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

Prepared by

Climate Prediction Center, NCEP/NOAA

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

This project, to deliver real-time ocean monitoring products, is implemented by CPC in cooperation with NOAA's Global Ocean Monitoring and Observing Program (GOMO)

Outline

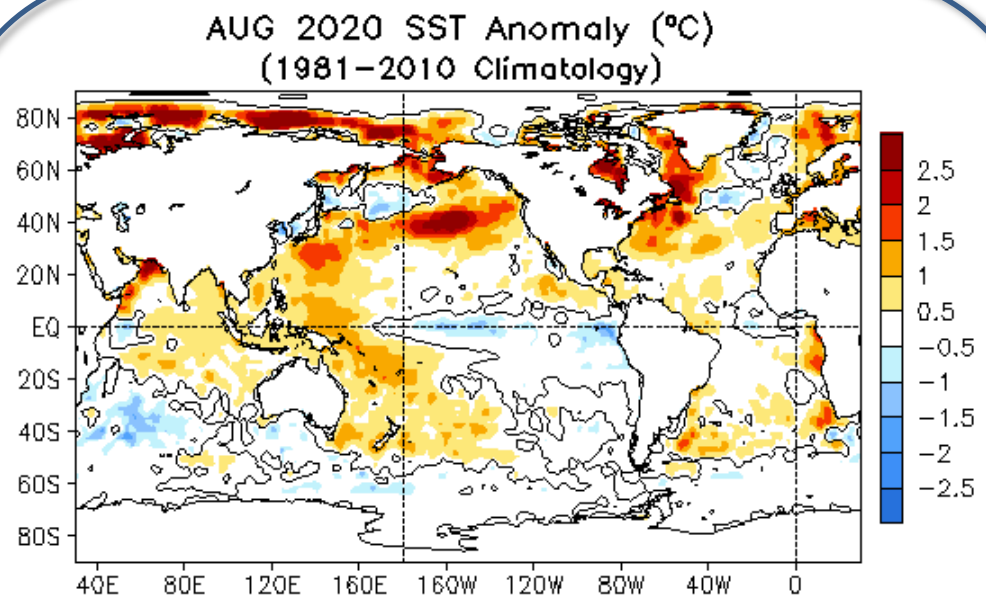
- Overview
- Recent highlights
  - Pacific/Arctic Ocean
  - Indian Ocean
  - Atlantic Ocean
- Global SSTA Predictions
- Special Topics
  - Will La Niña develop during winter 2020-21?
  - North Atlantic Hurricane and oceanic conditions
  - Global Marine Heatwave Monitoring and prediction

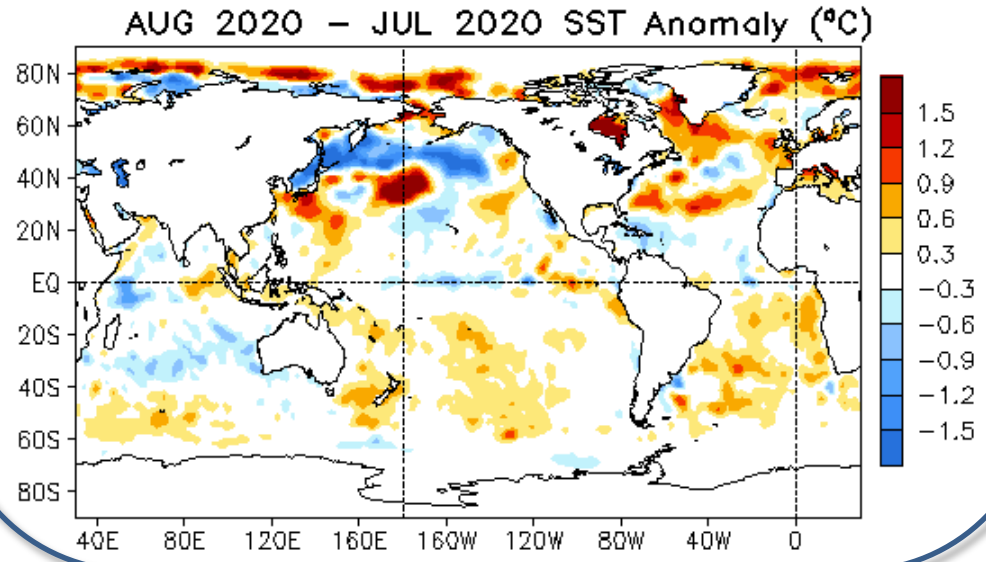
Overview

- Pacific Ocean
  - NOAA “ENSO Diagnostic Discussion” on 10 Sep 2020 issued La Niña Advisory : “La Niña conditions are present and are likely to continue through the Northern Hemisphere winter (~75% chance)”.
  - Marine Heat Waves (MHWs) persisted in North central Pacific.
  - Negative PDO phase continued, with PDOI = -0.9.
- Indian Ocean
  - Indian Ocean Dipole index switched to negative phase in Aug 2020.
- Atlantic Ocean
  - Atlantic Hurricane is very active during 2020 hurricane season.
  - MHWs persistent near the Labrador sea and Baffin Bay in Aug 2020.
- Arctic Ocean
  - The sea ice extent in Aug 2020 was ranked as the 3rd lowest since 1979.
  - SST warming enhanced in the sub-Arctic regions north of Eurasia with MHWs developed at the end of Aug 2020.

Global Oceans

Global SST Anomaly (^{0}C) and Anomaly Tendency



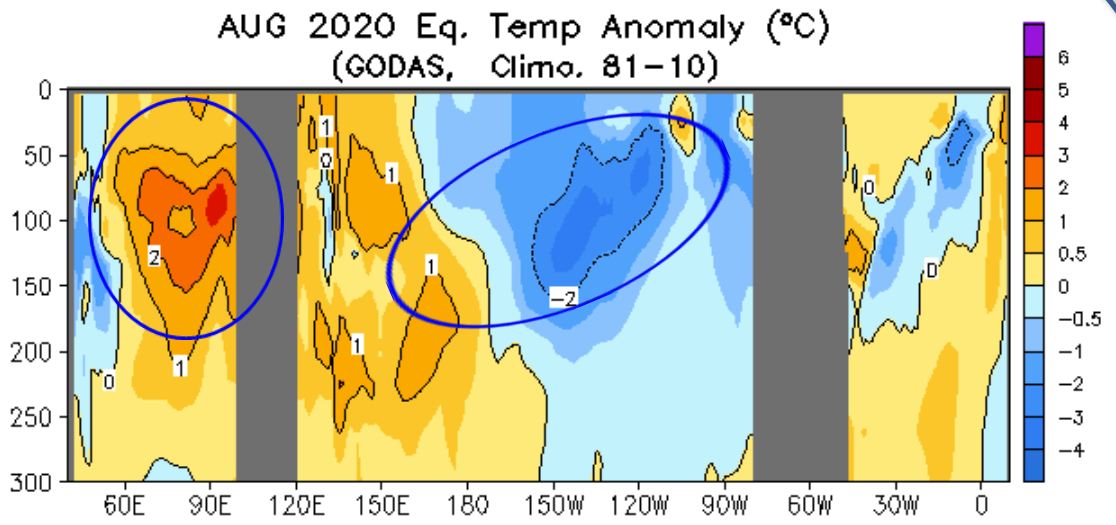


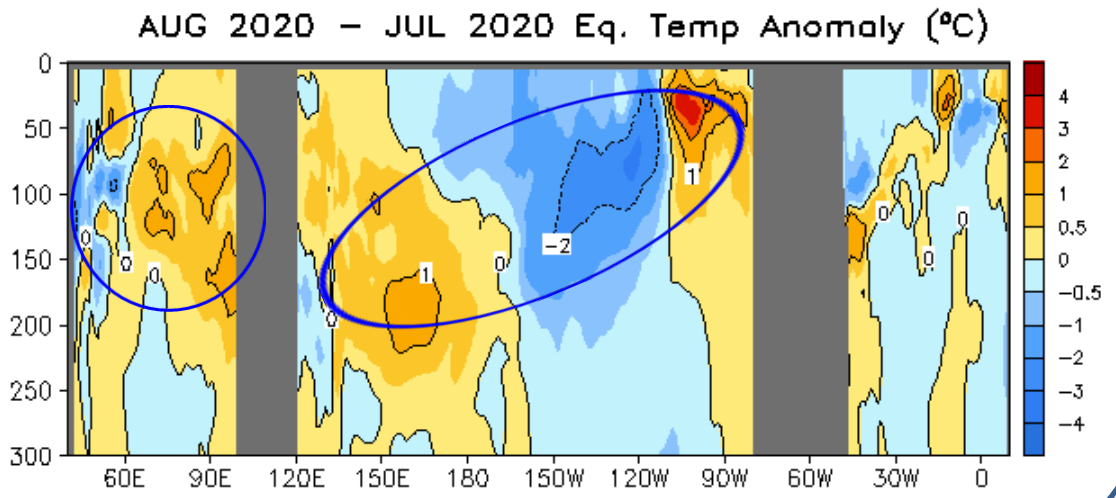
- SSTs were below-average in the central-eastern equatorial Pacific.
- Strong positive SSTAs were present in the NE Pacific and Northern Hemispheric subpolar regions.
- Positive SSTAs persisted in the tropical Indian Ocean and the western tropical Pacific.

- Negative (positive) SSTA tendencies were present in the central-eastern (far eastern) equatorial Pacific.
- Large SSTA tendencies presented in the high-latitude of North Pacific.
- Positive SSTA tendencies dominated the mid-high latitudes of North Atlantic.

Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2°S-2°N



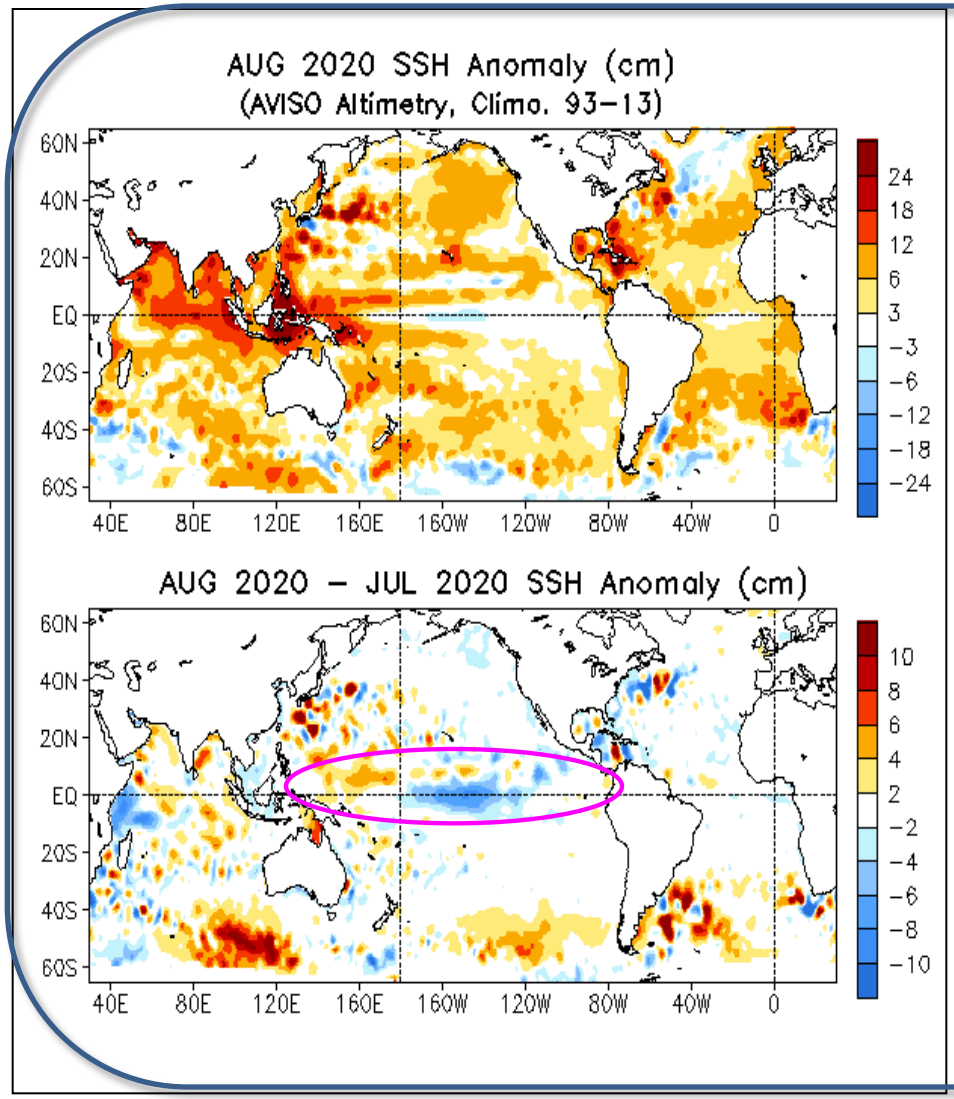


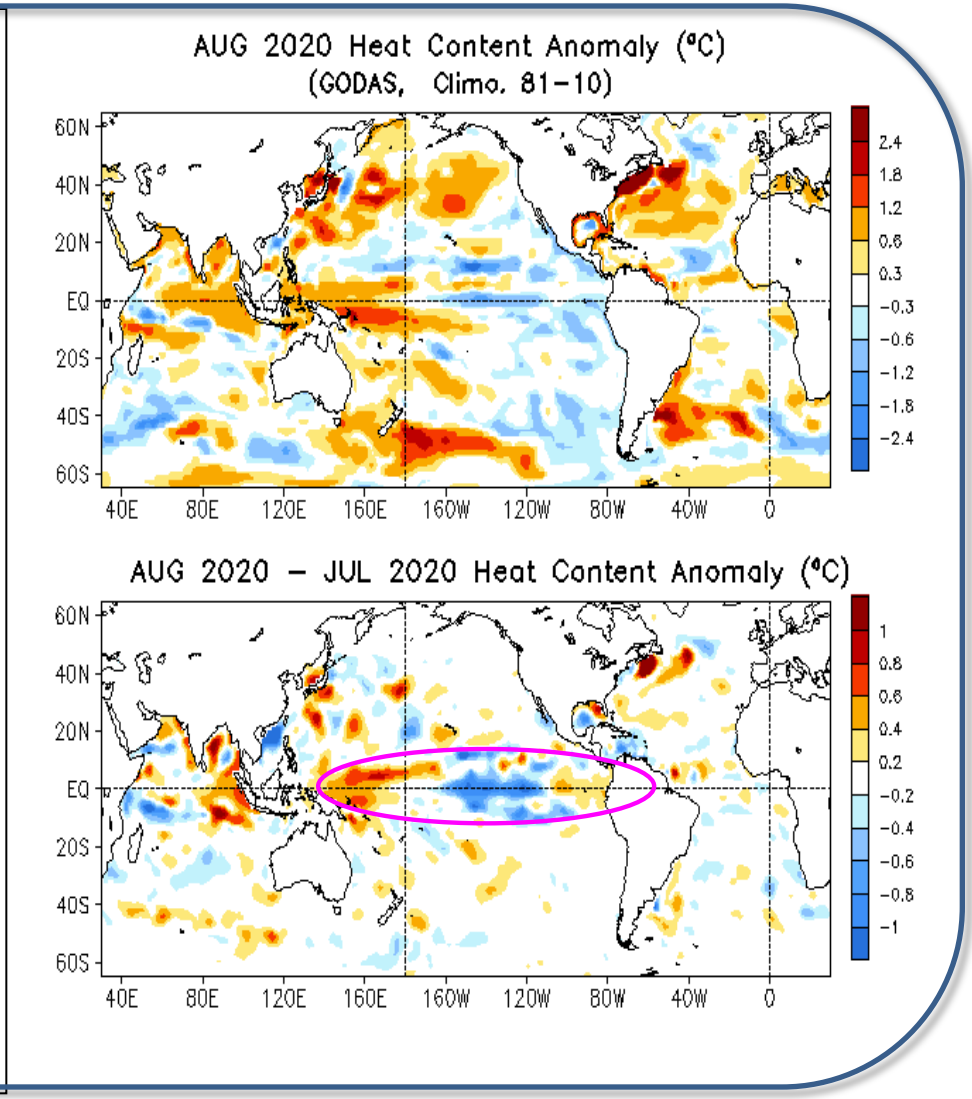
- Ocean temperature were 2°C cooler than average near the thermocline in the central-eastern Pacific.
- Positive temperature anomalies continued in the upper equatorial Indian Ocean.

- Negative(positive) temperature anomaly tendency presented in the central Pacific (western and far eastern Pacific).
- Positive temperature anomaly dominated in the Indian 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 1981-2010 base period means.

Global SSH and HC300 Anomaly & Anomaly Tendency

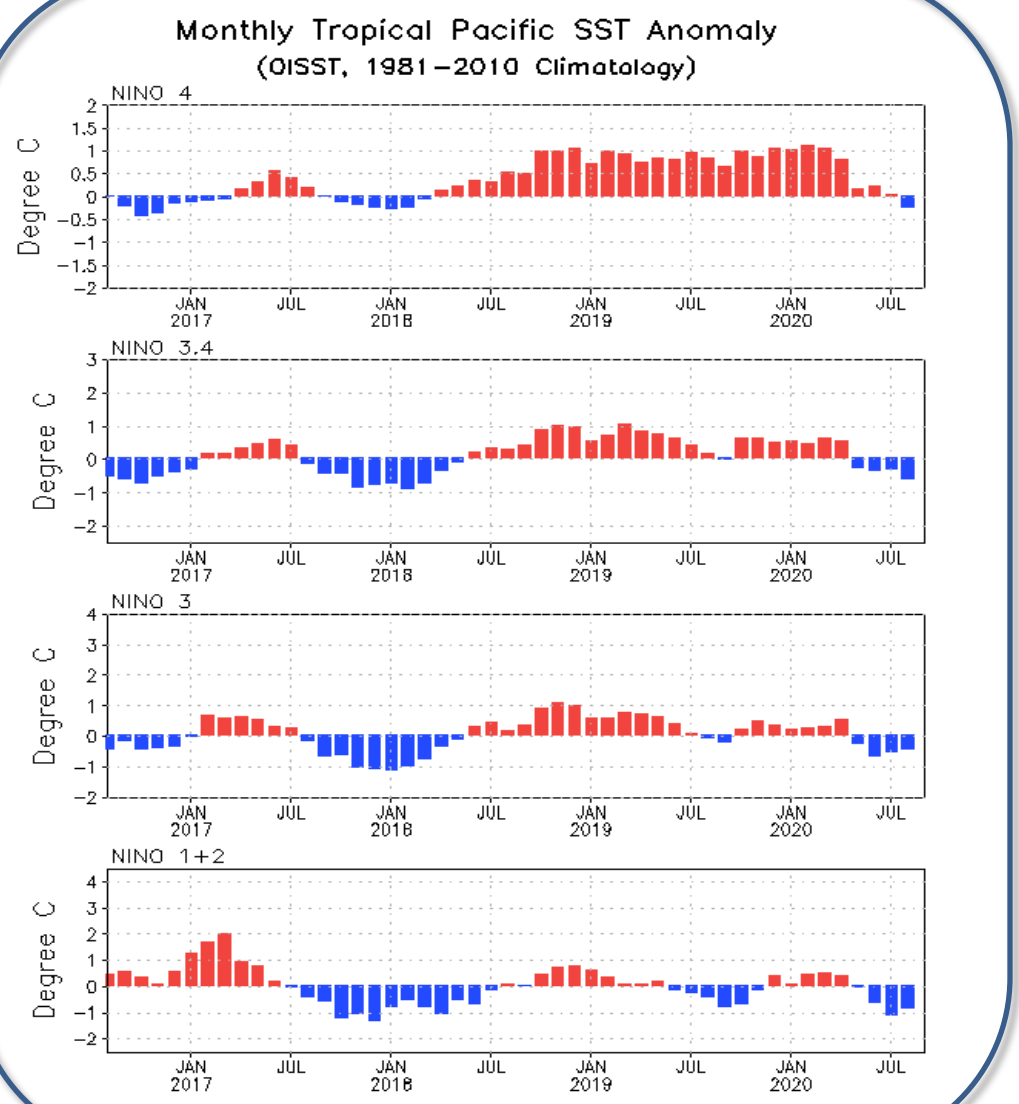


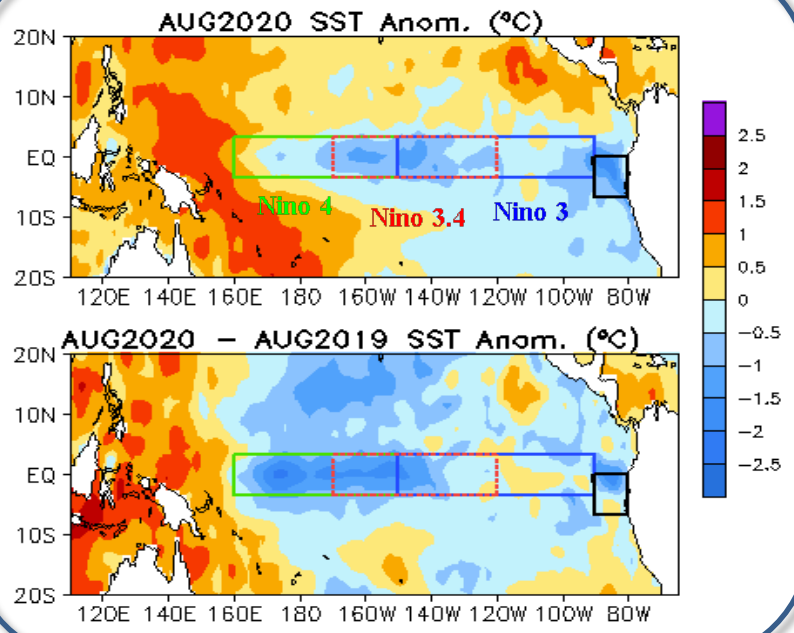


- The SSHA pattern was overall consistent with the HC300A pattern, but with a significant trend component in SSHA.
- Negative (positive) tendencies of SSHAs and HC300As presented in the central-eastern (western) tropical Pacific.

Tropical Pacific Ocean and ENSO Conditions

Evolution of Pacific NINO SST Indices





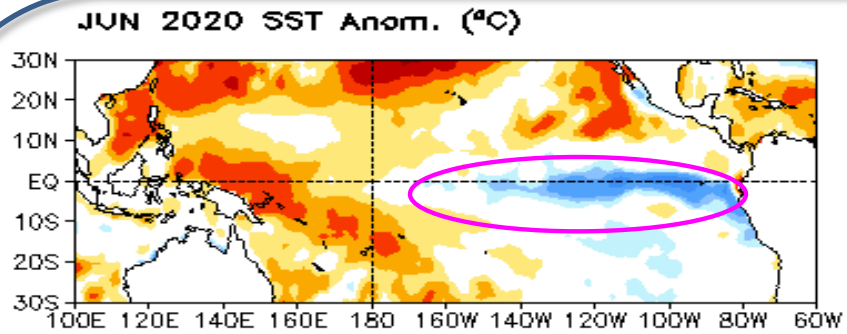
- Both NINO 4 and NINO34 regions cooled down in Aug 2020, with NINO3.4 = -0.64° C.

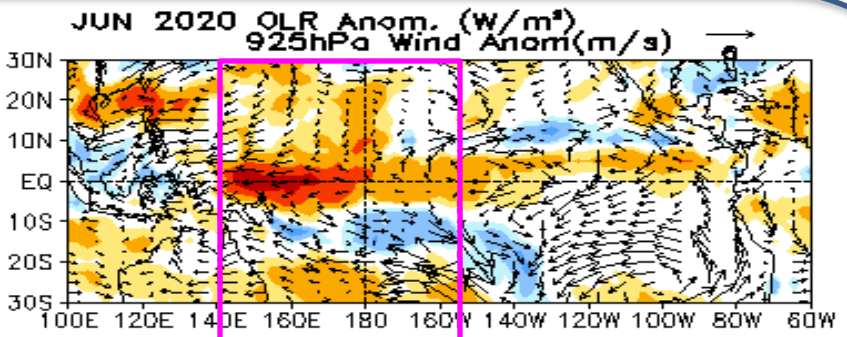
- Compared with Aug 2019, the central and eastern (far western) equatorial Pacific was cooler (warmer) in Aug 2020.

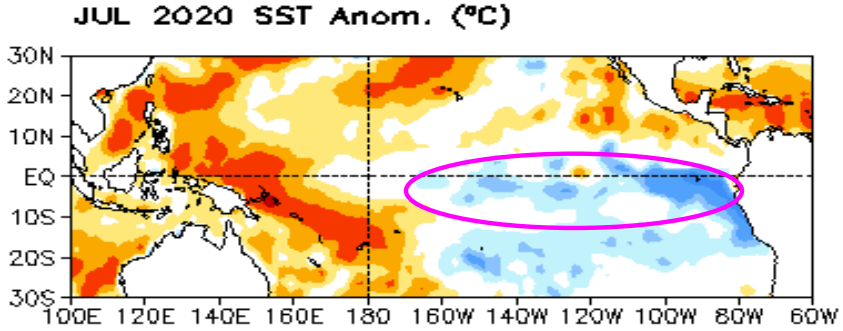
- The indices may have slight differences if based on different SST products

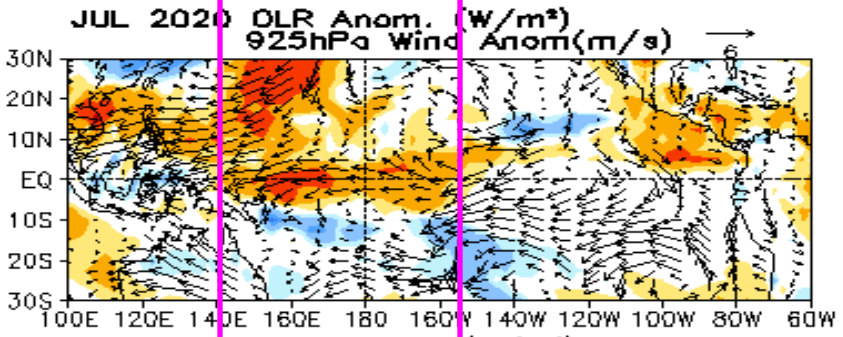
Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

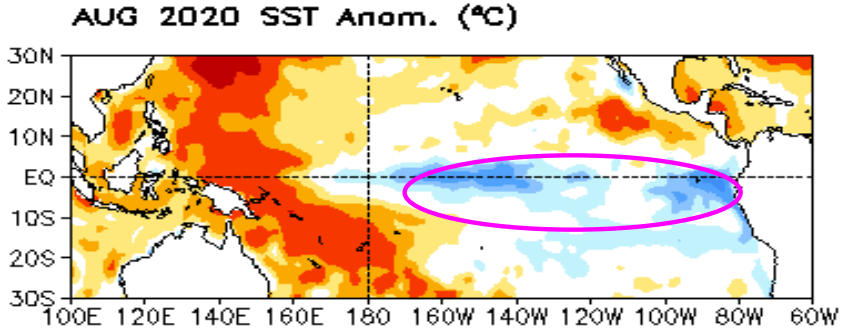
Last Three Month SST, OLR and 925hp Wind anomalies

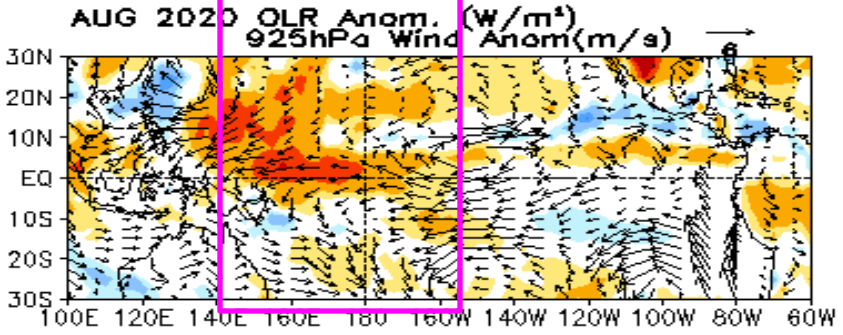


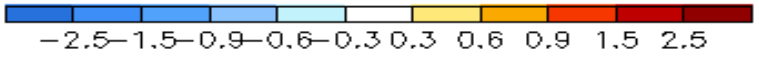


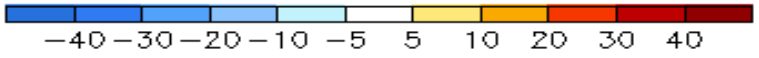






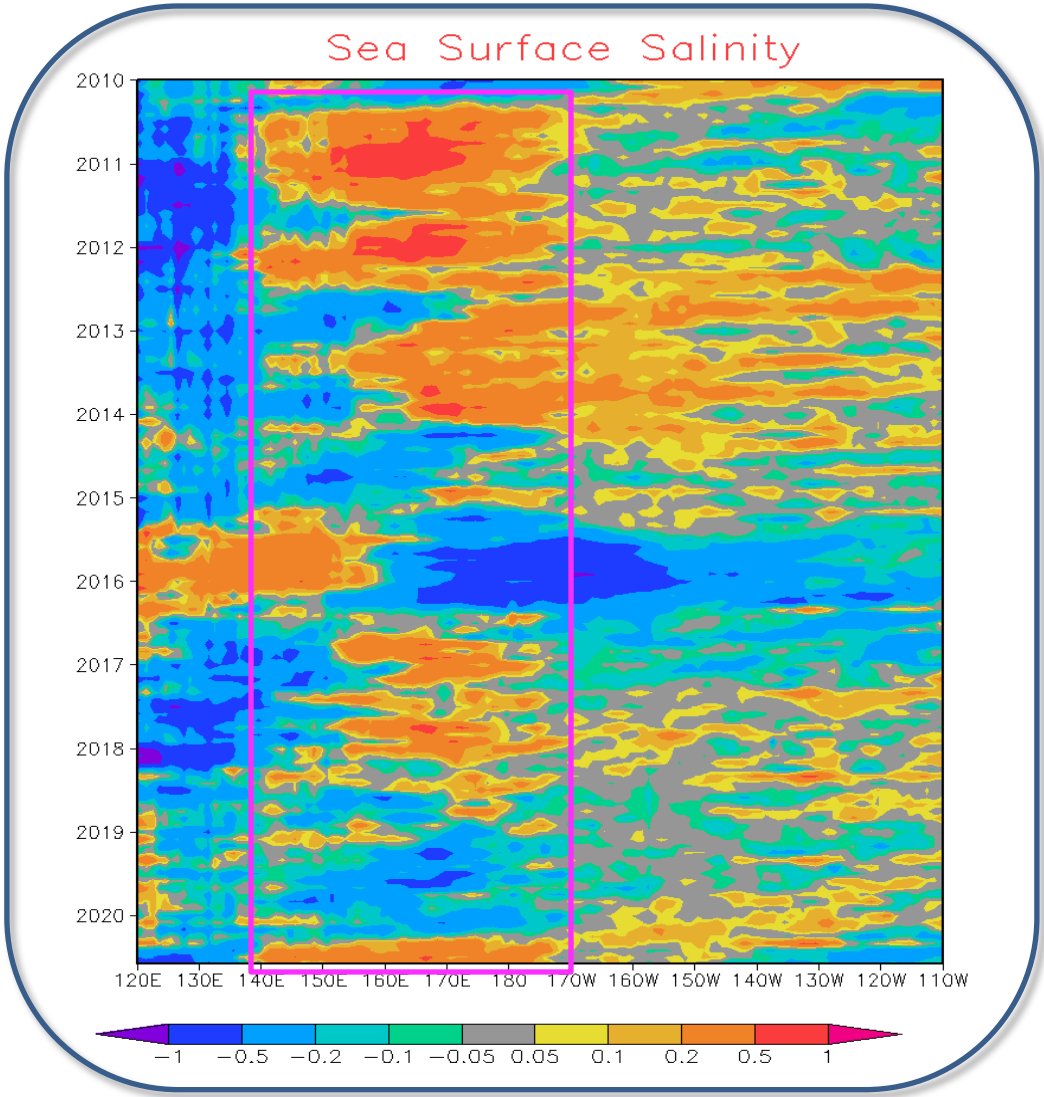






Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right; positive means heat into the ocean), 925-mb wind anomaly 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 1981-2010 base period means.

Equatorial Pacific Sea Surface Salinity(SSS) Anomaly

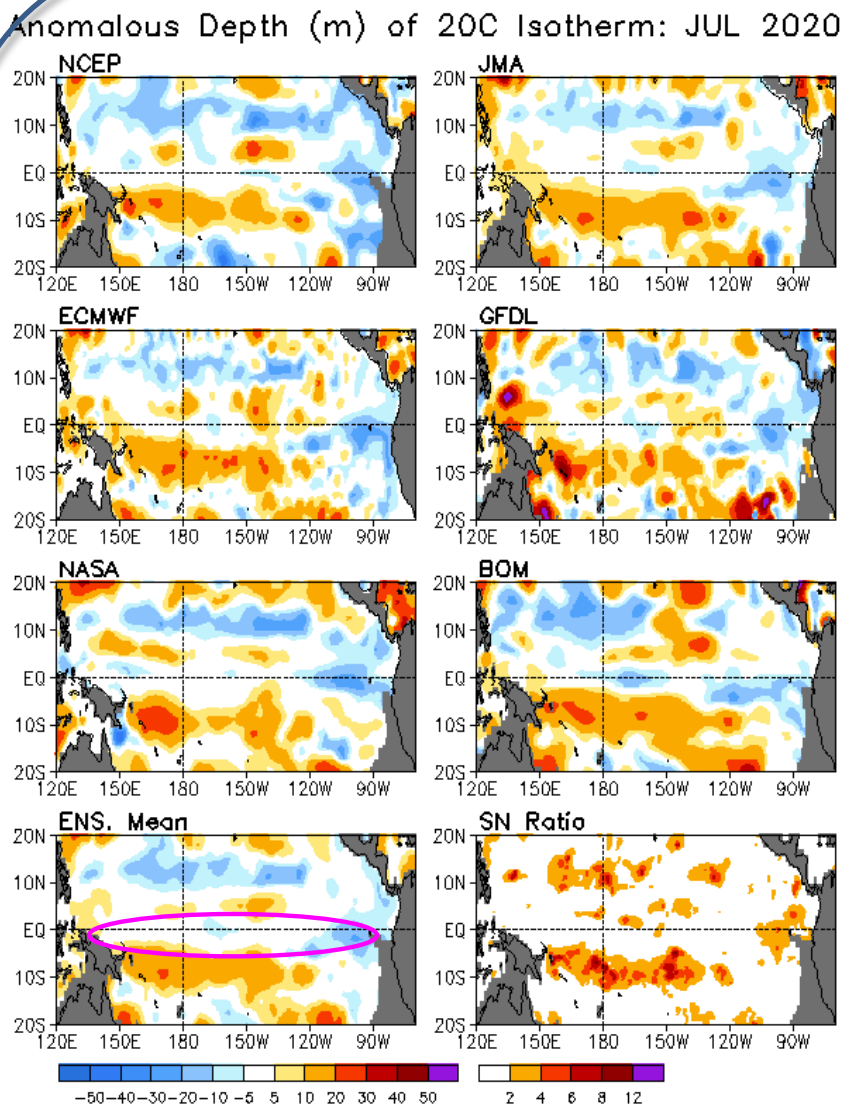


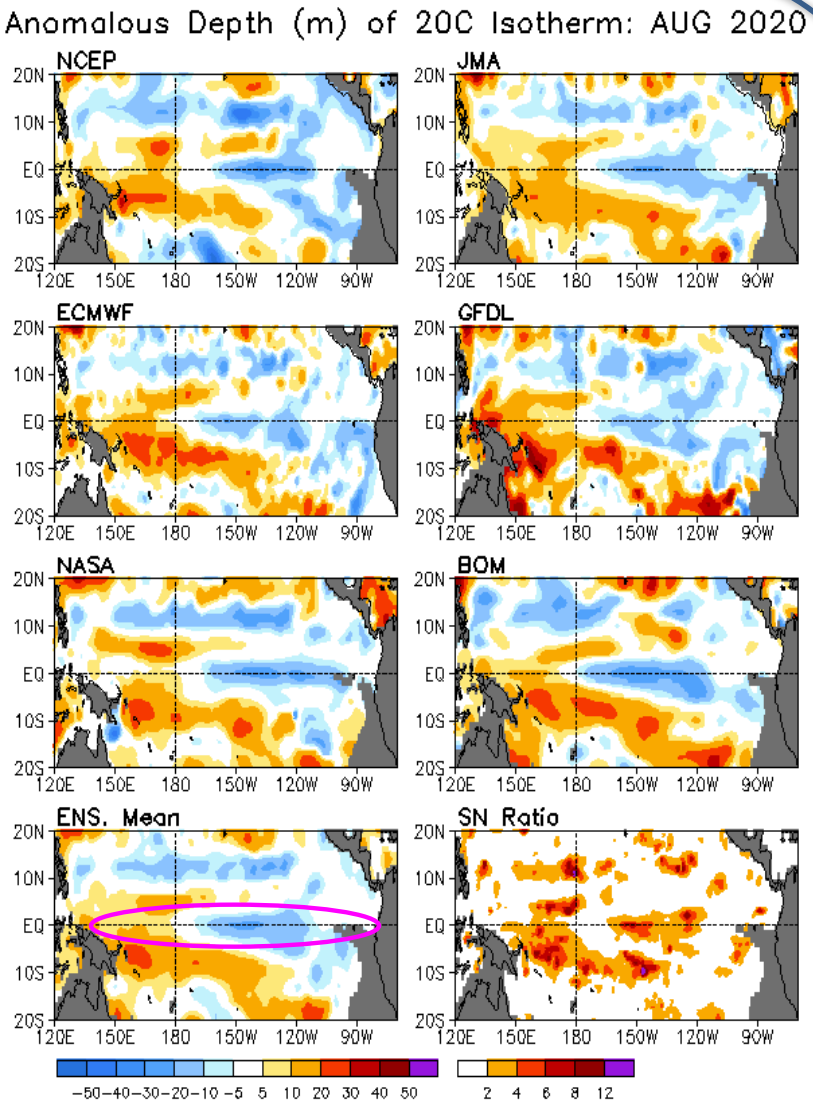
- Positive (negative) SSS anomaly presented east (west) of 140E during 2010, 2011, 2016,2017 La Nina events.

- Strong positive SSS anomaly persisted around 140E-170W in Aug 2020.

Sea surface salinity (SSS) anomalies are derived from Blended Analysis of Surface Salinity (BASS) V0.Z (Xie et al. 2014). Data is available at ftp.cpc.ncep.noaa.gov/precip/BAS.

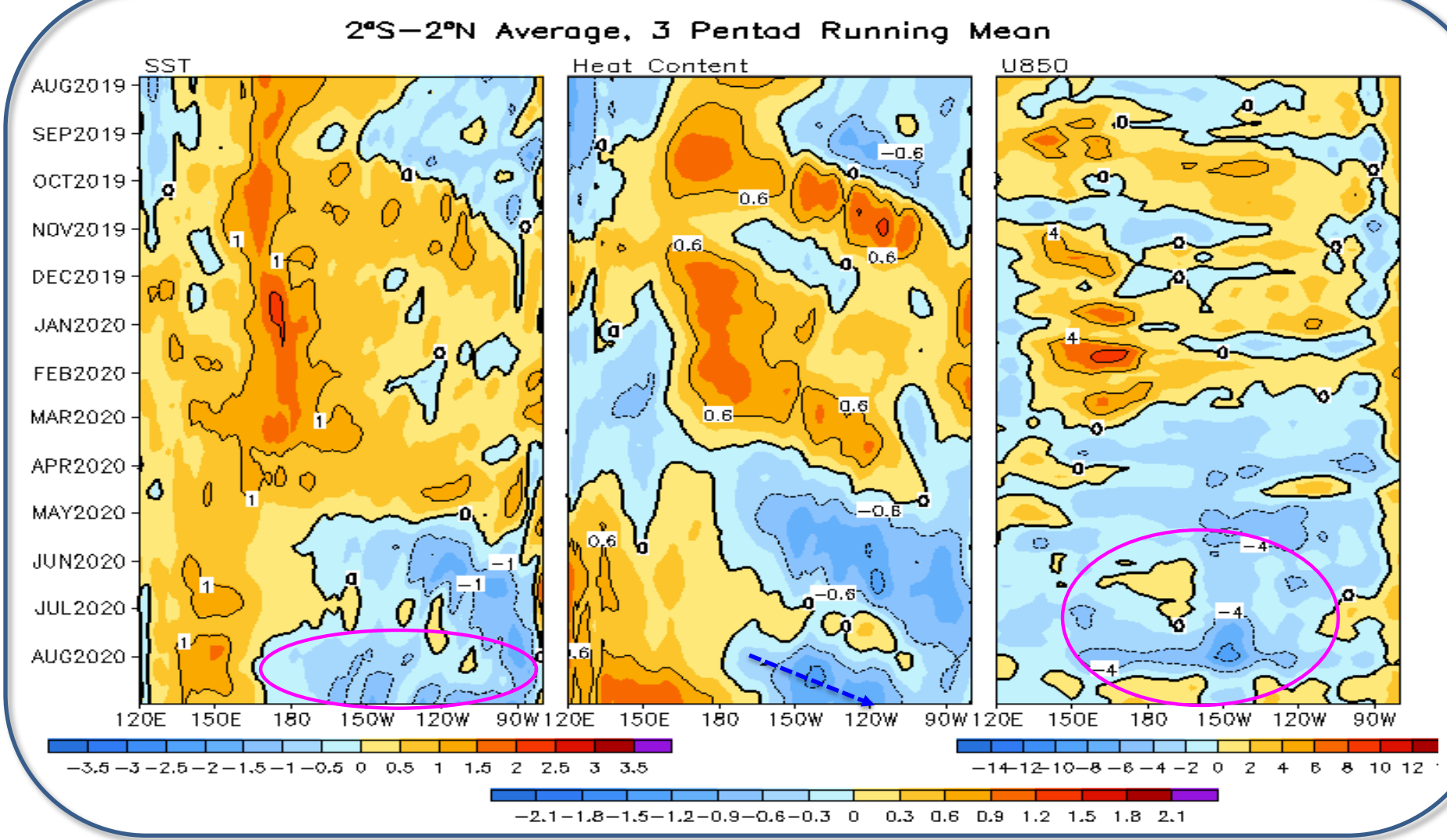
Real-Time Ocean Reanalysis Intercomparison: D20 Anomaly





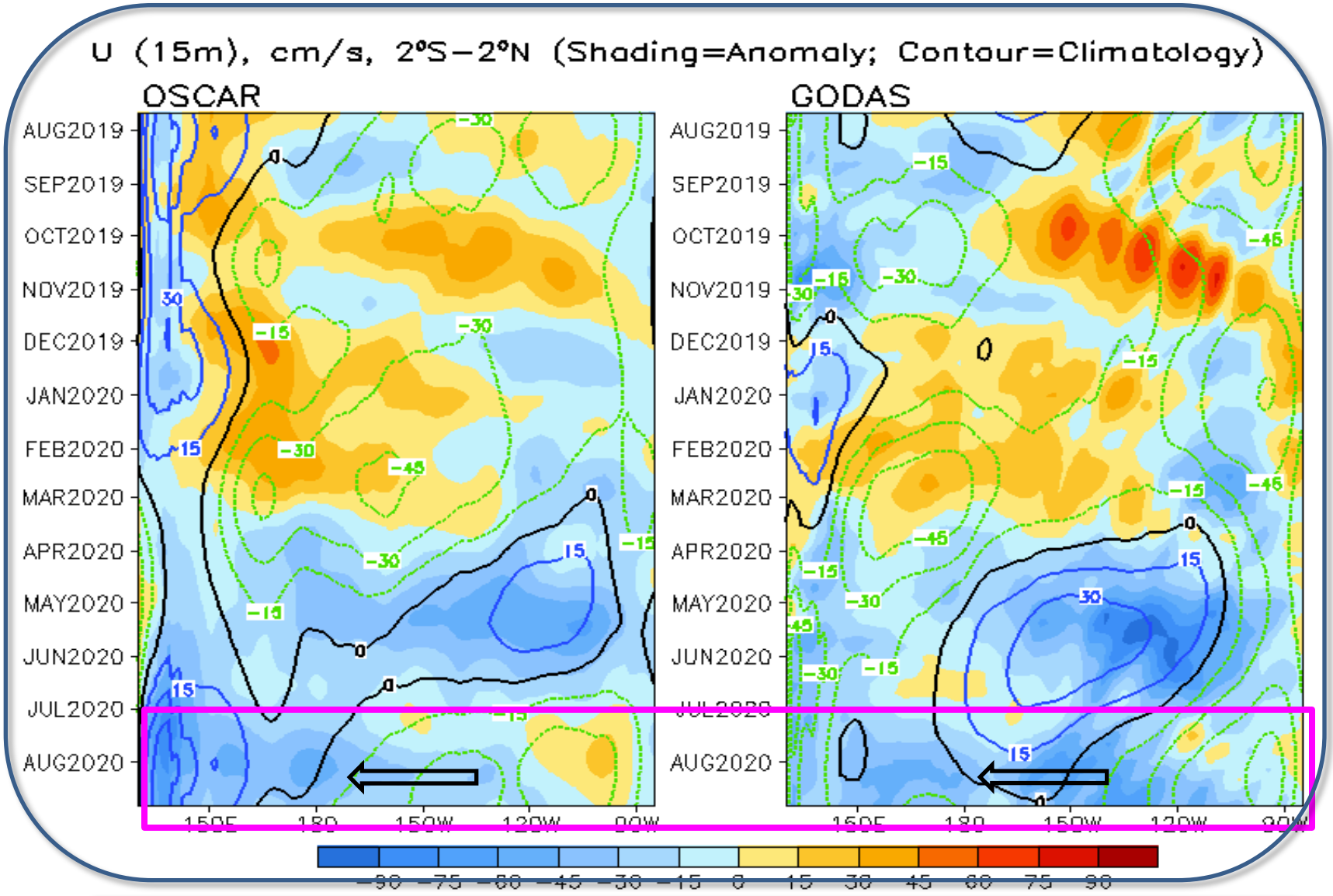
(http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html)

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



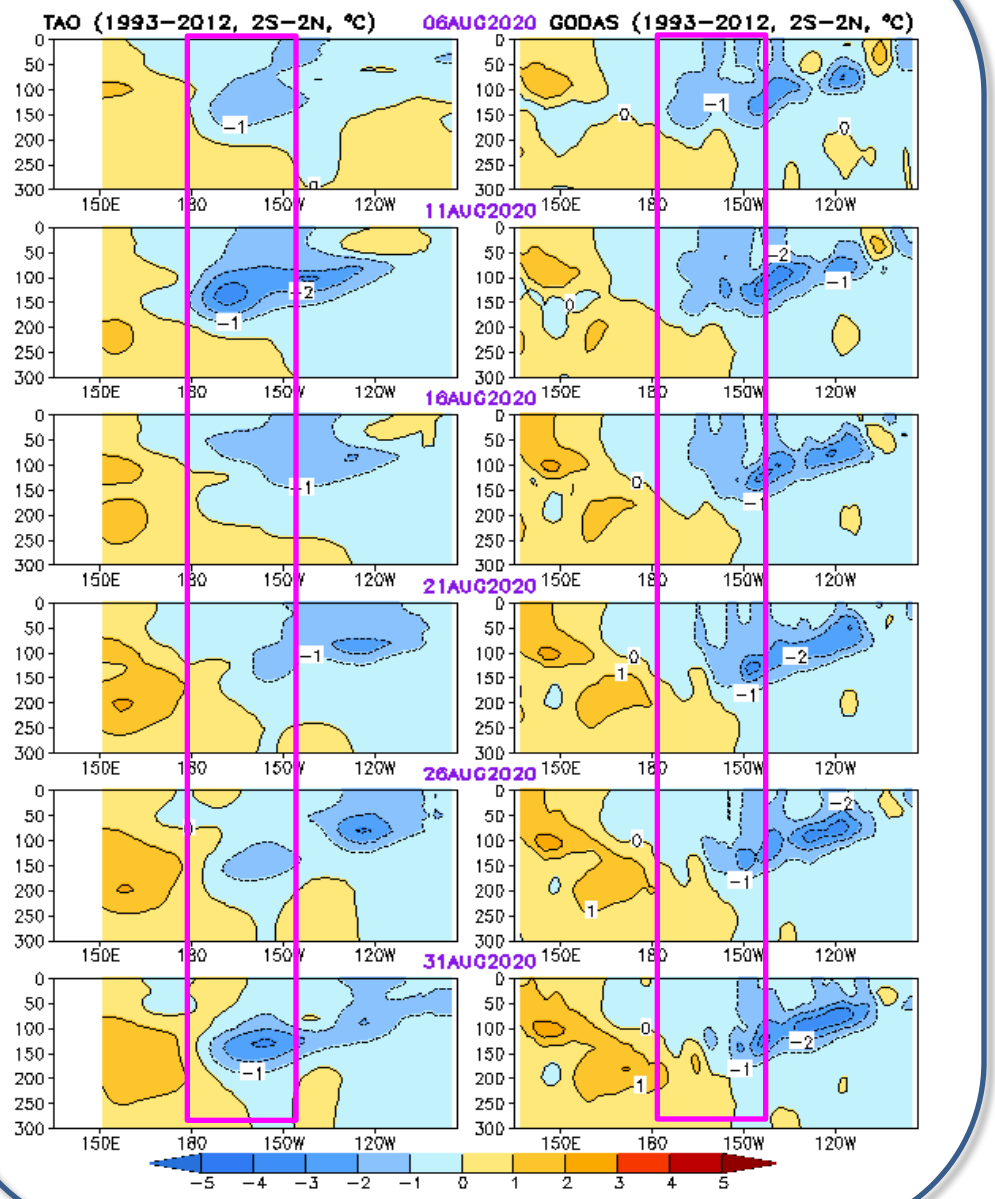
- Negative SSTA re-strengthened east of the Date Line in Aug, consistent with the eastward extension of negative subsurface temperature anomalies.
- Low-level zonal wind was near-normal at the end of Aug 2020.

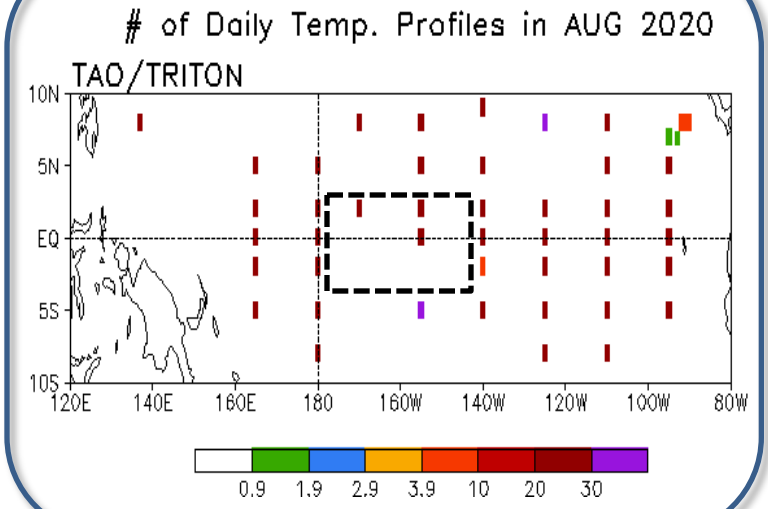
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- Anomalous westward currents strengthened along the equatorial Pacific in Aug 2020, favoring SST cooling.

Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



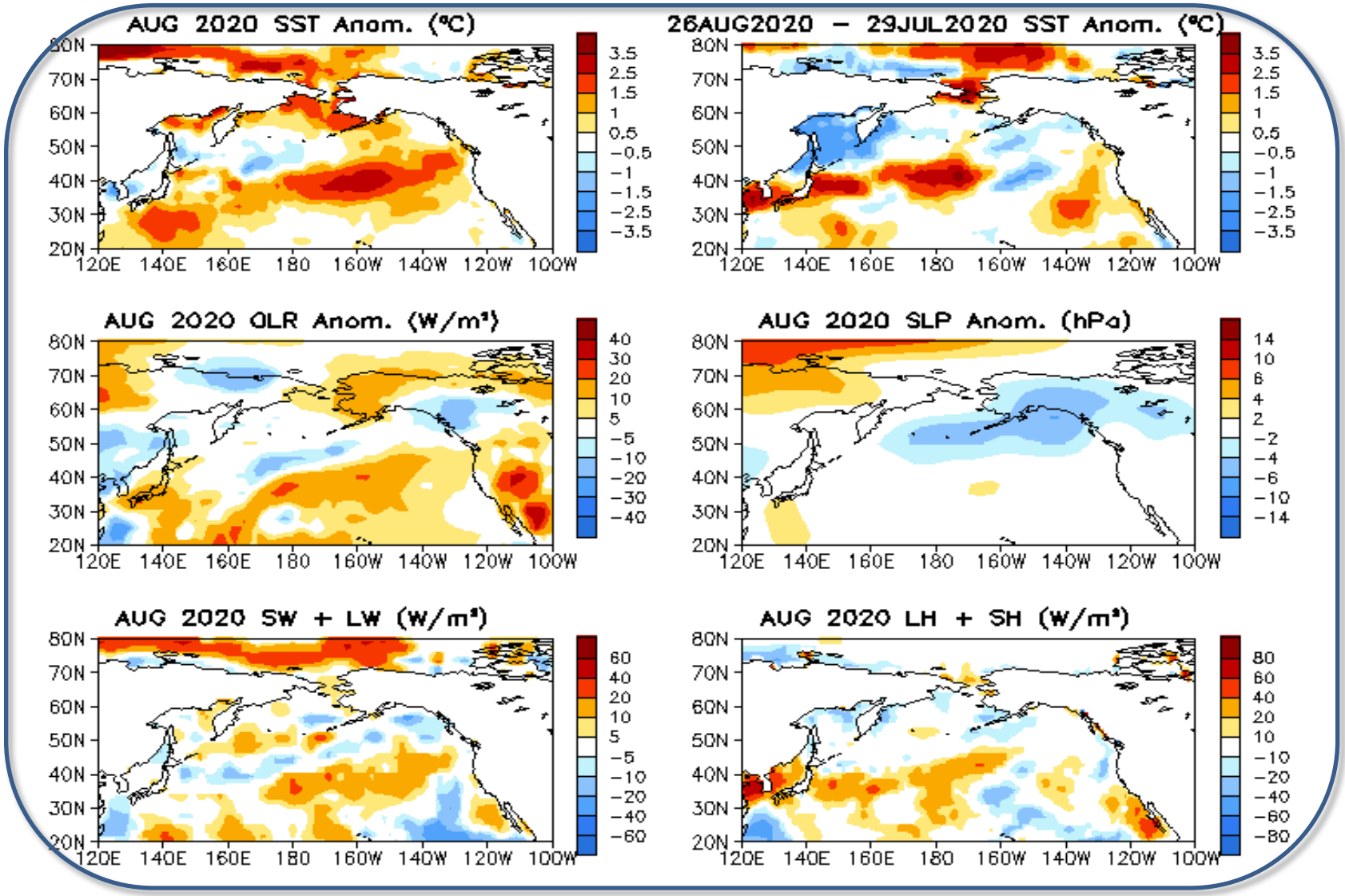


-TAO data indicates subsurface cooling enhanced by 2° C near 180° W-140° W, which was not observed in GODAS.

- Differences between GODAS and TAO is partially attributed to missing TAO data at the three moorings.

North Pacific & Arctic Oceans

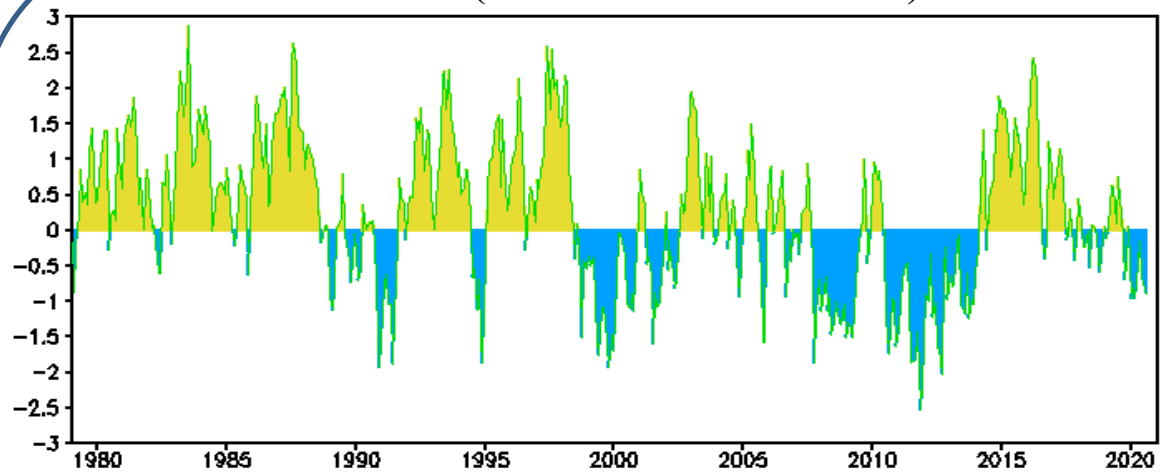
North Pacific & Arctic Ocean: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx



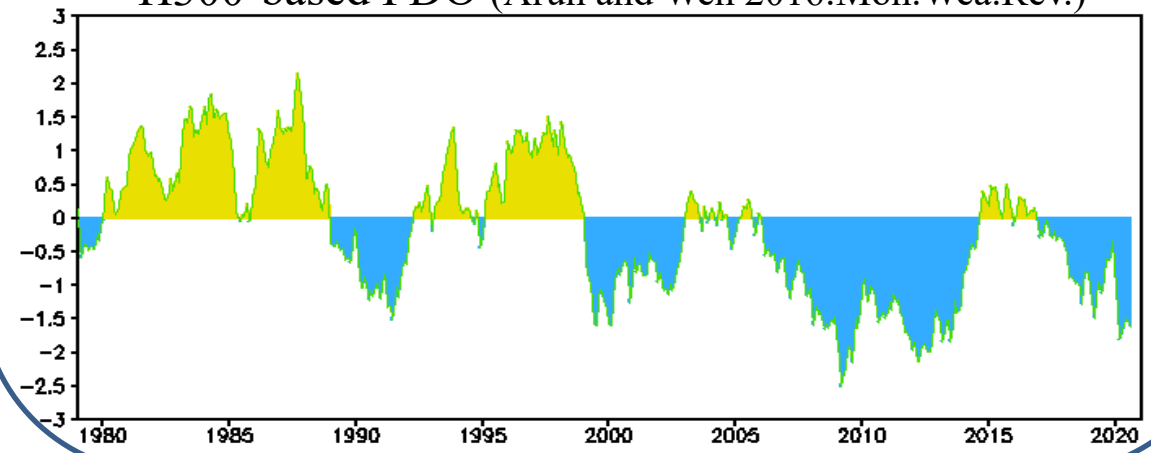
Sea surface temperature (top-left; NCEP OI SST Analysis), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) (middle-left; NOAA 18 AVHRR IR), sea surface pressure (middle-right; NCEP CDAS), sum of net surface short- and long-wave radiation (bottom-left; positive means heat into the ocean; NCEP CDAS), sum of latent and sensible heat flux (bottom-right; positive means heat into the ocean; NCEP CDAS). Anomalies are departures from the 1981-2010 base period means.

Two Oceanic PDO indices

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



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



- Negative SST-based PDO index enhanced in Aug 2020, with PDO index= -0.9.

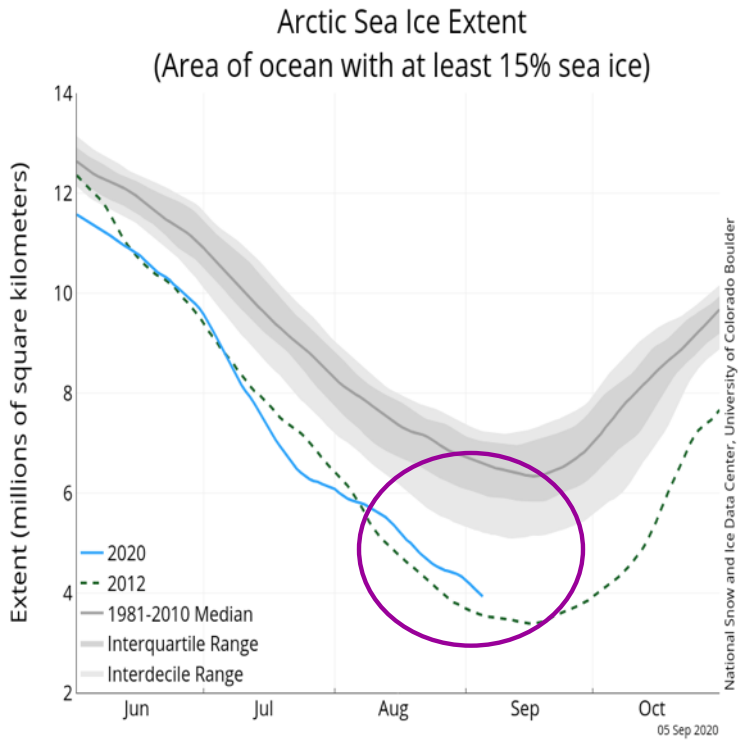
- Negative H300-based PDO index has persisted 47 months since Nov 2016, with HPDO = - 1.6 in Aug 2020.

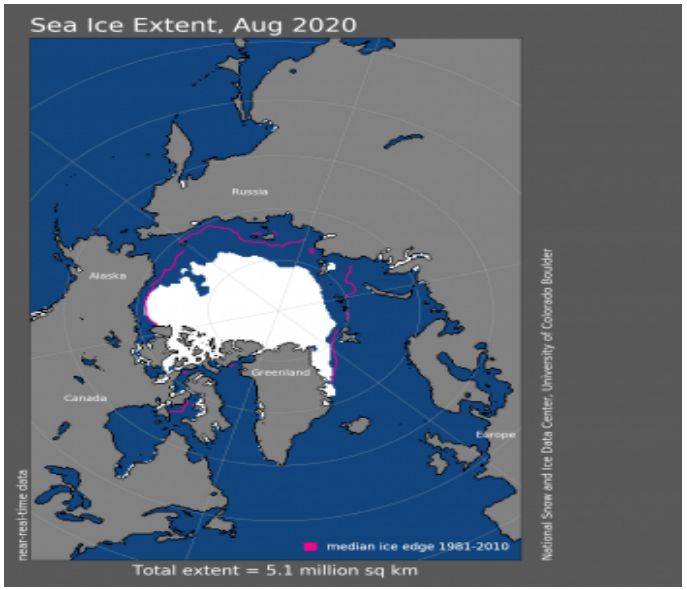
- SST-based PDO index has considerable variability both on seasonal and decadal time scales.

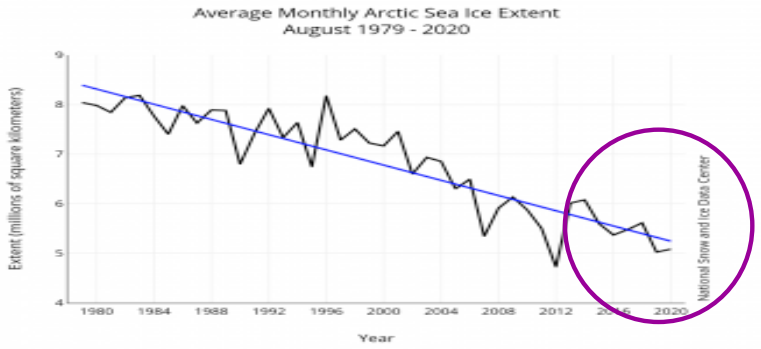
- H300-based PDO index highlights the slower variability and encapsulates an integrated view of temperature variability in the upper ocean.

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)

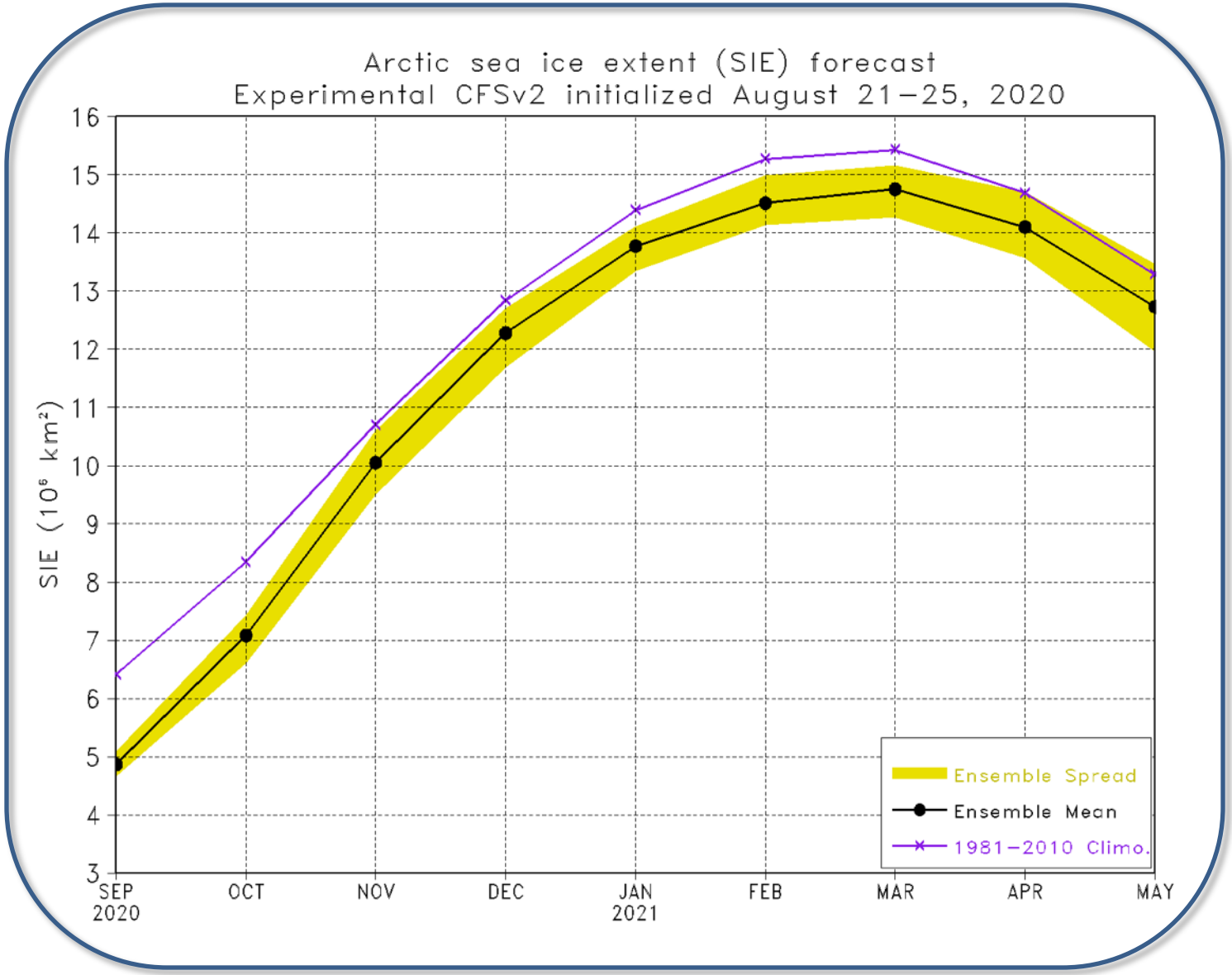






- Arctic sea ice extent was well below normal in Aug 2020.
- The monthly average extent for Aug 2020 is 5.08 million square kilometers, ranking the third lowest since satellite observations in 1979.

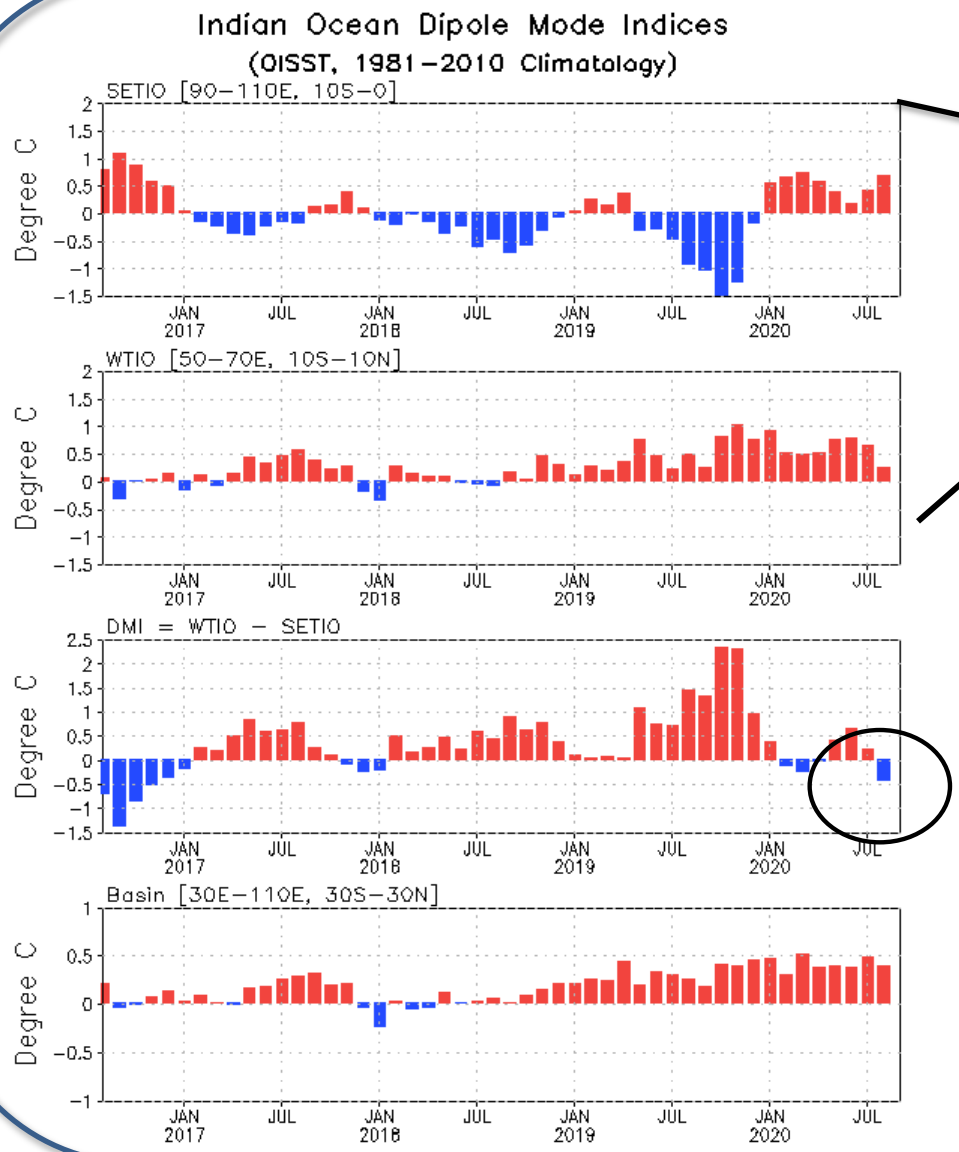
CPC Experimental Arctic Sea Ice extent forecast

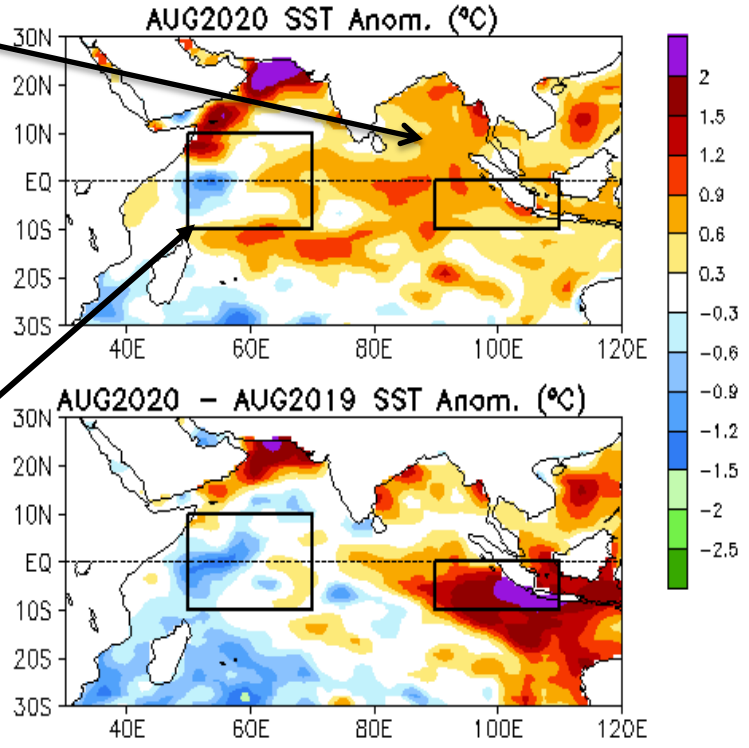


https://www.cpc.ncep.noaa.gov/products/people/wwang/seaice_seasonal/index.html

Indian Ocean

Evolution of Indian Ocean SST Indices

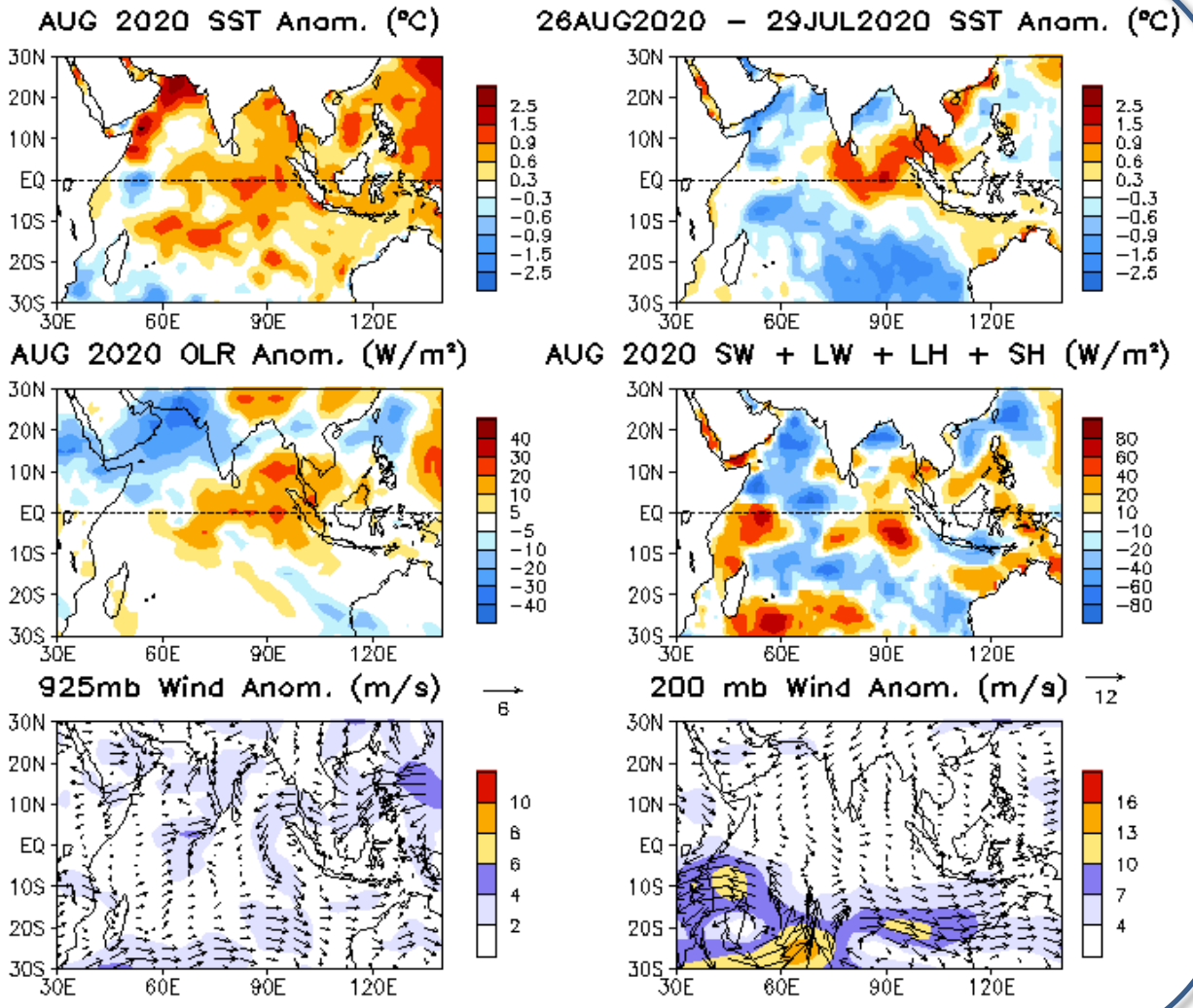




- Dipole index switched to negative phase in Aug 2020.

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 1981-2010 base period means.

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



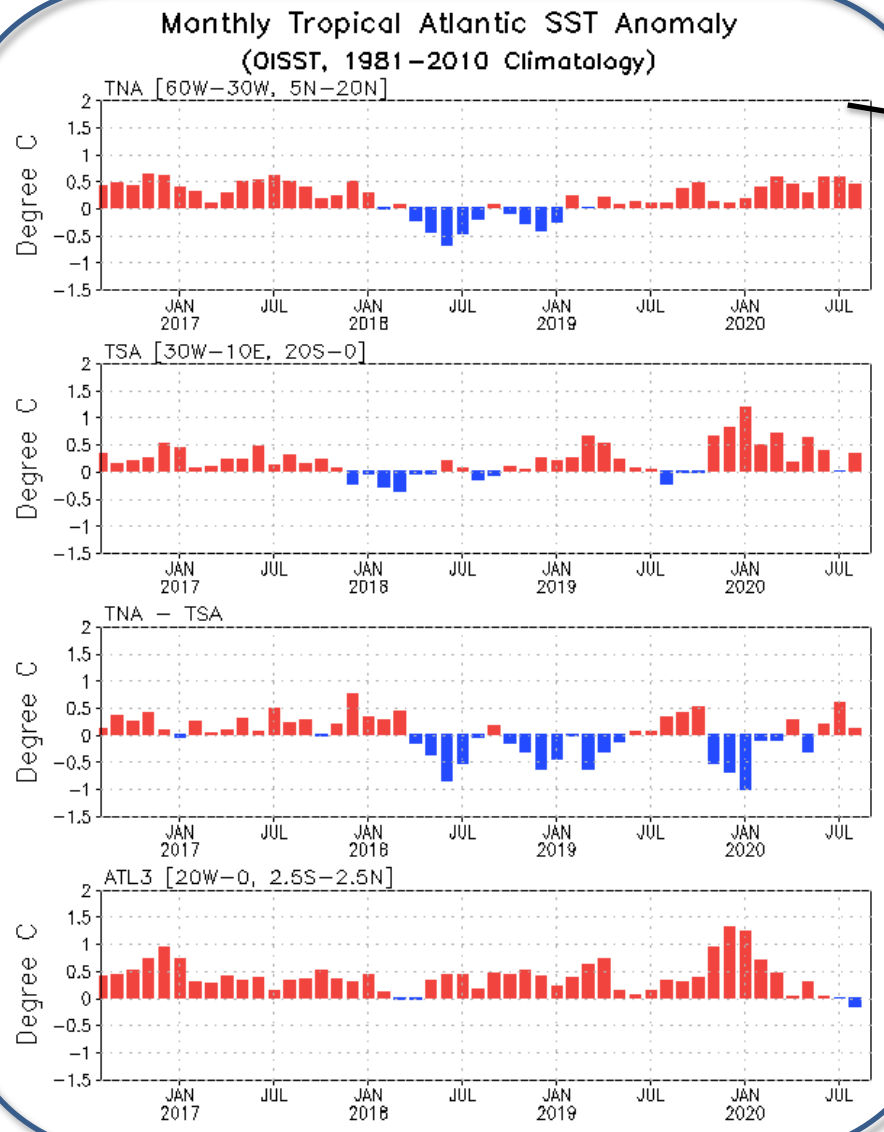
- Positive SSTA dominated the tropical Indian Ocean.

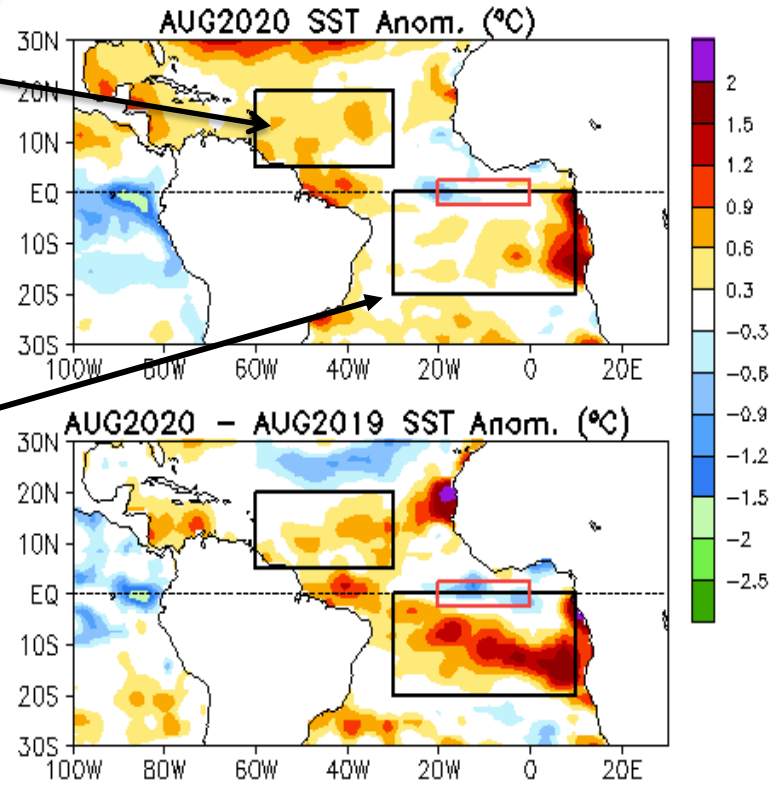
- Convectionwas enhanced over the Arabian Sea and suppressed over the belt from the eastern tropical Indian Ocean.

SST anomalies (top-left), anomaly 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 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 1981-2010 base period means.

Tropical and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices



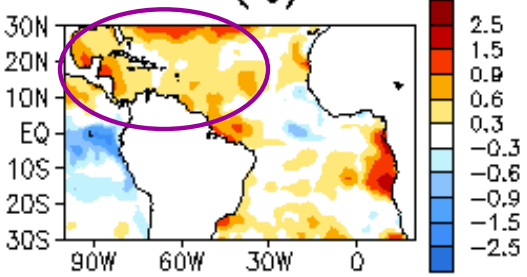


- Positive SSTAs dominated across the tropical Atlantic basin in Aug 2020.
- Indices representing the Atlantic Meridional and Nino modes were small (<0.5°C) in Aug 2020.

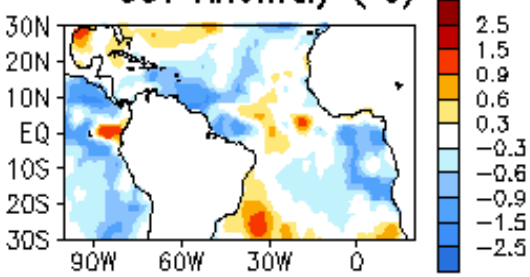
Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W-30°W, 5ºN-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between TNA and TSA. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Tropical Atlantic: SST Anom., SST Anom. Tend., TCHP,OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Wind Anom.

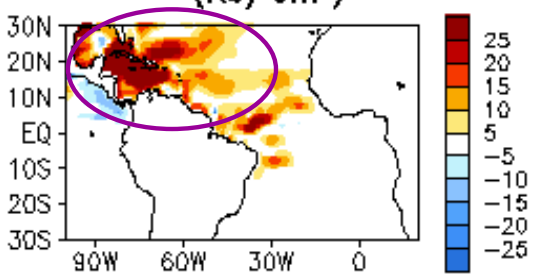
AUG 2020 SST Anom. (°C)



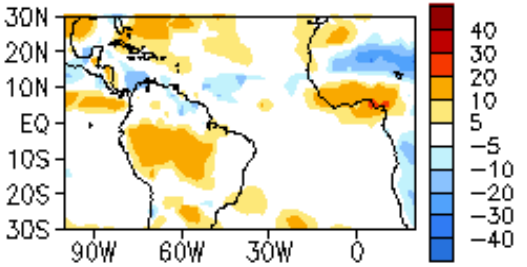
02SEP2020 – 05AUG2020 SST Anomaly (°C)



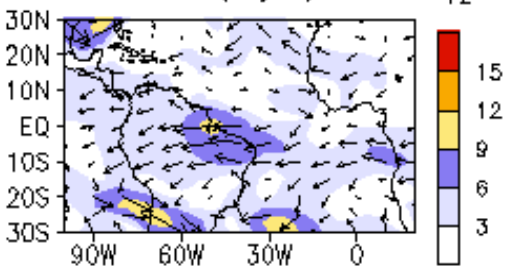
AUG 2020 TCHP Anom. (KJ/cm²)



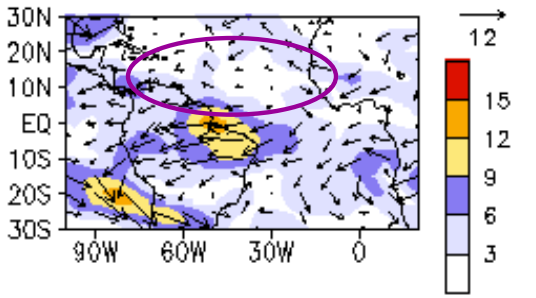
AUG 2020 OLR Anom. (W/m²)



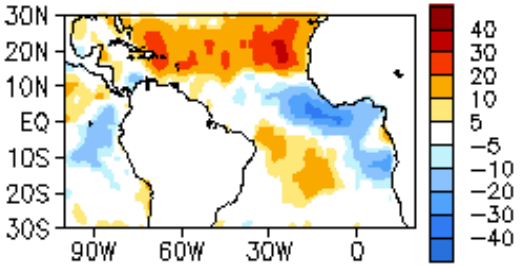
AUG 2020 200mb Wind Anom. (m/s)



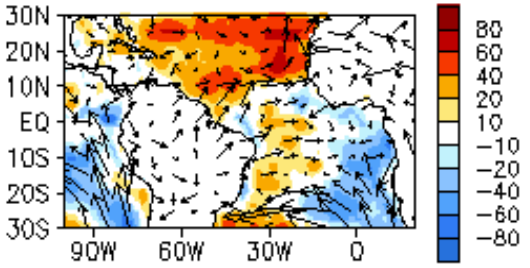
AUG 2020 200mb – 850mb Wind Shear Anom. (m/s)



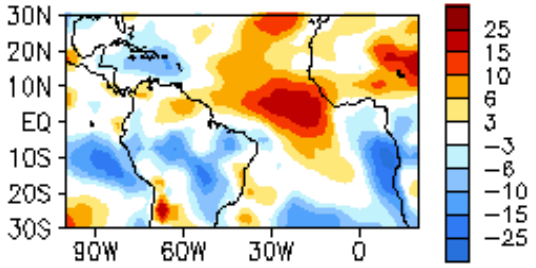
AUG 2020 SW + LW Anom. (W/m²)



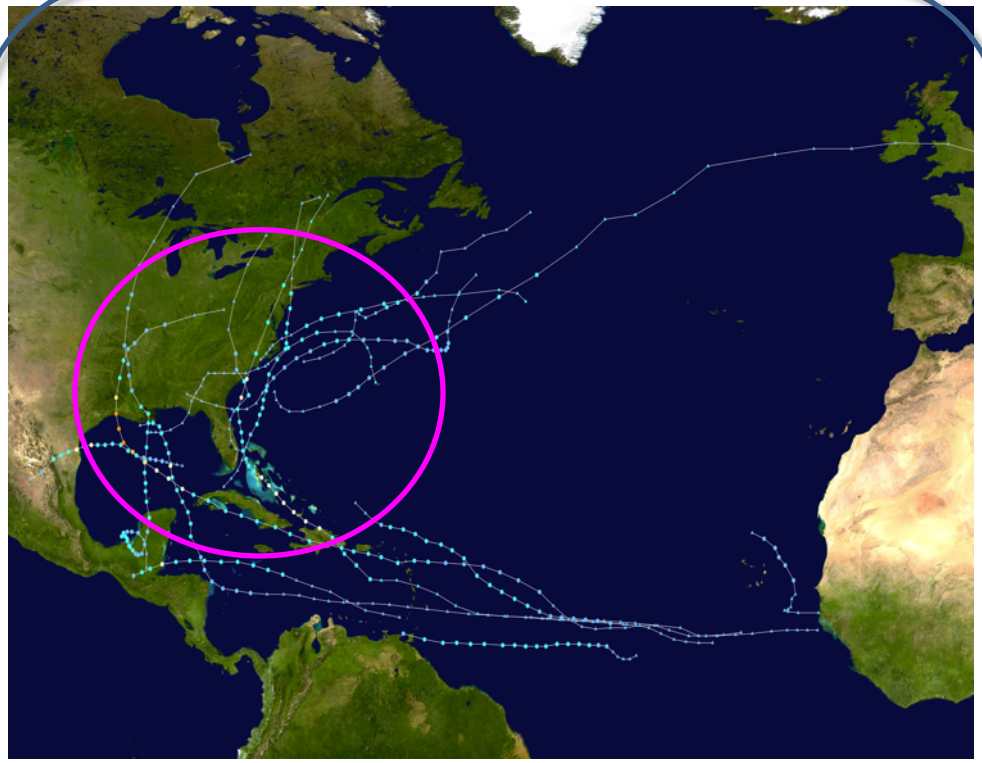
LH + SH Anom. (W/m²)
925mb Wind Anom. (m/s)



AUG 2020 700 mb RH Anom. (%)



2020 Atlantic Hurricane Season Activities

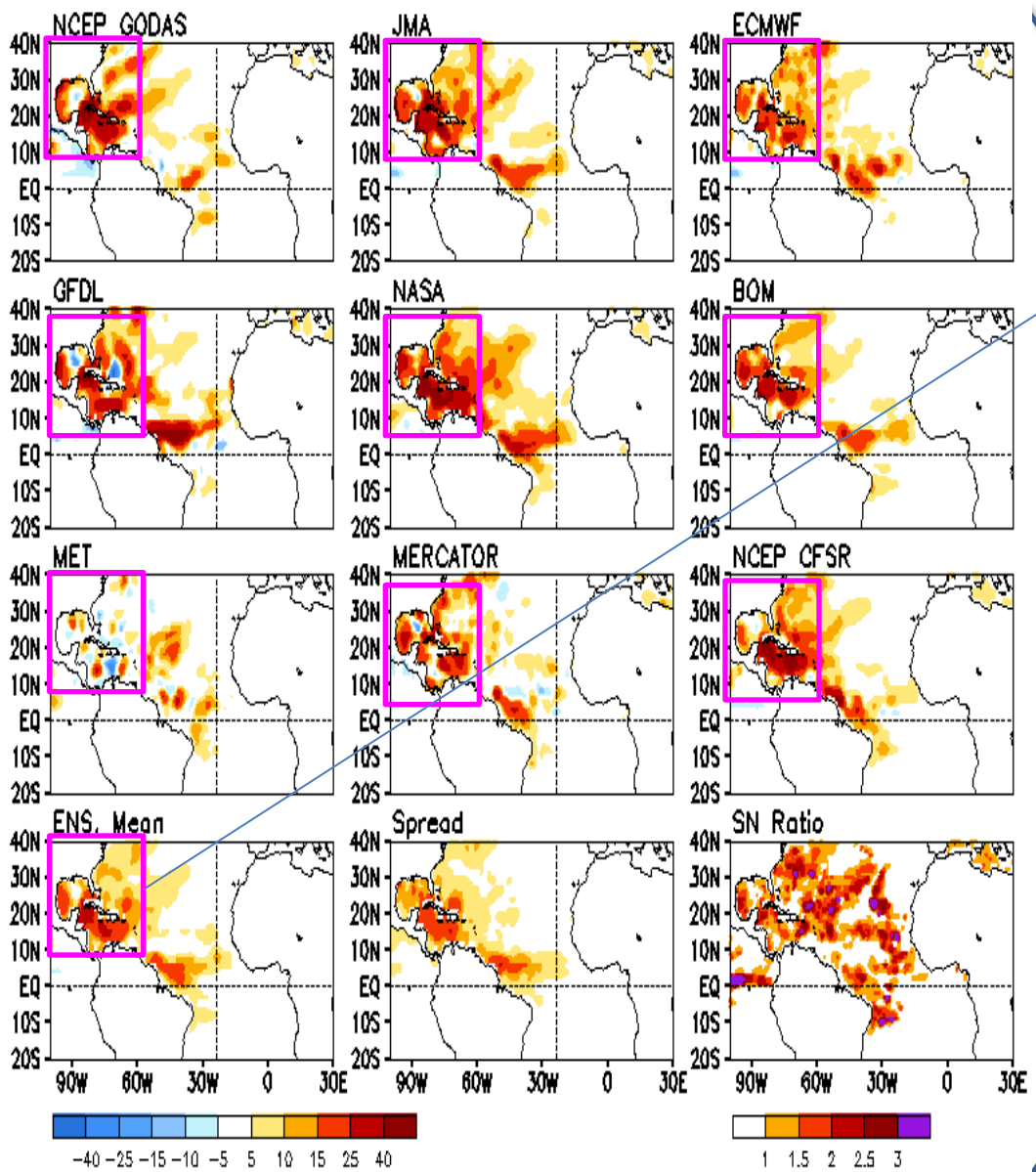


https://en.wikipedia.org/wiki/2020_Atlantic_hurricane_season

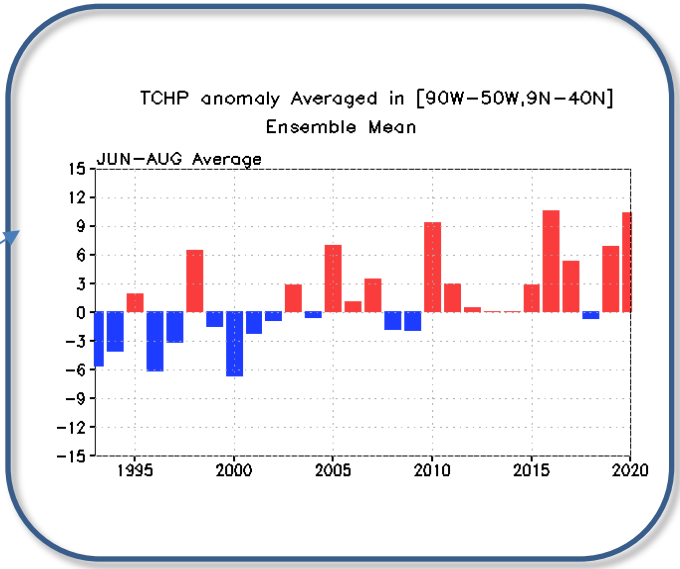
- Seventeen tropical storms with five developing into hurricane and one becoming major hurricane by Sep 10.
- Slightly more than one-half tropical storms did not form in the hurricane main development region(MDR).

Atlantic	Observations (By Sep 8)	Outlook (Aug. 6) 85% above-normal	Outlook (May 21) 60% above-normal	(1981-2010)
Total storms	17	19-25	13-19	12
Hurricanes	5	7-11	6-10	6
Major hurricanes	1	3-6	3-6	3

Real-Time Ocean Reanalysis Intercomparison :Tropical Cyclone Heat Potential Anomaly

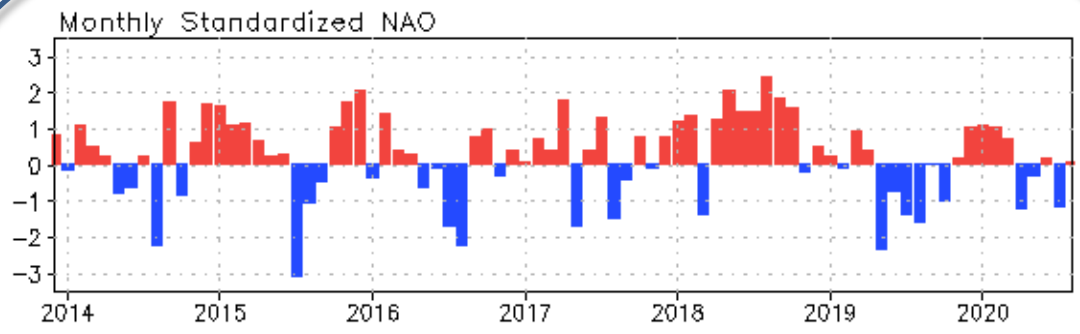


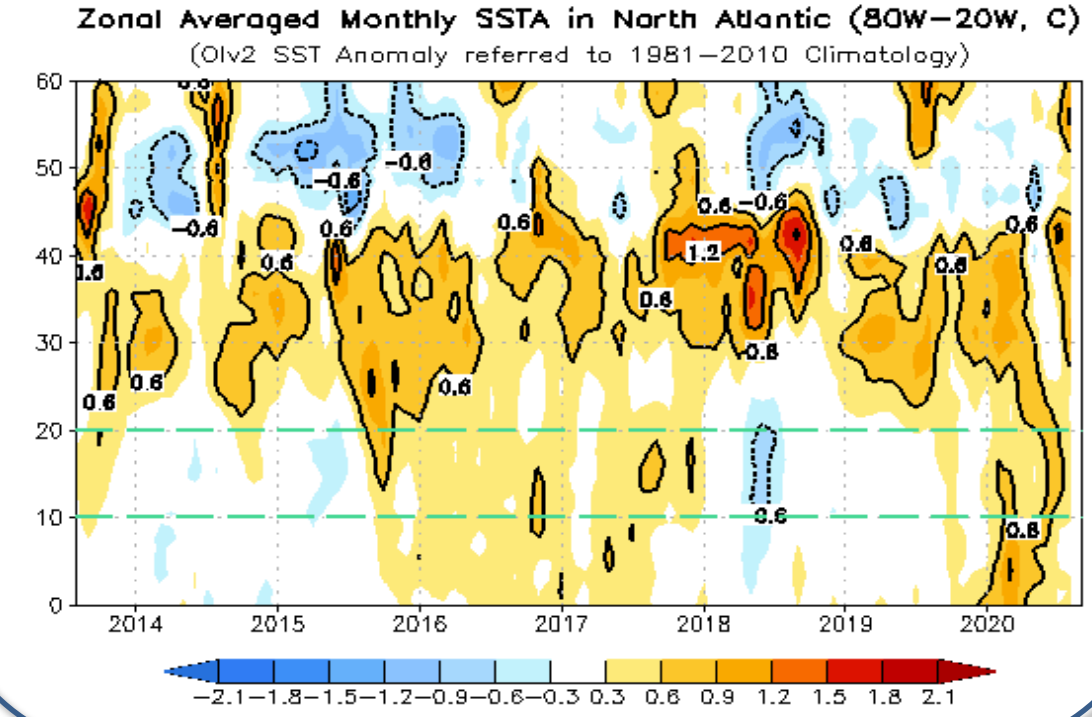
https://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html

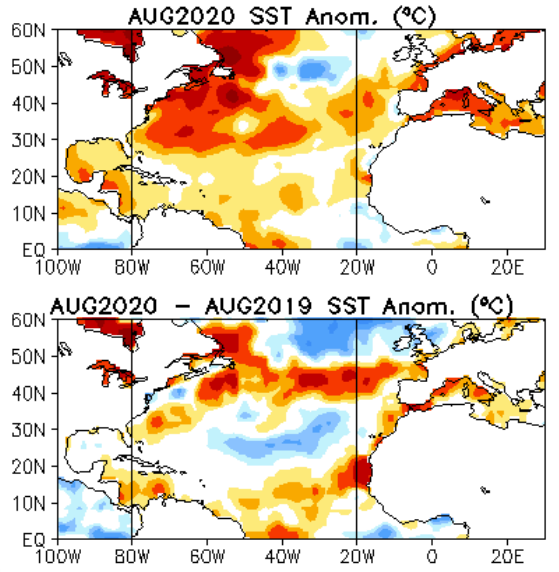


-2020 TCHP anomaly(JJA) averaged in Gulf of Mexico and western North Atlantic region ranked the second largest since 1993.

NAO and SST Anomaly in North Atlantic





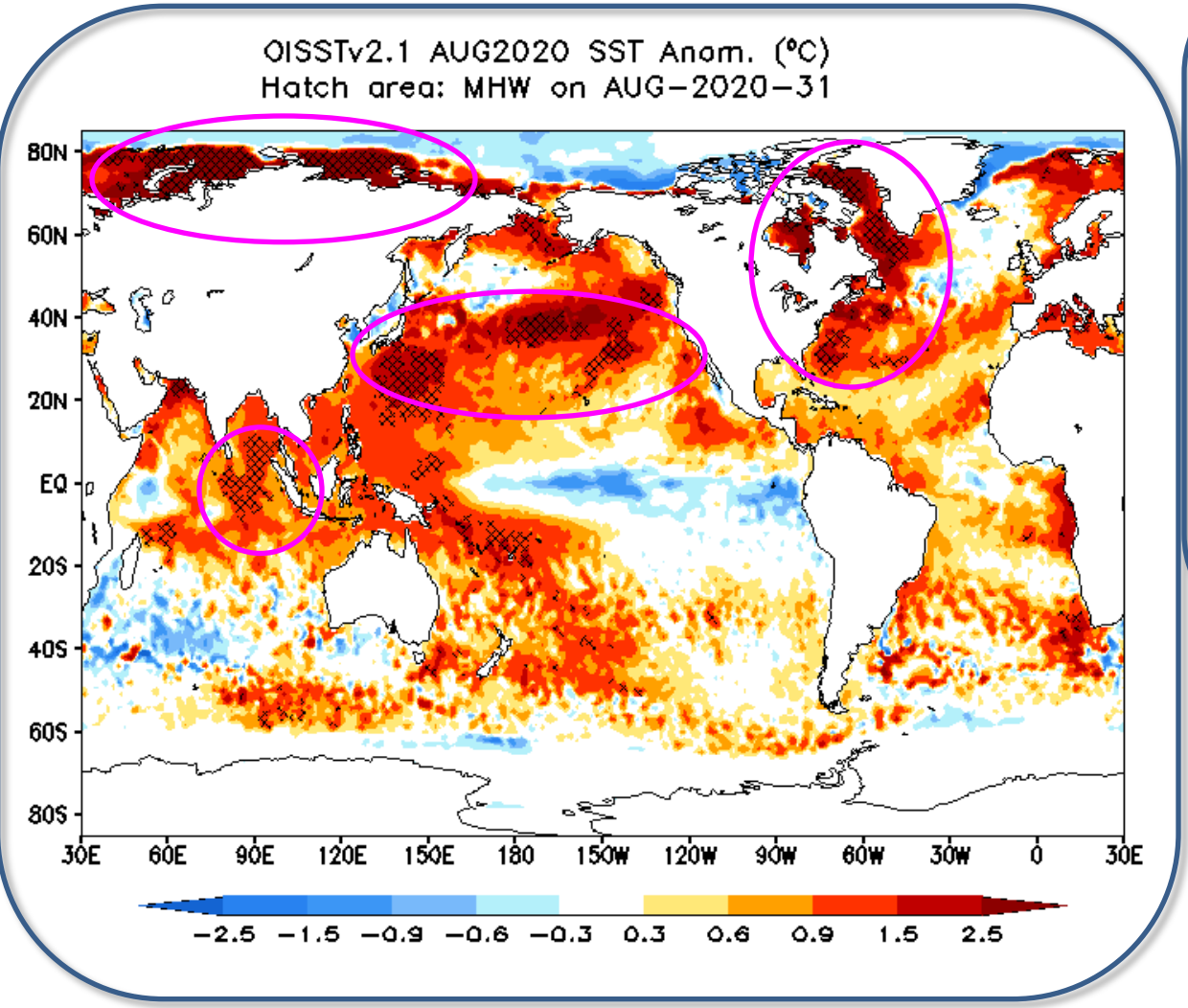


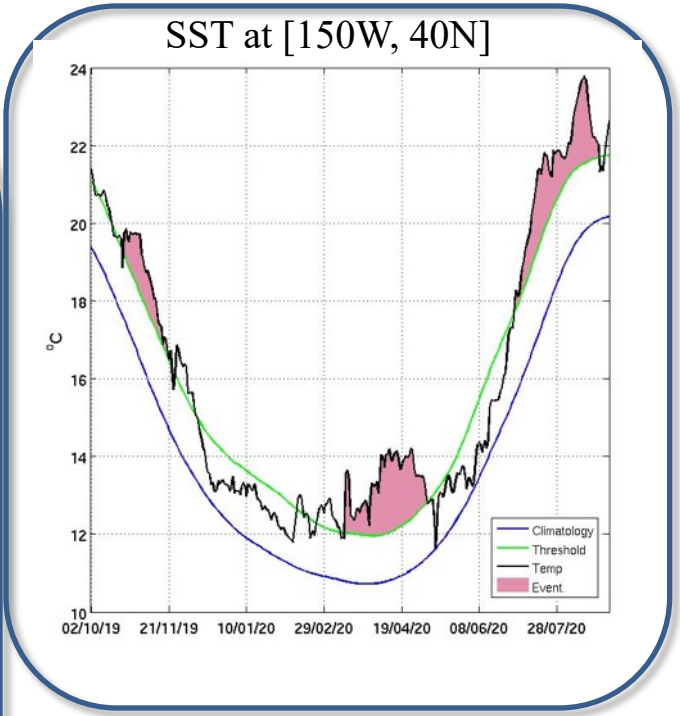
- Negative NAO weakened substantially in Aug 2020, with NAOI= 0.03.

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 1981-2010 base period means.

Global Marine Heat Waves

Global Monthly SST anomaly and Marine Heave wave (MHWs) activity

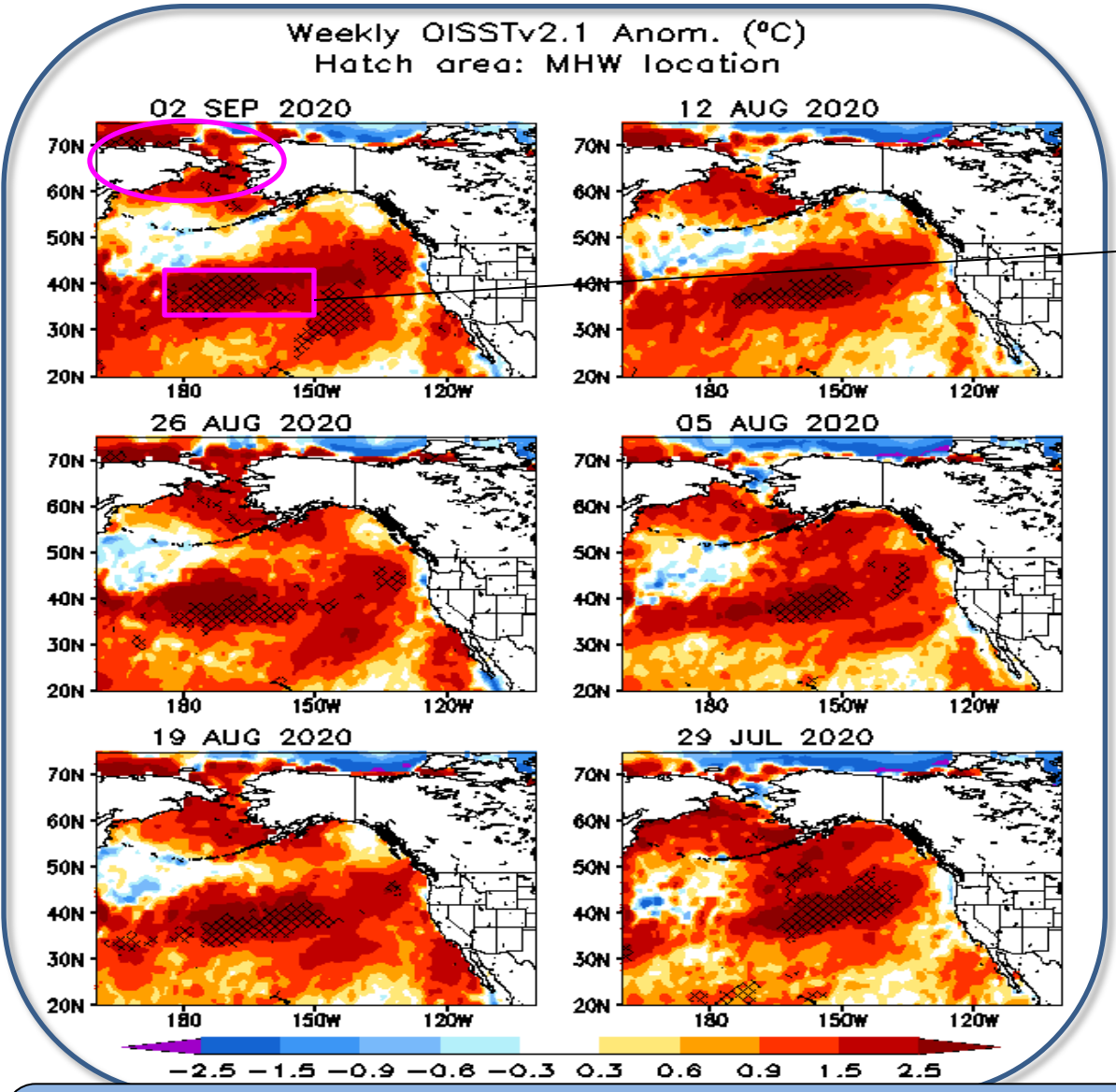


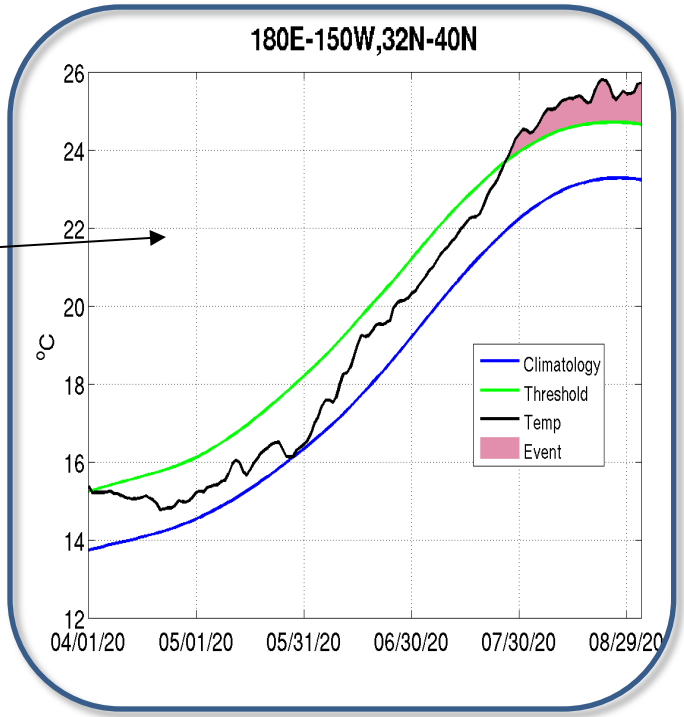


- MHWs were active in subarctic regions north of Eurasia, North eastern Pacific, Philippine Sea, tropical Indian Ocean and East coast of North America.

(Left panel) Monthly 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.

Weekly SST anomaly and MHWs in the North Pacific

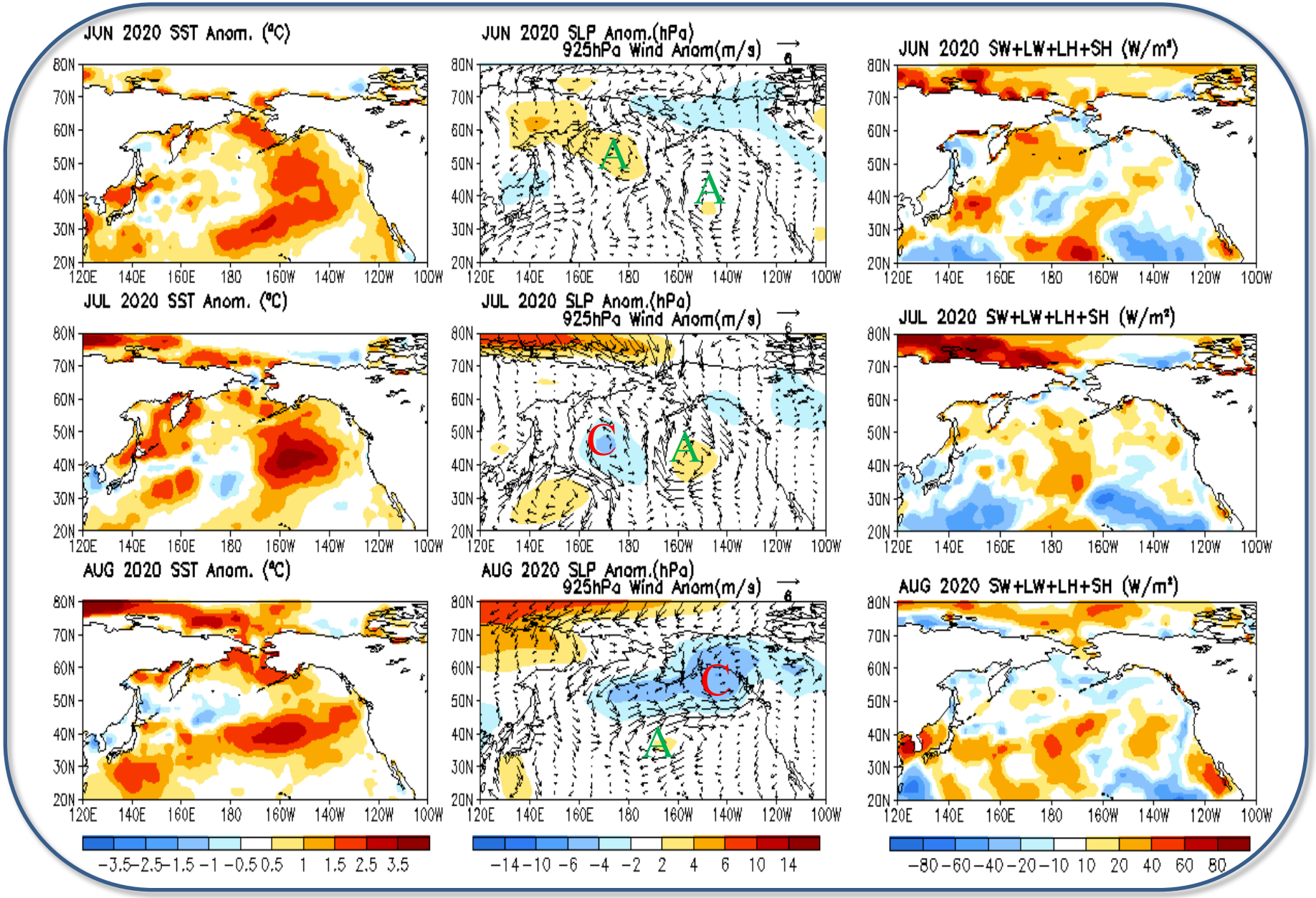




- MHWs persisted in the North central Pacific during the last six weeks.
- New MHWs developed near the Bering Sea and East Siberian Sea in the last couple of weeks.

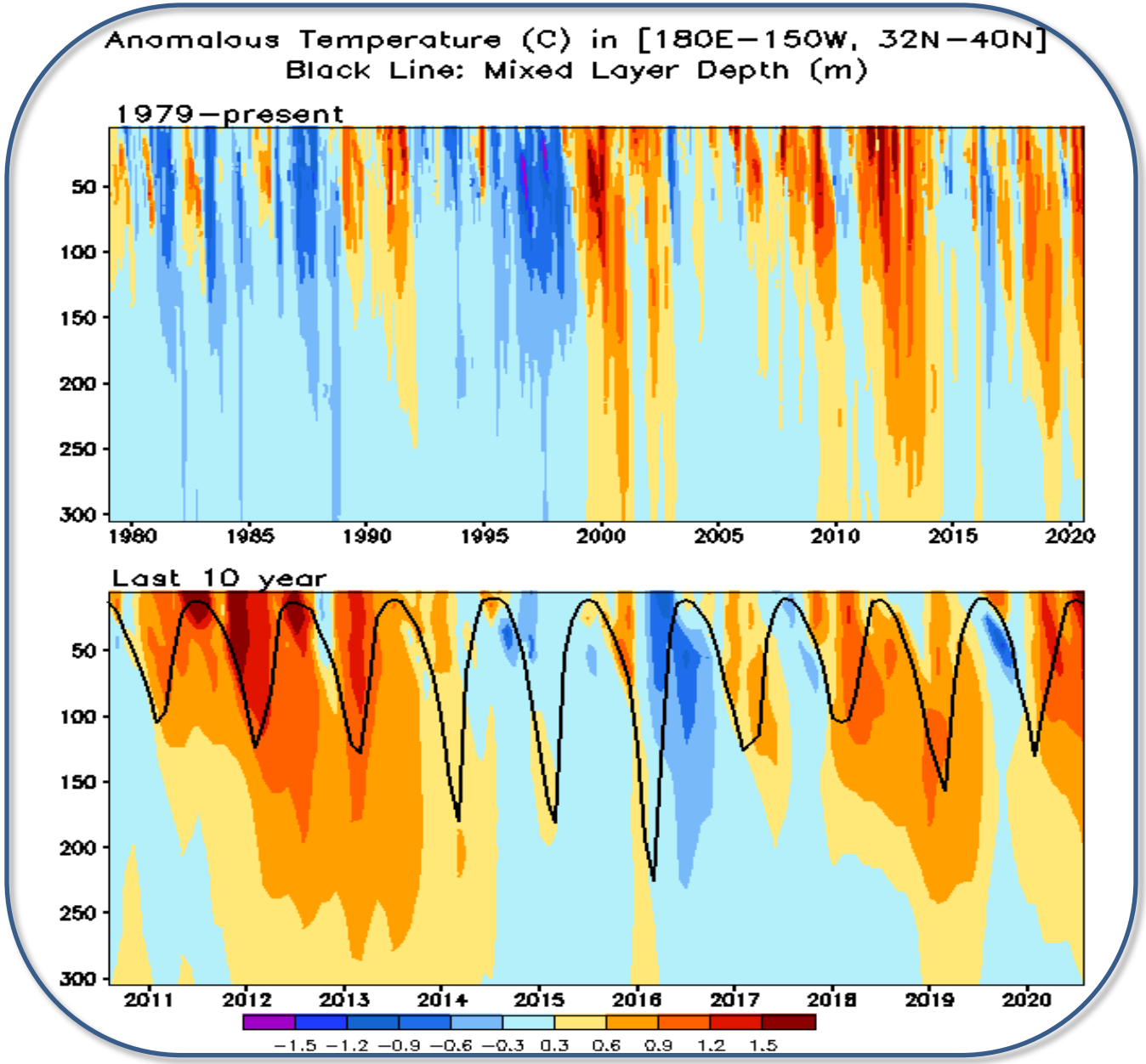
(Left panel) Weekly SST anomaly (shaded) and locations experience Marine heat waves (Hatched) by the date labelled in the plot. (right panel) SST evolution at a specific location. Green line and blue line denote the seasonal 90th percentile and daily climatology, respectively. Shaded area denotes the 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.

Last Three Month SST, SLP, 925hp Wind and Net heat flux anomalies



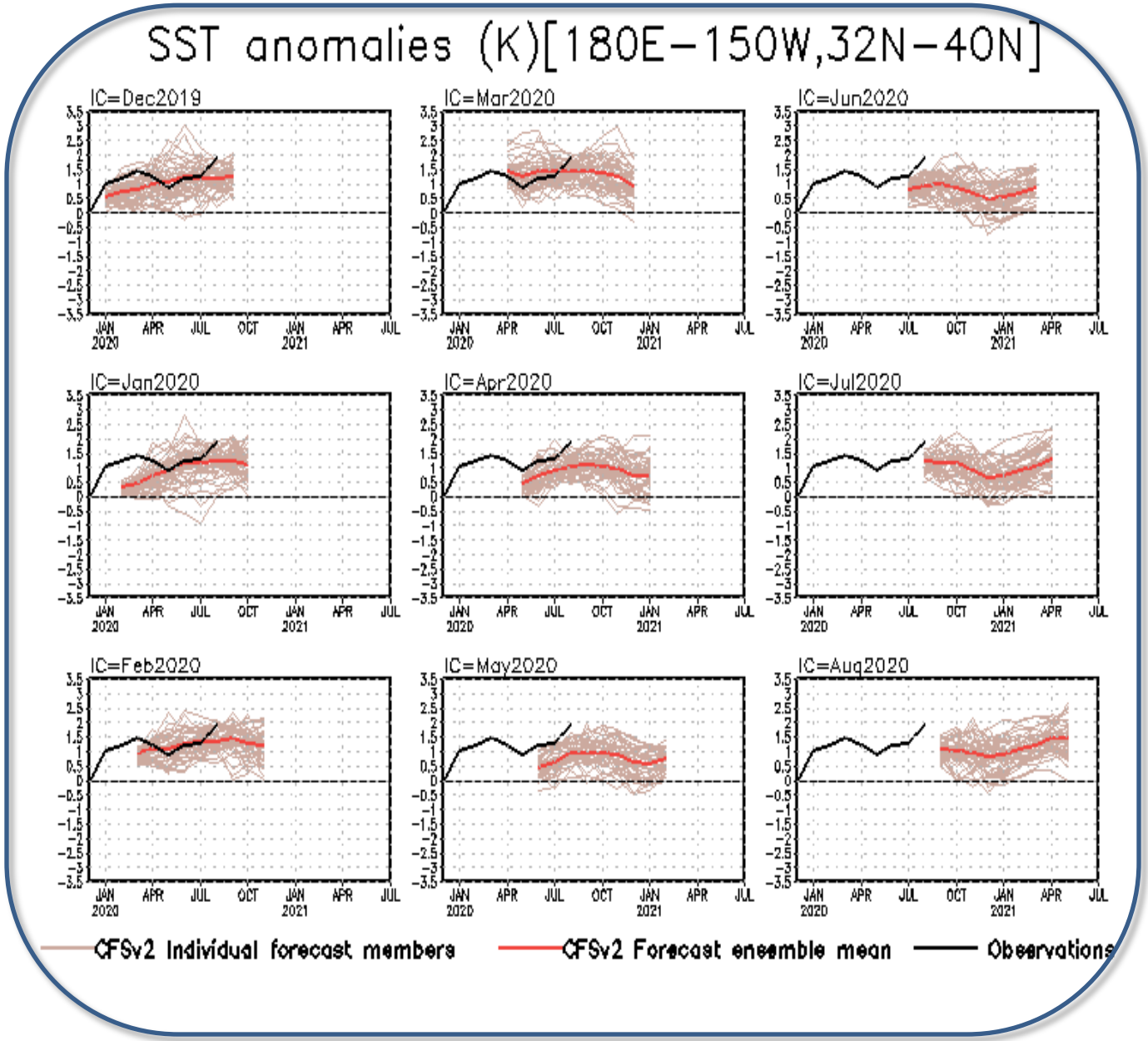
Data source: NCEP/NCAR Reanalysis 1

Subsurface Temperature Anomaly in the North Central Pacific



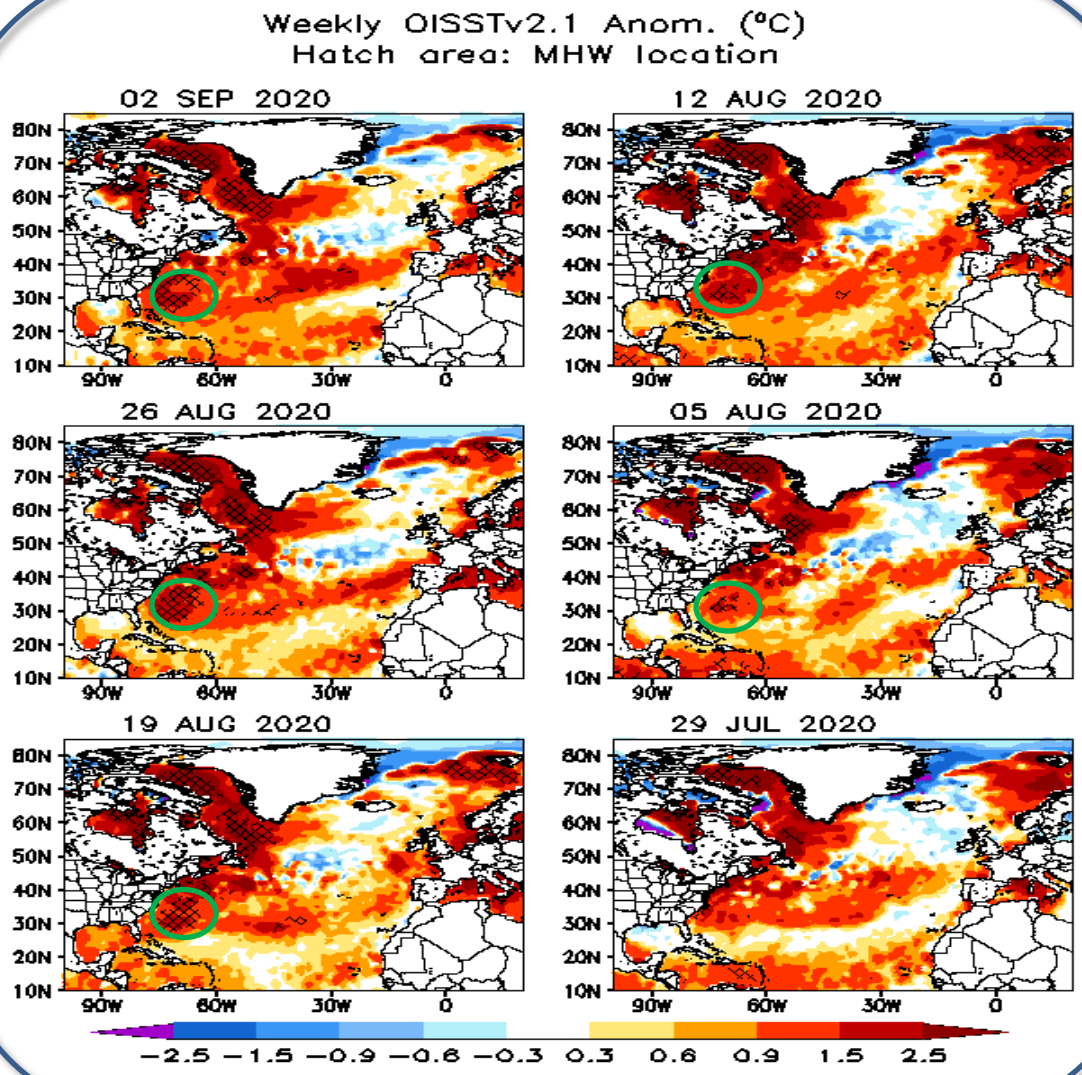
- Positive subsurface temperature anomaly penetrated to 200m.

CFSv2 N.C Pacific SST Predictions from Different Initial Months



- Earlier CFSv2 predictions underestimated the strength of N.C Pacific SST warming.
- Latest CFSv2 predictions suggest that the current warm state will continue in the next month.

Weekly SST anomaly and MHWs in the North Atlantic



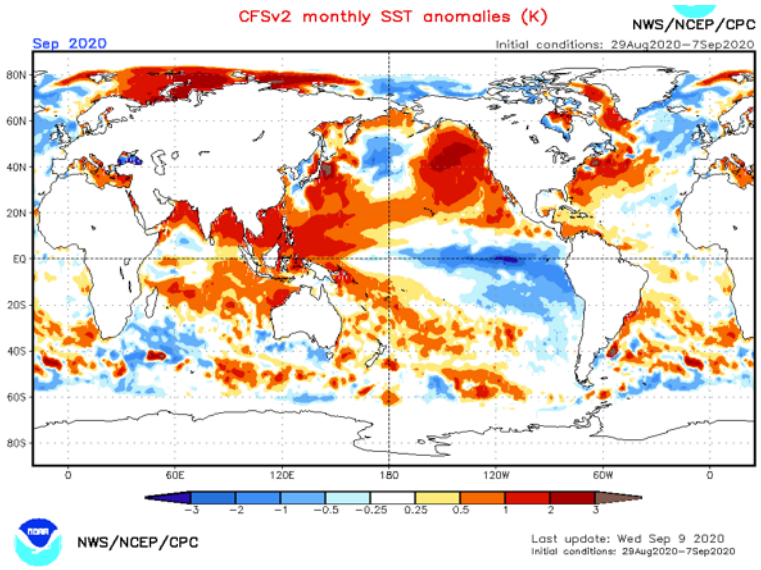
Tropical storm : Kyle
(Aug 14- Aug 16)

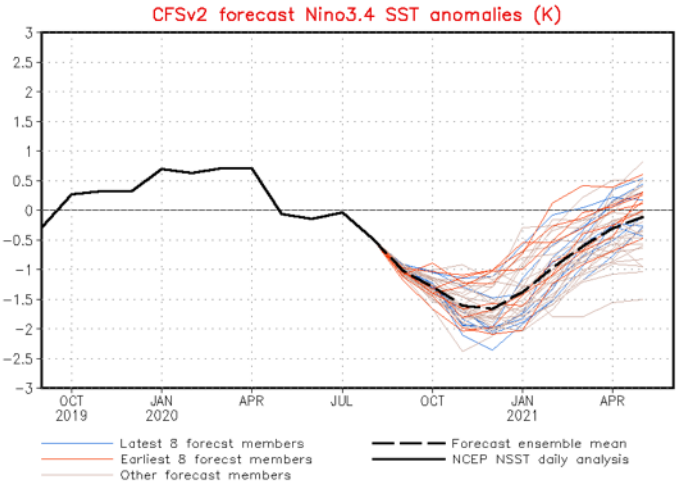
- MHWs were observed near the Gulf of stream since early Aug, coinciding with the development of TC Kyle .
- MHWs persisted near the Labrador sea and Baffin Bay in Aug 2020.

Weekly SST anomaly (shaded) and locations experience Marine heat waves (Hatched) by the date labelled in the plot. 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.

ENSO and Global SST Predictions

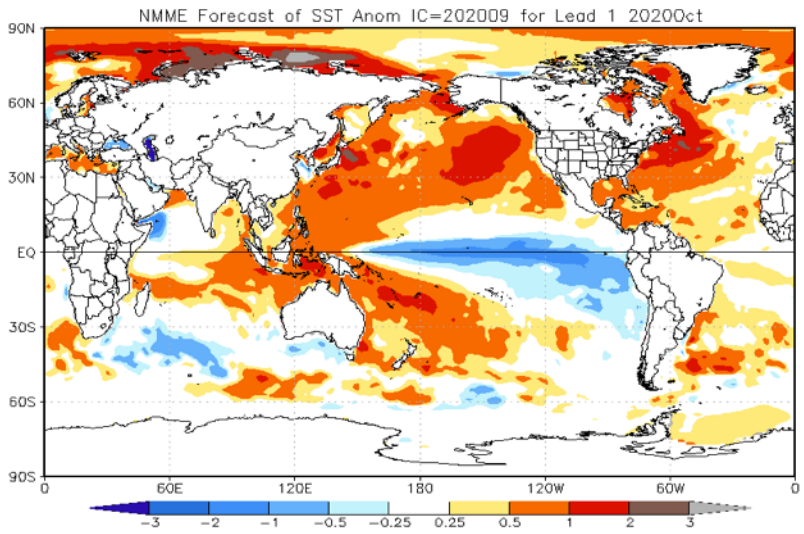
CFSv2 IC:Sep for 2020 Oct

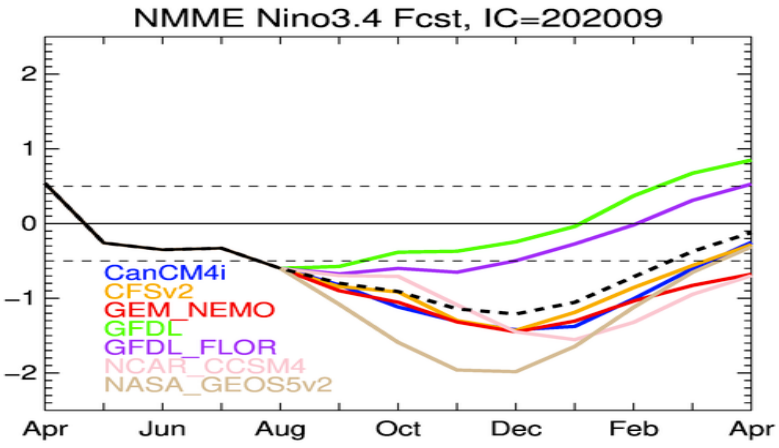




https://www.cpc.ncep.noaa.gov/products/CFSv2/CFSv2seasonal.shtml

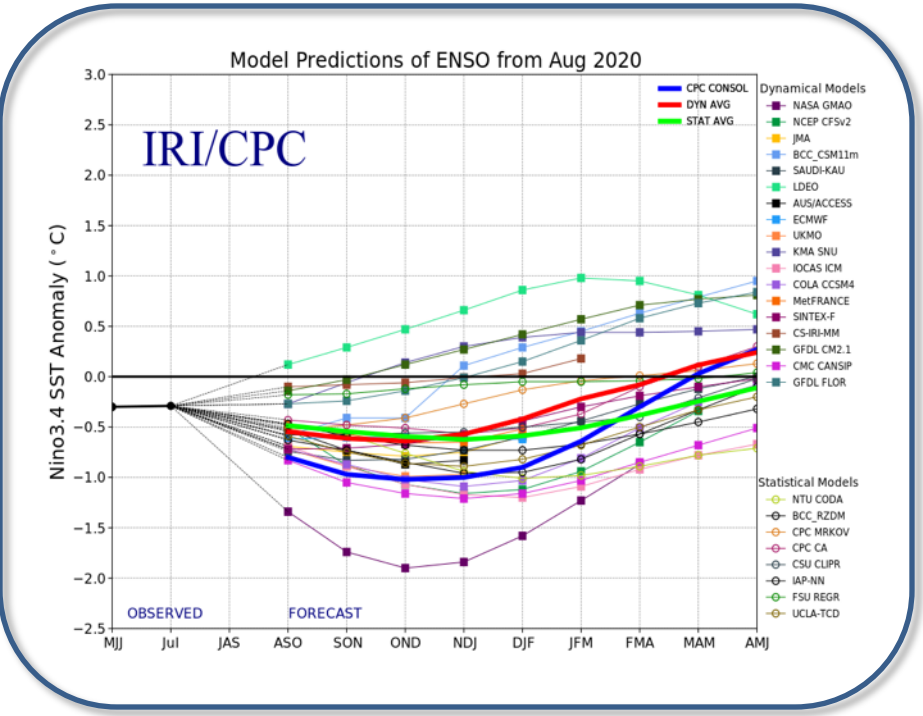
NMME IC:Sep for 2020 Oct

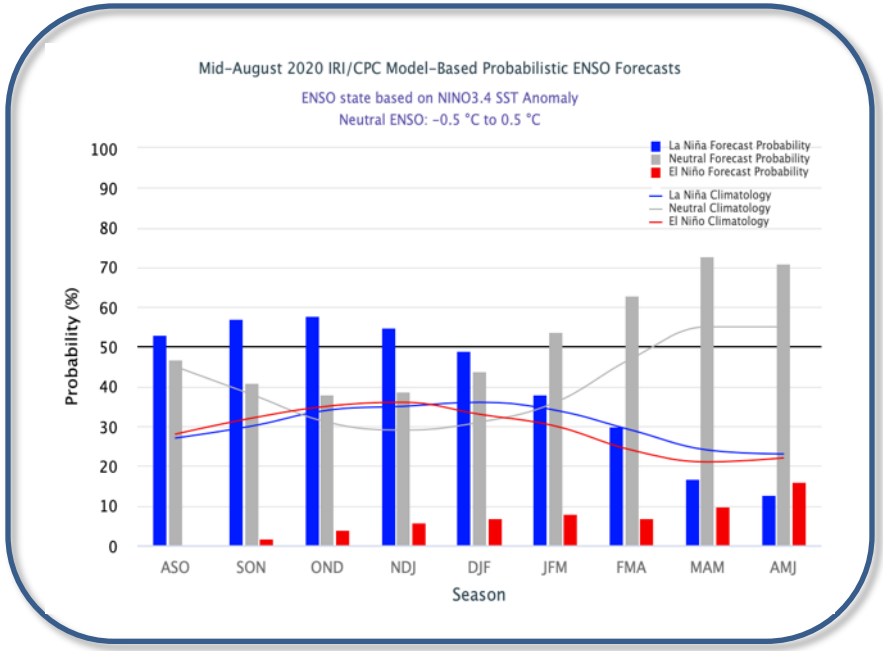




(https://www.cpc.ncep.noaa.gov/products/NMME/)

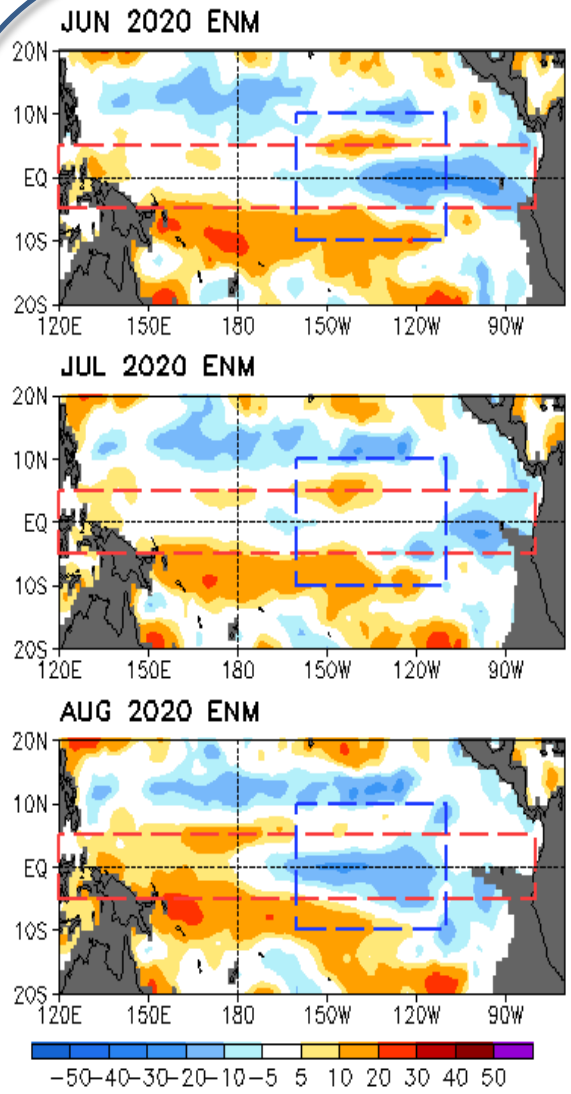
NOAA “ENSO Diagnostics Discussion ”: 10 September 2020

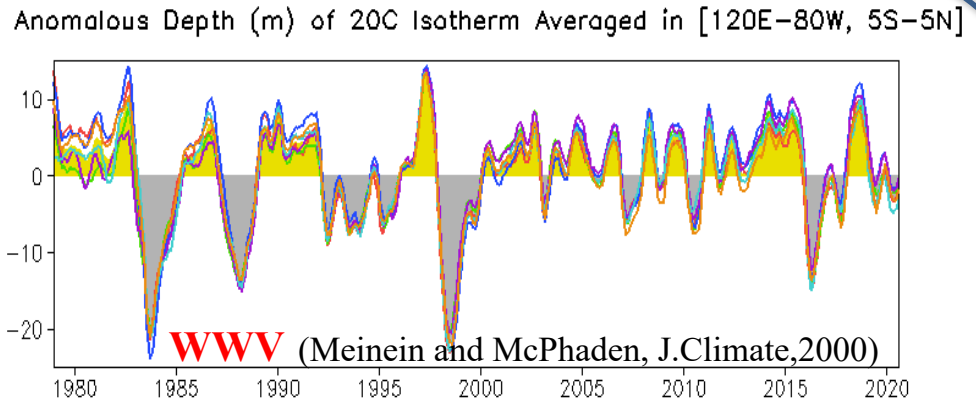


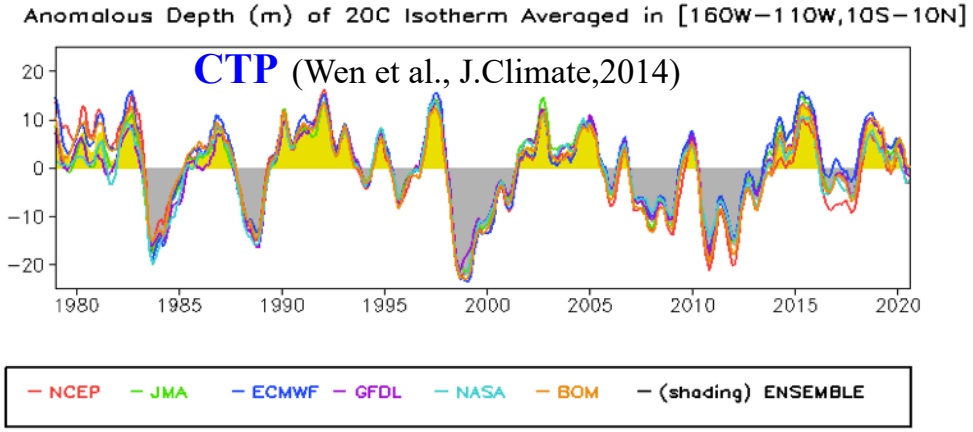


- A Majority of the models predict the continuation of La Niña through the Northern Hemisphere winter 2020-21.
- NOAA “ENSO Diagnostics Discussion” issued La Niña Advisory” on 10 Sep. It suggests that La Niña conditions are likely to continue through the Northern Hemisphere winter with 75% chance.

Oceanic ENSO precursors: WWV and CTP



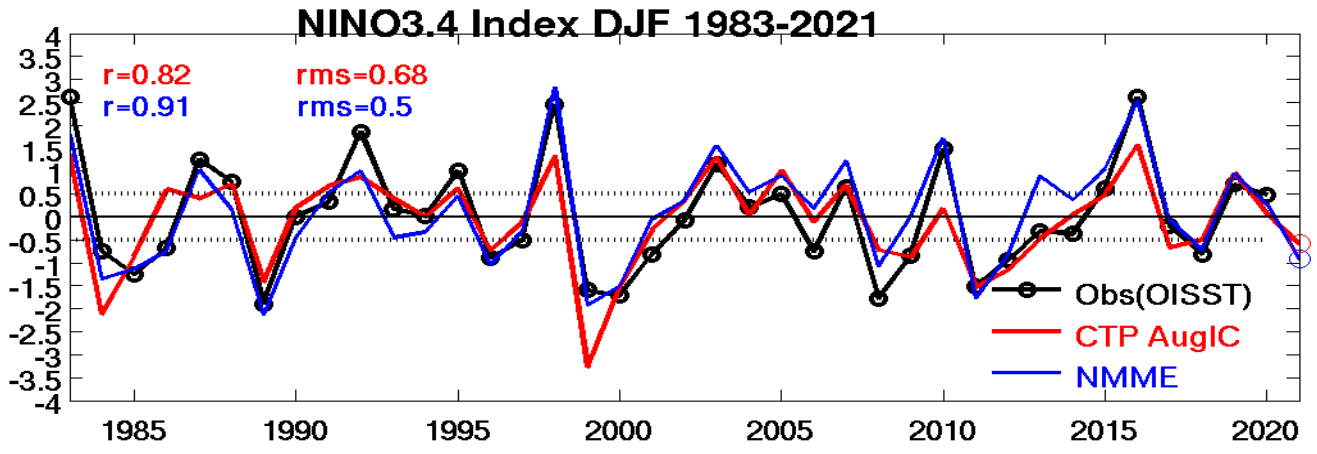


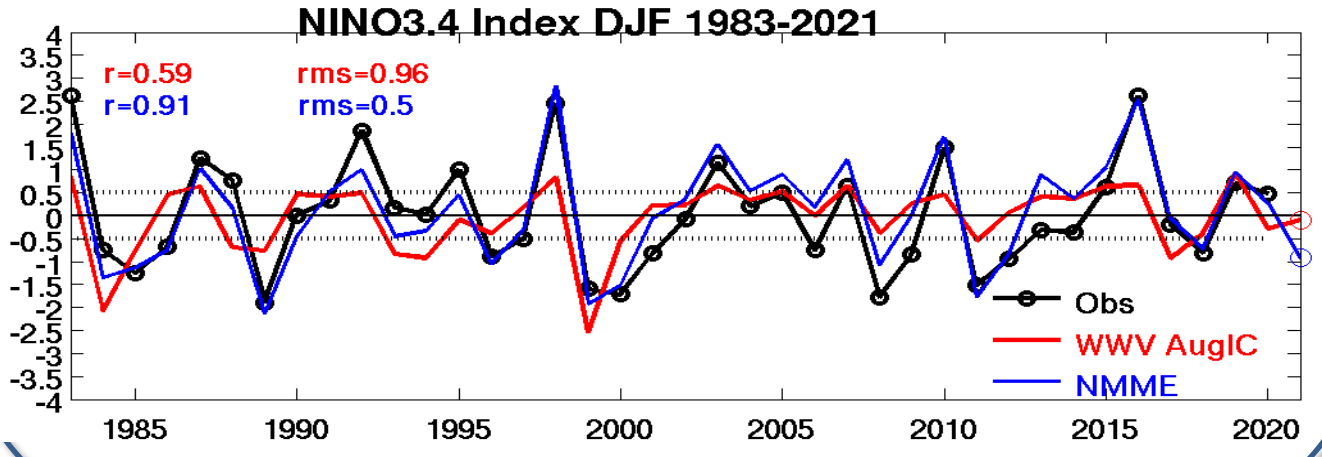


	WWV	CTP
Jun:	-2.9	-0.8
Jul:	-0.4	2.2
Aug:	-0.9	-4.7

(https://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html)

Precursor and NMME Nino34 Predictions with Aug IC for DJF



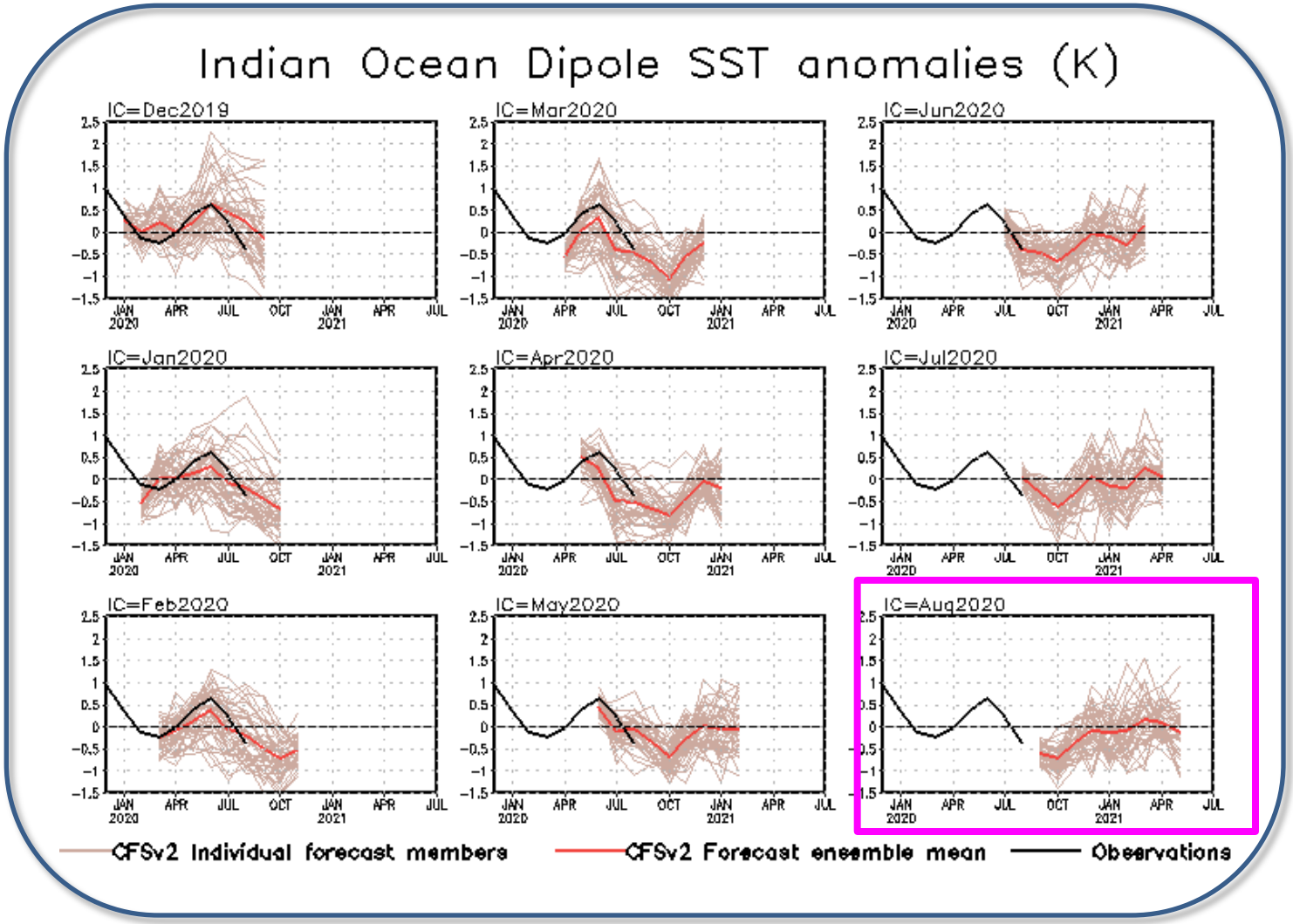


- Both CTP and NMME with Aug IC projects La Niño in DJF 2021.

- WWV with Aug IC projects ENSO neutral in DJF 2021.

Cross-validation with one-year-out is conducted for 1983-2020 prediction. For the 2021year prediction, 1982-2019 is used to get the regression coefficient. NMME Climatology:1982-2010.

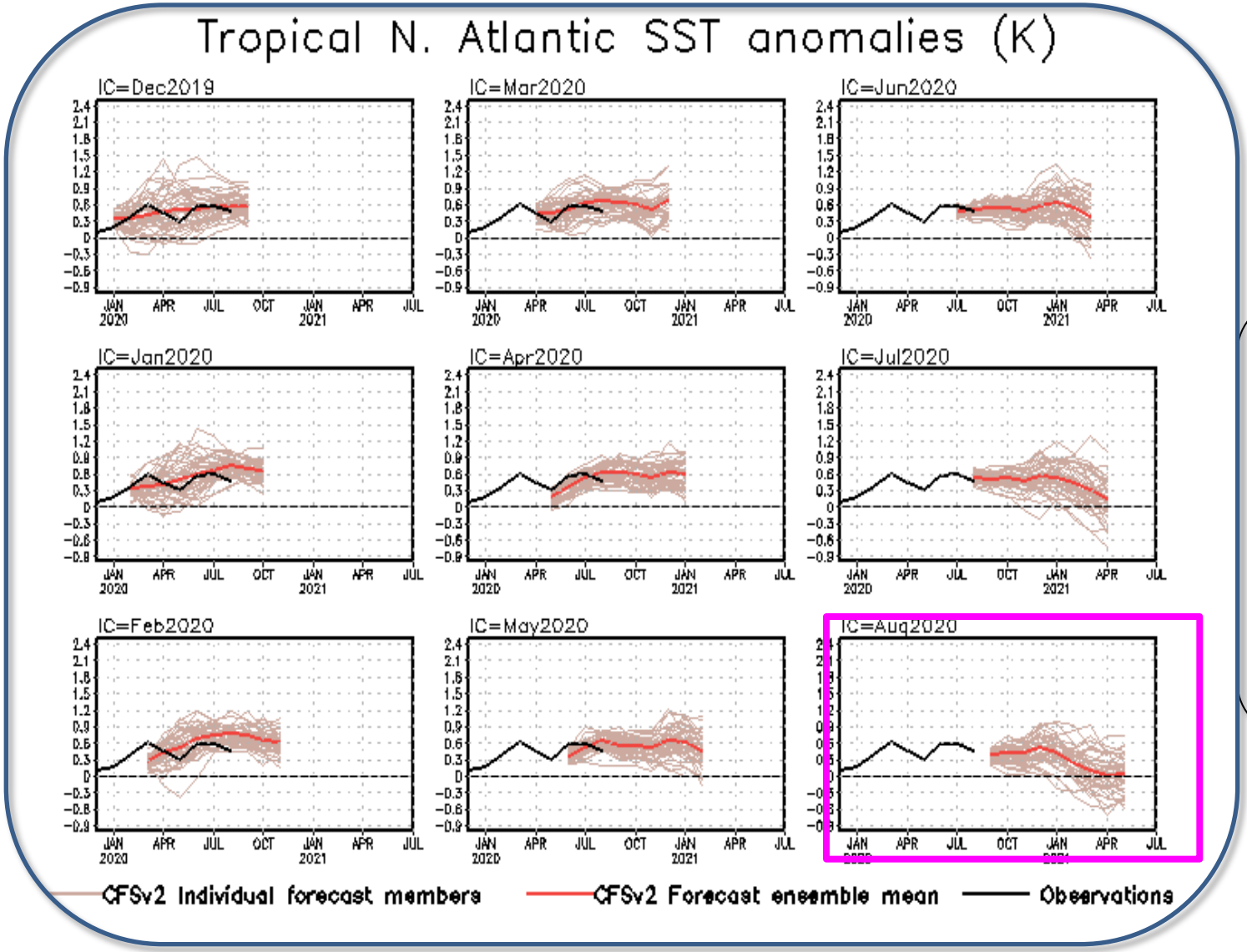
CFS Pacific Decadal Oscillation (PDO) Index Predictions from Different Initial Months



- CFSv2 predicts a negative phase of PDO in 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 1981-2010 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.

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



- Latest CFSv2 predictions call for above normal SSTA in the tropical N. Atlantic through the winter 2020.

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 1981-2010 base period means. TNA is the SST anomaly averaged in the region of [60oW-30oW, 5oN-20oN].

Acknowledgements

- Drs. Zeng-Zhen Hu, Jieshun Zhu, 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 provided the sea ice forecasts and maintained the CFSv2 forecast archive

Please send your comments and suggestions to:

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Caihong.Wen@noaa.gov

Jieshun.Zhu@noaa.gov

Data Sources (climatology is for 1981-2010)

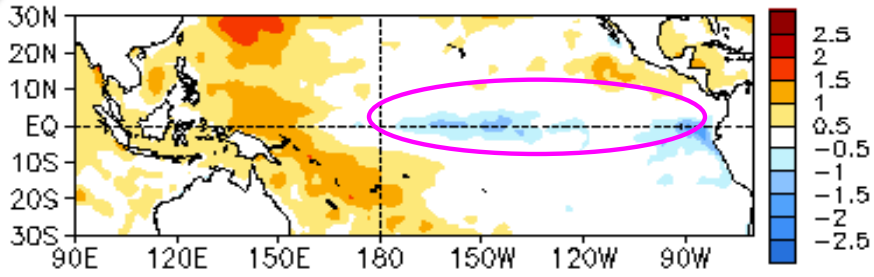
- Weekly Optimal Interpolation SST (OI SST) version 2 (Reynolds et al. 2002)
- Extended Reconstructed SST (ERSST) v5 (Huang et al. 2017)
- Daily Optimum Interpolation SST (OISST) version 2.1 (Huang et al. 2020)
- Blended Analysis of Surface Salinity (BASS) (Xie et al. 2014)
- CMORPH precipitation (Xie 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

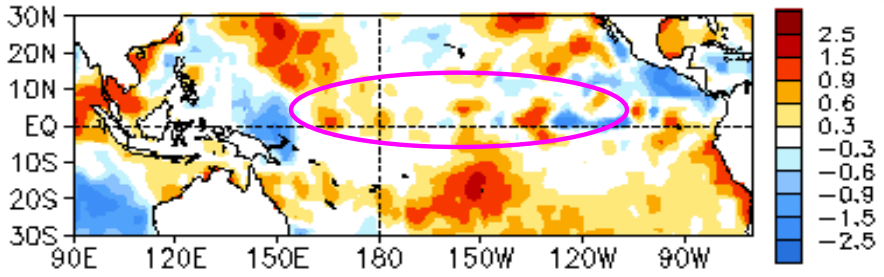
  http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html

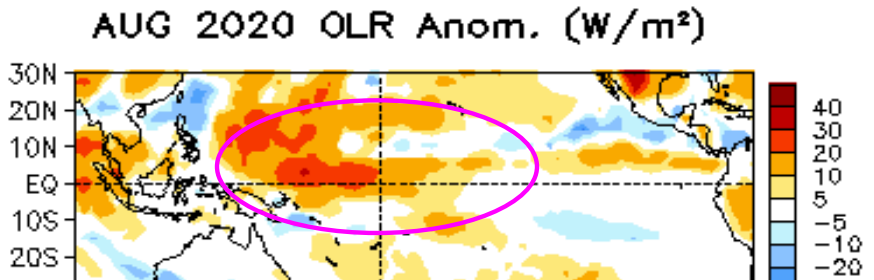
  http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html

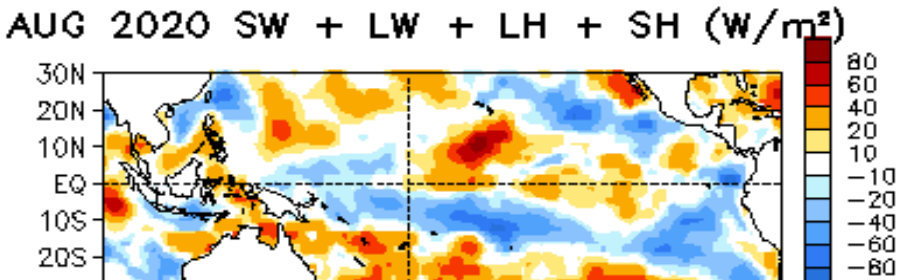
Backup Slides

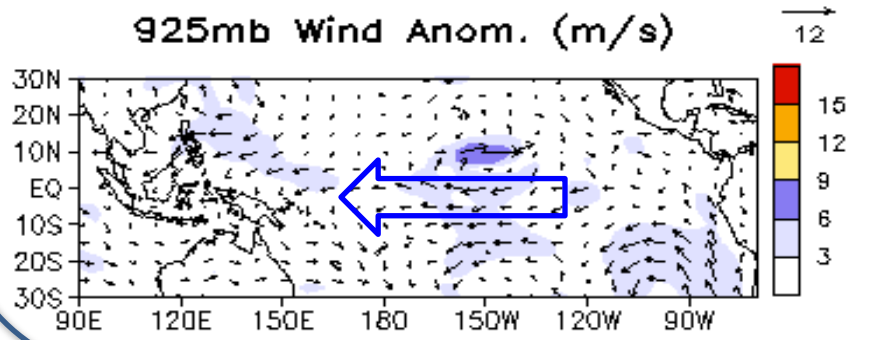
Tropical Pacific: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Winds

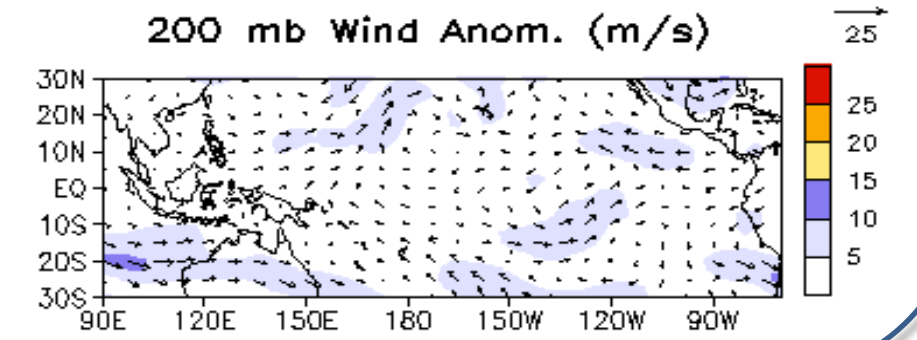






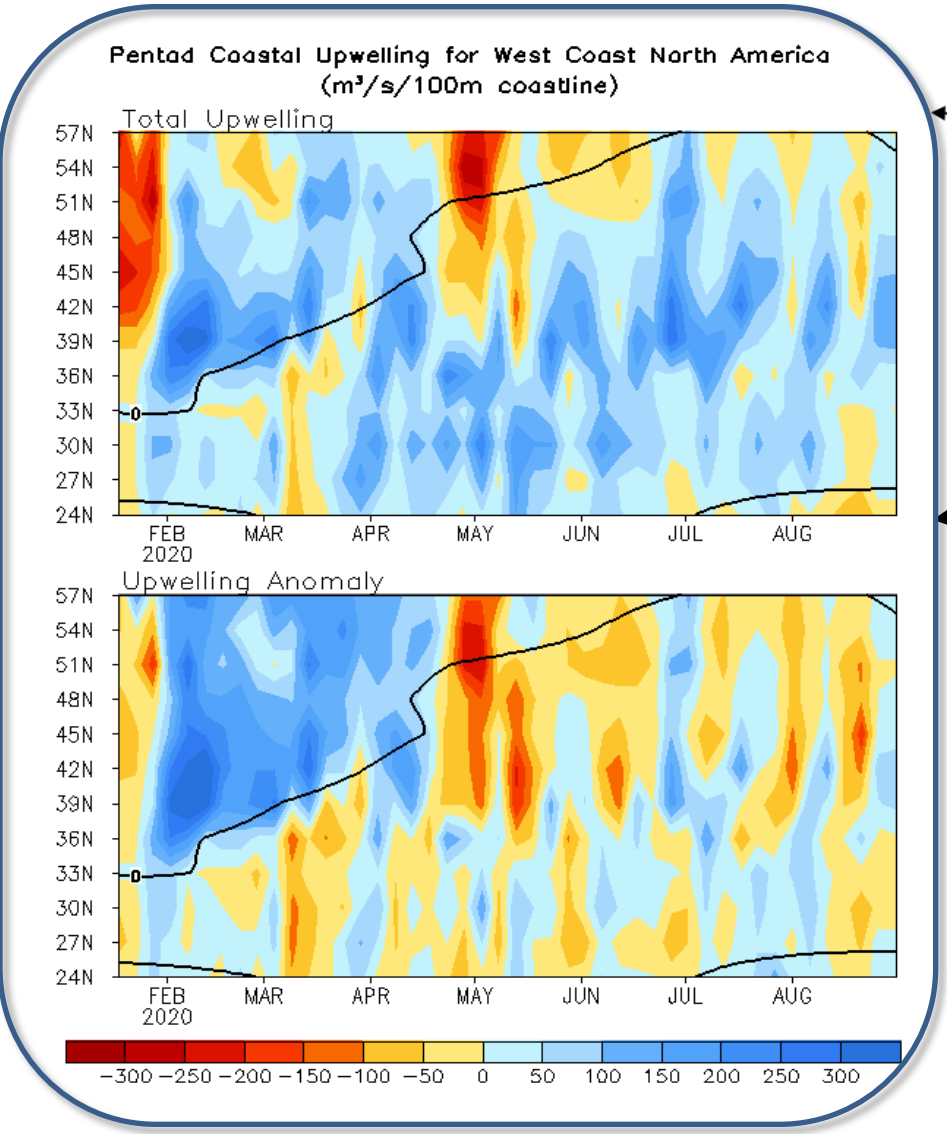


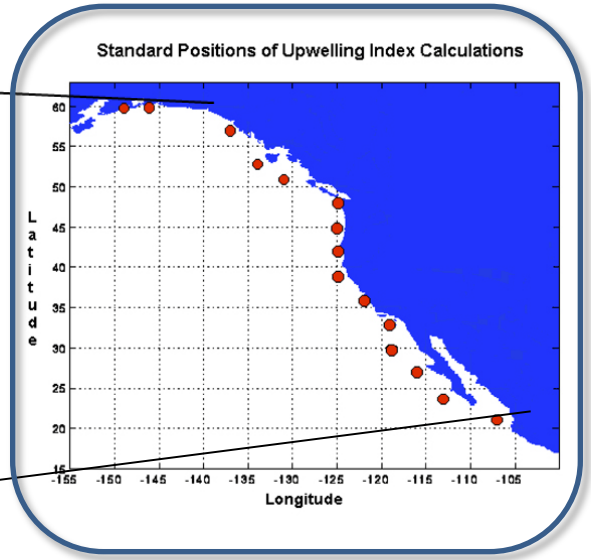




Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right; positive means heat into the ocean), 925-mb wind anomaly 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 1981-2010 base period means.

North America Western Coastal Upwelling

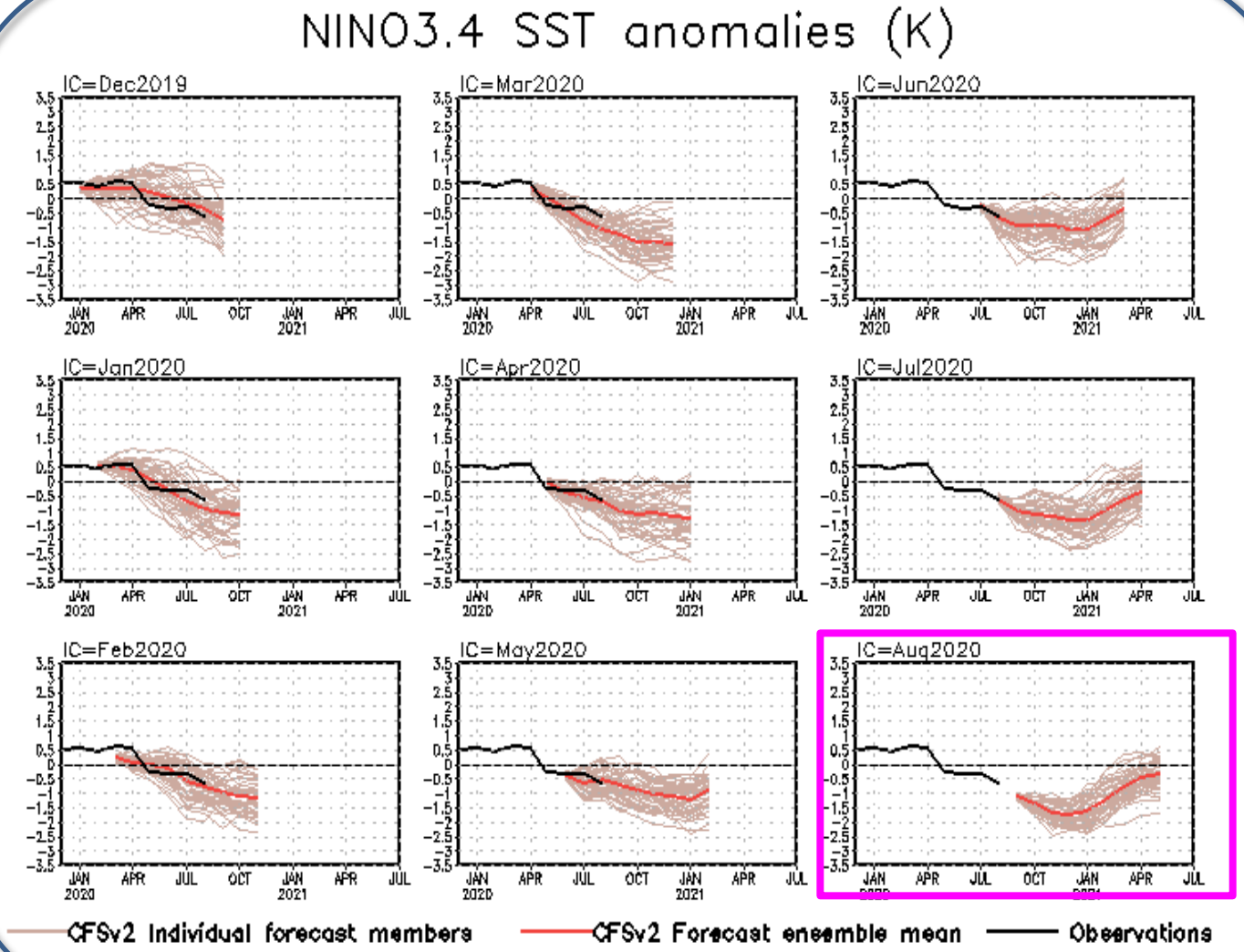




- Upwelling was near average in Aug 2020.

(top) Total and (bottom) anomalous upwelling indices at the 15 standard locations for the western coast of North America. derived from the vertical velocity of the NCEP's GODAS and are calculated as integrated vertical volume transport at 50-meter depth from each location to its nearest coast point (m³/s/100m coastline). Anomalies are departures from the 1981-2010 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.

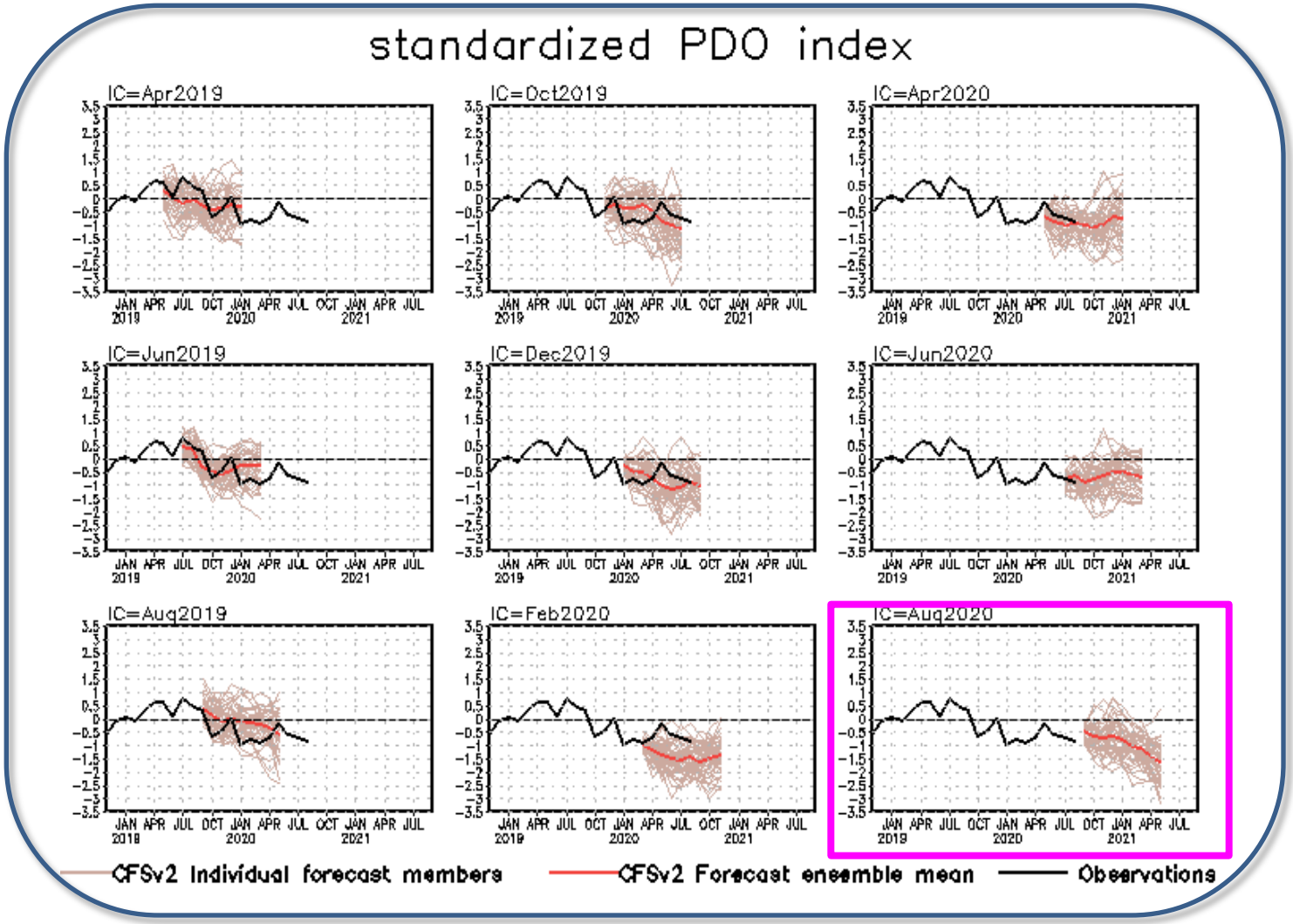
CFSv2 Niño3.4 SST Predictions from Different Initial Months



- The latest CFSv2 forecasts call for a La Nina state through this summer/fall peaking in winter.

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 1981-2010 base period means.

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



- CFSv2 predicts a negative phase of PDO in 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 1981-2010 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.