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

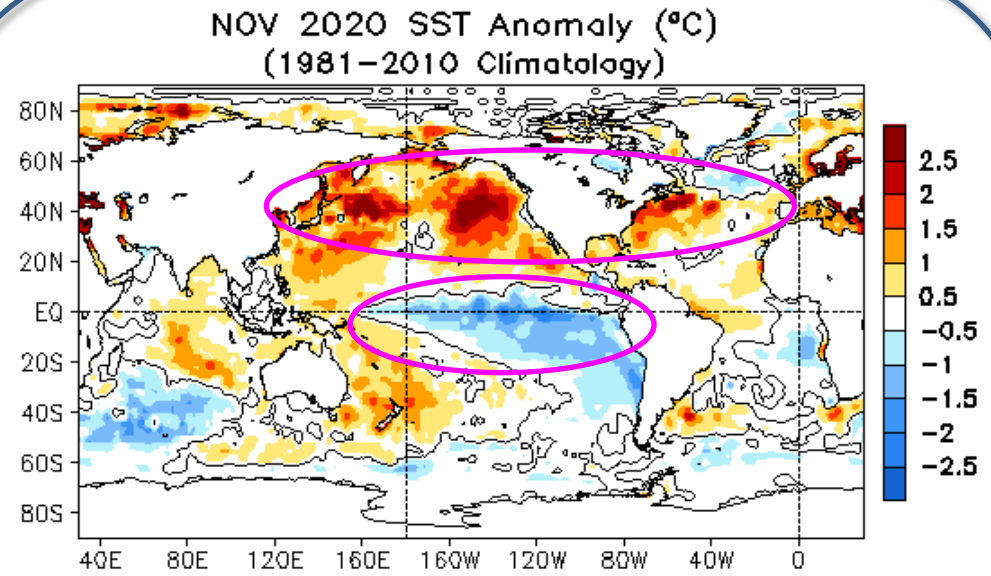
- Overview
- Recent highlights
  - Pacific/Arctic Ocean
  - Indian Ocean
  - Atlantic Ocean
- Global SSTA Predictions
- Special Topics
  - CPC new tool for Probabilities ENSO strength
  - Will a double-dip La Niña occur?
  - Conditions associated with extremely active 2020 Atlantic Hurricane season

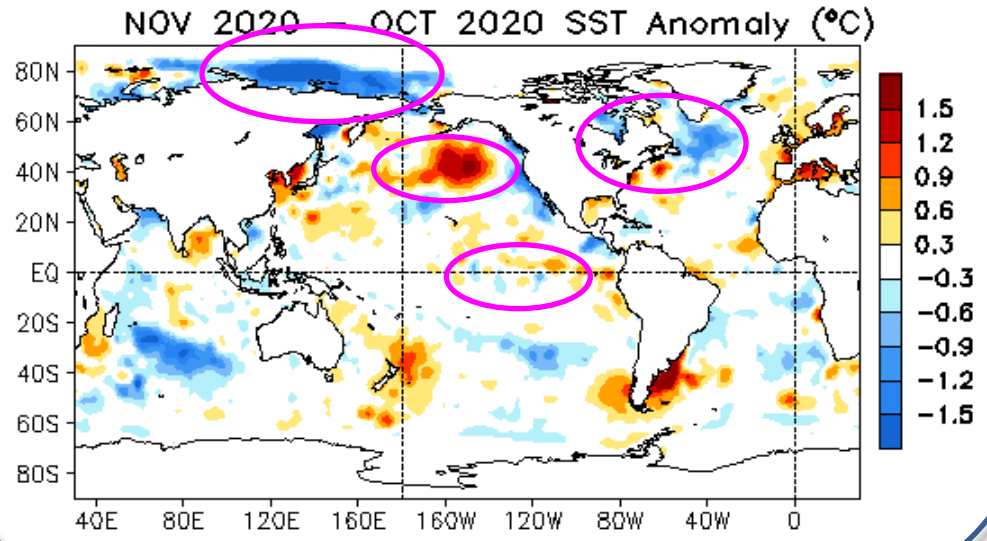
Overview

- Pacific Ocean
  - La Niña conditions continued in Nov 2020, with Nino3.4 = -1.3^{o} C .
  - NOAA “ENSO Diagnostic Discussion” released on 10 December 2020 states that “La Niña is likely to continue through the Northern Hemisphere winter(~95% chance), with a potential transition during spring 2021 (~50% chance)”.
  - Marine Heat Waves (MHWs) near the west coast of United States weakened in Nov 2020.
  - Negative PDO strengthened substantially in Nov 2020, with PDOI = -1.7.
- Indian Ocean
  - Neutral Indian Ocean Dipole index continued in Nov 2020.
- Atlantic Ocean
  - 2020 Atlantic hurricane season was the most active season since 1851.
- Arctic Ocean
  - The sea ice extent in Nov 2020 ranked the second minimum since 1979.

Global Oceans

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



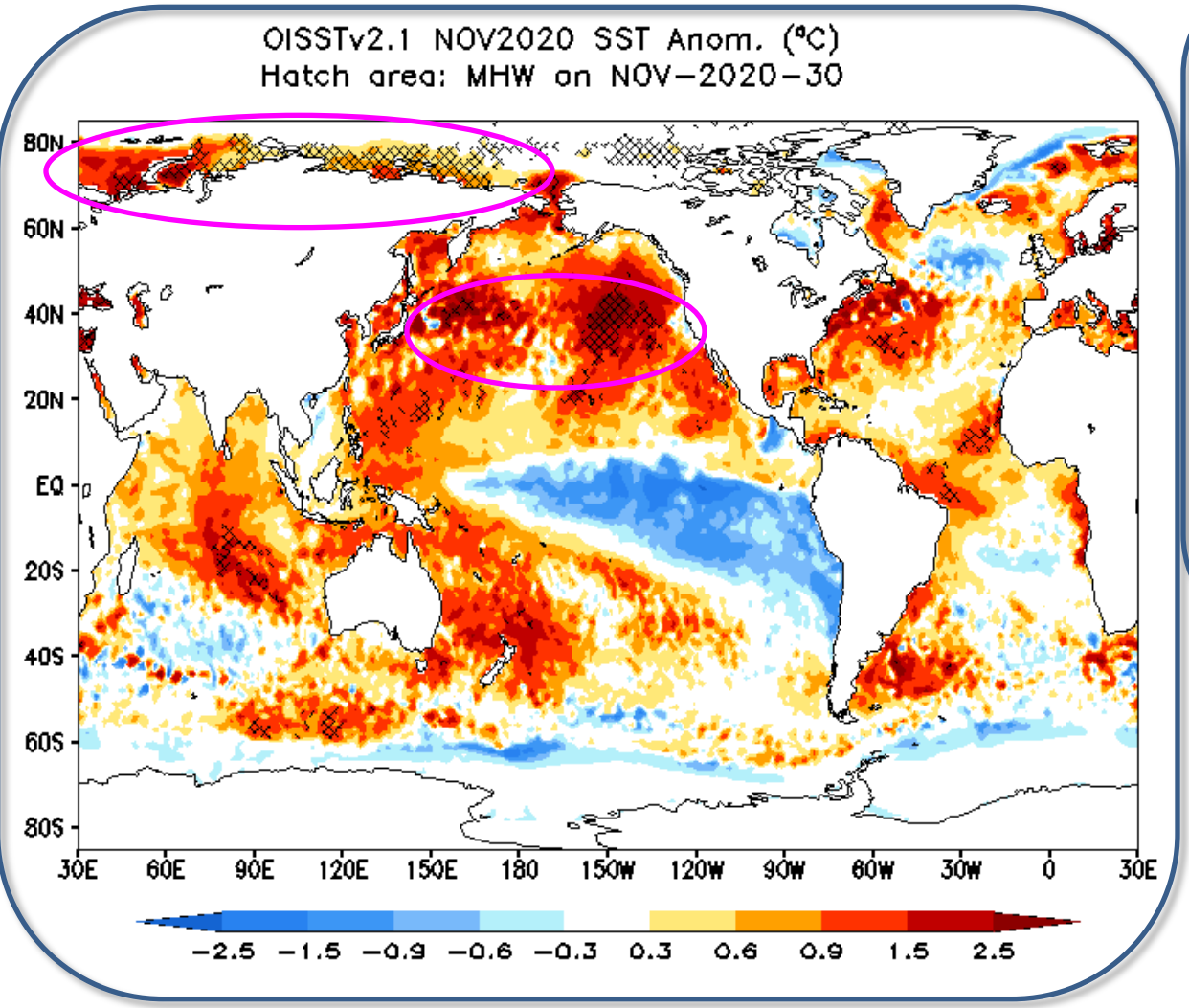


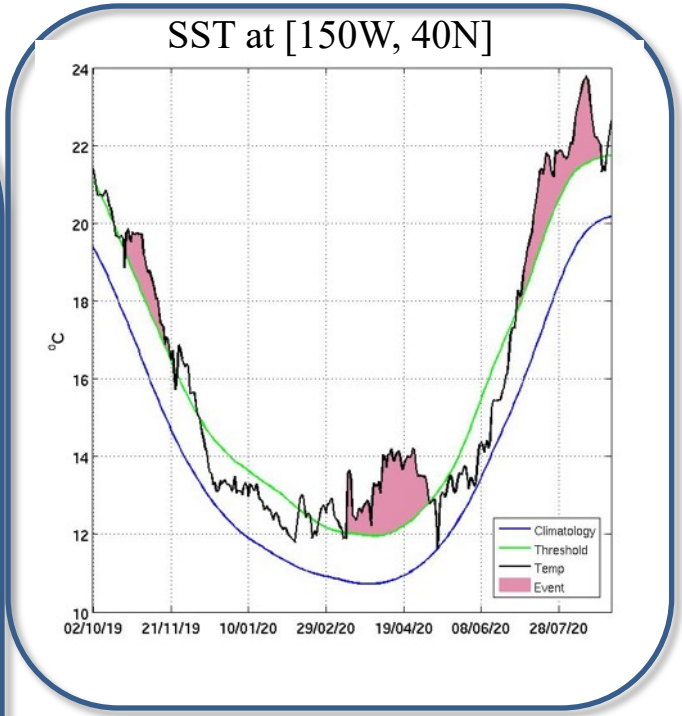
- Negative SSTA persisted in the central-eastern equatorial Pacific.
- Strong positive SSTAs continued in the mid-high latitudes of Northern Hemisphere.

- Positive SSTA tendencies dominated in the far eastern Pacific.
- Negative SSTA tendencies presented in the subarctic regions.
-Positive SSTA tendencies presented in the NE. Pacific Ocean.

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.

Global Monthly SST anomaly and Marine Heat wave (MHW) activity

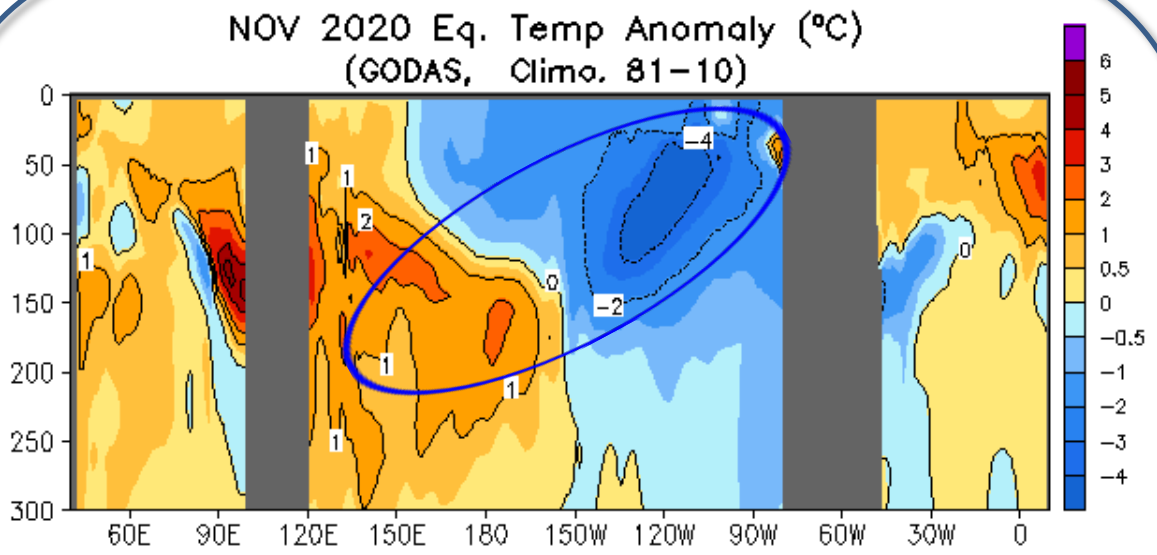


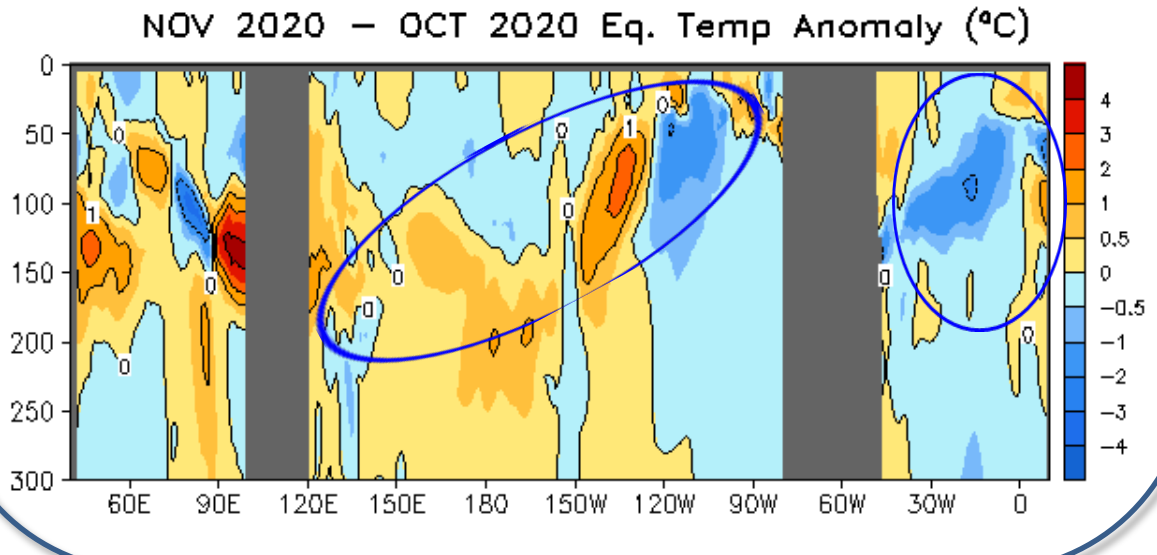


- MHWs presented in subarctic regions north of Eurasia and mid-latitude of North Pacific.

(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.

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





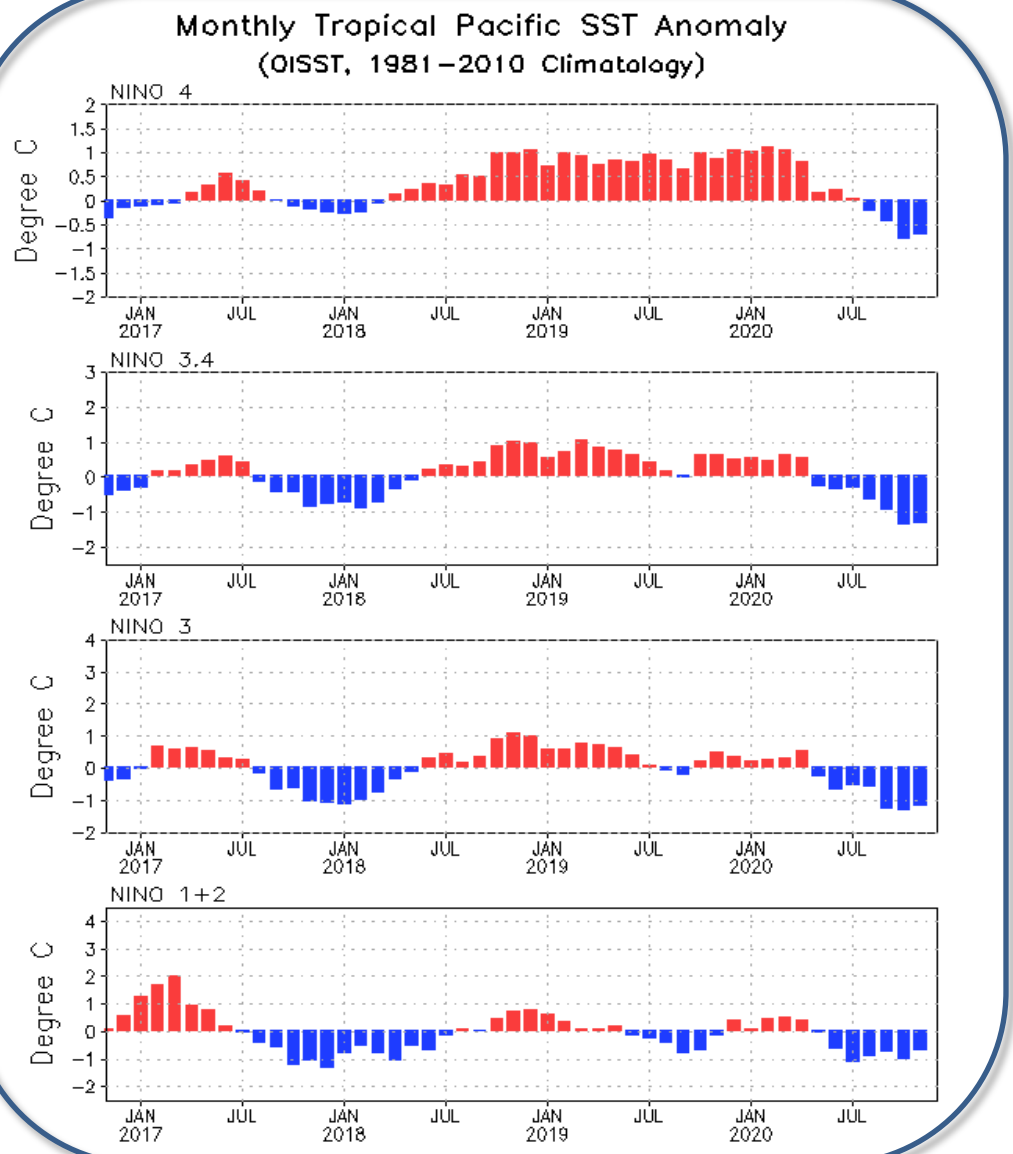
- Ocean temperature reached more than 4°C cooler than average near the thermocline in the eastern Pacific Ocean.
- Positive temperature anomalies dominated in the upper equatorial Indian and the Atlantic Oceans.

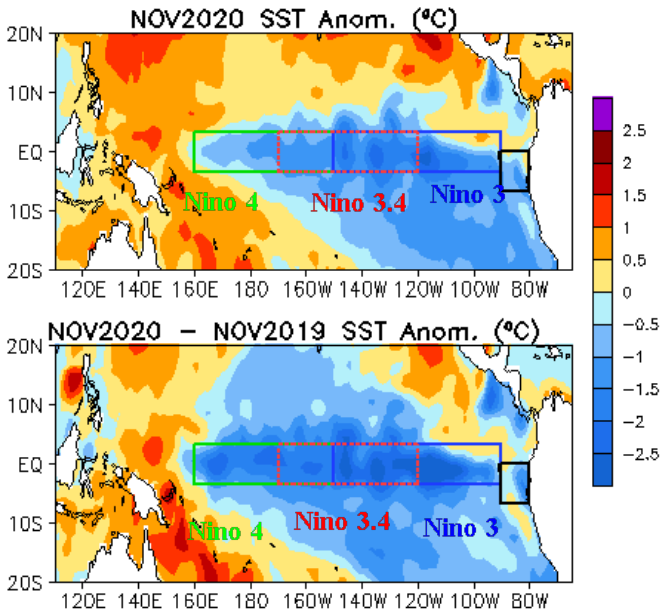
- Positive (negative) temperature anomaly tendency dominated in the western-central (far eastern) Pacific.
- Negative temperature anomaly tendency presented near the thermocline in the Atlantic Ocean.

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 1981-2010 base period means.

Tropical Pacific Ocean and ENSO Conditions

Evolution of Pacific NINO SST Indices





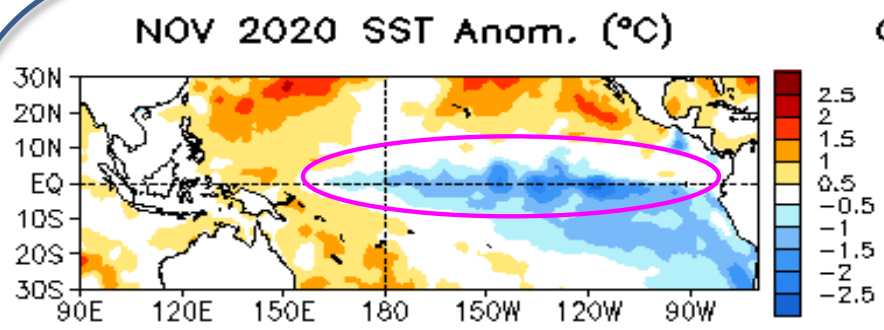
- All Nino indices weakened slightly in Nov 2020, with Nino3.4 = - 1.3°C.

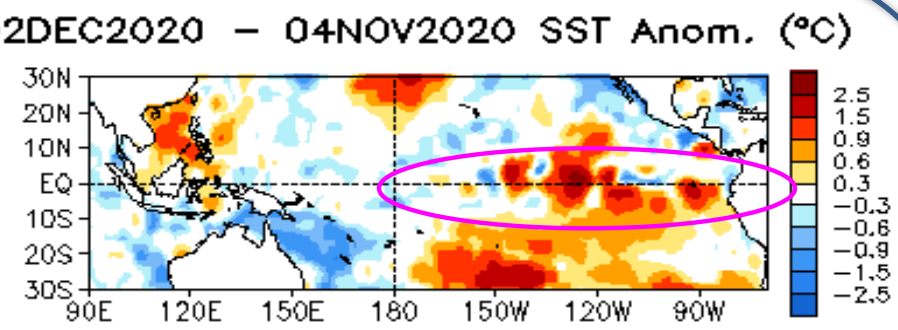
- Compared with Nov 2019, the central and eastern (far western) equatorial Pacific was cooler (warmer) in Nov 2020.

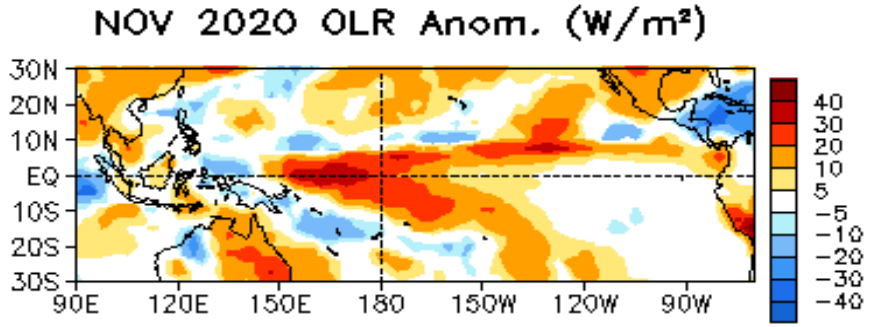
- The indices may have slight differences if based on different SST products.

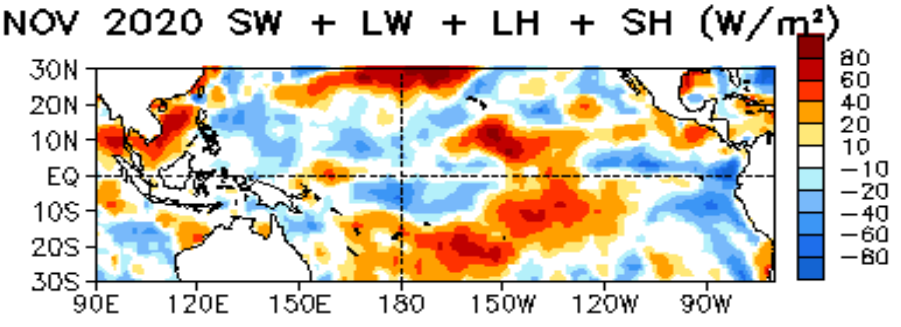
Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

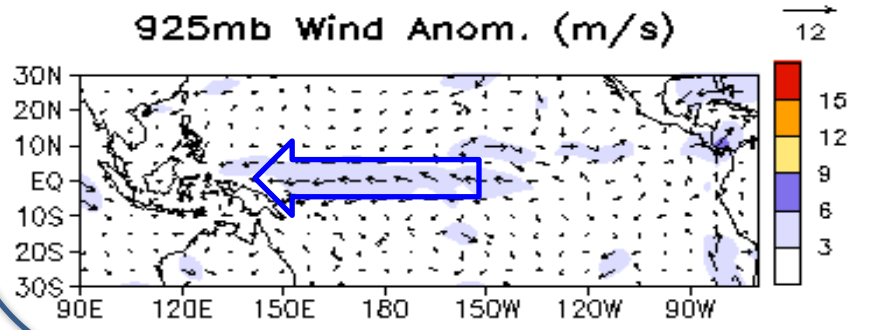
Tropical Pacific: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Winds

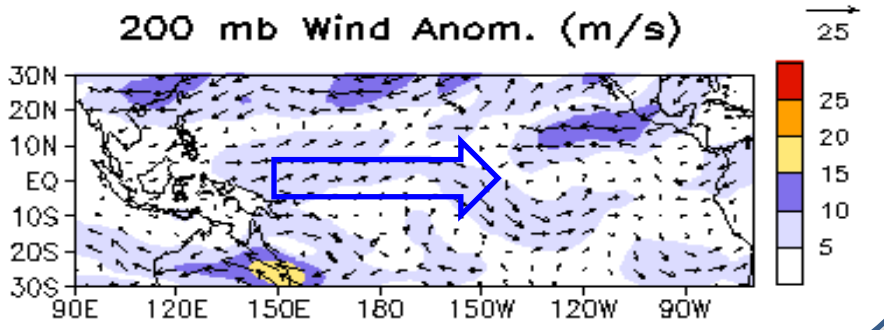






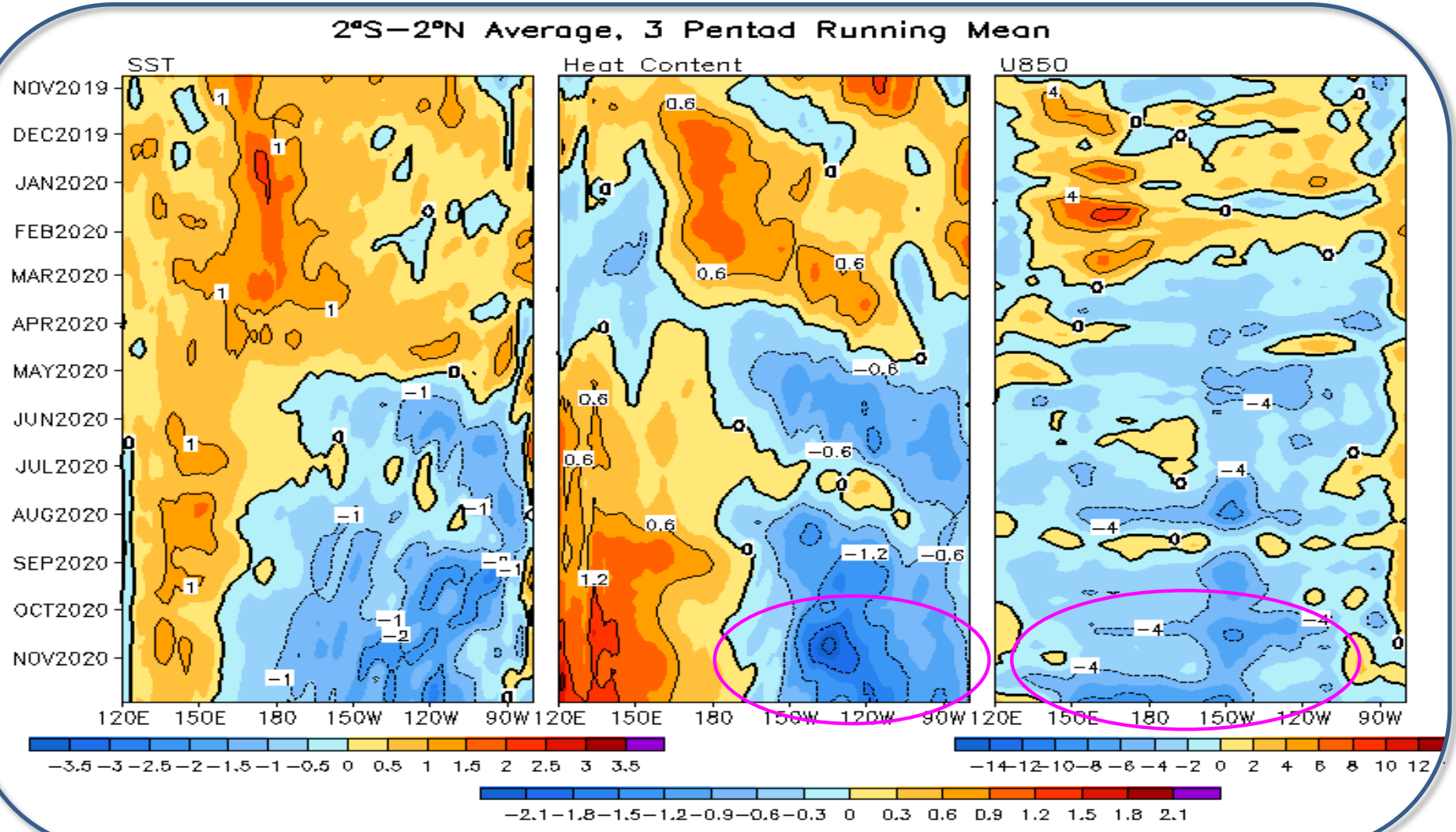






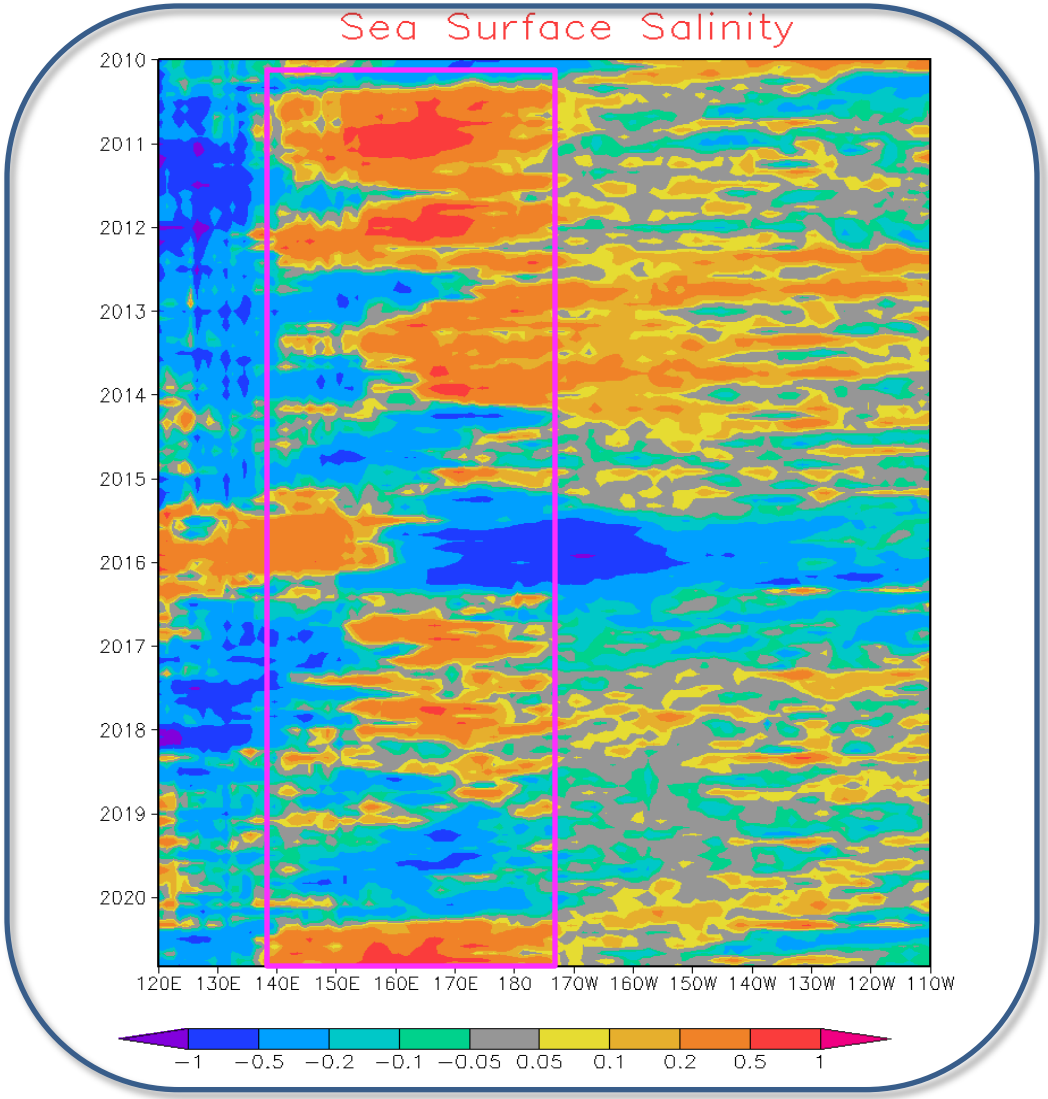
Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right; positive means heat into the ocean), 925-mb wind anomaly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

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



- Negative SSTA persisted in the central-eastern Pacific in Nov 2020, consistent with the negative subsurface temperature anomalies in the central-eastern Pacific.
- Easterly low-level zonal wind anomalies prevailed in the Pacific since Mar 2020.

Equatorial Pacific Sea Surface Salinity(SSS) Anomaly

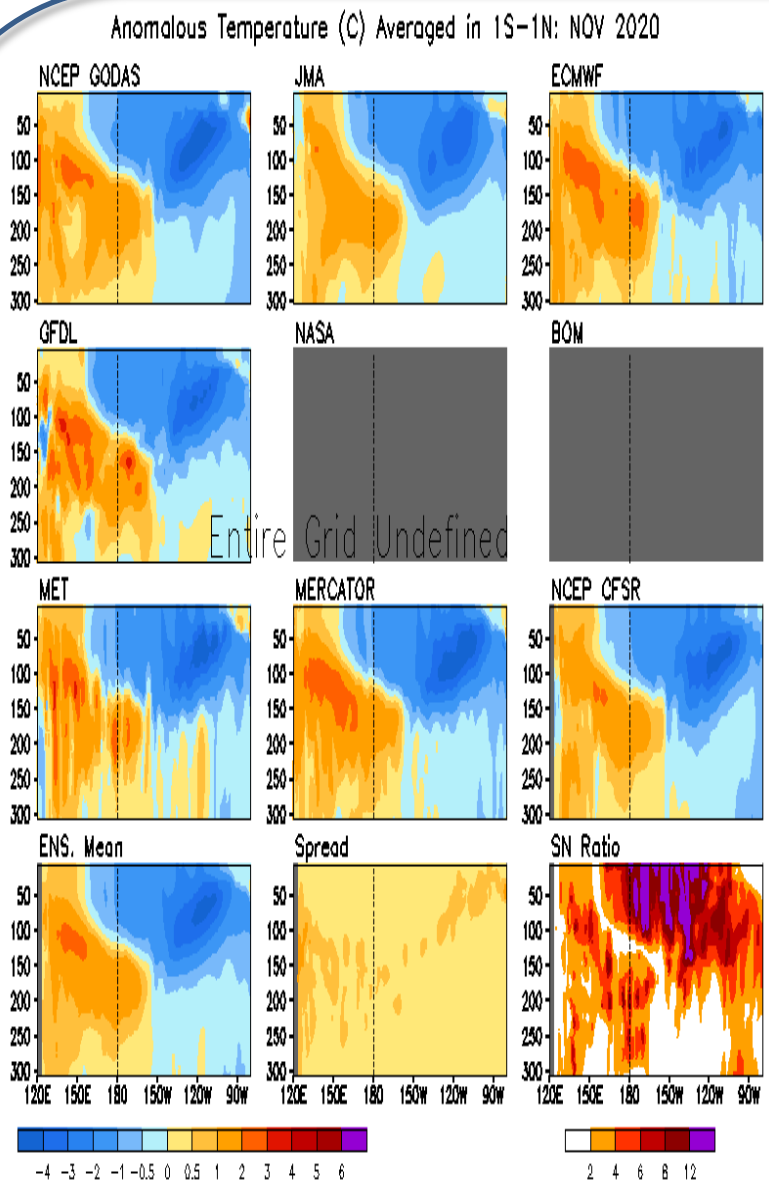


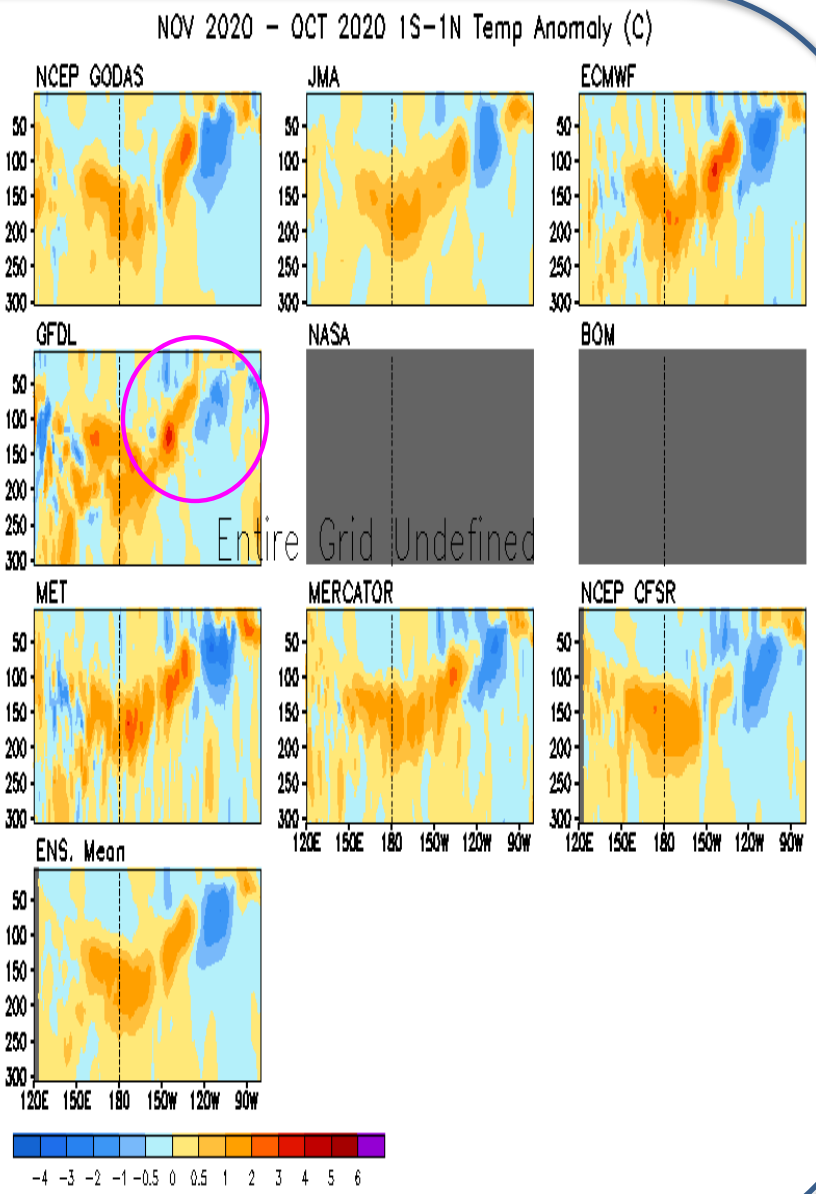
- Positive (negative) SSS anomaly presented east (west) of 140E during 2010, 2011, 2016,2017 La Nina events.

- Strong positive SSS anomaly continued around 140° E-170° W in Nov 2020.

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.

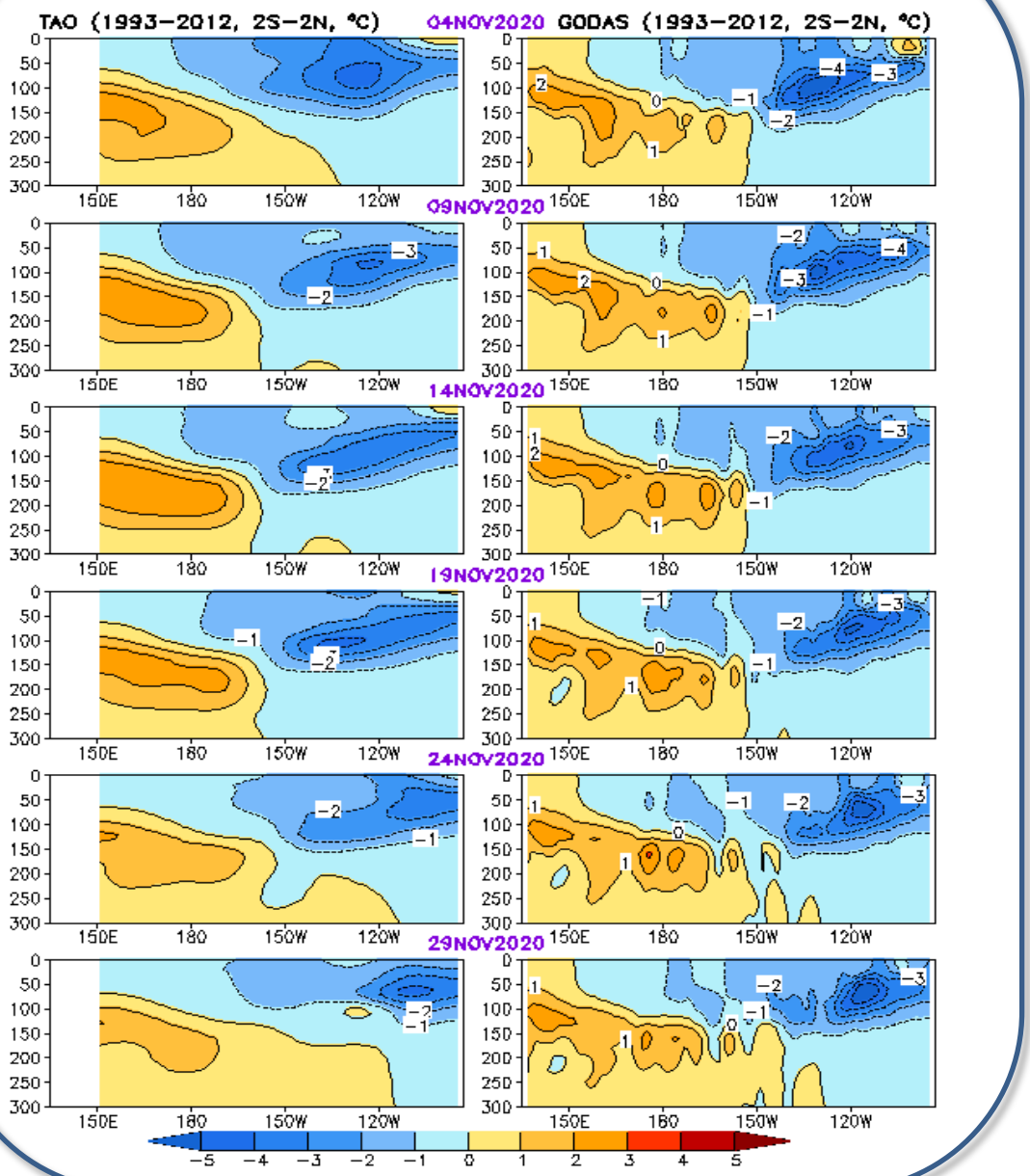
Equatorial Temperature Anomaly & Temperature Tendency





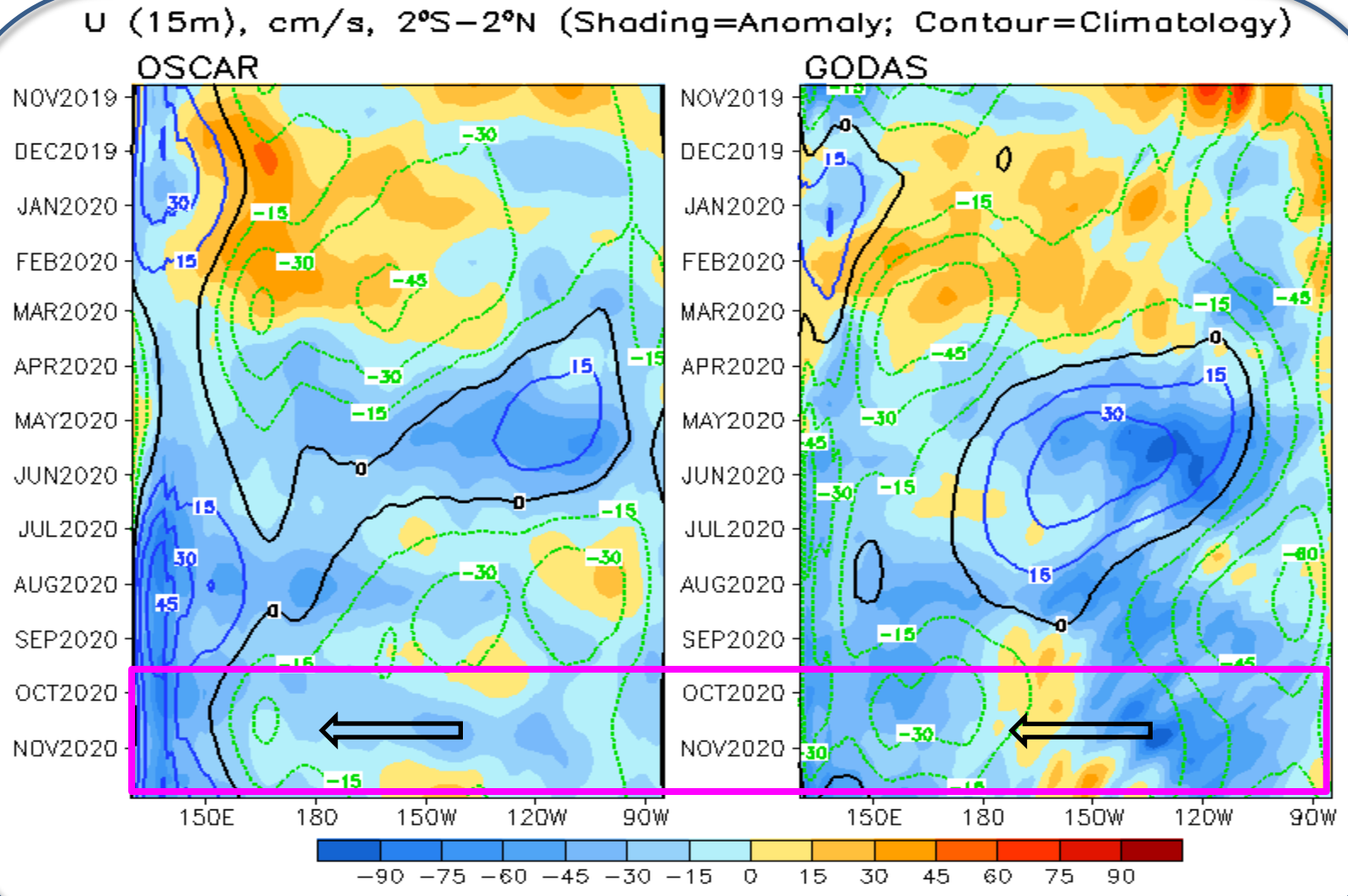
(http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html)

Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



- Negative ocean temperature anomalies strengthened near the thermocline in the far eastern Pacific, while weakened in central-eastern Pacific (160W-120W).

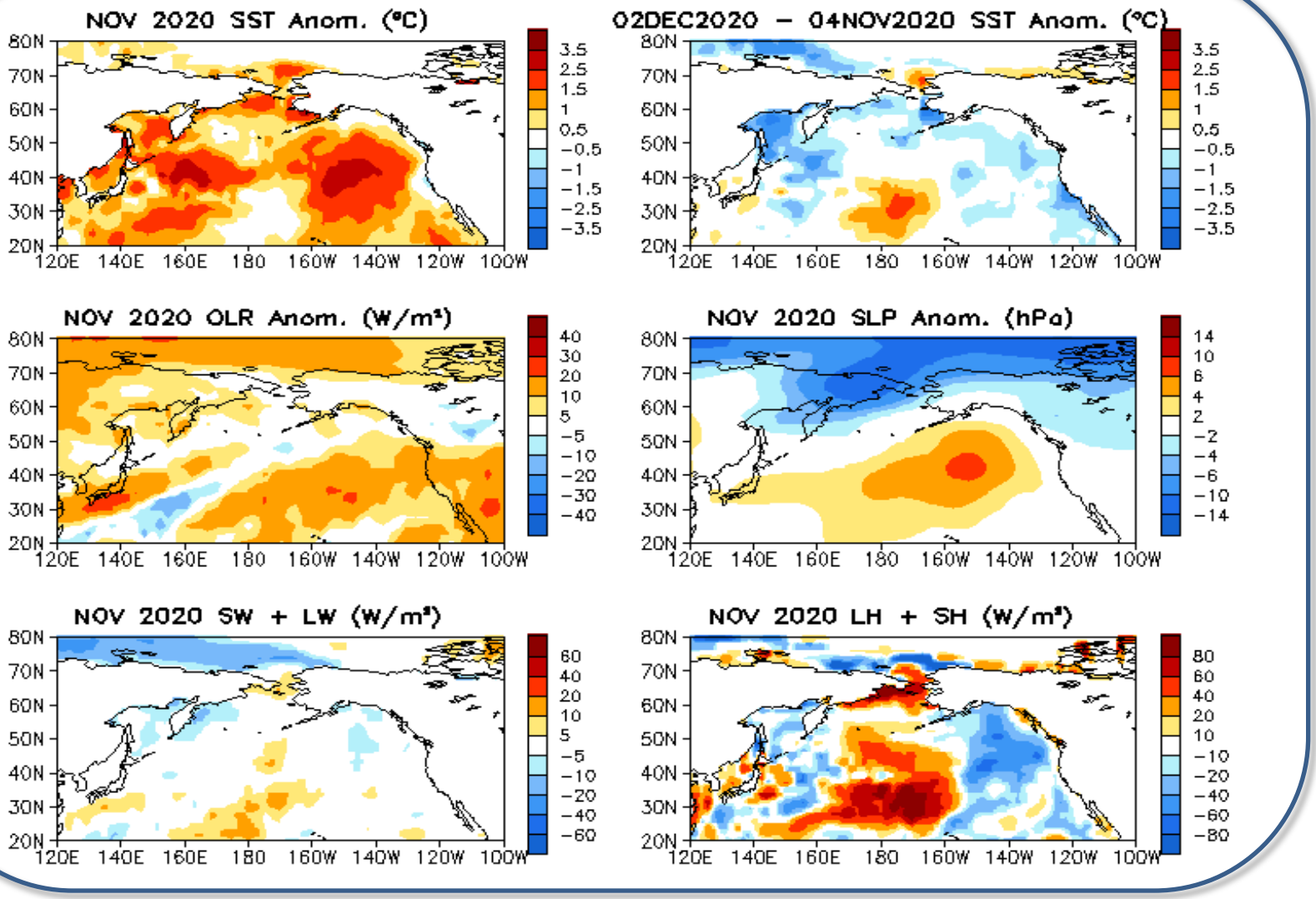
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- Anomalous westward currents dominated in the equatorial Pacific Ocean.

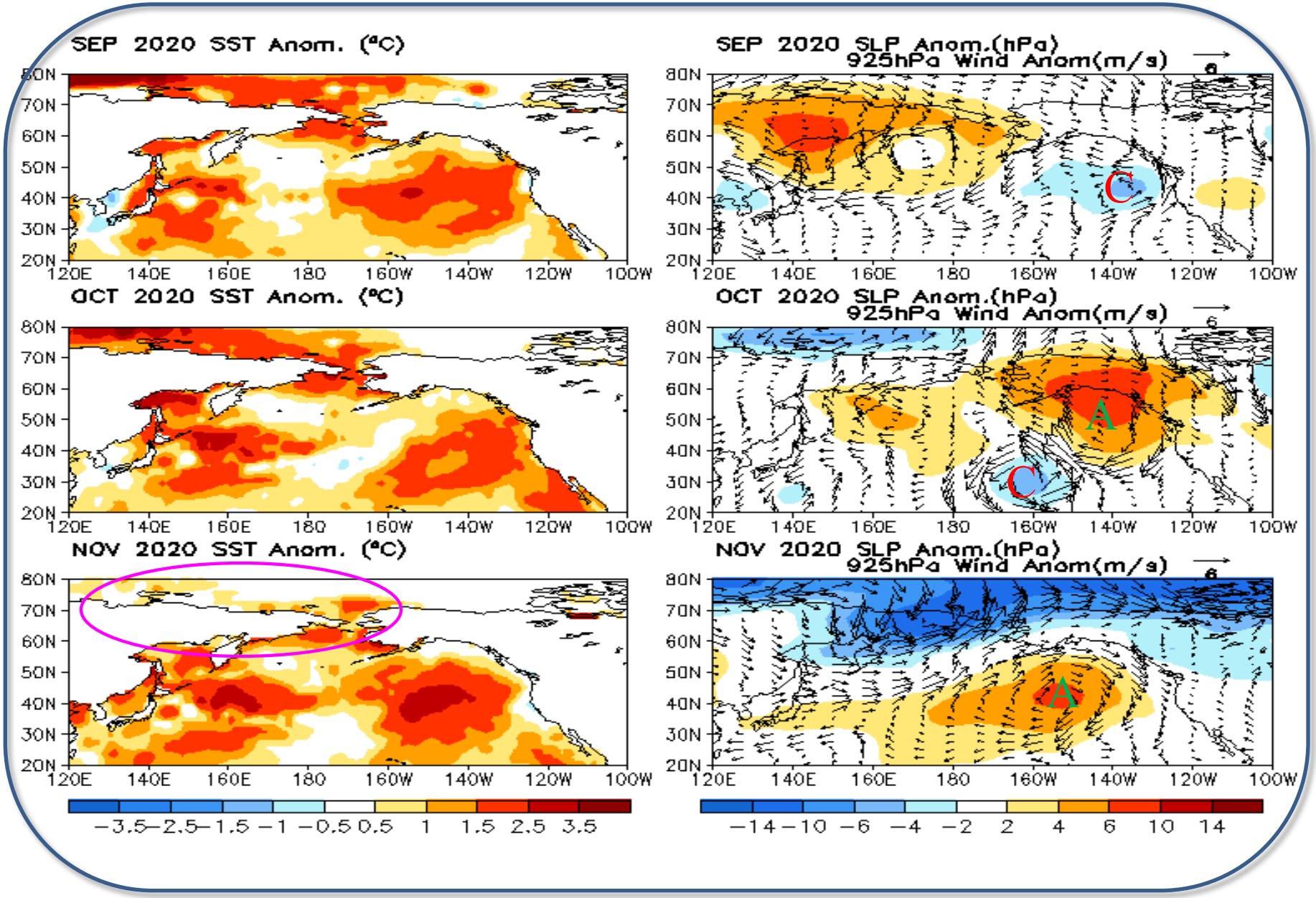
North Pacific & Arctic Oceans

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



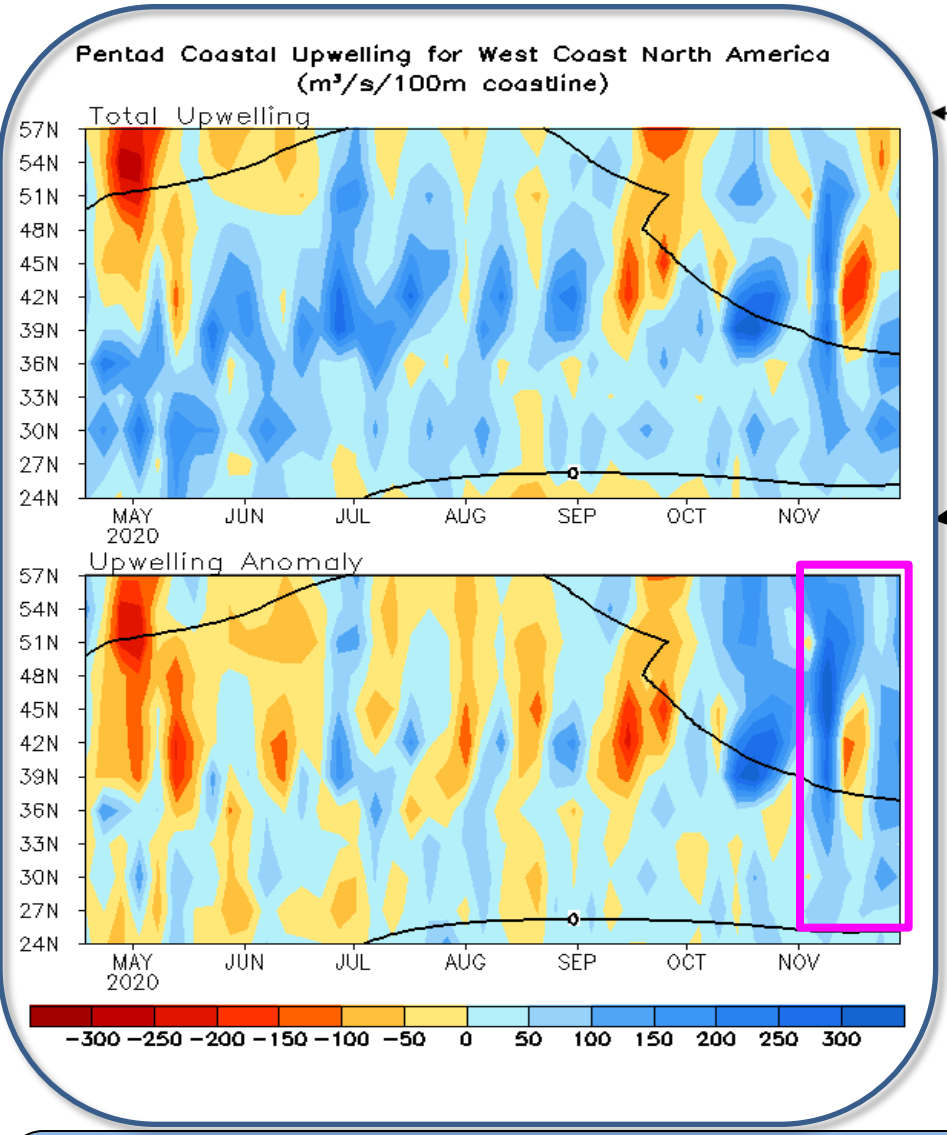
Sea surface temperature (top-left; NCEP OI SST Analysis), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) (middle-left; NOAA 18 AVHRR IR), sea surface pressure (middle-right; NCEP CDAS), sum of net surface short- and long-wave radiation (bottom-left; positive means heat into the ocean;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

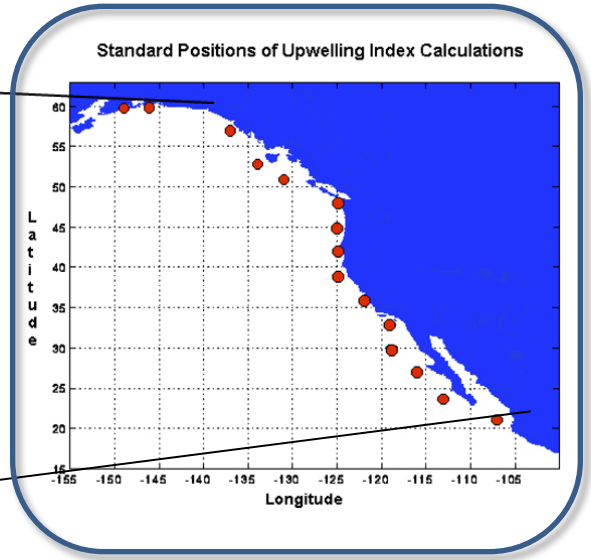
Last Three Month SST, SLP and 925hPa wind Anomalies



Data source: OISST, NCEP/NCAR Reanalysis 1

North America Western Coastal Upwelling



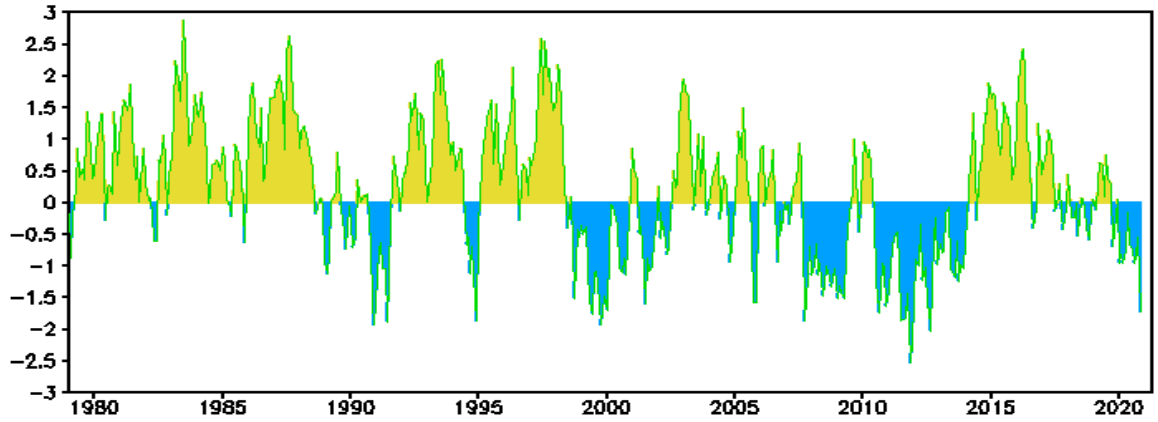


- Positive upwelling anomaly dominated in Nov 2020, consistent with the northwesterly wind anomaly.

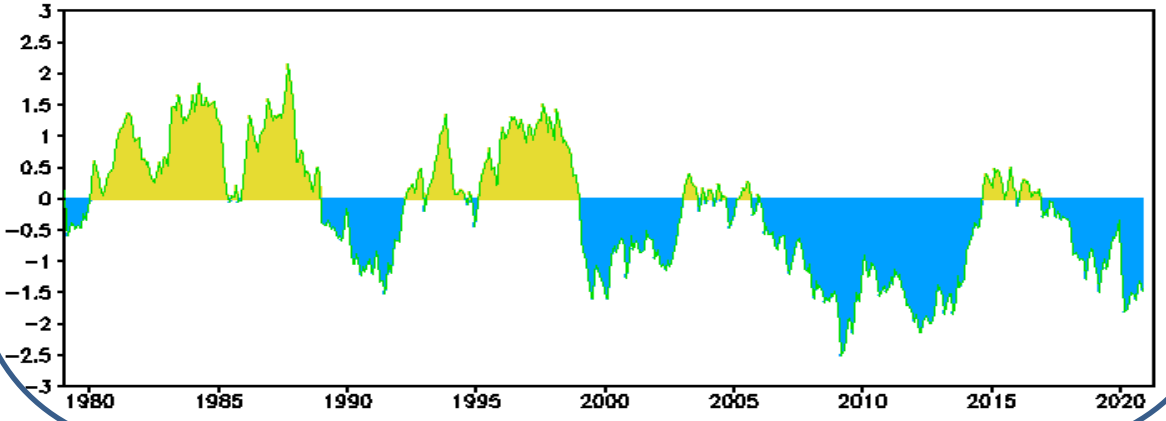
(top) Total and (bottom) anomalous upwelling indices at the 15 standard locations for the western coast of North America. derived from the vertical velocity of the NCEP's GODAS and are calculated as integrated vertical volume transport at 50-meter depth from each location to its nearest coast point (m³/s/100m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

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 increased substantially in Nov 2020, with PDO index= -1.7.

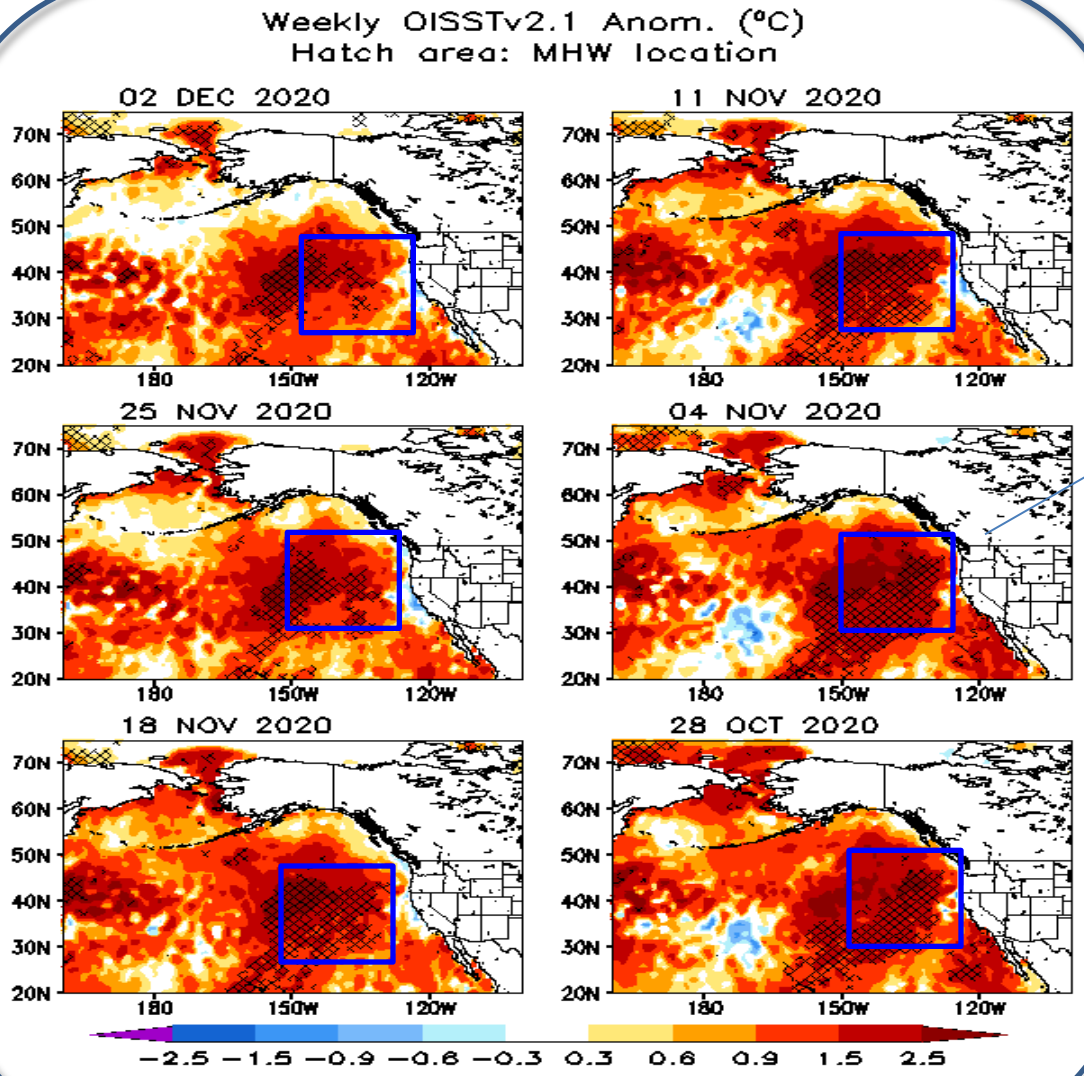
- Negative H300-based PDO index has persisted 50 months since Nov 2016, with HPDO = - 1.5 in Nov 2020.

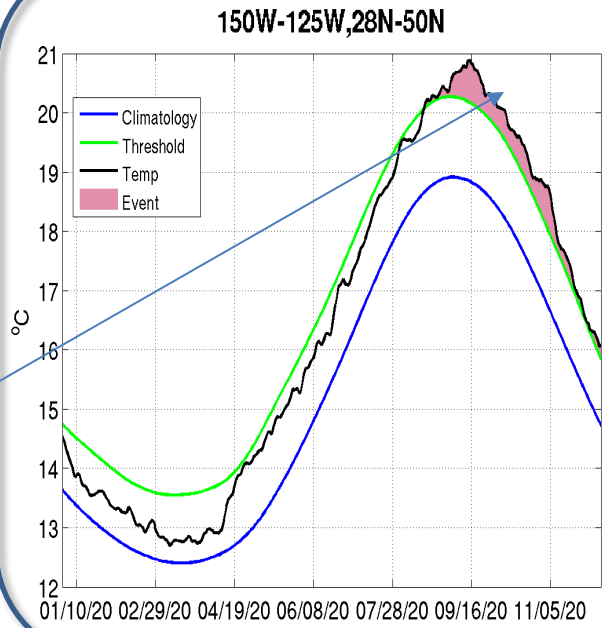
- SST-based PDO index has considerable variability both on seasonal and decadal time scales.

- 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.

Weekly SST anomaly and MHWs in the North Pacific

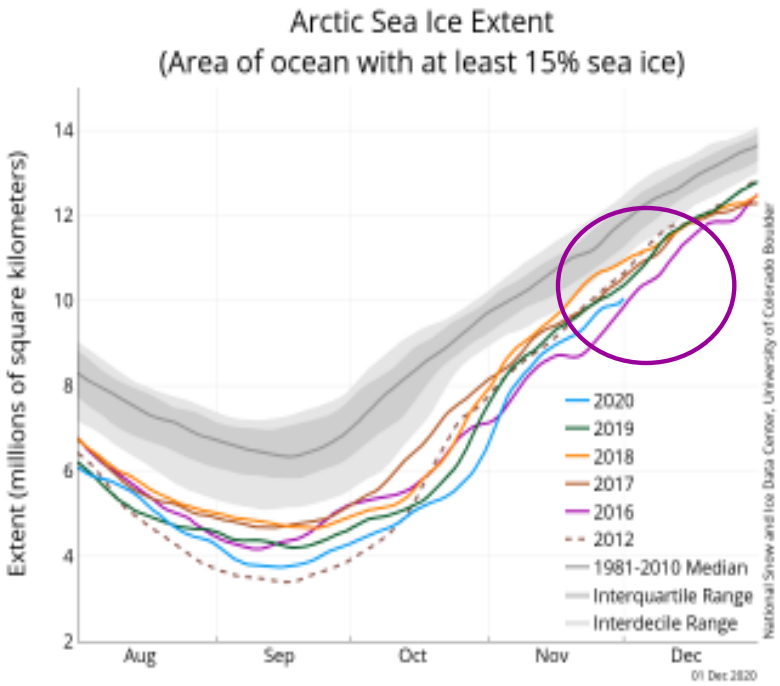


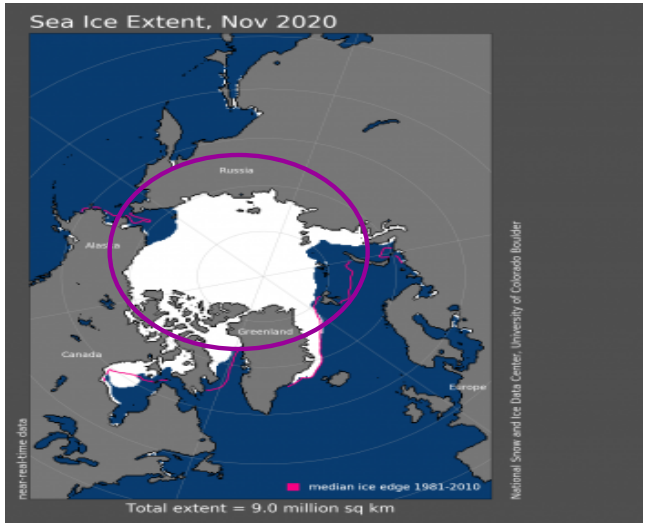


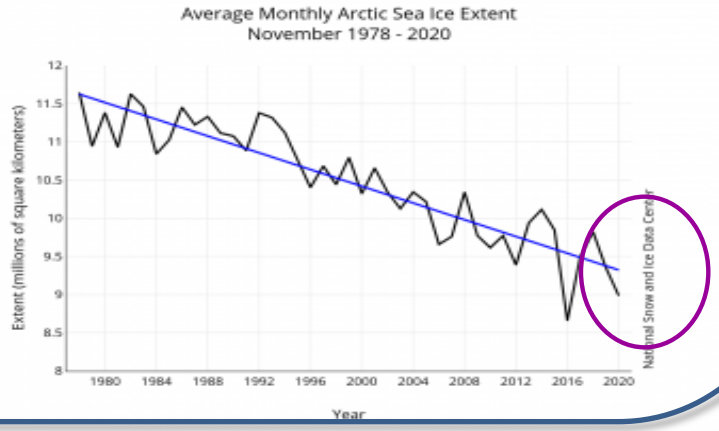
- MHWs near the west coast of United States weakened in Nov 2020.

(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.

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



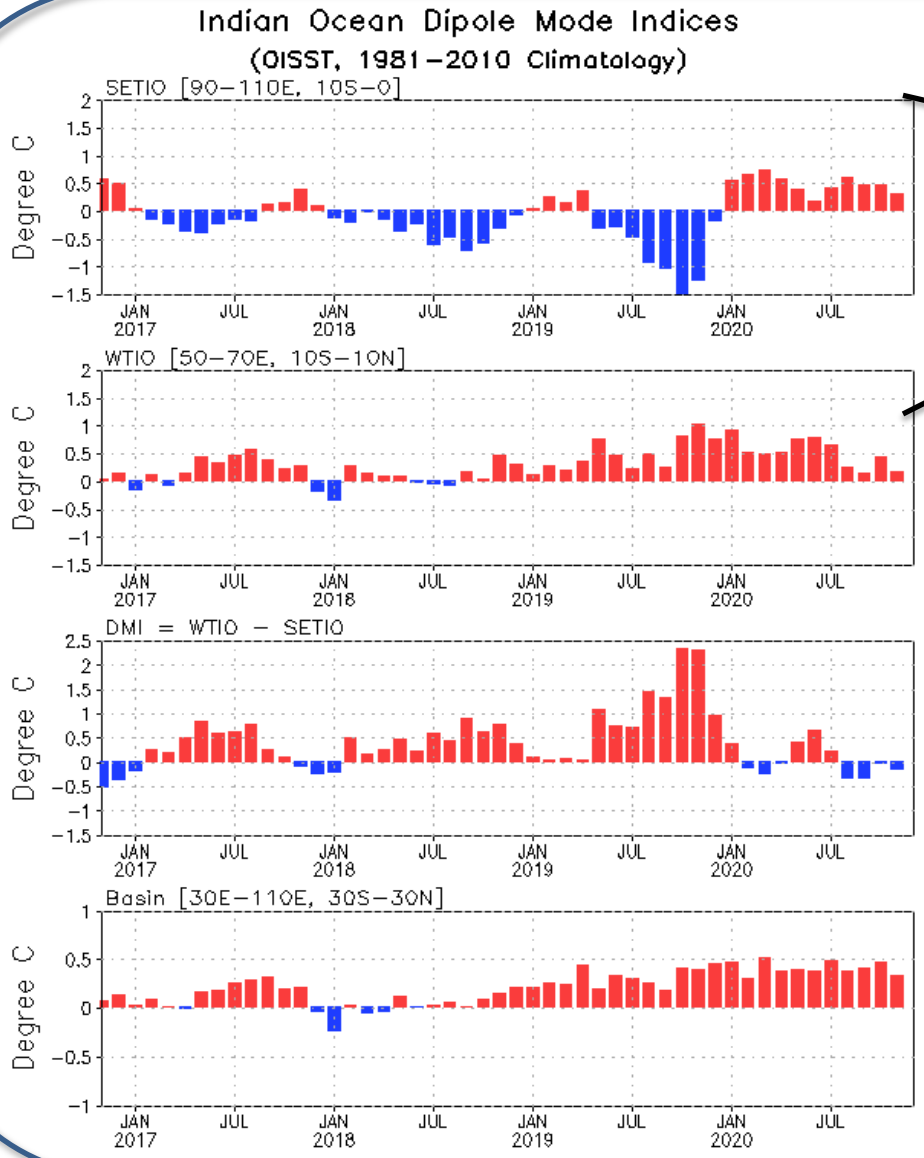


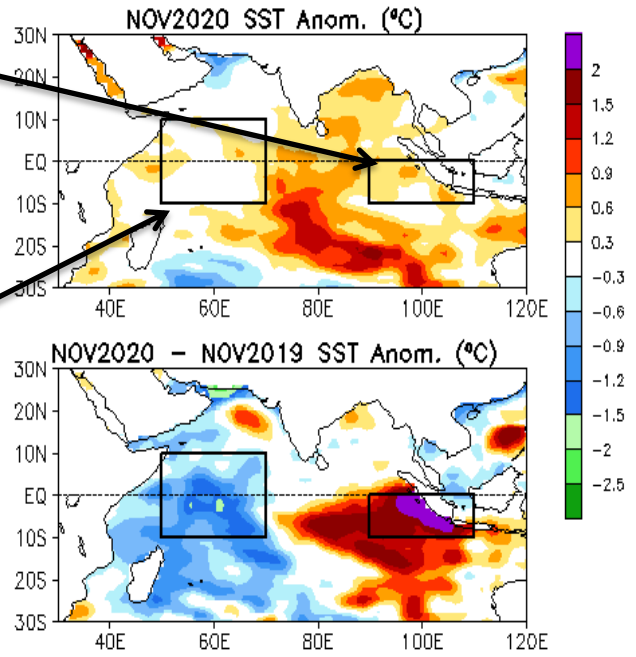


- Arctic ice extent was much below average over the Barents and Kara Seas on the Atlantic side and the Chukchi Sea on the Pacific side of the Arctic Ocean in November 2020.
- The monthly average extent for Nov 2020 is 8.99 million square kilometers, ranking the second lowest since satellite observations in 1979.

Indian Ocean

Evolution of Indian Ocean SST Indices

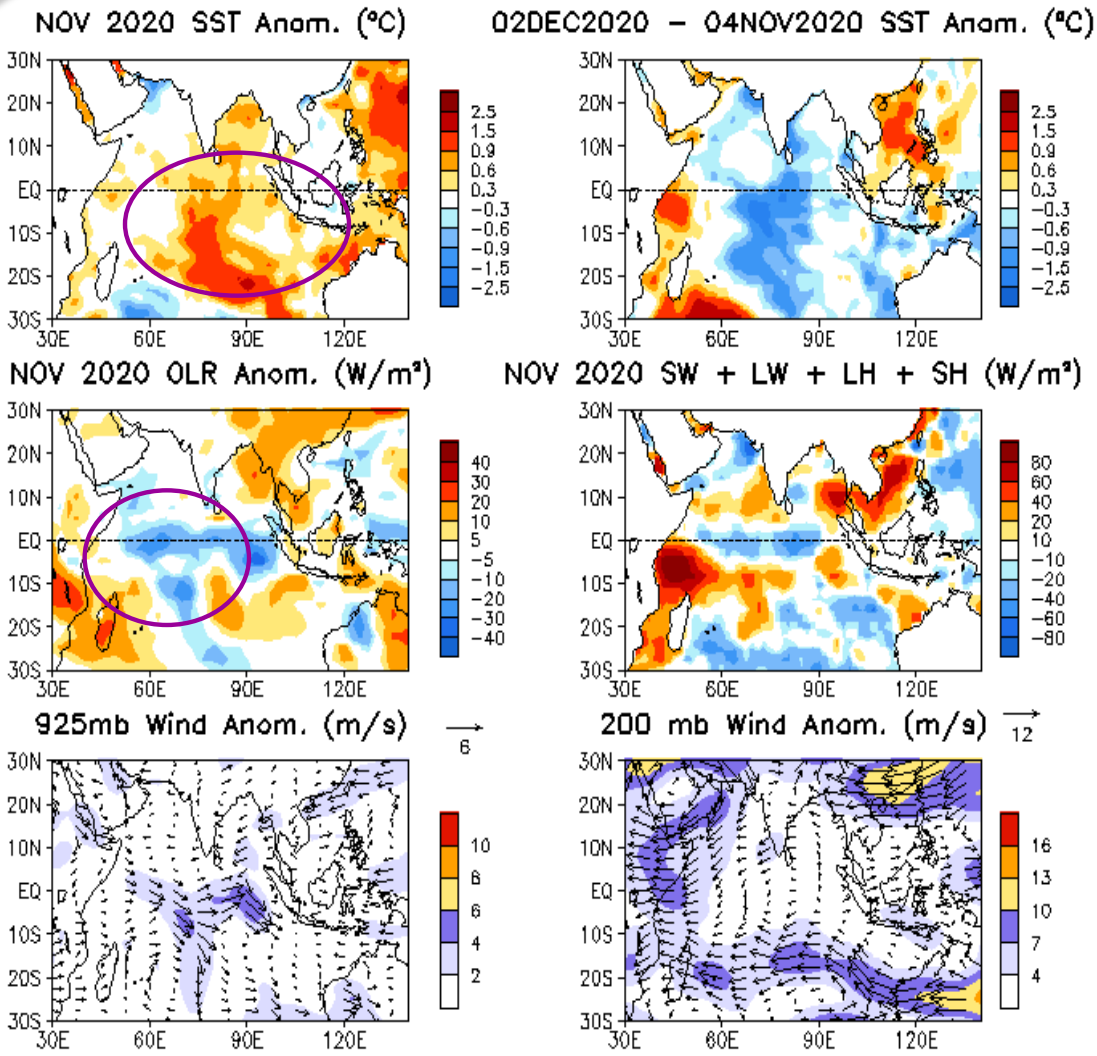




- Indian Ocean Dipole index was near average in Nov 2020.

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.



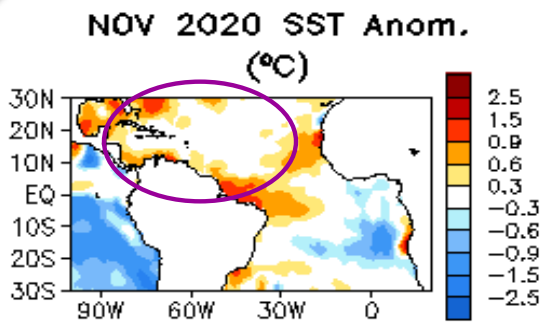
- Positive SSTA dominated the tropical Indian Ocean.

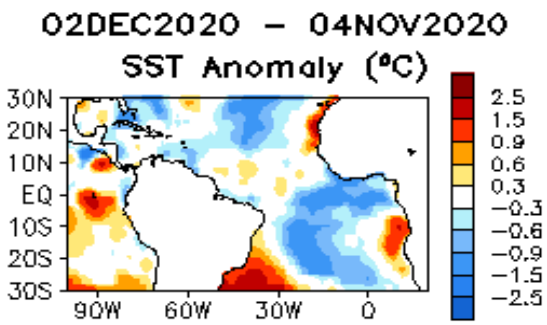
- Convection was enhanced over the equatorial Indian Ocean.

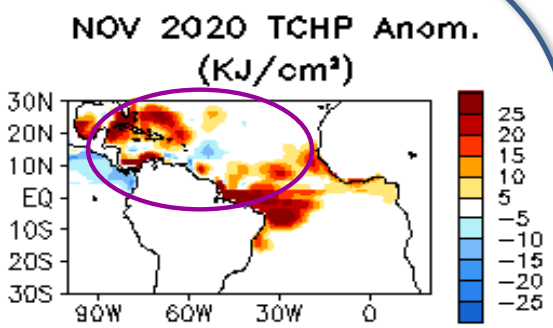
SST anomalies (top-left), anomaly tendency (top-right), OLR anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). 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.

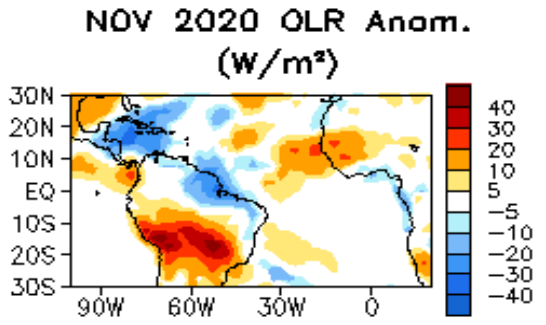
Tropical and North Atlantic Ocean

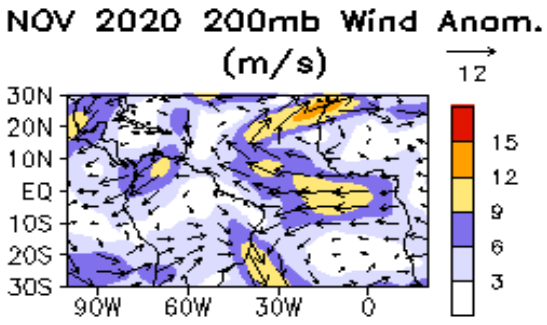
Tropical Atlantic: SST Anom., SST Anom. Tend., TCHP,OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Wind Anom.

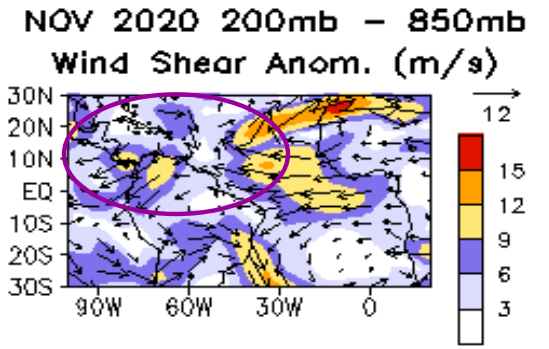


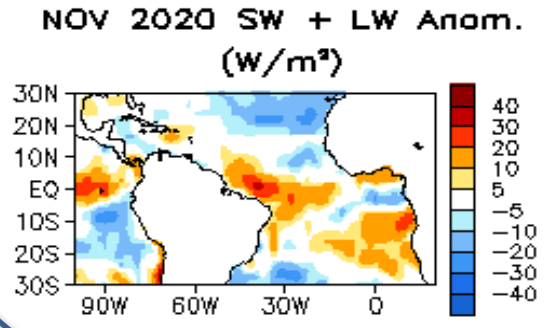


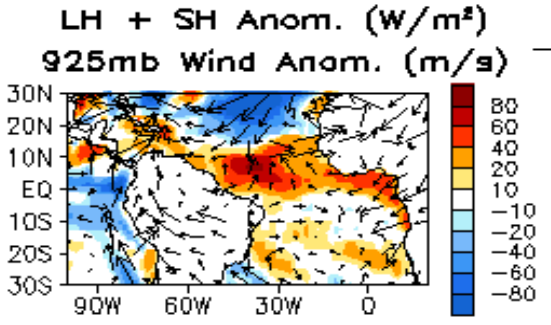


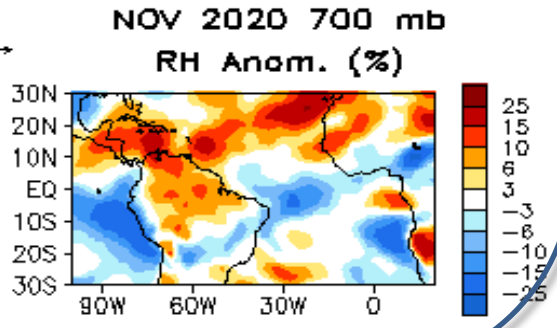




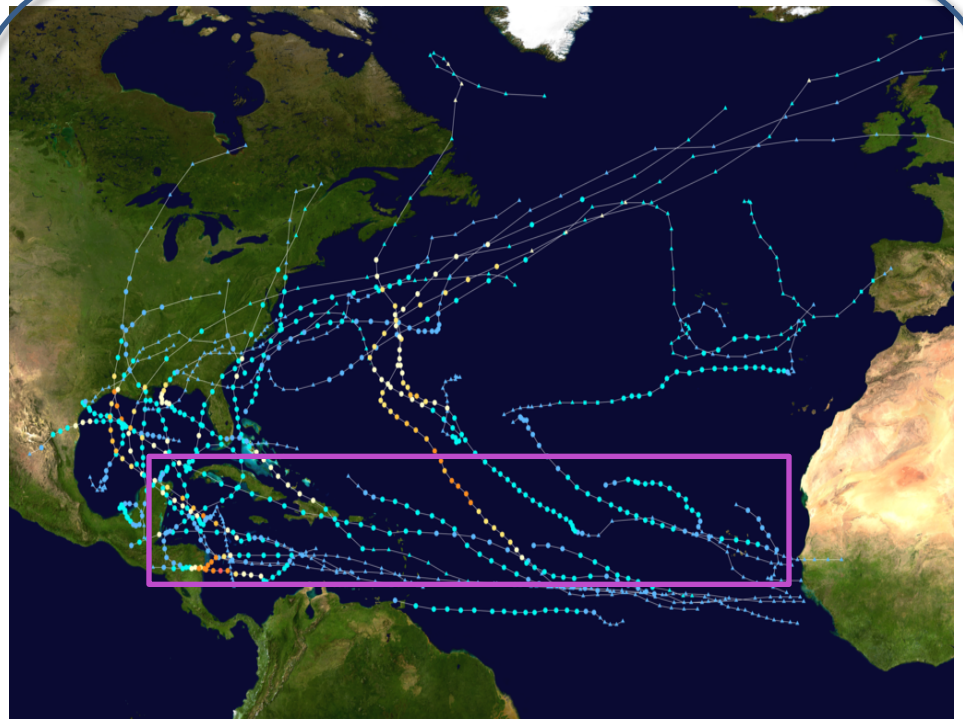








2020 Atlantic Hurricane Season Activities

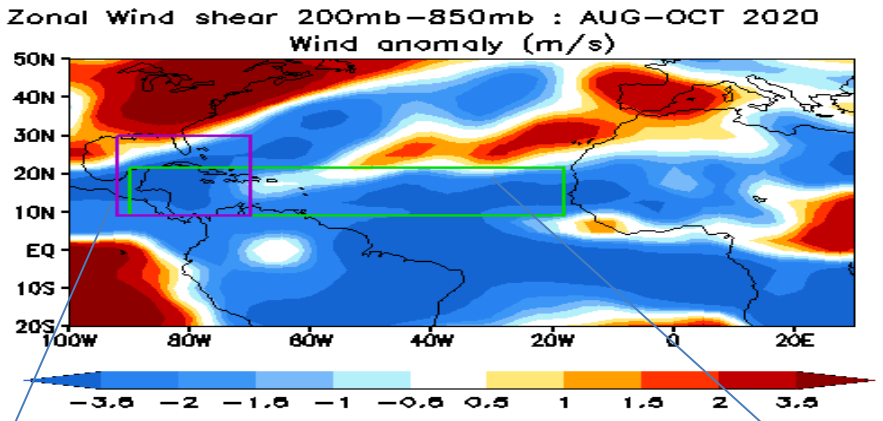


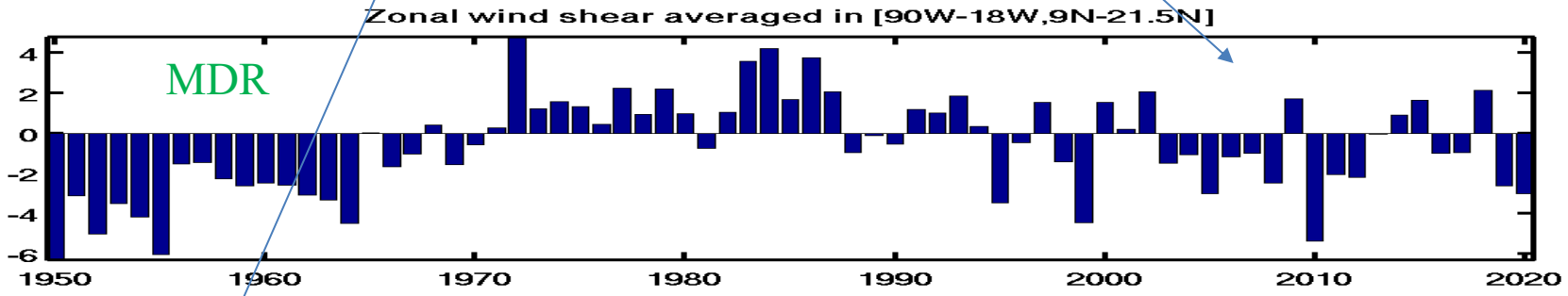
https://en.wikipedia.org/wiki/2020_Atlantic_hurricane_season

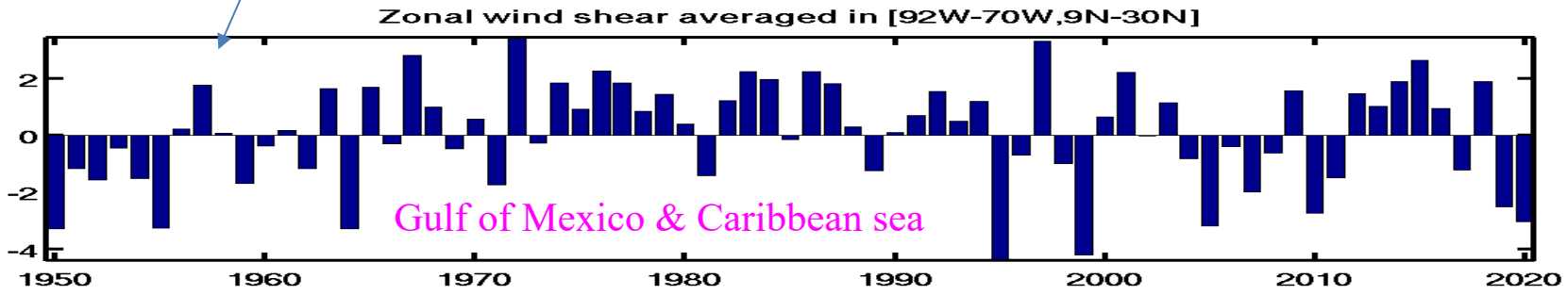
- 2020 Atlantic hurricane season was the most active season on record.
- Thirty tropical storms with thirteen developing into hurricane and six becoming major hurricane.
- 12 tropical storms made landfall over the contiguous United state, breaking the record of 1916.
- 12 out of 30 tropical storms were formed either in the Gulf of Mexico or in higher latitudes.

Atlantic	Observations (By Dec 9)	Outlook (Aug. 6) 85% above-normal	Outlook (May 21) 60% above-normal	(1981-2010)
Total storms	30	19-25	13-19	12
Hurricanes	12	7-11	6-10	6
Major hurricanes	6	3-6	3-6	3

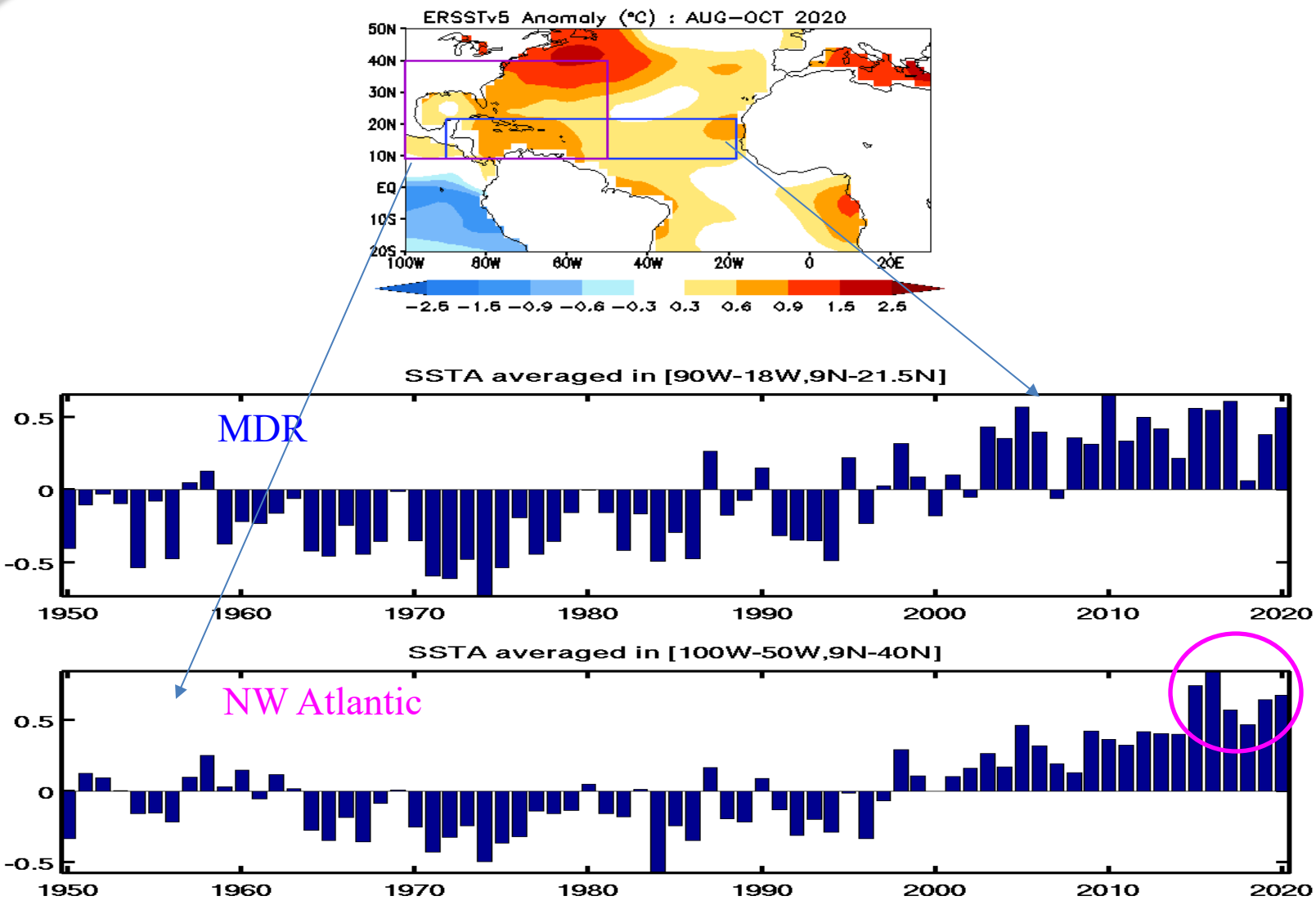
August-October zonal wind shear anomaly in the North Atlantic



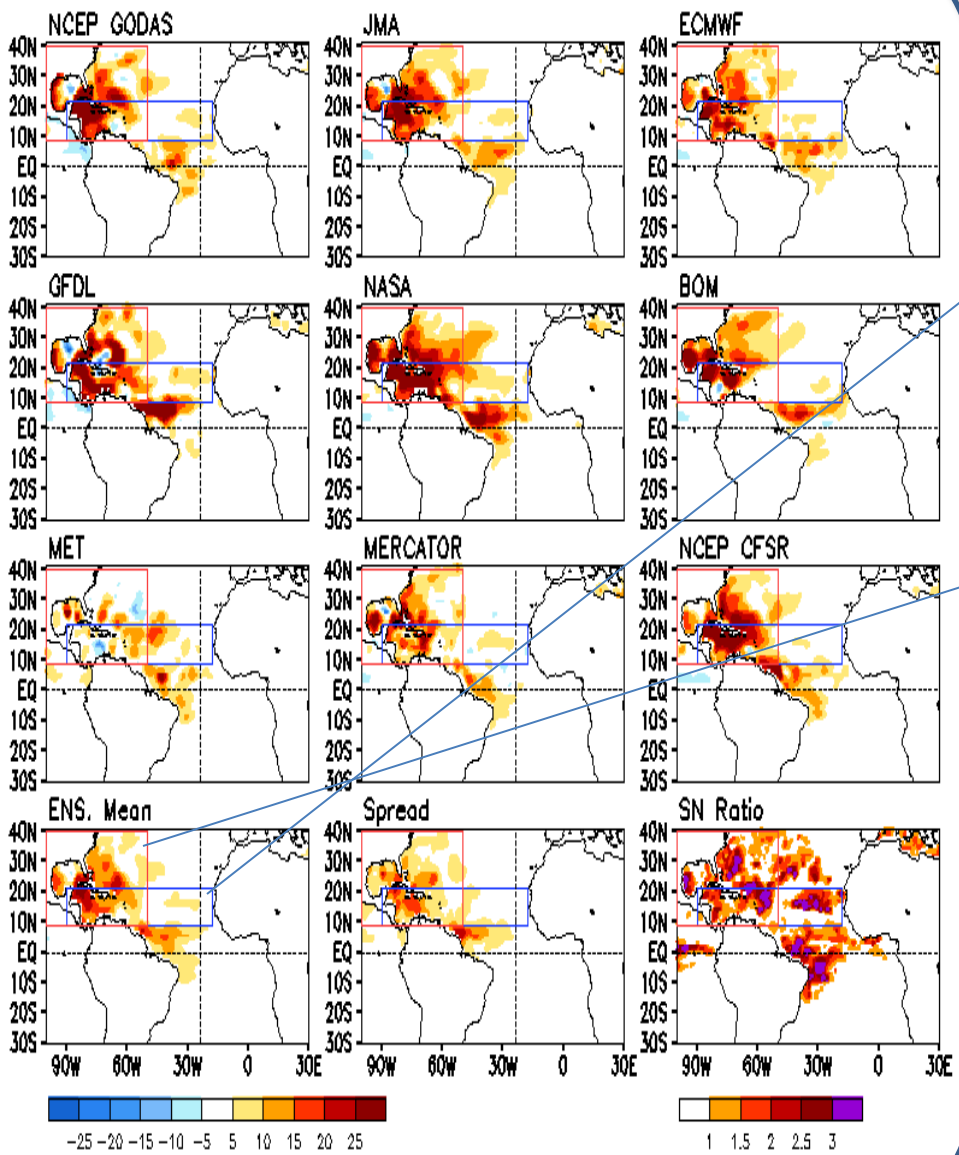


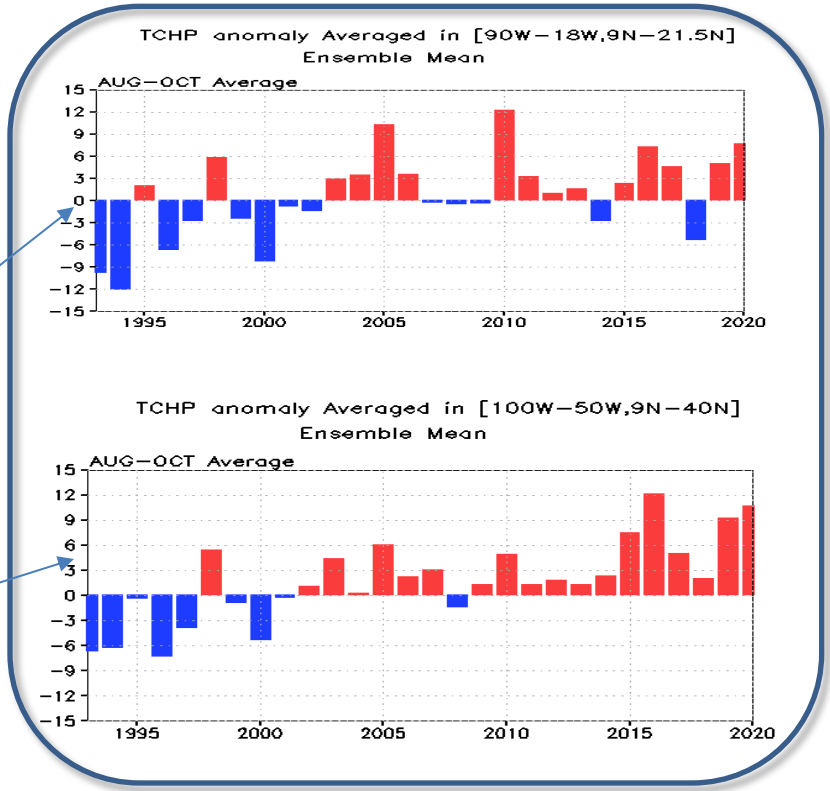


August-October SST anomaly in the North Atlantic



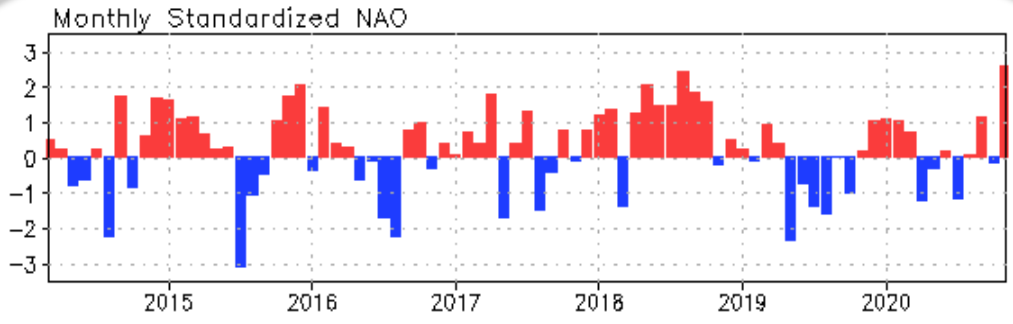
Real-Time Ocean Reanalysis Intercomparison :Tropical Cyclone Heat Potential Anomaly

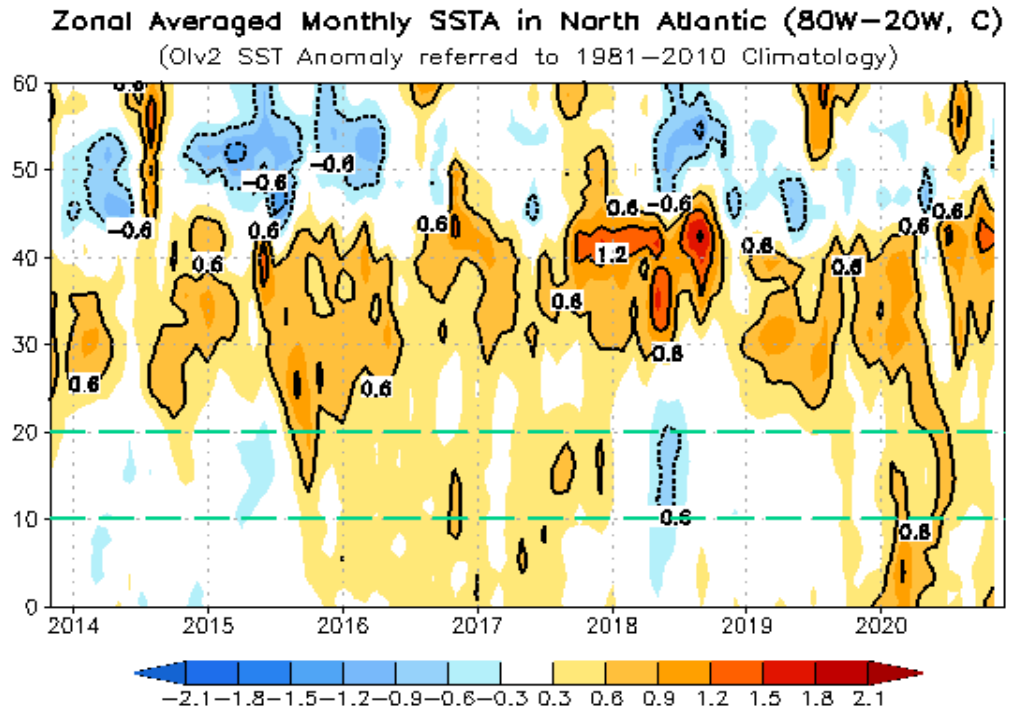


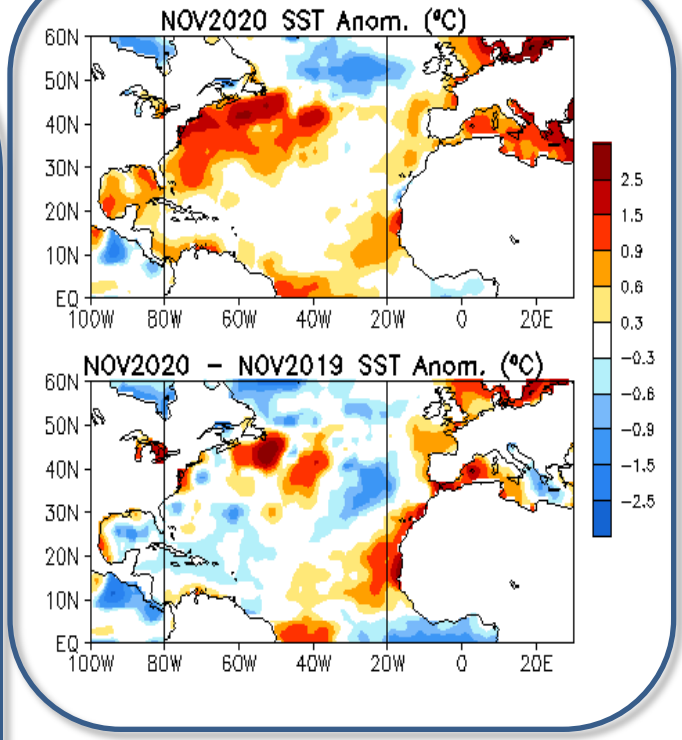


-2020 TCHP anomaly (ASO) averaged in Gulf of Mexico and western North Atlantic region ranked the second largest since 1993.

NAO and SST Anomaly in North Atlantic







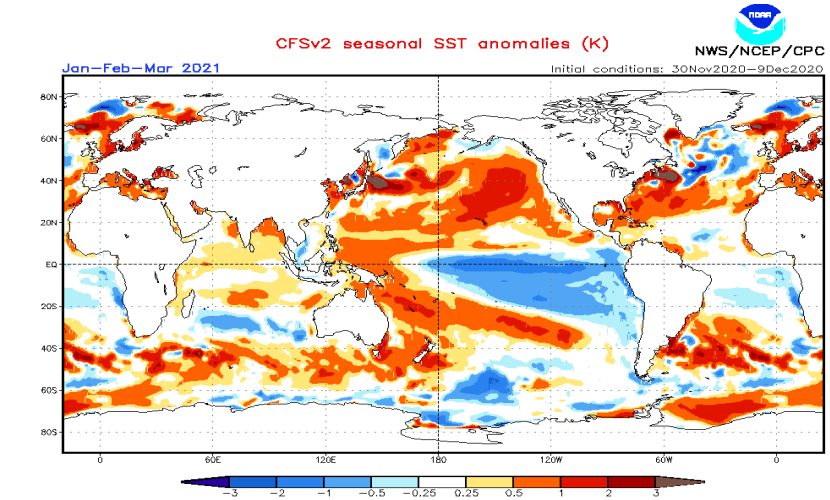
- NAO switched to a strong positive phase in Nov 2020 with NAOI= 2.54.

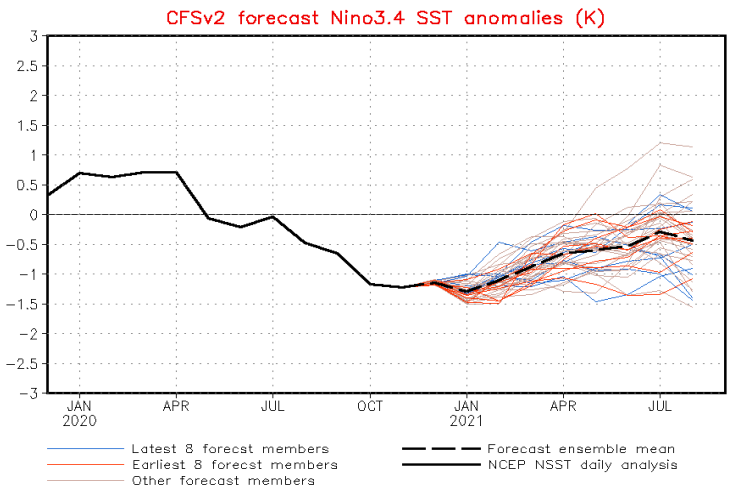
Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20°N-90°N (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80ºW and 20ºW (bottom). SST are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

ENSO and Global SST Predictions

CFSv2 and NMME SST predictions

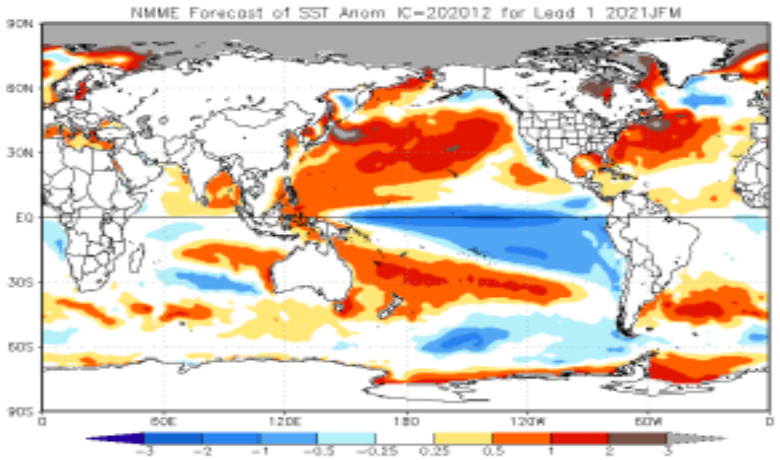
CFSv2 IC:Dec for 2020 JFM

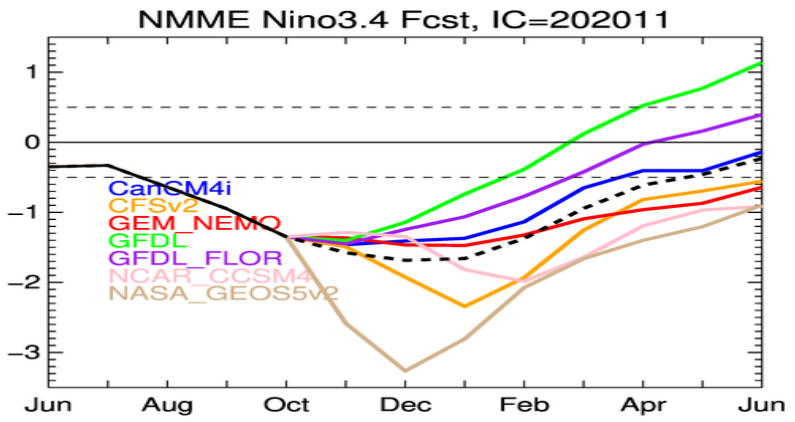




https://www.cpc.ncep.noaa.gov/products/CFSv2/CFSv2seasonal.shtml

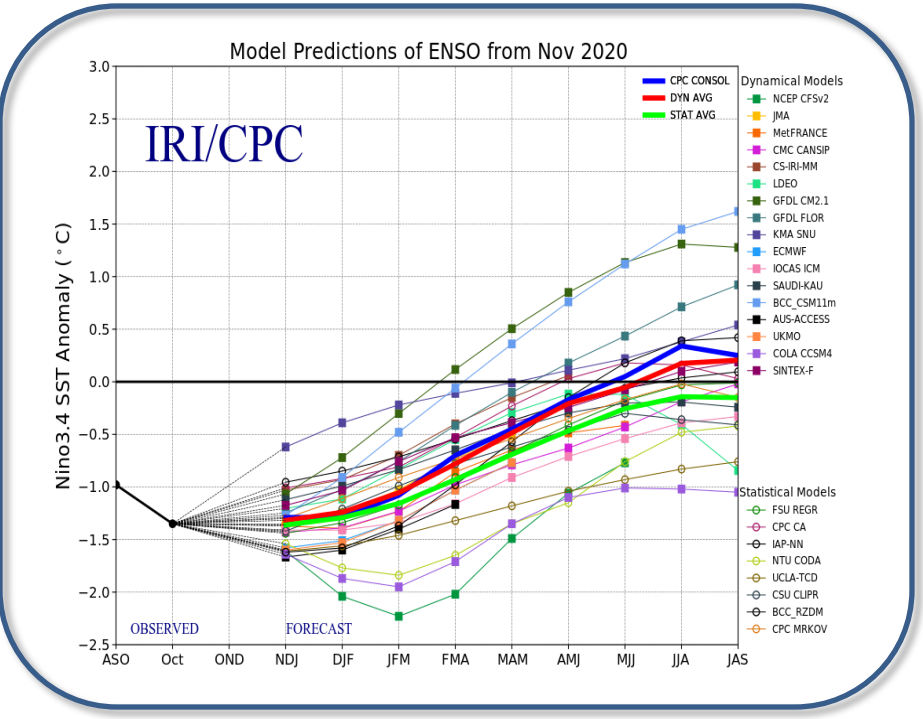
NMME IC:Dec for 2020 JFM



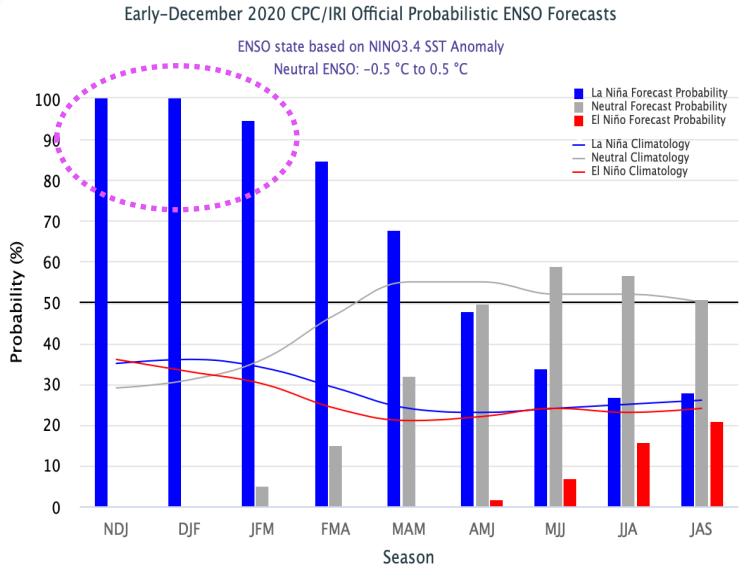


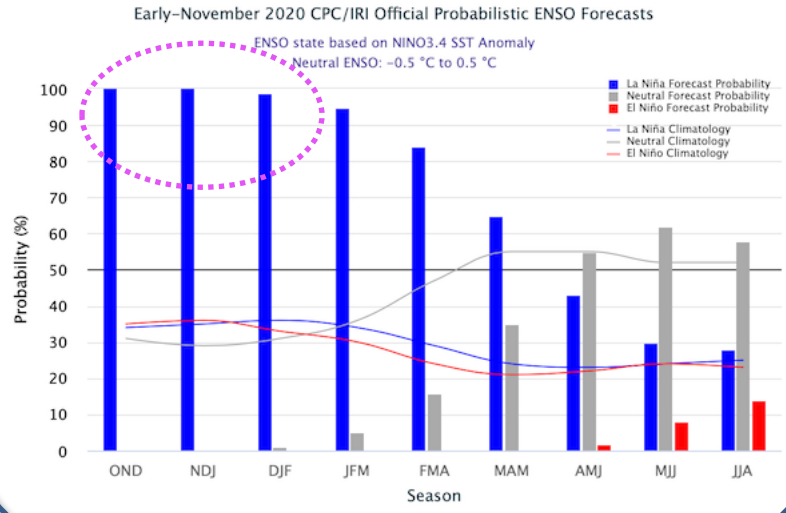
(https://www.cpc.ncep.noaa.gov/products/NMME/)

NOAA “ENSO Diagnostics Discussion ”:



- A Majority of the models predict the continuation of La Niña through the JFM 2021.
- NOAA “ENSO Diagnostics Discussion” on 10 Dec stated that “La Niña is likely to continue through the Northern Hemisphere winter 2020-21(~95% chance during January-March), with a potential transition during the spring 2021 (~50% chance of neutral during April-June)”.





New Probability Outlook for ENSO Strength!

(Courtesy of Michelle L' Heureux)

HOME> Climate & Weather Linkage> El Nino Southern Oscillation

ENSO Strengths

This table shows the forecast probability (%) of Niño-3.4 index exceeding a certain threshold (in degrees Celsius).
For negative thresholds, the table shows the probability (%) of a Niño-3.4 index value that is less than (more negative) that value.
For positive thresholds, the table shows the probability (%) of a Niño-3.4 index value that is greater than (more positive) that value.
This tool supports the official ENSO Diagnostic discussion updated on the 2nd Thursday of each month.

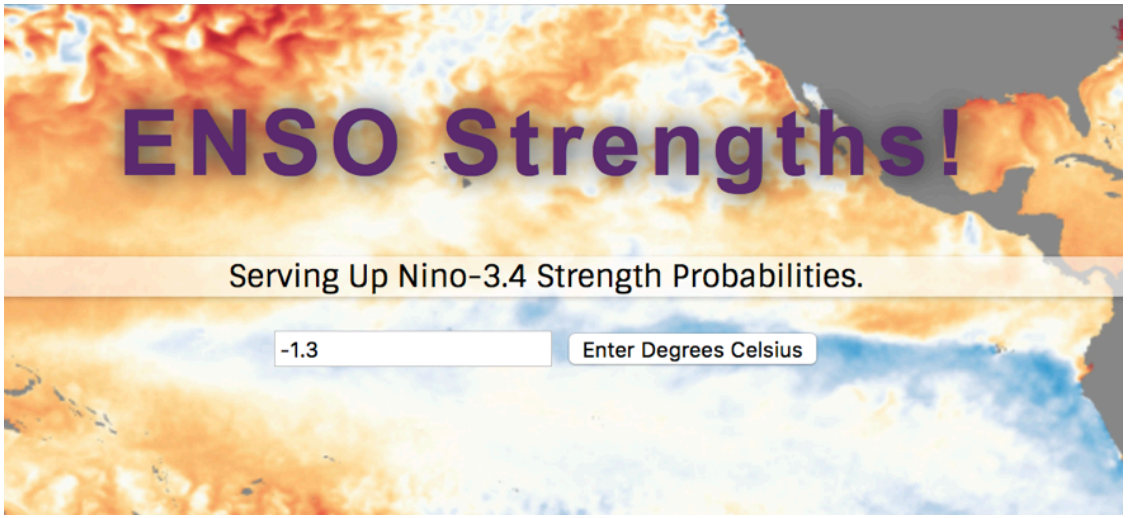
Target	< -1.5°C	< -1.0°C	< -0.5°C	> 0.5°C	> 1.0°C	> 1.5°C
NDJ	24	99	~100	~0	~0	~0
DJF	18	80	~100	~0	~0	~0
JFM	10	58	95	~0	~0	~0
FMA	4	36	85	~0	~0	~0
MAM	1	18	68	~0	~0	~0
AMJ	1	11	48	2	~0	~0
MJJ	1	7	34	7	1	~0
JJA	1	7	27	16	3	~0
JAS	2	9	28	21	6	1
	< -1.5°C	< -1.0°C	< -0.5°C	> 0.5°C	> 1.0°C	> 1.5°C

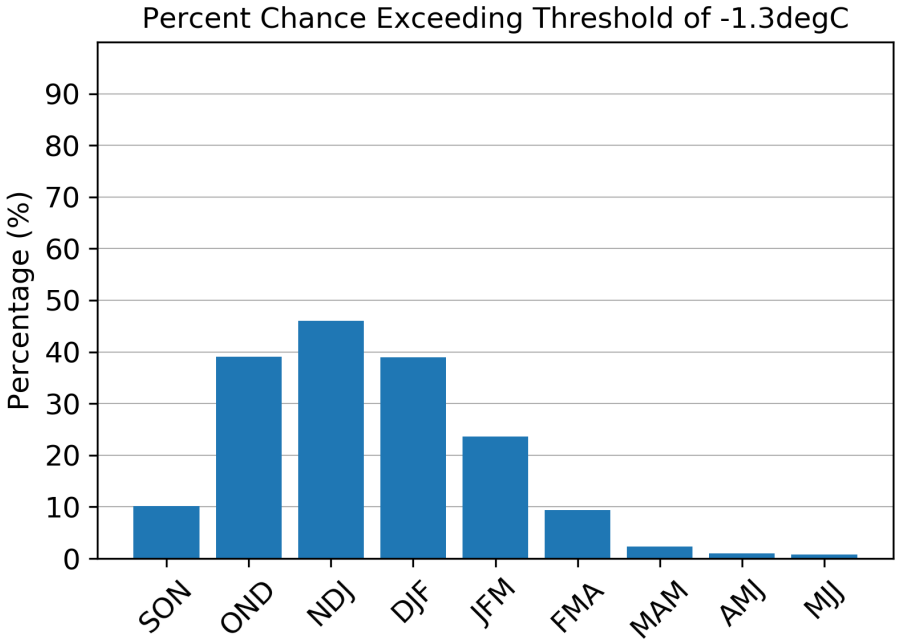
More info here:
https://www.climate.gov/news-features/blogs/enso/enso-forecast-mash-ups-what's-best-way-combine-human-expertise-models

For example, for the December-February season, there is a 18% chance of Niño-3.4 index less than -1.5°C (stronger event).

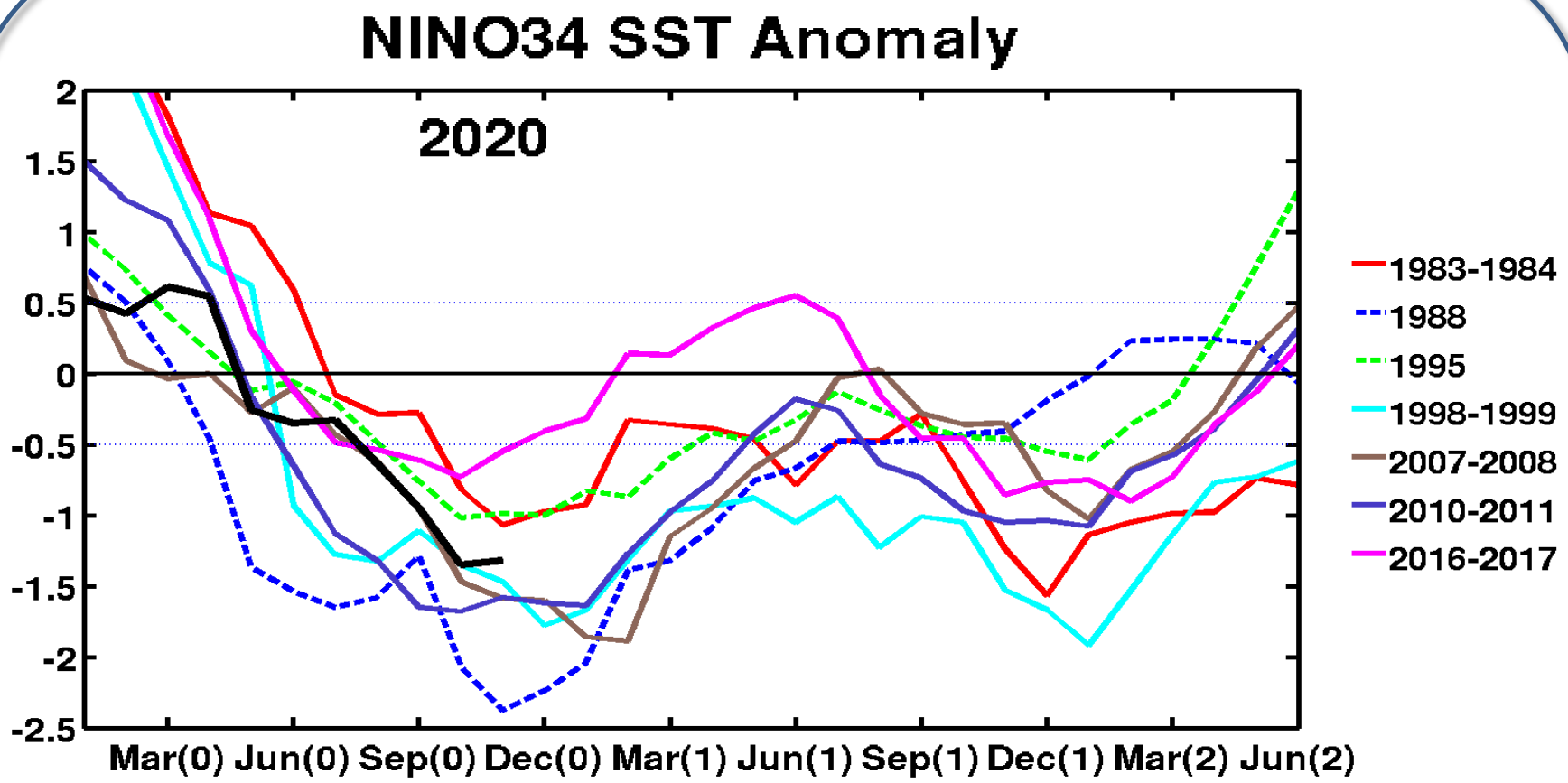
https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/strengths/index.php

We want to eventually roll out an interactive tool where user can decide on any cut-off value for ENSO amplitude and get the corresponding probability.





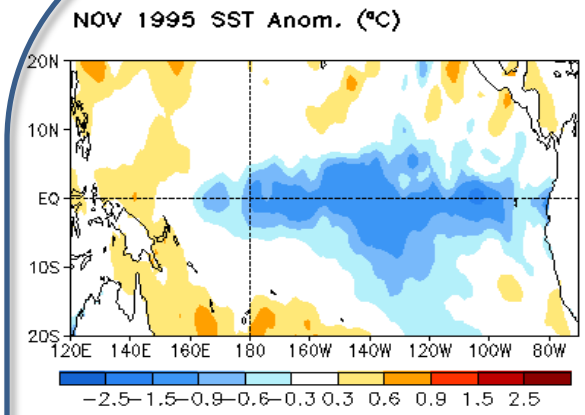
NINO Indices Evolution in La Niña Years

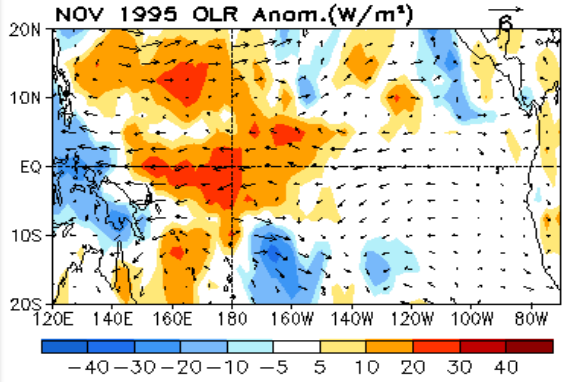


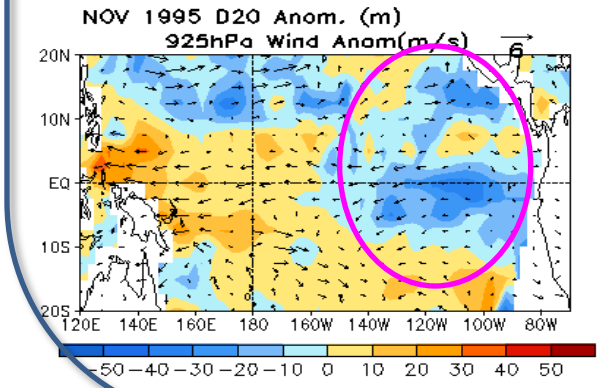
Weak La Niña (-0.5°C~-0.9°C): 1983,1995 2008,2016,2017
Moderate (-1°C~1.4°C): 1984,2011,
Strong (-1.5°C~1.9°C): 1988,1998,2007 2010

Current La Niña Condition Compared with 1995, 2007 La Niñas

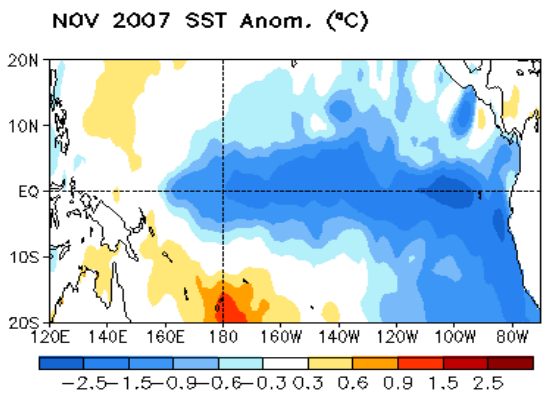
1995

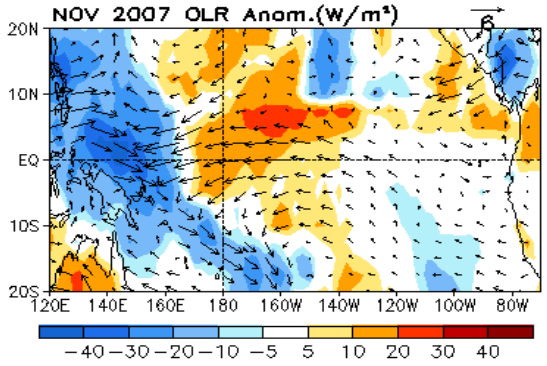


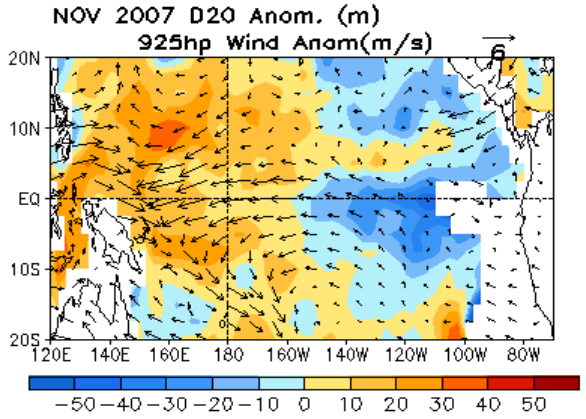




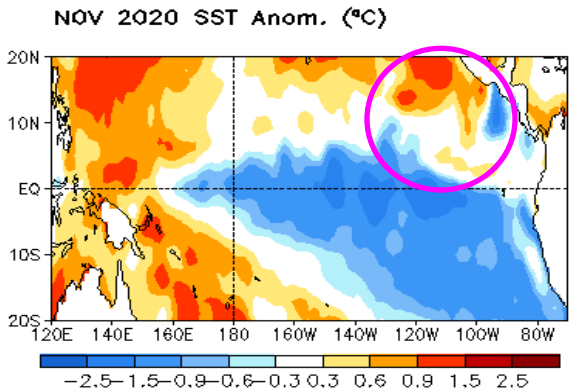
2007

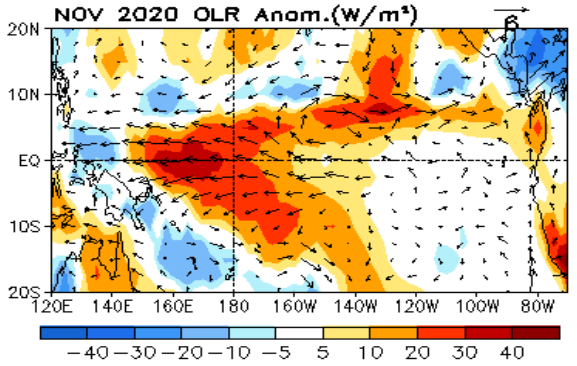


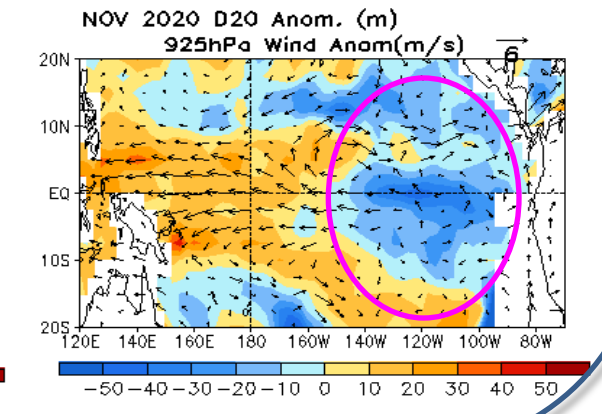




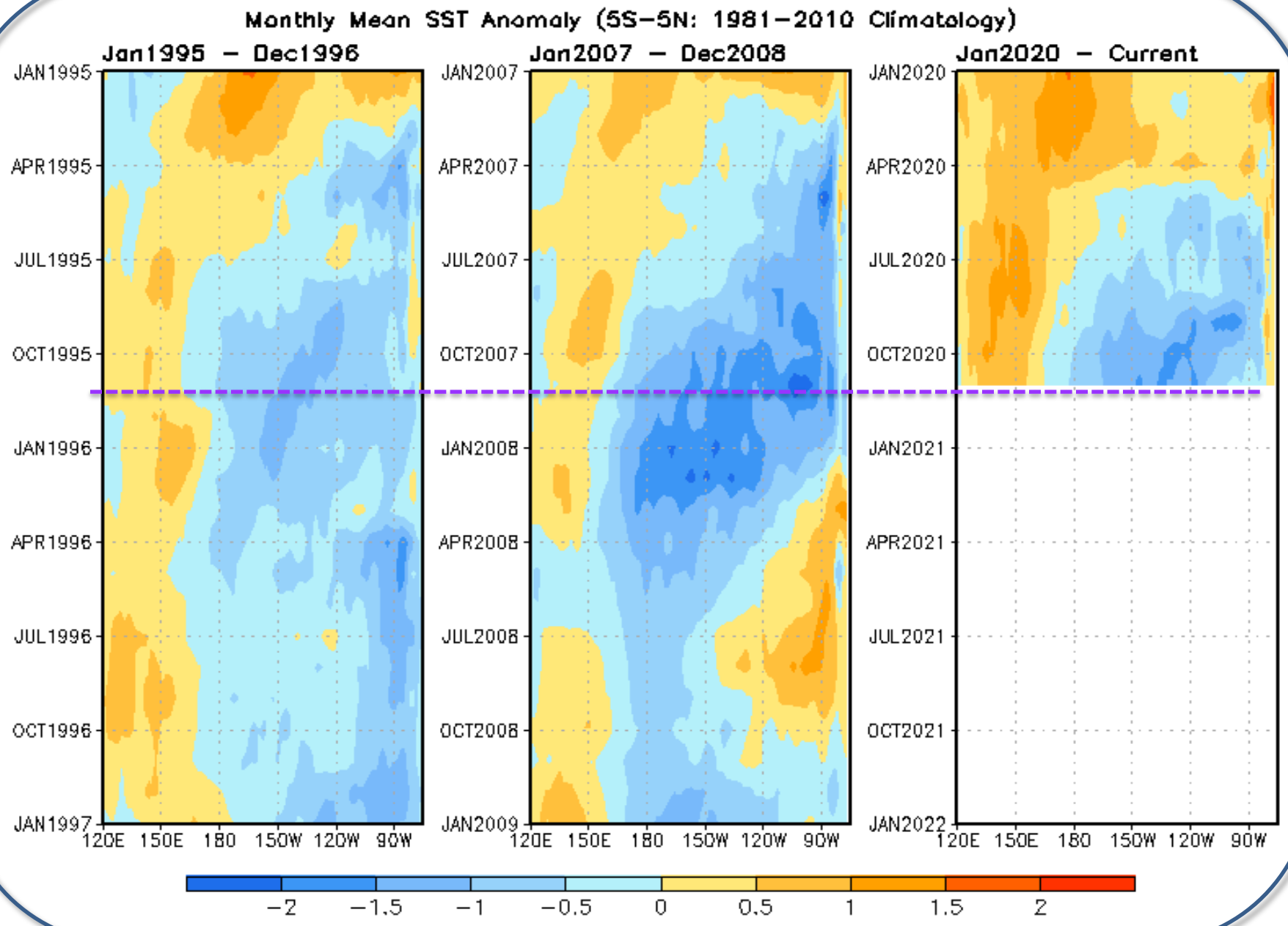
2020



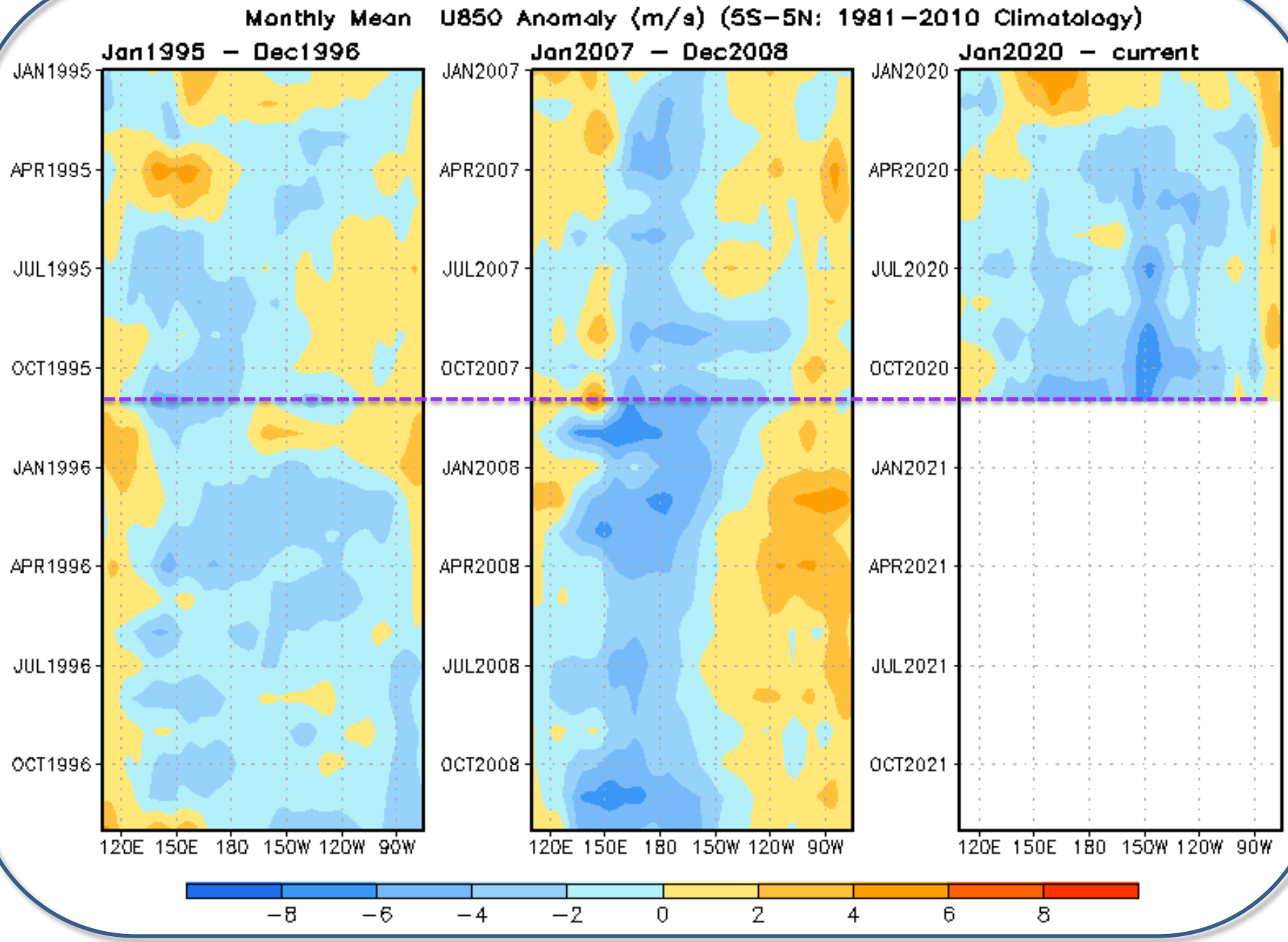




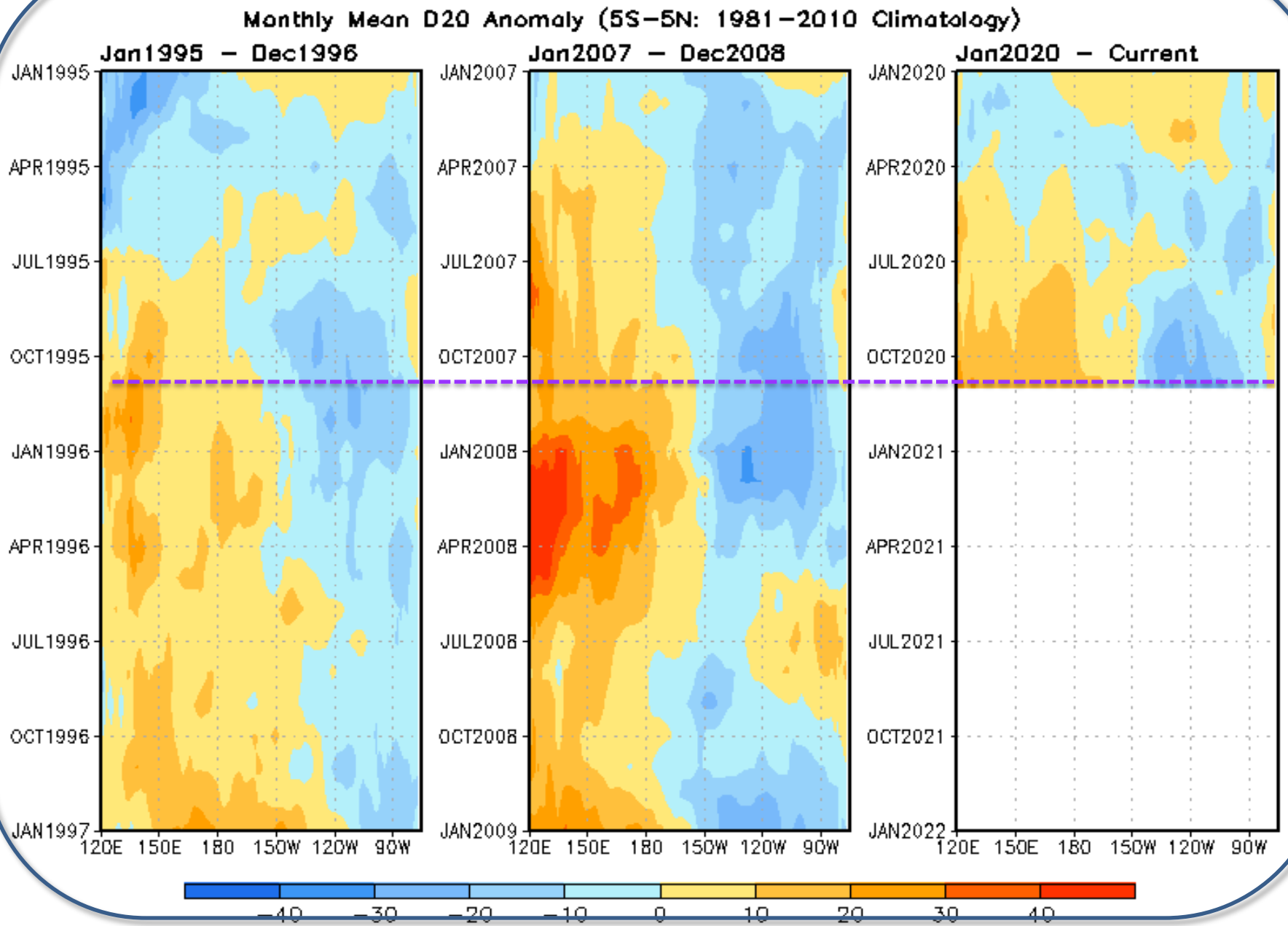
2020 SST anomalies Compared with 1995, 2007 La Niñas



2020 U850-mb anomalies Compared with 1995, 2007 La Niñas



2020 D20 anomalies Compared with 1995, 2007 La Niñas



Acknowledgements

- Drs. Arun Kumar ,Zeng-Zhen Hu, and Jieshun Zhu : reviewed PPT, and provide insightful suggestions and comments
- Drs. Li Ren and Pingping Xie provided the BASS/CMORPH/CFSR EVAP package
- Dr. Michelle L′ Heureux provided the CPC new tool for Probabilities ENSO Strength

Please send your comments and suggestions to:

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Jieshun.Zhu@noaa.gov

Data Sources (climatology is for 1981-2010)

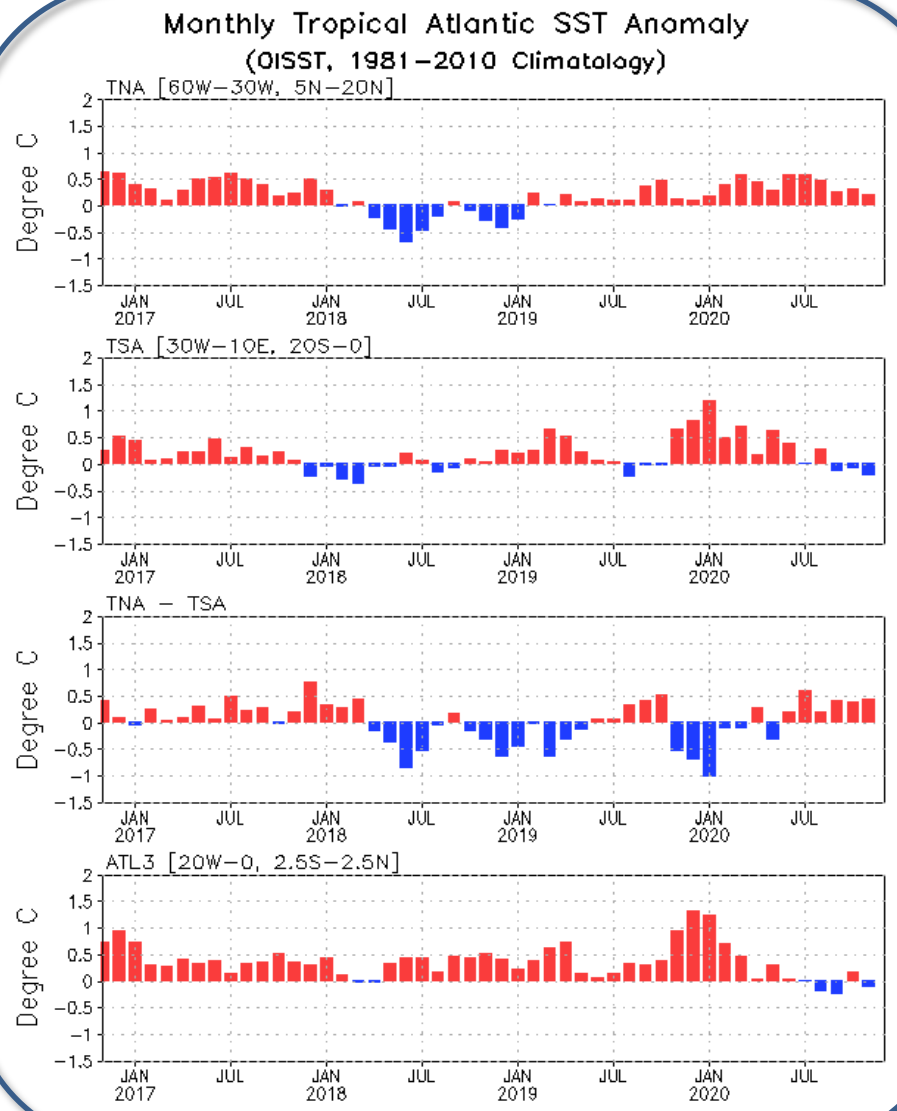
- Weekly Optimal Interpolation SST (OI SST) version 2 (Reynolds et al. 2002)
- Extended Reconstructed SST (ERSST) v5 (Huang et al. 2017)
- Blended Analysis of Surface Salinity (BASS) (Xie et al. 2014)
- CMORPH precipitation (Xie et al. 2017)
- CFSR evaporation adjusted to OAFlux (Xie and Ren 2018)
- 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

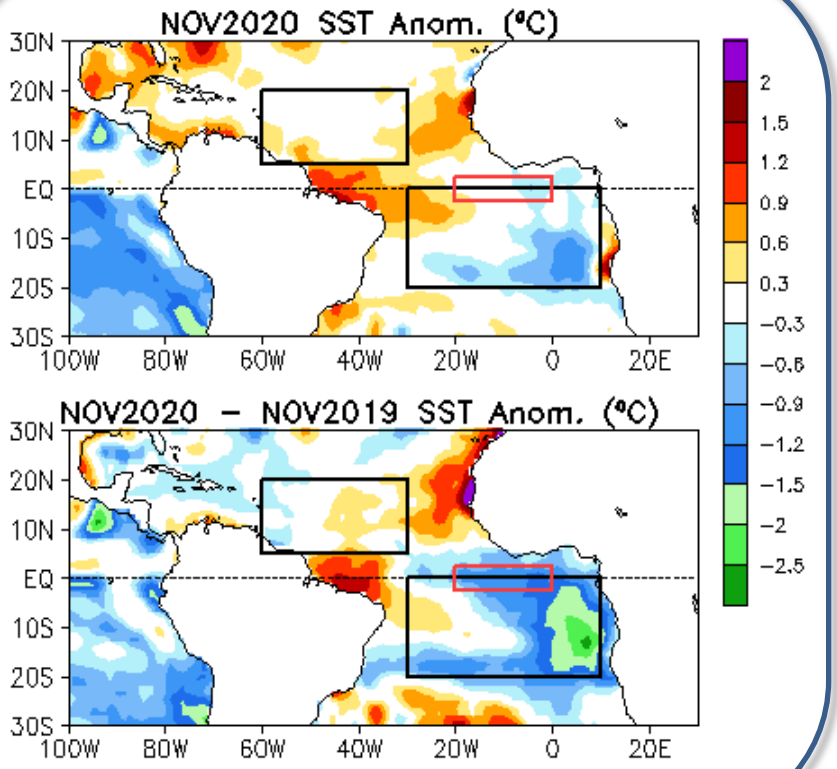
  http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html

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

Backup Slides

Evolution of Tropical Atlantic SST Indices

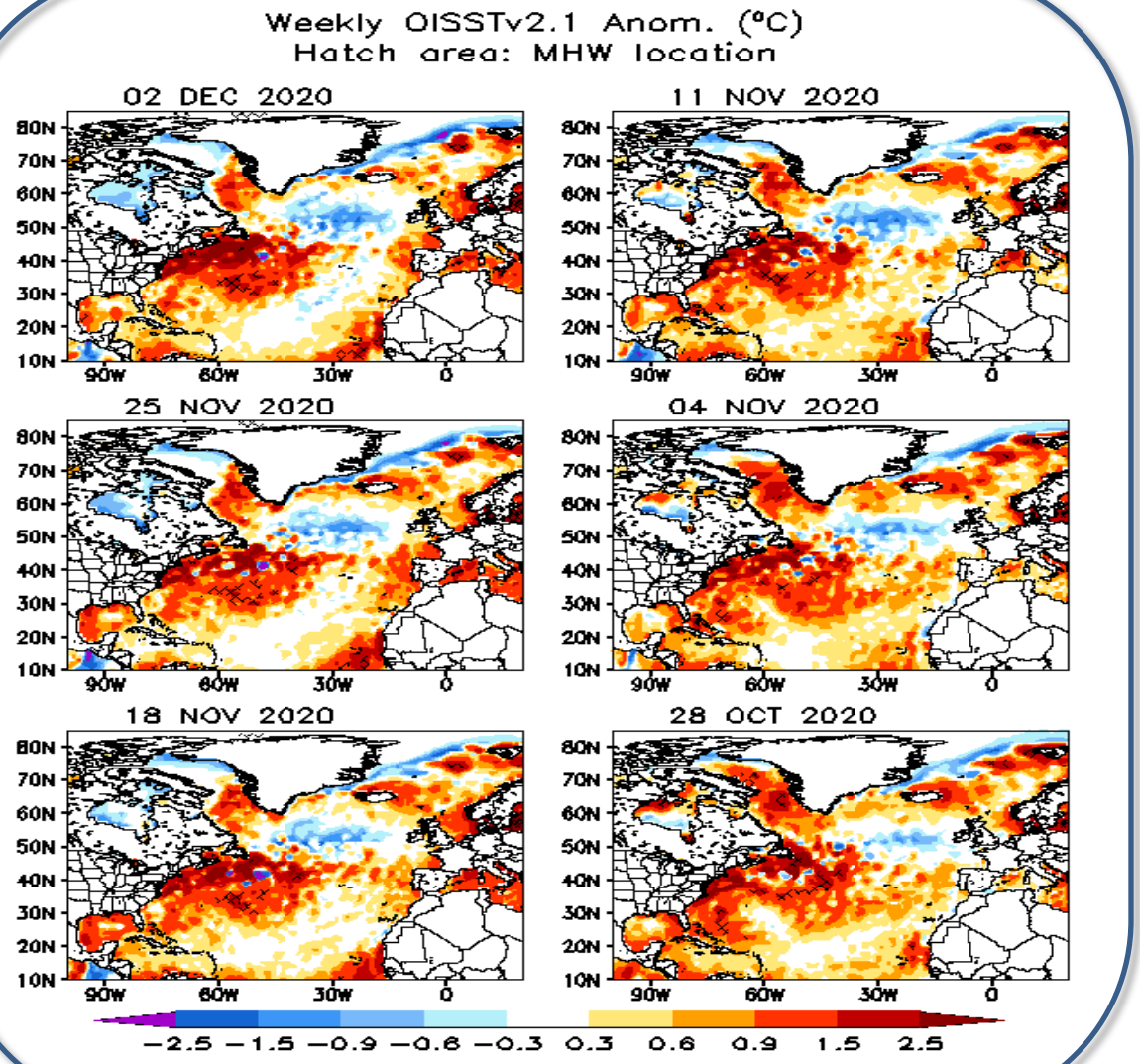




-The index representing the Atlantic Meridional mode enhanced slightly in Nov 2020.

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

Weekly SST anomaly and MHWs in the North Atlantic



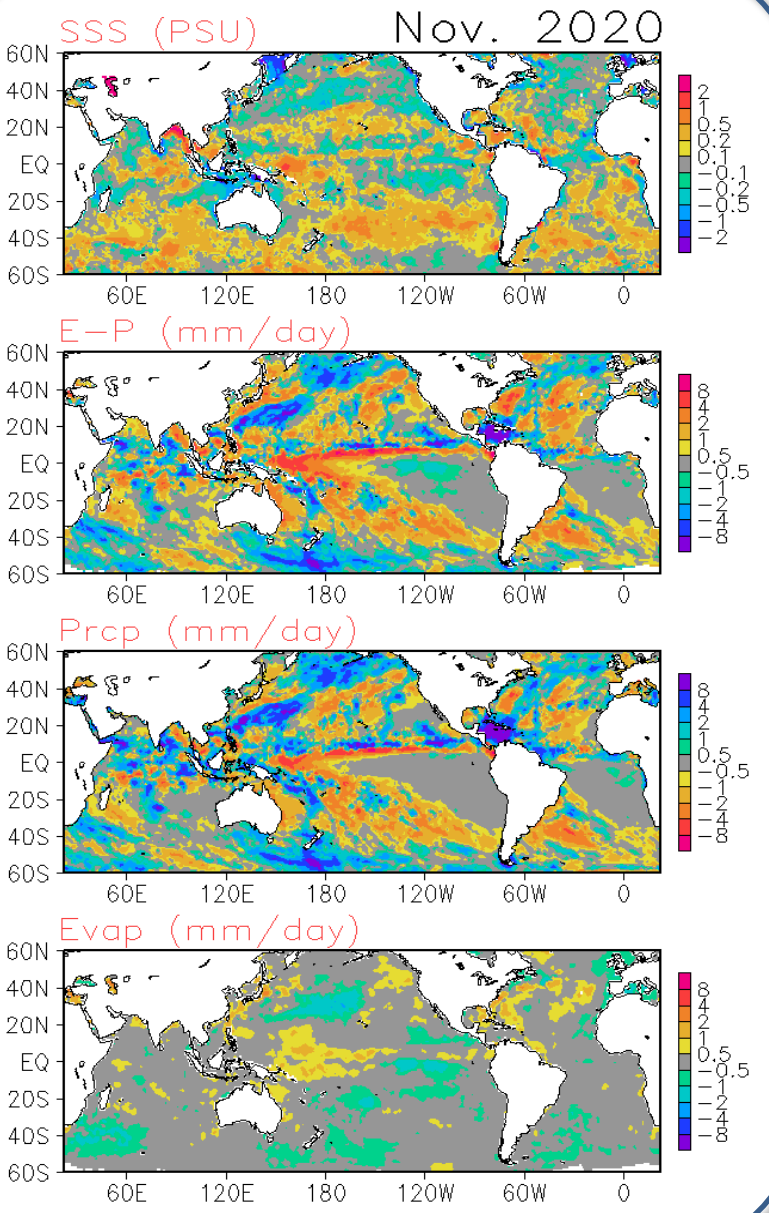
- MHWs near the Gulf of stream and the Baffin Bay retreated since the late September.
-

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.

Global Sea Surface Salinity (SSS): Anomaly for November 2020

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

Positive SSS anomaly continues along/nearby the equator in Pacific Ocean, which is likely caused by the reduced precipitation in the ITCZ region. Positive SSS anomaly continues in the subtropics of N. Pacific Ocean. Negative SSS anomaly along the storm track in the subarctic of N. Pacific Ocean is possibly due to increased precipitation. Negative SSS anomaly appears along the equator of Atlantic Ocean and is likely due to the oceanic advection/entrainment. Positive SSS anomaly in the Bay of Bengal continues with reduced precipitation appearing in this area.



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