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

Prepared by

Climate Prediction Center, NCEP/NOAA

July 11, 2019

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

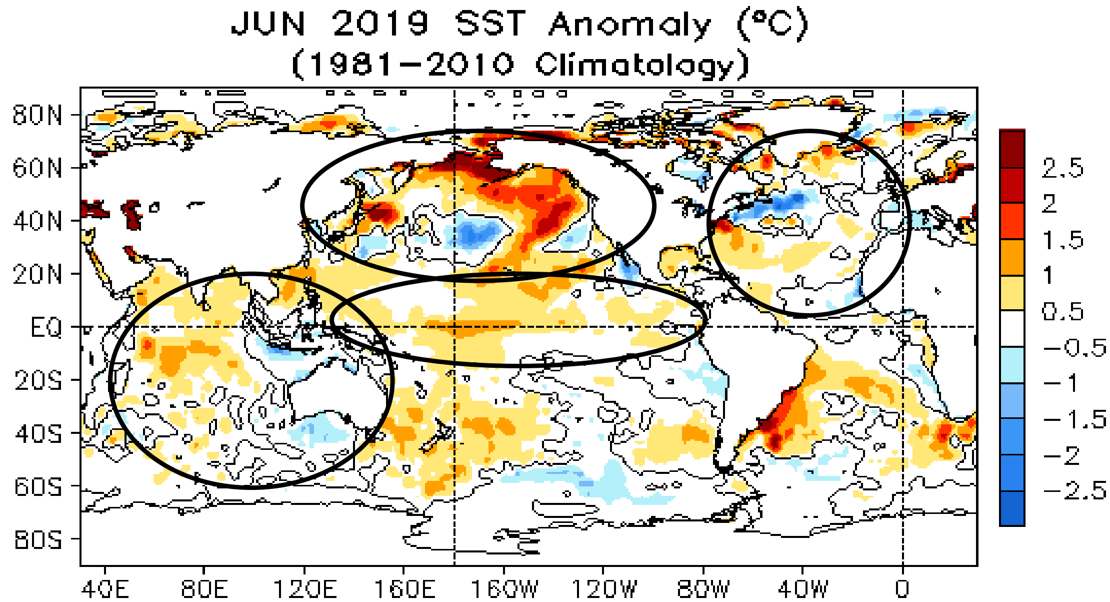
- **Overview**
- **Recent highlights**
  - **Pacific/Arctic Ocean**
  - **Indian Ocean**
  - **Atlantic Ocean**
- **Global SSTA Predictions**
- **NCEP/CPC Experimental Sea Ice Outlook**
- **GODAS/CFSR warm bias and its potential impact on the CFSv2 forecasts**

Overview

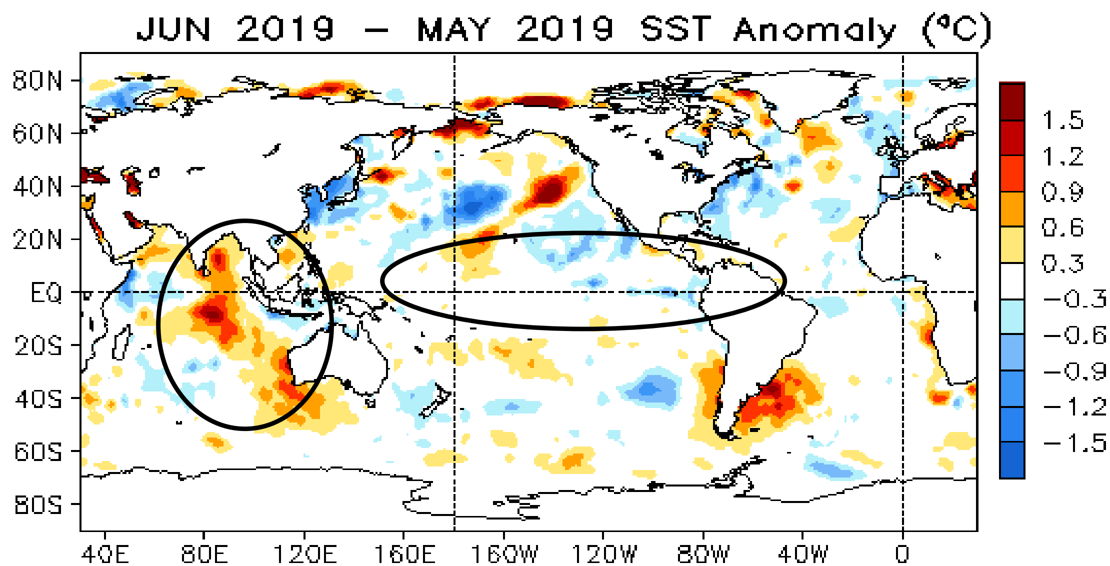
- **Pacific Ocean**
  - **NOAA "ENSO Diagnostic Discussion" on 11 July 2019 continuously issued "*El Nino Advisory*" and indicated that *"A transition from El Niño to ENSO-neutral is expected in the next month or two, with ENSO-neutral most likely to continue through Northern Hemisphere fall and winter."***
  - **El Nino conditions persisted, and positive SSTAs presented in the central tropical Pacific with NINO3.4=0.65°C in Jun 2019.**
  - **Positive SSTAs dominated in the N. Pacific in Jun 2019. The PDO index switched to positive phase since March 2019 with PDOI= 0.1 in Jun 2019.**
- **Indian Ocean**
  - **Positive (negative) SSTAs were in the west (far east), and IOD was in a strong positive phase in May and Jun 2019.**
- **Atlantic Ocean**
  - **NAO was in a negative phase with NAOI=-0.8 in Jun 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 (^0C) and Anomaly Tendency



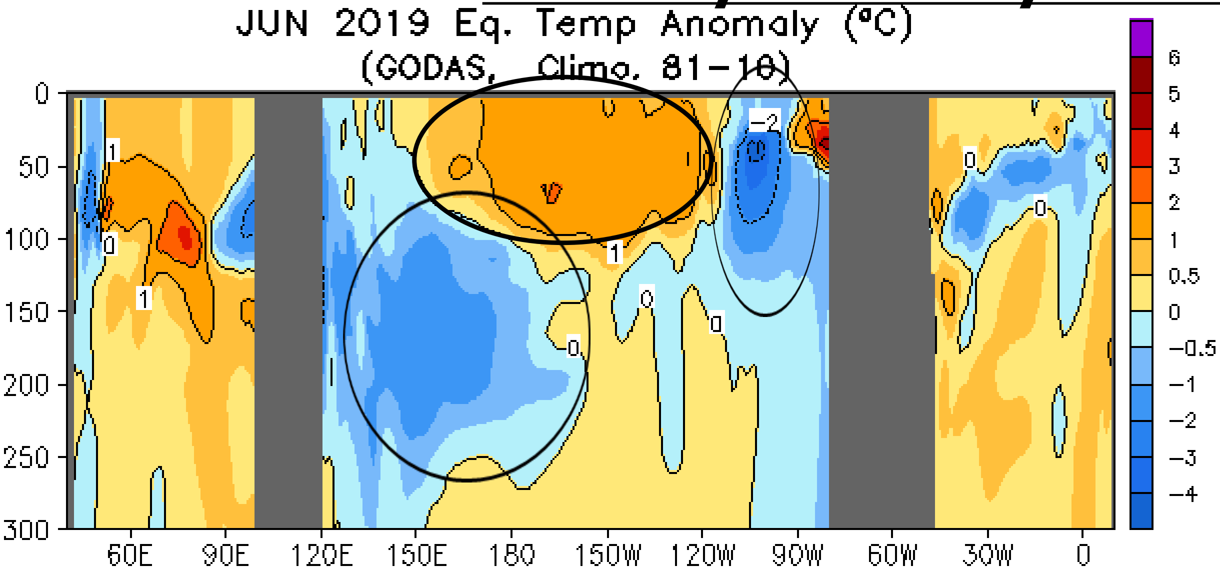
- **Positive SSTAs persisted in the central tropical Pacific, consistent with El Nino conditions.**
- **SSTAs were positive in the North Pacific.**
- **Horseshoe/tripole-like SSTA pattern was observed in the North Atlantic.**
- **In the Indian Ocean, SSTAs were positive in the west and central and negative in the far east.**



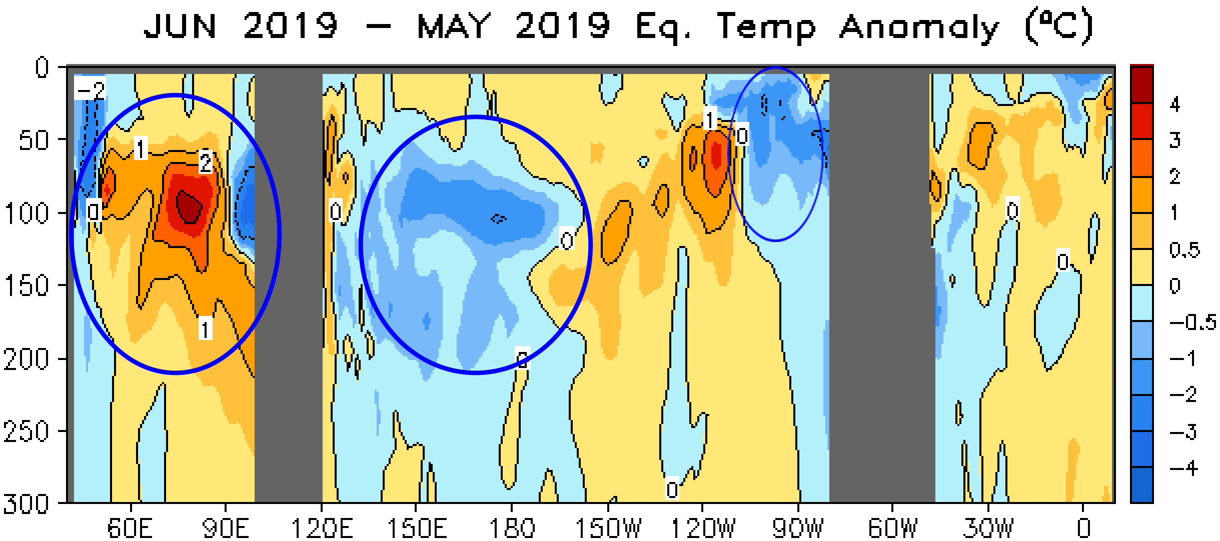
- **SSTA tendencies were small negative in the eastern tropical Pacific.**
- **SSTA tendencies in the Indian Ocean were positive in the central and east.**

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.

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



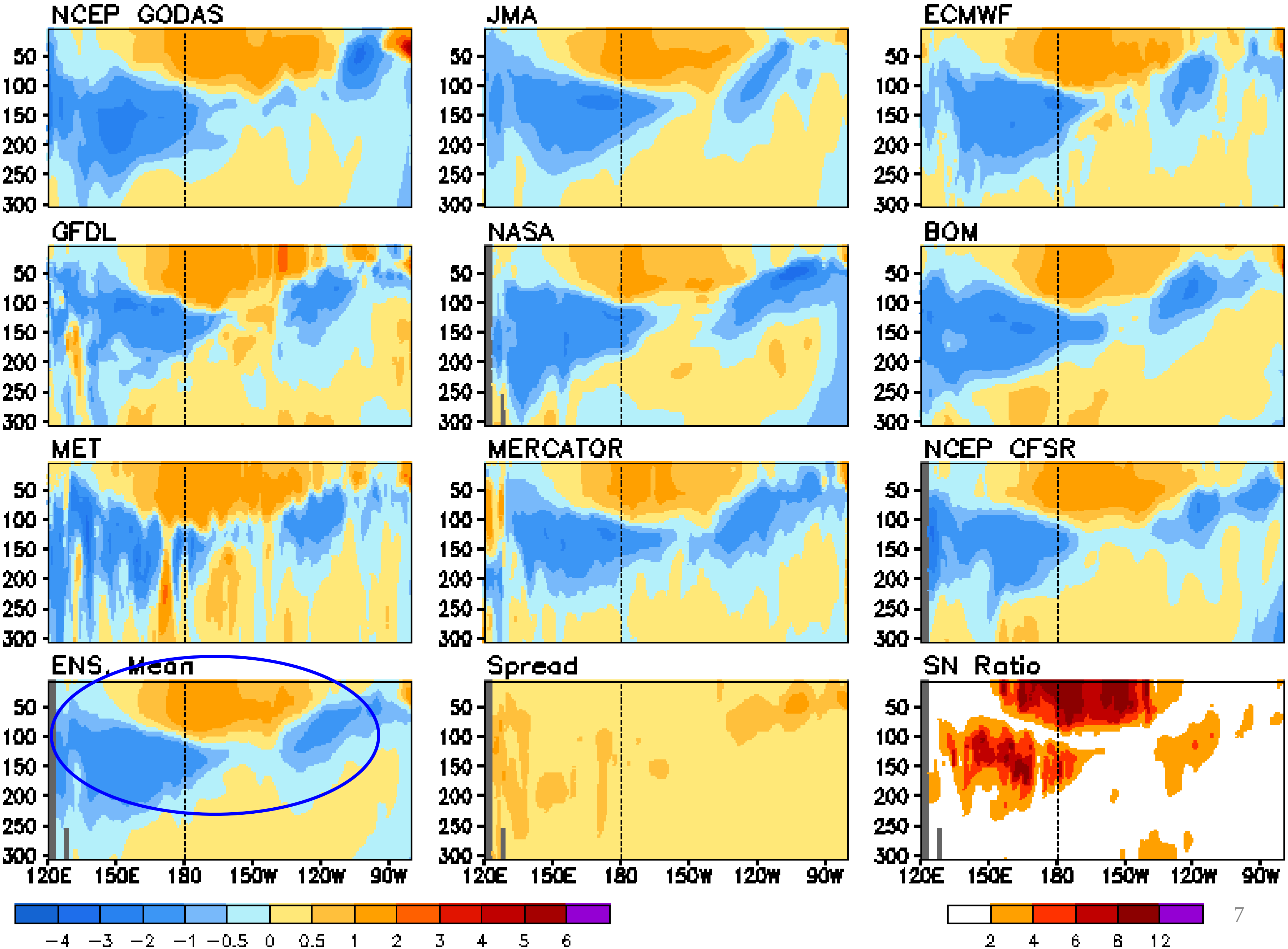
- **Positive (negative) ocean temperature anomalies presented in the central (western and eastern) equatorial Pacific.**



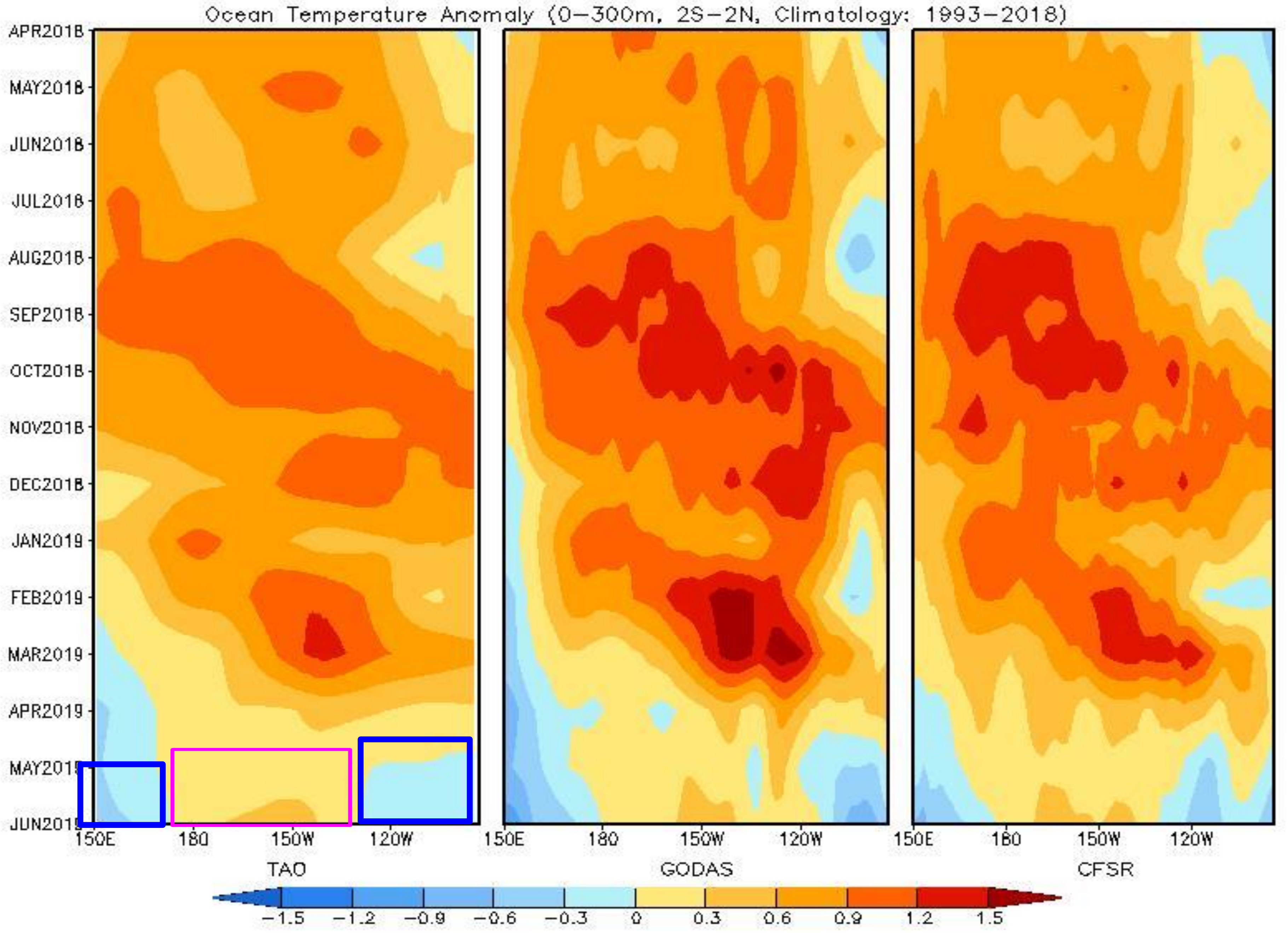
- **Anomalous ocean temperature tendency was negative in the western and far-eastern Pacific.**
- **Anomalous ocean temperature tendency was positive in the Indian Ocean.**

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.

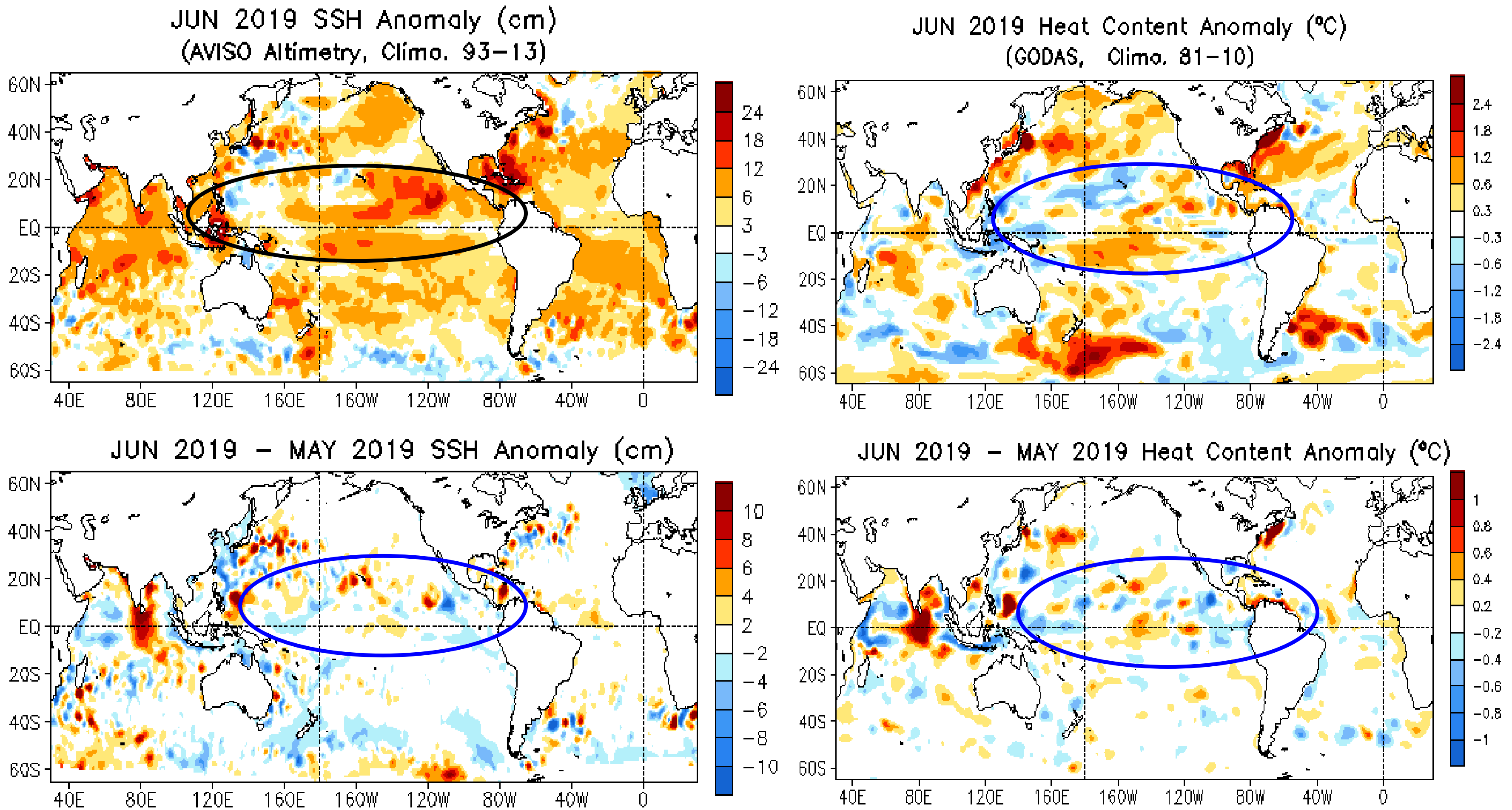
Anamalous Temperature (C) Averaged in 1S-1N: JUN 2019



H300A: TAO, GODAS, CFSR



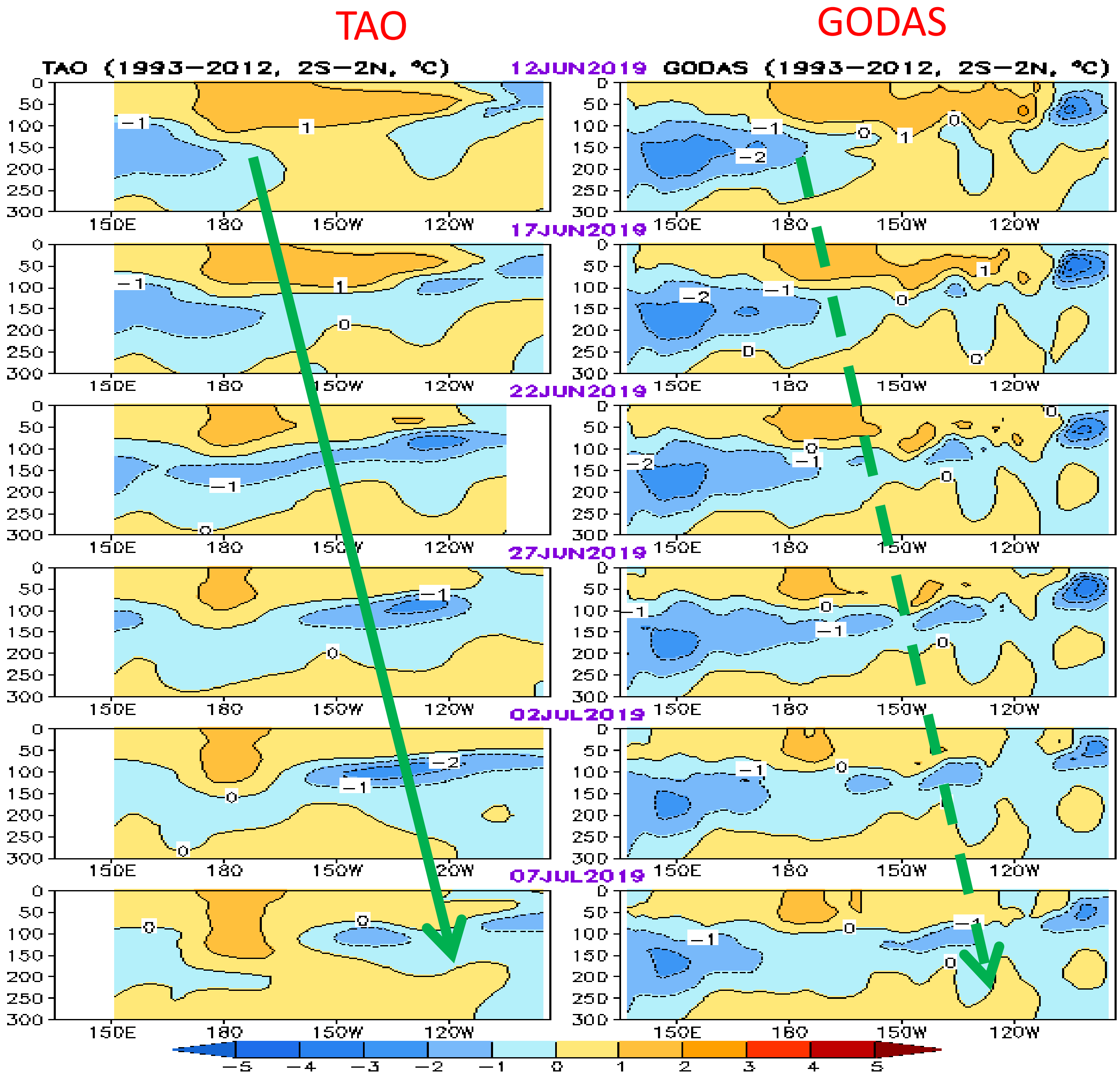
Global SSH and HC300 Anomaly & Anomaly Tendency



- **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 El Nino conditions.**
- **Both positive and negative tendencies of SSHA and HC300A presented in the eastern tropical Pacific.**

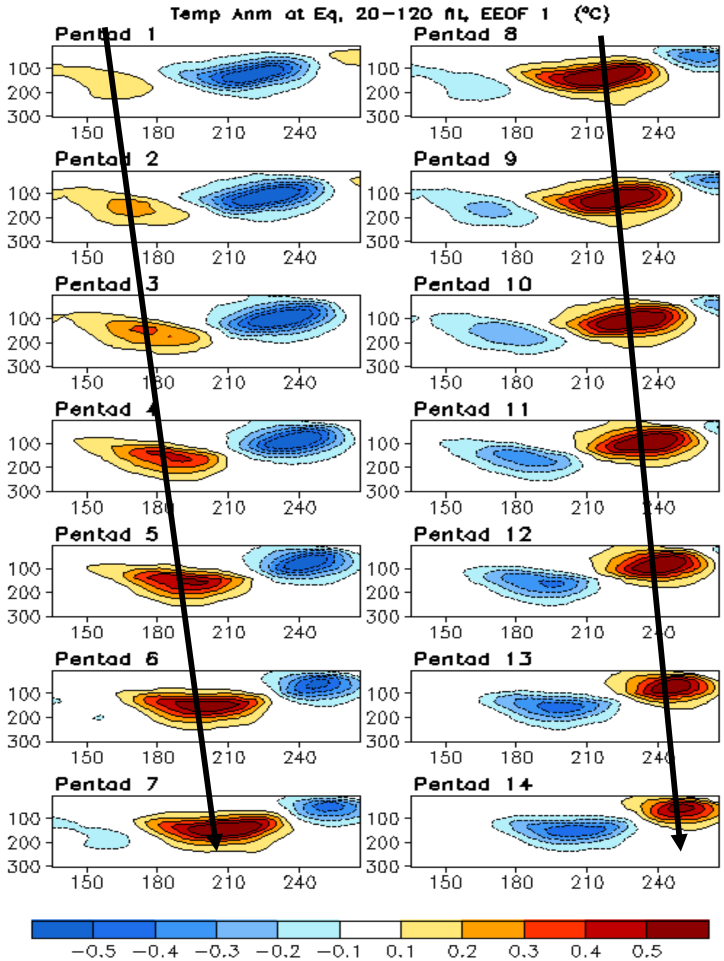
Tropical Pacific Ocean and ENSO Conditions

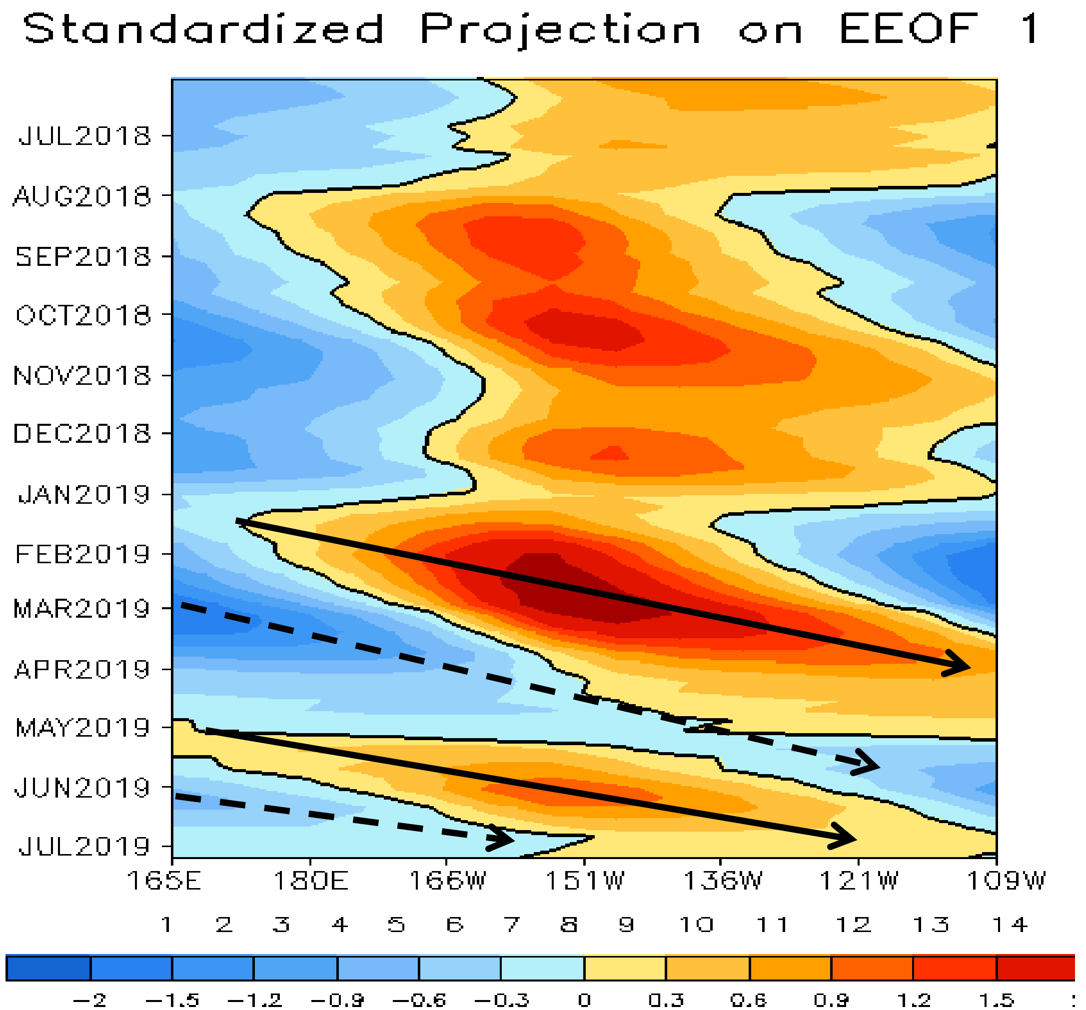
Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



- Negative ocean temperature anomalies presented during the last few months, and propagated eastward.
- The patterns of the ocean temperature anomalies between GODAS and TAO were similar.

Oceanic Kelvin Wave (OKW) Index

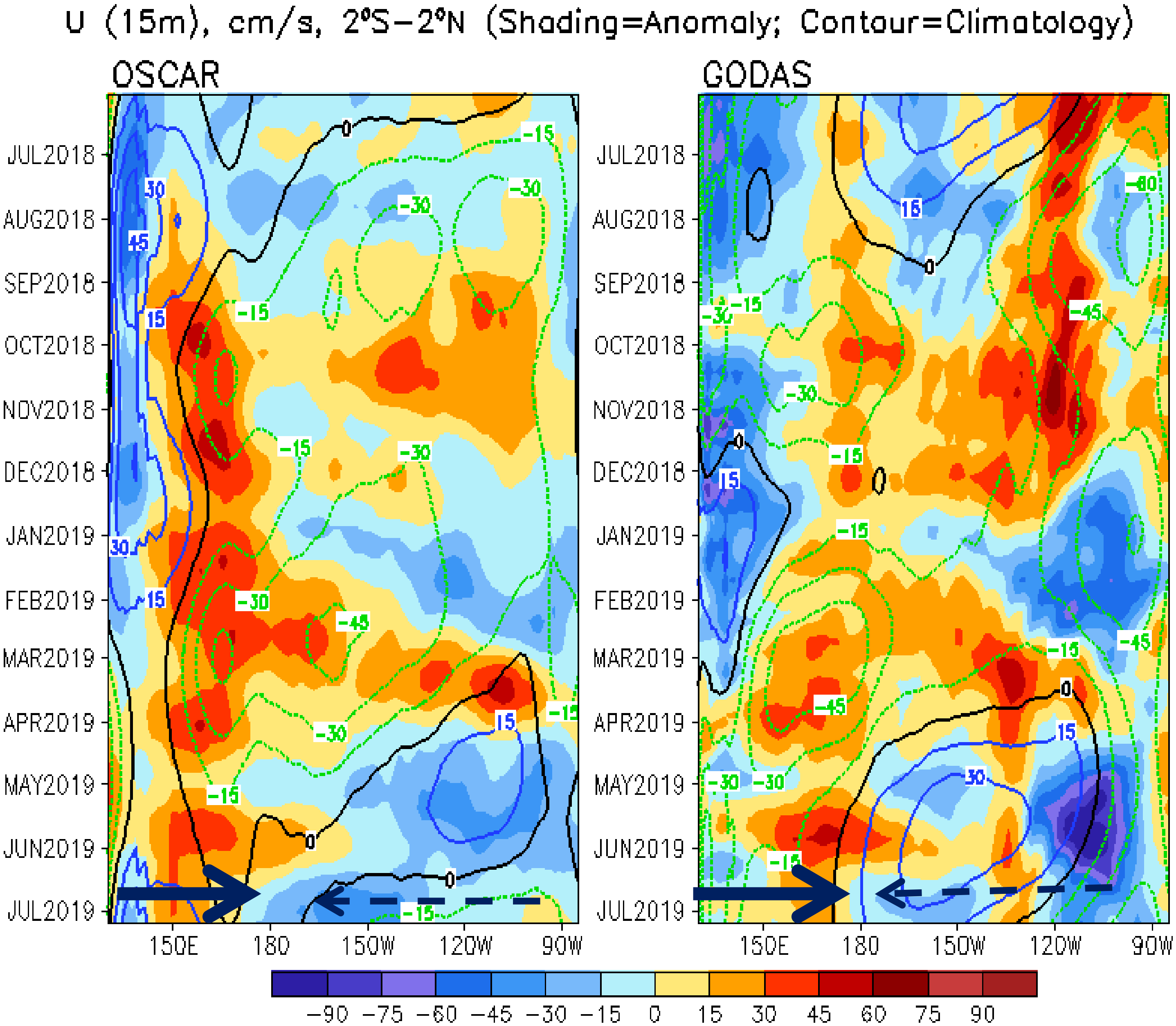




- **A downwelling Kelvin wave presented from Jan- Mar and May 2019, leading to increasing positive subsurface temperature anomalies in the eastern tropical Pacific.**
- **A weak upwelling Kelvin wave initiated in late Jan and Jun 2019 and propagated eastward.**

(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)

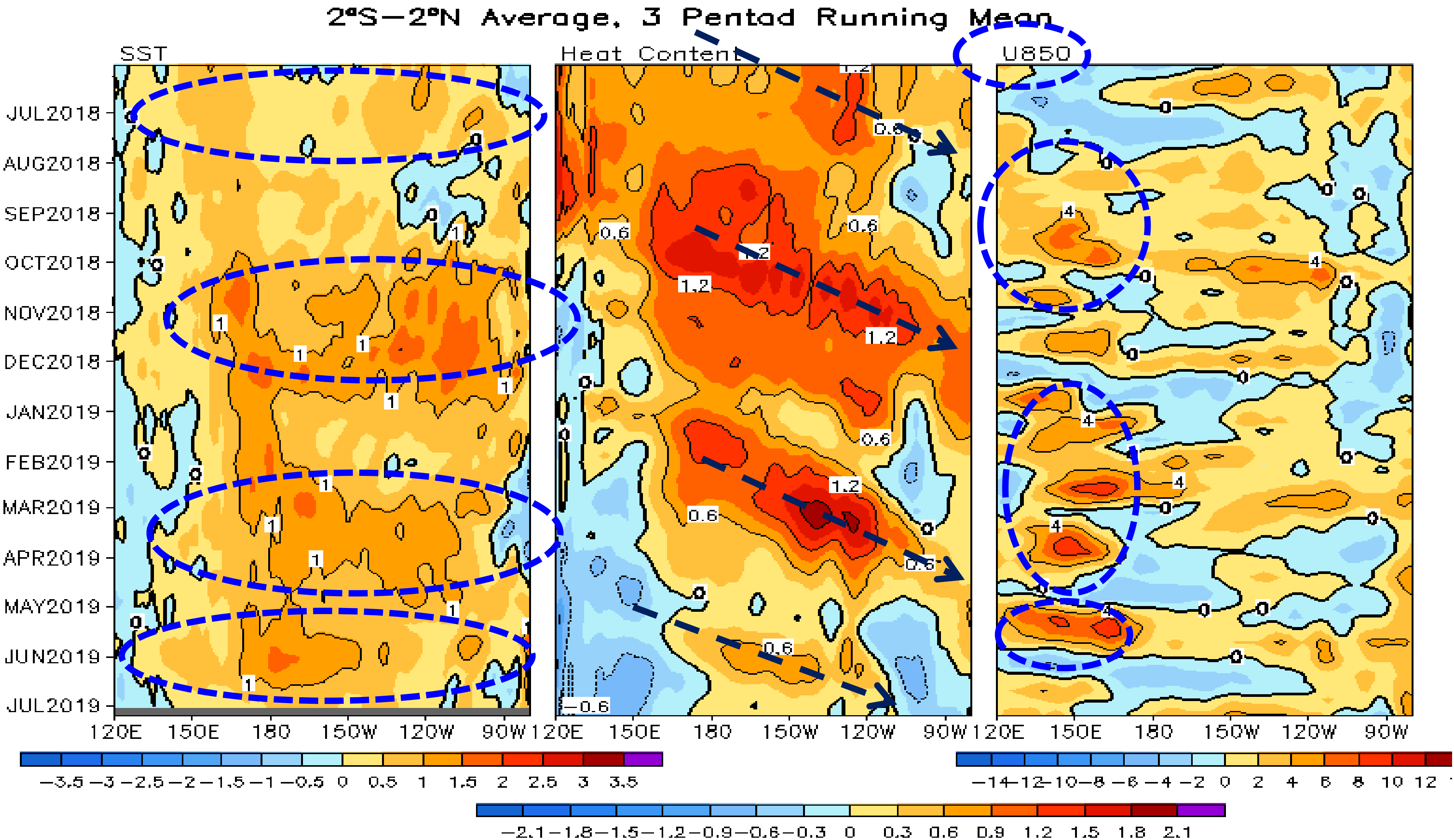


- Anomalous eastward (westward) currents persisted in the western (central and eastern) Pacific in Jun 2019 in both OSCAR and GODAS.

- The westwards zonal current anomalies in EP will result in SST cooling, favoring the El Nino transition.

- 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 central and eastern Pacific weakened in the last month.**
- **Negative HC300A presented in the western and far-eastern Pacific and positive in between in Jun 2019.**

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 discharged phase since Apr 2019.**

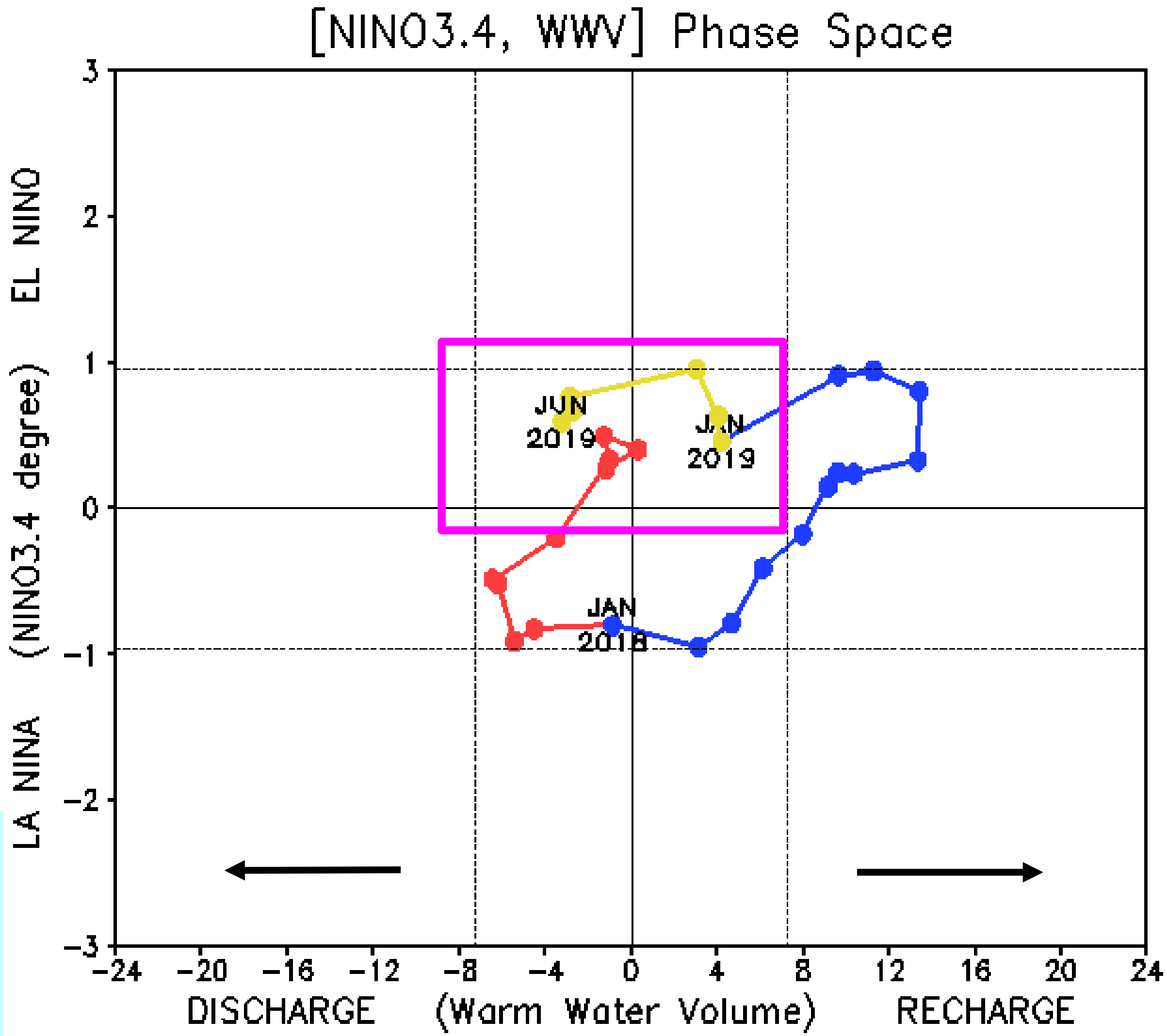
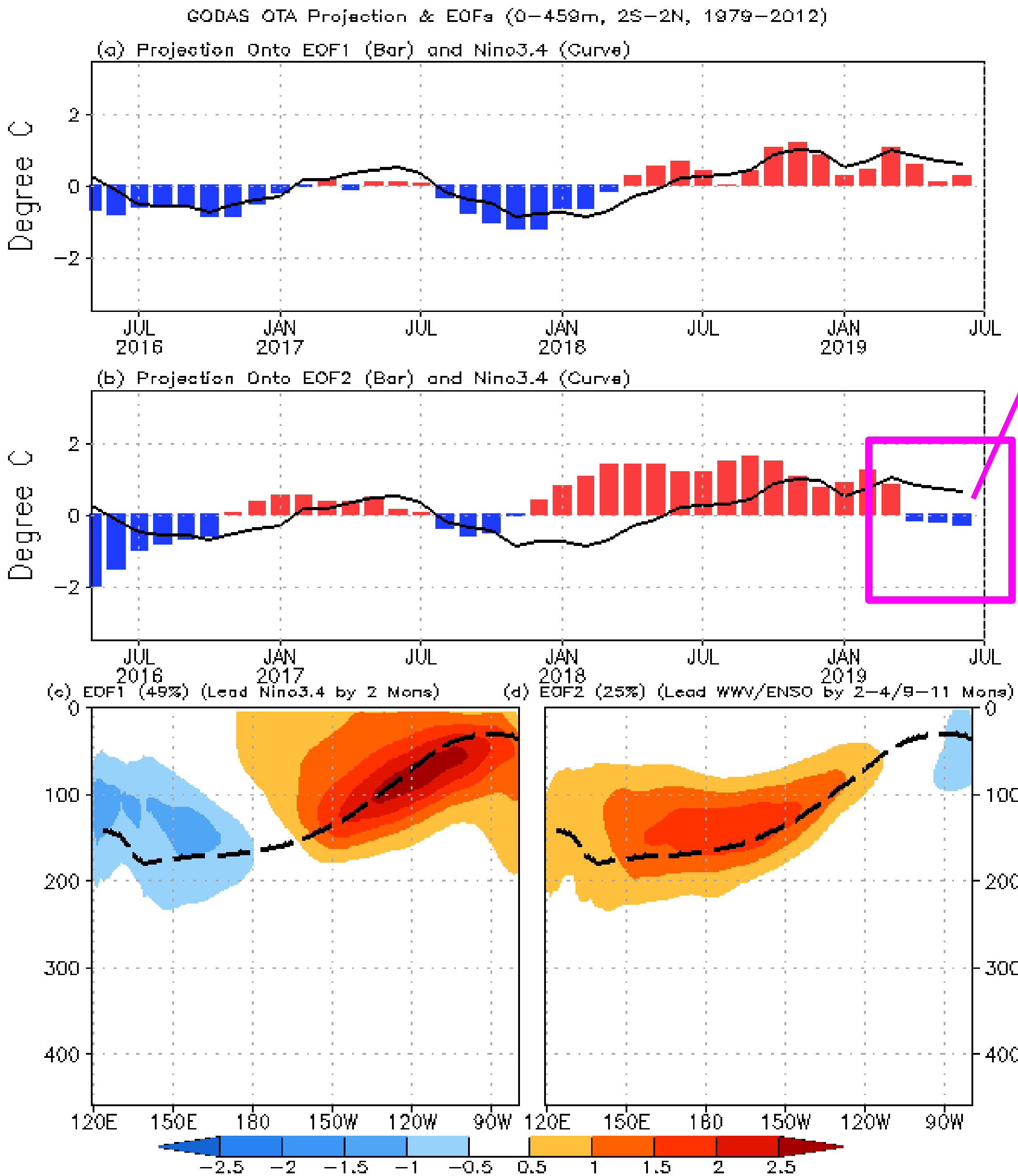


Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20°C in [120°E-80°W, 5°S-5°N] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.



Equatorial subsurface ocean temperature monitoring: ENSO was in a discharged phase in Jun 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).

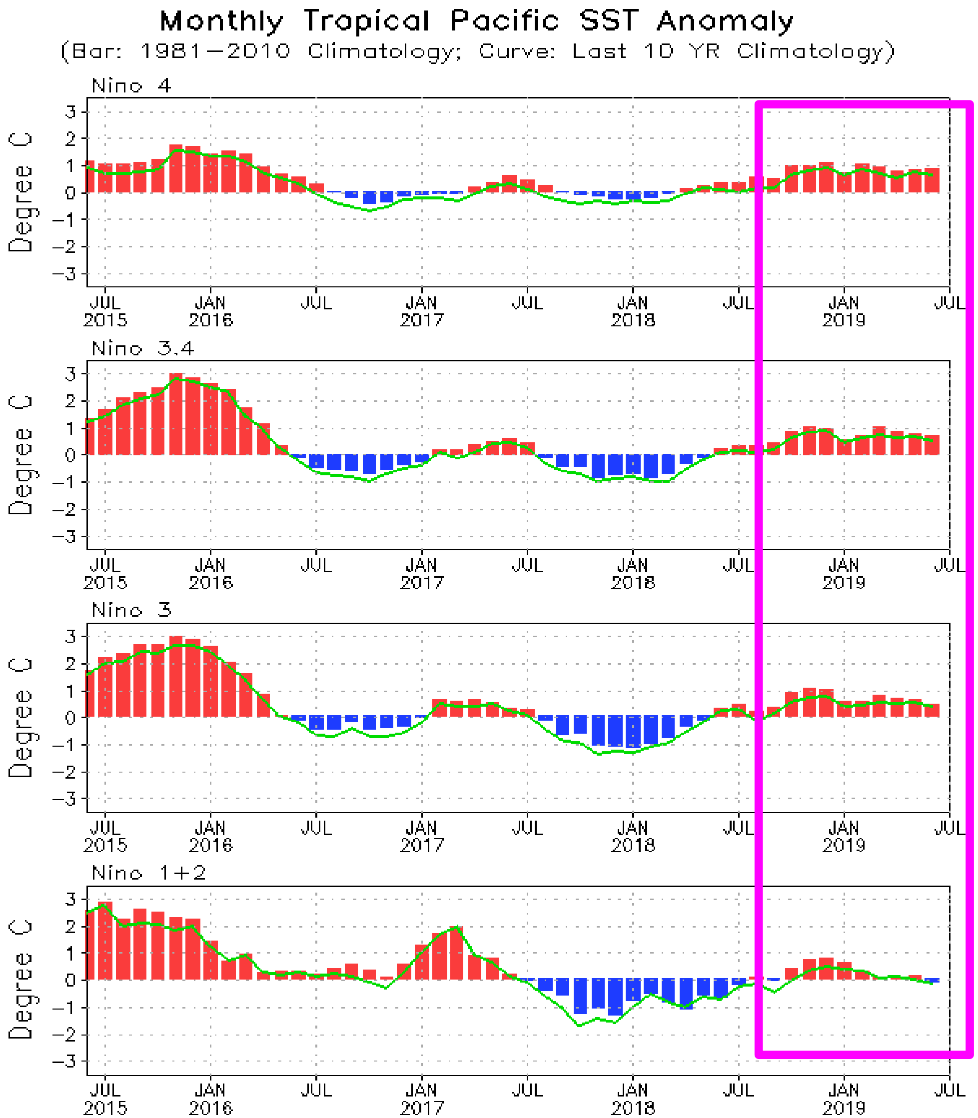
Recharge process: heat transport from outside of equator to equator : Negative -> positive phase of ENSO

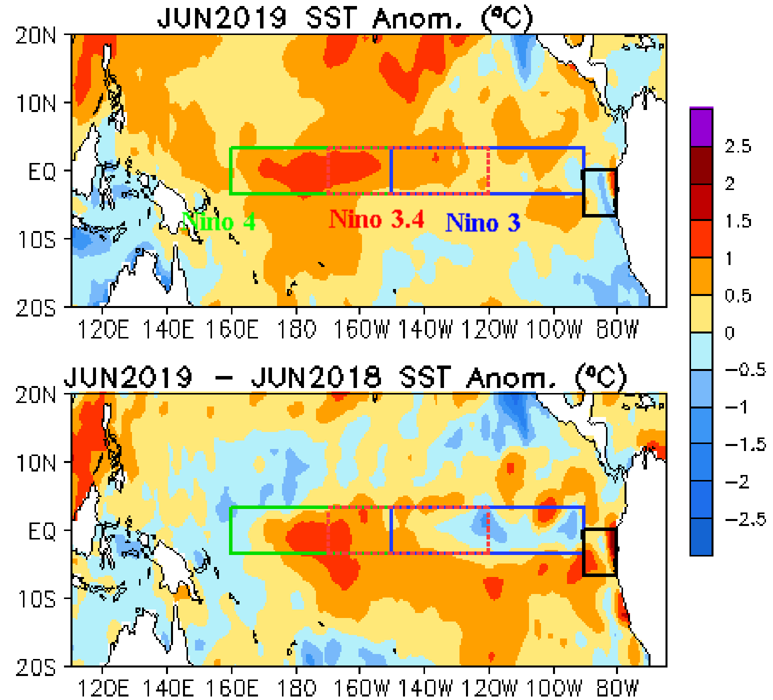
Discharge process: heat transport from equator to outside of equator: Positive -> Negative phase of ENSO

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*.

Evolution of Pacific NINO SST Indices





- **All indices, except Nino1+2, were positive in Jun 2019.**

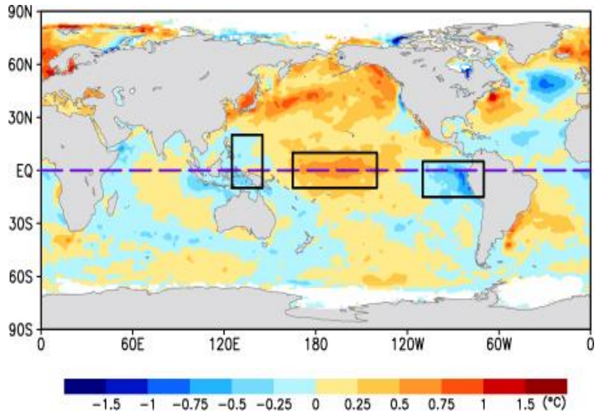
- **Nino3.4 = 0.65 C in Jun 2019.**

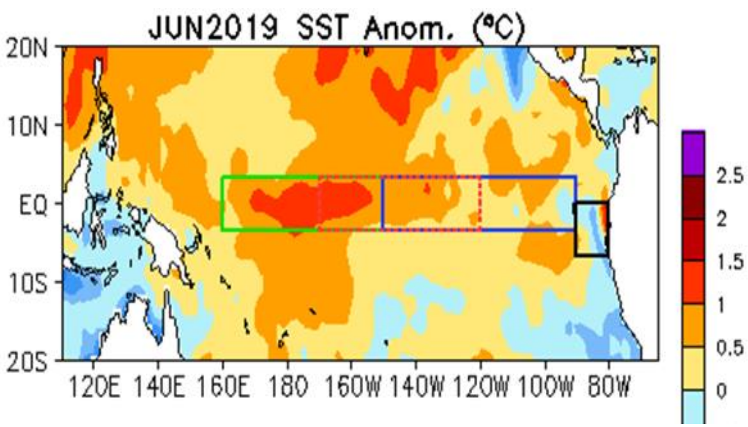
- **Compared with Jun 2018, the central and eastern equatorial Pacific was much warmer in Jun 2019.**

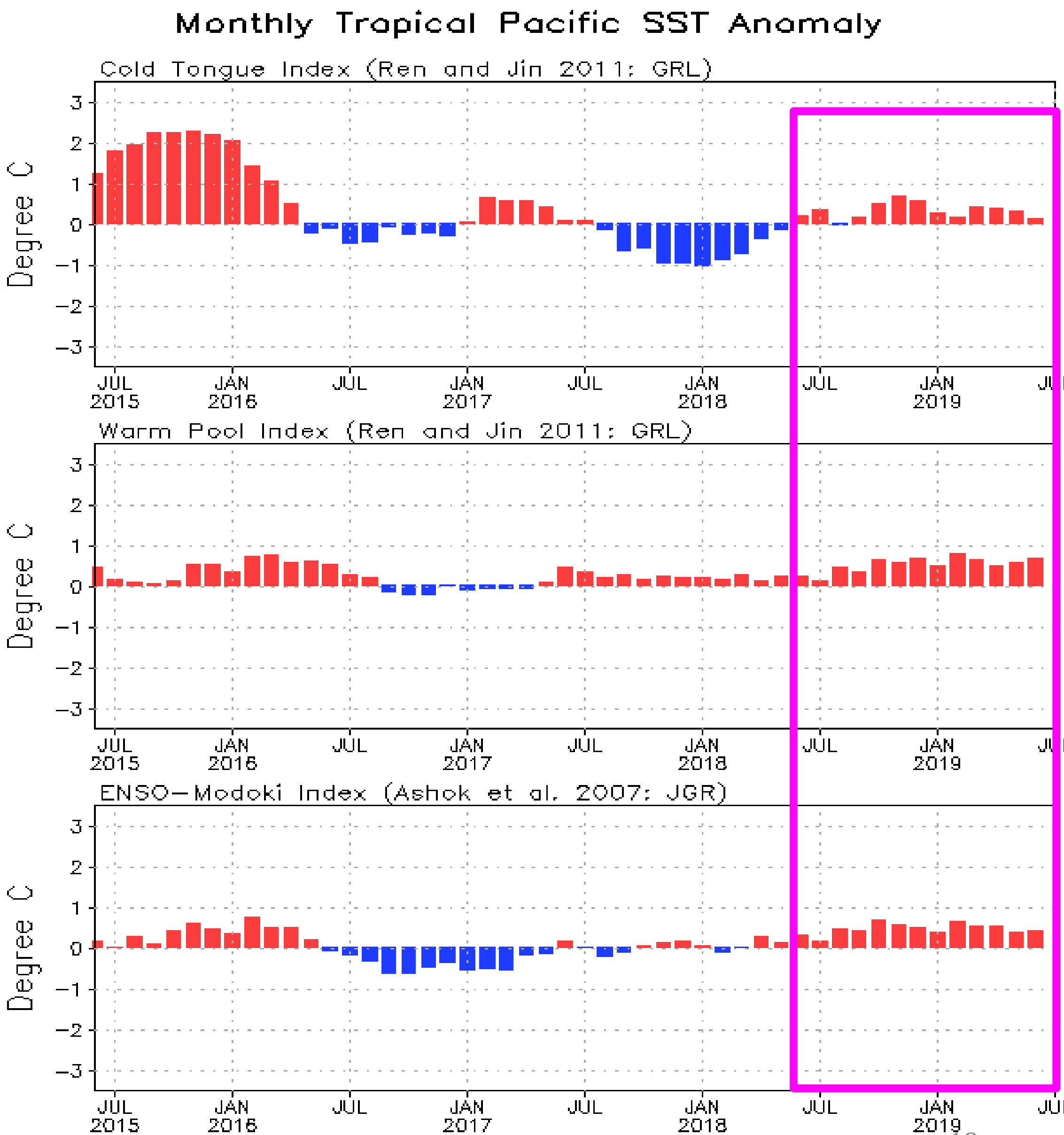
- **The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v5.**

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.

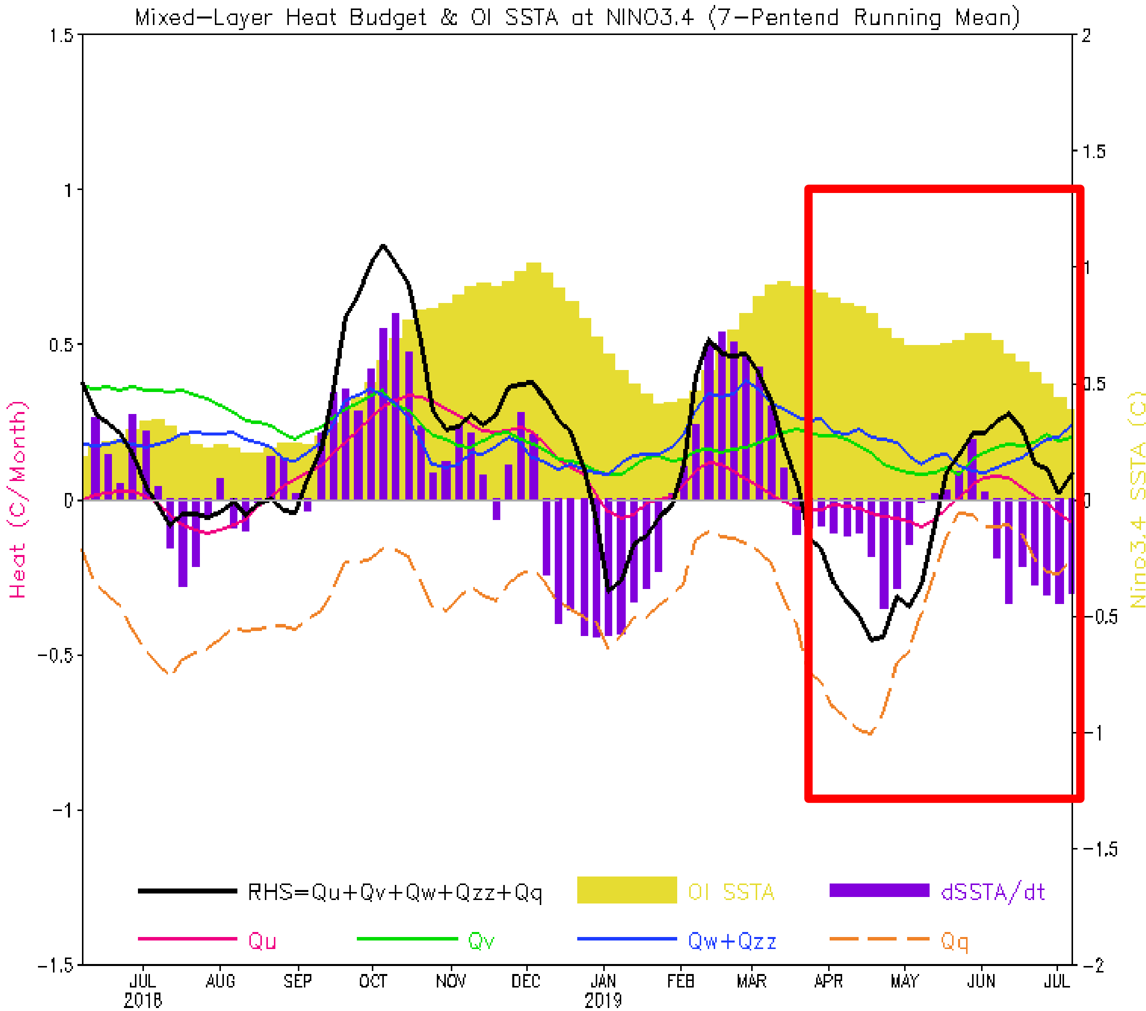
Positive SSTAs were larger in the warm pool than in the cold tongue.







NINO3.4 Heat Budget



- **Observed SSTA tendency (dSSTA/dt; bar) was negative in last a few pentads, and total heat budget (RHS; black line) was small since late Jun 2019.**

- **Dynamical terms (Qu, Qv, Qw+Qzz) were small positive or negative and heat-flux term (Qq) were negative in Jun 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;

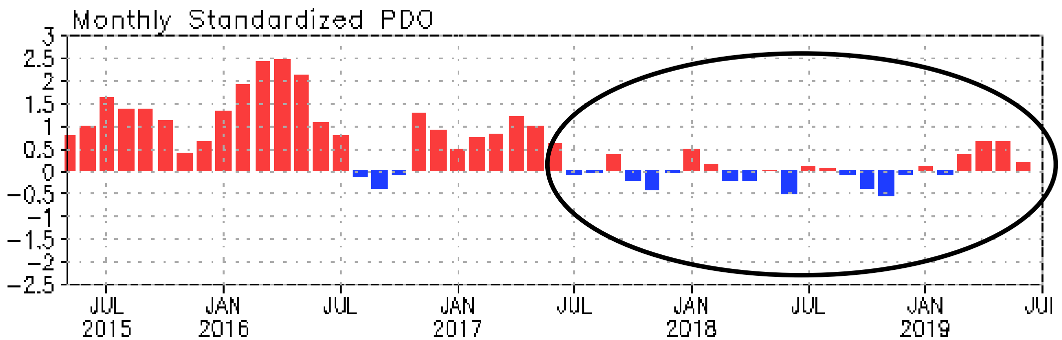
Qw: Vertical entrainment; Qzz: Vertical diffusion

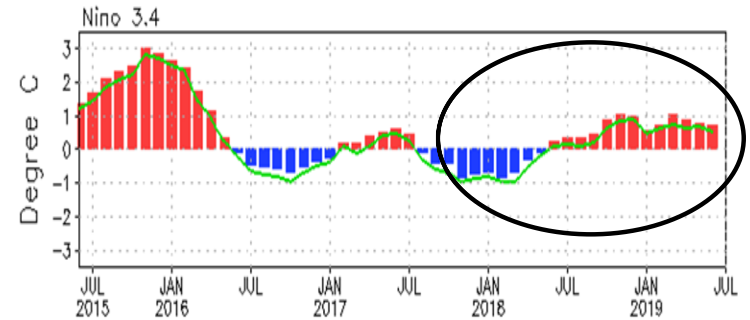
Qq: (Qnet - Qpen + Qcorr)/ρcph; Qnet = SW + LW + LH +SH;

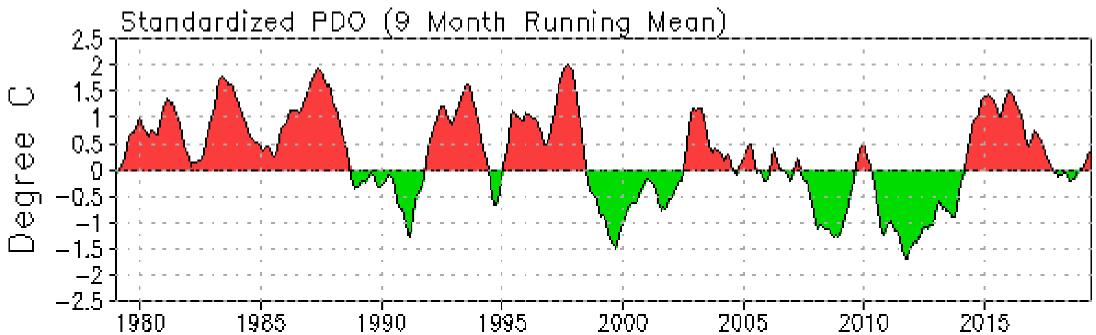
Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST

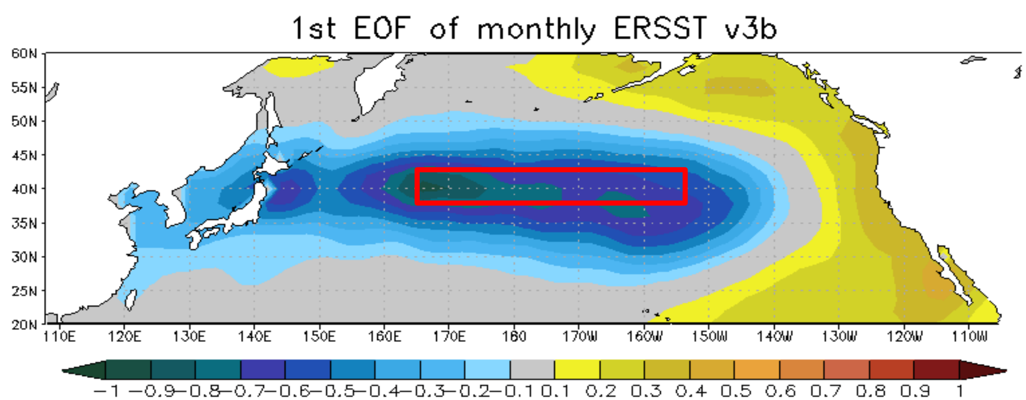
North Pacific & Arctic Oceans

PDO index









- The PDO index switched to positive phase since Mar 2019 with PDOI= 0.1 in Jun 2019.

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

- During the last 1~2 years, ENSO and PDO seem largely disconnected.

- 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

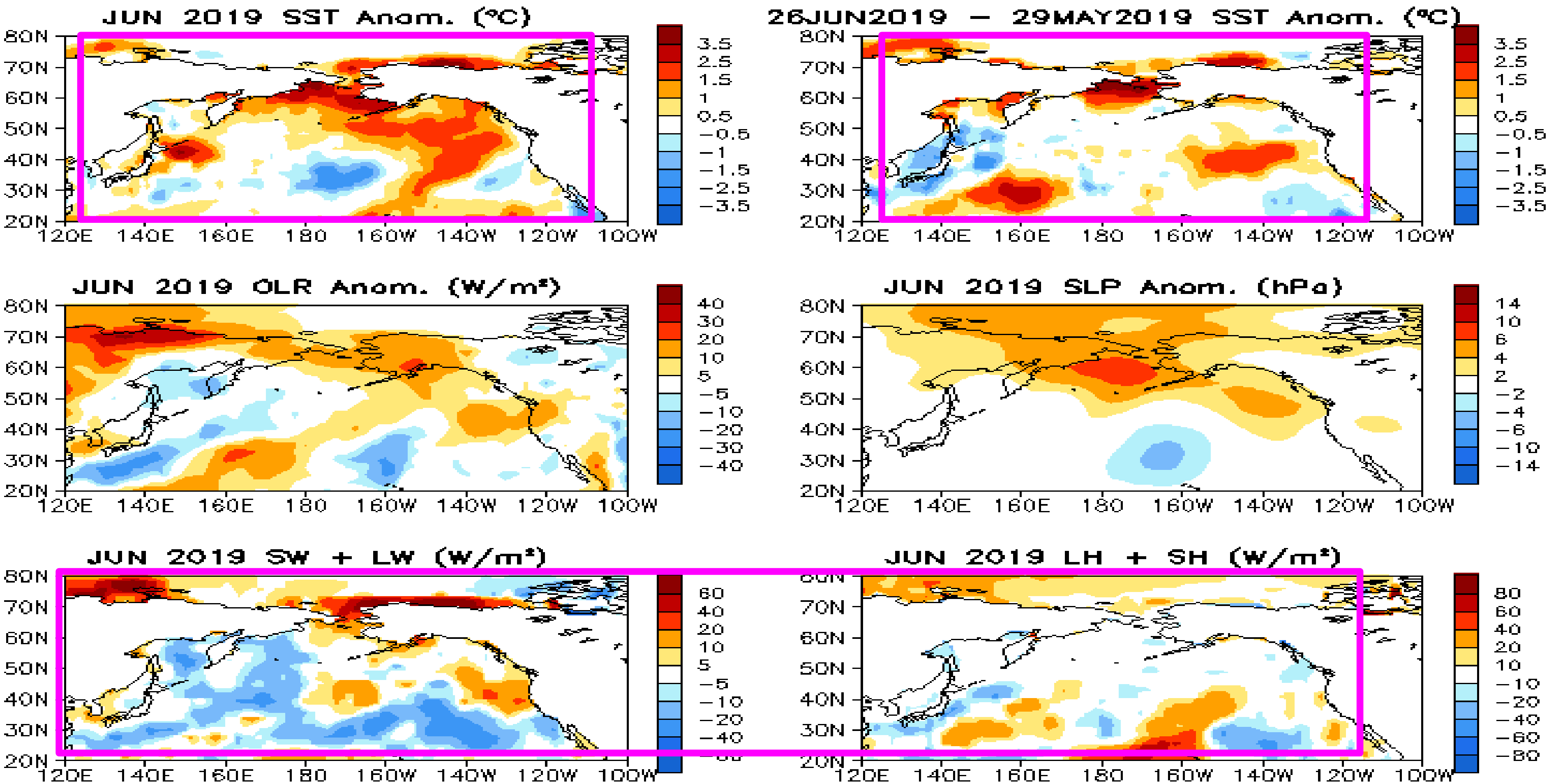
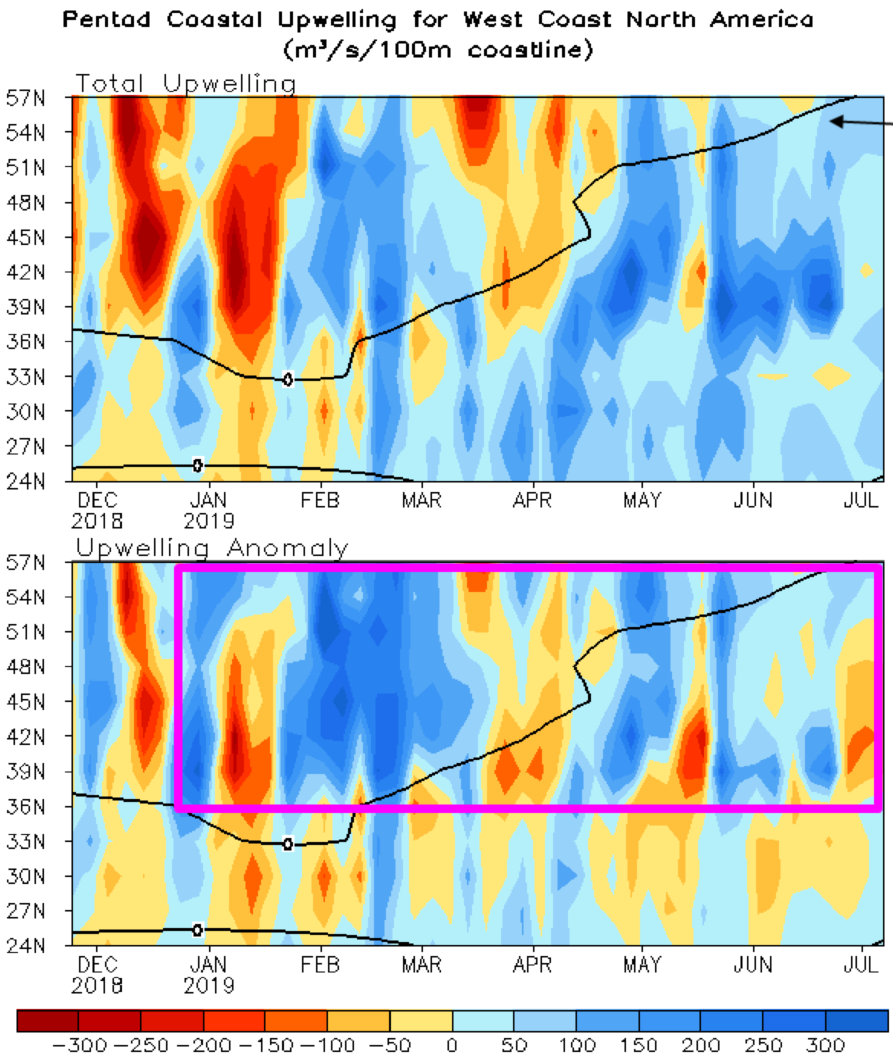
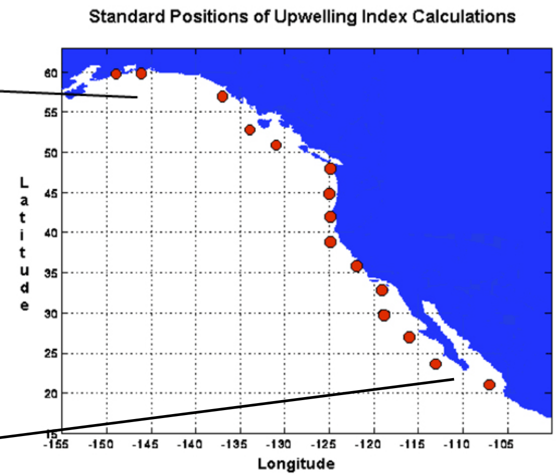


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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





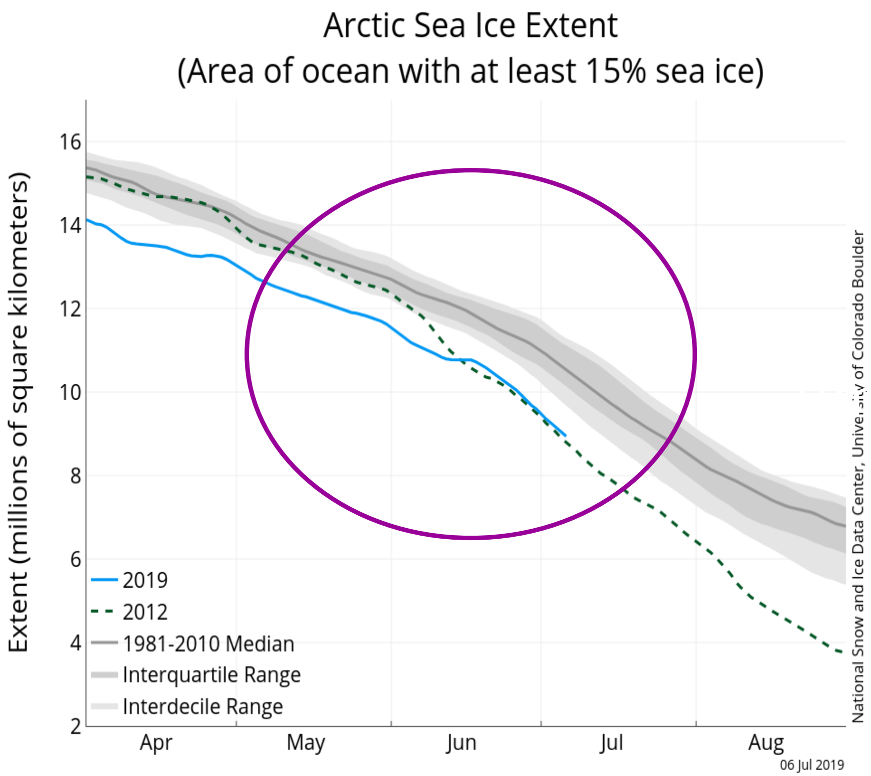
- **Anomalous upwelling was dominated north of 36N since late Jan 2019.**

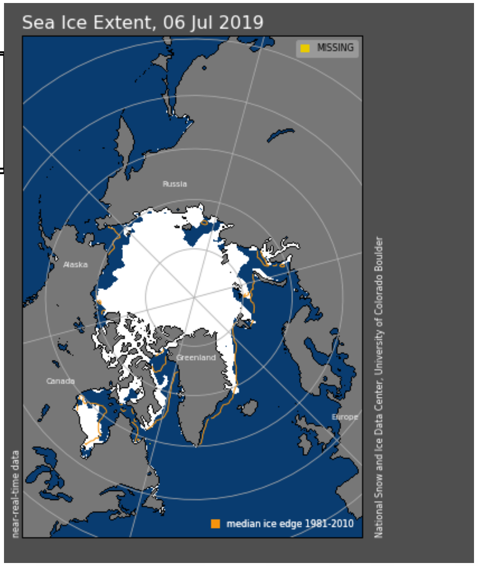
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

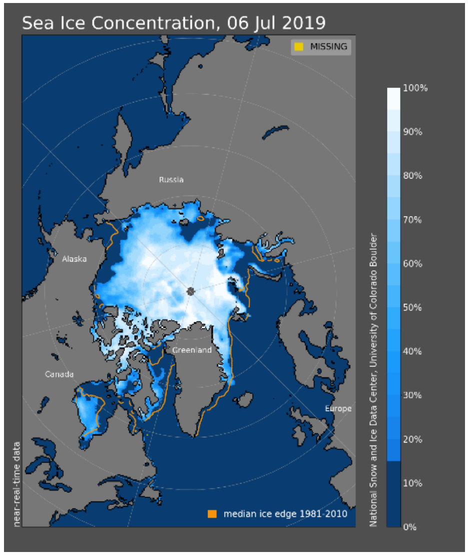
- **Area below (above) black line indicates climatological upwelling (downwelling) season.**
- **Climatologically upwelling season progresses from March to July along the west coast of North America from 36ºN to 57ºN.**

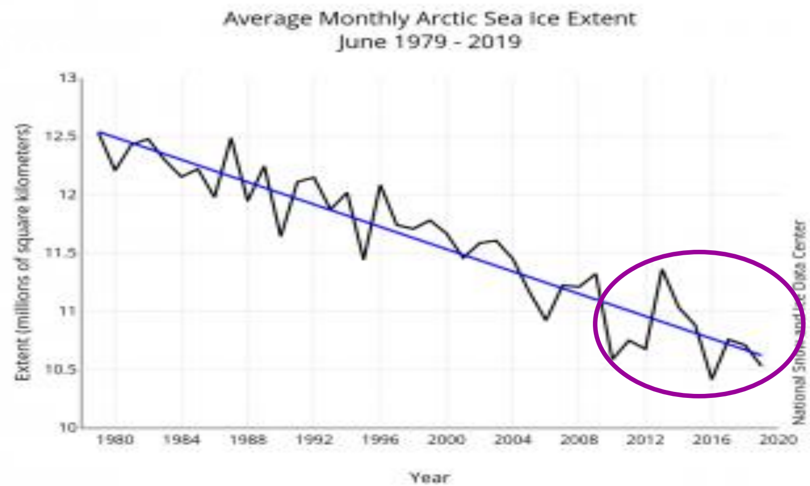
Arctic Sea Ice

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









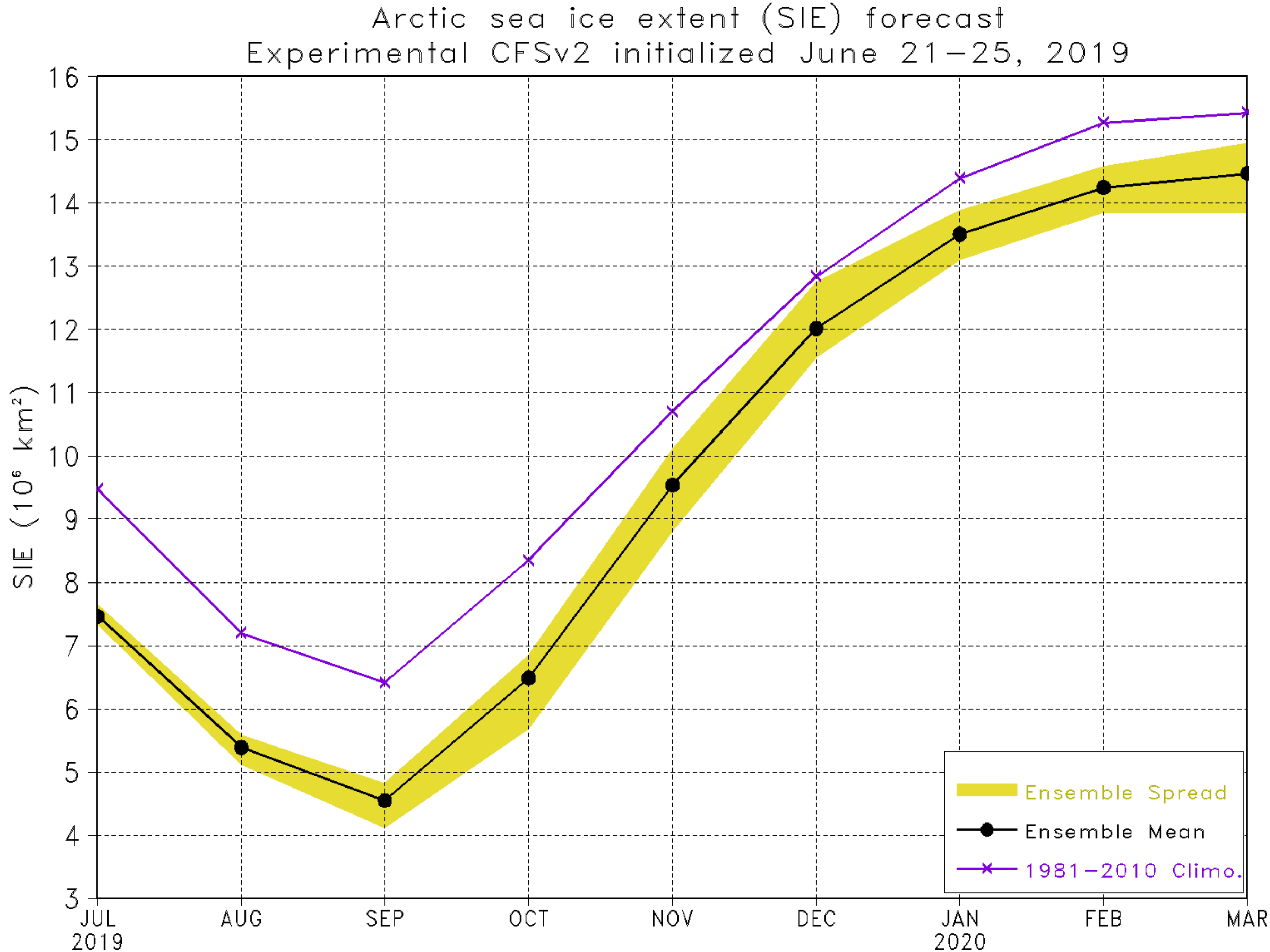
- **Arctic sea ice extent was below the normal in Jun 2019 and comparable with Jun 2012.**

- **The average extent for Jun 2019 of 10.53 million square kilometers ended up as the second lowest in the satellite record.**

Procedure of Experimental Sea Ice Outlook in Jun 2019

(Provided by Dr. Wanqiu Wang's Team, Climate Prediction Center, NCEP/NWS/NOAA)

- Use Climate Forecast System (CFS) coupled model initialized with CPC Sea Ice Initialization System (CSIS) initial sea ice conditions (20 initializations: Jun 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)


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

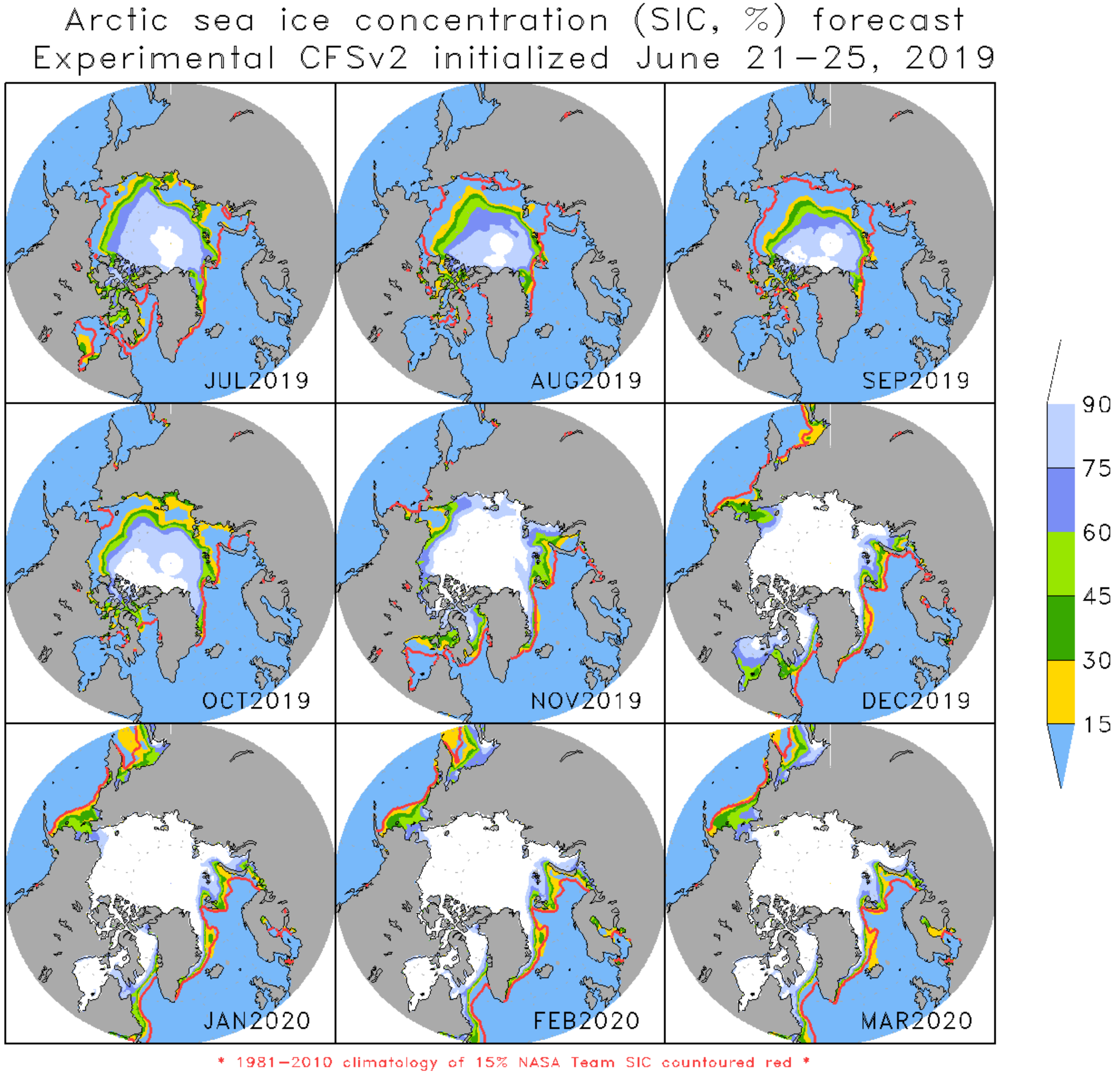
September 2019 SIE forecast

Source	SIE Value (10^6 km^2)
NSIDC 1981-2010 Climatology	6.41
NSIDC 2018	4.71
NSIDC 2012 (record low)	3.57
Experimental CFSv2 2019 forecast	**4.55**

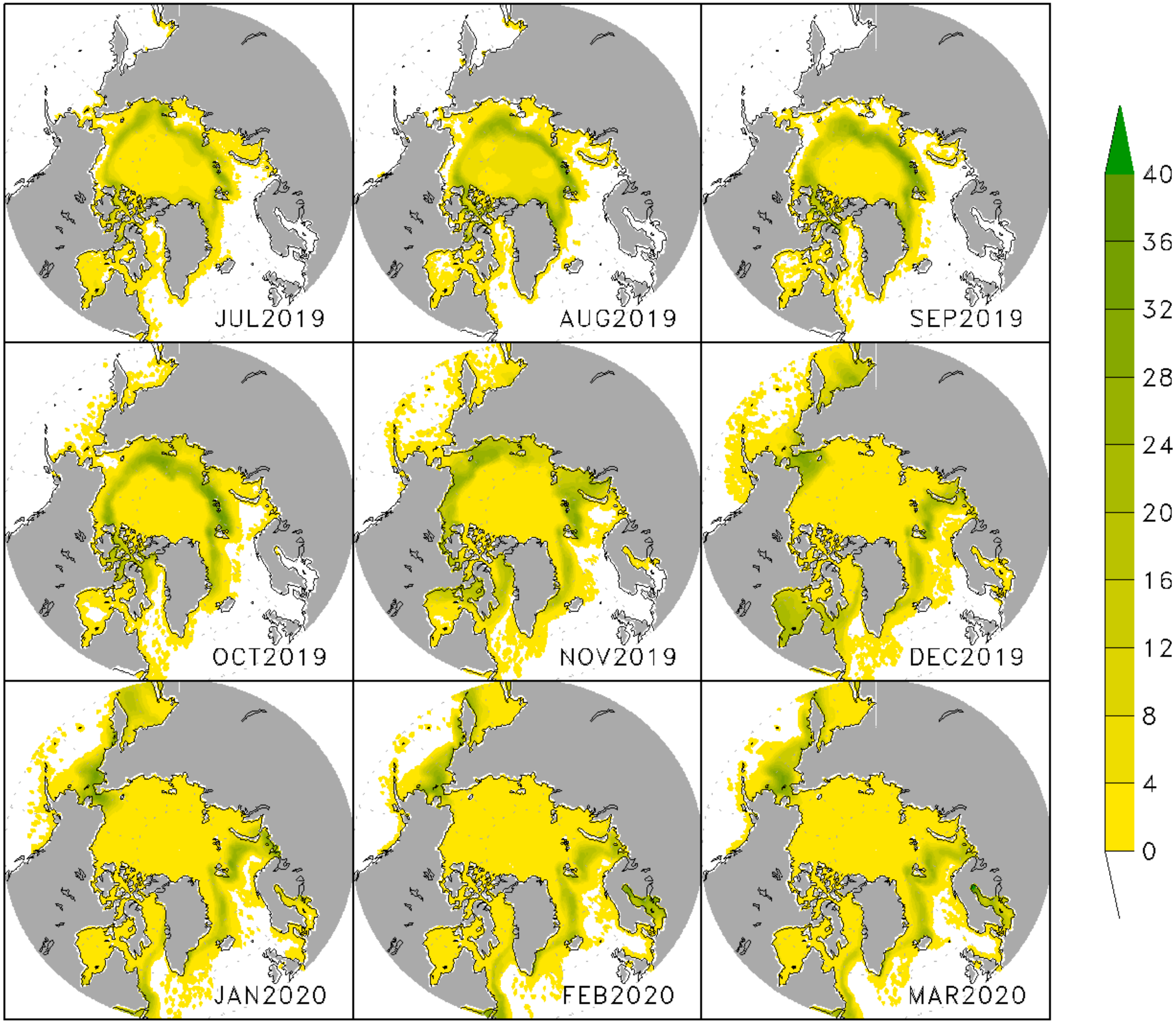
Based on these simulations, the September 2019 sea ice extent minimum is forecasted to be above the record minimum set in 2012 and slightly below last year's value.

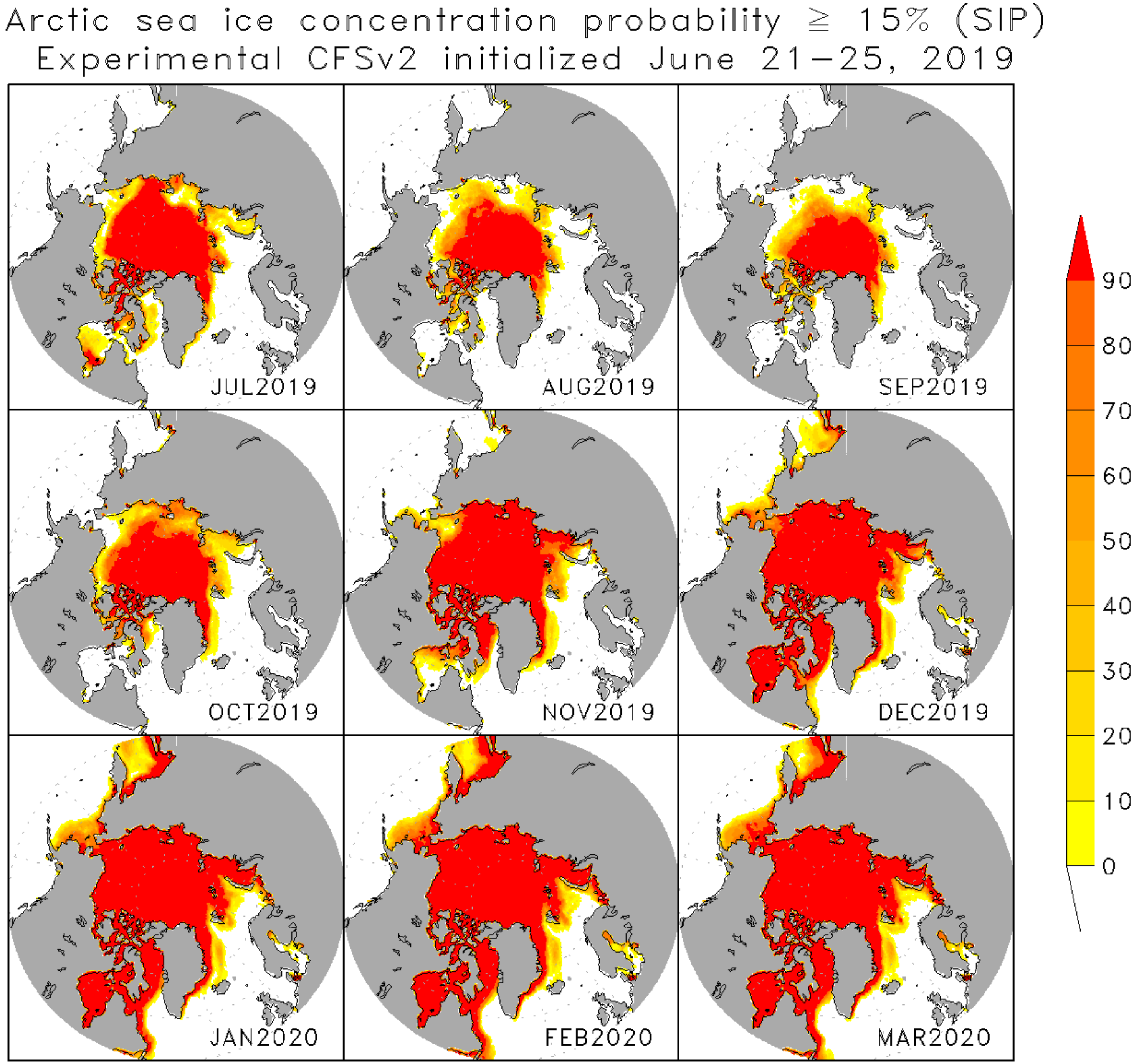
Month to Month September Prediction for this year's forecasts

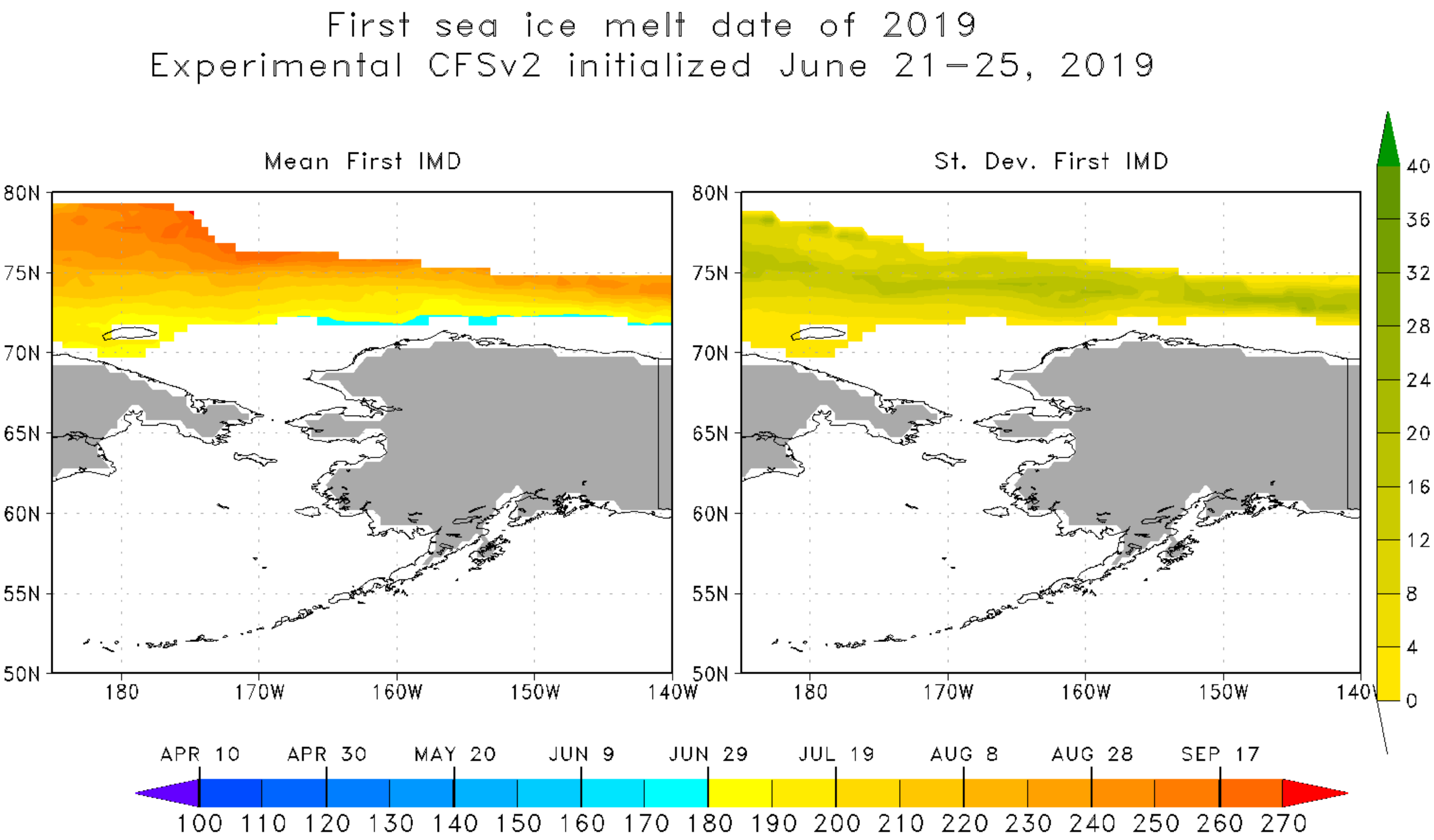
Month	March	April	May	June	July	August
Ens. Mean	4.87	4.71	4.62	4.55		
Std. Dev.	0.34	0.33	0.26	0.24		


Arctic sea ice concentration (SIC, %) forecast
Experimental CFSv2 initialized June 21–25, 2019
JUL2019
AUG2019
SEP2019
OCT2019
NOV2019
DEC2019
JAN2020
FEB2020
MAR2020
90
75
60
45
30
15
* 1981–2010 climatology of 15% NASA Team SIC countoured red *

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

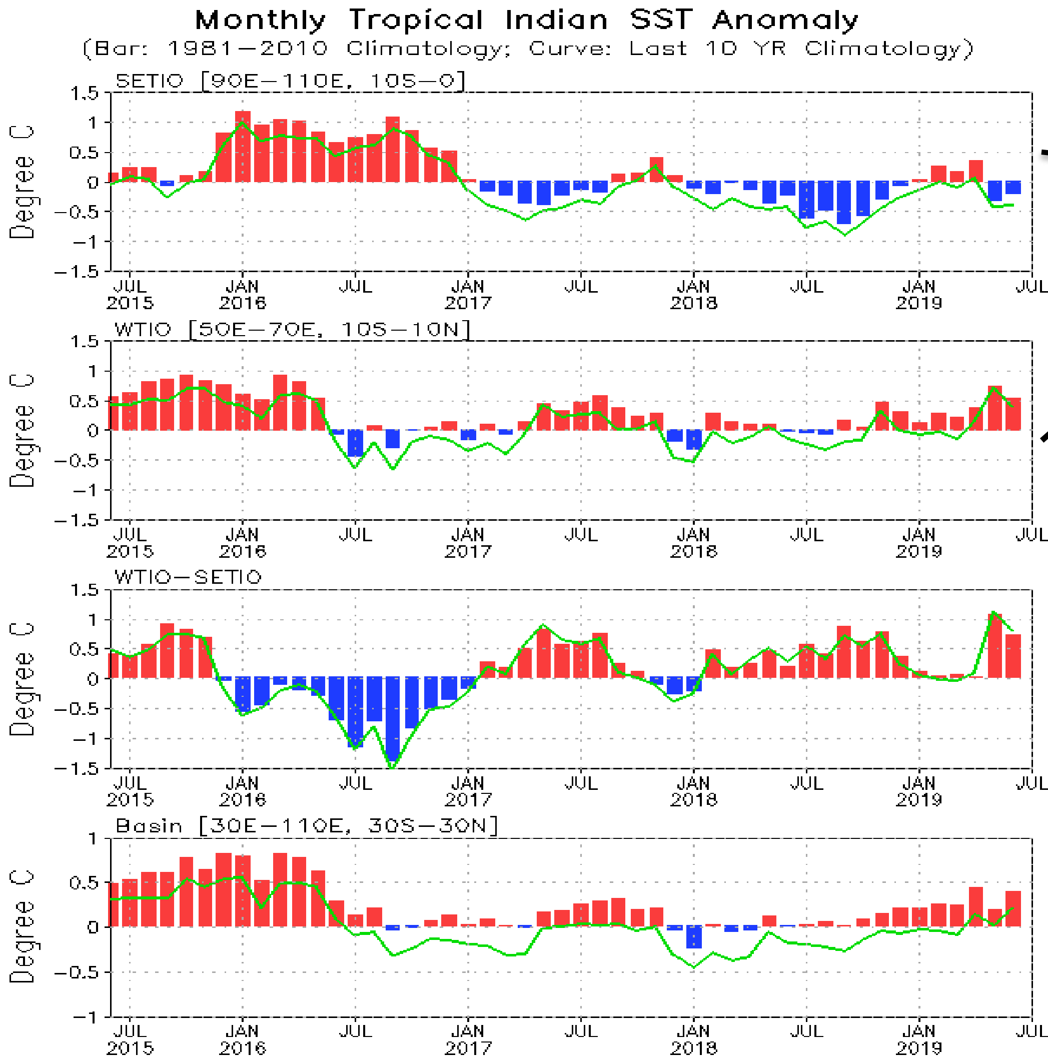


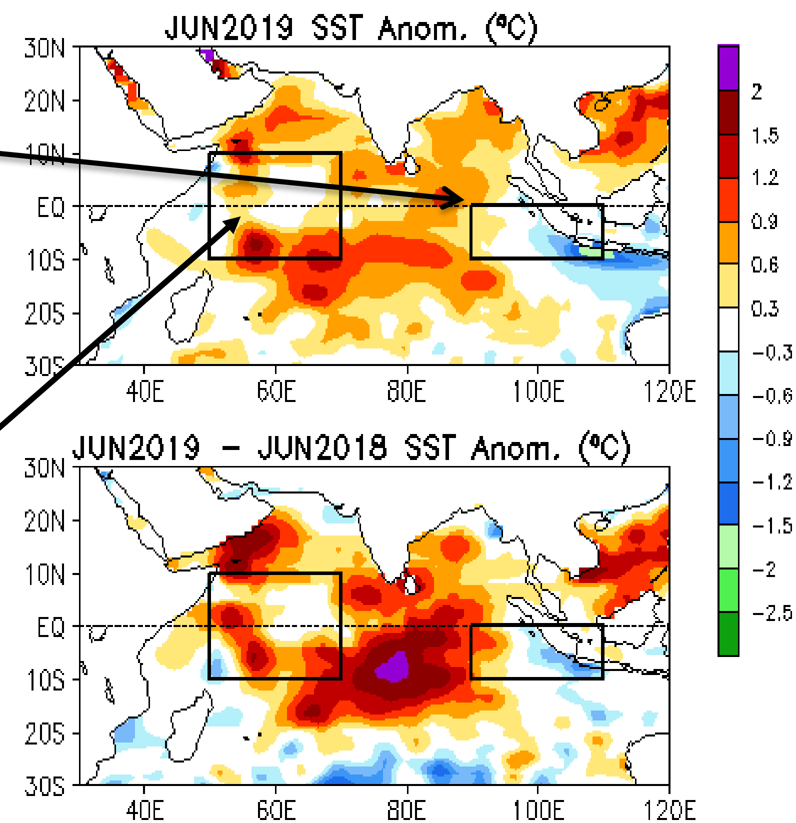

Arctic sea ice concentration probability ≧ 15% (SIP)
Experimental CFSv2 initialized June 21–25, 2019
JUL2019
AUG2019
SEP2019
OCT2019
NOV2019
DEC2019
JAN2020
FEB2020
MAR2020
90
80
70
60
50
40
30
20
10
0


First sea ice melt date of 2019
Experimental CFSv2 initialized June 21–25, 2019
Mean First IMD
St. Dev. First IMD
80N
75N
70N
65N
60N
55N
50N
180
170W
160W
150W
140W
APR 10
APR 30
MAY 20
JUN 9
JUN 29
JUL 19
AUG 8
AUG 28
SEP 17
100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270
0 4 8 12 16 20 24 28 32 36 40

<u>Indian Ocean</u>

Evolution of Indian Ocean SST Indices





- **Positive (negative) SSTAs were in the west ad cntral (far east), and IOD was in a strong positive phase in May and Jun 2019.**

- **The SST anomaly pattern is featured by a mix-up of basin mode and dipole mode.**

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.
- Convections were suppressed over the Indian Peninsular.

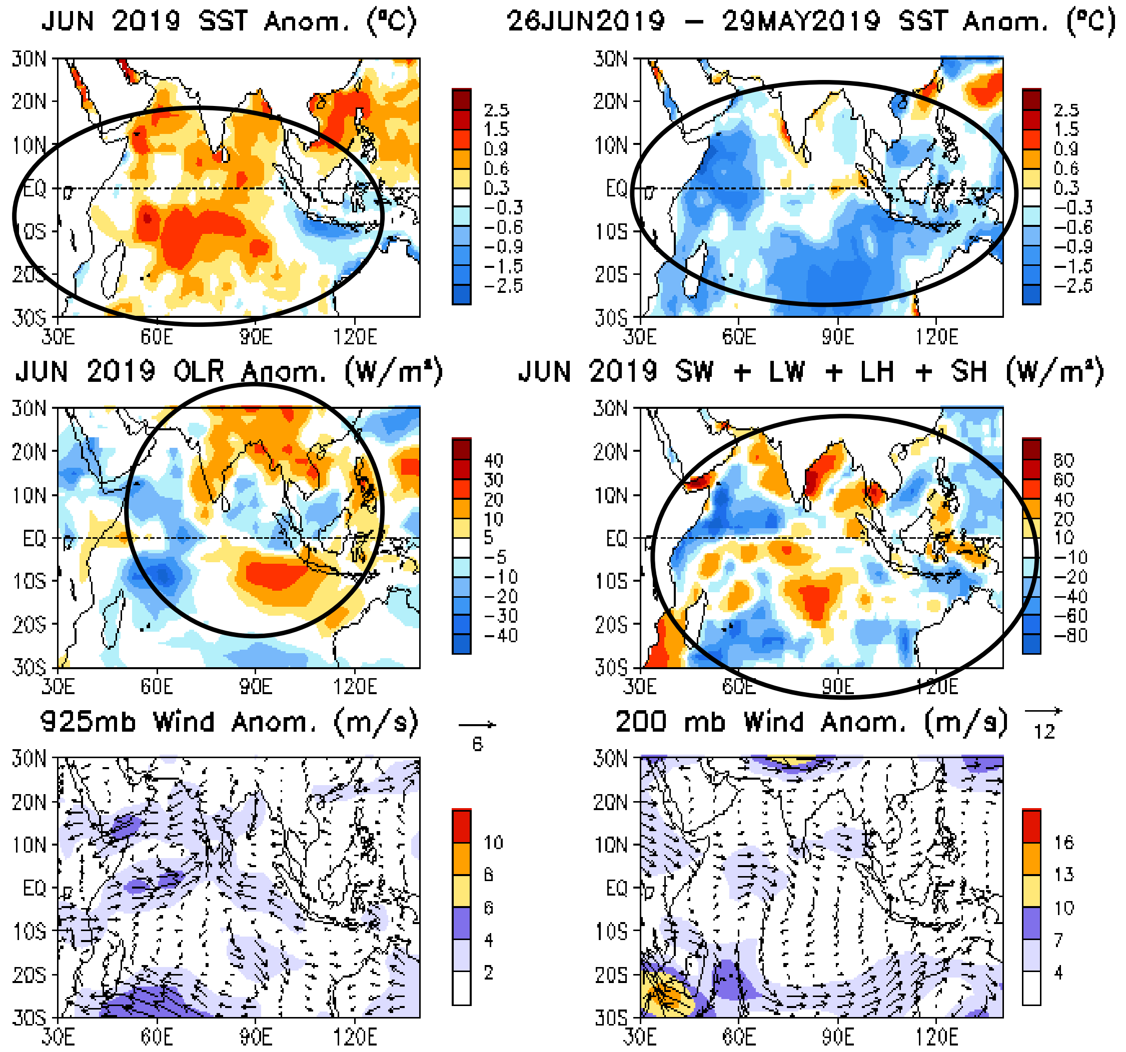
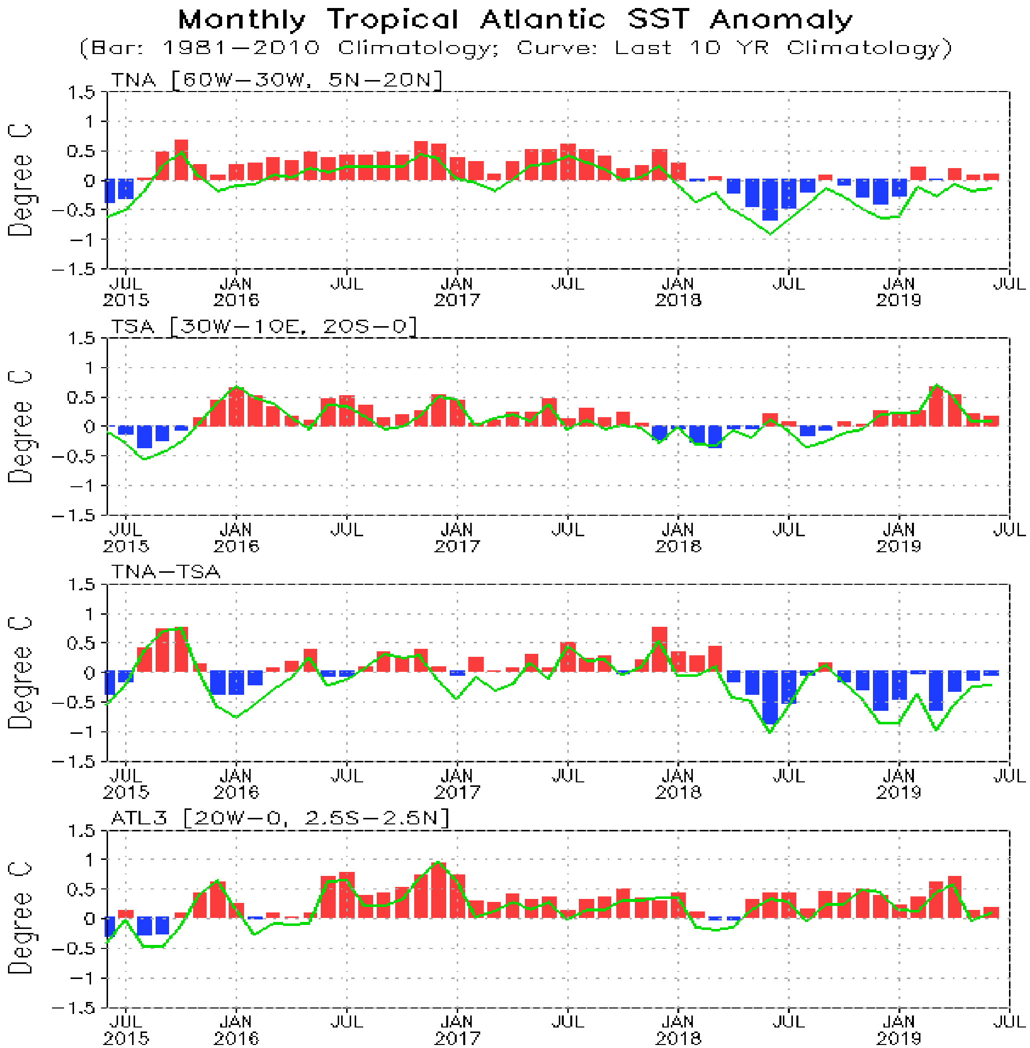
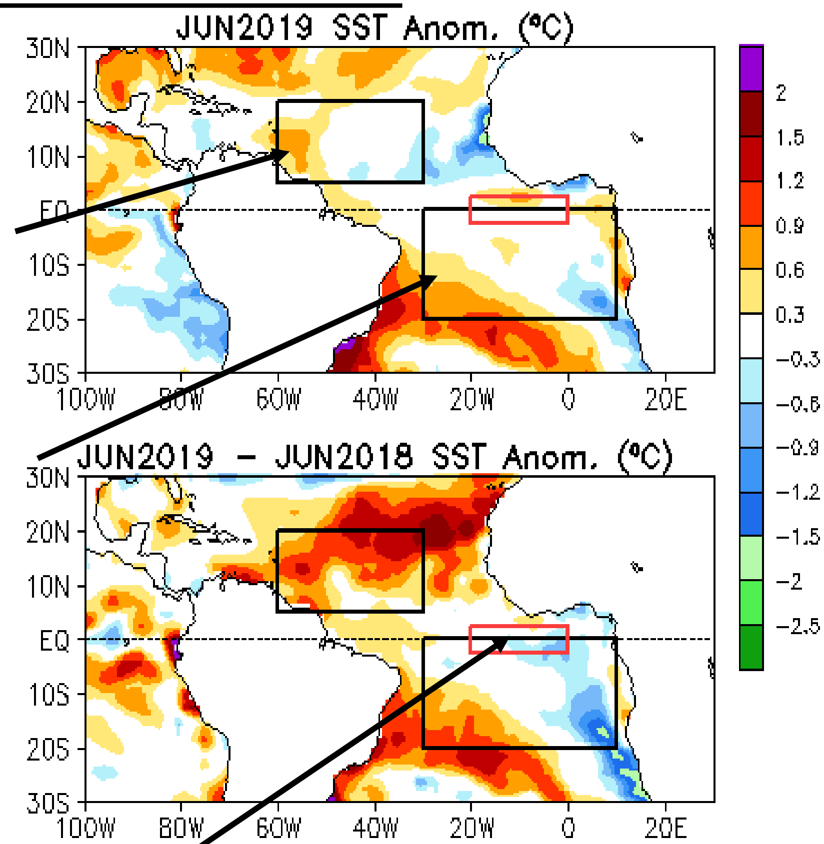


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

<u>Tropical and North Atlantic Ocean</u>

Evolution of Tropical Atlantic SST Indices

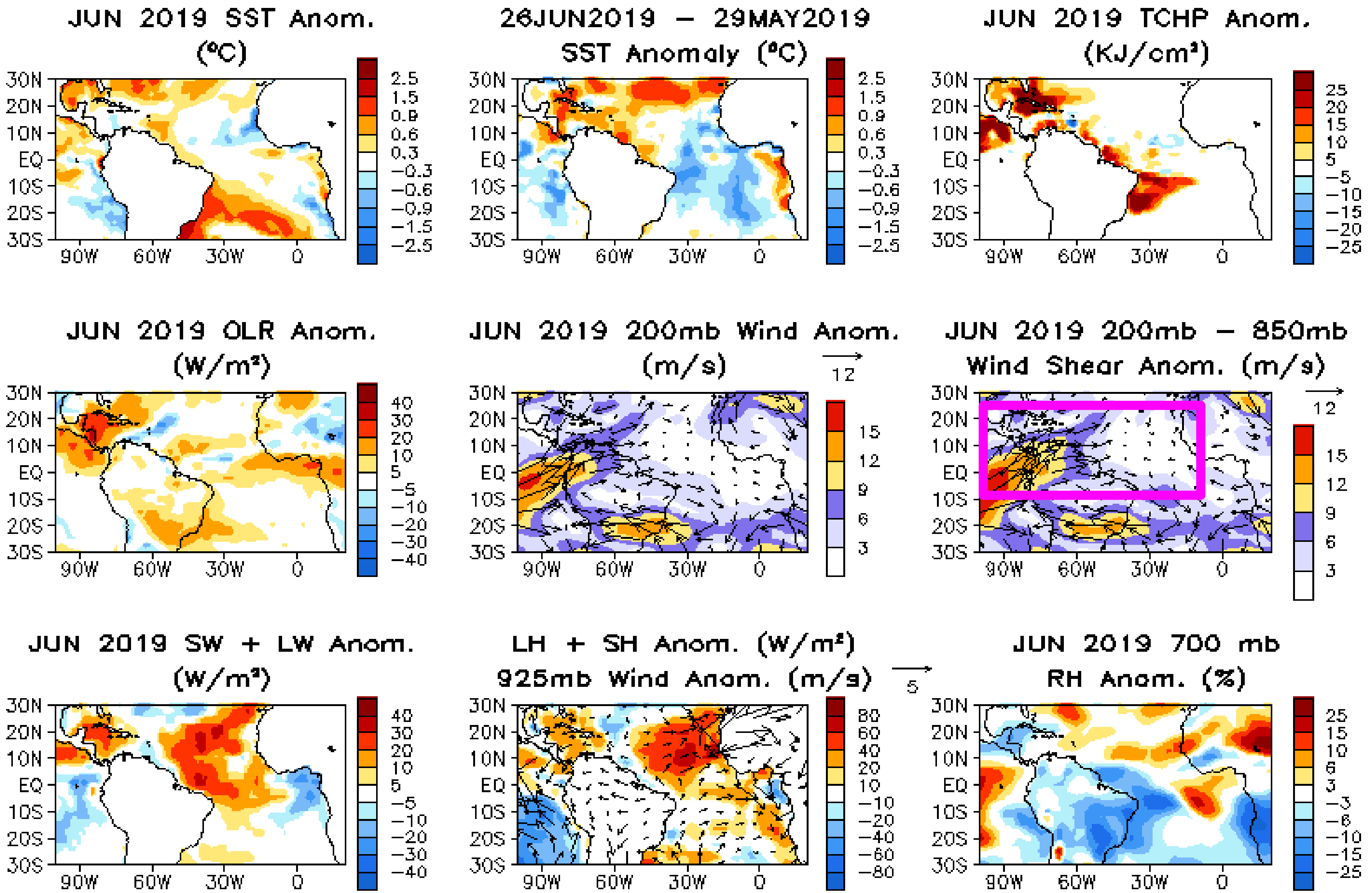




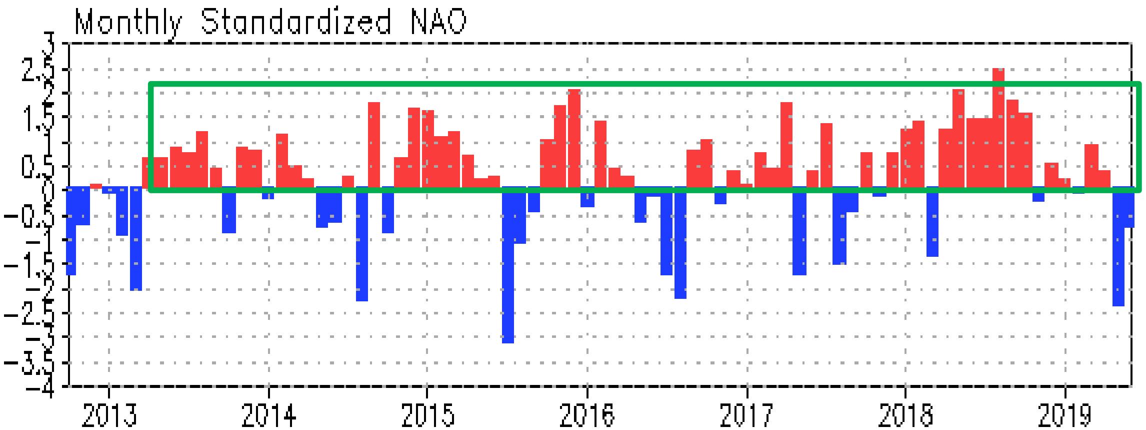
- All indices were small in May and Jun 2019.

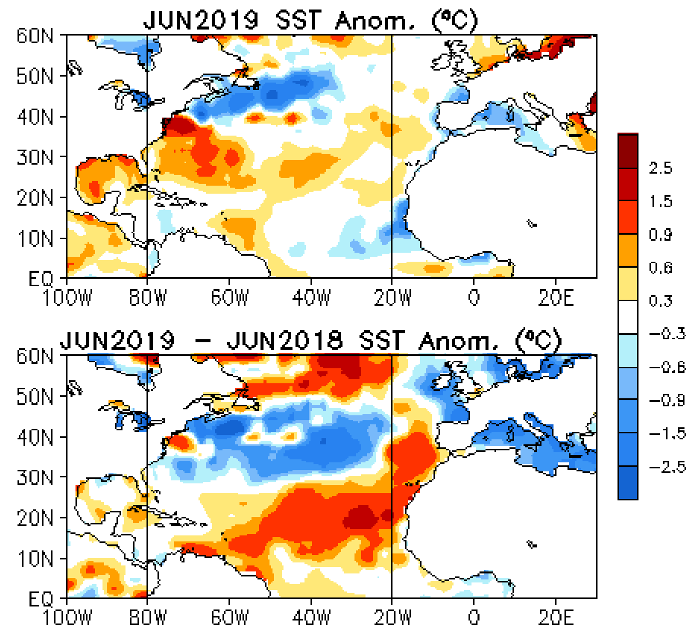
Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (ºC) for the TNA [60ºW-30ºW, 5ºN-20ºN], TSA [30ºW-10ºE, 20ºS-0] and ATL3 [20ºW-0, 2.5ºS-2.5ºN] regions, and Meridional Gradient Index, defined as differences between TNA and TSA. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

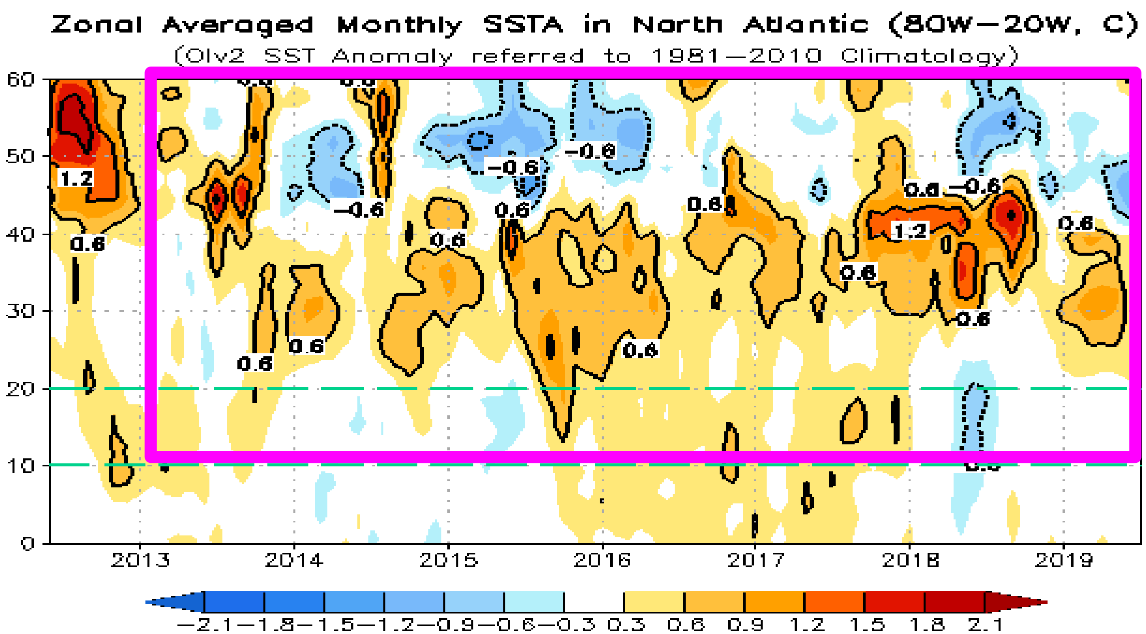
Tropical Atlantic:



NAO and SST Anomaly in North Atlantic

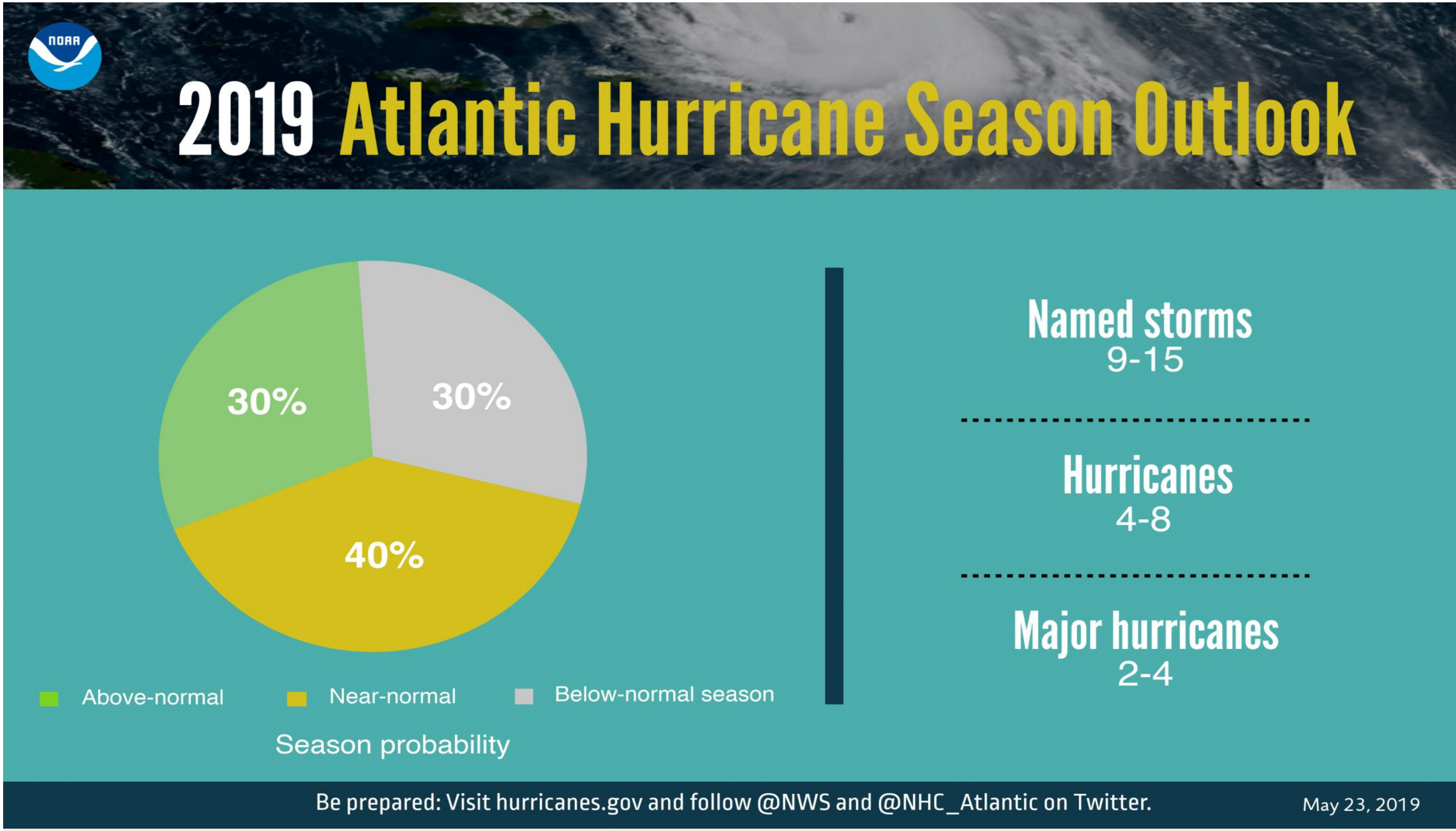






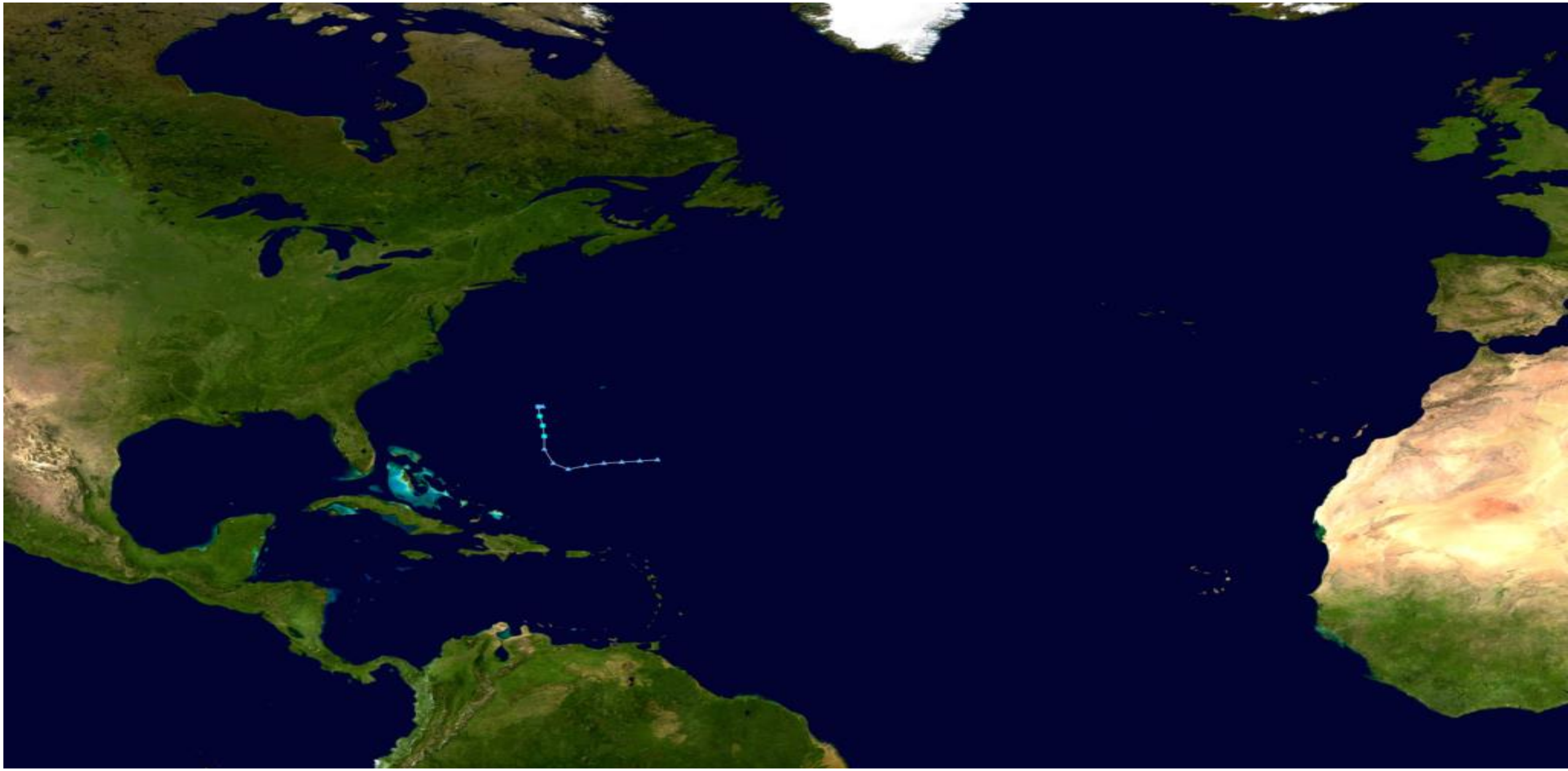
- NAO was still in a negative phase with NAOI= -0.8 in Jun 2019.
- SSTA was a tripole/horseshoe –like pattern with positive in the mid-latitudes and negative in the lower and higher latitudes, due to the long-term persistence of a positive phase of NAO.

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.



NOAA's outlook for the 2019 Atlantic hurricane season indicates that a near-normal season has the highest chance of occurring (40%), followed by equal chances (30%) of an above-normal season and a below-normal season.

https://www.noaa.gov/sites/default/files/thumbnails/image/2019%20Hurricane%20Numbers.png

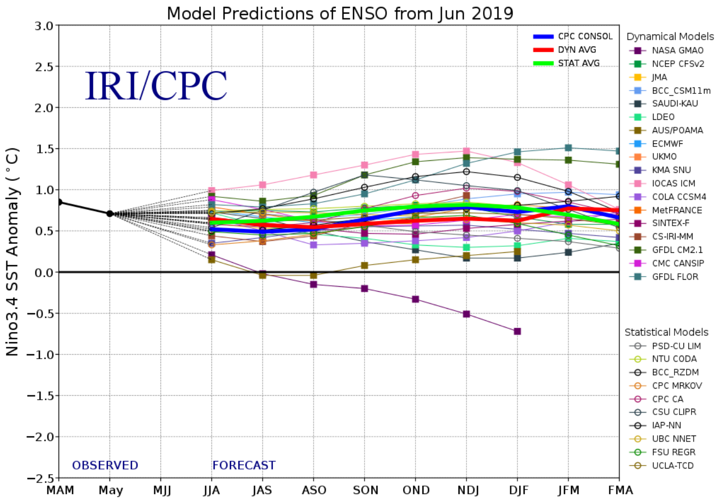


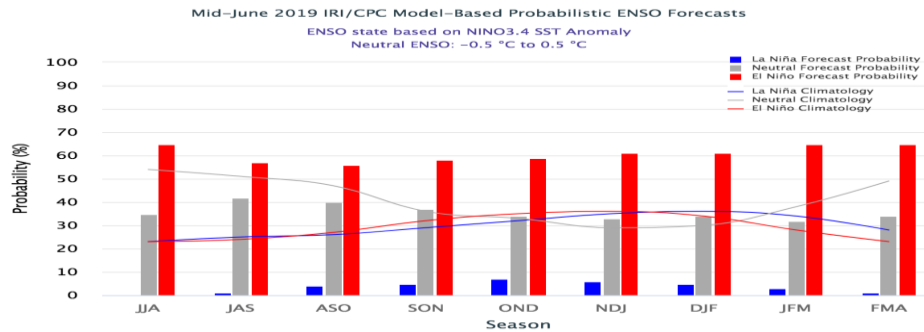
2019		(1981-2010)
Total storms	1	12.1
Hurricanes	0	6.4
Major hurricanes (Cat. 3+)	0	2.7

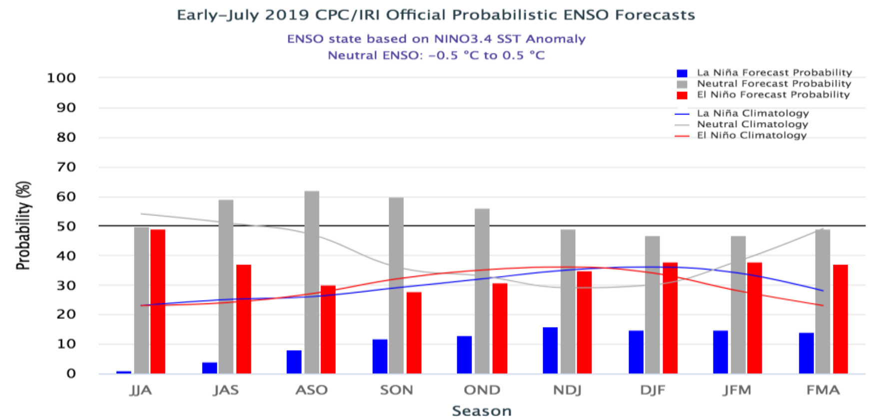
By July 10, 2019

ENSO and Global SST Predictions

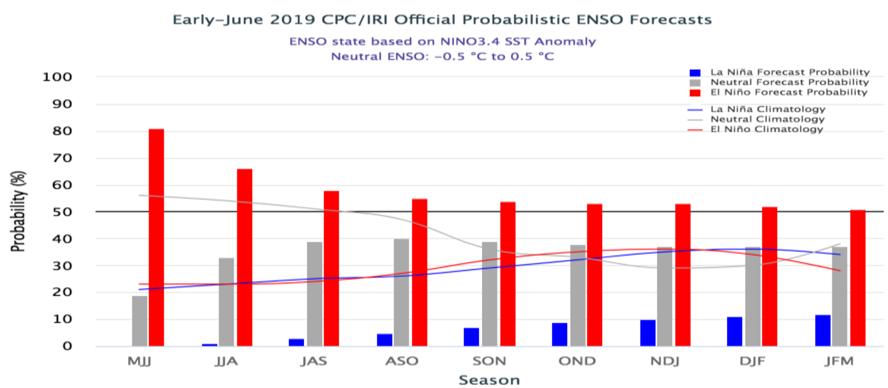
IRI NINO3.4 Forecast Plum





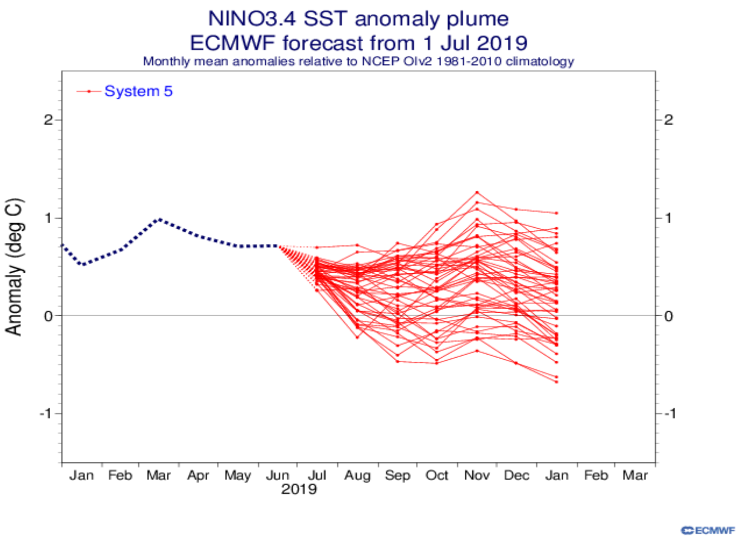


- **Majority of models predict continuation of weak El Nino or ENSO-neutral with ICs in Jun 2019.**
- **NOAA "ENSO Diagnostic Discussion" on 11 July 2019 continuously issued "*El Nino Advisory*" and indicated that *"A transition from El Niño to ENSO-neutral is expected in the next month or two, with ENSO-neutral most likely to continue through Northern Hemisphere fall and winter."***

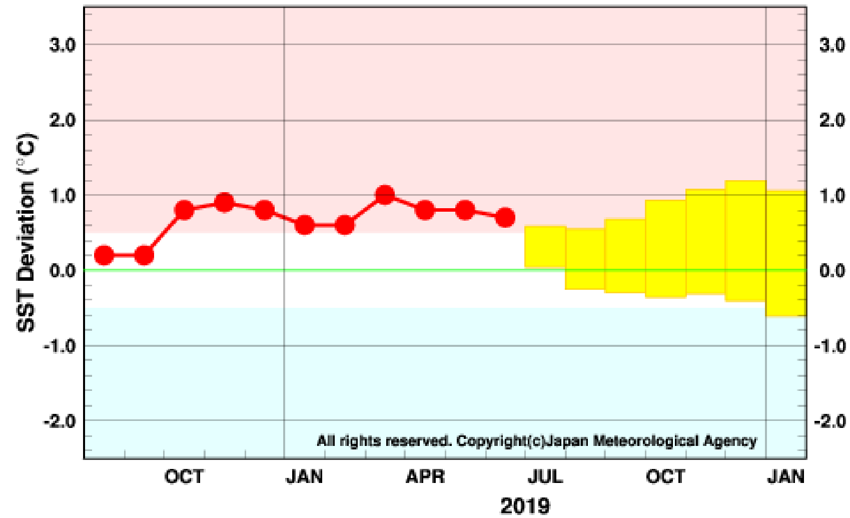


Individual Model Forecasts: Neutral or borderline El Nino

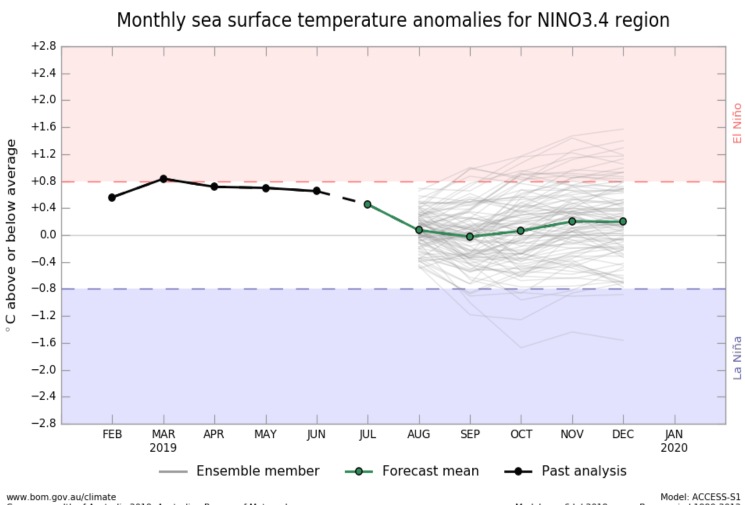
EC: Nino3.4, IC=01Jul 2019



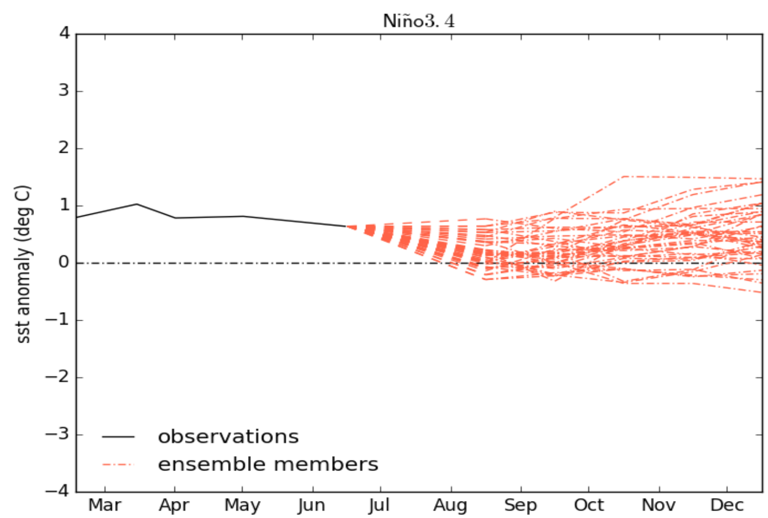
JMA: Nino3, Updated 10 Jul2019

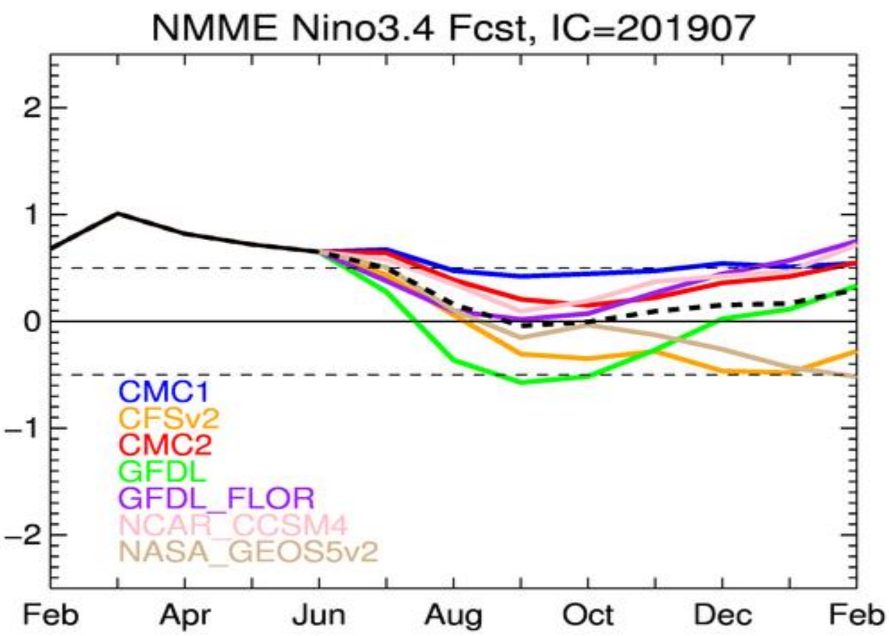


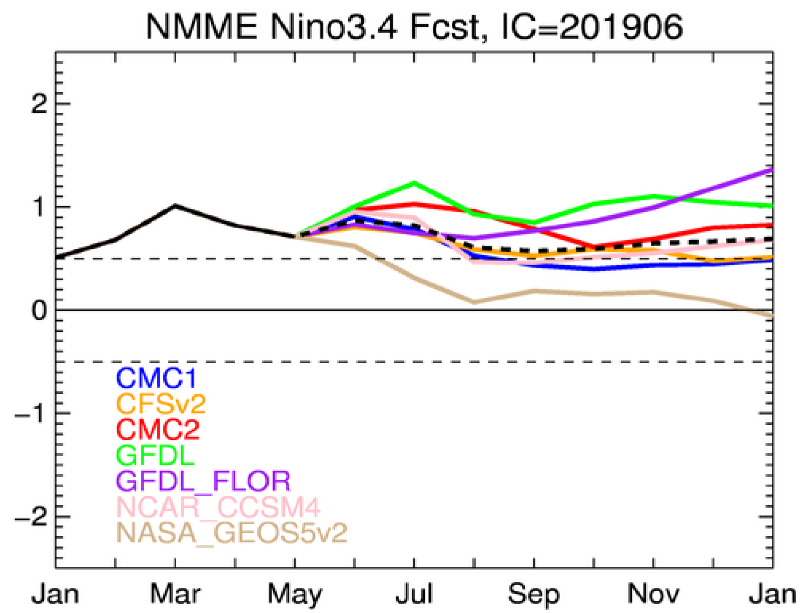
Australia: Nino3.4, Updated 06Jul 2019

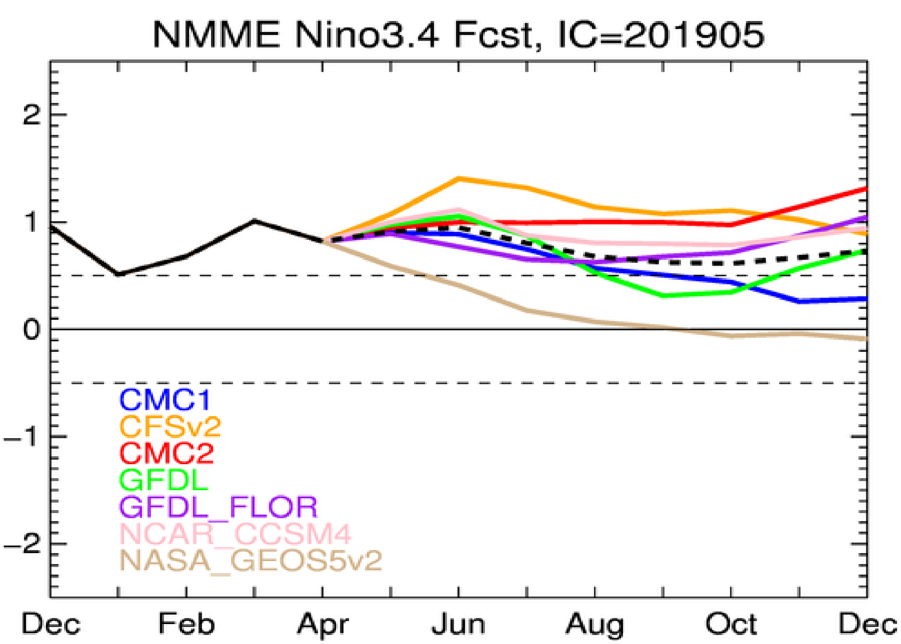


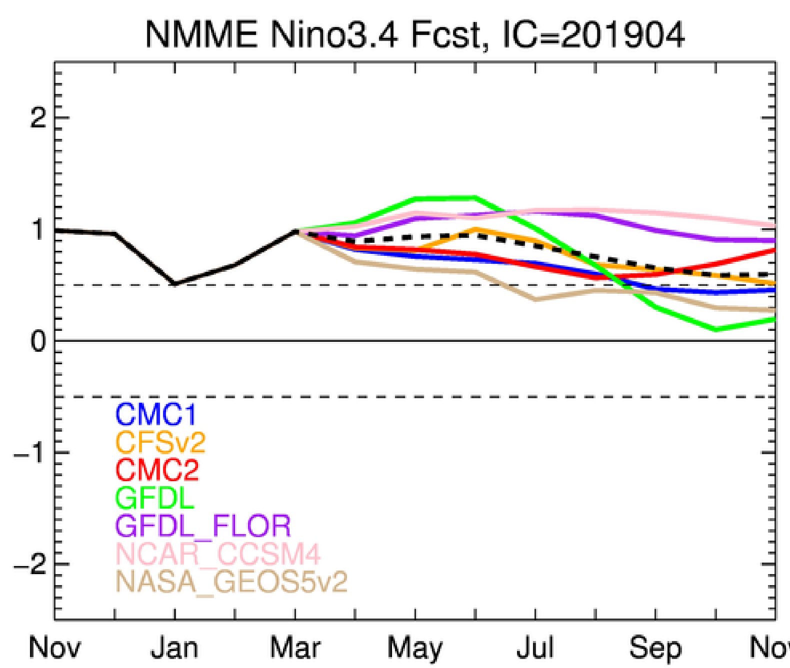
UKMO: Nino3.4, Updated 11Jul 2019



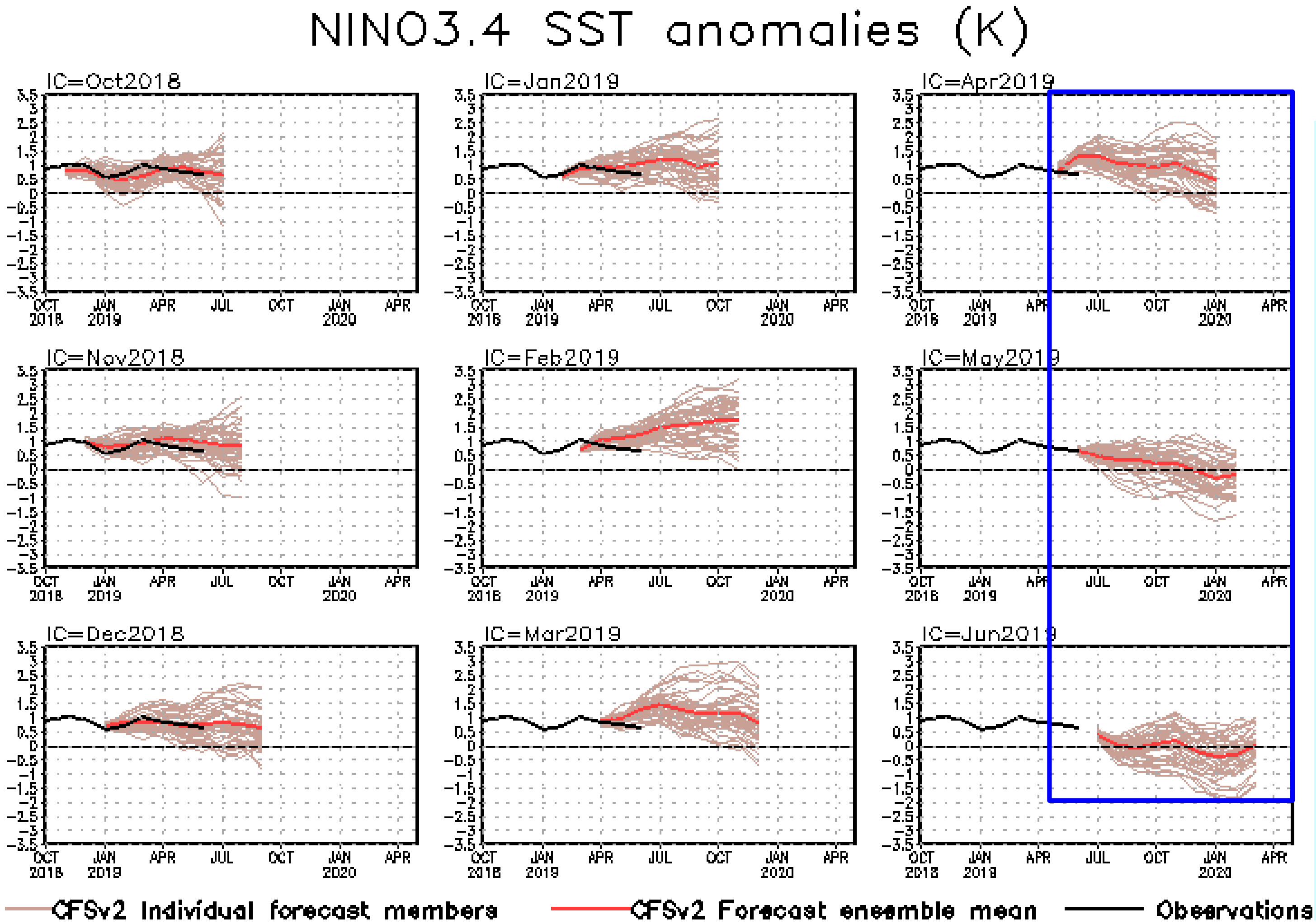

NMME Nino3.4 Fcst, IC=201907
2
1
0
−1
−2
Feb
Apr
Jun
Aug
Oct
Dec
Feb
CMC1
CFSv2
CMC2
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2


NMME Nino3.4 Fcst, IC=201906
2
1
0
−1
−2
Jan
Mar
May
Jul
Sep
Nov
Jan
CMC1
CFSv2
CMC2
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2


NMME Nino3.4 Fcst, IC=201905
2
1
0
−1
−2
Dec
Feb
Apr
Jun
Aug
Oct
Dec
CMC1
CFSv2
CMC2
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2


NMME Nino3.4 Fcst, IC=201904
2
1
0
−1
−2
Nov
Jan
Mar
May
Jul
Sep
Nov
CMC1
CFSv2
CMC2
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2

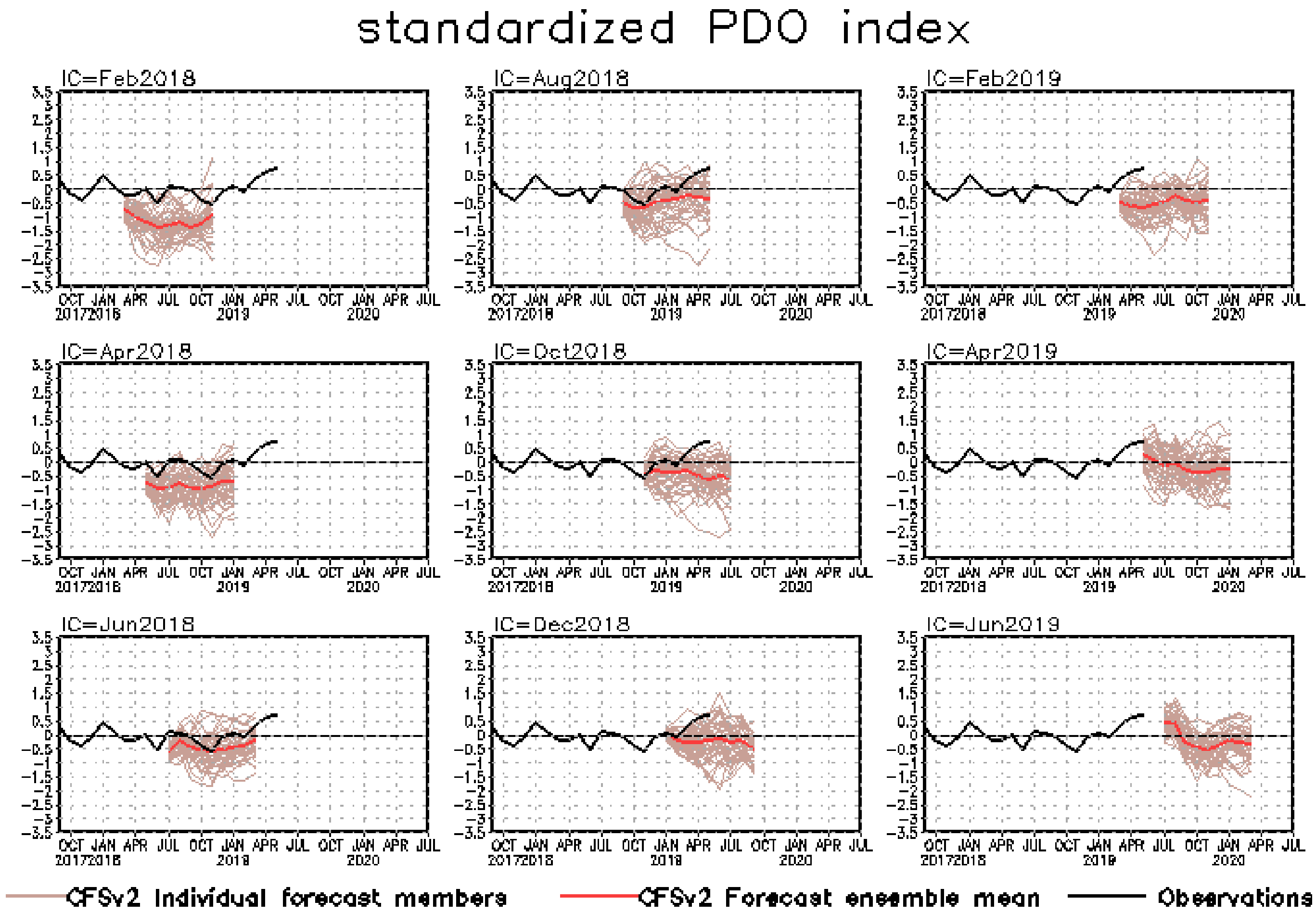
CFS Niño3.4 SST Predictions from Different Initial Months



- CFSv2 predicted a decline of positive SSTAs with ICs since Mar 2019.
- The latest forecasts call for ENSO neutral since summer 2019.

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



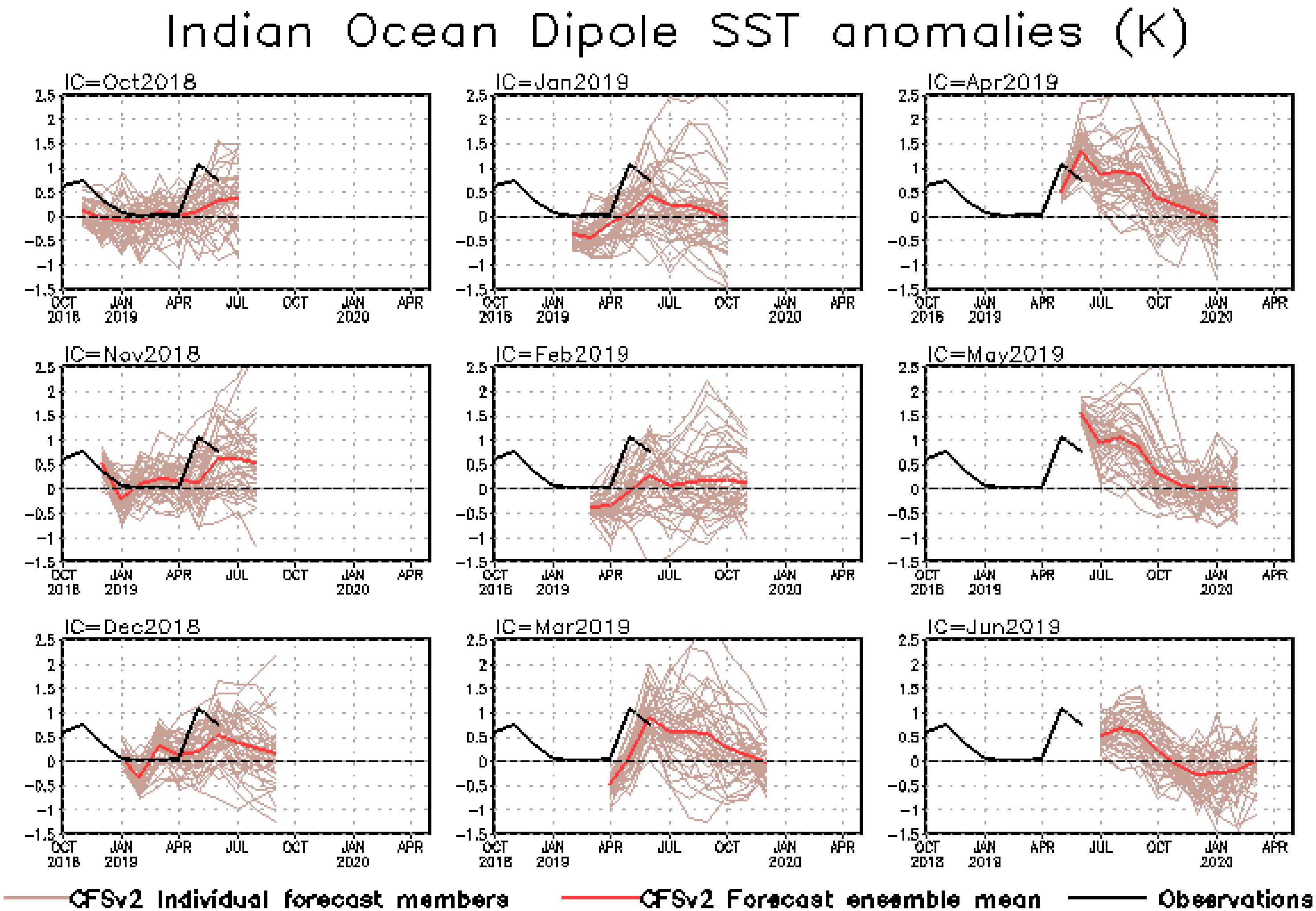
PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N].

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

- CFSv2 predicts a neutral phase of PDO in 2019.

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.

NCEP CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

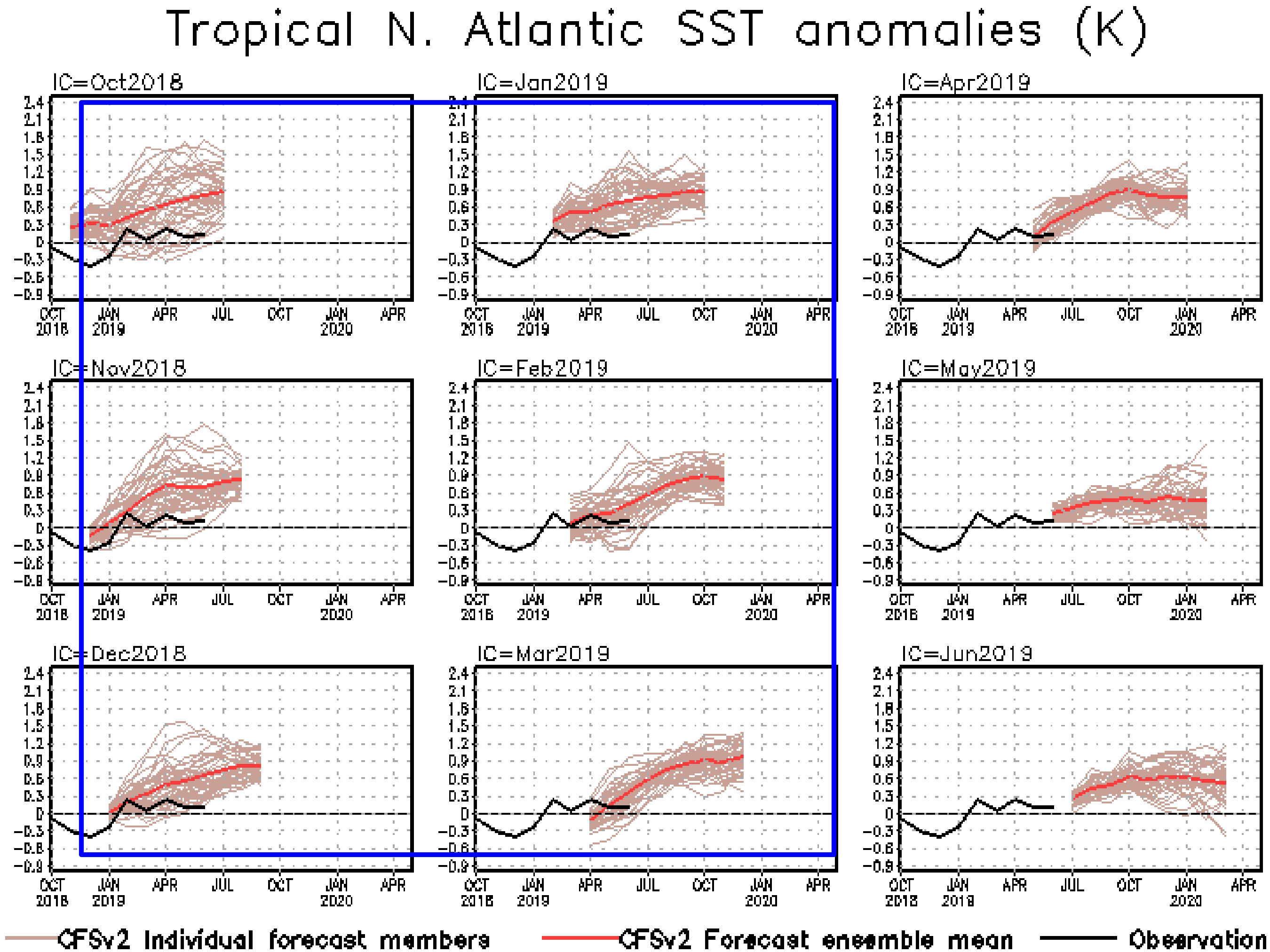
SETIO = SST anomaly in [90°E-110°E, 10°S-0]

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

- **Latest CFSv2 predictions call decline of the positive phase of IOD in 2019.**

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

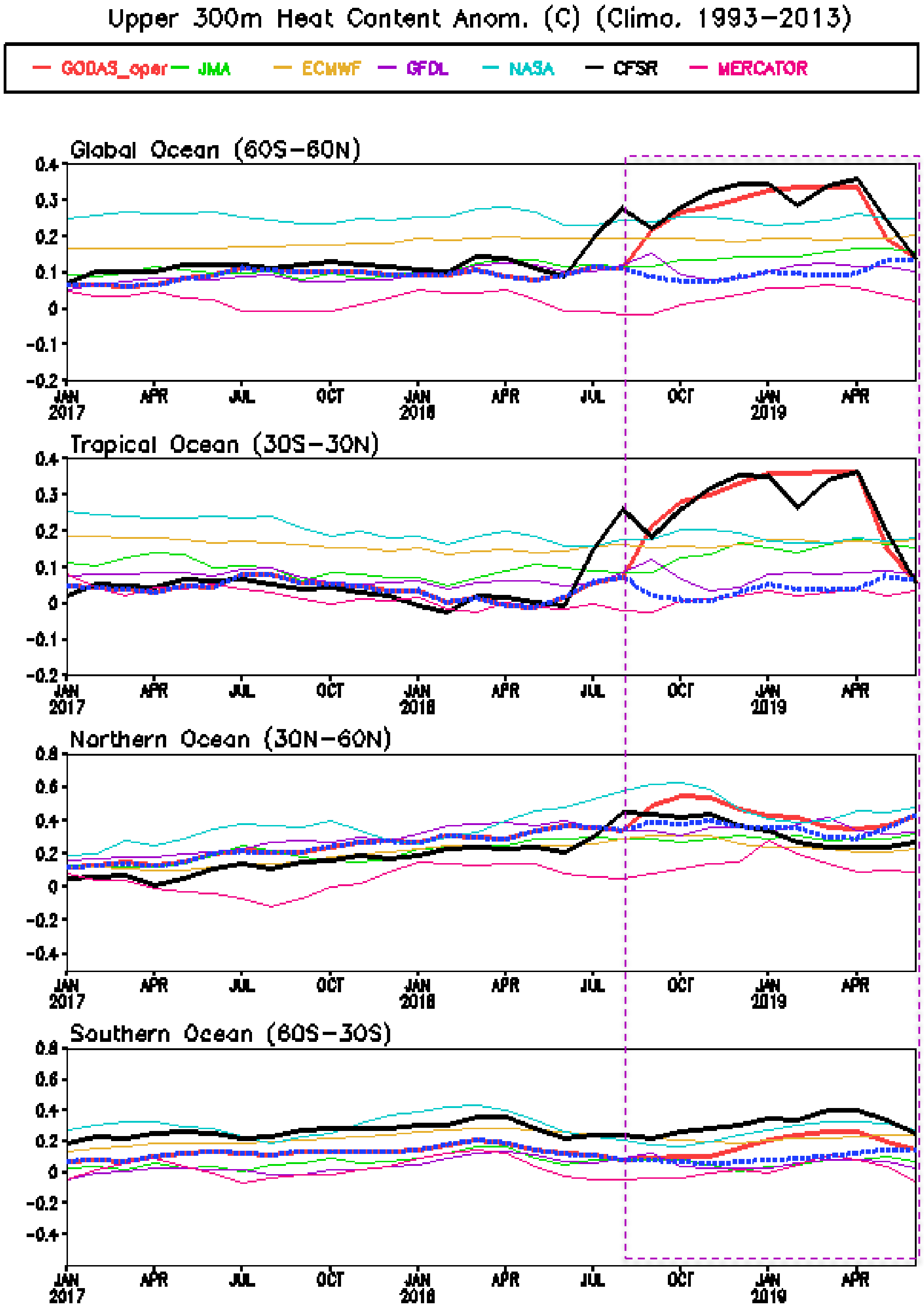


TNA is the SST anomaly averaged in the region of [60°W-30°W, 5°N-20°N].

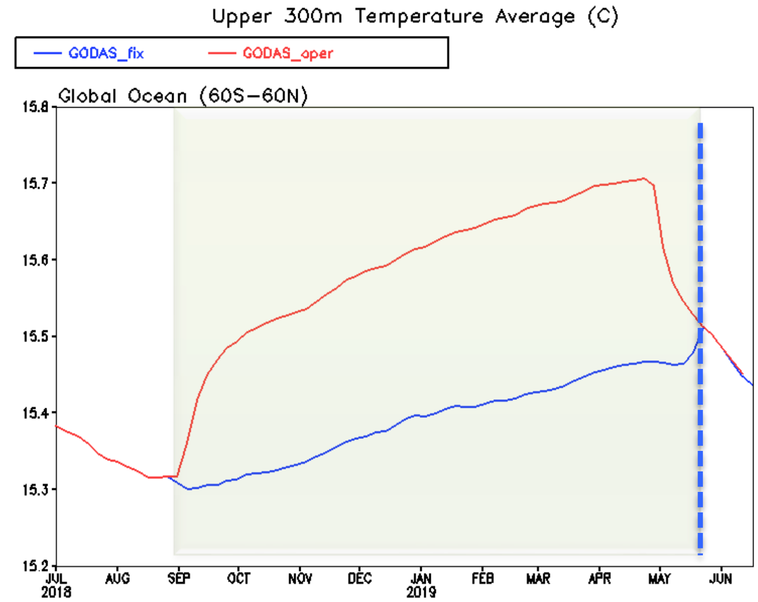
- **Predictions had warm biases for ICs in Sep 2018-Feb 2019. The warm bias may be partially associated with the warm bias in CFSR due to the decoding bug.**
- **Latest CFSv2 predictions call above normal SSTA in the tropical N. Atlantic in summer-autumn 2019, corresponding to the lag impact of the El Nino.**

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.

GODAS/CFSR warm bias and its potential impact on the CFSv2 forecasts

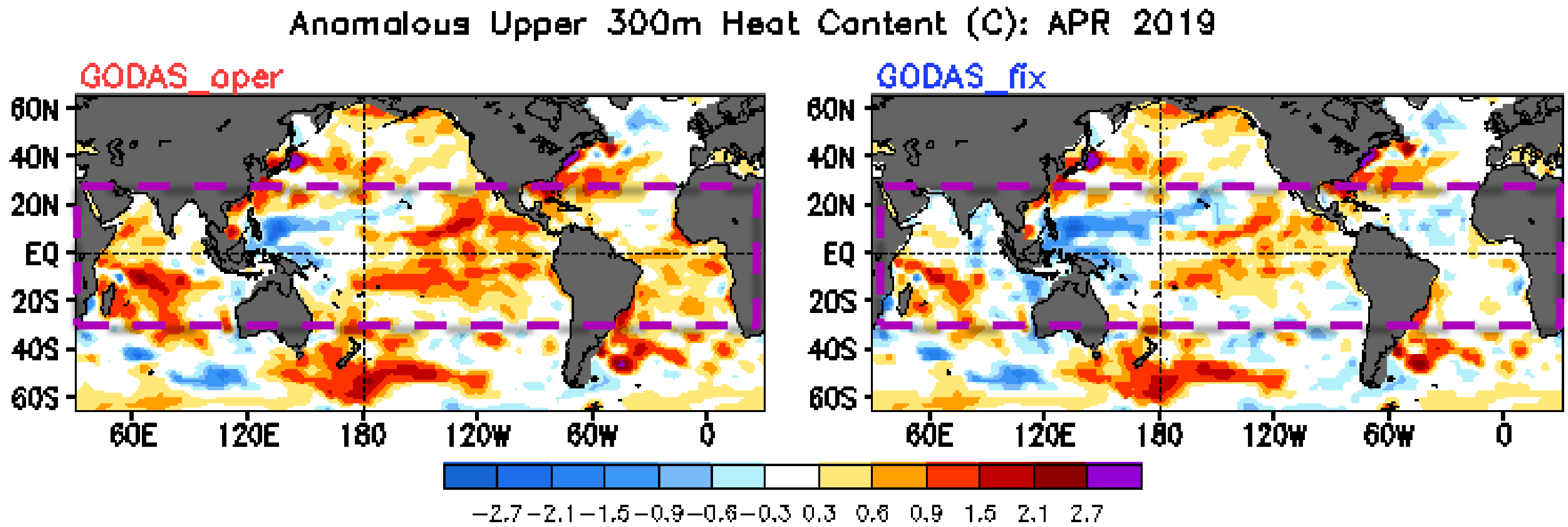


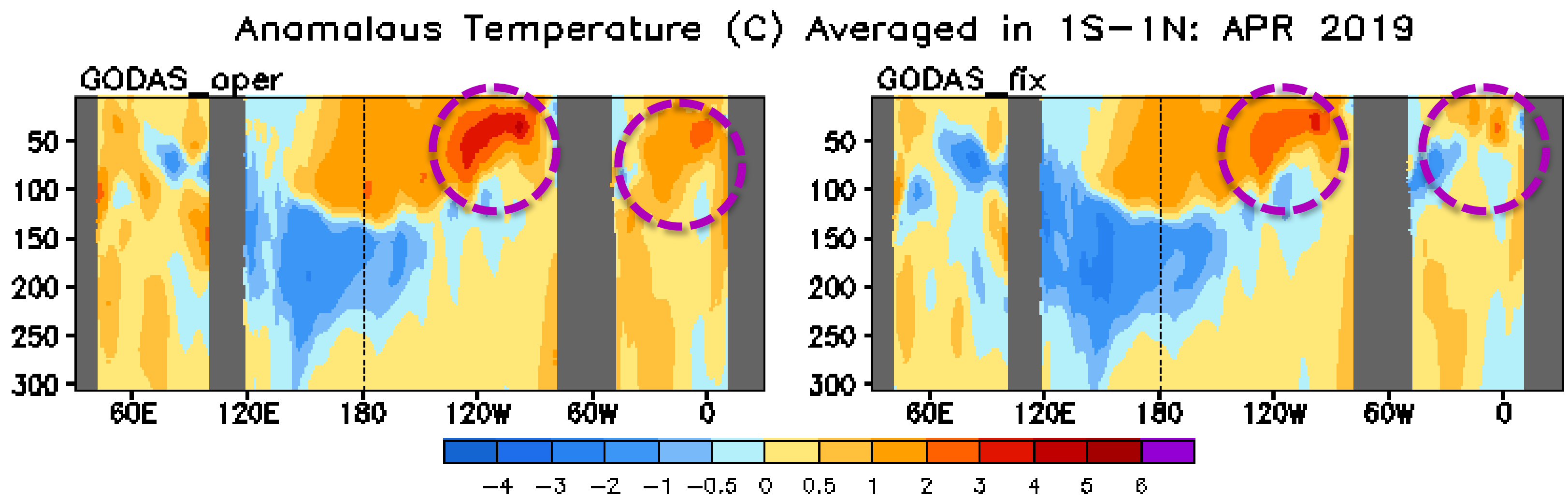
GODAS warm bias fix run



- **The sudden warming around Sep 2018 in GODAS and CFSR was caused by an error in decoding the Argo profile data in the new BUFR format.**
- **The sudden spurious warming was removed in a parallel run with a bug fix (blue dash line).**
- **An operational code change for GODAS and CFSR was made on May 13, 2019.**
- **Data from Sep 2018-May 2019 in CPC' GODAS archive/GODAS data server was replaced by the bug fix run.**

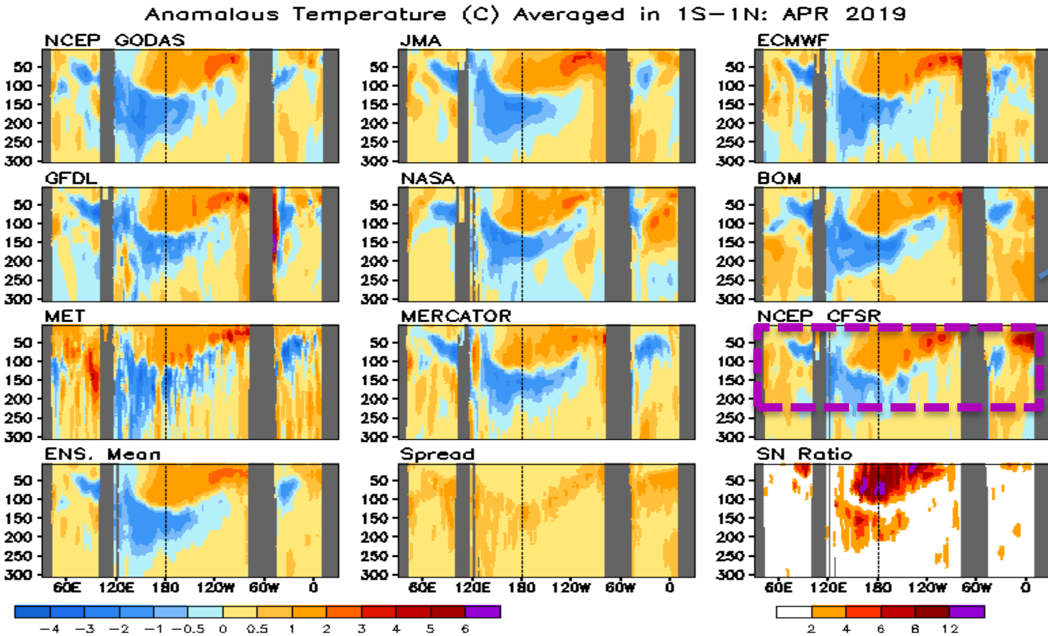
Comparison between GODAS operational run and bug fix run in Apr 2019

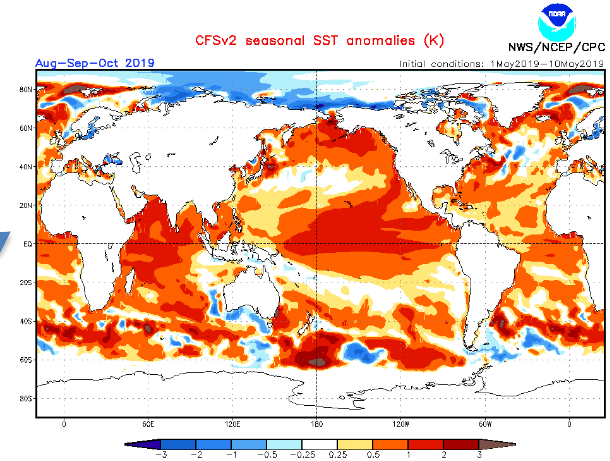




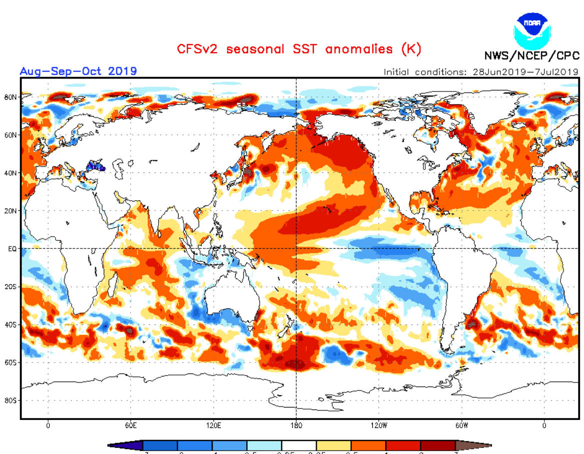
- **The warm bias was mainly observed in the tropical oceans.**
- **Equatorial subsurface temperature near the thermocline cooled by 1-2C (0.5-1C) in the Atlantic Ocean (Pacific and Indian Oceans) in the parallel run with bug fix.**

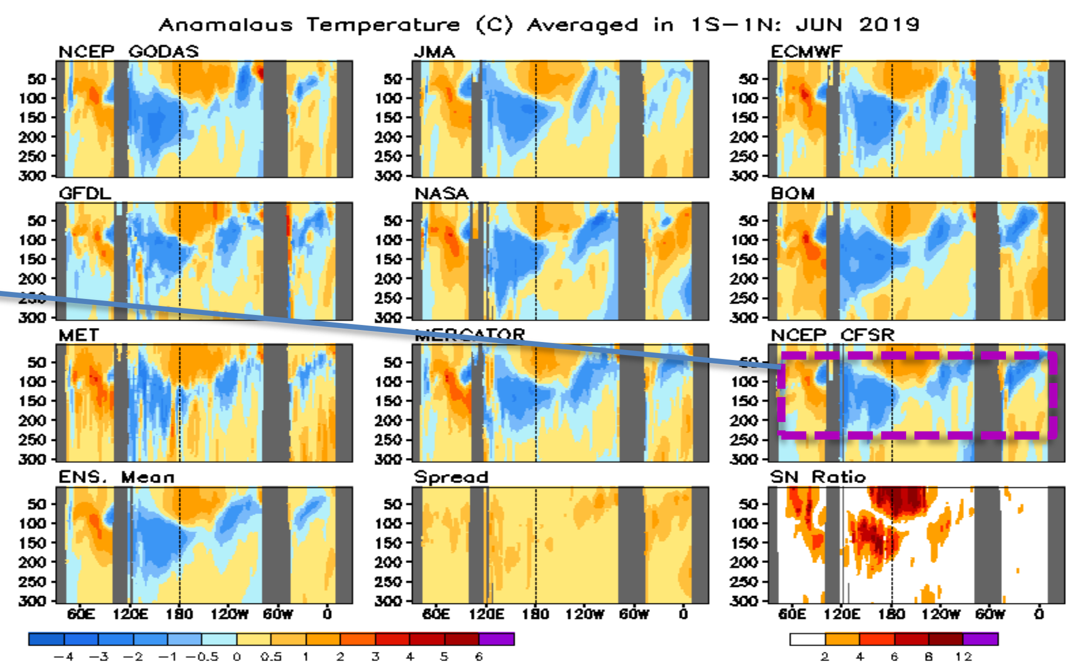
Possible impact of CFSR bias on CFSv2 forecasts



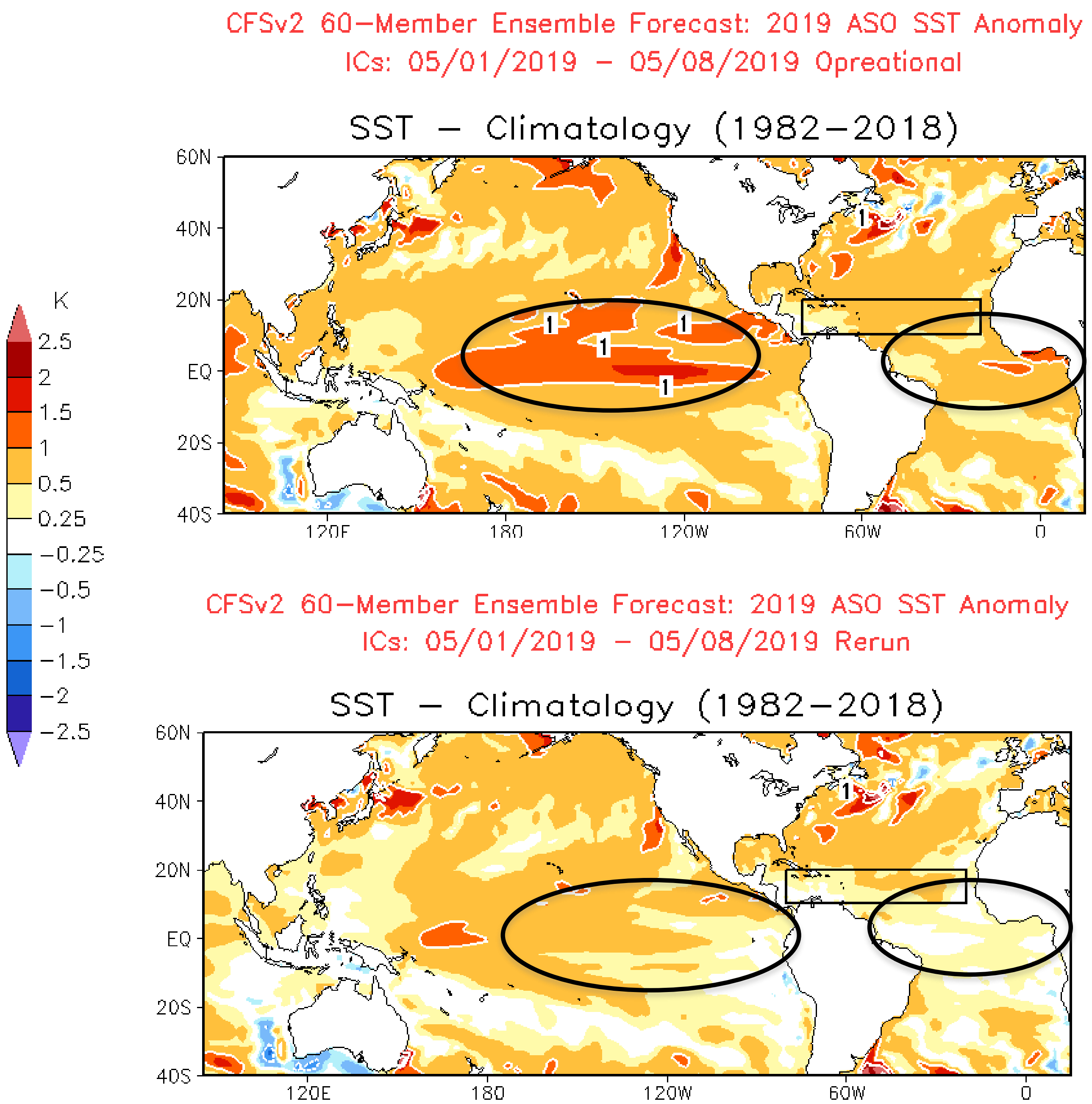


- CFSv2 predicts much cooler SST in the tropical Pacific and Atlantic Oceans with 28 Jun-07 Jul IC than those with 1-10th May IC.





Possible impact of CFSR bias on CFSv2 forecasts



I.C.: CFSR_operational

- Differences between CFSv2 forecasts with IC using CFSR_oper and CFSR_fix highlight the strong impact of CFSR warm bias on the forecasts.

I.C.: CFSR_fix

Courtesy of Hui Wang

Acknowledgements

- ❖ Drs. Caihong Wen, Jieshun Zhu, and Arun Kumar: reviewed PPT, and provide insight and constructive suggestions and comments
- ❖ Drs. Li Ren and Pingping Xie provided the BASS/CMORPH/CFSR EVAP package
- ❖ Dr. Hui Wang conducted and provided CFSv2 reforecasts
- ❖ Dr. Wanqiu Wang provided the sea ice forecasts and maintained the CFSv2 forecast achieve

Please send your comments and suggestions to:

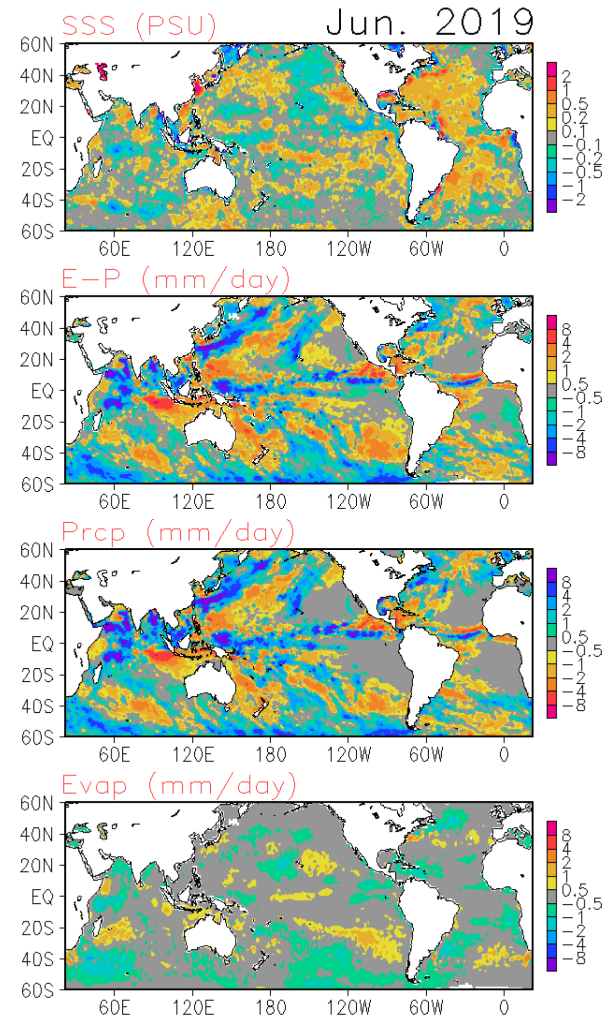
Zeng-Zhen.Hu@noaa.gov
Arun.Kumar@noaa.gov
Caihong.Wen@noaa.gov
Jieshun.Zhu@noaa.gov

Backup Slides

Global Sea Surface Salinity (SSS)

Anomaly for June 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.
- **Attention: SMAP has been in safe hold mode since 6/19/2019. So there is no SMAP SSS available since 06/19/2019**
- In the equatorial Pacific ITCZ region, negative SSS anomalies are still persistent and co-incident with increased precipitation. The negative SSS anomalies in the Northeast pacific Ocean continues and expands to the south which is likely due to the increased precipitation. While, in the west basin of the North pacific Ocean, positive SSS continues and it is possibly caused by the oceanic advection/entrainments, particular in the western boundary region. Meanwhile, in the Sea of Okhotsk, negative SSS anomalies continues and it is co-incident with increased precipitation.



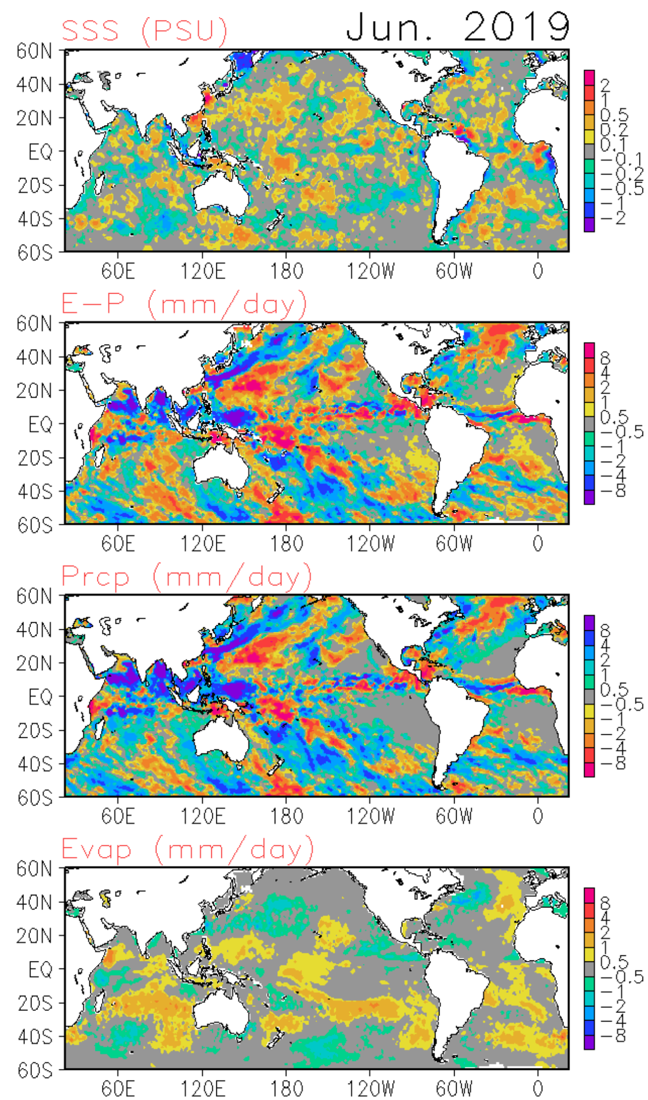
- **Data used**

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 June 2019

Compared with last month, the SSS increased in the Equatorial Pacific SPCZ region. Such SSS increasing is co-incident with reduced precipitation. The SSS continues increasing between equator and 40ºN in both Pacific and Atlantic ocean and it becomes weaker. The SSS continues decreasing in the Sea of Okhotsk, which is possibly caused by increased precipitation.

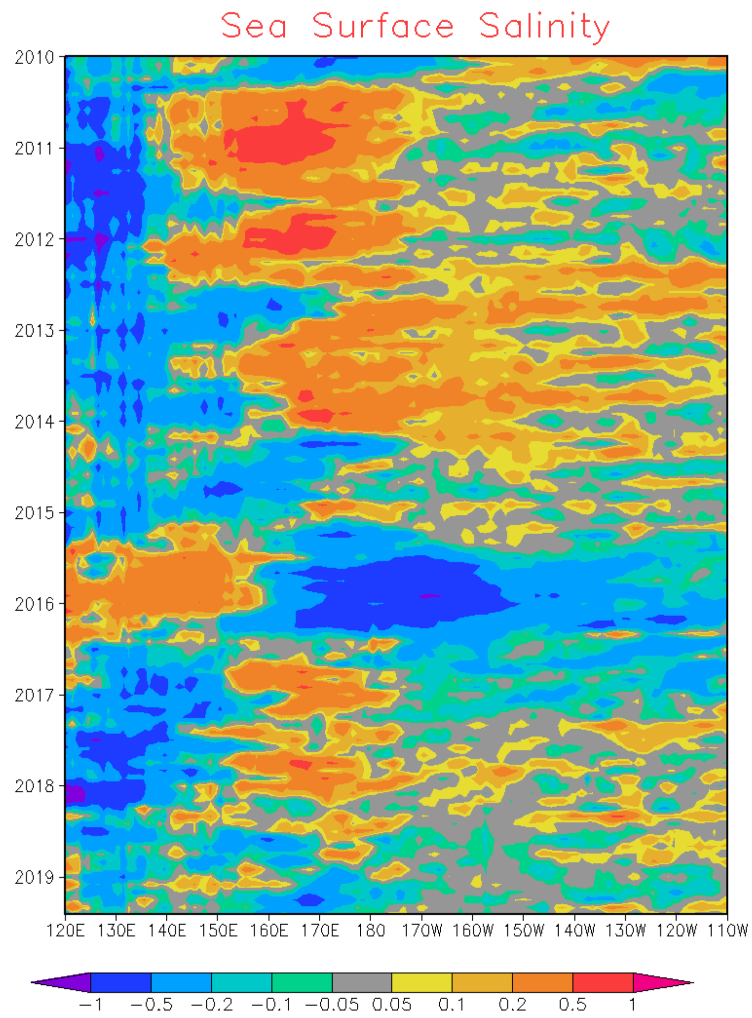


Global Sea Surface Salinity (SSS)

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 BASS SSS is from in situ, SMOS and Aquarius.

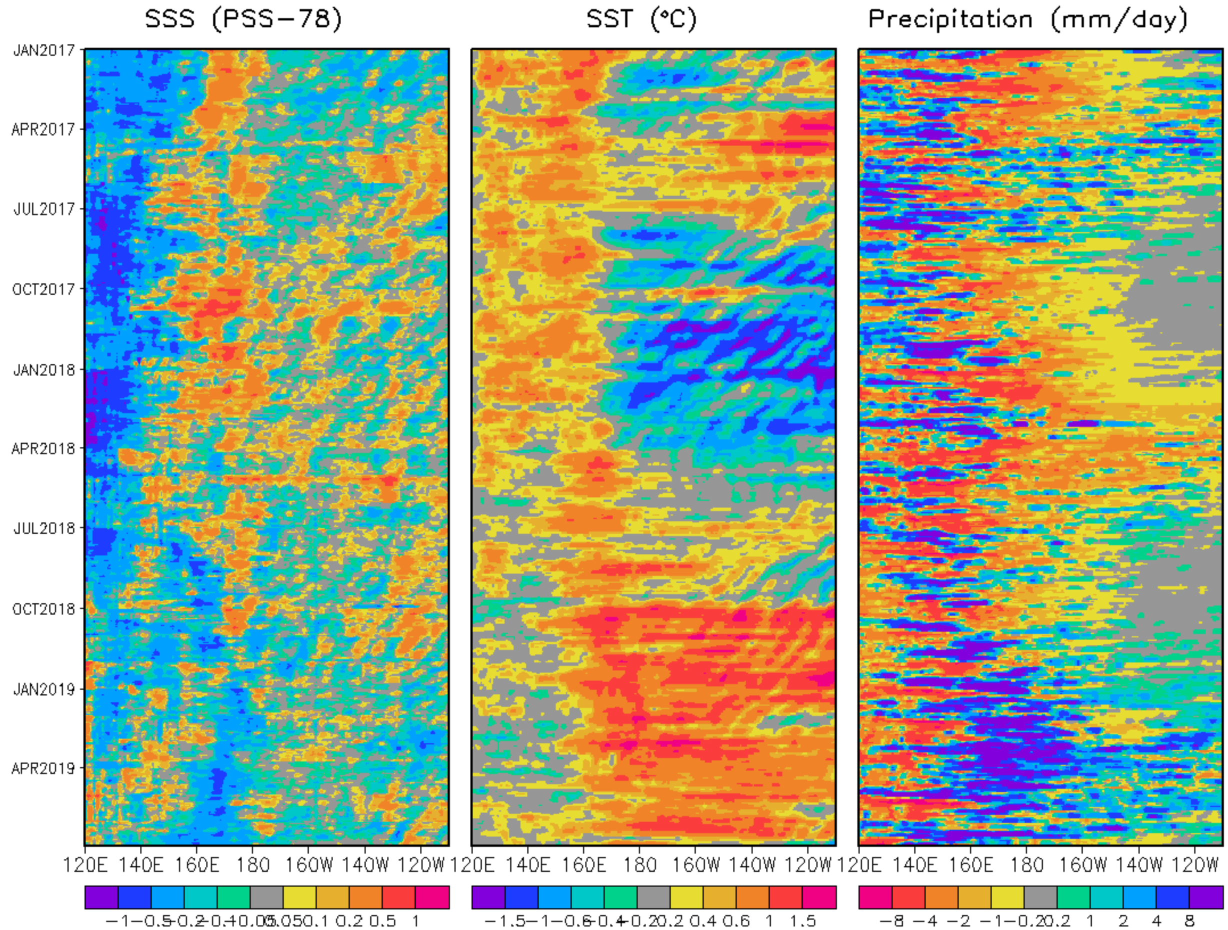
- Hovemoller diagram for equatorial SSS anomaly **(5° S-5° N);**
- In the equatorial Pacific Ocean, the SSS signal becomes likely neutral west of 150° E; the SSS shows negative anomalies between 150° E and dateline; east of dateline, the SSS signal is neutral and tends to be positive east of 140° W.



Global Sea Surface Salinity (SSS)

Anomaly Evolution over N. of 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.



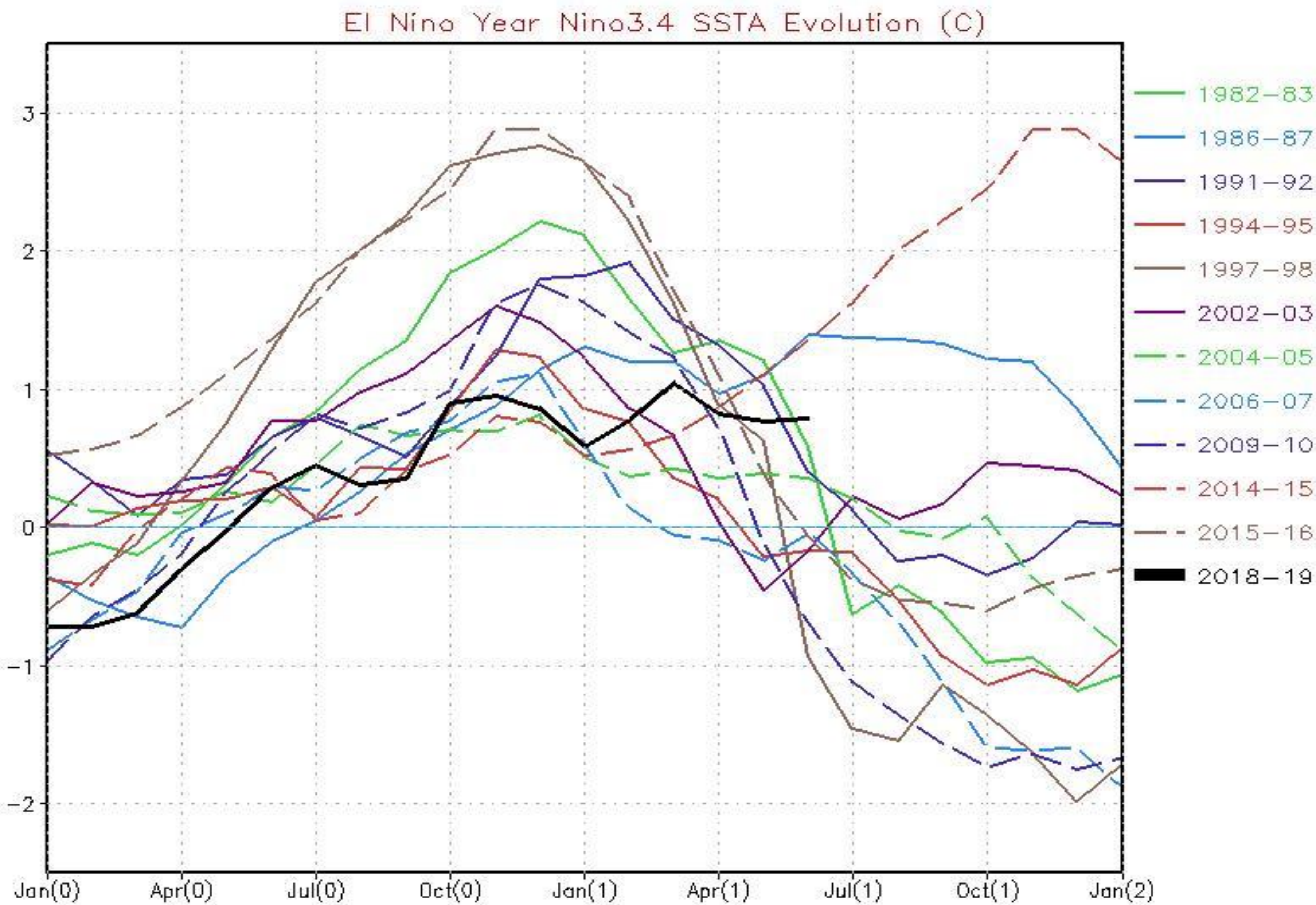
ENSO Evolution in 1986-88 and 2018-19

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1986	*-0.5*	*-0.5*	*-0.3*	*-0.2*	*-0.1*	*0.0*	*0.2*	*0.4*	***0.7***	***0.9***	***1.1***	***1.2***
1987	***1.2***	***1.2***	***1.1***	***0.9***	***1.0***	***1.2***	***1.5***	***1.7***	***1.6***	***1.5***	***1.3***	***1.1***
1988	***0.8***	***0.5***	*0.1*	*-0.3*	***-0.9***	***-1.3***	***-1.3***	***-1.1***	***-1.2***	***-1.5***	***-1.8***	***-1.8***
2018	**-0.9**	**-0.8**	**-0.6**	**-0.4**	**-0.1**	**0.1**	**0.1**	**0.2**	**0.4**	**0.7**	**0.9**	**0.8**
2019	**0.8**	**0.8**	**0.8**	**0.8**	**0.7**							

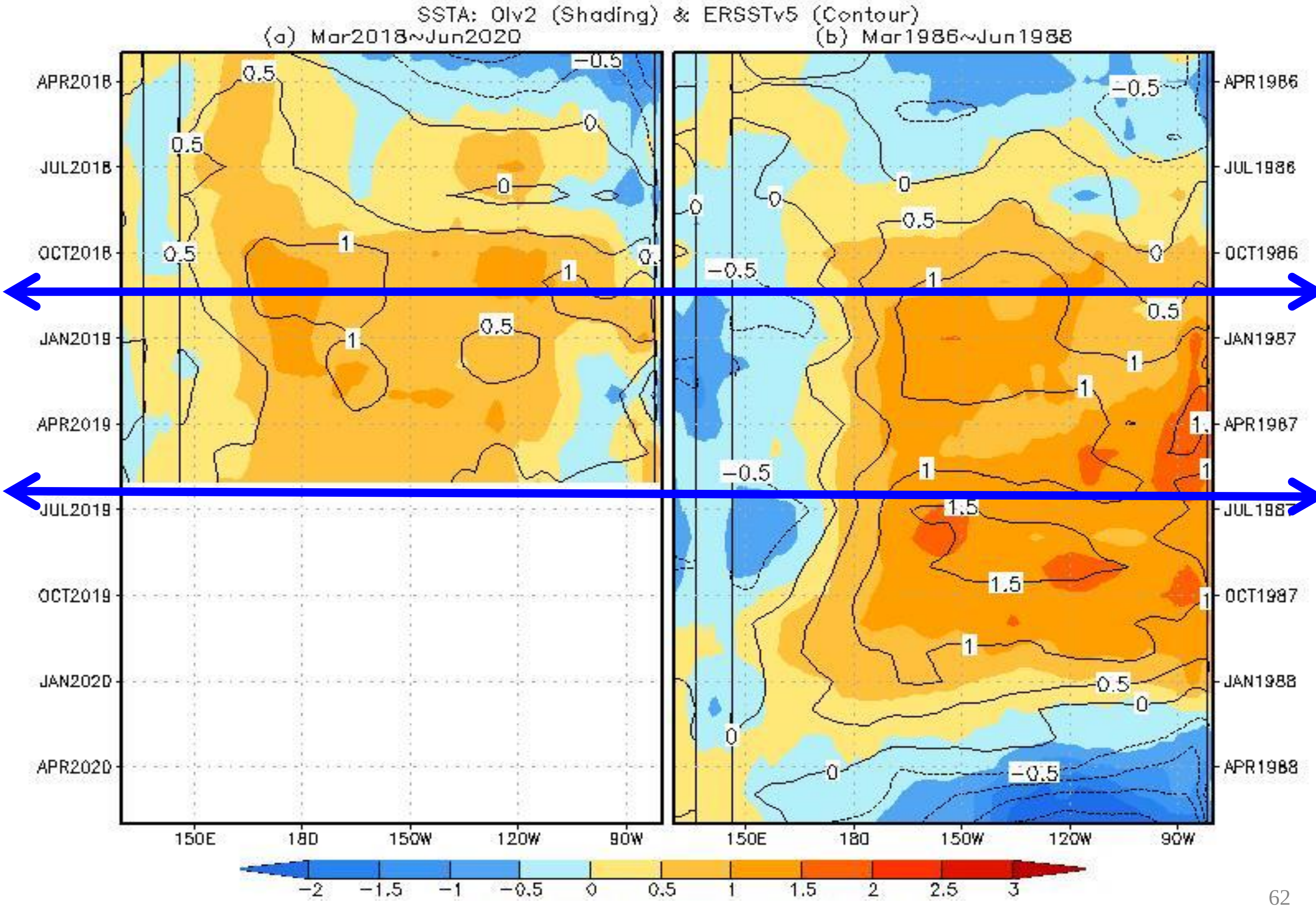
For historical purposes, periods of below and above normal SSTs are colored in blue and red when the threshold is met for a minimum of 5 consecutive overlapping seasons. The Oceanic Nino Index is one measure of the ENSO, and other indices can confirm whether features consistent with a coupled ocean-atmosphere phenomenon accompanied these periods.

https://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php

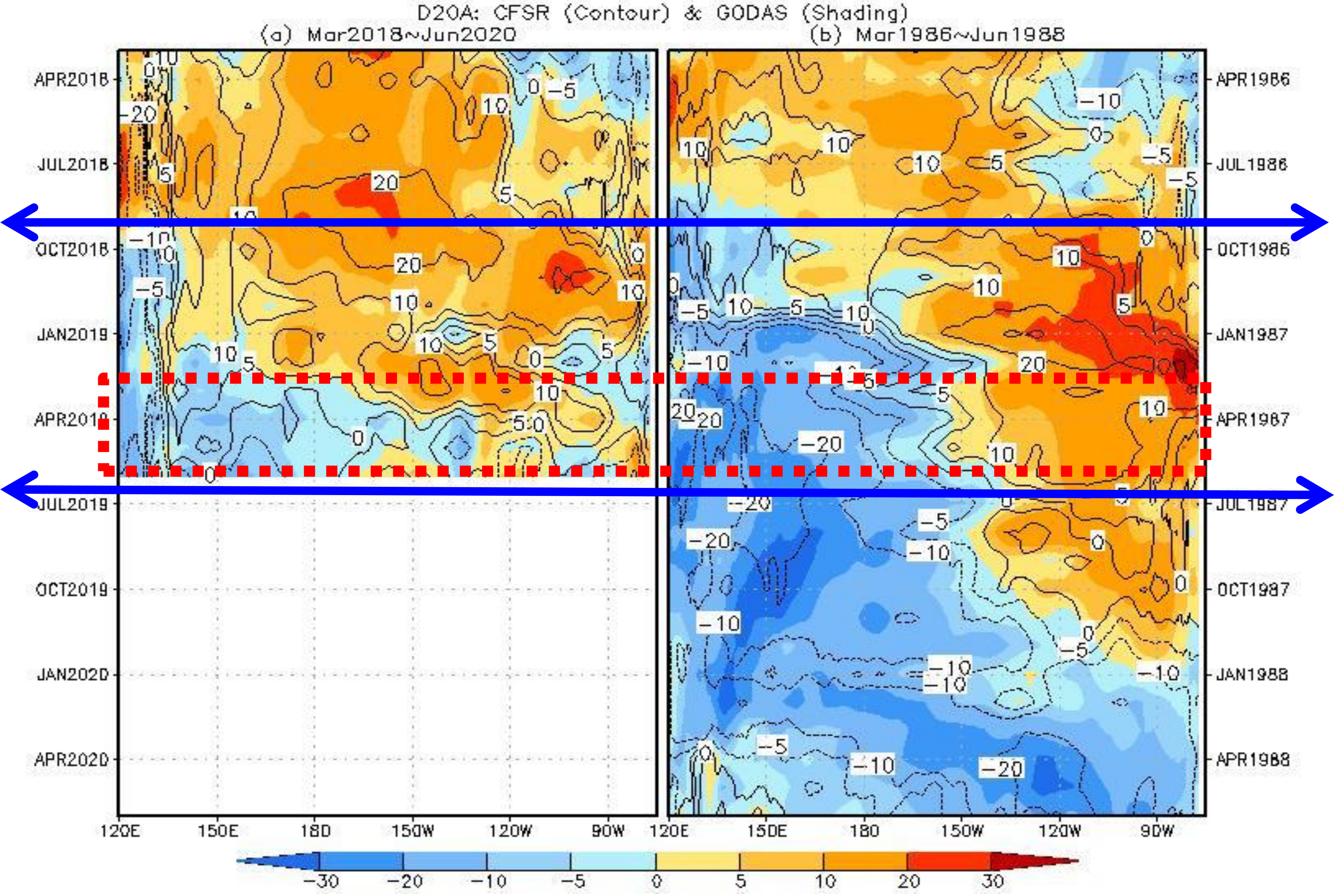
Nino3.4 Evolution In El Nino Years

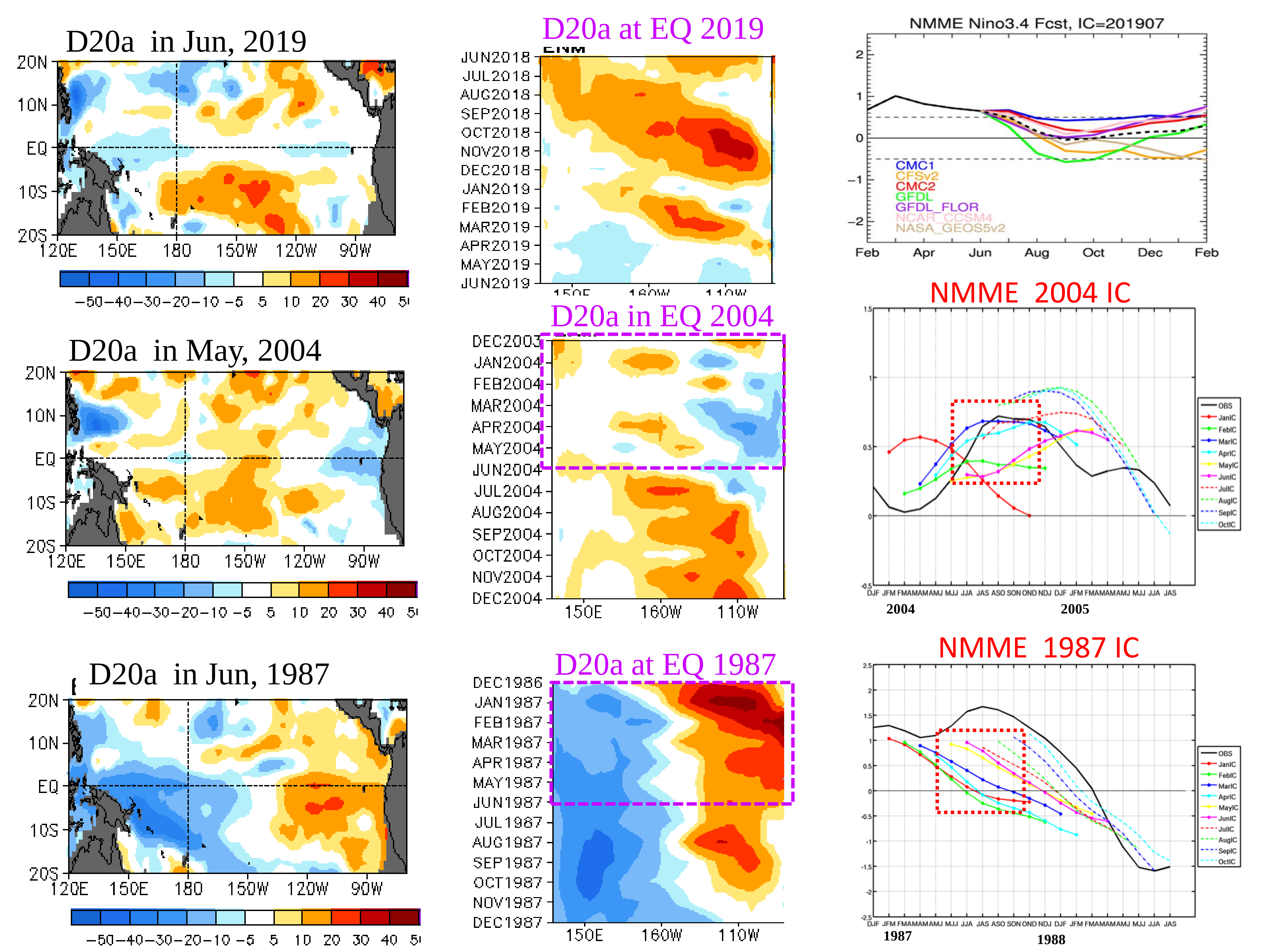


SST Anomalies along the Equator



D20 Anomalies along the Equator





D20a in Jun, 2019
20N
10N
EQ
10S
20S
120E 150E 180 150W 120W 90W
−50 −40 −30 −20 −10 −5 5 10 20 30 40 50
D20a at EQ 2019
JUN2018
JUL2018
AUG2018
SEP2018
OCT2018
NOV2018
DEC2018
JAN2019
FEB2019
MAR2019
APR2019
MAY2019
JUN2019
NMME Nino3.4 Fcst, IC=201907
CMC1
CFSv2
CMC2
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2
Feb Apr Jun Aug Oct Dec Feb
D20a in May, 2004
D20a in EQ 2004
DEC2003
JAN2004
FEB2004
MAR2004
APR2004
MAY2004
JUN2004
JUL2004
AUG2004
SEP2004
OCT2004
NOV2004
DEC2004
150E 160W 110W
NMME 2004 IC
OBS
JanIC
FebIC
MarIC
AprIC
MayIC
JunIC
JulIC
AugIC
SepIC
OctIC
2004
2005
D20a in Jun, 1987
D20a at EQ 1987
DEC1986
JAN1987
FEB1987
MAR1987
APR1987
MAY1987
JUN1987
JUL1987
AUG1987
SEP1987
OCT1987
NOV1987
DEC1987
NMME 1987 IC
1987
1988

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

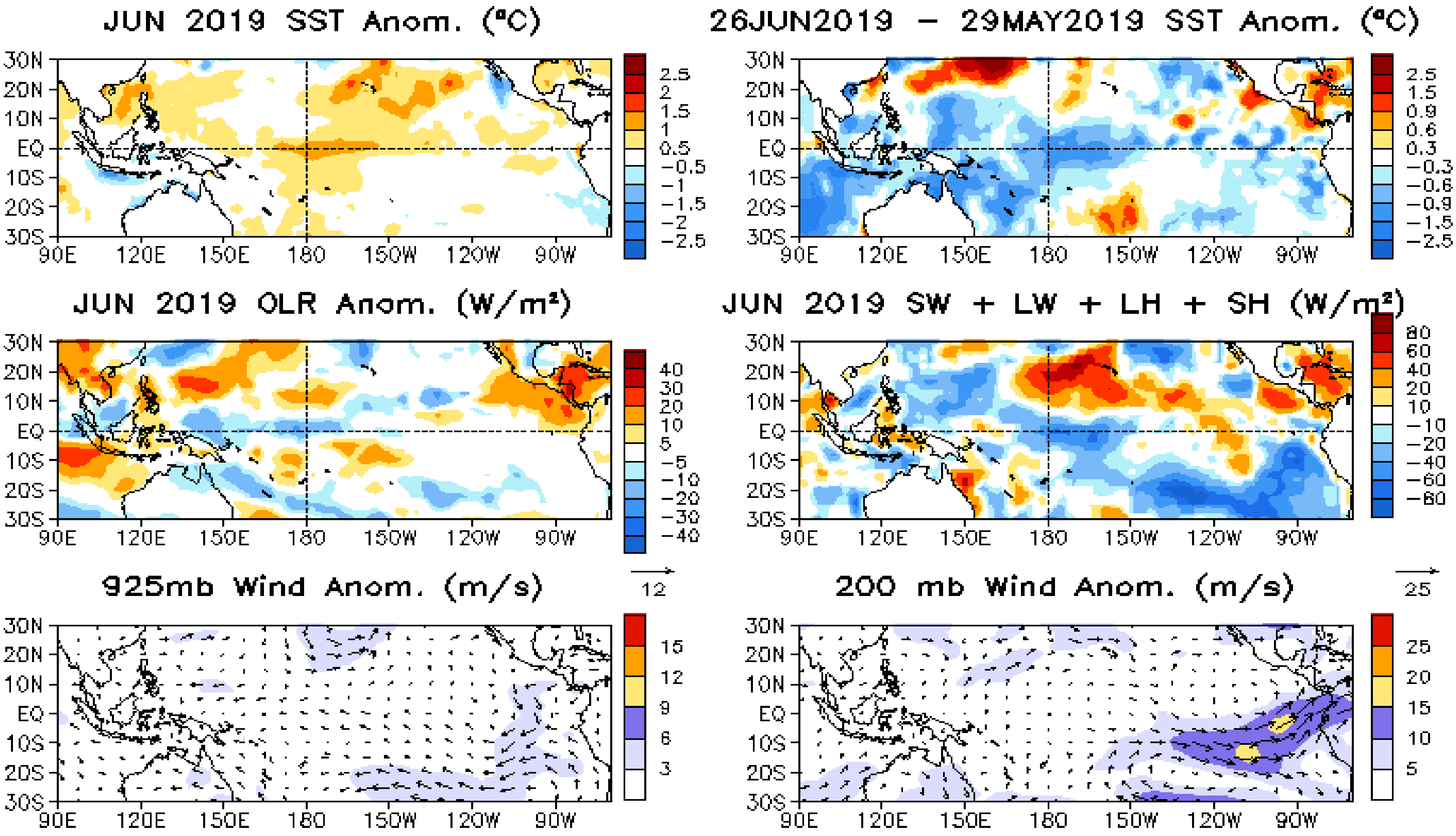


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

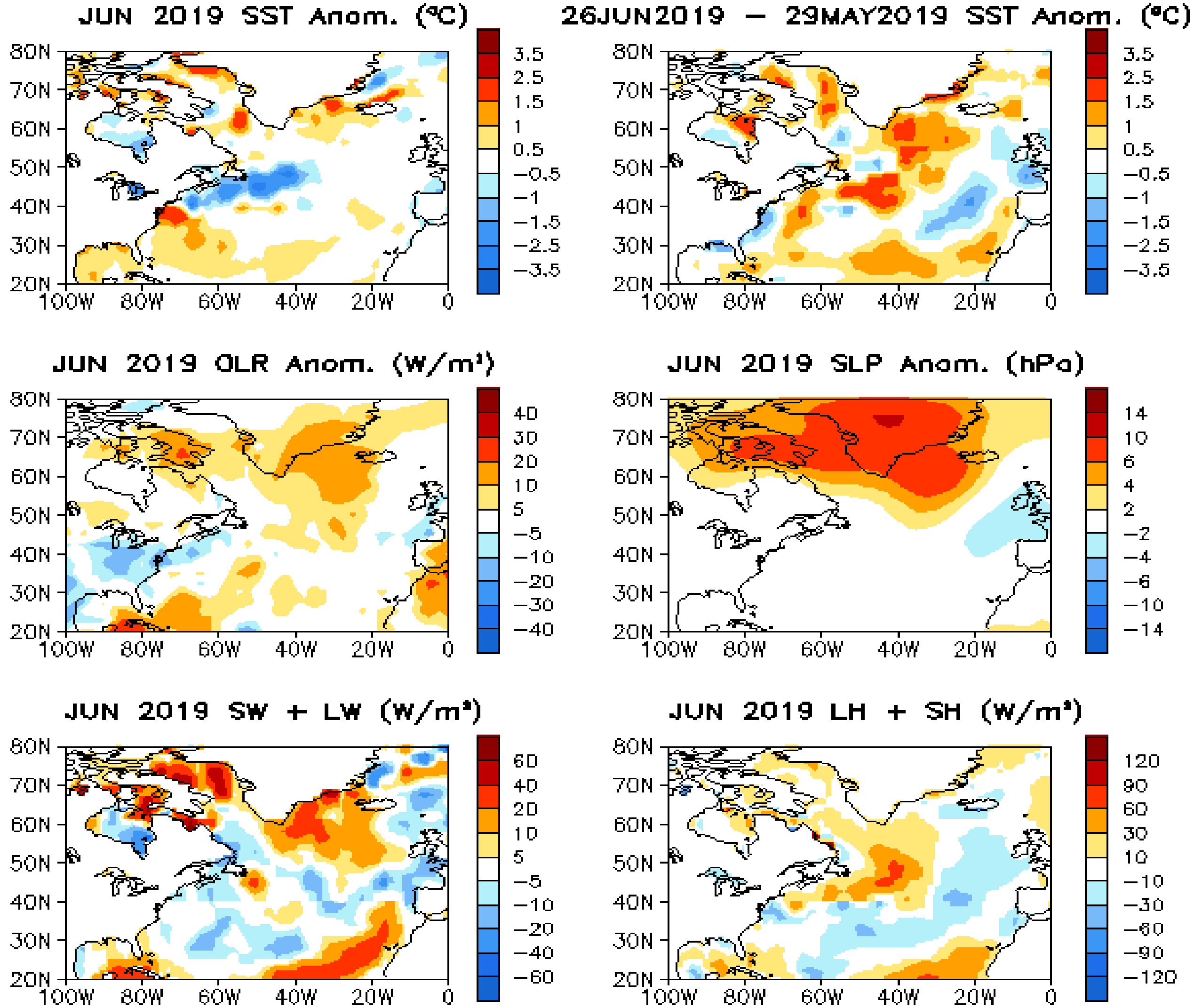


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

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