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

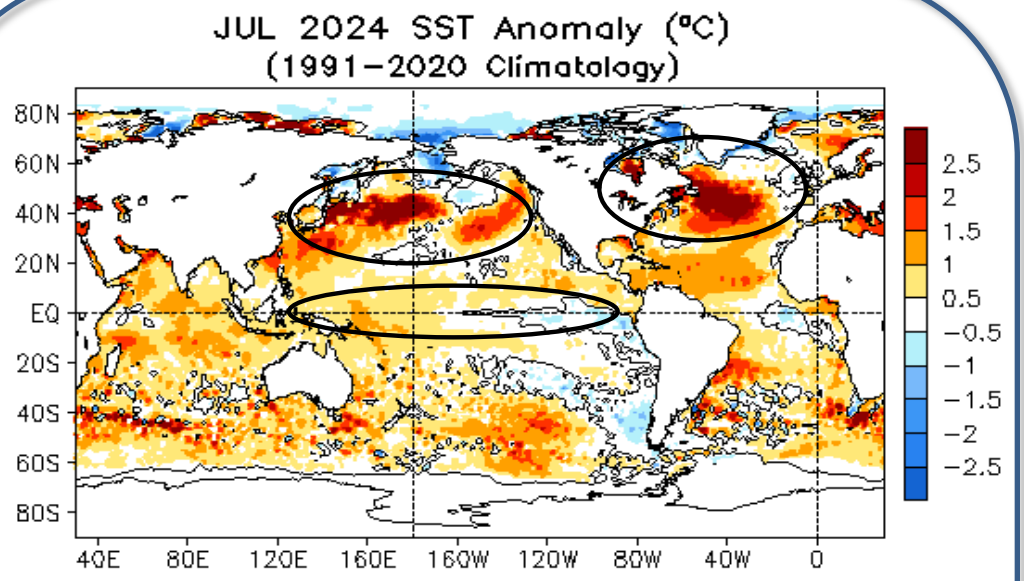
- Overview
- Recent highlights
  - Pacific Ocean
  - Arctic & Antarctic Oceans
  - Indian Ocean
  - Atlantic Ocean
- Global SSTA Predictions

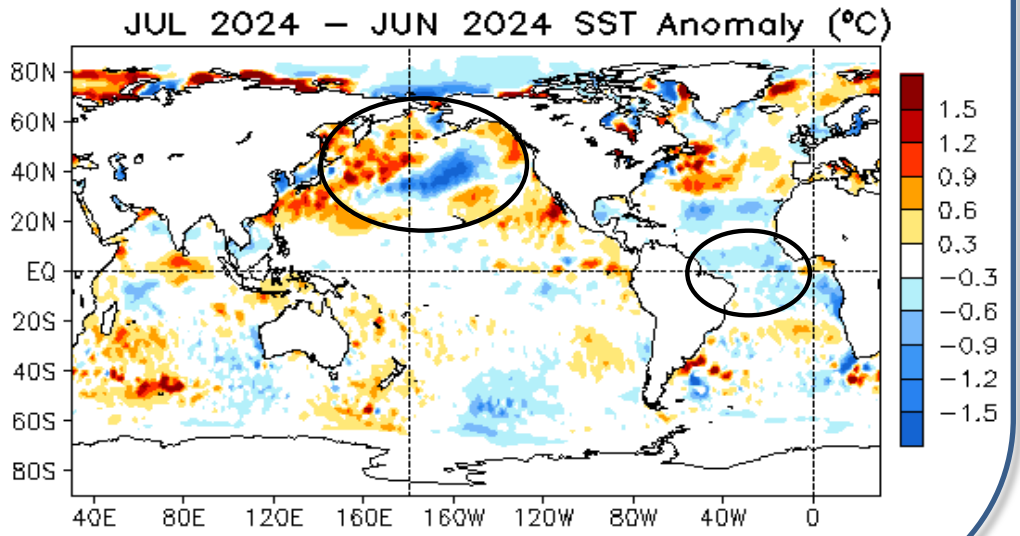
Overview

- Pacific Ocean
  - ENSO neutral conditions persisted with Niño3.4 = 0.2°C in Jul 2024.
  - NOAA "ENSO Diagnostic Discussion" on 8 Aug 2024 *continued with "La Niña Watch."*
  - The positive SSTA in the North Pacific continued and the negative phase of PDO weakened slightly with PDOI = -1.9 in Jul 2024.
  - Strong subsurface warming has persisted in the central North Pacific Ocean since 2020.
- Arctic & Antarctic Oceans
  - The average Arctic sea ice extent for Jul 2024 was 7.9 million km^2, ranking the sixth lowest Jul since 1979.
  - Antarctic sea ice extent continues to track at the 2nd historical low value.
  - CPC forecasts a below-normal Arctic sea ice extent minimum in Sep 2024.
- Indian Ocean
  - Positive SSTAs dominated the tropical Indian Ocean basin in Jul 2024.
  - The Indian Ocean dipole (IOD) was neutral in Jul 2024.
- Atlantic Ocean
  - SST warming in the hurricane main development region during Jun-Jul 2024 ranked the 2nd historical high of the same season since 1982.
  - Hurricane activity was relatively quiet in Jul 2024.
  - Strong Marine heat waves have persisted in the north tropical Atlantic since May 2023.

Global Oceans

Global SST Anomaly (°C) and Anomaly Tendency



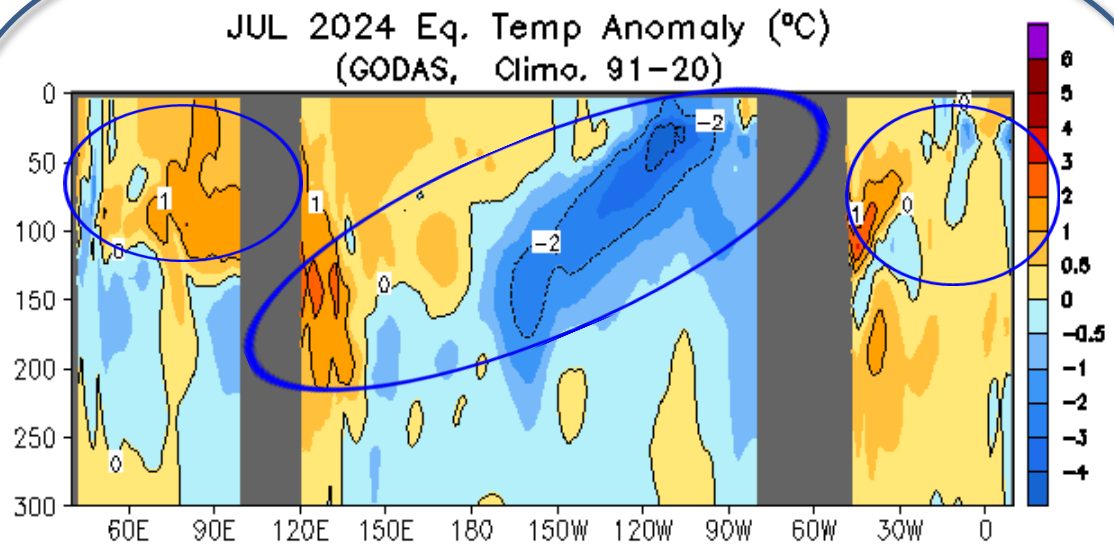


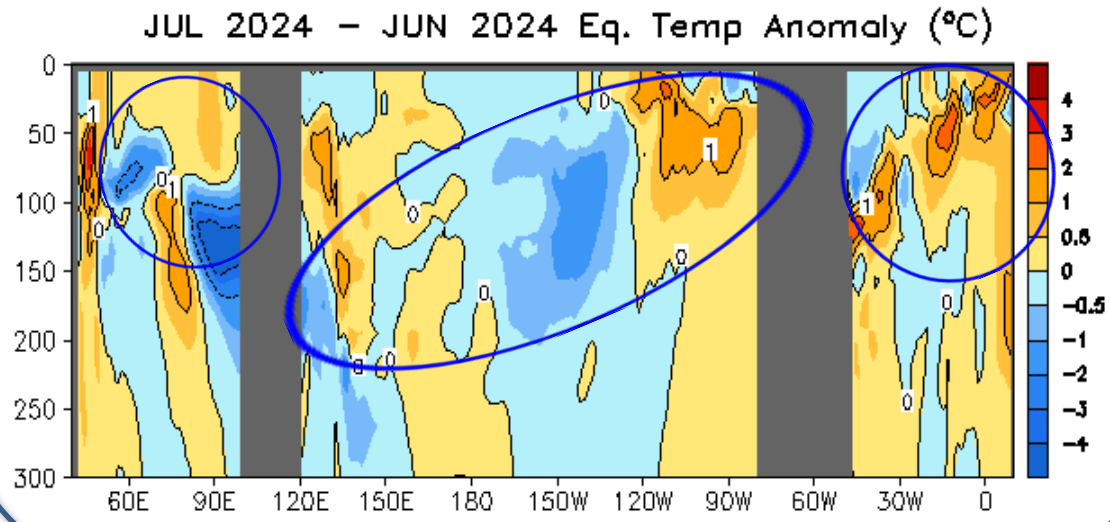
- SSTs were above average in the west-central Pacific Ocean, while near to below average SSTs were present in the eastern Pacific.
- Strong positive SSTAs continued in the mid-latitude of the North Pacific and North Atlantic Oceans.
- Positive SSTAs dominated the tropical Atlantic, Indian and Southern Oceans.

- Both positive and negative SSTA tendencies were observed in the North Pacific and Atlantic Oceans.
- SSTA tendencies were mostly negative in the tropical Atlantic Ocean.

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

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



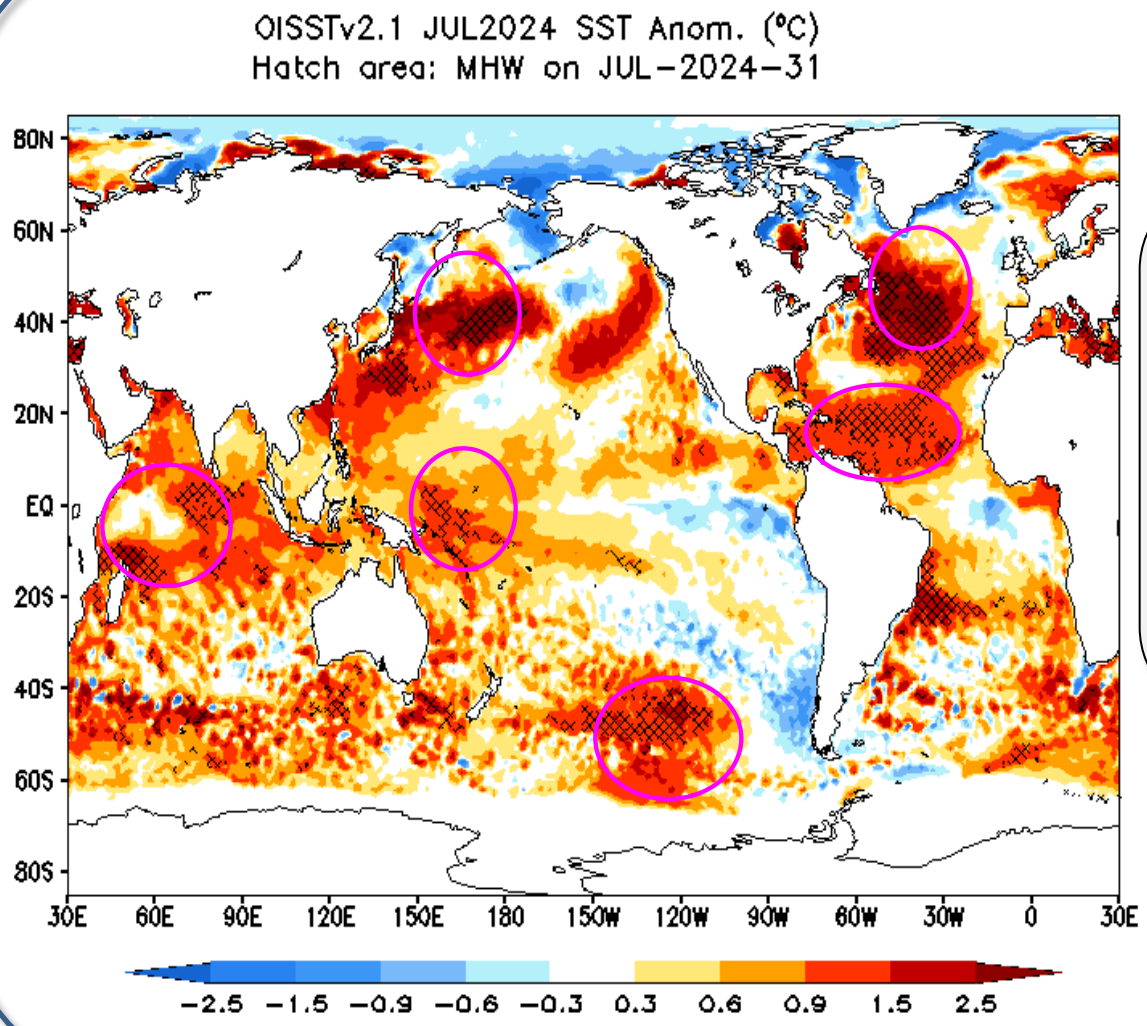


- Negative temperature anomalies persisted near the central-eastern thermocline in the Pacific.
- Positive temperature anomalies were present in the upper 150m of the Indian Ocean.
- Positive temperature anomaly dominated the upper ocean of the Atlantic.

- Both positive and negative anomaly tendencies were present along the thermocline in the Pacific Ocean.
- Positive temperature anomaly tendency dominated the Atlantic Ocean.

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

Global Monthly SST anomaly and Marine Heat Waves

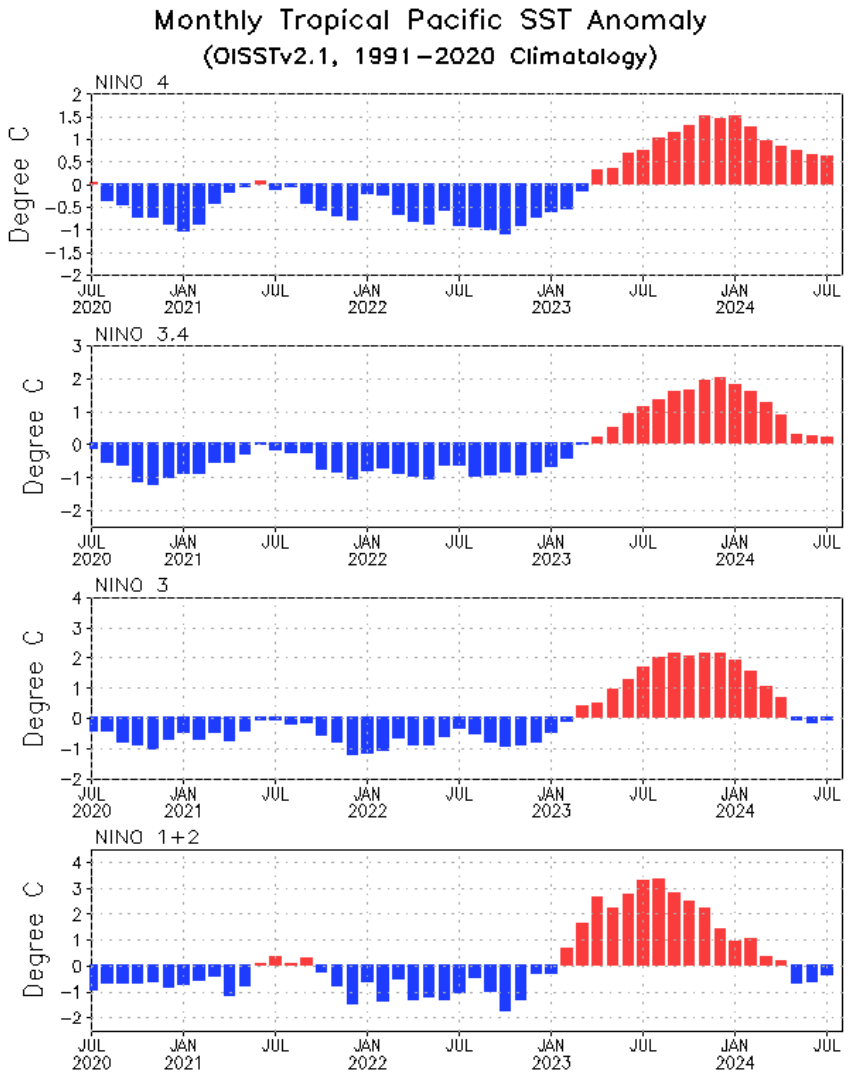


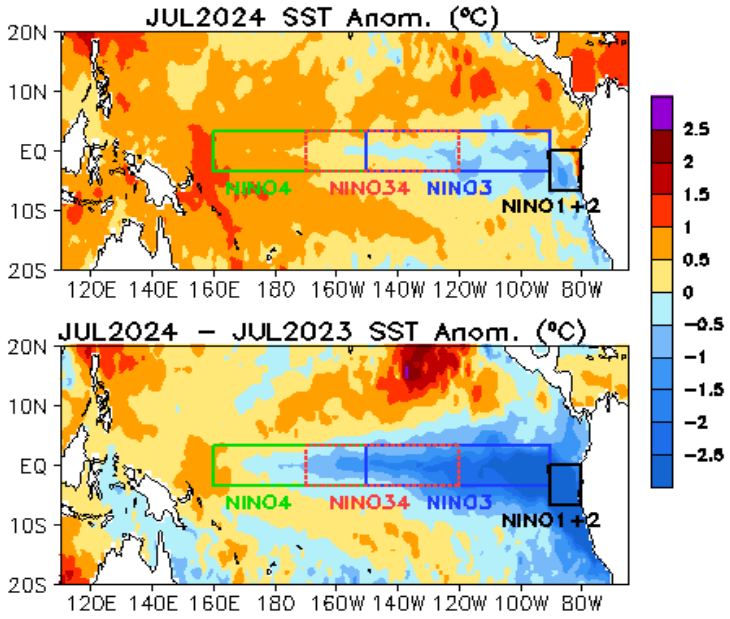
- MHWs were observed in much of the central North Atlantic, tropical North Atlantic, east coast of Brazil, north-western extratropical Pacific, central-equatorial Indian, and north of Madagascar.

((Left panel) Monthly SST anomaly (shaded) and locations experiencing marine heat waves (hatched) by the end date labelled in the plot. (right panel) SST evolution at a specific location. Green line and blue line are the 90th percentile and daily climatology, respectively. Shaded area denotes the periods experiencing MHW. MHW is defined as a prolonged warming exceeding 90th percentile of daily SST for at least 14 consecutive days. Data is derived from NCEI OISSTv2.1 and the reference period is 1991-2020

Tropical Pacific Ocean and ENSO Conditions

Evolution of Pacific Niño SST Indices

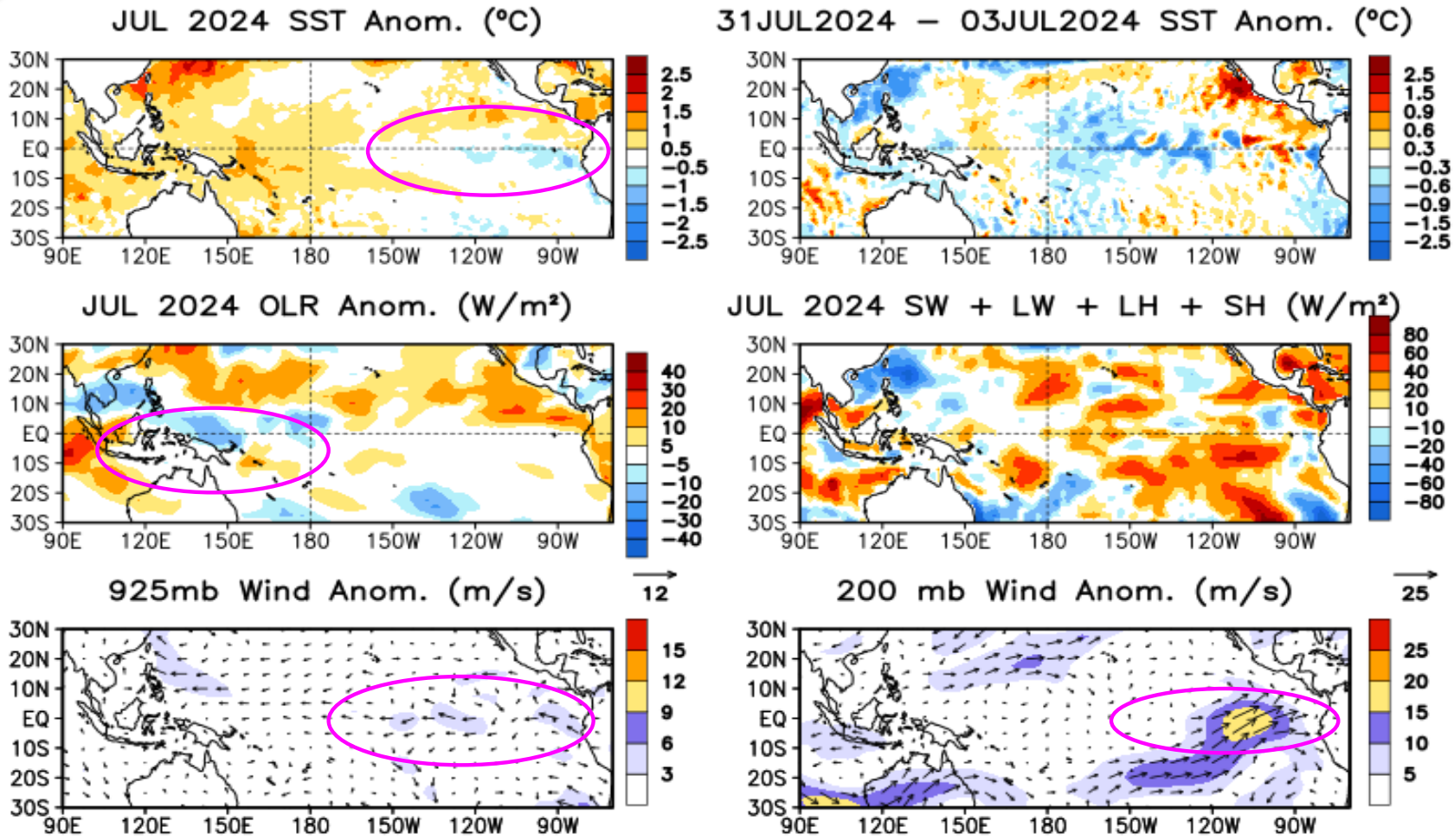




- Both Niño3.4 and Niño3 were near average in Jul 2024, with Niño3.4 = 0.2°C.
- Niño4 remained above 0.5 °C.
- Compared with Jul 2023, the tropical eastern Pacific was cooler in Jul 2024
- The indices may have differences if based on different SST products.

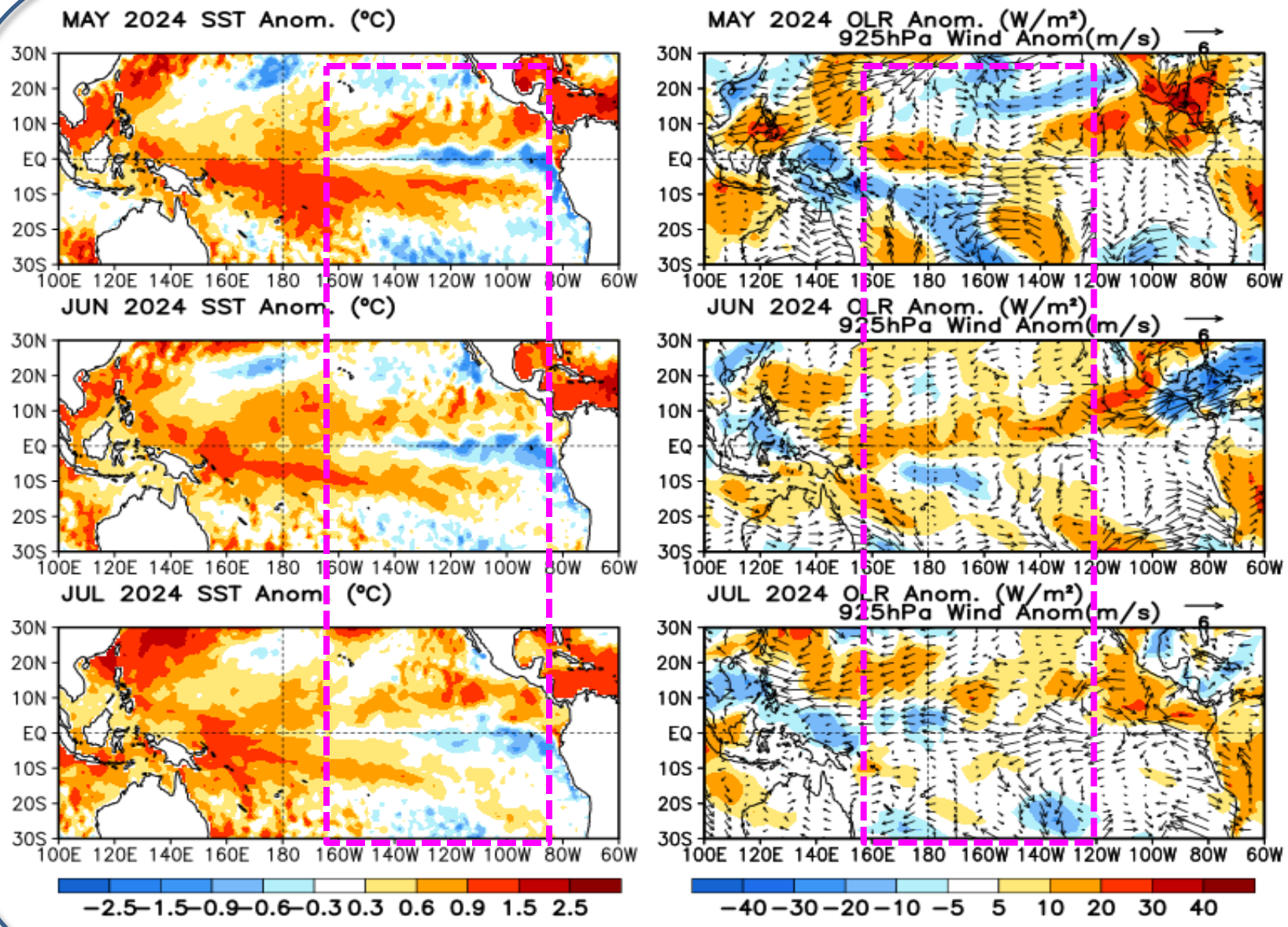
Niño region indices, calculated as the area-averaged monthly mean SSTAs (°C) for the specified region. Data are derived from the OIv2.1 SST analysis, and anomalies are departures from the 1991-2020 base period means.

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

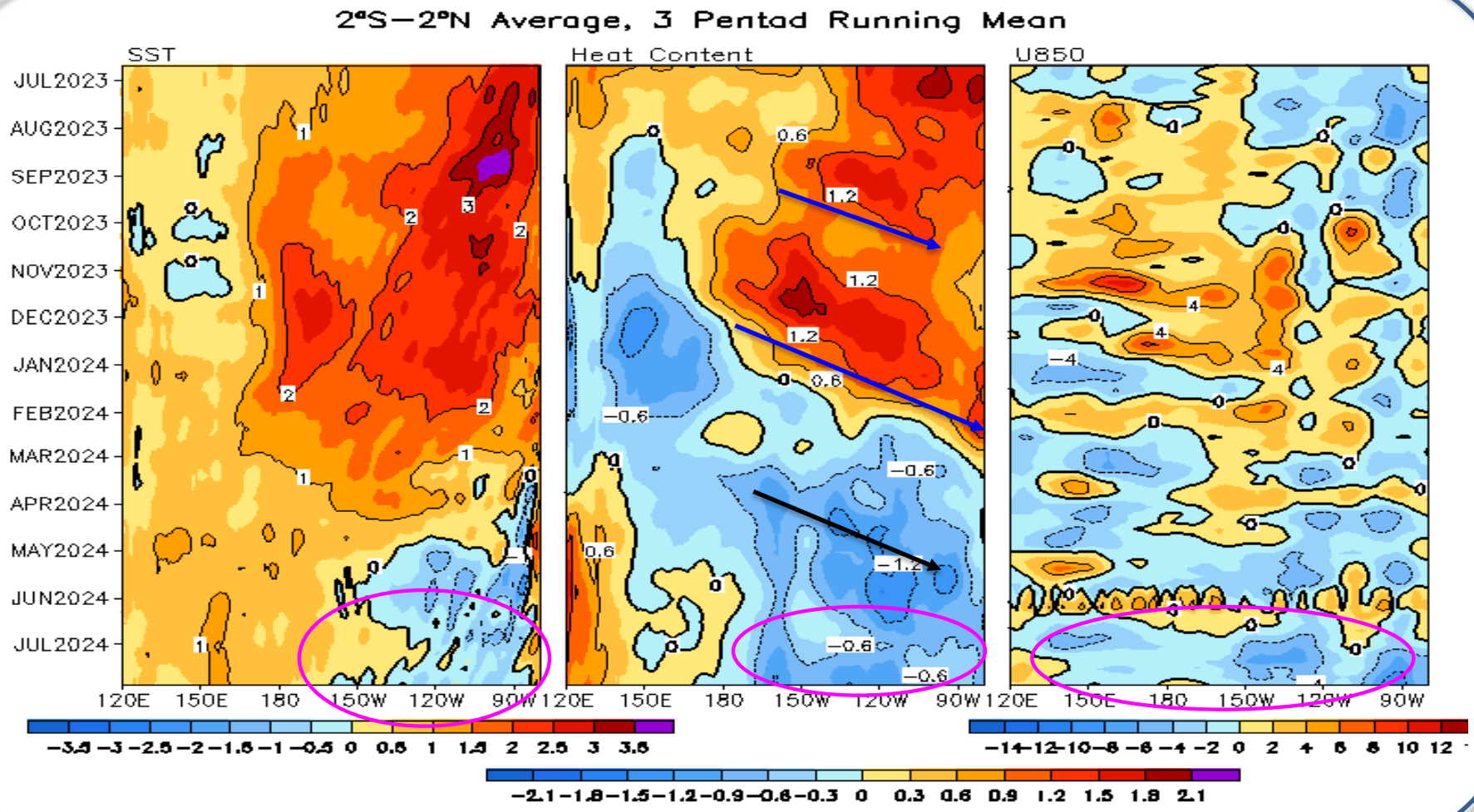


SSTAs (top-left), SSTA tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right; positive means heat into the ocean), 925-mb wind anomaly vector and its amplitude (bottom-left),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

Last 3- month tropical Pacific SST, OLR, and uv925 anomalies



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

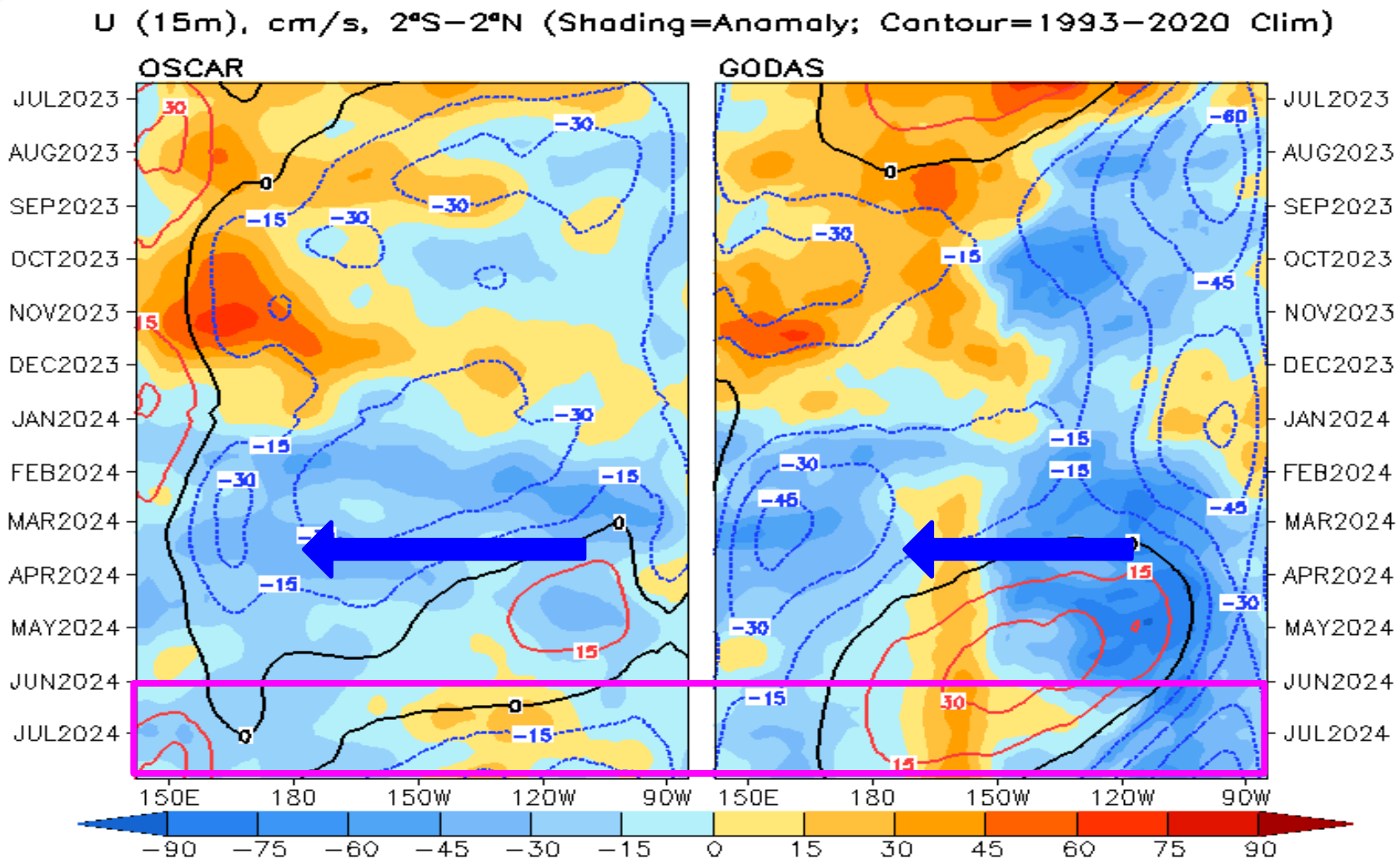


-The below average SST area increased slightly in Jul 2024, while positive SSTA persisted west of 150ºW.

- Negative H300 anomaly increased slightly in the central-eastern Pacific during Jul 2024.

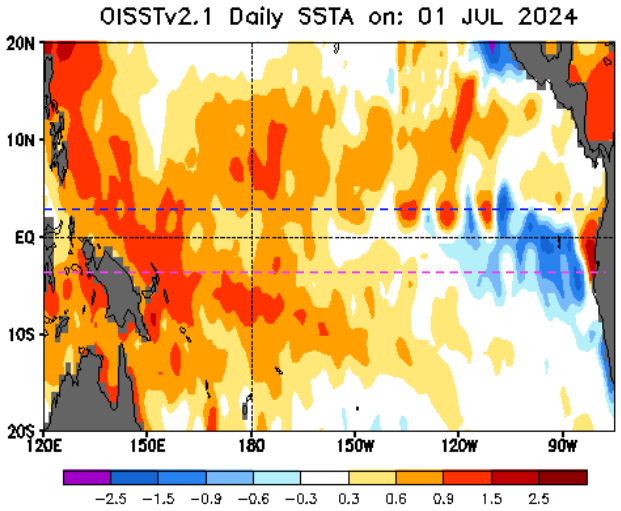
- Easterly wind anomalies persisted over much of central-eastern equatorial Pacific during Jul 2024, contributing to re-strengthening of subsurface cooling in the central Pacific.

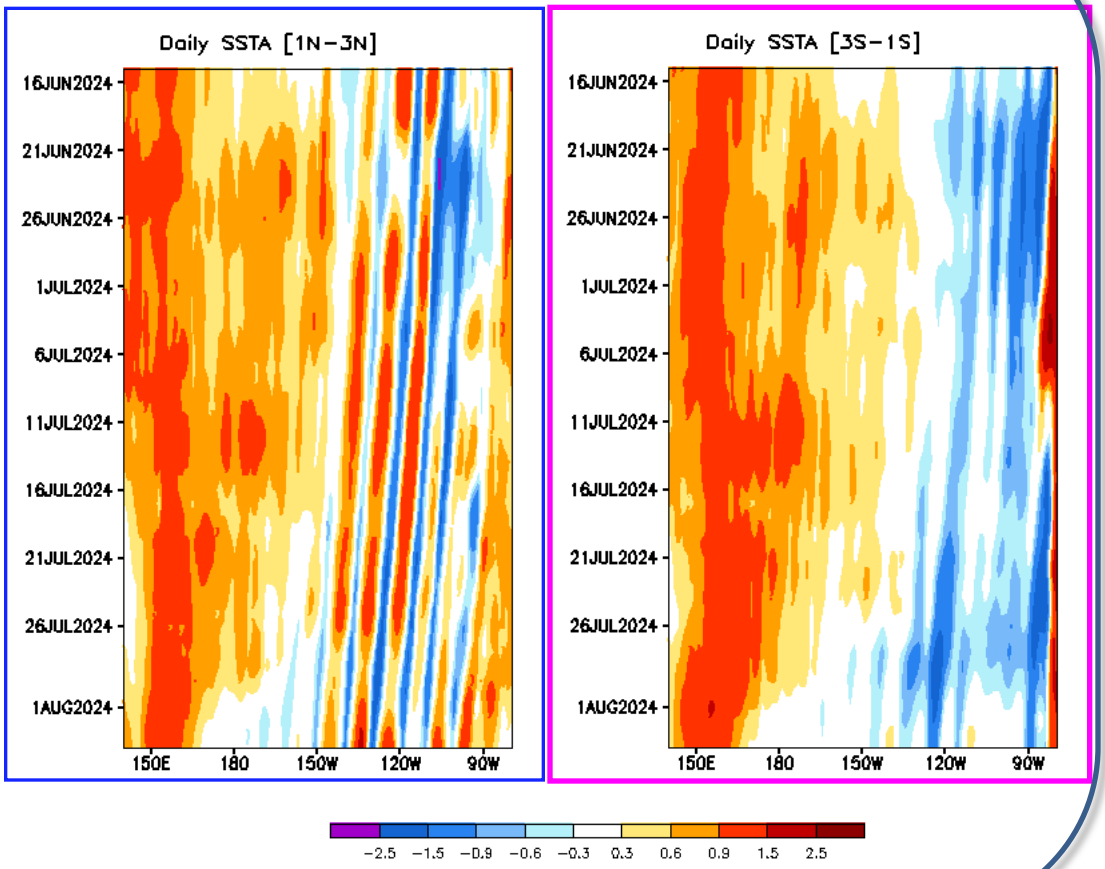
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- Anomalous westward currents have been observed since mid-Dec 2023 and weakened since May 2024.
- Anomalous westward currents strengthened in the eastern Pacific during Jul 2024 in GODAS, while currents were near average in OSCAR.

Tropical Instability Waves (TIWs) activities



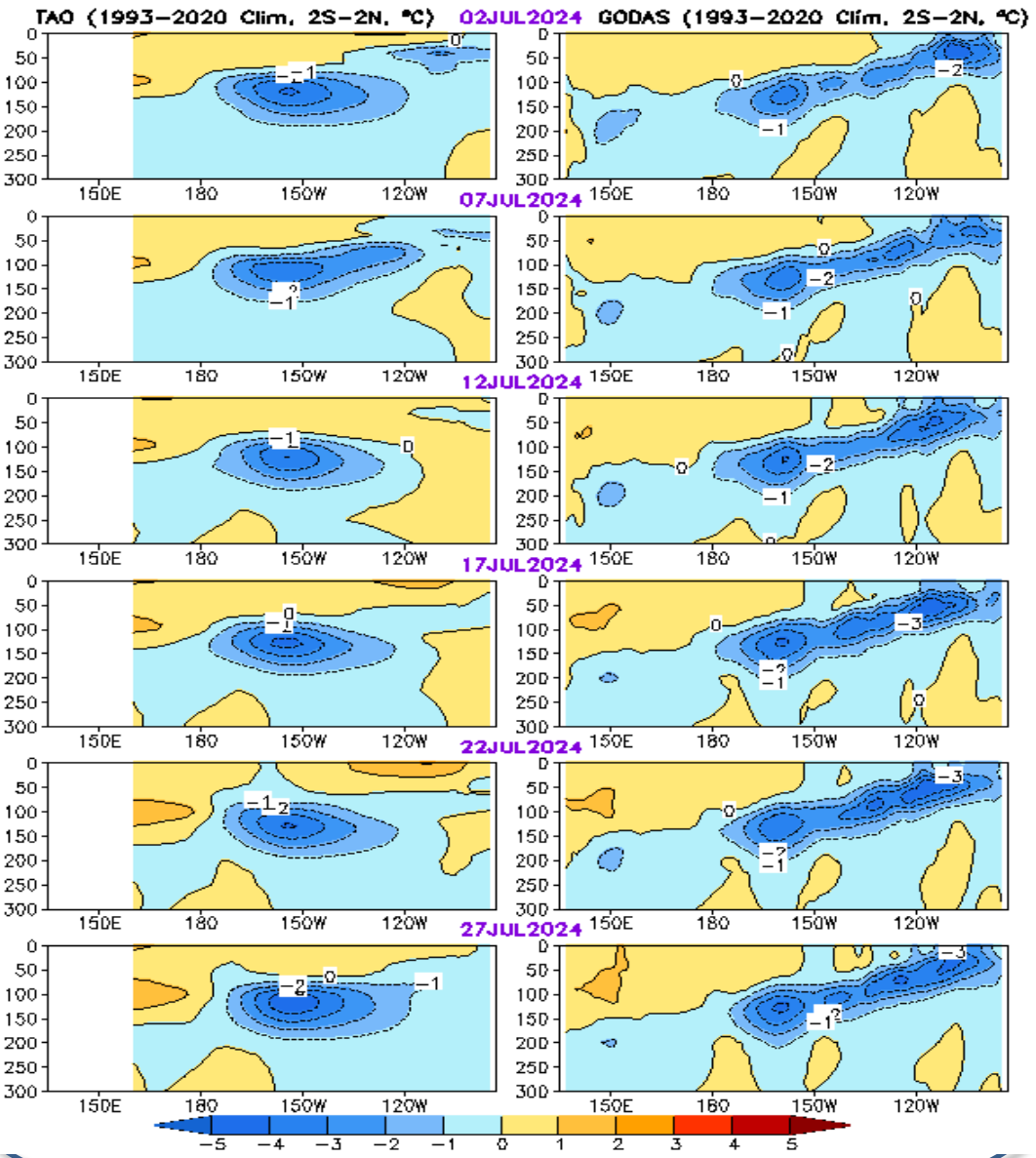


- Negative SSTA were generally located just to the south of the equator, consistent with asymmetric SSTA signals carried by TIWs in the northern and southern hemispheres.

-Nonlinear term related to TIWs play an important role in the slowdown of SST cooling tendency in the central-eastern region.

Equatorial Pacific Ocean Temperature Pentad Mean Anomaly

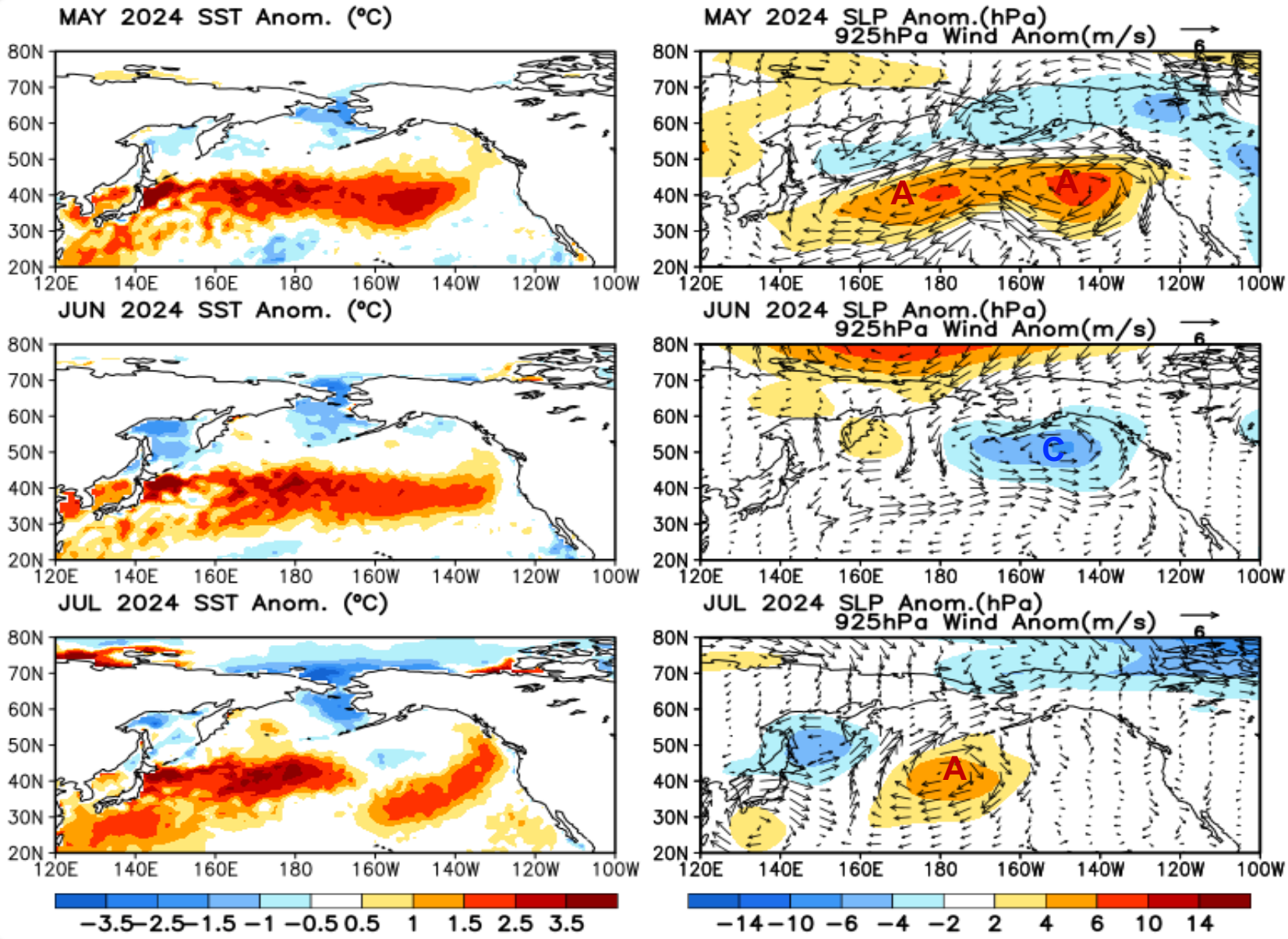
TAO GODAS



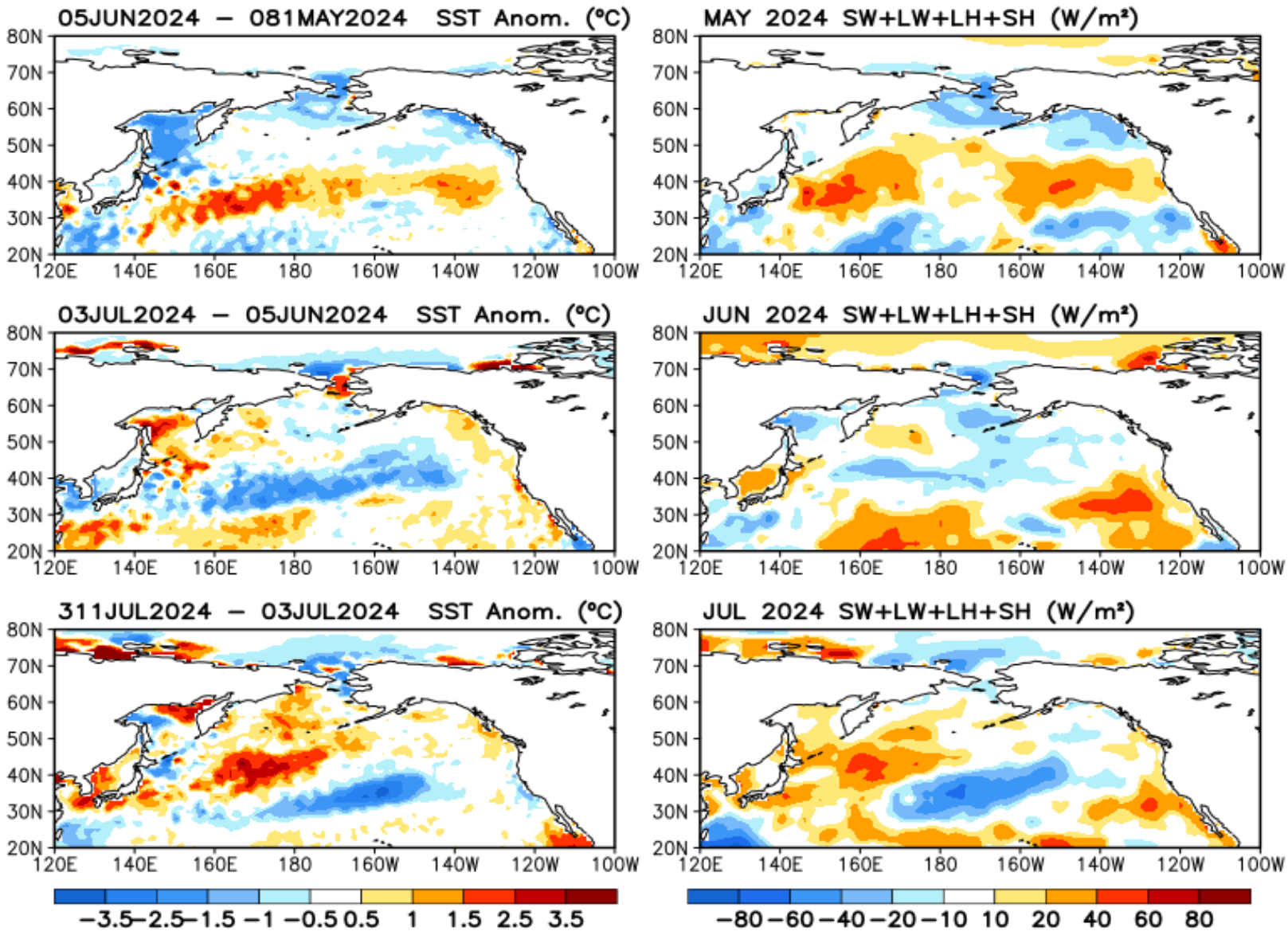
- Negative ocean temperature anomalies in the central Pacific restrengthened at the end of July.
- Positive SSTA persisted in east of 150ºW in TAO, while negative SSTAs were observed in GODAS.

North Pacific & Arctic Oceans

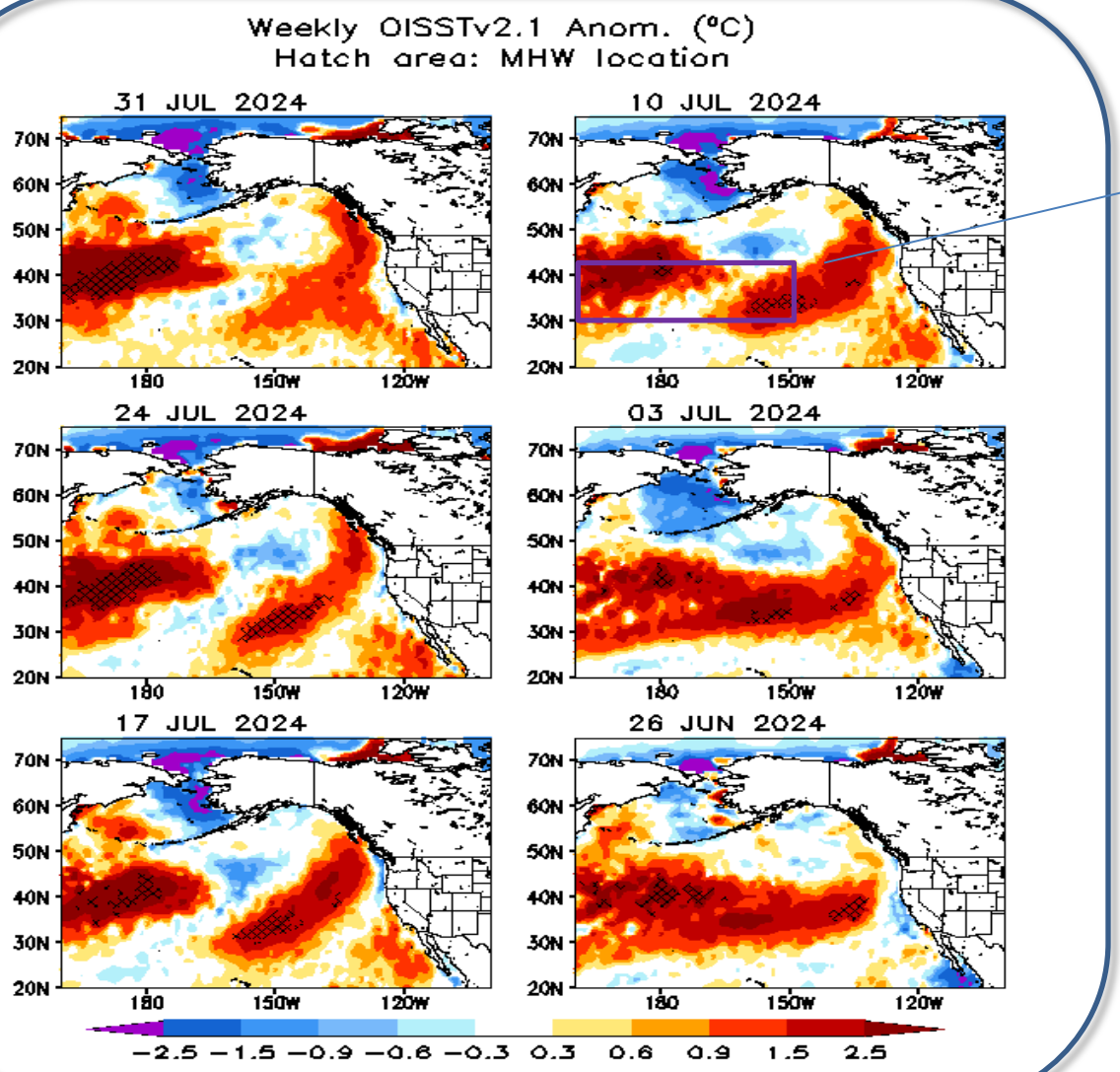
Last 3- month North Pacific SST, SLP, and uv925 anomalies

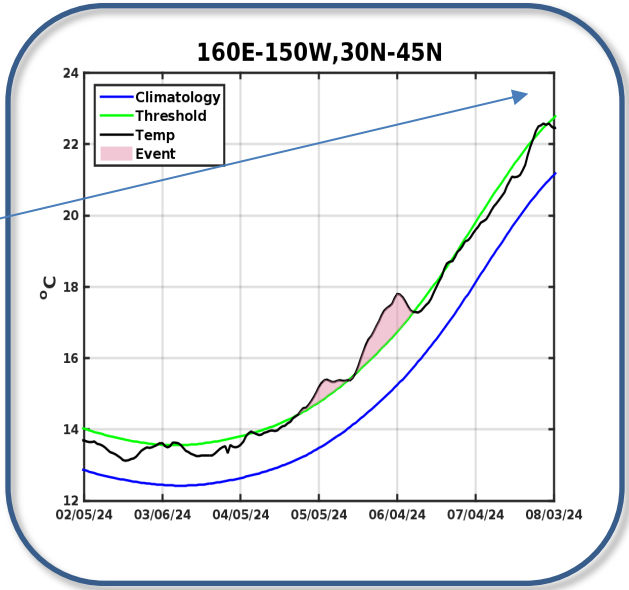


Last 3- month North Pacific SST Tendency and surface Heat Flux anomalies



Weekly SST anomaly and MHWs in the North Pacific

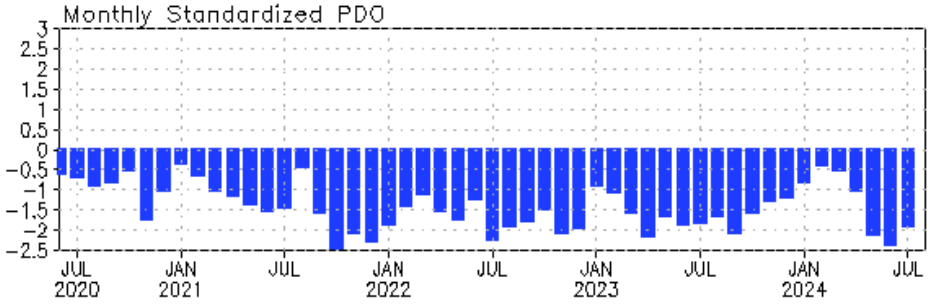


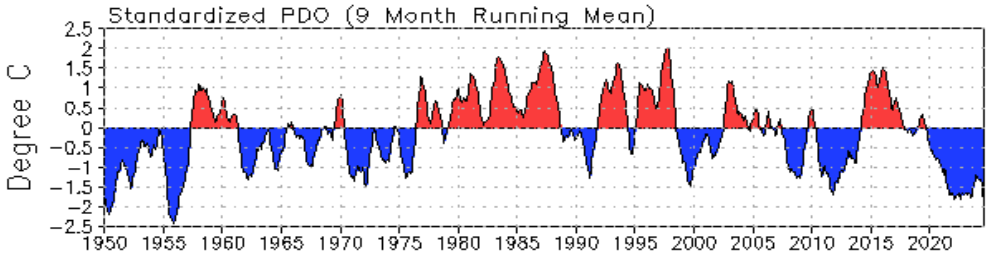


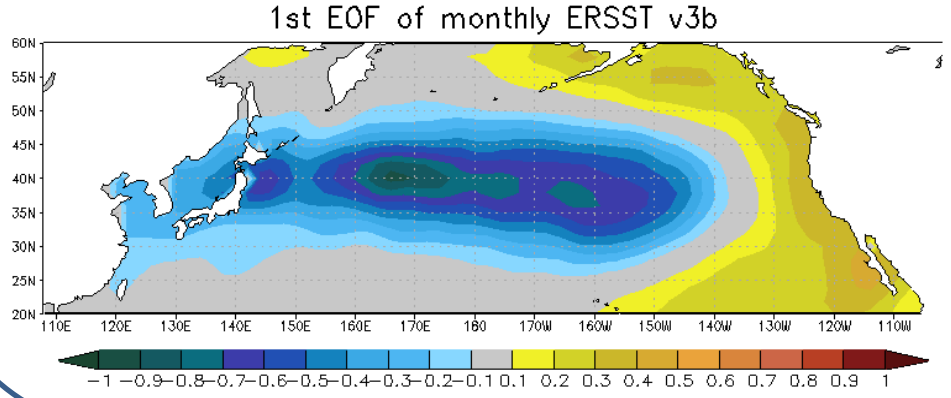
- MHW has persisted in the central North Pacific since early May , but the coverage area decreased in Jul 2024.

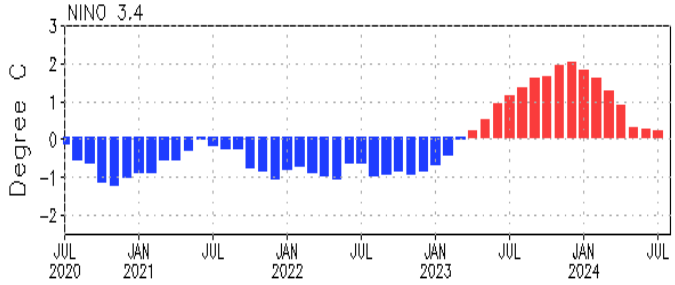
(Left panel) Weekly SST anomaly (shaded) and locations experience Marine heat waves (hatched) by the date labelled in the plot. (right panel) SST evolution at a specific location. Green line and blue line denote the seasonal 90th percentile and daily climatology, respectively. Shaded area denotes the periods experiencing MHW. MHW is defined as a discrete prolonged warmer than 90th percentile of daily SST for at least 14 days. Data is derived from NCEI OISSTv2.1 and the climatology reference period is 1991-2020

Pacific Decadal Oscillation (PDO) Index





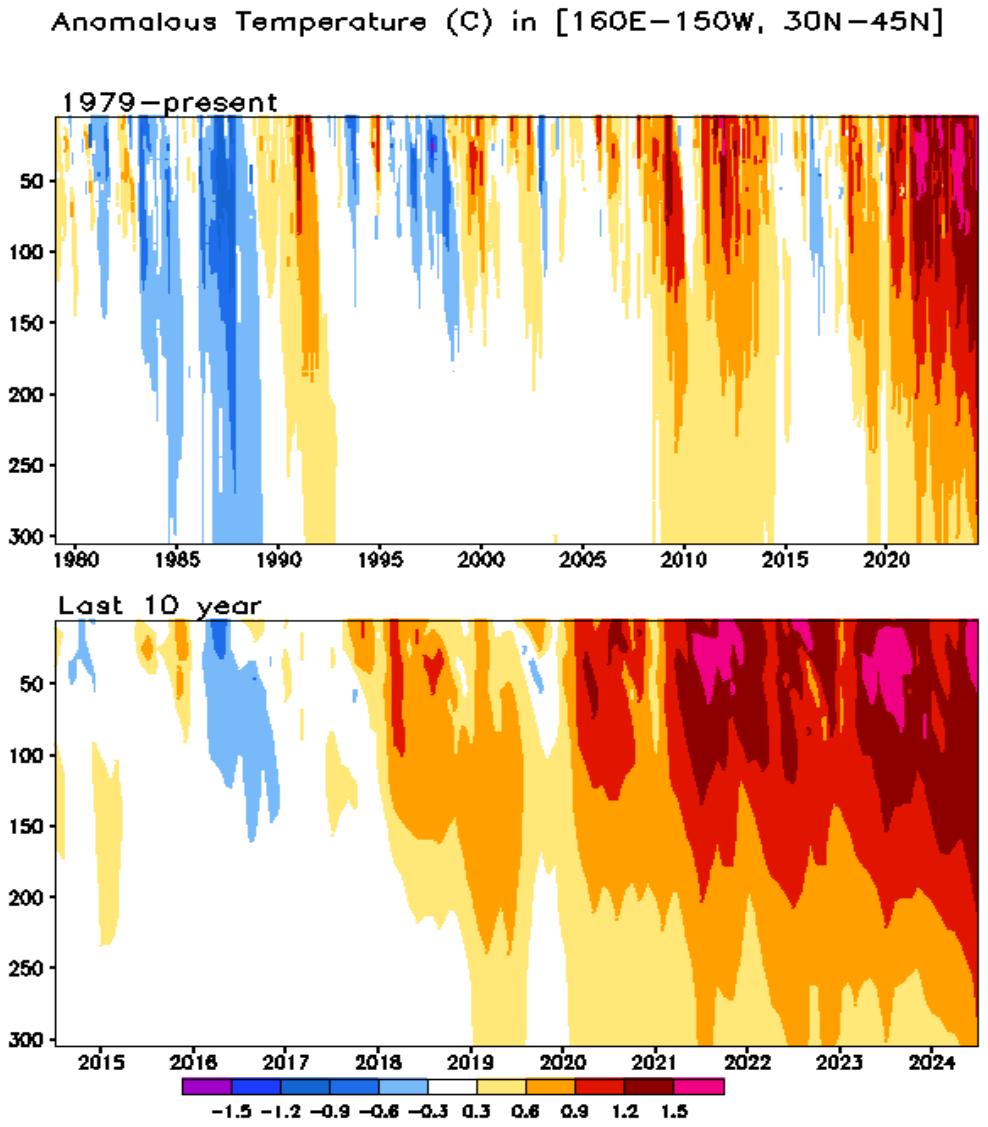


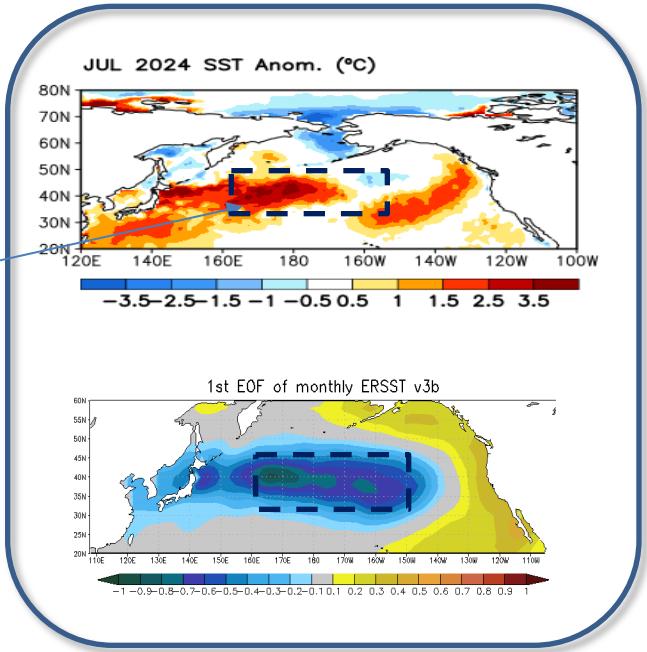


- The PDO has been in a negative phase since Jan 2020 and weakened slightly with PDOI = -1.9 in Jul 2024.
- Statistically, ENSO leads PDO by 3-4 months, through teleconnection via atmospheric bridge, with El Niño (La Niña) associated with positive (negative) PDO Index, but this relationship has weakened in recent years.

• 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.

Subsurface Temperature Anomaly in the Northcentral Pacific

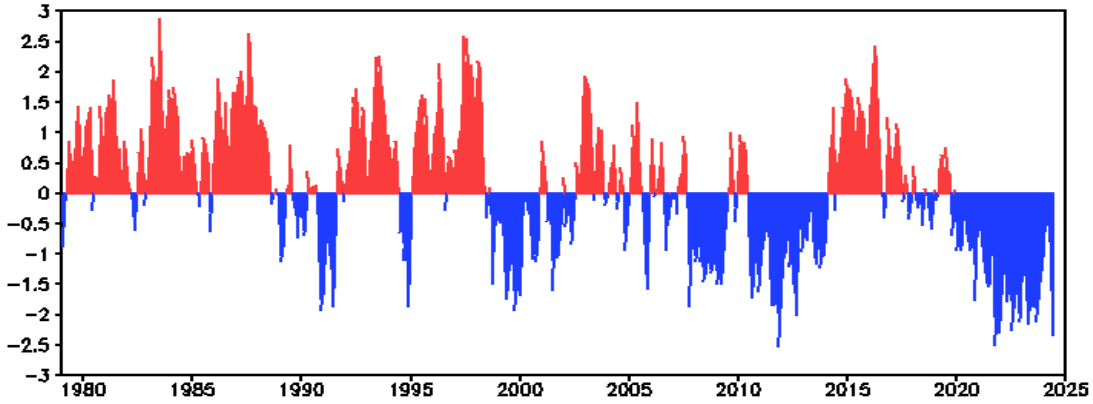




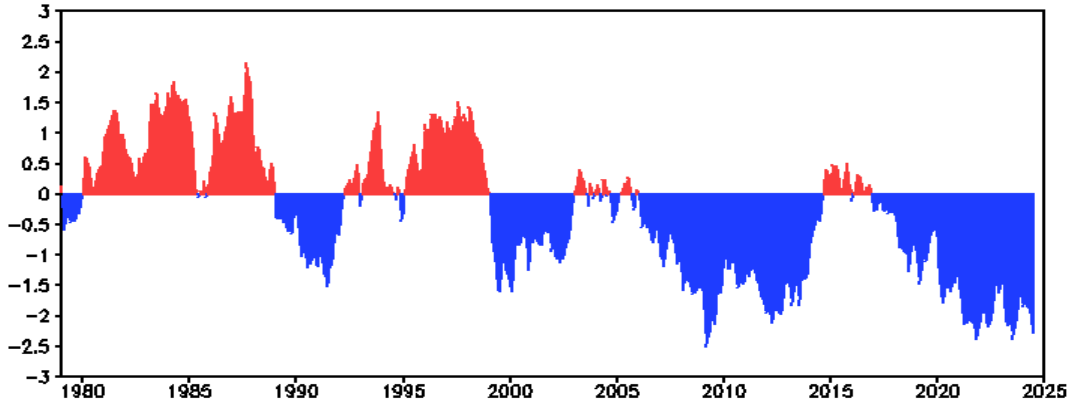
- Positive temperature anomaly (>0.9ºC) has persisted in the upper 100m since 2020, and penetrated to 300m in Jul 2024.
- Subsurface warming in the last four years is the strongest episode since 1979.

Two Oceanic PDO indices

SST-based PDO (Wen et al. 2014: GRL)



H300-based PDO (Arun and Wen 2016:Mon.Wea.Rev.)



- The negative phase of PDO has persisted since Jan 2020 with PDOI = -1.9. in Jul 2024.

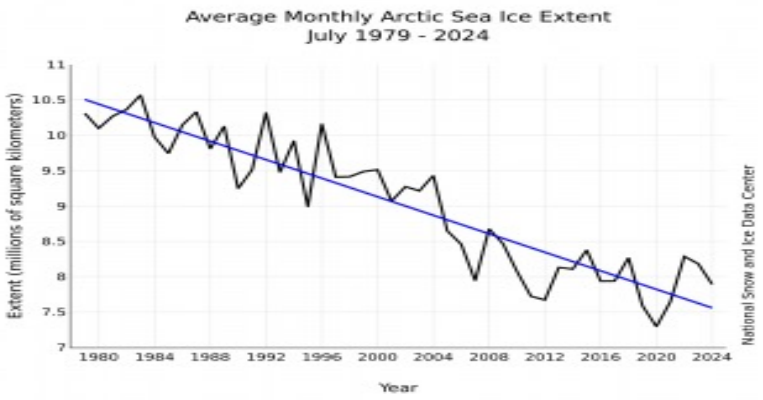
- Negative H300-based PDO index has persisted since Nov 2016, with HPDO = - 2.3 in Jul 2024.

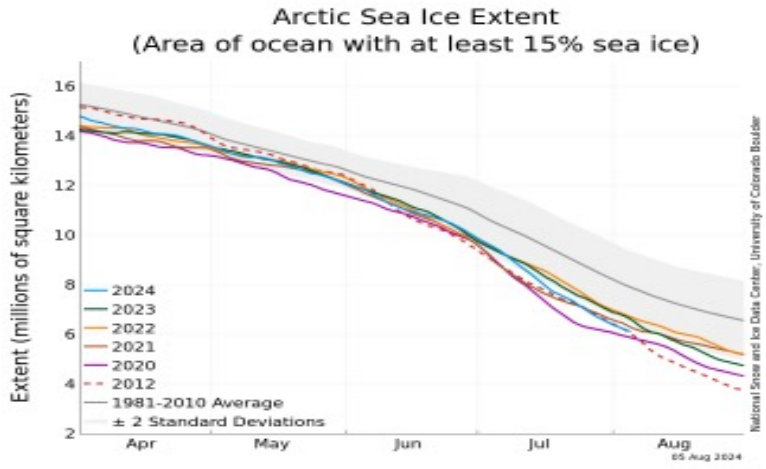
- SST-based PDO index has considerable variability both on seasonal and decadal time scales.

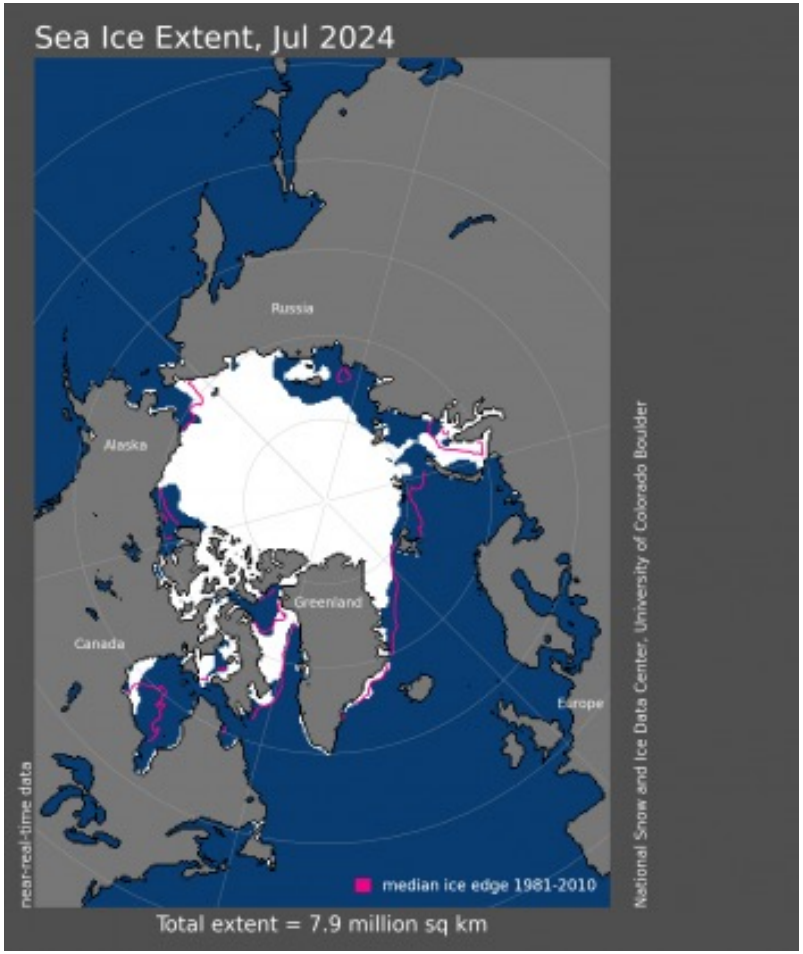
- H300-based PDO index highlights the slower variability and encapsulates an integrated view of temperature variability in the upper ocean.

SST-based 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 ERSSTv5 SST anomalies onto the 1st EOF pattern. H300-based Pacific Decadal Oscillation is defined as the projection of monthly mean H300 anomalies from NCEP GODAS onto their first EOF vector in the North Pacific. PDO indices are downloadable from https://www.cpc.ncep.noaa.gov/products/GODAS/ocean_briefing.shtml.

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

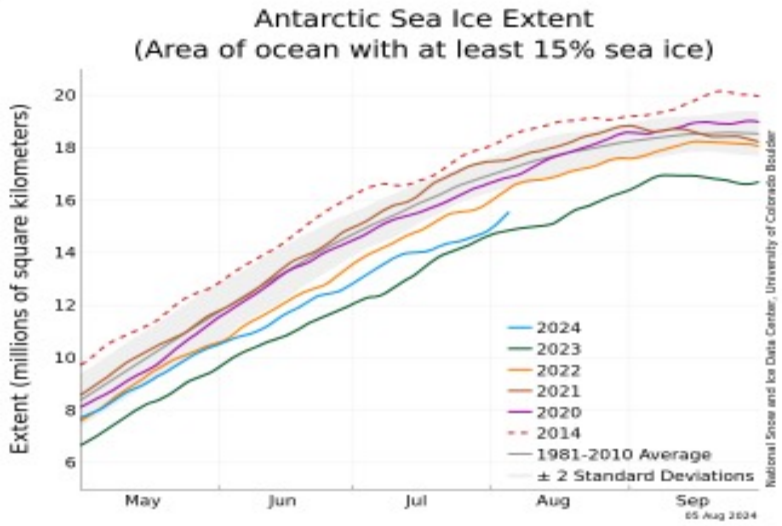


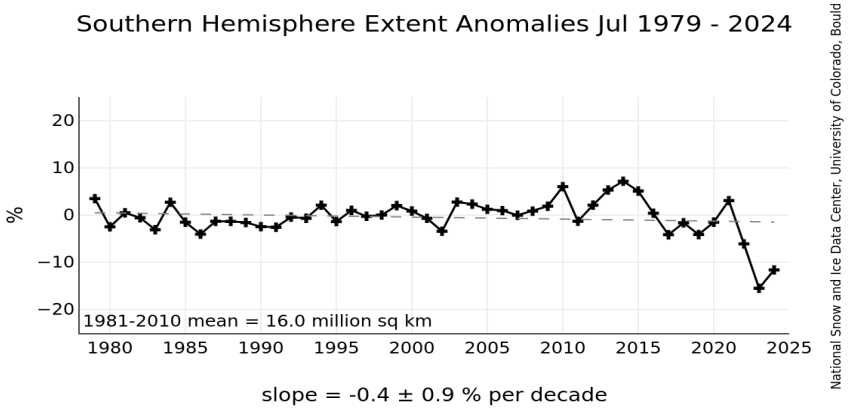


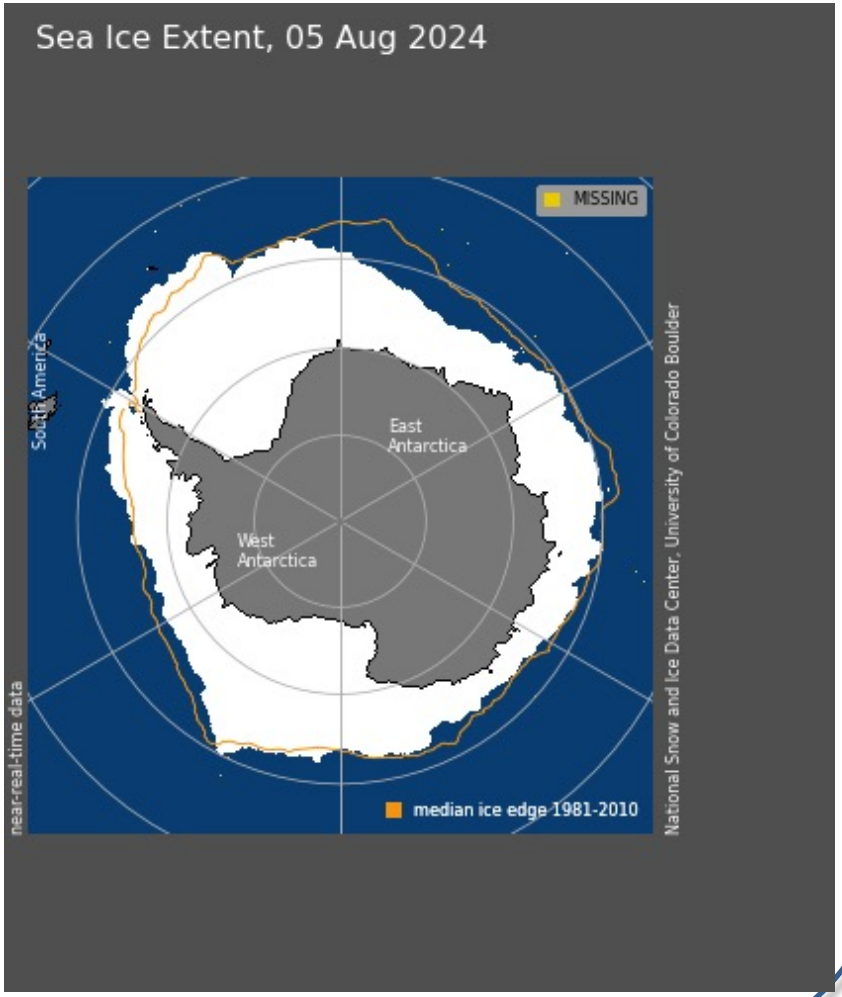


- Average Arctic sea ice extent during Jul 2024 was 7.9 million square kilometers, the sixth lowest Jul in the satellite record.

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

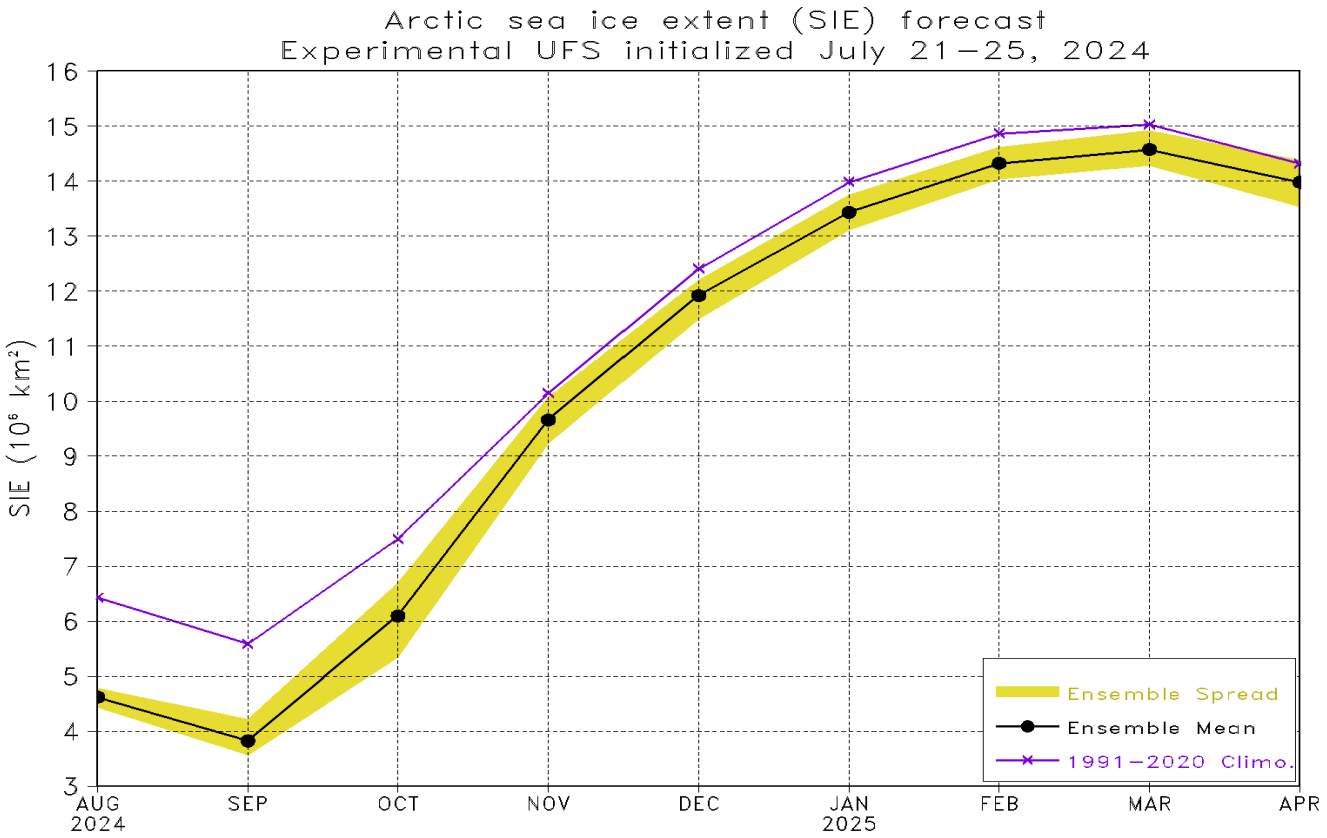






- Antarctic sea ice extent continues to track the second lowest ice extent in the satellite data record.

NCEP/CPC Arctic Sea Ice Extent (SIE) Forecast

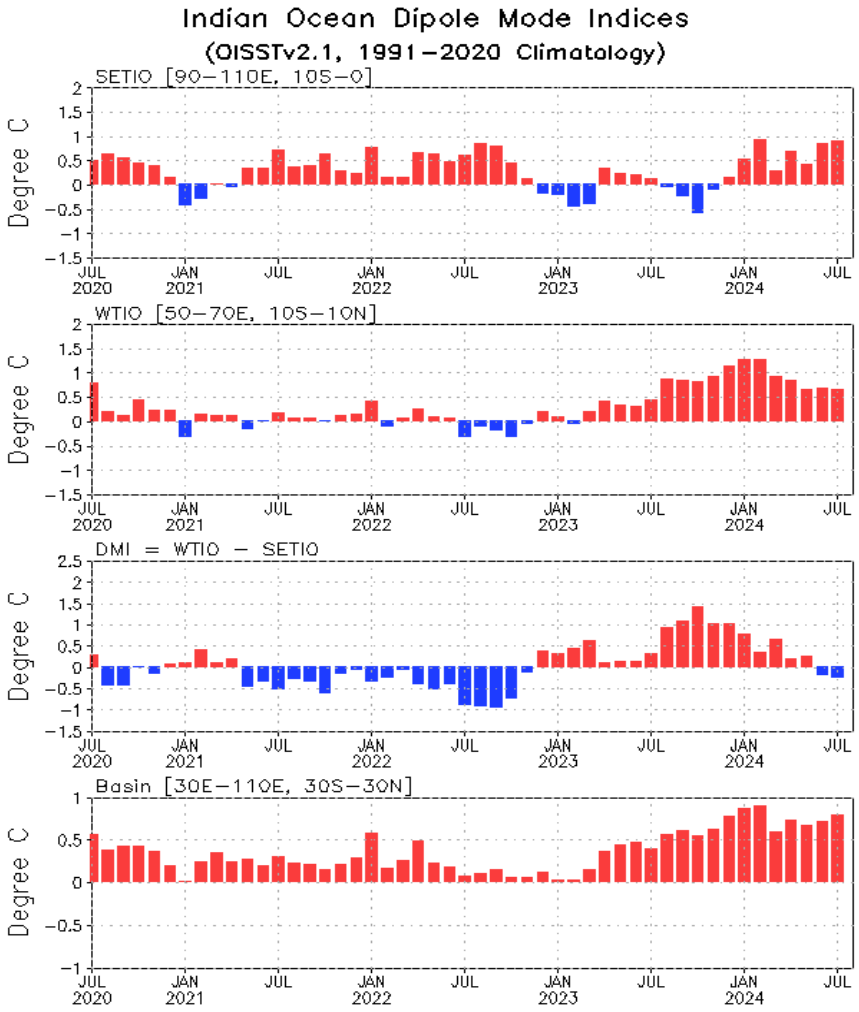


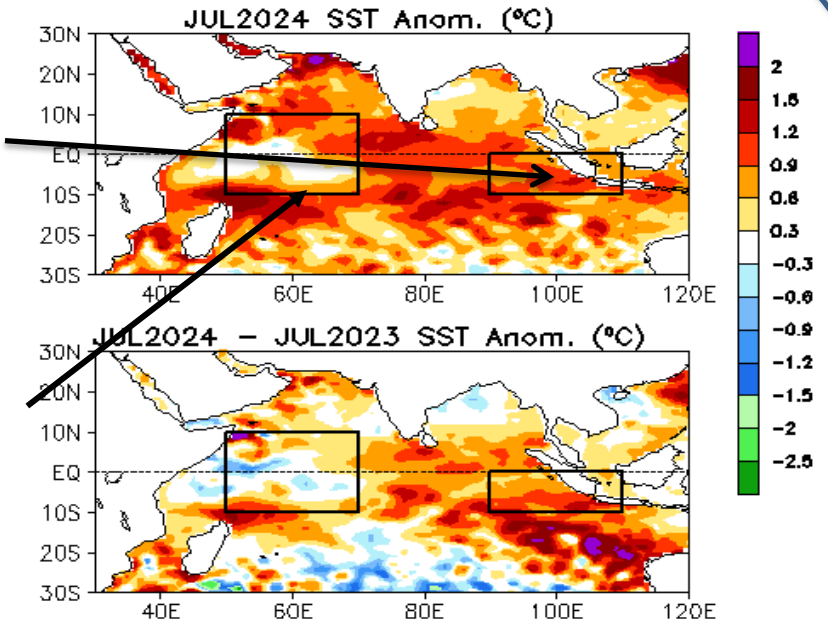
https://www.cpc.ncep.noaa.gov/products/people/jszhu/seaice_seasonal/index.html

- CPC forecasts call for a below normal sea ice extent minimum in the Arctic in Sep 2024.

Indian Ocean

Evolution of Indian Ocean SST Indices

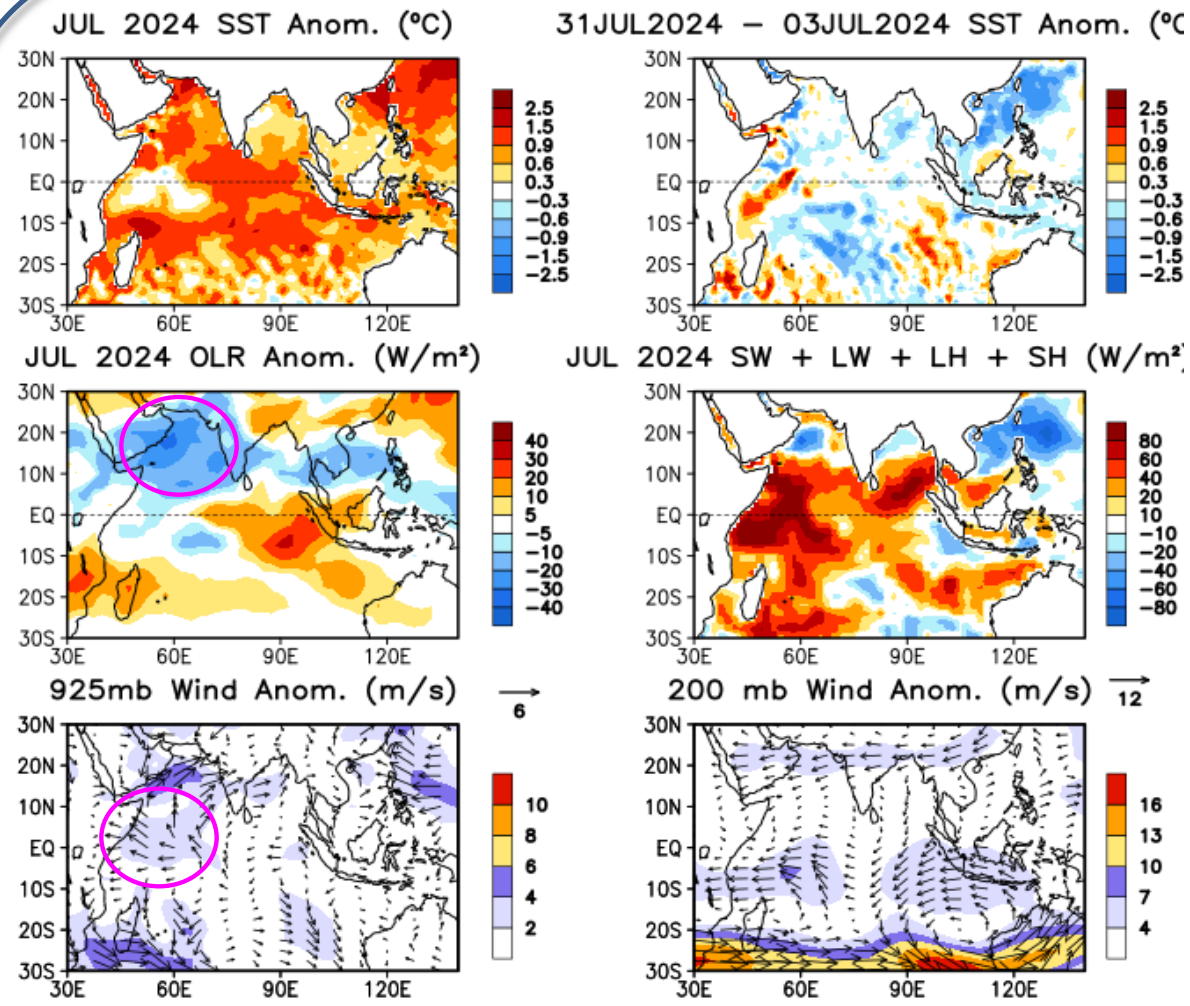




- Basin wide SST warming continued in the tropical Indian Ocean.
- Indian dipole mode was near neutral in Jul 2024.

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.

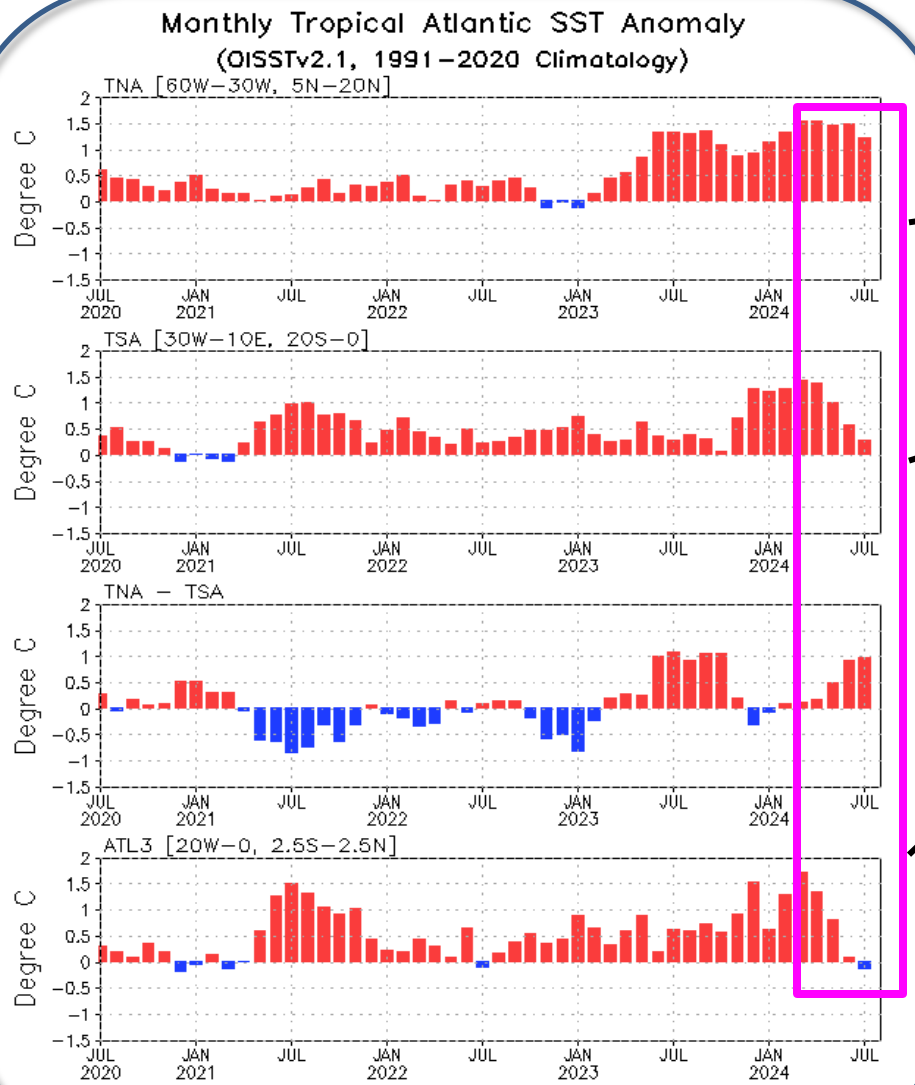


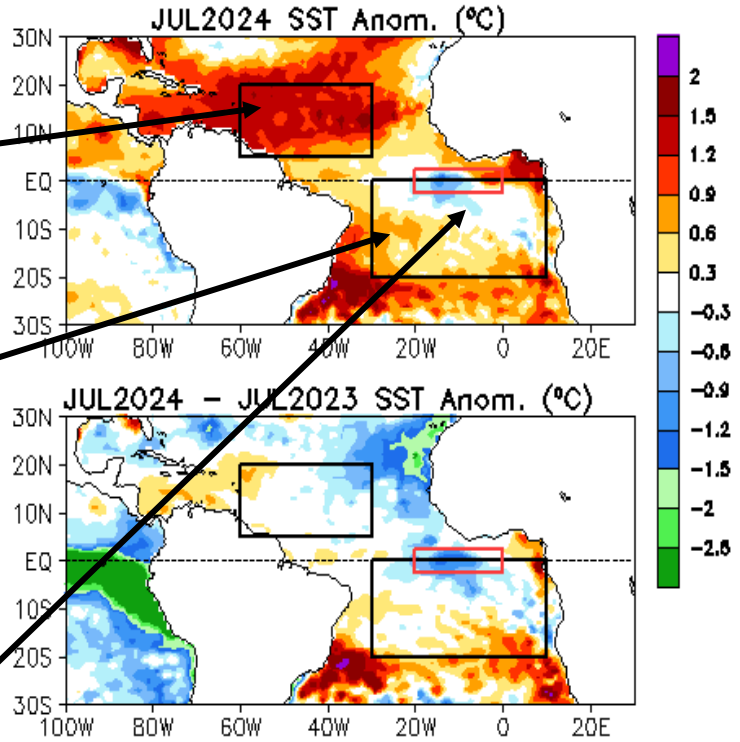
- Strong positive SSTA were present much of the tropical Indian Ocean.
- Enhanced convection was observed over Arabian Sea.
- Easterly wind anomaly prevailed over the eastern tropical Indian Ocean.

SSTAs (top-left), SSTA tendency (top-right), OLR anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 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.

Tropical and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

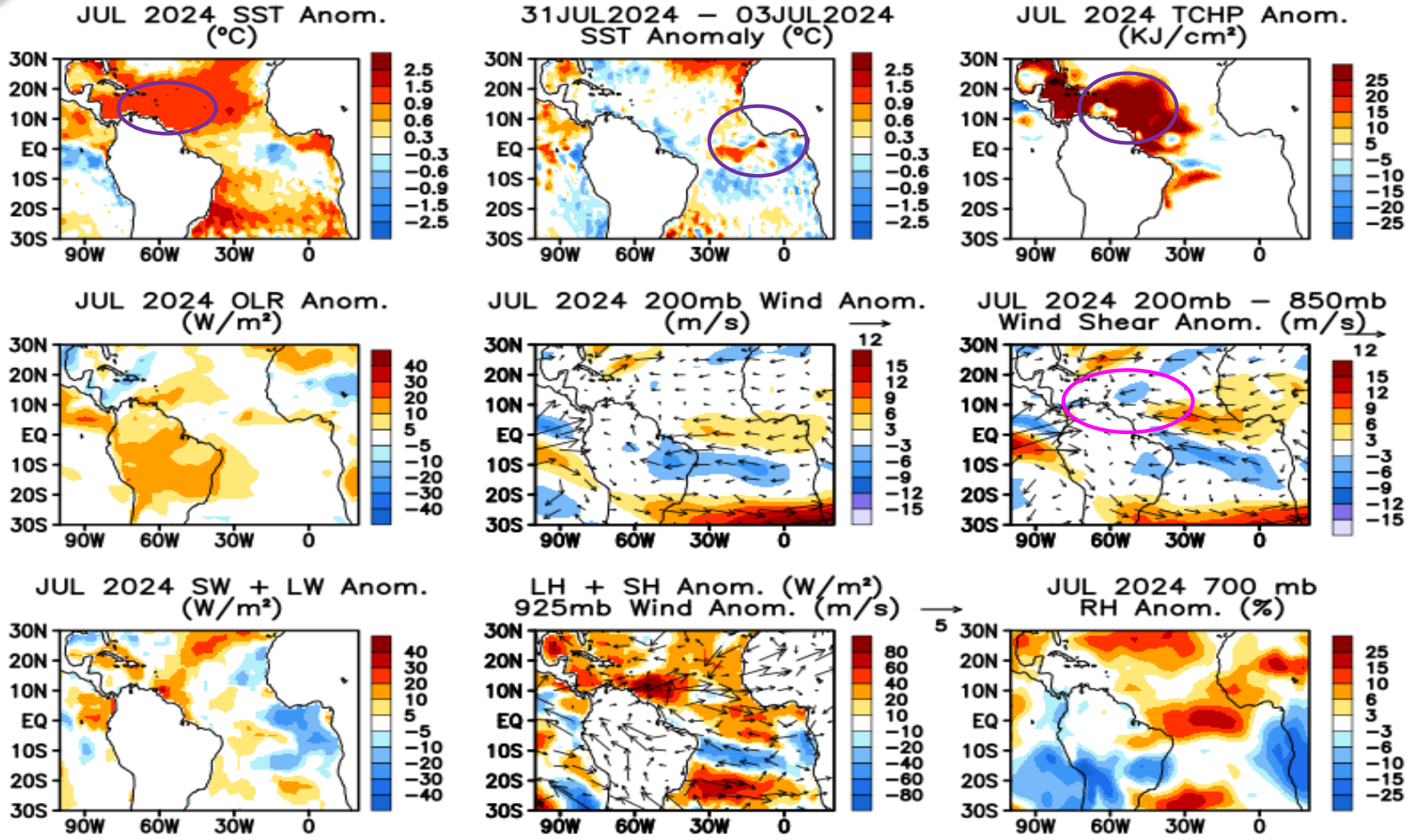




- Positive SSTA in the tropical south Atlantic weakened in Jul 2024, contributing to the enhanced Meridional mode index.
- ATL3 index was near average in Jul 2024.

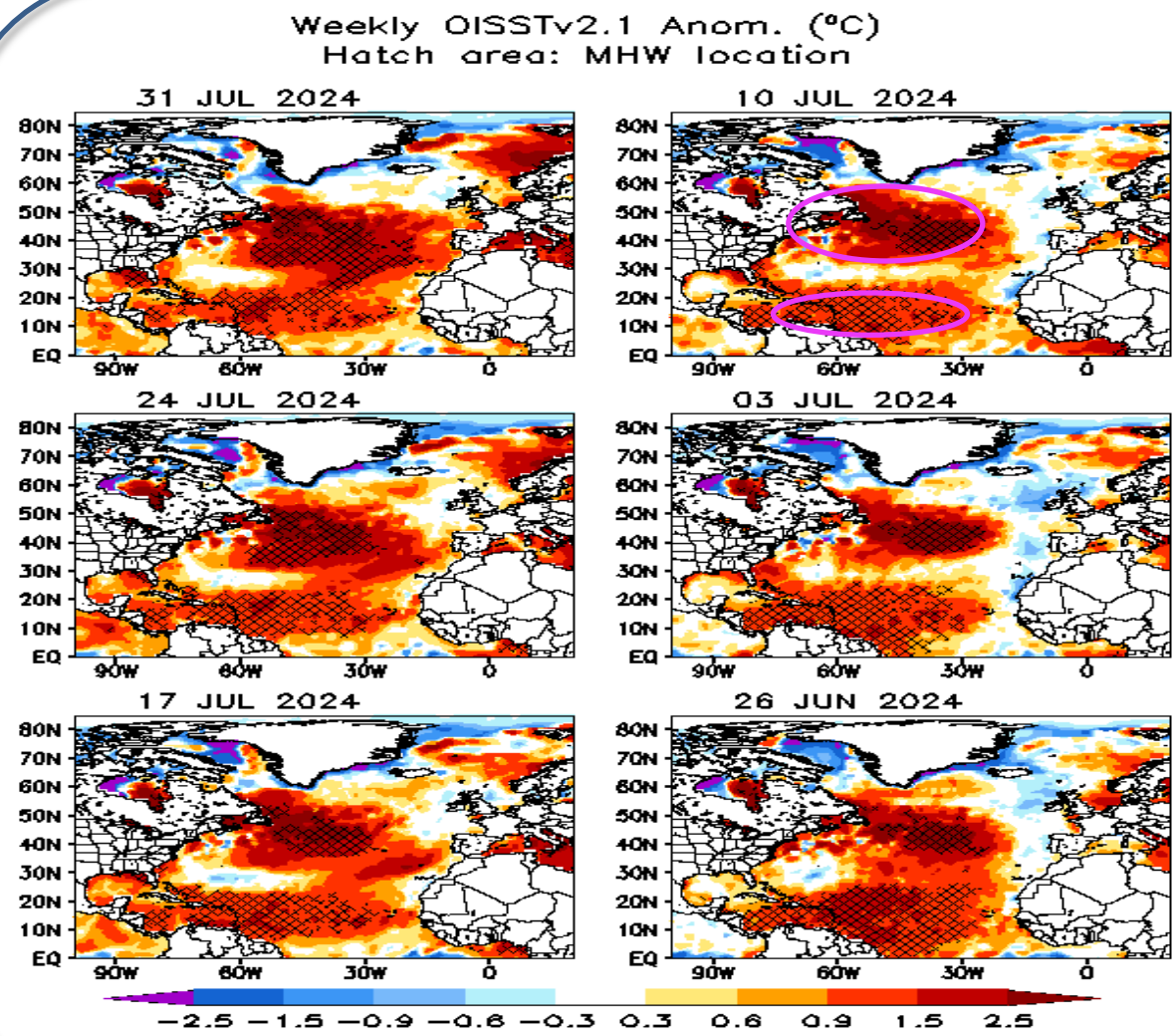
Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean SSTAs (°C) for the TNA [60°W-30°W, 5ºN-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between TNA and TSA. Data are derived from the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

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



Top Row: SSTA (left; OI SST), SSTA tendency (central), Tropical Cyclone Heat Potential anomaly (right; GODAS).
Middle row: OLR (left; NOAA 18 AVHRR IR), UV200 (central; NCEP CDAS), UV200-UV850 (right; NCEP CDAS) anomalies.
Bottom row: SW+LW (left), LH+SH (central), Relative humidity at 700 hPa (right; NCEP CDAS) anomalies.
Anomalies are departures from the 1991-2020 base period means.

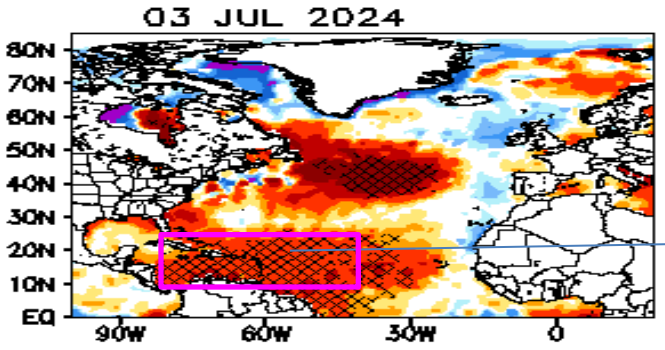
Weekly SST anomaly and MHWs in the North Atlantic



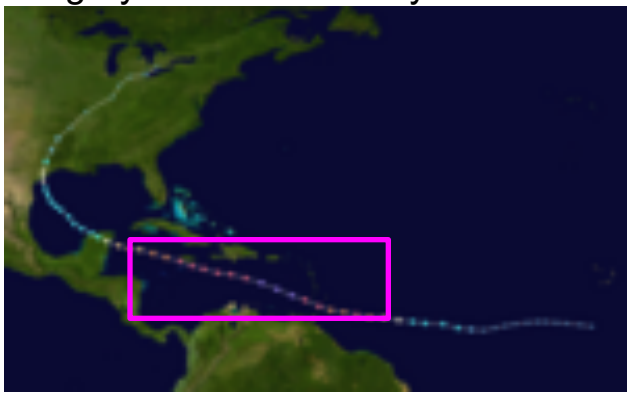
- Strong MHWs persisted in the northern tropical Atlantic.
- MHW area in the central extratropical Atlantic expanded during the last six weeks.

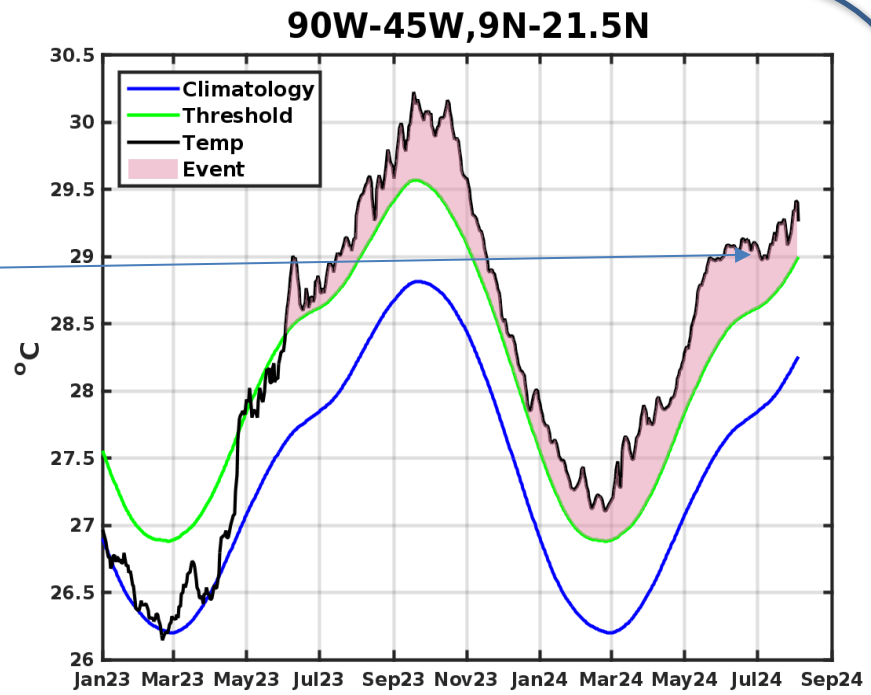
(Left panel) Weekly SST anomaly (shaded) and locations experience Marine heat waves (hatched) by the date labelled in the plot. (right panel) SST evolution at a specific location. Green line and blue line denote the seasonal 90th percentile and daily climatology, respectively. Shaded area denotes the periods experiencing MHW. MHW is defined as a discrete prolonged warmer than 90th percentile of daily SST for at least 14 days. Data is derived from NCEI OISSTv2.1 and the climatology reference period is 1991-2020

Prolonged MHWs in the northern tropical Atlantic



Category 5 Hurricane Beryl Jun 28-Jul 9



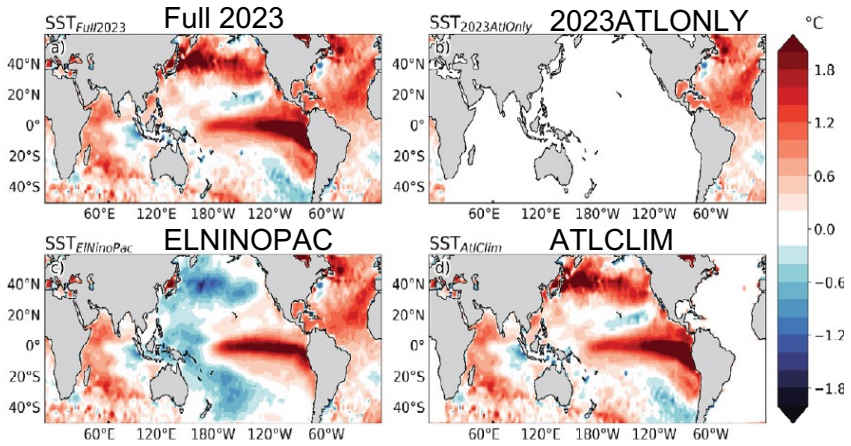


- MHWs in the northern tropical Atlantic has persisted since May 2023.
- Extraordinary warming in the western hurricane main development region helped to intensify Hurricane Beryl development.

(Left panel) Weekly SST anomaly (shaded) and locations experience Marine heat waves (hatched) by the date labelled in the plot. (right panel) SST evolution at a specific location. Green line and blue line denote the seasonal 90th percentile and daily climatology, respectively. Shaded area denotes the periods experiencing MHW. MHW is defined as a discrete prolonged warmer than 90th percentile of daily SST for at least 14 days. Data is derived from NCEI OISSTv2.1 and the climatology reference period is 1991-2020

Impact of Extremely Warm Atlantic on 2023 Hurricane Activity

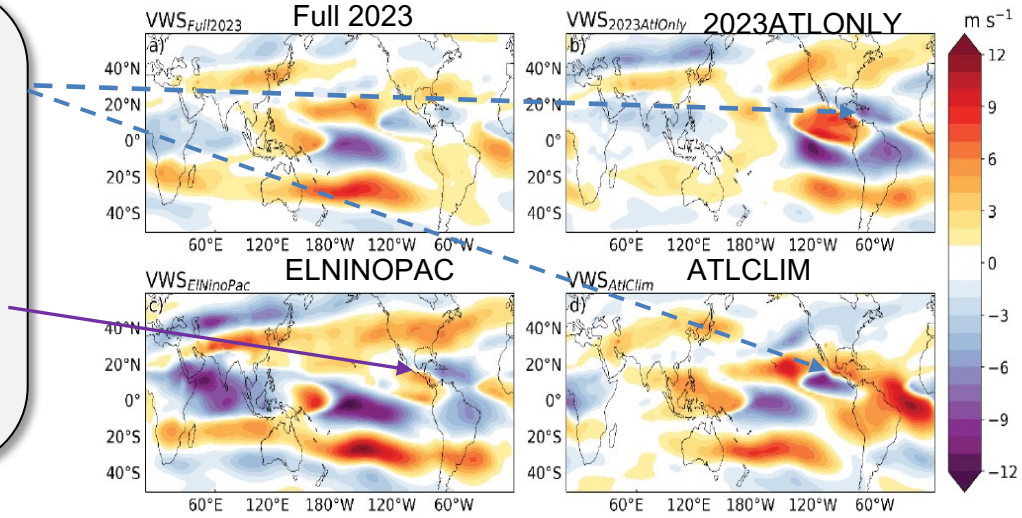
SST Configurations



- **Full2023**: 2023 Jan-Nov SST forcing
- **2023ATLONLY**: 2023 Atlantic SSTS only and climatology elsewhere
- **ELNINOPAC**: 2023 SSTs with Pacific SSTs swapped for El Nino composite (1982,1987,9997,20022125)
- **ATLCLIM**: Atlantic SSTs set to climatology with 2023 SSTs elsewhere

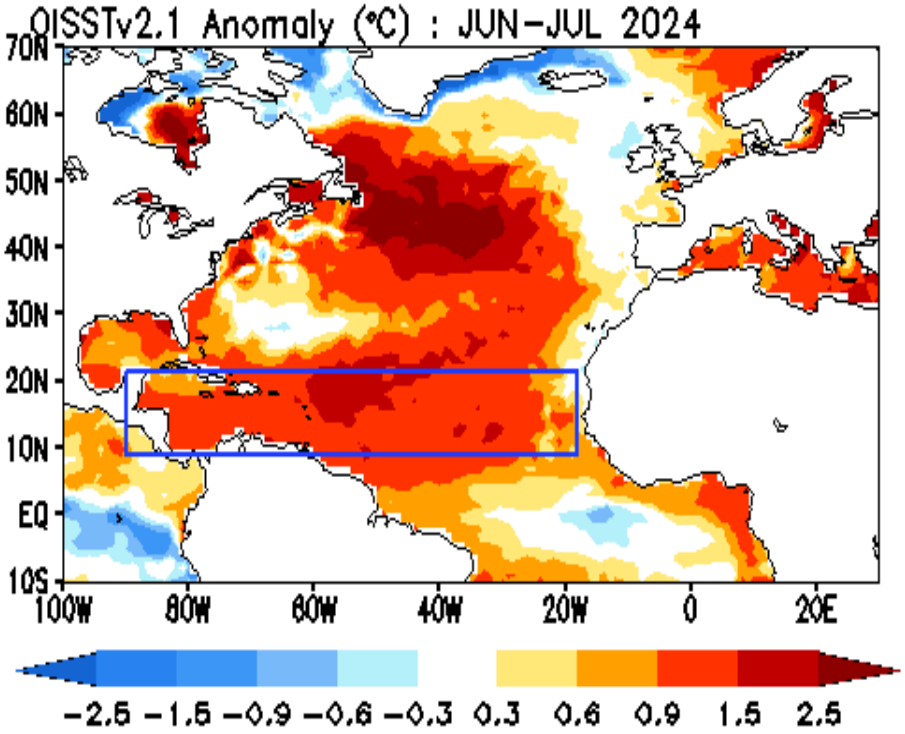
- Extremely warm Atlantic was the primary driver of the reduced vertical wind shear over the hurricane main development region.
- The unique spatial pattern of 2023 El Niño contributes to increased levels of vertical wind shear than historical moderate/strong El Niño composite.

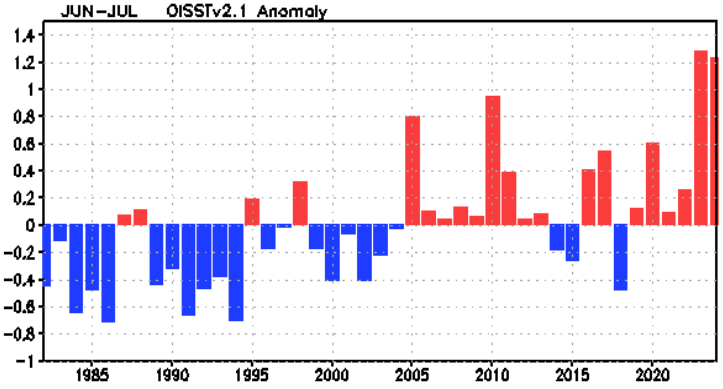
ASO Vertical Wind Shear Anomalies



Klotzbach et al, 2024: The 2023 Atlantic Hurricane Season: An Above-Normal Season Despite Strong El Niño Conditions Bull. Amer. Meteor. Soc. https://doi.org/10.1175/BAMS-D-23-0305.1

Evolution of SST anomaly in the North Atlantic





- SST warming in the hurricane main development region ranked the 2nd warmest Jun-Jul since 1982, nearly matching the record high set in 2023.

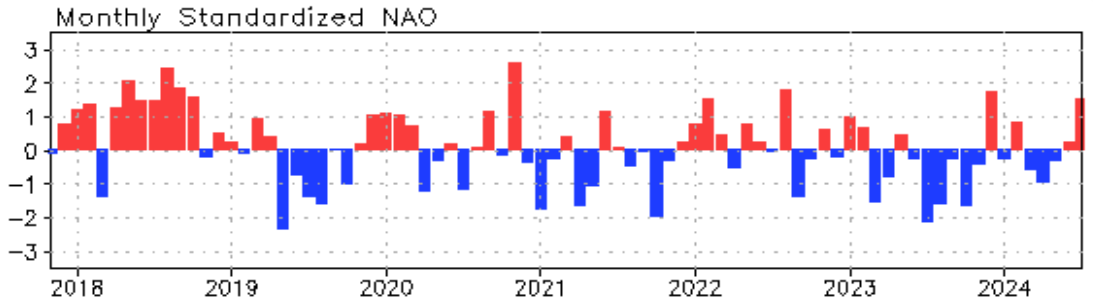
2024 Atlantic Hurricane Season Activities

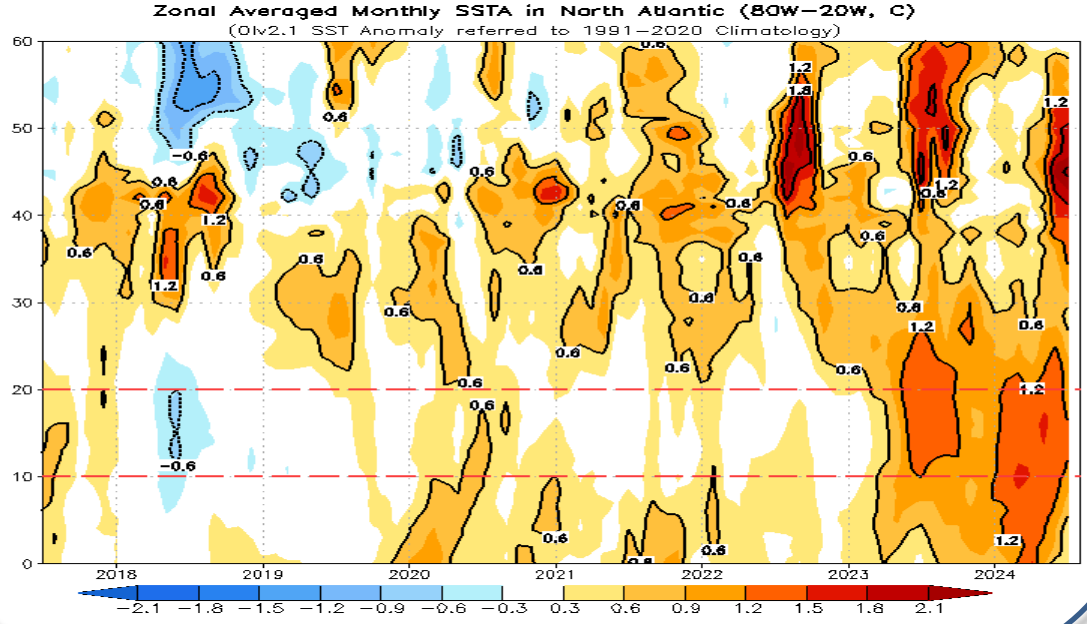
https://en.wikipedia.org/wiki/2024_Atlantic_hurricane_season

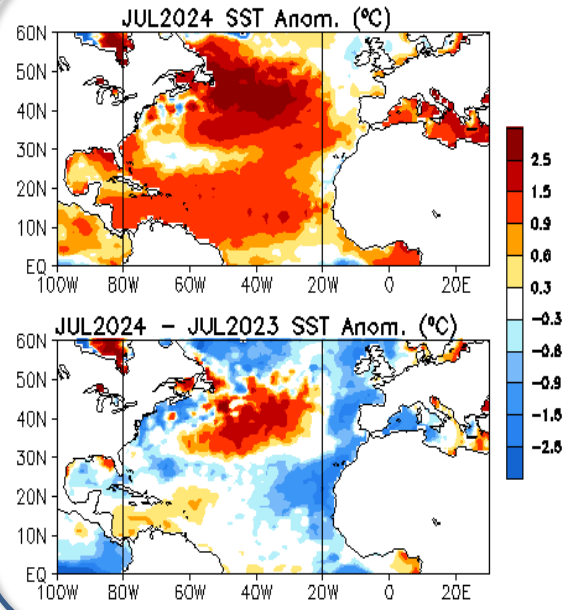
- By Aug 6 2024, four tropical storms formed, with one developing into major hurricane and one hurricane.

Atlantic	Observations (By Aug 6)	Outlook (May 23) 85% above-normal	(1991-2020)
Total storms	4	17-25	14
Hurricanes	2	8-13	7
Major hurricanes	1	4-7	3

NAO and SST Anomaly in North Atlantic





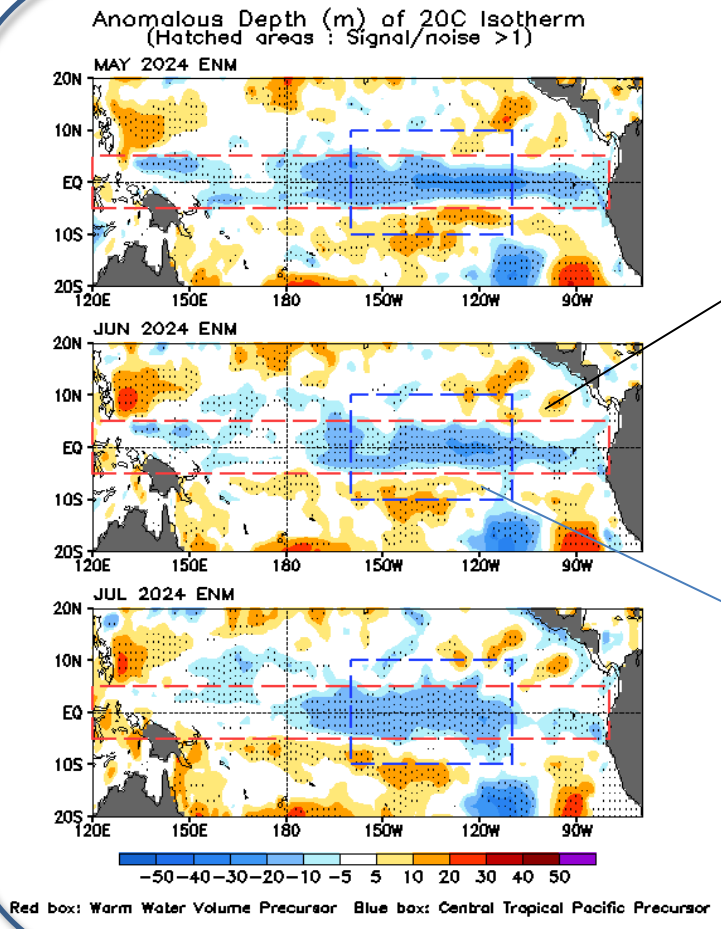


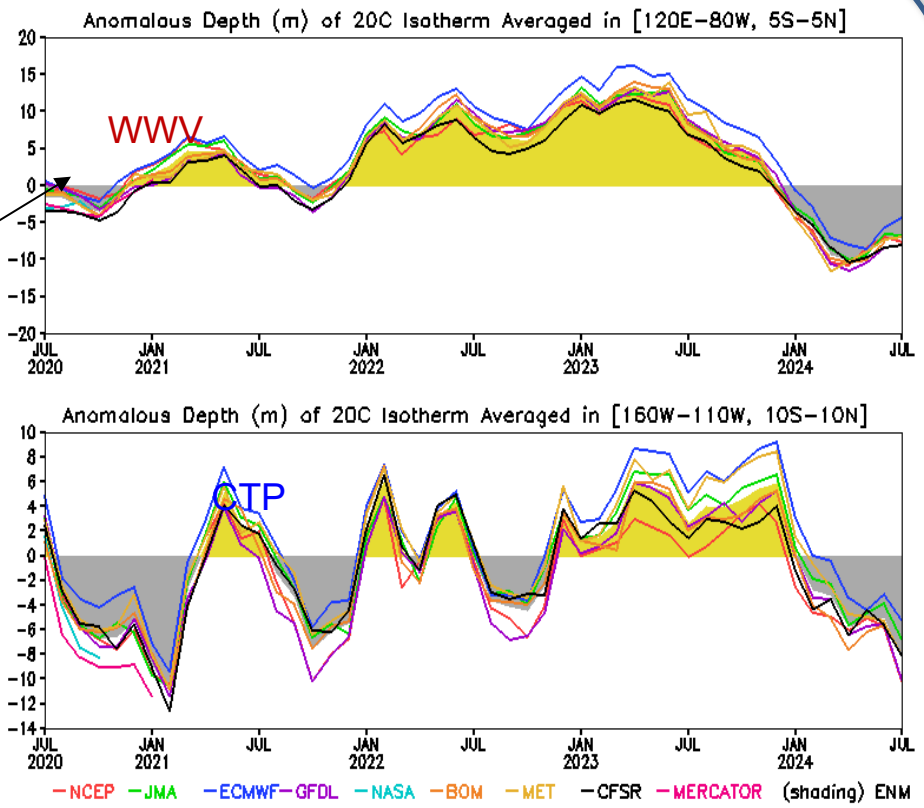
- Positive NAO increased substantially in Jul 2024, with NAO=1.5.
- Strong warming continued in the eastern North Atlantic Ocean.
- The prolonged positive SSTAs in the middle latitudes were evident, due to dominance of the positive phase of NAO during the last 5-6 years.

Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20°N-90°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

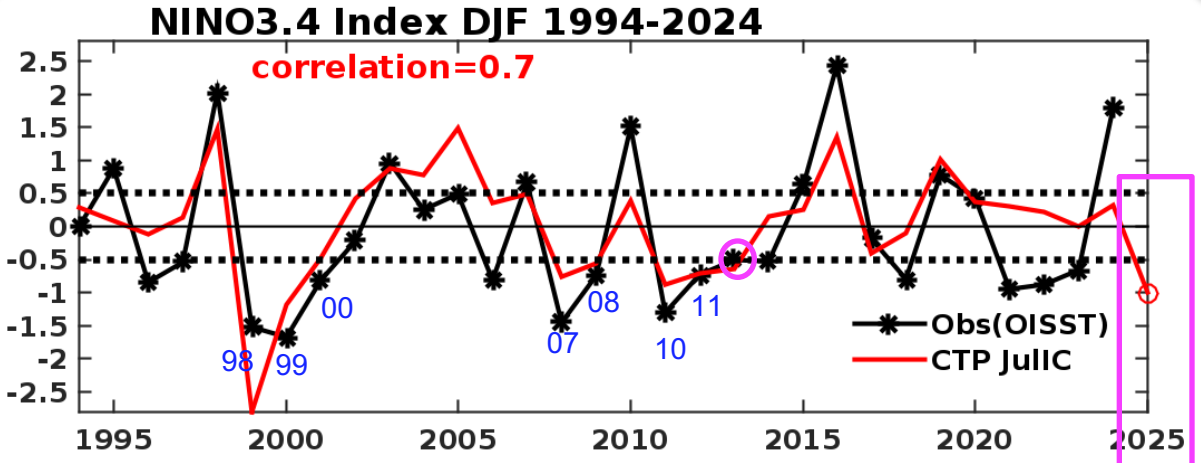
Oceanic ENSO Precursors: WWV & CTP

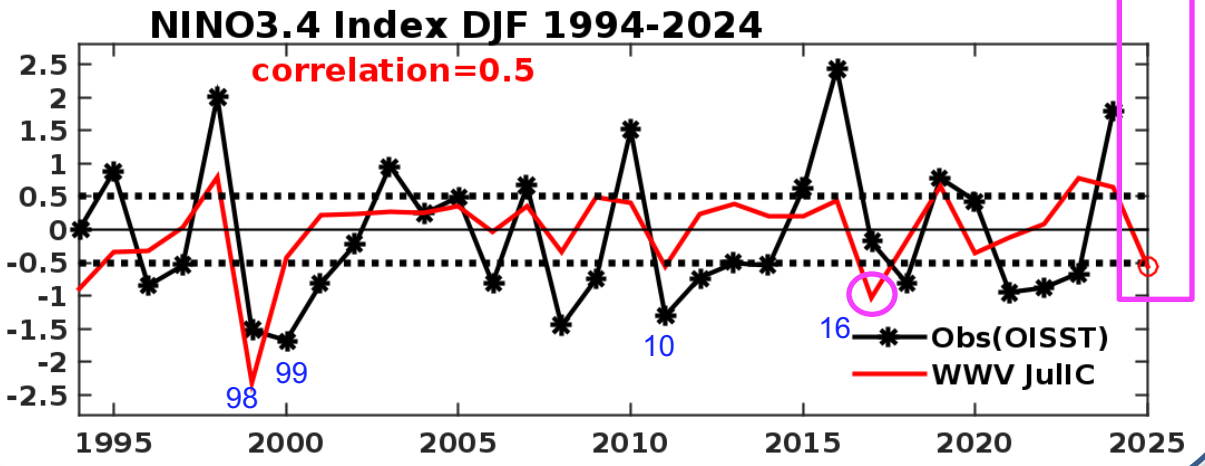




Warm water volume (WWV) is defined as an average of D20 anomaly across the equatorial Pacific (120° E – 80° W, 5° S-5° N) (Meinen and McPhaden 2000). Central tropical Pacific (CTP) index is calculated as the averaged D20 anomaly in the central tropical Pacific (160° W-110° W, 10° S-10° N) (Wen et al. 2014). The monthly D20 data is obtained from the Real-time Ocean Reanalysis Intercomparison Project(https://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html).

DJF Nino34 predictions based on ENSO precursors

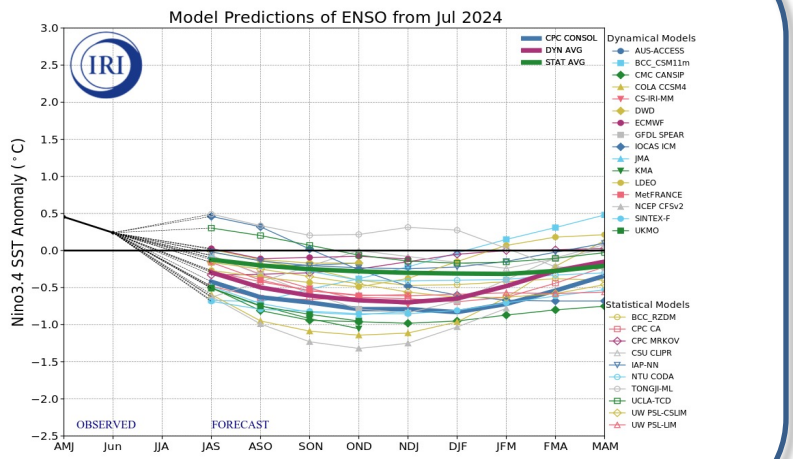




- Both WWV and CTP in Jul predict La Niña condition in DJF 2025.

Prediction models are constructed using leave-one-year-out cross validation over the full period by iteratively recomputing the coefficients with the target prediction year removed. For details Wen et al. (2021) DOI: https://doi.org/10.1175/JCLI-D-20-0648.1

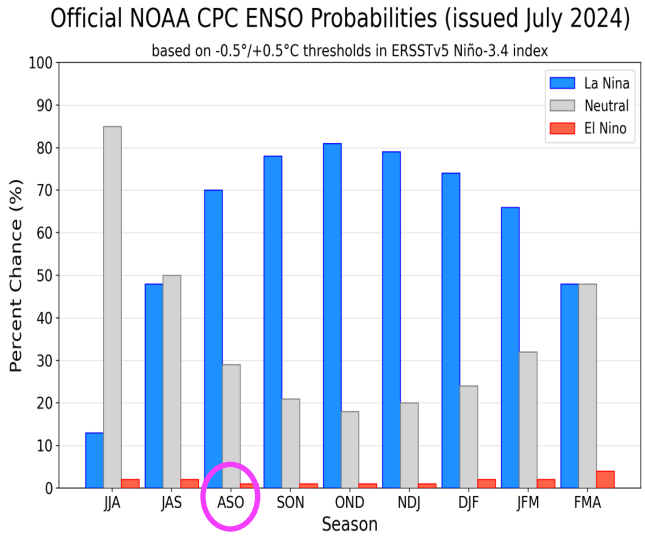
IRI/CPC Niño3.4 Forecast

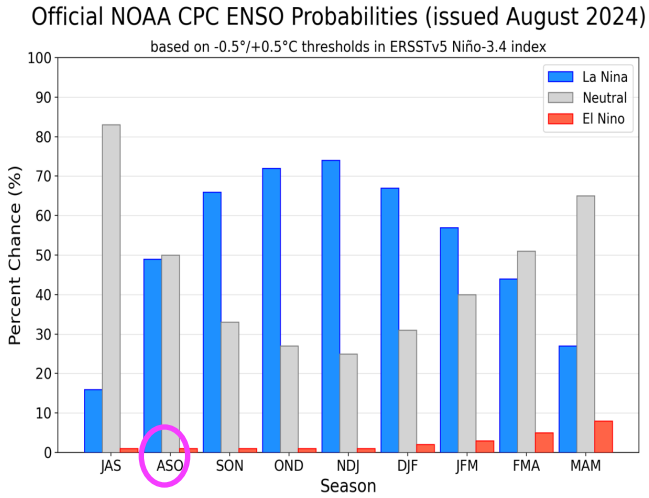


- Most of models favor ENSO neutral condition through Aug-Oct and La Niña since Sep-Nov 2024.

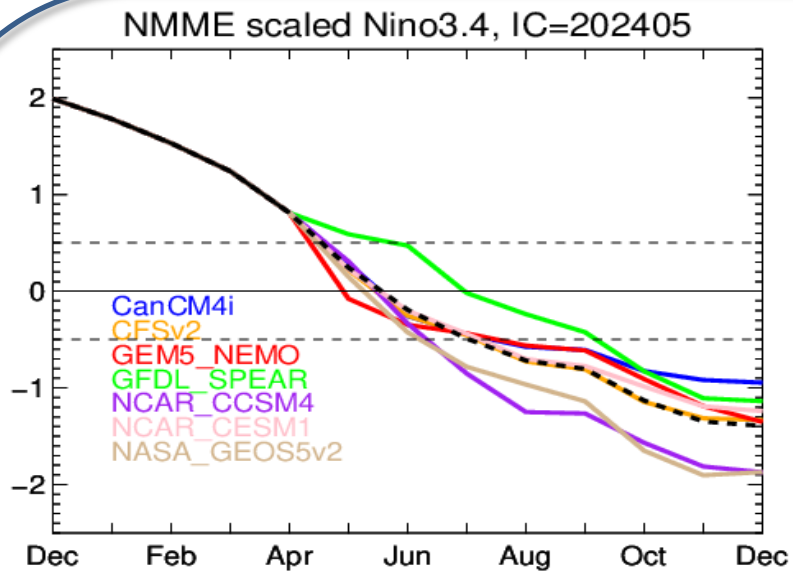
- On 9 Aug 2024, CPC maintained a "***La Niña Watch***".

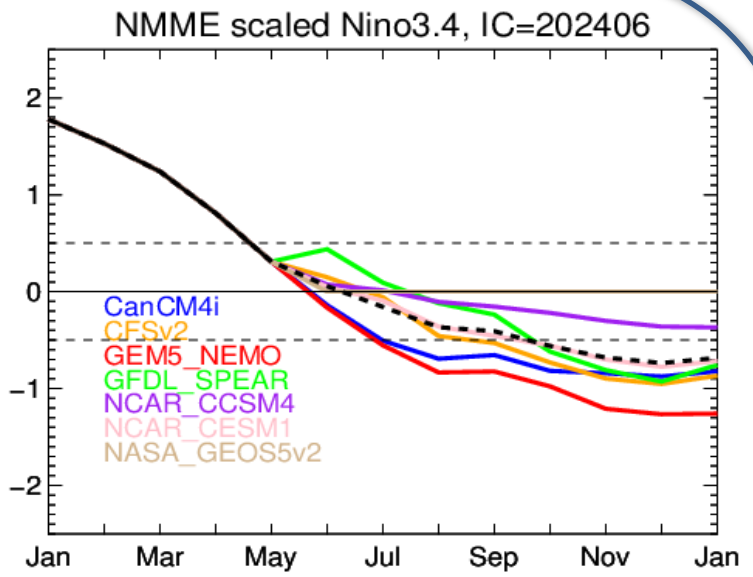
- Synopsis: "***ENSO-neutral is expected to continue for the next several months, with La Niña favored to emerge during September-November (66% chance) and persist into the Northern Hemisphere winter 2024-25 (74% chance during November-January)*** "

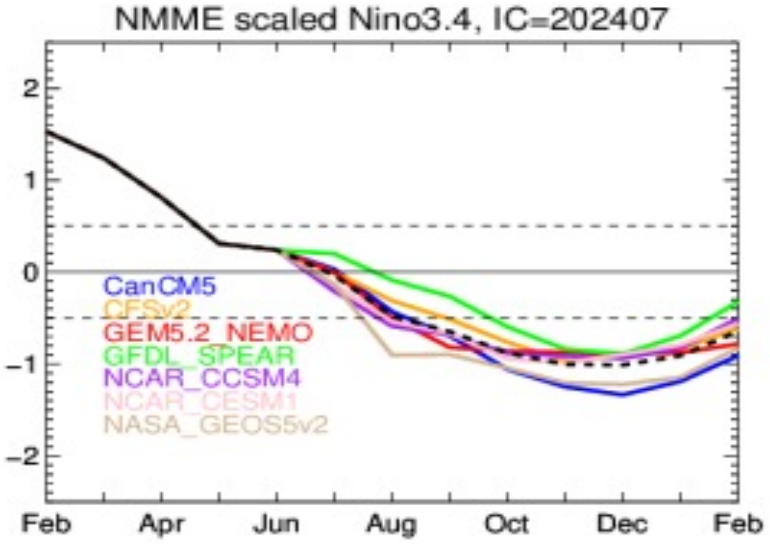


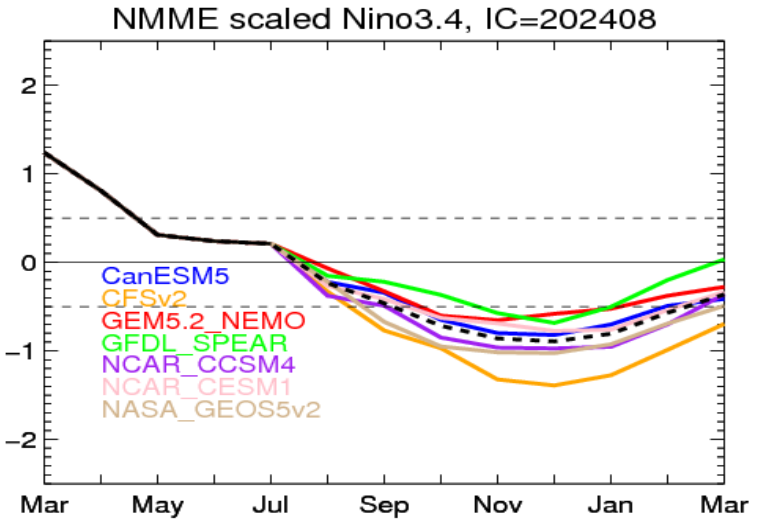


NMME forecasts from different initial conditions



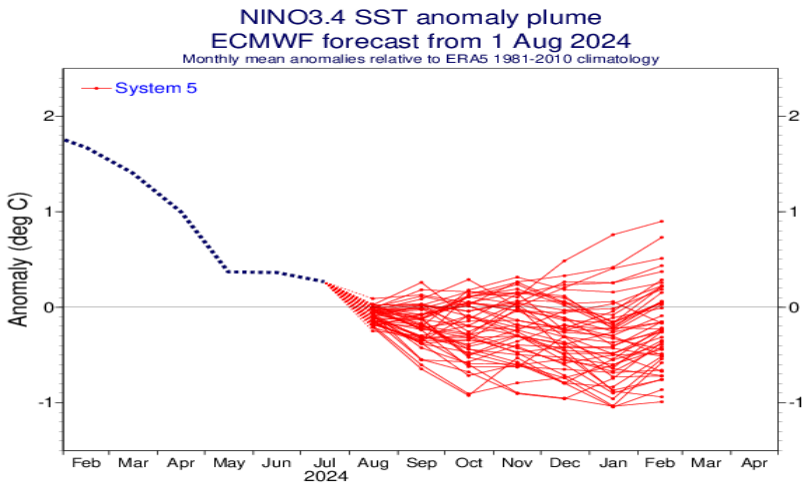




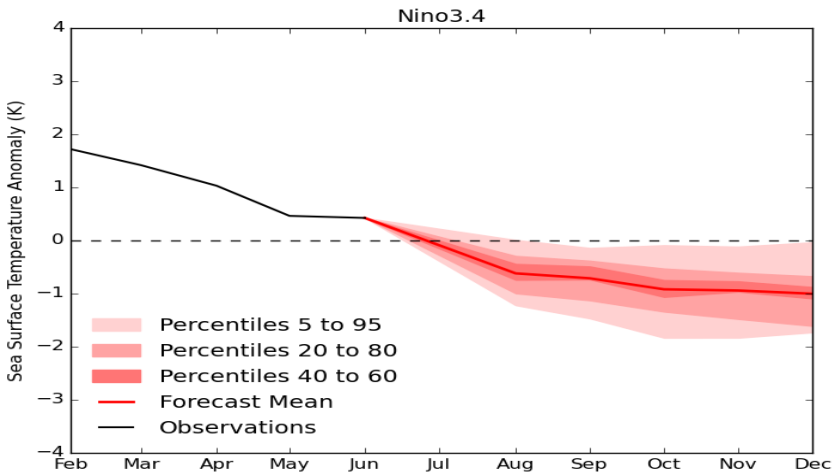


Individual Model Forecasts: El Niño transitions to neutral or La Niña in Summer-Autumn 2024

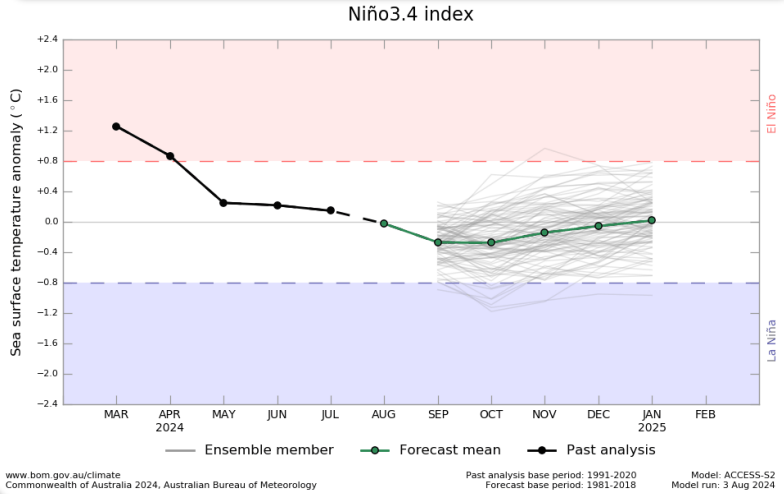
EC: Niño3.4, IC= 1 Aug 2024



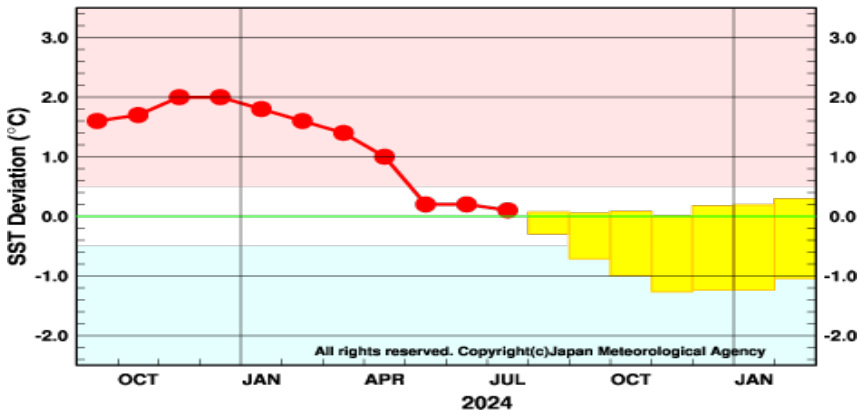
UKMO: Niño3.4, Updated 11 Jul 2024



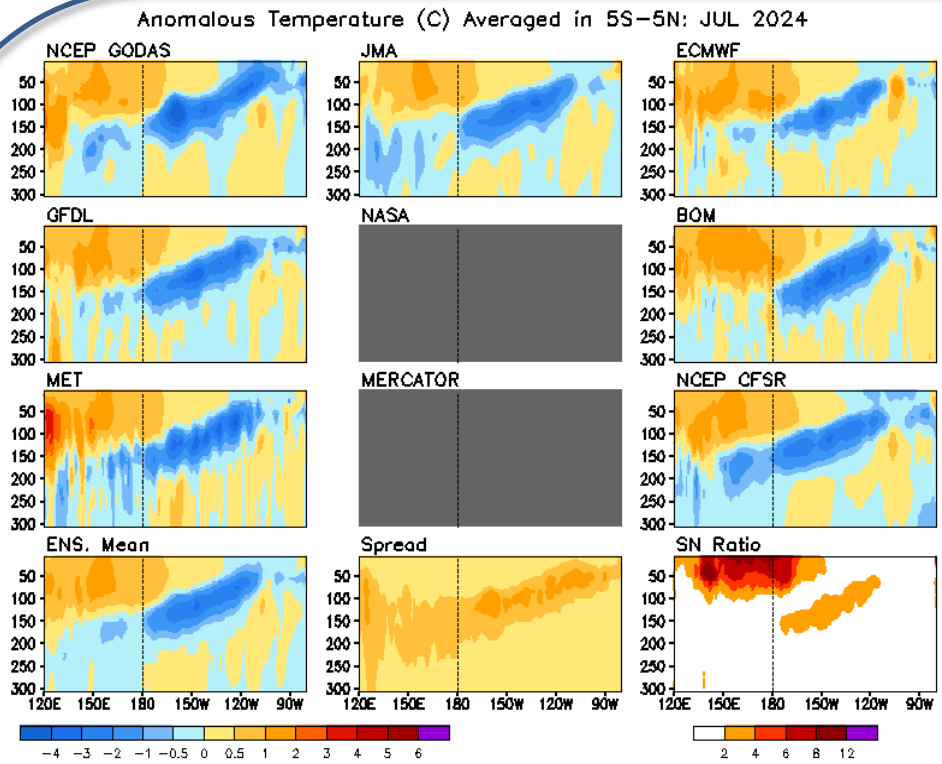
BOM: Niño3.4, Updated 3 Aug 2024



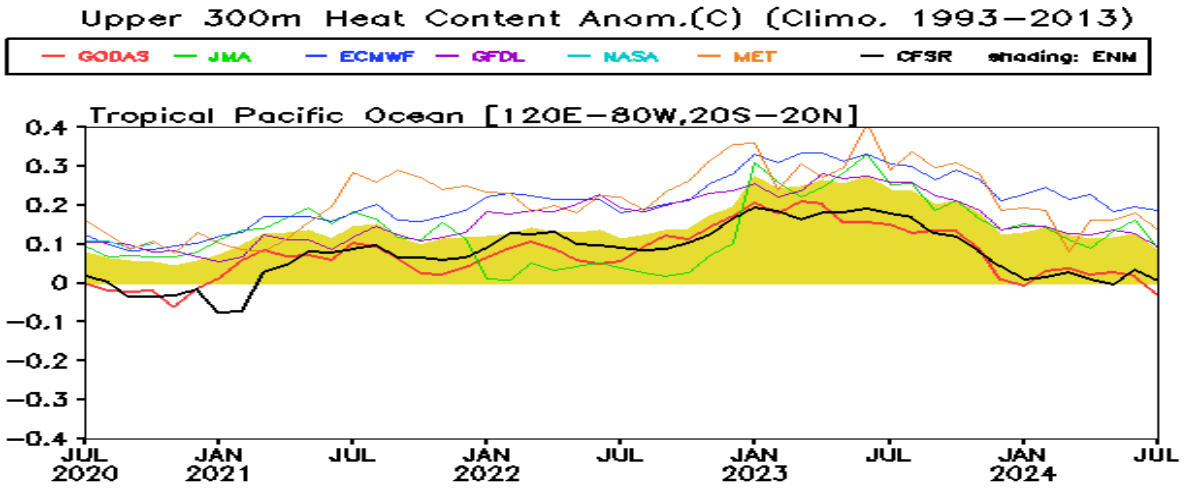
JMA: Niño3.4, Updated 9 Aug 2024



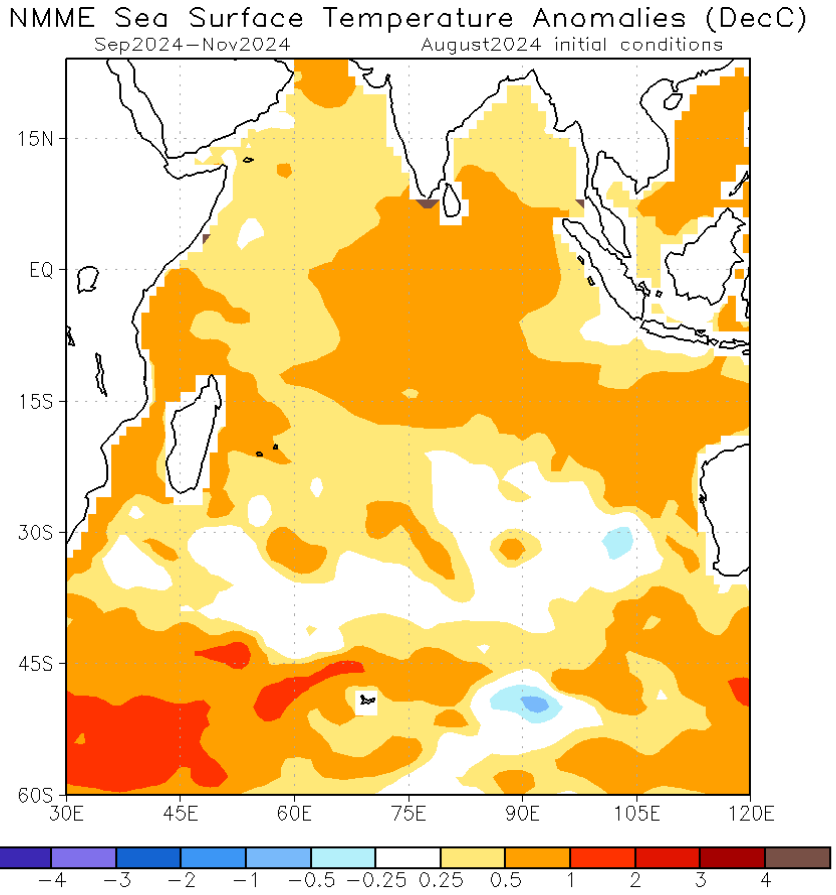
Potential Impact of ocean initial conditions on ENSO forecasts

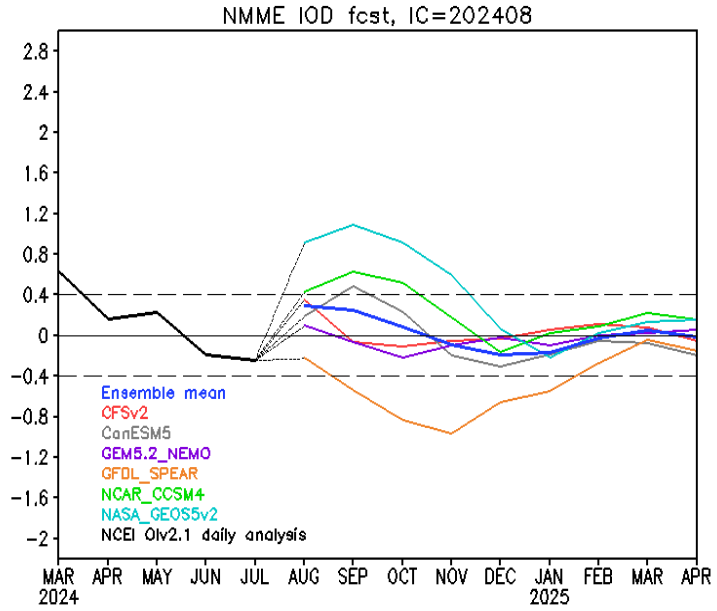


- Compared with other ocean reanalysis, CFSR has colder subsurface temperature near the thermocline in the western Pacific and near surface in the eastern Pacific.
- Both ECMWF and GFDL have greater H300 anomaly in the tropical Pacific during the last four years, which is consistent with difference in ENSO forecasts.



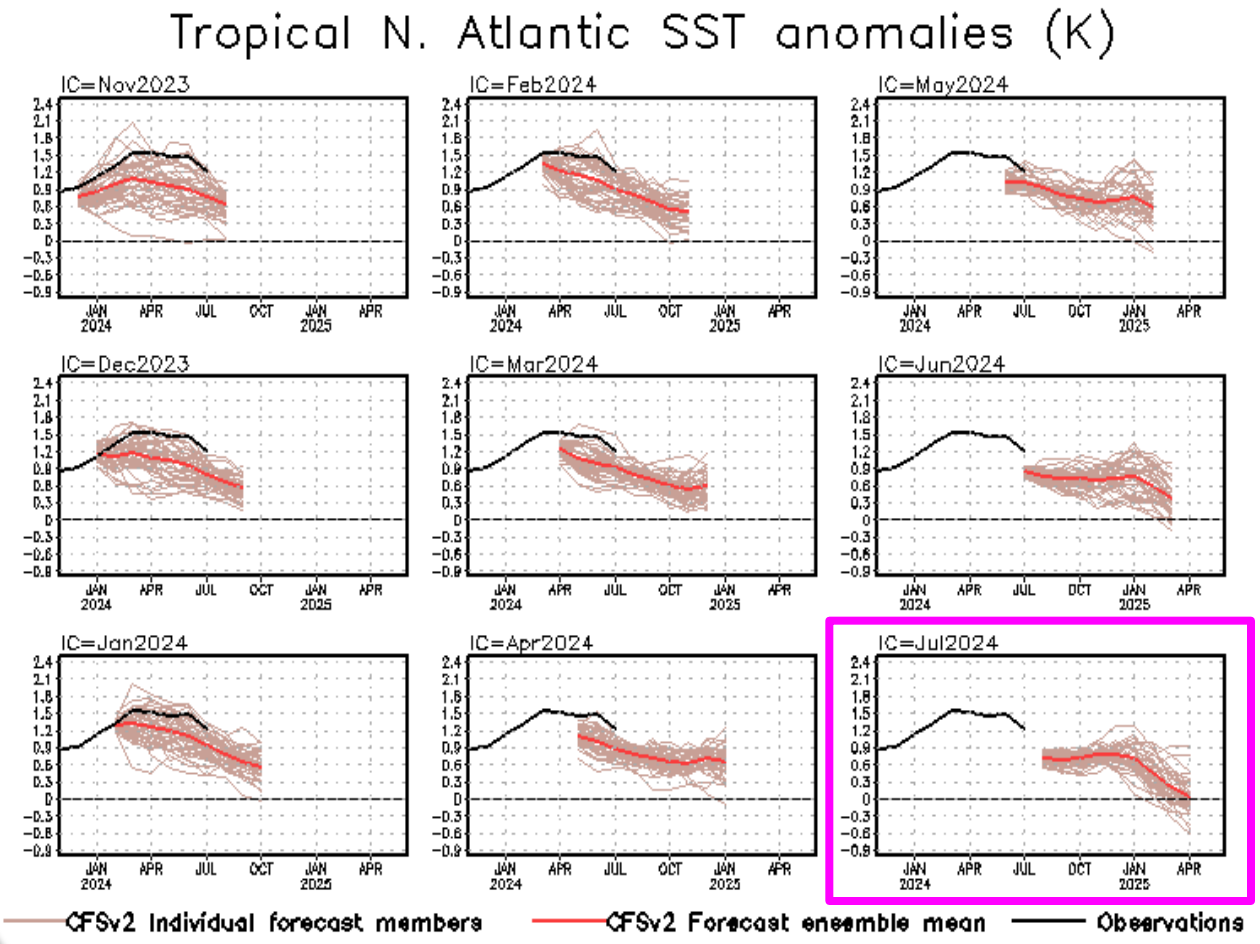
NMME Forecasts in the Indian Ocean





- NMME forecasts show a large spread of IOD condition during the coming Fall 2024.

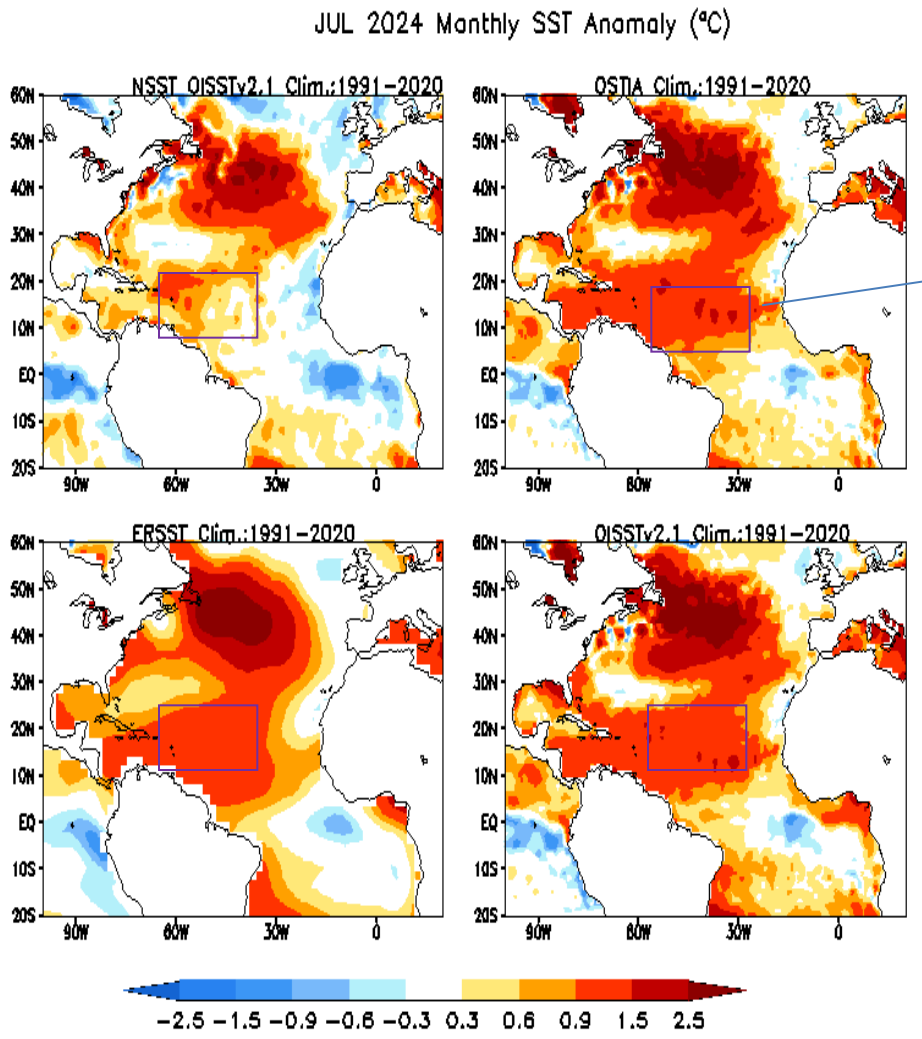
CFS Tropical North Atlantic (TNA) SST Predictions from Different Initial Months

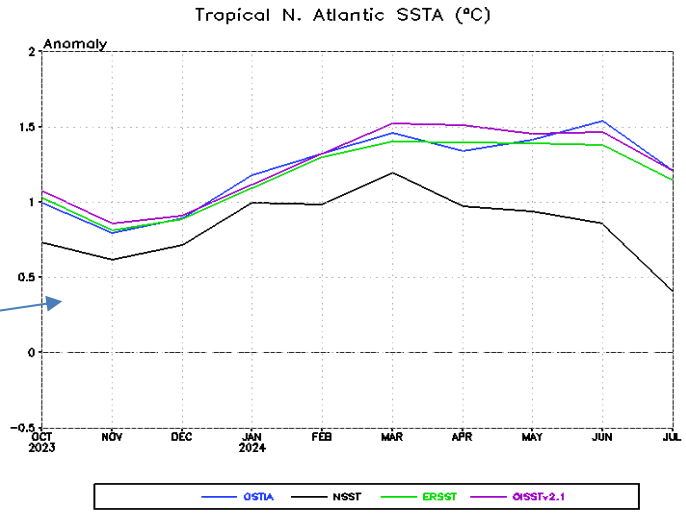


- Latest CFSv2 predictions call for above-normal SST in the tropical North Atlantic.
- CFSv2 has large cold bias at 0-month lead since Feb 2024.

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].

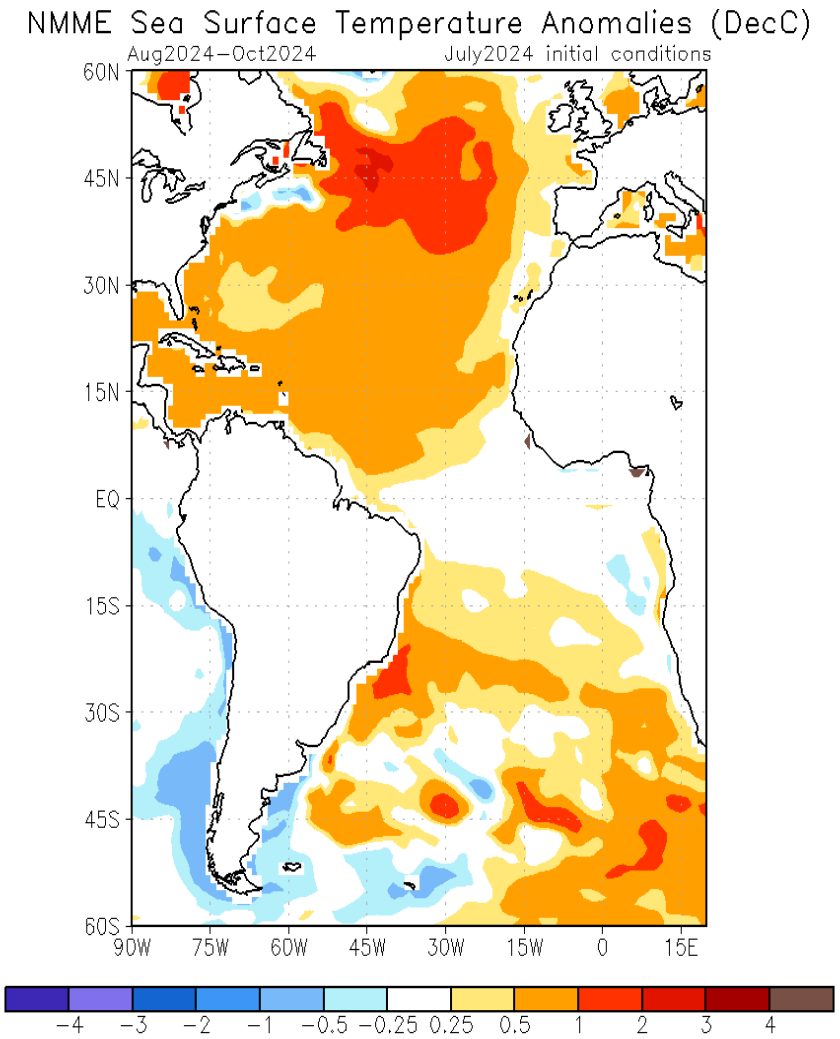
Monthly SST Anomaly in the Atlantic Ocean

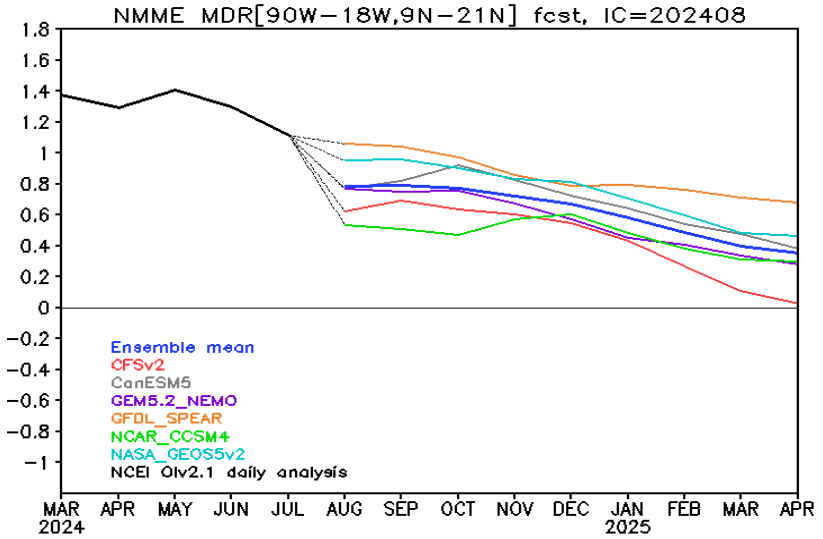


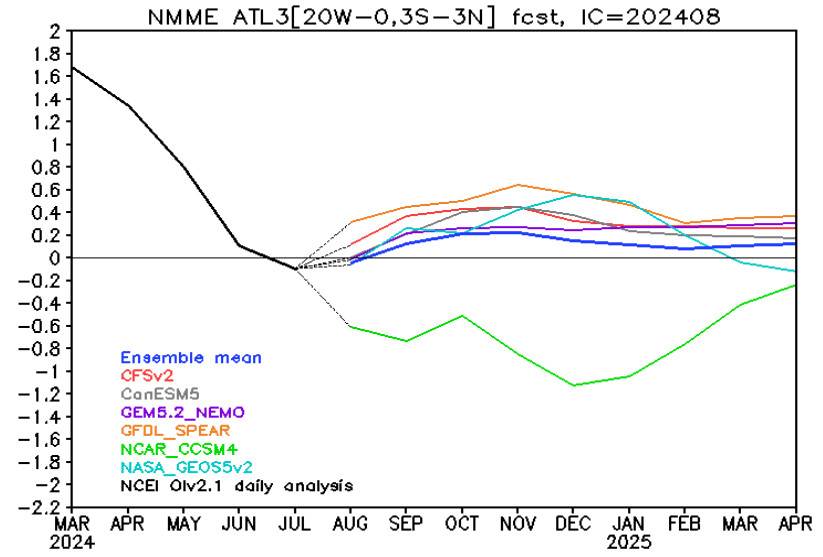


- NSST provide SST nudging source for CFSR.
- NSST was cooler than other SST analysis in most of tropical Atlantic Ocean.
- NSST anomaly in the northern tropical Atlantic Ocean region was colder than OISST v2.1 anomaly by 0.8C in Jul 2024.
- NSST cold bias at least partially contributed to cold bias in CFSv2 short-lead forecasts.

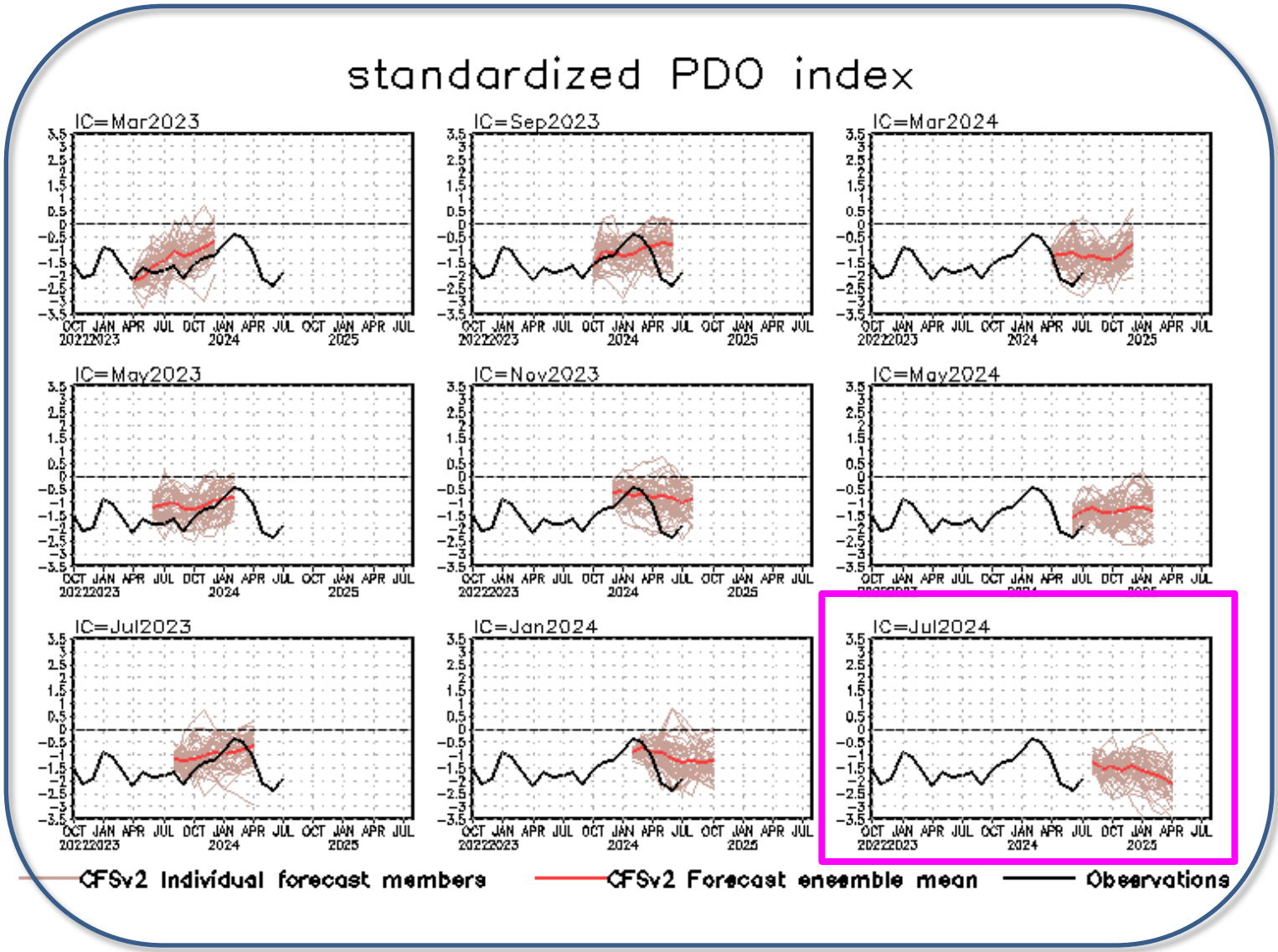
NMME Forecasts in the Atlantic Ocean







CFS Pacific Decadal Oscillation (PDO) Index Predictions from Different Initial Months



- CFSv2 predicts the negative phase of PDO will continue through winter 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.

Acknowledgement

- Drs. Arun Kumar, Zeng-Zhen Hu and Jieshun Zhu: 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

Please send your comments and suggestions to:

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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

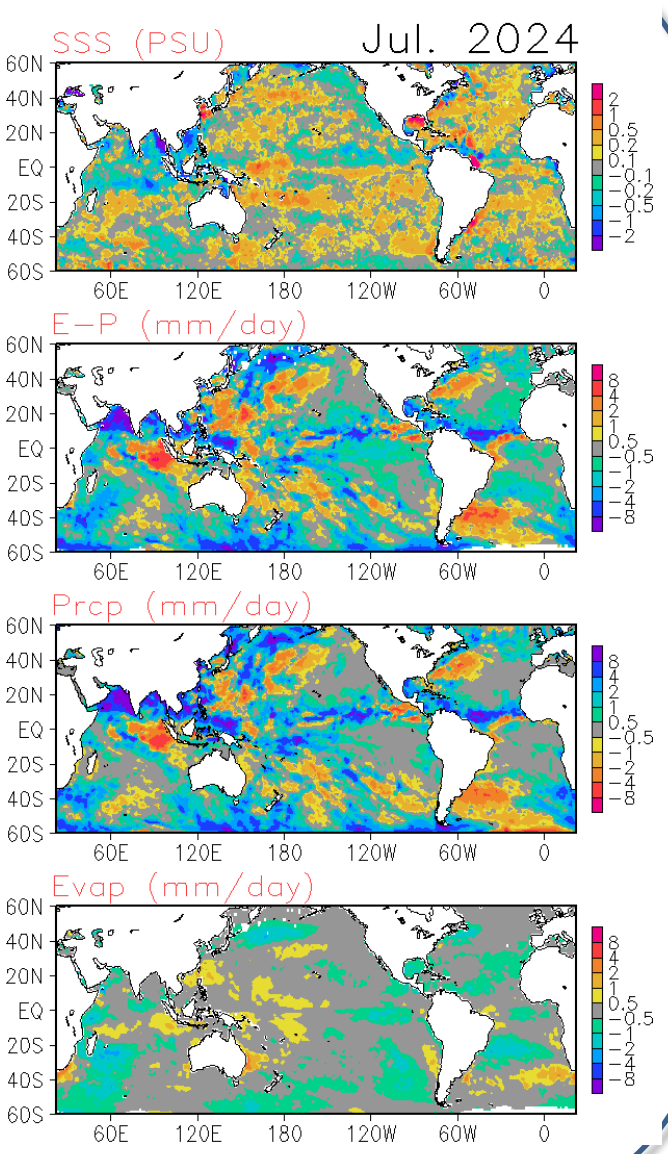
http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html

Backup Slides

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

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

The SSS exhibits positive anomalies in many regions over the Pacific and Atlantic oceans, while negative anomalies in the northern Indian ocean and the sea water around the mainland Southeast Asia. The anomalous pattern in the Indian ocean is partly due to large fresh water run off since it's much stronger than what can be explained by the E-P anomalies alone. The Pacific ITCZ is enhanced; 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.



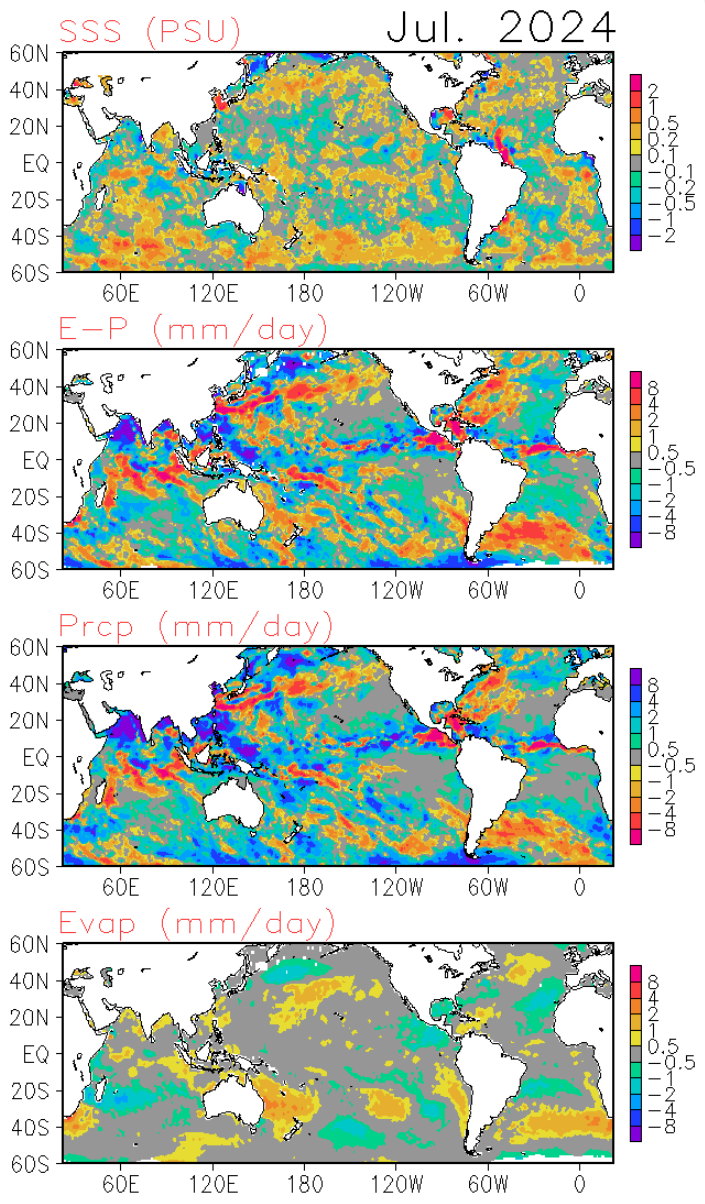
SSS : Blended Analysis of Surface Salinity (BASS) V0.Z
(a CPC-NESDIS/NODC-NESDIS/STAR joint effort)
ftp.cpc.ncep.noaa.gov/precip/BASS

Precipitation: CMORPH adjusted satellite precipitation estimates

Evaporation: Adjusted CFS Reanalysis

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

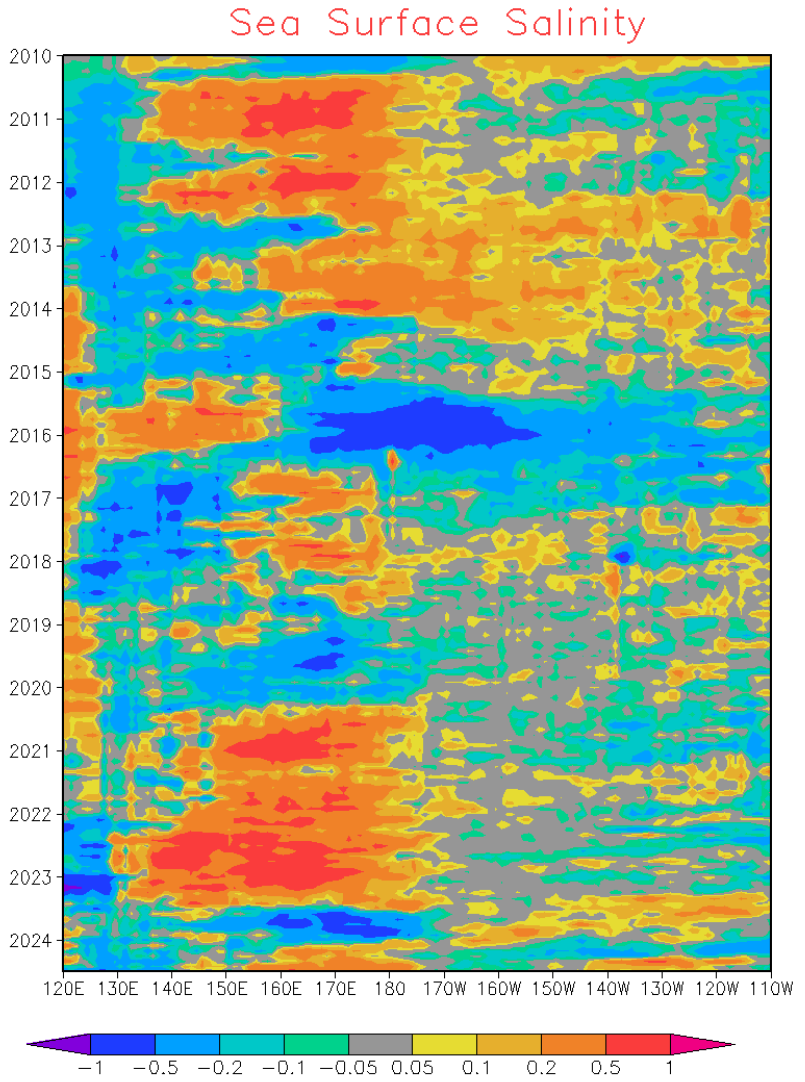
The global SSS tendency in July 2024 is overall weak and with mixed signs. The Precipitation are generally decreasing along the equator but enhancing off equator. Strong decreasing of precipitation is found in the tropical Indian ocean, while increasing . Stronger SPCZ is found with further extended 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

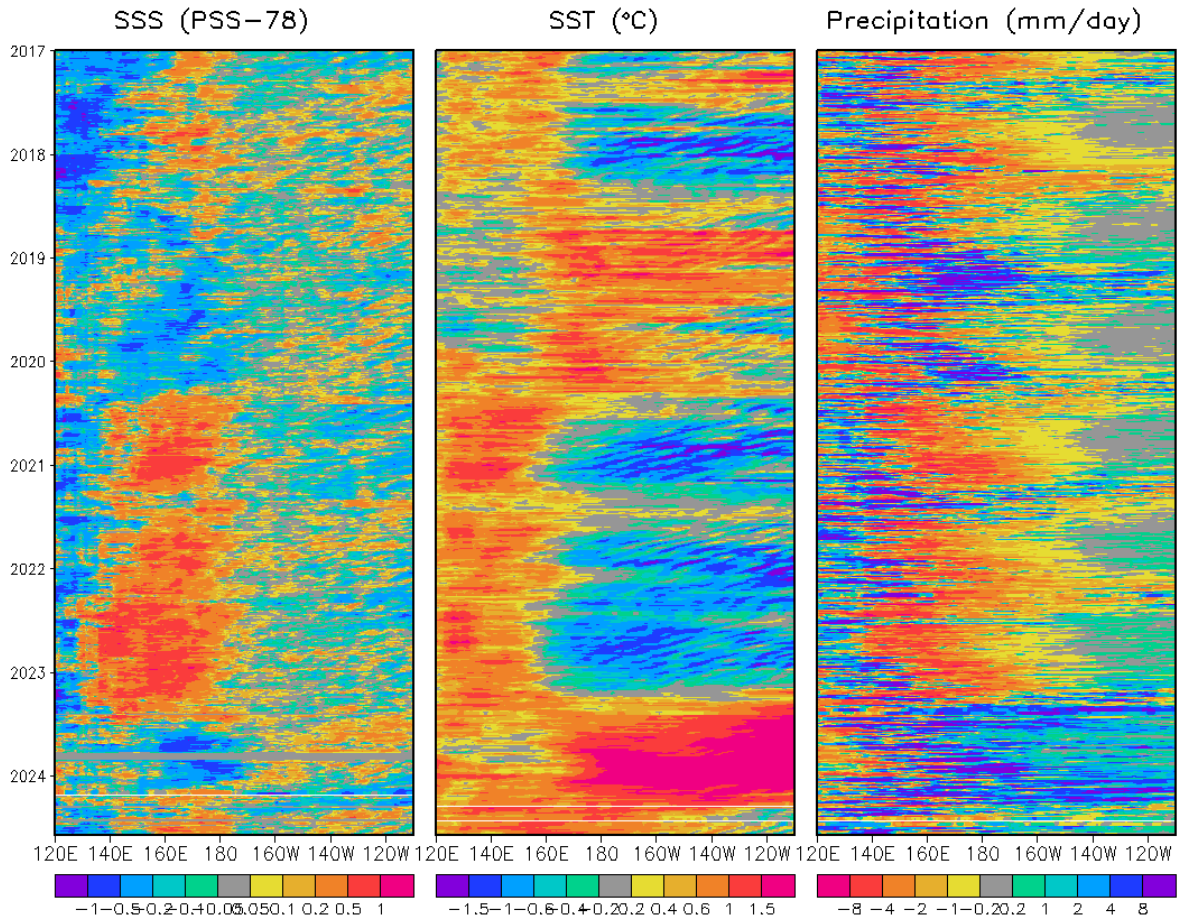
NOTE: Since July 2015, the BASS SSS is from in situ, SMOS and SMAP; before July 2015,The BASS SSS is from in situ, SMOS and Aquarius.

- 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.

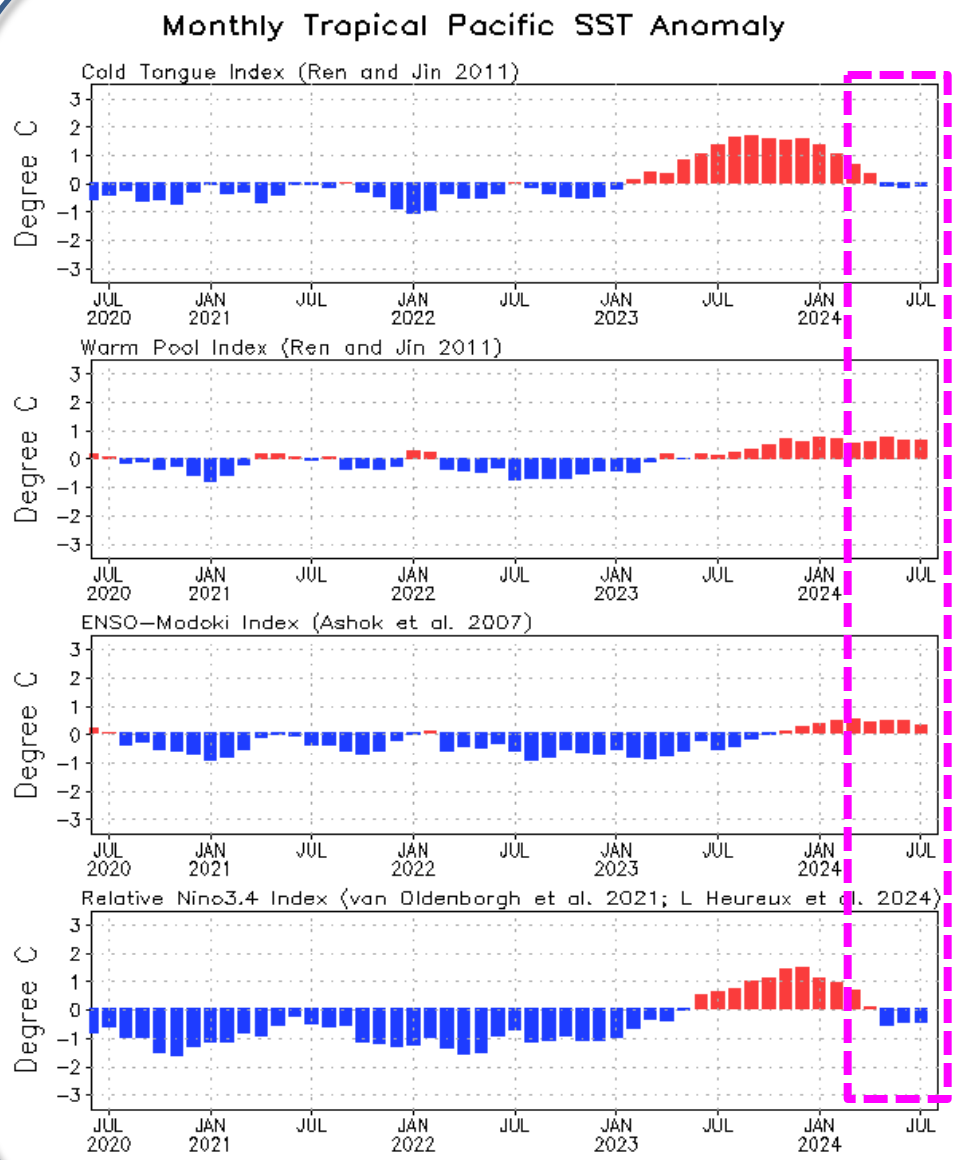


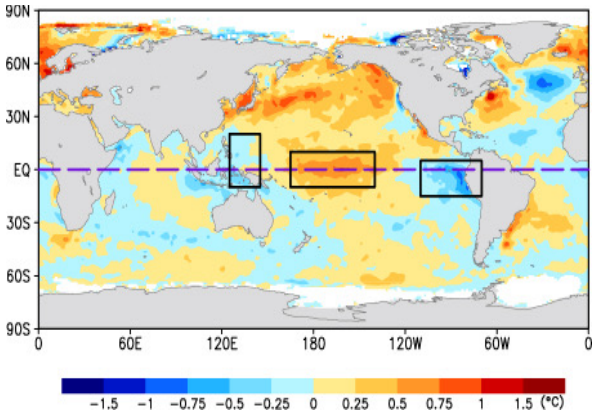
Pentad SSS Anomaly Evolution over Equatorial Pacific

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.



Evolution of Pacific Niño SST Indices



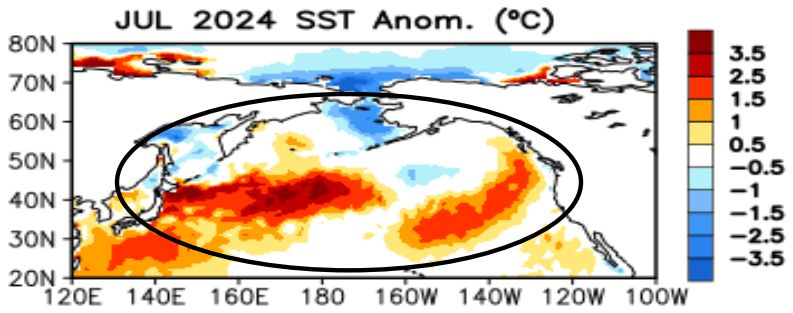


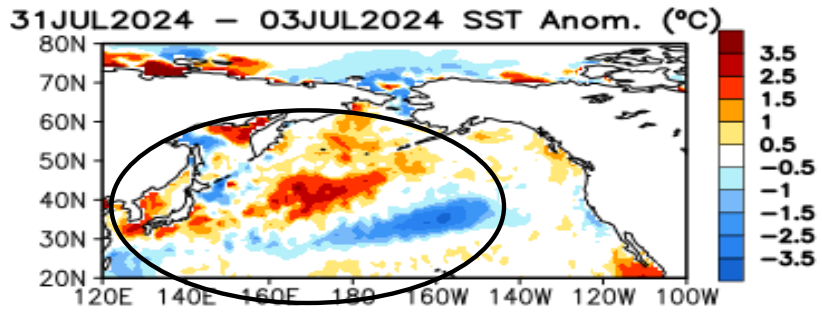
- Relative Niño3.4 index is now included in ENSO monitoring, which is defined as the conventional Niño3.4 index minus the SSTA averaged in the whole tropics (0º-360º, 20ºS-20ºN), in order to remove the global warming signal. Also, to have the same variability as the conventional Niño3.4 index, the relative Niño3.4 index is renormalized (van Oldenborgh et al. 2021: ERL, 10.1088/1748-9326/abe9ed).

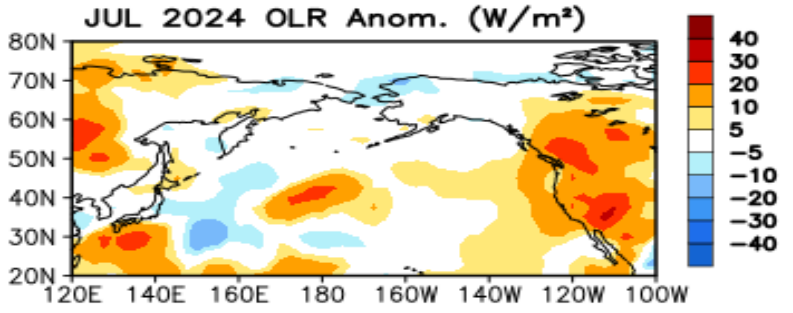
Relative Niño3.4 data updated monthly at:

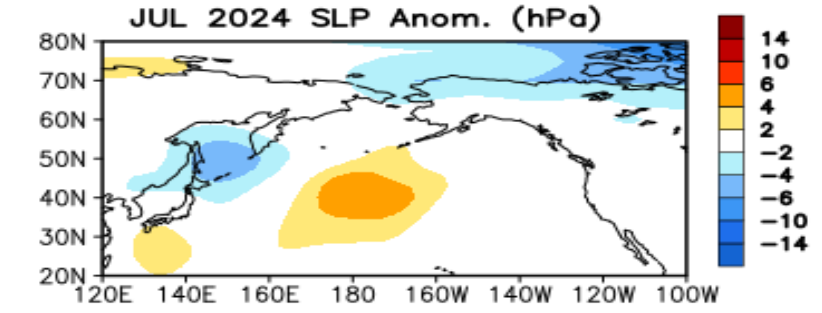
https://www.cpc.ncep.noaa.gov/data/indices/RONI.ascii.txt

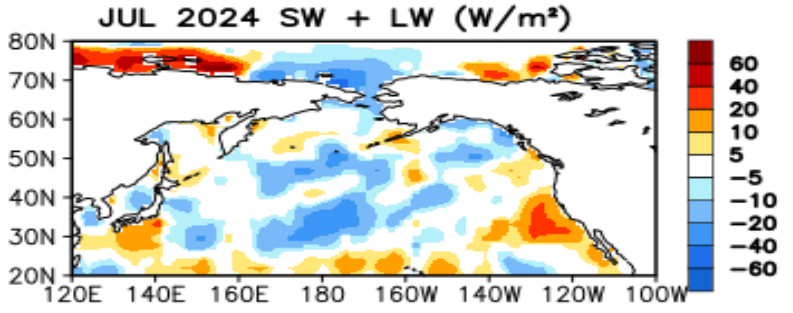
North Pacific & Arctic Ocean: SSTA, SSTA Tend., OLR, SLP, Sfc Rad, Sfc Flx Anomalies

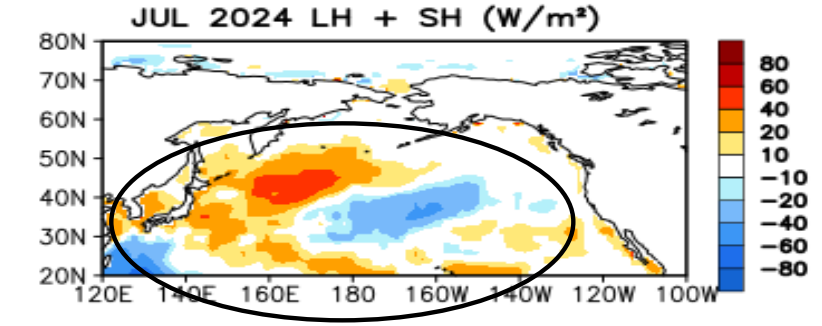






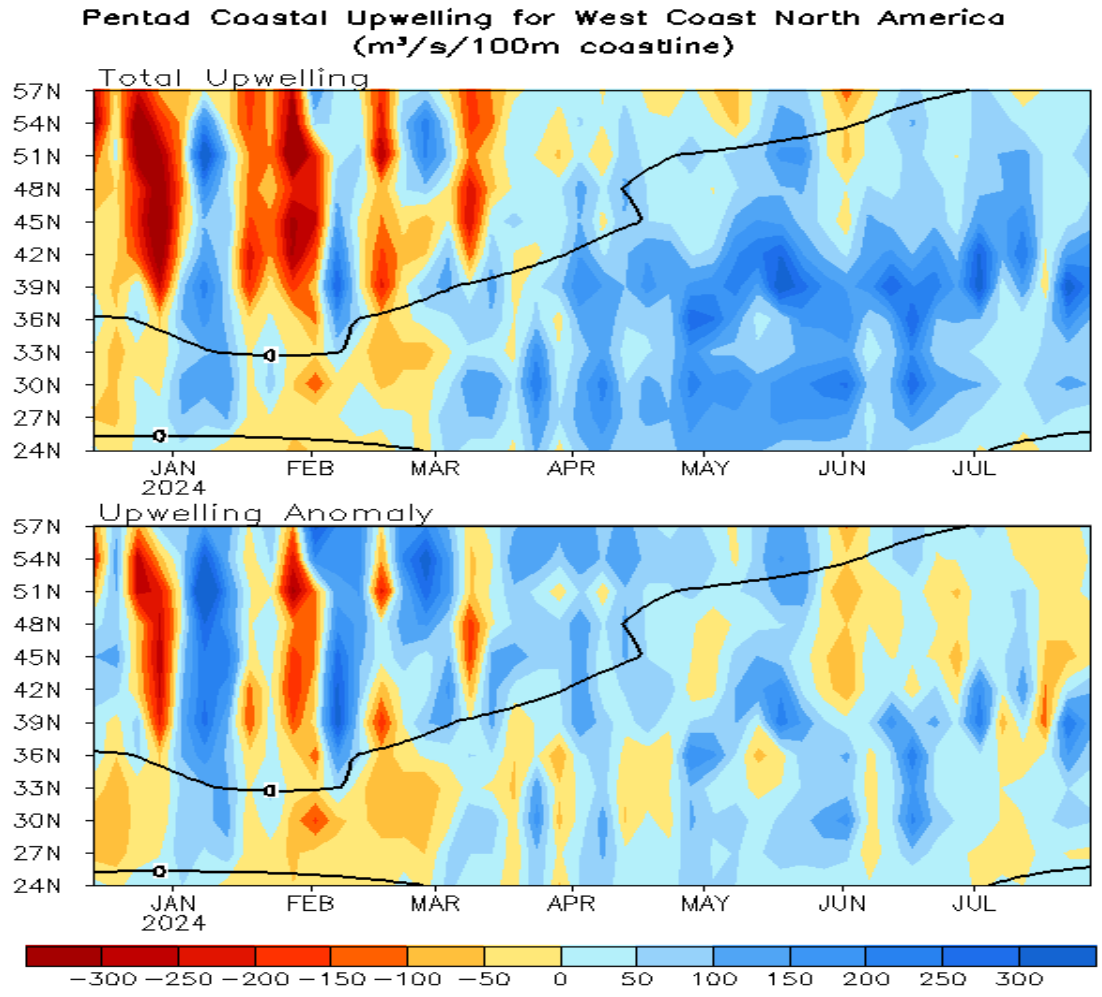


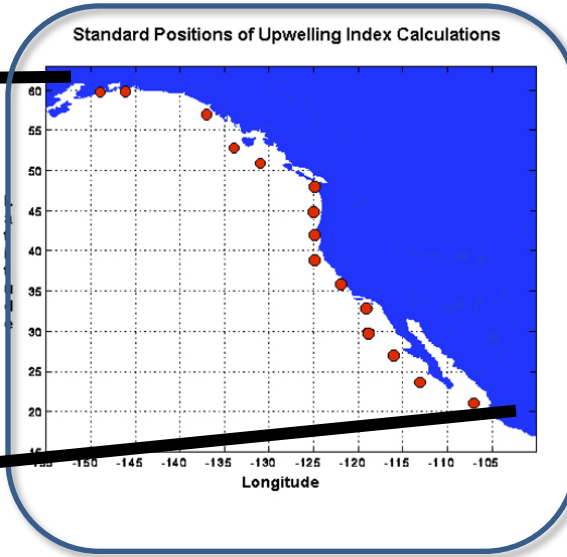




SSTA (top-left; OIv2.1 SST Analysis), SSTA tendency (top-right), Outgoing Long-wave Radiation (OLR) (middle-left; NOAA 18 AVHRR IR), sea surface pressure (middle-right; NCEP CDAS), sum of net surface short- and long-wave radiation (bottom-left; positive means heat into the ocean; NCEP CDAS), sum of latent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

North America Western Coastal Upwelling

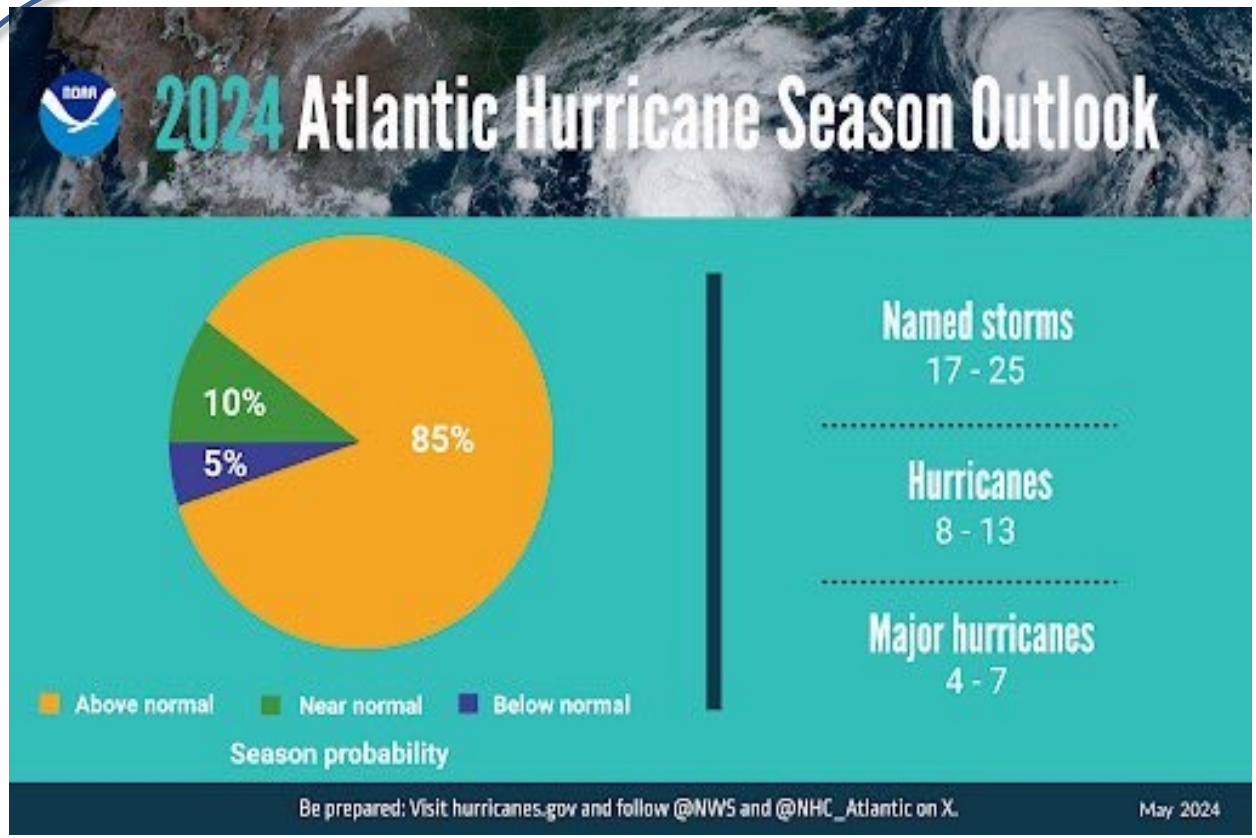




- Both **a**nomalous upwelling and downwelling were observed in Jul 2024.

(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.

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.

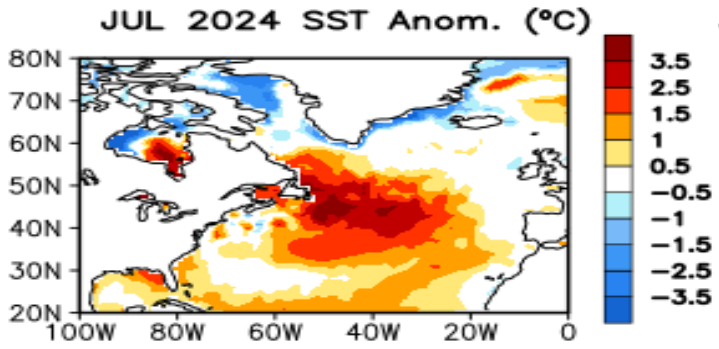
"…. the continuation of the high-activity era for Atlantic hurricanes, which began in 1995 in association with a transition to the warm phase of the Atlantic Multidecadal Oscillation (AMO). The recently observed and predicted atmospheric conditions for ASO 2024 reflect the warm AMV phase….

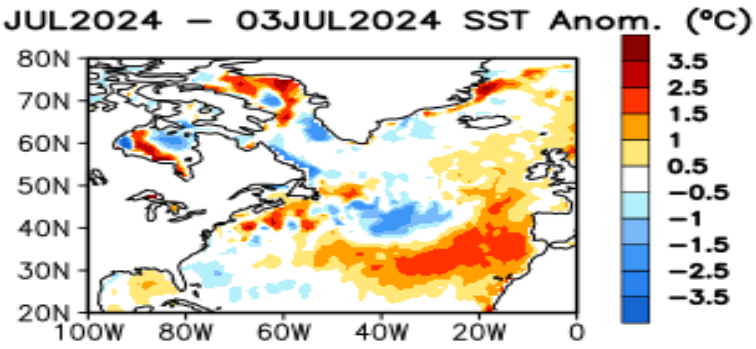
The SSTs in the MDR (North Atlantic) are at (near) record high levels.

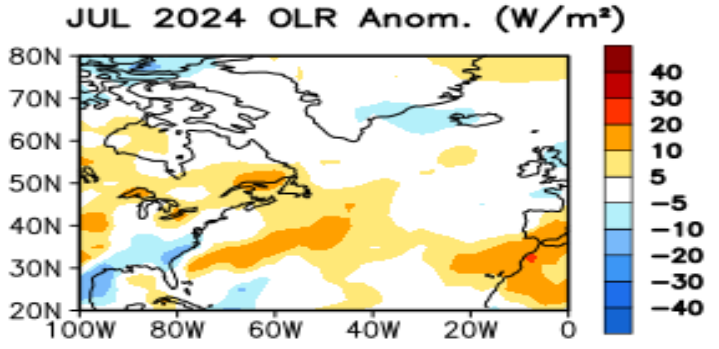
…. a 77% chance that La Niña conditions will develop through the hurricane season…."

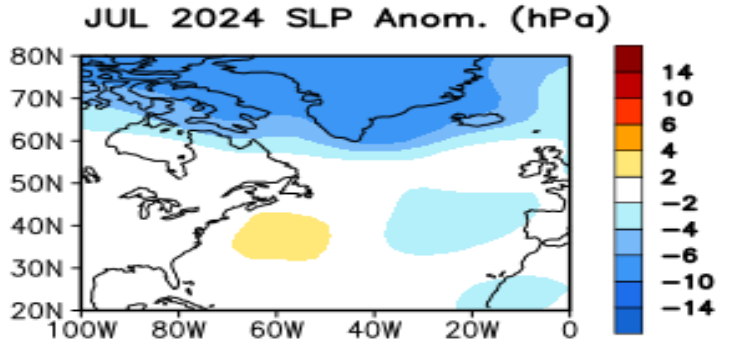
(https://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml)

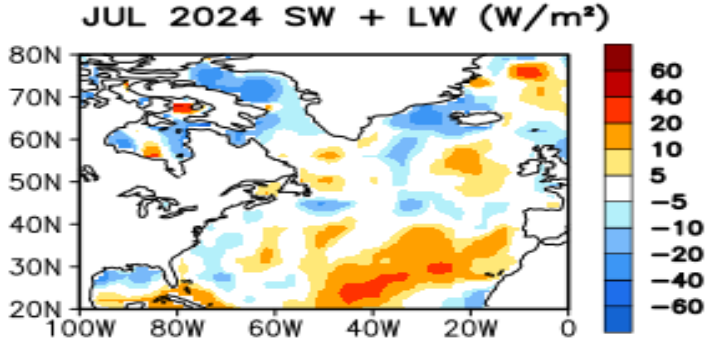
North Atlantic Ocean: SSTA, SSTA Tend., OLR, SLP, Sfc Rad, Sfc Flx Anomalies

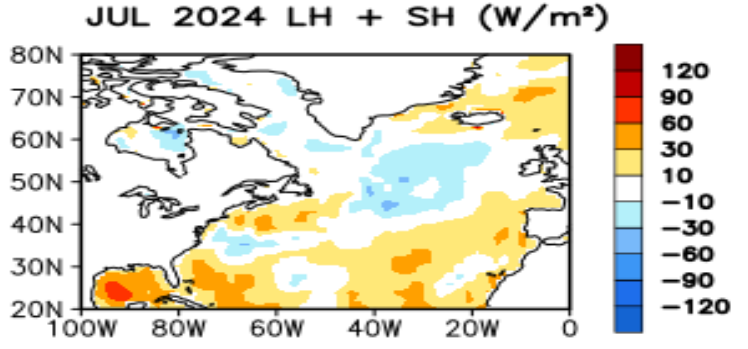




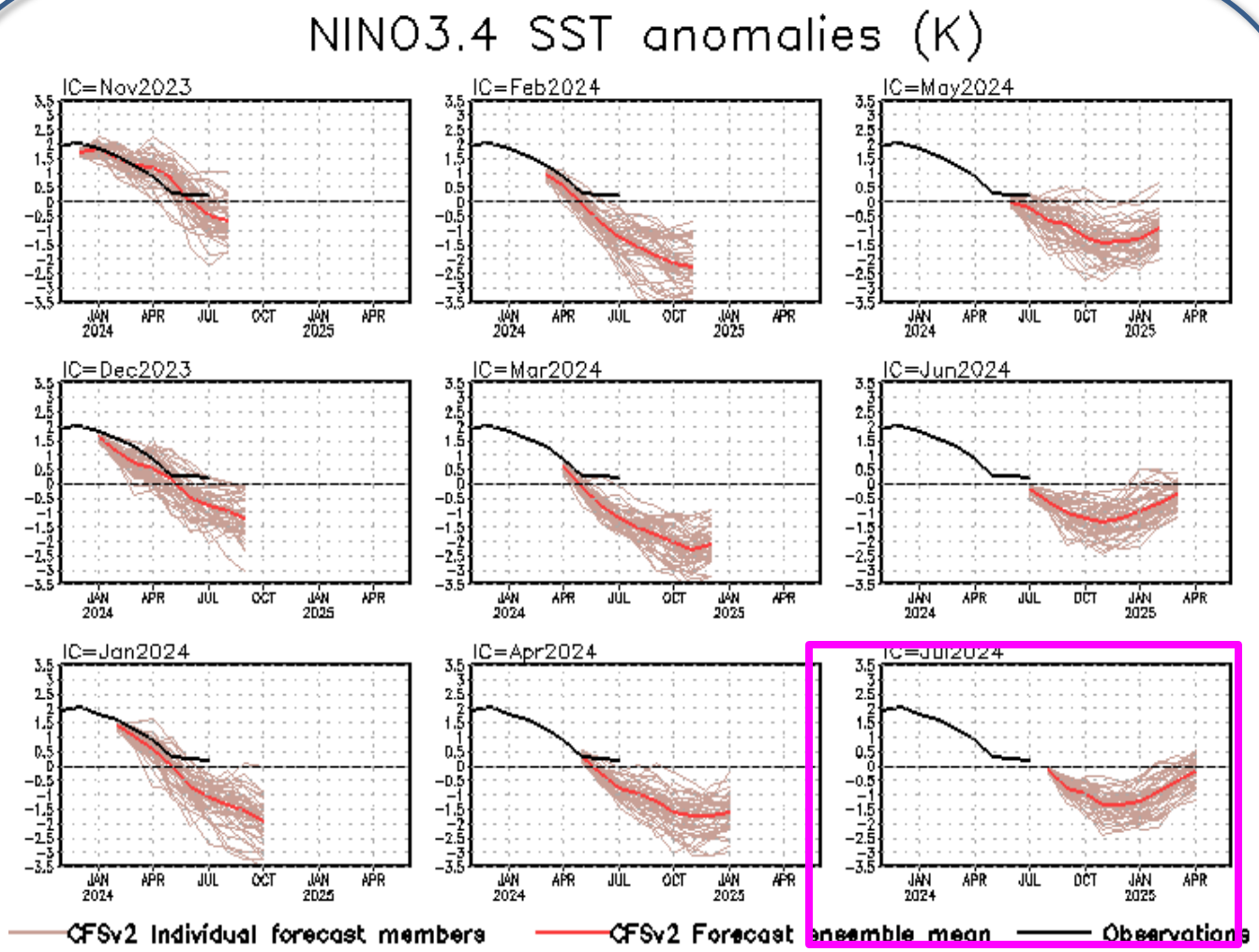








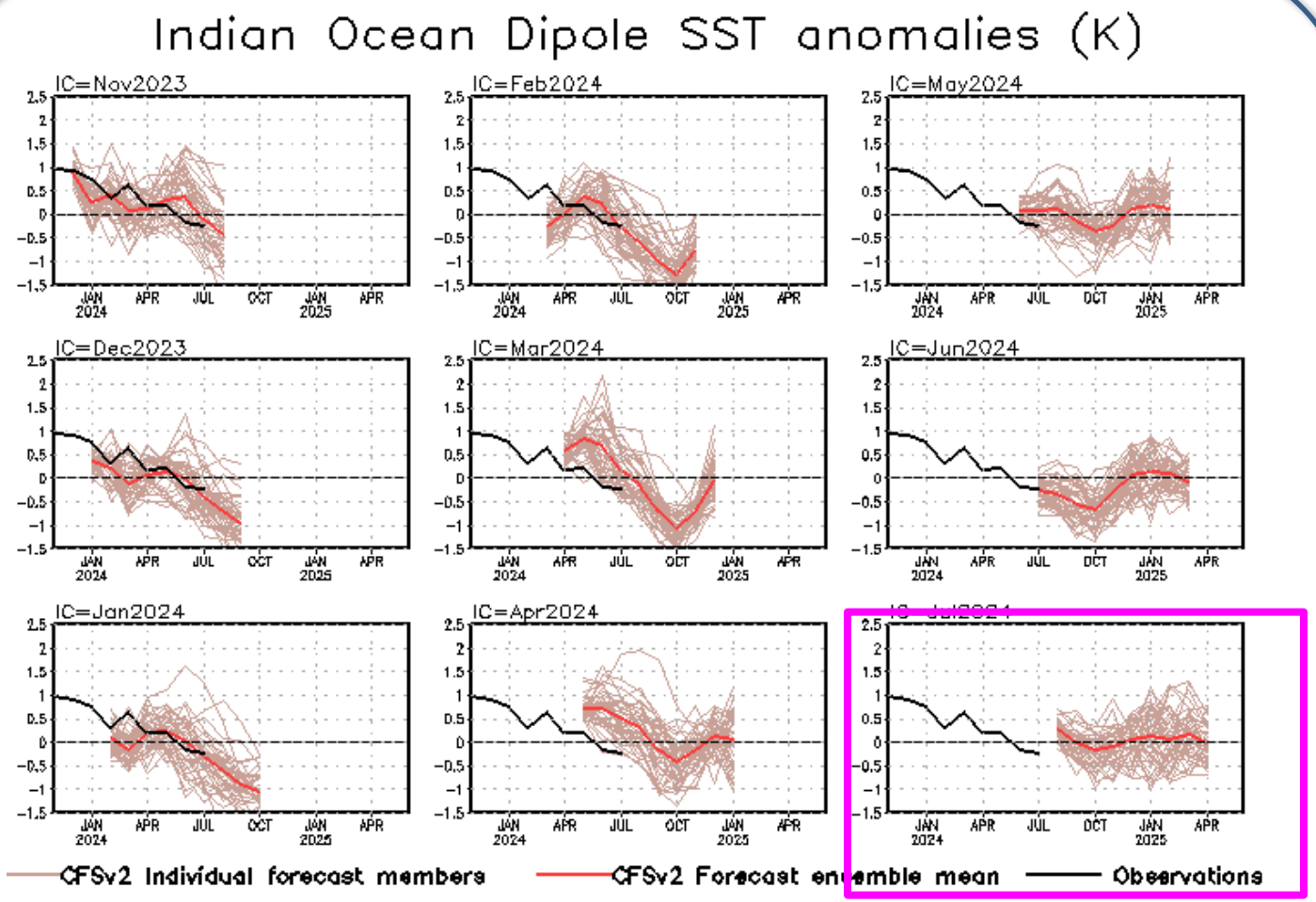
CFS Niño3.4 SST Predictions from Different Initial Months



- The latest CFSv2 forecasts an La Niña will develop in Sep 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 CFS DMI SST Predictions from Different Initial Months



- CFSv2 predicts a positive phase of IOD in the 2nd half of 2023.

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.