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

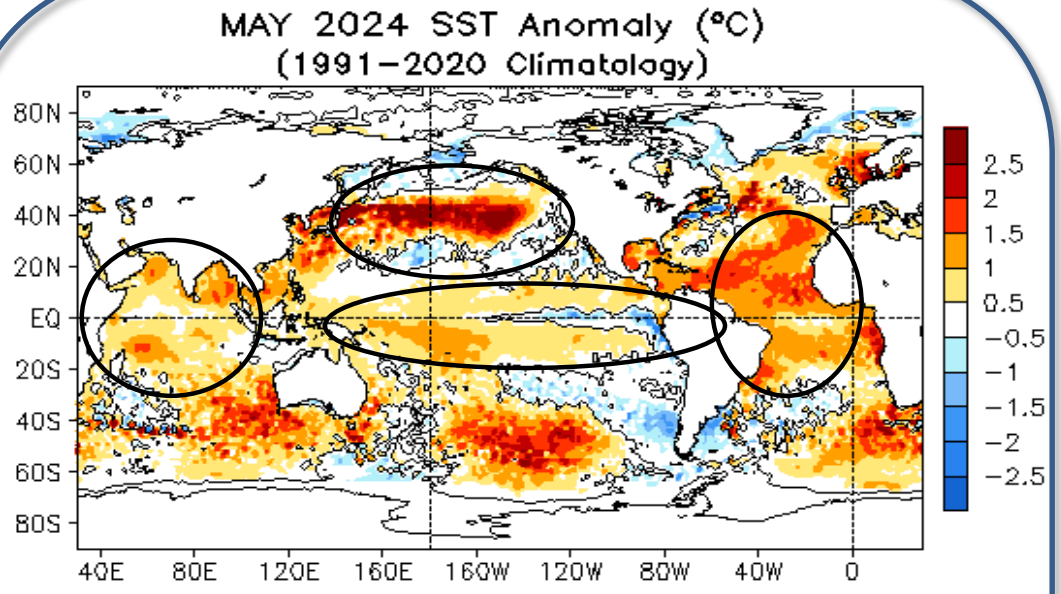
- **Overview**
- **Recent highlights**
  - Pacific Ocean
  - Arctic & Antarctic Oceans
  - Indian Ocean
  - Atlantic Ocean
- **Global SSTA Predictions**

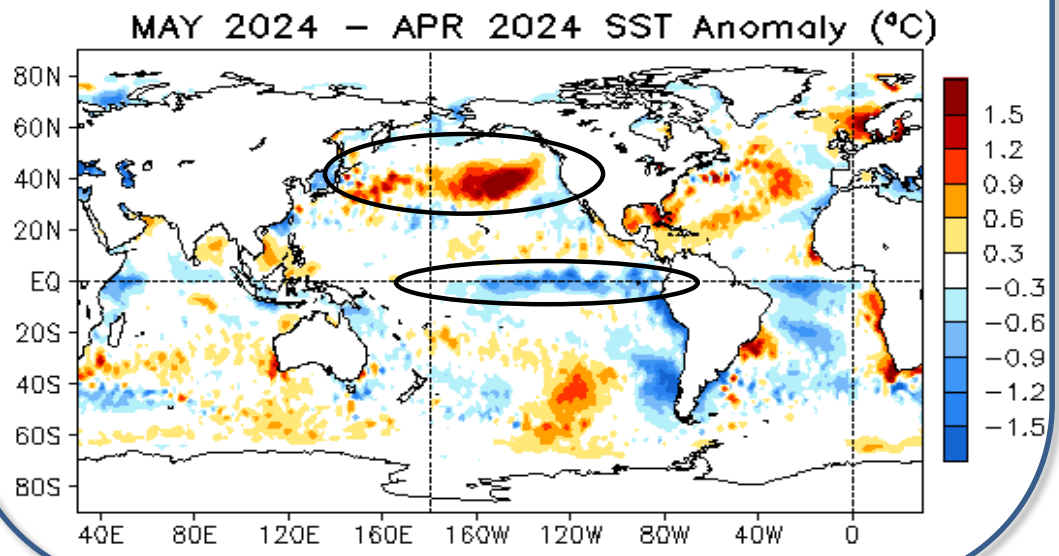
Overview

- Pacific Ocean
  - The tropical Pacific SST and atmospheric conditions have returned to ENSO neutral conditions with Niño3.4 = 0.3^{o}C in May 2024.
  - NOAA "ENSO Diagnostic Discussion" on 9 May 2024 continued with "*El Niño Advisory / La Niña Watch.*"
  - The positive SSTA in the North Pacific and the negative phase of PDO strengthened with PDOI = -2.1 in May 2024.
- Arctic & Antarctic Oceans
  - The average Arctic sea ice extent for May 2024 was 12.78 million km^2, tying for the 12th May lowest with 2007 in the passive microwave satellite record.
  - Antarctic sea ice extent for May 2024 was 10.52 million km^2, ranking the 5th lowest May extent since 1979.
  - CPC forecasts a below-normal Arctic sea ice extent minimum in Sep 2024.
- Indian Ocean
  - Positive SSTAs and positive phase of IOD weakened in the tropical Indian Ocean in May 2024.
- Atlantic Ocean
  - NOAA's outlook for the 2024 Atlantic Hurricane Season indicates that an above-normal season is most likely.
  - Positive SSTAs persisted in the tropical Atlantic Ocean.
  - NAO was in a negative phase in May 2024 with NAOI= -0.4.

Global Oceans

Global SST Anomaly (°C) and Anomaly Tendency



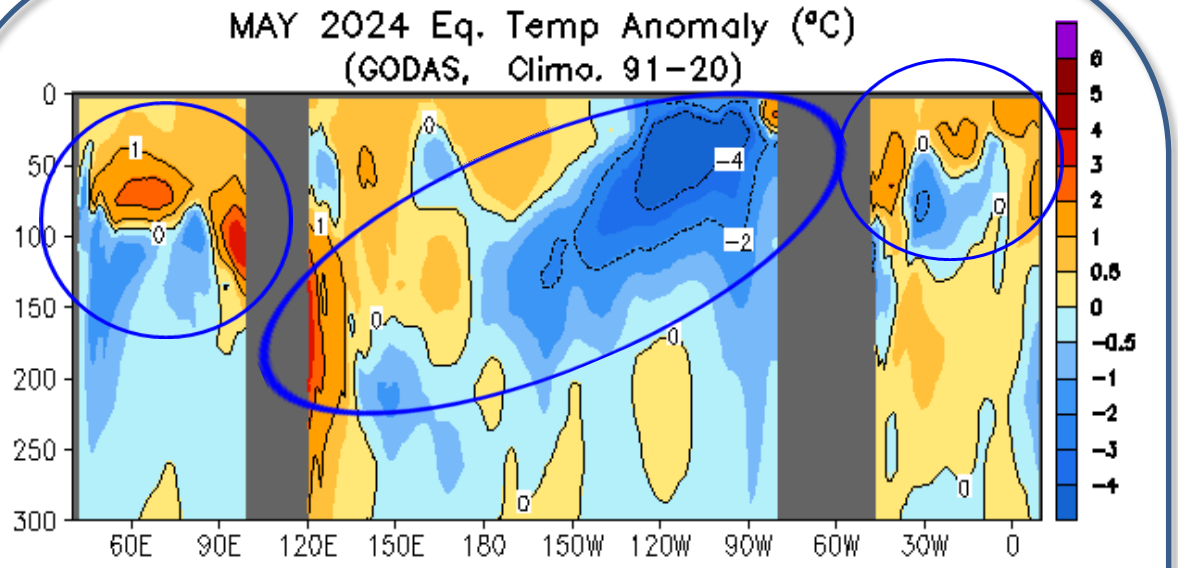


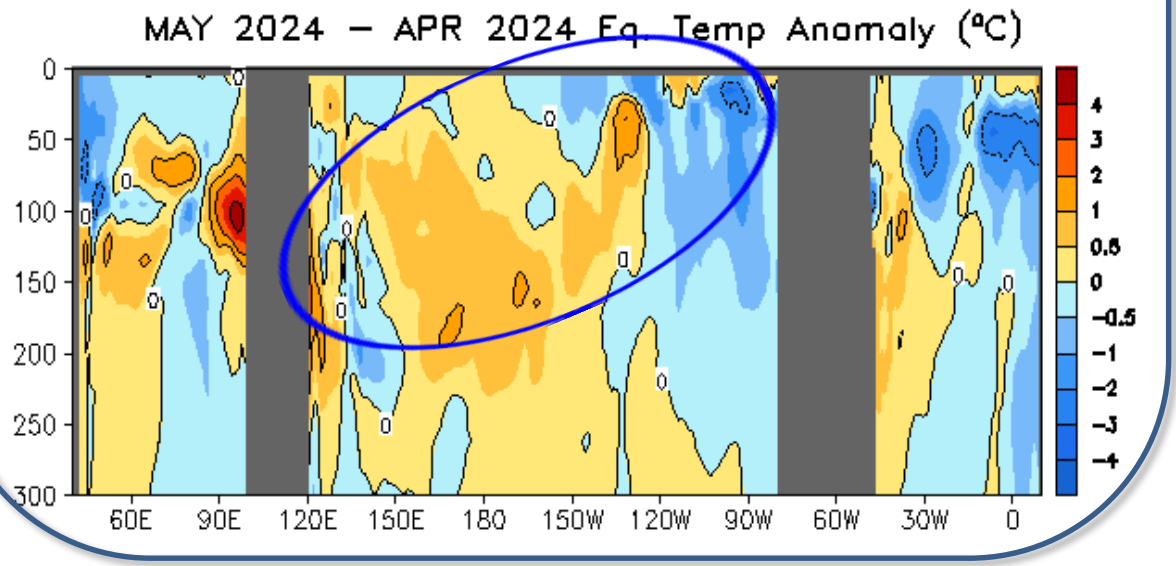
- Positive SSTAs weakened in the central equatorial Pacific and negative SSTAs emerged in the eastern equatorial Pacific Ocean.
- Positive SSTAs were present in the North Pacific and the tropical Atlantic Oceans.
- Small positive SSTAs were observed in the tropical Indian Ocean.

- Negative SSTA tendencies were present in the eastern equatorial Pacific Ocean.
- Positive SSTA tendencies were observed in the eastern North Pacific Ocean.
- SSTA tendencies were mostly negative 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.

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





- Negative anomalies around the thermocline were present and reached the surface in the eastern equatorial Pacific.
- Positive (negative) anomalies were observed above (below) the thermocline in the Indian Ocean.
- Anomalies were weak in the Atlantic Ocean.

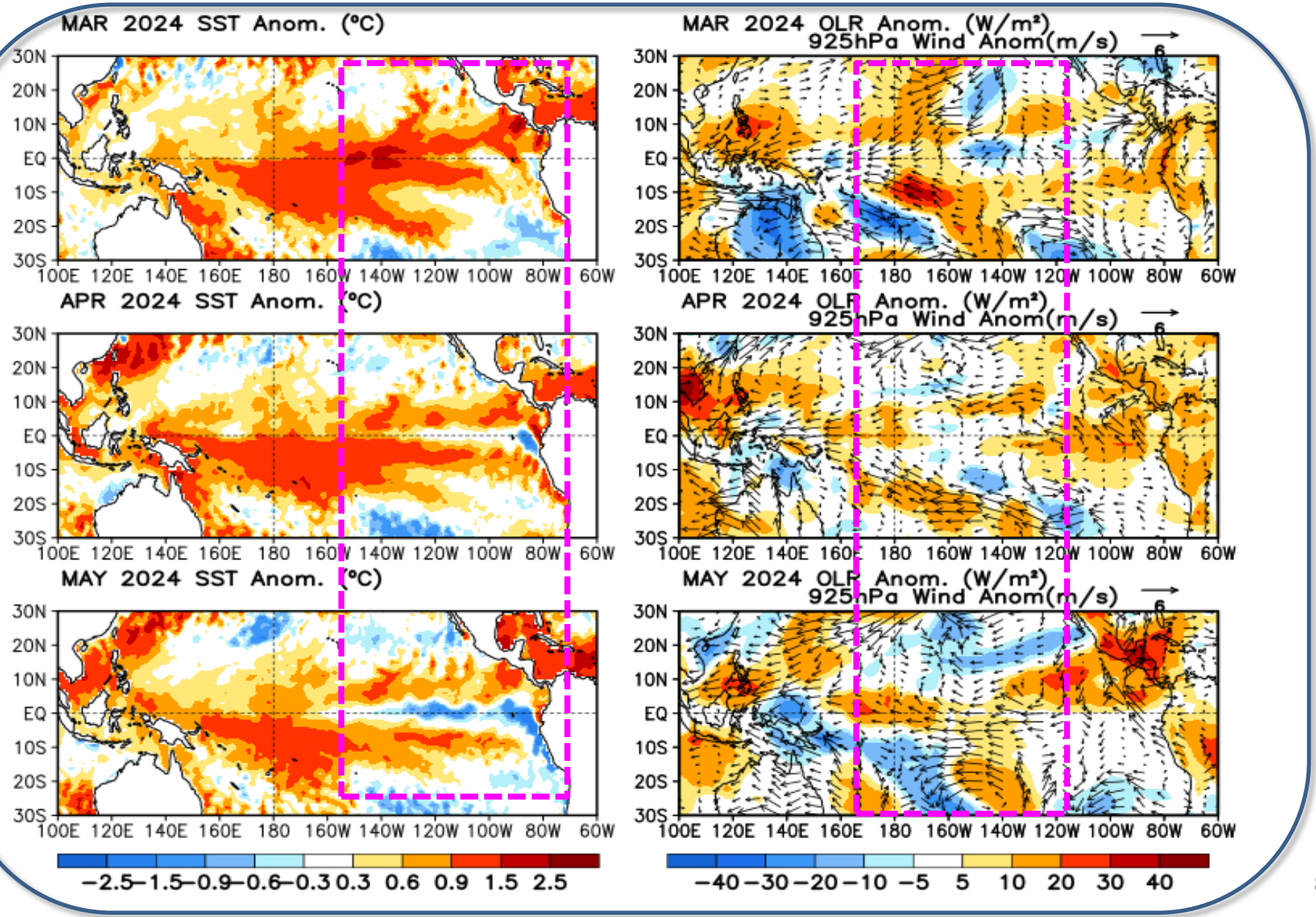
- Negative (positive) anomaly tendencies dominated along the thermocline in the eastern (western and central) Pacific Ocean.
- Both positive and negative anomaly tendencies were present along the thermocline in the Indian and Atlantic Oceans.

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.

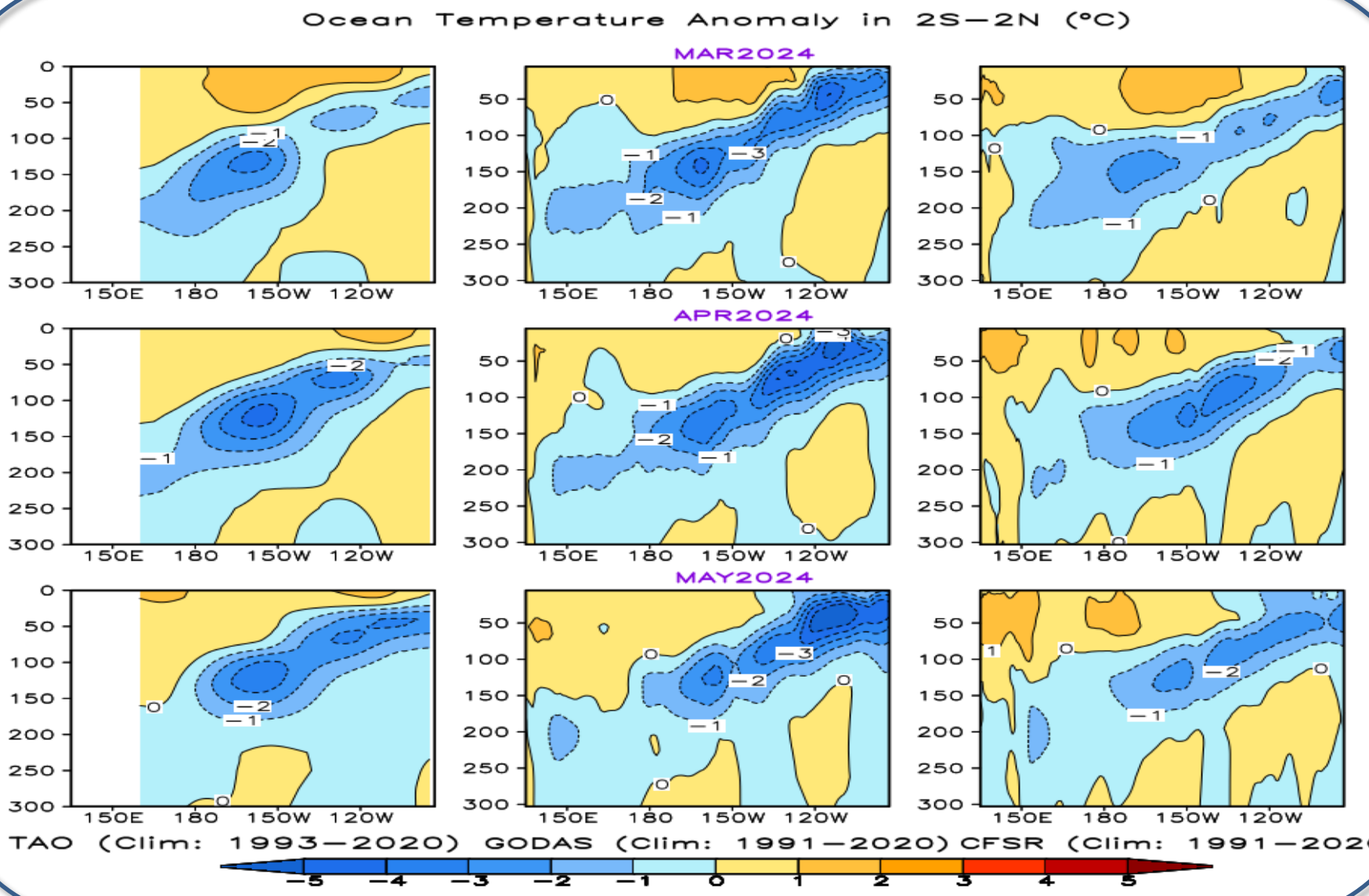
Tropical Pacific Ocean and ENSO Conditions

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

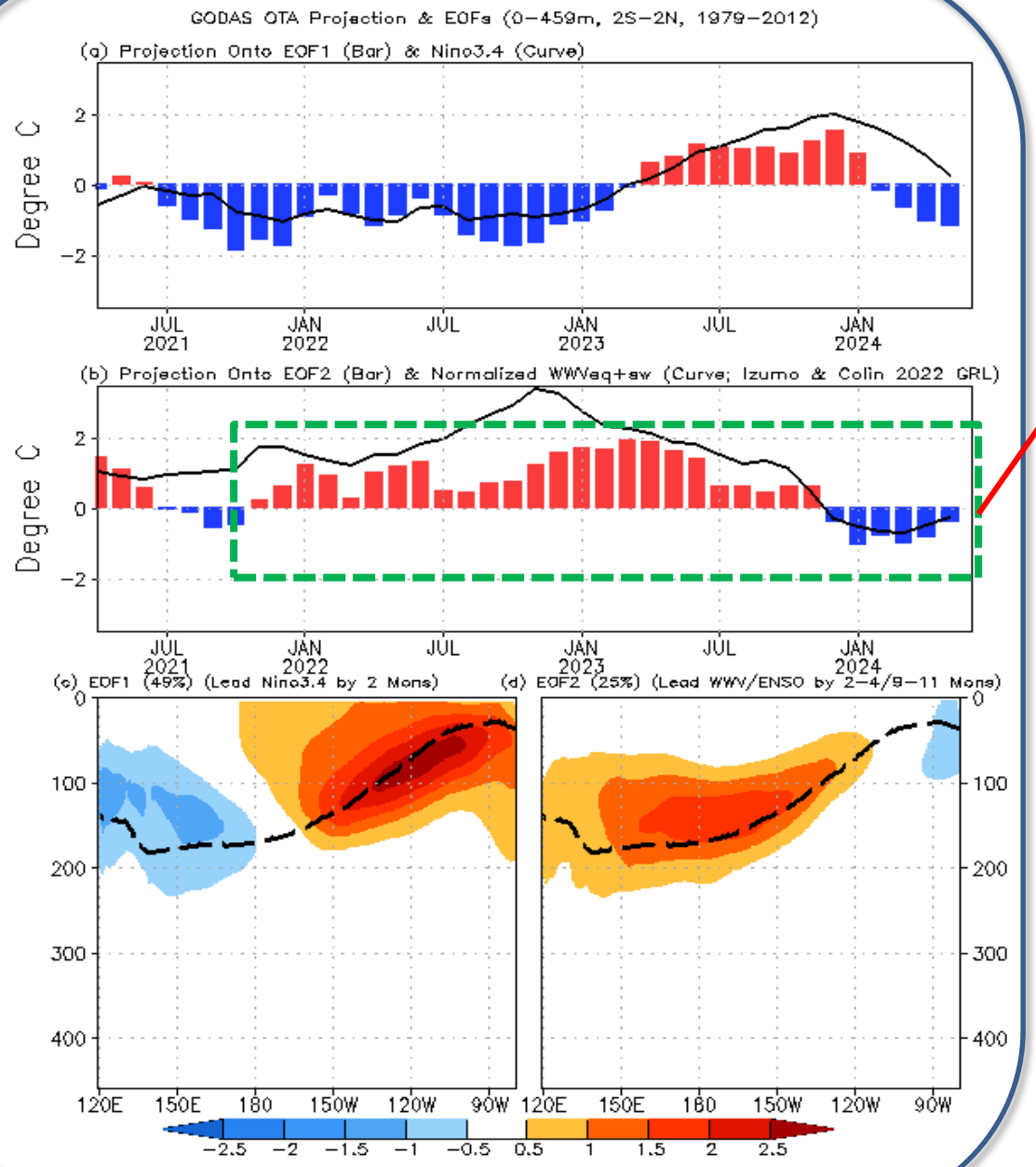
Negative SSTA (easterly wind anomalies) developed in the eastern (central) equatorial Pacific



Monthly mean subsurface temperature anomaly along the Equator:
Negative anomalies were persistent in the eastern Pacific



Equatorial Sub-surface Ocean Temperature Monitoring



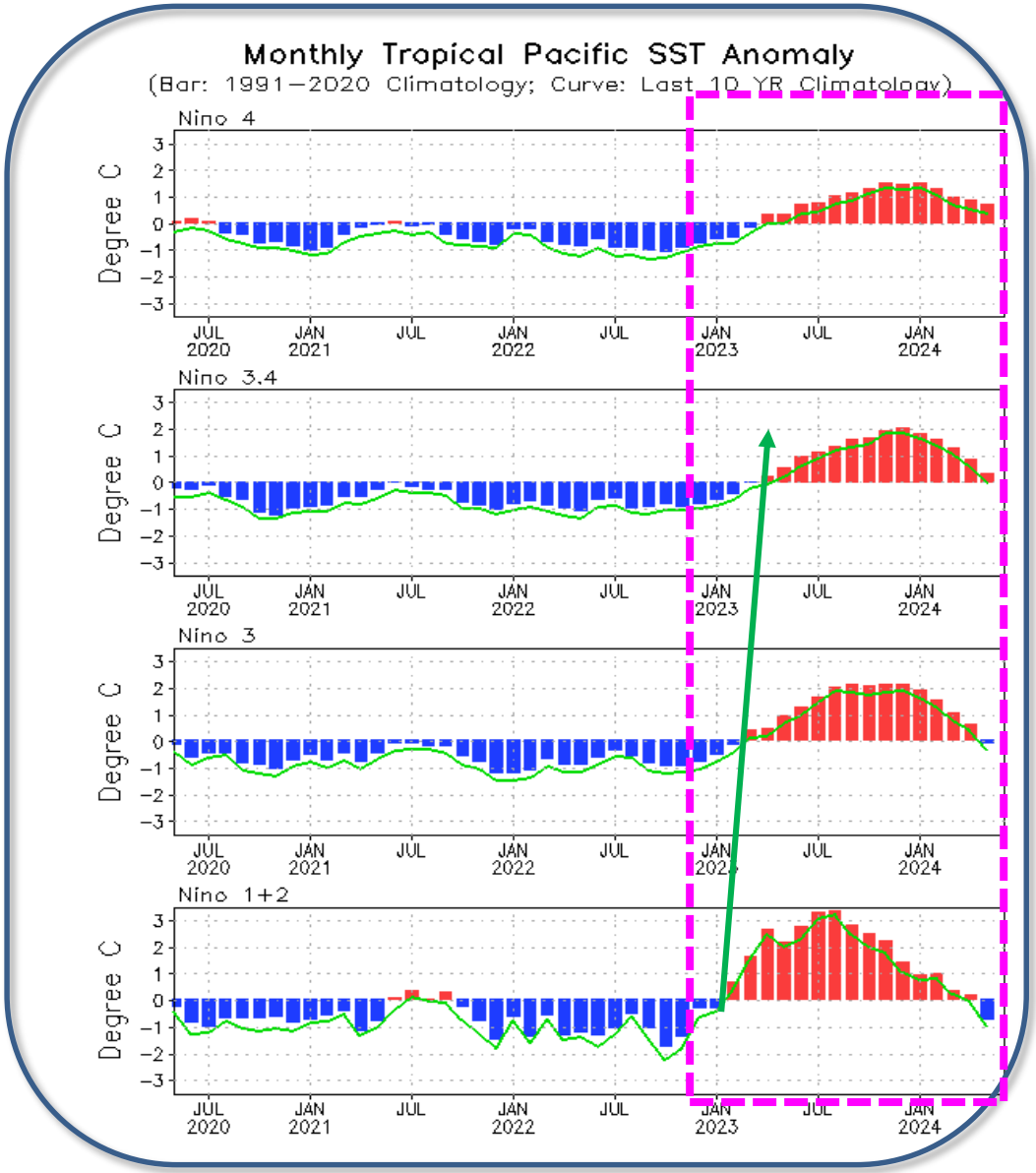
- After an extended-period of recharge since Nov 2021, the equatorial Pacific has switched to a discharge phase since Dec 2023.
- The discharge weakened in May 2024.

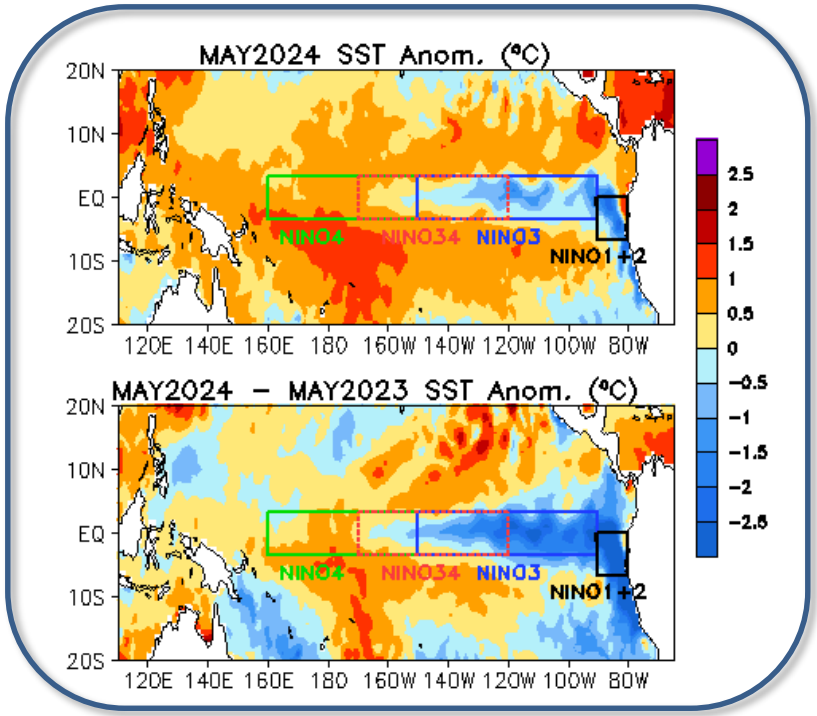
- Projection of ocean temperature anomalies onto EOF1 and EOF2; EOF1: Tilt/dipole mode (ENSO peak phase); EOF2: WWV mode.

- 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.

Evolution of Pacific Niño SST Indices





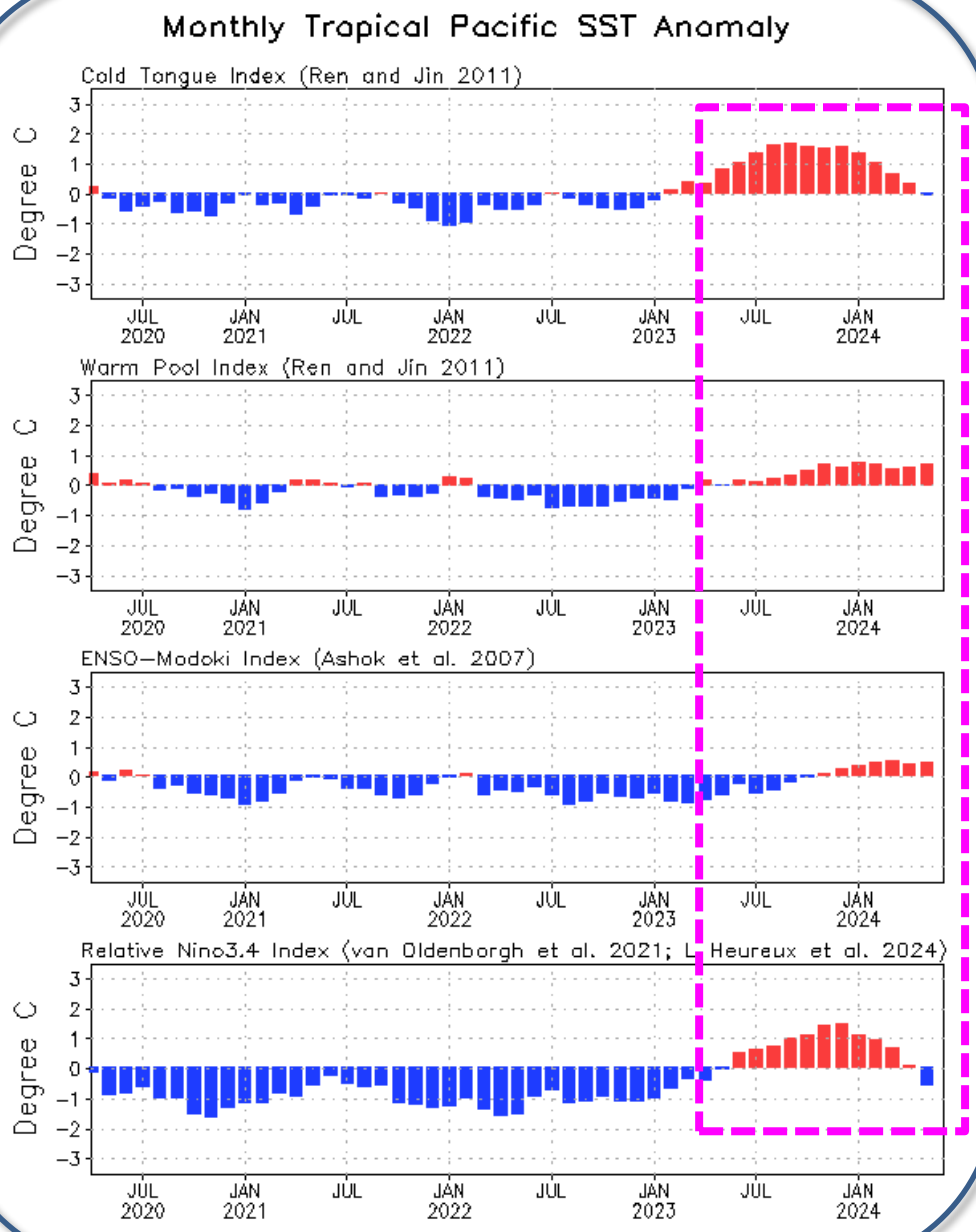
- In May 2024, Niño3.4 weakened further with Niño3.4 = 0.3°C (0.3°C in ERSSTv5 data); Nino1+2 declined further to -0.8°C (-1.2°C in ERSSTv5 data).

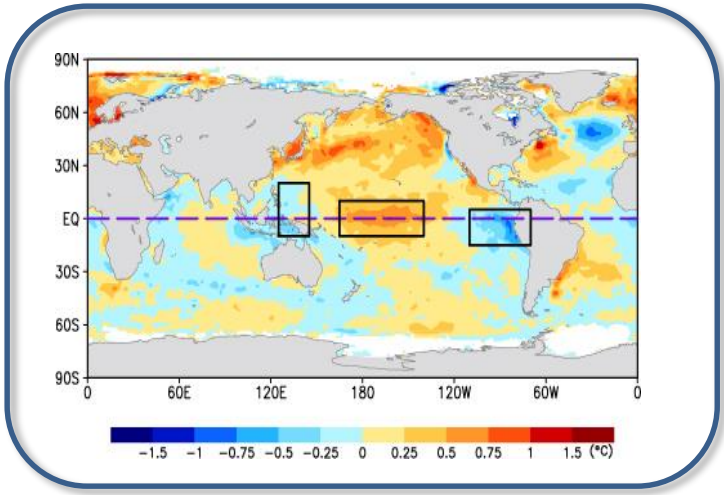
- Compared with May 2023, the tropical eastern Pacific was cooler in May 2024.

- 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: El Nino 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).

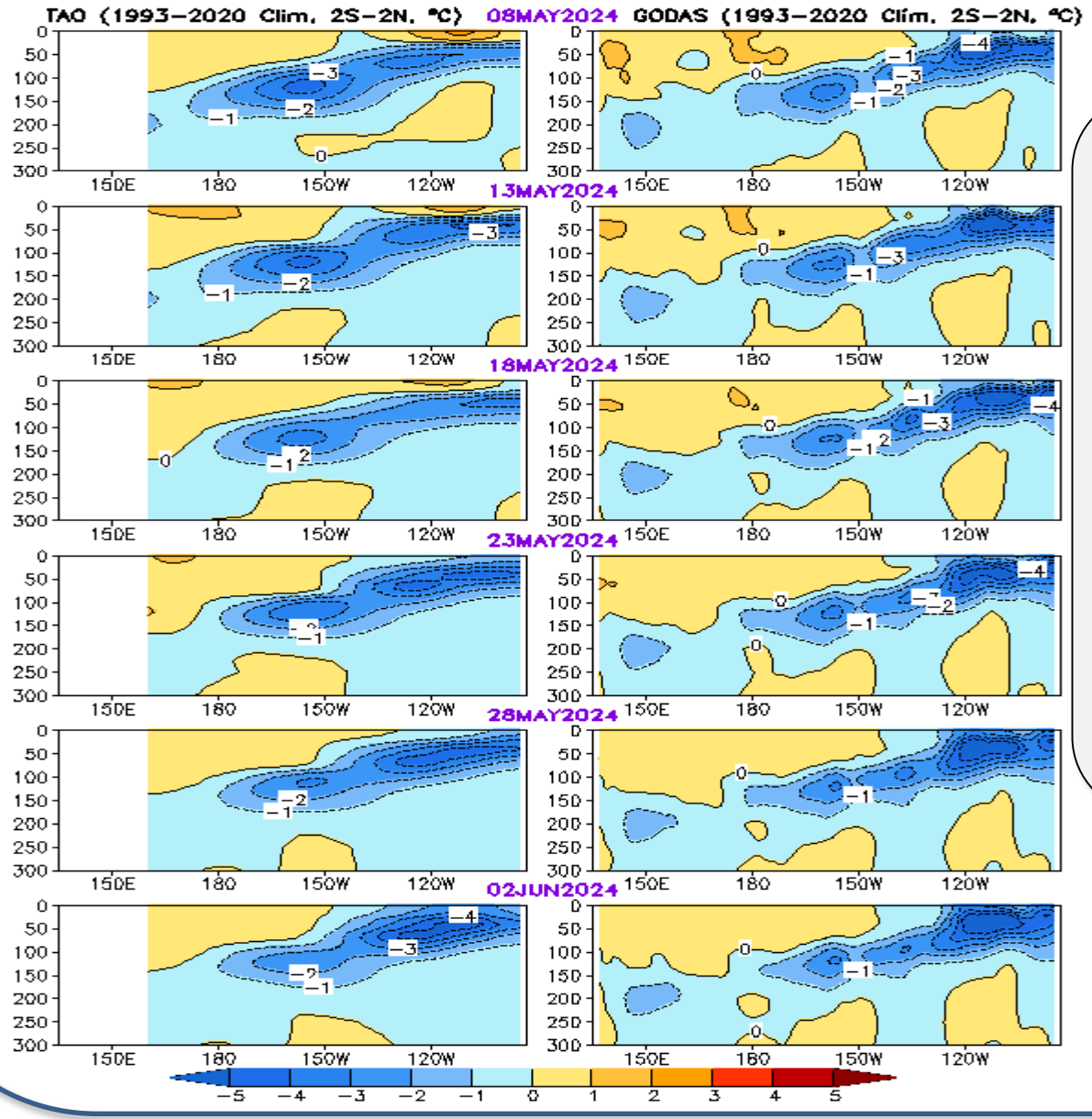
Relative Niño3.4 data updated monthly at:

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

Equatorial Pacific Ocean Temperature Pentad Mean Anomaly

TAO

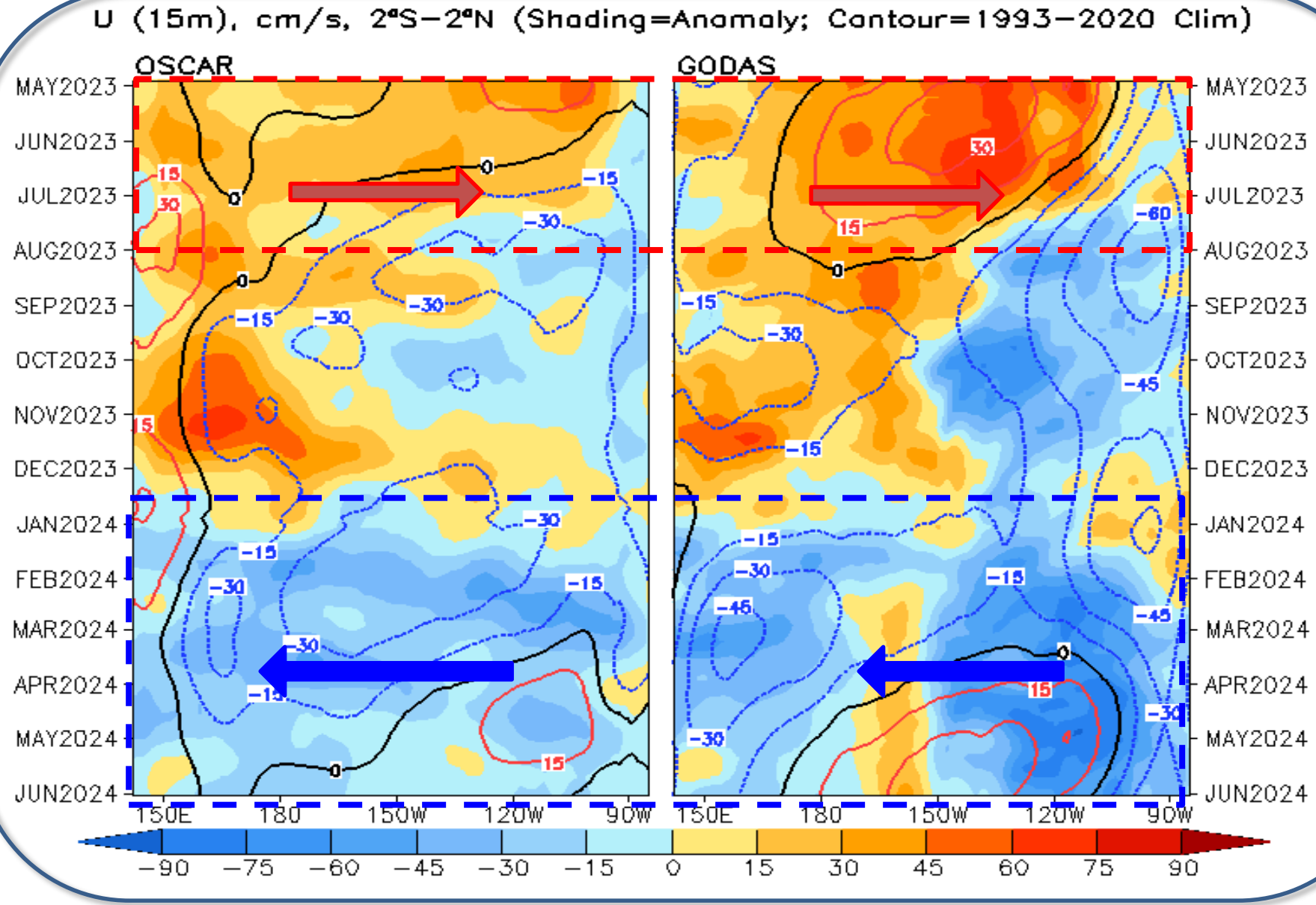
GODAS



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

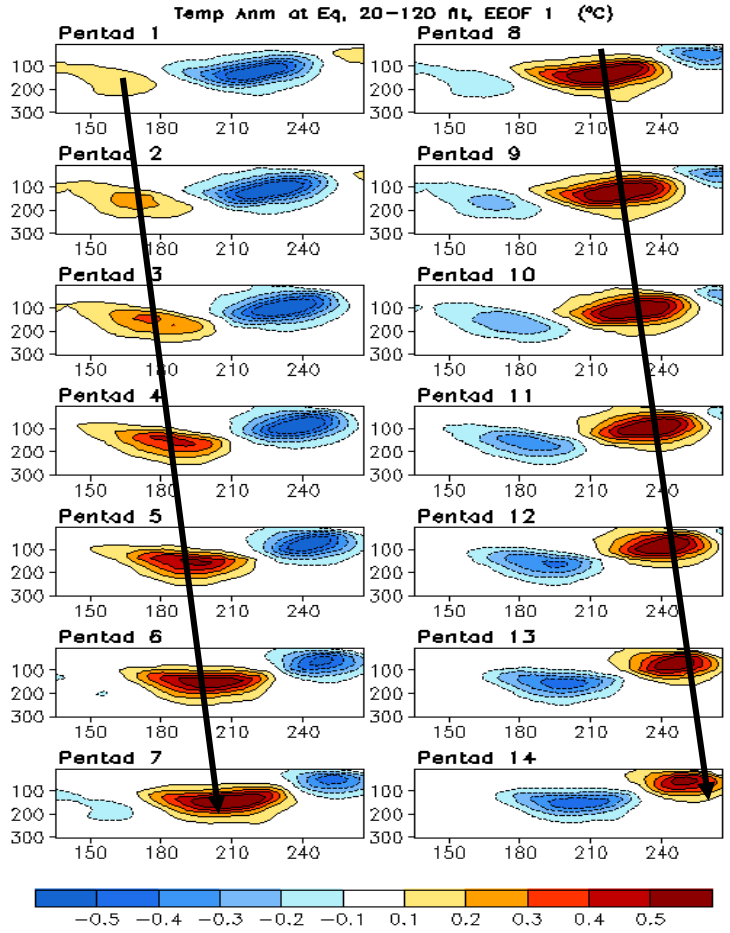
- The features of the ocean temperature anomalies were similar between GODAS and TAO analysis.

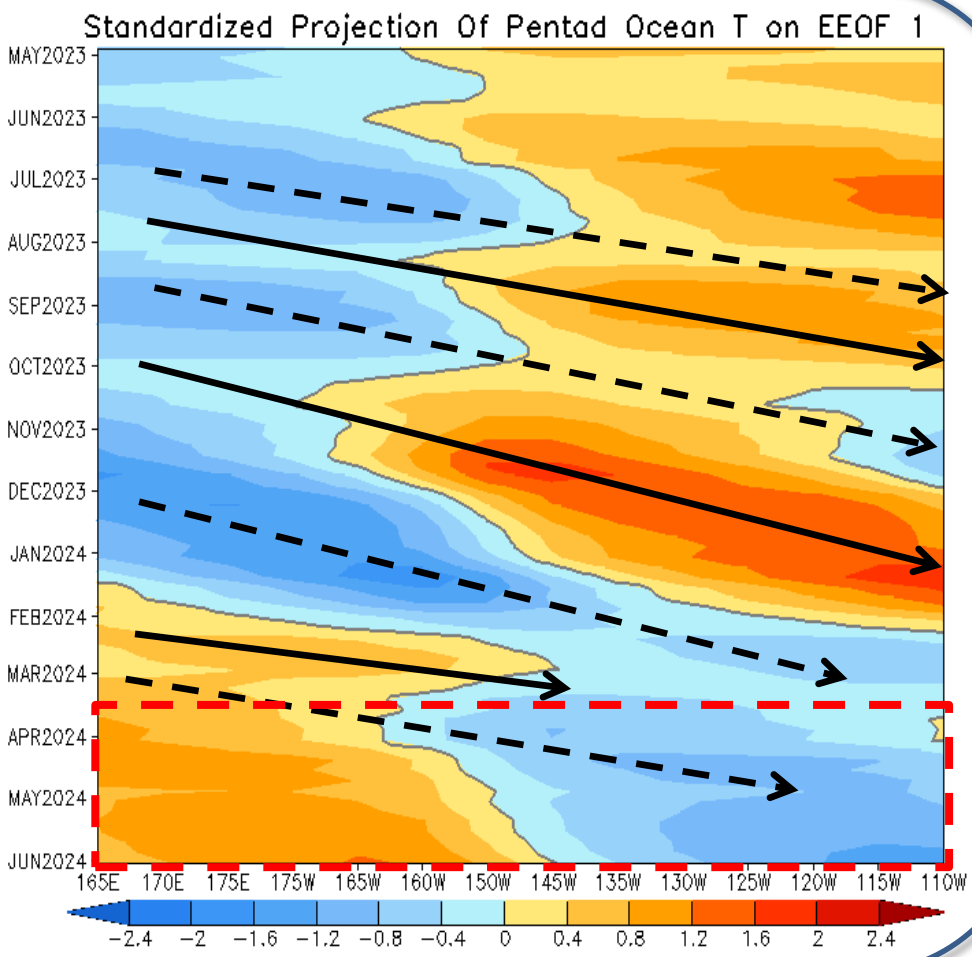
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- Anomalous westward currents have been observed since mid-Dec 2023 and weakened since May 2024.

Oceanic Kelvin Wave (OKW) Index





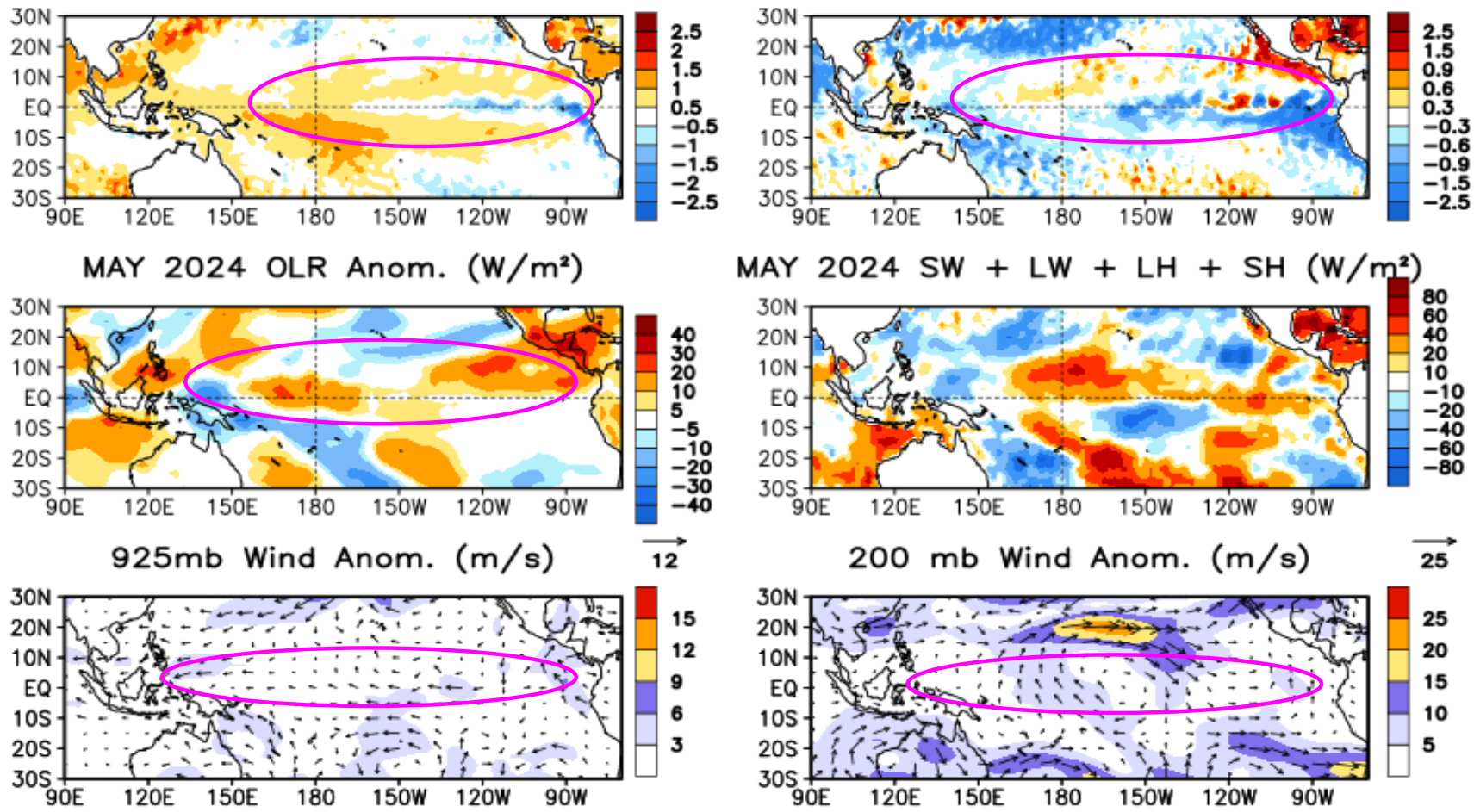
- **Multiple downwelling and upwelling Kelvin waves were observed in 2023-24, leading to fluctuation in SSTAs in the central and eastern equatorial Pacific and ENSO evolution.**

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

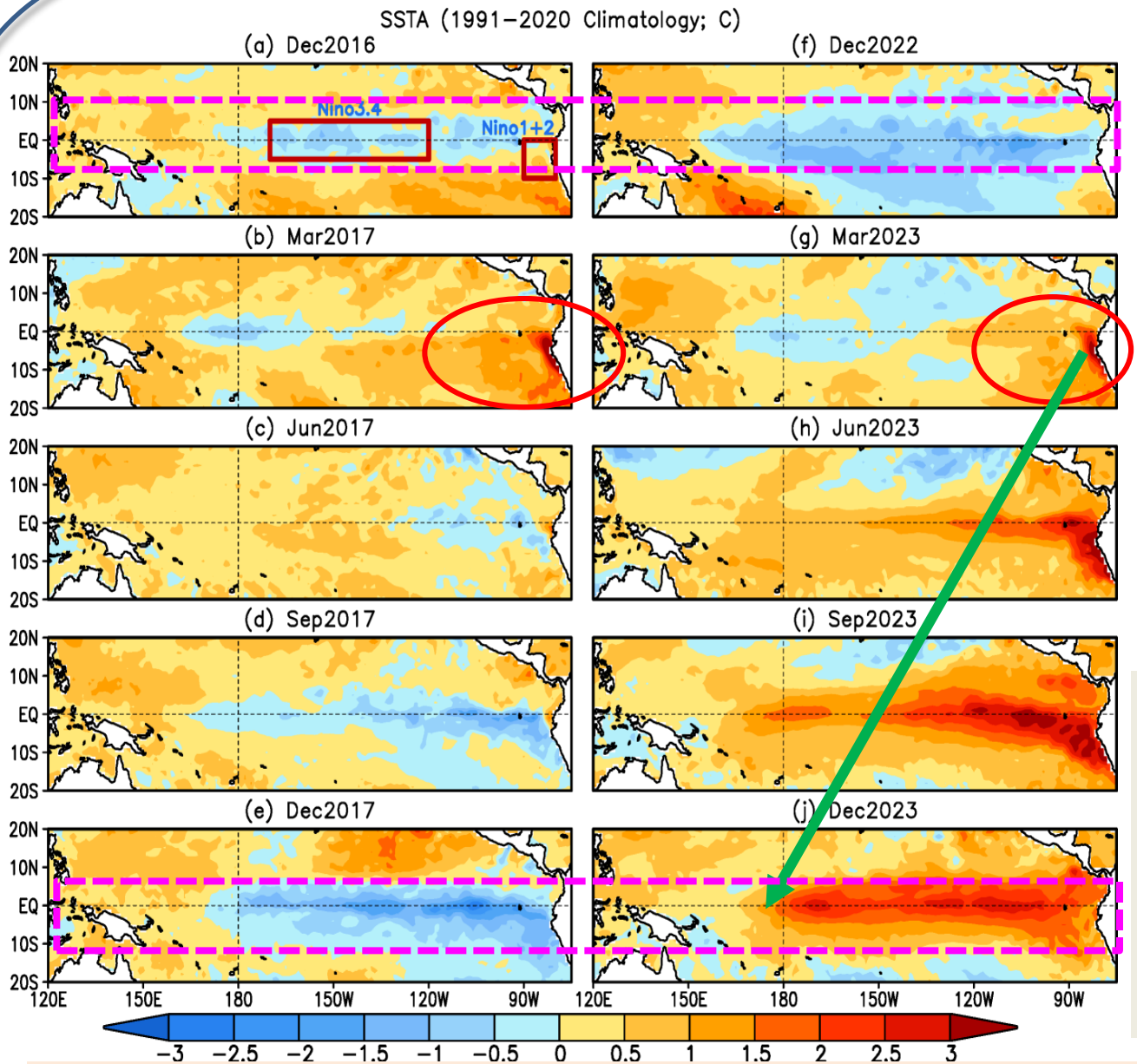
- **The variations were mostly stationary during the last few months.**

(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 mostly 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.



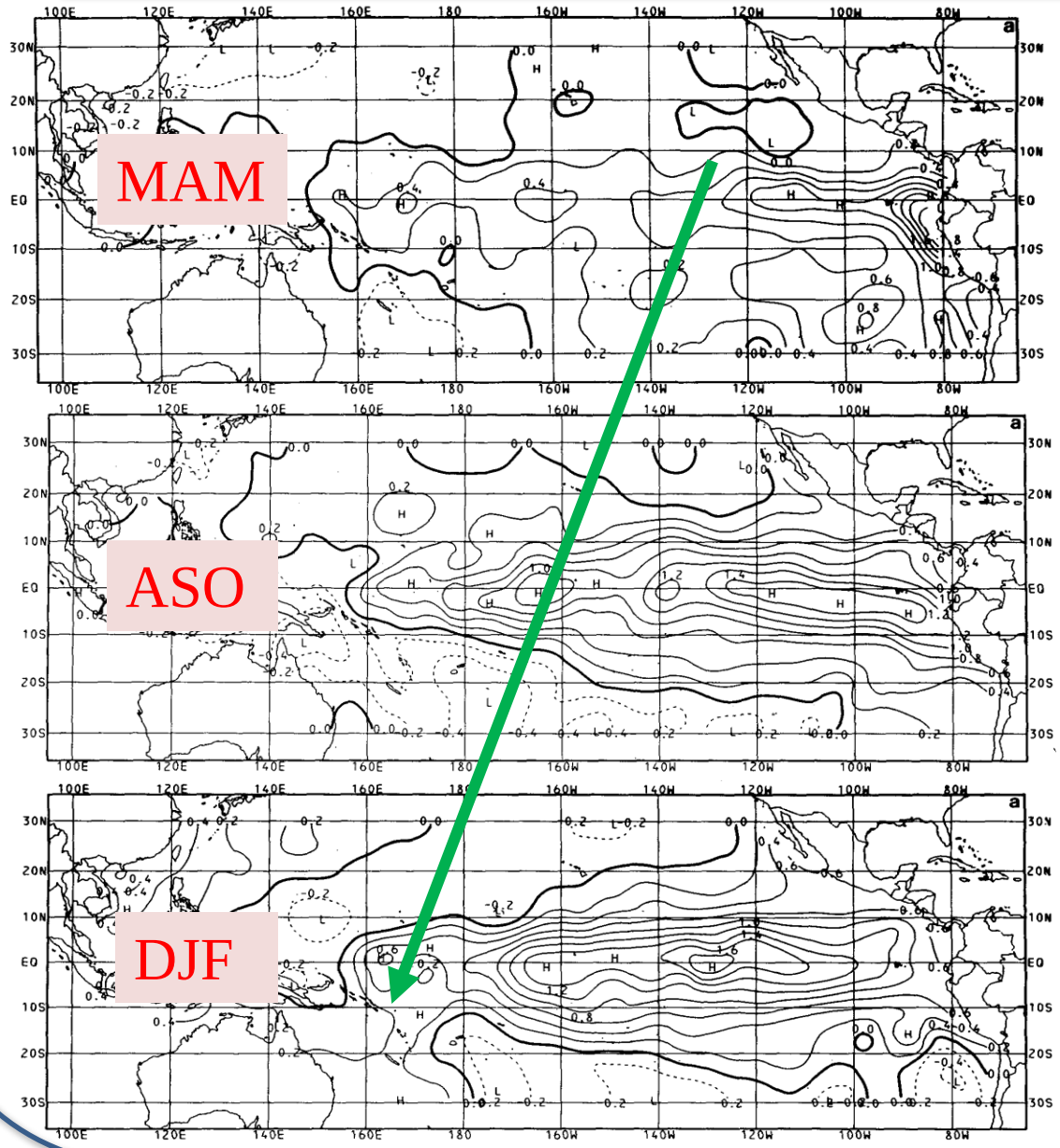
Divergent evolution:

- 2016-17: La Niña, coastal El Niño to La Niña.
- 2022-23: La Niña, coastal El Niño to El Niño.

SSTAs in (a) December 2016, (b) March 2017, (c) June 2017, (d) September 2017, (e) December 2017, (f) December 2022, (g) March 2023, (h) June 2023, (i) September 2023, and (j) December 2023. The unit is °C. The rectangles in (a) represent the regions for the Niño3.4 and Niño1+2 indices.

Tan, et al., 2024: On the divergent Evolution of ENSO after the Coastal El Niños in 2017 and 2023. Geophys. Res. Lett., 51 (9), DOI: 10.1029/2024GL108198.

ENSO-SSTa propagated westward from the Southern American costal to the central tropical Pacific during 1950s-1970s

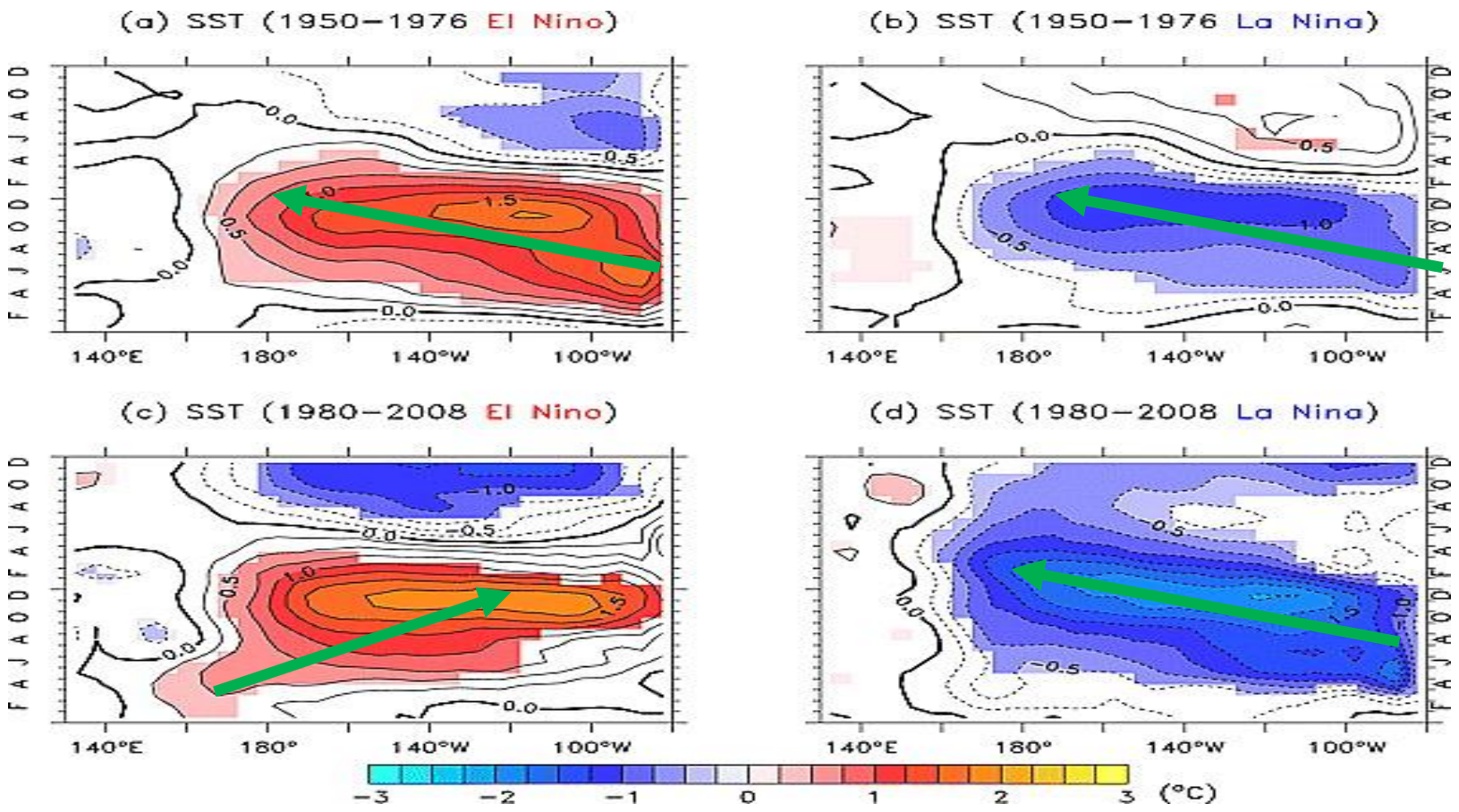


SSTa composites in 6 El Ninos:

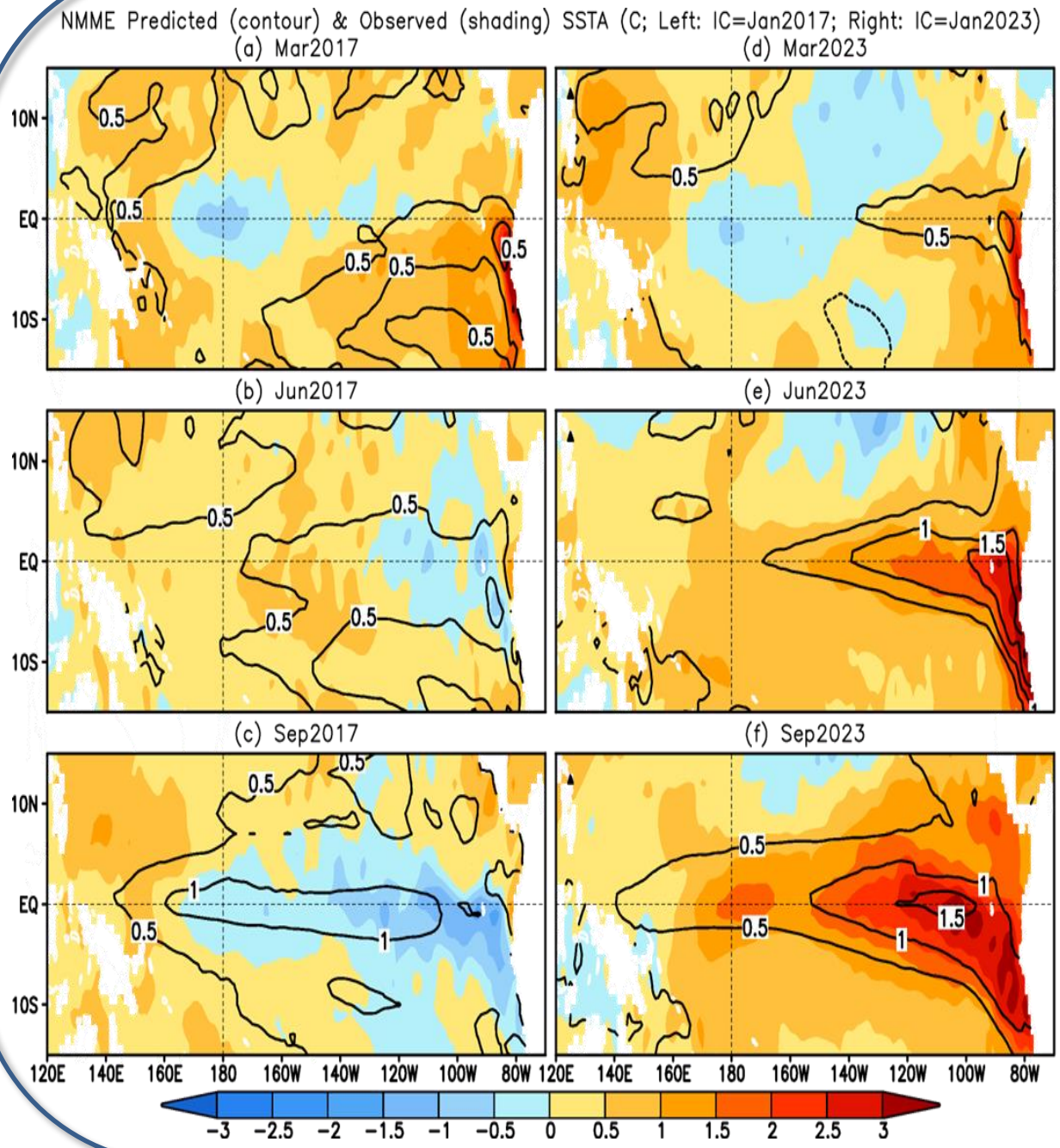
1951/52; 1953/54; 1957/58; 1965/66; 1969/70; 1972/73

Rasmusson, E. M., and T. H. Carpenter, 1982: Variation in tropical sea surface temperature and surface wind fields associated with Southern Oscillation/El Niño. Mon. Wea. Rev., 110, 354–384.

ENSO-SSTa propagated westward (eastward) from the costal to the central tropical Pacific during 1950-1976 (1980-2008) without change for La Nina

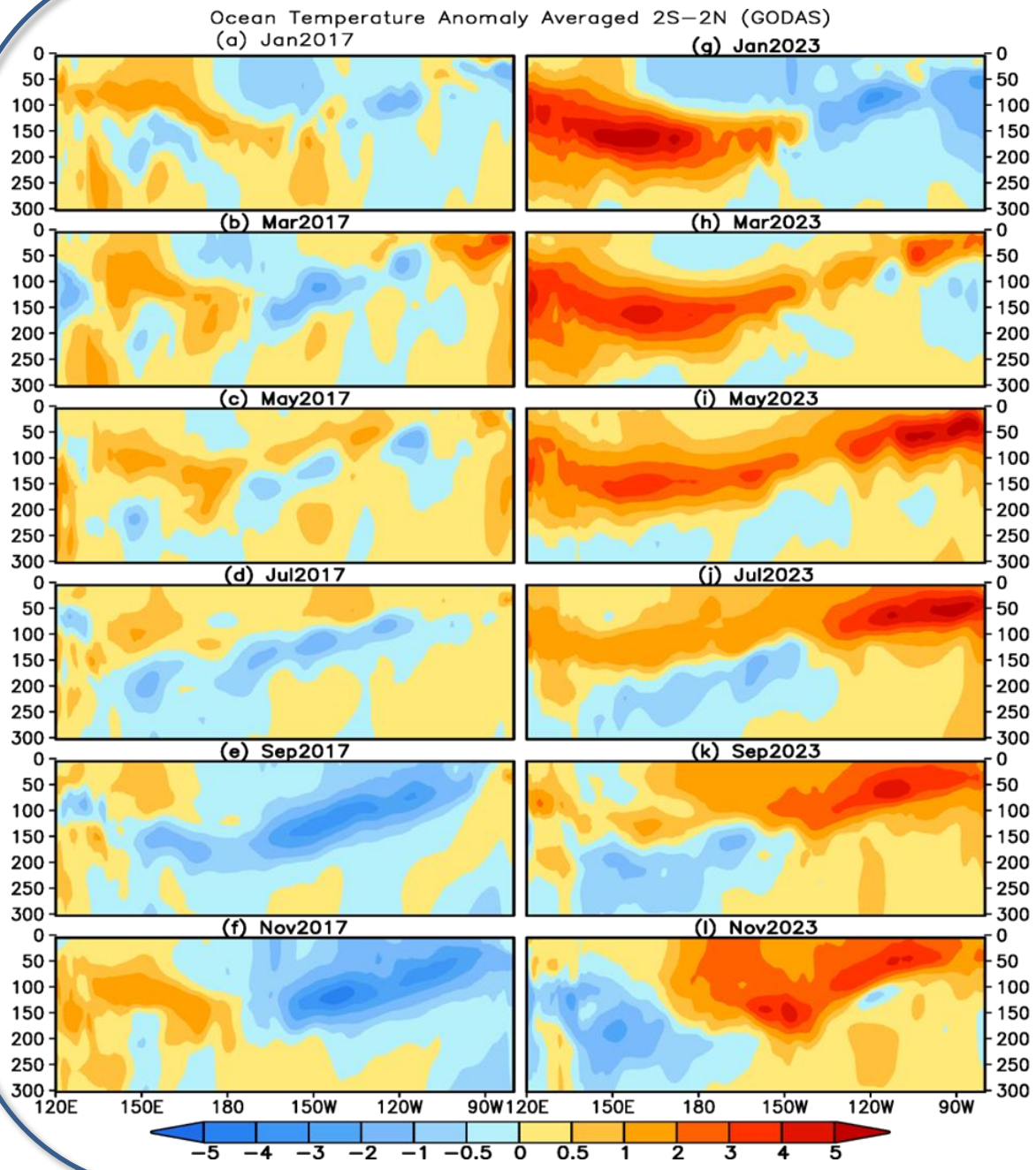


Composite of ENSO SST anomalies as a function of time and longitude along the equator for (a) El Niño and (b) La Niña for the period 1950–1977. (c) for El Niño and (d) for La Niña are repeated from Figure 2b and Figure 2f respectively for the period 1980–2008. Contour Interval is 0.25 °C for all plots. Shading indicates the most robust features of the composites where the mean exceeds one standard error (McPhaden, M. J., and X. Zhang, 2009: Asymmetry in zonal phase propagation of ENSO sea surface temperature anomalies. GRL, 36, L13703. DOI: 10.1029/2009GL038774)



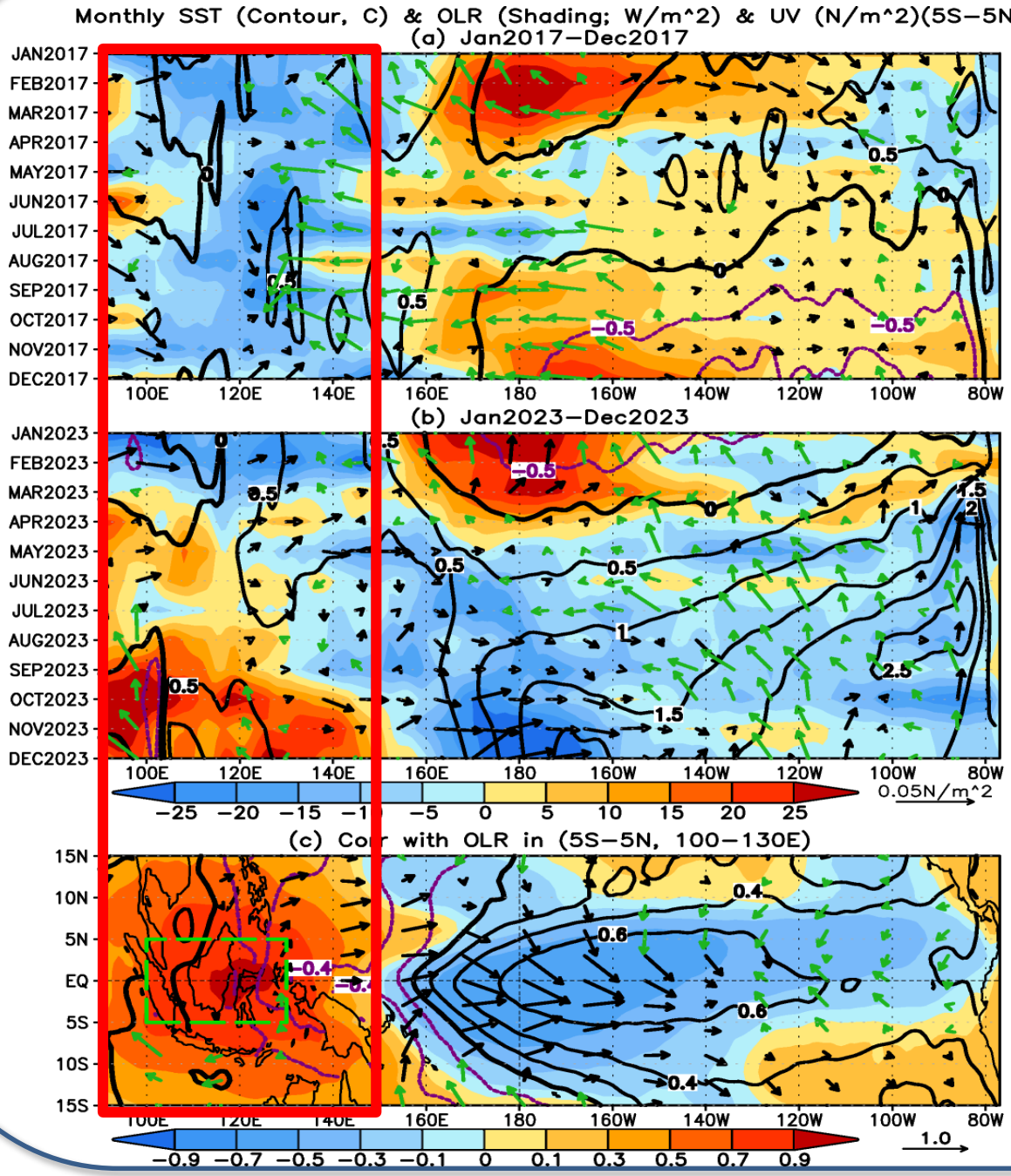
- The transition to La Niña in 2017 was not well predicted.
- The transition to El Niño in 2023 was well predicted, implying the importance of subsurface ocean heat conditions in ENSO prediction.

NMME predicted SSTAs (contours with interval of 0.5°C) in (a) March 2017, (b) June 2017, (c) September 2017 with initial conditions in January 2017, in (d) March 2023, (e) June 2023, and (f) September 2023 with initial conditions in January 2023. Shading represents the corresponding observations.



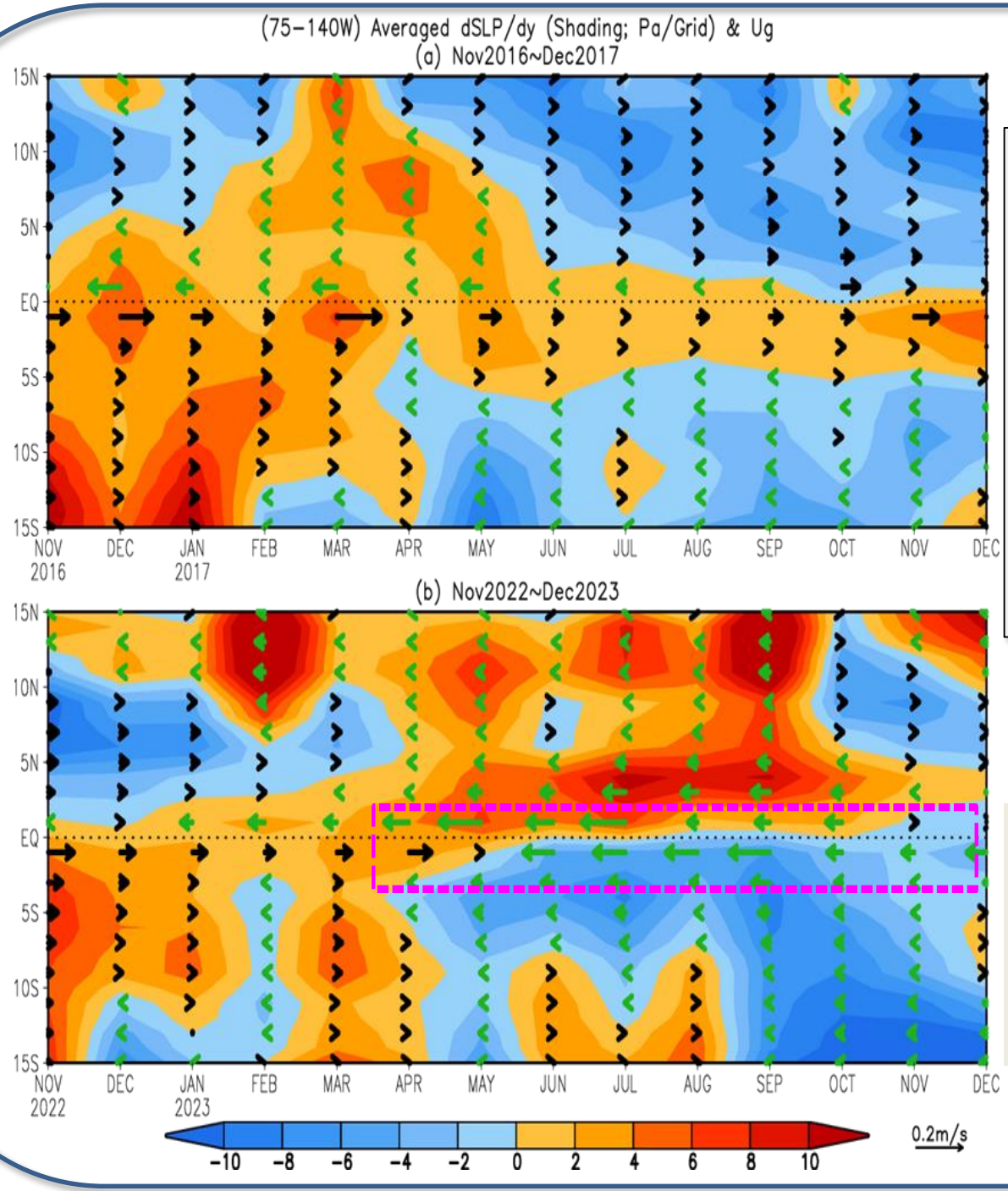
➢Subsurface ocean heat conditions are favorable (unfavorable) for a transition to El Niño in 2023 (2017).

GODAS ocean temperature anomalies averaged in 2°S-2°N in (a) January 2017, (b) March 2017, (c) May 2017, (d) July 2017, (e) September 2017, (f) November 2017, (g) January 2023, (h) March 2023, (i) May 2023, (j) July 2023, (k) September 2023, and (l) November 2023. The unit is °C.



- Statistically, suppressed (enhanced) convections in the W. Pacific are favorable westerly (easterly) wind in the c. Pacific.
- Enhanced convections in the w. Pacific in 2017 are favorable for transition to La Niña.

Hovmöller diagrams of the monthly mean anomalies of SST (contour interval 0.5°C), OLR (shading), and surface wind stress (vector) averaged in 5°S-5°N during (a) January-December 2017 and (b) July-December 2023. (c) Correlations of SST (contour interval 0.2), OLR (shading), and surface wind stress (vector) anomalies with OLR anomalies averaged in (5°S-5°N, 100°-130°E; the green rectangle) during January 1991 - July-December 2023. In (a, b), the units are °C for SST, W/m^2 for OLR, and N/m^2 for wind stress. The vectors in black (green) represent westerly (easterly) zonal wind anomalies.

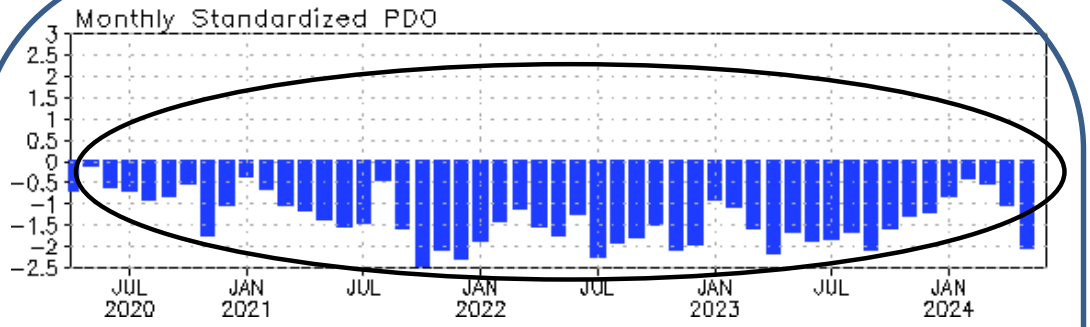


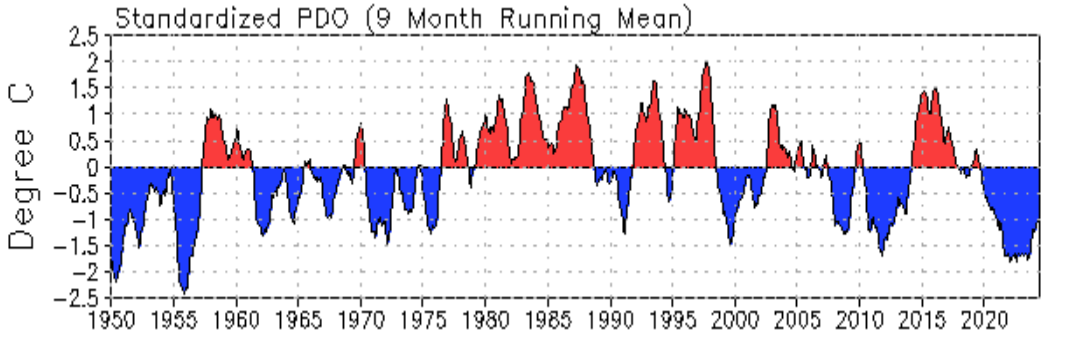
➢ SLP gradients across the equator in 2022-23 generated easterly wind anomalies, which count against the westerly associated with SSTA zonal gradient, resulting in weak westerly anomalies.

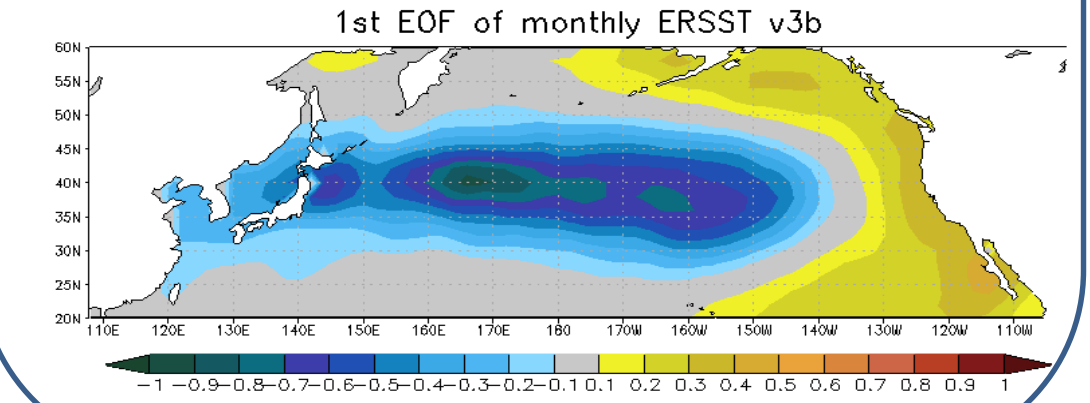
Hovmöller diagrams of 140°W-75°W averaged "∂SLP/∂y (shading; Pa/grid), and zonal geostrophic wind (m/s) anomalies during (a) November 2016-December 2017 and (b) November 2022-December2023. The vectors in black (green) represent westerly (easterly) zonal wind anomalies.

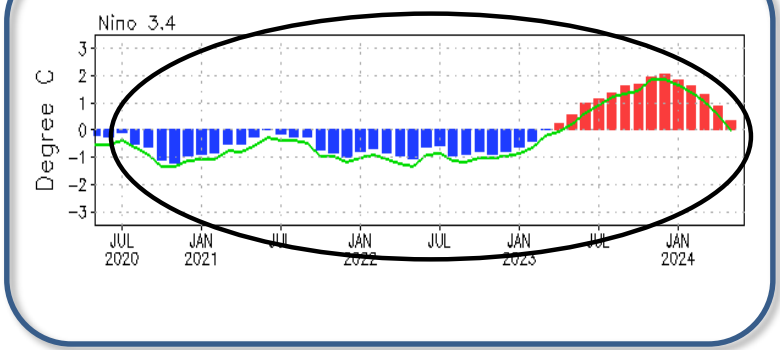
North Pacific, Arctic, & Antarctic Oceans

Pacific Decadal Oscillation (PDO) Index





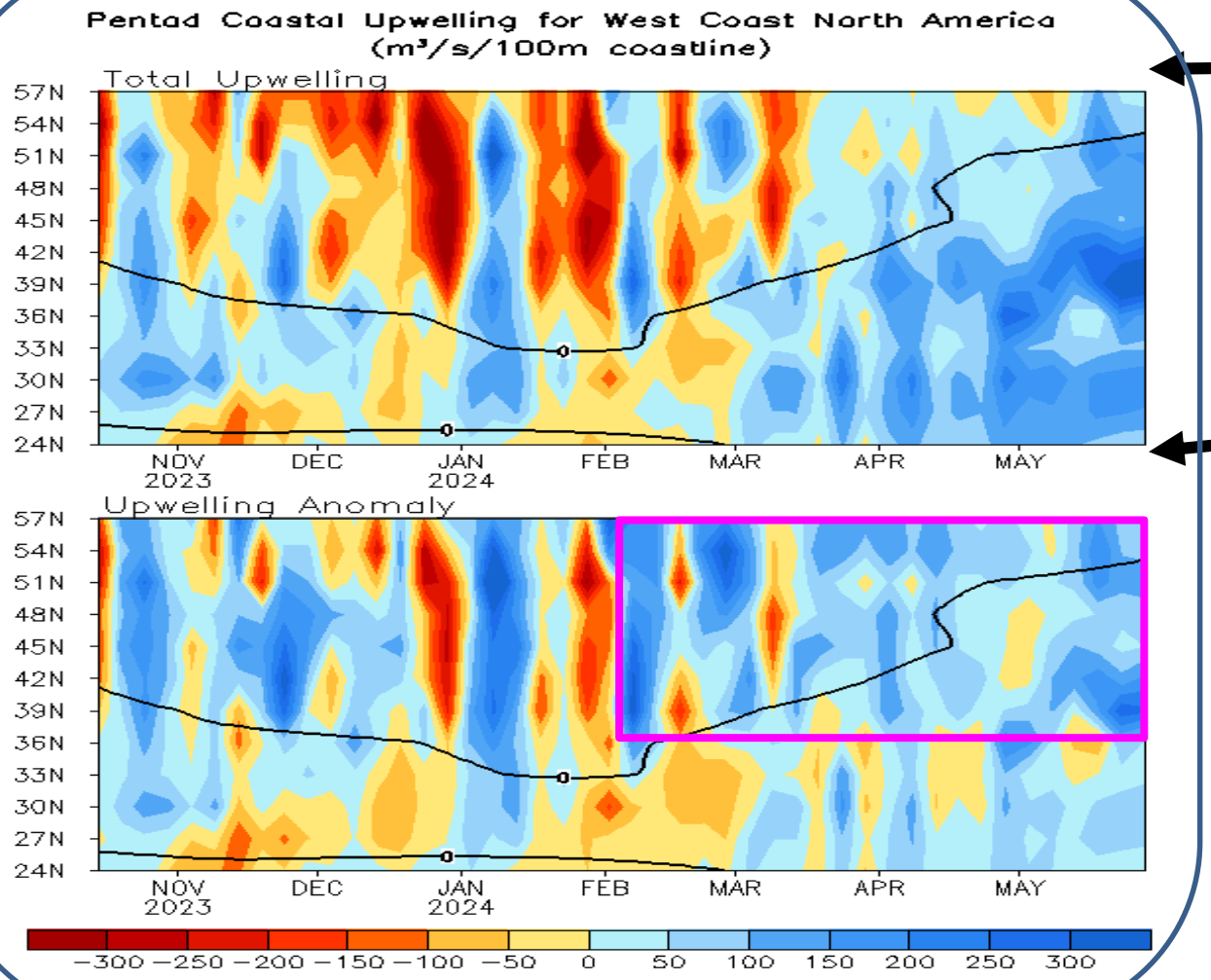


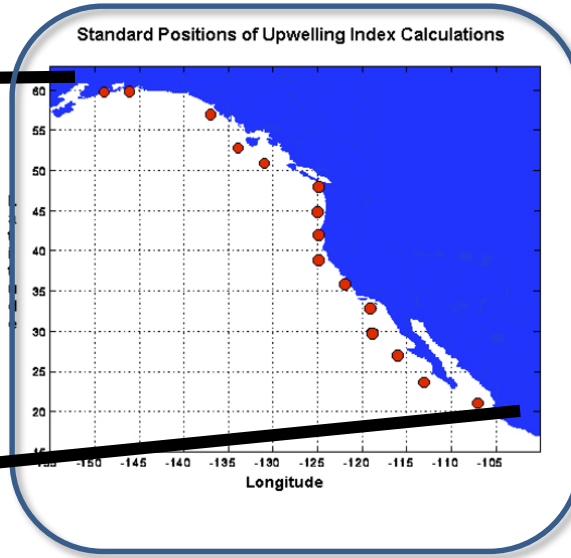


- The PDO has been in a negative phase since Jan 2020 and strengthened with PDOI = -2.1 in May 2024.
- Simultaneous correlation of PDO & Nino3.4 indices is 0.43 in 1961-1990 and 0.50 in 1991-2020.
- Statistically, ENSO leads PDO by 3-4 months, through teleconnection via atmospheric bridge, with El Niño (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

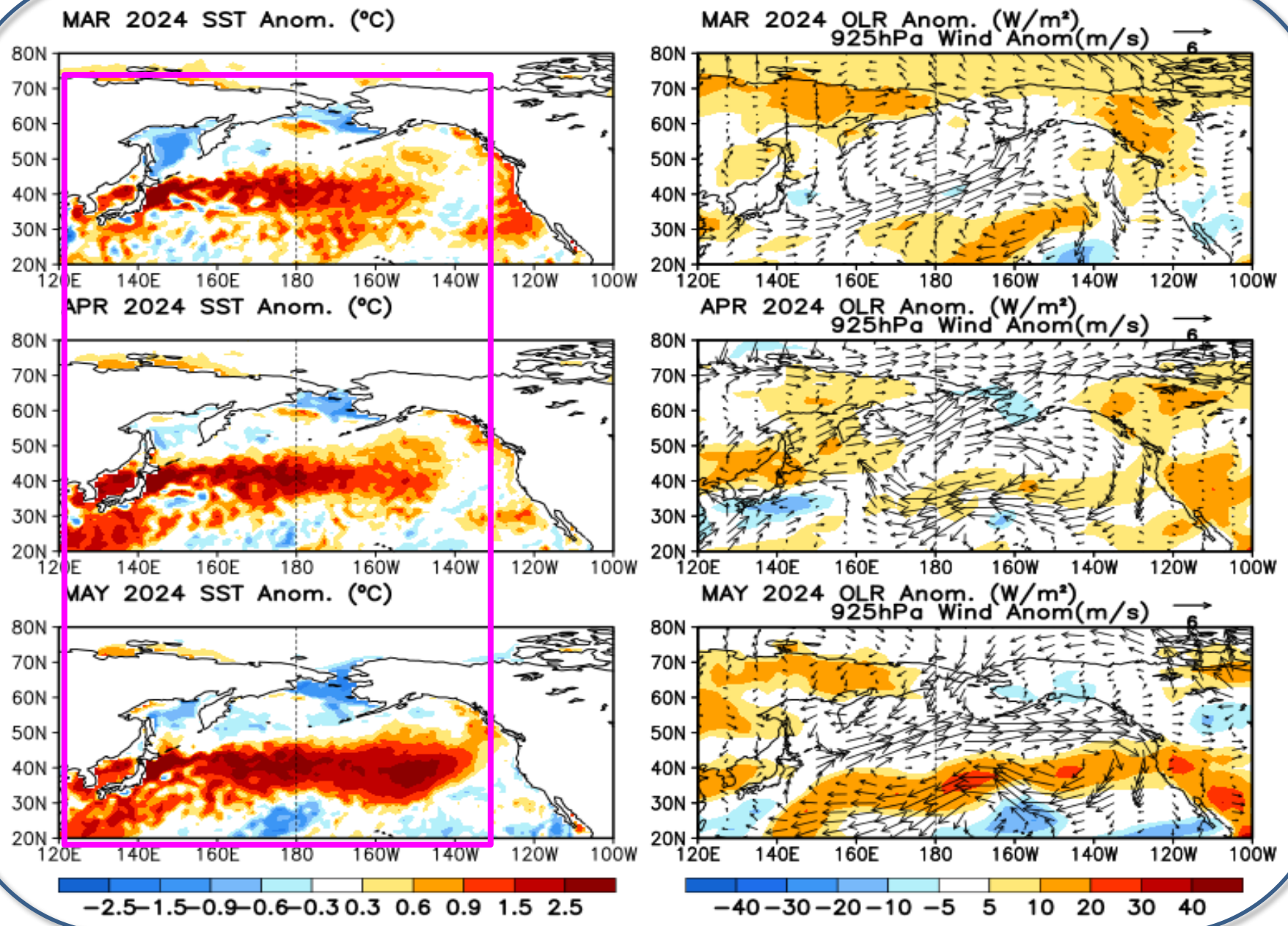




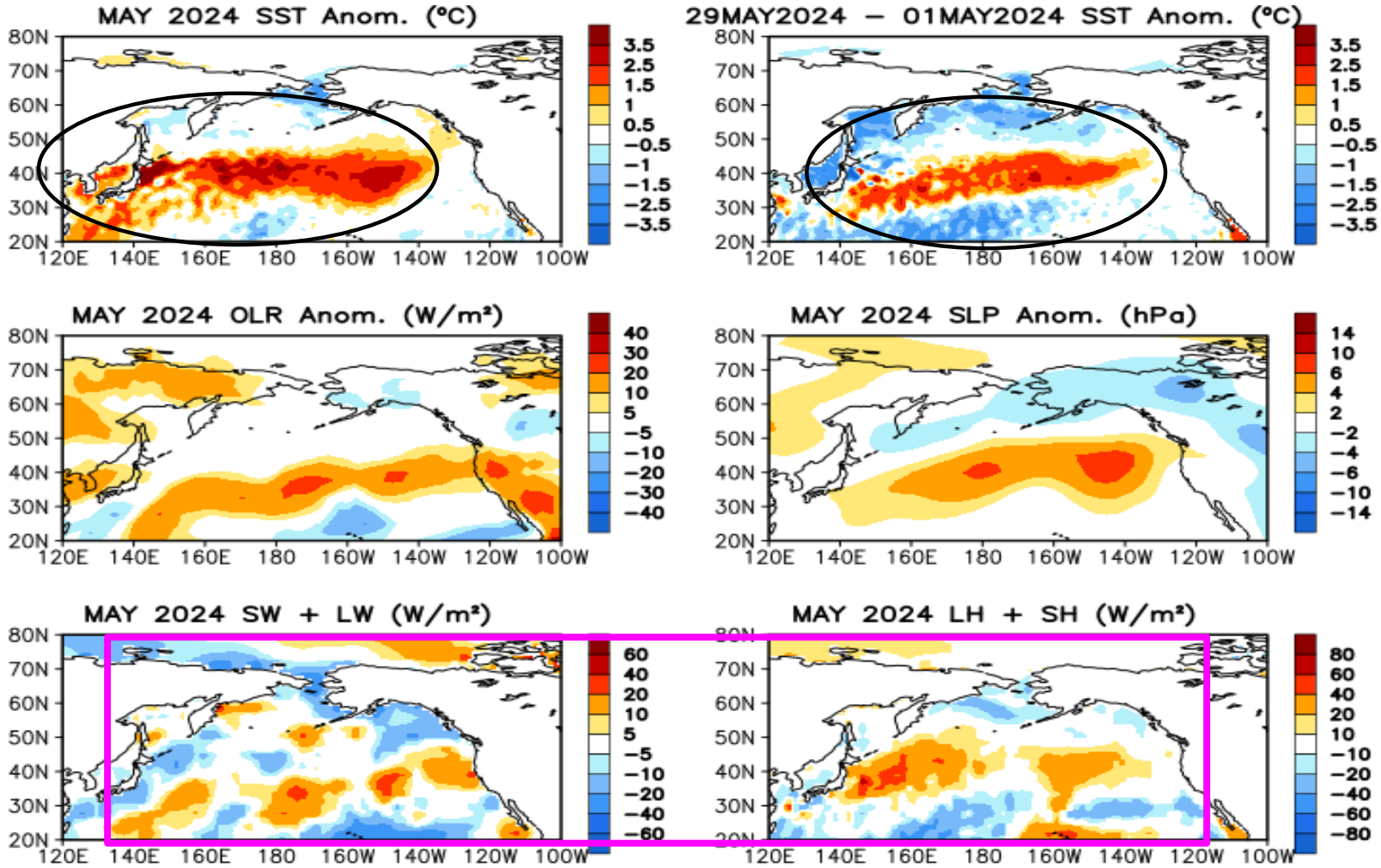
- Anomalous upwelling has been observed in the mid- and high latitudes since Feb 2024.

(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

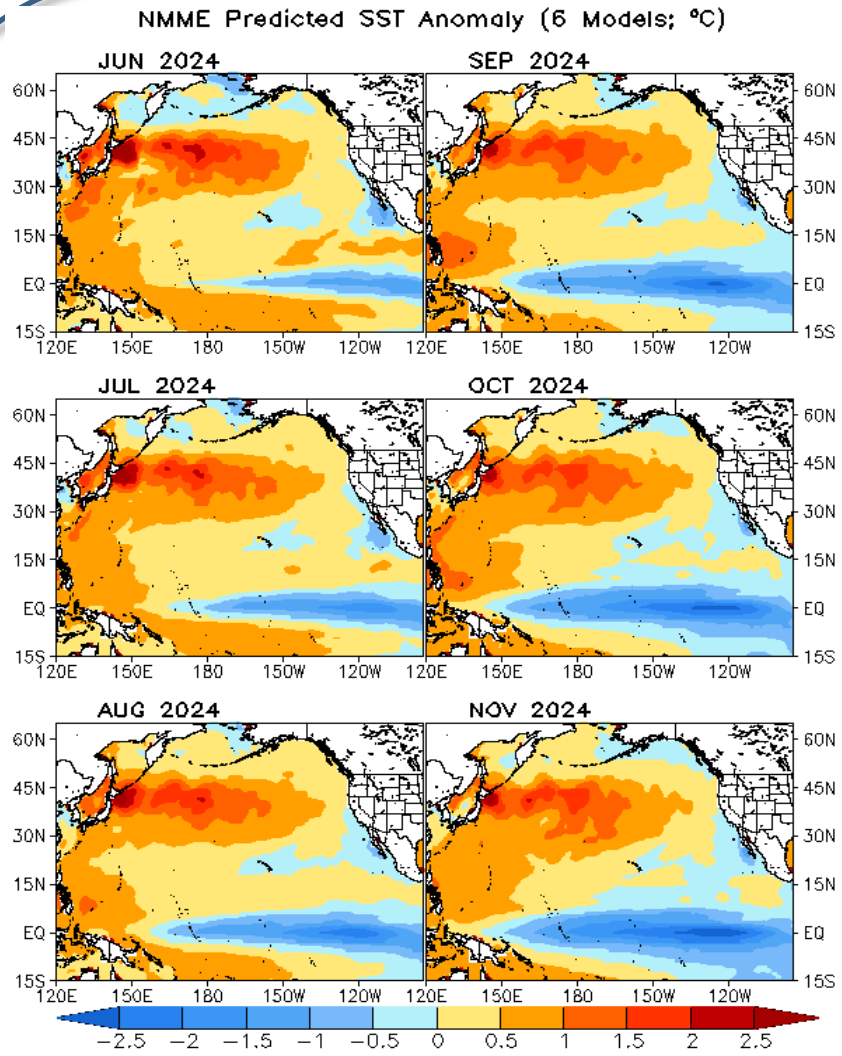


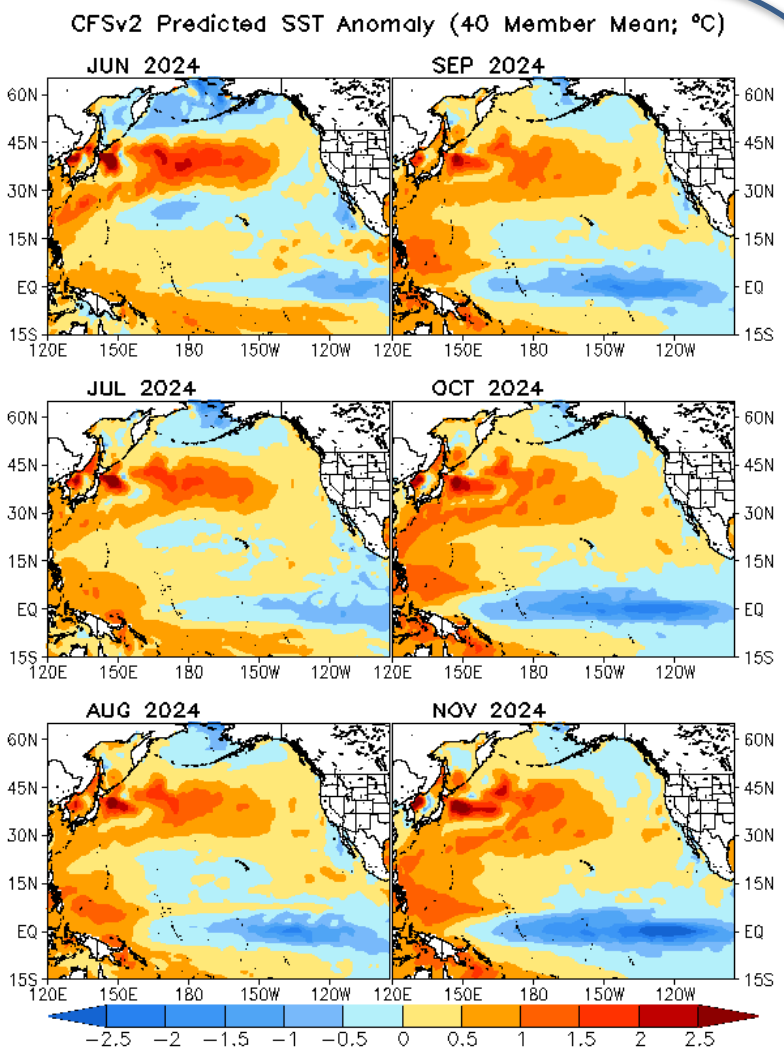
North Pacific Ocean: SSTA, SSTA Tend., OLR, SLP, Sfc Rad, Sfc Flx Anomalies



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.

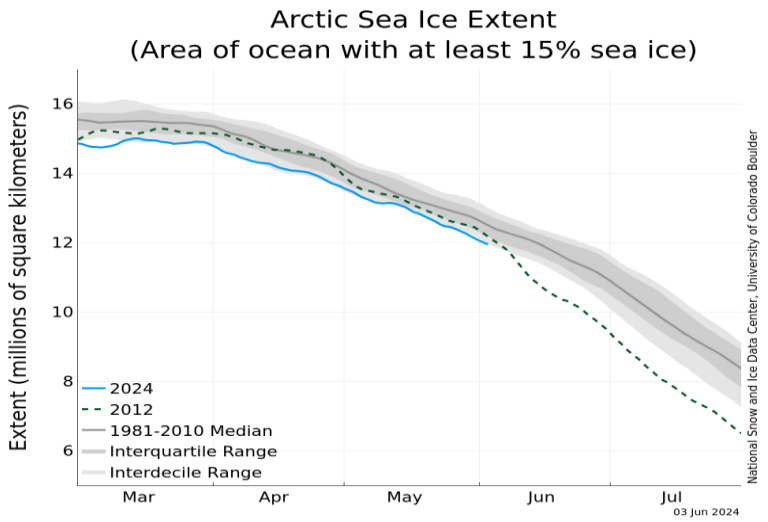
NMME & CFSv2 SSTA Predictions

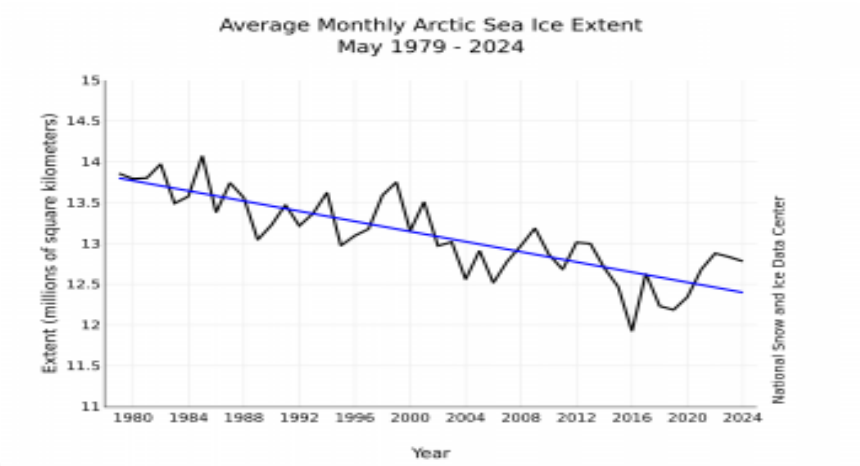


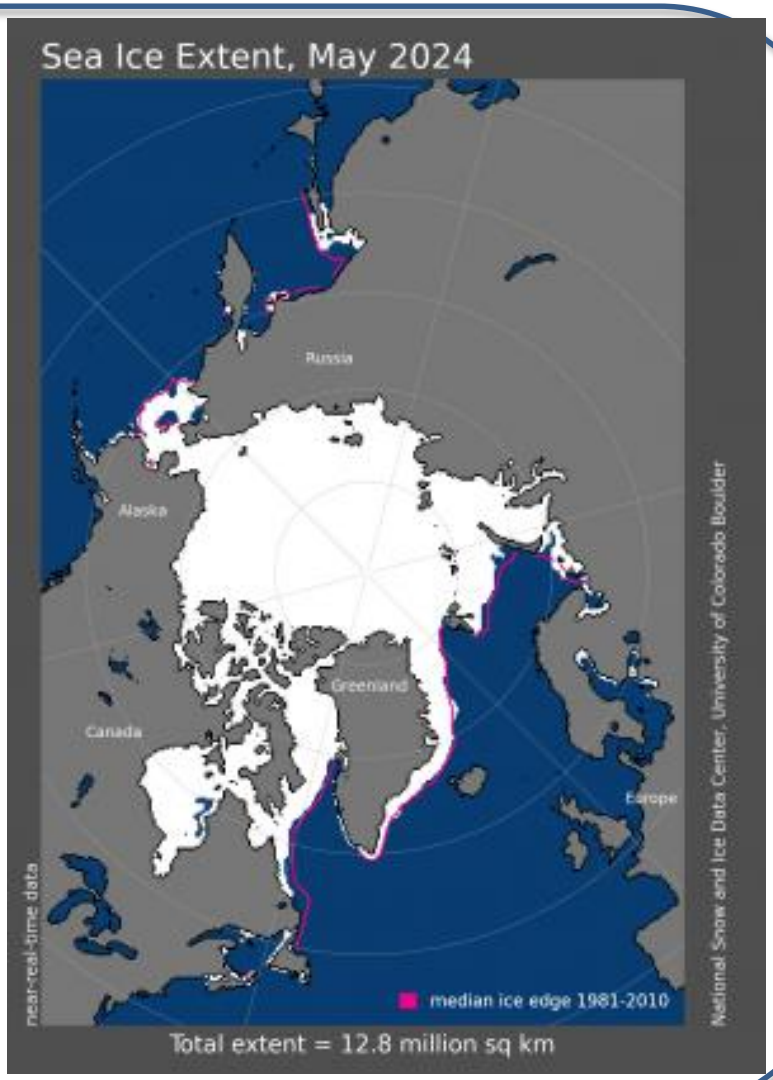


- NMME & CFSv2 predict that the current SST warm condition in the North Pacific will persist through fall 2024.

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

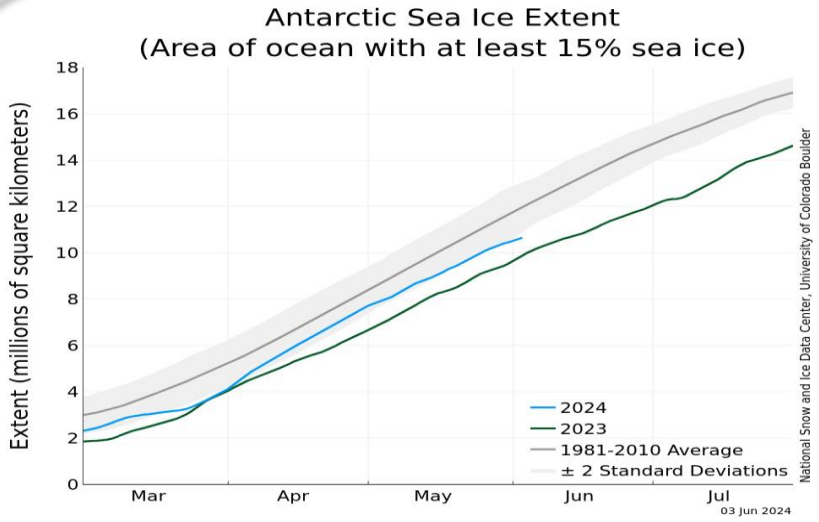


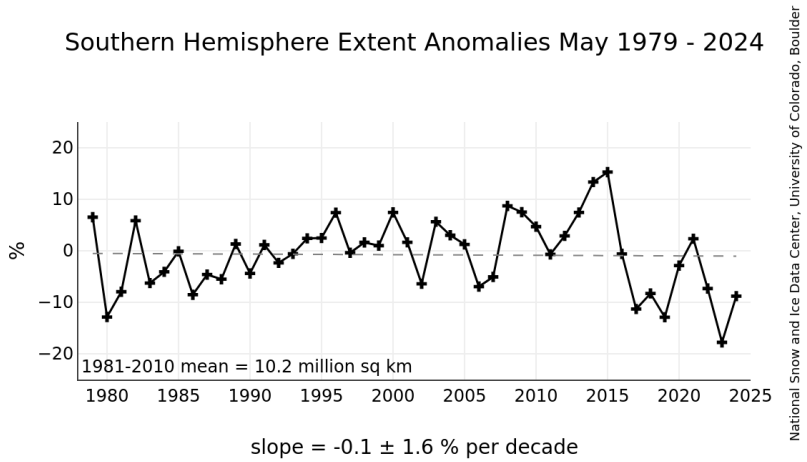


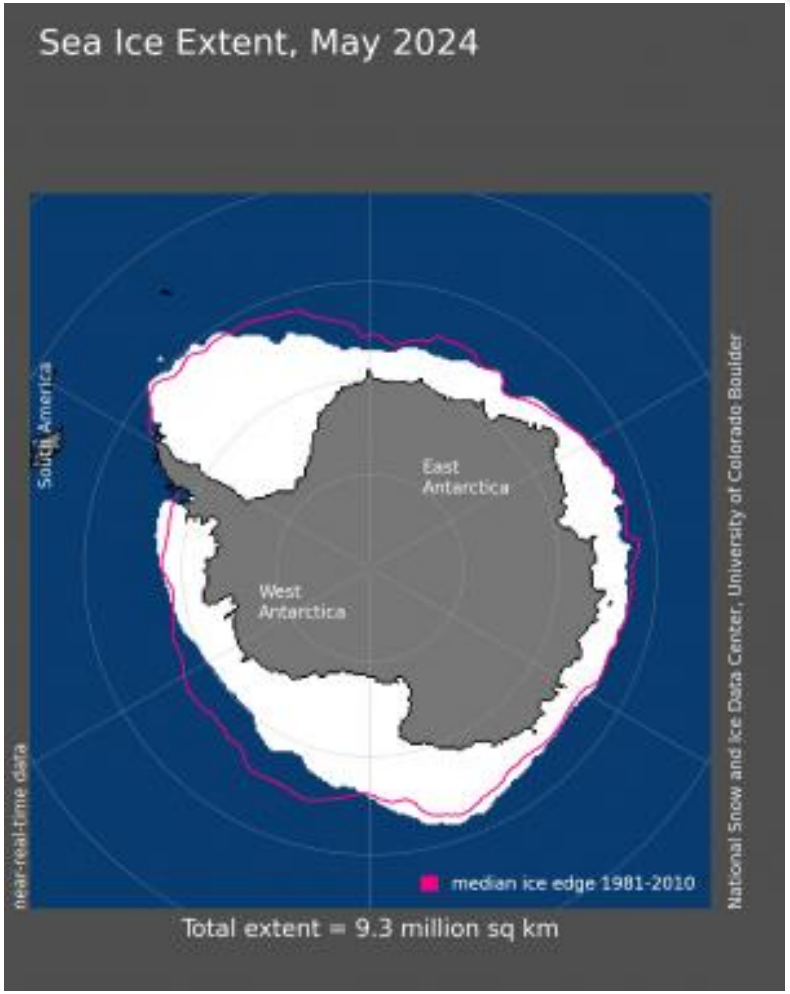


- The average Arctic sea ice extent for May 2024 was 12.78 million km^2, tying for 12th May lowest with 2007 in the passive microwave satellite record.

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



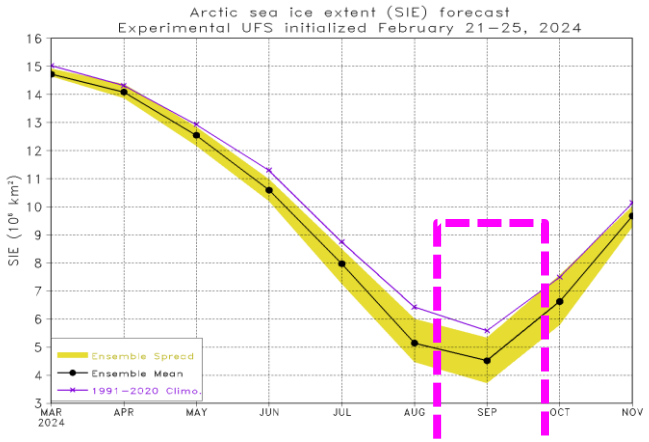


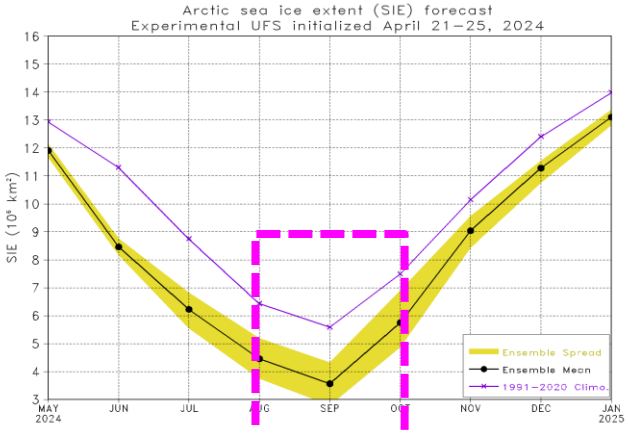


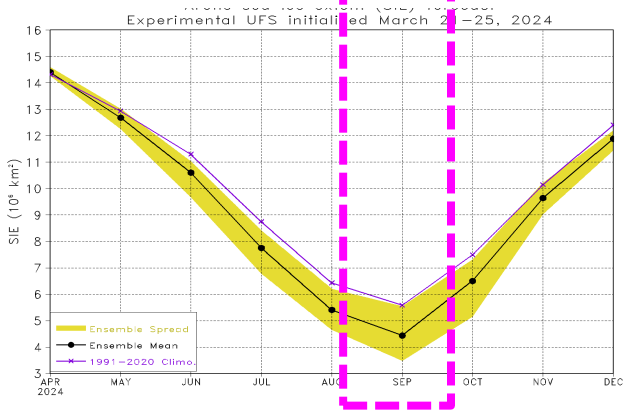
- Antarctic sea ice extent was 10.52 million km^2, ranking the 5th lowest May extent since 1979.

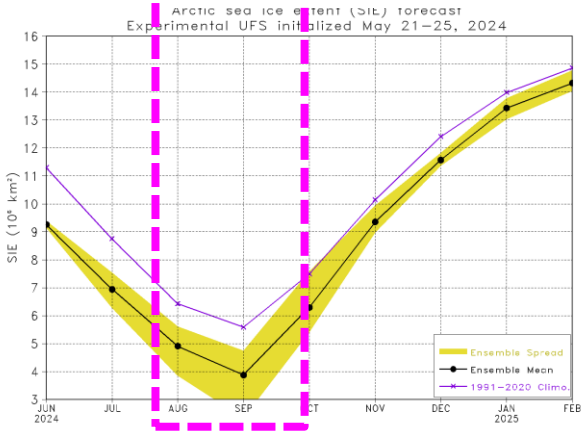
NCEP/CPC Arctic Sea Ice Extent (SIE) Forecast

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





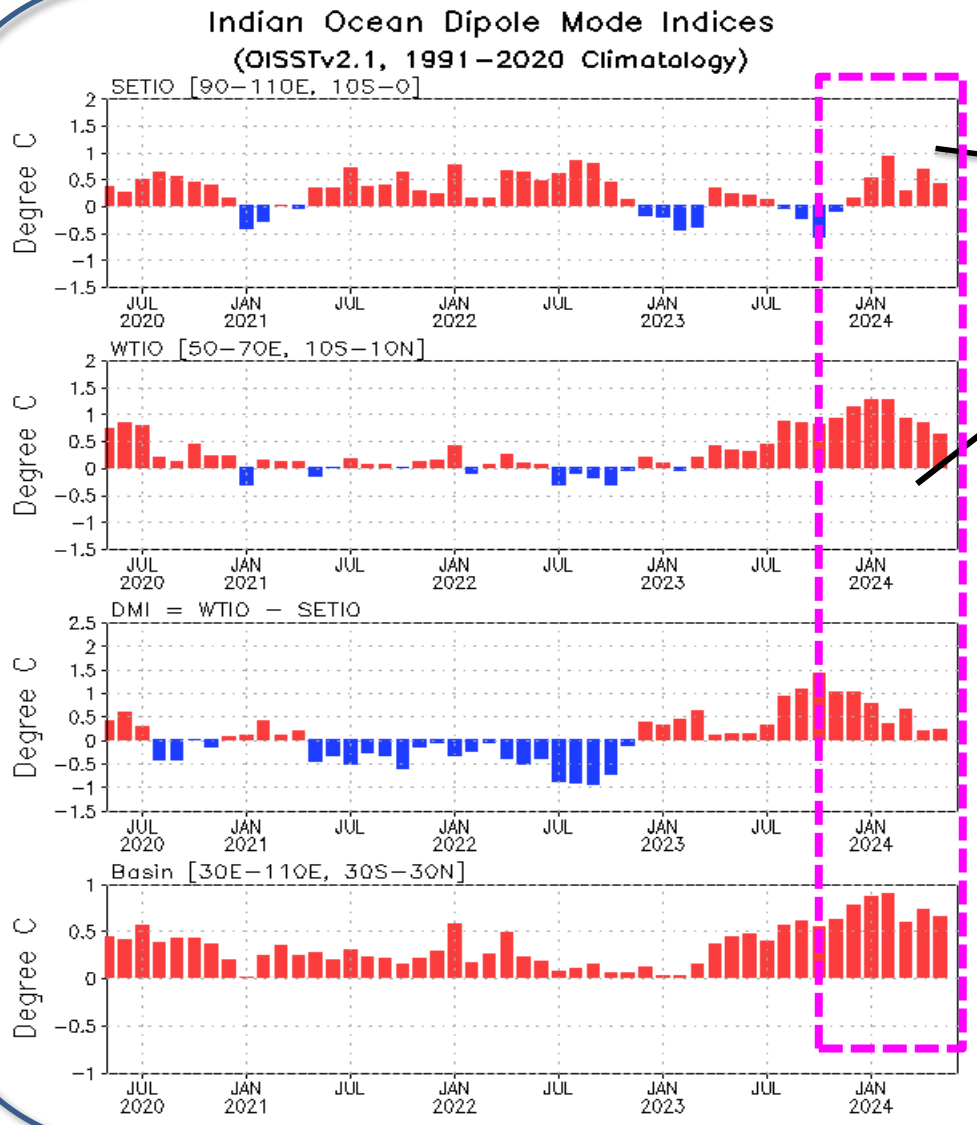


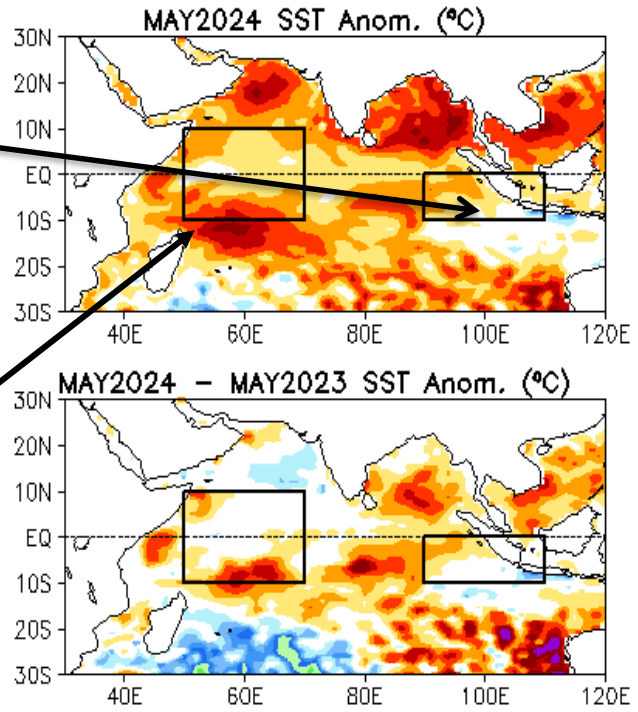


https://www.cpc.ncep.noaa.gov/products/people/jszhu/seaice_seasonal/index.html

Indian Ocean

Evolution of Indian Ocean SST Indices



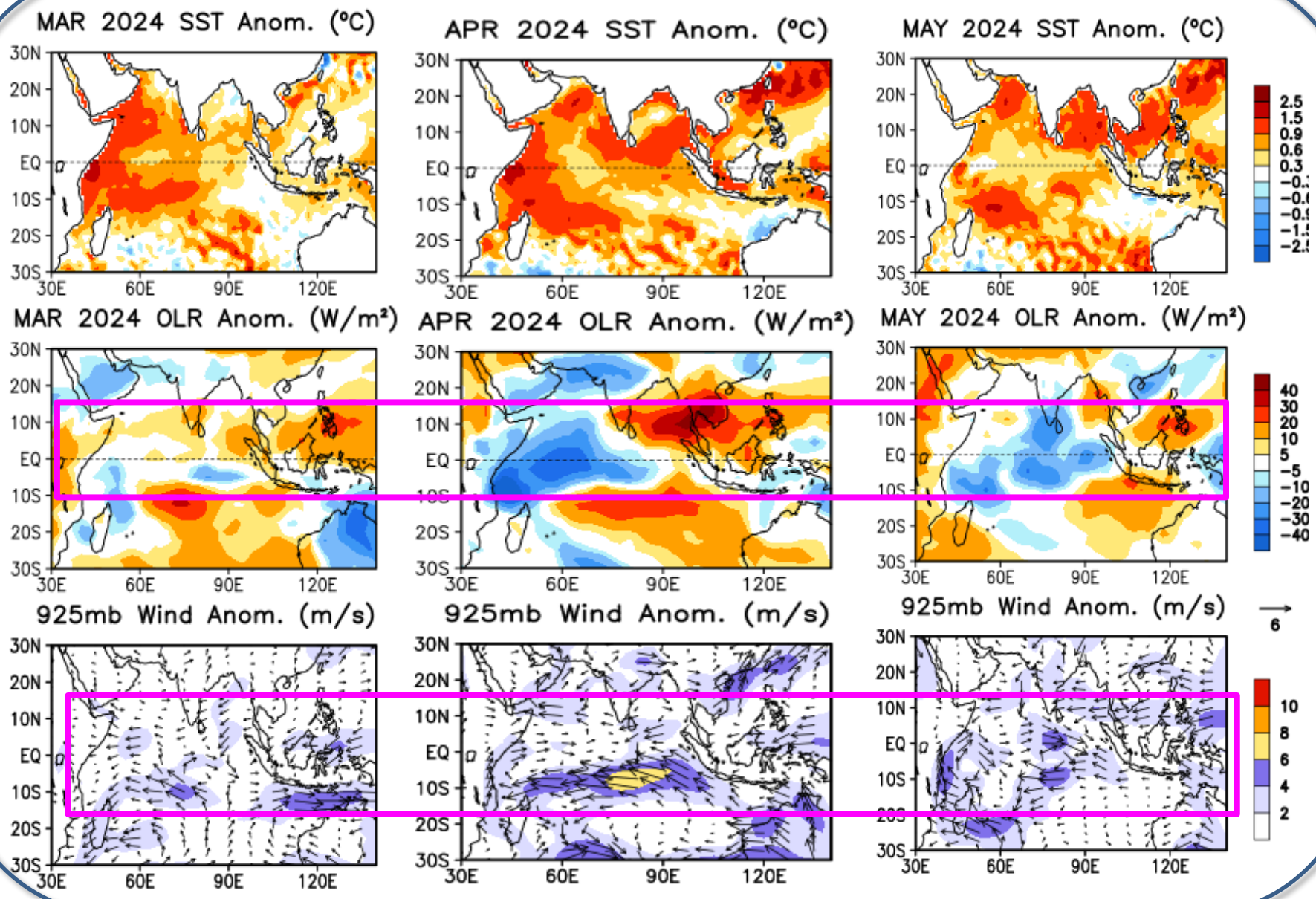


- Positive SSTAs weakened in the tropical Indian Ocean in May 2024, featuring a positive phase of the IOBM.

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.

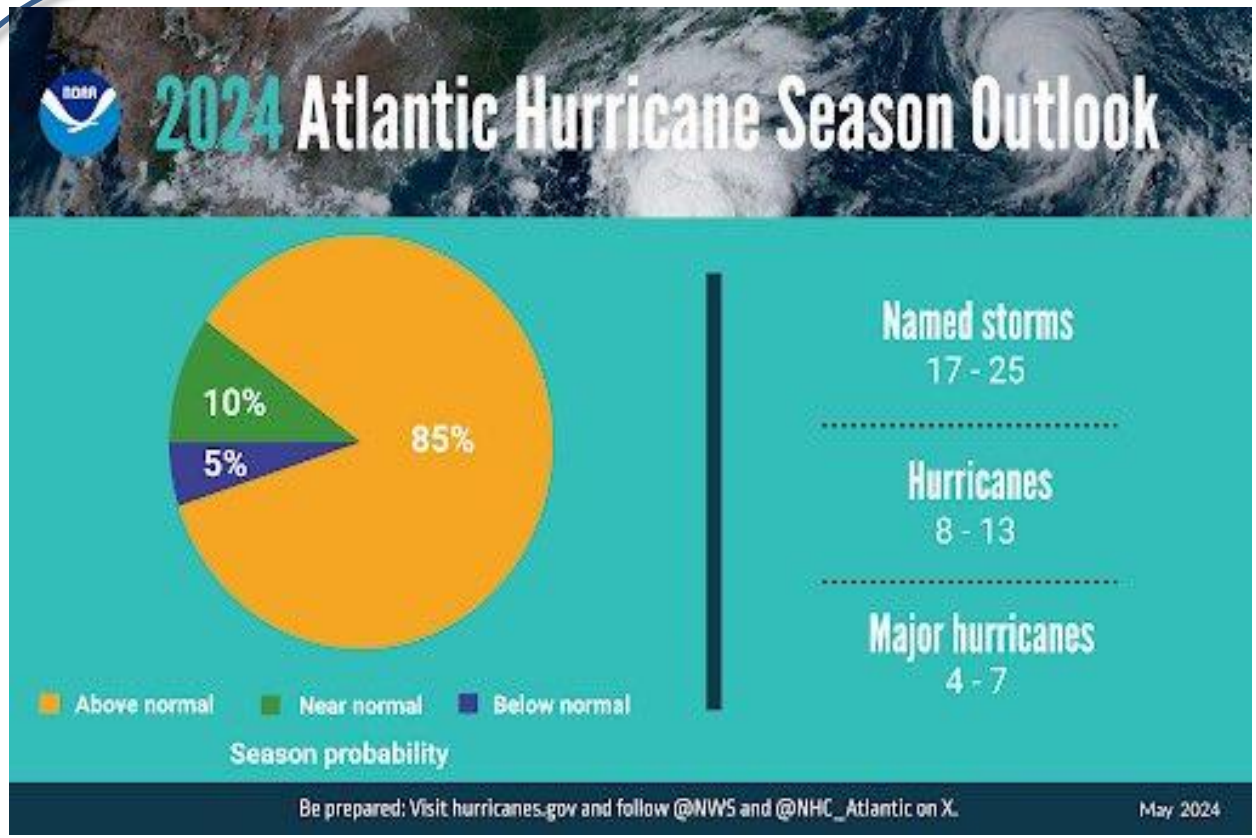
Tropical Indian: SSTA, SSTA Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Wind Anom.

The coupling associated with the IOD enhanced from Mar to Apr, & weakened from Apr to May 2024



Tropical and North Atlantic Ocean

NOAA's 2024 Atlantic Hurricane Season Outlook



- May 23, 2024: NOAA CPC forecast a range of 17-25 total named storms. Of those, 8-13 could become hurricanes, including 4-7 major hurricanes (category 3, 4 or 5).
- The corresponding climatological averages are 14, 7, & 3.

"…. the continuation of the high-activity era for Atlantic hurricanes, which began in 1995 in association with a transition to the warm phase of the Atlantic Multidecadal Oscillation (AMO). The recently observed and predicted atmospheric conditions for ASO 2024 reflect the warm AMV phase….

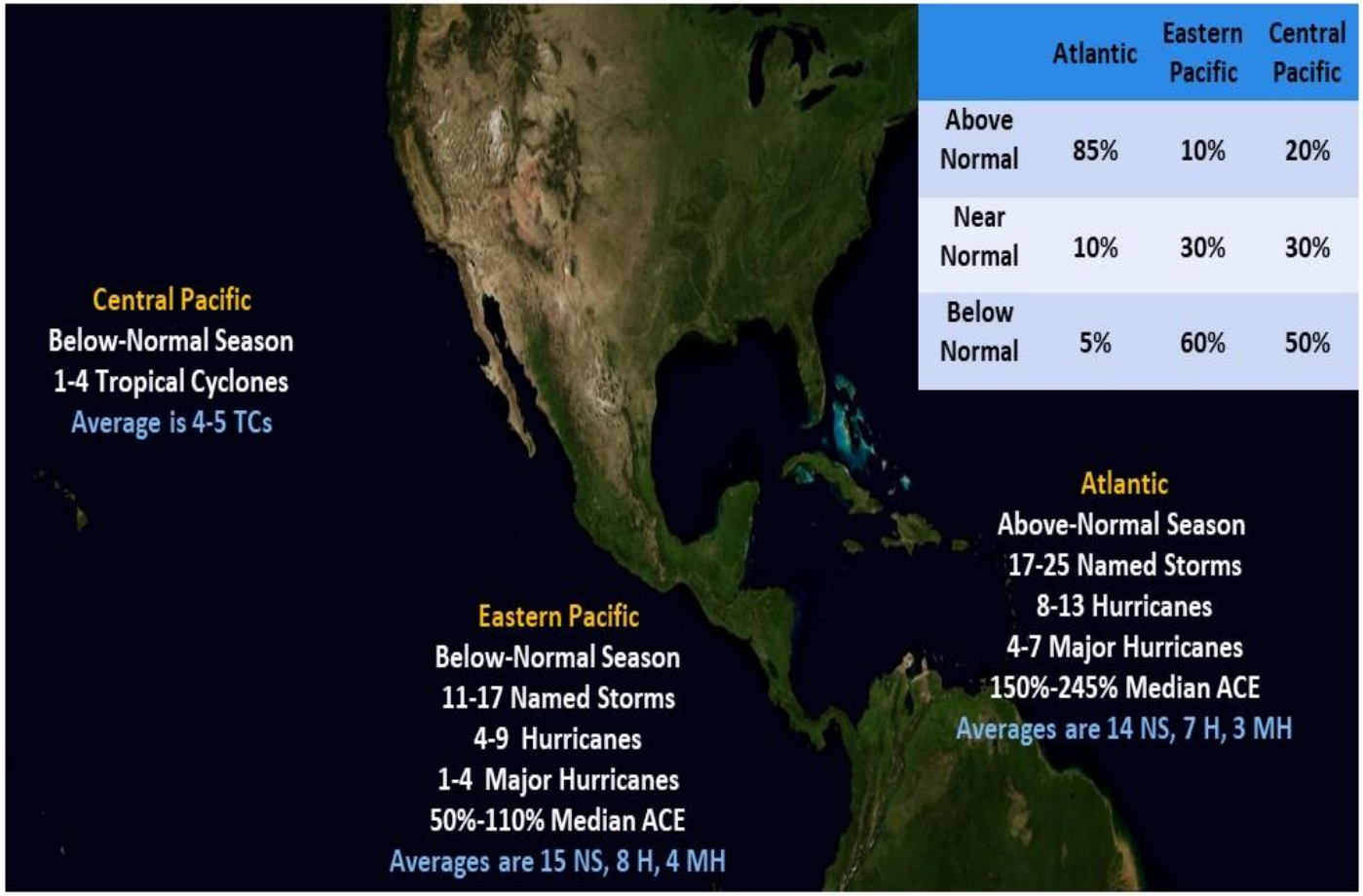
The SSTs in the MDR (North Atlantic) are at (near) record high levels.

…. a 77% chance that La Niña conditions will develop through the hurricane season…."

(https://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml)

NOAA's 2024 Hurricane Season Outlook

NOAA's 2024 Hurricane Season Outlooks

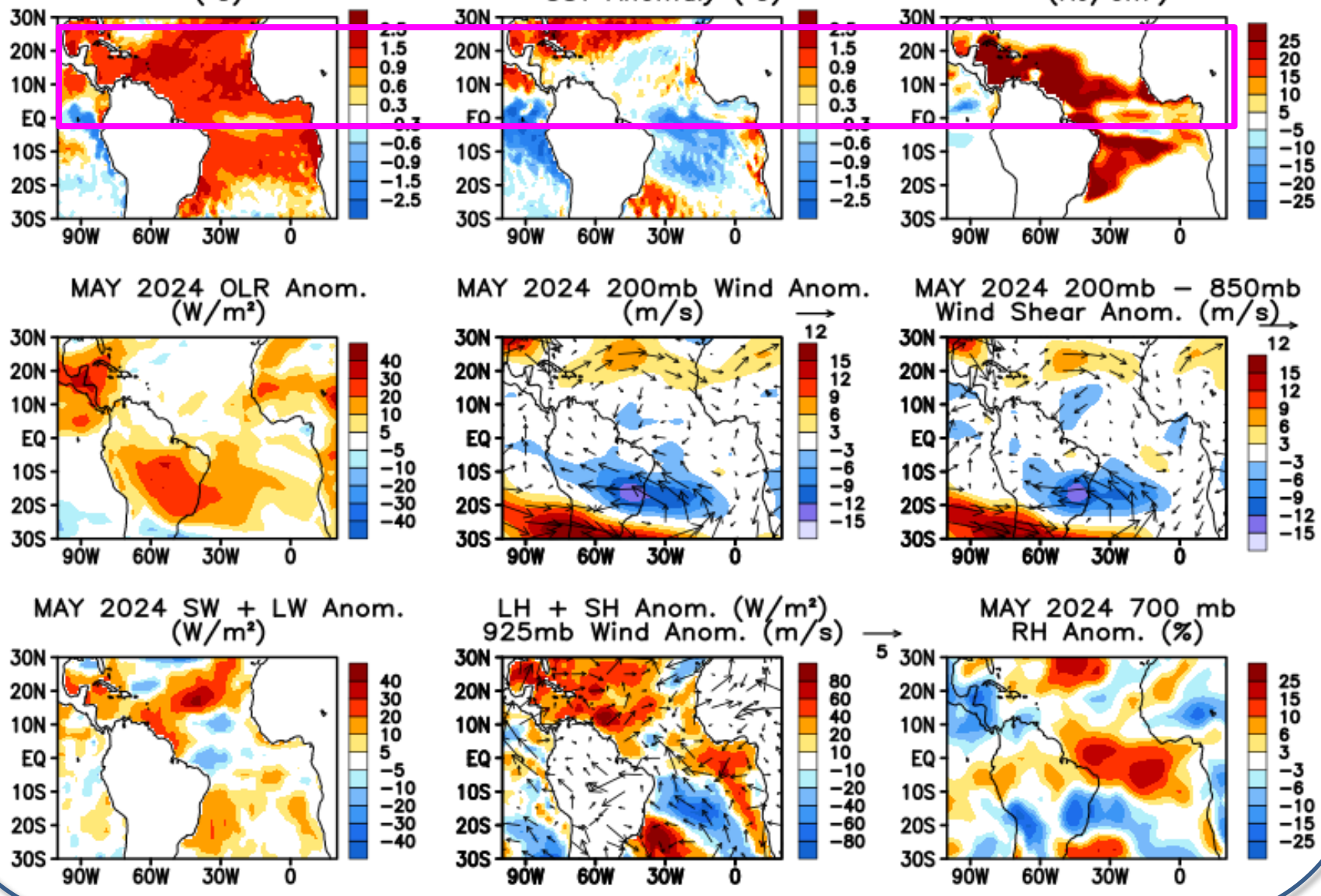


	Atlantic	Eastern Pacific	Central Pacific
Above Normal	85%	10%	20%
Near Normal	10%	30%	30%
Below Normal	5%	60%	50%

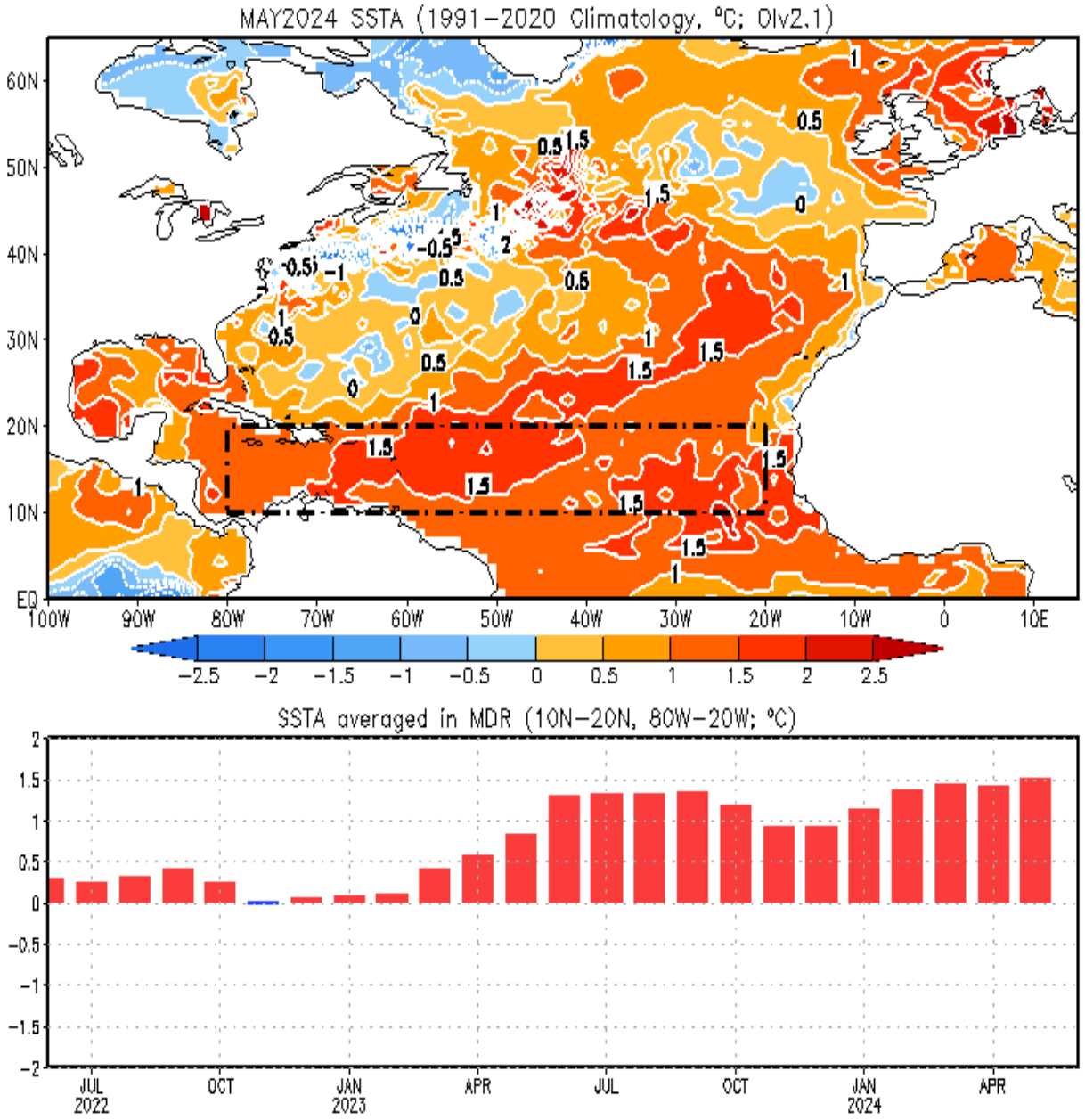
For the Atlantic hurricane region, the outlooks indicate a 85% chance of an above-normal season, a 10% chance of a near-normal season, and a 5% chance of a below-normal season. For the East Pacific Hurricane season, the outlooks indicate a 60% chance of below-normal activity, with a 30% chance for near-normal levels, and a 10% chance for below-normal levels.

These outlooks are for the overall seasonal activity. They are not a hurricane landfall forecast.

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

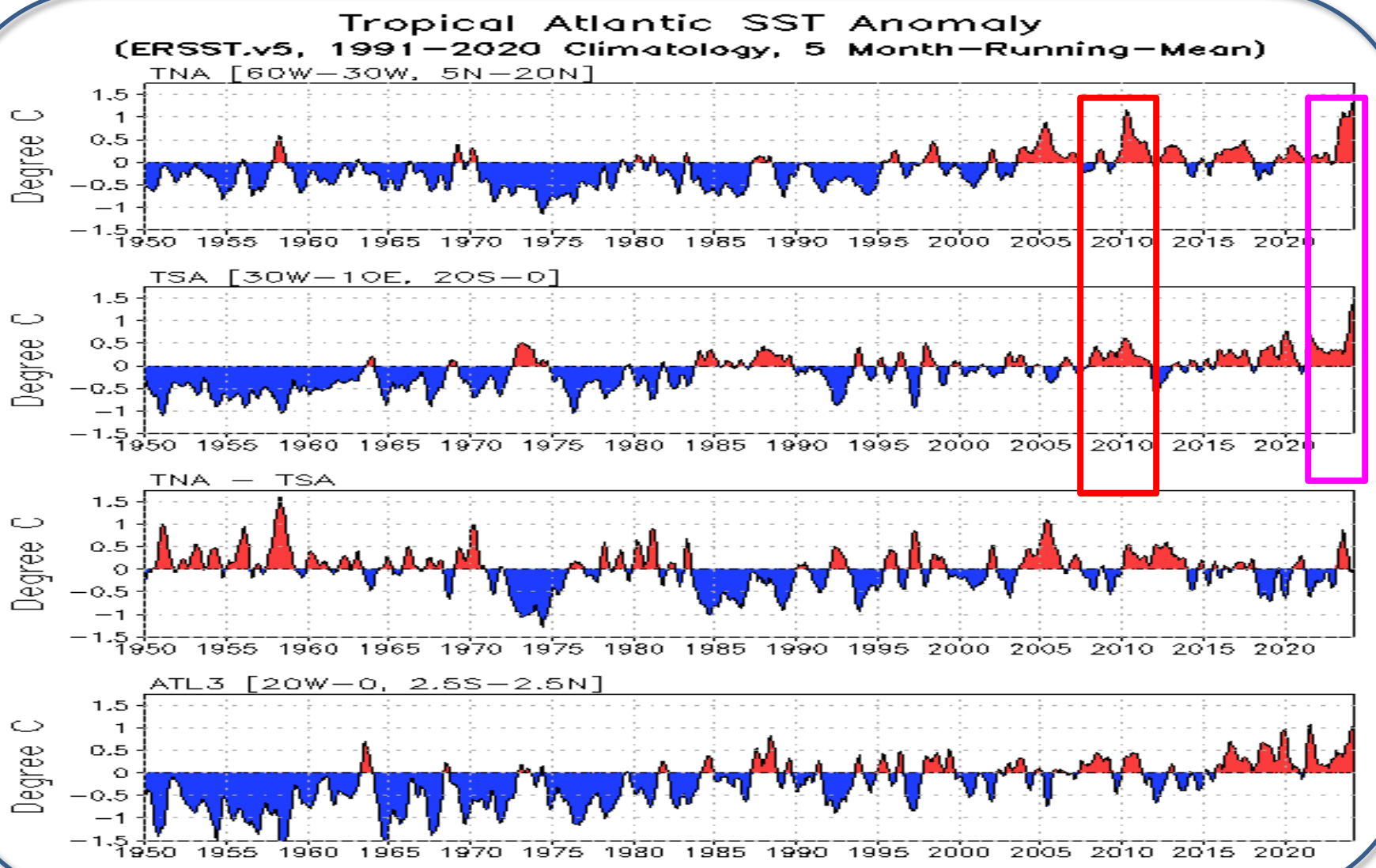


SSTAs in the North Atlantic & MDR



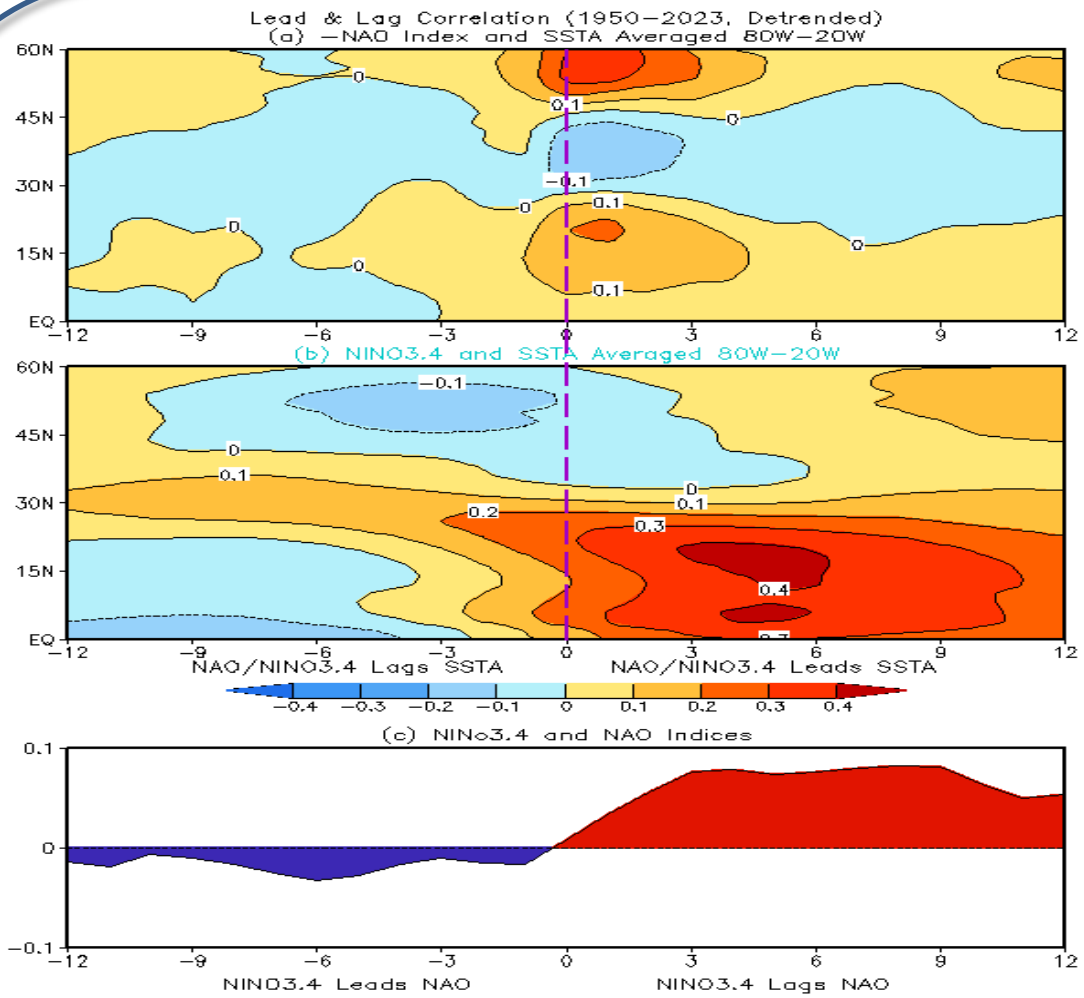
- SST in MDR was above average during the last 18 months.

Evolution of Tropical Atlantic SST Indices: Historical high TNA and TSA



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.

Historical Connection of tropical N Atlantic SST with Nino3.4 & NAO

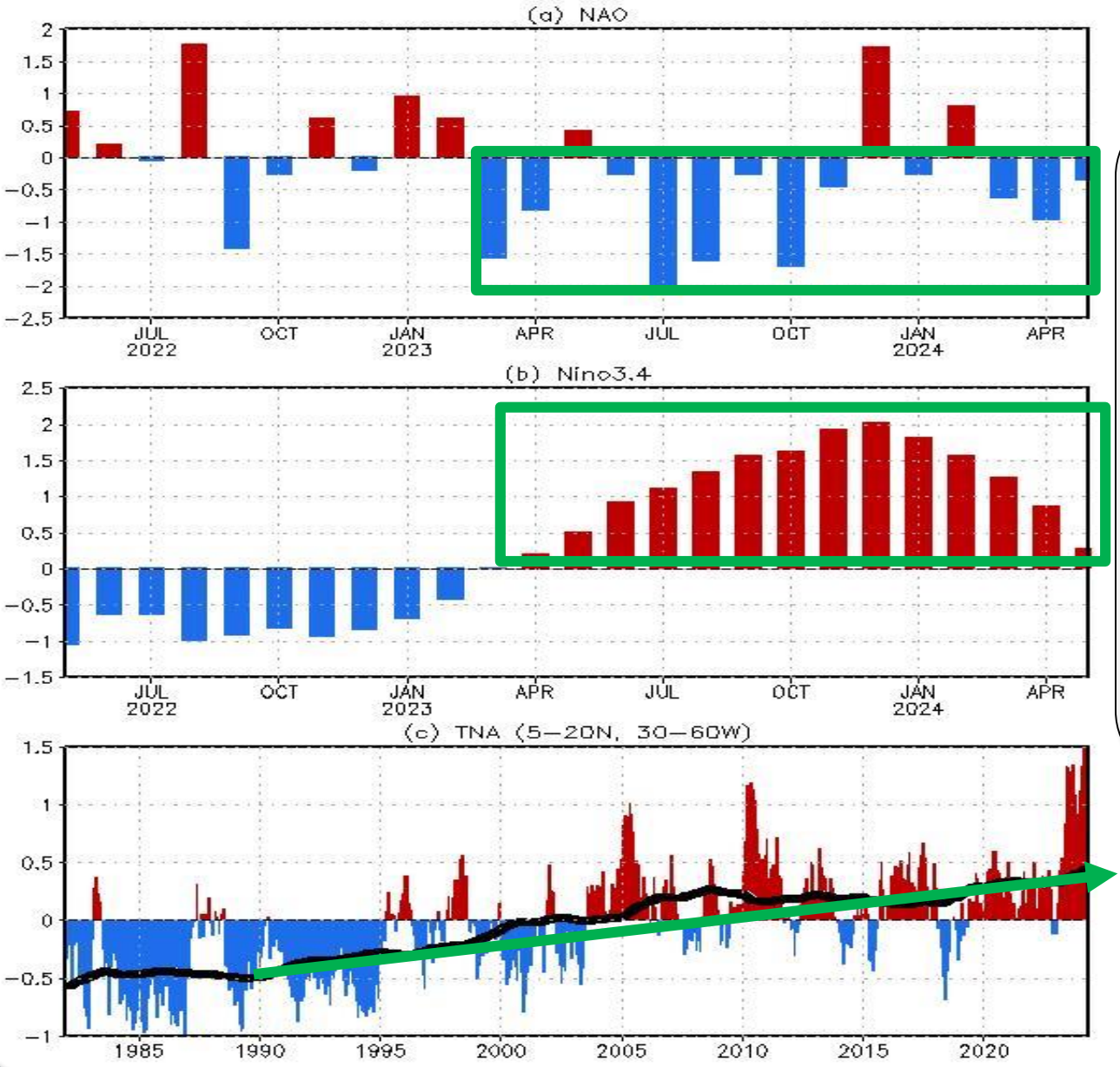


- NAO's impact on SST is mainly with 0-3 month lag.
- ENSO signals propagate into the tropical N. Atlantic in 3-8 months late. ENSO affects the trade wind through atmosphere (PNA), then changes the SST through WES mechanism.
- NAO correlation is smaller than ENSO.
- El Nino may slightly favor to the negative phase of NAO.

Lead and lag correlation of monthly zonal mean SSTA averaged in 80°-20°W with (a) *inverted* NAO index and (b) NINO3.4 index, and (c) between Nino3.4 and NAO indices during Jan 1950-Dec 2023. Positive (negative) numbers in the x-axis of (a, b) are the months of the indices leading (lagging) the SSTA. Contour interval is 0.1. The linear trends of SSTA and NAO index were removed prior to the correlation calculations.

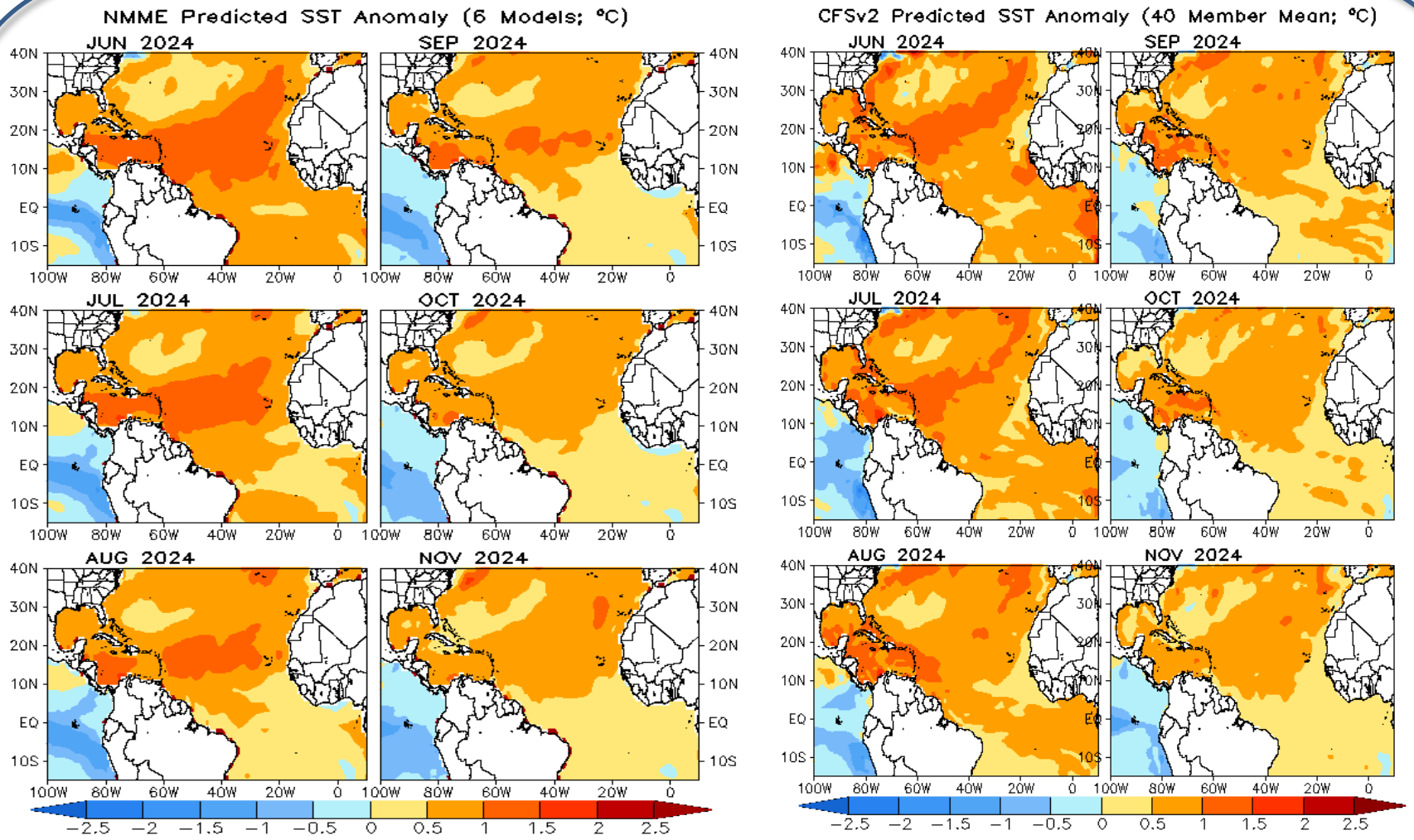
*Hu, Z.-Z., A. Kumar, B. Huang, Y. Xue, W. Wang, and B. Jha, 2011: Persistent atmospheric and oceanic anomalies in the North Atlantic from Summer 2009 to Summer 2010. J. Climate, **24(22)**, 5812-5830. DOI: 10.1175/2011JCLI4213.1.*

Possible causes of the historical high tropical N Atlantic SST



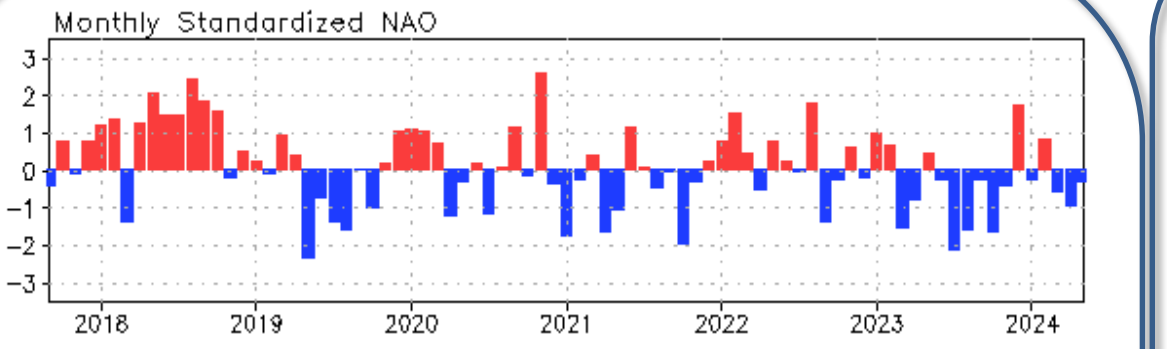
- It may be caused by the negative phase of NAO, El Nino, and long-term warm trend.
- That is similar to the extreme warming in 2009-2010 (Hu et al. 2011).

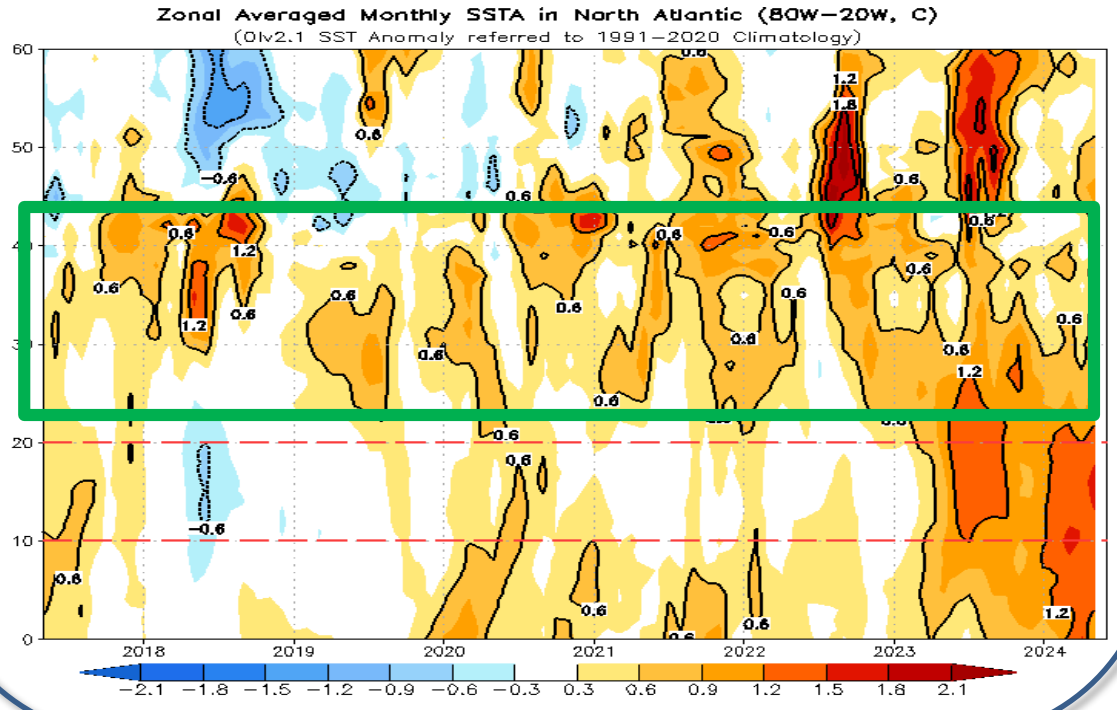
NMME & CFSv2 Atlantic SSTA Predictions

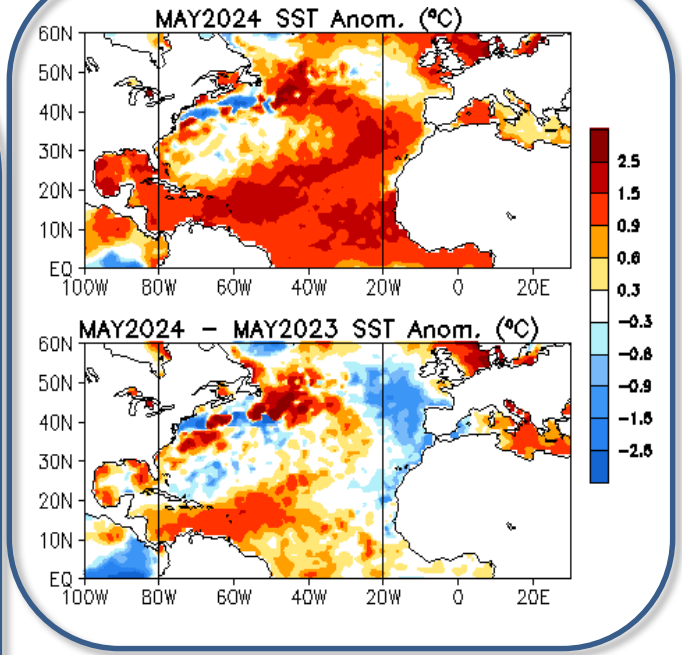


- Latest NMME & CFSv2 predictions indicate that positive SST anomalies in the tropical North Atlantic will weaken in summer-fall 2024.

NAO and SST Anomaly in North Atlantic





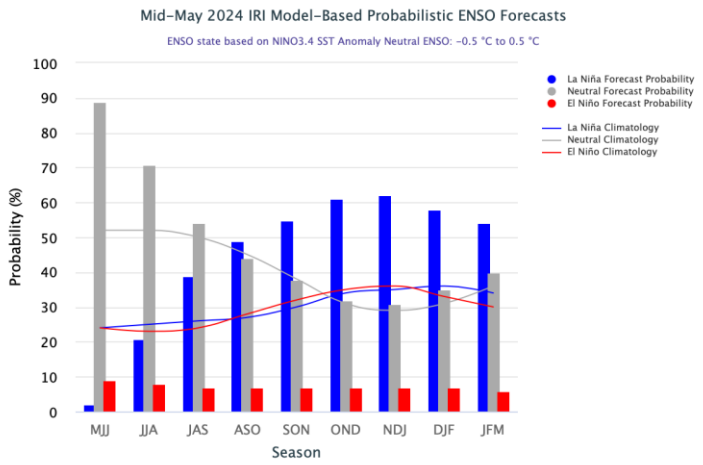


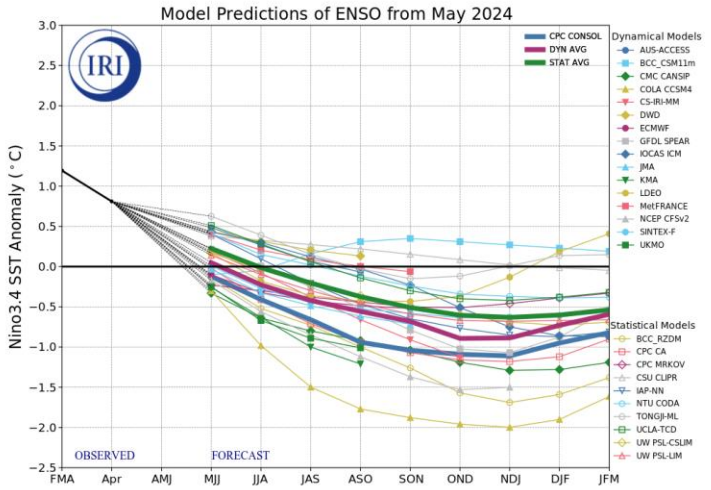
- NAO persisted in a negative phase in May 2024 with NAOI = -0.4.
- The prolonged positive SSTAs in the middle latitudes were evident during the last 5-6 years.

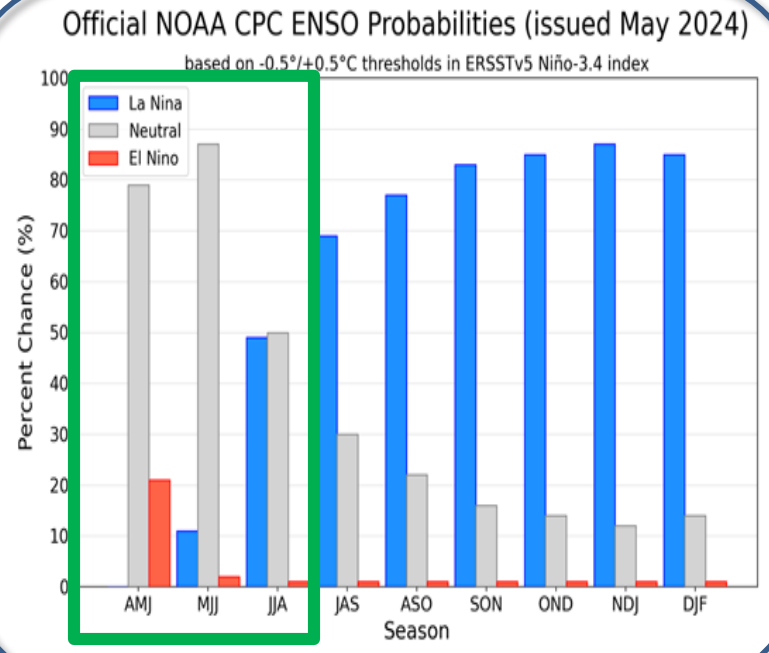
Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20^{O}N-90^{O}N. Time-latitude section of SSTAs averaged between 80ºW and 20ºW (bottom). SST are derived from the OIv2.1 SST analysis, and anomalies are departures from the 1991-2020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

ENSO and Global SST Predictions

CPC & IRI Niño3.4 Forecast



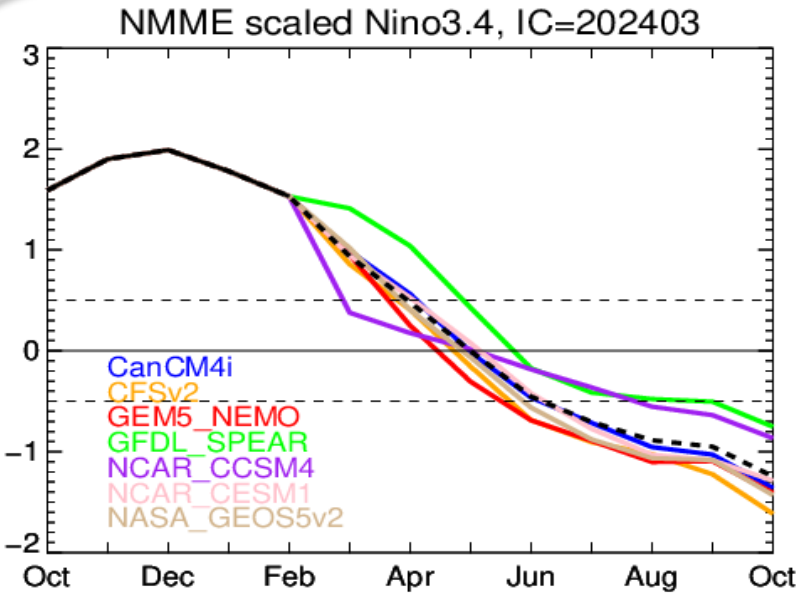


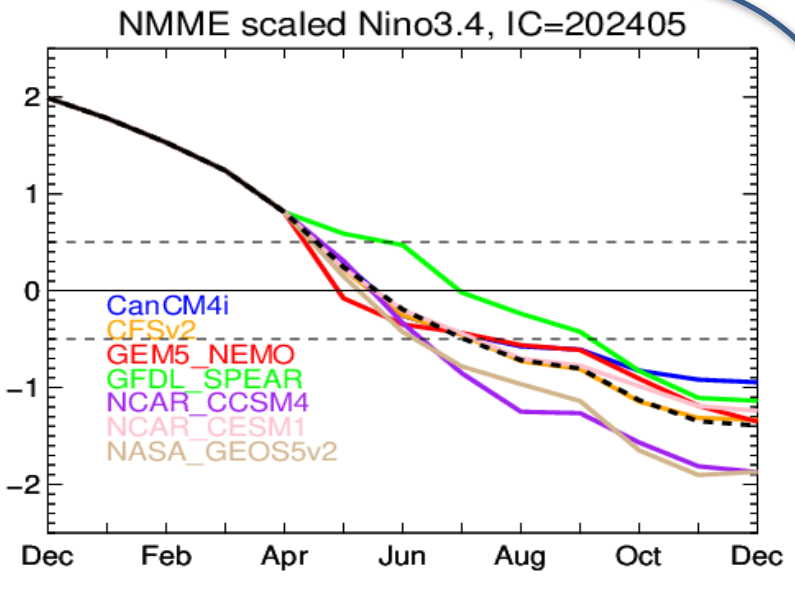


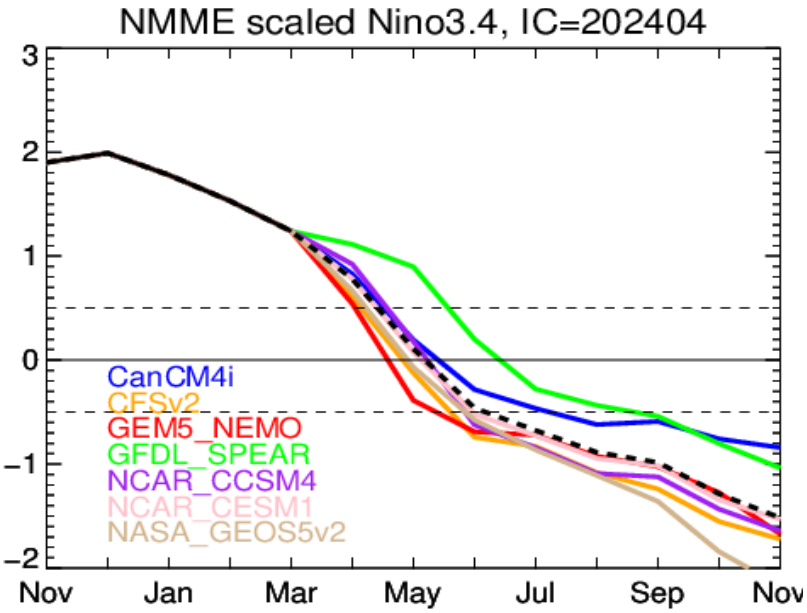
- Model ensemble mean predicts ENSO neutral condition from Apr-Jun to Jul-Sep 2024 and La Nina since Aug-Oct 2024.

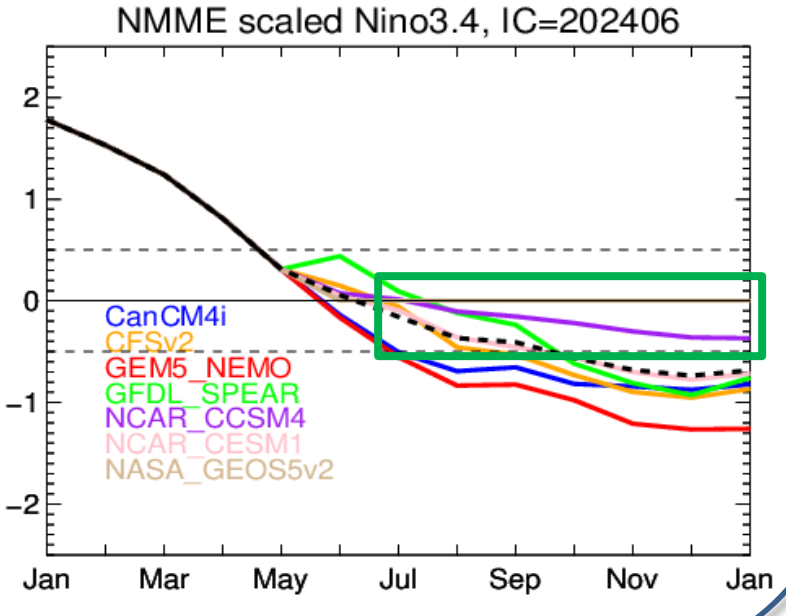
- **On 9 May 2024, CPC continuously issued: El Niño Advisory / La Niña Watch.**
- Synopsis: "*A transition from El Niño to ENSO-neutral is likely in the next month. La Niña may develop in June-August (49% chance) or July-September (69% chance).*"

NMME forecasts from different initial conditions



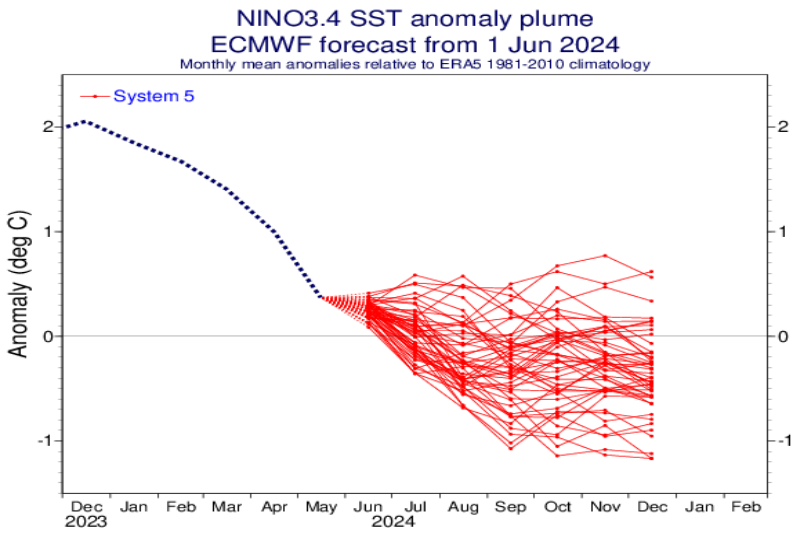




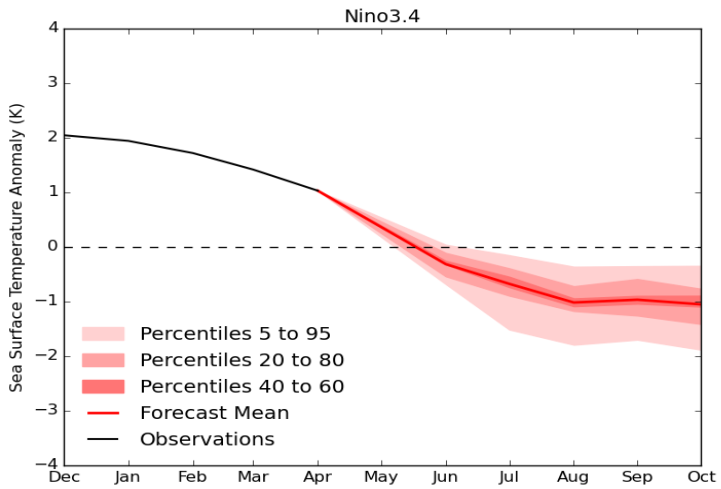


Individual Model Forecasts: El Niño transitions to neutral or La Niña in Summer-Autumn 2024

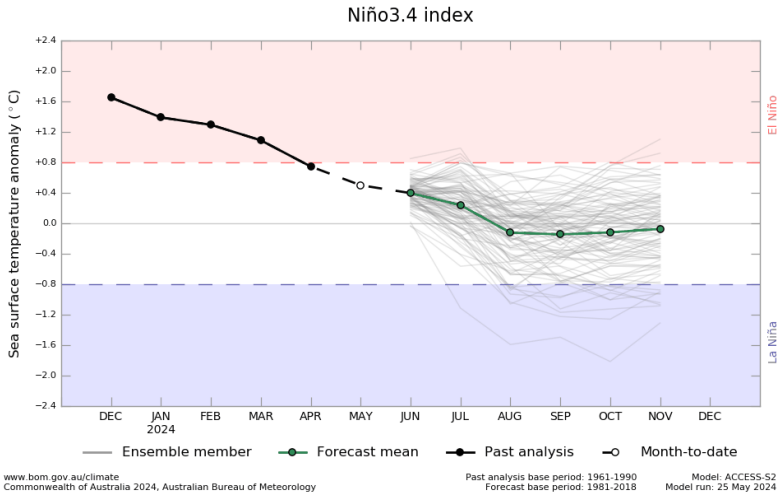
EC: Niño3.4, IC= 1 Jun 2024



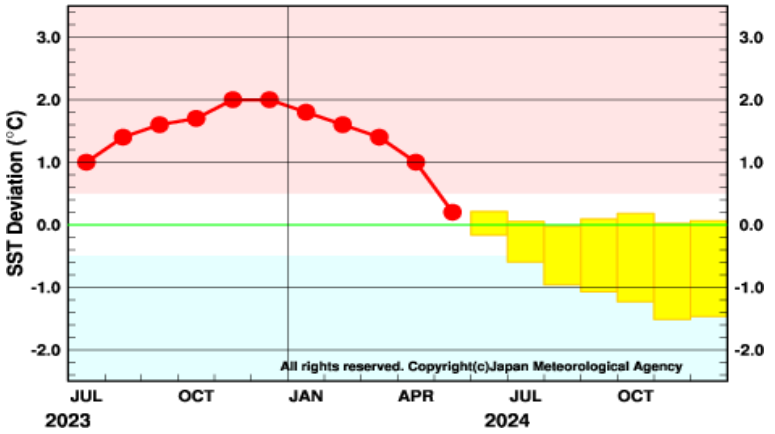
UKMO: Niño3.4, Updated 11 May 2024



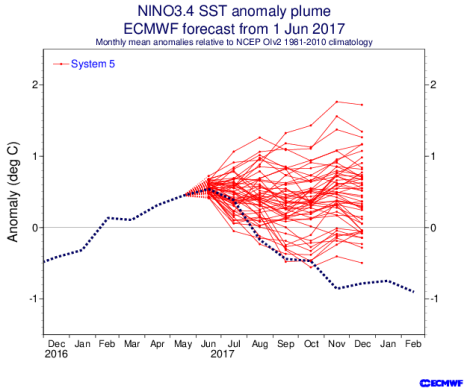
BOM: Niño3.4, Updated 25 May 2024

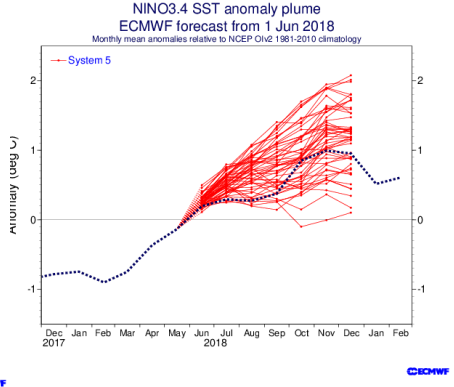


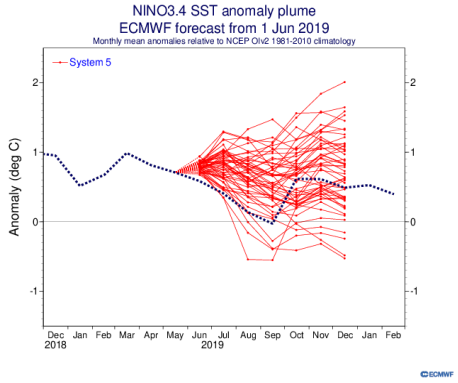
JMA: Niño3.4, Updated 10 Jun 2024

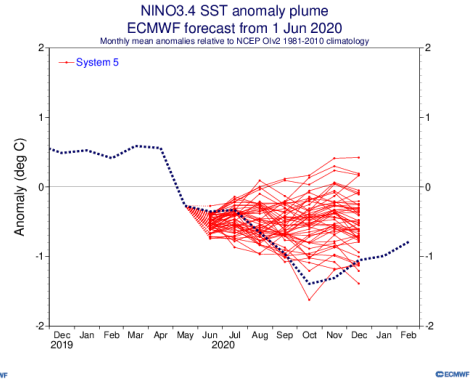


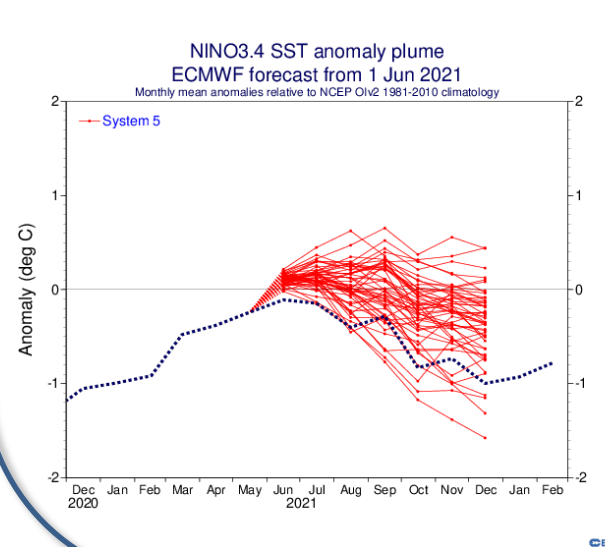
ECMWF Forecasts with IC in Jun since 2017: Warm biases

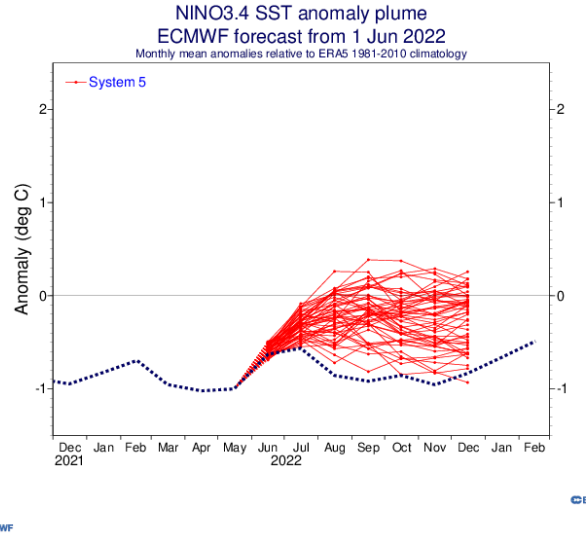


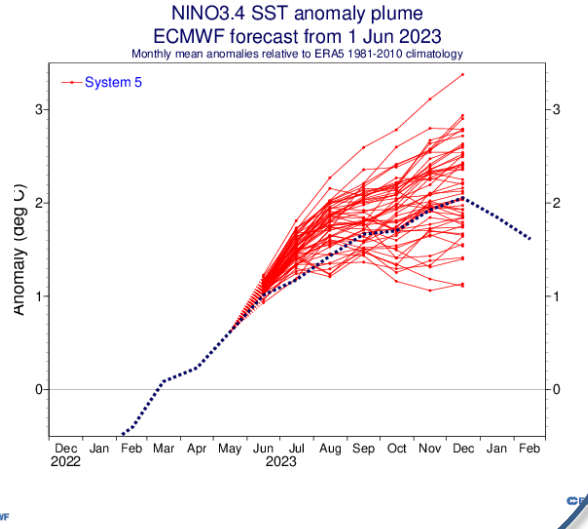




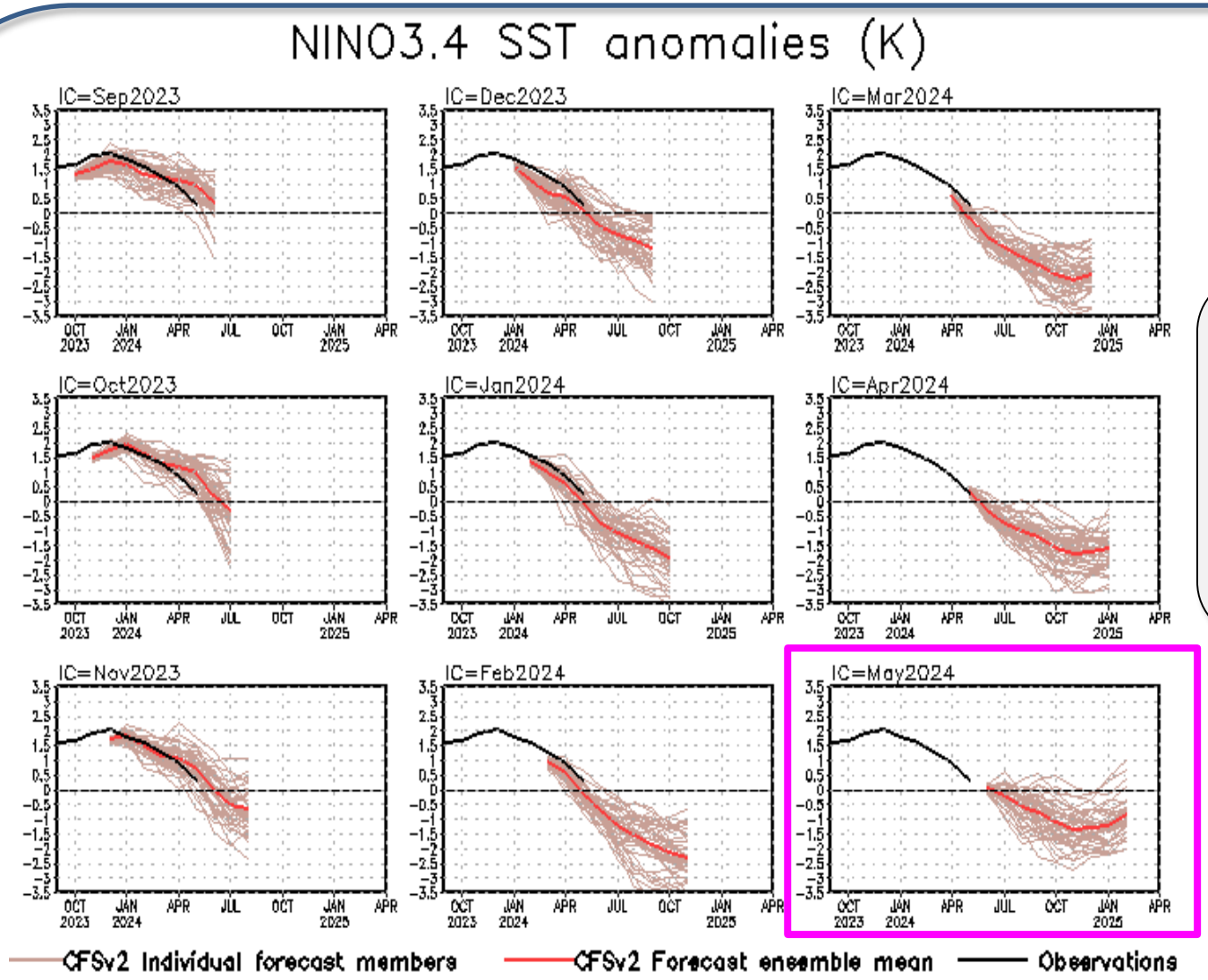








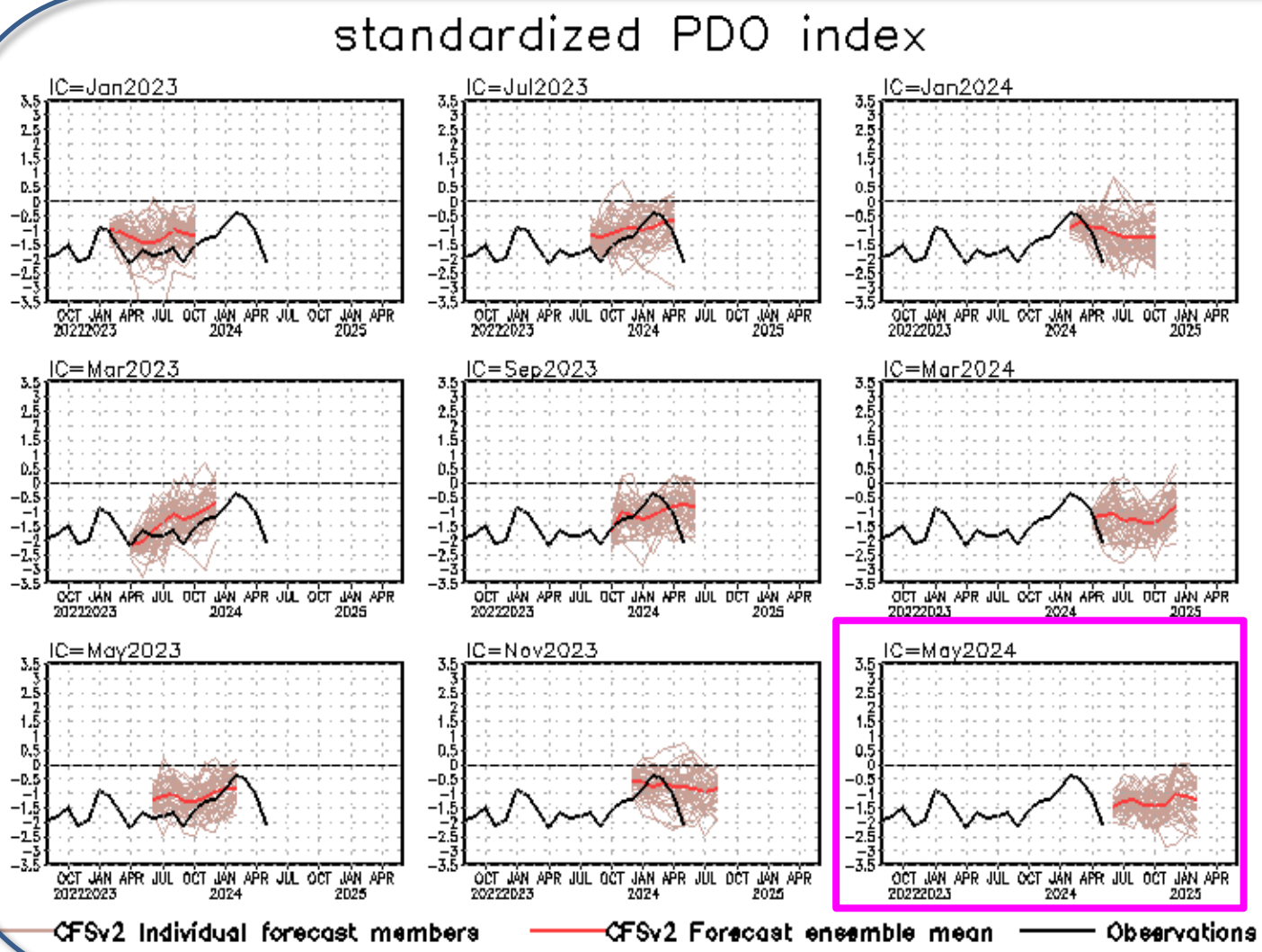
CFS Niño3.4 SST Predictions from Different Initial Months



- The latest CFSv2 forecasts call for 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.

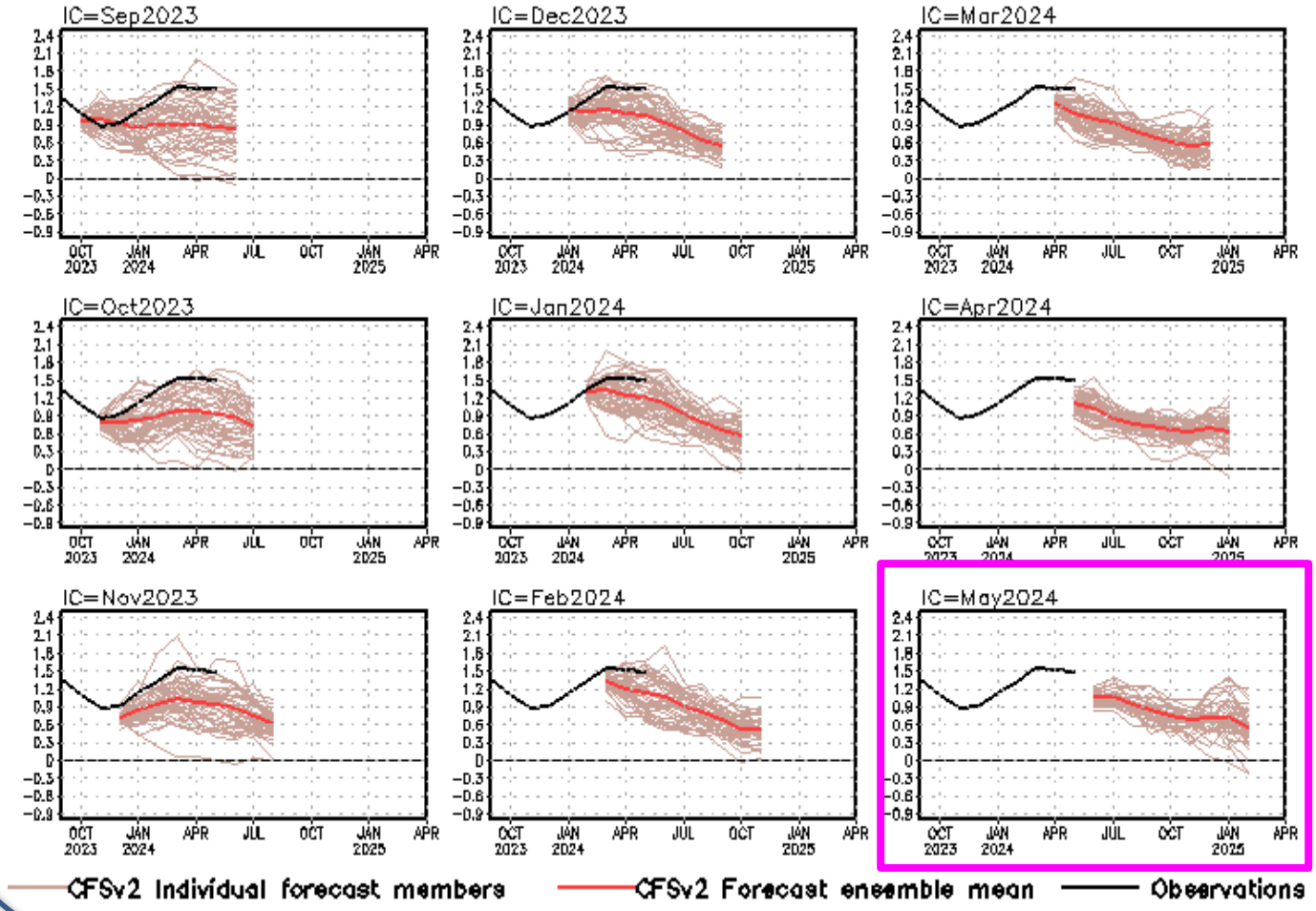
NCEP CFSv2 PDO Index Predictions from Different Initial Months



- 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.

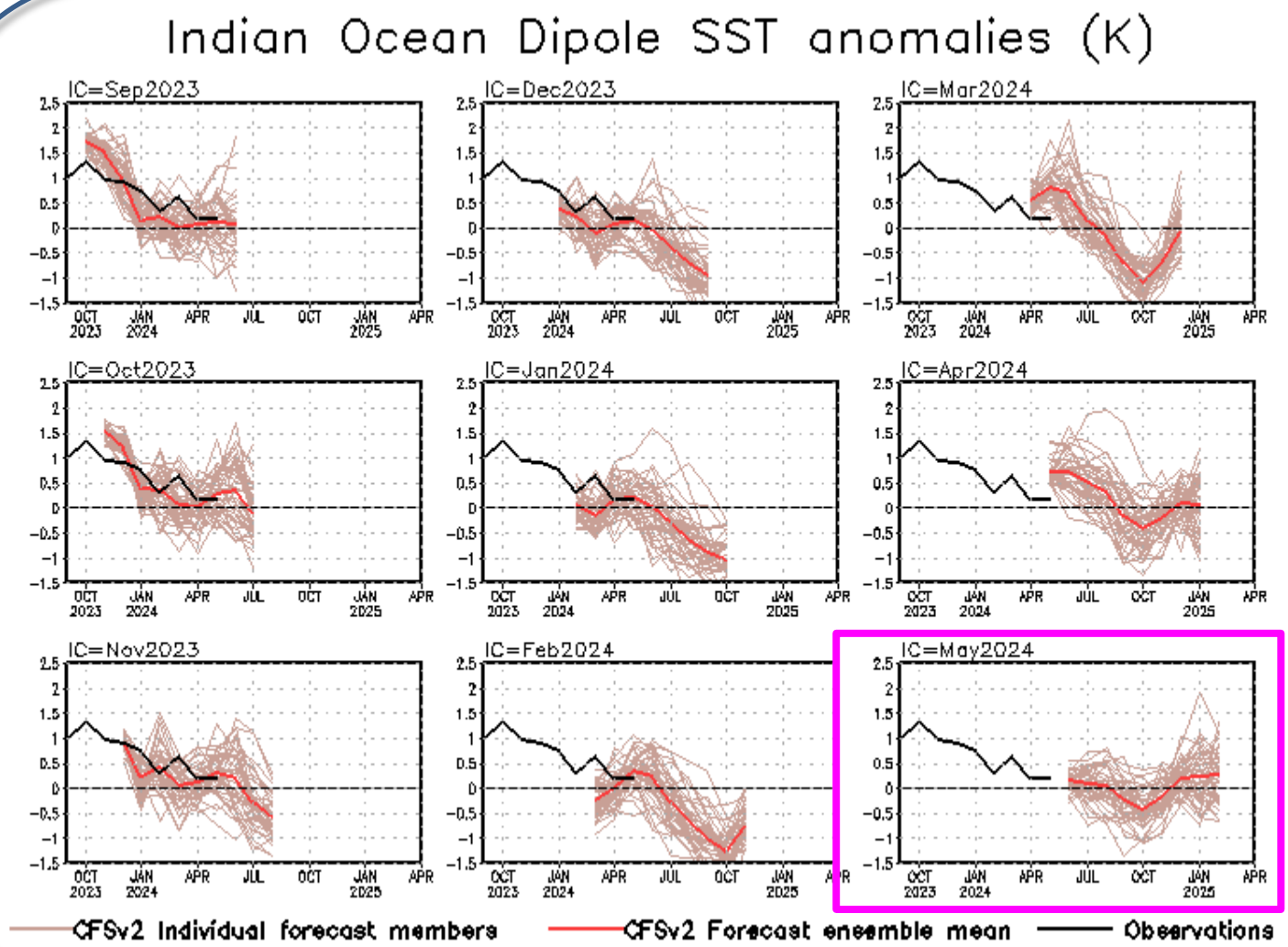
NCEP CFSv2 Tropical North Atlantic (TNA) SST Predictions from Different Initial Months



- Latest CFSv2 predictions call weakened 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 neutral phase of IOD in summer 2024-winter 2024/25.

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 gave insightful suggestions and comments
- Drs. Yanjuan Guo and Pingping Xie provided the BASS/CMORPH/CFSR EVAP package
- Drs. Jieshun Zhu & Wanqiu Wang maintained the sea ice forecasts

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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

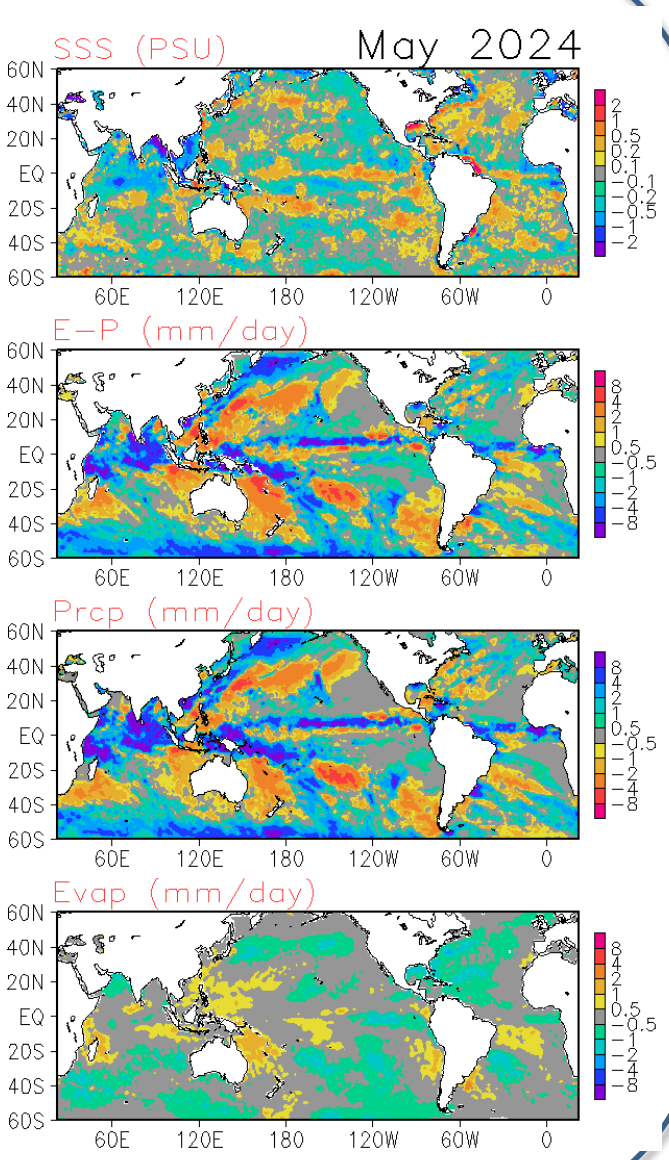
http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html

Backup Slides

Global Sea Surface Salinity (SSS): Anomaly for May 2024

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

The Pacific ITCZ is enhanced and displaced to the north; the SPCZ is also enhanced largely. The E-P anomalies are dominated by the precipitation anomalies over these regions, thus the salinity anomalies show overall consistent anomaly patterns. The salinity is found reduced in the tropical and northern hemispheric Indian ocean, mainly due to enhanced precipitation over there. Furthermore, pronounced salinity reduction is also found over the sea water around the mainland Southeast Asia, likely due to large fresh water run off since it's much stronger that what can be explained by the E-P anomalies alone.



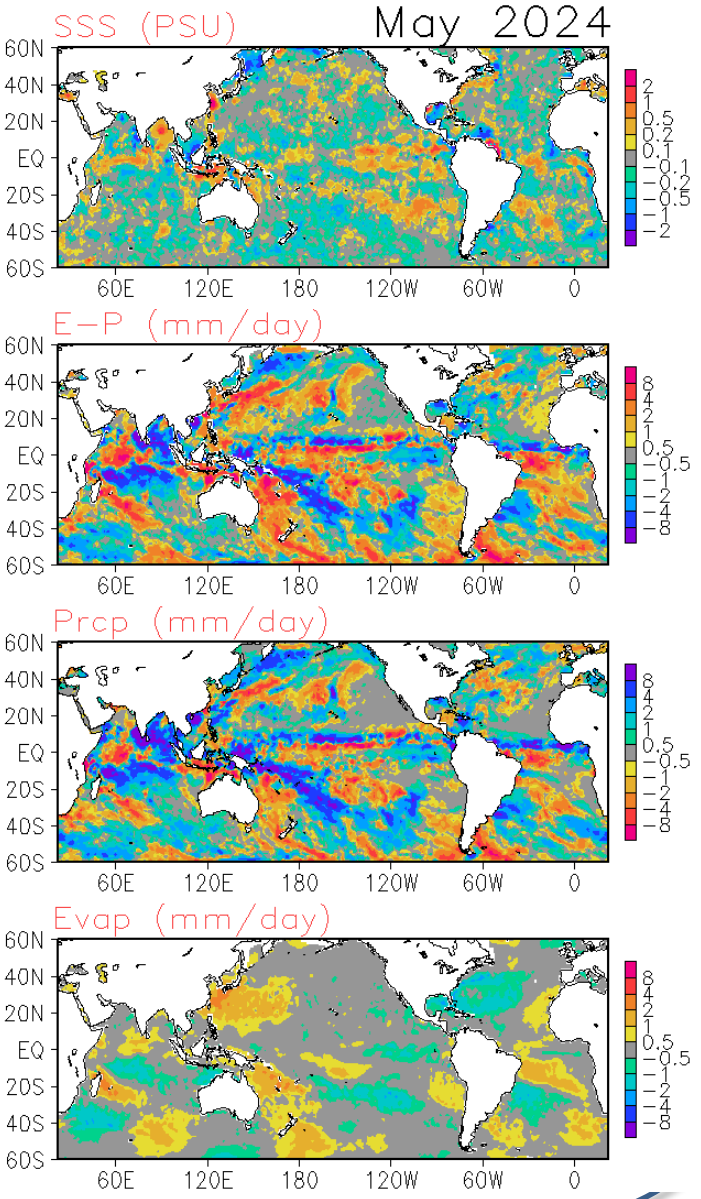
SSS : Blended Analysis of Surface Salinity (BASS) V0.Z
(a CPC-NESDIS/NODC-NESDIS/STAR joint effort)
ftp.cpc.ncep.noaa.gov/precip/BASS

Precipitation: CMORPH adjusted satellite precipitation estimates

Evaporation: Adjusted CFS Reanalysis

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

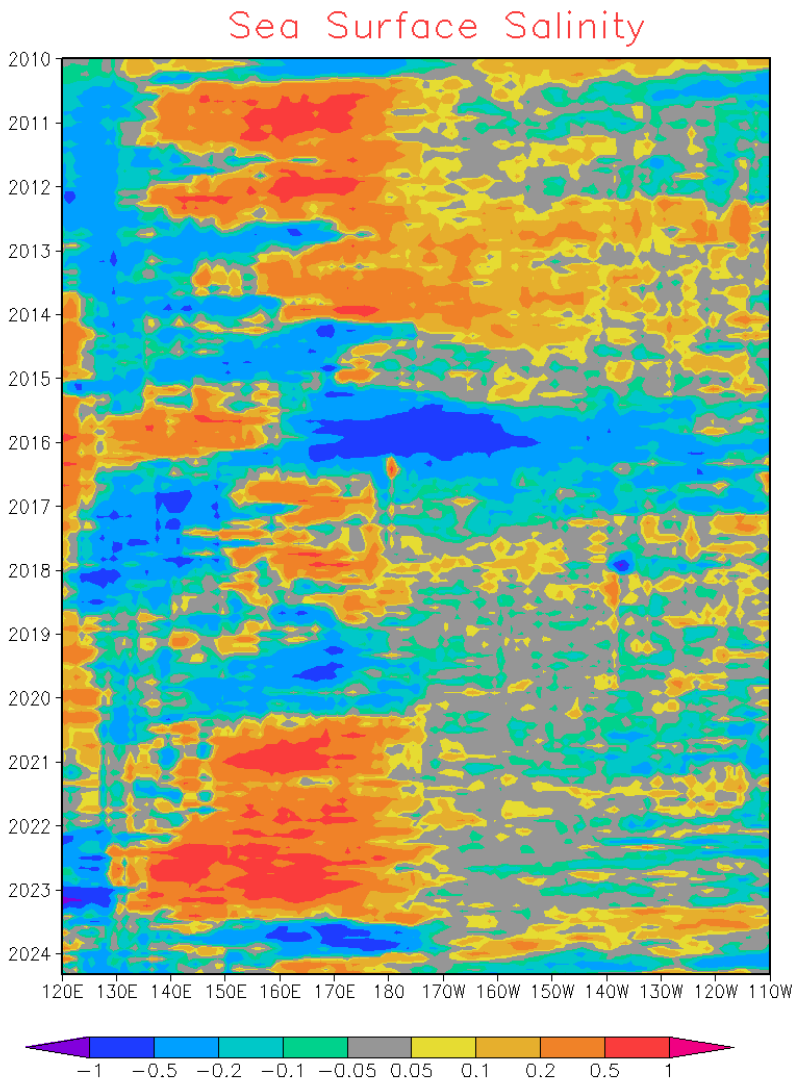
The global SSS tendency in May 2024 is overall weak and with mixed signs. The Precipitation are generally decreasing along the equator but enhancing off equator. Dipole mode of precipitation trend is again found in the Indian ocean. Stronger SPCZ is found with further extended precipitation into southern Pacific ocean. Large scale trends in the evaporation (e.g., decreasing/increasing in the western/eastern side of Pacific) are found, but still dominated by the precipitation trends. Overall the SSS trend doesn't show pronounced large scale pattern for this month.



Monthly SSS Anomaly Evolution over Equatorial Pacific

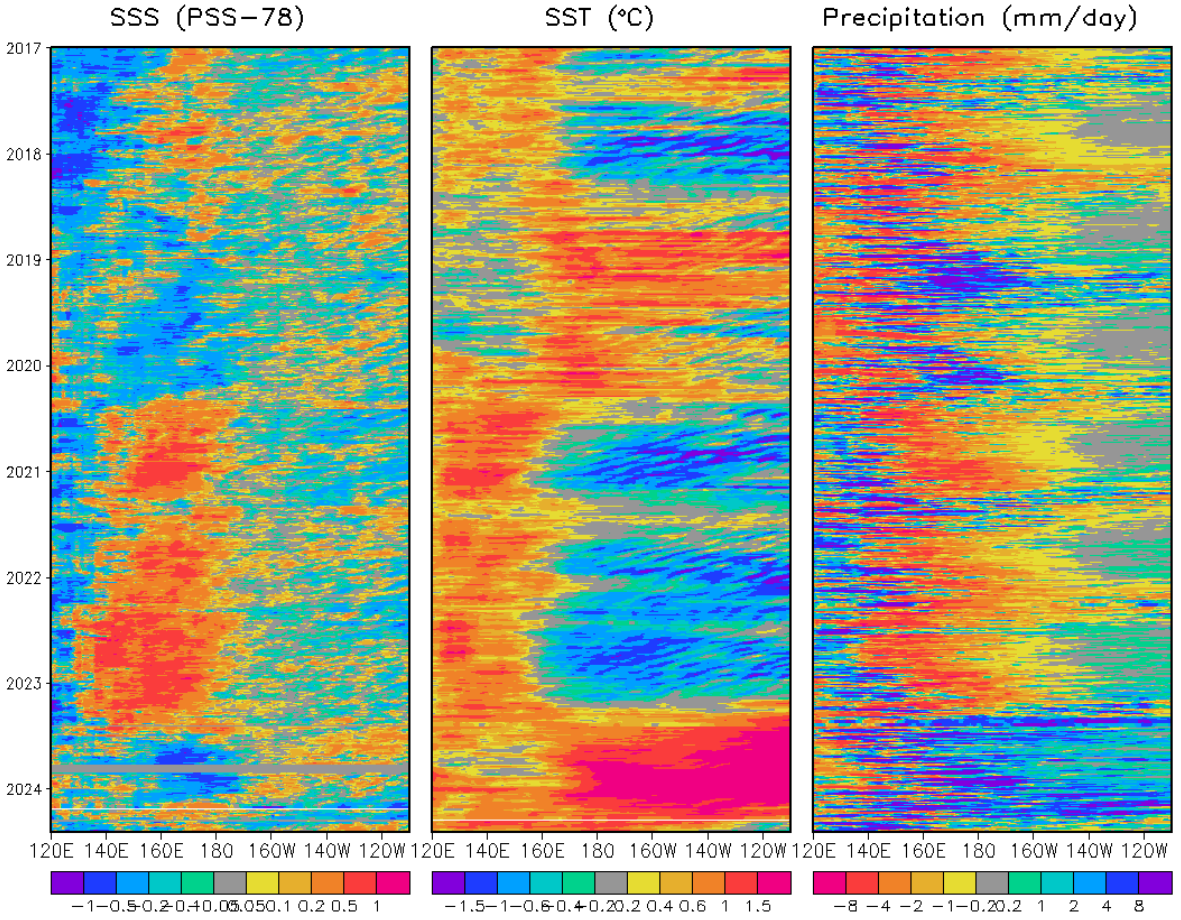
NOTE: Since June 2015, the BASS SSS is from in situ, SMOS and SMAP; before June 2015,The BASS SSS is from in situ, SMOS and Aquarius.

- Hovermoller diagram for equatorial SSS anomaly **(5S-5˚N);**
- Decreased SSS is found over the equatorial western Pacific, but is increased over the central Pacific. Freshening is also found over the equatorial eastern Pacific. Generally, these anomalies are not very strong.

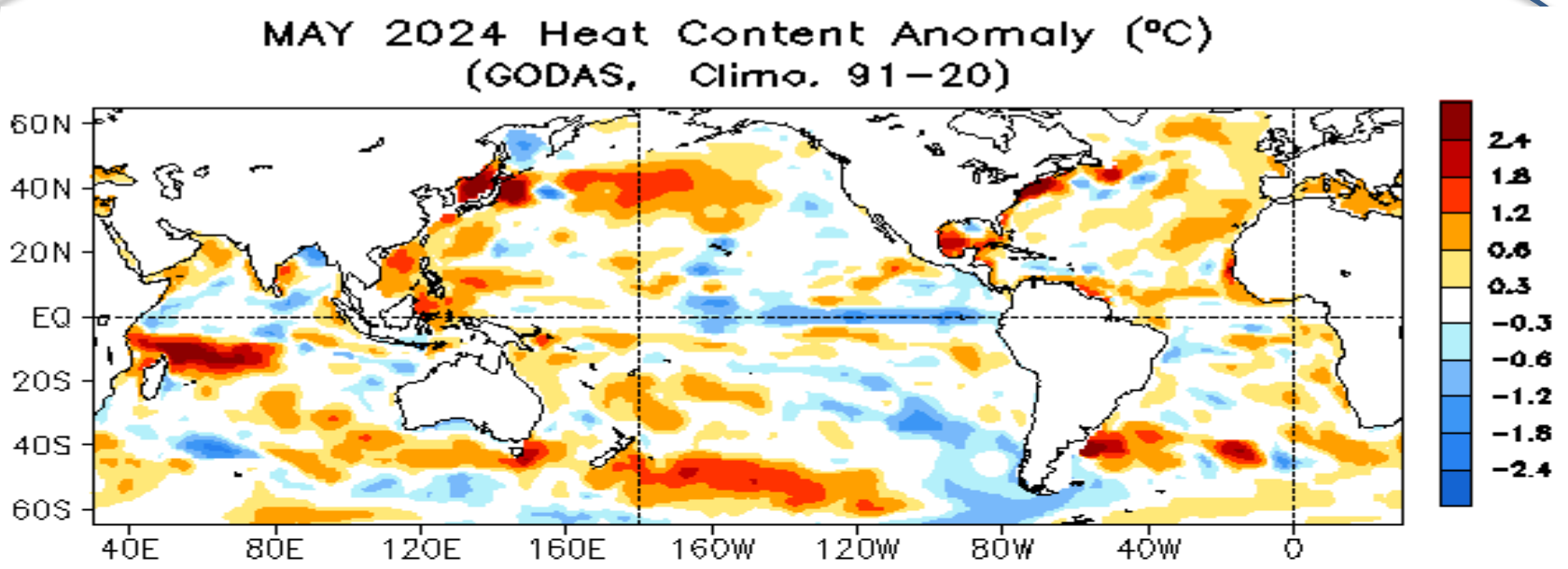


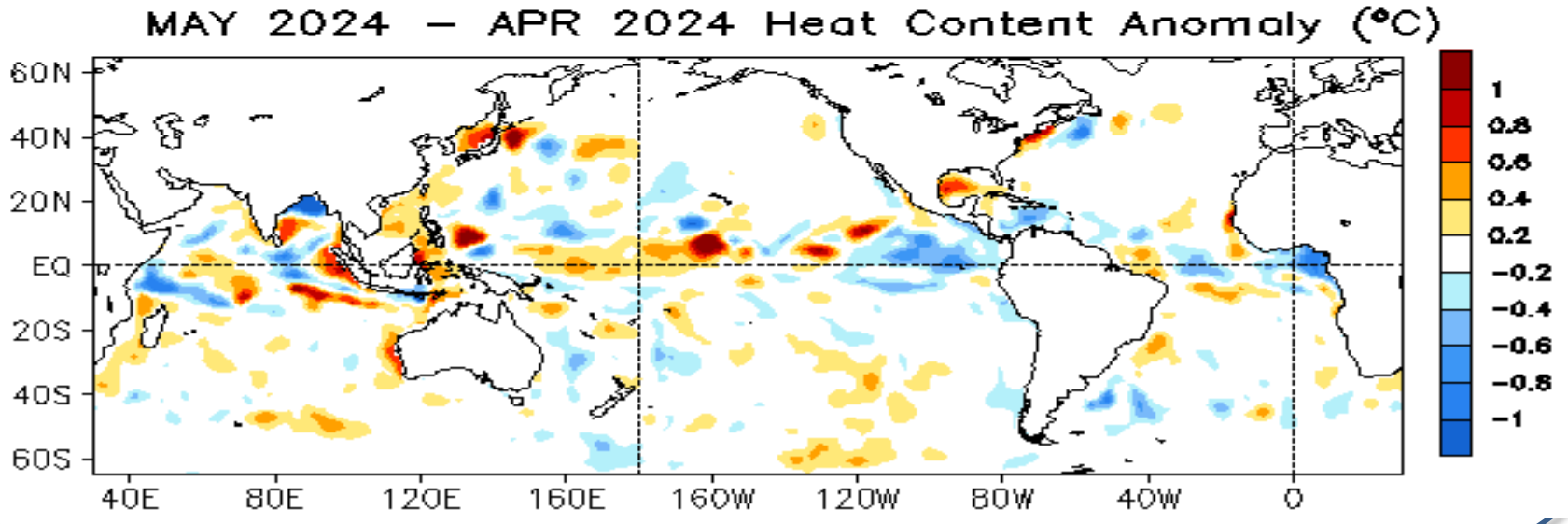
Pentad SSS Anomaly Evolution over Equatorial Pacific

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.

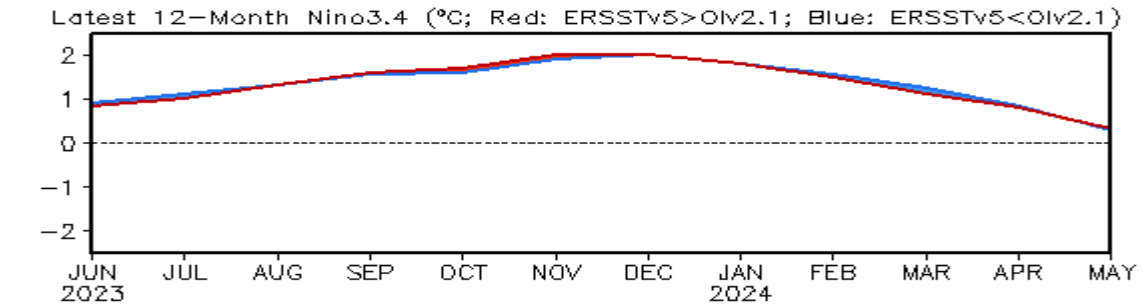


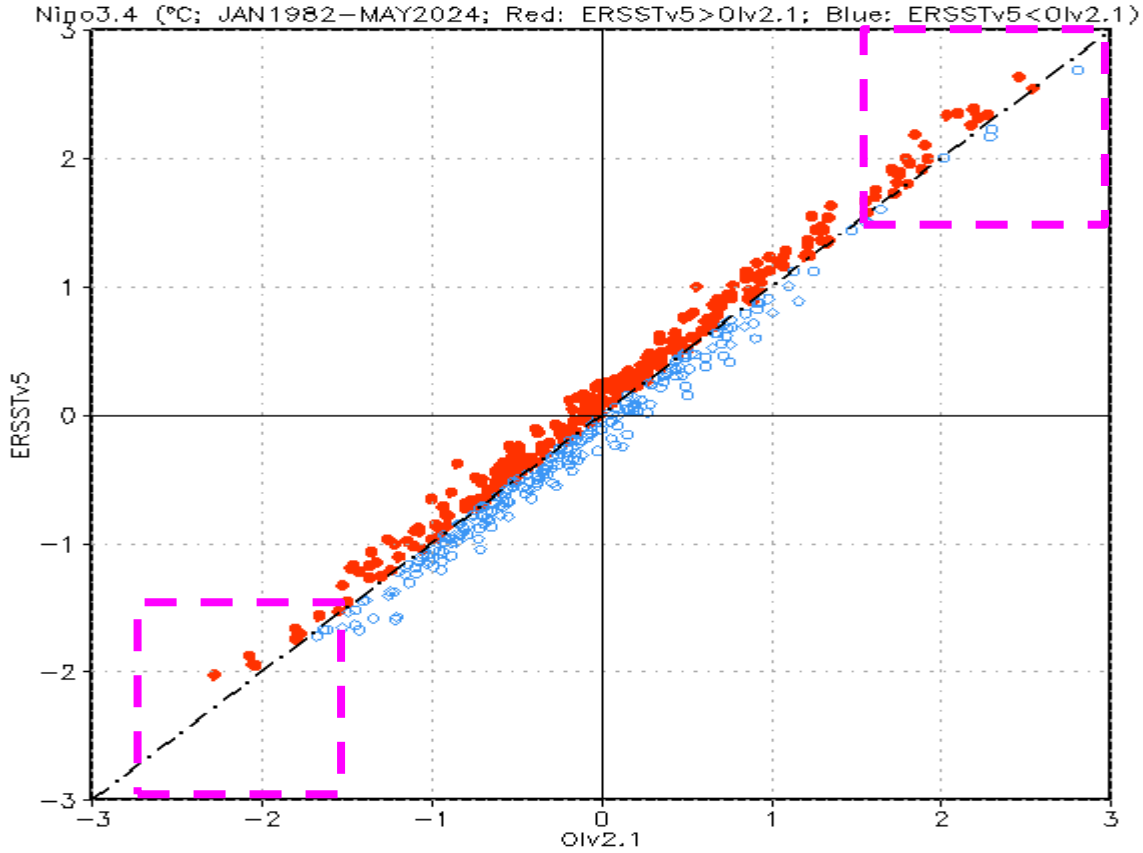
Global HC300 Anomaly & Anomaly Tendency





Comparison of ERSSTv5 & OIv2.1 Niño3.4 Index



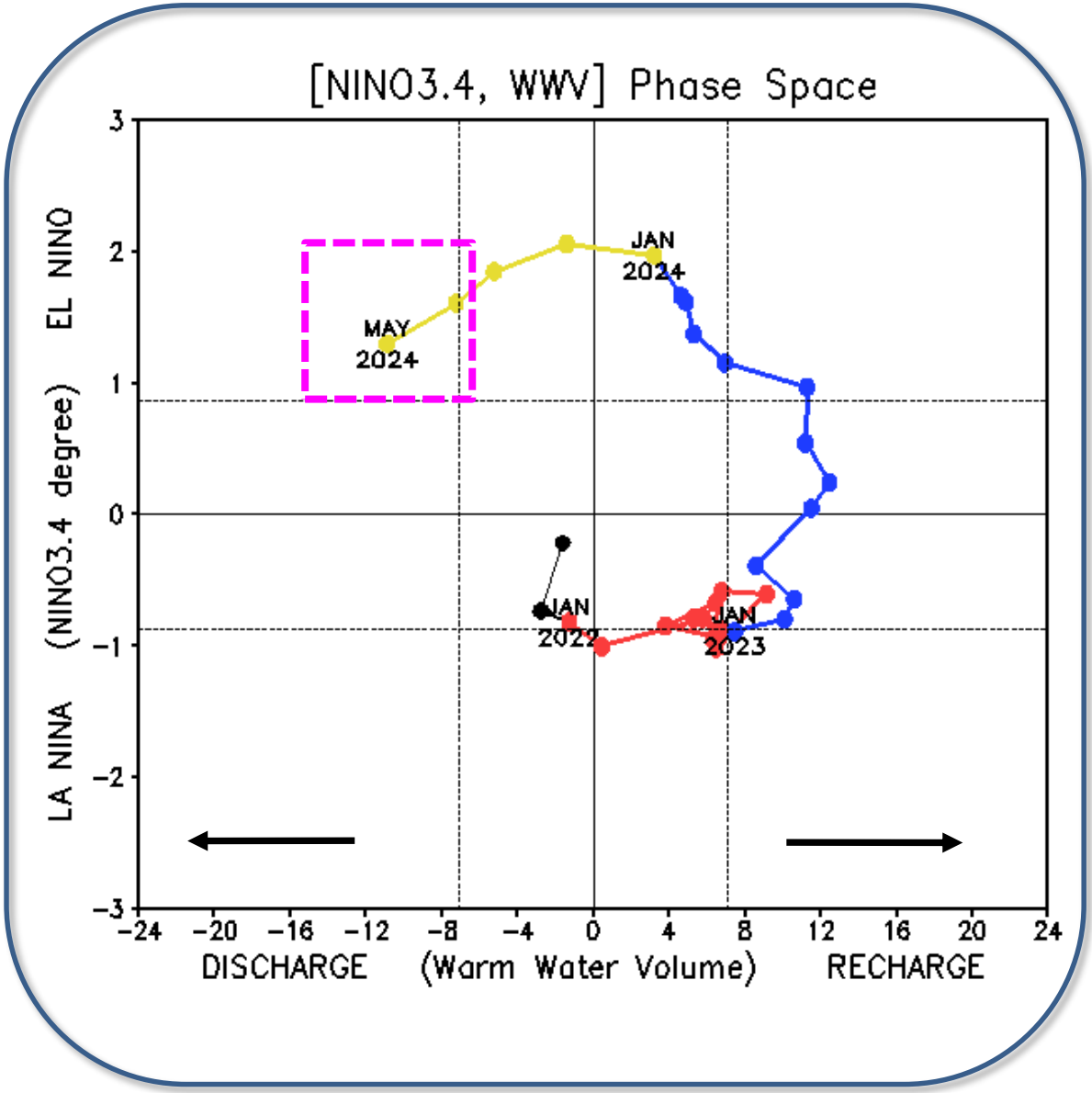


- During the last year, ERSSTv5 was close to OIv2.1.
- Sometimes, ERSSTv5 is either warmer or cooler than OIv2.1.
- For both the extreme positive and negative (>1.5°C or <-1.5°C) Niño3.4, ERSSTv5 is mostly warmer than OIv2.1.

Warm Water Volume (WWV) and Niño3.4 Anomalies

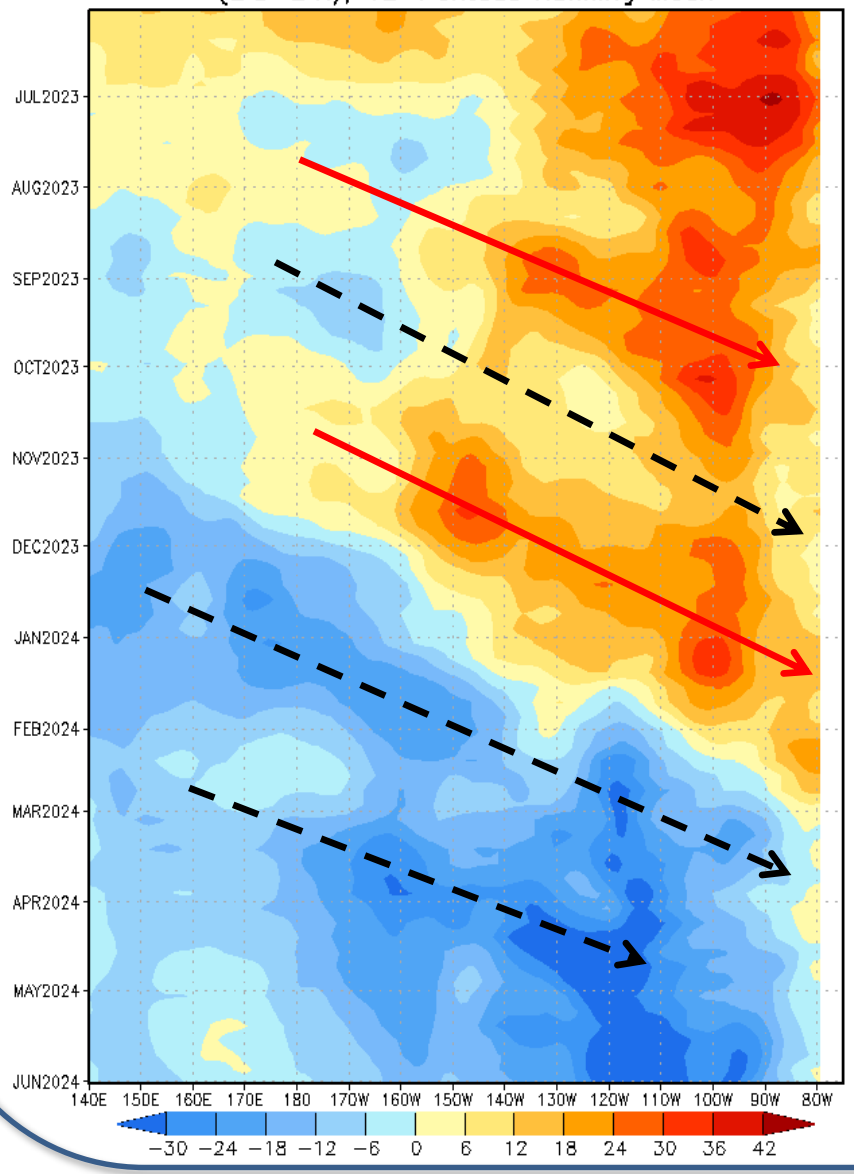
- Pacific equatorial Warm Water Volume (WWV) switched to a discharge phase since Feb 2024.

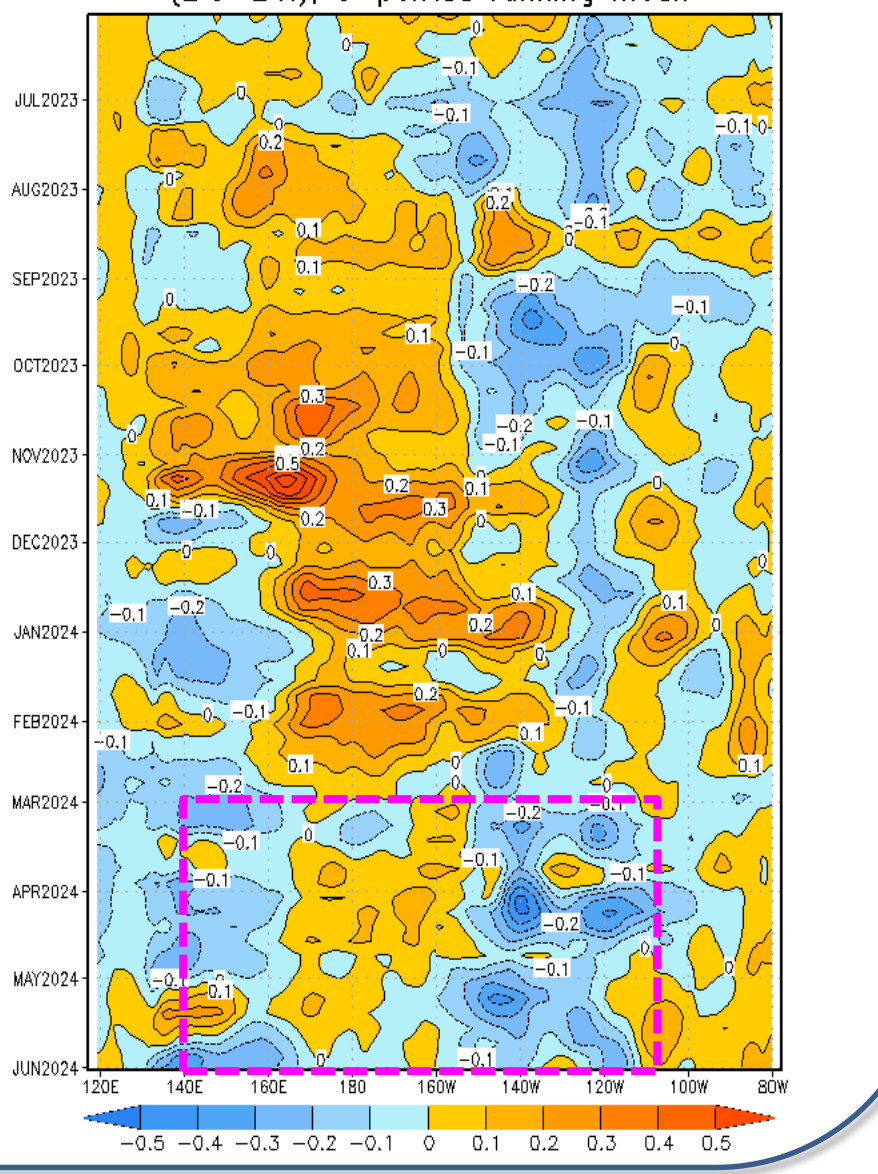
-As WWV is intimately linked to ENSO variability (Wyrtki 1985; Jin 1997), it is useful to monitor ENSO in a phase space of WWV and Niño3.4 (Kessler 2002).
- Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.



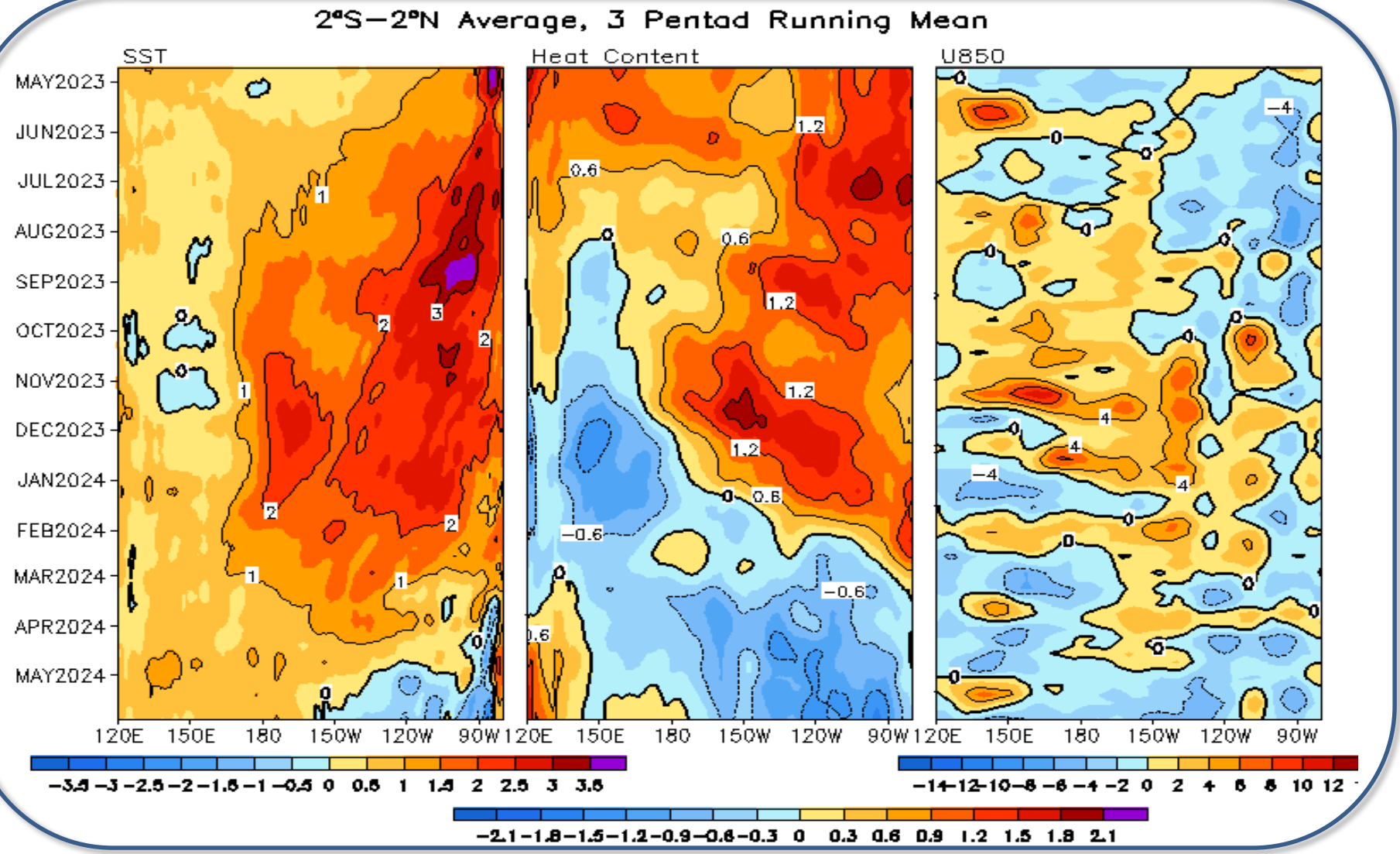
Phase diagram of Warm Water Volume (WWV) and Niño3.4 indices. WWV is the average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN] calculated with the NCEP's GODAS. Anomalies are departures from the 1991-2020 base period means.

Evolution of Pentad D20 and Taux anomalies along the equator



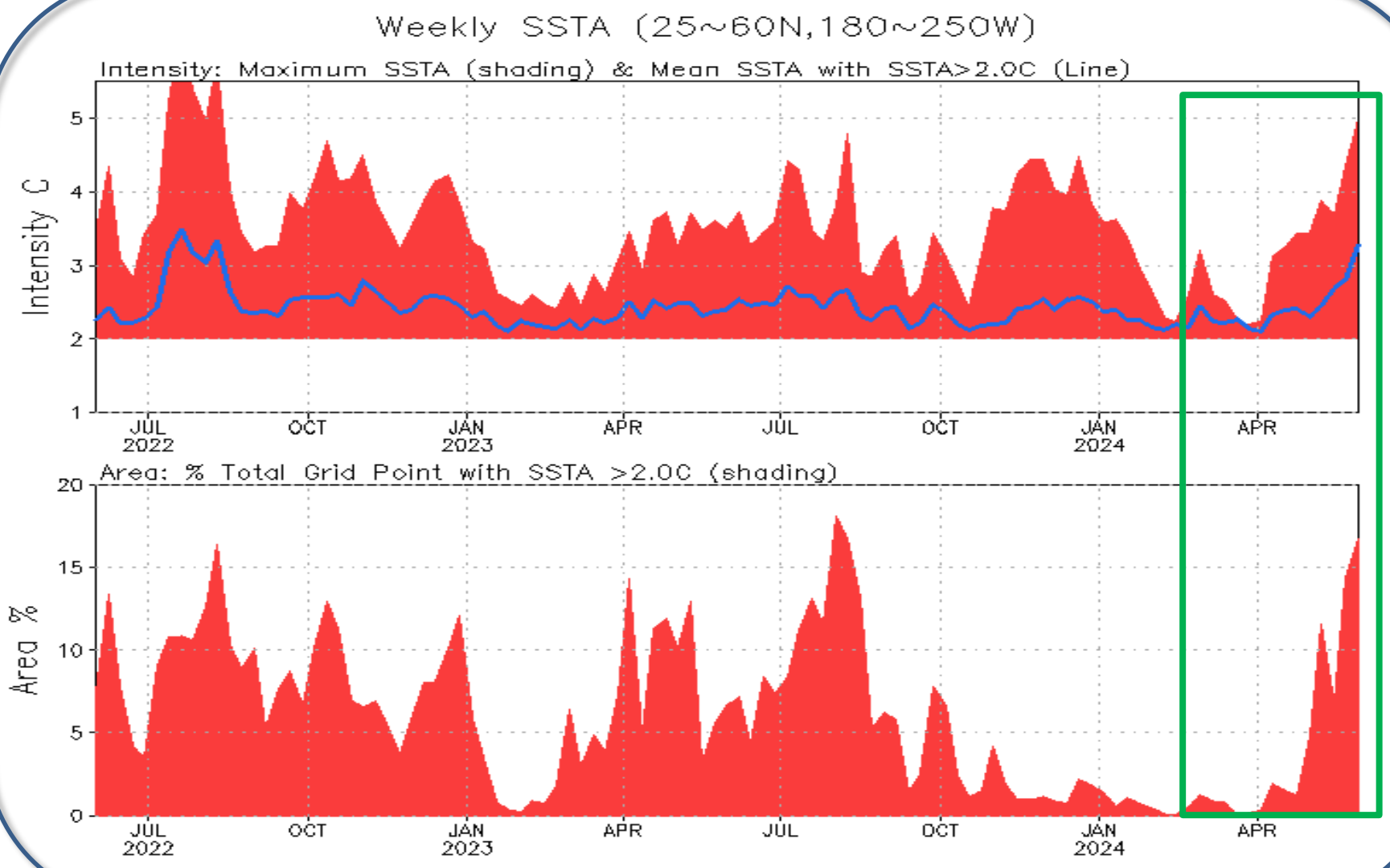


Equatorial Pacific SST (°C), HC300 (°C), u850 (m/s) Anomalies



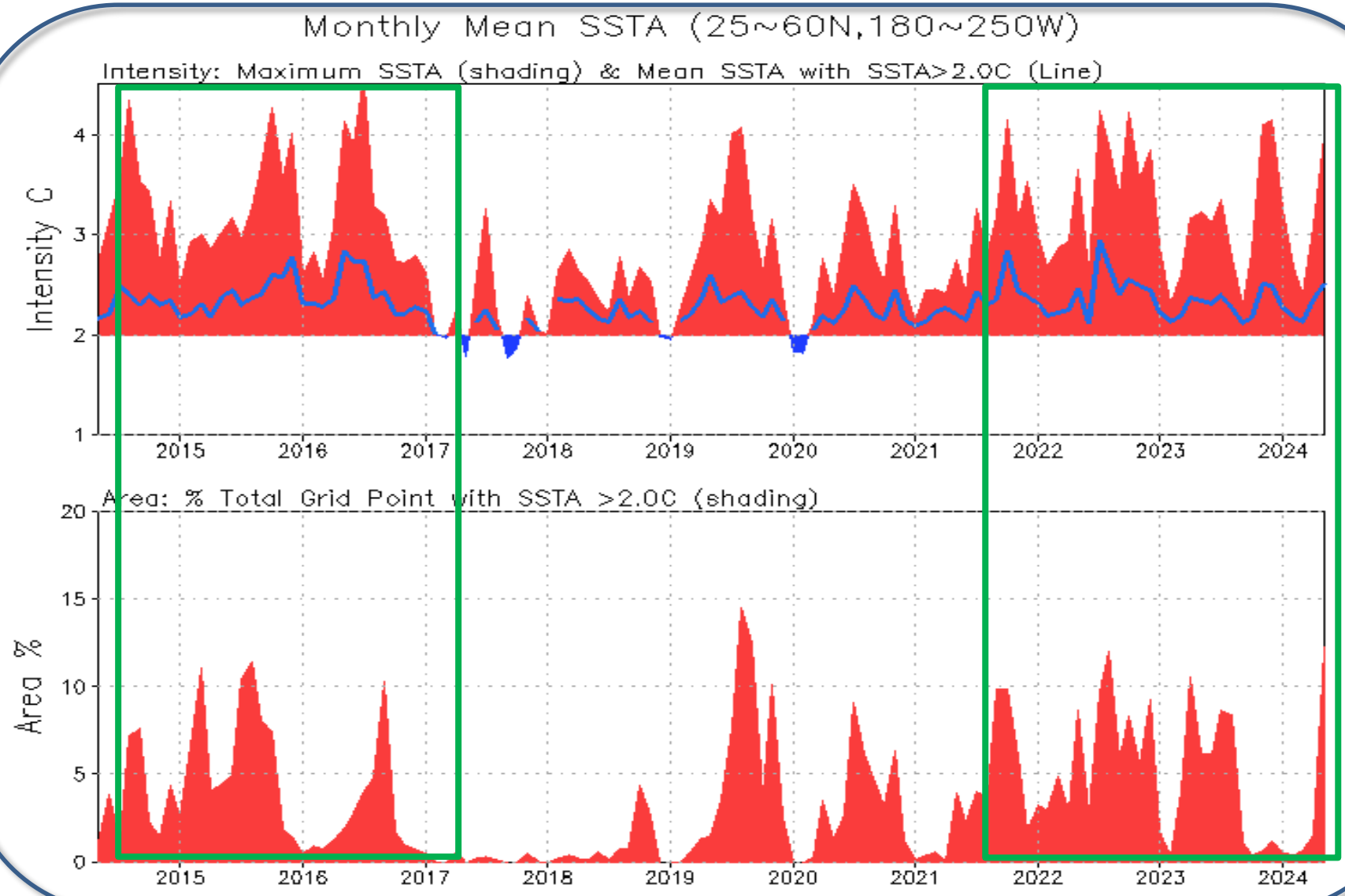
- Since Feb 2023, a set of westerly wind surges triggered downwelling Kelvin waves, reinforcing the subsurface warming in the central and eastern Pacific.
- Since Feb 2024, easterly wind anomalies have present, consistent with decrease in heat content and SST.

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

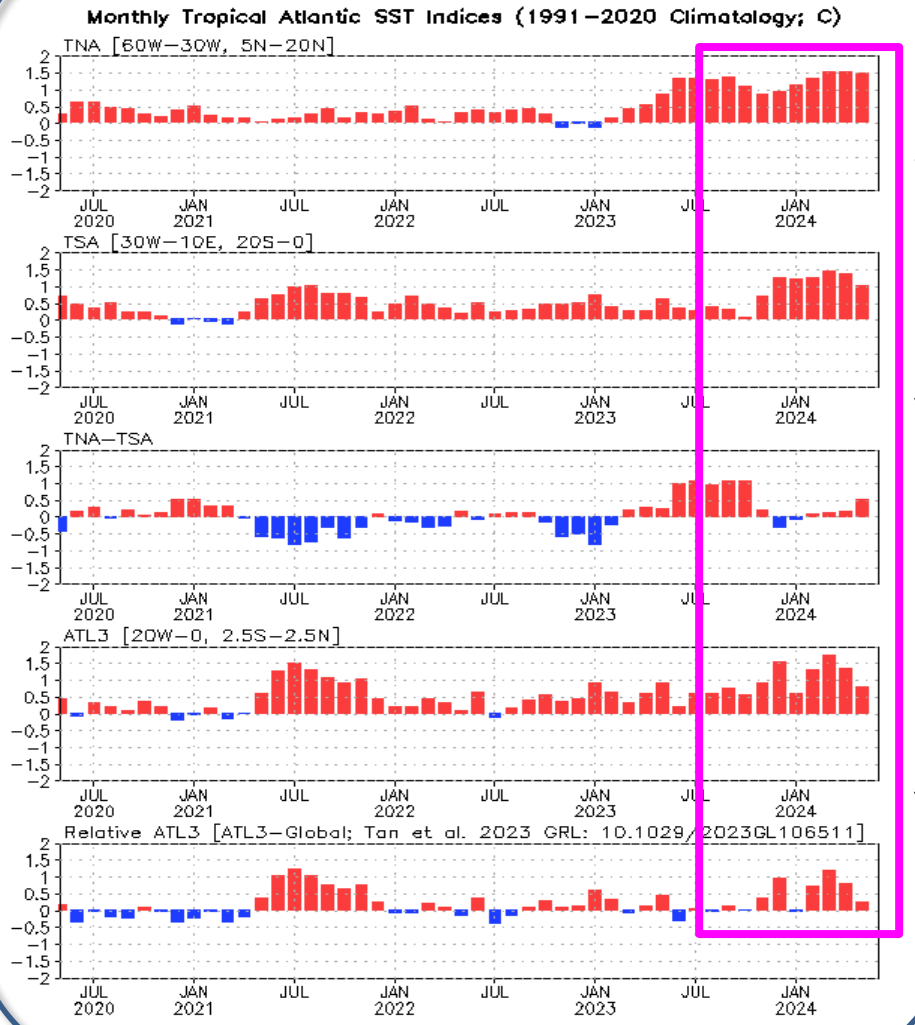
Marine Heatwave Monitoring and Forecast

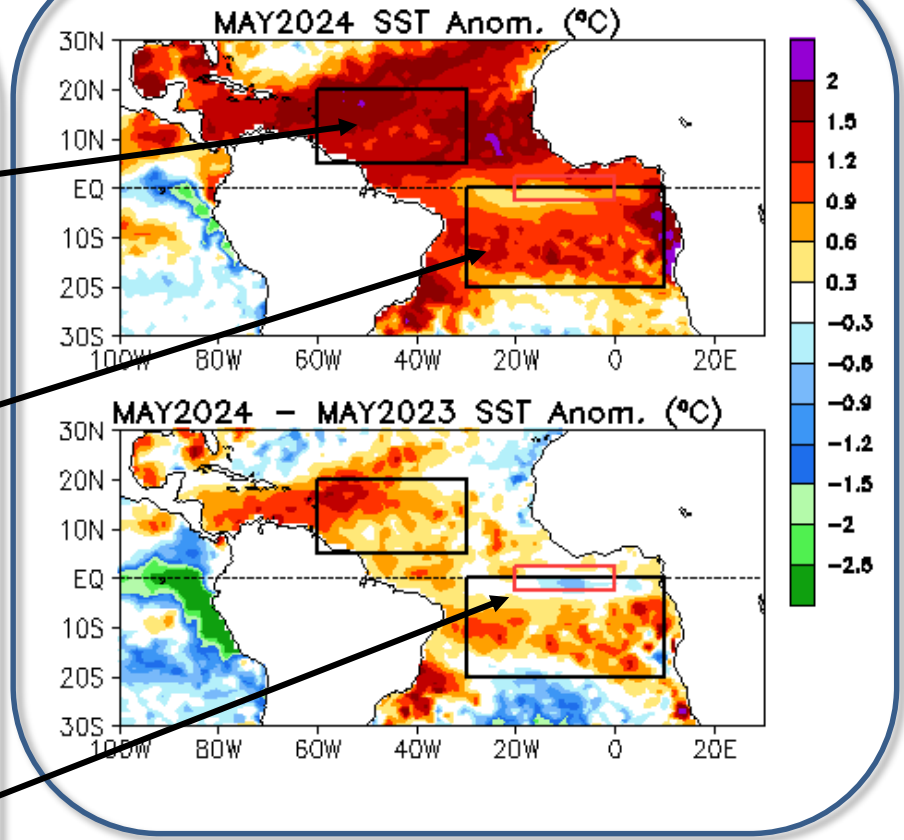
- **Indices & Time Series**
  - N. Pacific MHW Intensity & Area Indices: Weekly Monthly
  - Regional Mean SST: Global Monthly & Nino3.4 Since 1854 N. Pacific Weekly Gulf of Alaska & Subtropical Coast Weekly

- **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

Evolution of Tropical Atlantic SST Indices

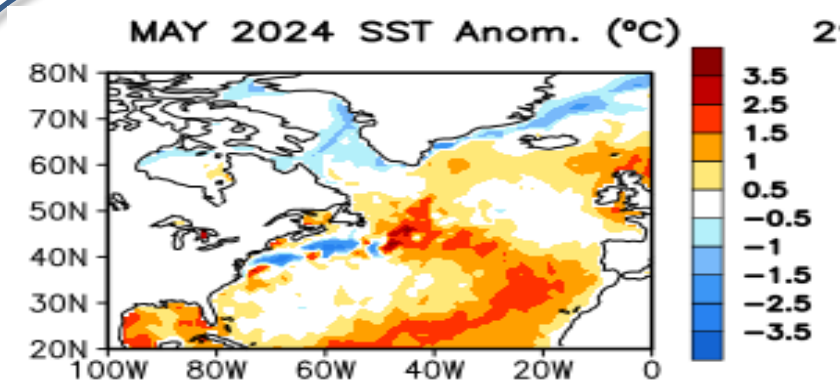


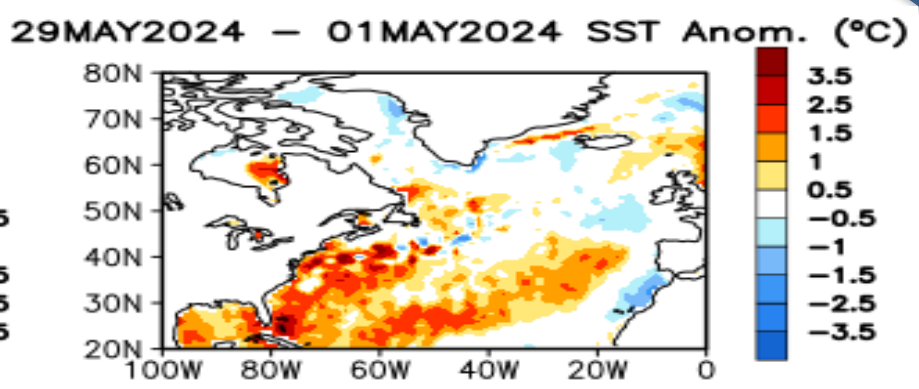


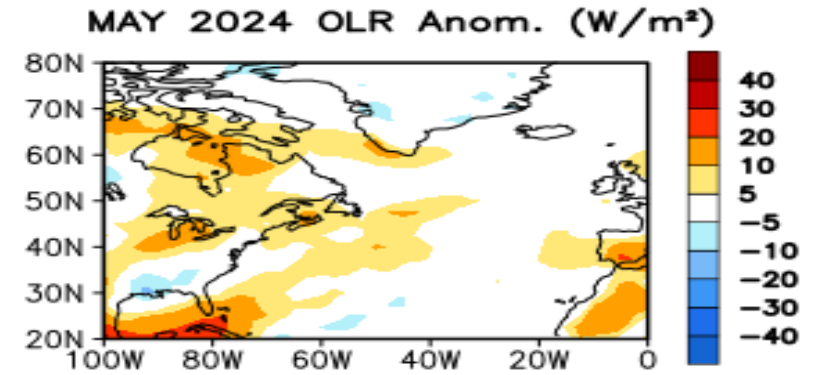
- Large positive SSTAs were observed in the tropical Atlantic in May 2024.
- ATL3 (rATL3) index was 0.7°C (0.2°C) in May 2024.
- A relative ATL3 (ATL3-Global) index has been included.

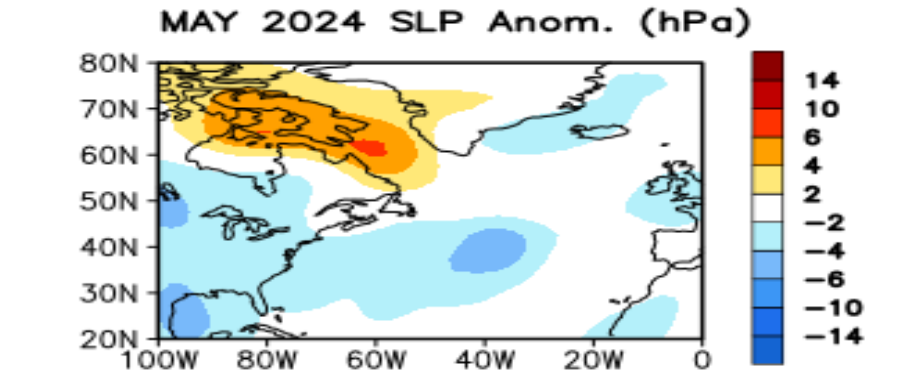
Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean SSTAs (°C) for the TNA [60°W-30°W, 5°N-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between TNA and TSA. Data are derived from the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

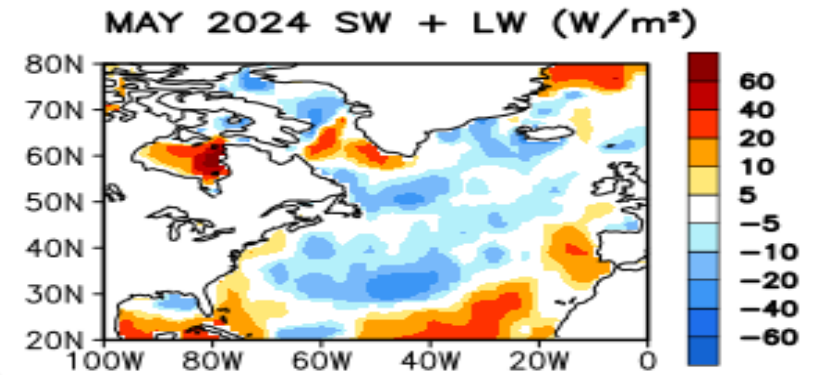
N. Atlantic: SST, SST tend., OLR, SLP, & heat flex anom.

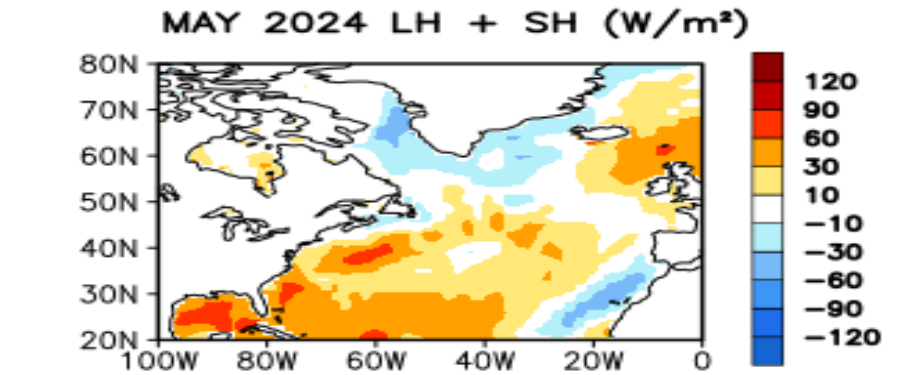












(a) Definition of coastal El Nino event

- 3-month running mean Niño1+2 index ≥ one STD (0.8°C; with 1982/83 & 1997/98)
- *ENSO-adjusted* 3-month running mean Niño1+2 index ≥ one STD (0.6°C; without 1982/83 & 1997/98)
- The anomaly of this magnitude persists for at least three consecutive months.

(b) 7 Coastal El Nino events since 1979:

- 1983 (March-October 1983)
  1987 (March-May 1987)
  1998 (April 1997-August 1998)
  2008 (July-September 2008)
  2014 (May-August 2014)
  2015 (May-July 2015)
  2017 (January-April 2017)

Hu, Z.-Z., B. Huang, J. Zhu, A. Kumar, and M. J. McPhaden: 2019: On the variety of coastal El Niño events. Climate Dyn., 52 (12), 7537-7552. DOI: 10.1007/s00382-018-4290-4.