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

Prepared by

Climate Prediction Center, NCEP/NOAA

May 10, 2024

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

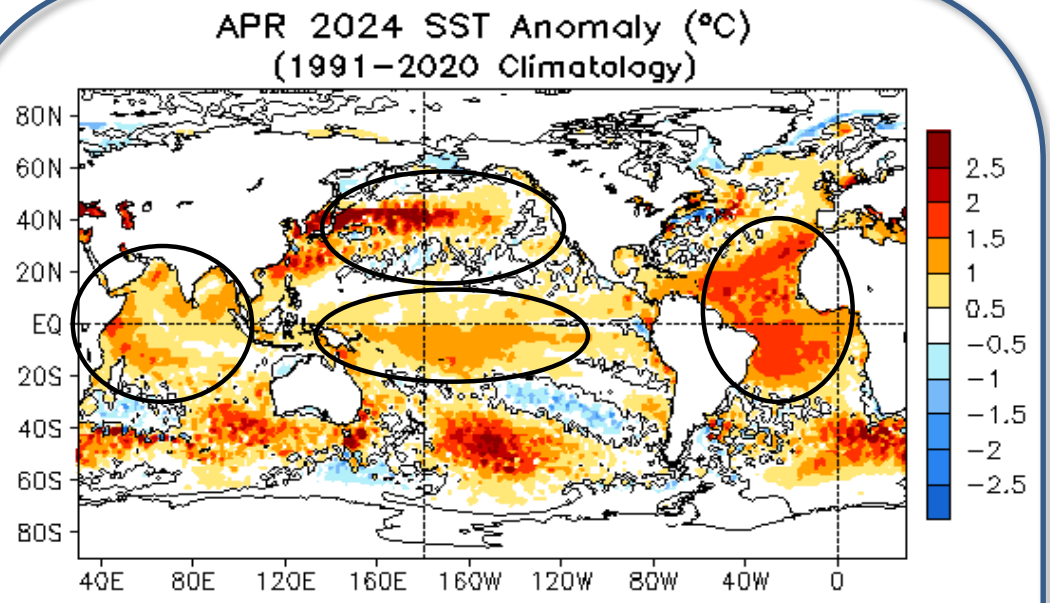
- **Overview**
- **Recent highlights**
  - Pacific Ocean
  - Arctic & Antarctic Oceans
  - Indian Ocean
  - Atlantic Ocean
- **Global SSTA Predictions**

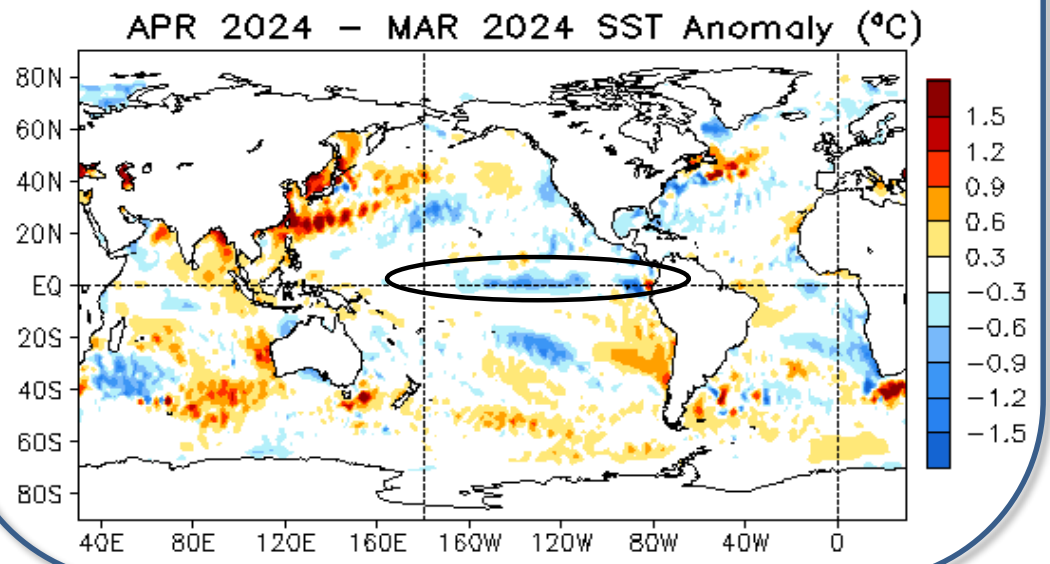
Overview

- Pacific Ocean
  - El Niño condition weakened with Niño3.4 = 0.8^{o}C and the atmospheric conditions in the tropical Pacific were near average in Apr 2024.
  - NOAA "ENSO Diagnostic Discussion" on 9 May 2024 continued with "*El Niño Advisory / La Niña Watch.*"
  - The positive SSTA persisted in the North Pacific and the negative phase of PDO strengthened with PDOI = -1.0 in Apr 2024.
- Arctic & Antarctic Oceans
  - The average Arctic sea ice extent for Apr 2024 was 14.12 million km^2, placing it 16th lowest in the satellite record in Apr.
  - Antarctic sea ice extent for Apr 2024 was 6.19 million km^2, ranking the 10th-lowest Apr extent since 1979.
  - 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 and enhanced coupling in Apr 2024.
- Atlantic Ocean
  - Positive SSTAs persisted in the tropical Atlantic Ocean.
  - NAO was in a negative phase in Apr 2024 with NAOI= -1.0.

Global Oceans

Global SST Anomaly (°C) and Anomaly Tendency



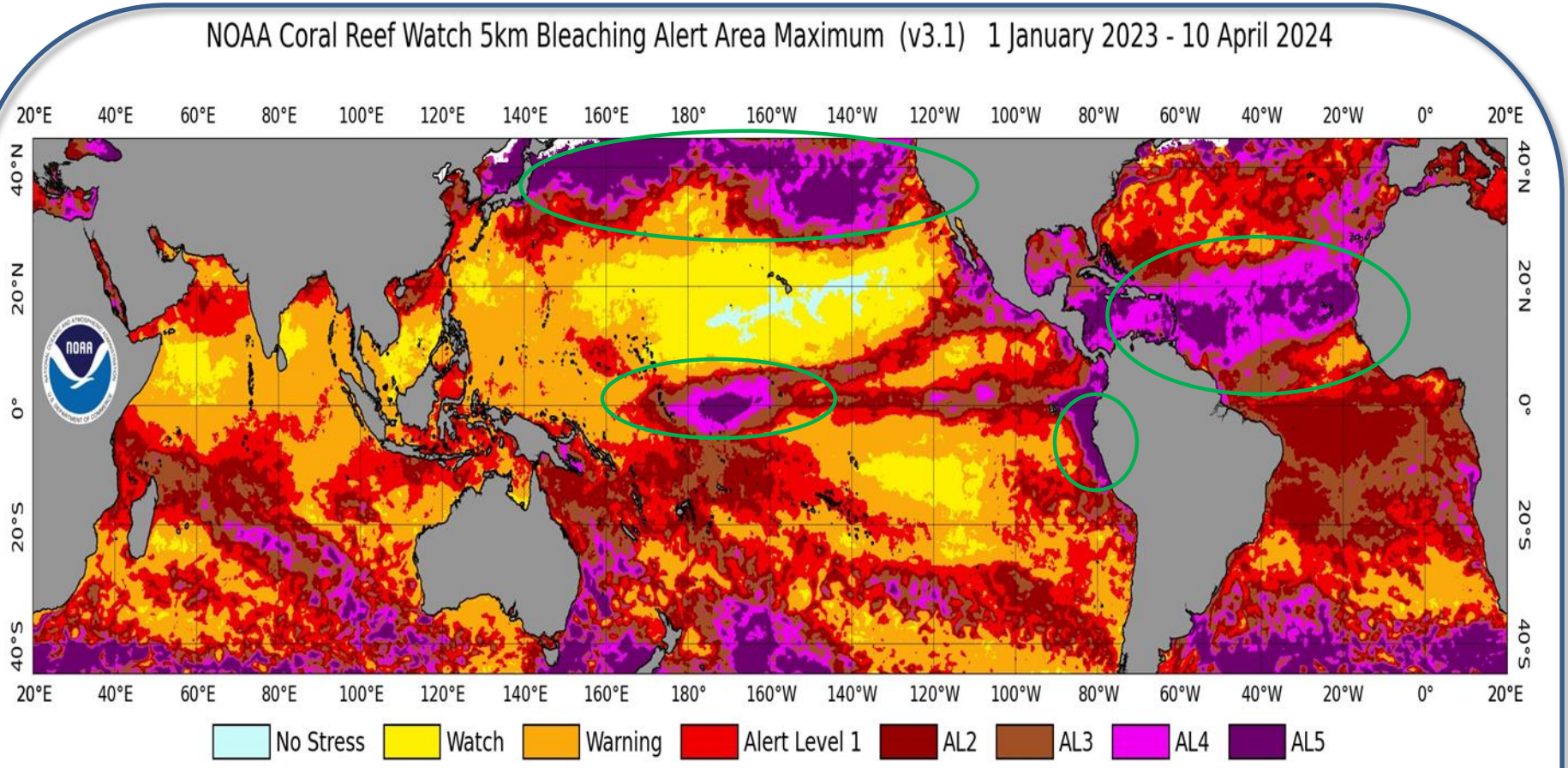


- Positive SSTAs weakened in the east-central equatorial Pacific and negative SSTAs merged in the eastern equatorial Pacific Ocean.
- Positive SSTAs were present in the North Pacific and the tropical Atlantic Oceans.
- Positive SSTAs were observed in the tropical Indian Ocean, with warmer SSTAs in the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

- Negative SSTA tendencies were present in the eastern equatorial Pacific Ocean.
- Positive SSTA tendencies were observed in the western North Pacific Ocean.
- Both positive and negative SSTA tendencies were present in the tropical Indian and Atlantic Oceans.

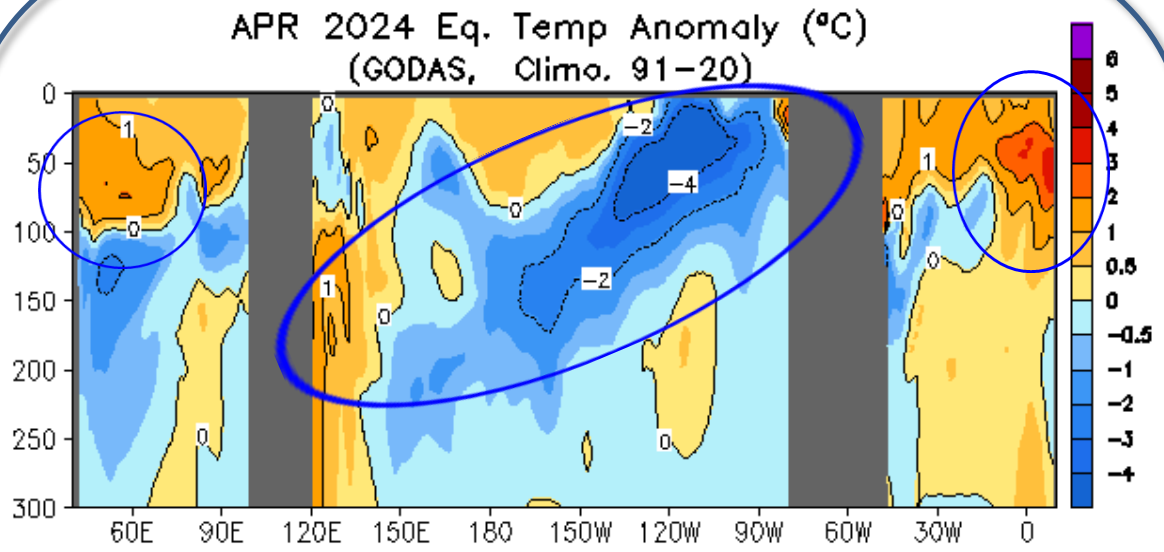
SSTAs (top) and SSTA tendency (bottom). Data are derived from the OIv2.1 SST analysis, and anomalies are departures from the 1991-2020 base period means.

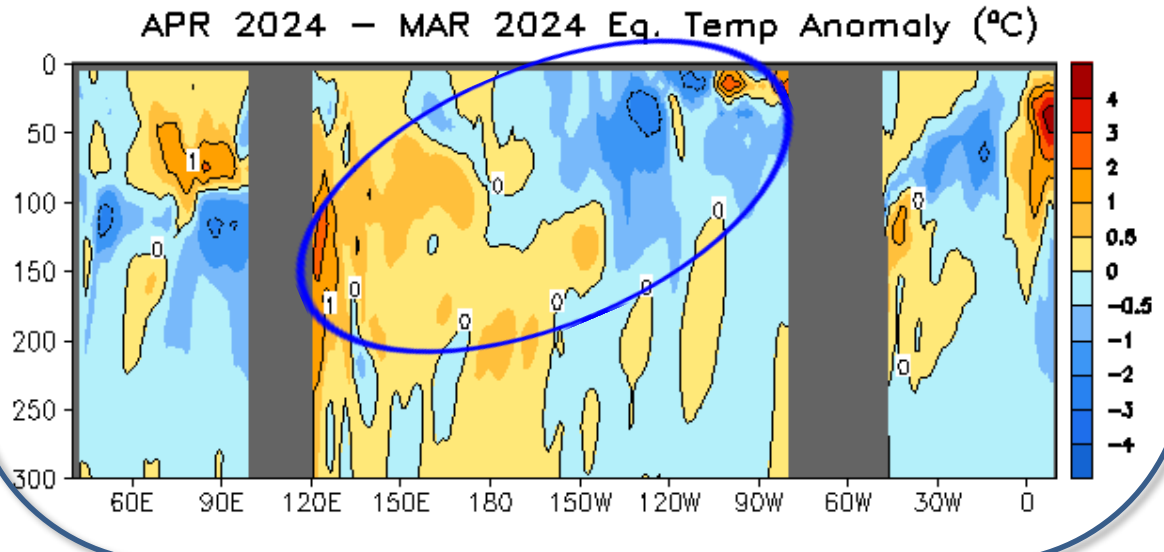
NOAA confirms 4th global coral bleaching event



- NOAA Coral Reef Watch's global 5km-resolution satellite Coral Bleaching Alert Area Maximum map, for January 1, 2023 to April 10, 2024.
- The world is currently experiencing a global coral bleaching event, according to NOAA scientists. This is the fourth global event on record since 1985 and the second in the last 10 years.
- This figure shows the regions, around the globe, that experienced high levels of marine heat stress (Bleaching Alert Levels 2-5) that can cause reef-wide coral bleaching and mortality. (https://www.noaa.gov/news-release/noaa-confirms-4th-global-coral-bleaching-event)

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 (negative) anomalies were above (below) the thermocline in the Indian Ocean.
- Large positive anomalies were present in the eastern Atlantic Ocean.

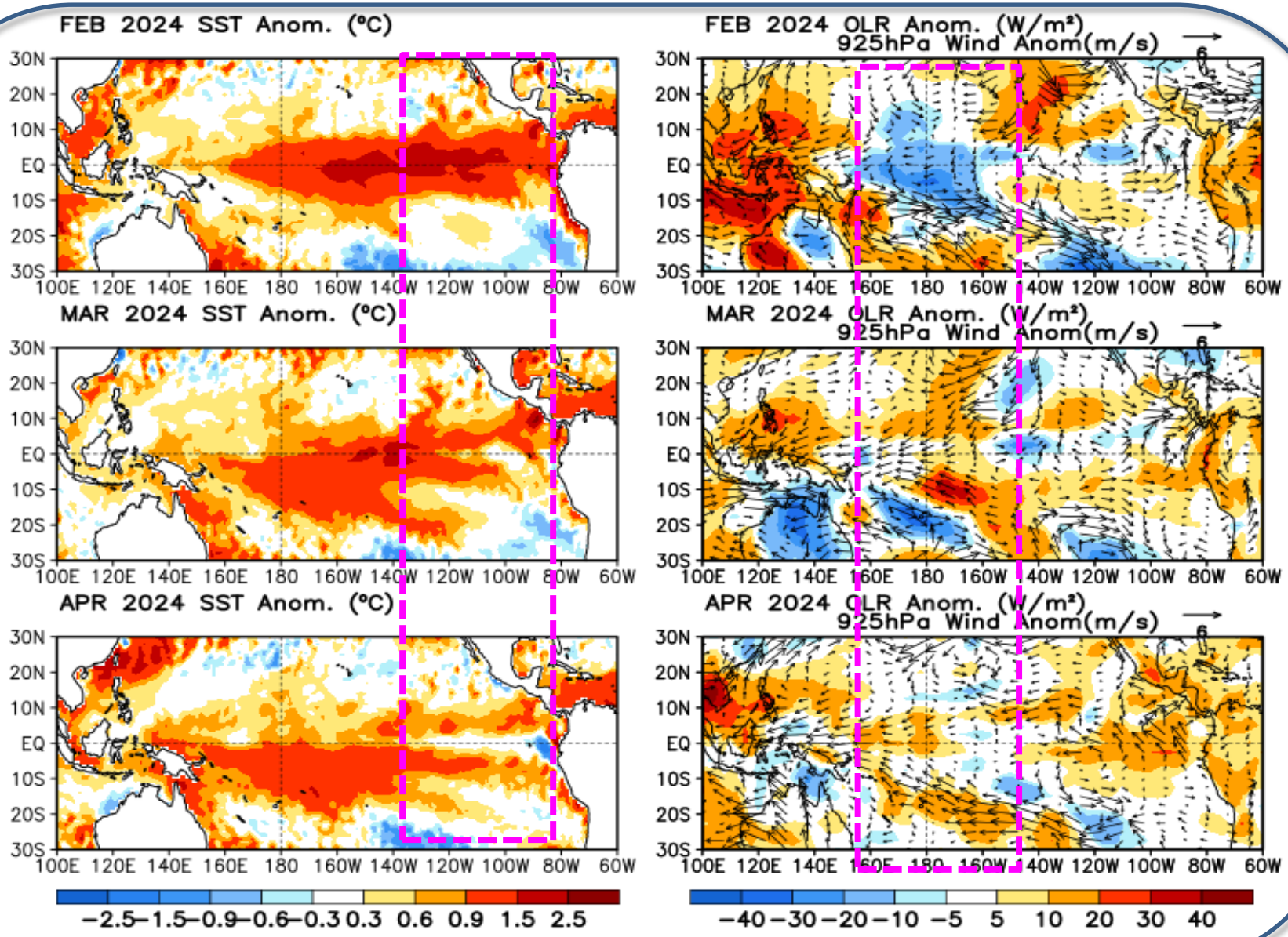
- Negative (positive) anomaly tendencies dominated along the thermocline in the eastern (western) Pacific Ocean.
- Both positive and negative anomaly tendencies were present along the thermocline in the Indian and Atlantic Oceans.

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

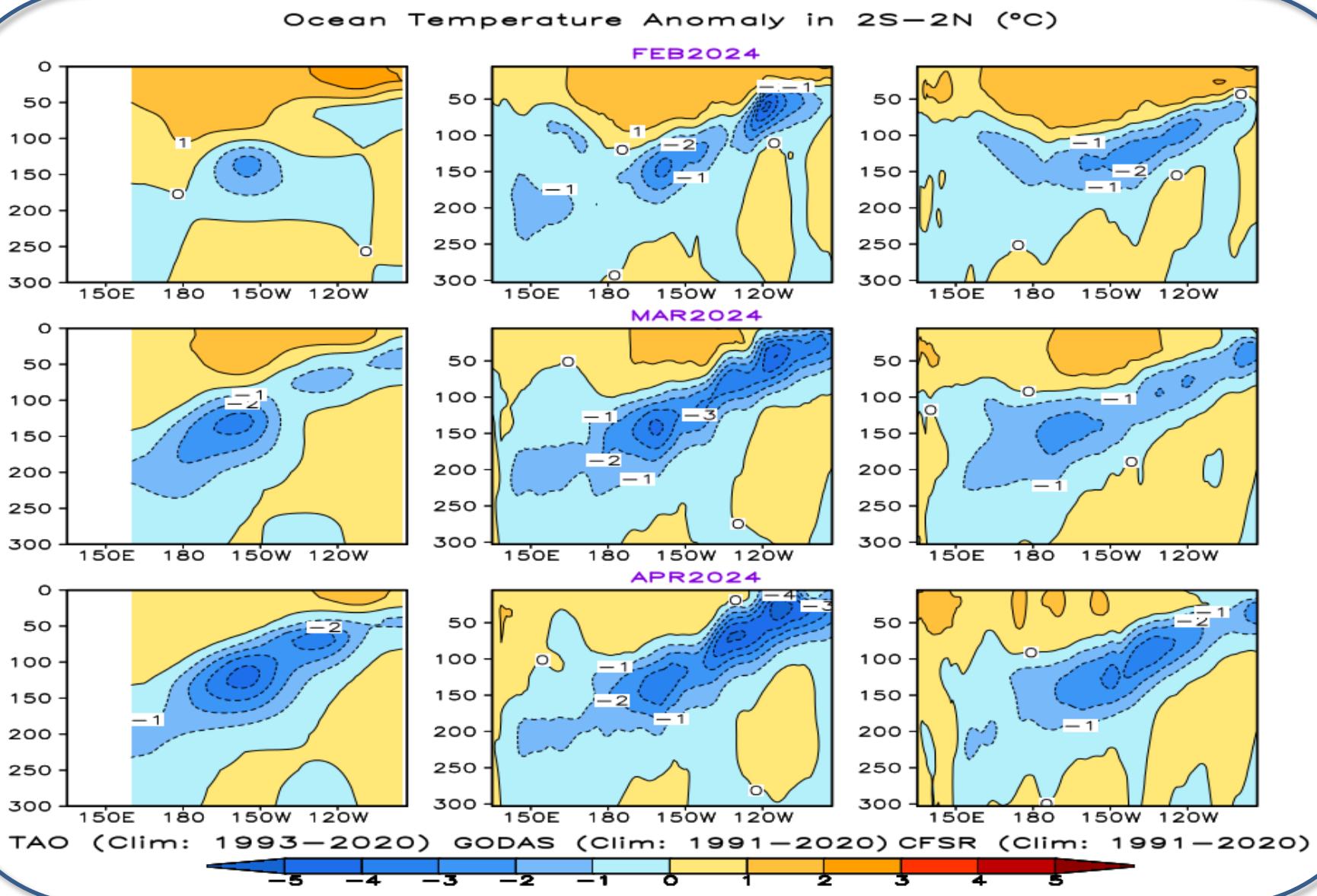
Last 3-month Tropical Pacific Ocean SST, OLR, and uv925 Anomalies:

Positive SSTA weakened in the E. Equatorial Pacific & atmosphere (OLR & uv925) were near average

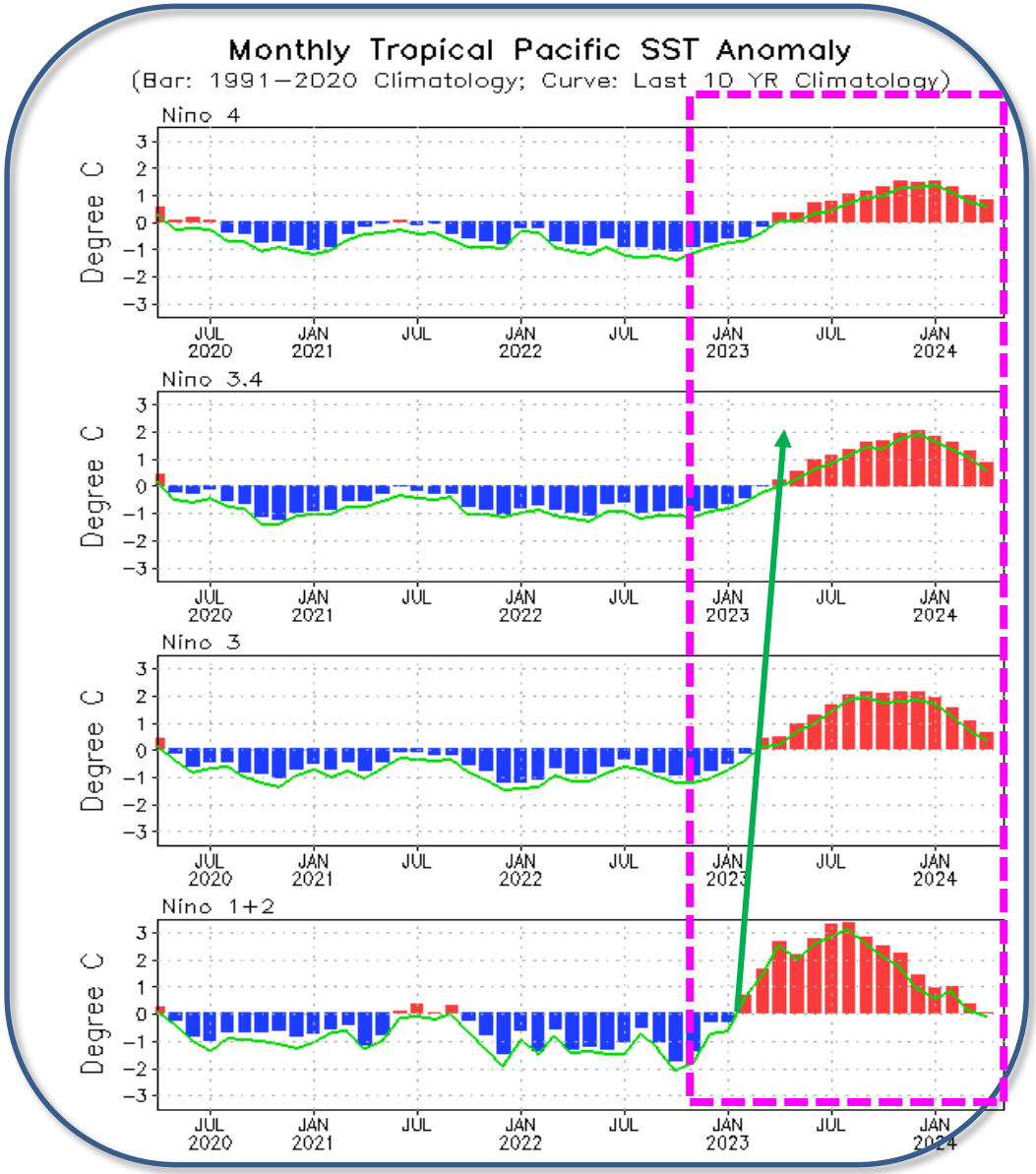


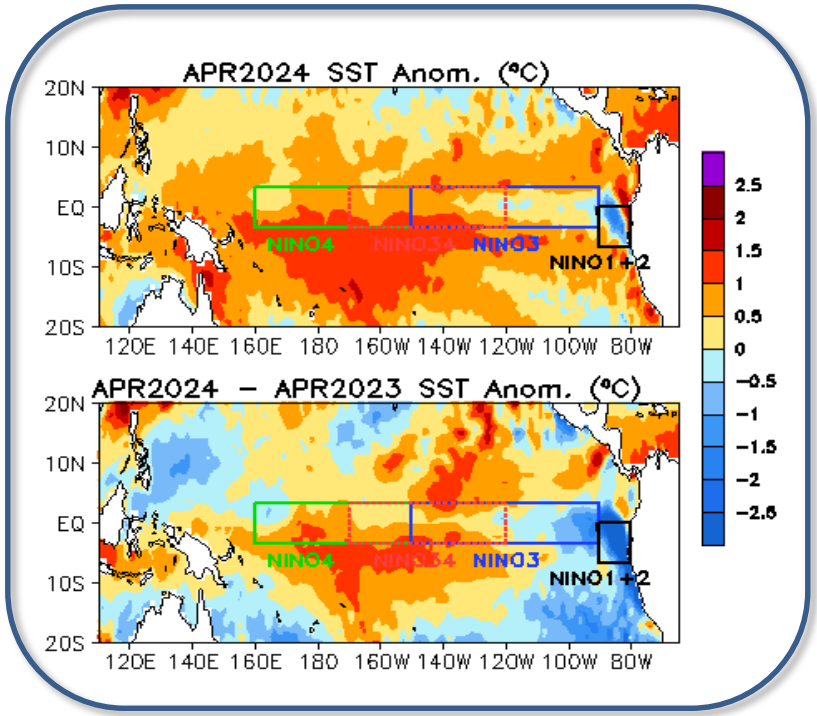
Monthly mean subsurface temperature anomaly along the Equator:

Negative anomalies strengthened in the central & eastern Pacific



Evolution of Pacific Niño SST Indices





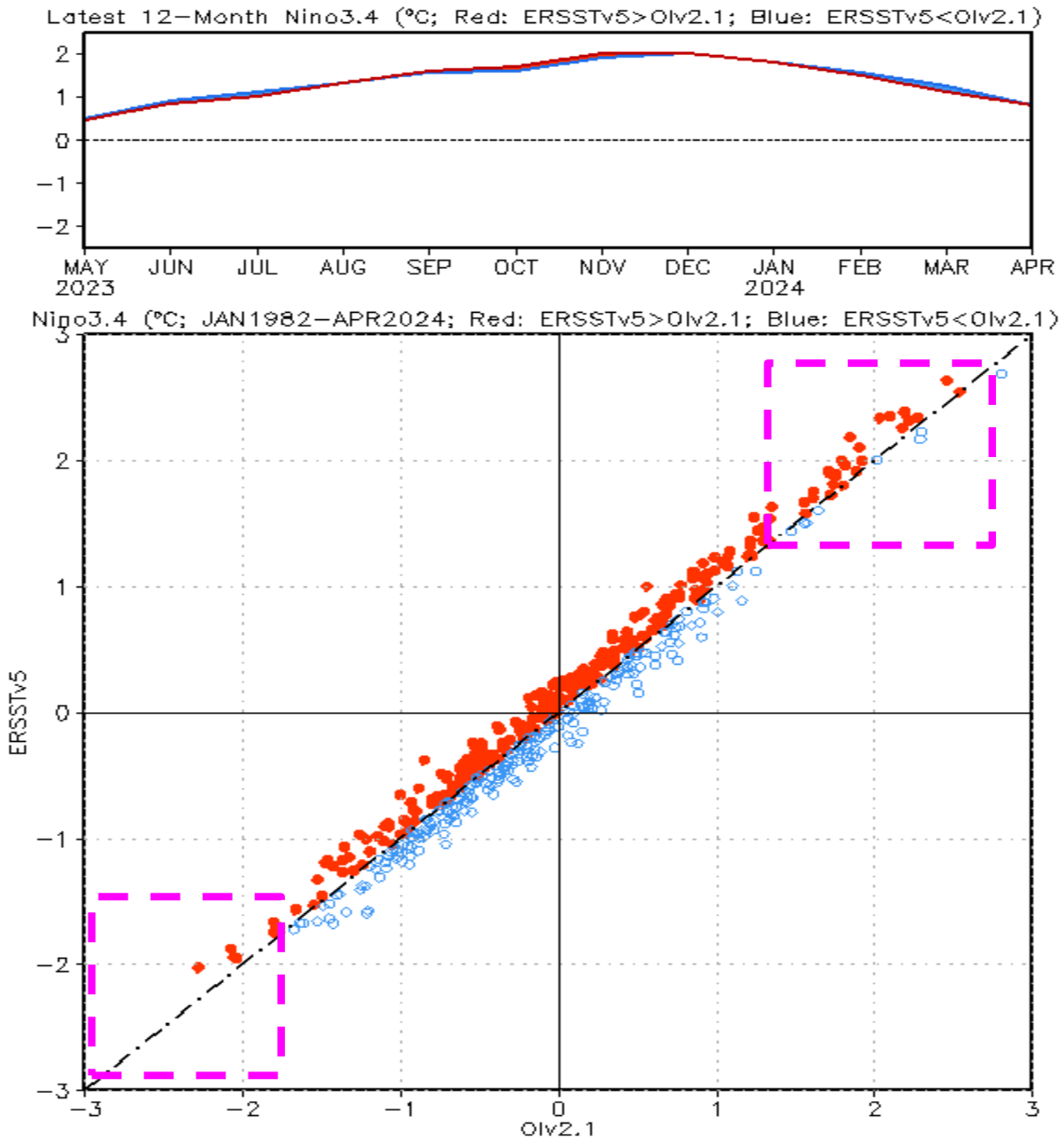
- In Apr 2024, Niño3.4 weakened further with Niño3.4 = 0.8°C (0.8°C in ERSSTv5 data); Nino1+2 declined further to 0.1°C.

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

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

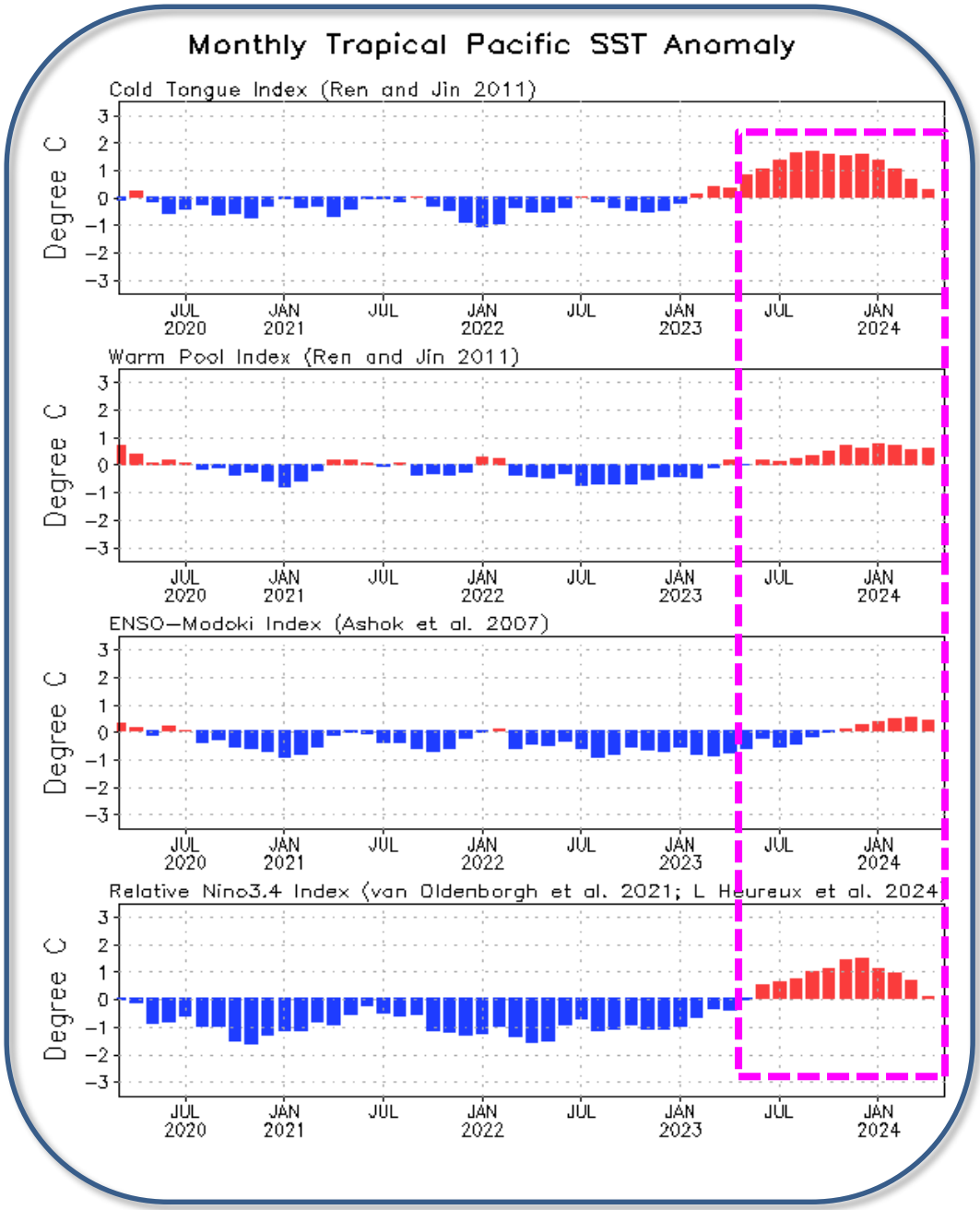
Niño region indices, calculated as the area-averaged monthly mean SSTAs (°C) for the specified region. Data are derived from the OIv2.1 SST analysis, and anomalies are departures from the 1991-2020 base period means.

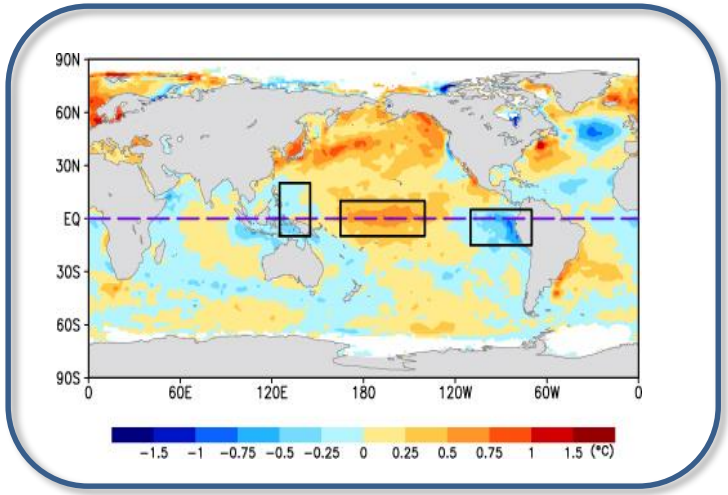
Comparison of ERSSTv5 & OIv2.1 Niño3.4 Index



- 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.

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



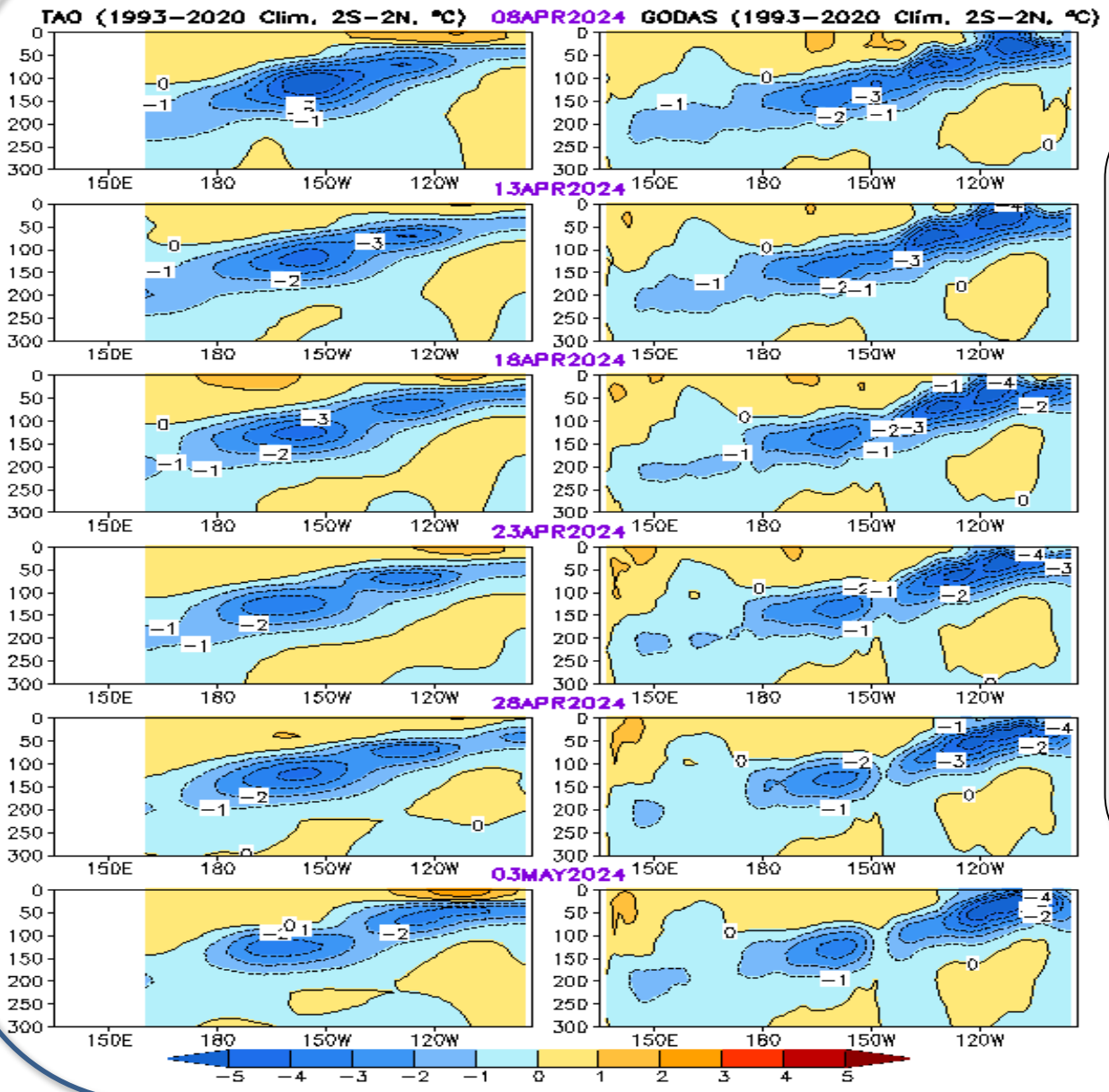


- Relative Niño3.4 index is now included in ENSO monitoring, which is defined as the conventional Niño3.4 index minus the SSTA averaged in the whole tropics (0°-360°, 20°S-20°N), in order to remove the global warming signal. Also, to have the same variability as the conventional Niño3.4 index, the relative 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

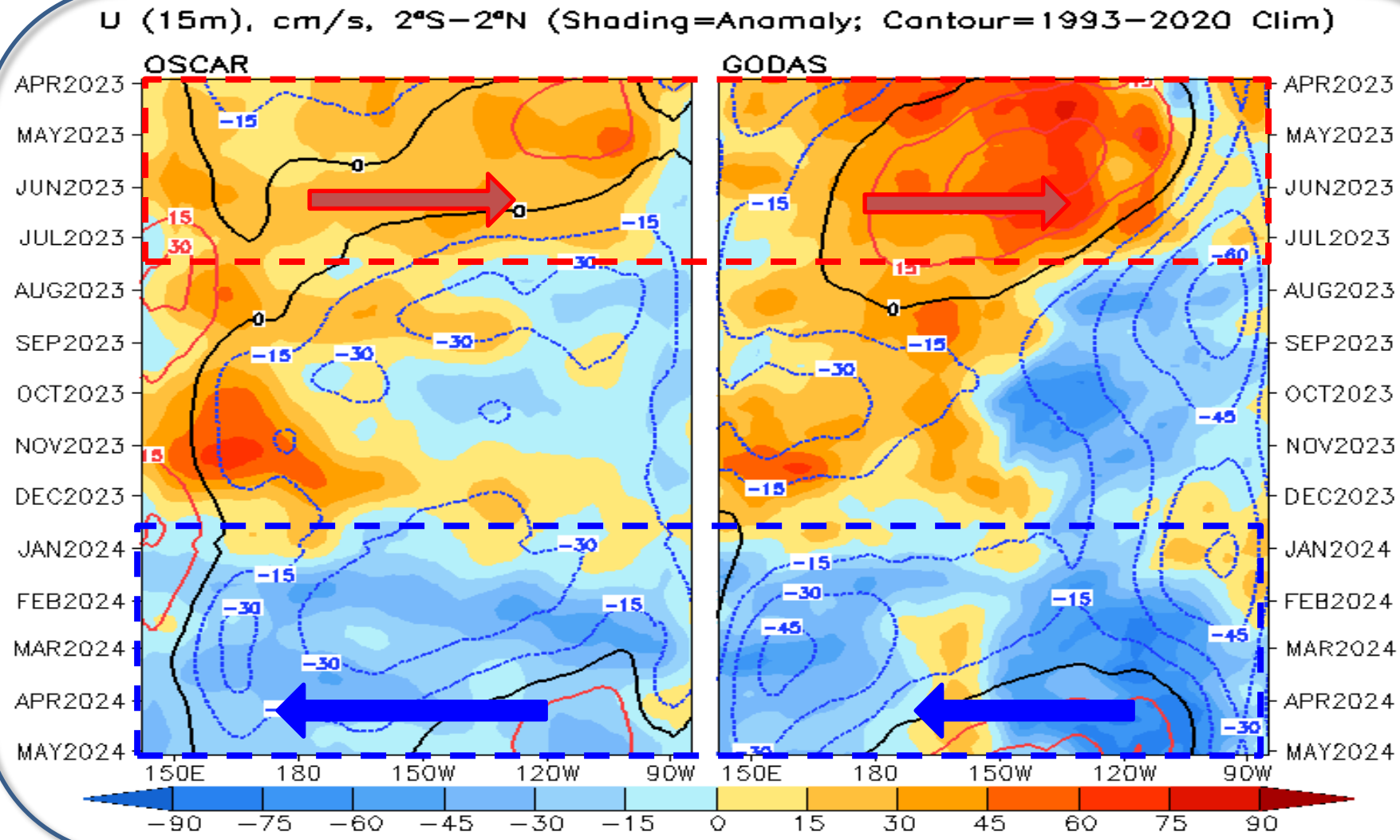
Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



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

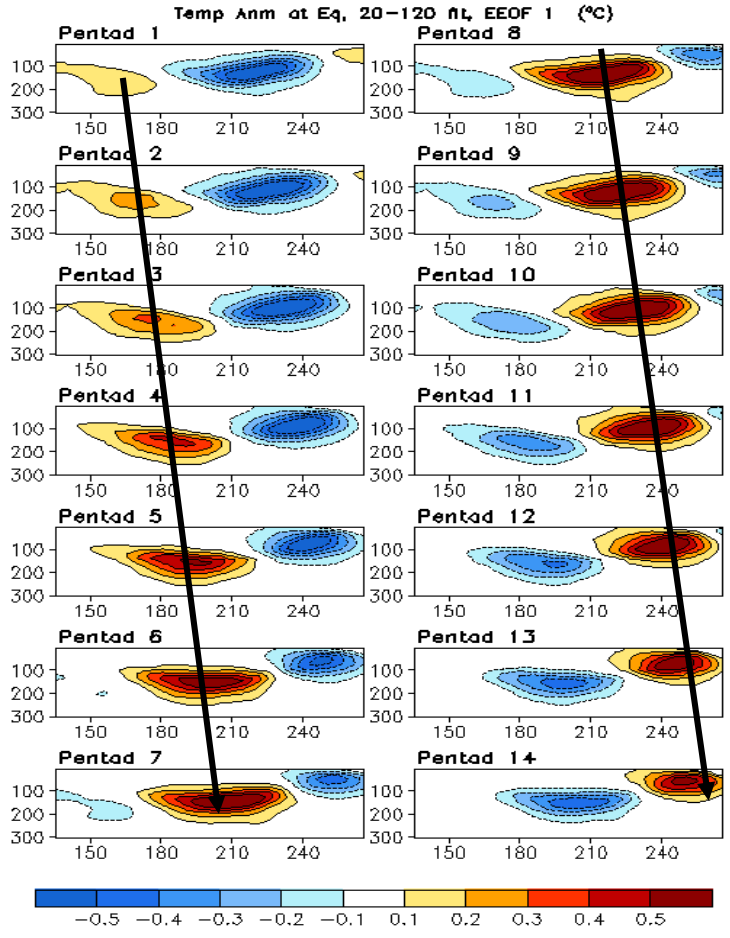
- The features of the ocean temperature anomalies were similar between GODAS and TAO analysis.

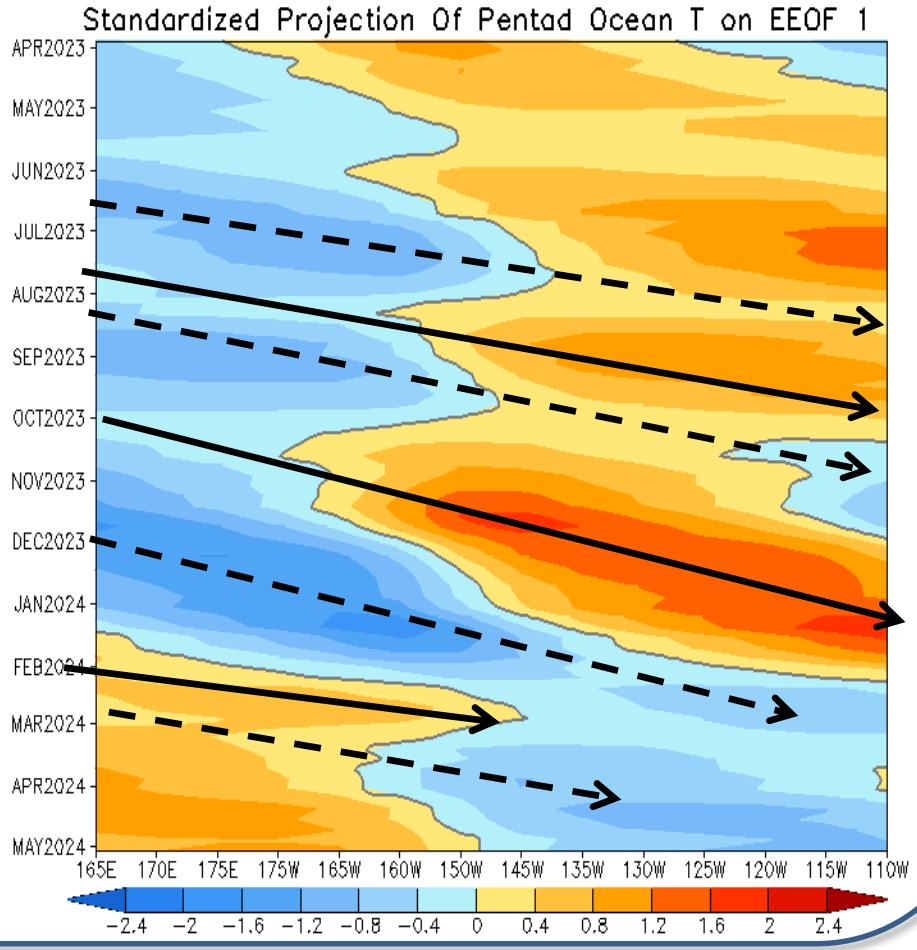
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- 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.

Oceanic Kelvin Wave (OKW) Index



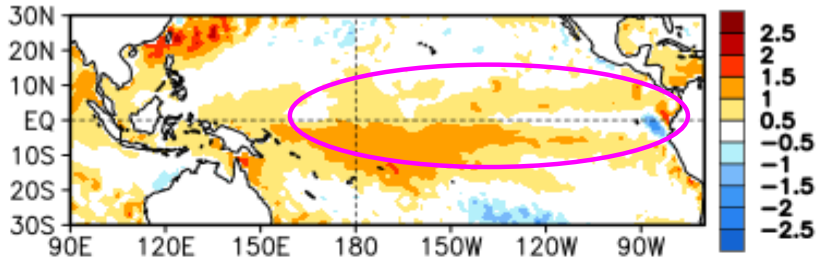


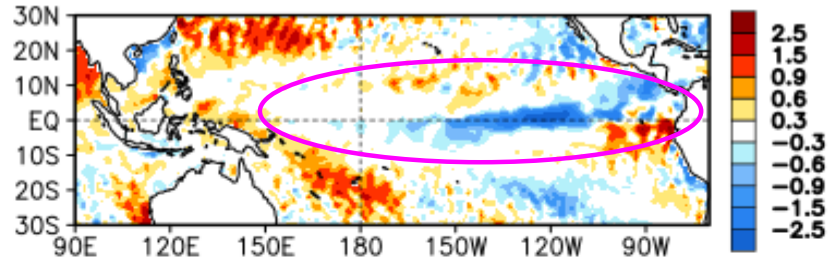
- **Multiple downwelling and upwelling Kelvin waves were observed in 2023-24, leading to fluctuation in SSTAs in the central and eastern equatorial Pacific and ENSO evolution.**

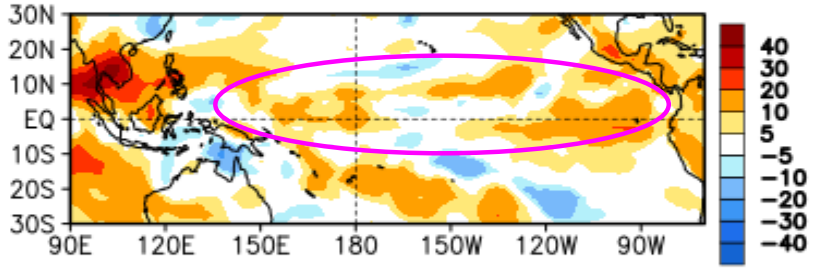
- **Weak downwelling and upwelling Kelvin waves propagated eastward since Feb 2024.**

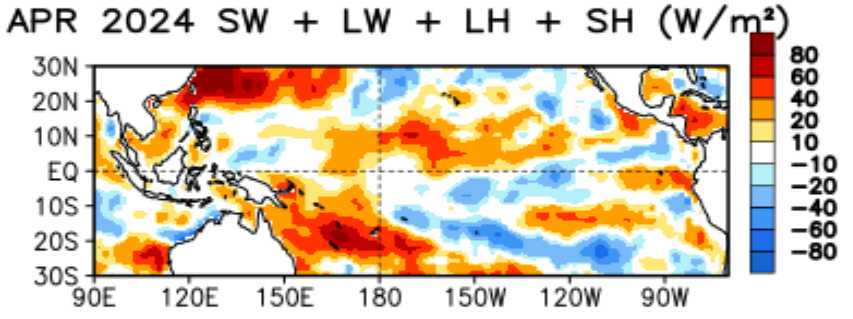
(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)

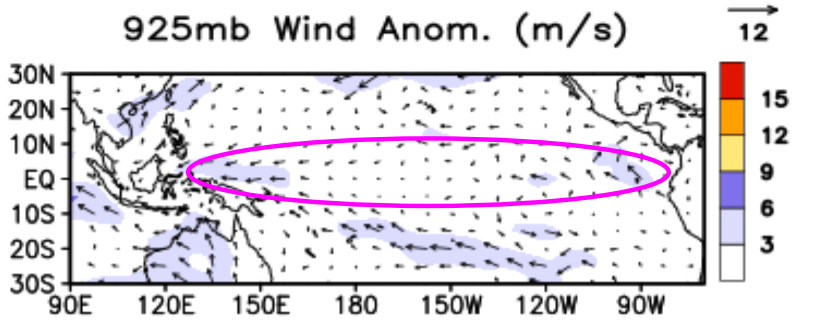
Tropical Pacific: SSTA, SSTA Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Winds: Tropical Pacific atmosphere conditions were near average

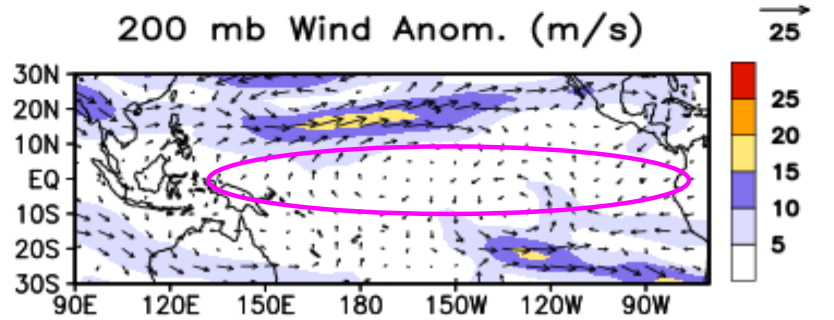






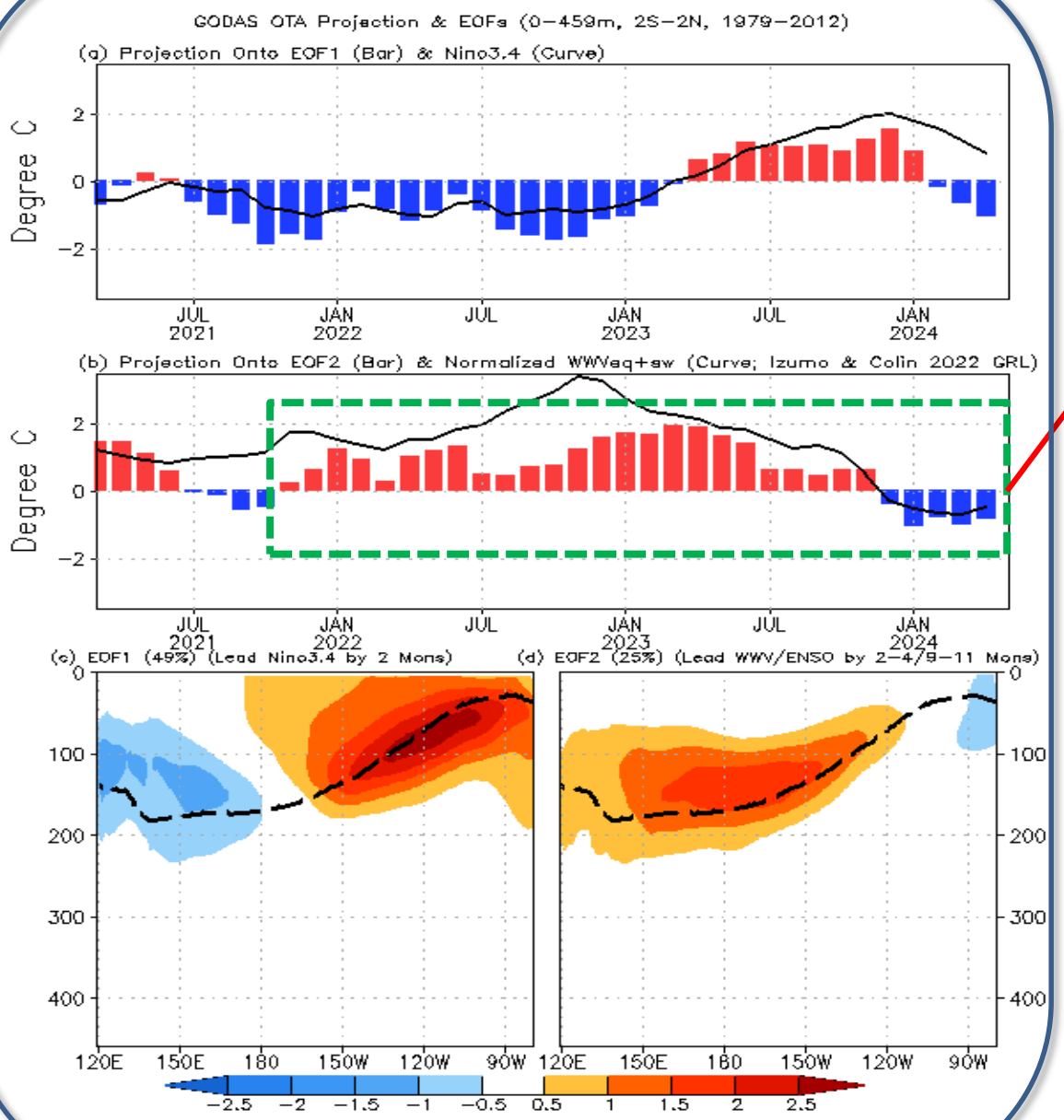






SSTAs (top-left), SSTA tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right; positive means heat into the ocean), 925-mb wind anomaly vector and its amplitude (bottom-left), 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.

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.

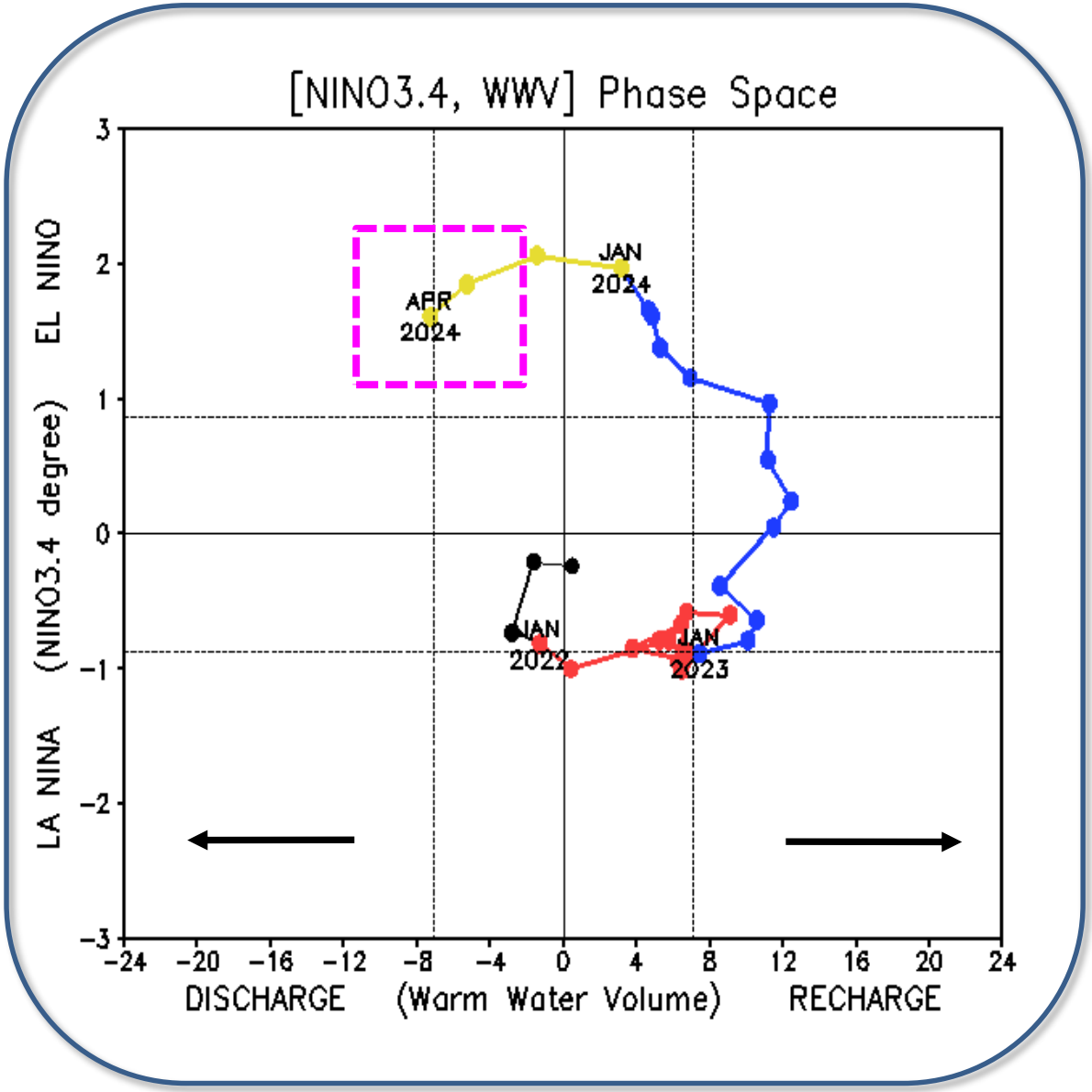
- Recharge/discharge oscillation (ENSO transition phase); Recharge process: heat transport from outside of equator to equator; Negative -> positive phase of ENSO

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

Warm Water Volume (WWV) and Niño3.4 Anomalies

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

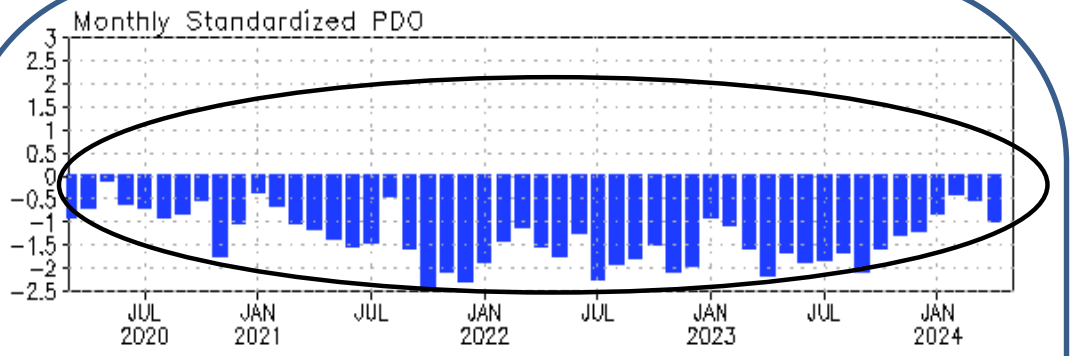
-As WWV is intimately linked to ENSO variability (Wyrtki 1985; Jin 1997), it is useful to monitor ENSO in a phase space of WWV and Niño3.4 (Kessler 2002).
- Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.

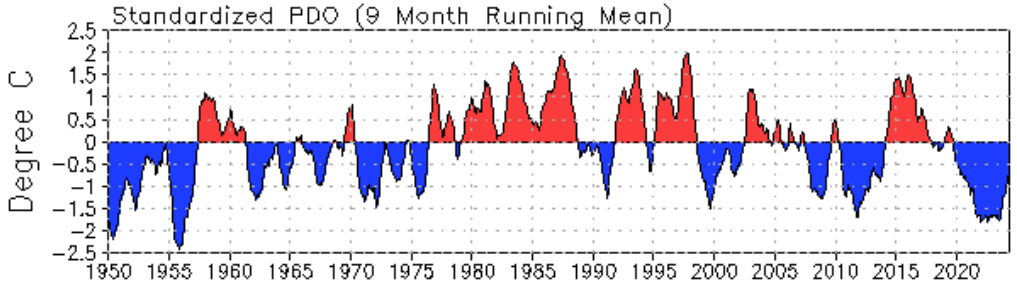


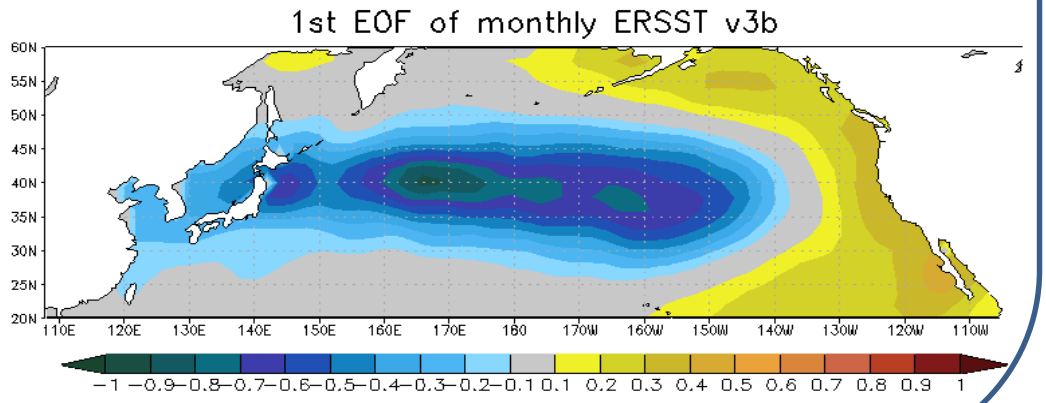
Phase diagram of Warm Water Volume (WWV) and Niño3.4 indices. WWV is the average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN] calculated with the NCEP's GODAS. Anomalies are departures from the 1991-2020 base period means.

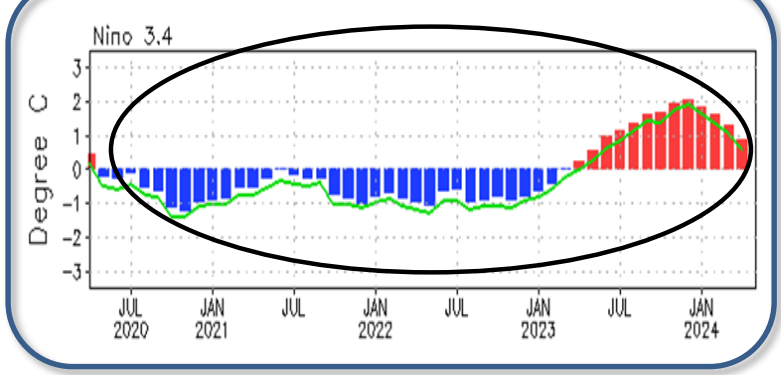
North Pacific, Arctic, & Antarctic Oceans

Pacific Decadal Oscillation (PDO) Index





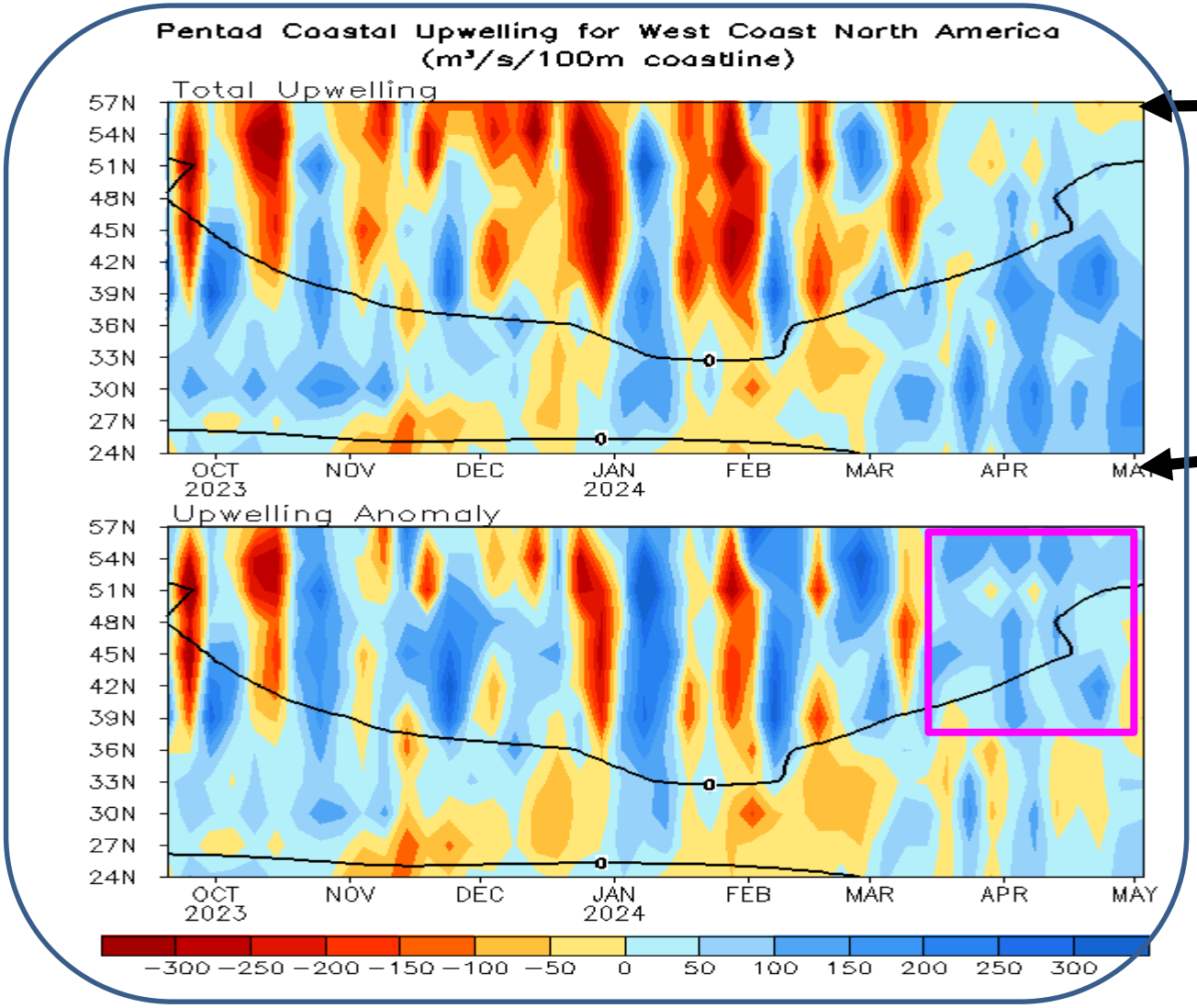


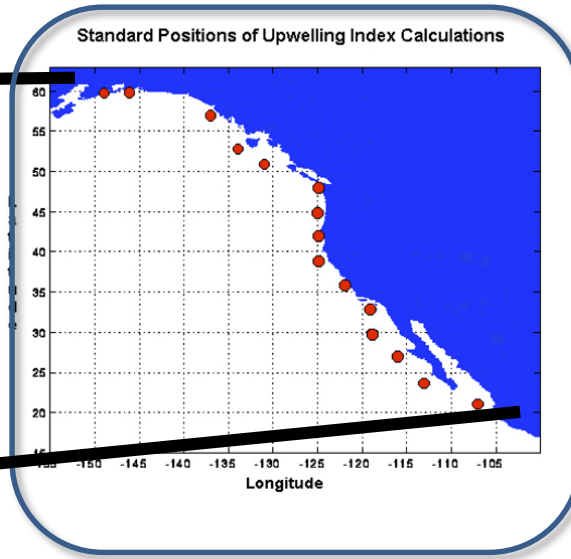


- The PDO has been in a negative phase since Jan 2020 and strengthened with PDOI = -1.0 in Apr 2024.
- Statistically, ENSO leads PDO by 3-4 months, through teleconnection via atmospheric bridge, with El Niño (La Niña) associated with positive (negative) PDO Index.

• 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

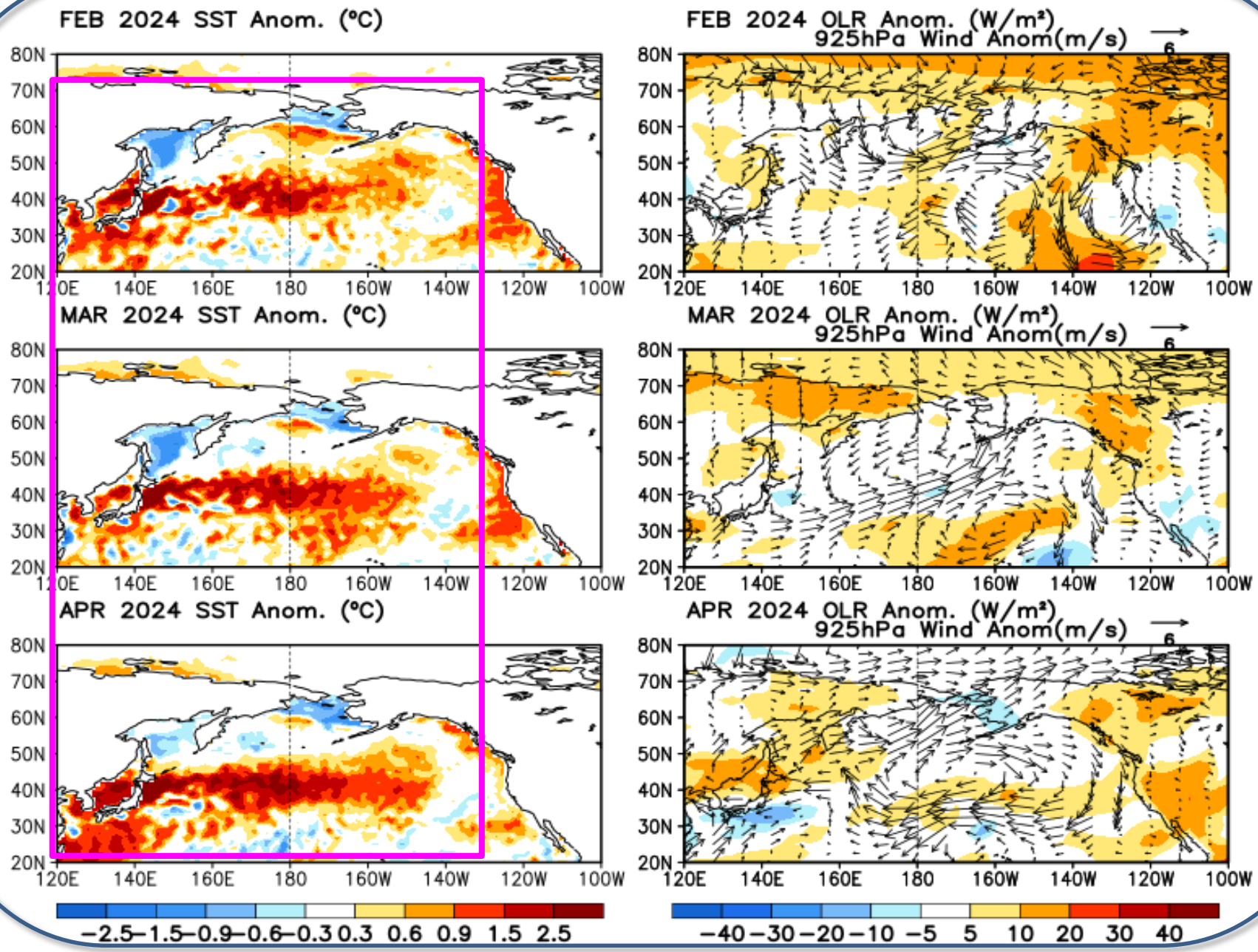




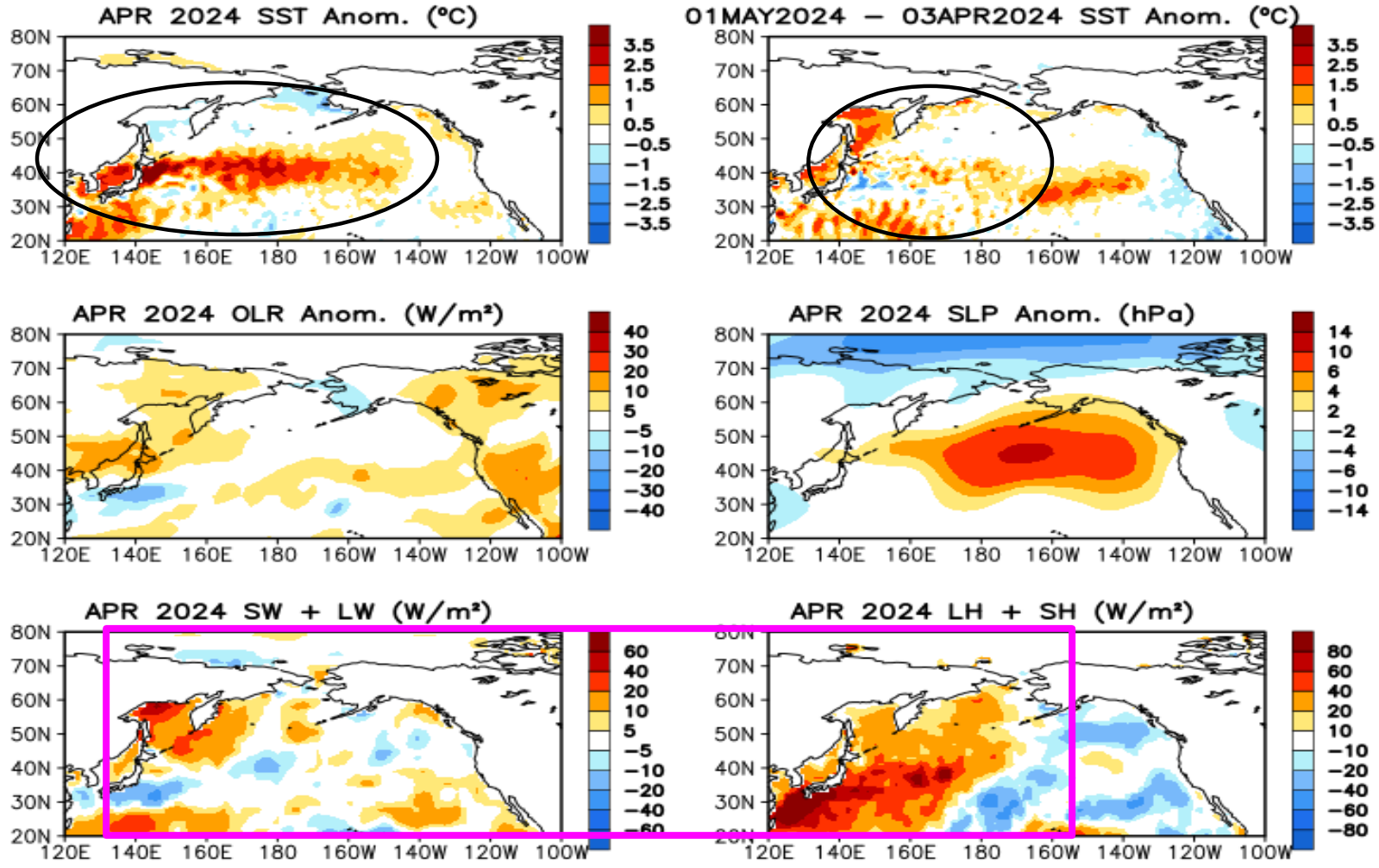
- Anomalous upwelling has been observed in the mid- and high latitudes since mid-March 2024.

(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

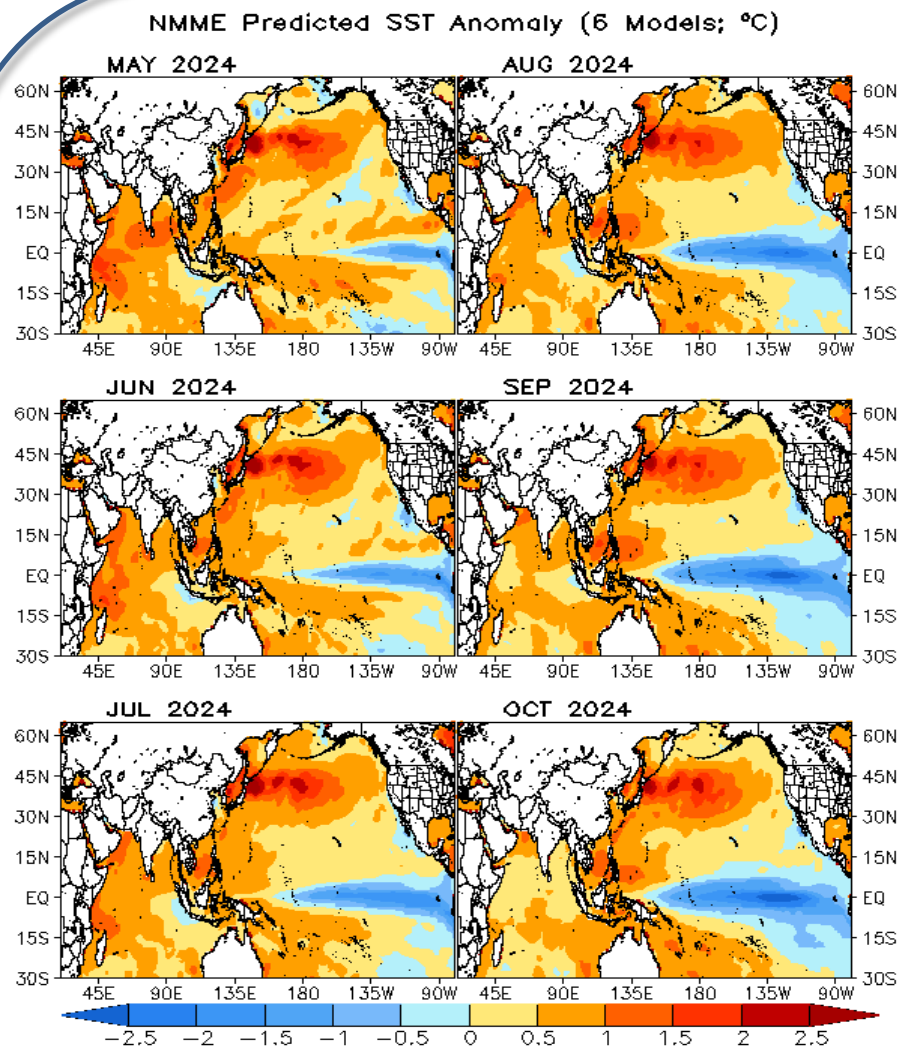


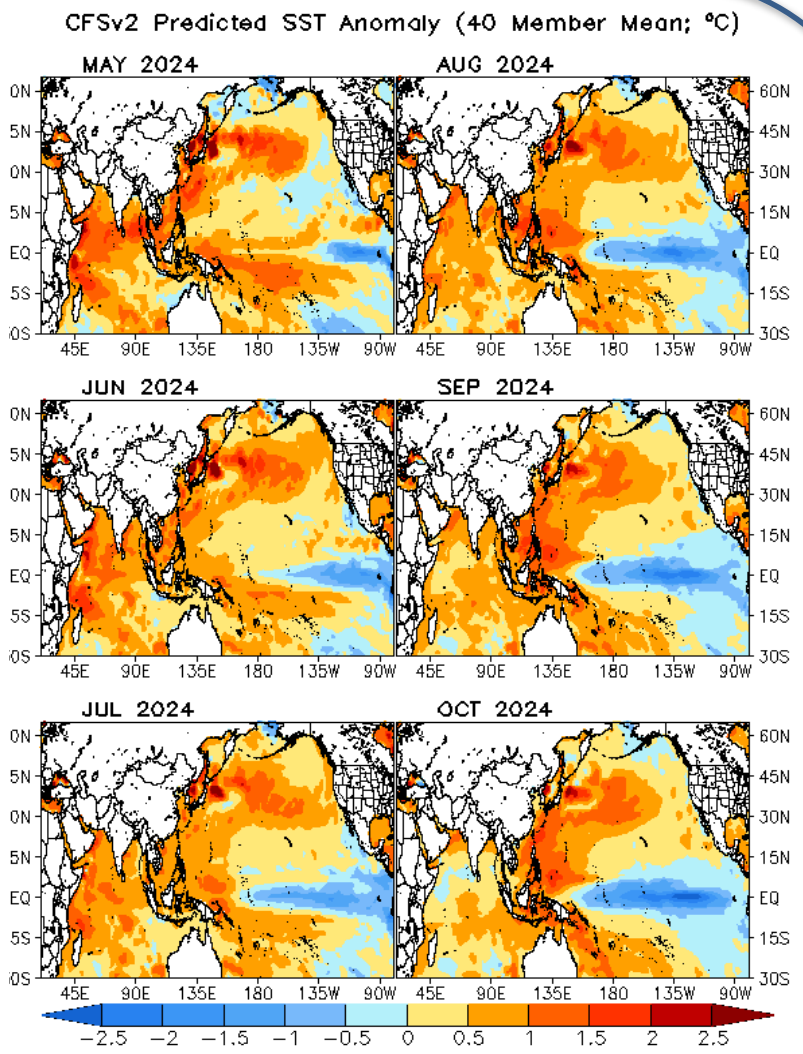
North Pacific Ocean: SSTA, SSTA Tend., OLR, SLP, Sfc Rad, Sfc Flx Anomalies



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.

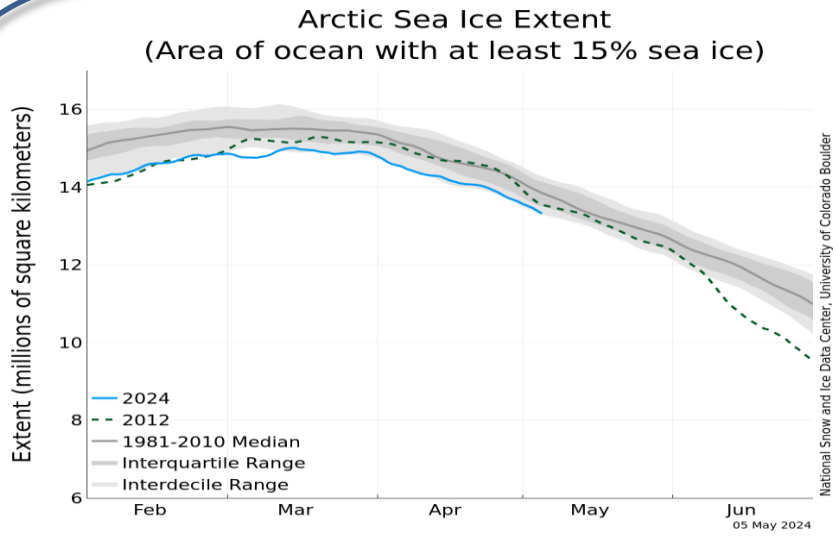
NMME & CFSv2 SSTA Predictions

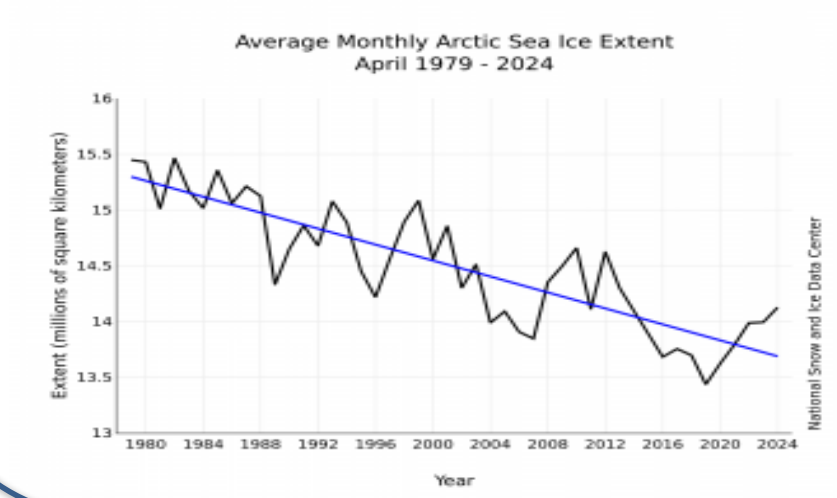


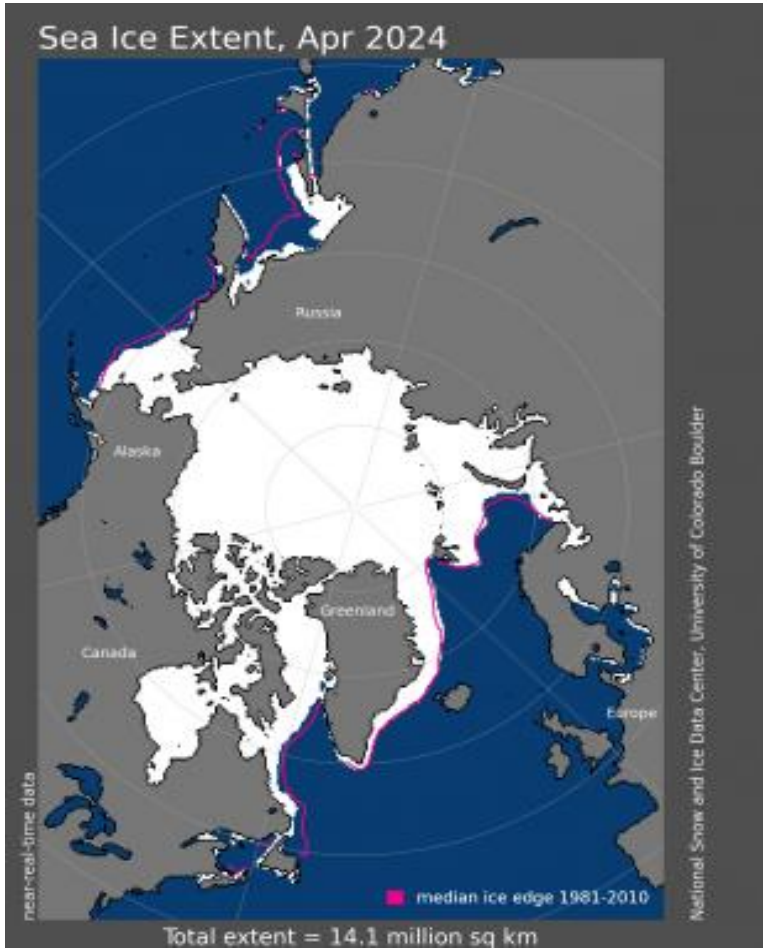


- NMME & CFSv2 predict that the current SST warm condition in the North Pacific will persist or strengthen through fall 2024.

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

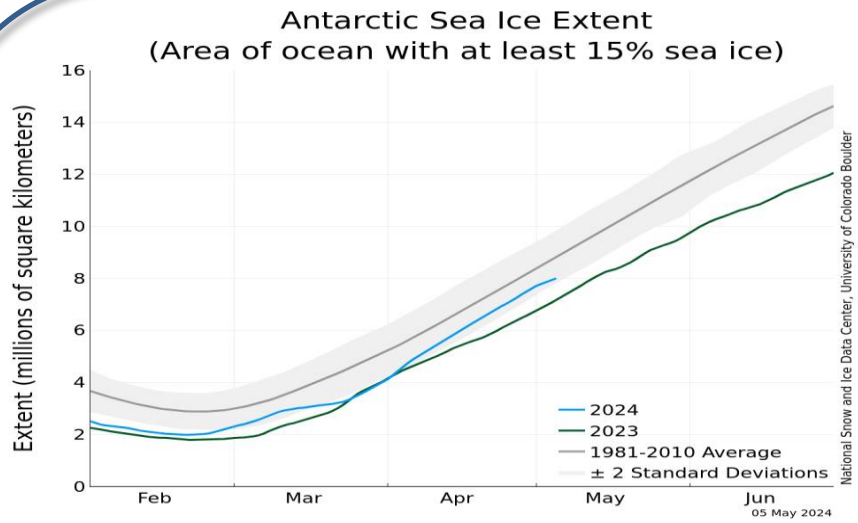


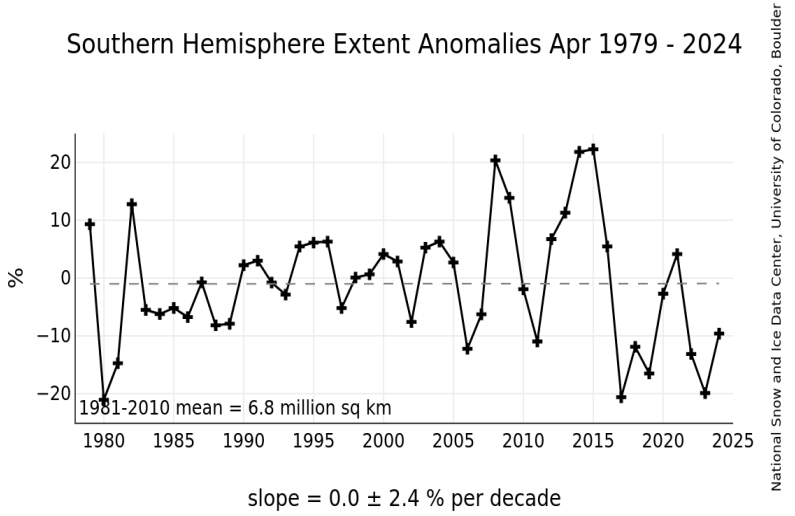


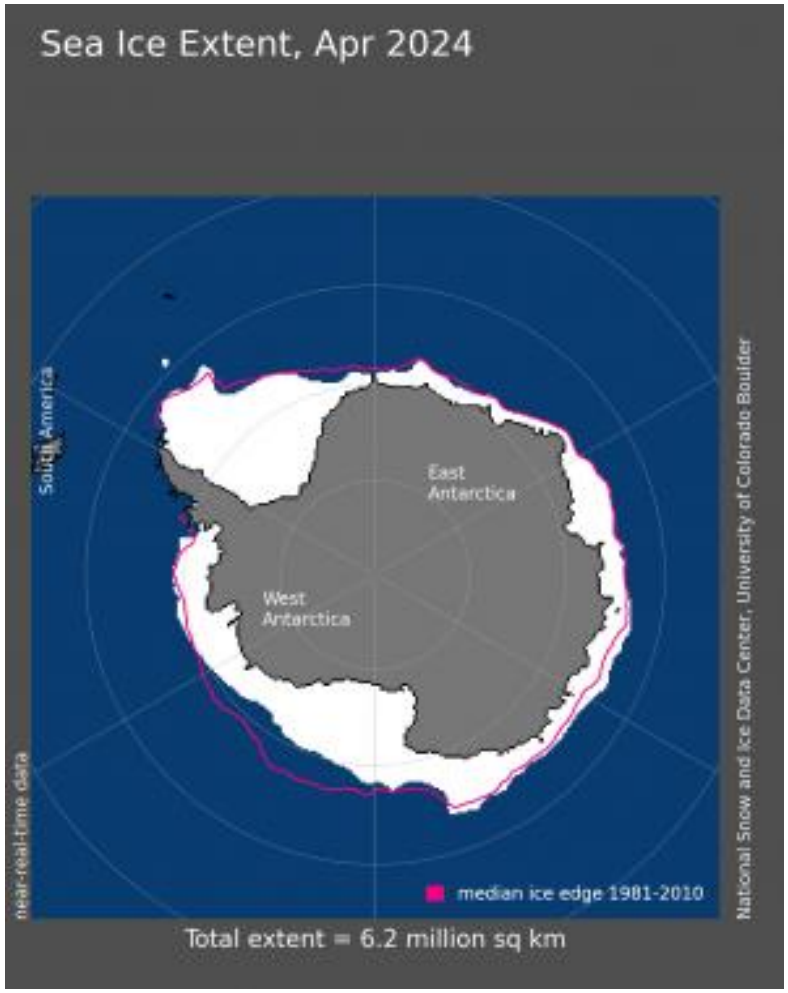


- The average Arctic sea ice extent for Apr 2024 was 14.12 million km^2, placing it 16th lowest in the satellite record in Apr.

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



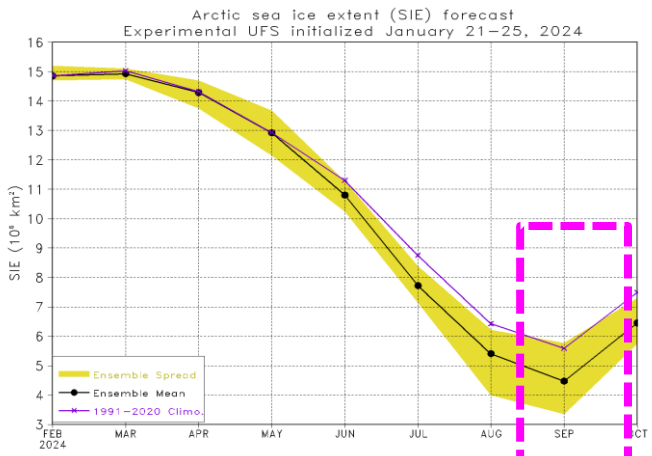


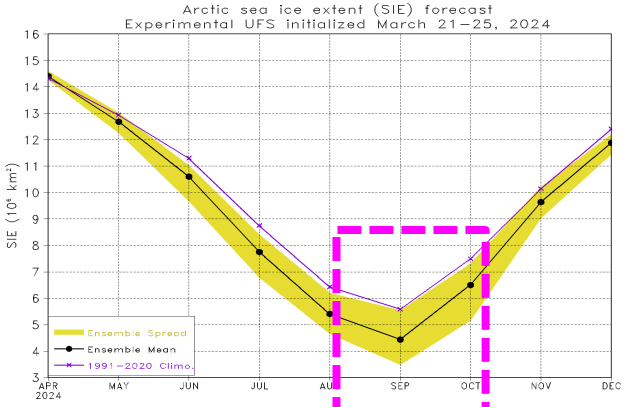


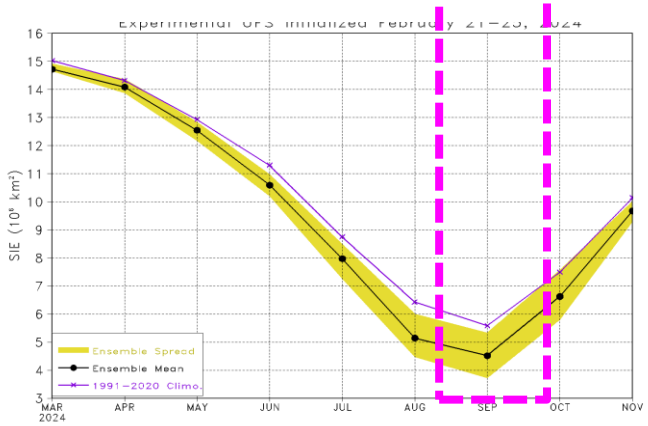
- Antarctic sea ice extent for Apr 2024 was 6.19 million km^2, ranking the 10th-lowest Apr extent since 1979.

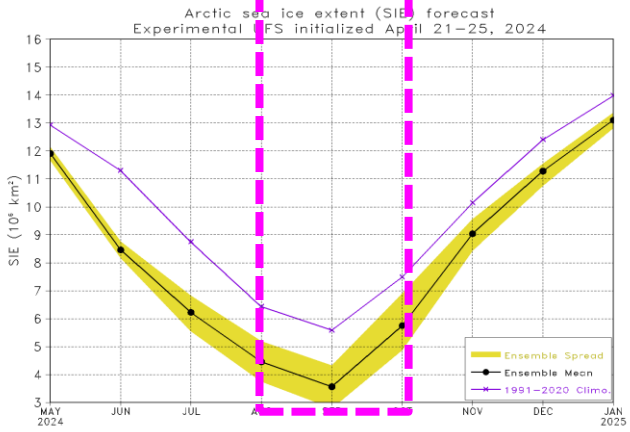
NCEP/CPC Arctic Sea Ice Extent (SIE) Forecast

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





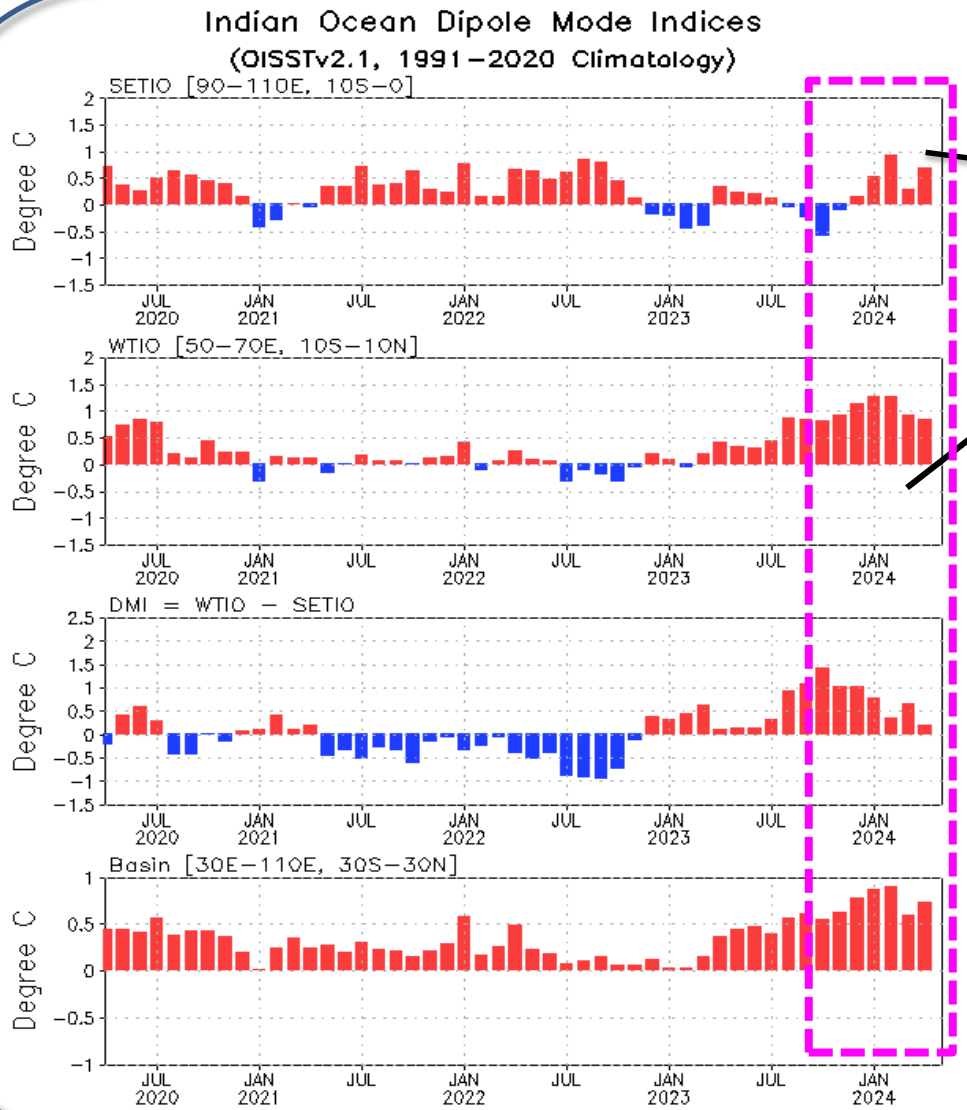


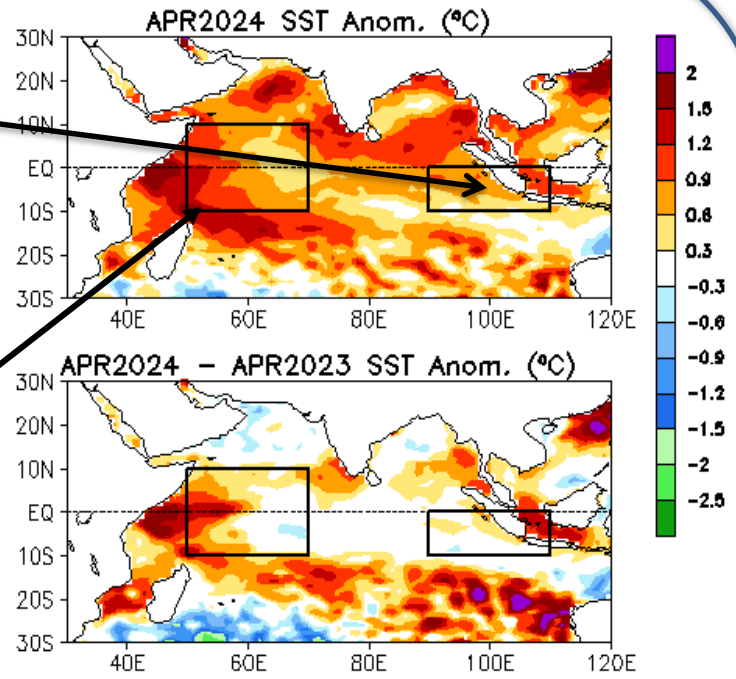


https://www.cpc.ncep.noaa.gov/products/people/jszhu/seaice_seasonal/index.html

Indian Ocean

Evolution of Indian Ocean SST Indices



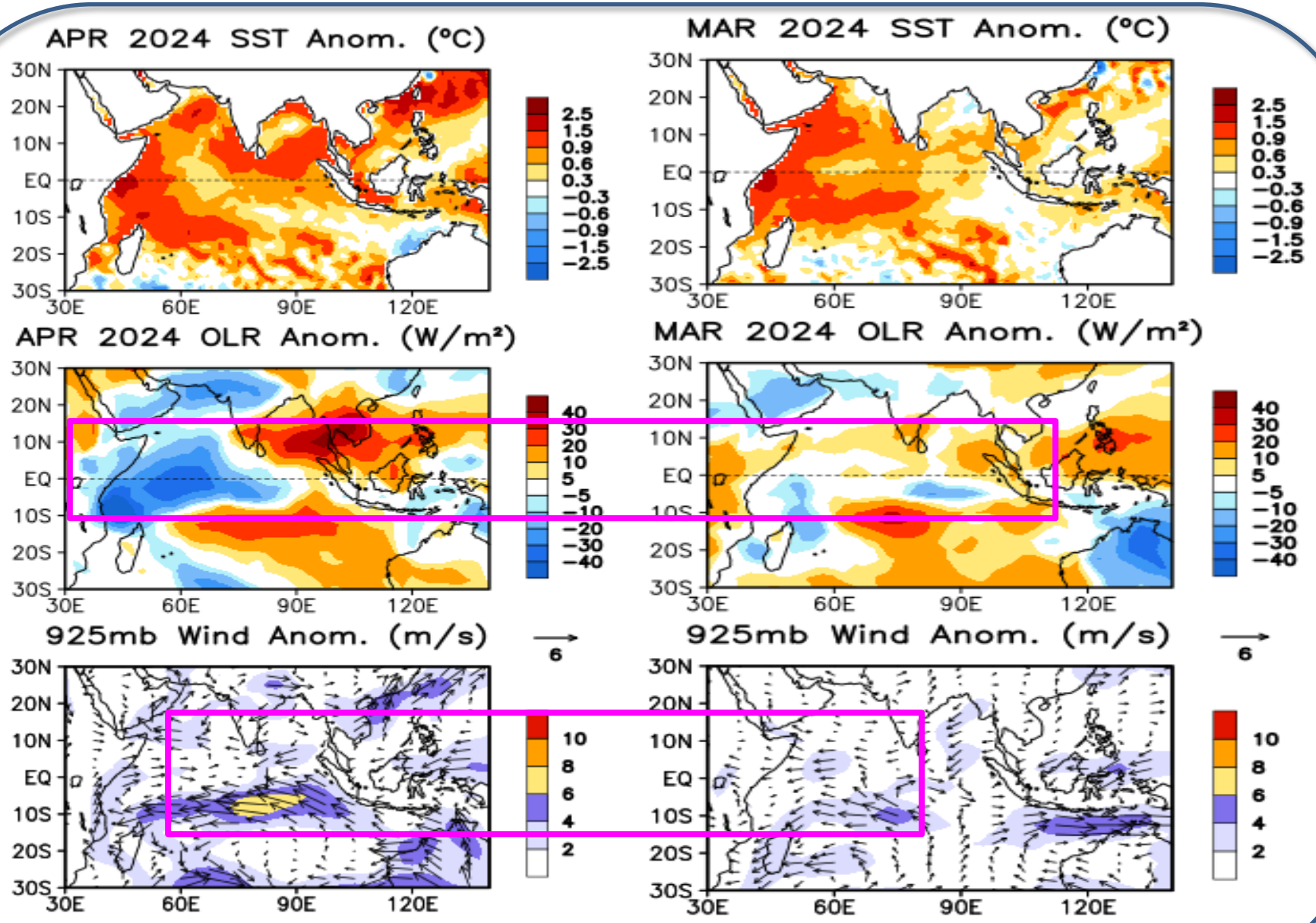


- Positive SSTAs were present in the tropical Indian Ocean with warmer SST in the west in Apr 2024, featuring a positive phase of the IOBM & IOD.

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.

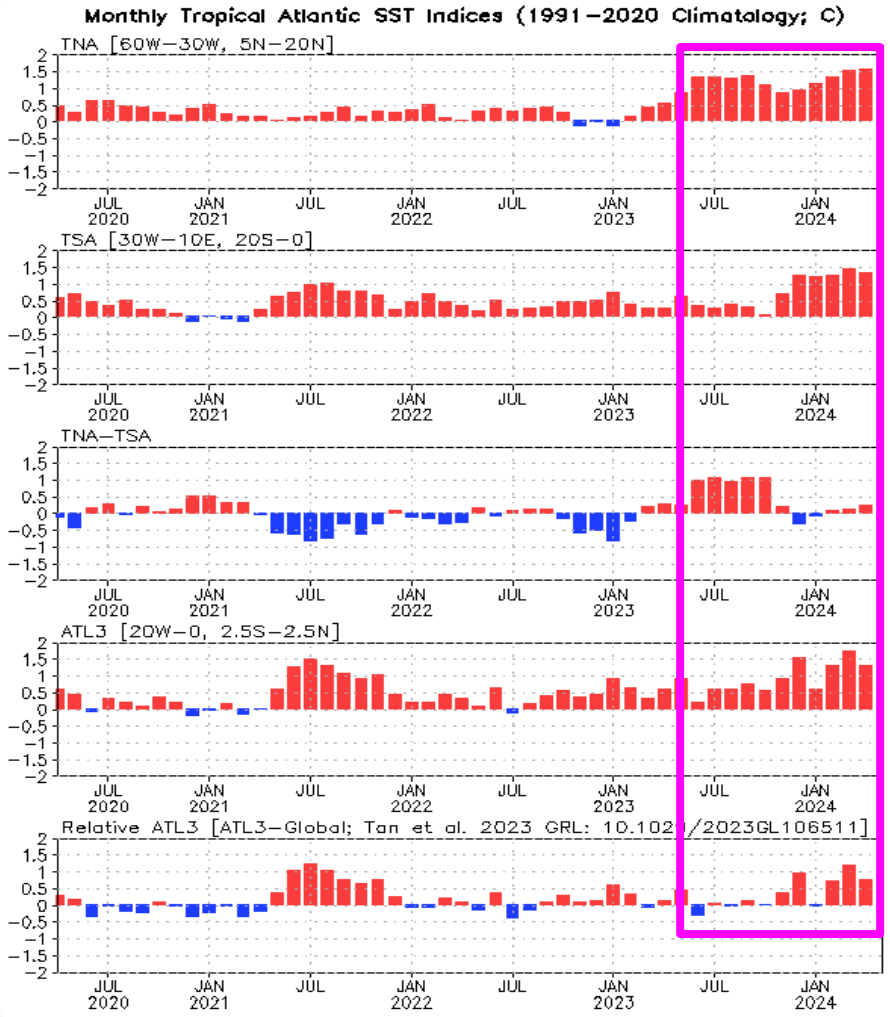
Tropical Indian: SSTA, SSTA Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Wind Anom.

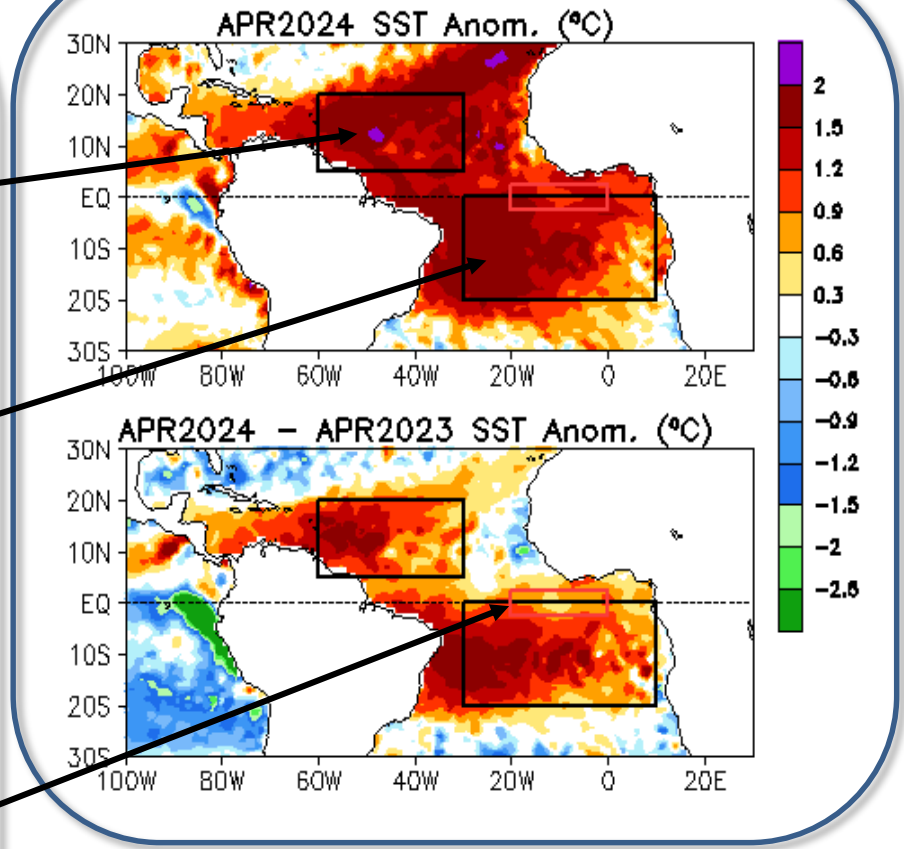
The coupling associated with the IOD enhanced from March to April 2024



Tropical and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

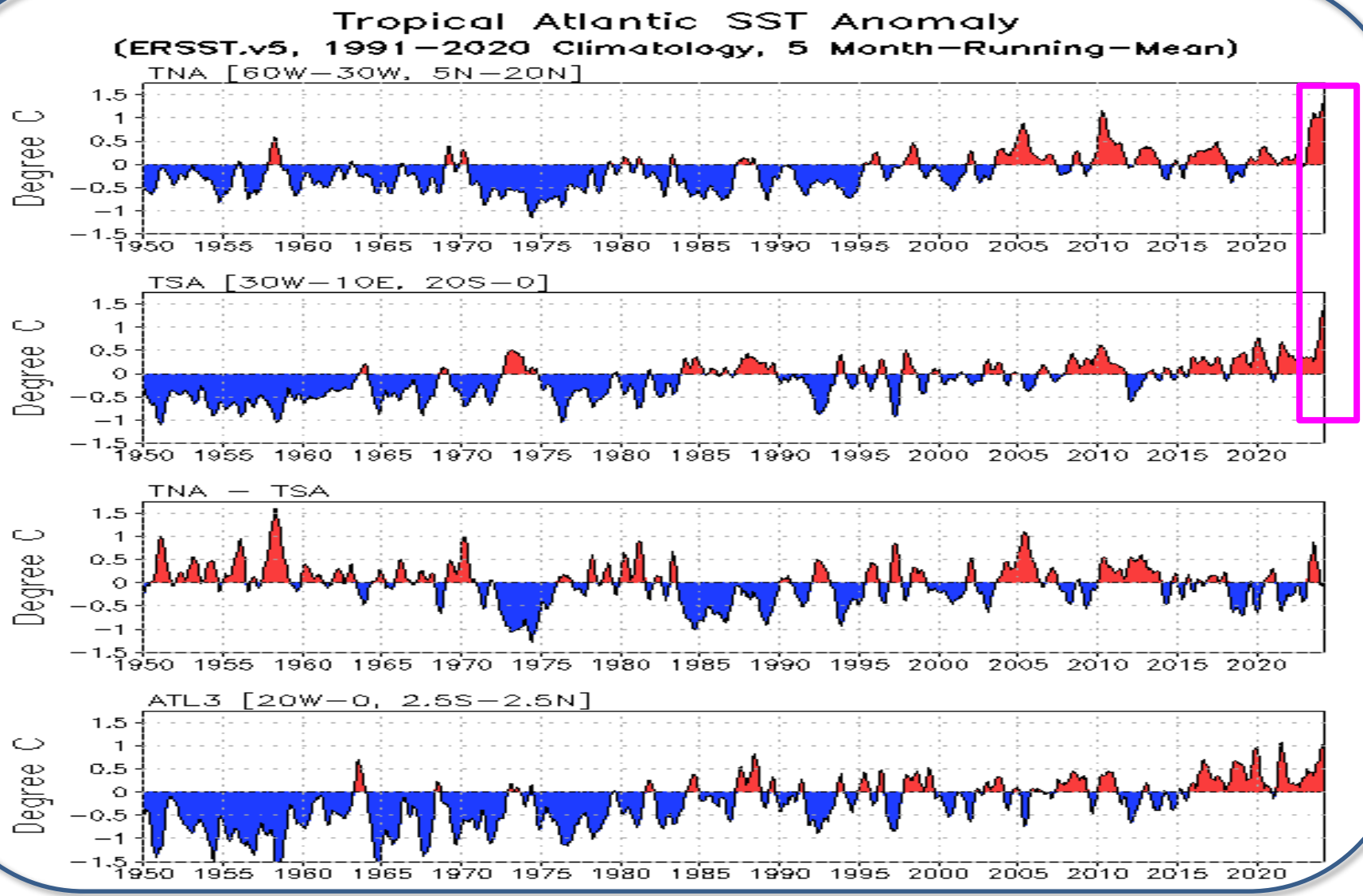




- Large positive SSTAs were observed in the tropical Atlantic in Apr 2024.
- ATL3 (rATL3) index was 1.3°C (0.7°C) in Apr 2024.
- A relative ATL3 (ATL3-Global) index has been included.

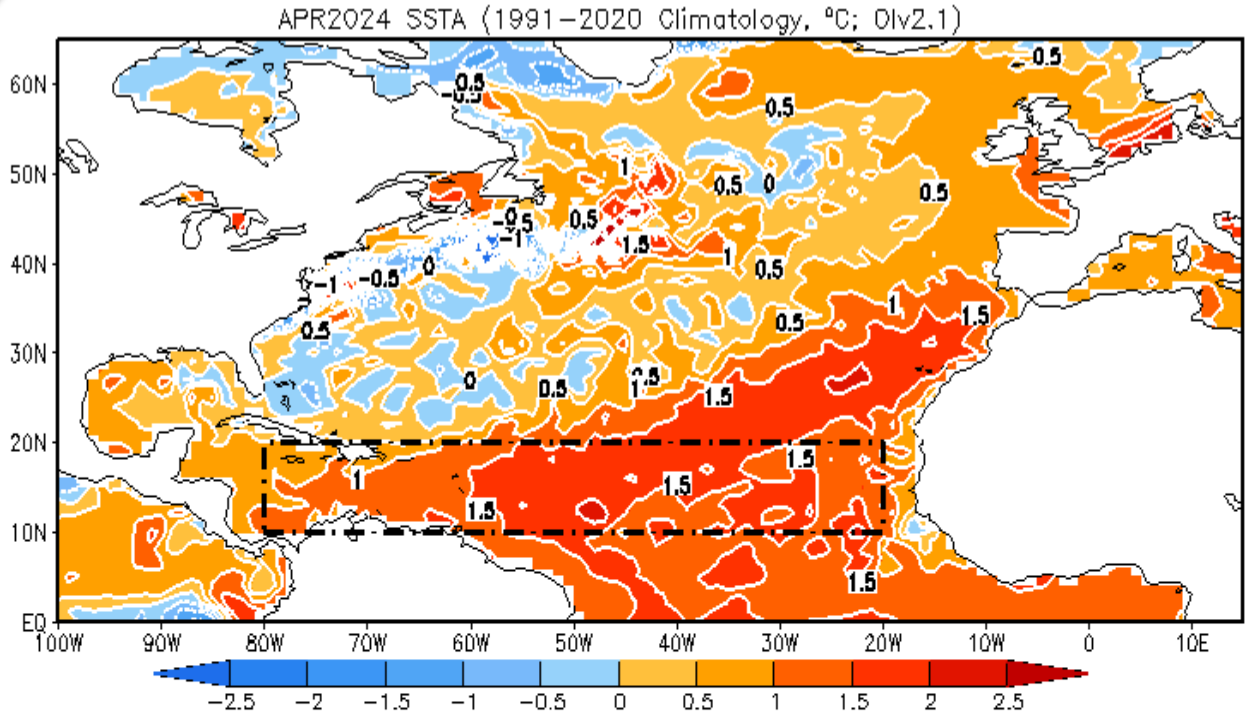
Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean SSTAs (°C) for the TNA [60°W-30°W, 5°N-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between TNA and TSA. Data are derived from the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

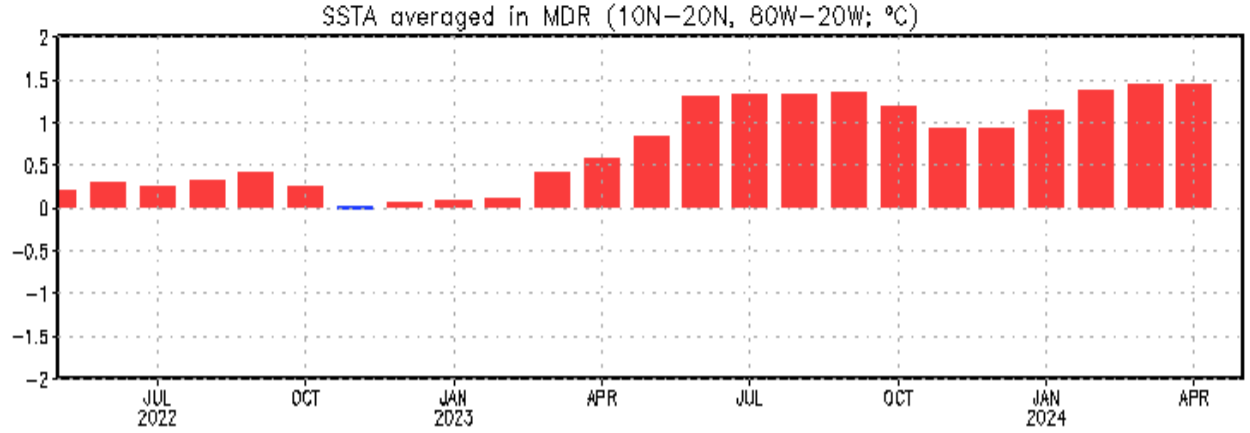
Evolution of Tropical Atlantic SST Indices



Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean SSTAs (^{O}C) for the TNA [60^{O}W-30^{O}W, 5ºN-20^{O}N], TSA [30^{O}W-10^{O}E, 20^{O}S-0] and ATL3 [20^{O}W-0, 2.5^{O}S-2.5^{O}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.

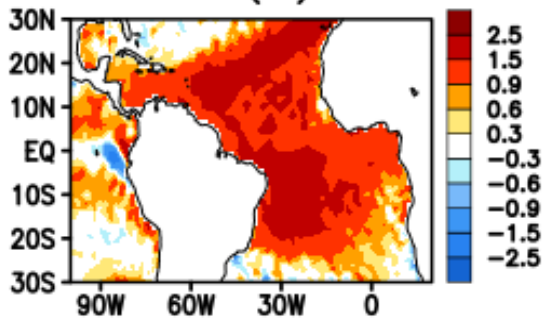
SSTAs in the North Atlantic & MDR

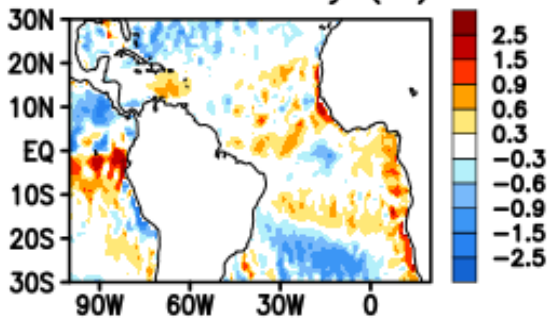


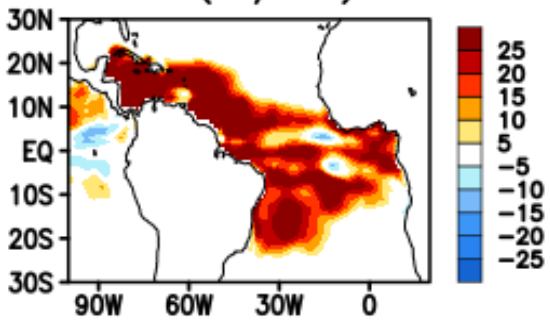


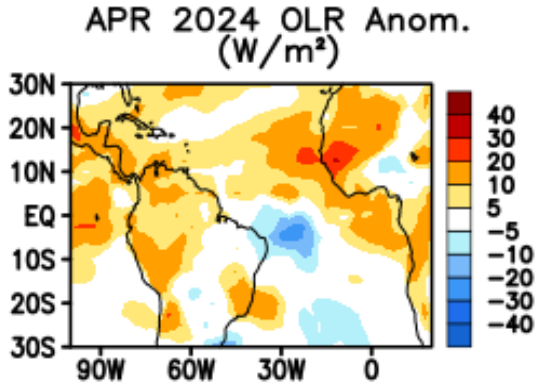
- SST in MDR was above average during the last 17 months.

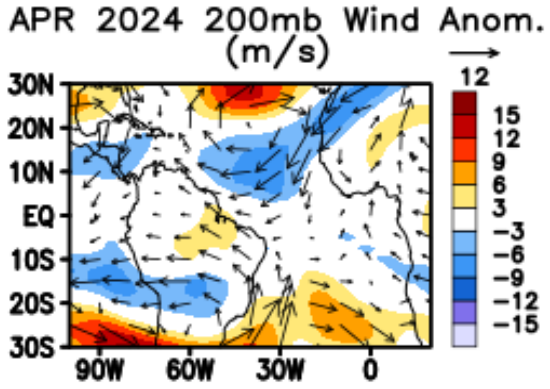
Tropical Atlantic: SST, SST tend., TCHP, OLR, 200 hPa wind, wind share, heat flex, & RH anom.

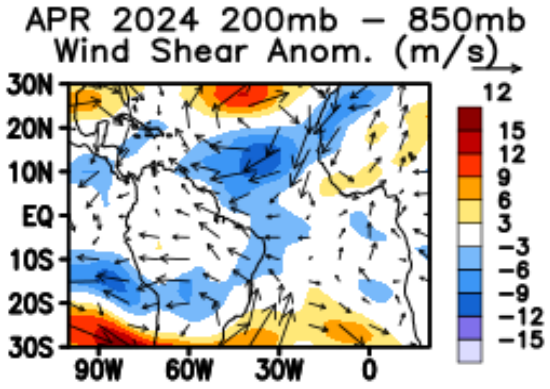


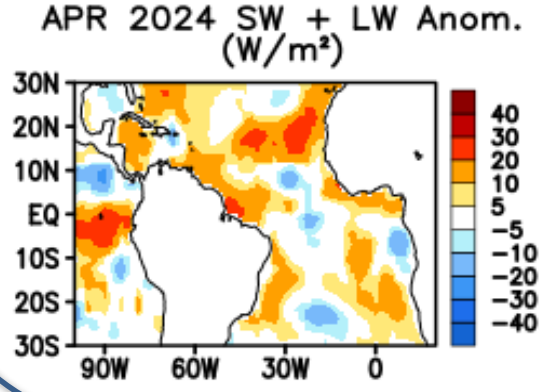


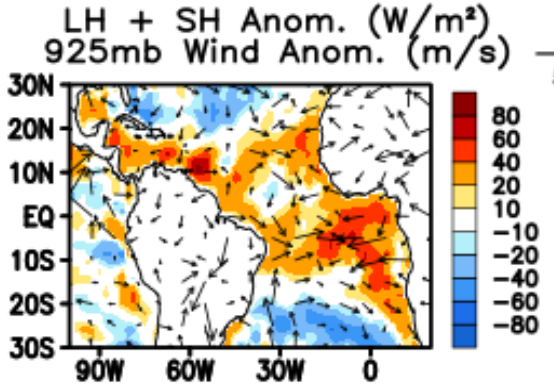


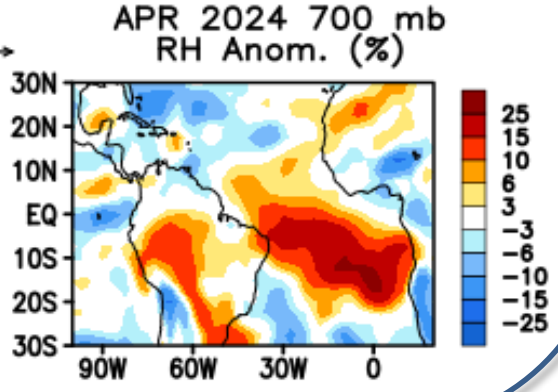




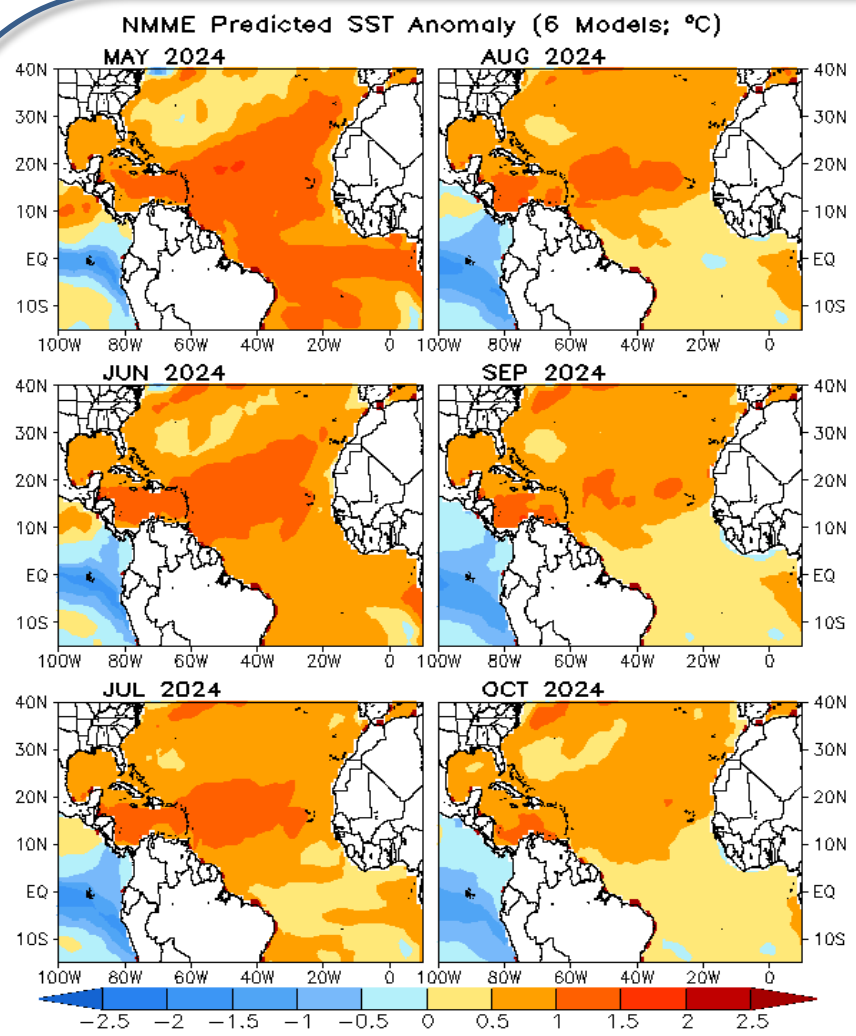


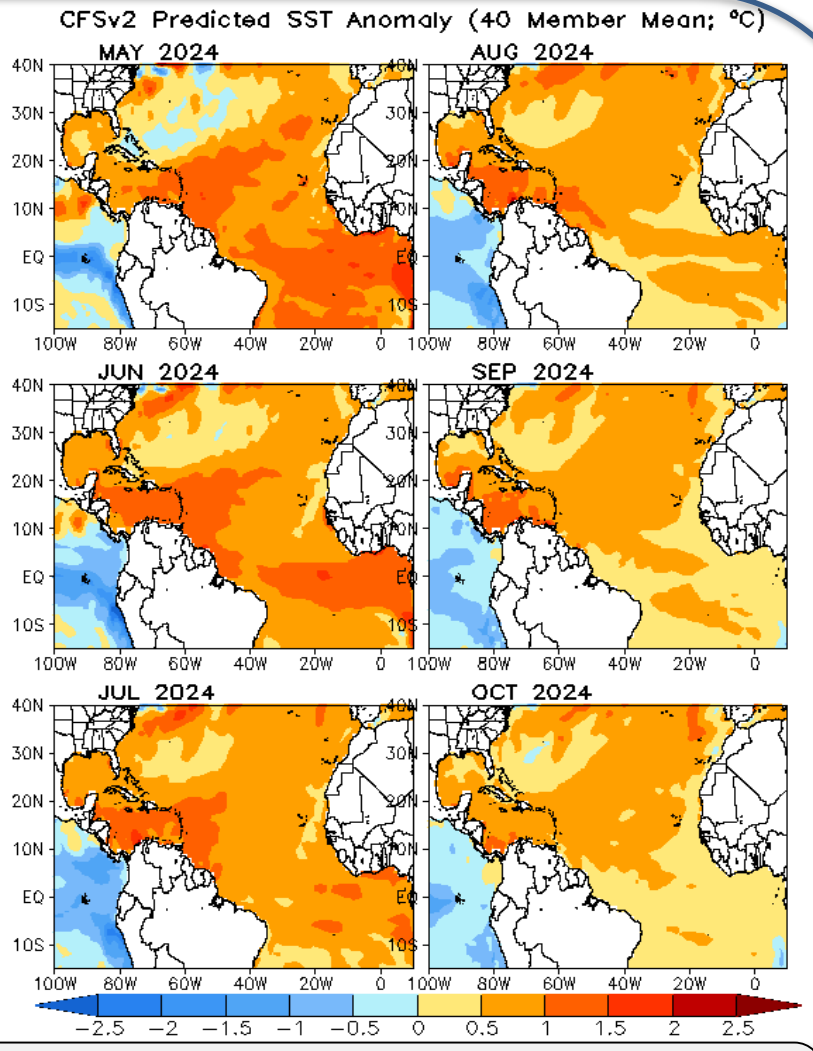






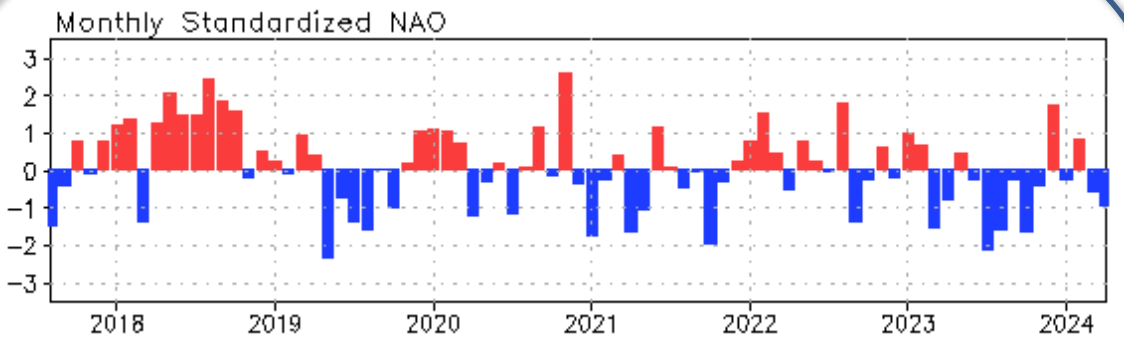
NMME & CFSv2 Atlantic SSTA Predictions

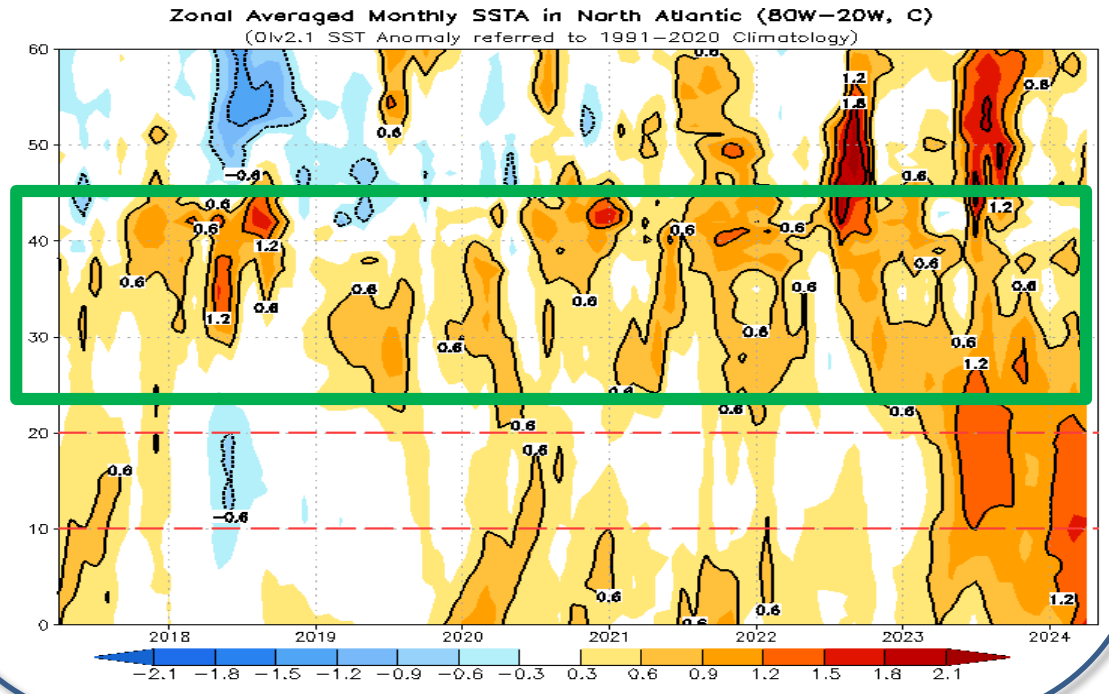


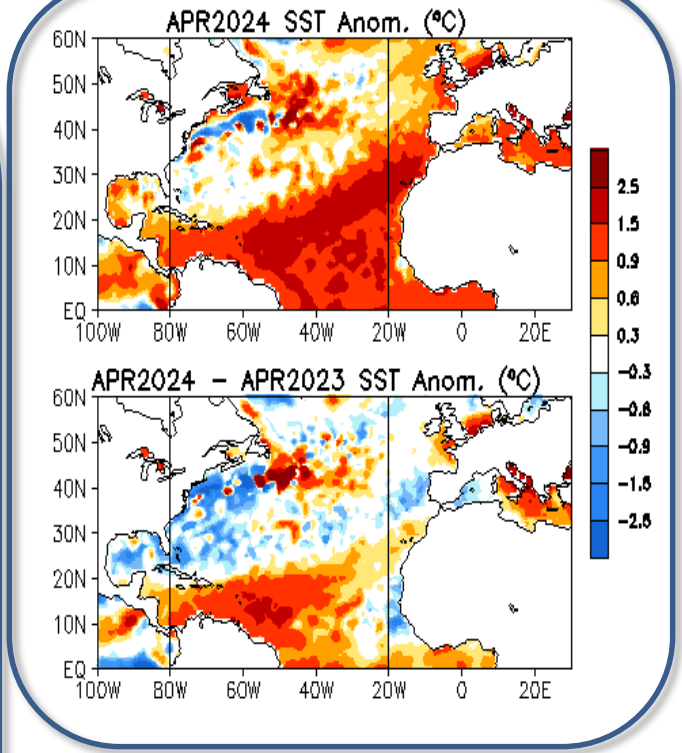


- Latest NMME & CFSv2 predictions indicate that positive SST anomalies in the tropical North Atlantic will weaken in summer-fall 2024.

NAO and SST Anomaly in North Atlantic





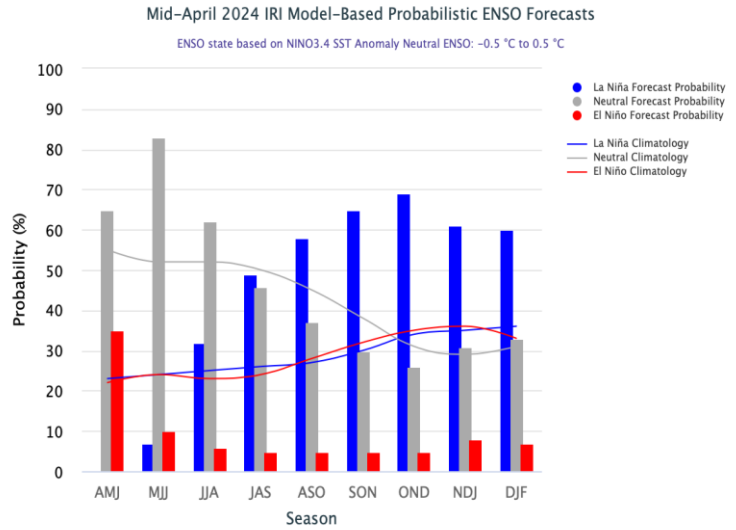


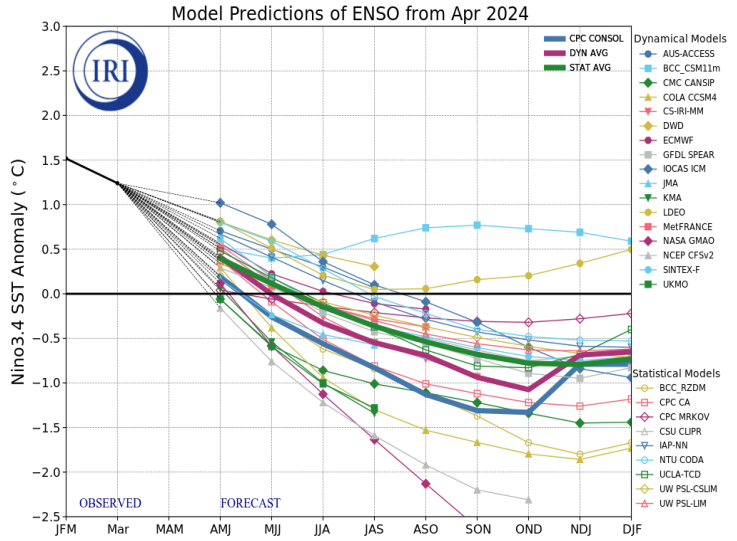
- NAO persisted in a negative phase in Apr 2024 with NAOI = -1.0.
- The prolonged positive SSTAs in the middle latitudes were evident during the last 5-6 years.

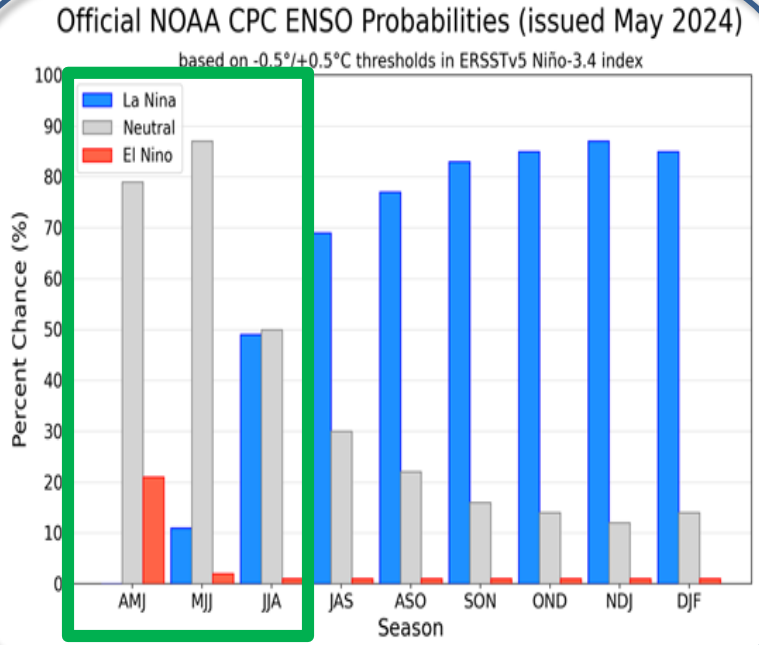
Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20^{O}N-90^{O}N. Time-latitude section of SSTAs averaged between 80ºW and 20ºW (bottom). SST are derived from the OIv2.1 SST analysis, and anomalies are departures from the 1991-2020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

ENSO and Global SST Predictions

CPC & IRI Niño3.4 Forecast



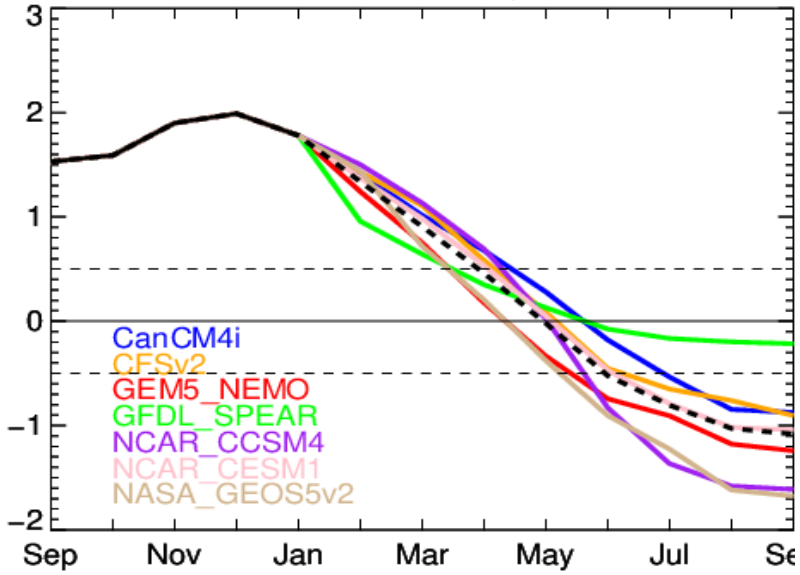


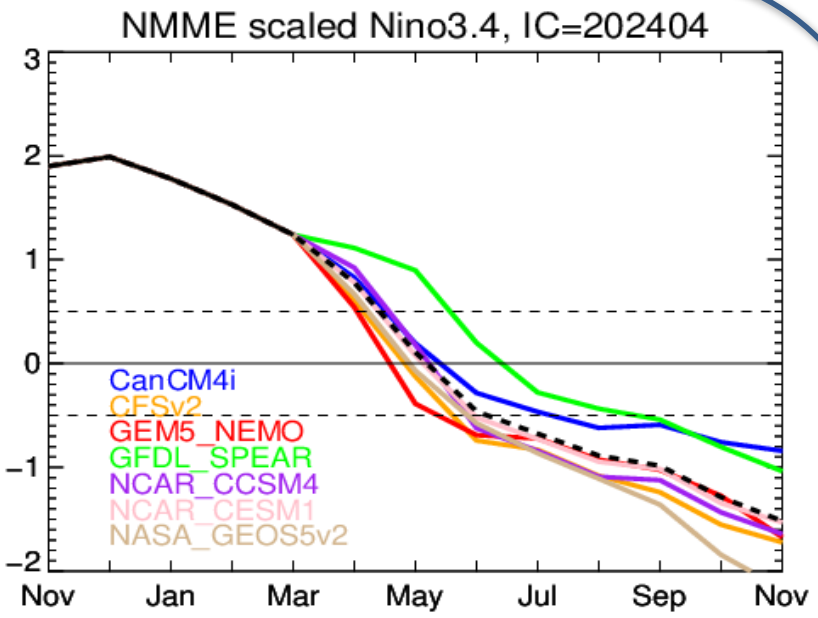


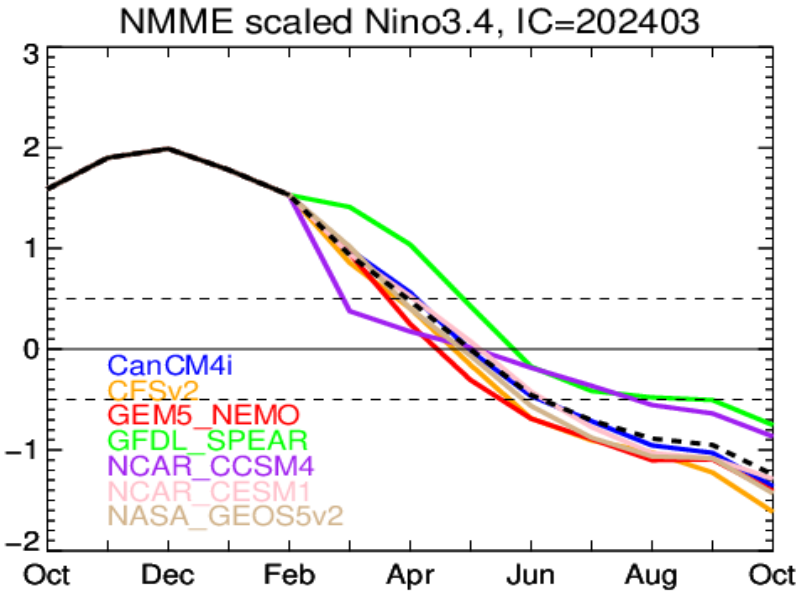
- Model ensemble mean predicts highest probability for ENSO neutral condition from Apr-Jun to Jun-Aug 2024.

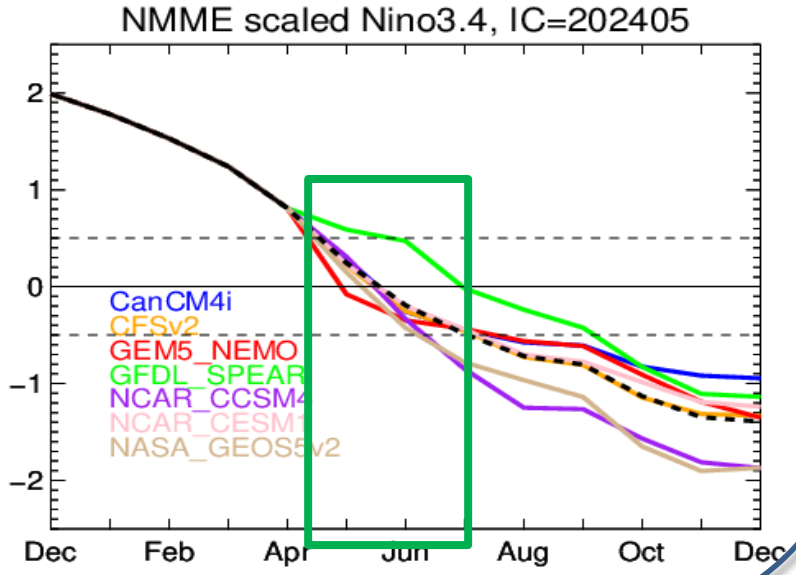
- **On 9 May 2024, CPC continuously issued: El Niño Advisory / La Niña Watch.**
- Synopsis: "*A transition from El Niño to ENSO-neutral is likely in the next month. La Niña may develop in June-August (49% chance) or July-September (69% chance).*"

NMME forecasts from different initial conditions



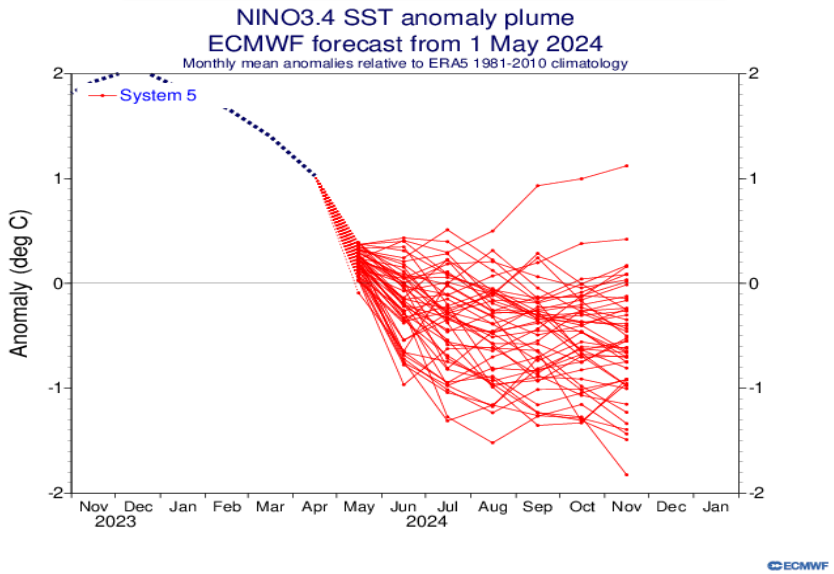




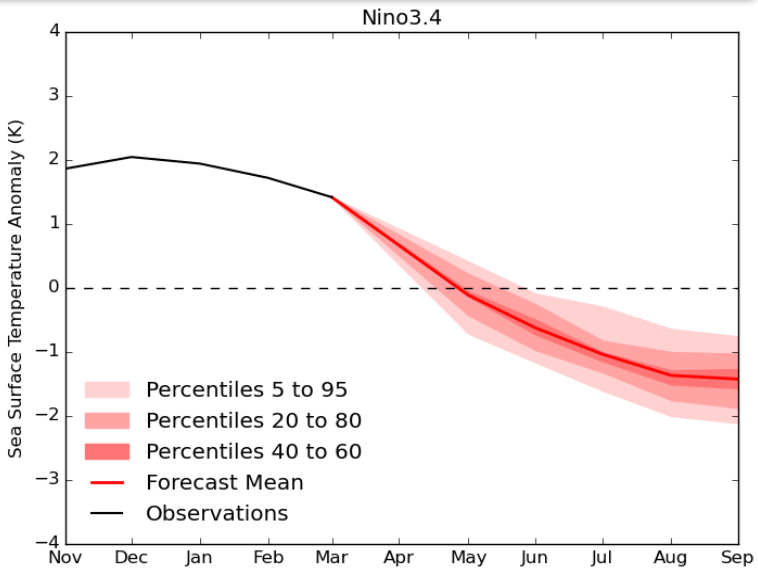


Individual Model Forecasts: El Niño transitions to neutral or La Niña in Summer 2024

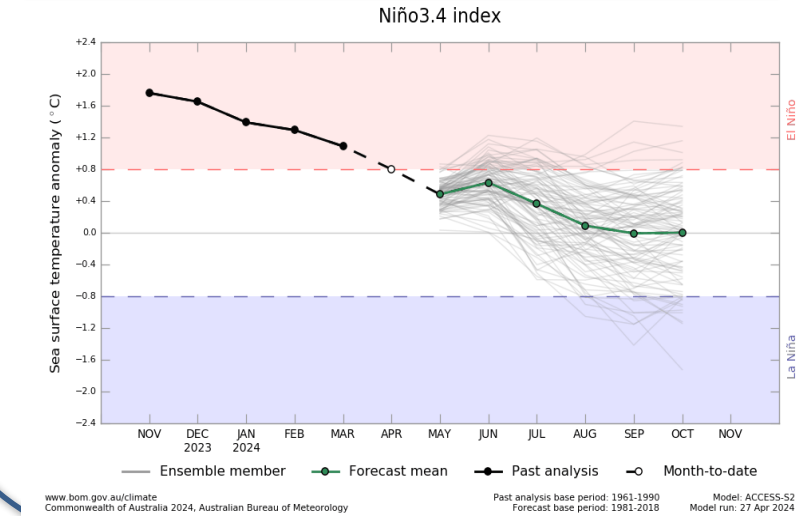
EC: Niño3.4, IC= 1 May 2024



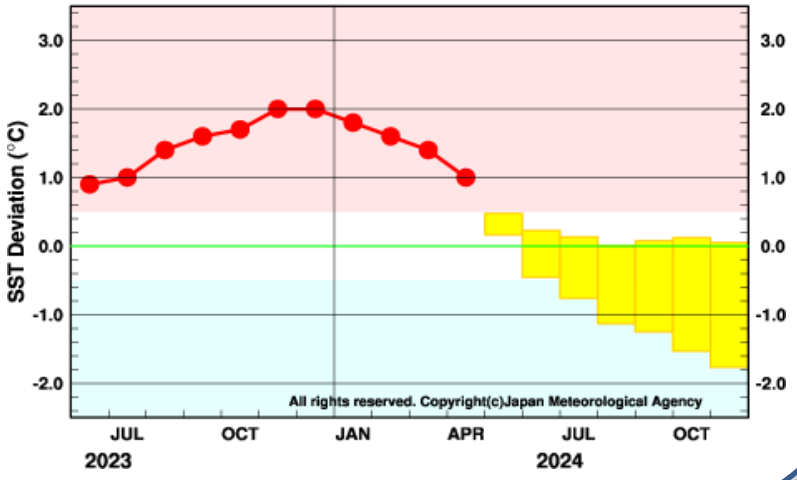
UKMO: Niño3.4, Updated 11 Apr 2024



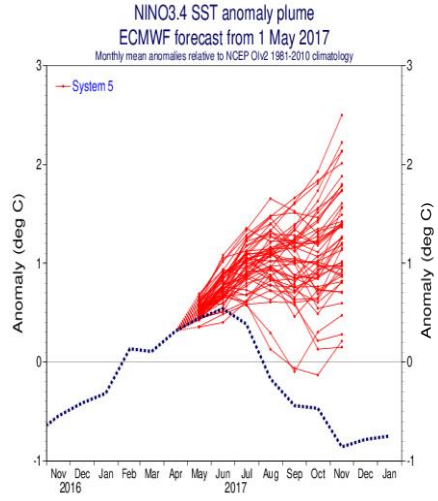
BOM: Niño3.4, Updated 27 Apr 2024

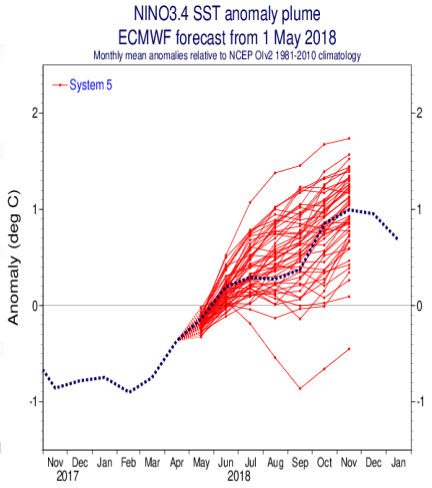


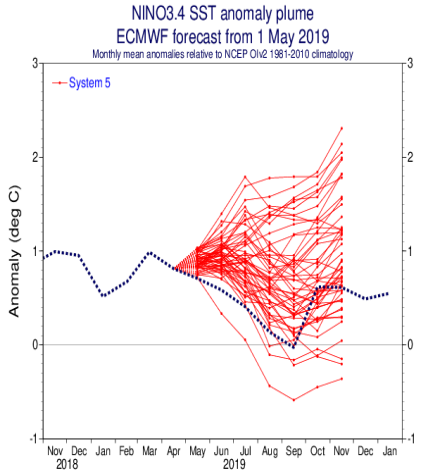
JMA: Niño3.4, Updated 10 May 2024

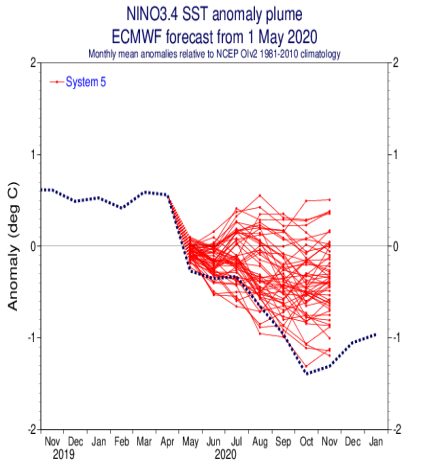


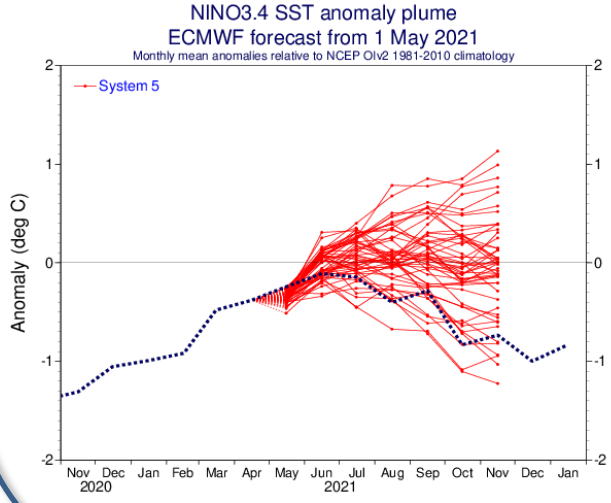
ECMWF Forecasts with IC in May since 2017: Warm Biases

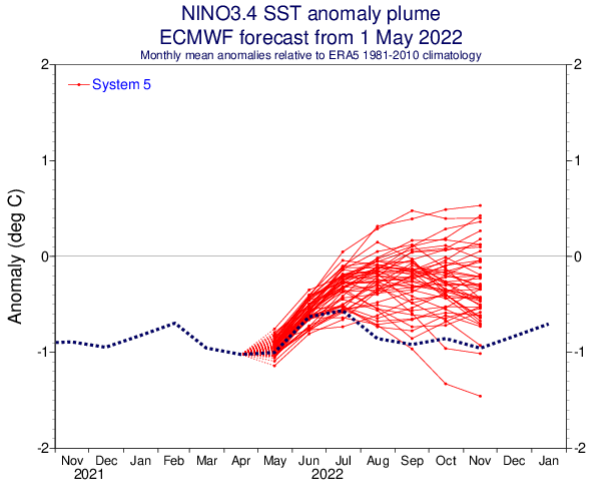


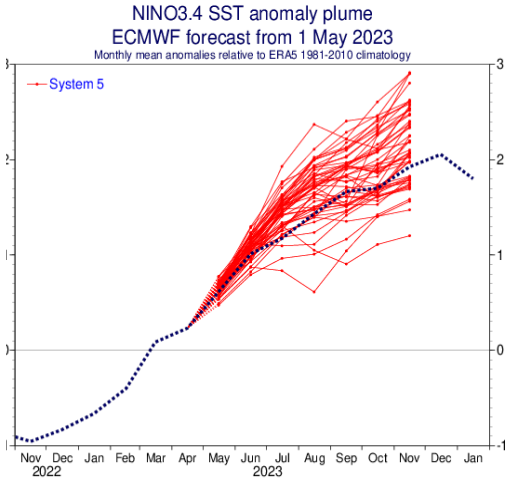












Availability of TAO data affects ENSO prediction skill

Control (with TAO) is closer to OBS than NoTAO

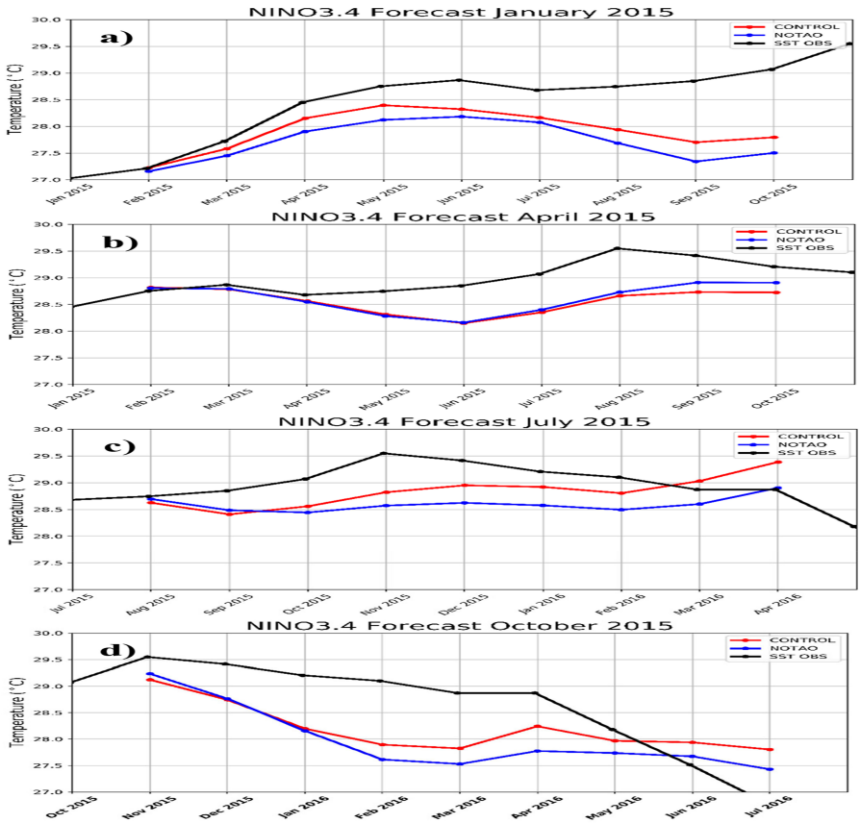


Fig. 6: Ensemble mean of Niño3.4 SST values for (a) Jan, (a) Apr, (c) Jul, and (d) Oct 2015. Red, blue, and black show results for CONTROL, NOTAO and observations, respectively.

Shoaled mixed layer depth amplifies the El Niño signal leading to improved ENSO forecasts.

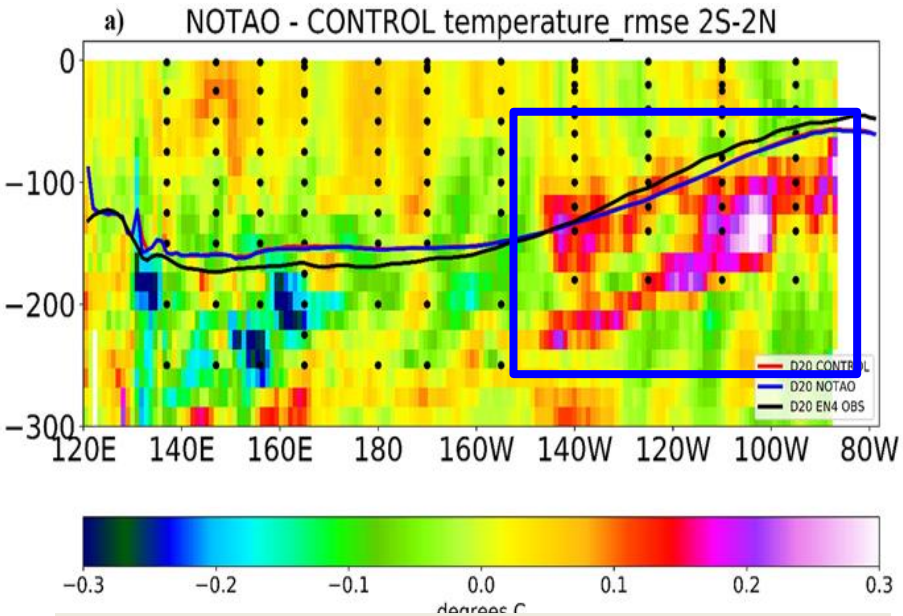
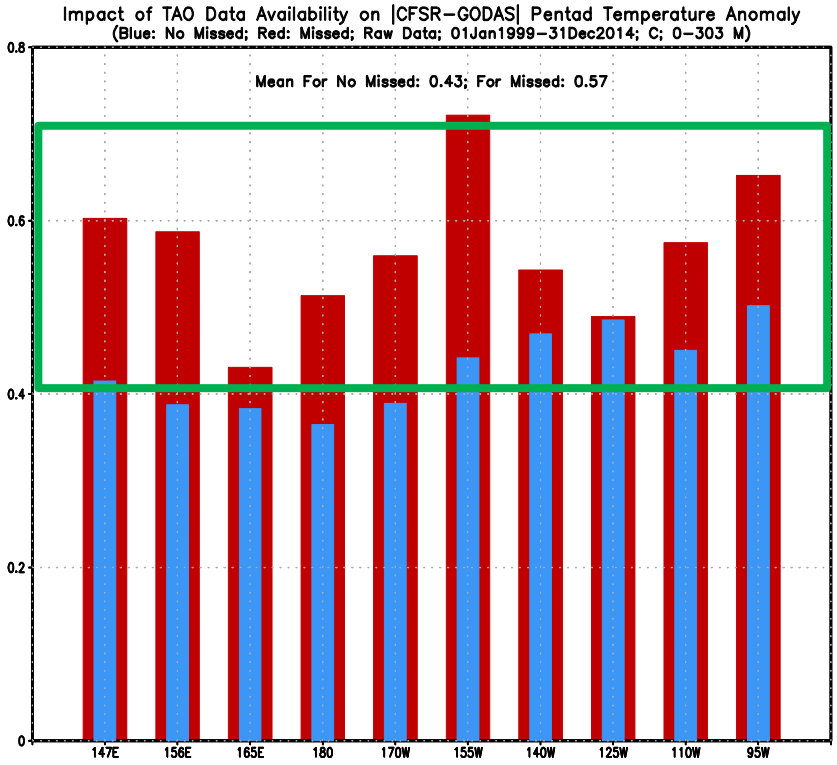


Fig. 5: Depth vs. longitude of the 2N-2S average RMSE of NOTAO vs. EN4 minus CONTROL vs. EN4 for (a) temperature, and (b) salinity. Positive values indicate regions where TAO assimilation improves the statistics. Solid blue, red and black lines illustrate the mean depth of the 20°C isotherm, representing the depth of the thermocline. Here the TAO sensor locations from Jan 2015 are shown as dots to be representative of data coverage for the entire period.

Hackert, E., Akella, S., Ren, L., Nakada, K., Carton, J. A., & Molod, A. (2023). Impact of the TAO/TRITON array on reanalyses and predictions of the 2015 El Niño. JGR: Oceans, 128, e2023JC020039. DOI: 10.1029/2023JC020039.

Less TAO observation data, less reliable of reanalysis data

Impact of availability of TAO observations on pentad mean OTA differences |CFSR-GODAS| averaged 5-303m: Differences are mainly along the thermocline **Differences are larger when TAO observations unavailable than available**



Hu & Kumar, 2015: Influence of availability of TAO data on NCEP ocean data assimilation systems along the equatorial Pacific. JGR (Ocean), 120, 5534-5544. DOI: 10.1002/2015JC010913.

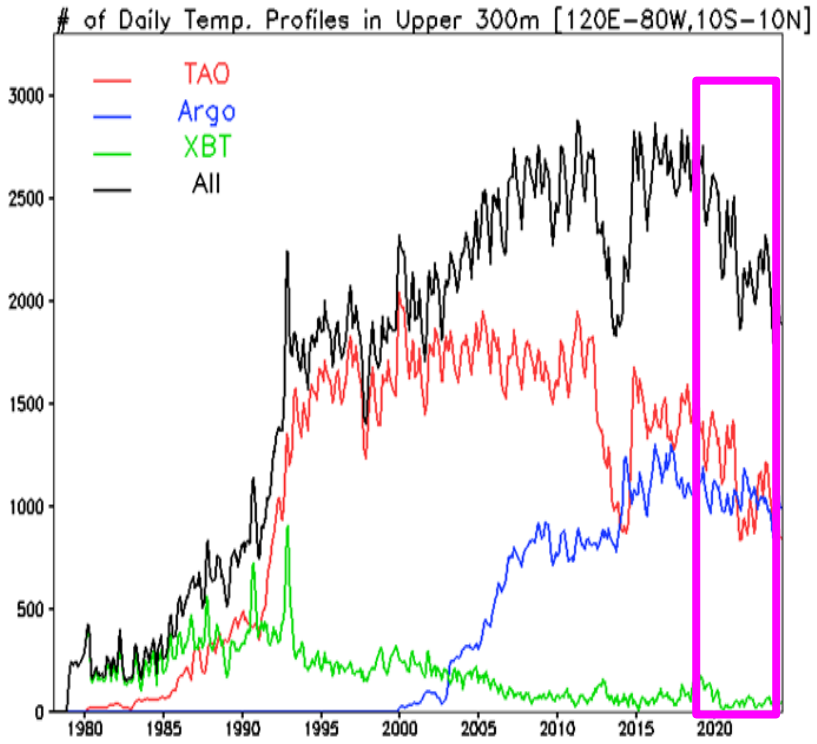


Fig. 9: Time series of the number of daily ocean temperature profiles per month accumulated in the tropical Pacific from the Tropical Atmosphere Ocean/Triangle Trans-Ocean Buoy Network (TAO/TRITON; red line), Argo (blue line), the Expendable Bathythermograph (XBT; green line), and TAO/TRITON/Argo/XBT together (black line) since Jan 1979.

Hu, et al., 2022: Global ocean monitoring and forecast at NOAA Climate Prediction Center: 15 Years of Operations. BAMS, 103 (12), E2701–E2718. DOI: 10.1175/BAMS-D-22-0056.1.

ENSO prediction skill is linked to its predictability, IC quality, & model fidelity

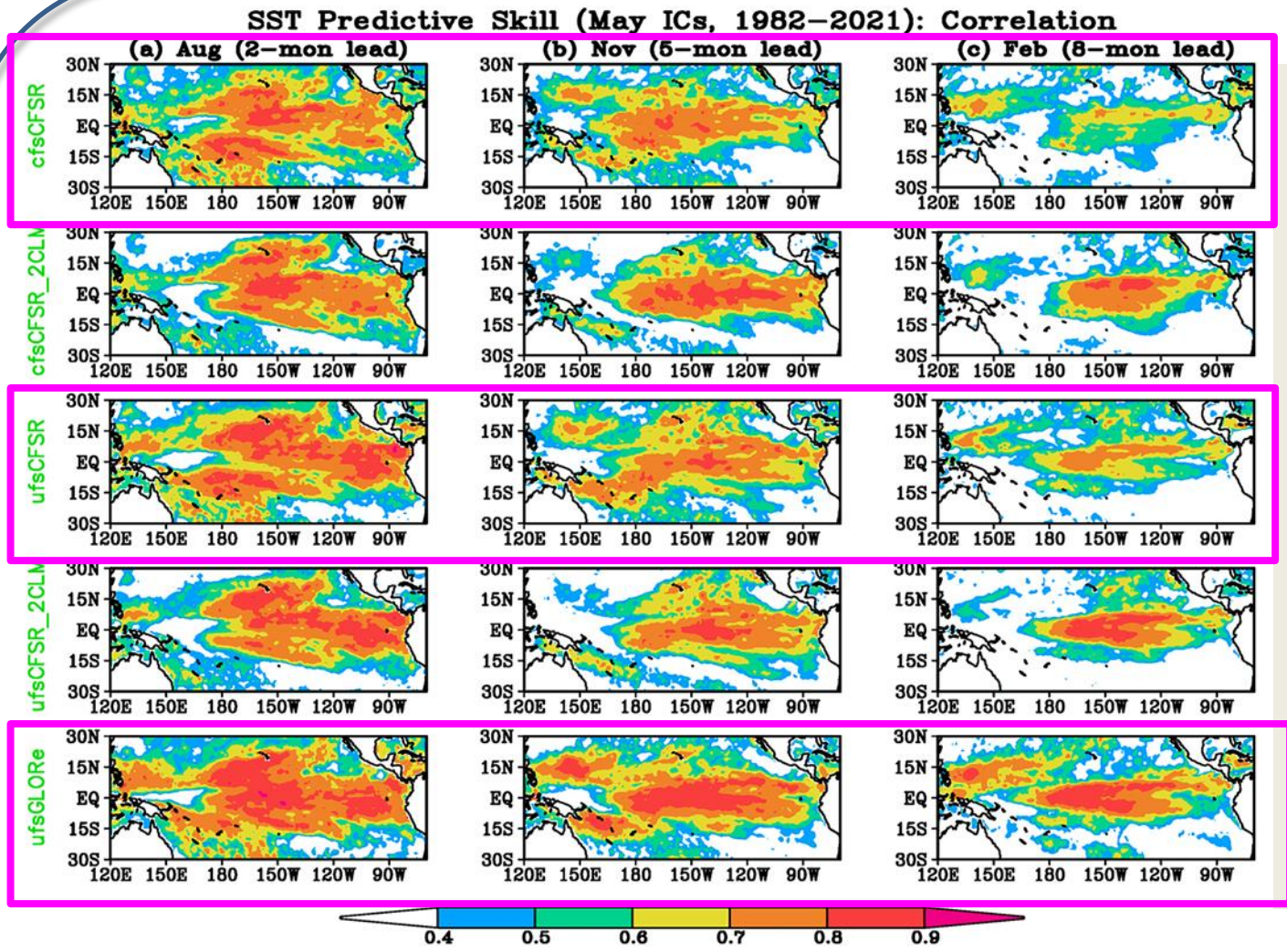
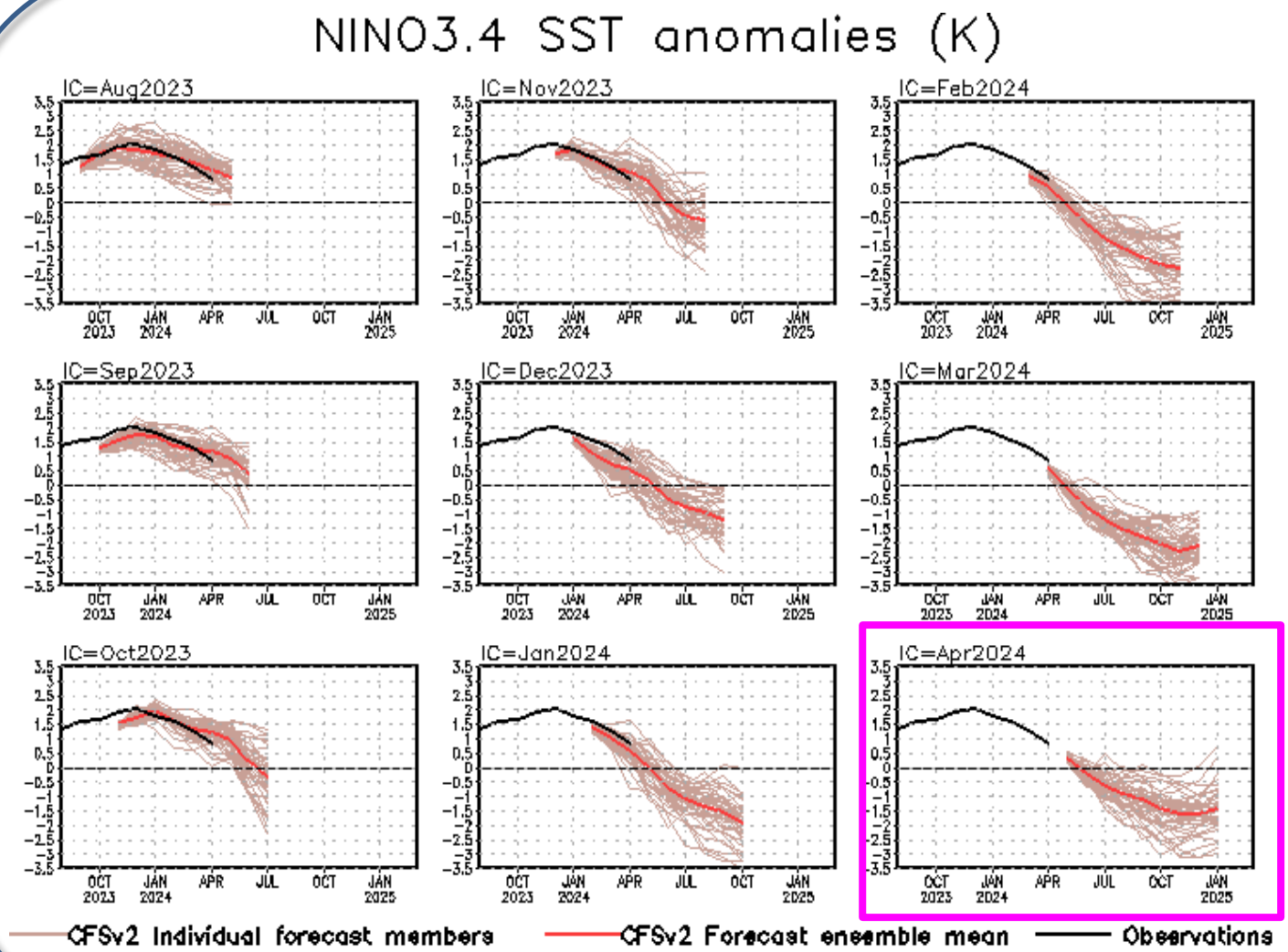


Fig. 1: Distribution of anomaly correlations between observed and predicted SST anomalies at (a) 2-, (b) 5-, and (c) 8-month lead times with being shown in the first, second and third column, respectively. From the top to bottom row are respectively shown for cfsCFSR, cfsCFSR_2CLM, ufsCFSR, ufsCFSR_2CLM and ufsGLORe. The hindcasts start from the May initial conditions during 1982–2021.

Zhu, J., Wang, W., Kumar, A., Liu, Y., & D. DeWitt, 2024: Assessment of a new global ocean reanalysis in ENSO predictions with NOAA UFS. GRL, 51, e2023GL106640. DOI: 10.1029/2023GL106640

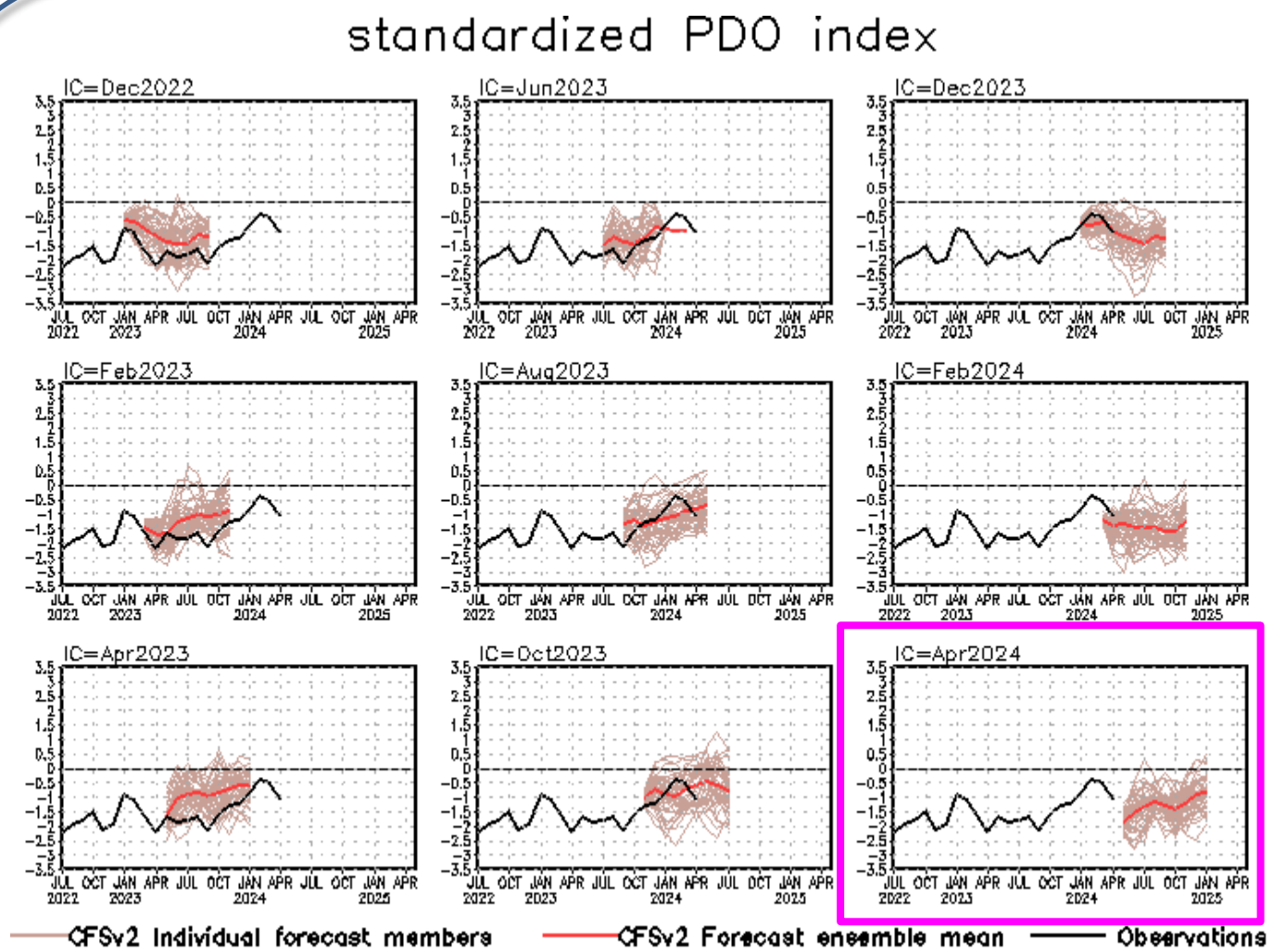
CFS Niño3.4 SST Predictions from Different Initial Months



- 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.

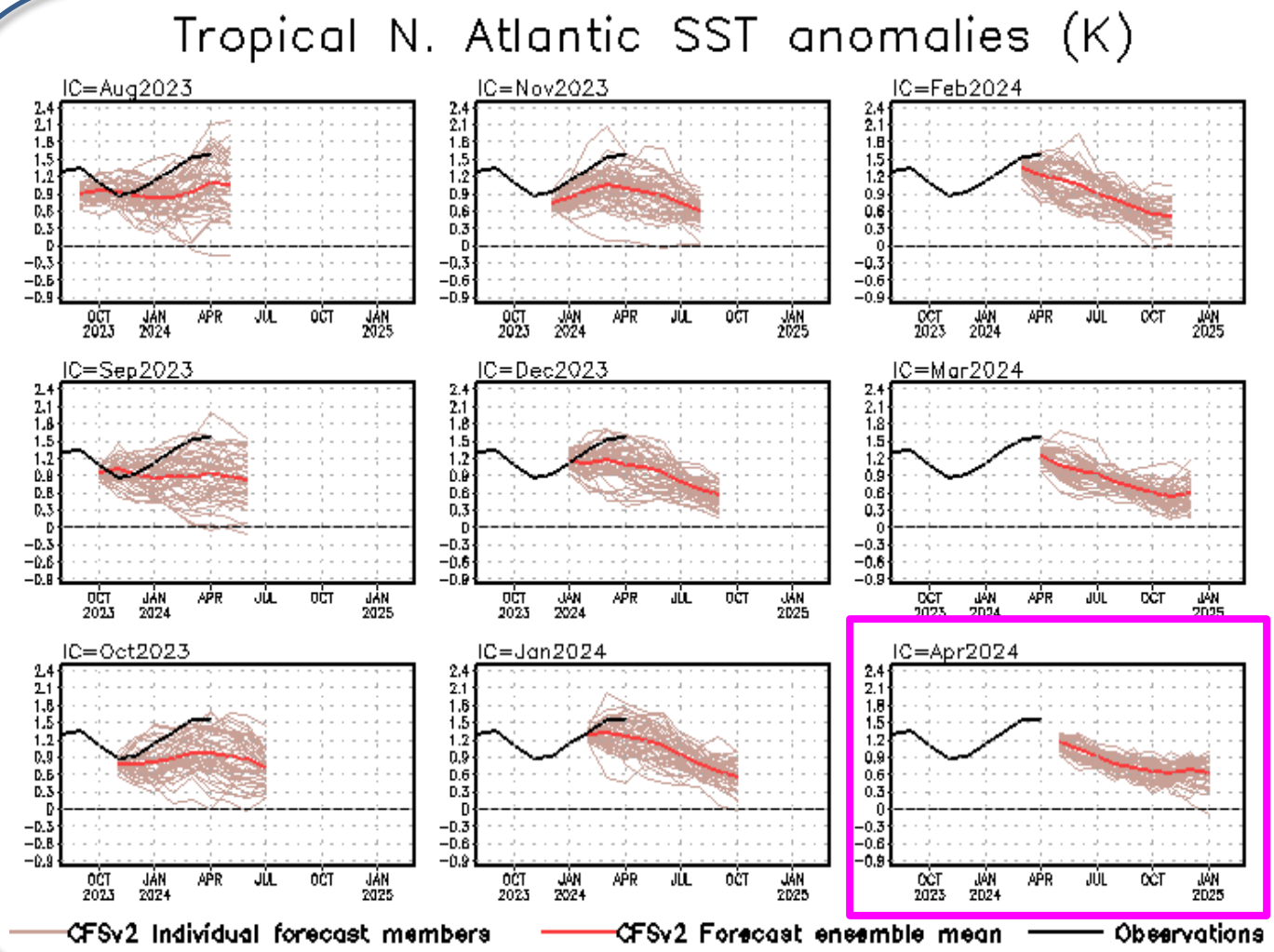
NCEP CFSv2 PDO Index Predictions from Different Initial Months



- 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.

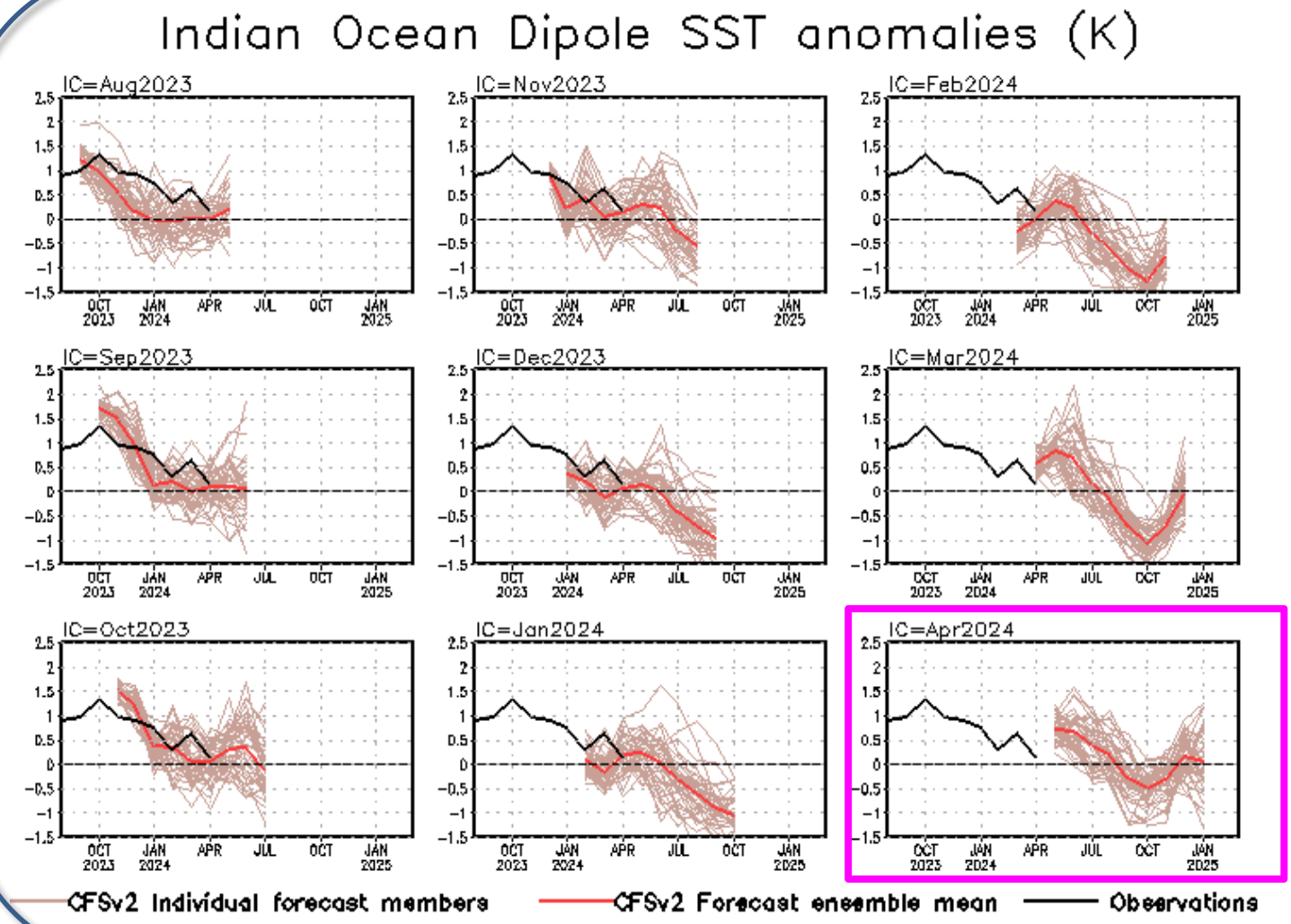
NCEP CFSv2 Tropical North Atlantic (TNA) SST Predictions from Different Initial Months



- 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 weakening of the positive phase of IOD in summer 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
- Dr. 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

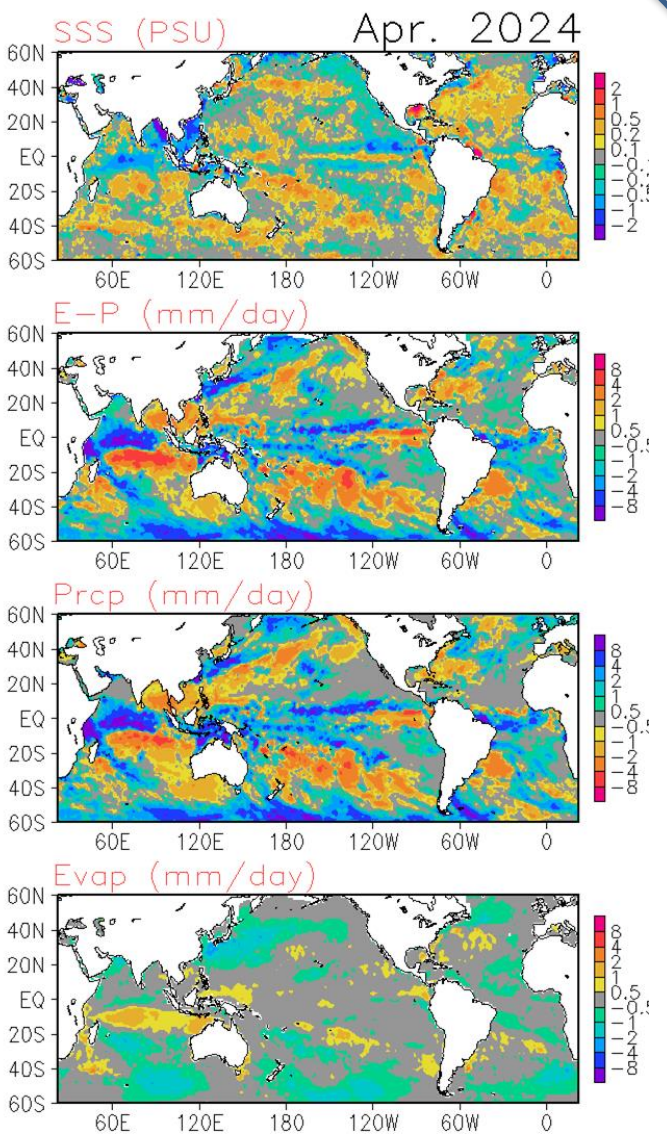
http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html

Backup Slides

Global Sea Surface Salinity (SSS): Anomaly for April 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 is enhanced and displaced to the north, which is indicated by the parallel bands of fresh water flux (precipitation) of opposite signs over the equator and off-equator Pacific. Therefore the salinity anomalies also show opposite signs over this region. Strong Indian dipole of precipitation anomalies is found, which leads to similar dipole pattern of the salinity anomalies over the tropical Indian ocean. South Pacific and Indian Ocean are prevailed by reduced precipitation despite the slightly decreased evaporation, leading overall increased SSS over the southern oceans.



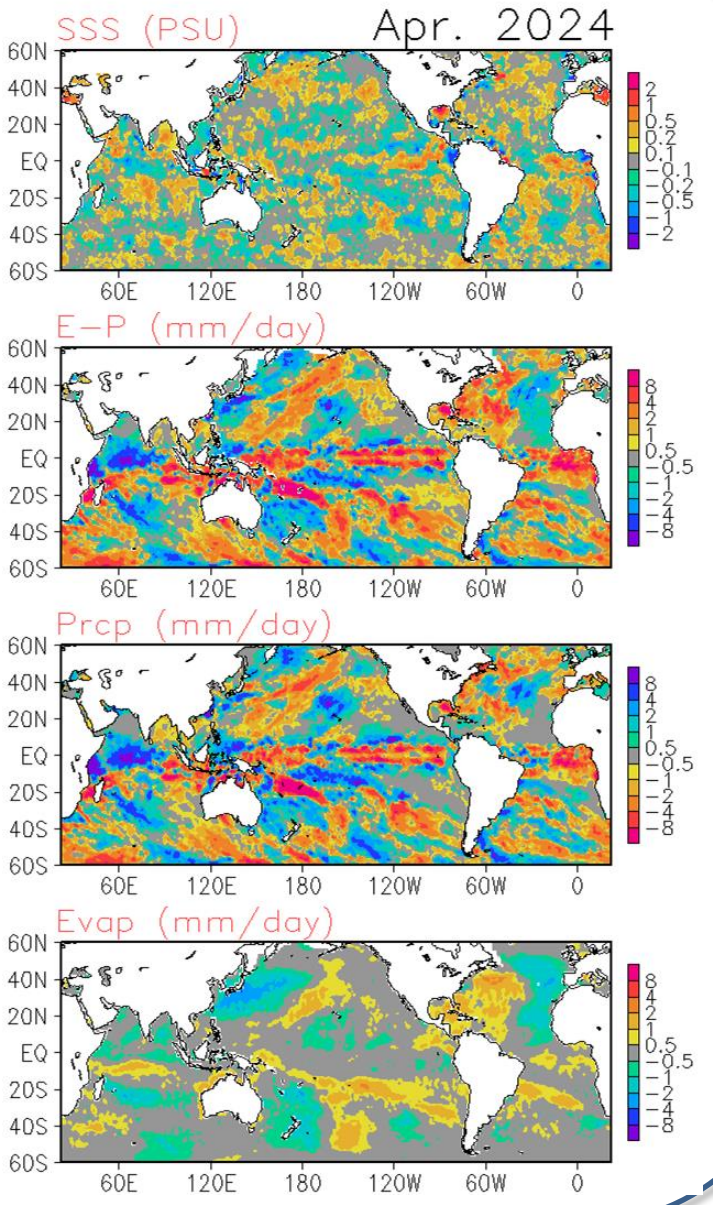
SSS : Blended Analysis of Surface Salinity (BASS) V0.Z
(a CPC-NESDIS/NODC-NESDIS/STAR joint effort)
ftp.cpc.ncep.noaa.gov/precip/BASS

Precipitation: CMORPH adjusted satellite precipitation estimates

Evaporation: Adjusted CFS Reanalysis

Global Sea Surface Salinity (SSS): Tendency for April 2024

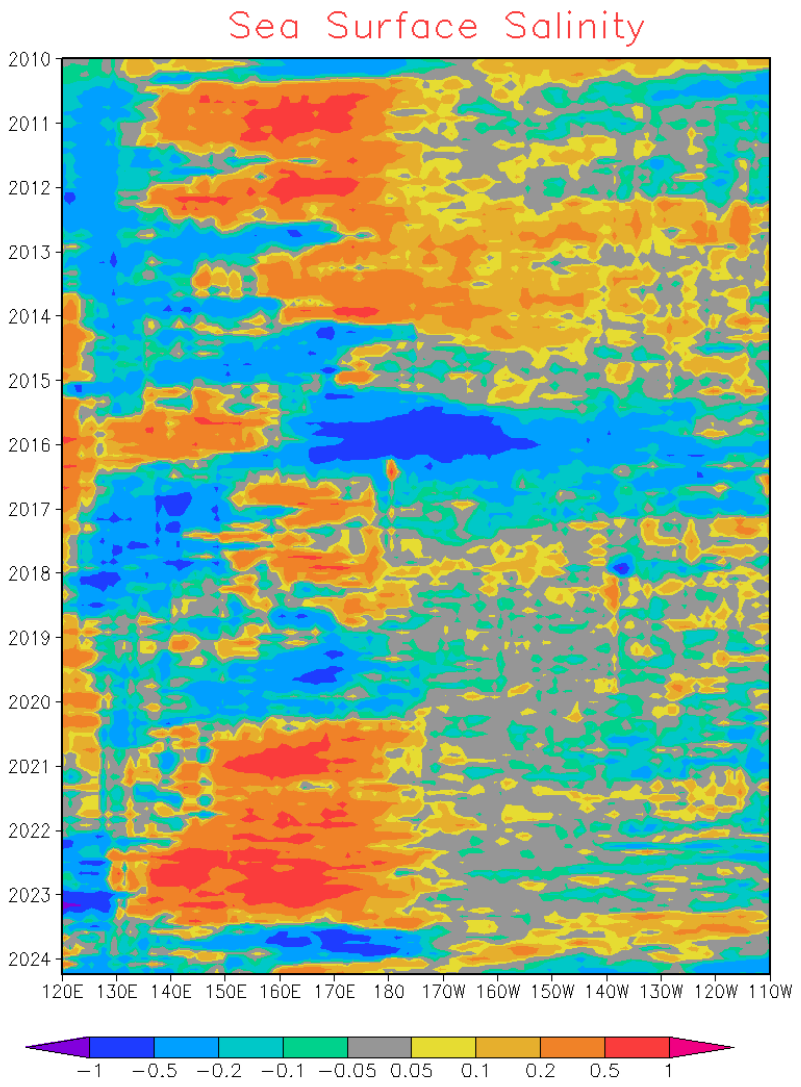
The global SSS tendency in April 2024 is overall weak and with mixed signs. Precipitation (and freshwater flux) are generally decreasing along the equator but enhancing off equator. Dipole mode of precipitation trend is again found in the Indian ocean. In the midlatitude oceans, the precipitation trends don't show clear basin wide patterns, especially for the southern oceans. Therefore, despite more clearer large scale trends in the evaporation (e.g., decreasing/increasing in the western/eastern side of Pacific), the SSS trend doesn't show pronounced large scale pattern for this month as we mentioned.



Monthly SSS Anomaly Evolution over Equatorial Pacific

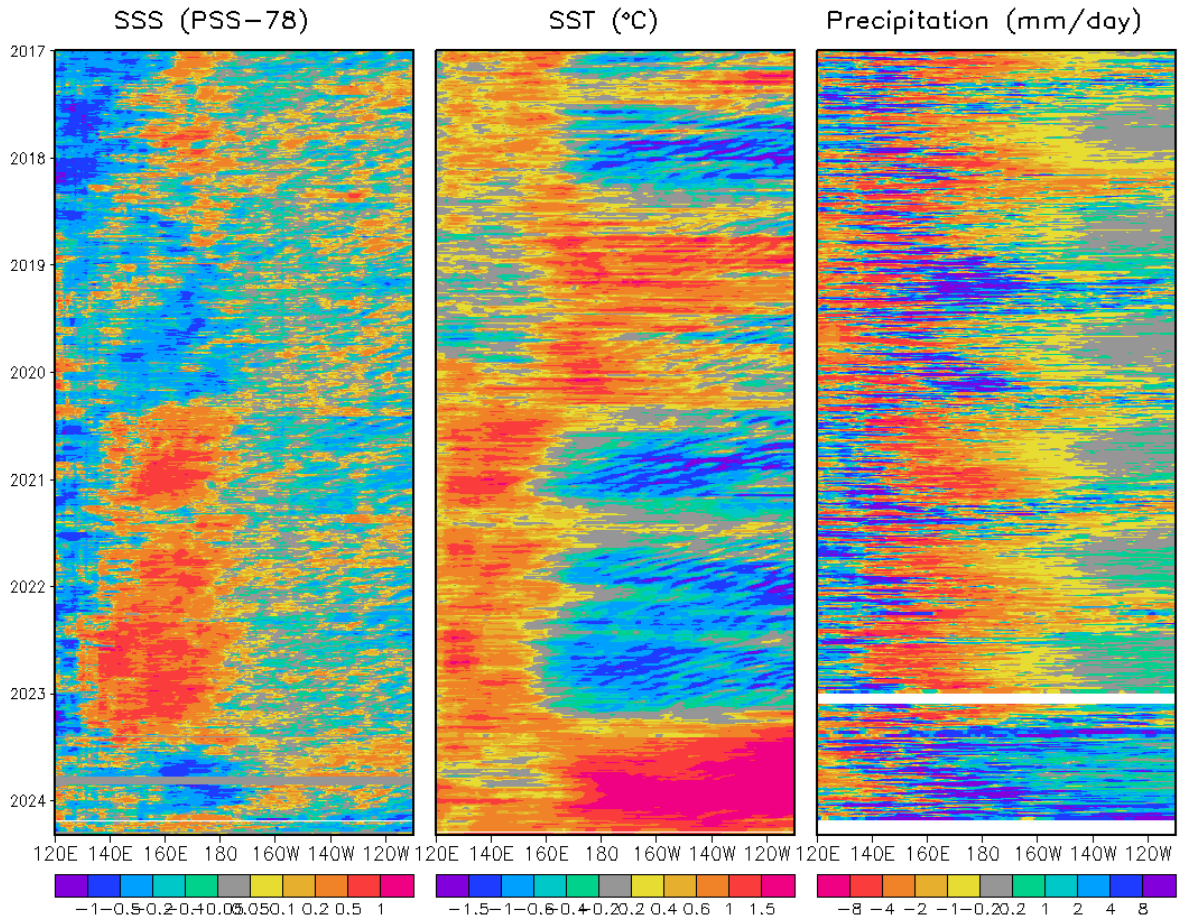
NOTE: Since June 2015, the BASS SSS is from in situ, SMOS and SMAP; before June 2015,The BASS SSS is from in situ, SMOS and Aquarius.

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

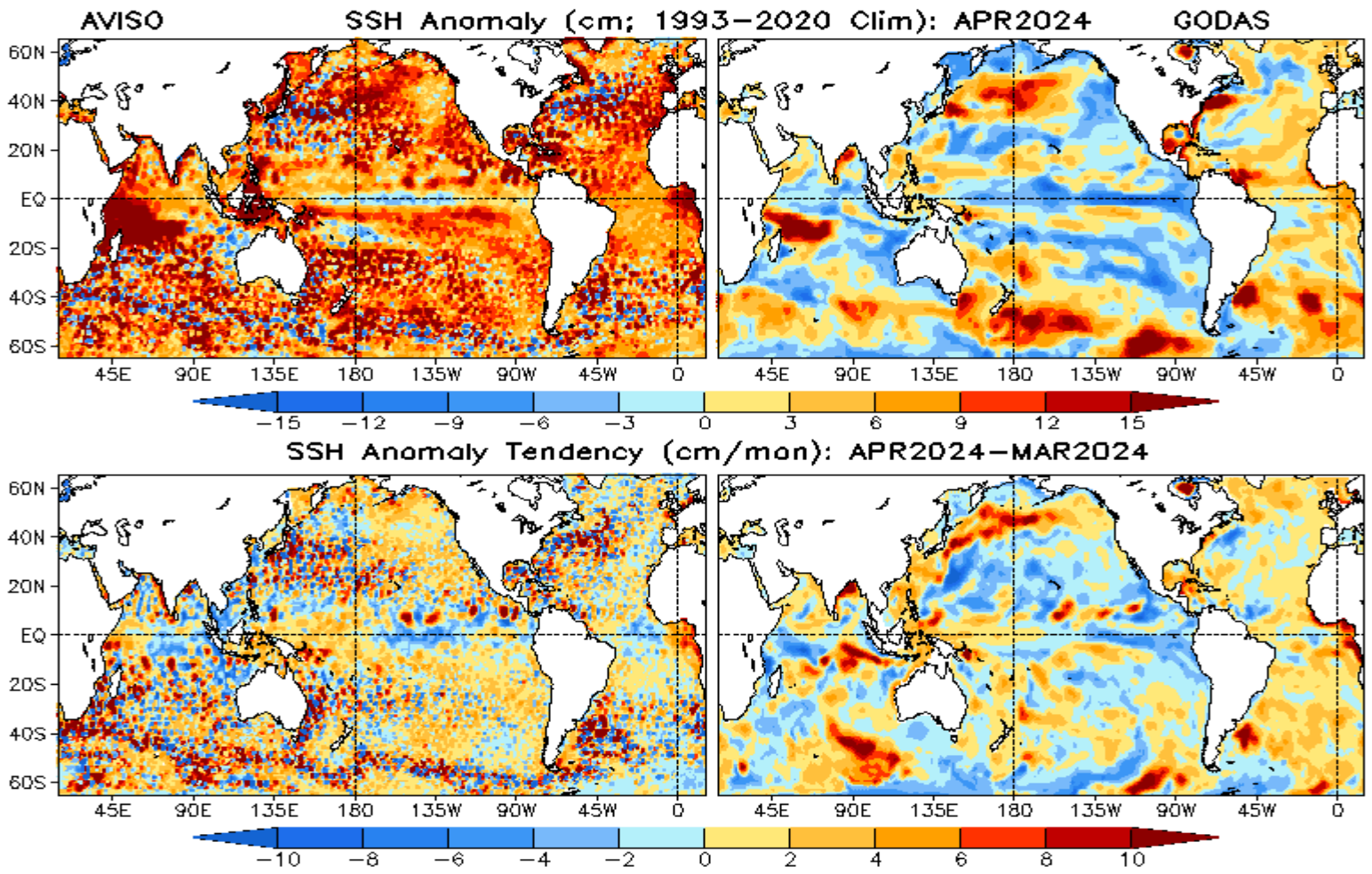


Pentad SSS Anomaly Evolution over Equatorial Pacific

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.

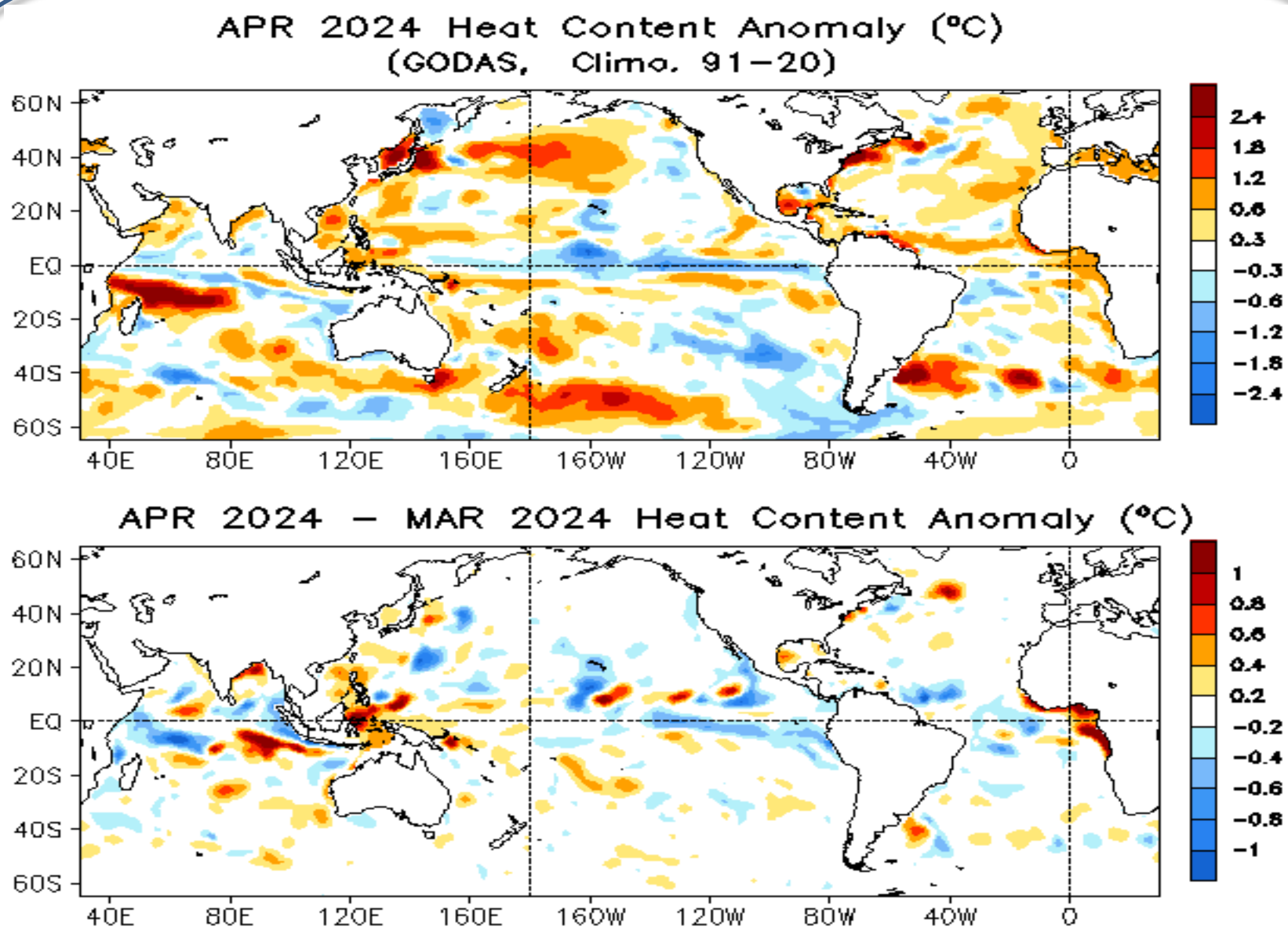


AVISO & GODAS SSH Anomaly (cm) and Anomaly Tendency

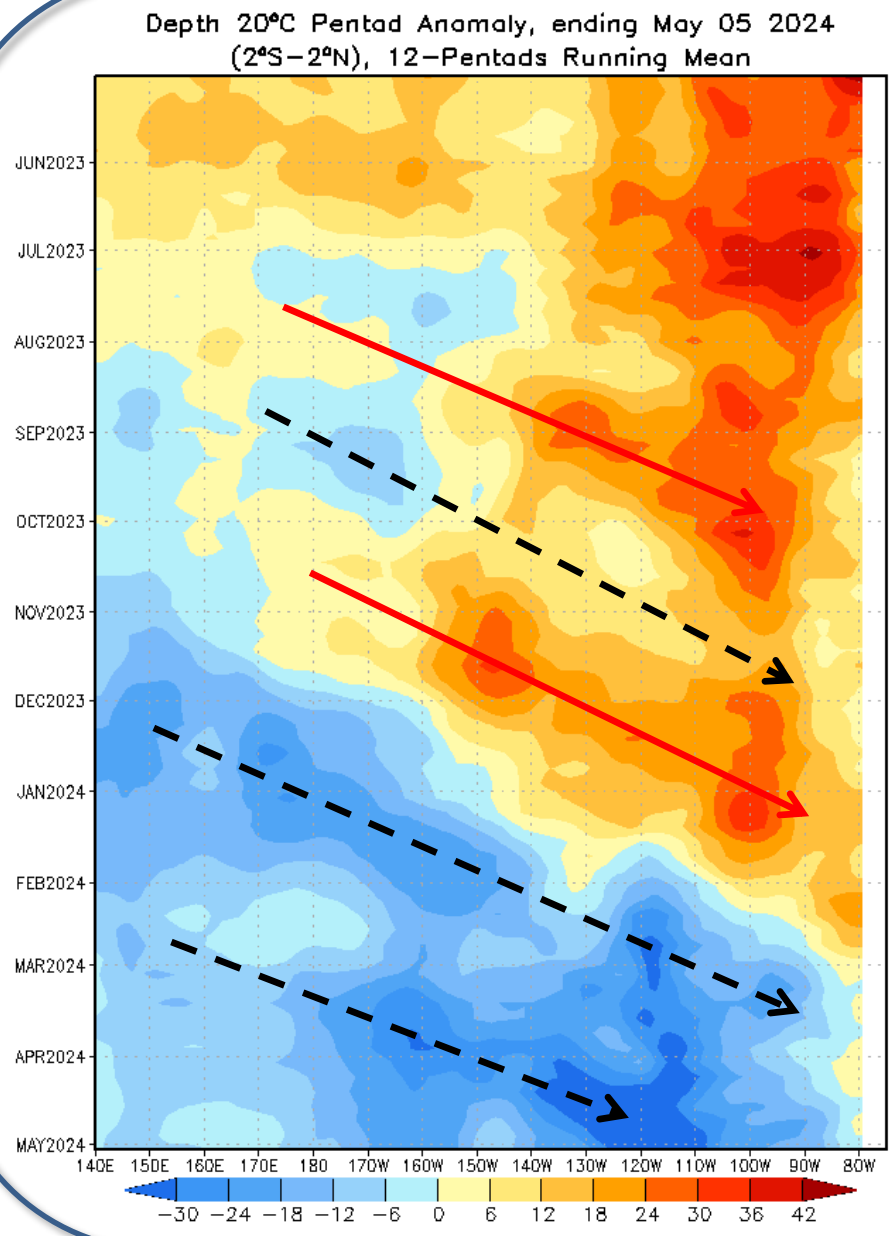


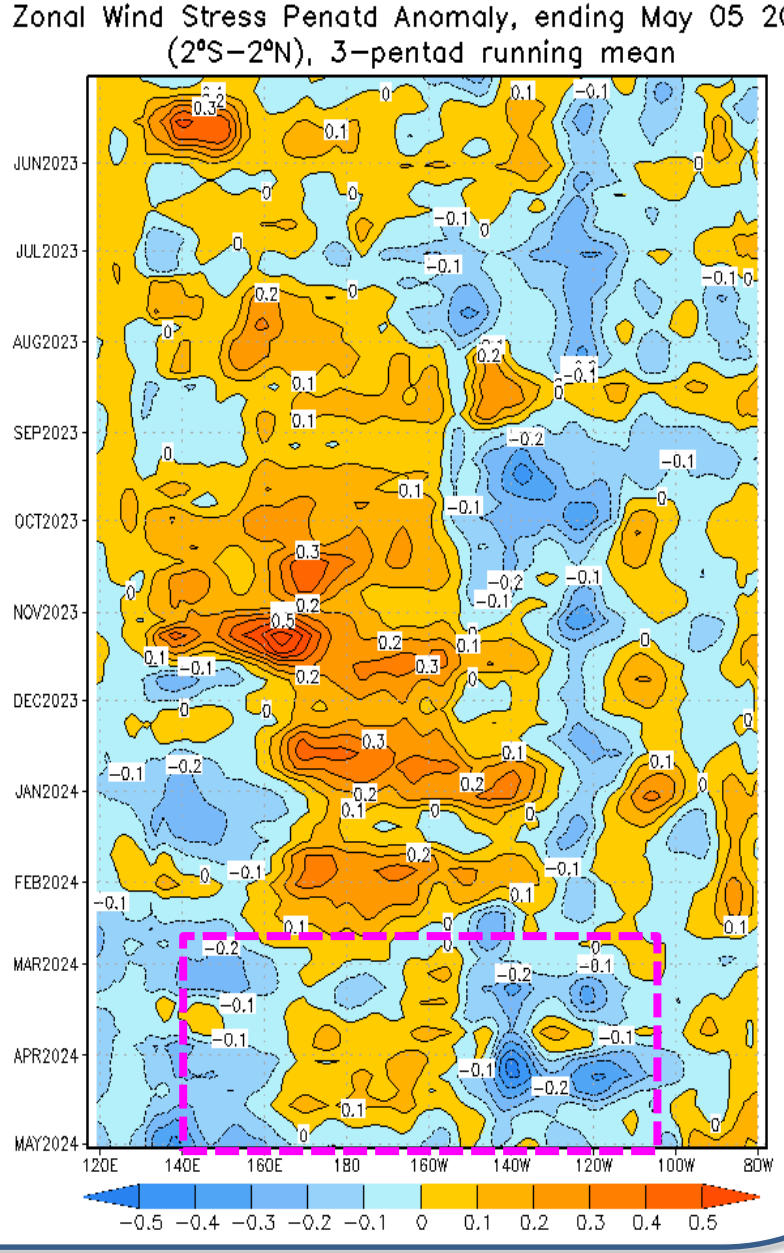
- The tendencies indicated a weakening trend of the El Niño conditions in the eastern tropical Pacific.

Global HC300 Anomaly & Anomaly Tendency

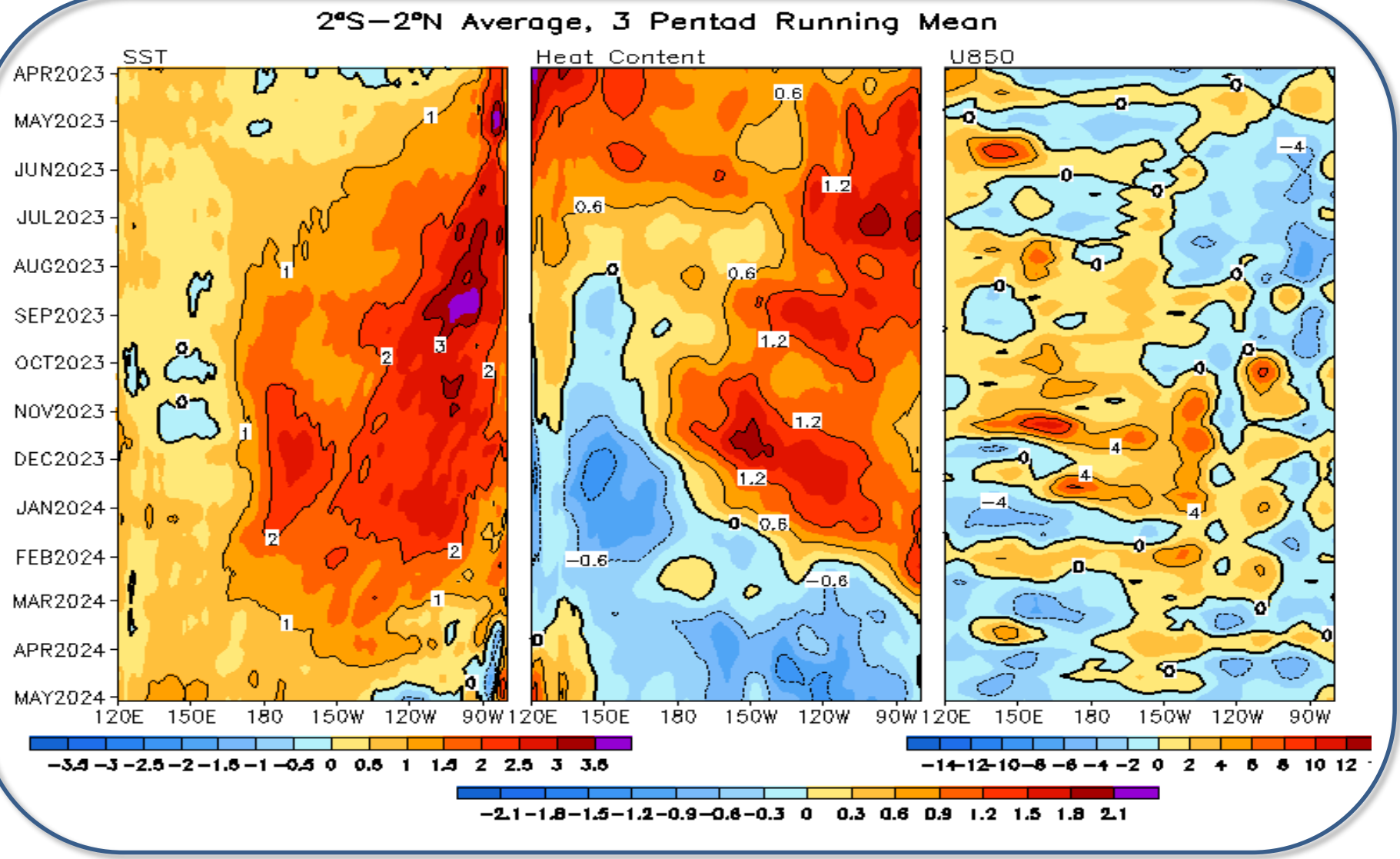


Evolution of Pentad D20 and Taux anomalies along the equator



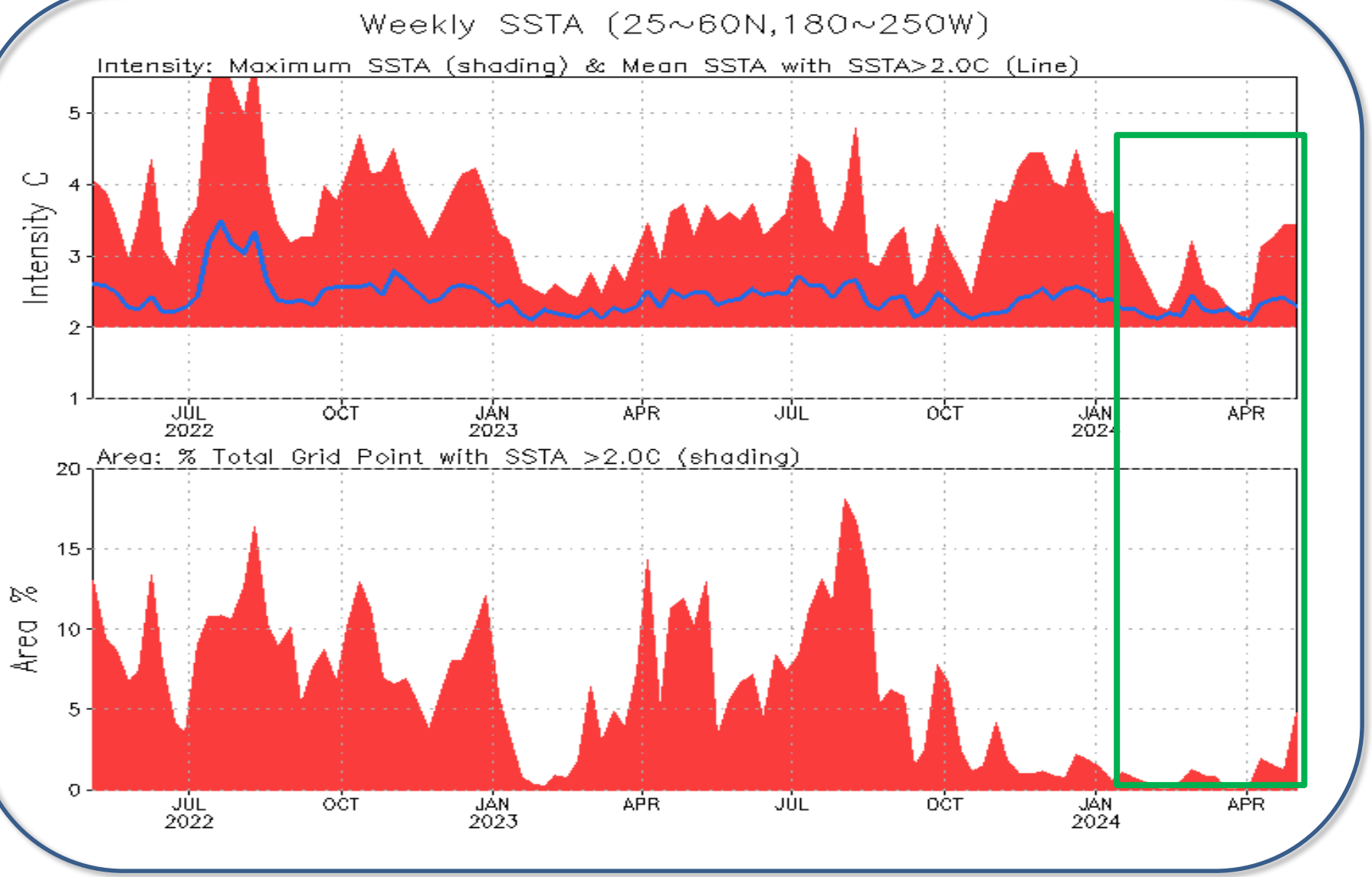


Equatorial Pacific SST (°C), HC300 (°C), u850 (m/s) Anomalies



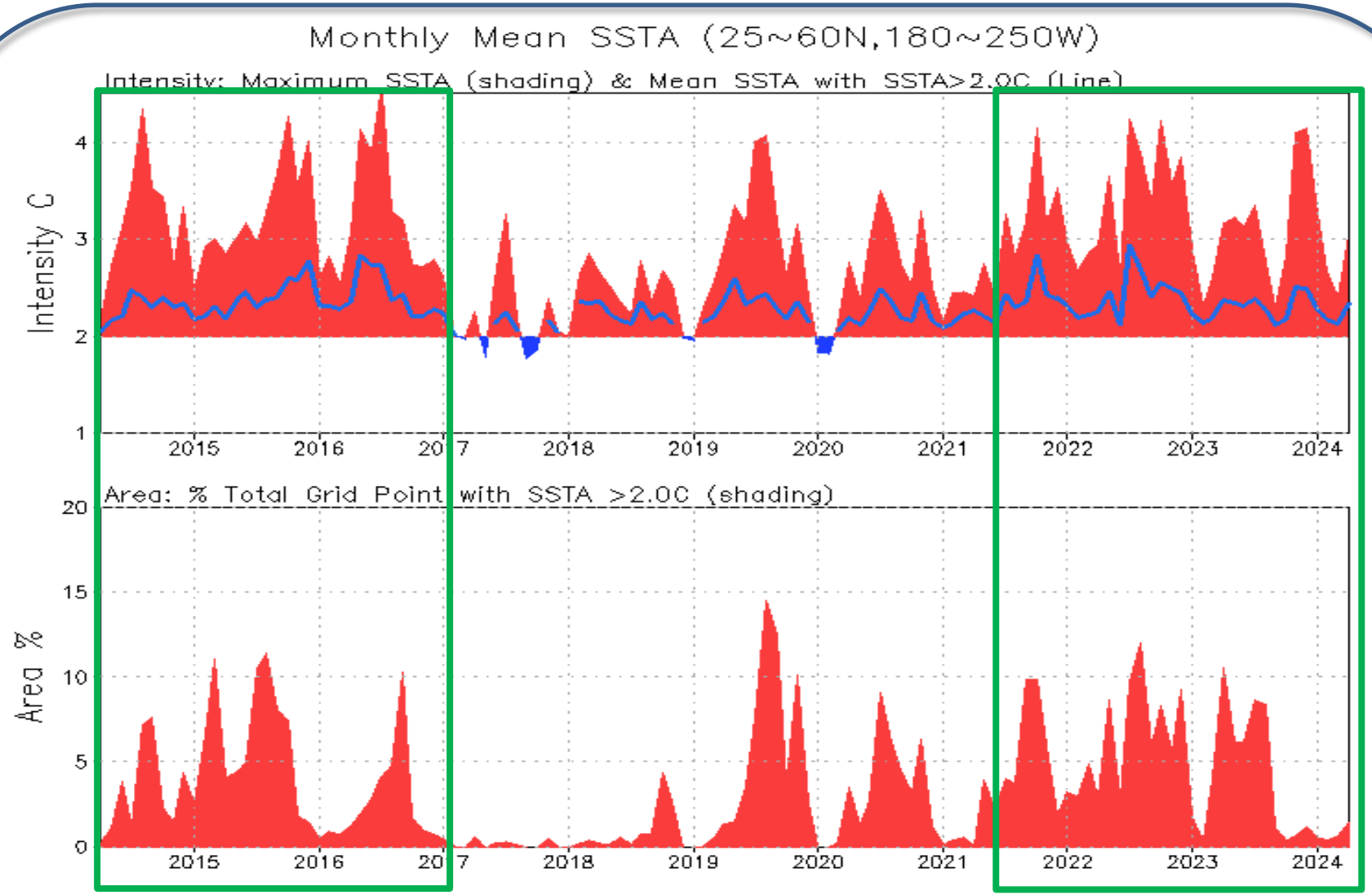
- Since Feb 2023, a set of westerly wind surges triggered downwelling Kelvin waves, reinforcing the subsurface warming in the central and eastern Pacific.

N. Pacific Marine Heat Wave Weakened



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

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

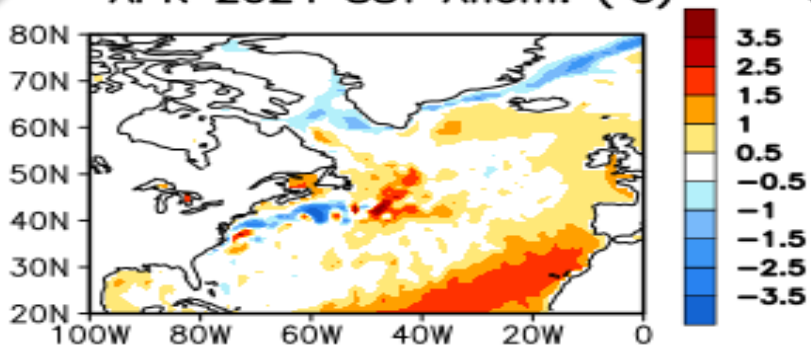
Marine Heatwave Monitoring and Forecast

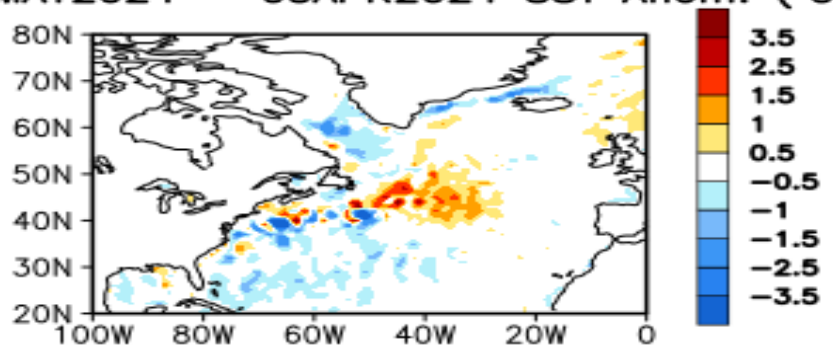
- **Indices & Time Series**
  - N. Pacific MHW Intensity & Area Indices: Weekly Monthly
  - Regional Mean SST: Global Monthly & Nino3.4 Since 1854 N. Pacific Weekly Gulf of Alaska & Subtropical Coast Weekly

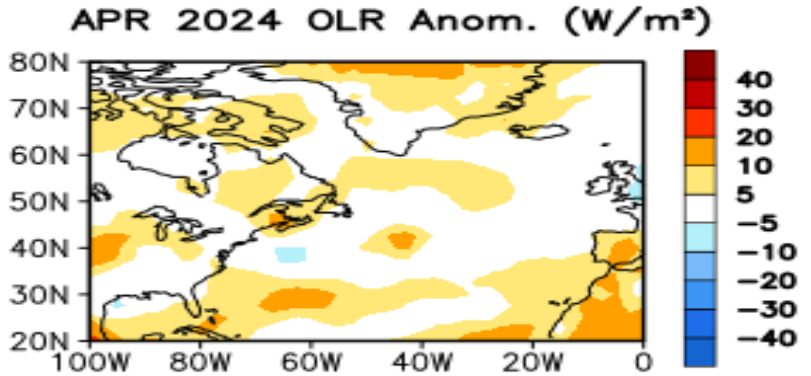
- **Spatial Distribution**
  - Global Monthly Anomaly
    - SST
  - N. Pacific Anomaly
    - Pentad Subsurface Ocean Temperature: 5m 55m 105m 155m
    - Weekly SST Weekly SST2
    - Pentad 300m Ocean Heat Content Pentad Ocean Surface Heigh Pentad Surface Heat Flux
    - 3-month SST, SLP, & UV925 SST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

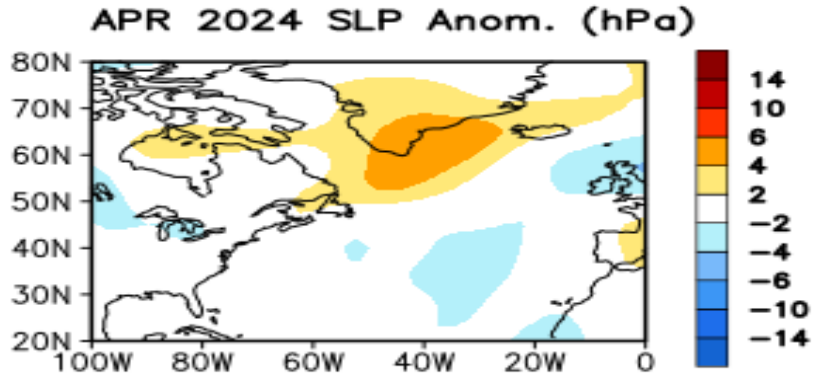
- **NMME & CFSv2 Forecasts**
  - Tropical N. Atlantic SSTA: NMME CFSv2
  - N. Pacific SSTA: NMME CFSv2
  - CFSv2: N. Pacific Sea Surface Height Anomaly
  - CFSv2 SSTA Index: Last month Last 9 months

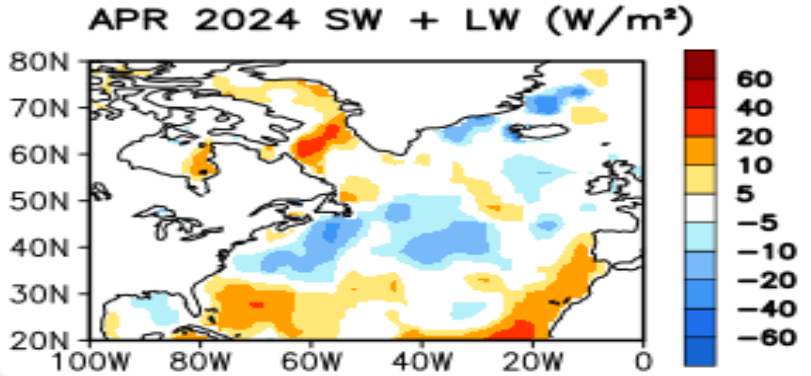
N. Atlantic: SST, SST tend., OLR, SLP, & heat flex anom.

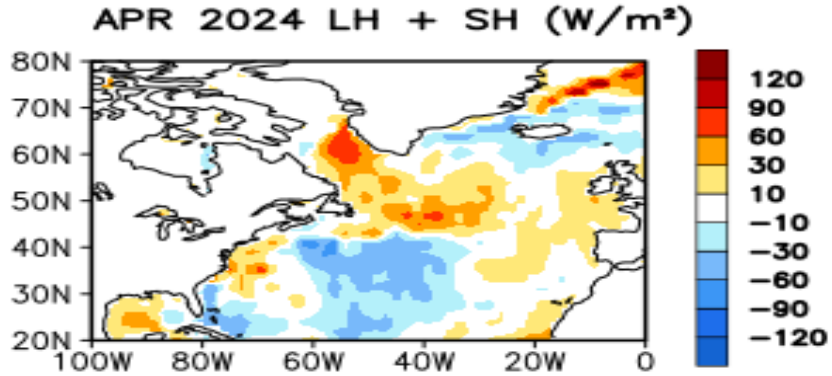




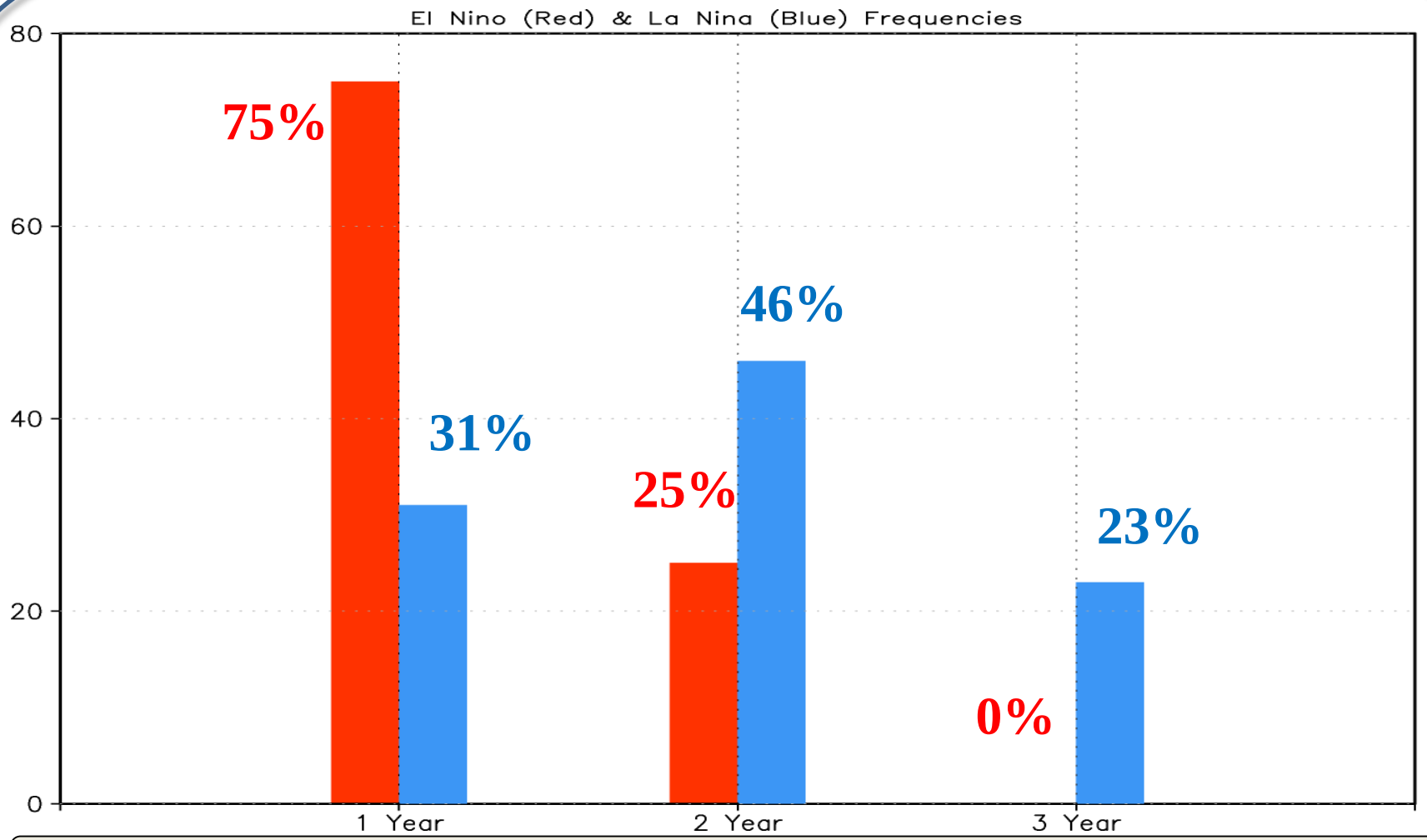








Percentages (%) of single-, double-, and triple-year El Niños (red bars) and La Niñas (blue bars) during 1951-2023



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