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**

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  - **Indian Ocean**
  - **Atlantic Ocean**
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- **Comparison of ENSO evolution in 2014/2016 and 2018/2019**
- **NOAA Atlantic and Eastern/Central Pacific Hurricane Outlooks**

Overview

Pacific Ocean

- NOAA "ENSO Diagnostic Discussion" on 9 May 2019 continuously issued "*El Nino Advisory*" and indicated that *"El Niño is likely to continue through the Northern Hemisphere summer 2019 (70% chance) and fall (55-60% chance)."*
- El Nino conditions persisted. Positive SSTAs persisted in the central and eastern tropical Pacific with NINO3.4=0.71°C in May 2019.
- Positive (negative) subsurface ocean temperature anomalies were above (blow) the thermocline along the equatorial Pacific in May 2019.
- Positive SSTAs dominated in the N. Pacific in May 2019. The PDO index switched to positive phase since Mar 2019 with PDOI= 0.7 in May 2019.

Indian Ocean

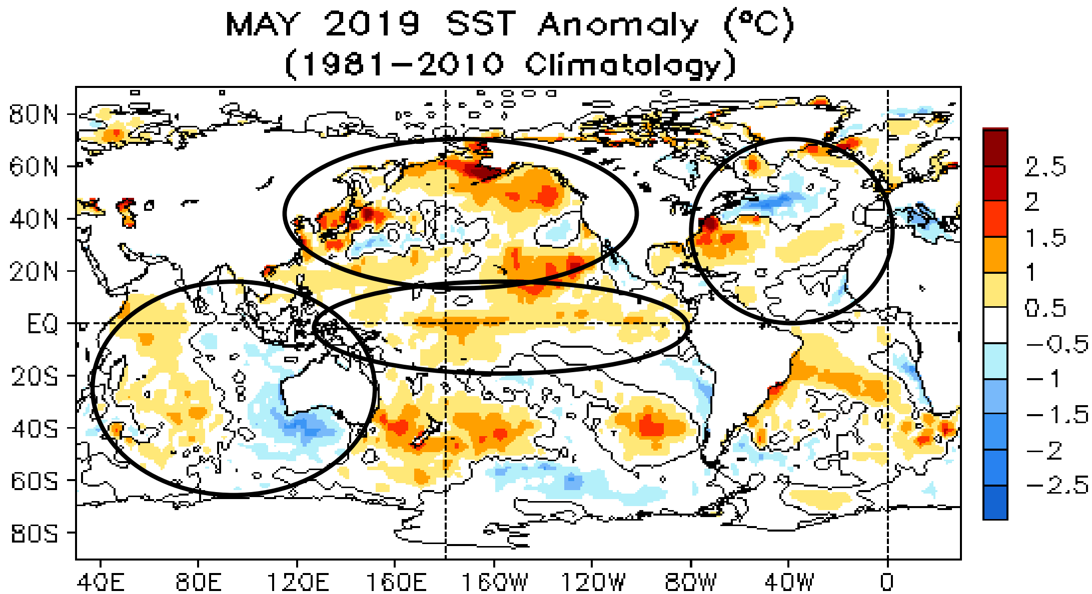
- Positive (negative) SSTAs were in the west (east), and IOD was in a strong positive phase in May 2019.

Atlantic Ocean

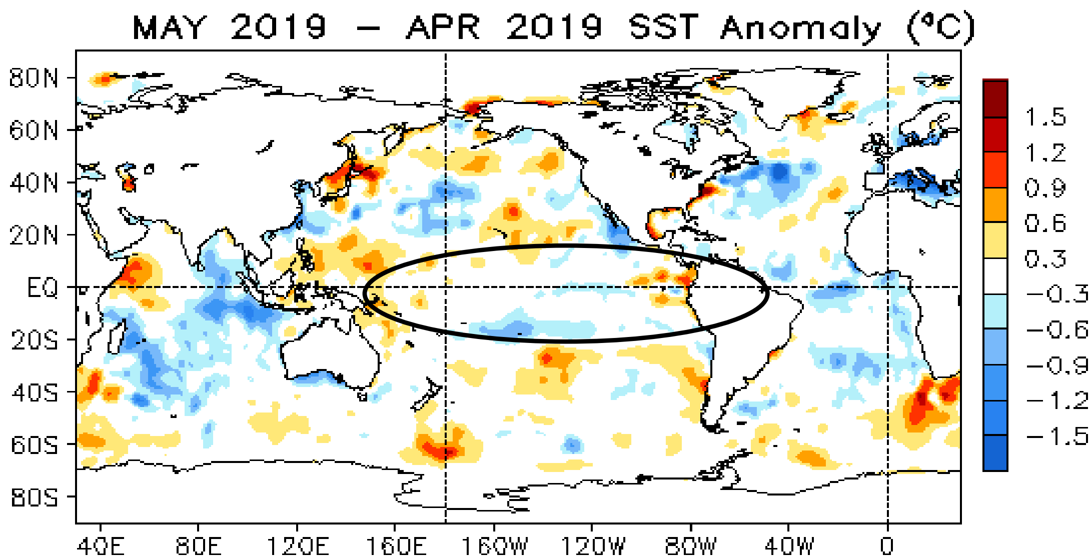
- NAO switched into a negative phase with NAOI=-2.4 in May 2019, and SSTAs were a tripole/horseshoe pattern with positive anomalies in the middle latitudes of N. Atlantic during 2013-2019.
- NOAA's outlook for the 2019 Atlantic hurricane season indicates that a near-normal season has the highest chance of occurring (40%), followed by equal chances (30%) of an above-normal season and a below-normal season.

<u>Global Oceans</u>

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



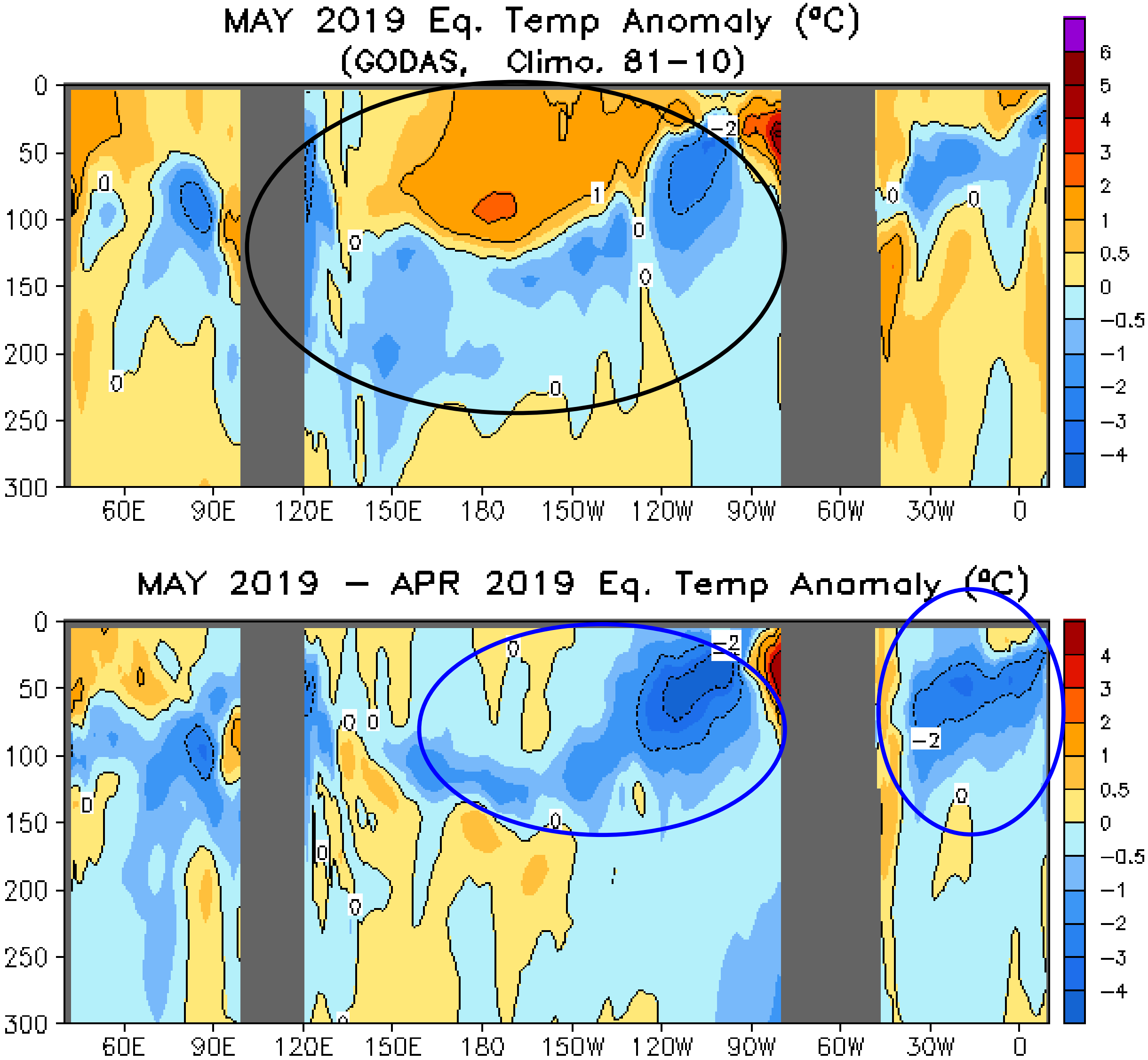
- Positive SSTAs persisted in the central and eastern tropical Pacific, consistent with El Nino conditions.
- Positive SSTAs dominated in the North Pacific.
- Horseshoe/tripole-like SSTA pattern was observed in the North Atlantic.
- In the Indian Ocean, SSTAs were positive in the west and negative in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



- Both positive and negative SSTA tendencies were observed in the tropical Pacific Ocean.
- SSTA tendencies in the Indian and Atlantic Oceans were mostly negative.

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^{o}S-2^{o}N



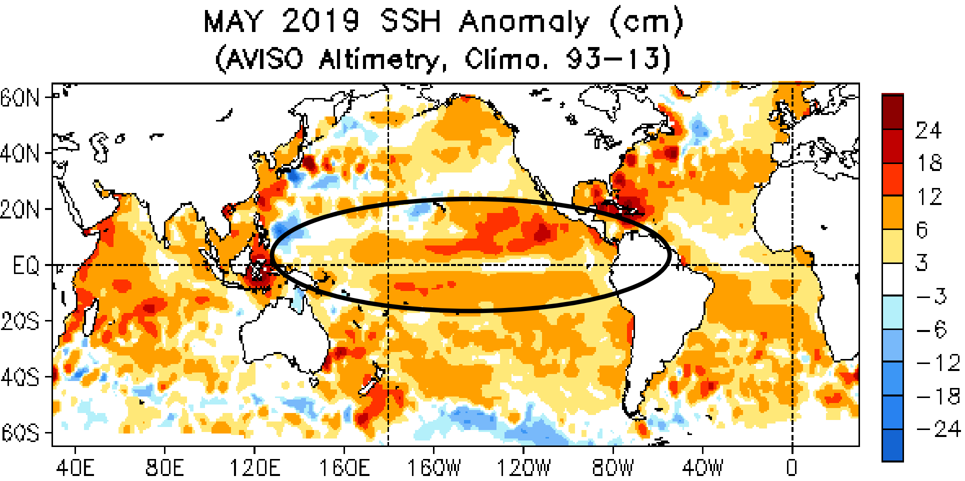
- Positive (negative) ocean temperature anomalies presented above (blow) the thermocline along the equatorial Pacific.

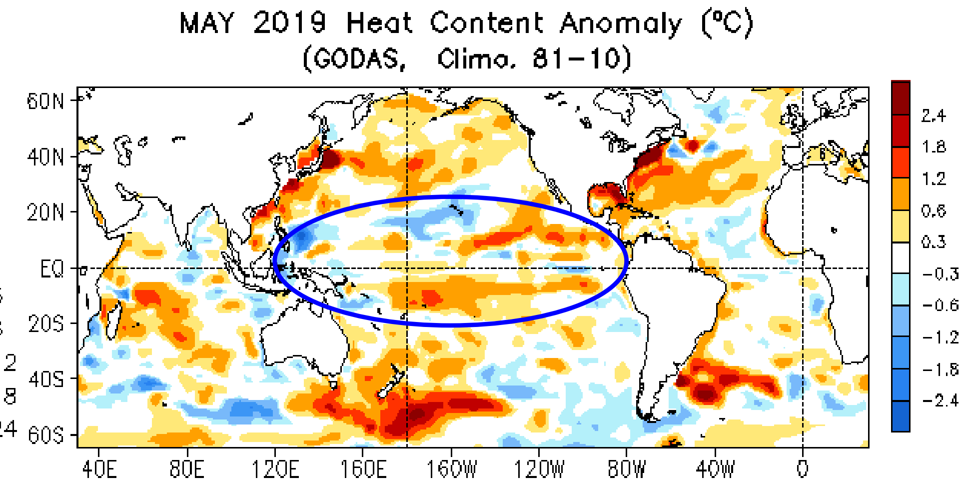
- Anomalous ocean temperature tendency was negative in the Pacific Ocean, particularly in the east.

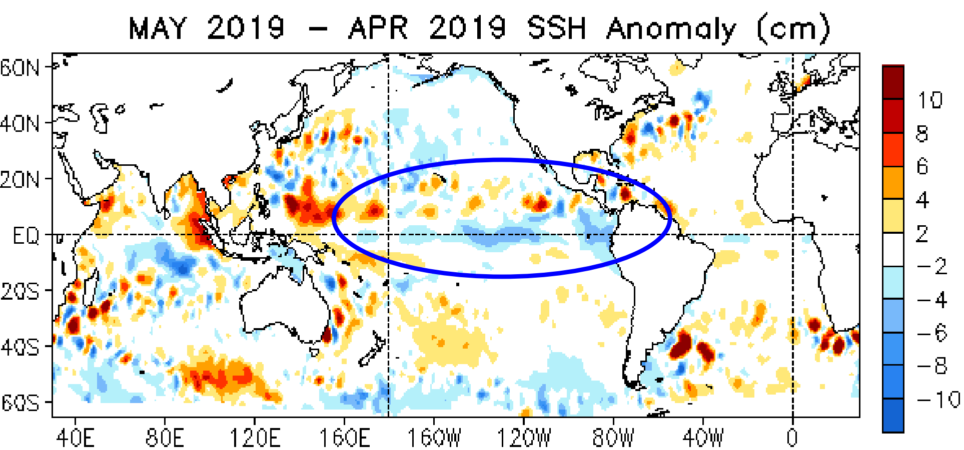
- Anomalous ocean temperature tendency was also negative in the Atlantic Ocean.

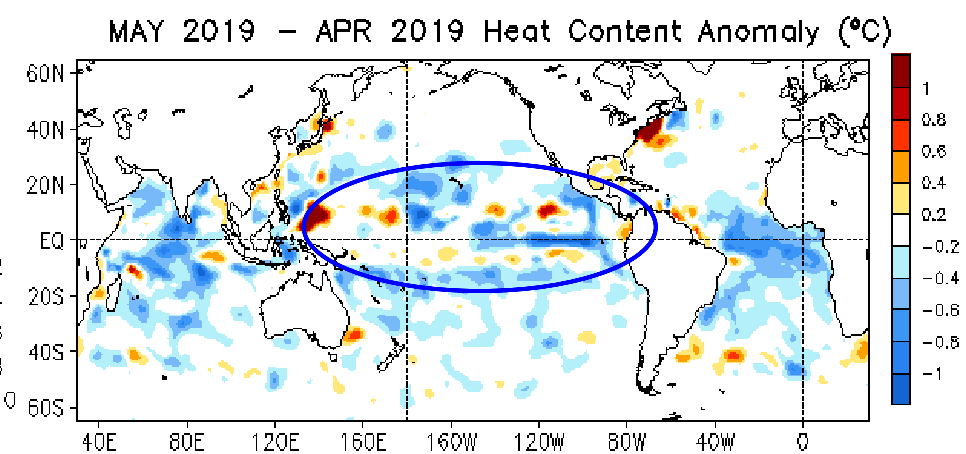
Fig. G3. Equatorial depth-longitude section of ocean temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP's global ocean data assimilation system which assimilates oceanic observations into an oceanic GCM. Anomalies are departures from the 1981-2010 base period means.

Global SSH and HC300 Anomaly & Anomaly Tendency





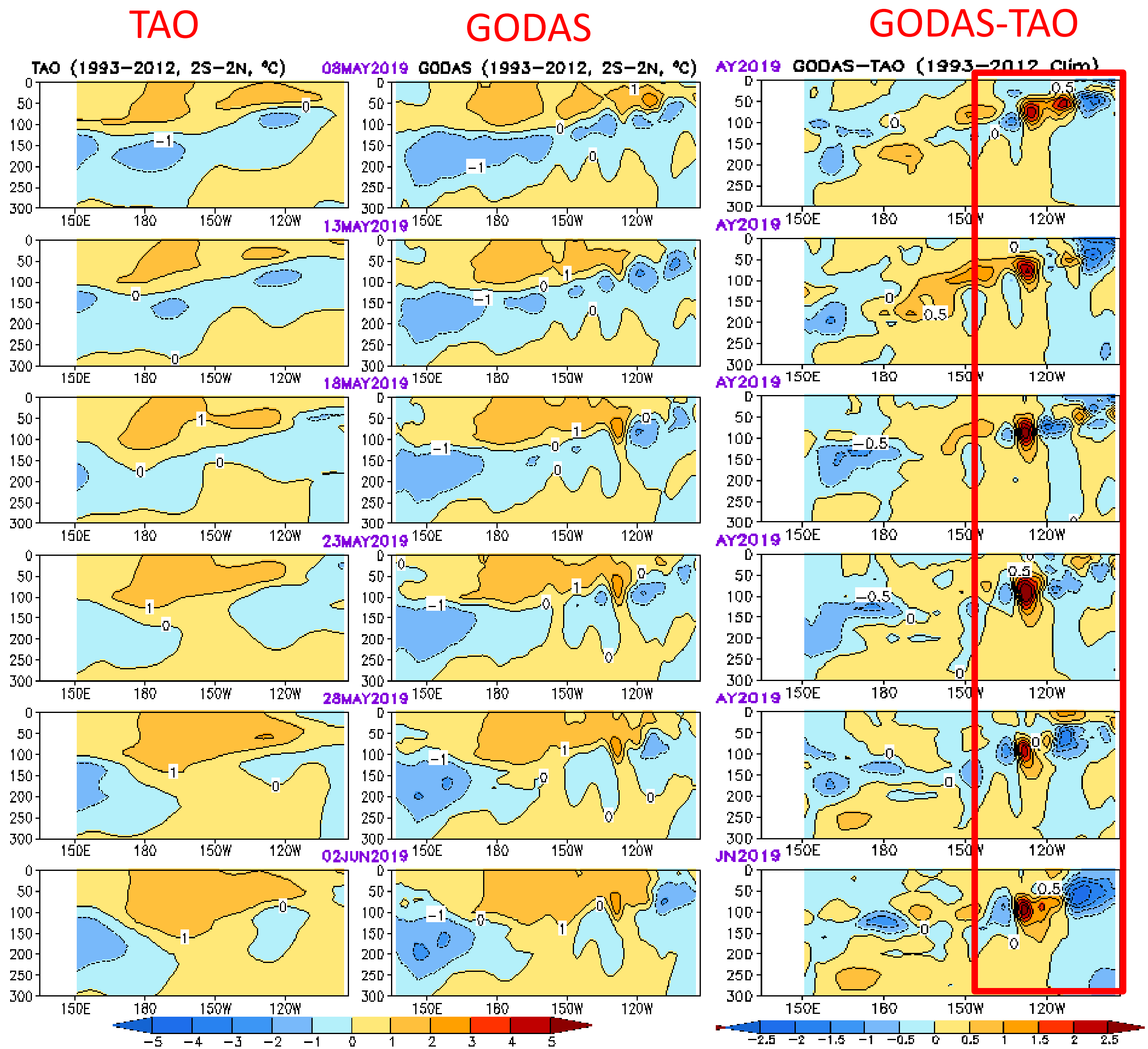




- **The SSHA pattern was overall consistent with the HC300A pattern, but there were many detailed differences between them.**
- **Both SSHA and HC300A in the tropical Pacific were consistent with El Nino conditions.**
- **Negative tendencies of SSHA and HC300A presented in the eastern tropical Pacific.**

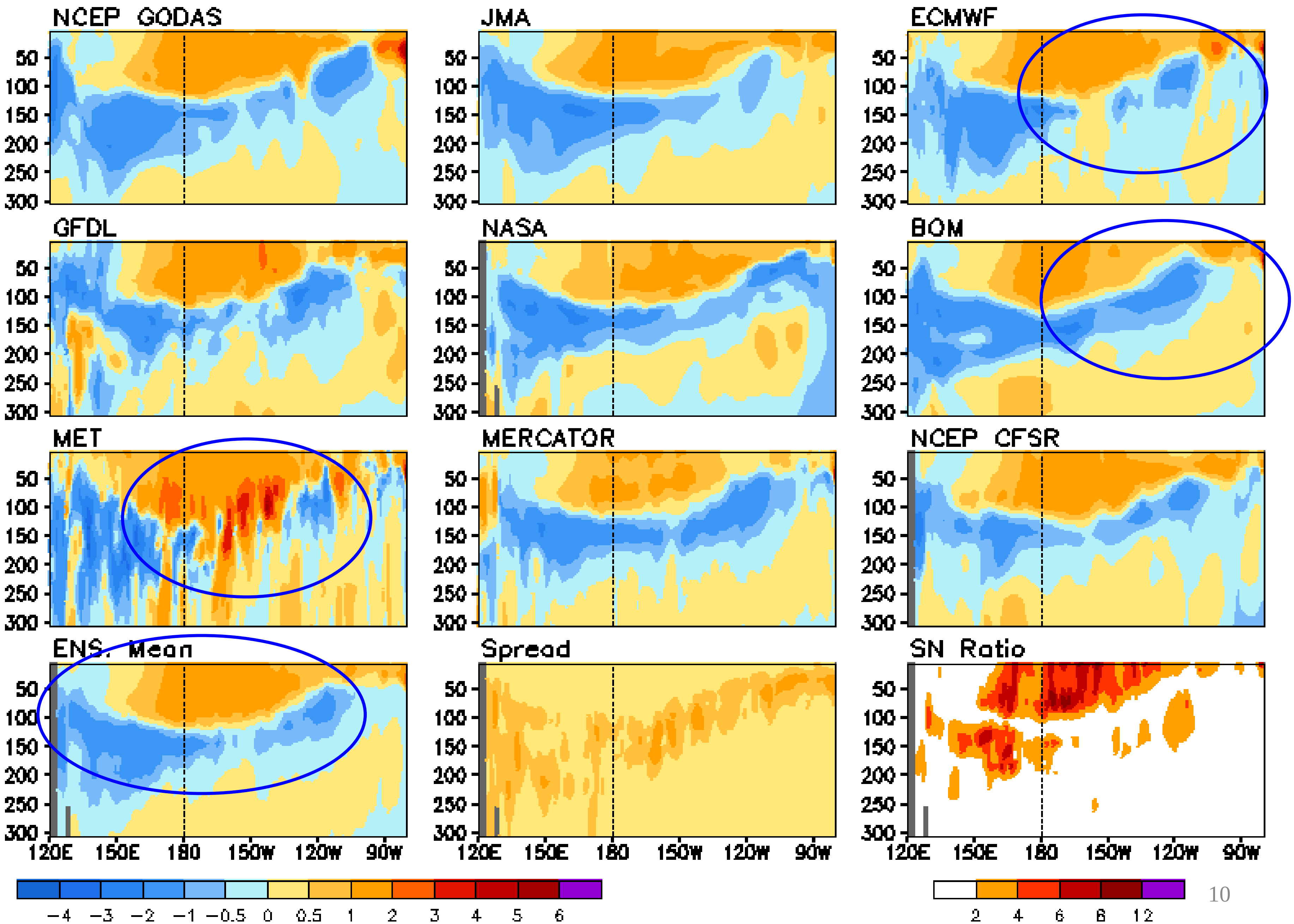
Tropical Pacific Ocean and ENSO Conditions

Equatorial Pacific Ocean Temperature Pentad Mean Anomaly

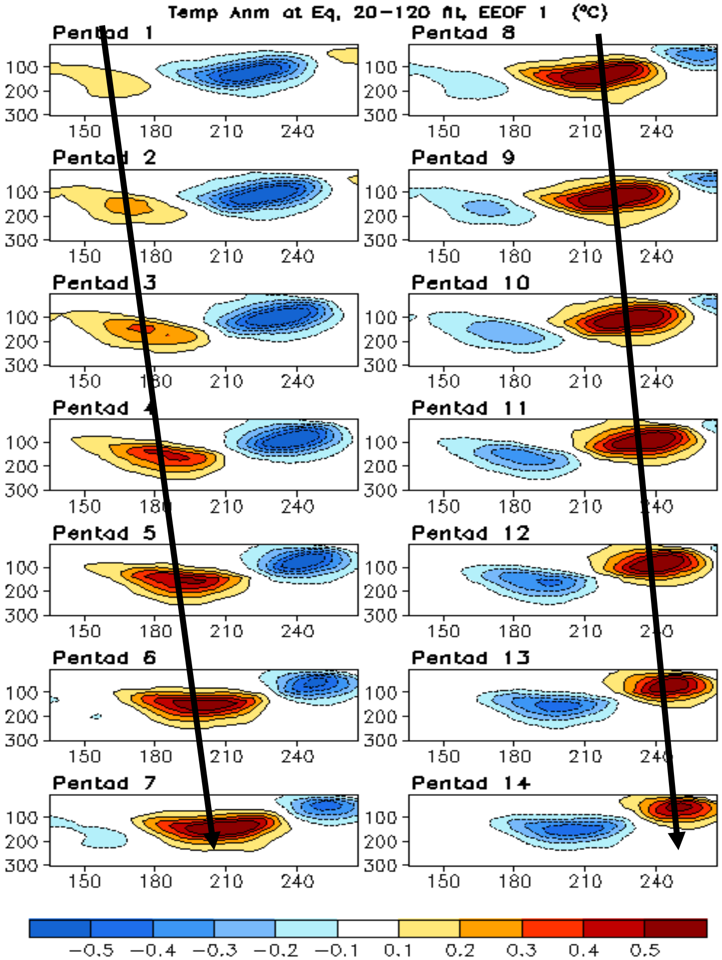


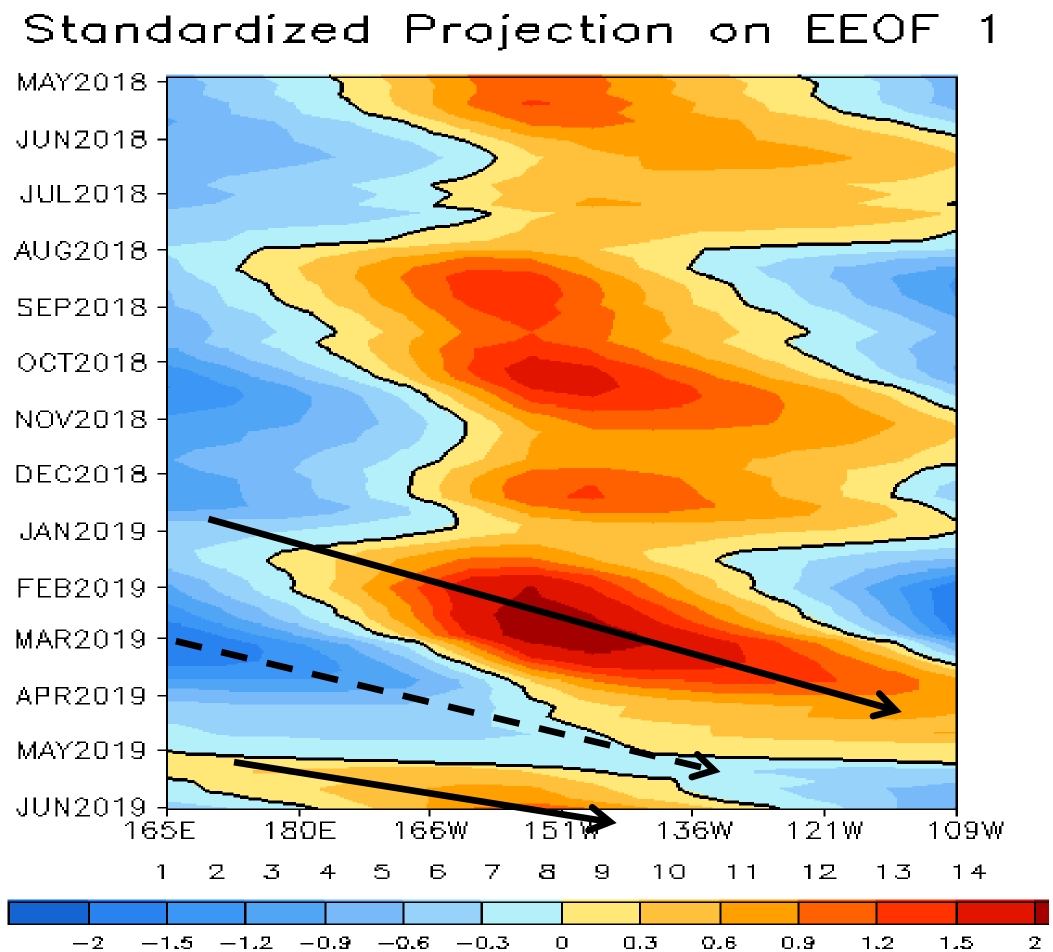
- **Positive ocean temperature anomalies persisted during the last few months, while negative anomalies were mainly below the thermocline and in the western Pacific.**
- **The differences of the ocean temperature anomalies between GODAS and TAO were large in the eastern Pacific.**

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



Oceanic Kelvin Wave (OKW) Index



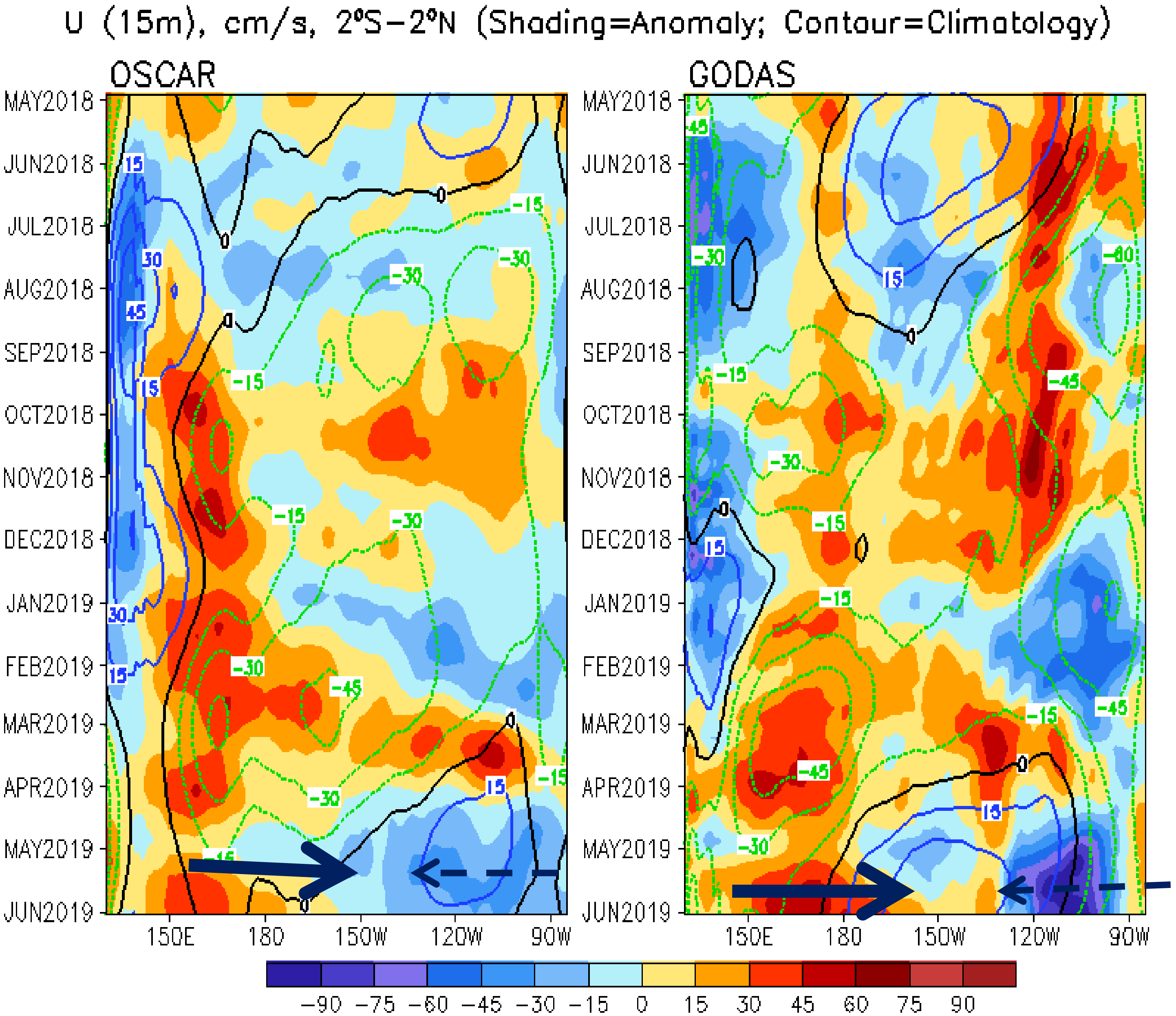


- **A downwelling Kelvin wave presented from Jan- Mar 2019, leading to increasing positive subsurface temperature anomalies in the eastern tropical Pacific.**

- **A upwelling Kelvin wave initiated in late Jan 2019 and propagated eastward.**

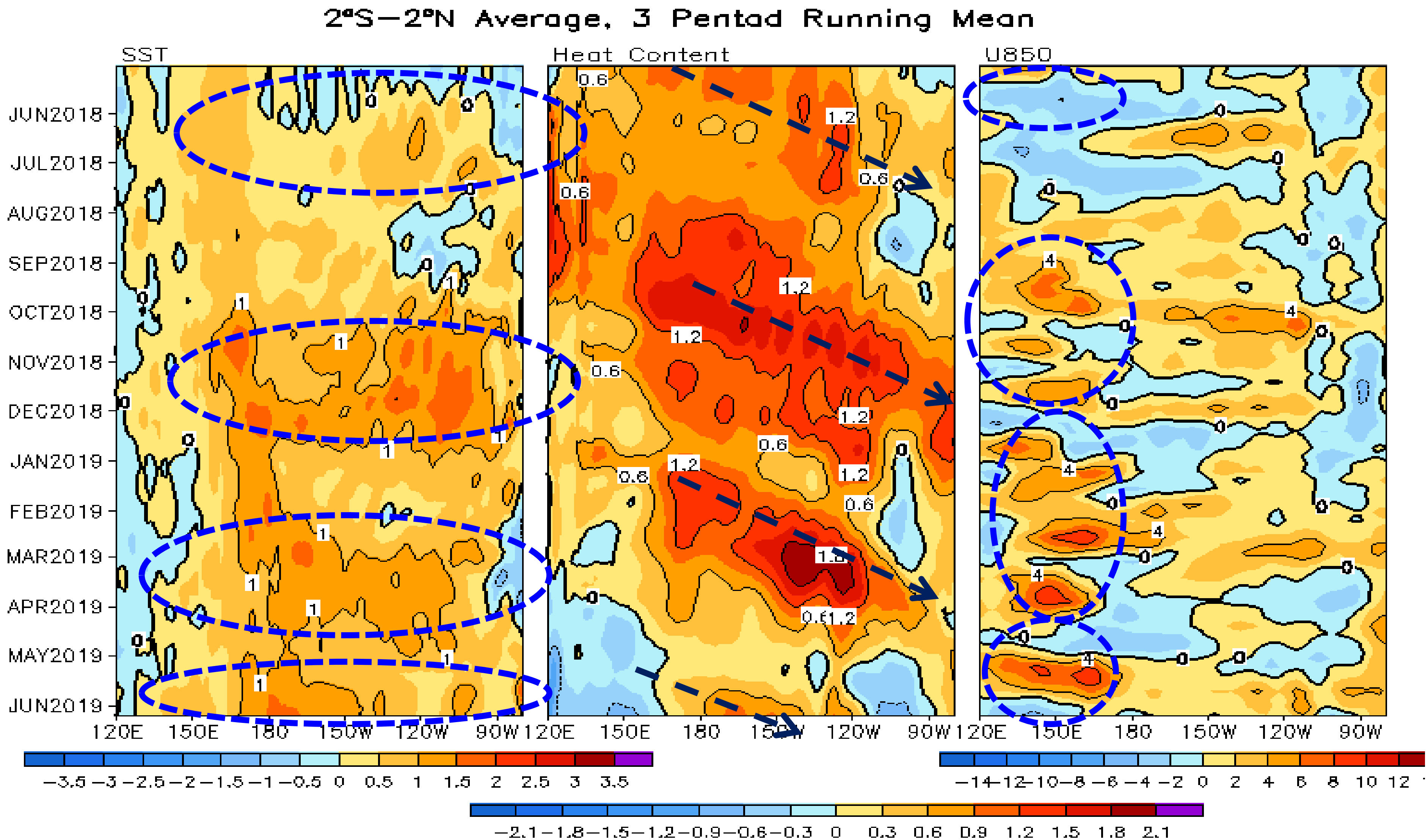
(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)

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



- Anomalous eastward (westward) currents persisted in the western (eastern) Pacific during the last 2 months 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 central and eastern Pacific persisted in the last month.**
- **Positive HC300A propagated eastward in Mar 2019, and low-level westerly wind bursts were observed in Feb-Mar, and May 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.**

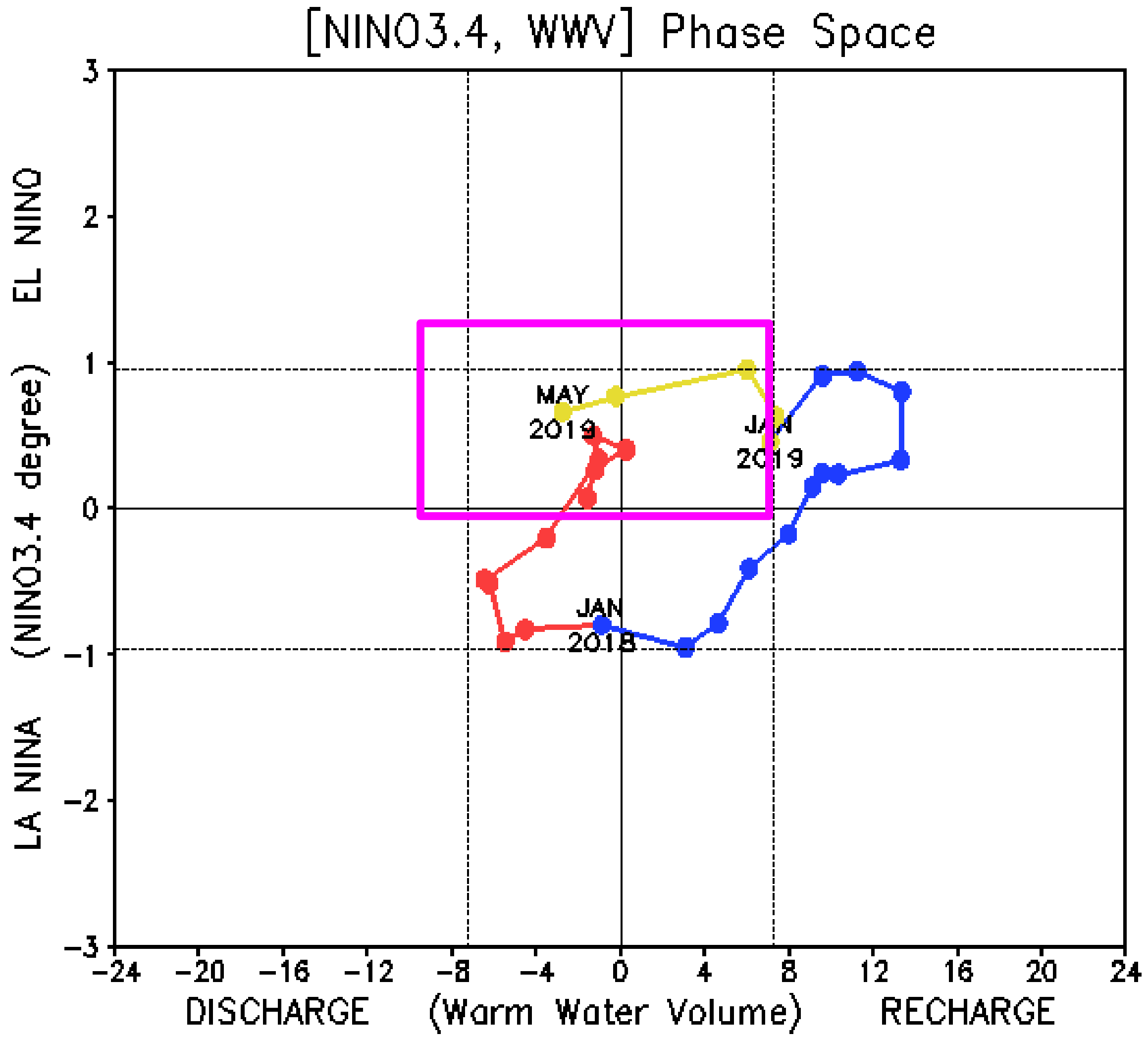
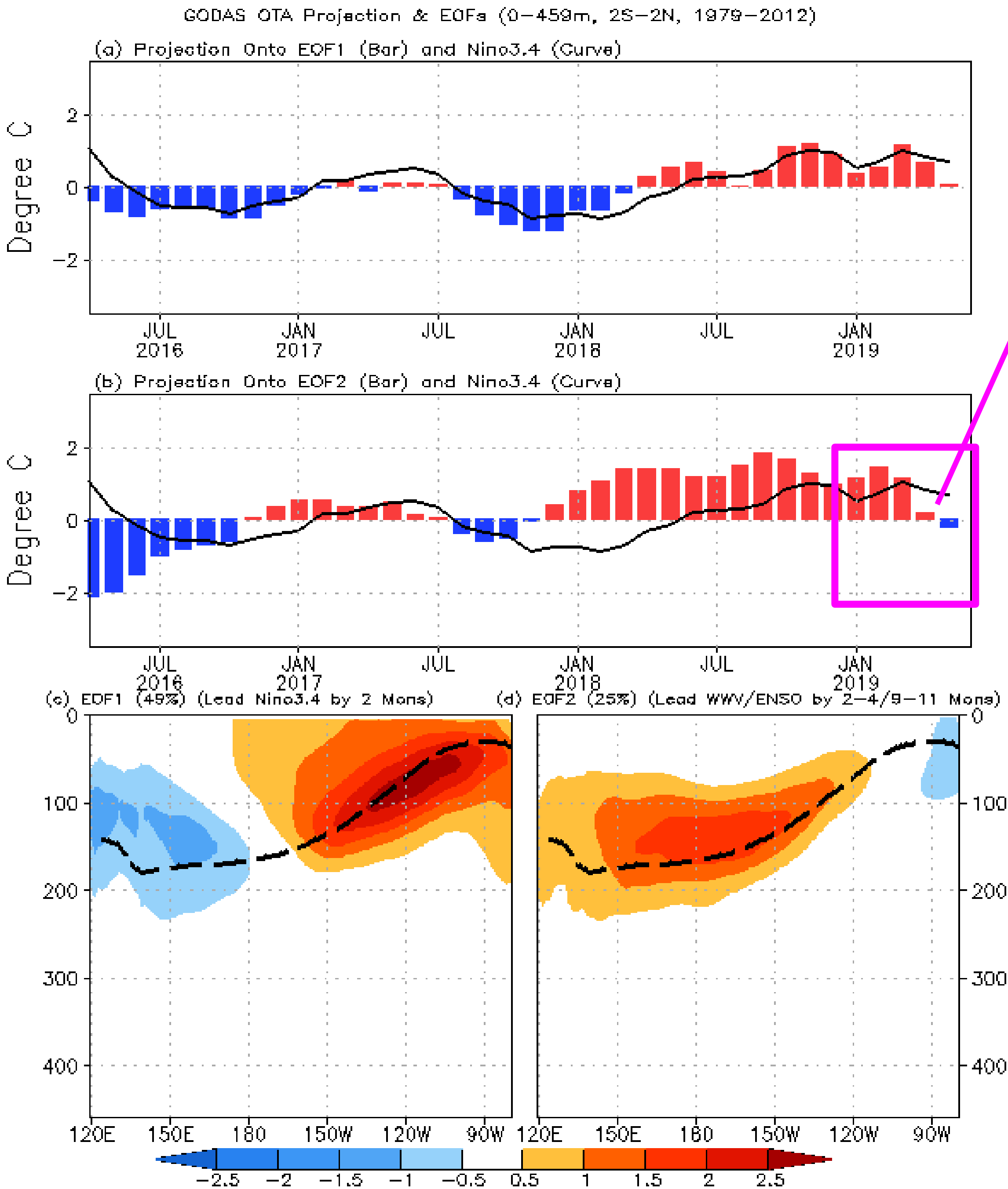


Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20°C in [120°E-80°W, 5°S-5°N] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.



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

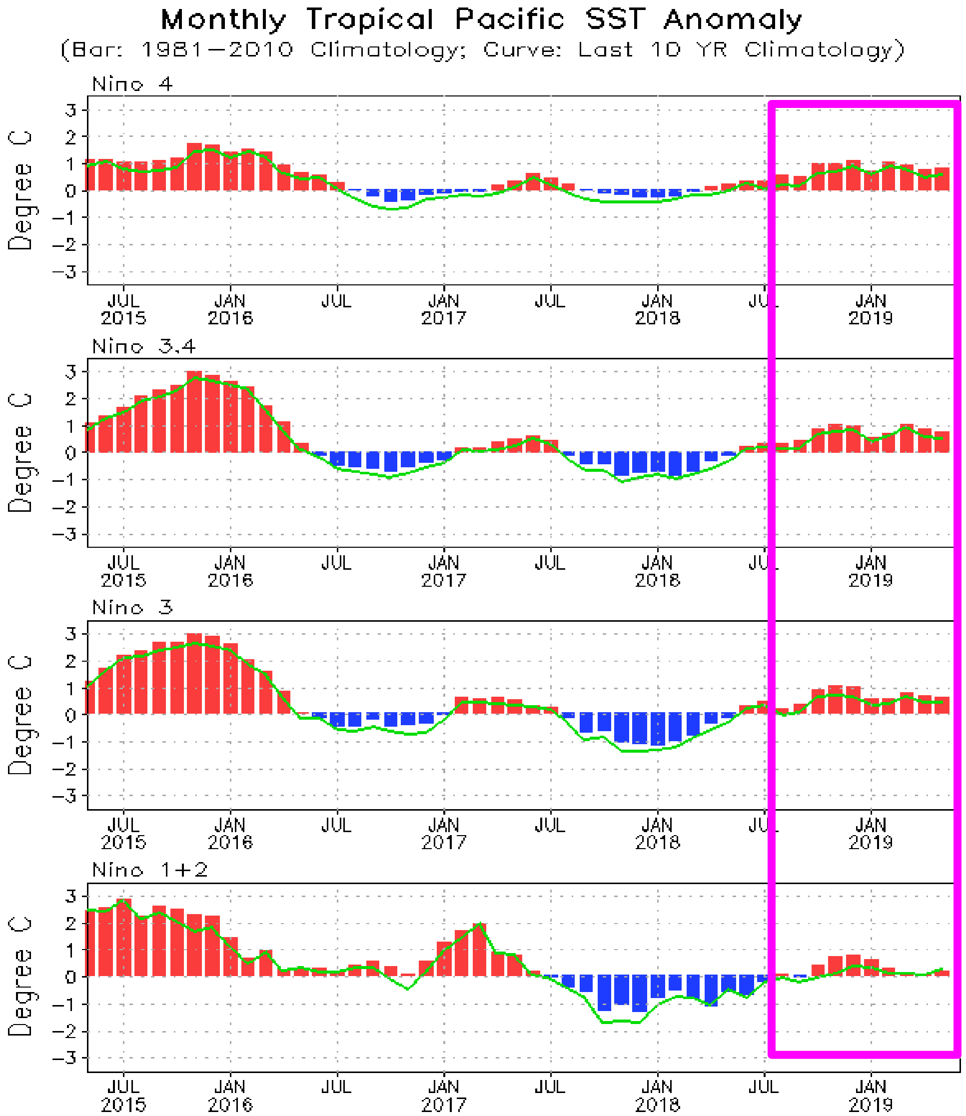
Recharge process: heat transport from outside of equator to equator : Negative -> positive phase of ENSO

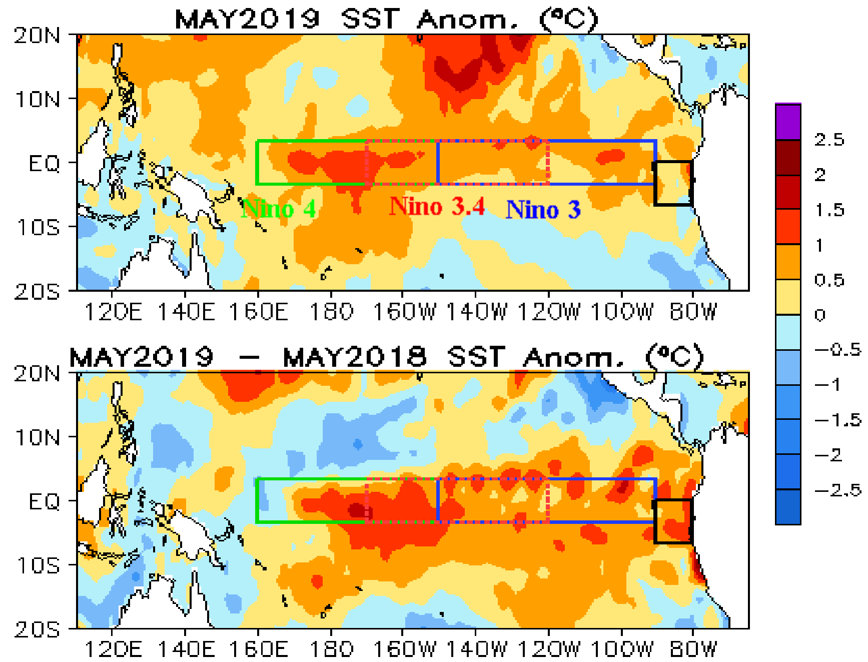
Discharge process: heat transport from equator to outside of equator: Positive -> Negative phase of ENSO

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

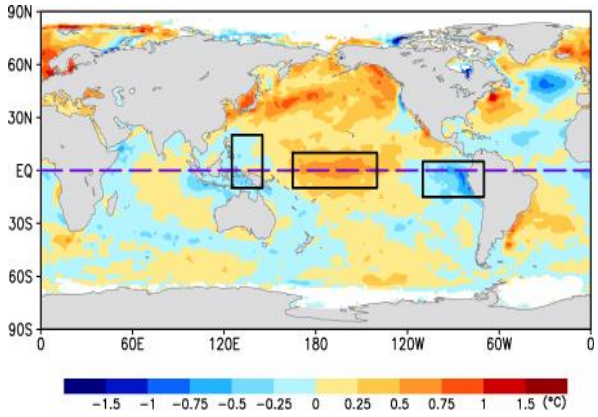


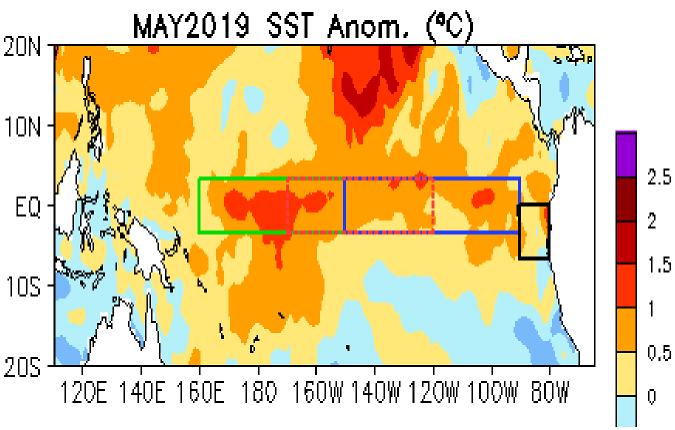


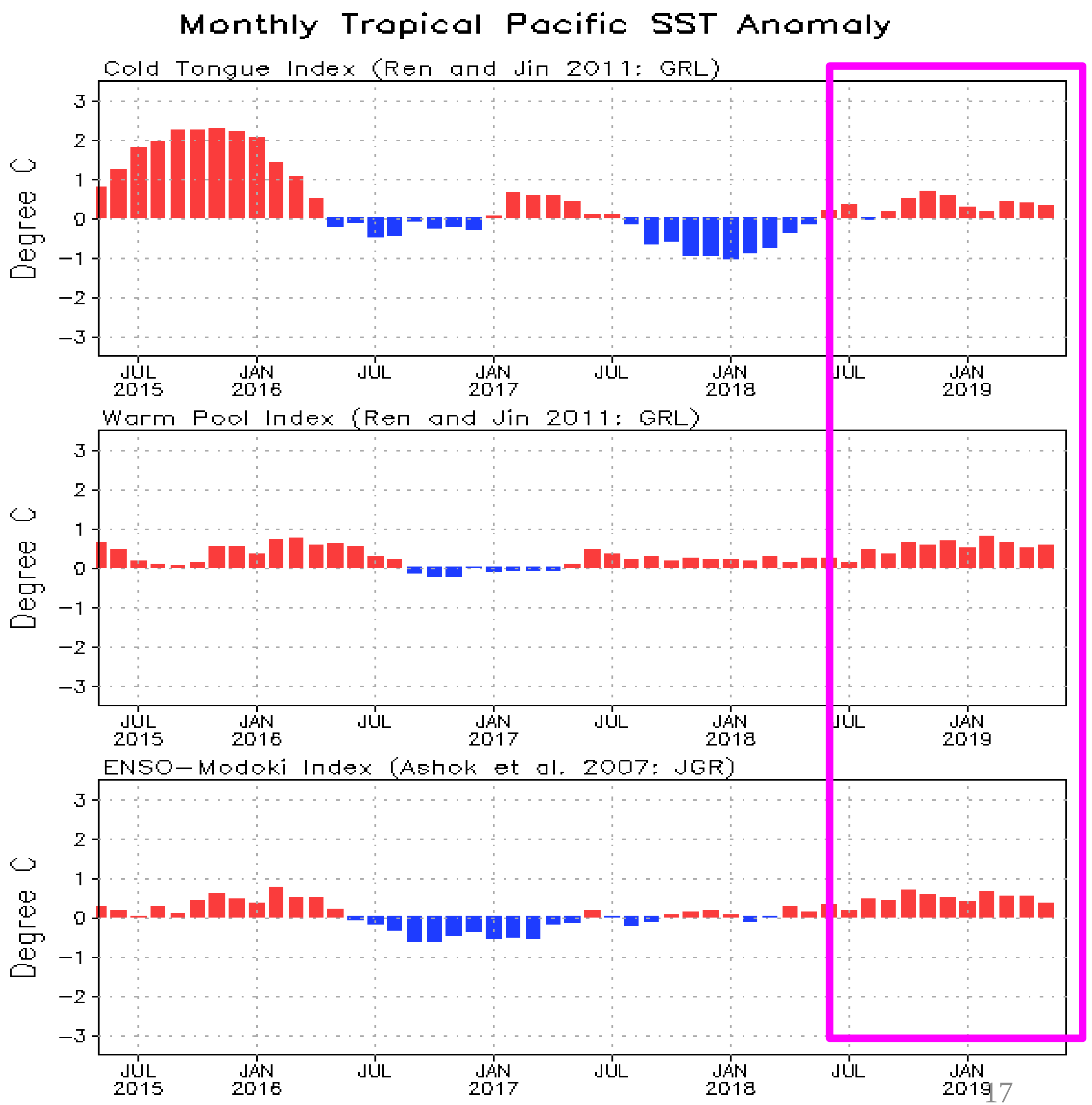
- **Nino3 and Nino3.4 slightly weakened, and Nino4 and Nino1+2 slightly strengthened in May 2019.**
- **Nino3.4 = 0.71C in May 2019.**
- **Compared with last May, the central and eastern equatorial Pacific was much warmer in May 2019.**
- **The indices were calculated based on OISST. They may have some 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.

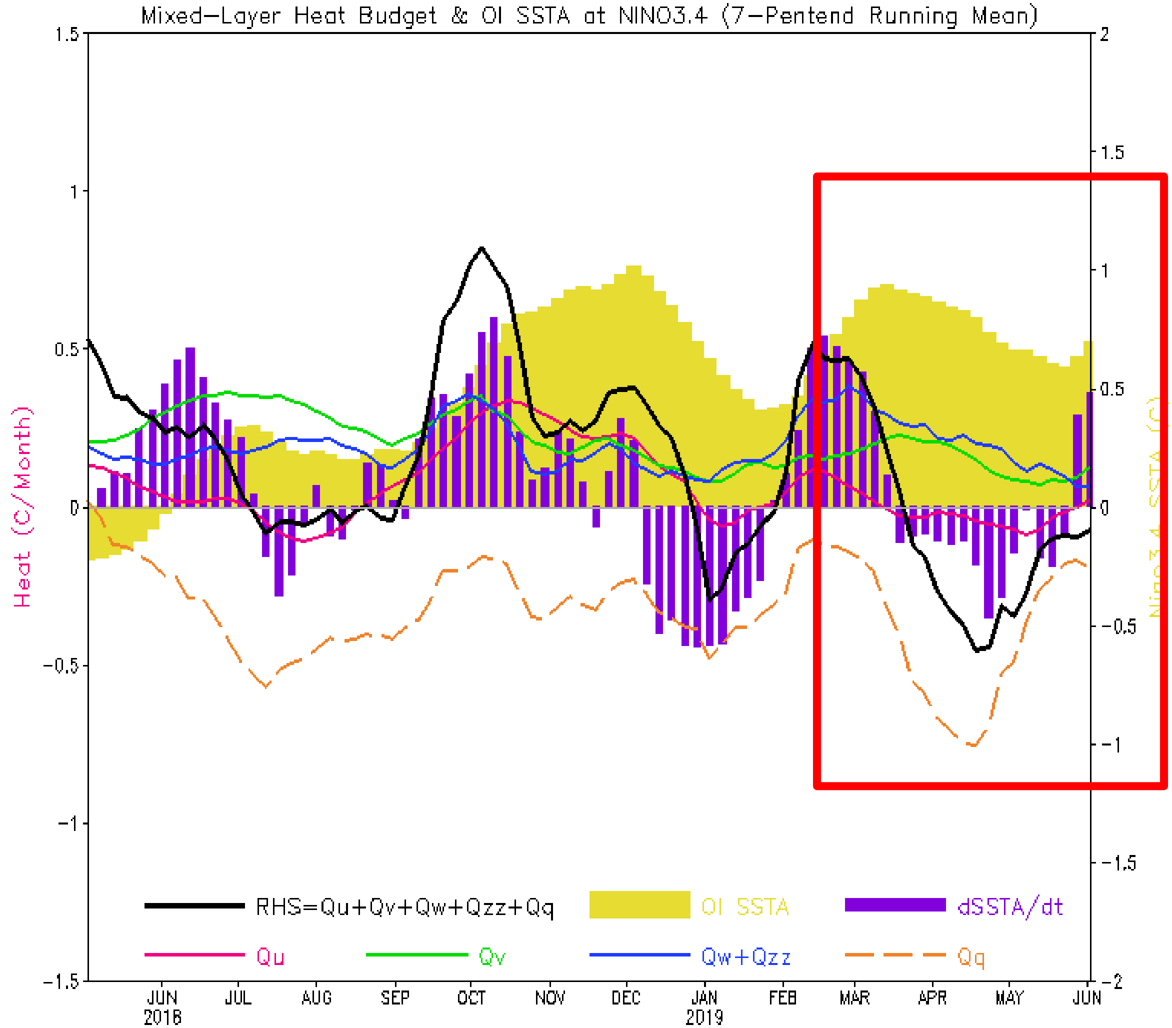
Positive SSTAs were larger in the warm pool than in the cold tongue, so 2018/19 event is CP or CP/EP mixed type El Nino.







NINO3.4 Heat Budget



- **Observed SSTA tendency (dSSTA/dt; bar) was positive in last 2 pentads, and total heat budget (RHS; black line) was negative since mid-Mar 2019.**

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

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

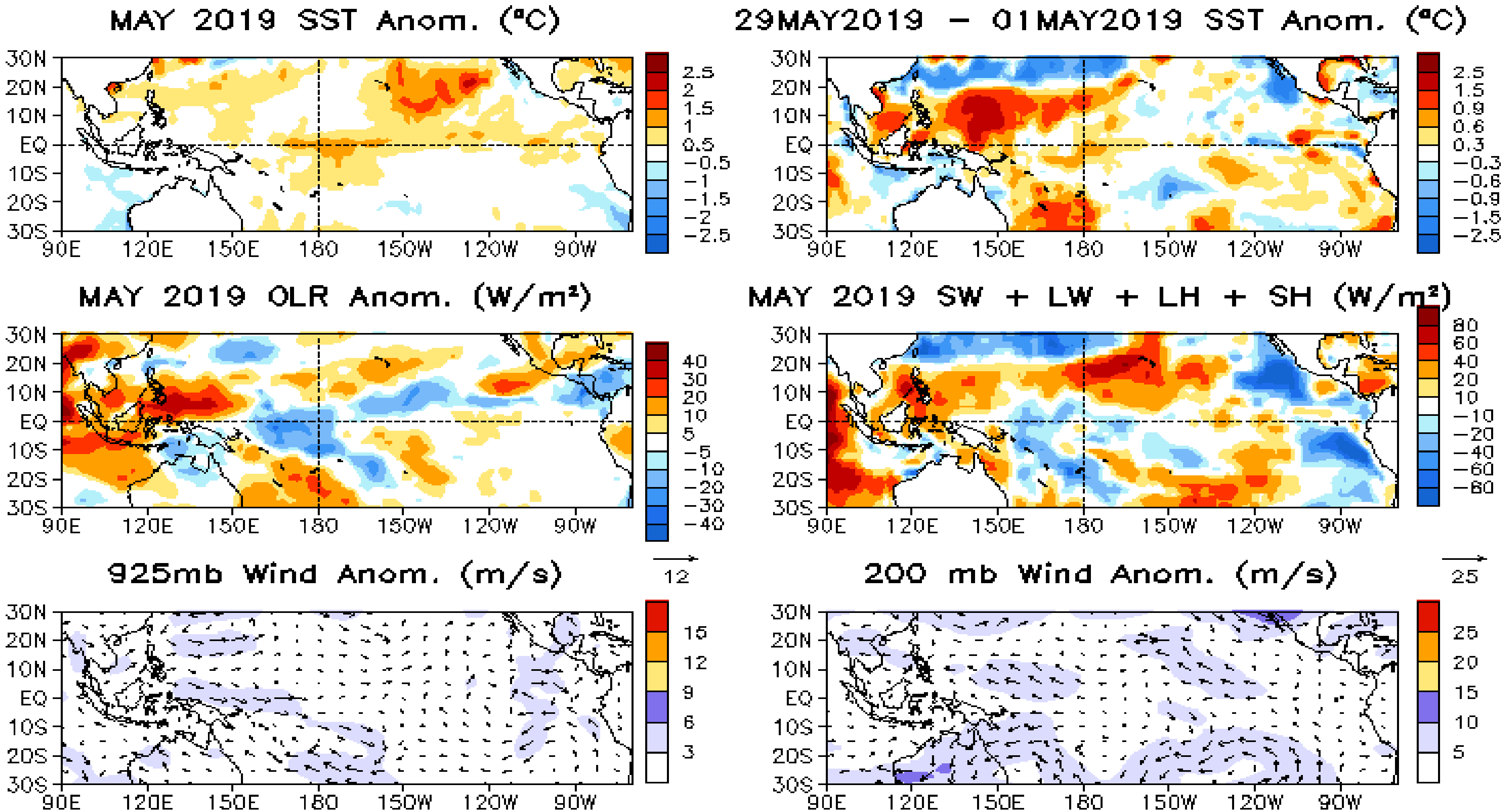
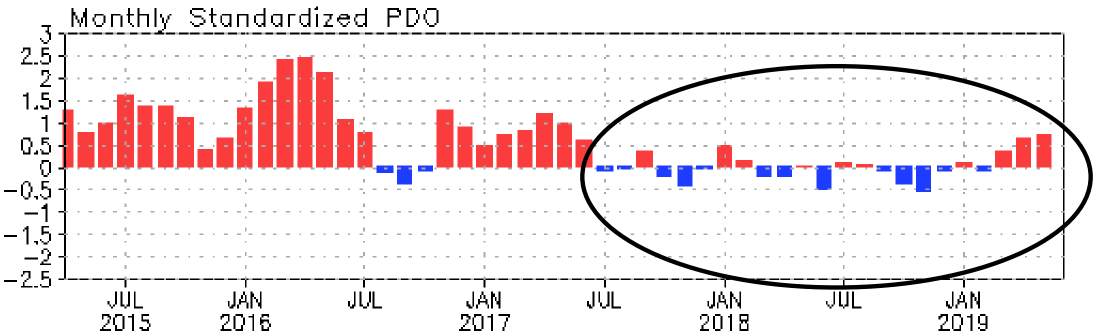
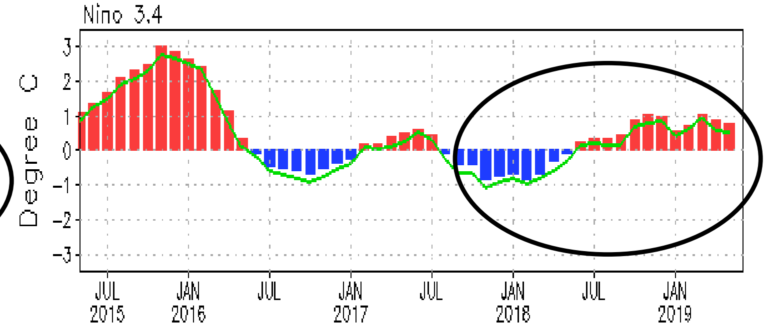


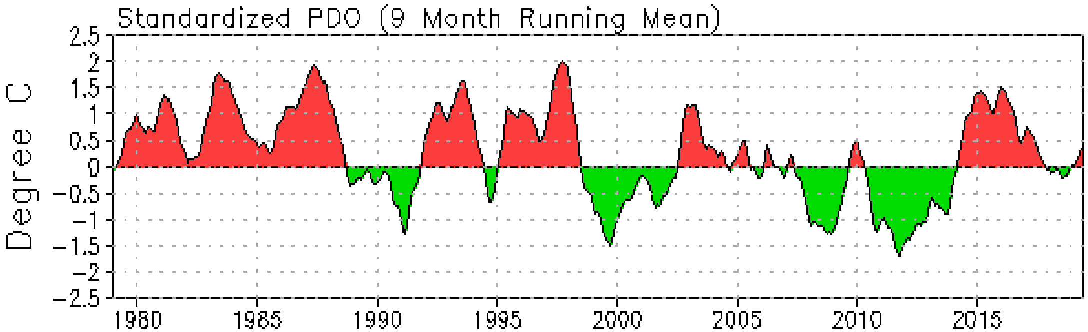
Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

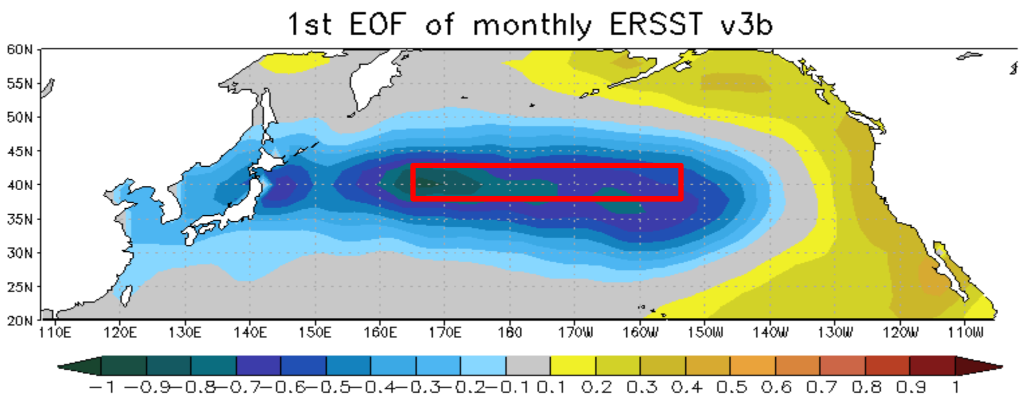
North Pacific & Arctic Oceans

PDO index









- The PDO index switched to positive phase since Mar 2019 with PDOI= 0.7 in May 2019.

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

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

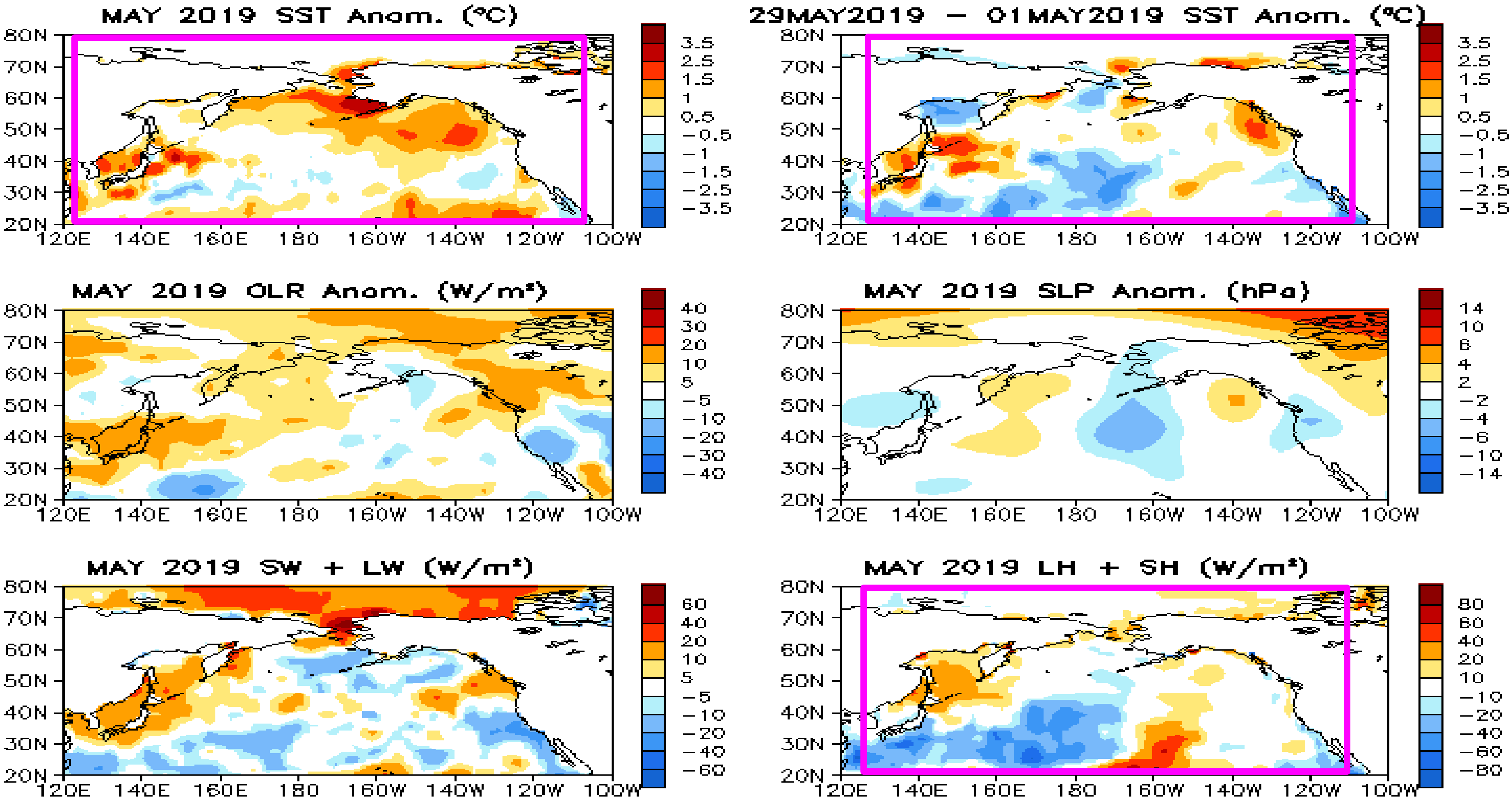
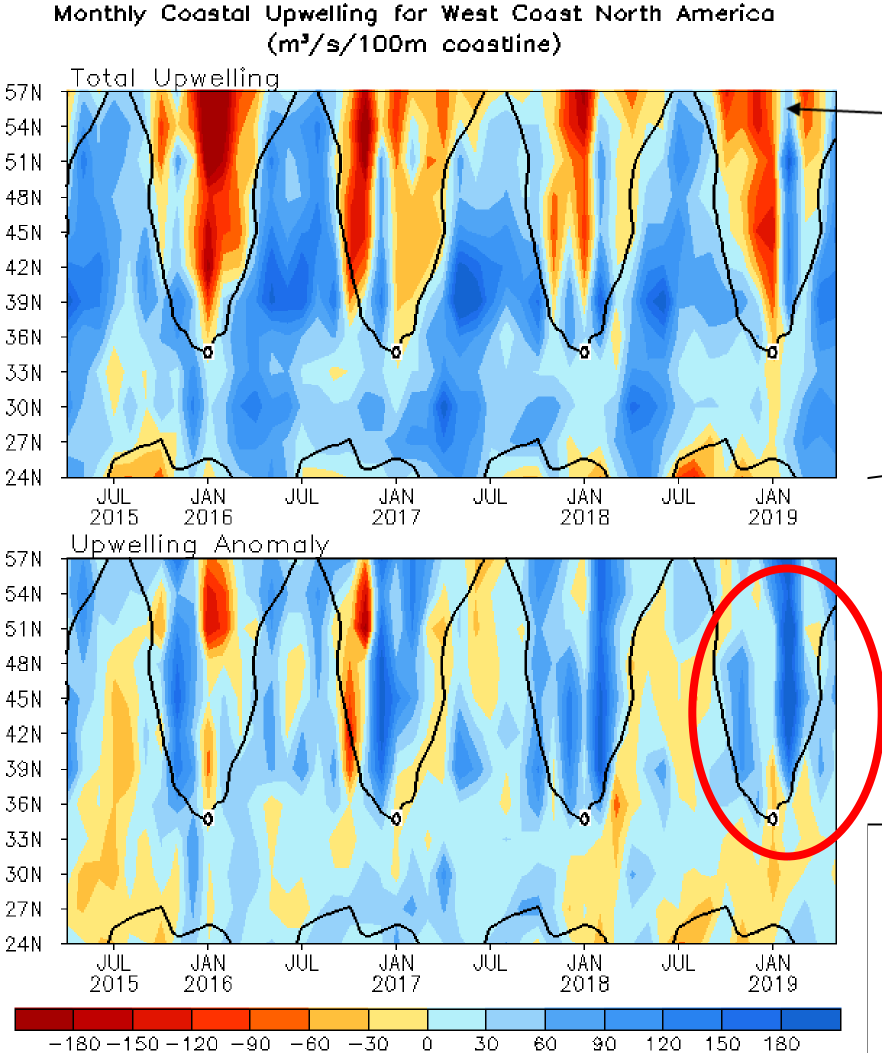
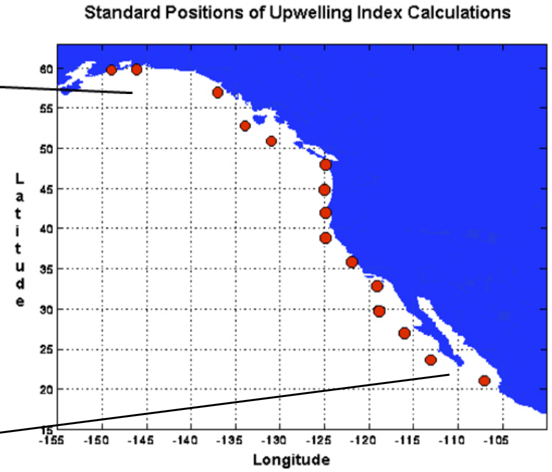


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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 39N since Jan 2019.**

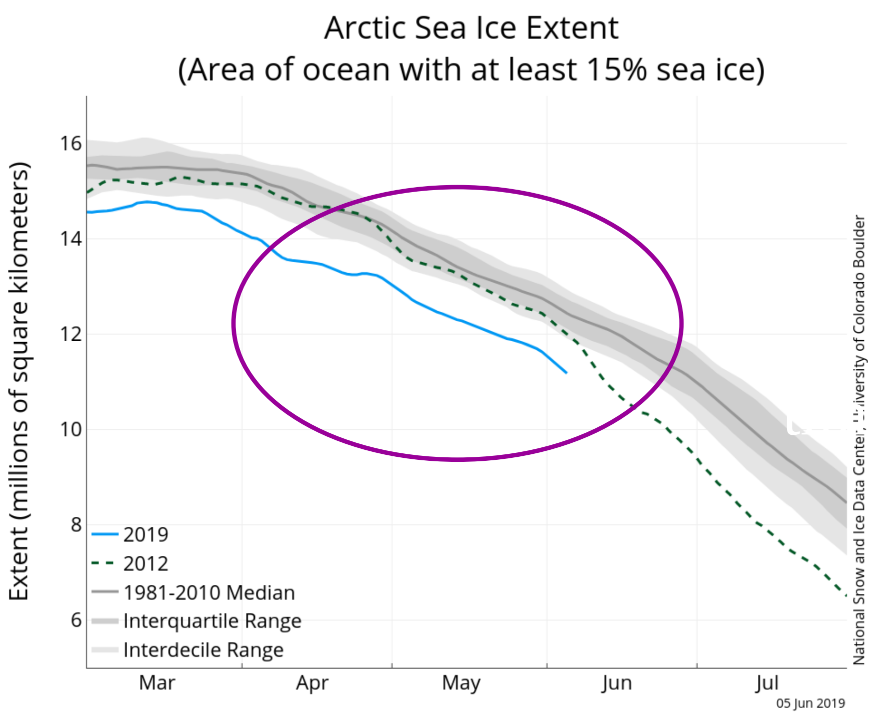
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

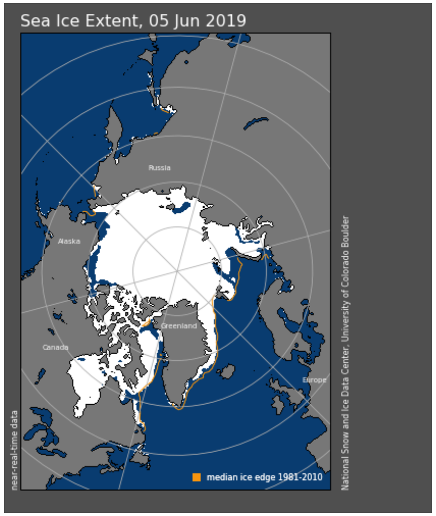
- **Area below (above) black line indicates climatological upwelling (downwelling) season.**
- **Climatologically upwelling season progresses from March to July along the west coast of North America from 36ºN to 57ºN.**

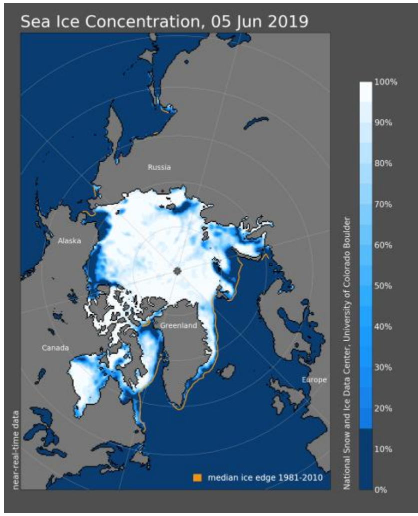
Arctic Sea Ice

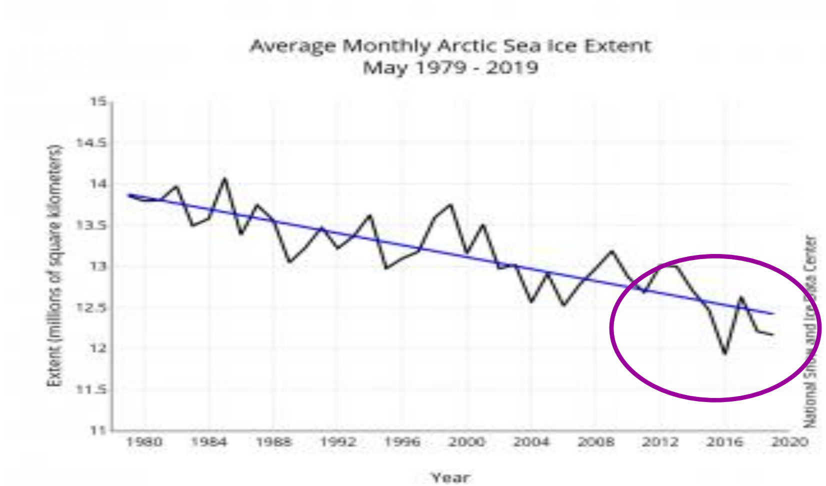
National Snow and Ice Data Center

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







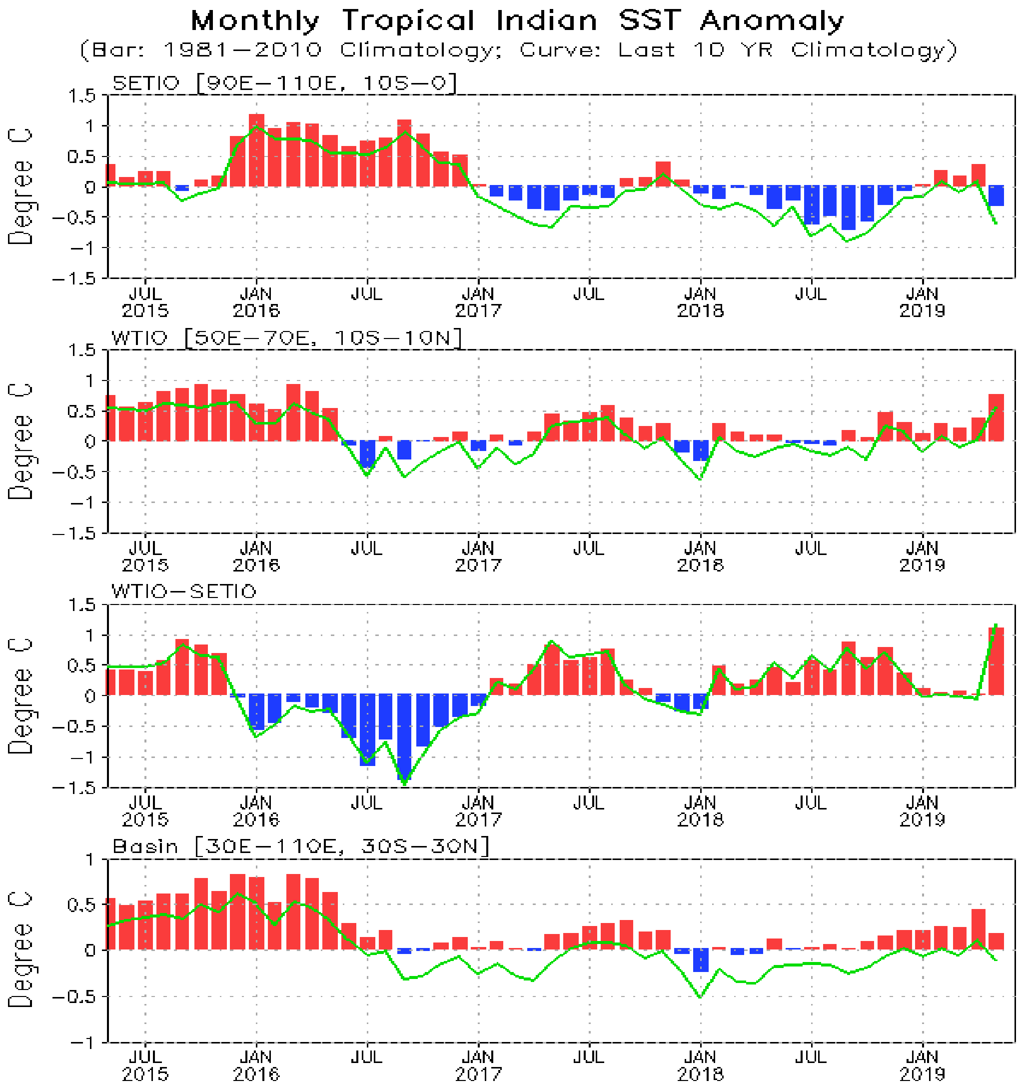


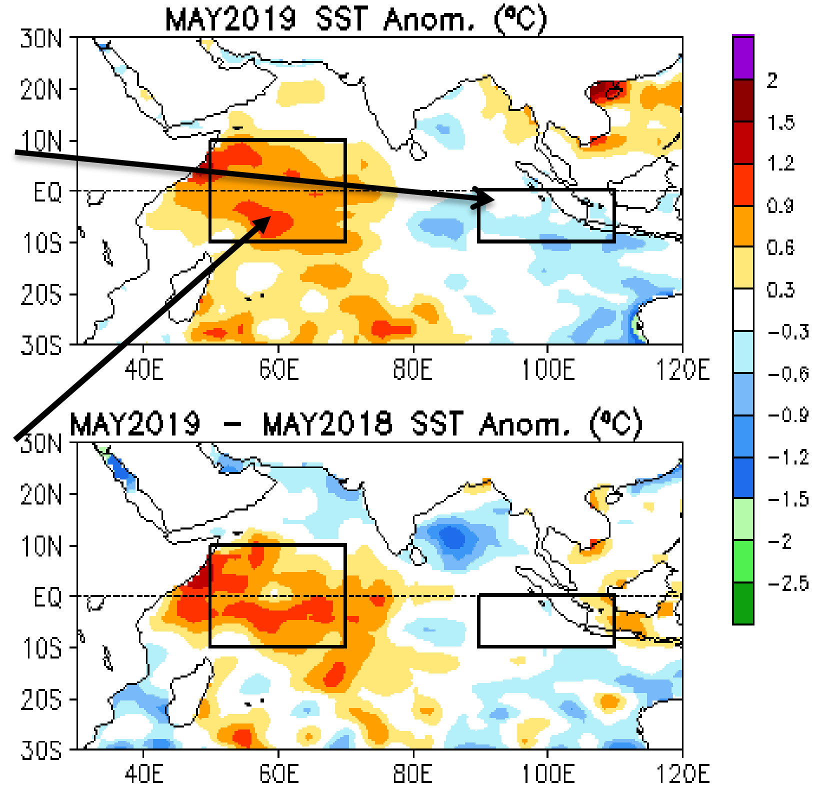
- Arctic sea ice extent was below the normal in 2019.

- At the end of May, Arctic sea ice daily extent stood at second lowest in the 40-year satellite record.

<u>Indian Ocean</u>

Evolution of Indian Ocean SST Indices





- **Positive (negative) SSTAs were in the west (east), and IOD was in a strong positive phase in May 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 negative in the east.
- SSTA tendency seems largely driven by heat flux.
- Convections were suppressed over the eastern Indian Ocean.

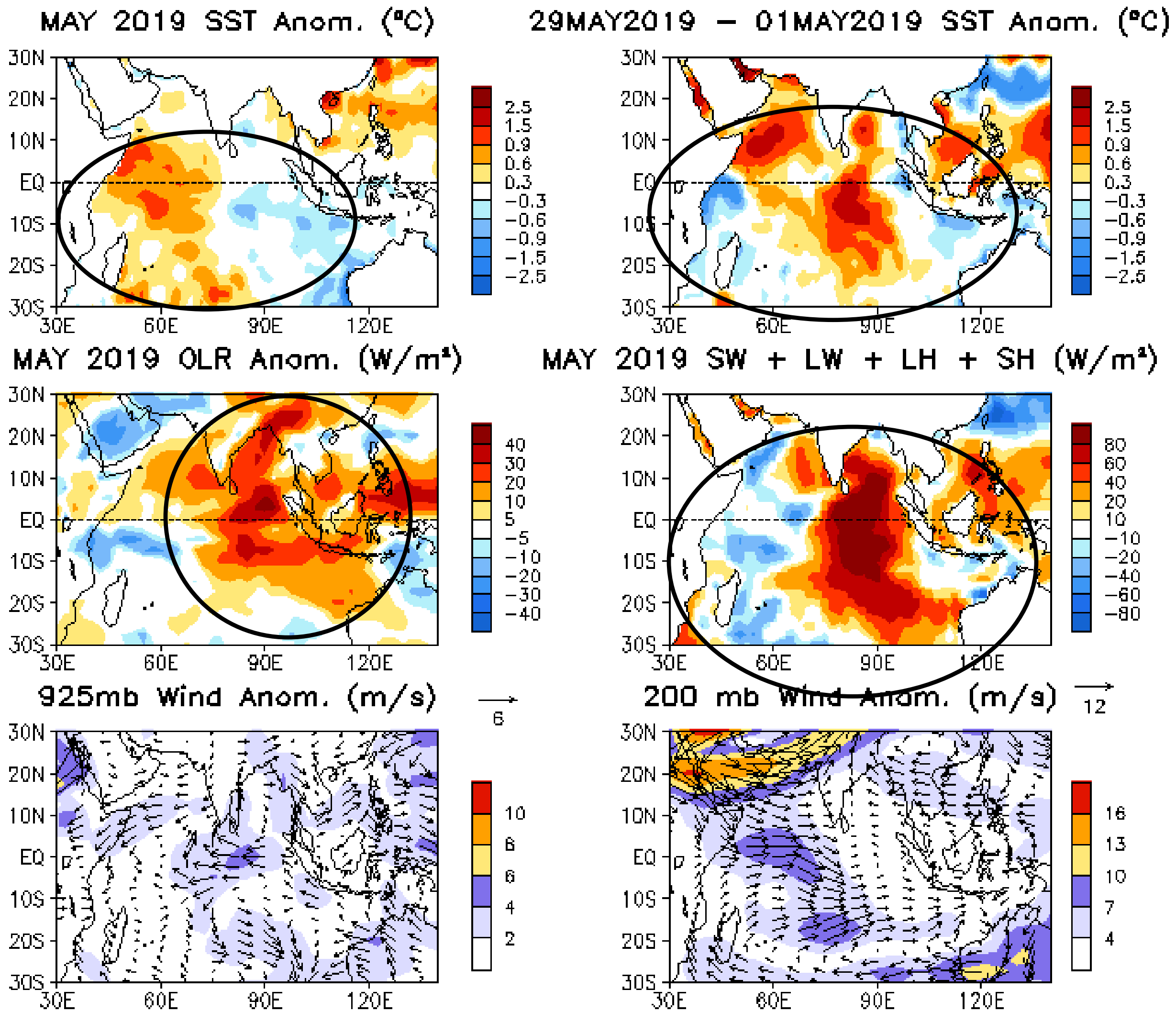
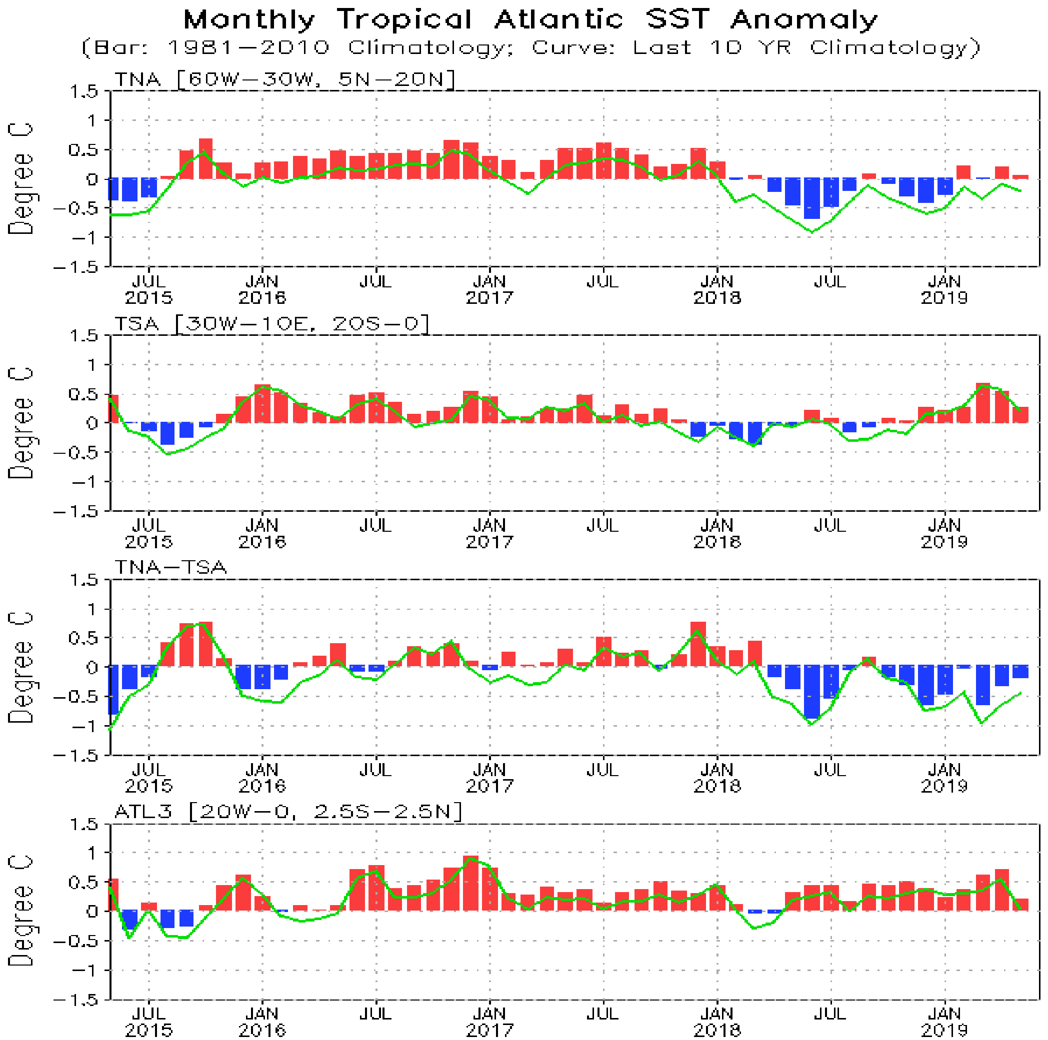
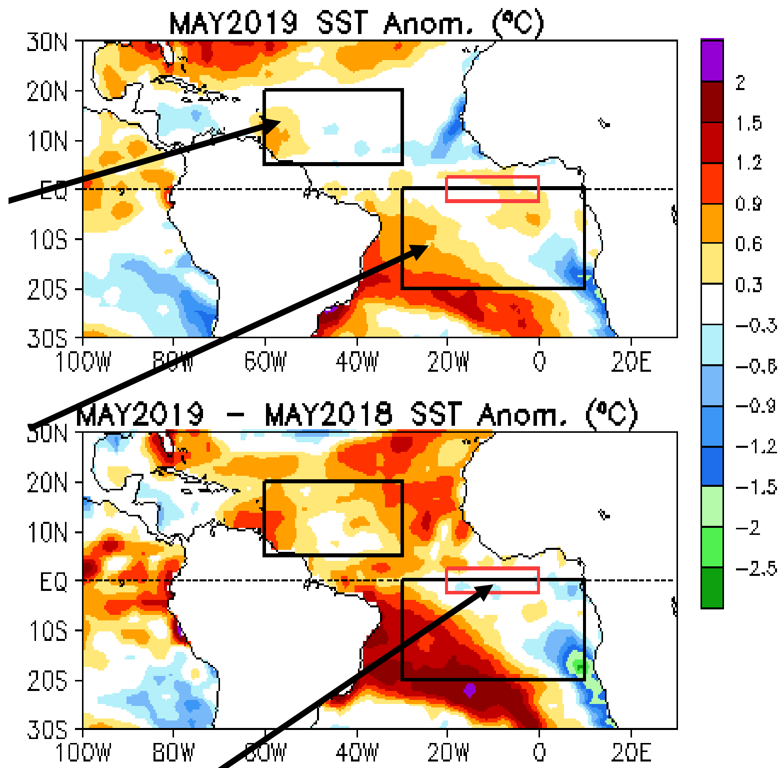


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, winds and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.

Tropical and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

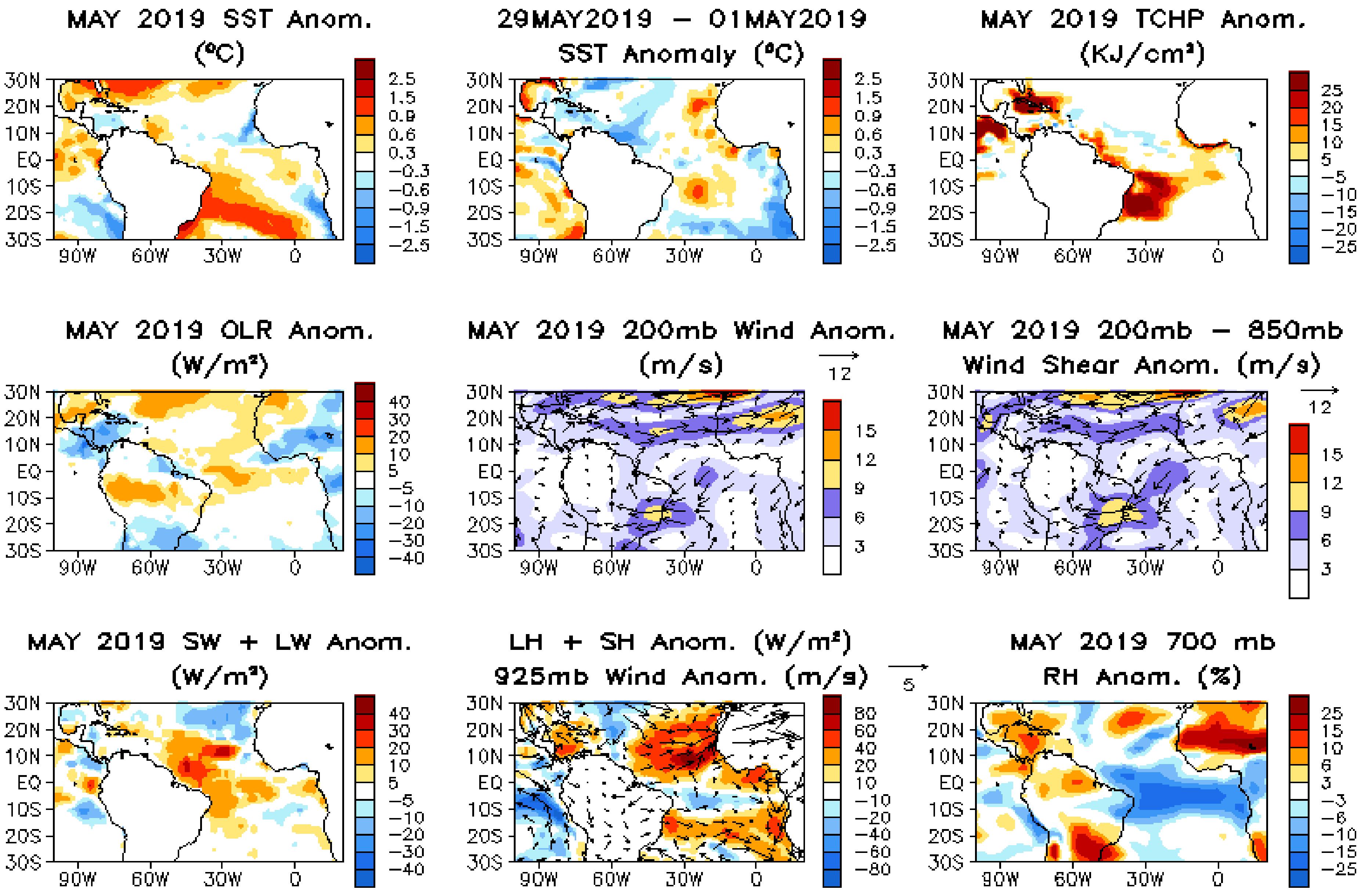




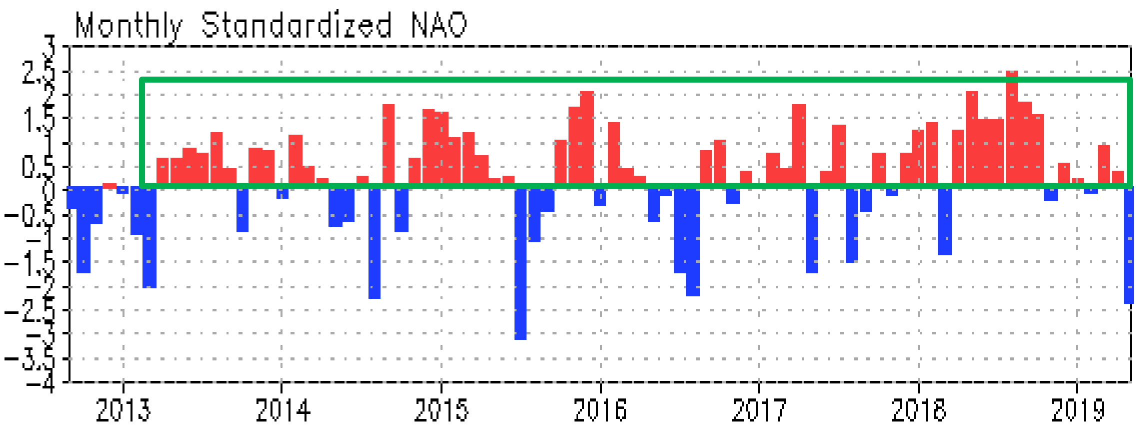
- All indices were small in May 2019.

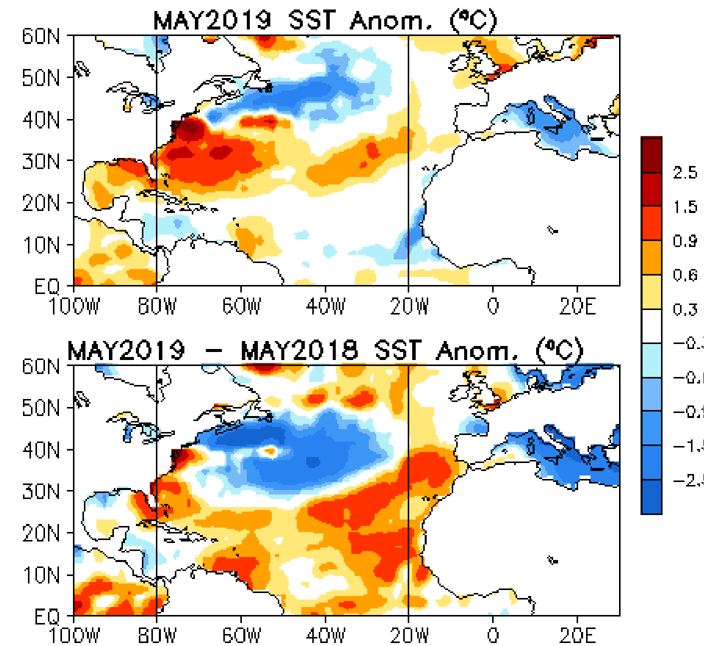
Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (ºC) for the TNA [60ºW-30ºW, 5ºN-20ºN], TSA [30ºW-10ºE, 20ºS-0] and ATL3 [20ºW-0, 2.5ºS-2.5ºN] regions, and Meridional Gradient Index, defined as differences between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

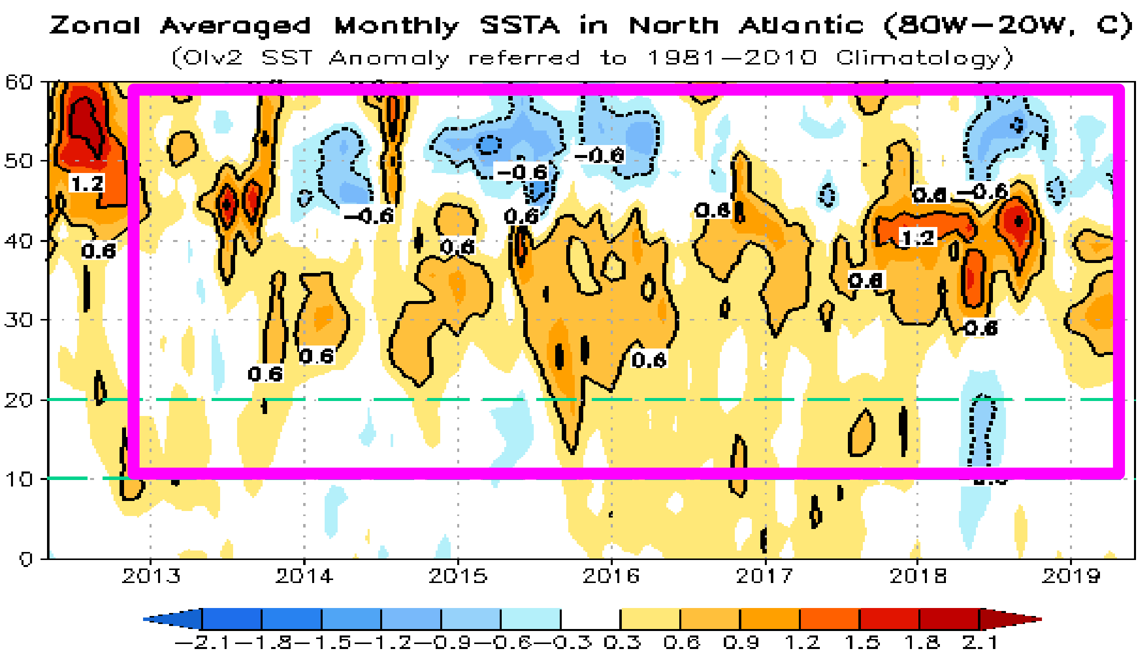
Tropical Atlantic:



NAO and SST Anomaly in North Atlantic

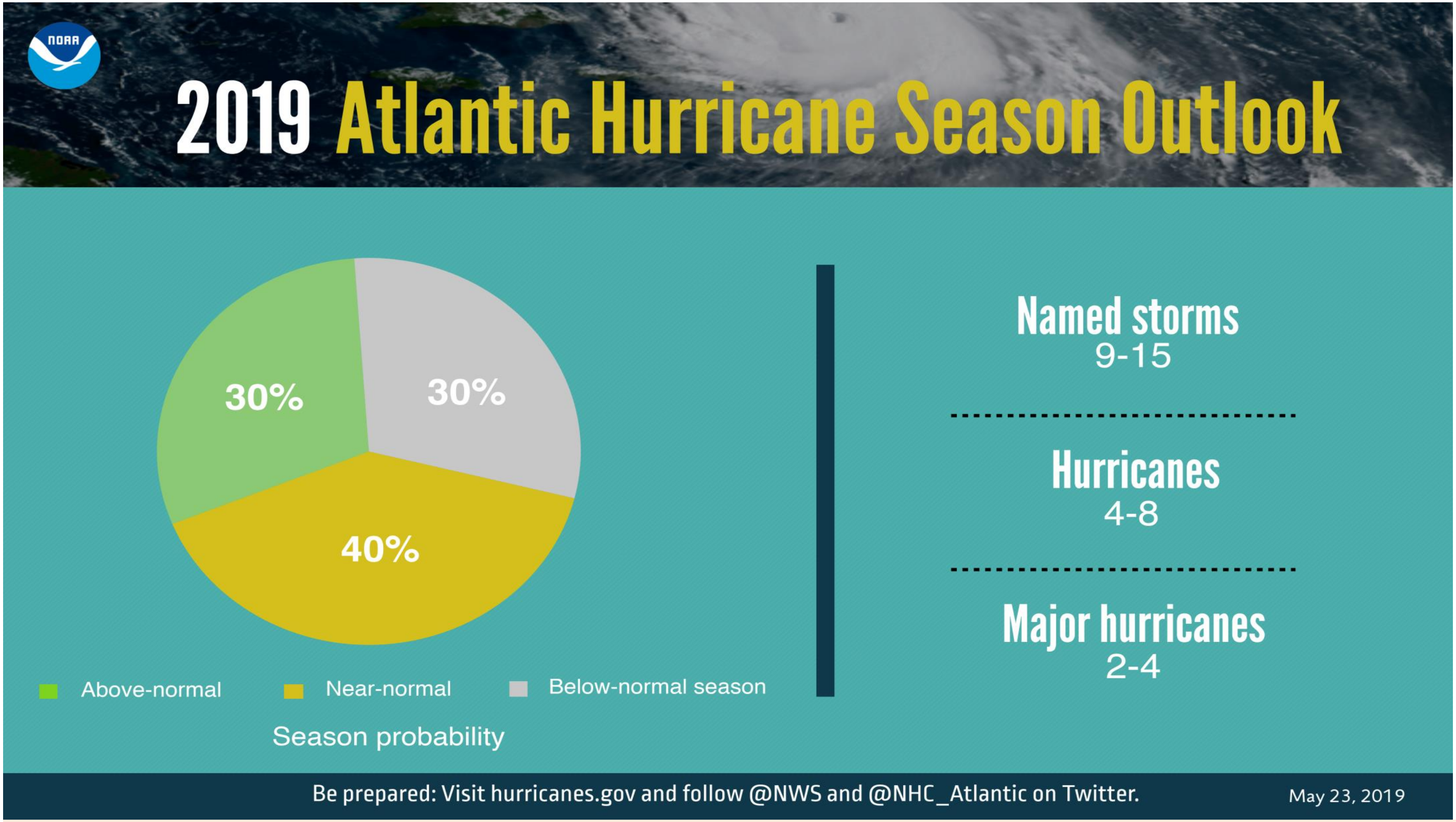






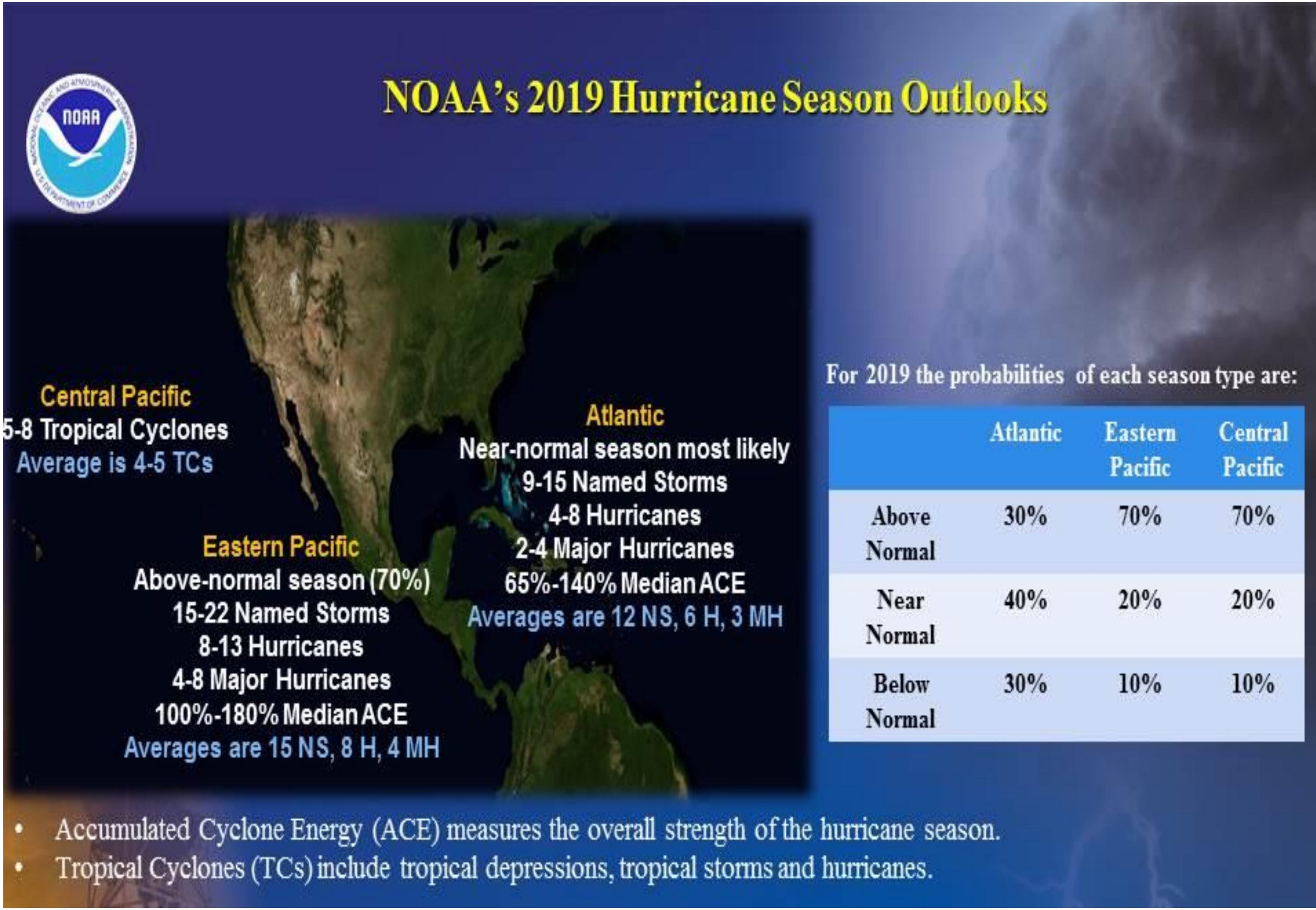
- NAO switched to a negative phase with NAOI= -2.4 in May 2019.
- SSTA was a tripole/horseshoe –like pattern with positive in the mid-latitudes and negative in the lower and higher latitudes, due to the long-term persistence of a positive phase of NAO.

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



https://www.cpc.ncep.noaa.gov/products/outlooks/Slide1.JPG

Reasoning behind the outlook

NOAA's 2019 Atlantic hurricane season outlook reflects three competing factors:

1) **Unfavorable due to El Niño:** The likely continuation of El Niño during the peak months (ASO) of the hurricane season. El Niño typically suppresses Atlantic hurricane activity by causing increased vertical wind shear, anomalous sinking motion, and increased atmospheric stability across the western MDR (i.e., mainly the Caribbean Sea) (Gray 1984).

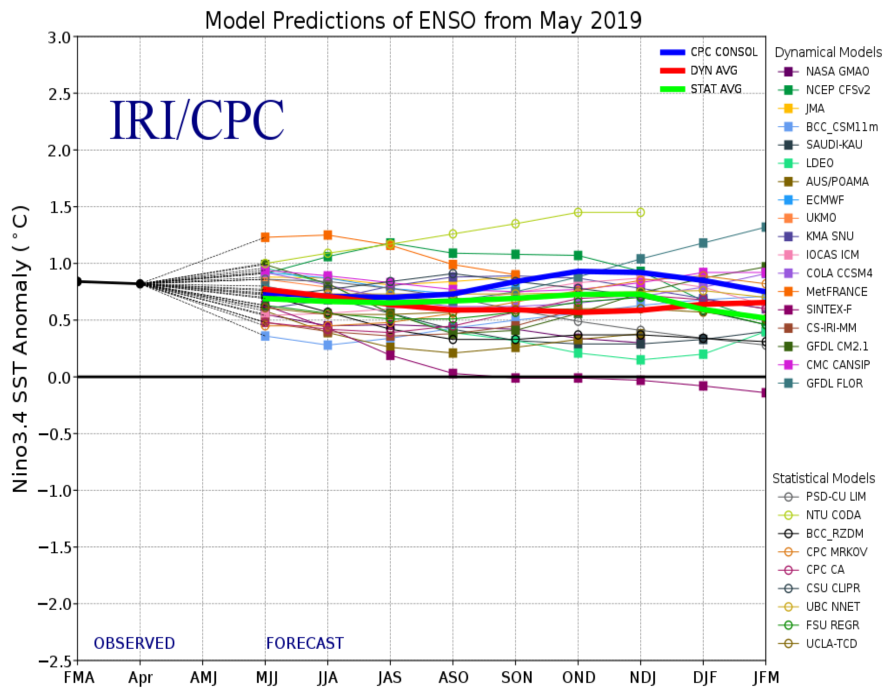
2) **Favorable due to +SSTA in MDR:** Competing with the possible suppressing influence of El Niño this year is the expectation of above-average SSTs in the MDR. Nearly all climate models predict SSTs to be above average in this region during ASO, with most predicting departures of +0.2°C to + 0.4°C. These predictions are consistent with the warm phase of the AMO, which has persisted during the ASO season since 1995 and has favored more active hurricane seasons.

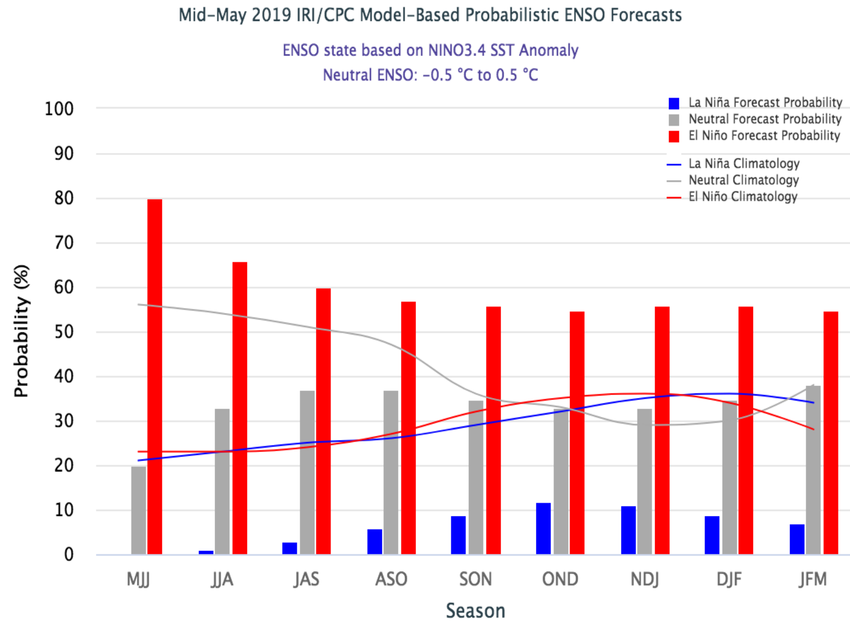
3) **Favorable due to weaker trade wind and enhanced west African Monsoon and warm phase of AMO:** Also competing with El Niño this season is the expectation for weaker trade winds in the eastern portion of the MDR, along with an enhanced West African monsoon. These conditions favor more active hurricane seasons, and are also typical of the warm AMO phase.

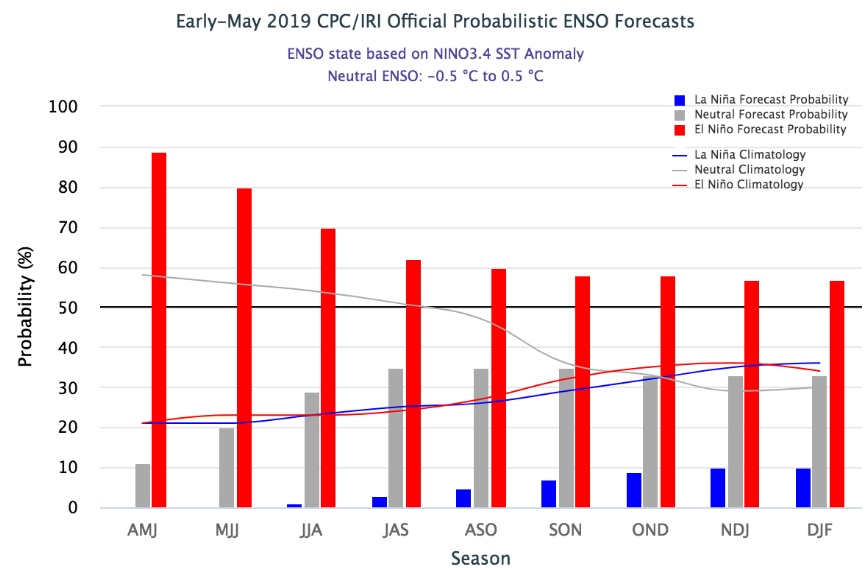
https://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml

ENSO and Global SST Predictions

IRI NINO3.4 Forecast Plum



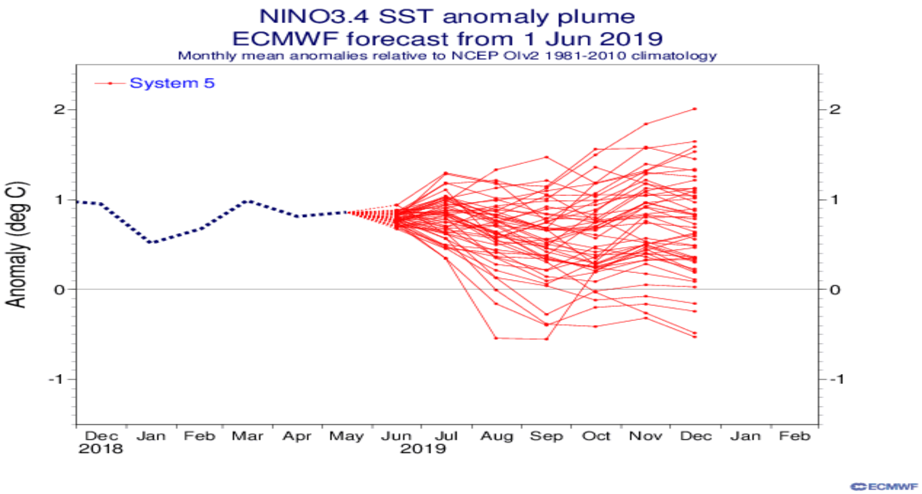




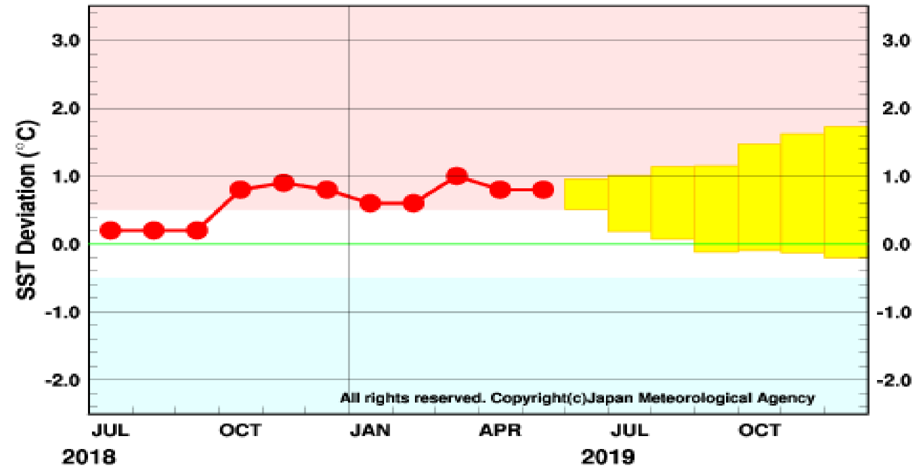
- **Majority of models predict continuation of El Nino with ICs in May 2019.**
- **NOAA "ENSO Diagnostic Discussion" on 9 May 2019 continuously issued "*El Nino Advisory*" and indicated that *"El Niño is likely to continue through the Northern Hemisphere summer 2019 (70% chance) and fall (55-60% chance)."***

Individual Model Forecasts: Neutral or Weak El Nino

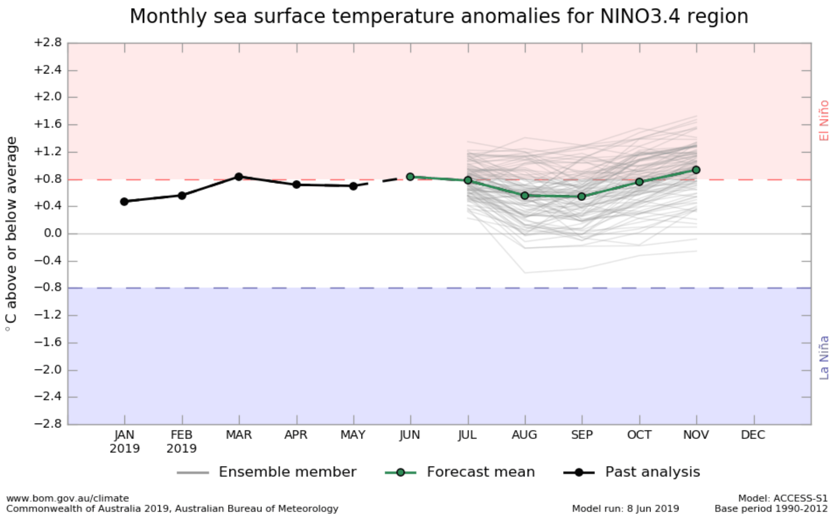
EC: Nino3.4, IC=01Jun 2019



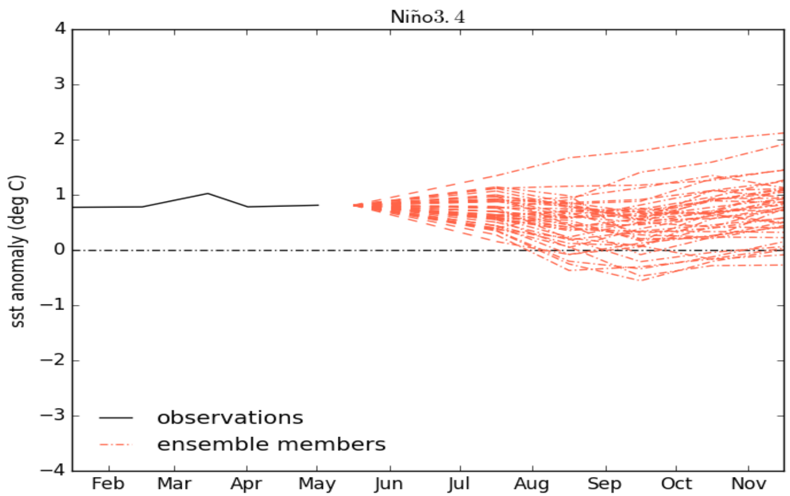
JMA: Nino3, Updated 10 Jun2019

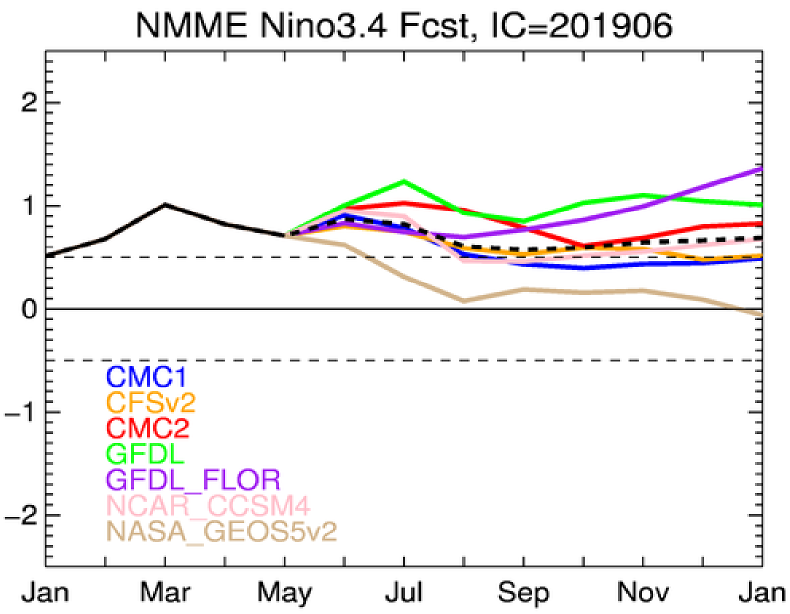


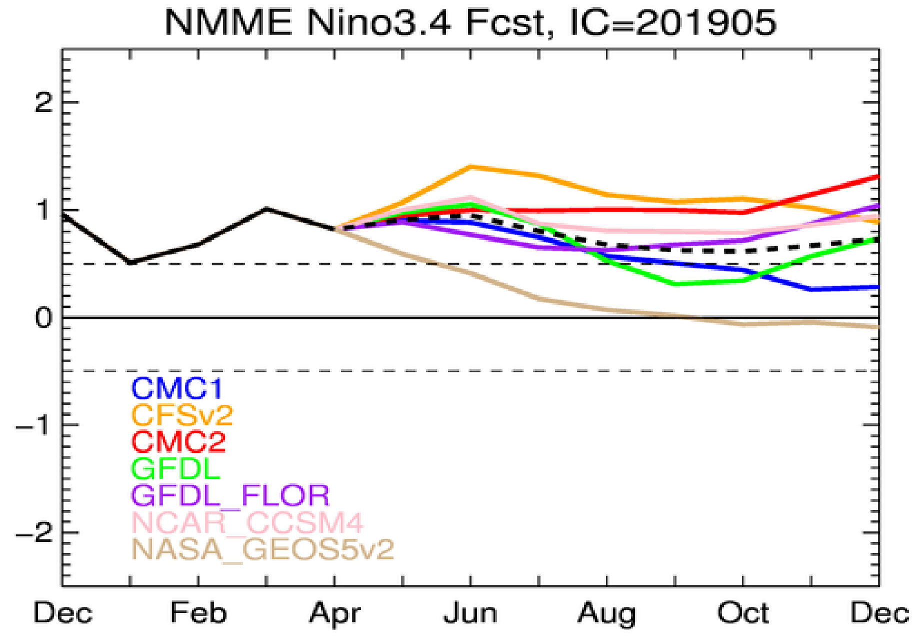
Australia: Nino3.4, Updated 8Jun 2019

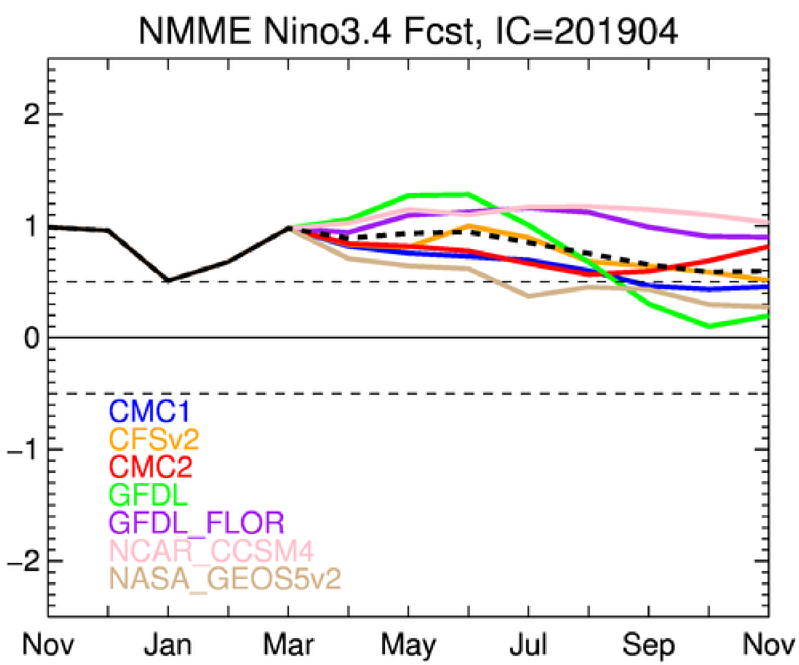


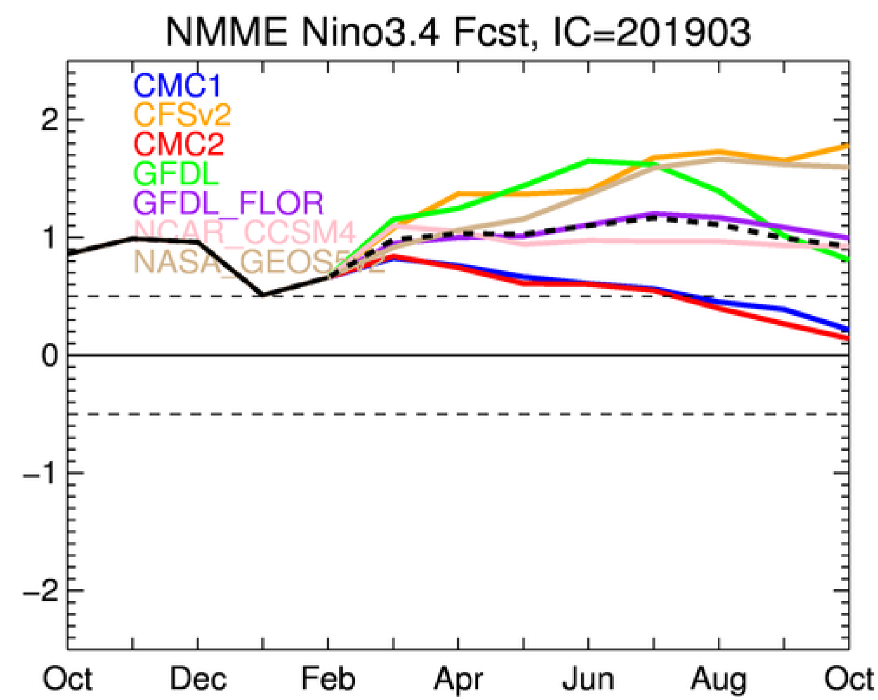
UKMO: Nino3.4, Updated 11Jun 2019



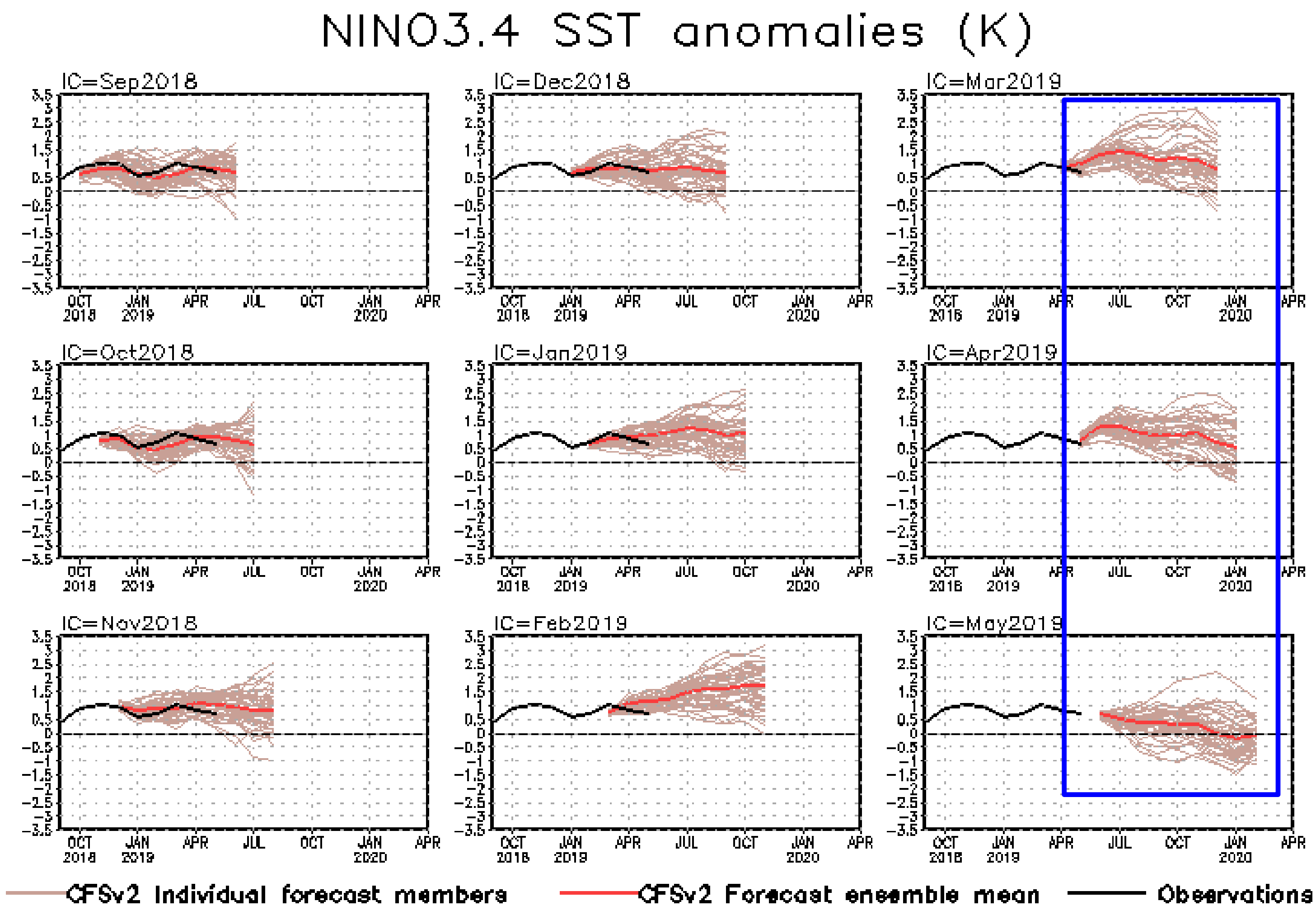

NMME Nino3.4 Fcst, IC=201906
2
1
0
−1
−2
Jan
Mar
May
Jul
Sep
Nov
Jan
CMC1
CFSv2
CMC2
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2


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


NMME Nino3.4 Fcst, IC=201903
2
1
0
−1
−2
Oct
Dec
Feb
Apr
Jun
Aug
Oct
CMC1
CFSv2
CMC2
GFDL
GFDL_FLOR
NCAR_CCSM4

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 late-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.

ENSO Evolution in 2014/2016 and 2018/2019

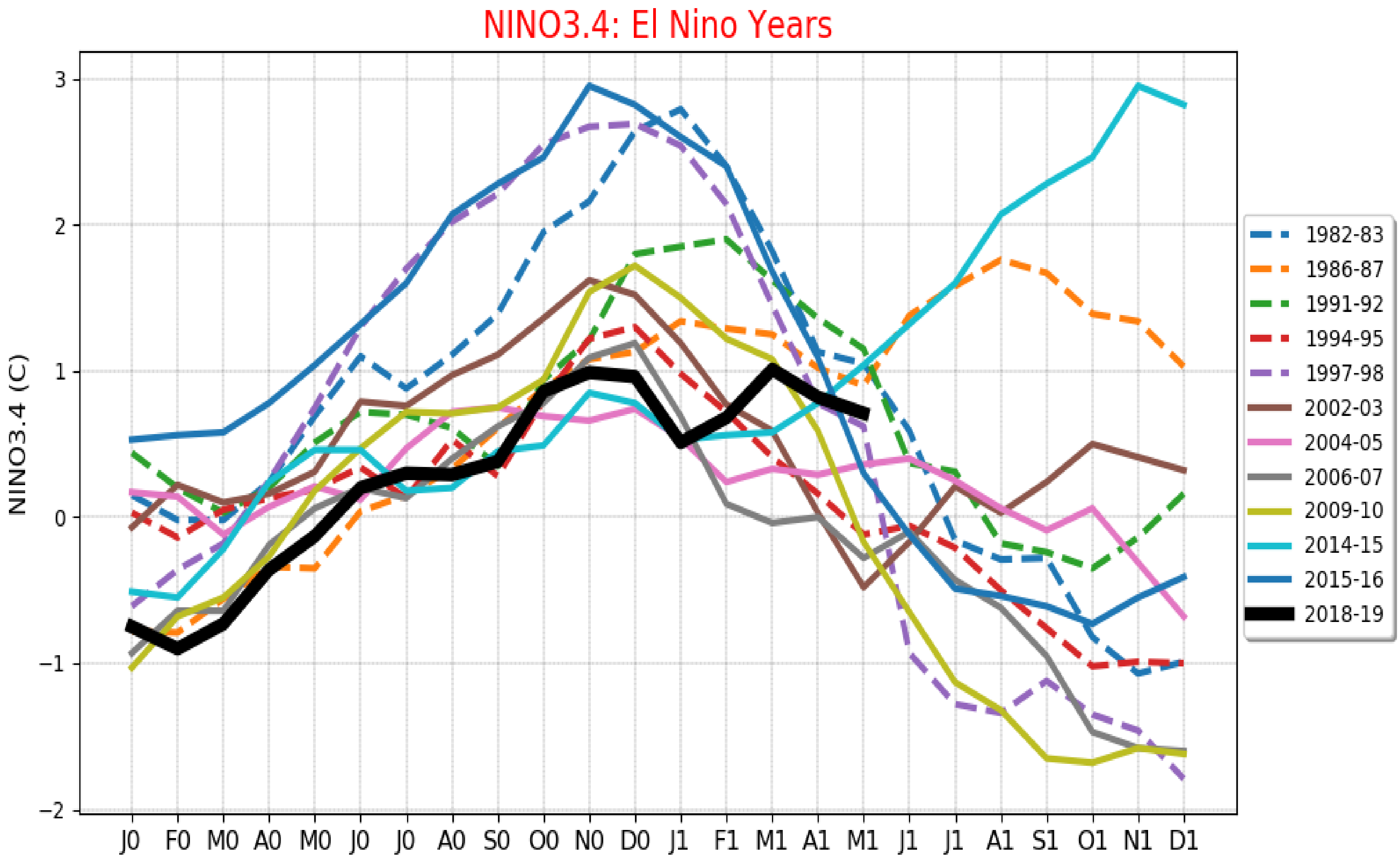
Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2014	-0.4	-0.4	-0.2	0.1	0.3	0.2	0.1	0.0	0.2	0.4	0.6	0.7
2015	0.6	0.6	0.6	0.8	1.0	1.2	1.5	1.8	2.1	2.4	2.5	2.6
2016	2.5	2.2	1.7	1.0	0.5	0.0	-0.3	-0.6	-0.7	-0.7	-0.7	-0.6
2017	-0.3	-0.1	0.1	0.3	0.4	0.4	0.2	-0.1	-0.4	-0.7	-0.9	-1.0
2018	-0.9	-0.8	-0.6	-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								

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.

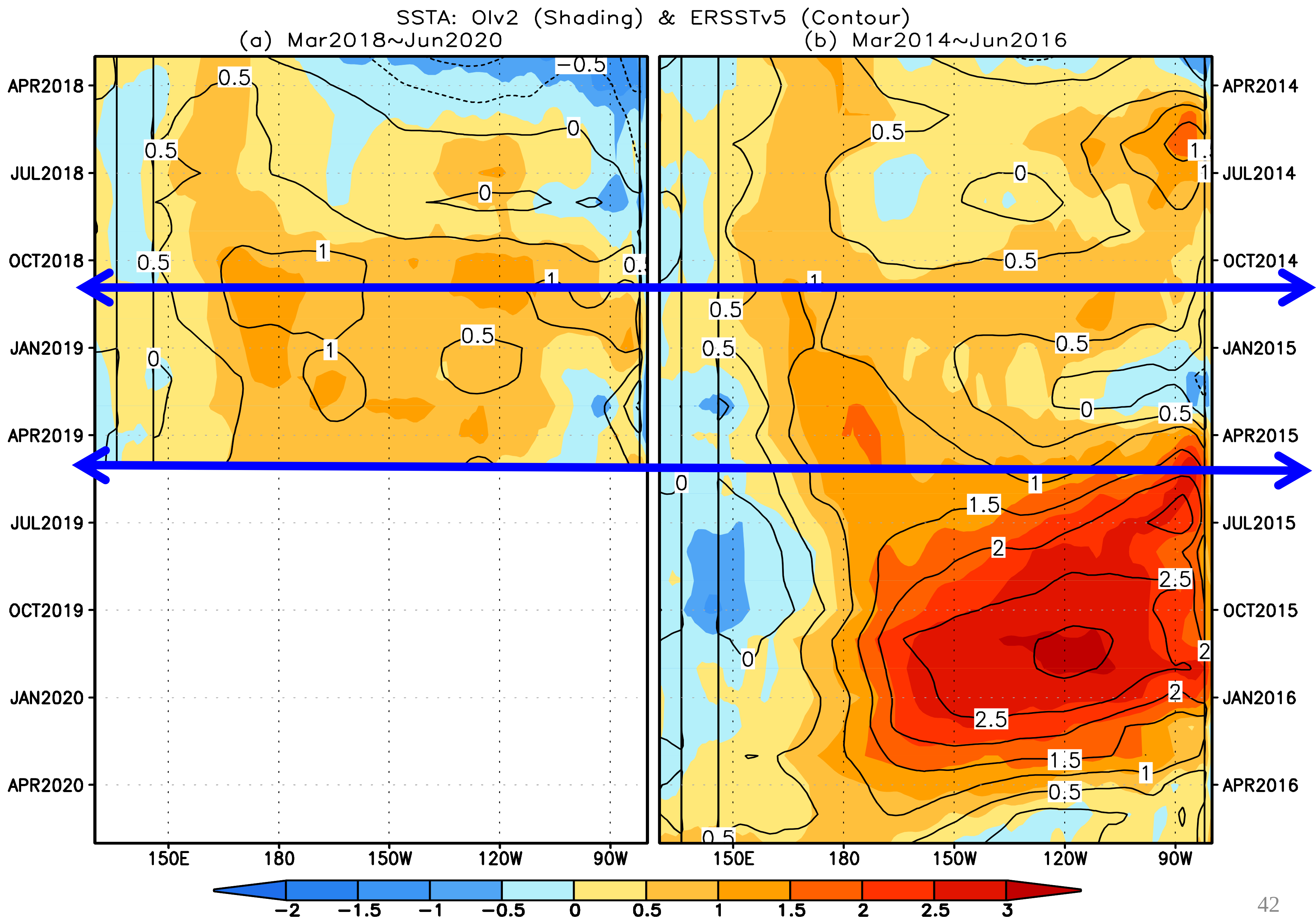
https://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php

Nino3.4 Evolution In El Nino Years

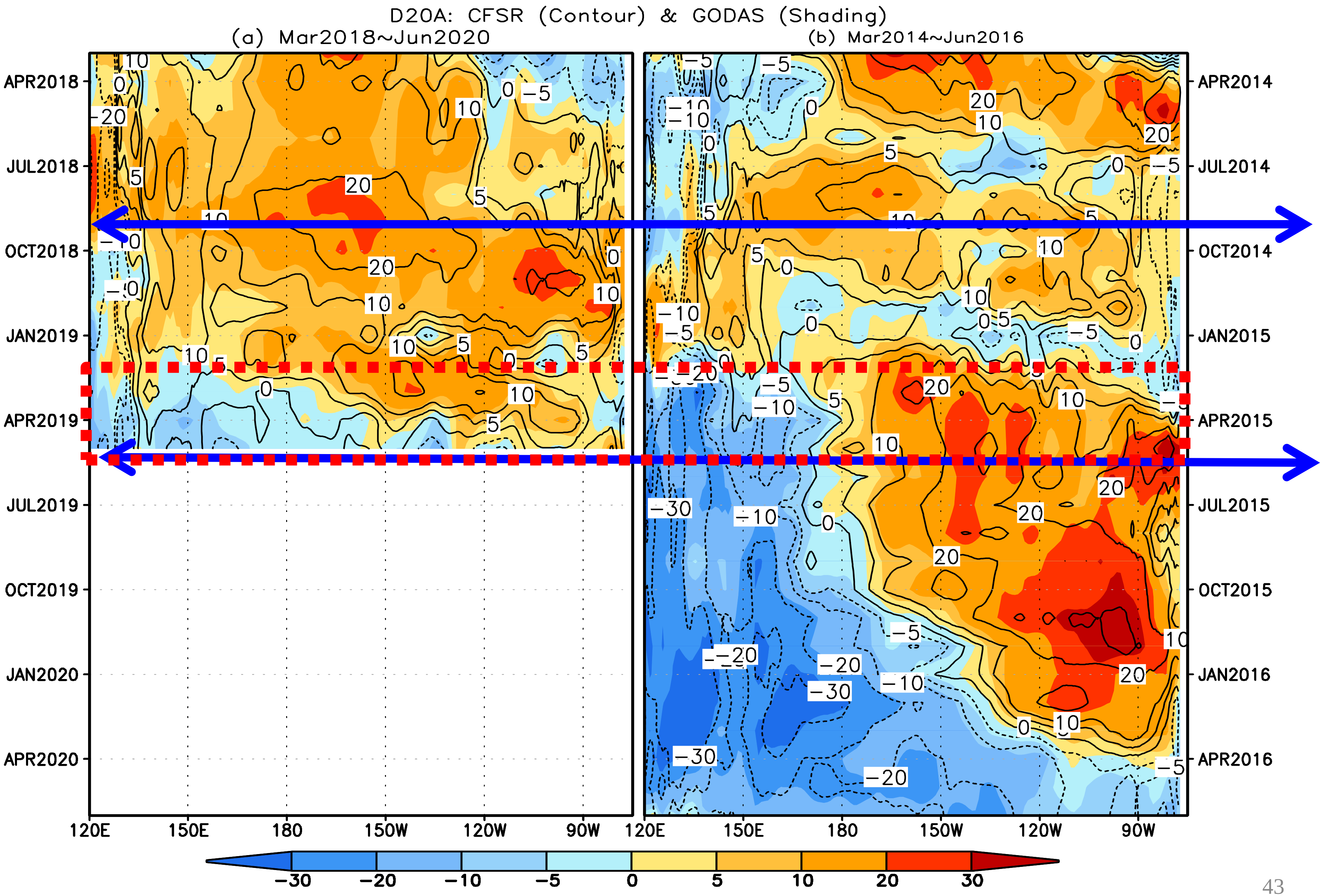
Provided by Yan Xue



SST Anomalies along the Equator

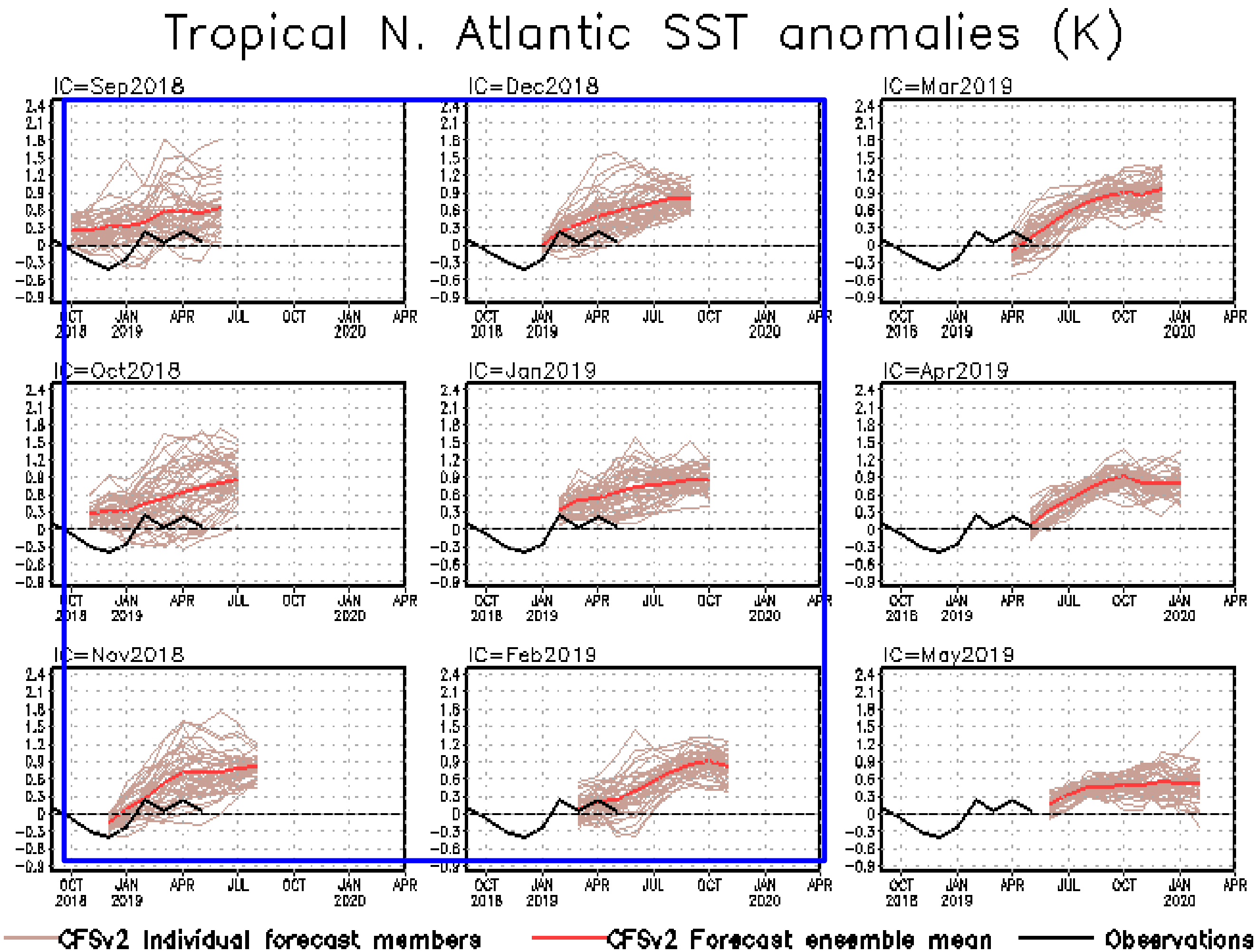


D20 Anomalies along the Equator



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

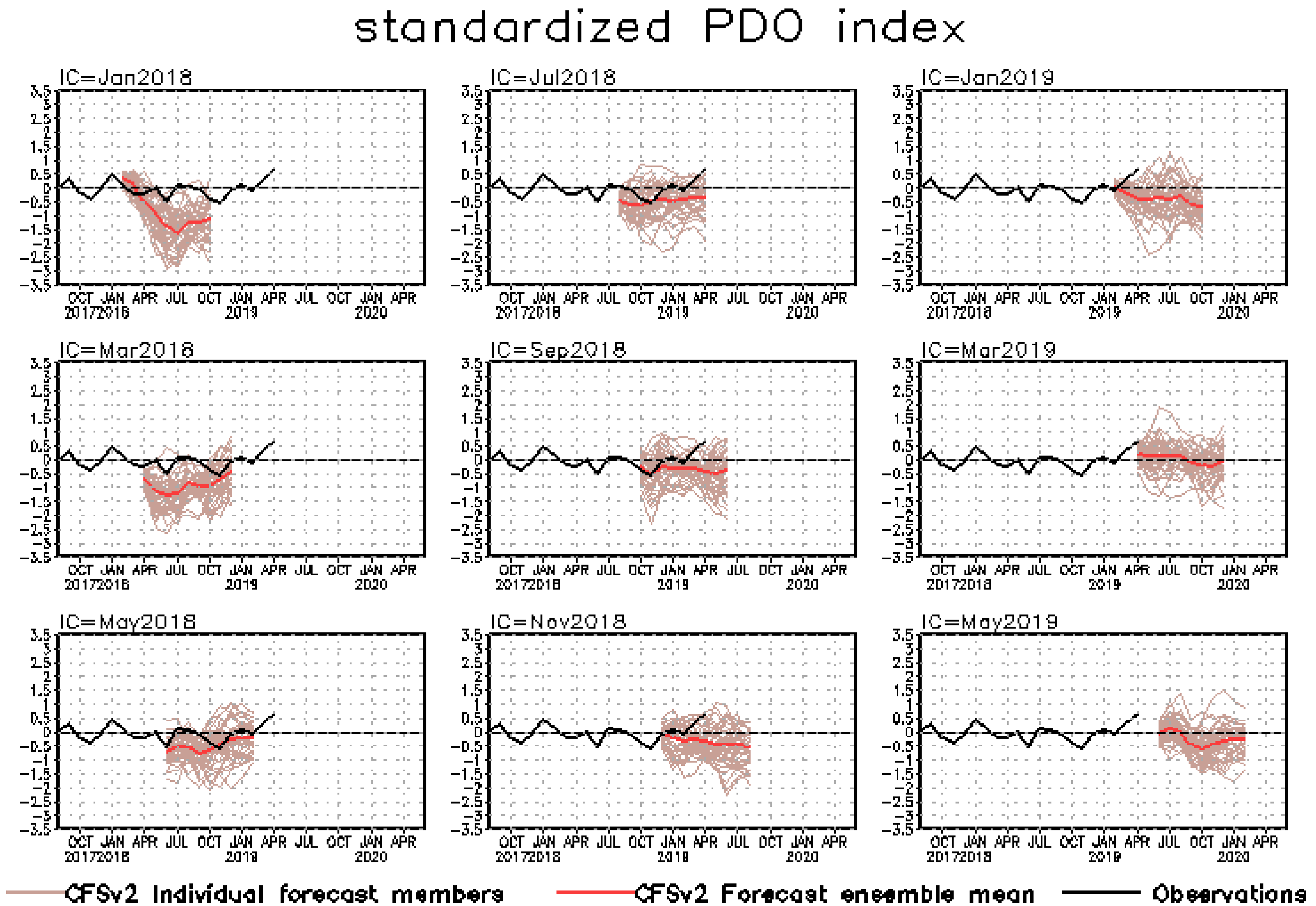
TNA is the SST anomaly averaged in the region of [60°W-30°W, 5°N-20°N].



- **Predictions had warm biases for ICs in Sep 2018-Feb 2019.**
- **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.

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



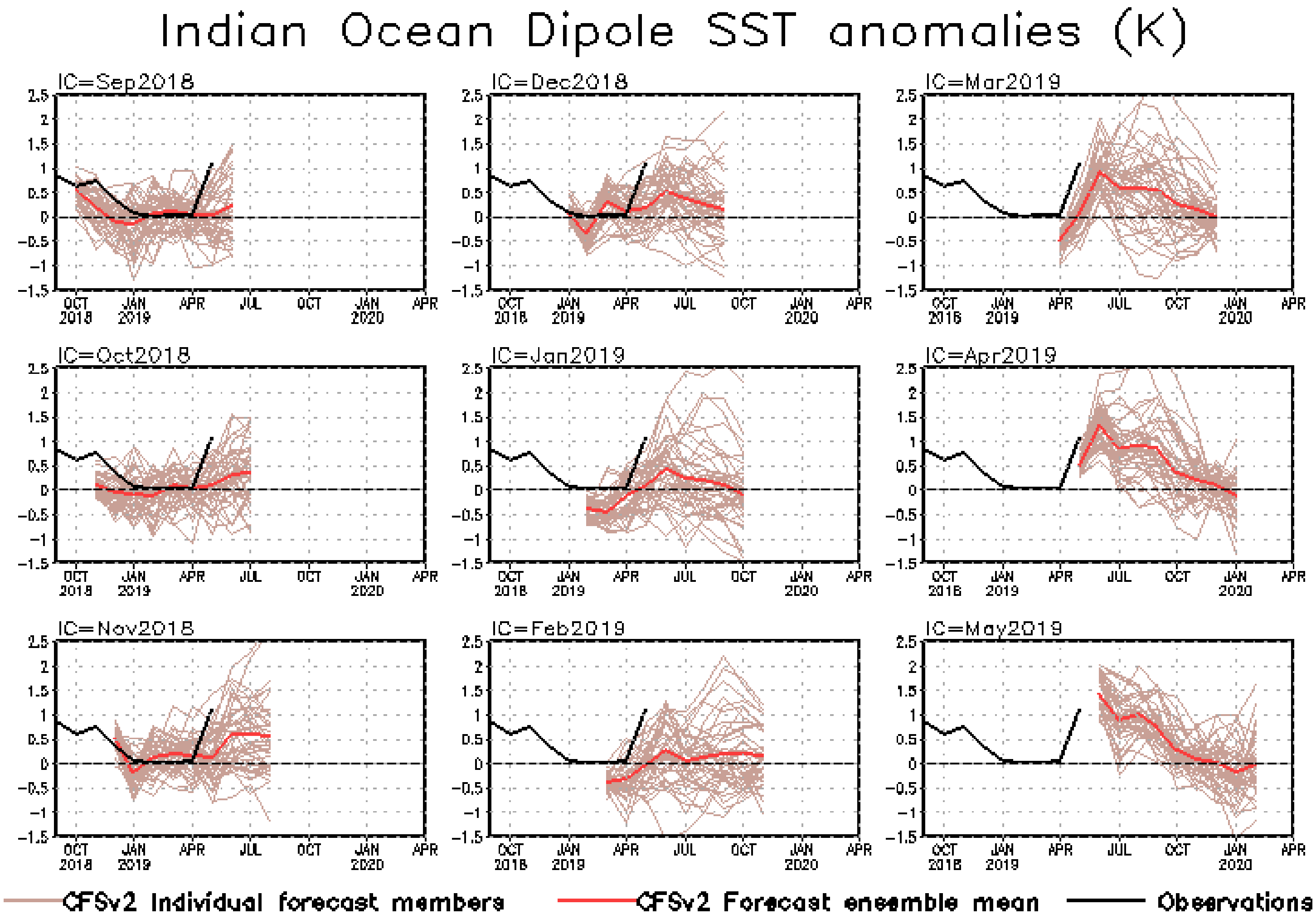
PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N].

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



MI = WTIO- SETIO

ETIO = SST anomaly in
90ºE-110ºE, 10ºS-0]

/TIO = SST anomaly in
50ºE-70ºE, 10ºS-10ºN]

- 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.

Acknowledgements

- Drs. Caihong Wen, Yan Xue, 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. Emily Becker provided the NMME NINO3.4 plot

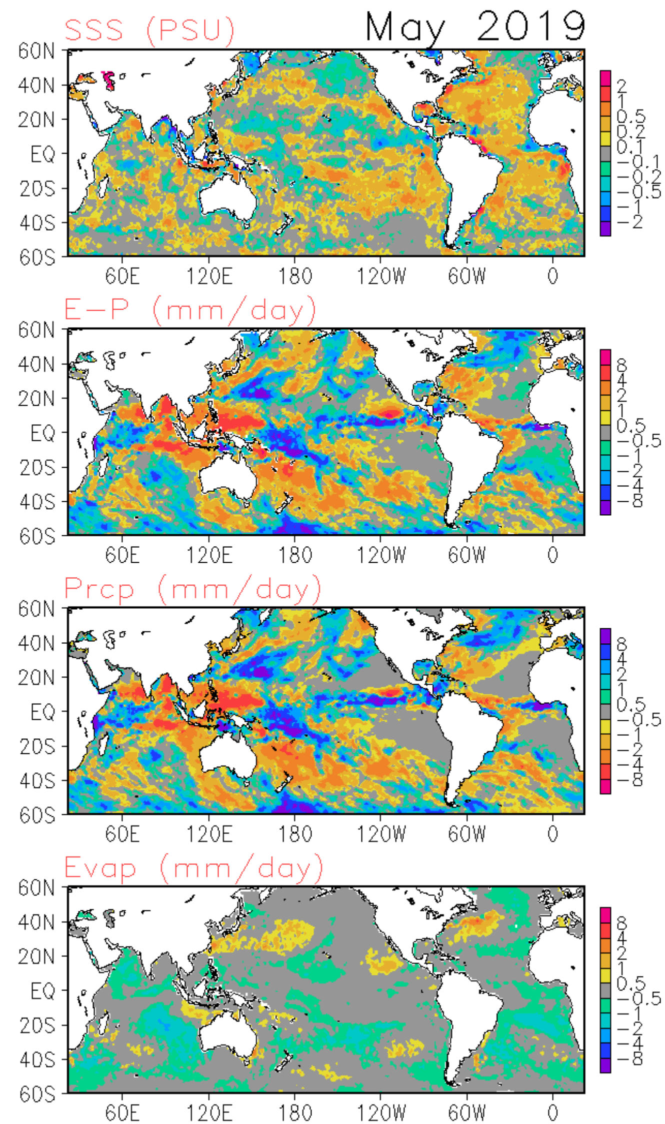
- Dr. Wanqiu Wang maintained the CFSv2 forecast achieve

Backup Slides

Global Sea Surface Salinity (SSS)

Anomaly for May 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: There is no SMAP SSS available in July 2018**
- In the equatorial Pacific ITCZ region, negative SSS anomalies are persistent and co-incident with increased precipitation. Negative SSS anomalies also appear in the equatorial Pacific SPCZ region. A significant negative SSS signal showed in the eastern Equatorial pacific region. A large scale of negative SSS signal in the Northeast pacific region continues, which is accompanied with heavier precipitation in some regions. Meanwhile, in the Sea of Okhotsk, negative SSS anomalies is co-incident with increased precipitation.

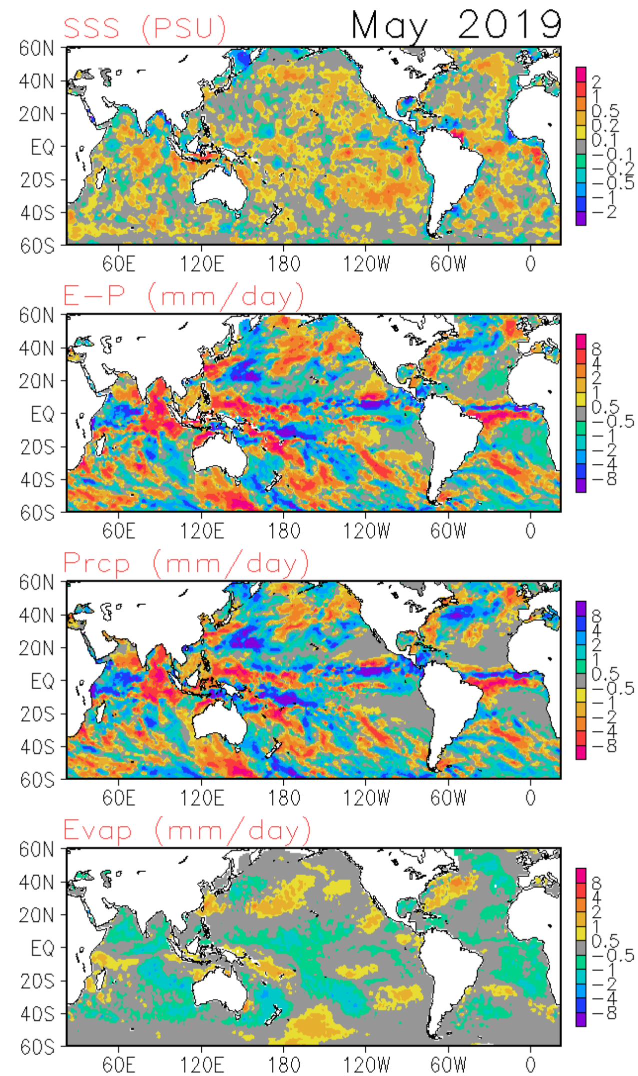


- **Data used**

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 May 2019



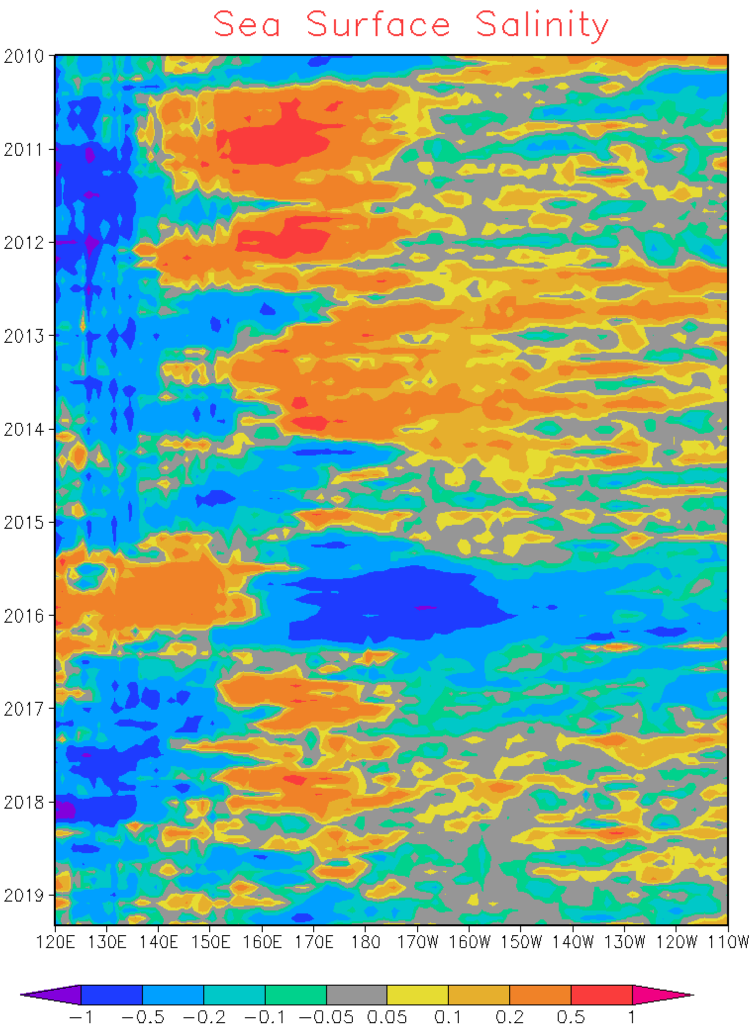
Compared with last month, the SSS decreased in the Equatorial Pacific region, particularly the eastern basin. Such SSS decreasing is likely caused by increasing precipitation. The SSS continues increasing between equator and 40ºN in both Pacific and Atlantic ocean, particularly in the east basin. The SSS significantly decreases in the Sea of Okhotsk, which is likely 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.

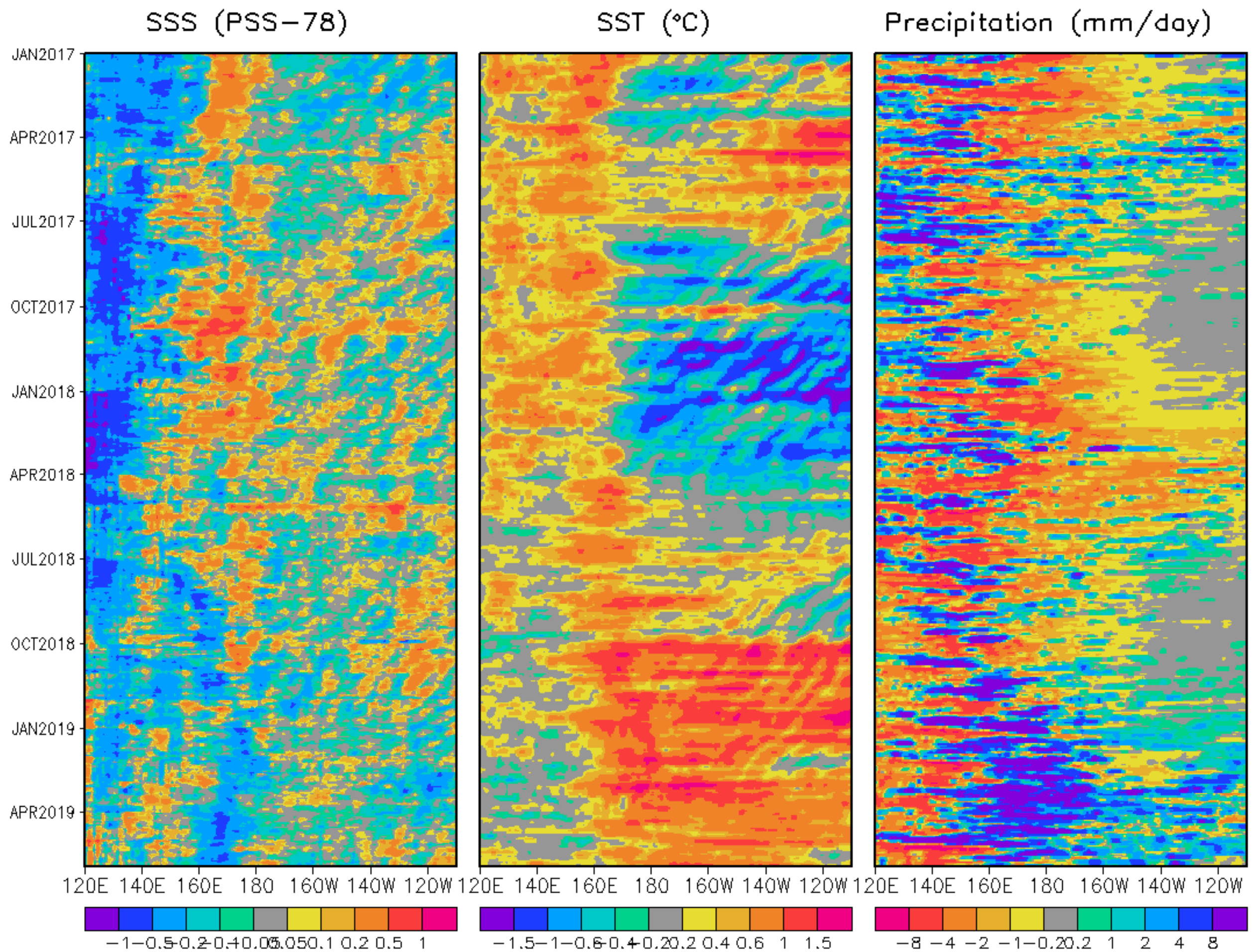
- Hovemoller diagram for equatorial SSS anomaly **(5˚S-5˚N);**
- In the equatorial Pacific Ocean, the positive SSS signal becomes weaker or neutral from 140°E to 160°E, the SSS shows negative anomalies east of 160°E and the negative signal is stronger between 160°E and dateline.



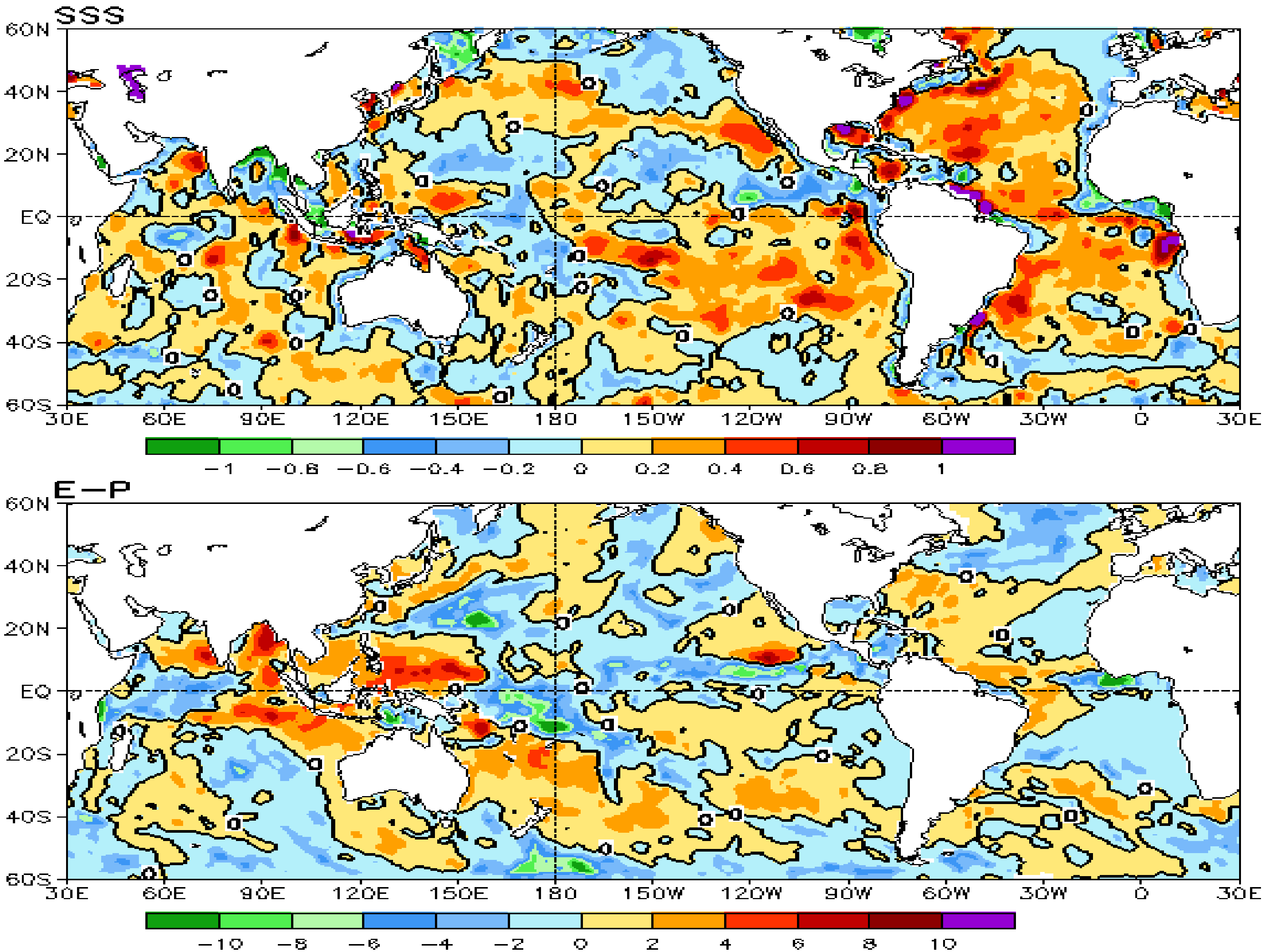
Global Sea Surface Salinity (SSS)

Anomaly Evolution over N. of Equatorial Pacific from Pentad SSS

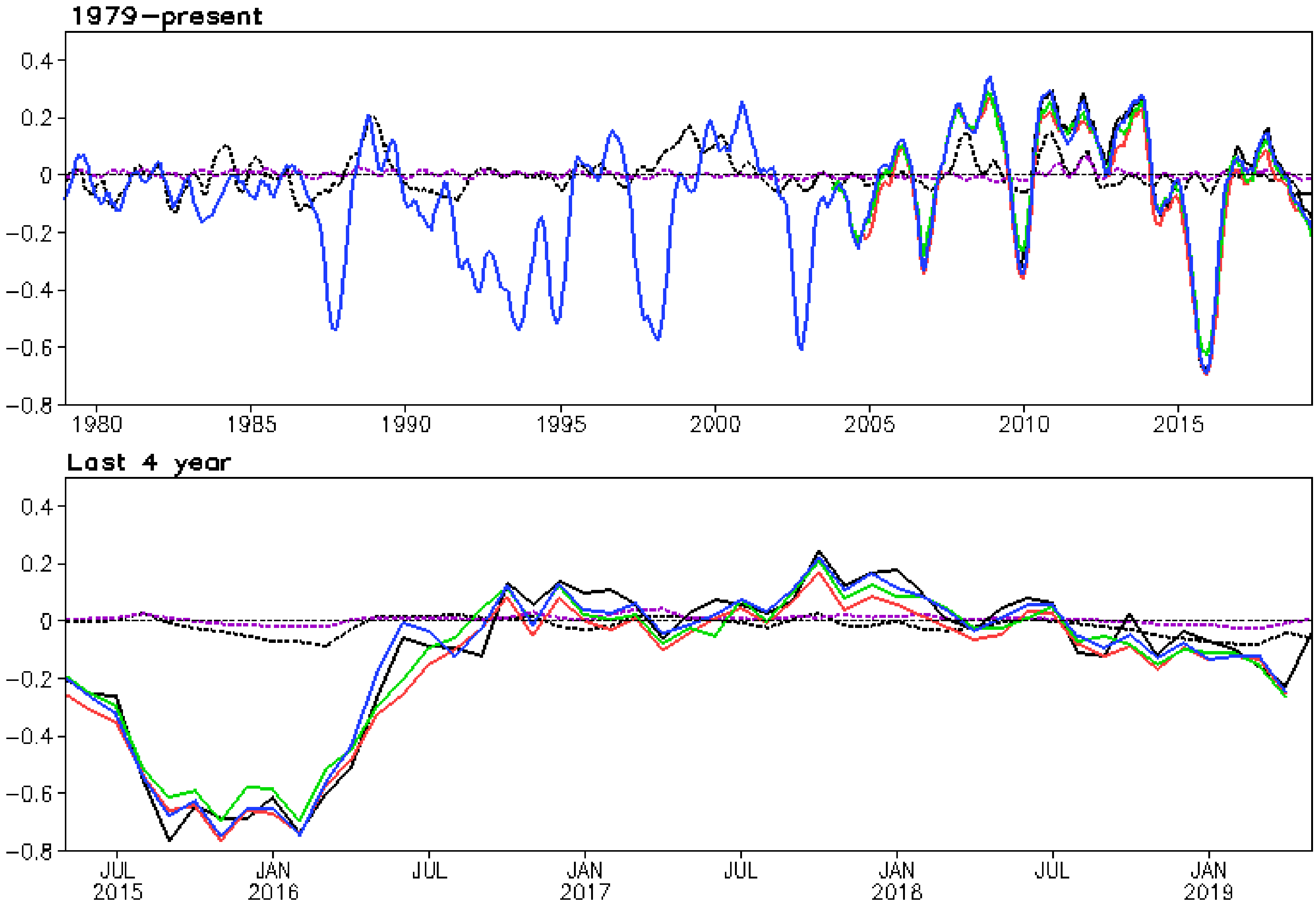
Figure caption:
Hovemoller diagram for equatorial (5˚S-5˚N) 5-day mean SSS, SST and precipitation anomalies. The climatology for SSS is Levitus 1994 climatology. The SST data used here is the OISST V2 AVHRR only daily dataset with its climatology being calculated from 1985 to 2010. The precipitation data used here is the adjusted CMORPH dataset with its climatology being calculated from 1999 to 2013.



MAY 2019 SSS Anomaly (PSU) & E−P Anomaly (mm/day)



SSS Anom. in [160E-160W, 5S-5N] (PSU), Levitus Clim
GODAS (dash black), CFSR (dash purple), BASS (solid black)
IPRC (red), SCRIPPS (green), EN4.2.1 (blue)



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

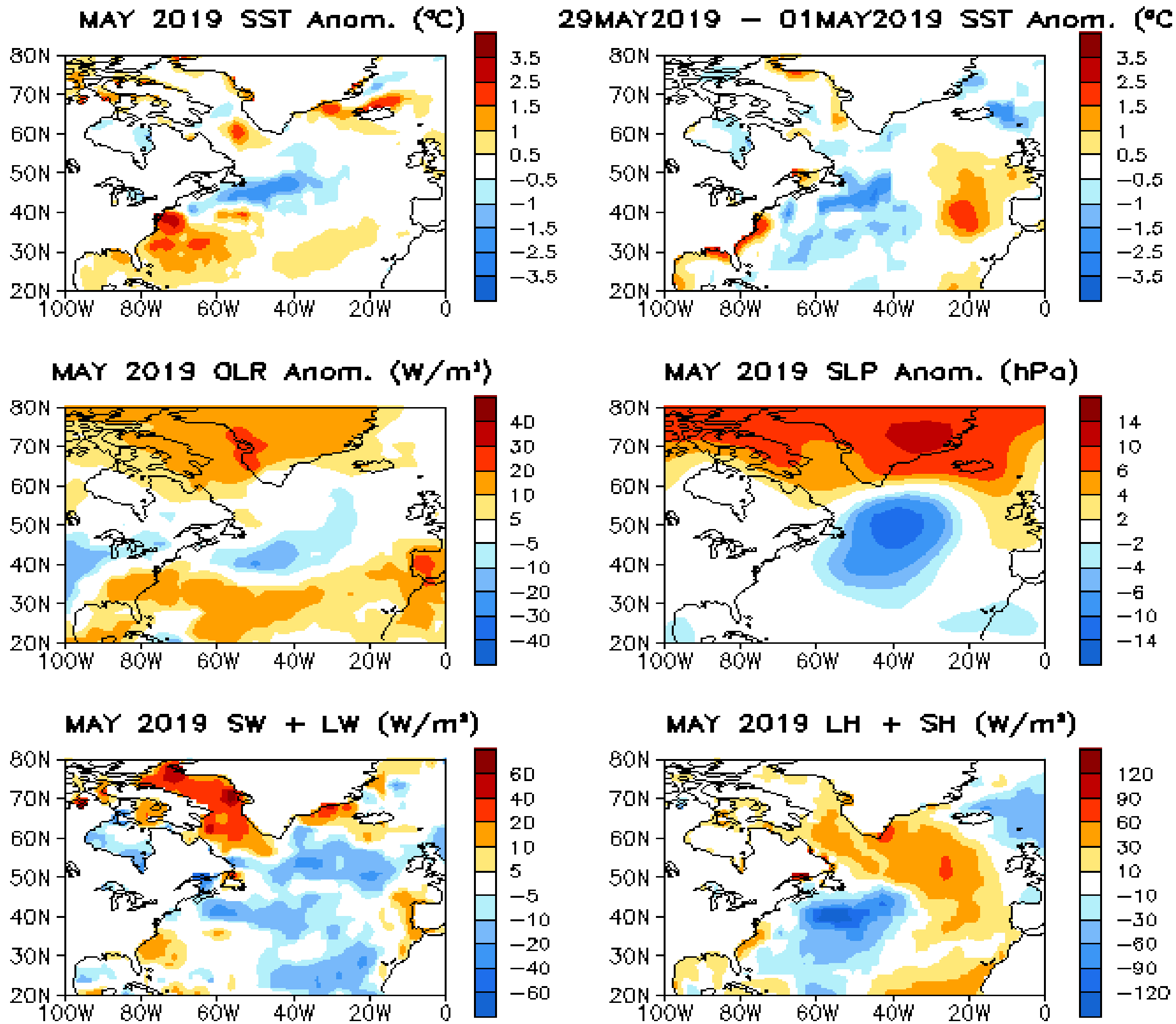
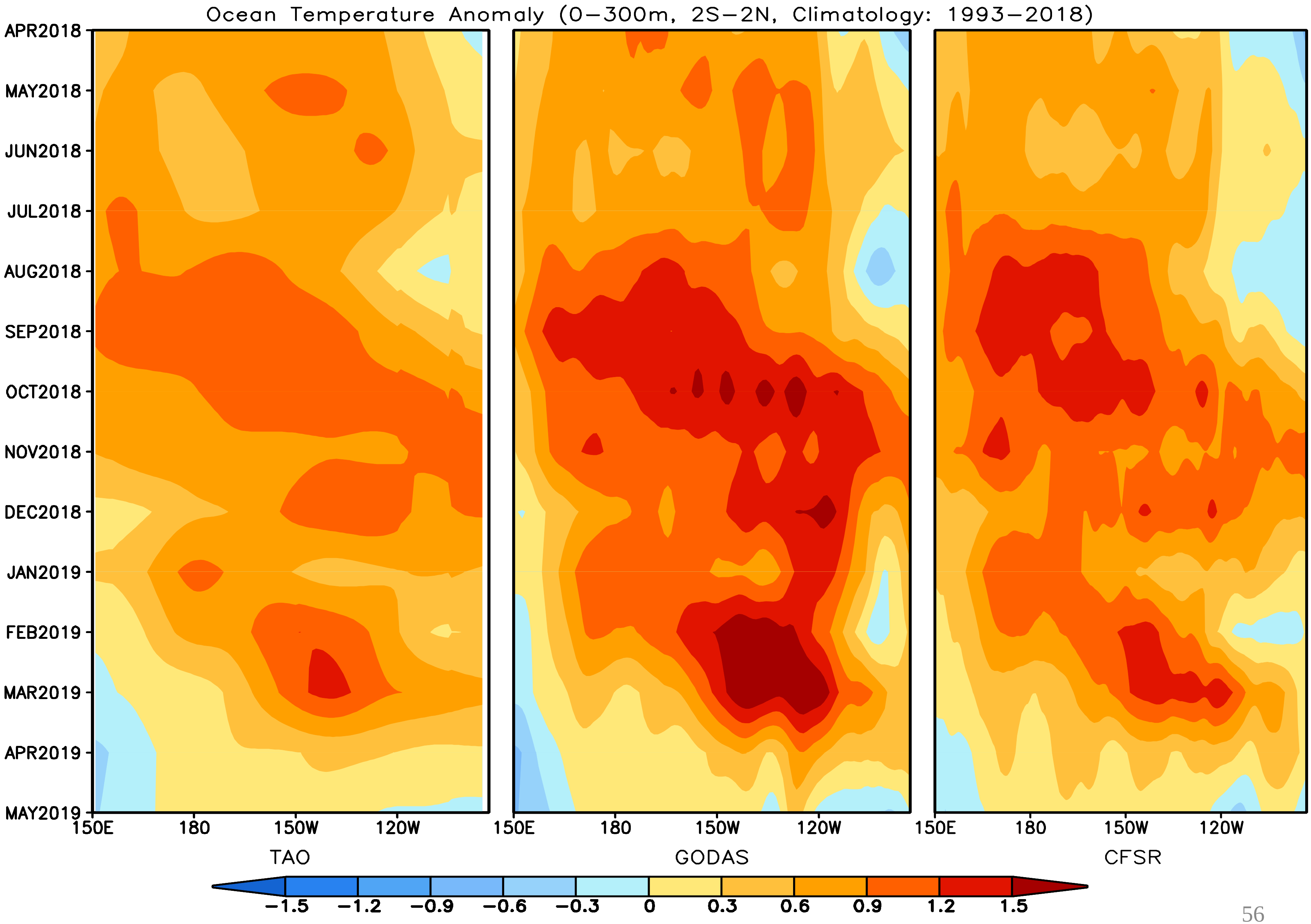


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

H300A: TAO, GODAS, CFSR



Data Sources and References

(climatology is for 1981-2010)

- **Weekly Optimal Interpolation SST (OI SST) version 2 (Reynolds et al. 2002)**
- **Extended Reconstructed Sea Surface Temperature (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**
- **NCEP's Global Ocean Data Assimilation System 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 reanalyses from Real-time 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

Please send your comments and suggestions to Yan.Xue@noaa.gov. Thanks!