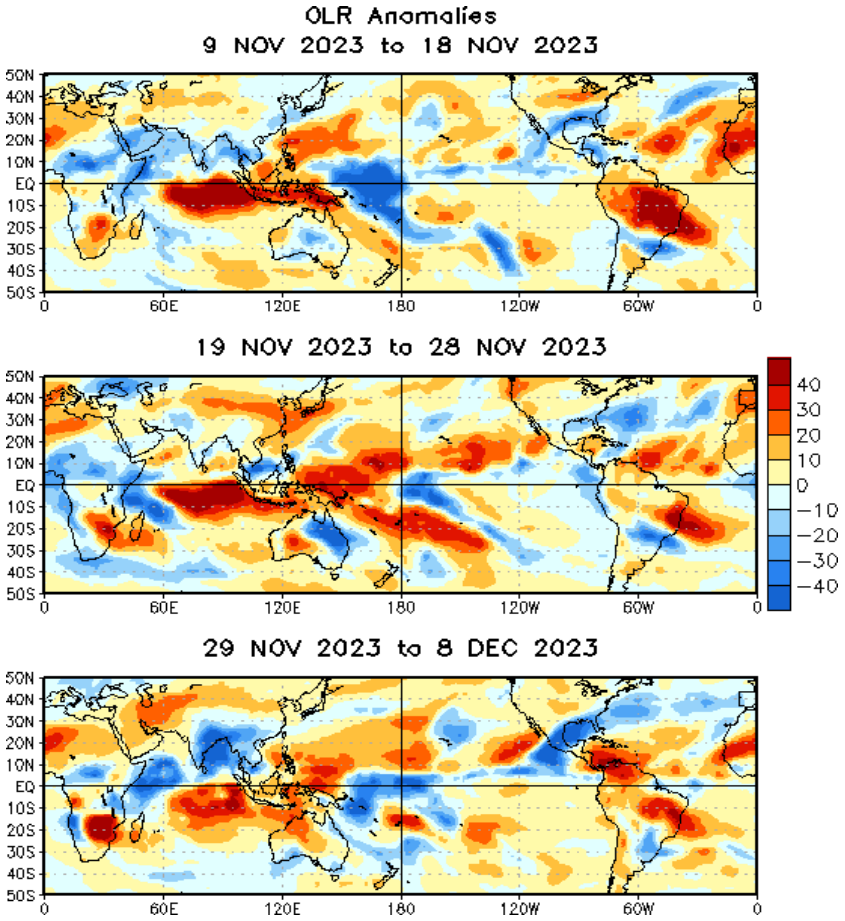


- The disruption of the strong +IOD response is similarly evident in the lower levels, as the MJO appears better expressed north of the equator over the Indian Ocean and Maritime Continent, and likely contributed to the development of tropical cyclone Michaung in the Bay of Bengal.
- Trades became more enhanced along and to the west of the Date Line, indicative of the suppressed phase of the MJO destructively interfering with the low frequency westerly footprint.

Outgoing Longwave Radiation (OLR) Anomalies

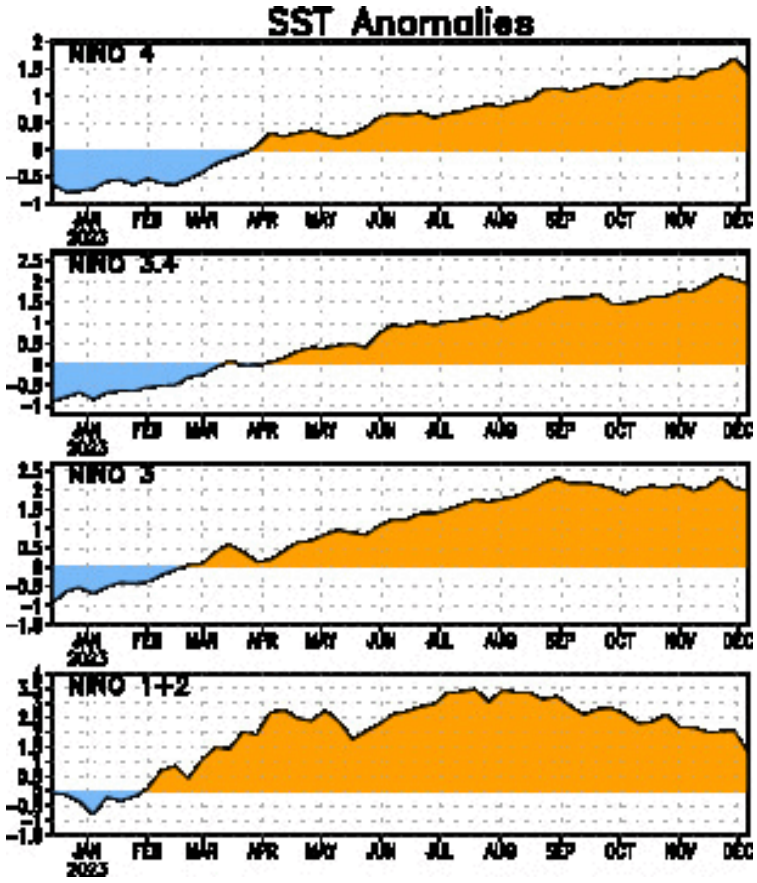
Green shades: Anomalous convection (wetness)
Brown shades: Anomalous subsidence (dryness)

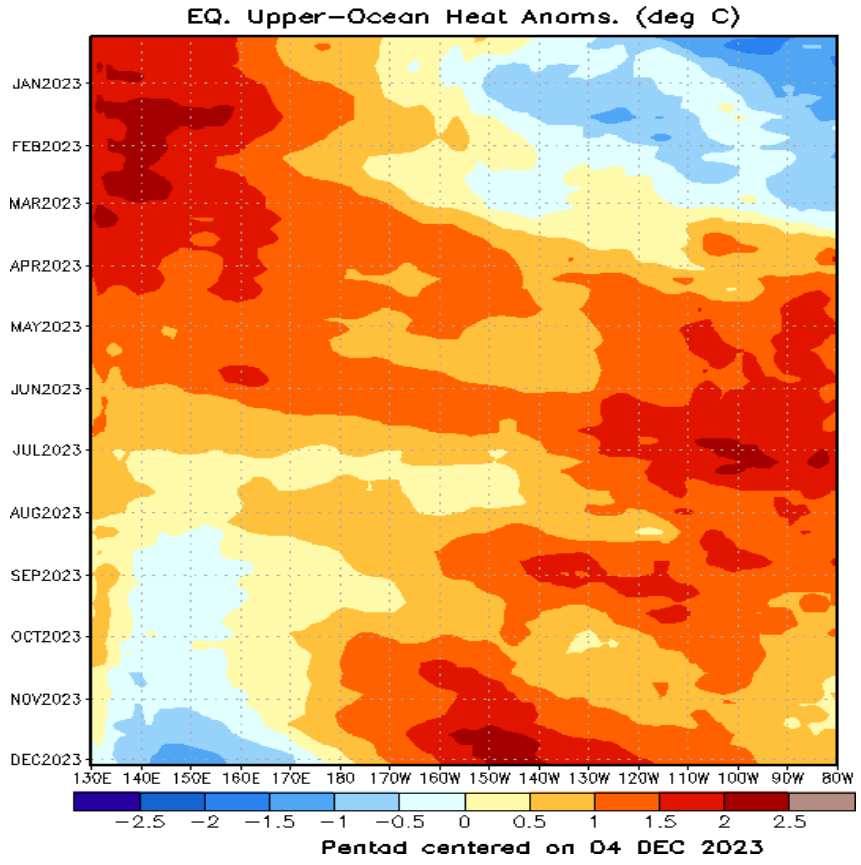




- Consistent with the evolution of lower-level wind anomalies, there is a pronounced increase in convection over northern Indian Ocean during early December.
- OLR forecasts favor a canonical El Nino convective response over the equatorial Pacific, with less of response farther west associated with declining +IOD.

SSTs and Weekly Heat Content Evolution in the Equatorial Pacific

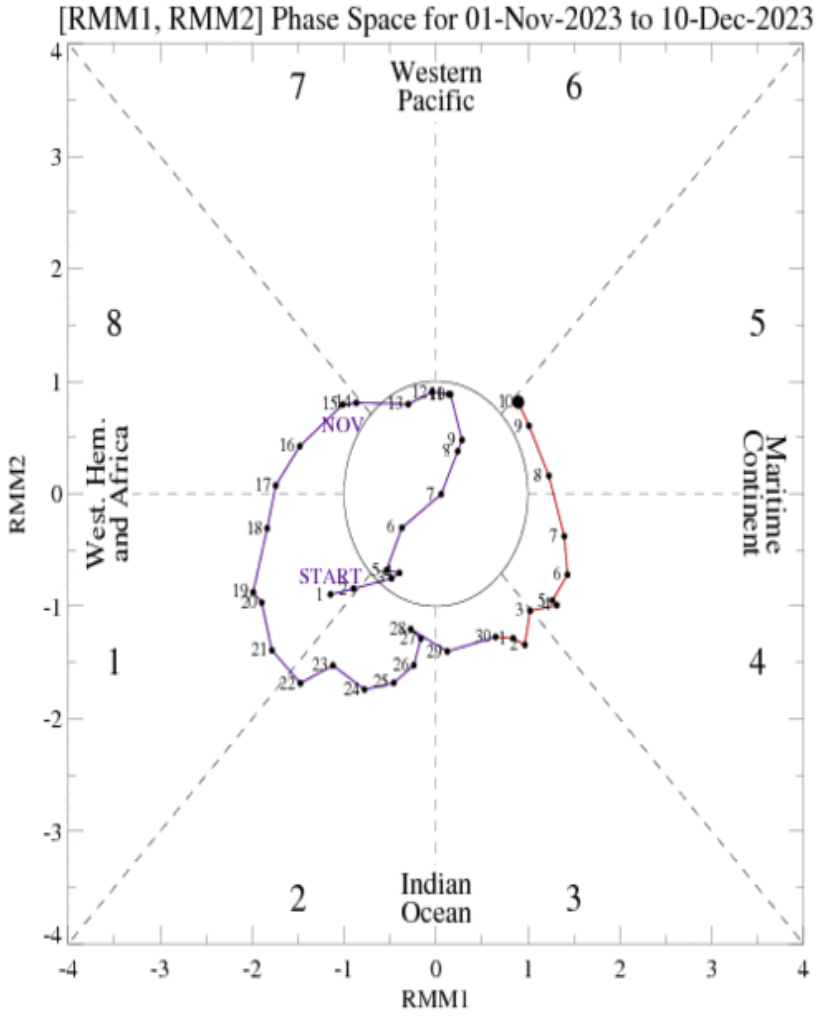




- Low-level westerly wind burst activity across the Pacific during November have resulted in rising SSTs across the Central Pacific, with the NINO 3.4 region now indicating SST anomalies greater than +2.0°C.
- Negative (Positive) upper-ocean heat content anomalies continue to intensify across the Western (Eastern and Central) Pacific. With cooling waters at and below the surface over the far eastern Pacific, the current anomalous warm pool appears more focused to the west compared to its onset earlier this year.

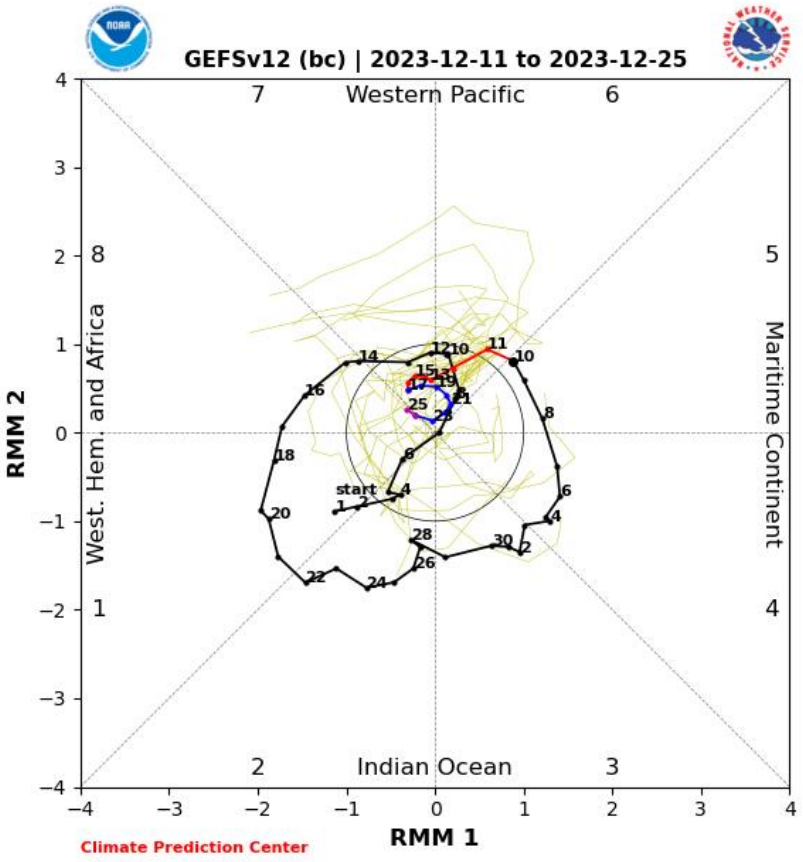
MJO Index: Recent Evolution

- The RMM-based MJO index shows the enhanced phase rapidly propagating eastward across the Maritime Continent, while losing some amplitude during the past week.

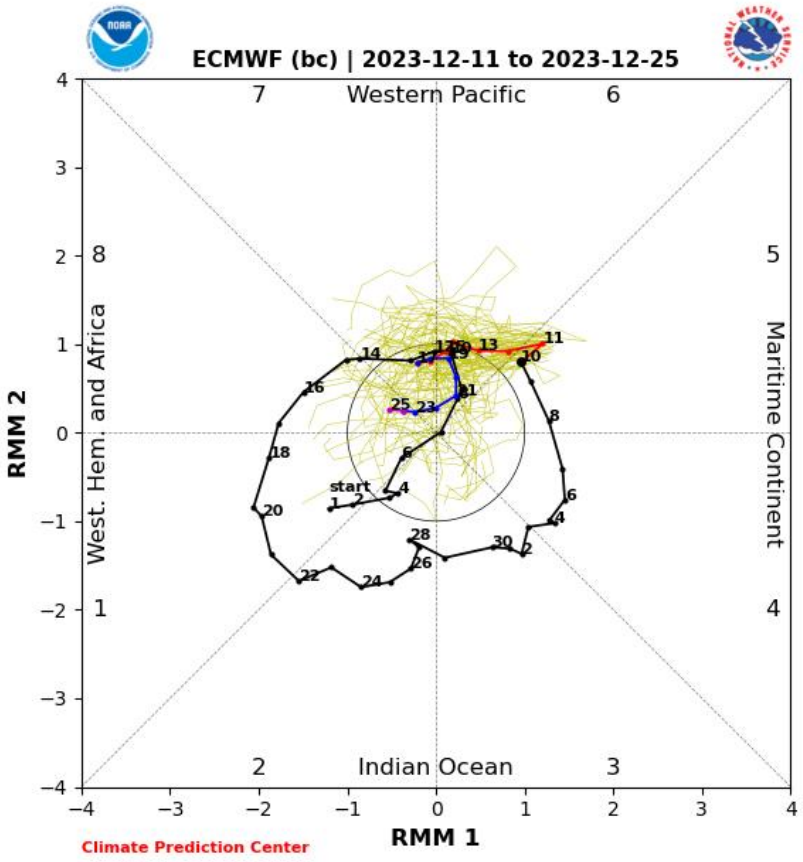


For more information on the RMM index and how to interpret its forecast please see:
https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CPC_MJOinformation.pdf

MJO Index: Forecast Evolution



GEFS Forecast

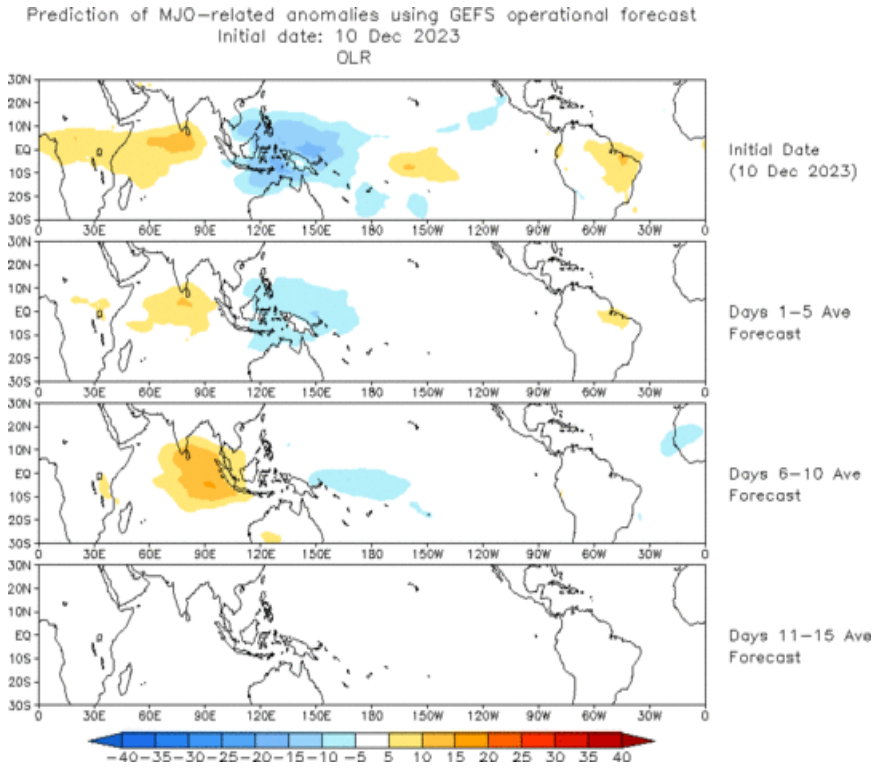


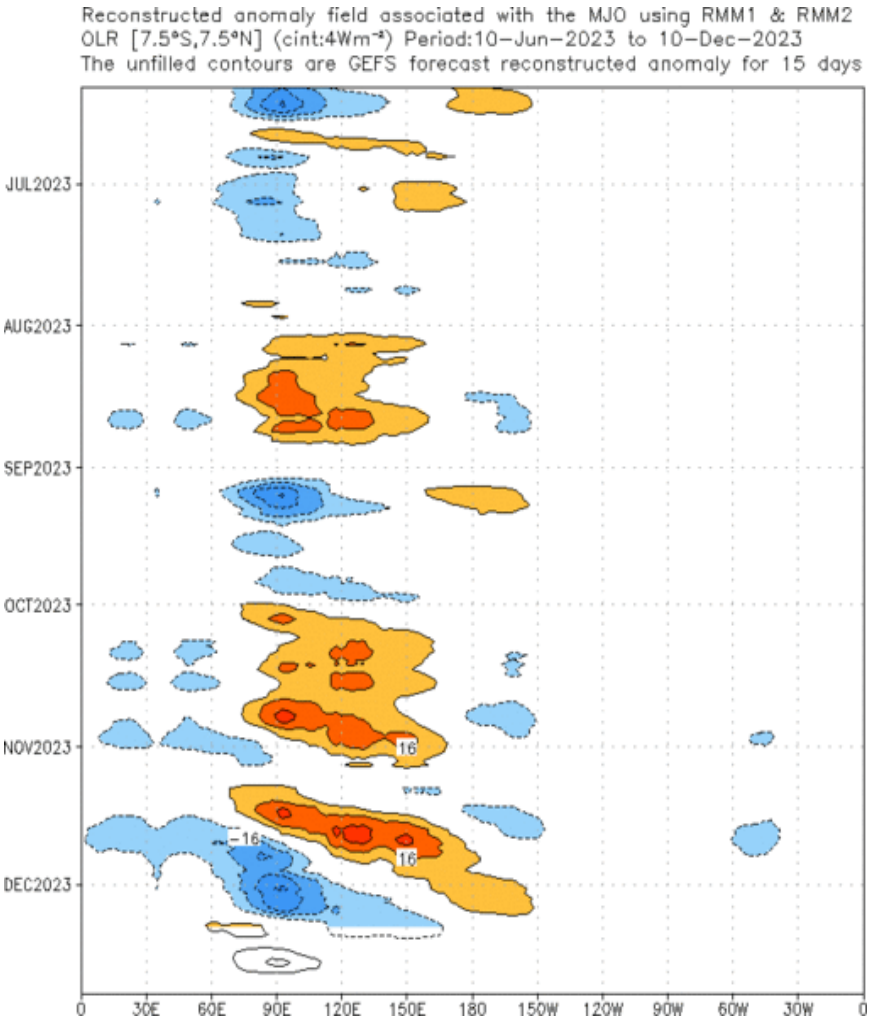
ECMWF Forecast

- Dynamical models generally favor a MJO signal that slows and reduces in amplitude as it shifts across and Western Pacific during the next 2 weeks. This behavior may be tied to a convectively couple Kelvin wave propagating across the Indian Ocean in the forecasts.
- Extended range solutions favor some reorganization of the MJO signal over the Western Hemisphere with continued eastward propagation towards the end of December and into early January.

MJO: GEFS Forecast Evolution

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.)

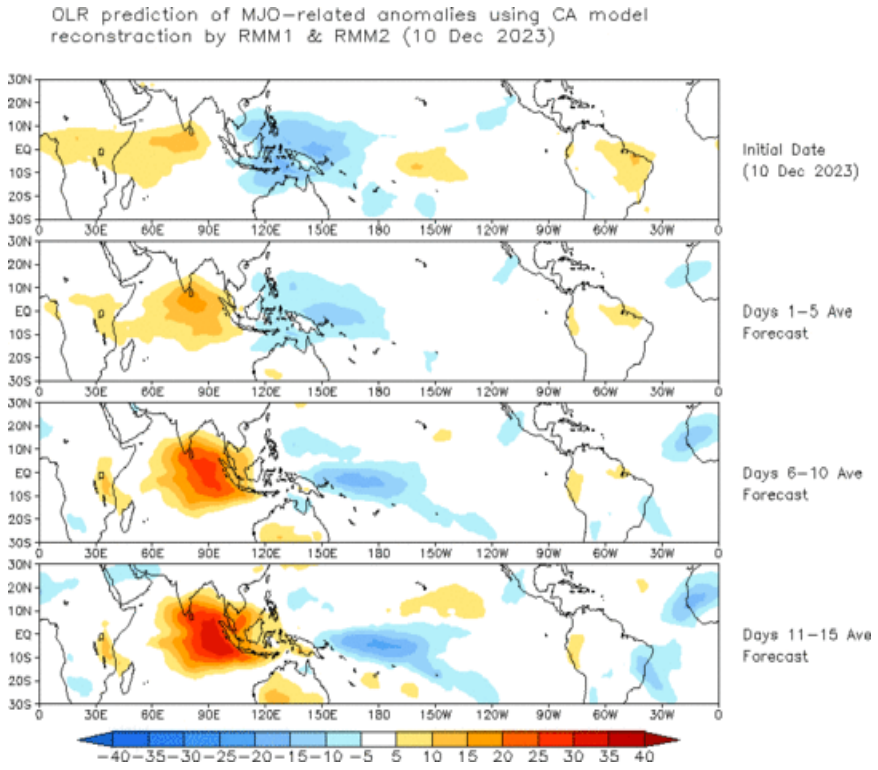


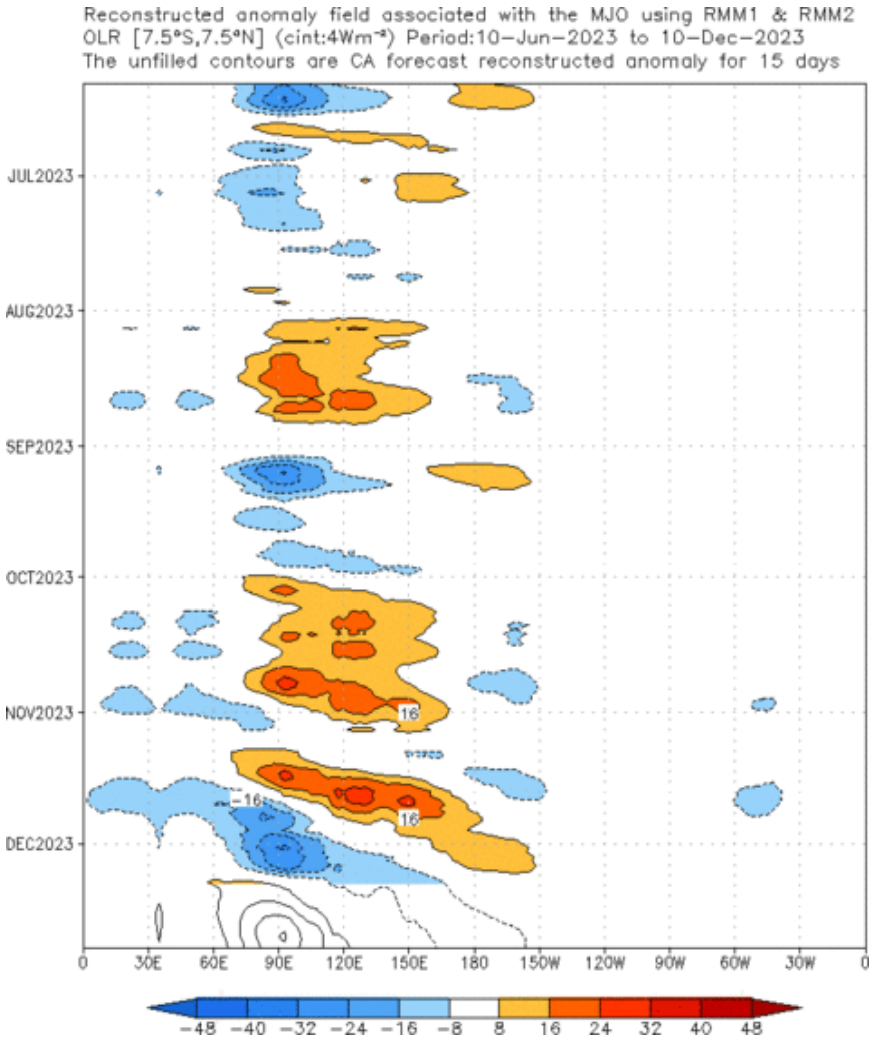


- The GEFS RMM-based OLR forecast depicts a connective dipole that propagates eastward while weakening to neutral during the next two weeks.

MJO: Constructed Analog Forecast Evolution

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.)

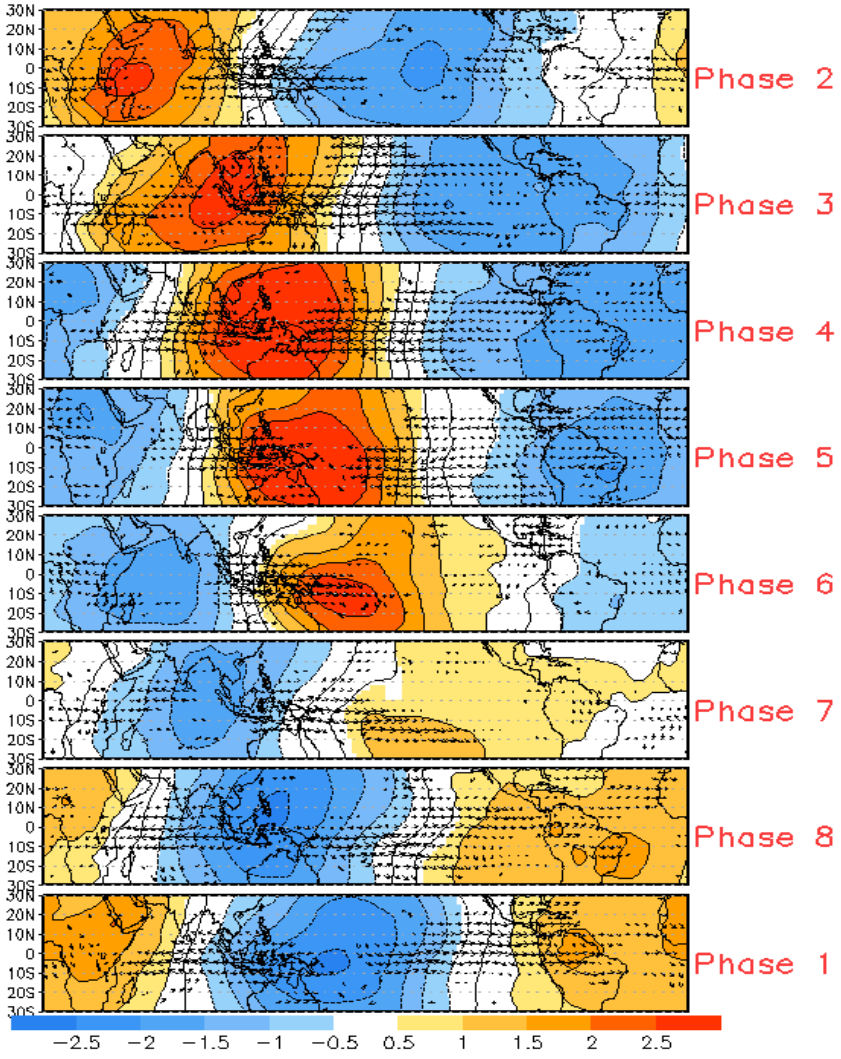




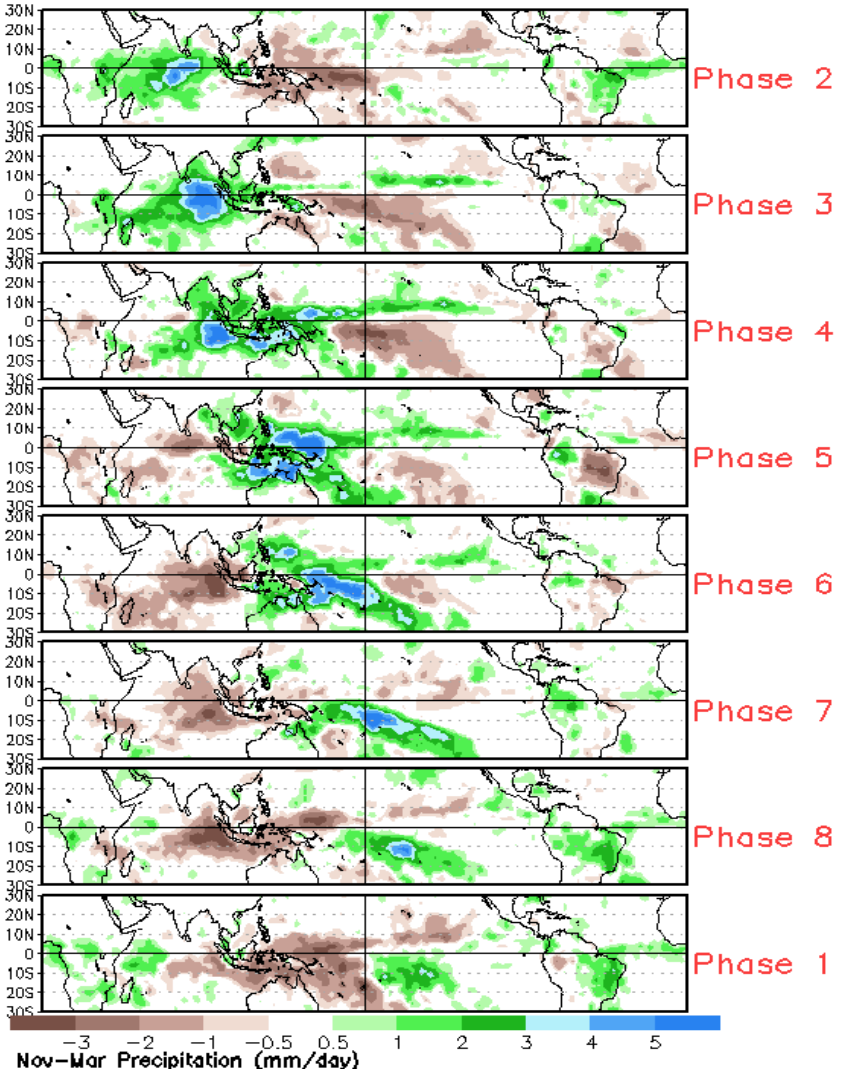
- The constructed analog RMM-based forecast maintains a more organized MJO compared to the GEFS, with enhanced convection returning to the Western Hemisphere and Africa.

MJO: Tropical Composite Maps by RMM Phase

850-hPa Velocity Potential and Wind Anomalies



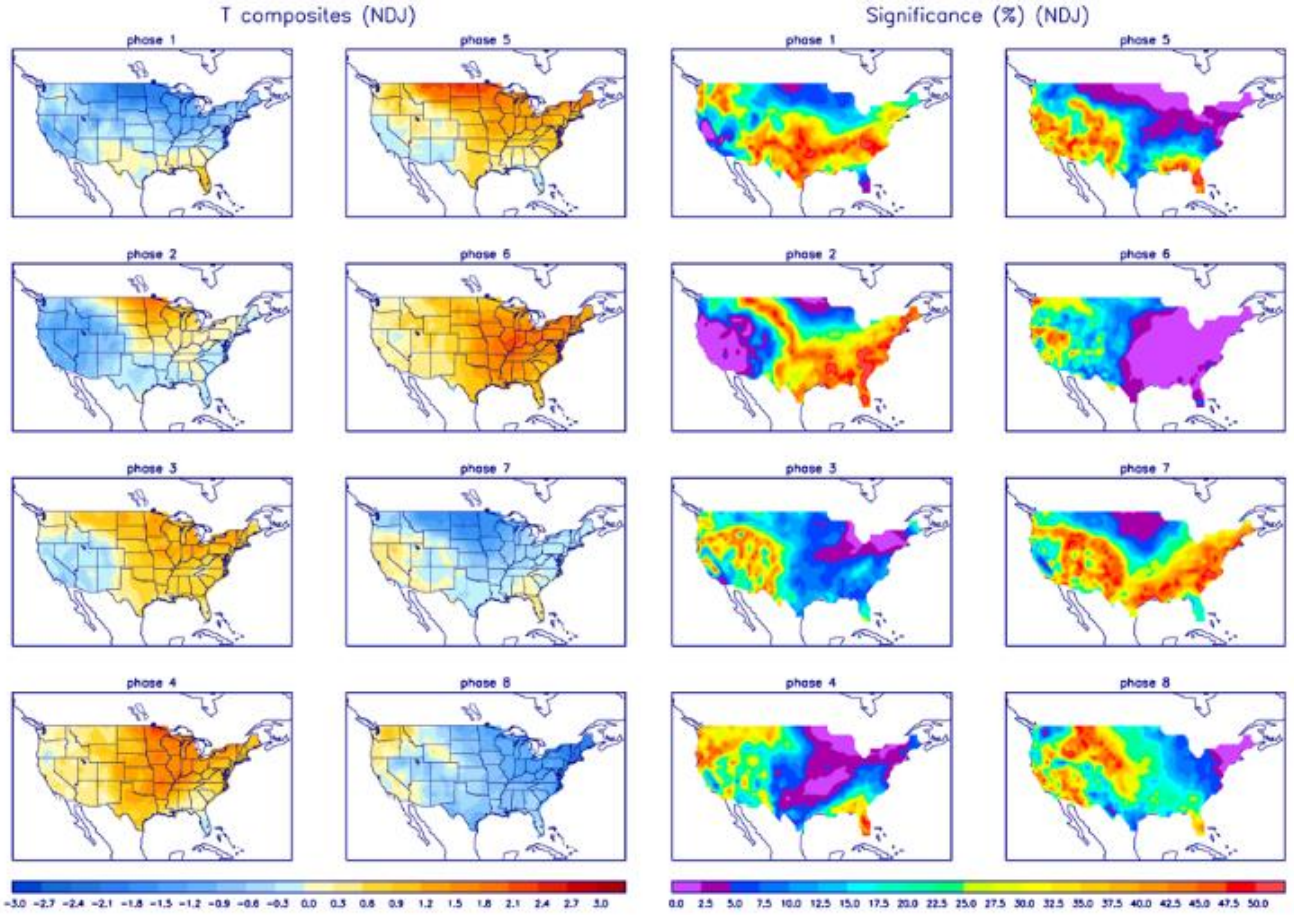
Precipitation Anomalies



MJO: CONUS Composite Maps by RMM Phase - 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 (red) 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.

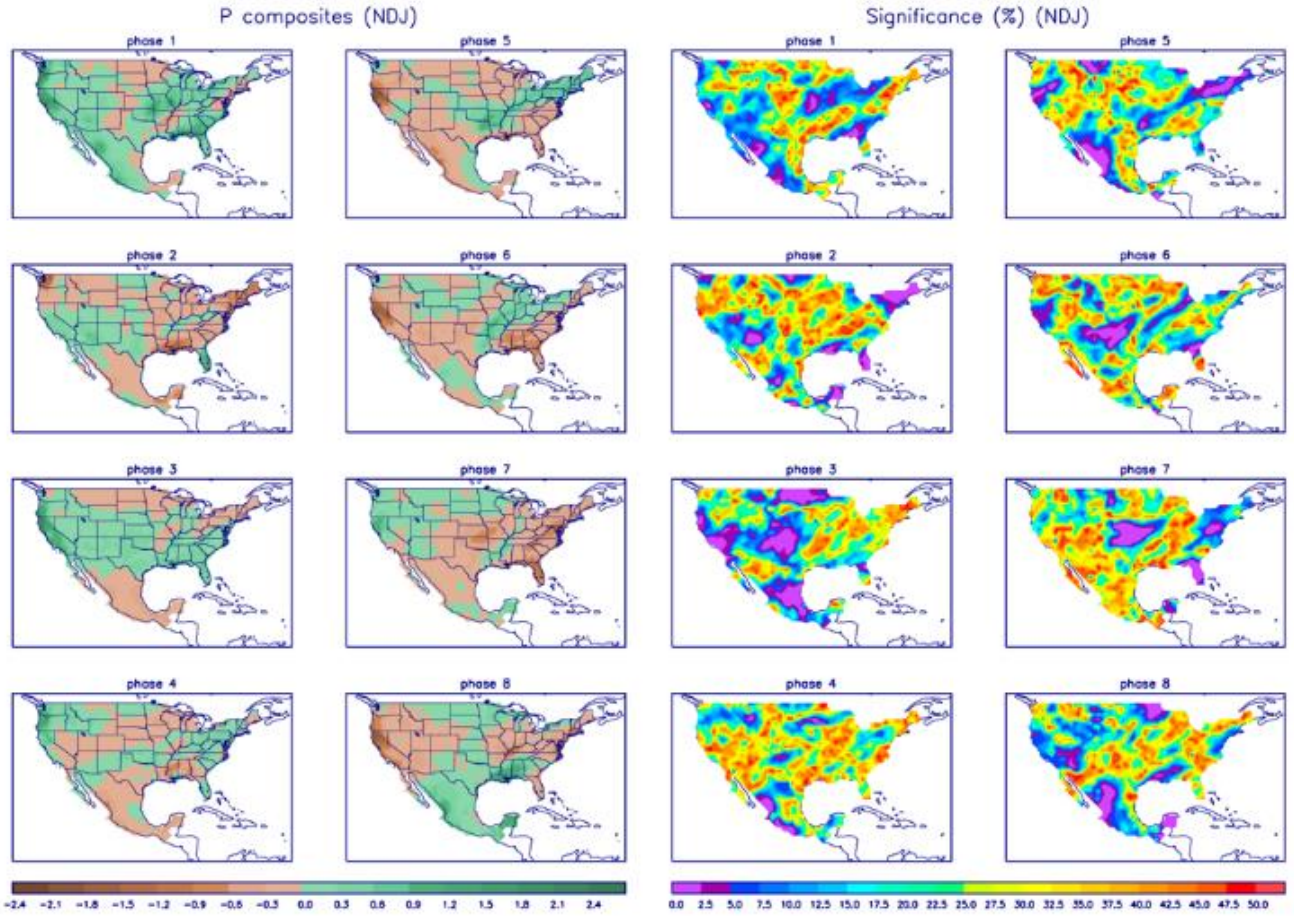


More information: http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml

MJO: CONUS Composite Maps by RMM Phase - 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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