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

Prepared by

Climate Prediction Center, NCEP/NOAA

April 10, 2020

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

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

Outline

- **Overview**
- **Recent highlights**
  - **Pacific/Arctic Ocean**
  - **Indian Ocean**
  - **Atlantic Ocean**
- **Global SSTA Predictions**
- ***Overshooting of ENSO Forecast in CFSv2***

Overview

Pacific Ocean

- **<u>NOAA "ENSO Diagnostic Discussion" on 9 Apr 2020 stated "*ENSO-neutral is favored for the Northern Hemisphere summer 2020 (~60% chance), remaining the most likely outcome through autumn.*"</u>**
- **ENSO neutral conditions persisted, and positive SSTAs were still present in the central tropical Pacific with NINO3.4=0.56^{o}C in Mar 2020.**
- **Positive SSTAs further weakened in the NE. Pacific in Mar 2020. The PDO index was negative with PDOI= -0.93 in Mar 2020.**
- **Sea ice extent in the Arctic Ocean in Mar 2020 was the 11th lowest March extent in the satellite record.**

Indian Ocean

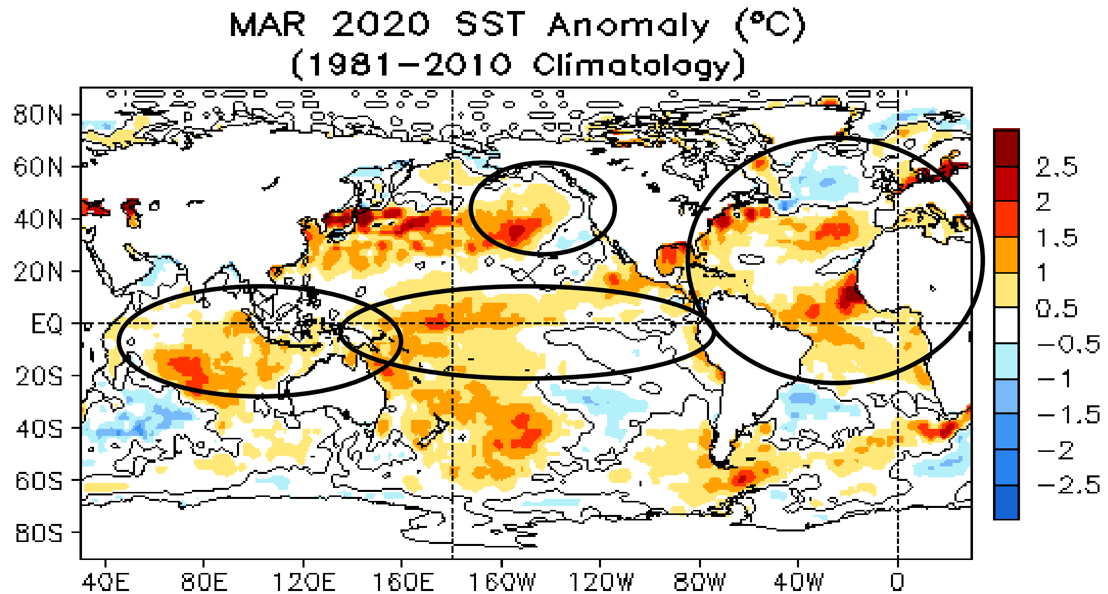
- **SSTAs were positive in the entire tropical Indian Ocean.**
- **The positive phase of IOD peaked in Oct-Nov 2019 and IOD switched to the negative phase since Feb 2020.**

Atlantic Ocean

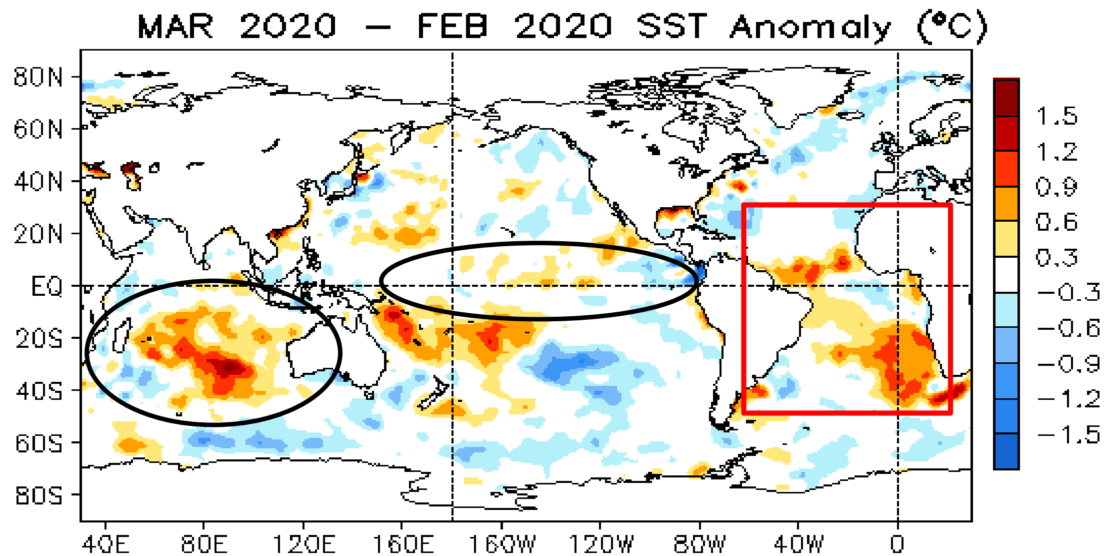
- **ATL3 (Atlantic Nino) weakened since Jan 2020 with ATL3=0.55 in Mar 2020.**
- **NAO was in a positive phase since Nov 2019 with NAOI= 0.66 in Mar 2020.**
- **SSTAs were a tripole/horseshoe pattern with positive anomalies in the middle latitudes of N. Atlantic during 2013-2019.**

Global Oceans

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



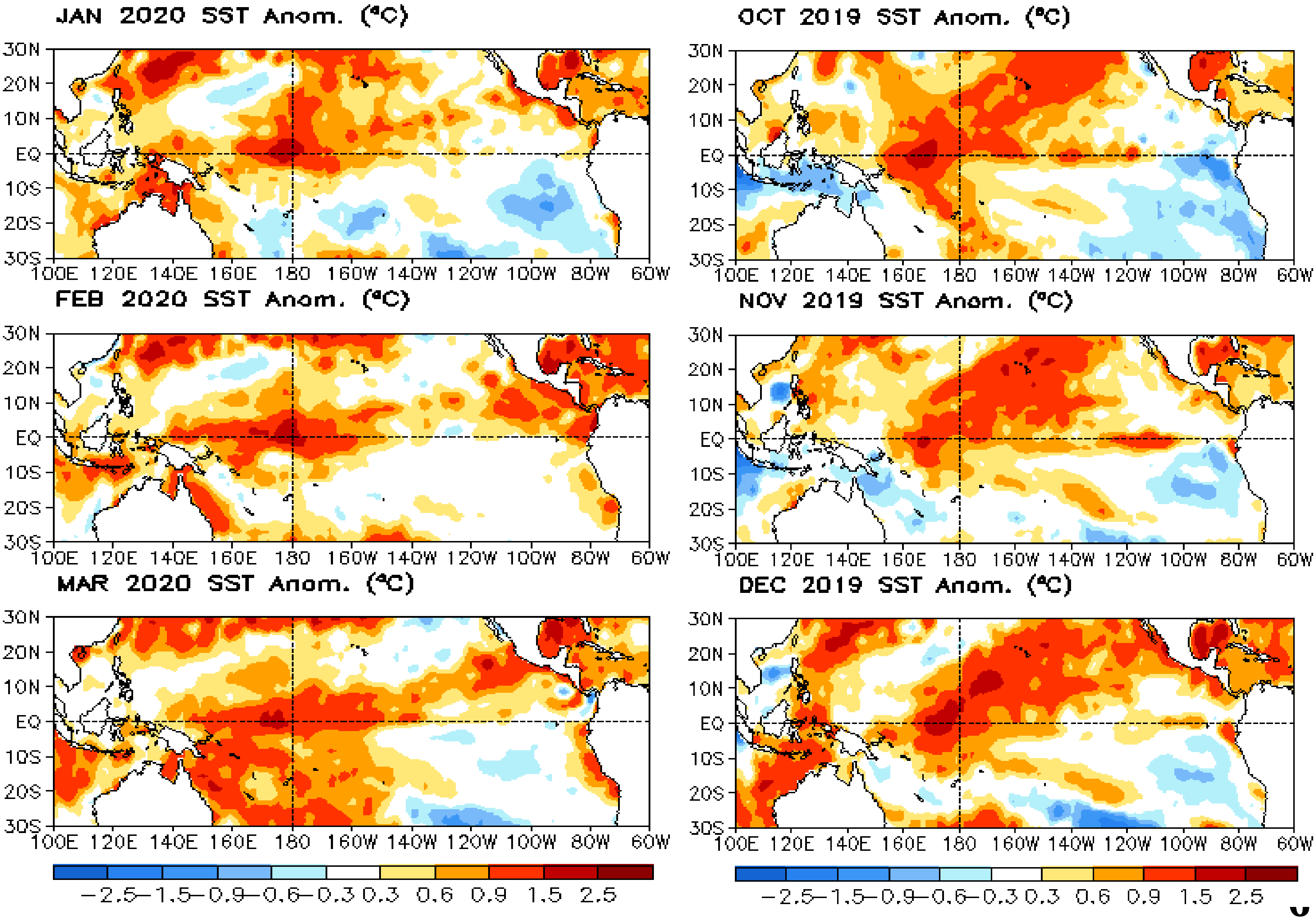
- **Positive SSTAs persisted in the central tropical Pacific.**
- **Positive SSTAs further weakened in the NE Pacific (Blob.2).**
- **Tripole-like SSTAs were observed in the North Atlantic and positive SSTAs in the tropical Atlantic weakened.**
- **Weak positive SSTAs presented in the tropical Indian Ocean.**

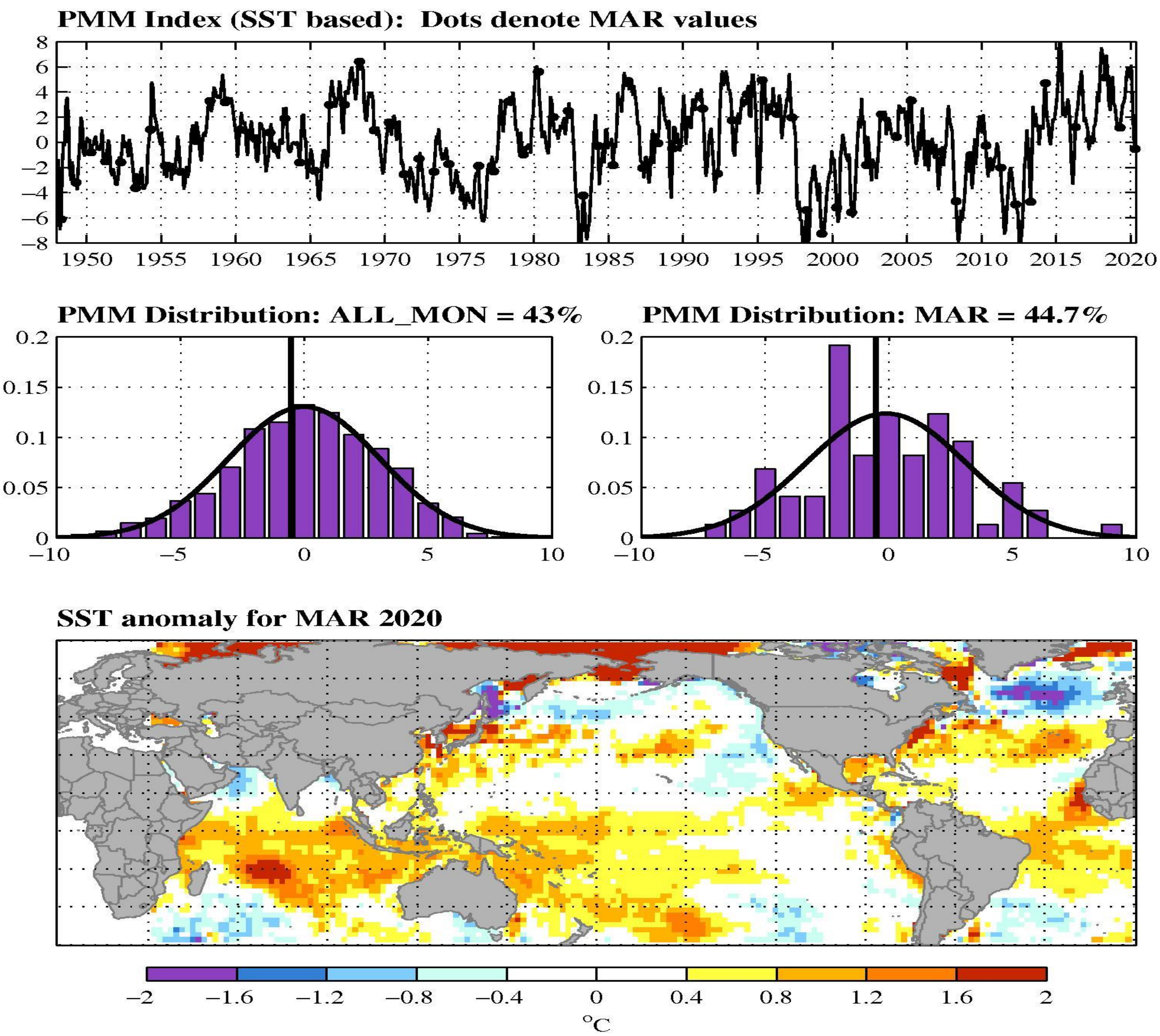


- **SSTA tendencies were small in the tropical Pacific.**
- **Large positive SSTA tendencies were in the southern Indian Ocean.**
- **Strong warming tendency presented in the SE Atlantic Ocean.**

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)

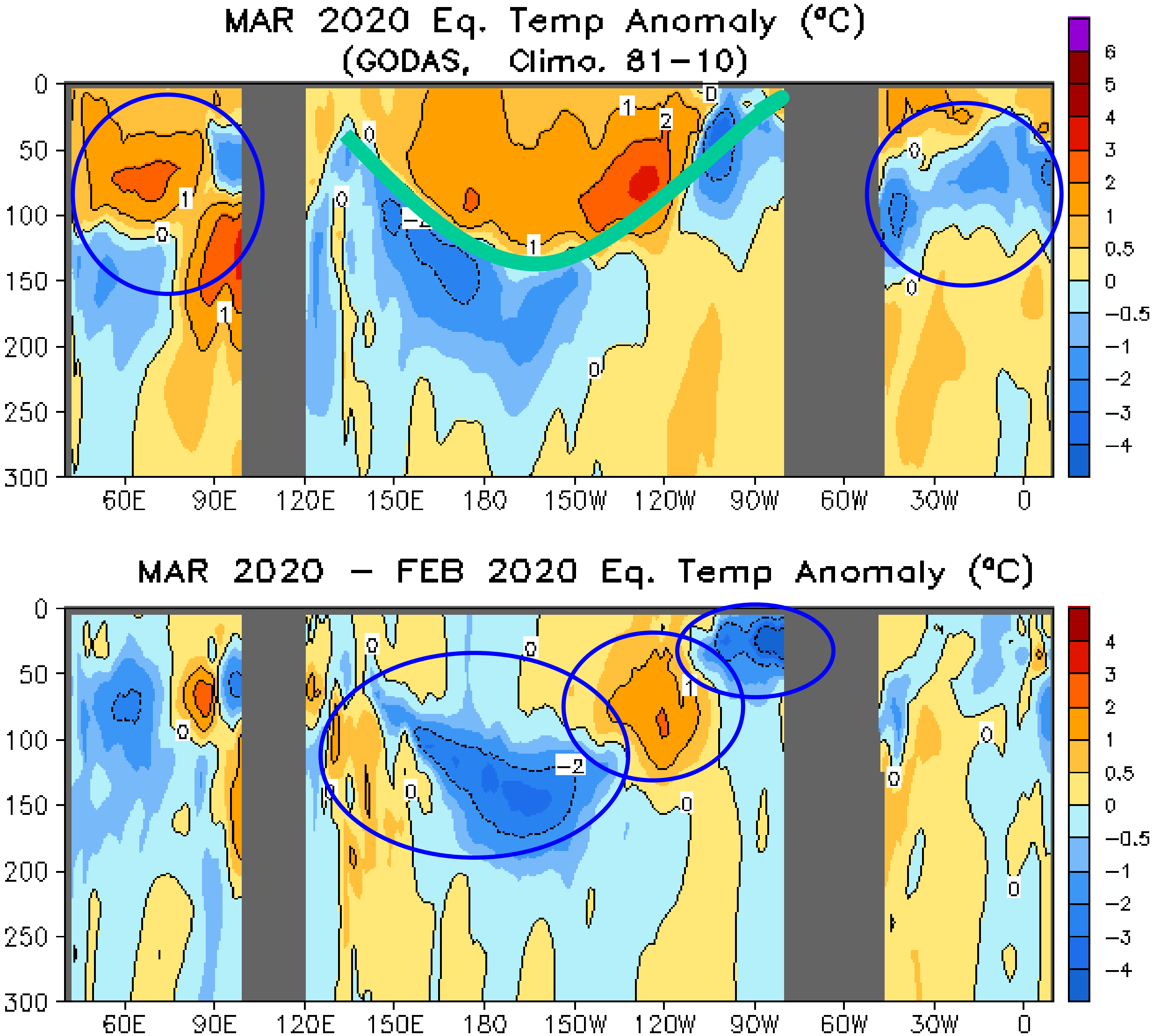




PMM was in a neutral phase.

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

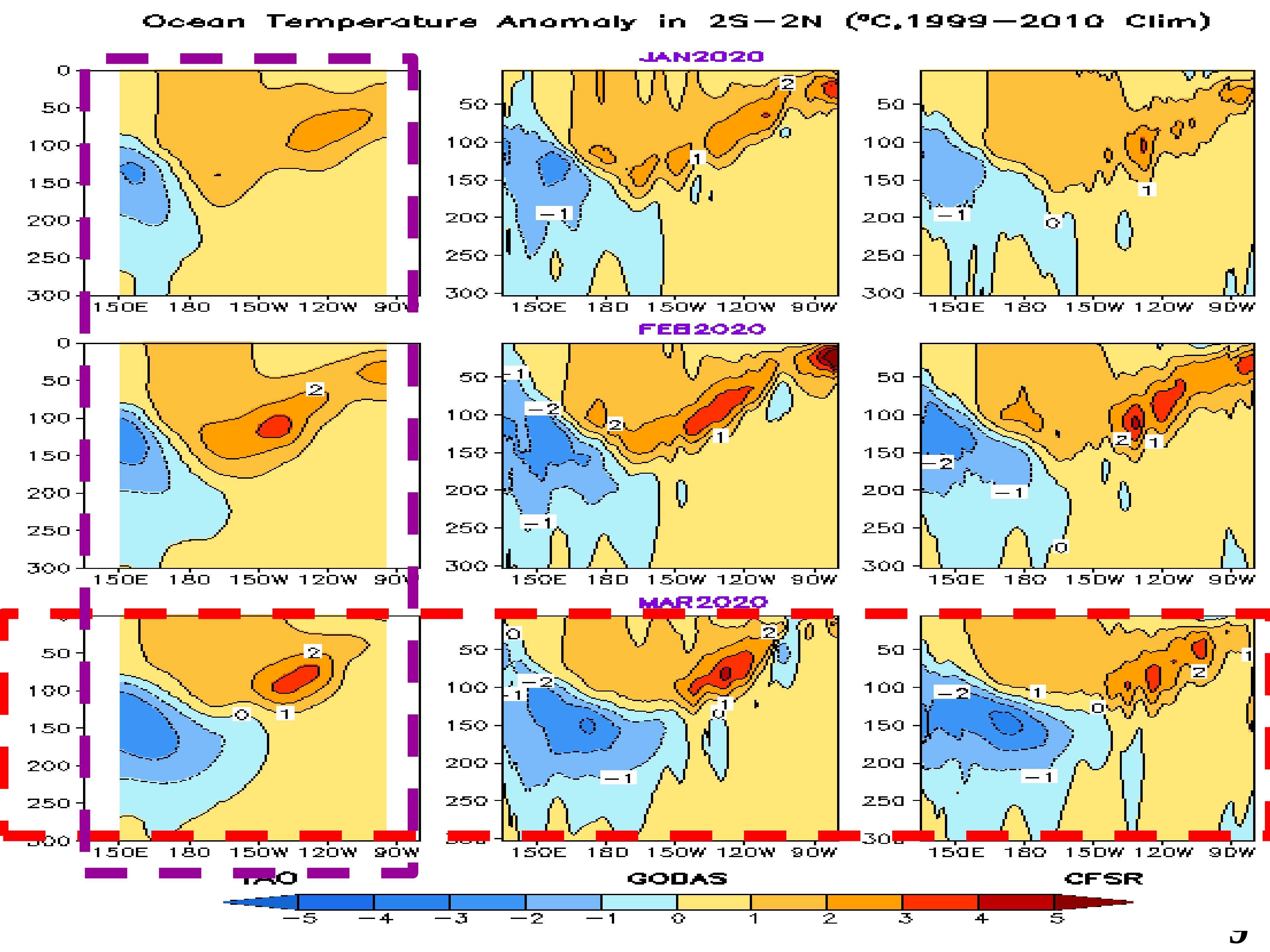
Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2^{O}S-2^{O}N



- **Positive (negative) ocean temperature anomalies presented in the upper-(lower-) layer in the tropical Pacific.**
- **Positive (negative) anomaly was observed in the western (far-eastern) Indian Ocean.**
- **Negative anomaly presented along the thermocline of the Atlantic Ocean.**

- **Negative anomalous ocean temperature tendencies were observed in the far-eastern and central Pacific, and positive ones were in the east-central Pacific.**

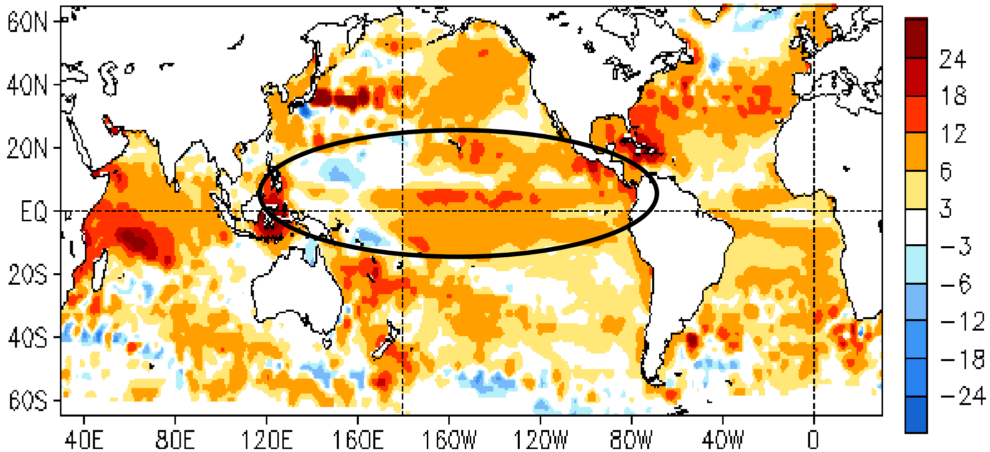
Fig. G3. Equatorial depth-longitude section of ocean temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP's global ocean data assimilation system which assimilates oceanic observations into an oceanic GCM. Anomalies are departures from the 1981-2010 base period means.



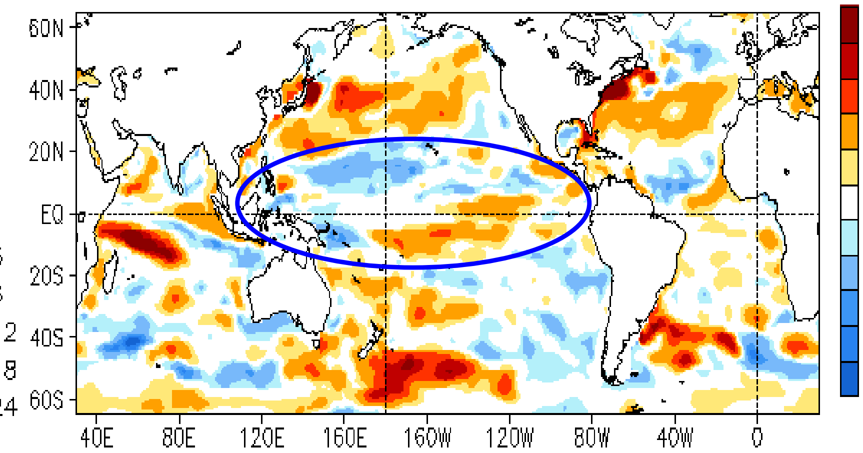
Ocean Temperature Anomaly in 2S-2N (°C,1999-2010 Clim)
JAN2020
FEB2020
MAR2020
TAO
GODAS
CFSR

Global SSH and HC300 Anomaly & Anomaly Tendency

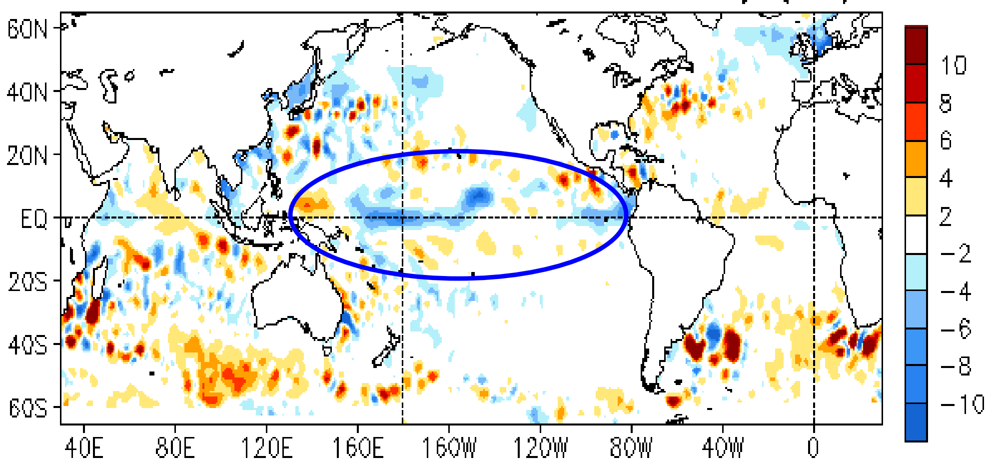
MAR 2020 SSH Anomaly (cm)
(AVISO Altimetry, Climo. 93-13)



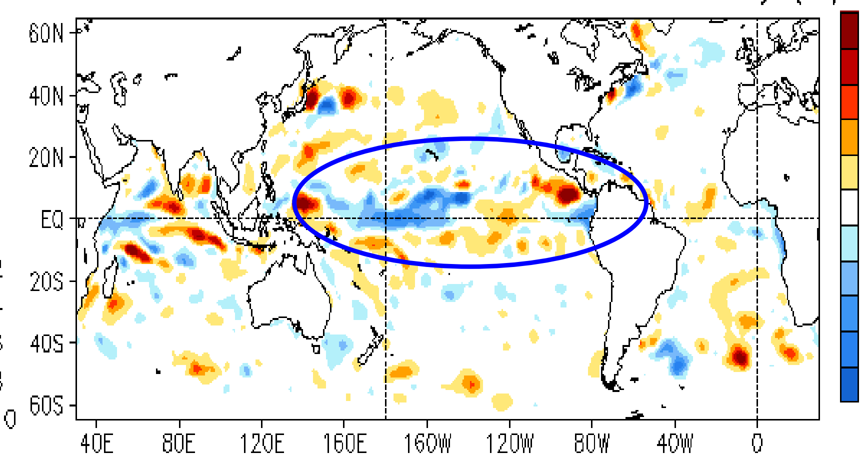
MAR 2020 Heat Content Anomaly (°C)
(GODAS, Climo. 81-10)



MAR 2020 - FEB 2020 SSH Anomaly (cm)



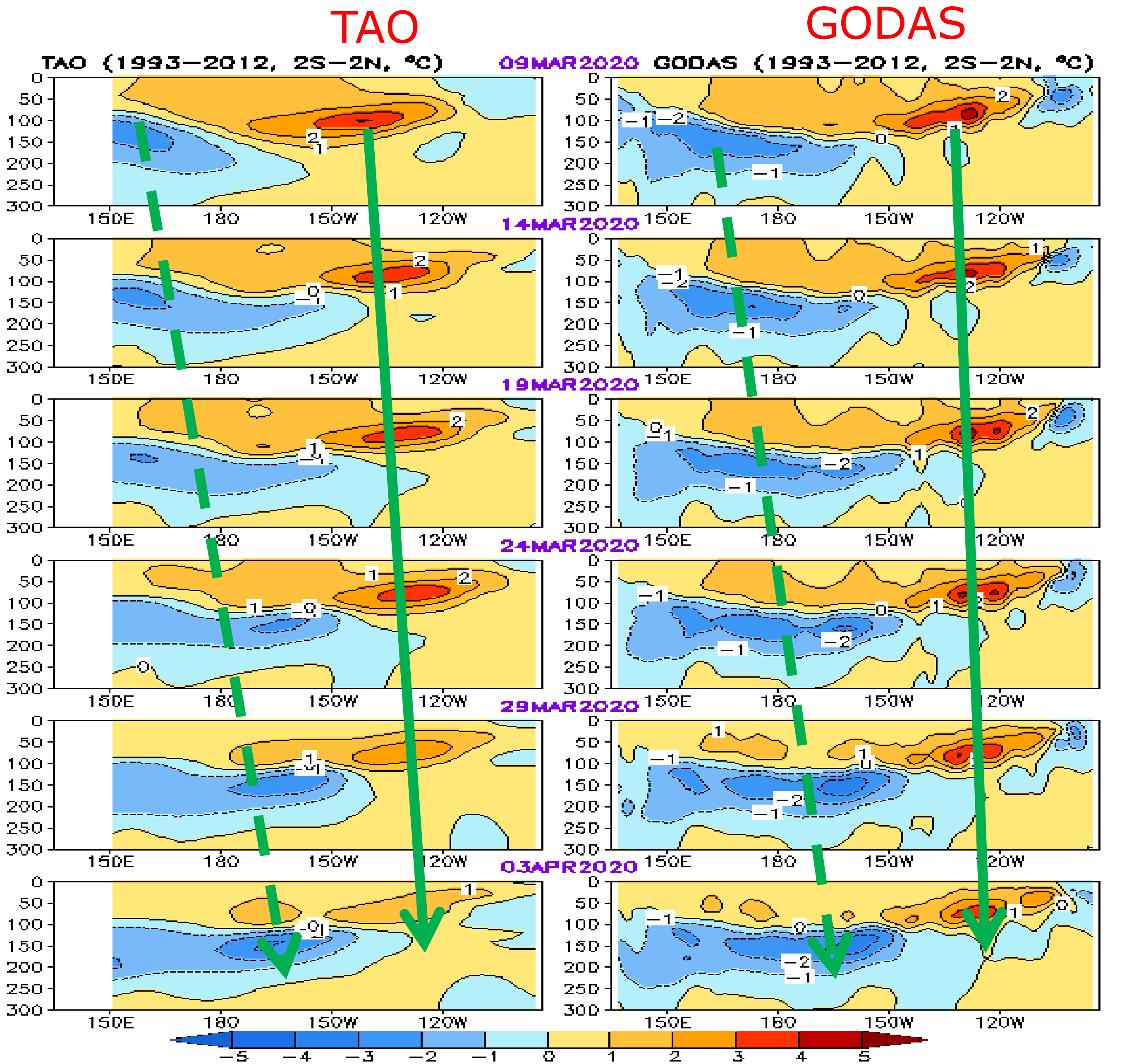
MAR 2020 - FEB 2020 Heat Content Anomaly (°C)



- **The SSHA pattern was generally consistent with the HC300A pattern, but there were many differences in details between them.**
- **Both SSHA and HC300A tendencies were negative in the central tropical Pacific, consistent with the tendencies of subsurface ocean temperature anomalies (Slides 8-9).**

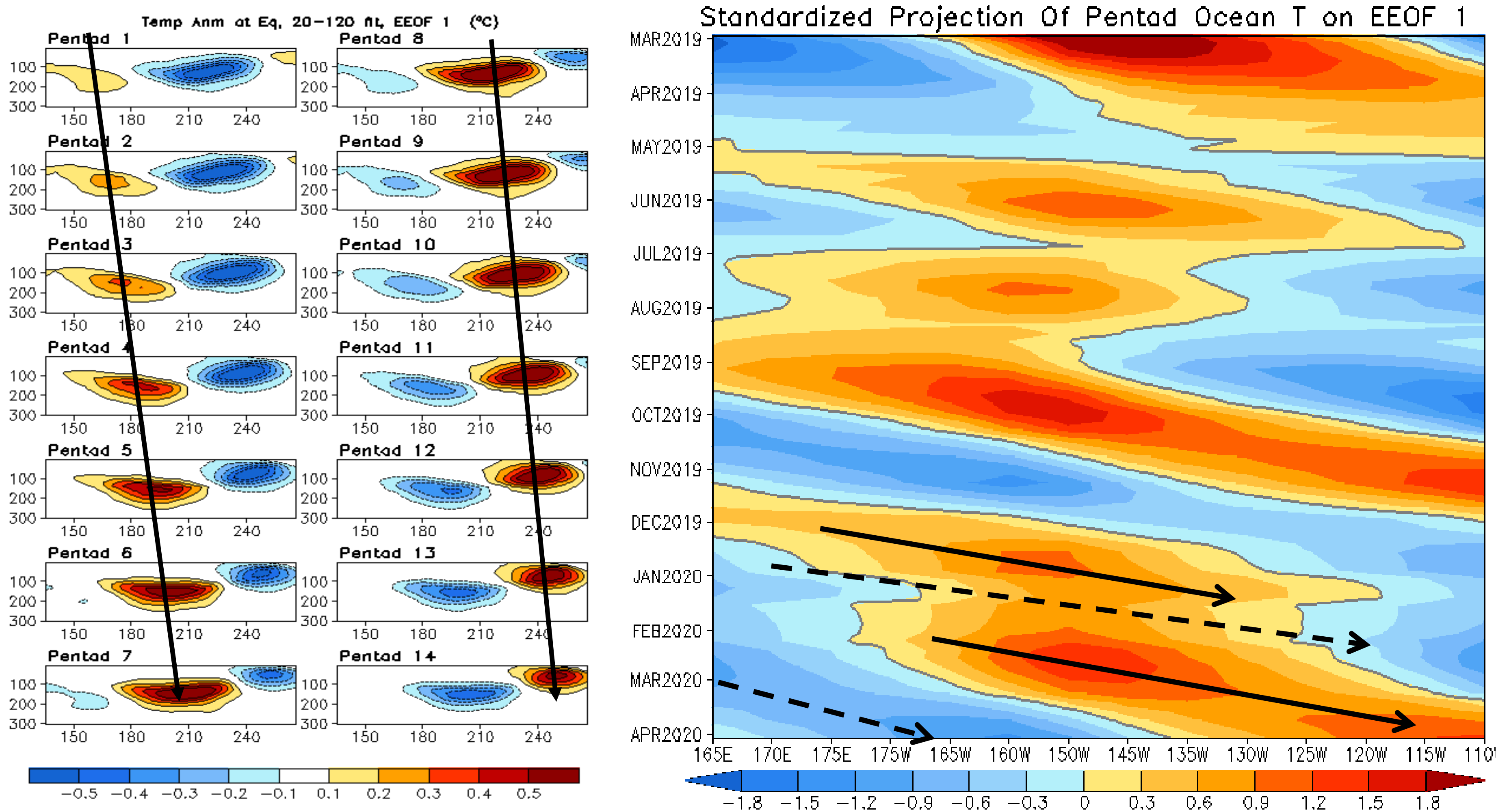
Tropical Pacific Ocean and ENSO Conditions

Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



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

Oceanic Kelvin Wave (OKW) Index

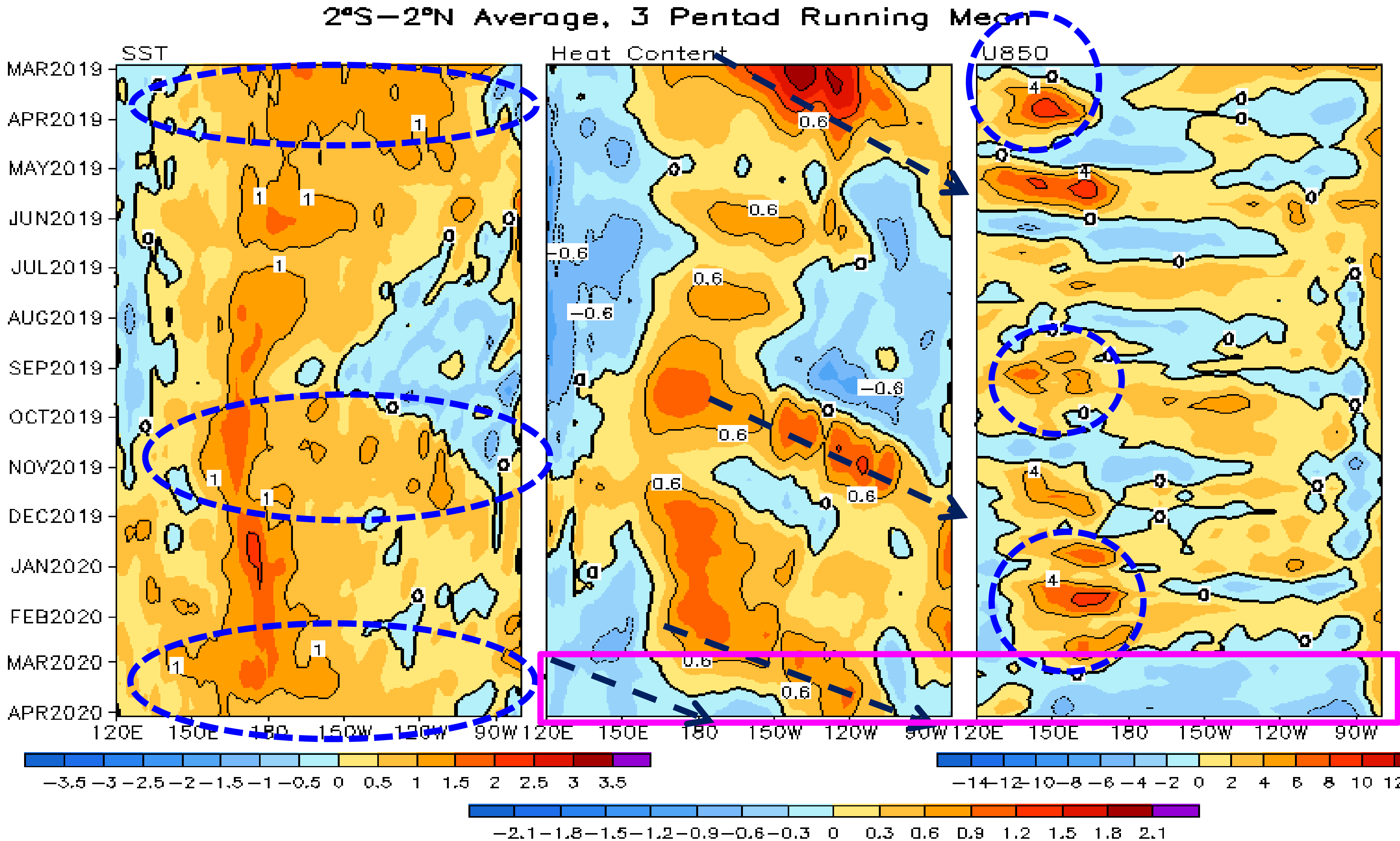


- A downwelling Kelvin wave presented from Nov 2019 and Jan 2020, leading to the increase of positive subsurface temperature anomalies in the central and eastern tropical Pacific.

- In Feb 2020, an upwelling Kelvin wave was initiated and propagated eastwards (slides 12 & 15).

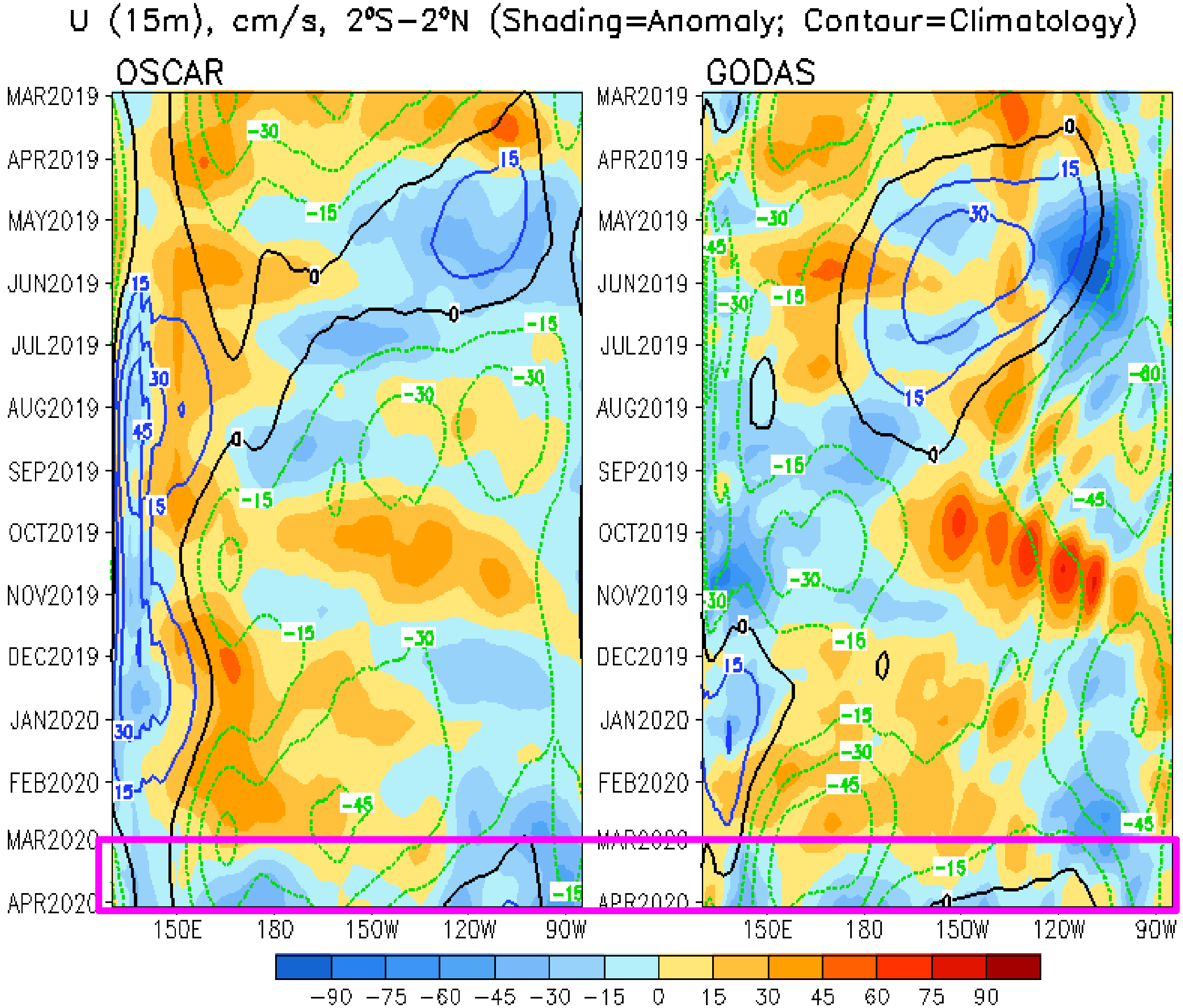
(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)

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



- **Positive SSTA in the entire Pacific persisted in the last month.**
- **Negative HC300A was observed in the central & western Pacific in Mar 2020.**
- **Easterly wind anomaly presented since mid-Mar 2020.**

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



- Anomalous westward currents were dominant in the equatorial Pacific since mid-Mar 2020 in both OSCAR and GODAS, consistent with easterly wind anomaly in the low atmosphere (next slide).

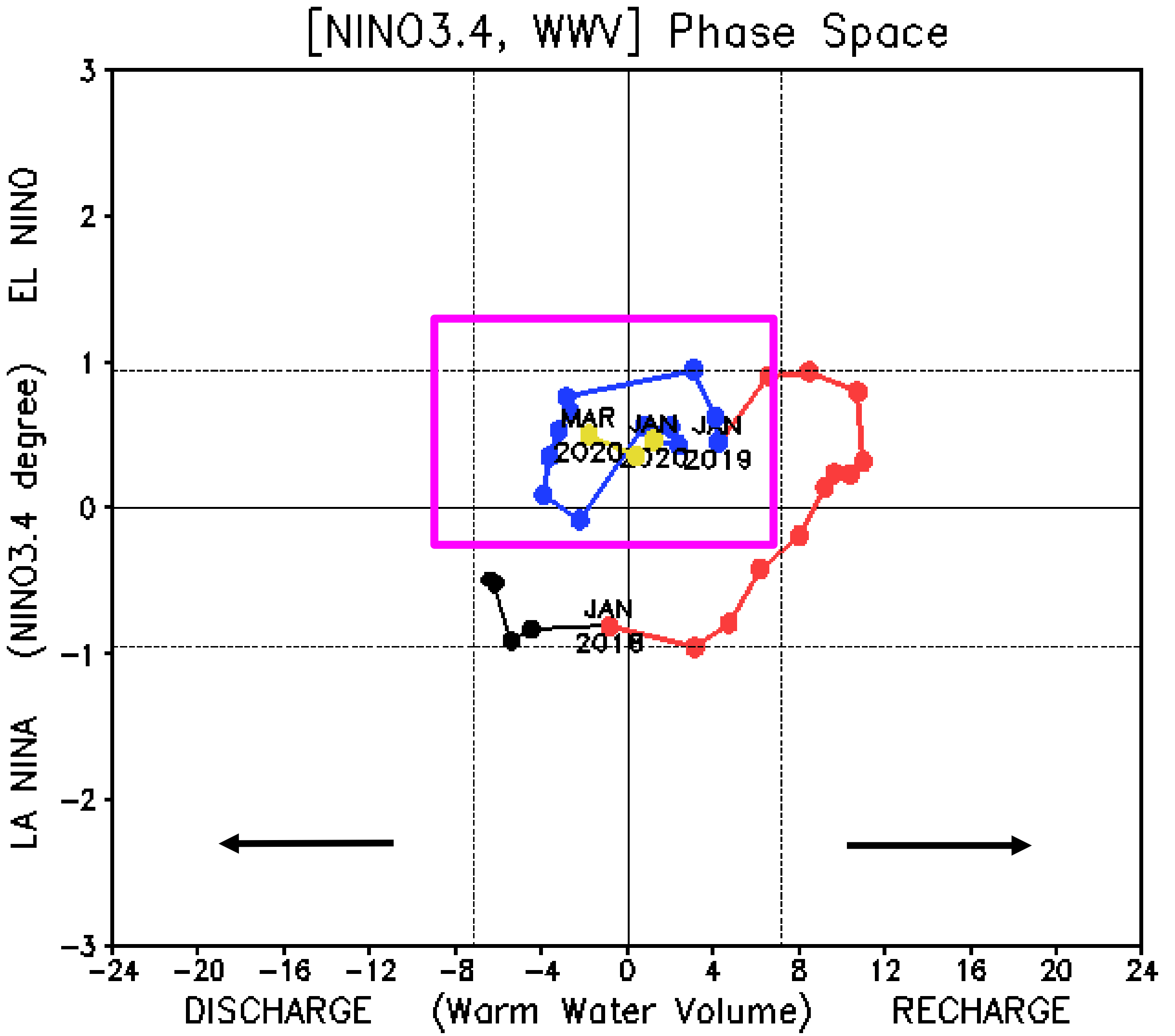
- The anomalous currents showed some differences between OSCAR and GODAS both in the anomalies and climatologies.

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).**

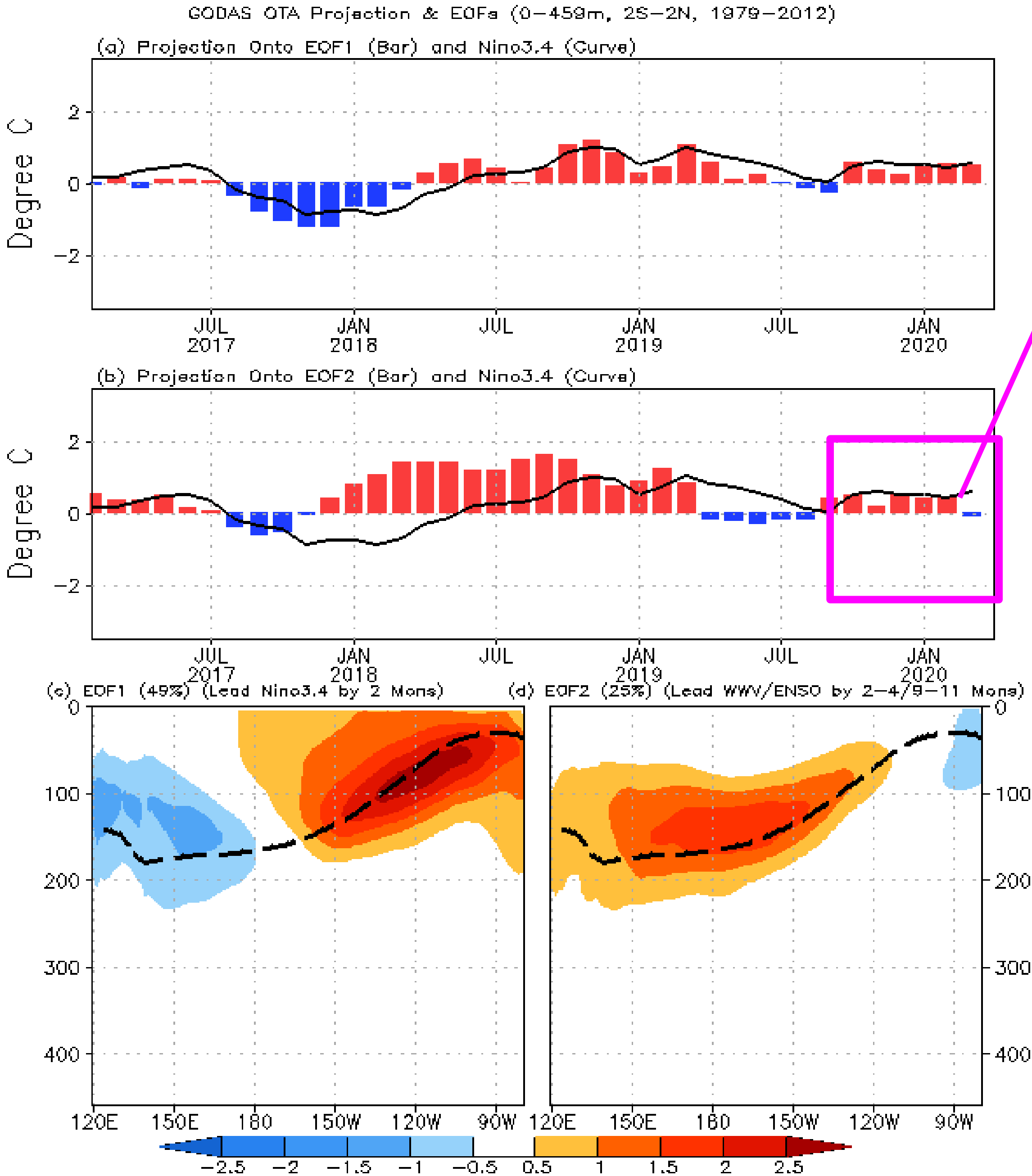
- **Since WWV is intimately linked to ENSO variability (Wyrtki 1985; Jin 1997), it is useful to monitor ENSO in a phase space of WWV and NINO3.4 (Kessler 2002).**

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



- **Equatorial Warm Water Volume (WWV) switched to a discharge phase in Mar 2020.**

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: The equatorial Pacific switched to a discharge phase since Mar 2020.

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).

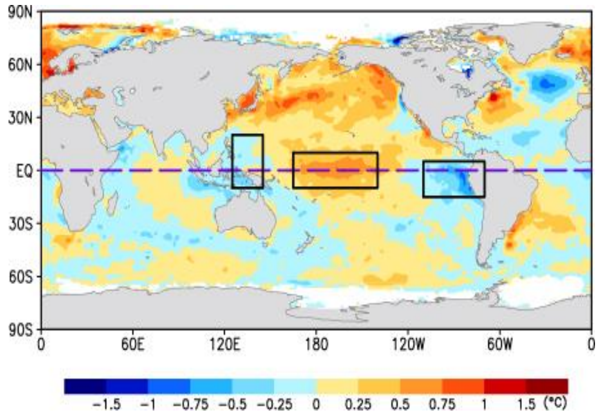
Recharge process: heat transport from outside of equator to equator : Negative -> positive phase of ENSO

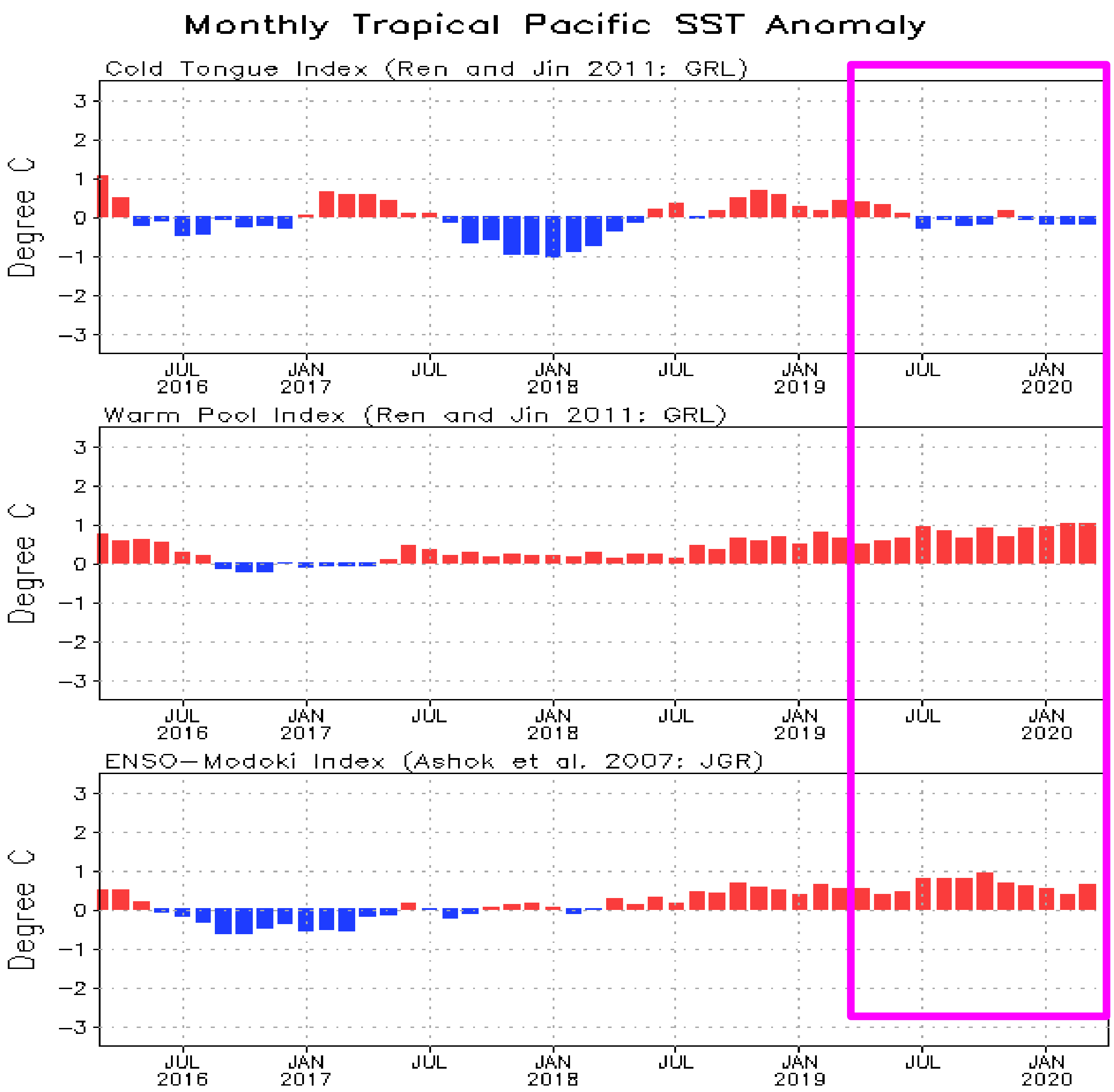
Discharge process: heat transport from equator to outside of equator: Positive -> Negative phase of ENSO

For details, see:

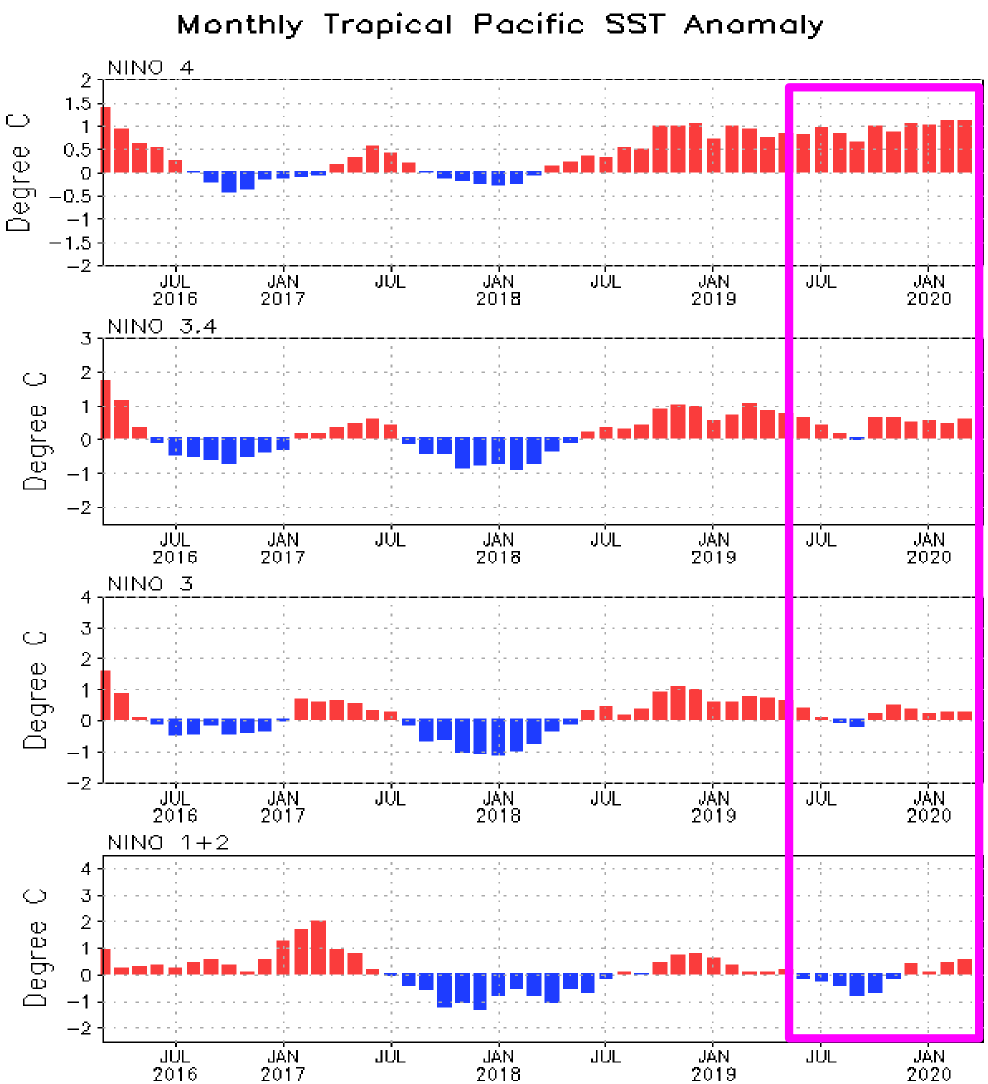
Kumar A, Z-Z Hu (2014) Interannual and interdecadal variability of ocean temperature along the equatorial Pacific in conjunction with ENSO. Clim. Dyn., 42 (5-6), **1243-1258.** *DOI: 10.1007/s00382-013-1721-0*.

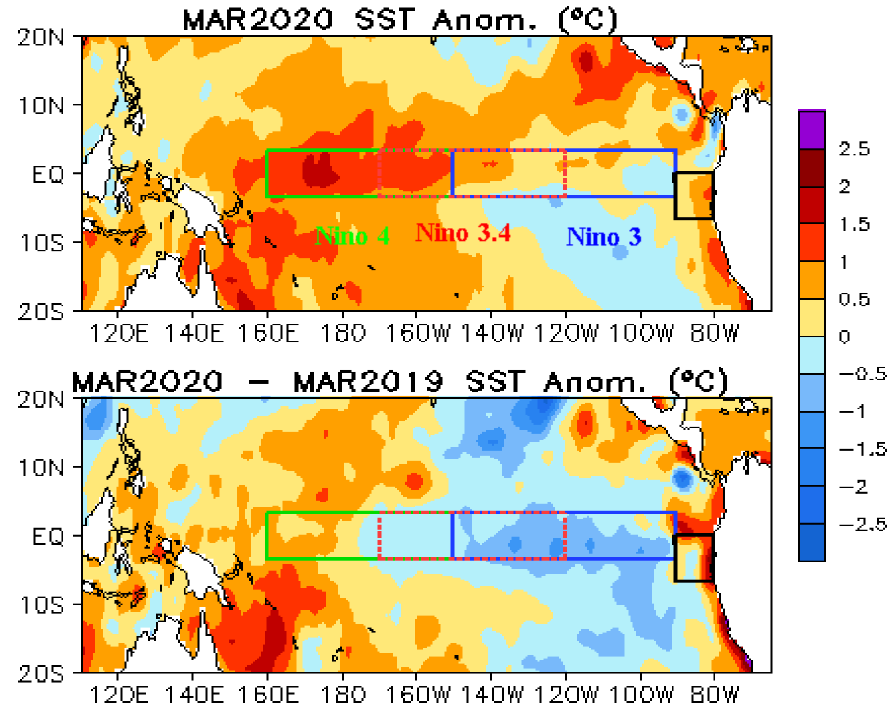
Positive SSTAs persisted in the warm pool, and SSTAs were negative in the cold tongue.





Evolution of Pacific NINO SST Indices





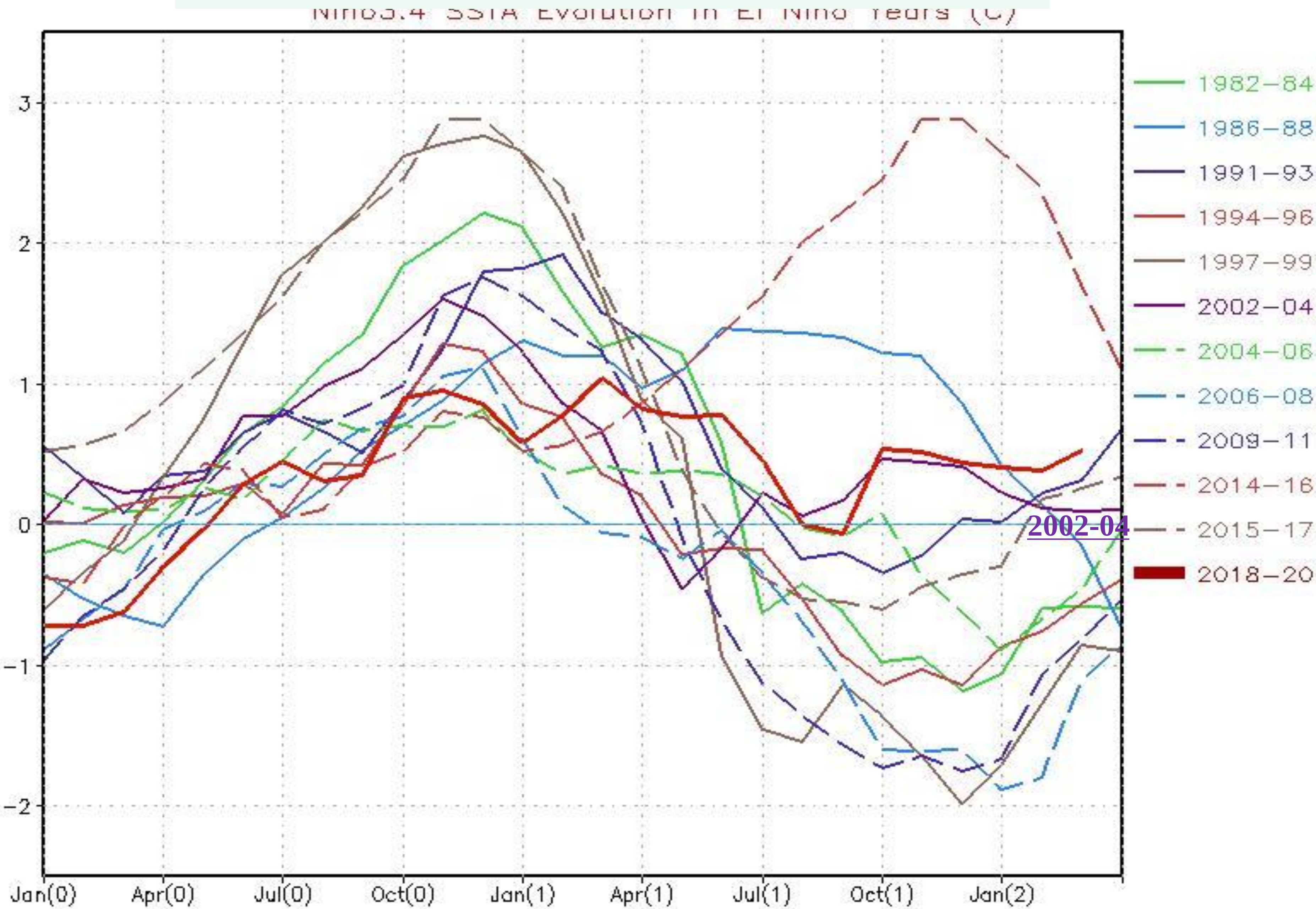
- All Nino indices were positive with Nino3.4 = 0.56 C in Mar 2020.

- Compared with Mar 2019, the western (eastern) equatorial Pacific was warmer (colder) in Mar 2020.

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

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

Nino3.4 Evolution In El Nino Years

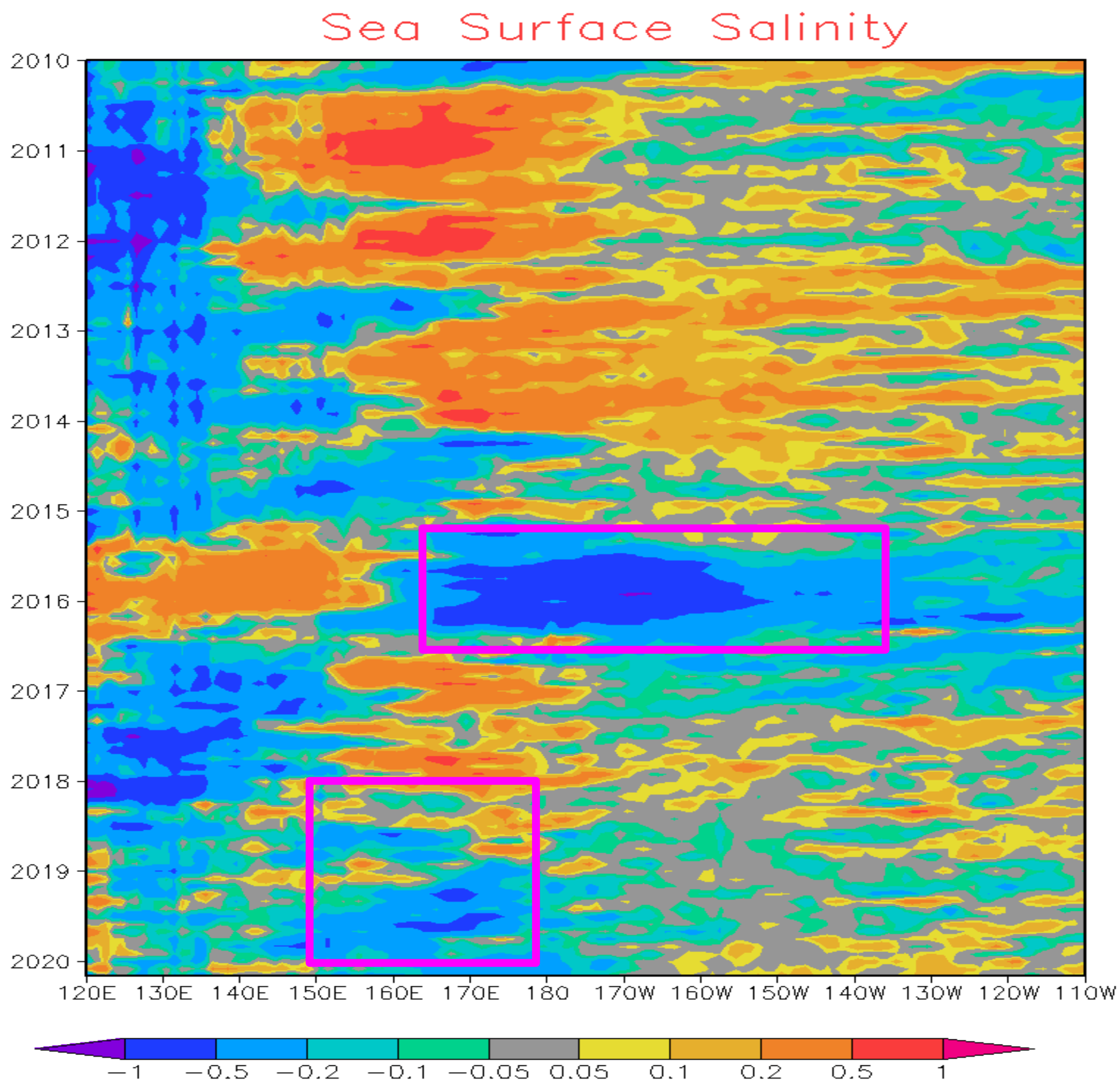


Global Sea Surface Salinity (SSS)

Anomaly Evolution over Equatorial Pacific from Monthly SSS

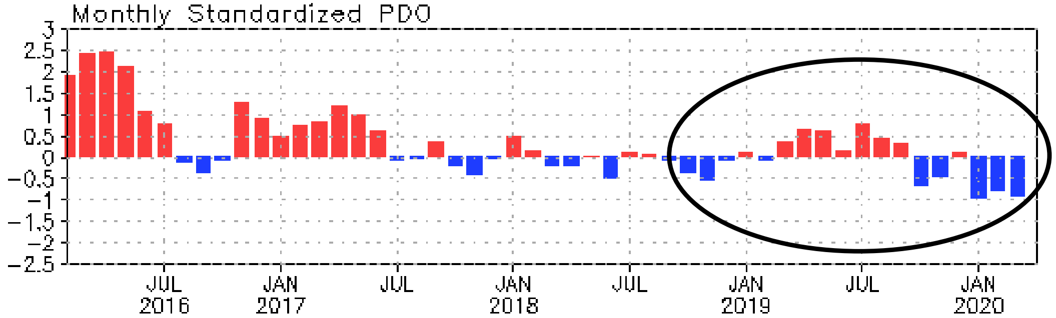
NOTE: Since June 2015, the BASS SSS is from in situ, SMOS and SMAP; before June 2015,The BASS SSS is from in situ, SMOS and Aquarius.

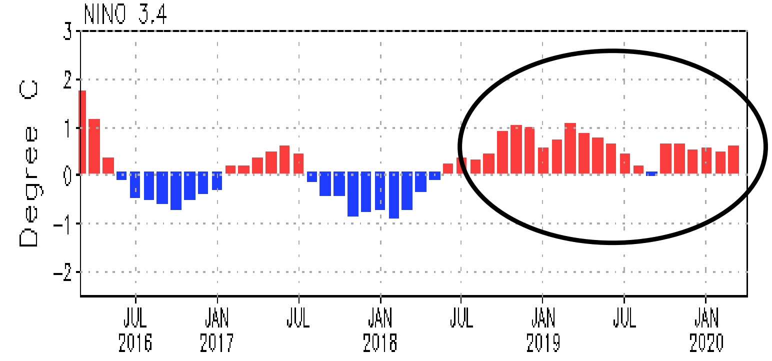
- Hovemoller diagram for equatorial SSS anomaly **(5° S-5° N);**
- In the equatorial Pacific Ocean, the SSS signal is negative in most of the area west of 170° W; the SSS shows positive anomalies east of 170° W.

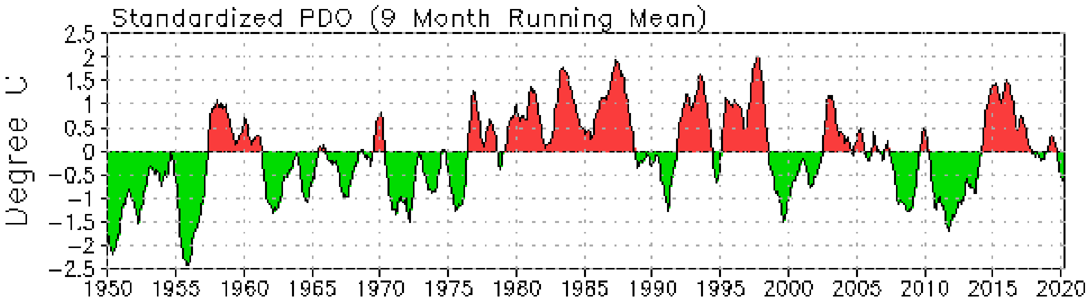


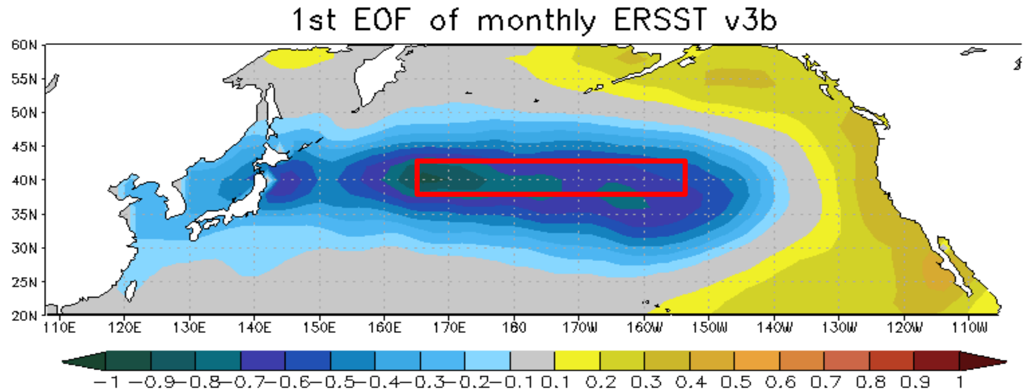
North Pacific & Arctic Oceans

PDO index









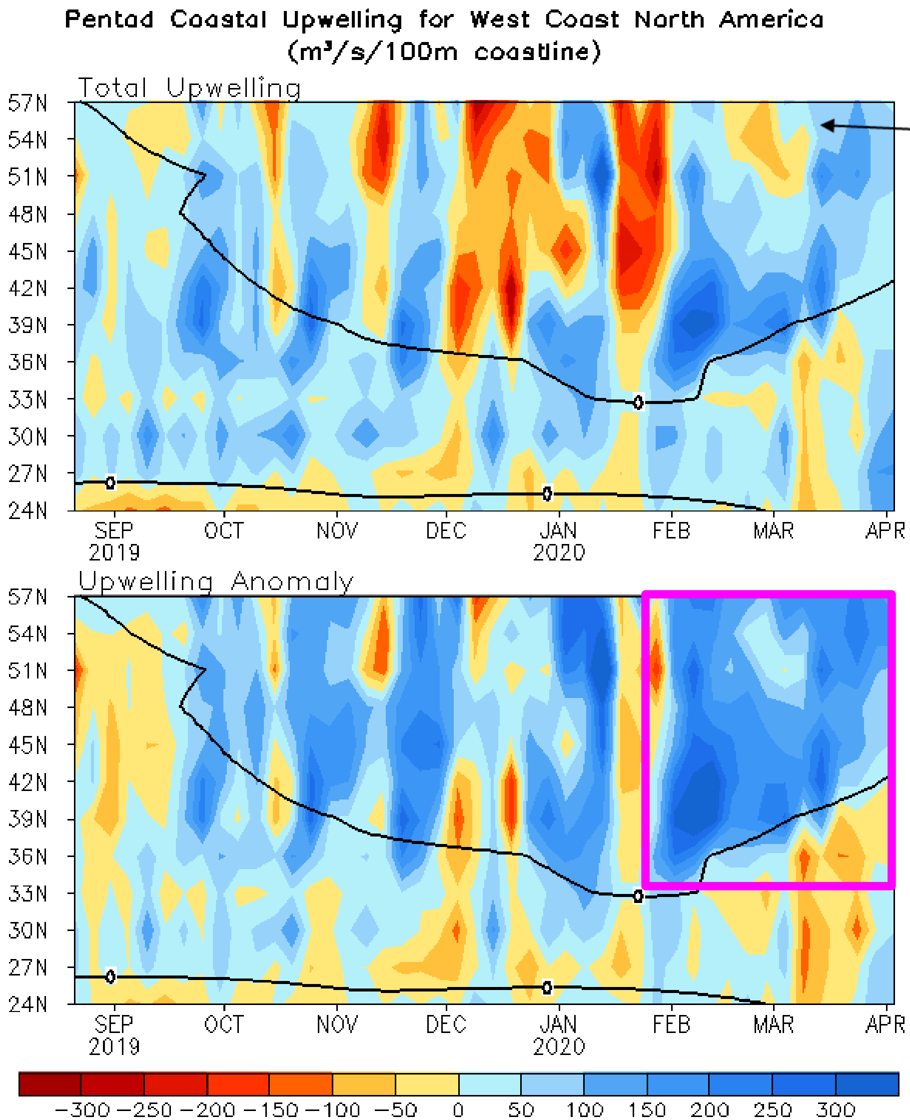
- **The PDO index was negative with PDOI= -0.93 in Mar 2020.**

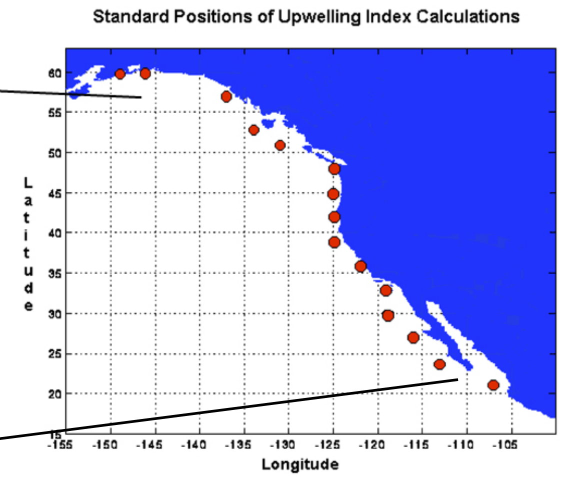
- **Statistically, ENSO leads PDO by 3-4 months, through teleconnection via atmospheric bridge.**

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

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

North America Western Coastal Upwelling



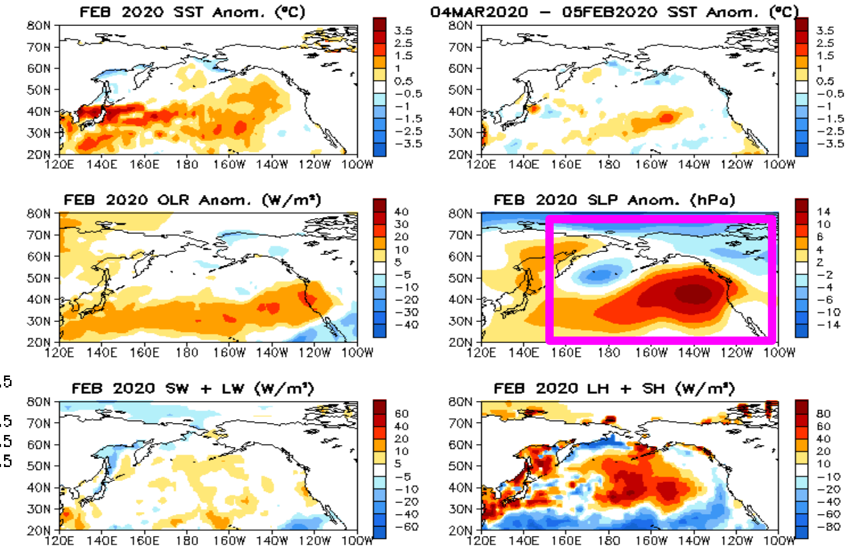


- Anomalous upwelling was observed in 35N northward since Feb 2020, that may be associated with the strong atmospheric ridge (next slide).

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.**

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



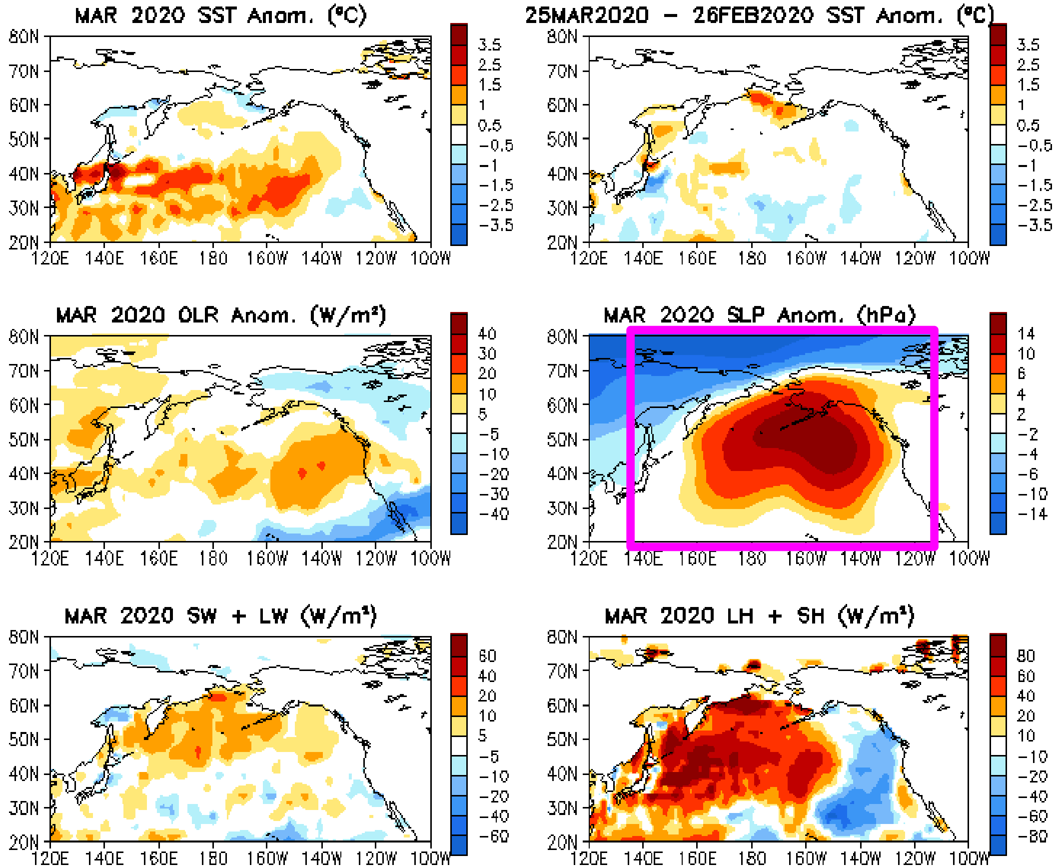
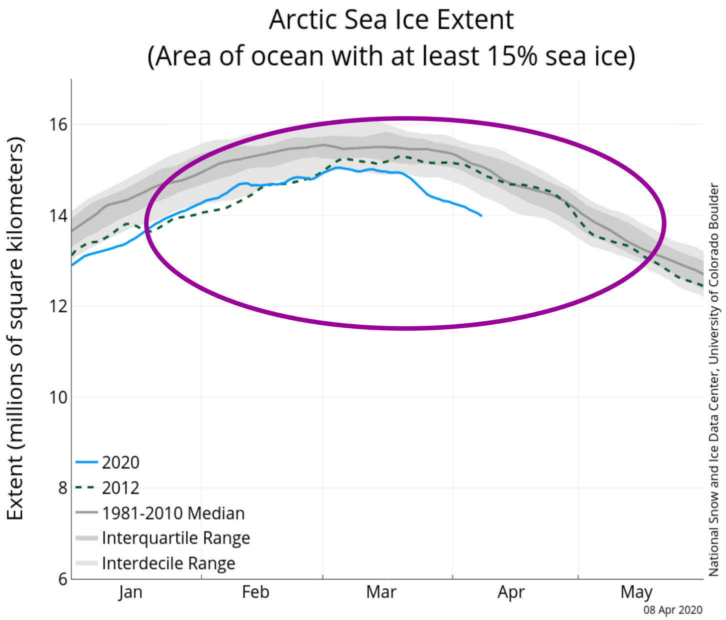


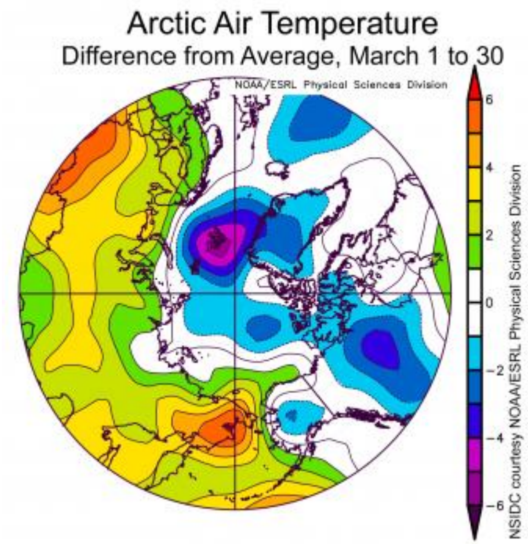
Fig. NP1. Sea surface temperature SSTAs (top-left), anomaly tendency (top-right), OLRAs (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible heat flux anomalies (bottom-right). SST are derived 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.

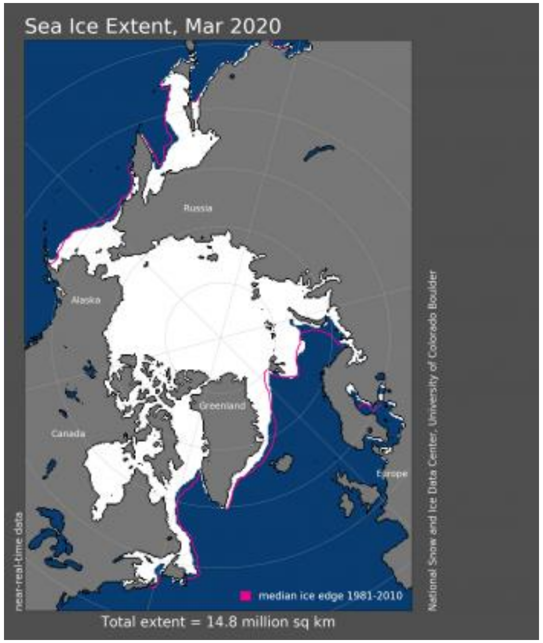
Arctic Sea Ice

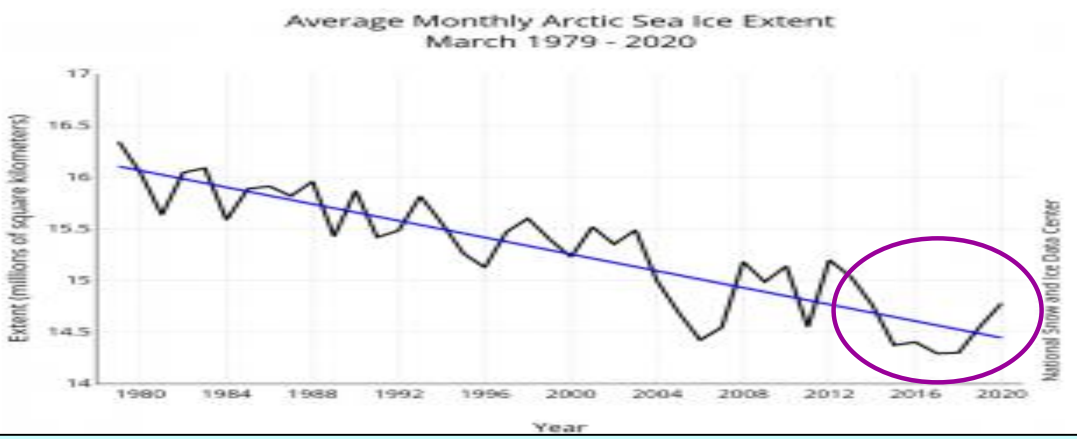
National Snow and Ice Data Center

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







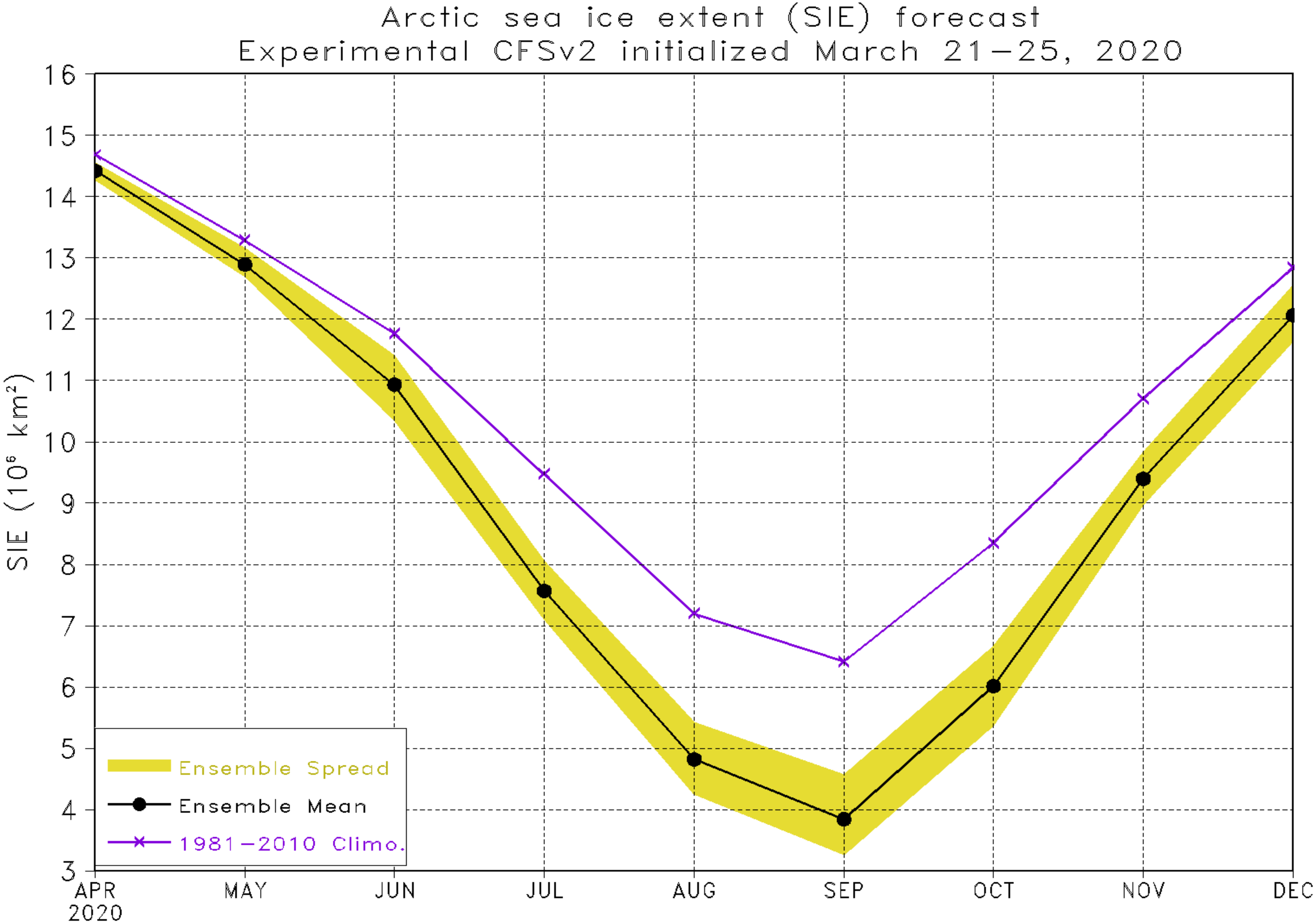


- **After reaching its annual maximum on Mar 5, Arctic sea ice extent remained stable for several days before it started clearly declining.**

- **Arctic sea ice extent for Mar 2020 was the 11th lowest in the satellite record.**

- **Including 2020, the linear rate of decline for Mar ice extent is 2.6 percent per decade.**

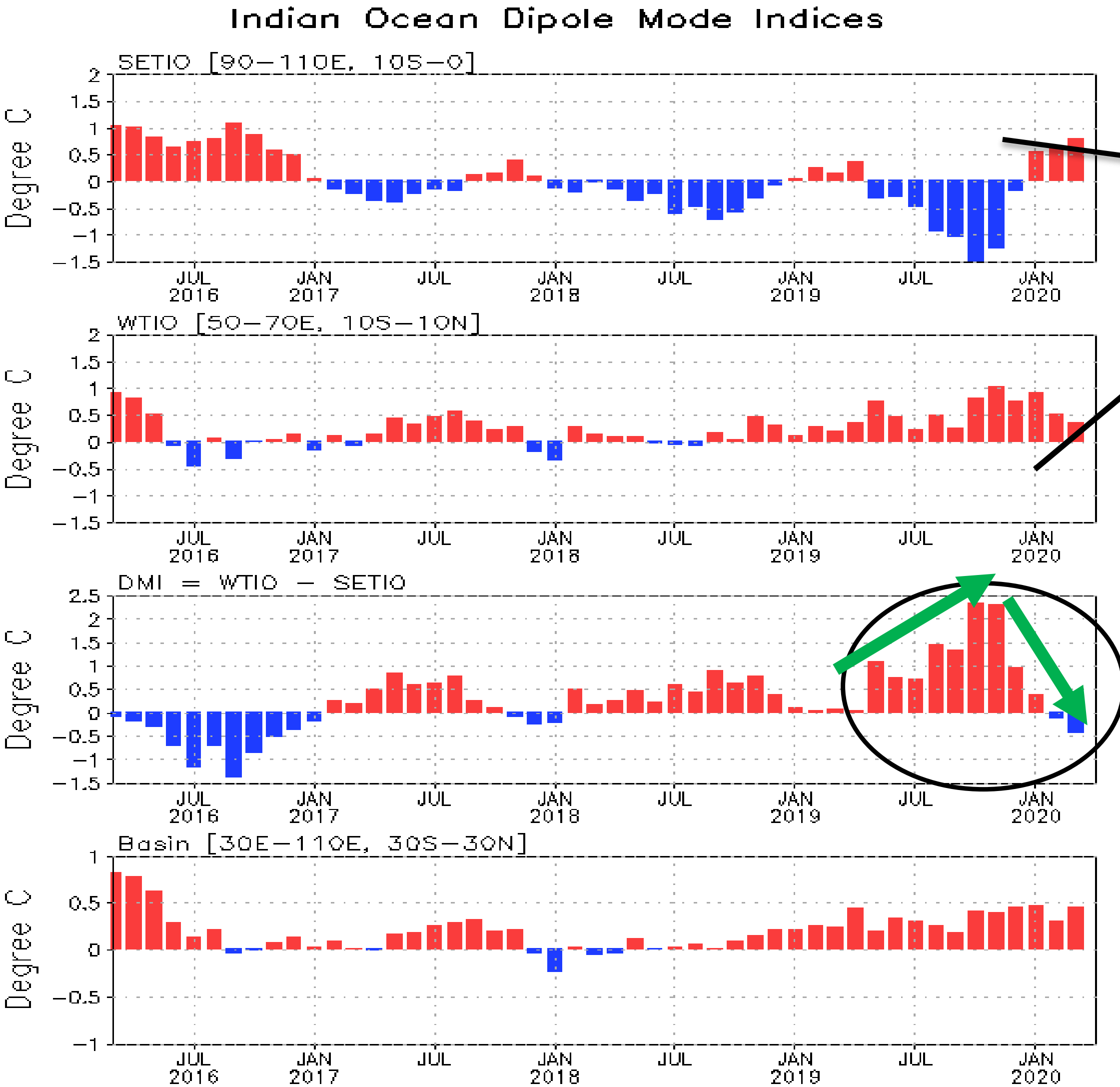
- **Over the 42-year satellite record, the area of sea ice loss in the Arctic is comparable to the size of the state of Alaska.**

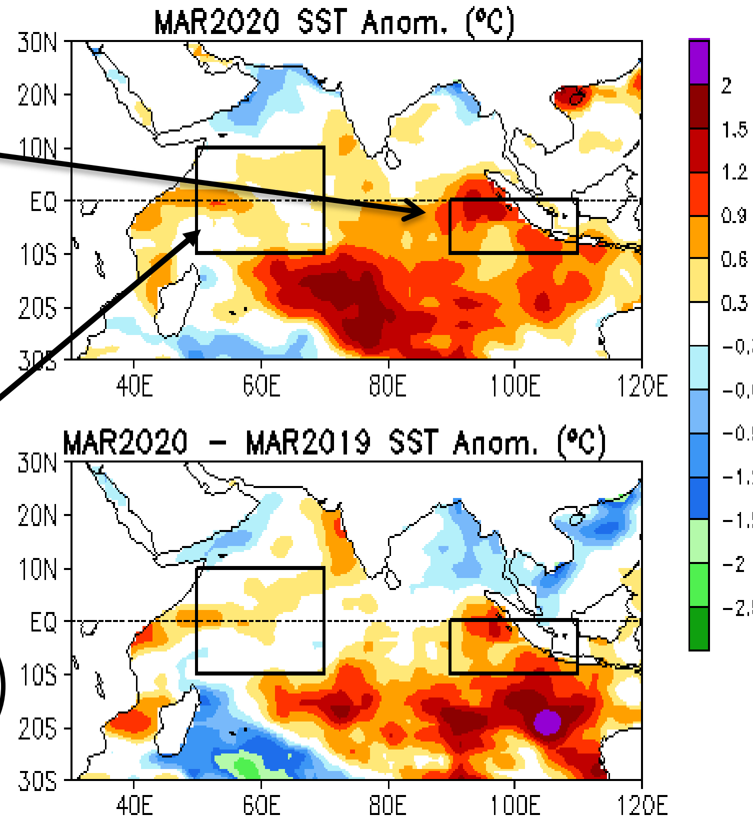


https://www.cpc.ncep.noaa.gov/products/people/wwang/seaice_seasonal/index.html

Indian Ocean

Evolution of Indian Ocean SST Indices





- Positive SSTAs were present in the entire tropical Indian Ocean.

- The positive phase of IOD peaked in Oct-Nov 2019 and IOD switched to the negative phase since Feb 2020.

Fig. I1a. Indian Ocean Dipole region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the SETIO [90°E-110°E, 10°S-0] and WTIO [50°E-70°E, 10°S-10°N] regions, and Dipole Mode Index, defined as differences between WTIO and SETIO. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

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

- SSTAs were positive in the entire tropical Indian Ocean.
- Pattern of monthly mean SSTA tendency was not consistent with that of net heat flux.

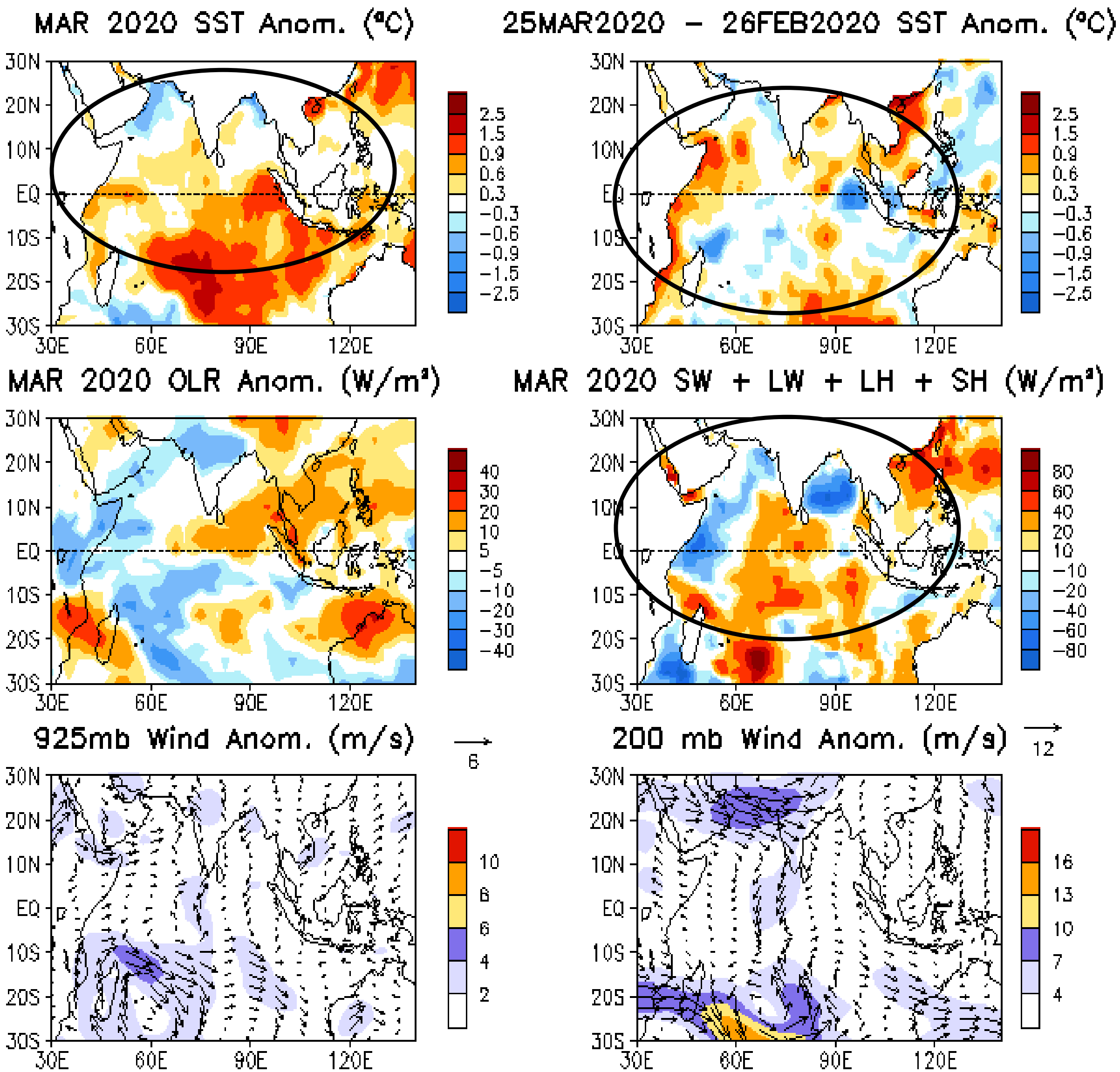
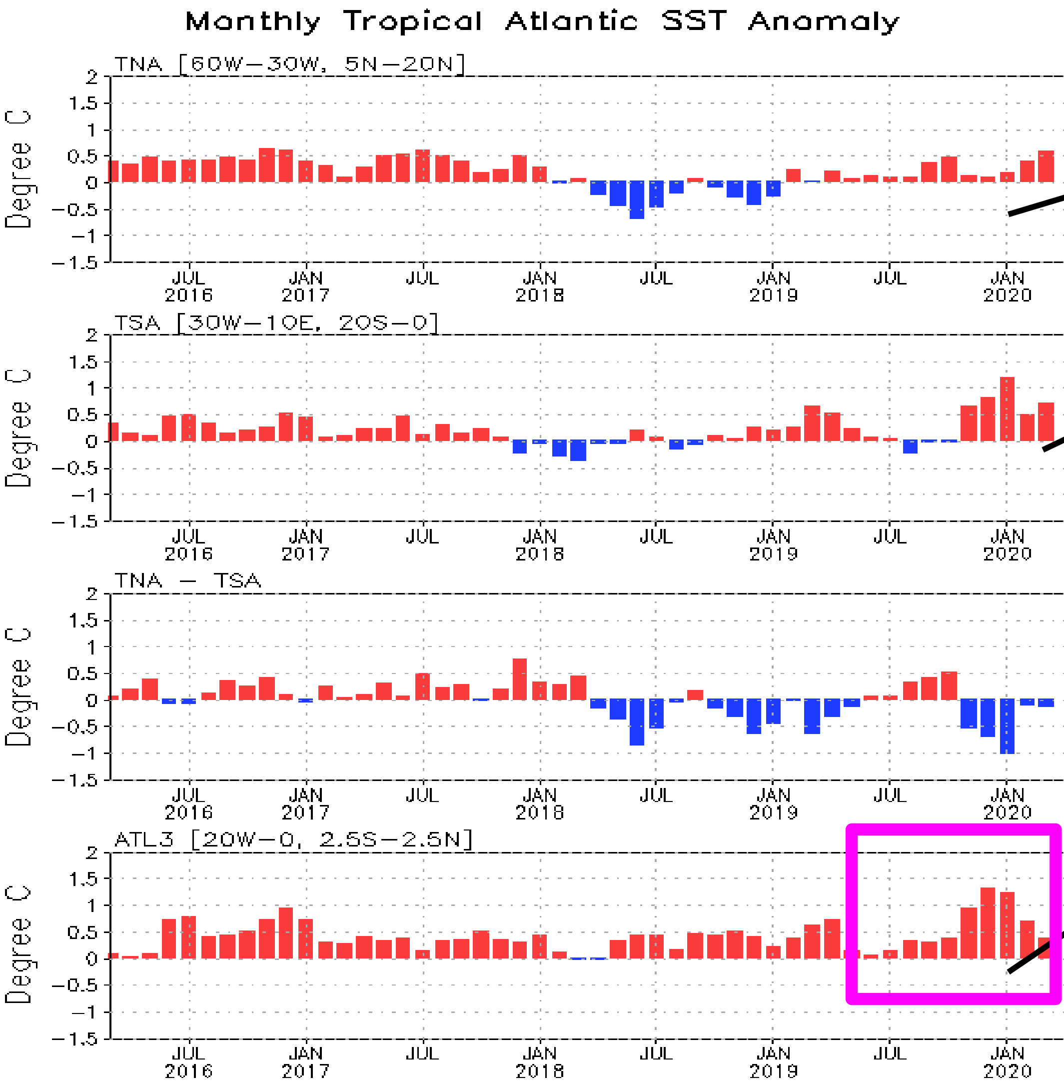
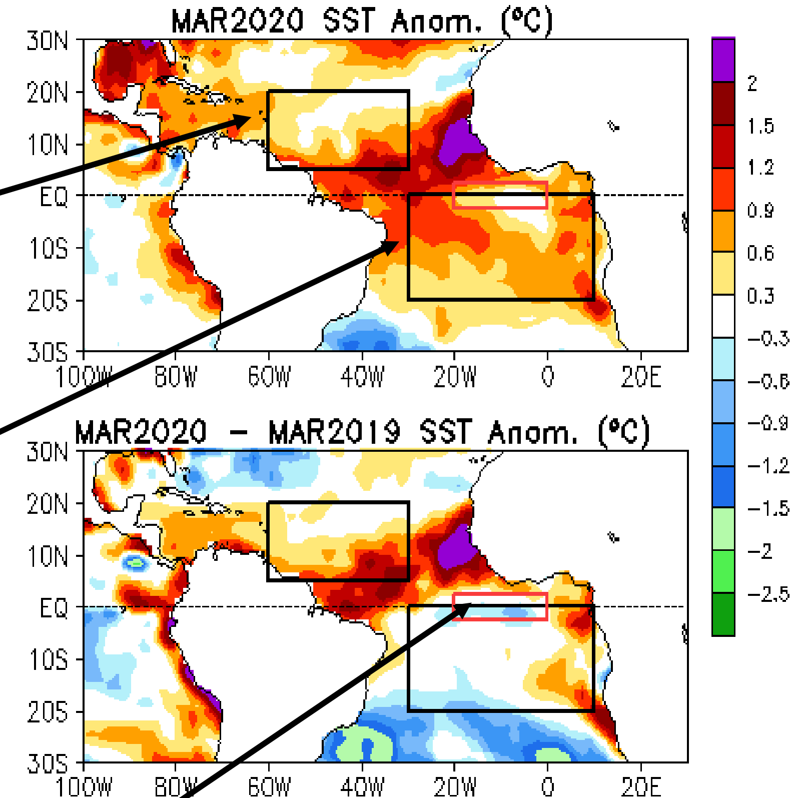


Fig. I2. SSTAs (top-left), anomaly tendency (top-right), OLRAs(middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right).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

Tropical and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

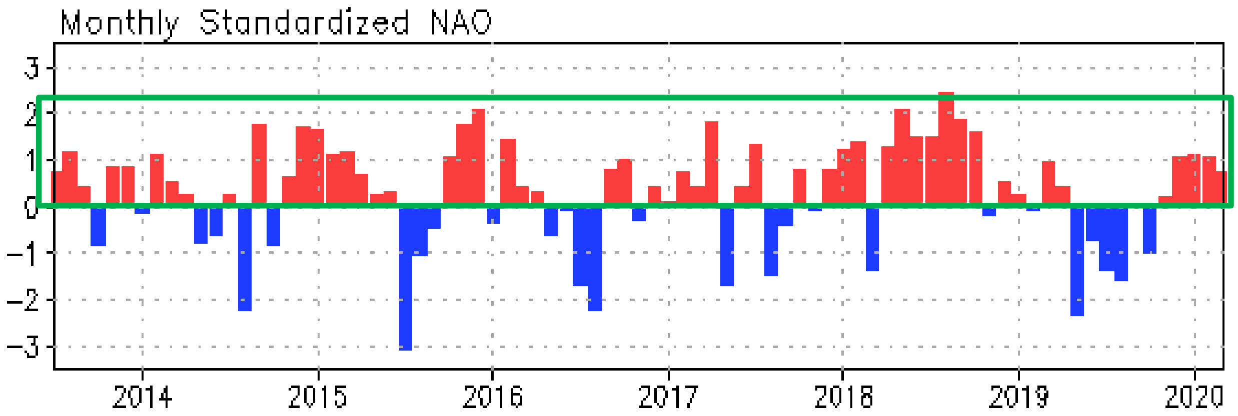


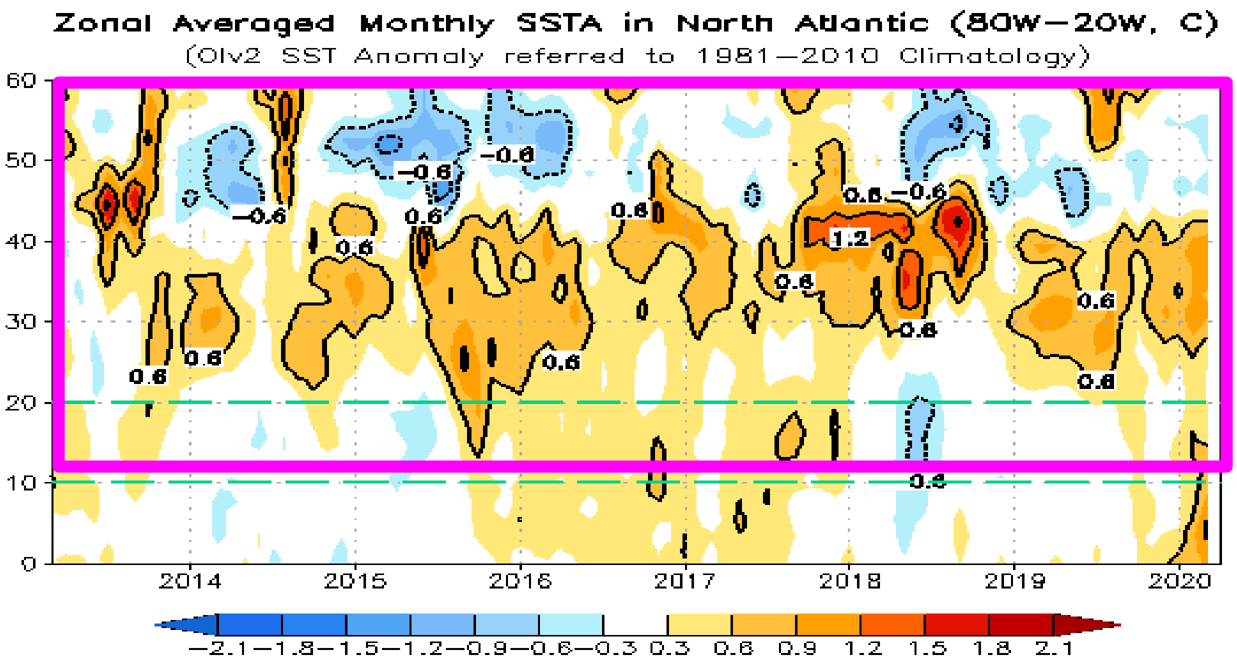


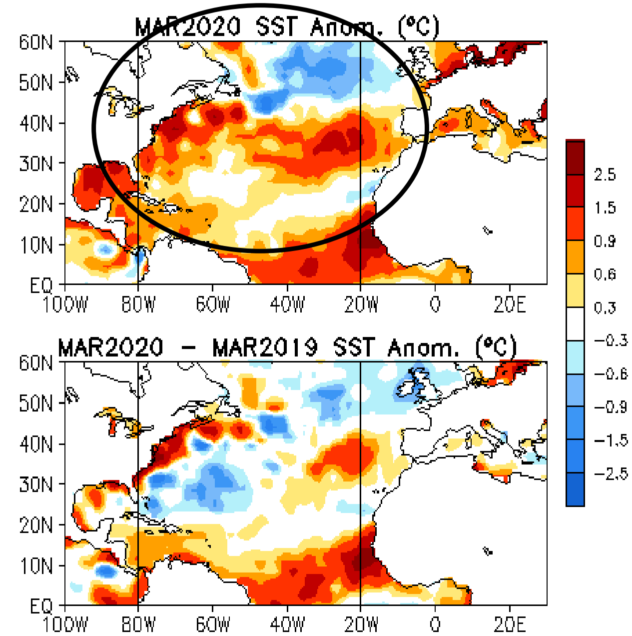
- **The dipole (or the meridional gradient) mode was in a negative phase since Nov 2019.**
- **ATL3 (Atlantic Nino) weakened since Jan 2020 with ATL3=0.55 in Mar 2020.**

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

NAO and SST Anomaly in North Atlantic







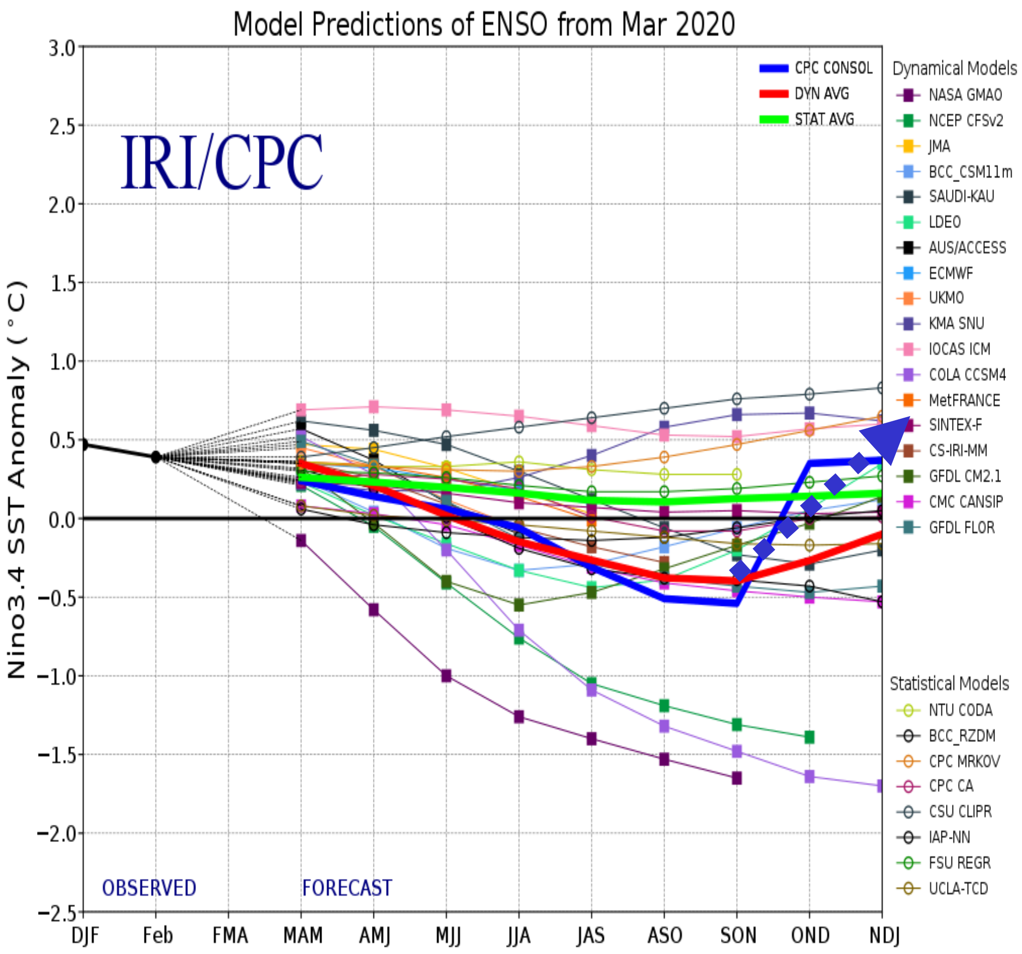
- NAO was in a positive phase since Nov 2019 with NAOI= 0.66 in Mar 2020.

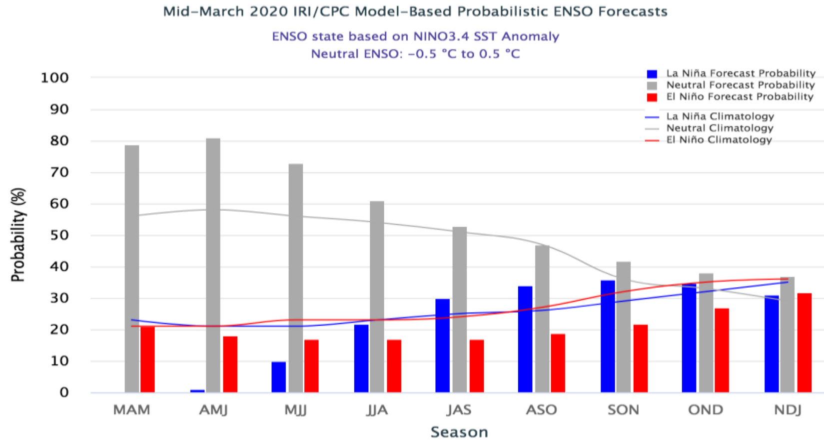
- SSTA was a tripole/horseshoe –like pattern with positive in the mid-latitudes and negative in the lower and higher latitudes, due to the long-term persistence of a positive phase of NAO.

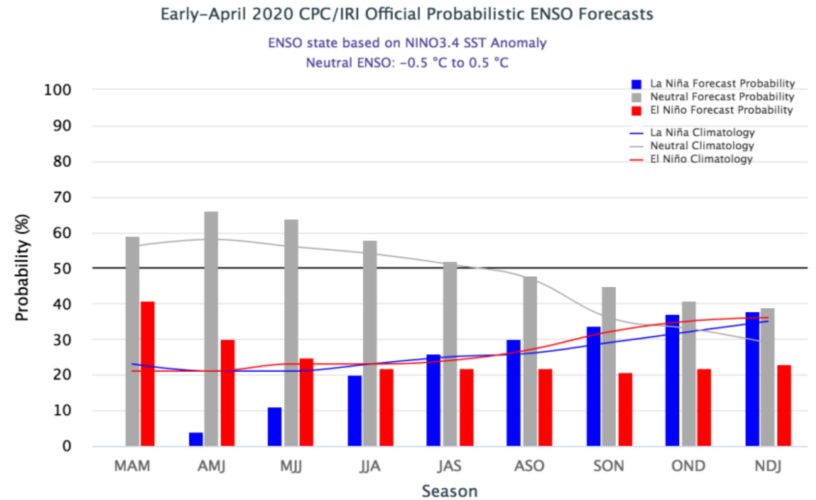
Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20ºN-90ºN (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80ºW and 20ºW (bottom). SST are derived from the NCEP OI SST analysis,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

ENSO and Global SST Predictions

IRI NINO3.4 Forecast Plume



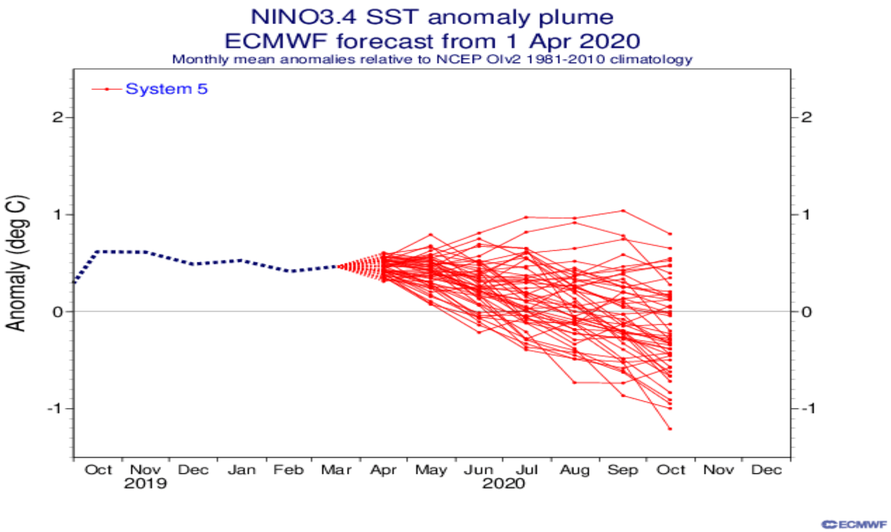




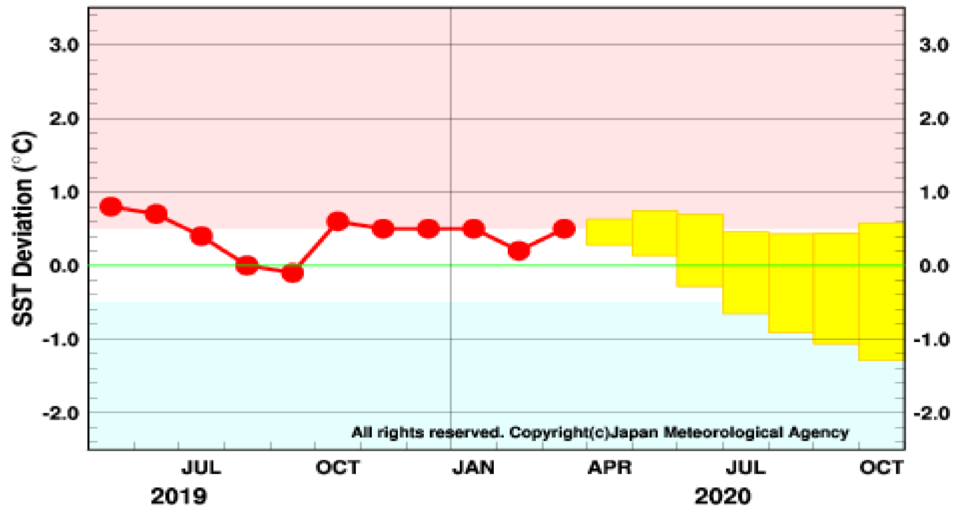
- **Majority of models predict continuation of ENSO-neutral with ICs in Mar 2020.**
- **NOAA "ENSO Diagnostic Discussion" on 9 Apr 2020 stated that** ***"ENSO-neutral is favored for the Northern Hemisphere summer 2020 (~60% chance), remaining the most likely outcome through autumn."***

Individual Model Forecasts: Neutral Condition or Borderline La Nina

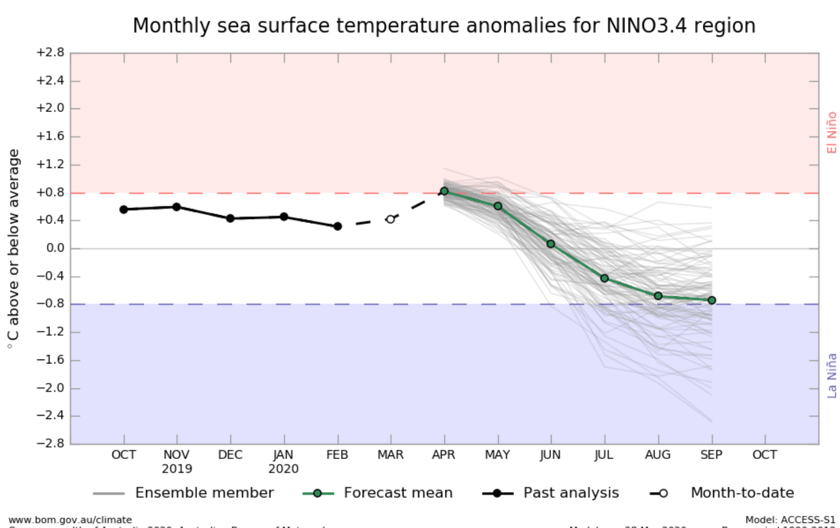
EC: Nino3.4, IC=01 Apr 2020



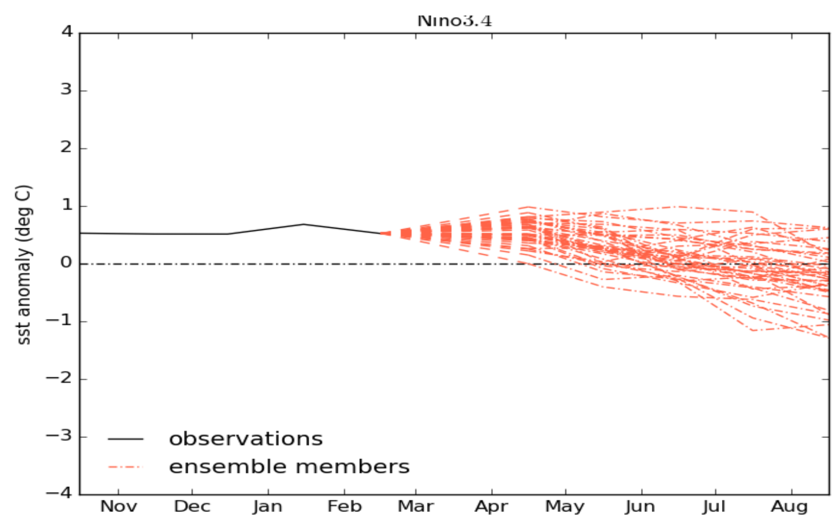
JMA: Nino3.4, Updated 10 Apr 2020

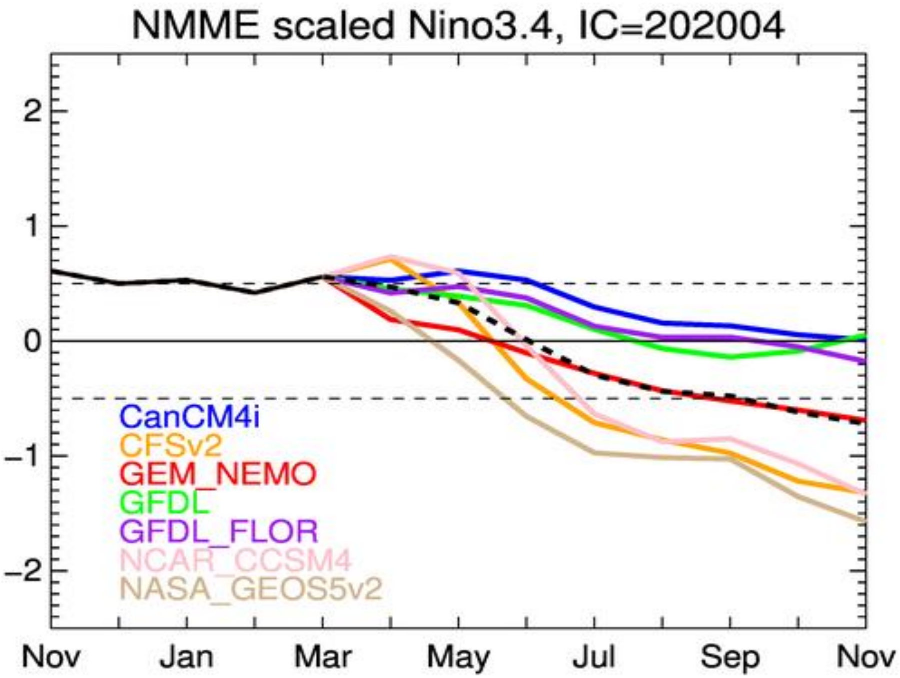
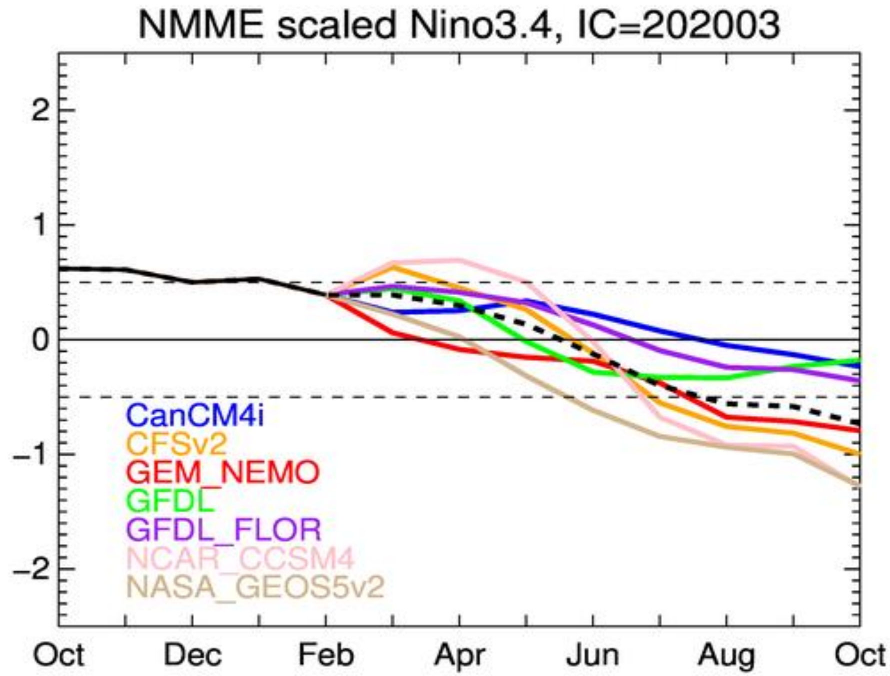
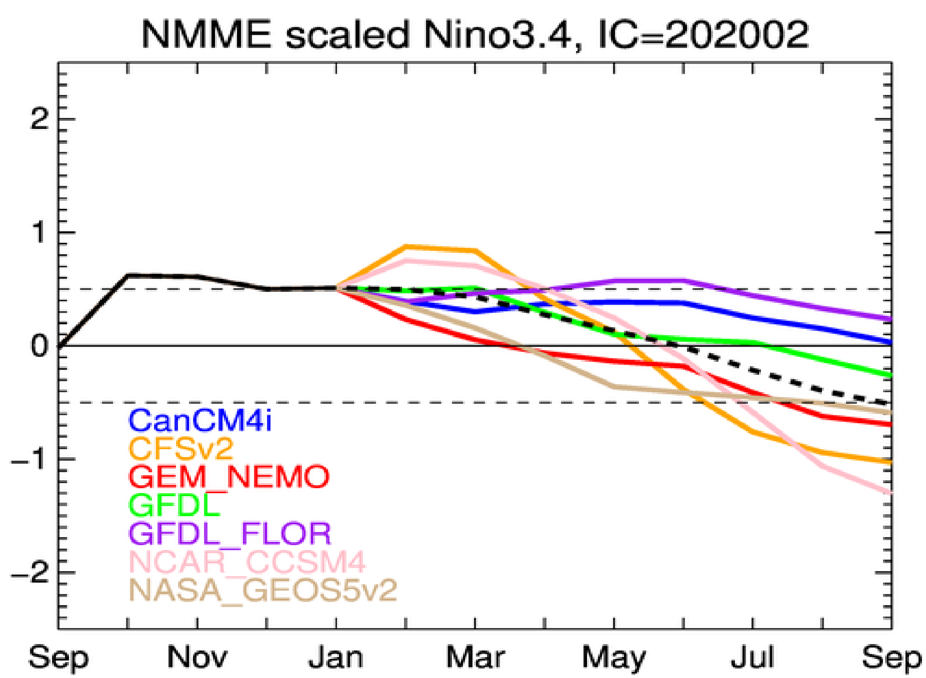
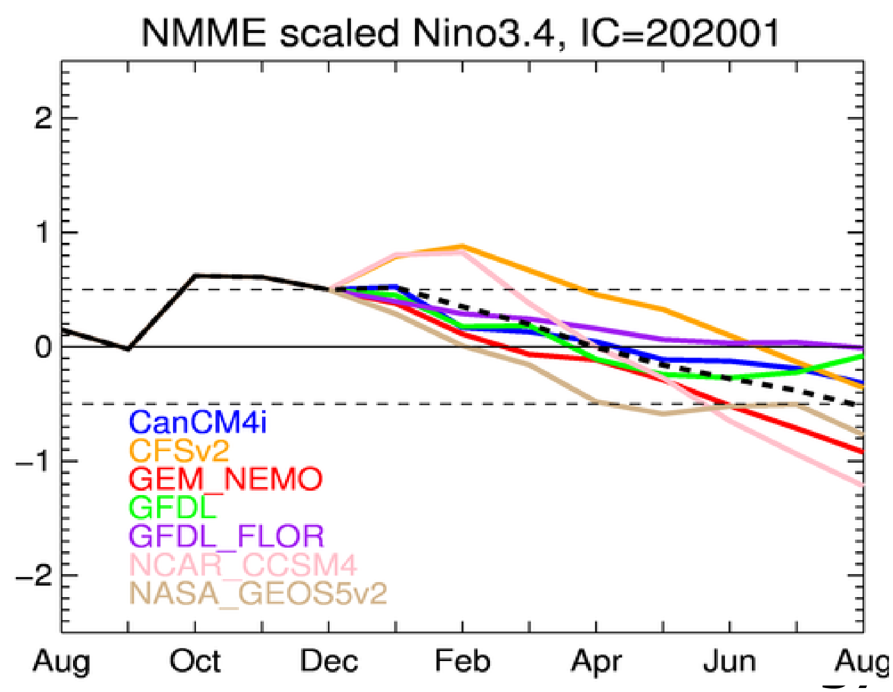


Australia: Nino3.4, Updated 28 Mar 2020

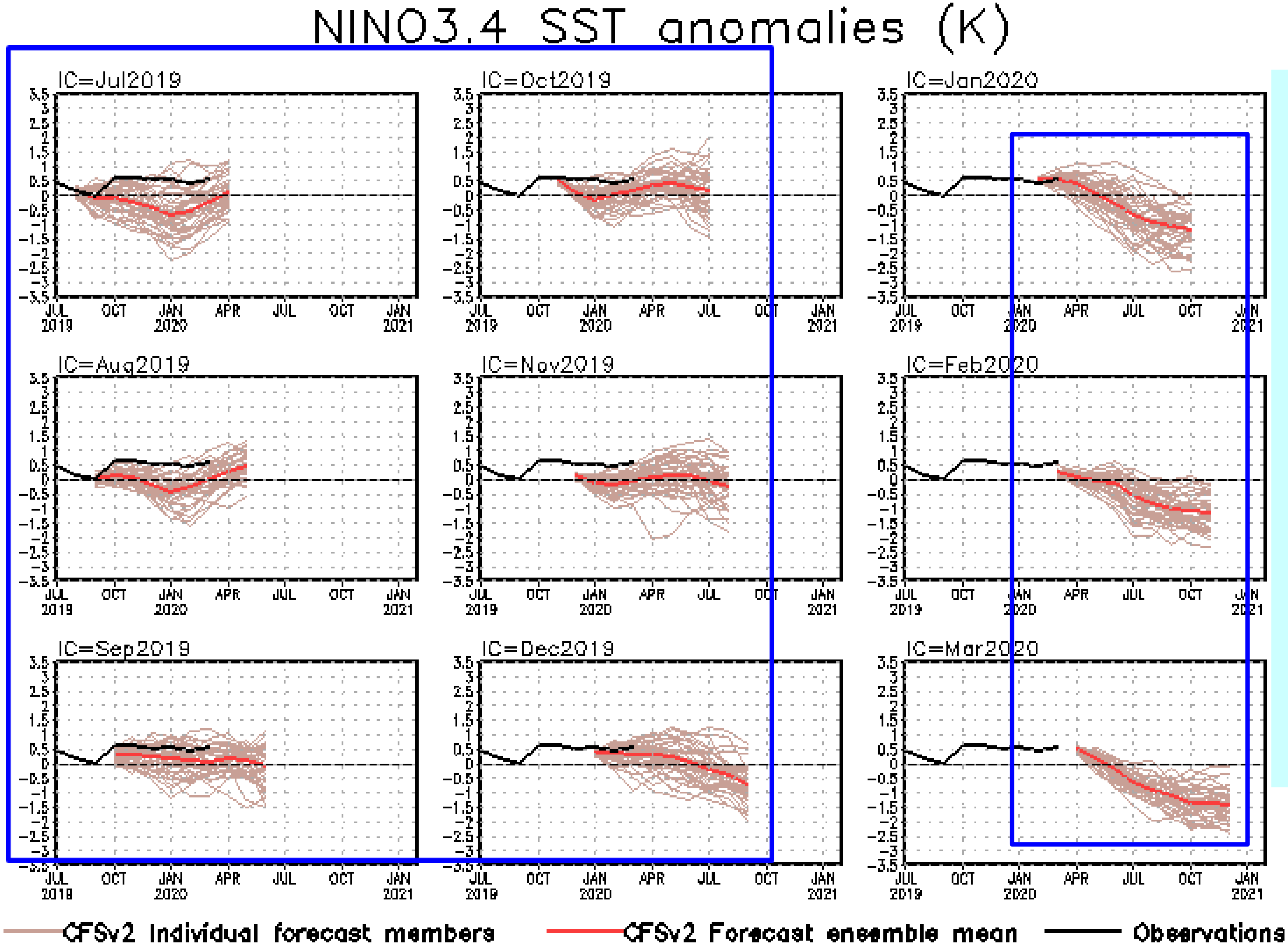


UKMO: Nino3.4, Updated 11 Mar 2020




NMME scaled Nino3.4, IC=202004
2
1
0
−1
−2
Nov
Jan
Mar
May
Jul
Sep
Nov
CanCM4i
CFSv2
GEM_NEMO
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2

NMME scaled Nino3.4, IC=202003
2
1
0
−1
−2
Oct
Dec
Feb
Apr
Jun
Aug
Oct
CanCM4i
CFSv2
GEM_NEMO
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2

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

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

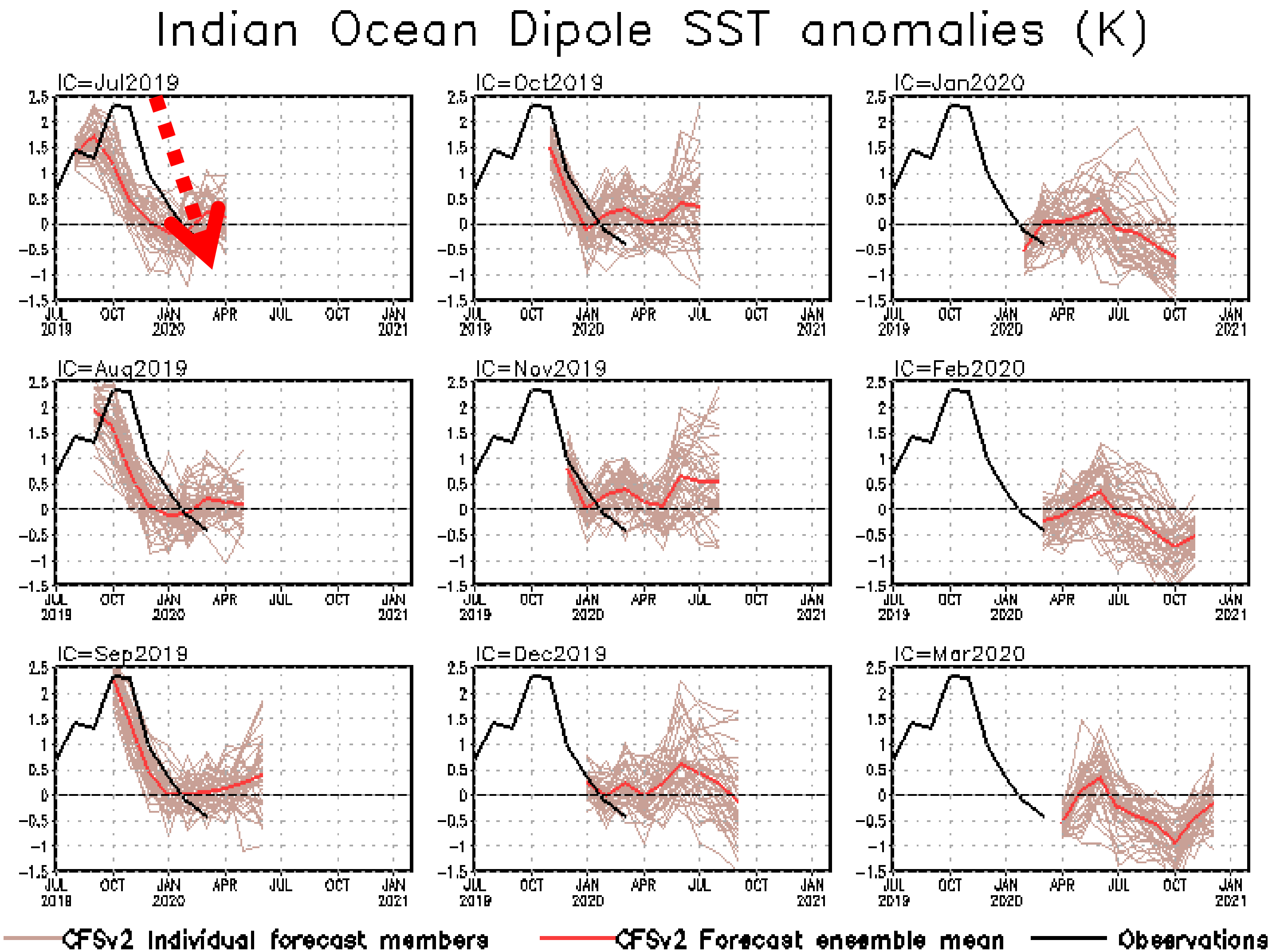
CFS Niño3.4 SST Predictions from Different Initial Months



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

Fig. M1. CFS Nino3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1981-2010 base period means.

NCEP CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

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

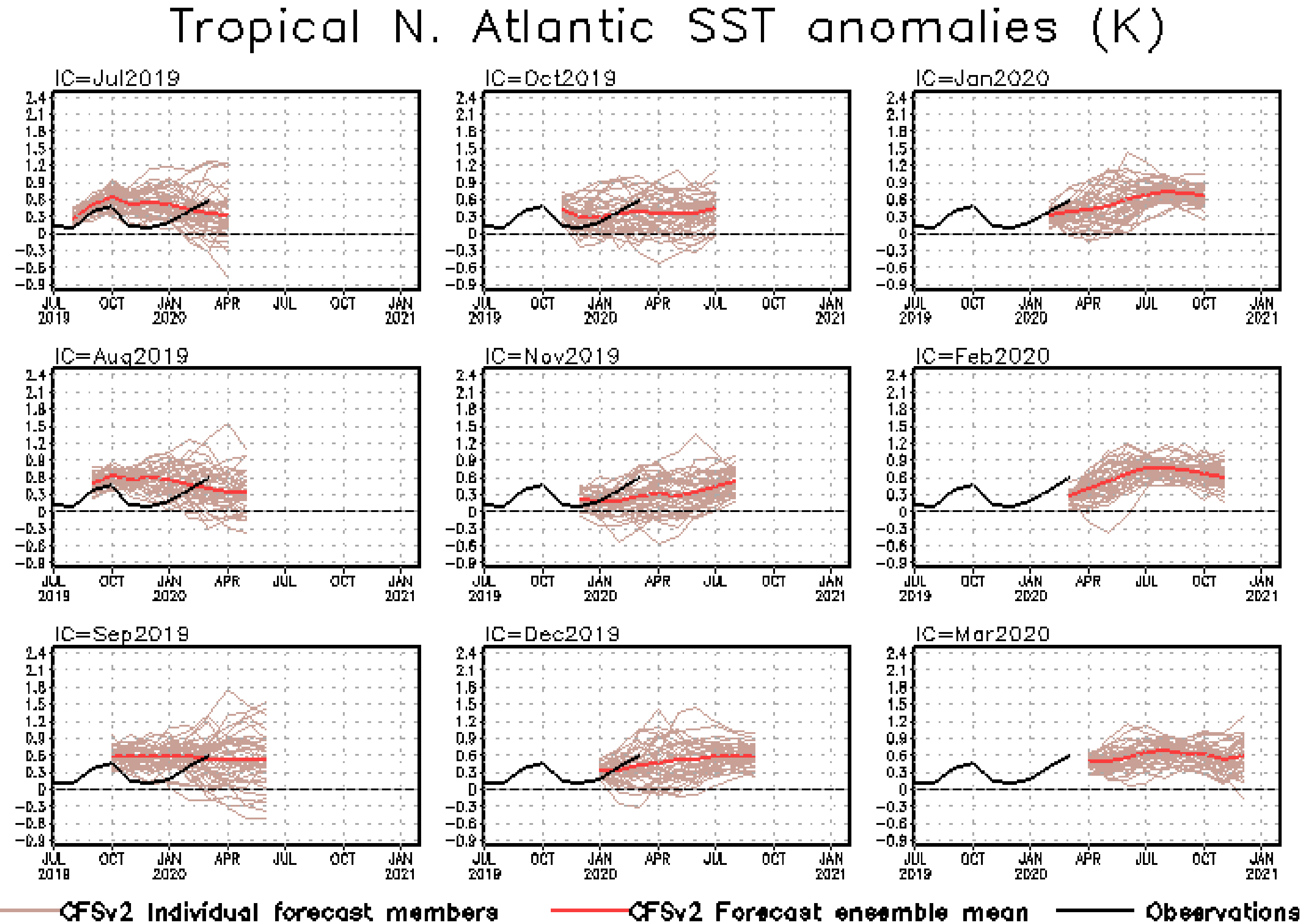
WTIO = SST anomaly in [50°E-70°E, 10°S-10°N]

- **Latest CFSv2 predictions call neutral or negative phase of IOD in 2020.**
- **Climatologically, IOD is present in late summer and fall, while the basin mode is present in other seasons.**

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

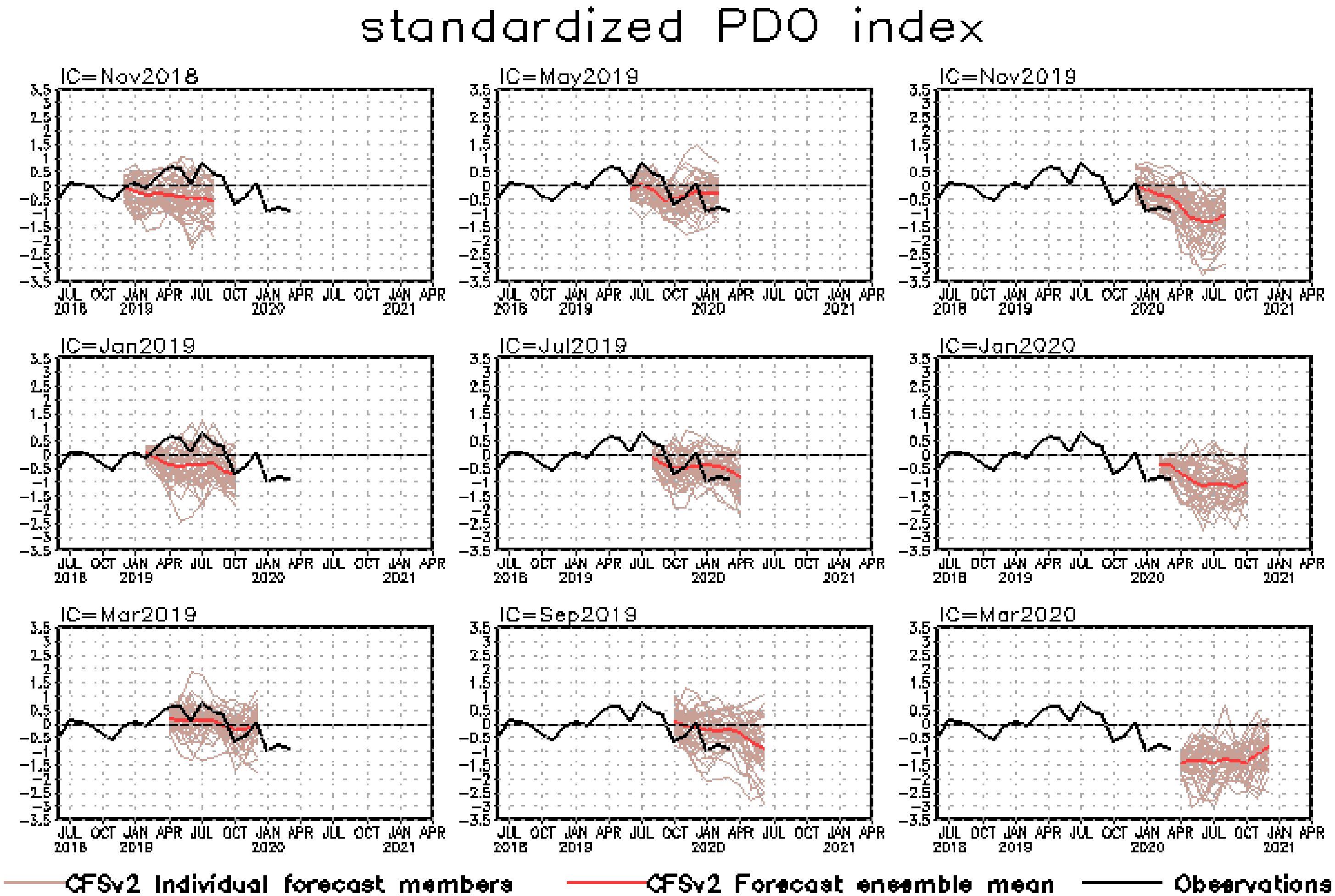
TNA is the SST anomaly averaged in the region of [60°W-30°W, 5°N-20°N].



- **Latest CFSv2 predictions call above normal SSTA in the tropical N. Atlantic in 2020.**

Fig. M3. CFS Tropical North Atlantic (TNA) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1981-2010 base period means.

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



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

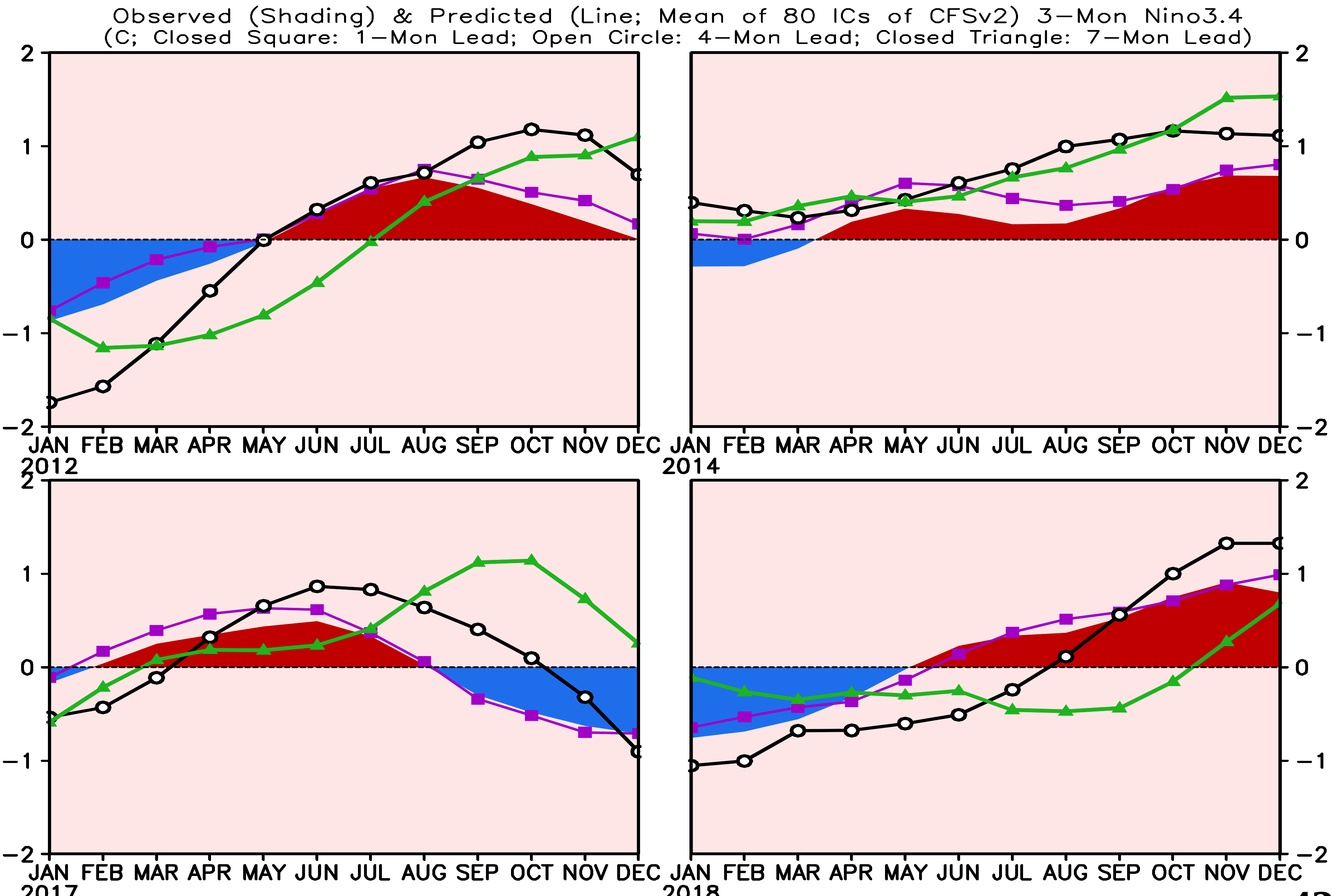
CFS PDO index is the standardized projection of CFS SST forecast anomalies onto the PDO EOF pattern.

- CFSv2 predicts a negative phase of PDO in 2020.

Fig. M4. CFS Pacific Decadal Oscillation (PDO) index predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1981-2010 base period means.

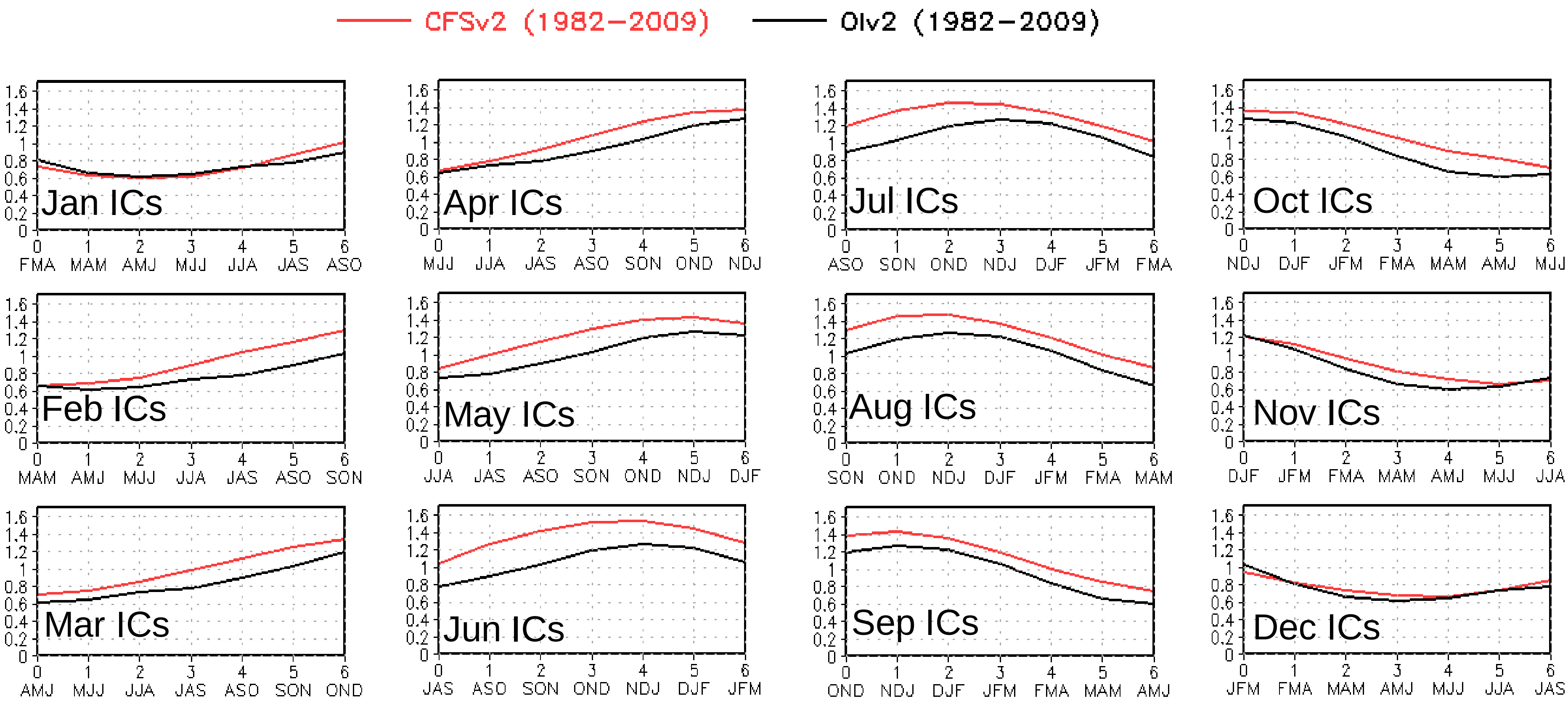
Overshooting of ENSO Forecast in CFSv2

False Alarms: 2012, 2014, 2017



Nino 3.4 standard deviation (K)

(From: Dr. Wanqiu Wang)



- CFS amplitude errors vary with initial month and target months.
- Amplitude in CFS is generally too large in JAS to NDJ in forecasts from spring and summer.

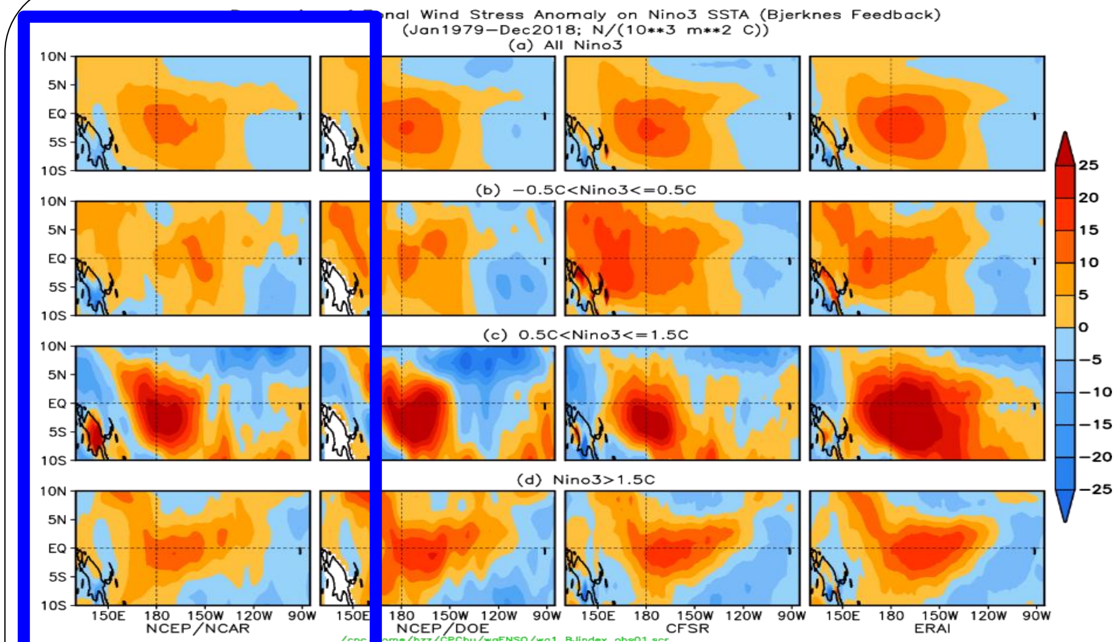
Possible factors lead to the false alarms (overshooting) in CFSv2?

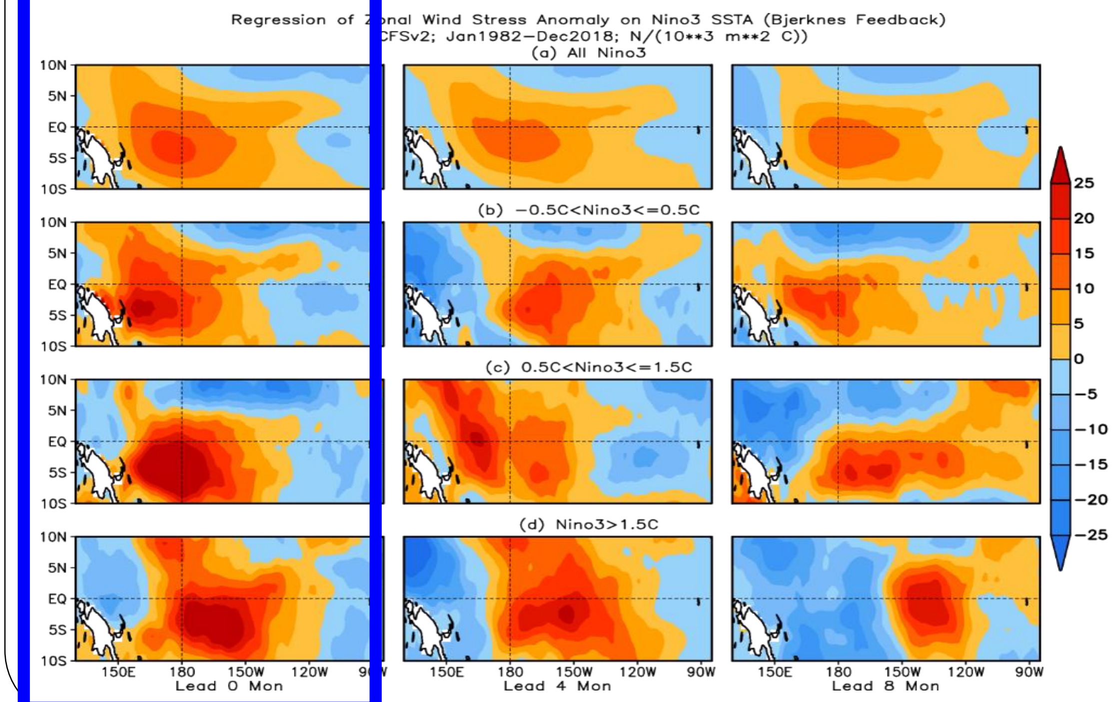
(1) Too strong dynamical (BJ; SST-wind) feedback?

(2) Too weak thermodynamical damping?

Comparison of "Zonal Wind-SST (dynamical)" and "Heat Flux-SST" (thermodynamical) feedbacks in Obs and CFSv2 forecasts/hindcasts:

- Different phase of ENSO (***Nino3*** or **Nino3.4**: all; -0.5~0.5C; 0.5~1.5C; >1.5C)
- CFSv2: A single member
- Observations: OAFlux, CERES, R1, R2, CFSR, ERAI



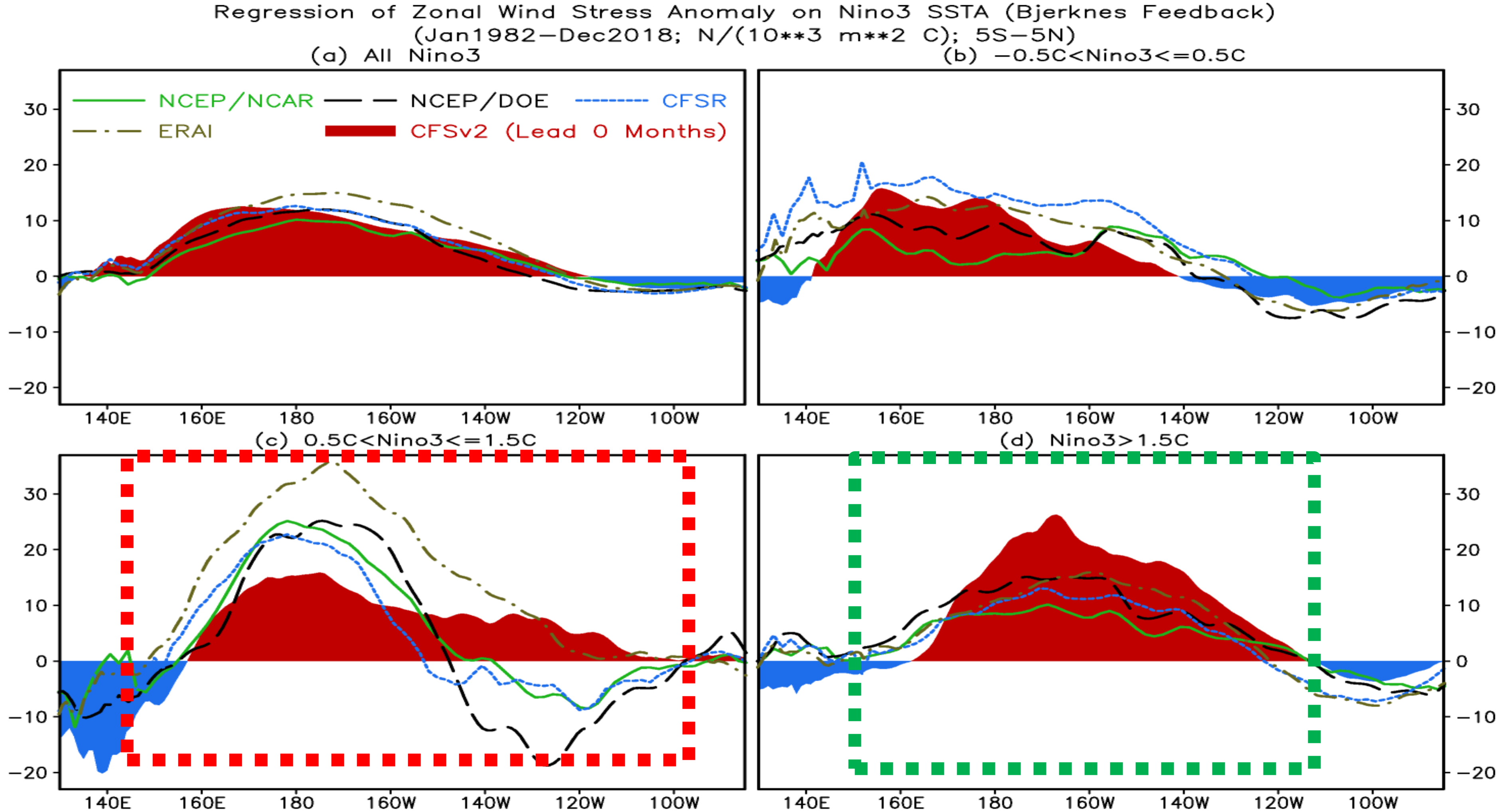


Obs (R1, R2, CFSR, ERAI): Jan1979-Dec2018

- Regression of tauxA onto Nino3 index, Atmospheric Bjerknes Feedback = Zonal Wind-SST feedback: TauxA=α*SSTA.
- Wind-SST feedback strength varies with reanalysis and with lead time in CFSv2.
- Compared with obs/reanalyses, zonal wind-SST feedback seems too strong in CFSv2 for lead=0mon.

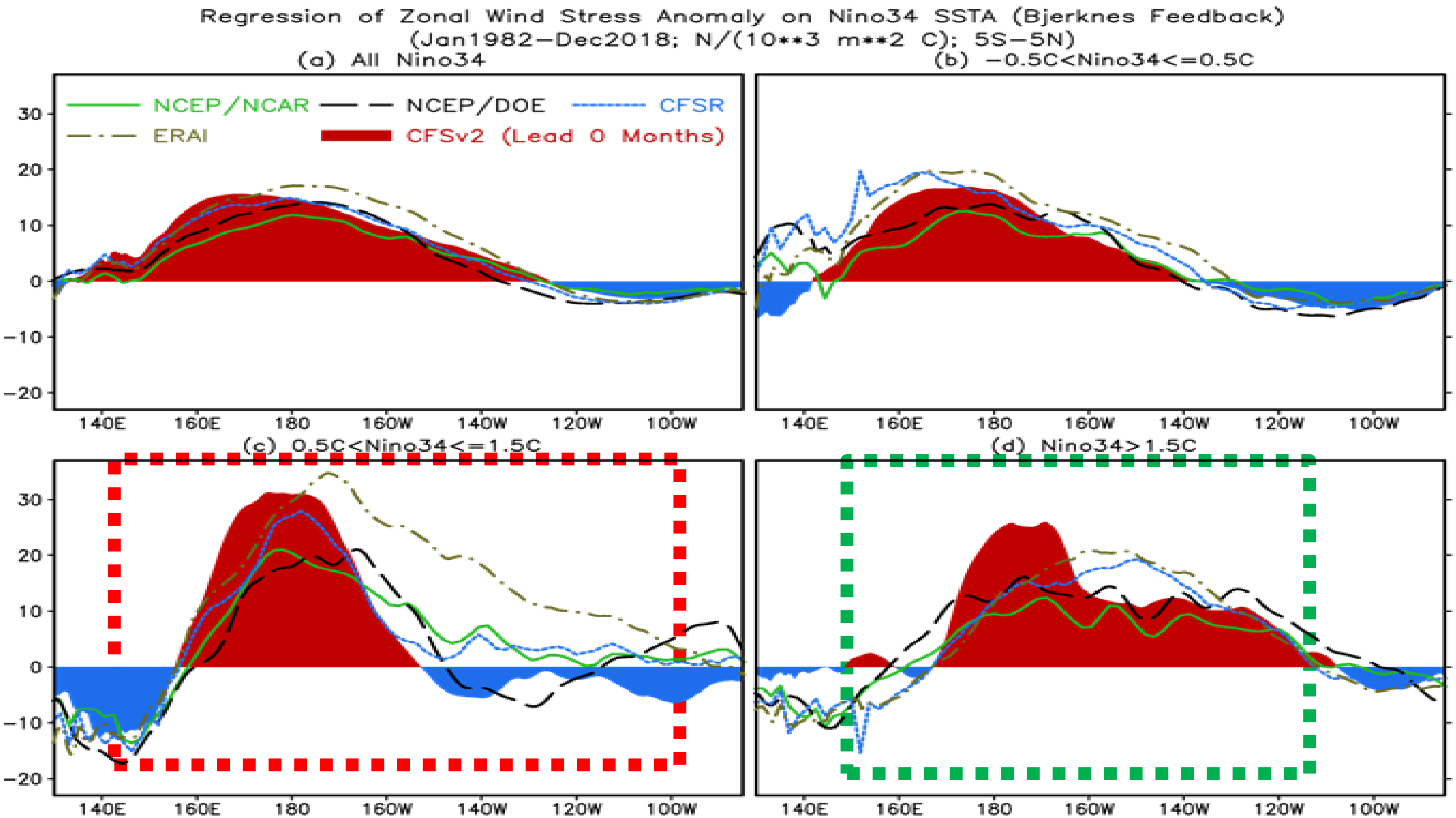
CFSv2: Jan1982-Dec2018 (Lead=0, 4, 8 months; 1 member)

5S-5N average based on Nino3

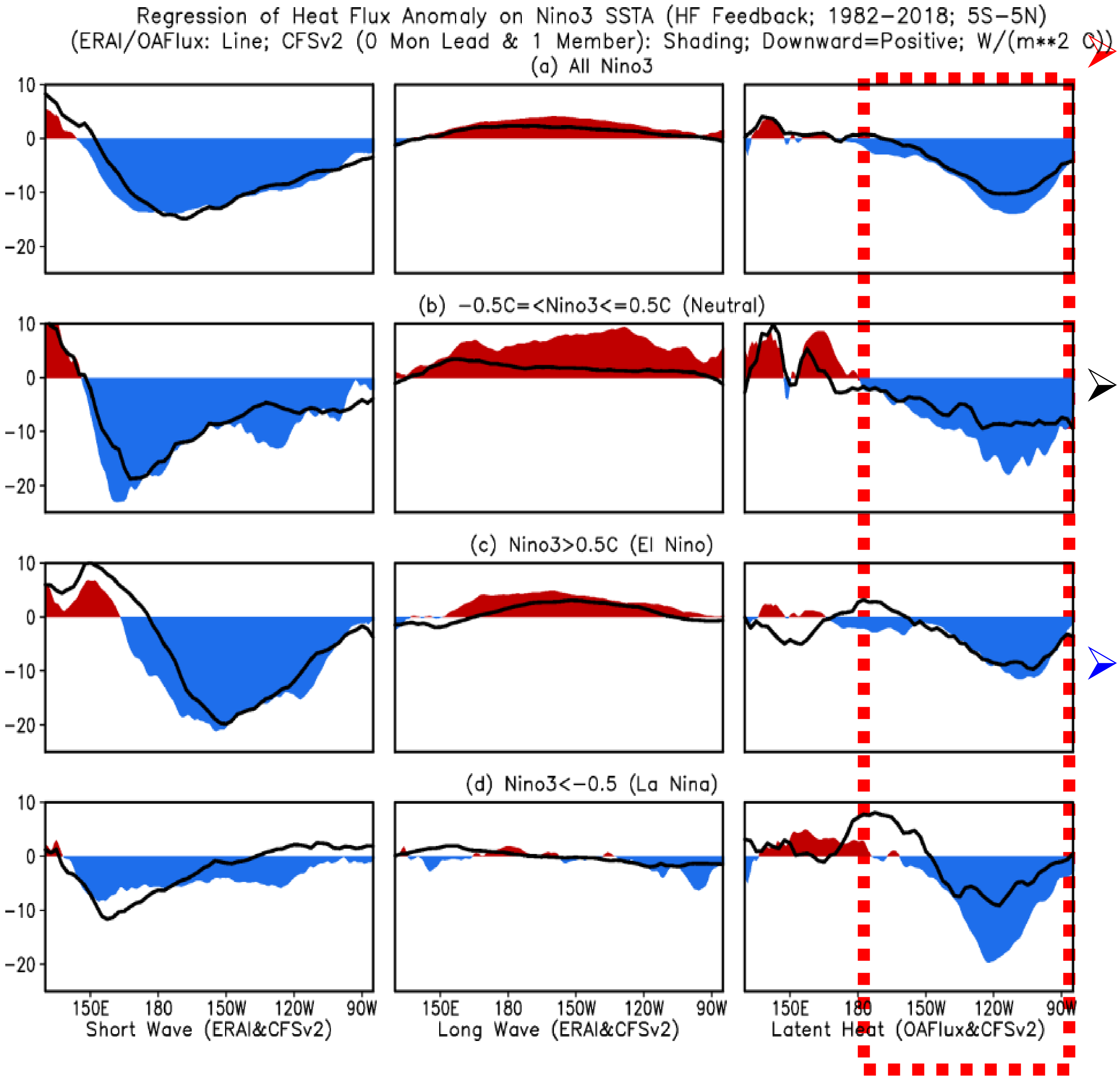


- ➢ Differences present for different reanalysis; ERAI is stronger than other reanalyses;
- ➢ For 0.5C<Nino3≤1.5C, positive values in CFSv2 are too small and extend too eastward (without negative values in the E. Pacific);
- ➢ For Nino3≥1.5C, positive values are too large in CFSv2.

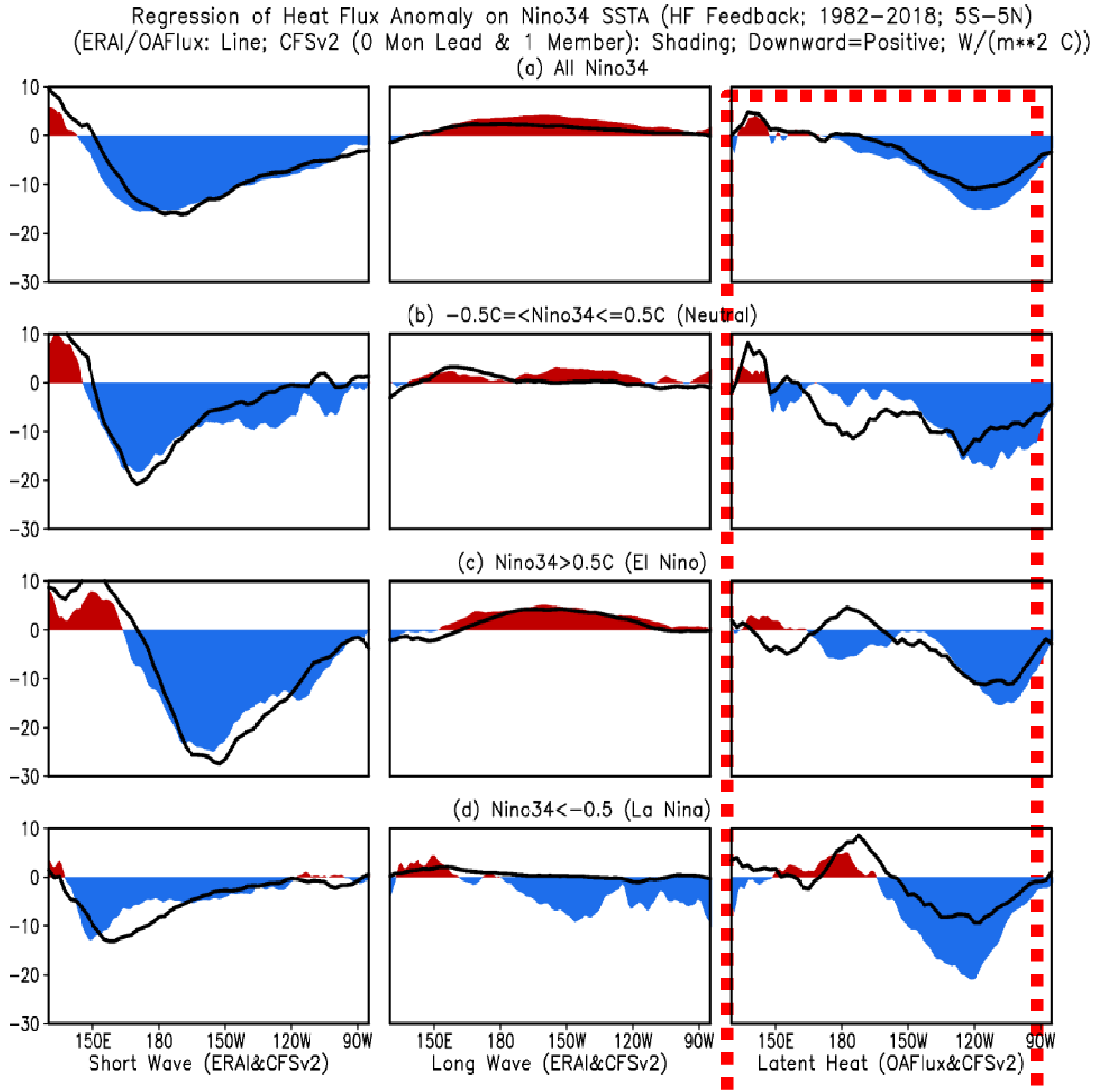
5S-5N average based on Nino3.4



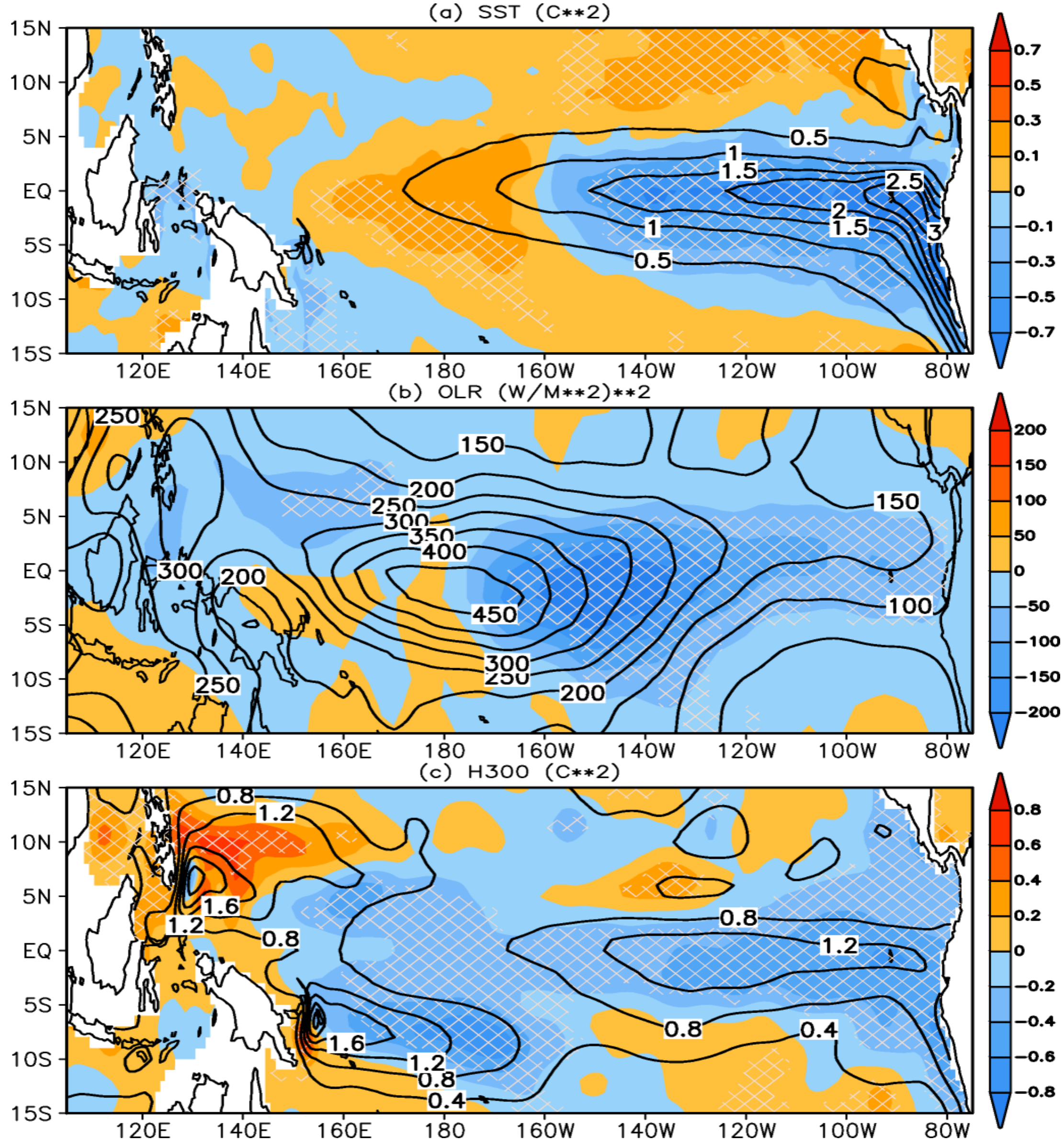
- ➢ Differences present for different reanalysis; ERAI is stronger than other reanalyses;
- ➢ For 0.5C<Nino3.4≤1.5C, positive values in CFSv2 extend too westward;
- ➢ For Nino3.4≥1.5C, positive values are too large in CFSv2 near the Dateline.



- Heat flux anomaly regression onto Nino3 (shading=obs; curve=CFSv2).
- Latent heat flux damping is stronger in CFSv2 than in obs.
- The sample size too small for (c) and (d), so the results may not be robust.



- Heat flux anomaly regression onto Nino3.4 (shading=obs; curve=CFSv2).
- Latent heat damping is stronger in CFSv2 than in obs.
- The sample size too small for (c) and (d), so the results may not be robust.



SST, H300, & OLR variance differences: <2000-2018>-<1979-1999>

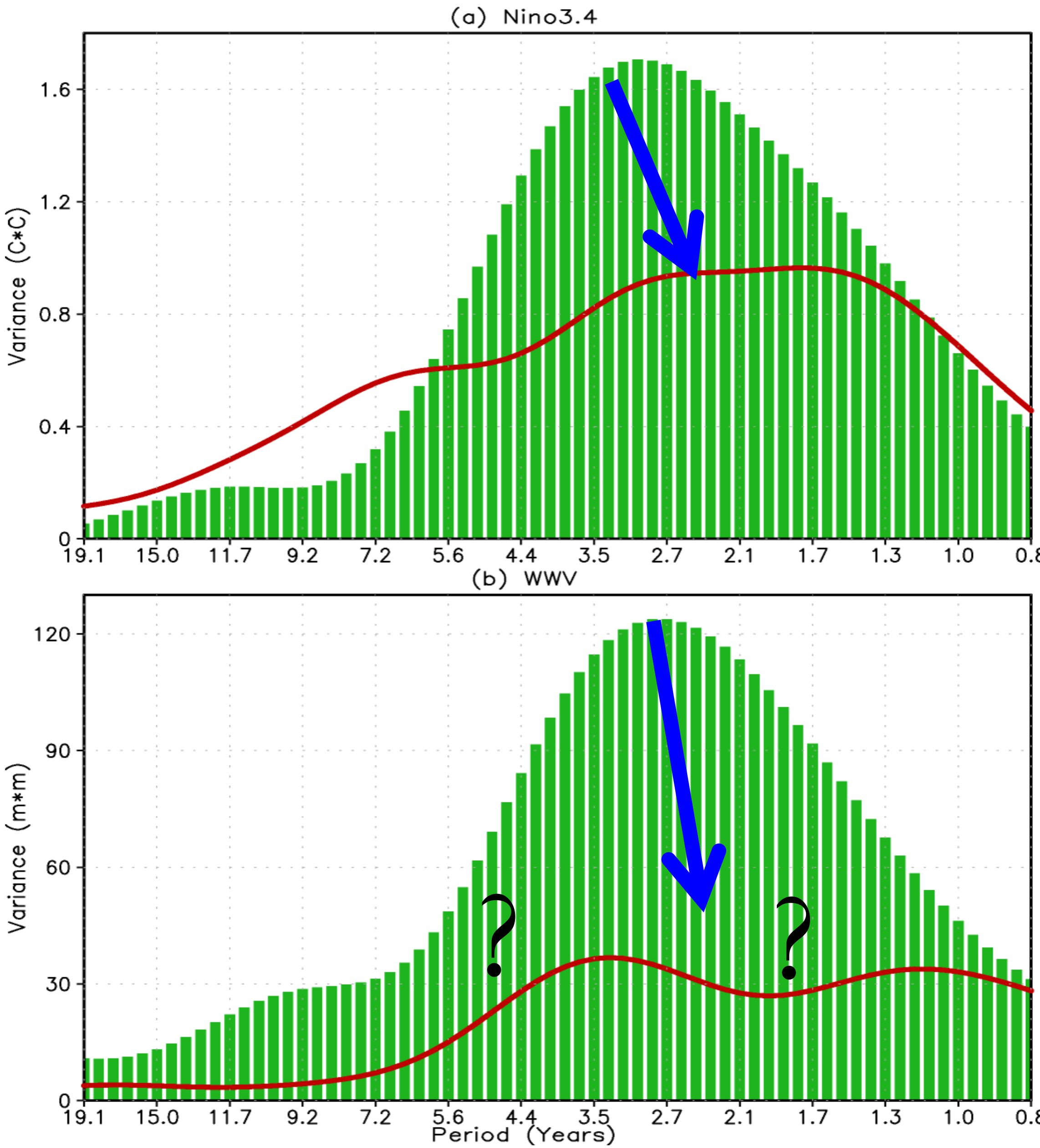
Suppressed variability:

(a) SSTA in the eastern Pacific;

(b) Precipitation, and deep convection in the central-eastern tropical Pacific;

© H300 along equatorial central and eastern Pacific, and around 5^{o}N/S in the western Pacific.

Hu, Z.-Z., et al.: 2020: The interdecadal shift of ENSO properties in 1999/2000: A review. J. Climate, DOI: 10.1175/JCLI-D-19-0316.1.

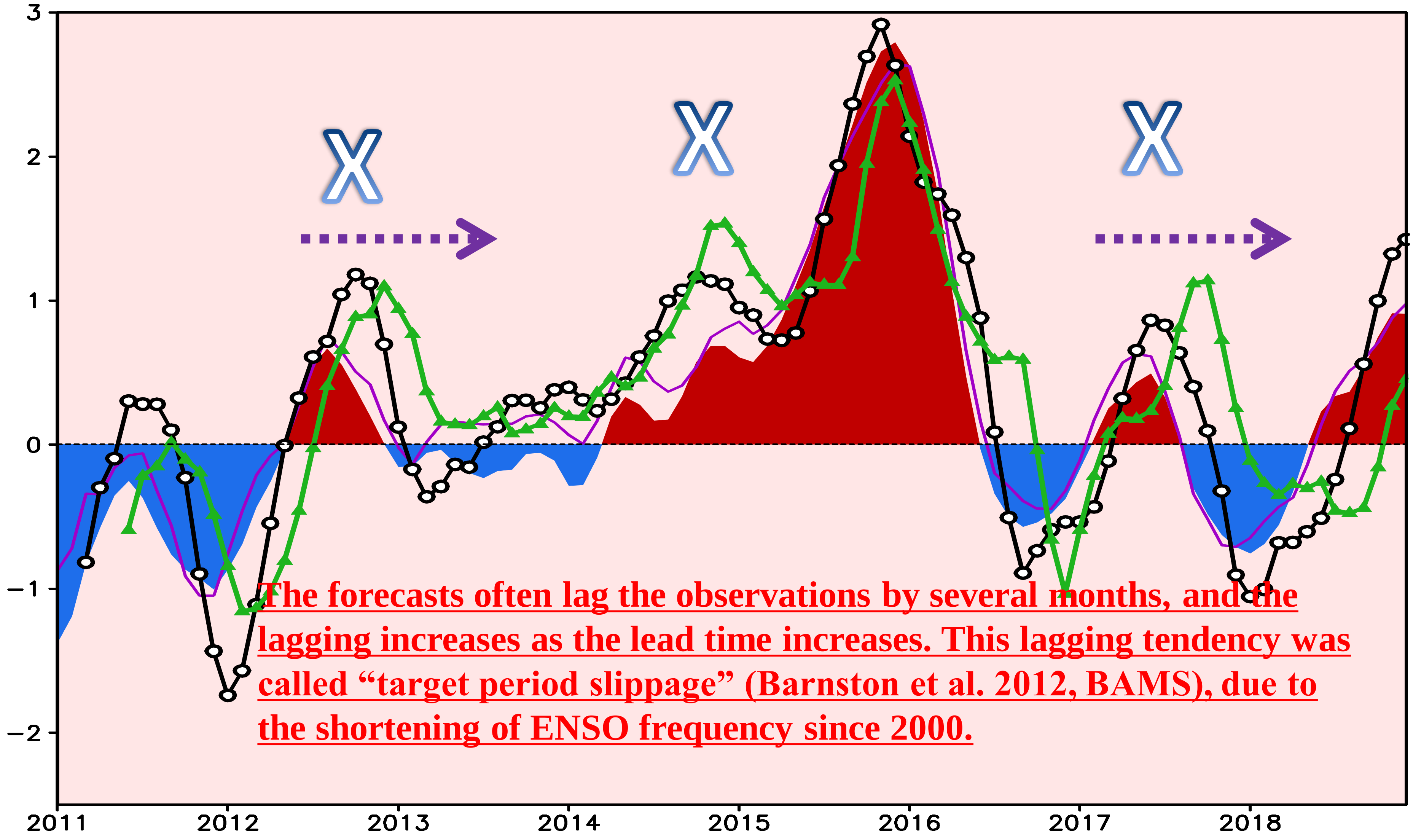


ENSO shifted to lower variability & higher frequency regime since 2000: Model may be unable to capture the decadal variation.

Specifically, the maximum variability of the Niño3.4 index was confined in the period band of 1.5-5 years in 1979-99, while the variance distribution was flatter with a much smaller peak around 1.5-3.5 years in 2000-18.

The WWV index was total no peak in 2000-18, implying closer to a white noise process in 2000-18.

Hu, Z.-Z., et al.: 2020: The interdecadal shift of ENSO properties in 1999/2000: A review. J. Climate. DOI: 10.1175/JCLI-D-19-0316.1.



Observed (shading) and CFSv2 predicted Niño3.4 index in January 2011-DecemberJuly 2018. The predictions of 1, 4, and 7 month leads are represented by purple, black with open circle, and green with closed triangle curves, respectively. The CFSv2 predictions are the ensemble mean of 80 members.

Hu, Z.-Z., et al.: 2020: The interdecadal shift of ENSO properties in 1999/2000: A review. J. Climate, DOI: 10.1175/JCLI-D-19-0316.1.

Results:

- Zonal Wind SST feedback is too weak and extended too eastward for 0.5C<Nino3≤1.5C.
- Zonal Wind SST feedback is too strong for Nino3>1.5C or Nino3.4>1.5C.
- There are some differences for the heat flux and its individual terms feedbacks associated with ENSO between CFSv2 and observations.
- In addition to biases in the dynamical and thermodynamical feedback, biases in IC and interdecadal shift of ENSO may also play a role in the forecast failure in CFSv2.

Acknowledgements

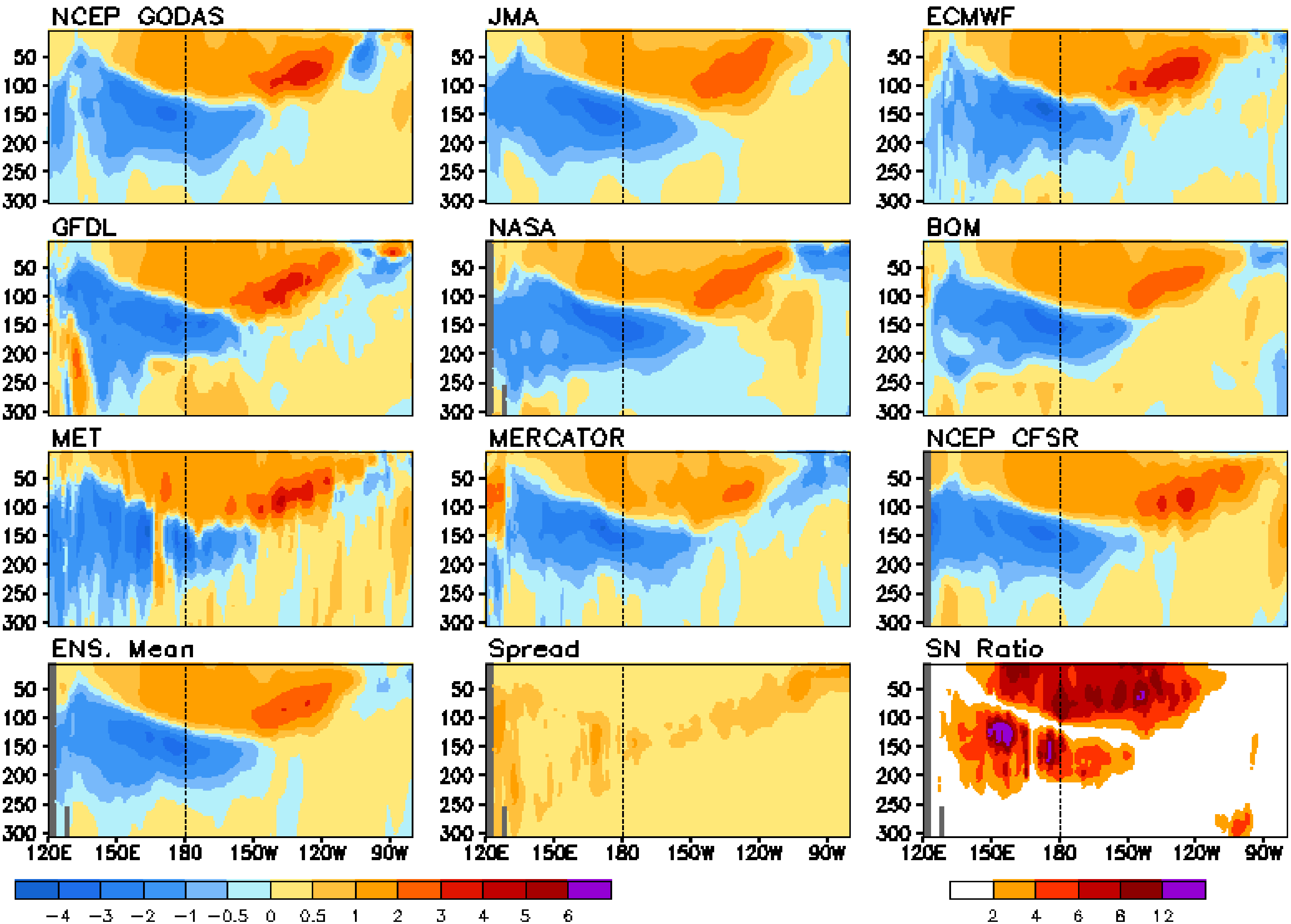
- Drs. Jieshun Zhu, Caihong Wen, and Arun Kumar: reviewed PPT, and provide insightful and constructive suggestions and comments
- Drs. Li Ren and Pingping Xie provided the SSS slides
- Dr. Wanqiu Wang provided the sea ice forecasts and maintained the CFSv2 forecast achieve

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

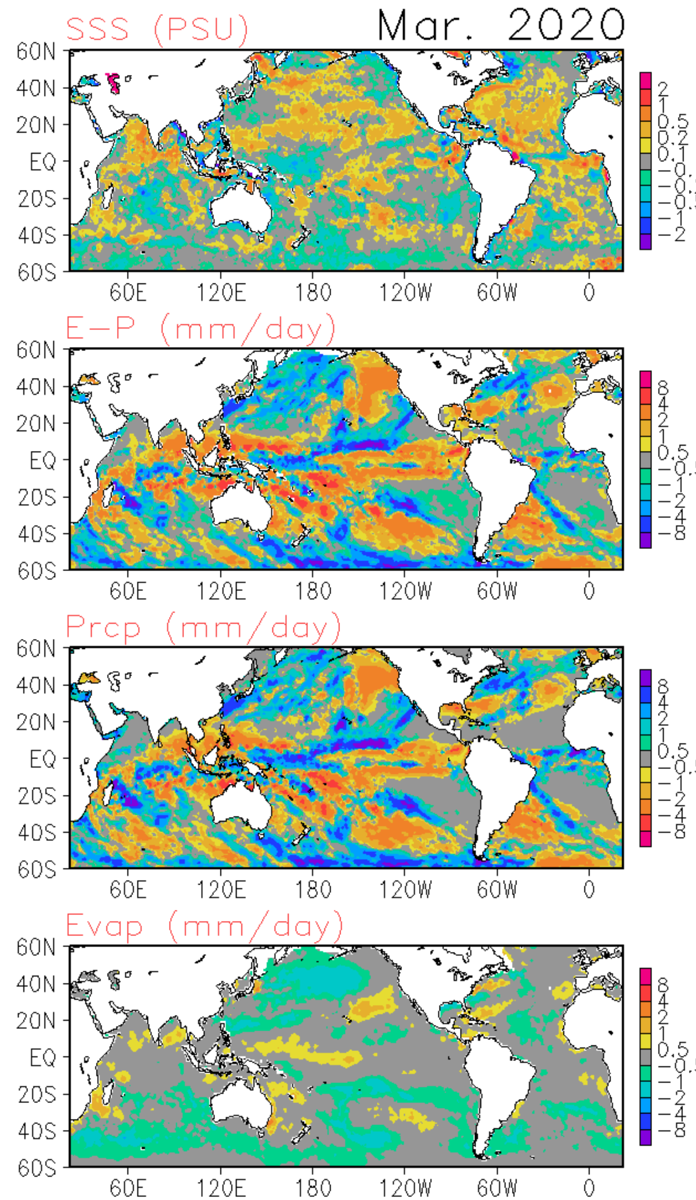
Anomalous Temperature (C) Averaged in 1S-1N: MAR 2020



Global Sea Surface Salinity (SSS)

Anomaly for March 2020

- New Update: The input satellite sea surface salinity of SMAP from NSAS/JPL was changed from Version 4.0 to Near Real Time product in August 2018.
- Positive SSS anomalies in the west and central subarctic N. Pacific ocean are likely caused by the oceanic advection and entrainments. Positive SSS anomalies in the subtropical N. Pacific ocean continues. Negative SSS signal in the west equatorial Pacific region is persistent with enhanced precipitation. Positive SSS in the N. Atlantic Ocean continues and strengthens. Negative SSS signal appears along the equator of Atlantic ocean, which is accompanied with heavier precipitation.



- **Data used**

SSS : Blended Analysis of Surface Salinity (BASS) V0.Z

(a CPC-NESDIS/NODC-NESDIS/STAR joint effort)

(Xie et al. 2014)

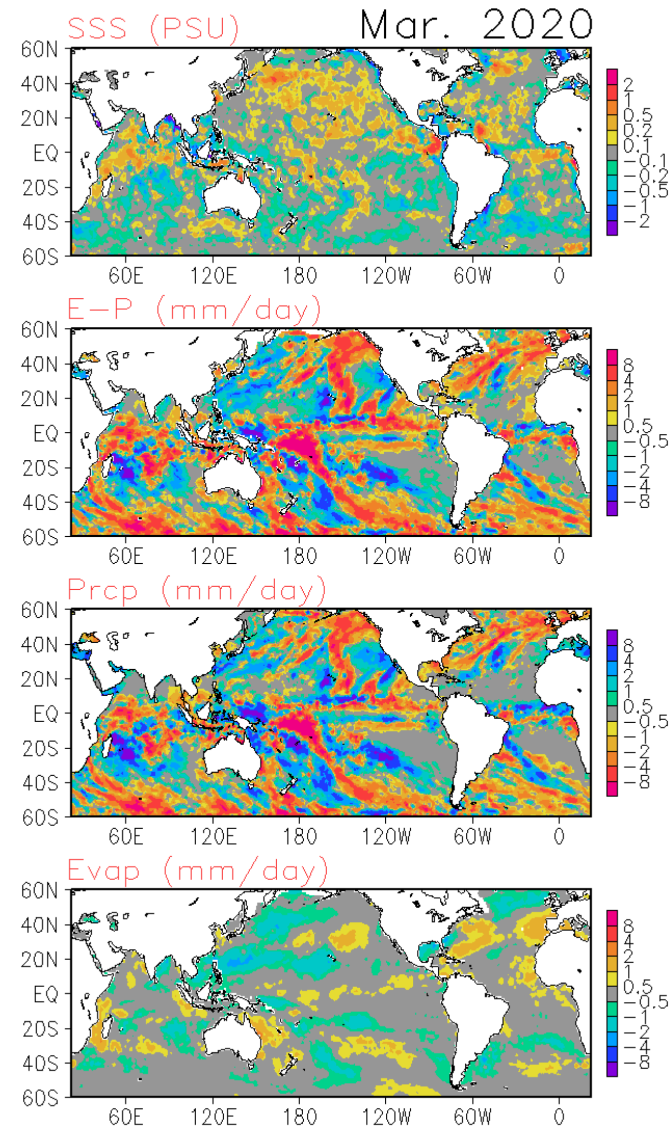
ftp.cpc.ncep.noaa.gov/precip/BASS

Precipitation: CMORPH adjusted satellite precipitation estimates

Evaporation: Adjusted CFS Reanalysis

Global Sea Surface Salinity (SSS)
Tendency for March 2020

Compared with last month, the SSS increased in most area of the N. Pacific ocean and N. Atlantic Ocean. The SSS signal is positive north of Equator in the Indian Ocean as well. The SSS decreased in the Bay of Bengal and such signal is accompanied with increased precipitation. In the equator of Atlantic Ocean, the decreased SSS is likely due to the increased precipitation.

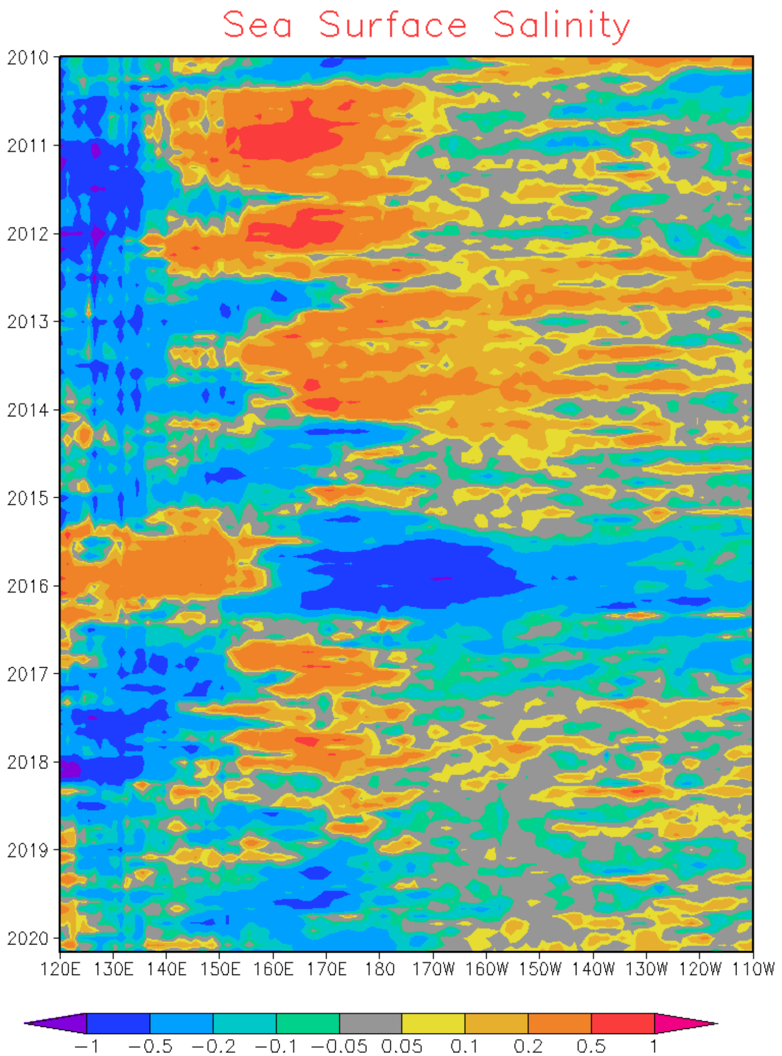


Global Sea Surface Salinity (SSS)

Anomaly Evolution over Equatorial Pacific from Monthly SSS

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

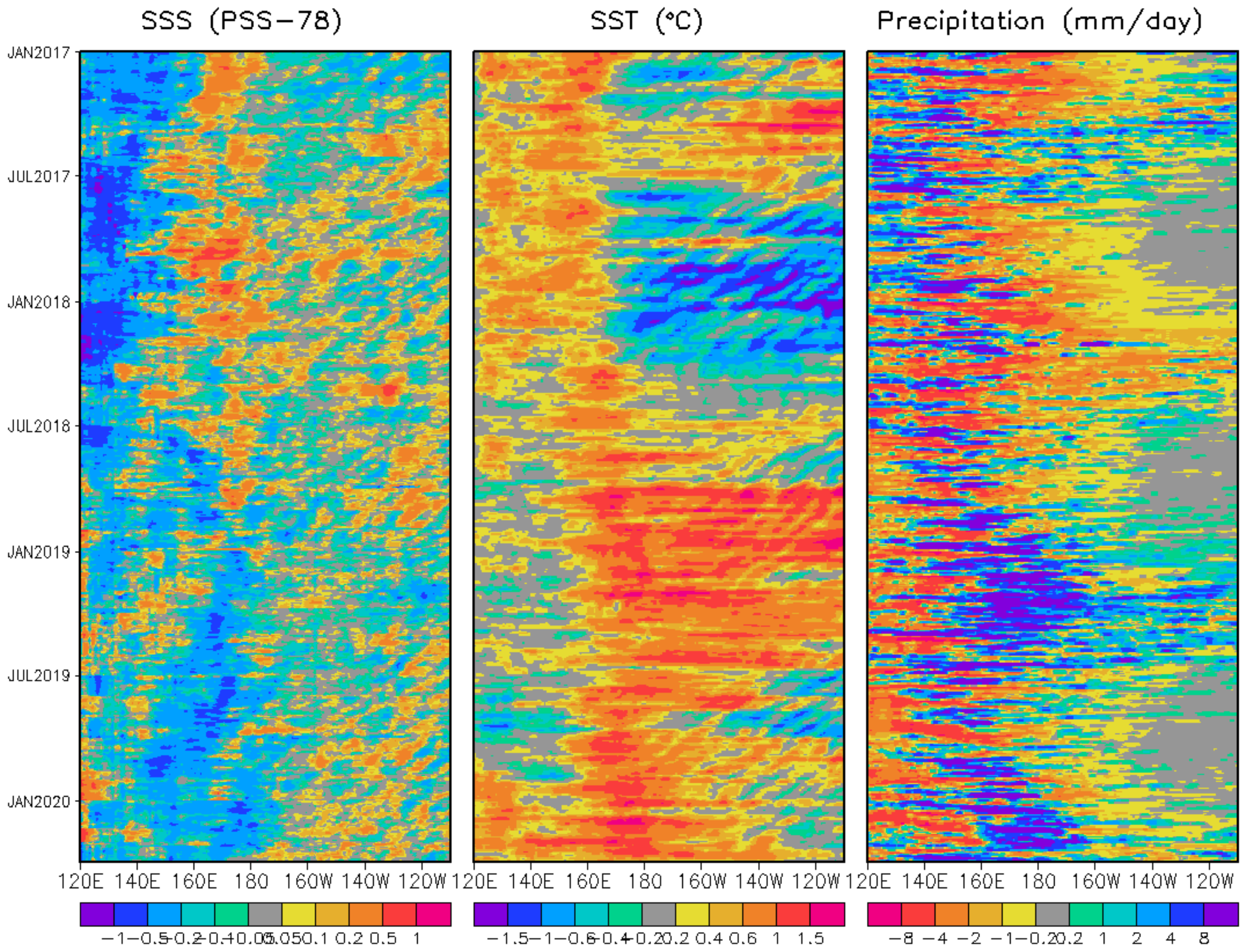
- Hovemoller diagram for equatorial SSS anomaly **(5° S-5° N);**
- In the equatorial Pacific Ocean, the SSS signal is negative in most of the area west of 170° W; the SSS shows positive anomalies east of 170° W.



Global Sea Surface Salinity (SSS)

Anomaly Evolution along the Equatorial Pacific from Pentad SSS

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



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

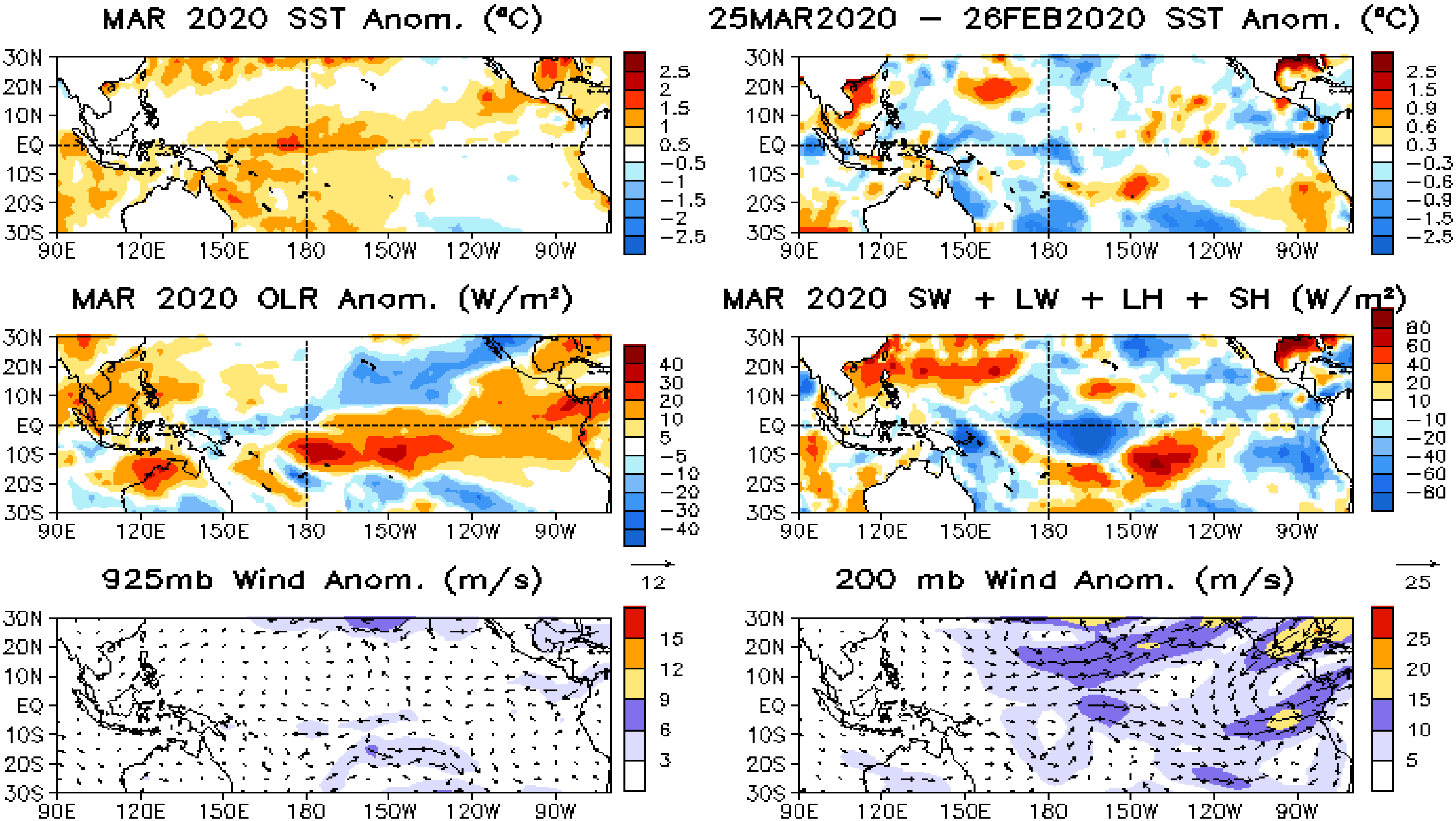
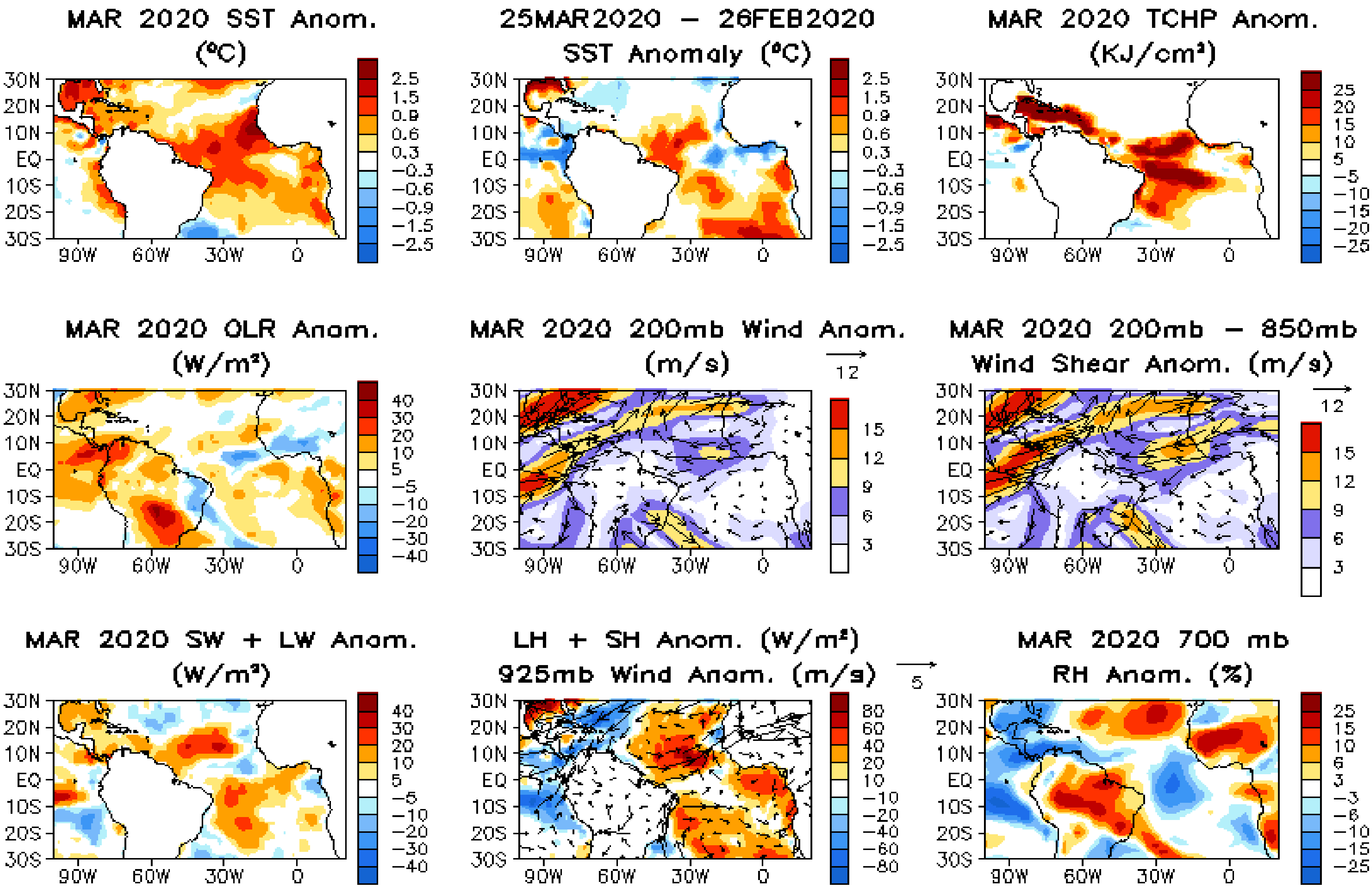


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, winds and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.

Tropical Atlantic Ocean



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

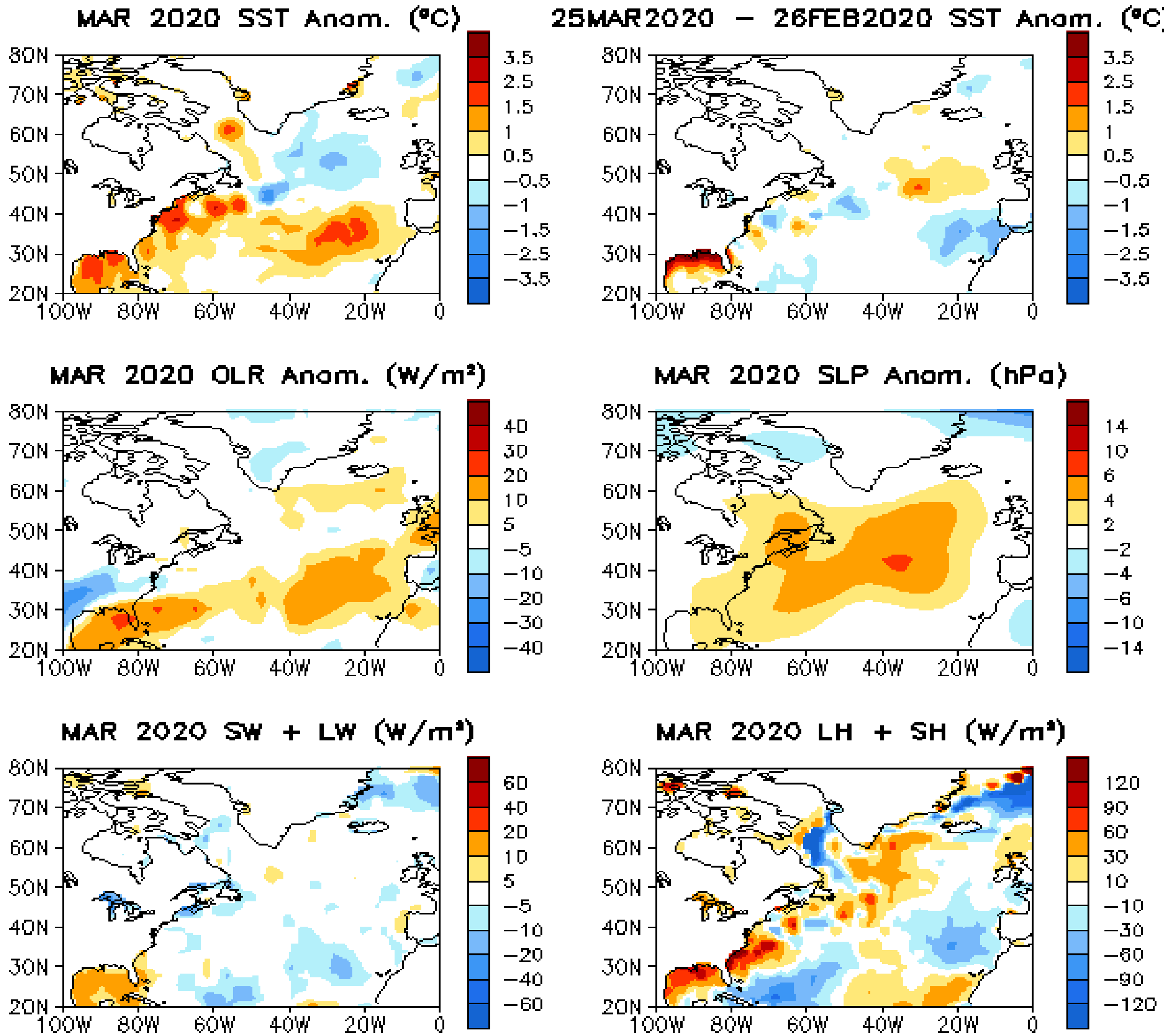


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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 2007)
- ❖ Aviso altimetry sea surface height from CMEMS (Pujol et al. 2016)
- ❖ Ocean Surface Current Analyses – Real-time (OSCAR; Dohan and Maximenko 2010)
- ❖ In situ data objective analyses (IPRC, Scripps, EN4.2.1, PMEL TAO; McPhaden et al. 1998)
- ➢ 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

65