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

Prepared by

Climate Prediction Center, NCEP/NOAA

August 10, 2021

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

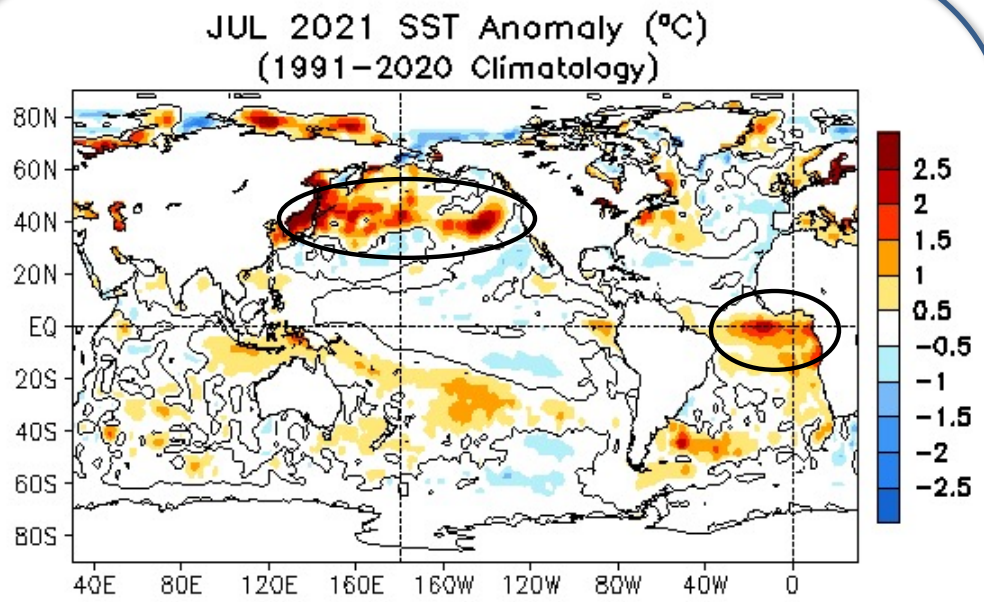
- Overview
- Recent highlights
  - Pacific/Arctic Ocean
  - Indian Ocean
  - Atlantic Ocean
- Global SST Anomaly Predictions

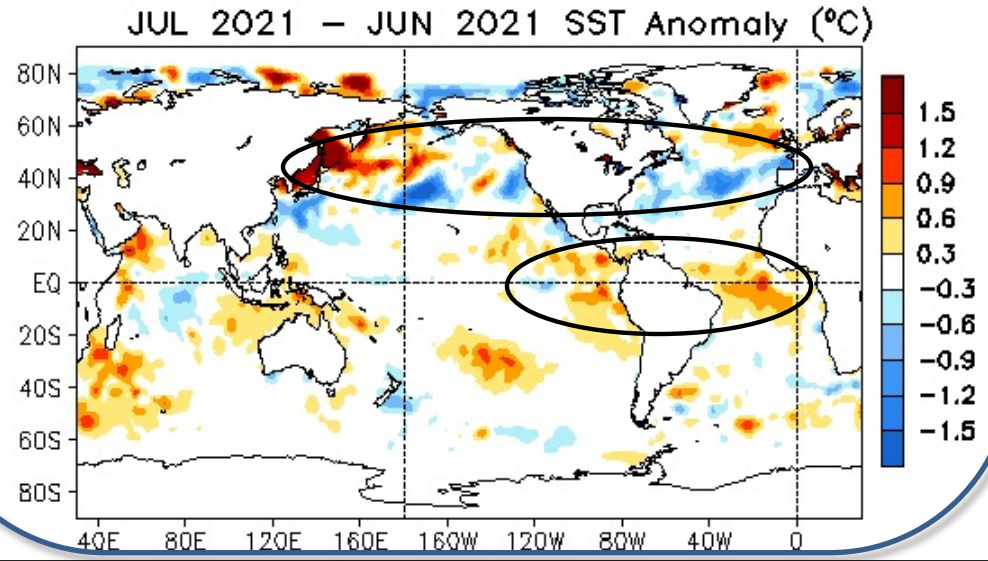
# Overview

- Pacific Ocean
  - ENSO neutral conditions continued in Jul 2021.
  - The negative phase of PDO has persisted since Jan 2020 with PDOI = -1.4 in Jul 2021.
  - MHWs were present in the N.E. Pacific.
- Indian Ocean
  - Negative Indian Ocean dipole (IOD) index persisted in Jul 2021, with IOD = -0.6C.
- Atlantic Ocean
  - Positive SSTA enhanced in the equatorial Atlantic Ocean in Jul 2021, developing into an extremely strong Atlantic Niño event.
  - NOAA's updated Atlantic Hurricane Season Outlook call for above-normal Atlantic hurricane season with 65% chance.
- Arctic Ocean
  - The monthly average extent for Jul 2021 ranks the fourth lowest in the satellite record.
  - With ICs in Jul 2021, NCEP/CPC predicted a well below-normal sea ice extent during summer and autumn 2021.

# Global Oceans

# Global SST Anomaly (°C) and Anomaly Tendency



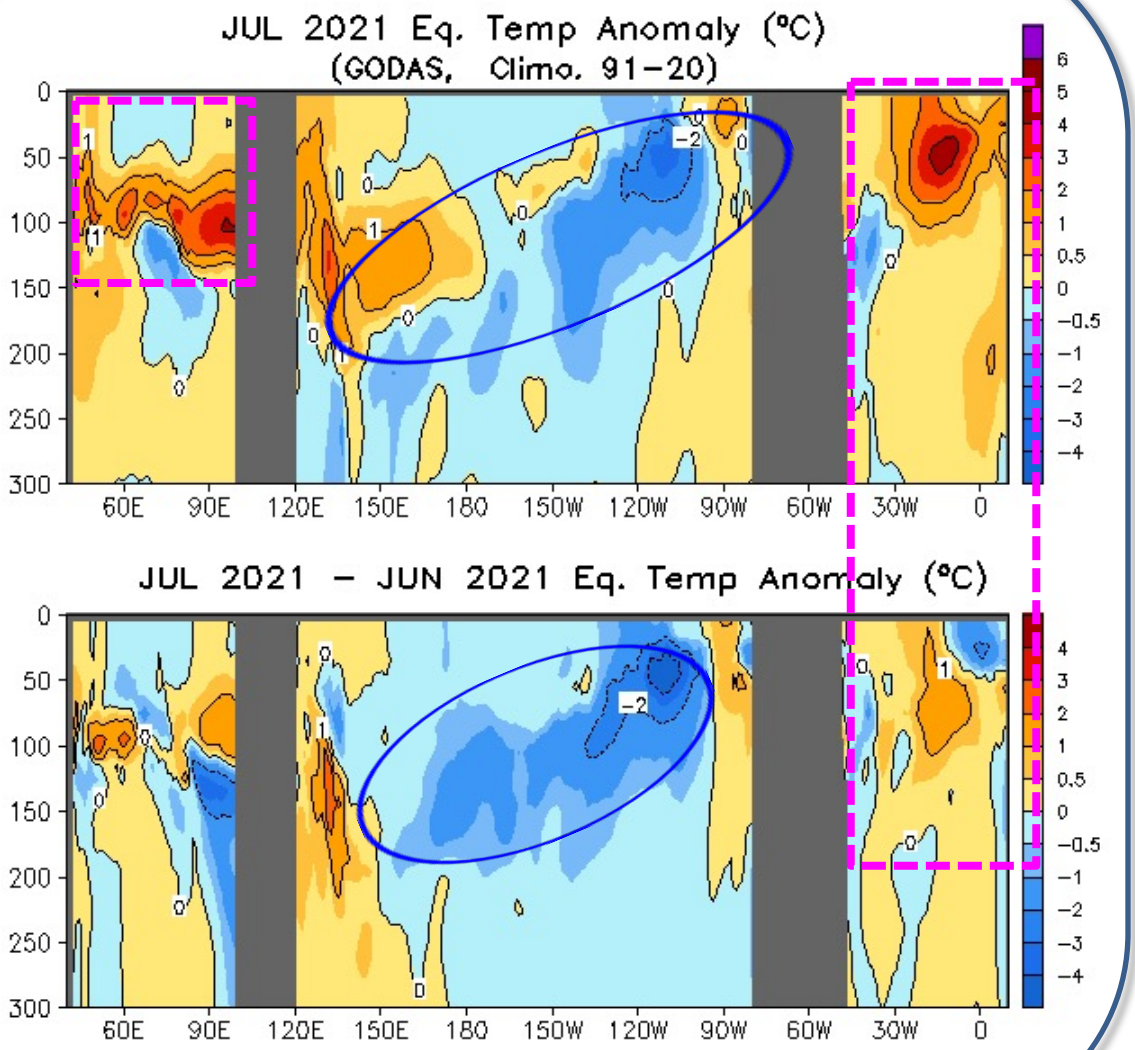




- SSTAs were small in most of the tropical Pacific and Indian Oceans.
- Positive SSTAs were present in mid-latitude of north Pacific.
- Positive SSTAs continued in the equatorial Atlantic Ocean and along the coast of African.

- Positive SSTA tendencies were present in the eastern equatorial Pacific and Atlantic Oceans.
- Large SSTA tendency 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



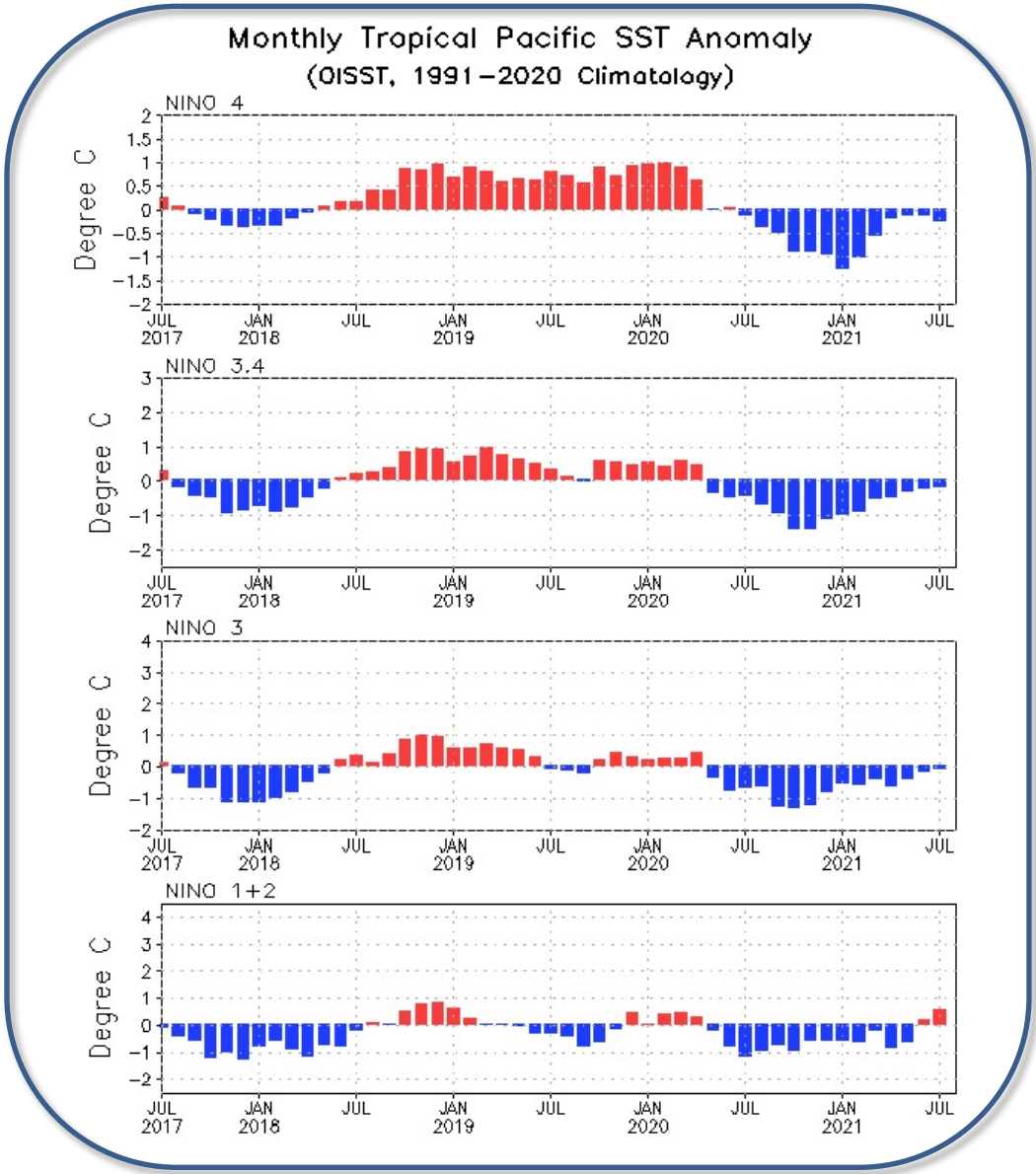

- Negative (positive) subsurface ocean anomalies were present along the central-eastern (western and far-eastern) thermocline in the equatorial Pacific.
- Positive anomalies continued in equatorial Atlantic Ocean, associated with the ongoing Atlantic Niño event.
- Positive subsurface anomalies persisted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

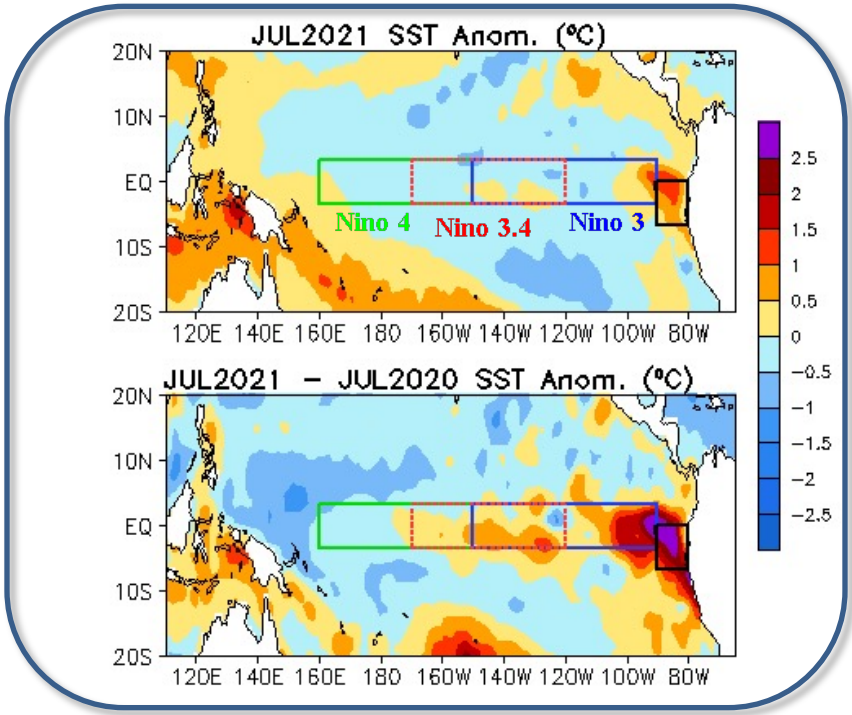
- Negative temperature anomaly tendency dominated along central-eastern thermocline in the equatorial Pacific.

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

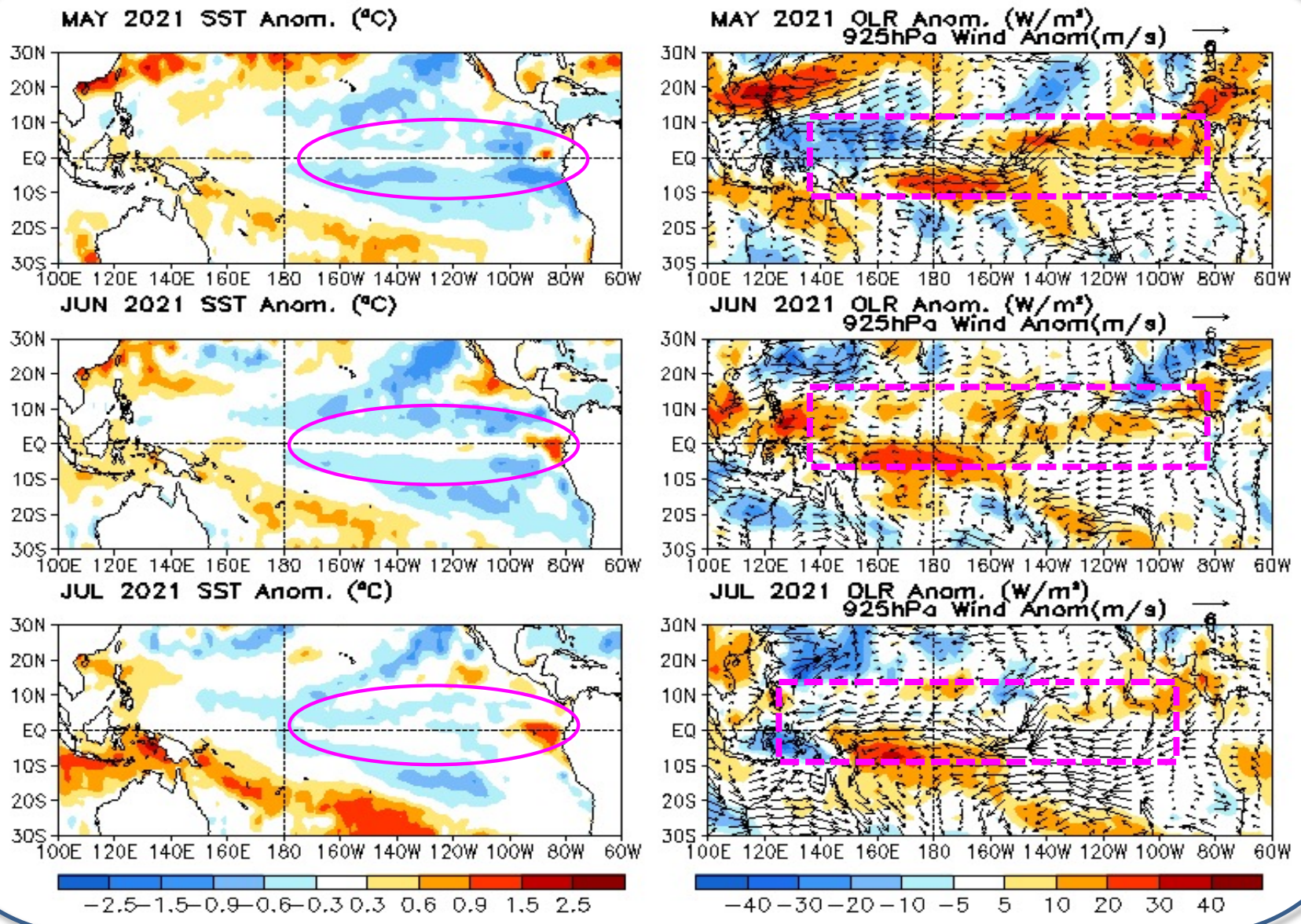


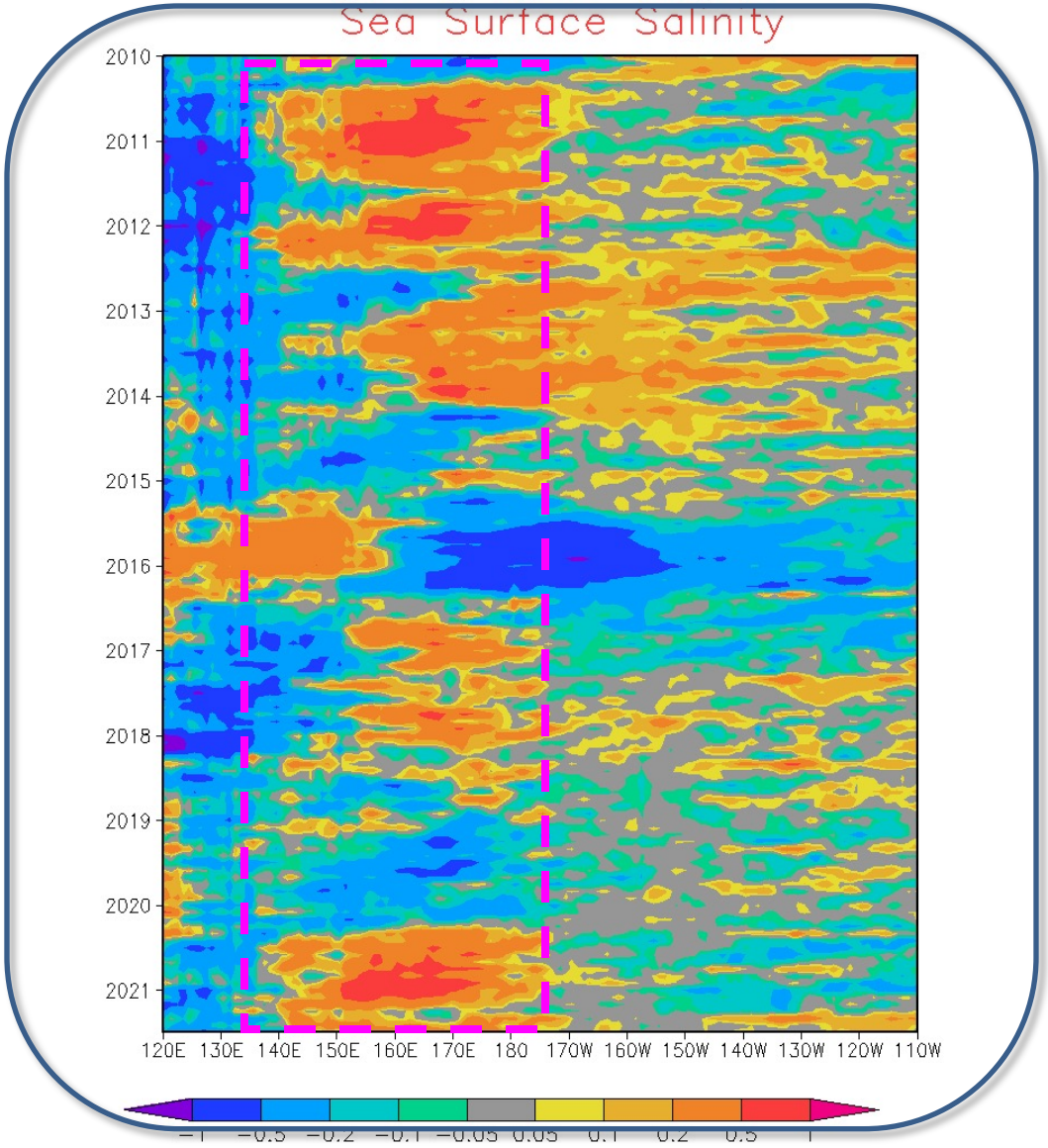

- Both negative Niño4 and positive Niño 1+2 enhanced in Jul 2021.
- Niño3.4 in Jul 2021 was -0.2°C .
- Compared with Jul 2020, the central and eastern equatorial Pacific was warmer in Jul 2021.
- The indices may have slight differences if based on different SST products.

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 Sea Surface Salinity(SSS) Anomaly

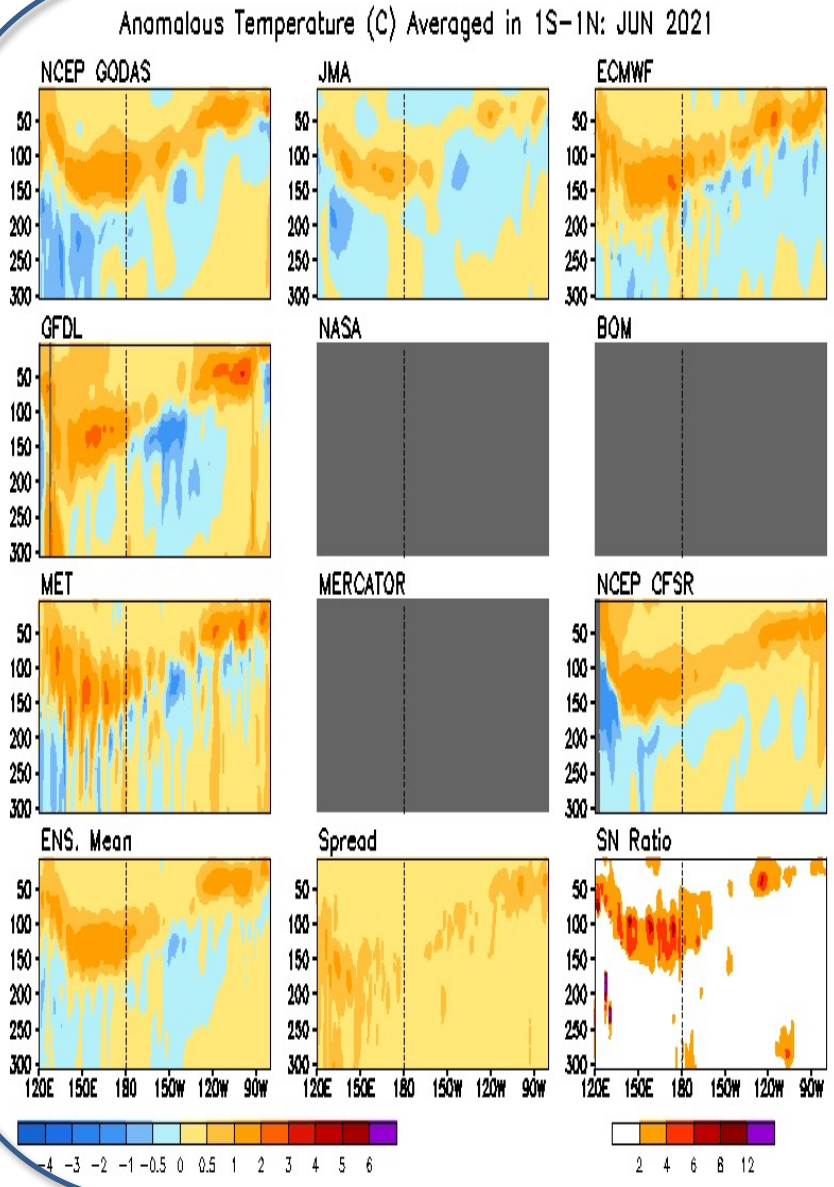


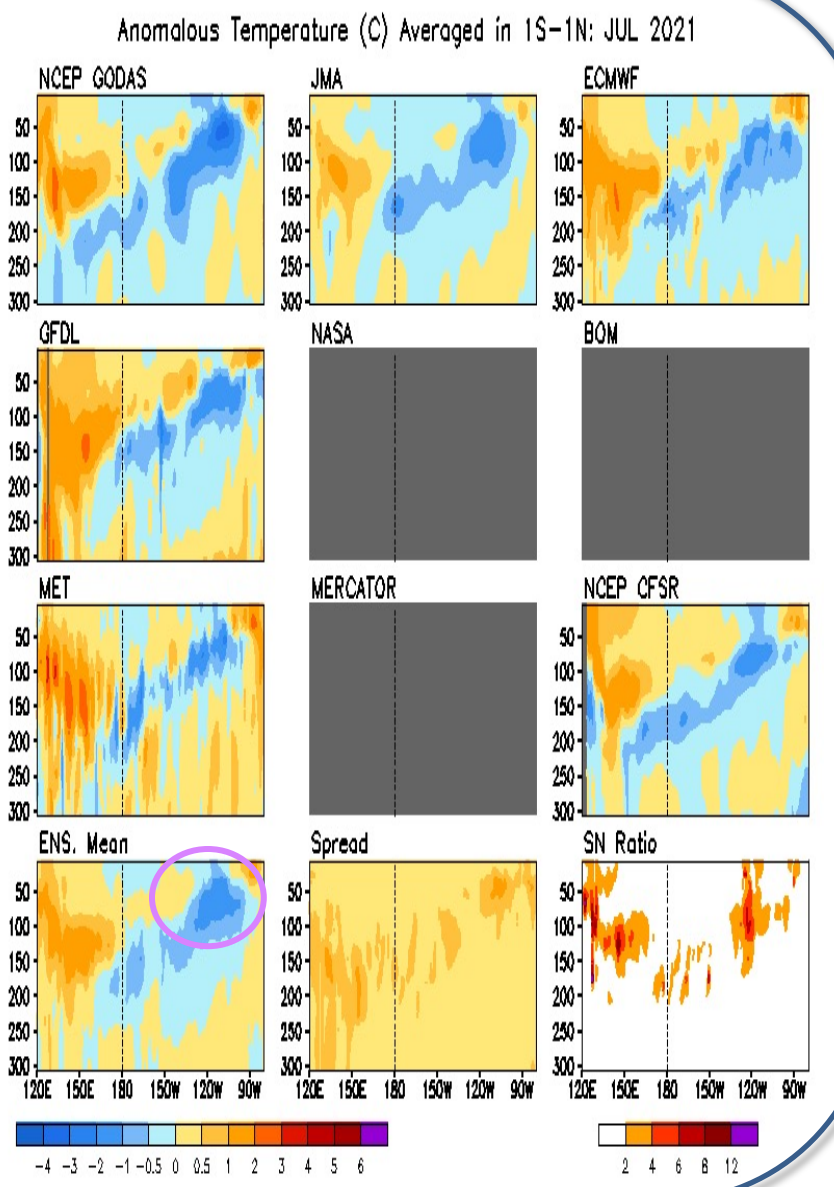

- Positive (negative) SSS anomaly presented east (west ) of 140E during 2010, 2011, 2016,2017, 2020 La Nina events.

- Positive SSS anomaly was present around 140E-170W in Jul 2021.

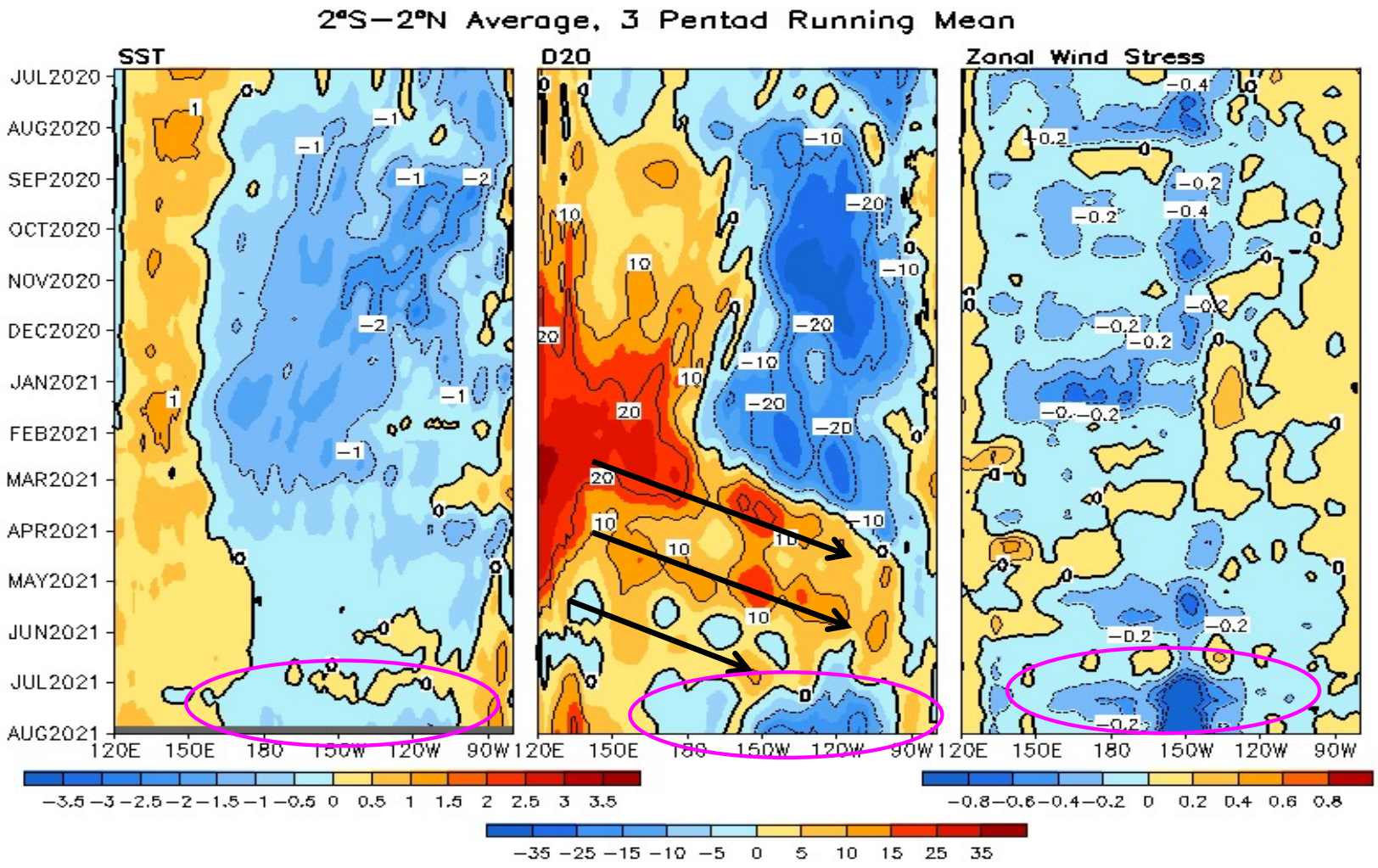
Sea surface salinity (SSS) anomalies are derived from Blended Analysis of Surface Salinity (BASS) V0.Z (Xie et al. 2014). Since June 2015, the BASS SSS is from in situ, SMOS and SMAP; before June 2015,The BASS SSS is from in situ, SMOS and Aquarius. Data is available at ftp.cpc.ncep.noaa.gov/precip/BAS.

# Multiple Ocean Reanalysis: Temperature anomaly at Equator



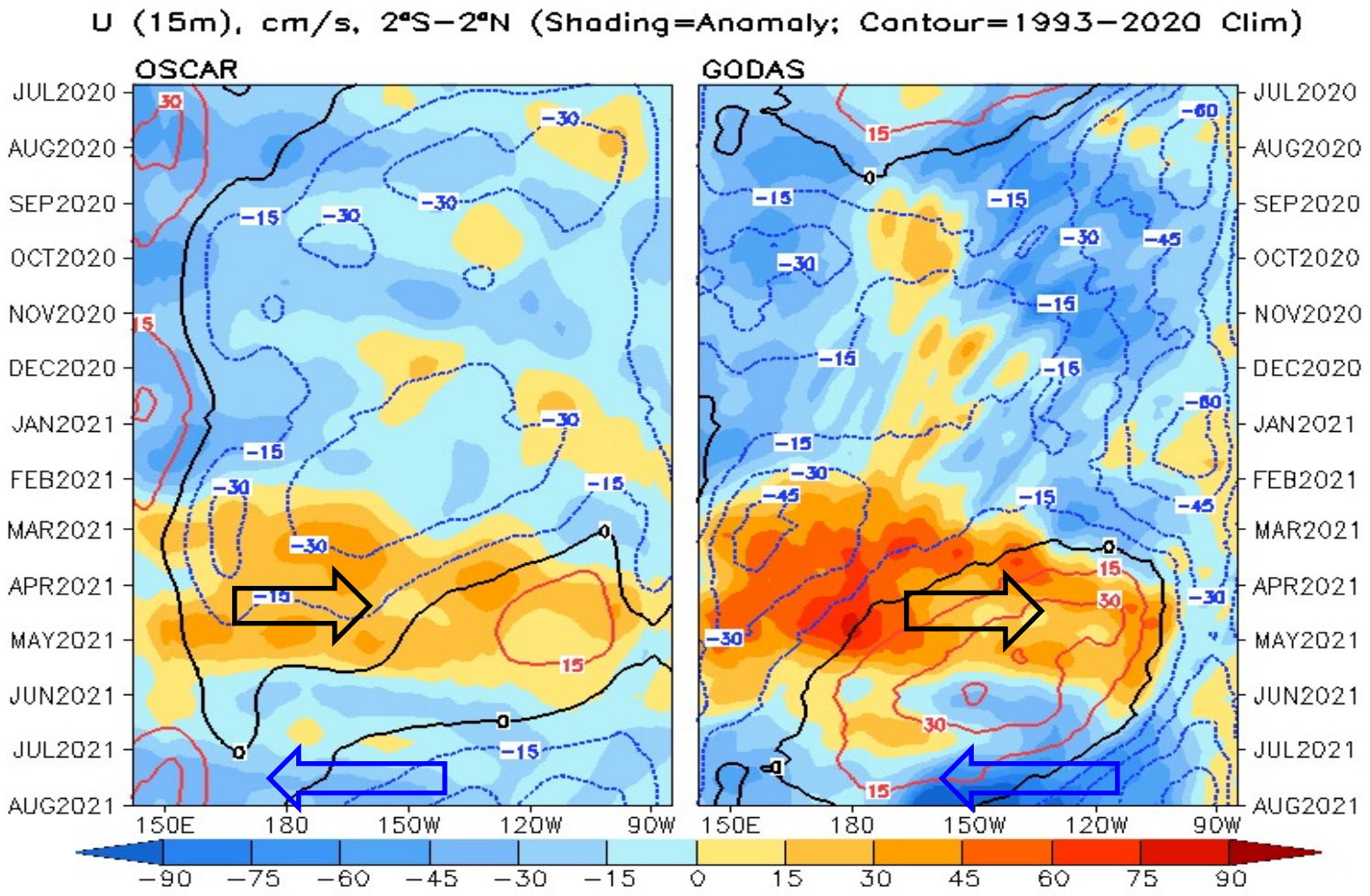



# Equatorial Pacific SST (°C), D20 (m ), zonal wind stress (dyn/cm $^2$ ) Anomalies



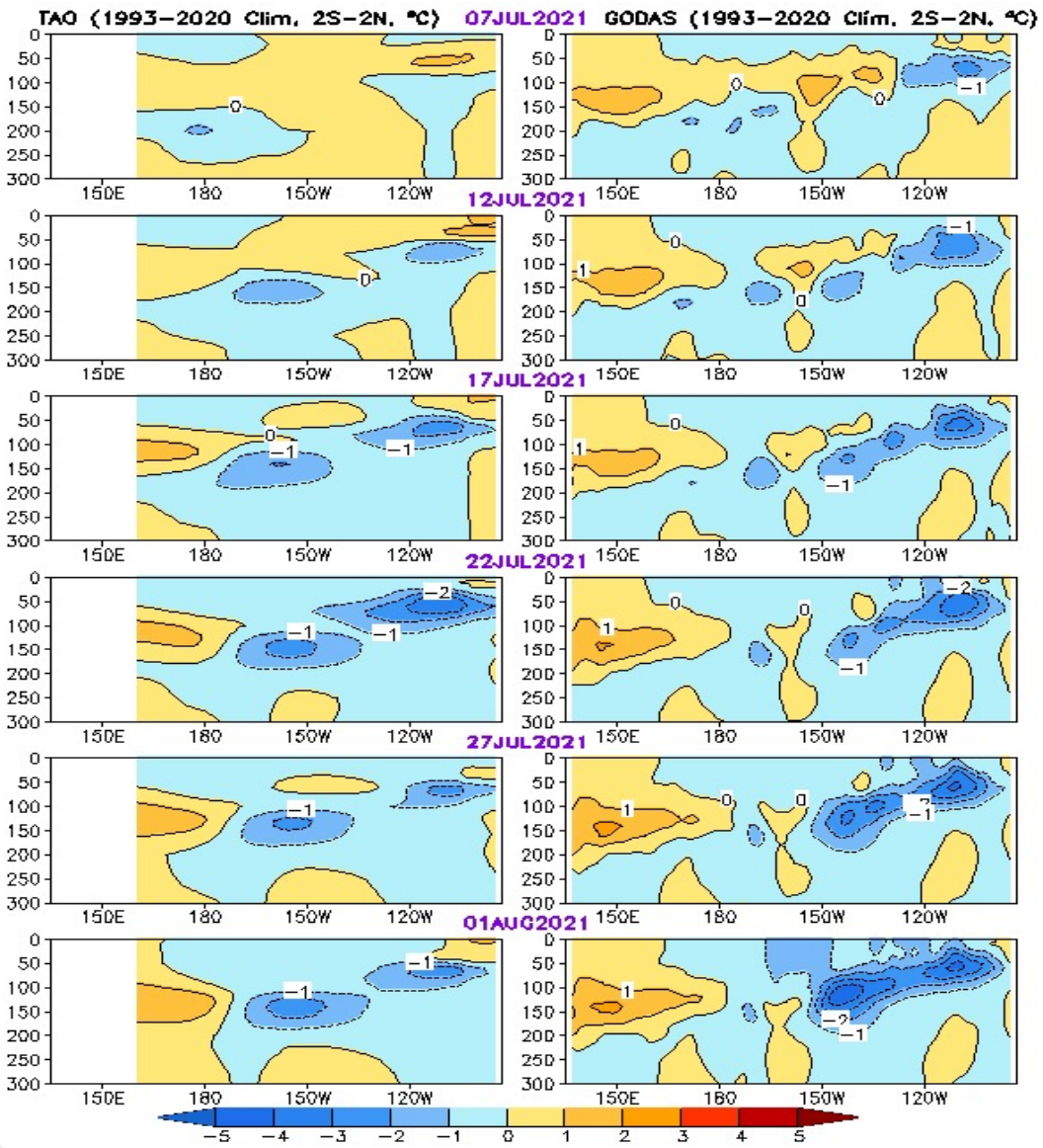

- Negative D20 anomaly emerged in the eastern Pacific in Jul 2021, contributing the emergent of negative SSTA.
- Easterly wind stress anomalies prevailed over most of the equatorial Pacific in Jul 2021.

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




- Anomalous westward currents were present across most of the equatorial Pacific in both OSCAR and GODAS in Jul 2021, favoring of further SST cooling.

# Equatorial Pacific Ocean Temperature Pentad Mean Anomaly

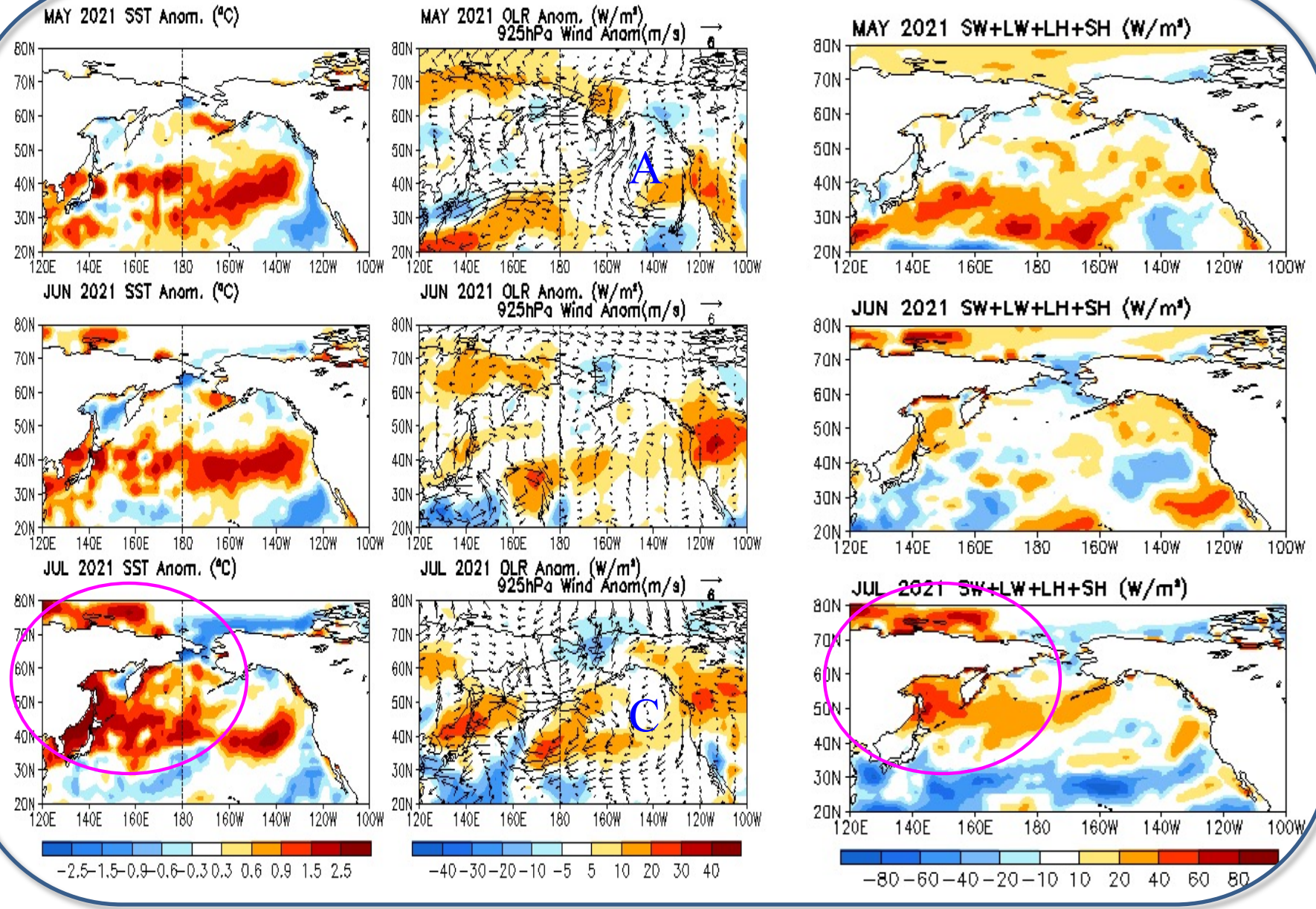



- In the last six pentads, negative subsurface temperature anomaly re-emerged and strengthened in the central-eastern Pacific Ocean.

- The features of the ocean temperature anomalies were overall similar between GODAS (model based) and TAO (objective) analysis.

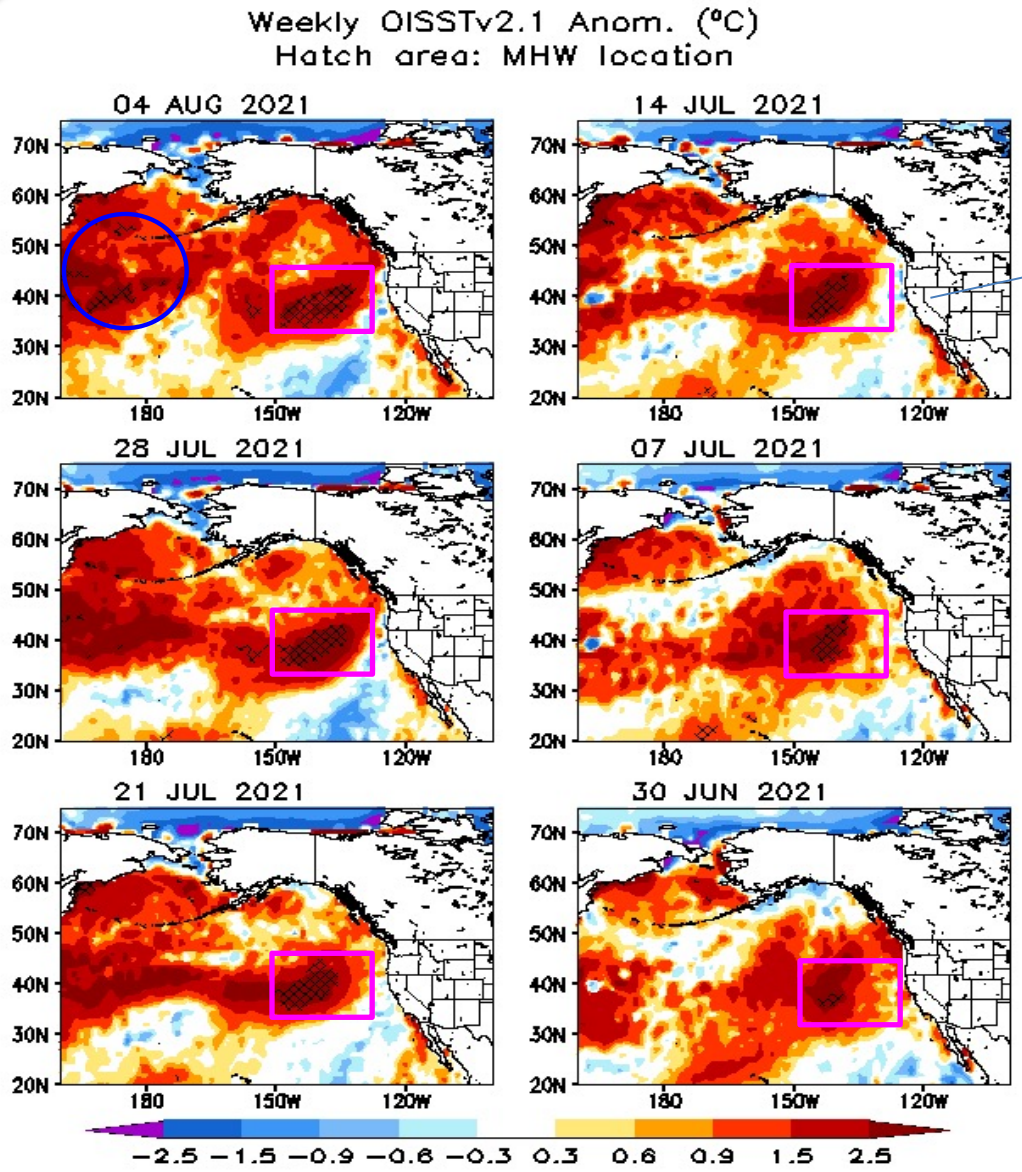
# North Pacific & Arctic Oceans

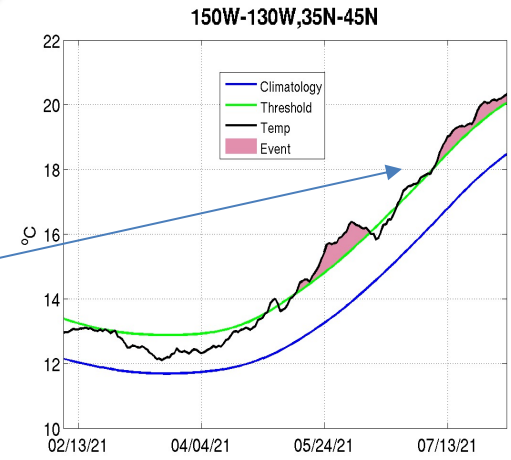
# Latest 3-month North Pacific SST, OLR & uv925 anomalies




Data source: NCEP/NCAR Reanalysis 1

# Weekly SST anomaly and MHWs in the North Pacific



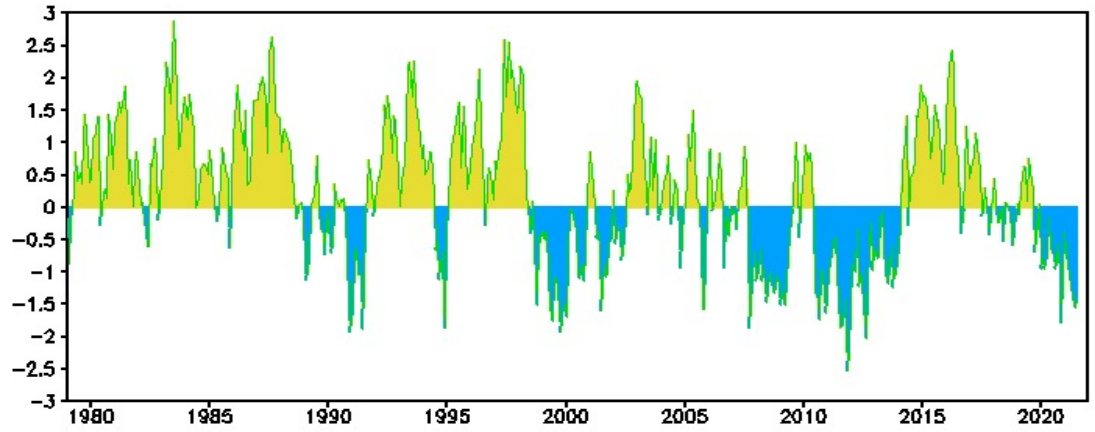




- MHWs were observed in the N.E Pacific since early July.

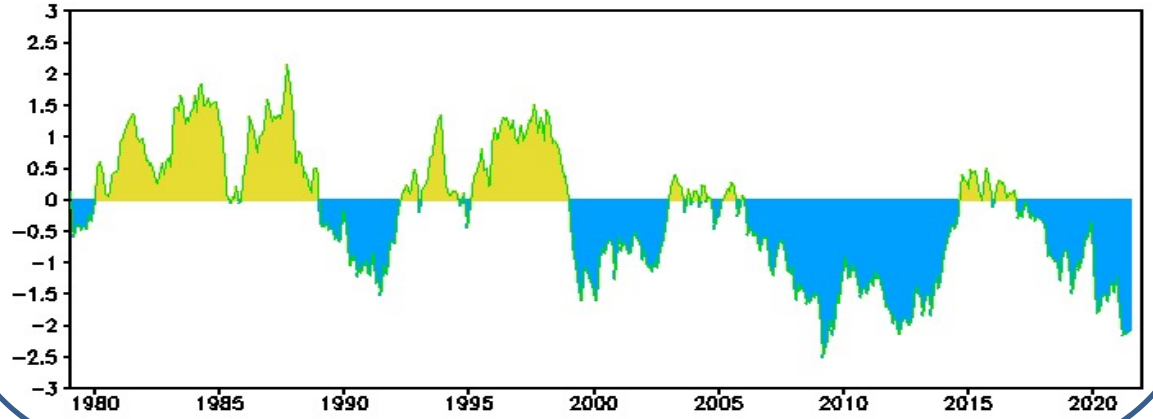
- Positive SSTA enhanced in the western Pacific Ocean and some developed into MHWs in the last week.

# Two Oceanic PDO indices

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




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




- The negative phase of PDO has persisted since Jan 2020 with PDOI = -1.4 in Jul 2021.

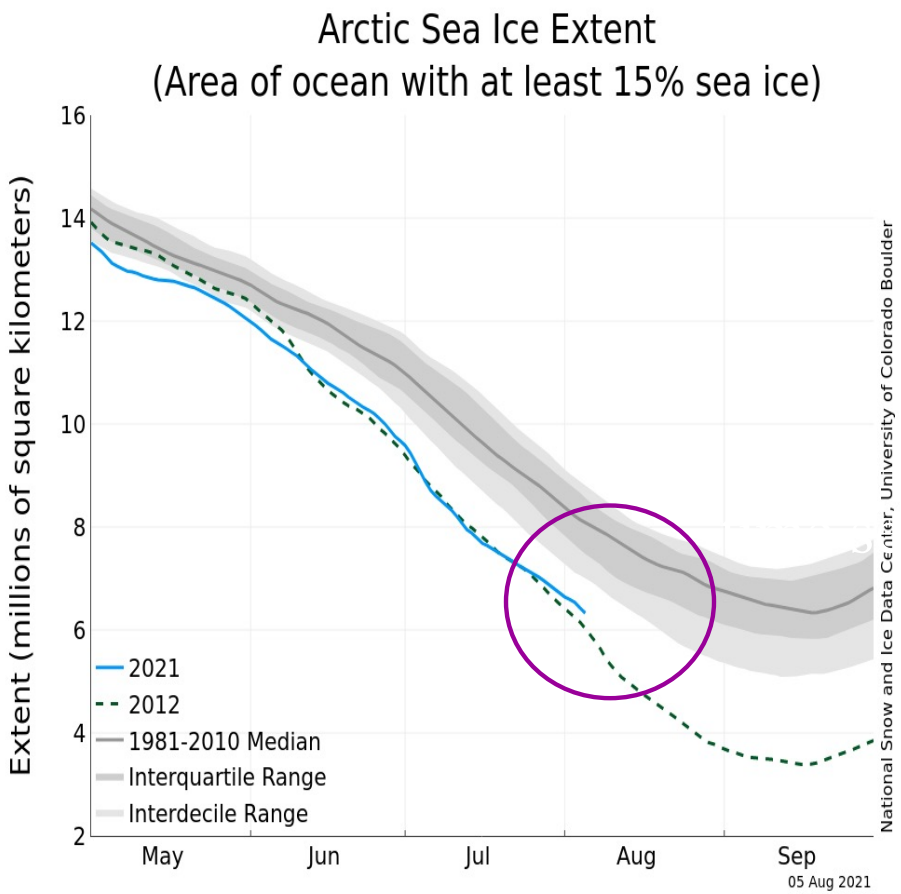
- Negative H300-based PDO index has persisted 58 months since Nov 2016, with HPDO = - 2.1 in Jul 2021.

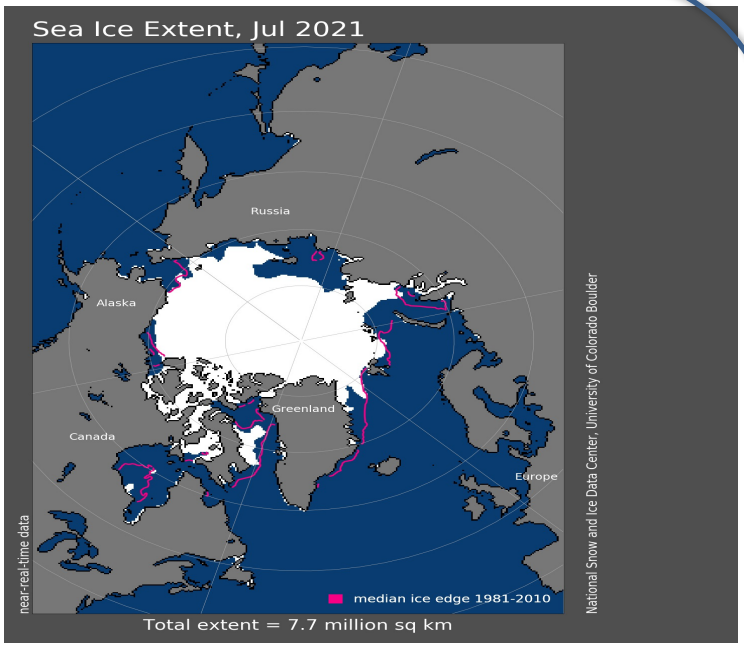
- SST-based PDO index has considerable variability both on seasonal and decadal time scales.

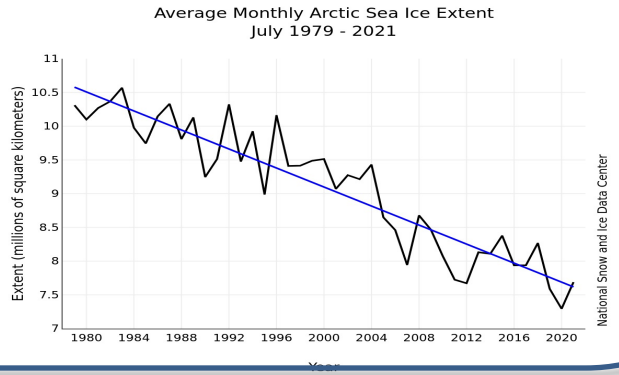
- H300-based PDO index highlights the slower variability and encapsulates an integrated view of temperature variability in the upper ocean.

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)

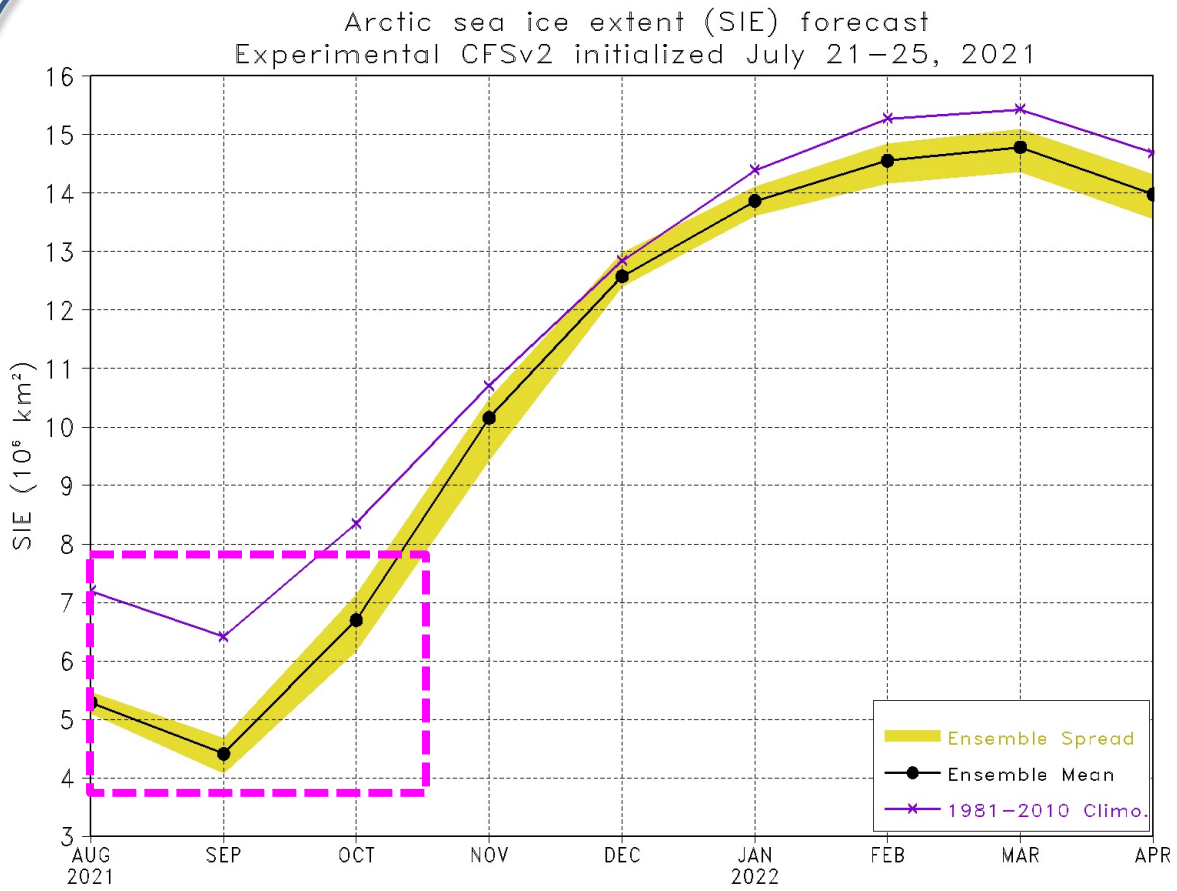



- The monthly average extent for Jul 2021 was 7.69 million square kilometers and it ranks the fourth lowest in the satellite record.

# NCEP/CPC Arctic Sea Ice Extent Forecasts

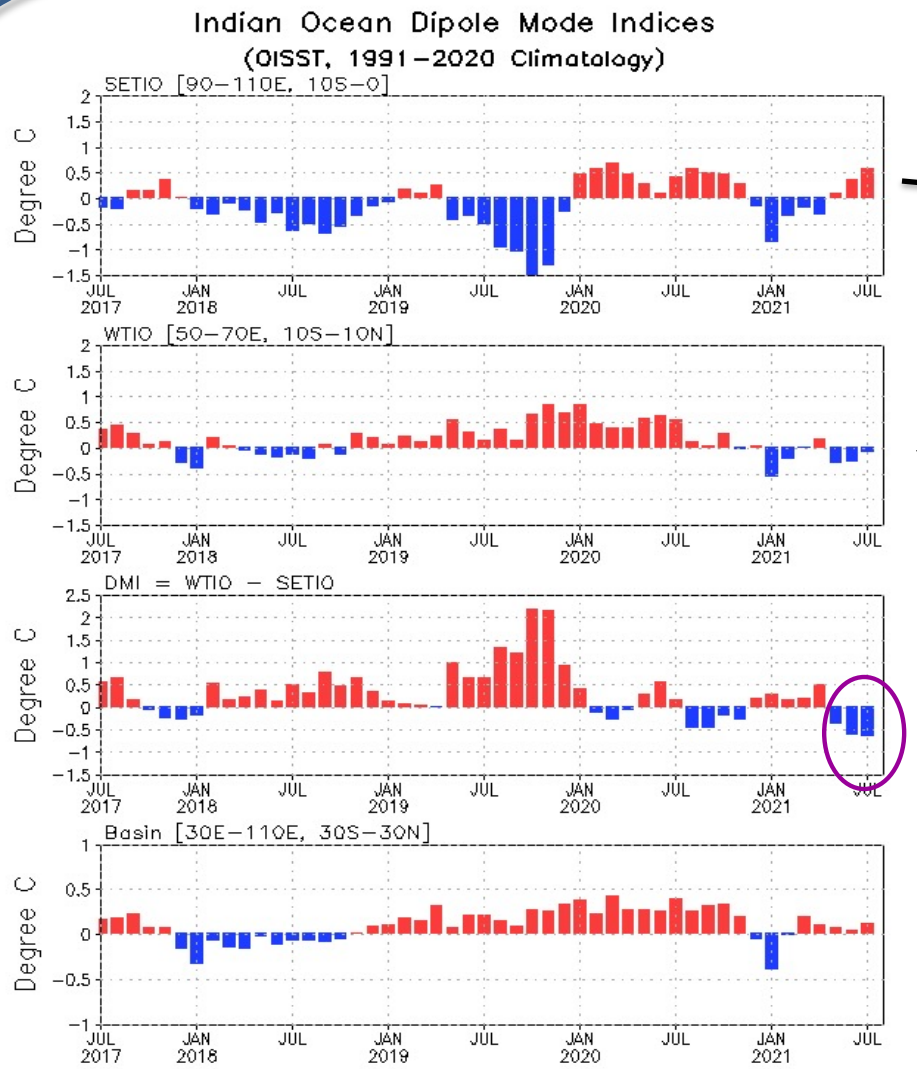


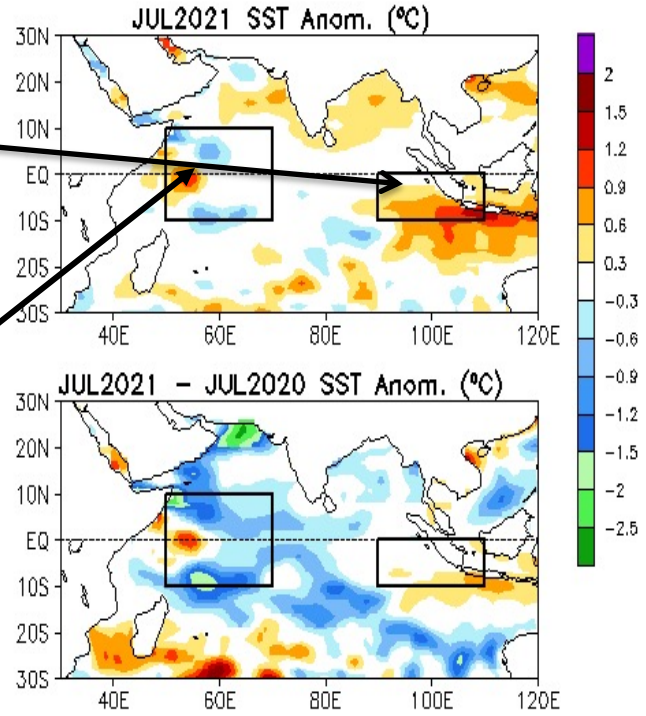

- For ICs in Jul 2021, NCEP/CPC predicted a well below-normal sea ice extent during summer and autumn 2021.

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

Indian Ocean

# Evolution of Indian Ocean SST Indices

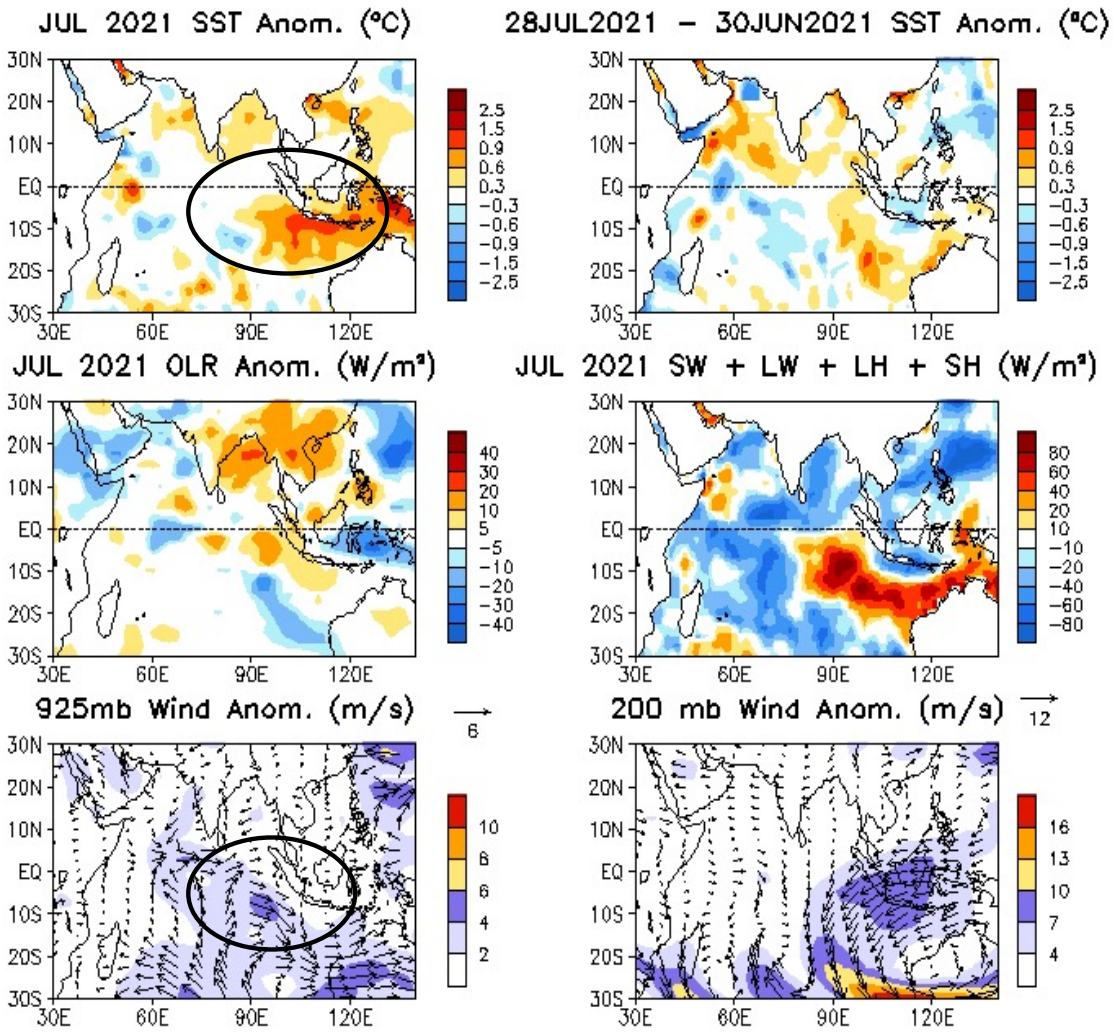



- Negative Indian Ocean dipole index persisted in Jul 2021, with IOD = -0.64° C.

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

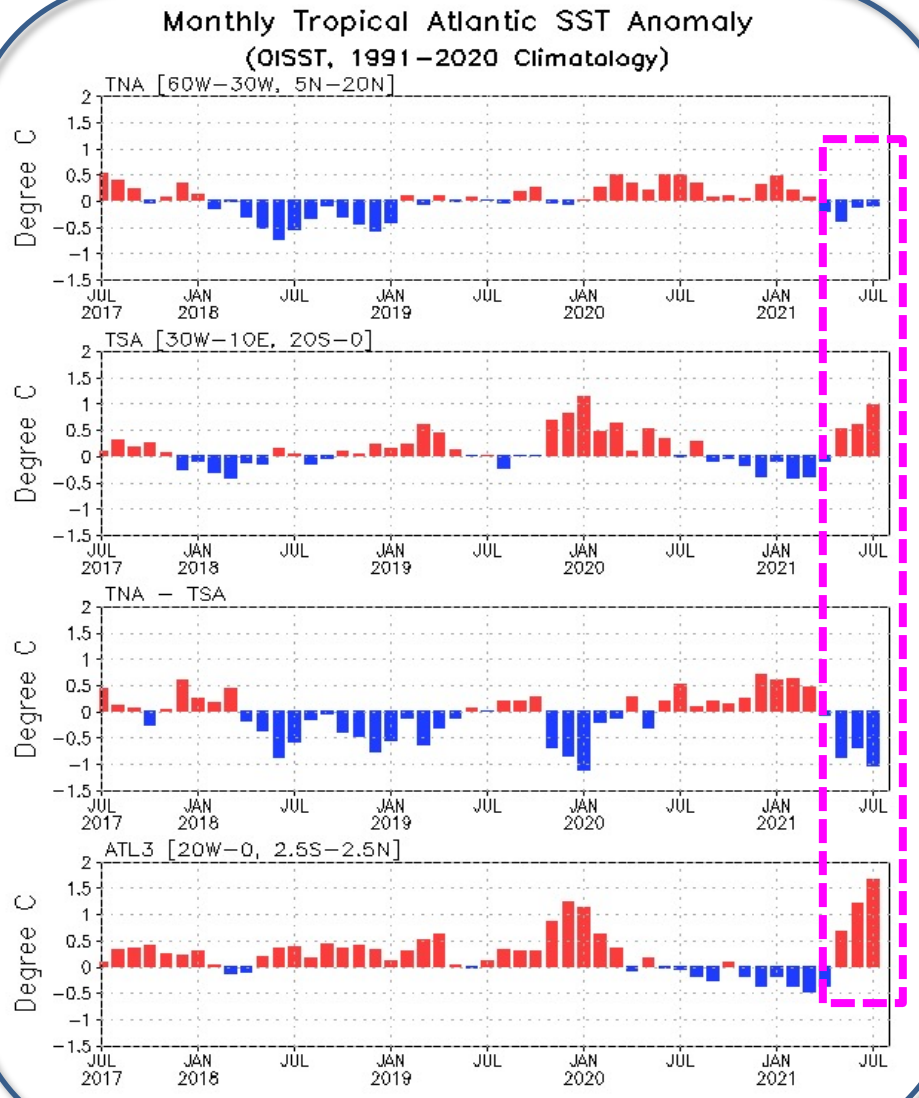


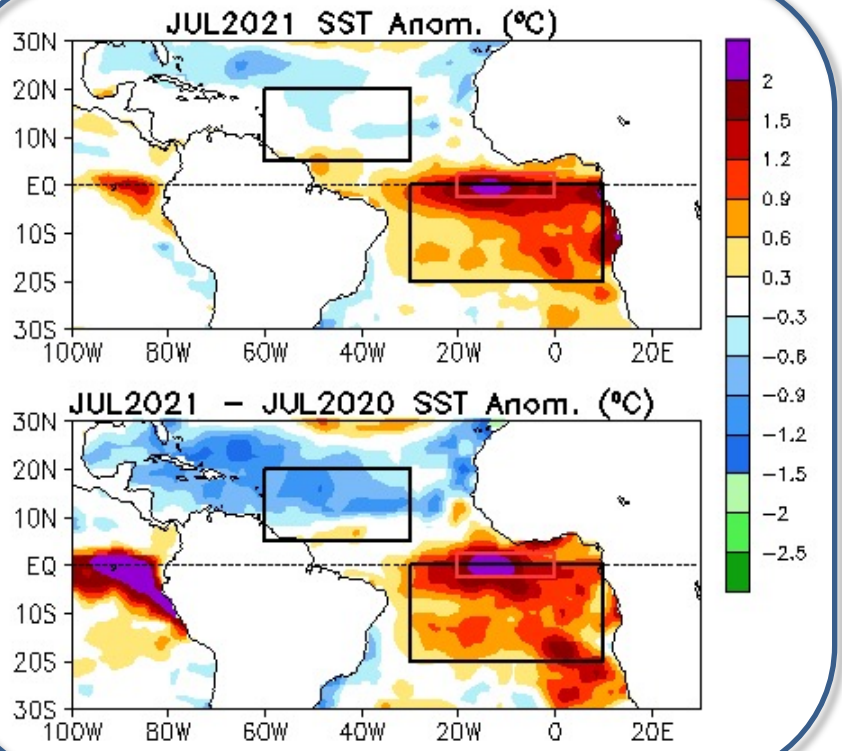

- Westerly wind anomaly prevailed over the southern eastern Indian Ocean, favoring further warming in the eastern Indian Ocean.

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

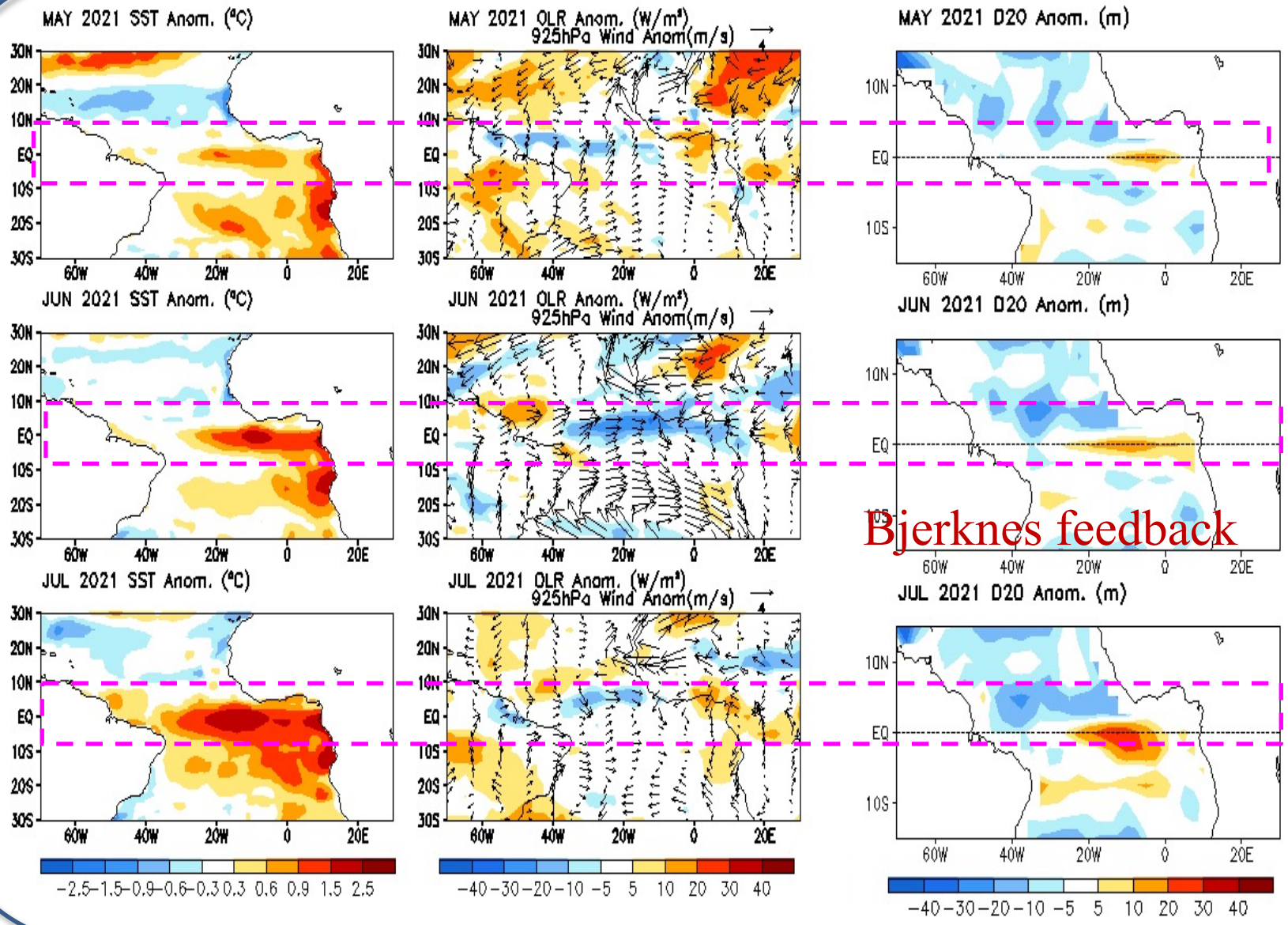



- Negative meridional dipole index strengthened in Jul 2021, with MDI = -1 °C.
- ATL 3 index in Jul 2021 hit a historical record since 1982, with ATL3 = 1.6°C.

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.

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




Bjerknes feedback

# Atlantic Niño and associated rainfall variability

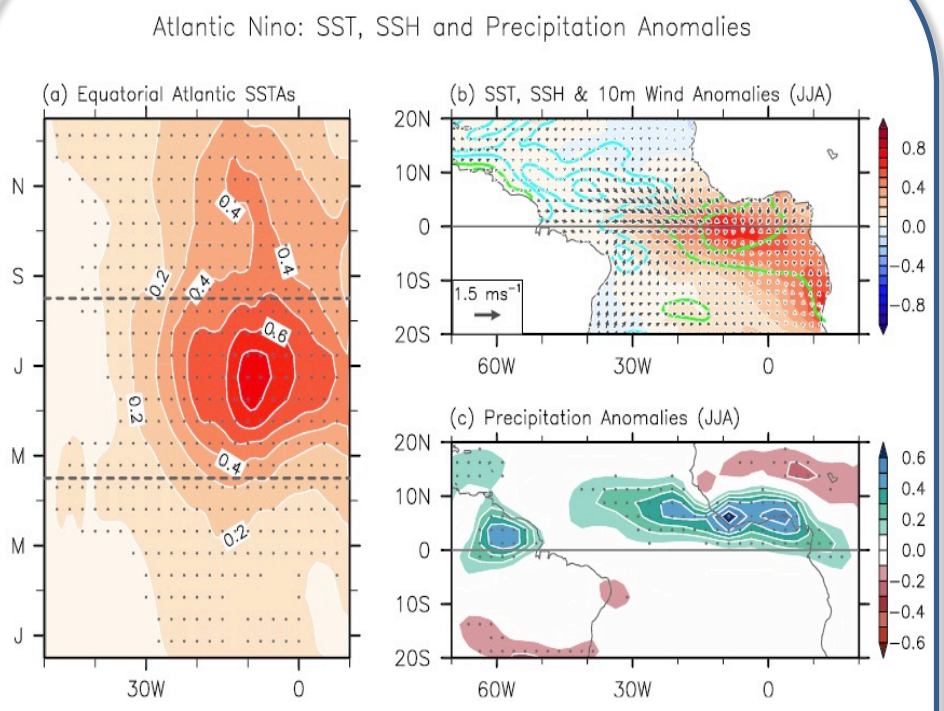
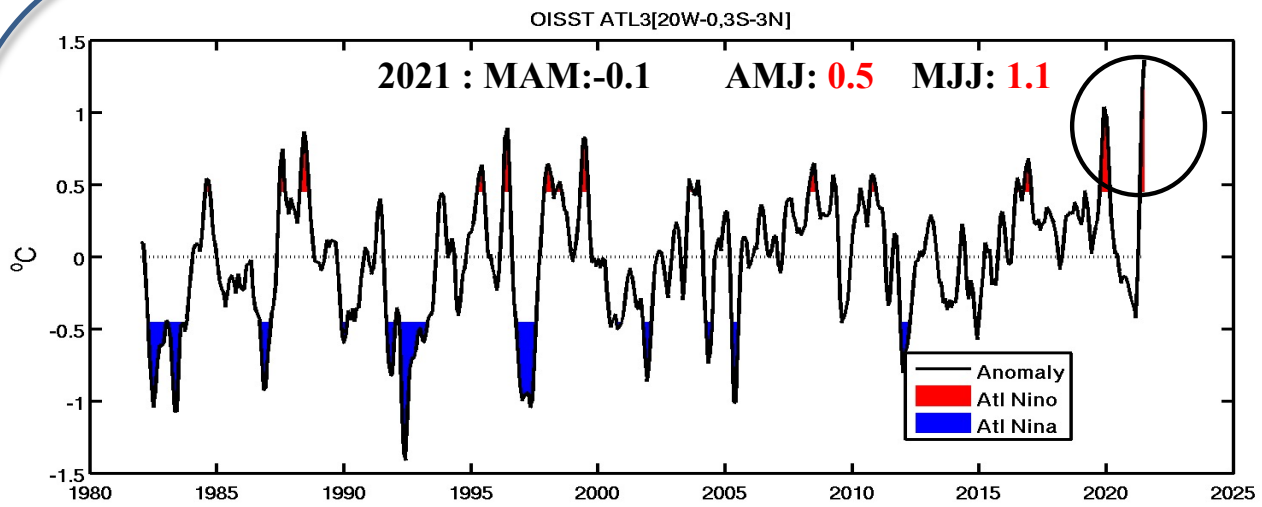



**Figure 1.** (a) Time-longitude plot of composite mean equatorial Atlantic SSTAs, averaged between 3°S and 3°N, from January to December derived from observed Atlantic Niño events. Significant SSTA values at 99% or above based on a Student's *t* test (two tailed) are indicated by gray dots. (b) Composite mean tropical Atlantic SST (shades), SSH (contours), and 10-m wind (vectors) anomalies; and (c) precipitation anomalies during June–August derived from observed Atlantic Niño events. Positive and negative SSHAs are indicated by green and cyan contour lines, respectively in (b). Significant precipitation anomaly values at 95% or above based on a Student's *t* test (two tailed) are indicated by gray dots in (c). The units for SST, SSH, winds and precipitation are in °C, cm, m $s^{-1}$, and mm $day^{-1}$, respectively. The contour interval for SSH anomalies is 0.5 cm.

- Atlantic Niño (Niña) is defined as the 3-month averaged SSTAs exceeding 0.5°C (-0.5 °C) in the ATL 3 region [3°S- 3°N, 20°W-0°] for at least two consecutive overlapping seasons.
- Atlantic Niño usually develops in boreal spring(MAM), peaks in summer (JJA) and dissipates in fall.
- Some Atlantic Niño events are responsible for a failure of the west African summer monsoon and increased frequency of flooding in the west African countries near the Gulf of Guinea and in the northeastern South American.
- Atlantic Niño and associated rainfall variability display large diversity.

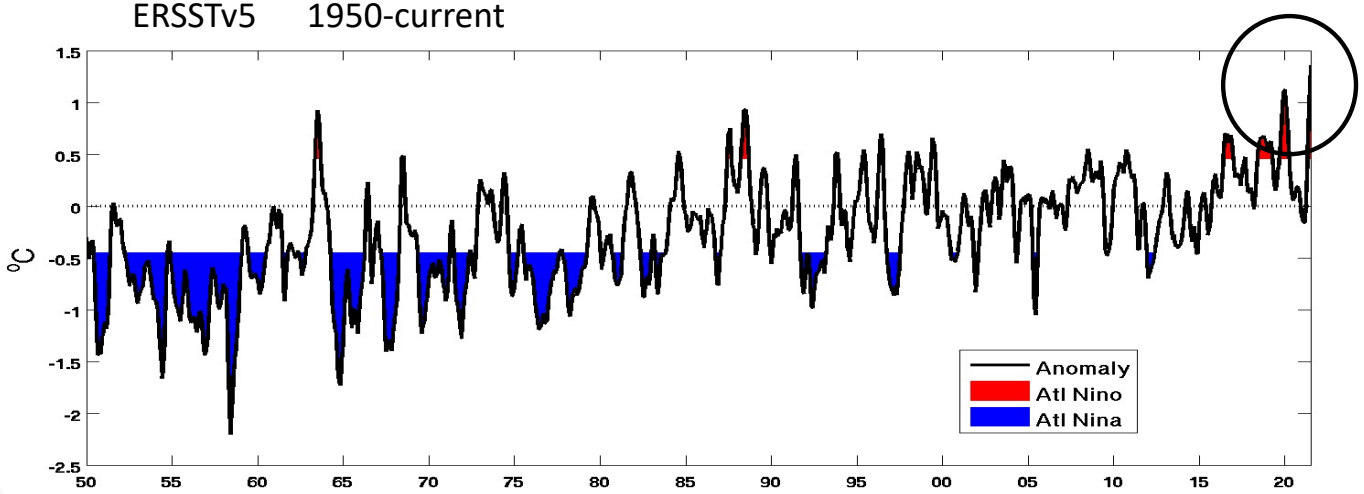
Vallès-Casanova, I., Lee, S.-K., Foltz, G. R. & Pelegrí, J. L. On the spatiotemporal diversity of Atlantic Niño and associated rainfall variability over West Africa and South America. *Geophys. Res. Lett.* **47**, e2020GL087108 (2020)

# Historical Atlantic Niño & Niña Events



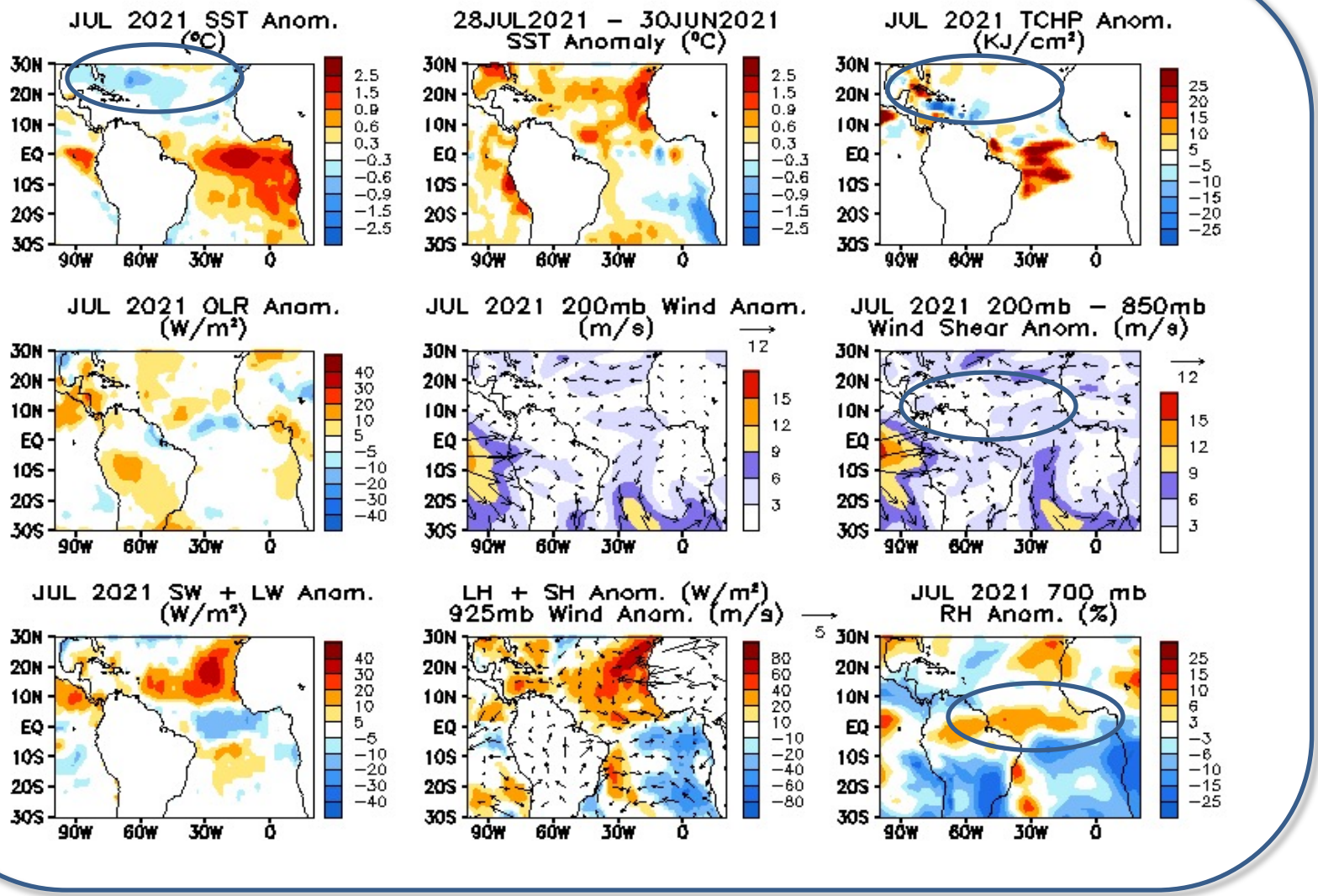

- 2021 Atlantic Nino is the strongest Atlantic Nino events both in ERSSTv5 and OISST data.

ERSSTv5 1950-current



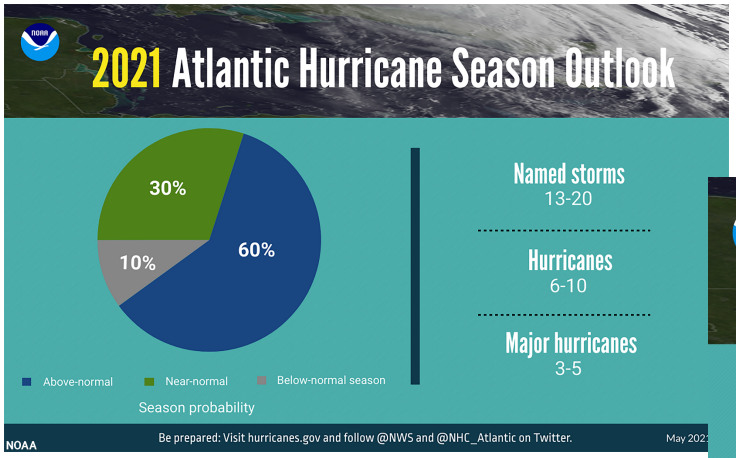

Climatology : 1991-2020

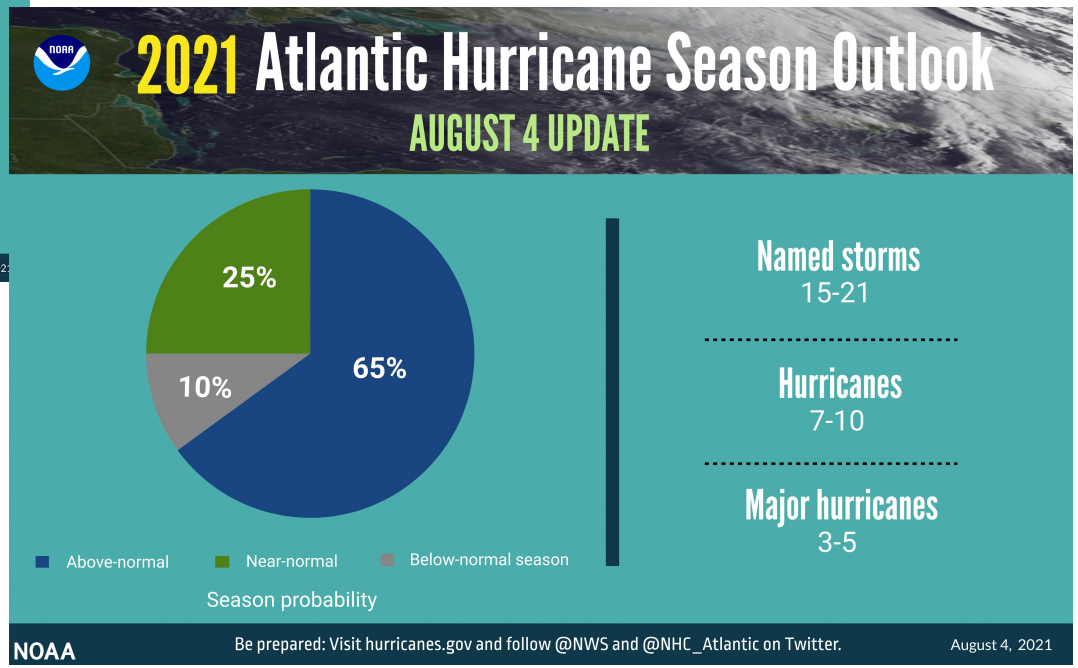
# Tropical Atlantic Ocean: SSTA, SSTA Tend, TCHP, OLR, UV200, UV200-UV850, Heat Flux Anomalies




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 Outlook: August Update

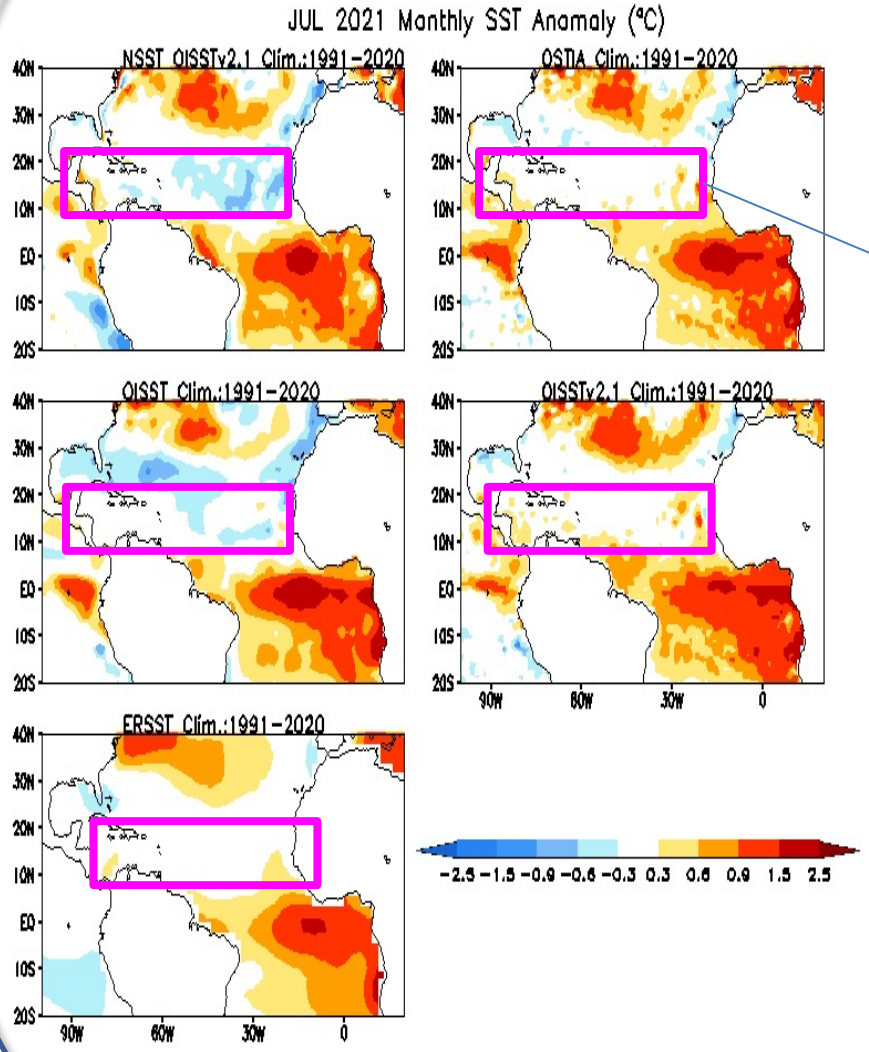


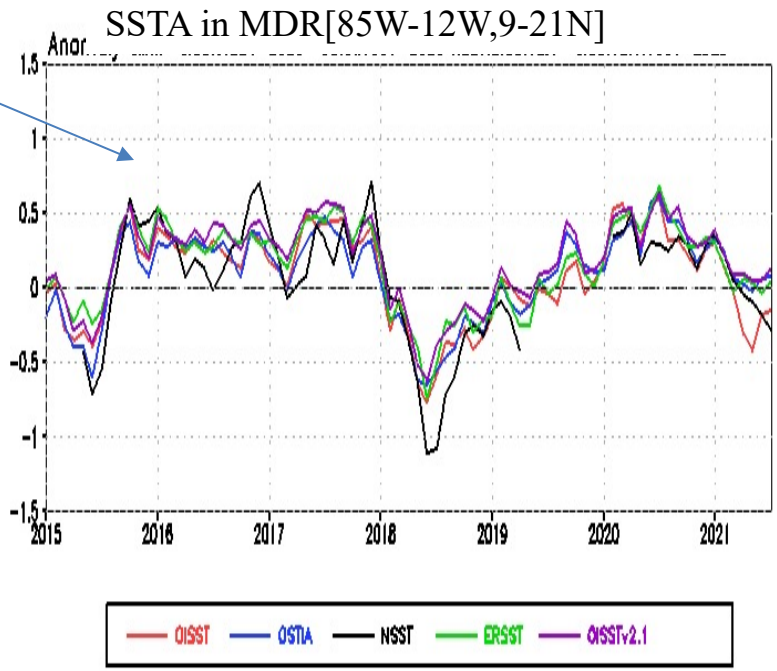




- NOAA's updated 2021 Atlantic Hurricane Season Outlook: above-normal Atlantic hurricane season is the most likely outcome with a possibility the season could be extremely active. The outlook indicates a 65% chance of an above-normal season, a 25% chance of a near-normal season, and a 10% chance of a below-normal season.
- Some observed conditions are not supportive of an active season: Near to slightly below average SST and above sea-level pressures in the northern tropical Atlantic.

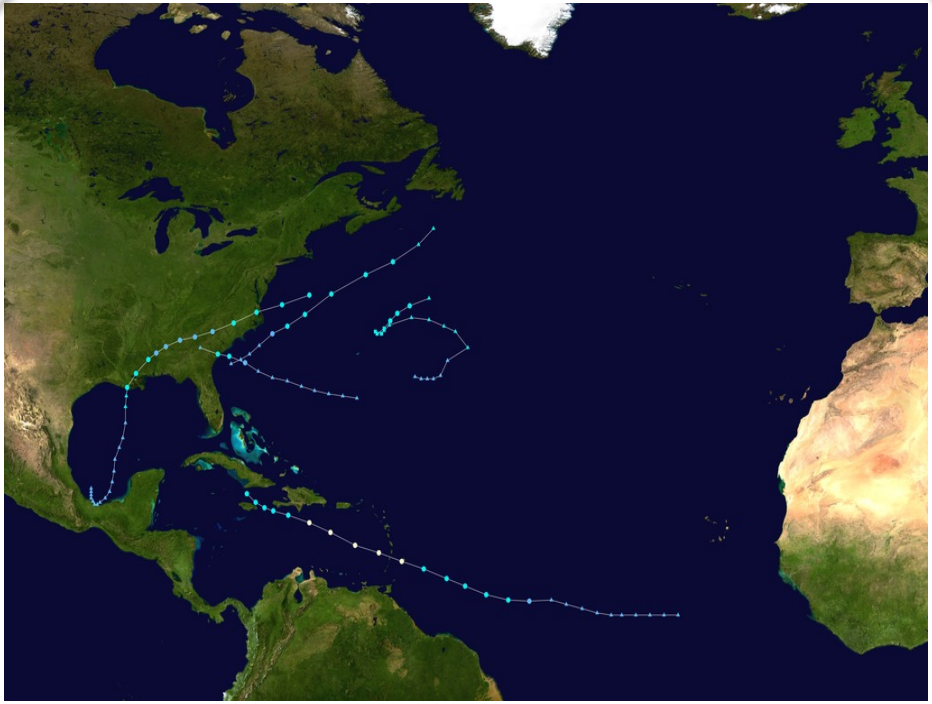
*(https://www.cpc.ncep.noaa.gov/products/outlooks/hurricane2021/August/hurricane.shtml)*

# Monthly SST Anomaly in the Atlantic Ocean



# 2021 Atlantic Hurricane Season Activities



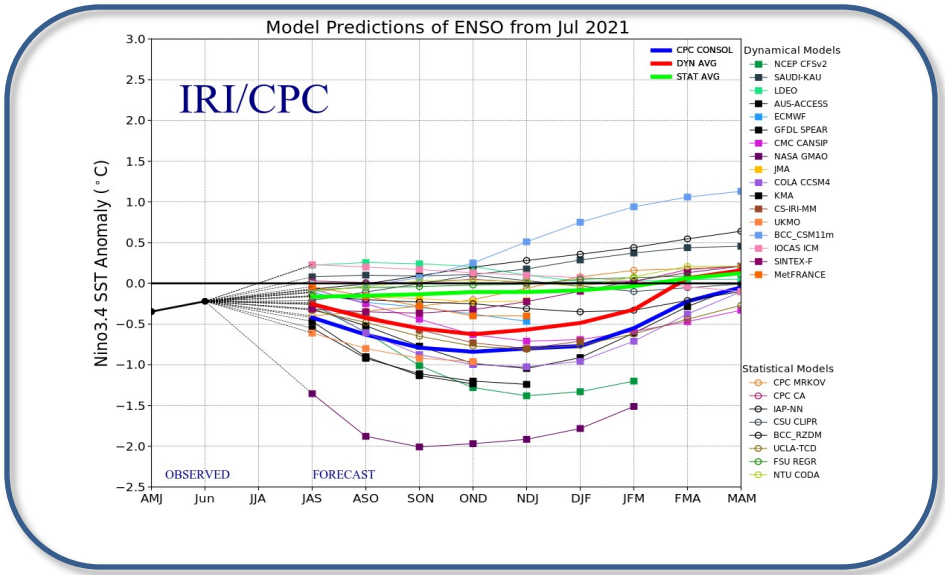
https://en.wikipedia.org/wiki/2021_Atlantic_hurricane_season

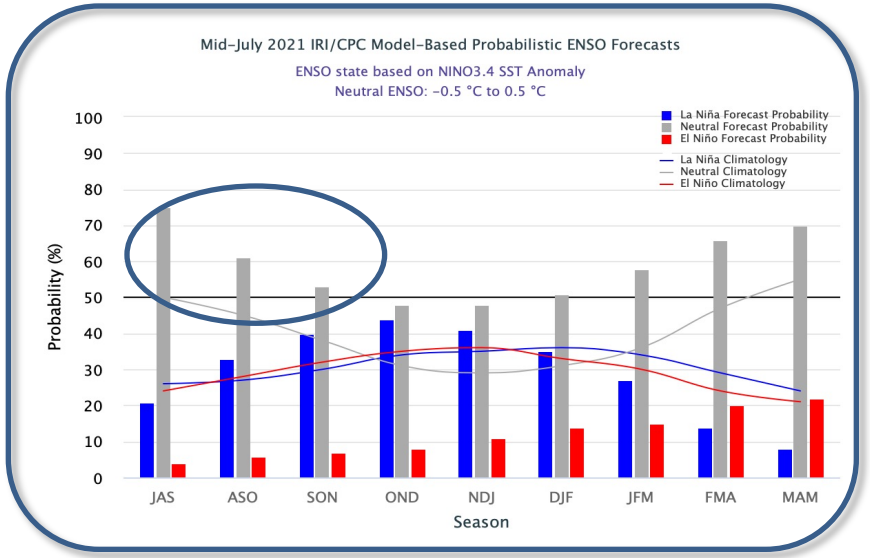
- No storms formed in the last 30 days.
-By Jul 10 2021, five tropical storms formed with one developing into hurricane.

| Atlantic | Observations (By Aug 8) | Updated Outlook (Aug 4) 65% above-normal | Outlook (May 21) 60% above-normal | (1991-2020) |
|---|---|---|---|---|
| Total storms | 5 | 15-21 | 13-20 | 14 |
| Hurricanes | 1 | 7-10 | 6-10 | 7 |
| Major hurricanes | 0 | 3-5 | 3-5 | 3 |

# ENSO and Global SST Predictions

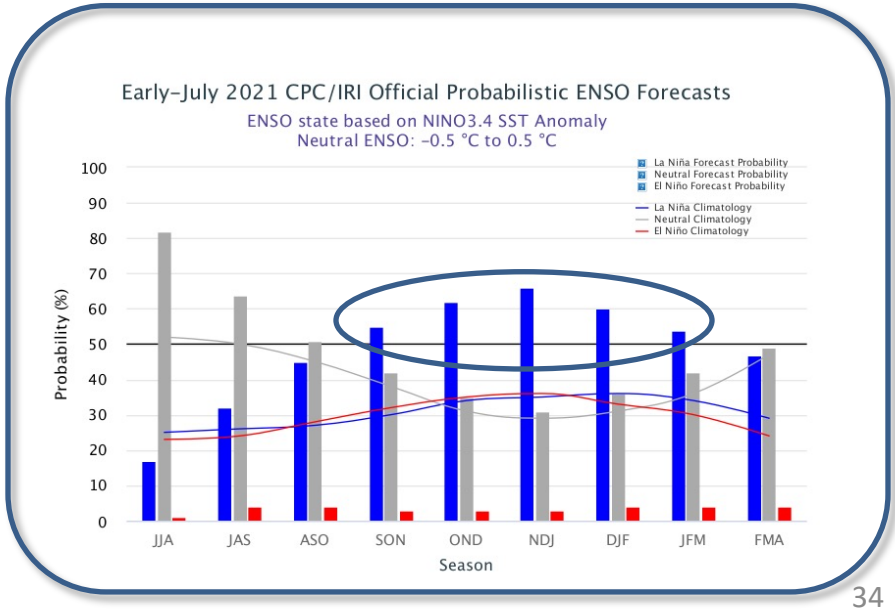
# IRI/CPC Niño3.4 Forecast



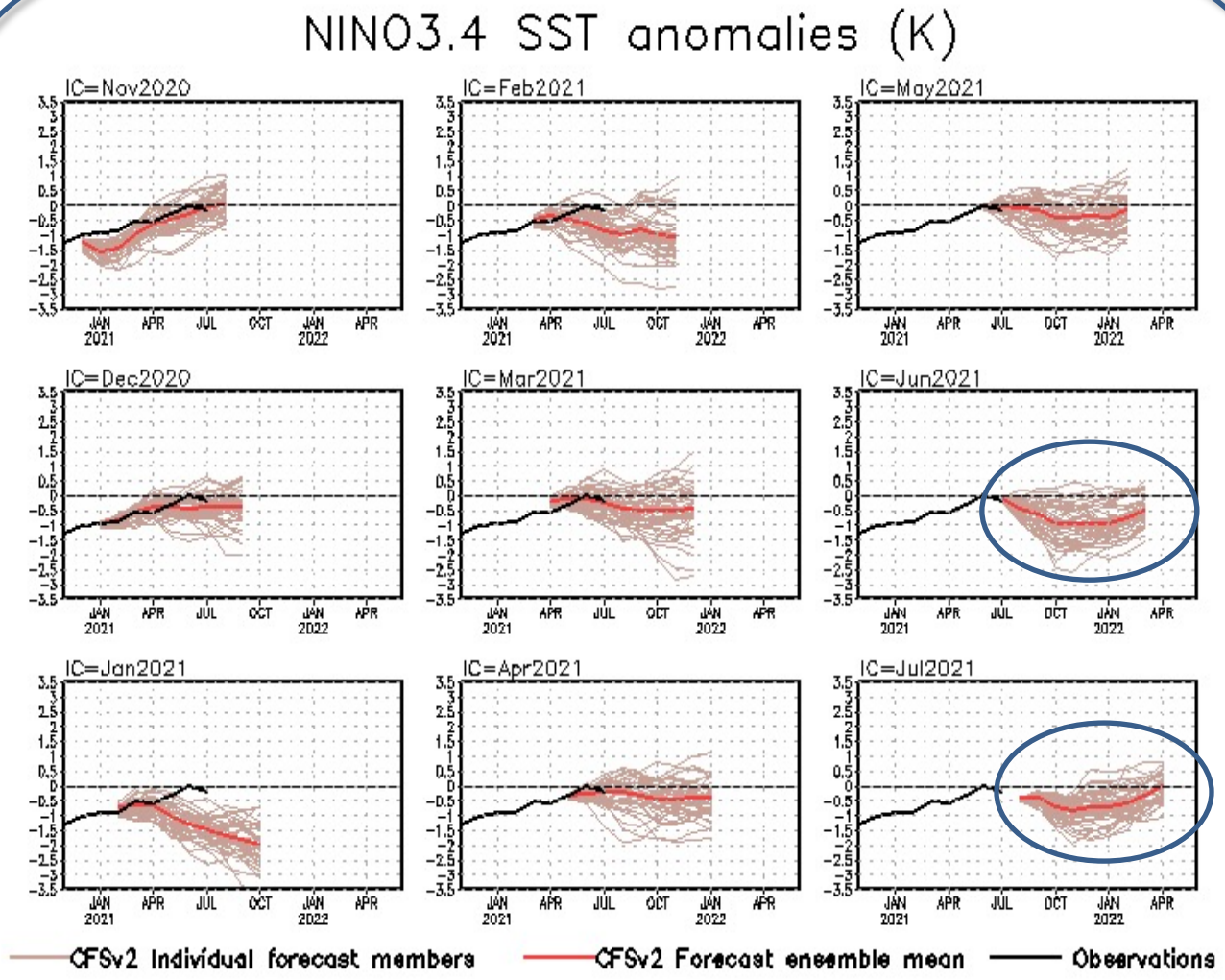




- A majority of dynamical and statistical models predict ENSO-neutral SST conditions likely to persist at least through Sep-Nov season.

- NOAA "ENSO Diagnostics Discussion" on July 8 stated that "*ENSO-neutral is favored through the Northern Hemisphere summer and into the fall , with La Niña potentially emerging during the September-November season and last through the 2021-22 winter*".



# CFSv2 Niño3.4 SST Predictions

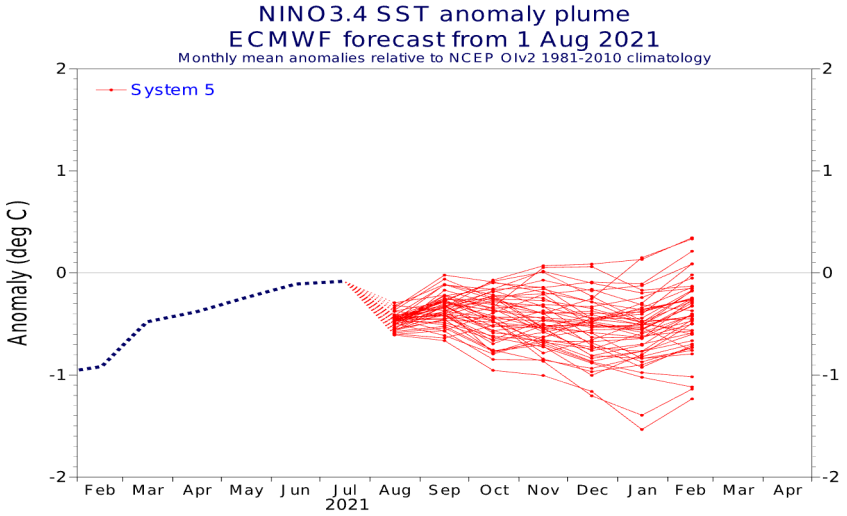



- Latest CFSv2 predictions call for a weak La Niña in the northern hemisphere 2021/22 winter.

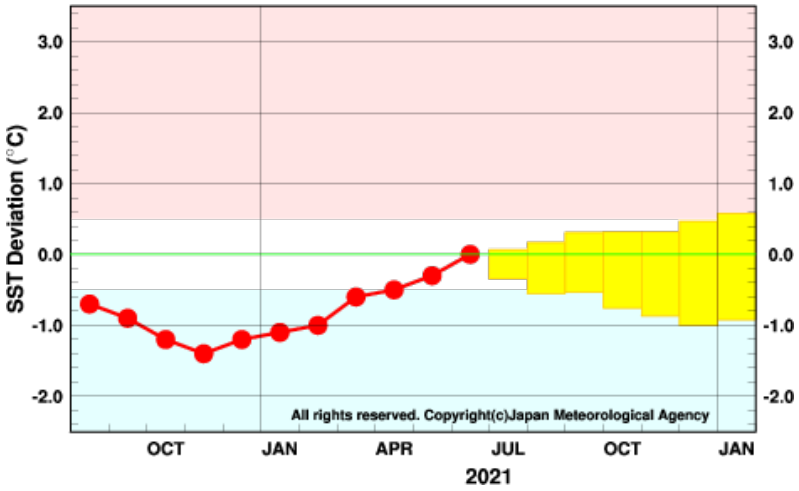
CFS Niño3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect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

# Individual Model Niño3.4 Forecasts

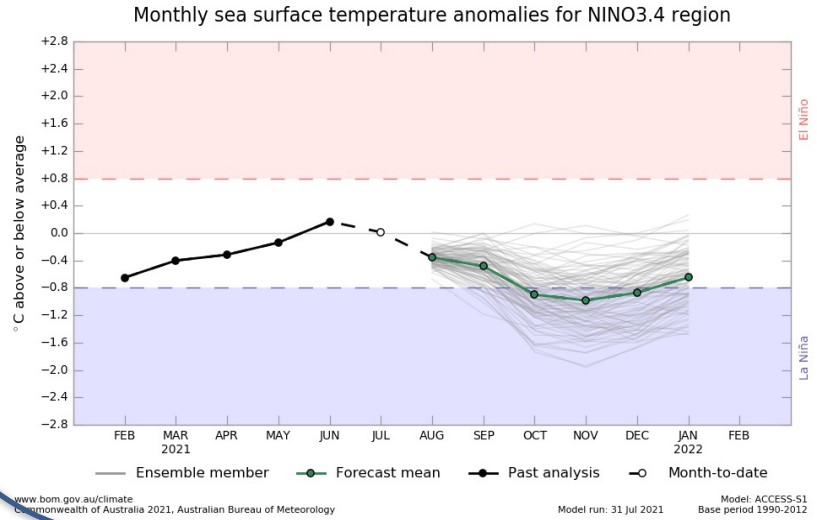
## EC: IC= 01 Aug, 2021



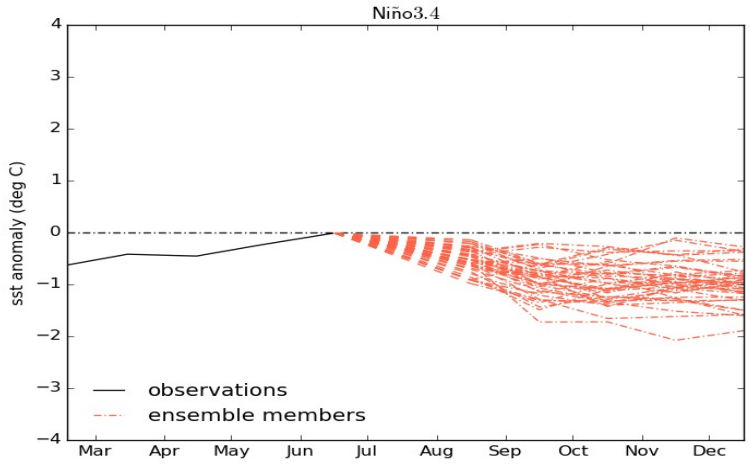

## JMA: Updated 9 July, 2021



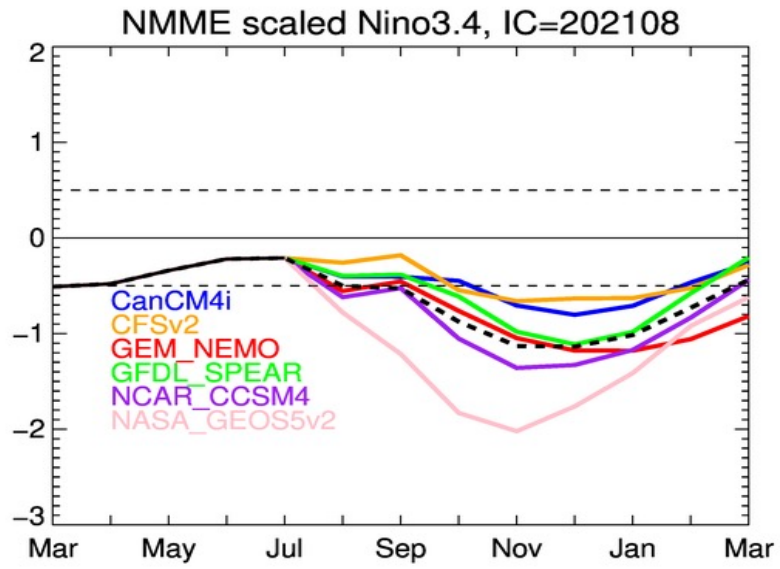

## BOM: Updated 31 July, 2021

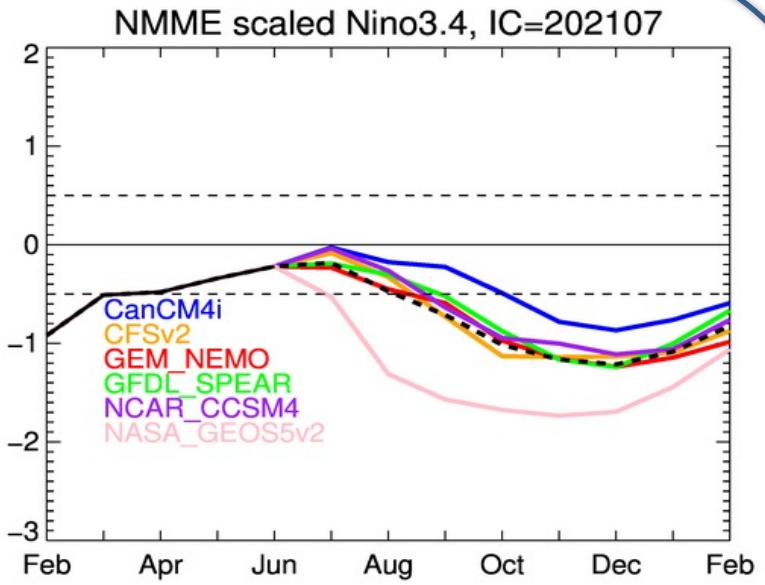


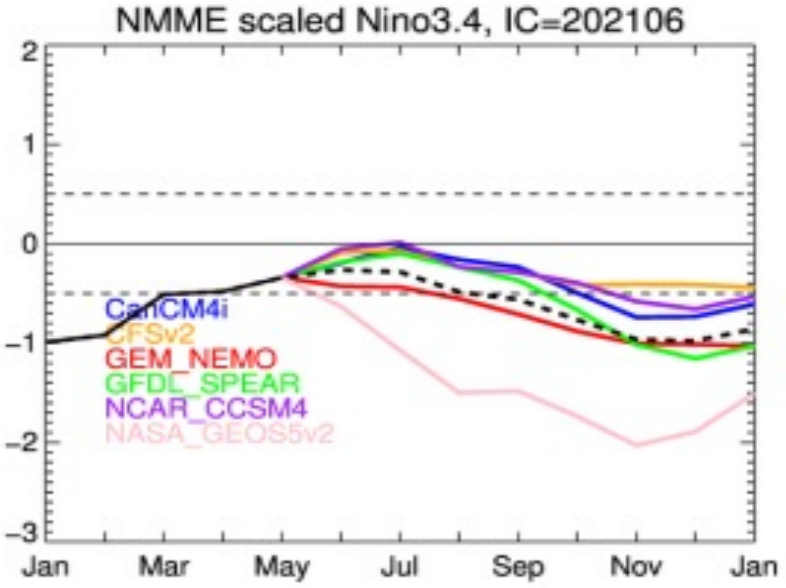

## UKMO: Updated 11 July, 2021

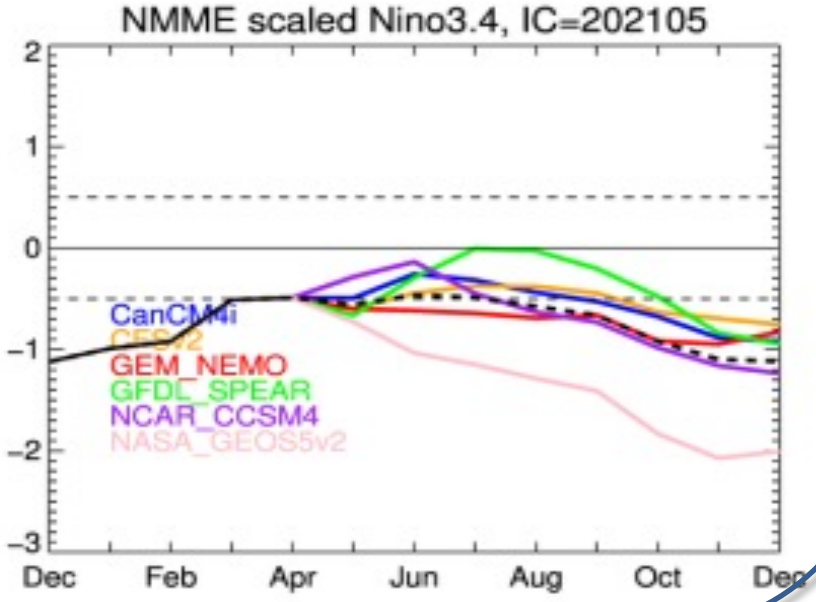


# NMME forecasts with the latest 4-month initial conditions

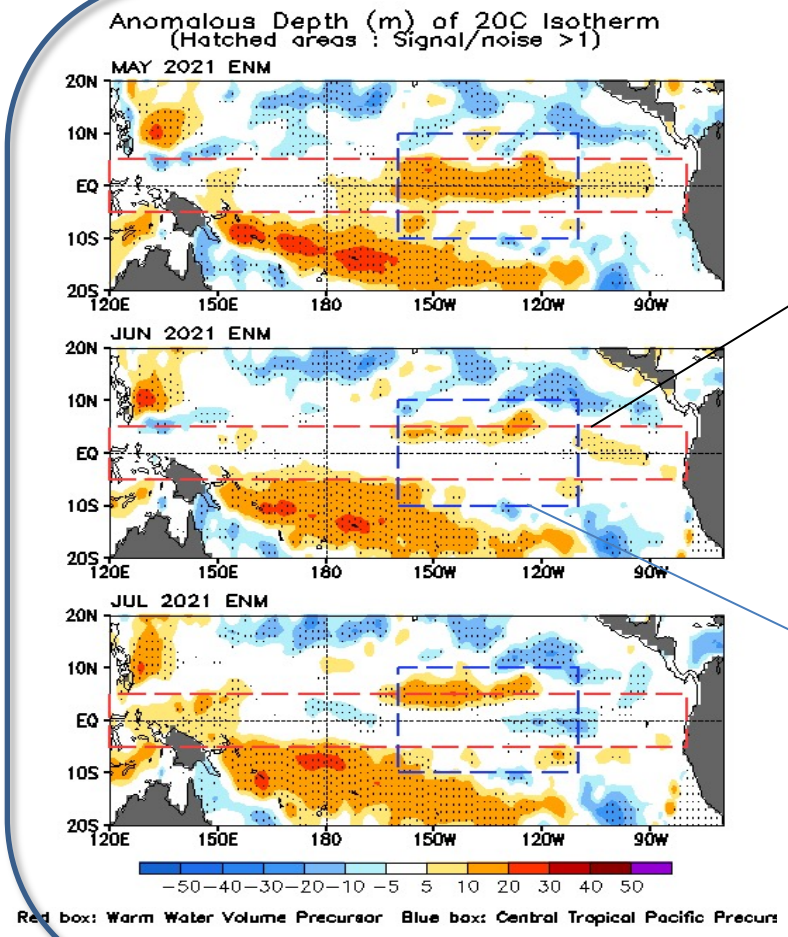


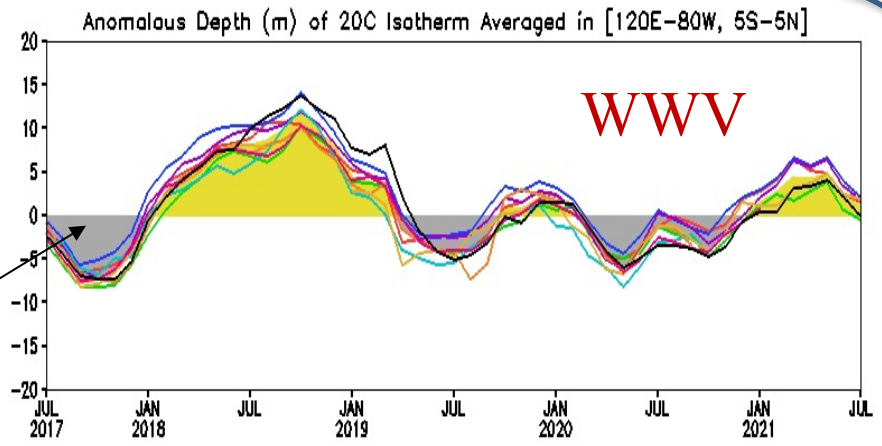



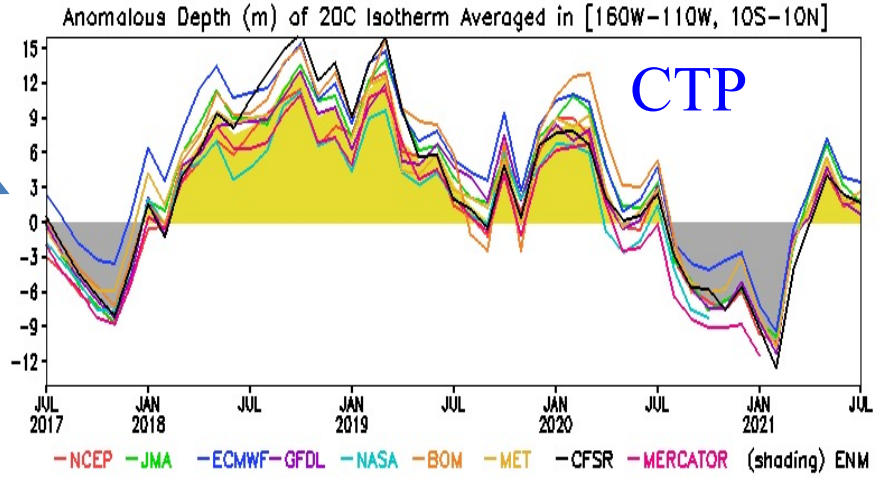



# Oceanic ENSO Precursors: WWV & CTP

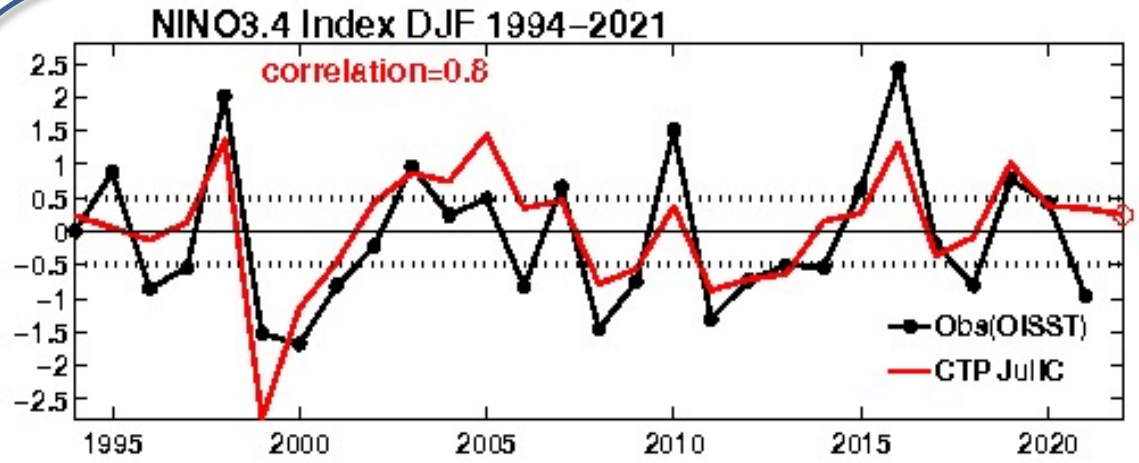


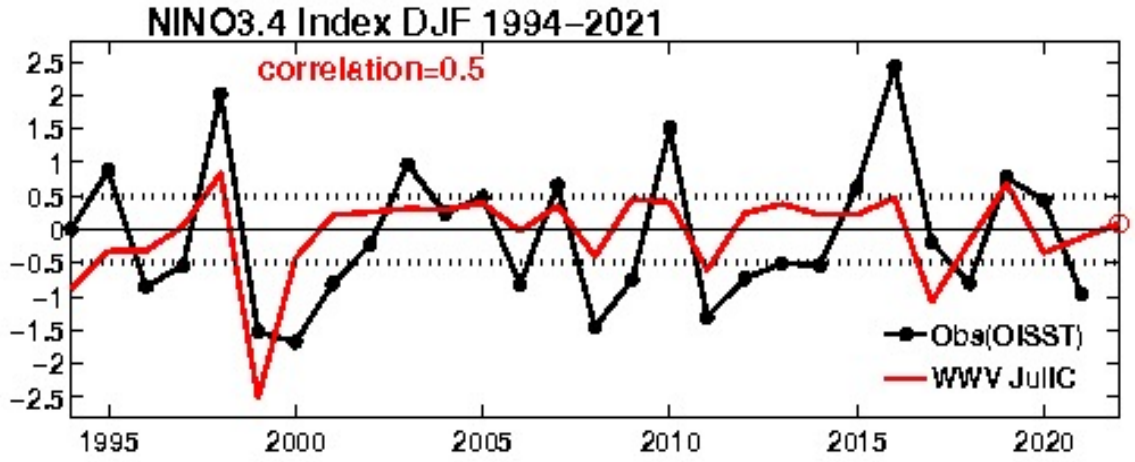




Warm water volume (WWV) is defined as an average of D20 anomaly across the equatorial Pacific (120° E – 80° W, 5° S-5° N) (Meinen and McPhaden 2000). Central tropical Pacific (CTP) index is calculated as the averaged D20 anomaly in the central tropical Pacific (160° W-110° W, 10° S-10° N) (Wen et al. 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

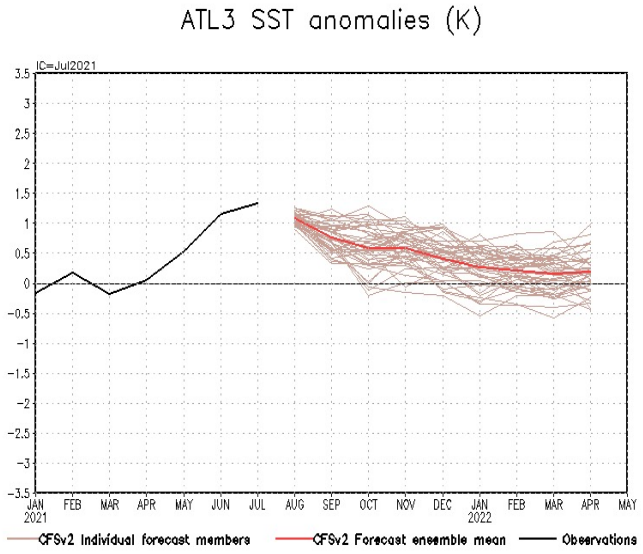



- Both WWV and CTP in July predict ENSO neutral condition in DJF 2022.

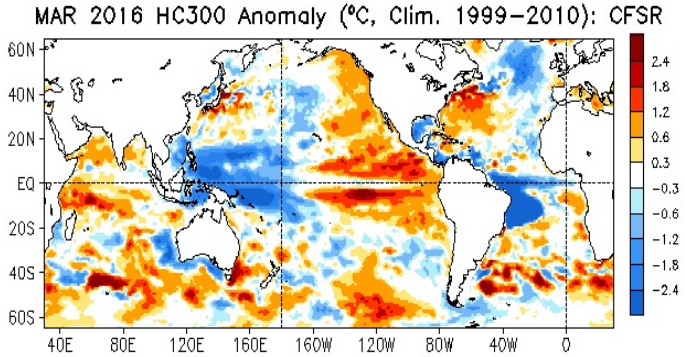
Prediction models are constructed using leave-one-year-out cross validation over the full period by iteratively recomputing the coefficients with the target prediction year removed. For details Wen et al. (2021) DOI: https://doi.org/10.1175/JCLI-D-20-0648.1

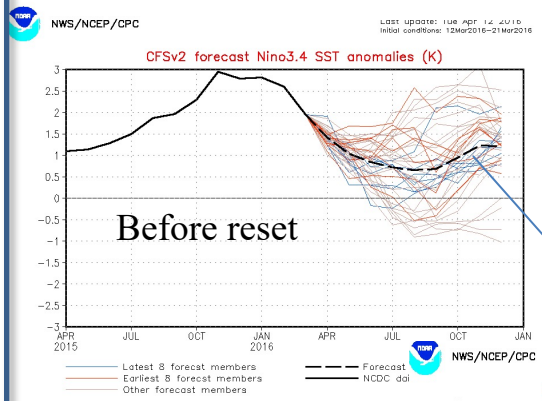
# CFSv2 ATL3 predictions

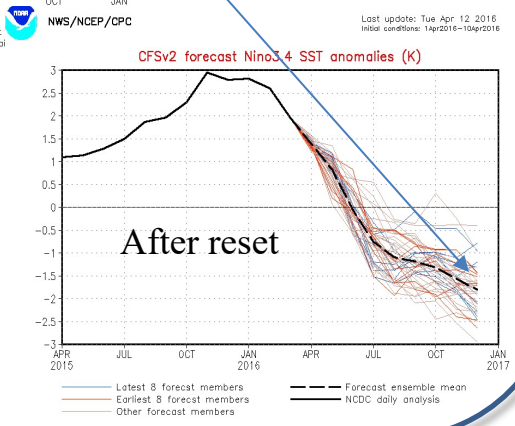



- Large cold bias in CFSR in March 2016 (ocean IC for CFSv2) led to a false El Nina prediction, providing evidence for the impact of tropical Atlantic SST on ENSO.
- Latest CFSv2 predict ATL3 will be above 0.5C through Nov 2021.

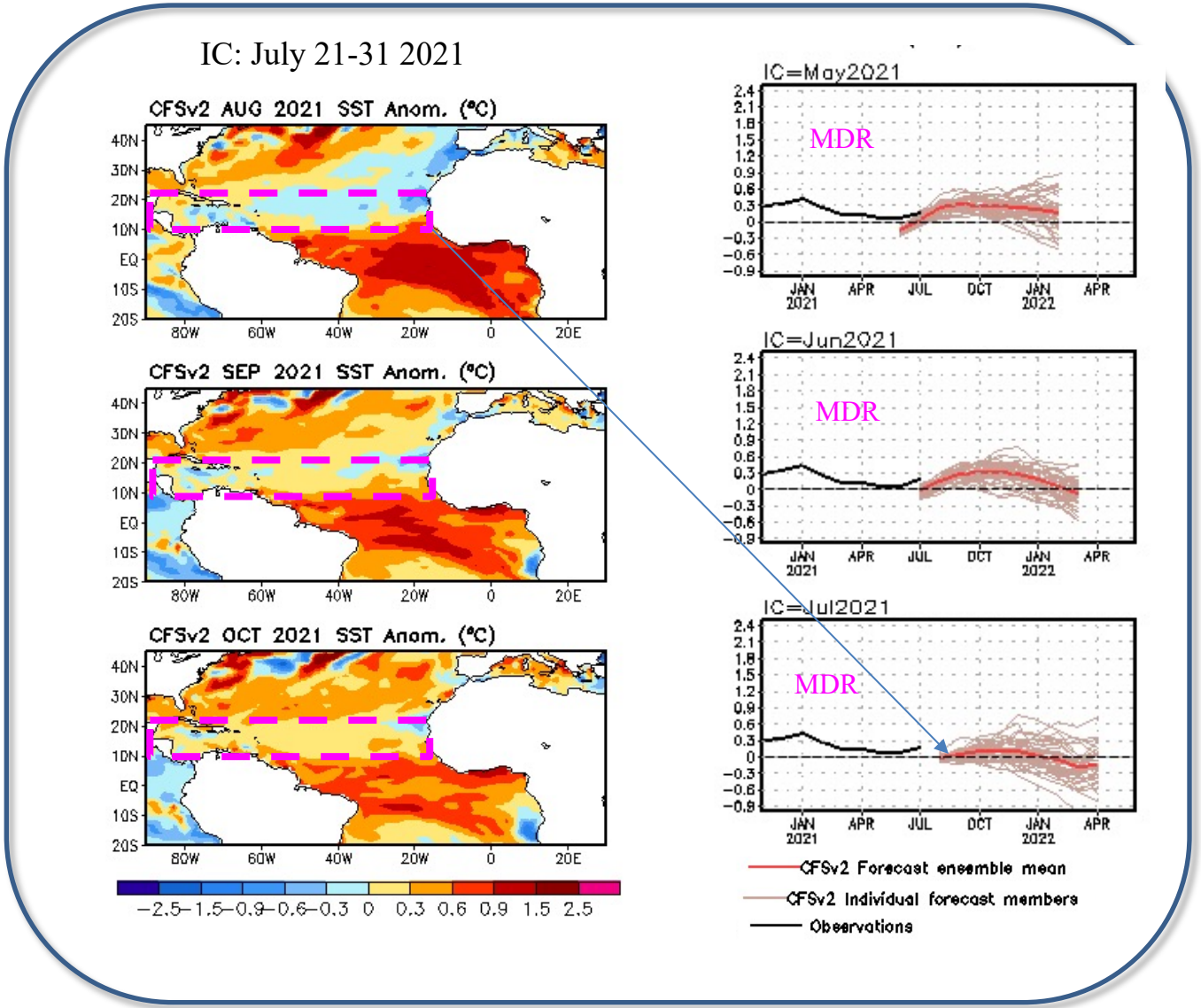
## Impact of CFSR cold bias in tropical Atlantic on ENSO predictions



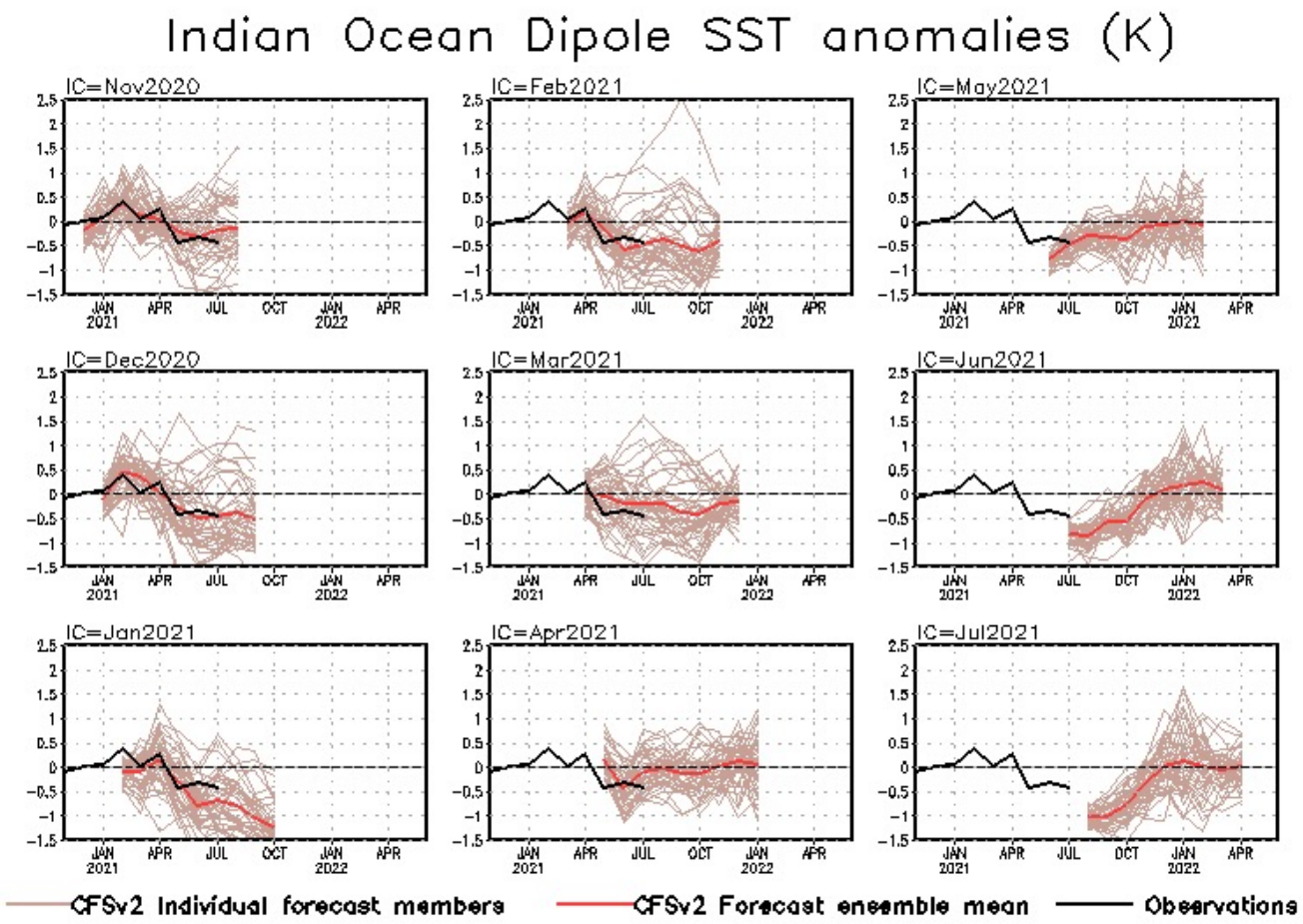
# CFSv2 Tropical Atlantic SST Predictions




- Latest CFSv2 predictions call for near normal SSTs in the hurricane main development region in Aug-Oct 2021 season.
- There are cold biases with ICs in May-Jun 2021.

CFS Tropical Atlantic 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. MDR is the SST anomaly averaged in the hurricane main development region of [90W-12W, 9oN-21oN].

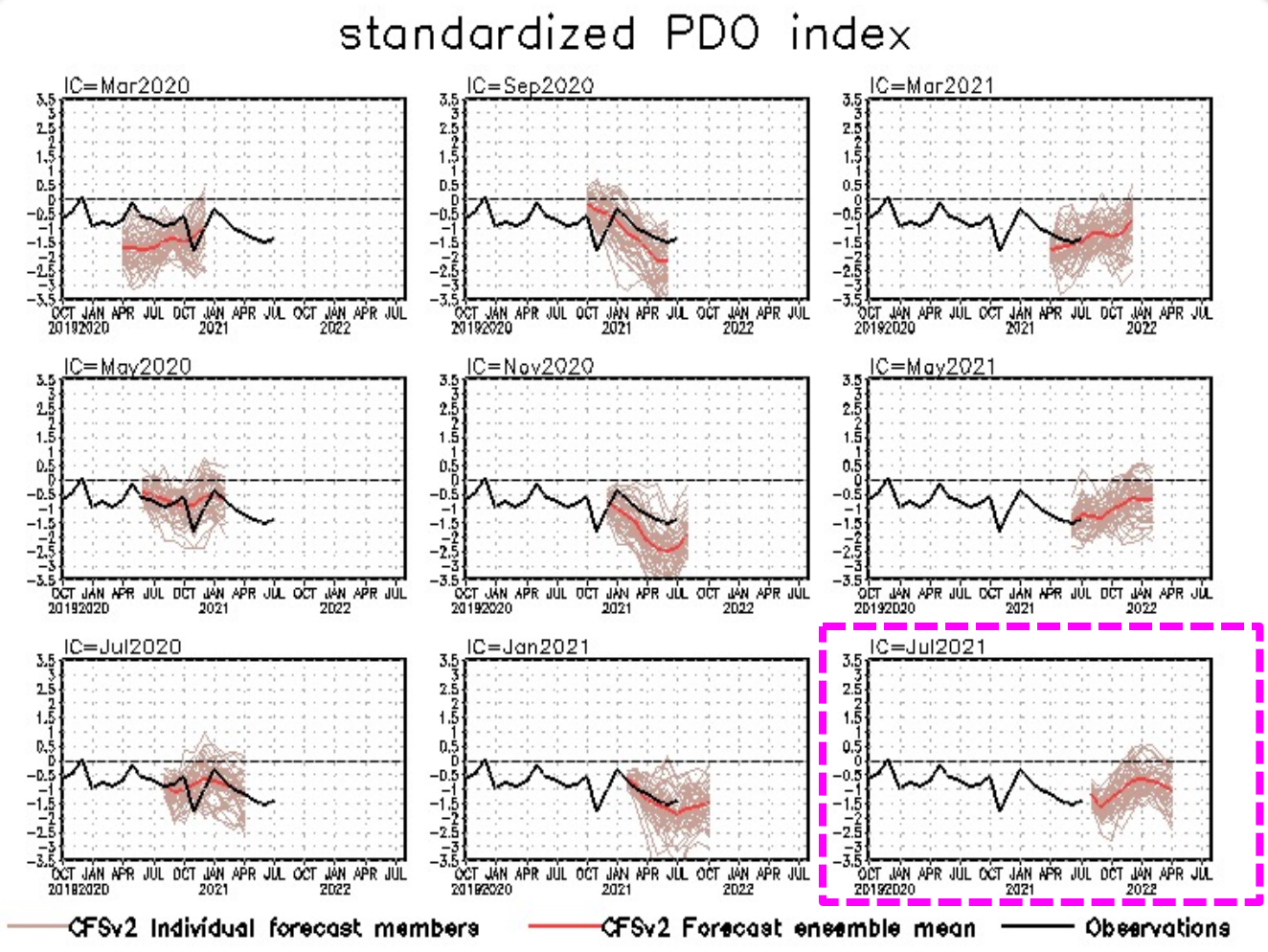
# CFSv2 DMI SST Predictions




- Latest CFSv2 predicts a negative phase of IOD in 2021.

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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**Jieshun.Zhu@noaa.gov**

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# Data Sources (climatology is for 1991-2020)

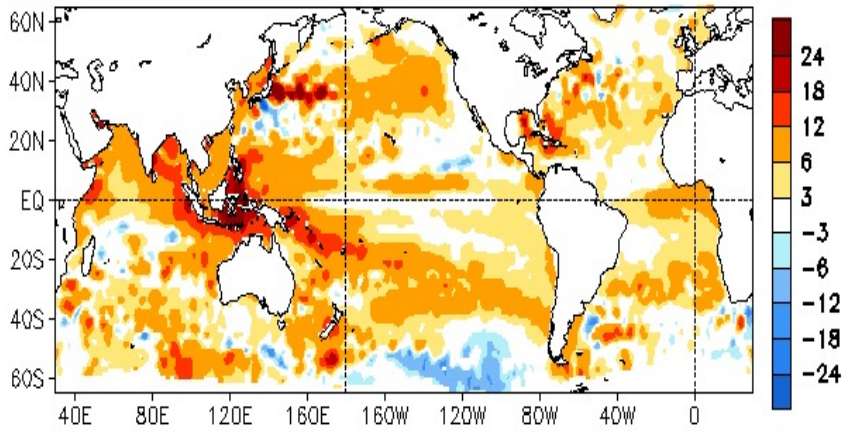
- **Weekly Optimal Interpolation SST (OI SST) version 2 (Reynolds et al. 2002)**
- **Extended Reconstructed SST (ERSST) v5 (Huang et al. 2017)**
- **Blended Analysis of Surface Salinity (BASS) (Xie et al. 2014)**
- **CMORPH precipitation (Xie et al. 2017)**
- **CFSR evaporation adjusted to OAFlux (Xie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

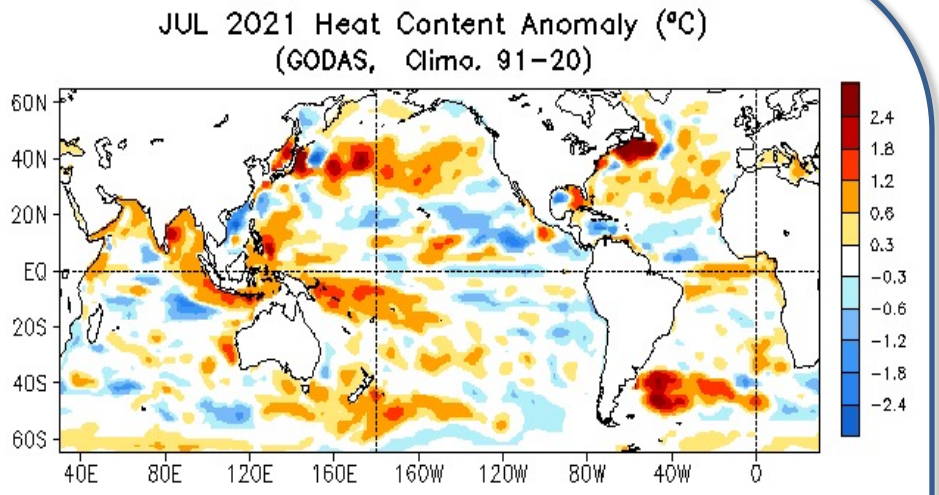
  **http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html**

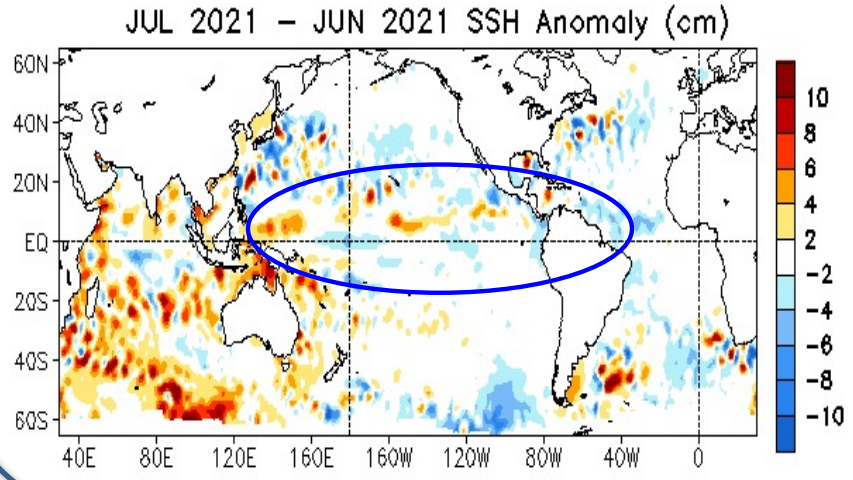
  **http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html**

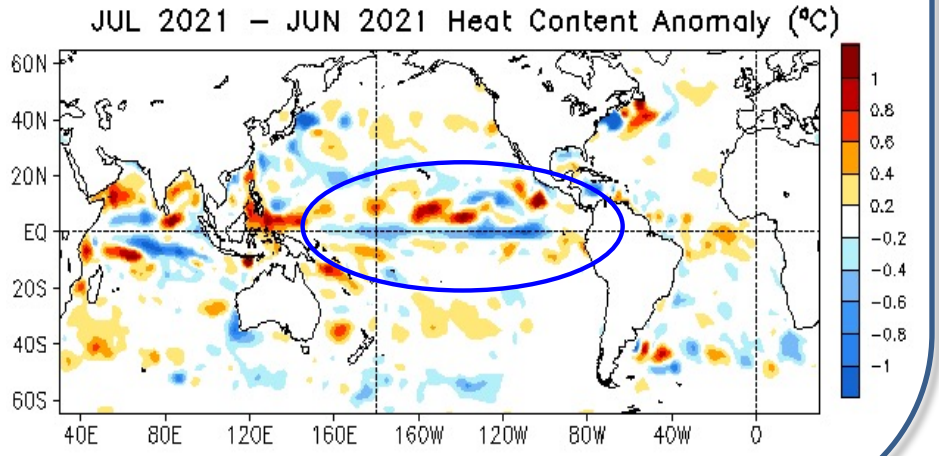
# Backup Slides

# Global SSH and HC300 Anomaly & Anomaly Tendency



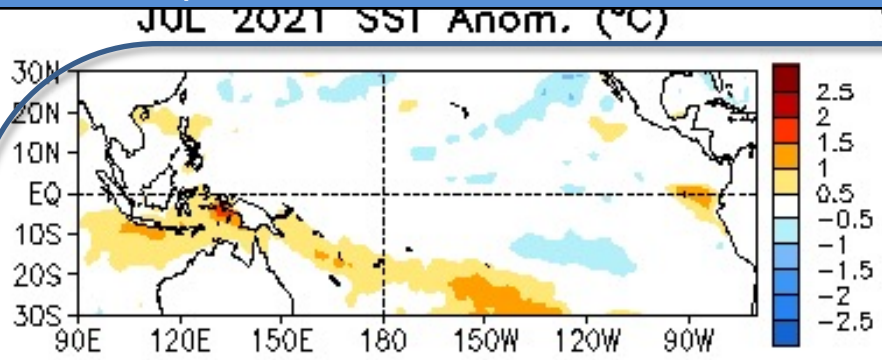



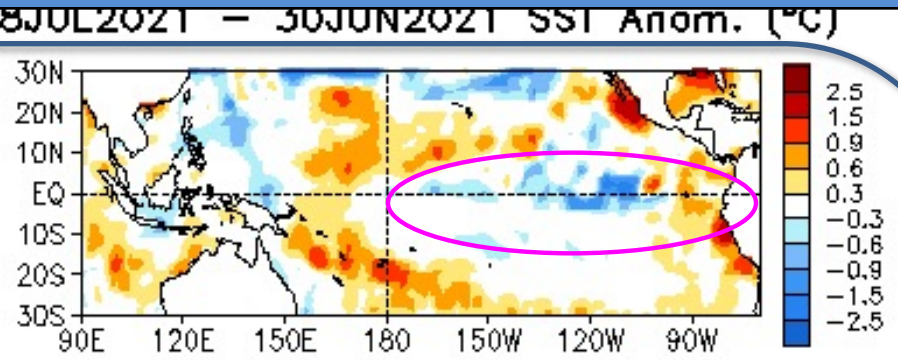



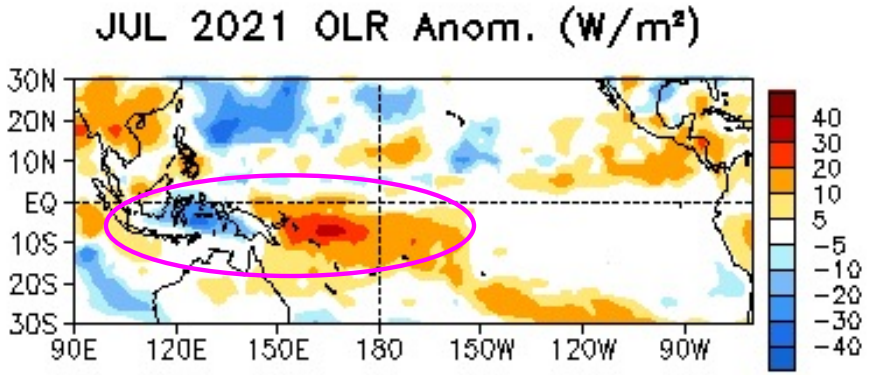



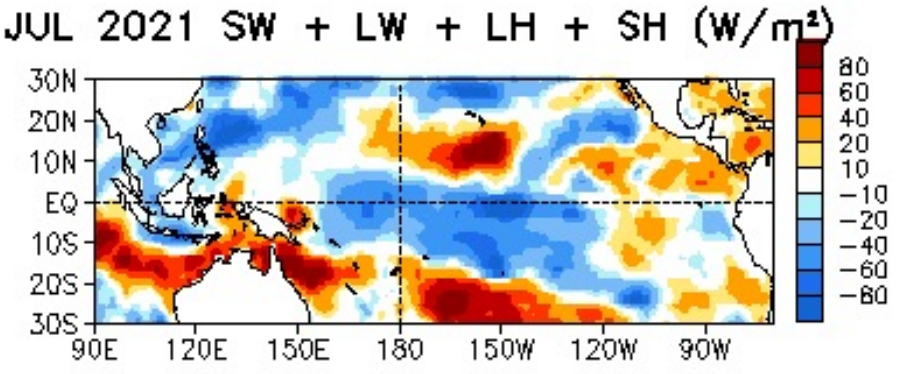

- The SSHA pattern was overall consistent with the HC300A pattern, but with a significant trend component in SSHA.
- Positive anomalies were present in the equatorial Atlantic.
- Negative tendencies were observed across most of the equatorial Pacific.

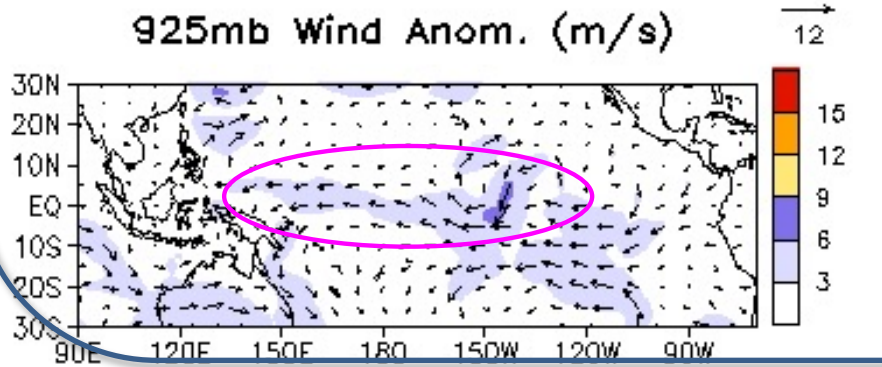
# Tropical Pacific: SSTA, SSTA Trend, OLR, heat flux, uv925 & uv200 anomalies

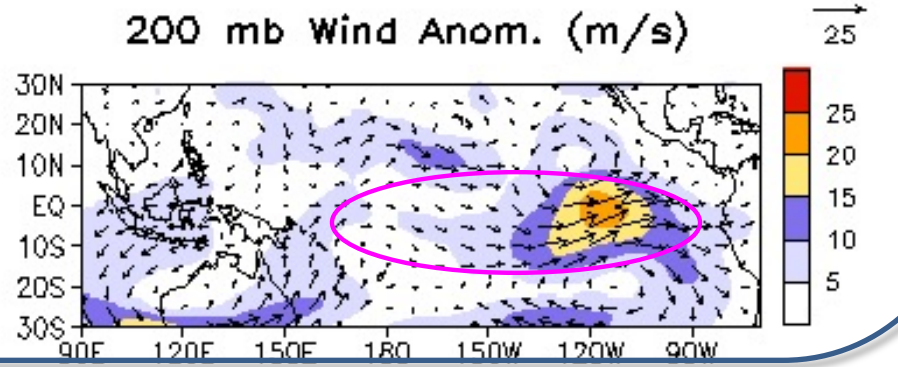



Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right; positive means heat into the ocean), 925-mb wind anomaly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

# Atlantic Niño and associated rainfall variability

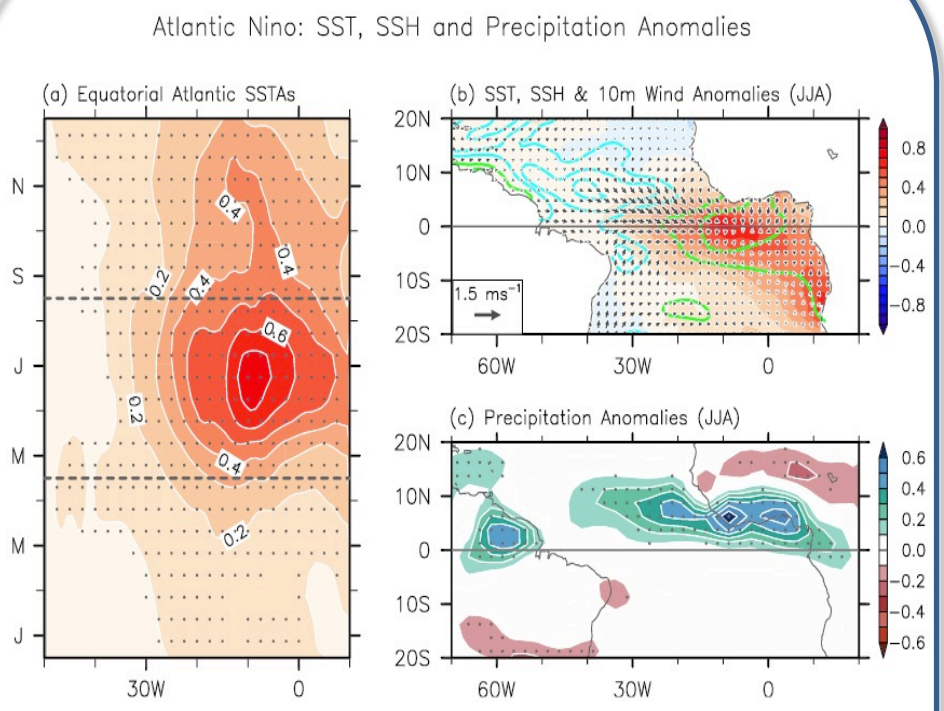
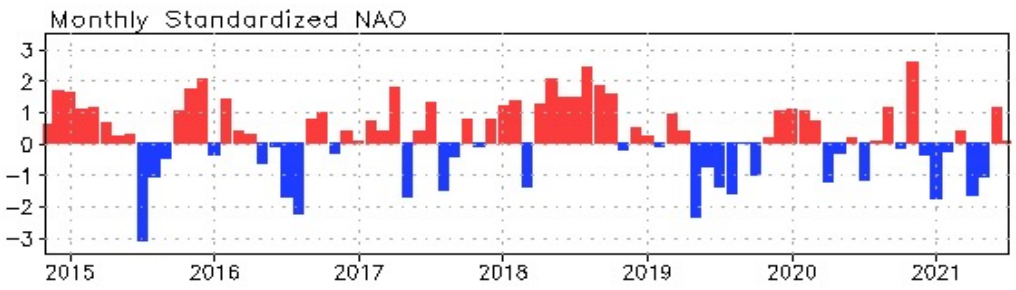


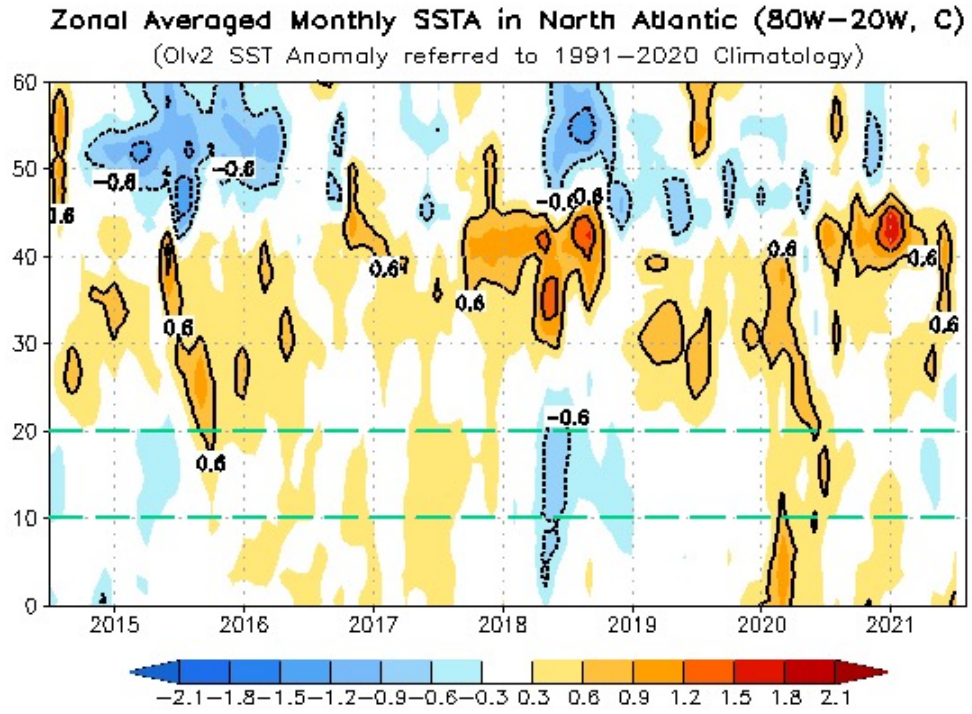

**Figure 1.** (a) Time-longitude plot of composite mean equatorial Atlantic SSTAs, averaged between 3°S and 3°N, from January to December derived from observed Atlantic Niño events. Significant SSTA values at 99% or above based on a Student's *t* test (two tailed) are indicated by gray dots. (b) Composite mean tropical Atlantic SST (shades), SSH (contours), and 10-m wind (vectors) anomalies; and (c) precipitation anomalies during June–August derived from observed Atlantic Niño events. Positive and negative SSHAs are indicated by green and cyan contour lines, respectively in (b). Significant precipitation anomaly values at 95% or above based on a Student's *t* test (two tailed) are indicated by gray dots in (c). The units for SST, SSH, winds and precipitation are in °C, cm, m $s^{-1}$, and mm $day^{-1}$, respectively. The contour interval for SSH anomalies is 0.5 cm.

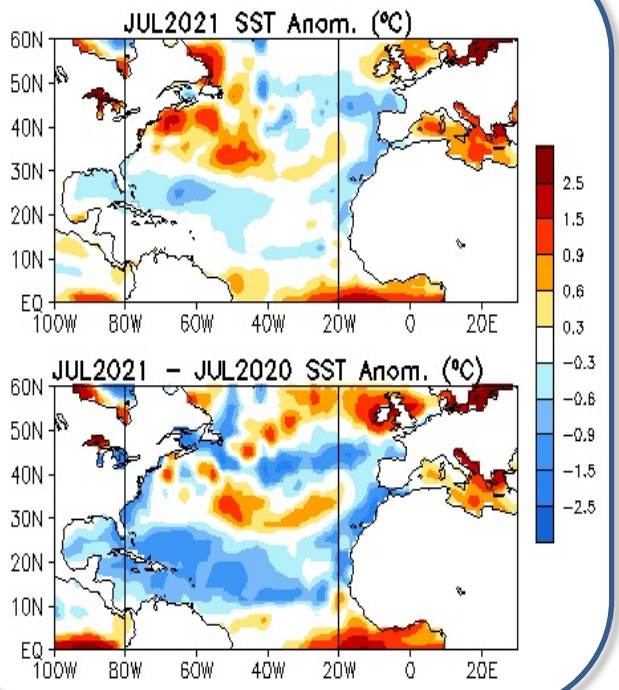
- Atlantic Niño (Niña) is defined as the 3-month averaged SSTAs exceeding 0.5°C (-0.5 °C) in the ATL 3 region [3°S- 3°N, 20°W-0°] for at least two consecutive overlapping seasons.
- Atlantic Niño usually develops in boreal spring(MAM), peaks in summer (JJA) and dissipates in fall.
- Some Atlantic Niño events are responsible for a failure of the west African summer monsoon and increased frequency of flooding in the west African countries near the Gulf of Guinea and in the northeastern South American.
- Atlantic Niño and associated rainfall variability display large diversity.

Vallès-Casanova, I., Lee, S.-K., Foltz, G. R. & Pelegrí, J. L. On the spatiotemporal diversity of Atlantic Niño and associated rainfall variability over West Africa and South America. *Geophys. Res. Lett.* **47**, e2020GL087108 (2020)

# NAO and SST Anomaly in North Atlantic



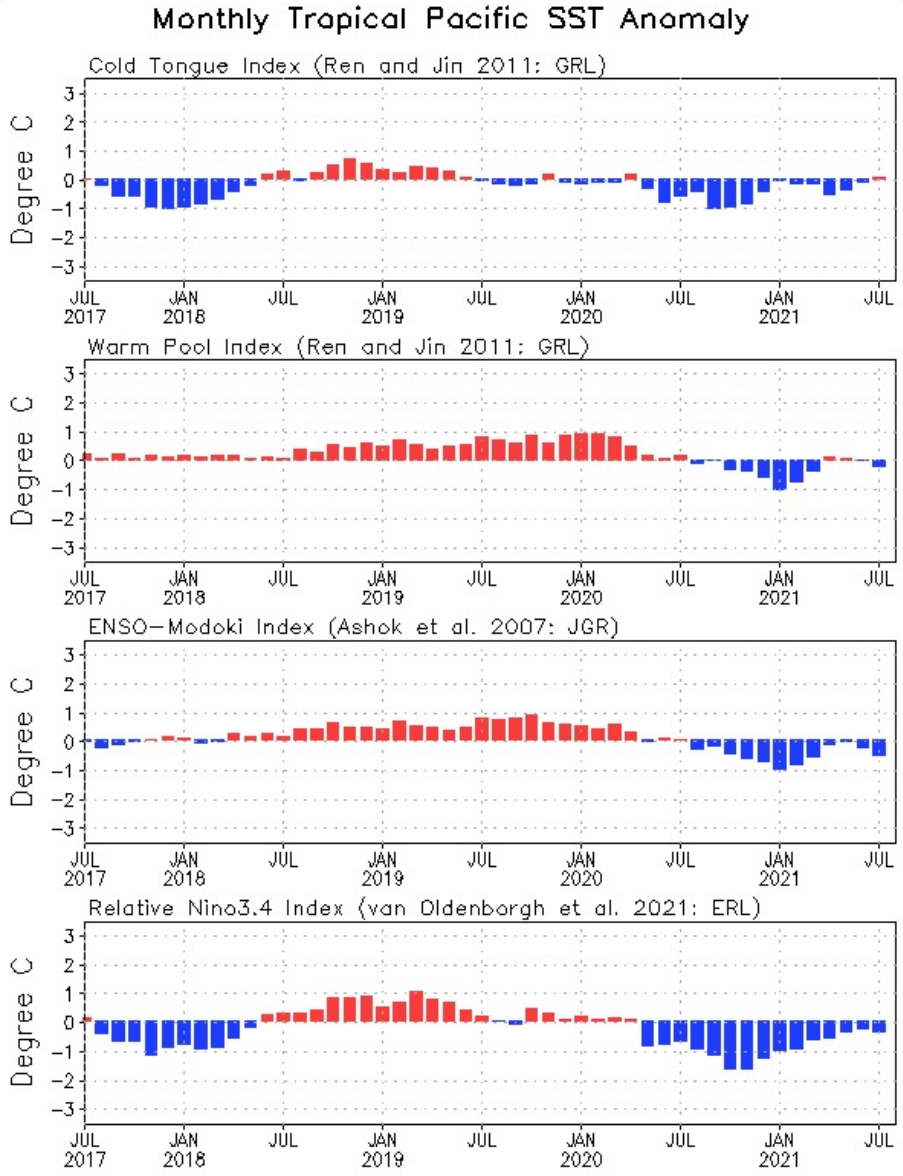



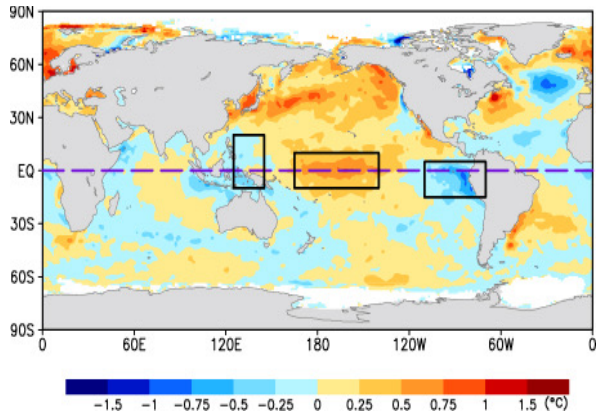




- NAO was near average in Jul 2021.
- The prolonged positive SSTAs in the middle latitudes were evident, due to the domination of the positive phase of NAO during the last 5-6 years.

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



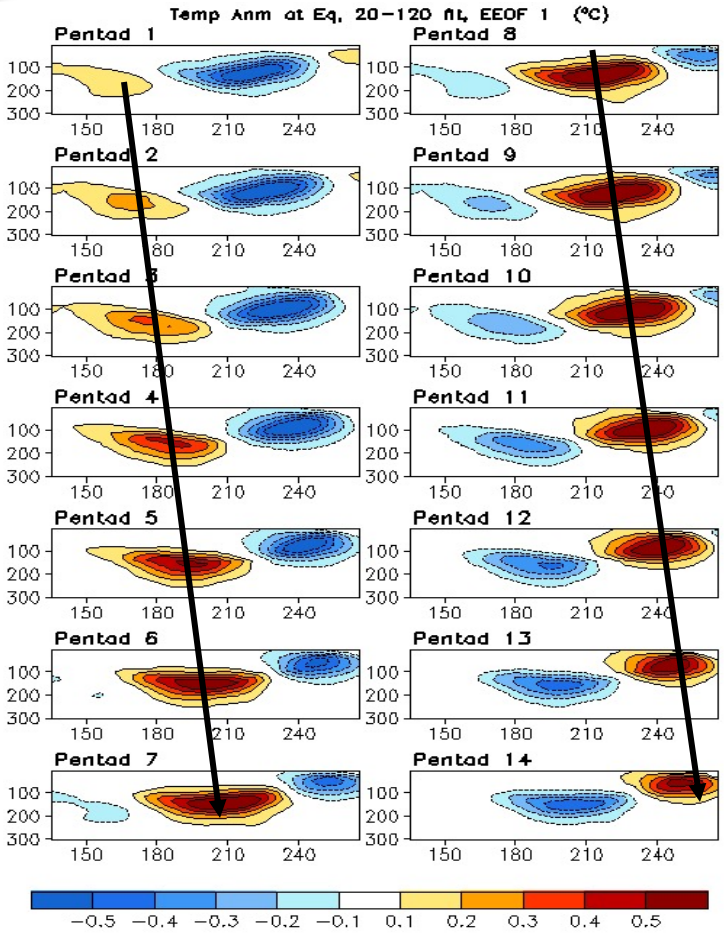



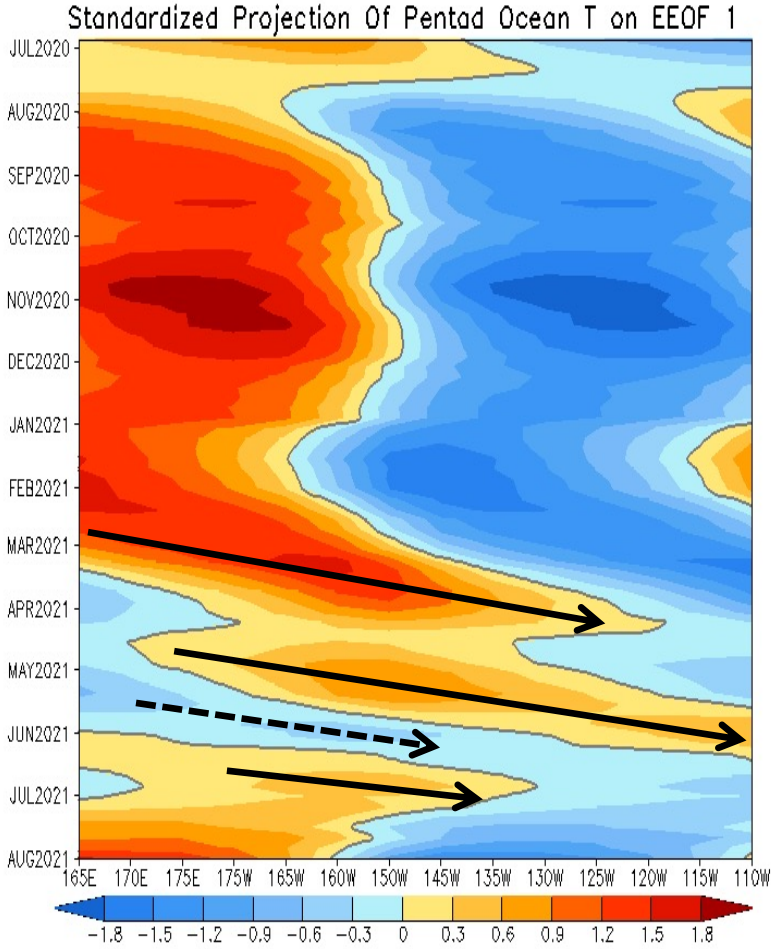

- Relative Niño3.4 index is now included in ENSO monitoring, which is defined as the conventional Niño3.4 index minus the SSTA averaged in the whole tropics (0º-360º, 20ºS-20ºN), in order to remove the global warming signal. Also, to have the same variability as the conventional Niño3.4 index, the relative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



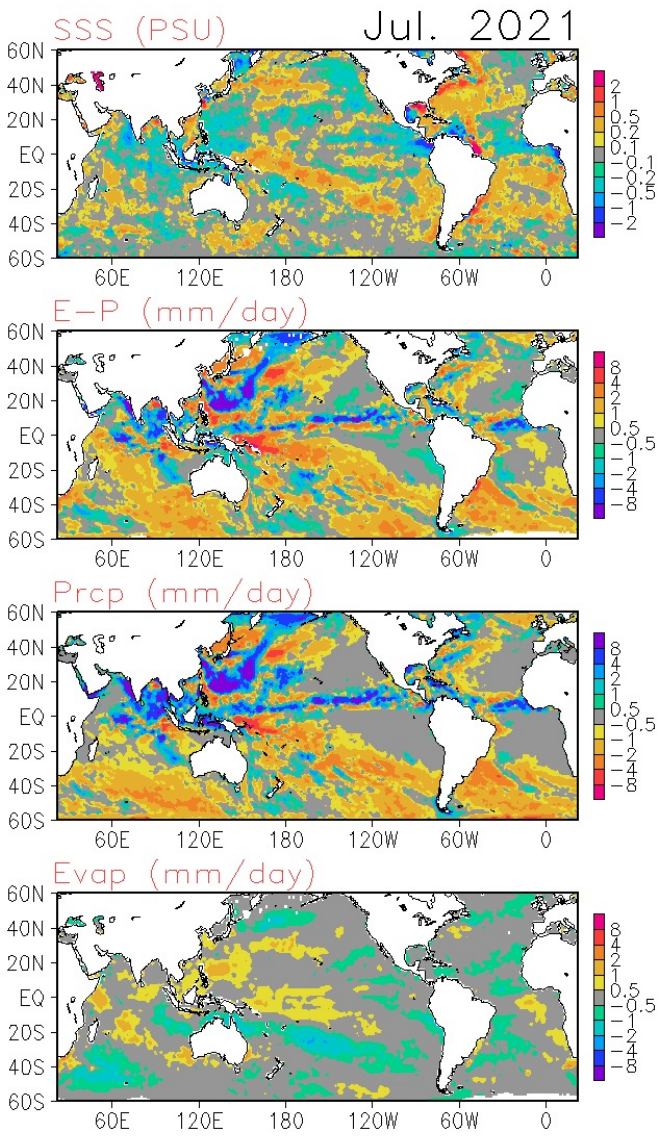

- Two weak downwelling Kelvin waves were initiated in Feb and Apr 2021, respectively, consisting with the weakening of La Niña.

*(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 July 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 and likely strengthens in the western equatorial Pacific Ocean and SPCZ region, which is likely caused by reduced precipitation. Negative SSS anomaly also continues in the eastern equatorial Pacific Ocean. Positive SSS anomaly continues between 20°N and 40°N in the North Atlantic Ocean. While, negative SSS anomaly along the Equatorial Atlantic Ocean continues which is likely due to increased precipitation. Negative SSS anomaly appears in the equator and north of equator of Indian Ocean.**




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

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

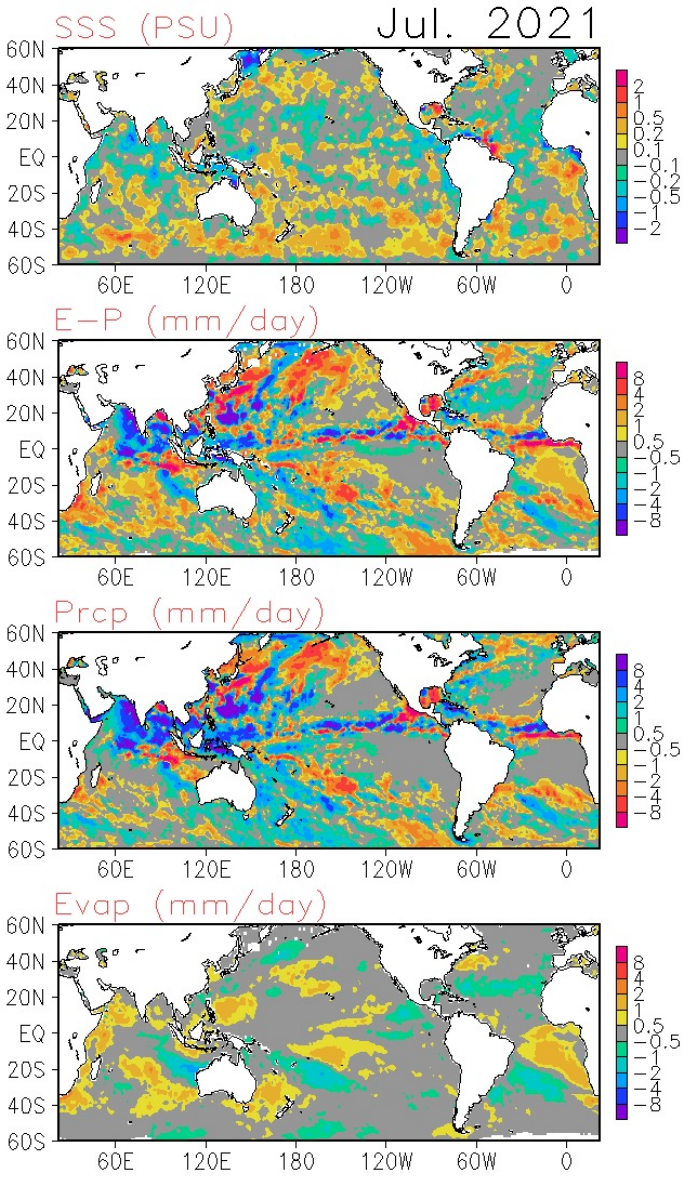
**ftp.cpc.ncep.noaa.gov/precip/BASS**

**Precipitation: CMORPH adjusted satellite precipitation estimates**

**Evaporation: Adjusted CFS Reanalysis**

# Global Sea Surface Salinity (SSS): Tendency for July 2021

Compared with last month, SSS increases in the western equatorial Pacific Ocean and SPCZ region. While, SSS decreases in the eastern equatorial Pacific Ocean. SSS increases in the Kuroshio and its extension region possibly due to reduced precipitation. SSS also increases in the gulf stream. SSS decreases in the Indian Ocean in most areas north of equator which is likely caused by increased 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.