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

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

Overview

- The MJO remains active, with the enhanced convective phase now over the Pacific, where it is constructively interfering with the El Niño base state.

- A strong westerly wind burst event is developing over the equatorial Pacific near the Date Line in response to the MJO-related enhancement.

- The atmospheric response to the positive Indian Ocean Dipole event has strengthened after being disrupted by the MJO in early December.

- Dynamical model MJO index forecasts show the signal propagating quickly across the Western Hemisphere during Week-1, returning to the Indian Ocean by Week-2. This evolution is on the fast end of the MJO spectrum, and may also reflect a further weakening of the IOD event.

- The MJO may contribute to Pacific TC development during Week-1, with Indian Ocean development on both sides of the Equator becoming more favorable during Weeks 2-3.

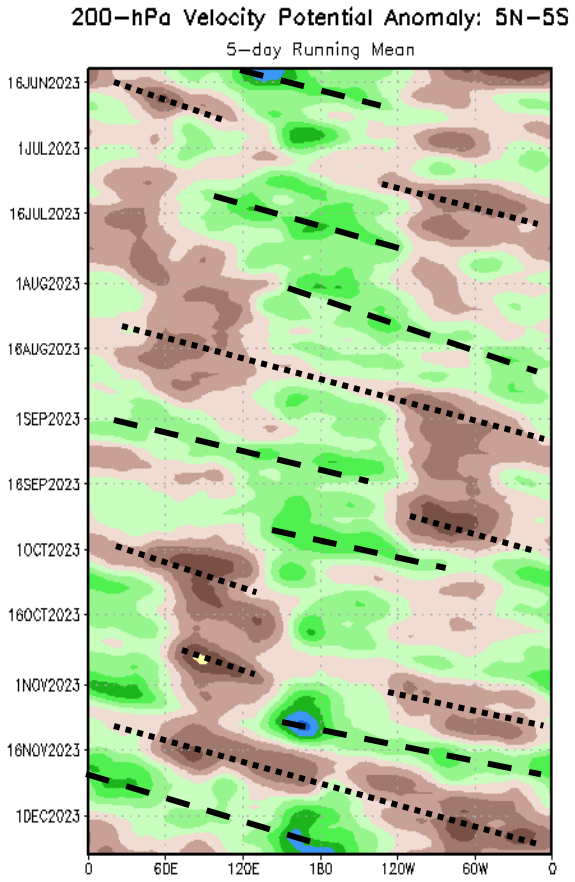
- Pacific MJO events are associated with a pattern change towards increased troughing over the CONUS during the Weeks 2-3 period; however, given the placement of the strong WWB near the Date Line, conditions consistent with the ongoing El Niño response seem to be most likely.

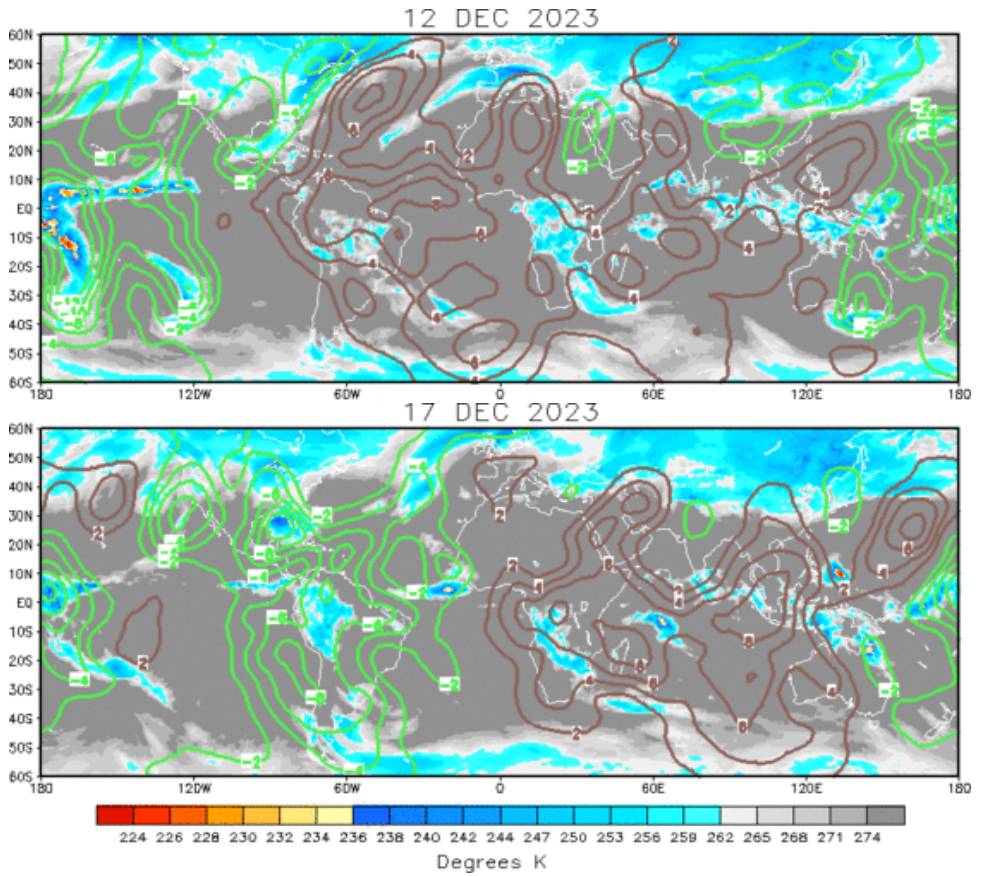
A discussion of potential impacts for the global tropics and those related to the U.S. are updated on Tuesday at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

200-hPa Velocity Potential Anomalies

Green shades: Anomalous divergence (favorable for precipitation)

Brown shades: Anomalous convergence (unfavorable for precipitation)

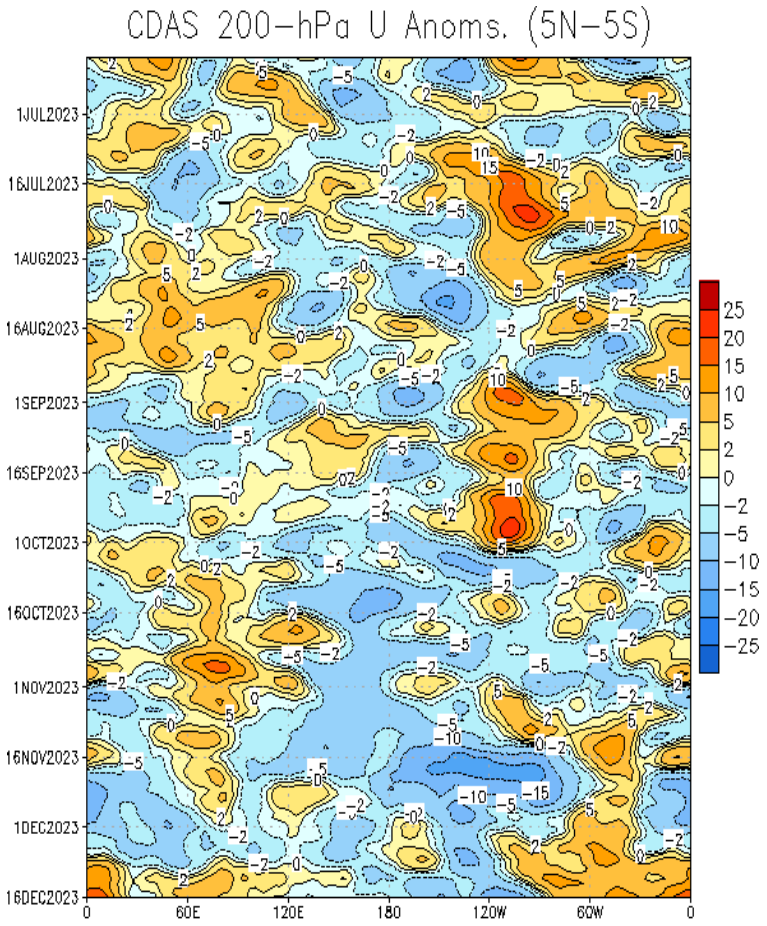


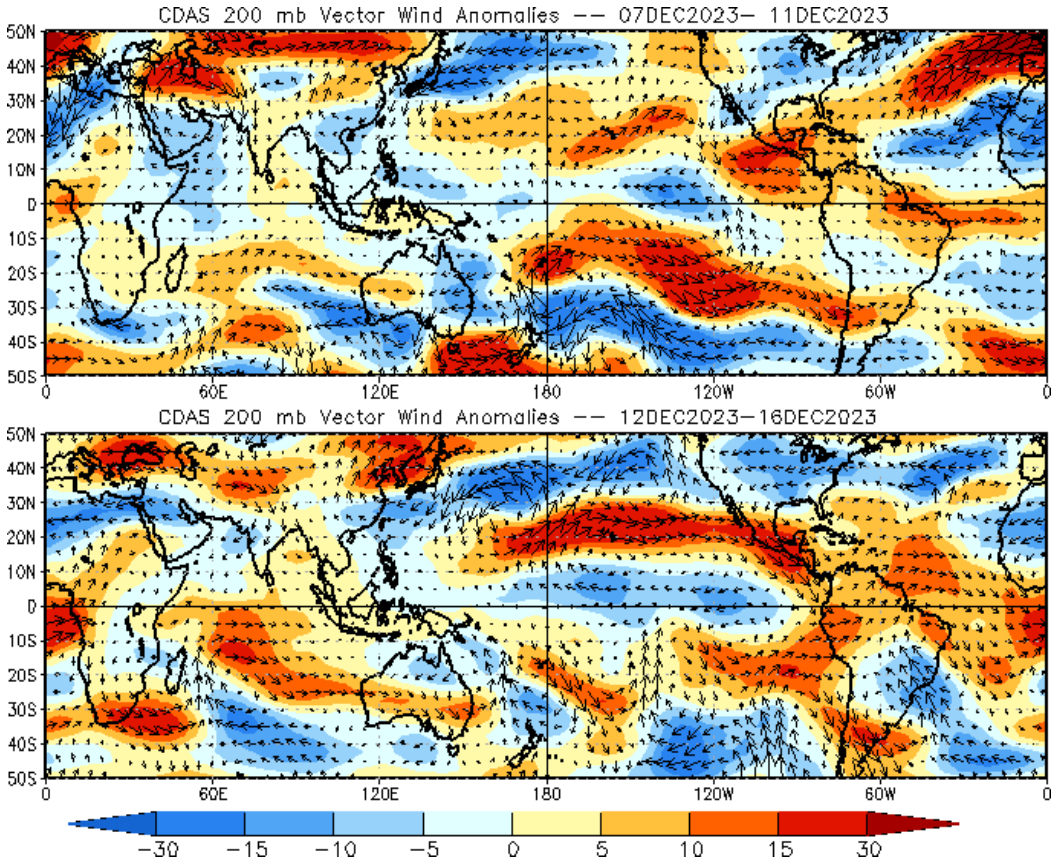


- The MJO remains active, with the enhanced phase currently constructively interfering with the El Niño base state over the central Pacific.
- Kelvin wave activity brought a rapid shift to negative upper-level VP anomalies across the Western Hemisphere.

200-hPa Wind Anomalies

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

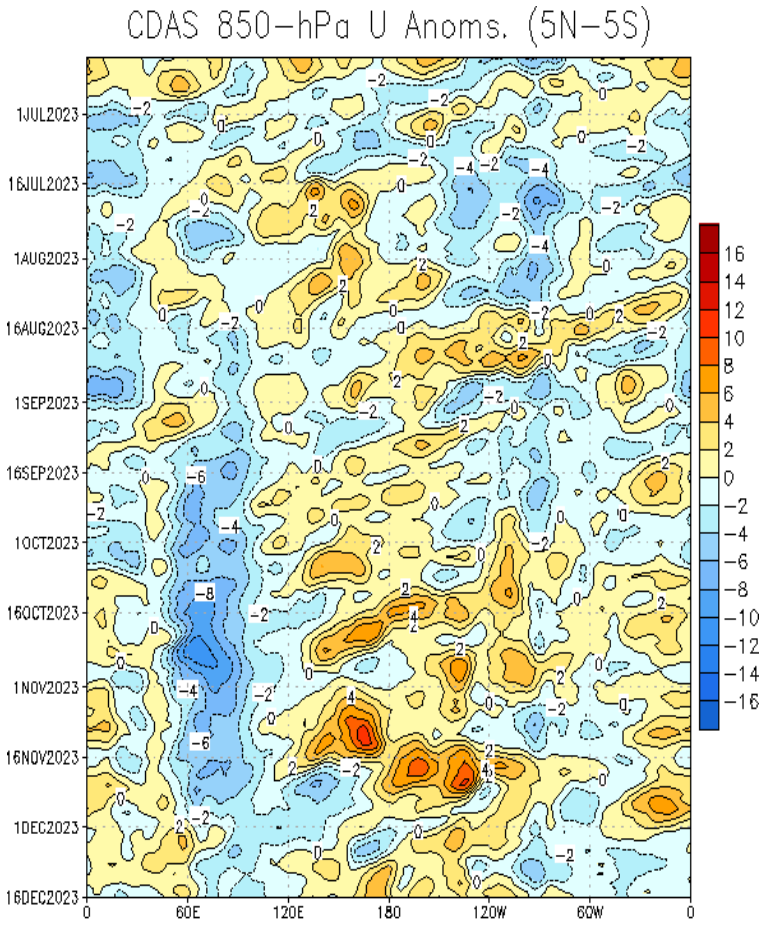


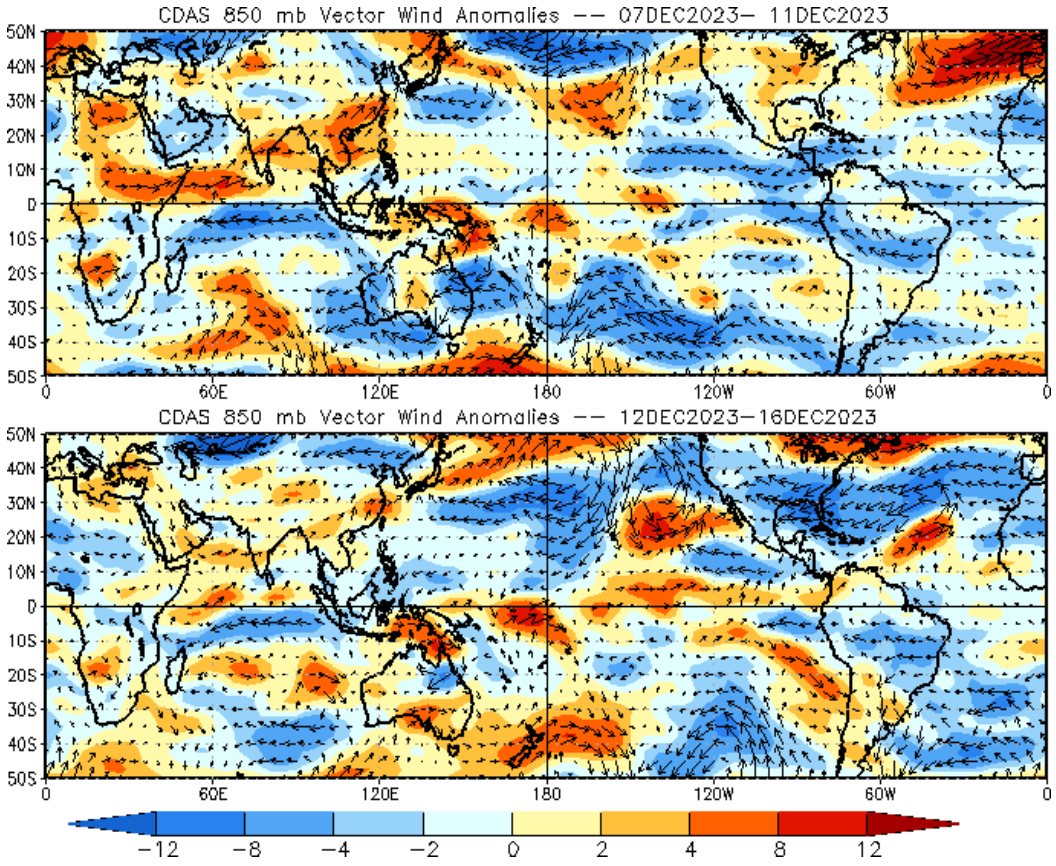


- Easterly (westerly) anomalies propagated across the Pacific (Western Hemisphere and the Indian Ocean), consistent with MJO activity.
- A strong Pacific jet is consistent with the El Niño response.

850-hPa Wind Anomalies

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

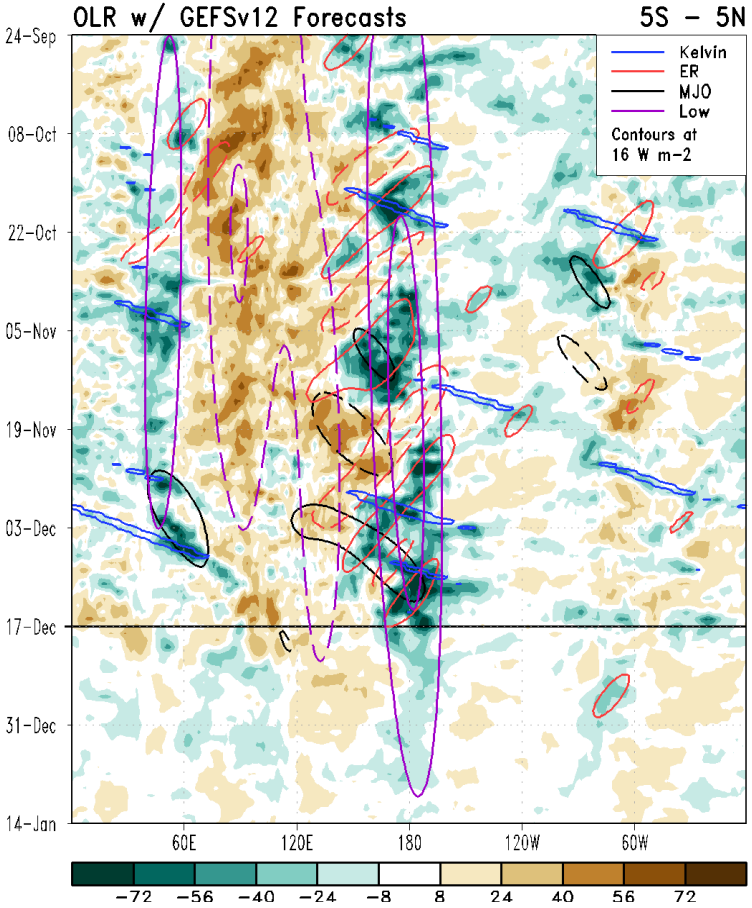


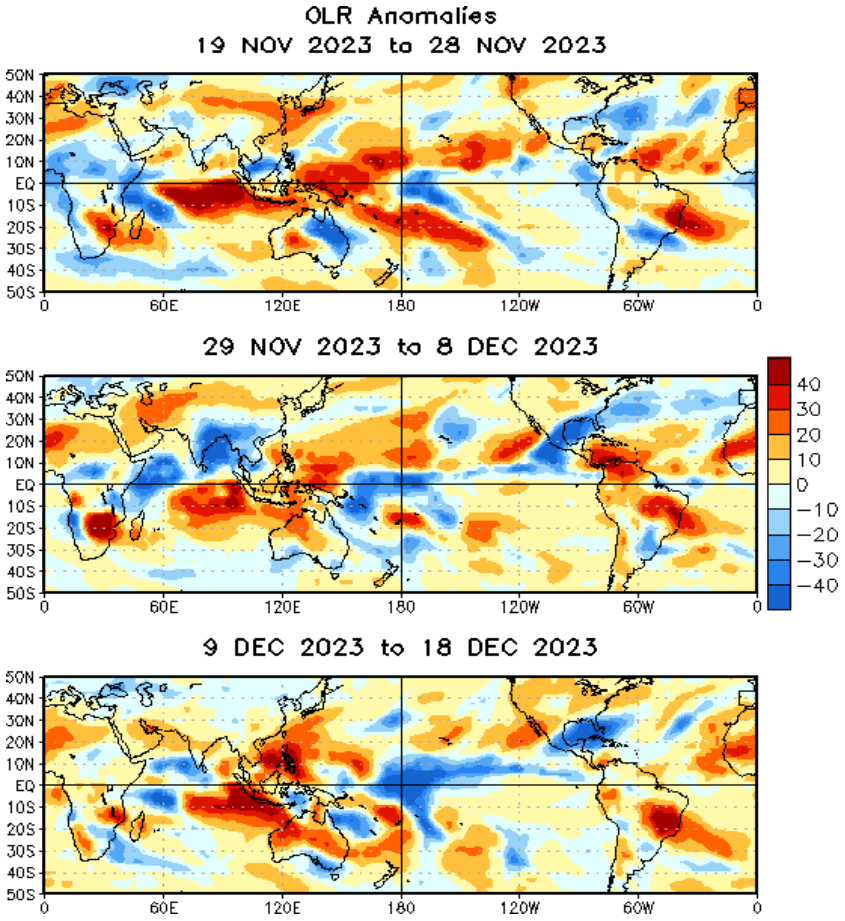


- MJO activity disrupted the ongoing +IOD response over the Indian Ocean during early December, but as the signal moved over the Pacific, constructive interference promoted a return of easterly anomalies across the equatorial Indian Ocean.
- A new westerly wind burst (WWB) is developing near the Date Line in response to constructive interference between the ENSO signal and the MJO.

Outgoing Longwave Radiation (OLR) Anomalies

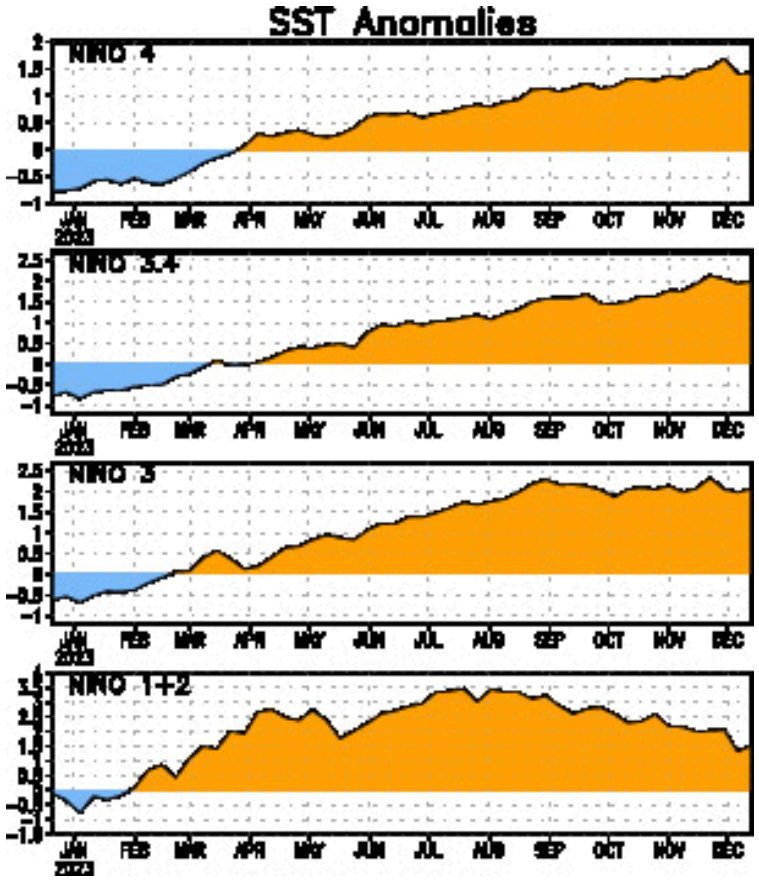
Green shades: Anomalous convection (wetness)
Brown shades: Anomalous subsidence (dryness)

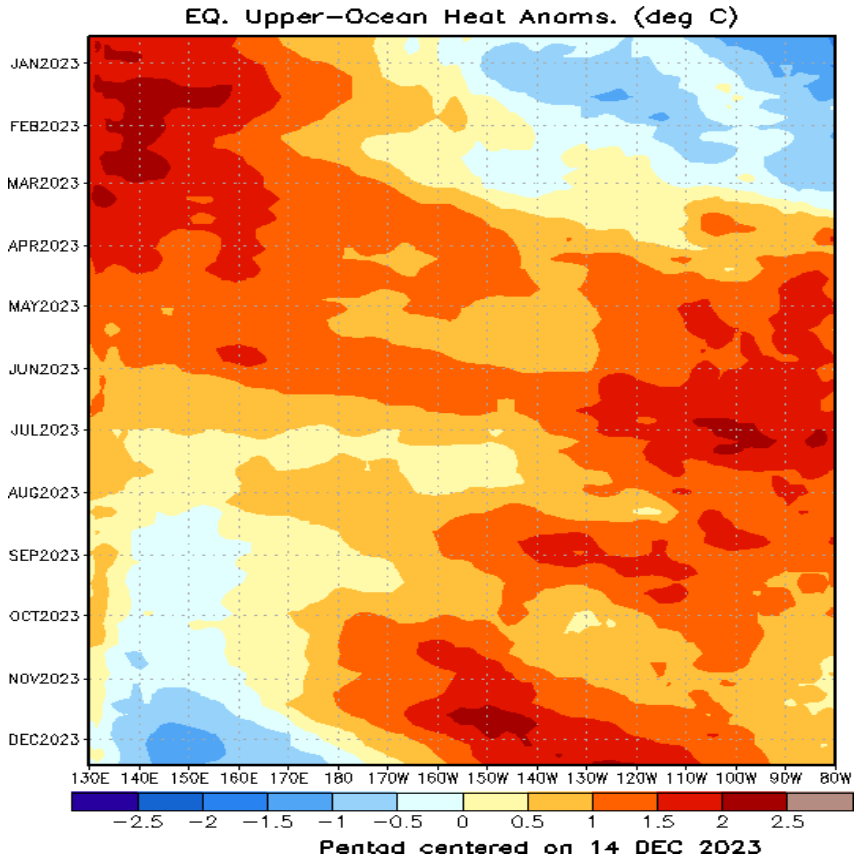




- MJO-related convective anomalies were primarily observed over the northern Indian Ocean during early December.
- A “Kona” low event brought a brief period of intense precipitation to Hawaii at the end of November and early December.
- Enhanced convection increased across the central Pacific in response to the MJO.

SSTs and Weekly Heat Content Evolution in the Equatorial Pacific

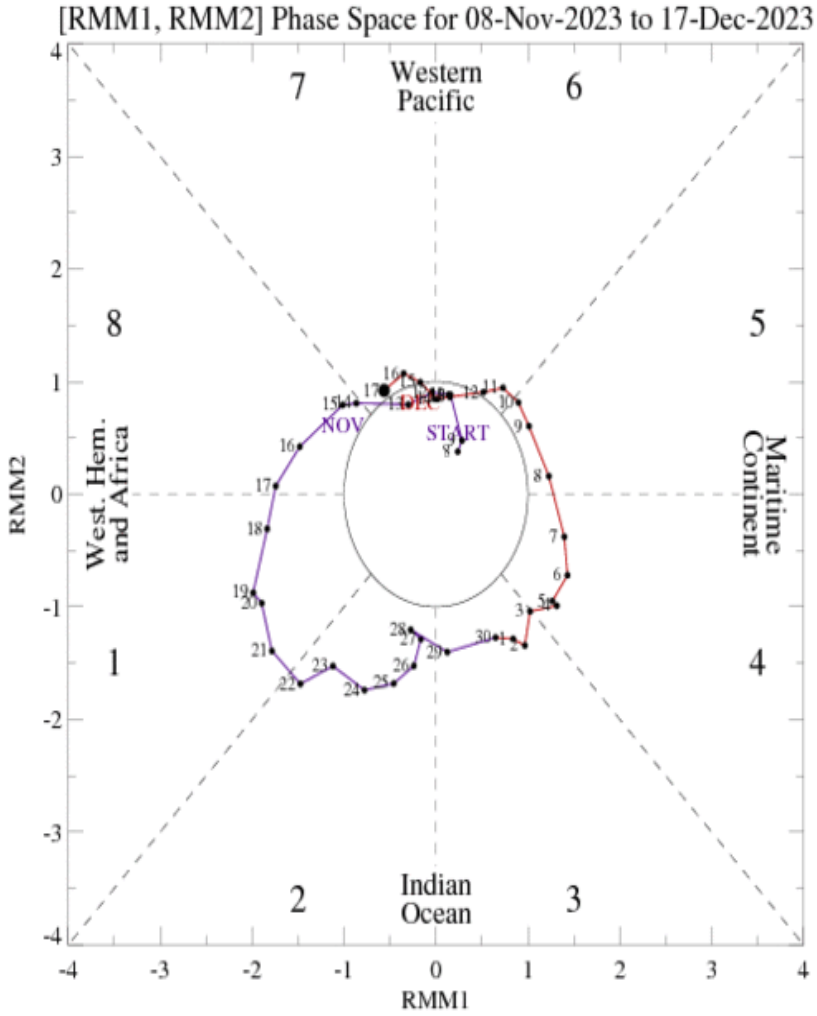




- Low-level westerly wind burst activity across the Pacific during November have resulted in rising SSTs across the Central Pacific, with the NINO 3.4 region now indicating SST anomalies greater than +2.0°C.
- Negative (Positive) upper-ocean heat content anomalies continue to intensify across the Western (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.

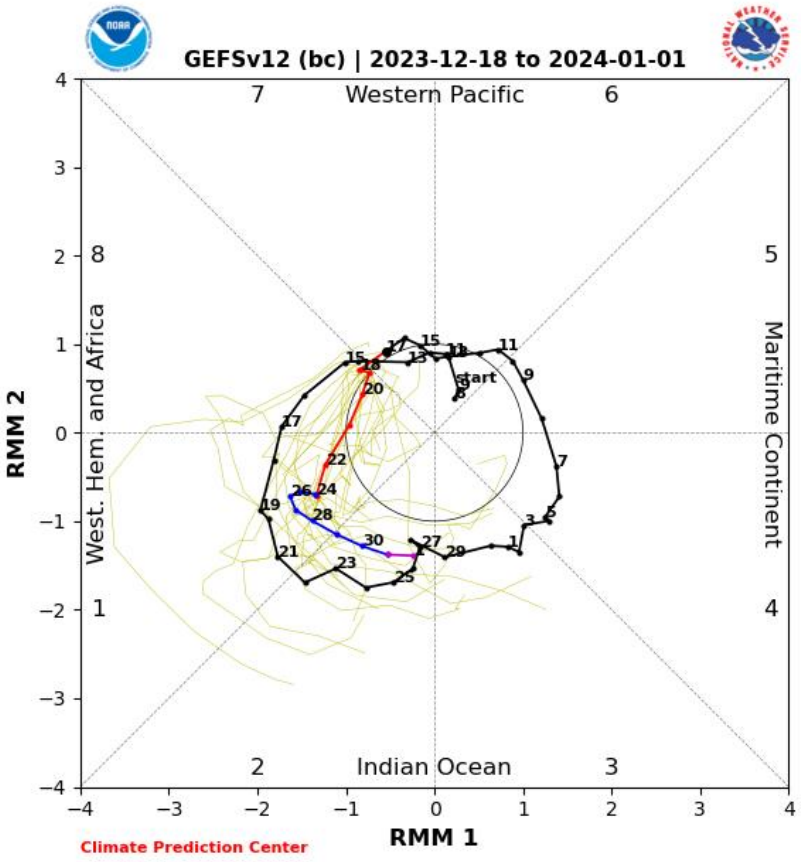
MJO Index: Recent Evolution

- Following a brief weakening of the index, the signal re-emerged from the unit circle over the West Pacific (Phase 7) in recent days.
- Given the well established ENSO footprint that is removed in the 120-day period mean, the somewhat weaker West Pacific signal doesn't preclude a substantial convective event.

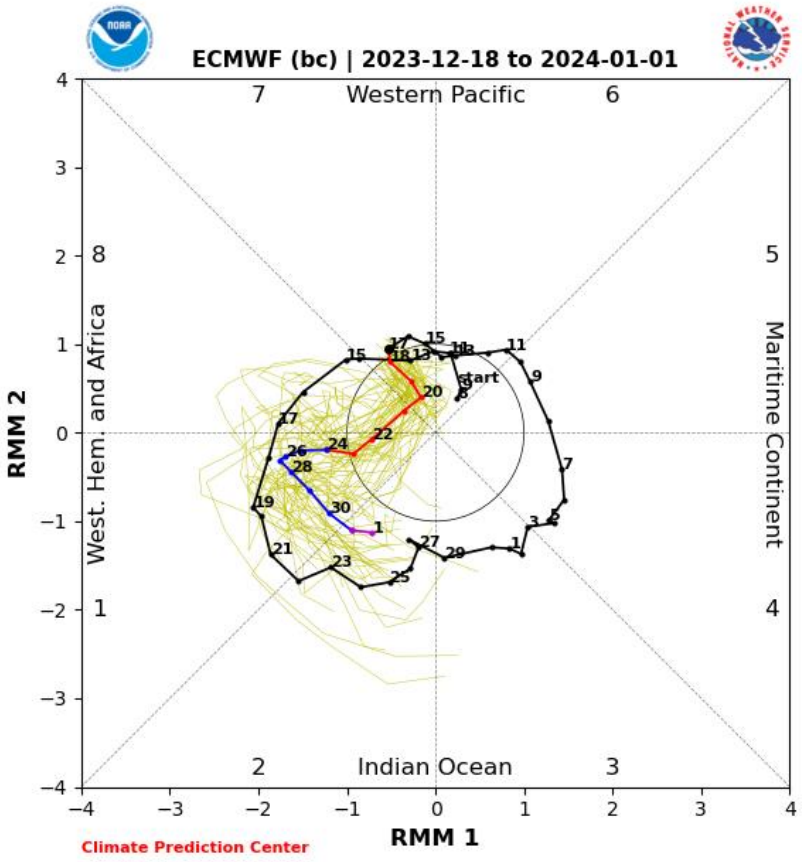


For more information on the RMM index and how to interpret its forecast please see:
https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CPC_MJOinformation.pdf

MJO Index: Forecast Evolution



GEFS Forecast

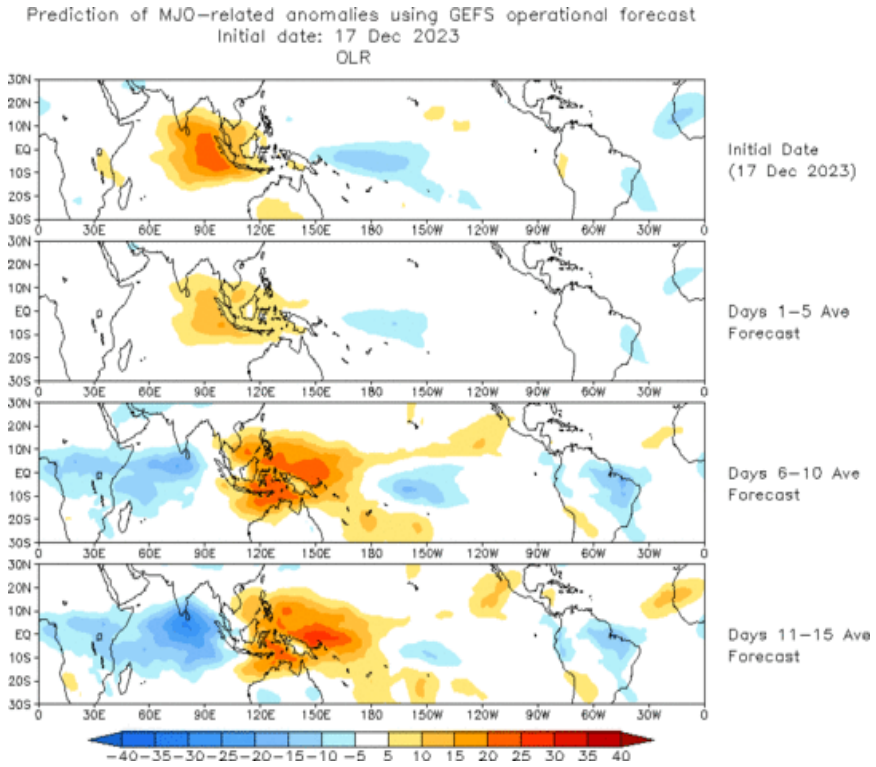


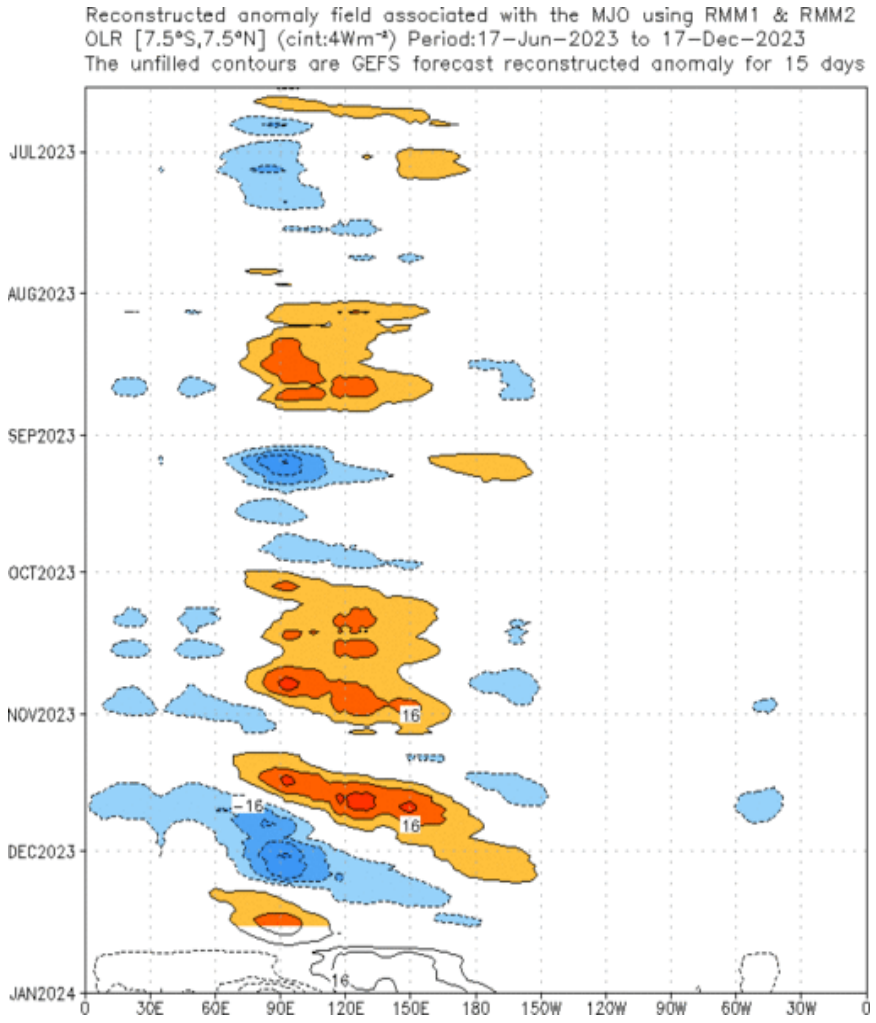
ECMWF Forecast

- Dynamical models indicate a renewed fast propagation of the MJO across the Western Hemisphere, with most ensemble members returning the signal to the western Indian Ocean by the end of Week-2.
- The weaker signal during Week-1 may be due to competing signals: the enhanced convection over the central Pacific and the faster moving signal that is already over the Western Hemisphere.

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.)

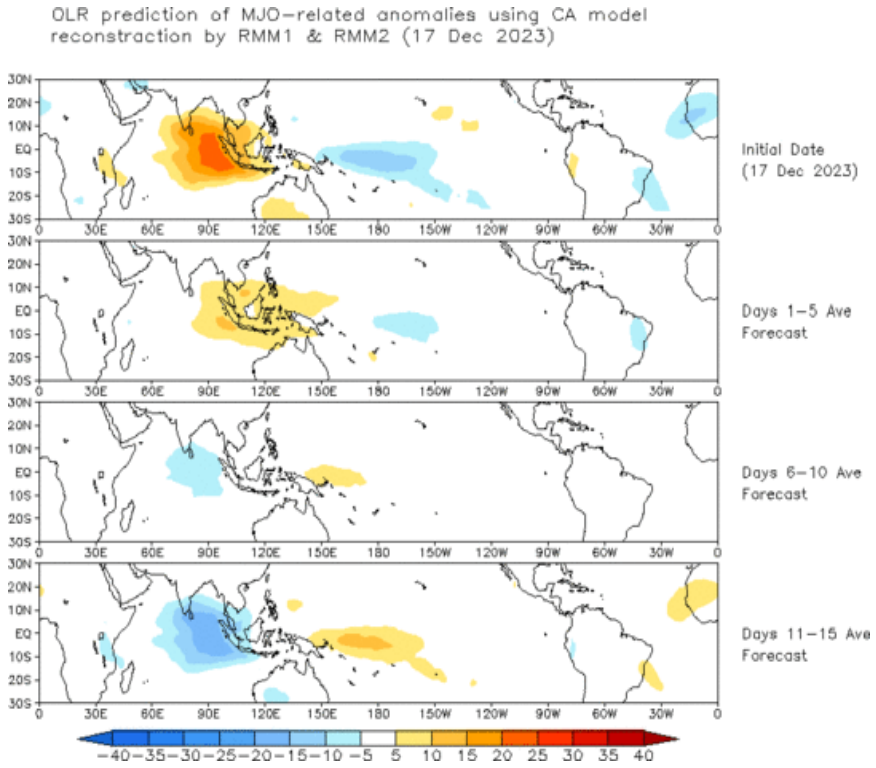


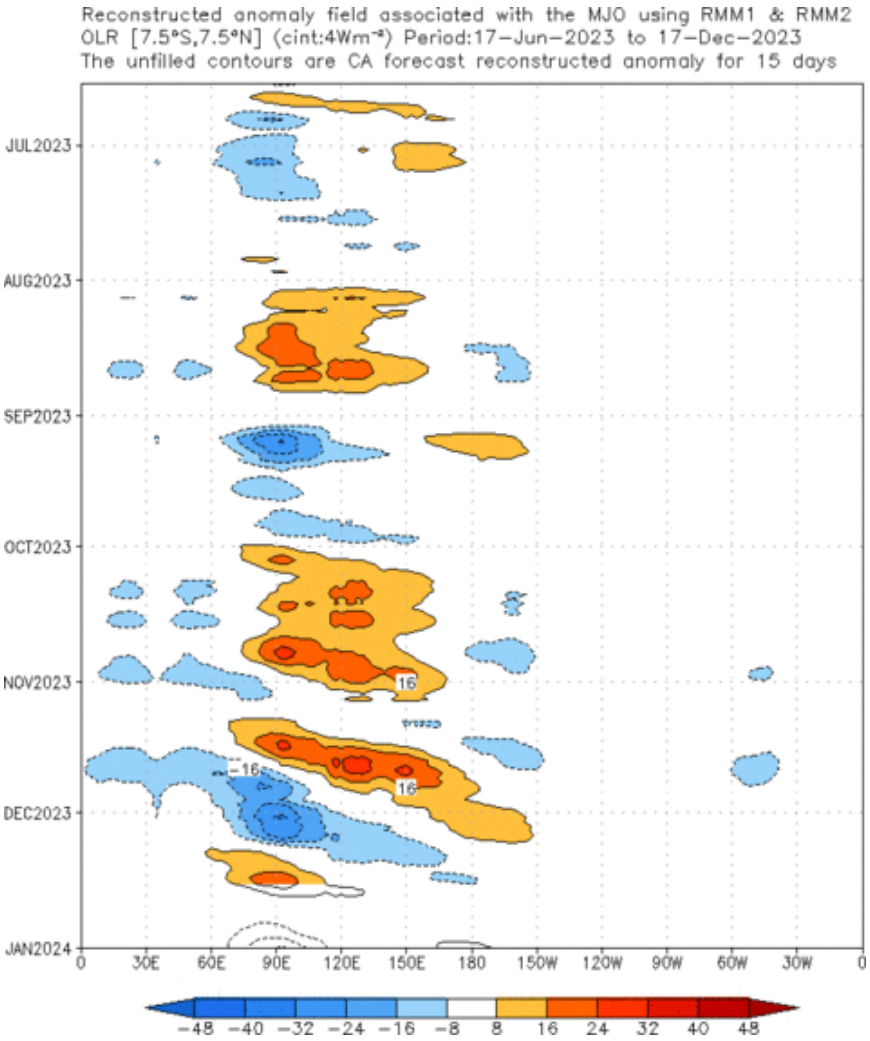


- The GEFS RMM-based OLR forecast depicts a robust MJO-related Wave-1 pattern that propagates to the Indian Ocean by the end of the period. The amplitude of the signal increases during Week-2.

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.)

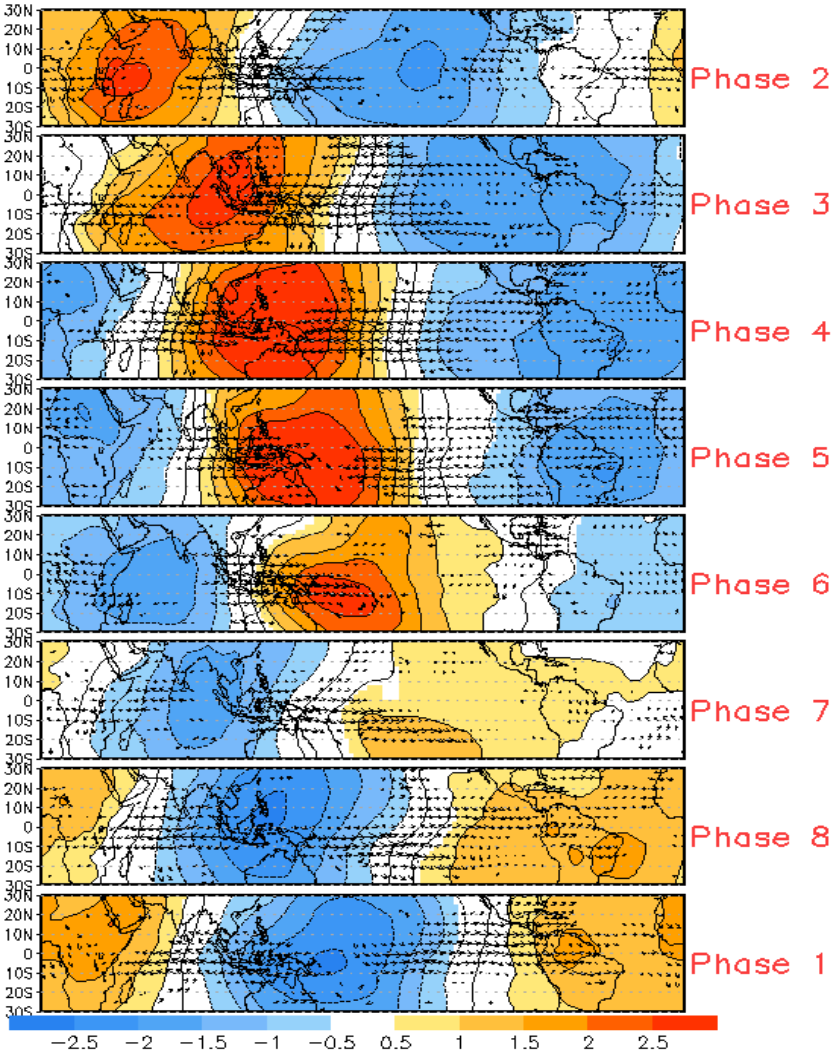




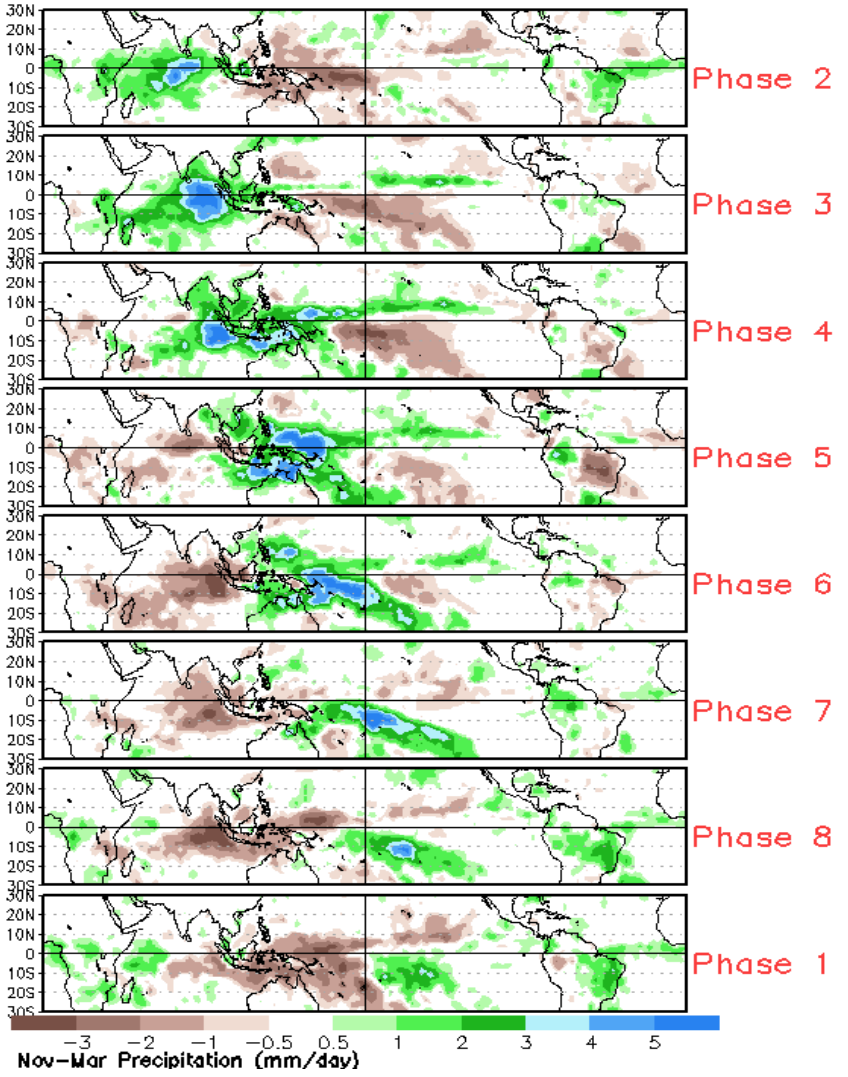
- The constructed analog RMM-based forecast also depicts a coherent MJO pattern, with a similar but less intense amplification over the Indian Ocean compared to the GEFS.

MJO: Tropical Composite Maps by RMM Phase

850-hPa Velocity Potential and Wind Anomalies



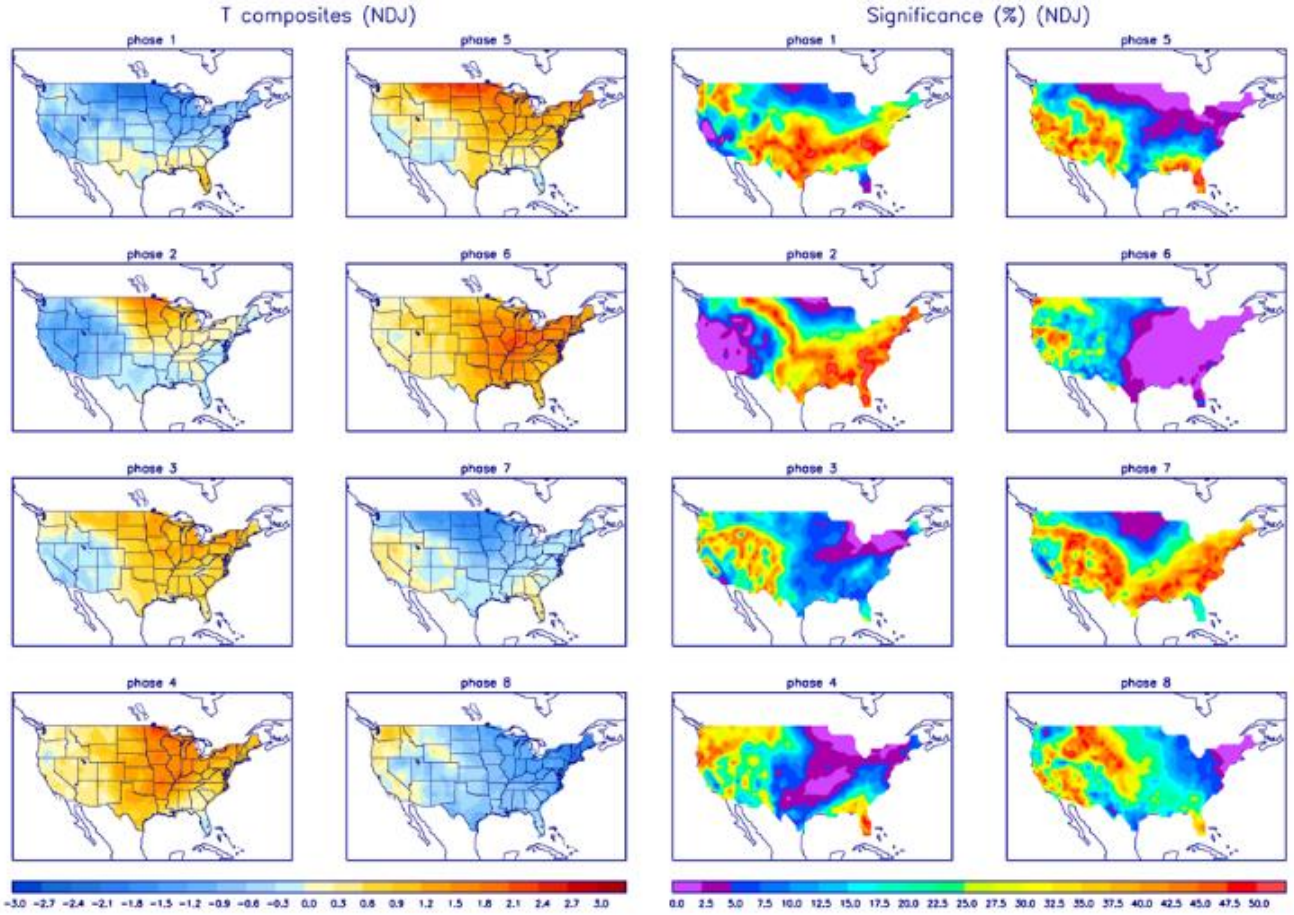
Precipitation Anomalies



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.

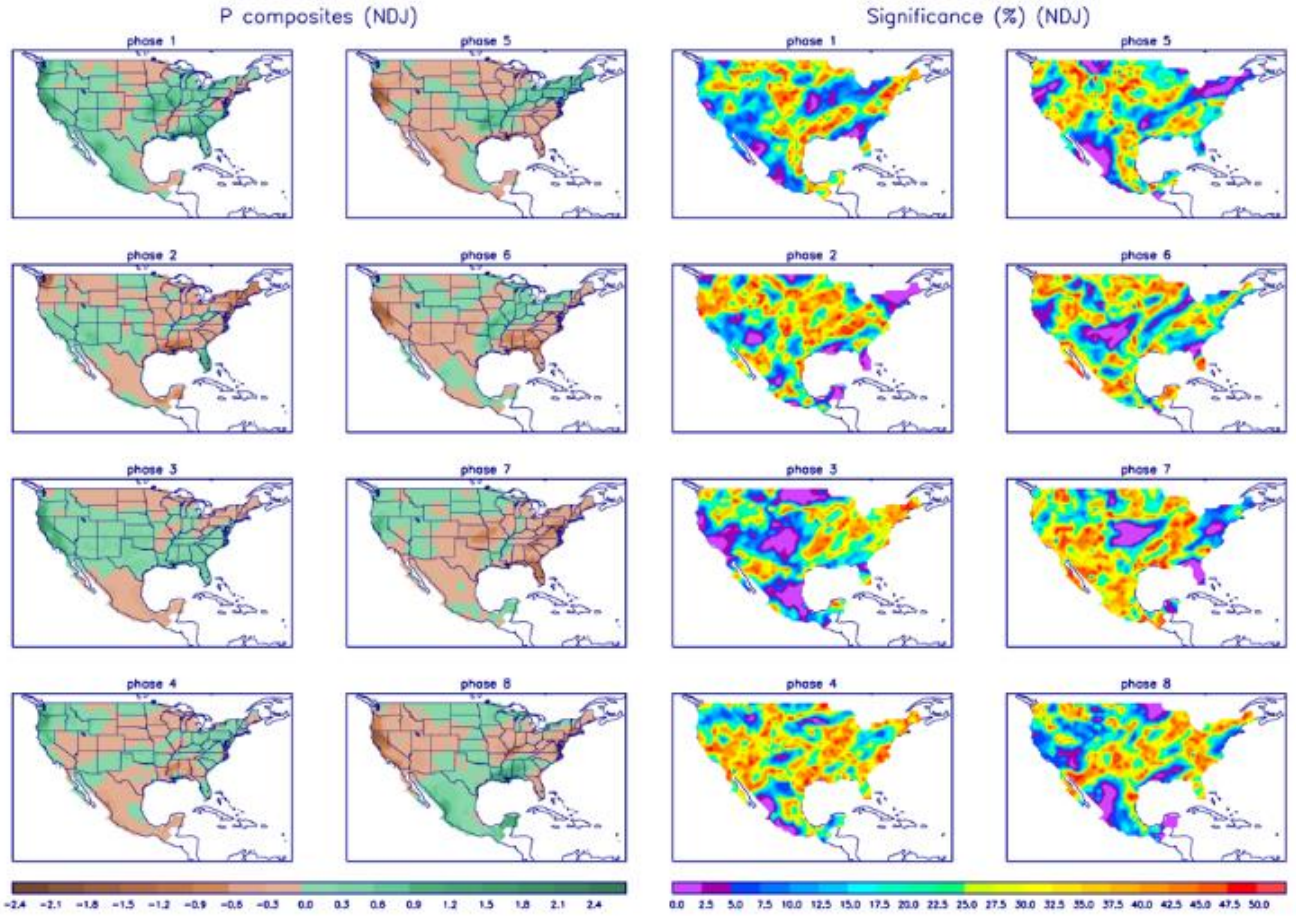


More information: http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml

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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