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

Prepared by

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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

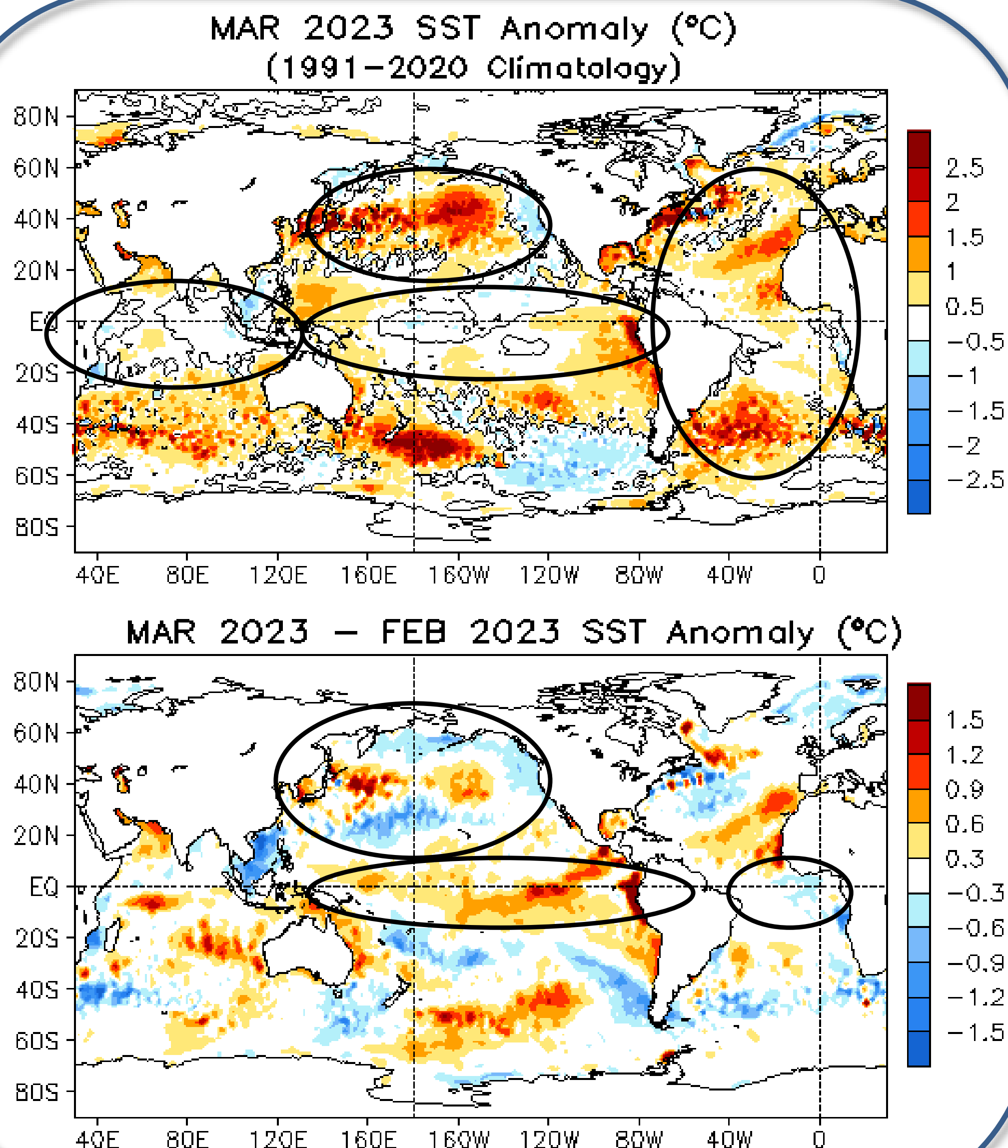
- Overview
- Recent highlights
  - Pacific Ocean
  - Arctic & Antarctic Oceans
  - Indian Ocean
  - Atlantic Ocean
- Global SSTA Predictions

Overview

- Pacific Ocean
  - NOAA "ENSO Diagnostic Discussion" on 9 Mar 2023 stated "La Niña has ended and ENSO-neutral conditions are expected to continue through the Northern Hemisphere spring and early summer 2023."
  - ENSO was in neutral conditions with Niño3.4 = -0.2°C (ERSSTv5) and 0.0°C (OIv2.1) in Mar 2023.
  - A strong coastal El Niño has been observed since Feb 2023 with Niño1+2 =1.5°C in Mar 2023.
  - Positive SSTAs persisted in the North Pacific in Mar 2023. The PDO has been in a negative phase since Feb 2020 with PDOI = -1.6 in Mar 2023.
- Arctic and Antarctic Oceans
  - The Mar 2023 average Arctic sea ice extent was 14.44 million square kilometers, the sixth lowest March in the satellite record.
  - The average sea ice extent around Antarctica was the second lowest March on record.
- Indian Ocean
  - Positive (negative) SSTAs were in the western (southeastern) tropical Indian Ocean in Mar 2023.
- Atlantic Ocean
  - NAO switched to a negative phase in Mar 2023 with NAOI= -1.6.

Global Oceans

Global SST Anomaly (°C) and Anomaly Tendency

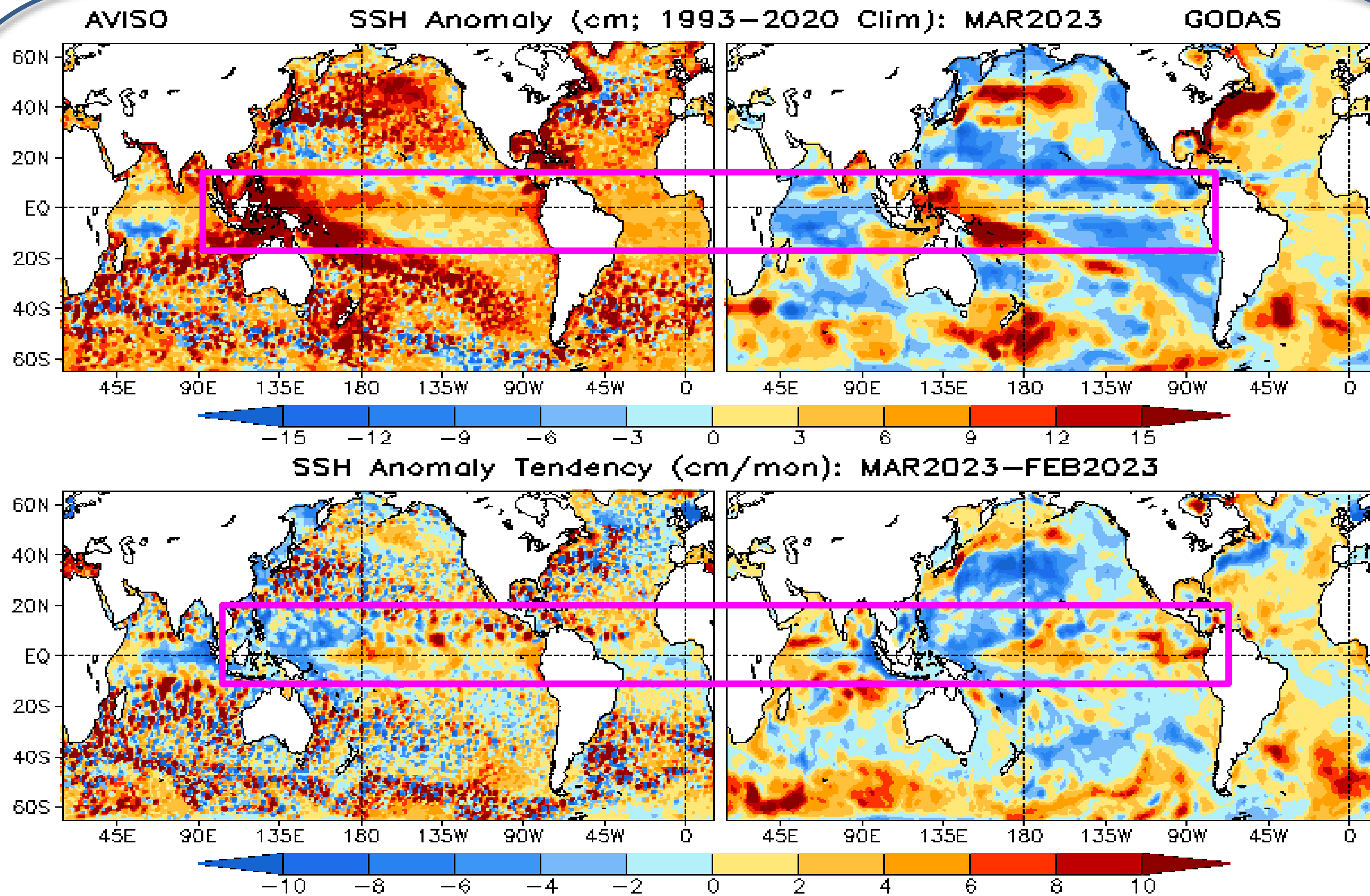


- Above (near) normal SSTs were present in the western and eastern (central) equatorial Pacific.
- Positive SSTAs were observed in the North Pacific and most of the Atlantic Ocean.
- Small SSTAs were observed in the tropical Indian Ocean.
- Appreciable positive and negative SSTAs were seen in the middle-latitudes of the Southern Hemisphere.

- Positive SSTA tendencies were observed in the equatorial Pacific.
- Both positive and negative SSTA tendencies were evident in the North Pacific.
- Negative SSTA tendencies were in the tropical central and eastern Atlantic Ocean.

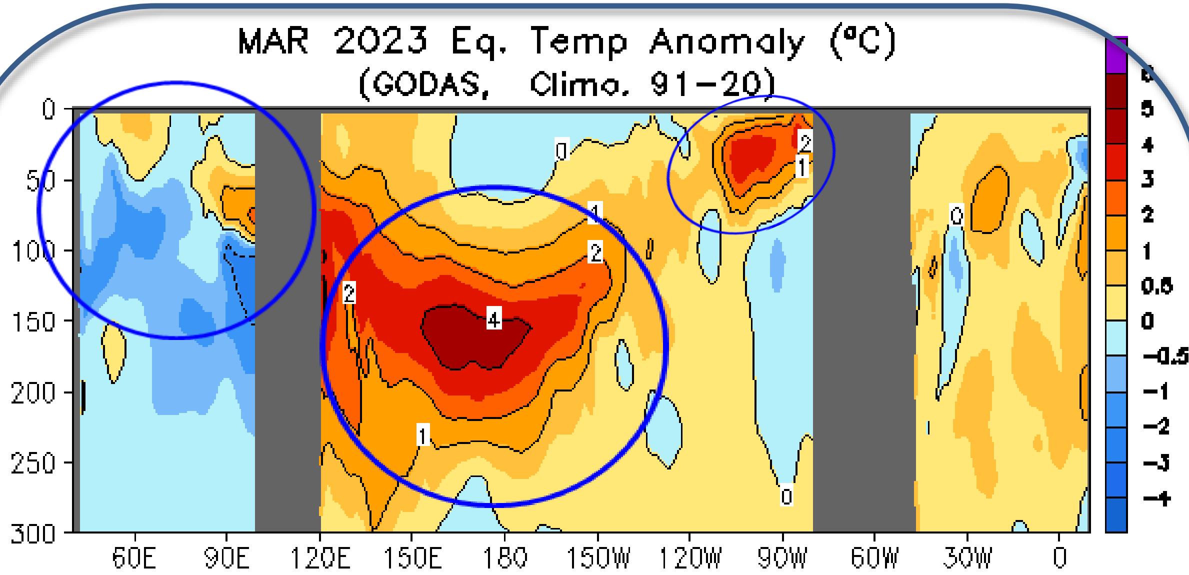
SSTAs (top) and SSTA tendency (bottom). Data are derived from the OIv2.1 SST analysis, and anomalies are departures from the 1991-2020 base period means.

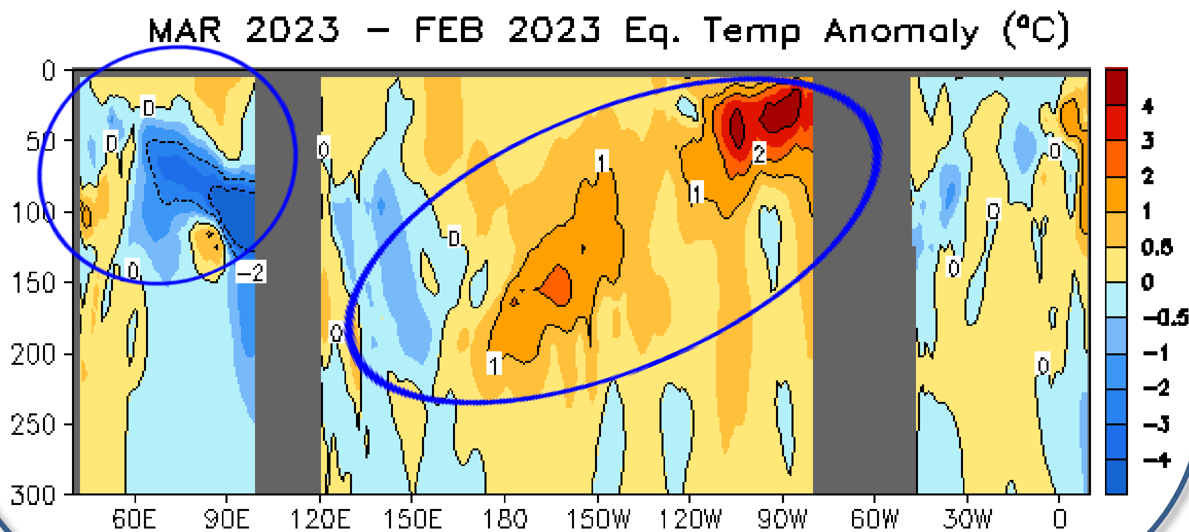
AVISO & GODAS SSH Anomaly (cm) and Anomaly Tendency



- SSHs were near normal along the eastern equatorial Pacific in GODAS.
- The tendencies indicated an increase of SSH in the central and eastern tropical Pacific.

Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2ºS-2ºN





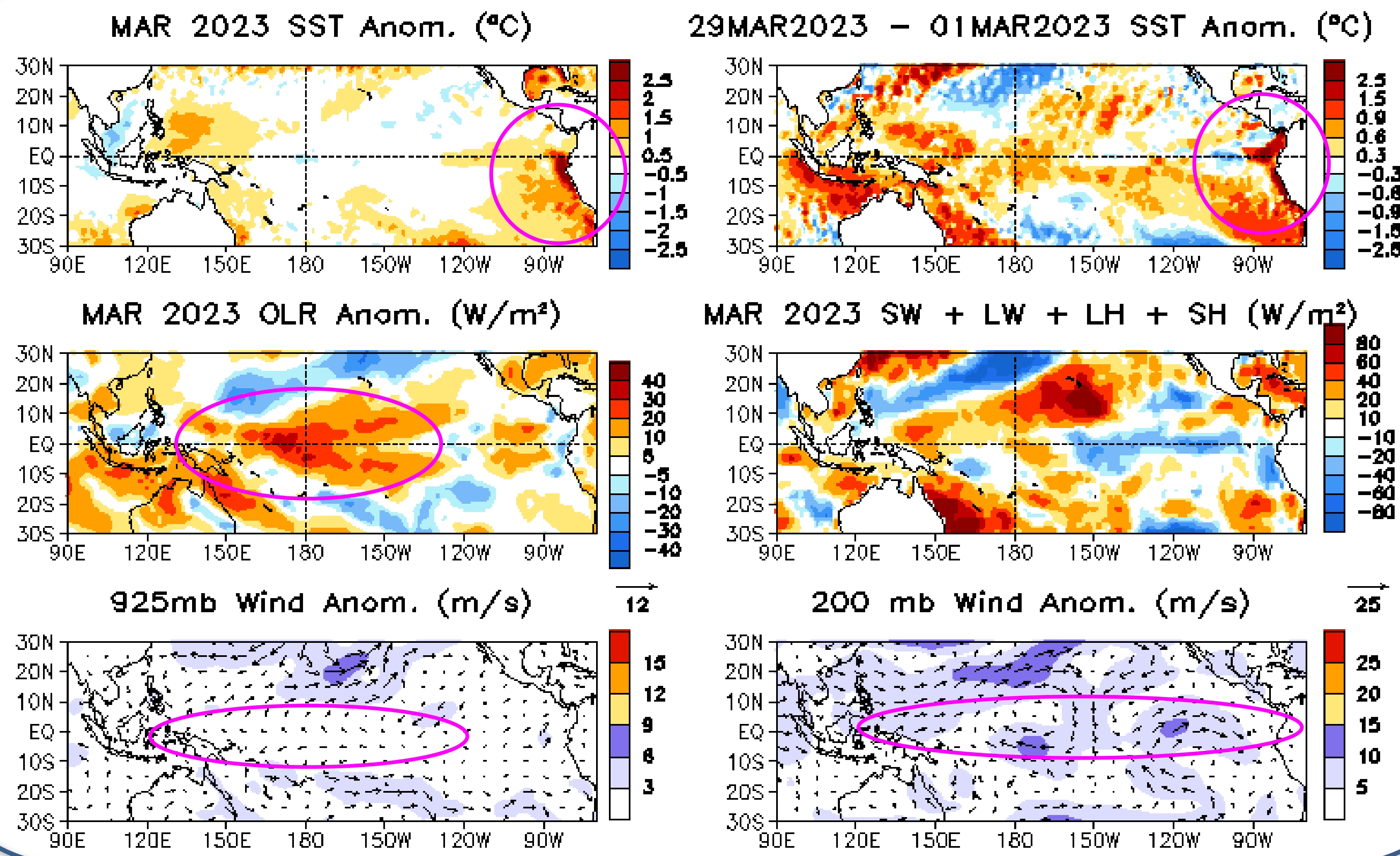
- Strong positive temperature anomalies were present along the thermocline in the western and central, and far-eastern equatorial Pacific.
- Positive (negative) temperature anomalies were observed above (below) the equatorial thermocline in the Indian Ocean.

- Temperature anomaly tendency was positive (negative) along the thermocline in the east-central and far-eastern (western) Pacific.
- Temperature anomaly tendency was positive (negative) above (below) the thermocline in the Indian Ocean.

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

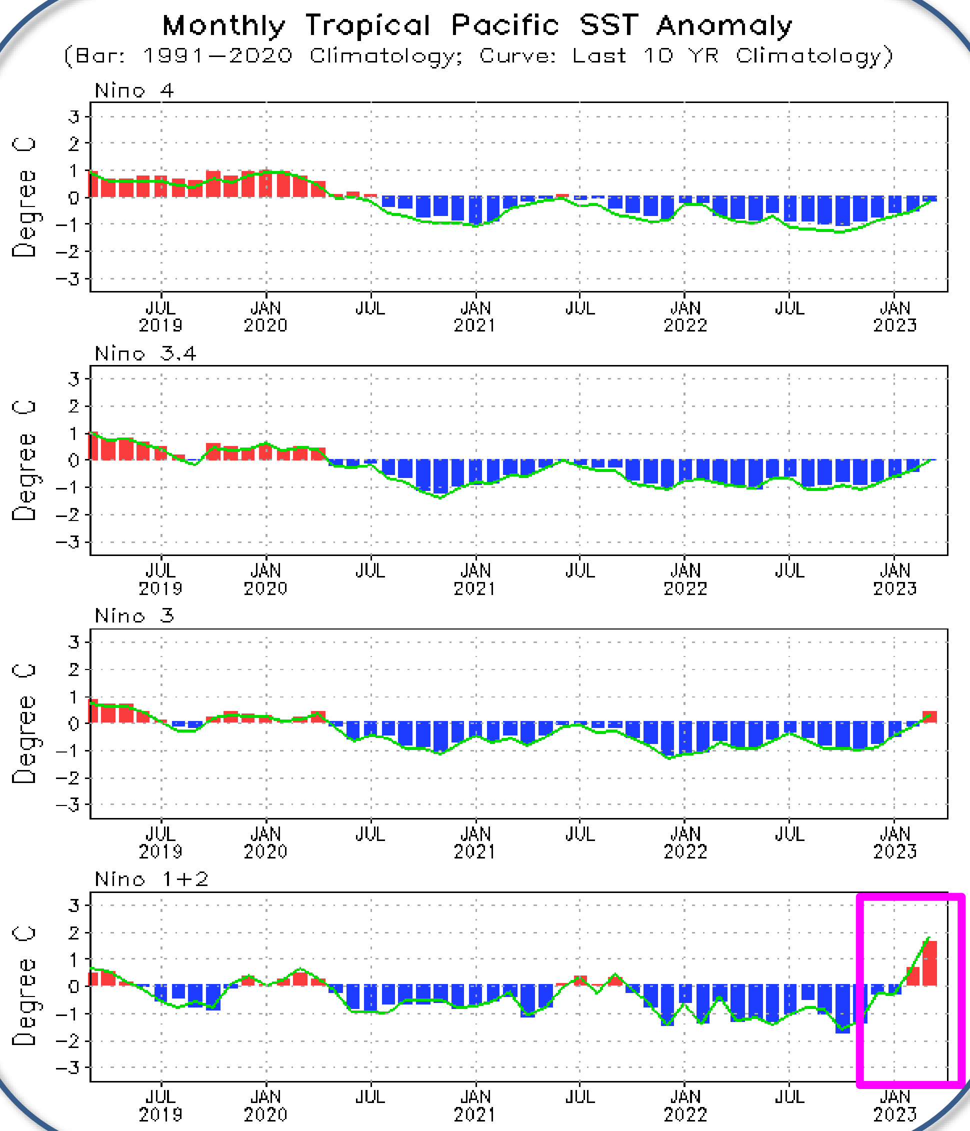
Tropical Pacific Ocean and ENSO Conditions

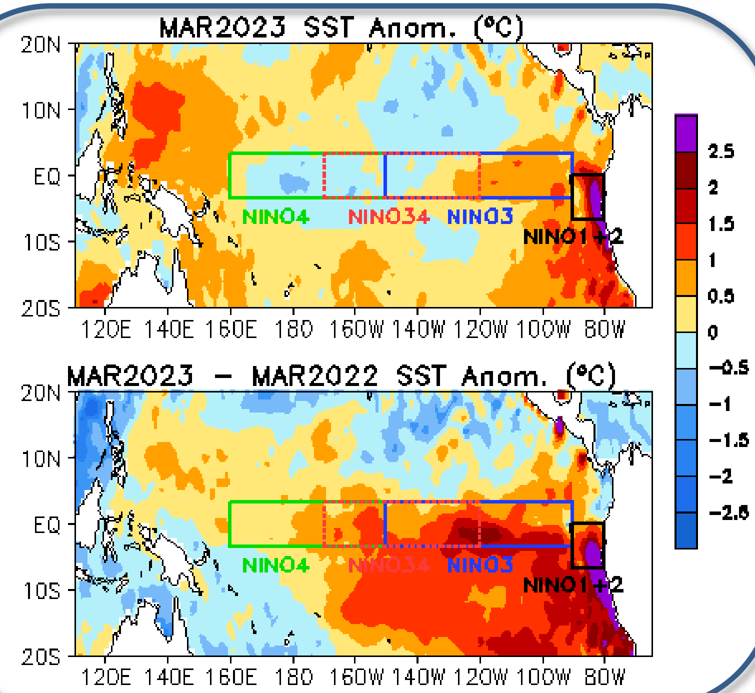
Tropical Pacific: SSTA, SSTA Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Winds



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.

Evolution of Pacific Niño SST Indices





- All Niño indices warmed up in Mar 2023, with Niño3.4 = 0.0°C (OIv2.1).

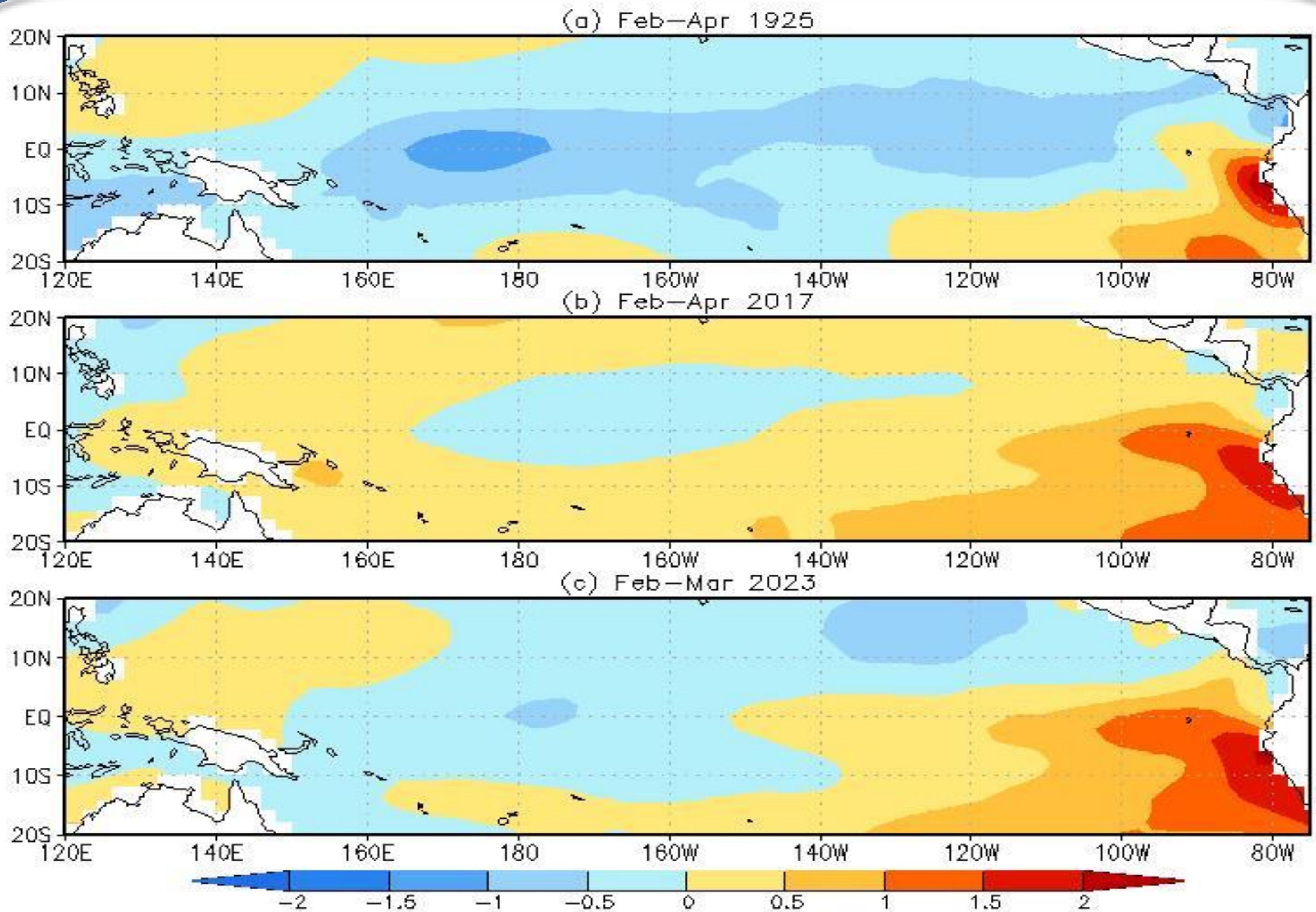
- A coastal Niño has been observed since Feb 2023 with Niño1+2= 1.5°C(OIv2.1) in Mar 2023.

- Compared with Mar 2022, the central and eastern equatorial Pacific was much warmer in Mar 2023.

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

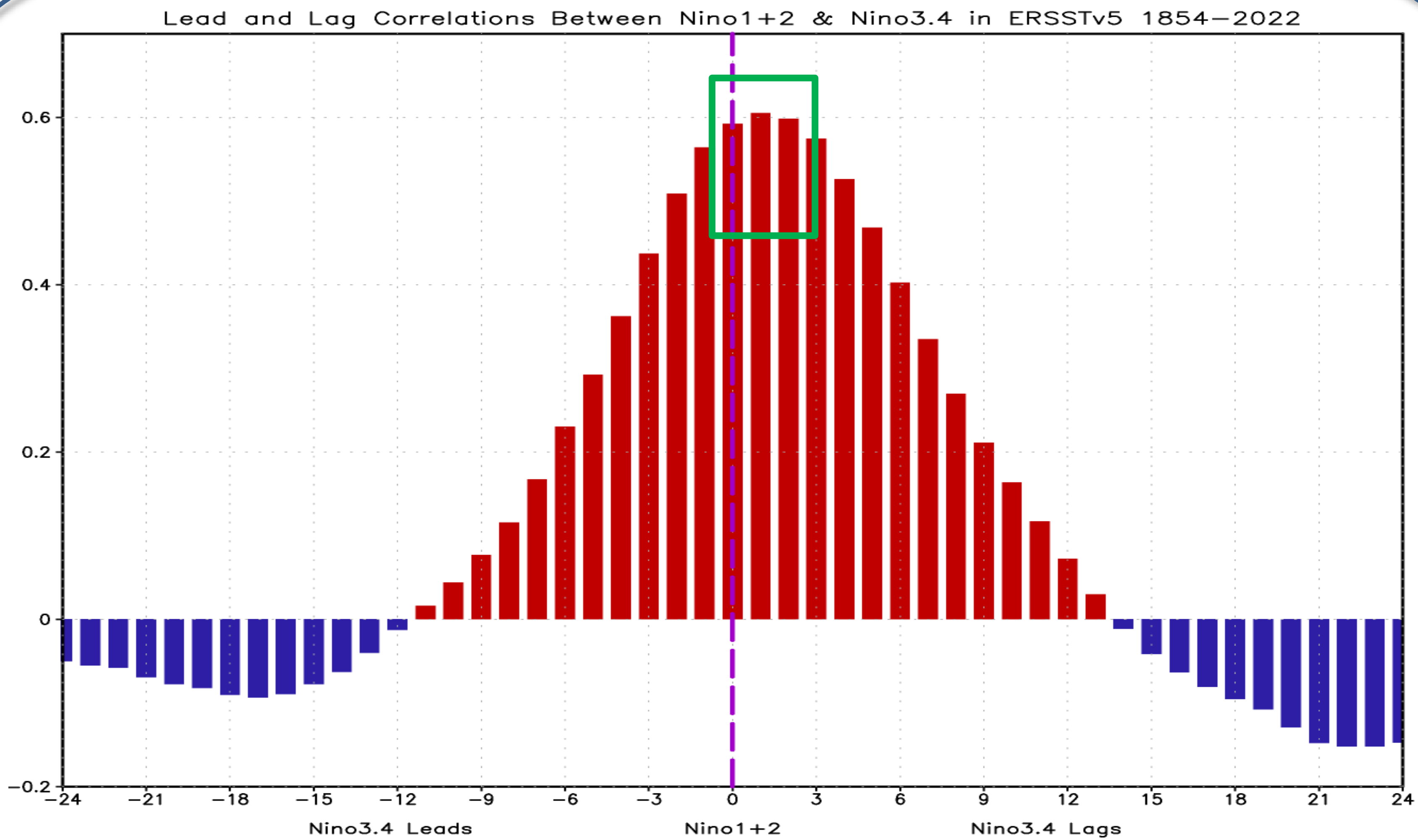
Niño region indices, calculated as the area-averaged monthly mean SSTAs (°C) for the specified region. Data are derived from the OIv2.1 SST analysis, and anomalies are departures from the 1991-2020 base period means.

Coastal El Niños in 1925, 2017, & 2023



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.

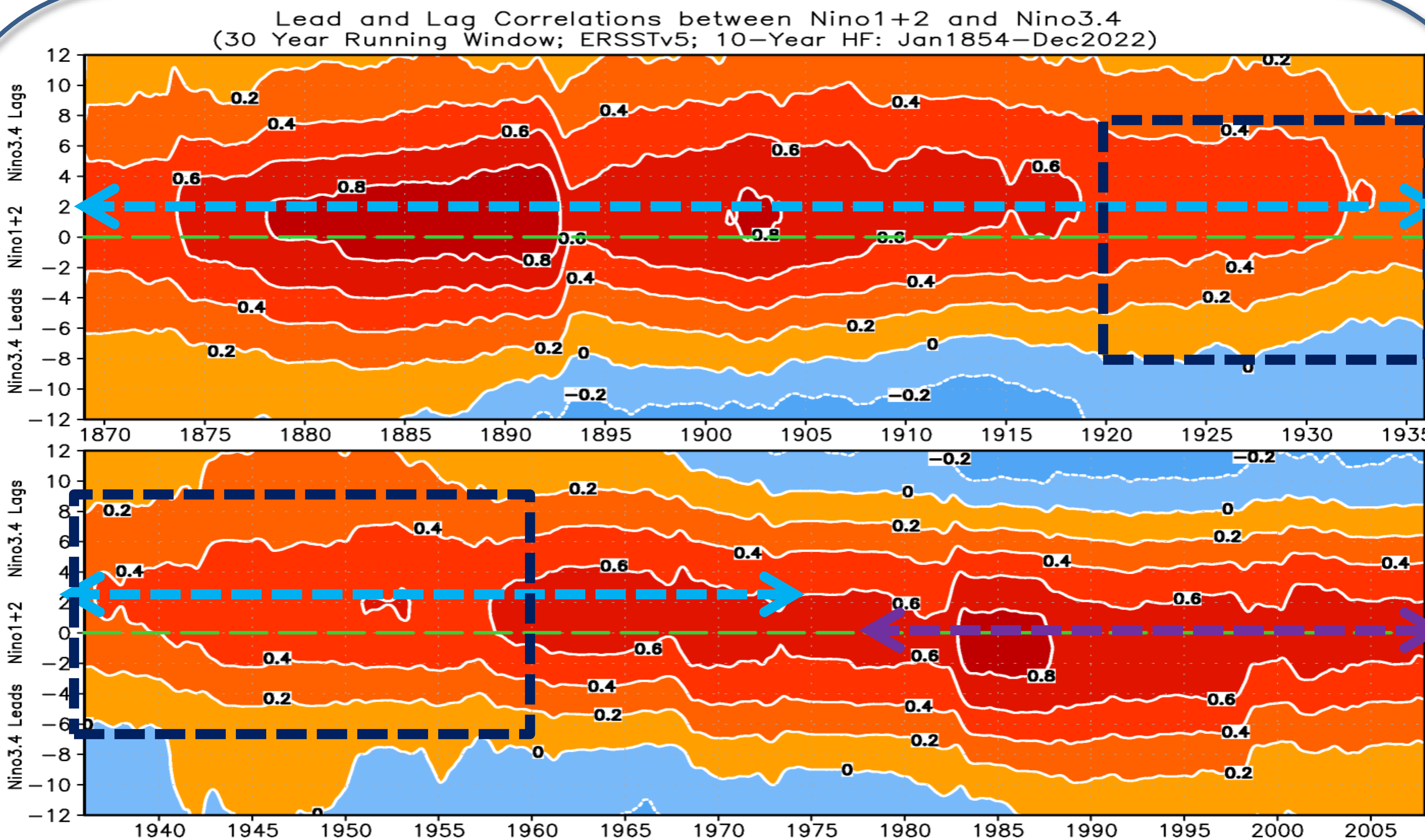
El Niño & Coastal El Niño



- Statistically, Niño1+2 (coastal El Niño) leads Niño3.4 (El Niño) by 1-2 months

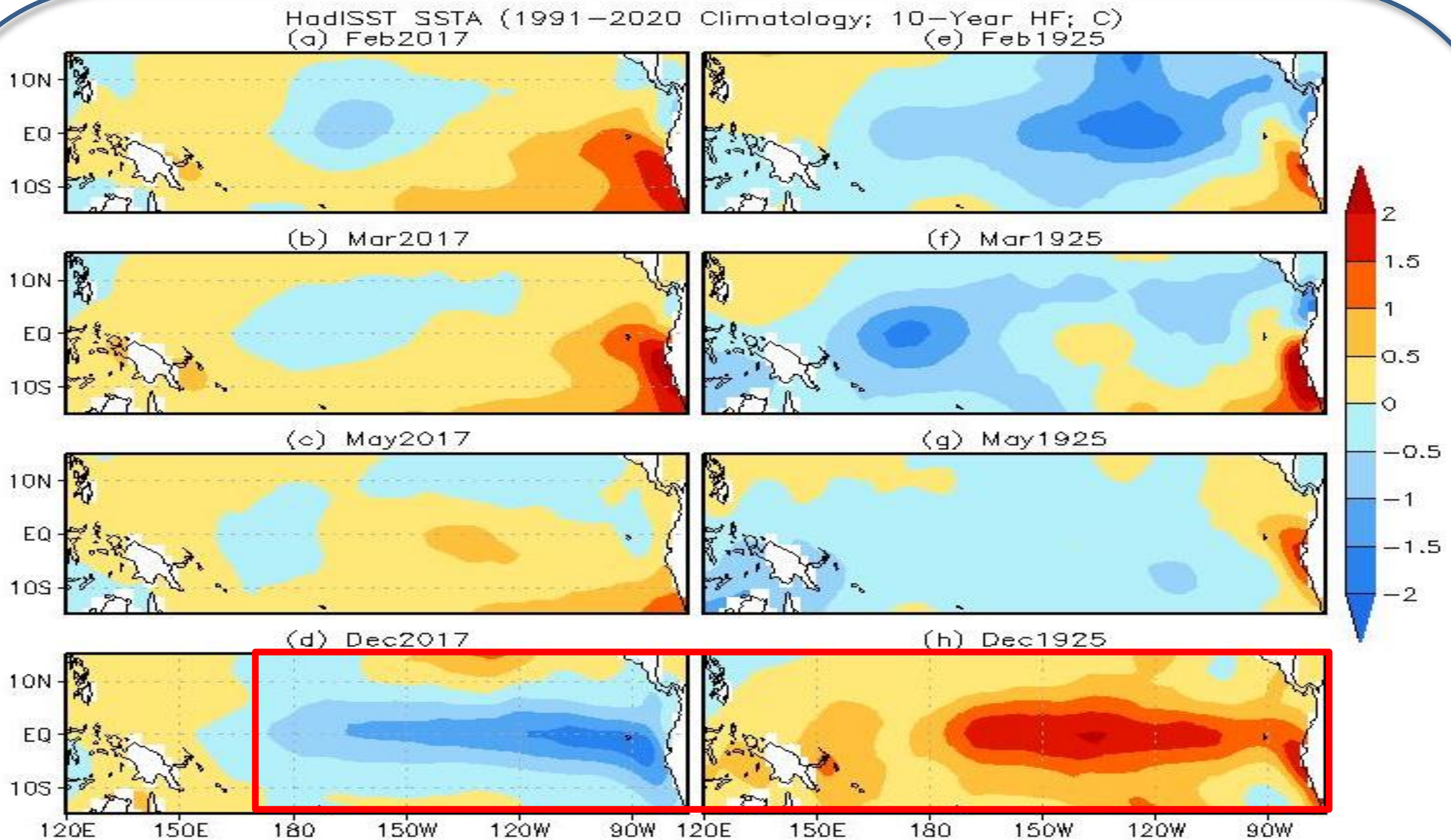
Hu, Z.-Z., B. Huang, J. Zhu, A. Kumar, and M. J. McPhaden: 2019: On the variety of coastal El Niño events. Climate Dyn., 52 (12), 7537-7552. DOI: 10.1007/s00382-018-4290-4.

El Niño & Coastal El Niño



- 30 year running window for lead-lag correlation between Niño1+2 & Niño3.4 (ERSSTv5, 10-year HF): Niño3.4 lags Niño1+2 by 1-3 months during 1870-1980 (westward propagation) ; no lead since 1980 (no propagation); correlations weak during 1920-1960 (*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)*

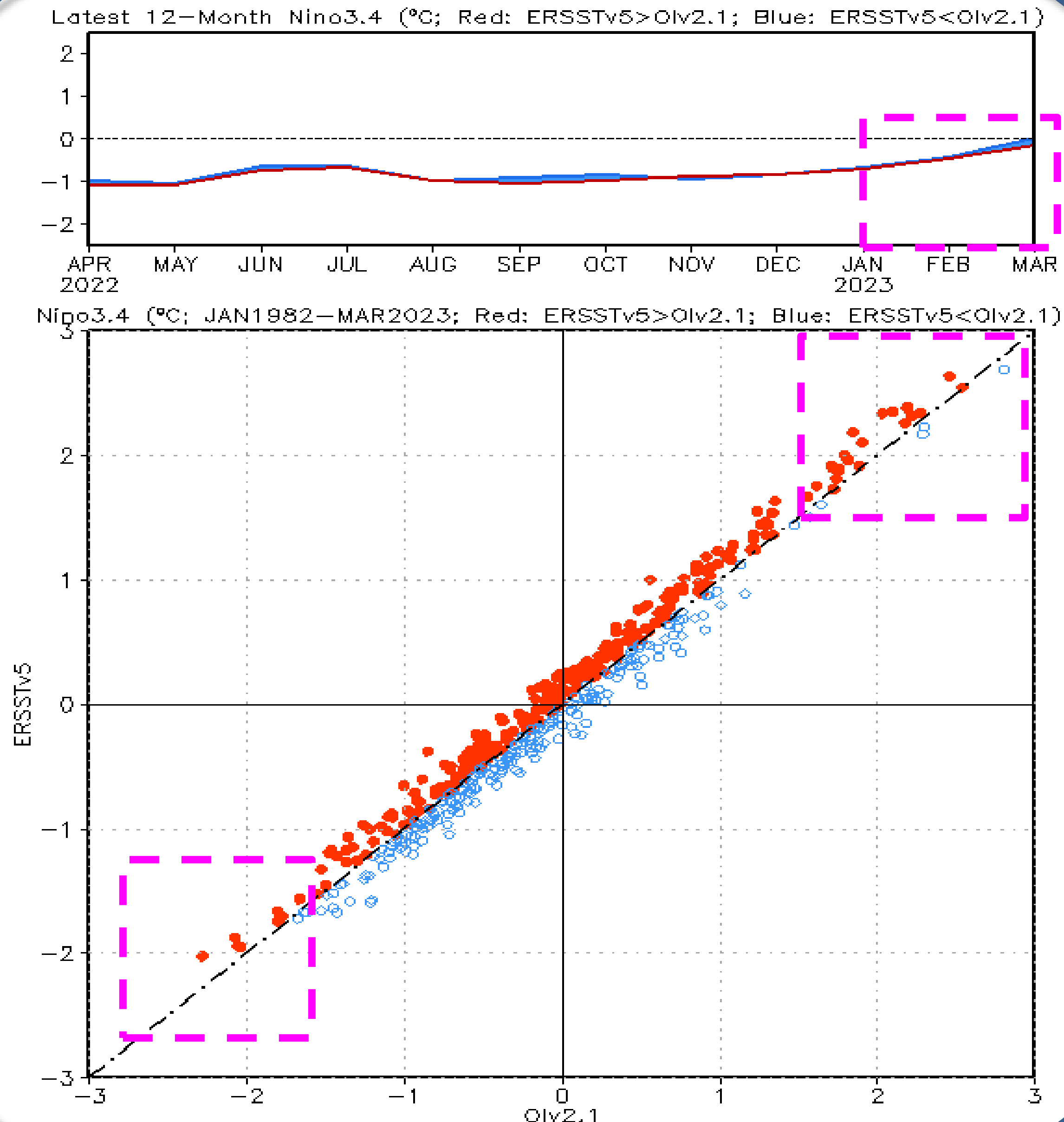
El Niño & Coastal El Niño



- Coastal El Niño in spring 2017 was followed by a La Niña, while coastal El Niño in spring 1925 was followed by a canonical El Niño.

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.

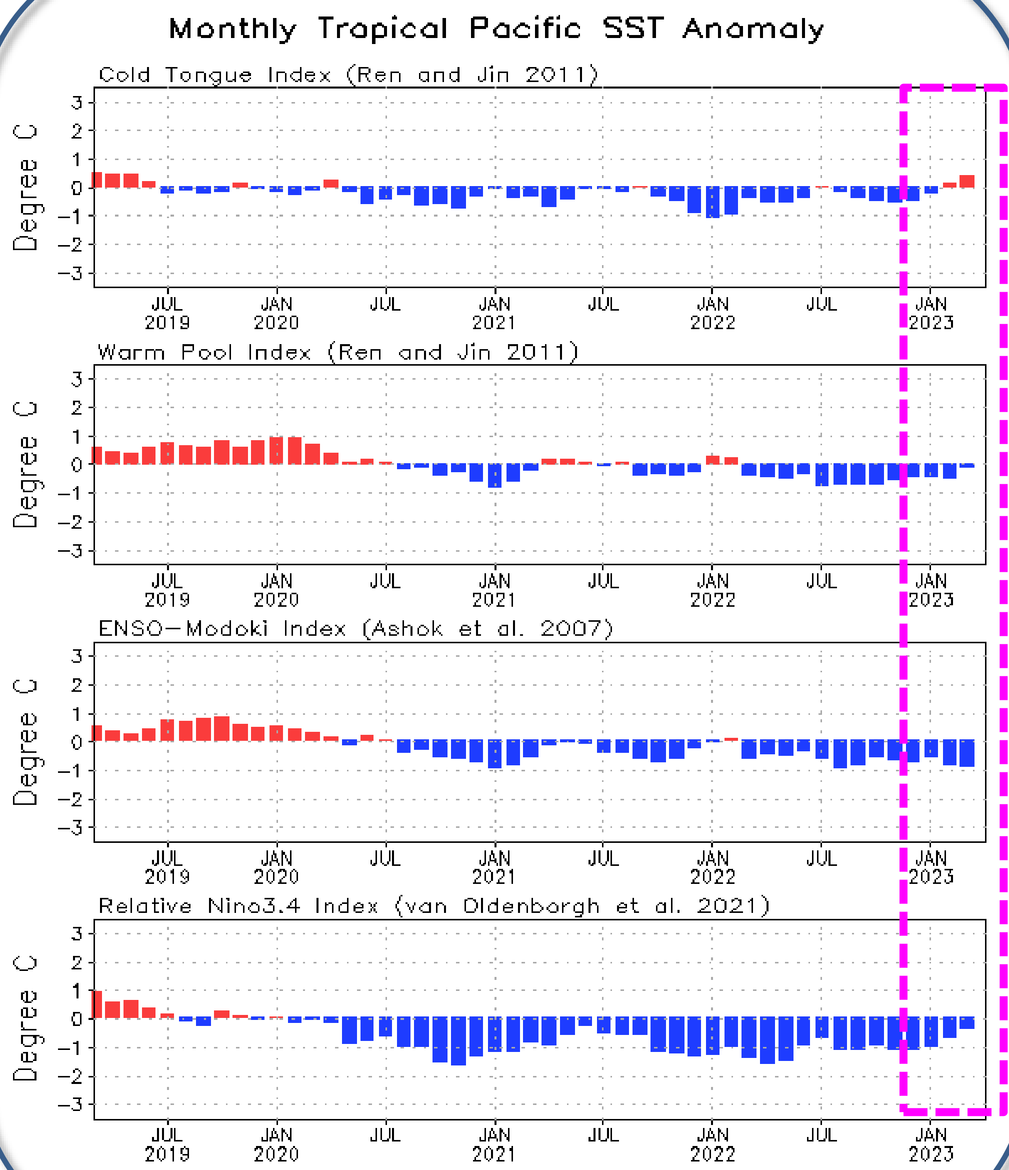
Comparison of ERSSTv5 & OIv2.1 Niño3.4 Index

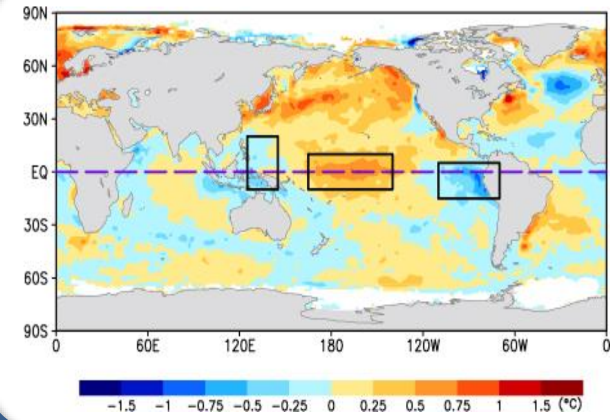


- Recently, ERSSTv5 is cooler than ERSSTv2.1: -0.0C (OIv2.1) & -0.2C (ERSSTv5).

- Historically, ERSSTv5 can be 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.
- During last few months, ERSSTv5 was similar to OIv2.1.

Evolution of Pacific Niño SST Indices



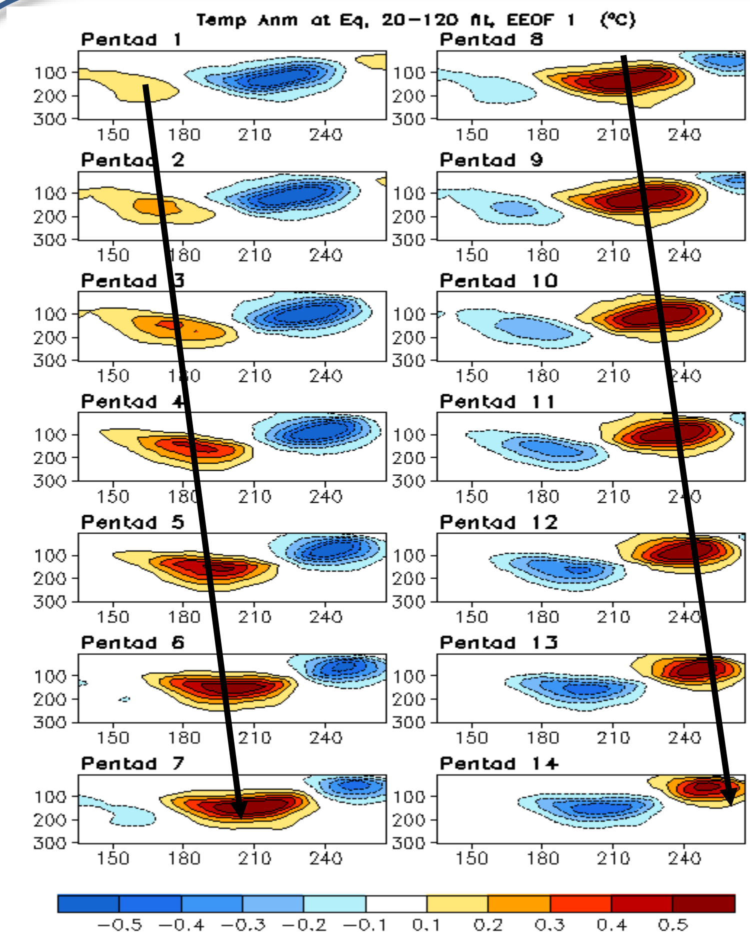


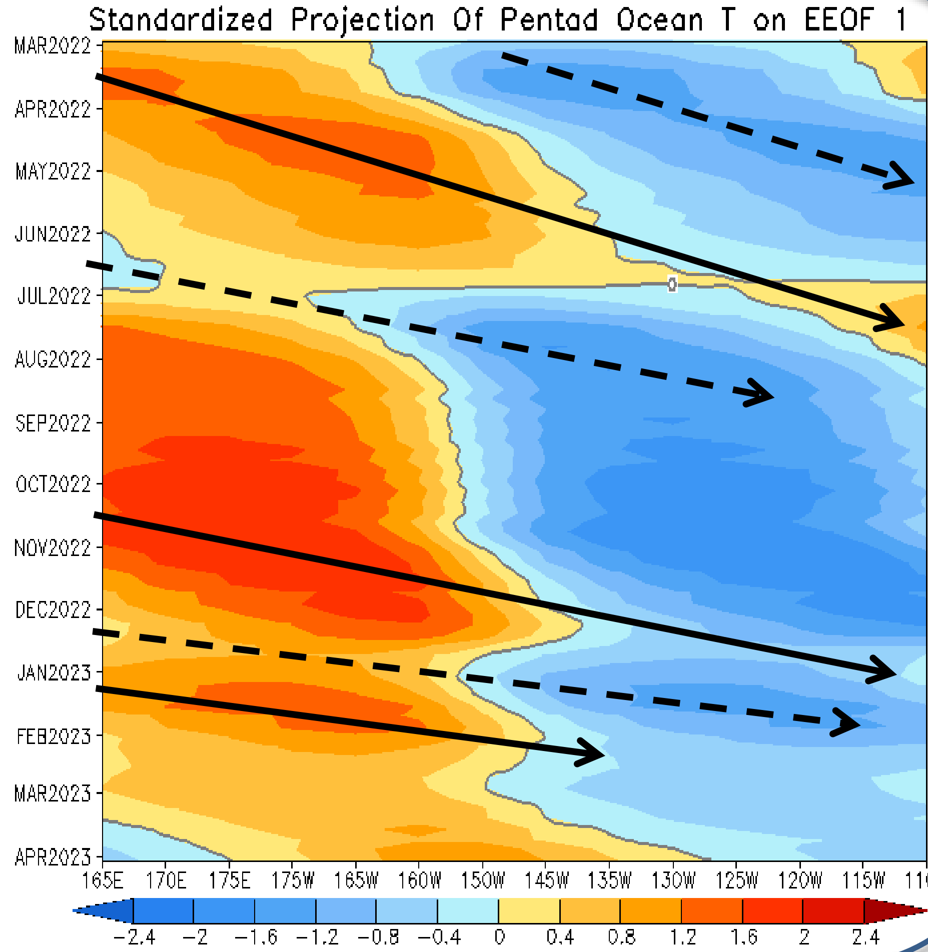
- Relative Niño3.4 index is now included in ENSO monitoring, which is defined as the conventional Niño3.4 index minus the SSTA averaged in the whole tropics (0º-360º, 20ºS-20ºN), in order to remove the global warming signal. Also, to have the same variability as the conventional Niño3.4 index, the relative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

Oceanic Kelvin Wave (OKW) Index



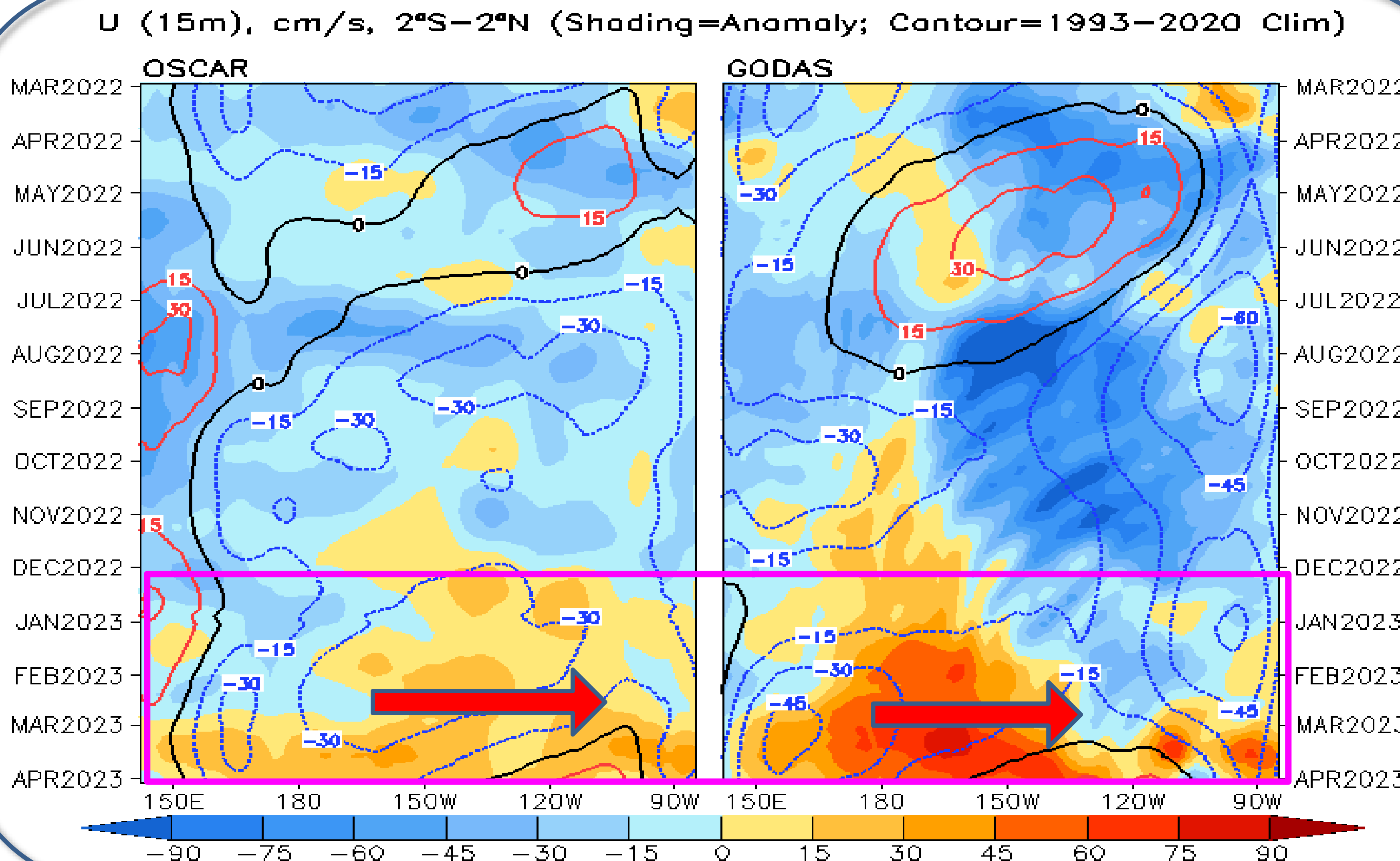


- **Multiple weak downwelling and upwelling Kelvin waves were observed in 2022, leading to the small fluctuation of SSTA in the central and eastern equatorial Pacific.**

- **A weak downwelling Kelvin wave propagated eastward since Jan 2023.**

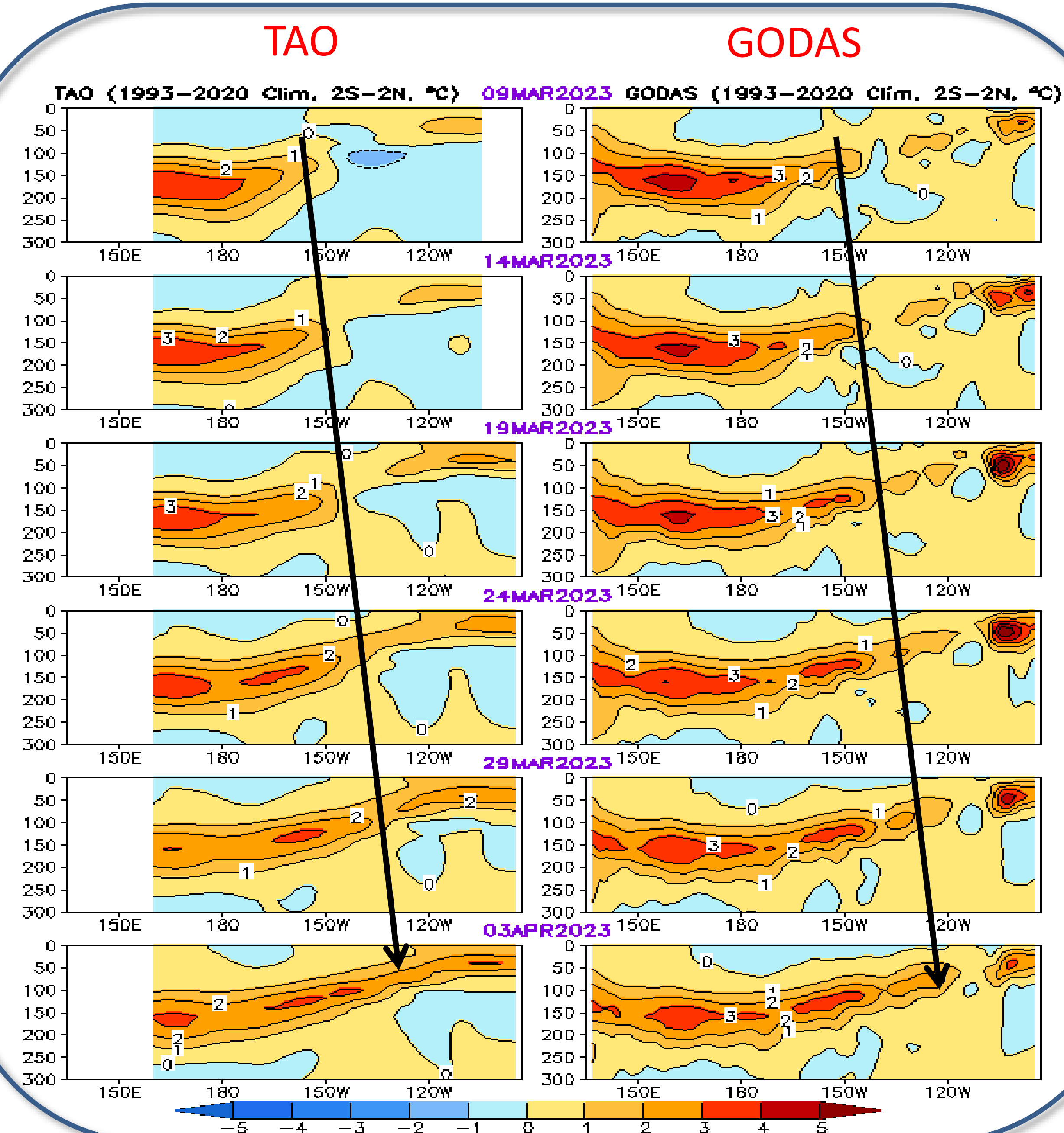
(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)

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



- Anomalous eastward currents were present in the east-central equatorial Pacific in both OSCAR and GODAS since Dec 2022, which were overall consistent with the weakening of the negative SSTA.

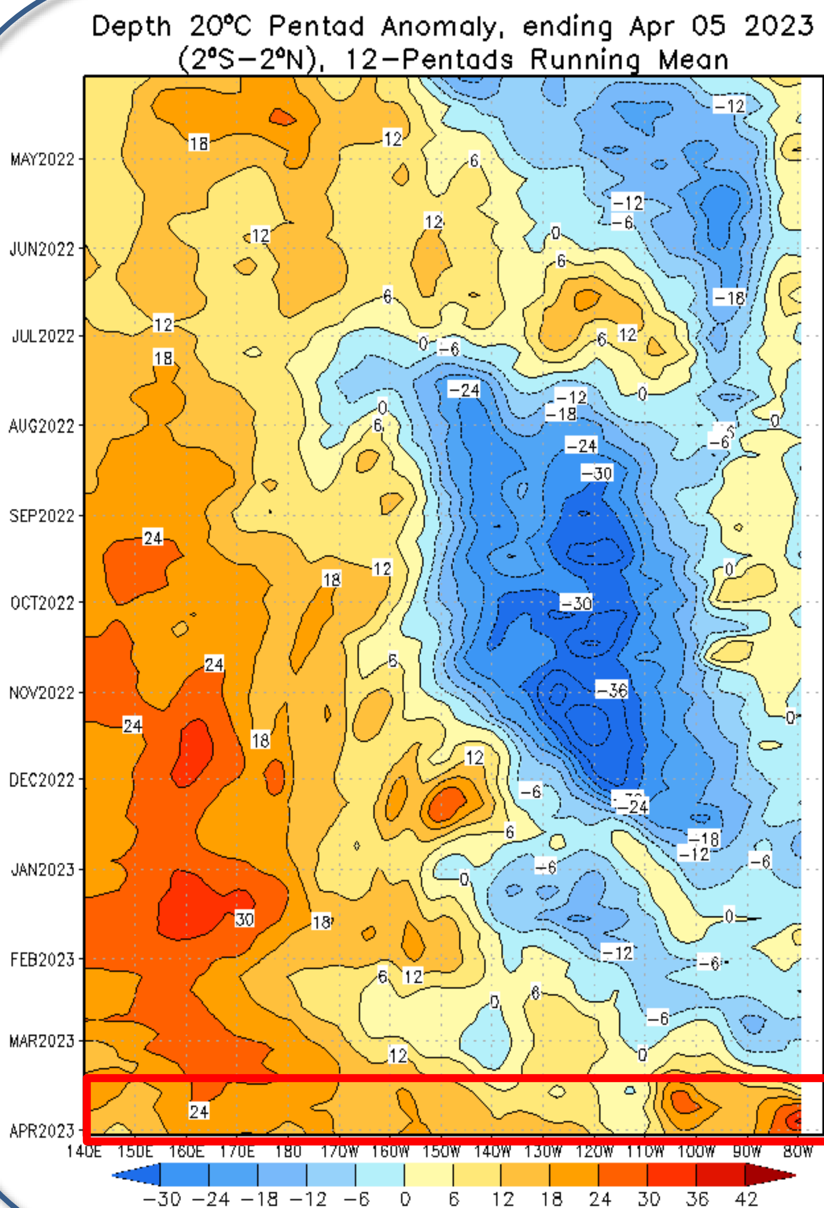
Equatorial Pacific Ocean Temperature Pentad Mean Anomaly

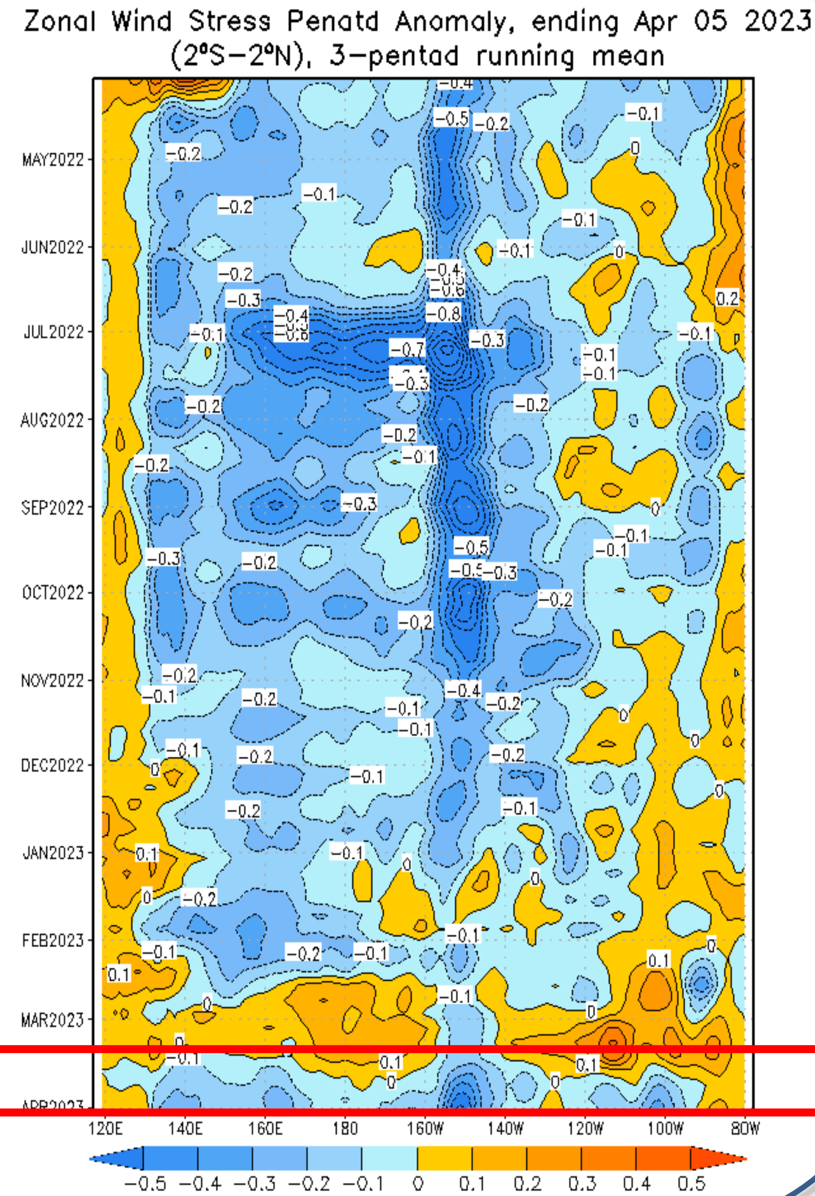


- Positive ocean temperature anomalies along the thermocline extended eastward in the last month.

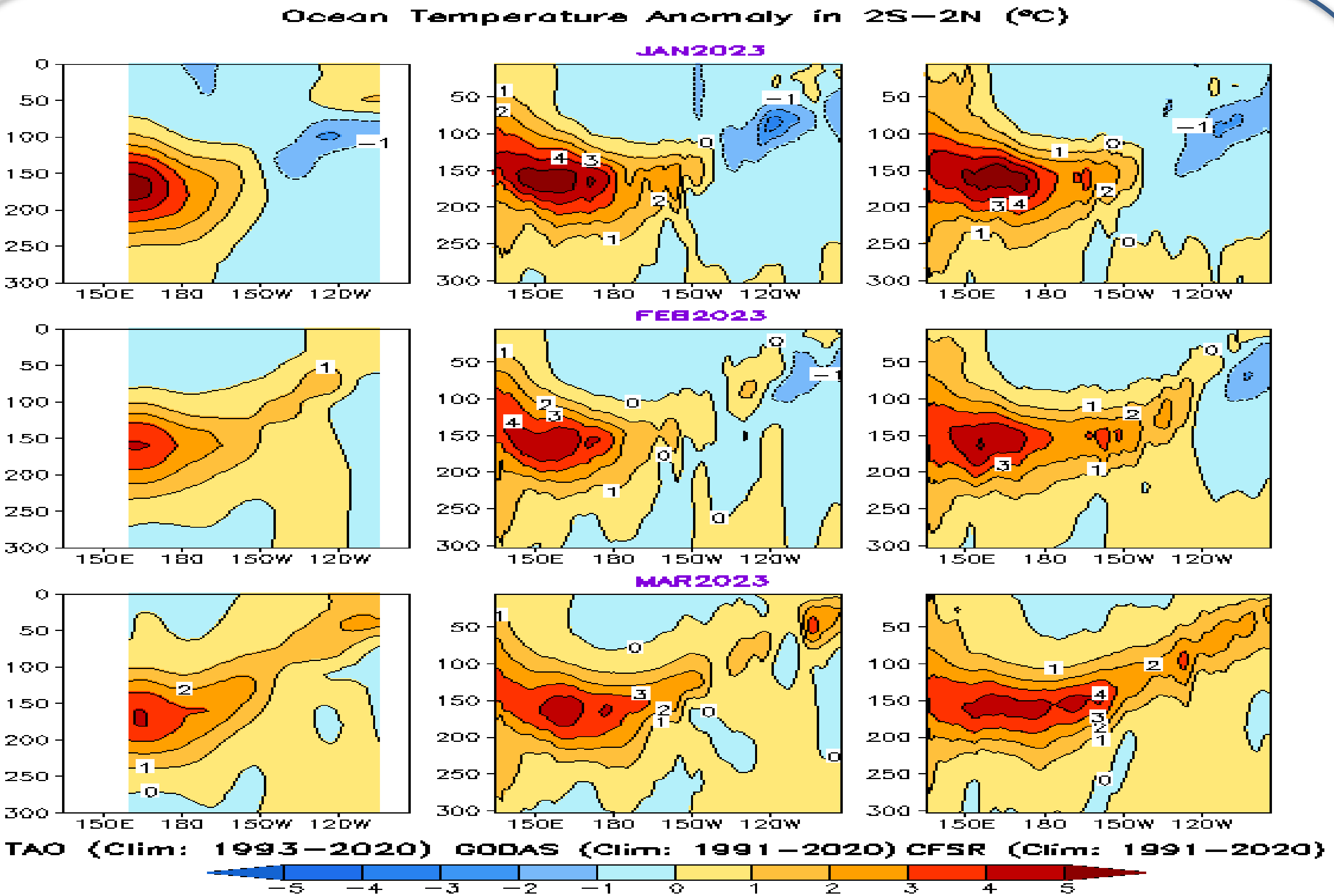
- The features of the ocean temperature anomalies were similar between GODAS and TAO analysis.

Monthly mean subsurface temperature anomaly along the Equator

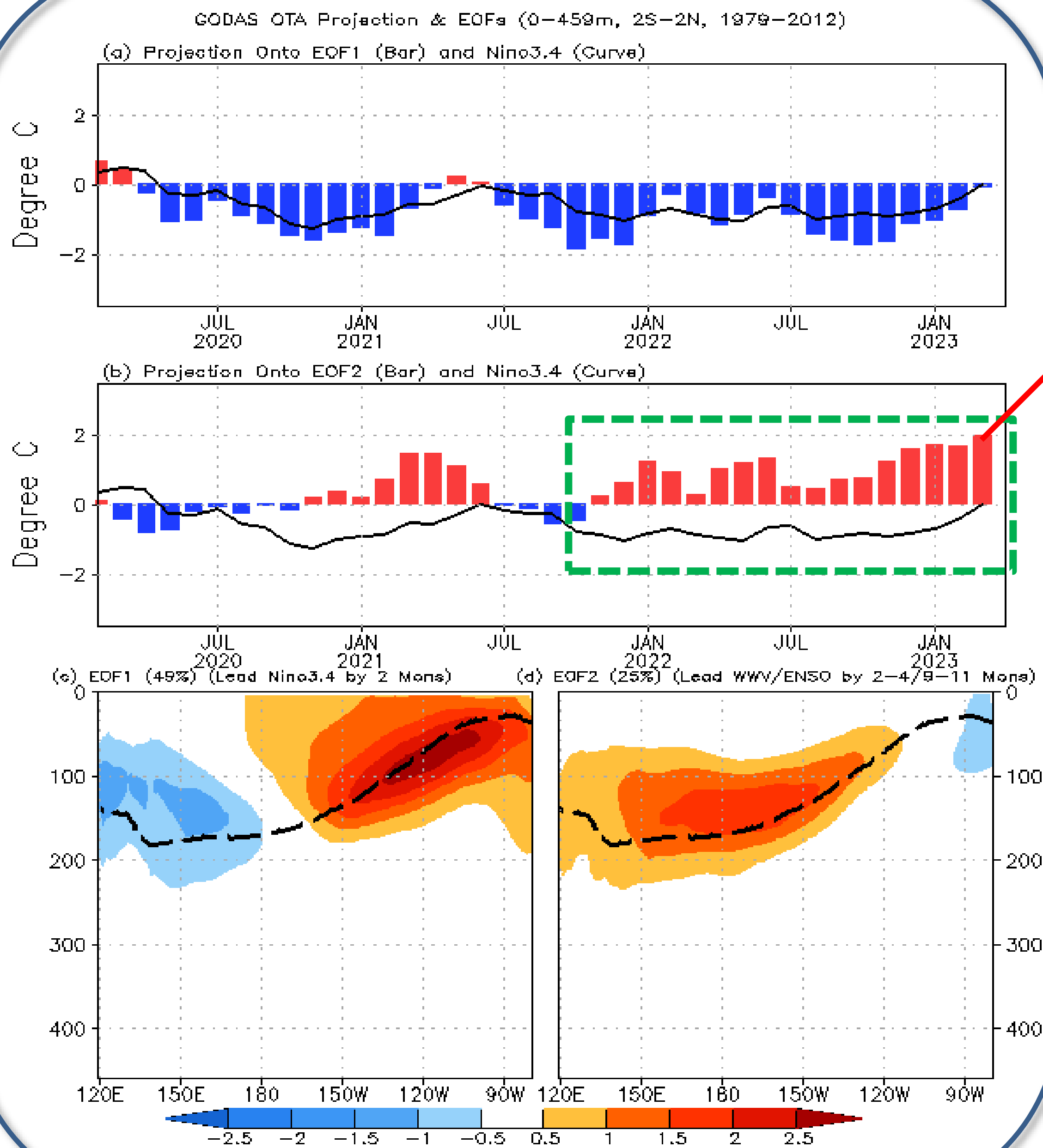




Monthly mean subsurface temperature anomaly along the Equator:
A consistent eastward expansion of the warm anomalies



Equatorial Sub-surface Ocean Temperature Monitoring



- The equatorial Pacific has been in a recharge phase since Nov 2021.

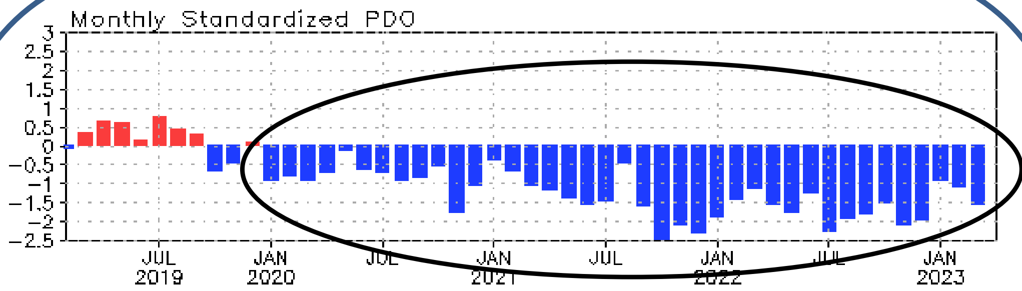
- Projection of ocean temperature anomalies onto EOF1 and EOF2; EOF1: Tilt/dipole mode (ENSO peak phase); EOF2: WWV mode.

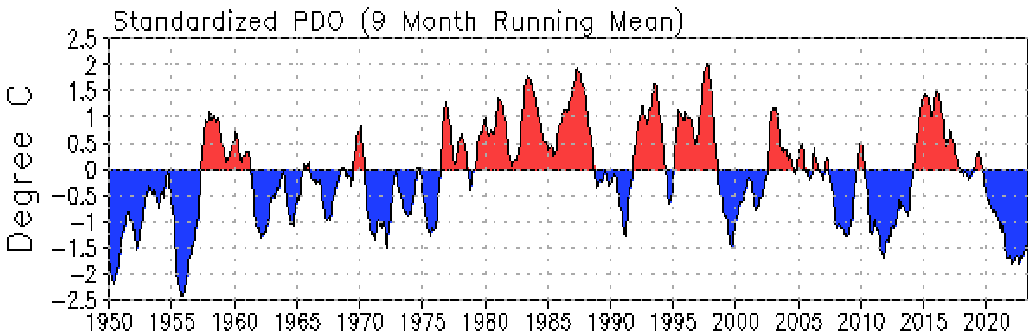
- Recharge/discharge oscillation (ENSO transition phase); Recharge process: heat transport from outside of equator to equator; Negative -> positive phase of ENSO

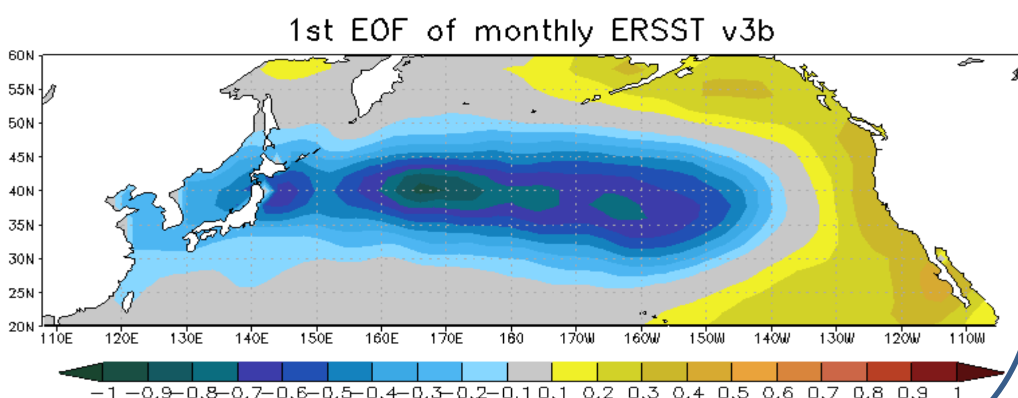
- For details, see: Kumar and Hu (2014) DOI: 10.1007/s00382-013-1721-0.

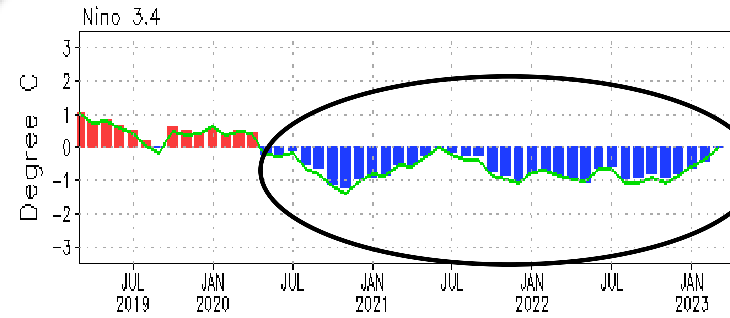
North Pacific & Arctic Oceans

Pacific Decadal Oscillation (PDO) Index







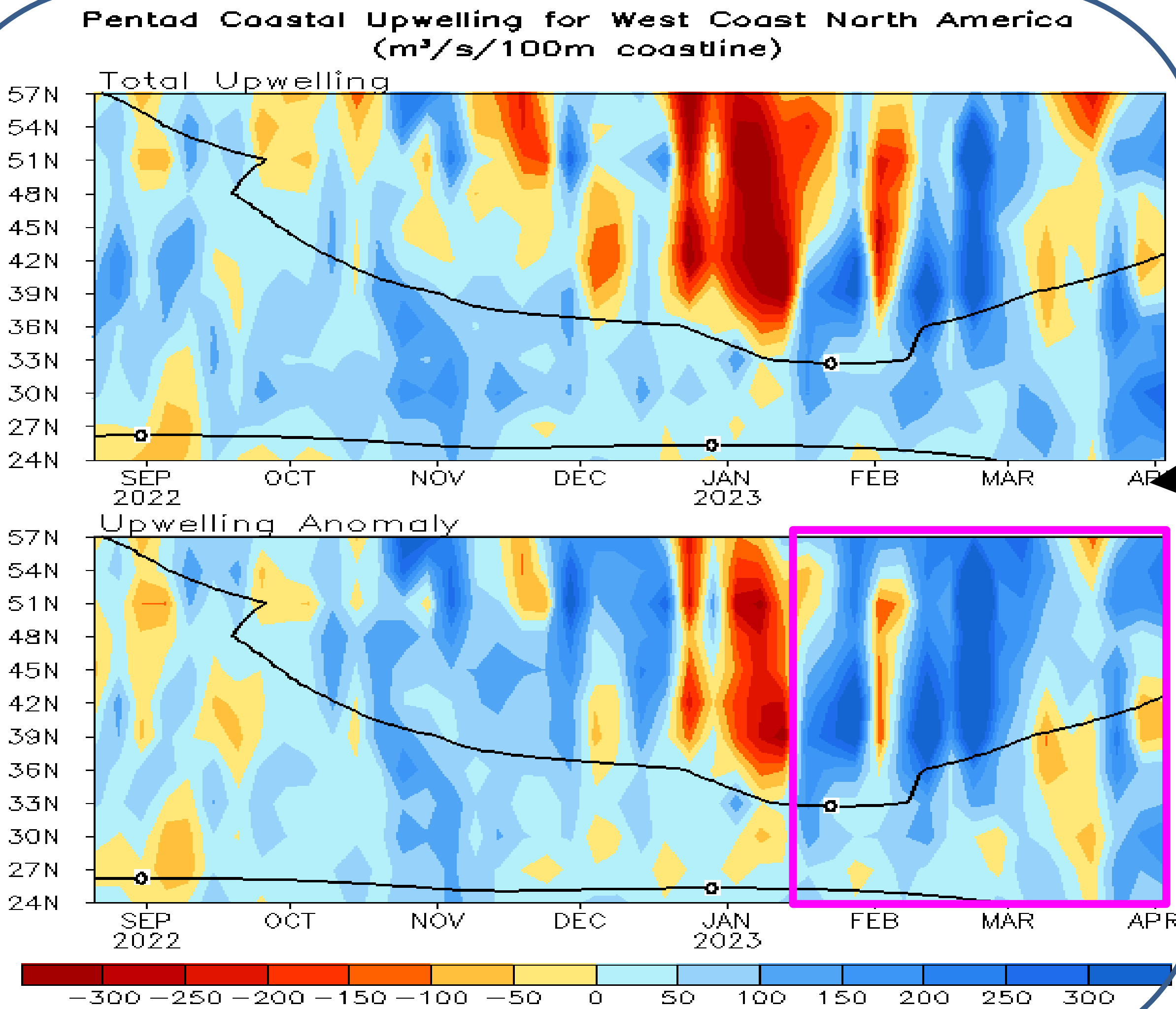


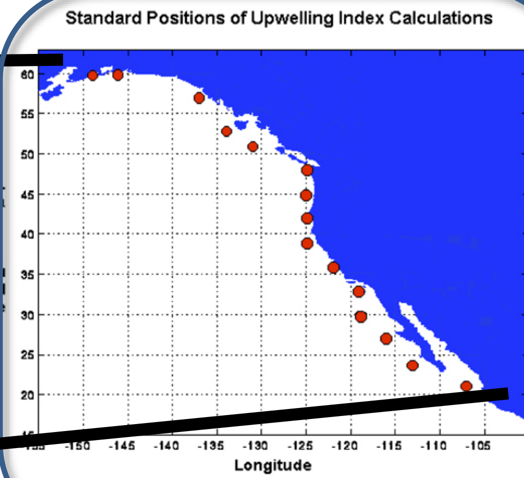
- The PDO has been in a negative phase since Feb 2020 with PDOI = -1.6 in Mar 2023.

- 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

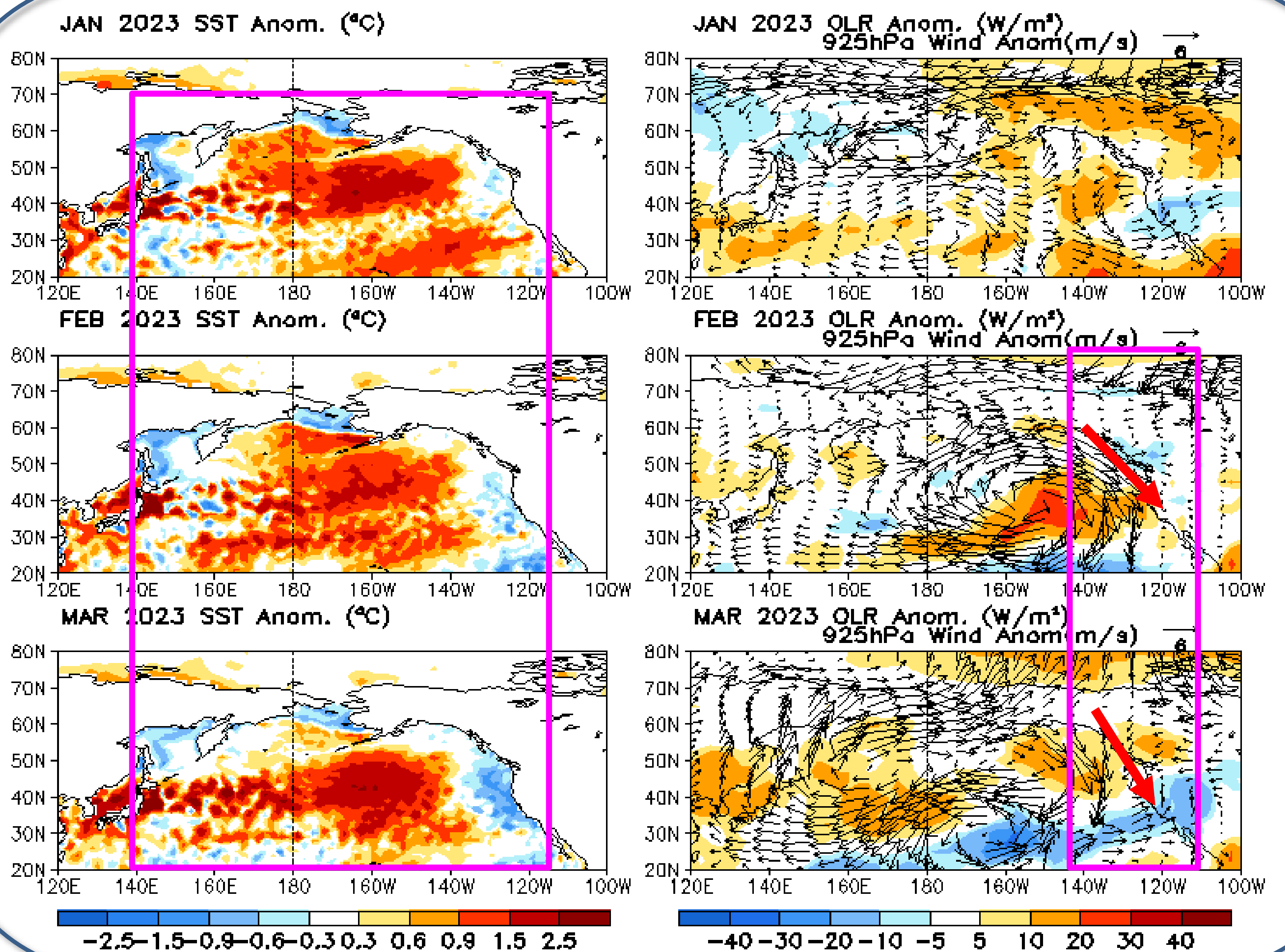




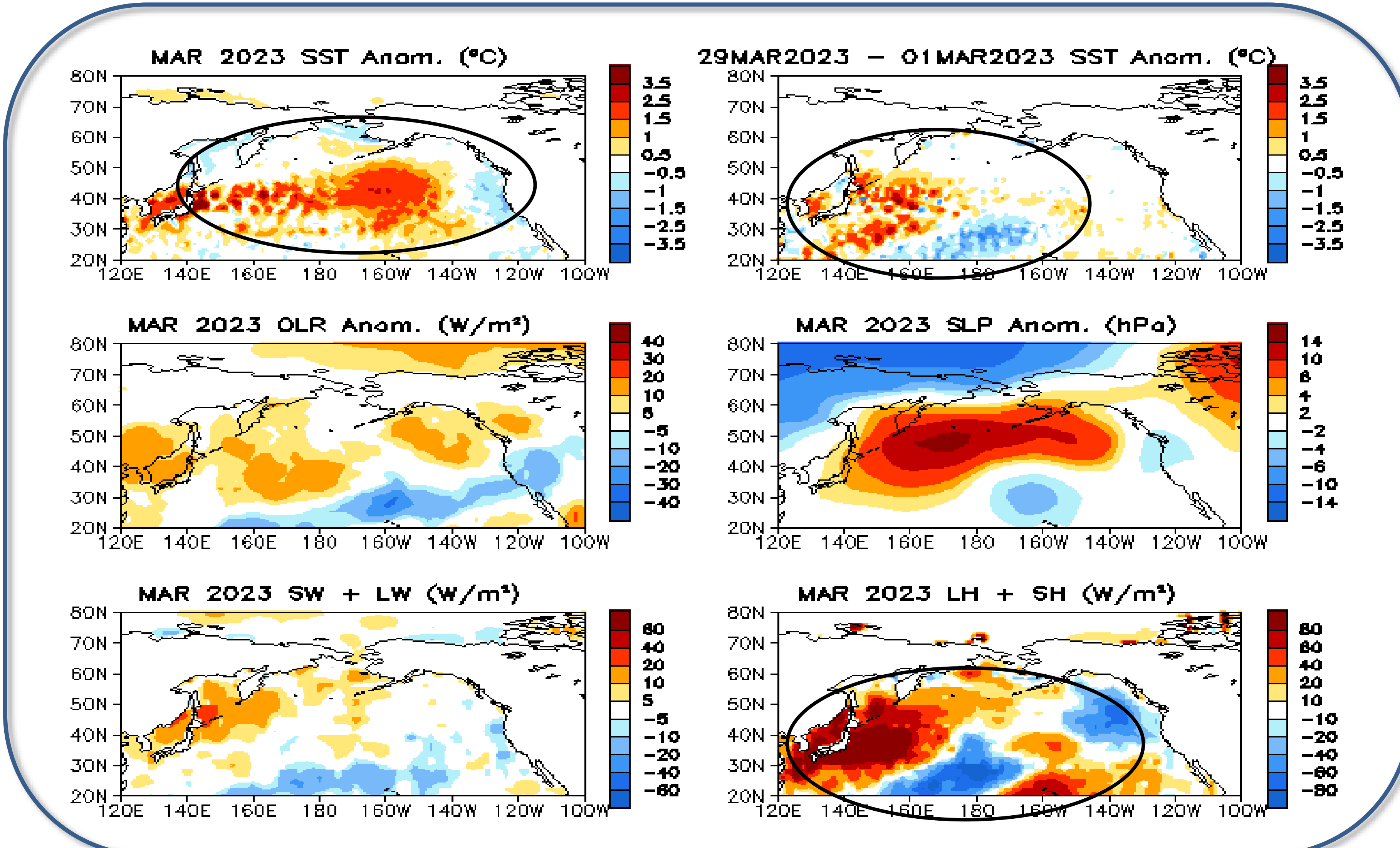
- Coastal anomalous upwelling was observed since mid-Jan 2023.

(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 (m³/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.

North Pacific SST, OLR, and uv925 anomalies

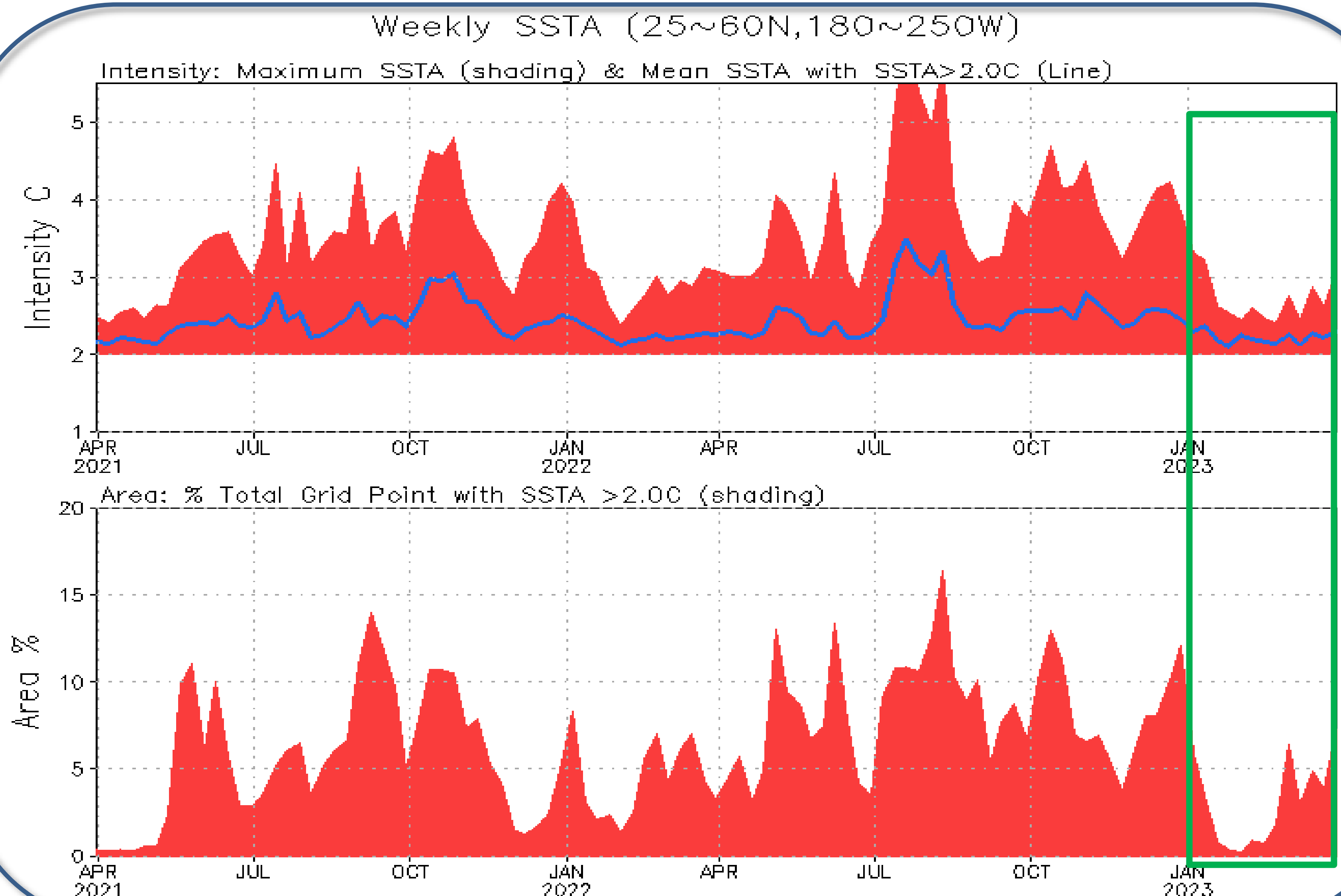


North Pacific & Arctic Ocean: SSTA, SSTA Tend., OLR, SLP, Sfc Rad, Sfc Flx Anomalies



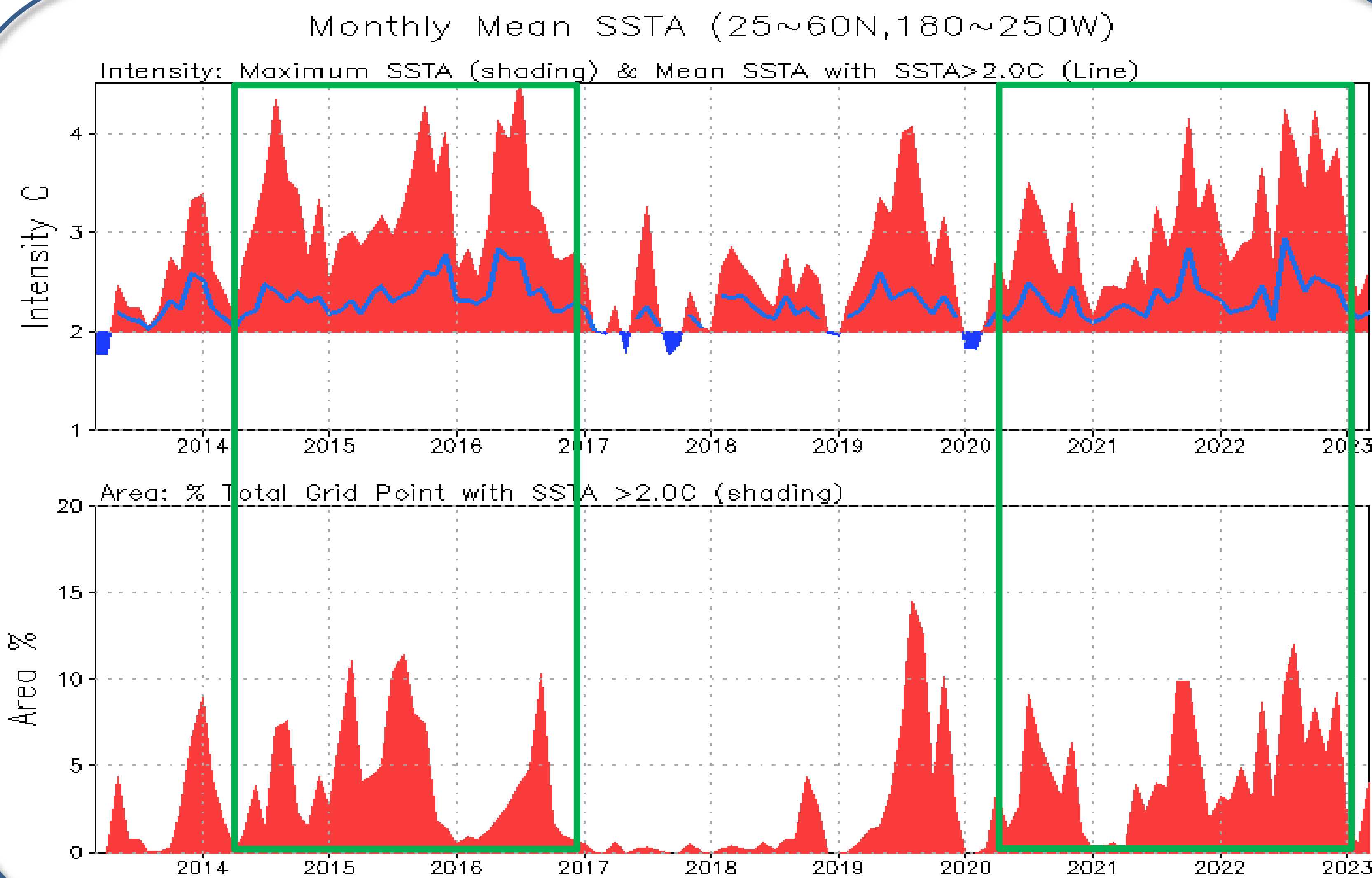
SSTA (top-left; OIv2.1 SST Analysis), SSTA tendency (top-right), Outgoing Long-wave Radiation (OLR) (middle-left; NOAA 18 AVHRR IR), sea surface pressure (middle-right; NCEP CDAS), sum of net surface short- and long-wave radiation (bottom-left; positive means heat into the ocean; NCEP CDAS), sum of latent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

N. Pacific Marine Heat Wave: Declined since Jan 2023



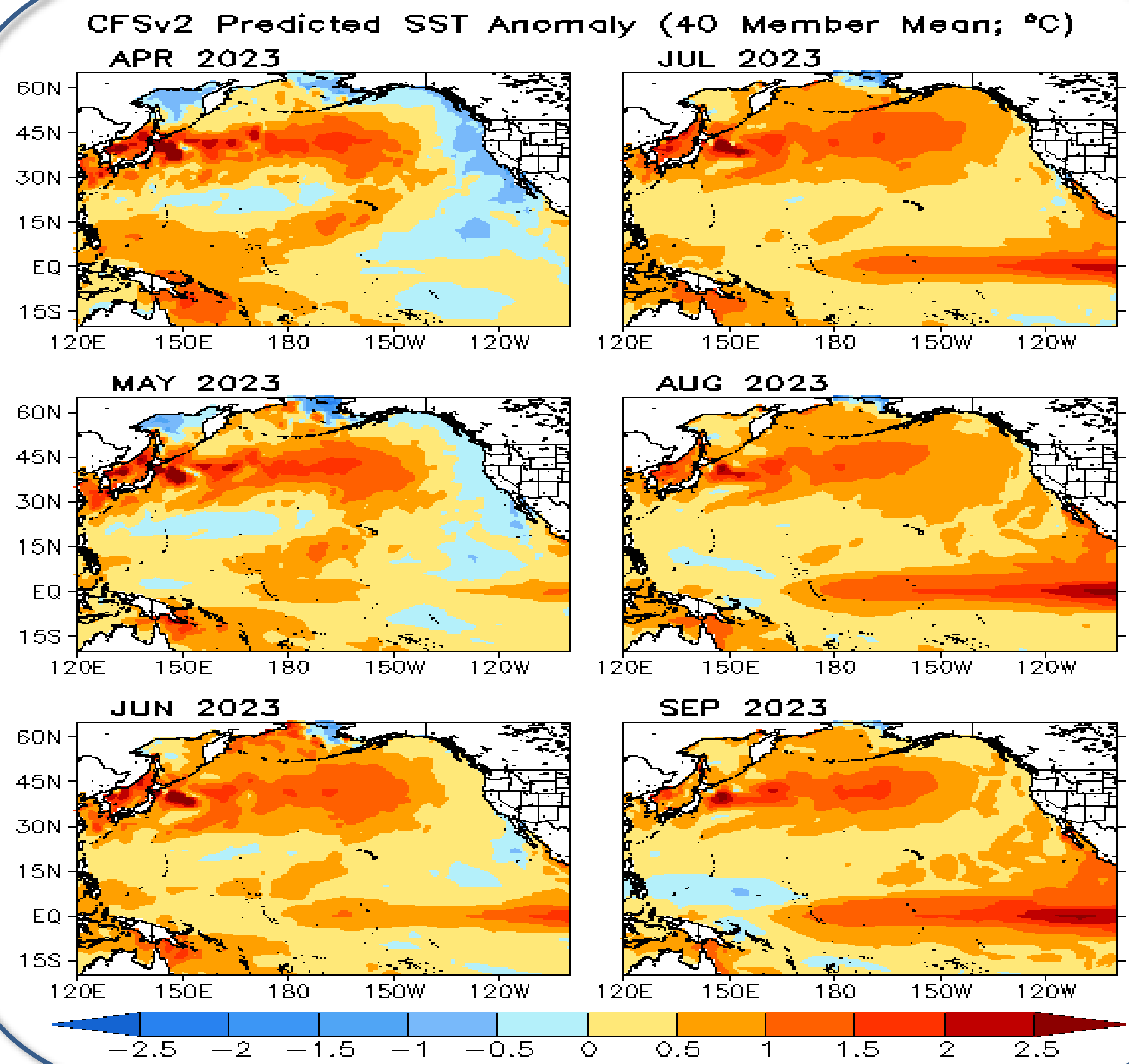
https://origin.cpc.ncep.noaa.gov/products/GODAS/MarineHeatWave.html

N. Pacific Marine Heat Wave



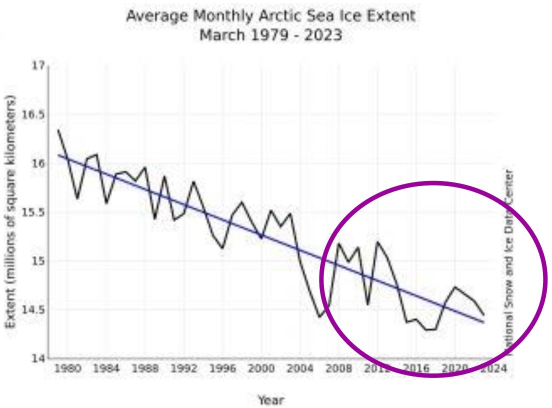
https://origin.cpc.ncep.noaa.gov/products/GODAS/MarineHeatWave.html

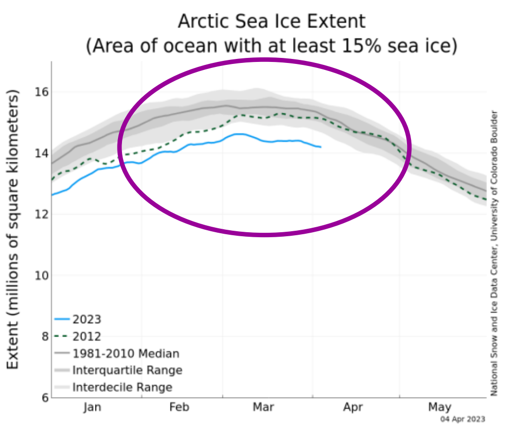
CFSv2 NE Pacific SSTA Predictions

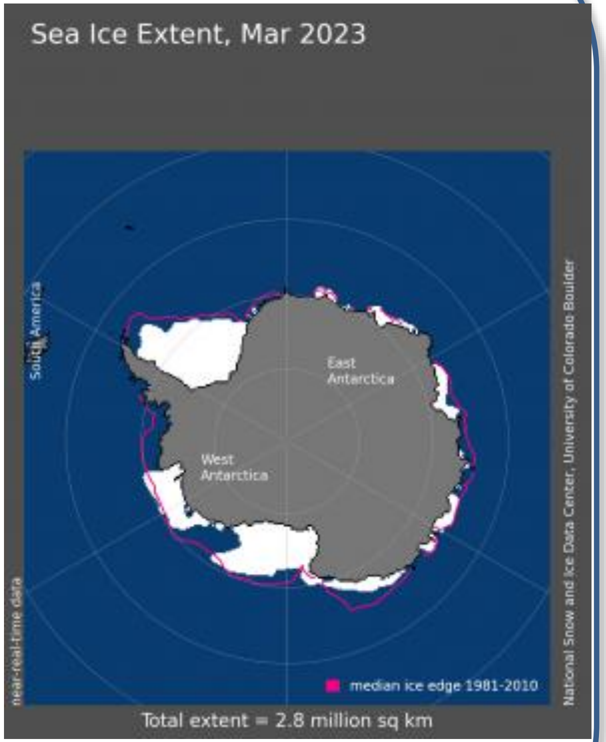


- The CFSv2 predicts above normal SSTs in the N. Pacific during spring – autumn 2023.

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

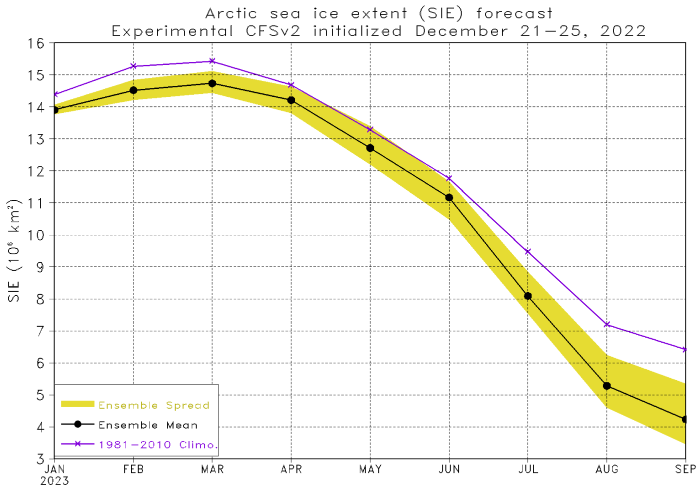


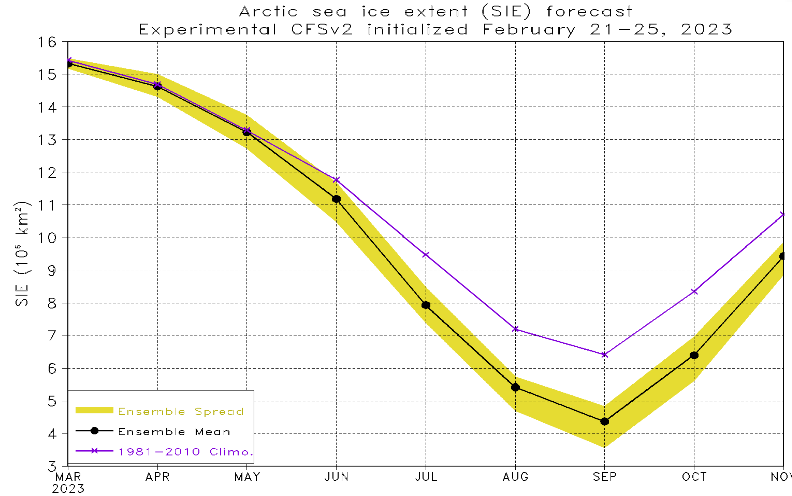


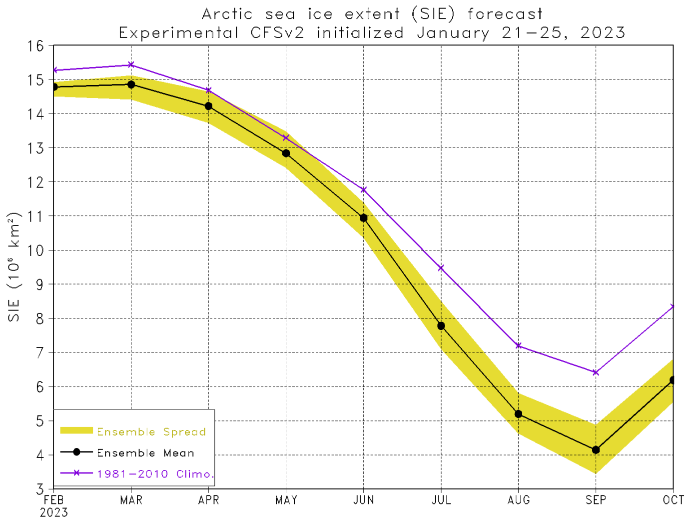


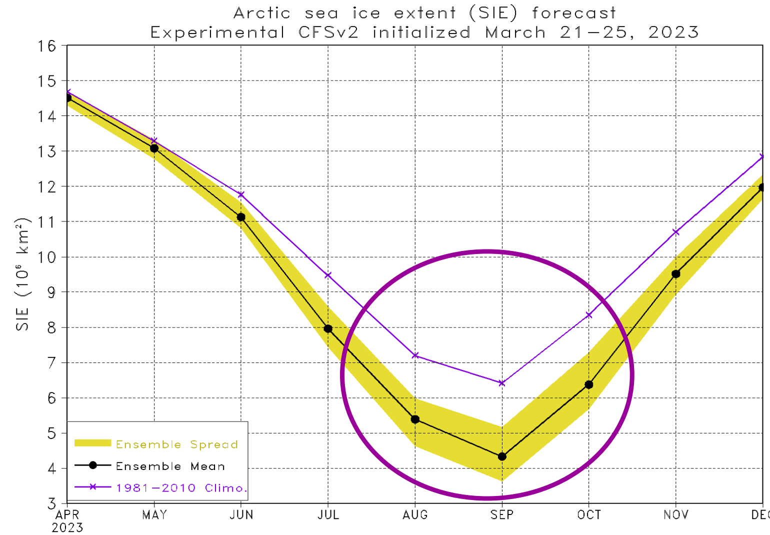
- The Mar 2023 average Arctic sea ice extent was 14.44 million square kilometers, the sixth lowest March in the satellite record.
- The downward linear trend for Arctic sea ice extent in March over the 45-year satellite record is 2.5% per decade relative to the 1981 to 2010 average.
-The March 2023 average sea ice extent around Antarctica was 2.80 million square kilometers, the second lowest March on record.

NCEP/CPC Arctic Sea Ice Extent Forecast





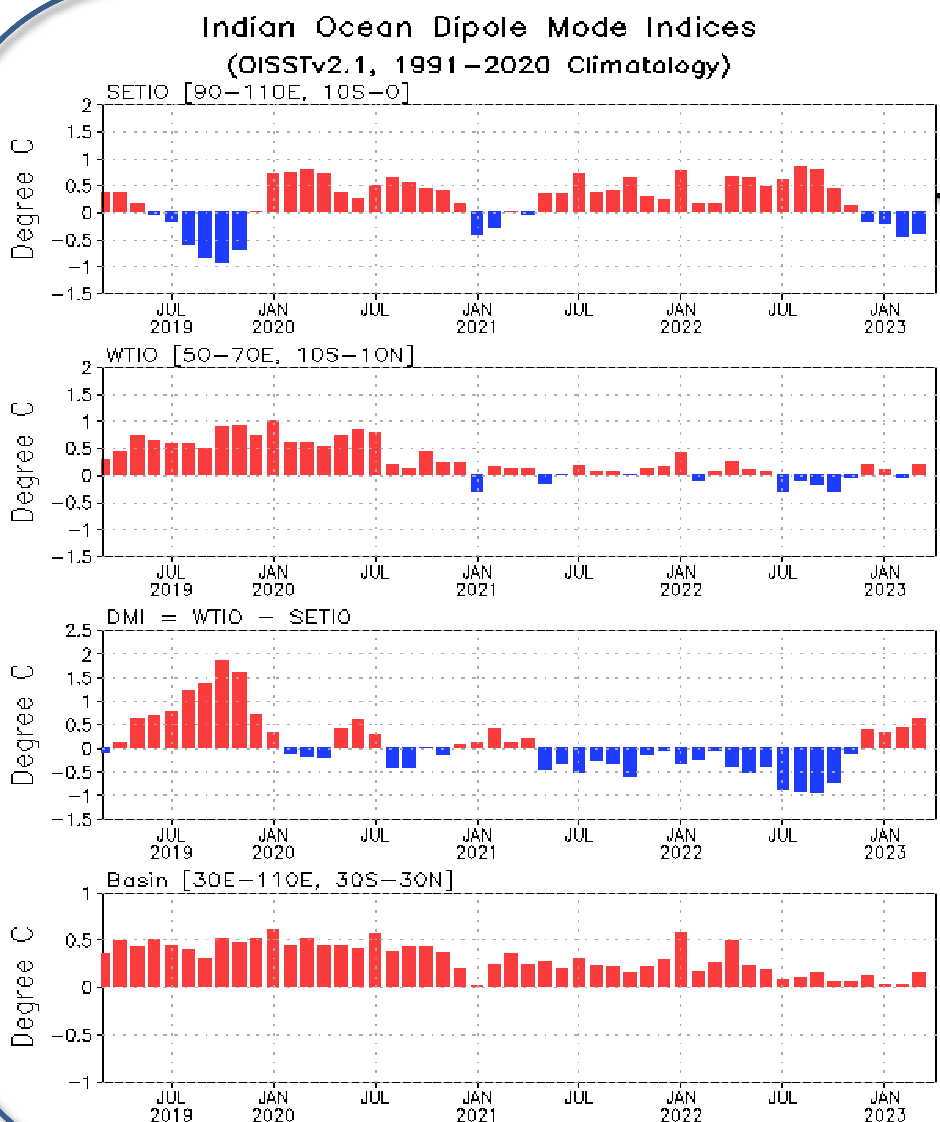


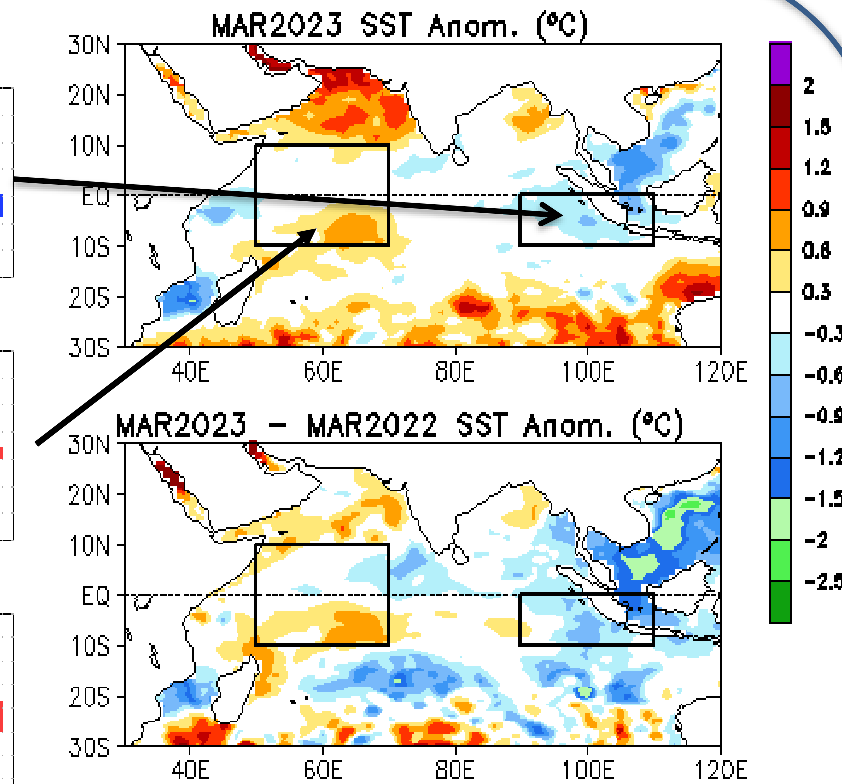


https://www.cpc.ncep.noaa.gov/products/people/wwang/seaice_seasonal/index.html

Indian Ocean

Evolution of Indian Ocean SST Indices



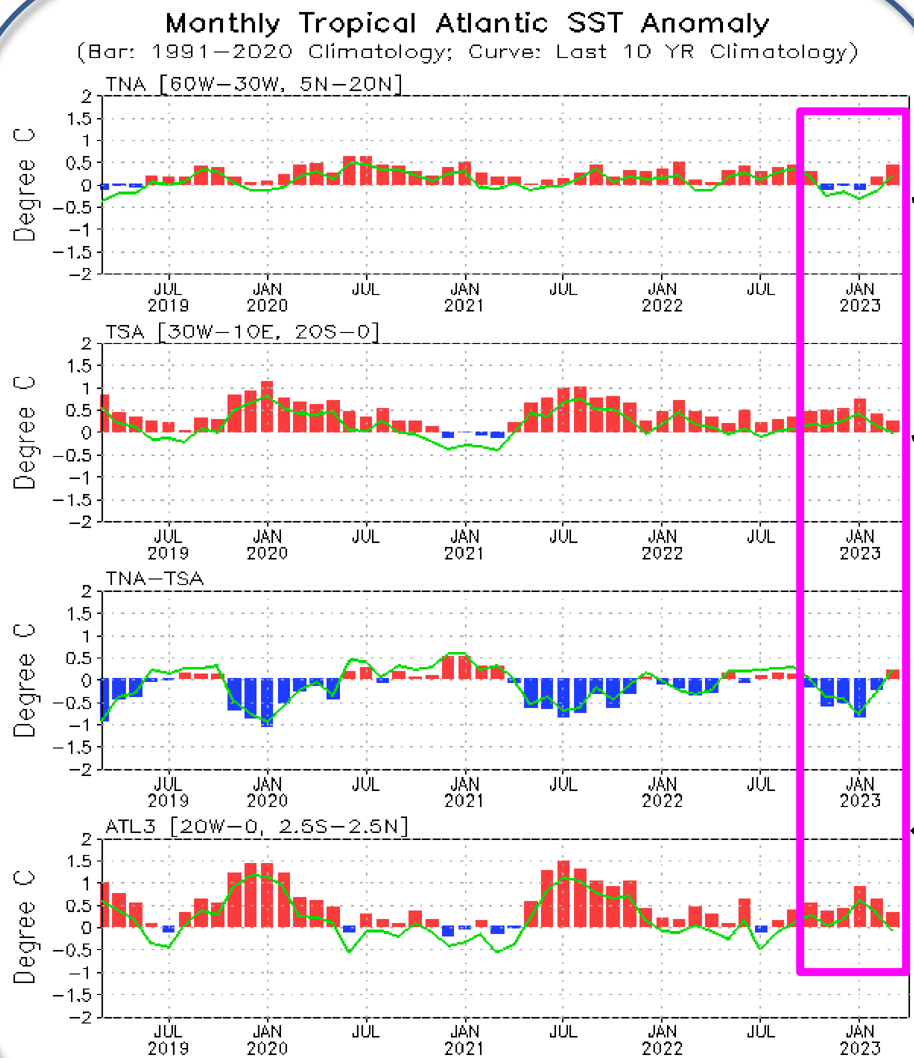


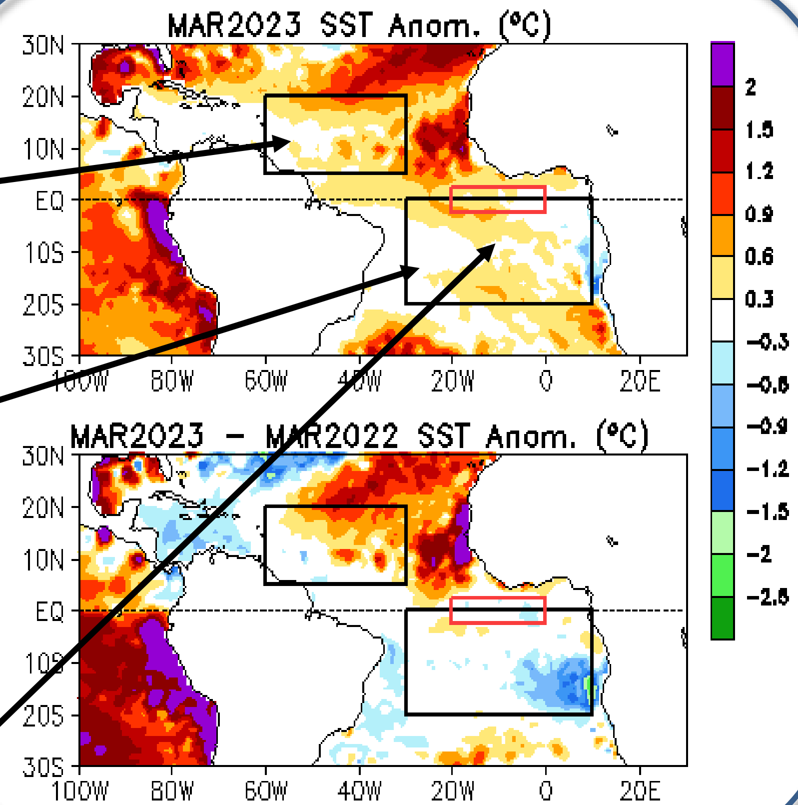
- Positive (negative) SSTAs were in the western (southeastern) tropical Indian Ocean in Mar 2023, resulting in a positive value of IOD index.

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 and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

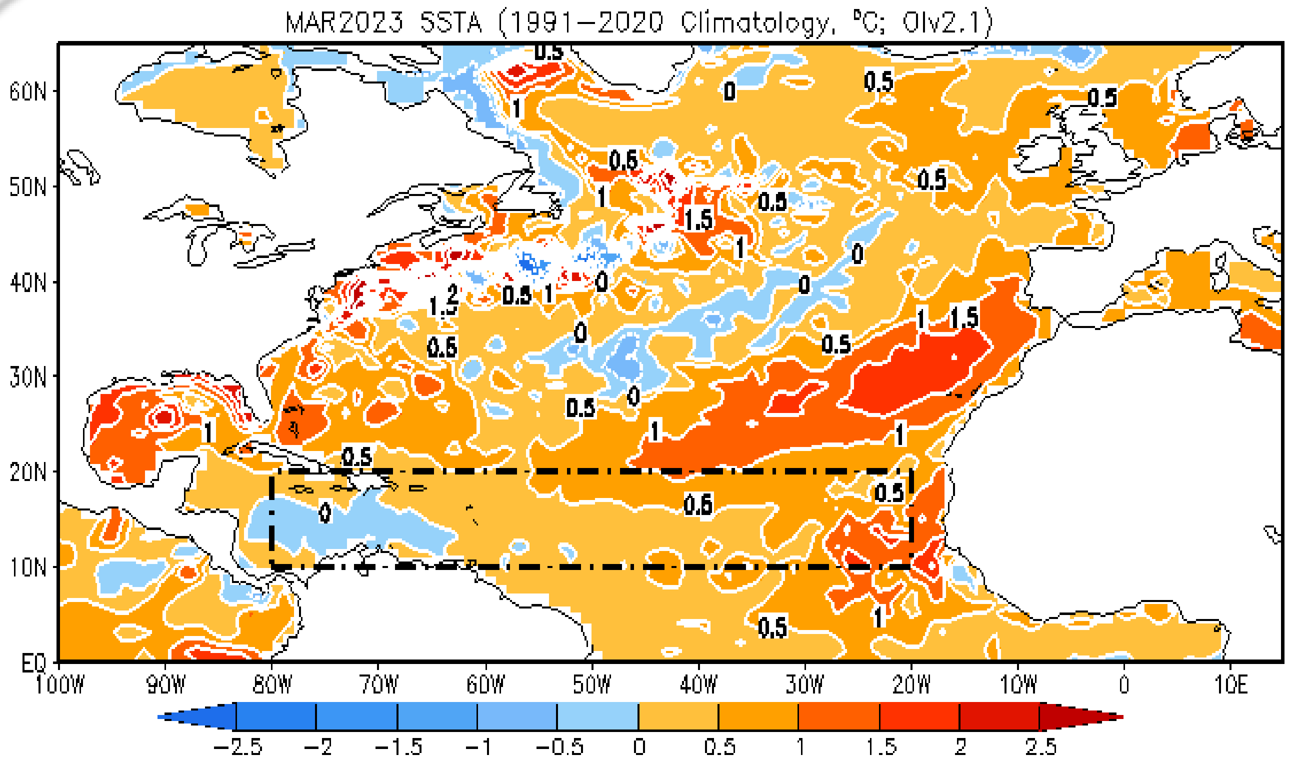


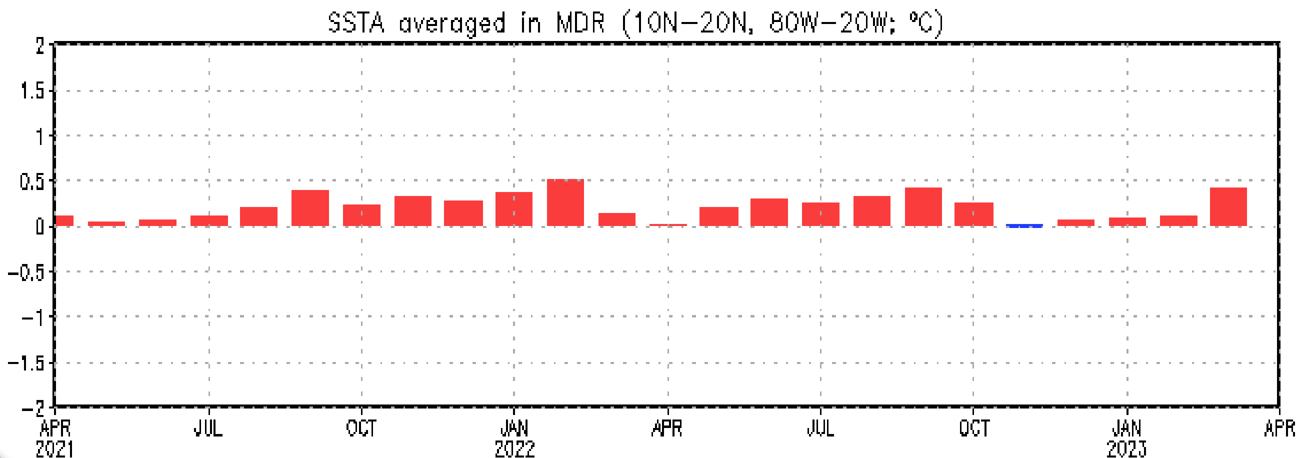


- Positive SSTAs were in the tropical South and North Atlantic.
- Positive ATL3 index weakened in Mar 2023.

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.

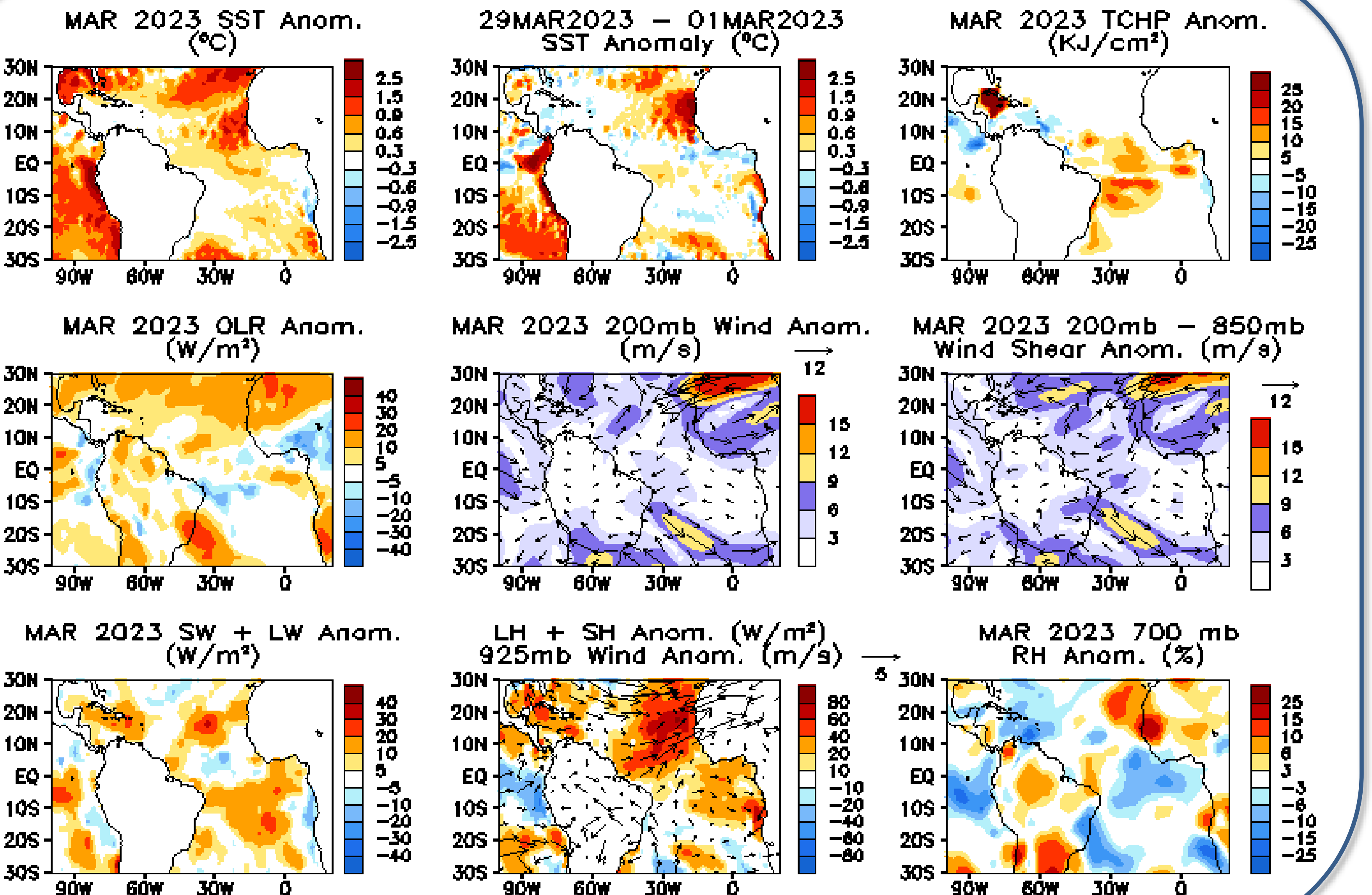
SSTAs in the North Atlantic & MDR



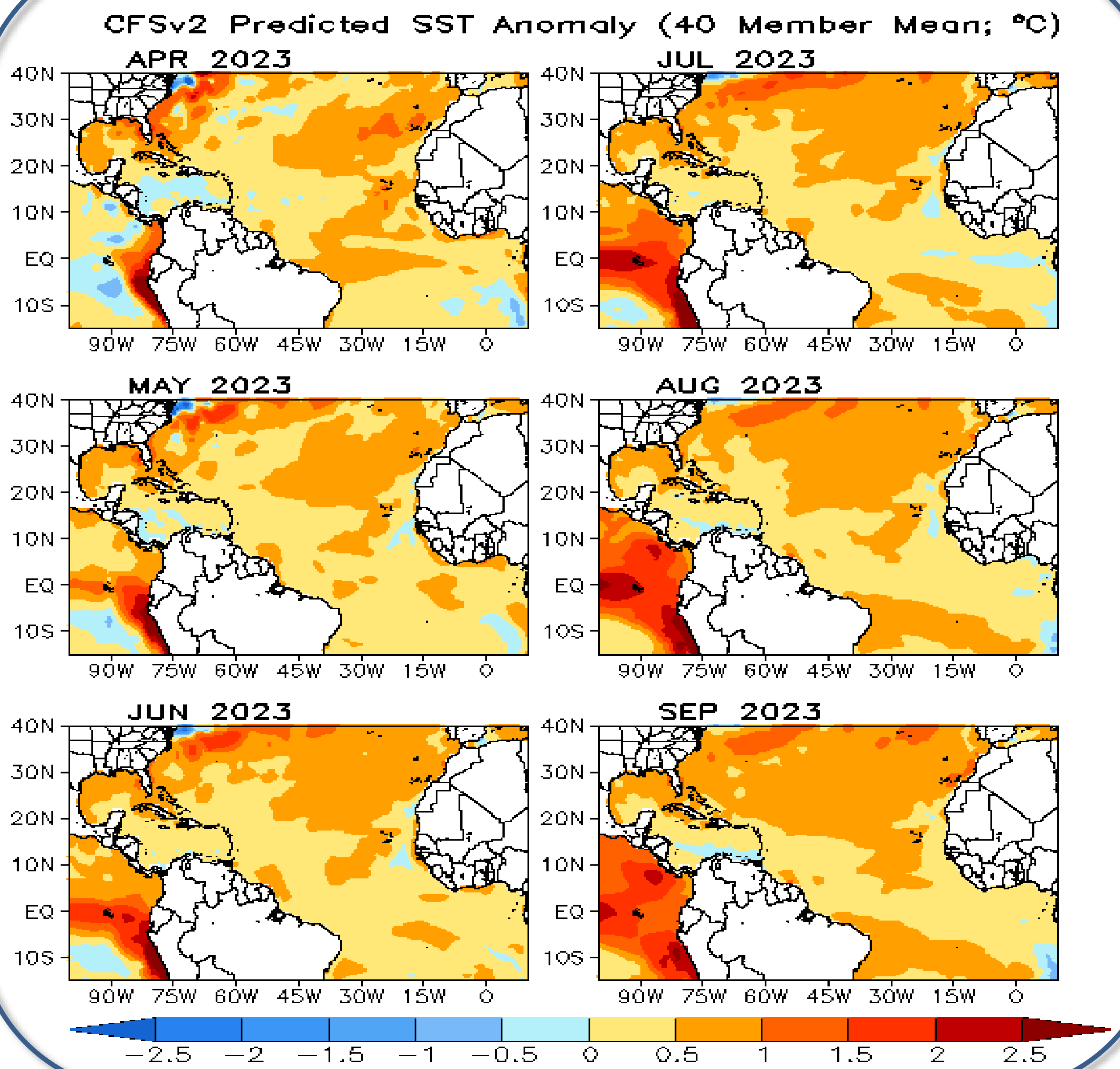


- SST in MDR was above average in Mar 2023.

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

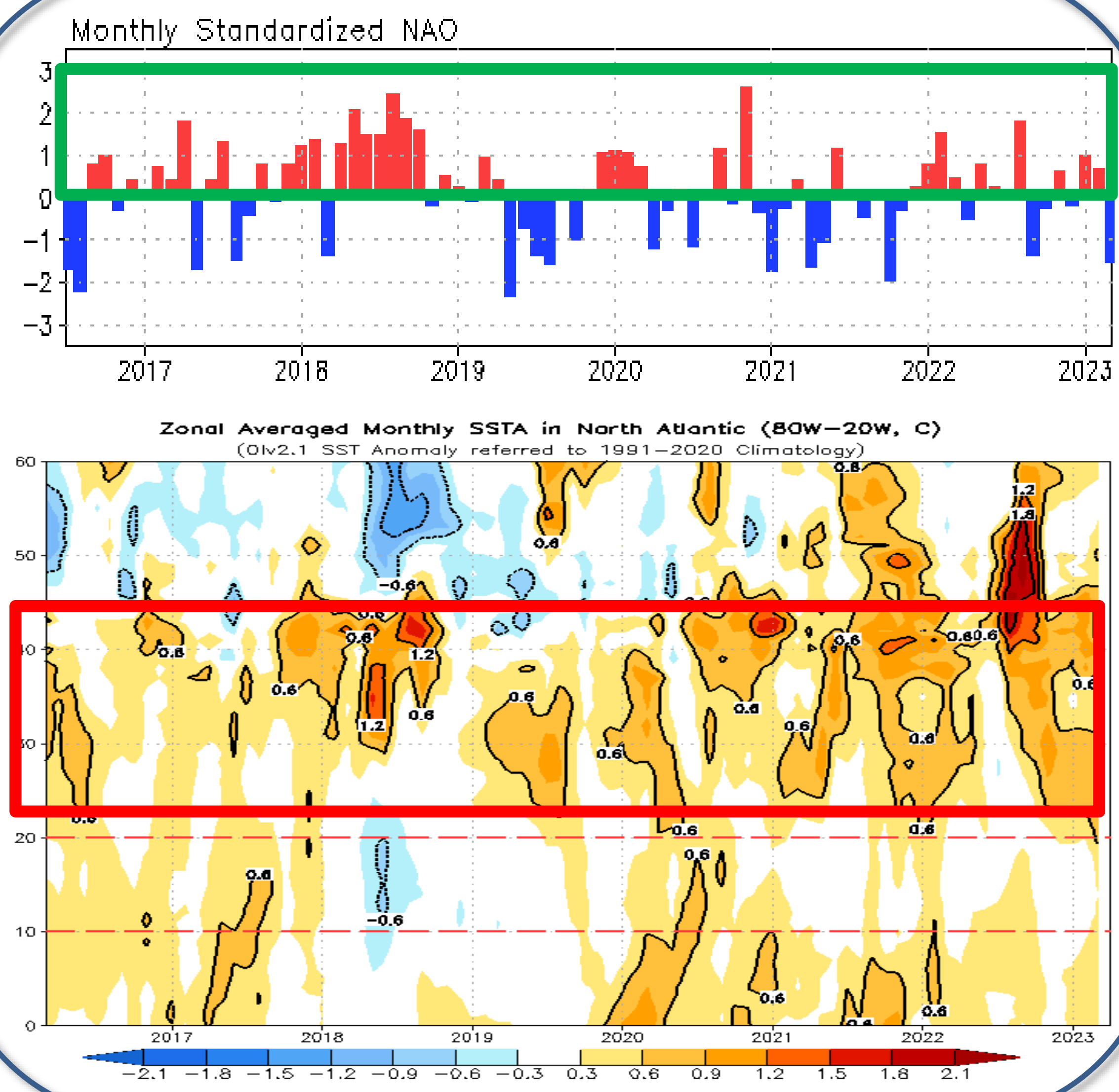


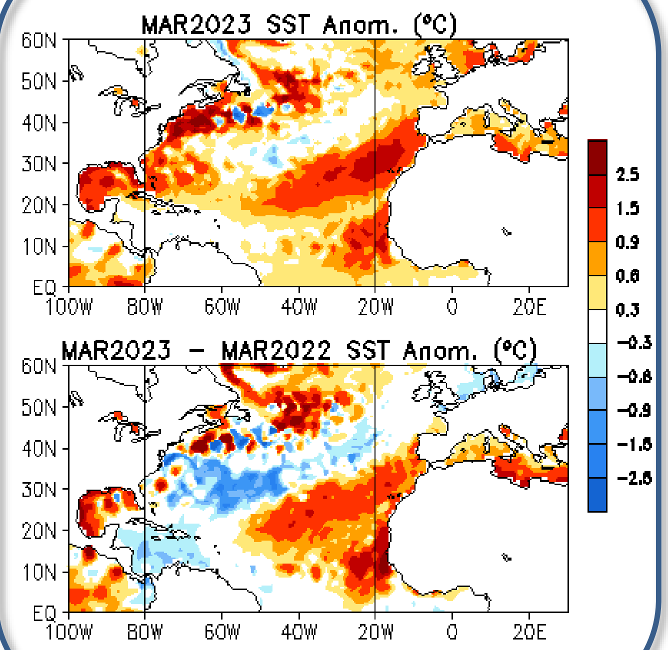
CFSv2 Atlantic SSTA Predictions



- The latest CFSv2 predictions call for above-normal SST in the middle latitudes of the N. Atlantic in the next 6 months.

NAO and SST Anomaly in North Atlantic



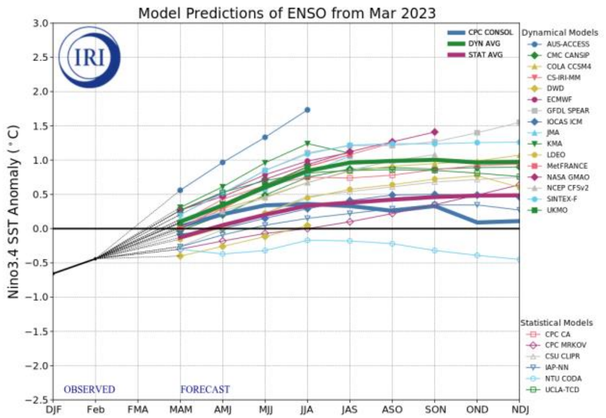


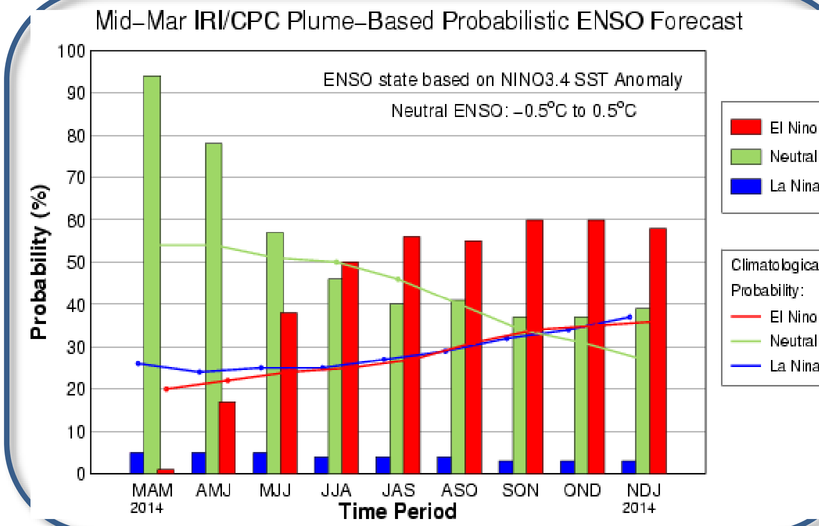
- NAO switched to a negative phase in Mar 2023 with NAOI= -1.6.
- The prolonged positive SSTAs in the middle latitudes were evident, due to dominance of the positive phase of NAO during the last 5-6 years.

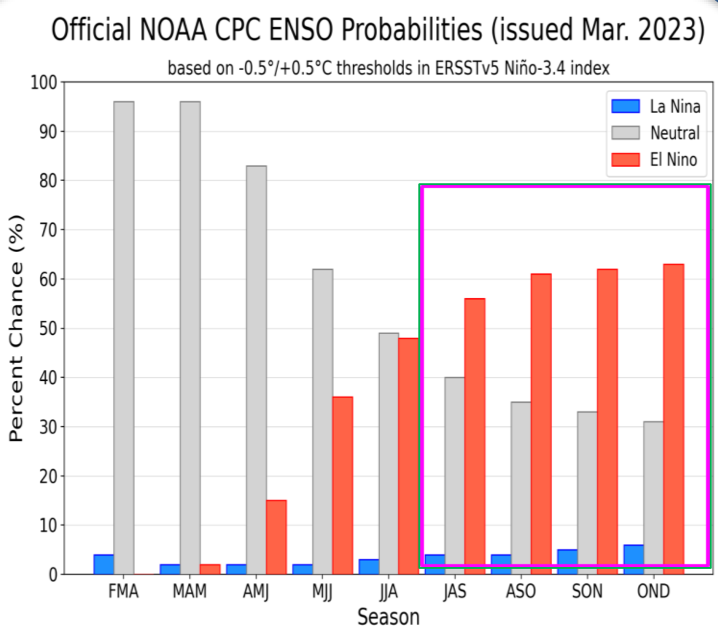
Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20^{O}N-90^{O}N. Time-latitude section of SSTAs averaged between 80ºW and 20ºW (bottom). SST are derived from the OIv2.1 SST analysis, and anomalies are departures from the 1991-2020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

ENSO and Global SST Predictions

IRI/CPC Niño3.4 Forecast

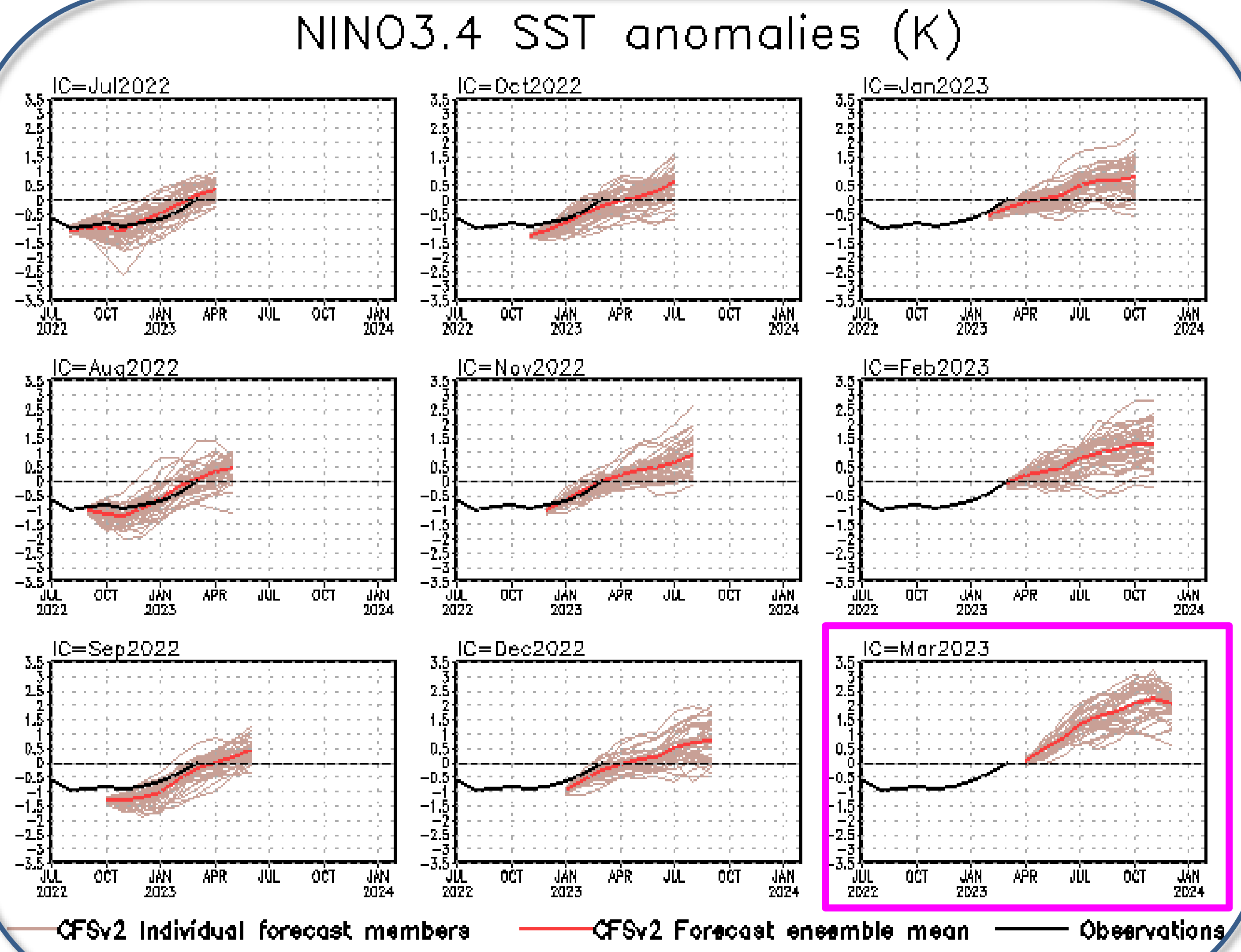






- **ENSO Alert System Status: Final La Niña Advisory**
- <u>Synopsis:</u> *"La Niña has ended and ENSO-neutral conditions are expected to continue through the Northern Hemisphere spring and early summer 2023."*

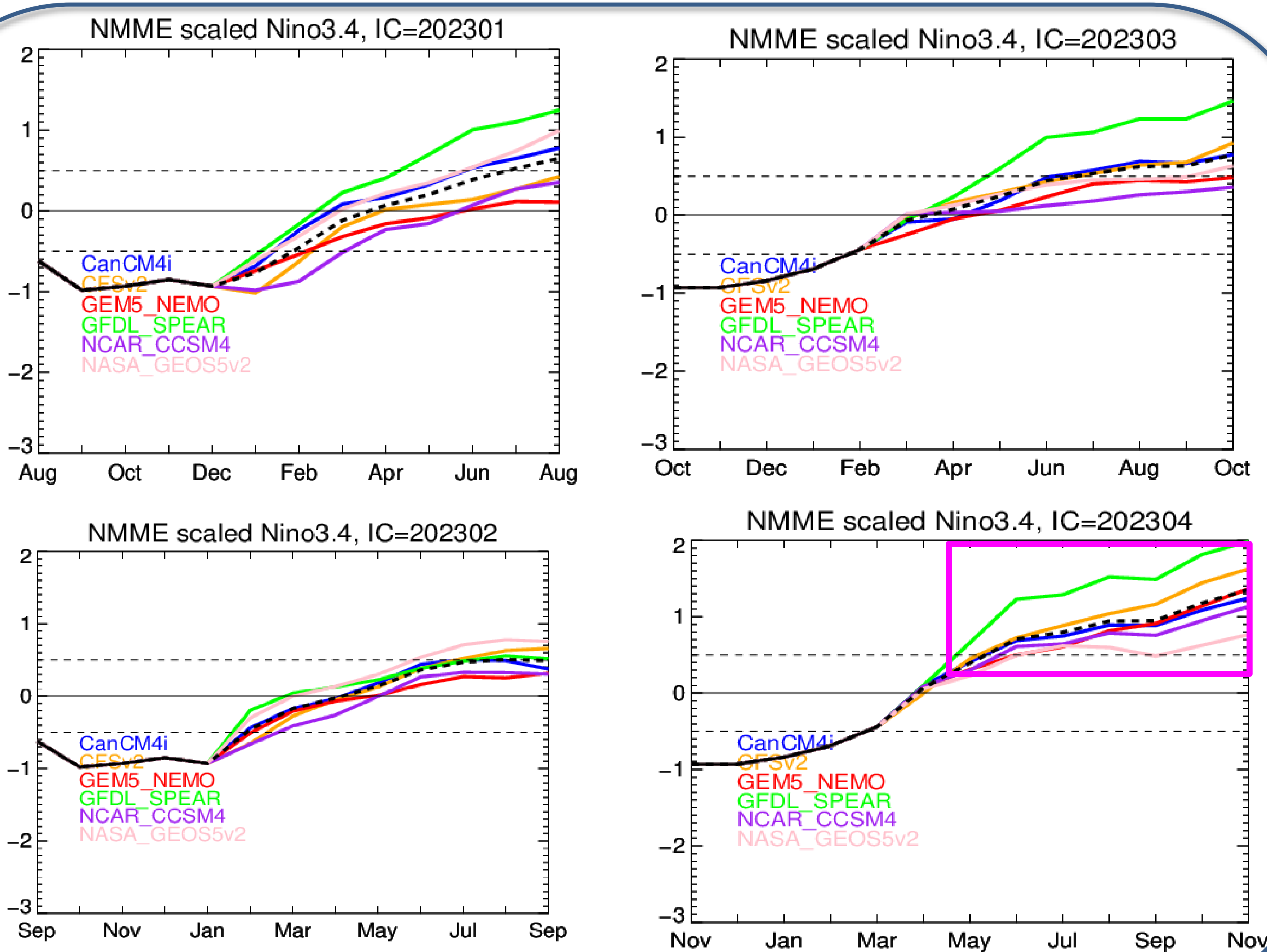
CFS Niño3.4 SST Predictions from Different Initial Months



- The latest CFSv2 forecasts call for an El Niño in the second half of 2023.

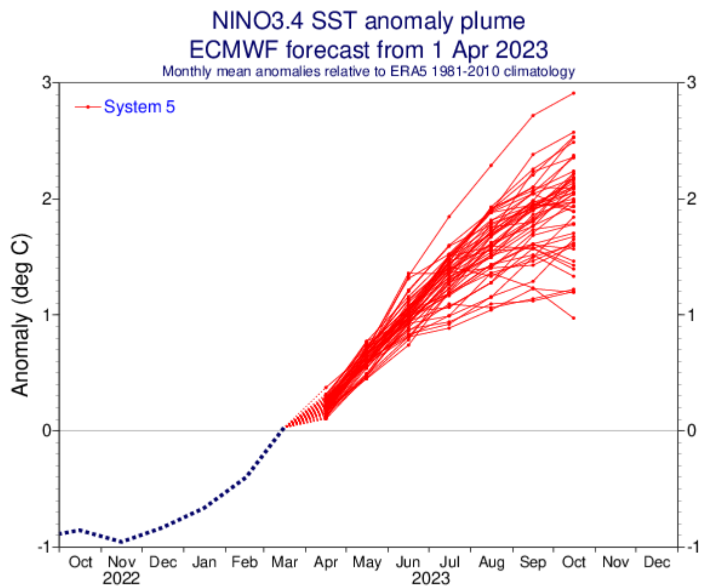
CFS Niño3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect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

NMME forecasts from different initial conditions

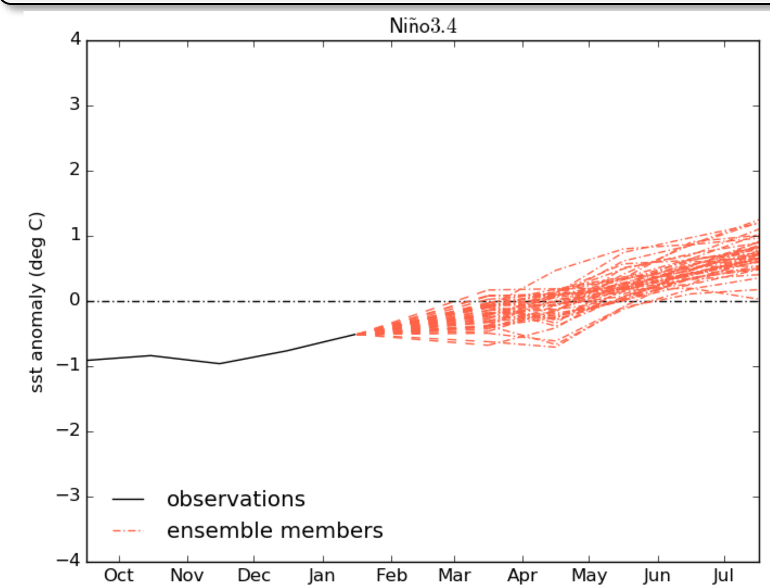


Individual Model Forecasts: La Niña will return to neutral in spring

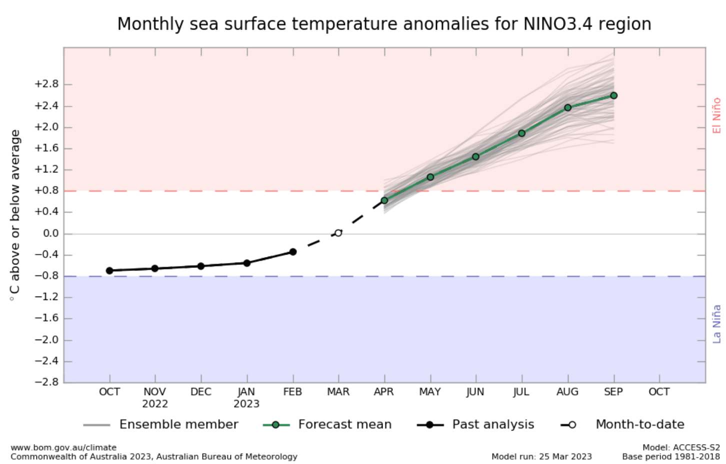
EC: Niño3.4, IC= 1 Apr 2023



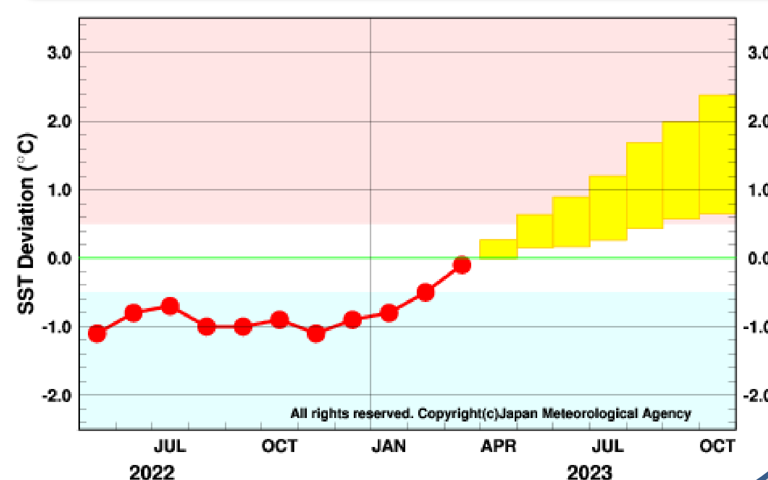
UKMO: Niño3.4, Updated 11 Mar 2023



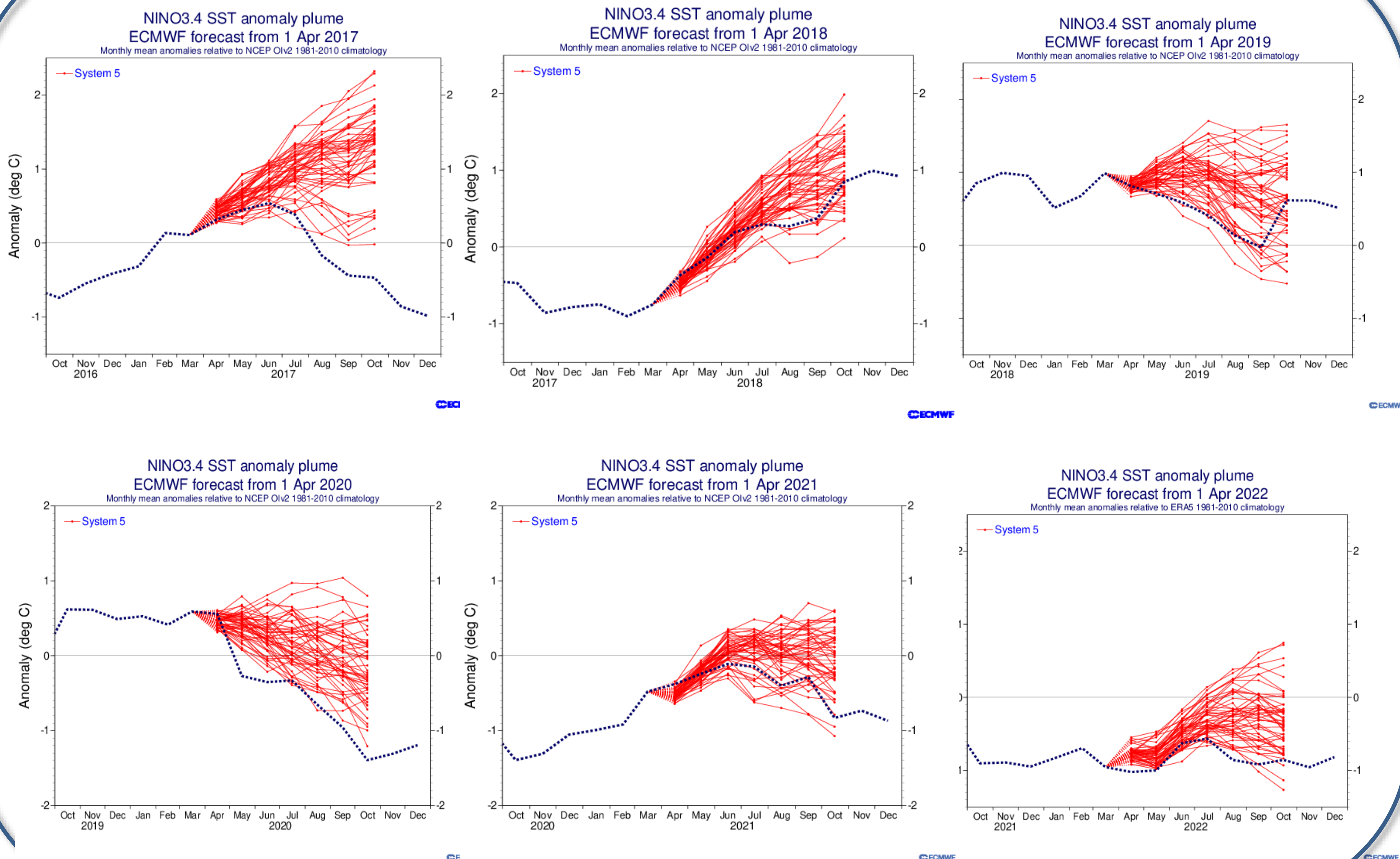
BOM: Niño3.4, Updated 25 Mar2023



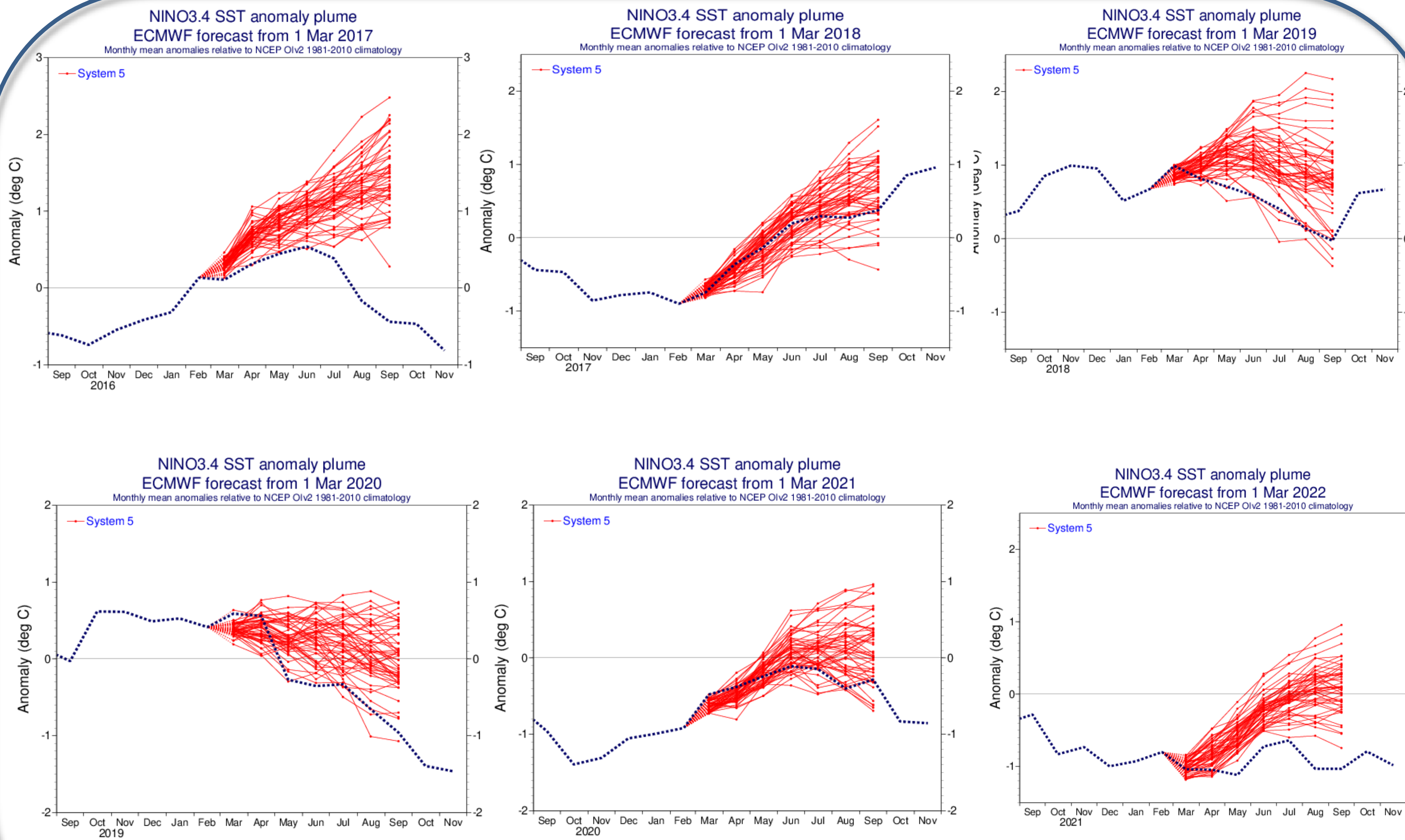
JMA: Niño3.4, Updated 10 Apr 2023



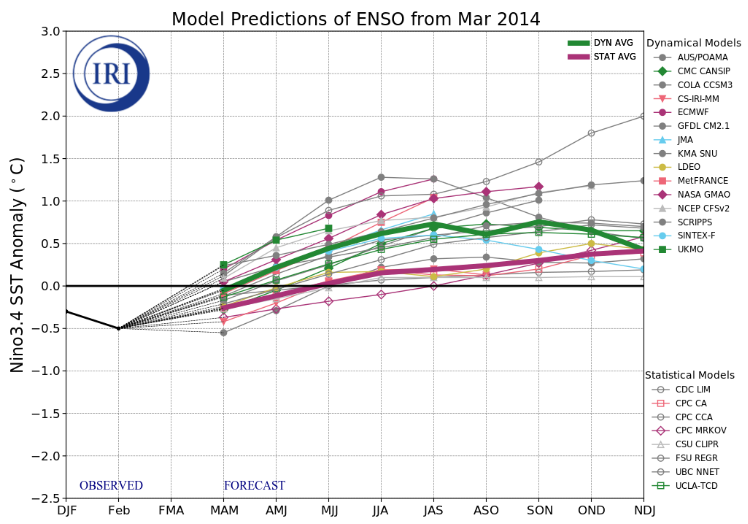
ECMWF Forecasts: warm bias in April IC runs since 2017

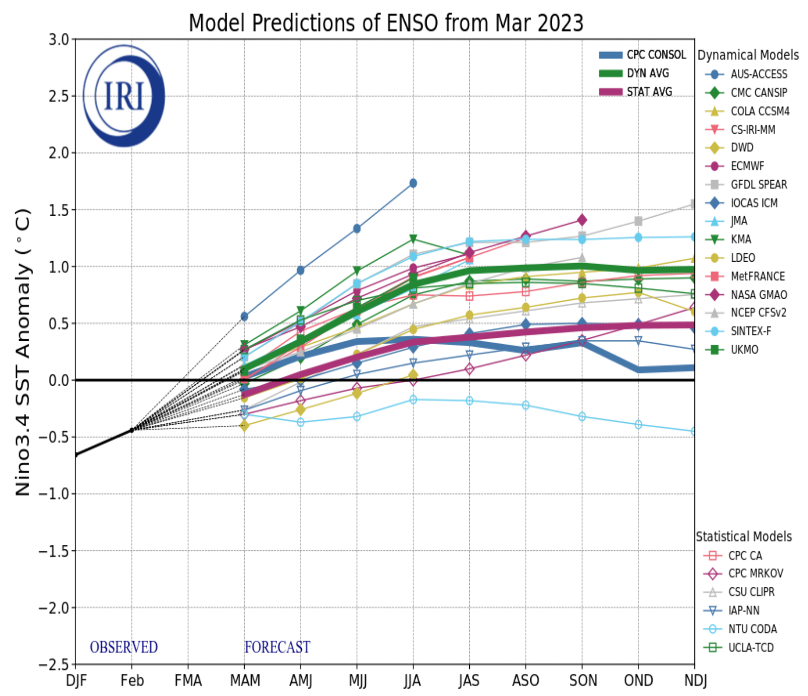


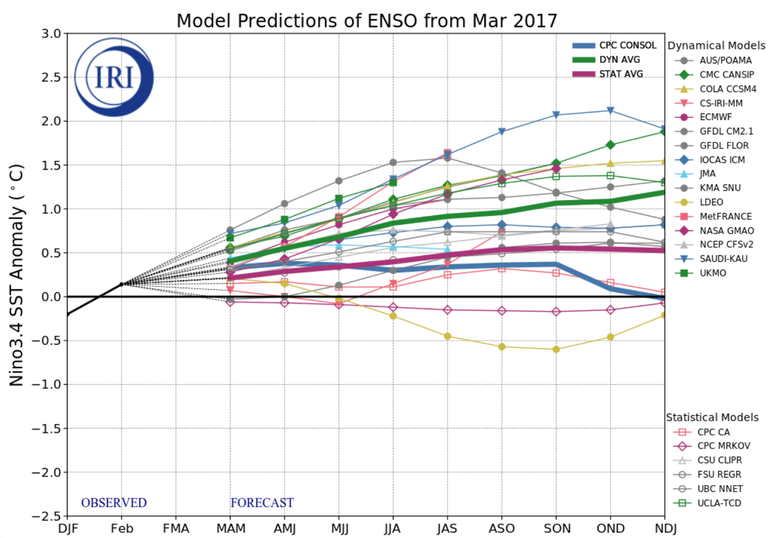
ECMWF Forecasts: warm bias in March IC runs since 2017

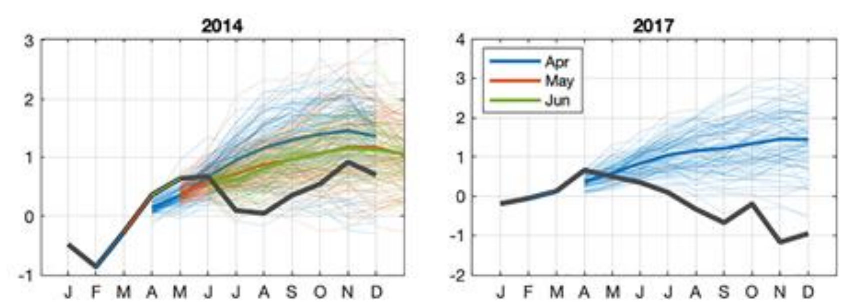


2023 ENSO Forecast, 2014 & 2017 El Niño False Alarm









Excessive Momentum and False Alarms in Late-Spring NMME ENSO Forecasts

(Courtesy of Michelle L'Heureux)

Geophysical Research Letters

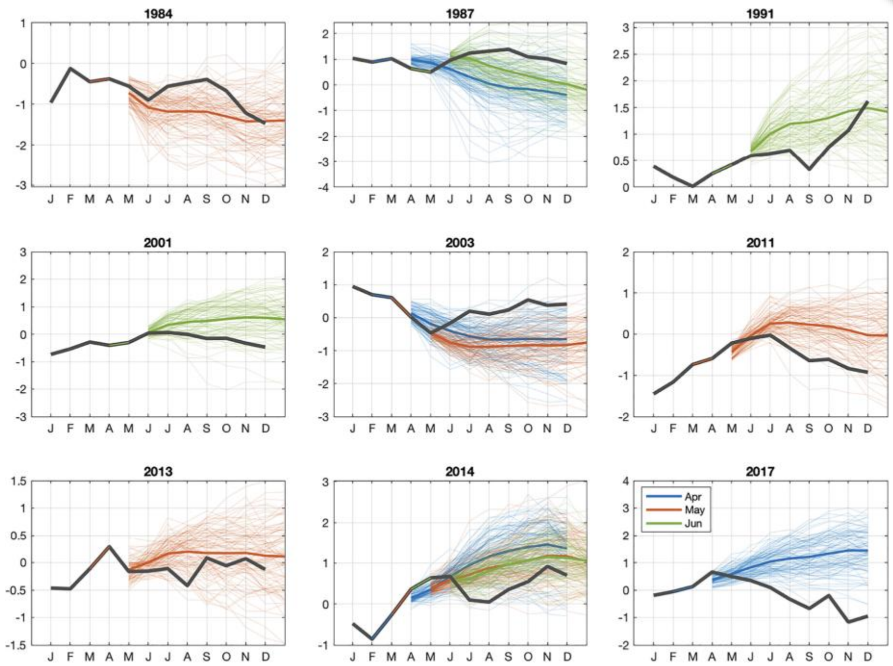
Research Letter | Free Access

Excessive Momentum and False Alarms in Late-Spring ENSO Forecasts

Michael K. Tippett, Michelle L. L'Heureux, Emily J. Becker, Arun Kumar

First published: 28 March 2020 | https://doi.org/10.1029/2020GL087008 | Citations: 6

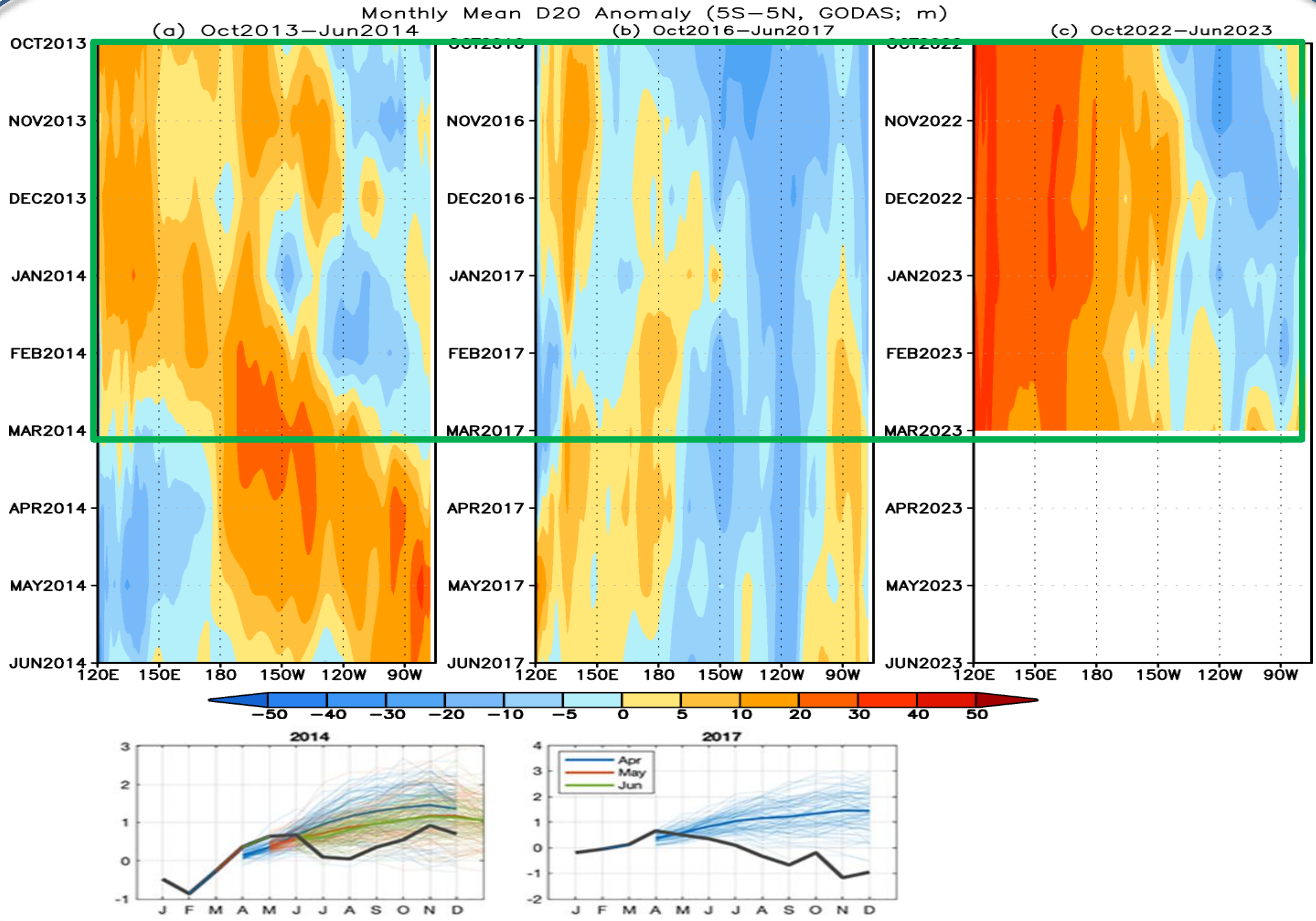
This article was corrected on 1 AUG 2020. See the end of the full text for details.



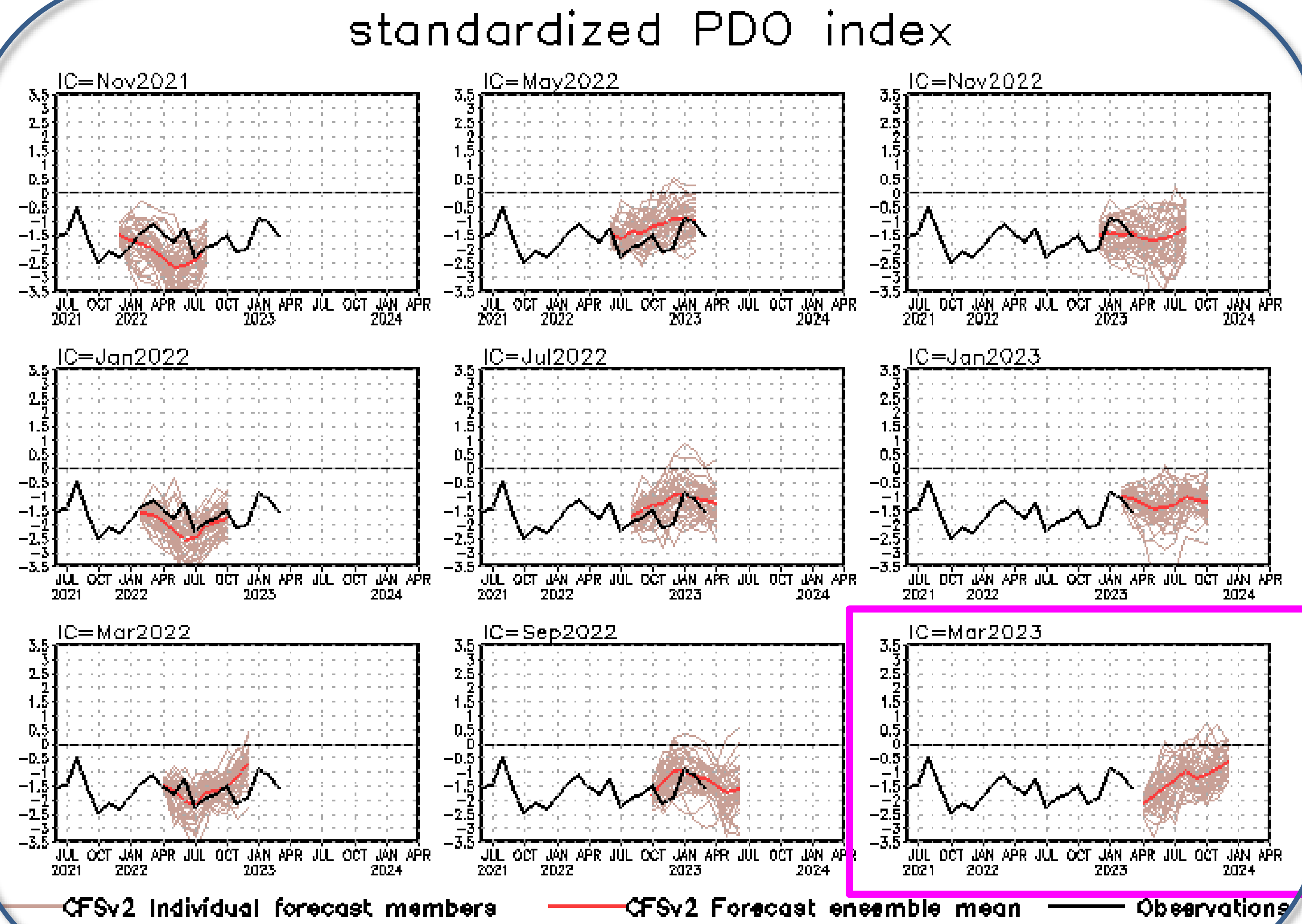
Abstract

The unanticipated stalled El Niño-Southern Oscillation (ENSO) evolution of 2014 raises questions about the reliability of the coupled models that were used for forecast guidance. Here we have analyzed the skill and reliability of forecasts of the Niño 3.4 tendency (3-month change) in the North American multimodel ensemble (1982–2018). We found that forecasts initialized April–June (AMJ) have "excessive momentum" in the sense that the forecast Niño 3.4 tendency is more likely to be a continuation of the prior observed conditions than it should be. Models tend to predict warming when initialized after observed warming conditions and cooling when initialized after observed cooling conditions. Excessive momentum appears in AMJ forecast busts and false alarms including the 2014 one. In some models, excessive momentum appears to be related to model formulation rather than initialization. A concerning trend is that four of the nine years with AMJ forecast busts occurred in the last decade.

Equatorial D20 anomalous evolution in 2013/14, 2016/17 & 2022/23



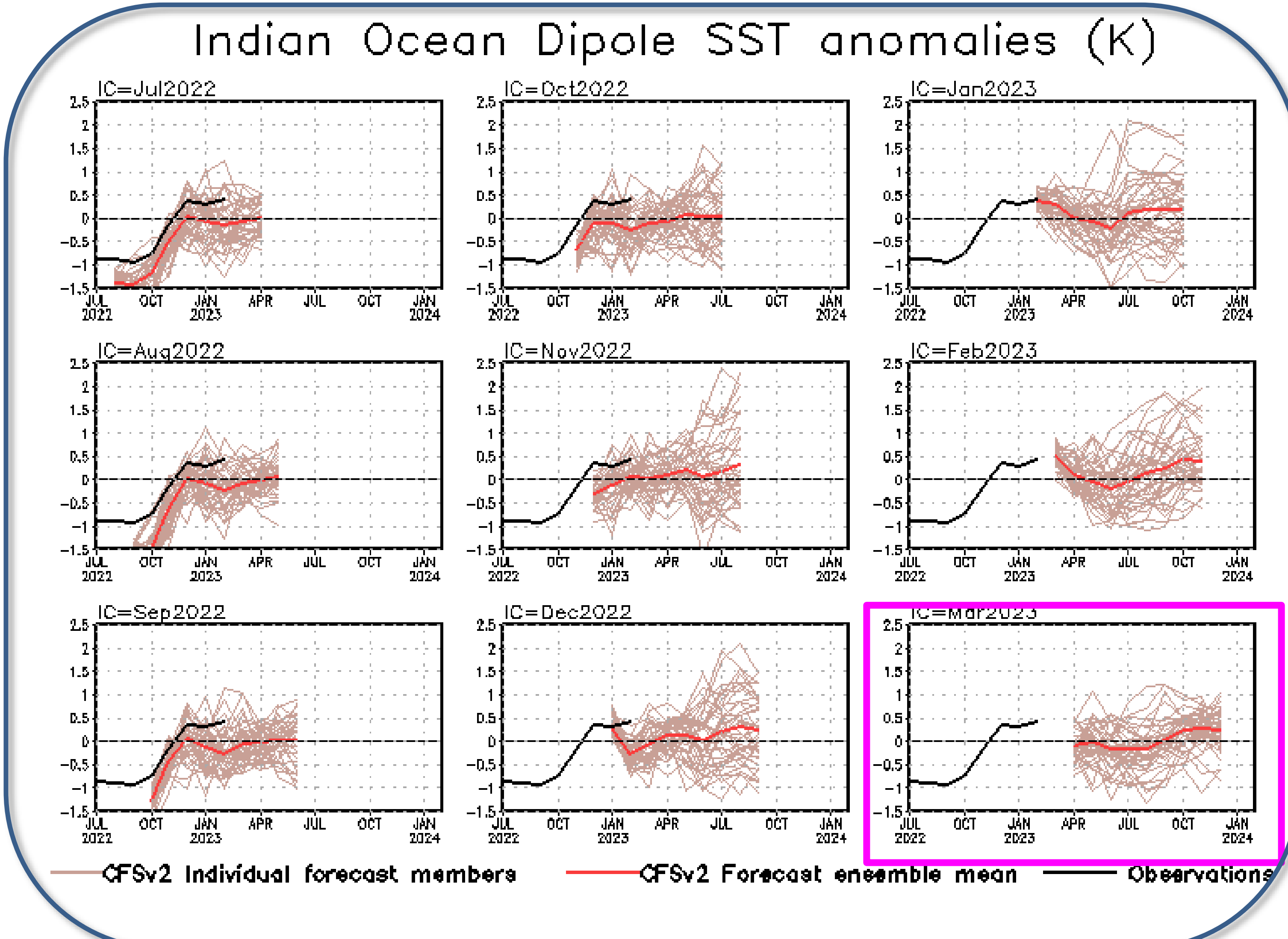
CFS Pacific Decadal Oscillation (PDO) Index Predictions from Different Initial Months



- CFSv2 predicts a persistent negative phase of PDO through autumn 2023.

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.

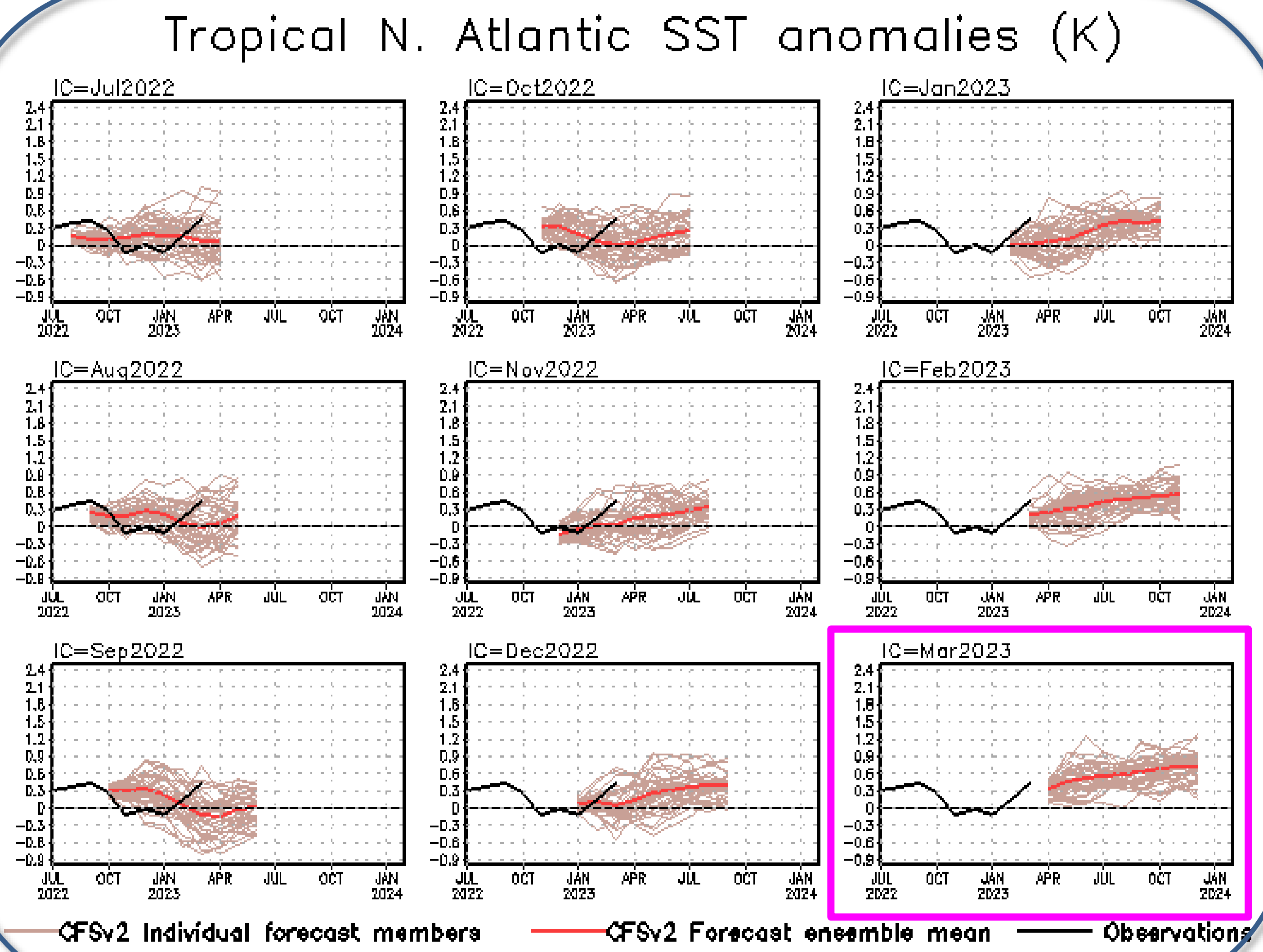
NCEP CFS DMI SST Predictions from Different Initial Months



- CFSv2 predicts a near-normal IOD through autumn 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.

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



- Latest CFSv2 predictions call for above-normal SST 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].

Acknowledgement

- Drs. Jieshun Zhu, Caihong Wen, and Arun Kumar: reviewed PPT, and provide insightful suggestions and comments

- Drs. Pingping Xie provided the BASS/CMORPH/CFSR EVAP package

- Dr. Wanqiu Wang provides the sea ice forecasts and maintains the CFSv2 forecast archive

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Arun.Kumar@noaa.gov
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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

BAMS
Article

Global Ocean Monitoring and Prediction at NOAA Climate Prediction Center

15 Years of Operations

Zeng-Zhen Hu, Yan Xue, Boyin Huang, Arun Kumar, Caihong Wen, Pingping Xie, Jieshun Zhu, Philip J. Pegion, Li Ren, and Wanqiu Wang

ABSTRACT: Climate variability on subseasonal to interannual time scales has significant impacts on our economy, society, and Earth's environment. Predictability for these time scales is largely due to the influence of the slowly varying climate anomalies in the oceans. The importance of the global oceans in governing climate variability demonstrates the need to monitor and forecast the global oceans in addition to El Niño–Southern Oscillation in the tropical Pacific. To meet this need, the Climate Prediction Center (CPC) of the National Centers for Environmental Prediction (NCEP) initiated real-time global ocean monitoring and a monthly briefing in 2007. The monitoring covers observations as well as forecasts for each ocean basin. In this paper, we introduce the monitoring and forecast products. CPC's efforts bridge the gap between the ocean observing system and the delivery of the analyzed products to the community. We also discuss the challenges involved in ocean monitoring and forecasting, as well as the future directions for these efforts.

KEYWORDS: Ocean; Atmosphere-ocean interaction; ENSO; Climate prediction; Oceanic variability; Climate services

https://doi.org/10.1175/BAMS-D-22-0056.1
Corresponding author: Zeng-Zhen Hu, zeng-zhen.hu@noaa.gov
In final form 15 August 2022

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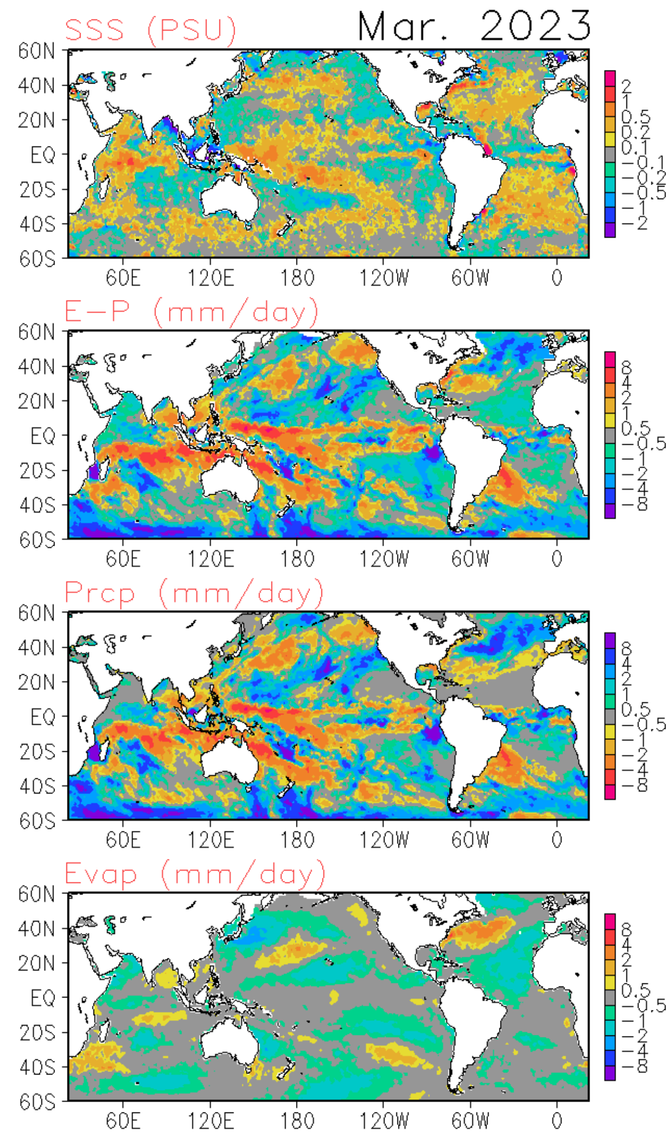
Backup Slides

Global Sea Surface Salinity (SSS): Anomaly for March 2023

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

Over the tropical Pacific and tropical Atlantic Ocean, large-scale salinity anomalies are dominated by variations of fresh water flux especially precipitation. A double ITCZ structure is observed over the eastern Pacific, a dominant feature of seasonal evolution of ITCZ there. The intensity of the ITCZ, however, is weakened across the basin, causing reduced precipitation and saltier SSS over the region. Freshened SSS appears over the eastern Bay of Bengal off shore of Burma that are not consistent with the freshwater flux anomalies, suggesting contributions of oceanic processes.



SSS : Blended Analysis of Surface Salinity (BASS) V0.Z

(a CPC-NESDIS/NODC-NESDIS/STAR joint effort)

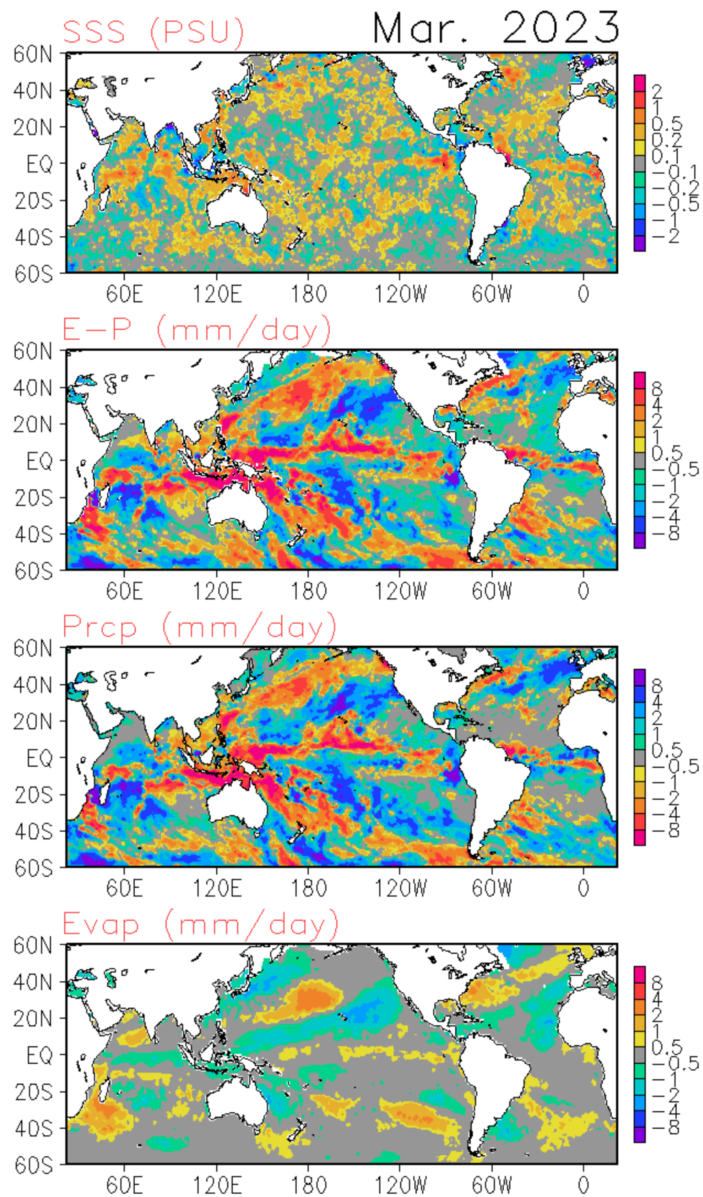
ftp.cpc.ncep.noaa.gov/precip/BASS

Precipitation: CMORPH adjusted satellite precipitation estimates

Evaporation: Adjusted CFS Reanalysis

Global Sea Surface Salinity (SSS): Tendency for March 2023

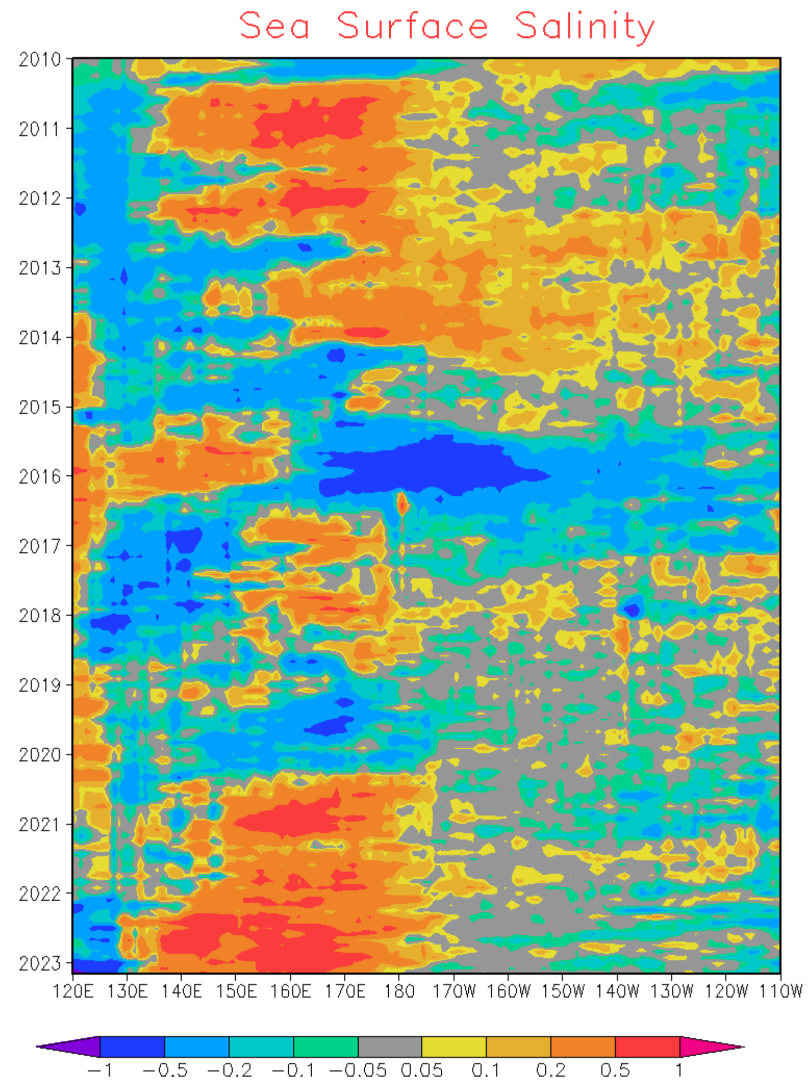
Major features of the SSS tendency for March 2023 include the zonally oriented belts of saltier SSS across the tropical Pacific and Atlantic oceans caused by those in the ITCZ. Tendencies of SSS over the mid- and high latitudes over the Pacific and Atlantic oceans are also broadly consistent with those of the E-P, suggesting substantial roles of the fresh water. Freshened SSS tendency is observed over the northern Bay of Bengal off the mouths of the Ganges River, likely attributable to the changes in the river runoff there.



Monthly SSS Anomaly Evolution over Equatorial Pacific

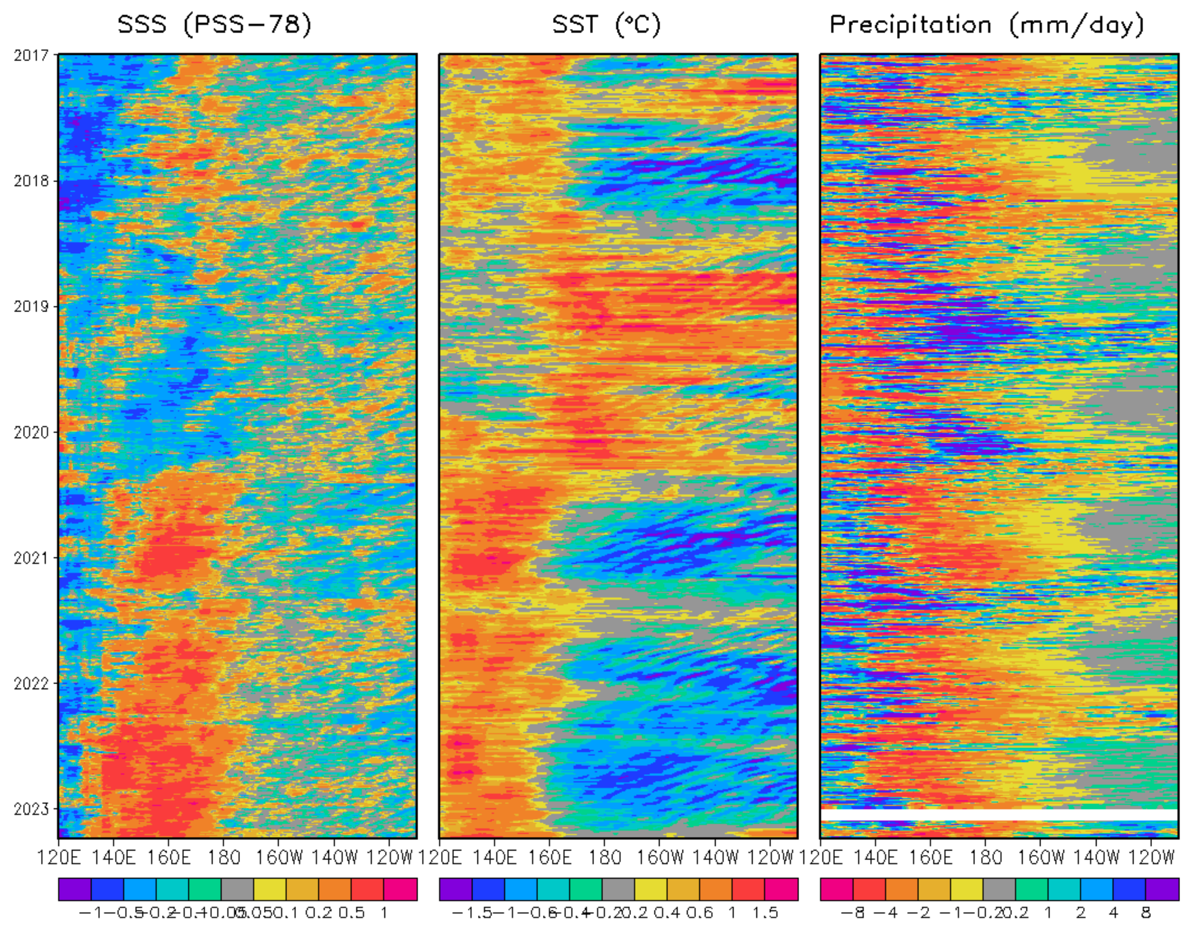
NOTE: Since June 2015, the BASS SSS is from in situ, SMOS and SMAP; before June 2015,The BASS SSS is from in situ, SMOS and Aquarius.

- Hovermoller diagram for equatorial SSS anomaly **(5˚S-5˚N);**
- Positive SSS anomalies continued over the western equatorial Pacific (135ºE-155ºE) and are enhanced over the Central Equatorial Pacific between 160ºE and 170ºW as a result of the ITCZ precipitation anomalies there.



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.

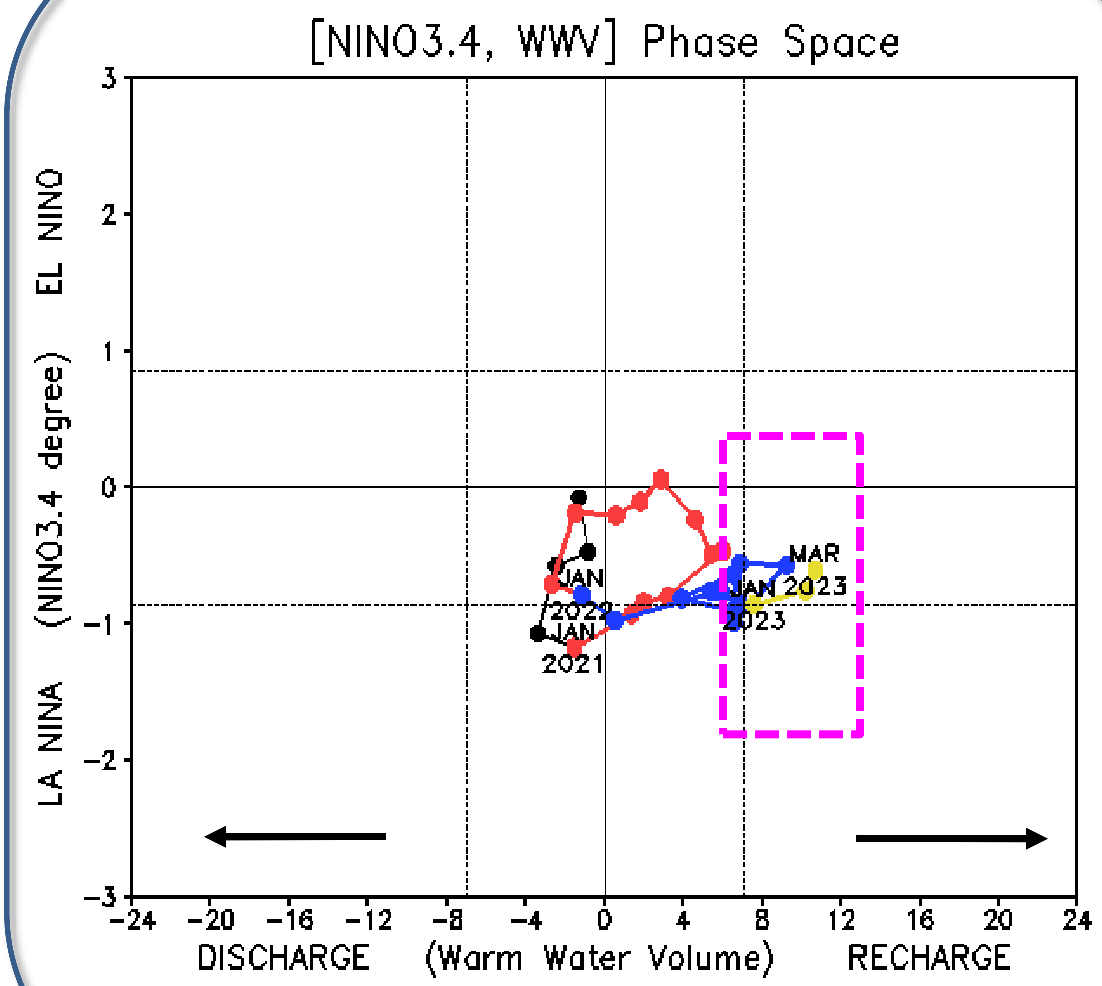


Warm Water Volume (WWV) and Niño3.4 Anomalies

- Equatorial Warm Water Volume (WWV) was in a recharge phase in Mar 2023.

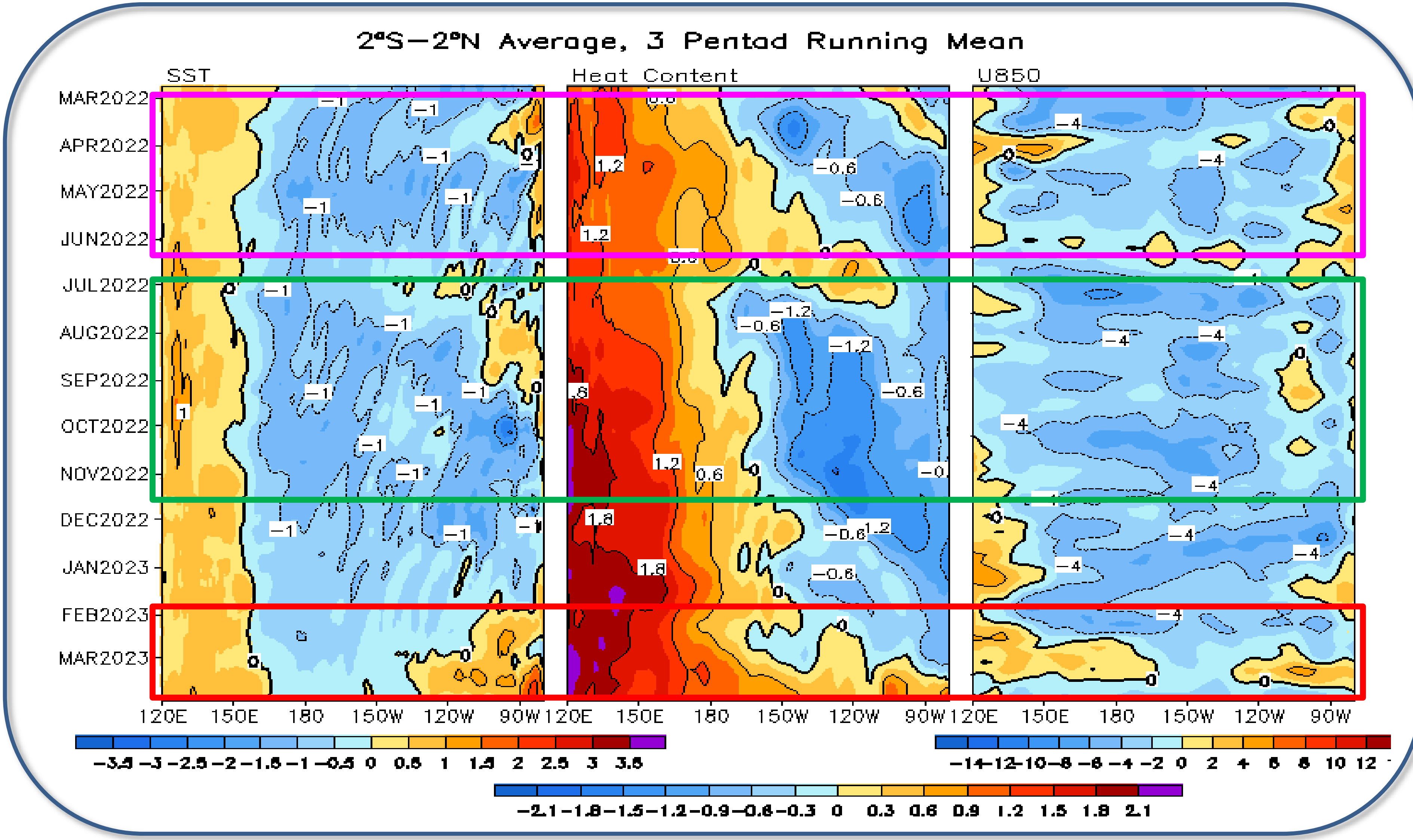
-As WWV is intimately linked to ENSO variability (Wyrtki 1985; Jin 1997), it is useful to monitor ENSO in a phase space of WWV and Niño3.4 (Kessler 2002).

- Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.



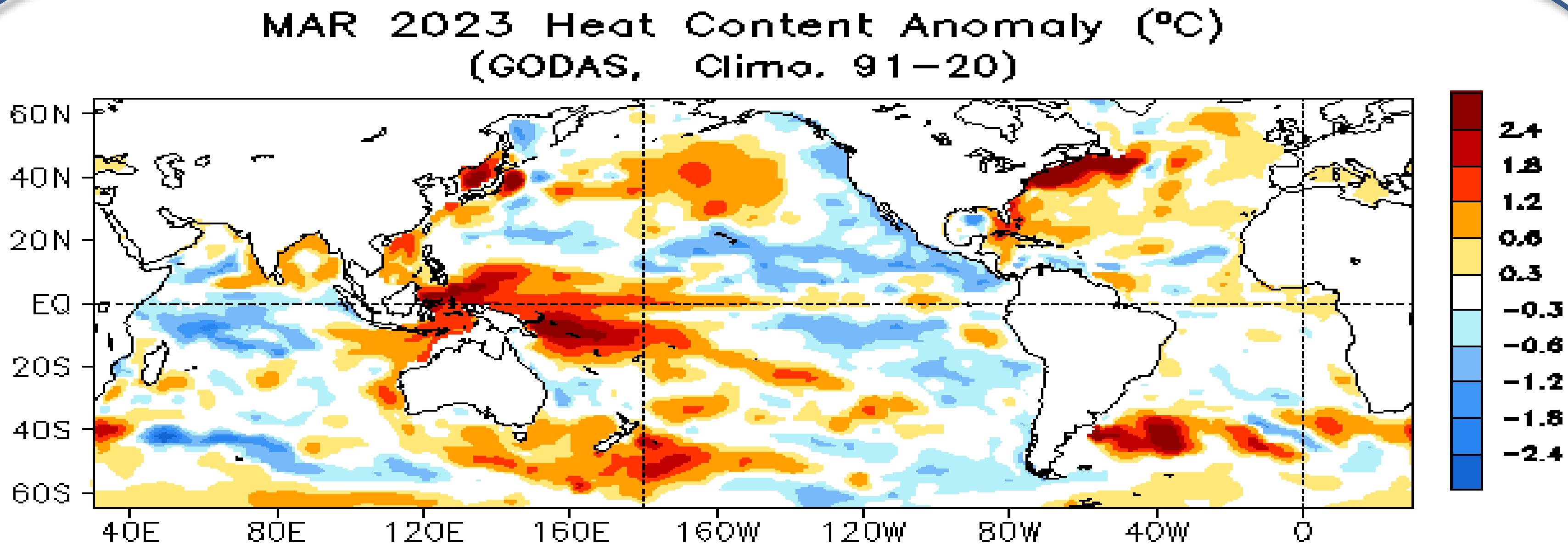
Phase diagram of Warm Water Volume (WWV) and Niño3.4 indices. WWV is the average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN] calculated with the NCEP's GODAS. Anomalies are departures from the 1991-2020 base period means.

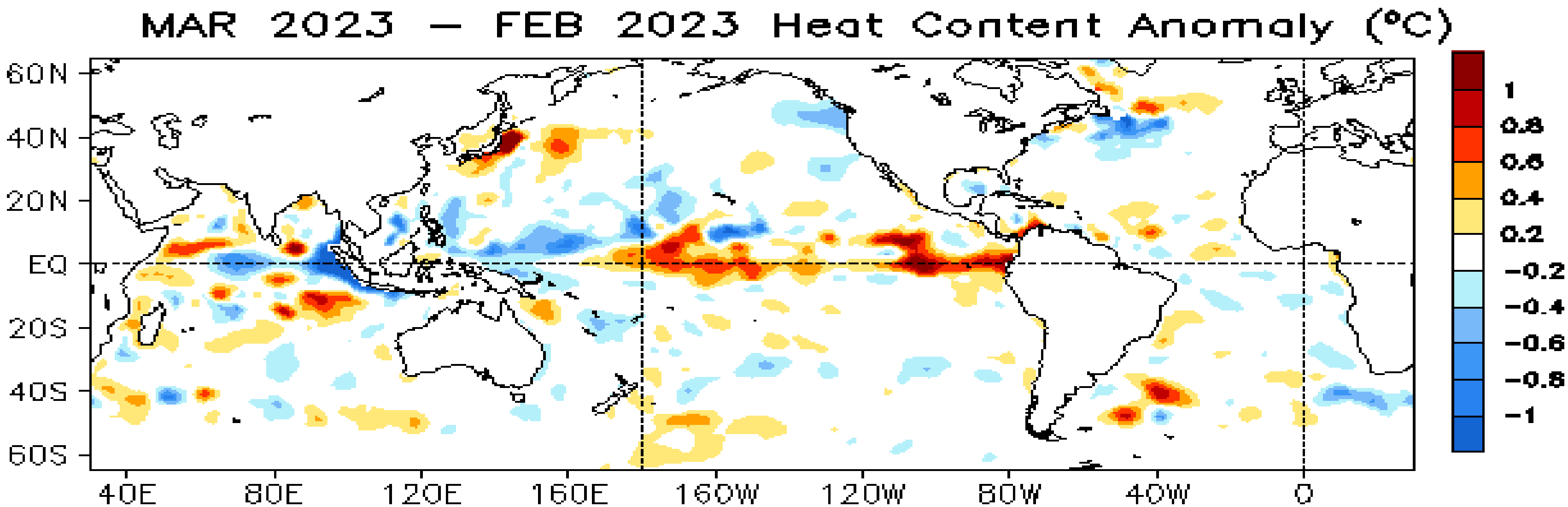
Equatorial Pacific SST (ºC), HC300 (ºC), u850 (m/s) Anomalies



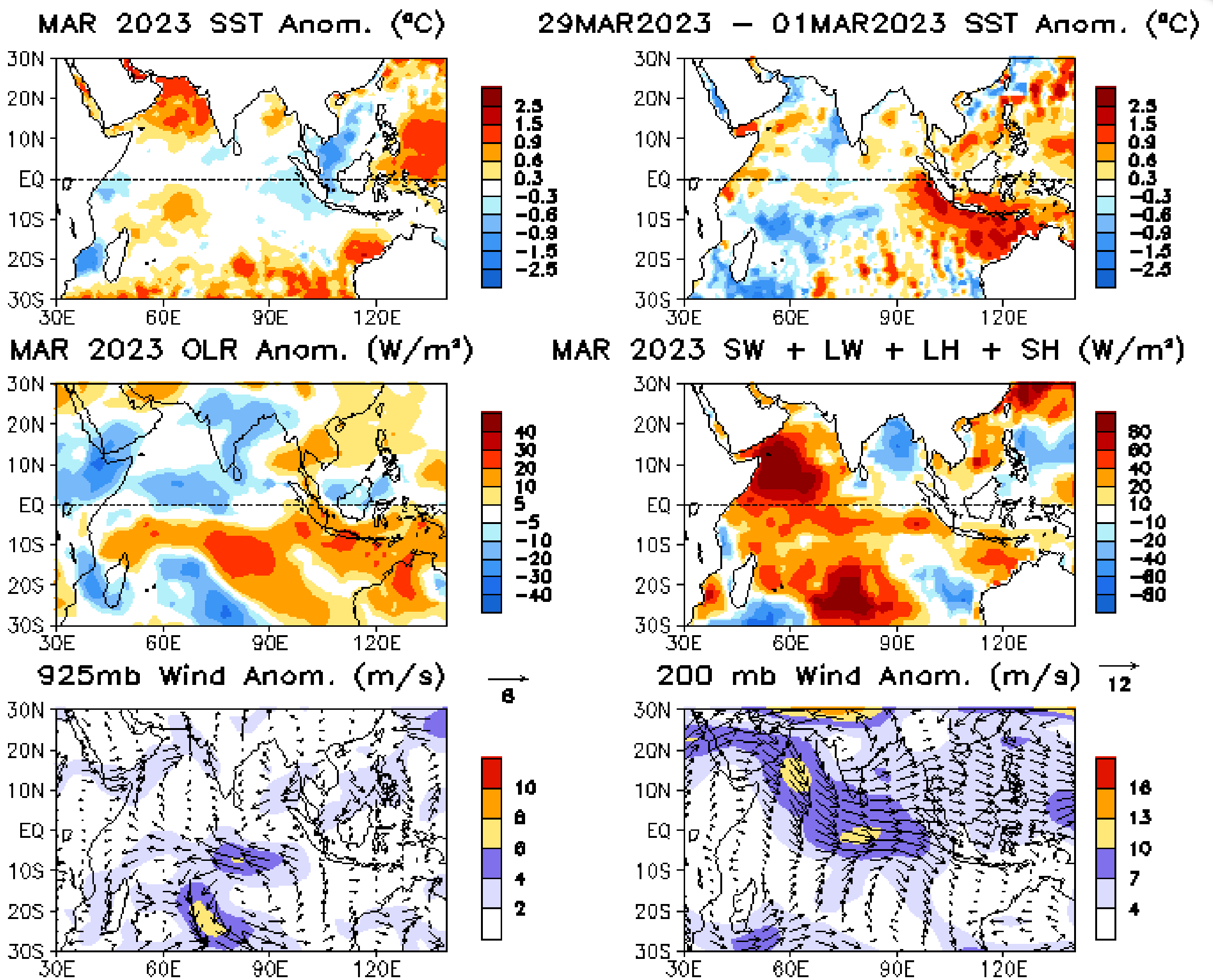
- The evolution of the triple-dip La Niña SSTA in 2020-23 was linked to low-level zonal wind anomalies and Kelvin wave activities.
- Since Feb 2023, positive HC300 anomaly extended eastward while westerly wind anomalies and positive SSTA were observed.

Global HC300 Anomaly & Anomaly Tendency





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



Convection was enhanced (suppressed) over the northern (southern) 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.

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