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/Arctic Ocean
  - Indian Ocean
  - Atlantic Ocean
- **Global SSTA Predictions**

Overview

•Pacific Ocean

- NOAA "ENSO Diagnostic Discussion" on 9 Dec 2021 stated *"La Niña is favored to continue through the Northern Hemisphere winter 2021-22 (~95% chance) and transition to ENSO-neutral during the spring 2022 (~60% chance during April-June)."*
- La Nina condition persisted with Nino3.4 = -1.1^{o}C in Dec 2021.
- Positive SSTAs continued in the North Pacific in Dec 2021.
- The PDO has been in a negative phase since Jan 2020 with PDOI = -2.3 in Dec 2021.

•Arctic Ocean

- Arctic sea ice extent averaged for Dec 2021 was the 13th lowest in the satellite record.

•Indian Ocean

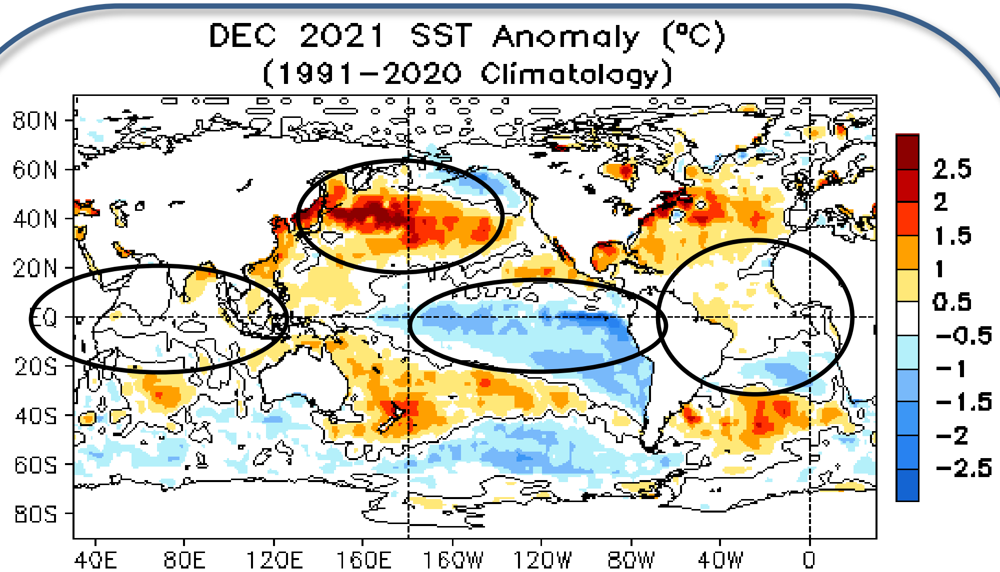
- SSTA in the tropical Indian Ocean was small in Dec 2021.

•Atlantic Ocean

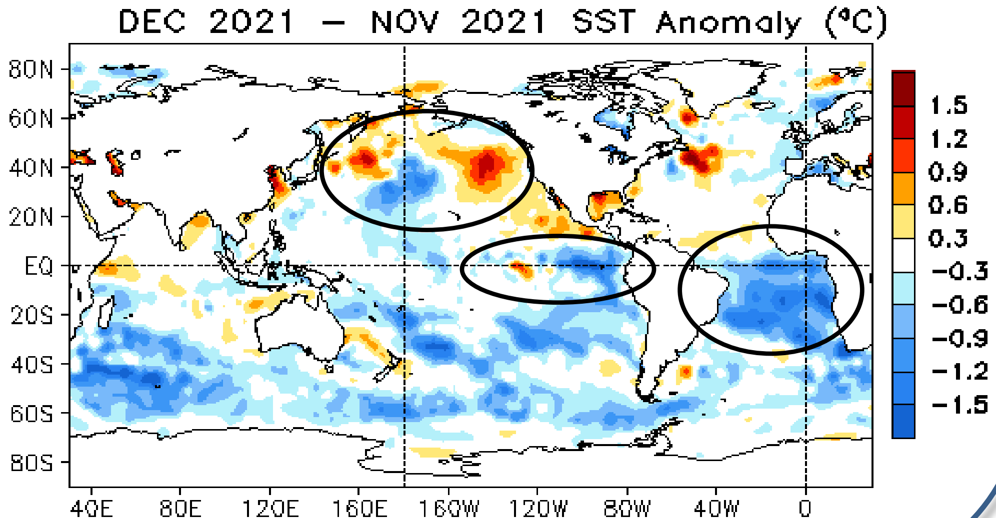
- SSTAs were small in the tropics in Dec 2021.
- NAO switched to a positive phase in Dec 2021 with NAOI= 0.2.
- Positive SSTAs in the mid-high latitudes of the N. Atlantic were evident in 2021.

Global Oceans

Global SST Anomaly (ºC) and Anomaly Tendency



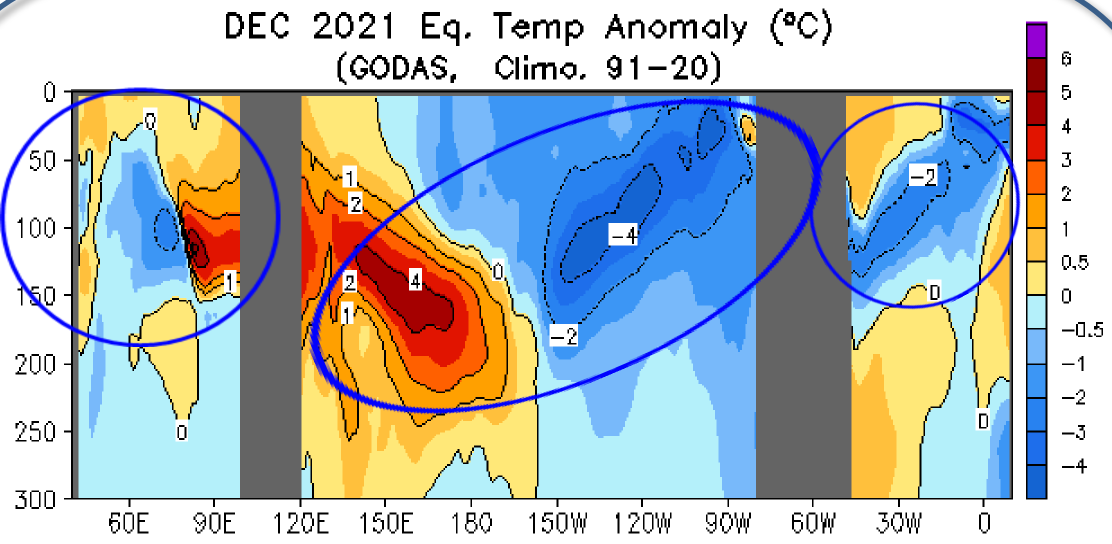
- Negative SSTAs persisted in the central and eastern equatorial Pacific.
- Positive SSTAs persisted in the North Pacific.
- Weak SSTAs were evident across the tropical Atlantic.
- SSTs were near average in the tropical Indian Ocean.

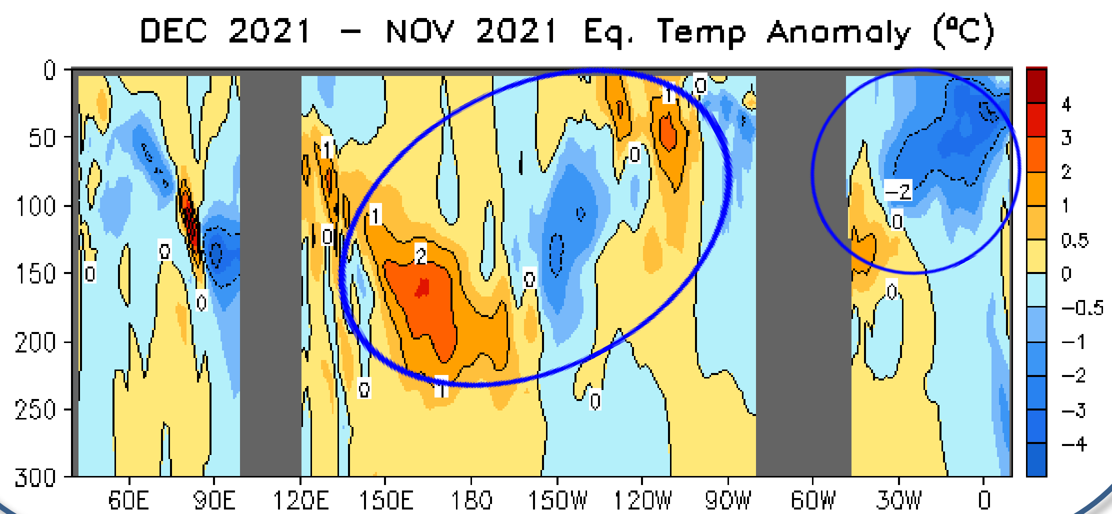


- Negative SSTA tendencies were observed in the eastern equatorial Pacific.
- Positive SSTA tendencies were evident in the western and eastern North Pacific.
- Negative SSTA tendencies were present in the equatorial and southern Atlantic Ocean.

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 2°S-2°N



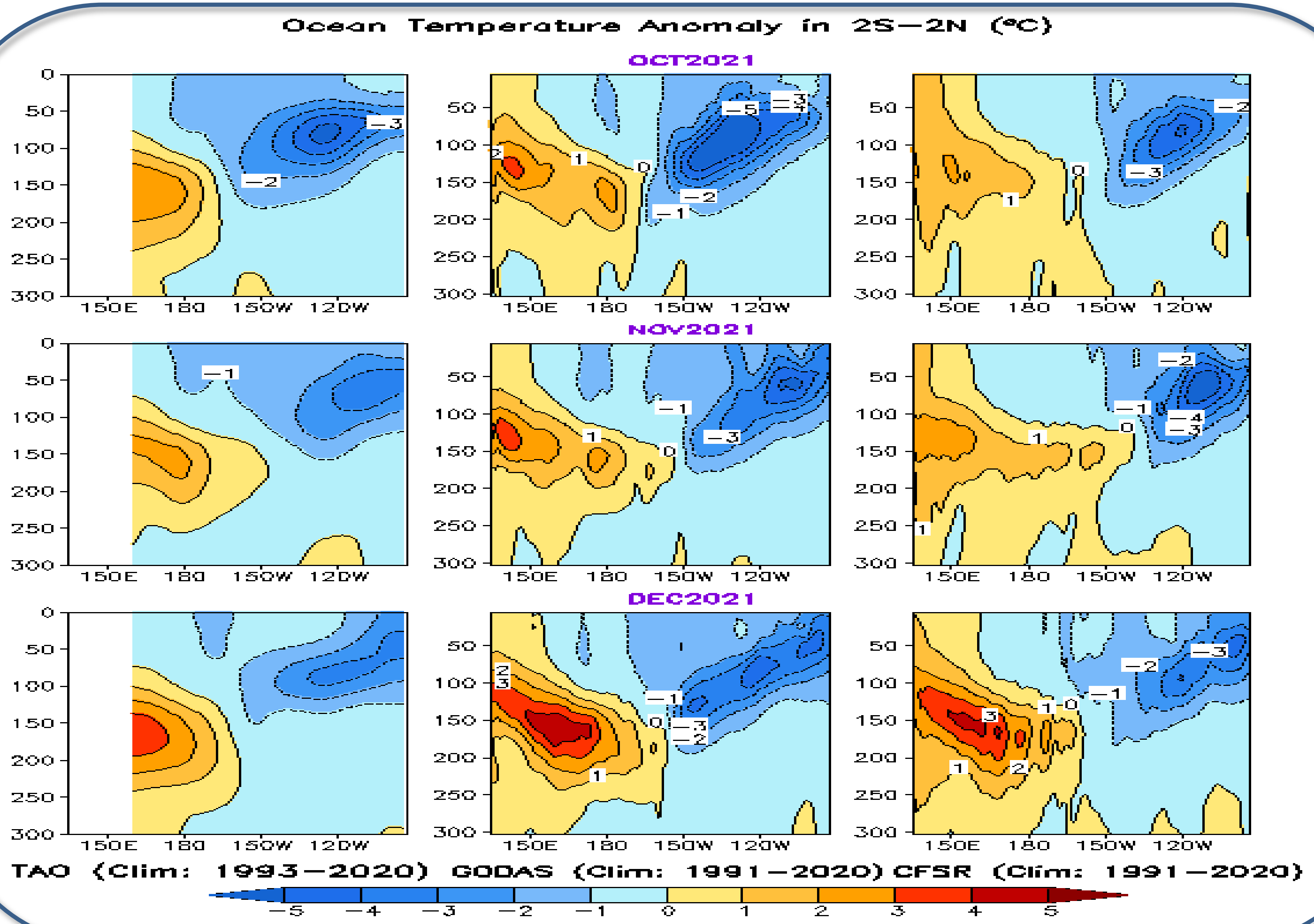


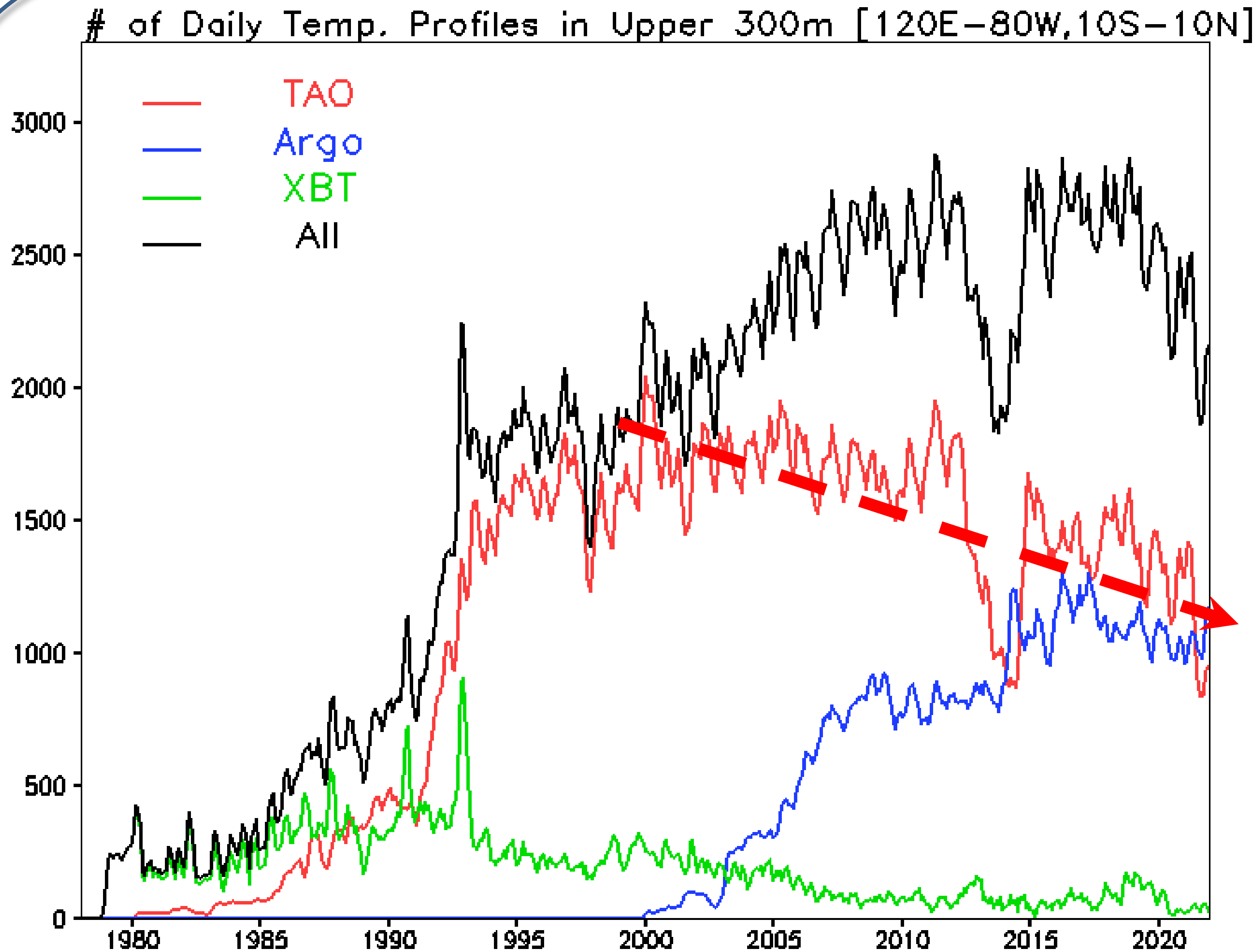
- Negative (positive) temperature anomalies were observed along the thermocline in the eastern (western) equatorial Pacific.
- A dipole-like pattern presented in the Indian Ocean.
- Negative temperature anomalies were observed along the thermocline in the equatorial Atlantic Ocean.

- Temperature anomaly tendency was positive (negative) along the thermocline in the western and central (east-central) Pacific.
- Positive (negative) temperature anomaly tendency was evident in the western (central and eastern) Atlantic Ocean.

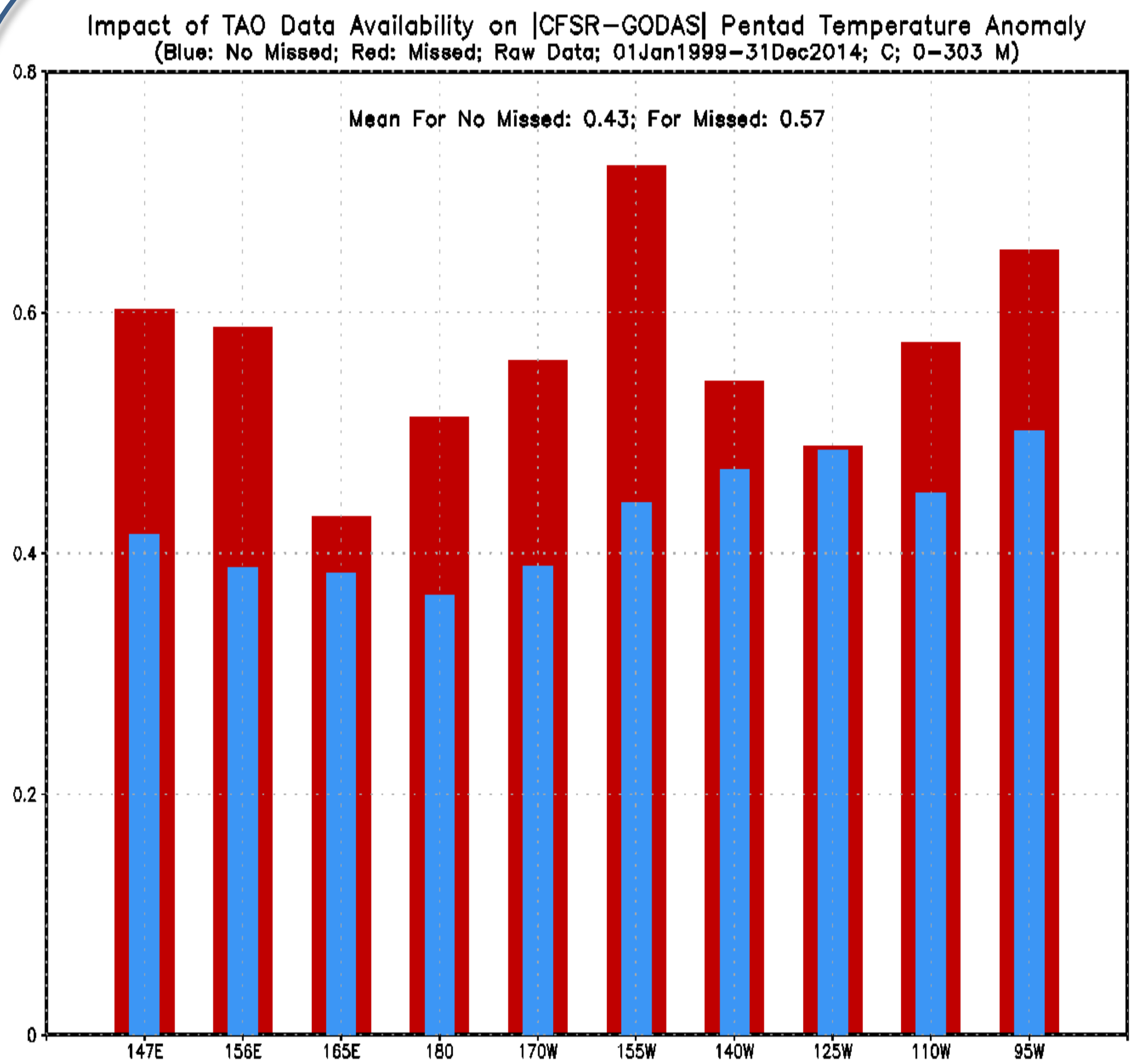
Equatorial depth-longitude section of ocean temperature anomalies (top) and anomaly tendency (bottom). Data is from the NCEP's GODAS. Anomalies are departures from the 1991-2020 base period means.

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



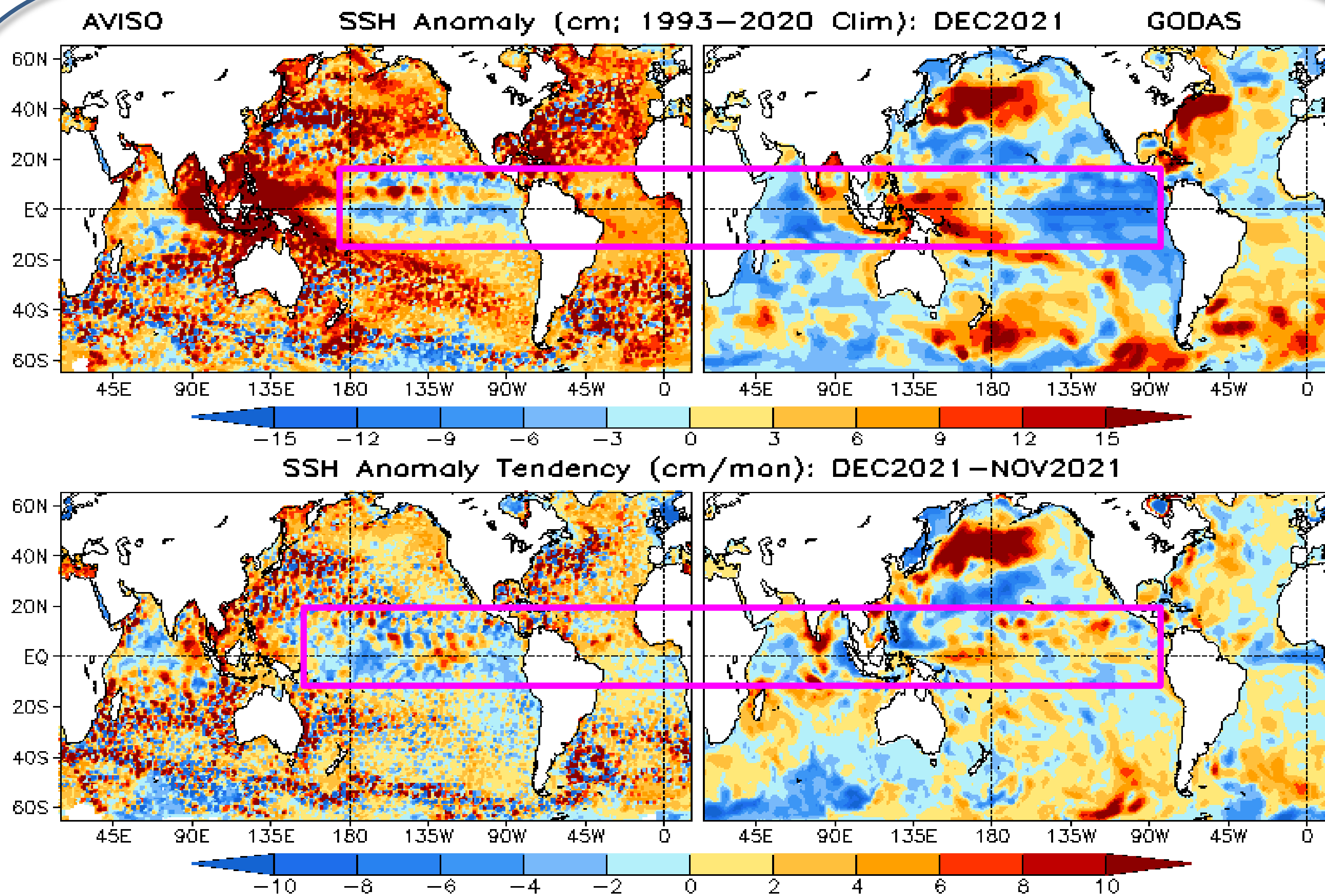


# of Daily Temp. Profiles in Upper 300m [120E-80W,10S-10N]
TAO
Argo
XBT
All
3000
2500
2000
1500
1000
500
0
1980
1985
1990
1995
2000
2005
2010
2015
2020



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

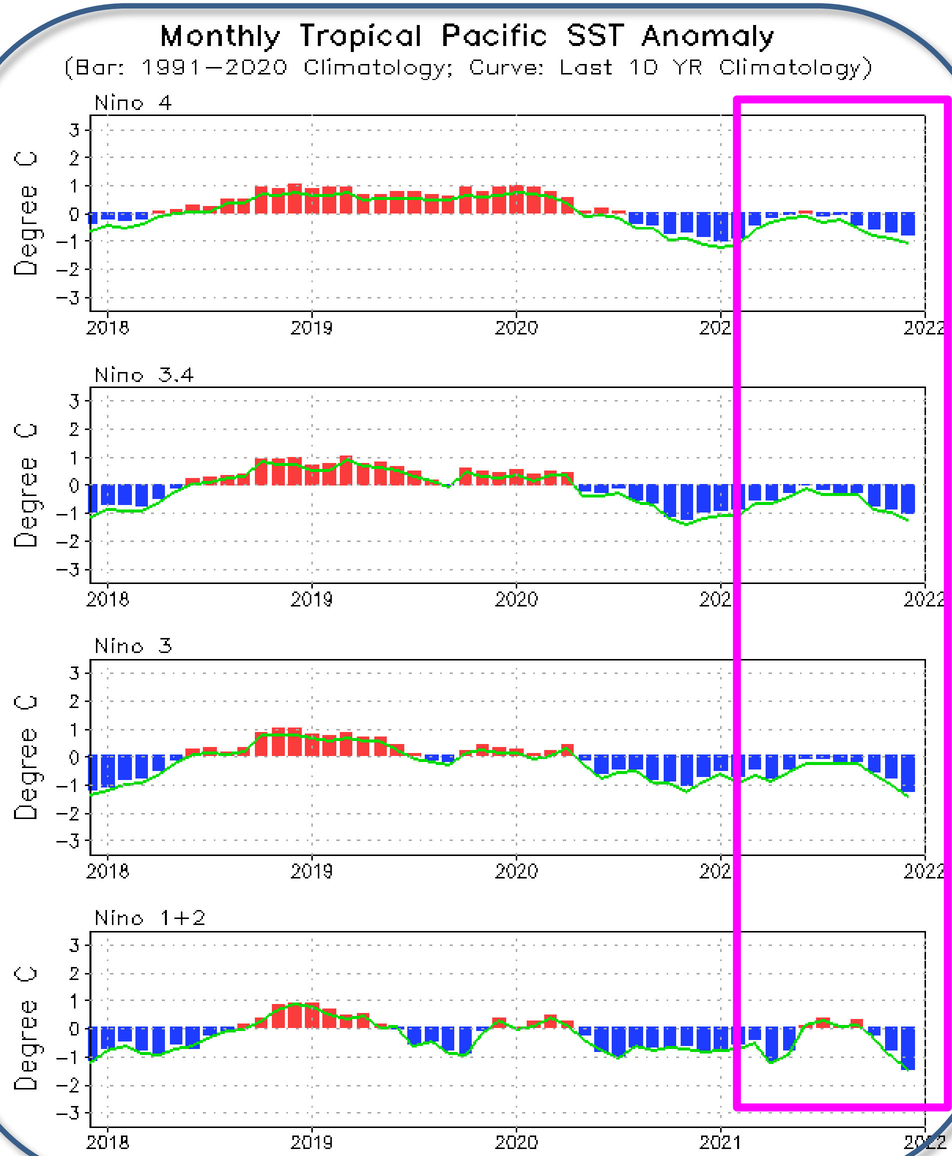
Hu, Z.-Z. and A. Kumar, 2015: Influence of availability of TAO data on NCEP ocean data assimilation systems along the equatorial Pacific. *J. Geophys. Res. (Ocean)*, **120**, 5534-5544. DOI: 10.1002/2015JC010913.

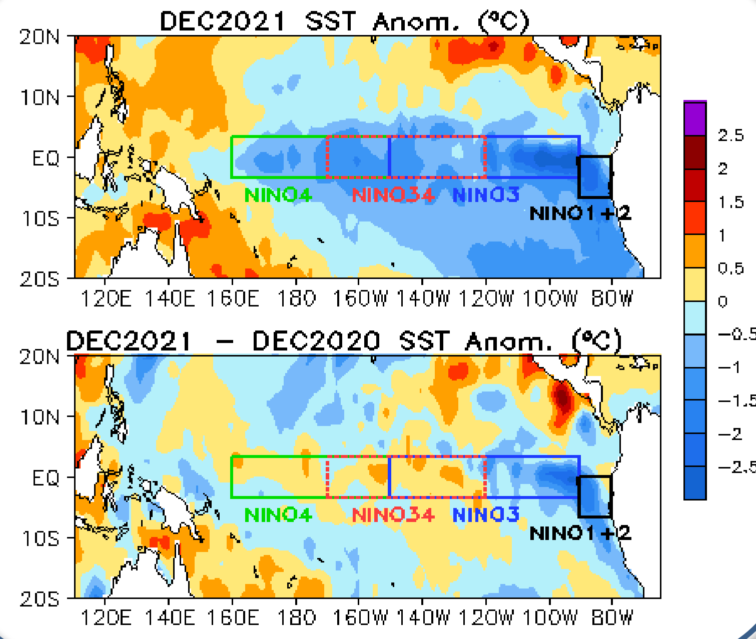


- There are some detailed differences between AVISO and GODAS with a lot of small-scale variabilities in AVISO.

Tropical Pacific Ocean and ENSO Conditions

Evolution of Pacific NINO SST Indices

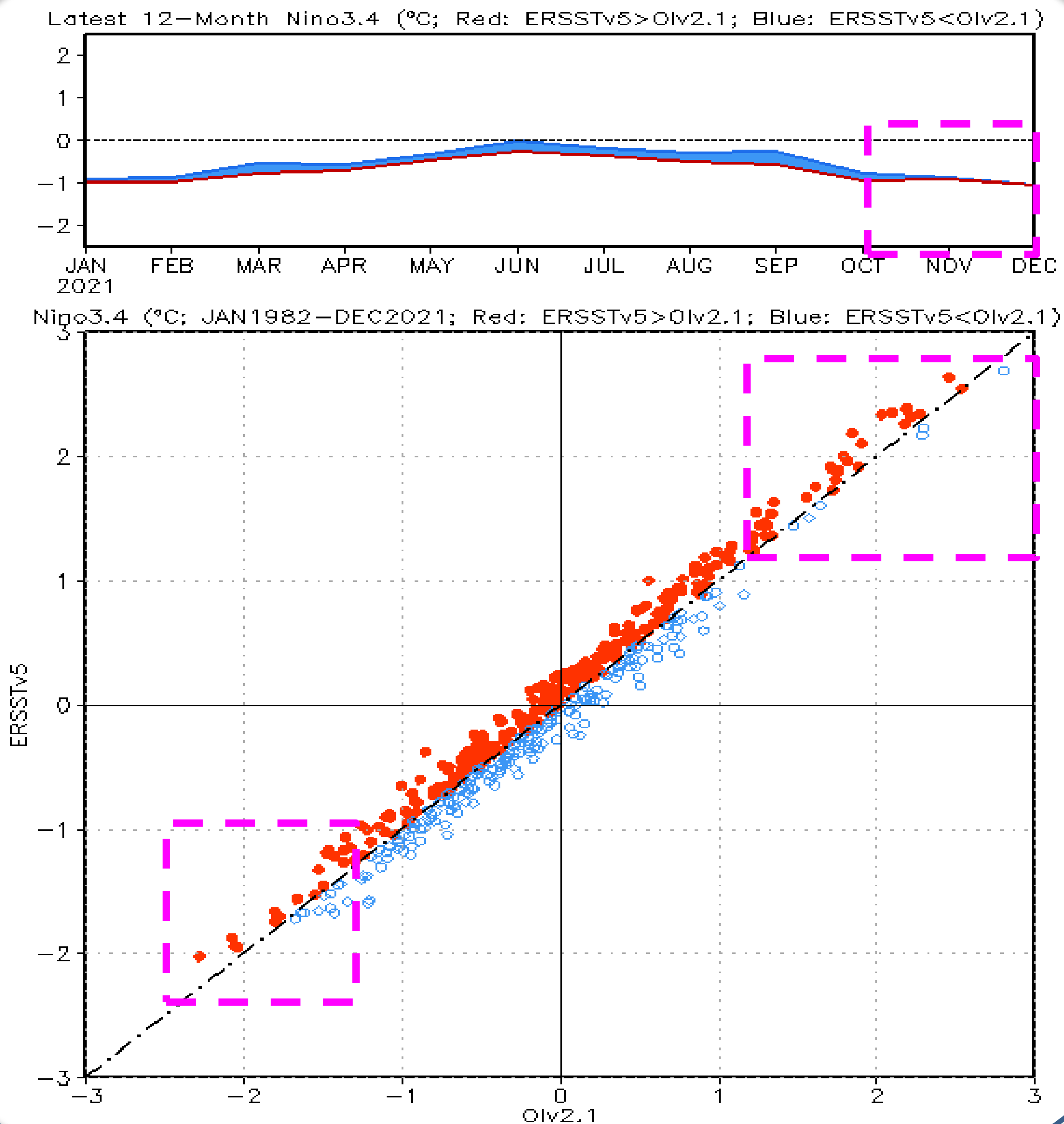




- All Nino indices strengthened in Dec 2021, with Nino3.4 = -1.1C.
- Compared with Dec 2020, the central (eastern) equatorial Pacific was warmer (cooler) in Dec 2021.
- The indices may have slight differences if based on different SST products.

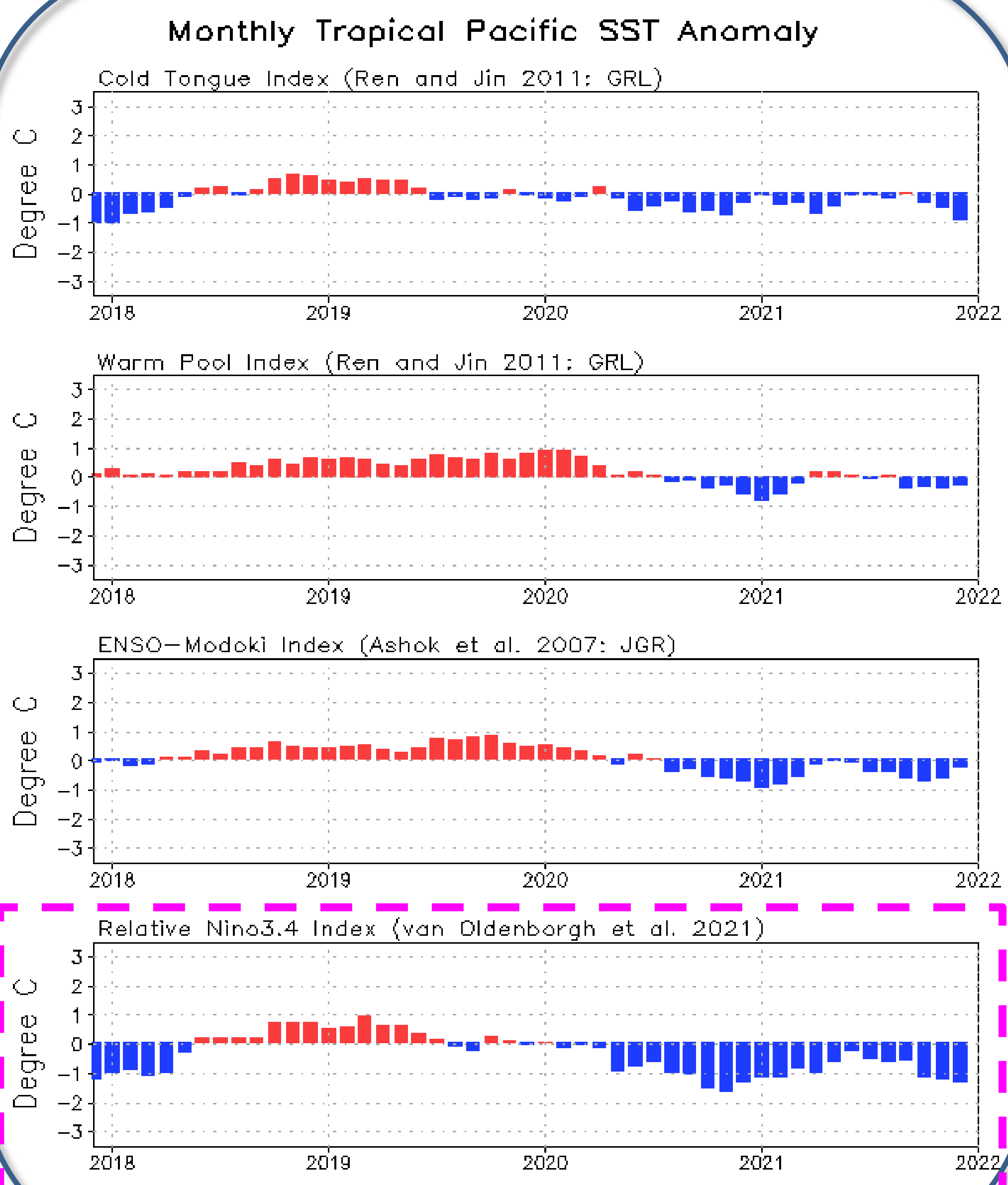
Nino region indices, calculated as the area-averaged monthly mean SSTAs (°C) for the specified region. Data are derived from the OI SST analysis, and anomalies are departures from the 1991-2020 base period means.

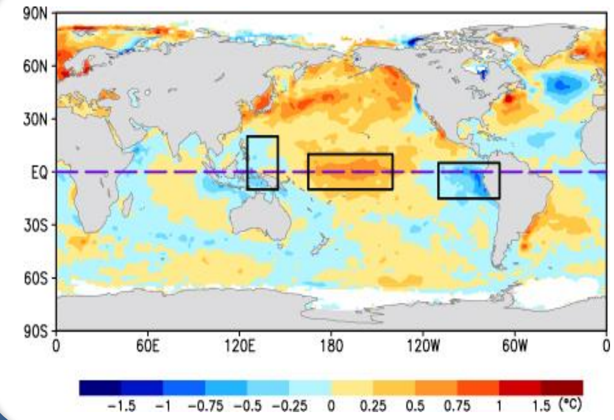
Comparison of ERSSTv5 & OIv2.1 Nino3.4 Index



- Sometimes, ERSSTv5 is warmer (cooler) than OIv2.1.
- For both the extreme positive (negative) Nino3.4, ERSSTv5 is mostly warmer than OIv2.1.
- During last year, ERSSTv5 was cooler than OIv2.1.

Evolution of Pacific Niño SST Indices



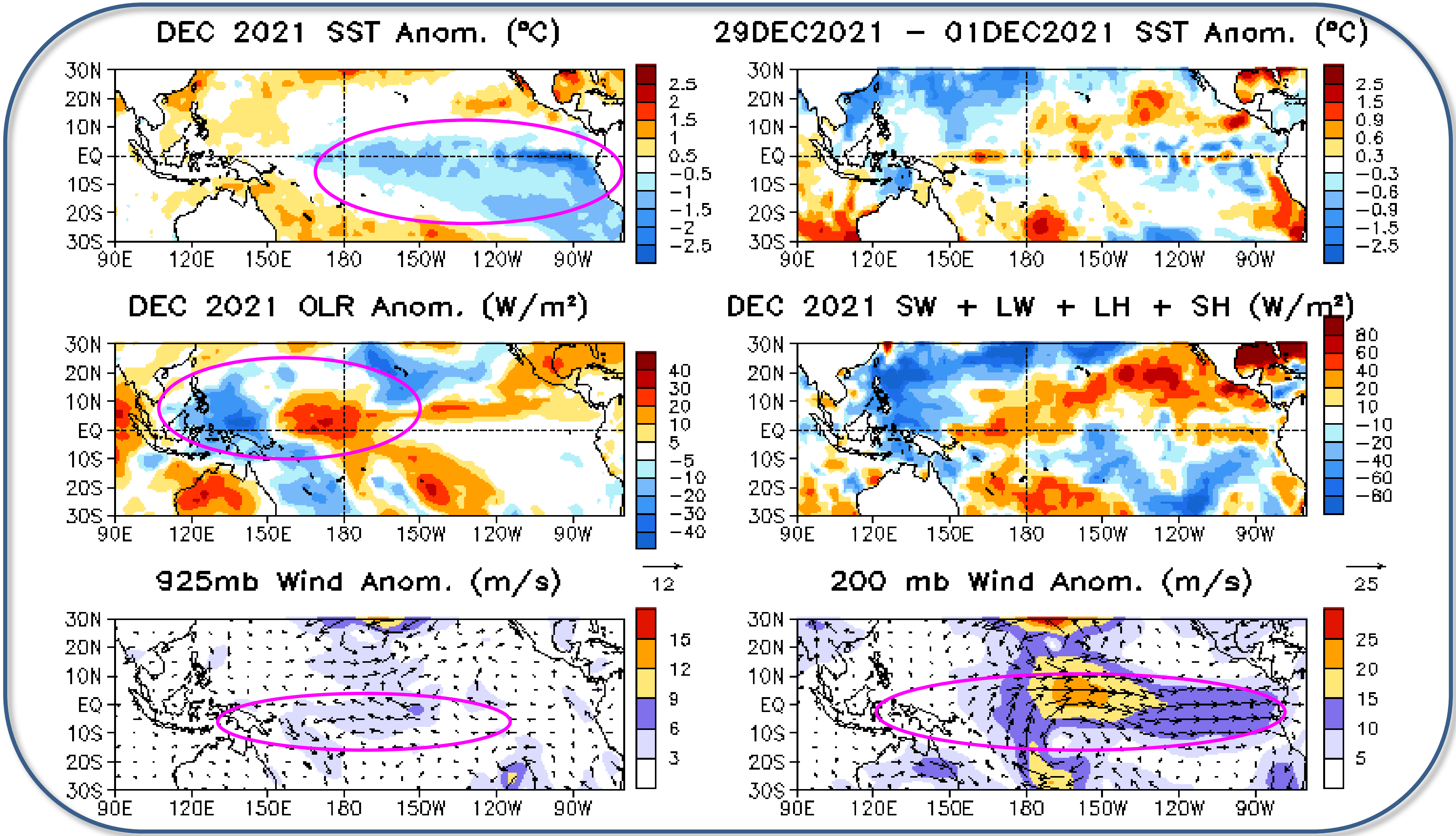


- Relative Niño3.4 index is defined as the conventional Niño3.4 index minus the SSTA averaged in the whole tropics (0º-360º, 20ºS-20ºN), in order to remove the global warming signal. Also, to have the same variability as the conventional Niño3.4 index, the relative Niño3.4 index is renormalized (van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

Relative Niño3.4 data updated monthly at:

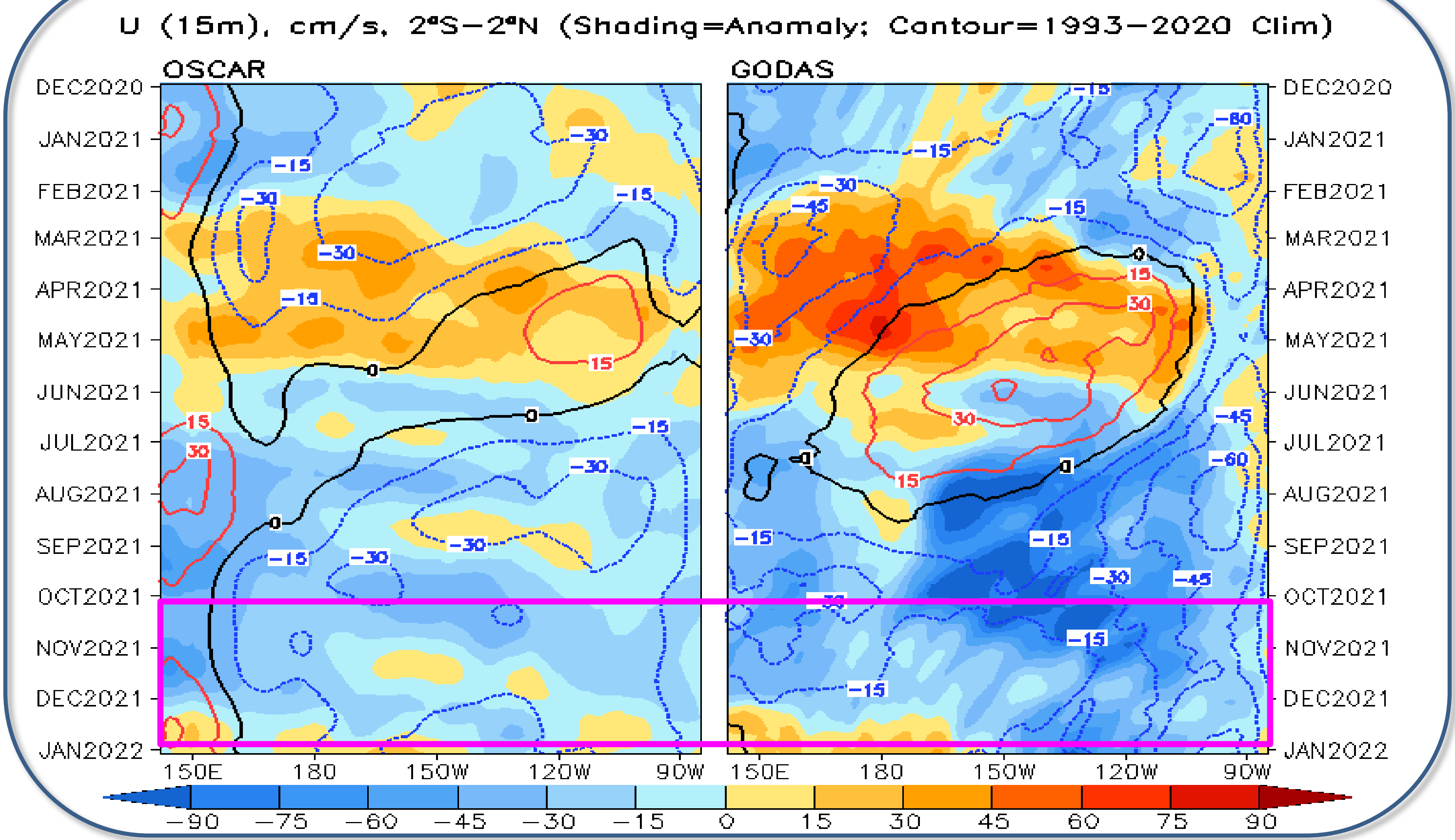
https://www.cpc.ncep.noaa.gov/data/indices/RONI.ascii.txt

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



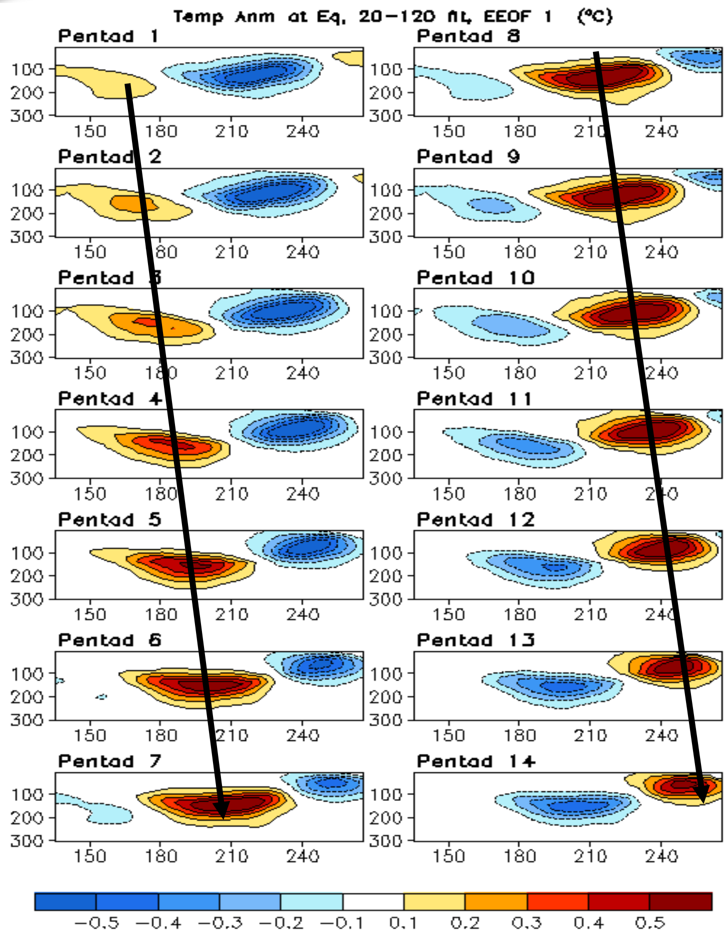
SSTAs (top-left), SSTA tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right; positive means heat into the ocean), 925-mb wind anomaly vector and its amplitude (bottom-left),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

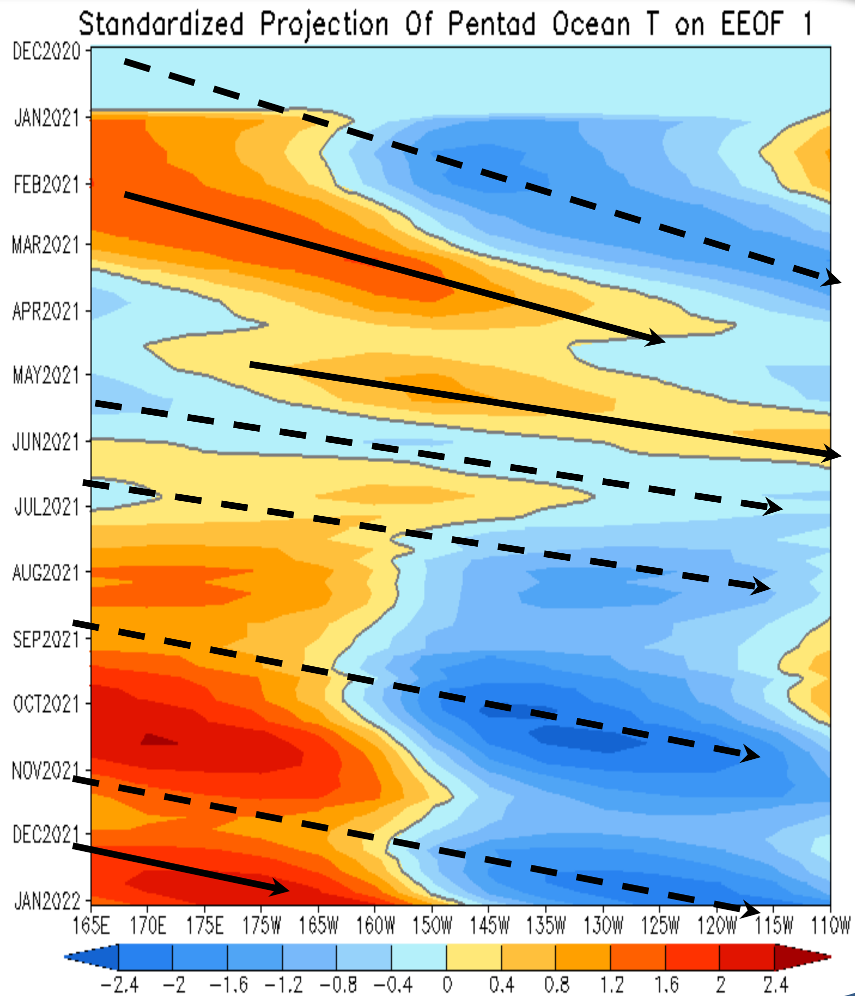
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- Anomalous westward currents and pockets of eastward currents were observed in the equatorial Pacific in both OSCAR and GODAS in Dec 2021.

Oceanic Kelvin Wave (OKW) Index



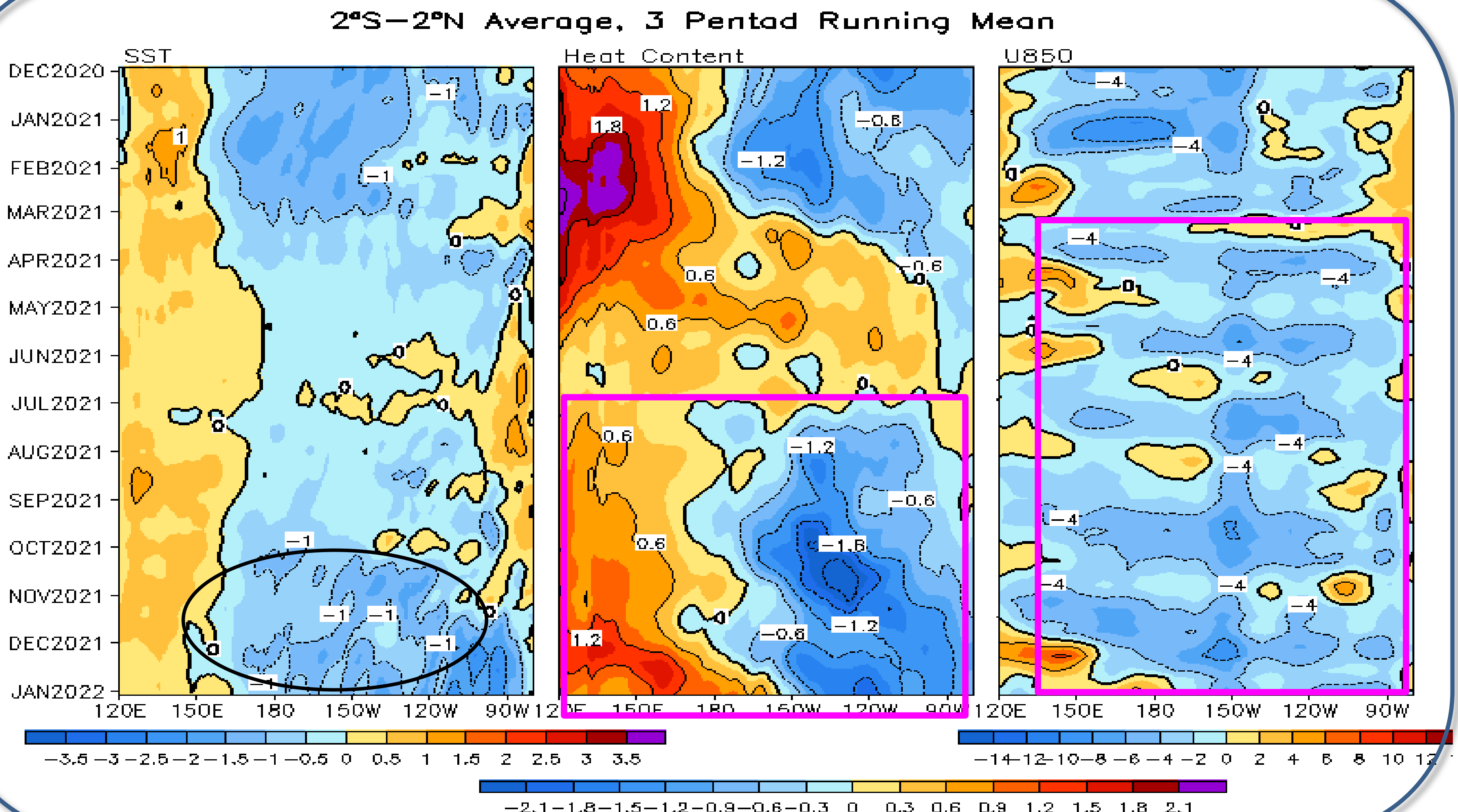


- **Upwelling Kelvin waves were initiated in Jun, Aug, & Nov 2021, leading to the subsurface cooling in the eastern equatorial Pacific and the development of the 2021/22 La Nina.**

- **Since Jun 2021, stationary component has dominated.**

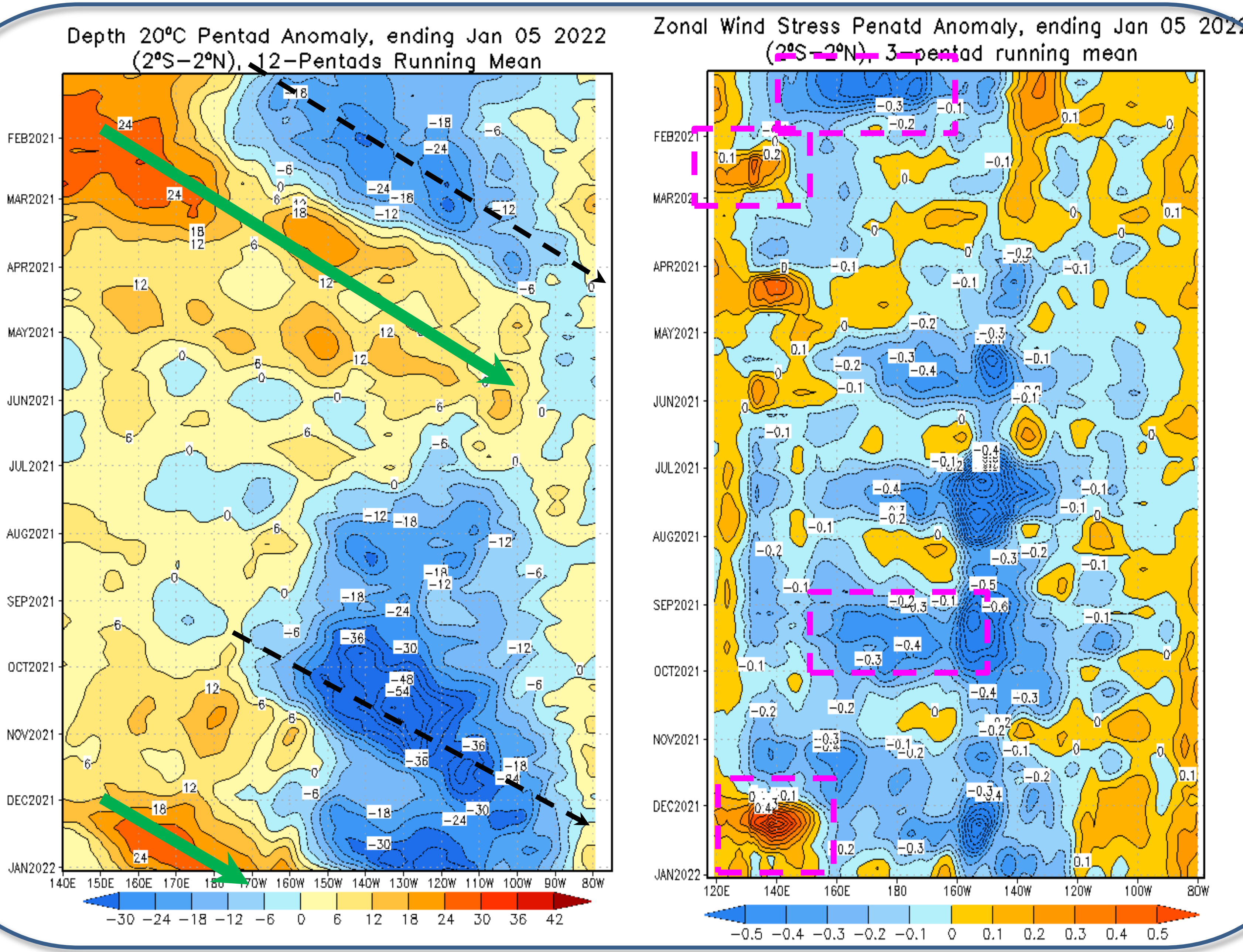
(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)

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



- Easterly wind anomaly was present across the equatorial Pacific since Mar 2021.
- Below- average HC300 was observed in the eastern Pacific since Jul 2021.
- Negative SSTA persisted in the central and eastern equatorial Pacific in Dec 2021.

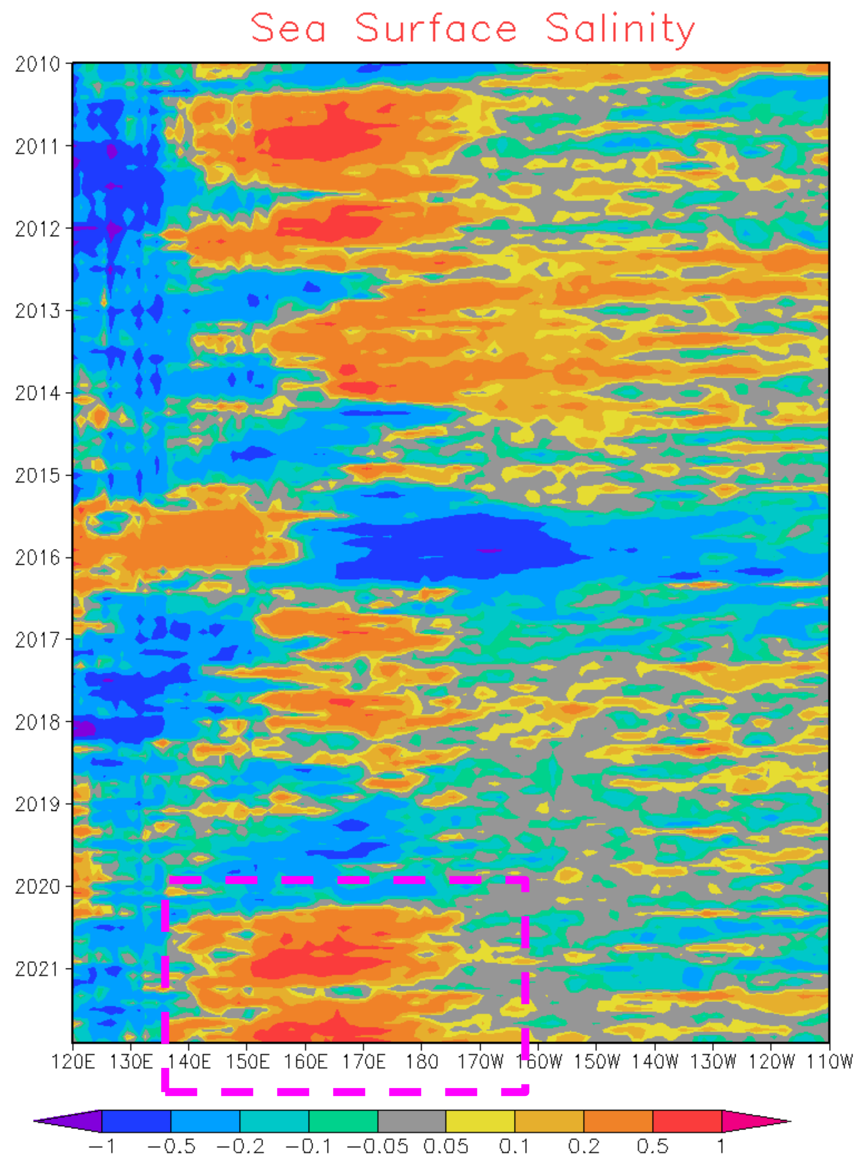
Evolution of Pentad D20 and Taux anomalies along the equator



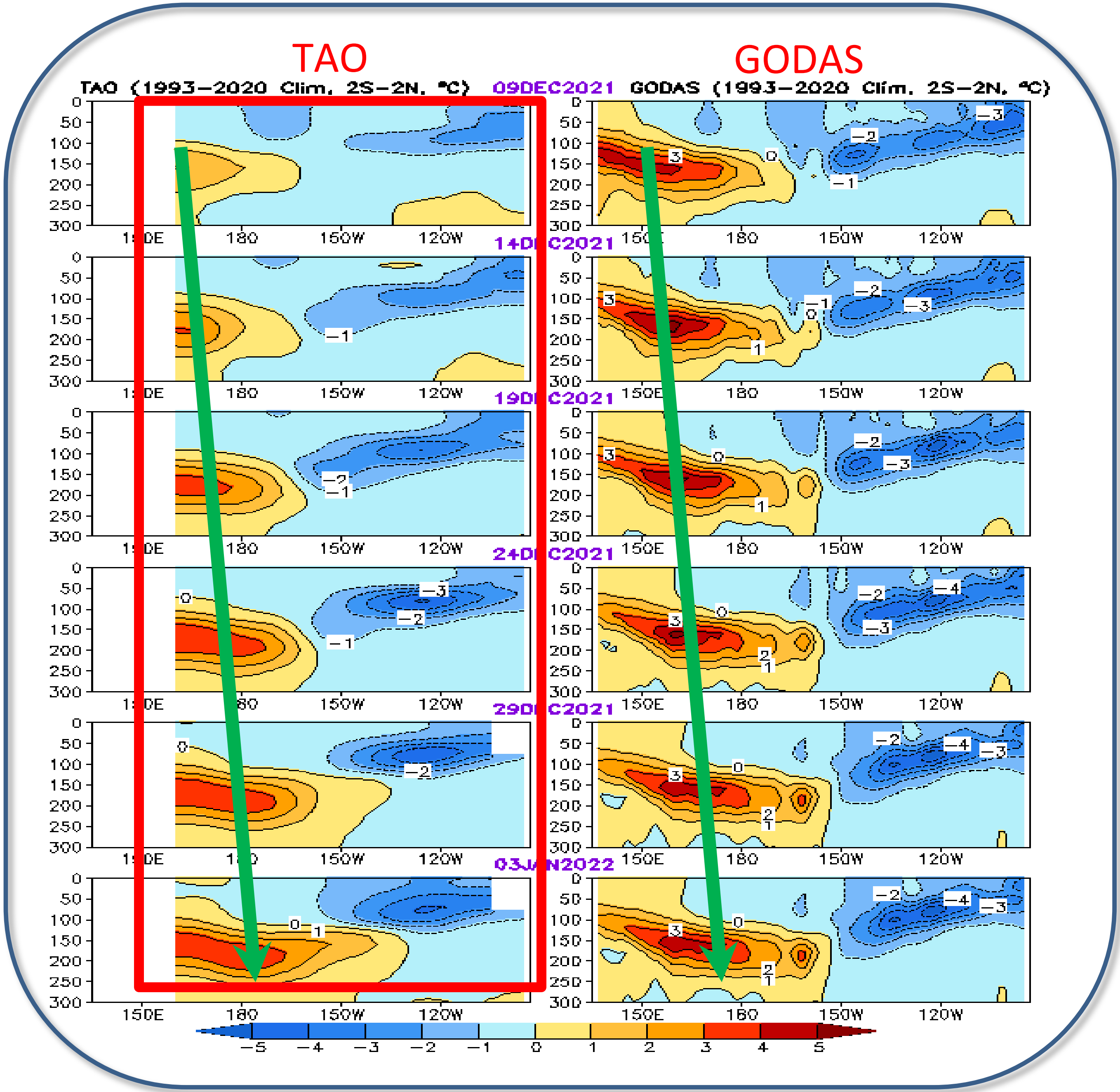
Monthly SSS Anomaly Evolution over Equatorial Pacific

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 shows east of 150°W.

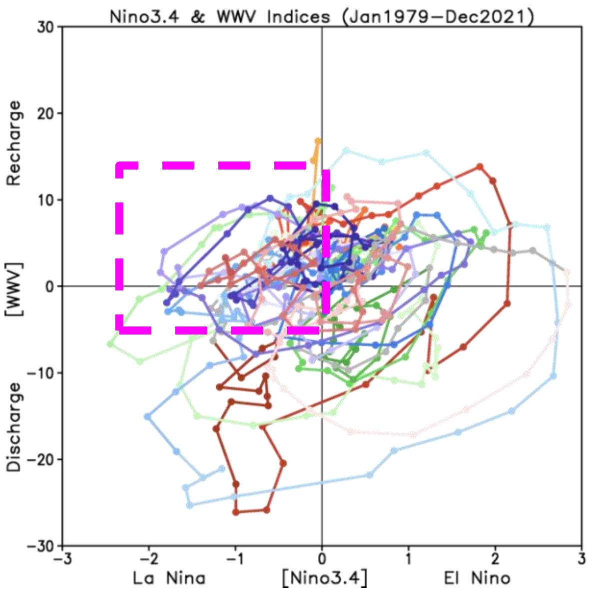


Equatorial Pacific Ocean Temperature Pentad Mean Anomaly

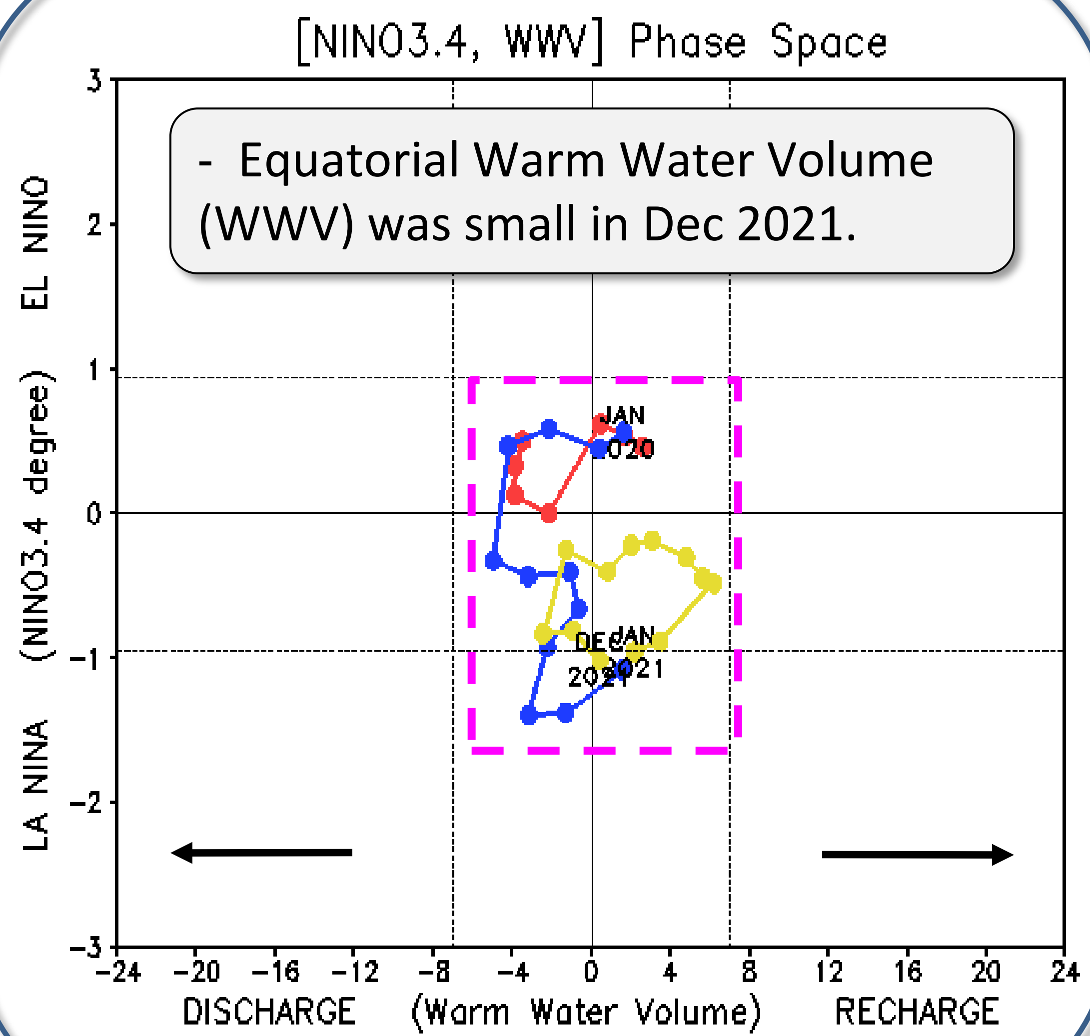


- Stationary variations with negative (positive) ocean temperature anomalies in the east (west) along the thermocline were evident in the last month, a feature in the mature phase of ENSO.
- Dipole-like pattern strengthened in TAO during Dec 2021.

Warm Water Volume (WWV) and Niño3.4 Anomalies

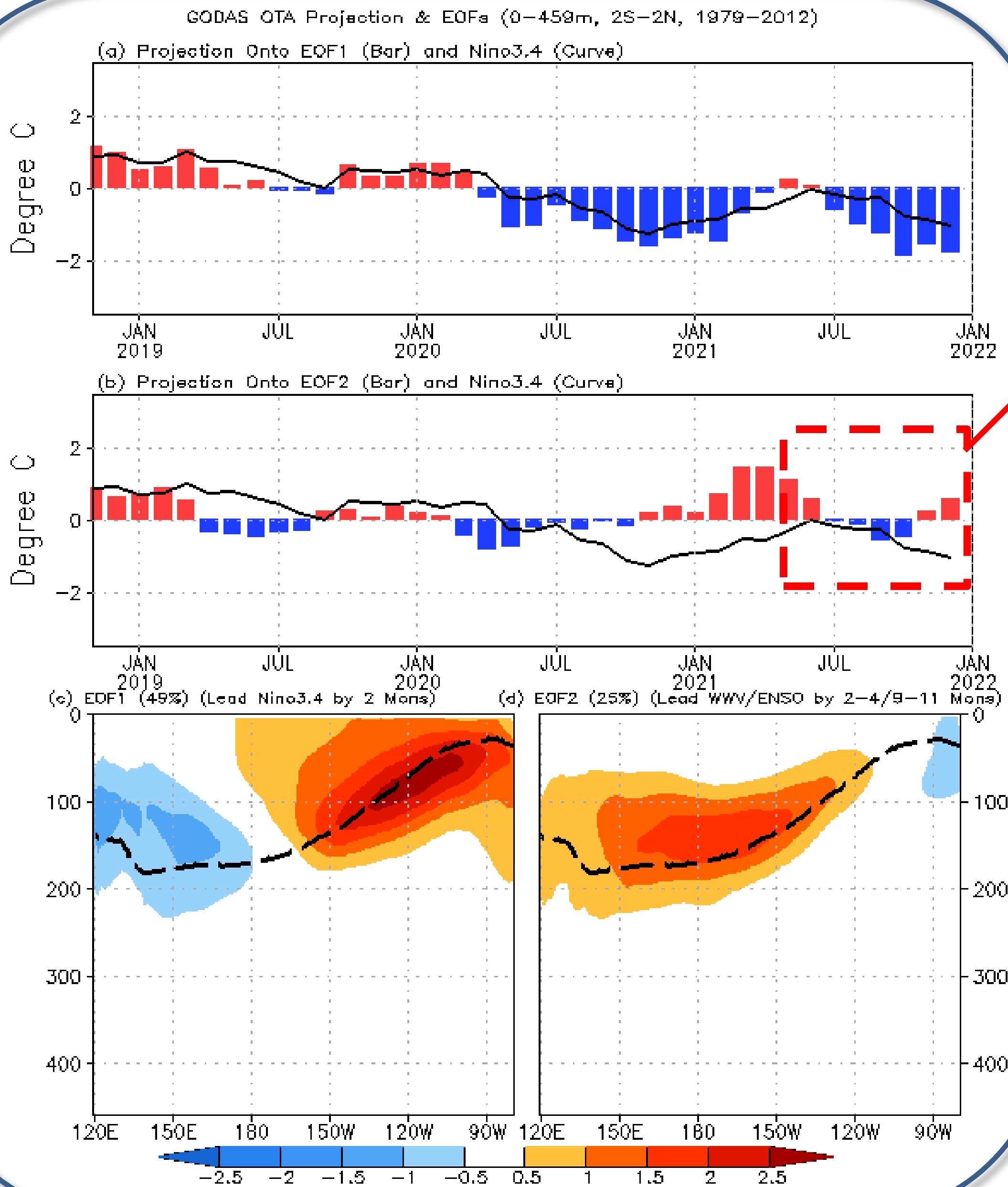


- As WWV is intimately linked to ENSO variability (Wyrtki 1985; Jin 1997), it is useful to monitor ENSO in a phase space of WWV and Niño3.4 (Kessler 2002).
- Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.



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 Sub-surface Ocean Temperature Monitoring



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

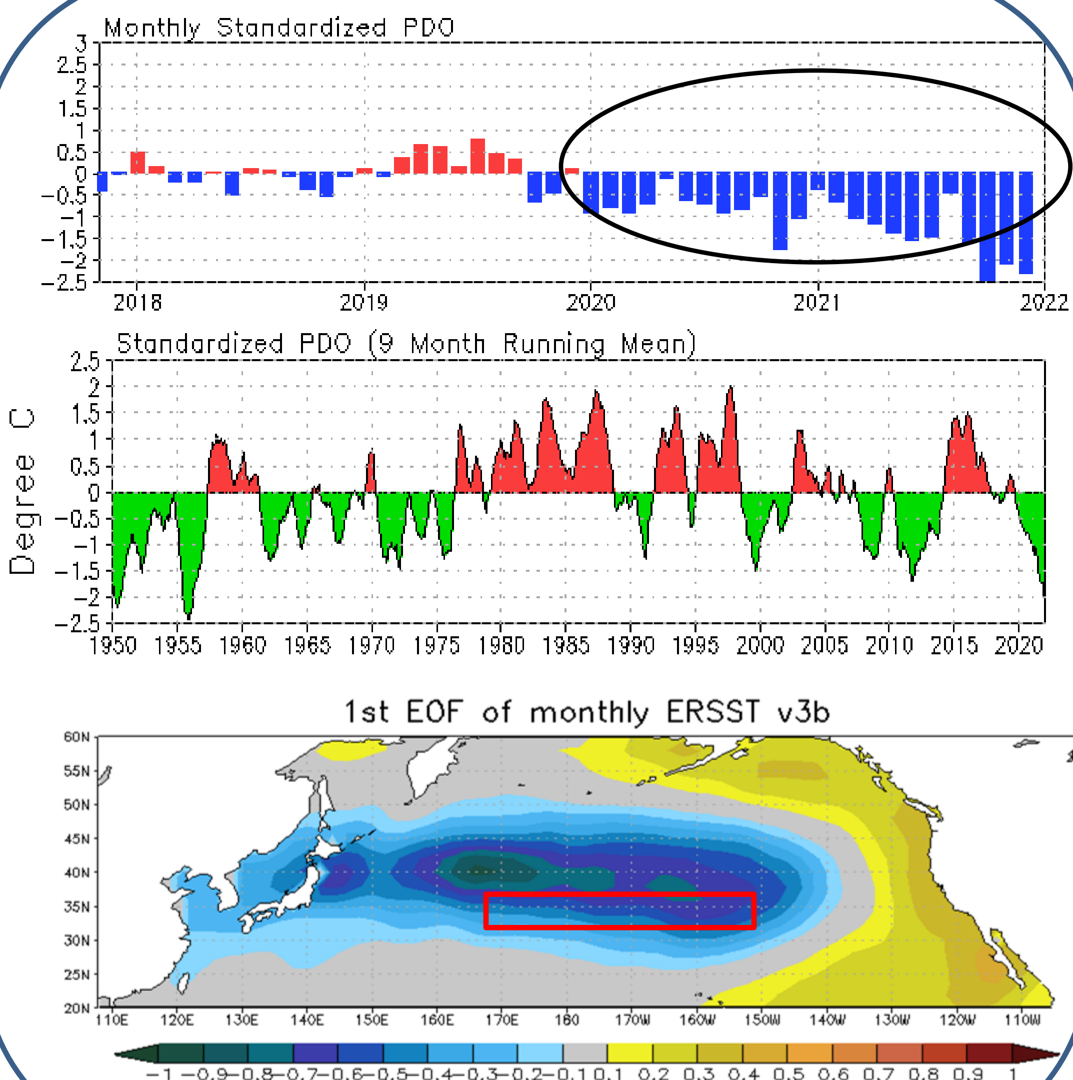
- Projection of ocean temperature anomalies onto EOF1 and EOF2; EOF1: Tilt/dipole mode (ENSO peak phase); EOF2: WWV mode.

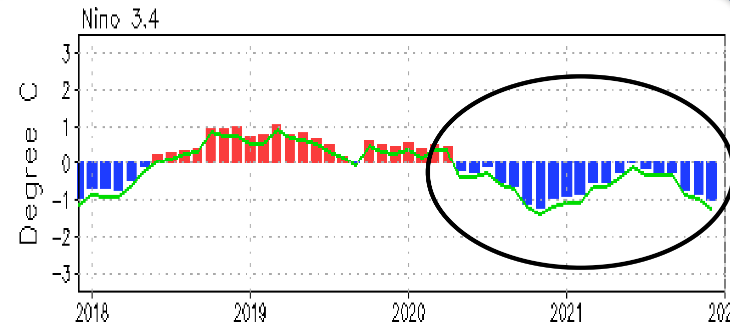
- Recharge/discharge oscillation (ENSO transition phase); Recharge process: heat transport from outside of equator to equator; Negative -> positive phase of ENSO

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

North Pacific & Arctic Oceans

Pacific Decadal Oscillation (PDO) Index



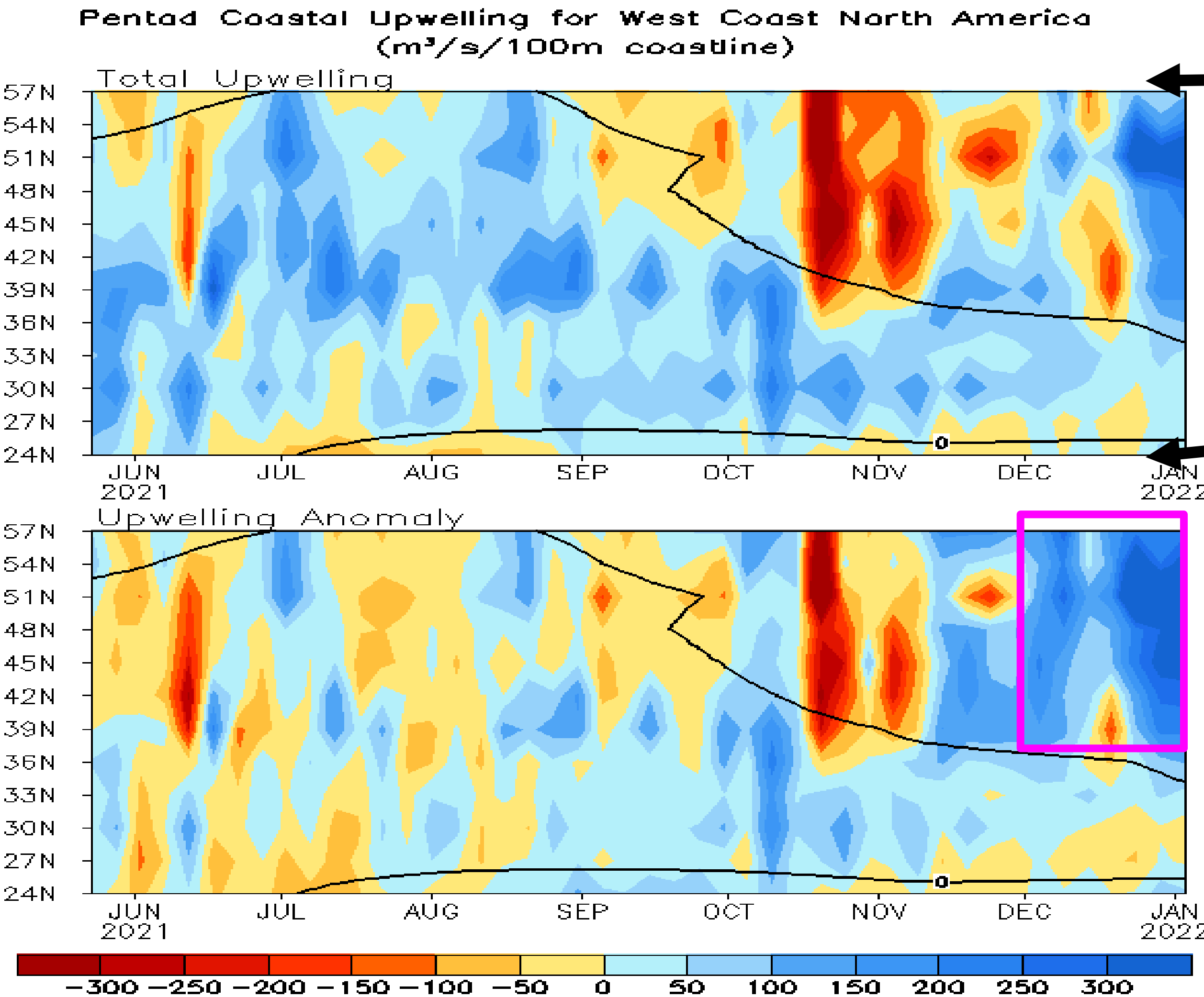


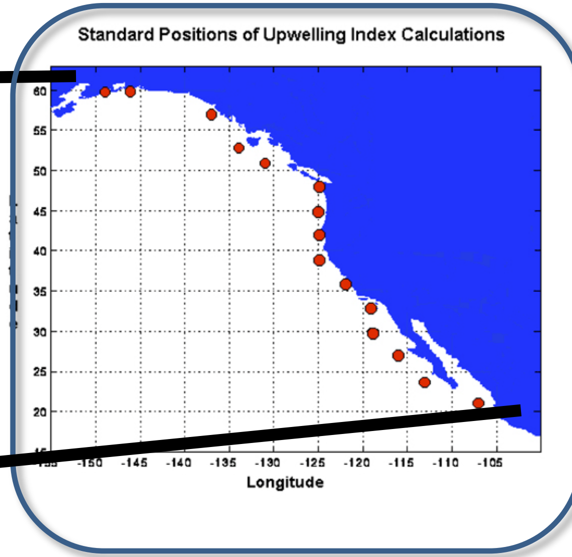
- The PDO has been in a negative phase since Jan 2020 with PDOI = -2.3 in Dec 2021.

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

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

North America Western Coastal Upwelling



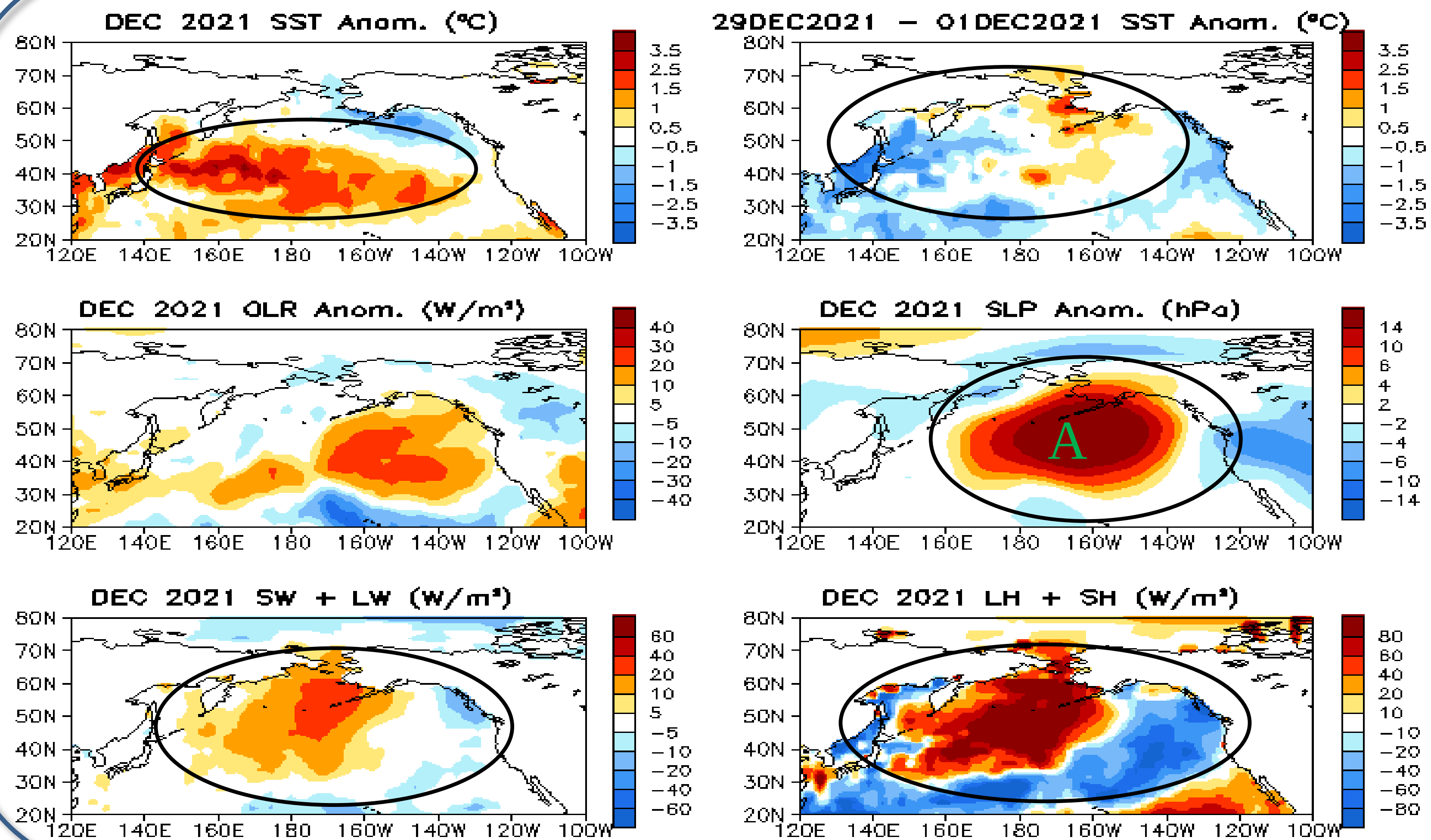


- Anomalous coastal upwelling was present in North of 40~50ºN in Dec 2021.

(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.

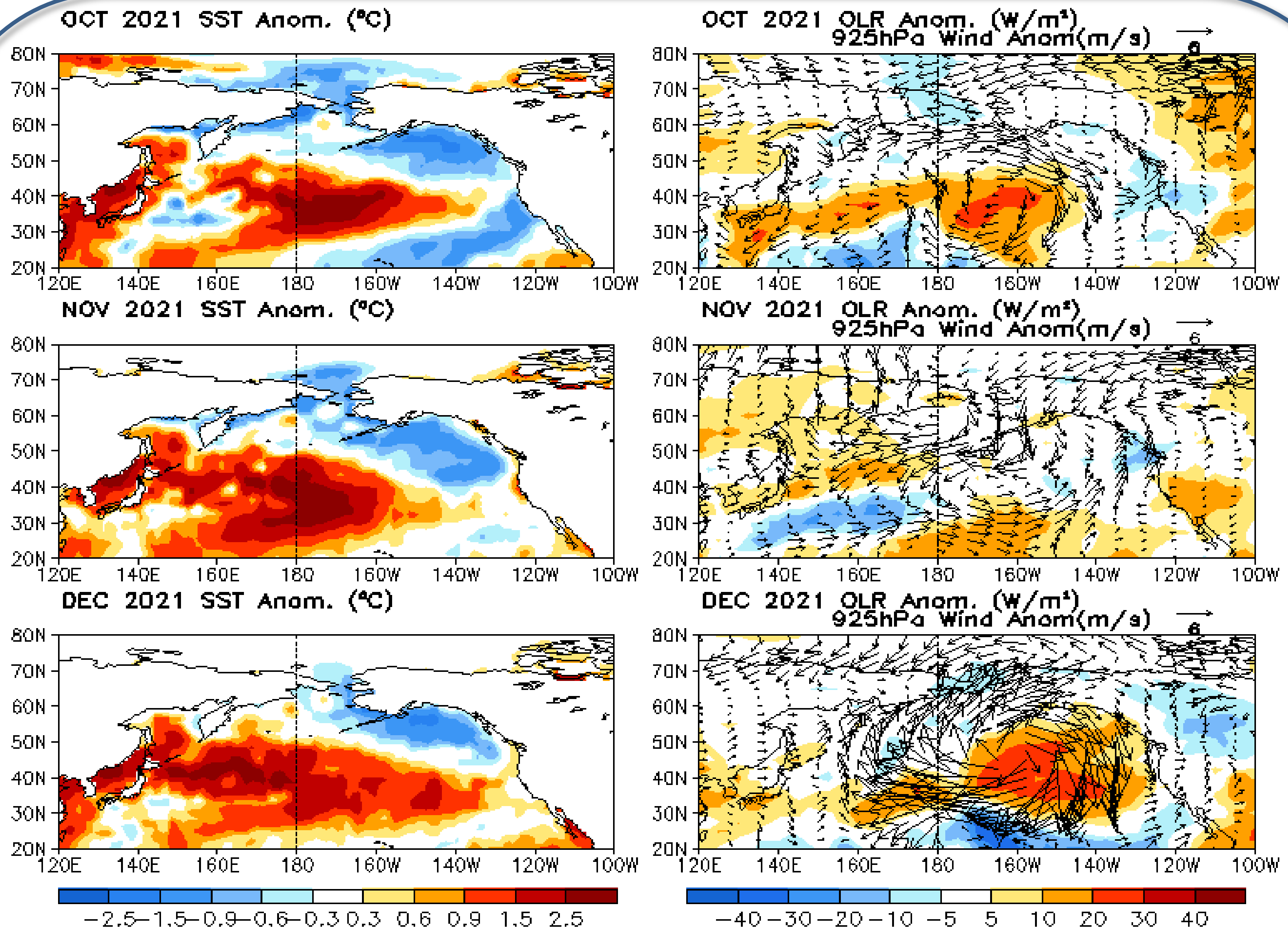
- Area below (above) black line indicates climatological upwelling (downwelling) season.
- Climatologically upwelling season progresses from March to July along the west coast of North America from 36ºN to 57ºN.

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

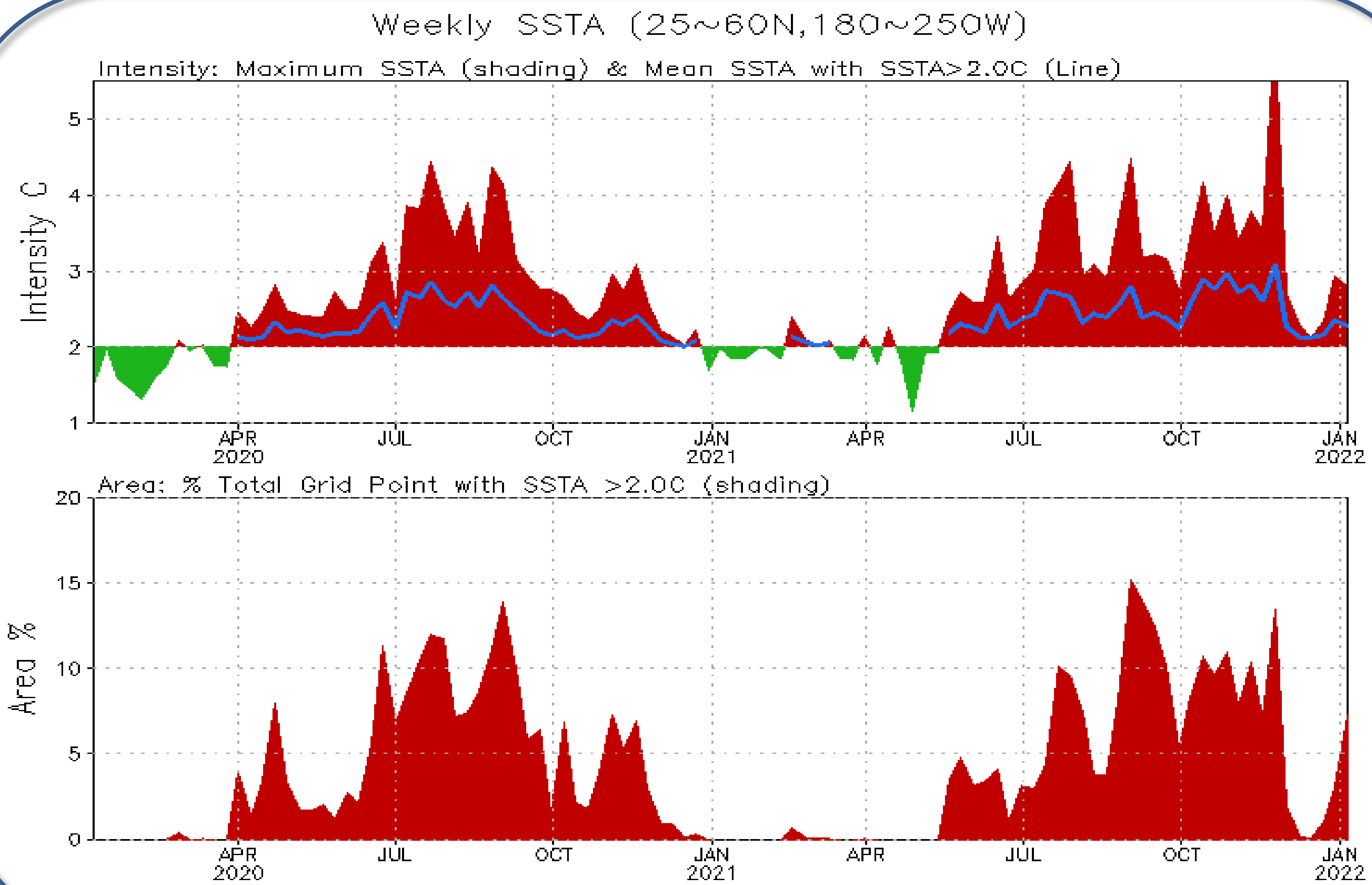


SSTA (top-left; OI SST Analysis), SSTA tendency (top-right), Outgoing Long-wave Radiation (OLR) (middle-left; NOAA 18 AVHRR IR), sea surface pressure (middle-right; NCEP CDAS), sum of net surface short- and long-wave radiation (bottom-left; positive means heat into the ocean; NCEP CDAS), sum of latent 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 Pacific SST, OLR, and uv925 anomalies

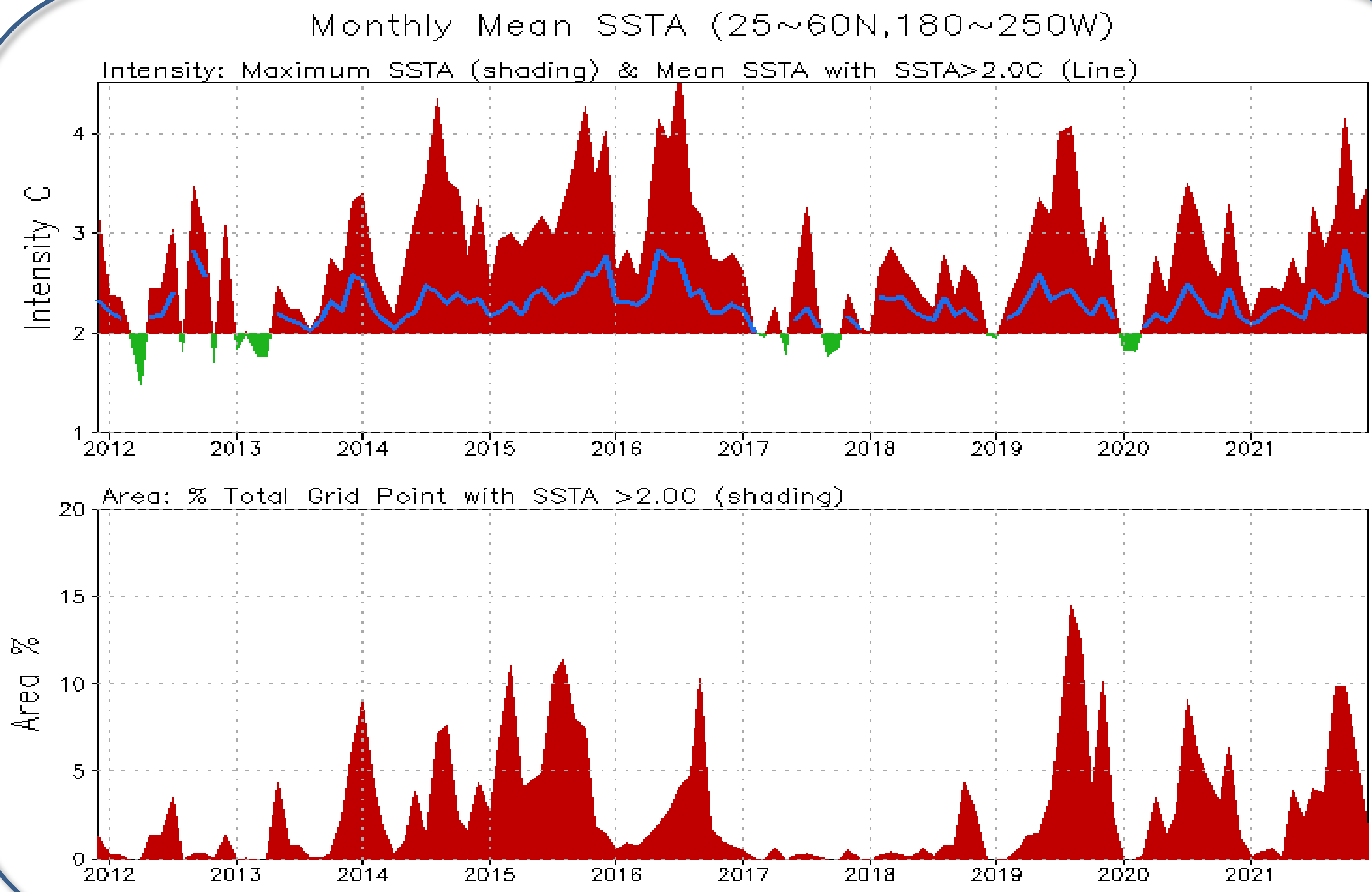


NE. Pacific Marine Heat Wave



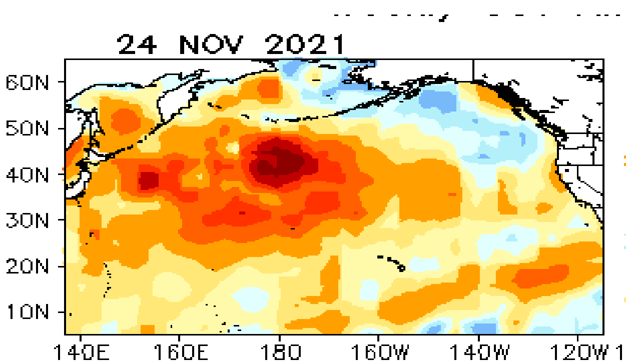
https://origin.cpc.ncep.noaa.gov/products/GODAS/MarineHeatWave.html

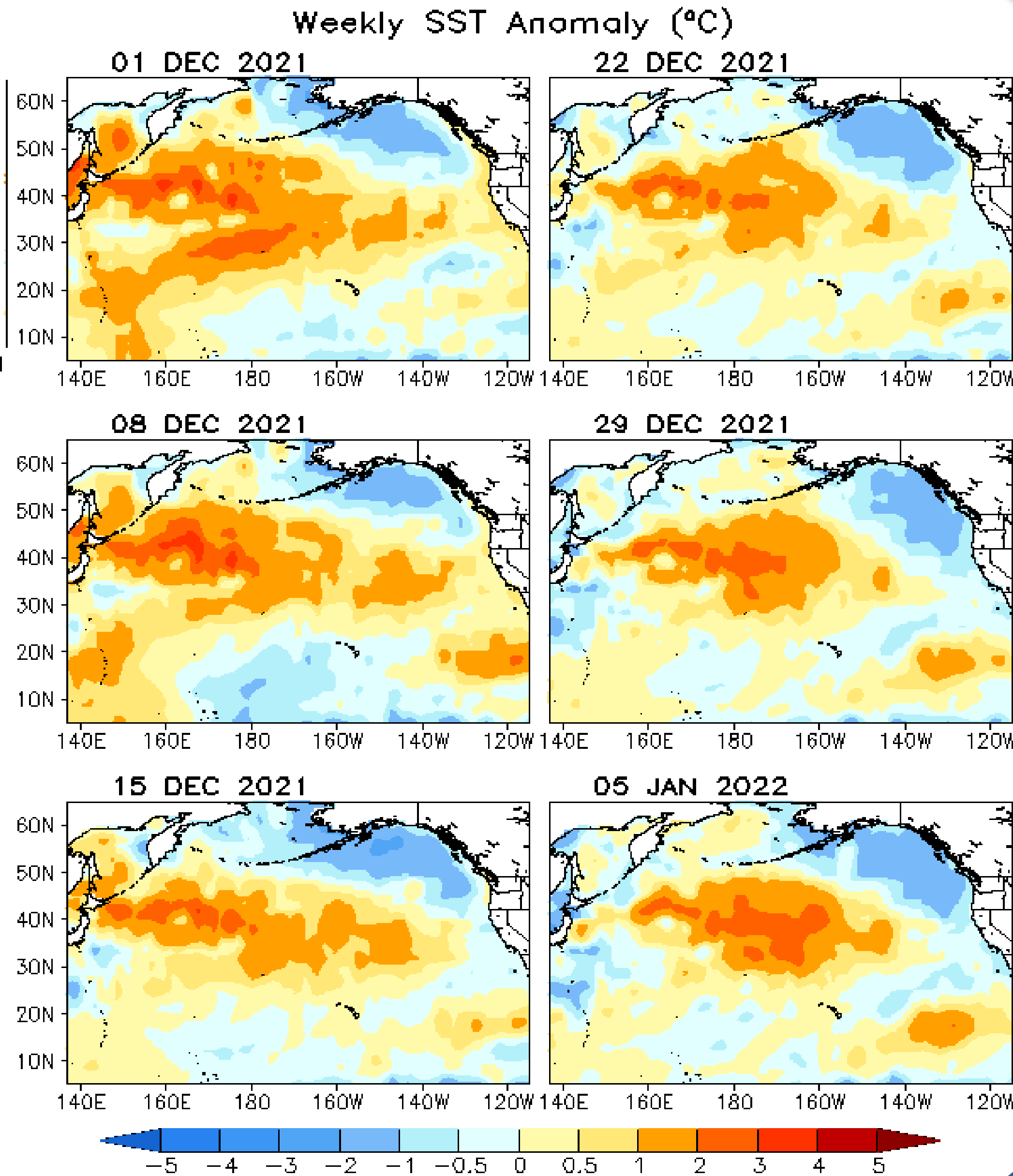
NE. Pacific Marine Heat Wave



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

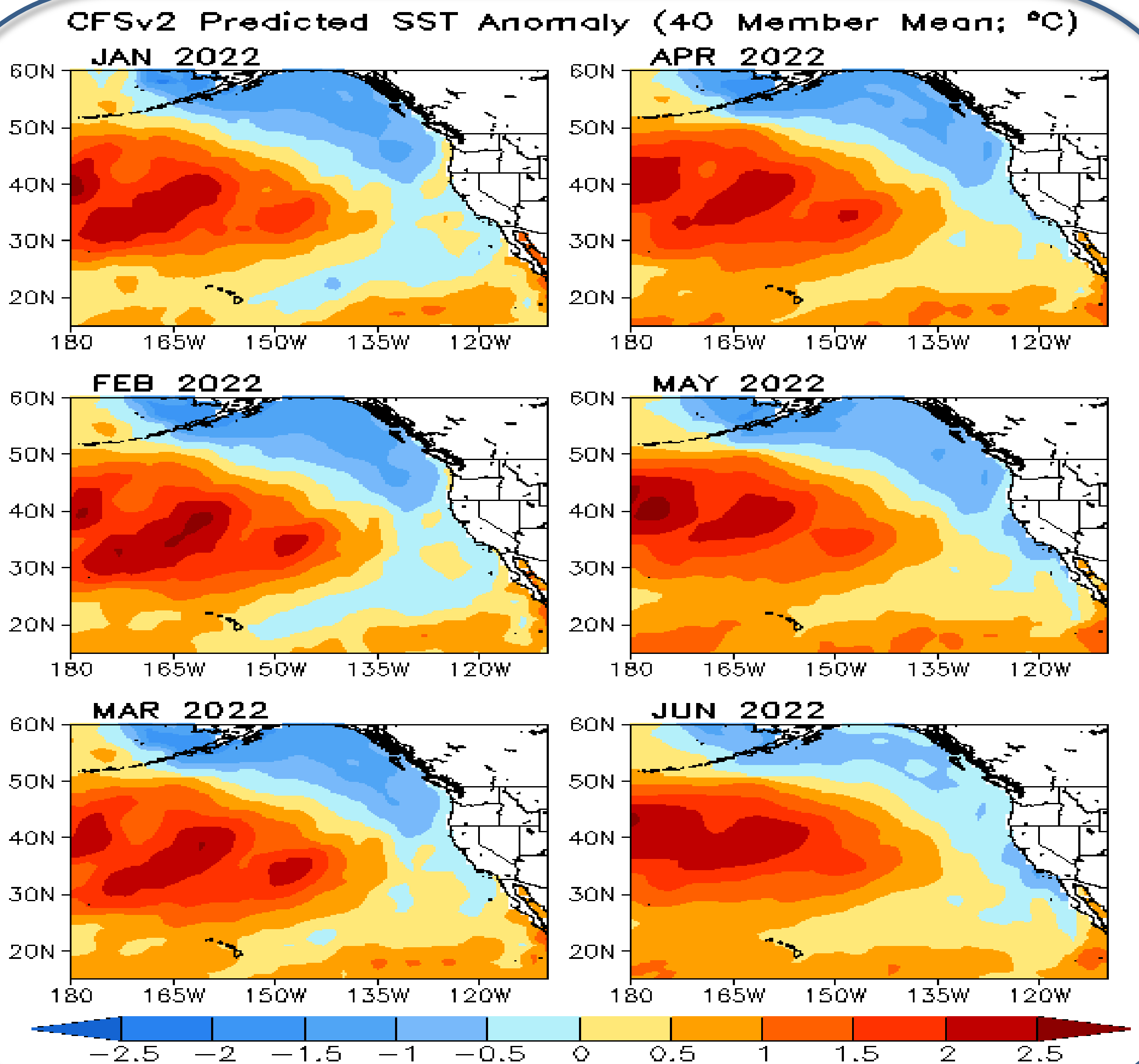
Weekly SSTA evolutions in the NE Pacific



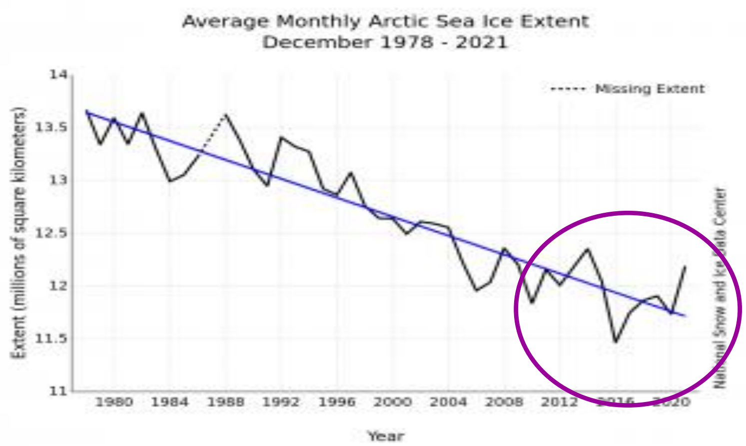


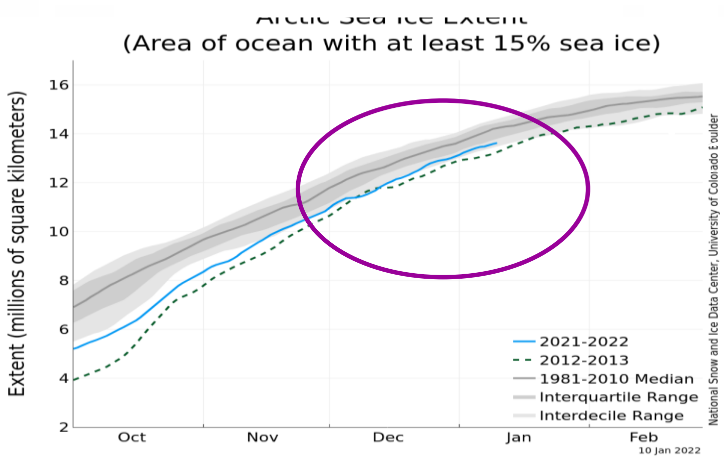
- The northern Pacific SST warming weakened during the last a couple of months.

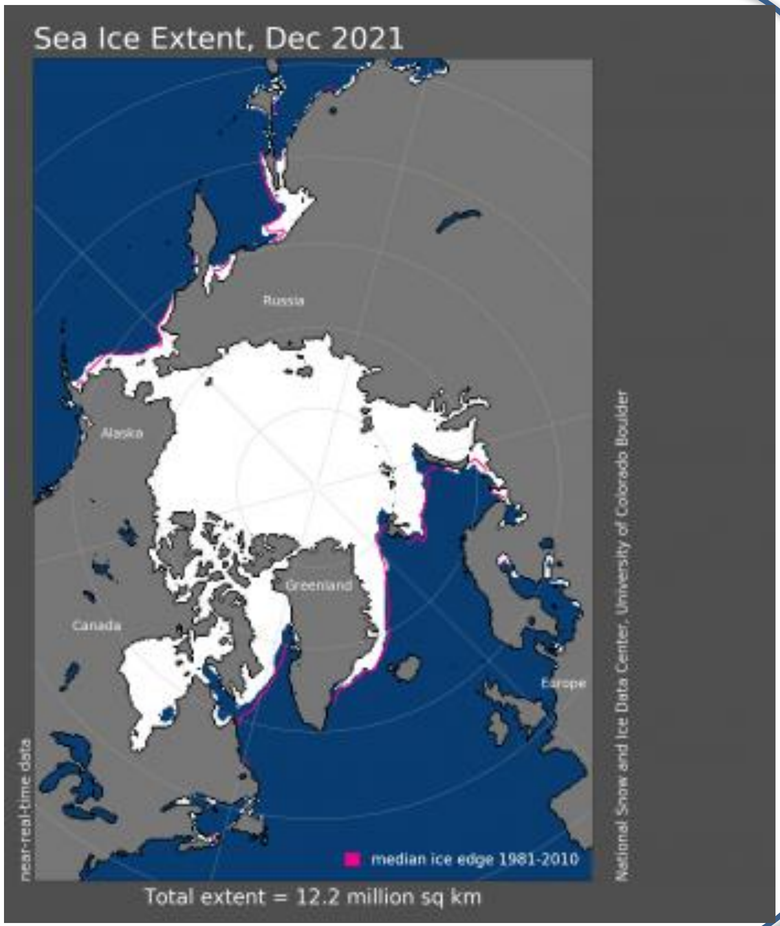
CFSv2 NE Pacific SSTA Predictions



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

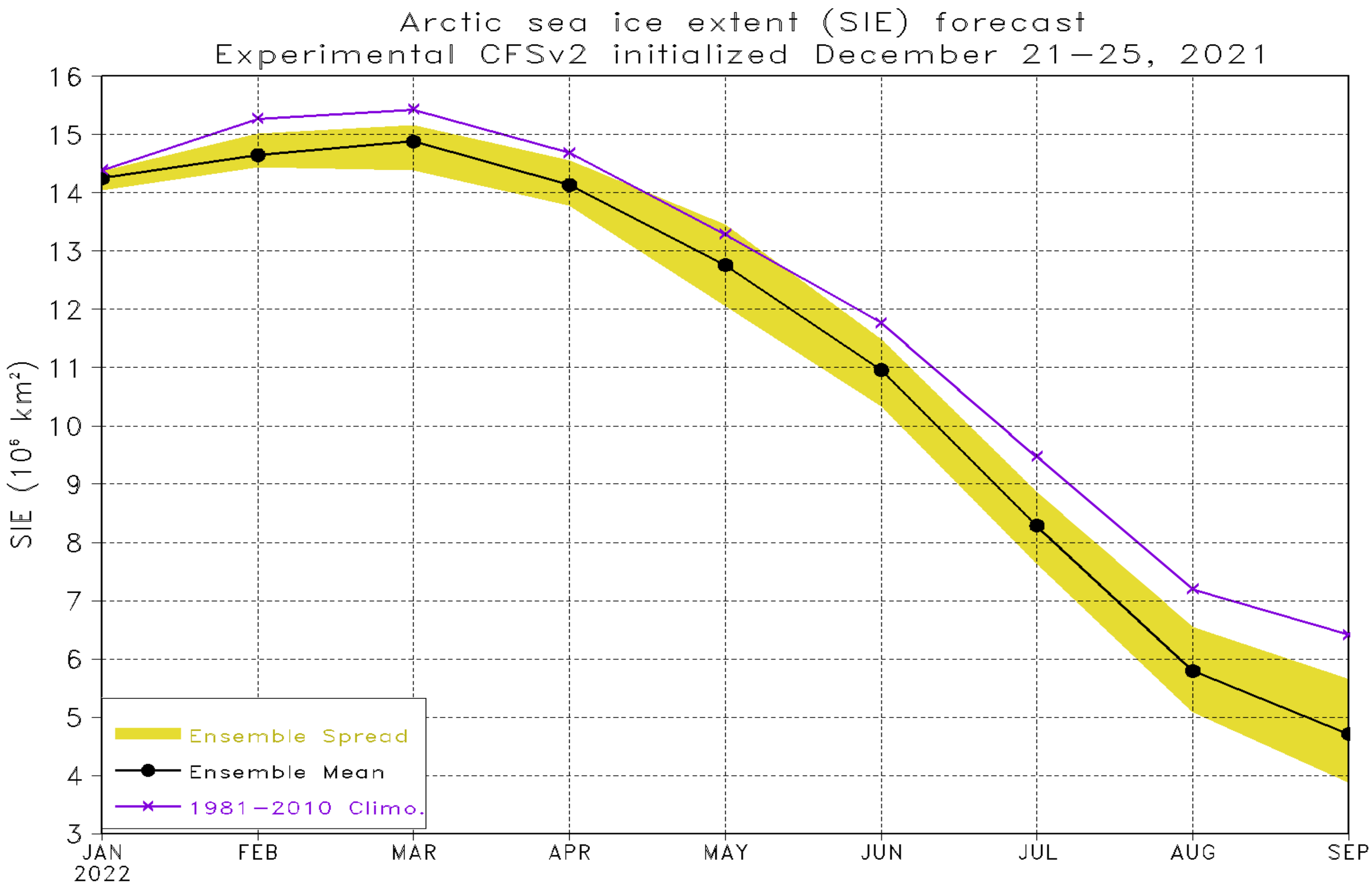






- Arctic sea ice extent averaged for Dec 2021 was the 13th lowest in the satellite record.
- The downward linear trend in December sea ice extent over the 43-year satellite record is 3.5% per decade relative to the 1981 to 2010 average.
- Based on the linear trend, since 1979, December has seen a loss of 1.88 million square kilometers. This is equivalent to about three times the size of Texas.

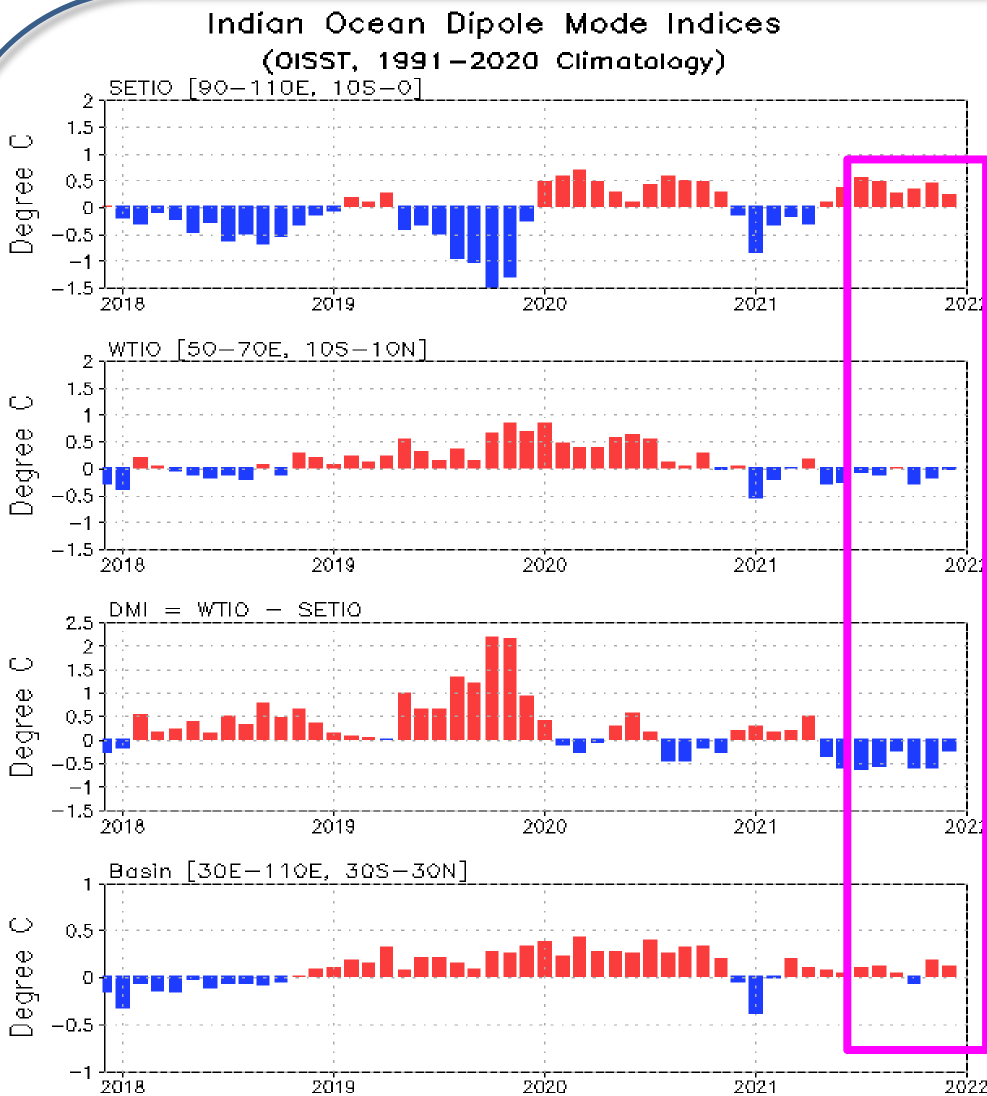
NCEP/CPC Arctic Sea Ice Extent Forecast

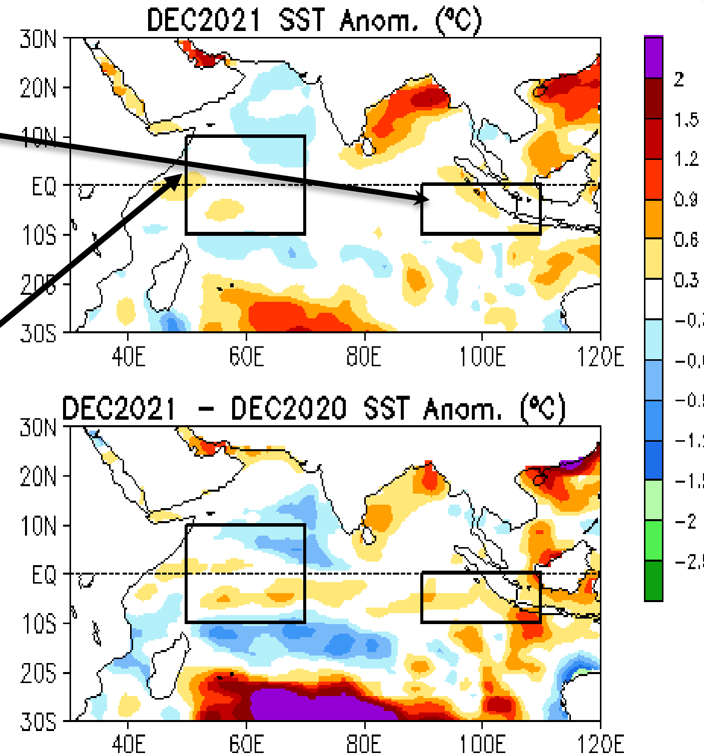


https://www.cpc.ncep.noaa.gov/products/people/wwang/seaice_seasonal/index.html

Indian Ocean

Evolution of Indian Ocean SST Indices

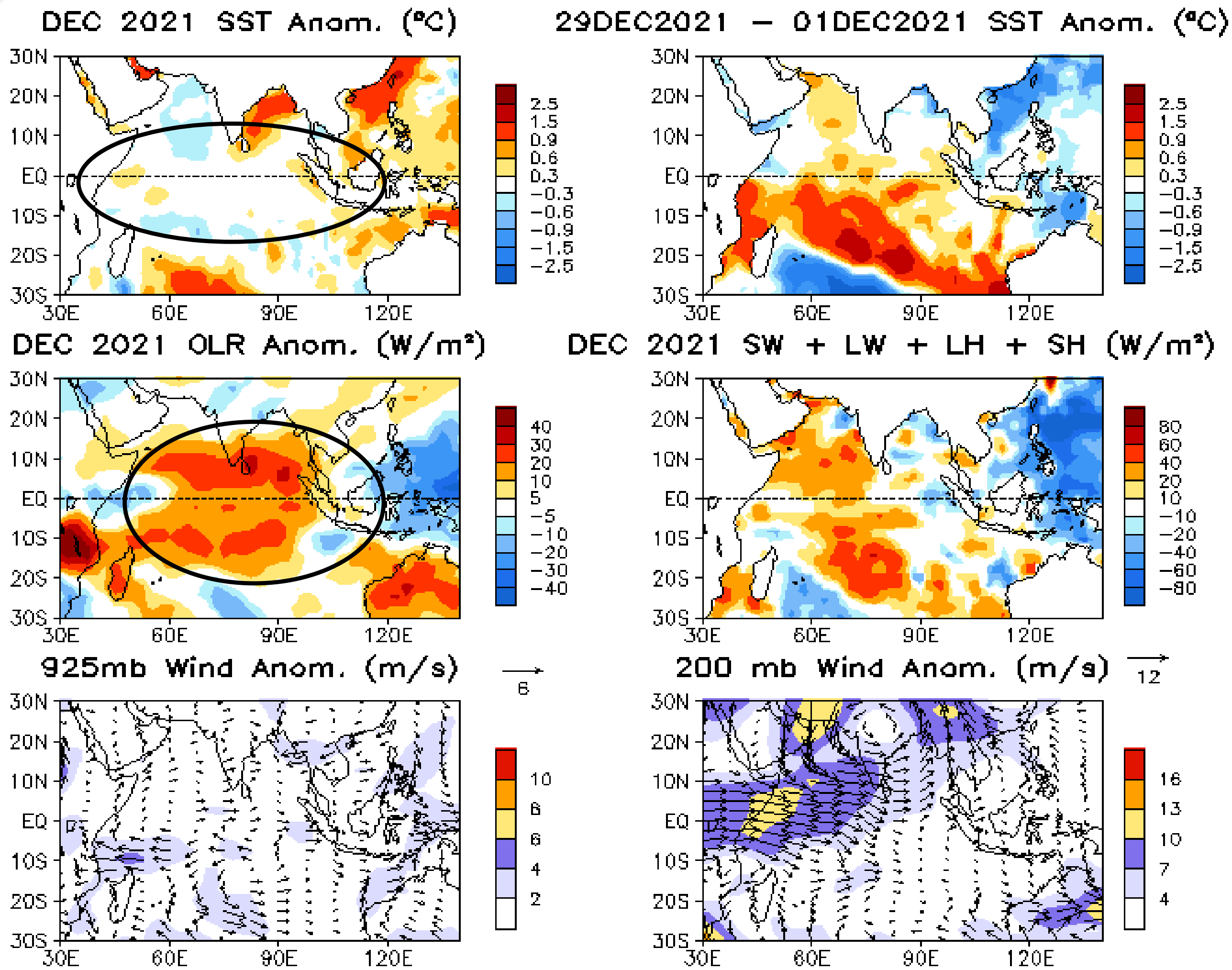




- Overall, SSTAs were small in the tropical Indian Ocean in Dec 2021.

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.

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



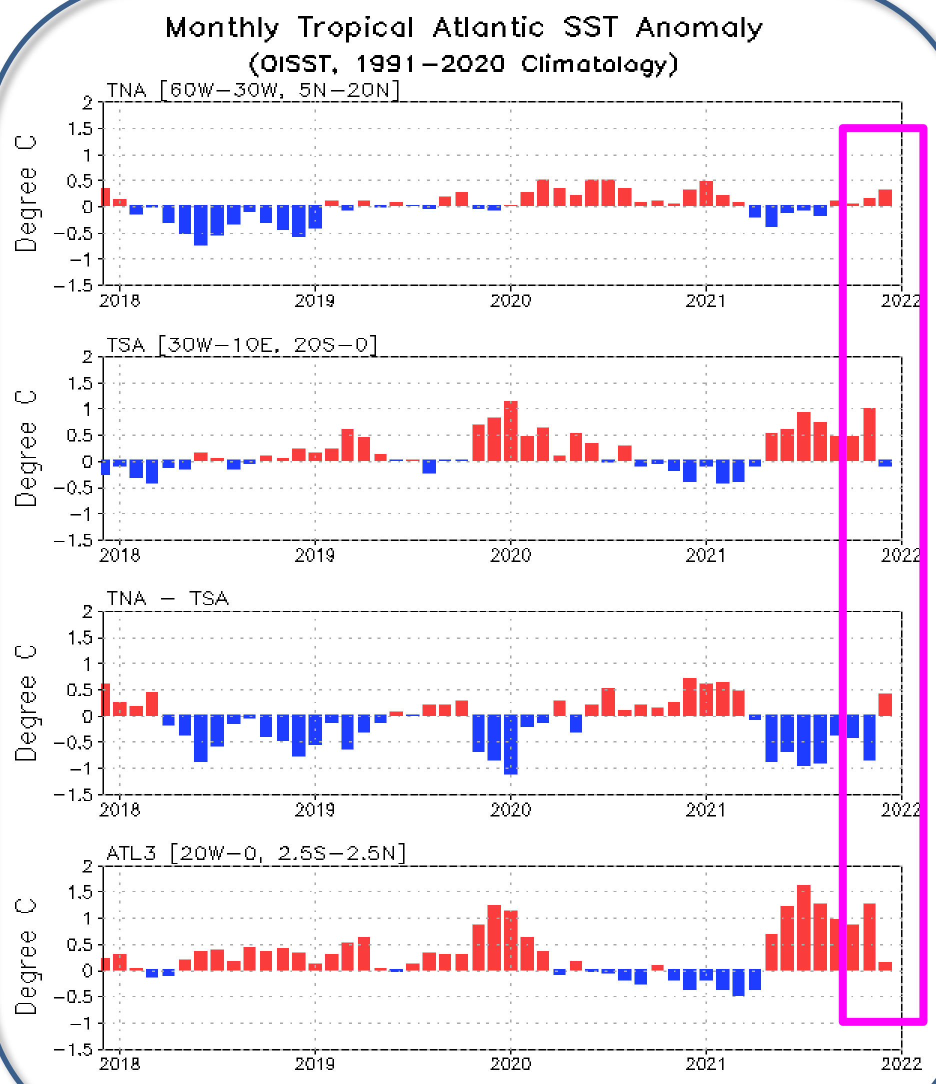
- SSTAs were overall small in the tropical Indian Ocean.

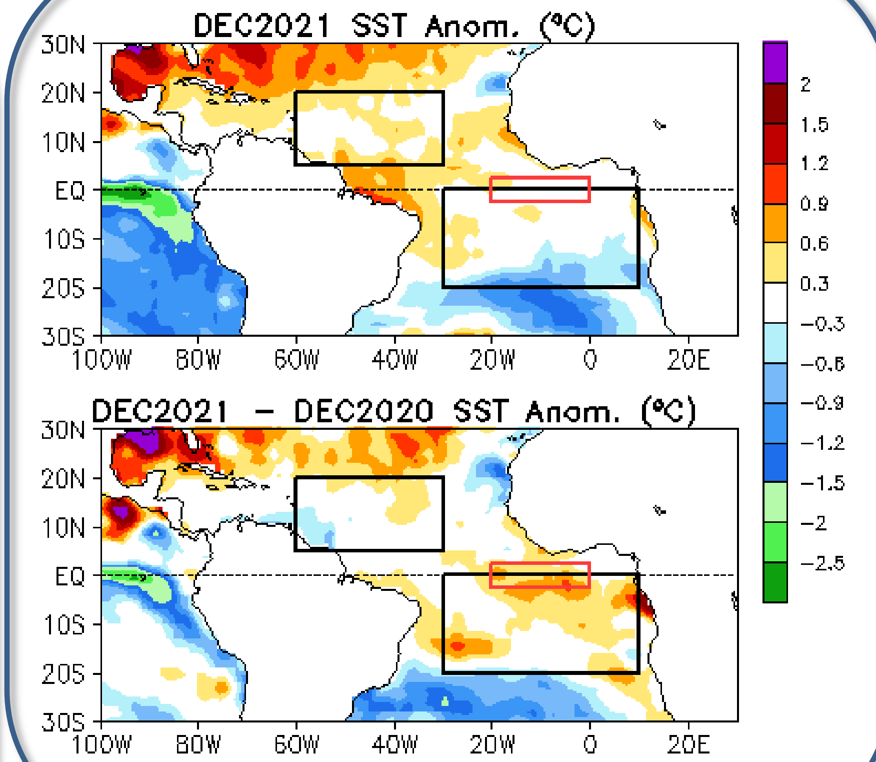
- Convection was suppressed over the tropical Indian Ocean.

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 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

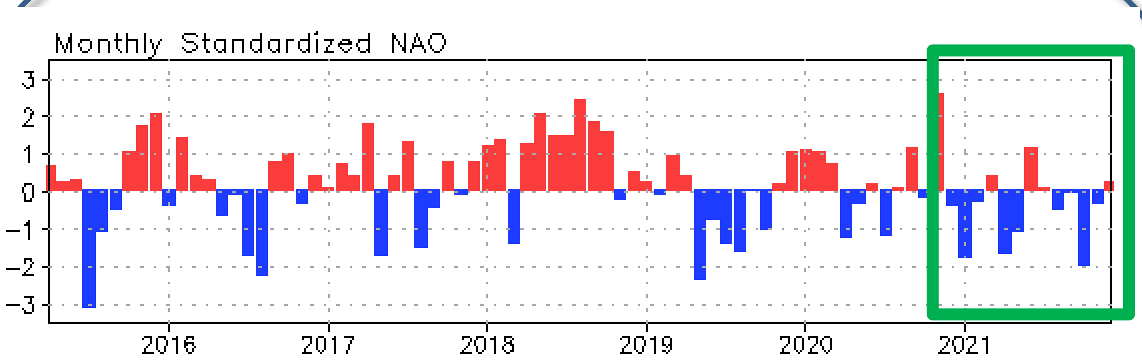


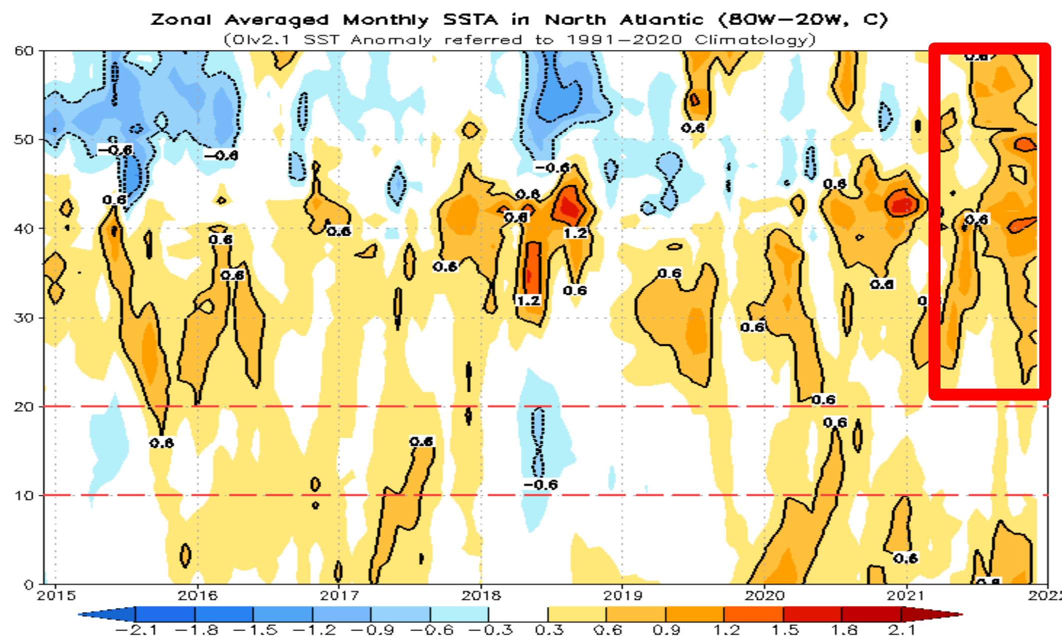


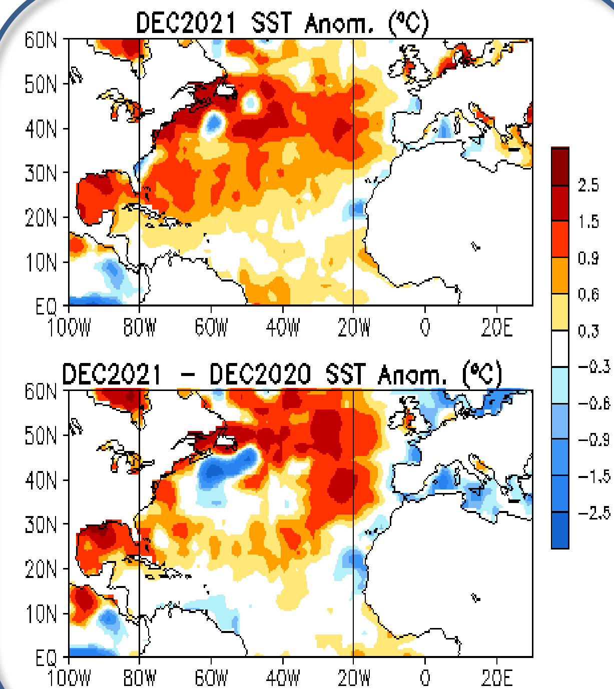
- SSTAs in the tropical Atlantic were small.
- The Atlantic Nino event ended in Dec 2021.

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







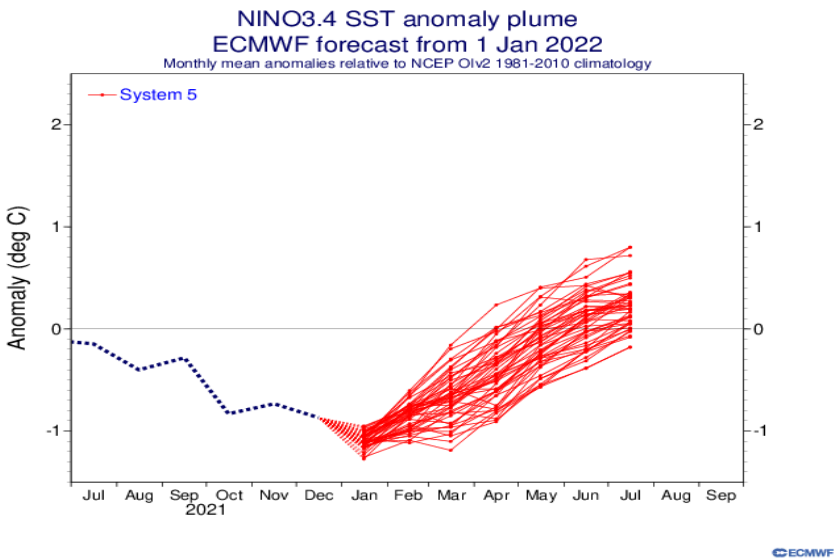
- NAO switched to a positive phase in Dec 2021 with NAOI= 0.2.
- The positive SSTAs in the mid-high latitudes of the North Atlantic Ocean were evident during last year.

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.

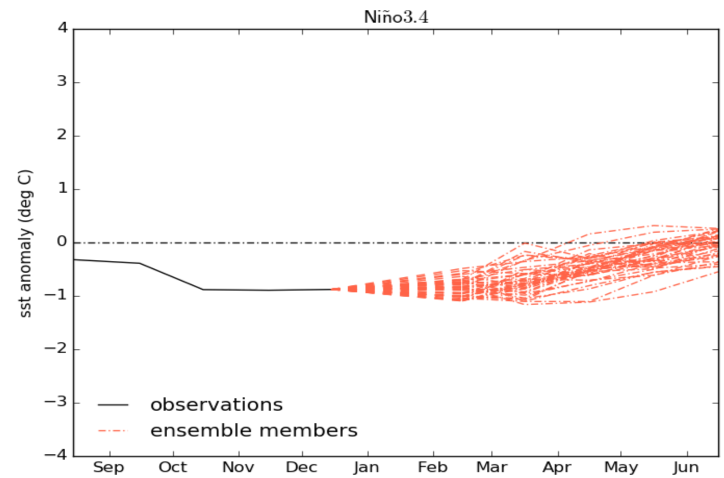
ENSO and Global SST Predictions

Individual Model Forecasts: Moderate La Nina will return to neutral in spring

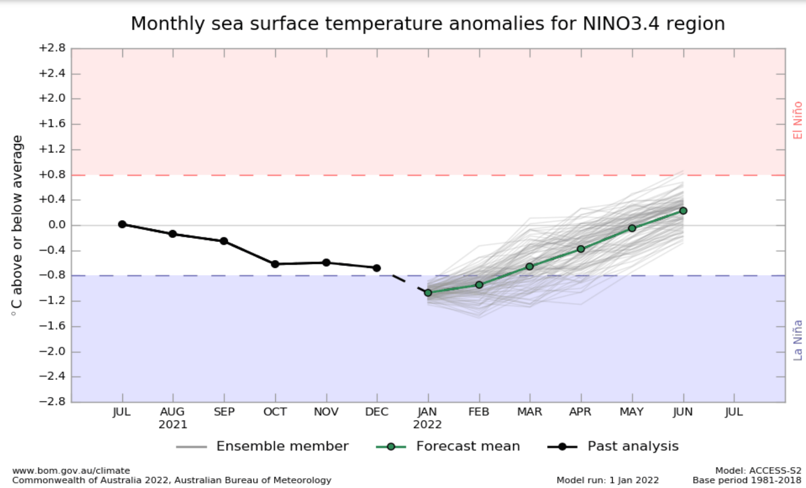
EC: Nino3.4, IC= 01Jan 2022



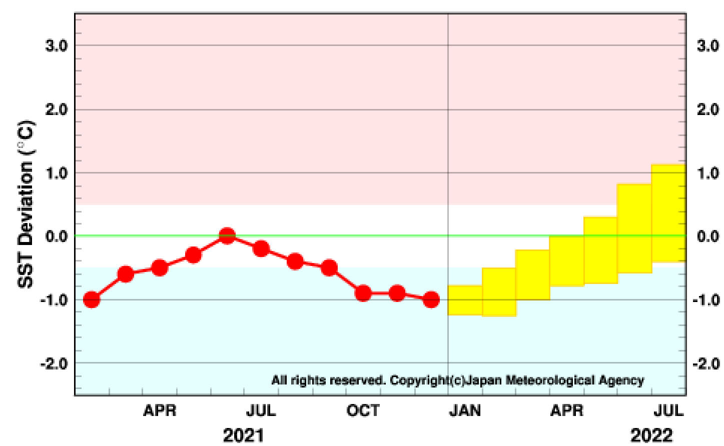
UKMO: Nino3.4, Updated 11 Jan 2022



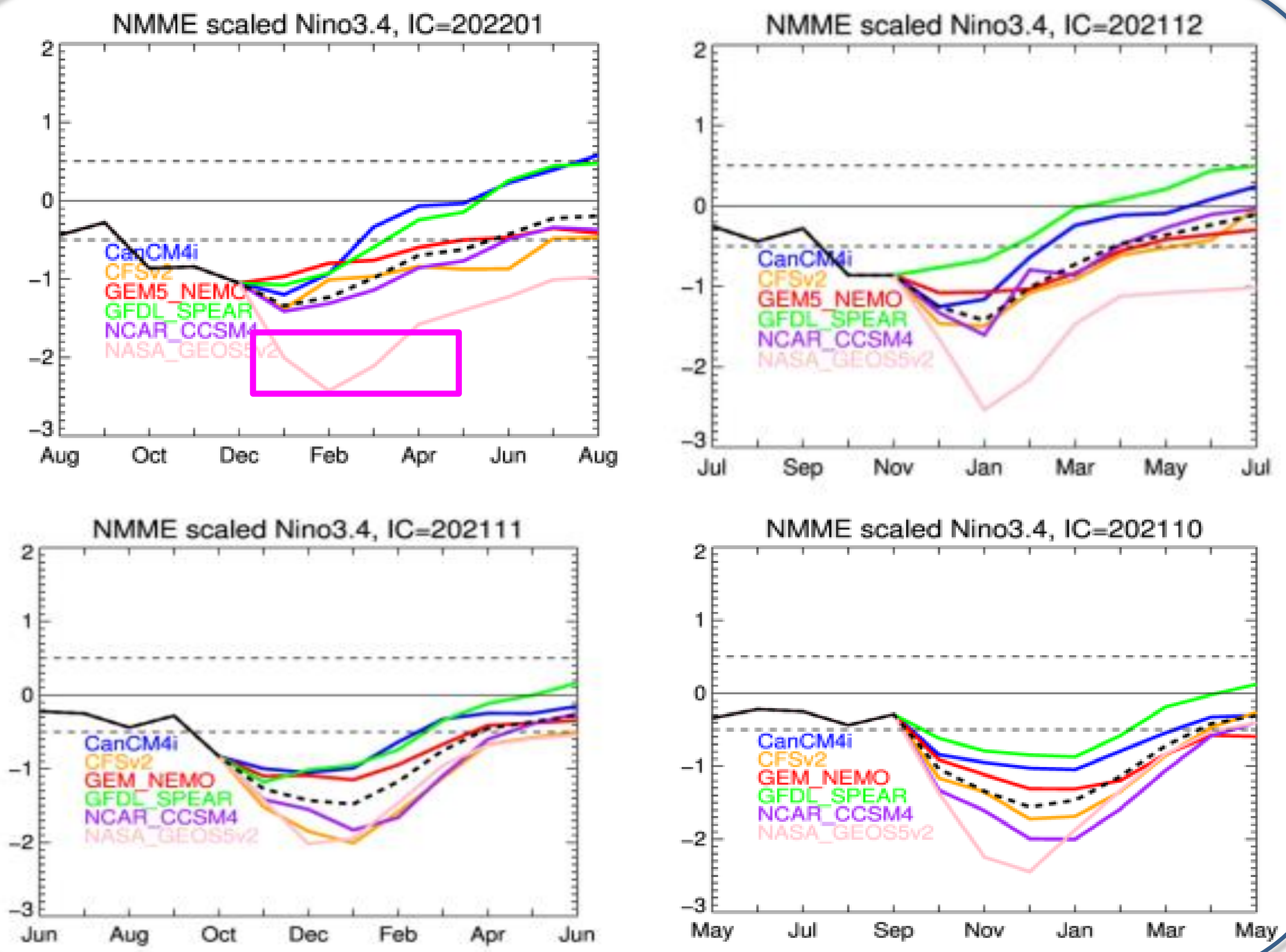
Australian BOM: Nino3.4, Updated 1 Jan 2022



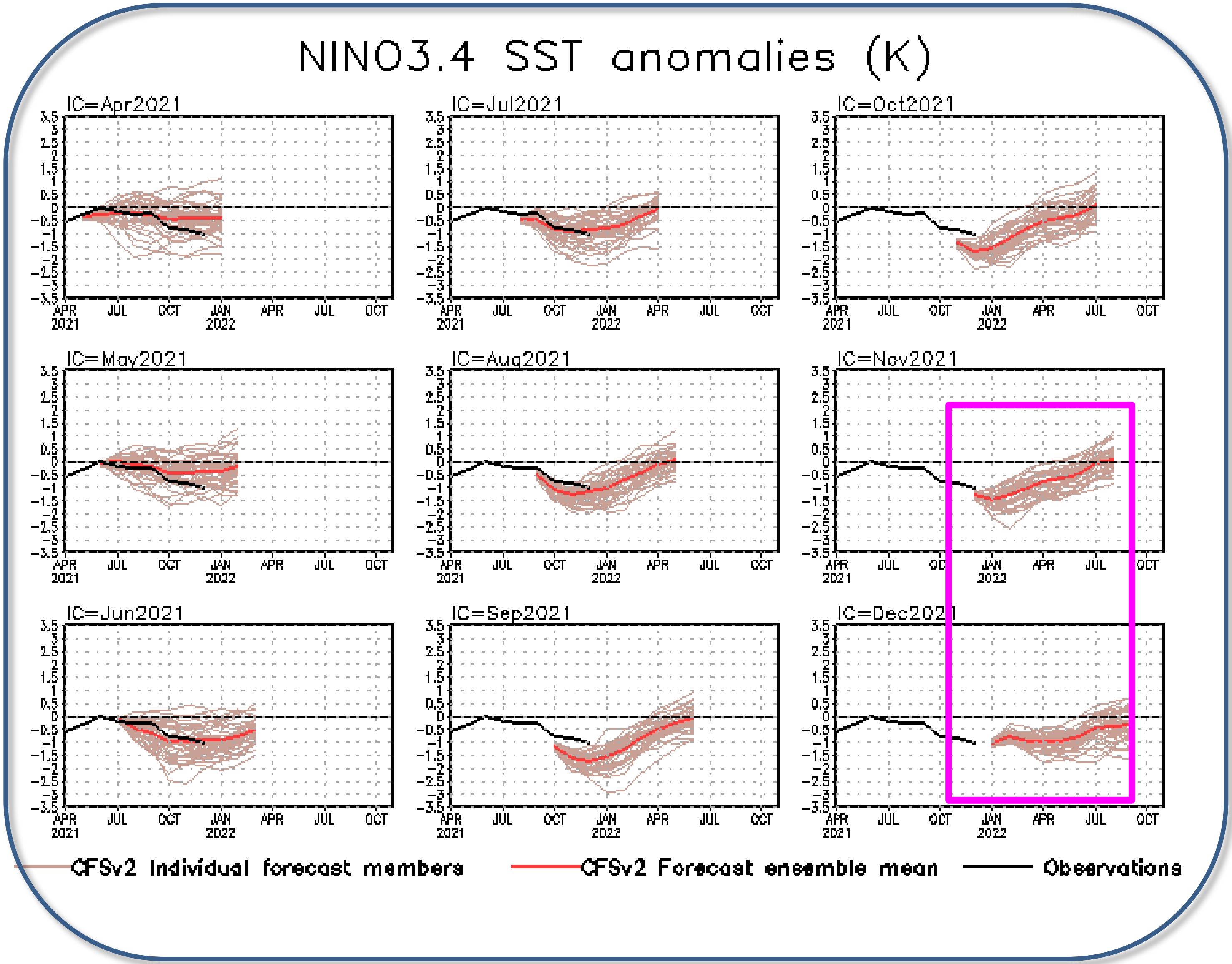
JMA: Nino3.4, Updated 11 Jan 2022



NMME forecasts from different initial conditions



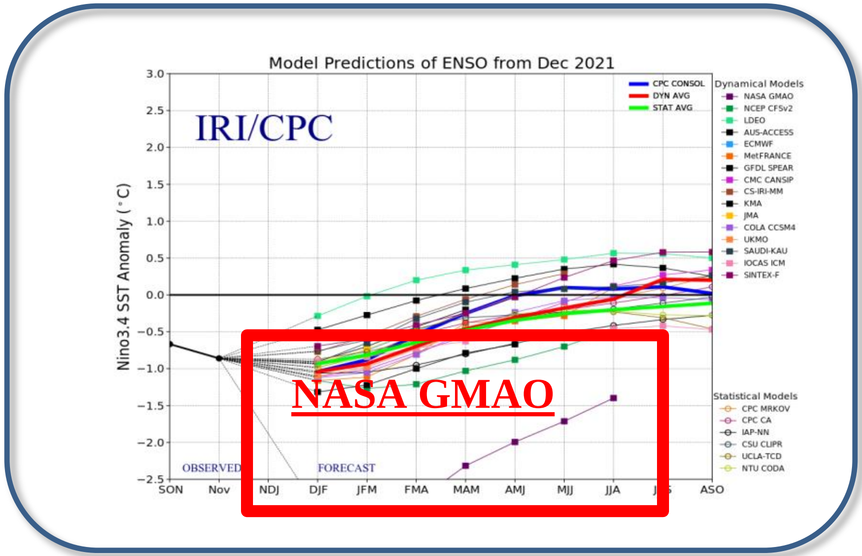
CFS Niño3.4 SST Predictions from Different Initial Months

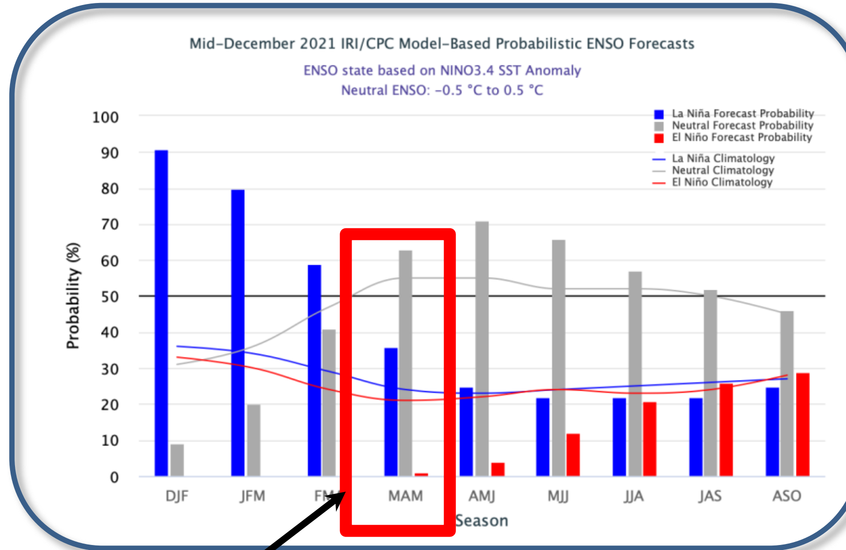


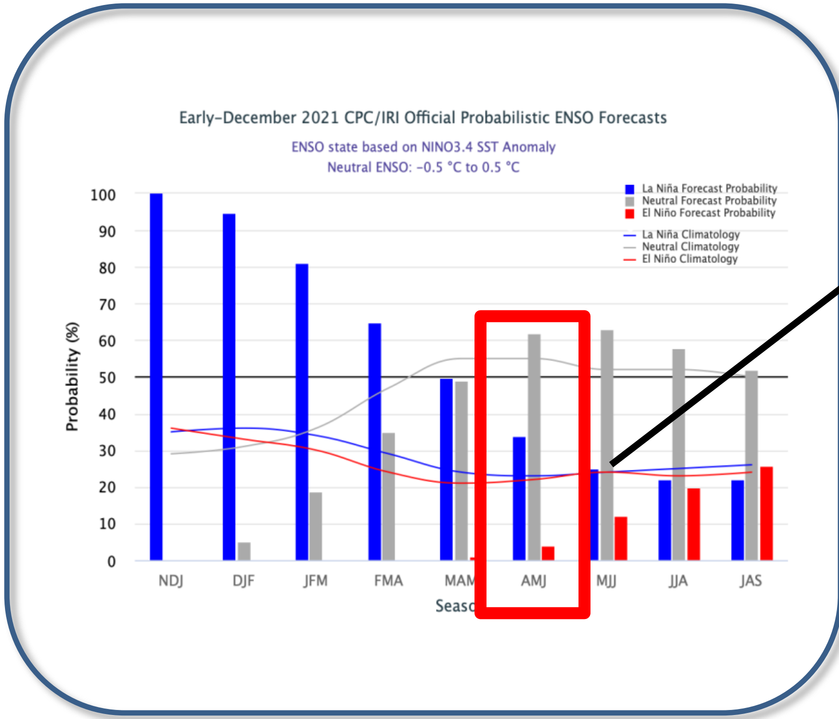
- The latest CFSv2 forecasts call that the ENSO will return to a neutral condition in summer 2022.

CFS Nino3.4 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.

IRI/CPC NINO3.4 Forecast: Dec 2021

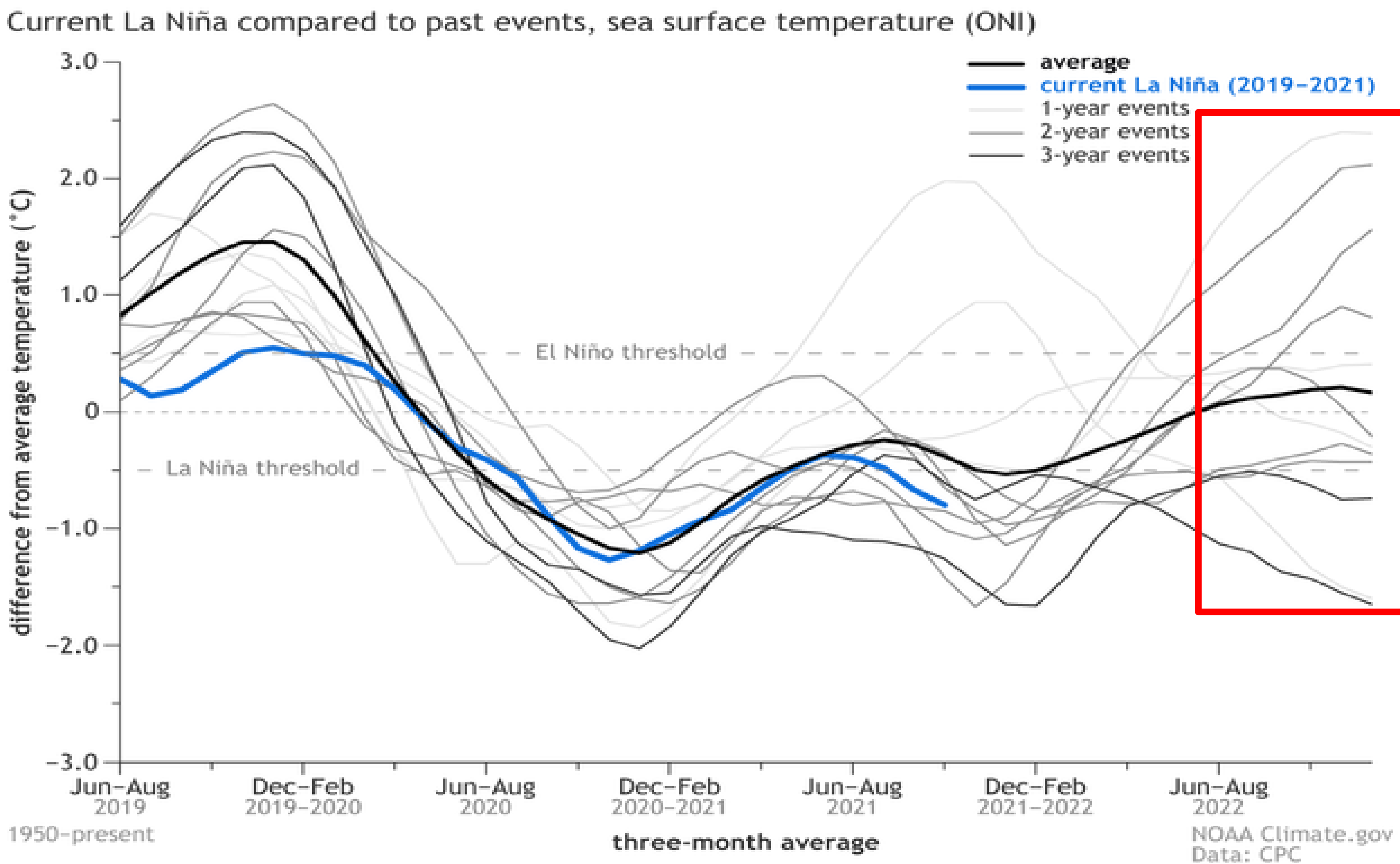






- **ENSO Alert System Status: La Niña Advisory**
- Synopsis: *La Niña is favored to continue through the Northern Hemisphere winter 2021-22 (~95% chance) and transition to ENSO-neutral during the spring 2022 (~60% chance during April-June)."*

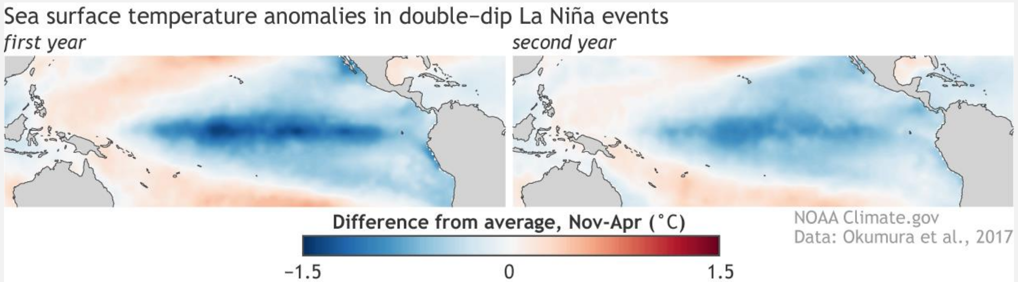
December 2021 La Niña Update: visual aids (Emily Becker; 12/9/2021)

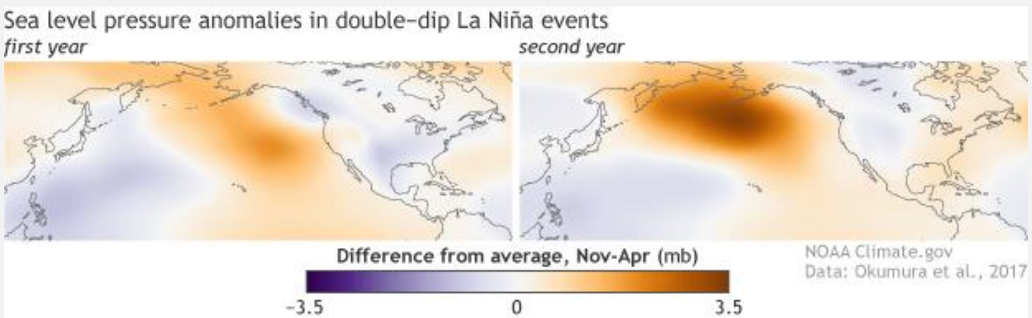


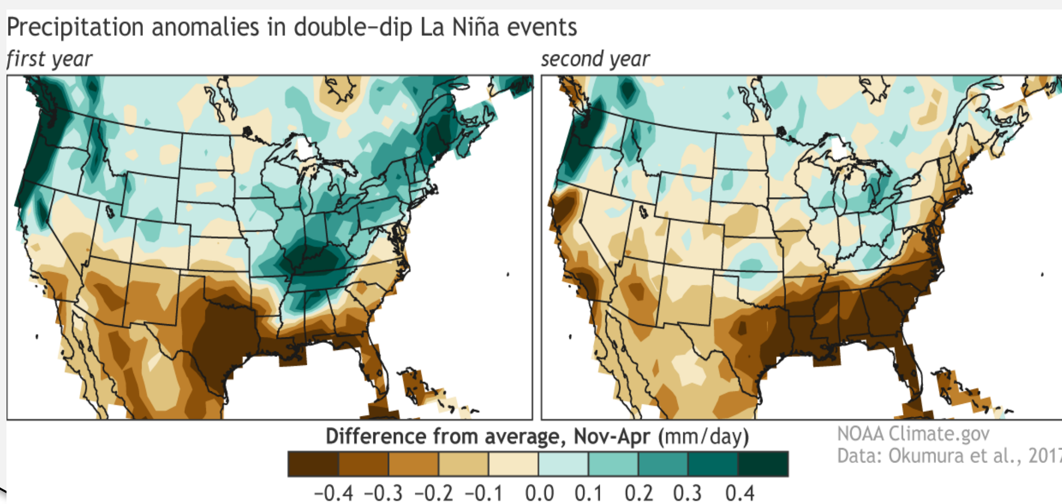
https://www.climate.gov/news-features/blogs/enso/december-2021-la-ni%C3%B1a-update-visual-aids

More U.S. drought in a second-year La Niña? (by Nat Johnson)

(https://www.climate.gov/news-features/blogs/enso/more-us-drought-second-year-la-ni%C3%B1a)







- Averaged SSTAs in Nov–Apr for the first (left) and second (right) extended winters of all multi-year La Niñas since 1900. Anomalies are compared to the 1900-2012 average, with the linear trend removed. Adapted from Okumura et al. (2017).

- Average SLPa during Nov–Apr

- Average precipitation anomalies (mm/day) for Nov–Apr.

Multiyear La Niña impact on summer temperature over Japan

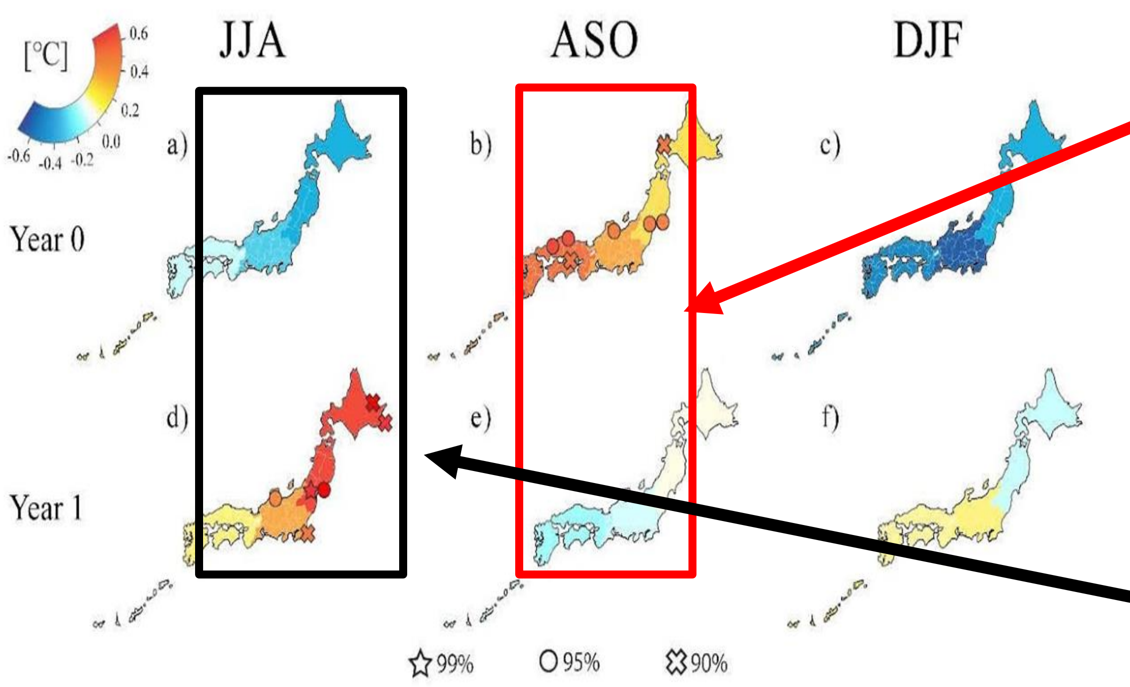
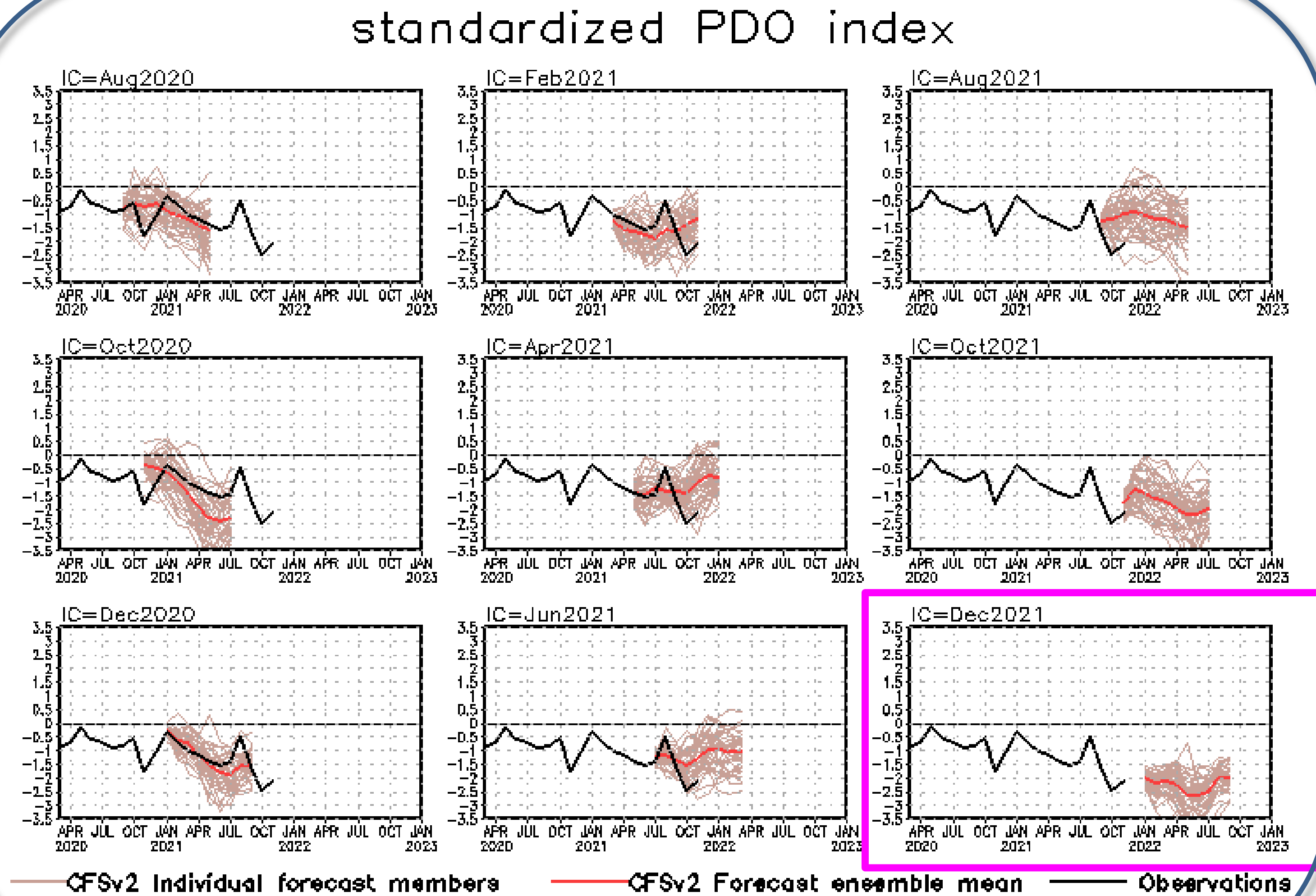


Fig. 4 As in Fig. 2b, but for multiyear La Niña events: (a) JJA(0), (b) ASO(0), (c) DJF(0/1), (d) JJA(1), (e) ASO(1), and (f) DJF(1/2).

- In the first summer, warm conditions are found in Aug-Oct (ASO) in the SW Japan, due to anomalous southwesterly winds in the lower troposphere associated with a La Niña-induced decrease in precipitation over the equatorial western Pacific.
- In the second summer, warm anomalies are found in Jun–Aug (JJA) over NE Japan which are accompanied by an anomalous barotropic high-pressure induced by negative precipitation anomalies over the equatorial Pacific.

Iwakiri, T., and M. Watanabe, 2020:. J. Meteor. Soc. Japan, 98. https://doi.org/10.2151/jmsj.2020-064)

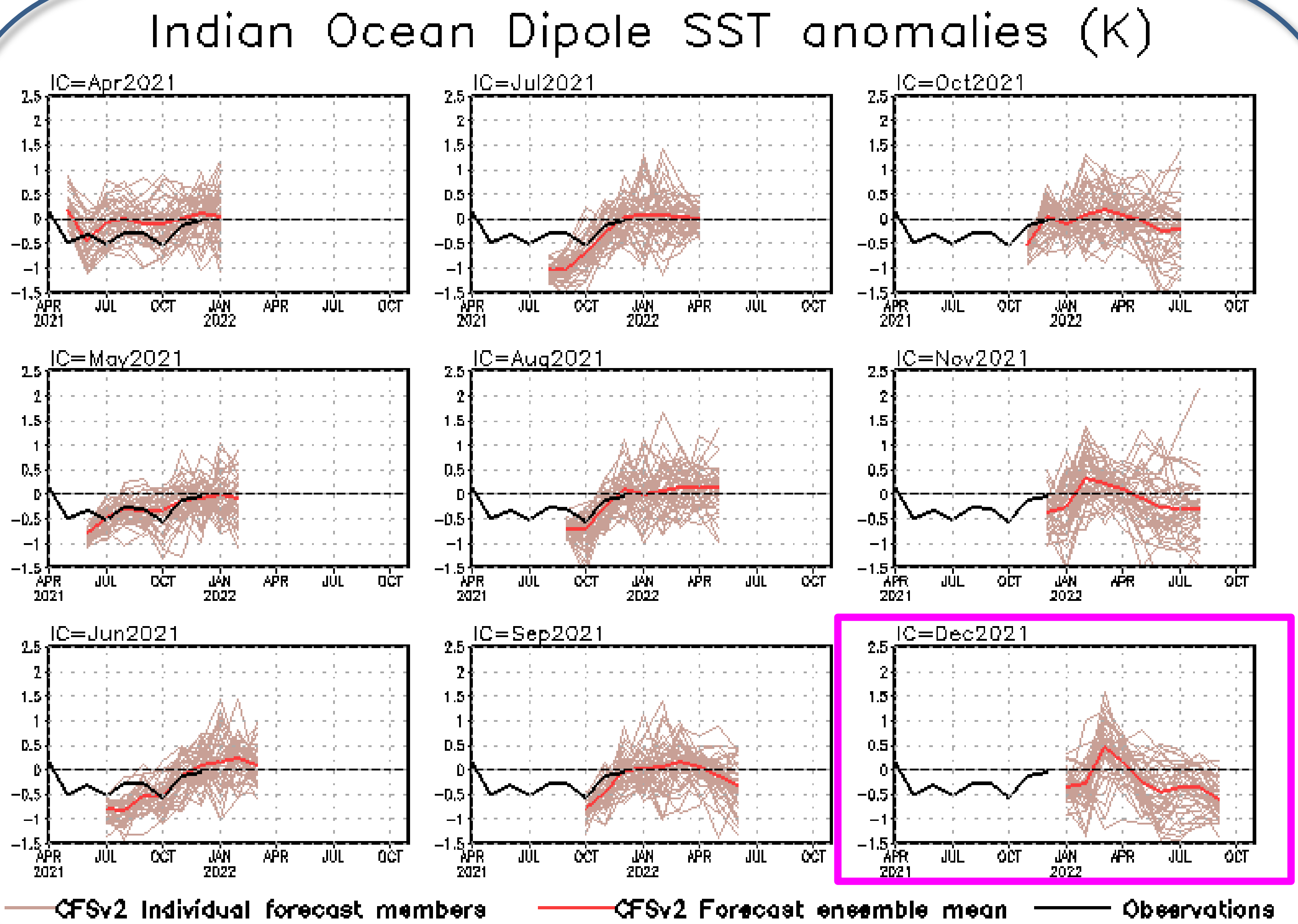
CFS Pacific Decadal Oscillation (PDO) Index Predictions from Different Initial Months



- 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°E-100°W, 20°N-60°N]. CFS PDO index is the standardized projection of CFS SST forecast anomalies onto the PDO EOF pattern.

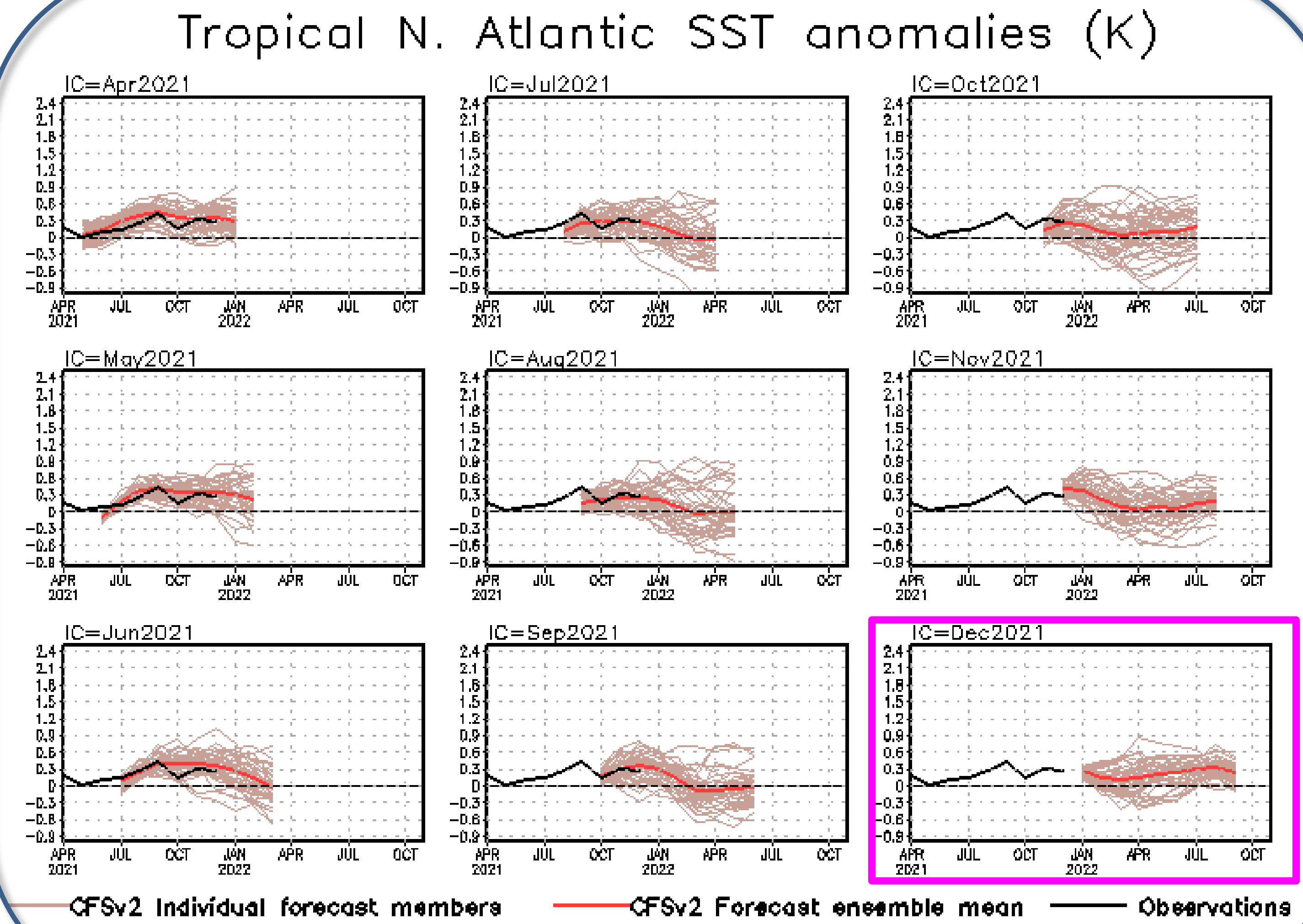
NCEP CFS DMI SST Predictions from Different Initial Months



- CFSv2 predicts a negative phase of IOD in summer 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 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].

Acknowledgement

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

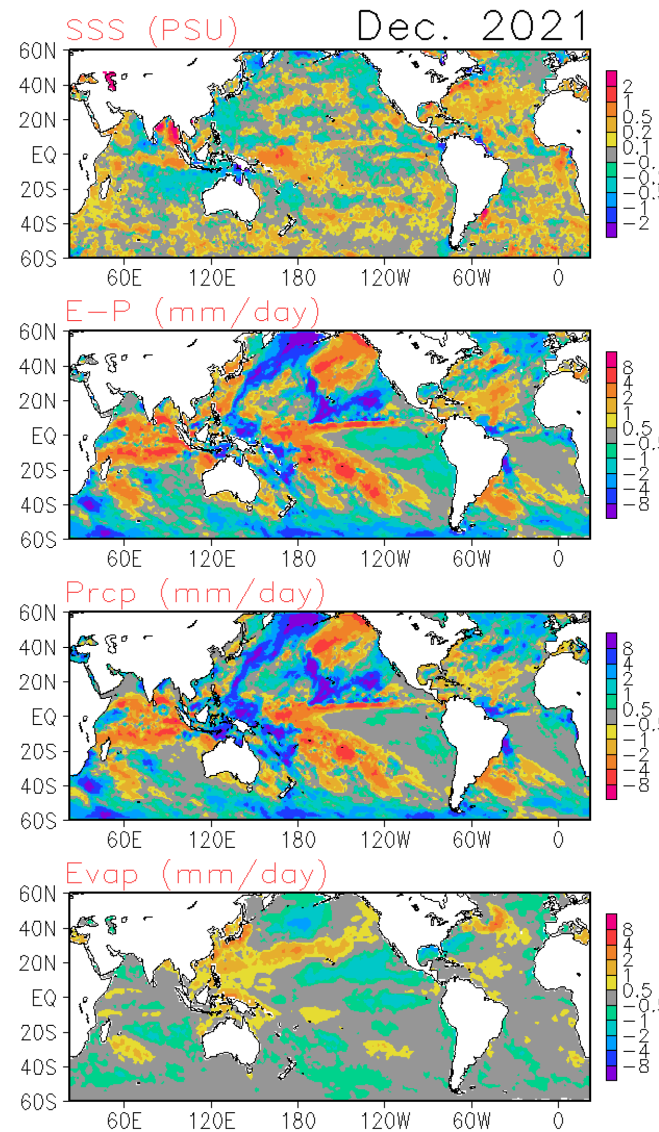
  http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html

Backup Slides

Global Sea Surface Salinity (SSS): Anomaly for December 2021

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/strengthens in the western equatorial Pacific Ocean with reduced precipitation in this area. Negative SSS anomaly also continues in the eastern equatorial Pacific Ocean (east of 120°W). Negative SSS anomaly in the northeast Pacific Ocean continues which is likely caused by oceanic advection/entrainments. Positive SSS anomaly continues between 20°N and 40°N in the Atlantic Ocean. Positive SSS anomaly shows in the Bay of Bengal and is accompanied with reduced precipitation.



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

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

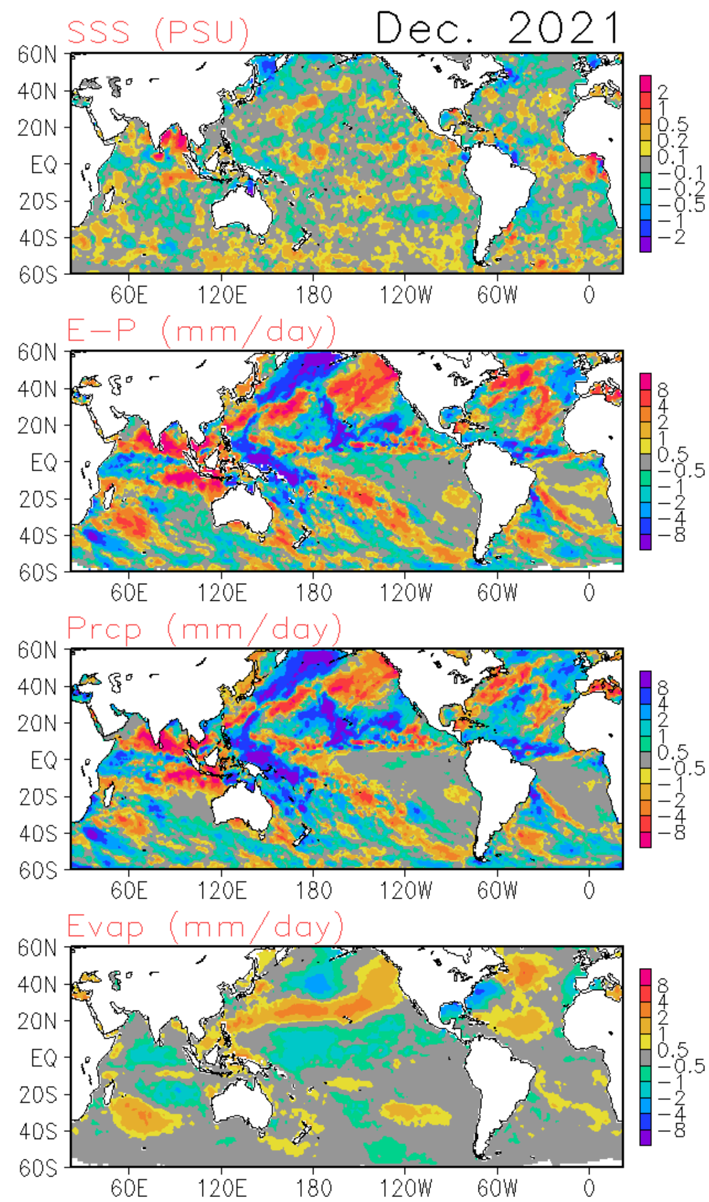
ftp.cpc.ncep.noaa.gov/precip/BASS

Precipitation: CMORPH adjusted satellite precipitation estimates

Evaporation: Adjusted CFS Reanalysis

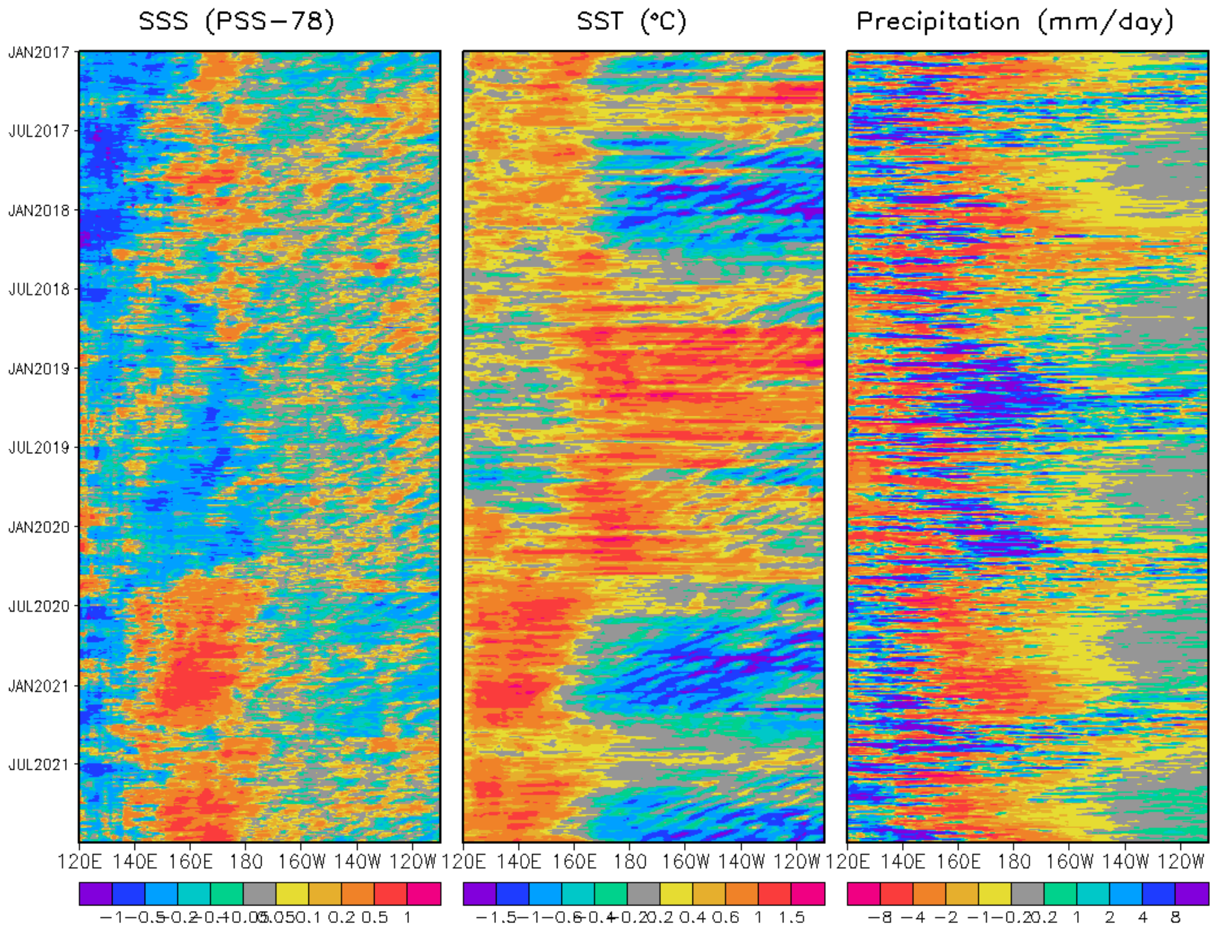
Global Sea Surface Salinity (SSS): Tendency for December 2021

Compared with last month, SSS increased in the western Equatorial Pacific Ocean likely due to reduced precipitation; while SSS increased along the equator in the eastern Equatorial Pacific Ocean. SSS increased along the equator in the Atlantic Ocean. SSS decreased in the Gulf Stream region. In Bay of Bengal, SSS increased which is possibly due to reduced precipitation.



Pentad SSS Anomaly Evolution over Equatorial Pacific

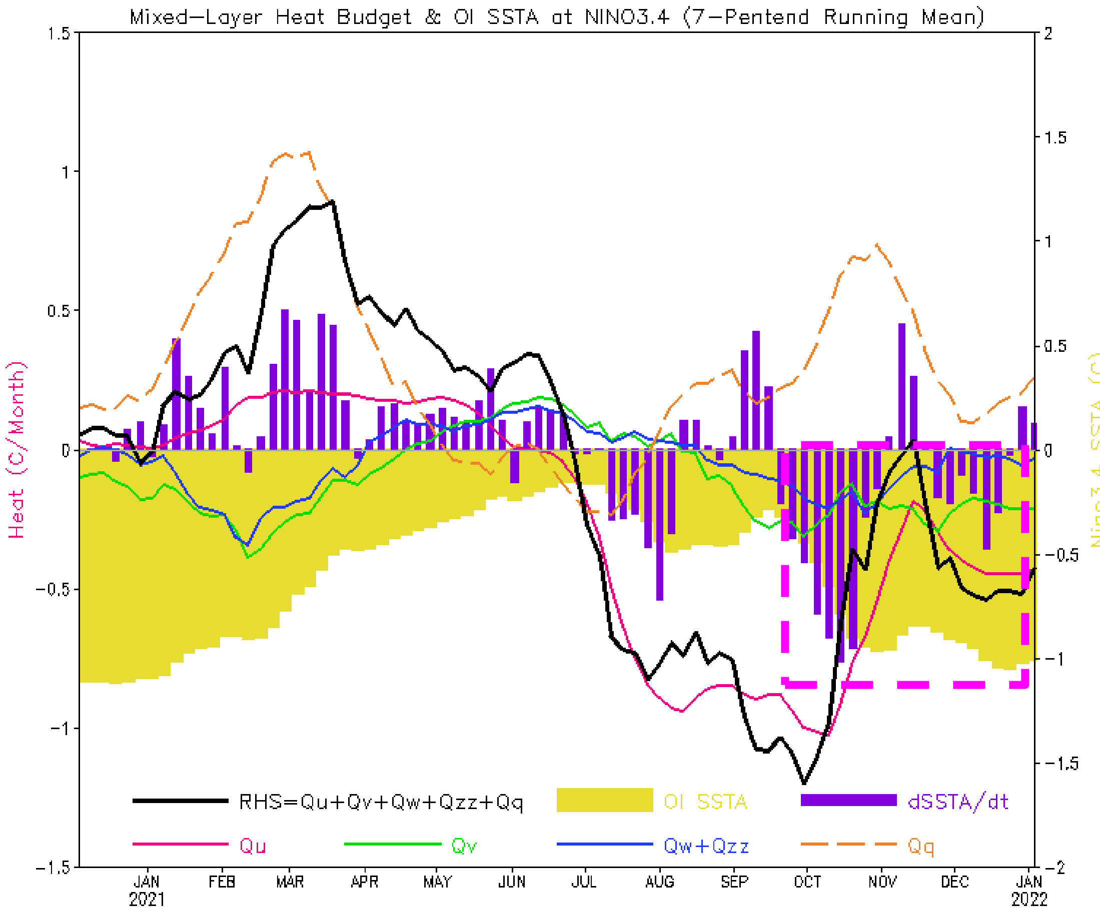
Figure caption: Hovemoller diagram for equatorial (5˚S-5˚N) 5-day mean SSS, SST and precipitation anomalies. The climatology for SSS is Levitus 1994 climatology. The SST data used here is the OISST V2 AVHRR only daily dataset with its climatology being calculated from 1985 to 2010. The precipitation data used here is the adjusted CMORPH dataset with its climatology being calculated from 1999 to 2013.



Ocean Mixed-Layer Heat Budget

-Observed SSTA tendency (dSSTA/dt; bar) was mostly negative, and total heat budget (RHS; black line) was negative in last a few pentads.

- Dynamical terms (Qu, Qv, Qw+Qzz) were negative and heat-flux term (Qq) was positive in Dec 2021.



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.

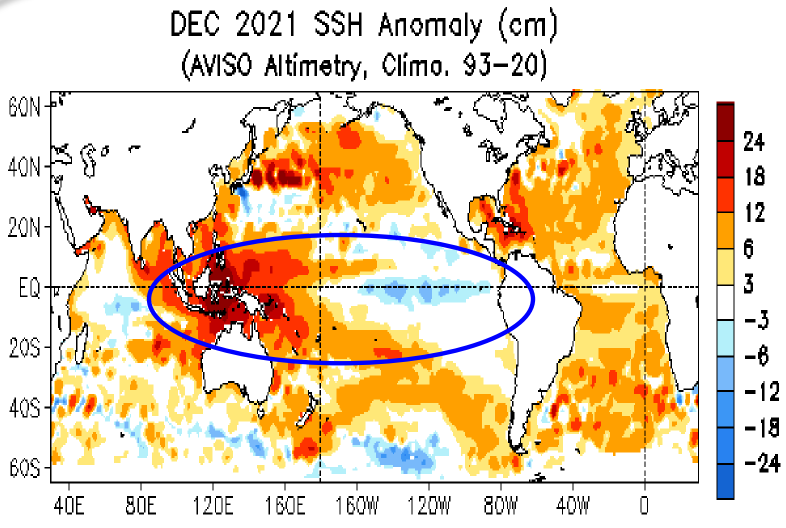
Qu: Zonal advection; Qv: Meridional advection;

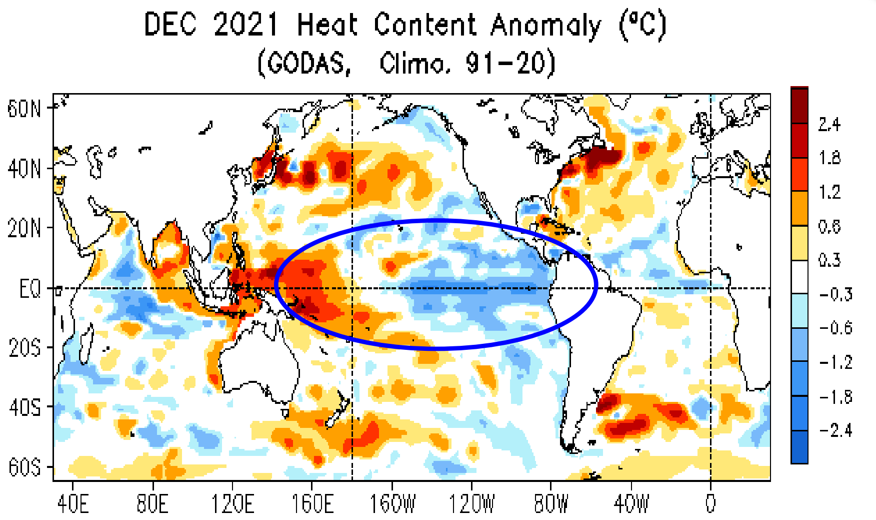
Qw: Vertical entrainment; Qzz: Vertical diffusion

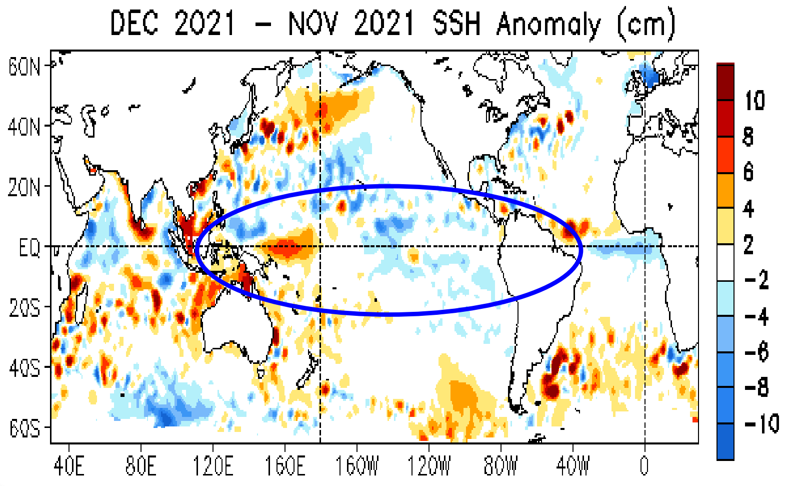
Qq: (Qnet - Qpen + Qcorr)/ρcph; Qnet = SW + LW + LH +SH;

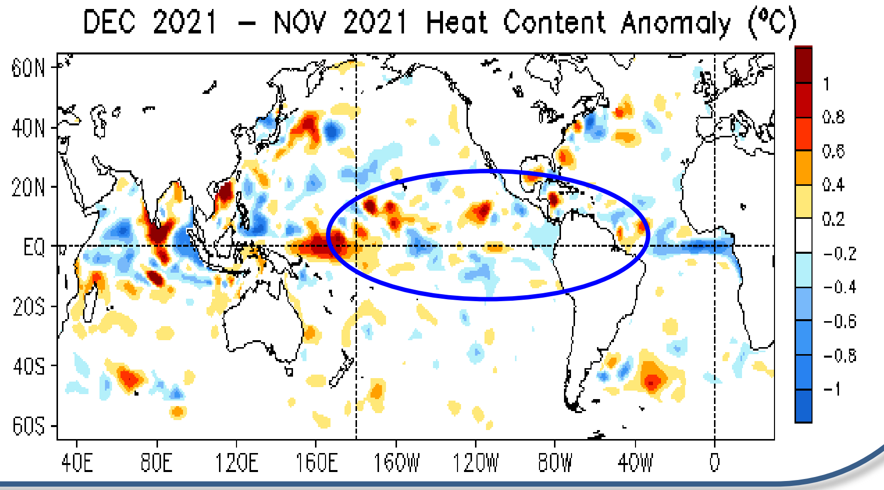
Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST

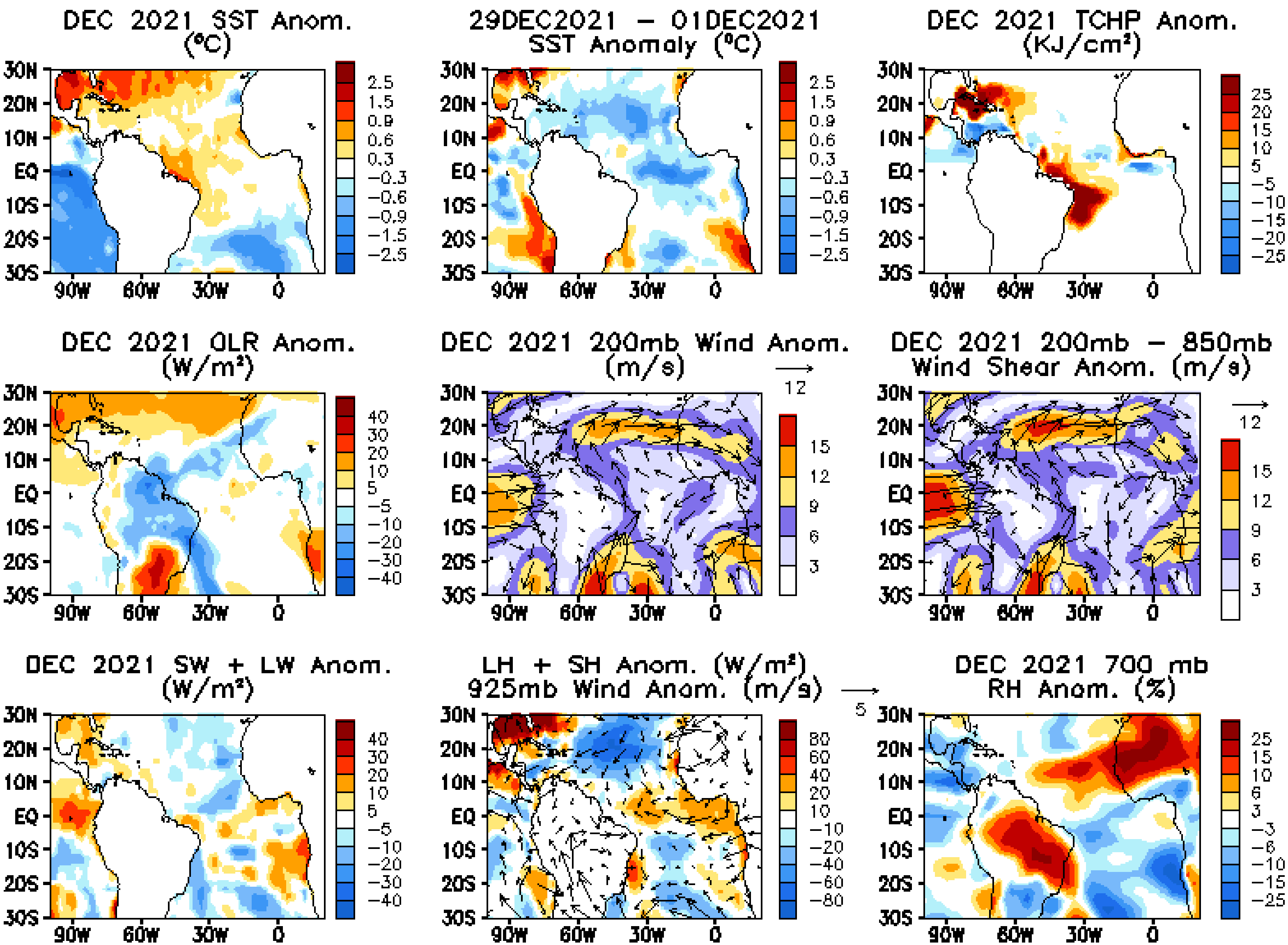
Global SSH and HC300 Anomaly & Anomaly Tendency



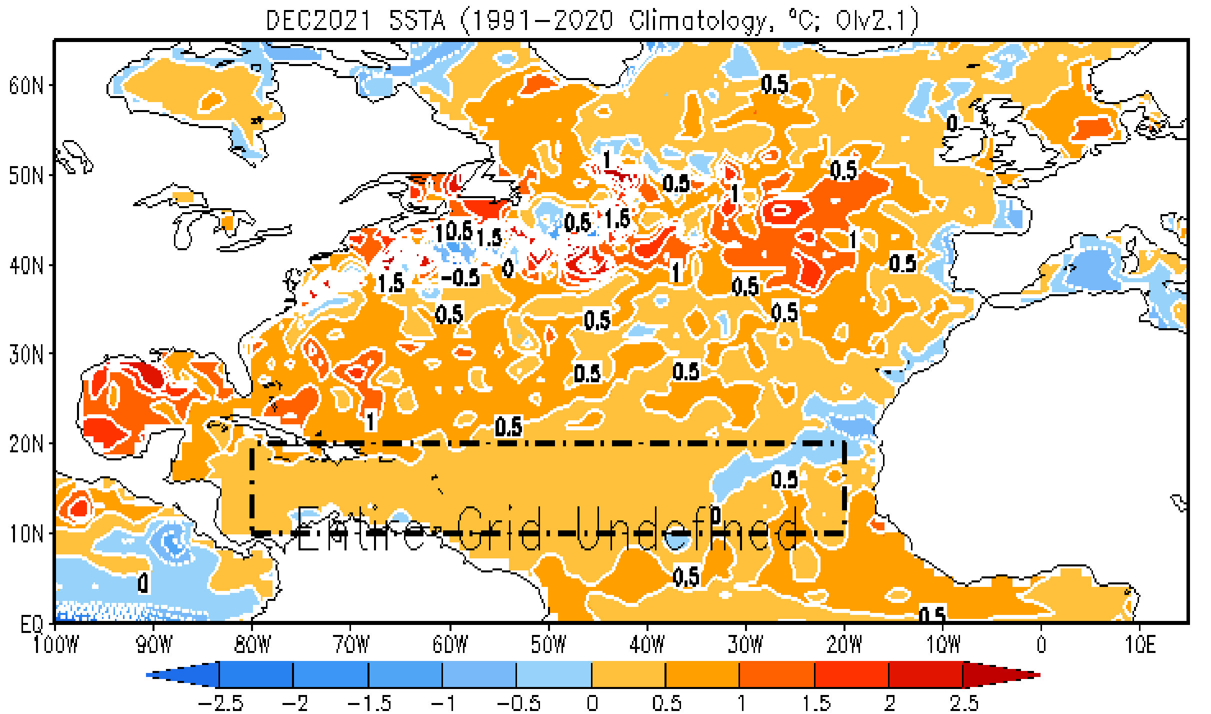


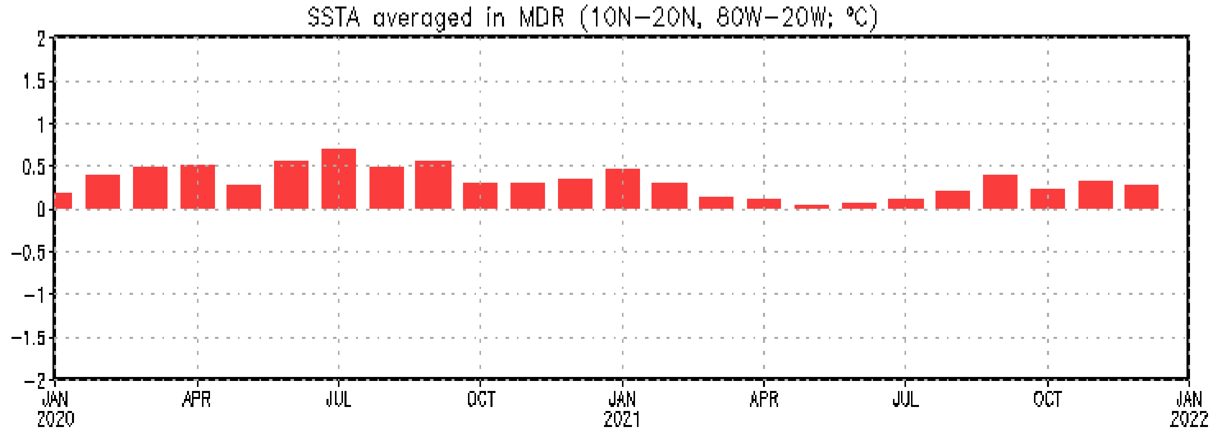





DEC 2021 SST Anom. (°C)
29DEC2021 – 01DEC2021 SST Anomaly (°C)
DEC 2021 TCHP Anom. (KJ/cm²)
DEC 2021 OLR Anom. (W/m²)
DEC 2021 200mb Wind Anom. (m/s)
DEC 2021 200mb – 850mb Wind Shear Anom. (m/s)
DEC 2021 SW + LW Anom. (W/m²)
LH + SH Anom. (W/m²) 925mb Wind Anom. (m/s)
DEC 2021 700 mb RH Anom. (%)
30N 20N 10N EQ 10S 20S 30S
90W 60W 30W 0
2.5 1.5 0.9 0.6 0.3 −0.3 −0.6 −0.9 −1.5 −2.5
25 20 15 10 5 −5 −10 −15 −20 −25
40 30 20 10 5 −5 −10 −20 −30 −40
12
15 12 9 6 3
80 60 40 20 10 −10 −20 −40 −60 −80
5
25 15 10 6 3 −3 −6 −10 −15 −25

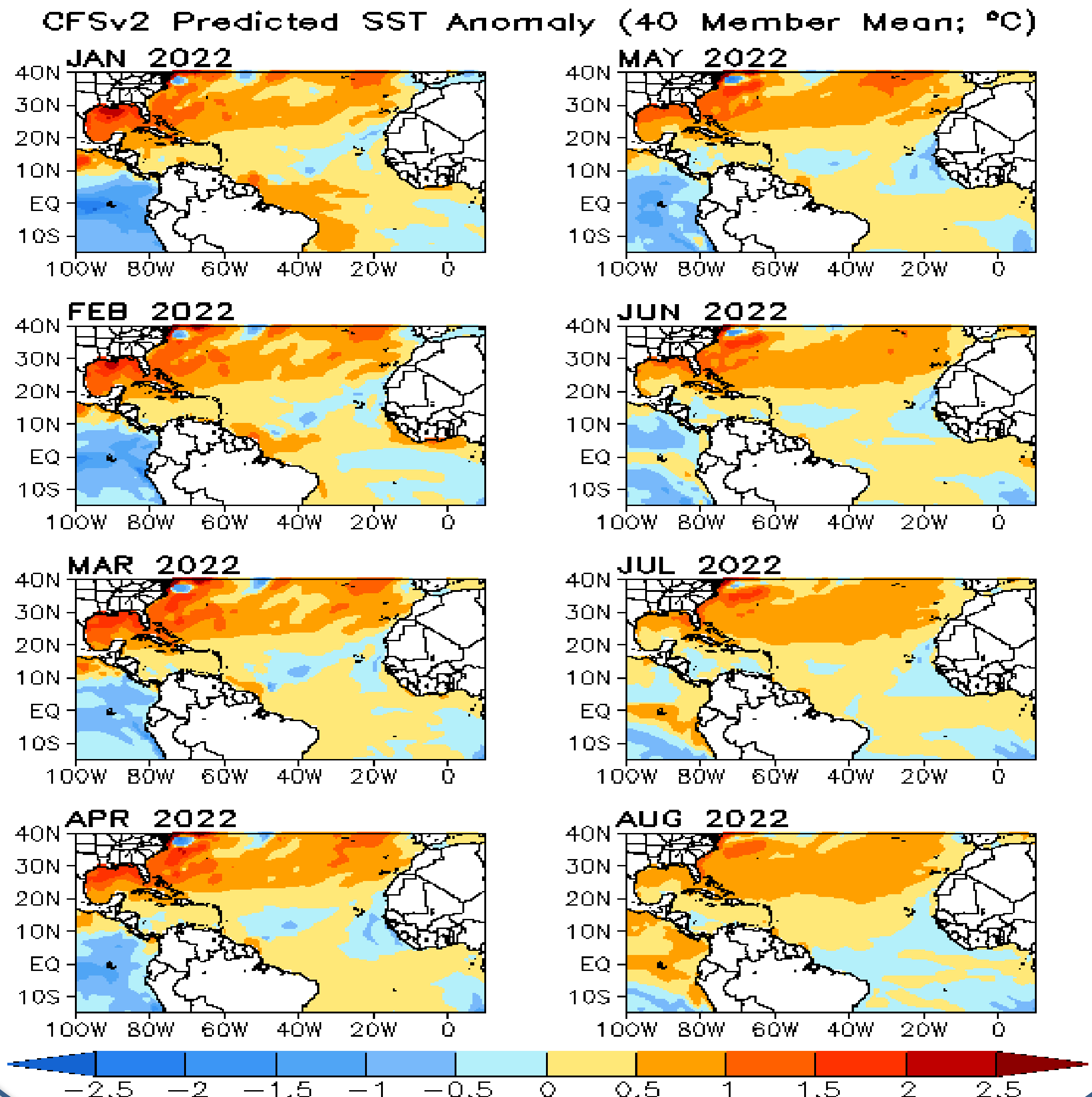
SSTAs in the North Atlantic & MDR



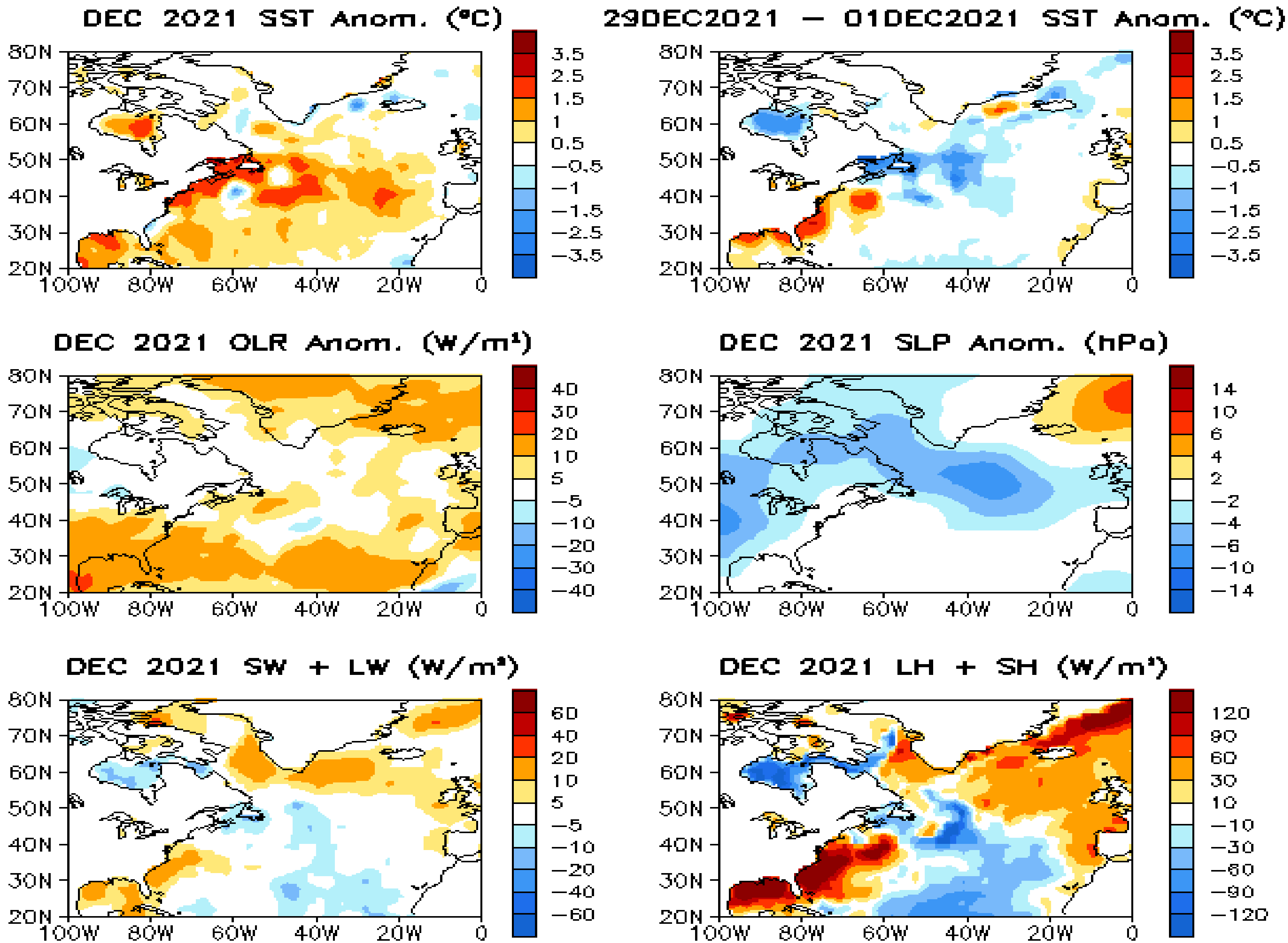


- SST in MDR was above average during the last two years.

CFSv2 Atlantic SSTA Predictions



- Latest CFSv2 predictions call near normal SST in the next 8 months.


DEC 2021 SST Anom. (°C)
29DEC2021 – 01DEC2021 SST Anom. (°C)
3.5 2.5 1.5 1 0.5 −0.5 −1 −1.5 −2.5 −3.5
DEC 2021 OLR Anom. (W/m²)
40 30 20 10 5 −5 −10 −20 −30 −40
DEC 2021 SLP Anom. (hPa)
14 10 6 4 2 −2 −4 −6 −10 −14
DEC 2021 SW + LW (W/m²)
60 40 20 10 5 −5 −10 −20 −40 −60
DEC 2021 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