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 Ocean Observing and Monitoring Division (OOMD)

Outline

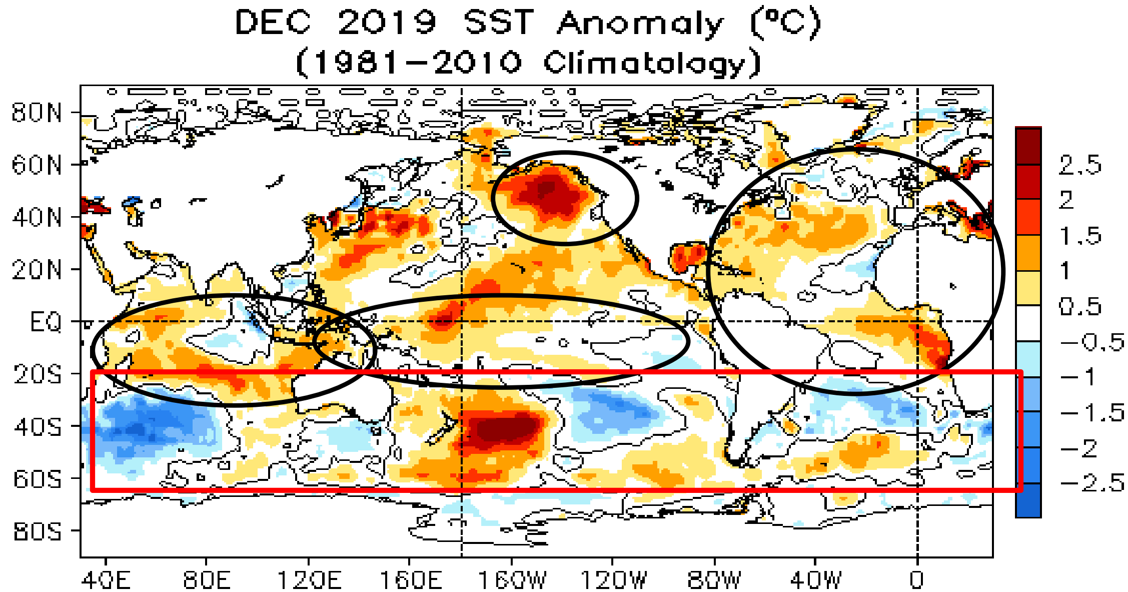
- **Overview**
- **Recent highlights**
  - **Pacific/Arctic Ocean**
  - **Indian Ocean**
  - **Atlantic Ocean**
- **Global SSTA Predictions**
- **NE Pacific Warming: Blob.2**
- **An extreme Indian Ocean Dipole event**

Overview

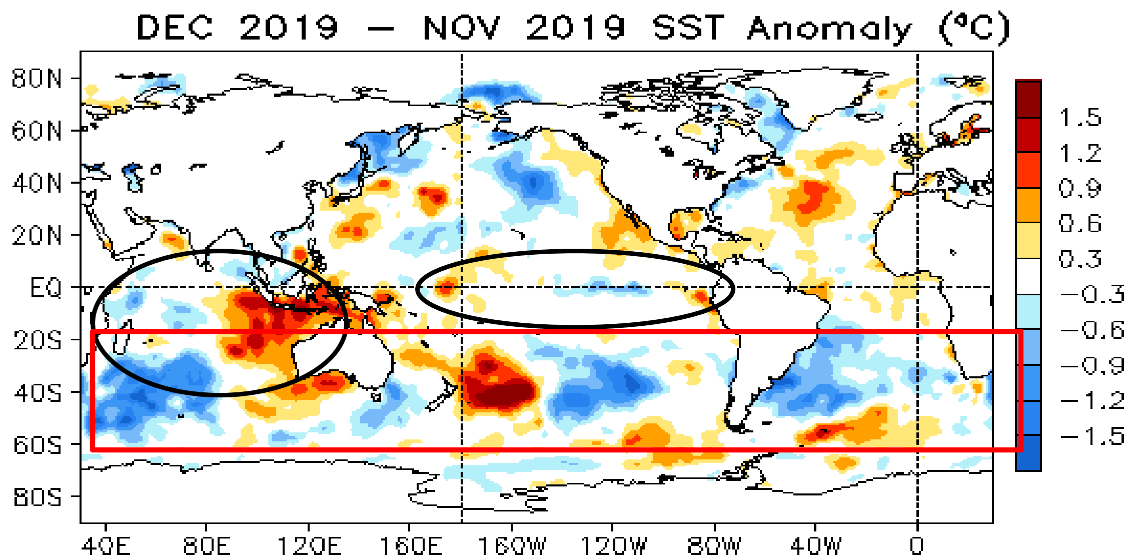
- **Pacific Ocean**
  - **<u>NOAA "ENSO Diagnostic Discussion" on 9 Jan 2020 stated "*ENSO-neutral is favored through Northern Hemisphere spring 2020 (~60% chance), continuing through summer 2020 (~50% chance)*</u>*.*"**
  - **ENSO neutral conditions persisted, and positive SSTAs still presented in the central tropical Pacific with NINO3.4=0.55^{o}C in Dec 2019.**
  - **Positive SSTAs persisted in the NE. Pacific in Dec 2019. The PDO index was near zero with PDOI= 0.05 in Dec 2019.**
  - **Sea ice concentration in the Arctic Ocean in Dec 2019 was tied with 2006 as the fifth lowest Dec extent in the satellite record.**
- **Indian Ocean**
  - **Positive (negative) SSTAs were in the west (far east).**
  - **IOD was still in a positive phase, but weakened in Dec 2019.**
- **Atlantic Ocean**
  - **NAO was in a positive phase with NAOI=1.0 in Dec 2019.**
  - **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 were still large in the NE Pacific (Blob.2).
- Overall positive SSTAs were observed in the North Atlantic and an Atlantic Nino was observed.
- In the Indian Ocean, SSTAs were positive in the west.
- There were strong positive & negative SSTAs in the mid-latitudes of the South Ocean.

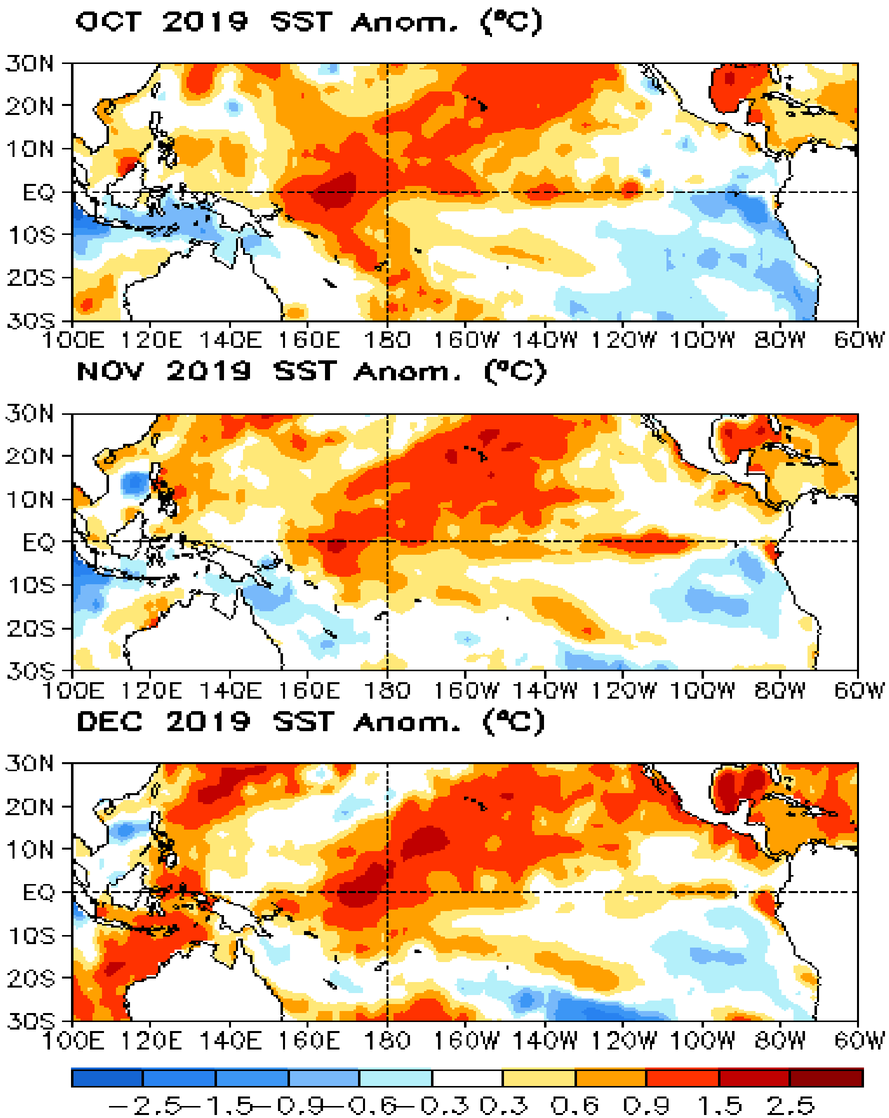


- SSTA tendencies were small negative (positive) in the eastern (central) tropical Pacific.
- SSTA tendencies in the Indian Ocean were positive in the east and negative in the west, implying weakening of the positive phase of current Indian Ocean dipole event.
- There were strong positive & negative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

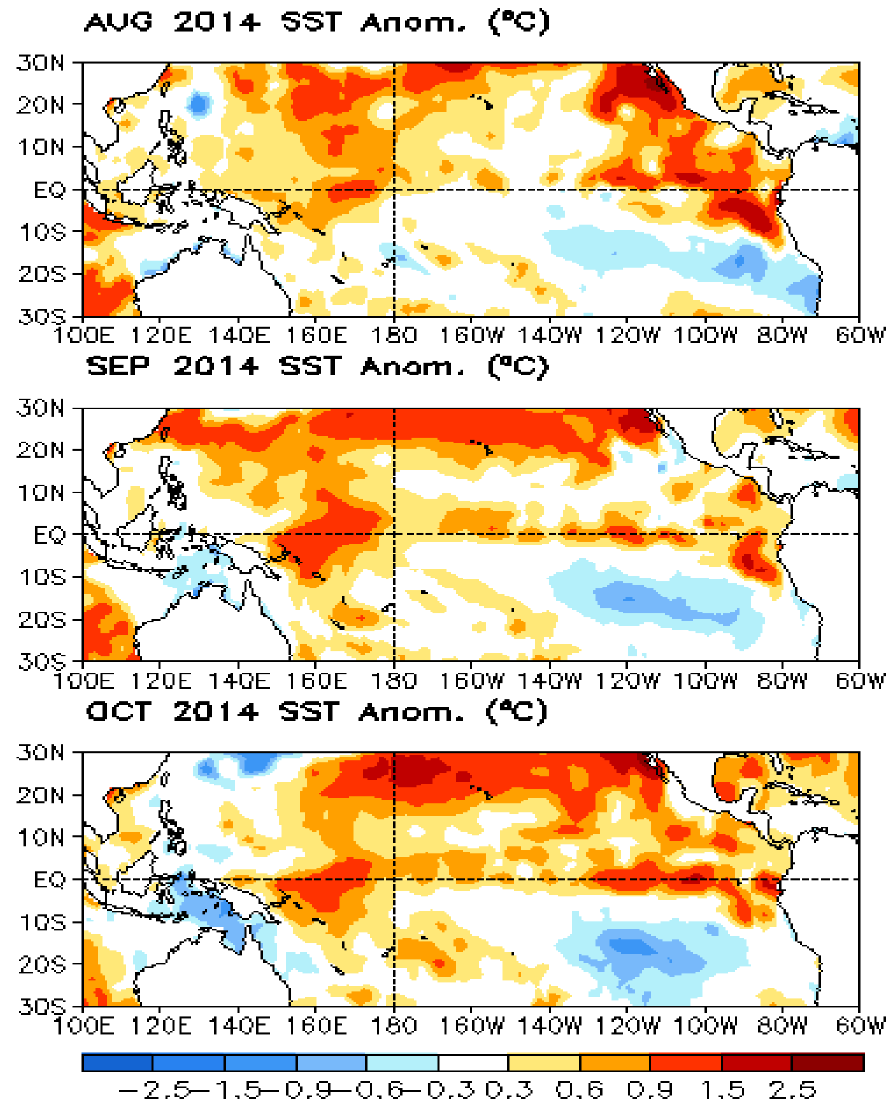
Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

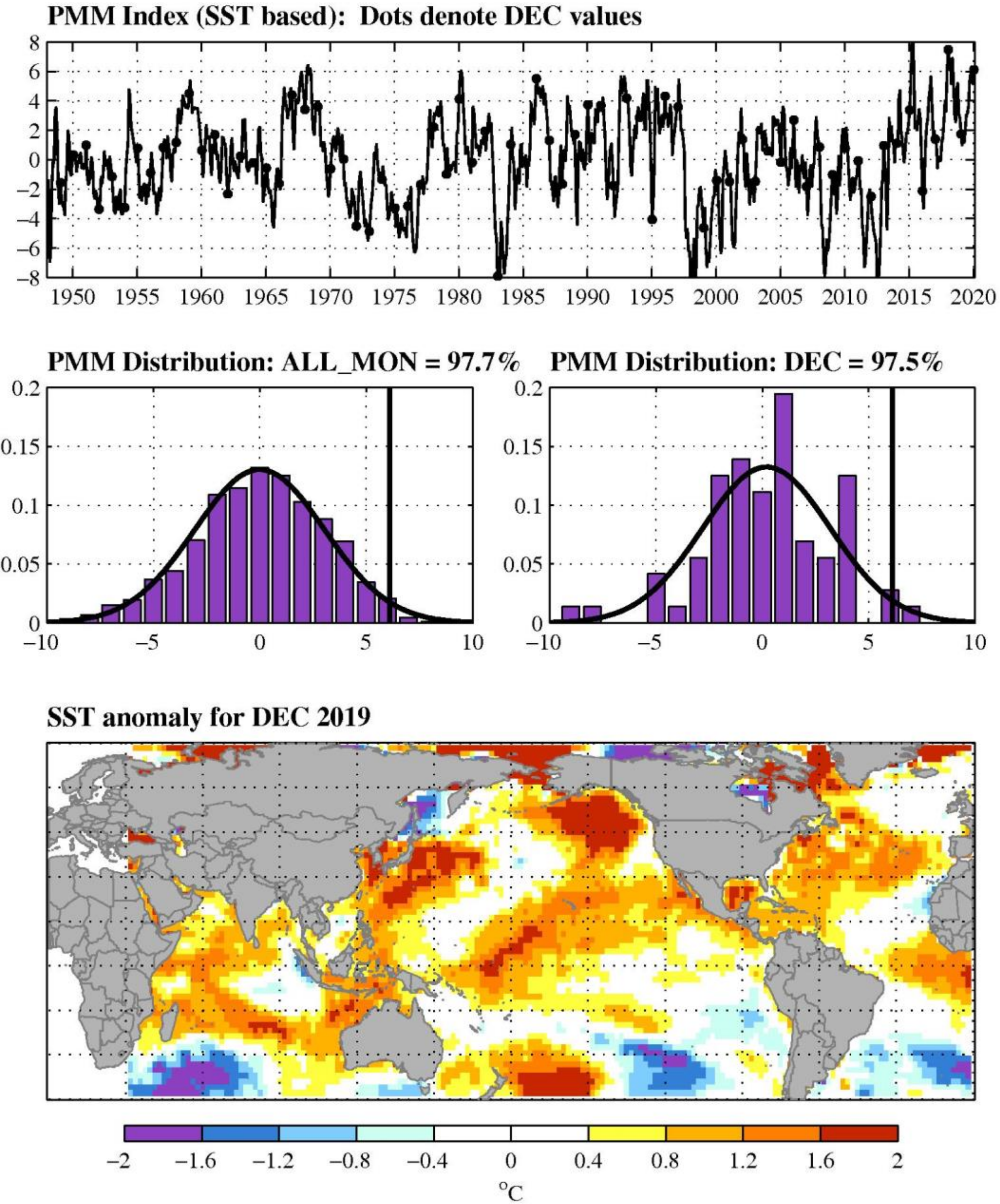
SST Anomalies: Pacific Meridional Mode (PMM)

2019



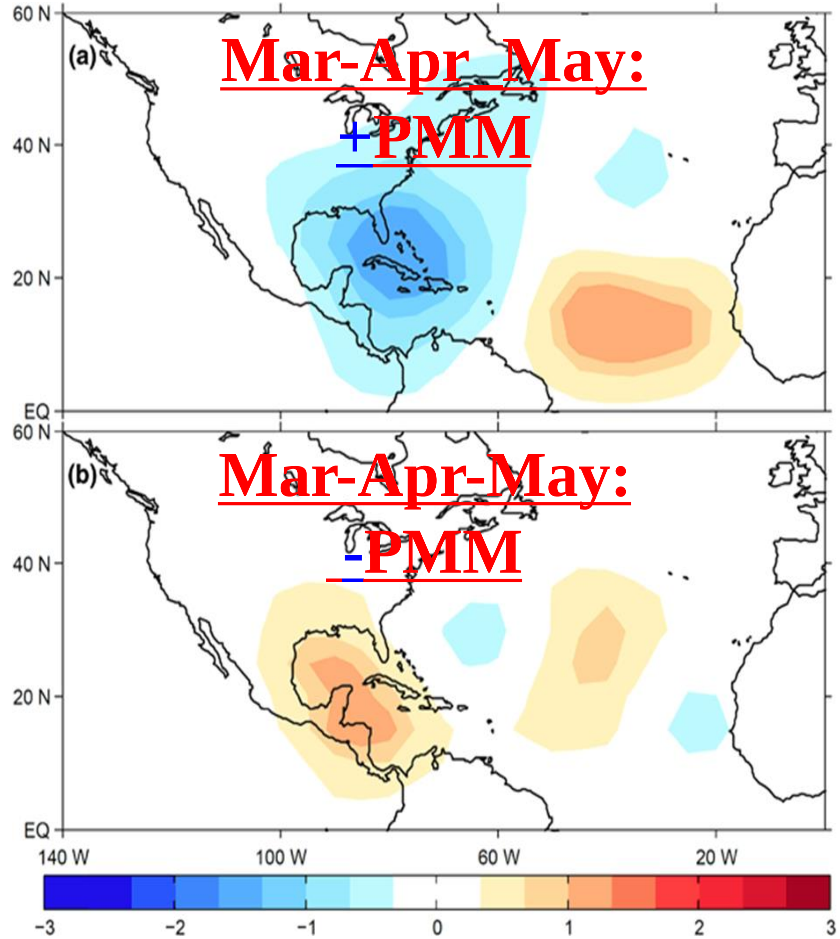
2014





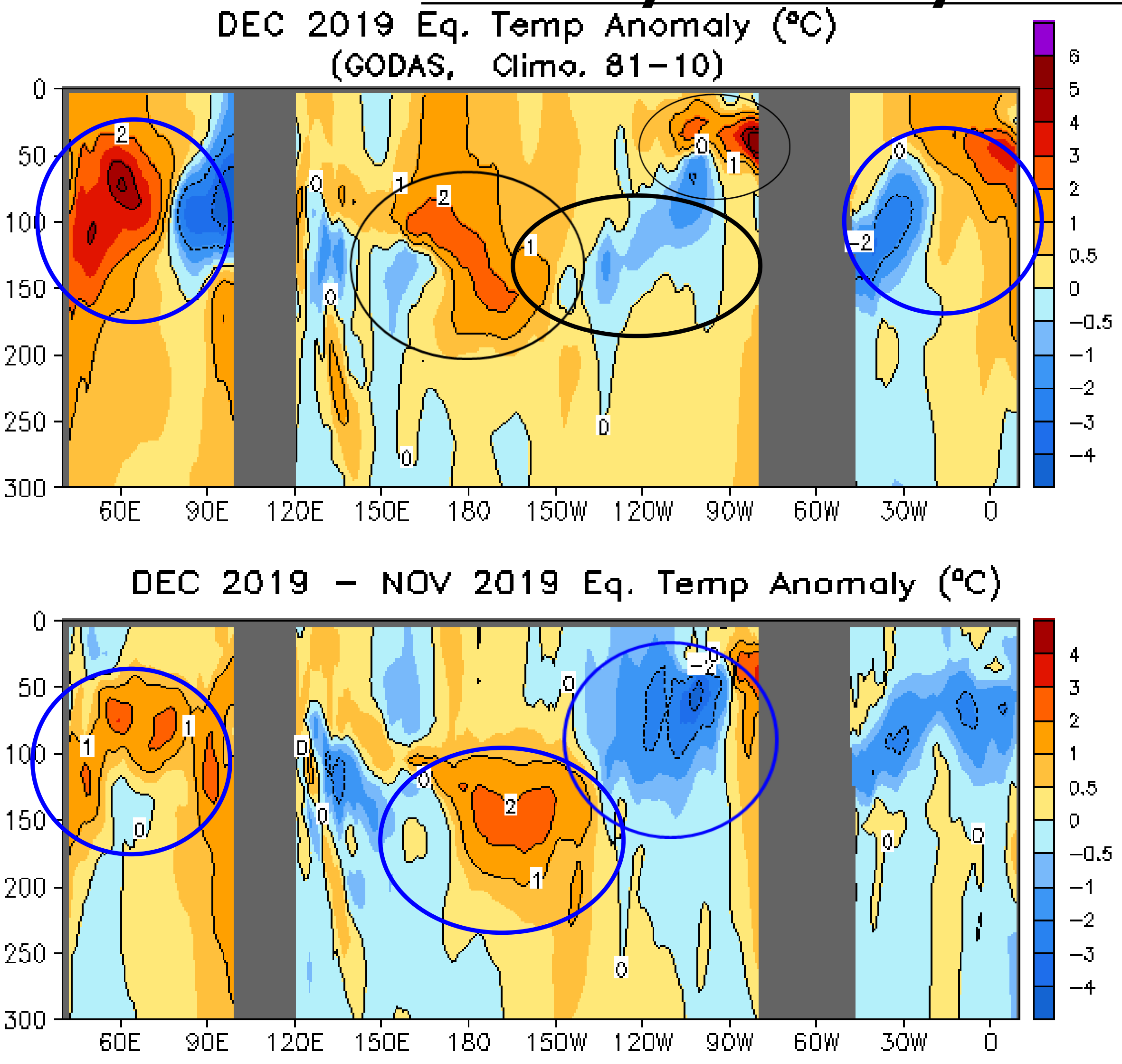
http://www.aos.wisc.edu/~dvimont/MModes/RealTime/pmm_current.jpg

ASO TC Track Density



ASO TC track density anomalies (occurrences/season) when MAM PMM is a positive and b negative. Hurricane track density is calculated by binning hurricane tracks into 5x 5 grid boxes. The base period for climatology is 1948–2015 (Zhang, W., et al., 2018: Impacts of the Pacific Meridional Mode on Landfalling North Atlantic tropical cyclones. Clim Dyn, 50, 991-1006.)

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



- Positive ocean temperature anomalies presented in the central and far-eastern Pacific, while negative in the eastern Pacific.

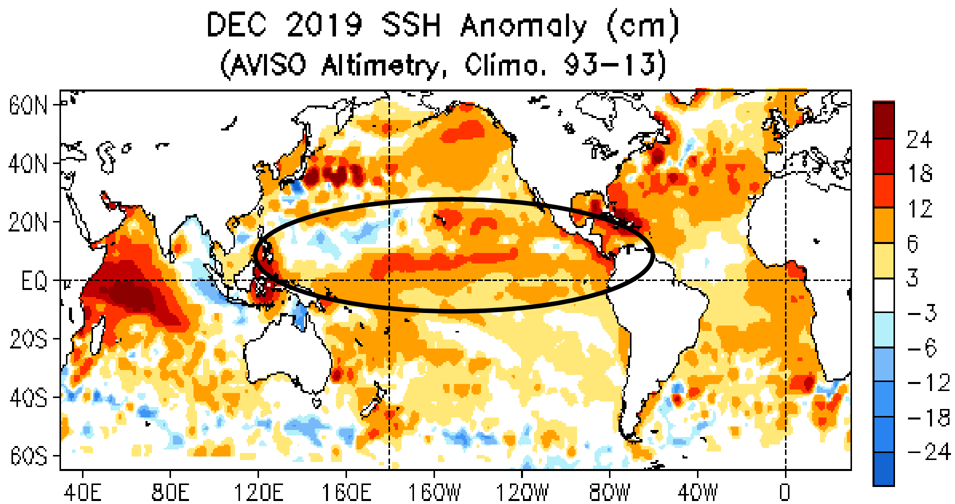
- Positive (negative) anomaly in the western (eastern) Indian Ocean was associated the Indian Ocean dipole pattern.

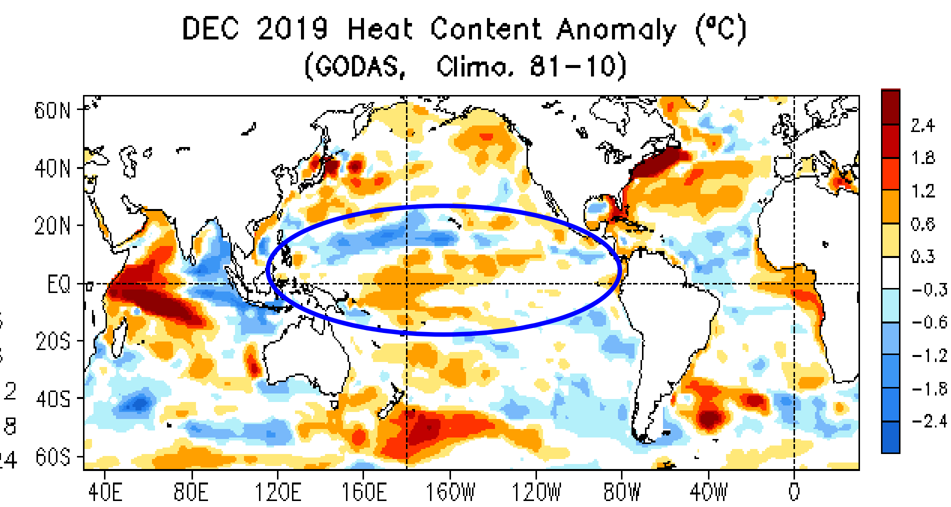
- Positive (negative) anomaly in the eastern (western) Atlantic Ocean was associated an Atlantic Nino.

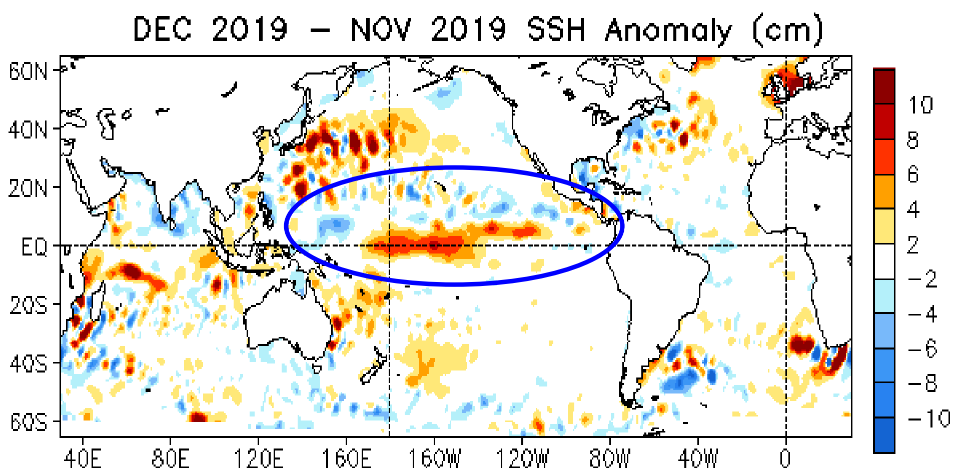
- Anomalous ocean temperature tendency was positive in the central and negative in the eastern Pacific associated with Kelvin wave activity.

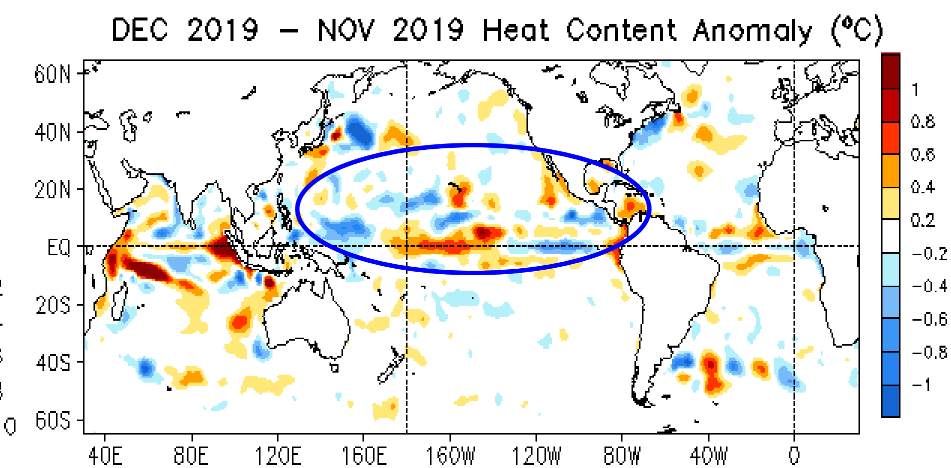
Fig. G3. Equatorial depth-longitude section of ocean temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP's global ocean data assimilation system which assimilates oceanic observations into an oceanic GCM. Anomalies are departures from the 1981-2010 base period means.

Global SSH and HC300 Anomaly & Anomaly Tendency





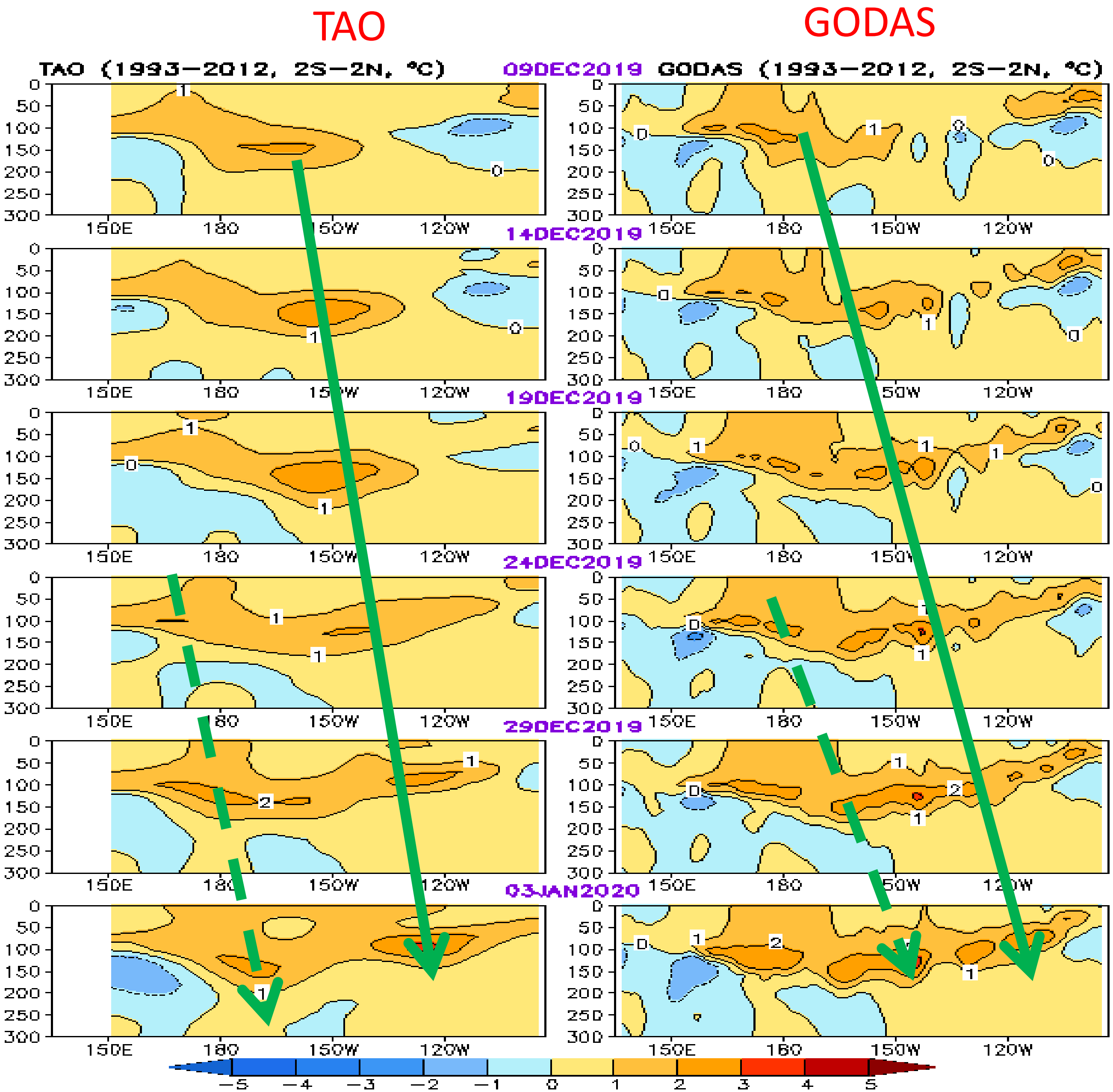




- **The SSHA pattern was overall consistent with the HC300A pattern, but there were many differences in details between them.**
- **Both SSHA and HC300A in the tropical Pacific were consistent with ENSO neutral.**
- **Positive tendencies of SSHA and HC300A presented in the central tropical Pacific.**

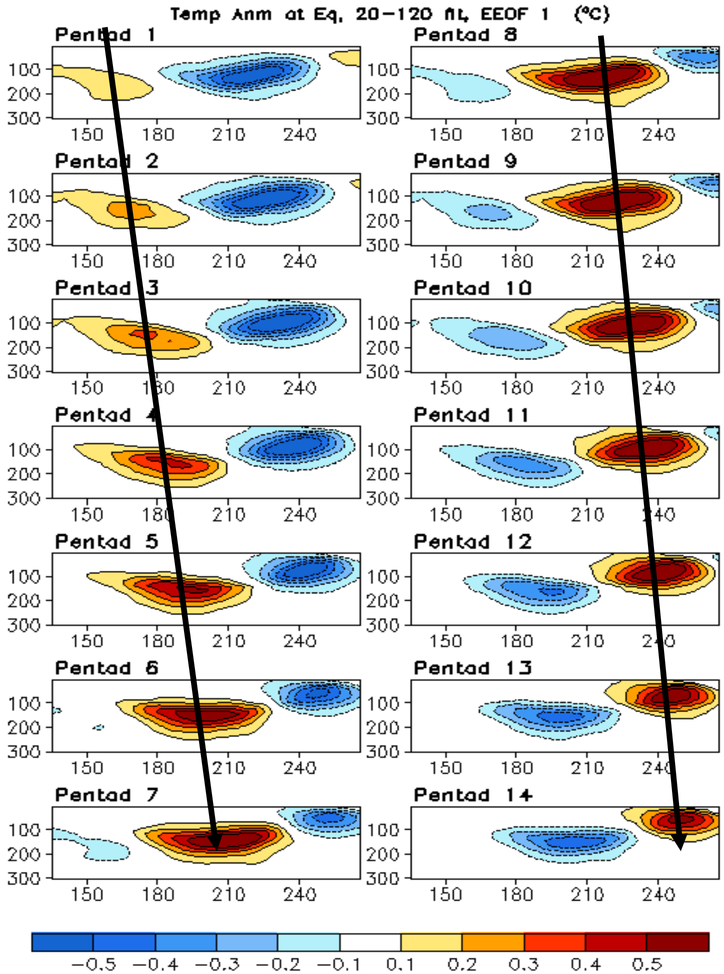
Tropical Pacific Ocean and ENSO Conditions

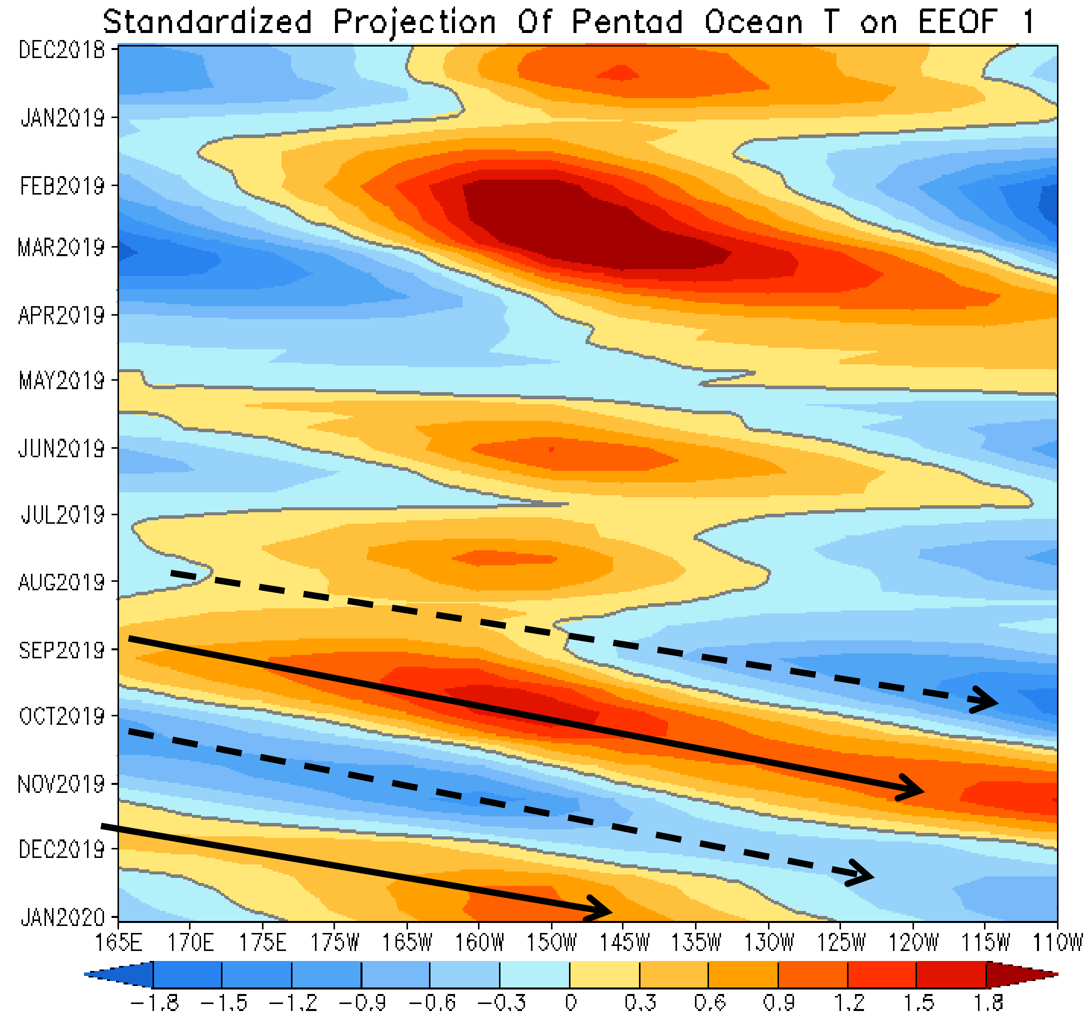
Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



- Positive ocean temperature anomalies presented during the last few months, 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



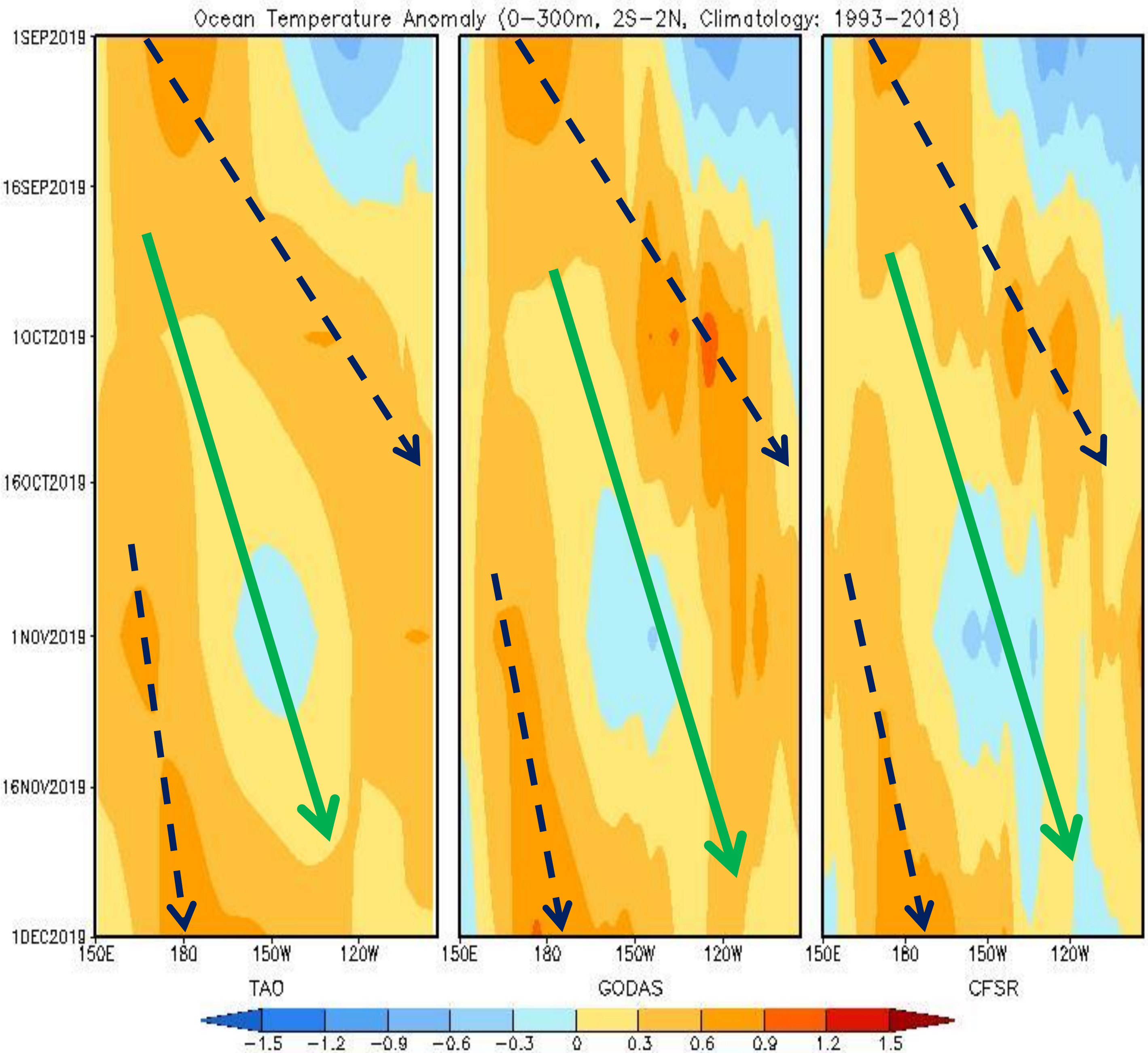


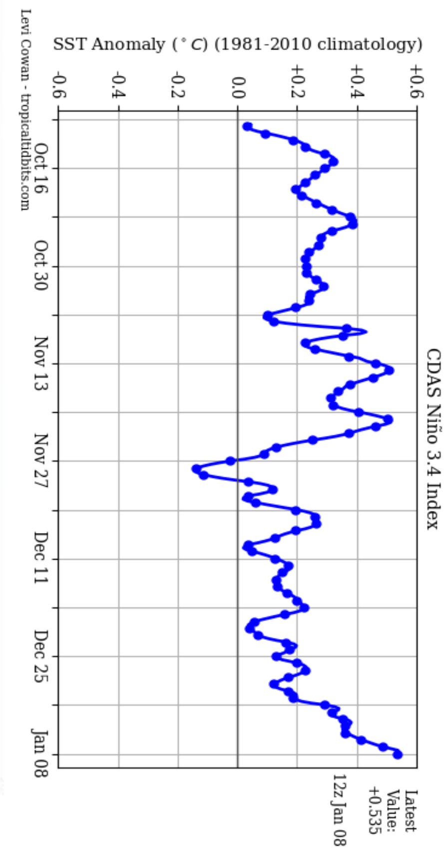
- **A upwelling Kelvin wave initiated in late Sep 2019 and propagated eastward and reached the southern American coast in Dec 2019.**

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

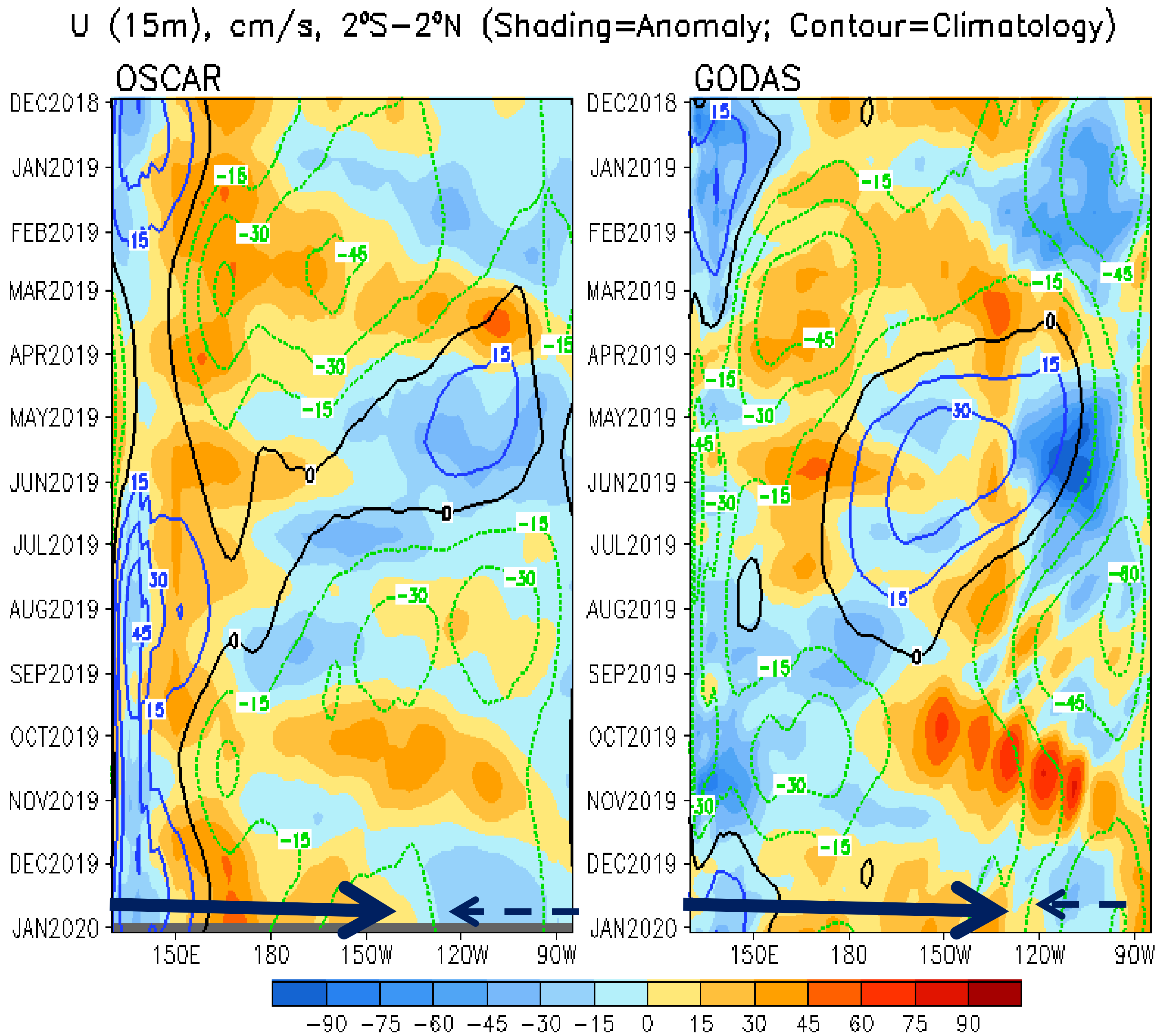
(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)

H300A: TAO, GODAS, CFSR





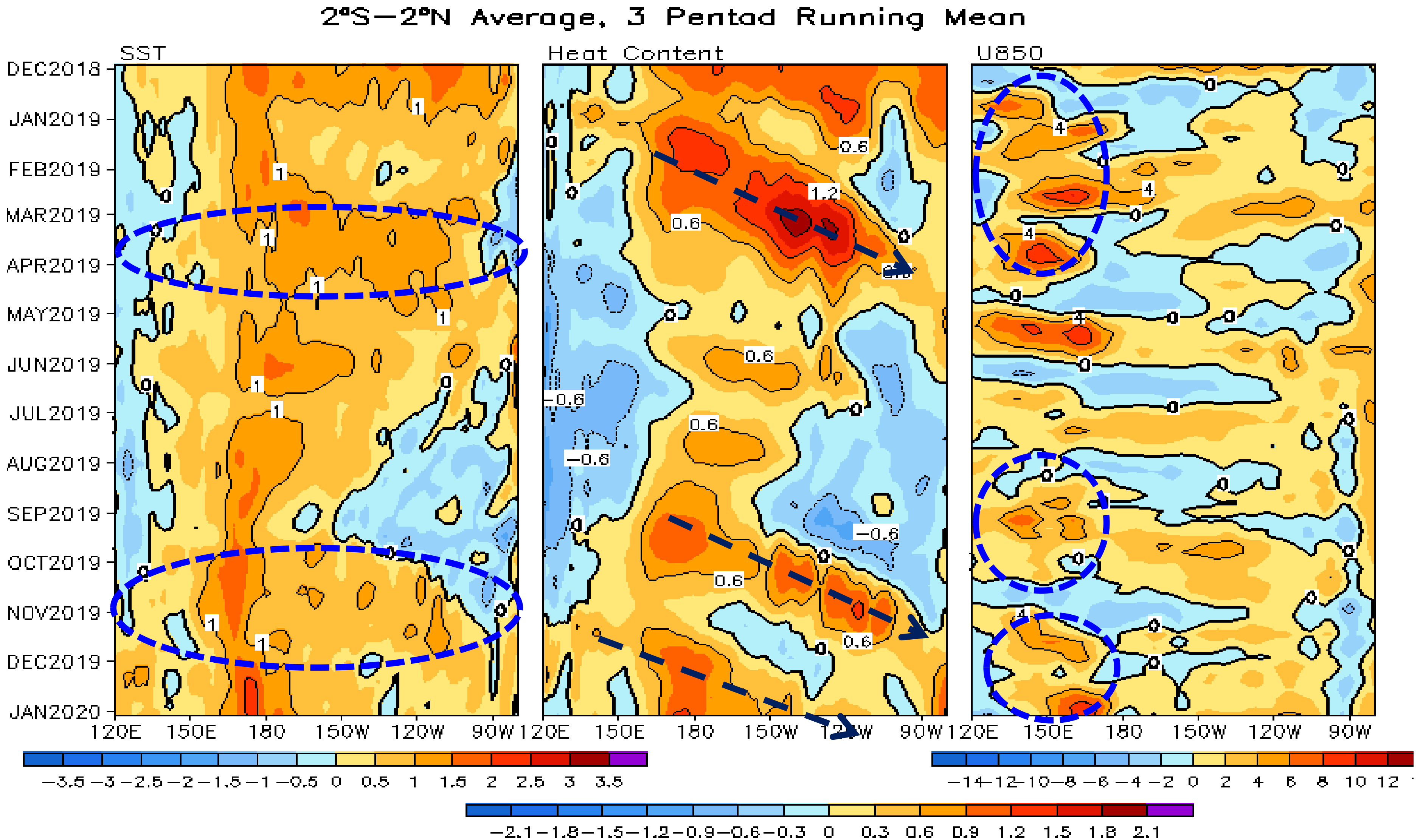
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



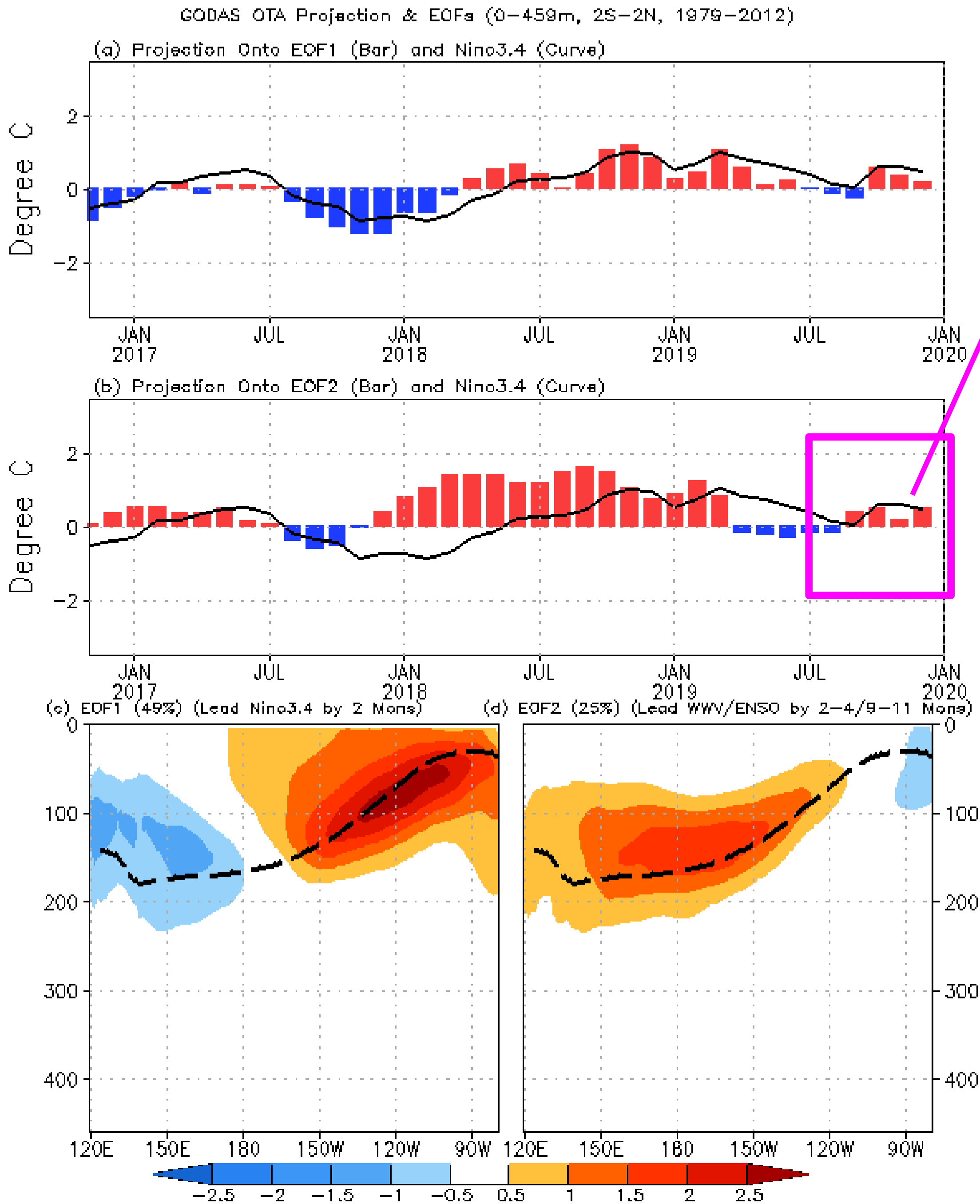
- Anomalous eastward (westward) currents persisted in the western and central (eastern) Pacific in Dec 2019 in both OSCAR and GODAS.

- 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 HC300A presented in the western and central Pacific in Dec 2019.**
- **Westerly wind anomalies dominated in the western Pacific**



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

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

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 : <u>Negative -> positive phase of ENSO</u>

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

<u>For details, see:</u>

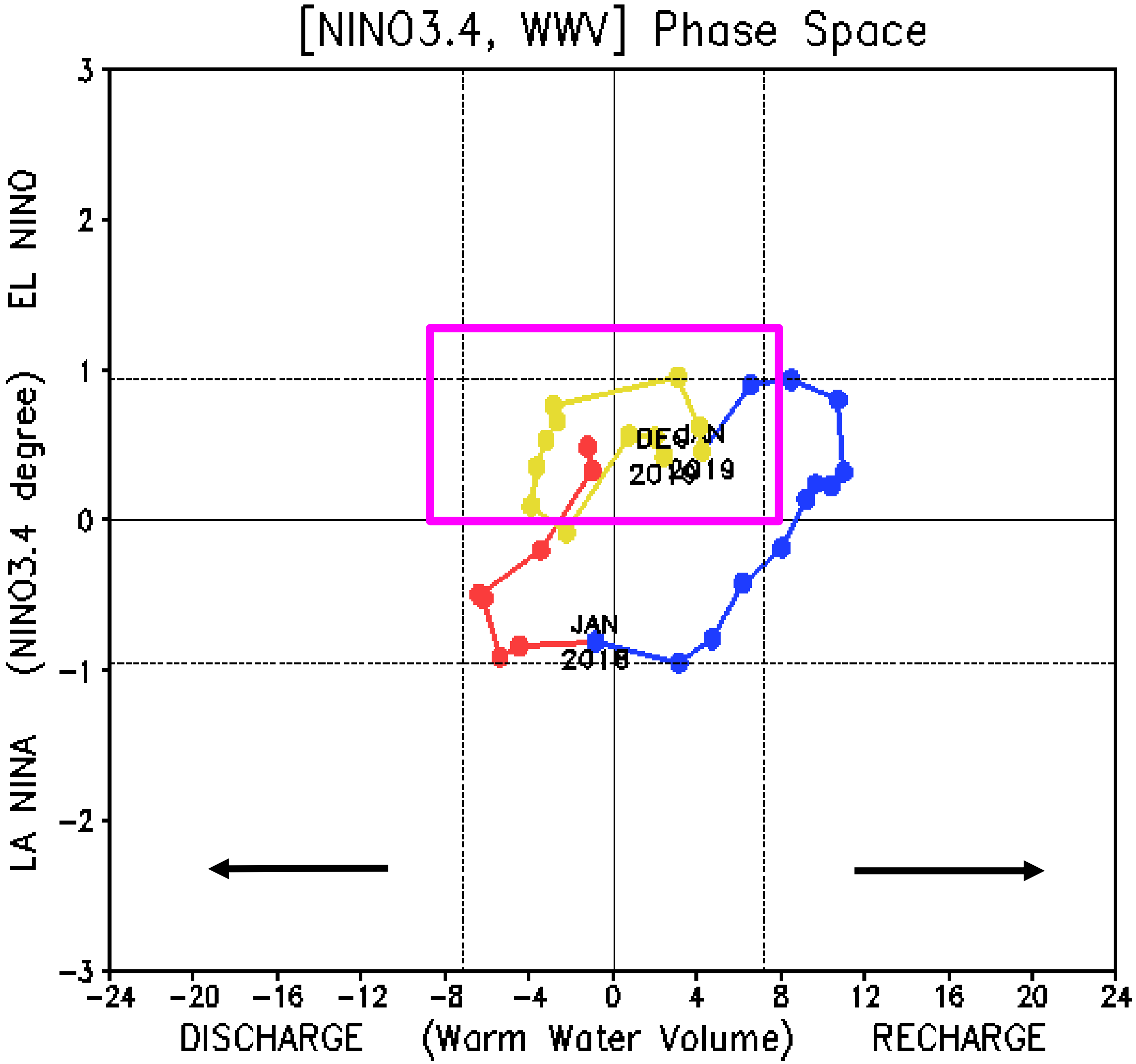
Kumar A, Z-Z Hu (2014) Interannual and interdecadal variability of ocean temperature along the equatorial Pacific in conjunction with ENSO. Clim. Dyn., 42 (5-6)**, 1243-1258.** *DOI: 10.1007/s00382-013-1721-0*.

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).**

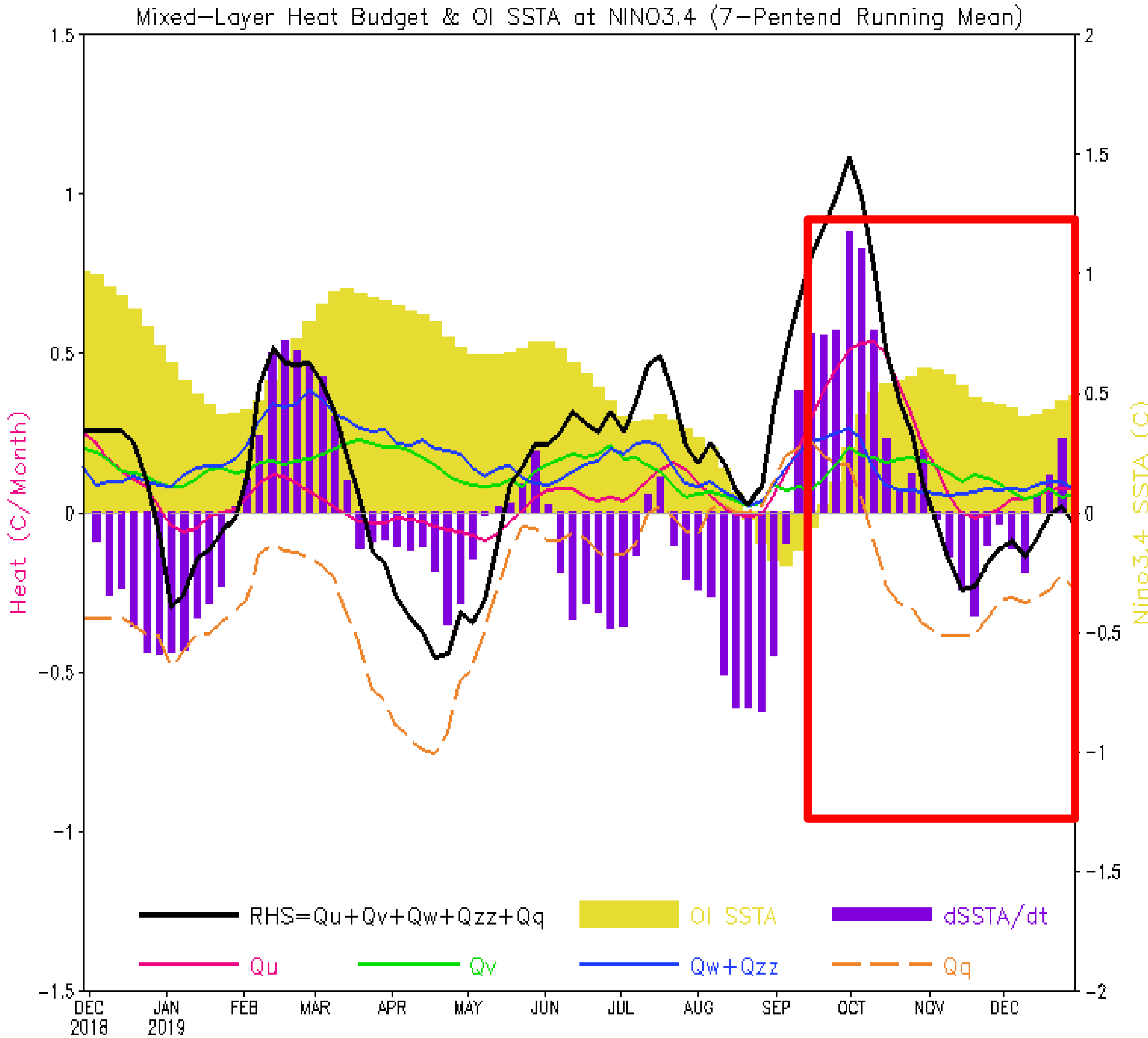
- **Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.**



- **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 20ºC in [120ºE-80ºW, 5ºS-5ºN] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.

NINO3.4 Heat Budget



- **Observed SSTA tendency (dSSTA/dt; bar) was positive, and total heat budget (RHS; black line) was small in last a few pentads.**

- **Dynamical terms (Qu, Qv, Qw+Qzz) were small positive and heat-flux term (Qq) was negative in Dec 2019.**

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.

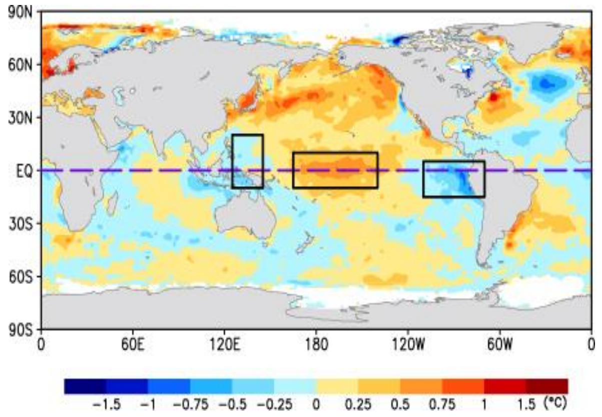
Qu: Zonal advection; Qv: Meridional advection;

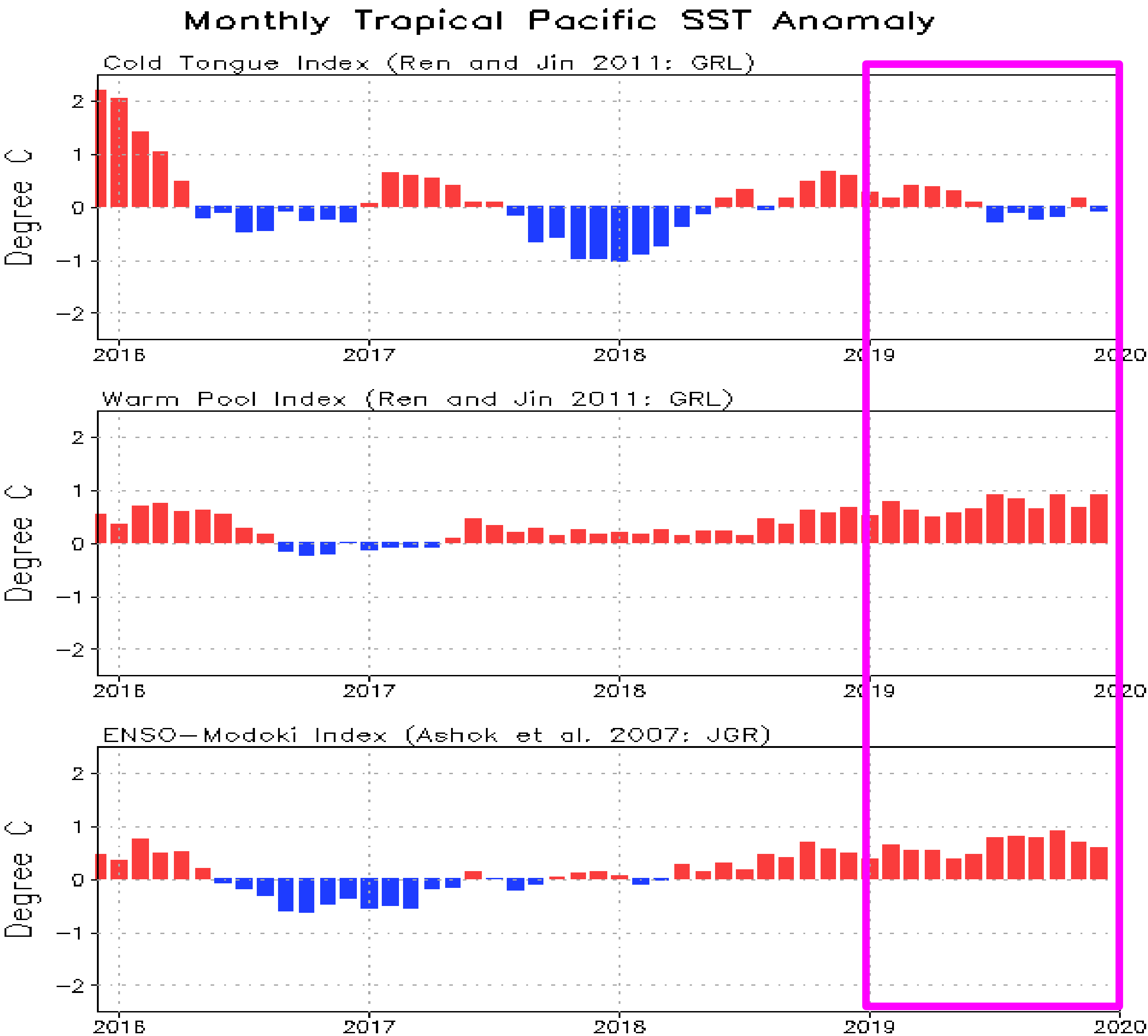
Qw: Vertical entrainment; Qzz: Vertical diffusion

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

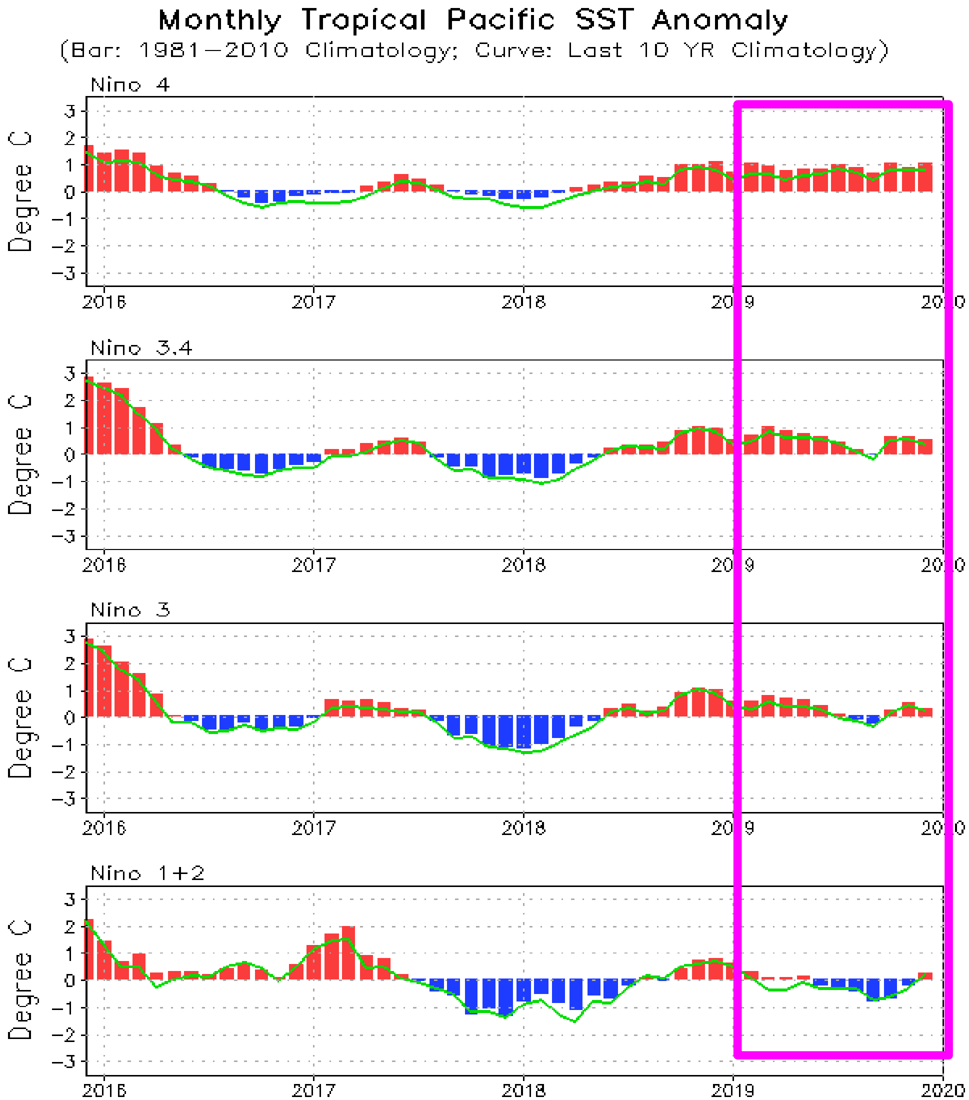
Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST

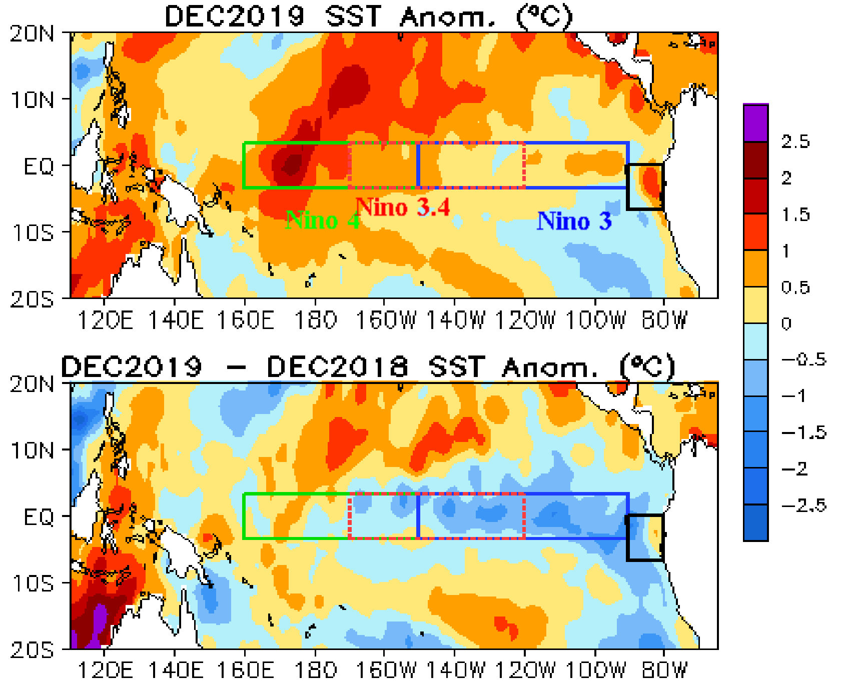
Positive SSTAs persisted in the warm pool, and SSTAs were small in the cold tongue.





Evolution of Pacific NINO SST Indices

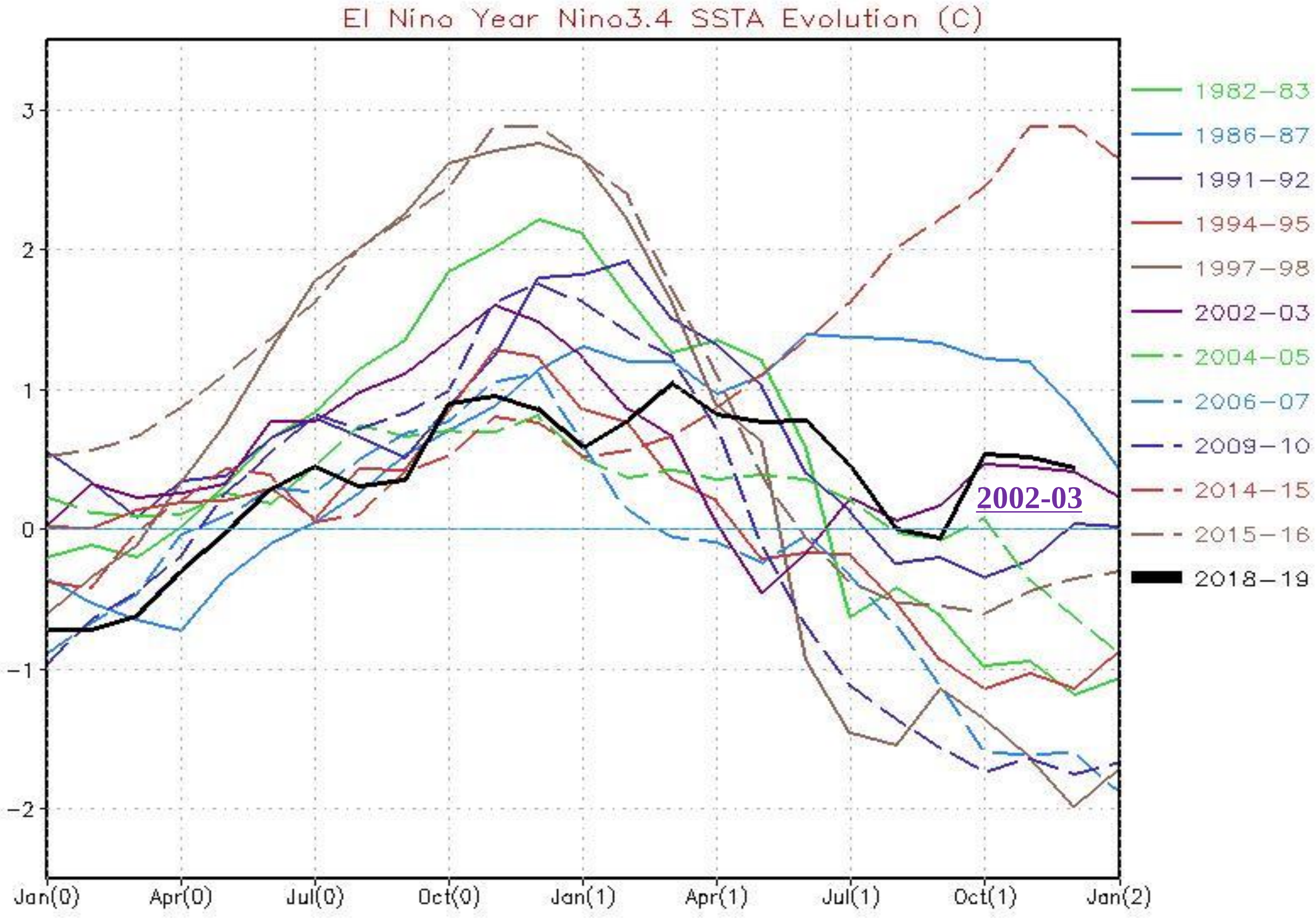




- **All indices were positive in Dec 2019.**
- **Nino3.4 = 0.55 C in Dec 2019.**
- **Compared with Dec 2018, the central and eastern equatorial Pacific was much warmer in Dec 2019.**
- **The indices may have some differences if different SST datasets were used in the calculations.**

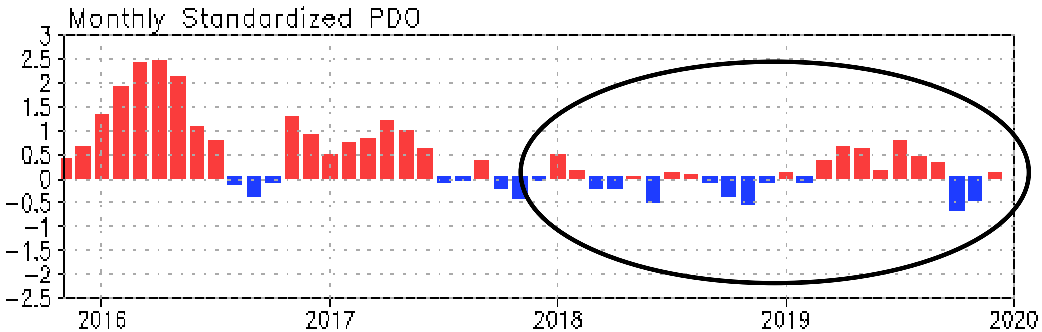
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

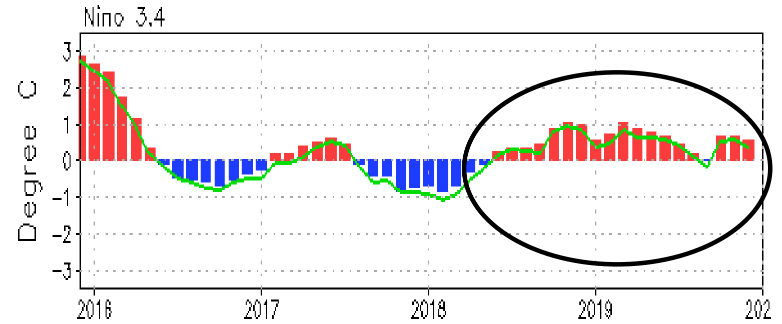
Nino3.4 Evolution In El Nino Years

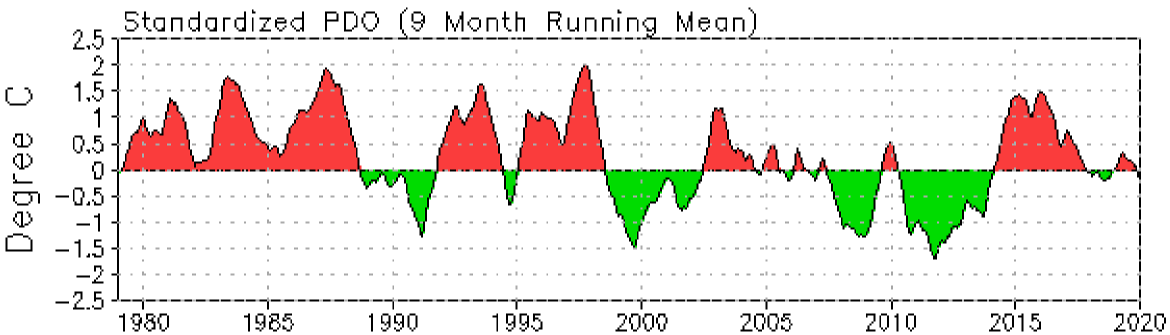


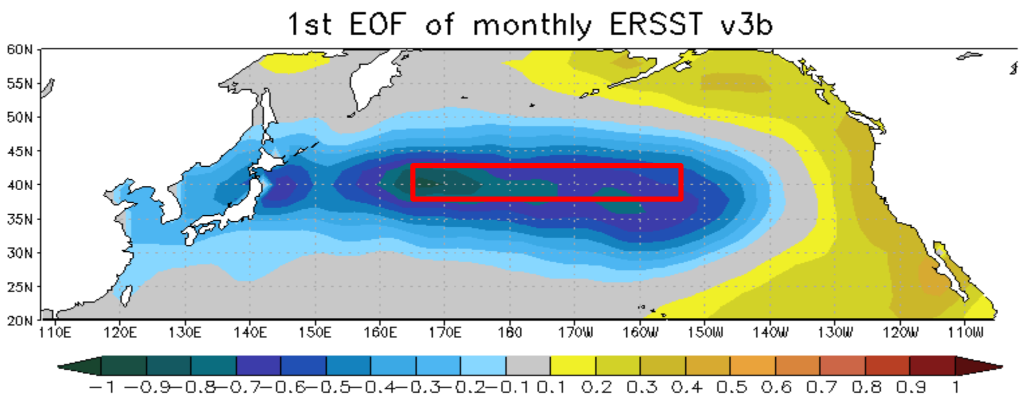
North Pacific & Arctic Oceans

PDO index









- The PDO index was near zero with PDOI= 0.05 in Dec 2019.

- 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

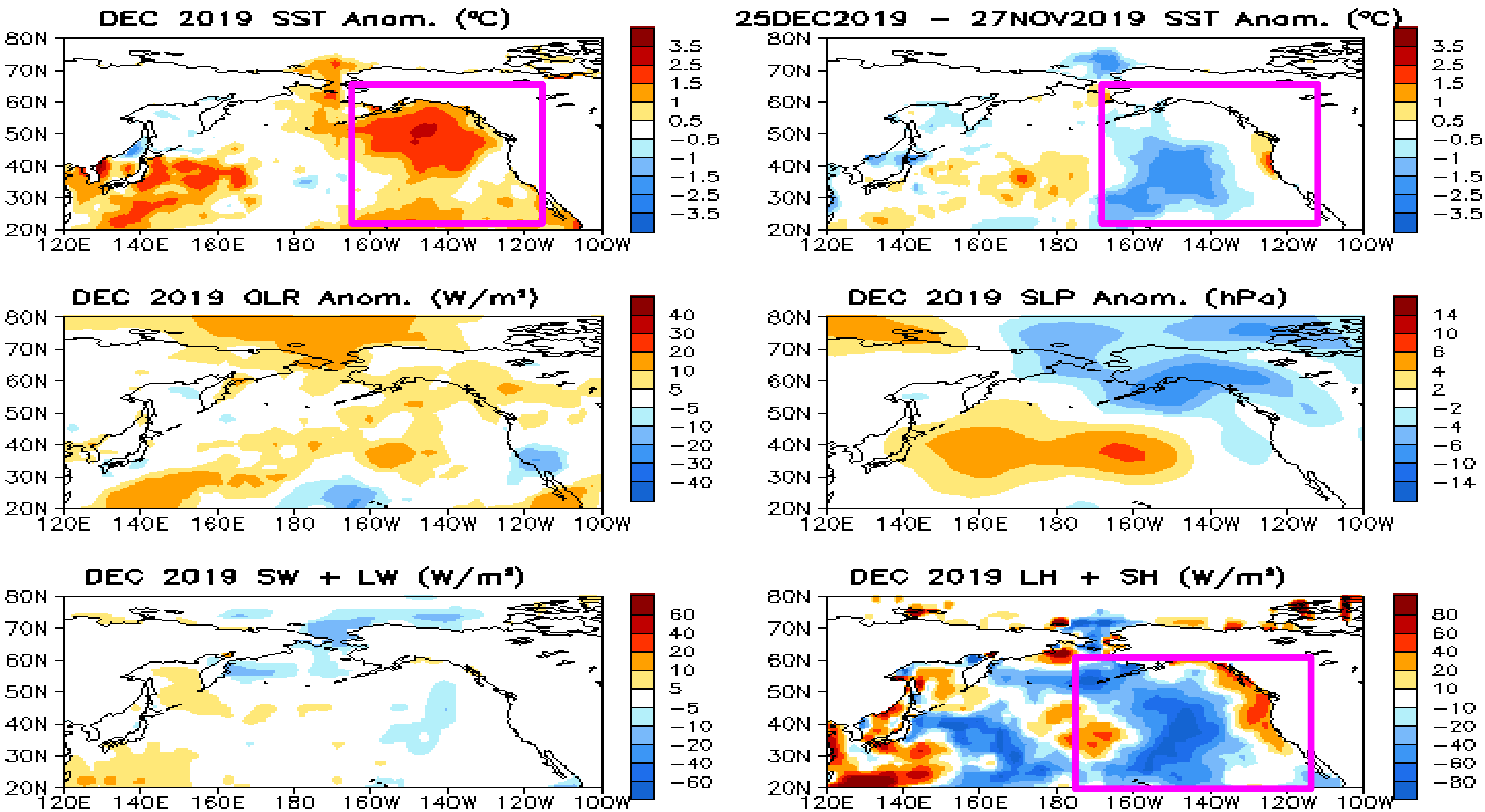
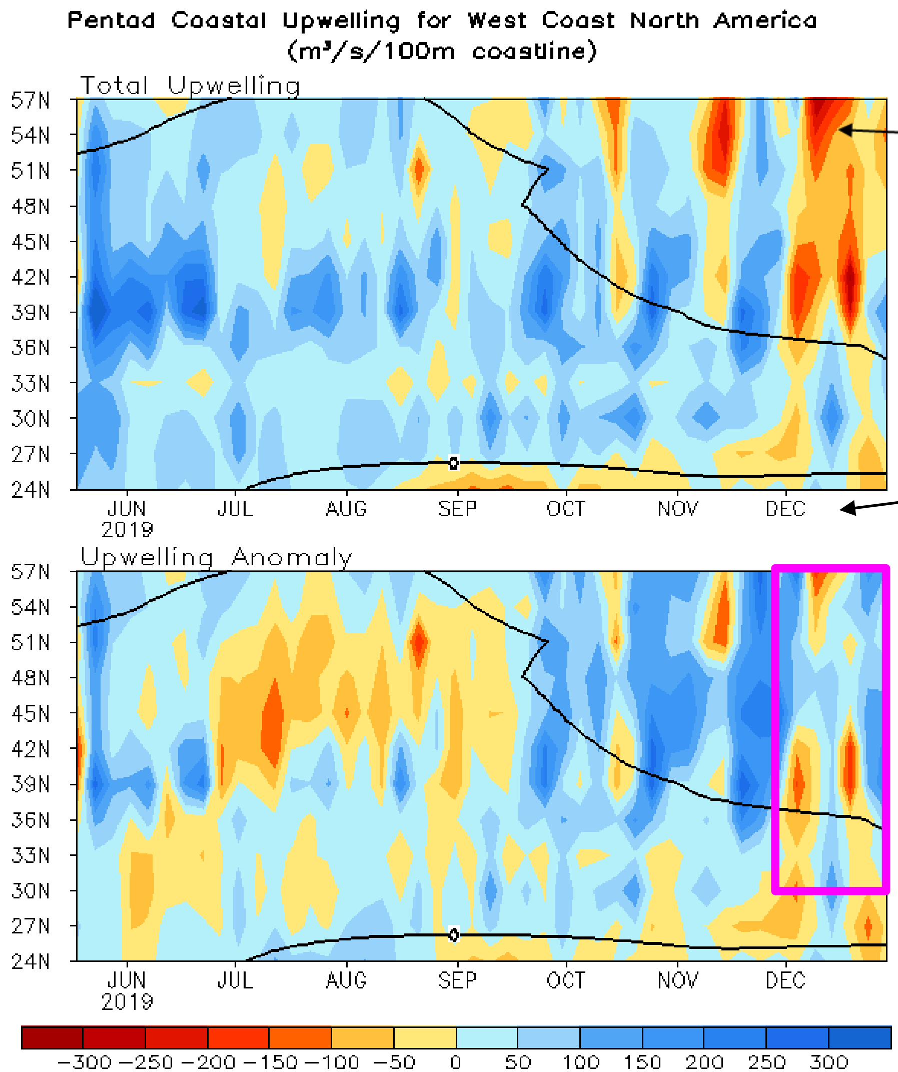
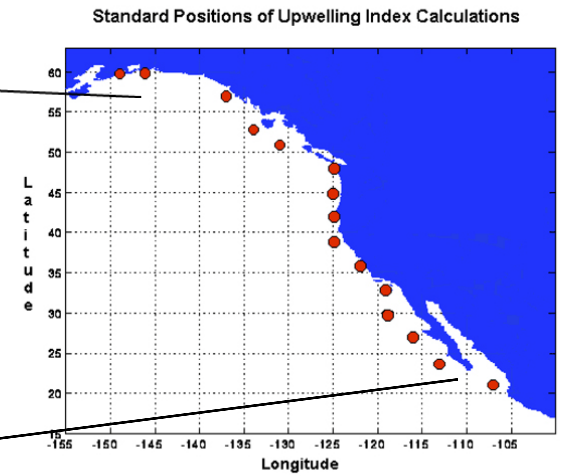


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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





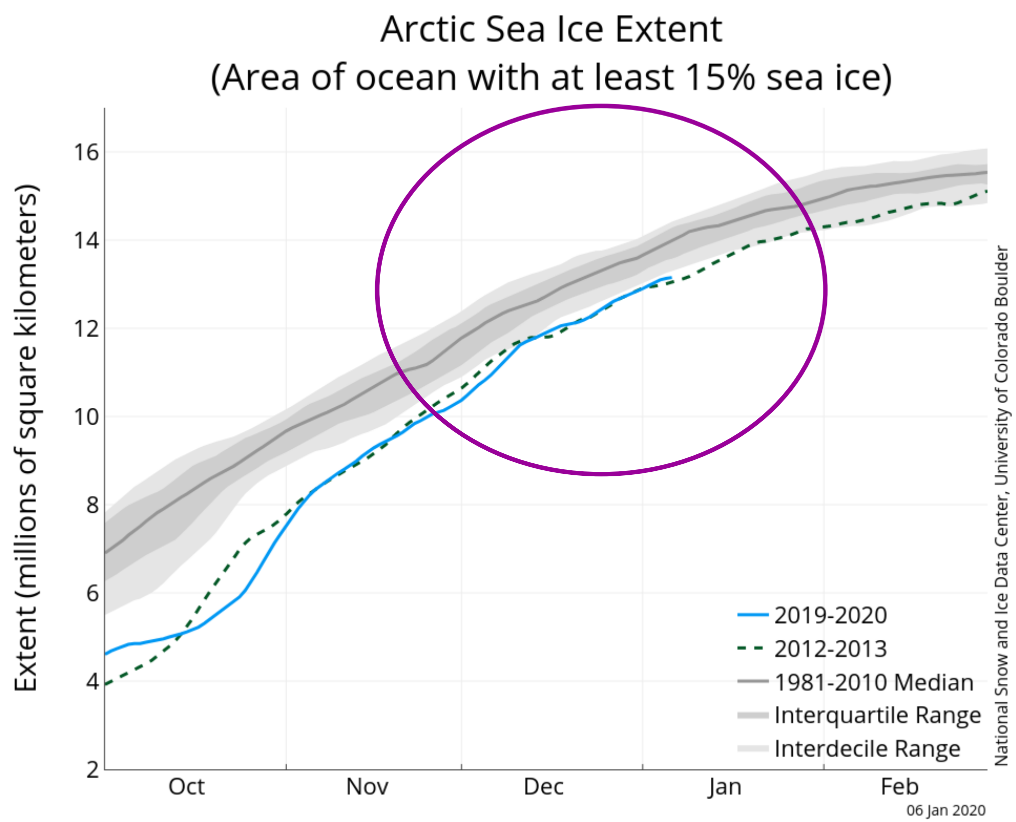
- **Anomalous upwelling and downwelling were small in Dec 2019.**

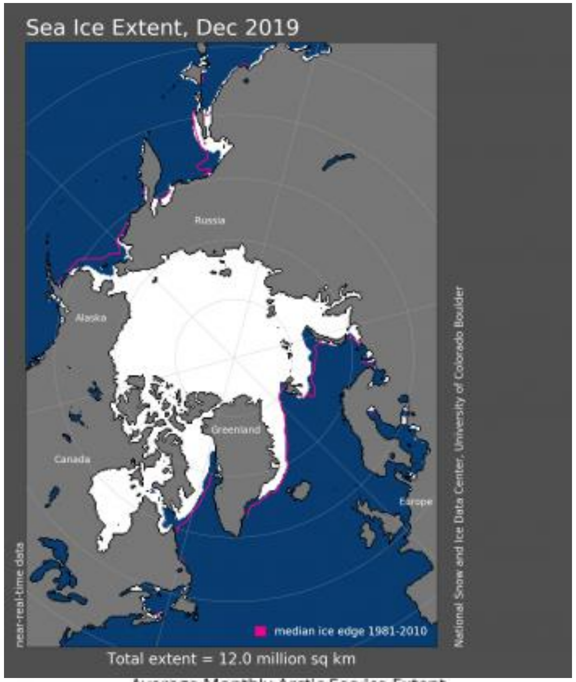
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport at 50 meter depth from each location to its nearest coast point ($m^3/s/100m$ coastline). Anomalies are departures from the 1981-2010 base period pentad means.

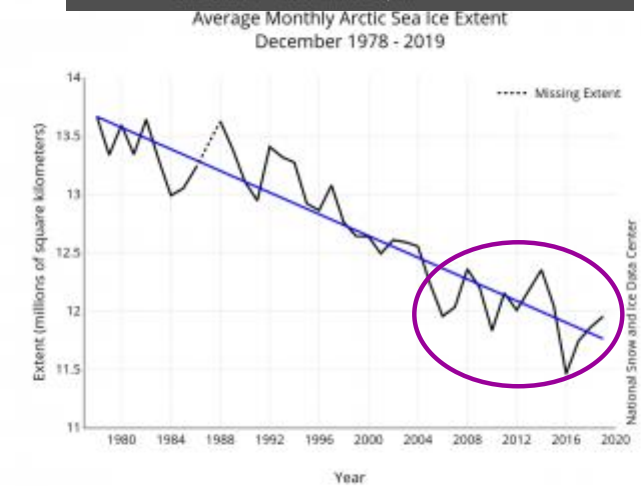
- **Area below (above) black line indicates climatological upwelling (downwelling) season.**
- **Climatologically upwelling season progresses from March to July along the west coast of North America from 36°N to 57°N.**

Arctic Sea Ice

National Snow and Ice Data Center
http://nsidc.org/arcticseaicenews/index.html

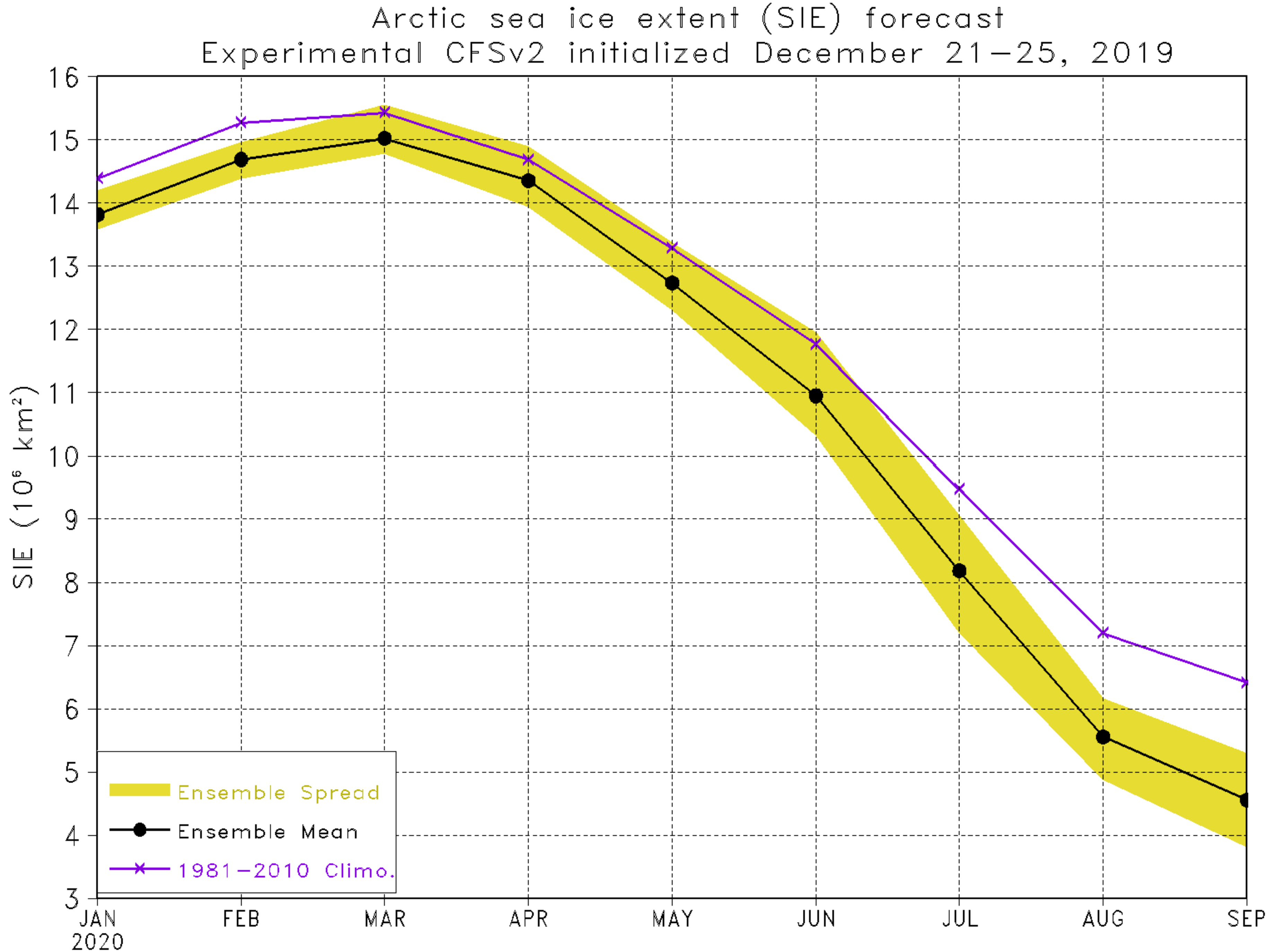






- In 2019, the Sep minimum extent ended up tied with 2007 and 2016 for second lowest in the satellite record. Autumn freeze up was slow.

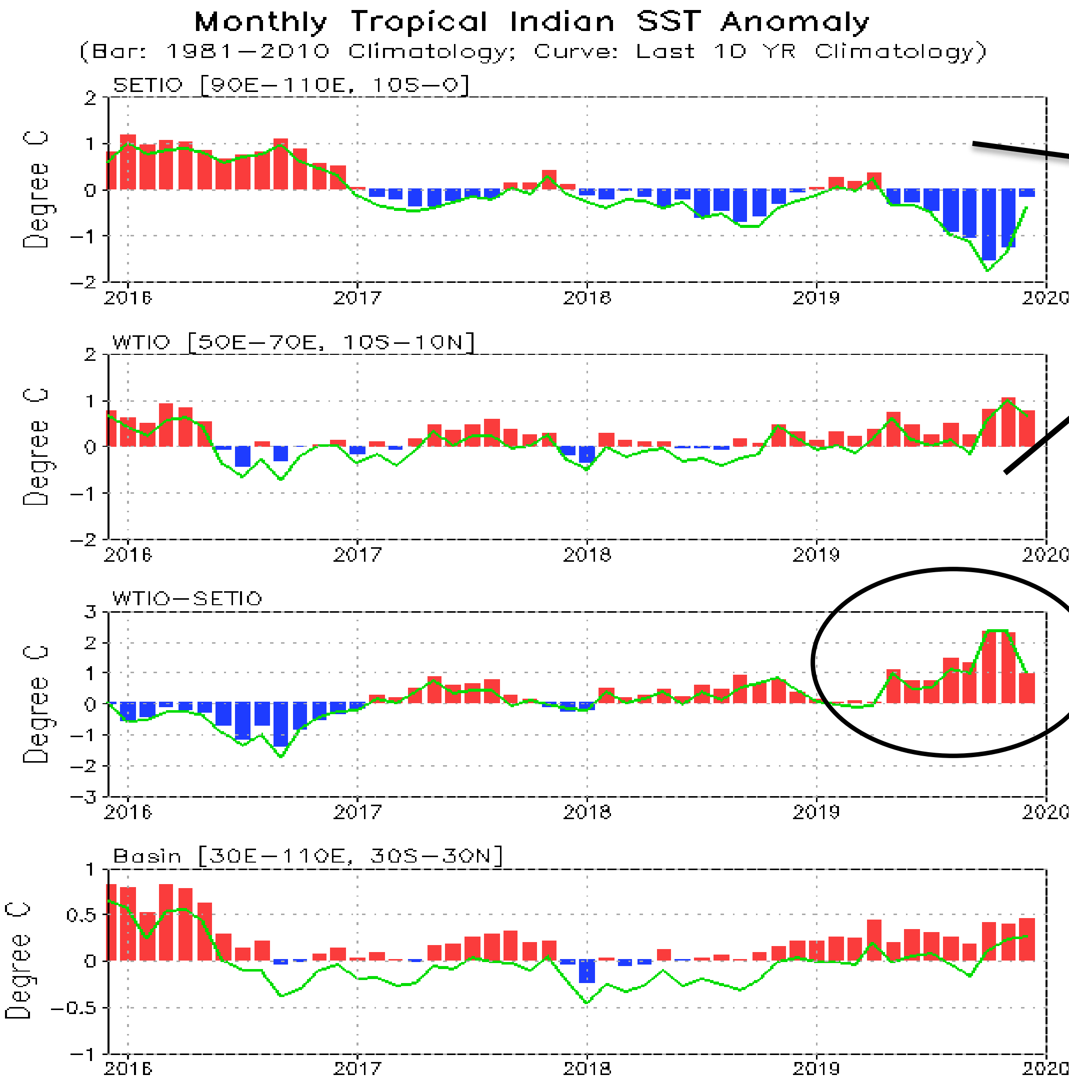
- Extent averaged for Dec 2019 was 11.95 million square kilometers (4.61 million square miles), tied with 2006 as the 5th lowest Dec extent in the satellite record.

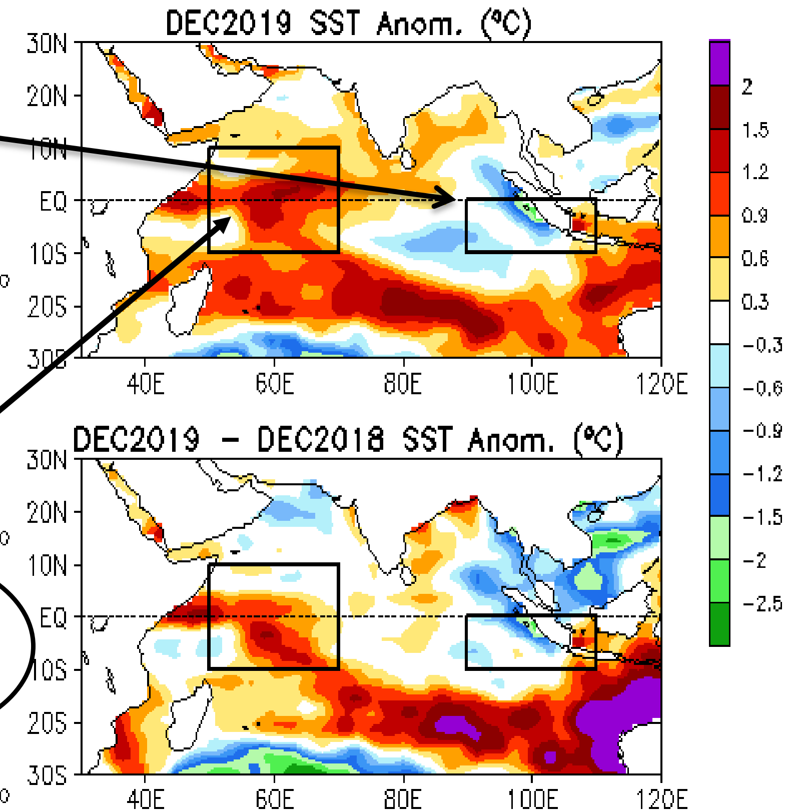


Arctic sea ice extent (SIE) forecast
Experimental CFSv2 initialized December 21–25, 2019
SIE (10^6 km^2)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
JAN
2020
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
Ensemble Spread
Ensemble Mean
1981–2010 Climo.

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-Dec 2019.**

- **The positive phase of dipole mode weakened in Dec 2019.**

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 negative in the far east.

- Positive phase of IOD weakened in Dec 2019.

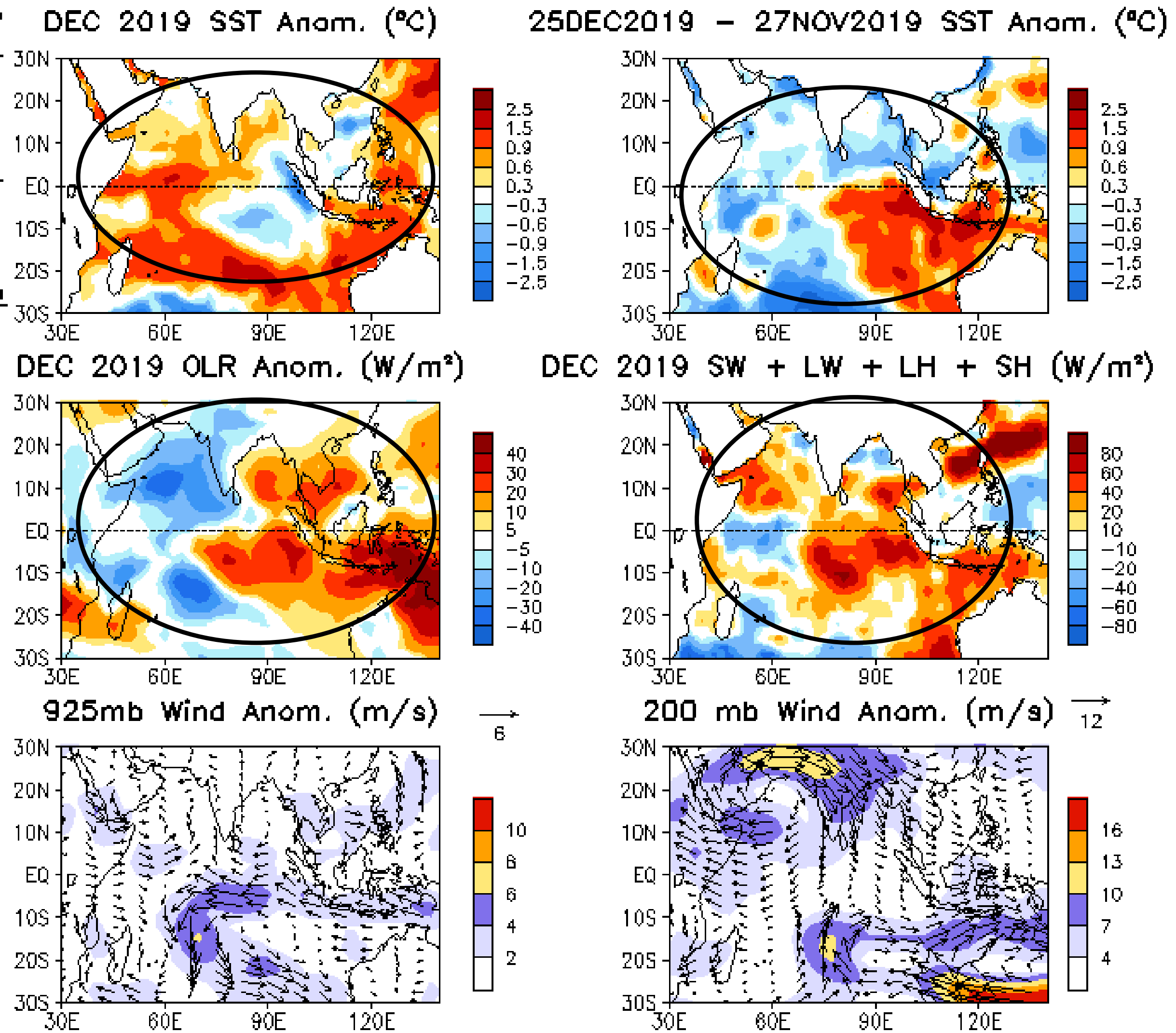
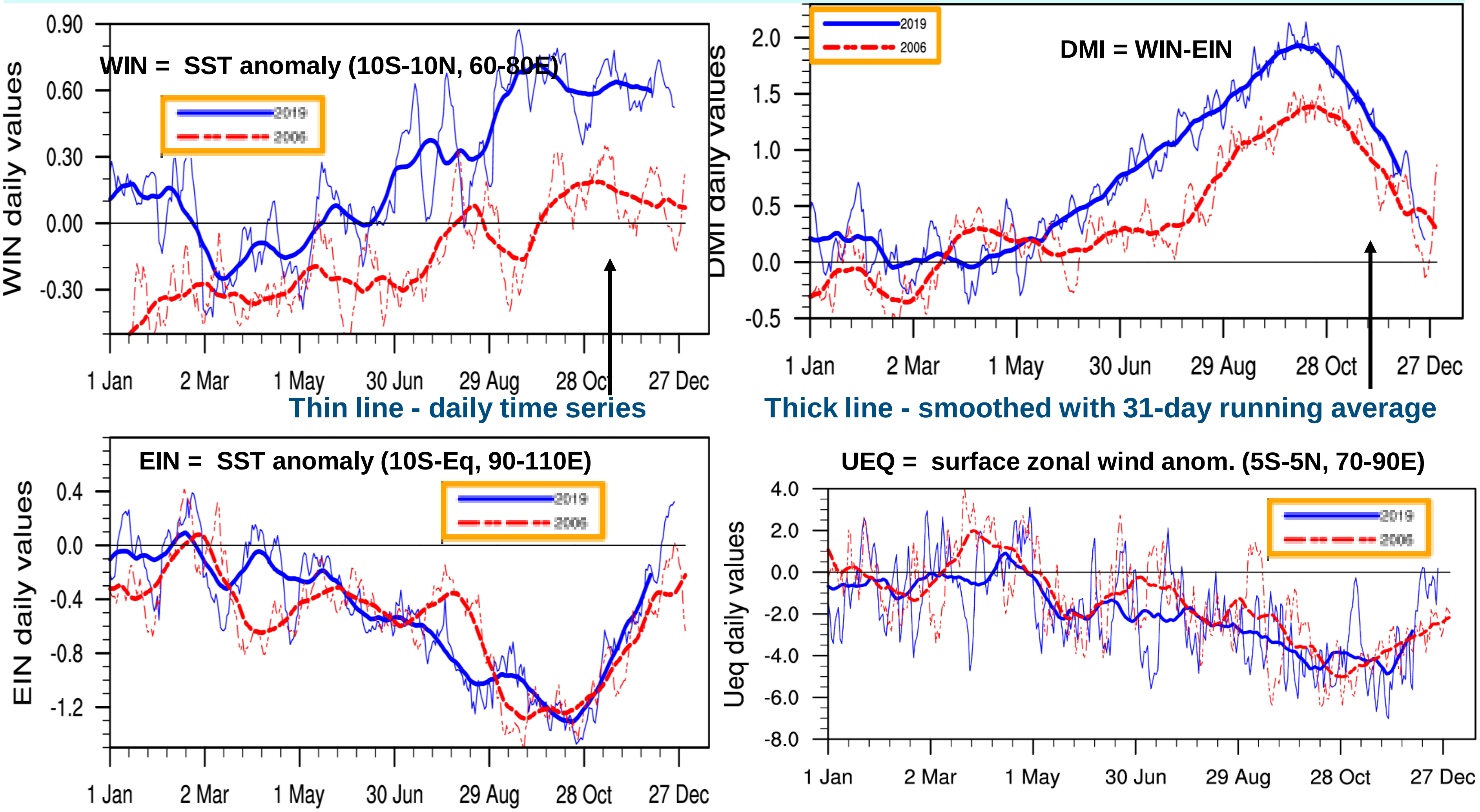


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

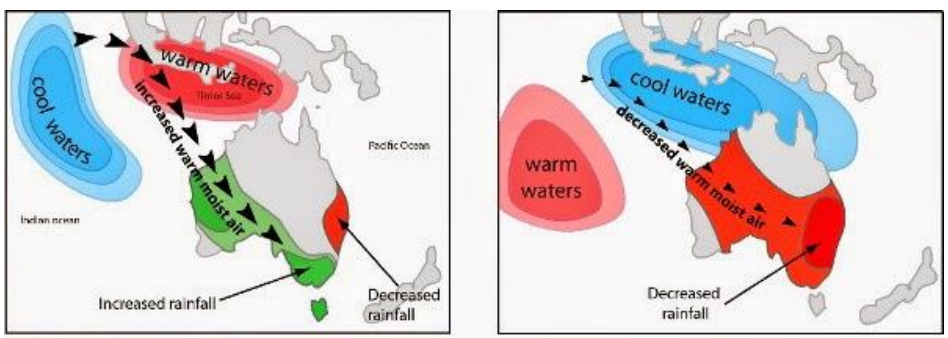
Strong Positive Phase of IOD in 2019 and 2006
(provided by Prof. Saji N Hameed)



IOD indices reference: Saji and Yamagata, 2003 (J. Climate)

Images from IOD monitoring pages at http://enformtk.u-aizu.ac.jp

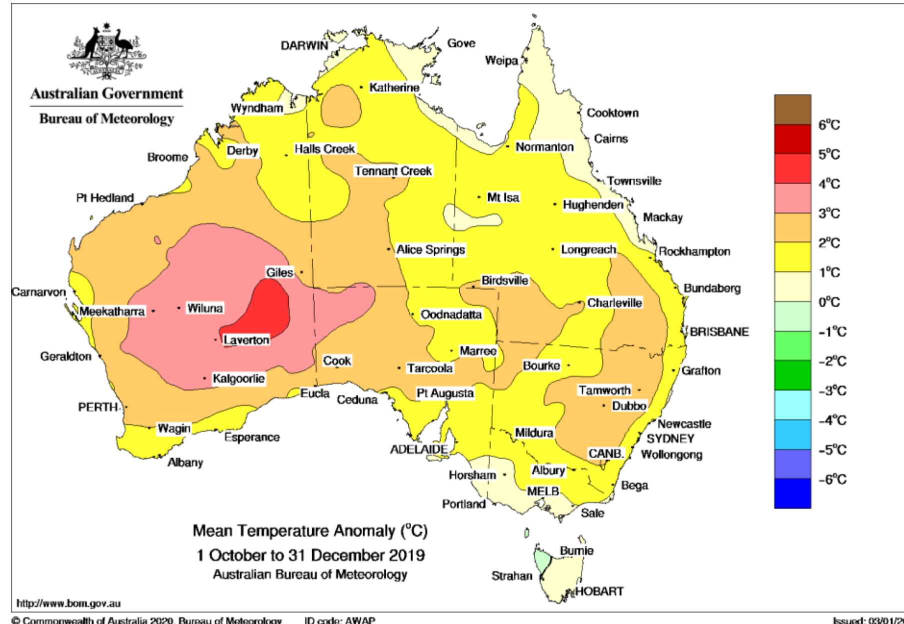
This is a Terra satellite image of Kangaroo Island on January 7, 2020. Credit: NASA Worldview, Earth Observing System Data and Information System (EOSDIS) (https://scitechdaily.com/satellite-view-of-australian-fires-shows-severe-burn-scars-across-kangaroo-island/)

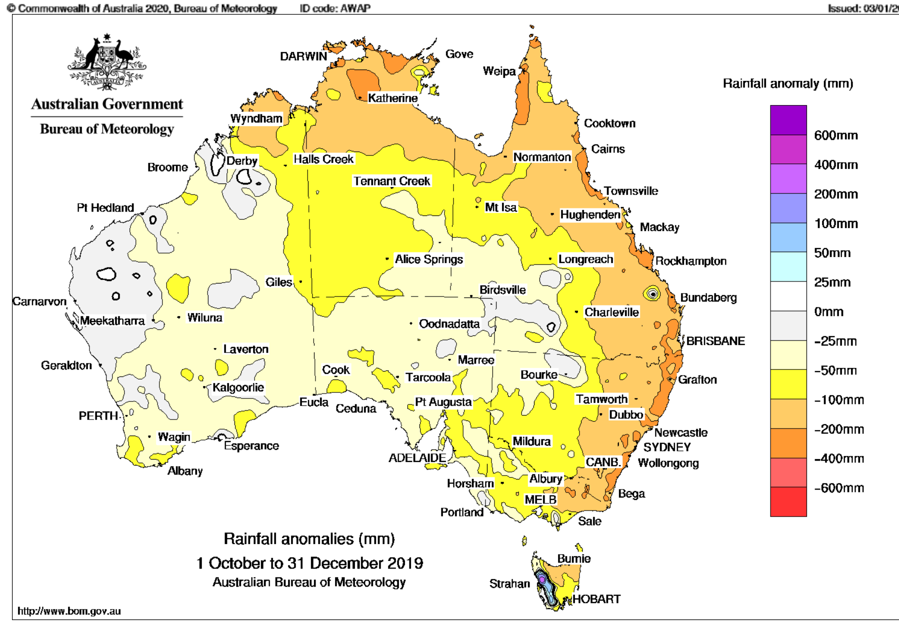


Negative phase: cool Indian Ocean water drives moist warm air and brings normal rainfall.

Positive phase: warm Indian Ocean water leads to weaker, drier winds and less rainfall.

https://takvera.blogspot.com/2014/06/indian-ocean-dipole-set-to-triple.html

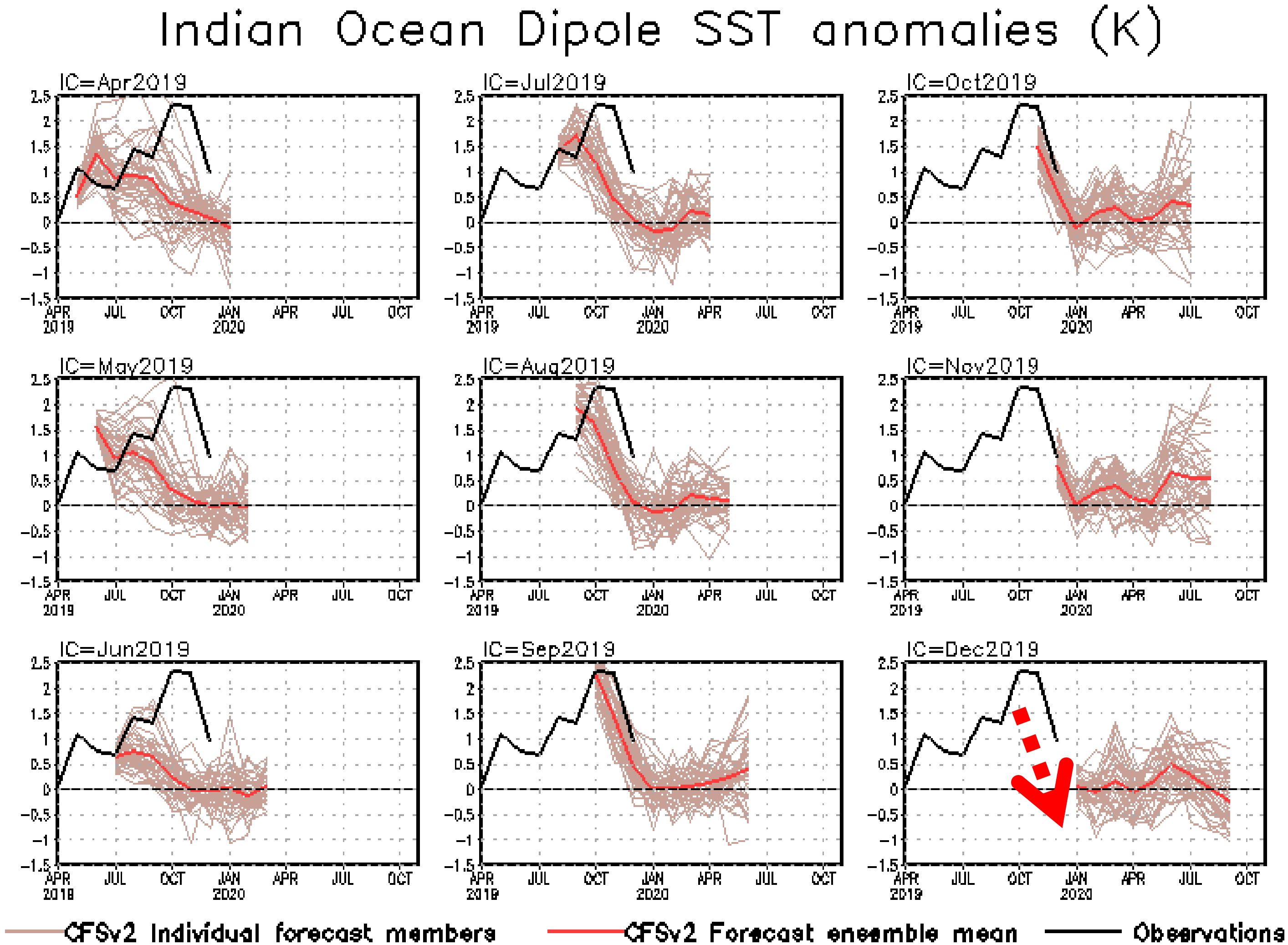




Oct-Dec T (top) & Precip (bottom) anomalies:

http://www.bom.gov.au/climate/maps/

NCEP CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

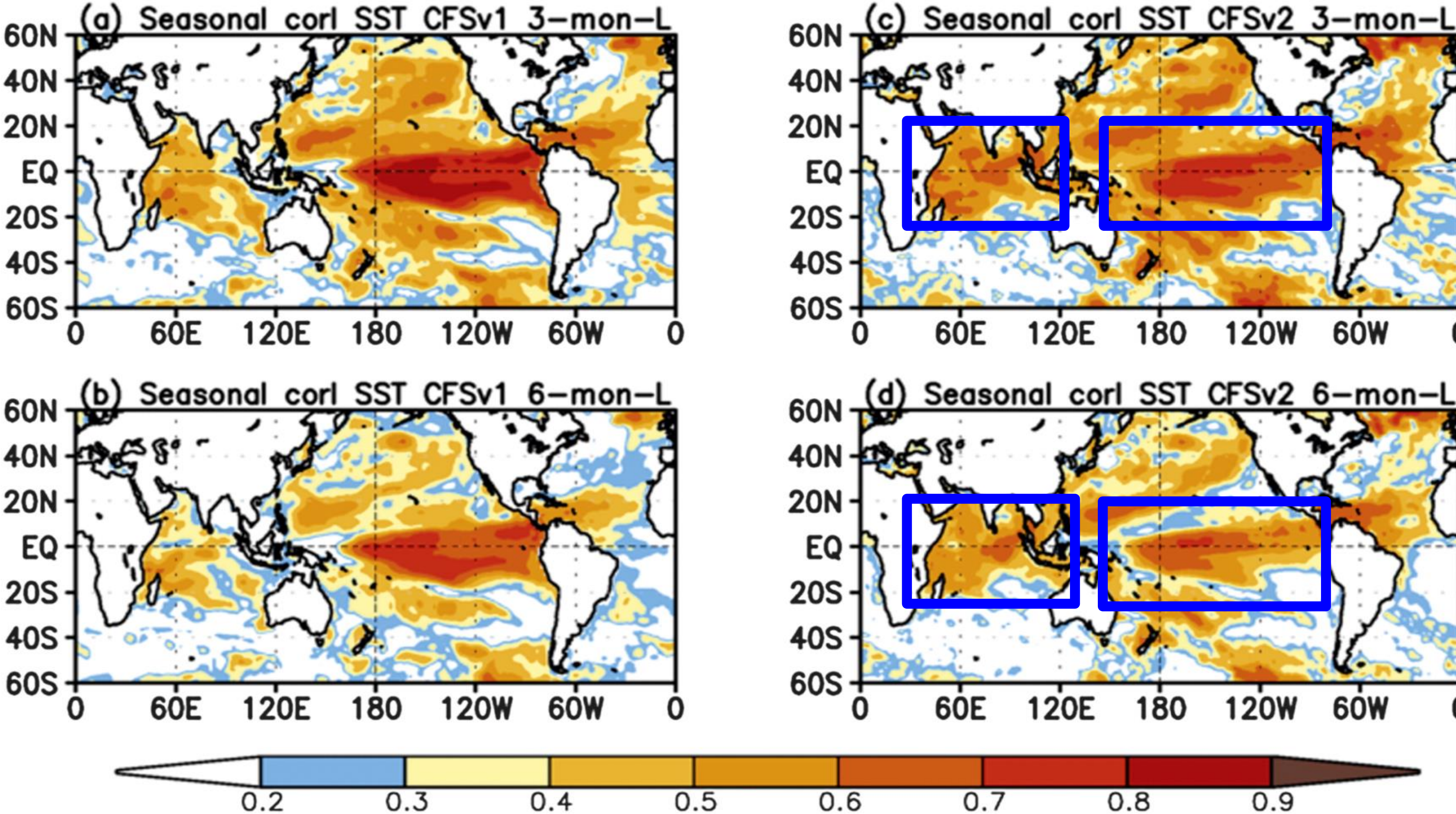
SETIO = SST anomaly in [90°E-110°E, 10°S-0]

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

- **Latest CFSv2 predictions call decline of the positive phase of IOD in 2020.**

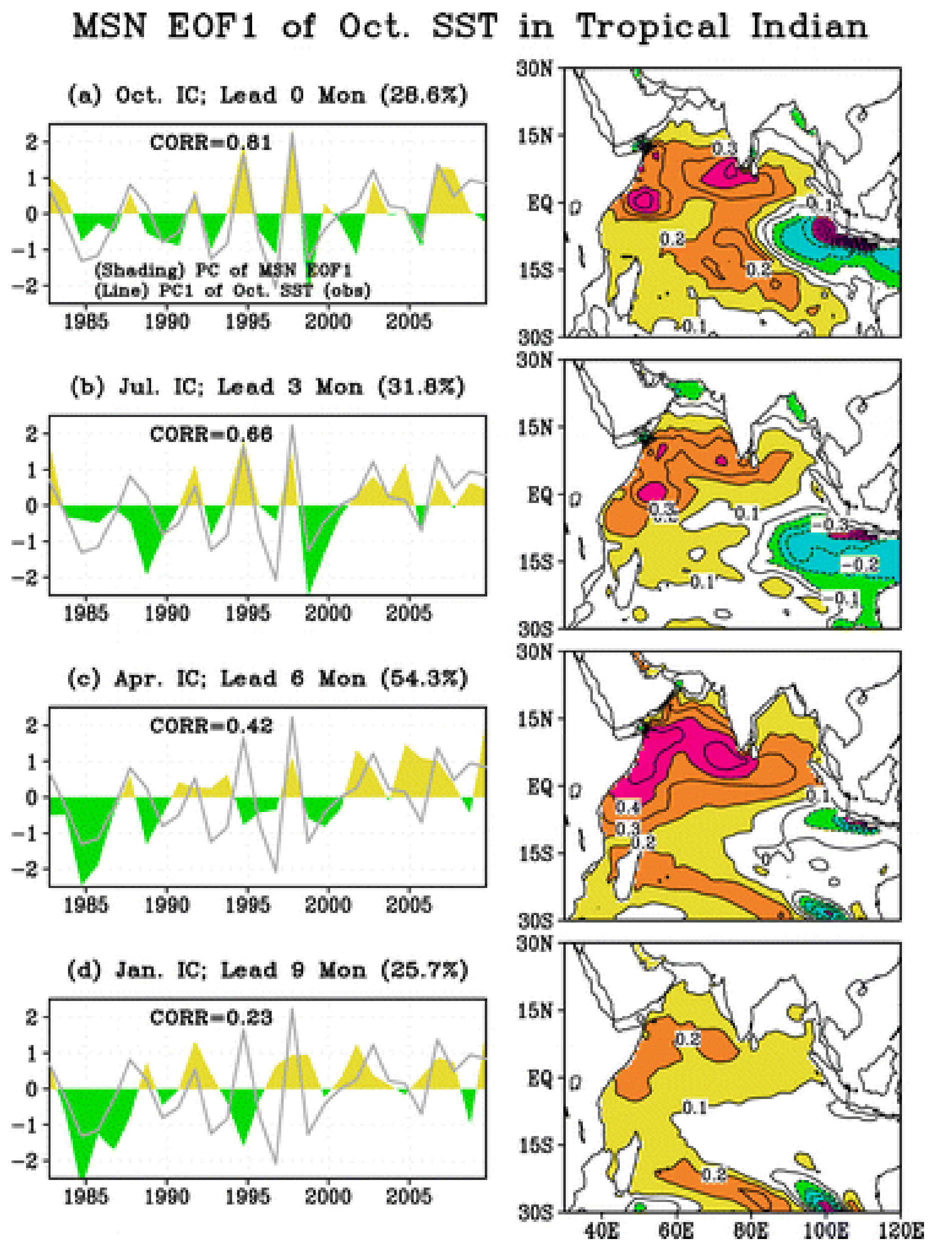
Fig. M2. CFS Dipole Model Index (DMI) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast 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.

Hindcast skill of SSTA is the highest in the central and eastern tropical Pacific associated with ENSO, and lower in IO (CFSv1 and CFSv2)



Anomaly correlation of 3-month-mean SST between model forecasts and observation: (a) 3-month lead CFSv1, (b) 6-month lead CFSv1, (c) 3-month lead CFSv2, and (d) 6-month lead CFSv2. Contours are plotted at an interval of 0.1.

Saha, S., et al., 2014: The NCEP Climate Forecast System Version 2. J. Climate, 27, 2185–2208.



Most Predictable Pattern: IOD

Fig. 12. (left) The normalized time series (color shading) and (right) spatial patterns of MSN EOF1 of the predicted October SSTAs during 1982–2009 at (a) 0-month lead with the October IC, (b) 3-month lead with the July IC, (c) 6-month lead with the April IC, and (d) 9-month lead with the January IC. The contour interval is 0.1C. The percentage of the explained variance for the ensemble mean anomalies is indicated in each panel. Overlaid in the shading time series is the normalized time series (gray lines) corresponding to EOF1 of observed October SSTA (i.e., Fig. 1b).

Zhu, J., B. Huang, A. Kumar, and J.L. Kinter III, 2015: Seasonality in Prediction Skill and Predictable Pattern of Tropical Indian Ocean SST. J. Climate, 28, 7962–7984, https://doi.org/10.1175/JCLI-D-15-0067.1

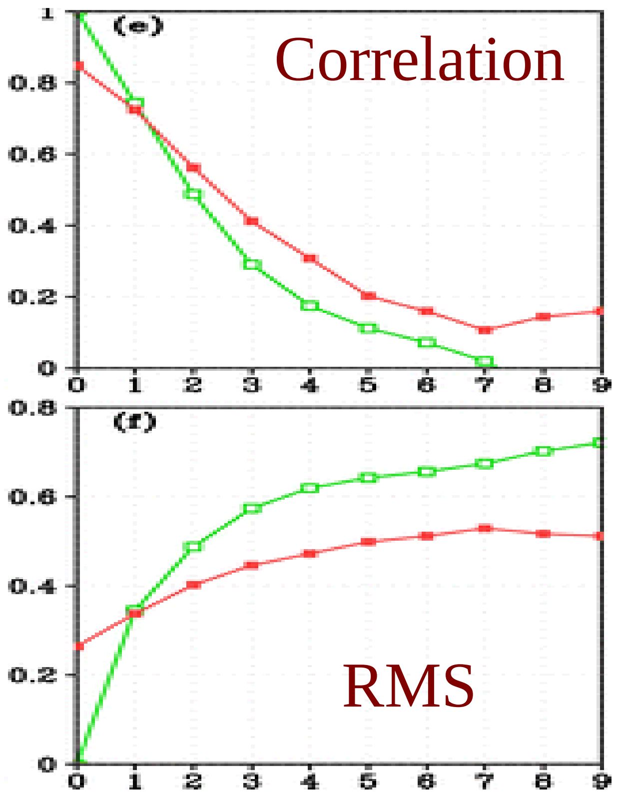


Fig. 4: …. Anomaly correlation coefficients (top) and RMS errors (bottom; °C) of persistence (green lines) and CFSRR forecast (red lines) as a function of lead months for the IOD index, based on CFSv2 predictions during 1982–2009.

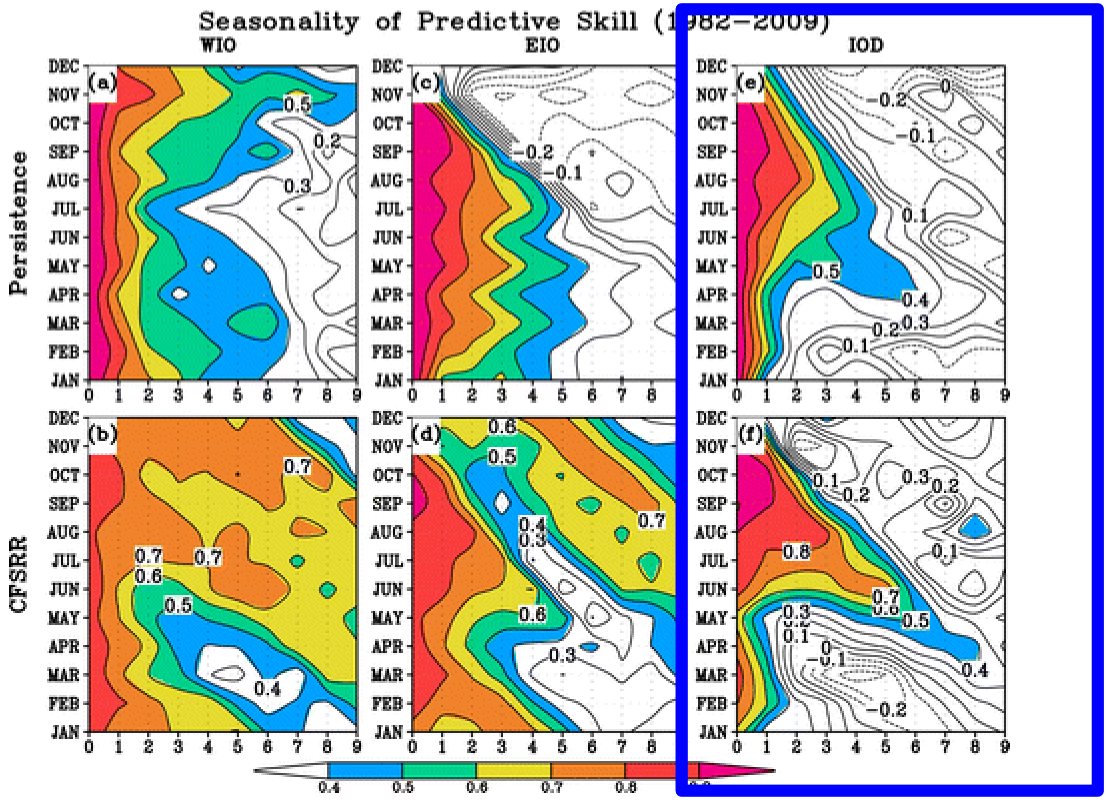
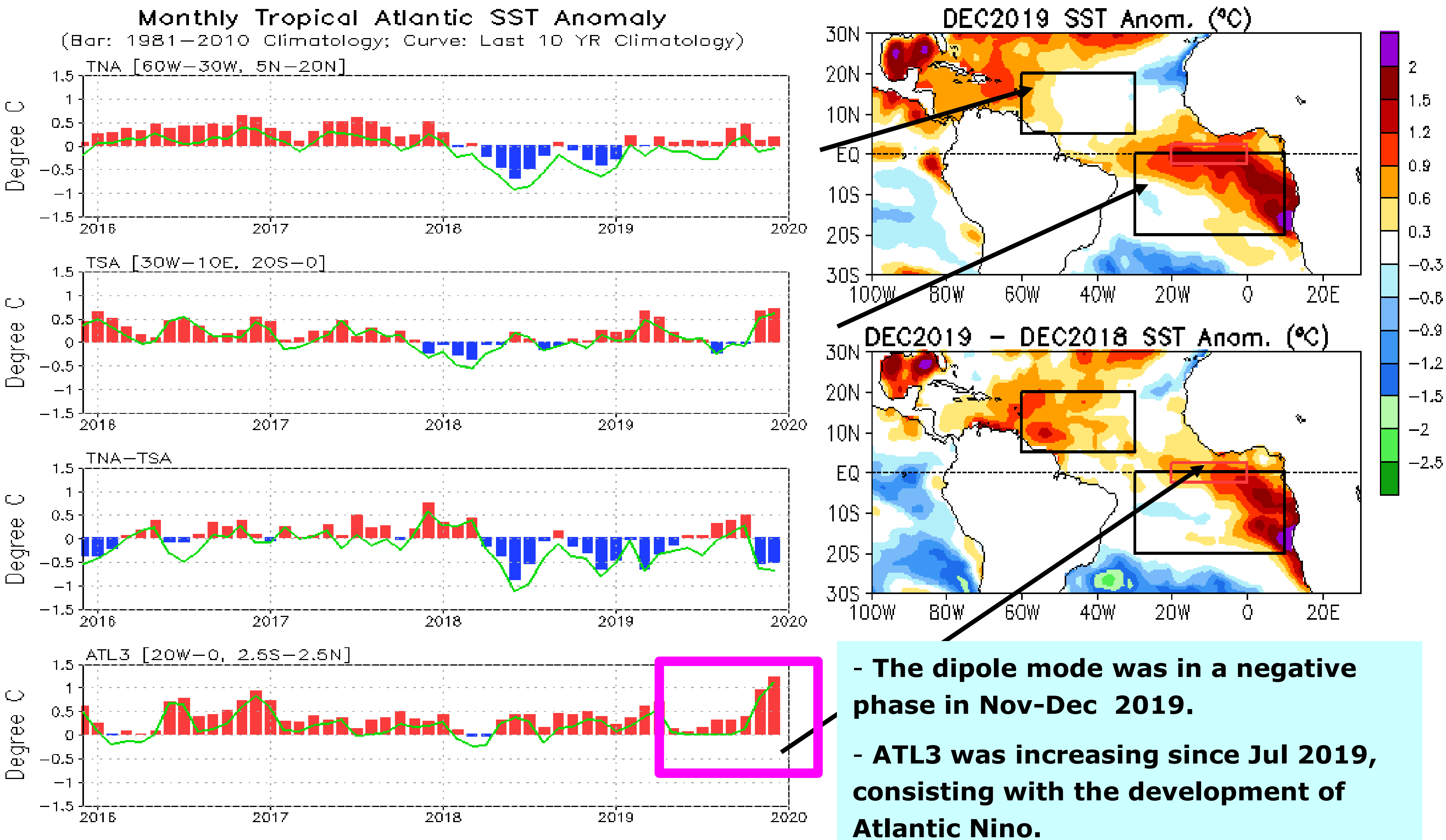


Fig. 5: Prediction skills (anomaly correlation coefficients) as functions of IC months (y-axis) and lead months (x-axis) for (a),(b) SST anomalies in the WIO (10°S–10°N, 50°–70°E), (c),(d) SST anomalies in the EIO (10°S–0°, 90°–110°E), and (e), (f) the IOD index, based on all predictions during 1982–2009, for (top) persistence and (bottom) CFSRR forecast.

Zhu, J., B. Huang, A. Kumar, and J.L. Kinter III, 2015: Seasonality in Prediction Skill and Predictable Pattern of Tropical Indian Ocean SST. J. Climate, 28, 7962–7984, https://doi.org/10.1175/JCLI-D-15-0067.1

Tropical and North Atlantic Ocean

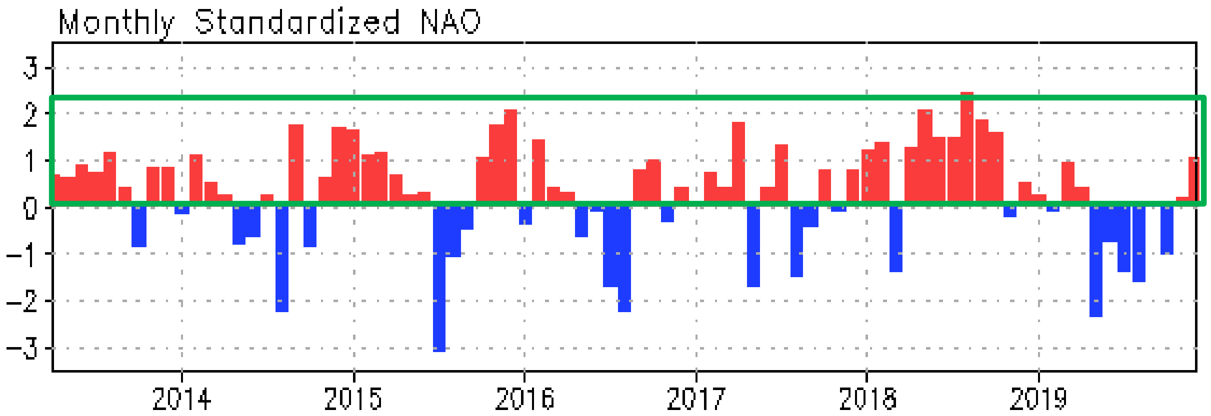
Evolution of Tropical Atlantic SST Indices

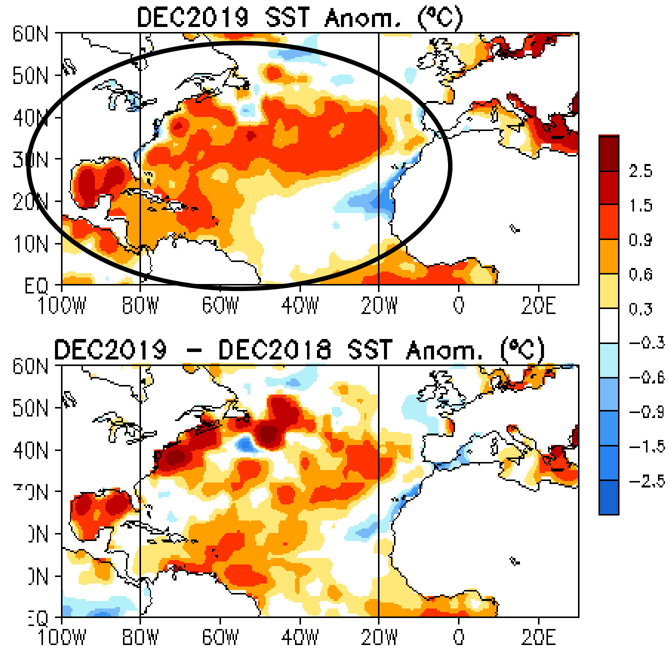


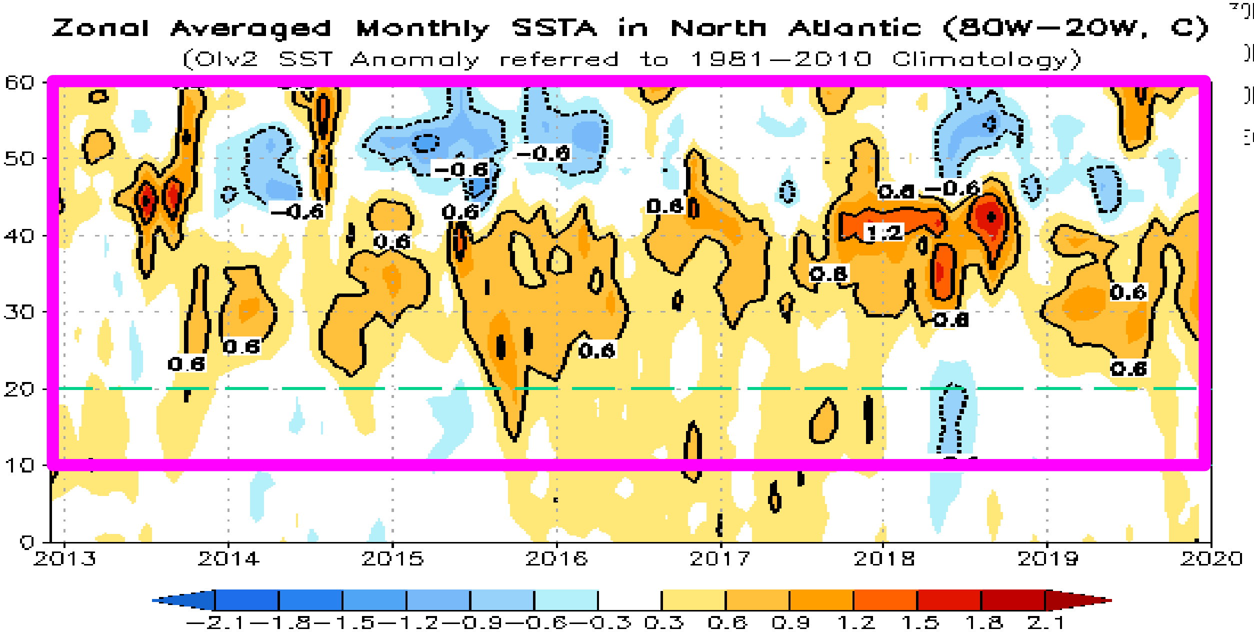
- The dipole mode was in a negative phase in Nov-Dec 2019.
- ATL3 was increasing since Jul 2019, consisting with the development of Atlantic Nino.

Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (ºC) for the TNA [60ºW-30ºW, 5ºN-20ºN], TSA [30ºW-10ºE, 20ºS-0] and ATL3 [20ºW-0, 2.5ºS-2.5ºN] 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







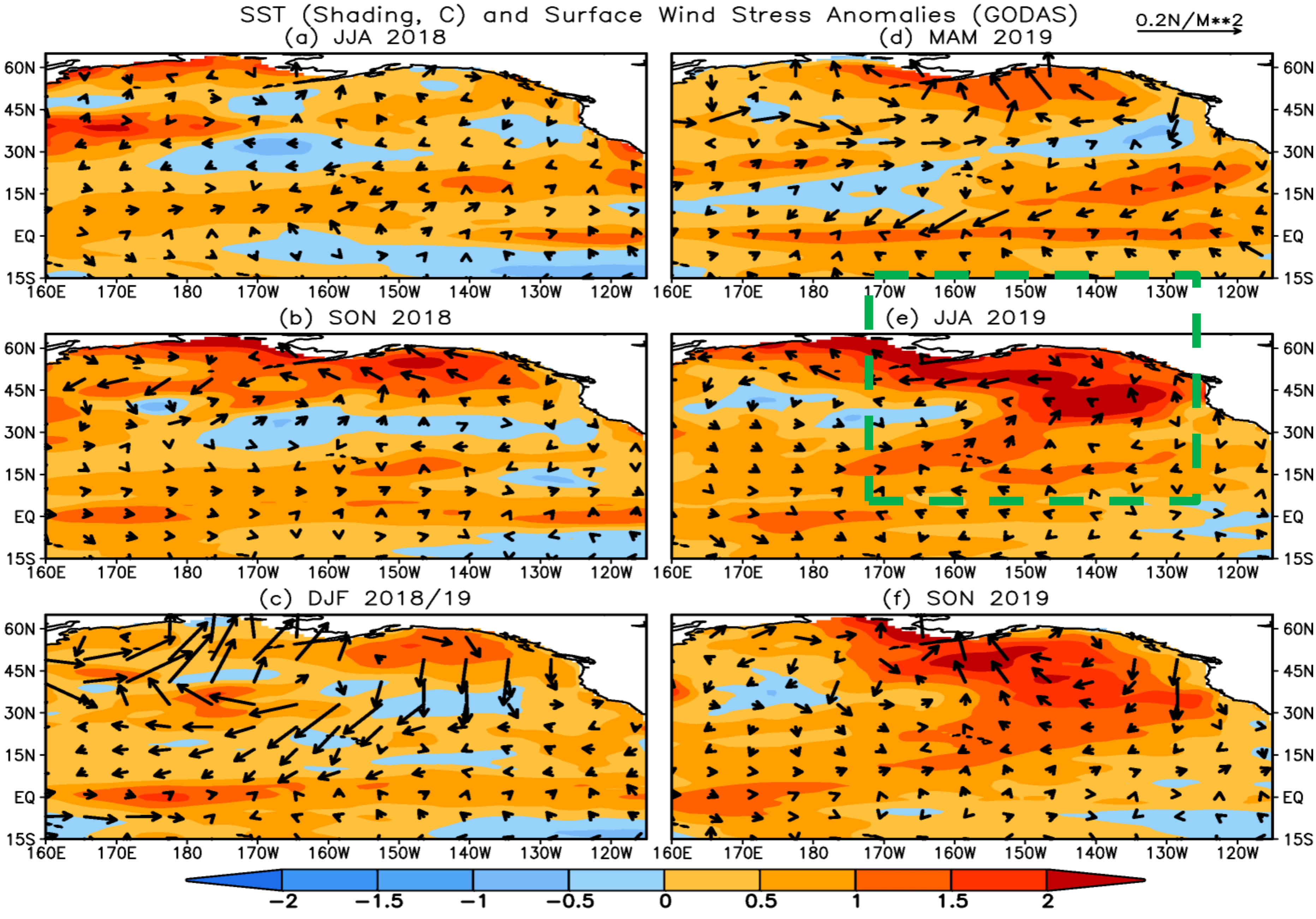
- NAO was still in a positive phase with NAOI= 1.0 in Dec 2019.
- SSTA was a tripole/horseshoe –like pattern with positive in the mid-latitudes and negative in the lower and higher latitudes, due to the long-term persistence of a positive phase of NAO.

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.

Marine Heatwaves in 2018/19 and 2014/16

(Blob.1 & Blob.2)

SST and Surface Wind Stress Anomalies



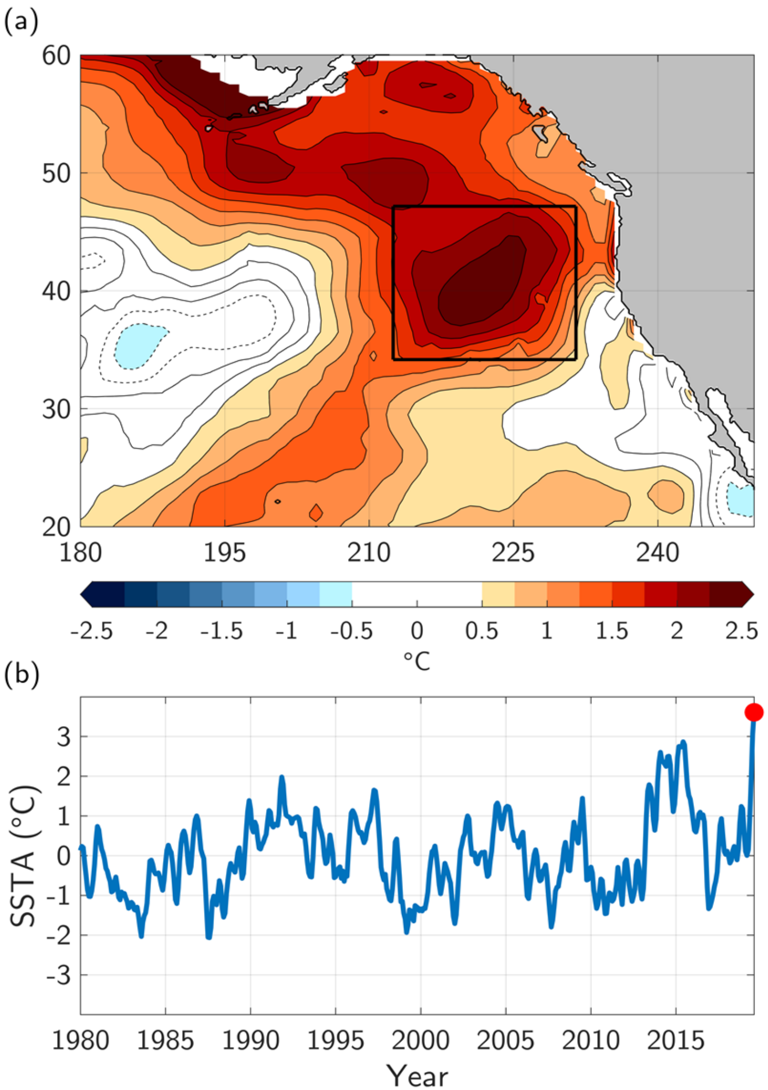
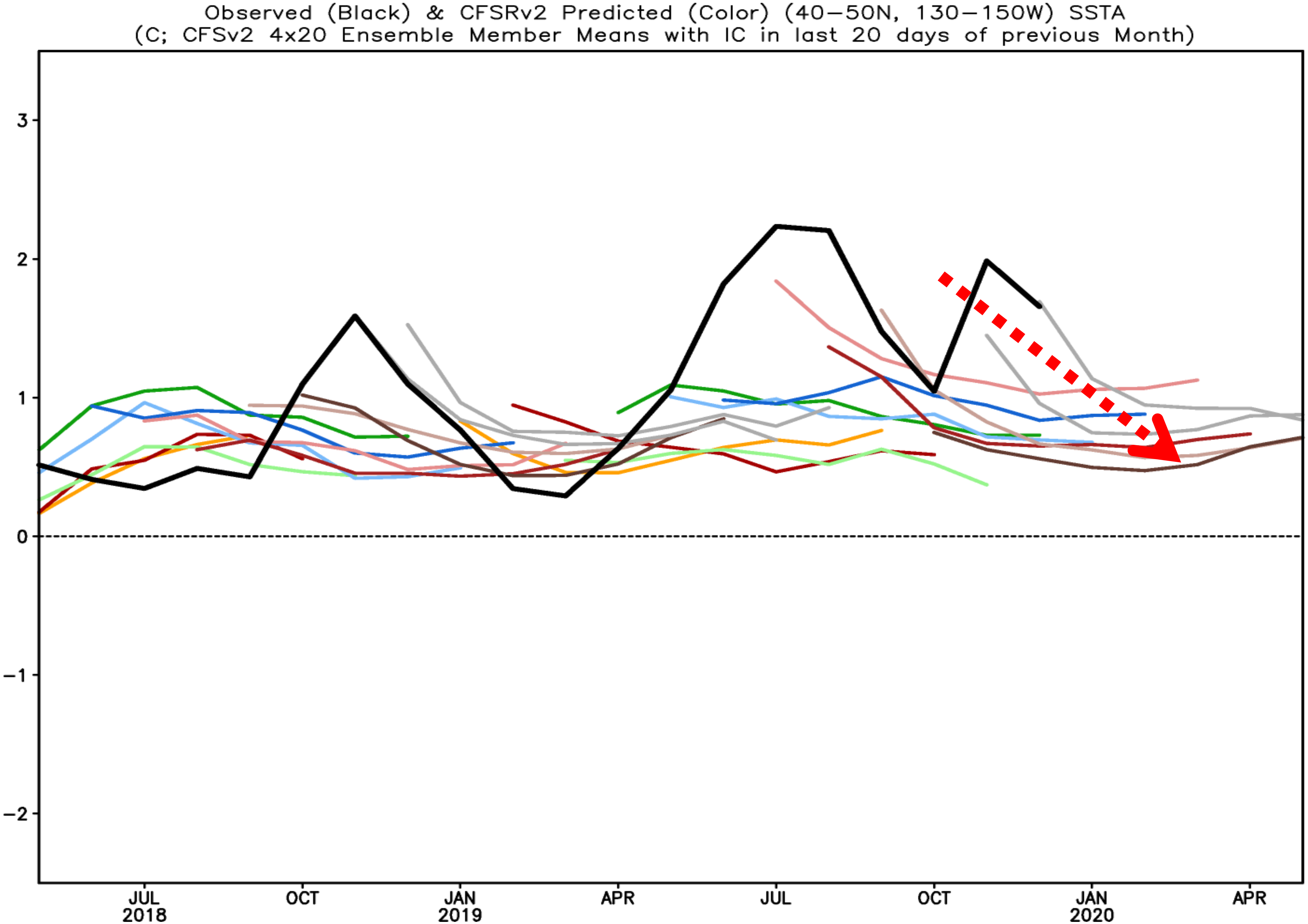


Fig. 1 The Blob 2.0 in observations. (a) Five-meter ocean temperature anomalies (°C) averaged for JJA 2019 in GODAS ocean reanalysis. (b) Time series of monthly mean SSTAs (°C) area-weighted averaged in black box above, smoothed with a 3-month running mean for the period 1980-2019. Red dot marks JJA 2019.

"Summer 2019 observations show a rapid resurgence of the "Blob"-like warm sea surface temperature (SST) anomalies that produced devastating marine impacts in the Northeast Pacific during winter 2013/2014. **Unlike the original Blob, Blob 2.0 occurred in the summer**, a season... Blob 2.0 primarily resulted from a prolonged weakening of the North Pacific High-Pressure System. This reduced surface winds, and resulted in decreased evaporative cooling and wind-driven upper ocean mixing. Warmer ocean conditions then reduced low-cloud fraction, reinforcing the marine heatwave through a positive low-cloud feedback."

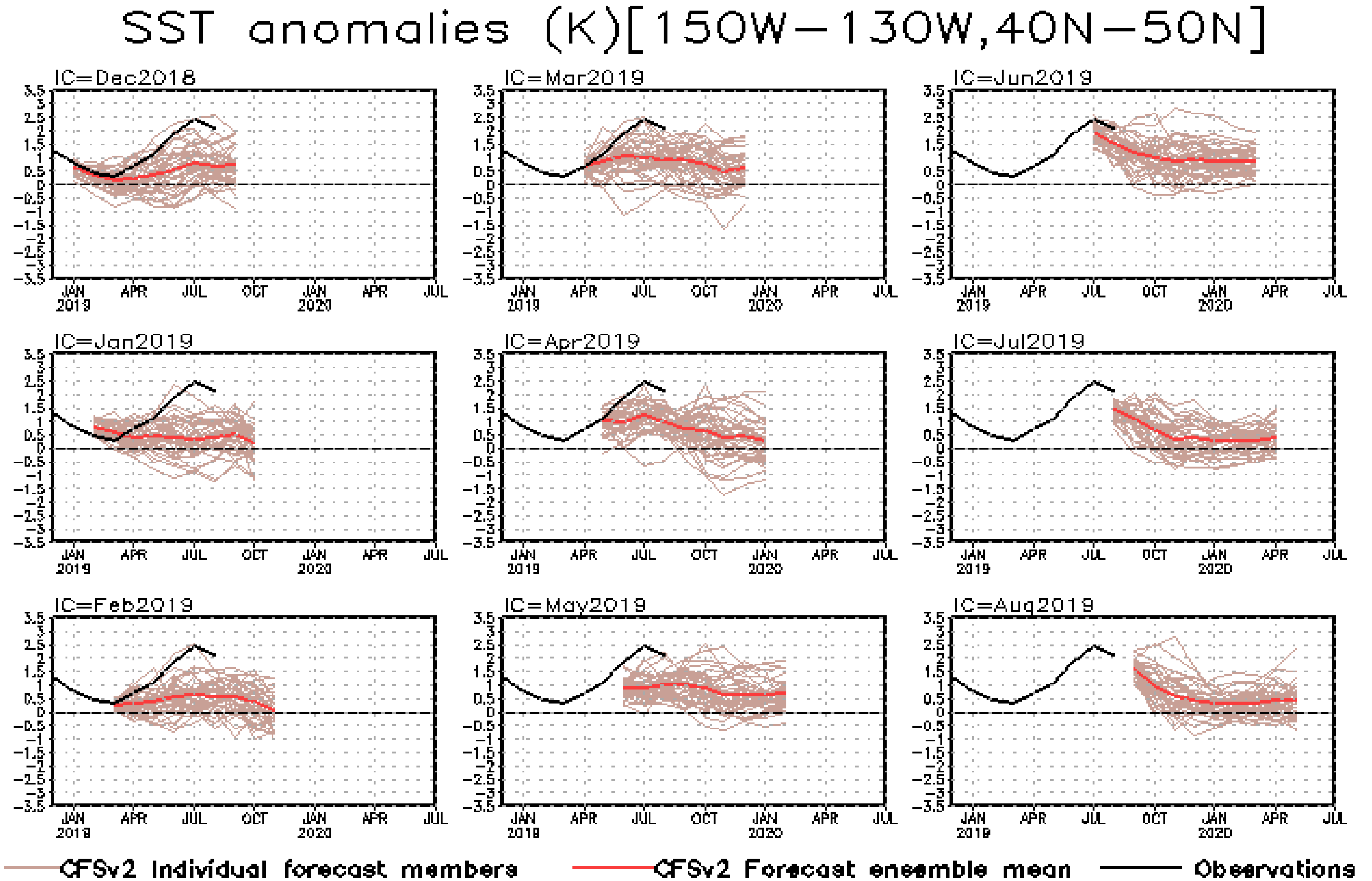
(Amaya, D. J., A. J. Miller, S.-P. Xie, & Y. Kosaka: 2019: Physical drivers of the summer 2019 North Pacific marine heatwave—the Blob 2.0.)

CFSv2 forecasts



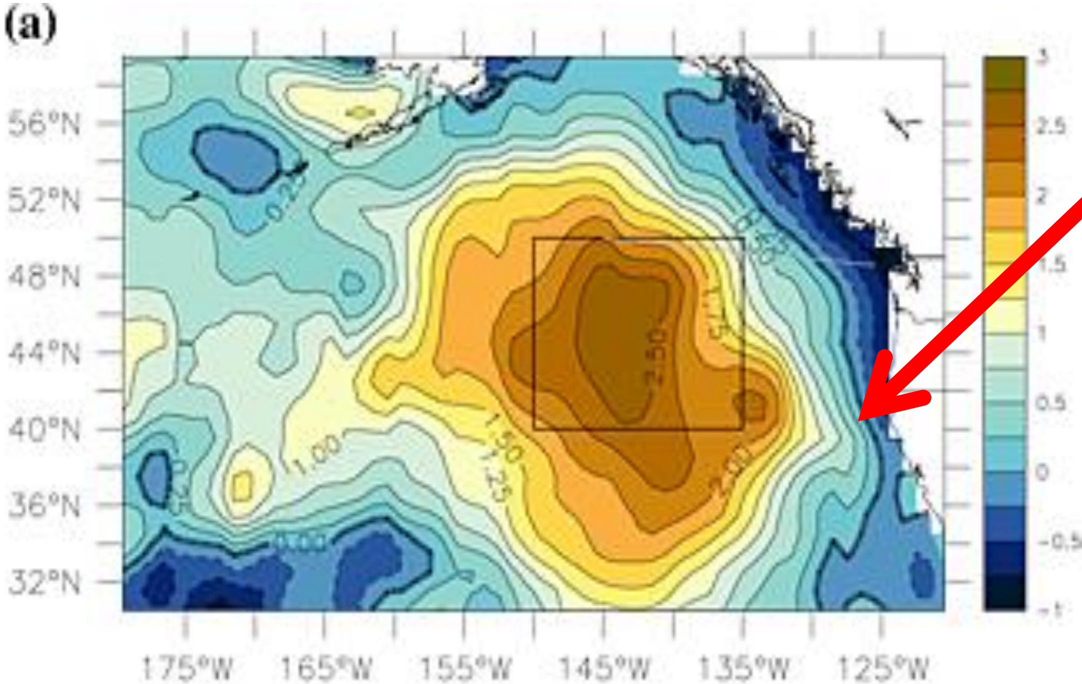
CFSv2 forecasts

Cold Biases: Underestimated the warming intensity



What is “Blob”?

Persistent warm water mass in NE Pacific during 2013-2015 (Bond et al. 2015).



SSTAs (°C) in NE Pacific Ocean for February 2014. Anomalies are calculated relative to the mean from 1981-2010.

*Bond, N. A., M. F. Cronin, H. Freeland, and N. Mantua (2015), Causes and impacts of the 2014 warm anomaly in the NE Pacific. Geophys. Res. Lett., **42**, 3414–3420, doi:10.1002/2015GL063306.*

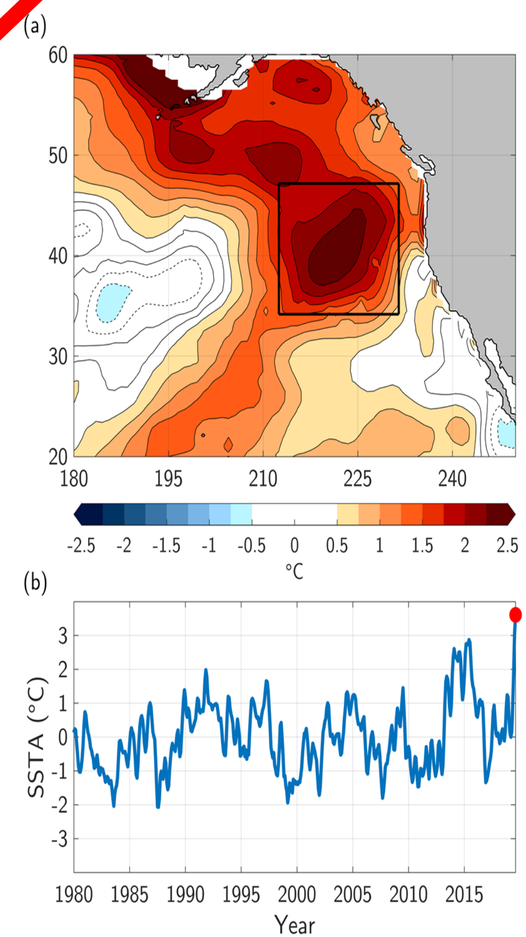
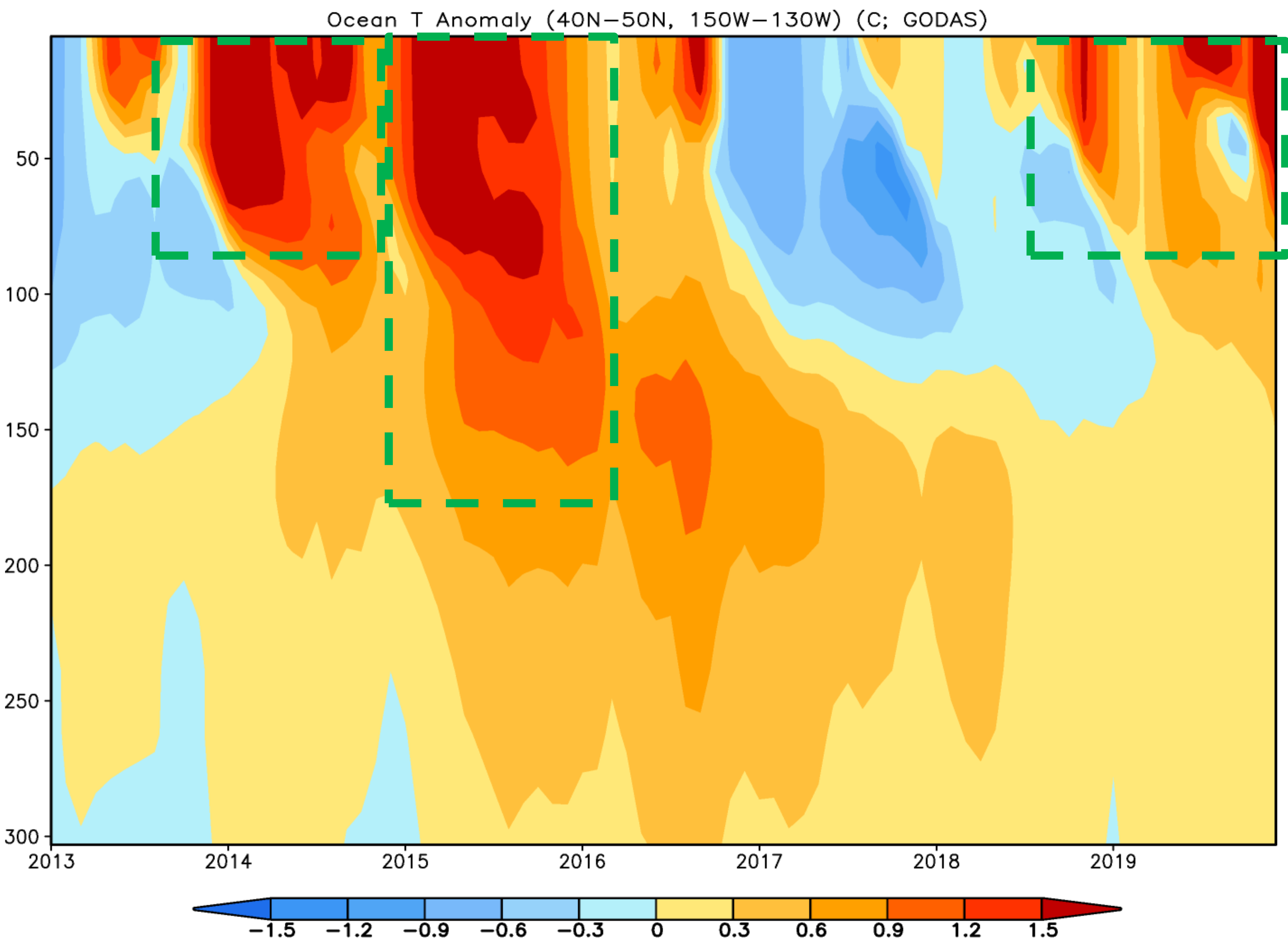
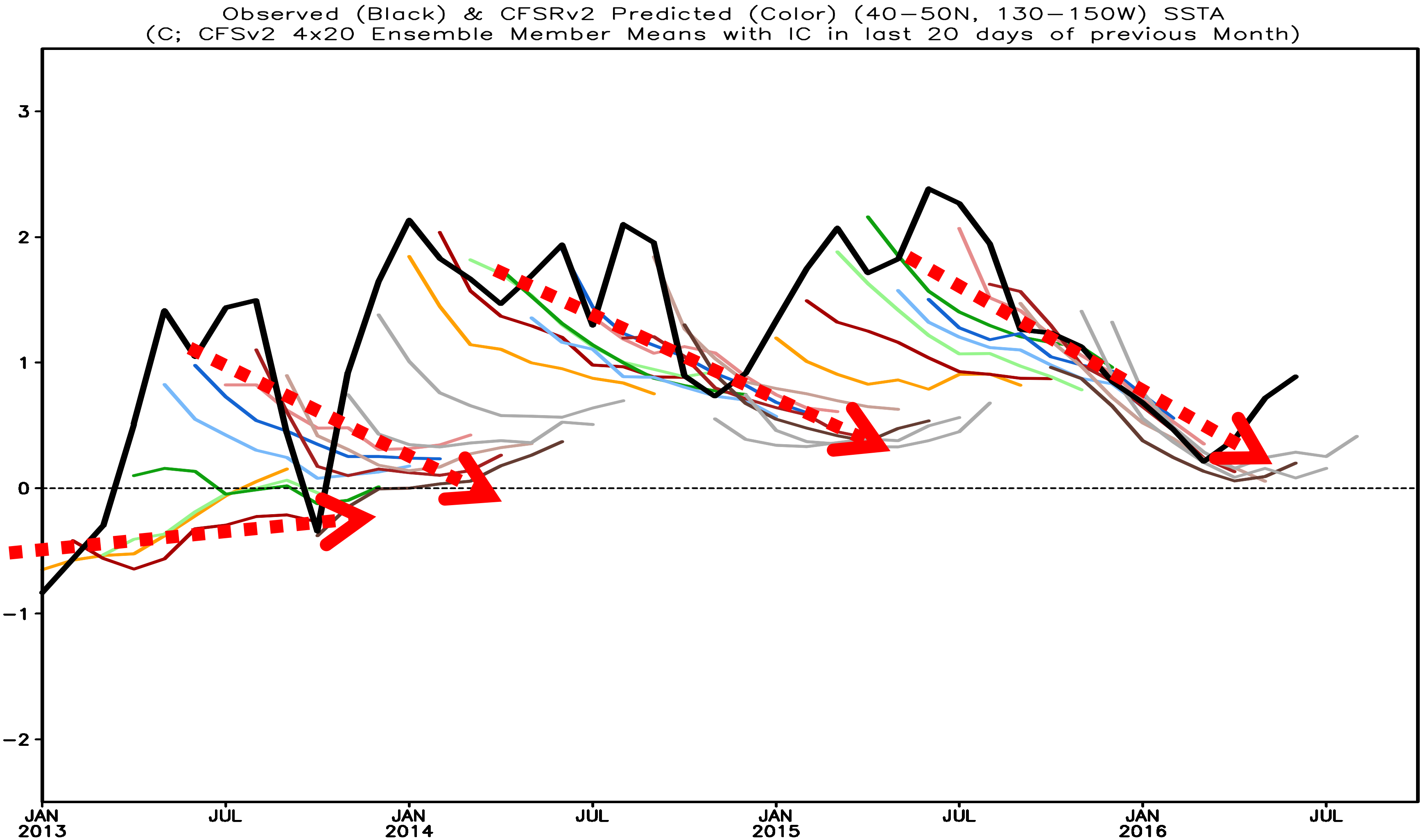


Fig. 1 The Blob 2.0 in observations. (a) Five-meter ocean temperature anomalies (°C) averaged for JJA 2019 in GODAS ocean reanalysis. (b) Time series of monthly mean SSTAs (°C) area-weighted averaged in black box above, smoothed with a 3-month running mean for the period 1980-2019. Red dot marks JJA 2019.


Ocean T Anomaly (40N–50N, 150W–130W) (C; GODAS)
50
100
150
200
250
300
2013
2014
2015
2016
2017
2018
2019
–1.5
–1.2
–0.9
–0.6
–0.3
0
0.3
0.6
0.9
1.2
1.5

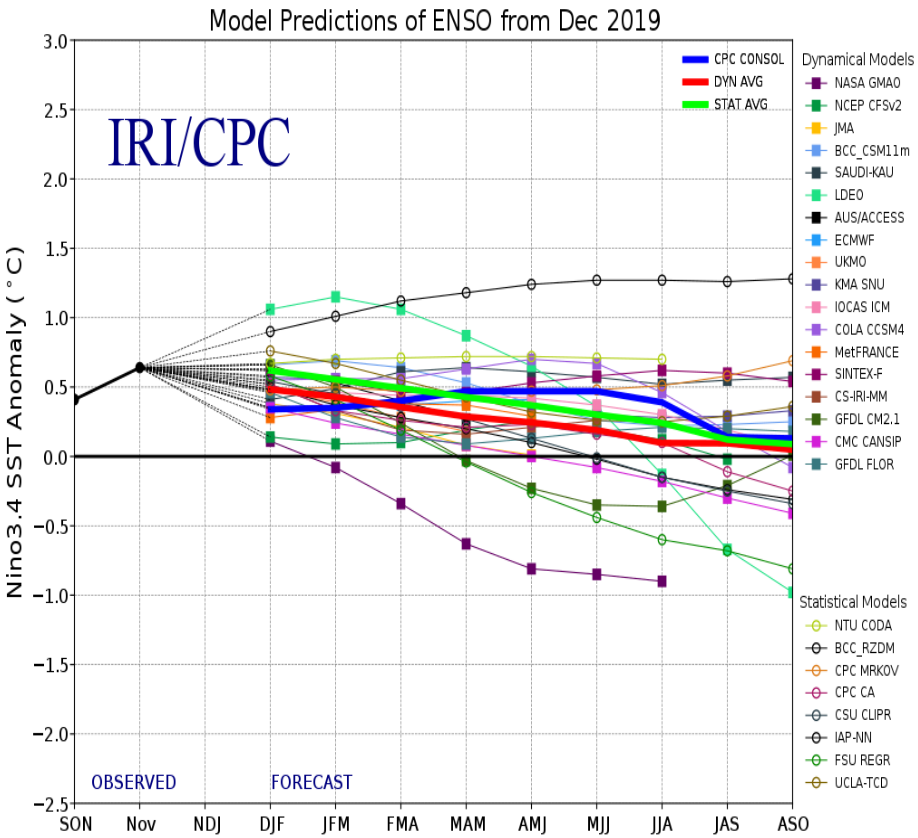
CFSv2 predictions damped the IC anomaly in NE Pacific (30-50N, 150W-130W)

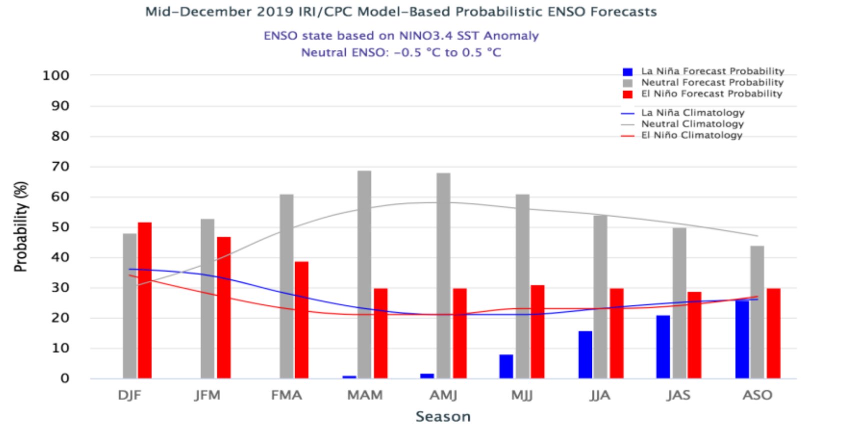


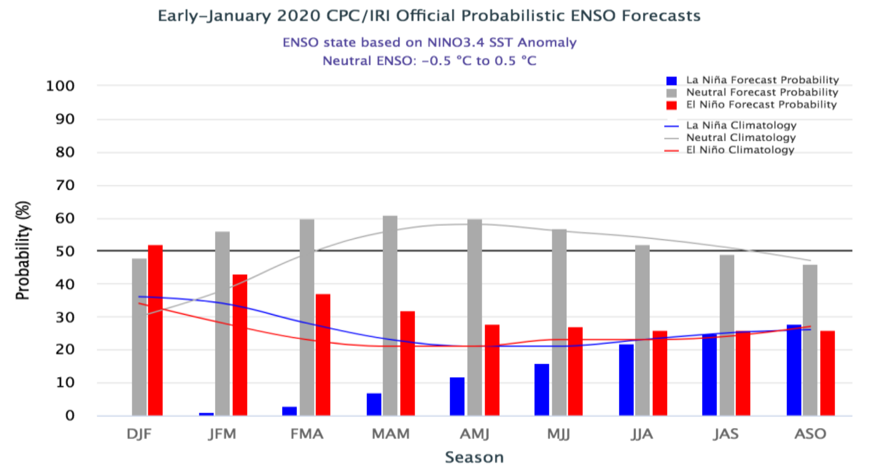
Hu, Z.-Z., A. Kumar, B. Jha, J. Zhu, and B. Huang, 2017: Persistence and predictions of the remarkable warm anomaly in the northeastern Pacific Ocean during 2014-2016. J. Climate, 30 (2), 689–702. DOI: 10.1175/JCLI-D-16-0348.1.

ENSO and Global SST Predictions

IRI NINO3.4 Forecast Plum



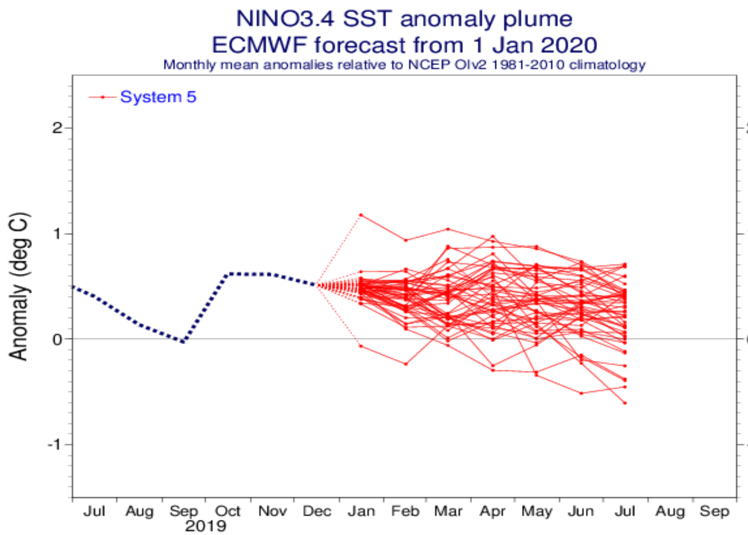




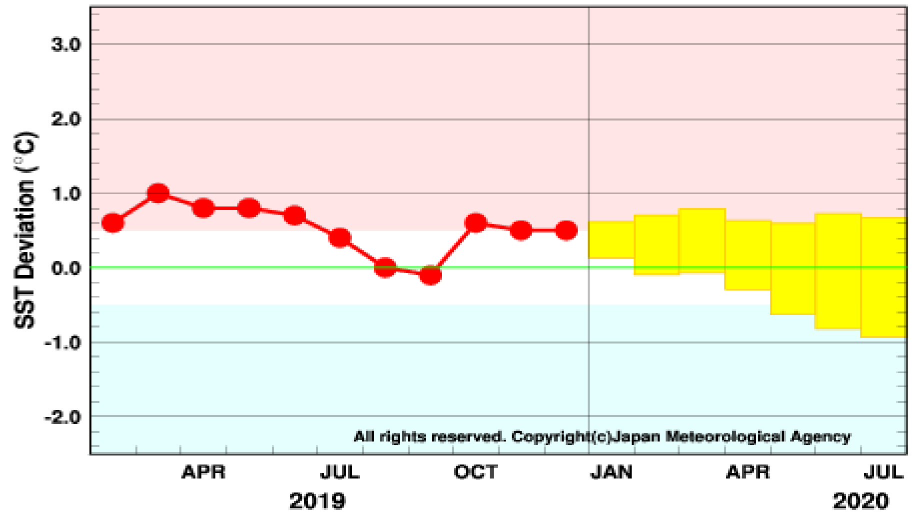
- **Majority of models predict continuation of ENSO-neutral with ICs in Dec 2019.**
- **NOAA "ENSO Diagnostic Discussion" on 9 Jan 2020 stated that** ***"ENSO-neutral is favored through Northern Hemisphere spring 2020 (~60% chance), continuing through summer 2020 (~50% chance)."***

Individual Model Forecasts: Neutral or borderline El Nino

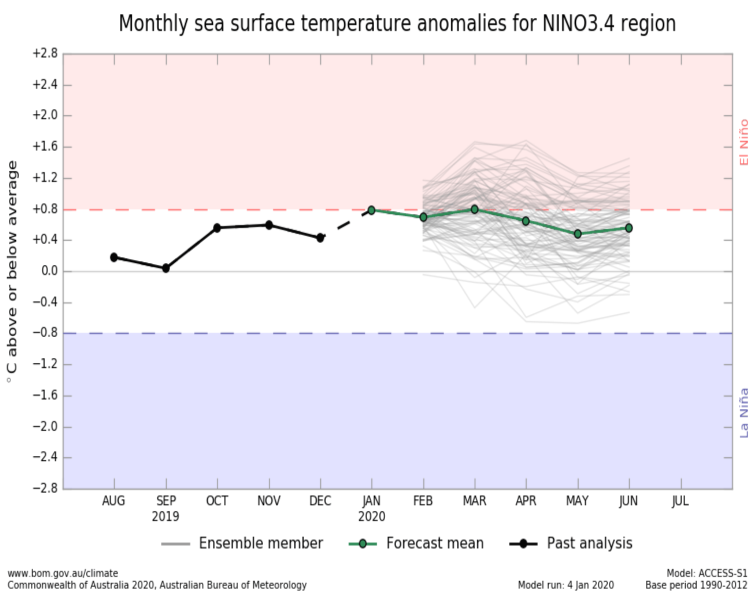
EC: Nino3.4, IC=01Jan 2020



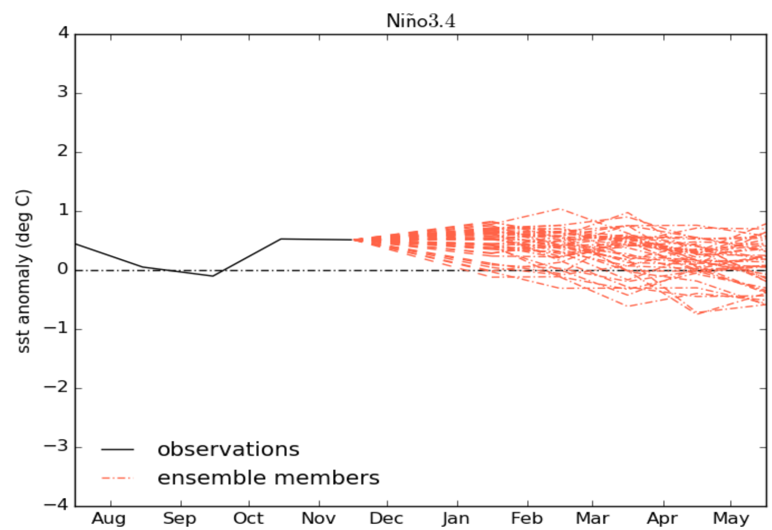
JMA: Nino3, Updated 10 Jan 2020

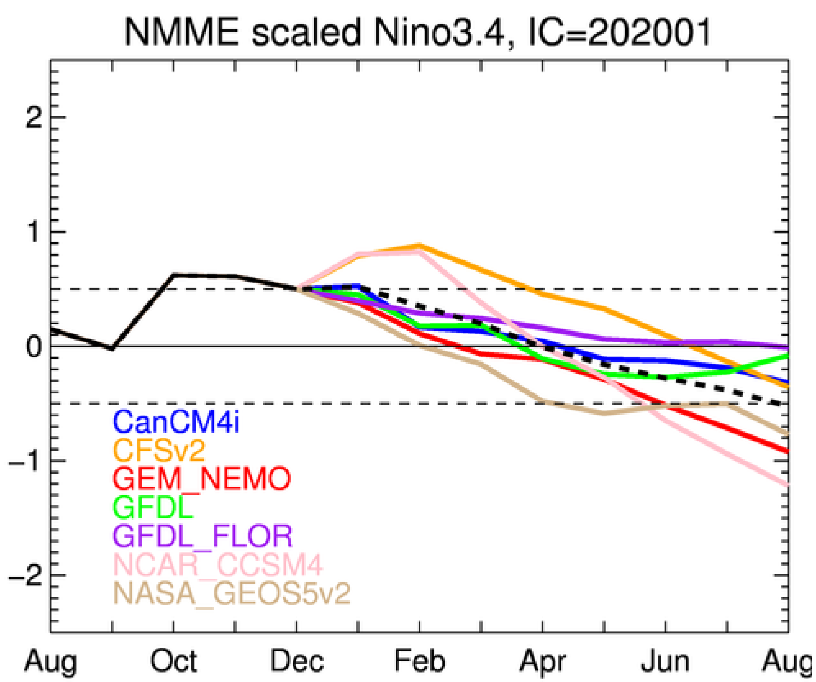


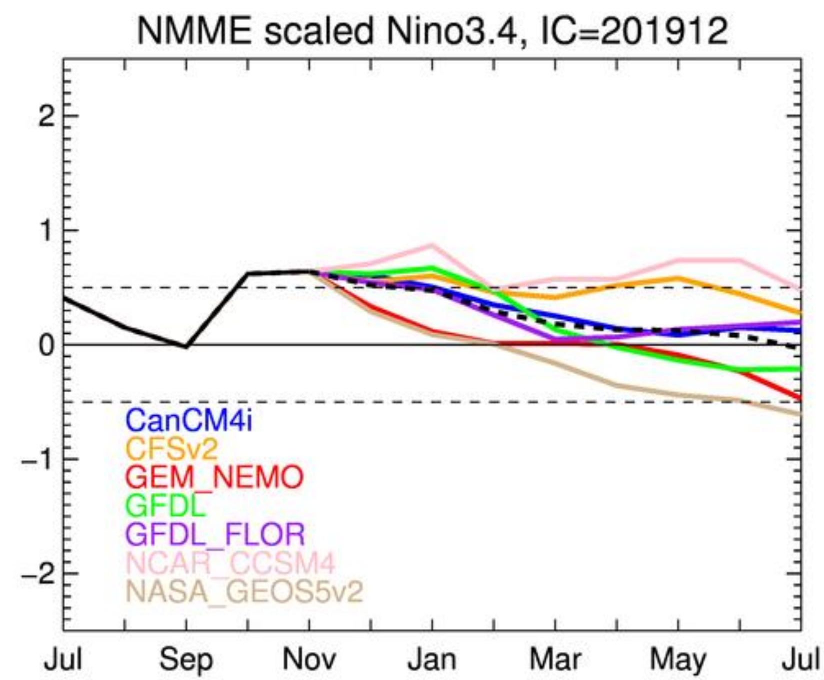
Australia: Nino3.4, Updated 4 Jan 2020

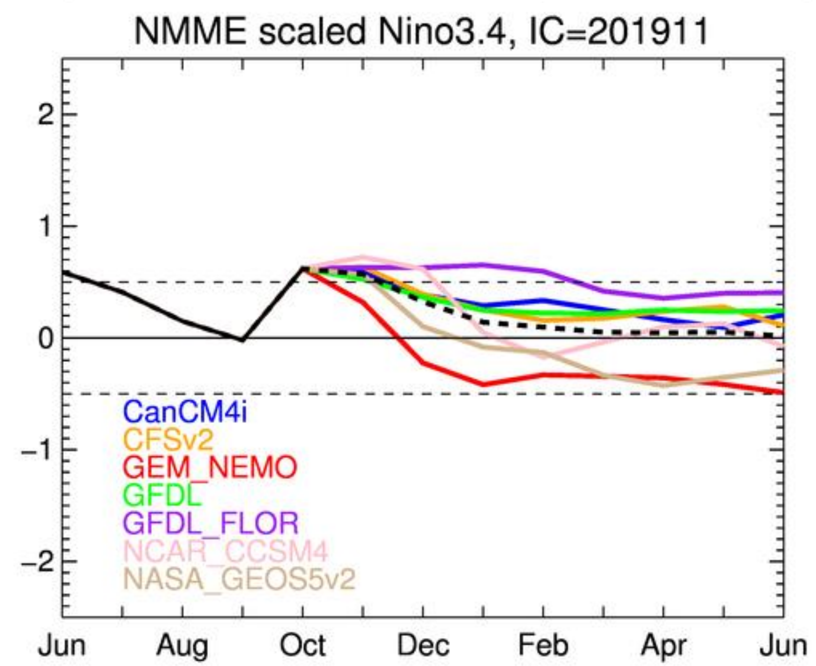


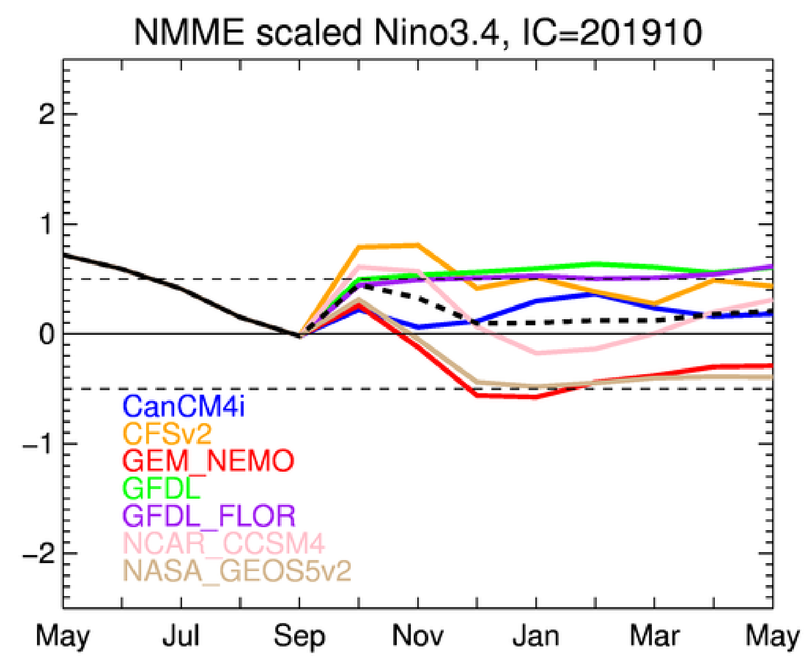
UKMO: Nino3.4, Updated 11 Dec 2019



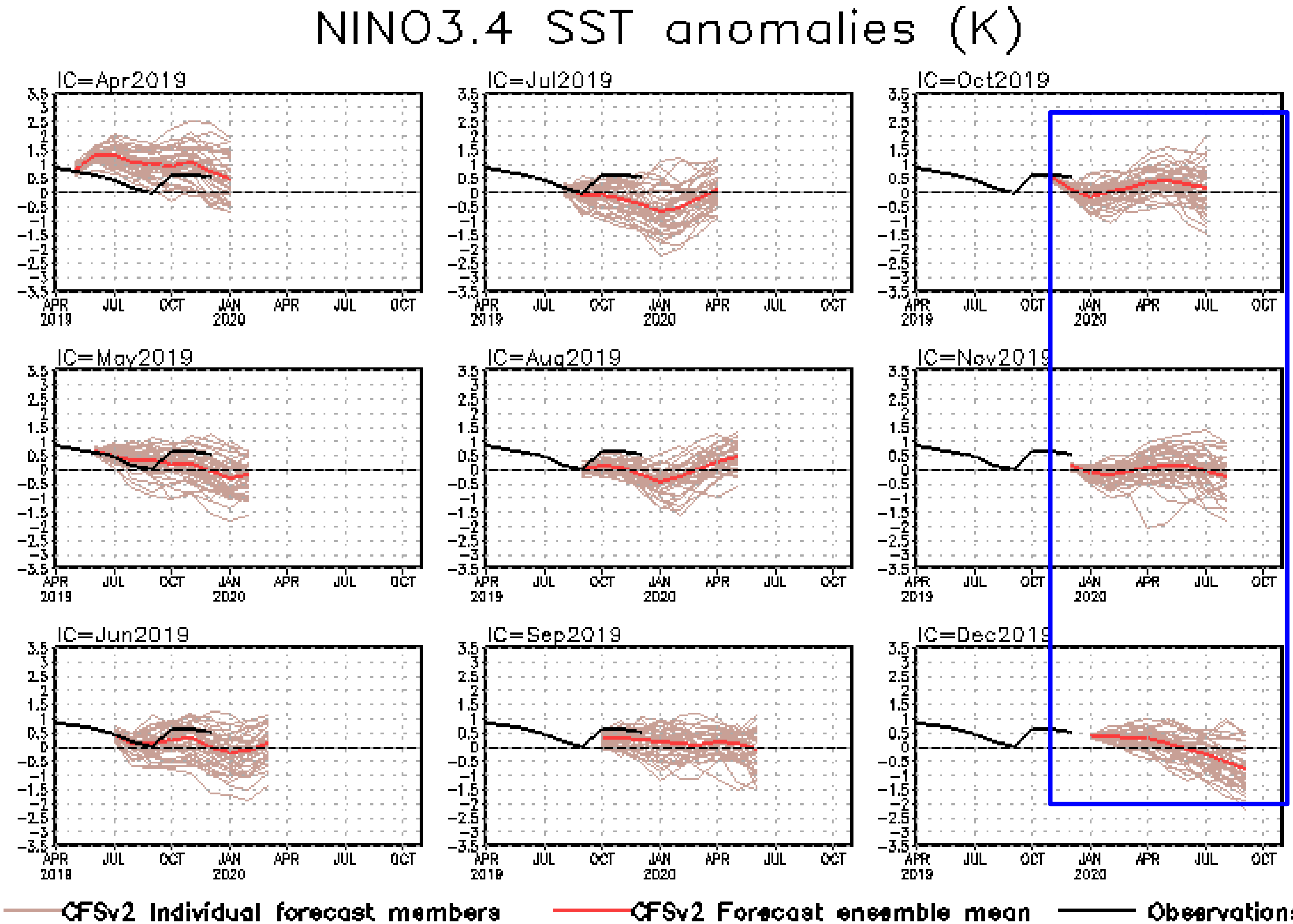

NMME scaled Nino3.4, IC=202001
CanCM4i
CFSv2
GEM_NEMO
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2
Aug Oct Dec Feb Apr Jun Aug


NMME scaled Nino3.4, IC=201912
CanCM4i
CFSv2
GEM_NEMO
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2
Jul Sep Nov Jan Mar May Jul


NMME scaled Nino3.4, IC=201911
CanCM4i
CFSv2
GEM_NEMO
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2
Jun Aug Oct Dec Feb Apr Jun


NMME scaled Nino3.4, IC=201910
CanCM4i
CFSv2
GEM_NEMO
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2
May Jul Sep Nov Jan Mar May

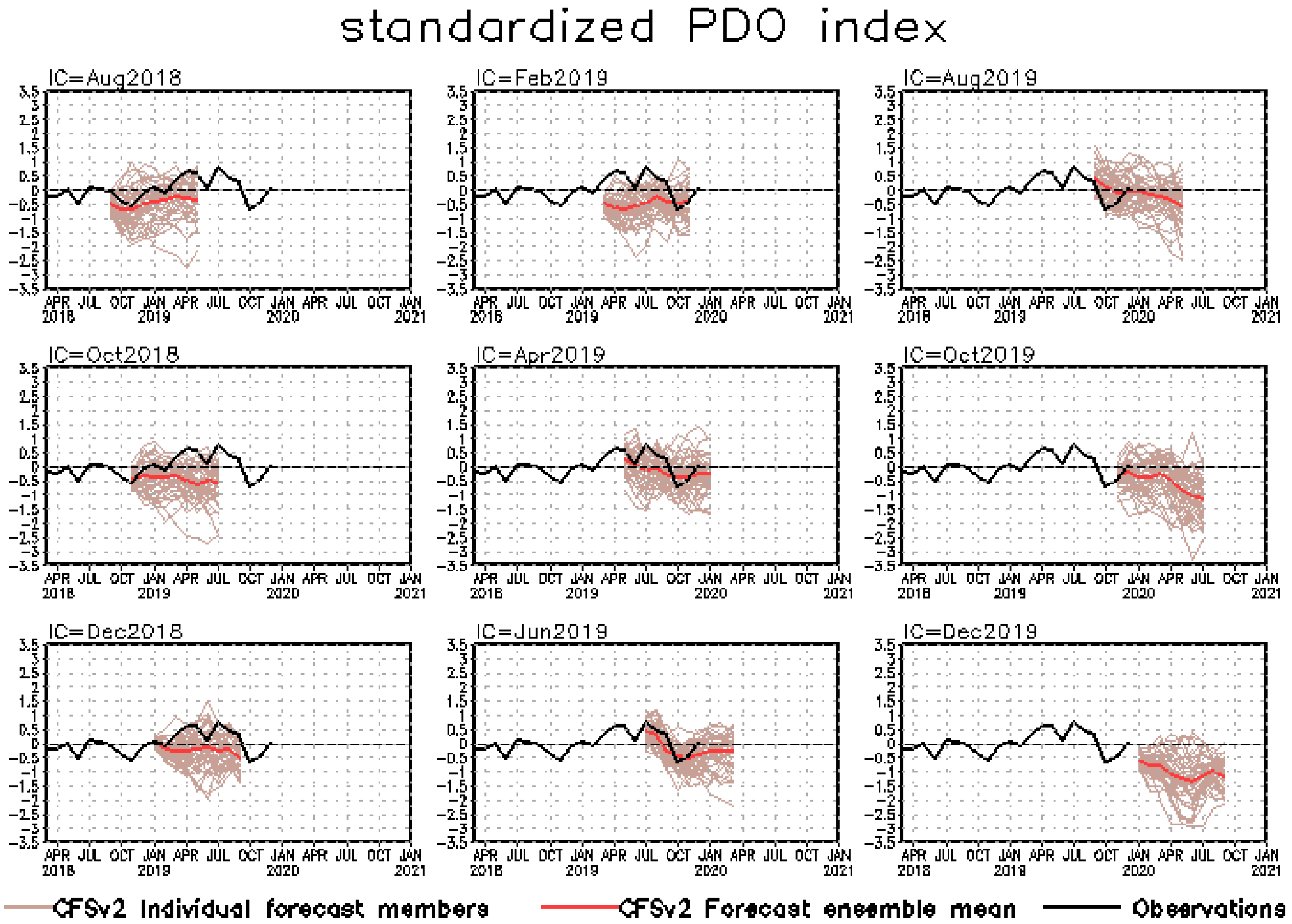
CFS Niño3.4 SST Predictions from Different Initial Months



- CFSv2 had cold bias with ICs during May-Sep 2019.
- The latest forecasts call for ENSO neutral until summer 2020.

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.

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].

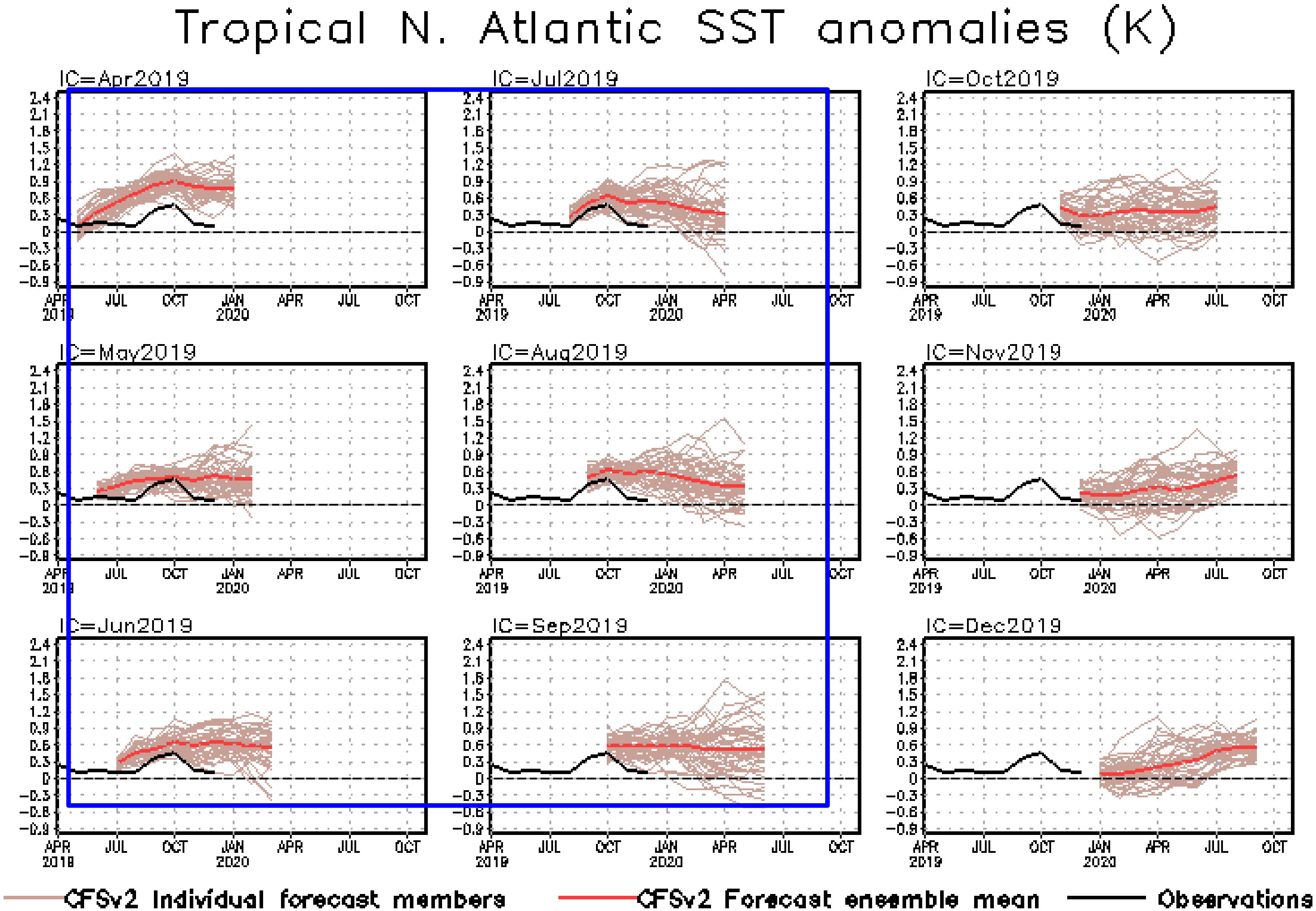
CFS PDO index is the standardized projection of CFS SST forecast anomalies onto the PDO EOF pattern.

- 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.

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.

Acknowledgements

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

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

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

❖ Dr. Wei Zhang (U. Iowa) provided the PMM slide

❖ Prof. Saji Hameed (U. Aizu, Japan) provide the IOD slide.

Please send your comments and suggestions to:

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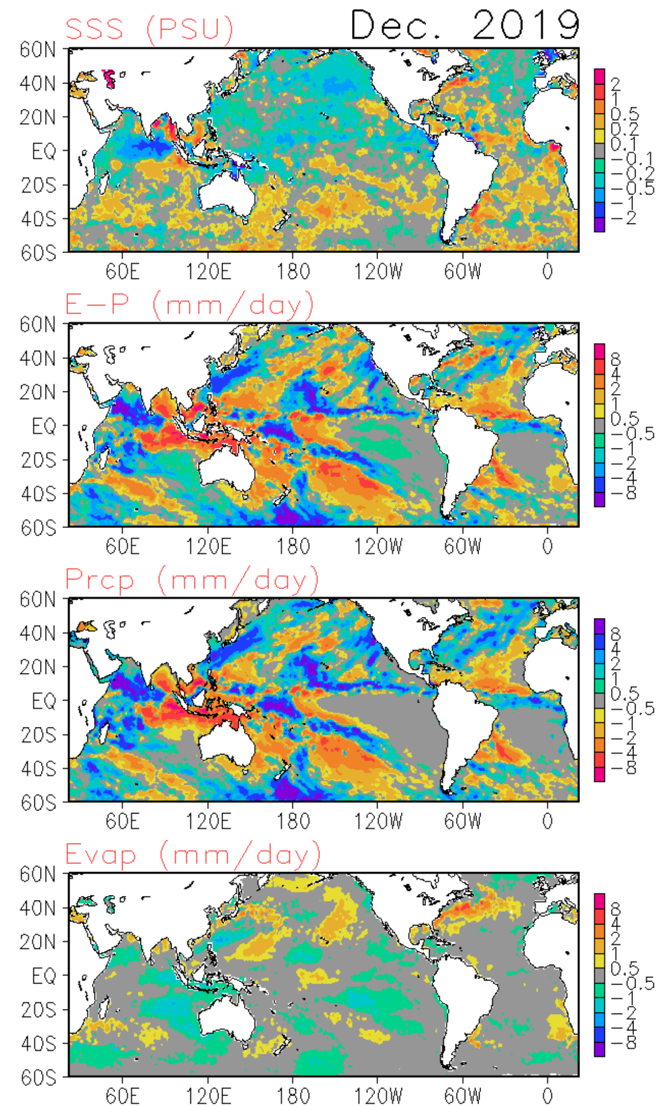
Caihong.Wen@noaa.gov
Jieshun.Zhu@noaa.gov

Backup Slides

Global Sea Surface Salinity (SSS)

Anomaly for December 2019

- 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 continuing in the northeast Pacific ocean, which are likely caused by oceanic advection/entrainments. Negative SSS signal shows north of equator along the Pacific Ocean, particularly in the east basin with enhanced precipitation in this area. In the Indian Ocean, the dipole pattern of negative/positive SSS signal in the east basin is continuing. In the Bay of Bengal, the positive SSS is persistent with decreased freshwater (E-P) input.



- **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

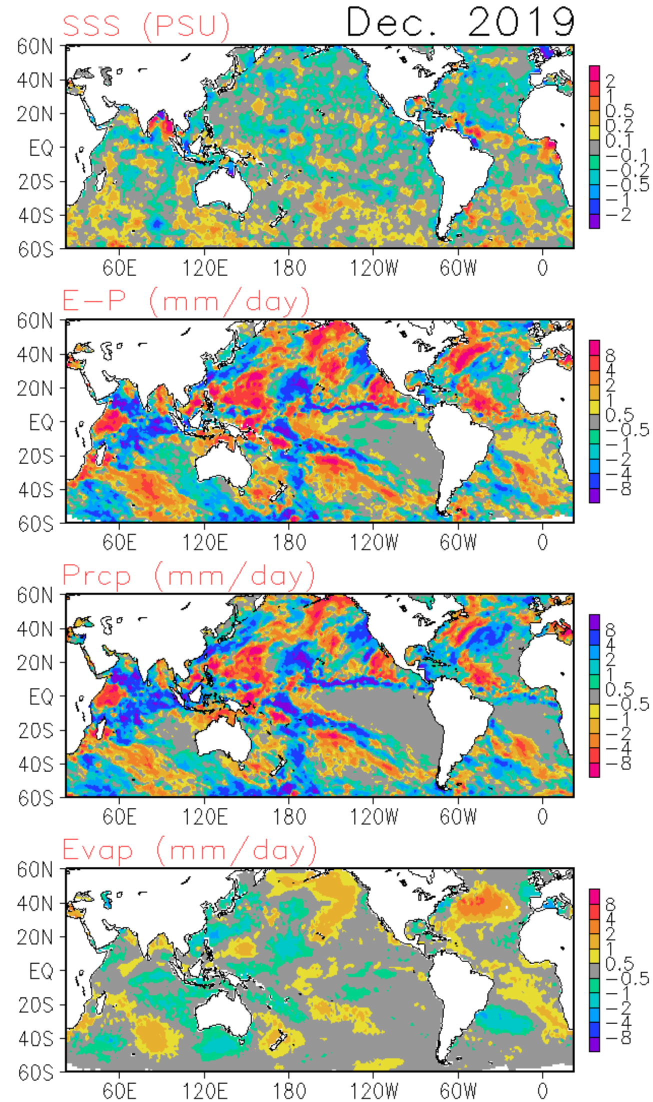
Precipitation: CMORPH adjusted satellite precipitation estimates

Evaporation: Adjusted CFS Reanalysis

Global Sea Surface Salinity (SSS)

Tendency for December 2019

Compared with last month, the SSS decreased in the SPCZ region due to the enhanced precipitation. The SSS also decreased in the N. Atlantic ocean south of 40ºN. The negative SSS in the west basin is likely caused by oceanic advection/entrainments, while in the east basin it is likely caused by the enhanced precipitation. In the Bay of Bengal, the SSS increased in most of the area, especially in the east basin. Such change is probably due to the decreased freshwater input.

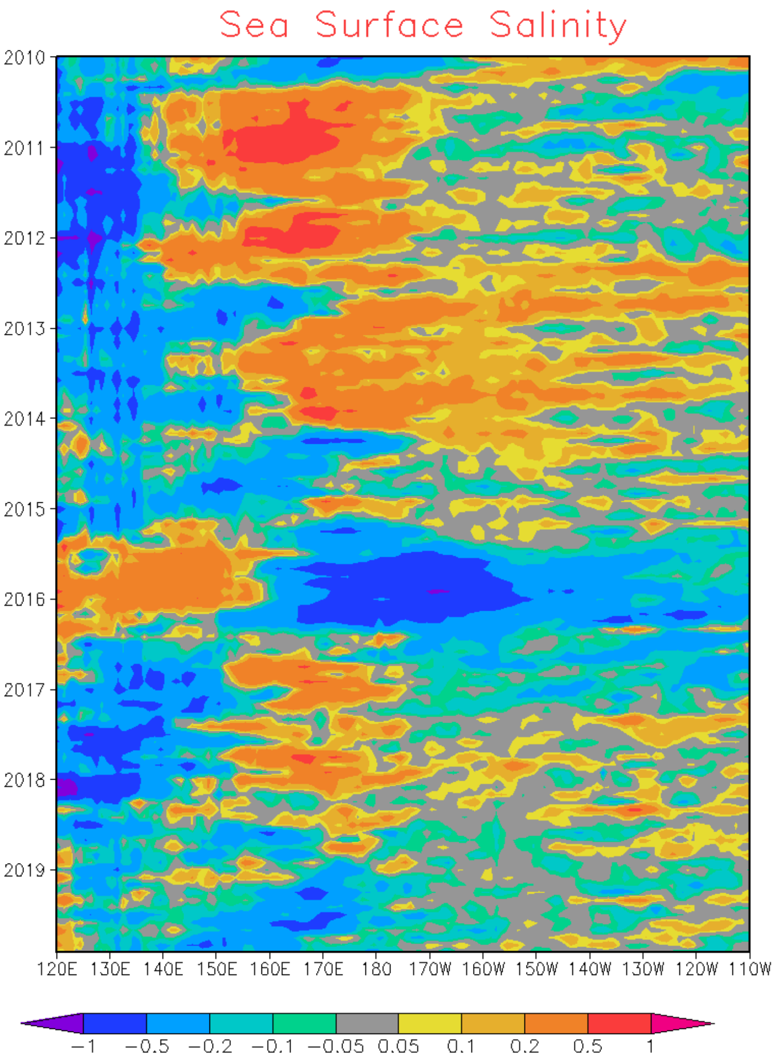


Global Sea Surface Salinity (SSS)

Anomaly Evolution along the Equatorial Pacific from Monthly SSS

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

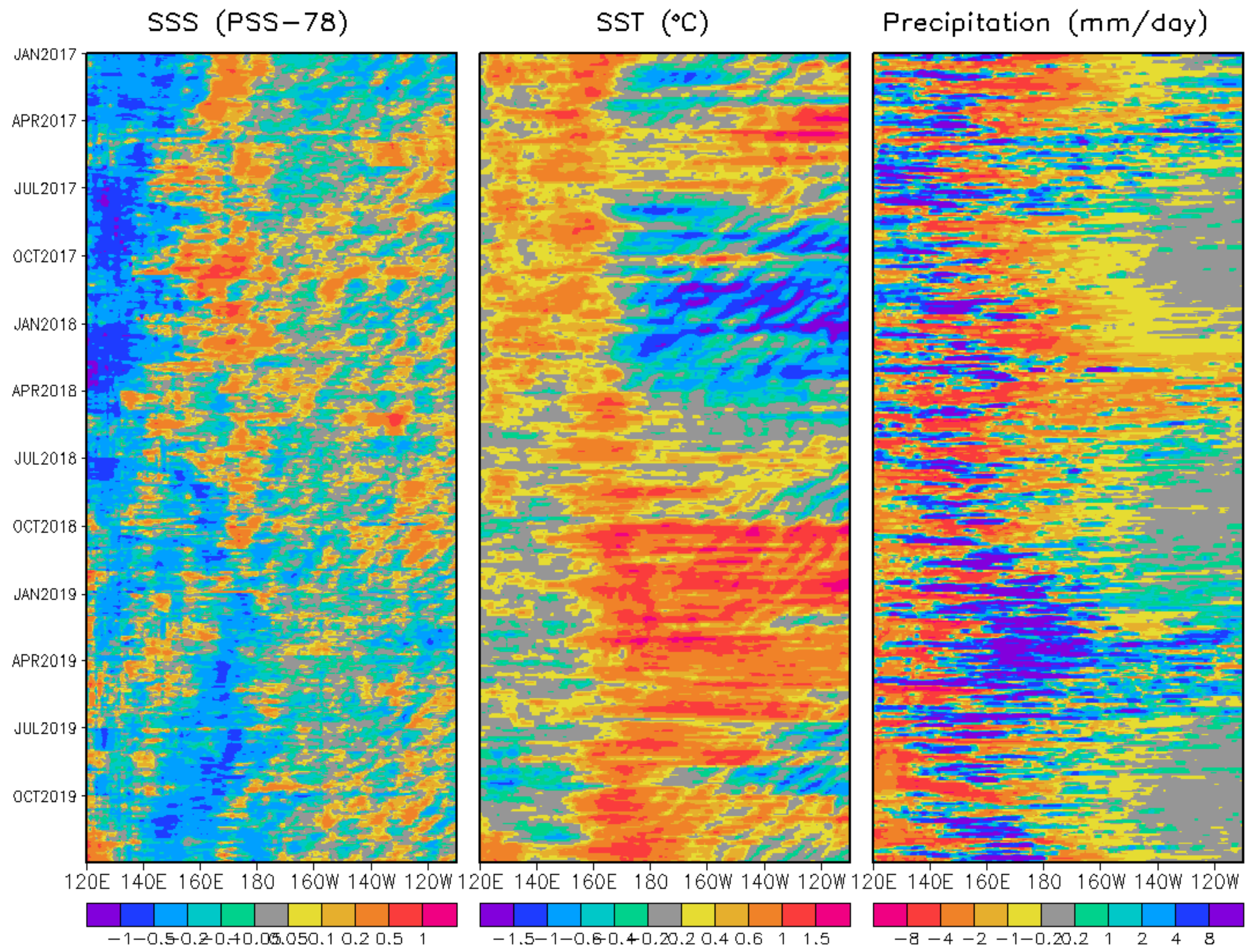
- Hovemoller diagram for equatorial SSS anomaly **(5˚ S-5˚ N);**
- In the equatorial Pacific Ocean, the SSS signal is negative west of 170˚ W with stronger signals between 140˚ E and 170˚ E; the SSS anomalies show positive/neutral signals east of 170˚ W.



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.



December 2019 Experimental Sea Ice Outlook

Climate Prediction Center, NCEP/NWS/NOAA

Acknowledgments: Both hindcasts and forecasts were produced on NOAA GAEA computer.

Procedure

- Use Climate Forecast System (CFS) coupled model initialized with CPC Sea Ice Initialization System (CSIS) initial sea ice conditions (20 initializations: December 21-25, 2019).
- Correct biases using 2006-2018 mean error with respect to NSIDC observations
- Present unbiased results
- The following maps are included
  - SIE Monthly time series (mean and spread)
  - SIC Monthly forecast panels (Ensemble mean)
  - SIC Monthly standard deviation panels
  - Monthly ice cover probability
  - Mean first ice melt day/ standard deviation (Alaska region)
  - First ice melt day prediction difference from previous month
  - Mean first ice freeze day/ standard deviation (Alaska region)

September 2019 SIE forecast

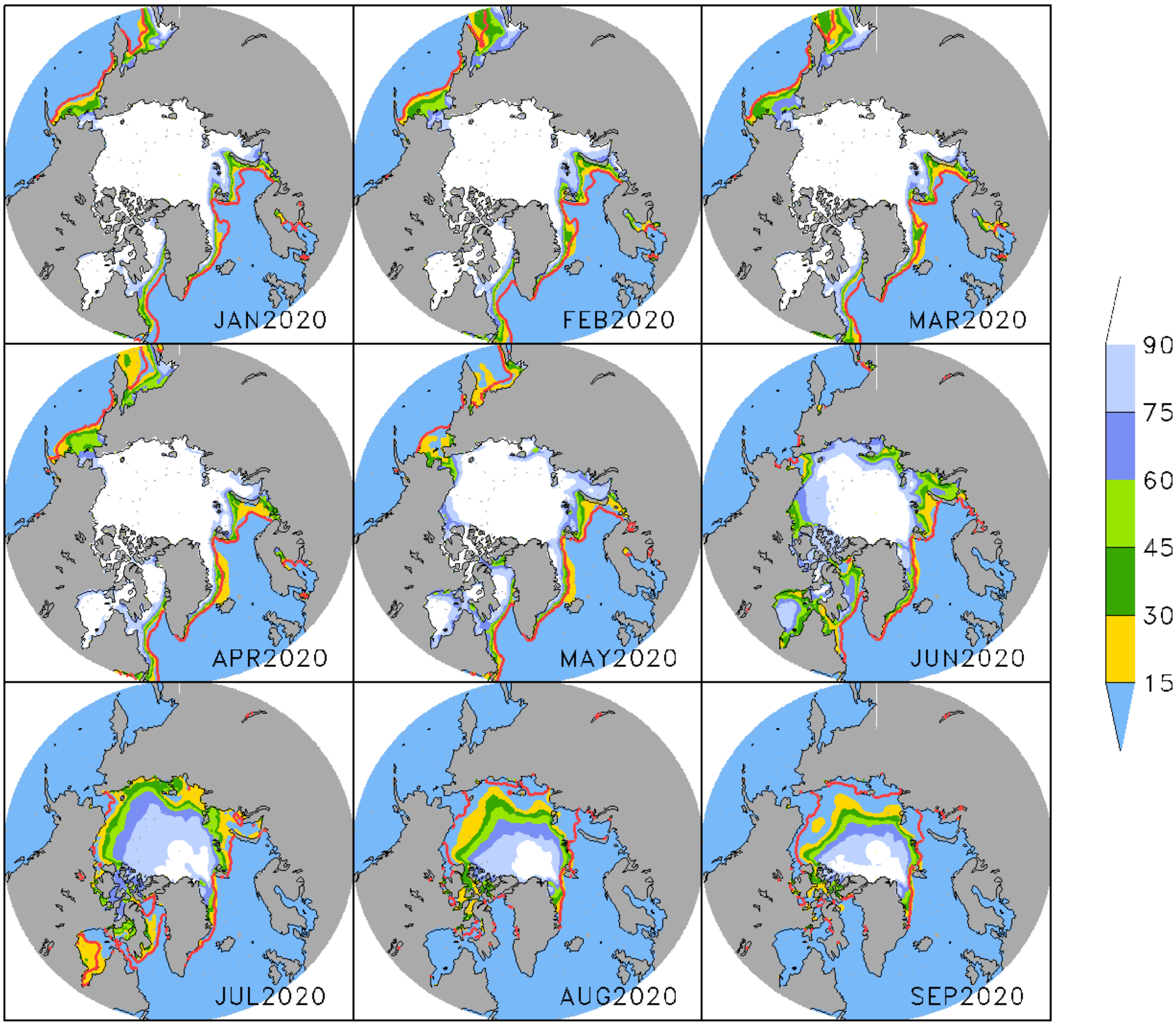
Source	SIE Value (10^6 km^2)
NSIDC 1981-2010 Climatology	6.41
NSIDC 2018	4.79
NSIDC 2012 (record low)	3.57
Experimental CFSv2 2019 forecast	**4.50**
September 2019 SIE Observation:	**4.32**

Based on these simulations, the September 2019 sea ice extent minimum is forecasted to be above the record minimum set in 2012 and slightly below last year's value.

Month to Month September Prediction for this year's forecasts

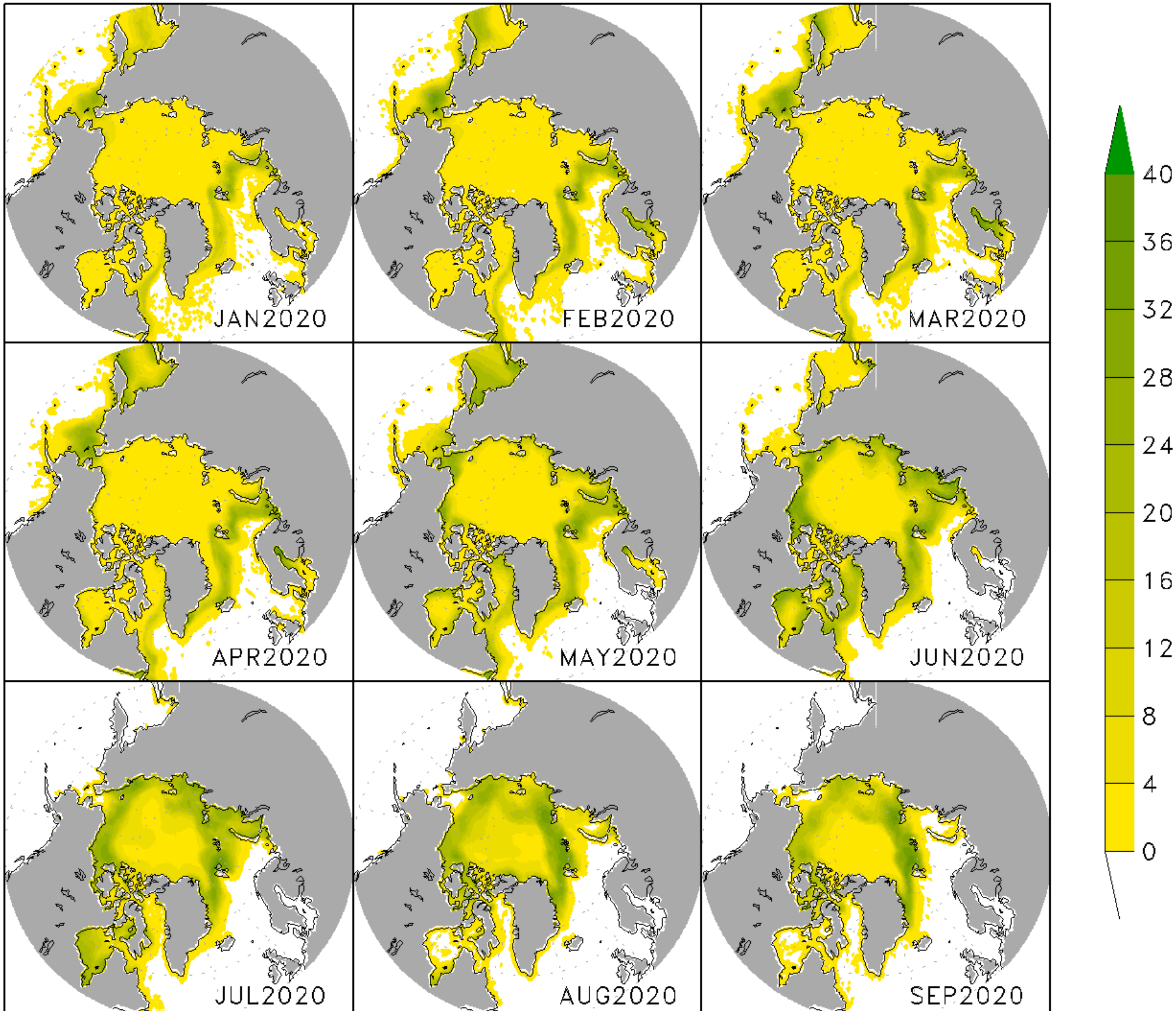
Month	March	April	May	June	July	August
Ens. Mean	4.87	4.71	4.62	4.55	4.31	4.50
Std. Dev.	0.34	0.33	0.26	0.24	0.14	0.11

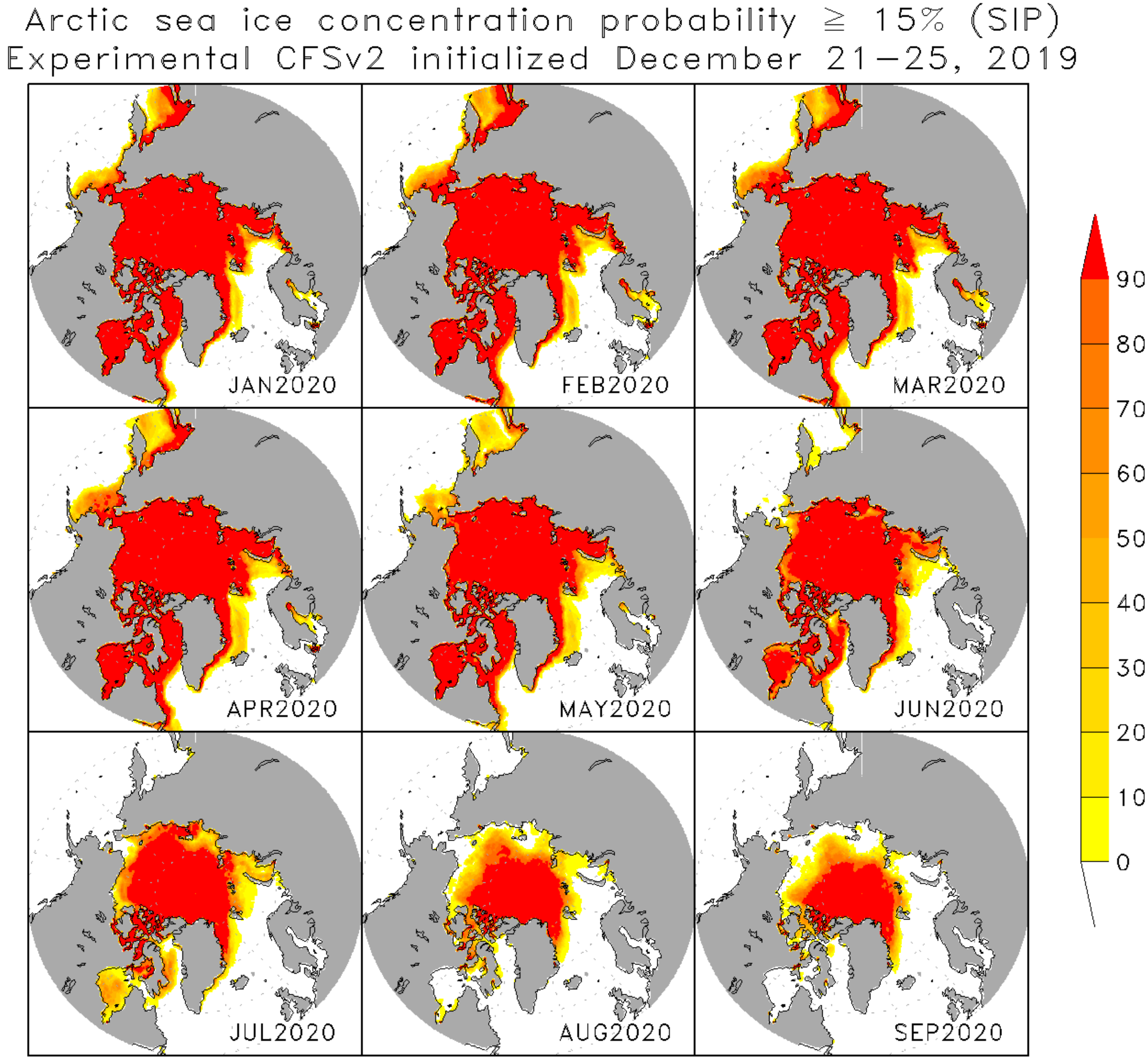
Arctic sea ice concentration (SIC, %) forecast
Experimental CFSv2 initialized December 21–25, 2019



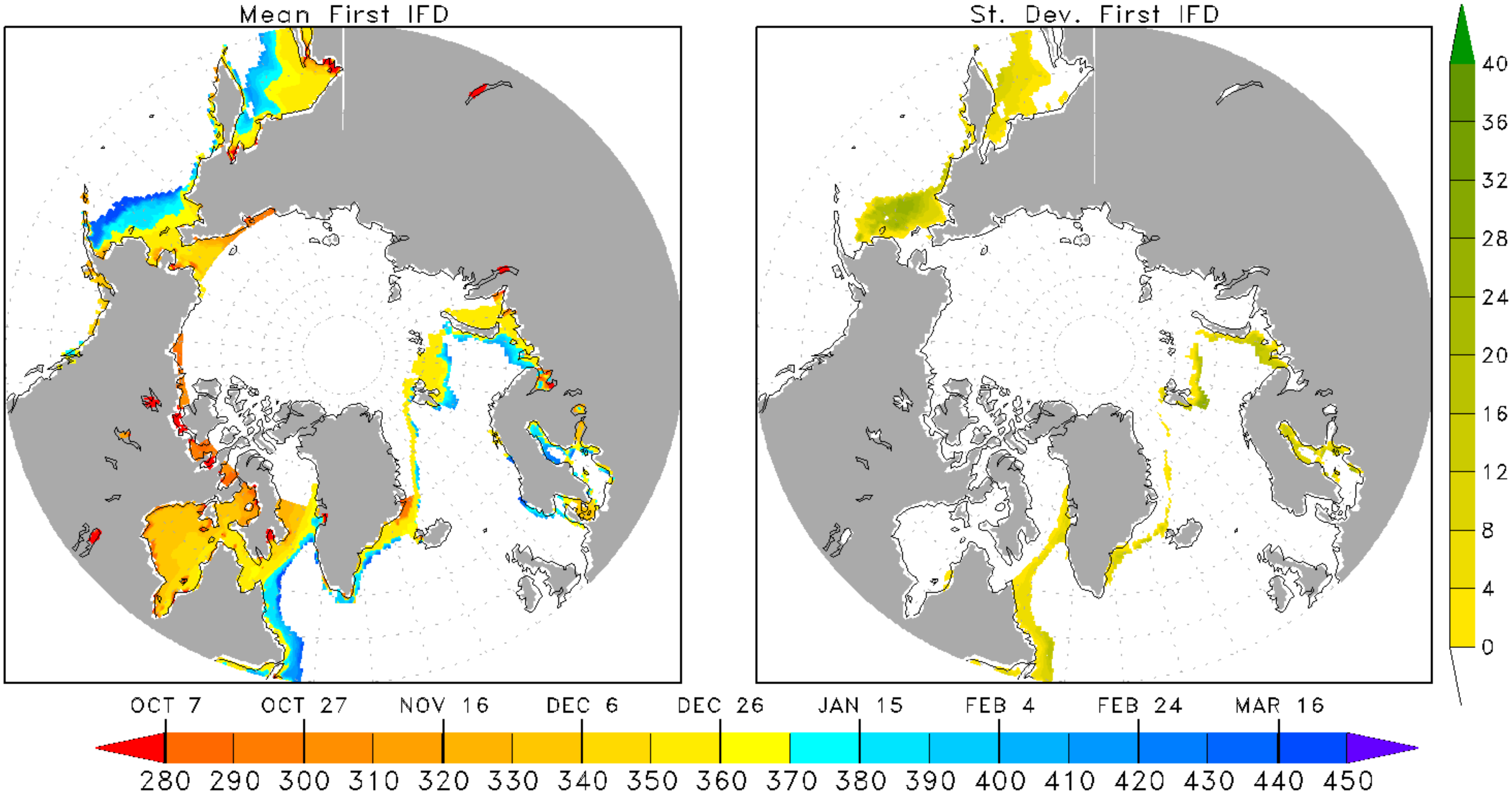
* 1981–2010 climatology of 15% NASA Team SIC countoured red *

Arctic sea ice concentration standard deviation (SICstd, %)
Experimental CFSv2 initialized December 21–25, 2019

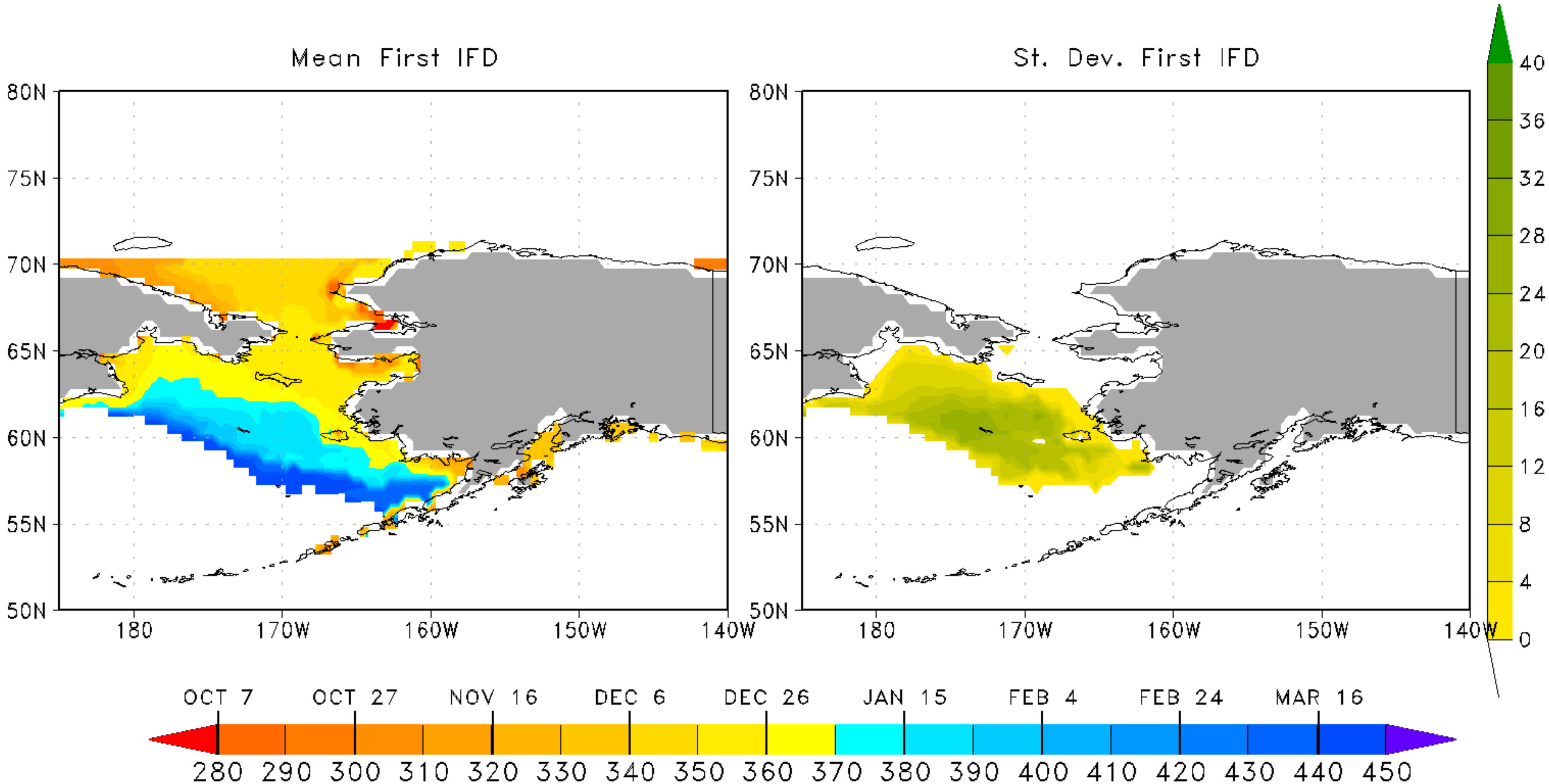



Arctic sea ice concentration probability ≧ 15% (SIP)
Experimental CFSv2 initialized December 21–25, 2019
JAN2020
FEB2020
MAR2020
APR2020
MAY2020
JUN2020
JUL2020
AUG2020
SEP2020
90
80
70
60
50
40
30
20
10
0

First sea ice freeze date of 2019−2020
Experimental CFSv2 initialized December 21−25, 2019



First sea ice freeze date of 2019–2020
Experimental CFSv2 initialized December 21–25, 2019



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

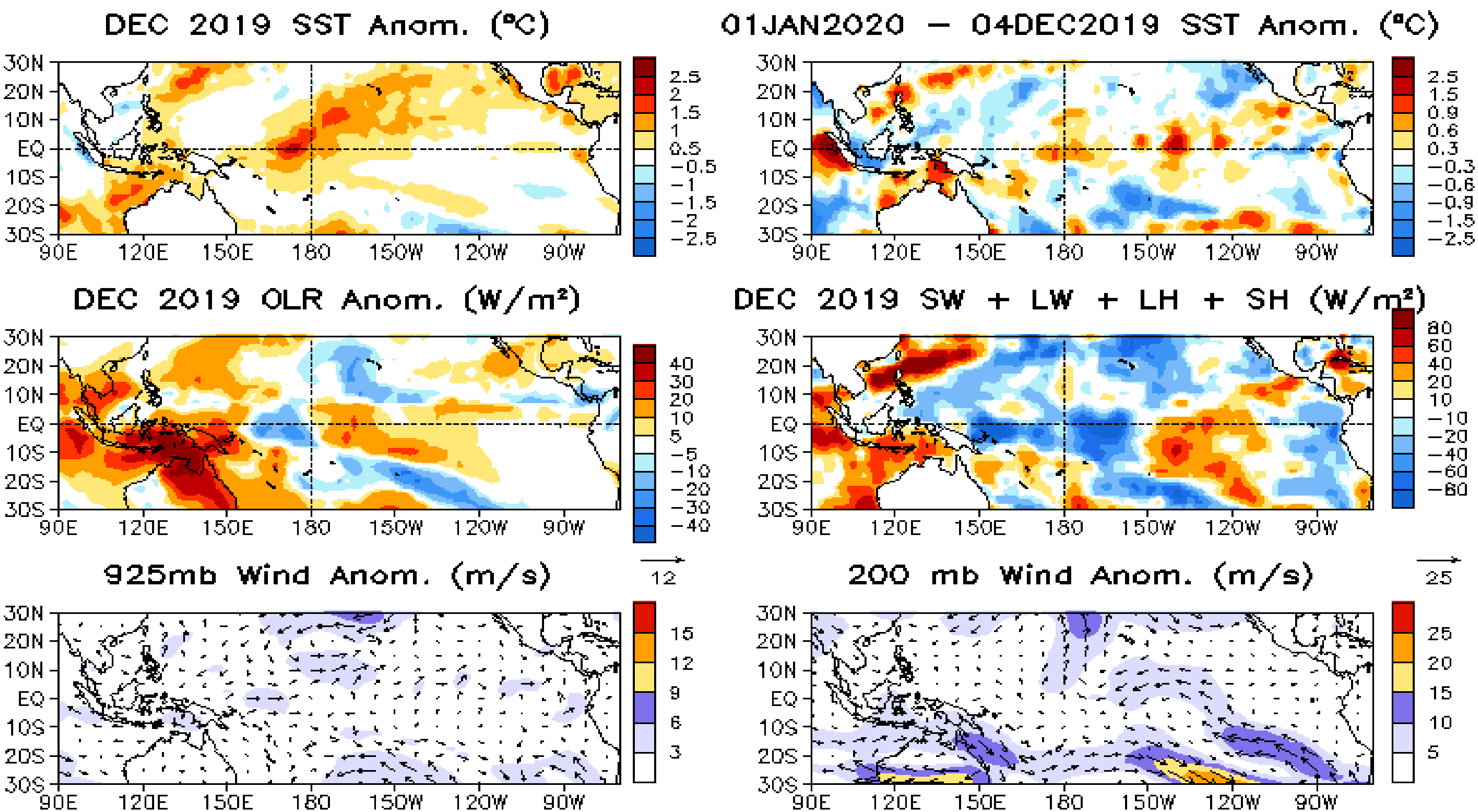


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

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

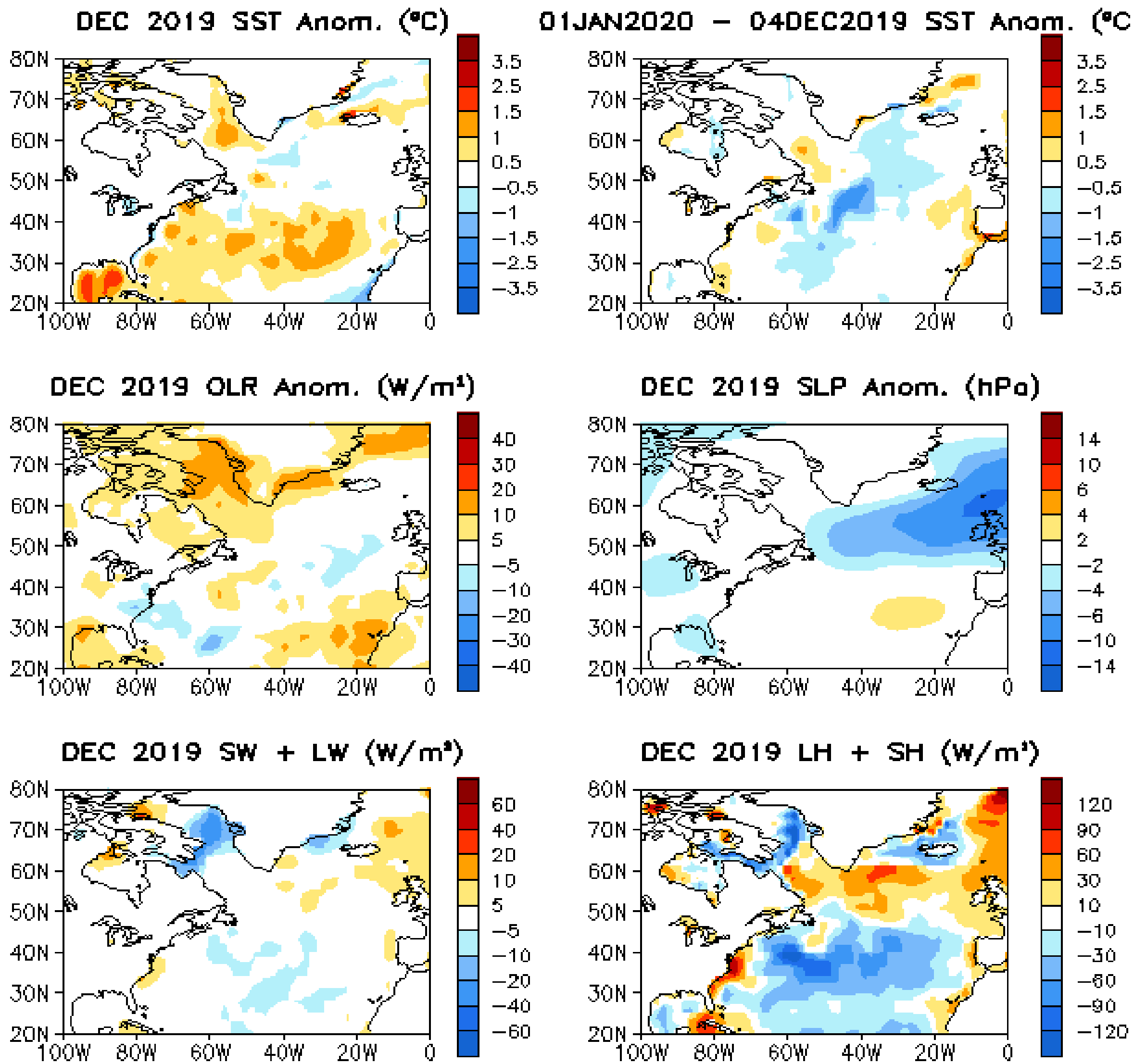
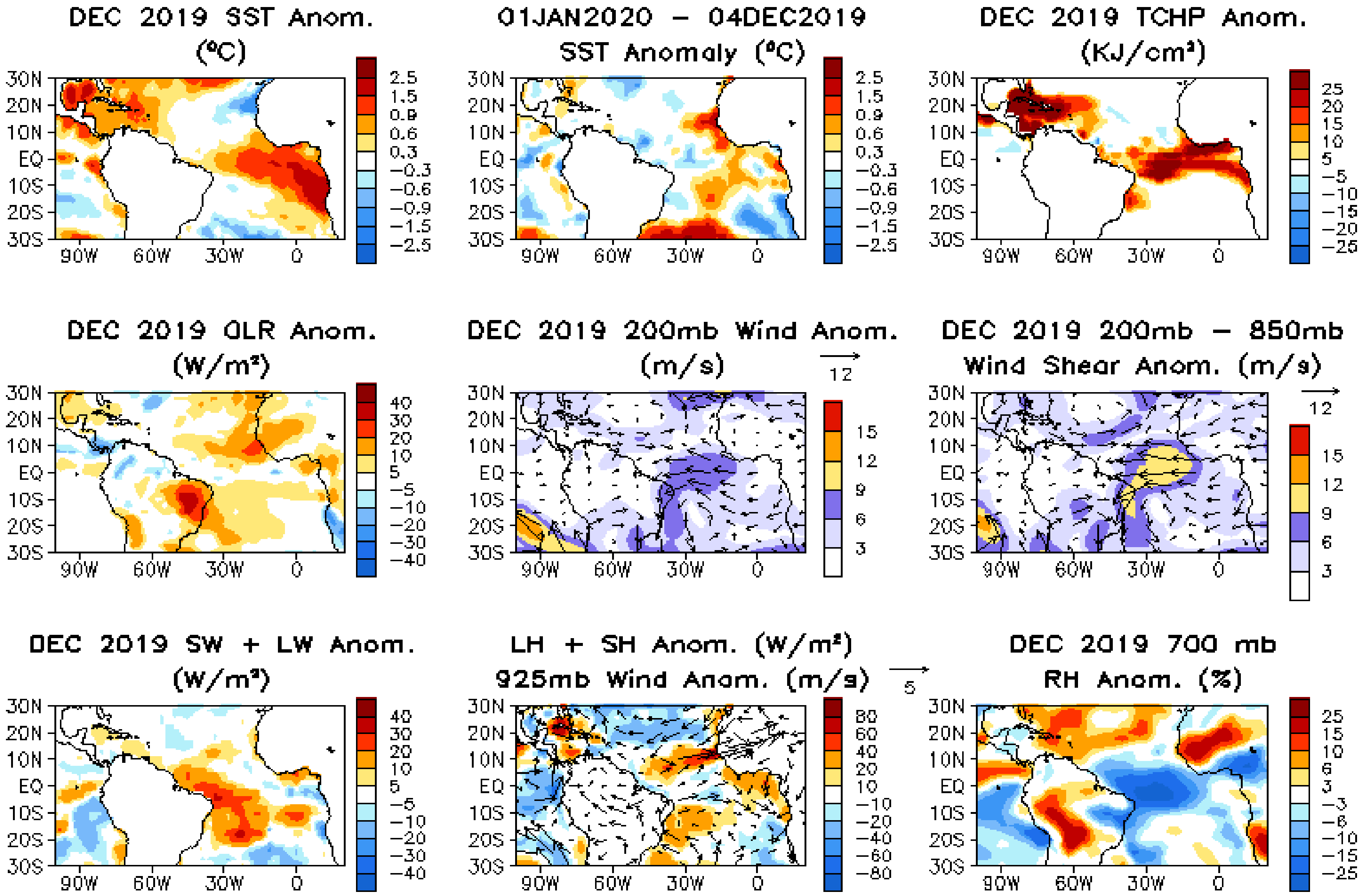
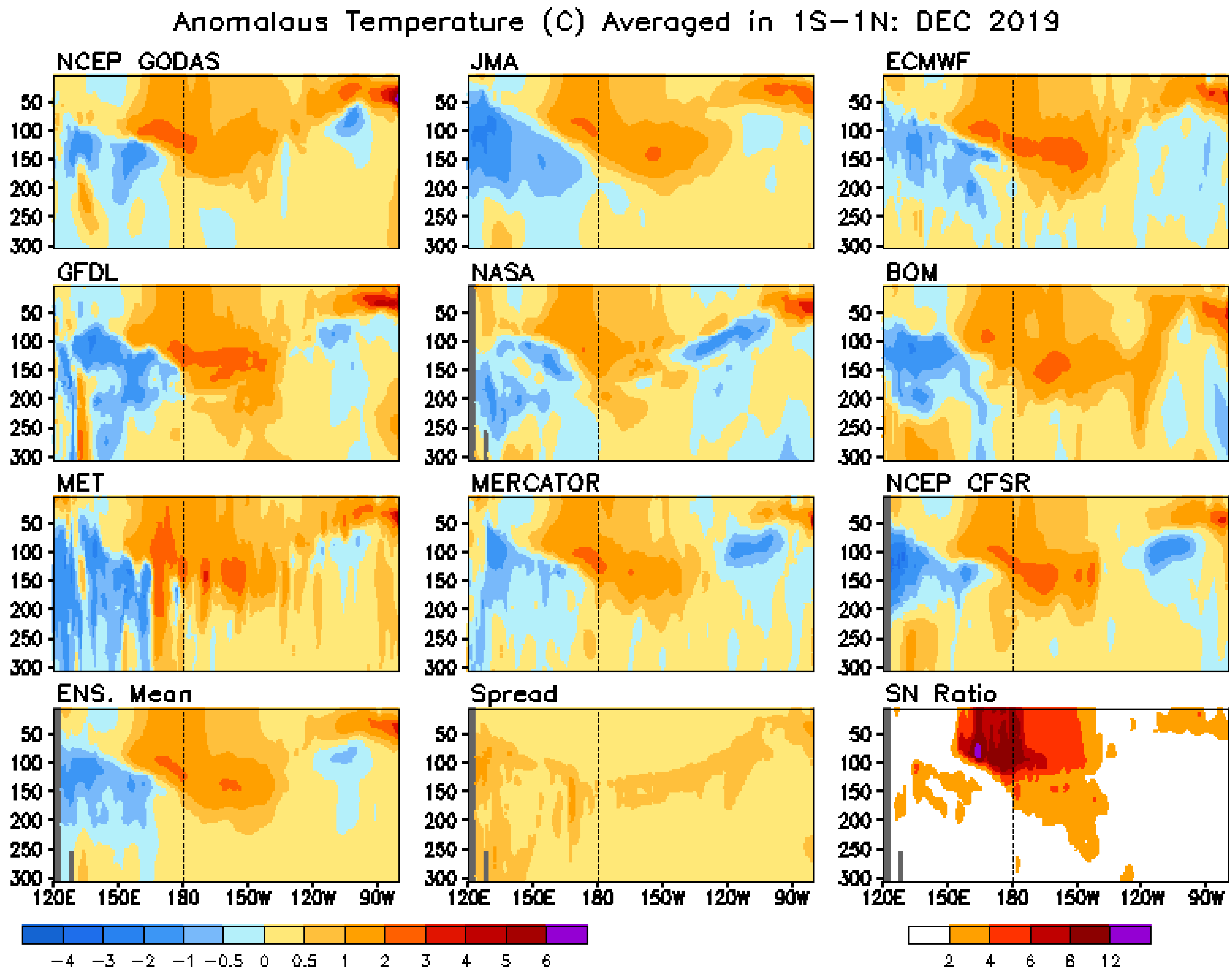


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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.

Tropical Atlantic:





Anomalous Temperature (C) Averaged in 1S-1N: DEC 2019
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

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