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

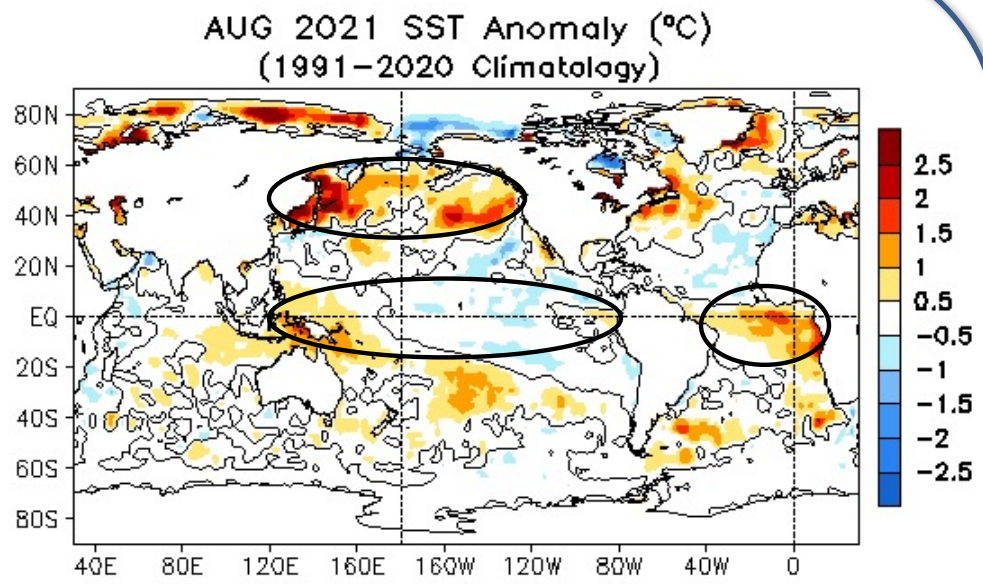
- Overview
- Recent highlights
  - Pacific/Arctic Ocean
  - Indian Ocean
  - Atlantic Ocean
- Global SST Anomaly Predictions

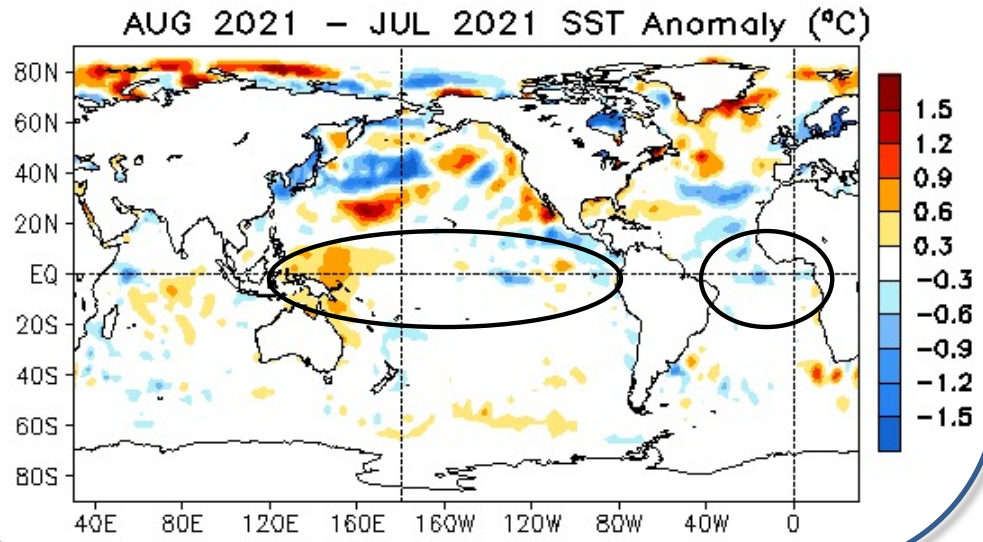
Overview

- Pacific Ocean
  - ENSO neutral conditions continued in August.
  - Negative phase of PDO weakened in Aug 2021, with PDOI = -0.5 .
  - Marine Heat Waves (MHWs) continued to expand in the N.E. Pacific and emerged in the N.W. Pacific.
- Indian Ocean
  - Negative Indian Ocean dipole (IOD) index continued to be below -0.4C, developing into a negative IOD event.
- Atlantic Ocean
  - 2021 Atlantic Niño event is the strongest event since 1950.
  - Atlantic hurricane genesis was very active in August, consistent with NOAA's updated Atlantic Hurricane season outlook.
- Arctic Ocean
  - The monthly average extent for Aug 2021 ranks the tenth lowest in the satellite record.

Global Oceans

Global SST Anomaly (°C) and Anomaly Tendency



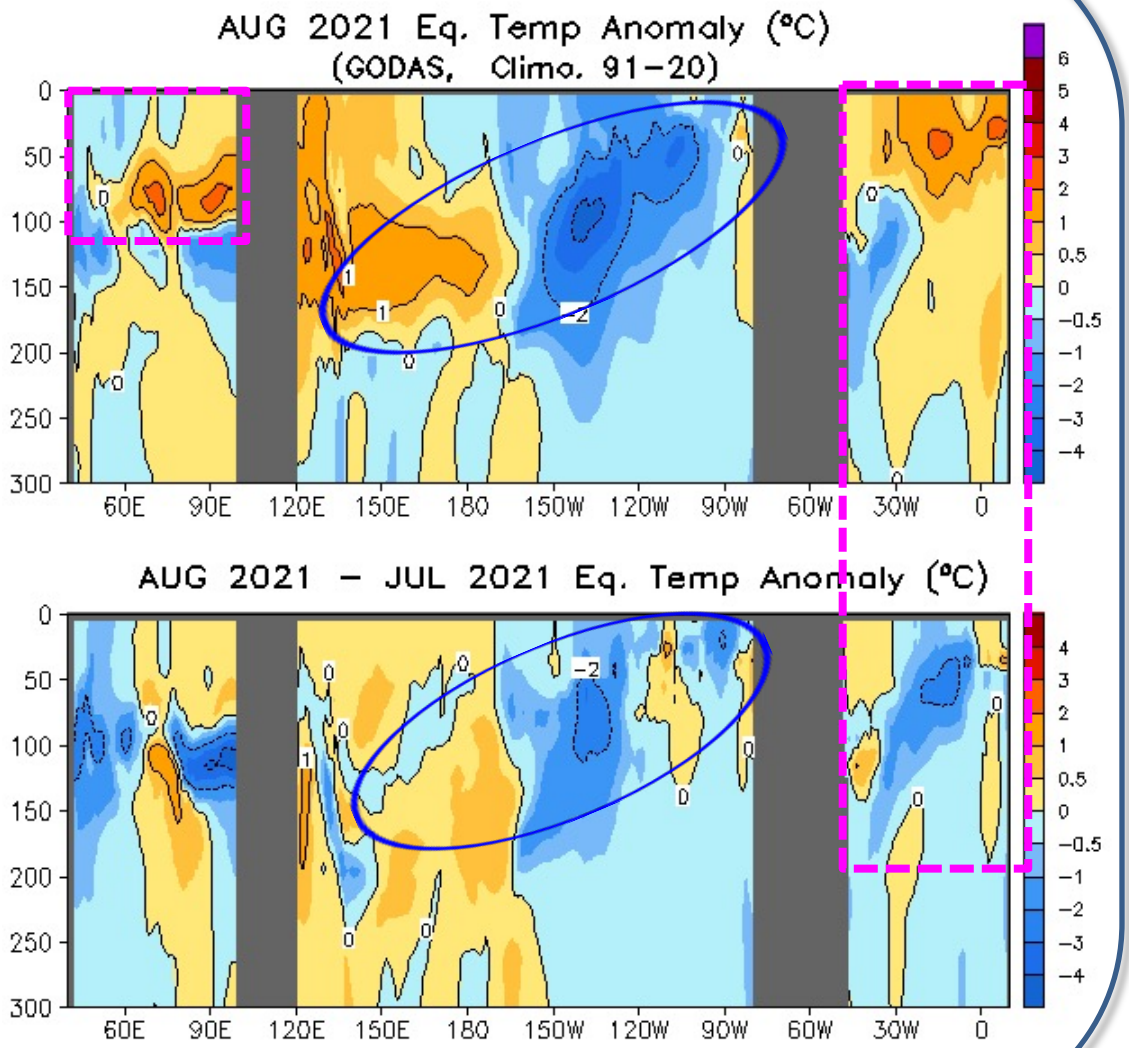


- SSTs were slightly below (above) normal in the central (western) tropical Pacific Ocean.
- Positive SSTAs continued in mid-latitude of north Pacific.
- Positive SSTAs persisted in the equatorial Atlantic Ocean and along the west coast of Africa.

- Negative (positive) SSTA tendencies were present in the eastern (western) equatorial Pacific Ocean.
- Negative SSTA tendency was present in the equatorial Atlantic Ocean.
- Large SSTA tendencies were present in the mid-high latitudes of northern hemisphere.

Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP 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



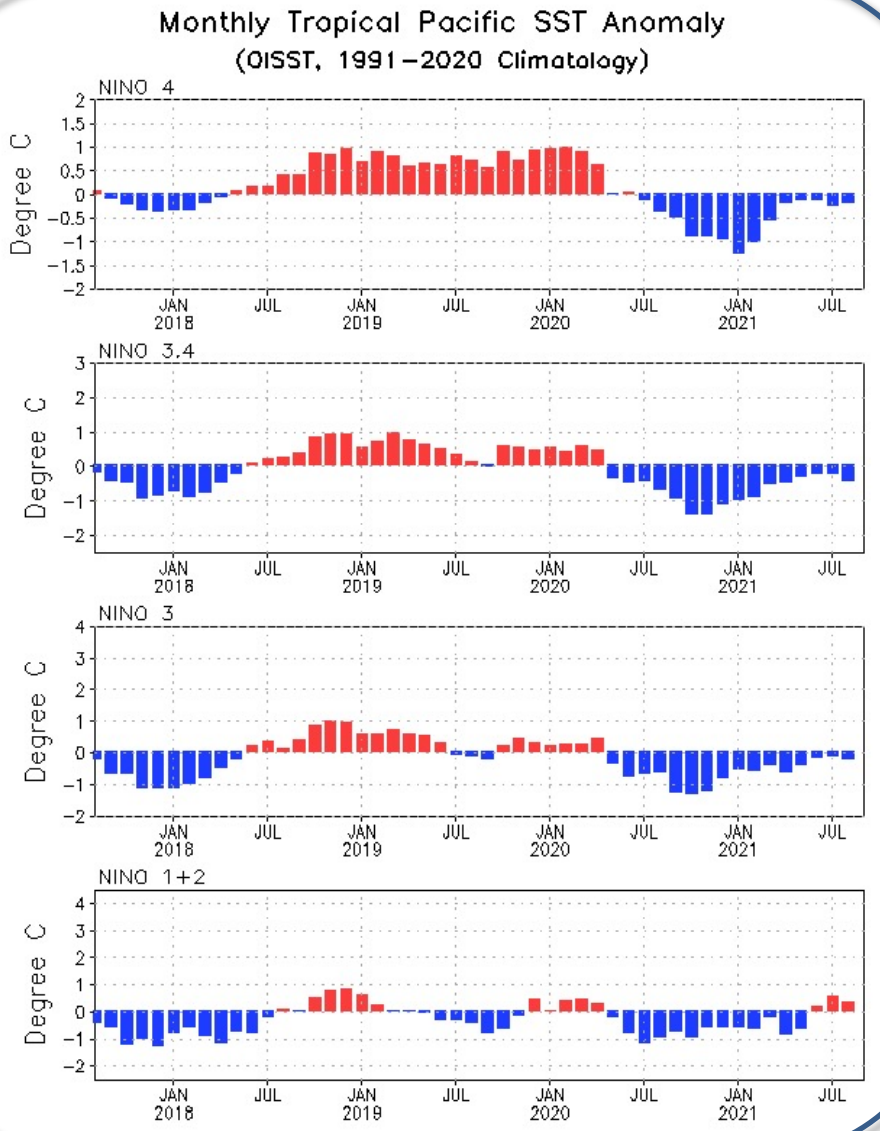
- Negative (positive) subsurface ocean anomalies were present along the central-eastern (western and far-eastern) thermocline in the equatorial Pacific.
- Positive anomalies continued in equatorial Atlantic Ocean, associated with the ongoing Atlantic Niño event.
- Positive subsurface anomalies persisted in the eastern Indian Ocean.

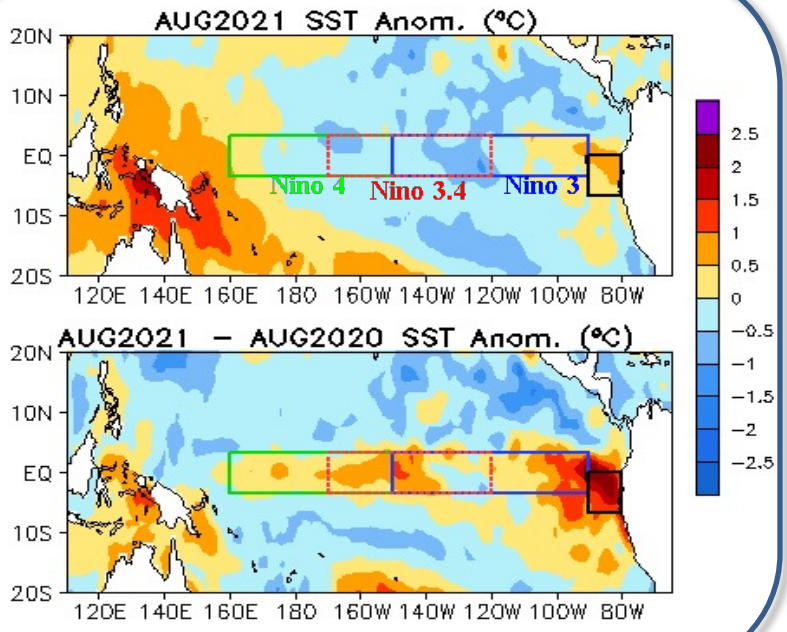
- Subsurface temperature anomaly tendencies were fairly localized near the thermocline in the equatorial Pacific.
- Negative temperature anomaly tendency dominated in the Atlantic Ocean.

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

Tropical Pacific Ocean and ENSO Conditions

Evolution of Pacific Niño SST Indices





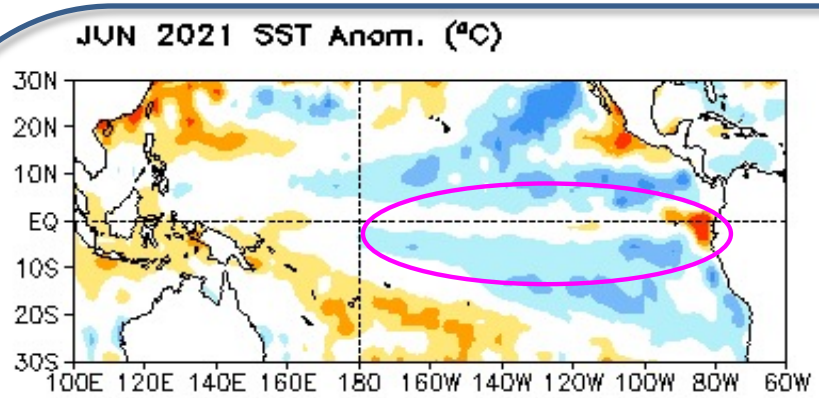
- Negative Niño3.4 enhanced in Aug 2021, with NINO34 = -0.4°C .

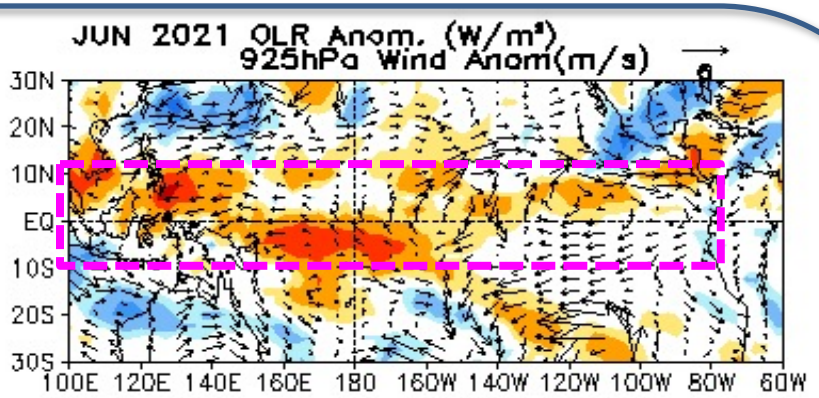
- Compared with Aug 2020, the central and eastern equatorial Pacific was warmer in Aug 2021.

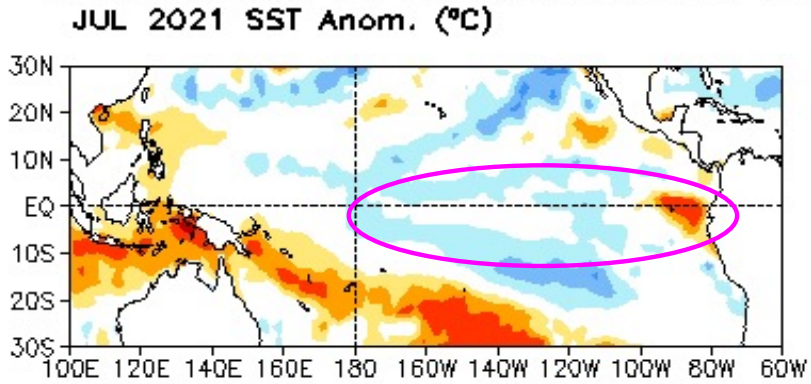
- The indices may have slight differences if based on different SST products.

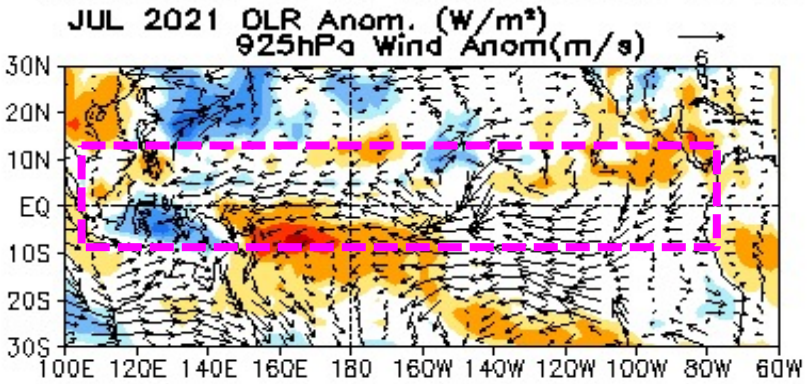
Niño region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1991-2020 base period means.

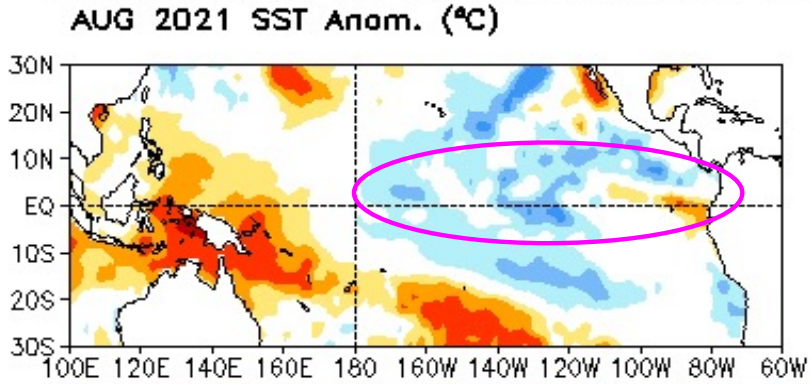
Latest 3-month Tropical Pacific SST , OLR, & uv925 anomalies

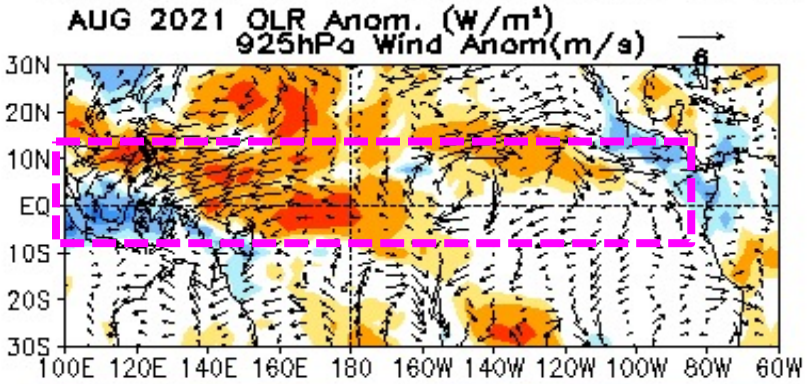




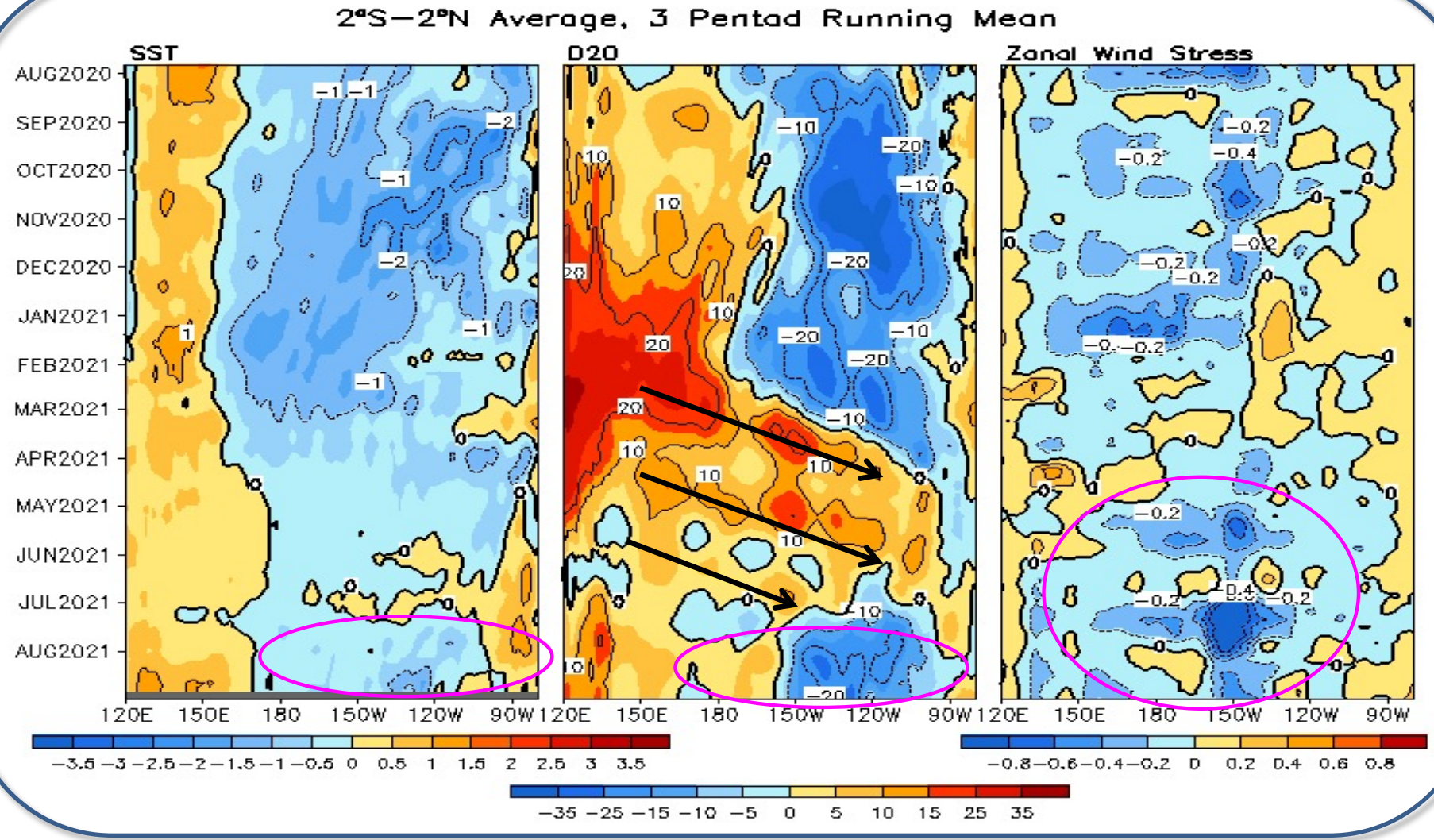






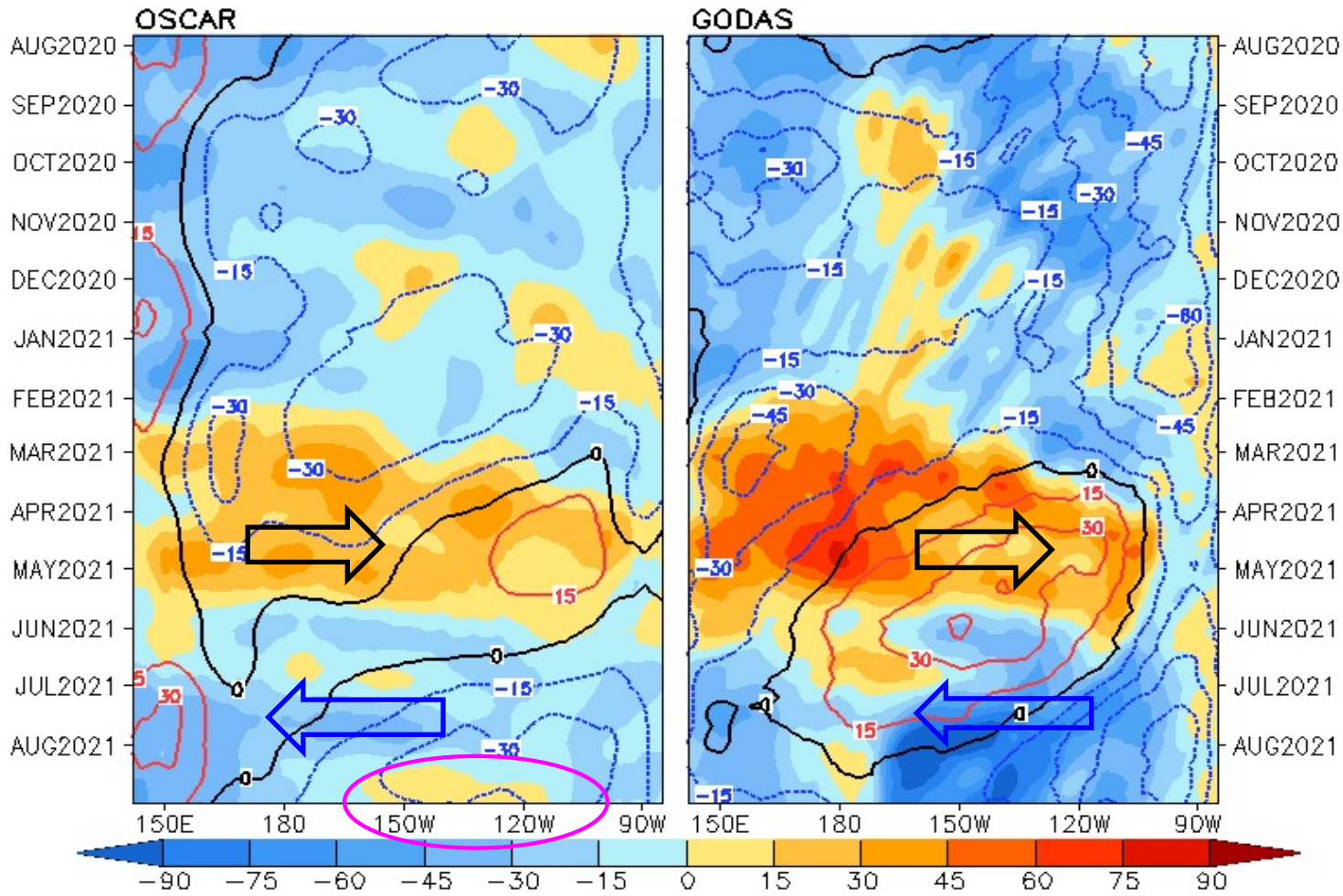


Equatorial Pacific SST (°C), D20 (m), zonal wind stress (dyn/cm ^{2}) Anomalies



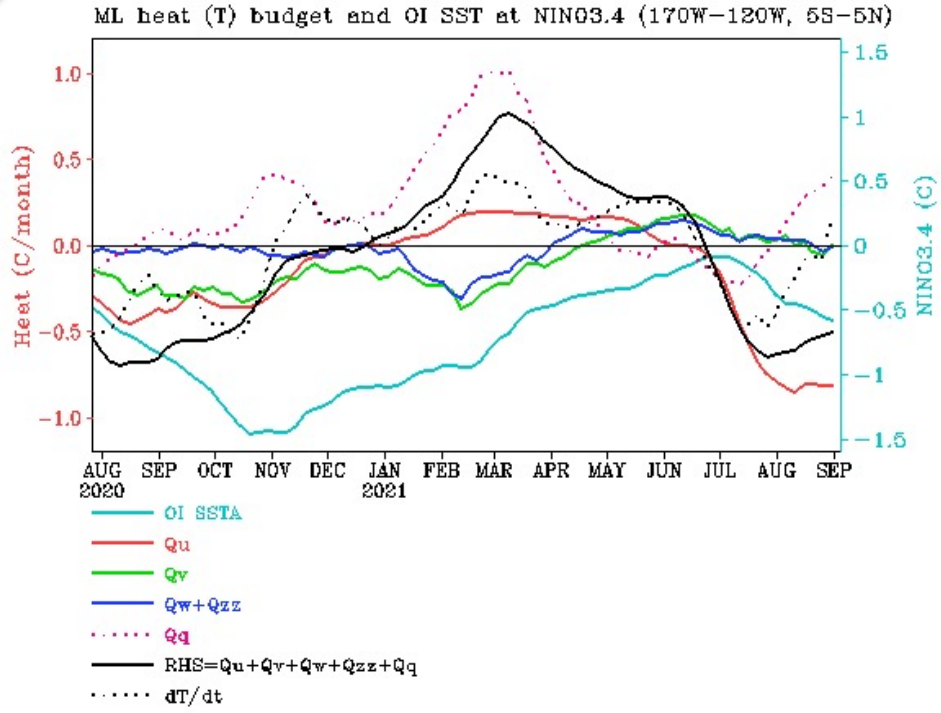
- Negative D20 anomaly persisted in the eastern Pacific since Jul 2021, contributing to the development of negative SSTA.
- Surface zonal wind stress was dominated by the subseasonal activity.

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



- Strong anomalous westward currents prevailed most of the equatorial Pacific in GODAS, while weak anomalous eastward currents were observed in OSCAR.

NINO3.4 Heat Budget



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

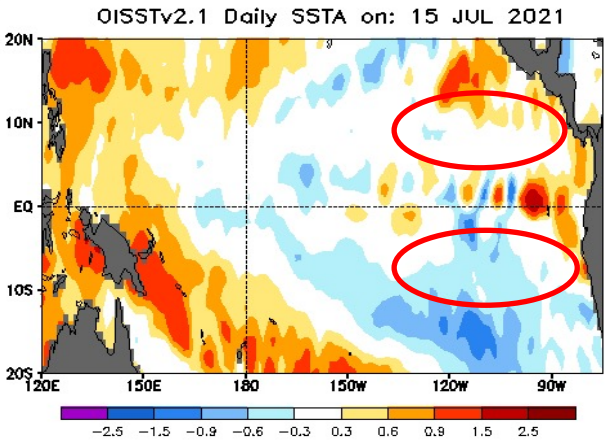
- Observed SSTA tendency (dT/dt) in Nino3.4 region (dotted black line) was negative since mid-Jun, and then switched to positive in the last pentad.

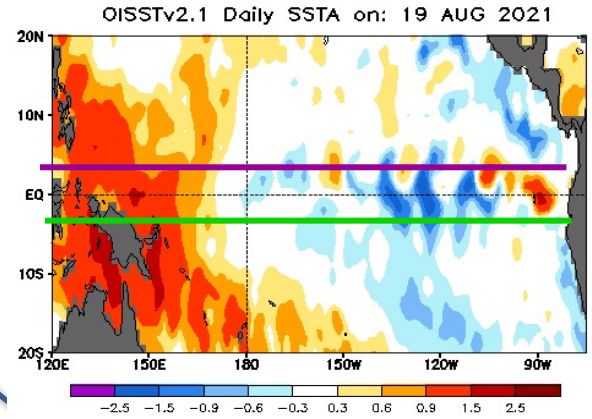
- Zonal advection (Qu, red line) is the primary term contributing to the total budget tendency (solid black line) .

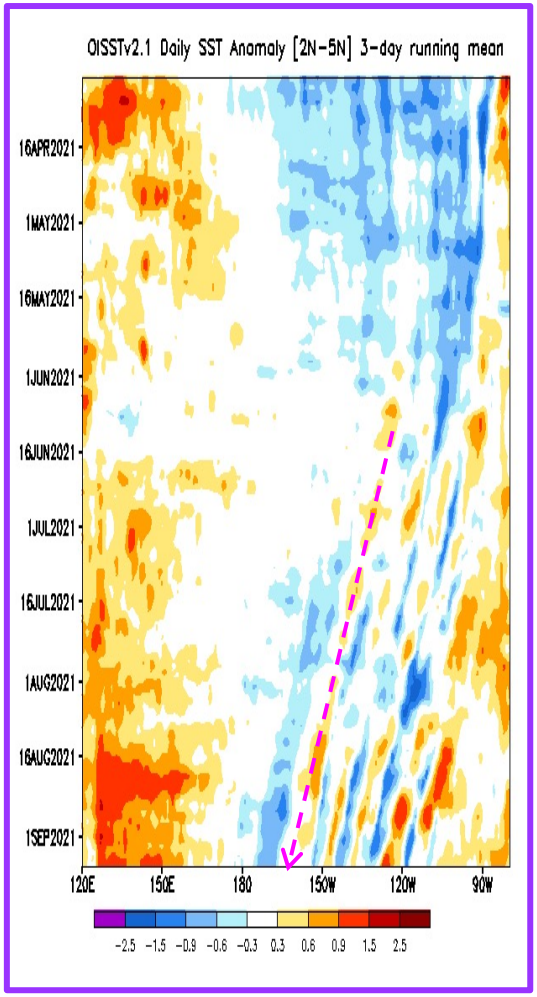
- There is large difference between observed SSTA tendency (dT/dt) and the total budget tendency (solid black line).

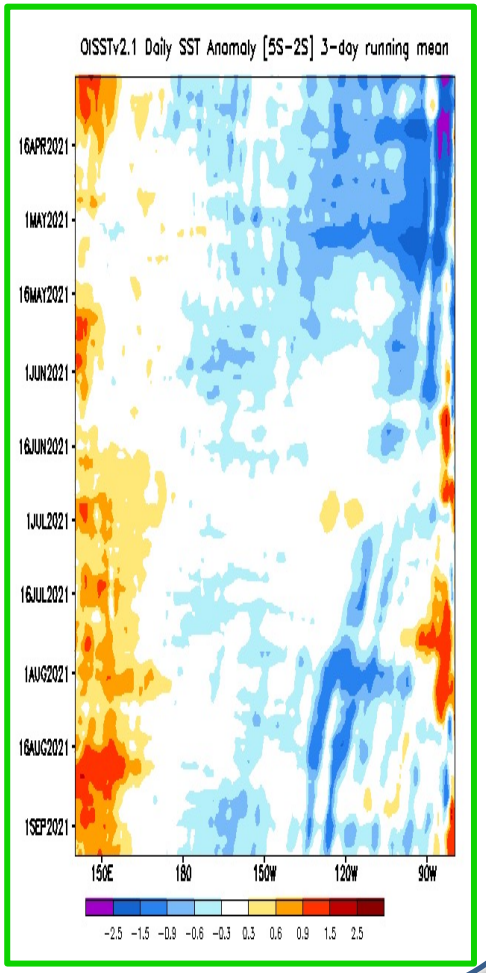
Huang, B., Y. Xue, X. Zhang, A. Kumar, and M. J. McPhaden, 2010 : The NCEP GODAS ocean analysis of the tropical Pacific mixed layer heat budget on seasonal to interannual time scales, J. Climate., 23, 4901-4925.

Tropical Instability Waves (TIWs) activities





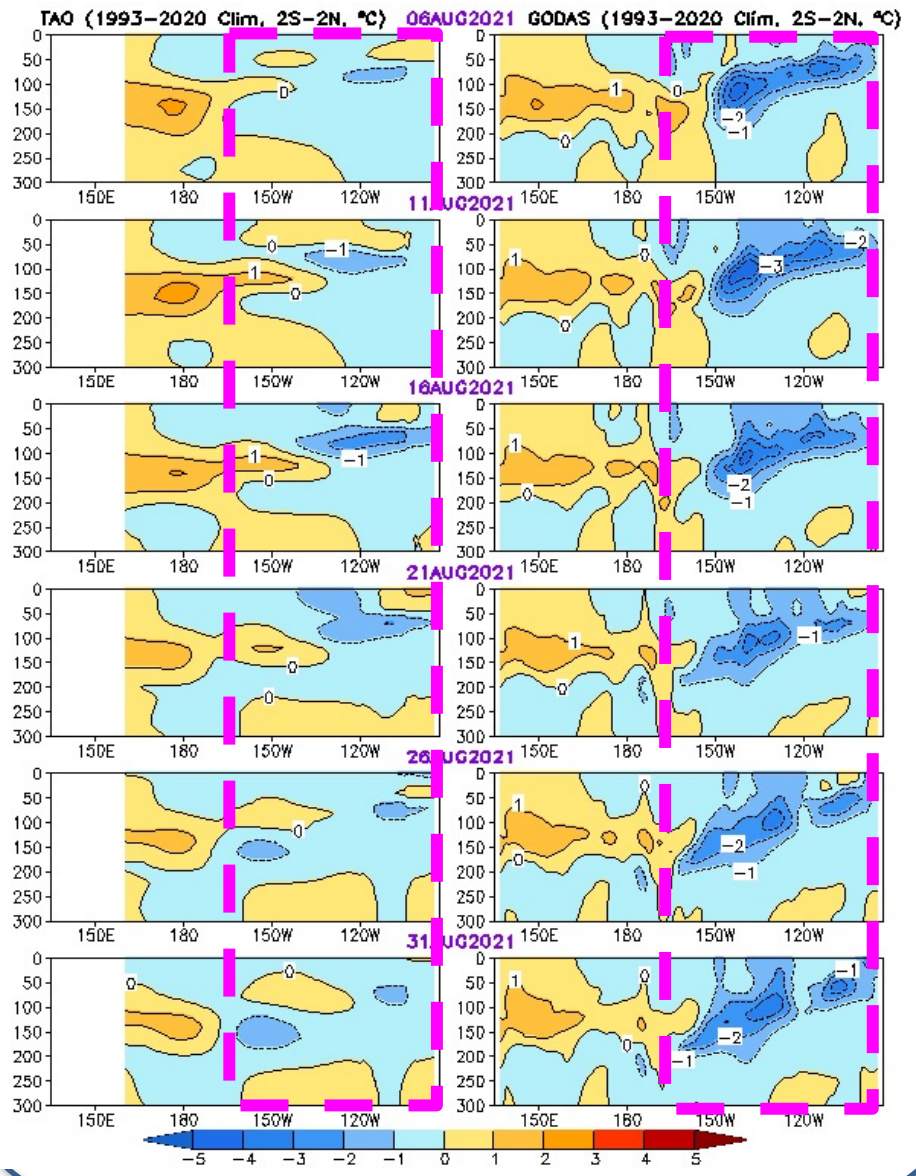




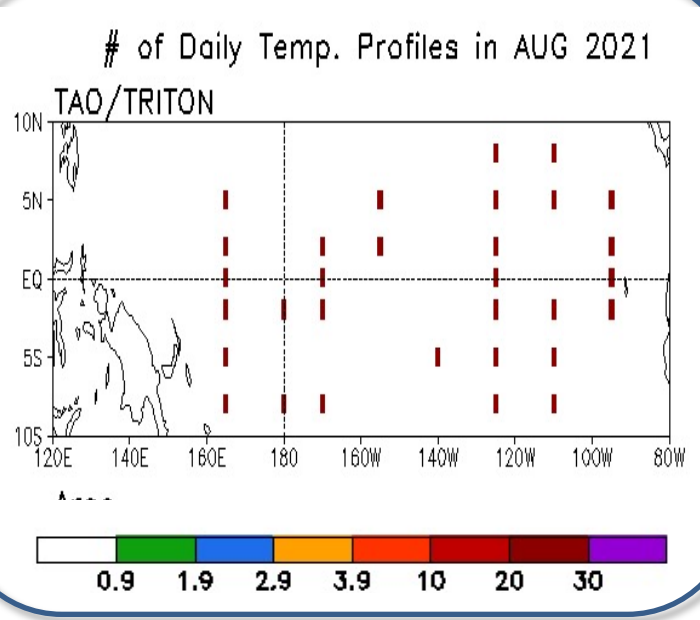
- Negative SSTA were generally located just to the south of the equator, consistent with asymmetric SSTA signals carried by TIWs in the northern and southern hemispheres.

-Nonlinear term related with TIWs play an important role in the slowdown SST cooling tendency in NINO34 region (previous slide).

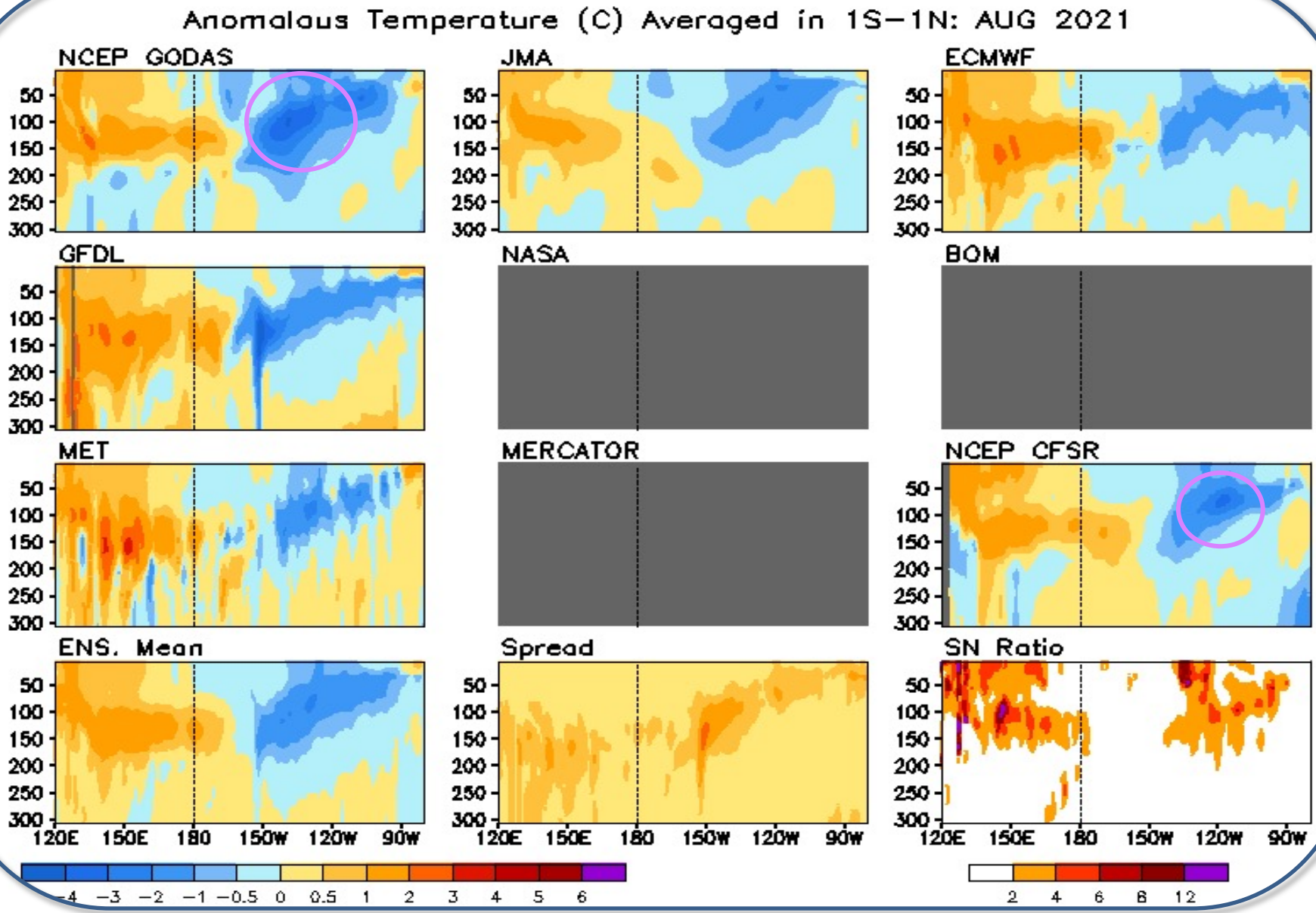
Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



- Subsurface cooling east of 170W in GODAS was much stronger than in TAO.
- Large difference between TAO and GODAS was partially associated with the missing TAO data near the equator.

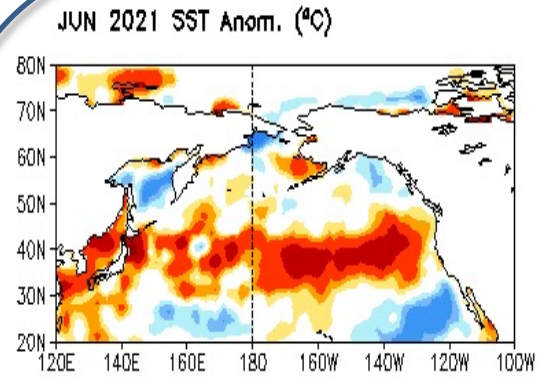


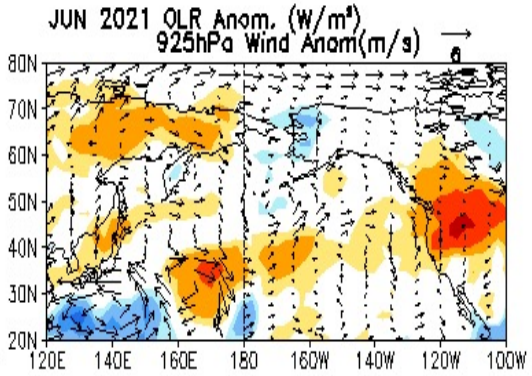
Multiple Ocean Reanalysis: Temperature anomaly at Equator

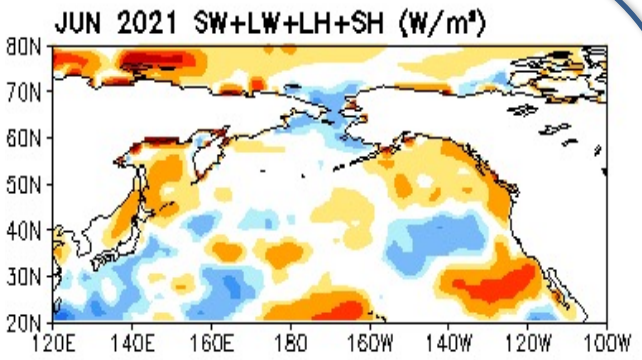


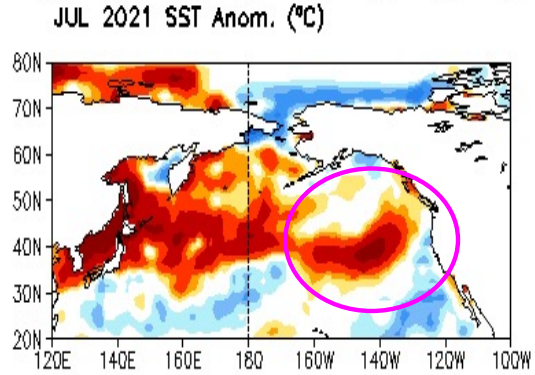
North Pacific & Arctic Oceans

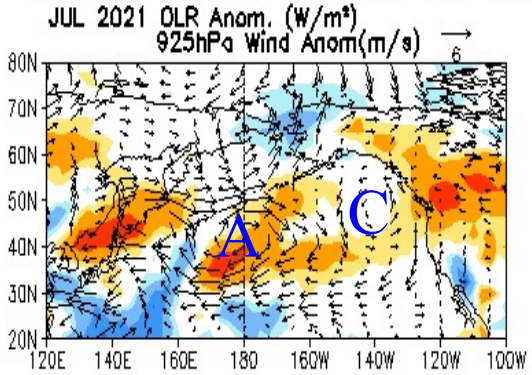
Latest 3-month North Pacific SST, OLR & uv925 anomalies

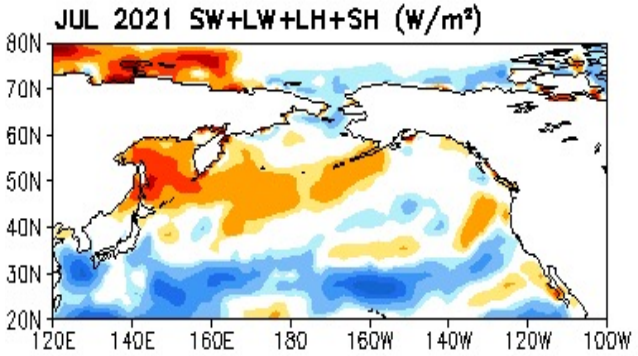


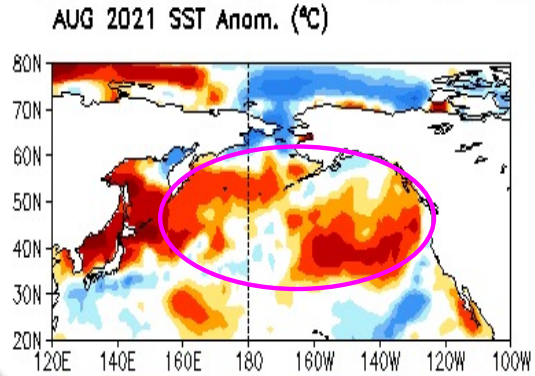


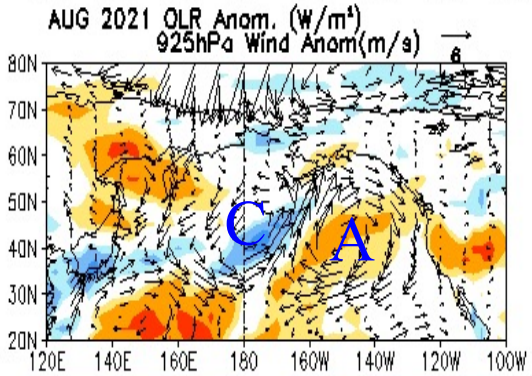


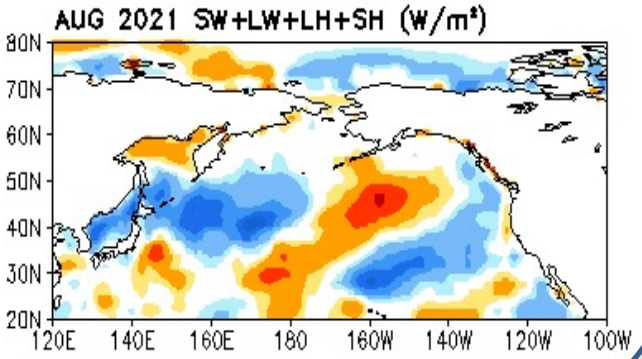






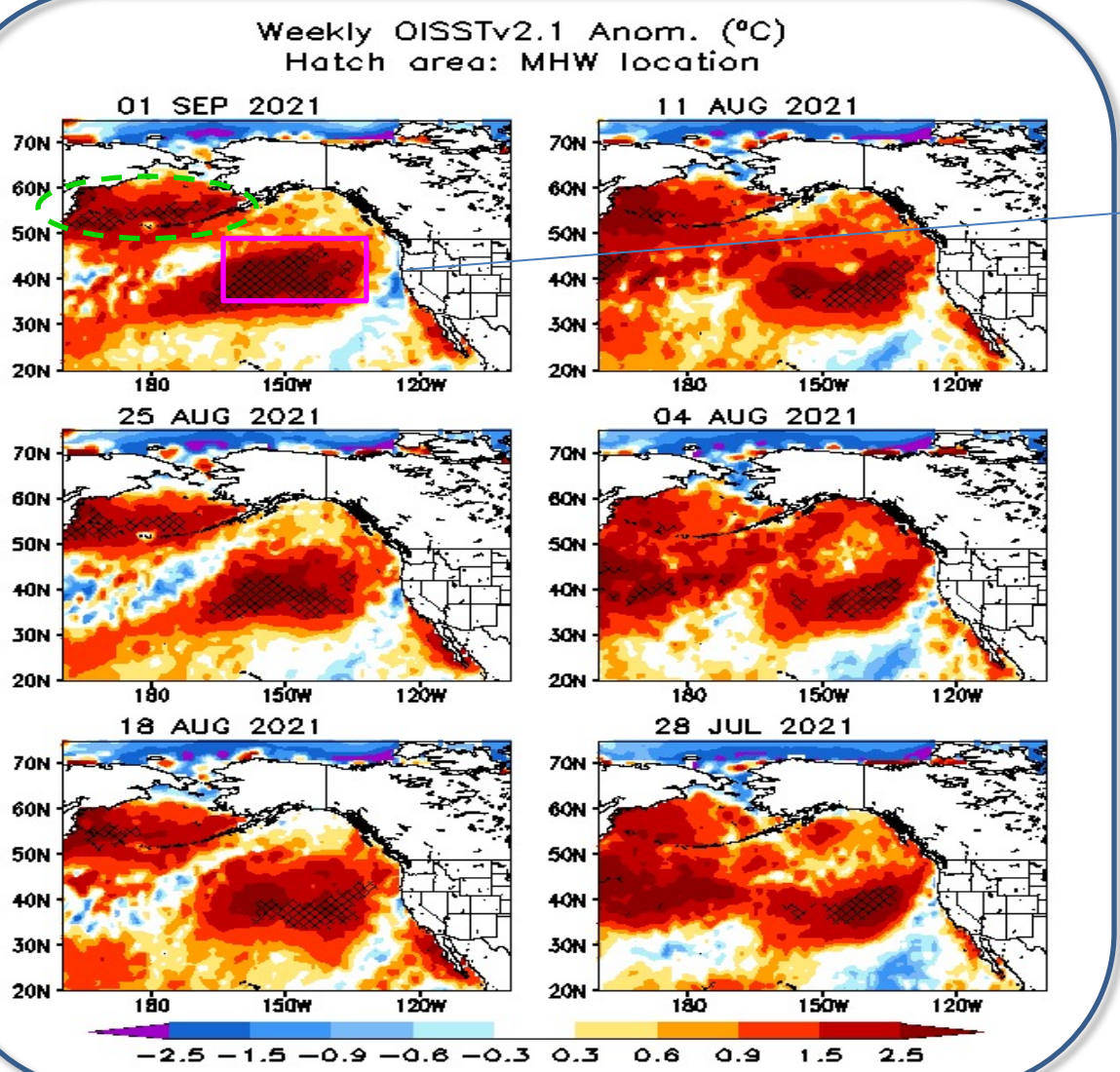


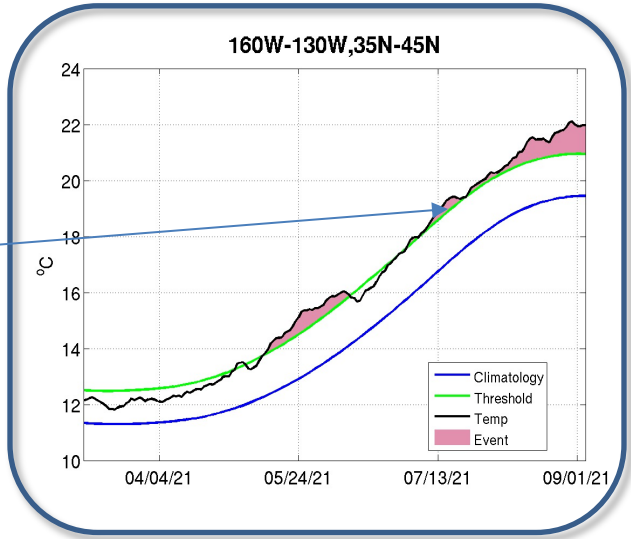




Data source: NCEP/NCAR Reanalysis 1

Weekly SST anomaly and MHWs in the North Pacific



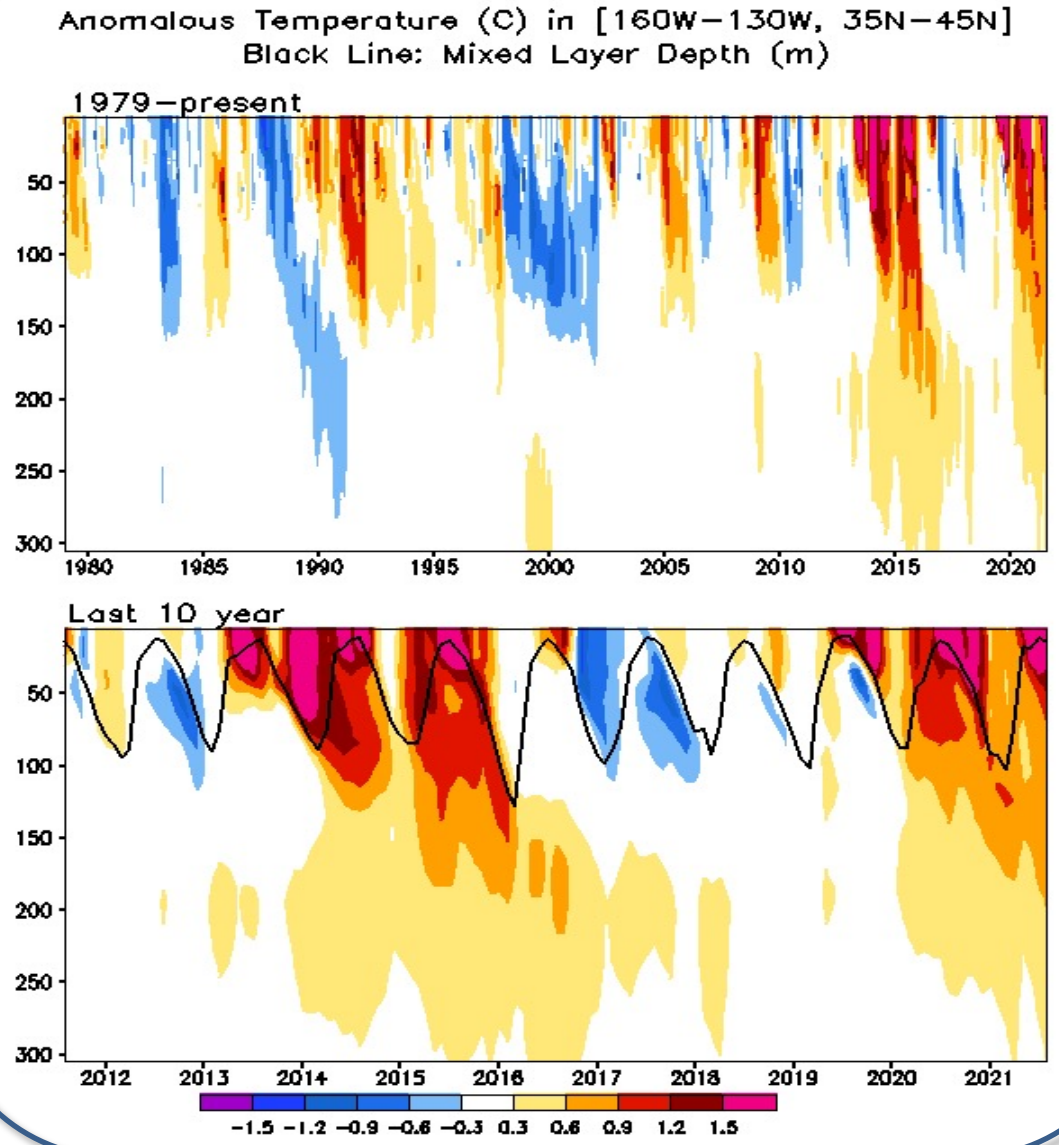


- MHWs were observed in the N.E Pacific since early July and continue to expand in Aug 2021.

- Positive SSTA enhanced in the western Pacific Ocean, and some developed into MHWs in recent weeks.

(Left panel) Weekly SST anomaly (shaded) and locations experience Marine heat waves (hatched) by the date labelled in the plot. (right panel) SST evolution at a specific location. Green line and blue line denote the seasonal 90th percentile and daily climatology, respectively. Shaded area denotes the periods experiencing MHW. MHW is defined as a discrete prolonged warmer than 90th percentile of daily SST for at least 14 days. Data is derived from NCEI OISSTv2.1 and the climatology reference period is 1982-2010.

Subsurface Temperature Anomaly in N.E. Pacific



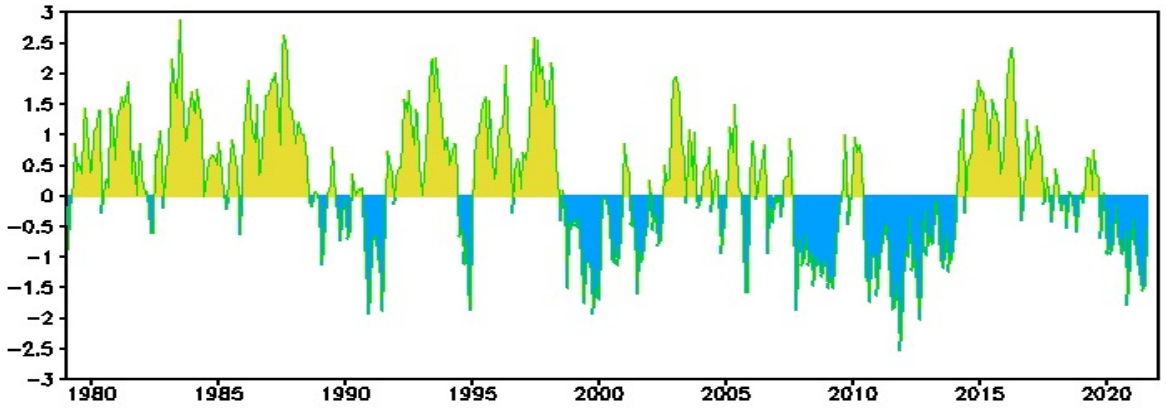
- Positive subsurface temperature anomaly in the N.E Pacific has persisted since 2019.

- Subsurface warming in recent months has extended to 200m, close to the strongest event during 2015-16.

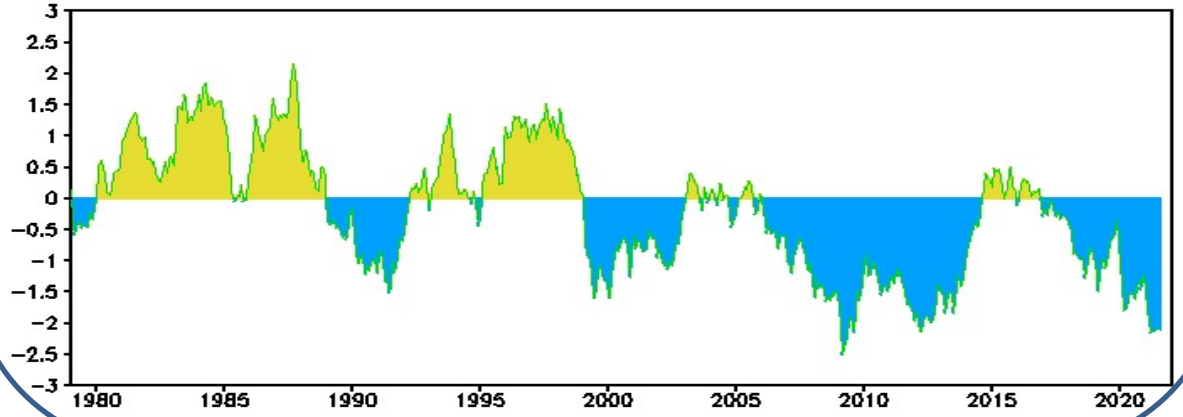
Data source: NCEP GODAS

Two Oceanic PDO indices

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



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



- The negative phase of PDO weakened in Aug 2021, with PDOI = -0.5.

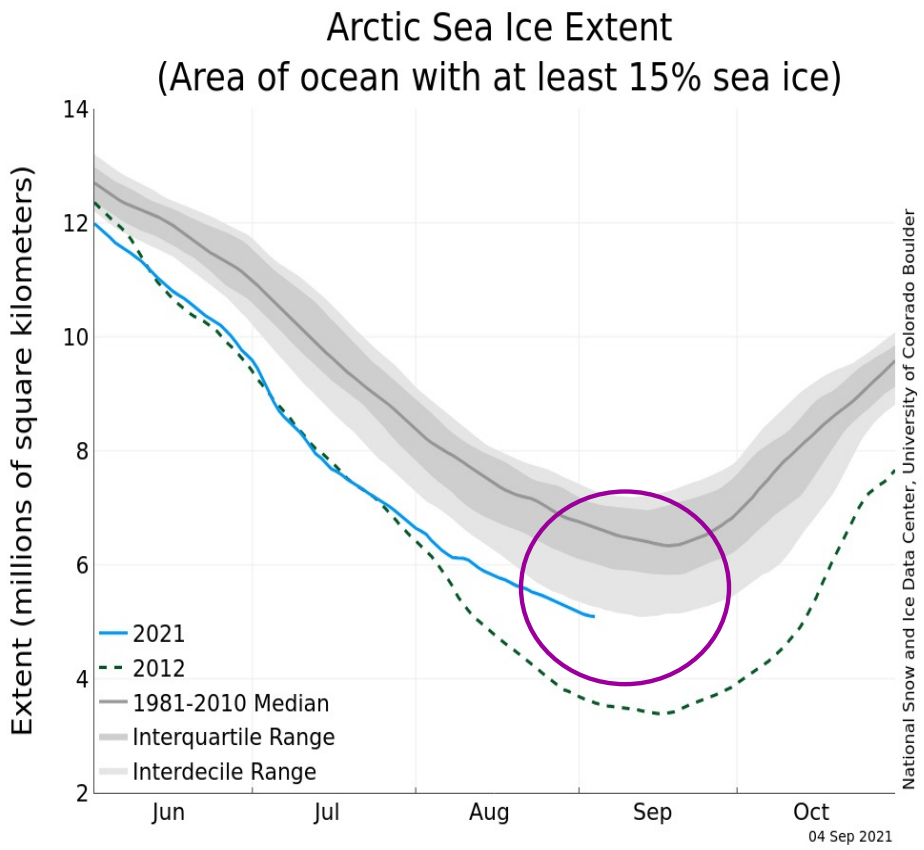
- Negative H300-based PDO index has persisted 59 months since Nov 2016, with HPDO = - 2.1 in Aug 2021.

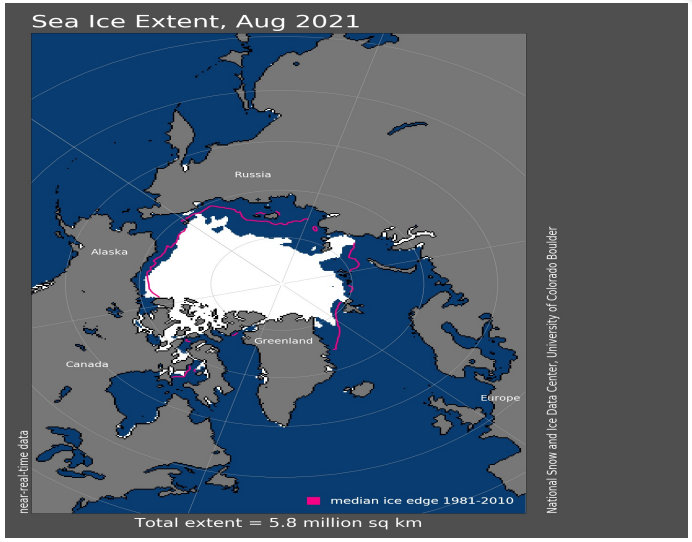
- SST-based PDO index has considerable variability both on seasonal and decadal time scales.

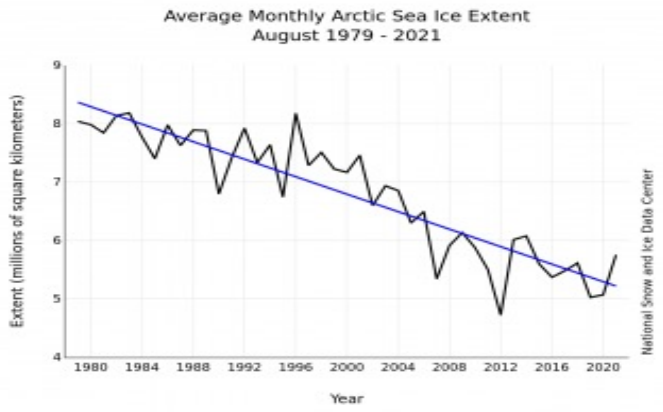
- H300-based PDO index highlights the slower variability and encapsulates an integrated view of temperature variability in the upper ocean.

SST-based PDO is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly ERSSTv5 SST anomalies onto the 1st EOF pattern. H300-based Pacific Decadal Oscillation is defined as the projection of monthly mean H300 anomalies from NCEP GODAS onto their first EOF vector in the North Pacific. PDO indices are downloadable from https://www.cpc.ncep.noaa.gov/products/GODAS/ocean_briefing.shtml.

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

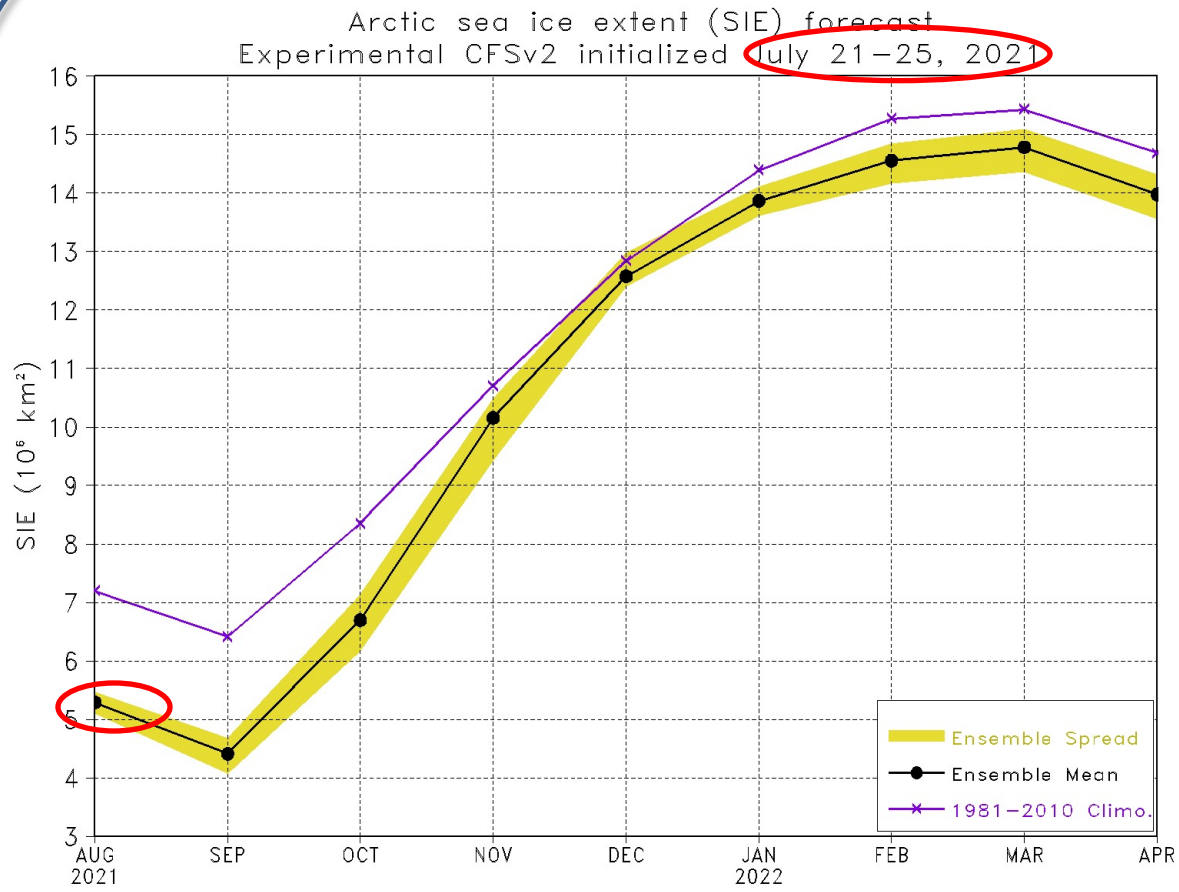






- The monthly average extent for Aug 2021 was 5.75 million square kilometers and it ranks the tenth lowest in the satellite record.

NCEP/CPC Arctic Sea Ice Extent Forecasts

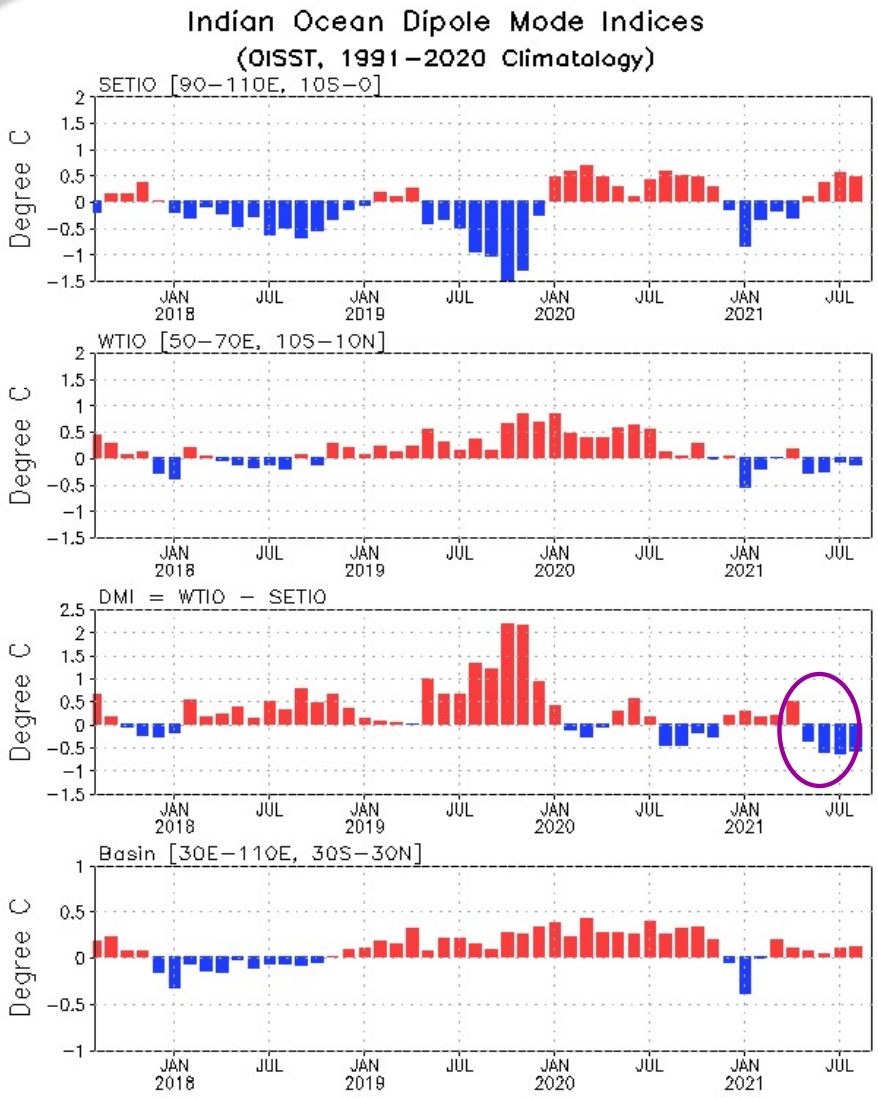


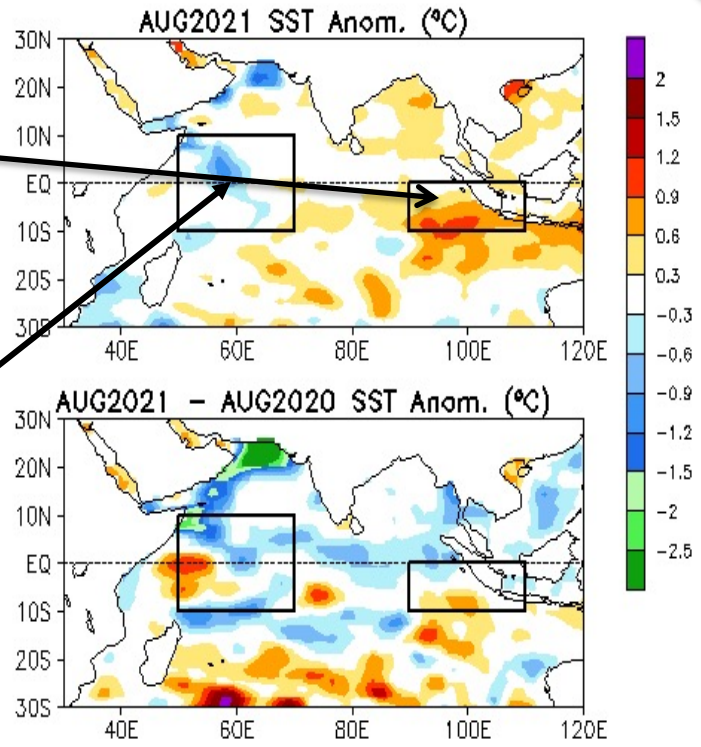
- For ICs in Jul 2021, NCEP/CPC model predicted a well below-normal sea ice extent during summer and autumn 2021.
- Predicted August sea ice extent value with ICs in Jul 2021 is very close to the observed value.

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

Indian Ocean

Evolution of Indian Ocean SST Indices

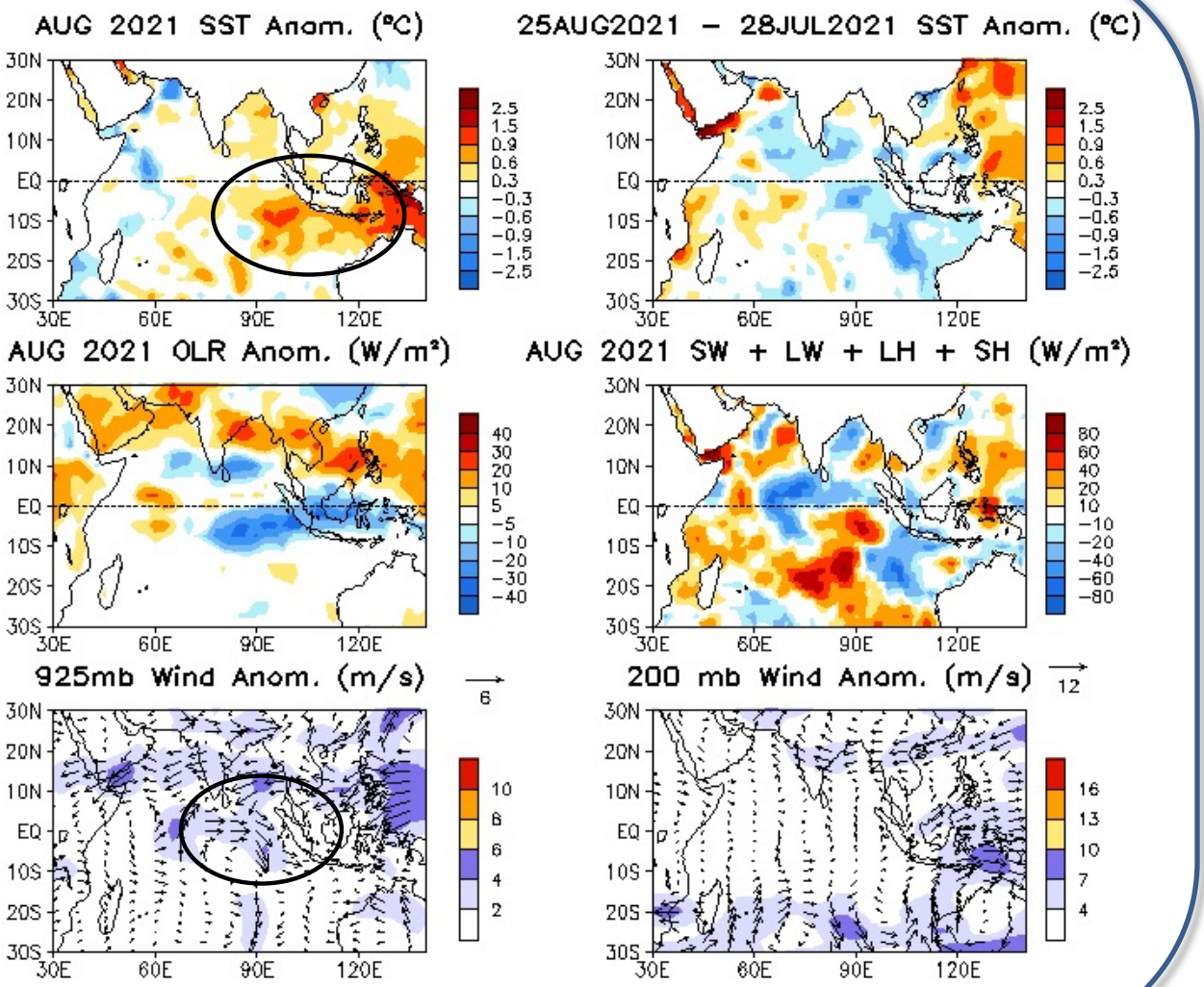




- Negative Indian Ocean Dipole Mode index (DMI) persisted in Aug 2021, with IODI = -0.6° C
- IOD has been below -0.4°C for three months, developing into a negative IOD event.

Indian Ocean Dipole region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (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 NCEP OI SST analysis, and anomalies are departures from the 1991-2020 base period means.

Tropical Indian: SSTA, SSTA Trend, OLR, heat flux uv925-mb & uv200 anomalies

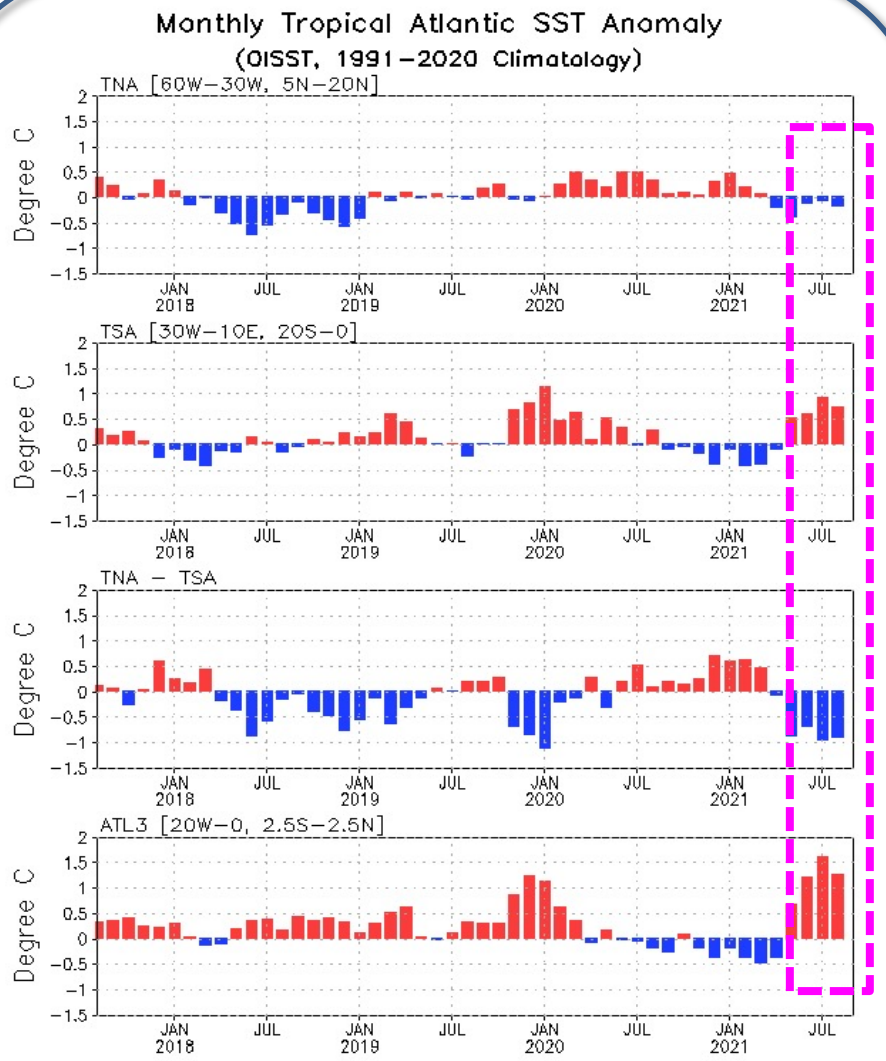


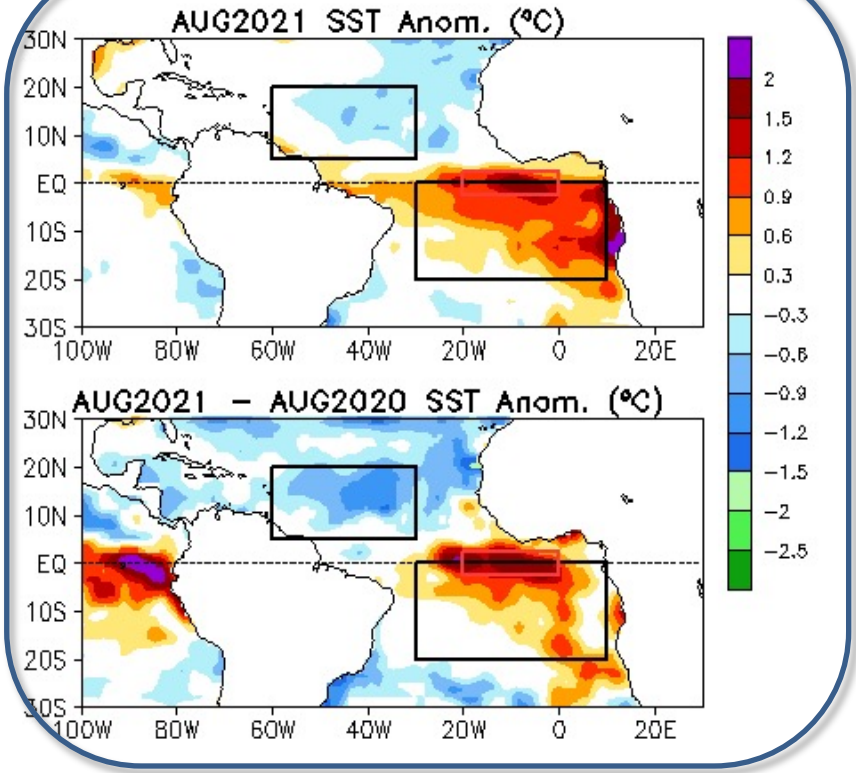
- Westerly wind anomaly prevailed over the southern eastern Indian Ocean, favoring further warming in the eastern Indian Ocean.

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

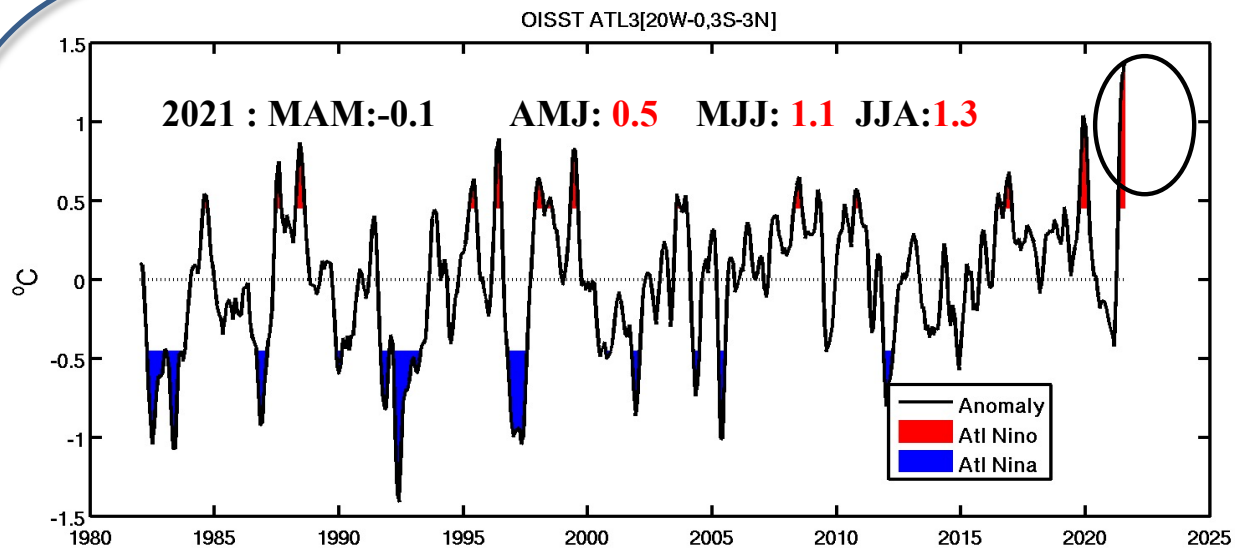




- Negative meridional dipole index weakened slightly in Aug 2021, with MDI = -0.9 °C.
- Positive ATL 3 index weakened in Aug 2021, with ATL 3=1.3 °C ,indicating the Atlantic Niño event reaching its peak.

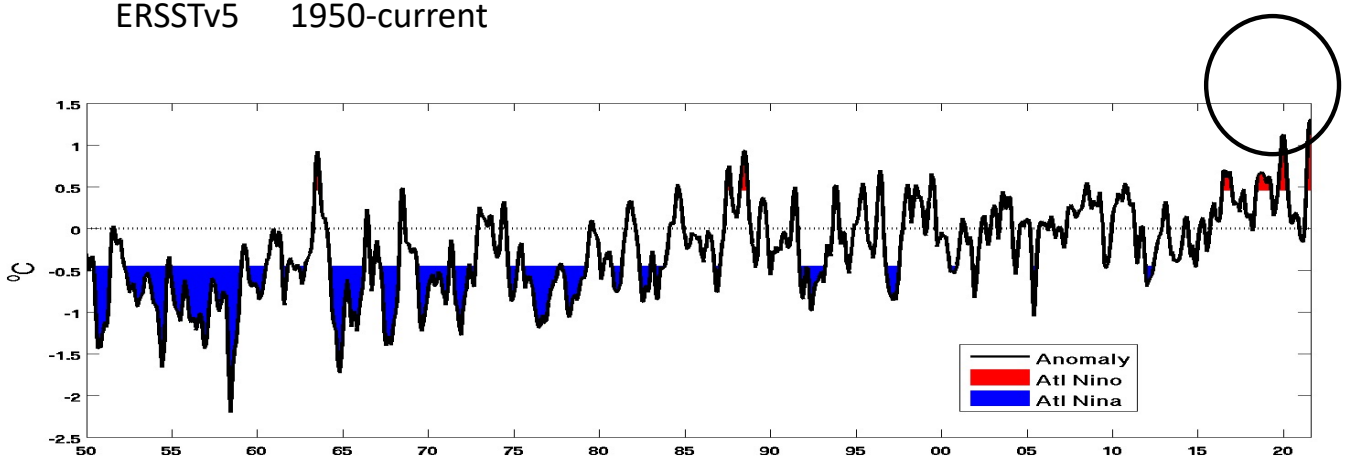
Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W-30°W, 5ºN-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between TNA and TSA.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

Historical Atlantic Niño & Niña Events



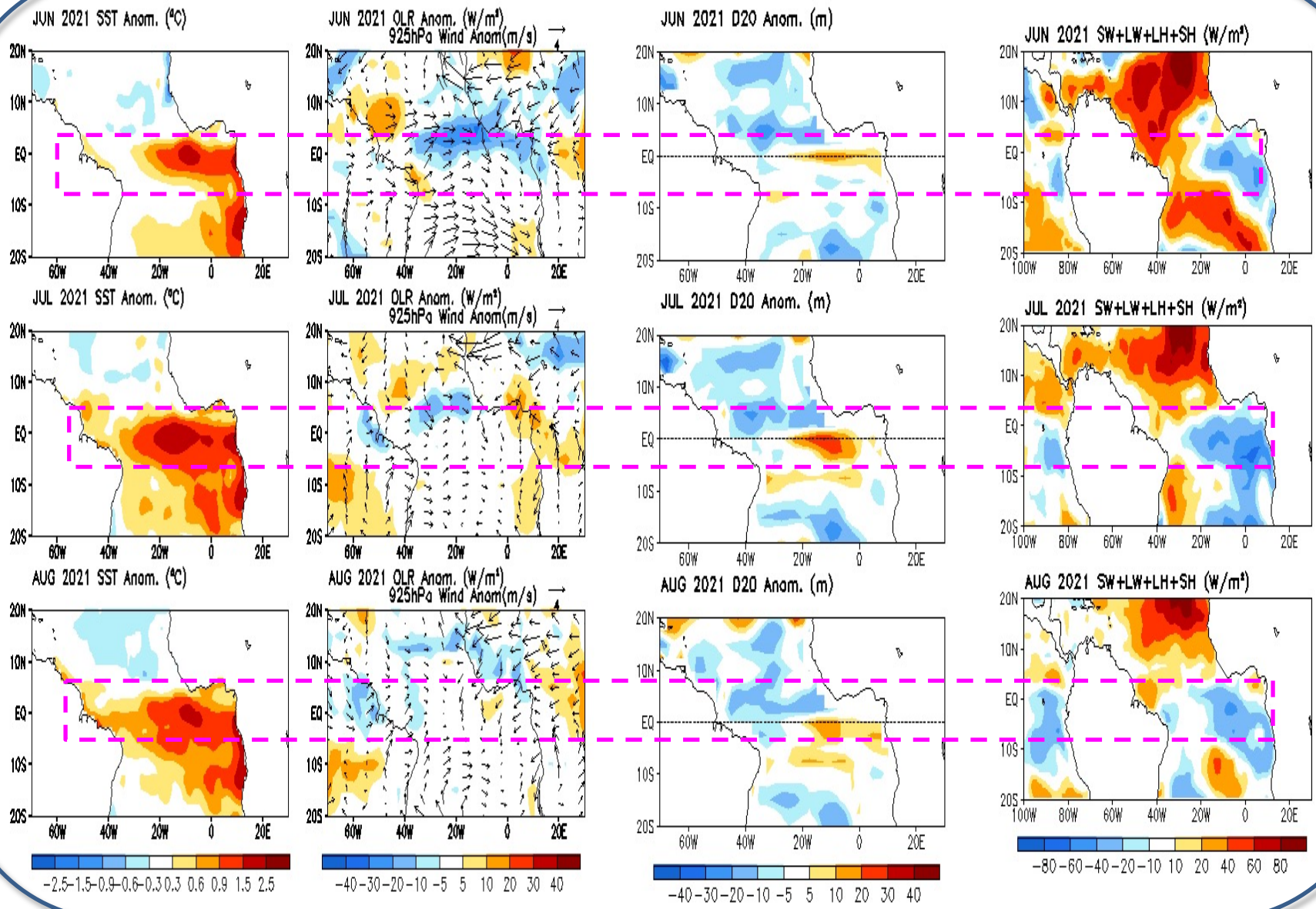
- 2021 Atlantic Nino is the strongest Atlantic Nino events both in ERSSTv5 and OISST data.

ERSSTv5 1950-current

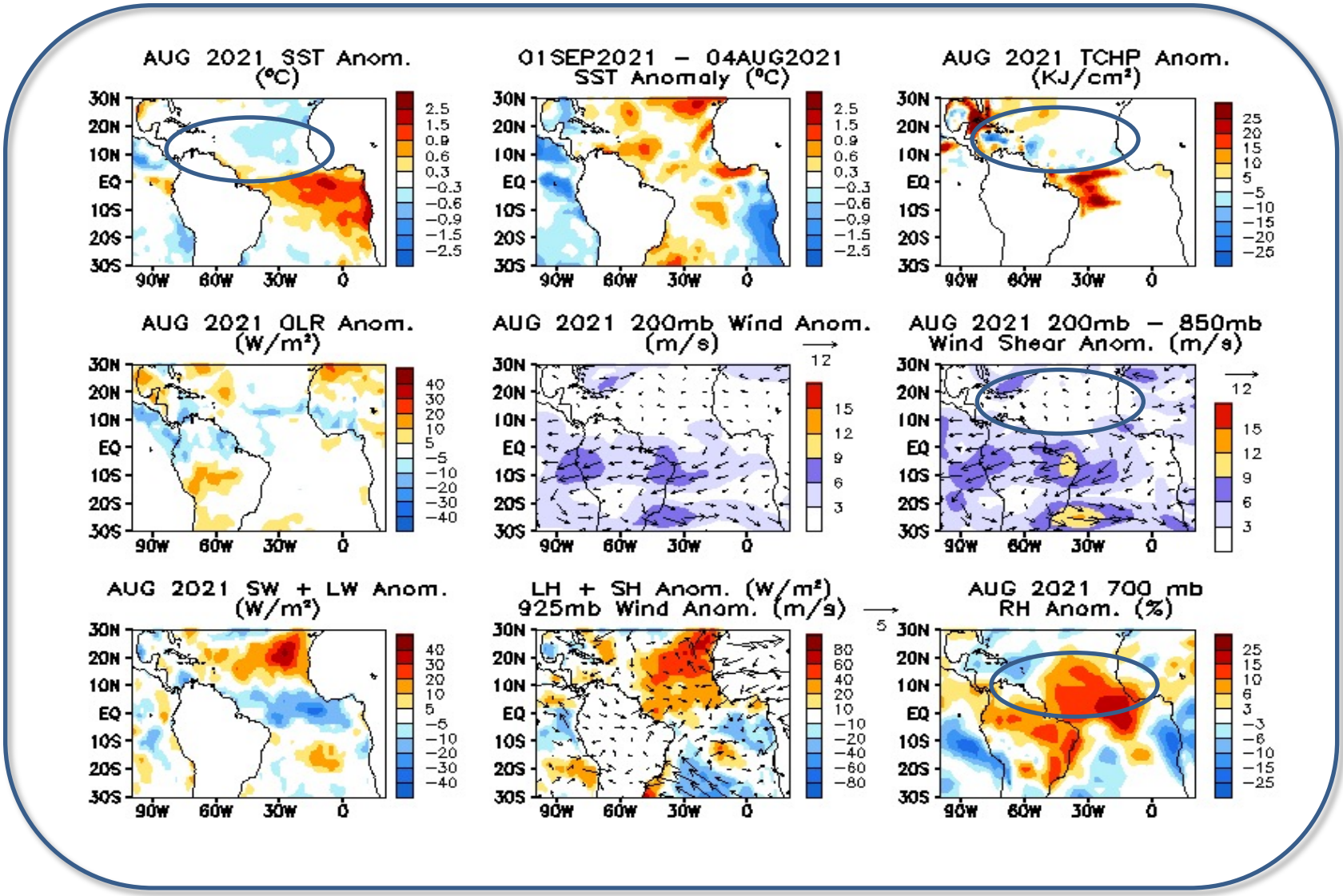


Climatology : 1991-2020

Latest 3-month Tropical Atlantic SST , OLR & uv925 and D20 anomalies

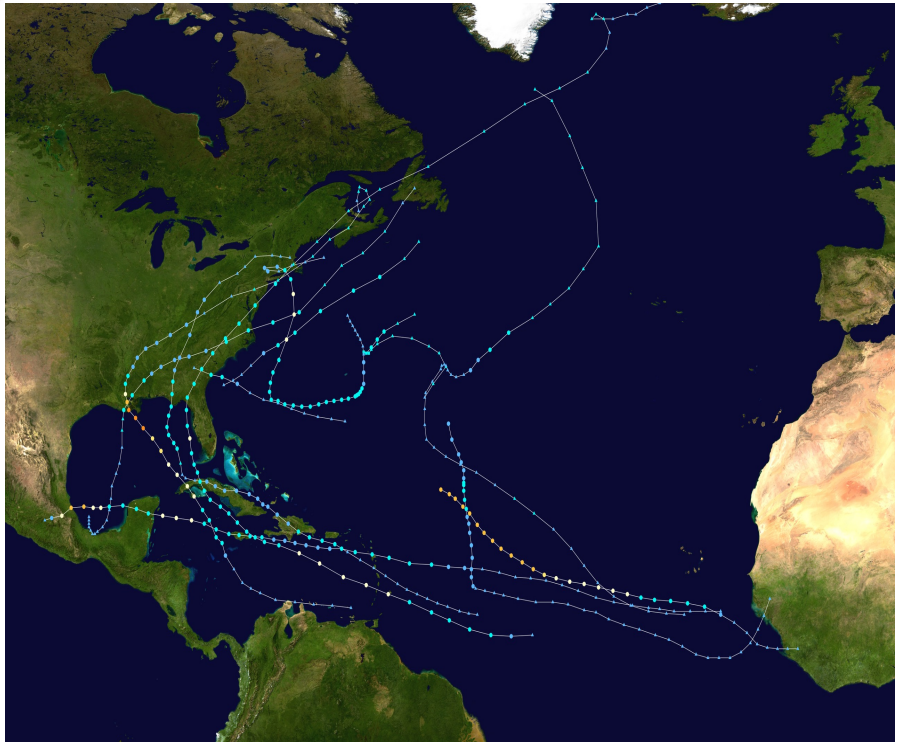


Tropical Atlantic Ocean: SSTA, SSTA Tend, TCHP, OLR, UV200, UV200-UV850, Heat Flux Anomalies



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

2021 Atlantic Hurricane Season Activities

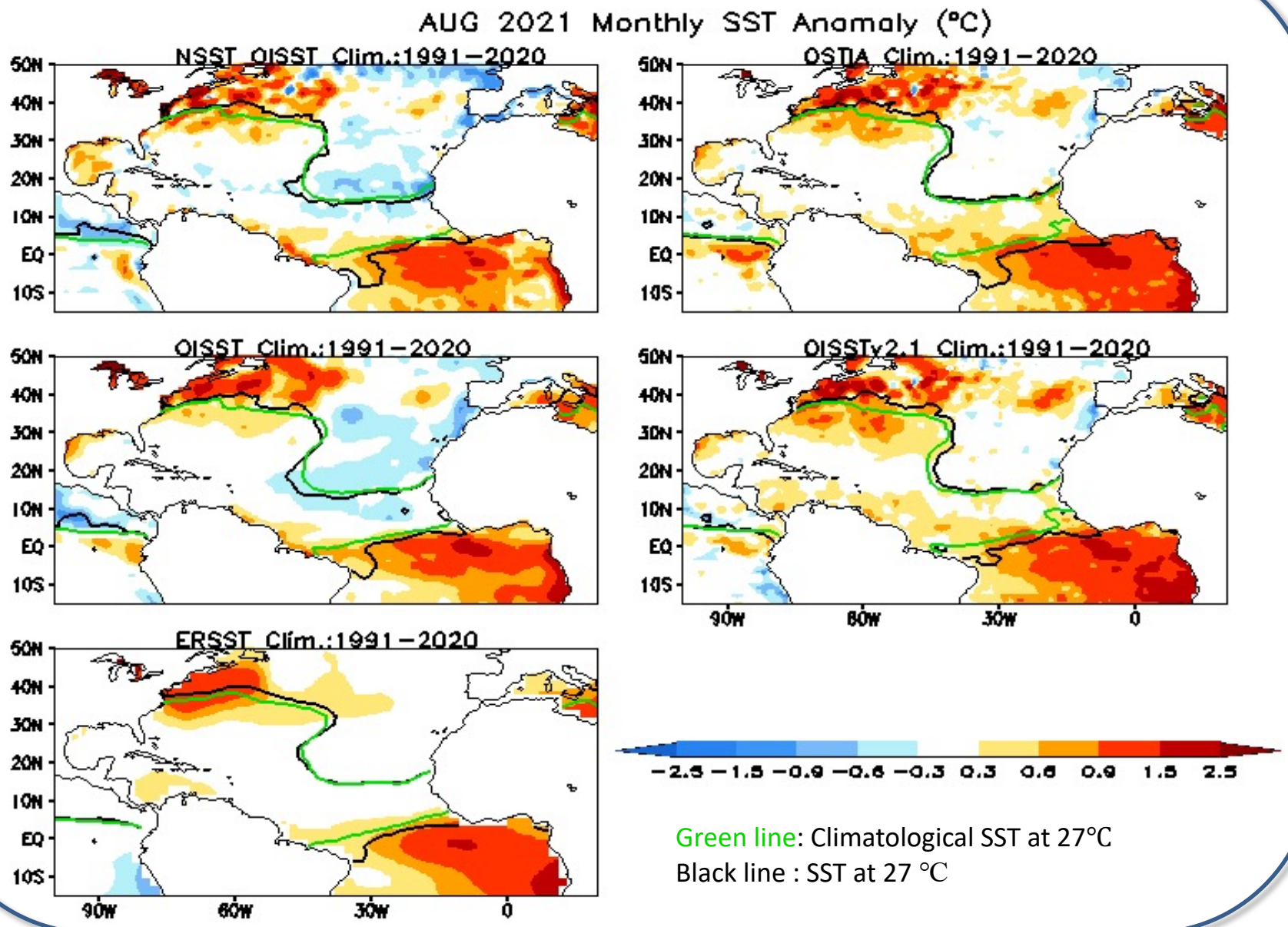


https://en.wikipedia.org/wiki/2021_Atlantic_hurricane_season

- Seven storms formed in the Aug 2021.
- By Sep 7, 2021, twelve tropical storms formed with five developing to hurricane, and three developing to major hurricanes.

Atlantic	Observations (By Sep7)	Updated Outlook (Aug 4) 65% above-normal	Outlook (May 21) 60% above-normal	(1991-2020)
Total storms	12	15-21	13-20	14
Hurricanes	5	7-10	6-10	7
Major hurricanes	3	3-5	3-5	3

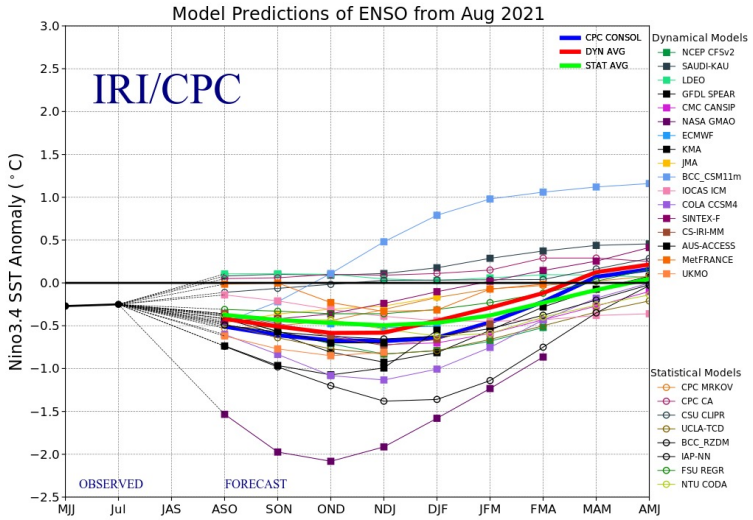
Monthly SST Anomaly in the Atlantic Ocean

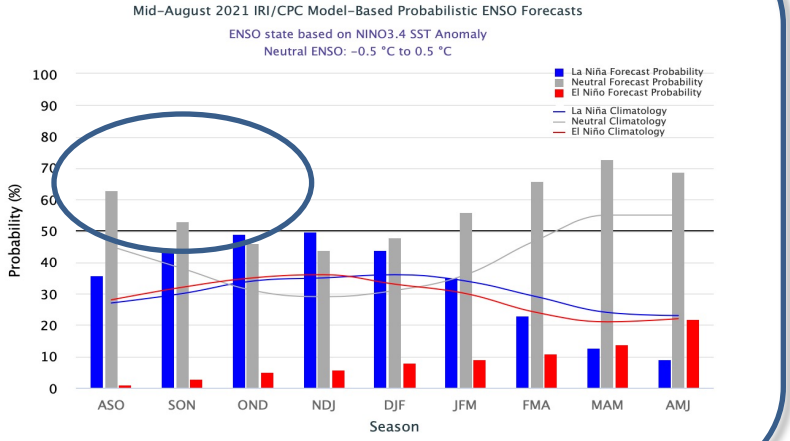


Green line: Climatological SST at 27℃
Black line : SST at 27 ℃

ENSO and Global SST Predictions

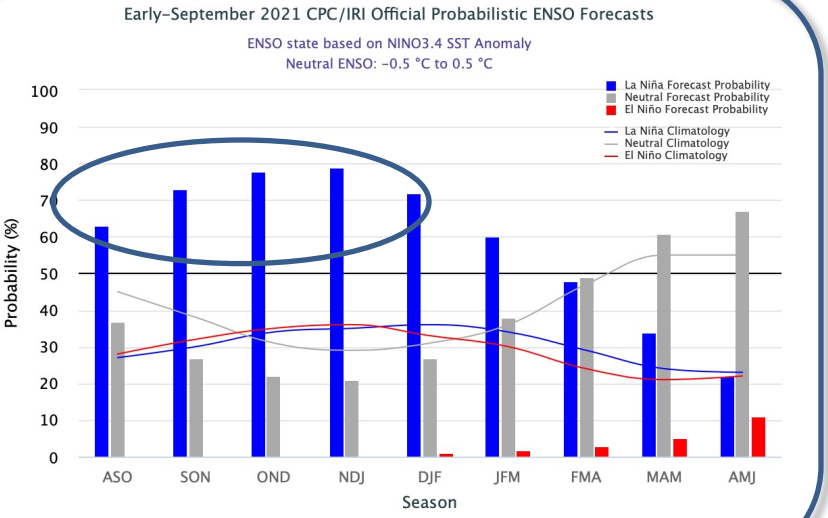
IRI/CPC Niño3.4 Forecast



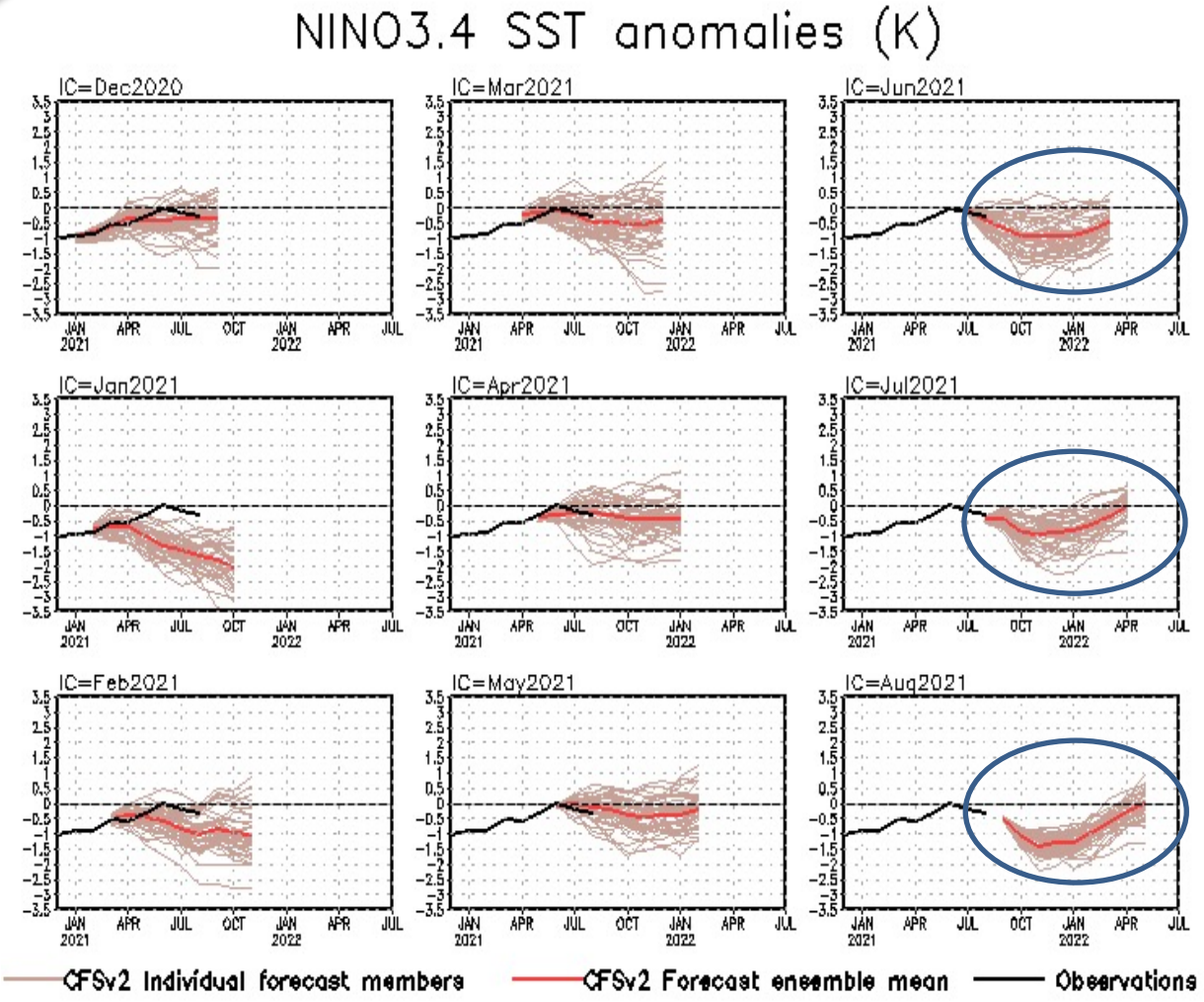


- A majority of dynamical and statistical models predict ENSO-neutral SST conditions likely to persist at least through Sep-Nov season.

- NOAA "ENSO Diagnostics Discussion" on September 9 stated that "*A transition from ENSO-neutral to La Niña is favored in the next couple of months, with a 70-80% chance of La Niña during the Northern Hemisphere winter 2021-22*".



CFSv2 Niño3.4 SST Predictions

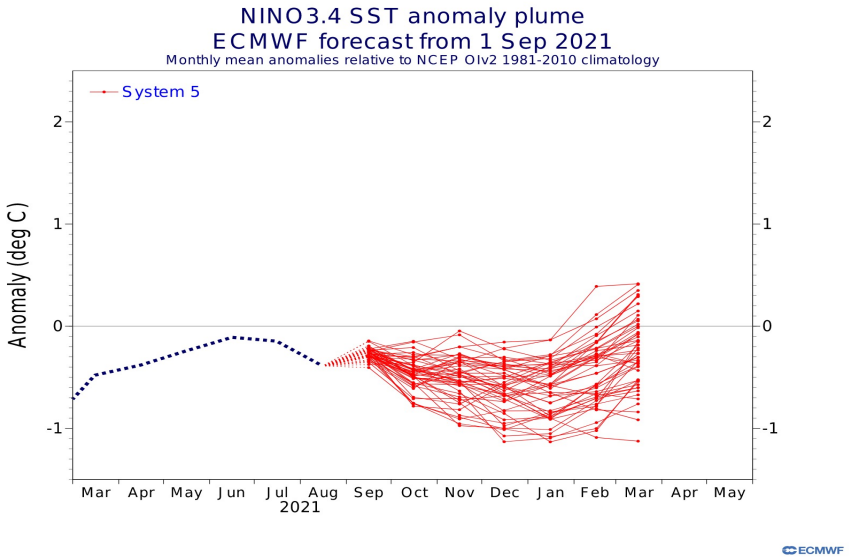


- Latest CFSv2 predictions call for a moderate La Niña in the northern hemisphere 2021/22 winter.

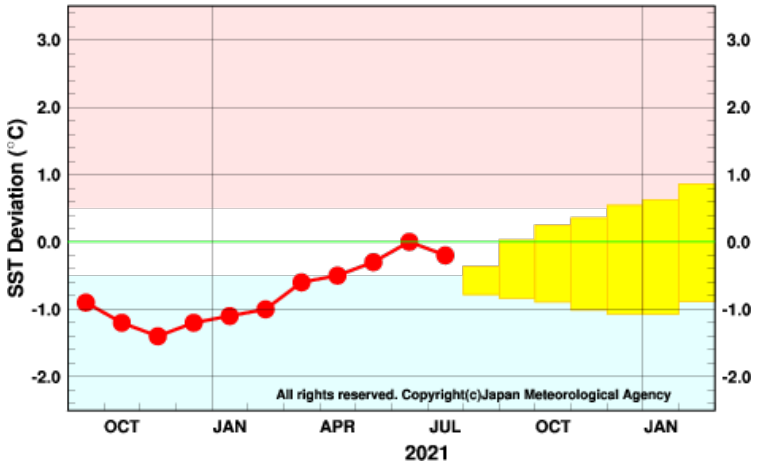
CFS Niño3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect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

Individual Model Niño3.4 Forecasts

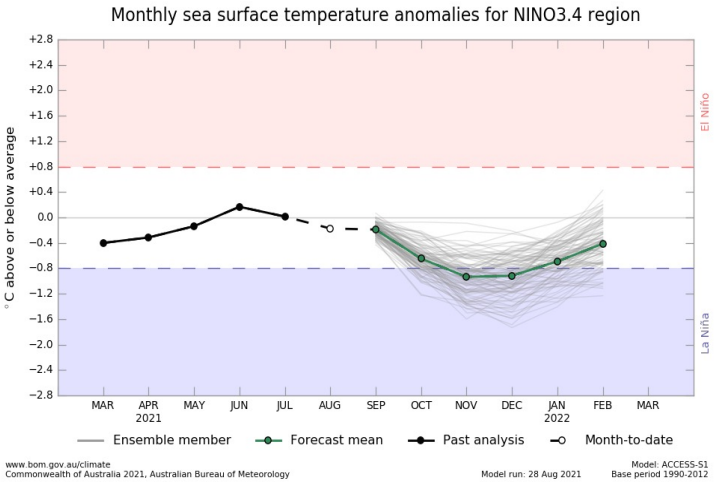
EC: IC= 01 Sep, 2021



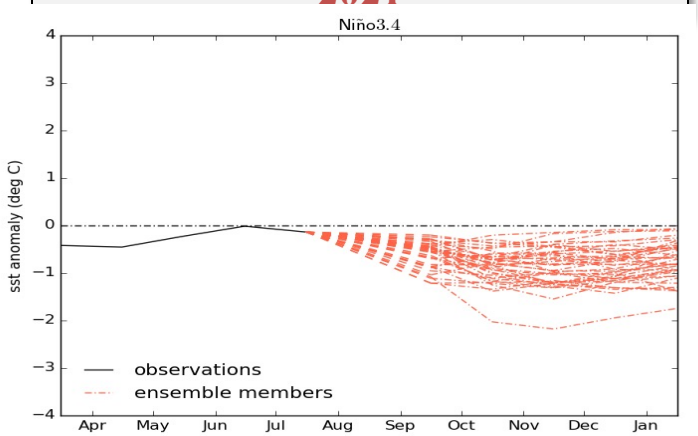
JMA: Updated 11 August, 2021



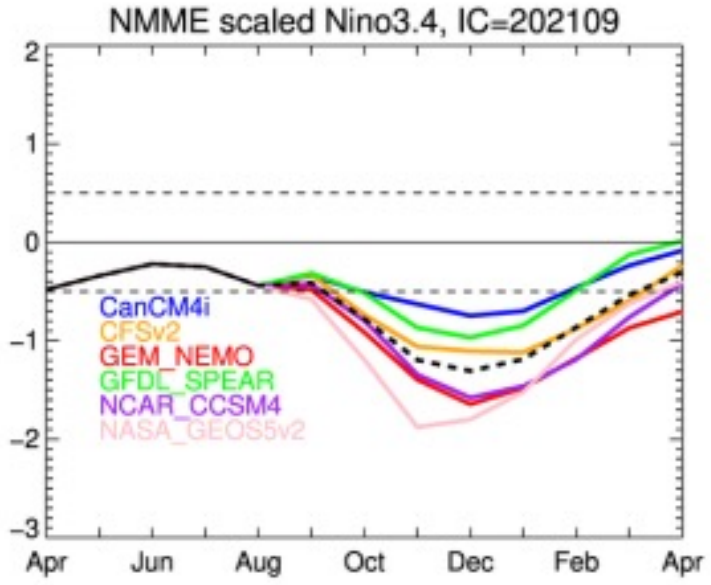
BOM: Updated 28 Aug, 2021

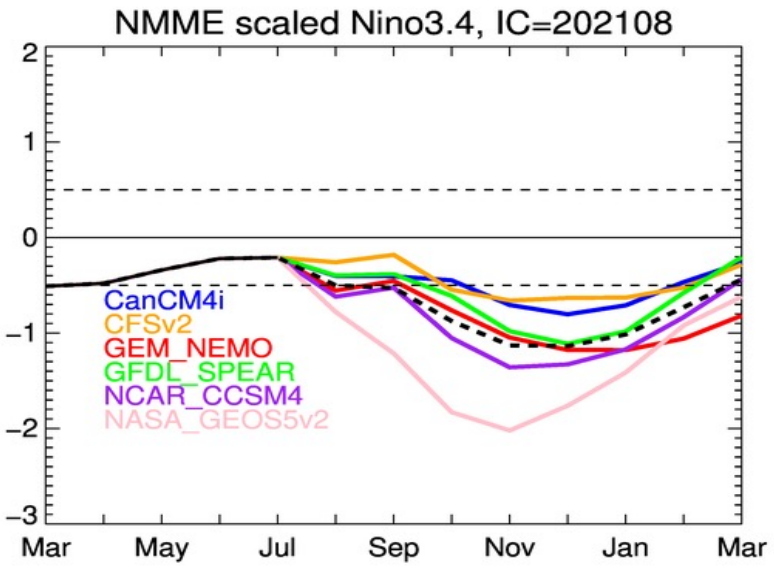


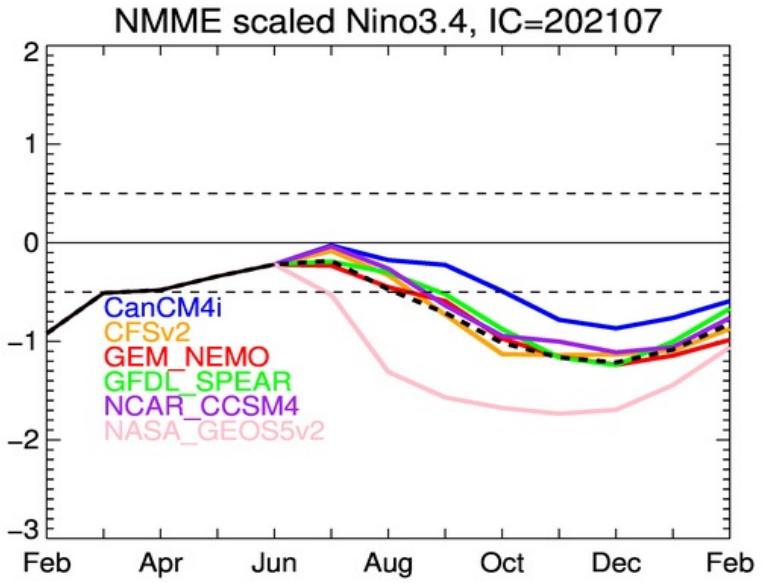
UKMO: Updated 11 August, 2021

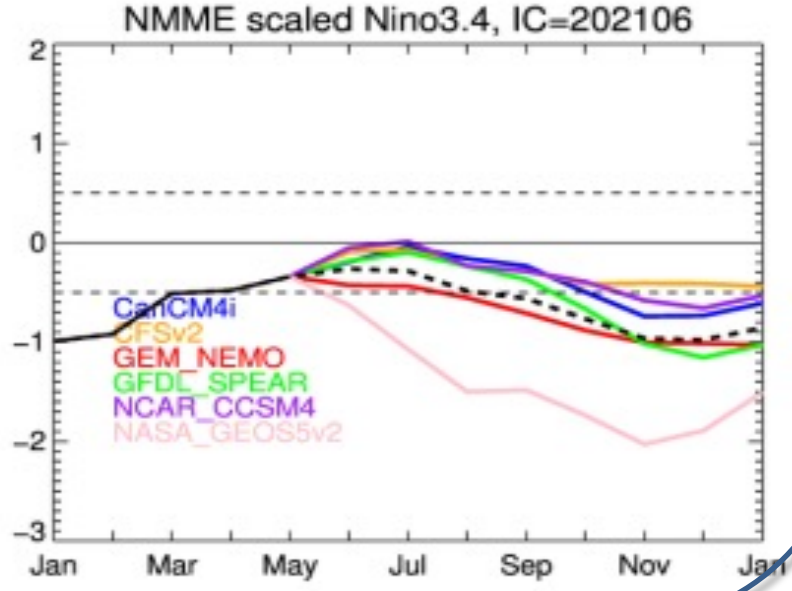


NMME forecasts with the latest 4-month initial conditions

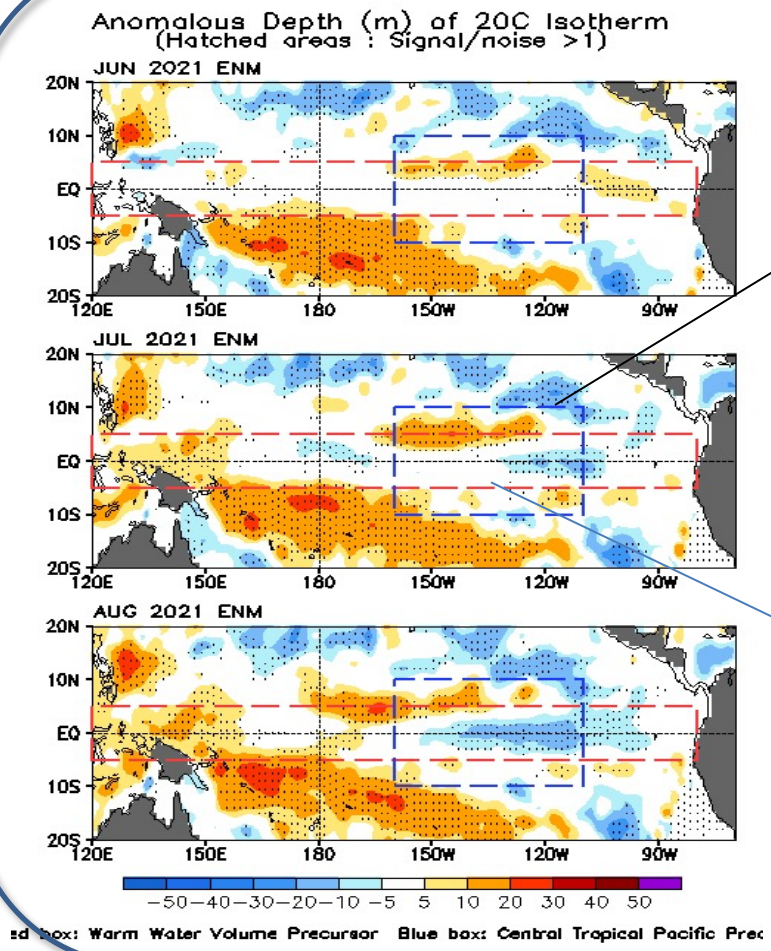


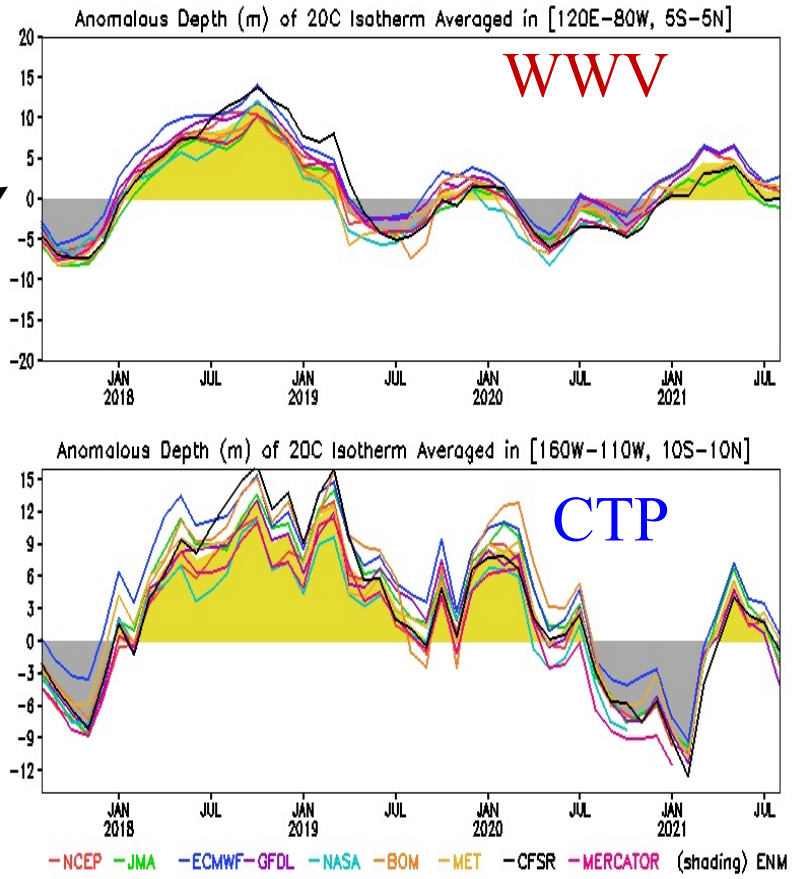






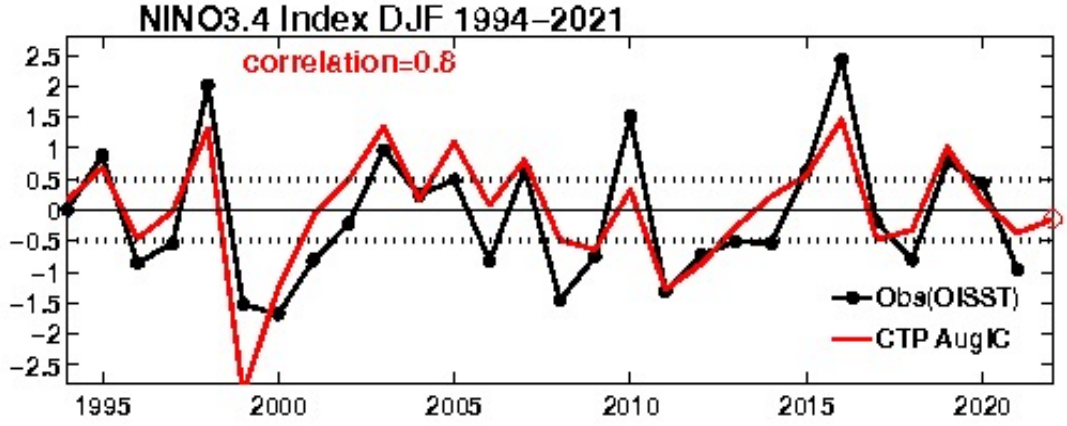
Oceanic ENSO Precursors: WWV & CTP

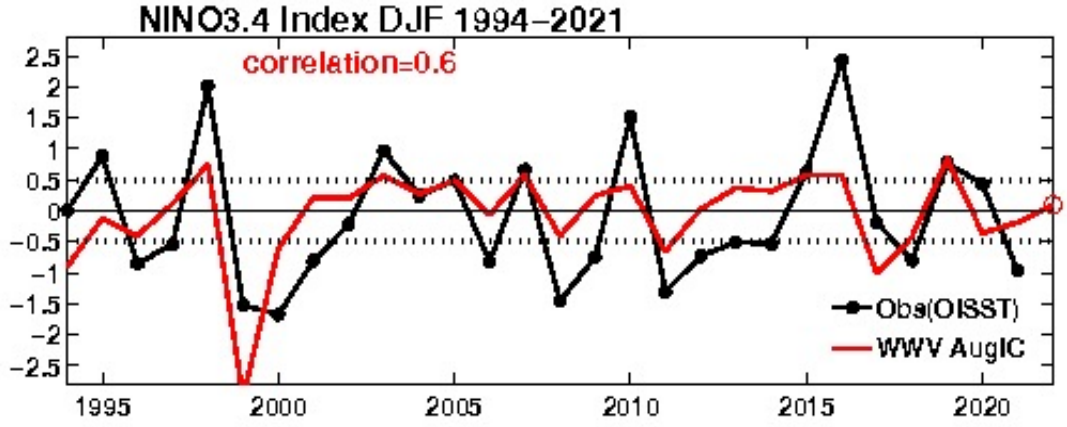




Warm water volume (WWV) is defined as an average of D20 anomaly across the equatorial Pacific (120° E – 80° W, 5° S-5° N) (Meinen and McPhaden 2000). Central tropical Pacific (CTP) index is calculated as the averaged D20 anomaly in the central tropical Pacific (160° W-110° W, 10° S-10° N) (Wen et al.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

DJF Nino34 predictions based on ENSO precursors

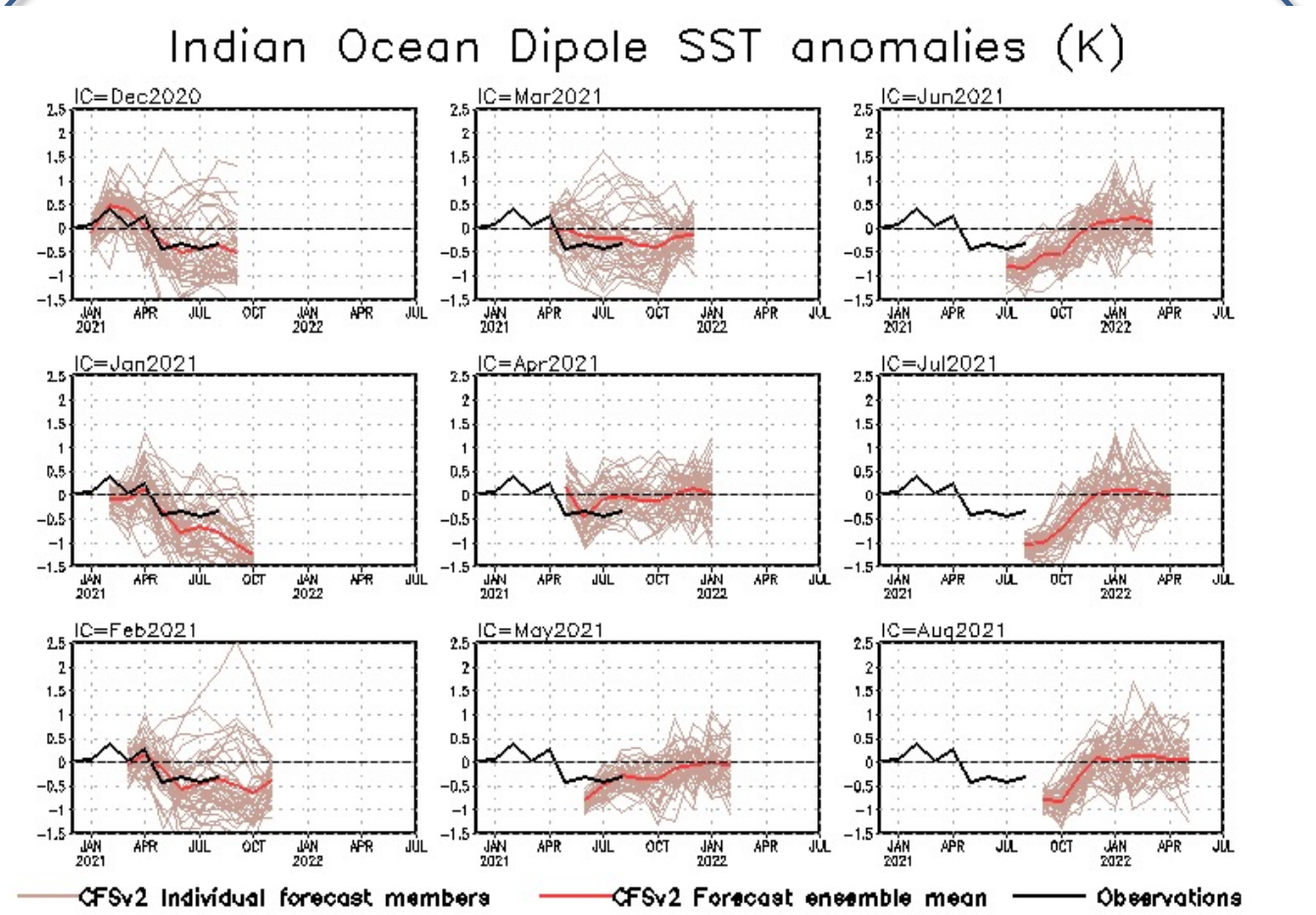




- Both WWV and CTP in August predict ENSO neutral condition in DJF 2022.

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

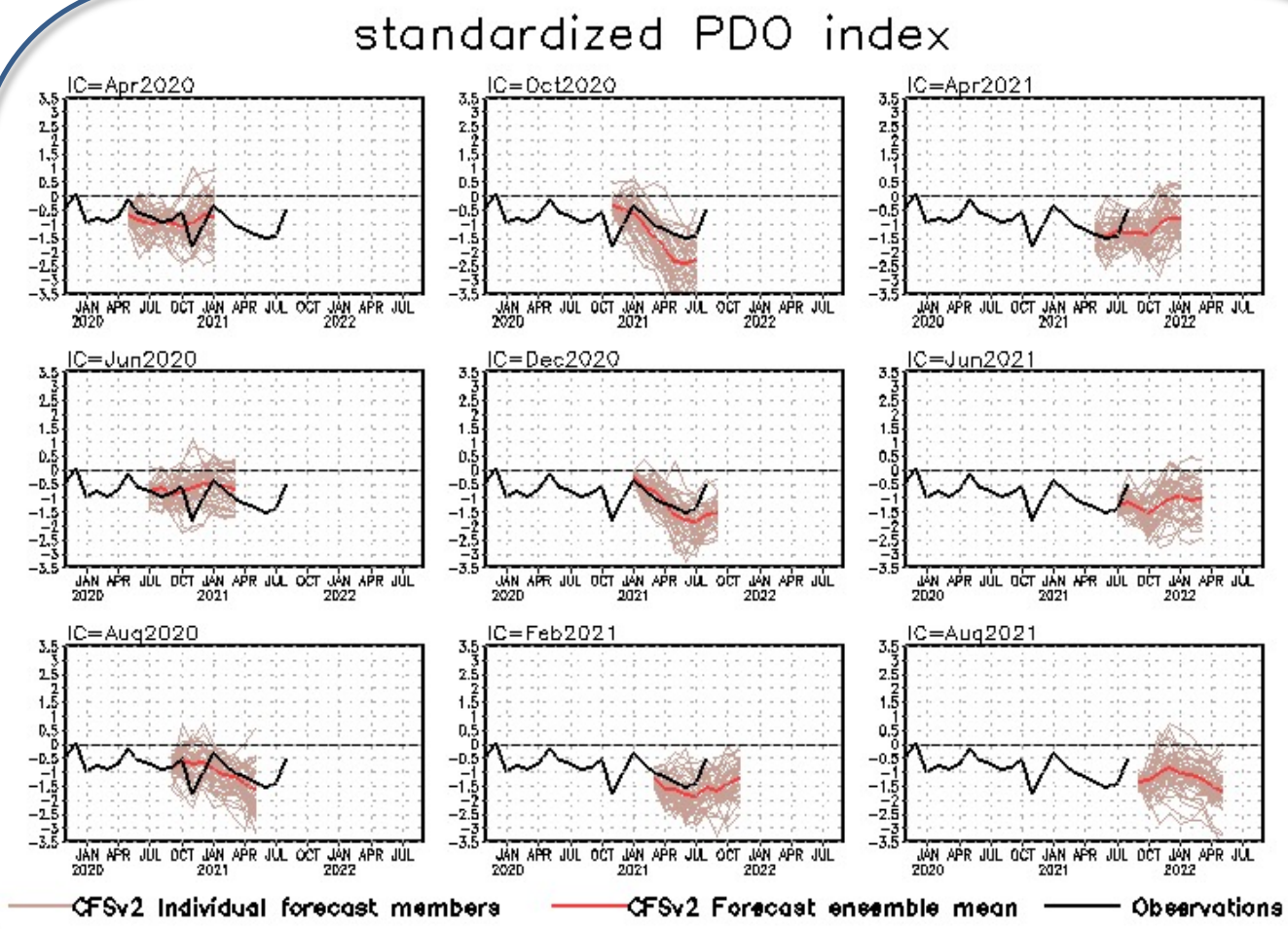
CFSv2 DMI SST Predictions



- Latest CFSv2 predicts the negative IOD event will persist through SON season.

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.

CFSv2 Pacific Decadal Oscillation (PDO) Index Predictions



- CFSv2 predicts a negative phase of PDO in the coming seasons.

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.

Acknowledgements

- Drs. Arun Kumar, Zeng-Zhen Hu, and Jieshun Zhu: reviewed PPT, and provided insightful suggestions and comments

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

- Dr. Wanqiu Wang provided the sea ice forecasts and maintained the CFSv2 forecast archive

Please send your comments and suggestions to:

Arun.Kumar@noaa.gov

Caihong.Wen@noaa.gov

Jieshun.Zhu@noaa.gov

Zeng-Zhen.Hu@noaa.gov

Data Sources (climatology is for 1991-2020)

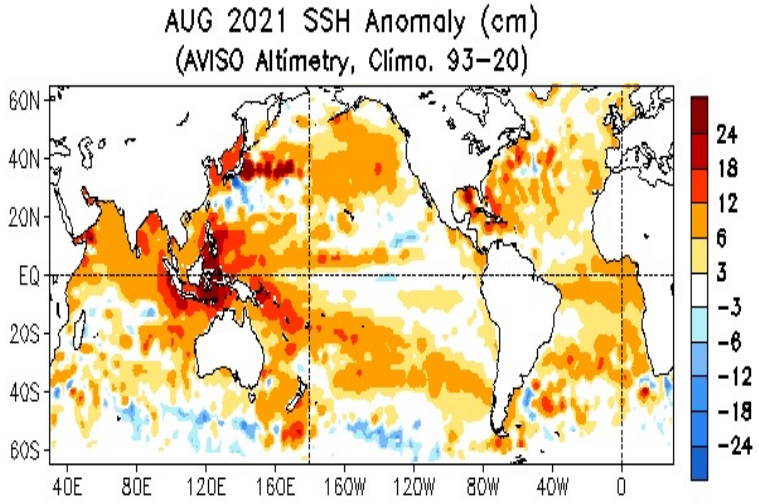
- **Weekly Optimal Interpolation SST (OI SST) version 2 (Reynolds et al. 2002)**
- **Extended Reconstructed SST (ERSST) v5 (Huang et al. 2017)**
- **Blended Analysis of Surface Salinity (BASS) (Xie et al. 2014)**
- **CMORPH precipitation (Xie et al. 2017)**
- **CFSR evaporation adjusted to OAFlux (Xie 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**

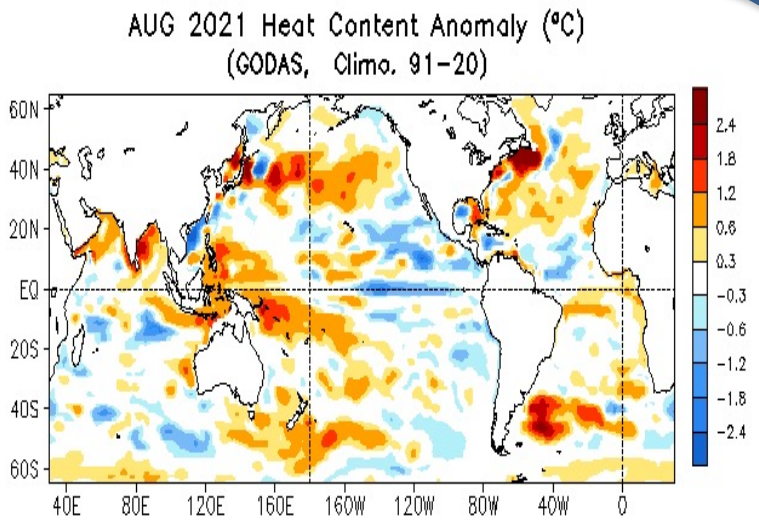
  http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html

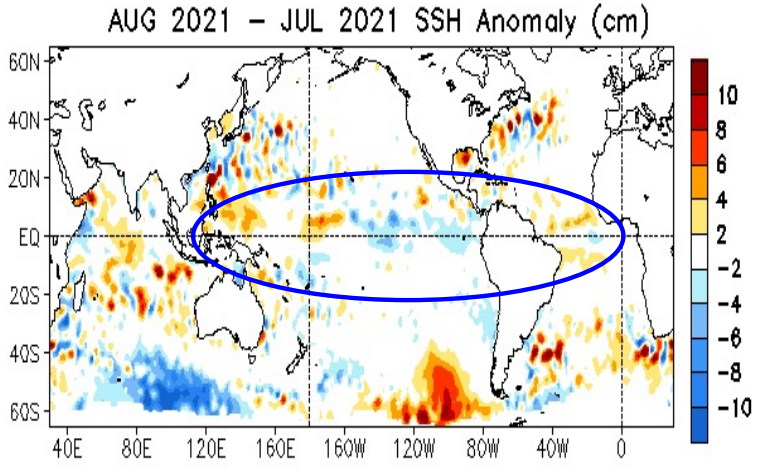
  http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html

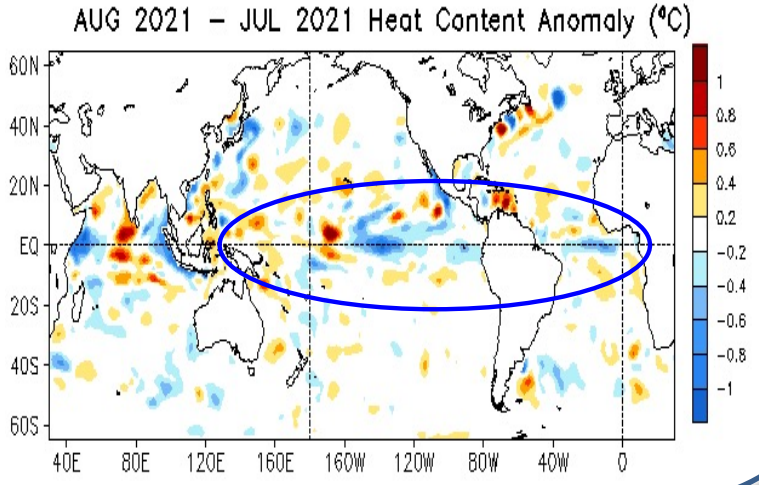
Backup Slides

Global SSH and HC300 Anomaly & Anomaly Tendency



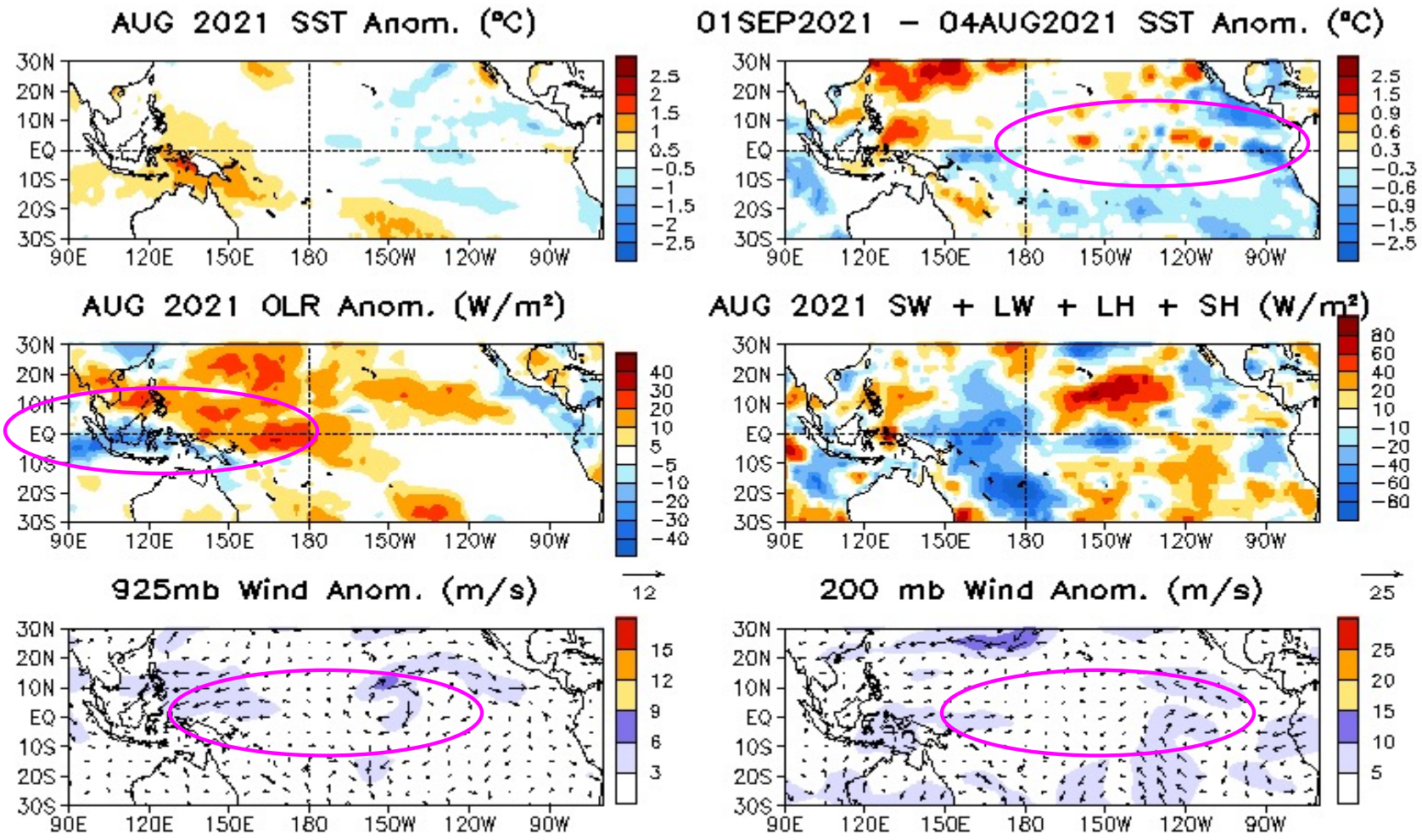






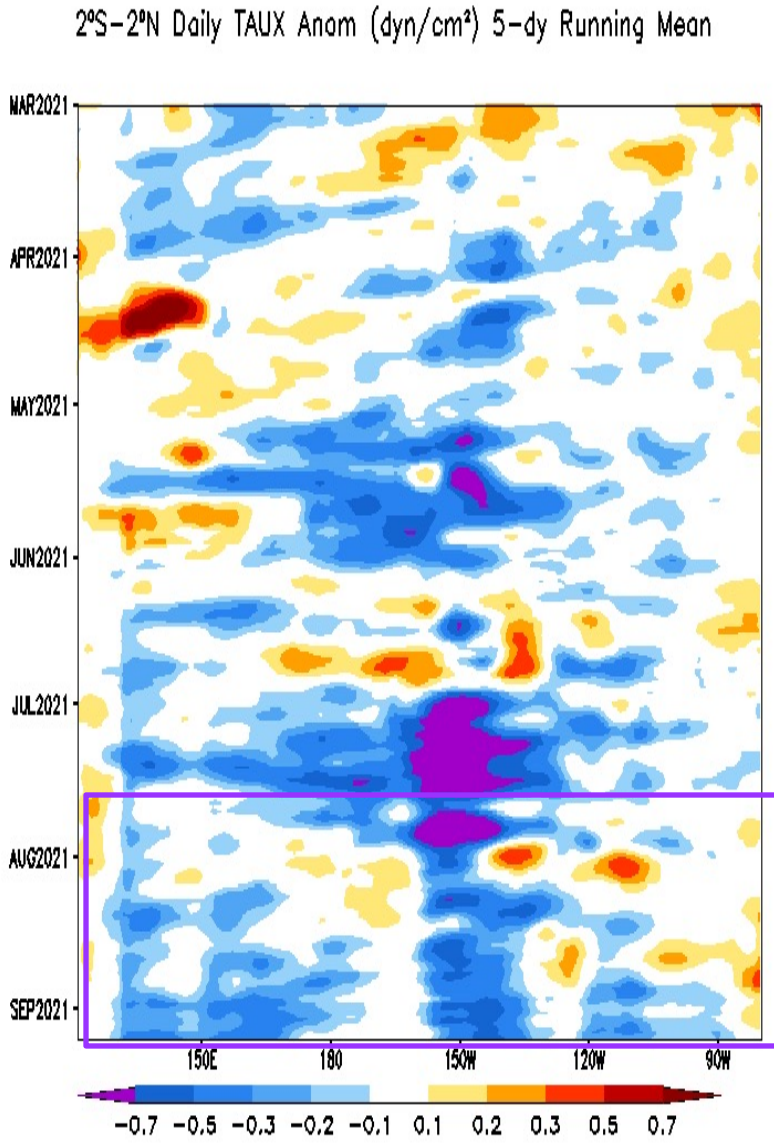
- The SSHA pattern was overall consistent with the HC300A pattern, but with a significant trend component in SSHA.
- Positive anomalies were present in the equatorial Atlantic.
- Negative tendencies were observed across most of the equatorial Pacific.

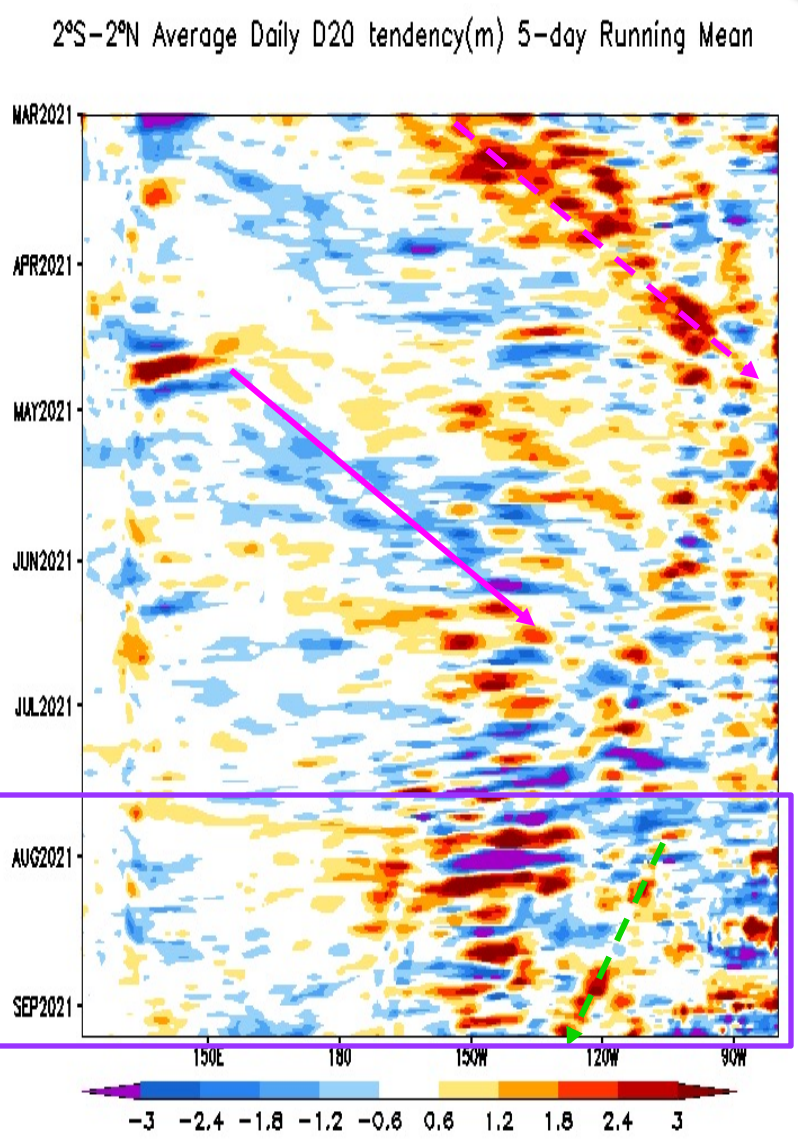
Tropical Pacific: SSTA, SSTA Trend, OLR, heat flux, uv925 & uv200 anomalies



Sea surface temperature (SST) anomalies (top-left), anomaly 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 NCEP 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.

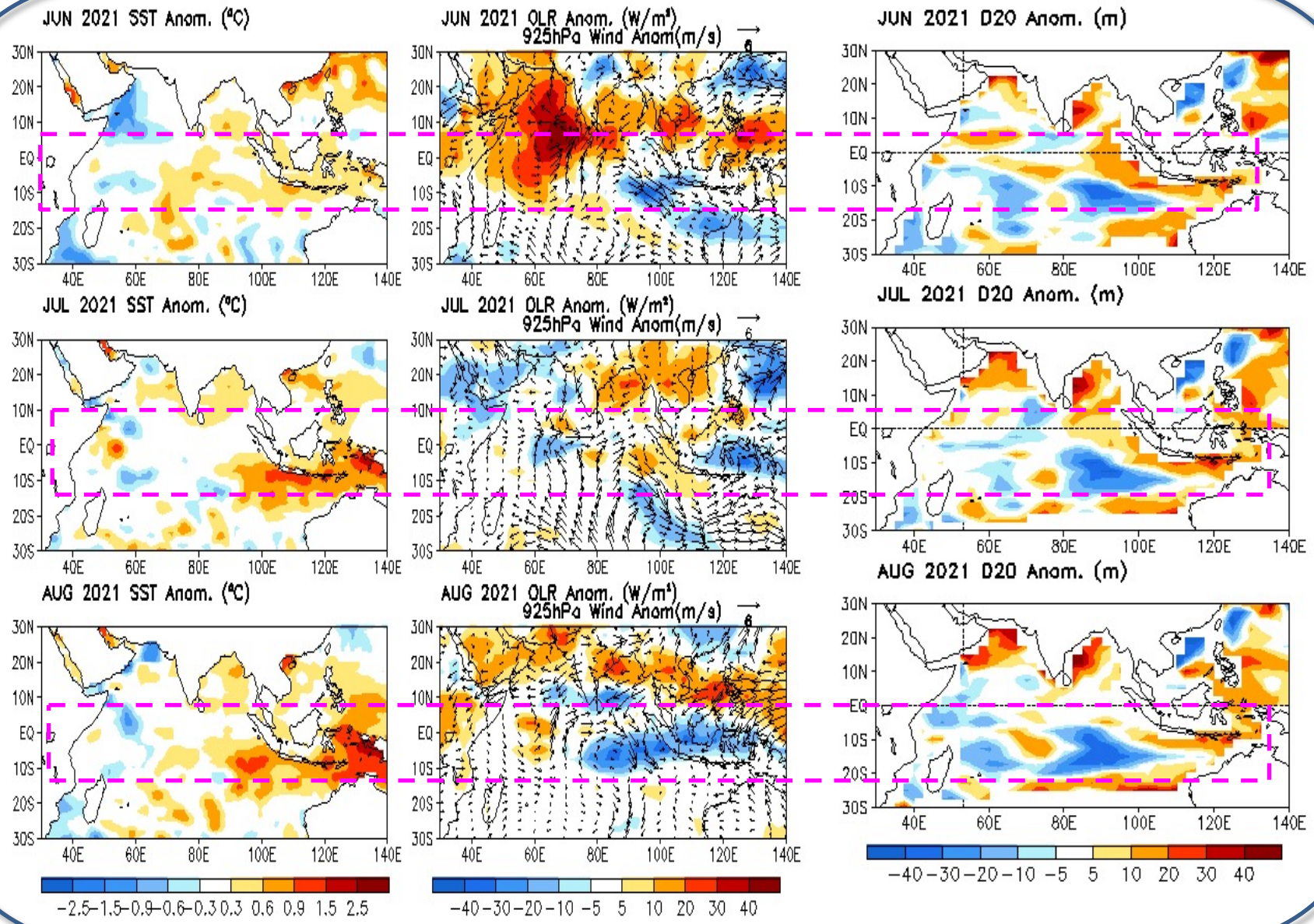
Daily Equatorial Zonal Wind stress anomaly and D20 Tendency



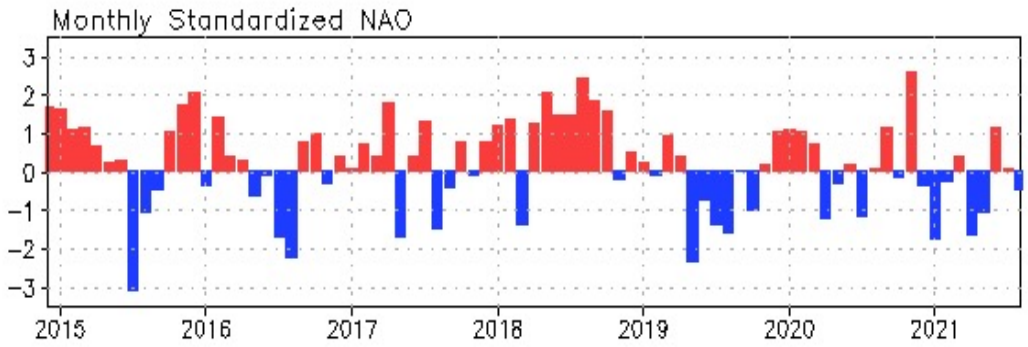


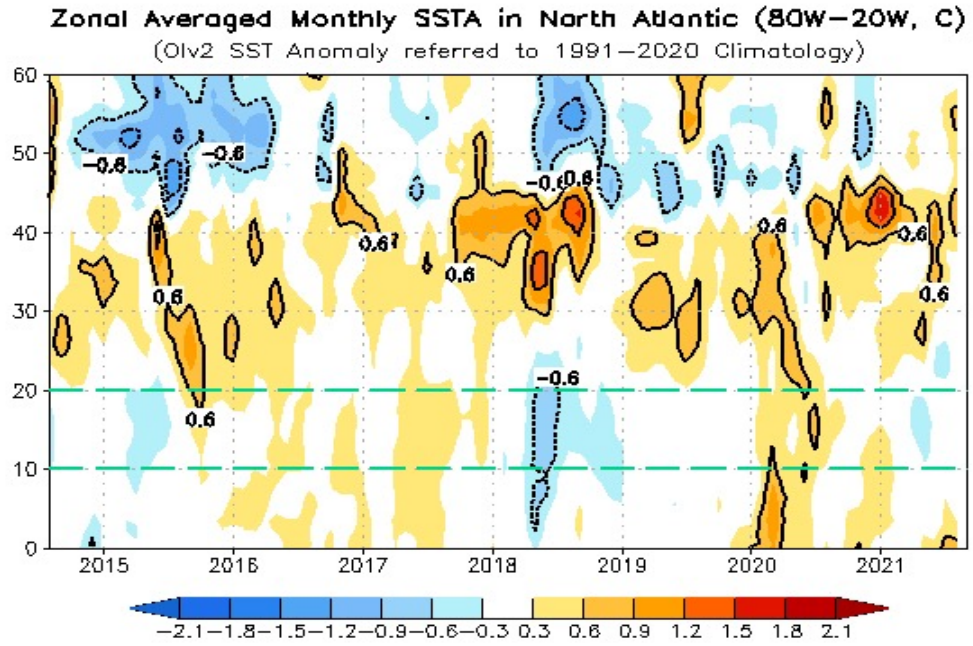
Data source: NCEP GODAS

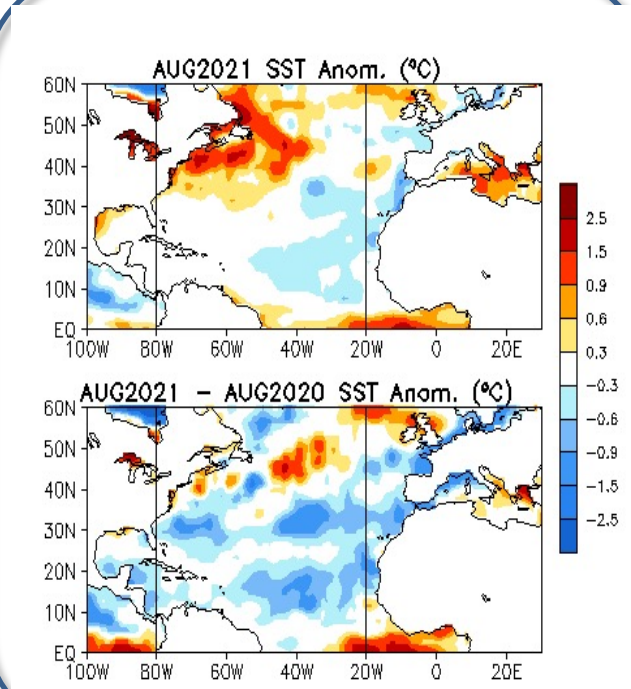
Latest 3-month Tropical Indian SST , OLR & uv925 and D20 anomalies



NAO and SST Anomaly in North Atlantic



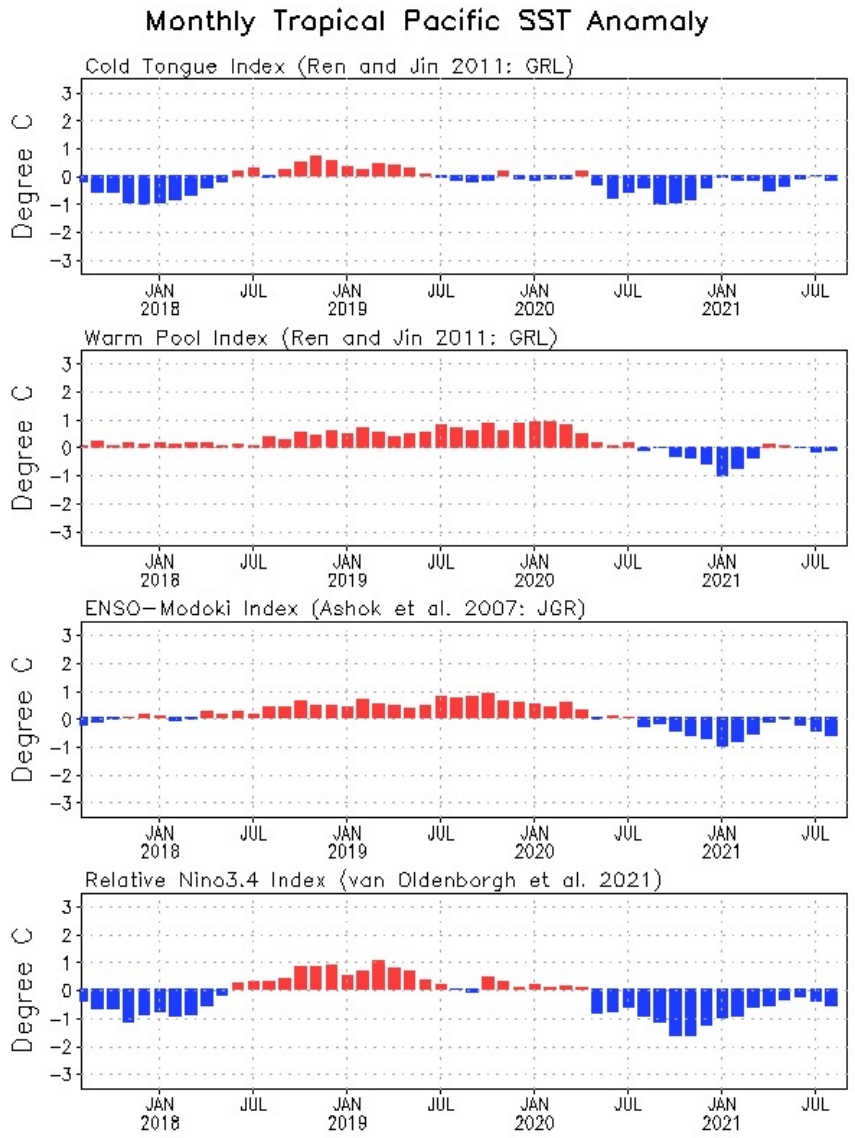


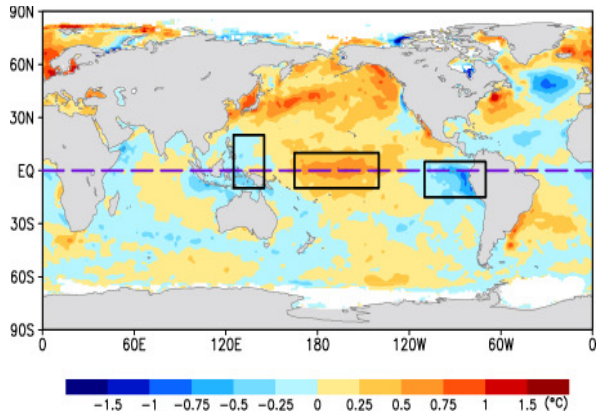


- NAO switched to negative phase in Agu 2021.
- The prolonged positive SSTAs in the middle latitudes were evident, due to the domination of the positive phase of NAO during the last 5-6 years.

Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20°N-90°N (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80ºW and 20ºW (bottom). SST are derived from the NCEP OI SST analysis, and anomalies are departures from the 1991-2020 base period means.

Evolution of Pacific Niño SST Indices



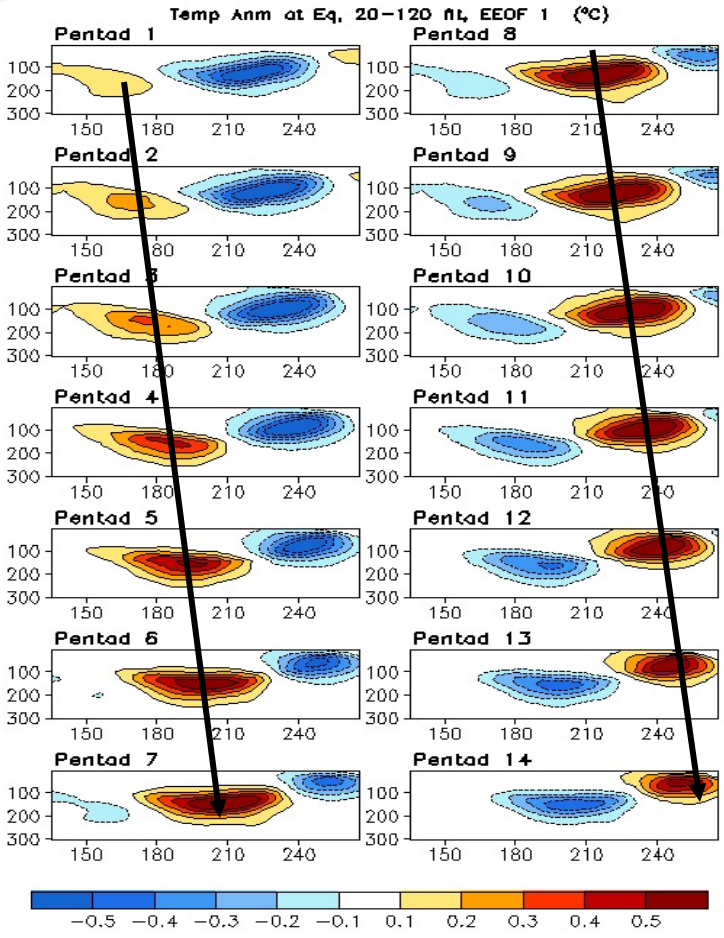


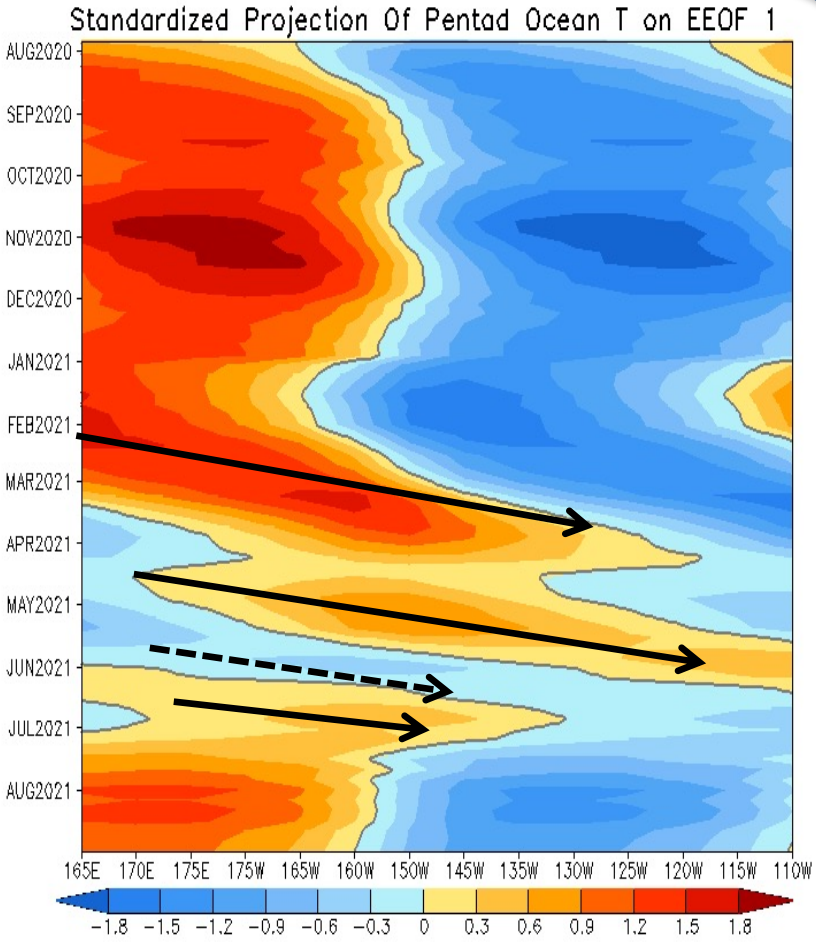
- Relative Niño3.4 index is now included in ENSO monitoring, which is defined as the conventional Niño3.4 index minus the SSTA averaged in the whole tropics (0º-360º, 20ºS-20ºN), in order to remove the global warming signal. Also, to have the same variability as the conventional Niño3.4 index, the relative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





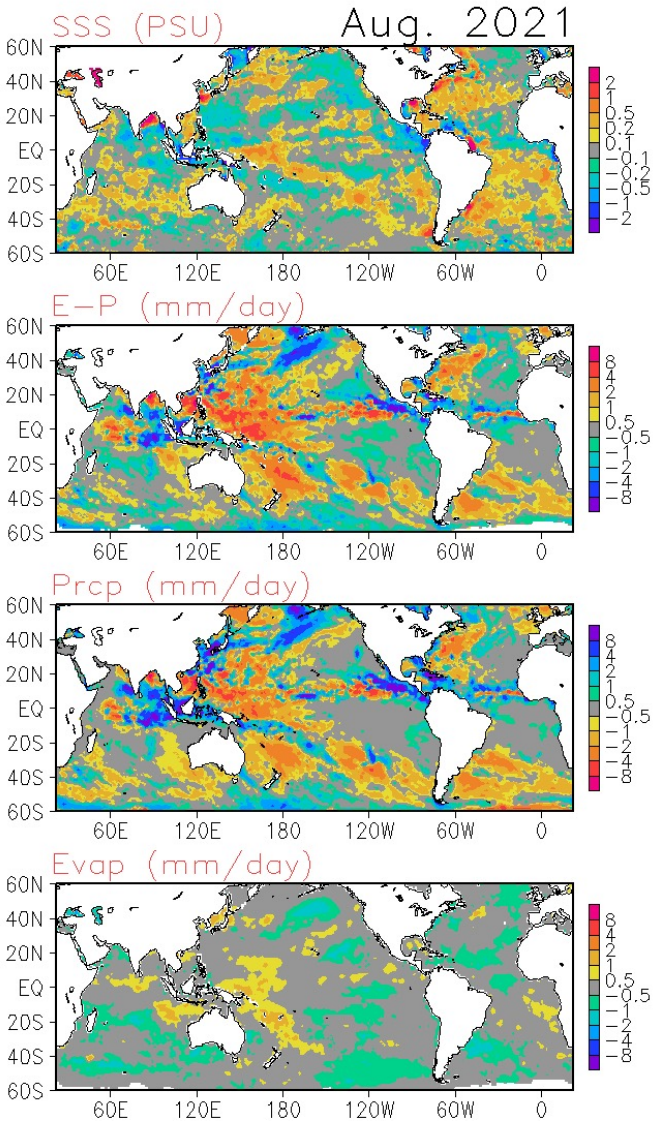
- Two weak downwelling Kelvin waves were initiated in Feb and Apr 2021, respectively, consisting with the weakening of La Niña.

(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).)

Global Sea Surface Salinity (SSS): Anomaly for August 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 still continues but likely weakens in the western equatorial Pacific Ocean and SPCZ region. Negative SSS anomaly also continues in the eastern equatorial Pacific Ocean, which is likely caused by increased precipitation. Negative SSS anomaly in the northeast Pacific Ocean is accompanied with enhanced precipitation. Positive SSS anomaly continues between 20°N/20°S and 40°N/40°S in the Atlantic Ocean. Negative SSS anomaly appears in the east Indian Ocean possibly due to increased precipitation.



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

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

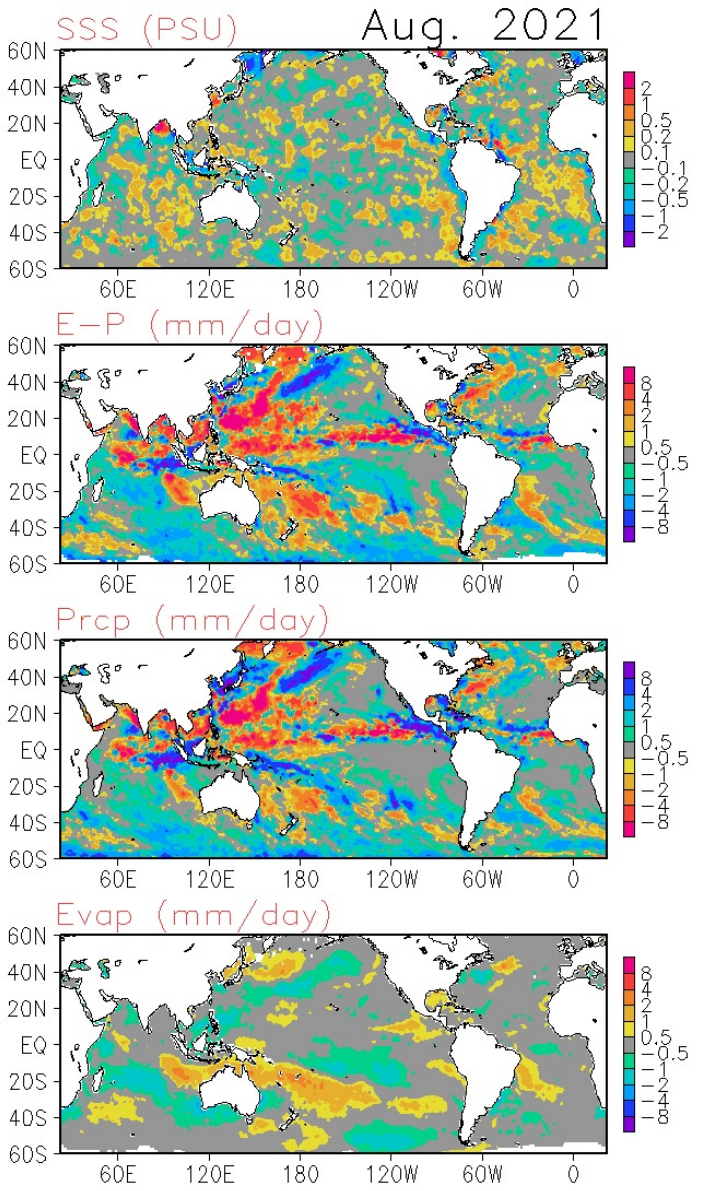
ftp.cpc.ncep.noaa.gov/precip/BASS

Precipitation: CMORPH adjusted satellite precipitation estimates

Evaporation: Adjusted CFS Reanalysis

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

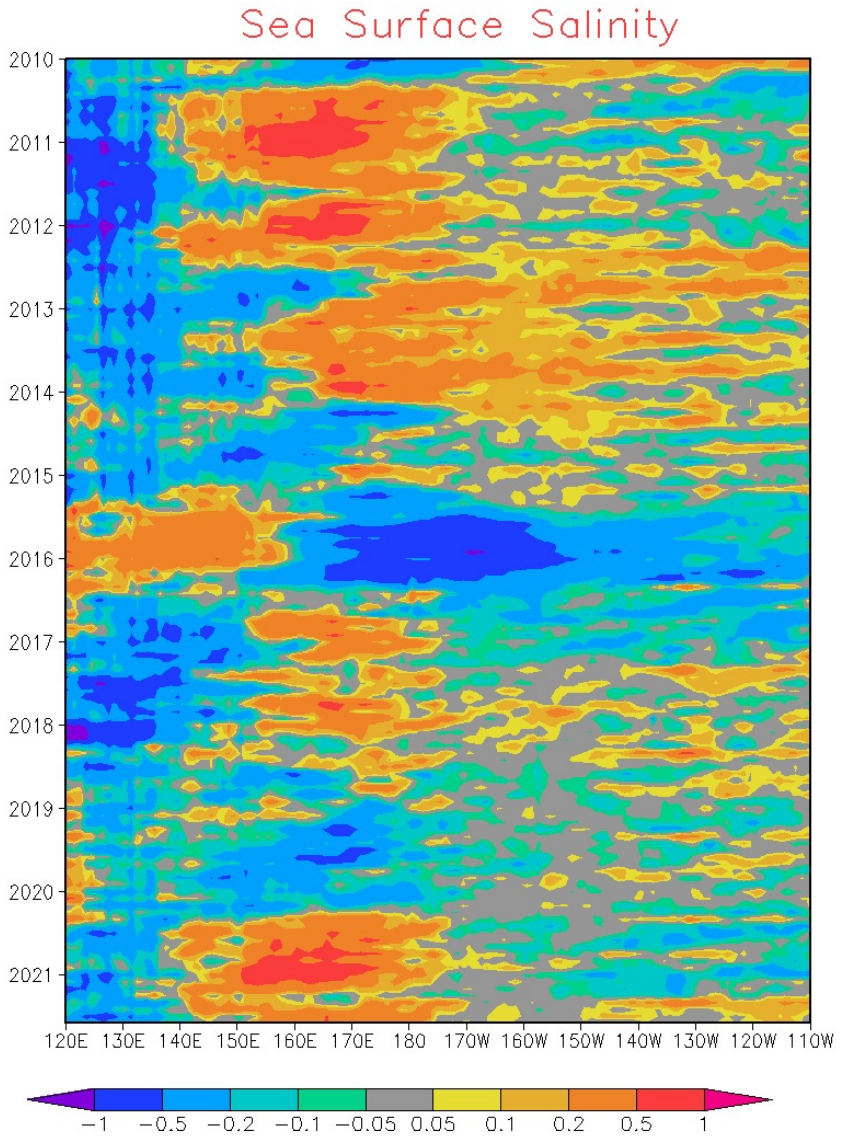
Compared with last month, SSS decreased in the western equatorial Pacific Ocean and SPCZ region. While, SSS increased in the east Equatorial Pacific Ocean, especially between 130°W and 110°W. SSS increased in the south Atlantic Ocean likely being caused by oceanic advection. SSS decreased in the Indian Ocean in most areas north of equator, except northern basin of Bay of Bengal.



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 also continues between 140°E and 170°W; while positive SSS signal appears 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.