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

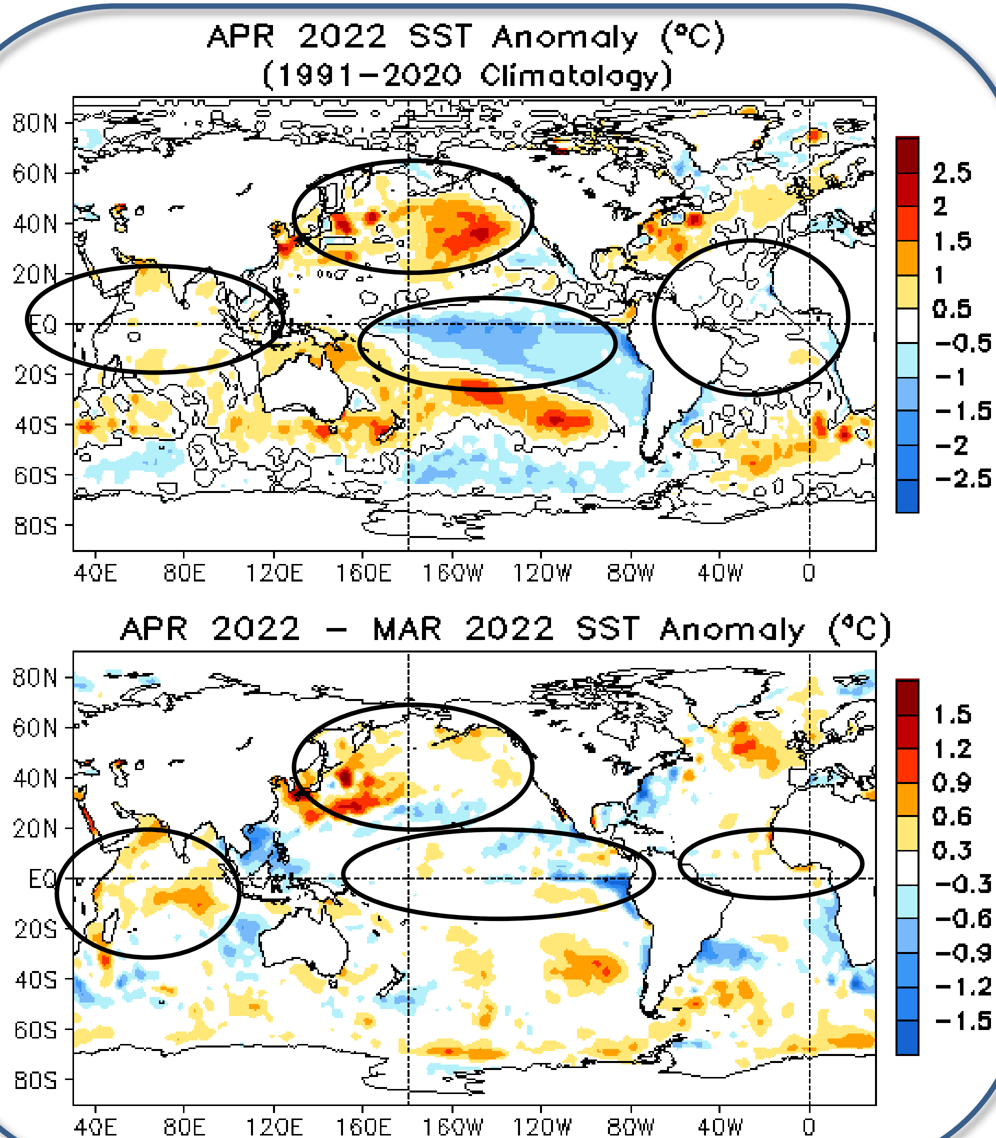
- **Overview**
- **Recent highlights**
  - Pacific/Arctic Ocean
  - Indian Ocean
  - Atlantic Ocean
- **Global SSTA Predictions**

Overview

- **Pacific Ocean**
  - NOAA "ENSO Diagnostic Discussion" on 14 Apr 2022 stated *"La Niña is favored to continue through the Northern Hemisphere summer (59% chance during June-August 2022), with a 50-55% chance through the fall."*
  - La Niña condition persisted with Niño3.4 = -1.1°C in Apr 2022.
  - Positive SSTAs continued in the North Pacific.
  - The PDO has been in a negative phase since Jan 2020 with PDOI = -1.5 in Apr 2022.
- **Arctic Ocean**
  - Arctic spring melt has started. Overall decline was slower than average through the month. Average Arctic sea ice extent for April 2022 ranked the eleventh lowest in the 44-year satellite record.
- **Indian Ocean**
  - SSTAs were small in the tropical Indian Ocean in Apr 2022.
- **Atlantic Ocean**
  - SSTs were near average in the tropical Atlantic Ocean in Apr 2022.
  - NAO switched to a negative phase in Apr 2022 with NAOI= -0.5.

Global Oceans

Global SST Anomaly (°C) and Anomaly Tendency

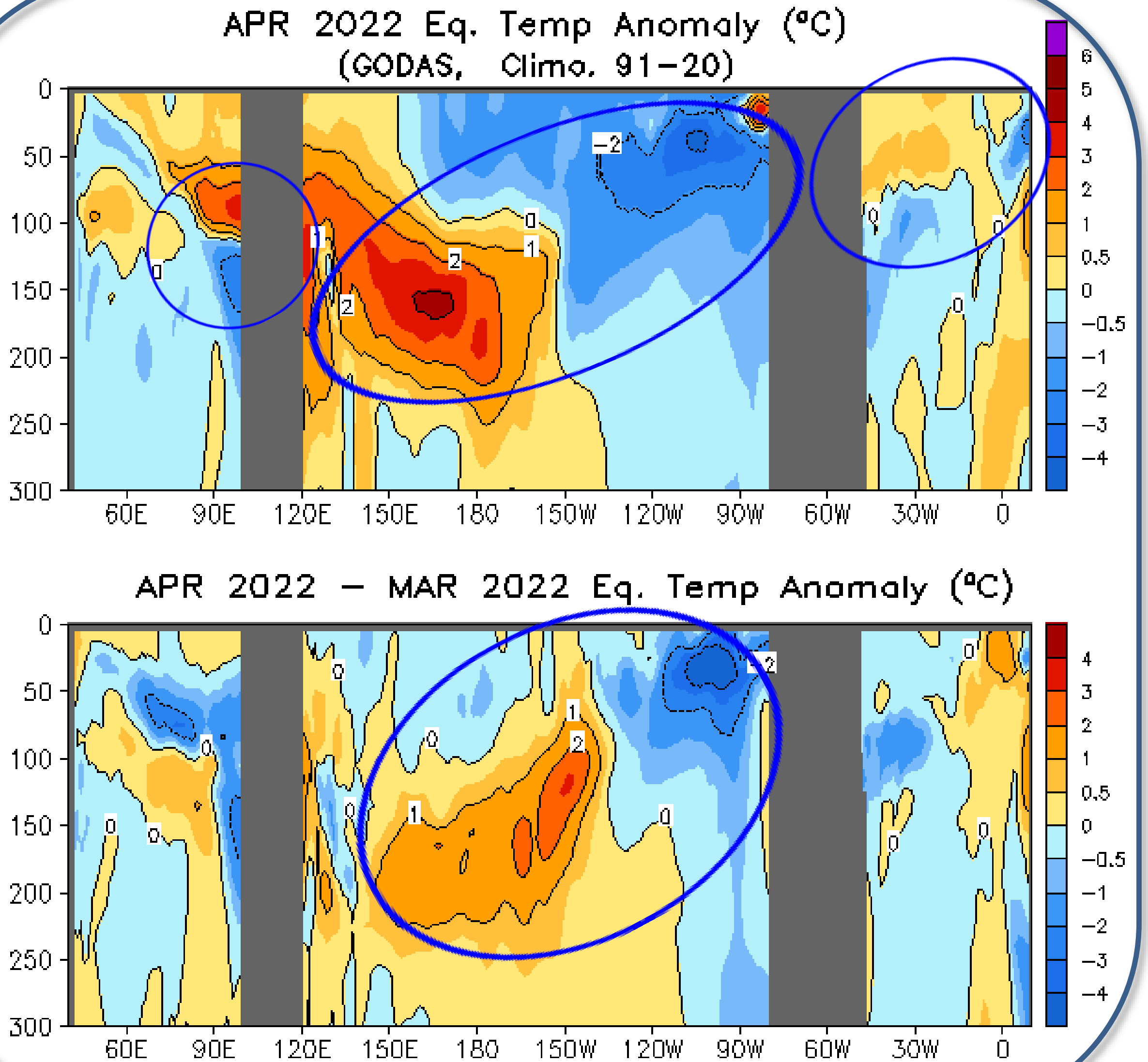


- Negative SSTAs persisted in the central and southeastern tropical Pacific.
- Positive SSTAs persisted in part of the North Pacific.
- SSTs were near average in the tropical Atlantic and Indian Oceans.

- Negative SSTA tendencies were observed in the eastern equatorial Pacific.
- Positive (negative) SSTA tendencies were evident in the western (southern) North Pacific.
- SSTA tendencies were small in the equatorial Atlantic Ocean and central equatorial Indian Ocean.

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

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

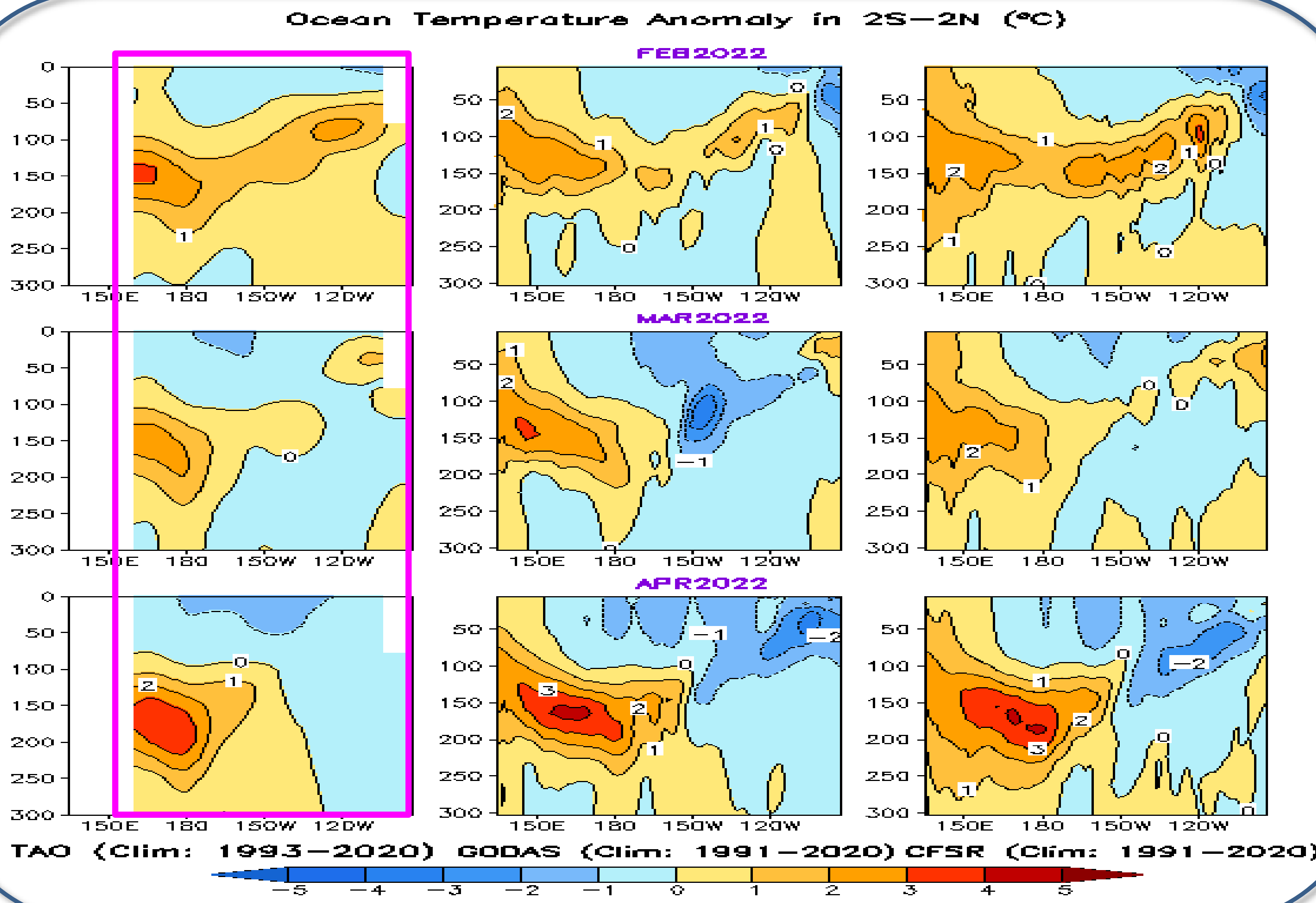


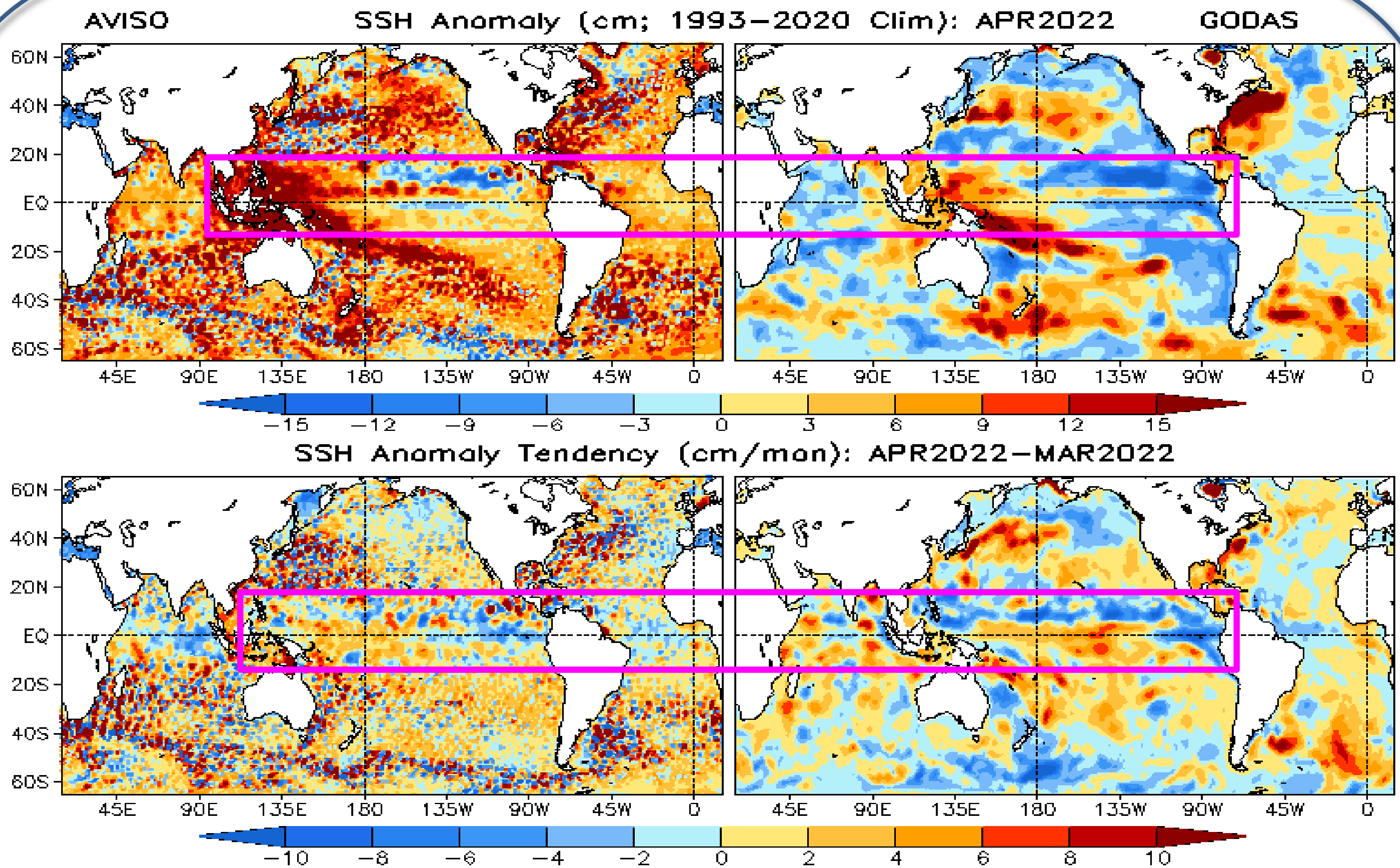
- Positive (negative) temperature anomalies were observed along the thermocline in the western (eastern) equatorial Pacific.
- Temperature anomalies were small along the thermocline in the equatorial Atlantic Ocean.
- Positive (negative) temperature anomalies were present in the upper (lower) layers of the eastern equatorial Indian Ocean.

- Temperature anomaly tendency was positive (negative) along the thermocline in the western and central (eastern) Pacific, strengthening the tilt/dipole mode associated with ENSO.

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.

TAO, GODAS, & CFSR monthly mean subsurface temperature anomalies along the Equator during the last 3 months

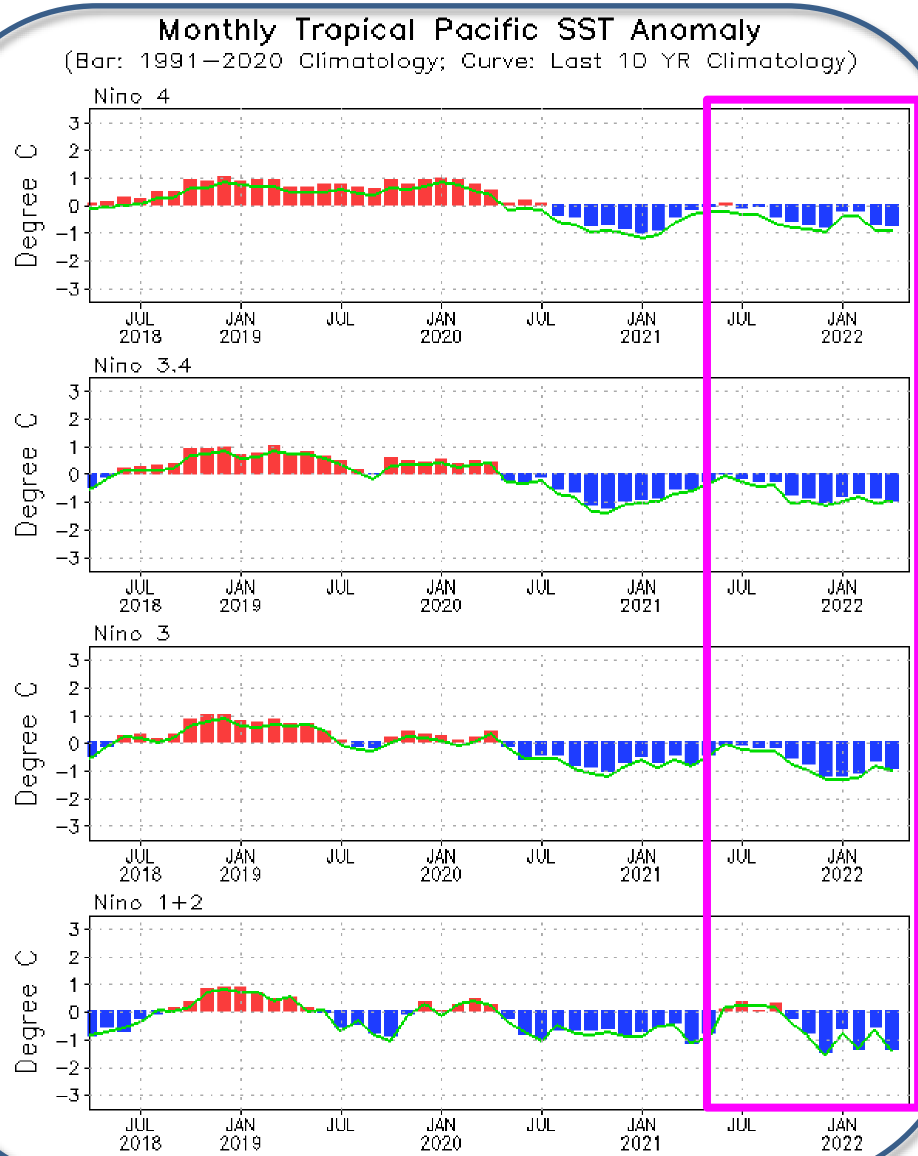


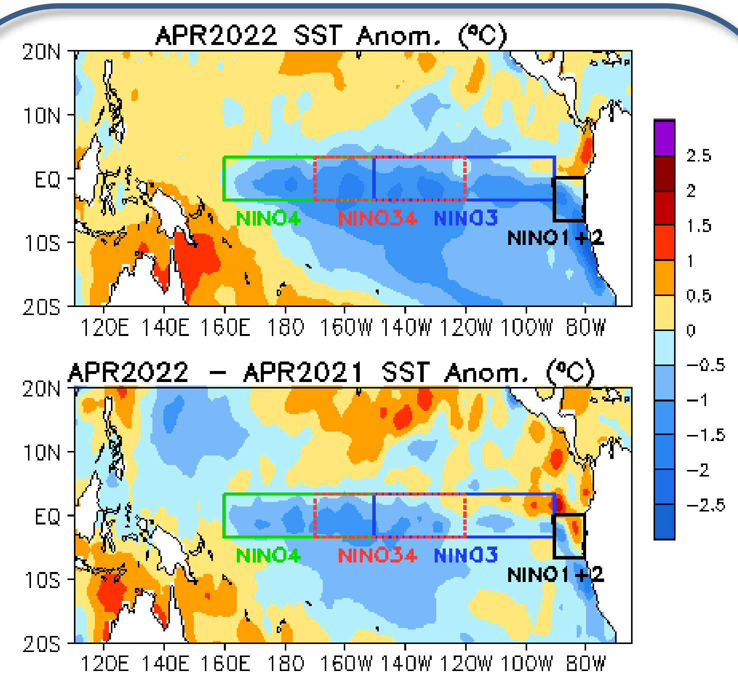


- Basic features in the tropical Pacific associated with La Nina evolution are consistent between AVISO and GODAS.
- Positive (negative) anomalous tendencies were present in the east-central (eastern) equatorial Pacific.
- There are some differences in details between AVISO & GODAS with small scale features dominating AVISO.

Tropical Pacific Ocean and ENSO Conditions

Evolution of Pacific Niño SST Indices





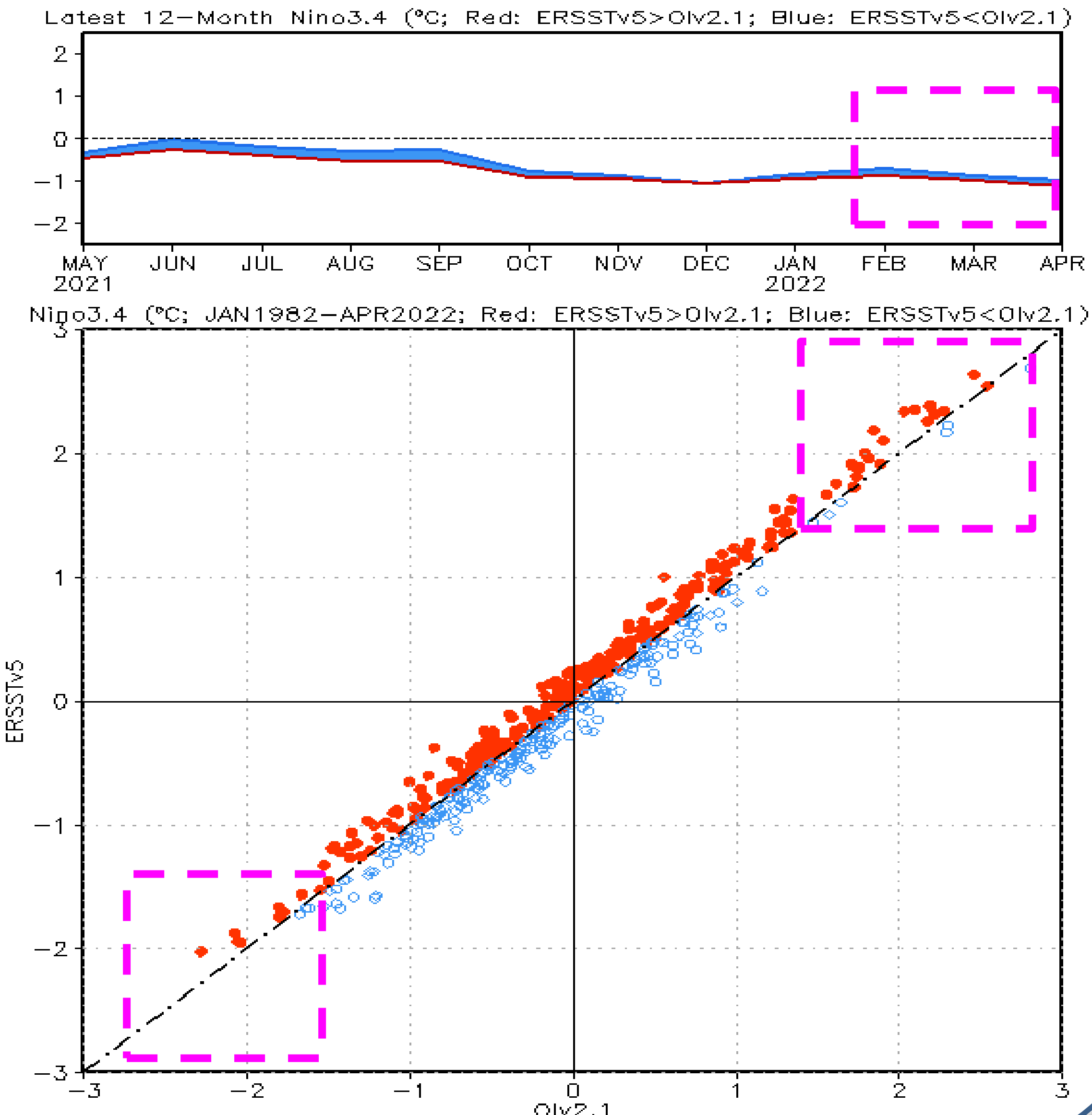
- All Niño indices strengthened in Apr 2022, with Niño3.4 = -1.1C.

- Compared with Apr 2021, the east-central and southeastern tropical Pacific was cooler in Apr 2022.

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

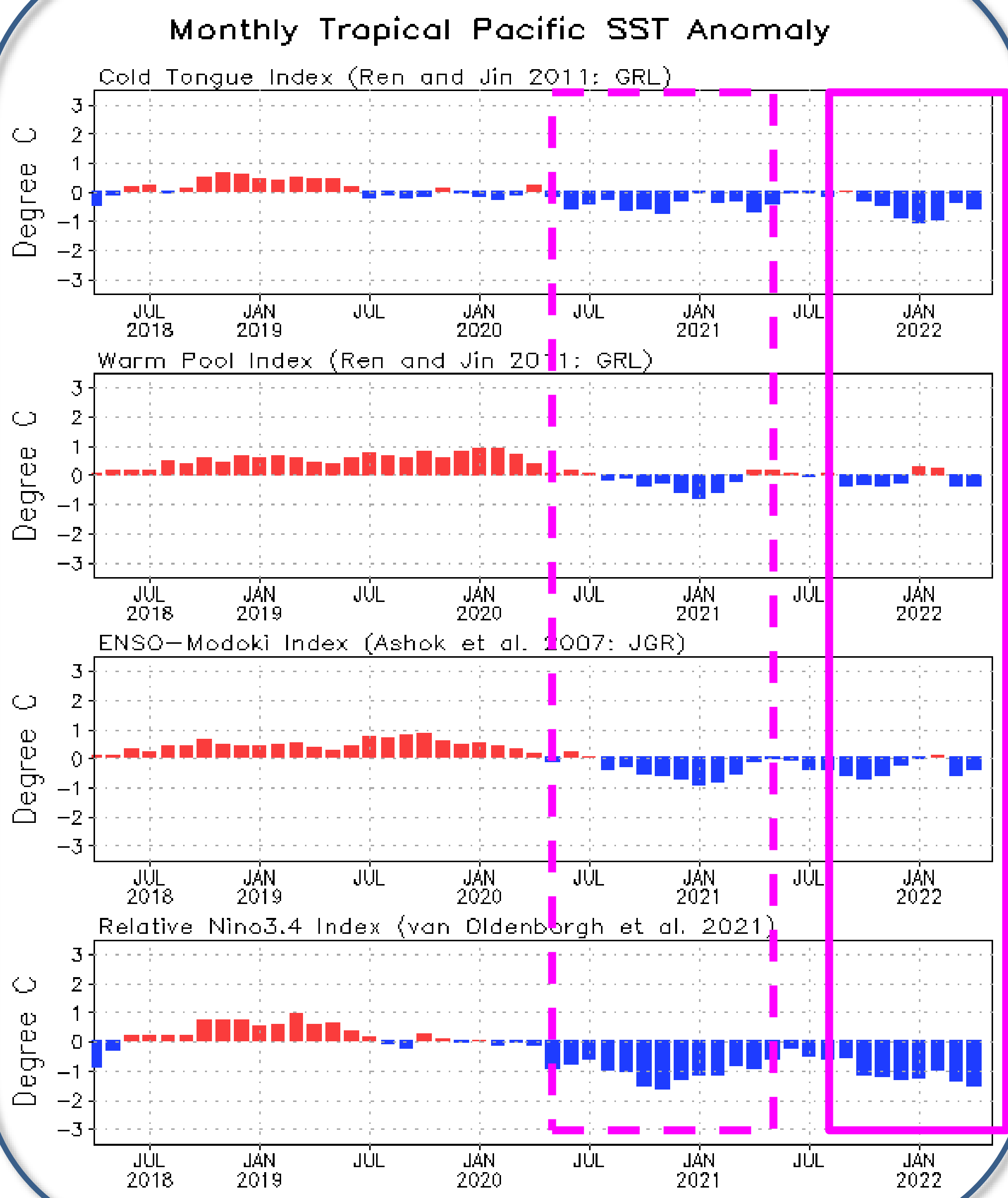
Niño region indices, calculated as the area-averaged monthly mean SSTAs (°C) for the specified region. Data are derived from the OI SST analysis, and anomalies are departures from the 1991-2020 base period means.

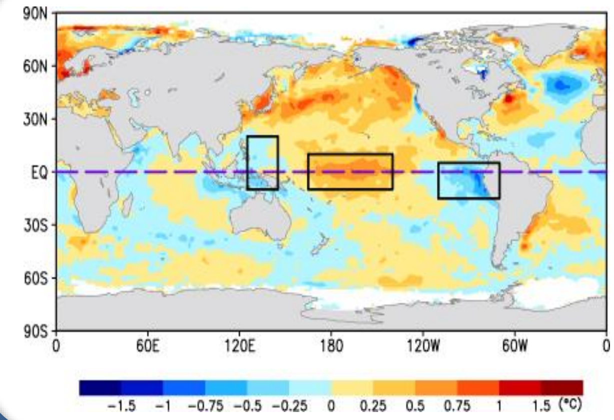
Comparison of ERSSTv5 & OIv2.1 Niño3.4 Index



- Sometimes, ERSSTv5 is warmer or cooler than OIv2.1.
- For both the extreme positive and negative (>1.5^{o}C or <-1.5^{o}C) Niño3.4, ERSSTv5 is mostly warmer than OIv2.1.
- During last couple months, ERSSTv5 was slightly cooler than OIv2.1.

Evolution of Pacific Niño SST Indices



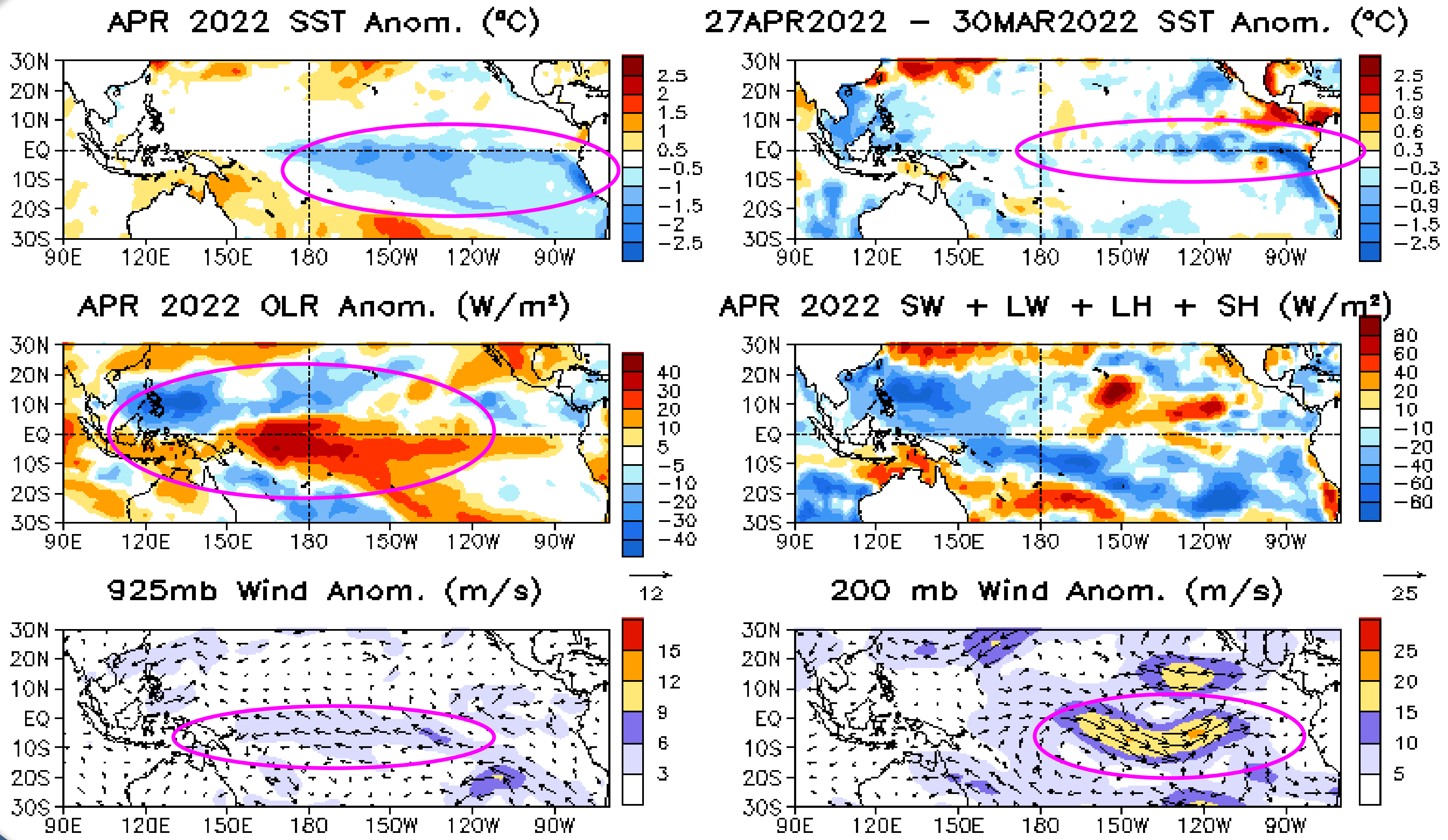


- Relative Niño3.4 index is defined as the conventional Niño3.4 index minus the SSTA averaged in the whole tropics (0°-360°, 20°S-20°N), in order to remove the global warming signal. Also, to have the same variability as the conventional Niño3.4 index, the relative Niño3.4 index is renormalized (van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

Relative Niño3.4 data updated monthly at:

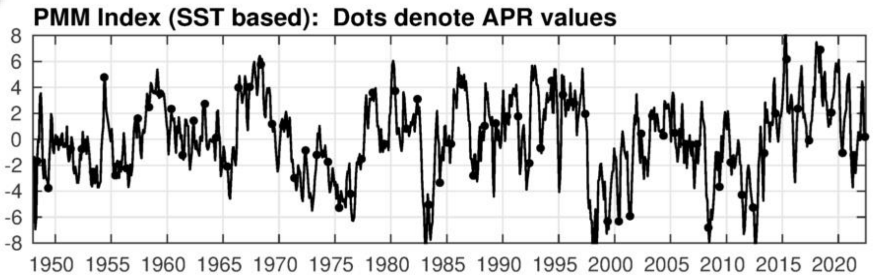
https://www.cpc.ncep.noaa.gov/data/indices/RONI.ascii.txt

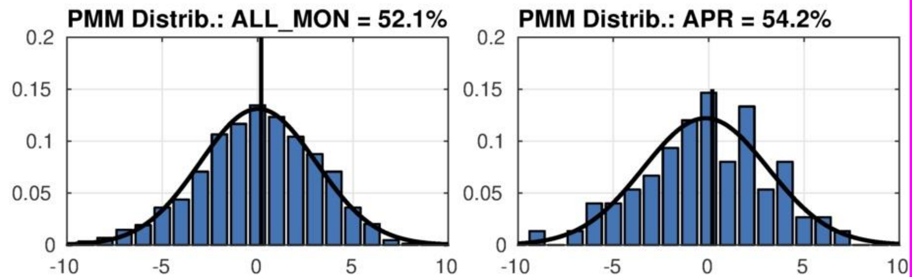
Tropical Pacific: SSTA, SSTA Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Winds

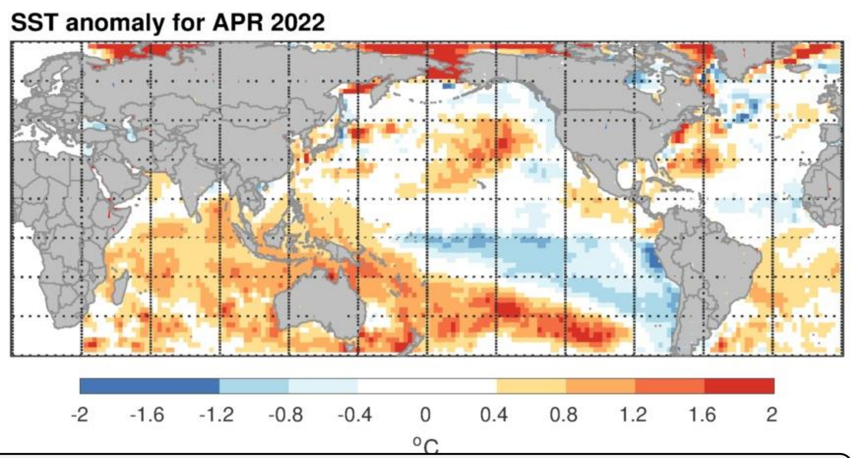


SSTAs (top-left), SSTA tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right; positive means heat into the ocean), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the OI 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.

Current Status of the Pacific Meridional Mode (PMM)

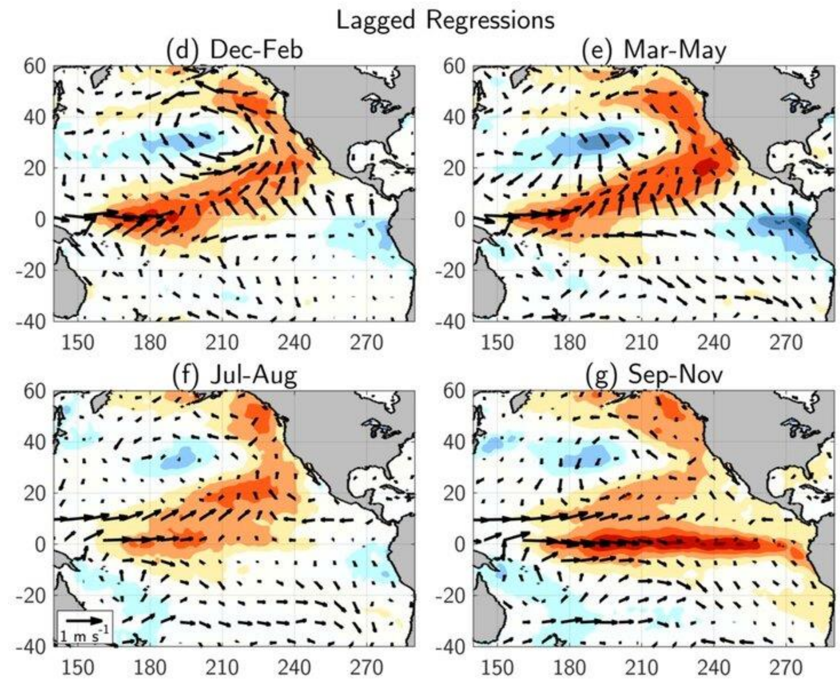






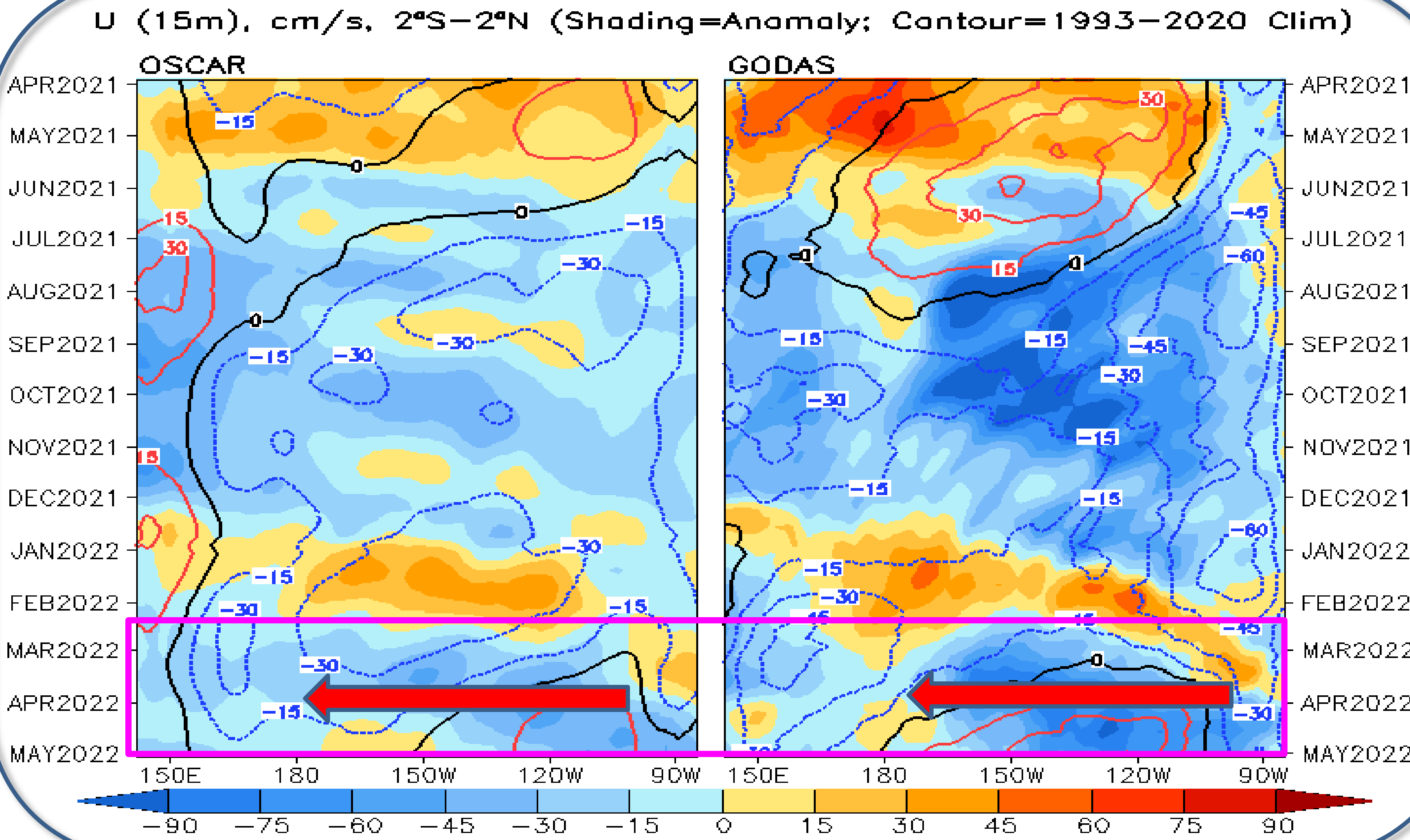
https://www.aos.wisc.edu/~dvimont/MModes/PMM.html

Lagged regressions of seasonally averaged SST and surface wind anomalies on NPMM SST time series calculated from a Maximum Covariance Analysis.



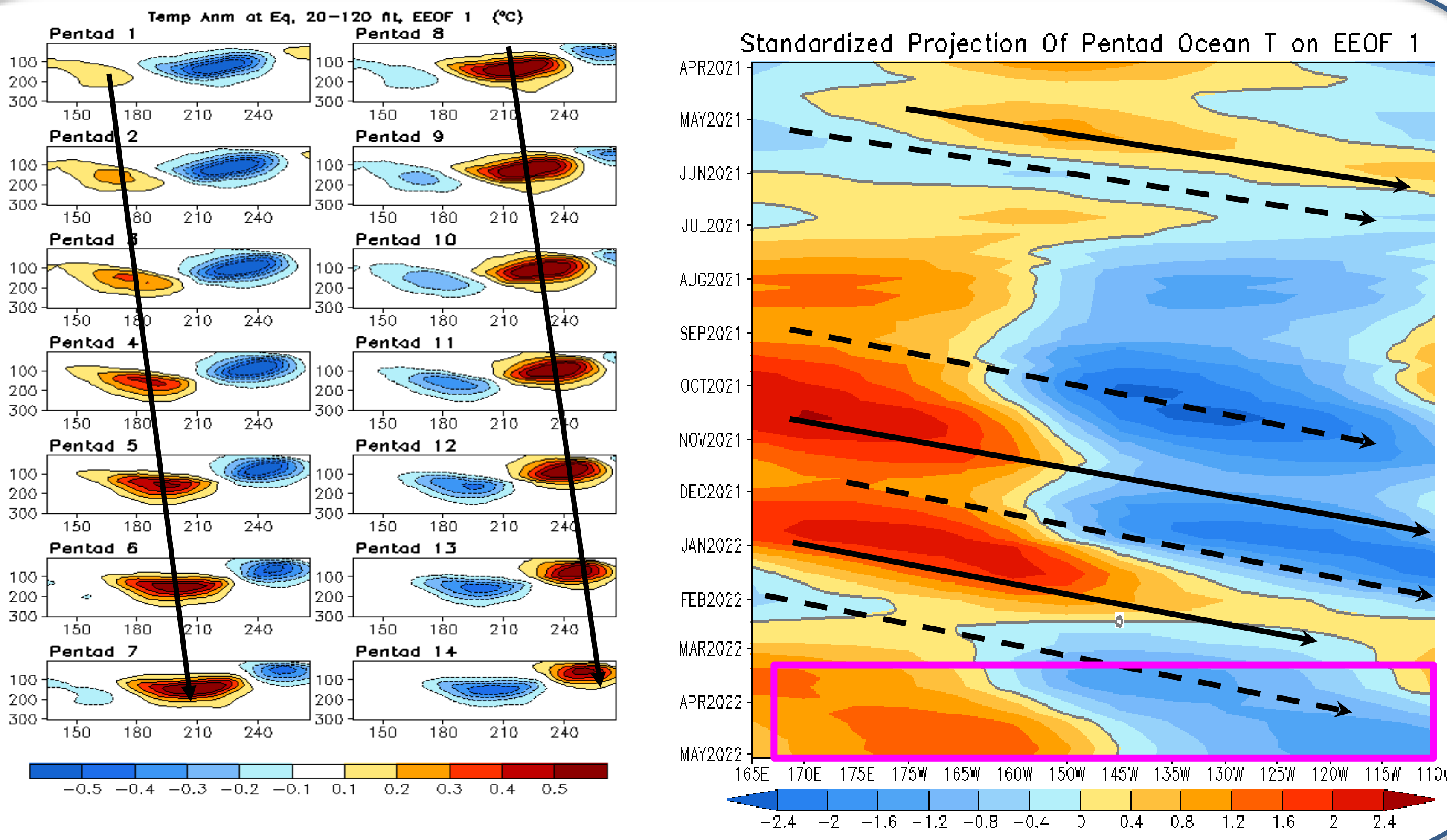
Amaya, D. J., 2019: The Pacific meridional mode and ENSO: A review. Curr. Climate Change Rep., 5, 296–307, 10.1007/s40641-019-00142-x.

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



- Anomalous westward currents were observed in both OSCAR and GODAS since Feb 2022.

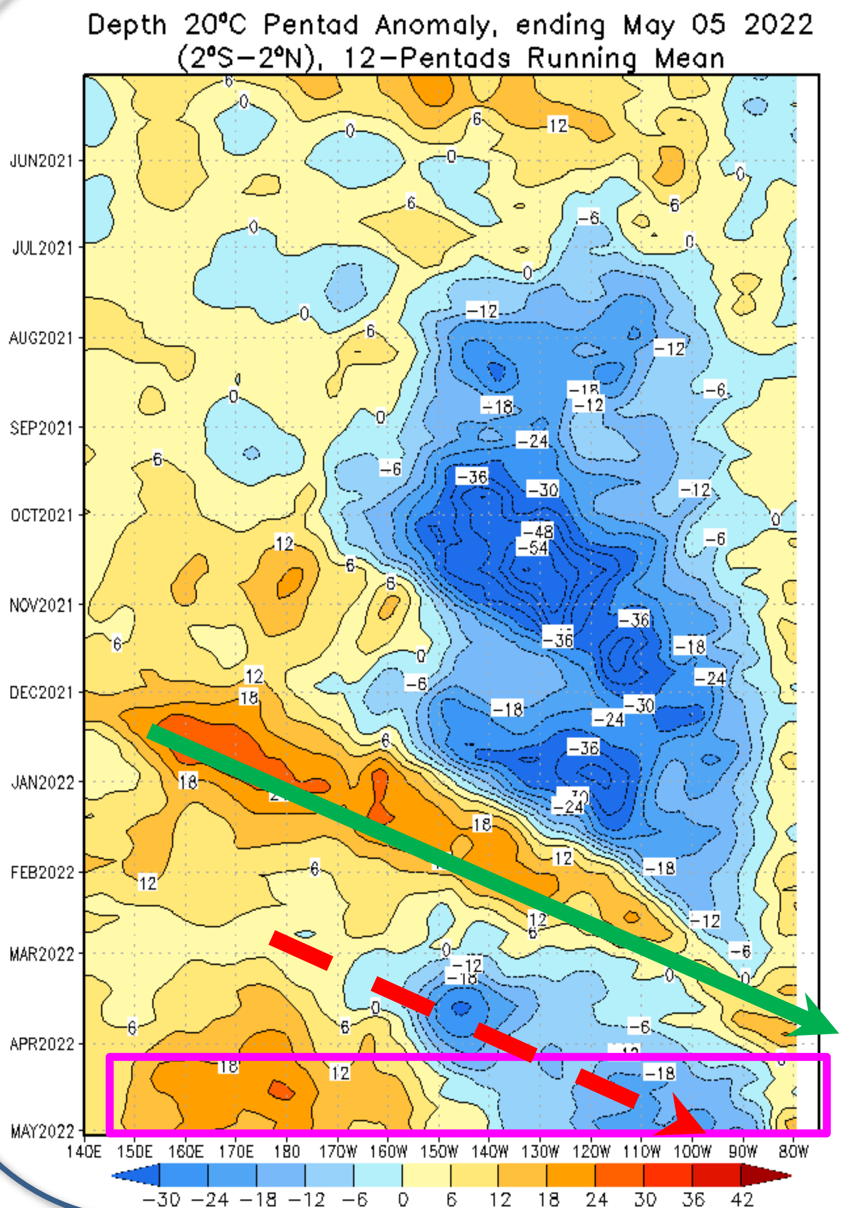
Oceanic Kelvin Wave (OKW) Index

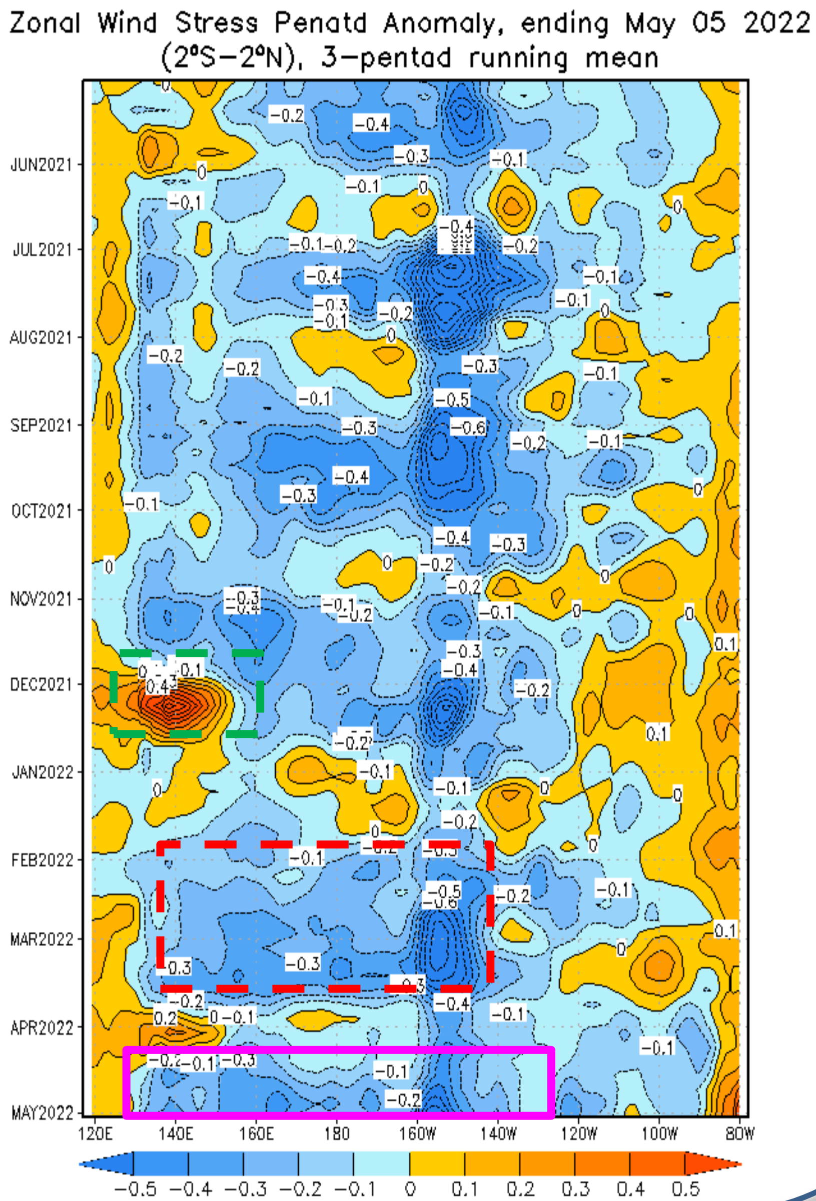


- **A downwelling Kelvin wave initiated in Dec 2021 led to the weakening of 2021/22 La Niña. An upwelling Kelvin wave was initiated in Jan-Feb 2022.**
- **Dipole-like variations with positive (negative) anomalies in the west (east) were observed since Mar 2022.**

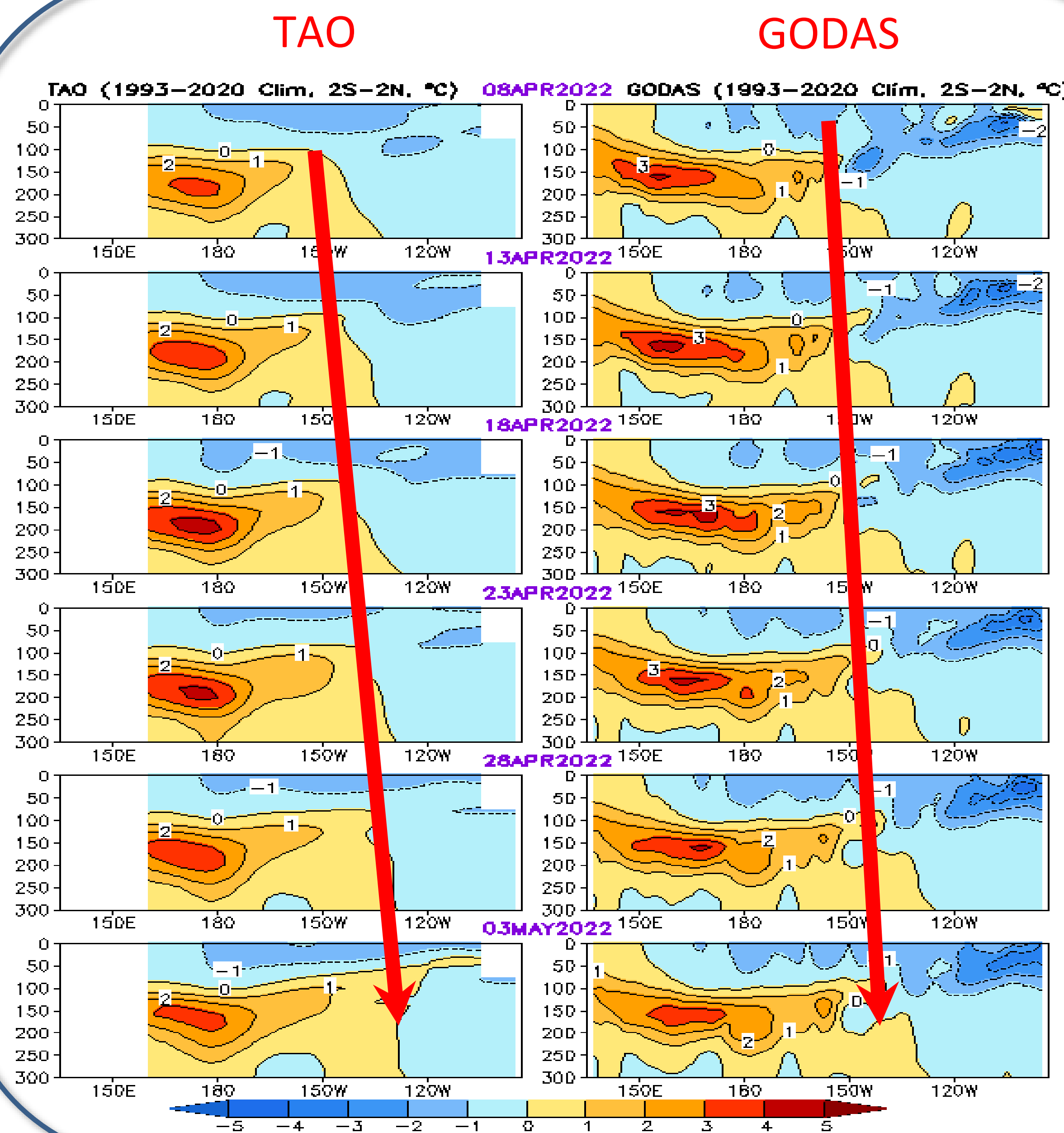
(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)

Evolution of Pentad D20 and Taux anomalies along the equator



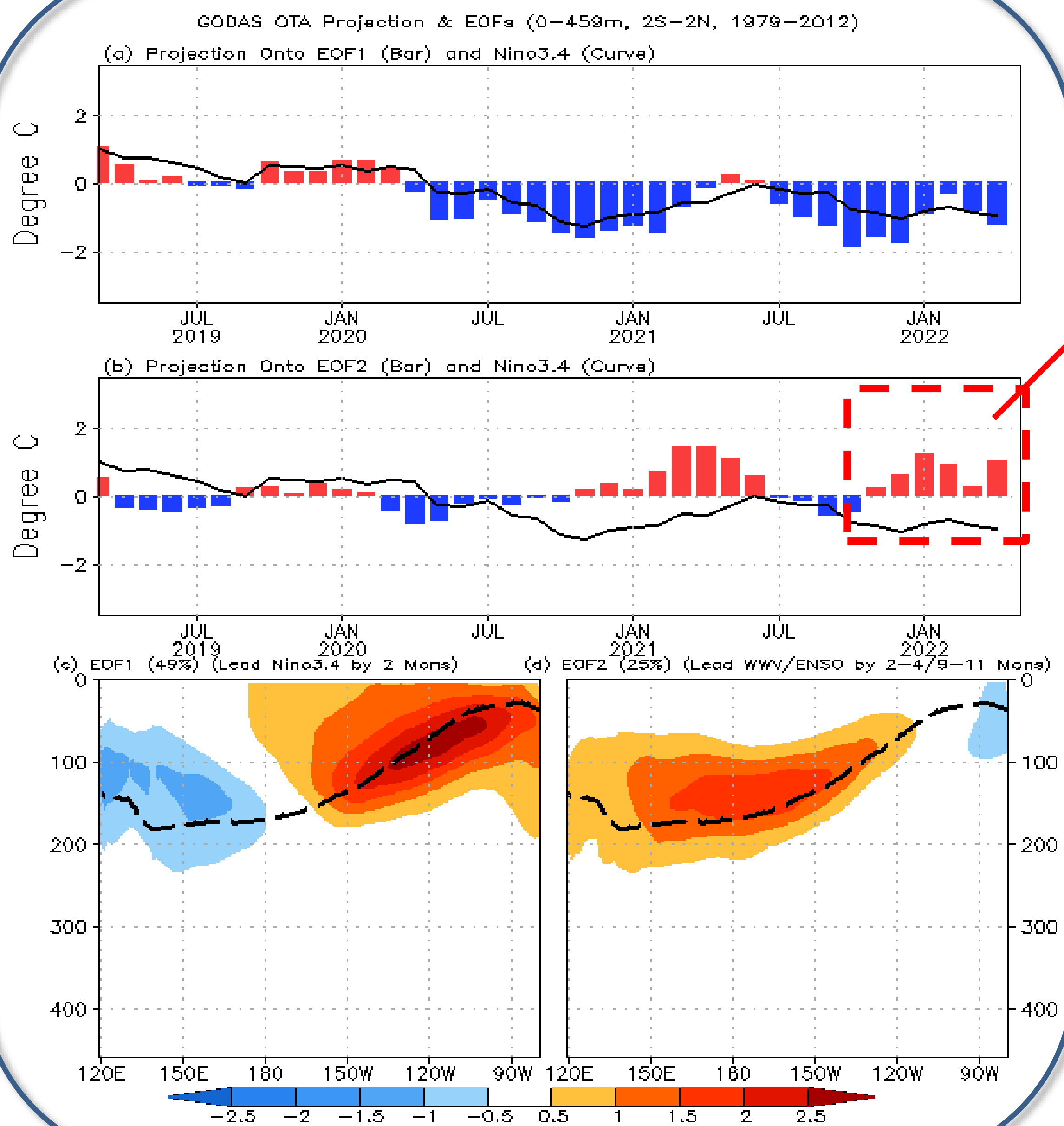


Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



- Positive (negative) ocean temperature anomalies were present in the central (east-central) Pacific.
- In addition to the stationary component, there is a slightly eastward propagation.
- The anomalies of GODAS were overall larger than TAO.

Equatorial Sub-surface Ocean Temperature Monitoring



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

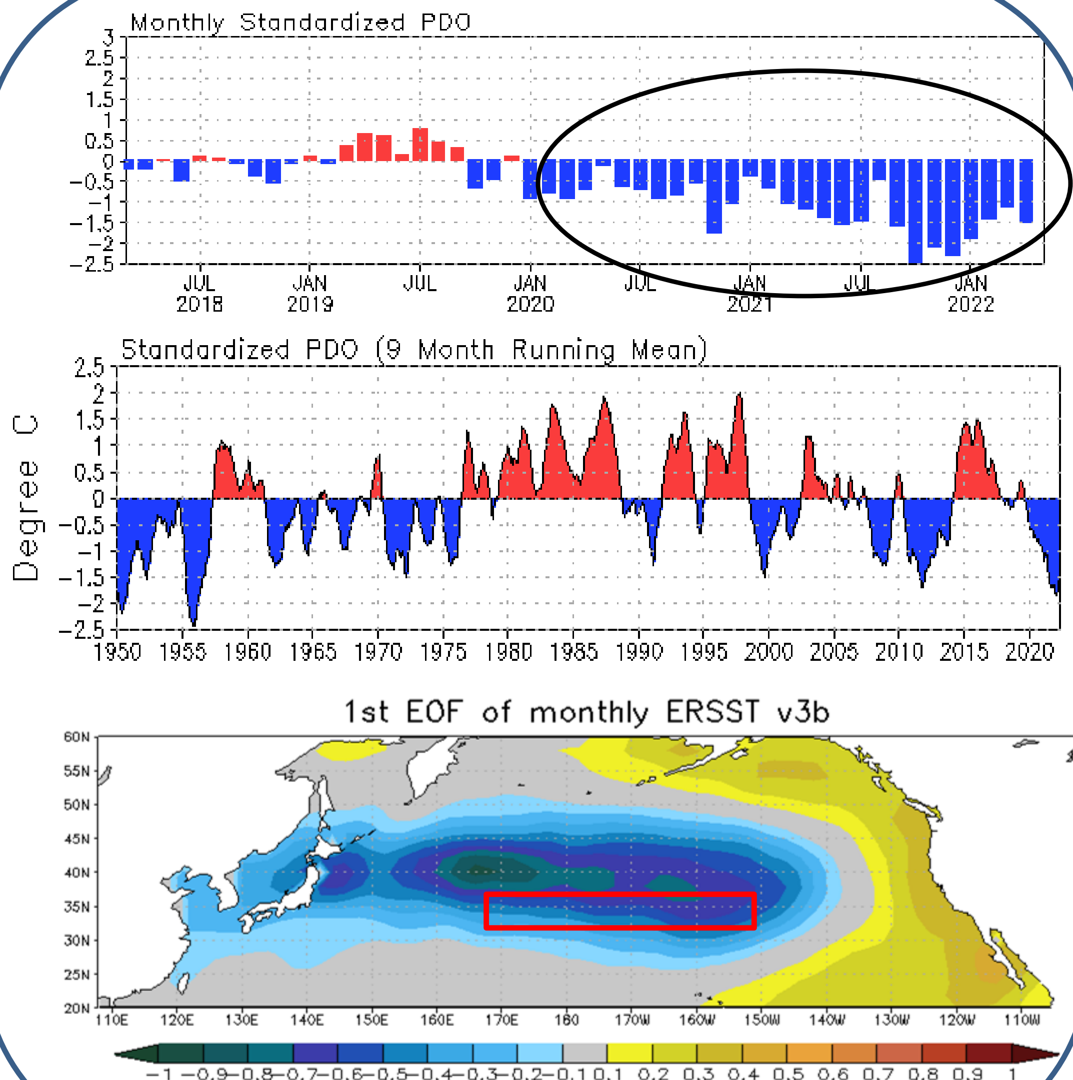
- Projection of ocean temperature anomalies onto EOF1 and EOF2; EOF1: Tilt/dipole mode (ENSO peak phase); EOF2: WWV mode.

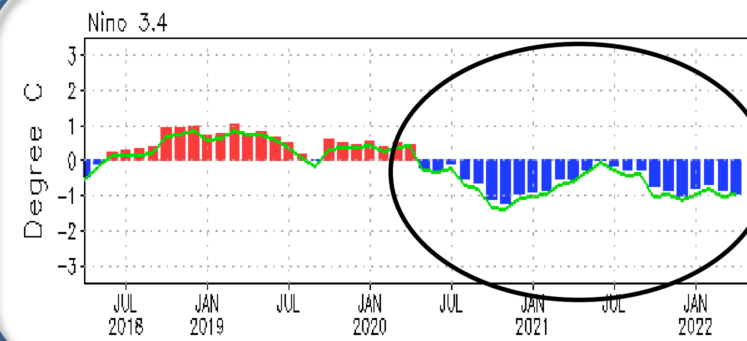
- Recharge/discharge oscillation (ENSO transition phase); Recharge process: heat transport from outside of equator to equator; Negative -> positive phase of ENSO

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

North Pacific & Arctic Oceans

Pacific Decadal Oscillation (PDO) Index



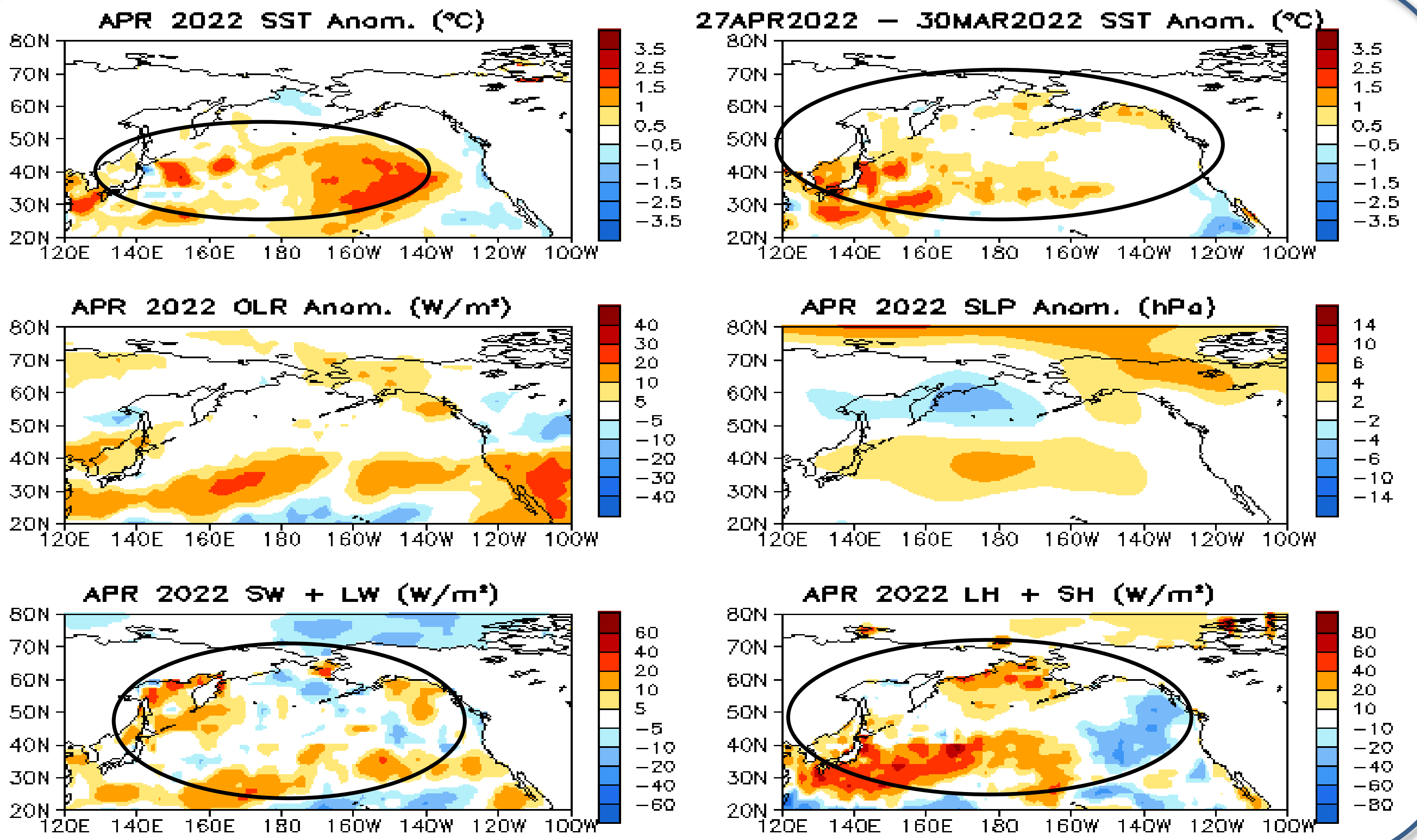


- The PDO has been in a negative phase since Jan 2020 with PDOI = -1.5 in Apr 2022.

- Statistically, ENSO leads PDO by 3-4 months, through teleconnection via atmospheric bridge, with El Niño (La Niña) associated with positive (negative) PDO Index.

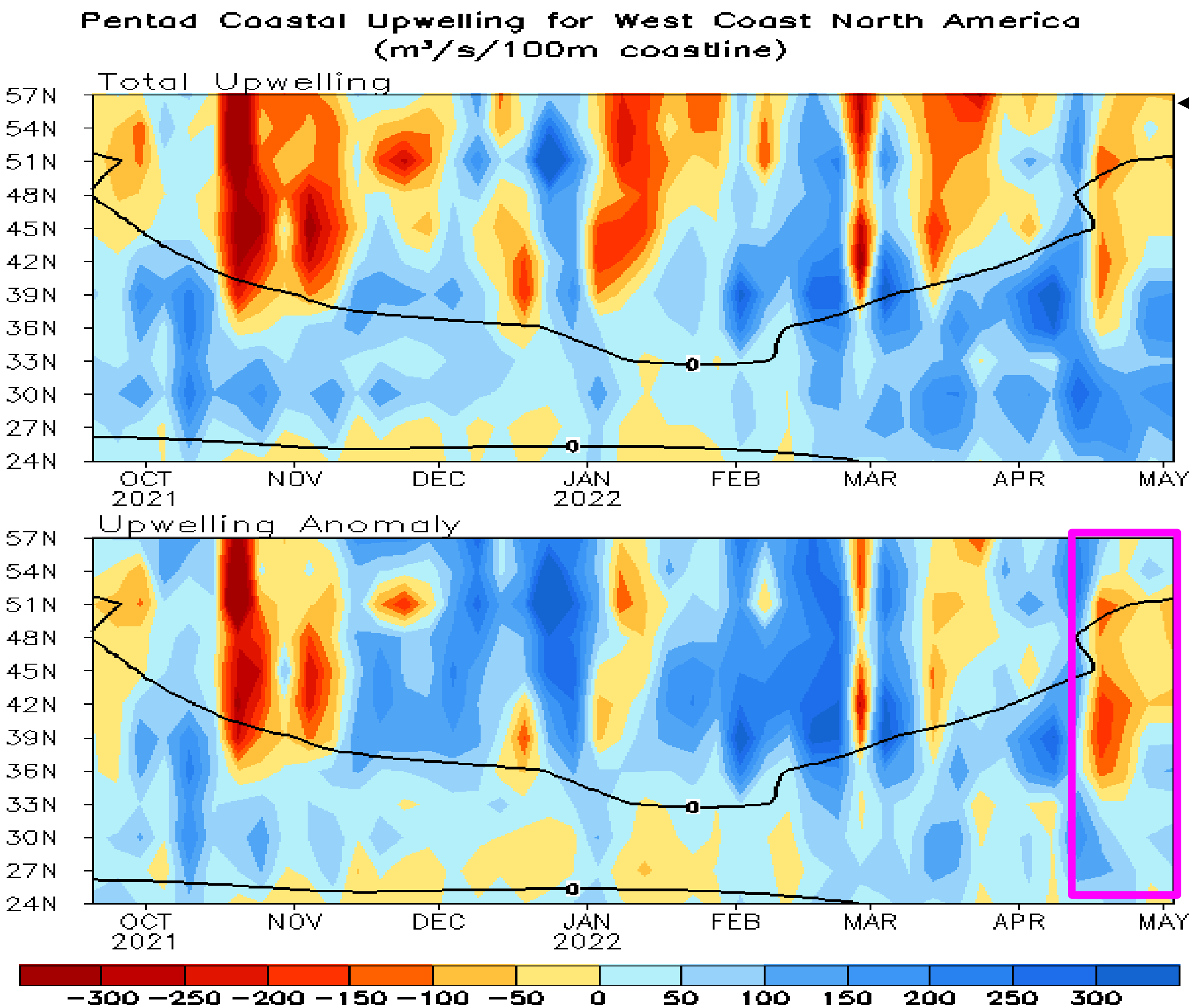
- PDO is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.

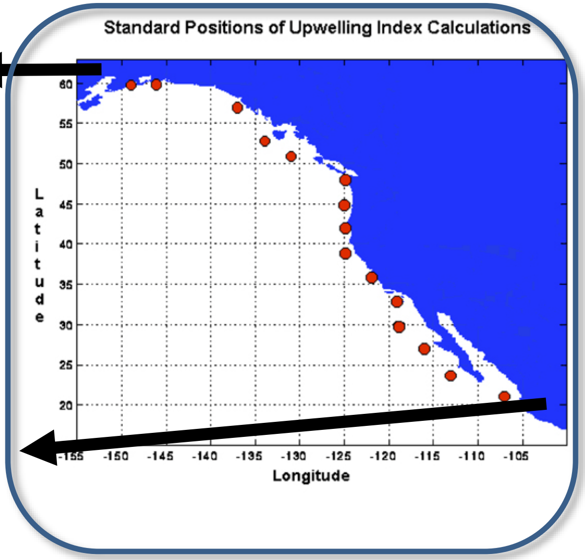
North Pacific & Arctic Ocean: SSTA, SSTA Tend., OLR, SLP, Sfc Rad, Sfc Flx Anomalies



SSTA (top-left; OI 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

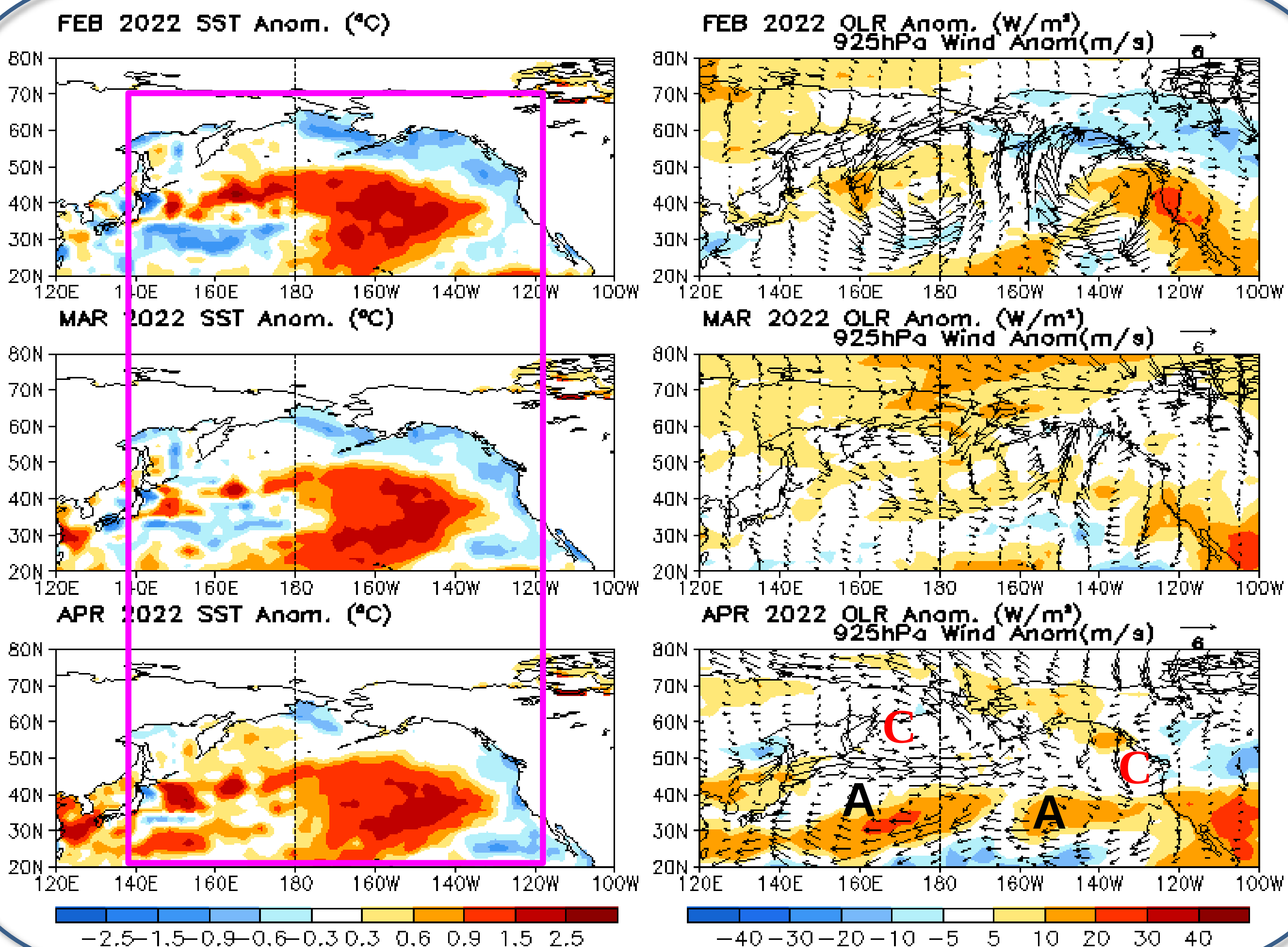




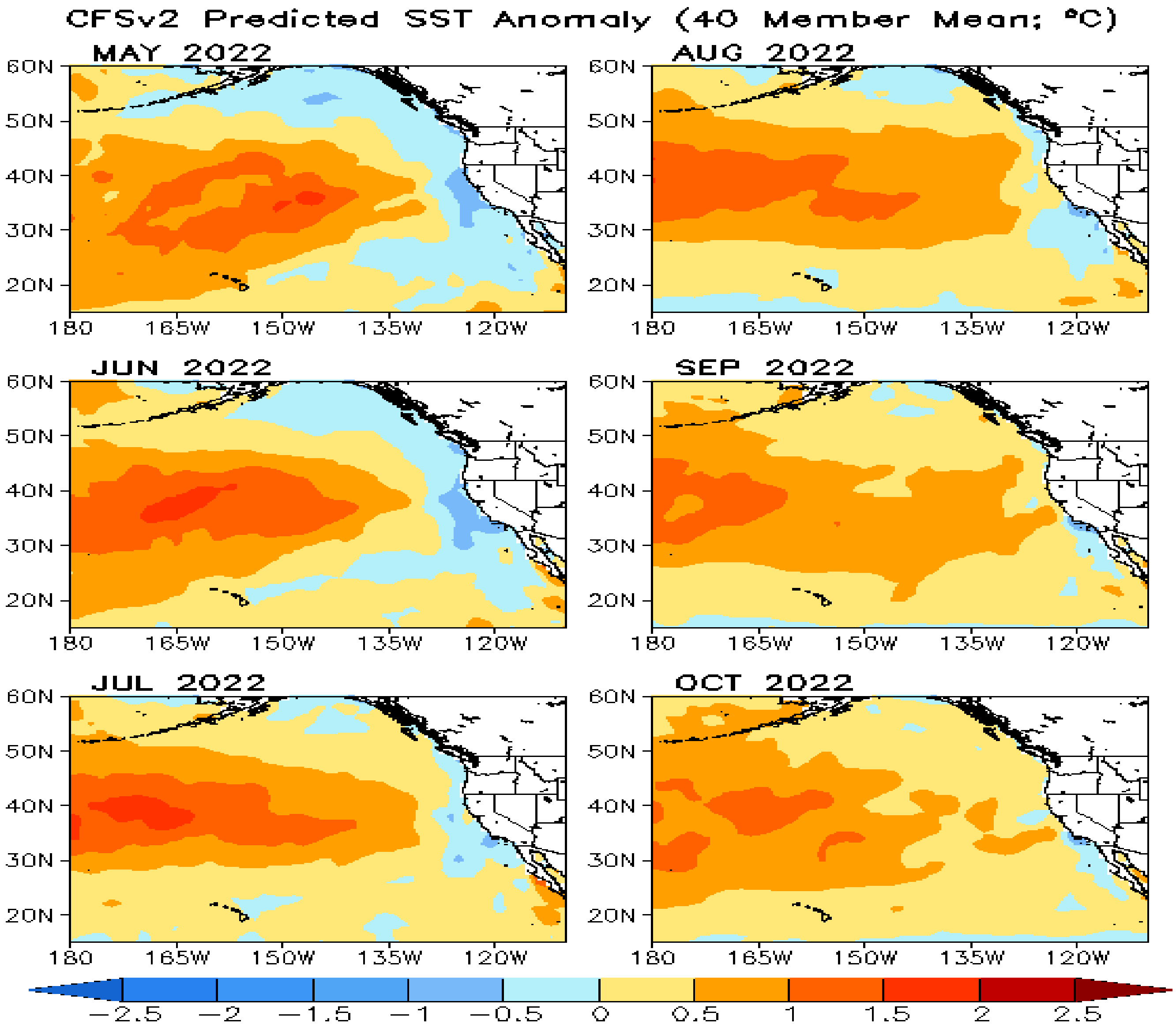
- Anomalous coastal downwelling was observed since mid-Apr 2022.

(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.

North Pacific SST, OLR, and uv925 anomalies

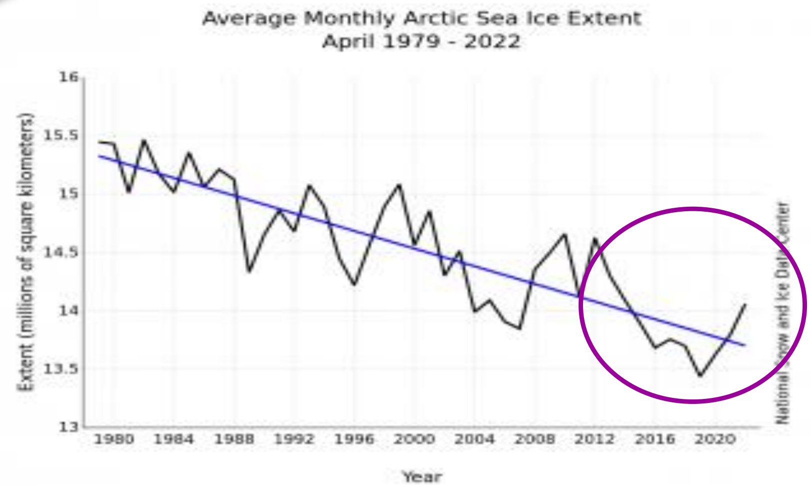


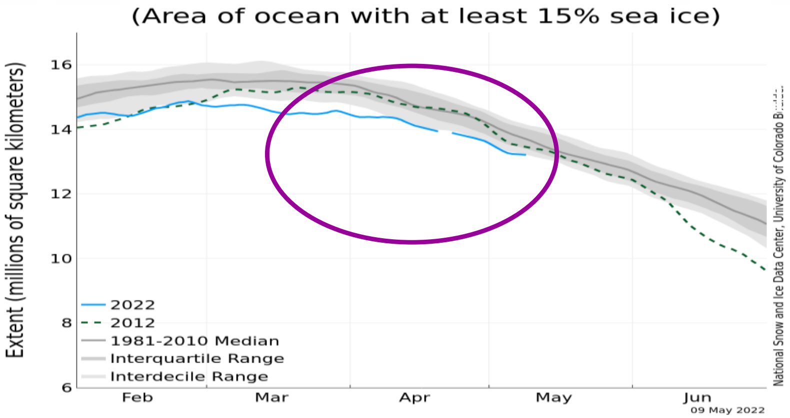
CFSv2 North Pacific SSTA Predictions

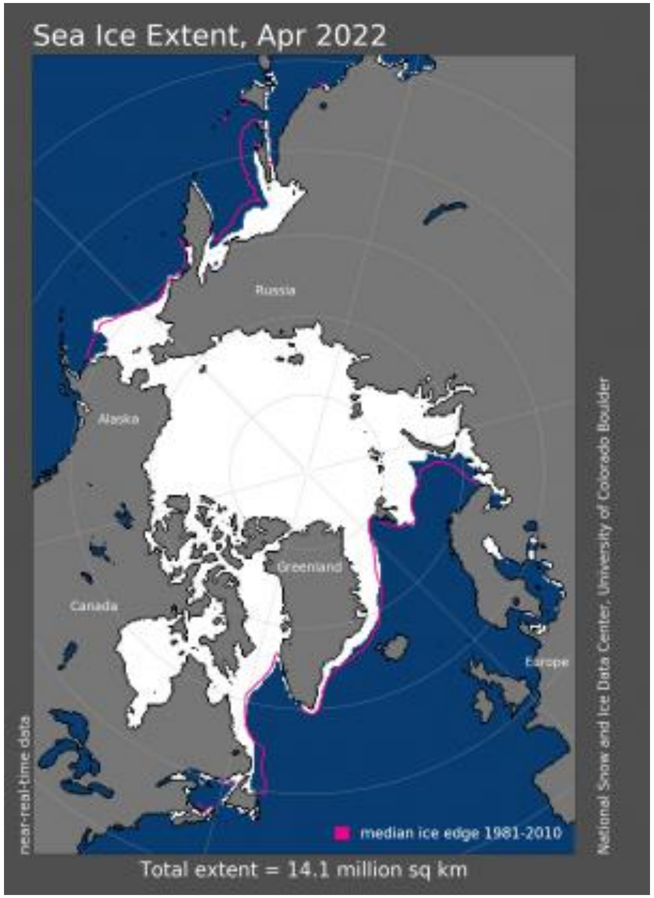


- The CFSv2 predicts that the current SST warm state will continue.

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

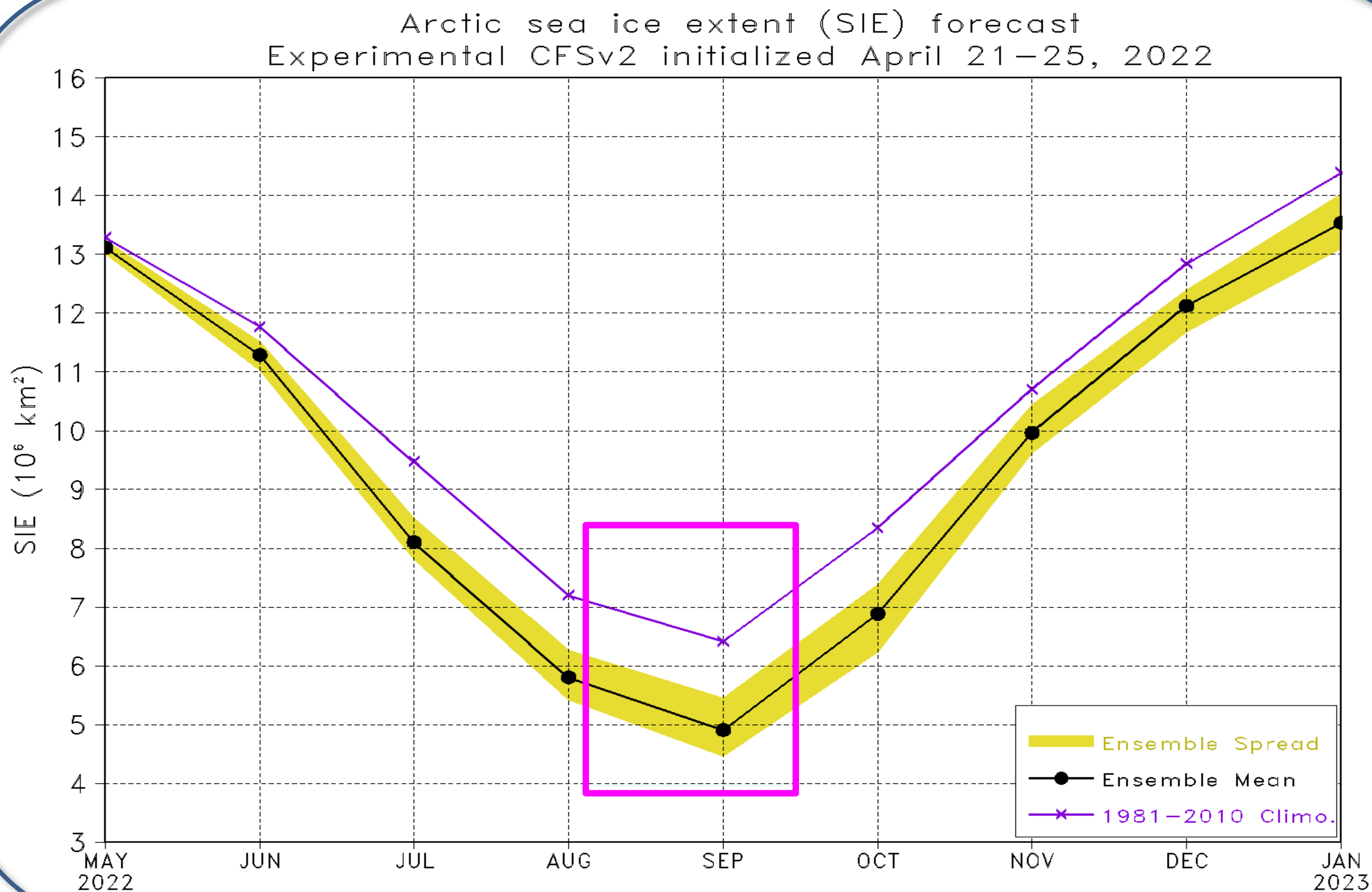






- Arctic spring melt has started. Overall decline was slower than average through the month.
- Average Arctic sea ice extent for April 2022 ranked the eleventh lowest in the 44-year satellite record.
- The downward linear trend in April sea ice extent over the 44-year-satellite record is 2.6 percent per decade relative to the 1981 to 2010 average.

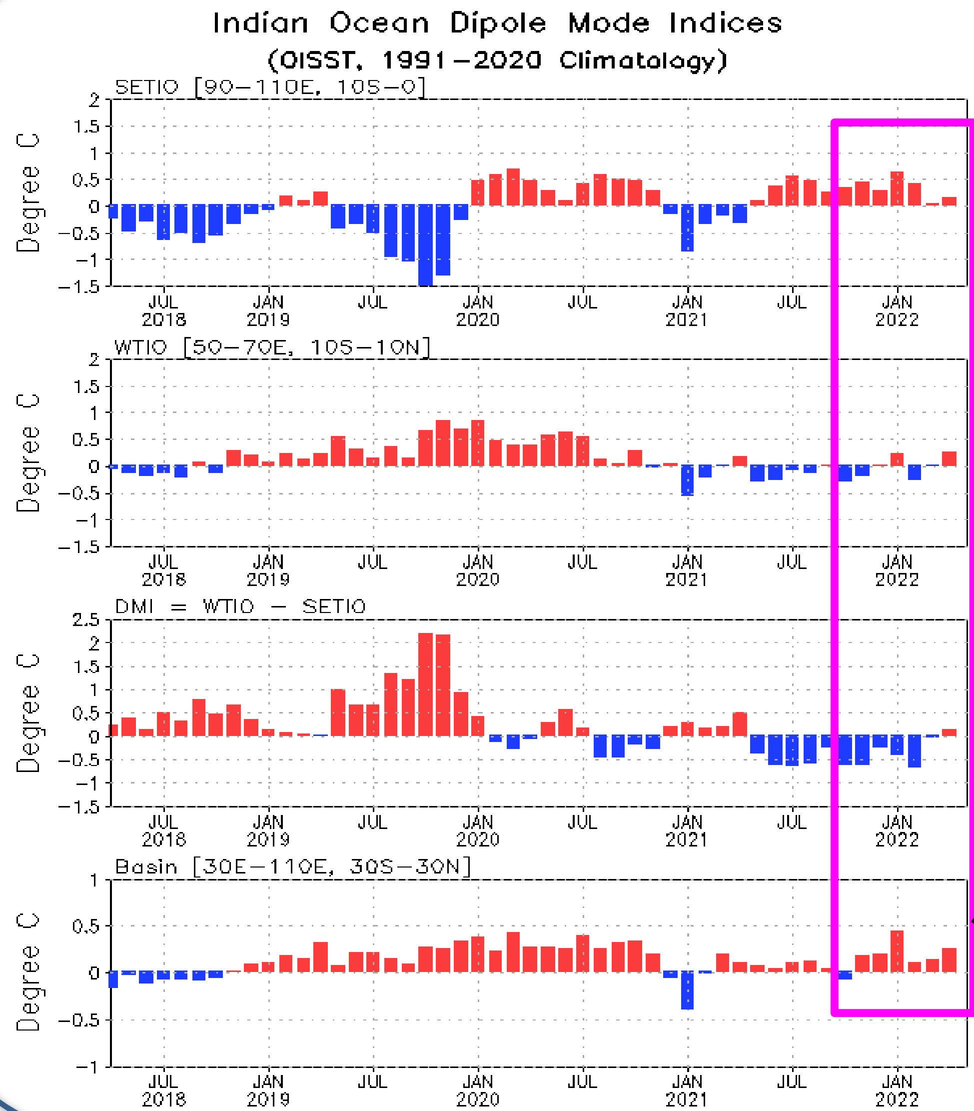
NCEP/CPC Arctic Sea Ice Extent Forecast

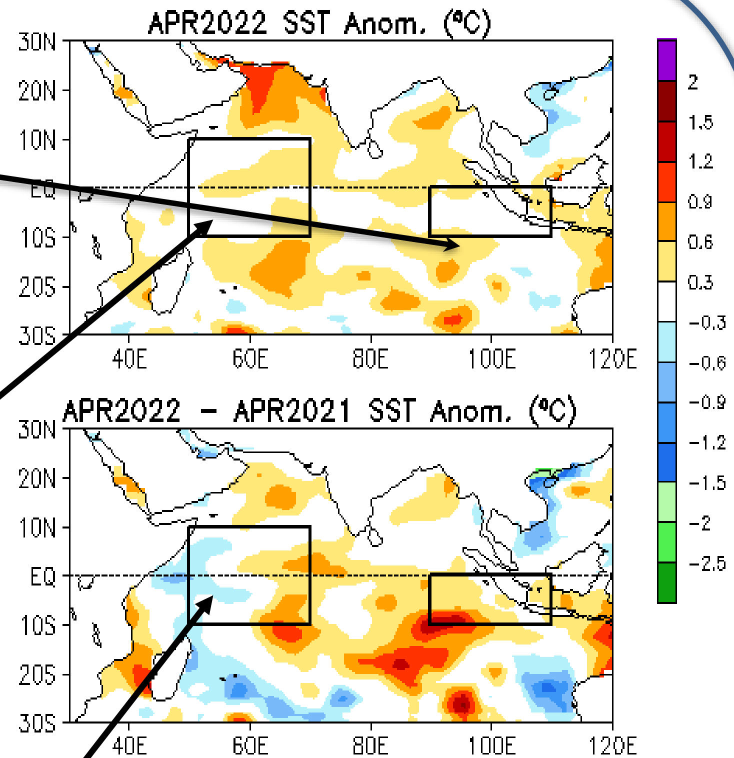


https://www.cpc.ncep.noaa.gov/products/people/wwang/seaice_seasonal/index.html

Indian Ocean

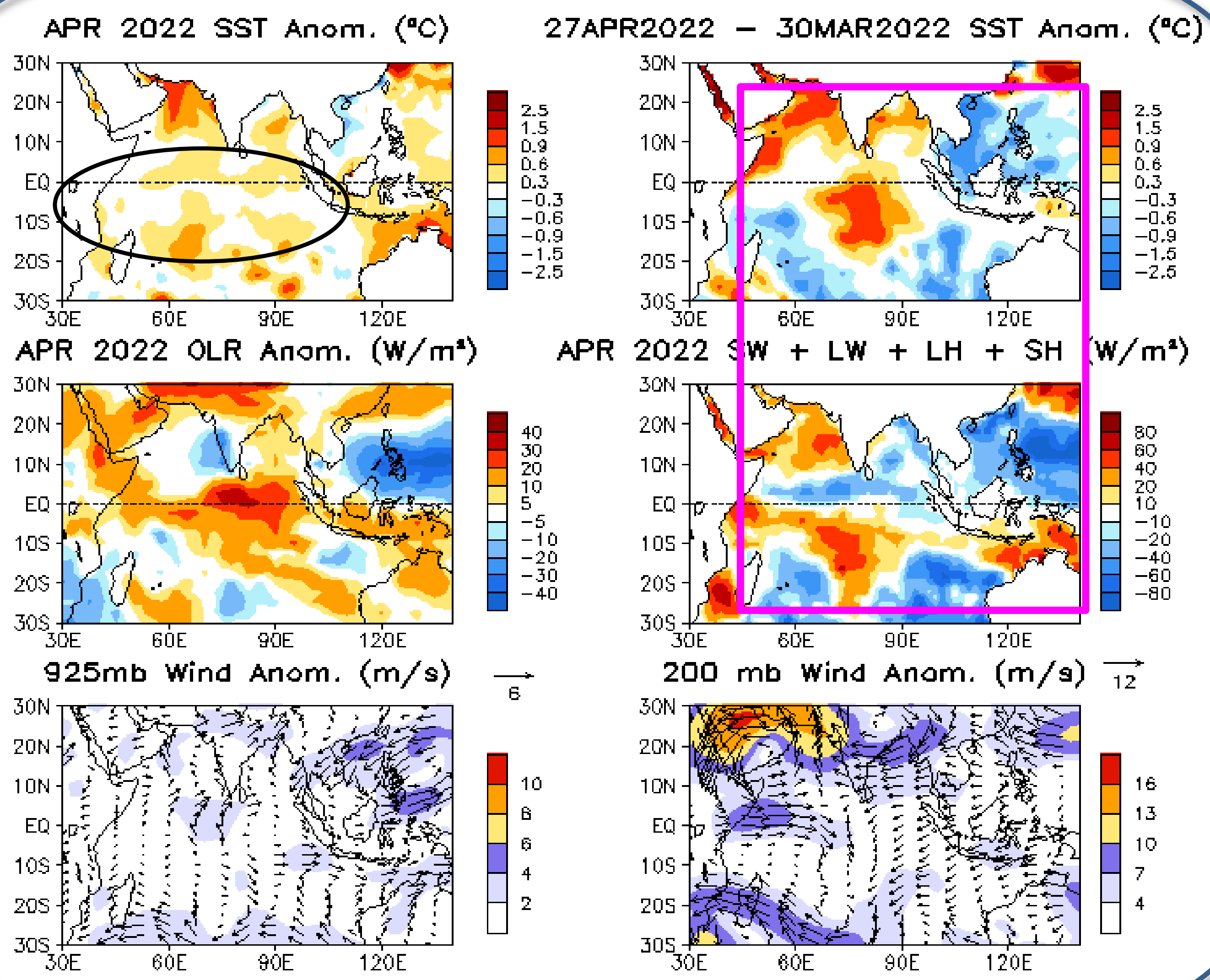
Evolution of Indian Ocean SST Indices





- Overall, SSTs were slightly above average in the tropical Indian Ocean in Apr 2022.

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 OI SST analysis, and anomalies are departures from the 1991-2020 base period means.

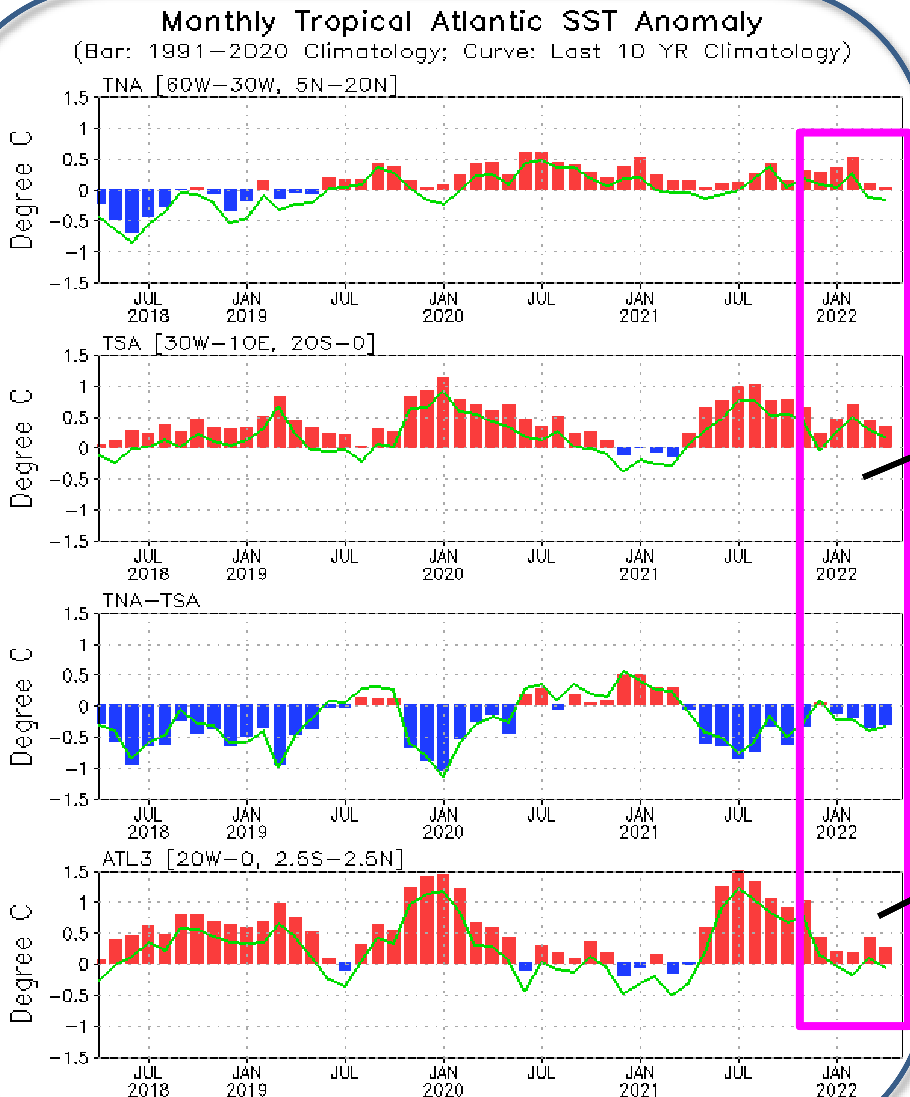


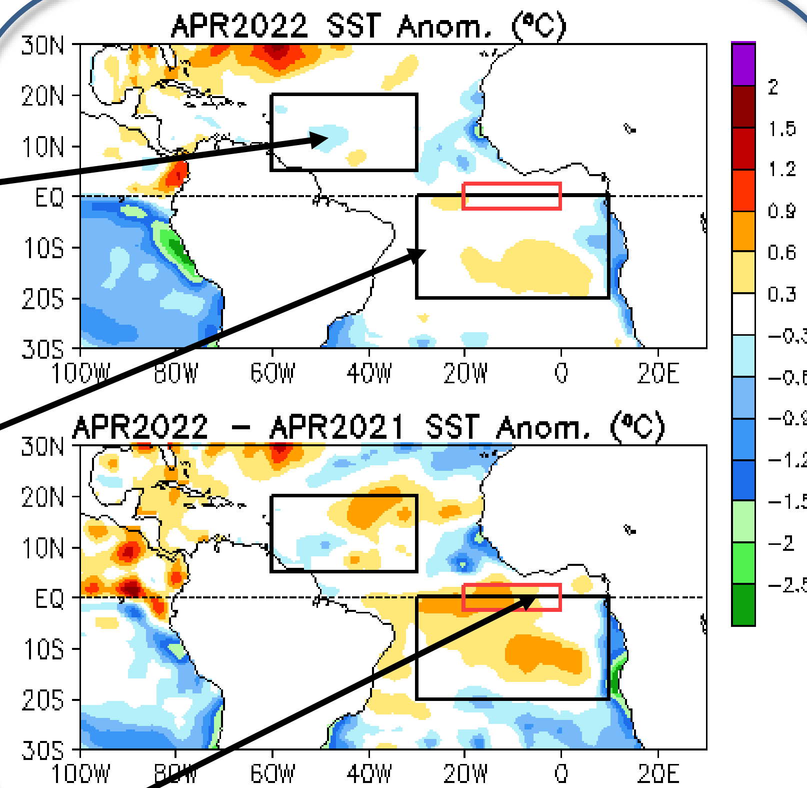
- SSTAs were small in the tropical Indian Ocean.
- SSTA tendencies along the equator were partially consistent with the net heat flux anomalies.

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 OI 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

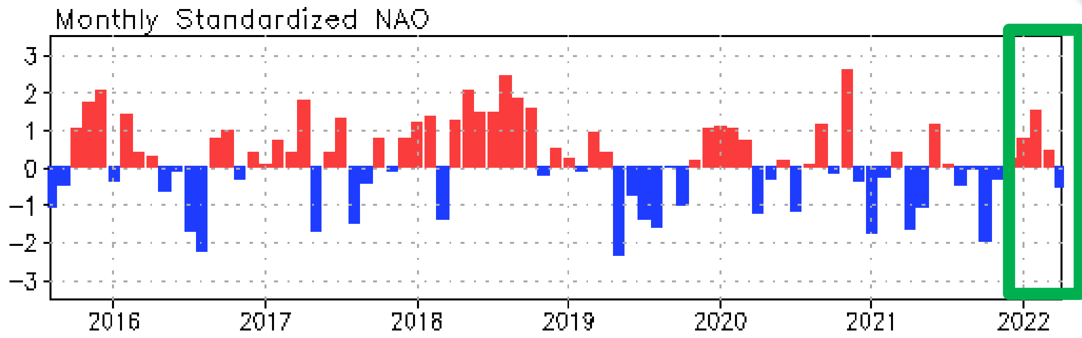


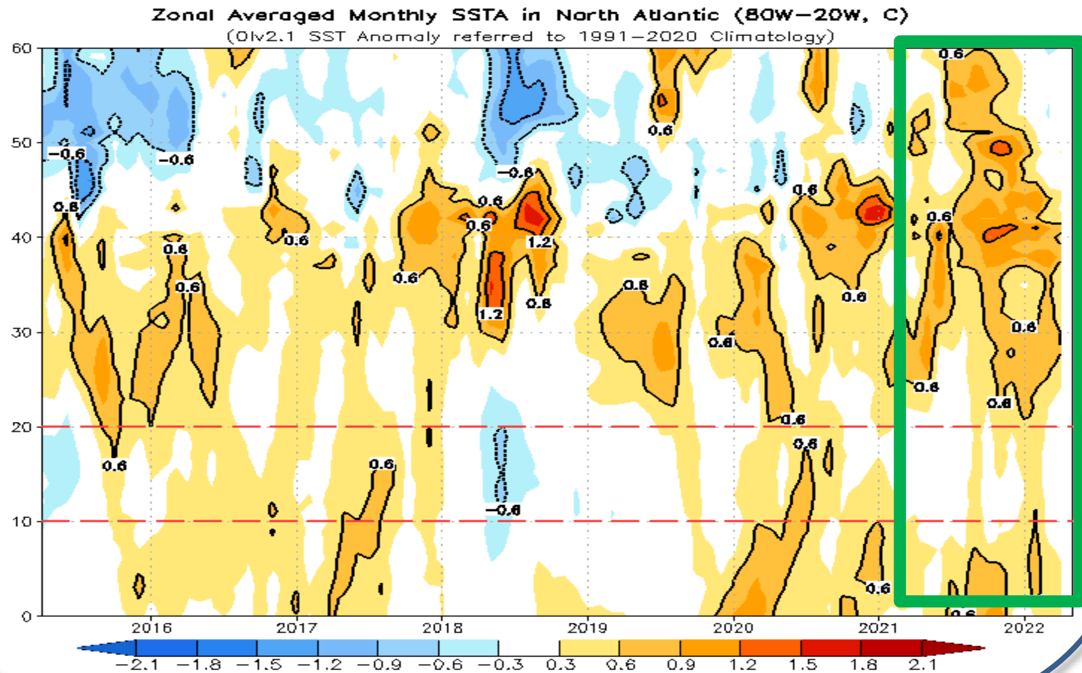


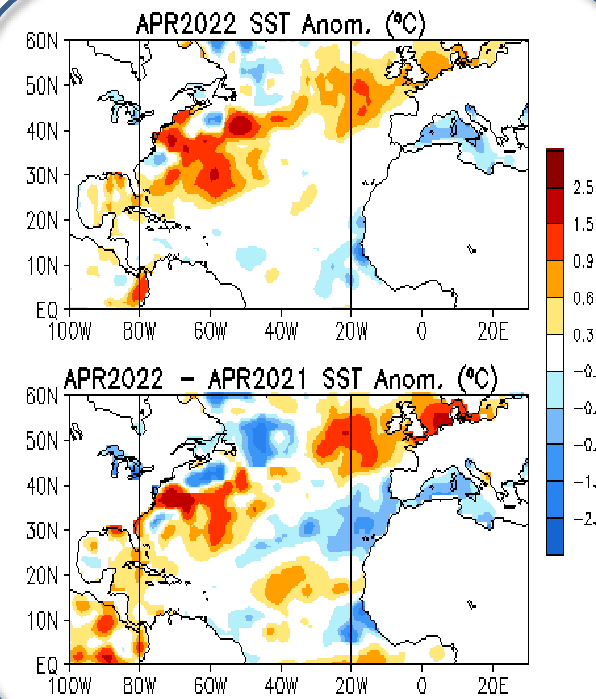
- SSTAs were small in the tropical Atlantic.
- The Atlantic Niño event ended in Dec 2021.

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

NAO and SST Anomaly in North Atlantic



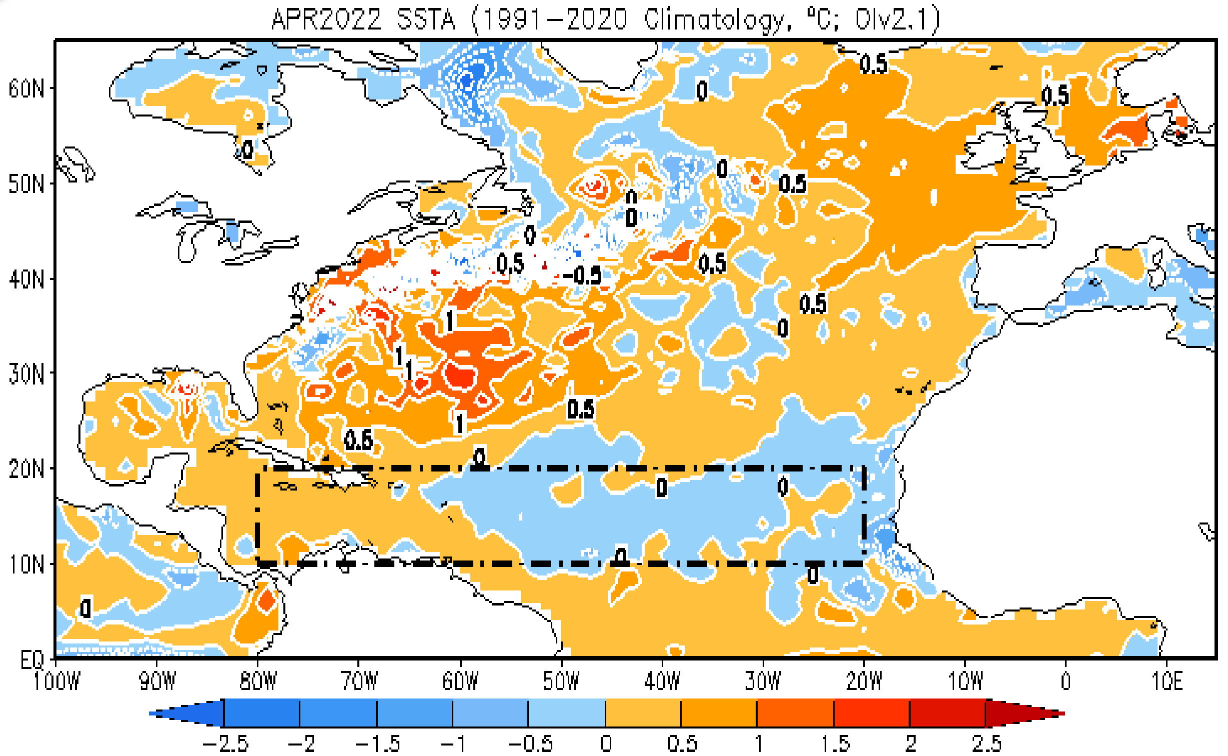


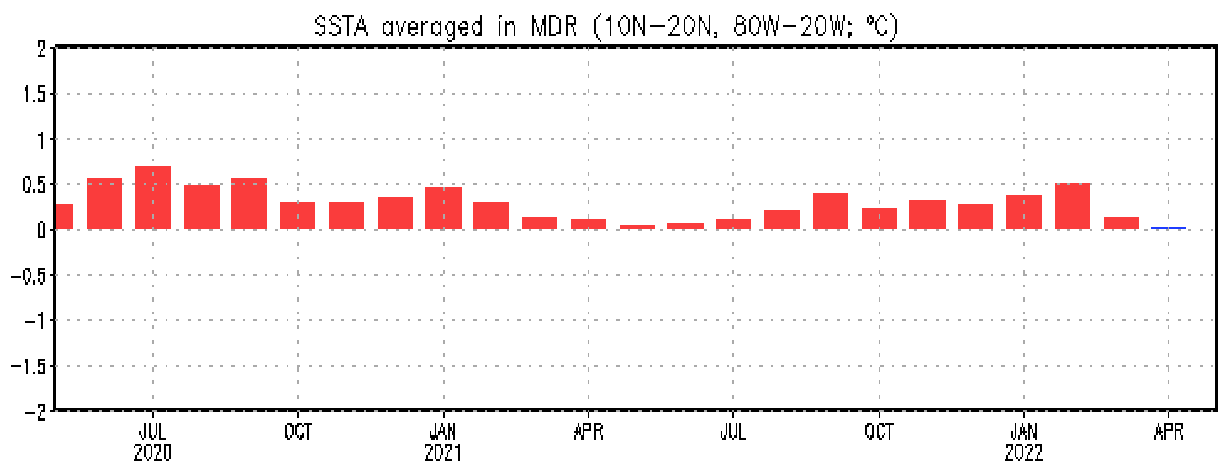


- NAO switched to a negative phase in Apr 2022 with NAOI= -0.5.
- The positive SSTAs in the mid-high latitudes of the North Atlantic Ocean were evident since 2021.

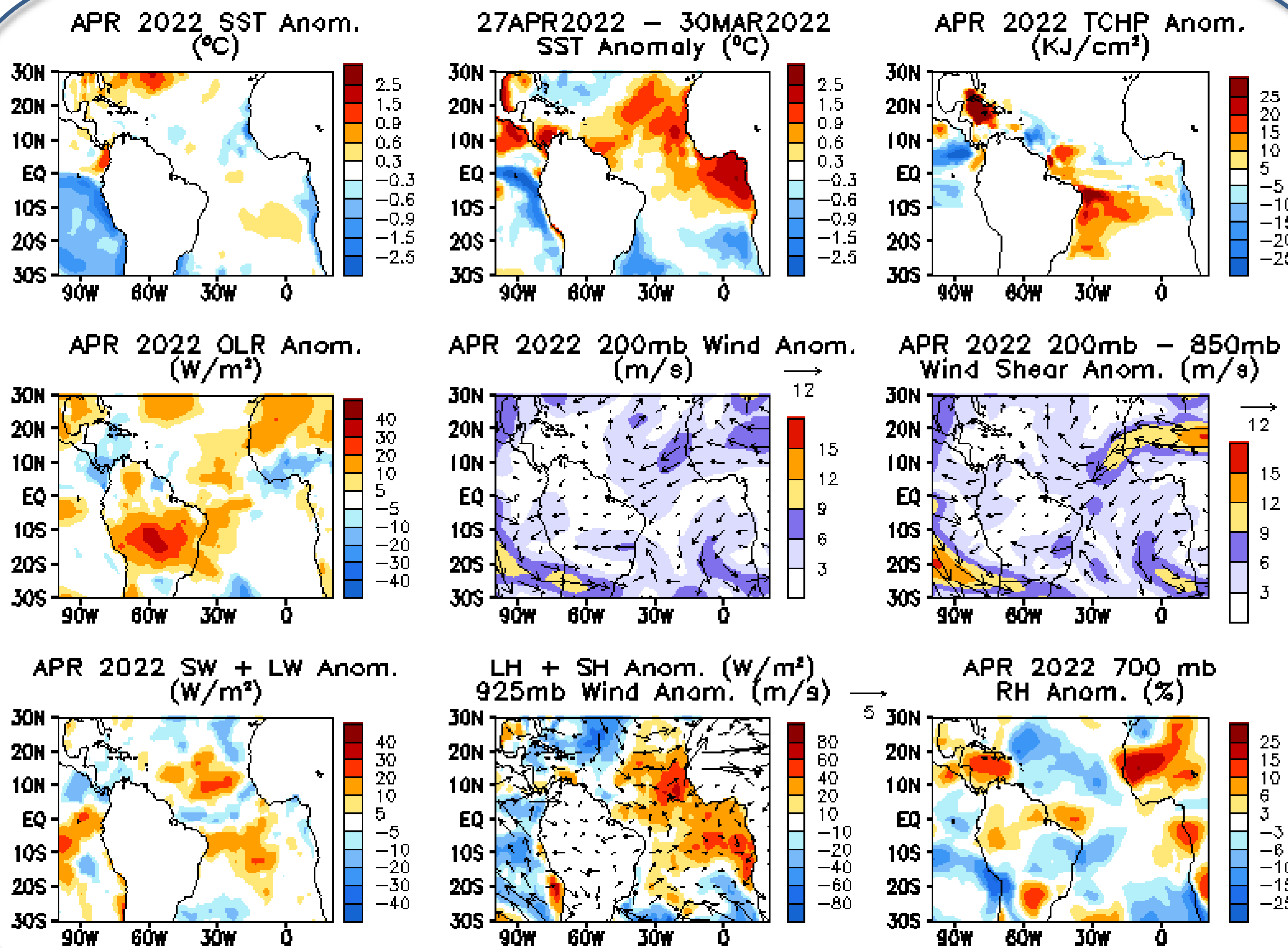
Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20^{O}N-90^{O}N. Time-latitude section of SSTAs averaged between 80ºW and 20ºW (bottom). SST are derived from the OI SST analysis, and anomalies are departures from the 1991-2020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

SSTAs in the North Atlantic & MDR



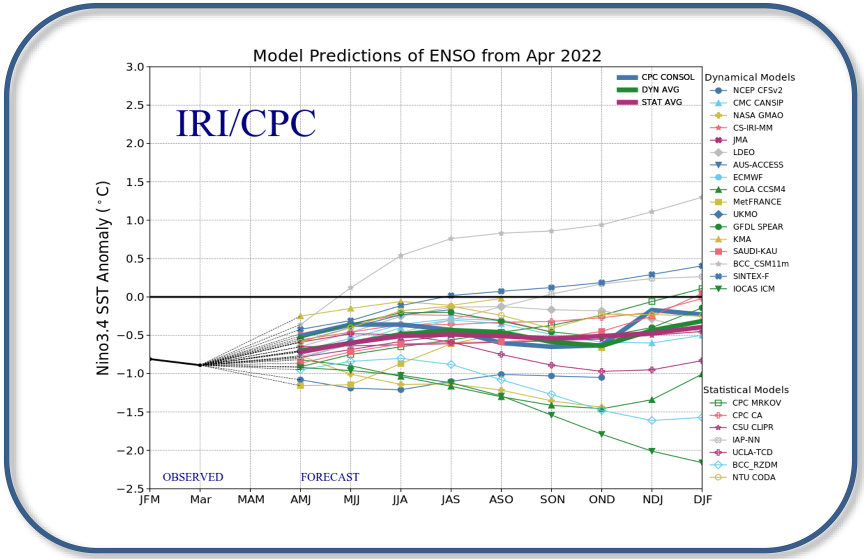


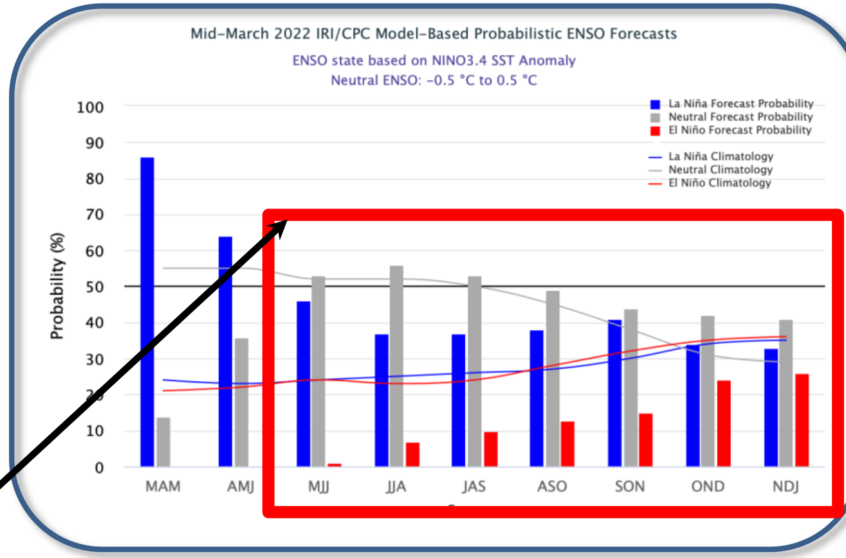
- SST in MDR was mostly above average during the last two years.
- SSTA was positive (negative) in the western (central and eastern) MDR in the last month.

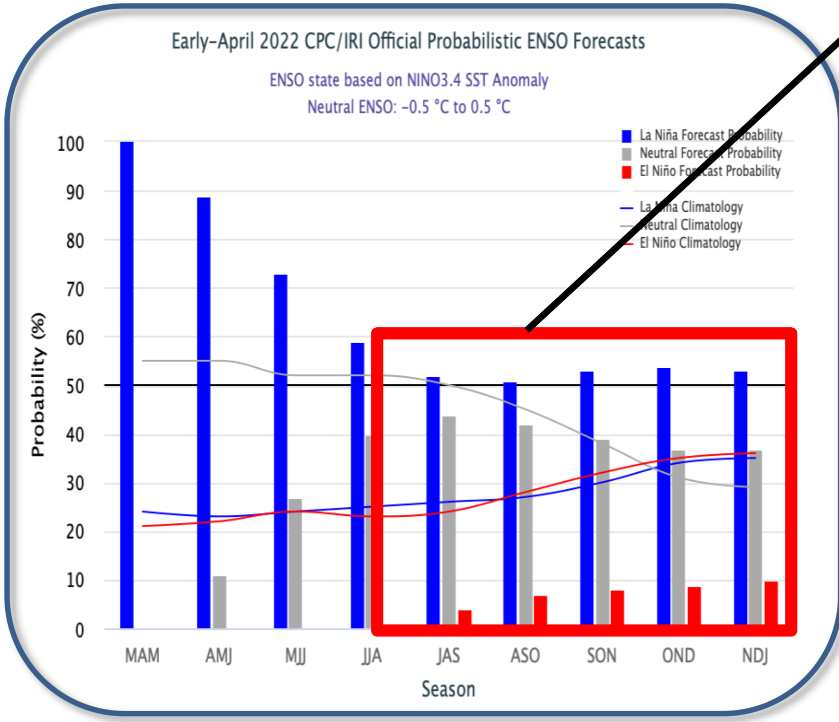

APR 2022 SST Anom. (°C)
27APR2022 – 30MAR2022 SST Anomaly (°C)
APR 2022 TCHP Anom. (KJ/cm²)
APR 2022 OLR Anom. (W/m²)
APR 2022 200mb Wind Anom. (m/s)
APR 2022 200mb – 850mb Wind Shear Anom. (m/s)
APR 2022 SW + LW Anom. (W/m²)
LH + SH Anom. (W/m²) 925mb Wind Anom. (m/s)
APR 2022 700 mb RH Anom. (%)
30N 20N 10N EQ 10S 20S 30S
90W 60W 30W 0

ENSO and Global SST Predictions

IRI/CPC Niño3.4 Forecast: Apr 2022



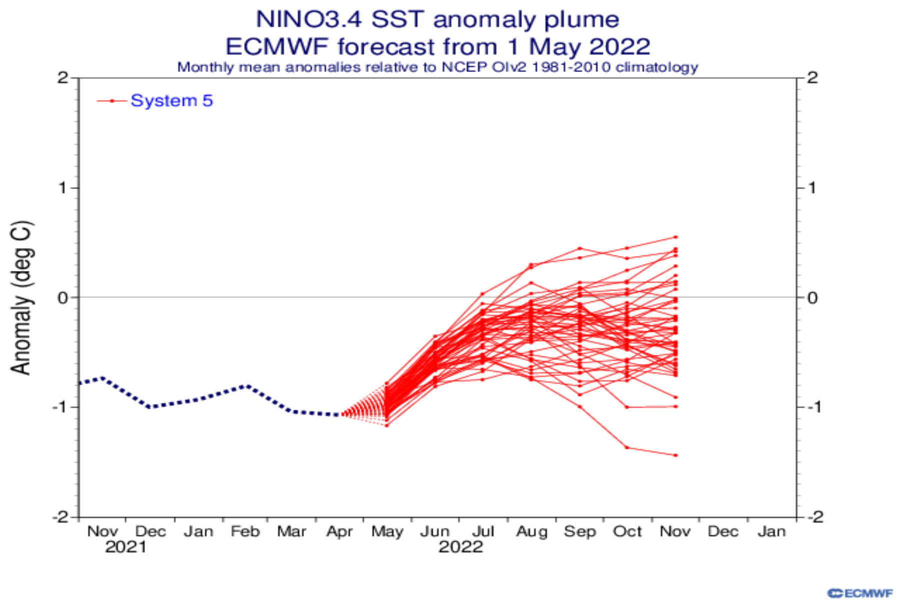




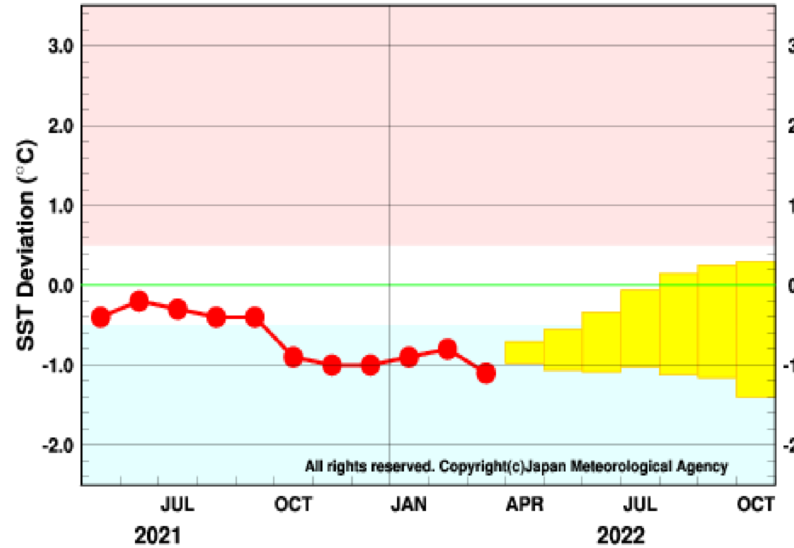
- **ENSO Alert System Status: La Niña Advisory**
- <u>Synopsis:</u> *La Niña is favored to continue through the Northern Hemisphere summer (59% chance during June-August 2022), with a 50-55% chance through the fall.*

Individual Model Forecasts: ENSO neutral or borderline La Nina

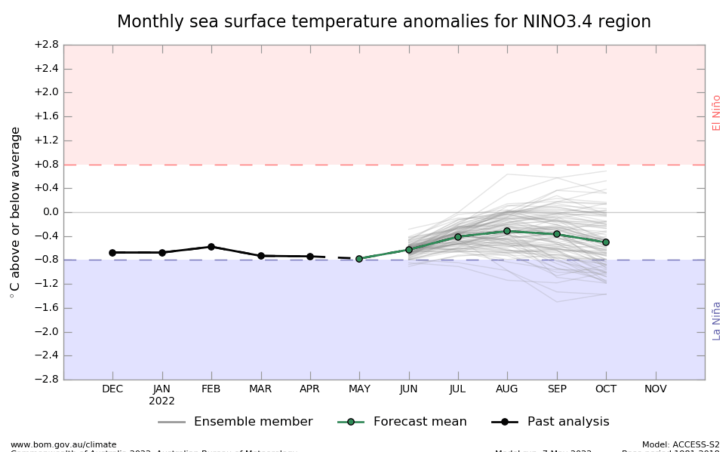
EC: IC= 1 May 2022



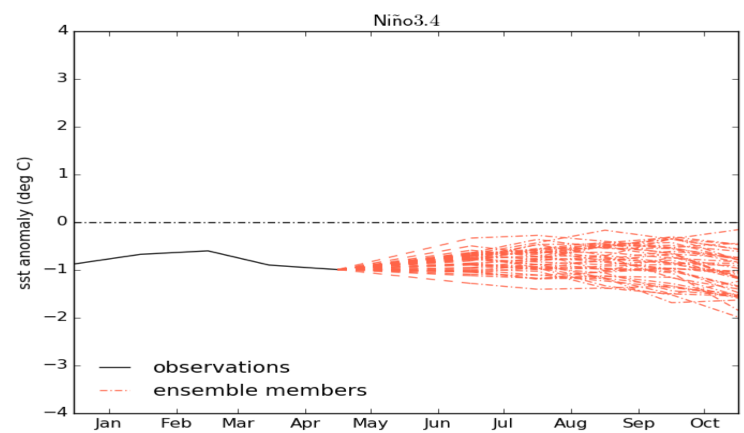
JMA: Updated 11 Apr 2022



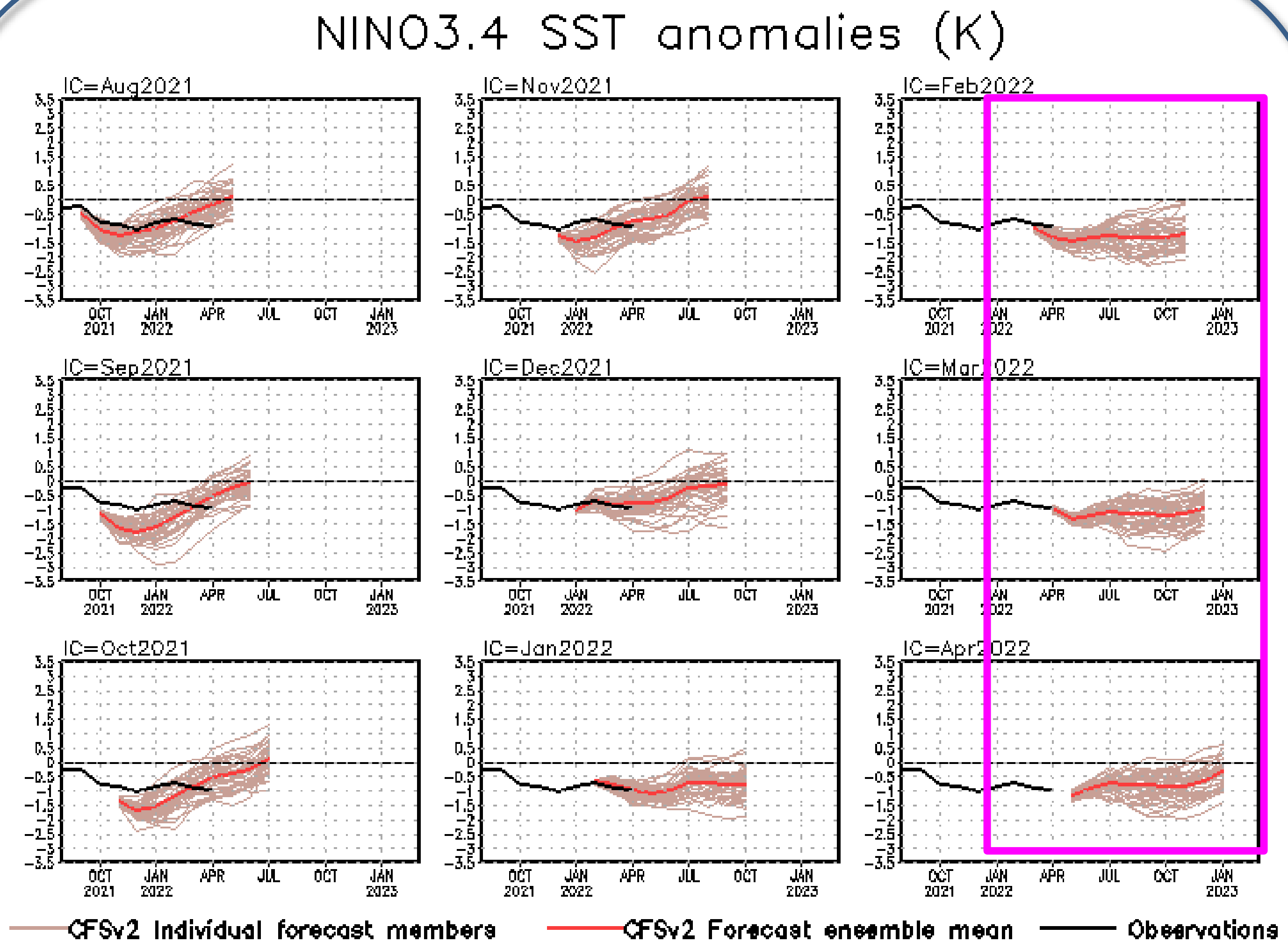
Australian BOM: Updated 7 May 2022



UKMO: Updated 11 My 2022



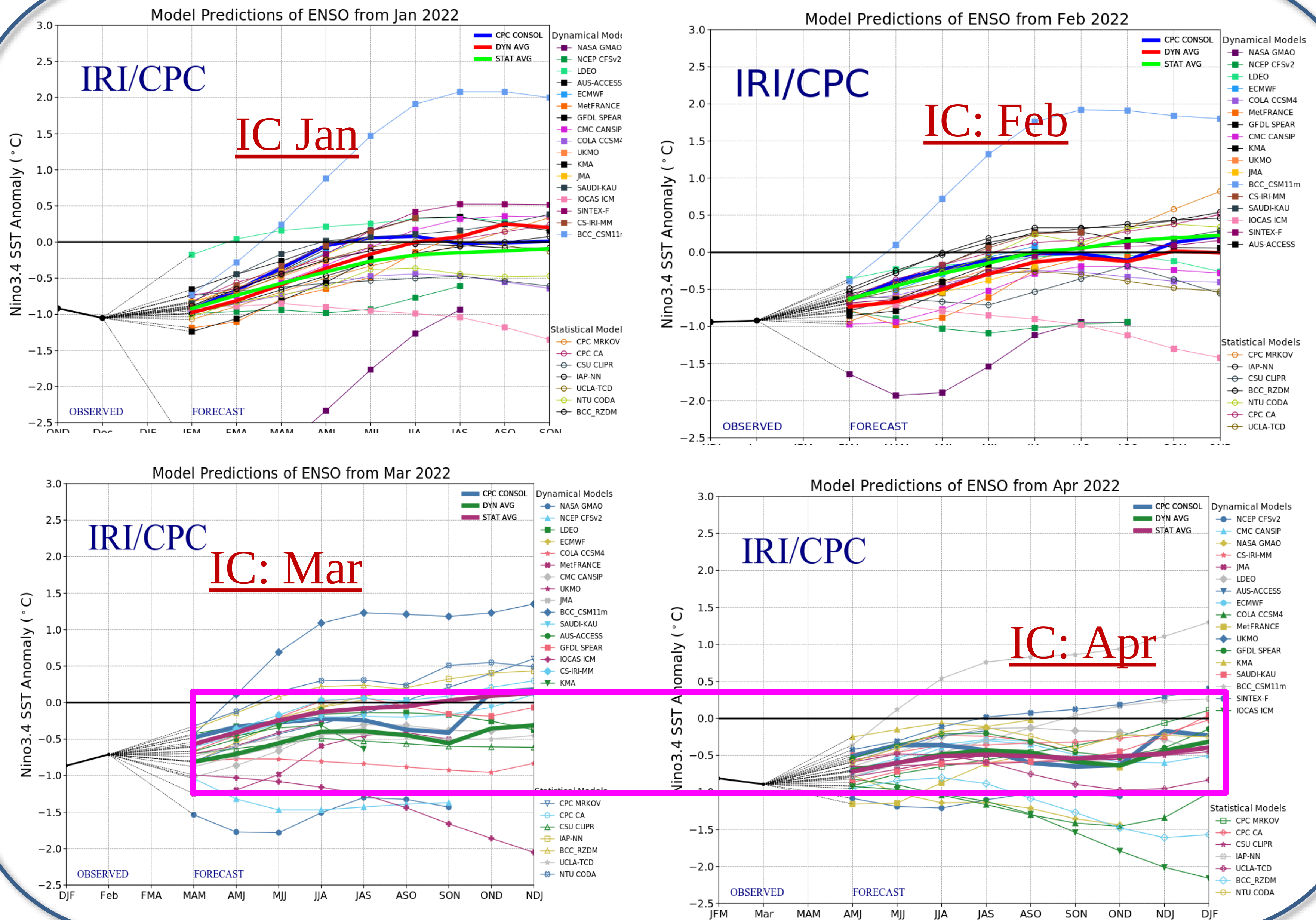
CFS Niño3.4 SST Predictions from Different Initial Months



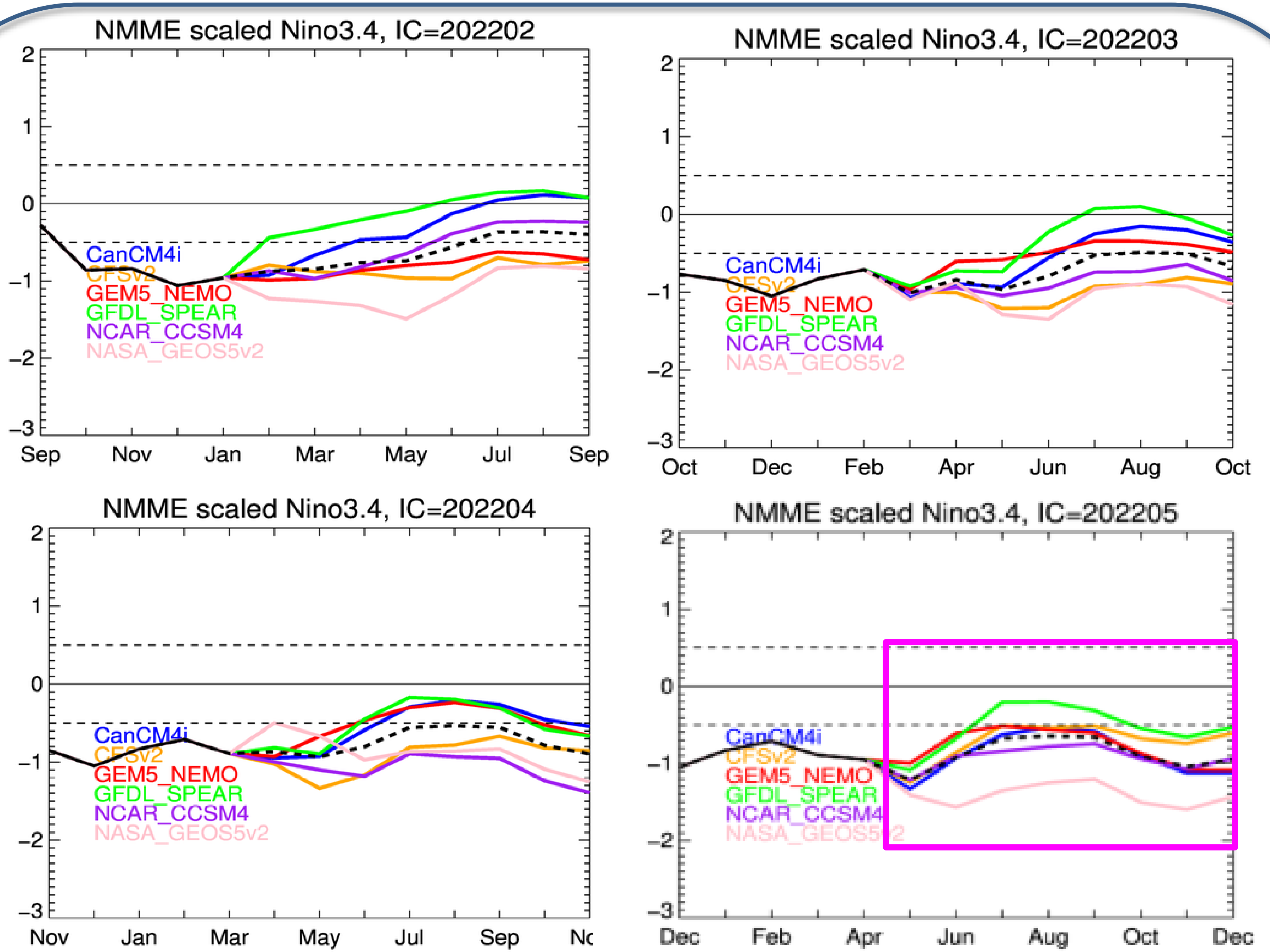
- The latest CFSv2 forecasts indicate that La Niña will persist in summer – autumn 2022.

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.

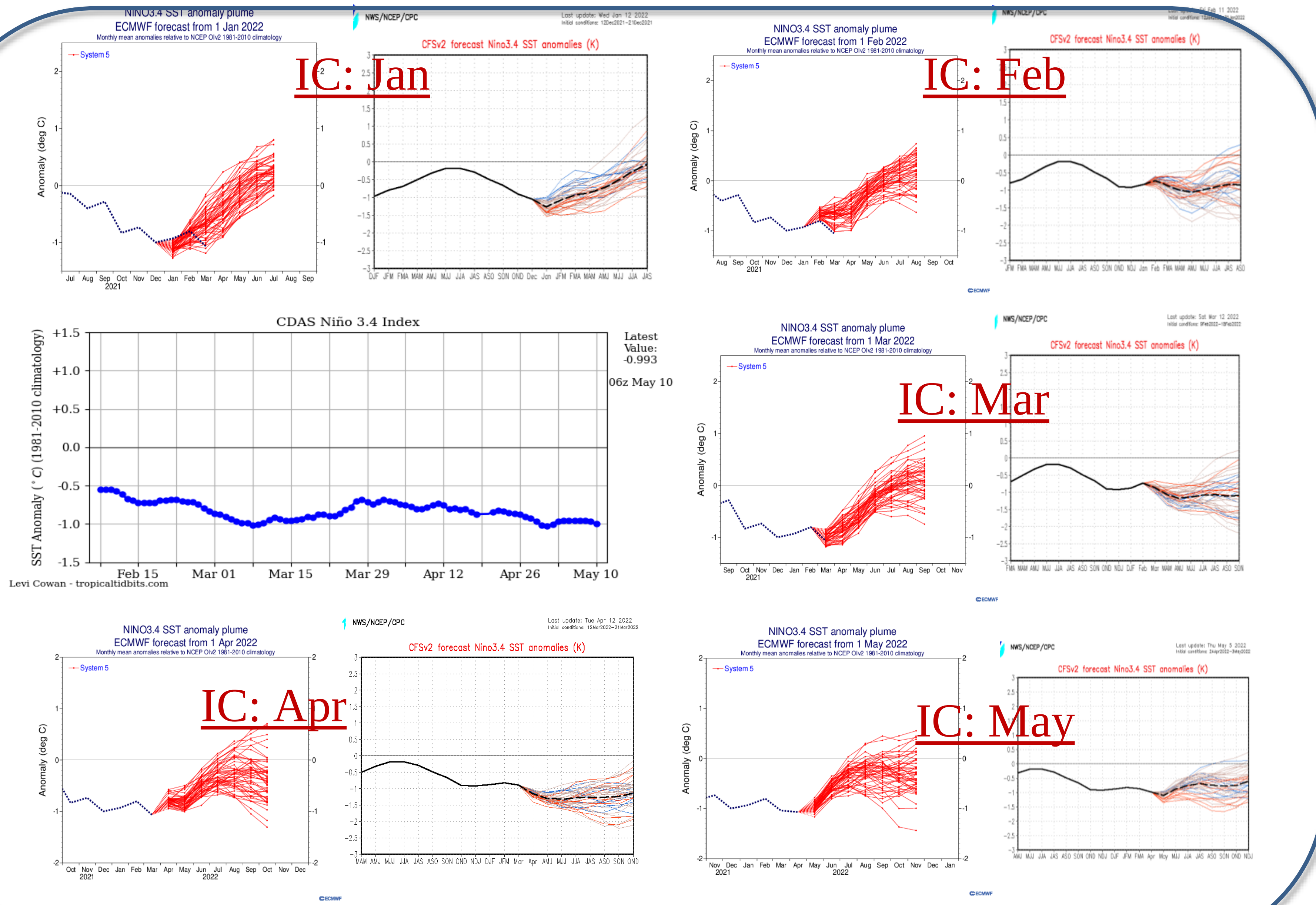
Cooling Tendency: IRI/CPC ENSO Plume with ICs in Jan-Apr 2022



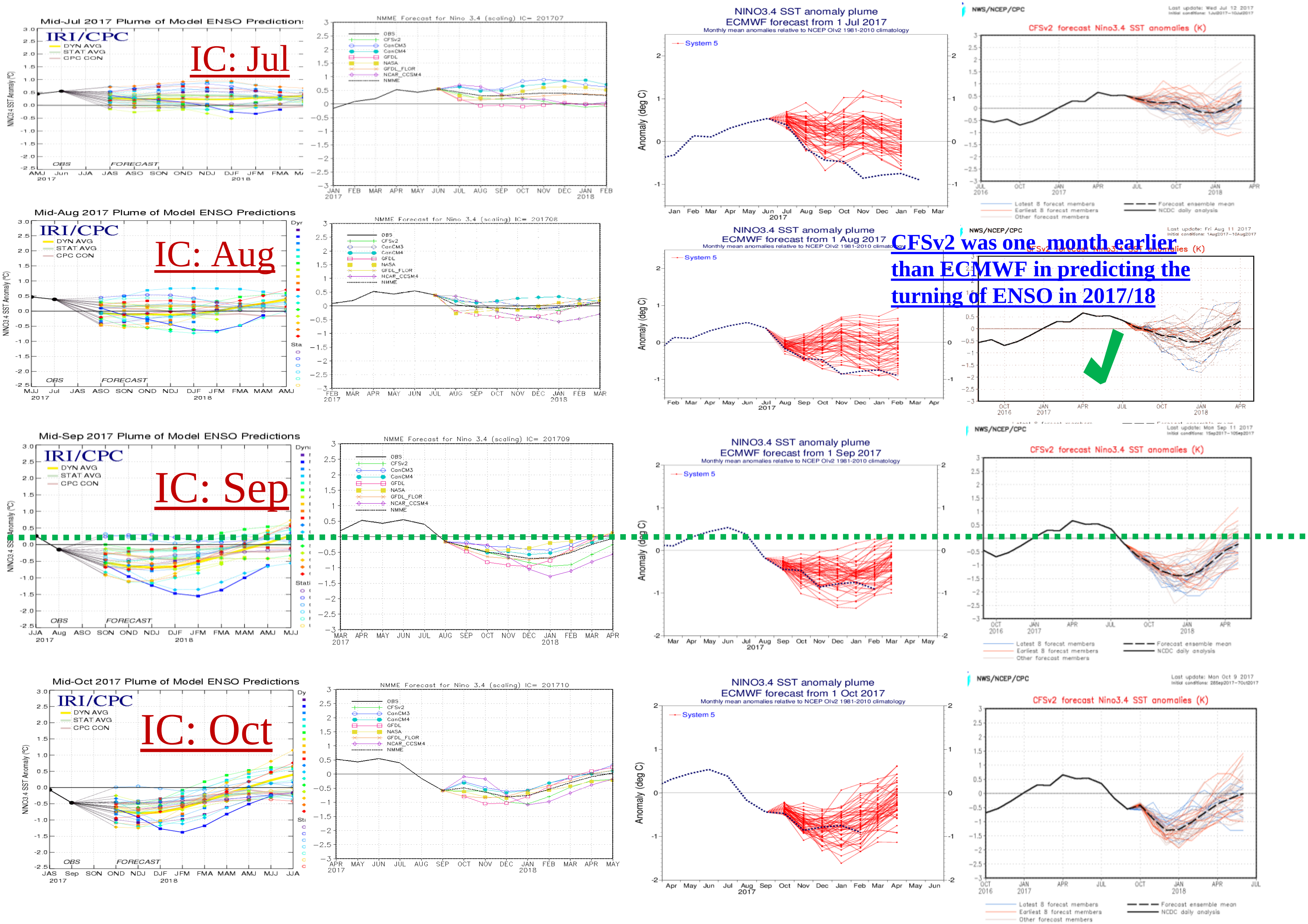
NMME forecasts from different initial conditions



CFSv2 Predicted the cooling tendency earlier & stronger than ECMWF Model

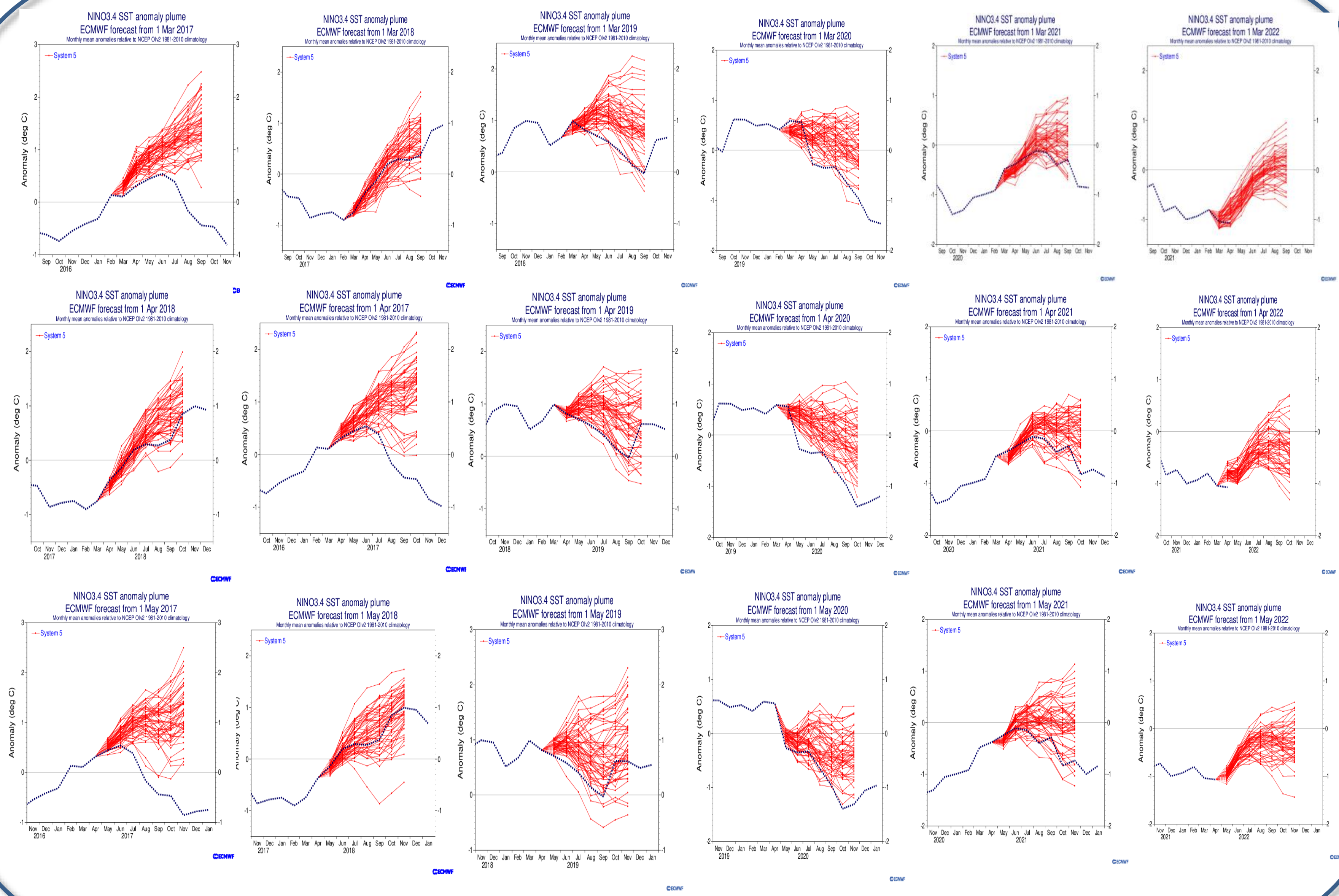


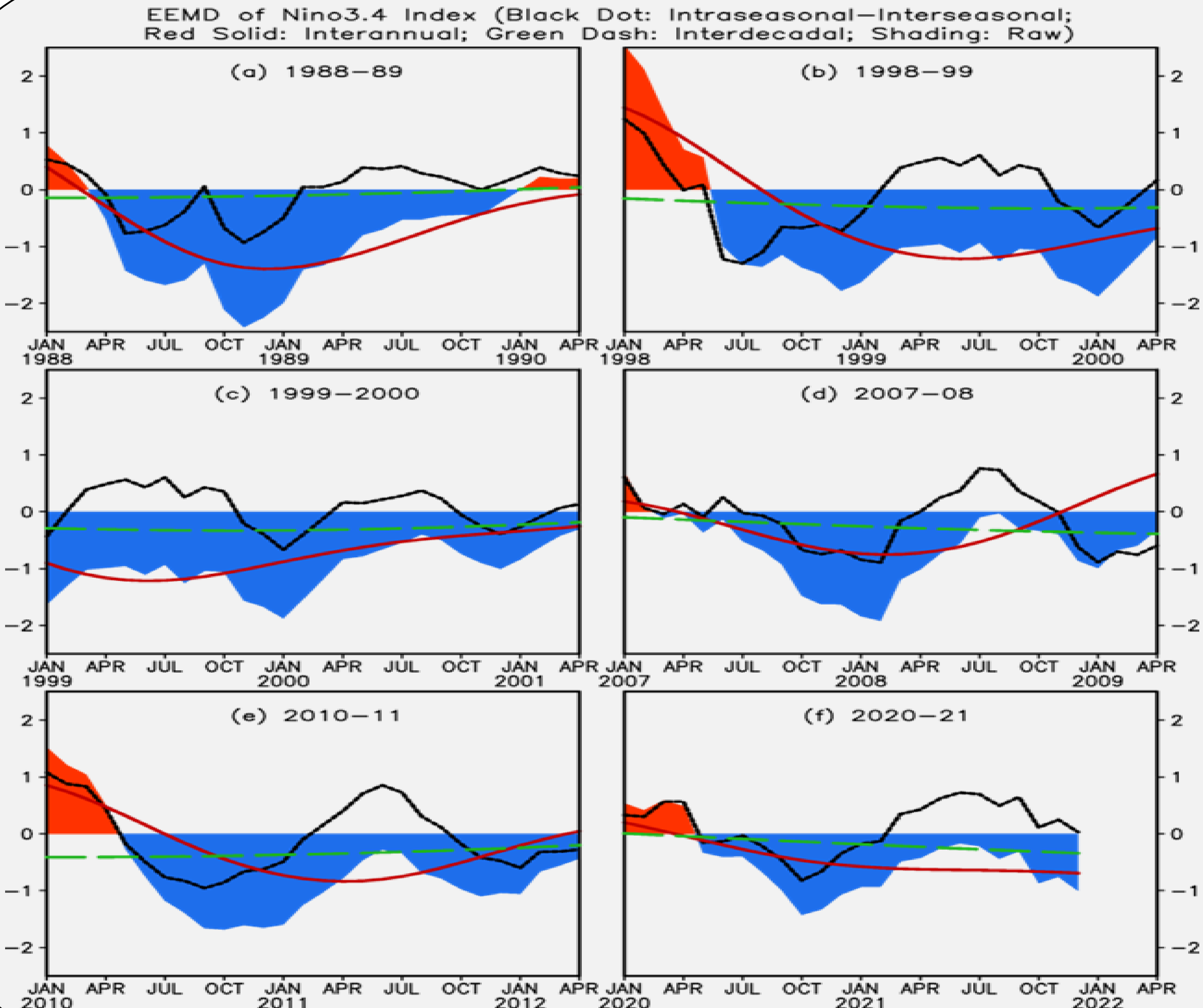
Another Example: 2017/18 La Nina



CFSv2 was one month earlier than ECMWF in predicting the turning of ENSO in 2017/18

ECMWF Warm bias for summer-winter with IC in Mar-May in 2017-2022





Monthly mean Niño3.4 index during (a) Jan 1988-Apr 1990, (b) Jan 1998-Apr 2000, (c) Jan 1999-Apr 2001, (d) Jan 2007-Apr 2009, (e) Jan 2010-Apr 2012, and (f) Jan 2020-May 2021. The shading, black dot, red solid, and green dash lines represent raw data, EEMD components at intraseasonal-interseasonal, interannual, and interdecadal and longer time scales, respectively. The unit is ^{o}C..

- ➢ The strength of all the strong La Niña events is determined by the in-phase amplification of all time scale variations.
- ➢ Their decay in the boreal spring and early summer is mainly controlled by the intraseasonal-interseasonal variation.

Li et al. 2022: A Historical Perspective of the La Niña Event in 2020/21. JGR 127 (7), e2021JD035546. DOI: 10.1029/2021JD035546.

Excessive Momentum and False Alarms in Late-Spring ENSO Forecasts

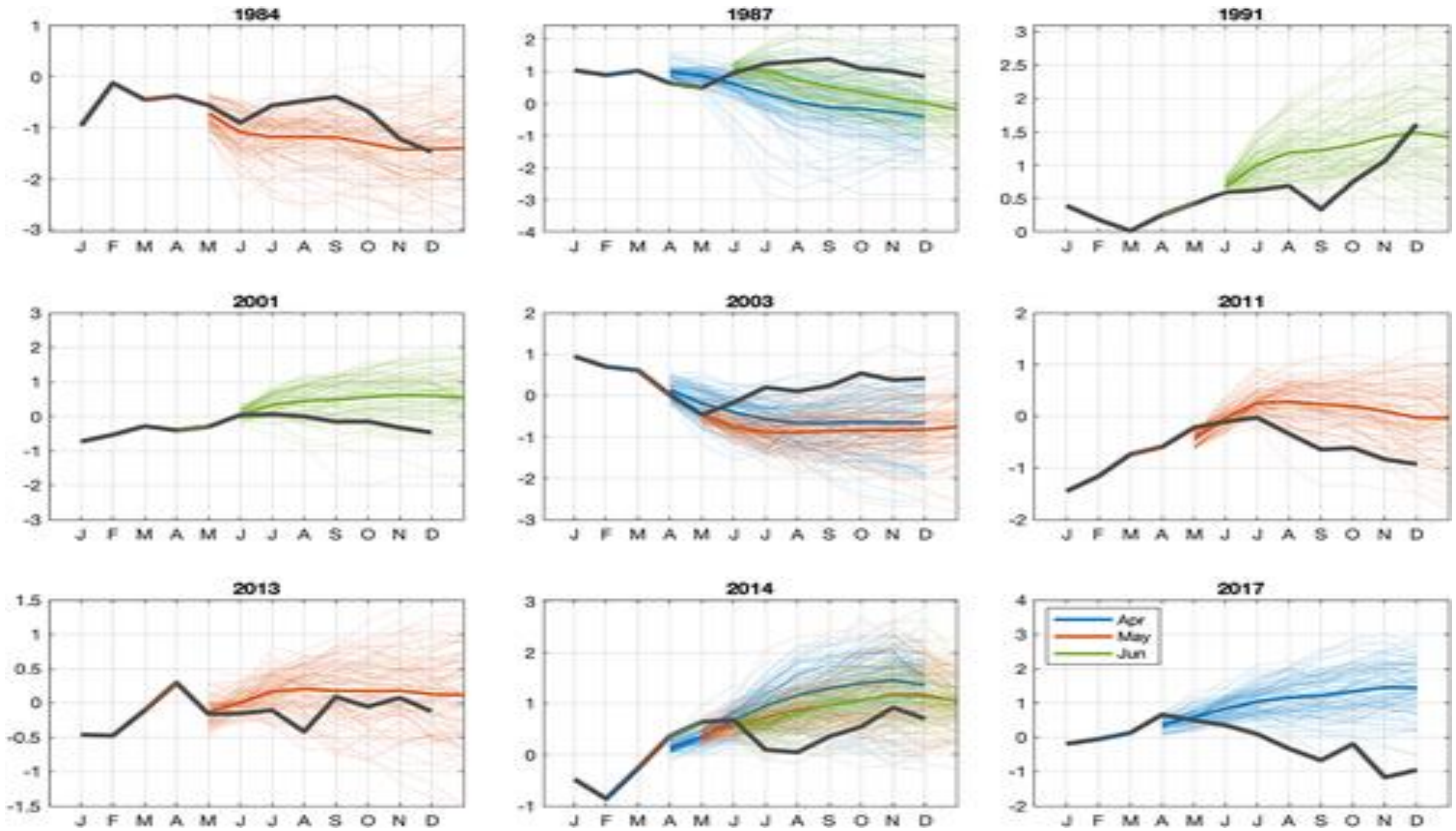
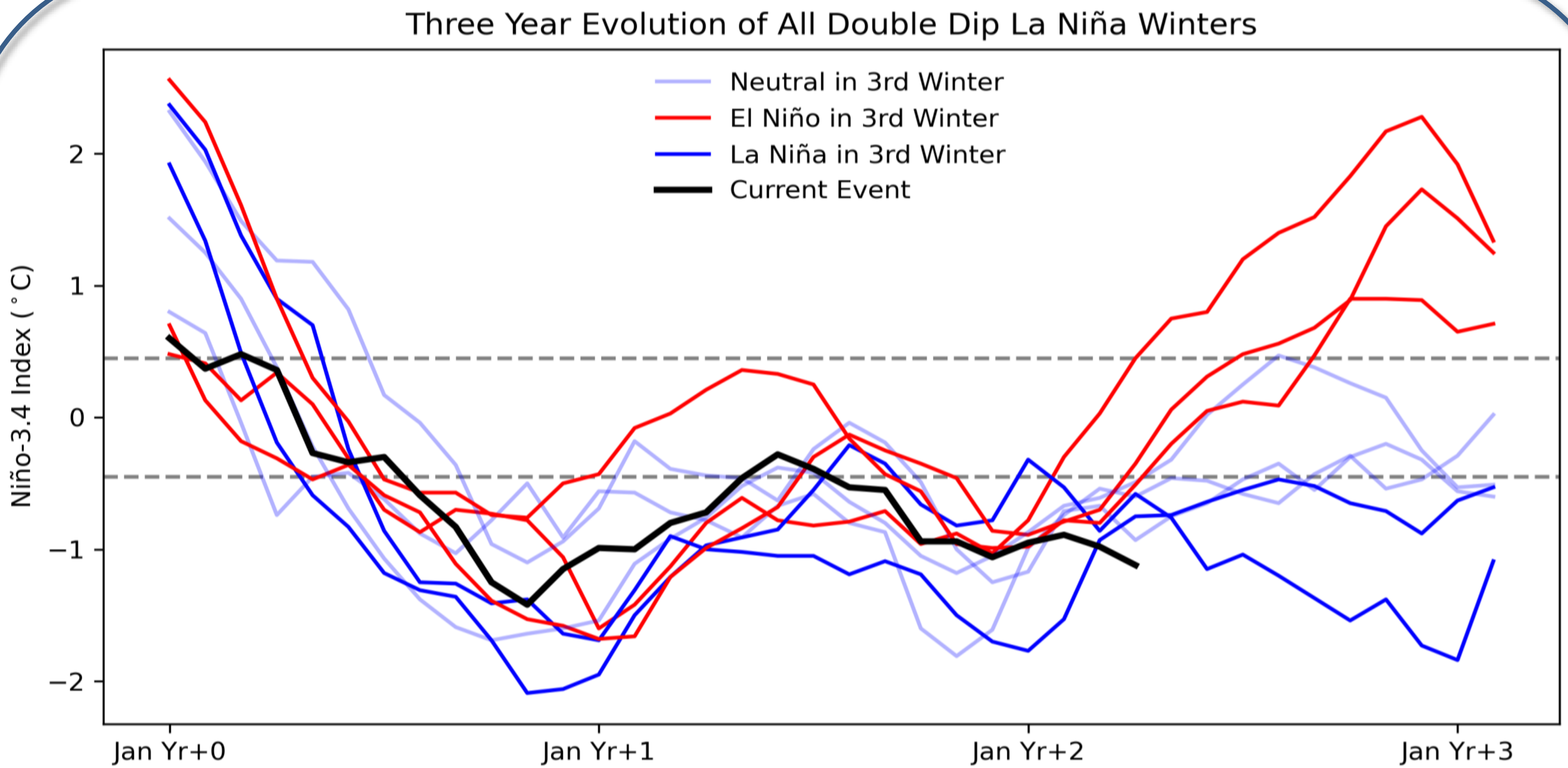


Fig. 3 False alarm years (1984, 1987, 1991, 2001, 2003, 2011, 2013, 2014, and 2017) in which the forecast probability of the wrong sign of the 3-month tendency exceeded 80% for April–June starts. The black curves are observed monthly values of the Niño 3.4 index with 1-month prior tendencies highlighted in the same color as the corresponding forecast. The colored curves are forecast values with heavy lines for the North American multimodel ensemble mean and light lines for North American multimodel ensemble members. Note the differing vertical scales.

Tippett, M. K., L'Heureux, M. L., Becker, E. J., & Kumar, A. (2020). Excessive momentum and false alarms in late-spring ENSO forecasts. Geophysical Research Letters, 47, e2020GL087008. https://doi.org/10.1029/2020GL087008

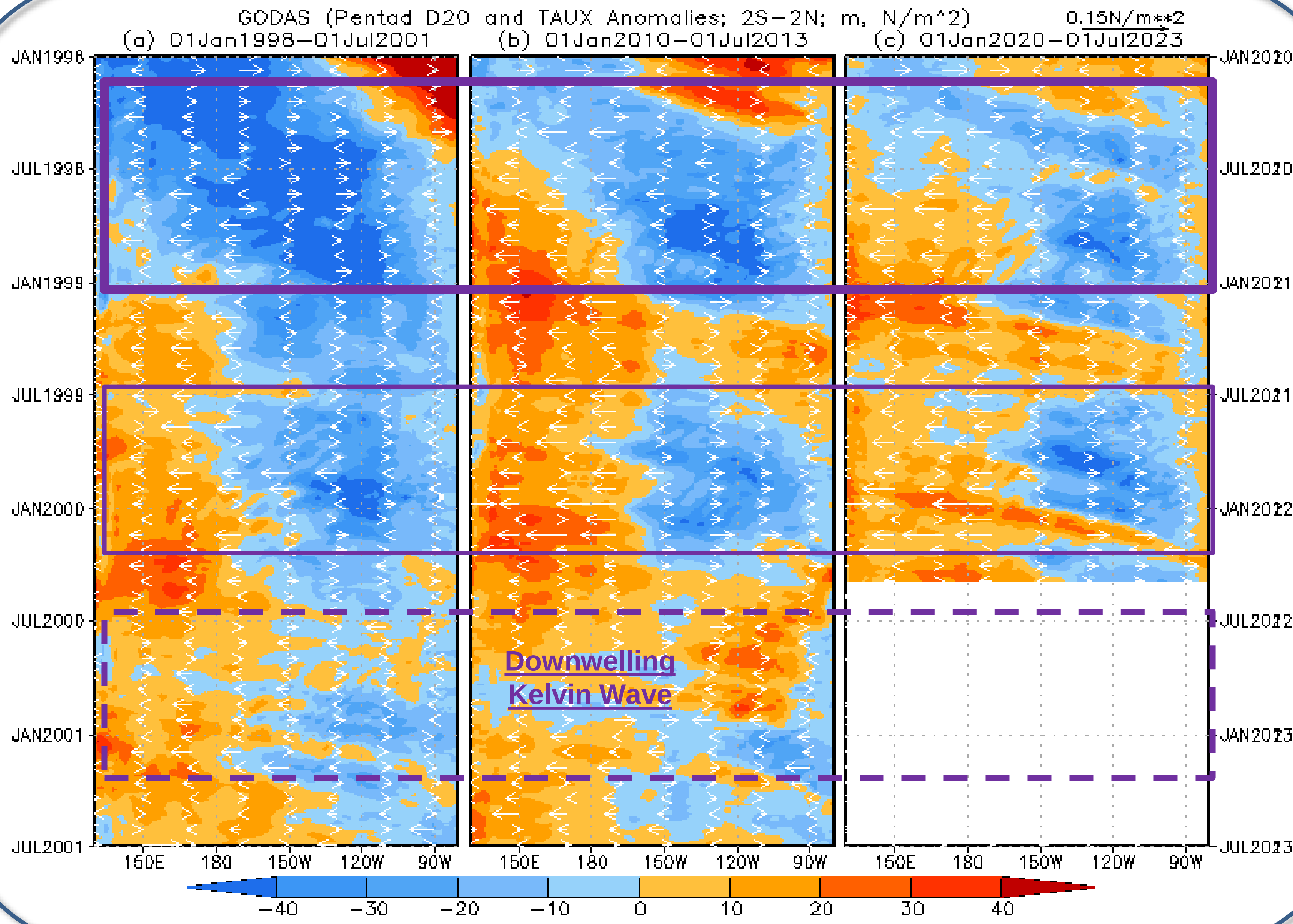
March 2022 La Niña update: three-bean salad (MICHELLE L'HEUREUX)



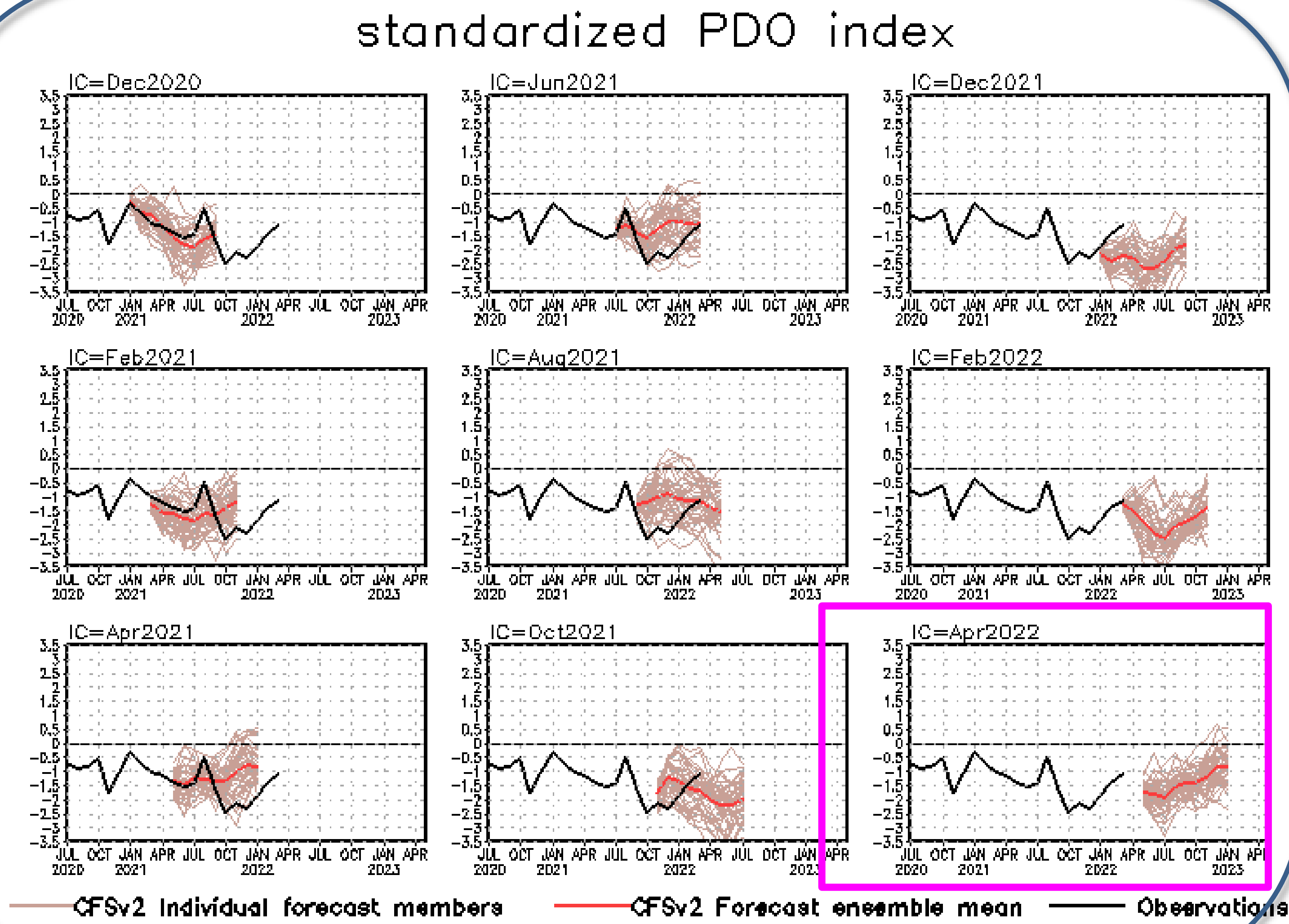
Three-year history of sea surface temperatures in the Niño-3.4 region of the tropical Pacific for 8 previous double-dip La Niña events. The color of the line indicates the state of ENSO for the third winter (red: El Niño, darker blue: La Niña, lighter blue: neutral). The black line shows the current event. Monthly Niño-3.4 index is from CPC using ERSSTv5.

https://www.climate.gov/news-features/blogs/enso/march-2022-la-ni%C3%B1a-update-three-bean-salad

D20 & Taux in 3-year (1998-2001) & 2-year (2010-13) La Nina & 2020-22 (Suggested by Eric Blake; NHC/NCEP)



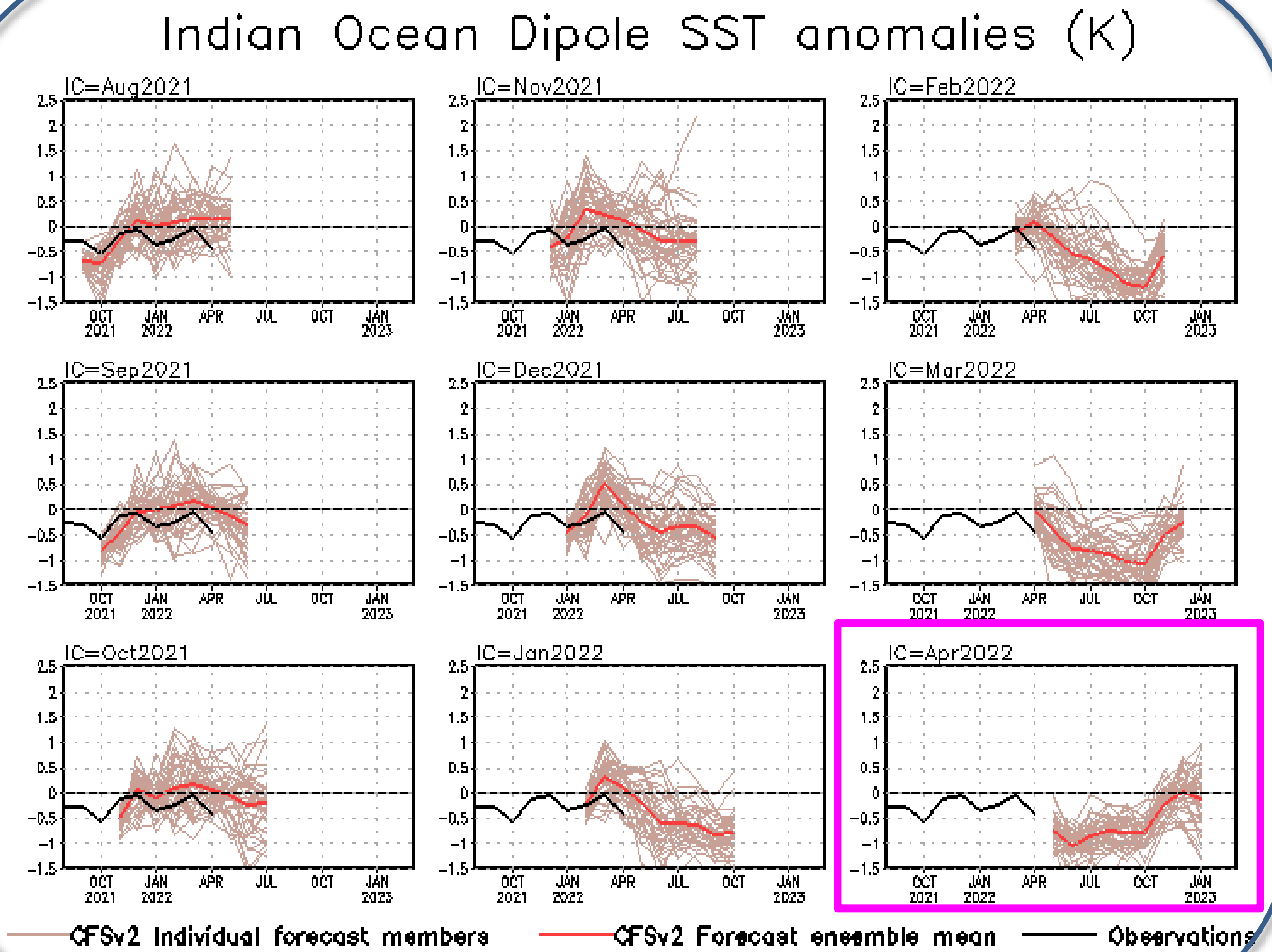
CFS Pacific Decadal Oscillation (PDO) Index Predictions from Different Initial Months

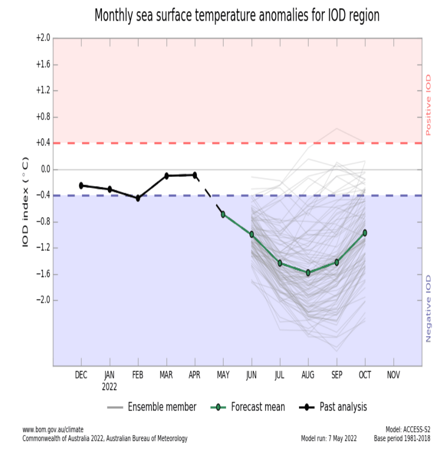


- CFSv2 predicts a negative phase of PDO in 2022.

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^{o}E-100^{o}W, 20^{o}N-60^{o}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

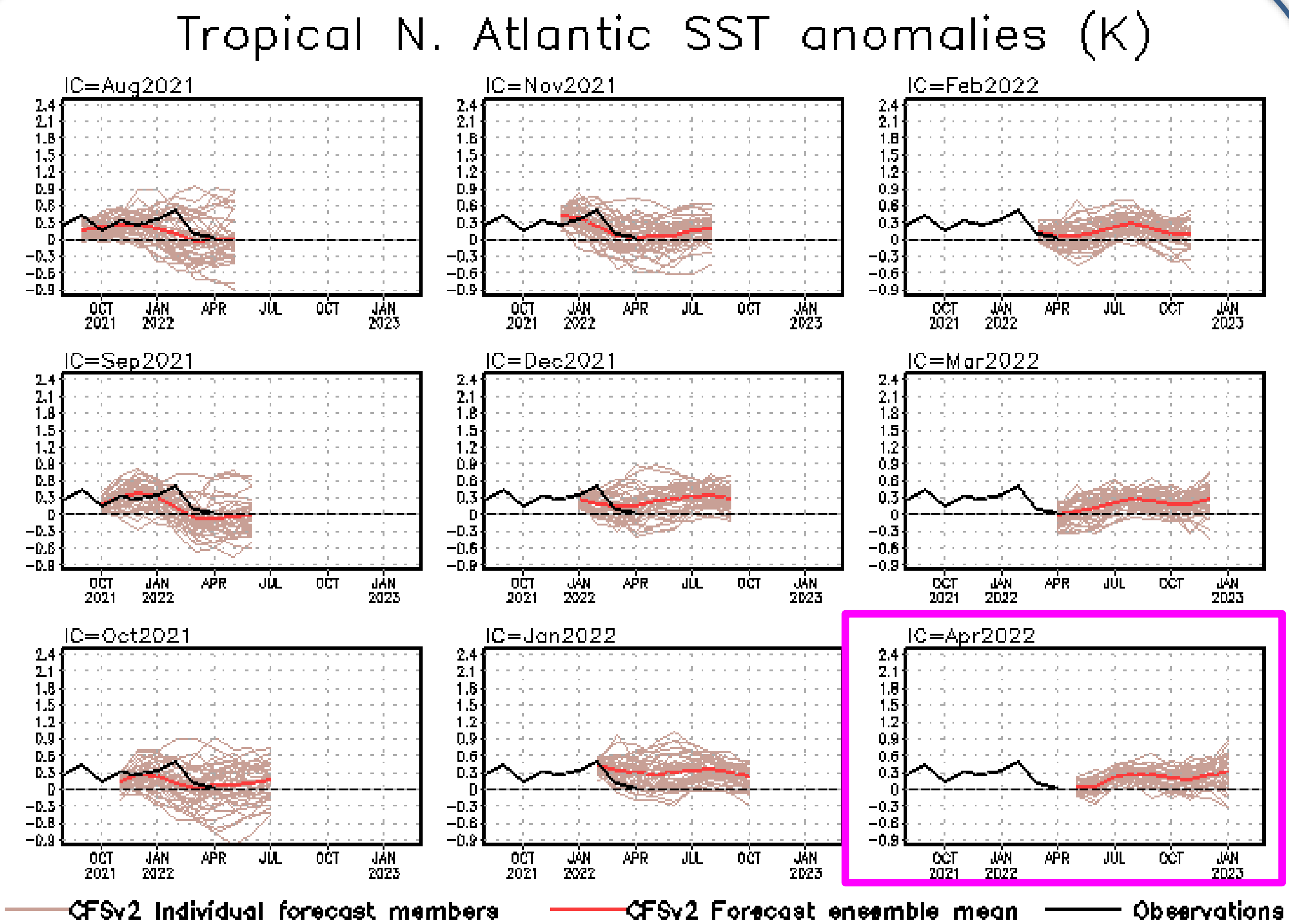




- CFSv2 predicts a negative phase of IOD in summer-autumn 2022.

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.

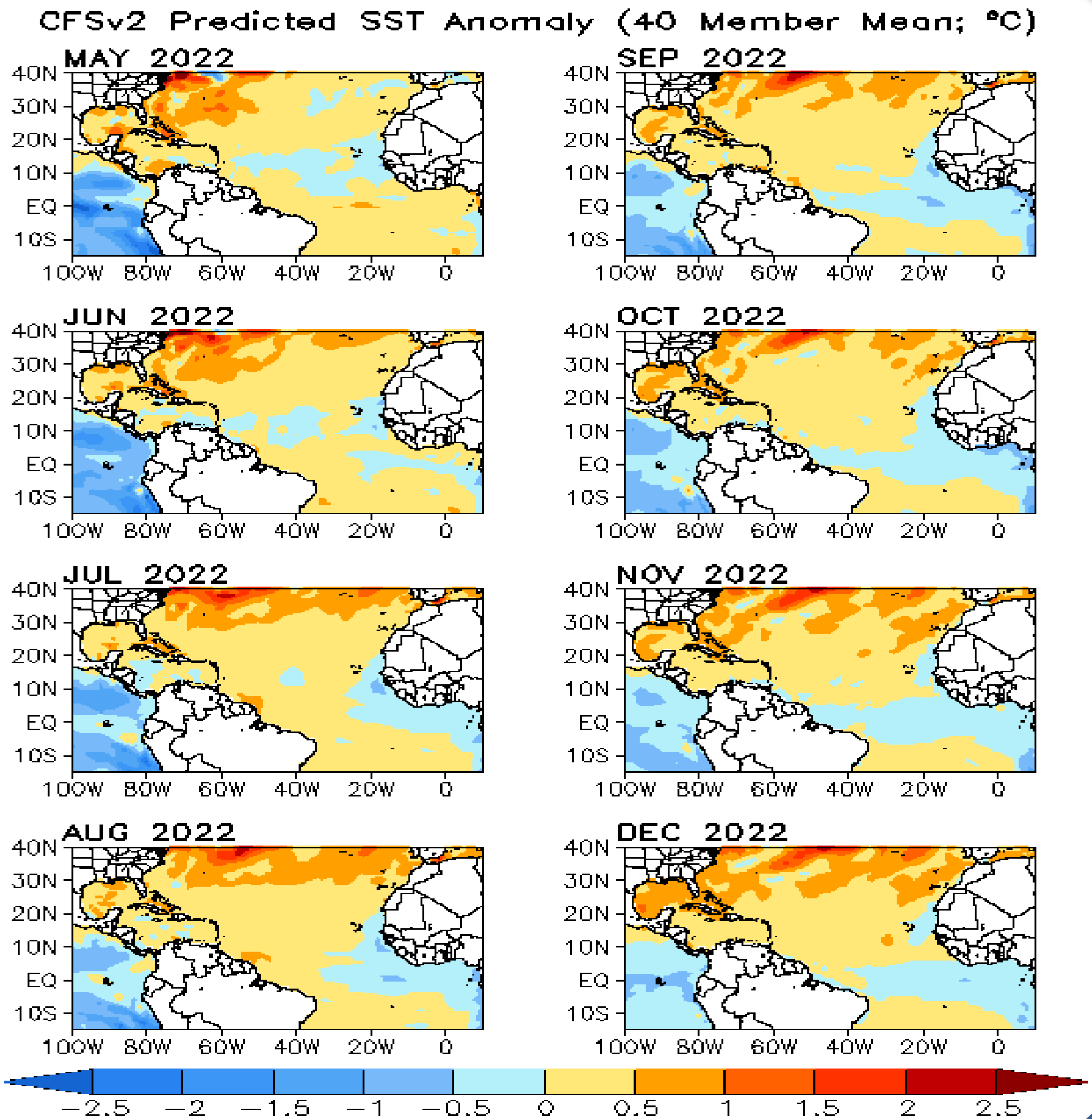
CFS Tropical North Atlantic (TNA) SST Predictions from Different Initial Months



- Latest CFSv2 predictions call for slightly above normal SST in the tropical North Atlantic in 2022.

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].

CFSv2 Atlantic SSTA Predictions



- Latest CFSv2 predictions call slightly above or near average SST in the tropical North Atlantic in the next 8 months.

Acknowledgement

- ❖ Drs. Jieshun Zhu, Caihong Wen, and Arun Kumar: reviewed PPT, and provide insightful suggestions and comments
- ❖ Dr. Pingping Xie provided the BASS/CMORPH/CFSR EVAP package
- ❖ Dr. Wanqiu Wang provides the sea ice forecasts and maintains the CFSv2 forecast archive

Please send your comments and suggestions to:
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Jieshun.Zhu@noaa.gov
Caihong.Wen@noaa.gov
Zeng-Zhen.Hu@noaa.gov

Data Sources (climatology is for 1991-2020)

- **Weekly Optimal Interpolation SST (OI SST) version 2 (Reynolds et al. 2002)**
- **Extended Reconstructed SST (ERSST) v5 (Huang et al. 2017)**
- **Blended Analysis of Surface Salinity (BASS) (Xie et al. 2014)**
- **CMORPH precipitation (Xie et al. 2017)**
- **CFSR evaporation adjusted to OAFlux (Xie and Ren 2018)**
- **NCEP CDAS winds, surface radiation and heat fluxes (Kalnay et al. 1996)**
- **NESDIS Outgoing Long-wave Radiation (Liebmann and Smith 1996)**
- **NCEP's GODAS temperature, heat content, currents (Behringer and Xue 2004)**
- **Aviso altimetry sea surface height from CMEMS**
- **Ocean Surface Current Analyses – Realtime (OSCAR)**
- **In situ data objective analyses (IPRC, Scripps, EN4.2.1, PMEL TAO)**
- **Operational Ocean Reanalysis Intercomparison Project**

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

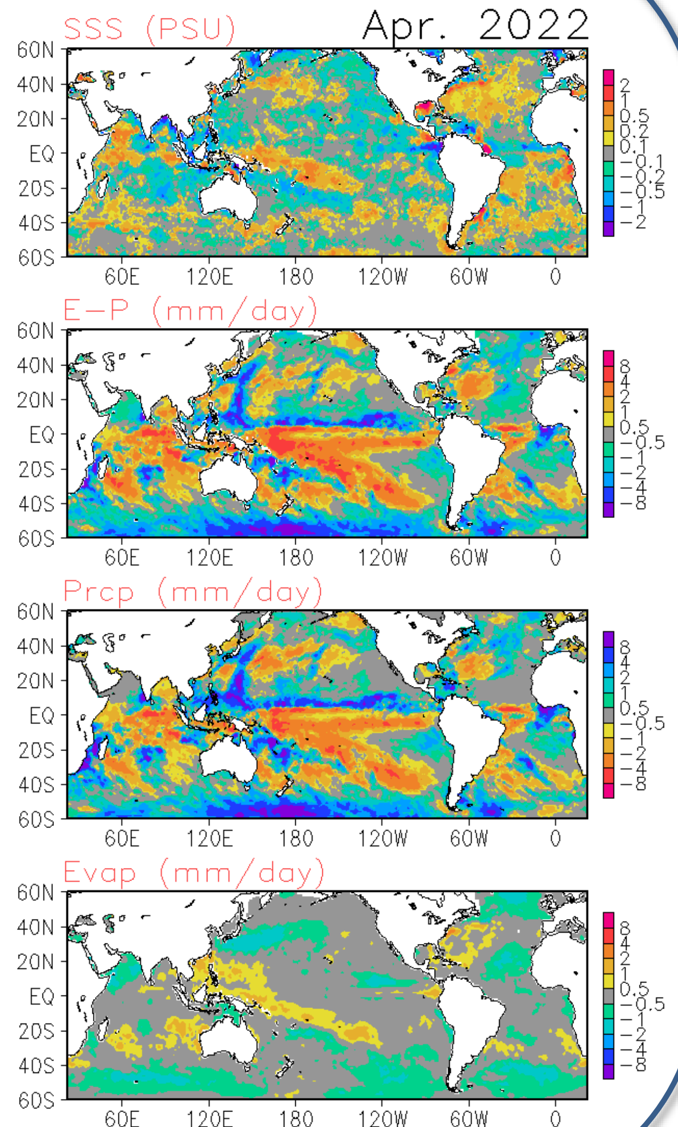
  http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html

Backup Slides

Global Sea Surface Salinity (SSS): Anomaly for April 2022

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

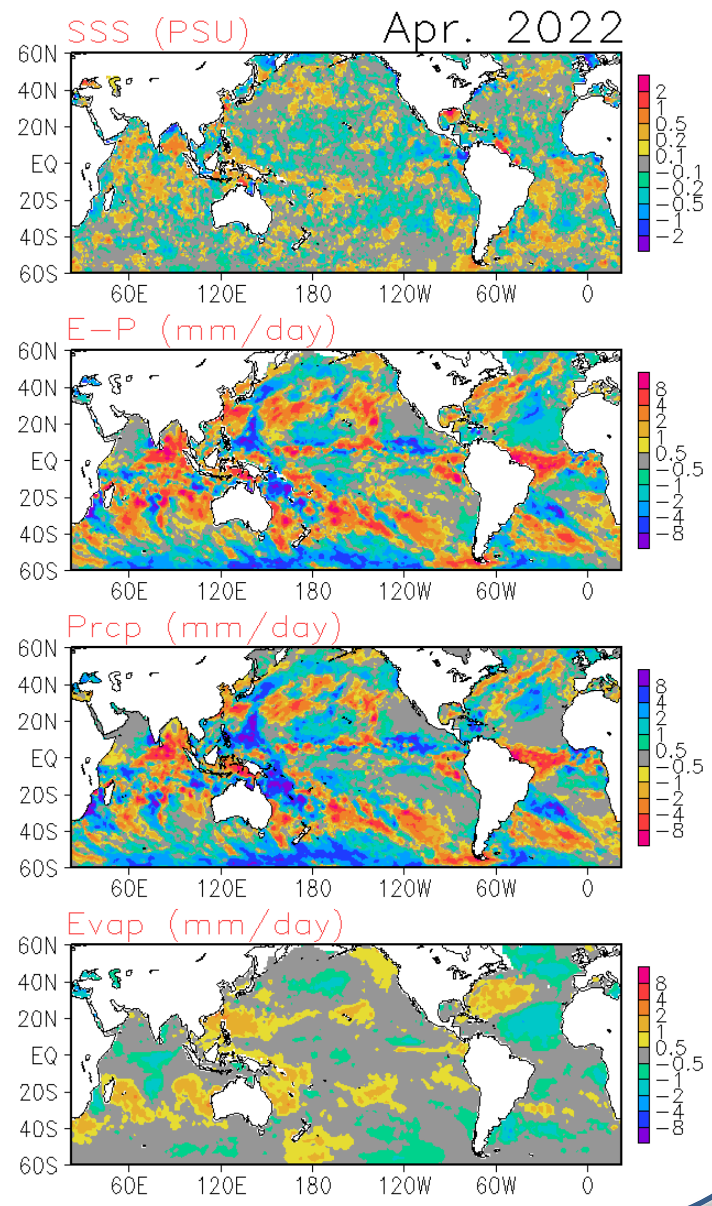
Positive SSS anomaly continues in the western equatorial Pacific Ocean and NE side of the SPCZ regions caused by the reduced precipitation in these areas, while positive SSS anomalies are observed over the SW side of the SPCZ and across the North Atlantic Ocean 10° N and 40° N. Negative SSS anomaly remains over the equatorial Atlantic Ocean, despite of a deficit precipitation and positive E-P anomaly over the region. Negative SSS anomaly continues in the Bay of Bengal, possibly attributable to the increased runoffs into the bay.



SSS : Blended Analysis of Surface Salinity (BASS) V0.Z
(a CPC-NESDIS/NODC-NESDIS/STAR joint effort)
ftp.cpc.ncep.noaa.gov/precip/BASS
Precipitation: CMORPH adjusted satellite precipitation estimates
Evaporation: Adjusted CFS Reanalysis

Global Sea Surface Salinity (SSS): Tendency for April 2022

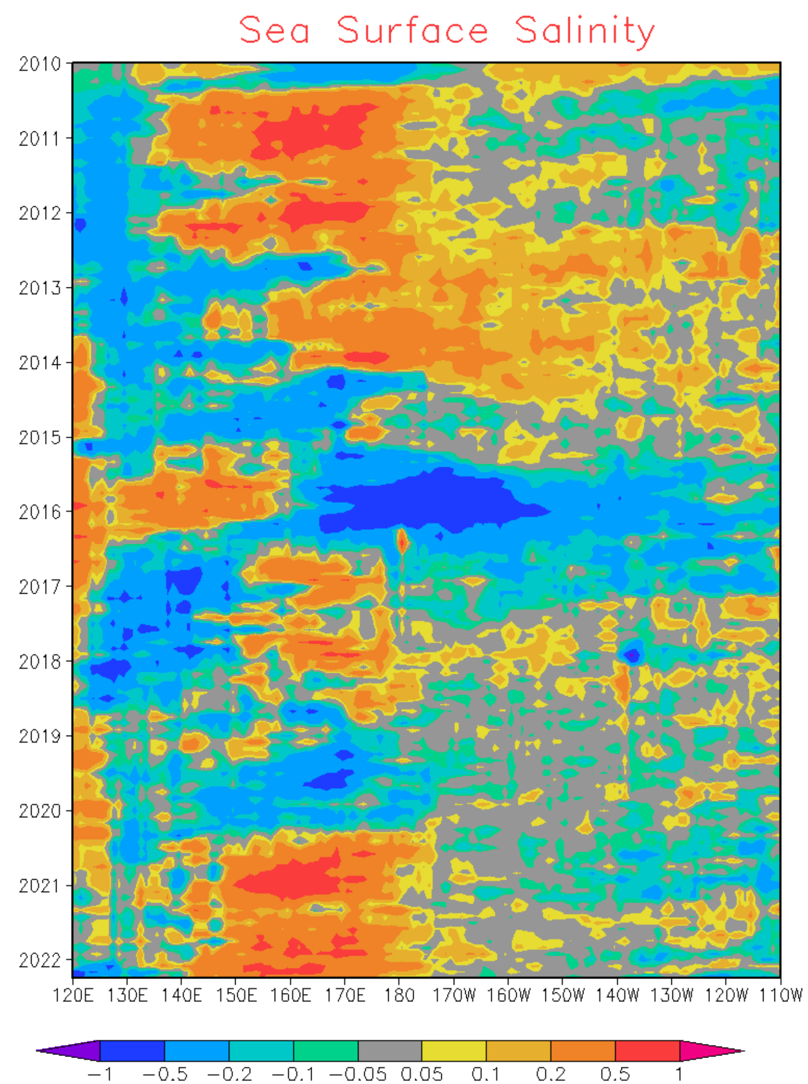
ITCZ precipitation is enhanced over the eastern Pacific but weakened across the Atlantic ocean. SPCZ is shifted southwesterly, causing a positive (negative) precipitation anomaly over the SW (NE) side of the SPCZ region. At the meantime, evaporation is increased (decreased) over NW Atlantic, western Pacific (equatorial Atlantic), respectively. These changes in the oceanic fresh water, combined with the effects of oceanic transportation and mixed layer processes, created a slight freshened (saltier) tendency of SSS over the eastern Pacific and SW side of the SPCZ (NE side of SPCZ), respectively.



Monthly SSS Anomaly Evolution over Equatorial Pacific

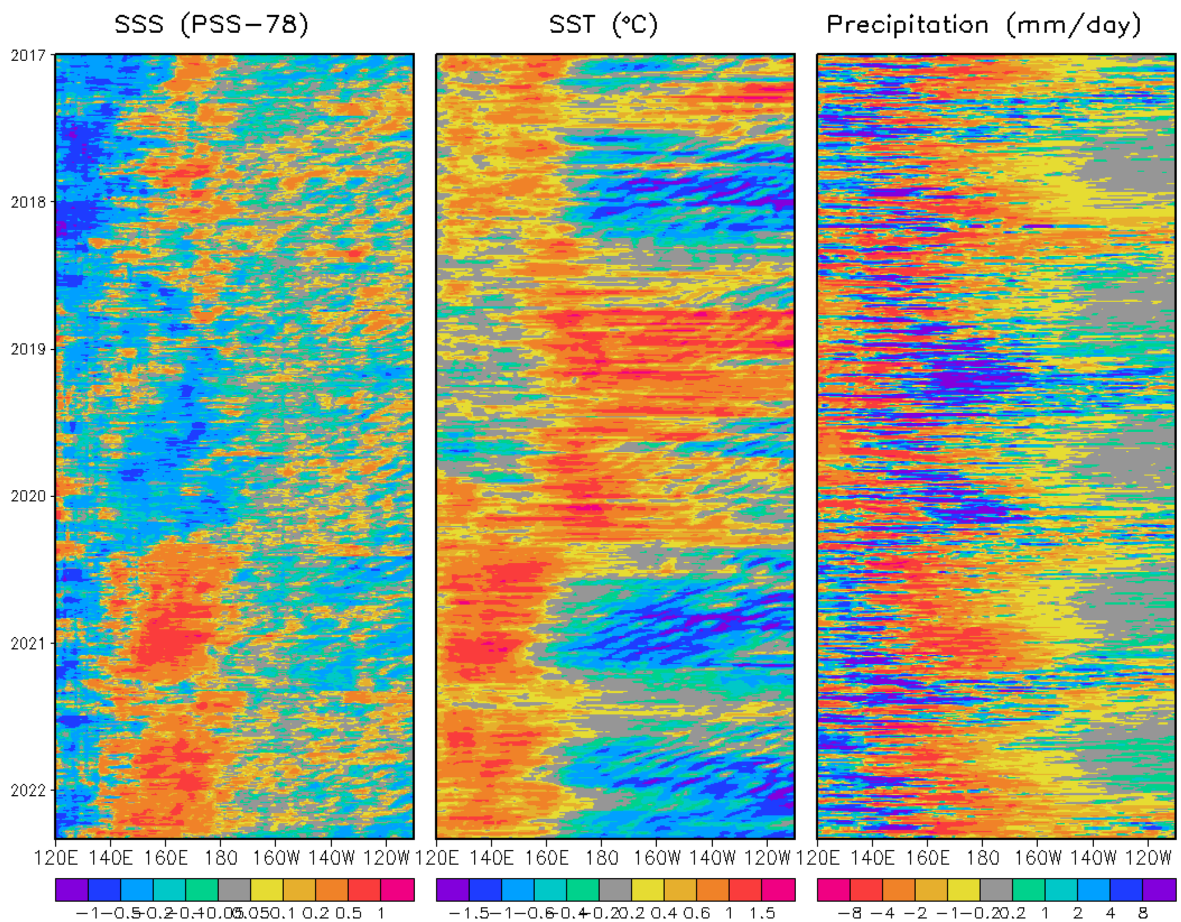
NOTE: Since June 2015, the BASS SSS is from in situ, SMOS and SMAP; before June 2015,The BASS SSS is from in situ, SMOS and Aquarius.

- Hovemoller diagram for equatorial SSS anomaly **(5° S-5° N);**
- In the equatorial Pacific Ocean, west of 140° E, negative SSS signal continues; positive SSS signal continues between 140° E and 170° W; neutral or likely negative signal continues east of 150° W.

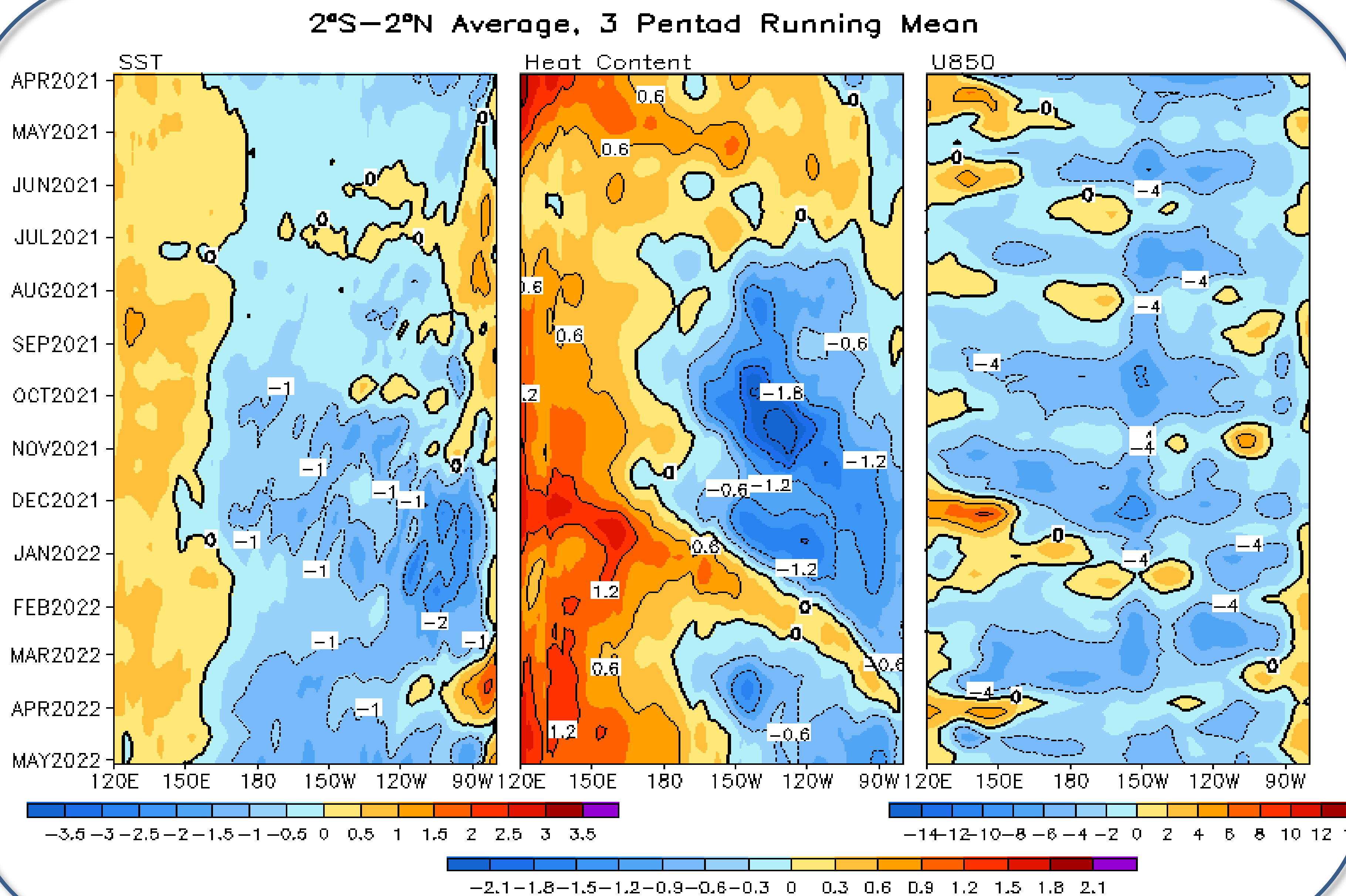


Pentad SSS Anomaly Evolution over Equatorial Pacific

Figure caption: Hovemoller 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.



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

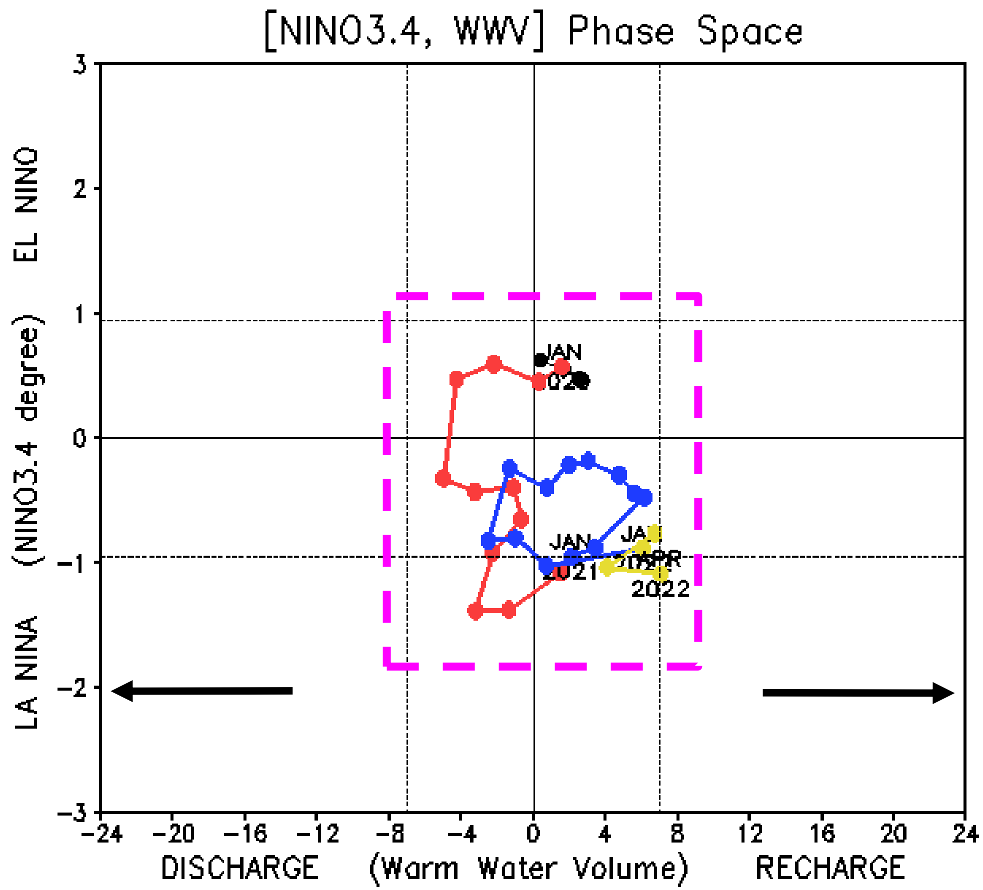


Warm Water Volume (WWV) and Niño3.4 Anomalies

- As WWV is 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.
- Different color curves represent different years.

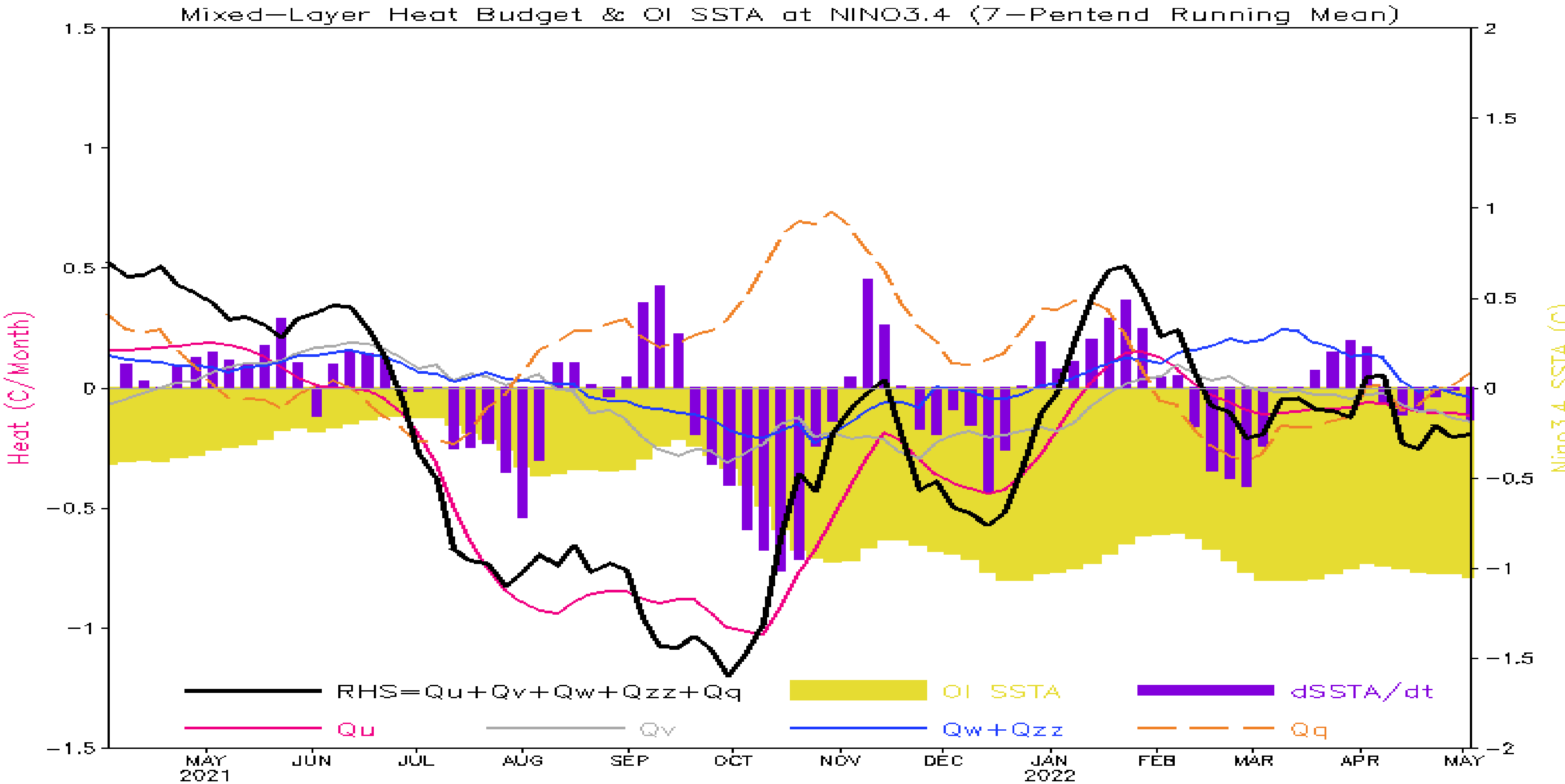
- In the WWV index definition, it is the average of ocean temperature anomaly along the whole equatorial Pacific, which sometimes have no coherent variations.

- Equatorial Warm Water Volume (WWV) was the recharge phase in Apr 2022.



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.

Ocean Mixed-Layer Heat Budget



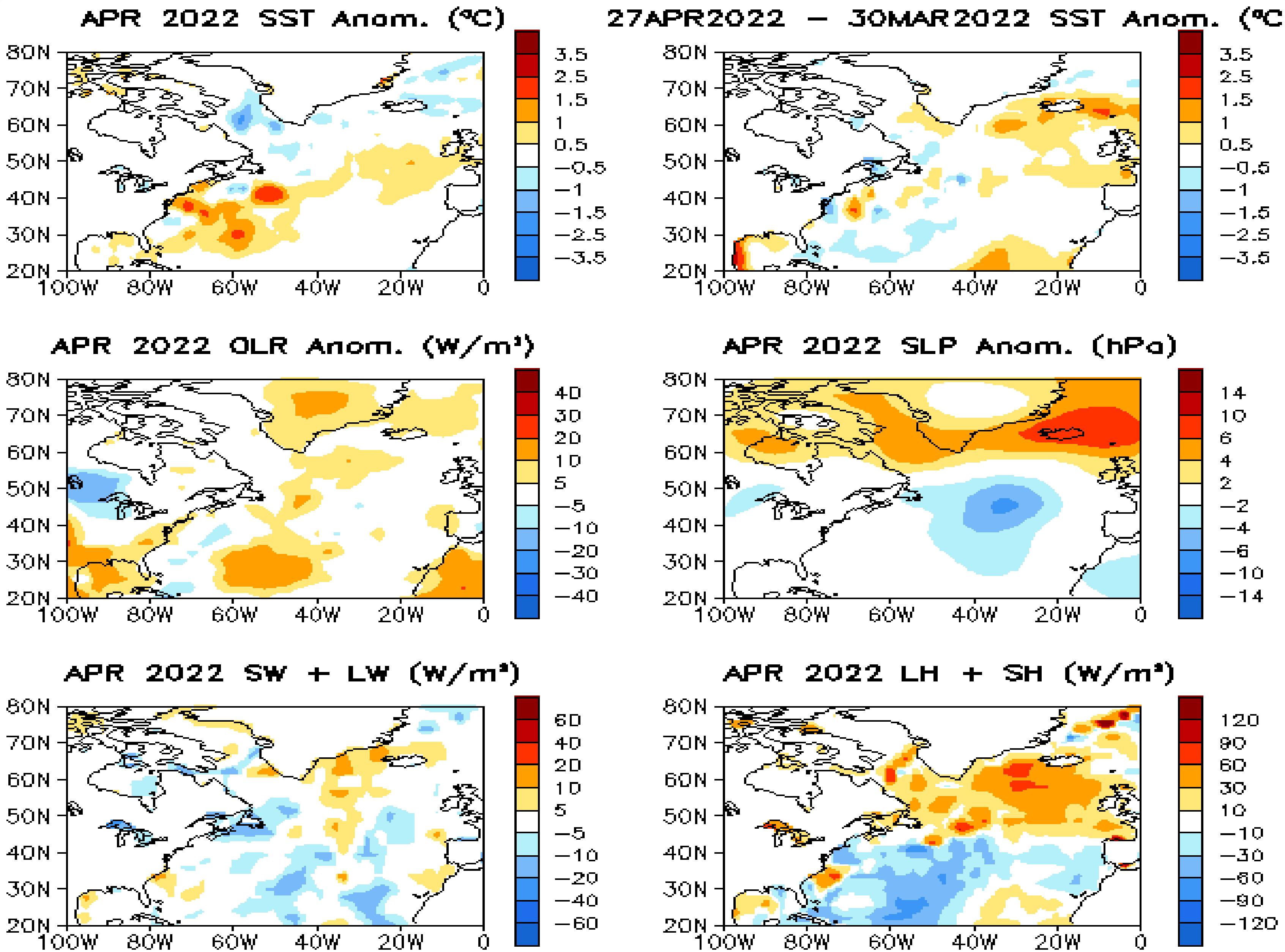
Huang, B., Y. Xue, X. Zhang, A. Kumar, and M. J. McPhaden, 2010 : The NCEP GODAS ocean analysis of the tropical Pacific mixed layer heat budget on seasonal to interannual time scales, J. Climate., 23, 4901-4925.

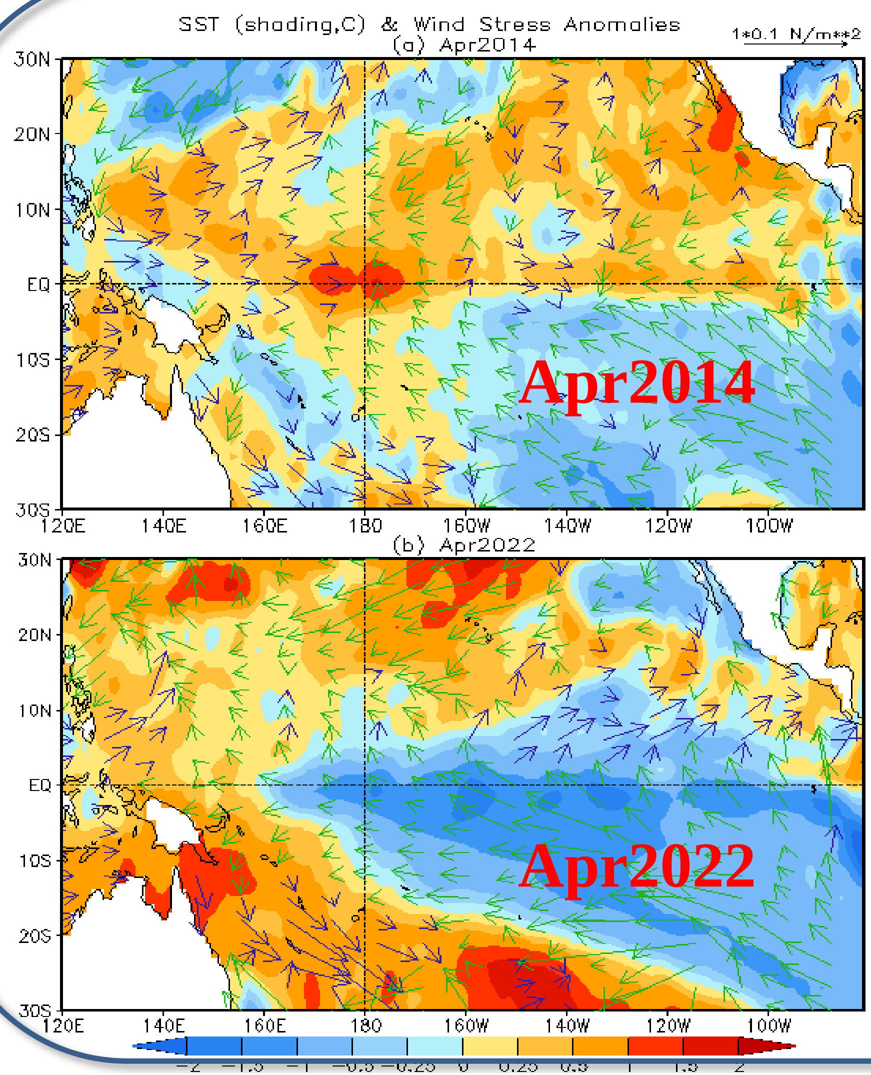
Qu: Zonal advection; Qv: Meridional advection;

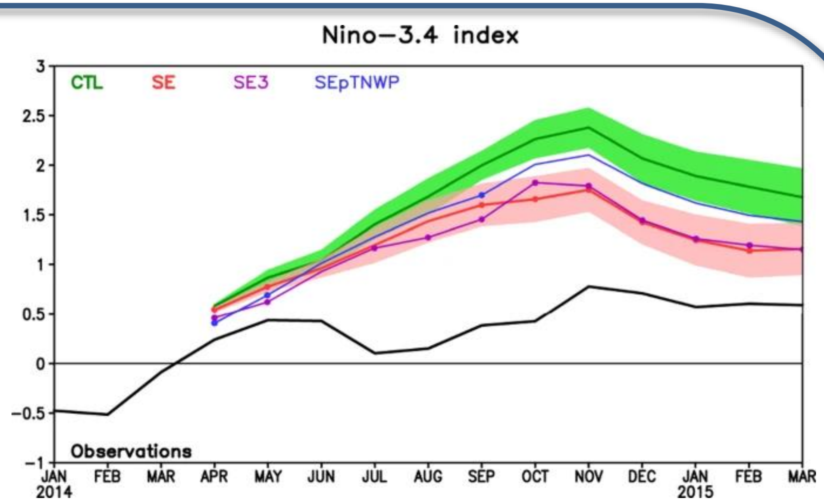
Qw: Vertical entrainment; Qzz: Vertical diffusion

Qq: (Qnet - Qpen + Qcorr)/ρcph; Qnet = SW + LW + LH +SH;

Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST


APR 2022 SST Anom. (°C)
27APR2022 – 30MAR2022 SST Anom. (°C)
3.5 2.5 1.5 1 0.5 −0.5 −1 −1.5 −2.5 −3.5
APR 2022 OLR Anom. (W/m²)
40 30 20 10 5 −5 −10 −20 −30 −40
APR 2022 SLP Anom. (hPa)
14 10 6 4 2 −2 −4 −6 −10 −14
APR 2022 SW + LW (W/m²)
60 40 20 10 5 −5 −10 −20 −40 −60
APR 2022 LH + SH (W/m²)
120 90 60 30 10 −10 −30 −60 −90 −120
80N 70N 60N 50N 40N 30N 20N
100W 80W 60W 40W 20W 0





Niño-3.4 SST anomalies (°C) during January 2014–March 2015. Black, green, red, purple and blue curves are for SST anomalies in observations, CTL, SE, SE3 and SEpTNWP, respectively. For forecasts, solid curves represent the ensemble mean. Shaded areas in light green and light red represent ensemble spread for CTL and SE. The dots in red, purple and blue curves means that the ensemble mean SST anomalies in SE, SE3 and SEpTNWP are significantly different from those in CTL at the 95% confidence level.

For 2014/15 Nino3.4, "Our experiments show that 40% of the amplitude error at the peak phase could be attributed to the lack of prediction of negative SST anomalies in the southeastern Pacific." (Zhu et al. 2016)

Zhu, J., et al., 2016: The role of off-equatorial surface temperature anomalies in the 2014 El Niño prediction. Sci. Rep., 6, 19677. DOI: 10.1038/srep19677.