2019 Annual Ocean Review

Prepared by
Climate Prediction Center, NCEP/NOAA

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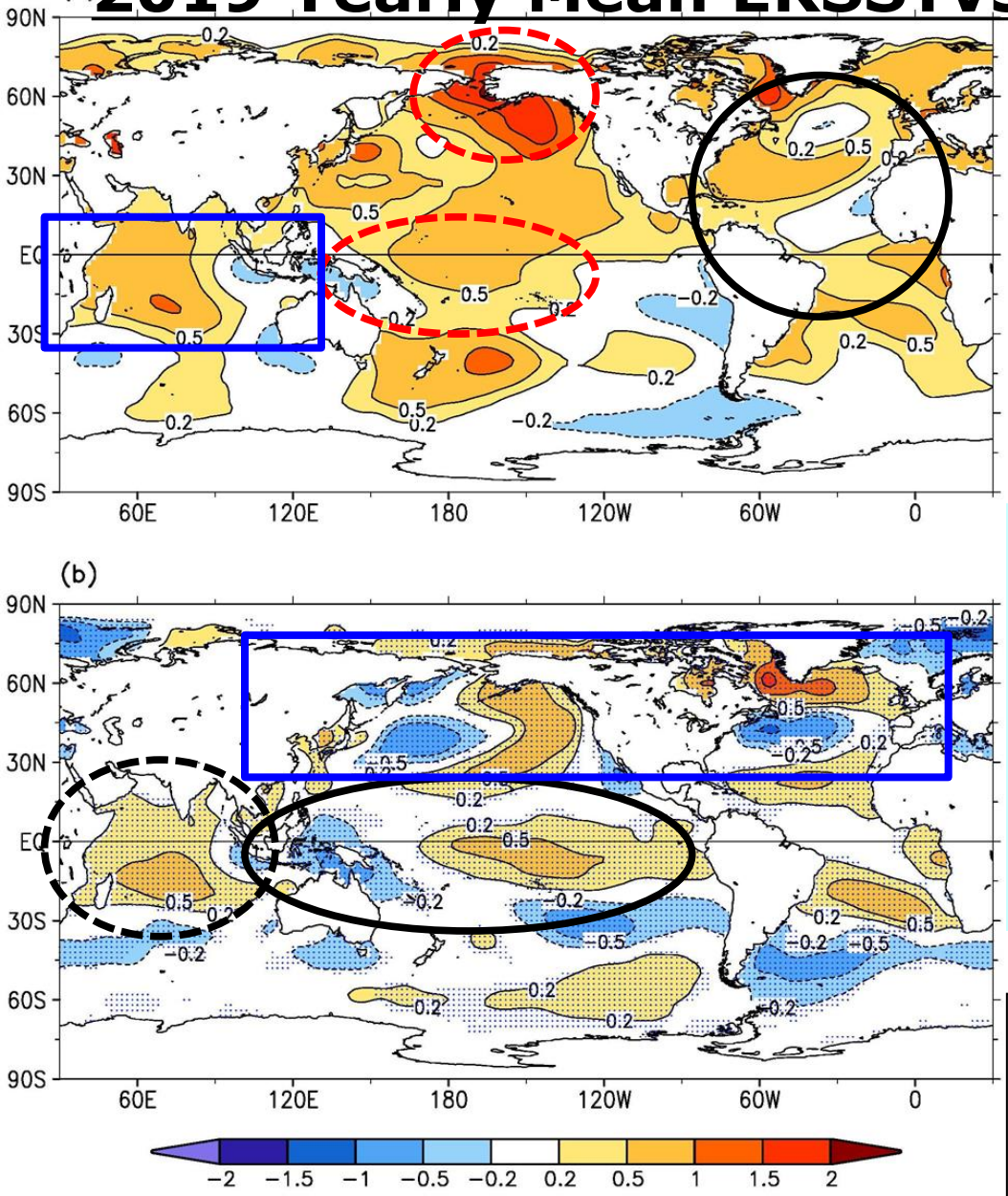
http://www.cpc.ncep.noaa.gov/products/GODAS/

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

Outline

- **Annual Ocean Review for 2019**
- **Highlights in January 2020**
  - **Pacific/Arctic Ocean**
  - **Indian Ocean**
  - **Atlantic Ocean**
- **Global SST Predictions**

2019 Yearly Mean ERSSTv5 SSTA & Tendency



- **Positive SSTA dominated in the global ocean, particularly in NH.**
- **The profound warmings are in the sub-polar area of N. Pacific, the middle latitudes and sub-polar region of N. Atlantic, & the western tropical Indian Ocean.**

- **Negative SSTA presented in limited regions, including the SE tropical Pacific, high-latitudes of N. Atlantic, the eastern Indian Ocean-the marine-time continent, and high-latitudes of Eastern S. Ocean.**

- **Compared with 2018, positive (negative) differences are in the central and eastern (western) tropical Pacific, associated with evolution from La Nina in 2018 to El Nino in 2019.**
- **There was a horse-shoe-like pattern in both N. Pacific and N. Atlantic, associated with more and stronger positive phase of PDO & NAO in 2019, respectively.**
- **IOD positive phase –like pattern presented in the differences over the Indian Ocean, associated with the extreme positive phase of IOD in 2019.**

Fig. 3.1. (a) Annually averaged SSTAs in 2019, and (b) Difference of annually averaged SSTAs between 2019 and 2018. SSTAs (° C) are relative to 1981–2010 climatology. The SSTAs and their differences are assessed using 1000-member ERSSTv5 ensemble, and the SST difference is significant at 95% level in stippled area in (b).

Global SST Section in the BAMS State of the Climate in 2019 by Huang et al.

Seasonal Mean ERSSTv5 SSTA in 2019

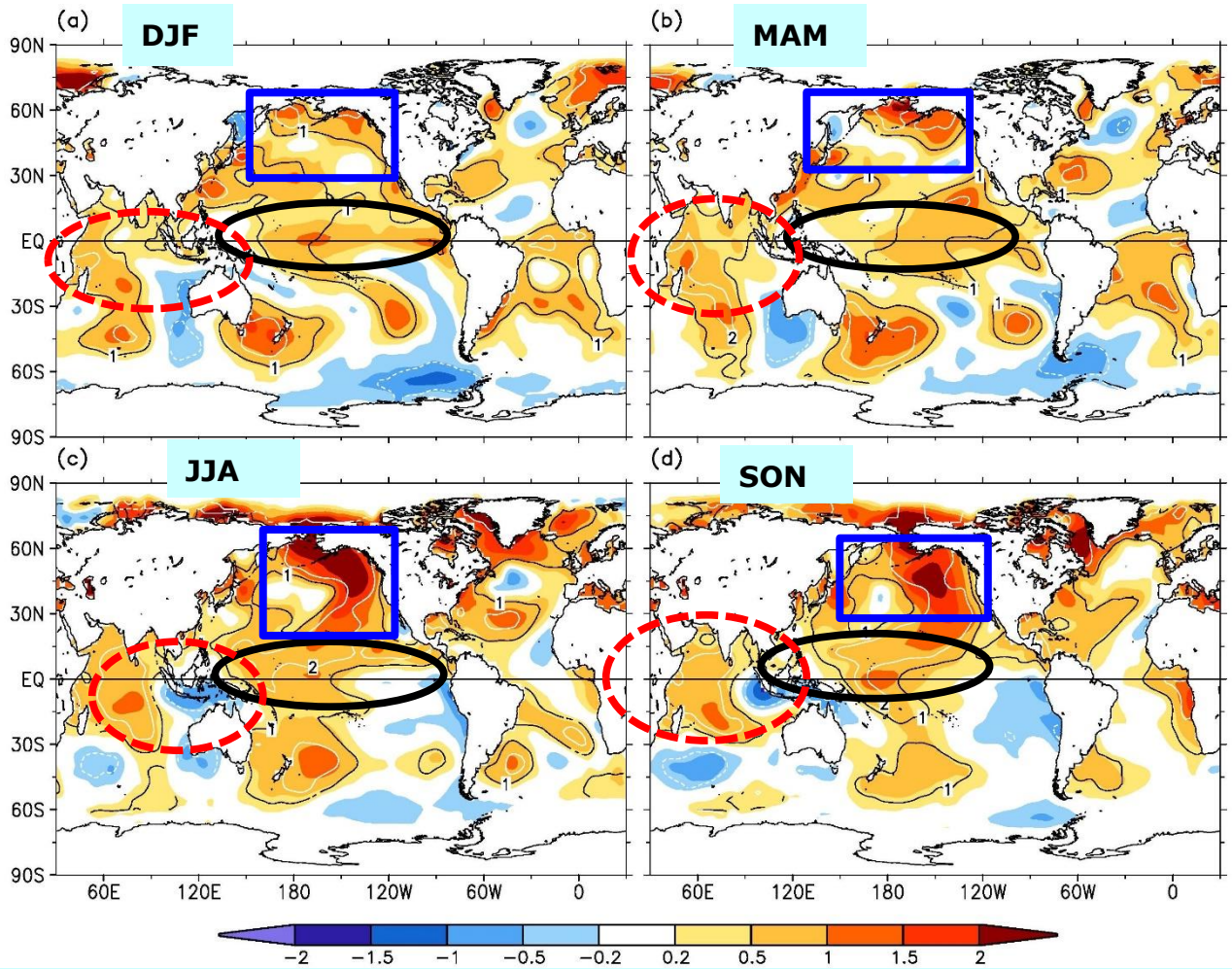


Fig 3.2. Seasonal averaged SSTAs of ERSSTv5 (°C; shading) for (a) Dec 2018 to Feb 2019, (b) Mar to May 2019, (c) Jun to Aug 2019, and (d) Sep to Nov 2019. The normalized seasonal mean SSTA based on seasonal mean standard deviation (STD, 1σ) over 1981-2010 are indicated by contours of -1 (dashed white), 1 (solid black), and 2 (solid white).

Global SST Section in the BAMS State of the Climate in 2019 by Huang et al.

- Winter 2018/19: A moderate positive SSTA presented in eq. Pacific associated with the El Nino of 2018/19, with positive SSTA exceeding +1 STD in the central tropical Pacific and mid-latitudes of N. Pacific. Positive SSTA exceeding +1 STD dominated in the western Indian, NW & S. Atlantic, and Southwestern S. Pacific Oceans.

- Spring/summer2019: Overall SSTA patterns are similar to winter 2018/19. The positive SSTA in NE Pacific (Blob.2) strengthened with amplitude larger than 3 STDs. Positive phase of IOD also strengthened.

- Fall 2019: Overall similar SSTA patterns persisted. Positive phase of IOD also strengthened with positive SSTA larger than 3 STDs in the west. A Benguela Nino emerged (Florenchie, P., J. R. E. Lutjeharms, and C. J. C. Reason, 2003: The source of Benguela Ninos in the South Atlantic Ocean. GRL, 30, NO. 10, 1505, doi:10.1029/2003GL017172).

Yearly Mean SSTA Indices

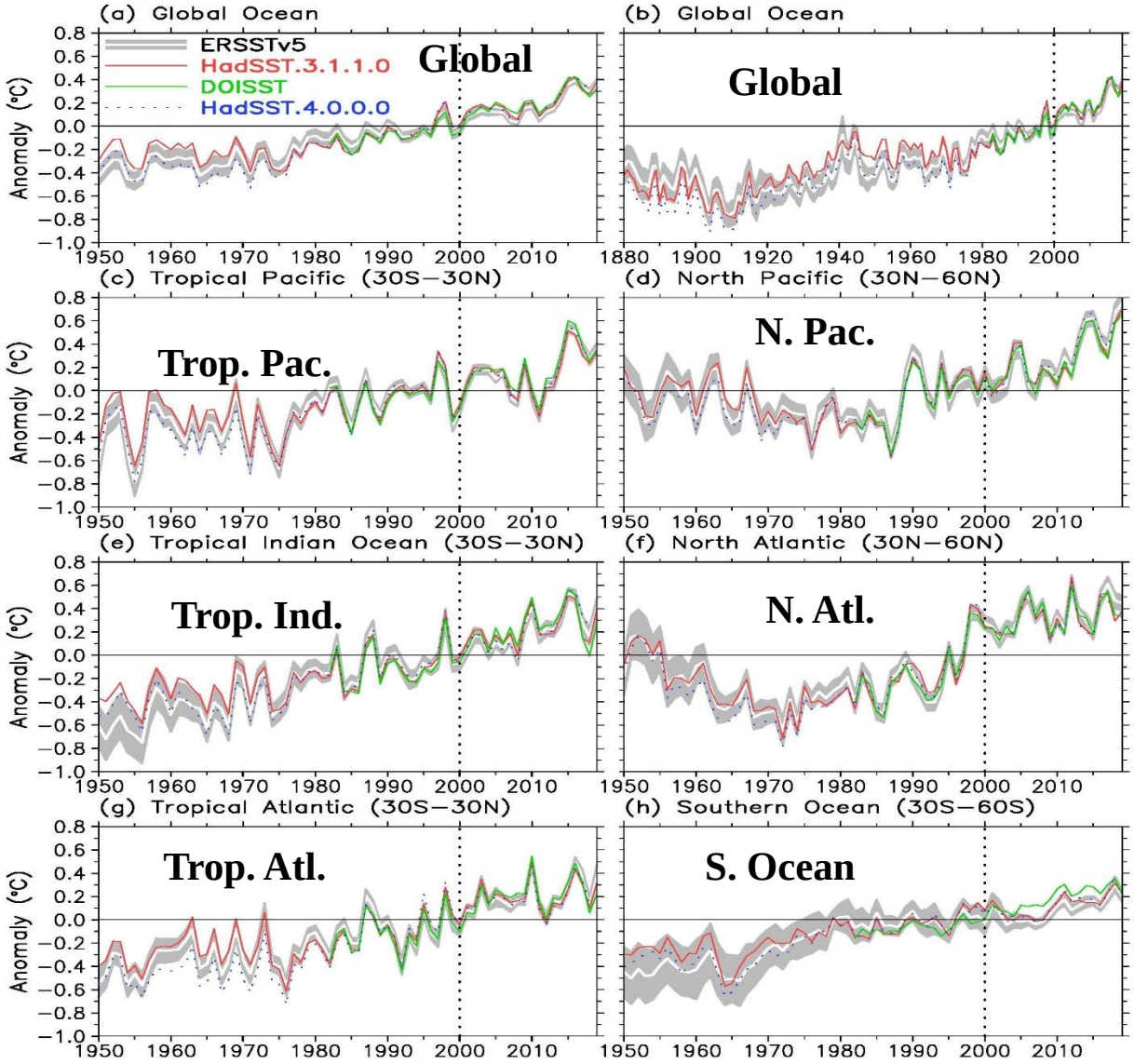


Fig 3.3. Annually averaged SSTAs of ERSSTv5 (solid white) and 2σ STD (grey shading) of ERSSTv5, SSTAs of DOISST (solid green), and SSTAs of HadSST.3.1.1.0 (solid red) and HadSST.4.0.0.0 (dotted blue) in 1950–2019 except for (b). (a) Global, (b) Global in 1880–2019, (c) Tropical Pacific, (d) Tropical Indian Ocean, (e) Tropical Atlantic, (f) North Pacific, (g) North Atlantic, and (h) Southern Oceans. The year 2000 is indicated by a vertical black dotted line.

Global SST Section in the BAMS State of the Climate in 2019 by Huang et al.

- **Averaged over the global oceans, ERSSTv5 analysis shows that SSTAs increased from 0.33C in 2018 to 0.41C in 2019 associated with transition from La Nina of 2017/18 to El Nino of 2018/19.**
- **2019 was the 2nd warmest year after 2016 (0.44C).**

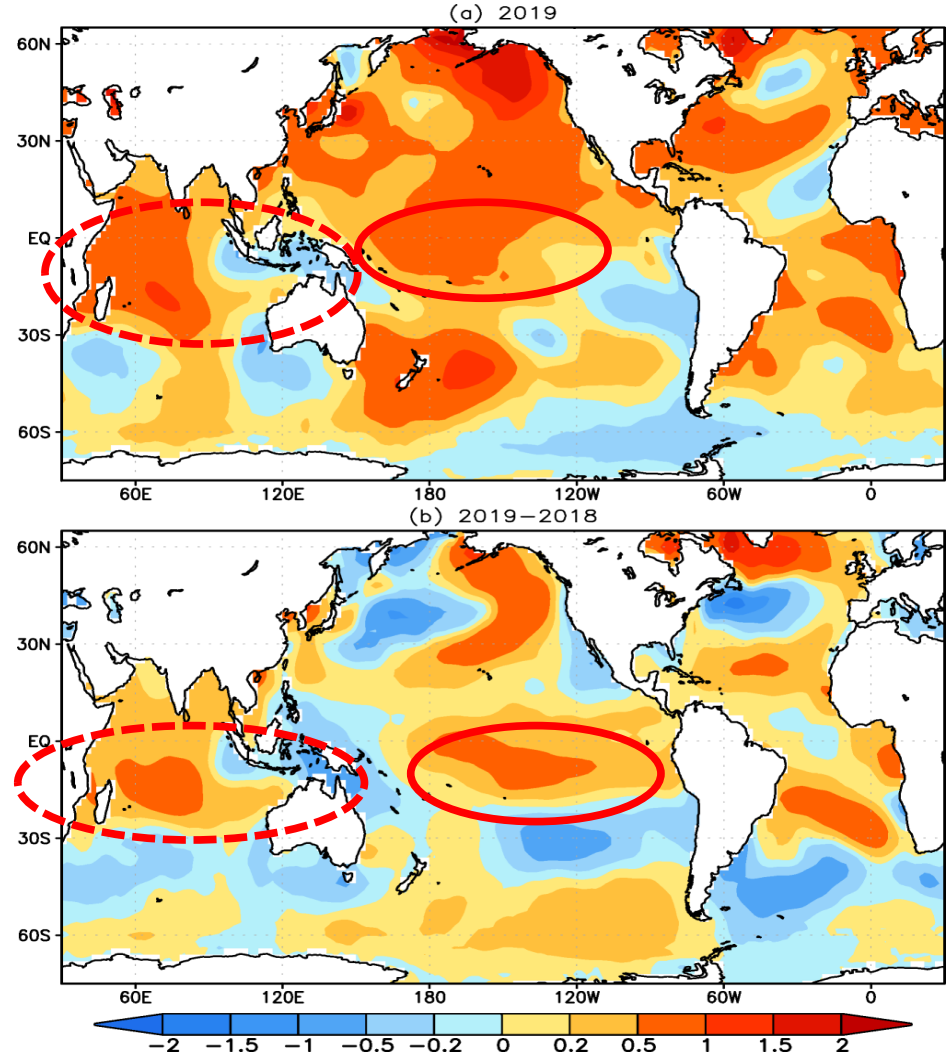
Table 3.1. Linear trends (°C decade–1) of annually and regionally averaged SSTAs from ERSSTv5, HadSST3, and DOISST. The uncertainties at 95% confidence level are estimated by accounting for AR(1) effect on the degrees of freedom of annually averaged SST series.

Global SST Section in the BAMS State of the Climate in 2019 by Huang et al.

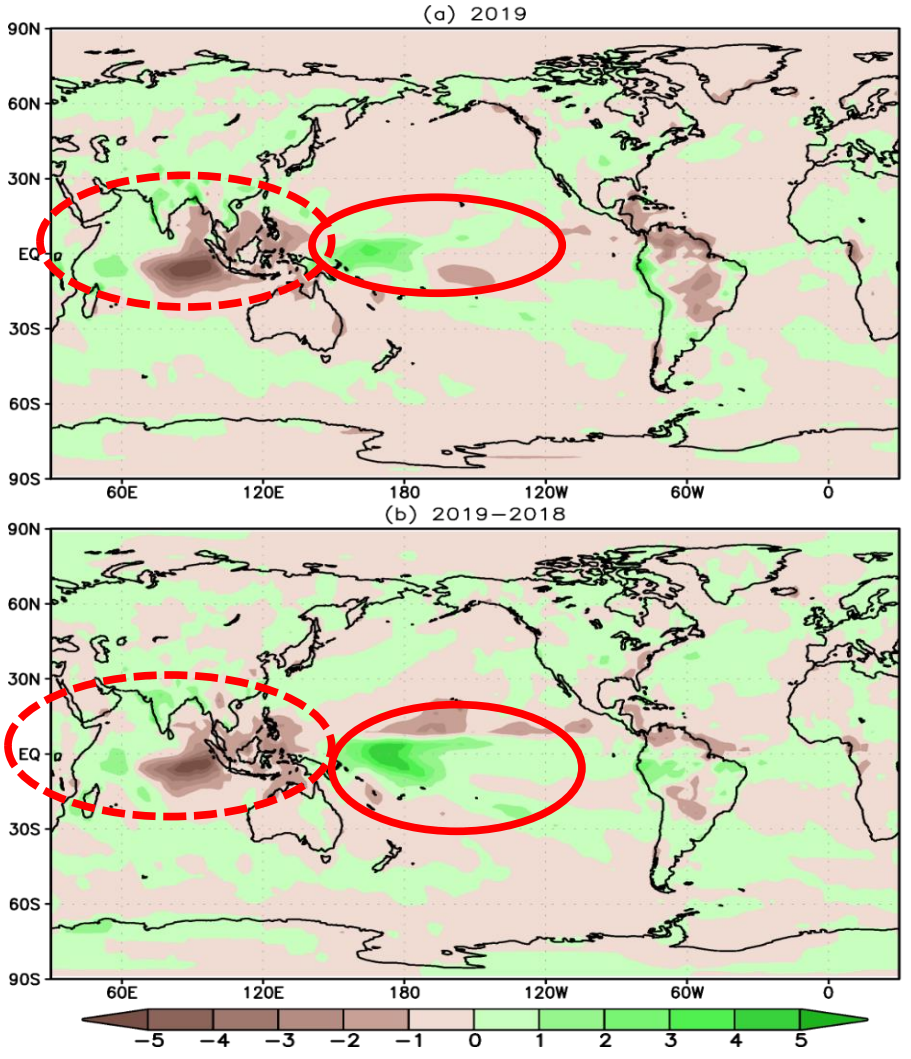
Product	**Region**	**2000–2019**	**1950–2019**
HadSST.3.1.1.0	Global	0.140±0.065	0.086±0.016
DOISST	Global	0.156±0.058	N/A
ERSSTv5	***Global***	*0.170+/-0.075*	***0.101±0.013***
ERSSTv5	Tropical Pacific (30° S–30° N)	0.188±0.185	0.102±0.028
ERSSTv5	North Pacific (30° N–60° N)	0.287±0.172	**0.087±0.028**
ERSSTv5	Tropical Indian Ocean (30° S–30° N)	0.199±0.098	**0.141±0.018**
ERSSTv5	North Atlantic (30° N–60° N)	0.142±0.087	0.101±0.034
ERSSTv5	Tropical Atlantic (30° S–30° N)	0.133±0.097	0.109±0.020
ERSSTv5	Southern Ocean (30° S–60° S)	0.129±0.060	0.099±0.016

- **The linear trend of globally averaged SSTA based on ERSSTv5 is 0.101 (°C/decade) in 1950–2019.**
- **The largest warming trend (°C/decade) in 1950-2019 was observed in the tropical Indian (0.141), smallest warming in the North Pacific (0.087).**

ERSSTv5 SSTA

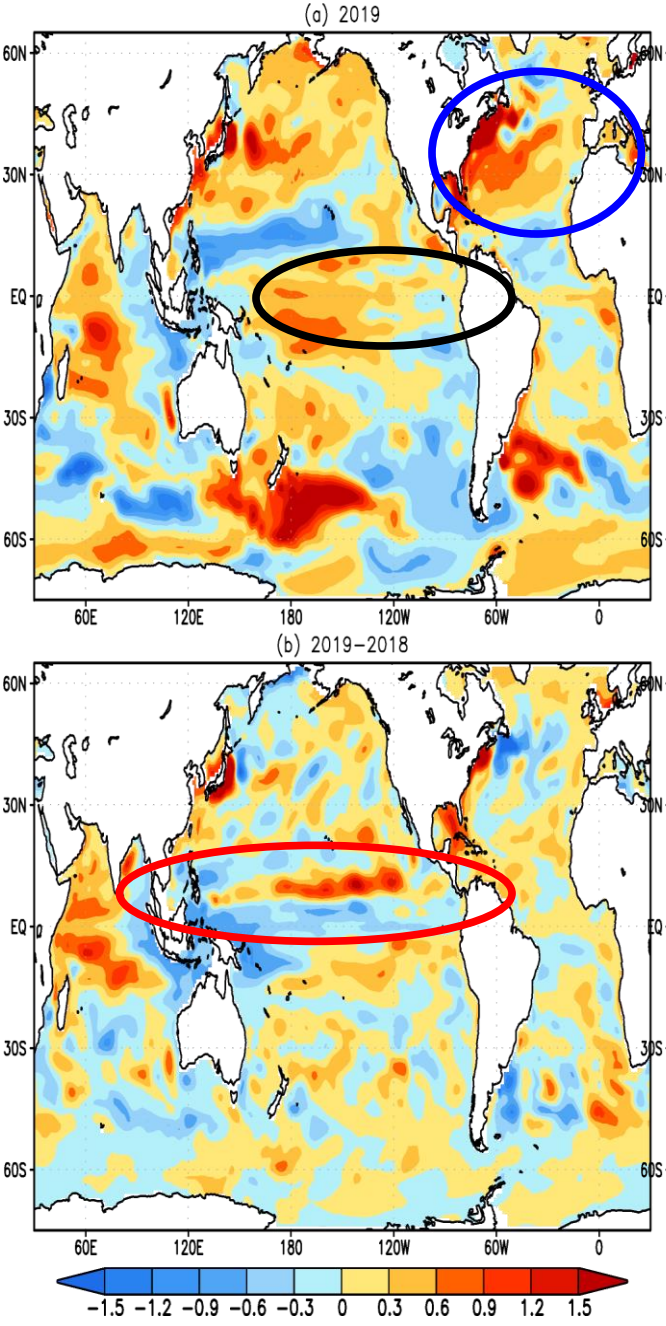


CAMS_OPI Prec. Anom.

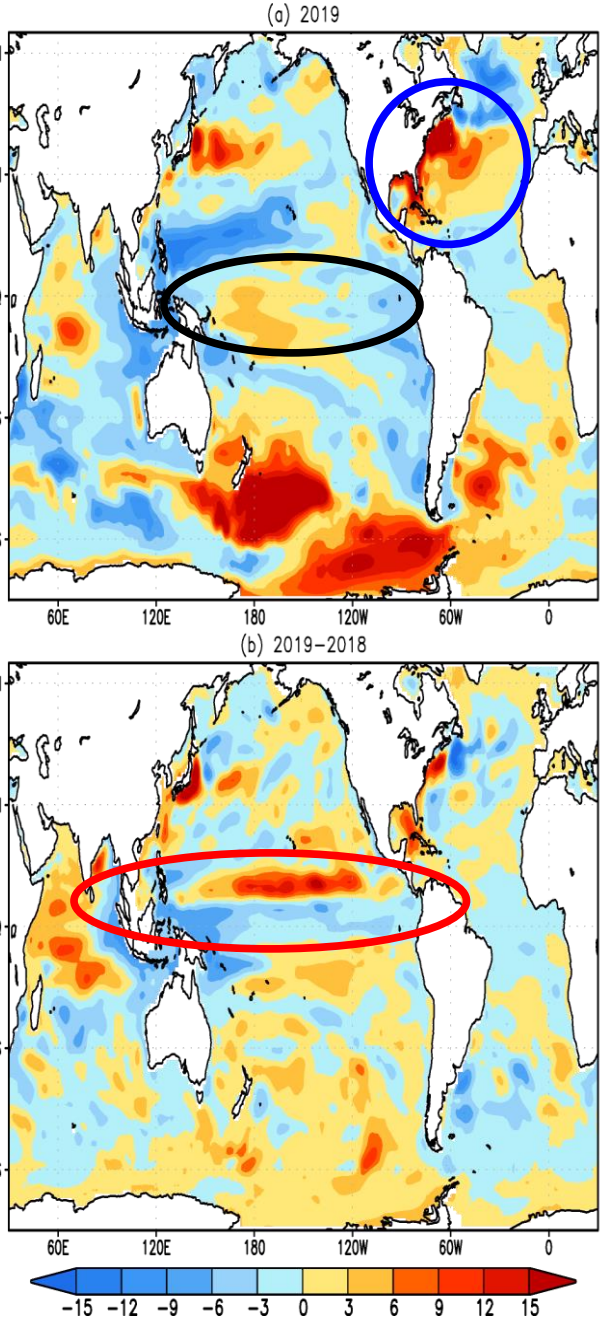


- **In 2019, consistent with the SSTA pattern, precipitation was above normal in the central and blow normal in the far-western & east-central tropical Pacific.**
- **In the Indian Ocean, positive (negative) anomaly of precipitation presented in the western (eastern) tropics, consistent with the positive phase of IOD.**
- **The precipitation anomaly in the N. Atlantic was consistent with the horse-shoe-pattern of SSTA.**
- **2019 minus 2018 prec. anomaly was similar to the 2019 prec. anom., impling the association with ENSO cycle (2018/2019 El Nino; 2017/2018 La Nina).**

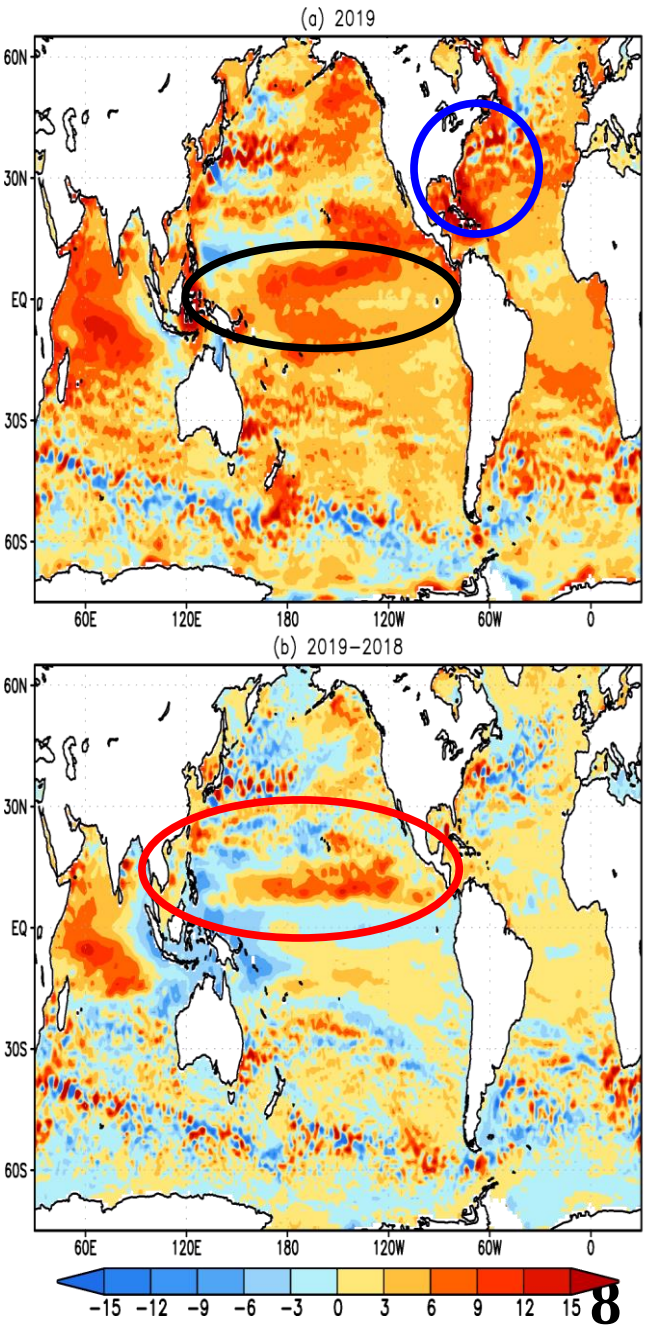
GODAS HC300A & Tendency

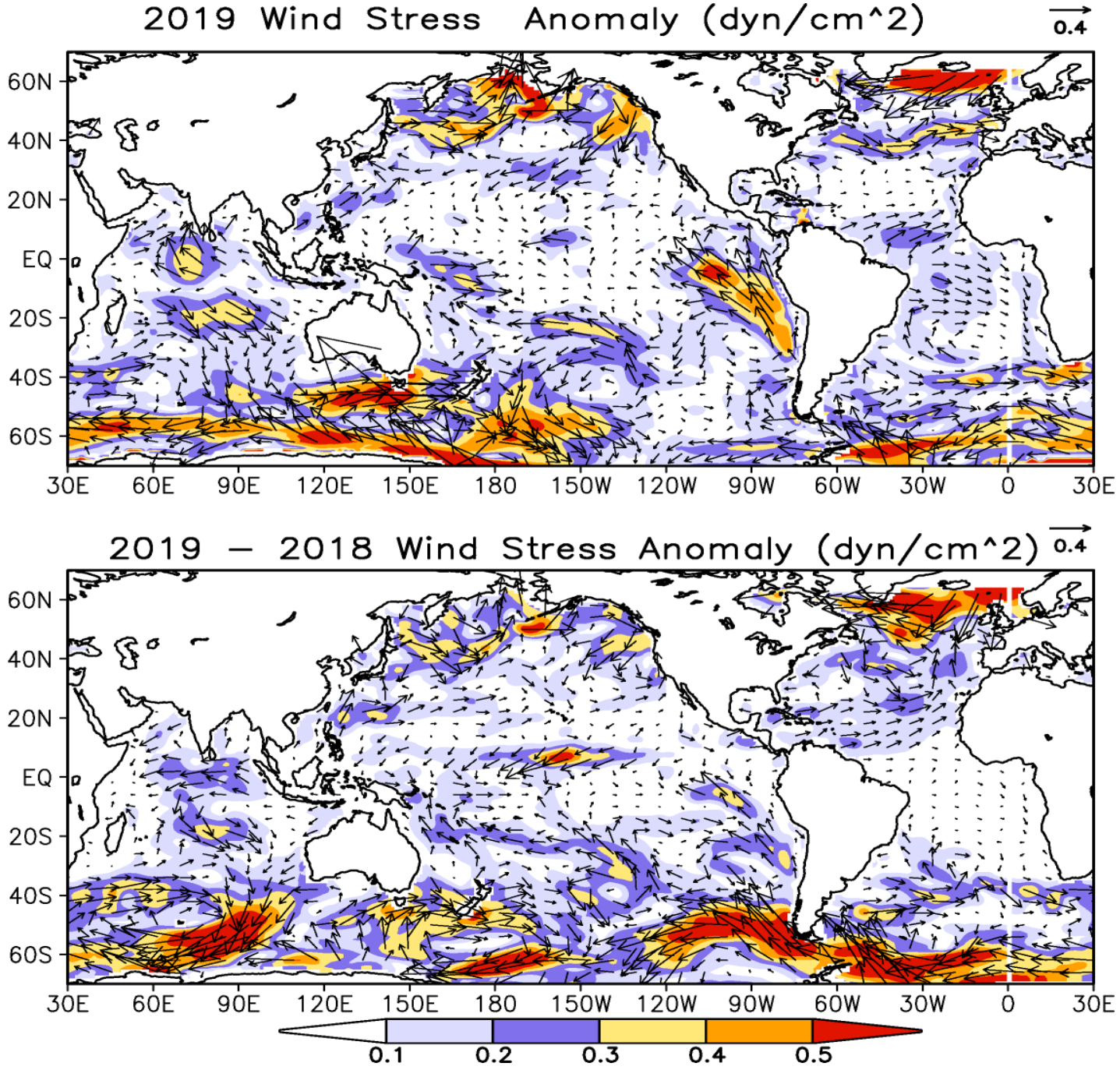


GODAS SSHA



AVISO SSHA: 1992-2019





R2 Wind Stress Anomaly

Highlights in January 2020

Outline

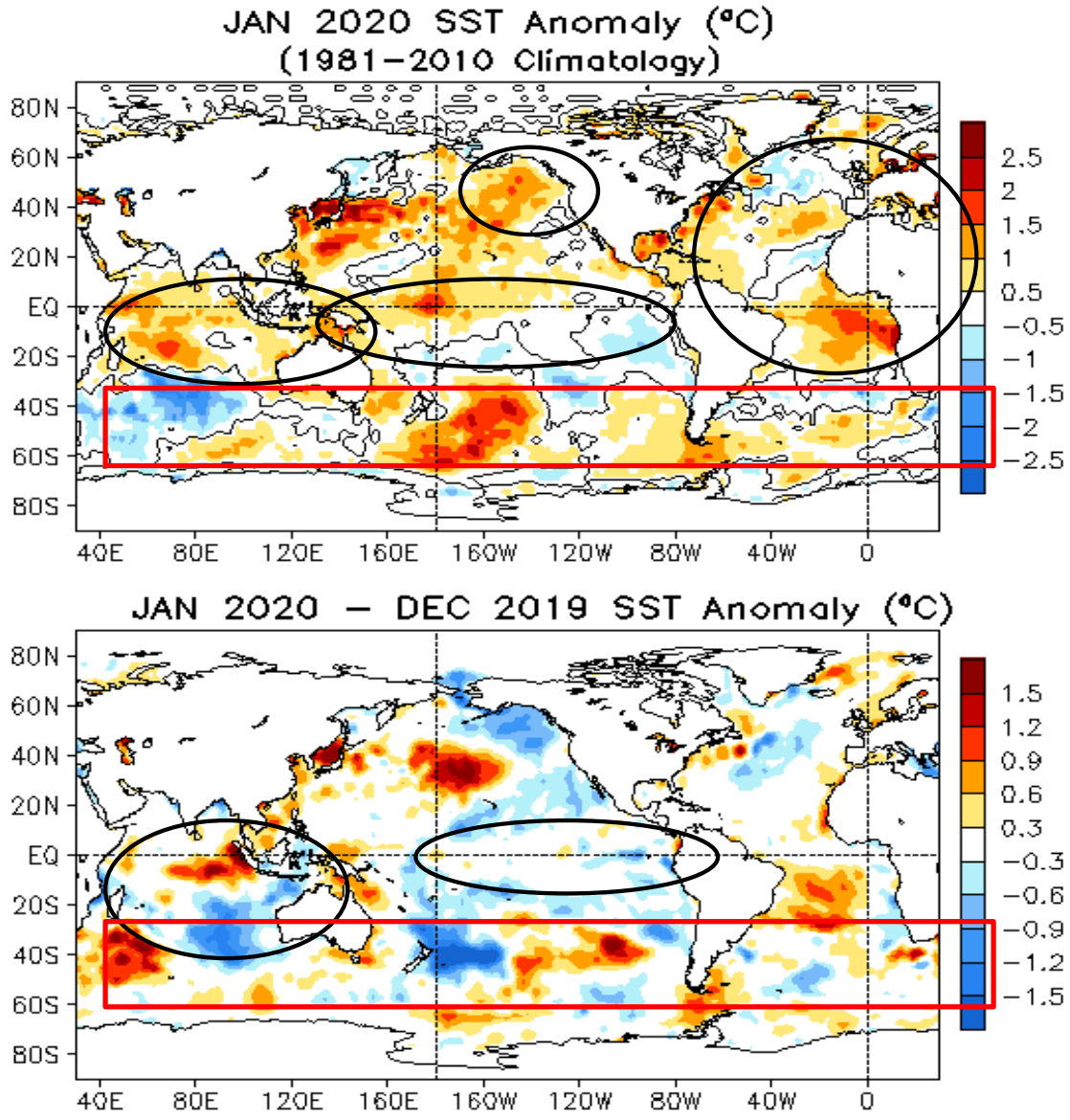
- **Overview**
- **Recent highlights**
  - **Pacific/Arctic Ocean**
  - **Indian Ocean**
  - **Atlantic Ocean**
- **Global SSTA Predictions**

Overview

- **Pacific Ocean**
  - **NOAA "ENSO Diagnostic Discussion" on 13 Feb 2020 stated "*ENSO-neutral is favored through Northern Hemisphere spring 2020 (~60% chance), continuing through summer 2020 (~50% chance).*"**
  - **ENSO neutral conditions persisted, and positive SSTAs still presented in the central tropical Pacific with NINO3.4=0.51ºC in Jan 2020.**
  - **Positive SSTAs weakened in the NE. Pacific in Jan 2020. The PDO index was negative with PDOI= -0.85 in Jan 2020.**
  - **Sea ice concentration in the Arctic Ocean in Jan 2020 was the 9th lowest Jan concentration in the satellite record.**
- **Indian Ocean**
  - **SSTAs were positive in the west and small in the east.**
  - **IOD was still in a positive phase, but further weakened in Jan 2020.**
- **Atlantic Ocean**
  - **NAO was in a positive phase with NAOI=1.0 in Jan 2020.**
  - **SSTAs were a tripole/horseshoe pattern with positive anomalies in the middle latitudes of N. Atlantic during 2013-2019.**

Global Oceans

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



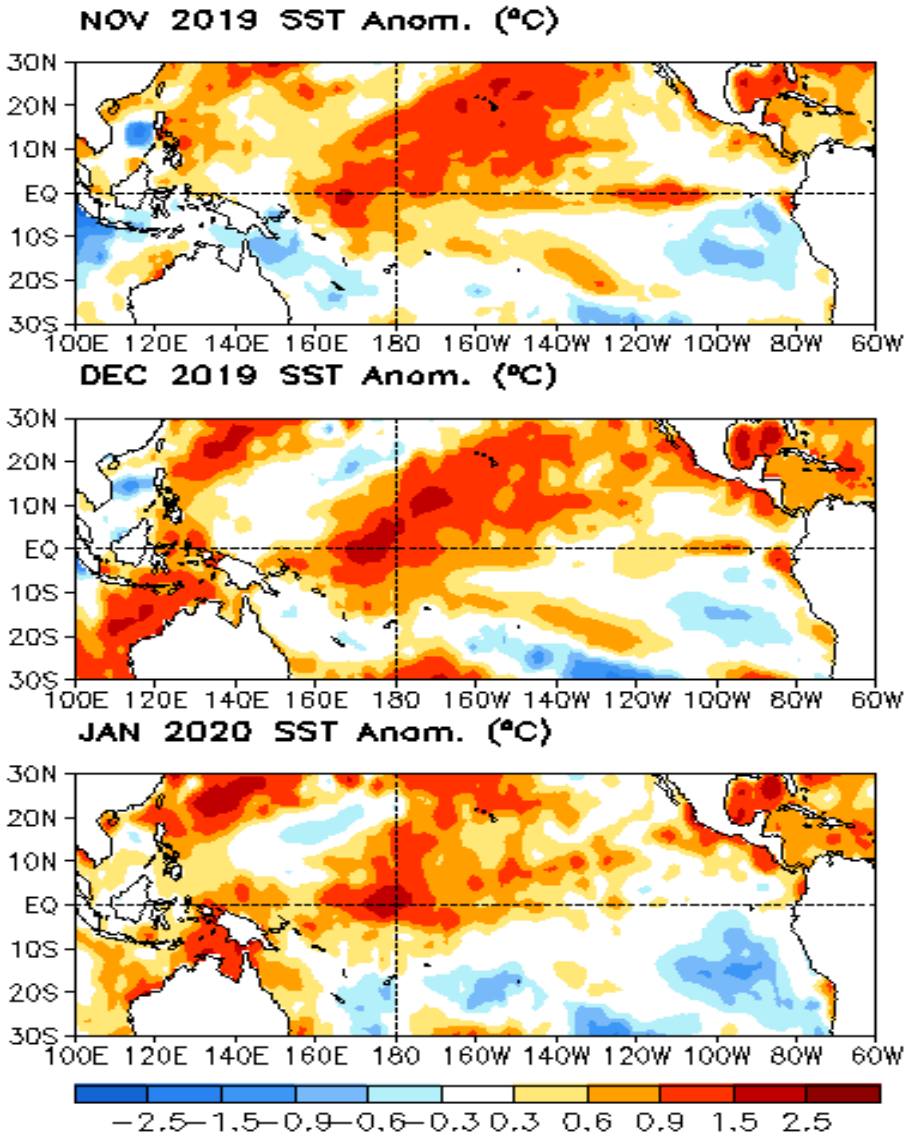
- **Positive SSTAs persisted in the central tropical Pacific.**
- **Positive SSTAs weakened in the NE Pacific (Blob.2).**
- **Tripole-like SSTAs were observed in the North Atlantic and positive SSTAs in the tropical Atlantic were associated with an Atlantic Nino.**
- **In the Indian Ocean, SSTAs were overall positive.**
- **There were strong positive & negative SSTAs in the mid-latitudes of the South Ocean.**

- **SSTA tendencies were small in the tropical Pacific.**
- **SSTA tendencies in the Indian Ocean were positive in the east and small in the west, implying dismissing of the positive phase of current Indian Ocean dipole event.**
- **There were strong positive & negative SSTA tendencies in the mid-latitudes of the South Ocean.**

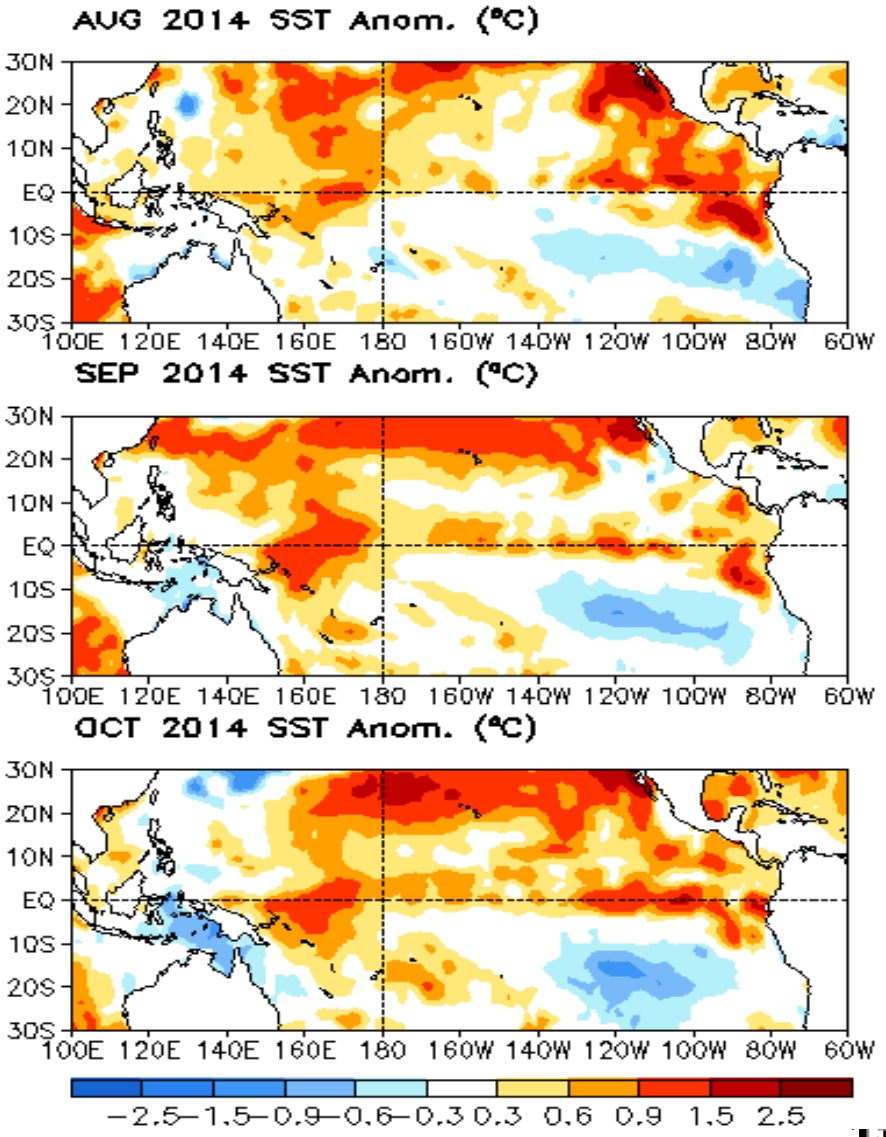
Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

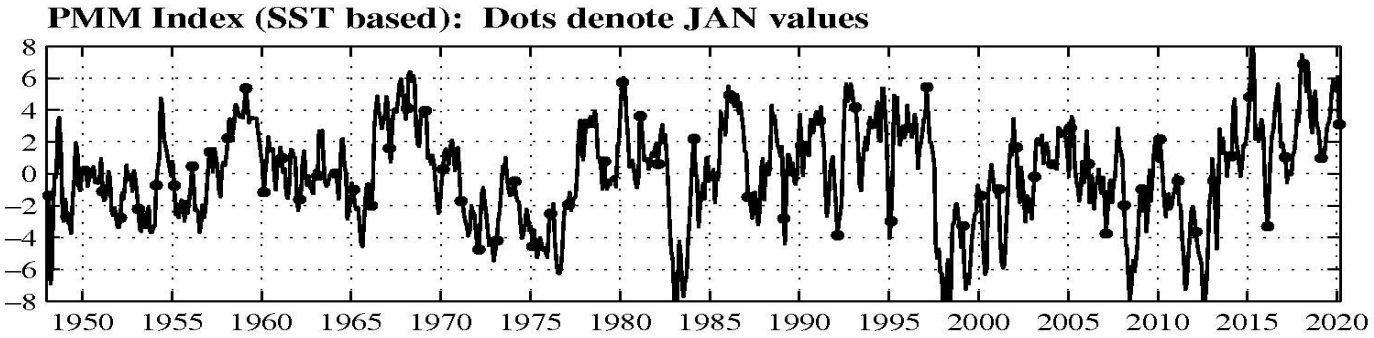
SST Anomalies: Pacific Meridional Mode (PMM)

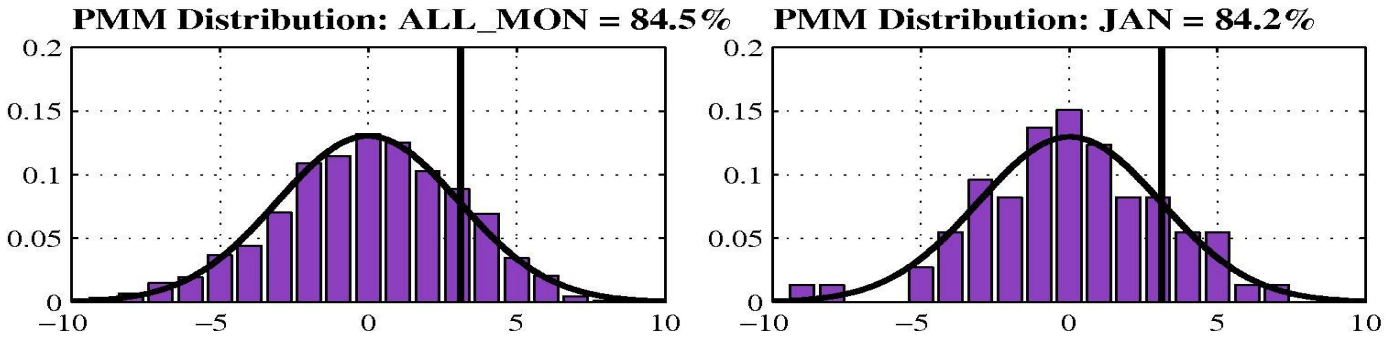
2019

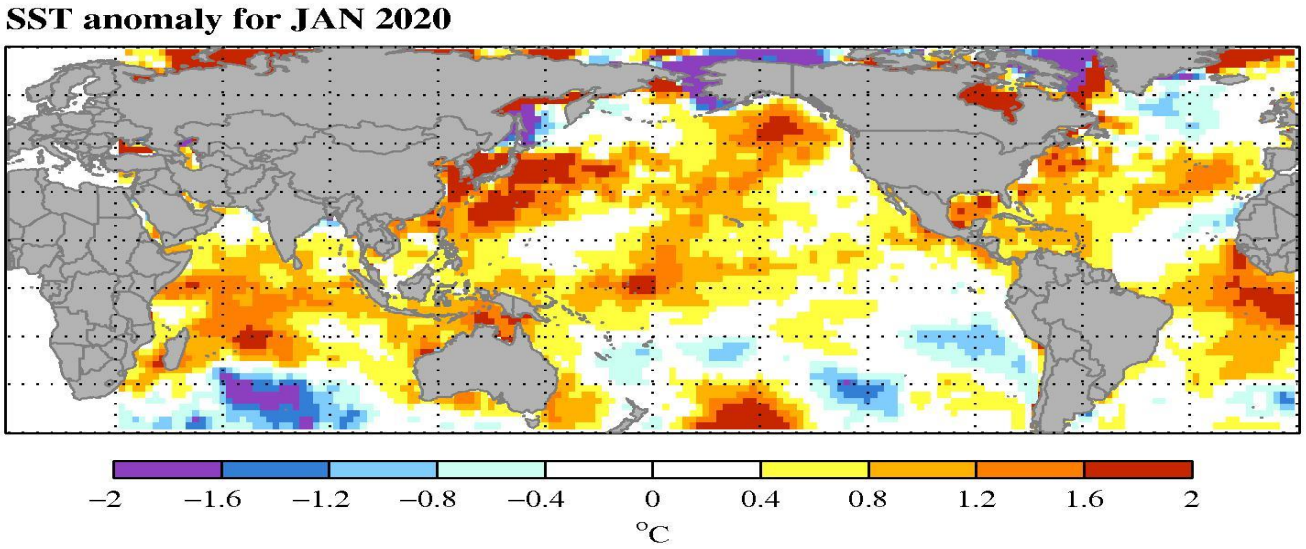


2014





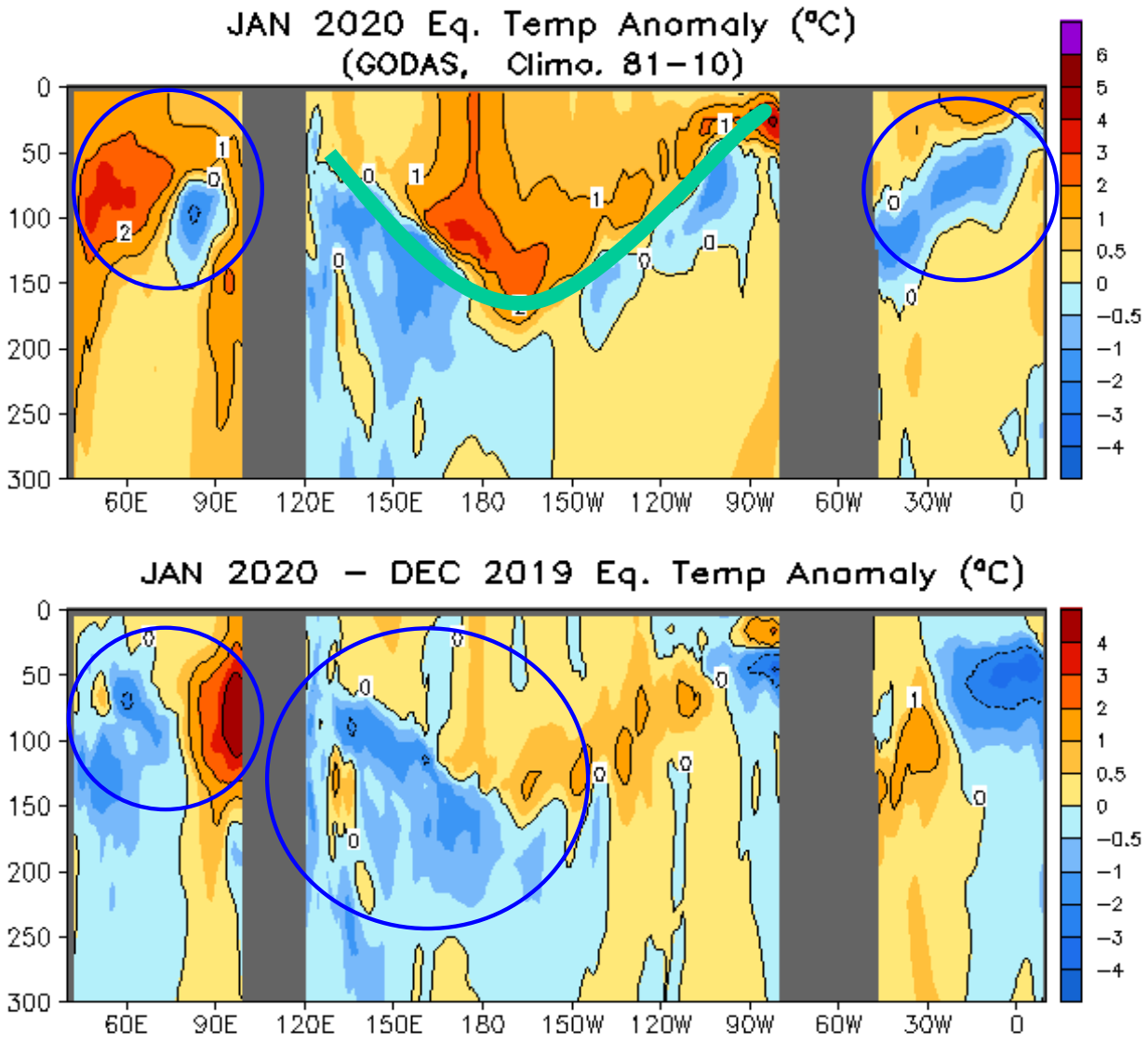




PMM was still in a strong positive phase, but weakened compared with previous months.

http://www.aos.wisc.edu/~dvimont/MModes/RealTime/pmm_current.jpg

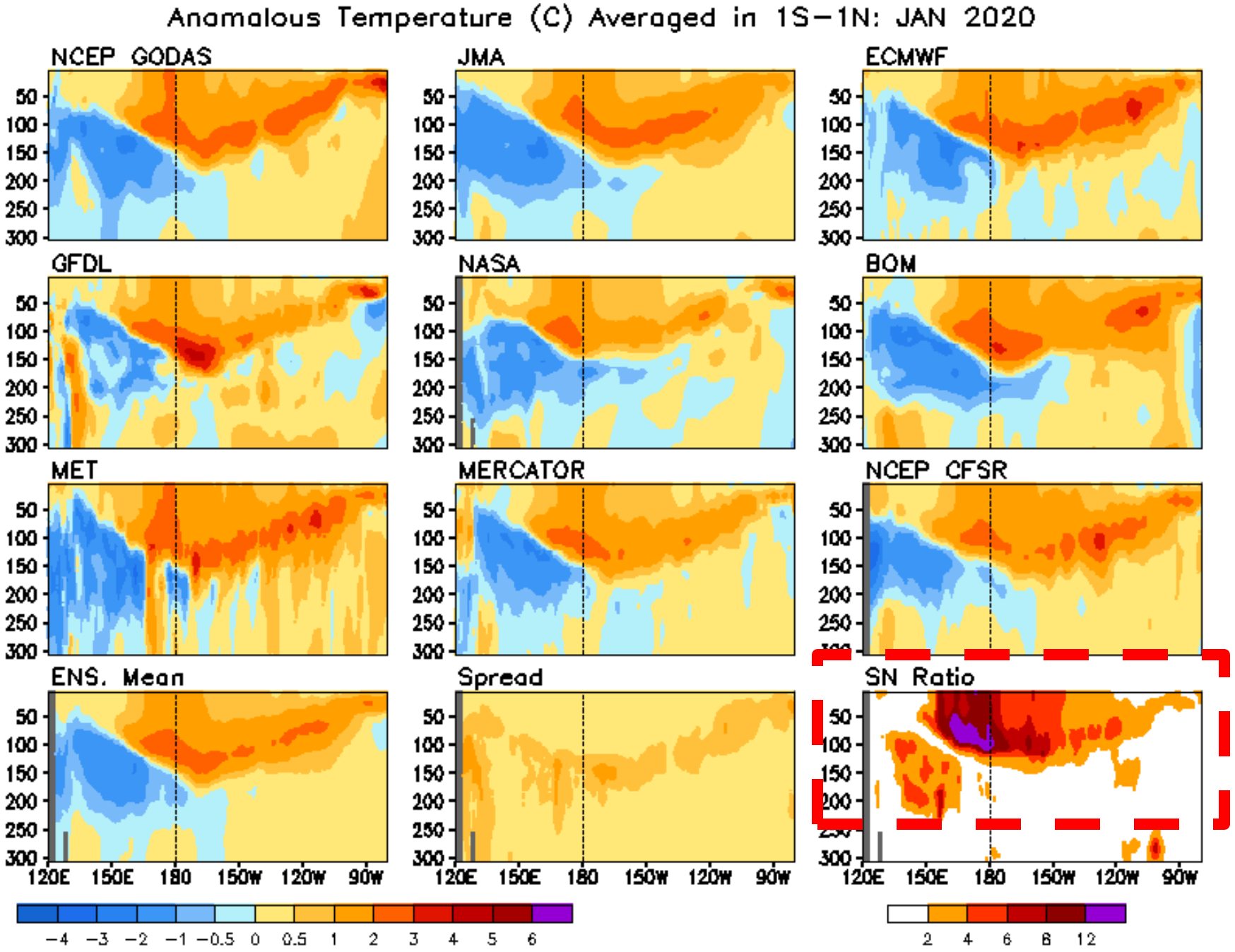
Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2°S-2°N



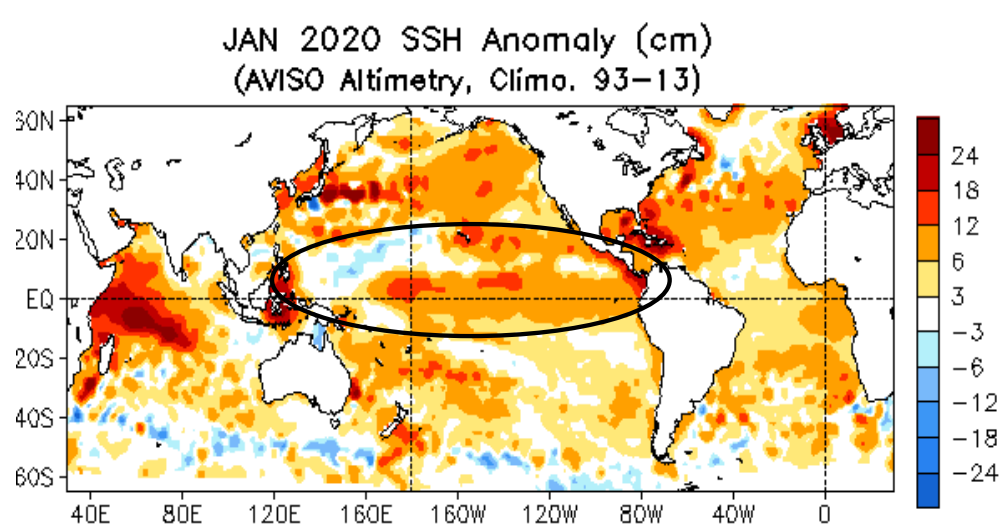
- **Positive (negative) ocean temperature anomalies presented in the up- (low-) layer in the tropical Pacific.**
- **Positive (negative) anomaly in the western (eastern) Indian Ocean may be associated with the residue of the latest strong IOD.**
- **Negative anomaly was along the thermocline of Atlantic Ocean.**

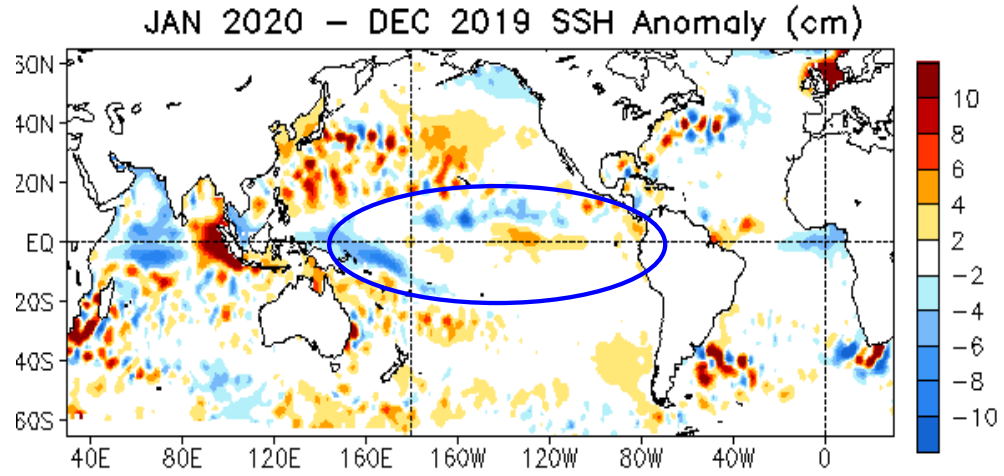
- **Negative anomalous ocean temperature tendency was observed in the western Pacific.**
- **Positive in the east and negative anomalies in the Indian Ocean imply a decay of the positive phase of IOD.**

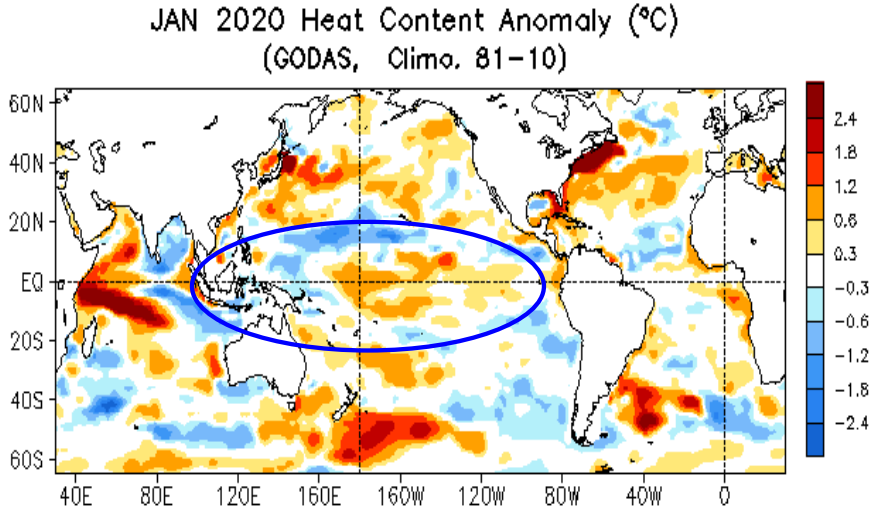
Fig. G3. Equatorial depth-longitude section of ocean temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP's global ocean data assimilation system which assimilates oceanic observations into an oceanic GCM. Anomalies are departures from the 1981-2010 base period means.

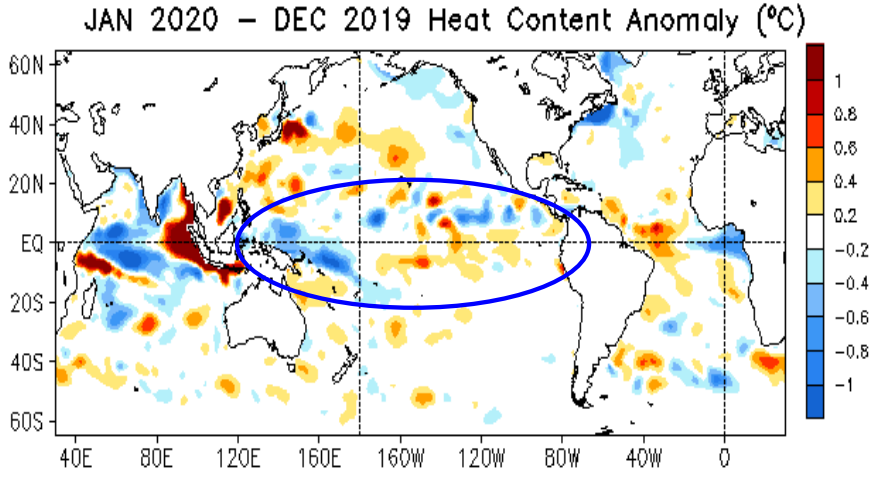

Anomalous Temperature (C) Averaged in 1S−1N: JAN 2020
NCEP GODAS
JMA
ECMWF
GFDL
NASA
BOM
MET
MERCATOR
NCEP CFSR
ENS. Mean
Spread
SN Ratio
50
100
150
200
250
300
120E
150E
180
150W
120W
90W
−4 −3 −2 −1 −0.5 0 0.5 1 2 3 4 5 6
2 4 6 8 12

Global SSH and HC300 Anomaly & Anomaly Tendency





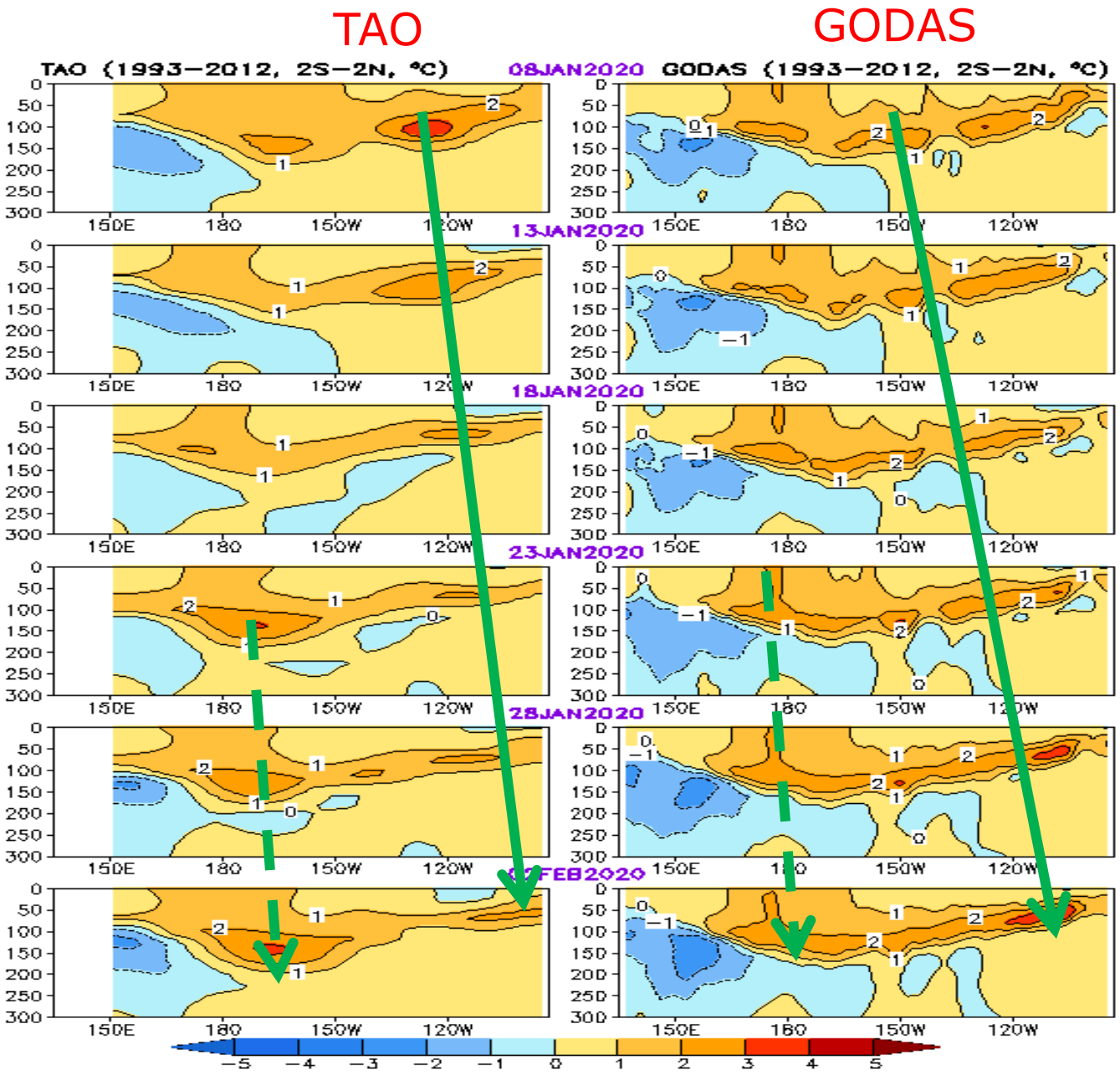




- **The SSHA pattern was overall consistent with the HC300A pattern, but there were many differences in details between them.**
- **Both SSHA and HC300A in the tropical Pacific were consistent with ENSO neutral.**

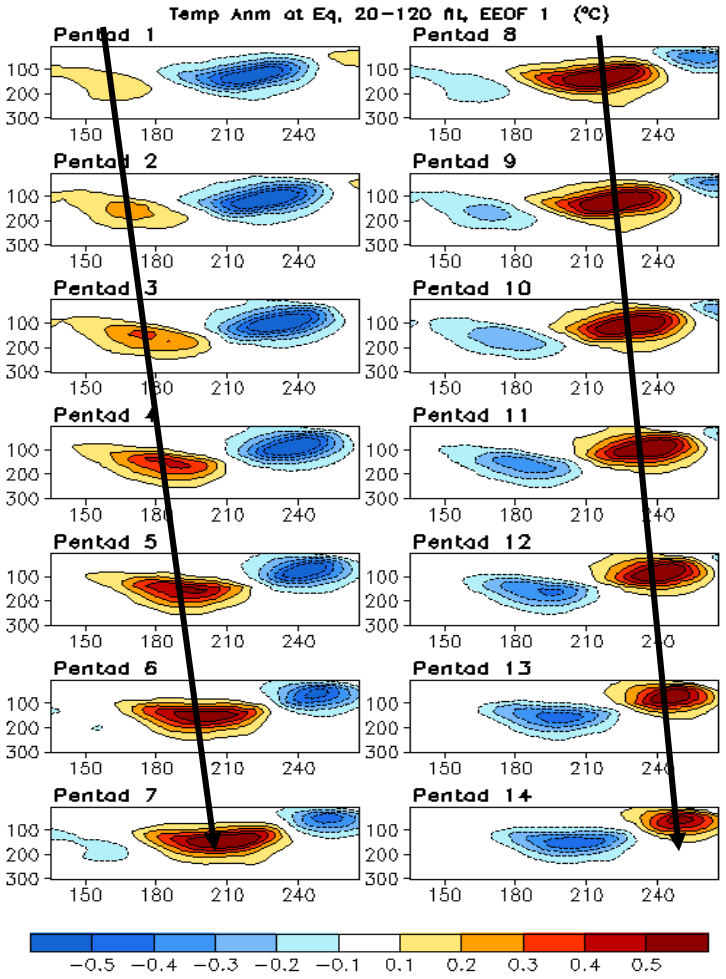
Tropical Pacific Ocean and ENSO Conditions

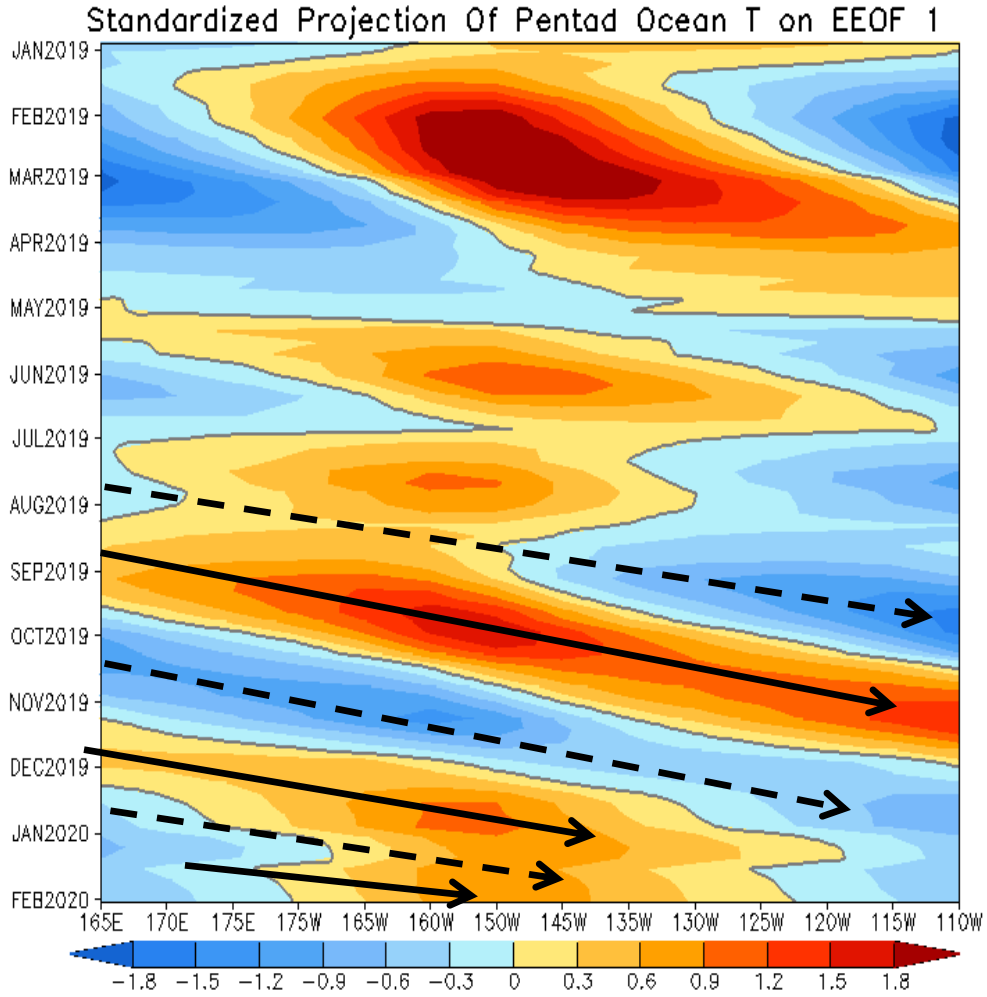
Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



- **Positive ocean temperature anomalies presented in the central and eastern Pacific during the last few pentads, and propagated eastward.**
- **Negative anomalies emerged in the western Pacific.**
- **The patterns of the ocean temperature anomalies between GODAS and TAO were similar.**

Oceanic Kelvin Wave (OKW) Index



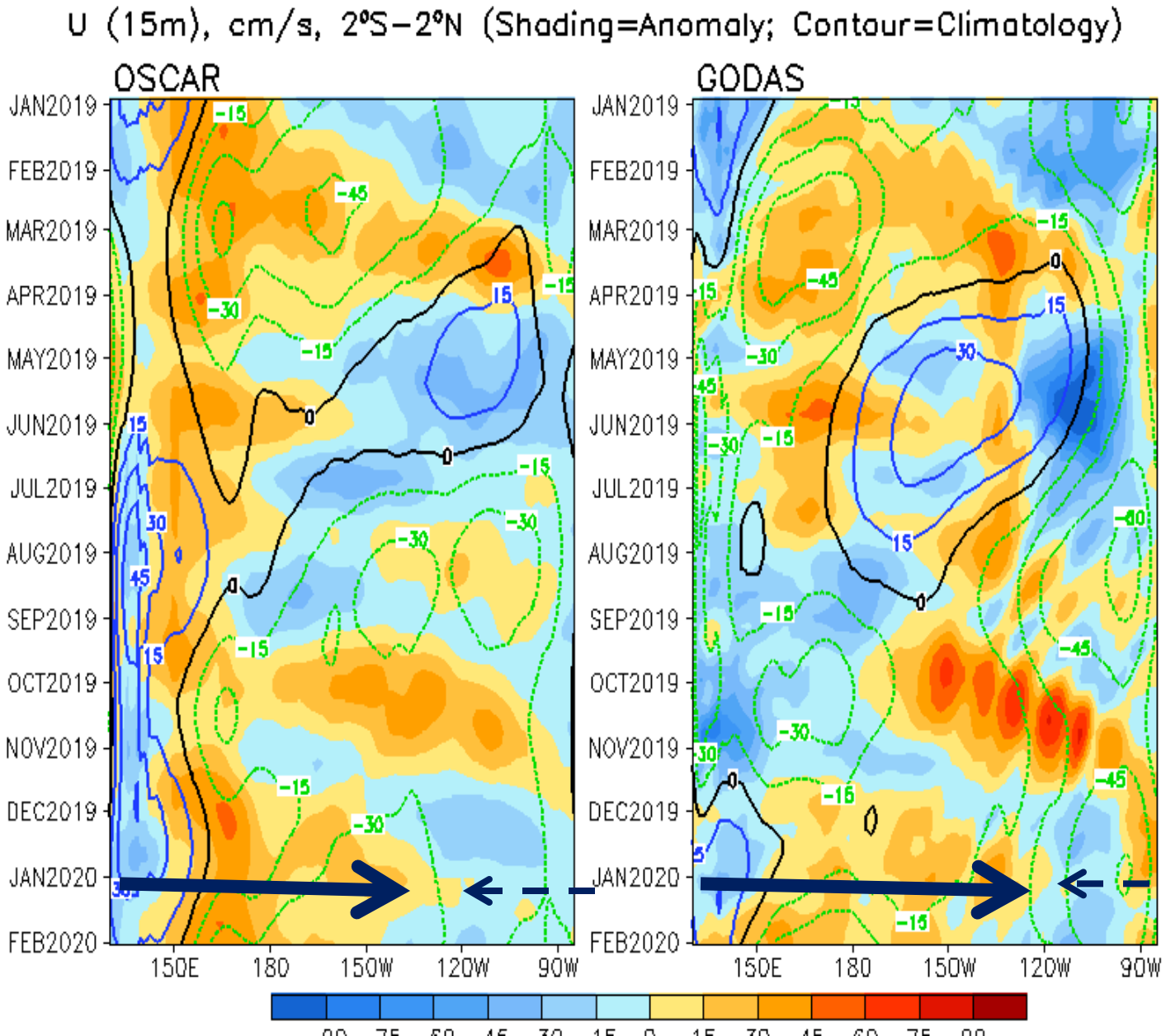


- **A downwelling Kelvin wave presented from Nov 2019, leading to the increase of positive subsurface temperature anomalies in the central tropical Pacific.**

- **During the last two months, Kelvin wave activity was weak.**

(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).)

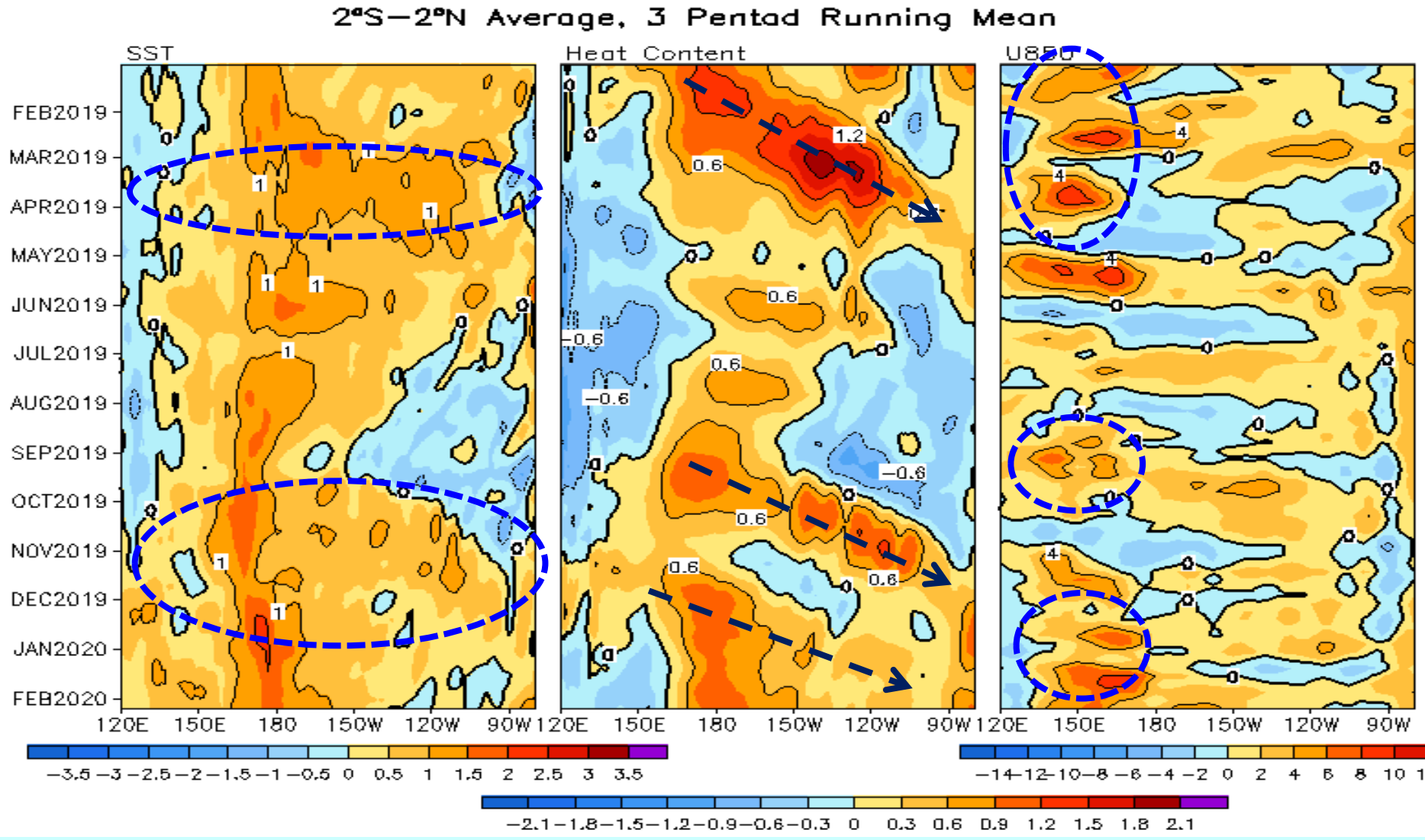
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- Anomalous eastward (westward) currents persisted in the western and central (eastern) Pacific in Jan 2020 in both OSCAR and GODAS.

- The anomalous currents showed some differences between OSCAR and GODAS both in the anomalies and climatologies.

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



- **Positive SSTA in the entire Pacific persisted in the last month.**
- **Positive (negative) HC300A presented in the central & eastern (western) Pacific in Jan 2020.**
- **Westerly wind burst presented in late Jan 2020.**

Warm Water Volume (WWV) and NINO3.4 Anomalies

- **WWV is defined as average of depth of 20°C in [120°E-80°W, 5°S-5°N]. Statistically, peak correlation of Nino3 with WWV occurs at 7 month lag (Meinen and McPhaden, 2000).**

- **Since WWV is intimately linked to ENSO variability (Wyrtki 1985; Jin 1997), it is useful to monitor ENSO in a phase space of WWV and NINO3.4 (Kessler 2002).**

- **Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.**

- Equatorial Warm Water Volume (WWV) switched to a recharge phase in Oct 2019.

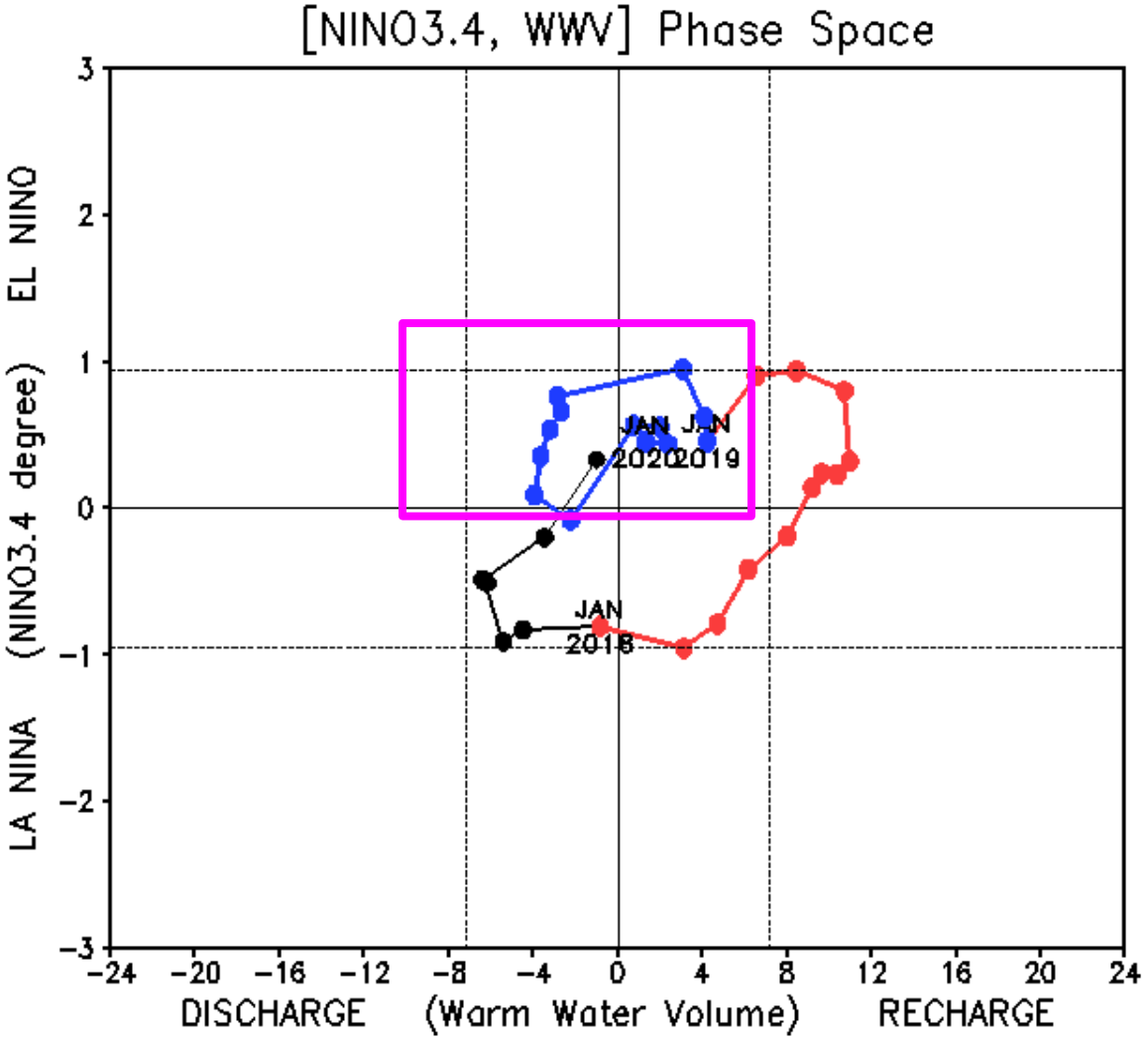
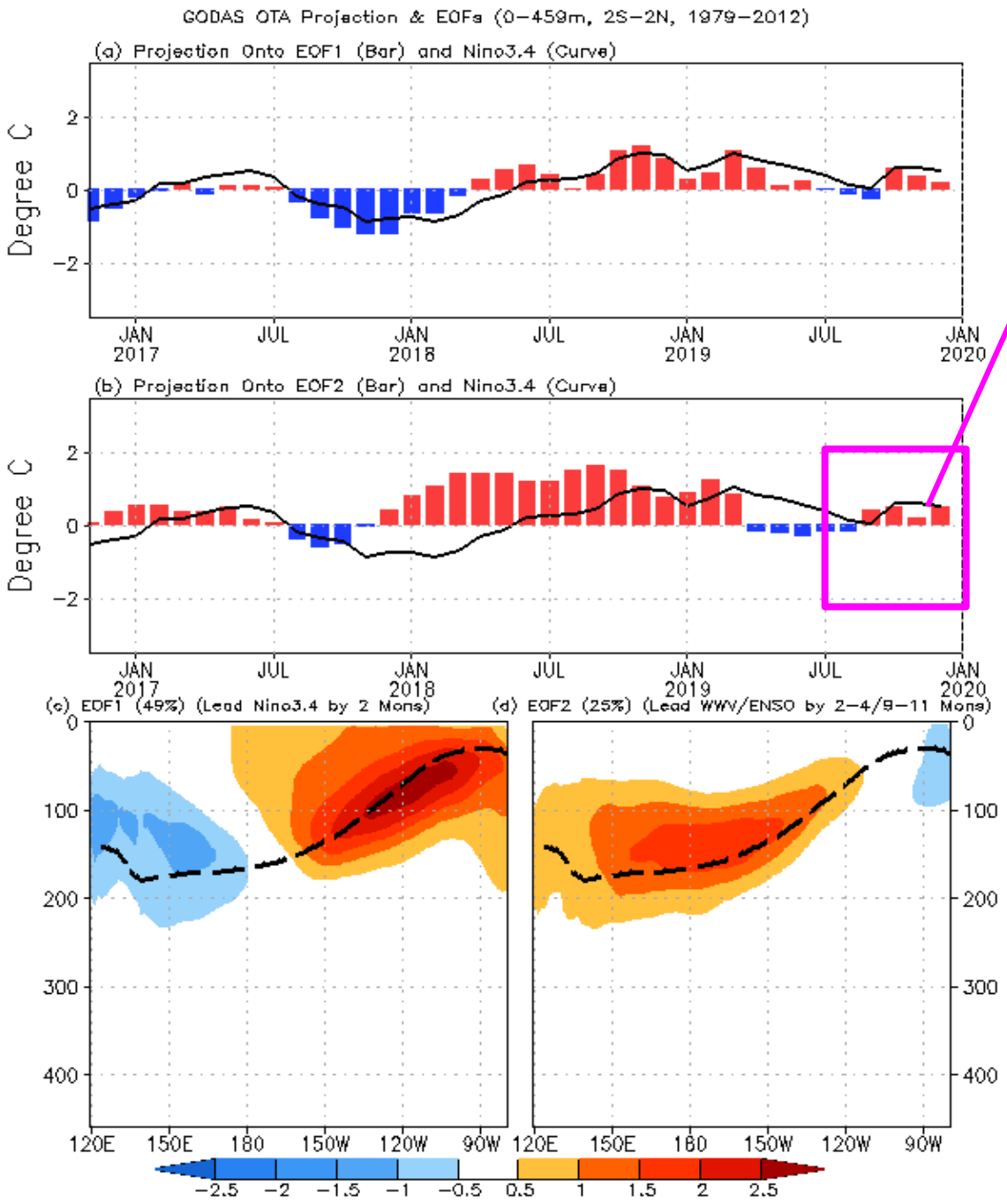


Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20°C in [120°E-80°W, 5°S-5°N] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.



Equatorial subsurface ocean temperature monitoring: ENSO was in a recharge phase since Sep 2019.

Projection of OTA onto EOF1 and EOF2 (2S-2N, 0-459m, 1979-2010)

EOF1: Tilt mode (ENSO peak phase);

EOF2: WWV mode, Recharge/discharge oscillation (ENSO transition phase).

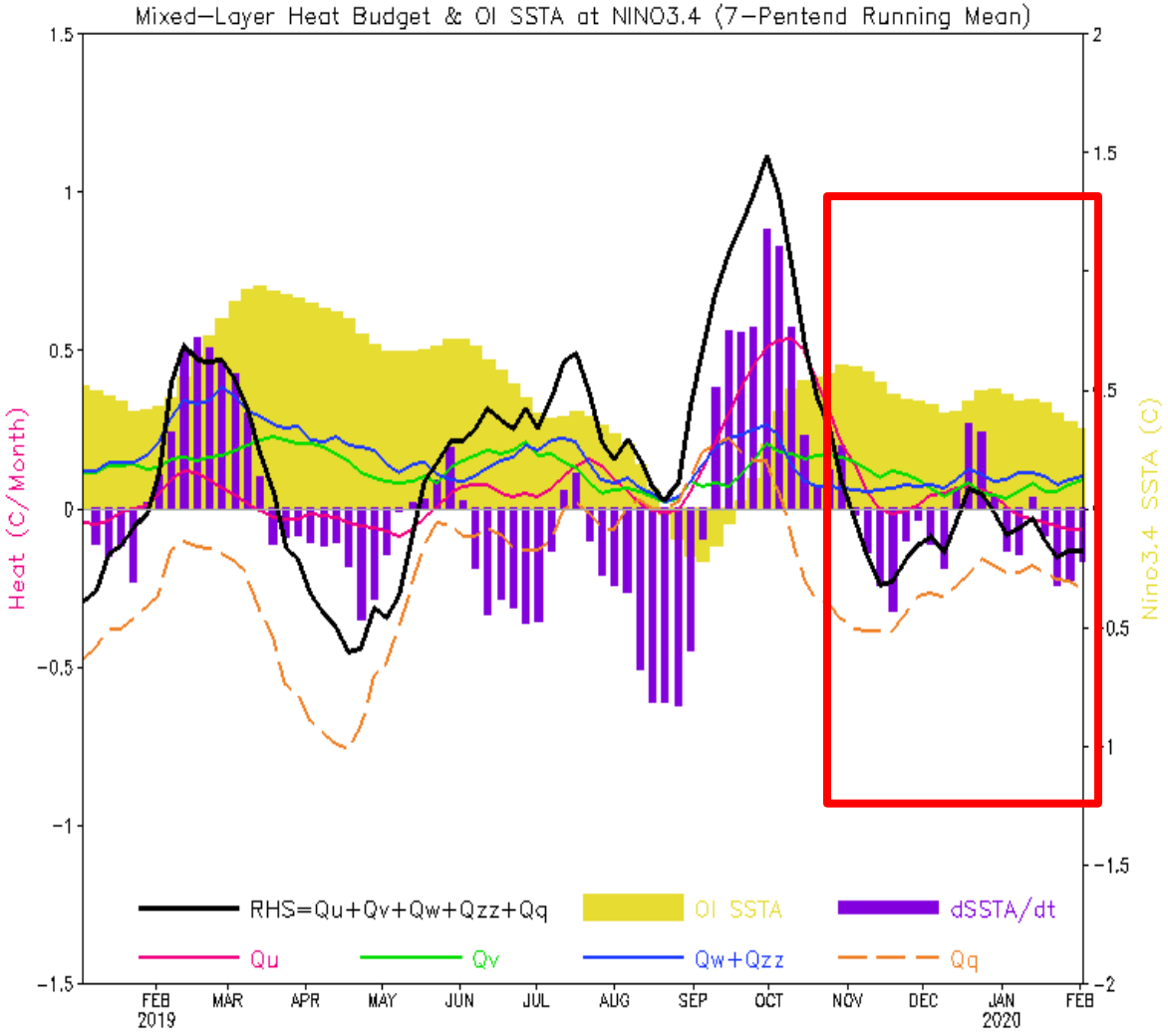
Recharge process: heat transport from outside of equator to equator : Negative -> positive phase of ENSO

Discharge process: heat transport from equator to outside of equator: Positive -> Negative phase of ENSO

For details, see:

Kumar A, Z-Z Hu (2014) Interannual and interdecadal variability of ocean temperature along the equatorial Pacific in conjunction with ENSO. Clim. Dyn., 42 (5-6)**, 1243-1258.** *DOI: 10.1007/s00382-013-1721-0*.

NINO3.4 Heat Budget



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

- Dynamical terms (Qu, Qv, Qw+Qzz) were small positive or negative, and heat-flux term (Qq) was negative in Jan 2020.

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

Qu: Zonal advection; Qv: Meridional advection;

Qw: Vertical entrainment; Qzz: Vertical diffusion

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

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

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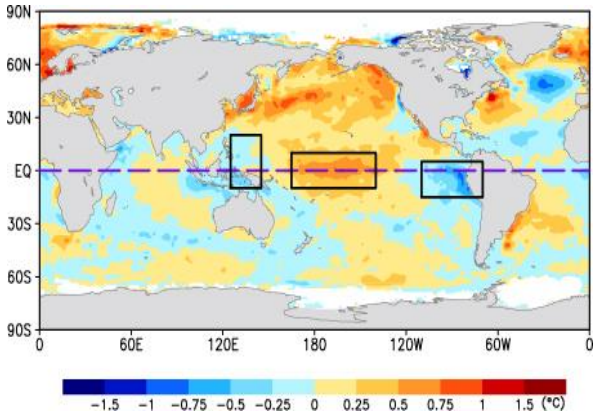
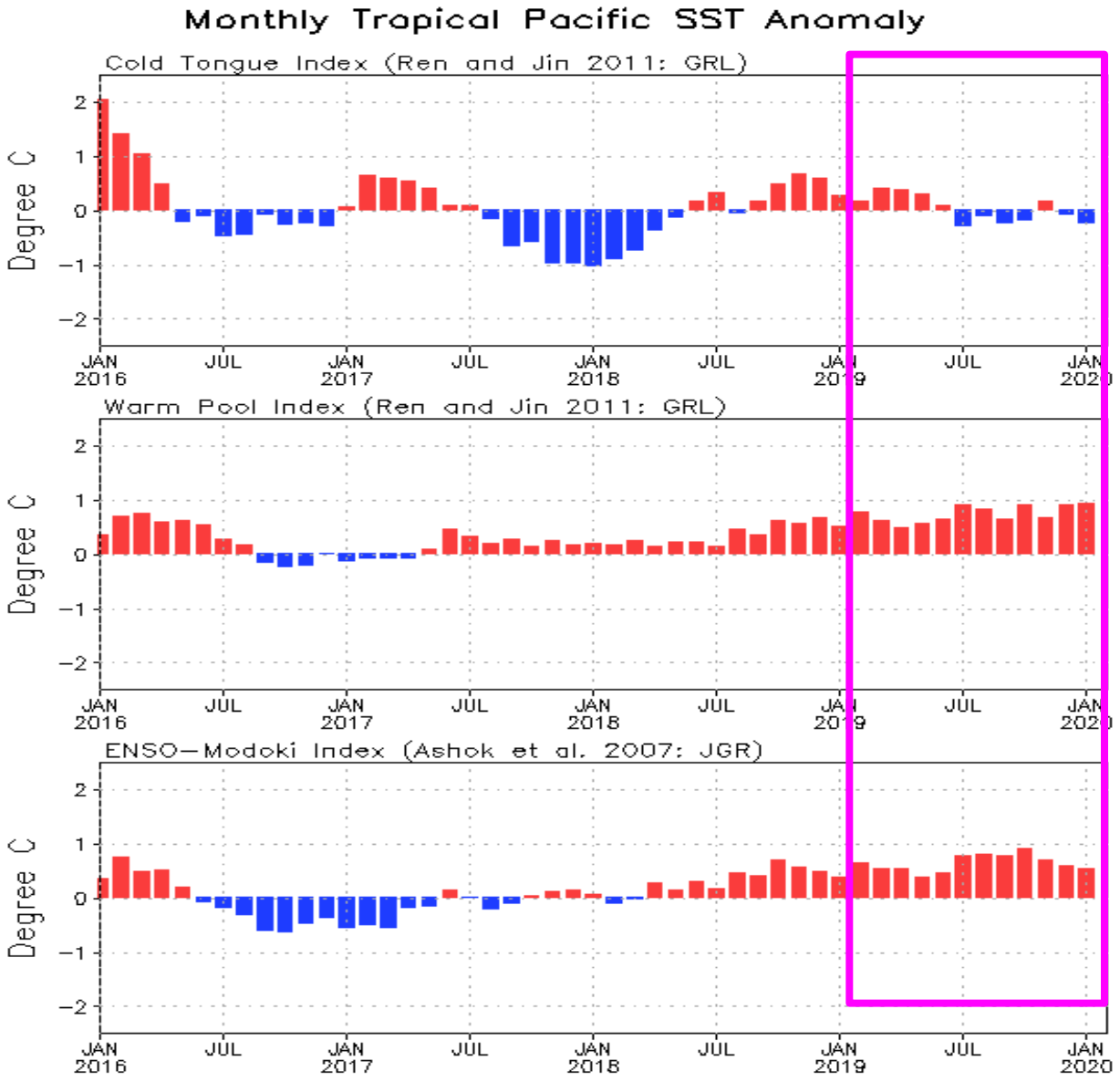
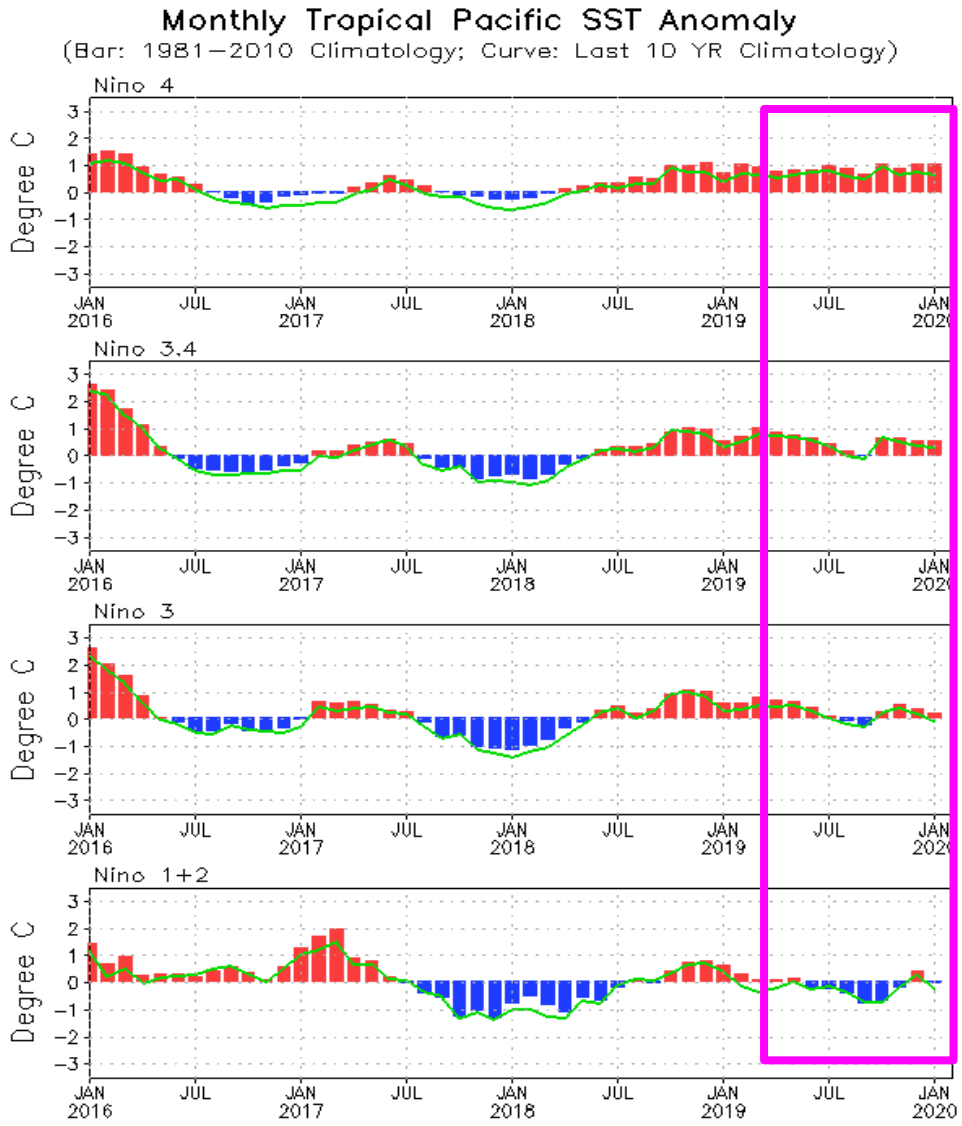
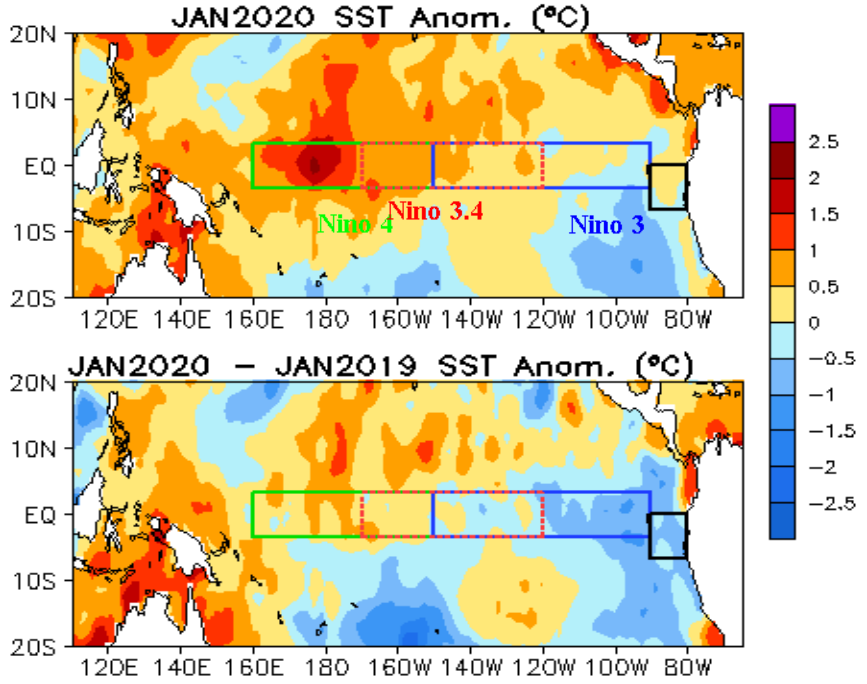
Positive SSTAs persisted in the warm pool, and SSTAs were small in the cold tongue.





Evolution of Pacific NINO SST Indices





- **Except Nino1+2, all indices were positive in Jan 2020.**

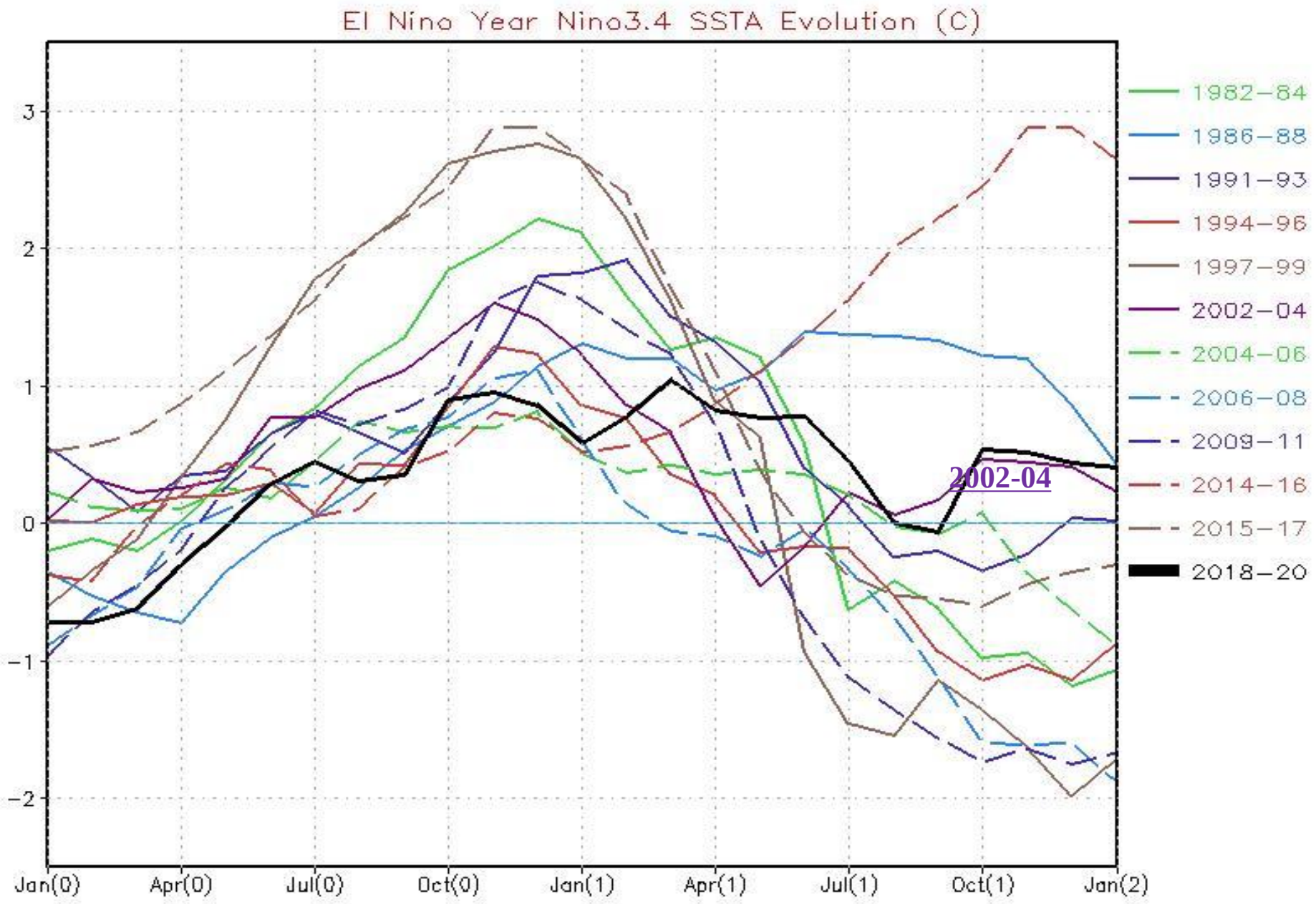
- **Nino3.4 = 0.51 C in Jan 2020.**

- **Compared with Jan 2019, the central equatorial Pacific was warmer in Jan 2020.**

- **The indices may have some differences if different SST datasets were used in the calculations.**

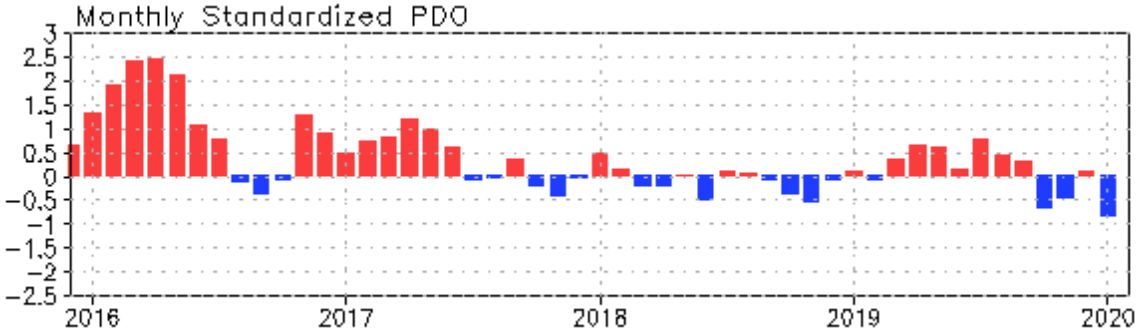
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

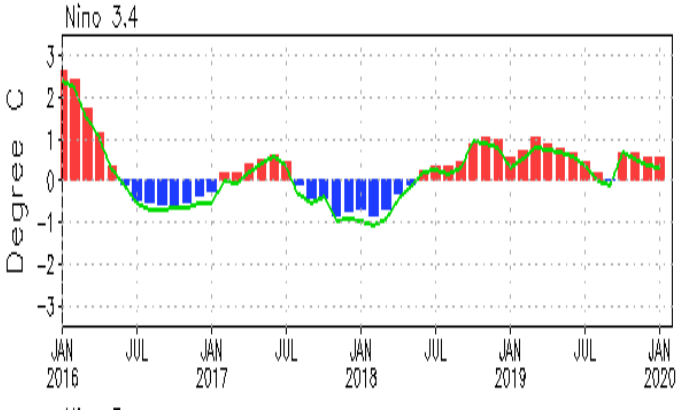
Nino3.4 Evolution In El Nino Years

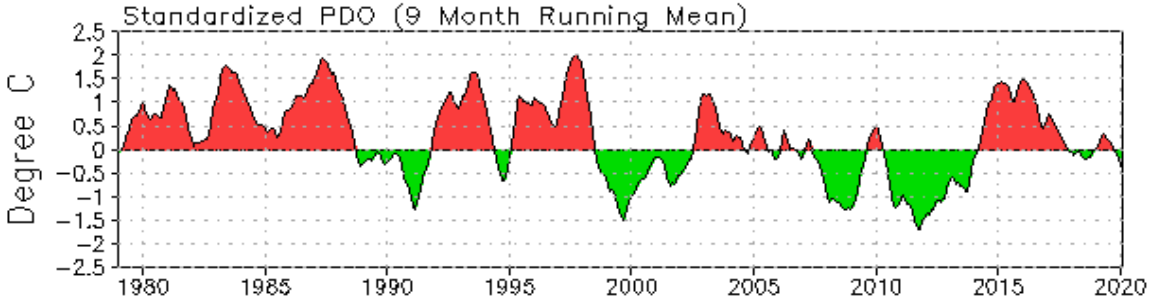


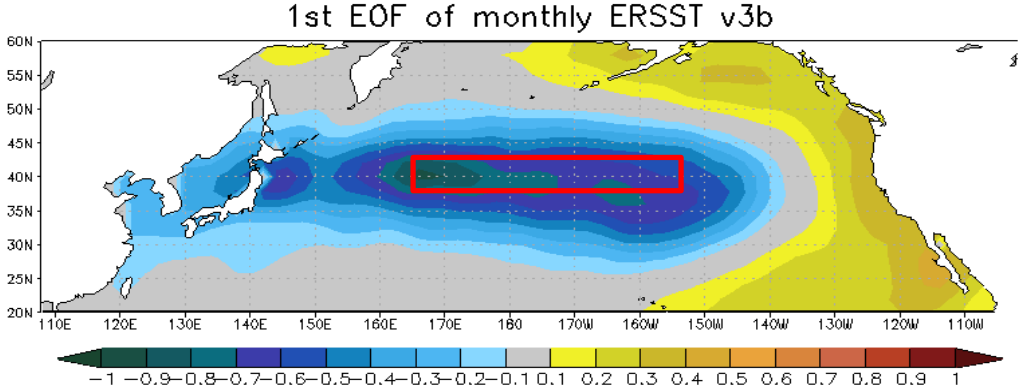
North Pacific & Arctic Oceans

PDO index









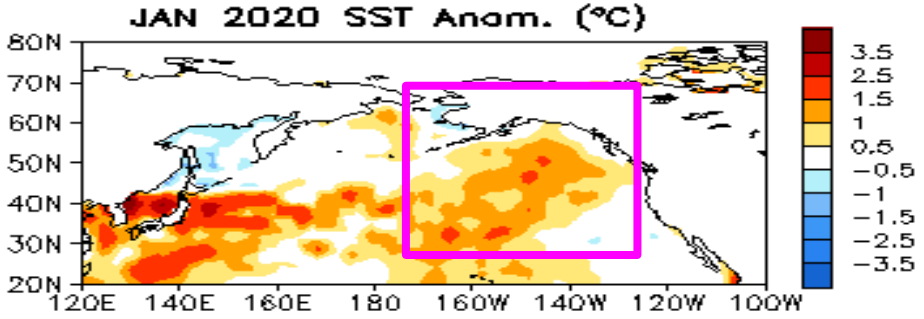
- The PDO index was negative with PDOI= -0.85 in Jan 2020.

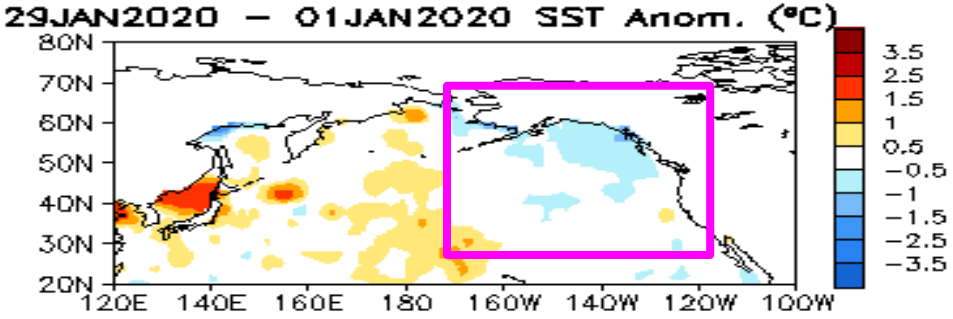
- Statistically, ENSO leads PDO by 3-4 months, through teleconnection via atmospheric bridge.

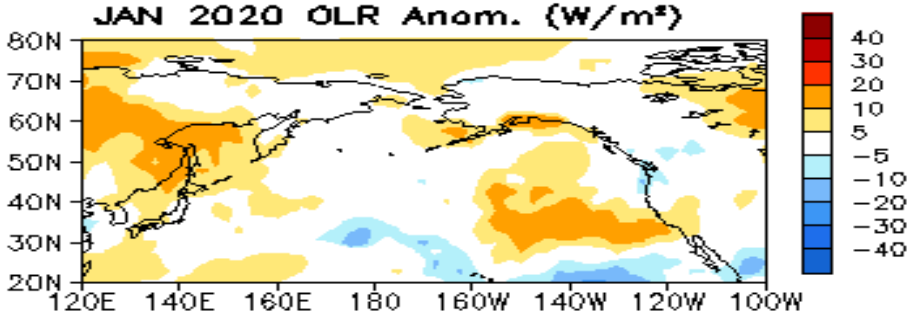
- Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.

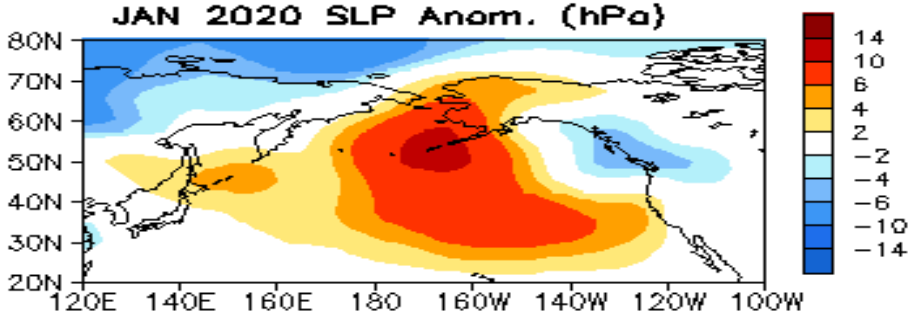
- The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.

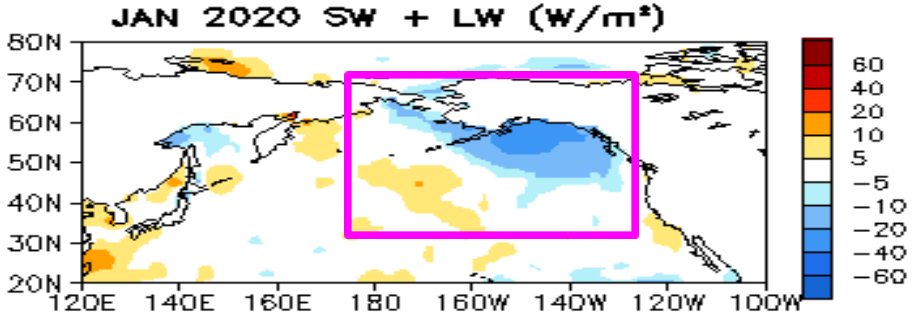
North Pacific & Arctic Ocean: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx











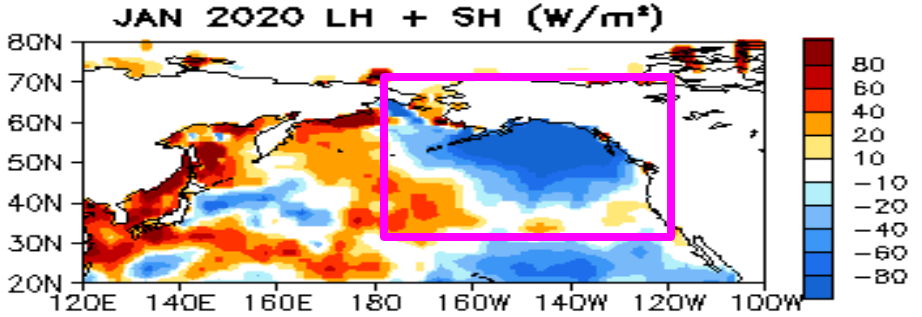
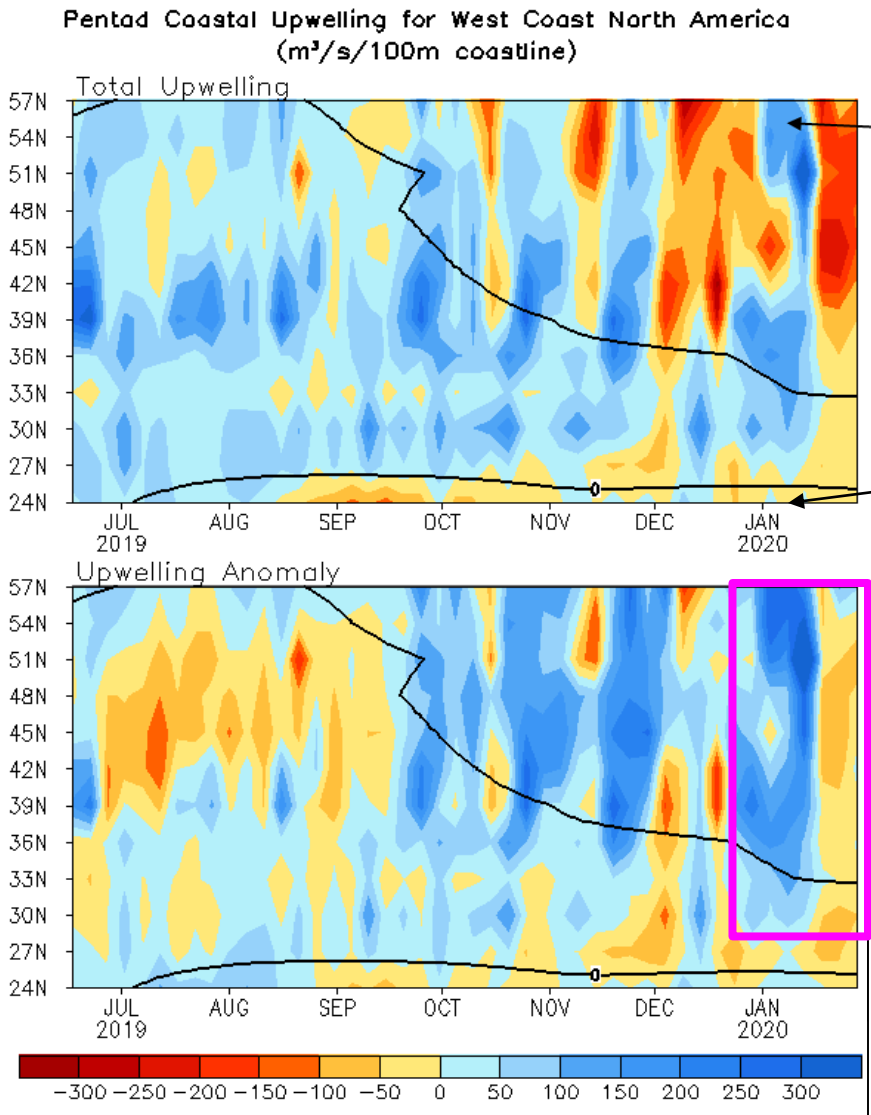
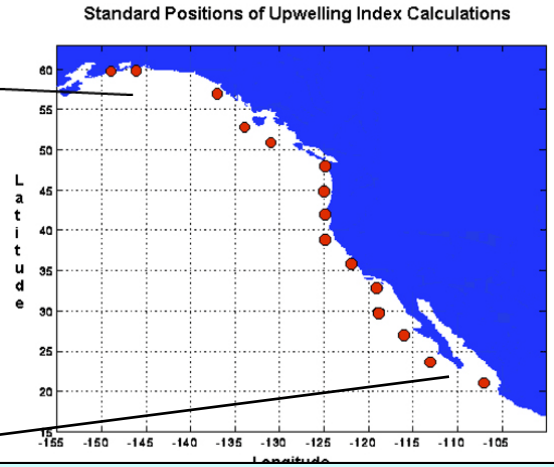


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible heat flux anomalies (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, sea surface pressure 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





- Anomalous upwelling (downwelling) were presented in first (second) half of Jan 2020.

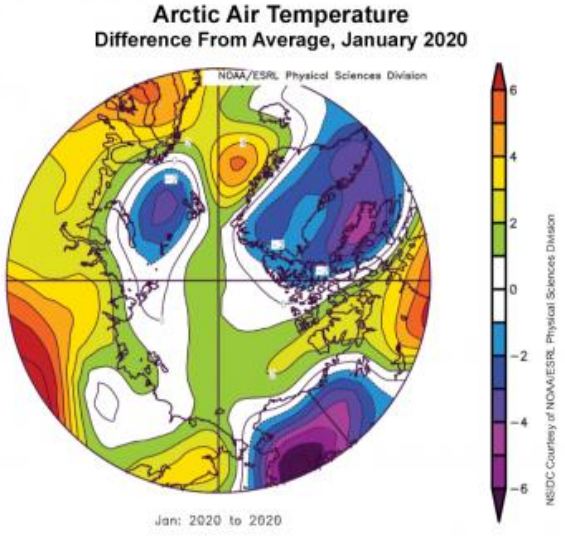
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport 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.

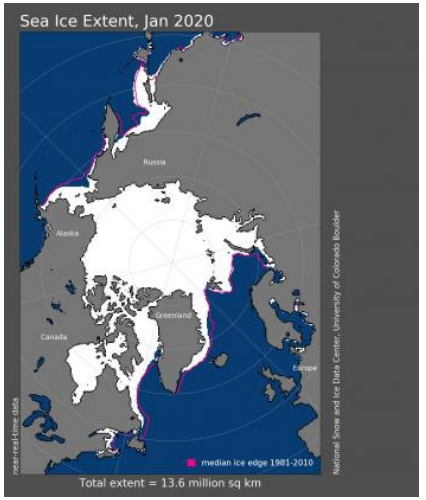
- **Area below (above) black line indicates climatological upwelling (downwelling) season.**
- **Climatologically upwelling season progresses from March to July along the west coast of North America from 36ºN to 57ºN.**

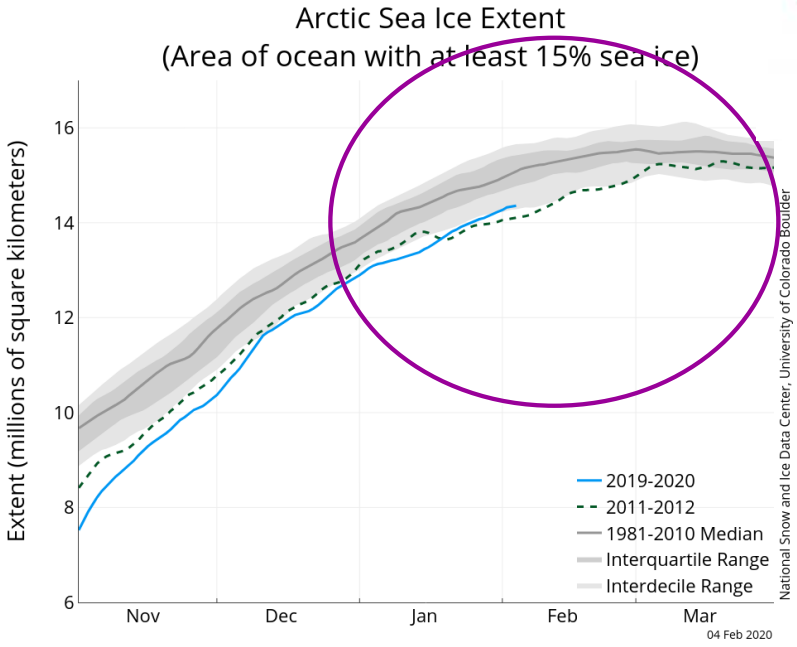
Arctic Sea Ice

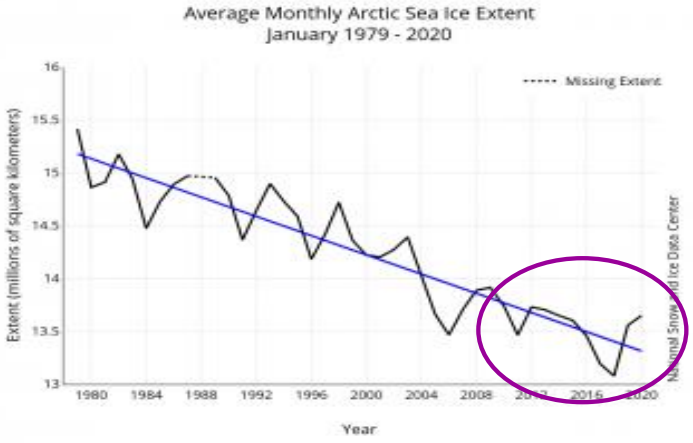
National Snow and Ice Data Center

http://nsidc.org/arcticseaicenews/index.html



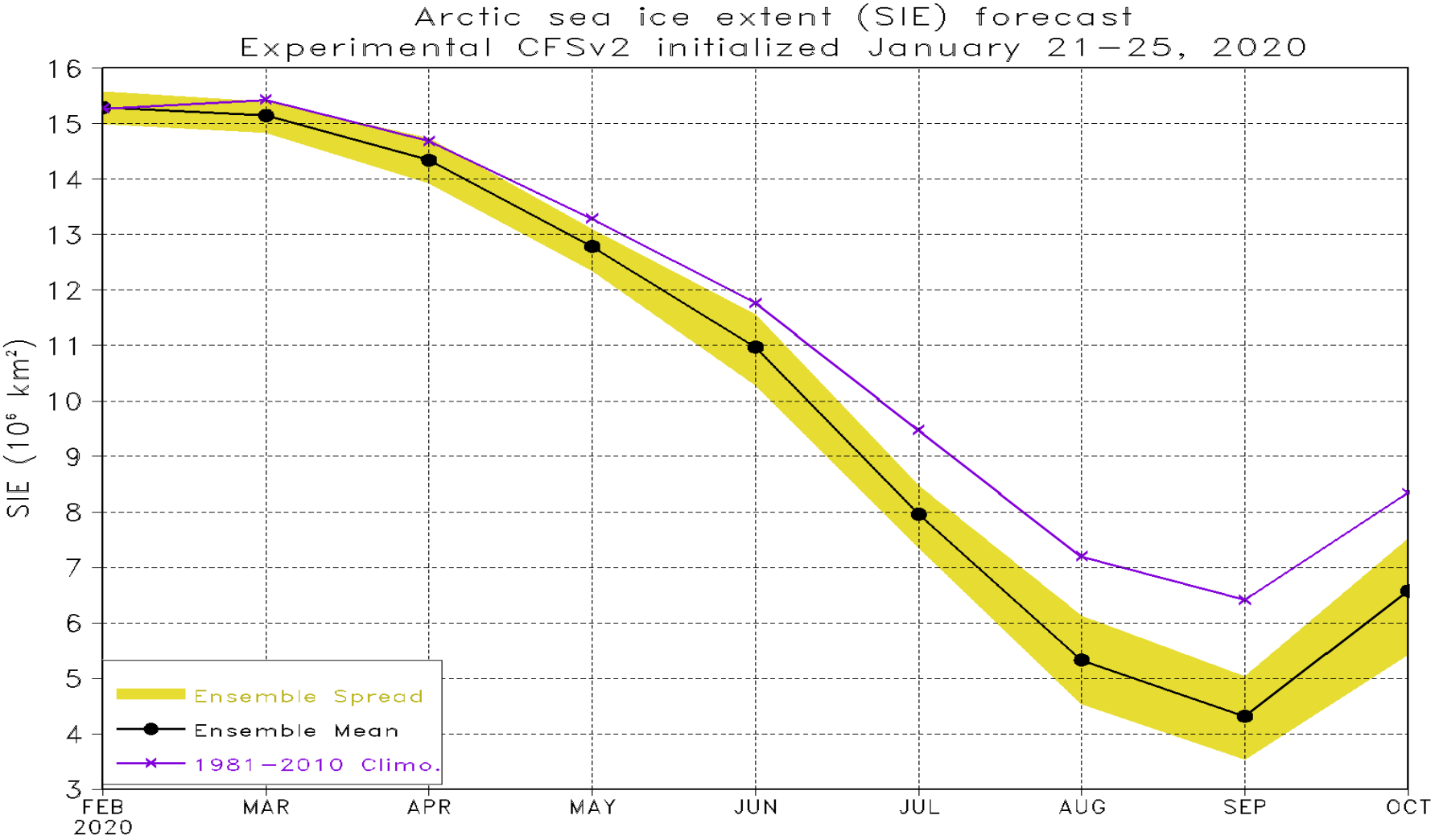






- Sea ice extent for Jan 2020 tracked well below average, with the monthly average ranking as 9th lowest in the satellite record.

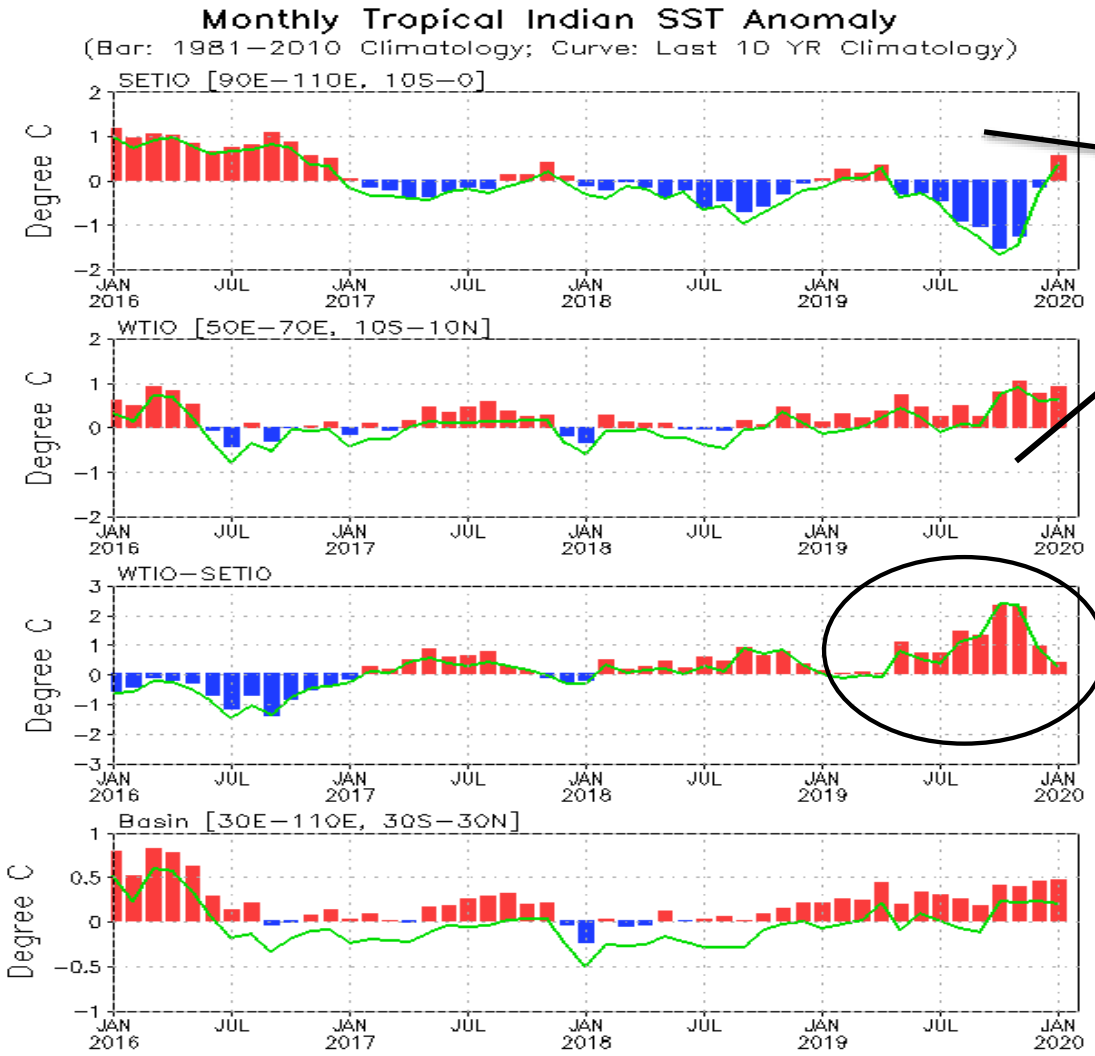
- While air temperatures were above average across much of the Arctic Ocean, it was colder than average over the northern Barents Sea, Alaska, the eastern Canadian Arctic Archipelago, and Greenland.

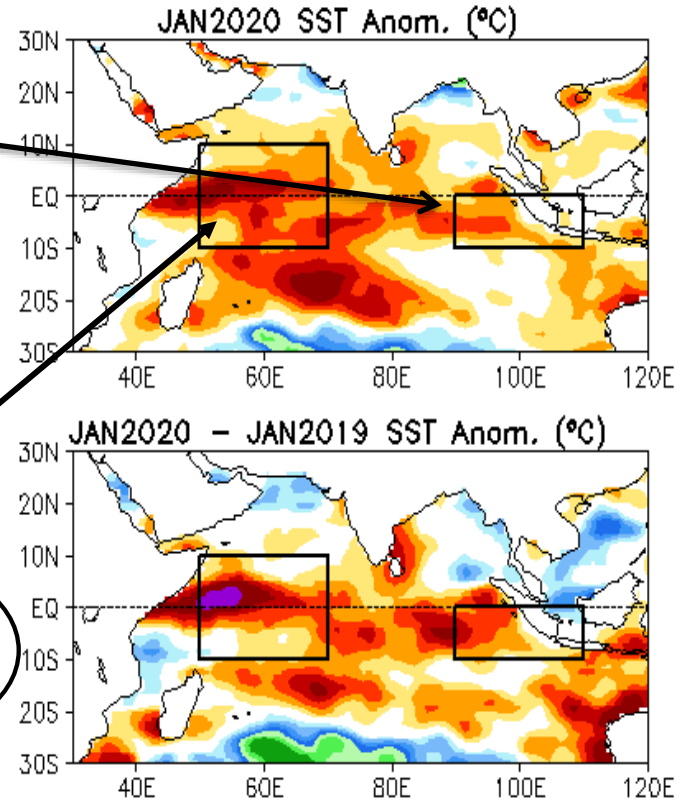


https://www.cpc.ncep.noaa.gov/products/people/wwang/seaice_seasonal/index.html

Indian Ocean

Evolution of Indian Ocean SST Indices





- **Positive (negative) SSTAs were in the west (east), and IOD was in a strong positive phase during May-Jan 2020.**

- **The positive phase of dipole mode further weakened in Jan 2020.**

Fig. I1a. Indian Ocean Dipole region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the SETIO [90°E-110°E, 10°S-0] and WTIO [50°E-70°E, 10°S-10°N] 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.

- SSTAs were positive in the west and central, and small in the far east.
- Positive phase of IOD dismissed and a weak zonal gradient persisted in Jan 2020.

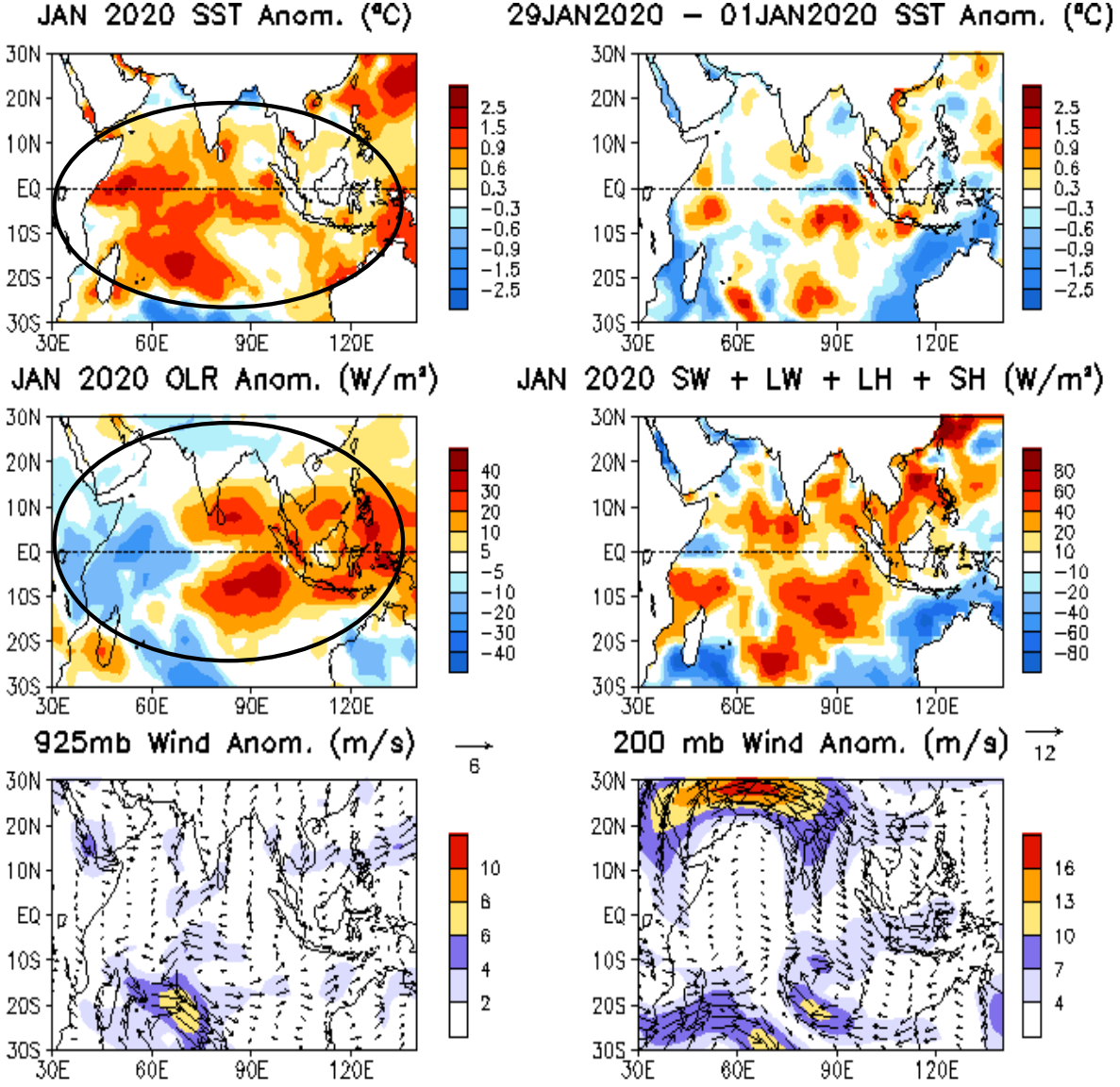
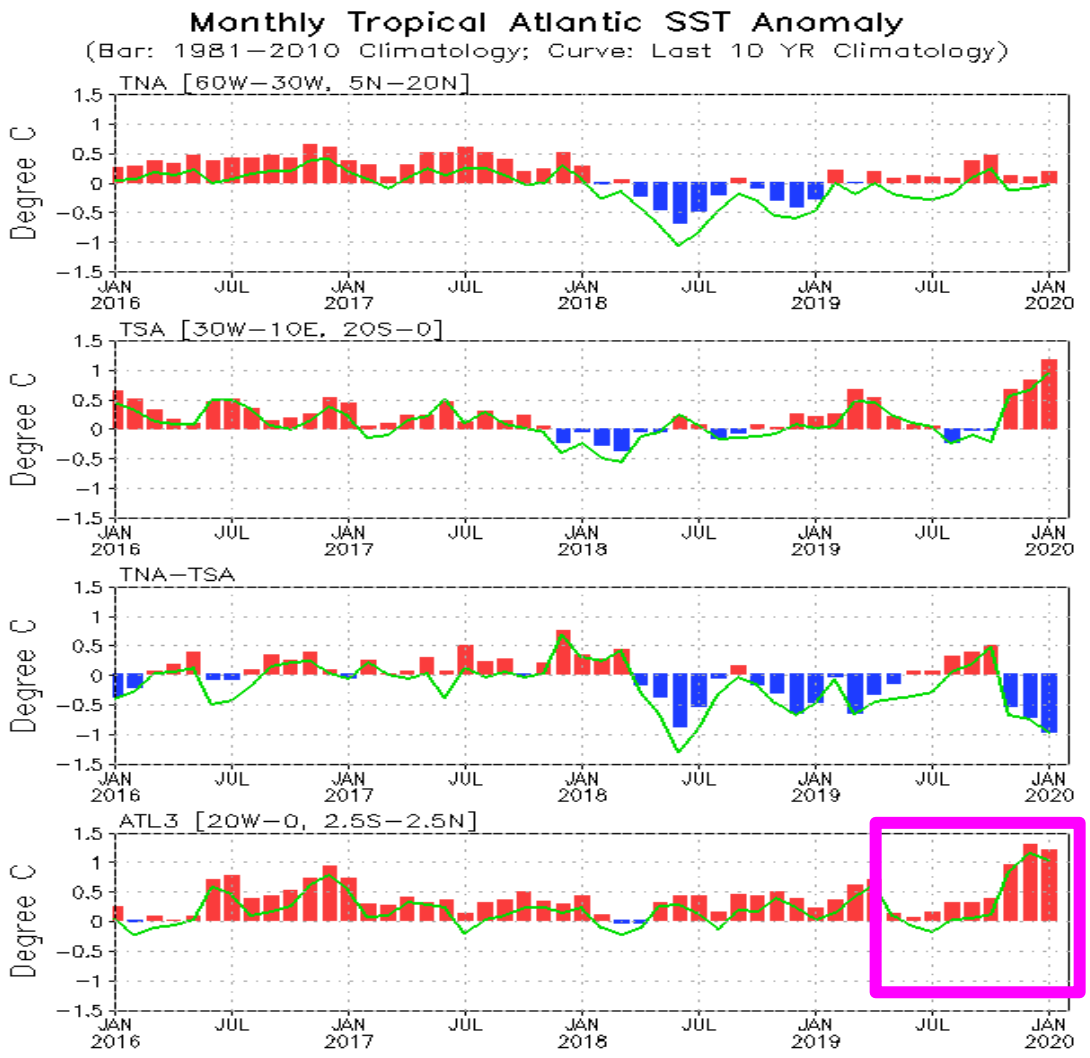
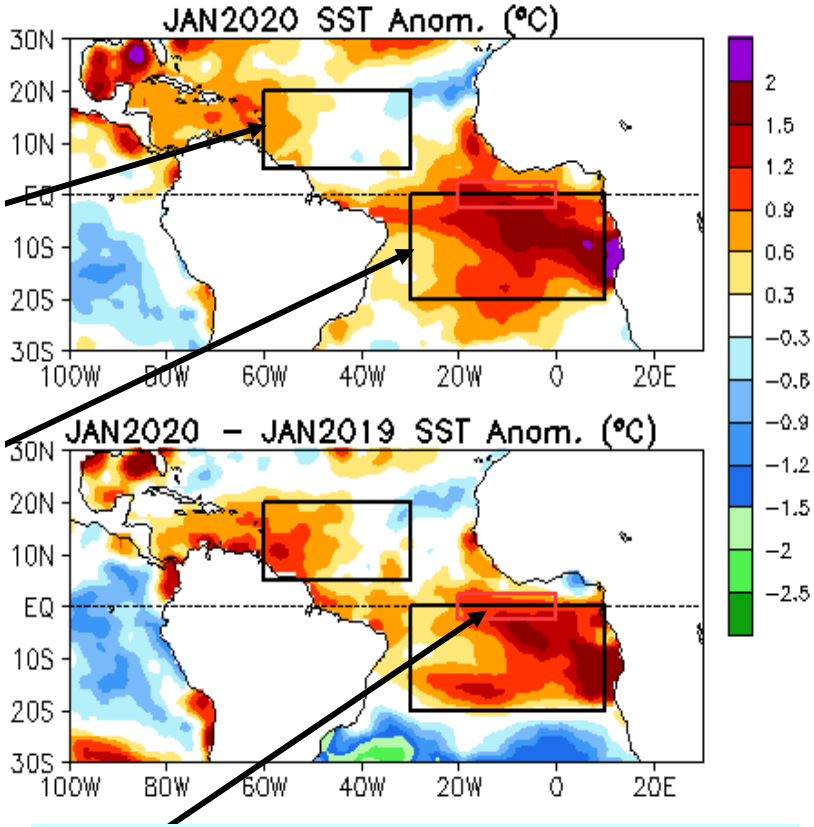


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (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

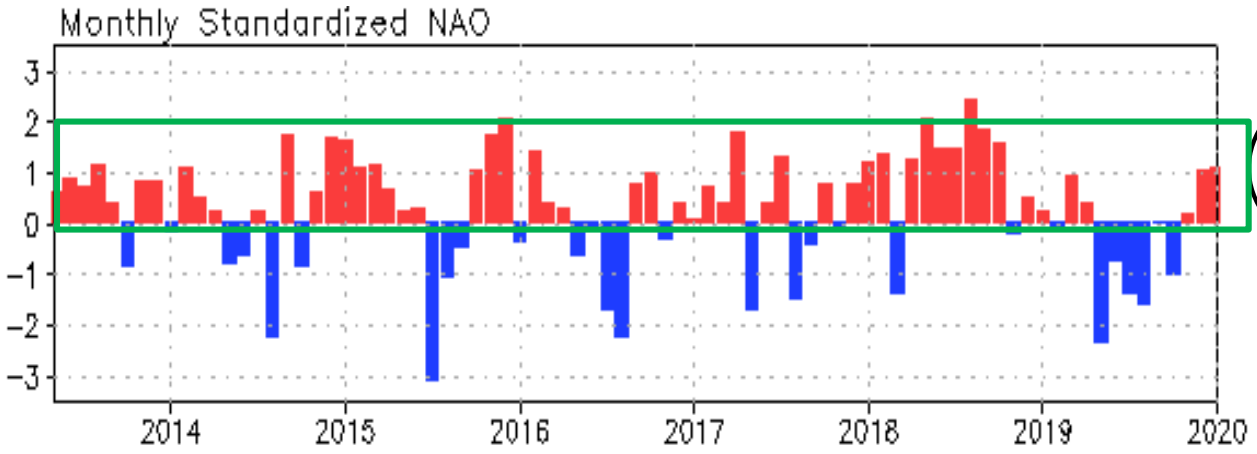


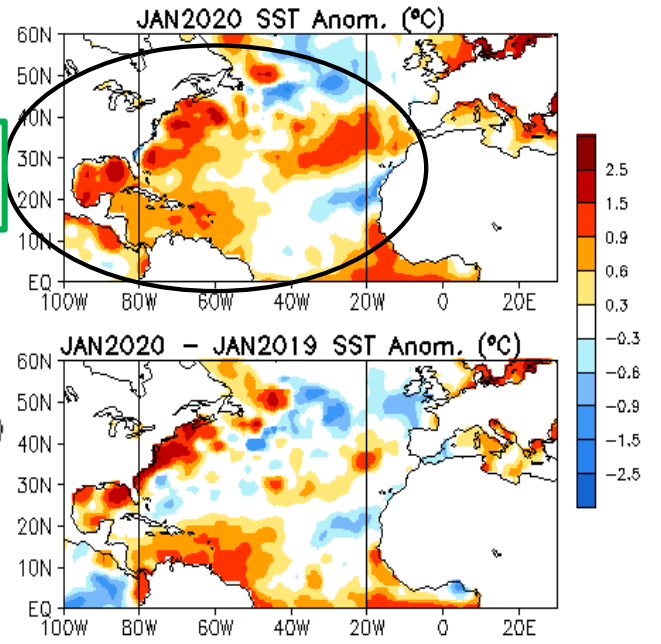


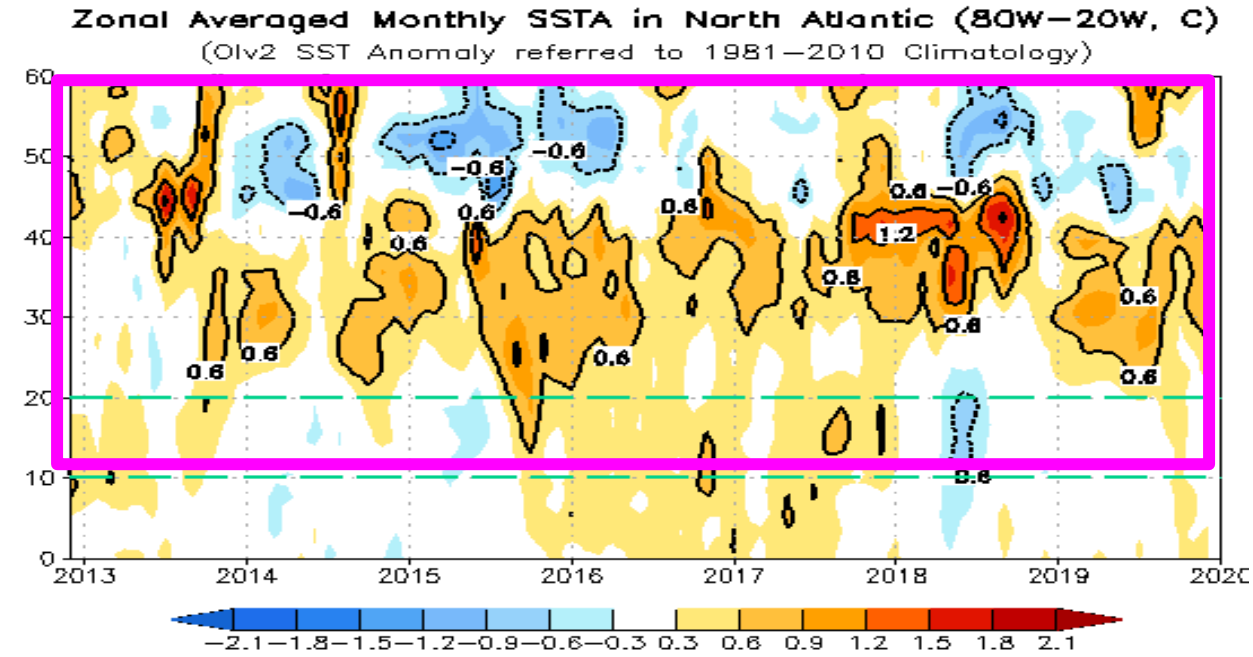
- **The dipole mode was in a negative phase in Nov-Dec 2019 and Jan 2020.**
- **ATL3 was increasing since Jul 2019, consistent with the development of Atlantic Nino.**

Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W-30°W, 5°N-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.

NAO and SST Anomaly in North Atlantic







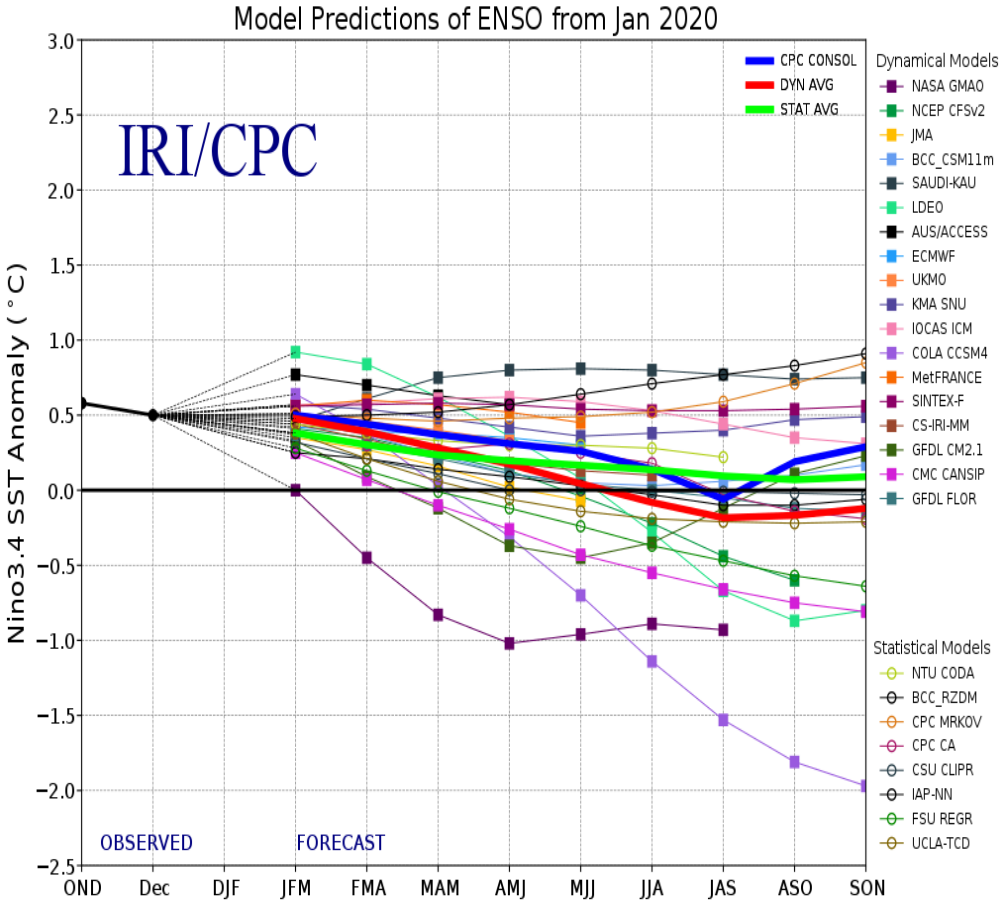
- NAO was still in a positive phase with NAOI= 1.0 in Jan 2020.

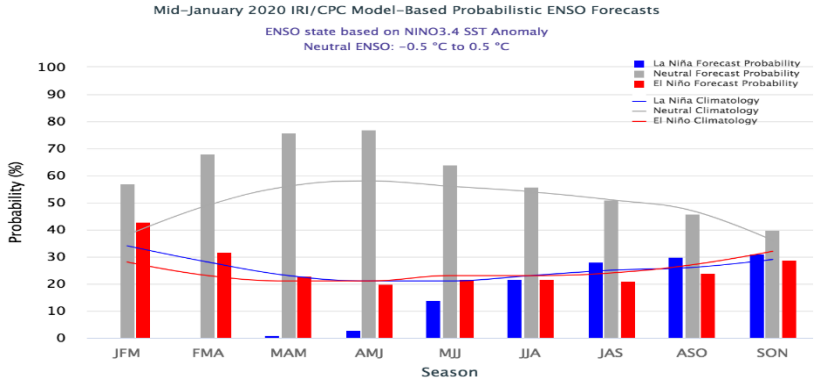
- SSTA was a tripole/horseshoe –like pattern with positive in the mid-latitudes and negative in the lower and higher latitudes, due to the long-term persistence of a positive phase of NAO.

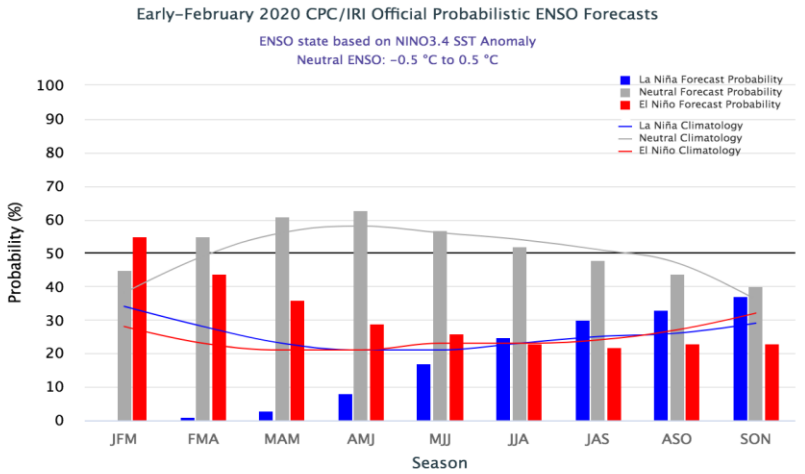
Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20ºN-90ºN (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80ºW and 20ºW (bottom). SST are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

ENSO and Global SST Predictions

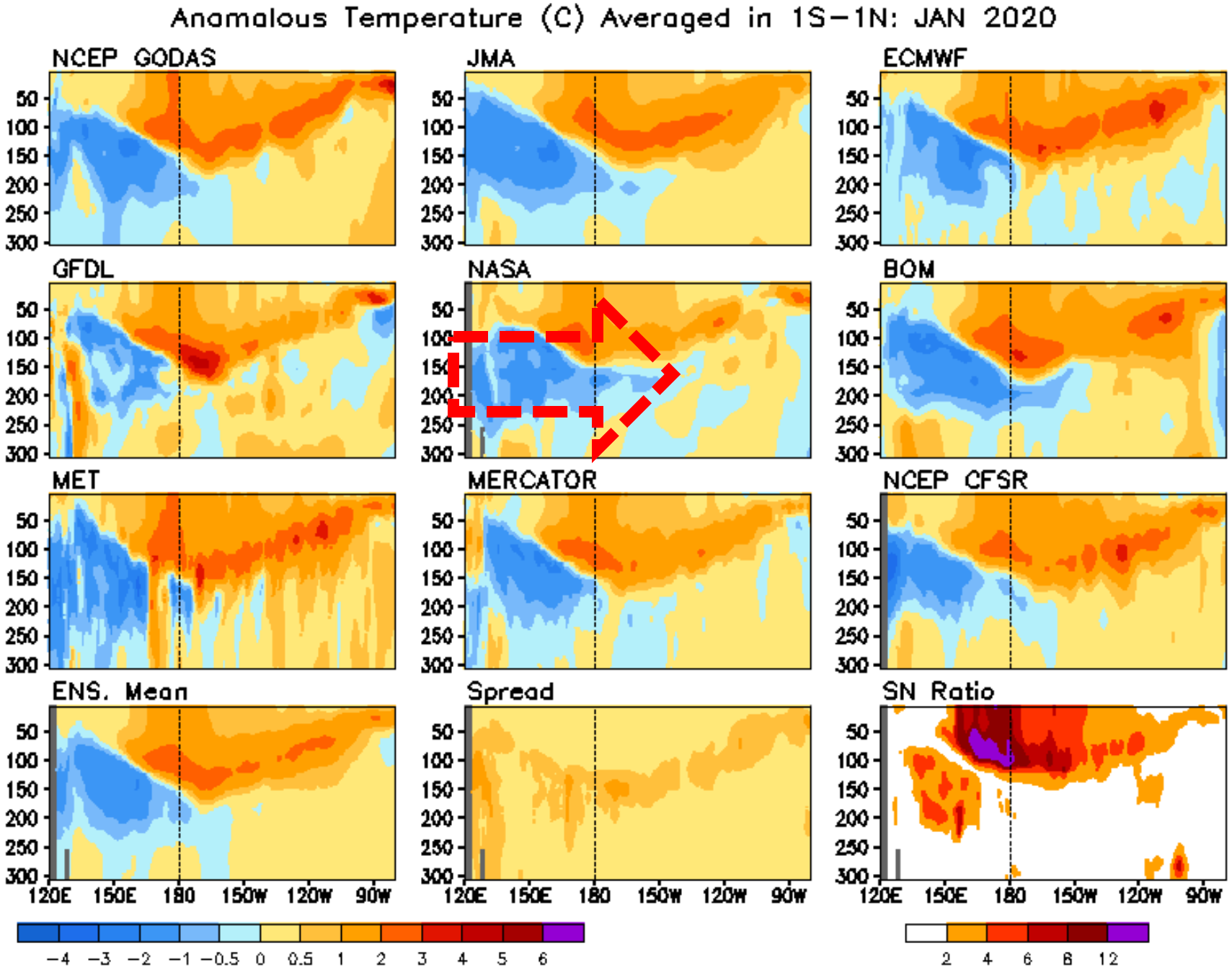
IRI NINO3.4 Forecast Plume





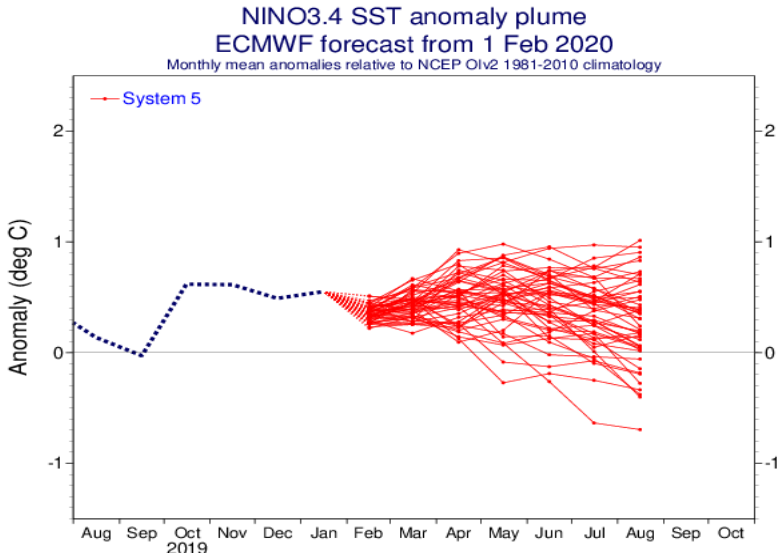


- **Majority of models predict continuation of ENSO-neutral with ICs in Jan 2020.**
- **NOAA "ENSO Diagnostic Discussion" on 13 Feb 2020 stated that *"ENSO-neutral is favored through Northern Hemisphere spring 2020 (~60% chance), continuing through summer 2020 (~50% chance)."***
- **NASA's prediction is an outlier.** It might be associated with the western subsurface cold signal penetrated eastward along the thermocline the most in NASA ODA.

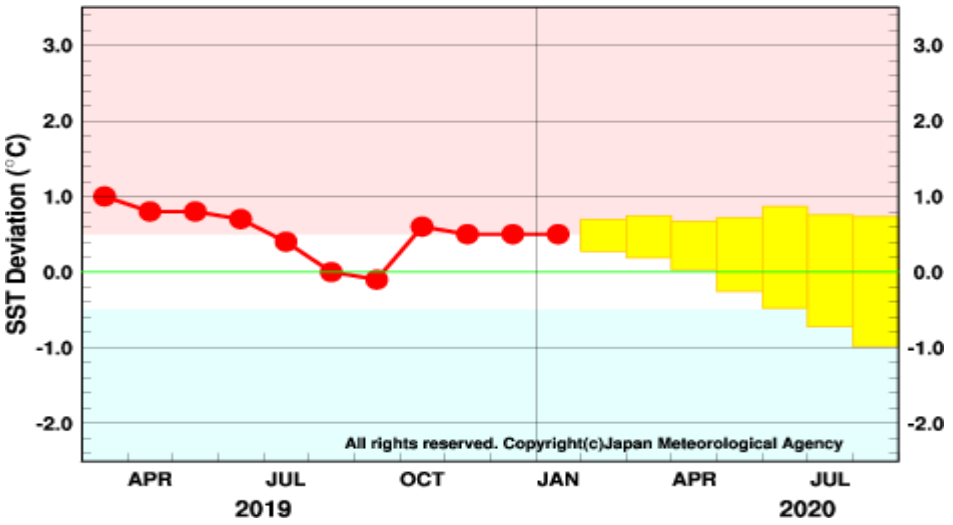

Anomalous Temperature (C) Averaged in 1S−1N: JAN 2020
NCEP GODAS
JMA
ECMWF
GFDL
NASA
BOM
MET
MERCATOR
NCEP CFSR
ENS. Mean
Spread
SN Ratio
50
100
150
200
250
300
120E
150E
180
150W
120W
90W
−4 −3 −2 −1 −0.5 0 0.5 1 2 3 4 5 6
2 4 6 8 12

Individual Model Forecasts: Neutral or borderline El Nino

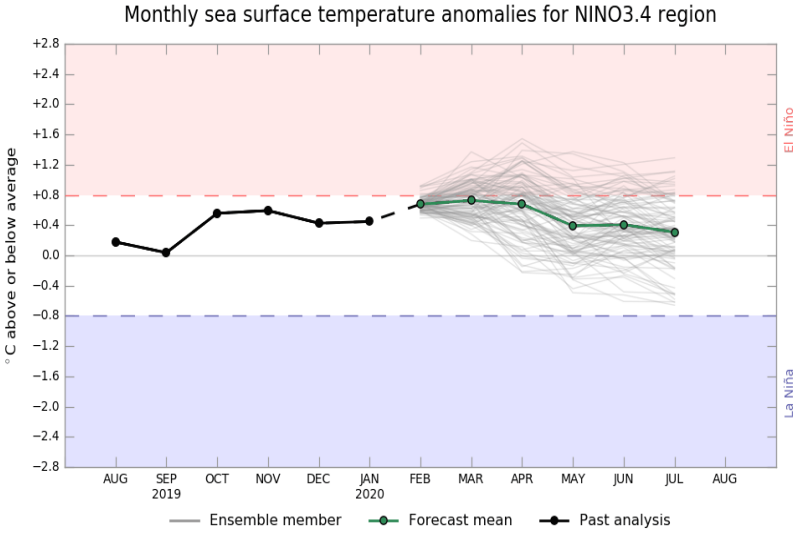
EC: Nino3.4, IC=01 Feb 2020



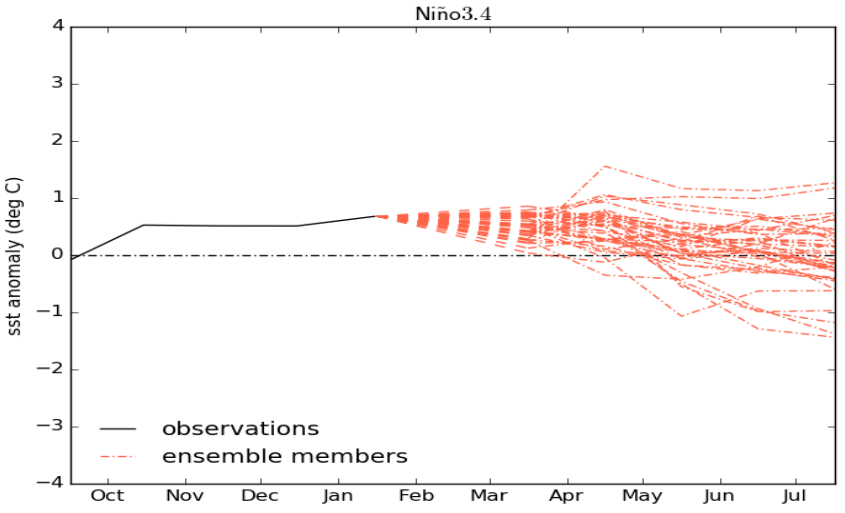
JMA: Nino3.4, Updated 10 Feb 2020

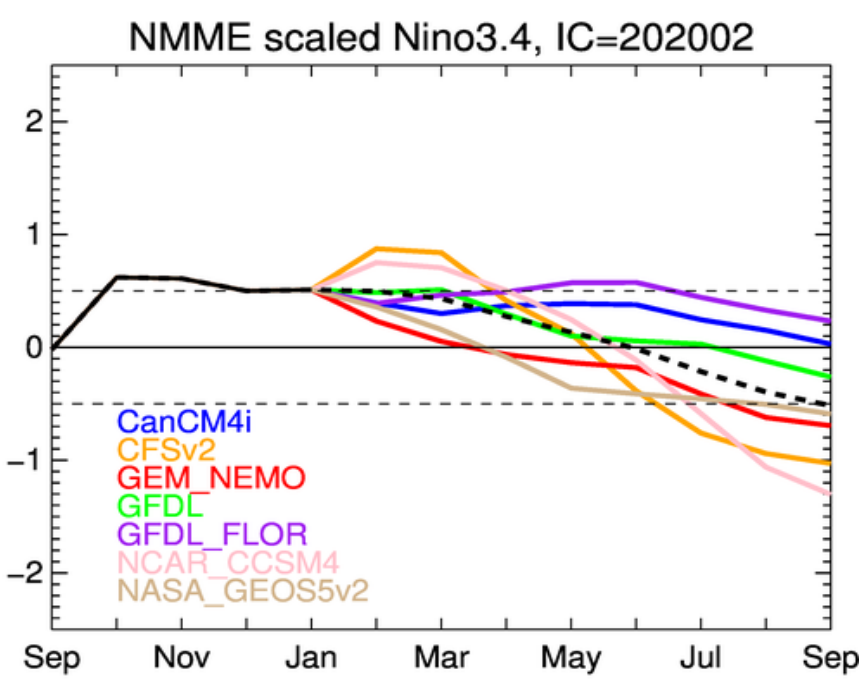


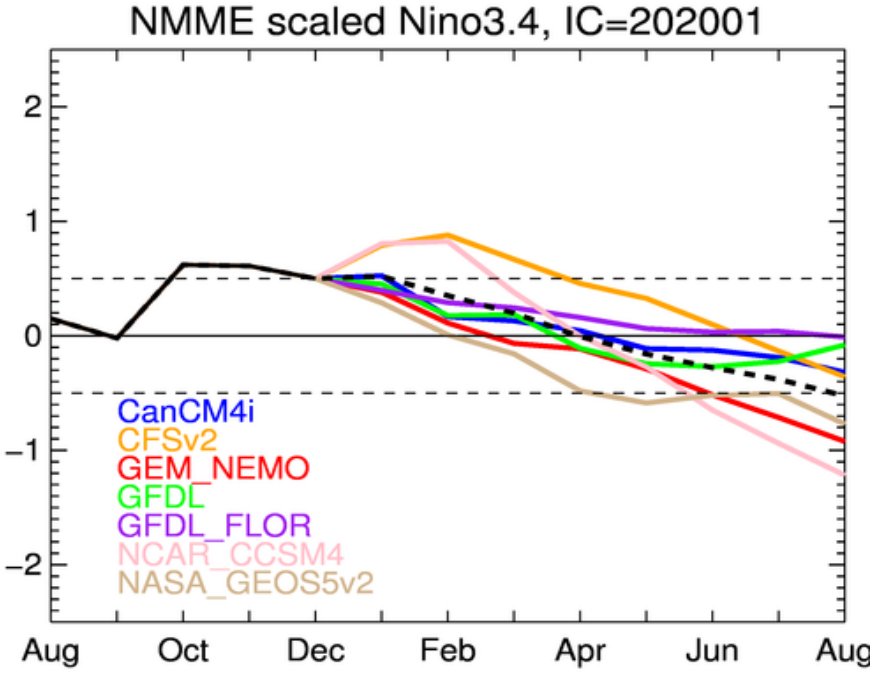
Australia: Nino3.4, Updated 01 Feb 2020

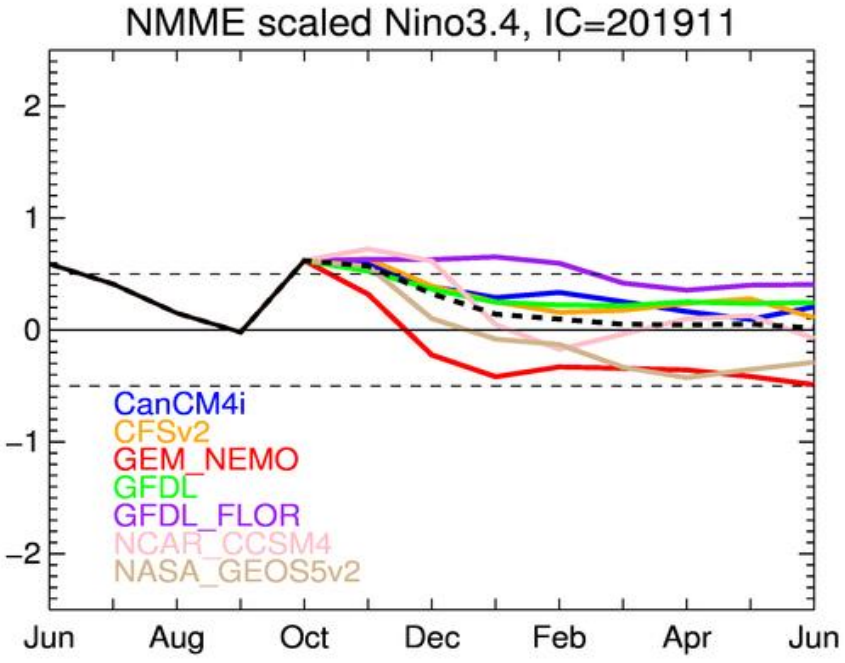


UKMO: Nino3.4, Updated 11 Feb 2020




NMME scaled Nino3.4, IC=202002
2
1
0
−1
−2
CanCM4i
CFSv2
GEM_NEMO
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2
Sep
Nov
Jan
Mar
May
Jul
Sep


NMME scaled Nino3.4, IC=202001
2
1
0
−1
−2
CanCM4i
CFSv2
GEM_NEMO
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2
Aug
Oct
Dec
Feb
Apr
Jun
Aug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GFDL
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NASA_GEOS5v2
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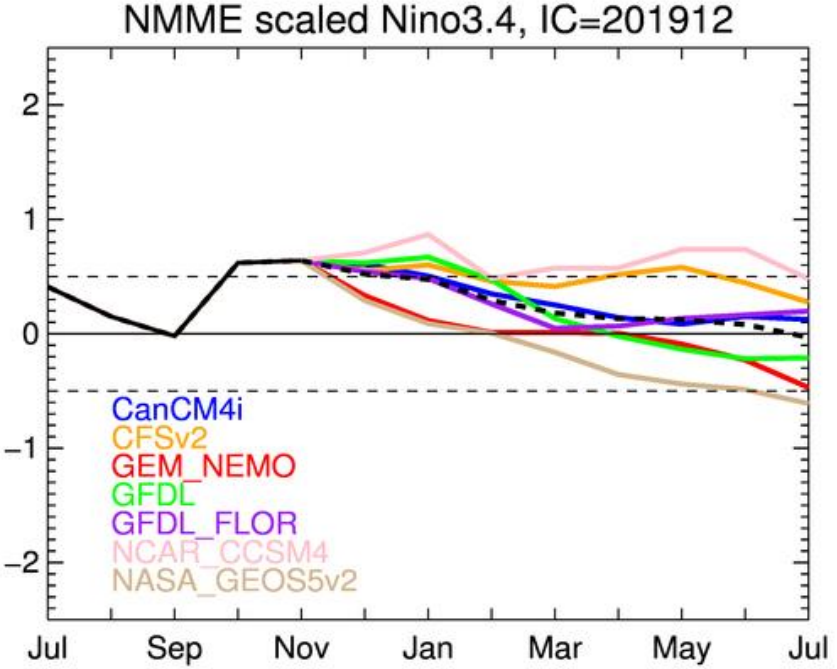
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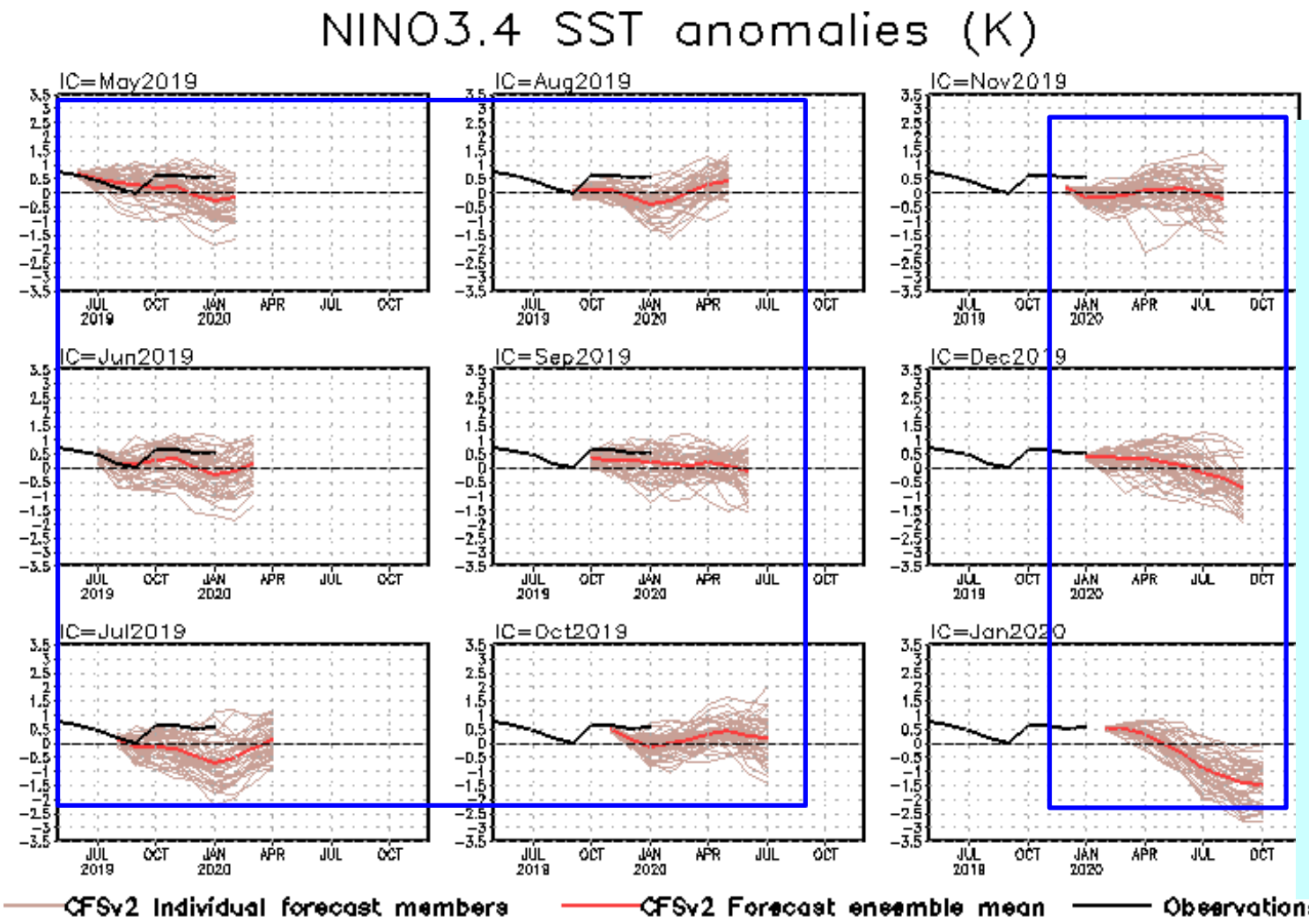
CFSv2
GEM_NEMO
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2
Jul
Sep
Nov
Jan
Mar
May
Jul

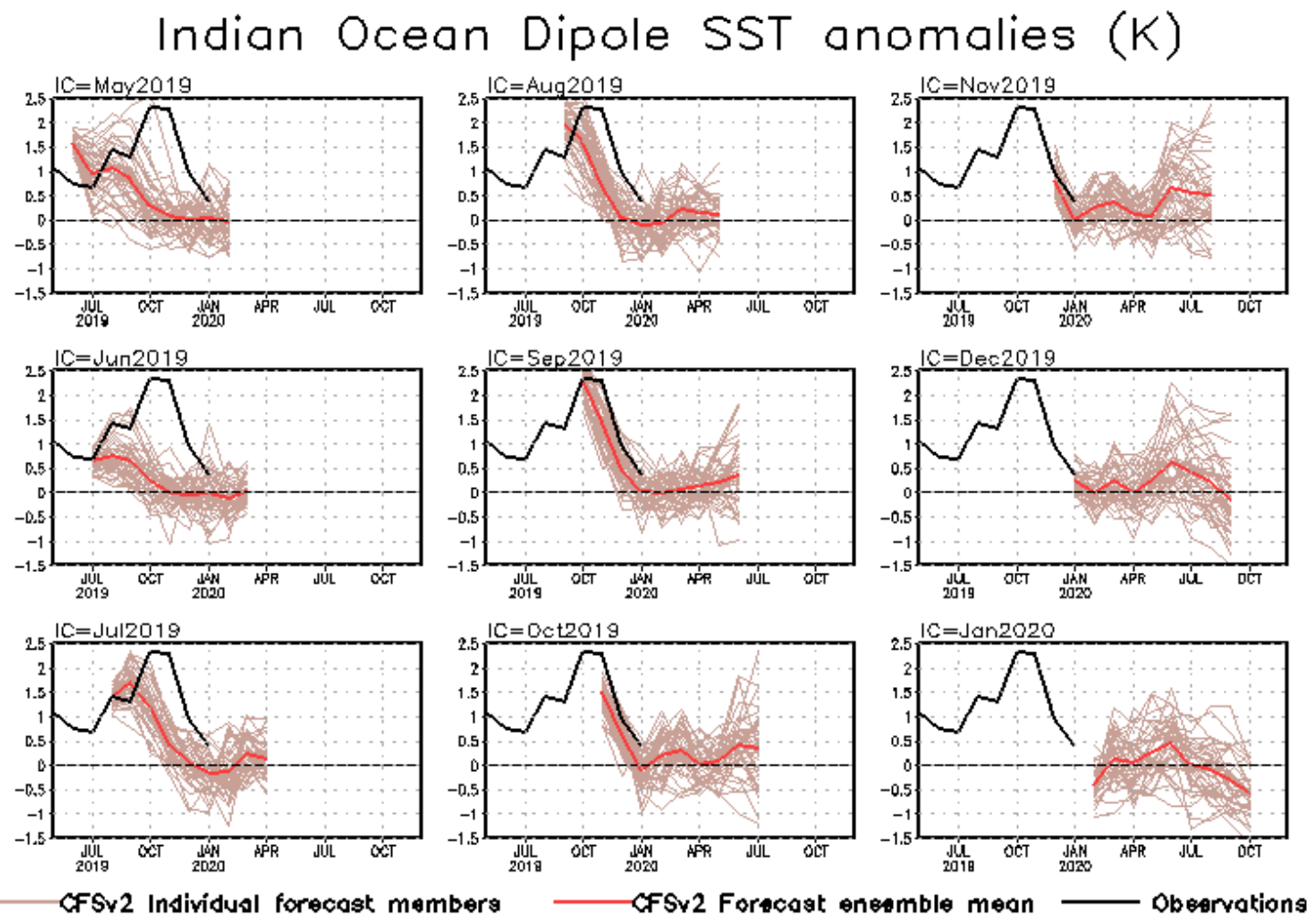
CFS Niño3.4 SST Predictions from Different Initial Months



- CFSv2 had cold bias with ICs during May-Nov 2019.
- The latest forecasts call for ENSO neutral until early summer 2020, for La Nina since mid-summer.

Fig. M1. 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.

NCEP CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

SETIO = SST anomaly in [90°E-110°E, 10°S-0]

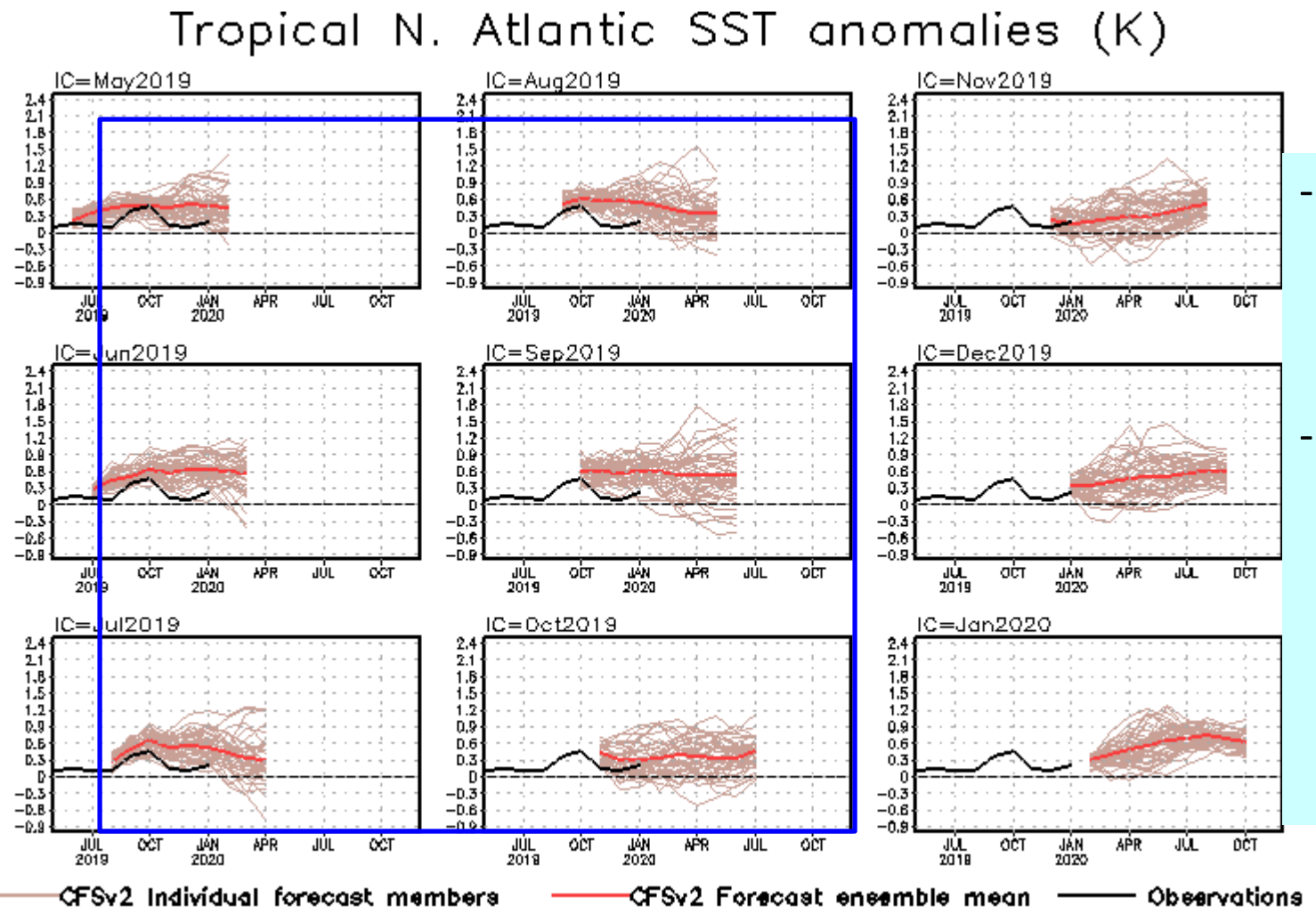
WTIO = SST anomaly in [50°E-70°E, 10°S-10°N]

- **Latest CFSv2 predictions call neutral phase of IOD in 2020.**

Fig. M2. 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 1981-2010 base period means.

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

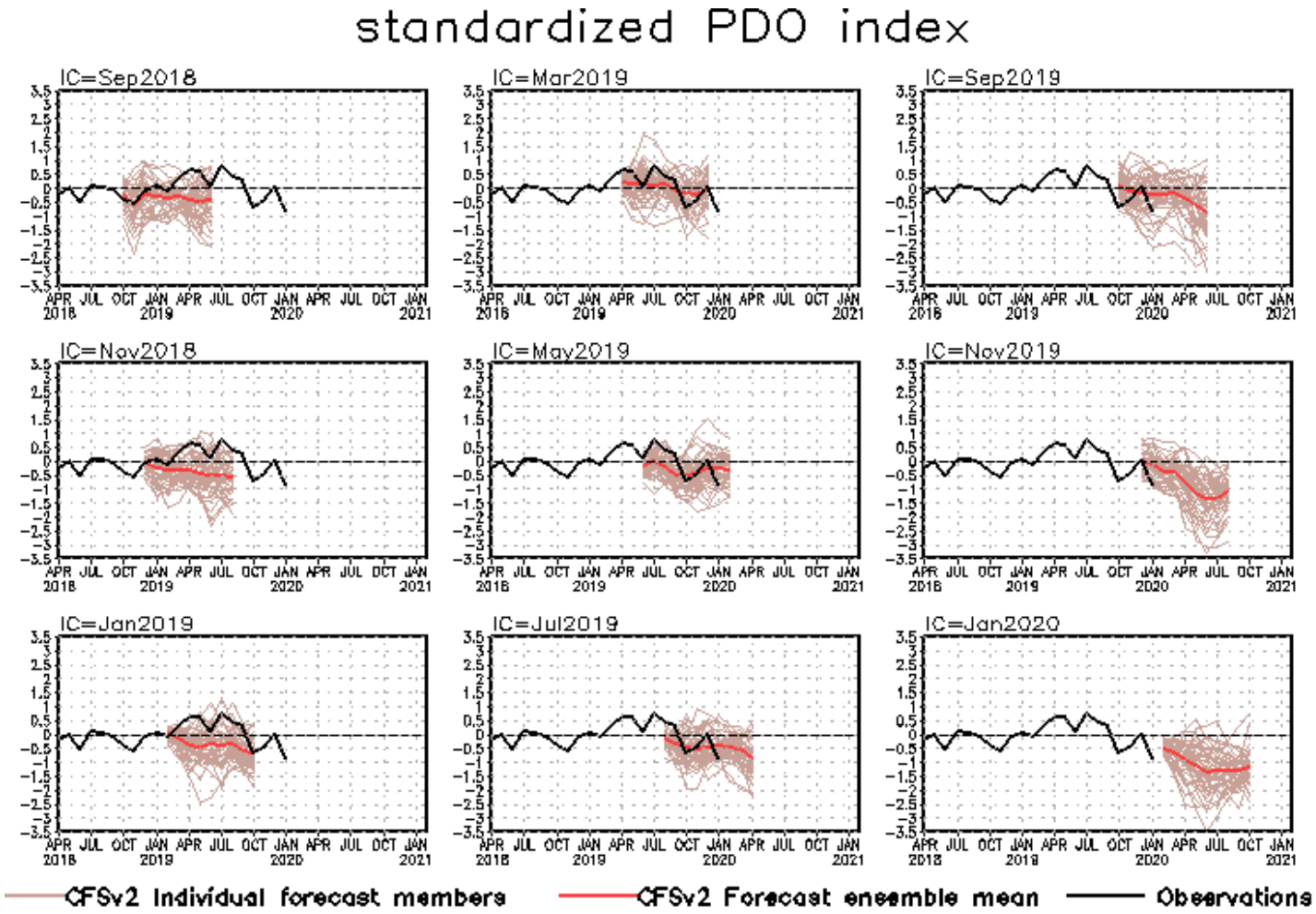
TNA is the SST anomaly averaged in the region of [60°W-30°W, 5°N-20°N].



- **Predictions had warm biases for ICs in Sep 2018-Oct 2019.**
- **Latest CFSv2 predictions call above normal SSTA in the tropical N. Atlantic in 2020.**

Fig. M3. 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.

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



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.

- CFSv2 predicts a negative phase of PDO in 2020.

Fig. M4. 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.

Acknowledgements

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

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- Drs. Li Ren and Pingping Xie provided the SSS slides

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

Please send your comments and suggestions to:

Zeng-Zhen.Hu@noaa.gov

Arun.Kumar@noaa.gov

Caihong.Wen@noaa.gov

Jieshun.Zhu@noaa.gov

Backup Slides

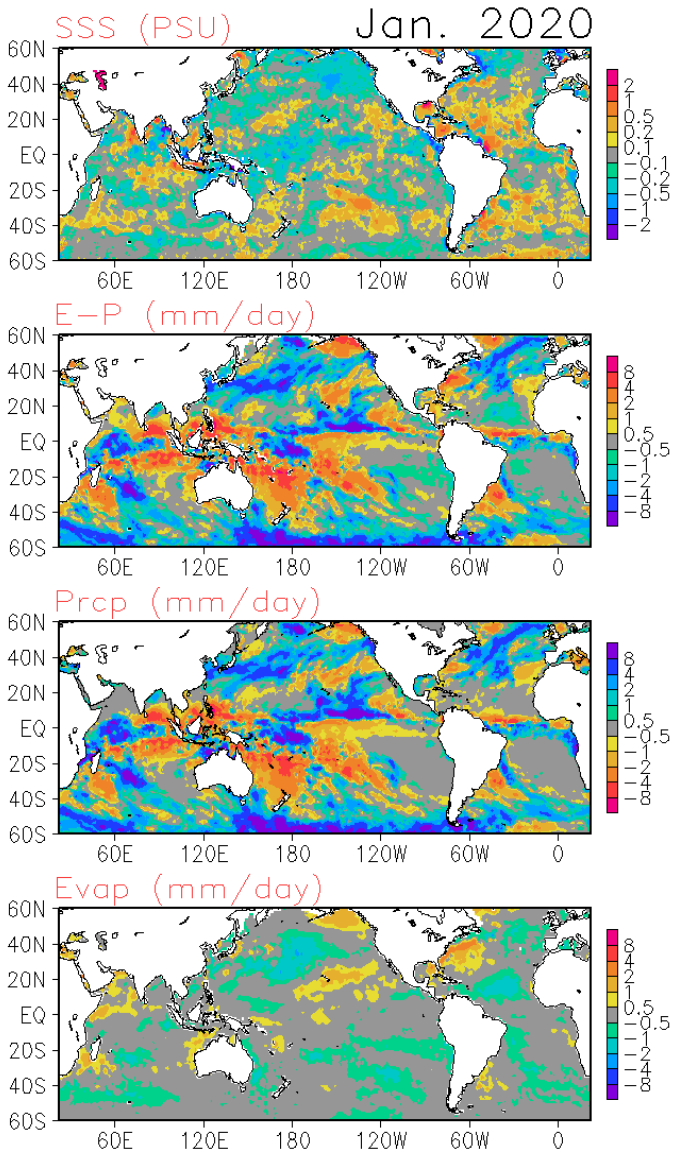
Global Sea Surface Salinity (SSS)

Anomaly for January 2020

- New Update: The input satellite sea surface salinity of SMAP from NSAS/JPL was changed from Version 4.0 to Near Real Time product in August 2018.
- Negative SSS anomalies are showing in the subarctic N. Pacific ocean and N. Atlantic ocean along the storm track, which are likely caused by the enhanced precipitation. Negative SSS signal in the west region of equatorial Pacific is accompanied with enhanced precipitation. Negative SSS appears south of the Equator in the Atlantic ocean which is co-incident with heavier precipitation. In the Indian Ocean, the dipole pattern of negative/positive SSS signal in the east basin is continuing but likely weakening.

- **Data used**

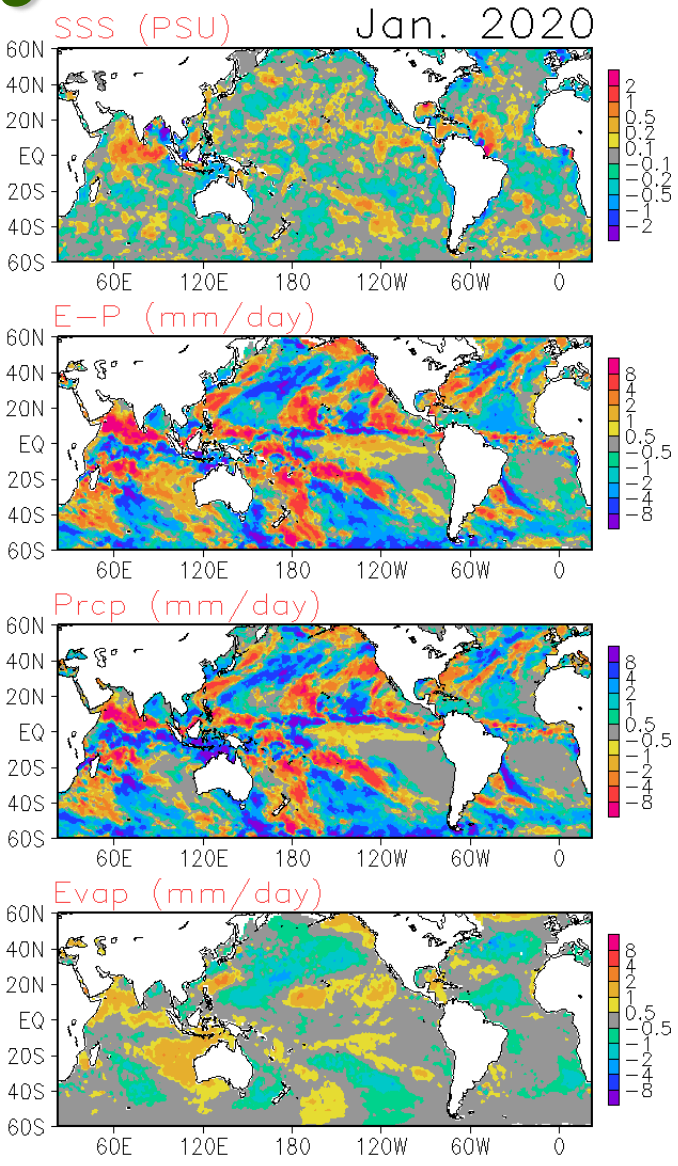
  SSS : Blended Analysis of Surface Salinity (BASS) V0.Z
  (a CPC-NESDIS/NODC-NESDIS/STAR joint effort)
  (Xie et al. 2014)
  ftp.cpc.ncep.noaa.gov/precip/BASS
  Precipitation: CMORPH adjusted satellite precipitation estimates
  Evaporation: Adjusted CFS Reanalysis



Global Sea Surface Salinity (SSS)

Tendency for January 2020

Compared with last month, the SSS decreased in the subarctic N. Pacific ocean along the storm track due to the enhanced precipitation. The large scale positive SSS signal in the Equatorial region of the Indian Ocean is accompanied with reduced freshwater input. In the Bay of Bengal, the SSS decreased in most of the area, especially in the east basin. Such change is probably due to the increased precipitation.

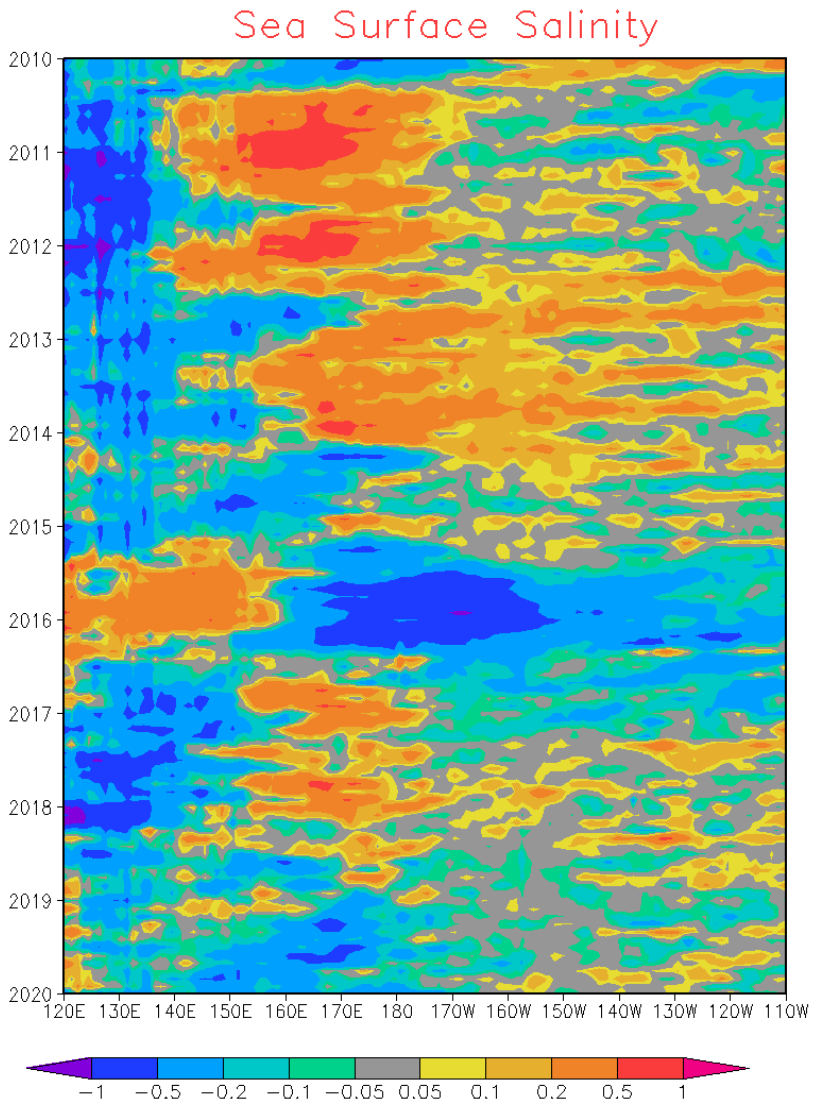


Global Sea Surface Salinity (SSS)

Anomaly Evolution over Equatorial Pacific from Monthly SSS

NOTE: Since June 2015, the BASS SSS is from in situ, SMOS and SMAP; before June 2015,The BAS SSS is from in situ, SMOS and Aquarius.

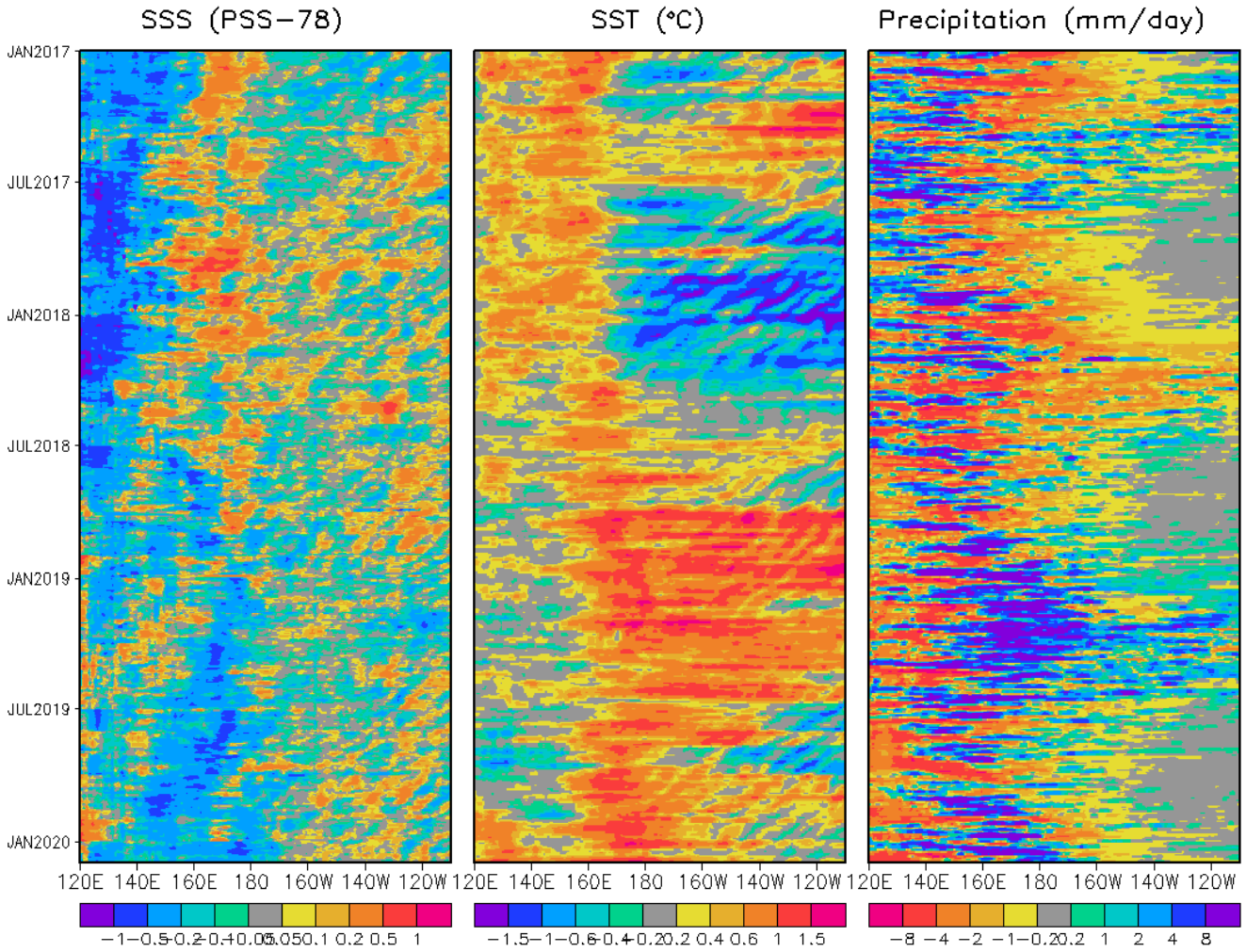
- Hovemoller diagram for equatorial SSS anomaly **(5˚ S-5˚ N);**
- In the equatorial Pacific Ocean, the SSS signal is negative west of 170˚ W with stronger signals between 140˚ E and 170˚ E; the SSS anomalies show positive/neutral signals east of 170˚ W.



Global Sea Surface Salinity (SSS)

Anomaly Evolution along the Equatorial Pacific from Pentad SSS

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.



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

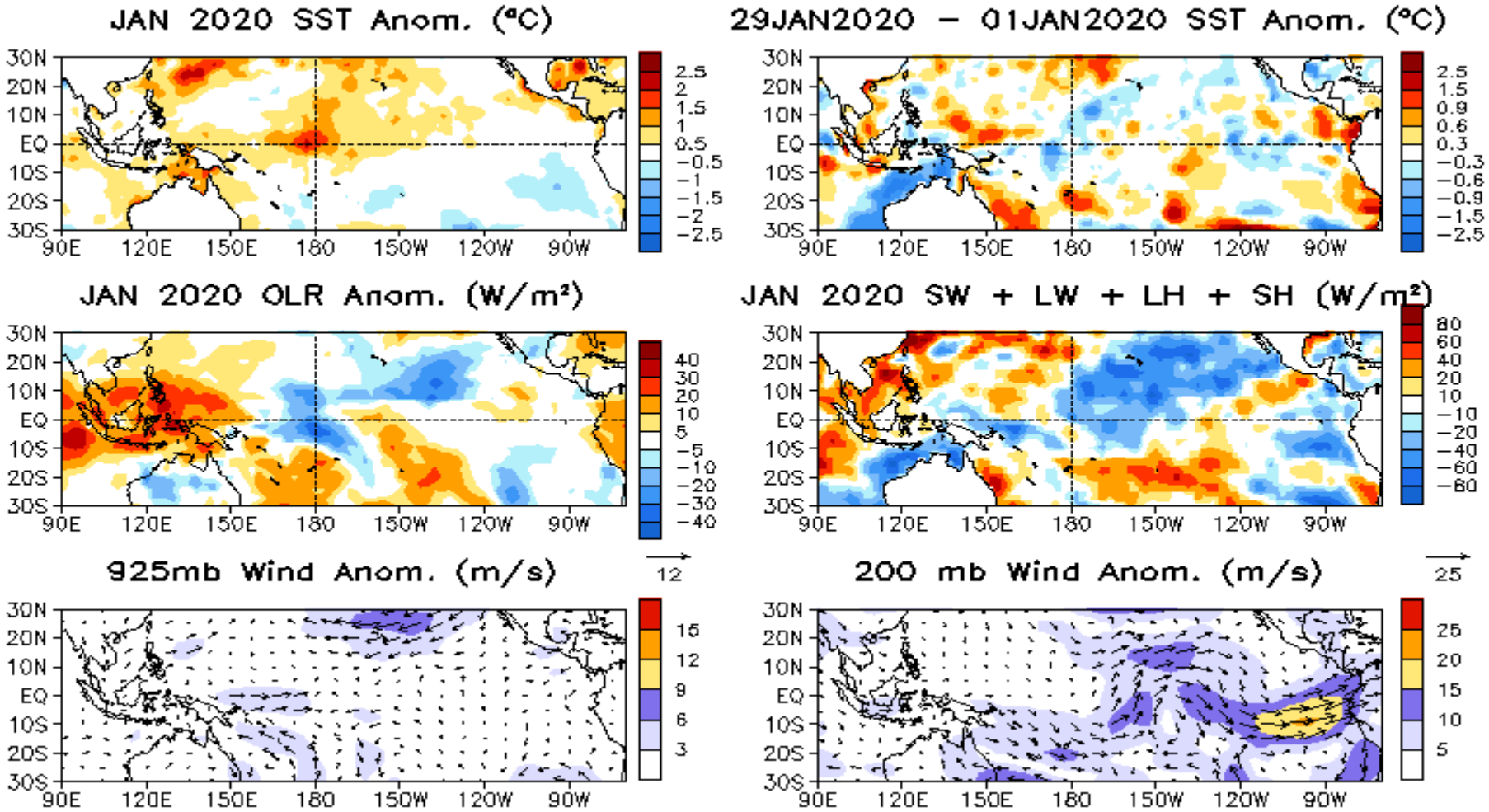
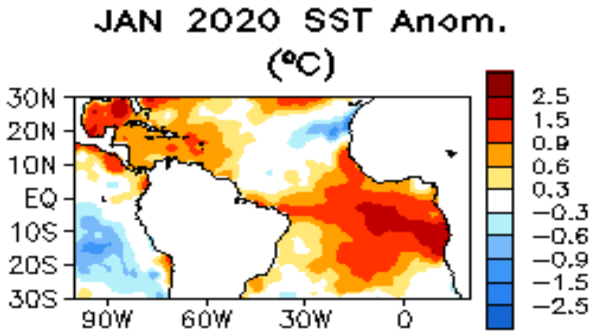
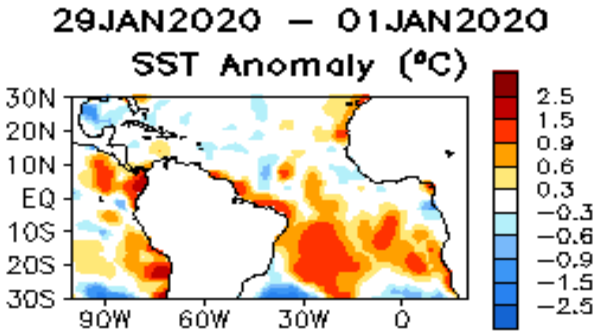
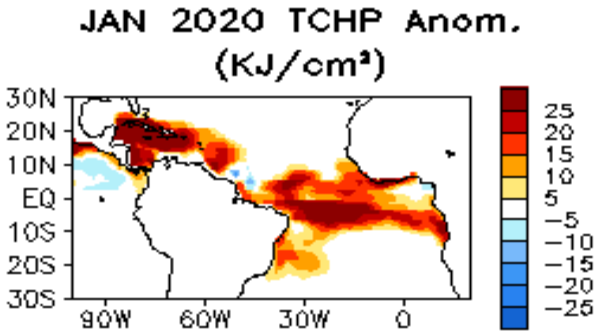


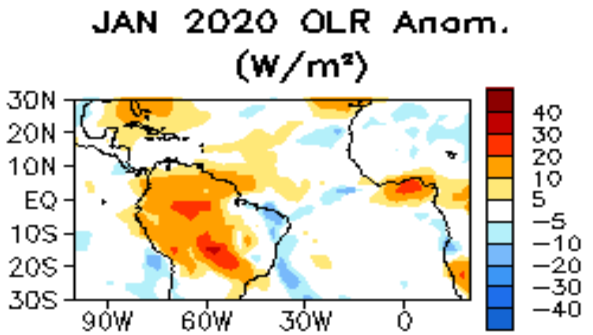
Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (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.

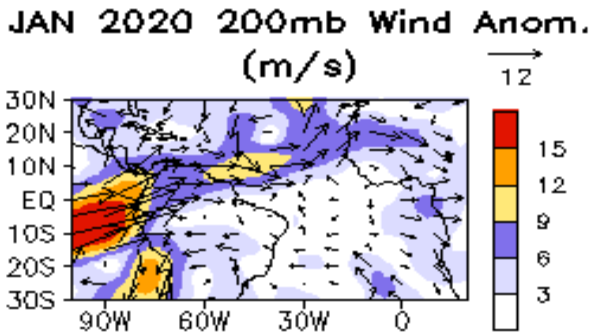
Tropical Atlantic:

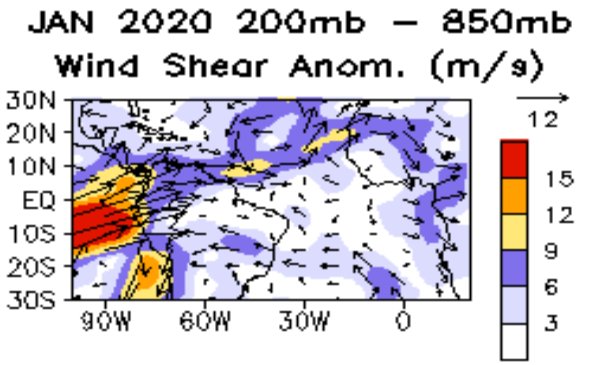


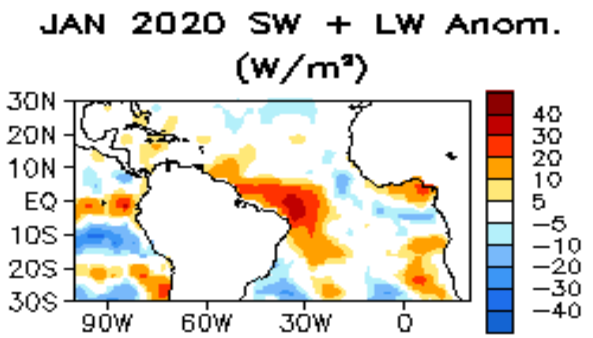


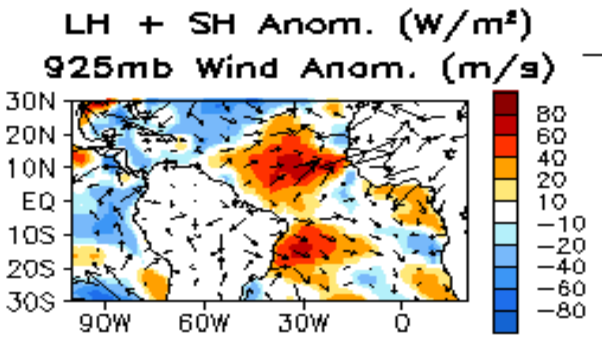


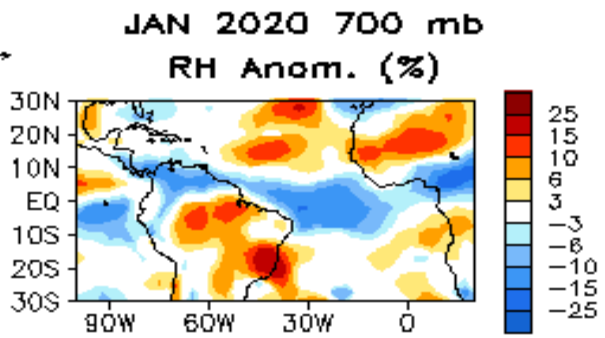












North Atlantic: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx

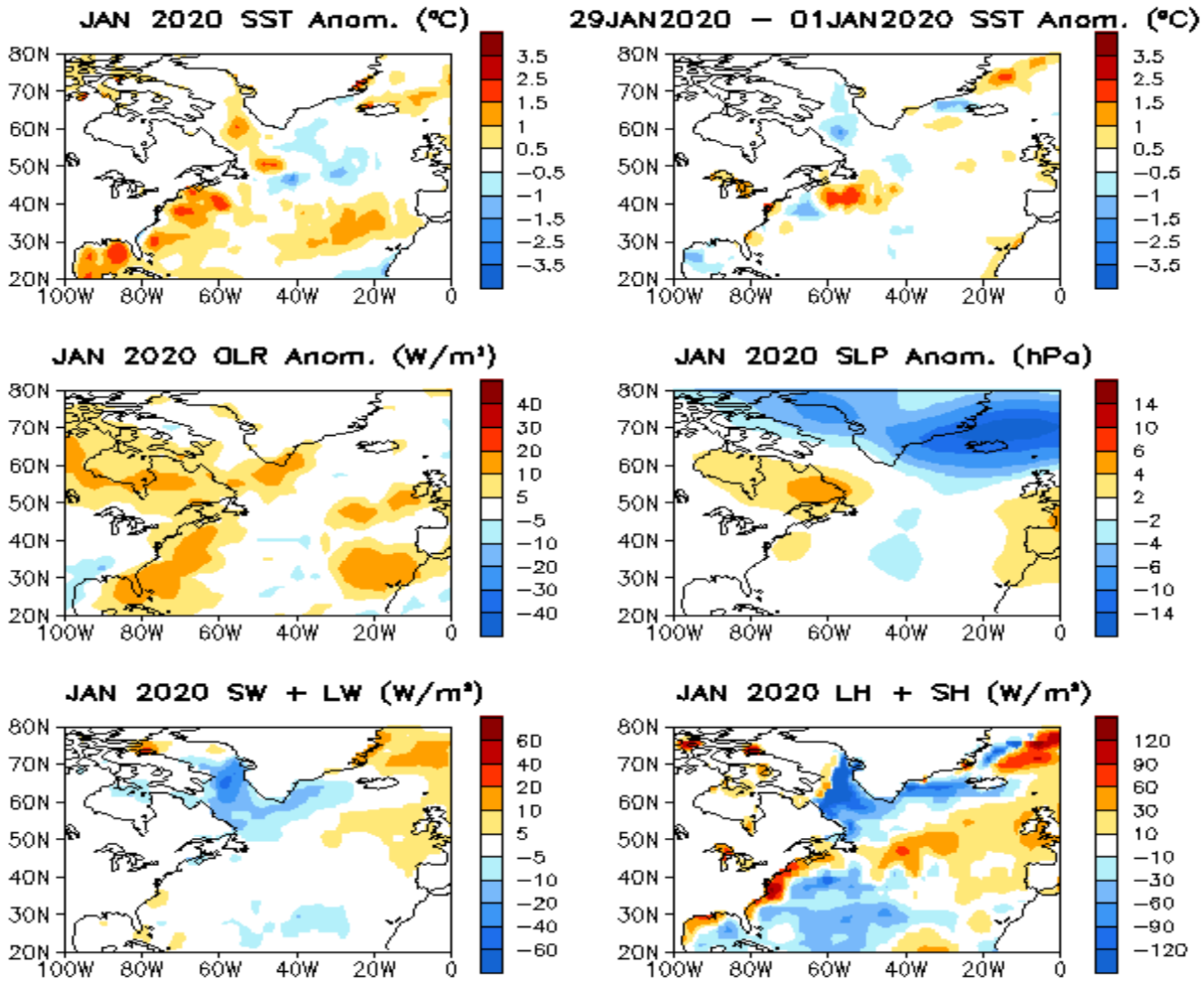


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible heat flux anomalies (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, sea surface pressure and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.

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

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