# Global Ocean Monitoring: Recent Evolution, Current Status, and Predictions

Prepared by

Climate Prediction Center, NCEP/NOAA

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http://www.cpc.ncep.noaa.gov/products/GODAS/

This project, to deliver real-time ocean monitoring products, is implemented by CPC in cooperation with NOAA's Global Ocean Monitoring and Observing Program (GOMO)

# Outline

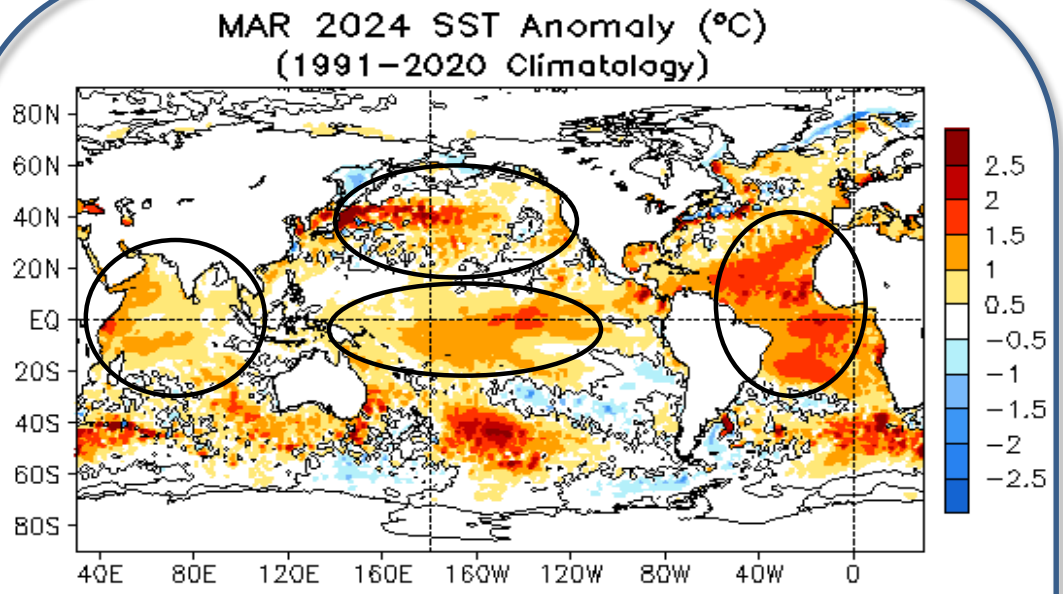
- **Overview**
- **Recent highlights**
  - Pacific Ocean
  - Arctic & Antarctic Oceans
  - Indian Ocean
  - Atlantic Ocean
- **Global SSTA Predictions**

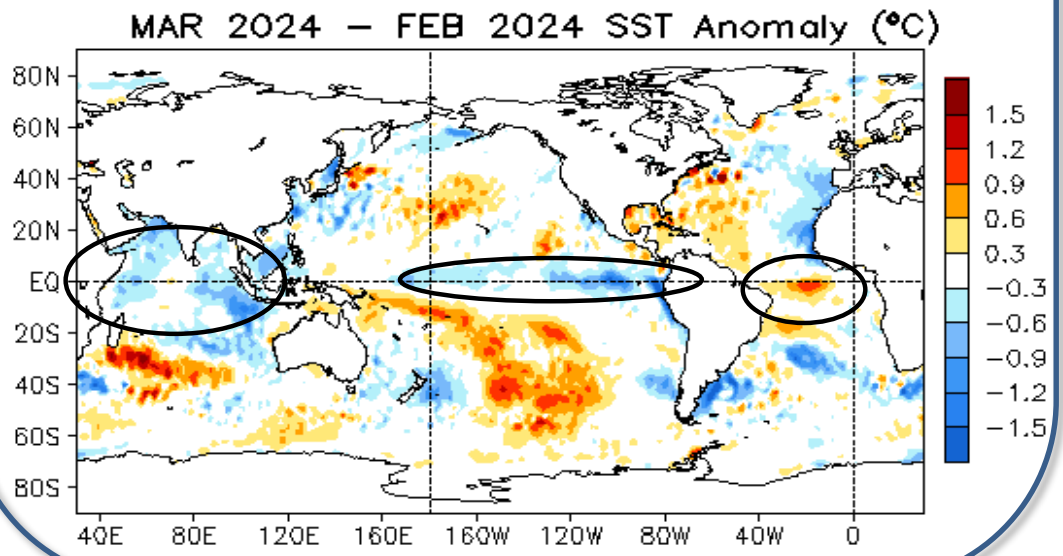
# Overview

- Pacific Ocean
  - El Niño condition weakened with Niño3.4 = 1.2$^{o}$C in Mar 2024.
  - NOAA "ENSO Diagnostic Discussion" on 14 Mar 2024 issued "*El Niño Advisory / La Niña Watch.*"
  - The positive SSTA in the North Pacific and the negative phase of PDO persisted with PDOI = -0.6 in Mar 2024.
- Arctic & Antarctic Oceans
  - Arctic ice extent for Mar 2024 was 14.87 million square kilometers, 15$^{th}$ lowest in the satellite record.
  - Antarctic sea ice extent reached its summer minimum extent on 21 Feb 2024, and the monthly sea ice extent was the 4$^{th}$ lowest in the satellite record.
  - CPC forecasts a below-normal Arctic sea ice extent minimum in Sep 2024.
- Indian Ocean
  - Positive SSTAs were observed in the tropical Indian Ocean with stronger warming in the west than in the east in Mar 2024.
- Atlantic Ocean
  - Positive SSTAs persisted in the tropical Atlantic Ocean.
  - NAO returned to a negative phase in Mar 2024 with NAOI= -0.6.

# Global Oceans

# Global SST Anomaly (°C) and Anomaly Tendency



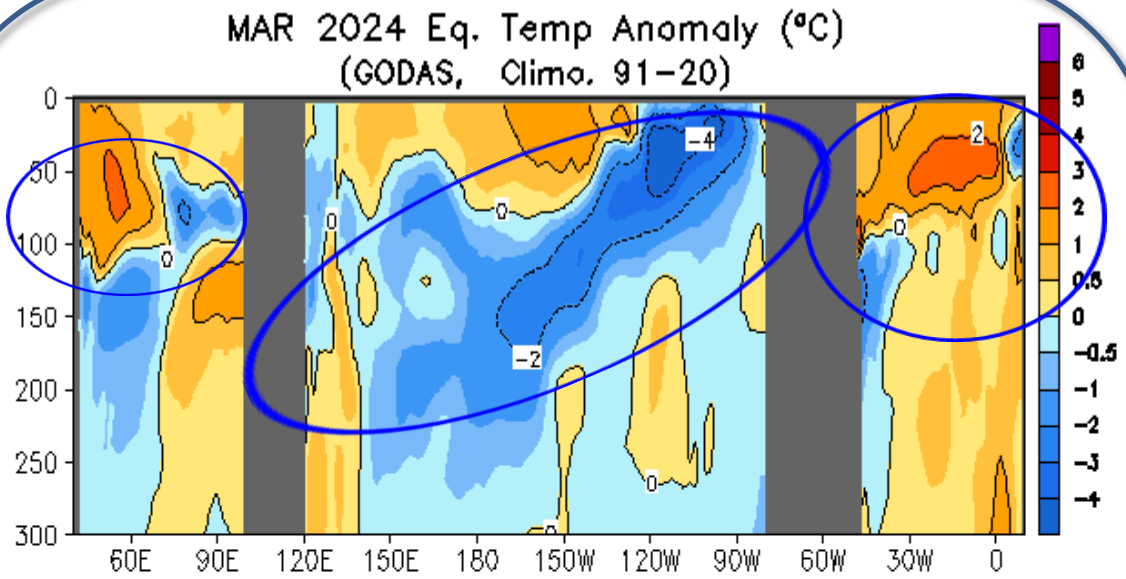



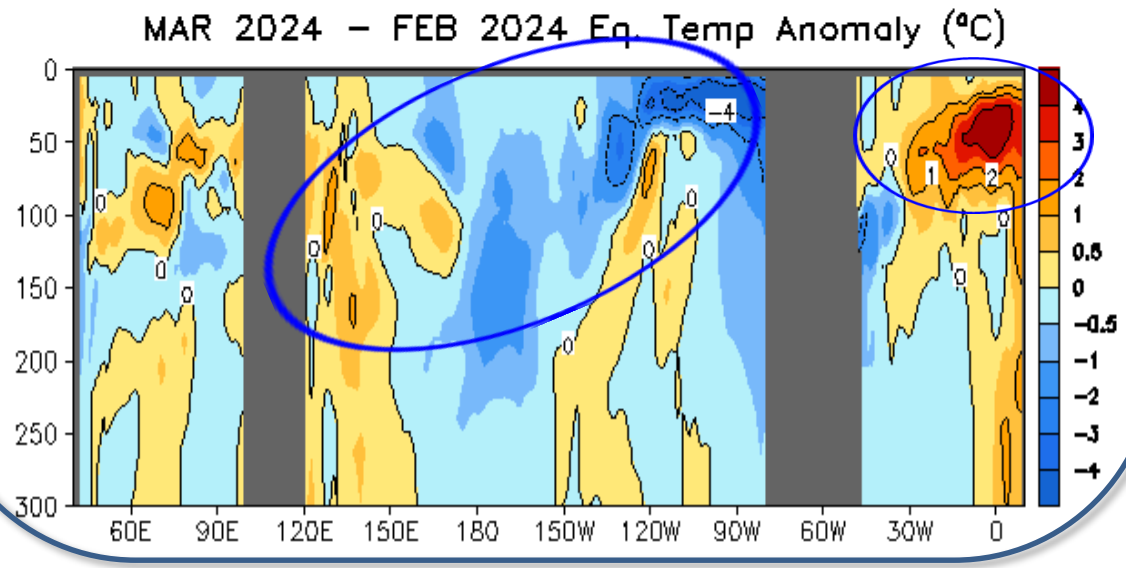

- Positive SSTAs persisted in the central and east-central equatorial Pacific Ocean.
- Positive SSTAs were present in the North Pacific, and the North and South Atlantic Oceans.
- Positive SSTAs were observed in the tropical Indian Ocean, with warmer SSTAs in the west.

- Negative SSTA tendencies were present in the central and eastern equatorial Pacific Ocean, implying a decaying in El Niño.
- Positive SSTA tendencies were observed in the central equatorial Atlantic Ocean.
- Negative SSTA tendencies dominated the tropical Indian Ocean.

SSTAs (top) and SSTA tendency (bottom). Data are derived from the OIv2.1 SST analysis, and anomalies are departures from the 1991-2020 base period means.

# Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2°S-2°N



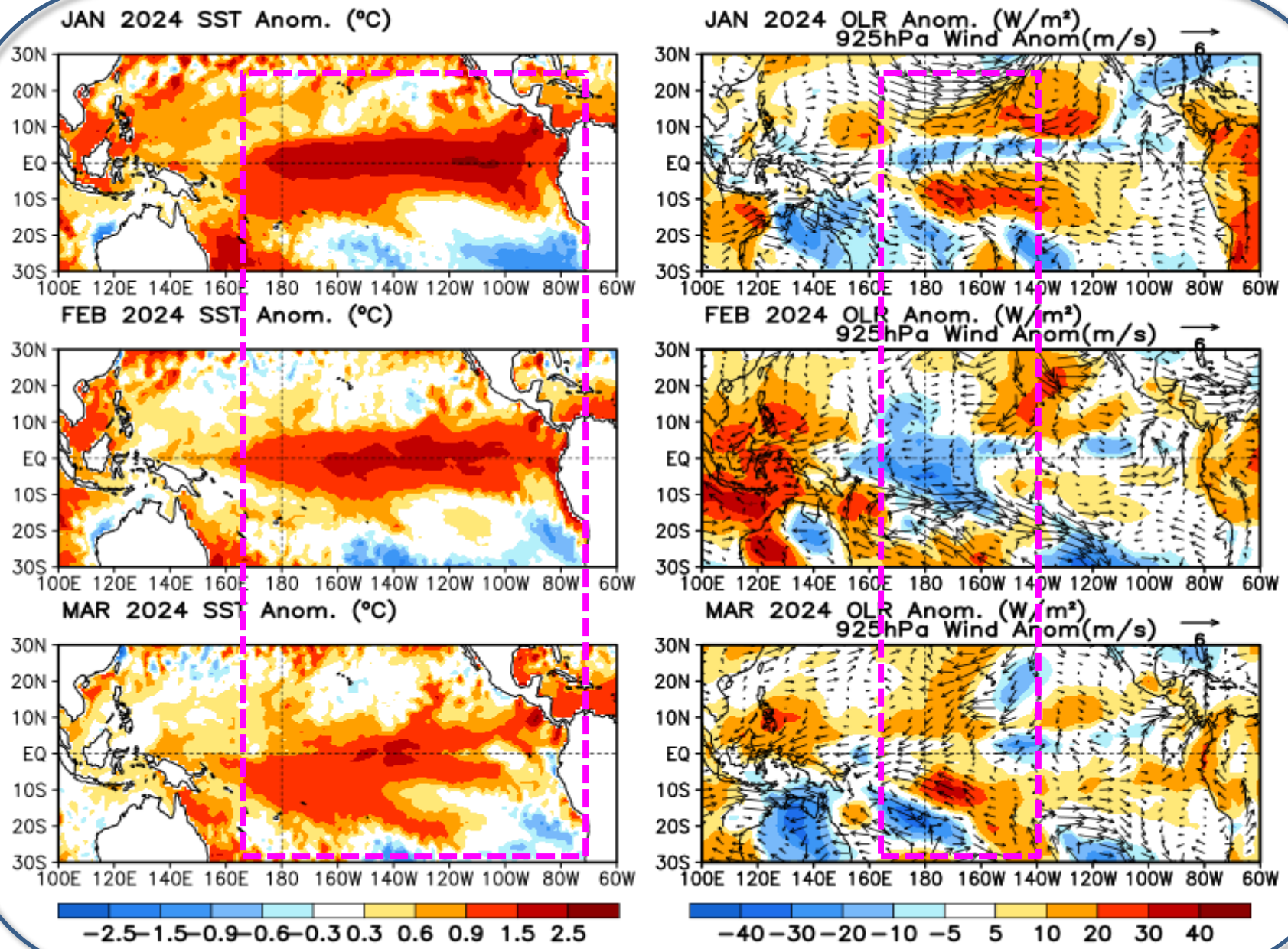

- Negative anomalies around the thermocline were observed in the central and eastern equatorial Pacific and reached the surface in the east.
- Positive anomalies along the thermocline were present in the western Indian Ocean and the western and central Atlantic Ocean.

- Negative (positive) anomaly tendencies dominated along the thermocline in the central and eastern (western) Pacific Ocean.
- Strong positive anomaly tendencies were present along the thermocline in the eastern Atlantic Ocean.

Equatorial depth-longitude section of ocean temperature anomalies (top) and anomaly tendency (bottom). Data is from the NCEP's GODAS. Anomalies are departures from the 1991-2020 base period means.

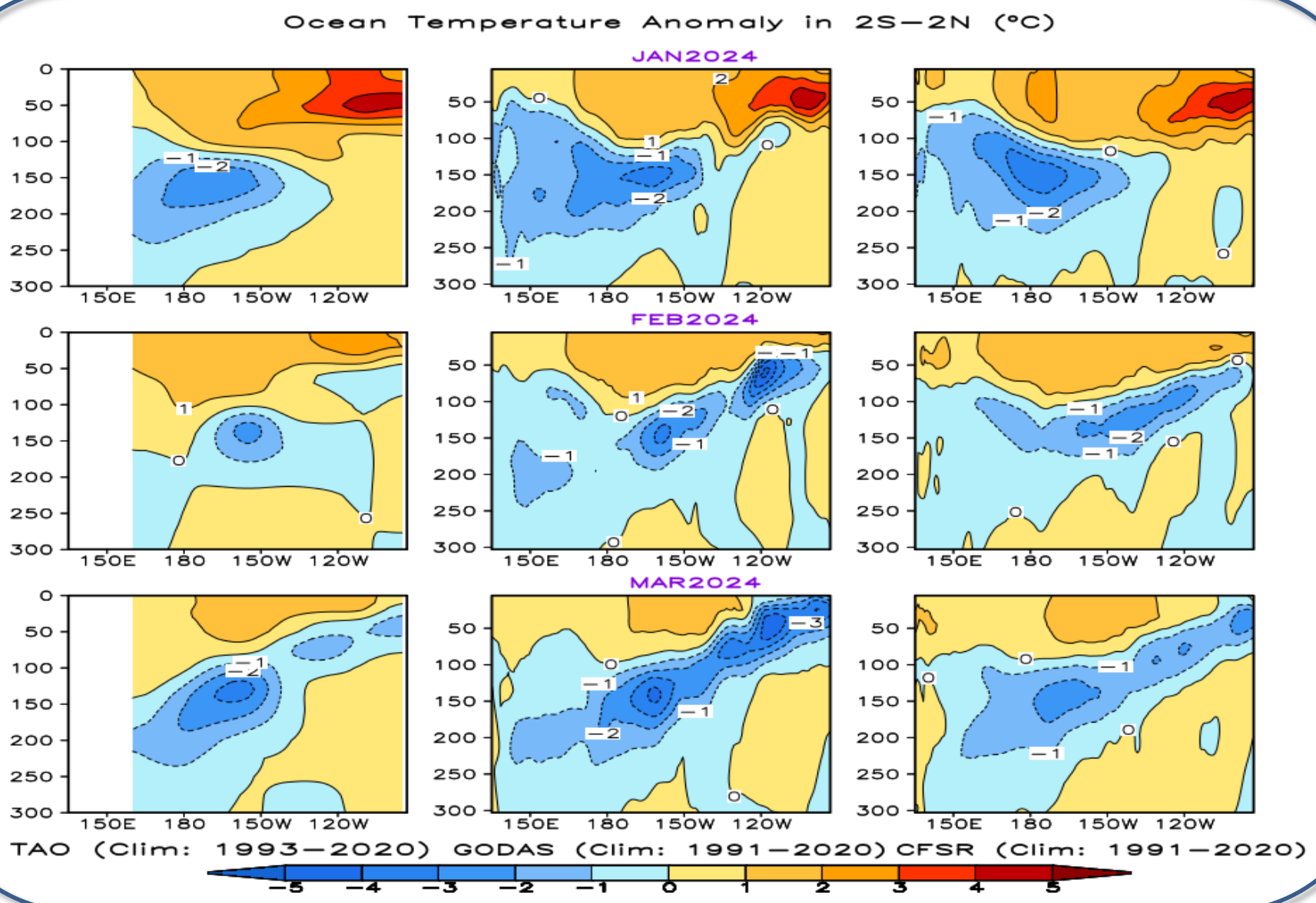
# Tropical Pacific Ocean and ENSO Conditions

# Last 3-month Tropical Pacific Ocean SST, OLR, and uv925 Anomalies

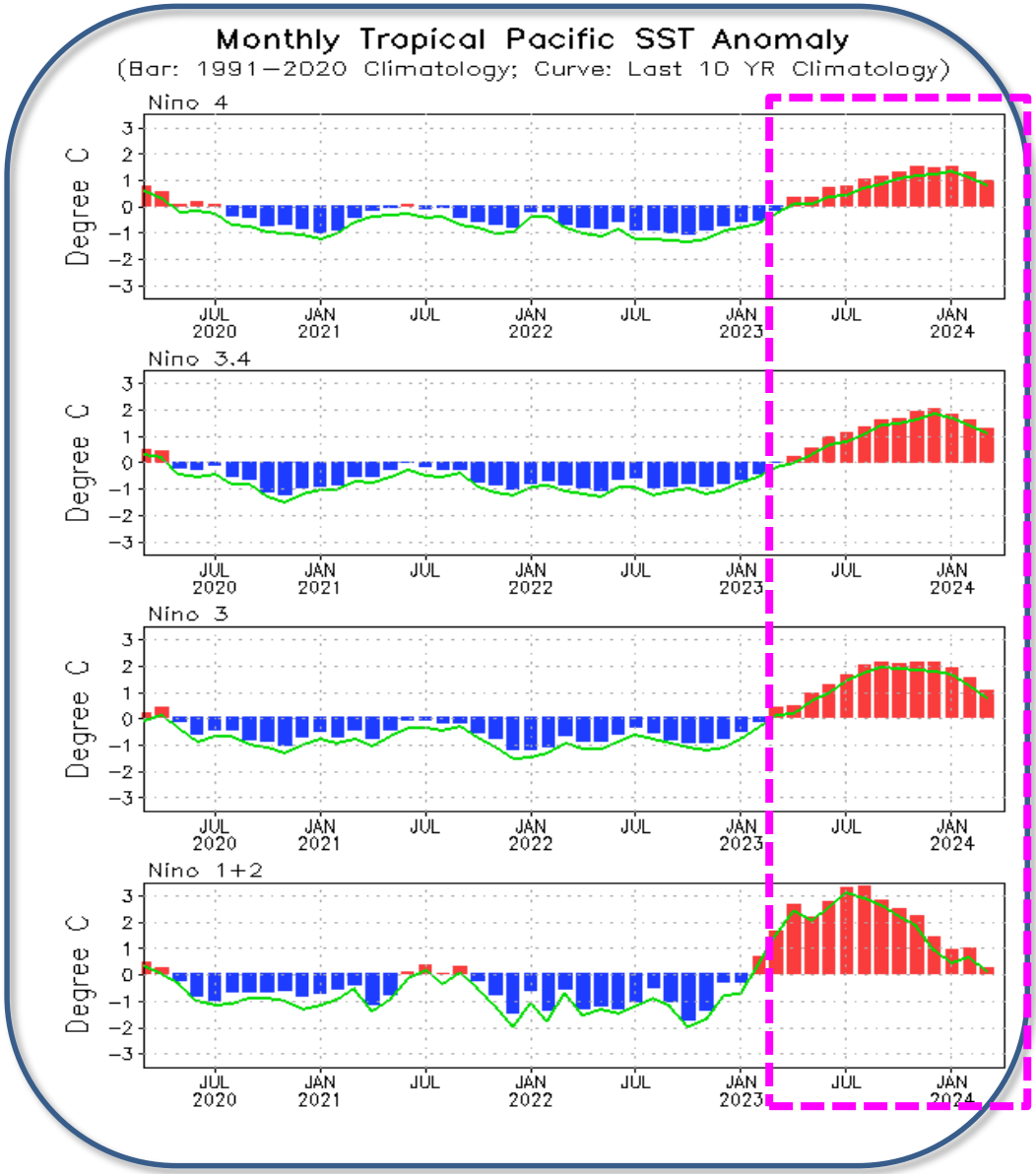


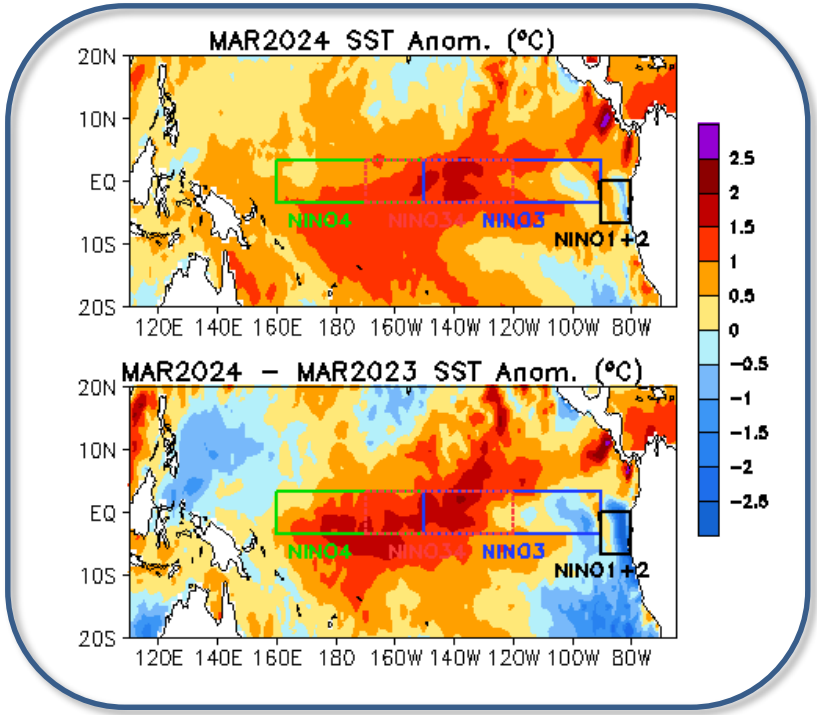
# Monthly mean subsurface temperature anomaly along the Equator:

## Three products with strengthened negative anomalies in the central & east in Mar 2024 were consistent



# Evolution of Pacific Niño SST Indices



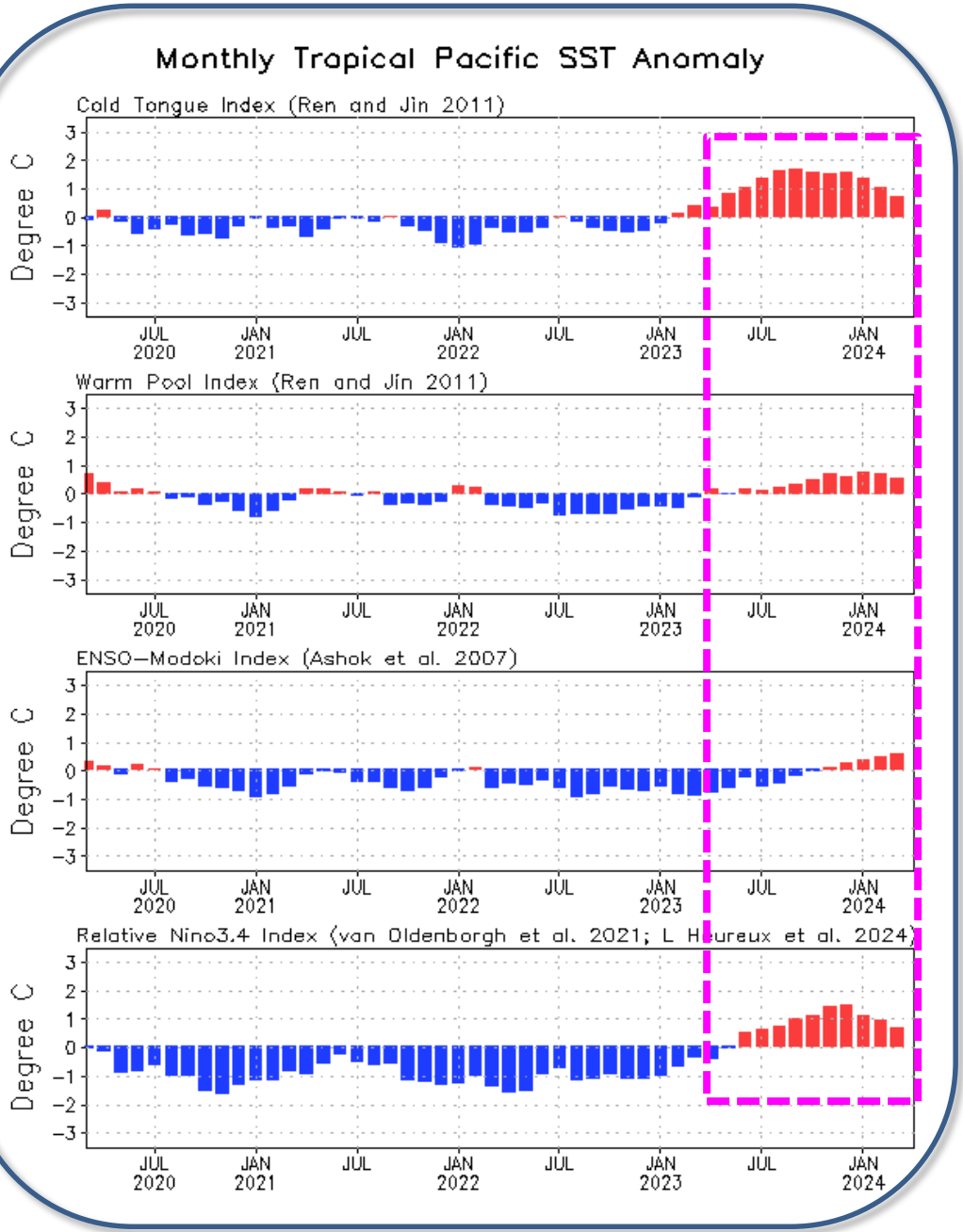

- In Mar 2024, Niño3.4 weakened further with Niño3.4 = 1.2°C (1.2°C in ERSSTv5 data); Nino1+2 decayed further to 0.3°C.

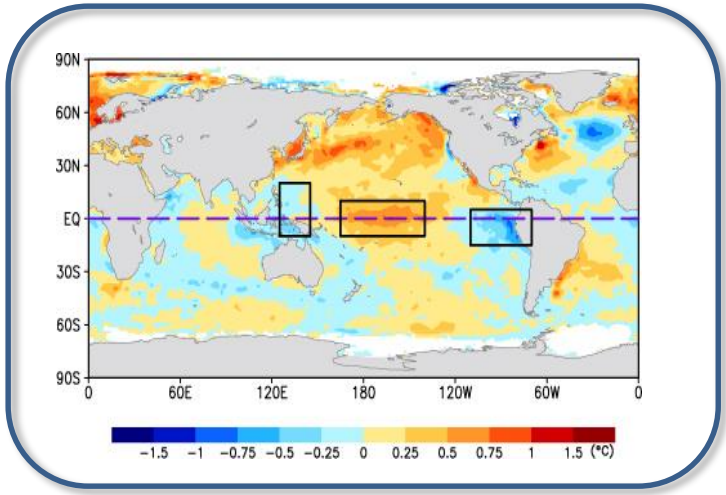
- Compared with Mar 2023, the tropical central and east-central Pacific was warmer in Mar 2024.

- The values of the indices may have differences if based on different SST products.

Niño region indices, calculated as the area-averaged monthly mean SSTAs (°C) for the specified region. Data are derived from the OIv2.1 SST analysis, and anomalies are departures from the 1991-2020 base period means.

# Evolution of Pacific Niño SST Indices: Warming mainly in the cold tongue



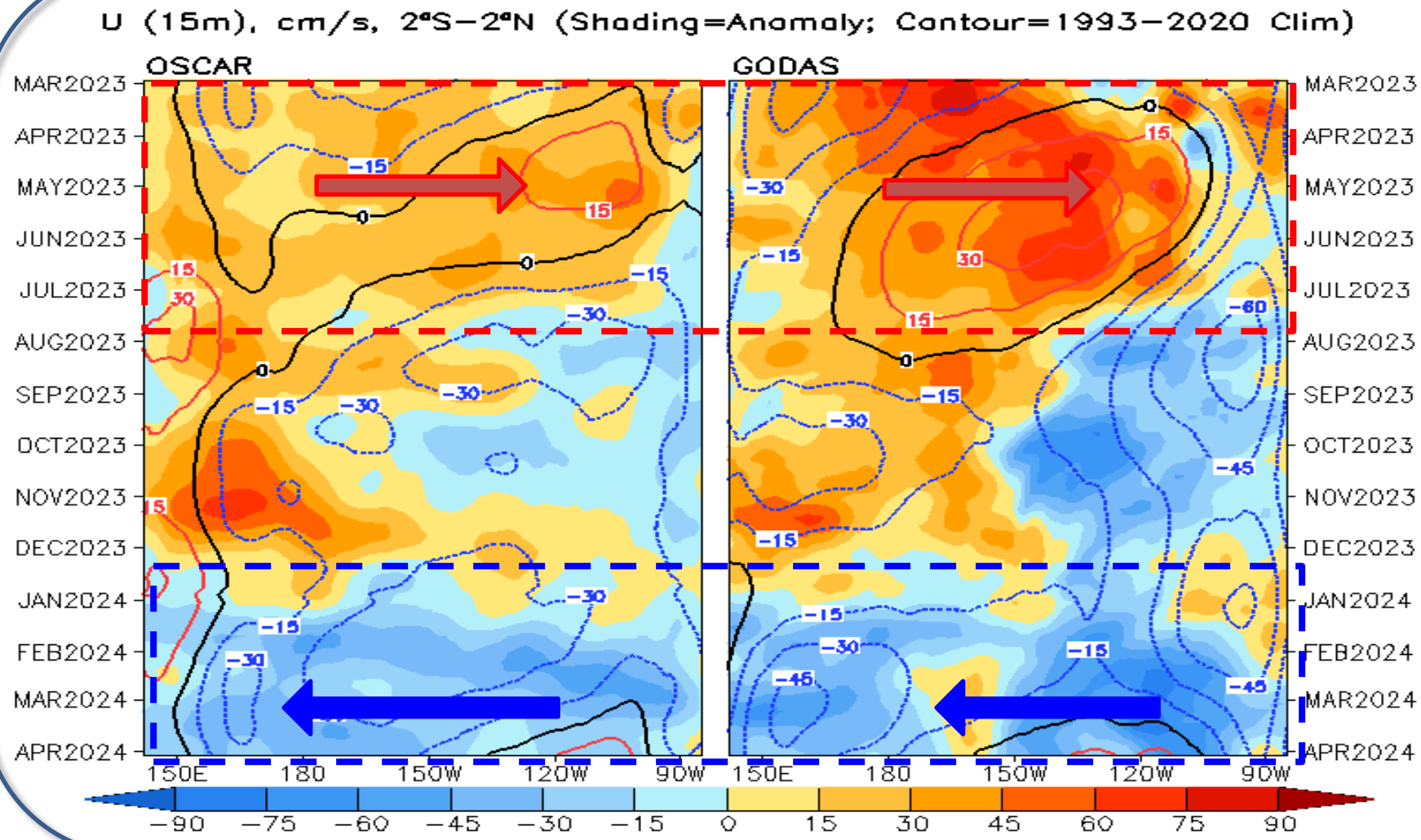




- Relative Niño3.4 index is now included in ENSO monitoring, which is defined as the conventional Niño3.4 index minus the SSTA averaged in the whole tropics (0°-360°, 20°S-20°N), in order to remove the global warming signal. Also, to have the same variability as the conventional Niño3.4 index, the relative Niño3.4 index is renormalized (Izumo et al. 2020: GRL, 10.1029/2019GL086182; van Oldenborgh et al. 2021: ERL, 10.1088/1748-9326/abe9ed; L'Heureux, et al. 2024: J. Climate, 10.1175/JCLI-D-23-0406.1).

Relative Niño3.4 data updated monthly at:

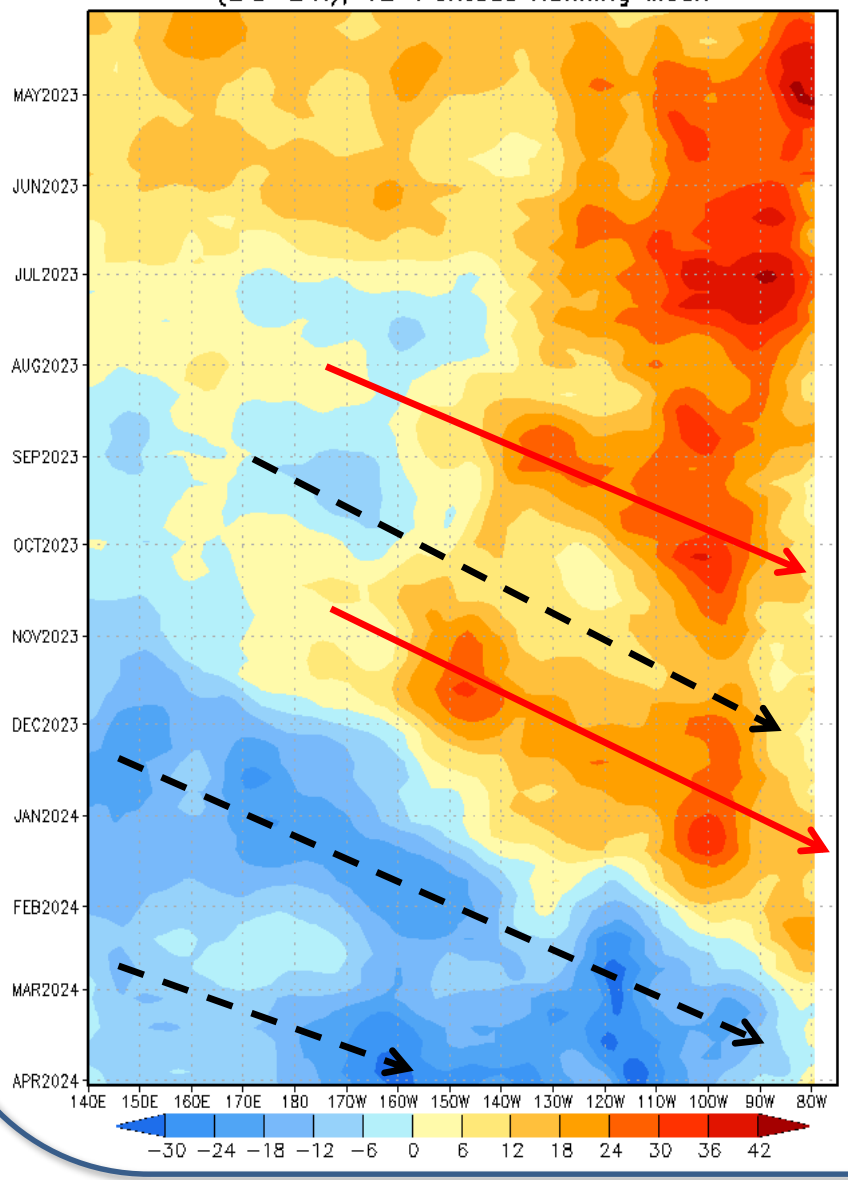
https://www.cpc.ncep.noaa.gov/data/indices/RONI.ascii.txt

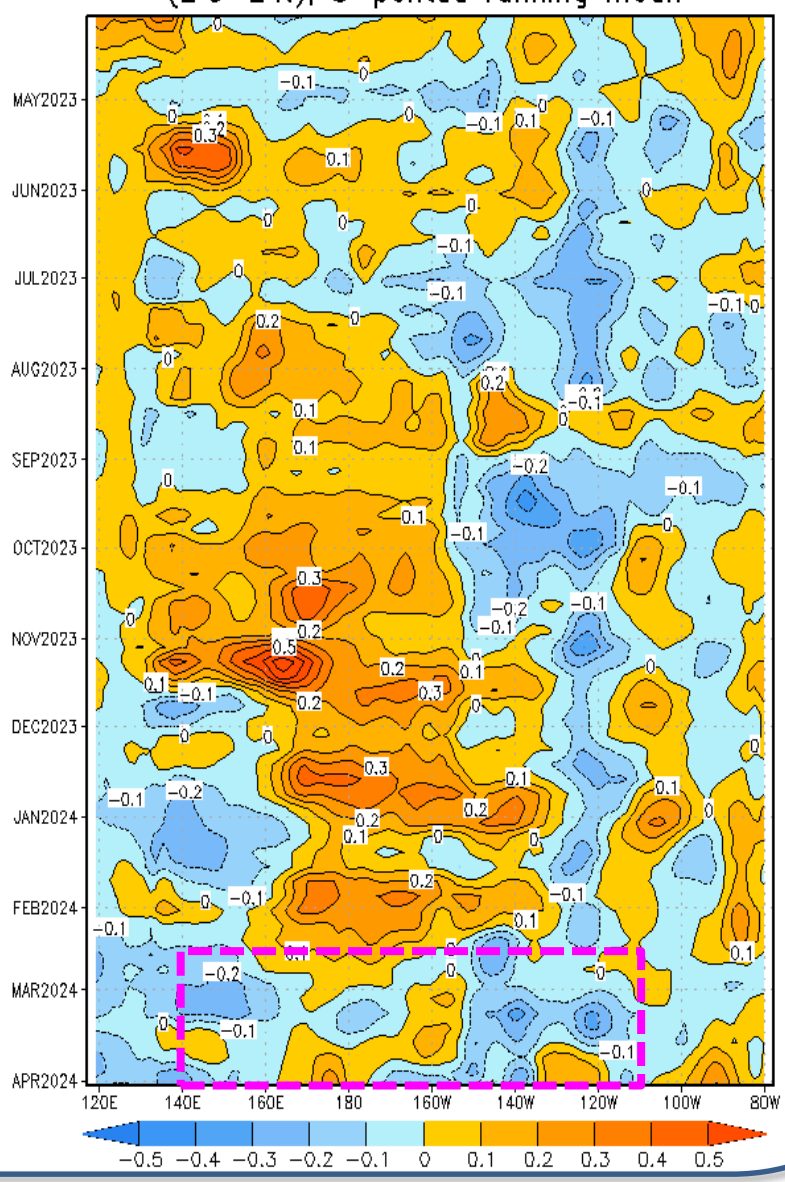
# Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



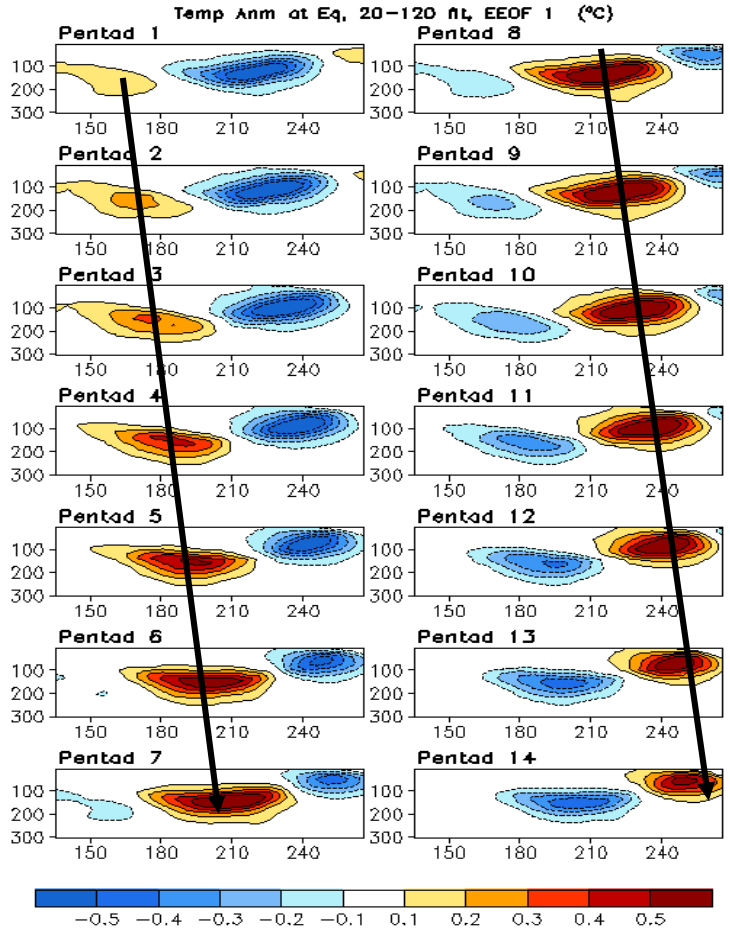

- Anomalous eastward currents were present in the equatorial Pacific in both OSCAR and GODAS during Feb-Jul 2023, which were consistent with the growth of the positive SSTA.
- Anomalous westward currents have been observed since mid-Dec 2023.

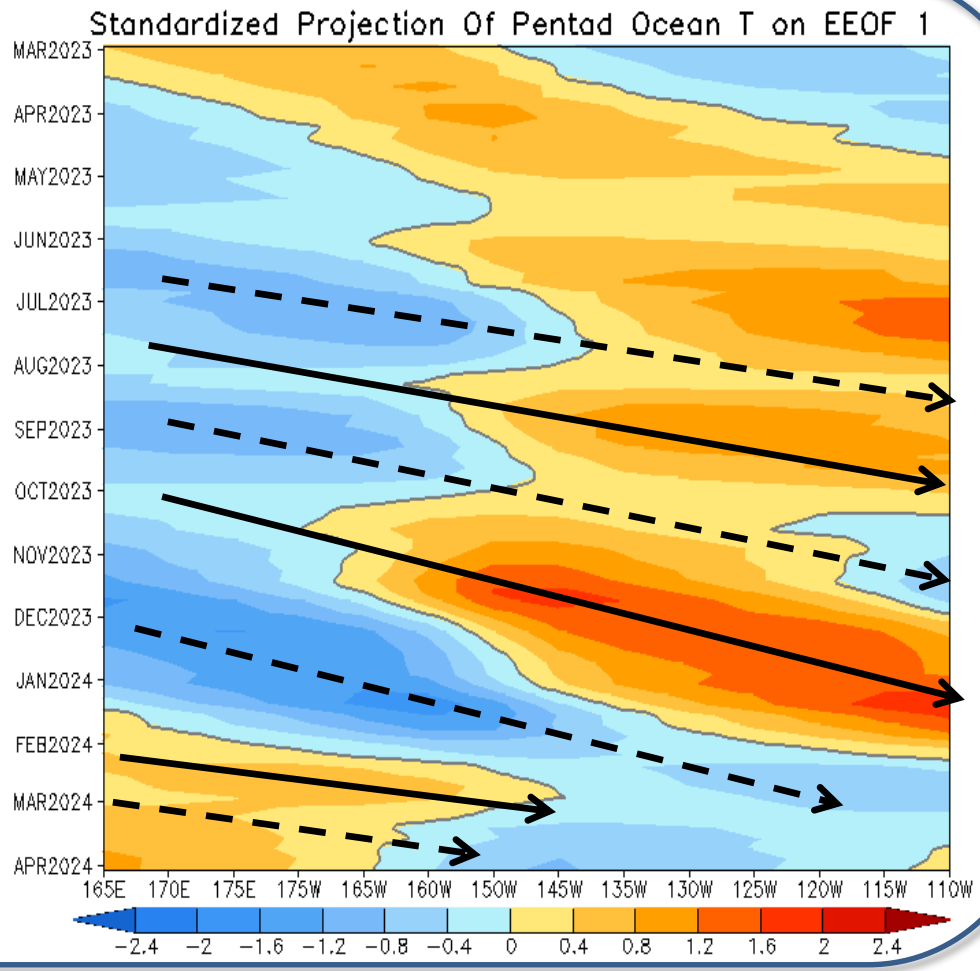
# Evolution of Pentad D20 and Taux anomalies along the equator



# Oceanic Kelvin Wave (OKW) Index



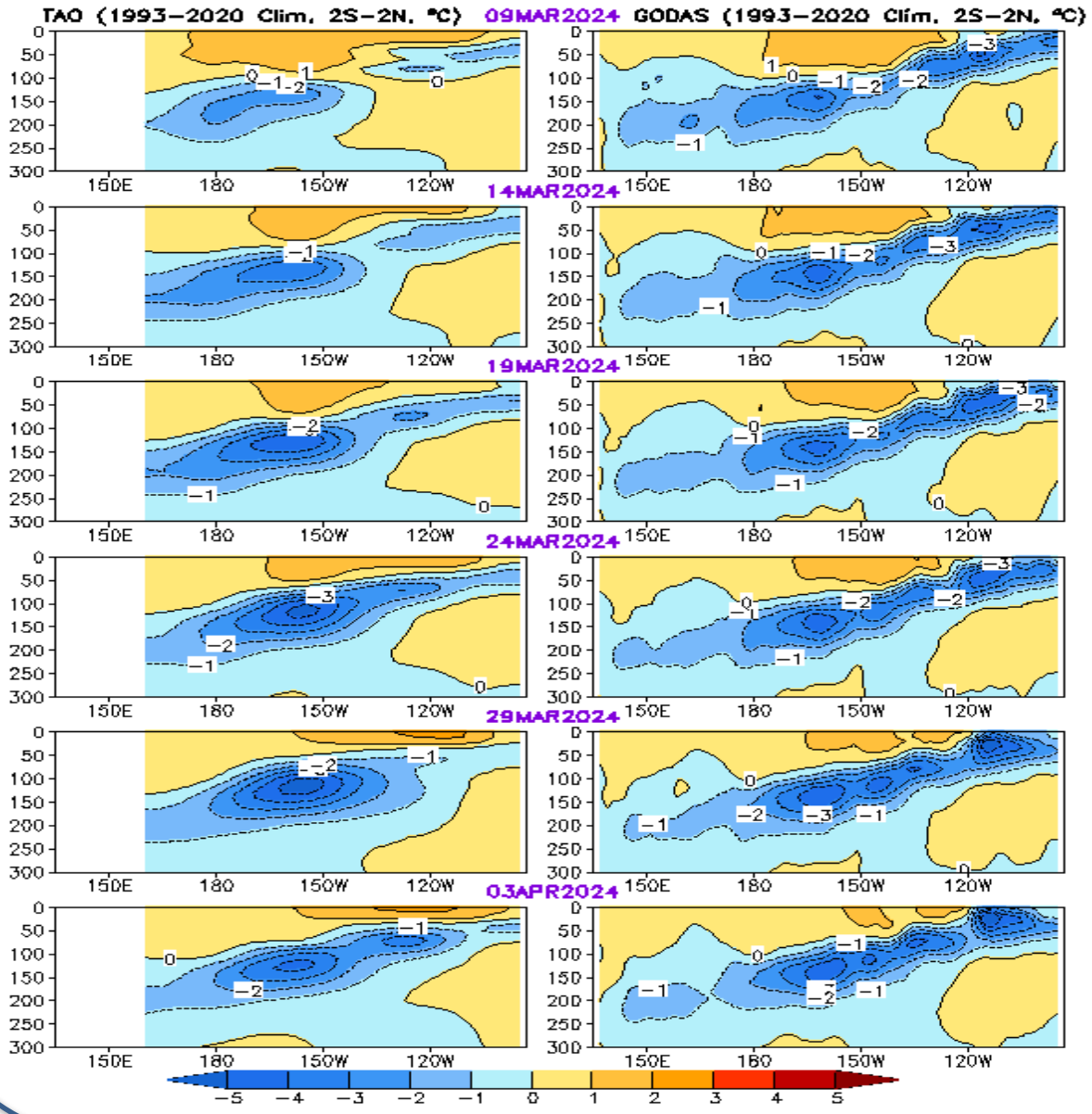




- **Multiple downwelling and upwelling Kelvin waves were observed in 2023-24, leading to fluctuation in SSTAs in the central and eastern equatorial Pacific and ENSO evolution.**

- **Weak downwelling and upwelling Kelvin waves propagated eastward since Feb 2024.**

*(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)*

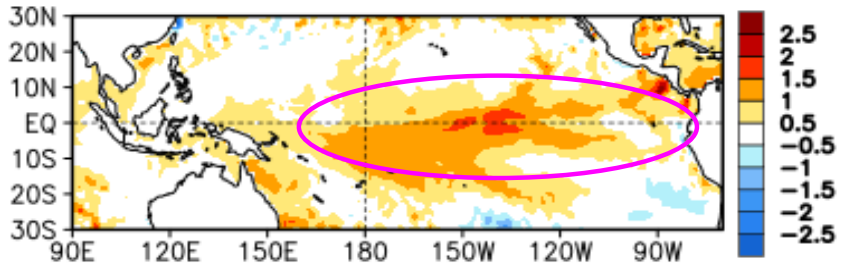
# Equatorial Pacific Ocean Temperature Pentad Mean Anomaly

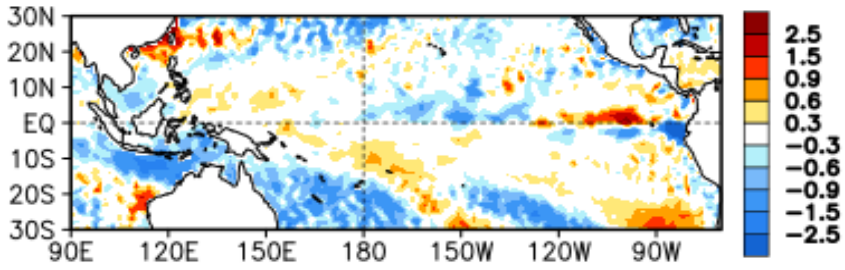


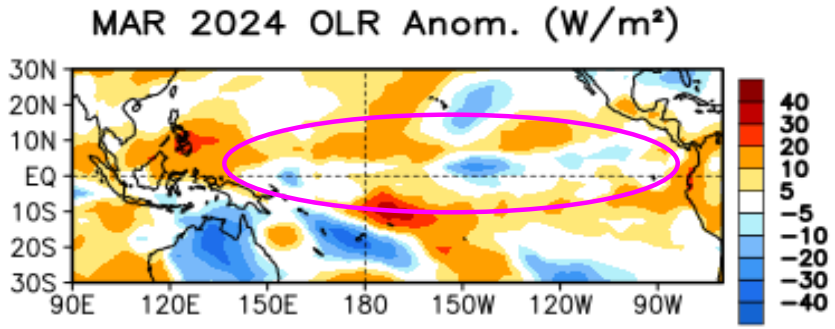

- Negative ocean temperature anomalies along the thermocline in the central and eastern Pacific strengthened during the last month.

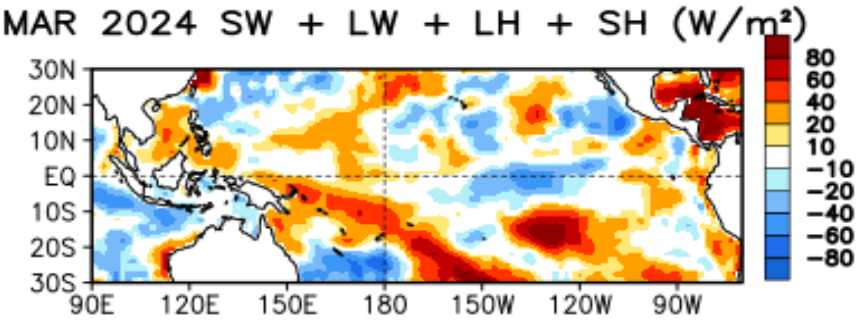
- The features of the ocean temperature anomalies were similar between GODAS and TAO analysis.

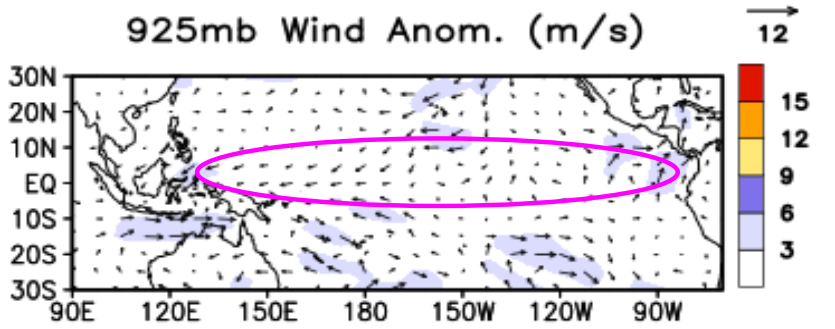
# Tropical Pacific: SSTA, SSTA Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Winds

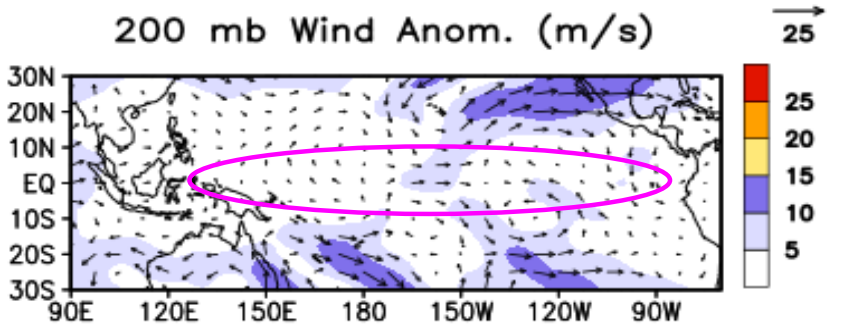


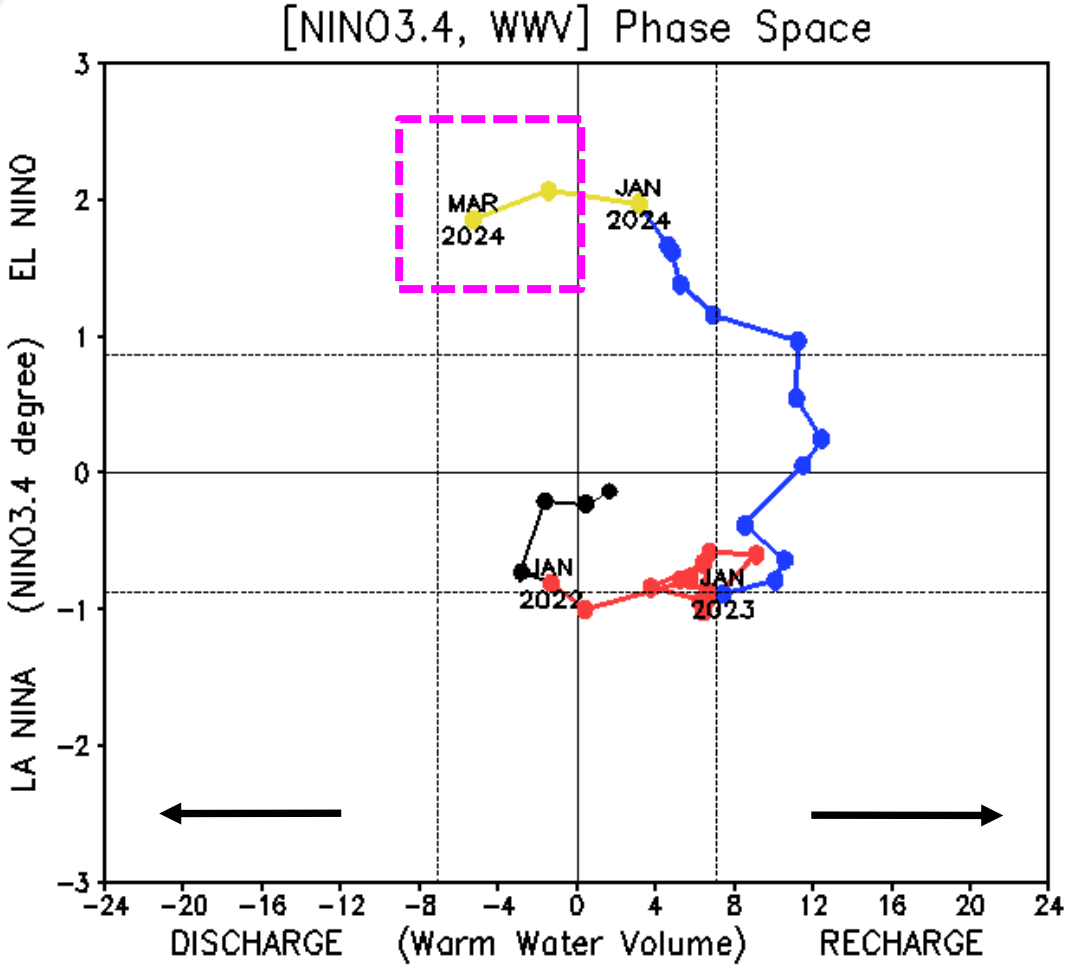




SSTAs (top-left), SSTA tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right; positive means heat into the ocean), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the OIv2.1 SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, winds and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1991-2020 base period means.

# Warm Water Volume (WWV) and Niño3.4 Anomalies

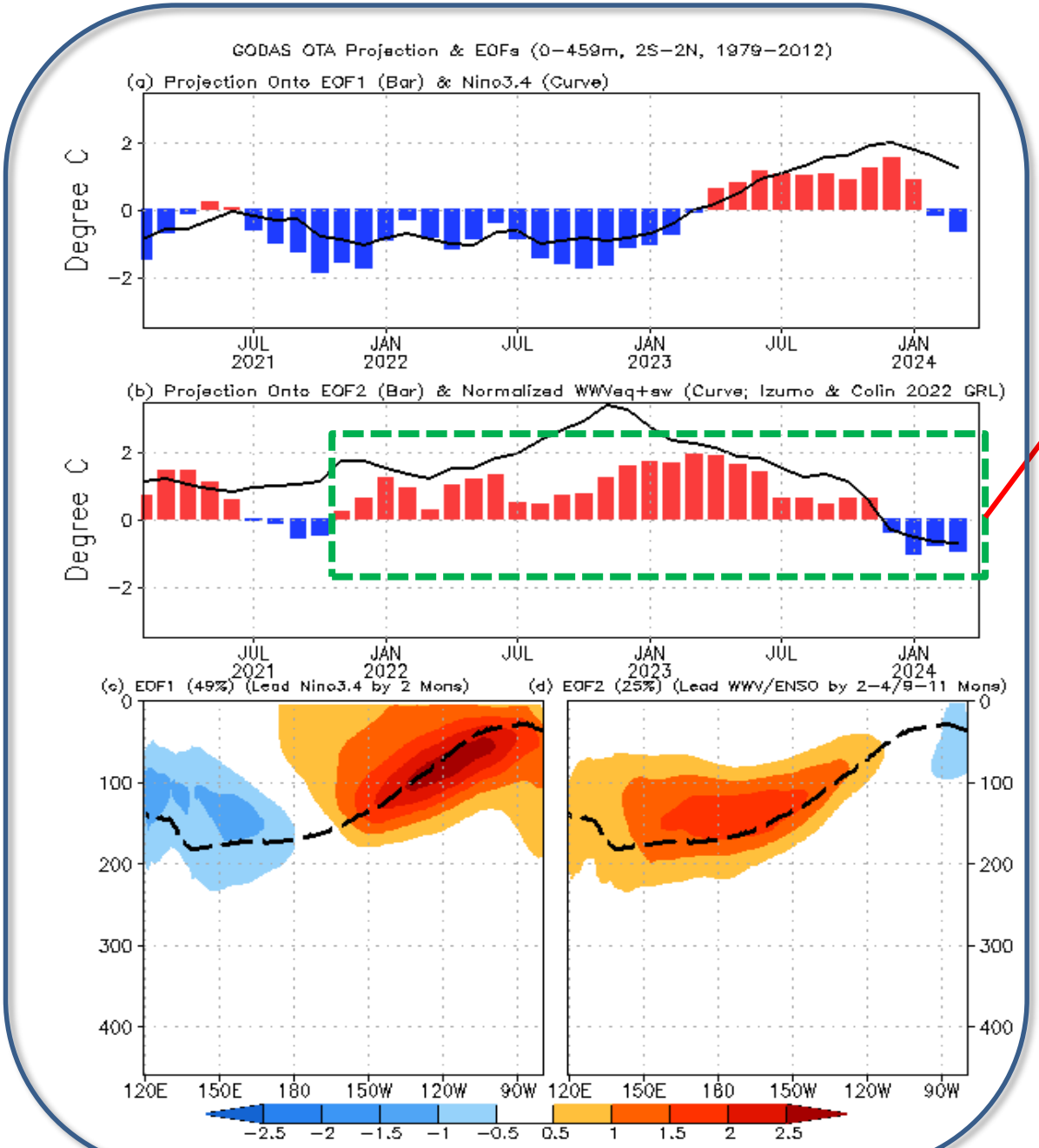
- Pacific equatorial Warm Water Volume (WWV) switched to a discharge phase since Feb 2024.

-As WWV is intimately linked to ENSO variability (Wyrtki 1985; Jin 1997), it is useful to monitor ENSO in a phase space of WWV and Niño3.4 (Kessler 2002).
- Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.




Phase diagram of Warm Water Volume (WWV) and Niño3.4 indices. WWV is the average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN] calculated with the NCEP's GODAS. Anomalies are departures from the 1991-2020 base period means.

# Equatorial Sub-surface Ocean Temperature Monitoring




- After an extended-period of recharge since Nov 2021, the equatorial Pacific has switched to a discharge phase since Dec 2023.

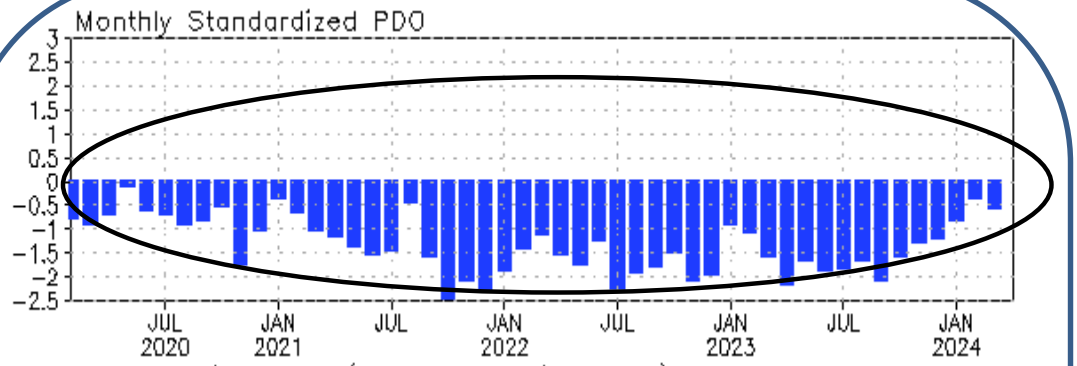
- Projection of ocean temperature anomalies onto EOF1 and EOF2; EOF1: Tilt/dipole mode (ENSO peak phase); EOF2: WWV mode.

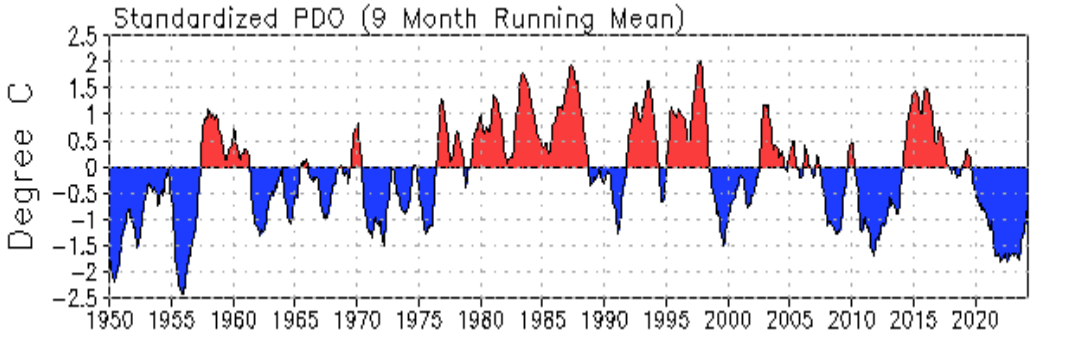
- Recharge/discharge oscillation (ENSO transition phase); Recharge process: heat transport from outside of equator to equator; Negative -> positive phase of ENSO

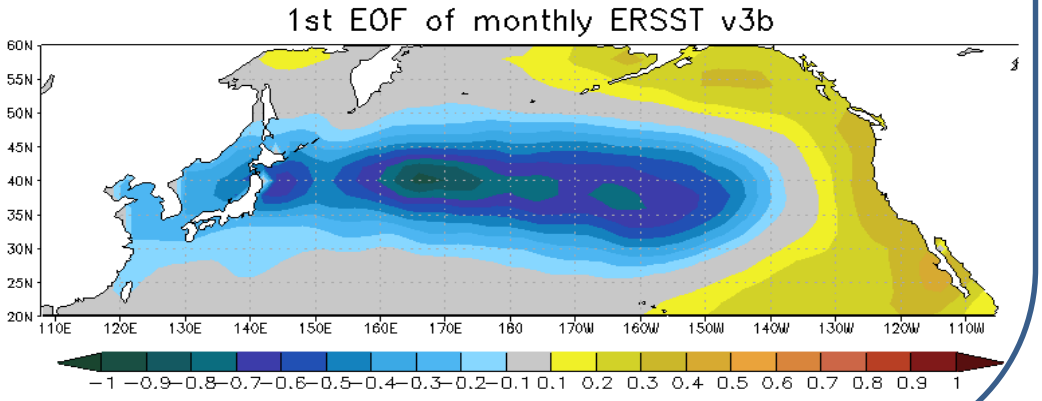
- For details, see: Kumar and Hu (2014) DOI: 10.1007/s00382-013-1721-0; Izumo & Colin (2022) DOI: 10.1029/2022GL101003.

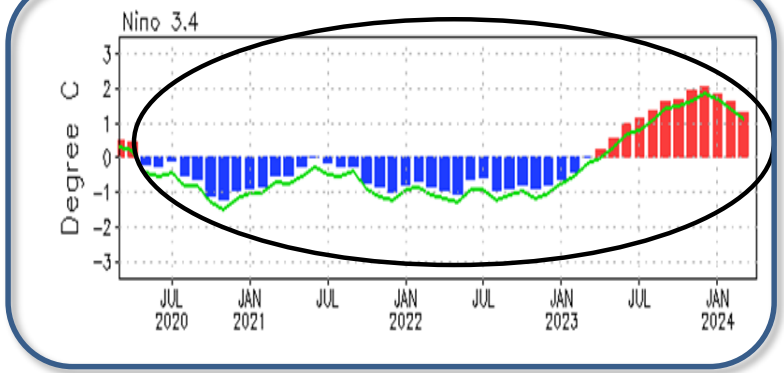
# North Pacific, Arctic, & Antarctic Oceans

# Pacific Decadal Oscillation (PDO) Index



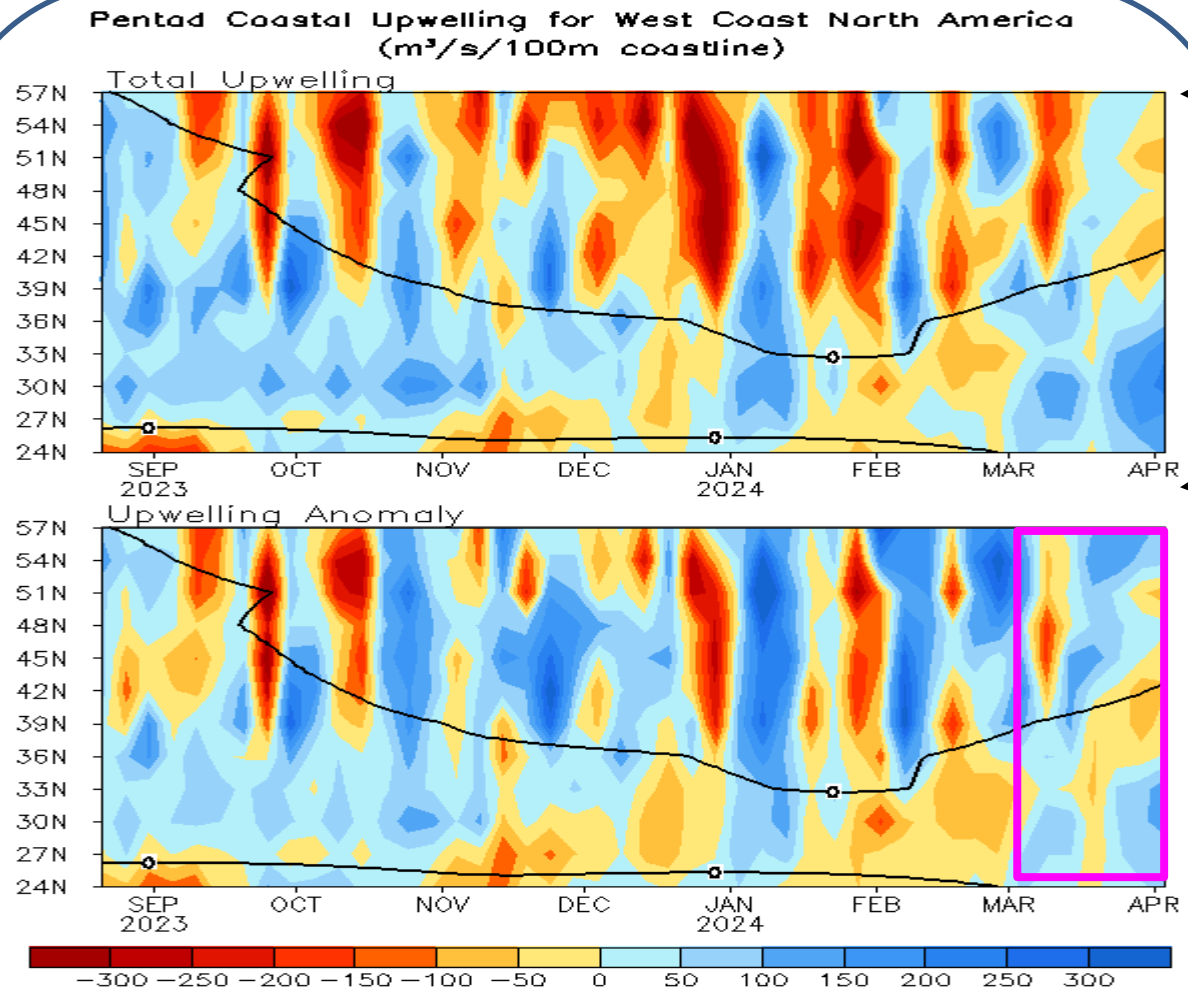



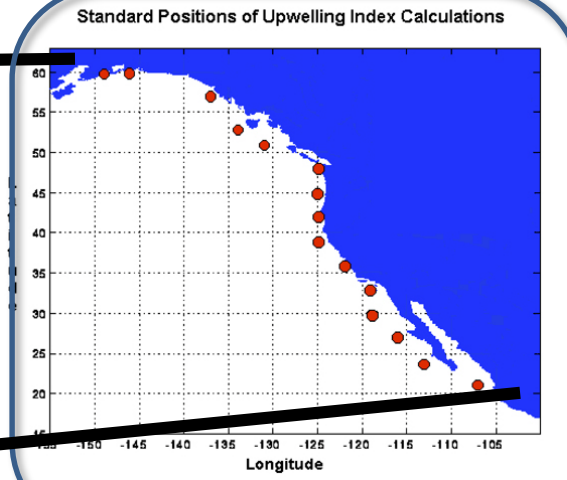




- The PDO has been in a negative phase since Jan 2020 and persisted with PDOI = -0.6 in Mar 2024.
- The negative phase of PDO since the 2nd half of 2023 is opposite to what is expected during El Niño.
- Statistically, ENSO leads PDO by 3-4 months, through teleconnection via atmospheric bridge, with El Niño (La Niña) associated with positive (negative) PDO Index.

• PDO is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.

# North America Western Coastal Upwelling

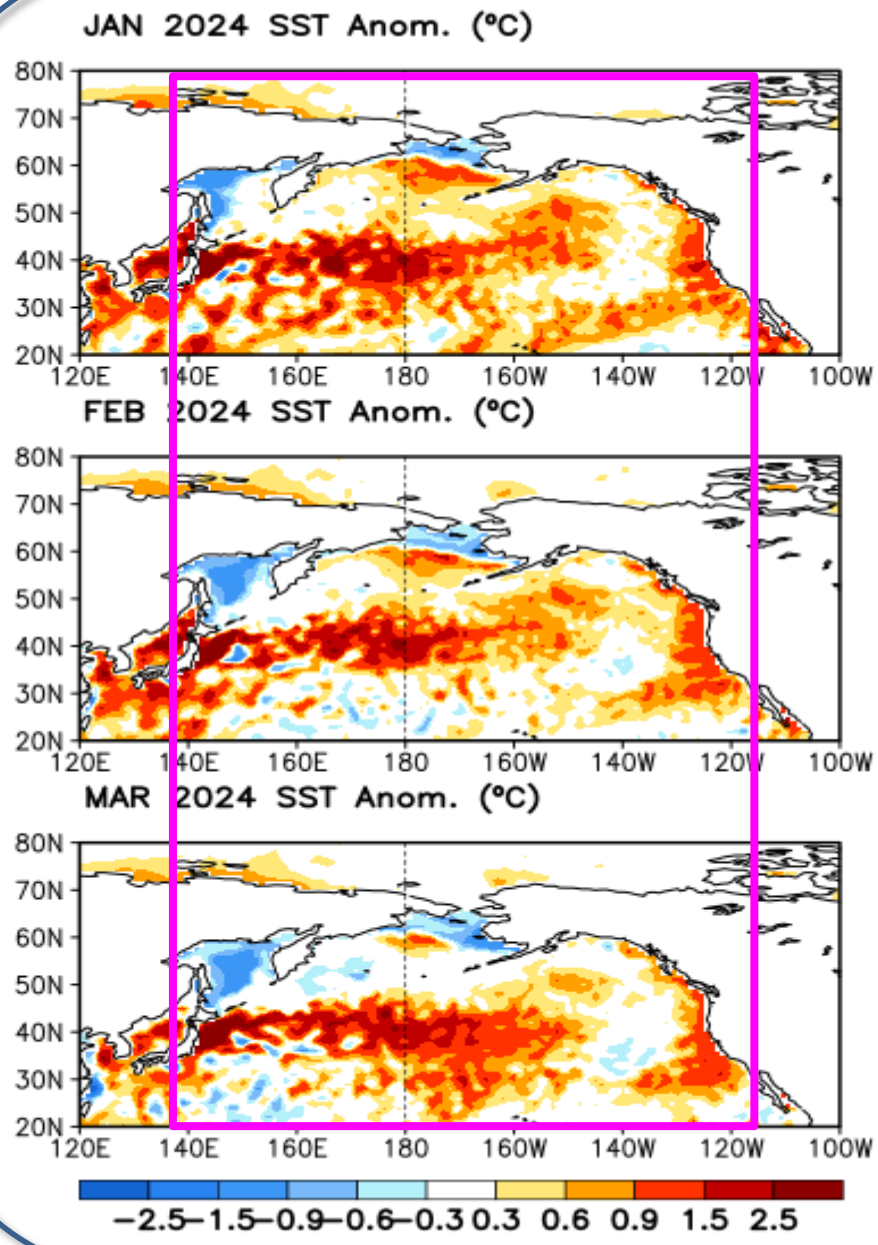


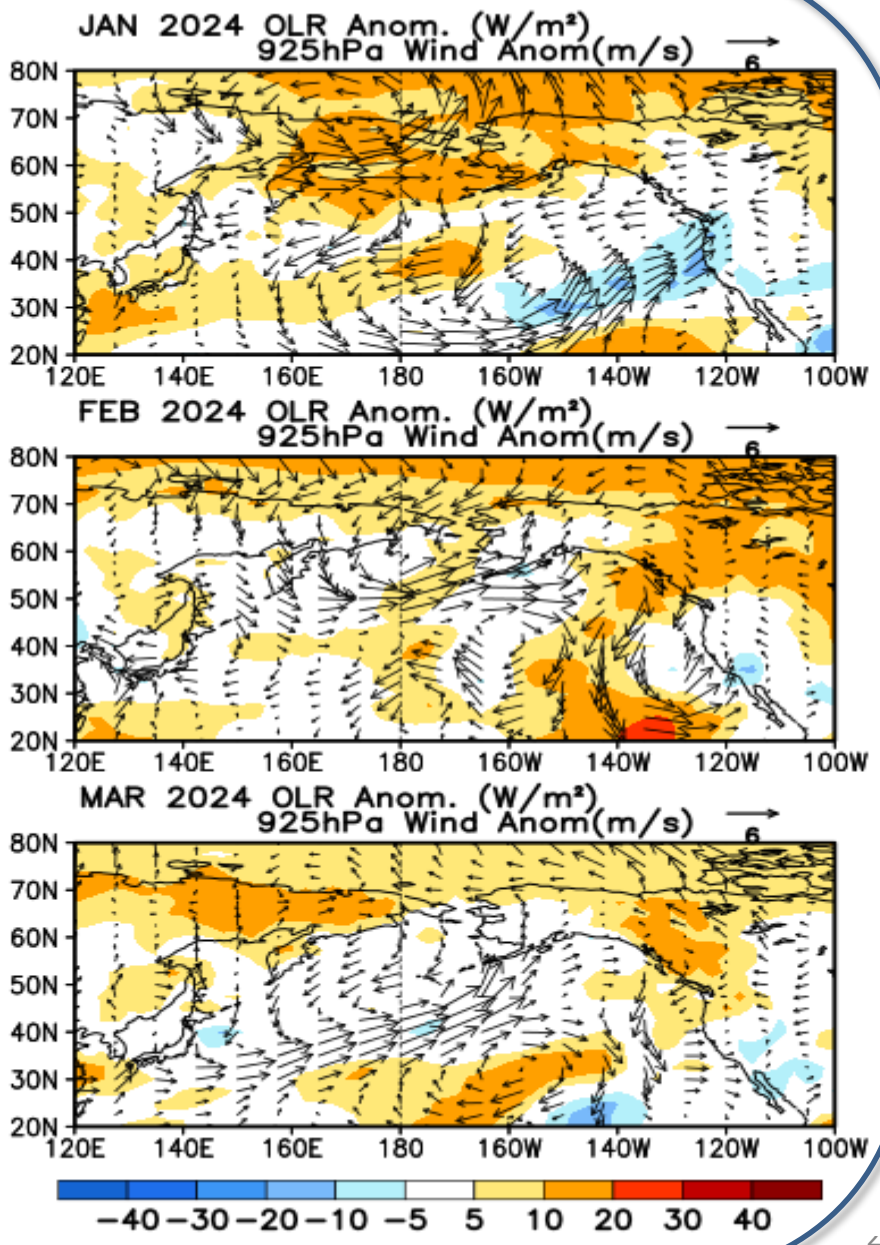




- Both anomalous upwelling and downwelling were present in Mar 2024.

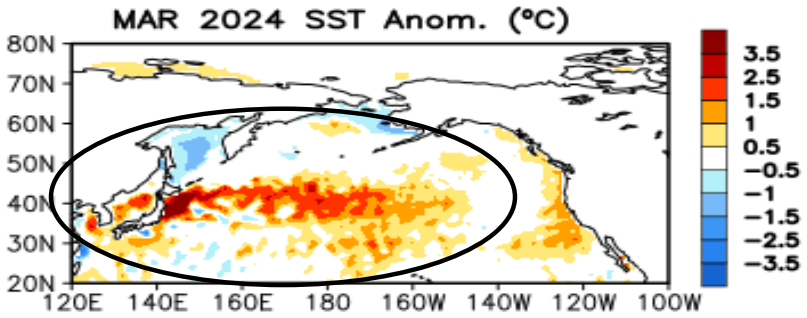
(top) Total and (bottom) anomalous upwelling indices at the 15 standard locations for the western coast of North America. Derived from the vertical velocity of the NCEP's GODAS and are calculated as integrated vertical volume transport at 50-meter depth from each location to its nearest coast point ($m^3/s/100m$ coastline). Anomalies are departures from the 1991-2020 base period pentad means.
- Area below (above) black line indicates climatological upwelling (downwelling) season.
- Climatologically upwelling season progresses from March to July along the west coast of North America from 36ºN to 57ºN.

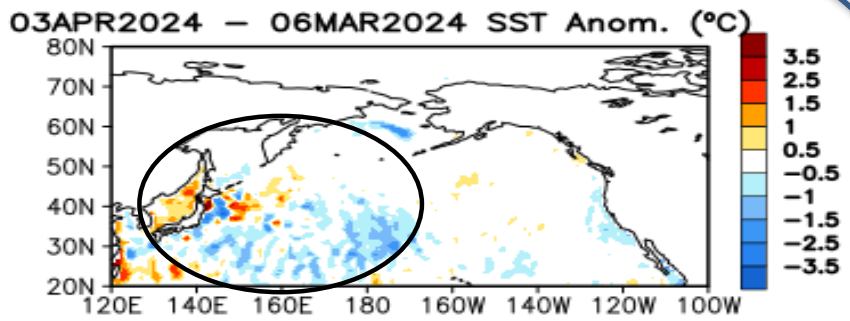
# Last 3-month North Pacific SST, OLR, and uv925 anomalies

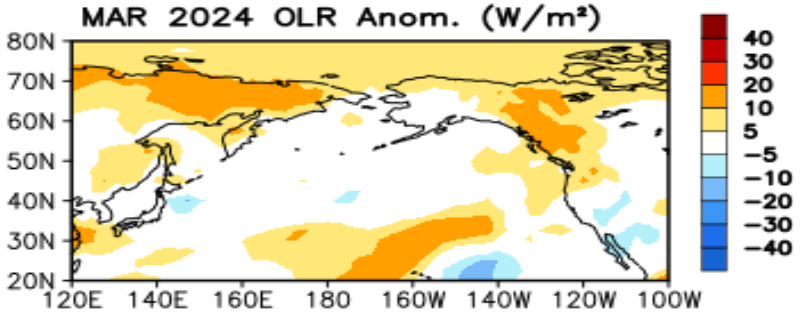


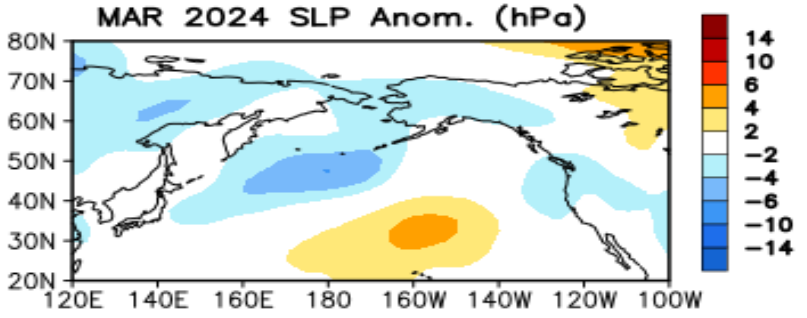



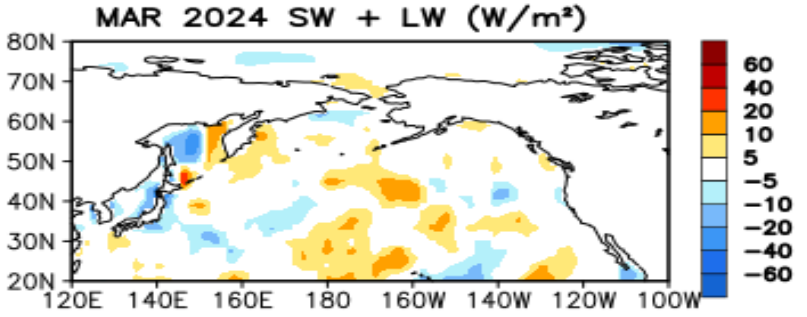
# North Pacific Ocean: SSTA, SSTA Tend., OLR, SLP, Sfc Rad, Sfc Flx Anomalies

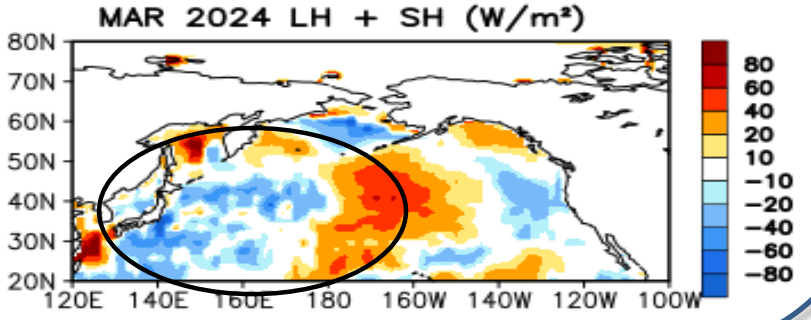


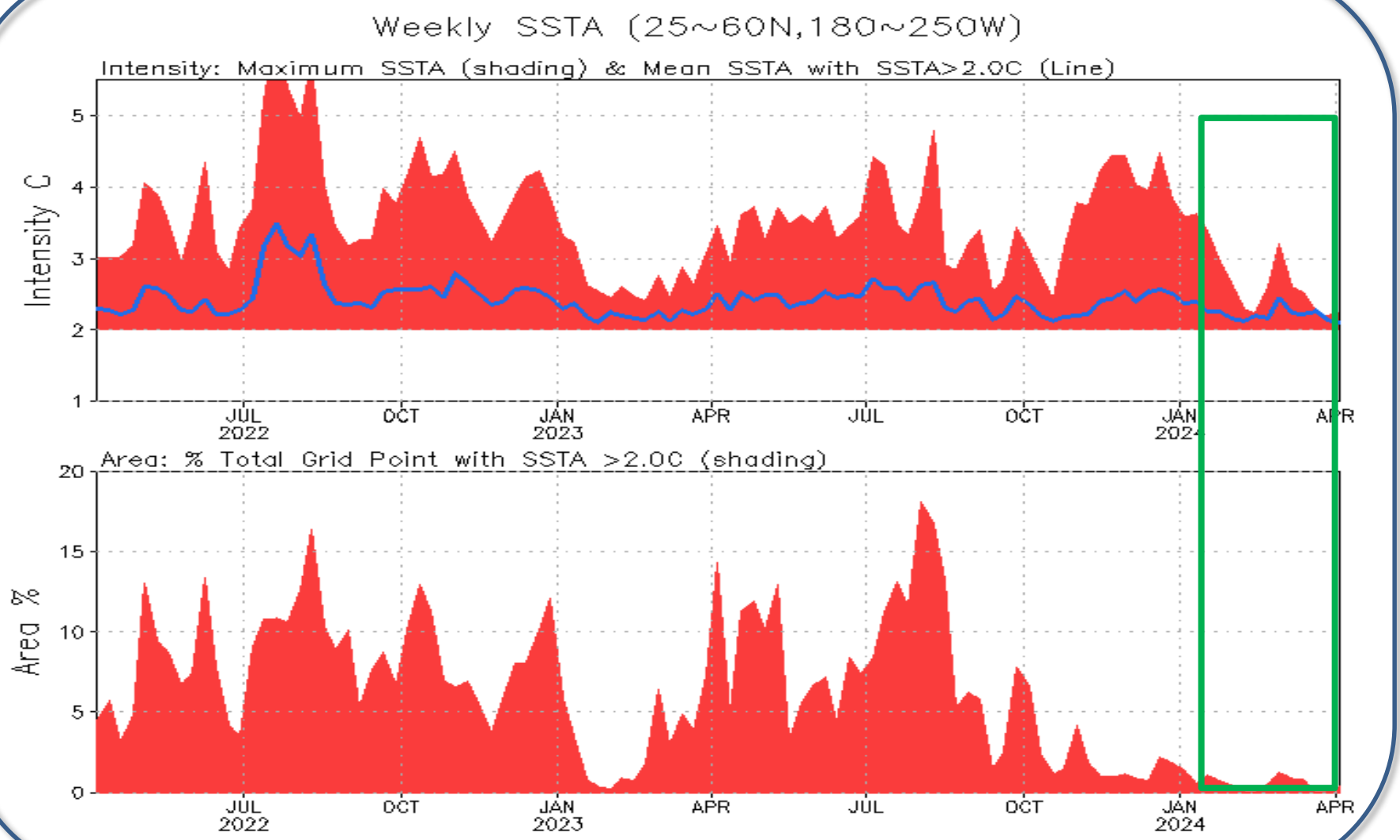



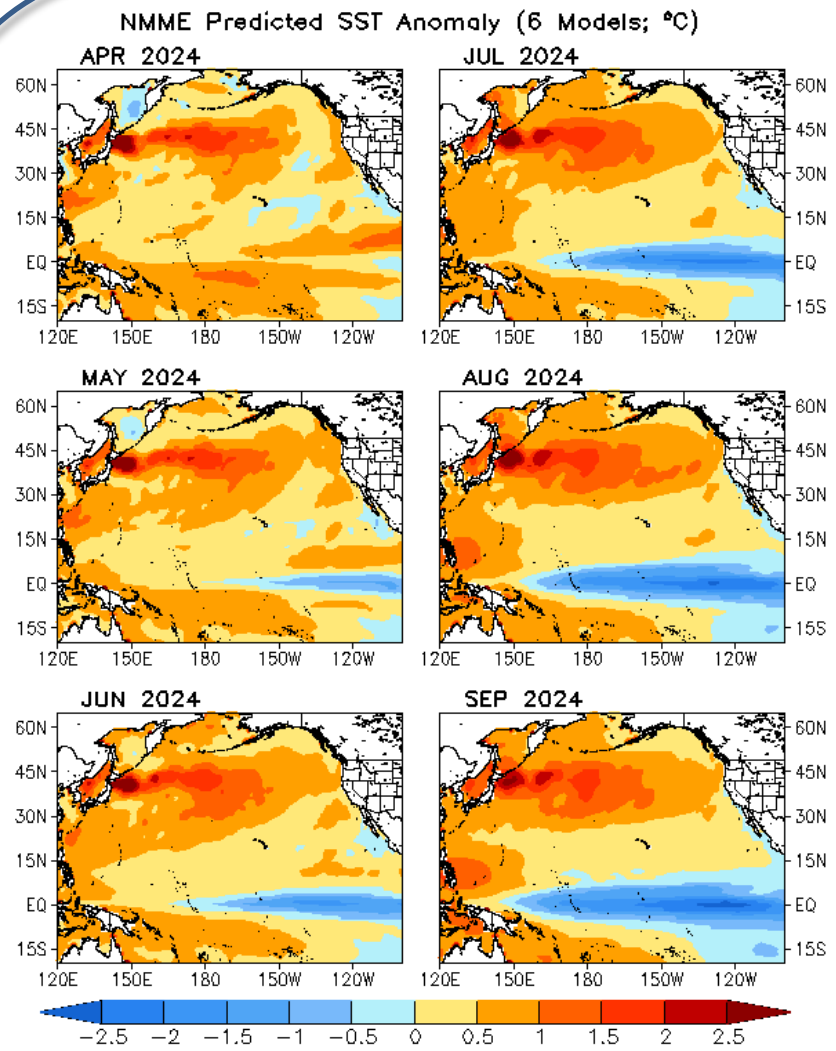

SSTA (top-left; OIv2.1 SST Analysis), SSTA tendency (top-right), Outgoing Long-wave Radiation (OLR) (middle-left; NOAA 18 AVHRR IR ), sea surface pressure (middle-right; NCEP CDAS), sum of net surface short- and long-wave radiation (bottom-left; positive means heat into the ocean; NCEP CDAS), sum of latent and sensible heat flux (bottom-right; positive means heat into the ocean; NCEP CDAS). Anomalies are departures from the 1991-2020 base period means.

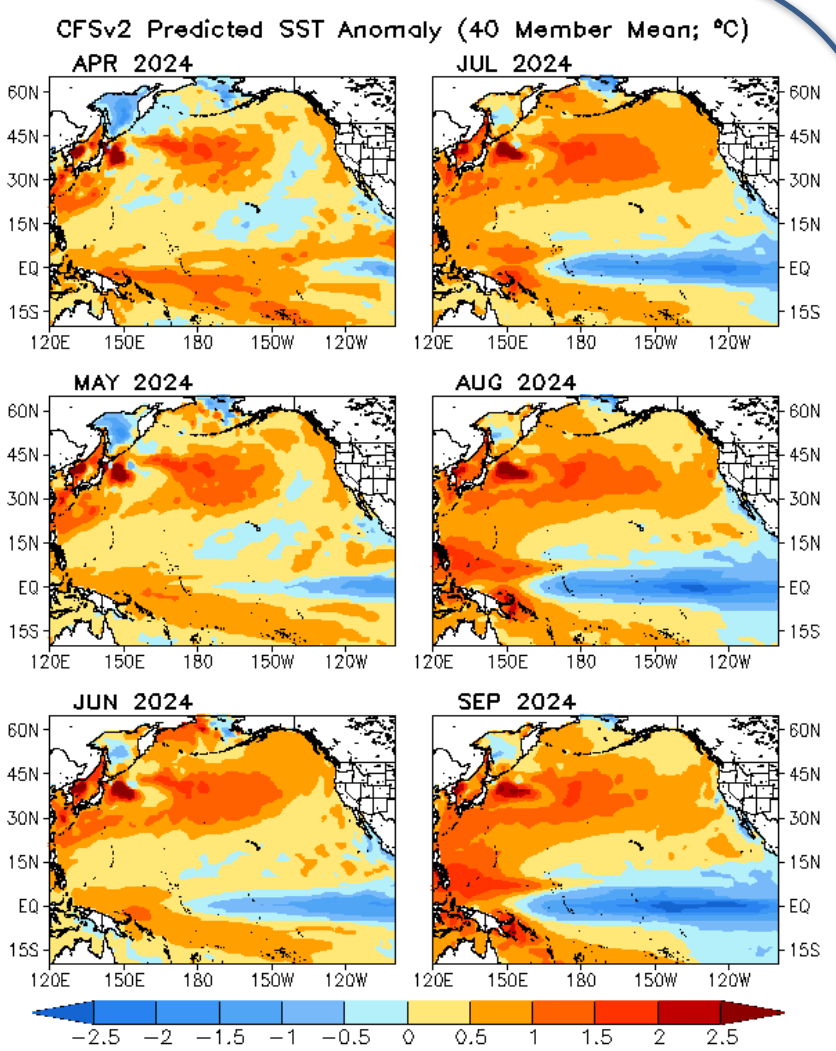
# N. Pacific Marine Heat Wave Weakened




https://origin.cpc.ncep.noaa.gov/products/GODAS/MarineHeatWave.html

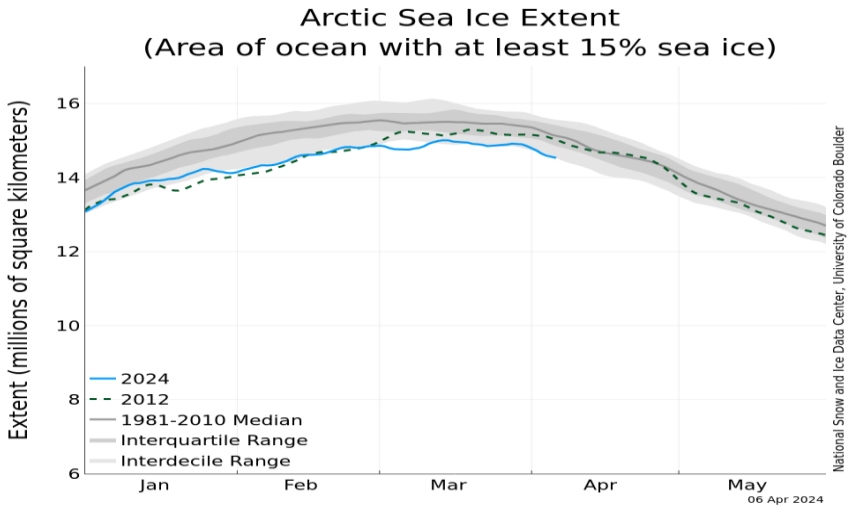
# NMME & CFSv2 North Pacific SSTA Predictions

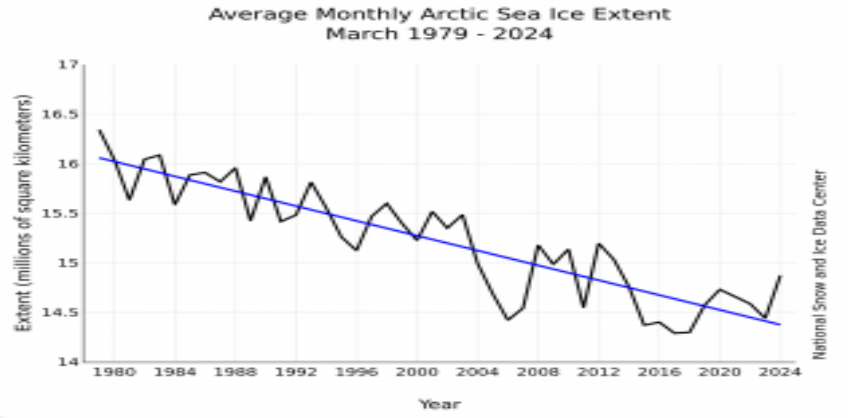


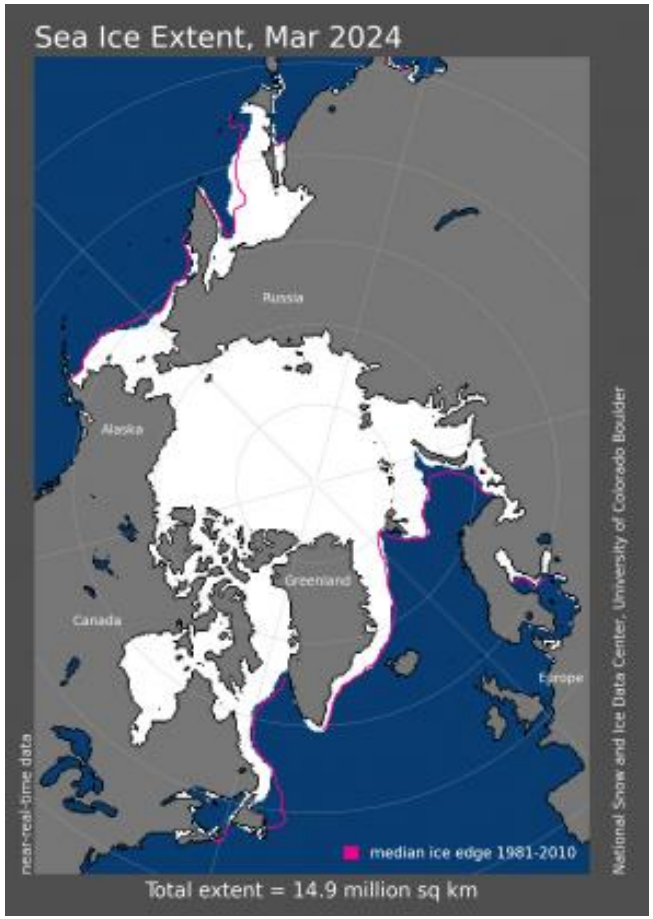




- NMME & CFSv2 predict that the current SST warm condition in the North Pacific will persist or strengthen through fall 2024.

# Arctic Sea Ice; NSIDC (https://nsidc.org/arcticseaicenews/)

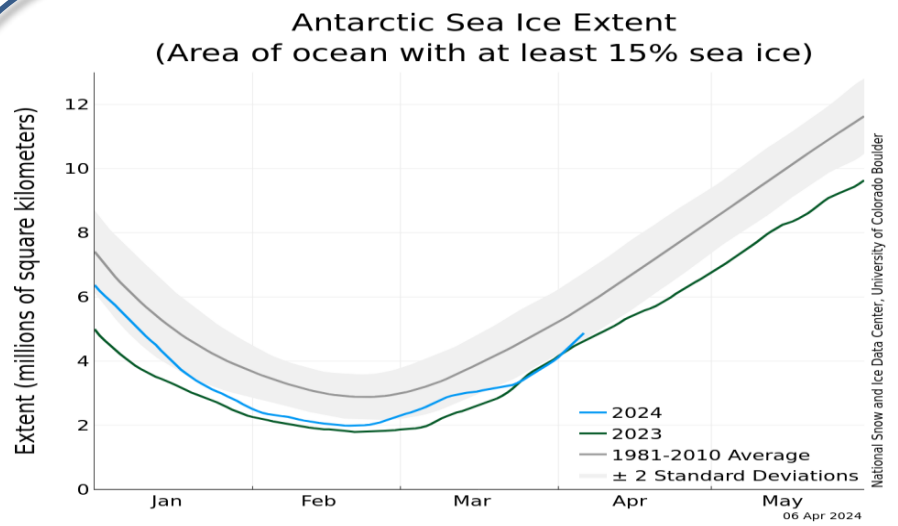


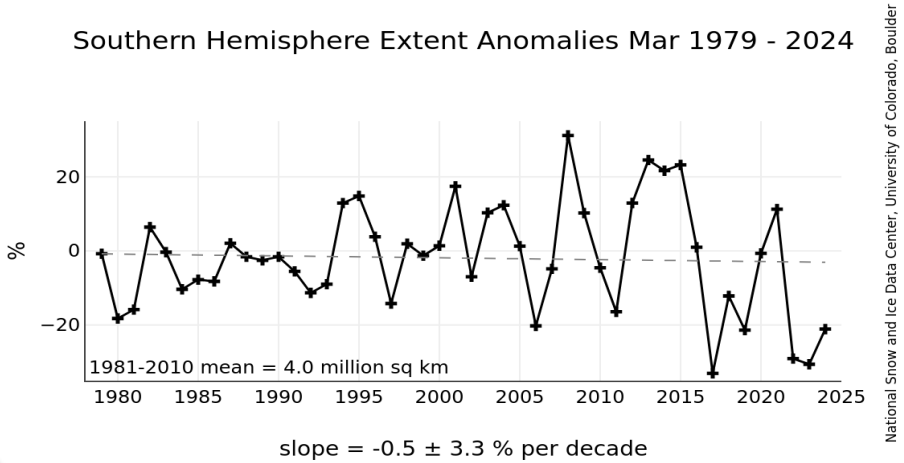



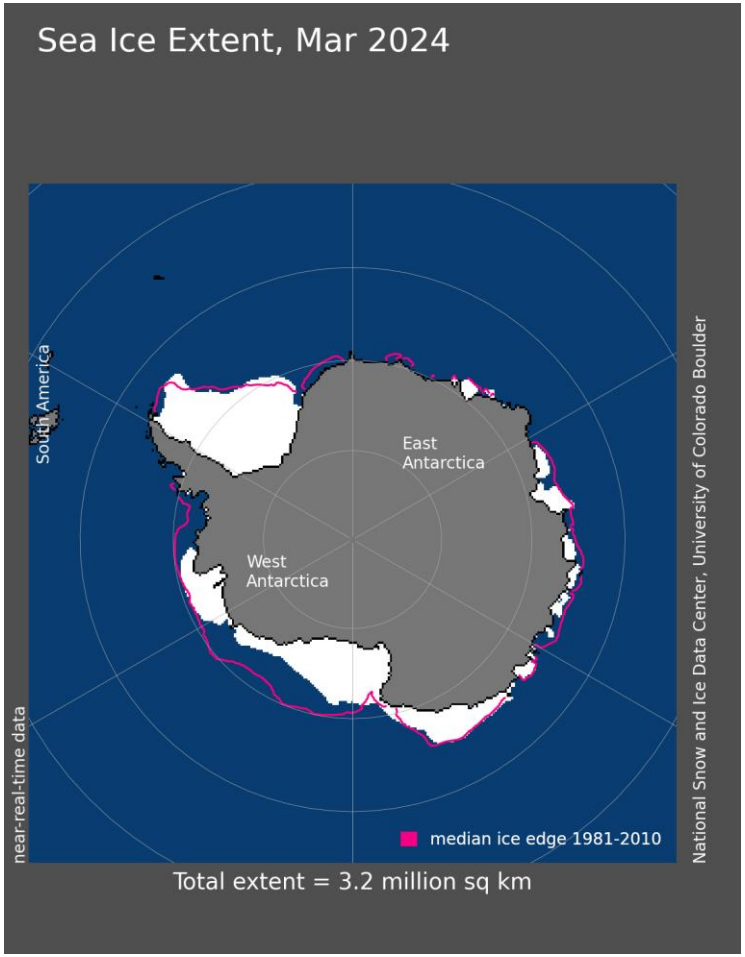




- The average Arctic ice extent for Mar 2024 is 14.87 million square kilometers, 15th lowest in the satellite record.

# Antarctic Sea Ice; NSIDC (https://nsidc.org/arcticseaicenews/)



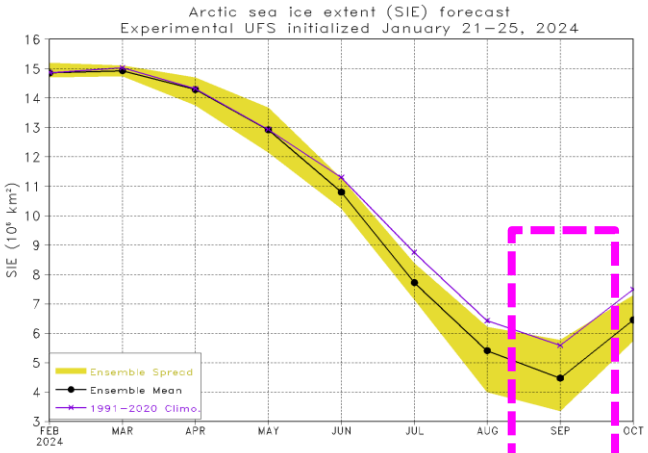



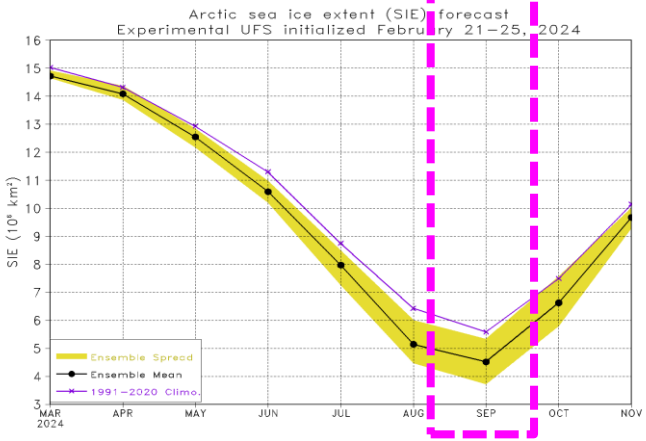



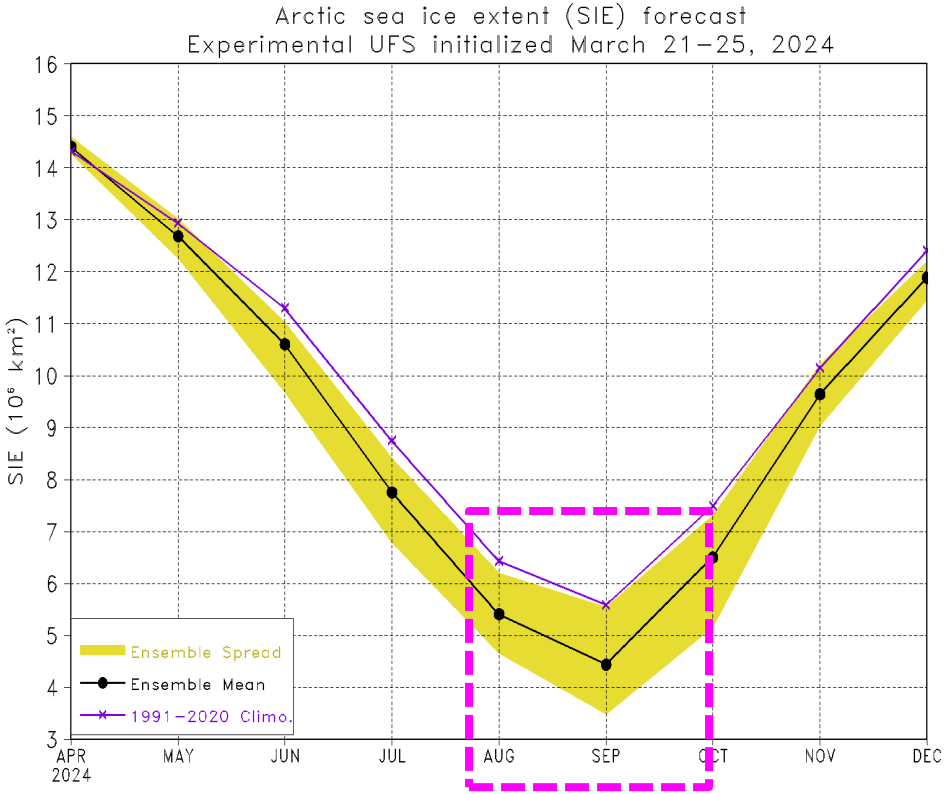

- Antarctic sea ice extent expanded slowly in mid-Mar after reaching its summer minimum extent on 21 Feb 2024, and monthly sea ice extent was the 4th lowest in the satellite record.

# NCEP/CPC Arctic Sea Ice Extent (SIE) Forecast

- Forecasts suggest a below normal sea ice extent minimum in the Arctic in Sep 2024.



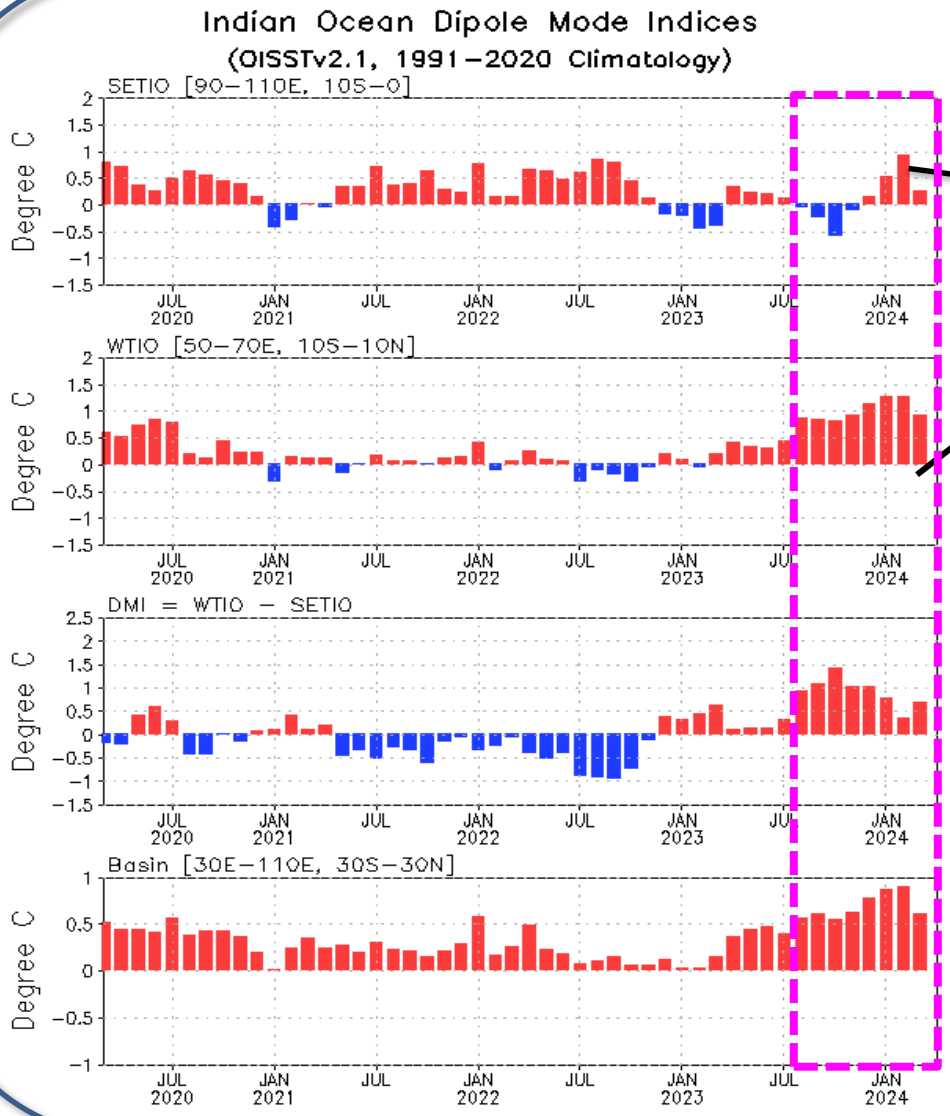



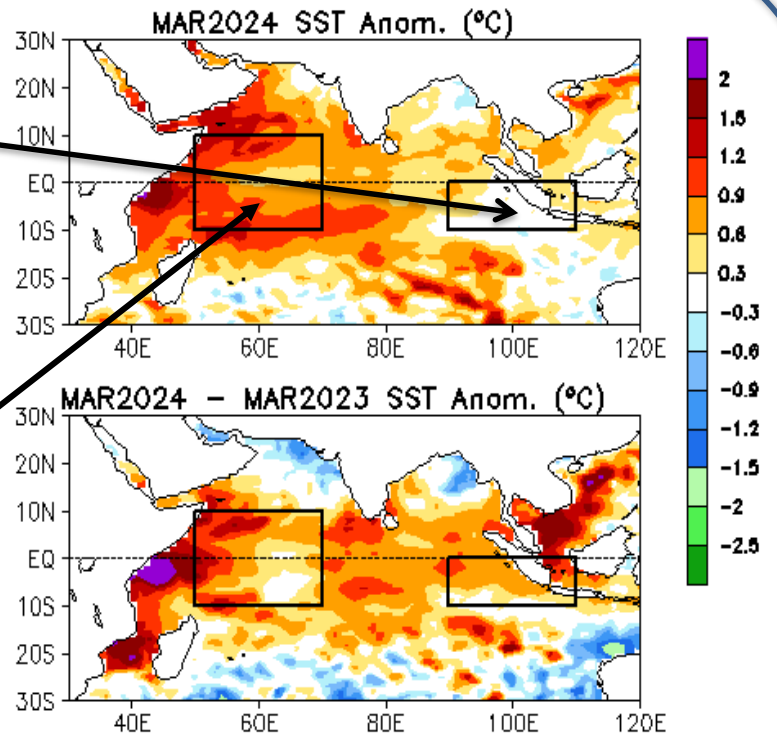




https://www.cpc.ncep.noaa.gov/products/people/jszhu/seaice_seasonal/index.html

Indian Ocean

# Evolution of Indian Ocean SST Indices

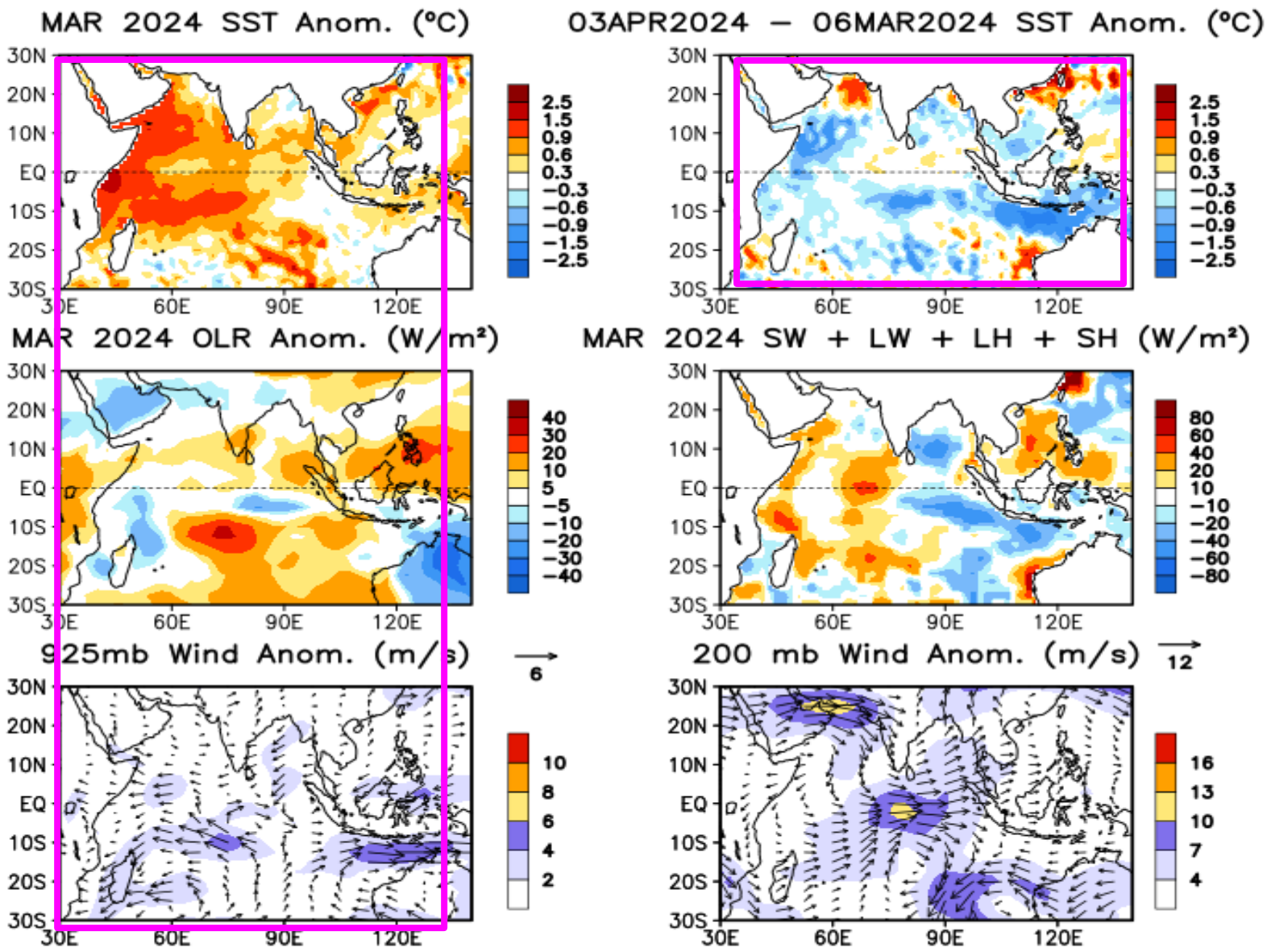



- Positive SSTAs were present in the tropical Indian Ocean with warmer SST in the west in Mar 2024, featuring a positive phase of the IOD.

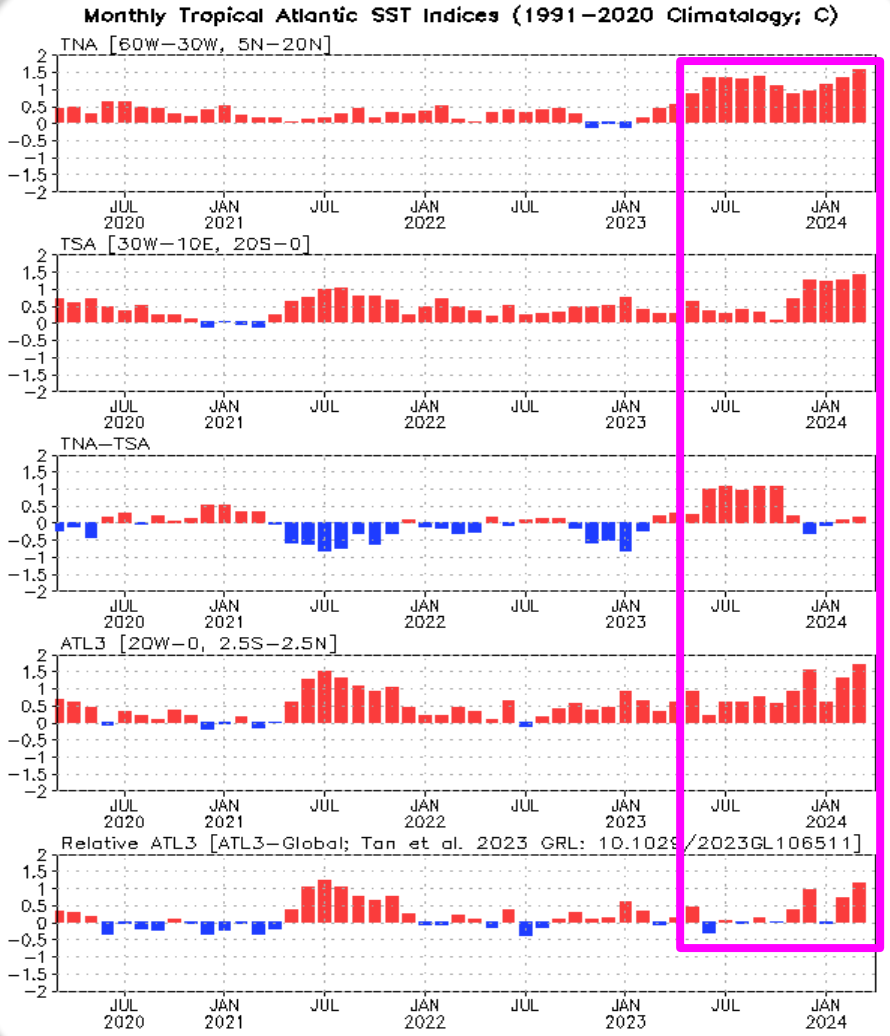
Indian Ocean region indices, calculated as the area-averaged monthly mean SSTA (OC) for the SETIO [90ºE-110ºE, 10ºS-0] and WTIO [50ºE-70ºE, 10ºS-10ºN] regions, and Dipole Mode Index, defined as differences between WTIO and SETIO. Data are derived from the OIv2.1 SST analysis, and anomalies are departures from the 1991-2020 base period means.

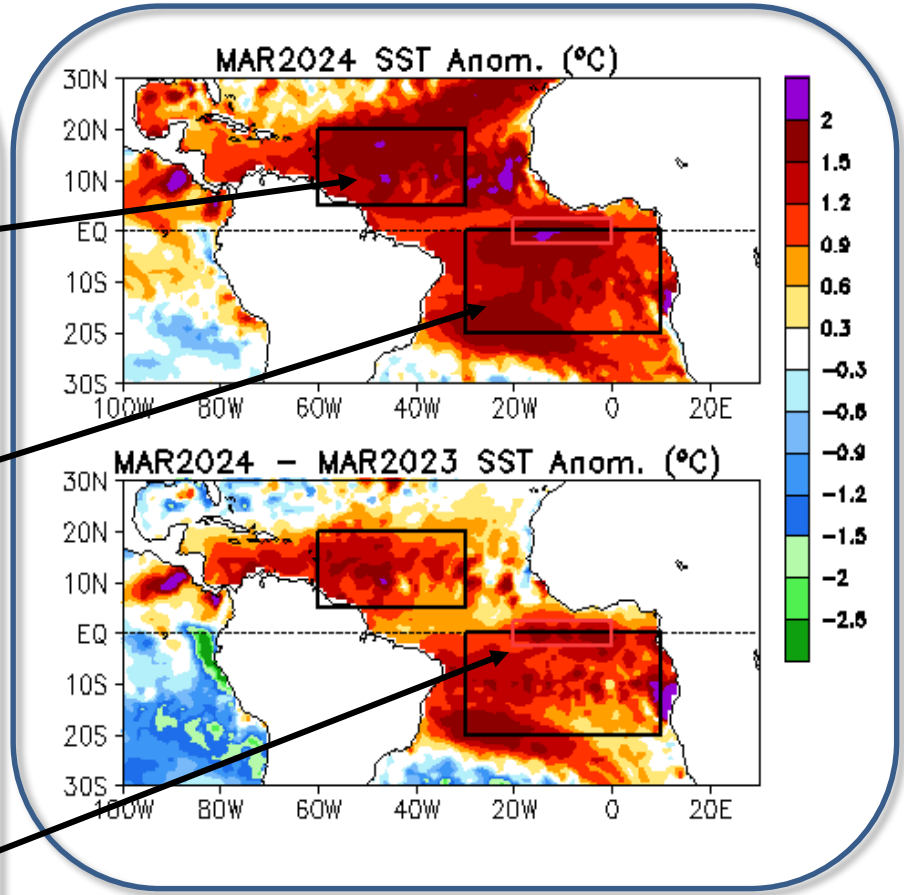
# Tropical Indian: SSTA, SSTA Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Wind Anom.



# Tropical and North Atlantic Ocean

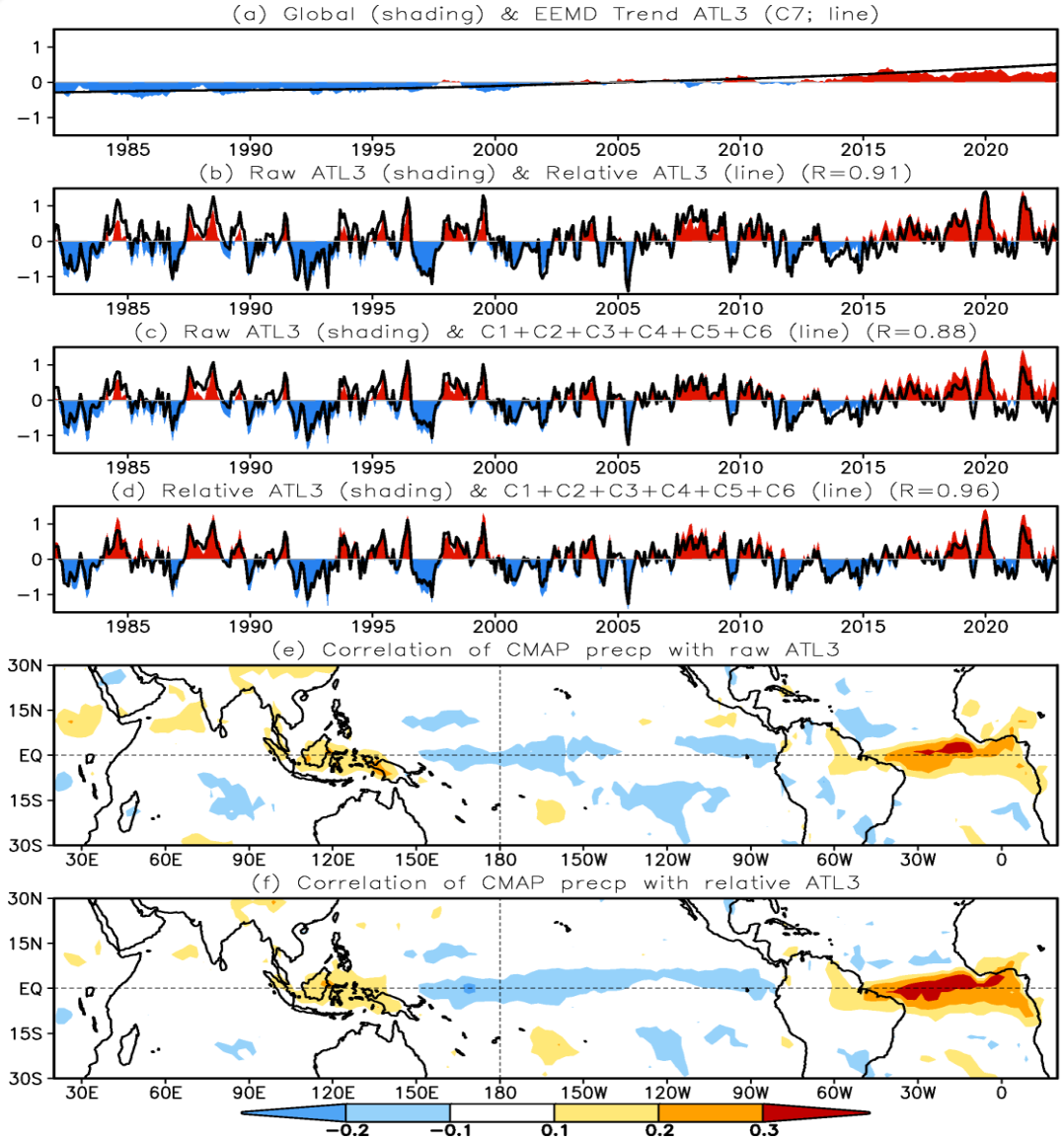
# Evolution of Tropical Atlantic SST Indices




- Large positive SSTAs were observed in the tropical Atlantic in Mar 2024.
- ATL3 (rATL3) index was 1.7°C (1.2°C) in Mar 2024.
- A relative ATL3 (ATL3-Global) index has been included.

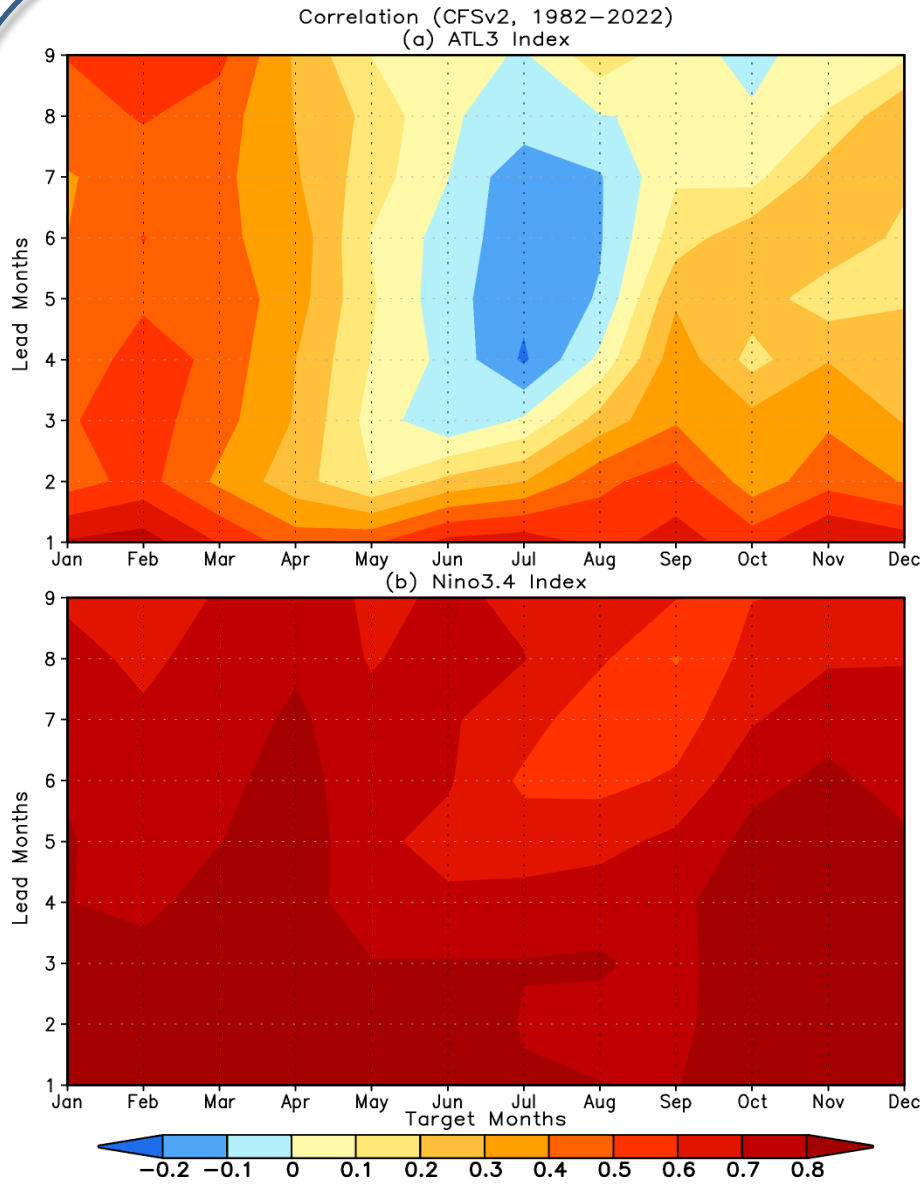
Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean SSTAs (°C) for the TNA [60°W-30°W, 5°N-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between TNA and TSA. Data are derived from the OIv2.1 SST analysis, and anomalies are departures from the 1991-2020 base period means.




- Relative ATL3 (raw ATL3 – global/90S-90N mean) well represents the detrended ATL3 (C1+C2+C3+C4+C5+C6).
- Compared with the correlations of precipitation with the raw ATL3, the correlations with the relative ATL3 index are higher and spatially more organized in the central and eastern tropical Pacific and the tropical Atlantic.

*Fig. 5: (a) global averaged SSTA (shading) and the EEMD trend component (C7) of the ATL3 index (line); (b) the raw (shading) and relative ATL3 index (line) with correlation of 0.90, (c) the raw ATL3 index (shading) and the EEMD components of the ATL3 index (C1+C2+C3+C4+C5+C6; line) with correlation of 0.88, and (d) the relative ATL3 index (shading) and the EEMD components of the ATL3 index (C1+C2+C3+C4+C5+C6; line) with correlation of 0.96 in January 1982-December 2022. The unit is °C. Correlations of CMAP precipitation with (e) the raw ATL3 index and (f) the relative ATL3 index in January 1982-December 2022.*

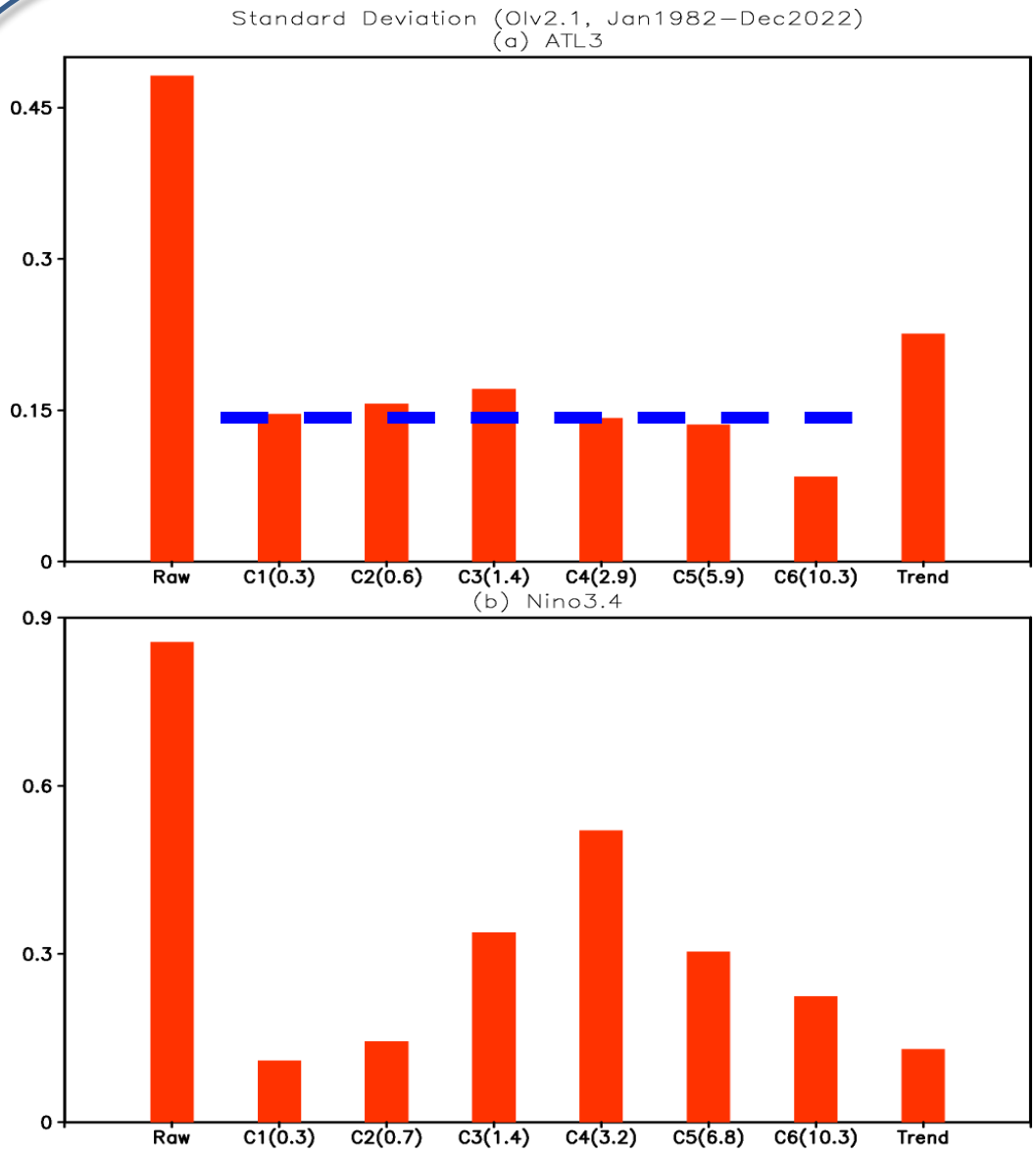
Tan, et al., 2024: Multi-Time Scale Variations in Atlantic Niño and a Relative Atlantic Niño Index. Geophys. Res. Lett., 50 (24), e2023GL106511. DOI: 10.1029/2023GL106511




- Overall, the prediction skill is lower for ATL3 than for Niño3.4.
- That may be relevant to the time scale feature: Atlantic Niño doesn't have dominant time scales and is a white-noise-like process, while ENSO is a quasi-periodic oscillation with time scales of 2-7 years.

*Fig. 4: Lead time (y-axis) and target month (x-axis) dependent correlations between CFSv2 predicted and observed monthly mean (a) ATL3 and (b) Niño3.4 indices during January 1982-December 2022.*

Tan, et al., 2024: Multi-Time Scale Variations in Atlantic Niño and a Relative Atlantic Niño Index. Geophys. Res. Lett., 50 (24), e2023GL106511. DOI: 10.1029/2023GL106511

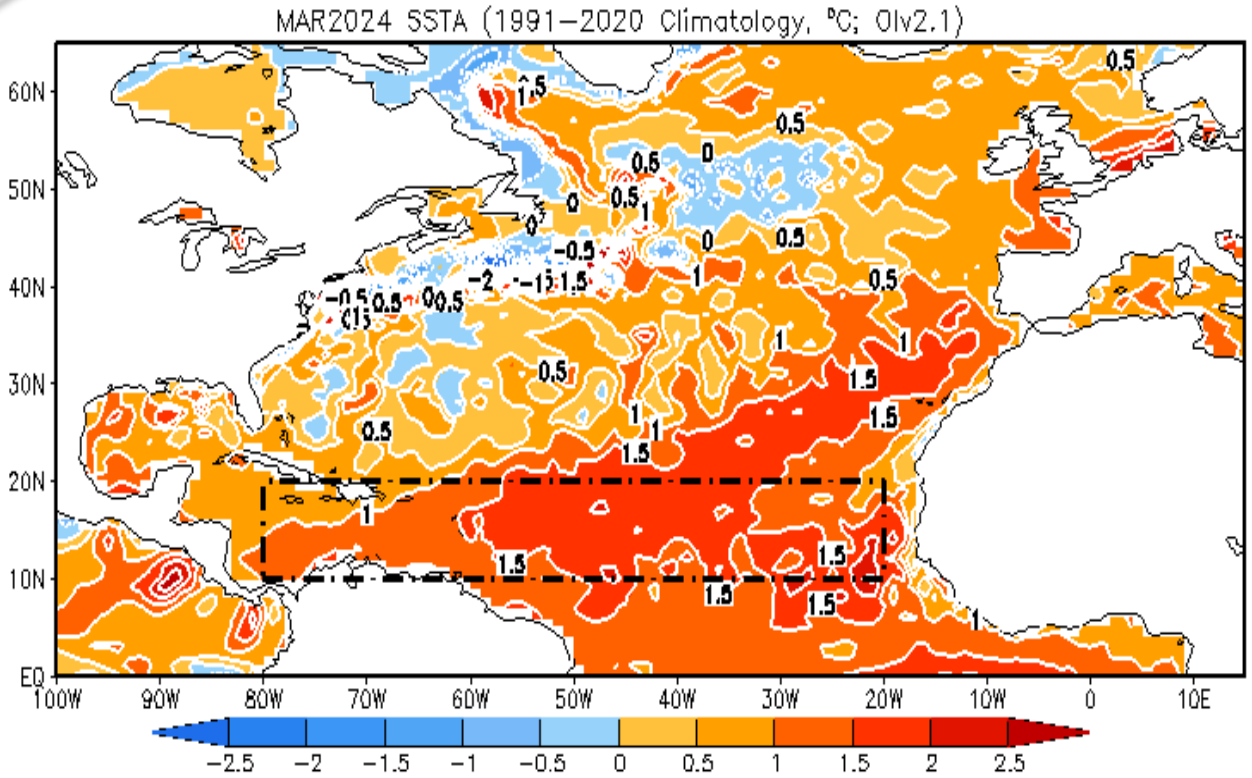


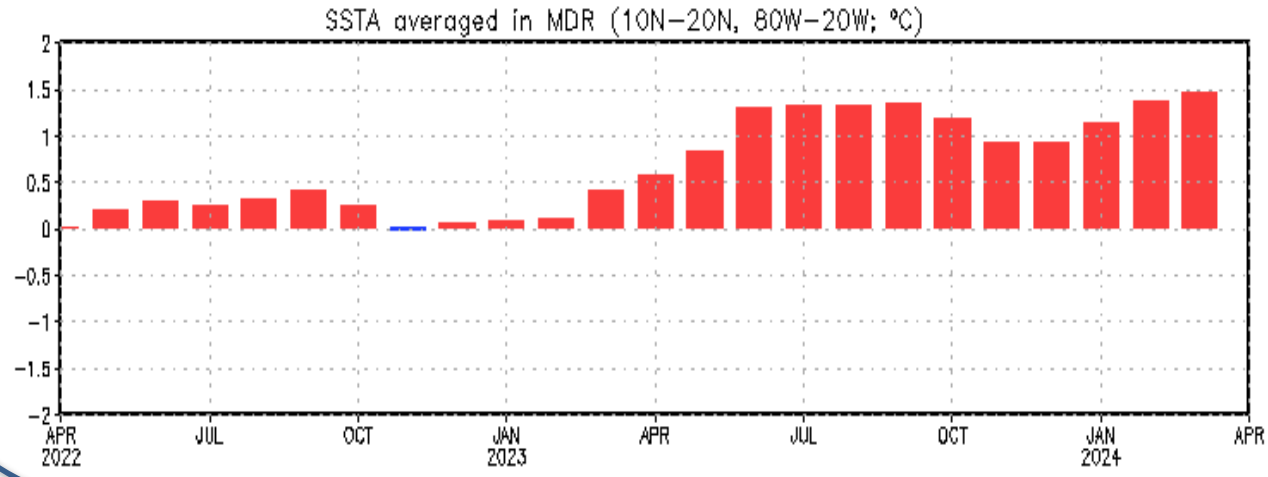

- ATL3 has no dominant time scale with an appreciable contribution from the linear trend, similar to a white-noise-like process.
- Niño3.4 has a dominant time scale with a period of 3.2 years, with a smaller contribution from the linear trend.

Fig. 3: Standard deviations of the monthly mean of (a) the ATL3 index and the EEMD components; (b) the Niño3.4 index and the EEMD components. The numbers in the brackets of the x-axis represent the averaged periods of the EEMD components. The unit is oC for the bars.

Tan, et al., 2024: Multi-Time Scale Variations in Atlantic Niño and a Relative Atlantic Niño Index. Geophys. Res. Lett., 50 (24), e2023GL106511. DOI: 10.1029/2023GL106511

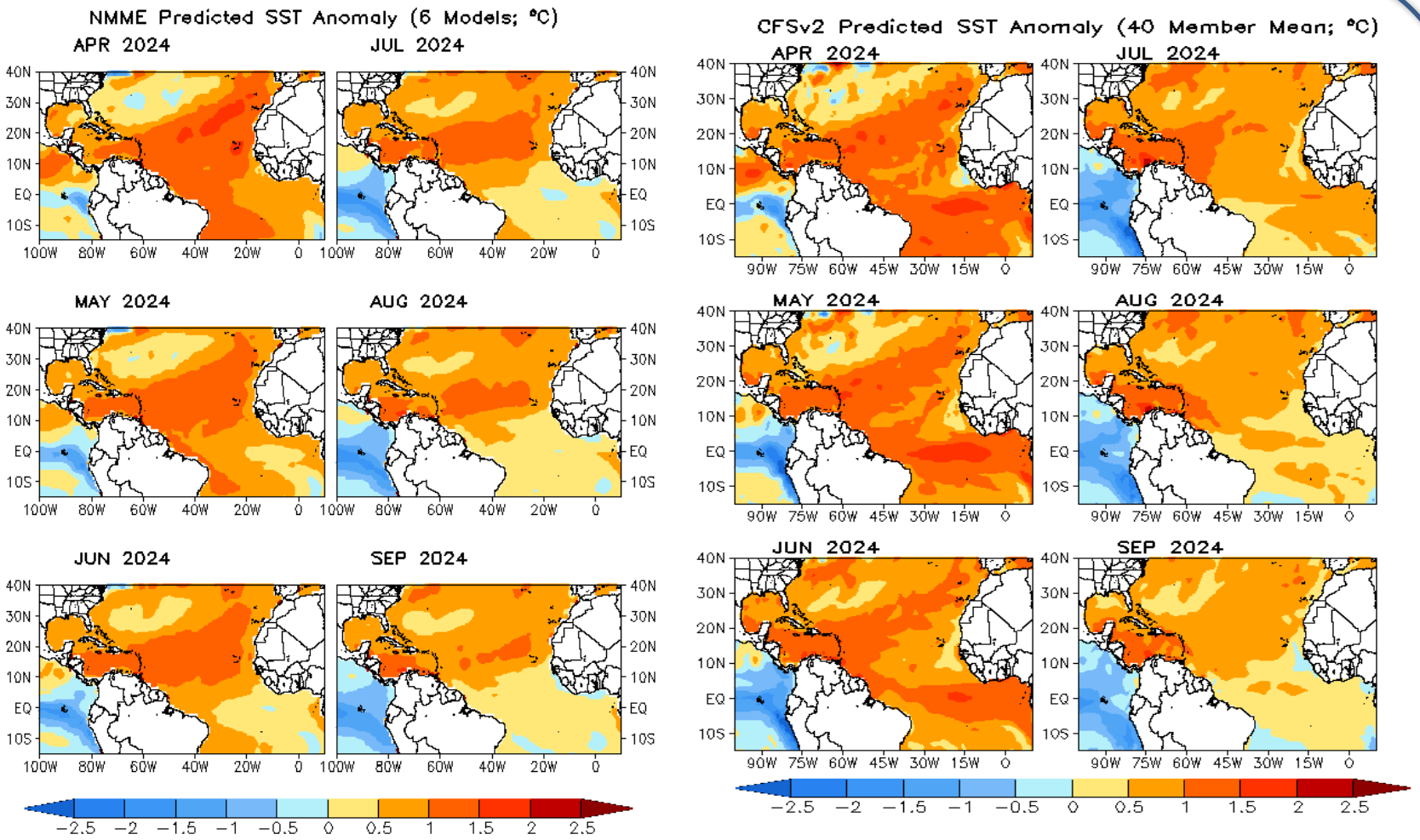
# SSTAs in the North Atlantic & MDR



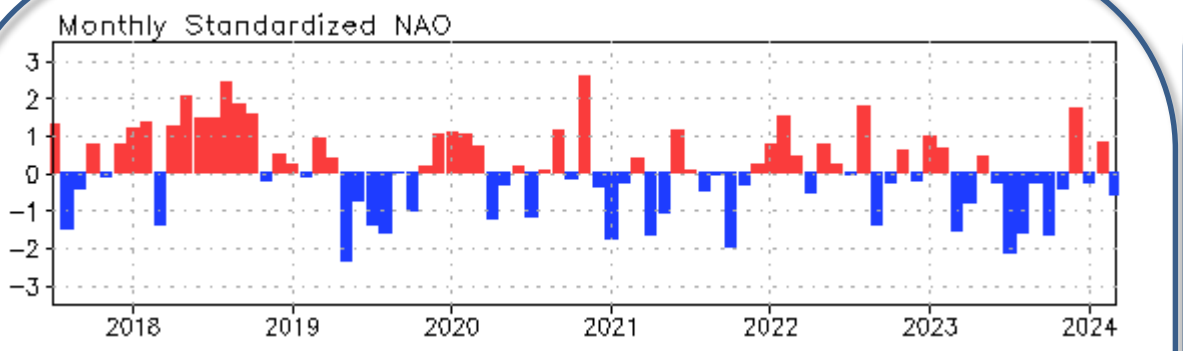

- SST in MDR was above average during the last 16 months.

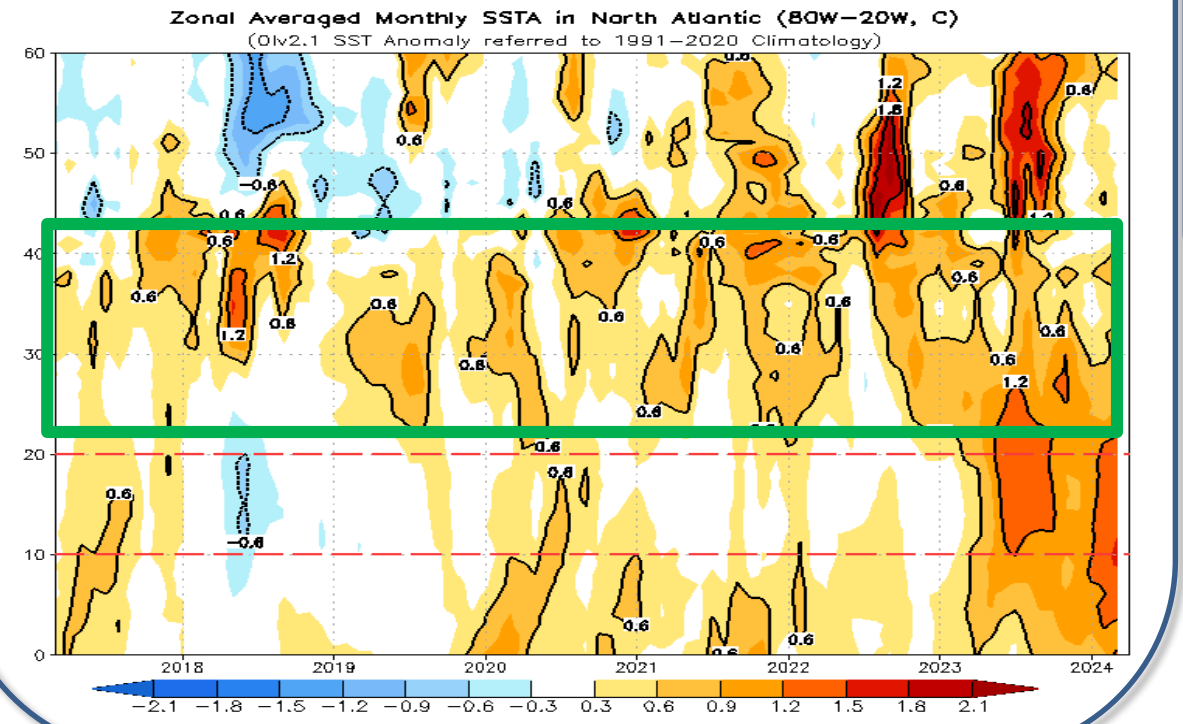
# NMME & CFSv2 Atlantic SSTA Predictions

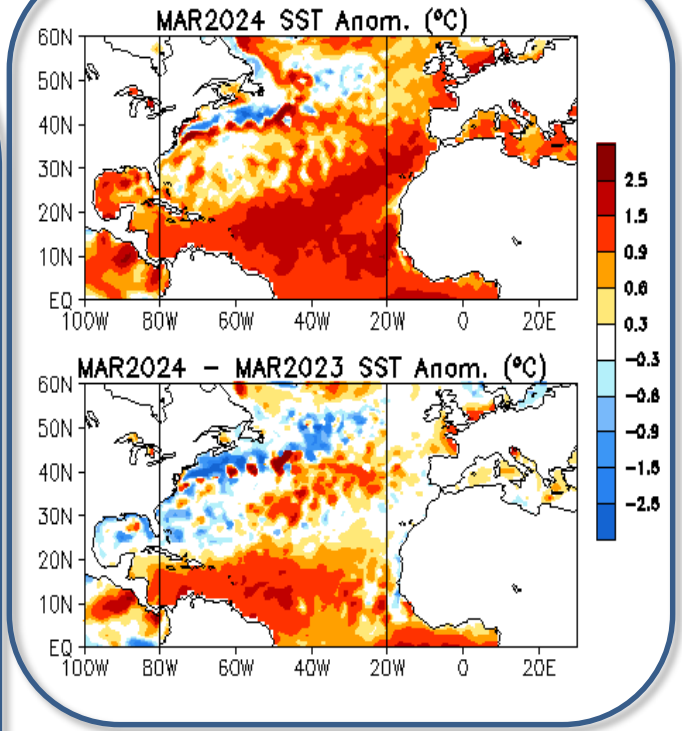



- Latest NMME & CFSv2 predictions call that positive SST anomalies in the middle-latitudes of the North Atlantic will weaken in summer-fall 2024.

# NAO and SST Anomaly in North Atlantic



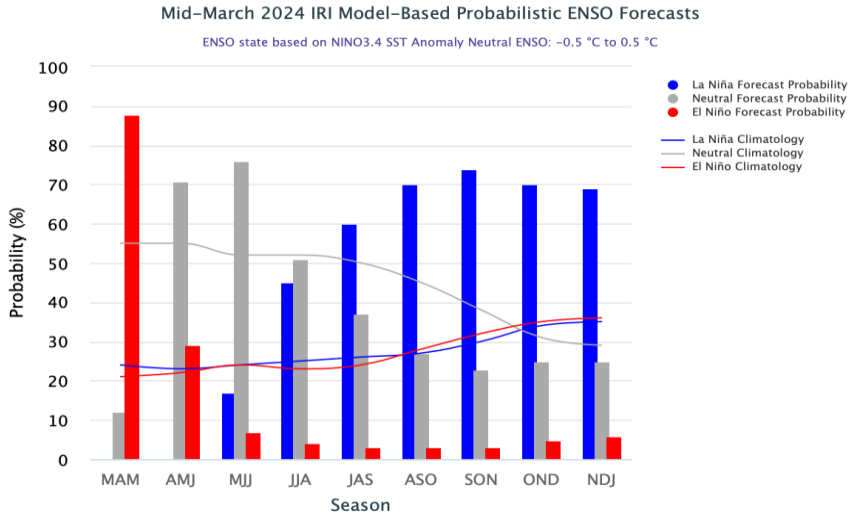



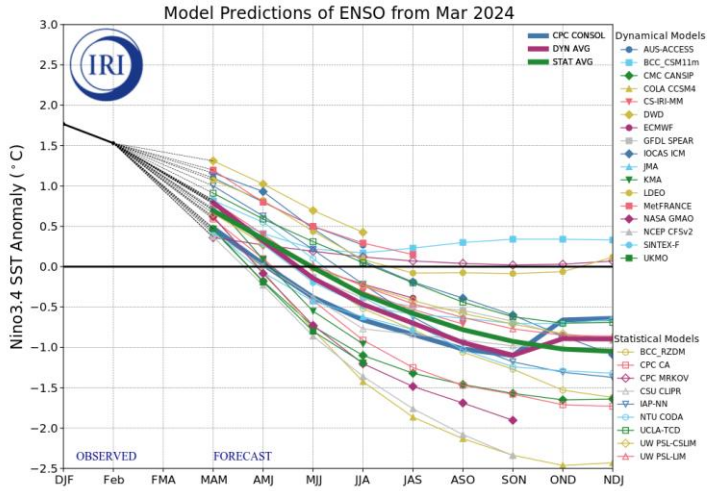

- NAO returned to a negative phase in Mar 2024 with NAOI = -0.6.
- The prolonged positive SSTAs in the middle latitudes were evident during the last 5-6 years.

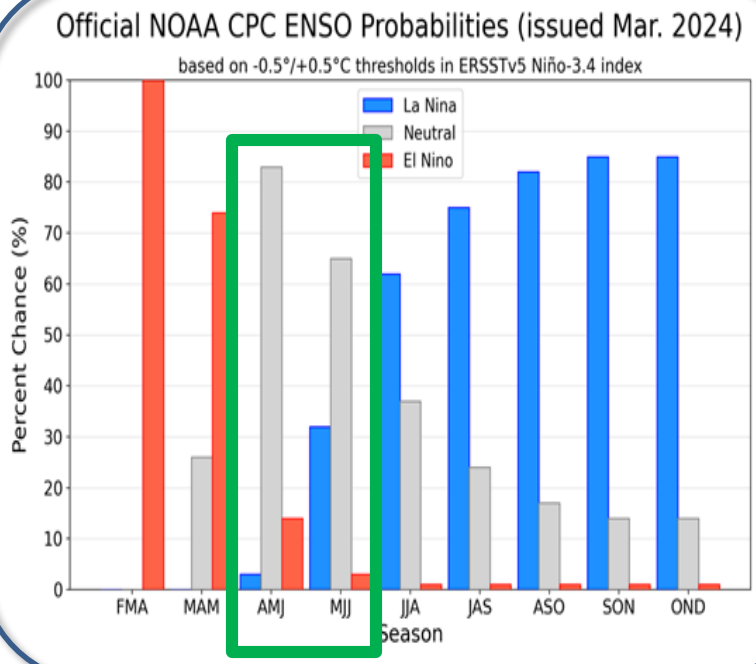
Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20$^{O}$N-90$^{O}$N. Time-latitude section of SSTAs averaged between 80ºW and 20ºW (bottom). SST are derived from the OIv2.1 SST analysis, and anomalies are departures from the 1991-2020 base period means.

# ENSO and Global SST Predictions

# CPC & IRI Niño3.4 Forecast



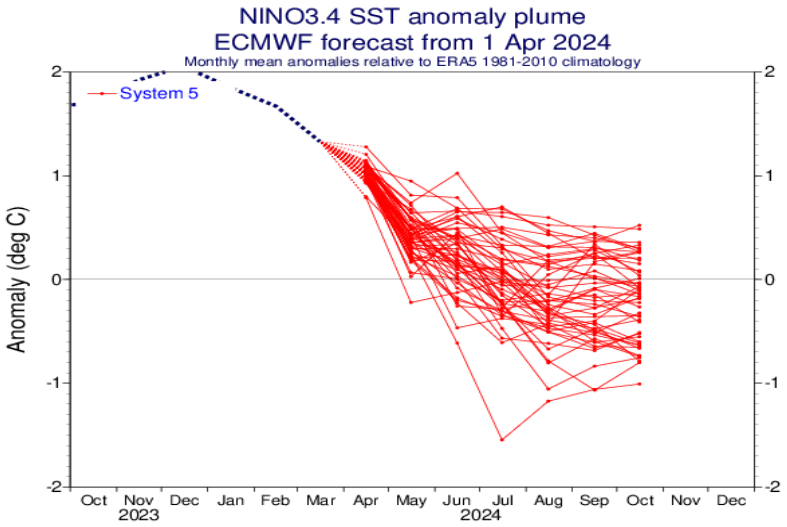



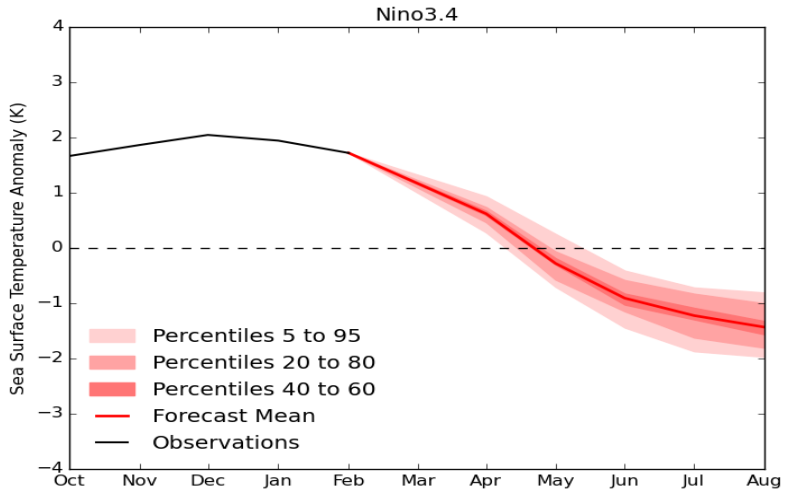

- Model ensemble mean predicts a neutral condition from Apr-Jun to Jun-Aug 2024.
- **On 14 Mar 2024, CPC issued: El Niño Advisory / La Niña Watch.**
- Synopsis: "*A transition from El Niño to ENSO-neutral is likely by April-June 2024 (83% chance), with the odds of La Niña developing by June-August 2024 (62% chance).*"

# Individual Model Forecasts: El Niño transitions to neutral or La Niña in Summer 2024

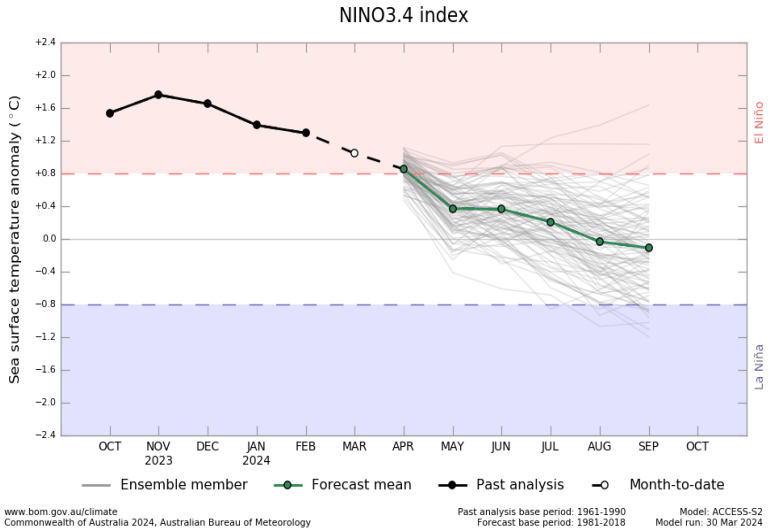
## EC: Niño3.4, IC= 1 Apr 2024



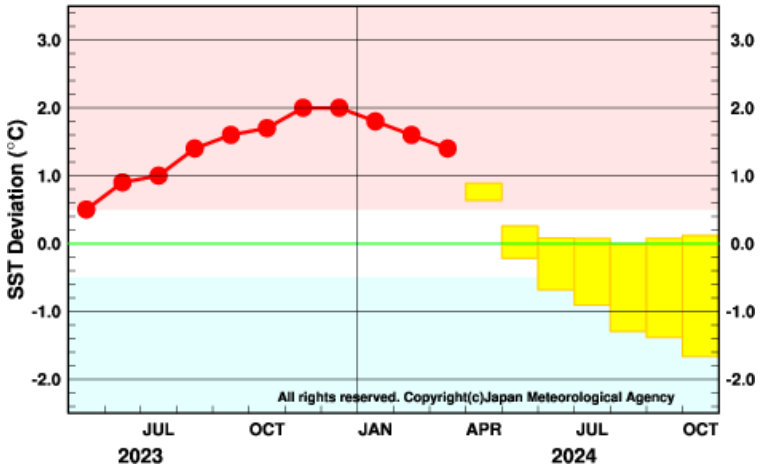

## UKMO: Niño3.4, Updated 11 Mar 2024



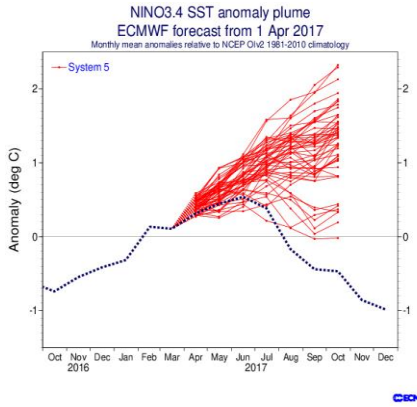

## BOM: Niño3.4, Updated 30 Mar 2024

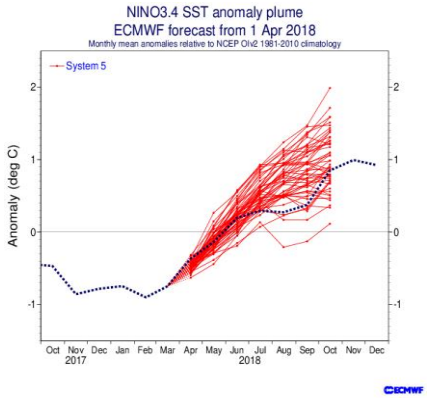


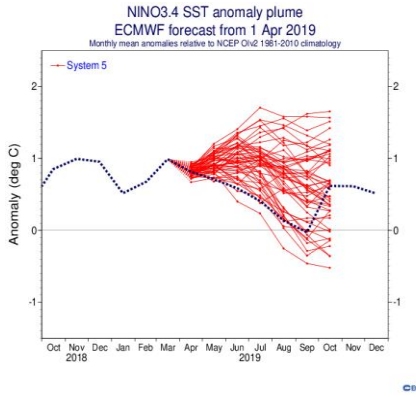

## JMA: Niño3.4, Updated 10 Apr 2024

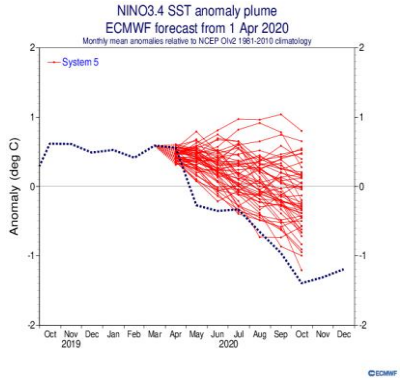


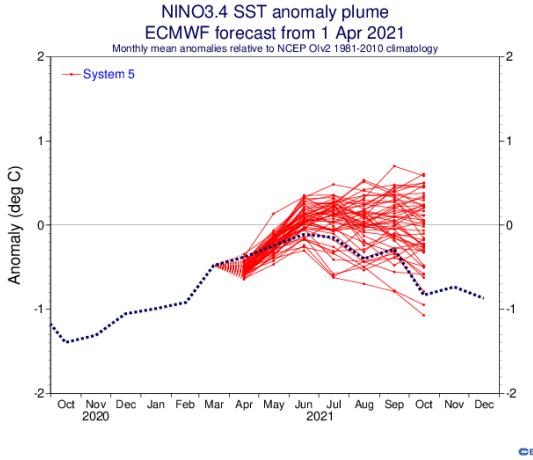
# ECMWF Forecasts with IC in Apr since 2017

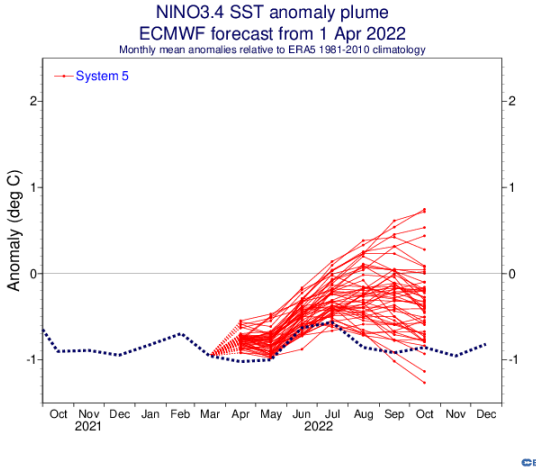


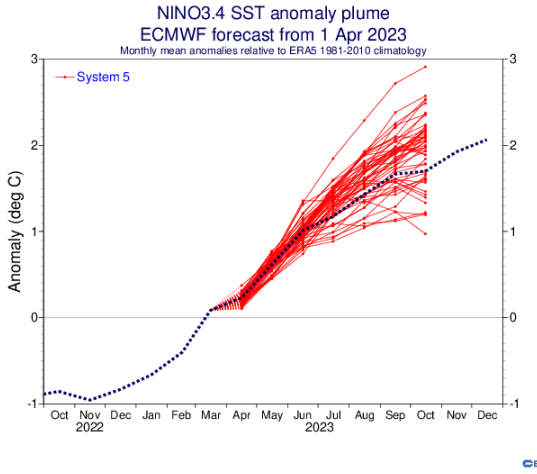



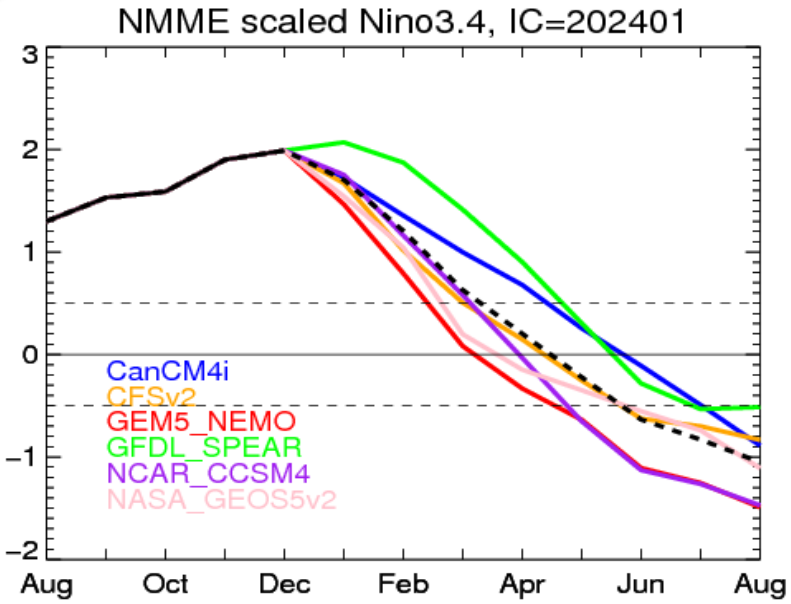



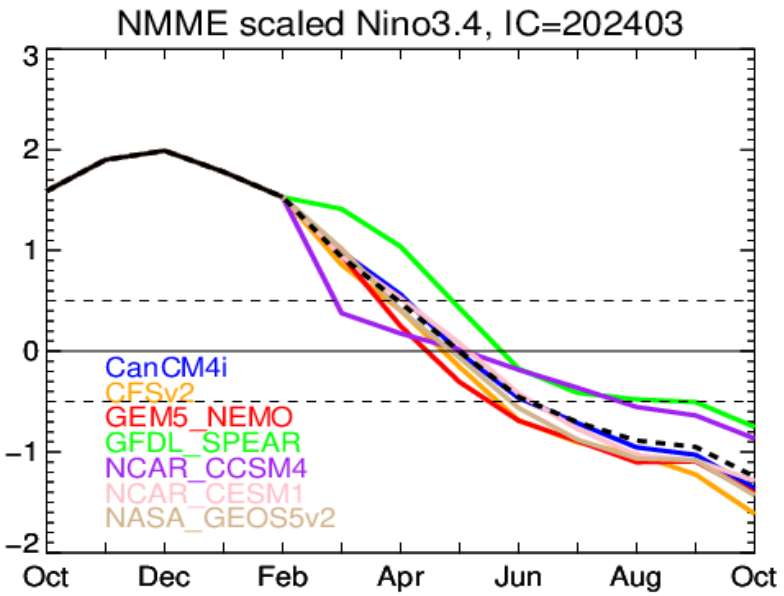



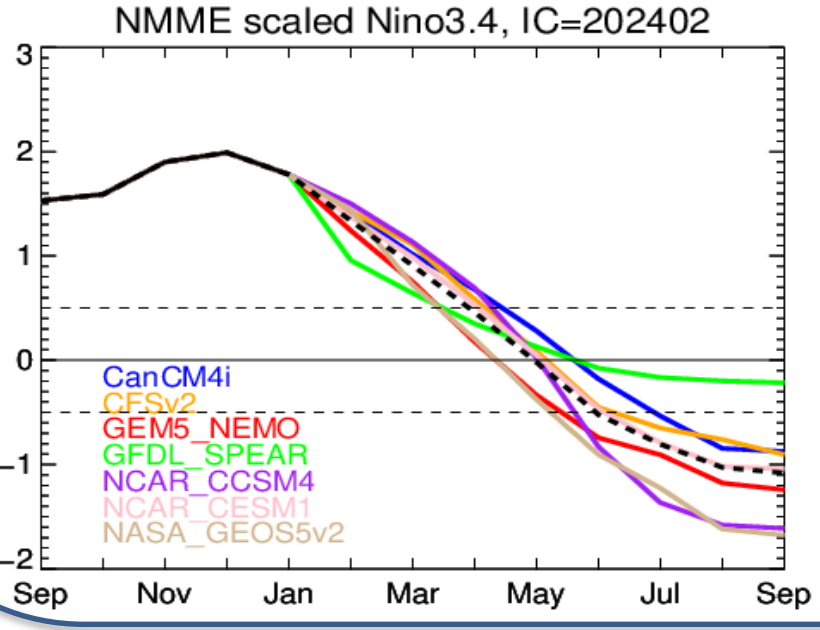



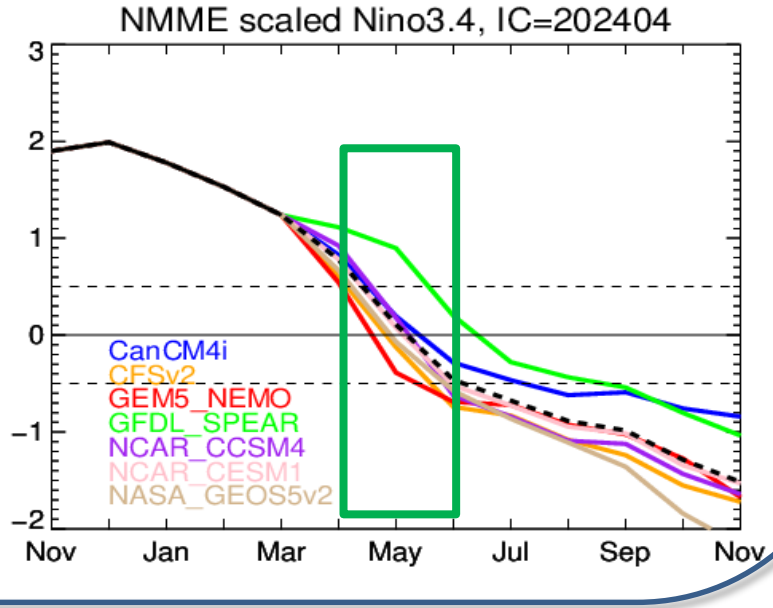



# NMME forecasts from different initial conditions

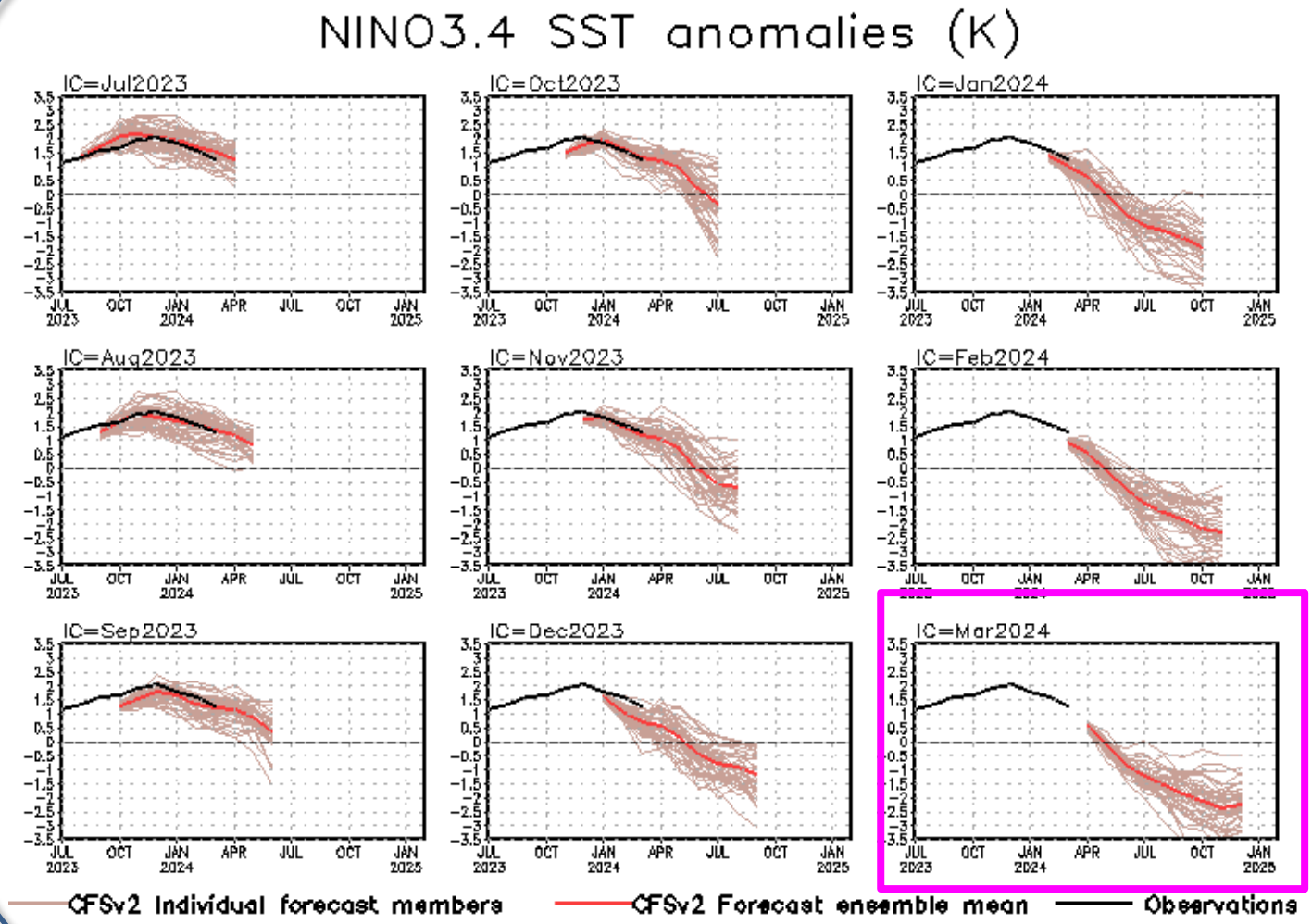


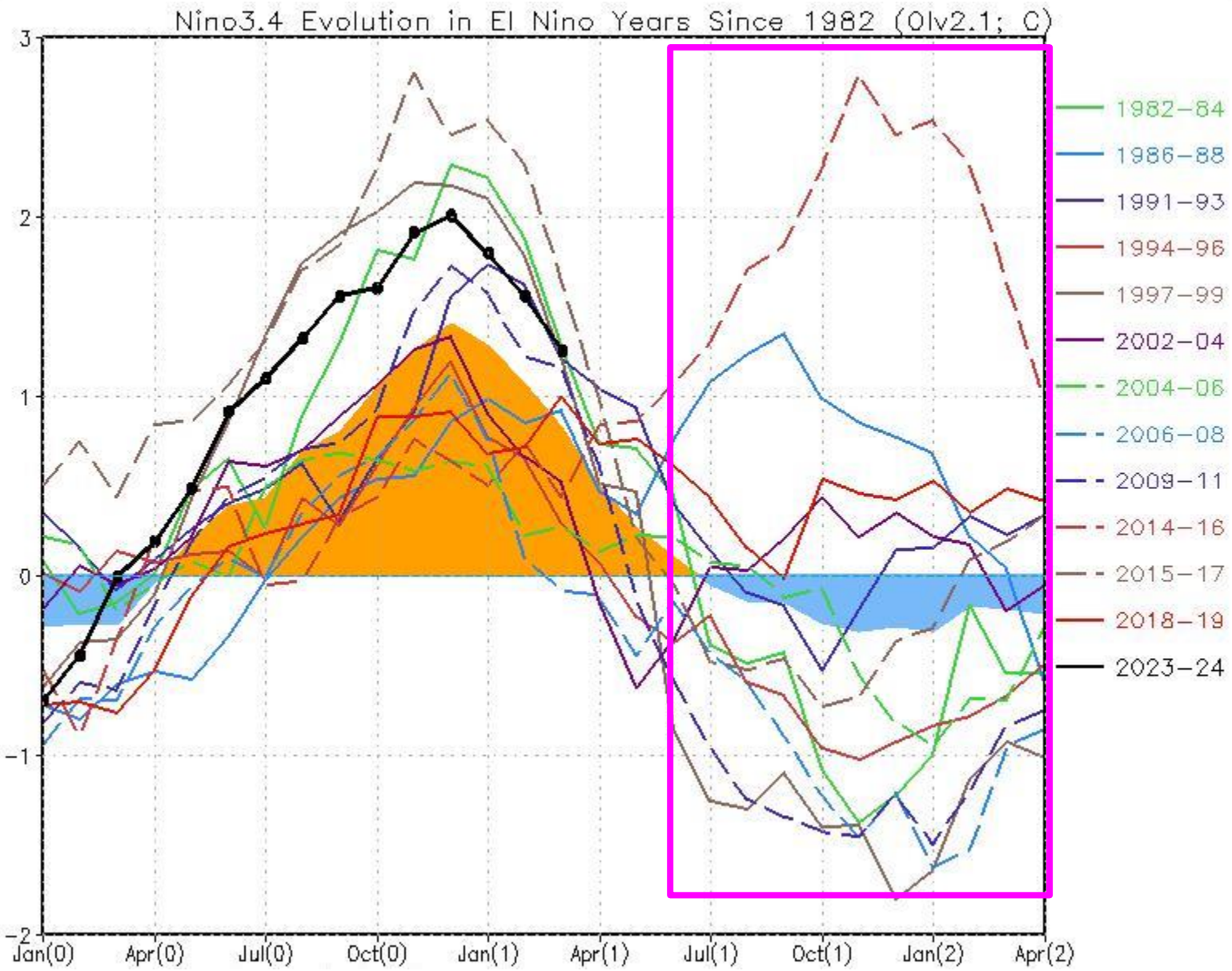
# CFS Niño3.4 SST Predictions from Different Initial Months



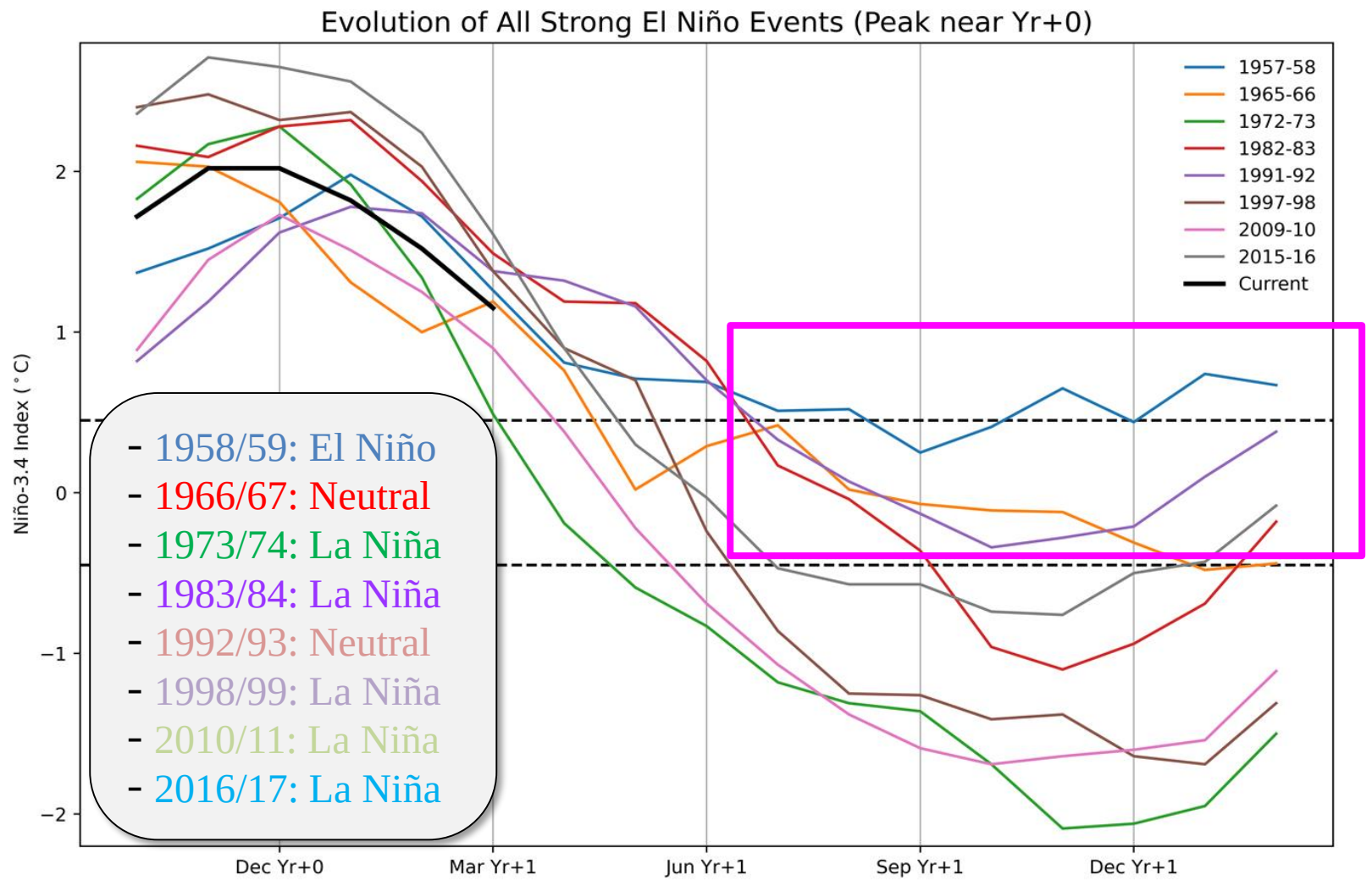

- The latest CFSv2 forecasts call for a neutral condition in spring 2024 and La Niña in the 2nd half of 2024.

CFS Niño3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1991-2020 base period means.

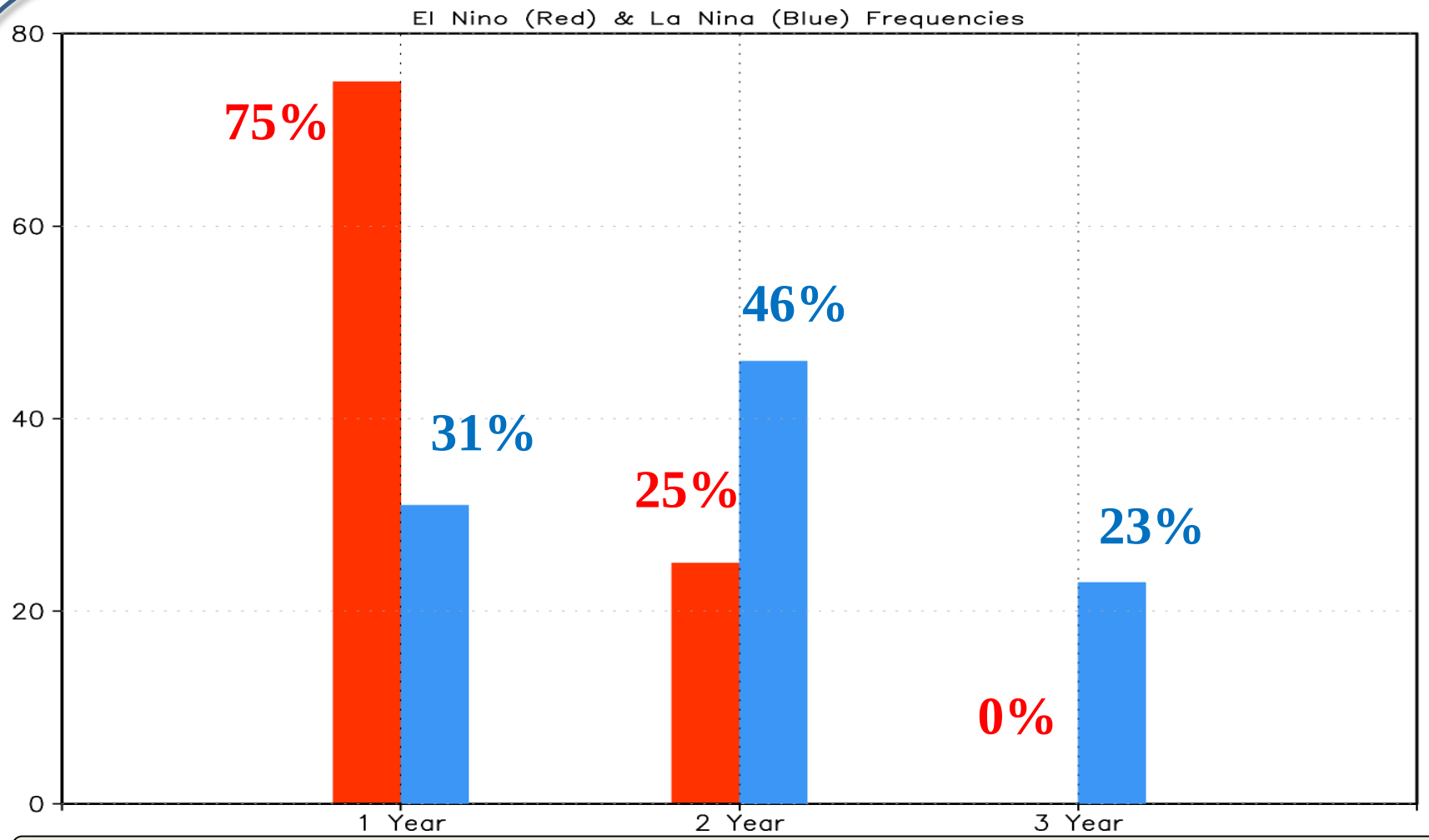
# All El Niños since 1982 & their evolution for the following year



# Strong El Niños (since 1950) and their evolution for the following year (Michelle L'Heureux )

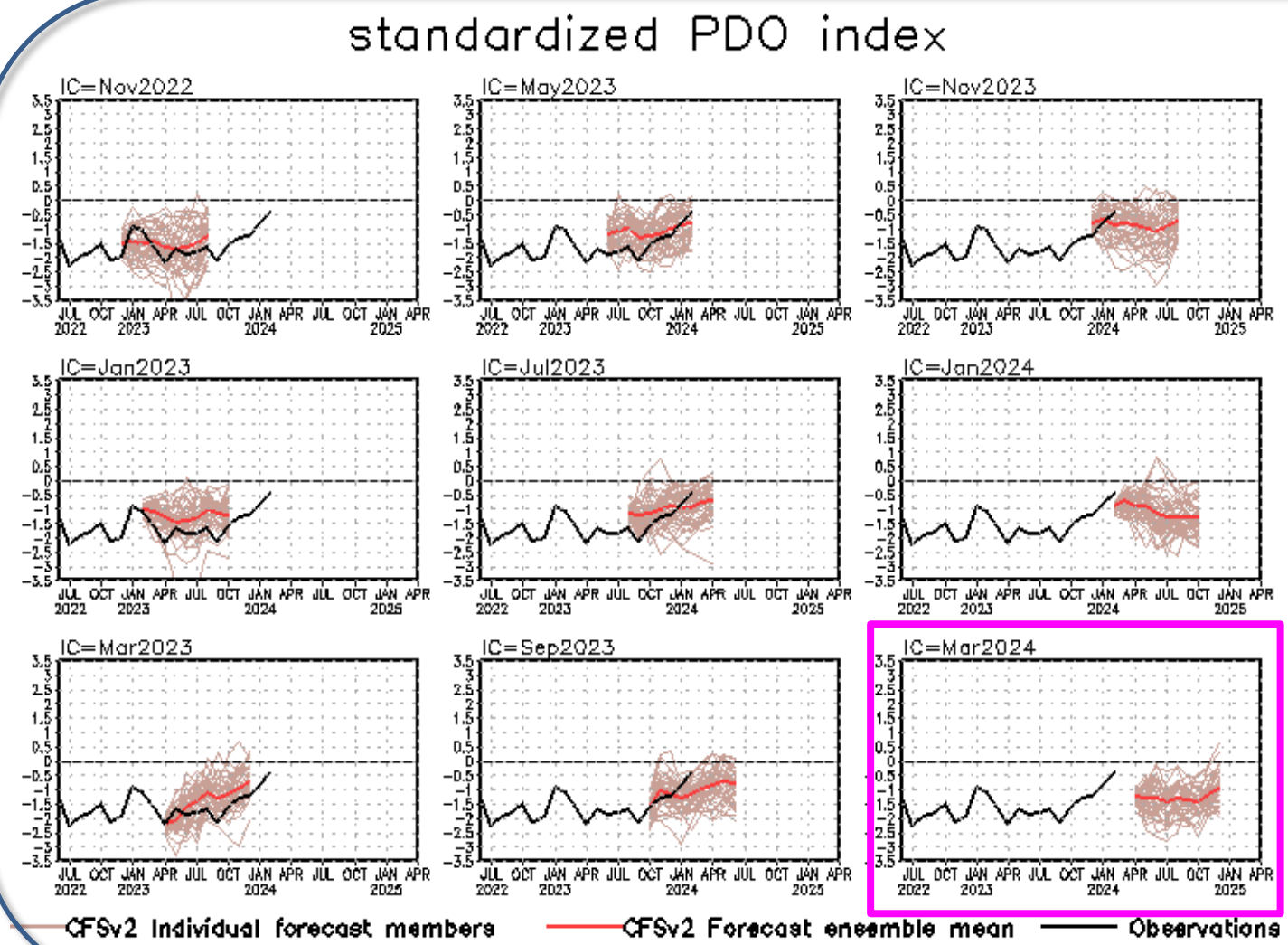


# Percentages (%) of single-, double-, and triple-year El Niños (red bars) and La Niñas (blue bars) during 1951-2023




Gao, et al. 2023: Single-Year and Double-Year El Niños. Clim Dyn 60 (7-8), 2235–2243. 10.1007/s00382-022-06425-8.

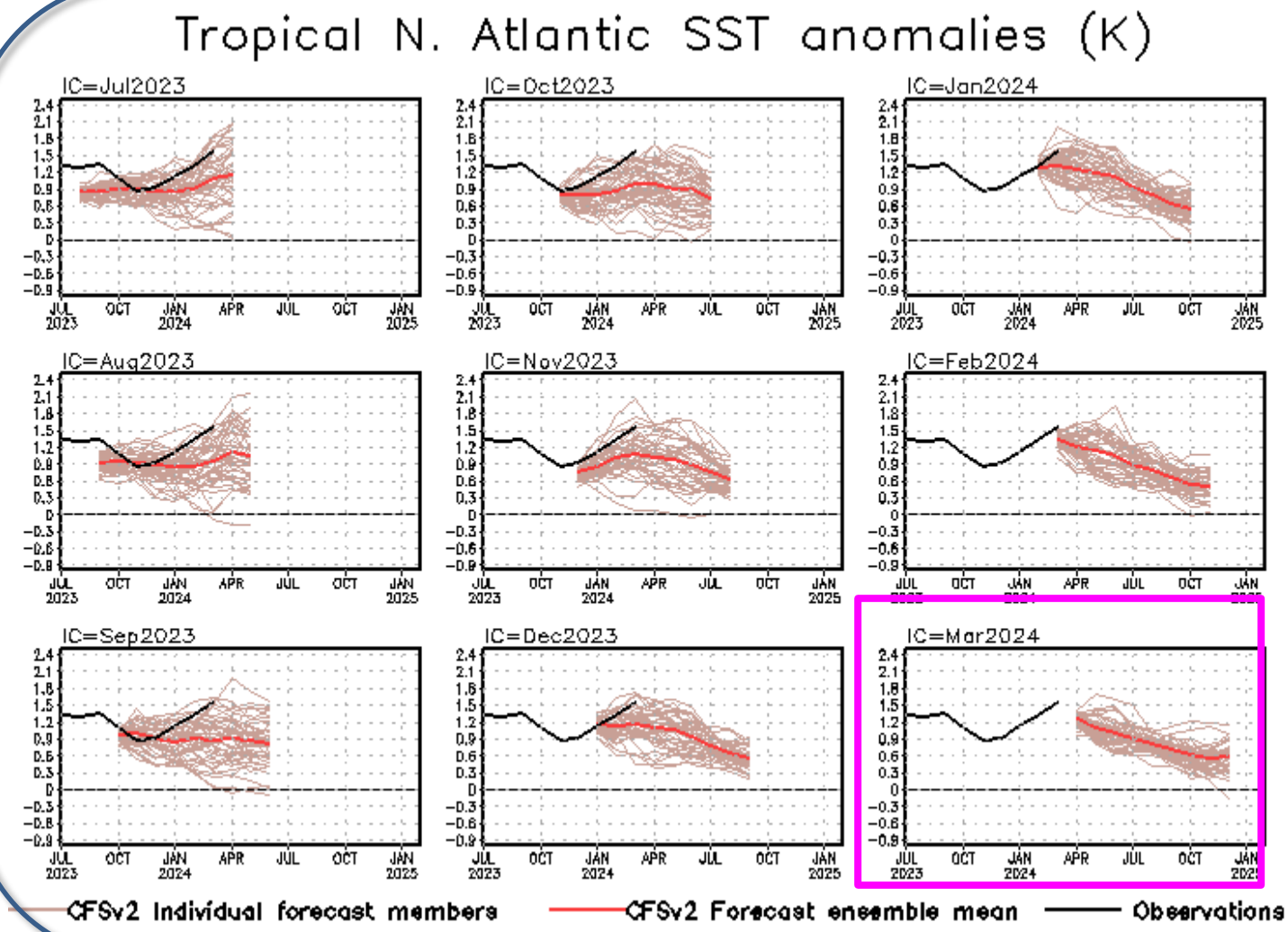
# NCEP CFSv2 PDO Index Predictions from Different Initial Months




- CFSv2 predicts a persistent negative phase of PDO in 2024.

CFS Pacific Decadal Oscillation (PDO) index predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1991-2020 base period means. PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N]. CFS PDO index is the standardized projection of CFS SST forecast anomalies onto the PDO EOF pattern.

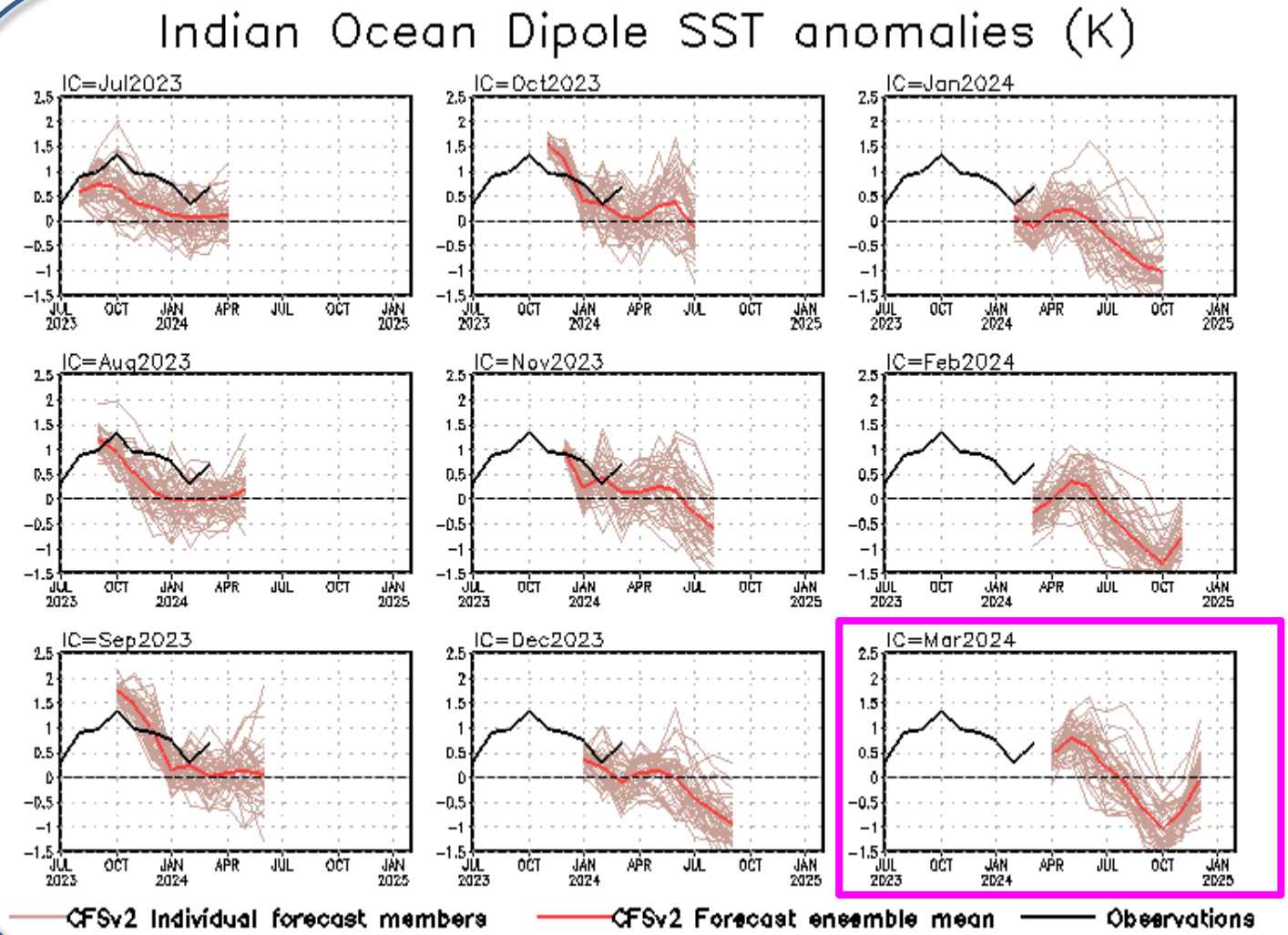
# NCEP CFSv2 Tropical North Atlantic (TNA) SST Predictions from Different Initial Months




- Latest CFSv2 predictions call for above-normal SSTA in the tropical North Atlantic.

CFS Tropical North Atlantic (TNA) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1991-2020 base period means. TNA is the SST anomaly averaged in the region of [60oW-30oW, 5oN-20oN].

# NCEP CFSv2 DMI SST Predictions from Different Initial Months




- CFSv2 predicts a negative phase of IOD since the summer of 2024.

CFS Dipole Model Index (DMI) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast climatology for 1981-2006 was removed, and replaced by corresponding observation climatology for the same period. Anomalies were computed with respect to the 1991-2020 base period means.

# Acknowledgement


- Drs. Jieshun Zhu, Caihong Wen, and Arun Kumar: reviewed PPT, and provide insightful suggestions and comments
- Drs. Yanjuan Guo and Pingping Xie provided the BASS/CMORPH/CFSR EVAP package
- Drs. Jieshun Zhu & Wanqiu Wang provided the sea ice forecasts


**Please send your comments and suggestions to:**


**Arun.Kumar@noaa.gov**
**Caihong.Wen@noaa.gov**
**Jieshun.Zhu@noaa.gov**
**Zeng-Zhen.Hu@noaa.gov**

# Data Sources (climatology is for 1991-2020)

- **NCEP/CPC Ocean Monitoring & Briefing Operation (Hu et al., 2022, BAMS)**
- **Weekly Optimal Interpolation SST (OIv2.1 SST; Huang et al. 2021)**
- **Extended Reconstructed SST (ERSST) v5 (Huang et al. 2017)**
- **Blended Analysis of Surface Salinity (BASS) (Xie et al. 2014)**
- **CMORPH precipitation (Xie et al. 2017)**
- **CFSR evaporation adjusted to OAFlux (Xie and Ren 2018)**
- **NCEP CDAS winds, surface radiation and heat fluxes (Kalnay et al. 1996)**
- **NESDIS Outgoing Long-wave Radiation (Liebmann and Smith 1996)**
- **NCEP's GODAS temperature, heat content, currents (Behringer and Xue 2004)**
- **Aviso altimetry sea surface height from CMEMS**
- **Ocean Surface Current Analyses – Realtime (OSCAR)**
- **In situ data objective analyses (IPRC, Scripps, EN4.2.1, PMEL TAO)**
- **Operational Ocean Reanalysis Intercomparison Project**

**http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html**

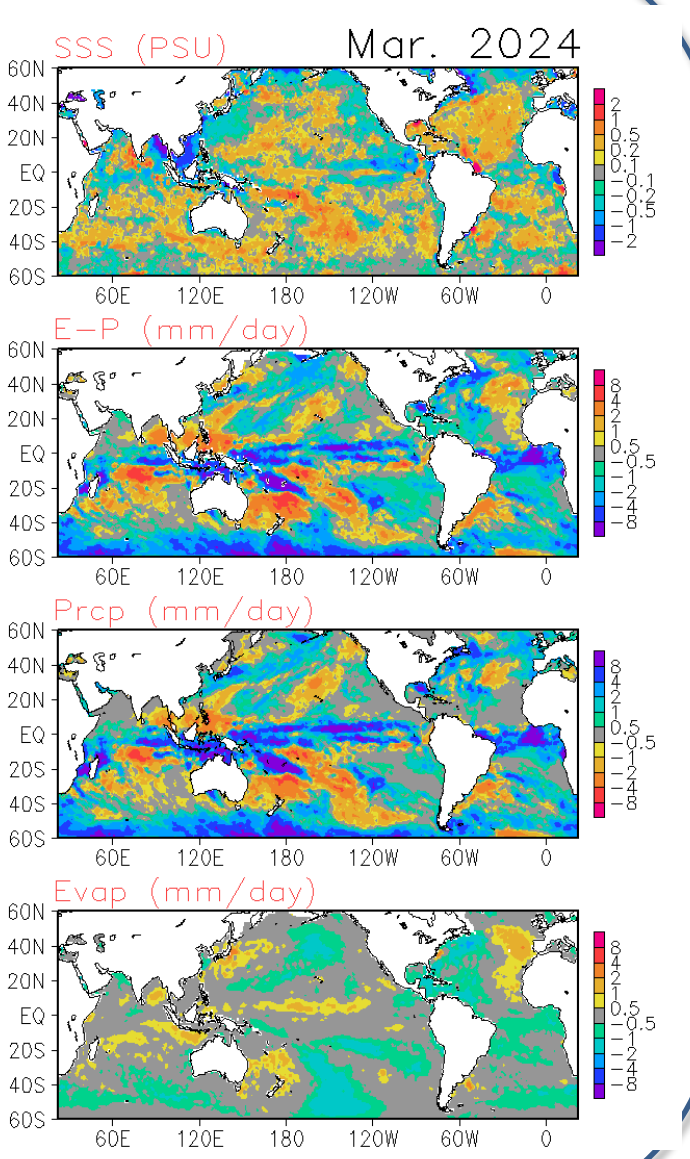
**http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html**

# Backup Slides

# Global Sea Surface Salinity (SSS): Anomaly for March 2024

**New Update: The NCEI SST data used in the quality control procedure has been updated to version 2.1 since May 2020;**

**Pacific ITCZ and SPCA are both enhanced and located northward than their normal positions. This creates parallel bands of fresh water flux (precipitation) and thereby salinity anomalies of opposite signs over the oceanic regions. Similar intensification and northward shift of convection and resulting SSS anomaly patterns are also present with SACA and SIOCZ over the southern Atlantic and southwest Indian ocean. Freshened SS anomalies are observed over the Bay of Bengal despite the deficit ocean entering E-P there, suggesting impacts of river runoff and oceanic circulations.**



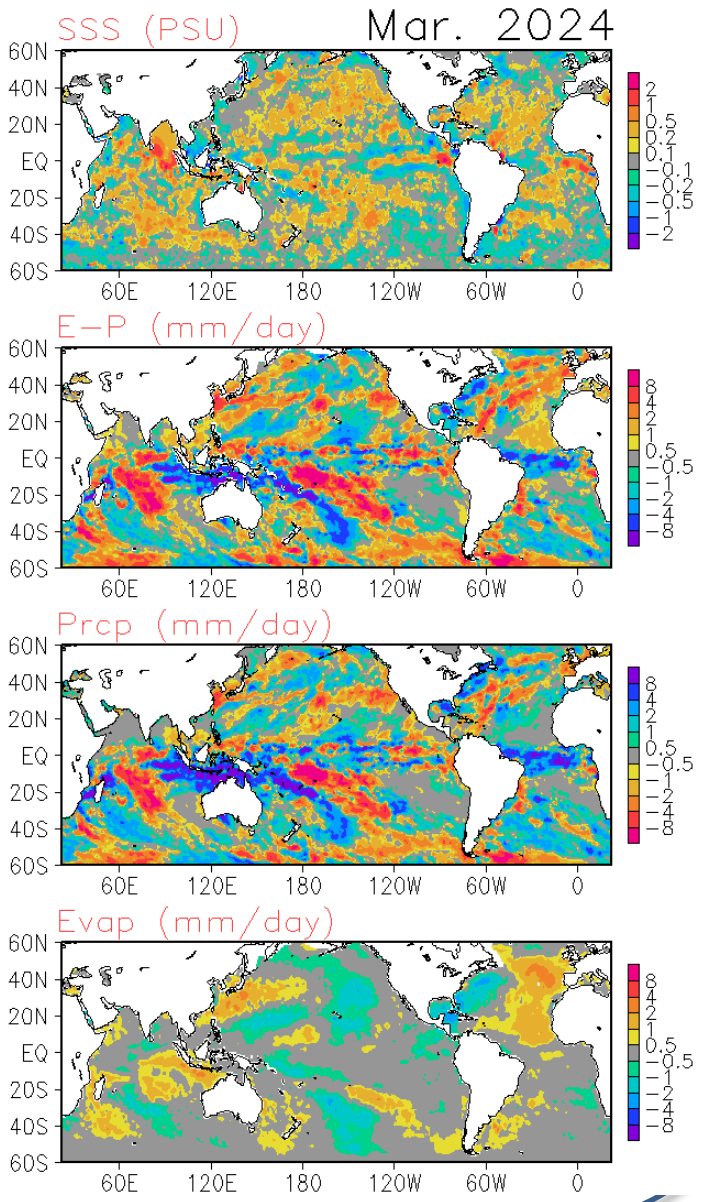

**SSS : Blended Analysis of Surface Salinity (BASS) V0.Z**
**(a CPC-NESDIS/NODC-NESDIS/STAR joint effort)**
**ftp.cpc.ncep.noaa.gov/precip/BASS**

**Precipitation: CMORPH adjusted satellite precipitation estimates**

**Evaporation: Adjusted CFS Reanalysis**

# Global Sea Surface Salinity (SSS): Tendency for March 2024

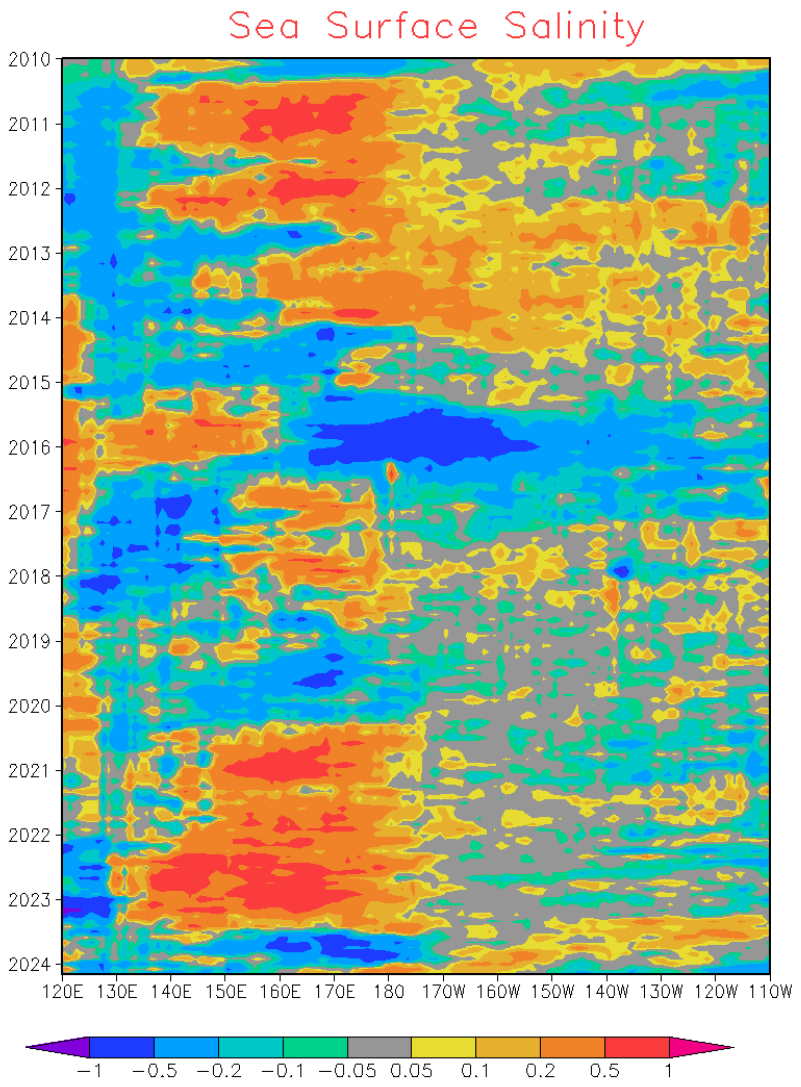
Precipitation (and freshwater flux) anomalies are enhanced over the western and central tropical Pacific, creating freshened SSS tendencies. Tendency for enhanced precipitation is found over the maritime continents, leading to negative E-P, thus fresh water surplus in this region. Coherently, there is a tendency for decreased surface salinity over the overall maritime continent region. Similar intensification and southward move of convection anomalies are also observed for the Atlantic ITCZ, creating a zonally oriented band of saltier SSS tendency over the region.



# Monthly SSS Anomaly Evolution over Equatorial Pacific

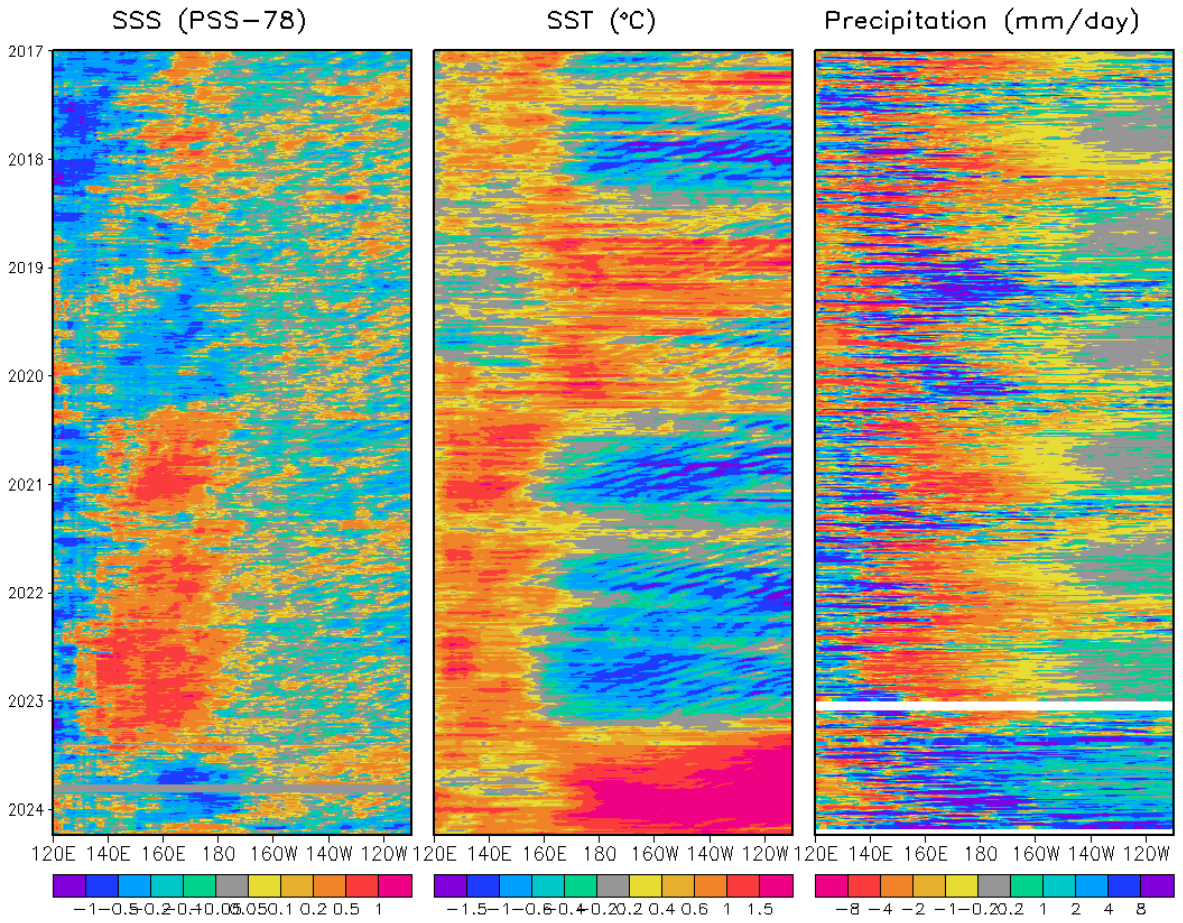
**NOTE: Since June 2015, the BASS SSS is from in situ, SMOS and SMAP; before June 2015, the BASS SSS is from in situ, SMOS and Aquarius.**

- Hovermoller diagram for equatorial SSS anomaly **(5° S-5° N);**
- Freshened SSS anomalies maintain but are weakened over the western and central Pacific during March 2024. SSS anomalies over the equatorial eastern Pacific present mixed signs and are not very strong in general.

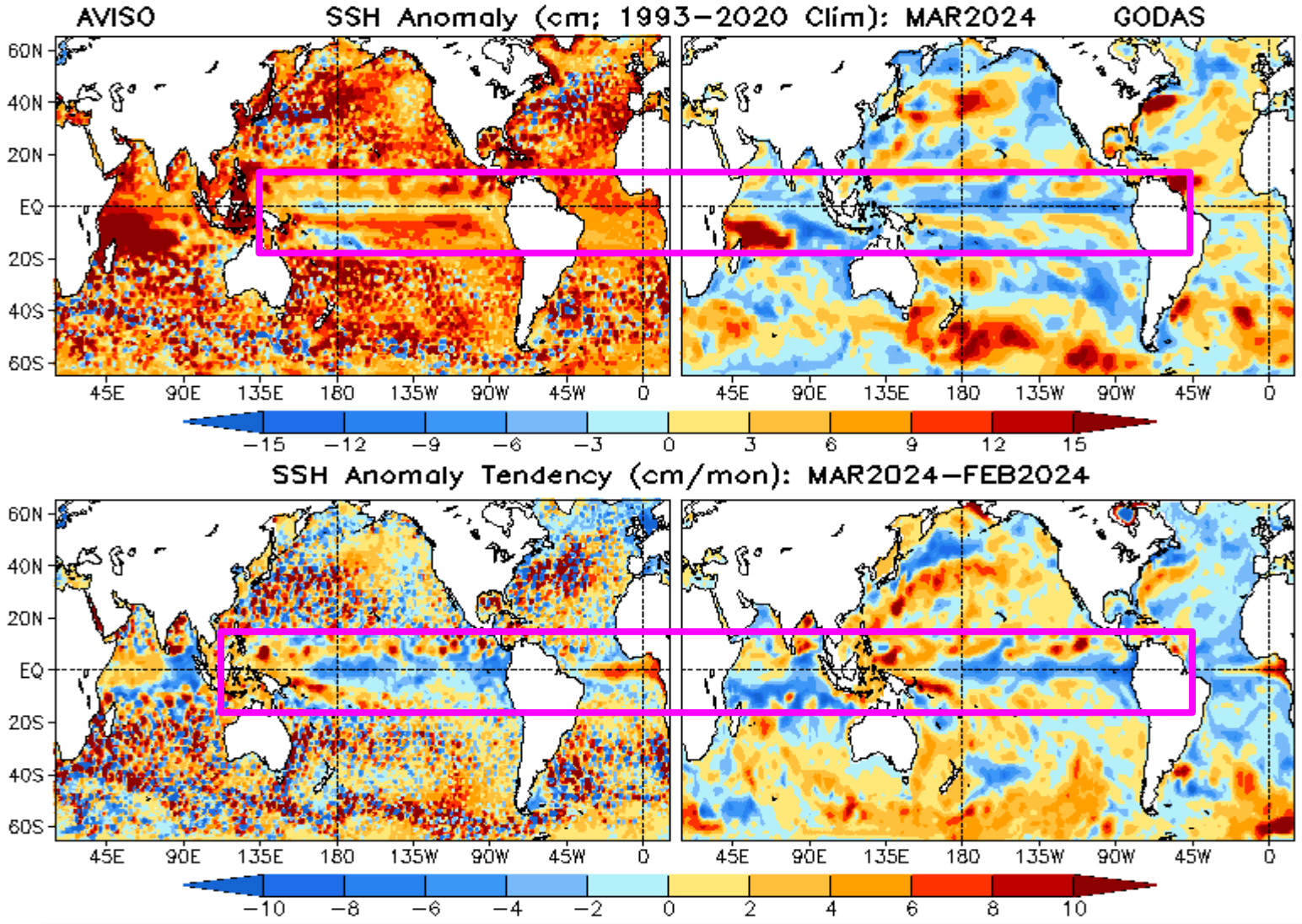


# Pentad SSS Anomaly Evolution over Equatorial Pacific

**Figure caption**:
Hovermoller diagram for equatorial (5° S-5° N) 5-day mean SSS, SST and precipitation anomalies. The climatology for SSS is Levitus 1994 climatology. The SST data used here is the OISST V2 AVHRR only daily dataset with its climatology being calculated from 1985 to 2010. The precipitation data used here is the adjusted CMORPH dataset with its climatology being calculated from 1999 to 2013.

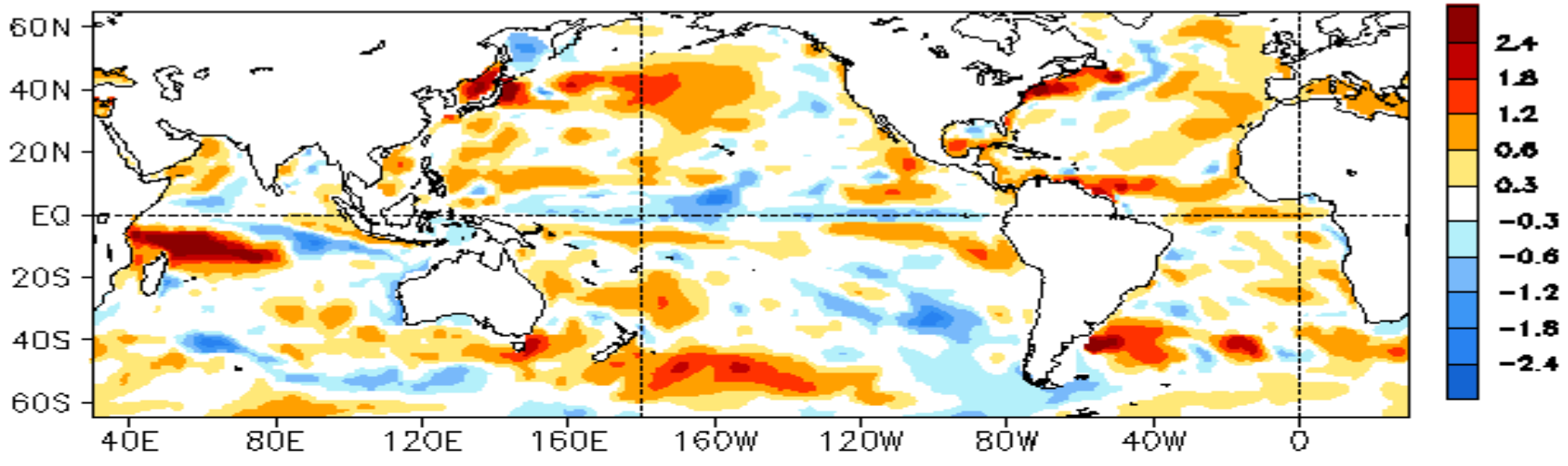


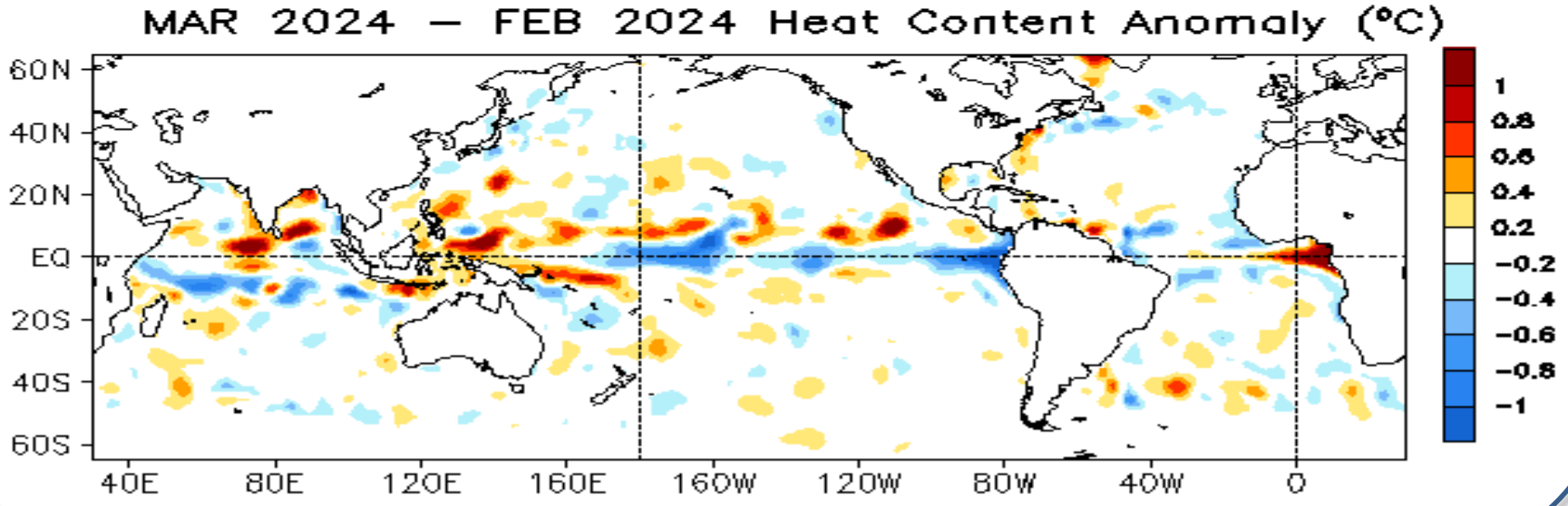
# AVISO & GODAS SSH Anomaly (cm) and Anomaly Tendency



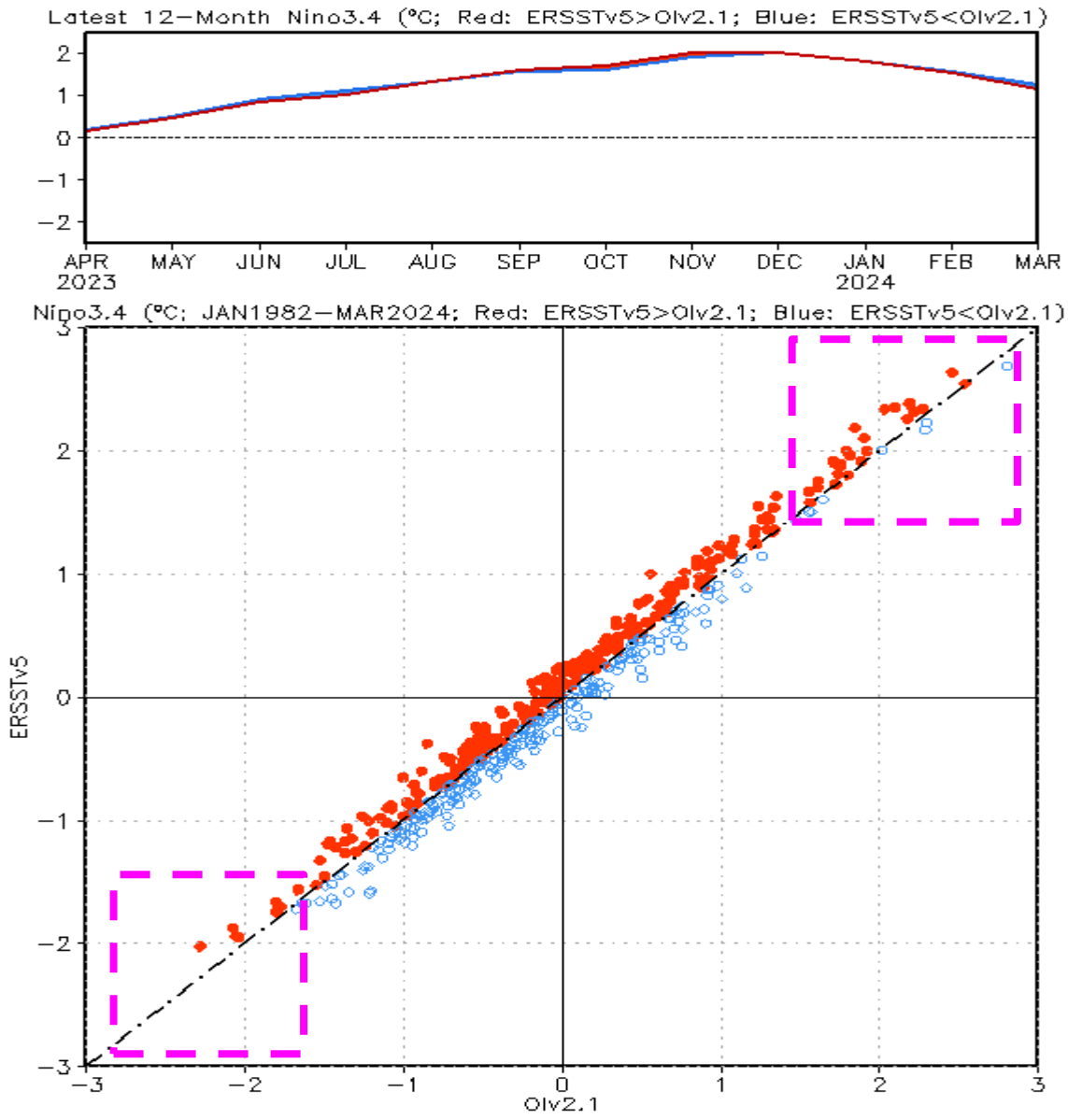

- The tendencies indicated a weakening trend of the El Niño conditions in the eastern tropical Pacific.

# Global HC300 Anomaly & Anomaly Tendency



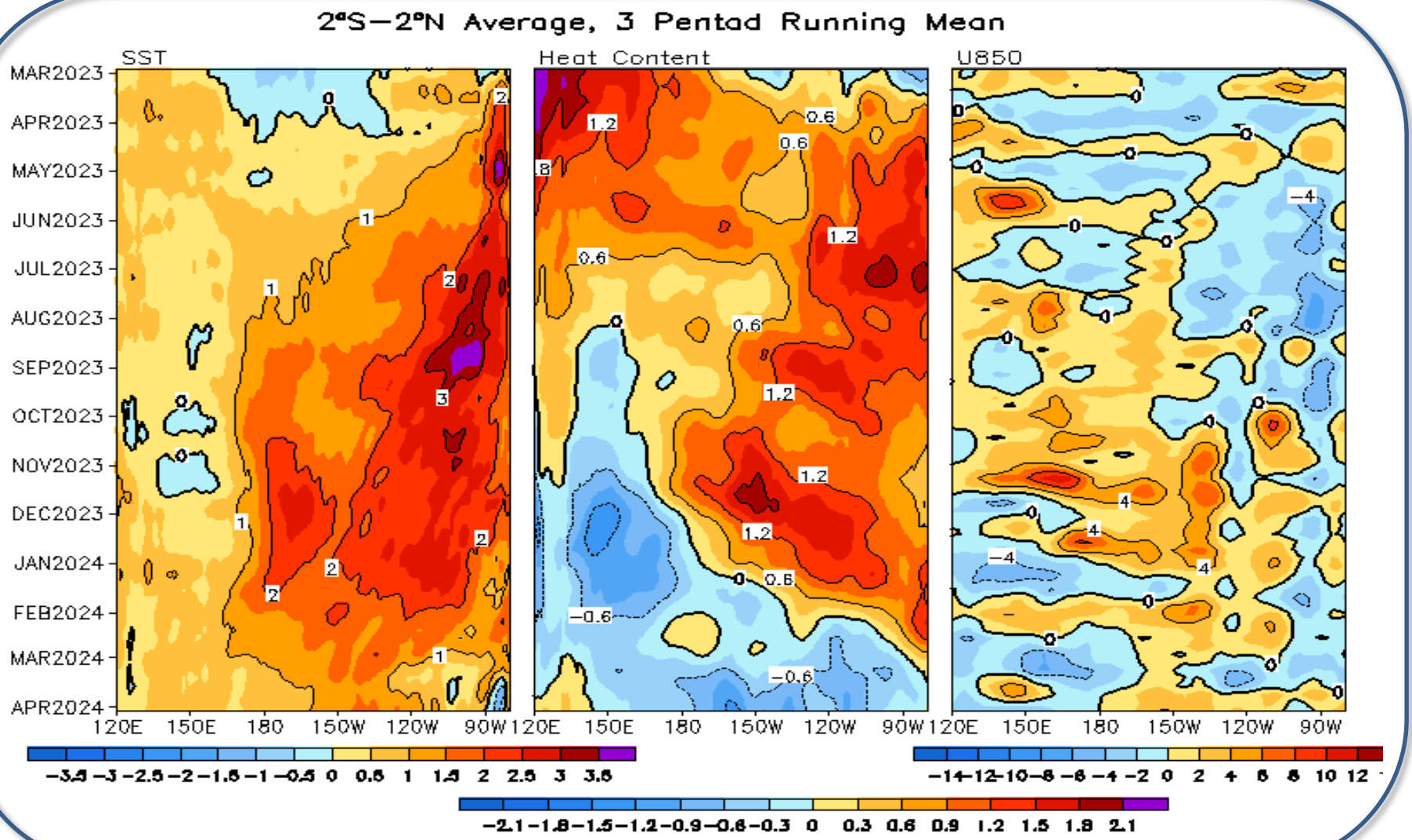



# Comparison of ERSSTv5 & OIv2.1 Niño3.4 Index



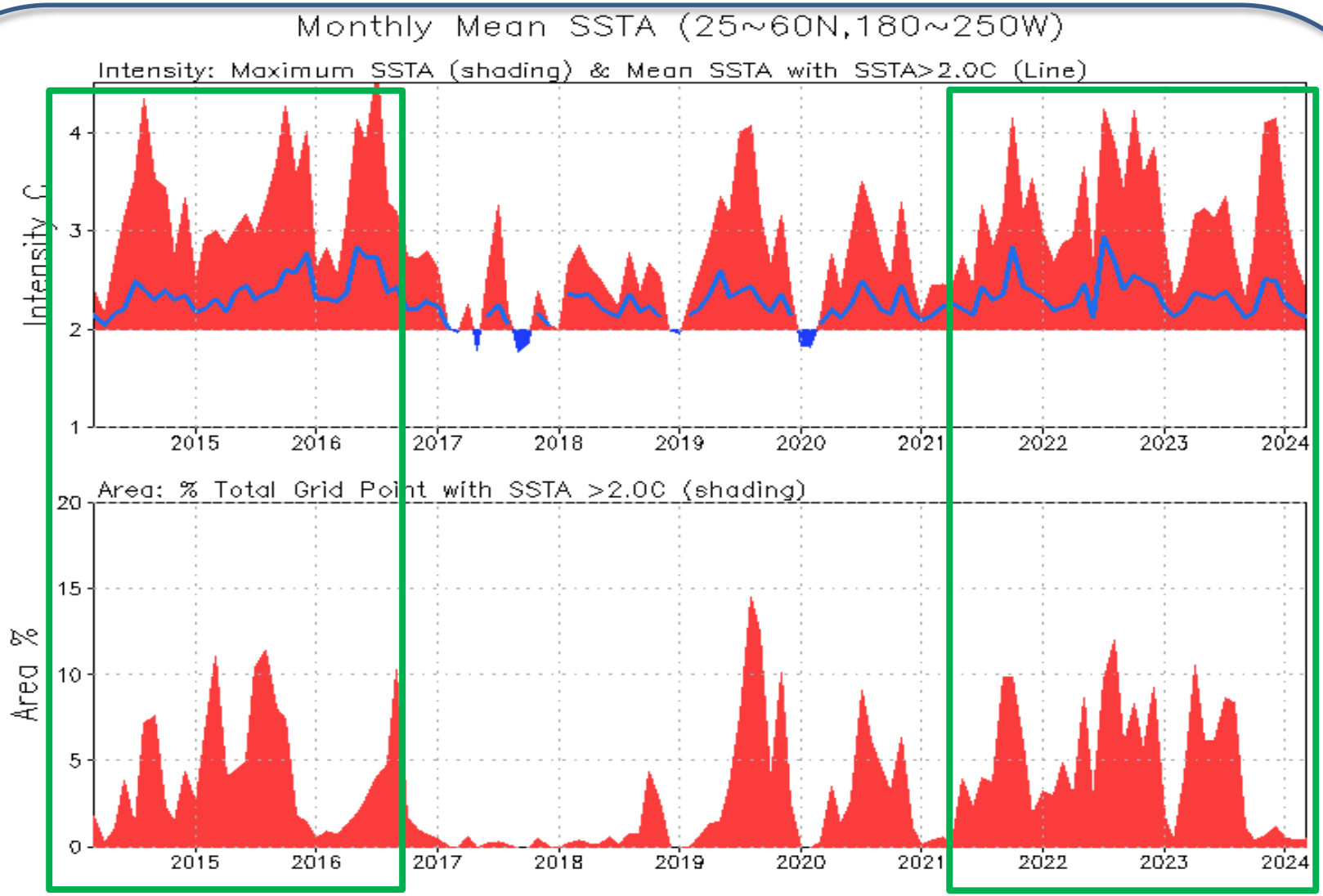

- During the last year, ERSSTv5 was close to OIv2.1.
- Sometimes, ERSSTv5 is either warmer or cooler than OIv2.1.
- For both the extreme positive and negative (>1.5°C or <-1.5°C) Niño3.4, ERSSTv5 is mostly warmer than OIv2.1.

# Equatorial Pacific SST (°C), HC300 (°C), u850 (m/s) Anomalies




- Since Feb 2023, a set of westerly wind surges triggered downwelling Kelvin waves, reinforcing the subsurface warming in the central and eastern Pacific.

# N. Pacific Marine Heat Wave




https://origin.cpc.ncep.noaa.gov/products/GODAS/MarineHeatWave.html

# NOAA/NWS/NCEP CPC Marine Heat Wave Webpage

https://www.cpc.ncep.noaa.gov/products/GODAS/MarineHeatWave.html

## NOAA/NCEP Climate Prediction Center

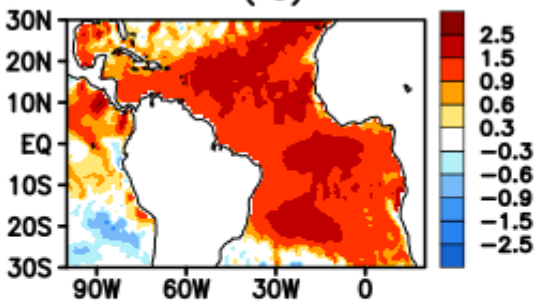
### Marine Heatwave Monitoring and Forecast

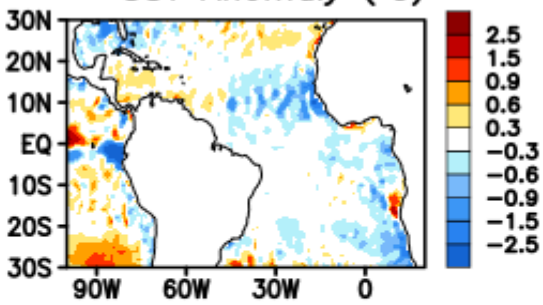
- **Indices & Time Series**
  - N. Pacific MHW Intensity & Area Indices: Weekly Monthly
  - Regional Mean SST: Global Monthly & Nino3.4 Since 1854 N. Pacific Weekly Gulf of Alaska & Subtropical Coast Weekly

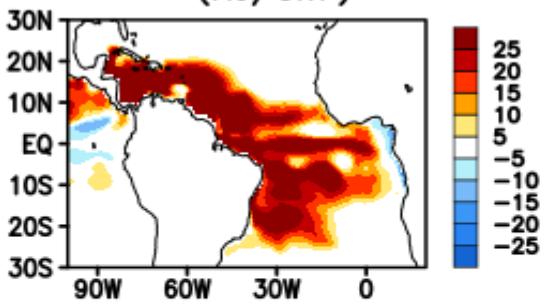
- **Spatial Distribution**
  - Global Monthly Anomaly
    - SST
  - N. Pacific Anomaly
    - Pentad Subsurface Ocean Temperature: 5m 55m 105m 155m
    - Weekly SST Weekly SST2
    - Pentad 300m Ocean Heat Content Pentad Ocean Surface Heigh Pentad Surface Heat Flux
    - 3-month SST, SLP, & UV925 SST Tendency & 3-Month Heat Flux
    - Ocean Temperature Profile GODAS Ocean Temperature Profile
  - N. Atlantic Anomaly
    - Weekly SSTA Monthly MDR SSTA
    - 3-month SST, SLP, & UV925 SST Tendency & 3-Month Heat Flux

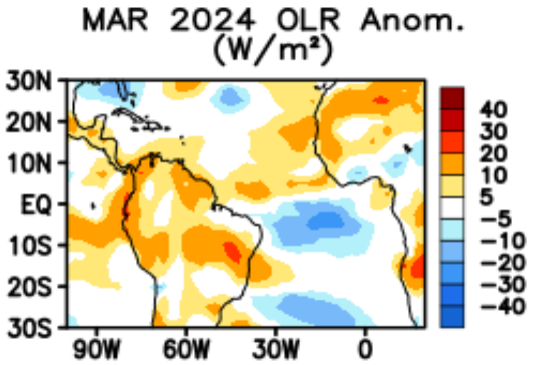
- **NMME & CFSv2 Forecasts**
  - Tropical N. Atlantic SSTA: NMME CFSv2
  - N. Pacific SSTA: NMME CFSv2
  - CFSv2: N. Pacific Sea Surface Height Anomaly
  - CFSv2 SSTA Index: Last month Last 9 months

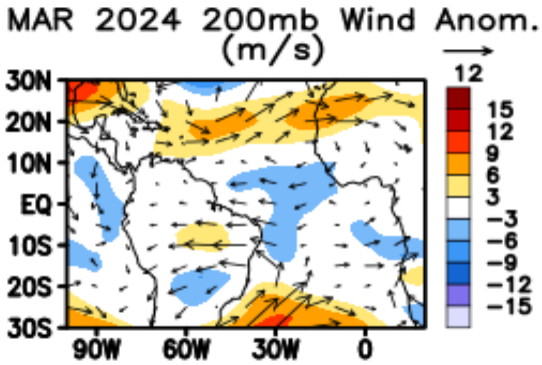
# Tropical Atlantic: SST, SST tend., TCHP, OLR, 200 hPa wind, wind share, heat flex, & RH anom.

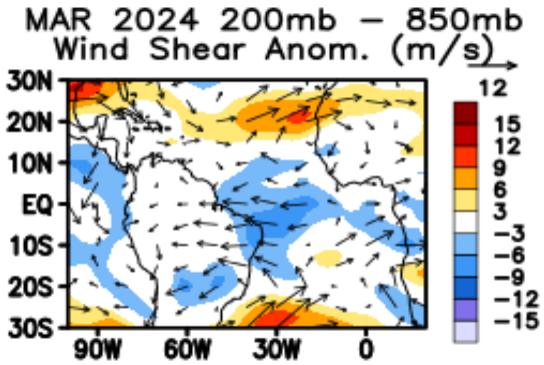


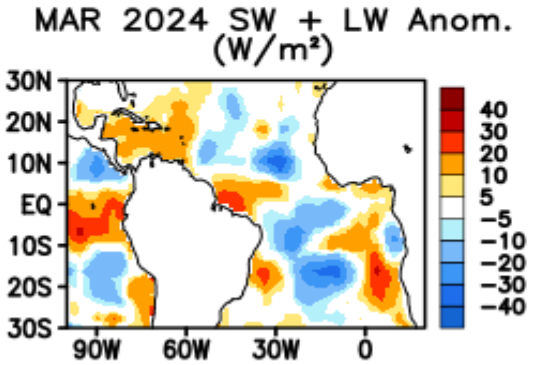



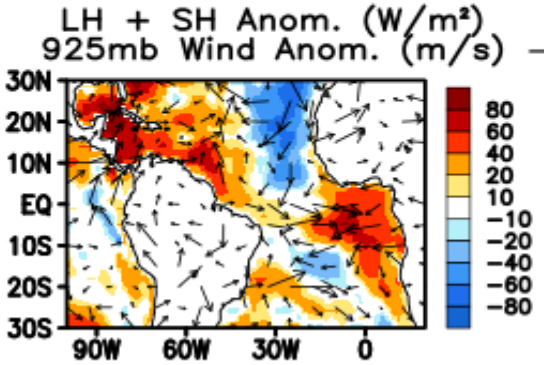



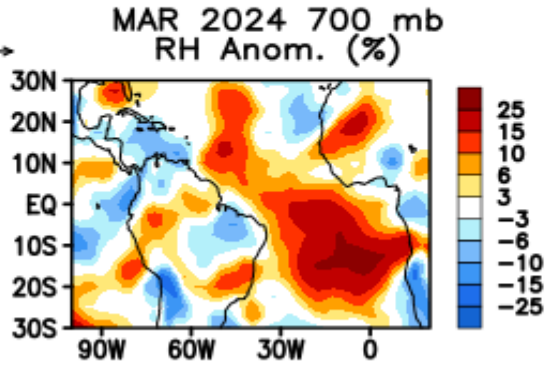



# N. Atlantic: SST, SST tend., OLR, SLP, & heat flex anom.