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

Prepared by

Climate Prediction Center, NCEP/NOAA

April 9, 2021

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

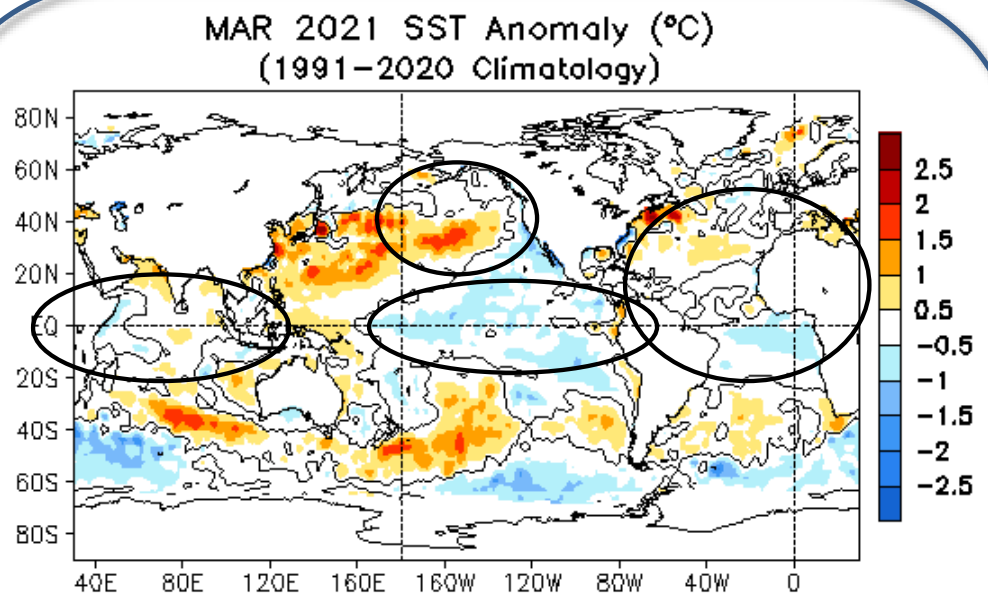
- Overview
- Recent highlights
  - Pacific/Arctic Ocean
  - Indian Ocean
  - Atlantic Ocean
- Global SSTA Predictions

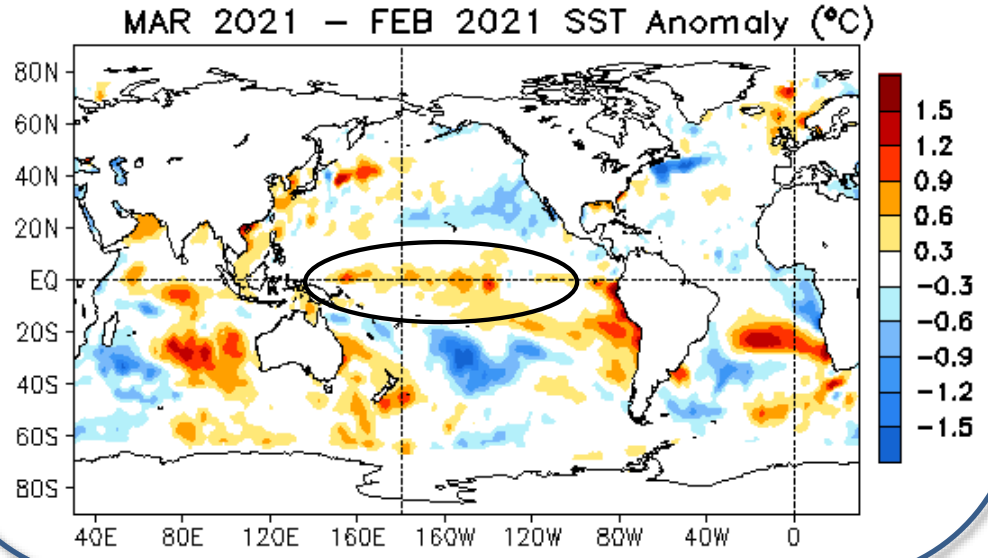
Overview

- Pacific Ocean
  - NOAA "ENSO Diagnostic Discussion" on 8 Apr 2021 stated *"A transition from La Niña to ENSO-Neutral is likely in the next month or so, with an 80% chance of ENSO-neutral during May-July 2021."*
  - La Niña conditions weakened with Niño3.4 = -0.51°C in Mar 2021.
  - The negative phase of PDO has persisted since Jan 2020 with PDOI = -1.0 in Mar 2021.
- Indian Ocean
  - SSTAs were small in the tropical Indian Ocean in Mar 2021.
- Atlantic Ocean
  - A positive phase of the meridional dipole mode persisted in Mar 2021.
  - NAO was in a positive phase in Mar 2021 with NAOI= 0.36.
- Arctic Ocean
  - The seasonal maximum in the sea ice extent was observed on 21 Mar 2021.
  - The sea ice extent for Mar 2021 was the 9th lowest since 1979.
  - With ICs in Jan-Mar 2021, NCEP/CPC predicted a near-normal sea ice extent during spring and early summer 2021.

Global Oceans

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



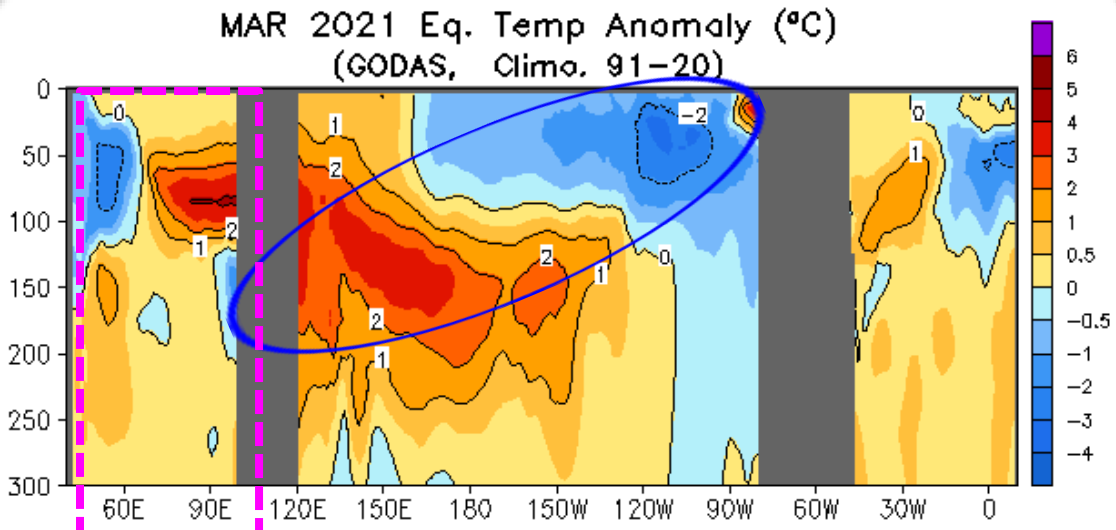


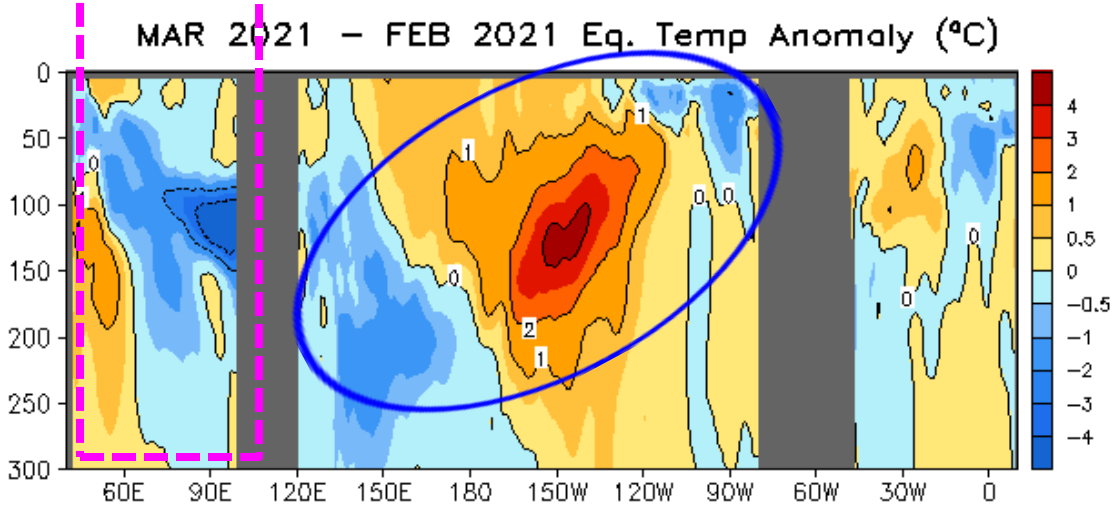
- Negative SSTAs weakened in the central and eastern tropical Pacific.
- Positive SSTAs were evident in the NE Pacific.
- Positive (negative) SSTAs were present in the tropical North (South) Atlantic Ocean.
- SSTAs were small in the tropical Indian Ocean.

- Positive SSTA tendencies were present in the equatorial Pacific.

Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1991-2020 base period means.

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



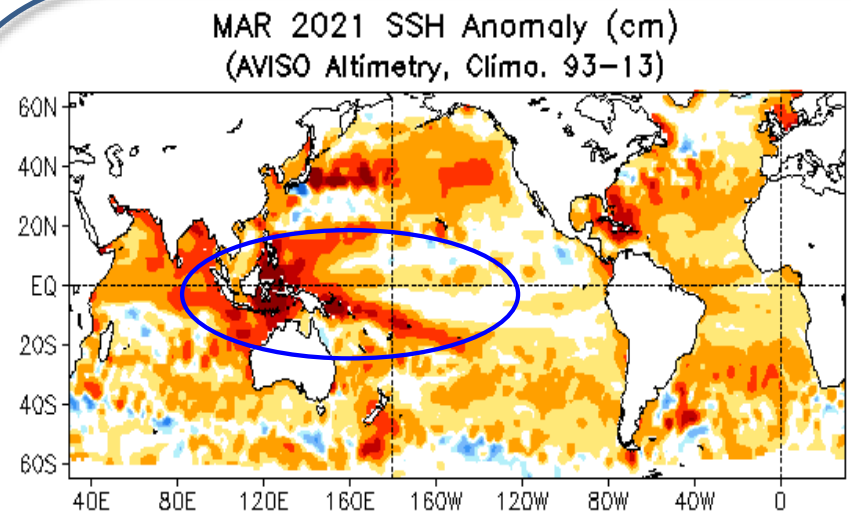


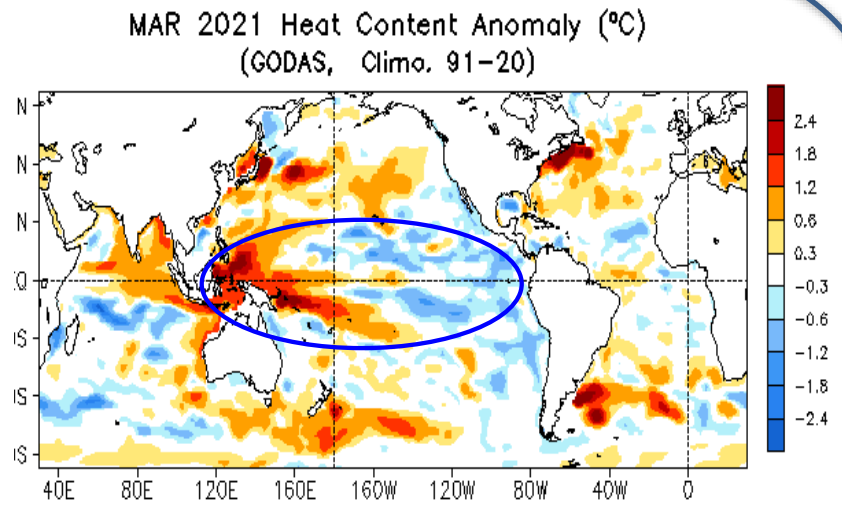
- A dipole-like temperature structure (tilt mode) persisted with positive (negative) anomalies in the western (eastern) Pacific.
- Positive anomalies have been observed in the eastern Indian Ocean since Oct 2020.

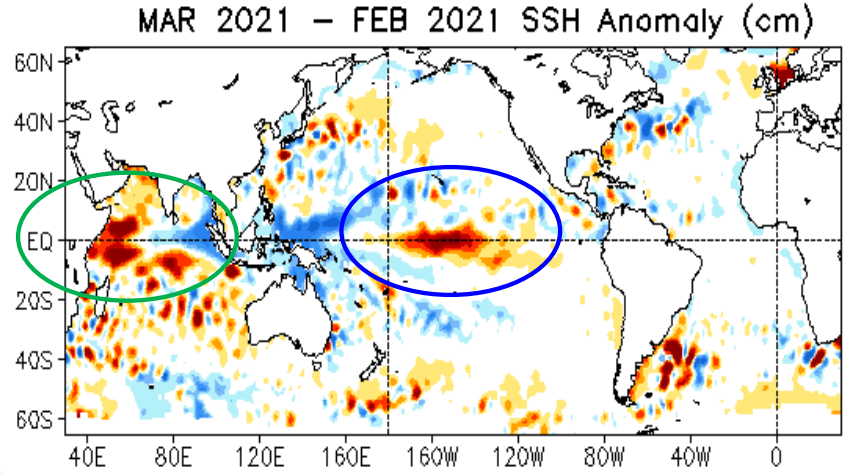
- Temperature anomaly tendency was positive (negative) along the thermocline in the east-central (western and eastern) Pacific, implying an eastward propagation of the positive anomalies.

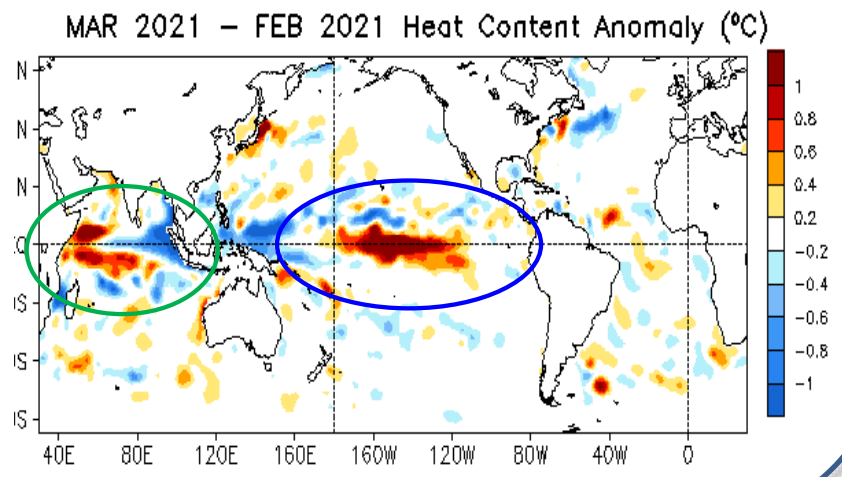
Equatorial depth-longitude section of ocean temperature anomalies (top) and anomaly tendency (bottom). Data is from the NCEP's global ocean data assimilation system. Anomalies are departures from the 1991-2020 base period means.

Global SSH and HC300 Anomaly & Anomaly Tendency







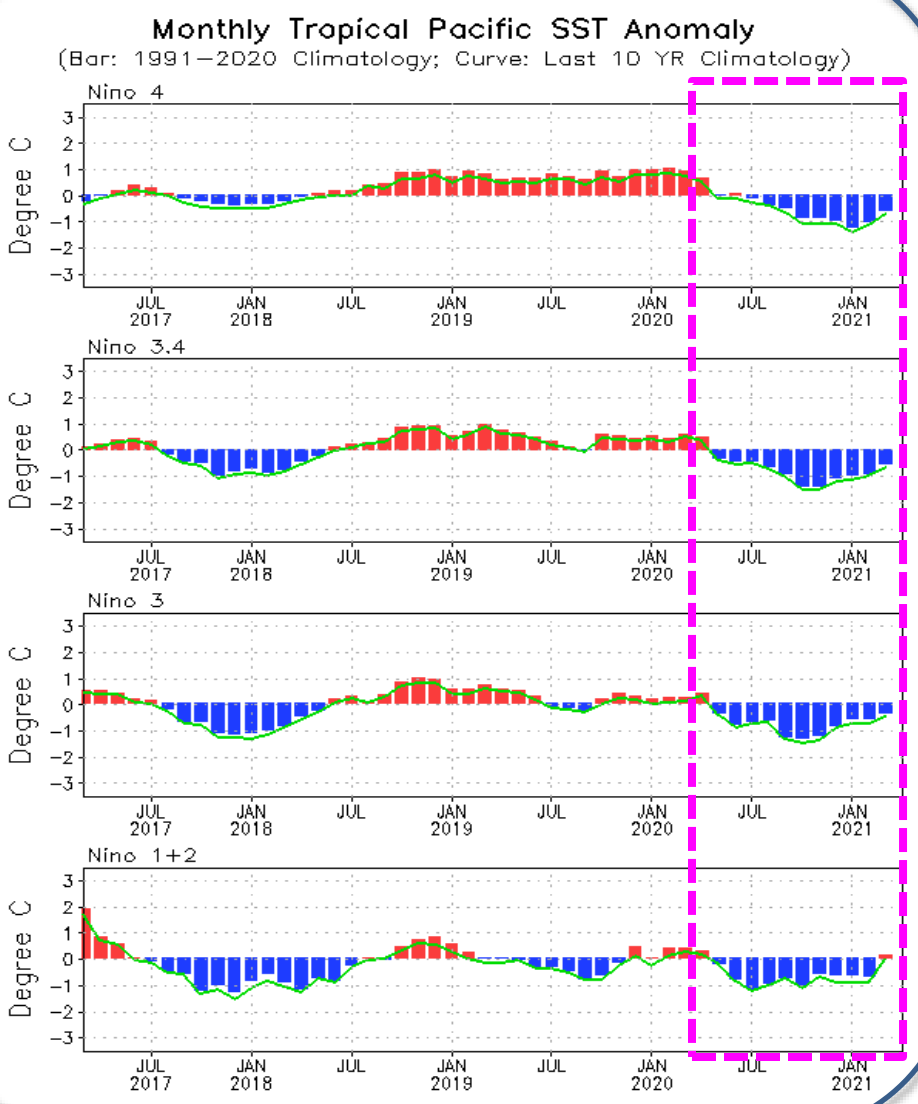


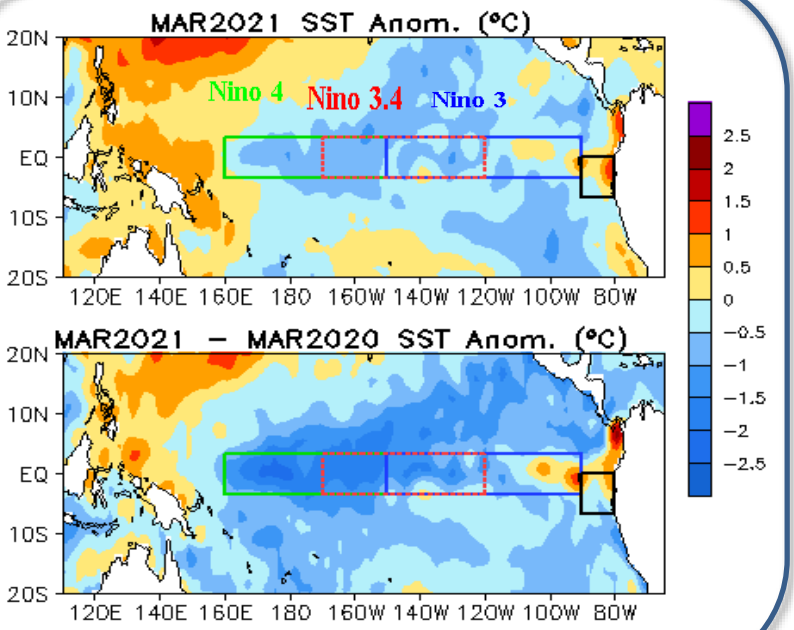
- The SSHA pattern was overall consistent with the HC300A pattern, but with a significant trend component in SSHA.

- Anomaly tendencies: Positive in the east-central tropical Pacific and western tropical Indian Oceans; negative in the western tropical Pacific and eastern Indian Oceans.

Tropical Pacific Ocean and ENSO Conditions

Evolution of Pacific Niño SST Indices





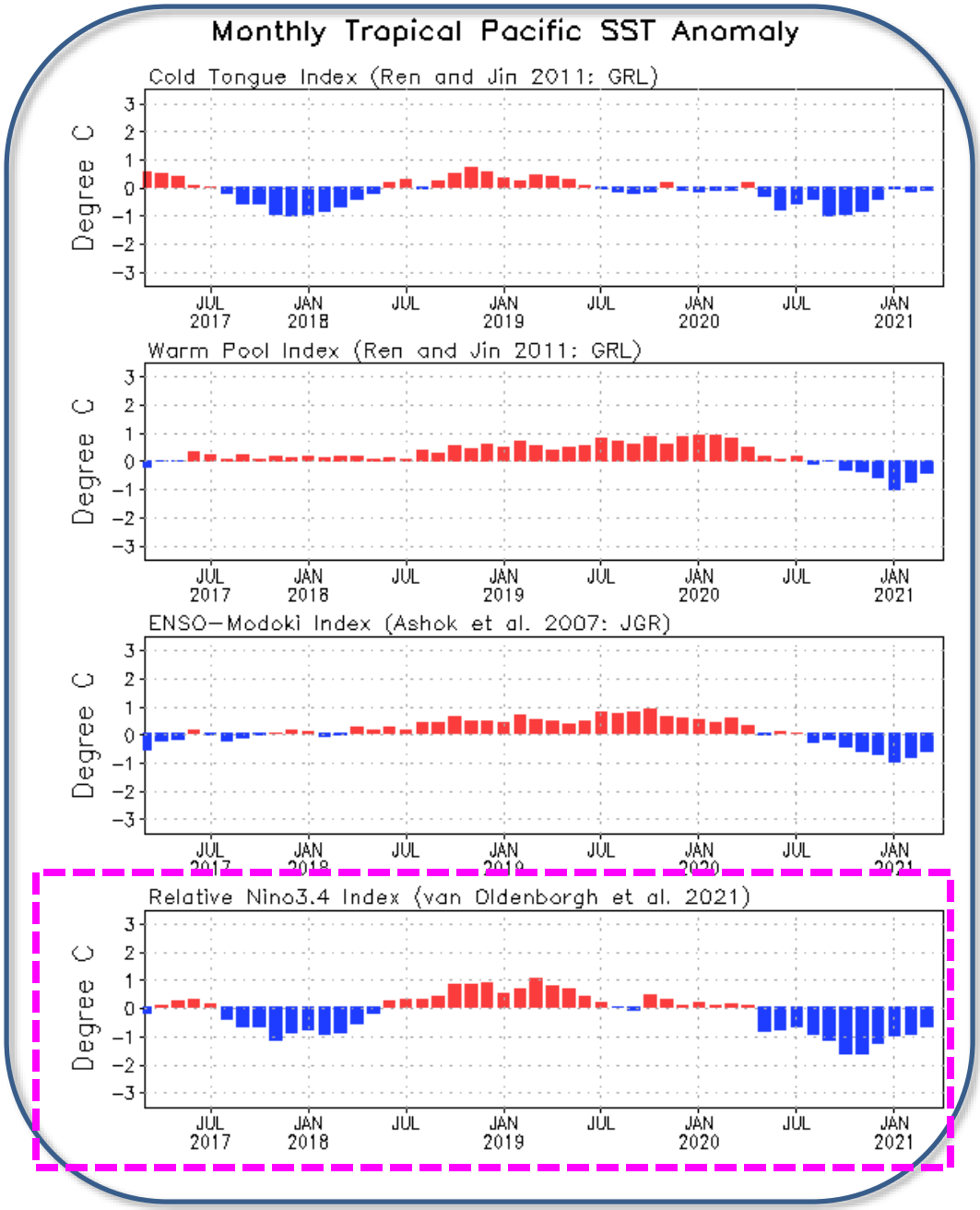
- All Niño indices weakened and Niño1+2 became positive, with Niño3.4 = -0.51°C in Mar 2021.

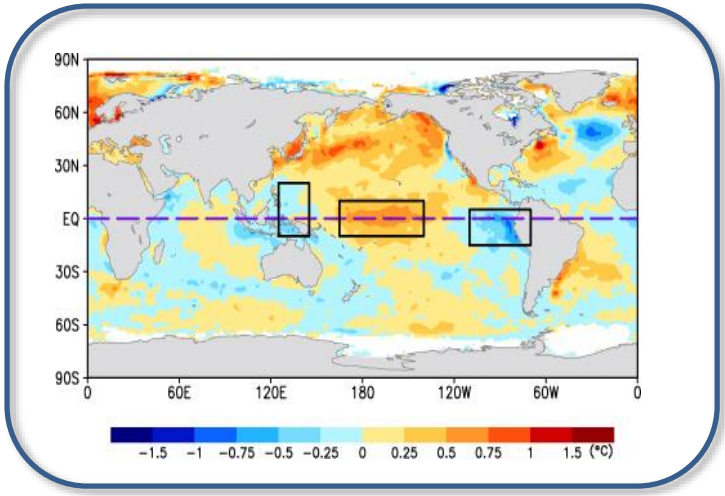
- Compared with Mar 2020, the central and eastern tropical Pacific was cooler in Mar 2021.

- The indices may have slight differences if based on different SST products.

Niño 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 1991-2020 base period means.

Evolution of Pacific Niño SST Indices



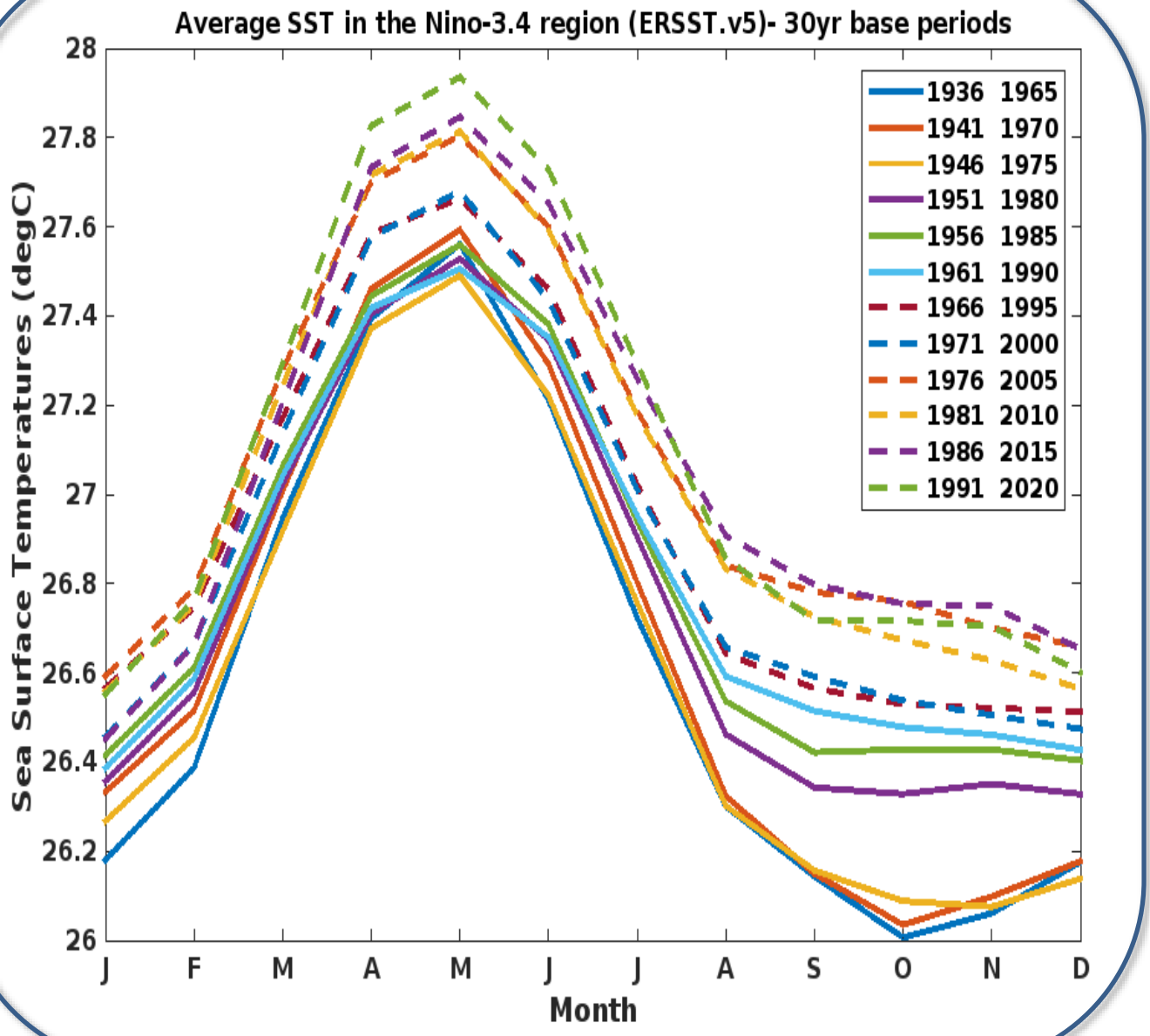


- Relative Niño3.4 index is now included, which is defined as the conventional Niño3.4 index minus the SSTA averaged in the whole tropics (0°-360°, 20°S-20°N), in order to remove the global warming signal. Also, to have the same variability as the conventional Niño3.4 index, the relative Niño3.4 index is renormalized (van Oldenborgh et al. 2021: ERL, 10.1088/1748-9326/abe9ed).

Relative Niño3.4 data updated monthly at:

https://www.cpc.ncep.noaa.gov/data/indices/RONI.ascii.txt

Why Relative Niño3.4 Index?



- CPC's the Oceanic Niño Index (ONI) is 3-month running mean of ERSST.v5 SSTAs in the Niño 3.4 region (5°N-5°S, 120°-170°W), based on centered 30-year base periods updated every 5 years.

- **So, the ENSO classifications based on the CPC's ONI in the latest 15-years are subjected to be modified due to a climatology update.**

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

Why Relative Niño3.4 Index?

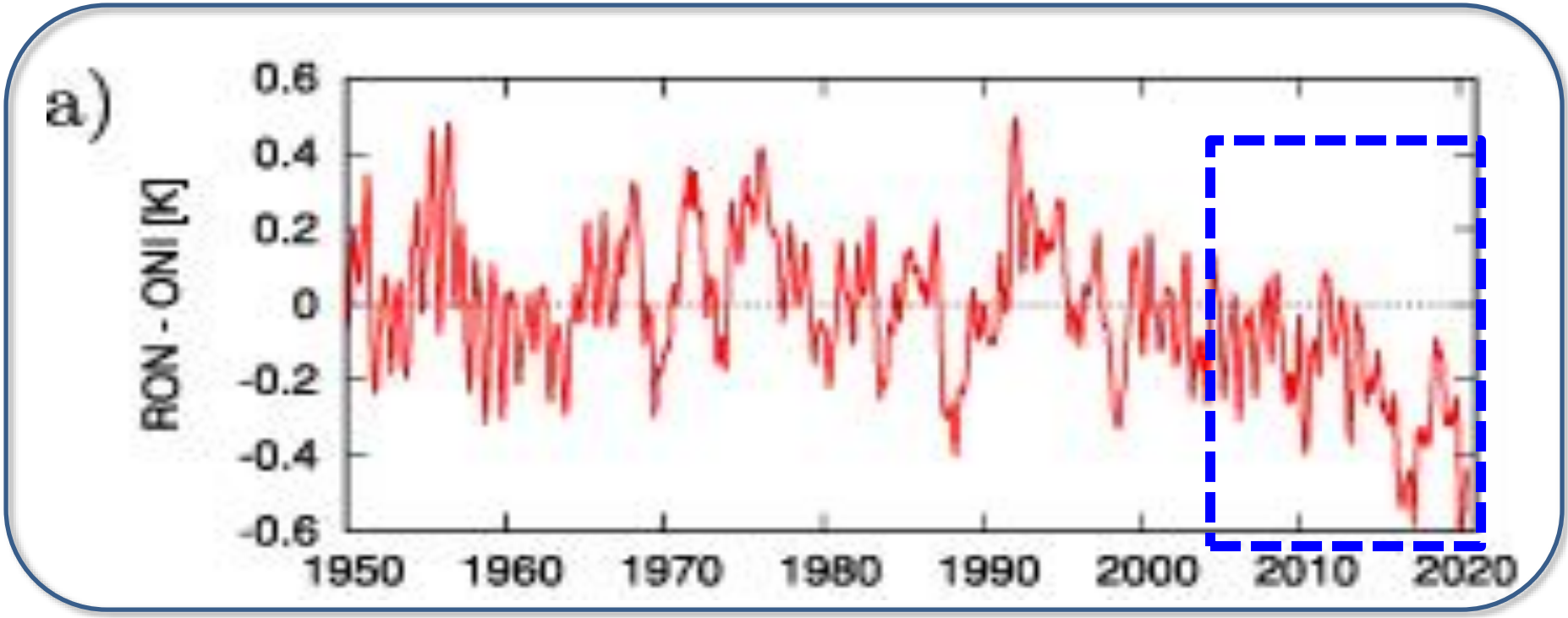
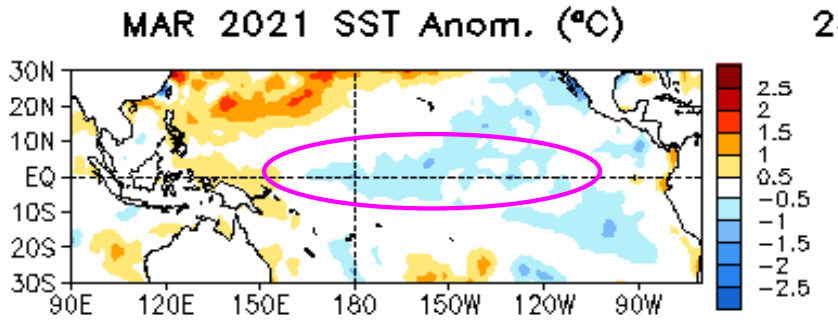


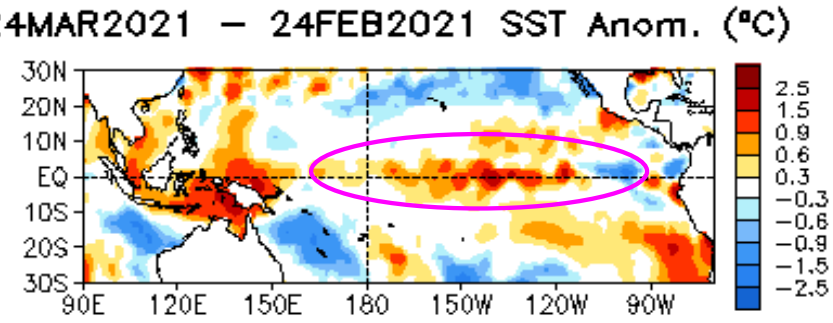
Figure 3. (a) Difference between the relative Ocean Niño Index (ONI) proposed here and the current NOAA/NCEP ONI definition

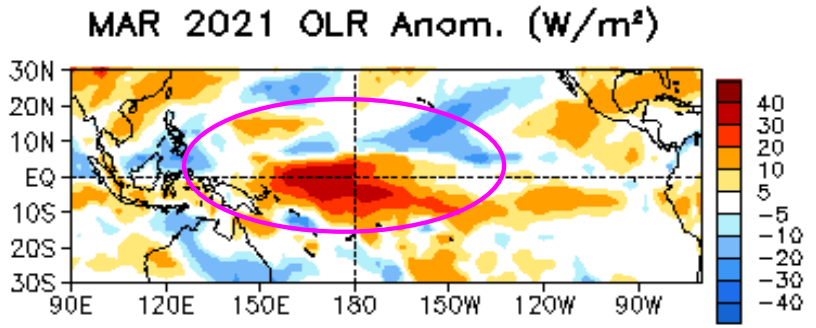
- Relative Niño3.4 index is now included, which is define as the conventional Niño3.4 index minus the SSTA averaged in the whole tropics (0º-360º, 20ºS-20ºN), in order to remove the global warming signal. Also, to have the same variability as the conventional Niño3.4 index, the relative Niño3.4 index is renormalized (van Oldenborgh et al. 2021: ERL, 10.1088/1748-9326/abe9ed) .

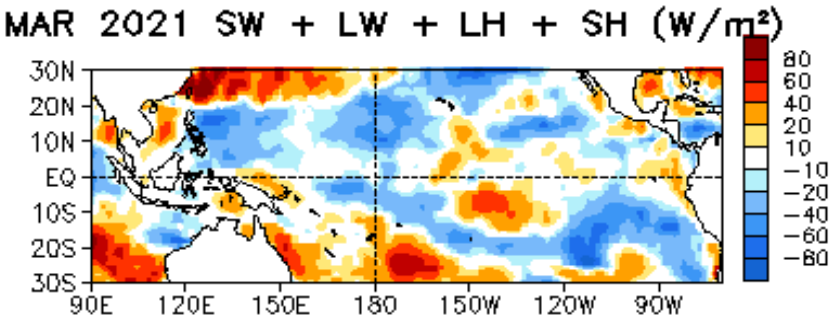
- Compared with the relative Niño3.4, due to the warming trend in the Niño3.4, El Niño may be overestimated & La Niña may be underestimated based on the Niño3.4 during the latest 15 years.

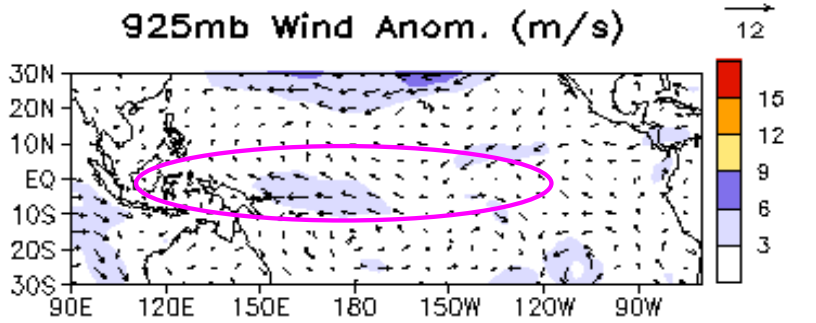
Tropical Pacific: SSTA, SSTA Trend, OLR, heat flux, uv925 & uv200 anomalies

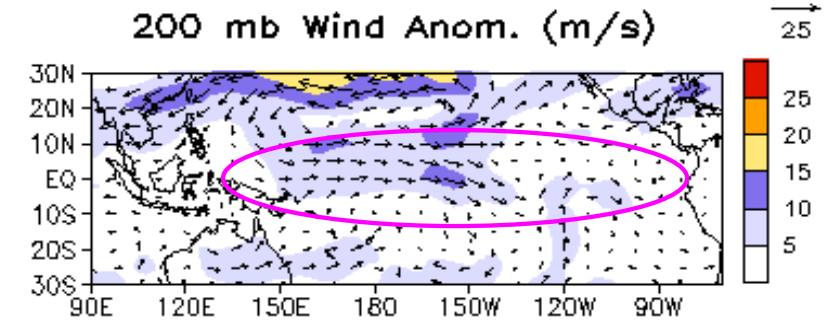






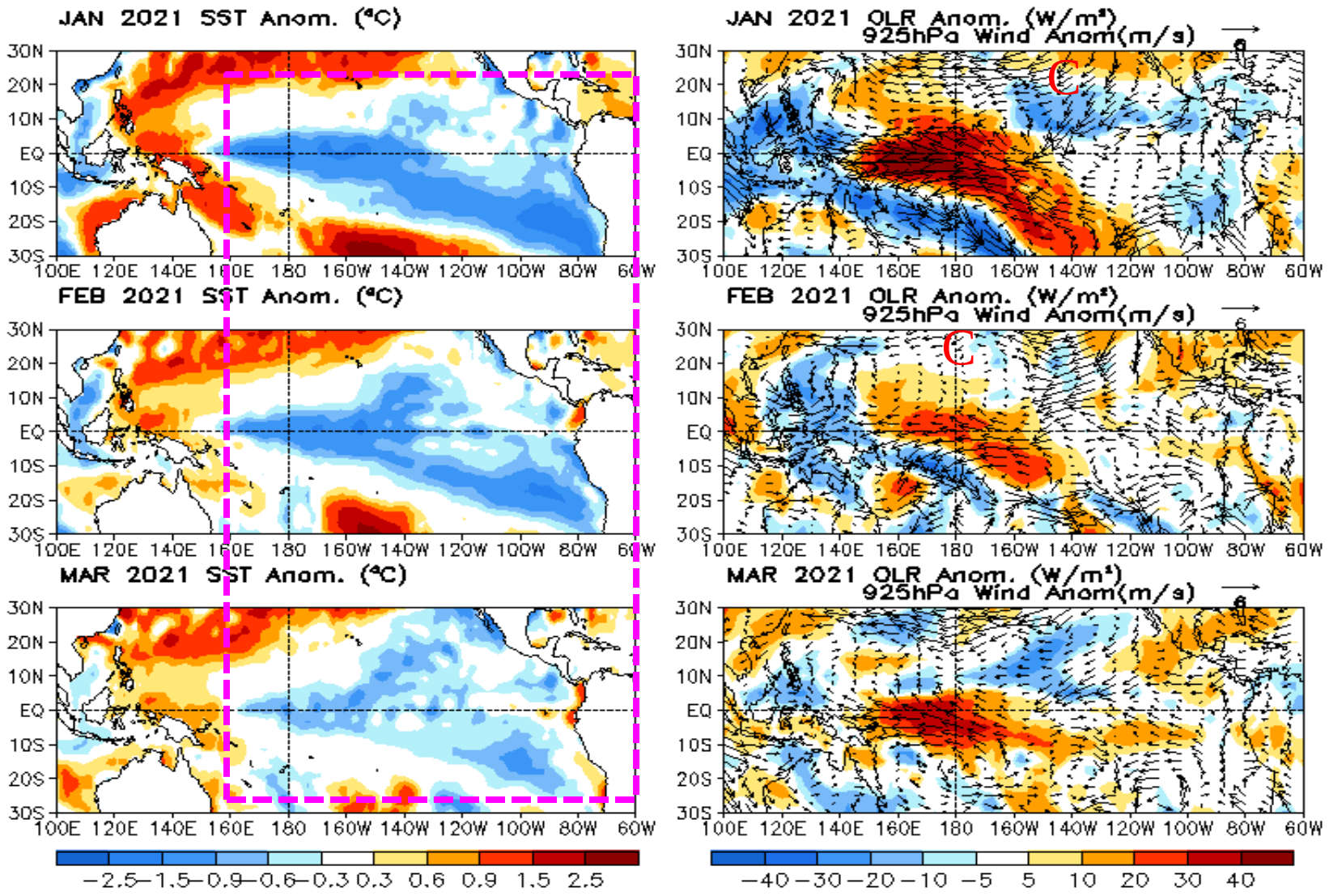




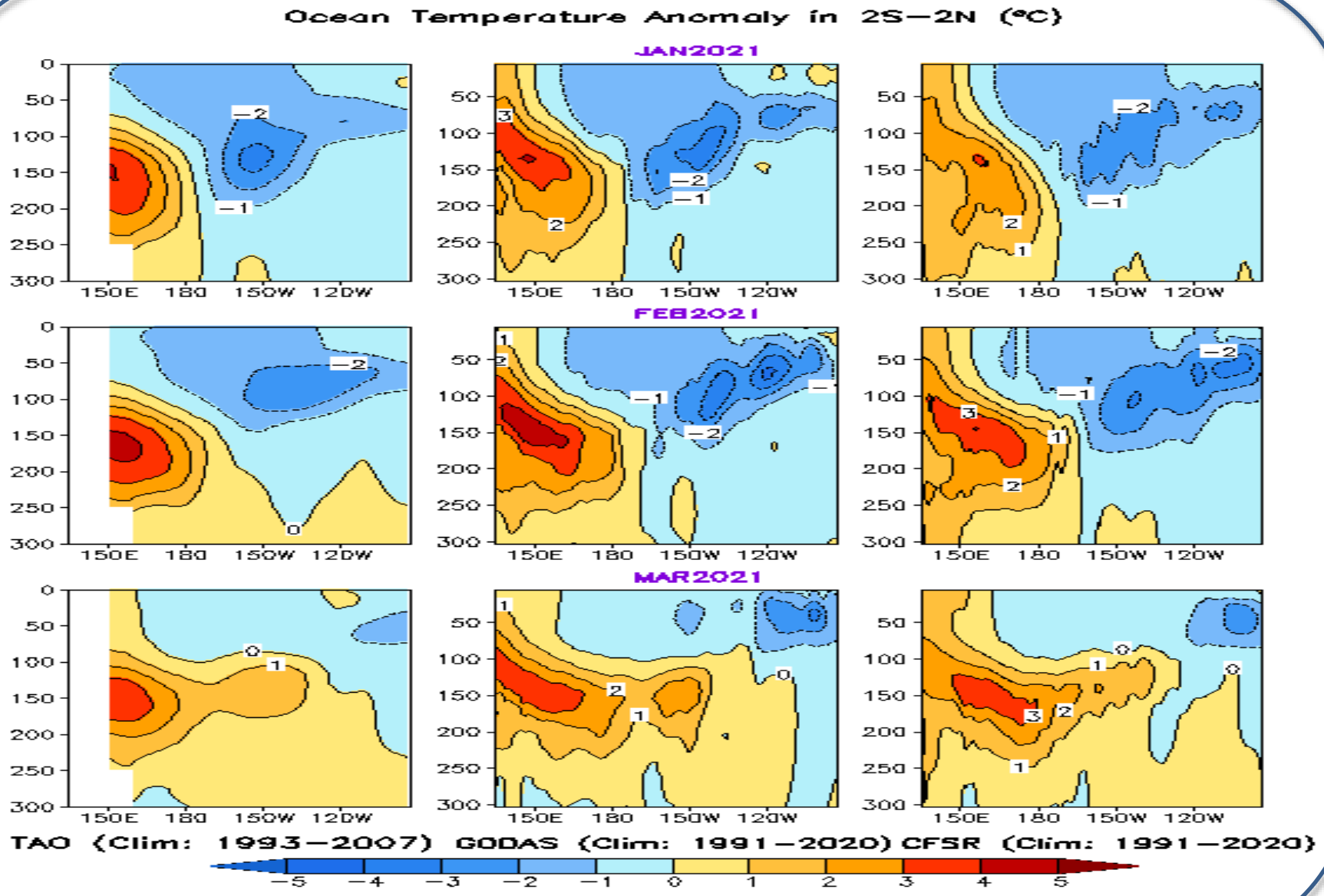


Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right; positive means heat into the ocean), 925-mb wind anomaly 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 1991-2020 base period means.

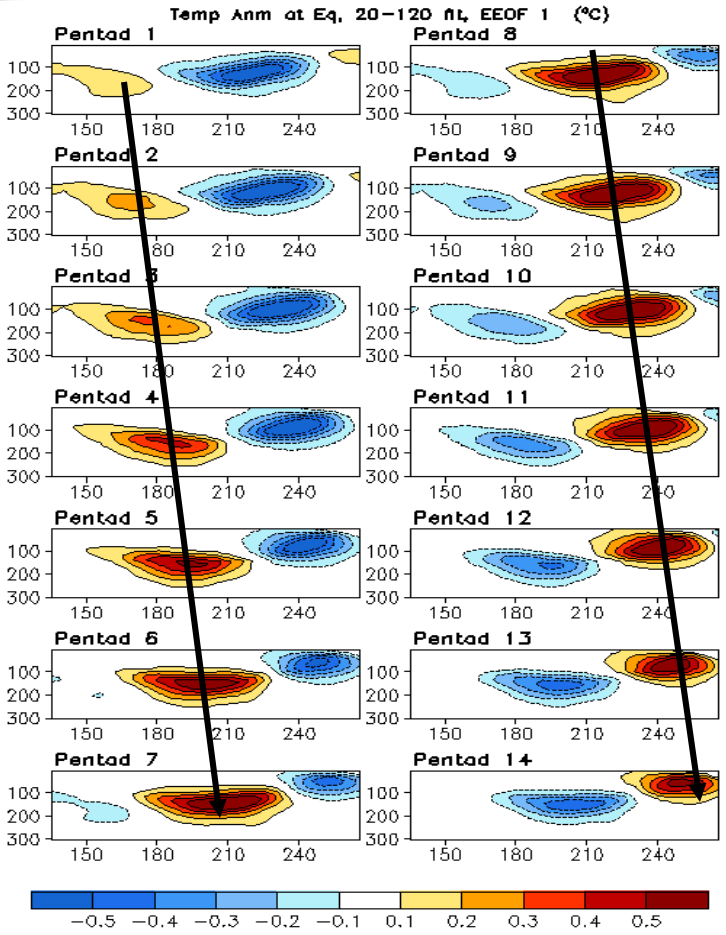
Latest 3-month Tropical Pacific SST , OLR, & uv925 anomalies

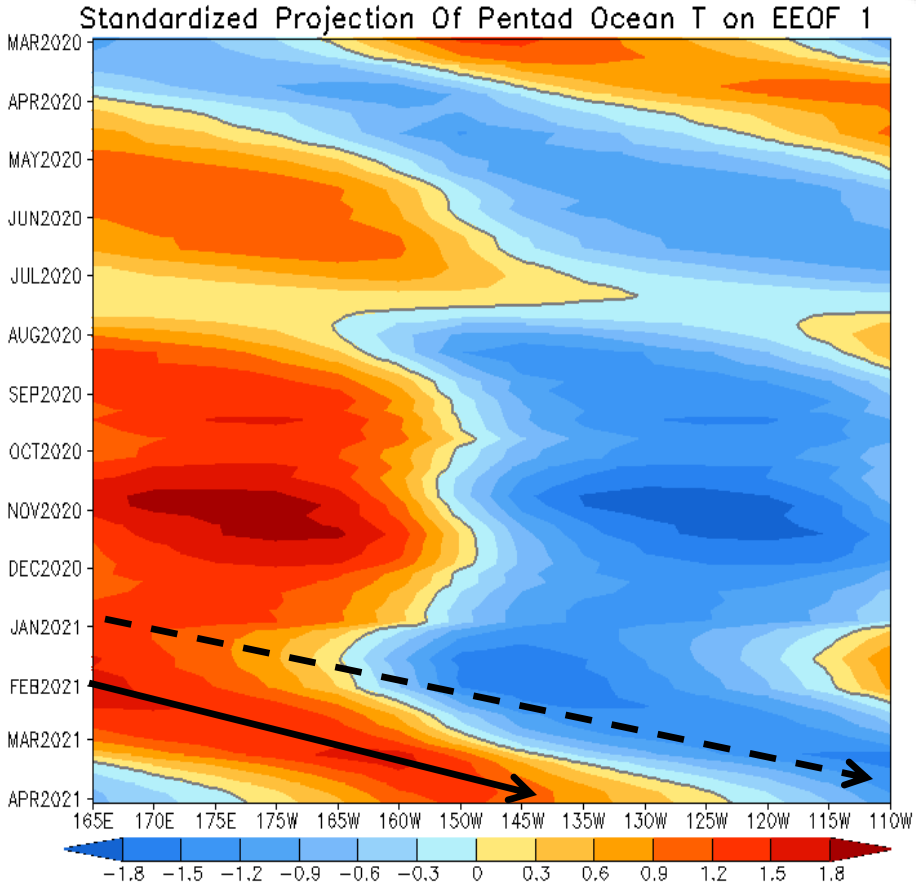


Latest 3-month subsurface temperature anomaly along the Equator



Oceanic Kelvin Wave (OKW) Index



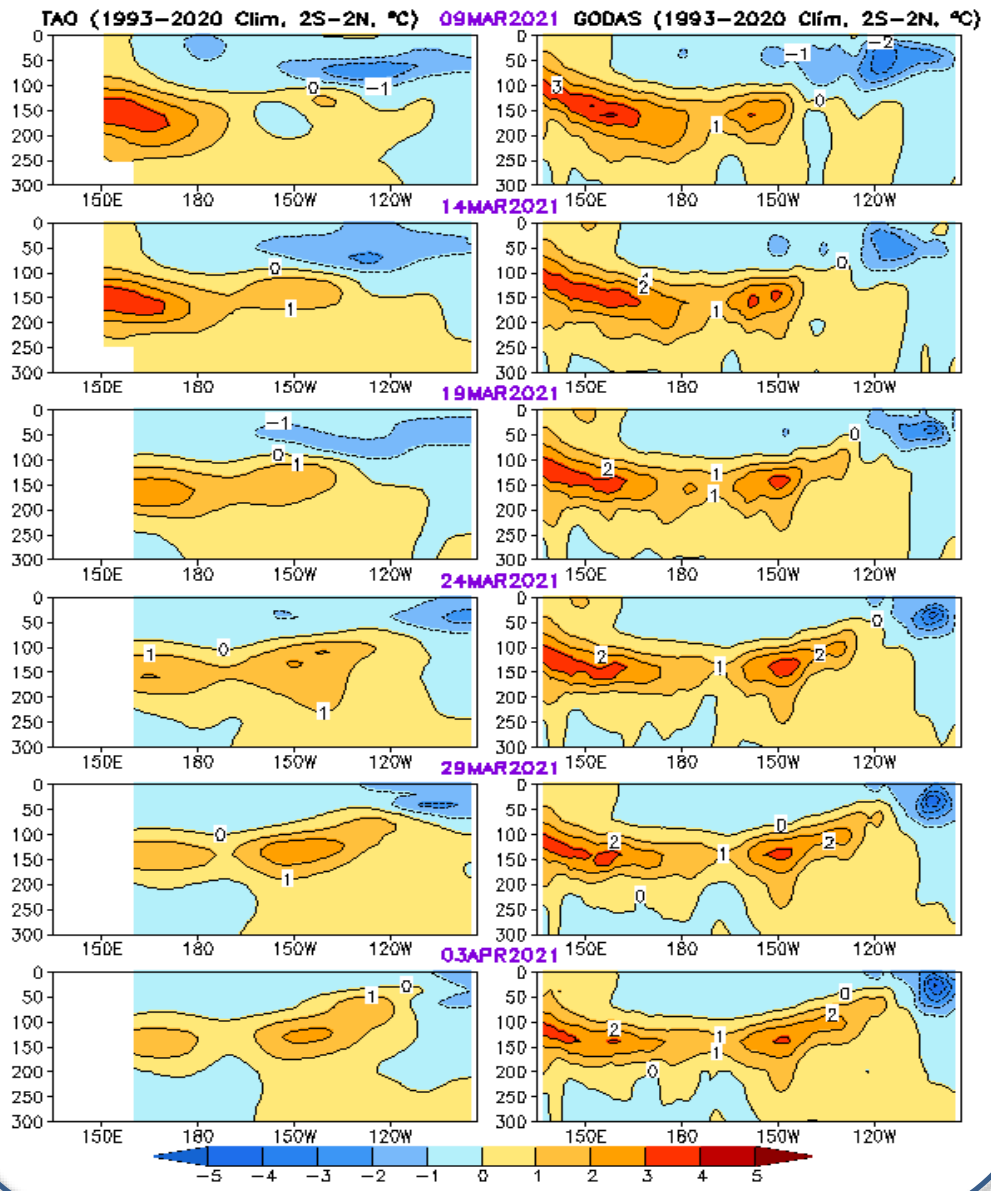


- Upwelling Kelvin waves were initiated in Mar & Jul 2020, leading to the subsurface cooling in the eastern equatorial Pacific.

- Downwelling Kelvin wave was initiated in Jan 2021, consisting with the weakening of La Niña.

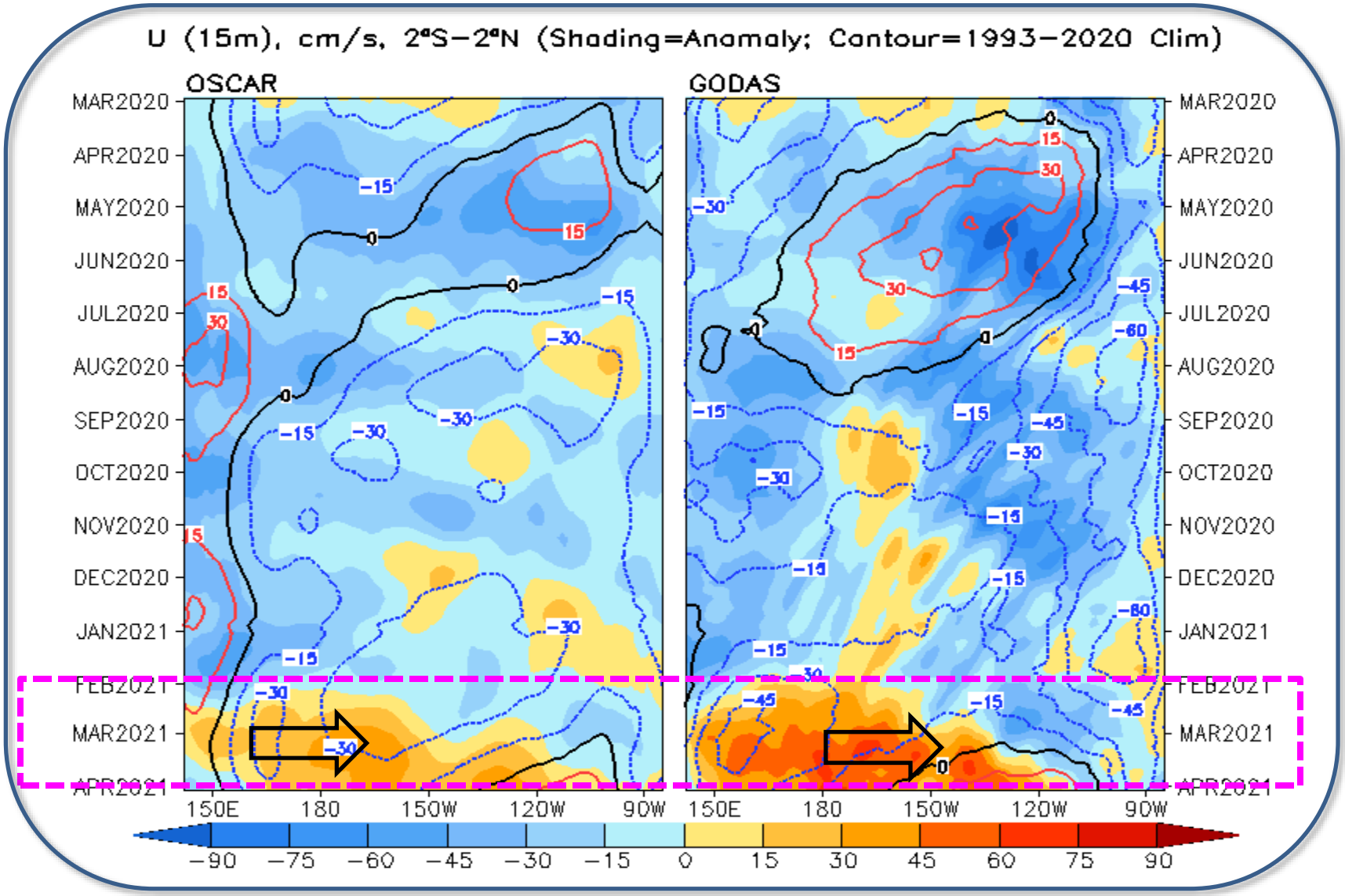
(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)

Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



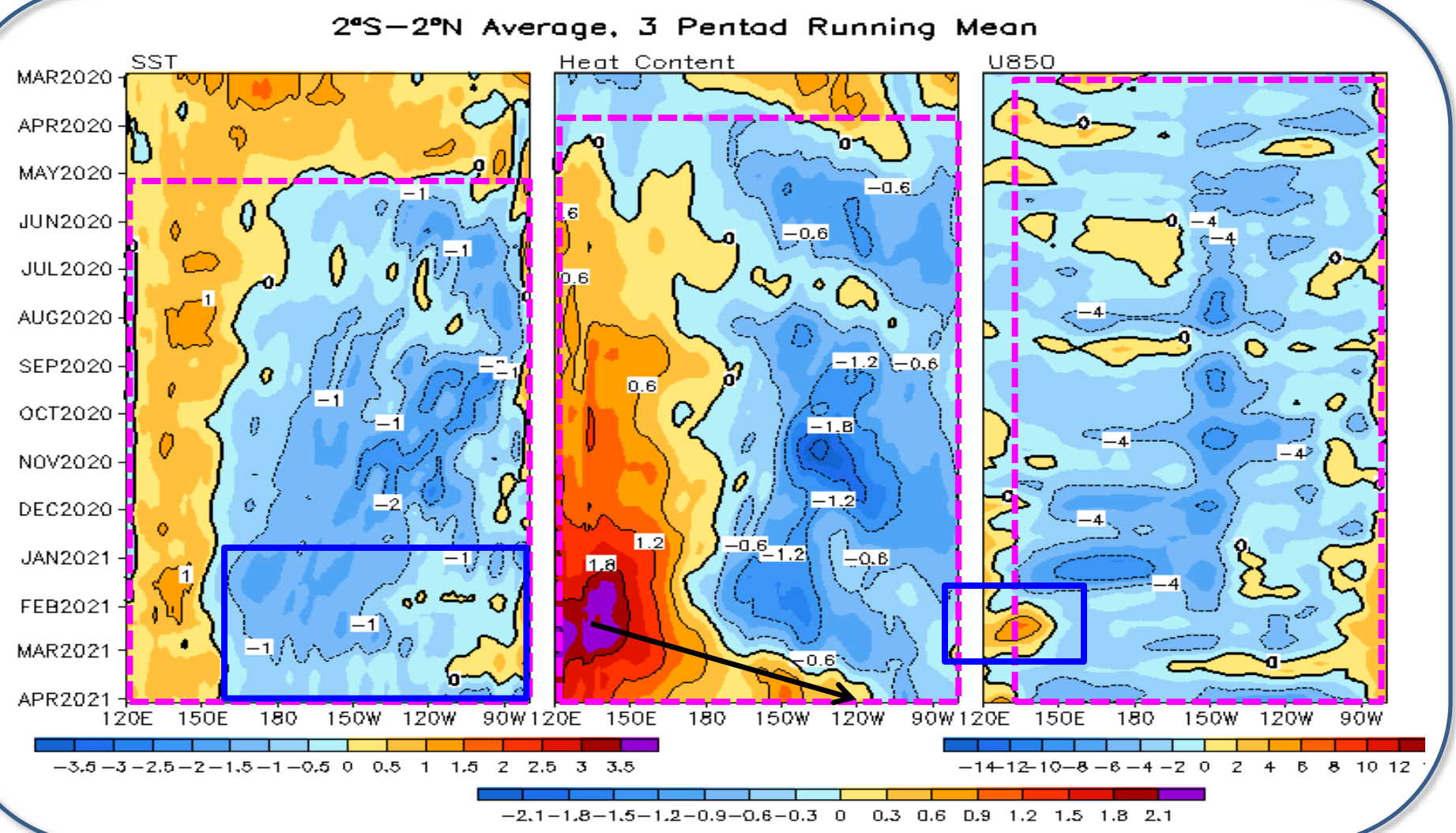
- Positive ocean temperature anomalies along the thermocline in the western and east-central Pacific propagated eastward and negative anomalies in the far-eastern Pacific weakened in the last 2-months, consisting with the weakening of La Niña
- The features of the ocean temperature anomalies were similar between GODAS and TAO analysis.

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



- Anomalous eastward currents emerged in the western & central equatorial Pacific in both OSCAR and GODAS in Feb and Mar 2021, contributing to the weakening of the La Niña.

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

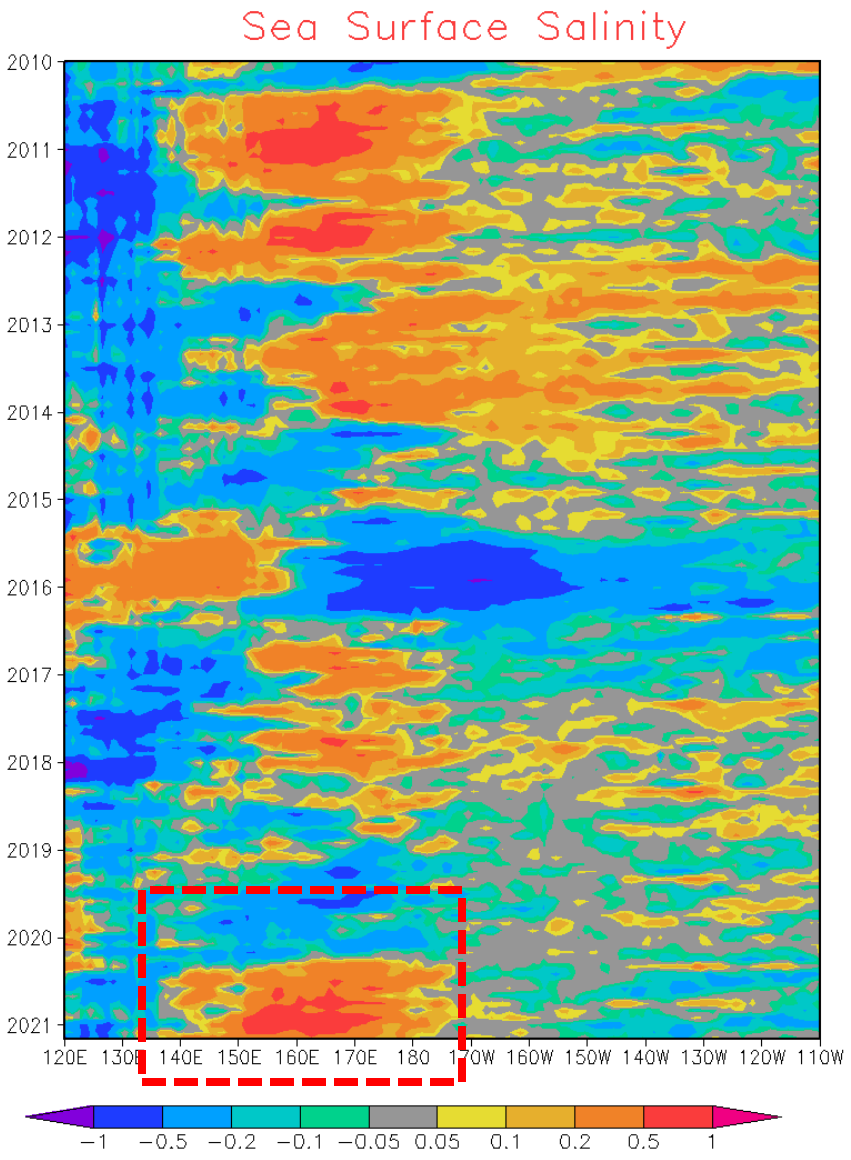


- Easterly wind anomaly was present across the equatorial Pacific since Mar 2020.
- Negative HC300A weakened in the eastern Pacific and positive HC300A in the western Pacific propagated eastward in Feb-Mar 2021.
- Negative SSTAs weakened in the eastern equatorial Pacific since Jan 2021.

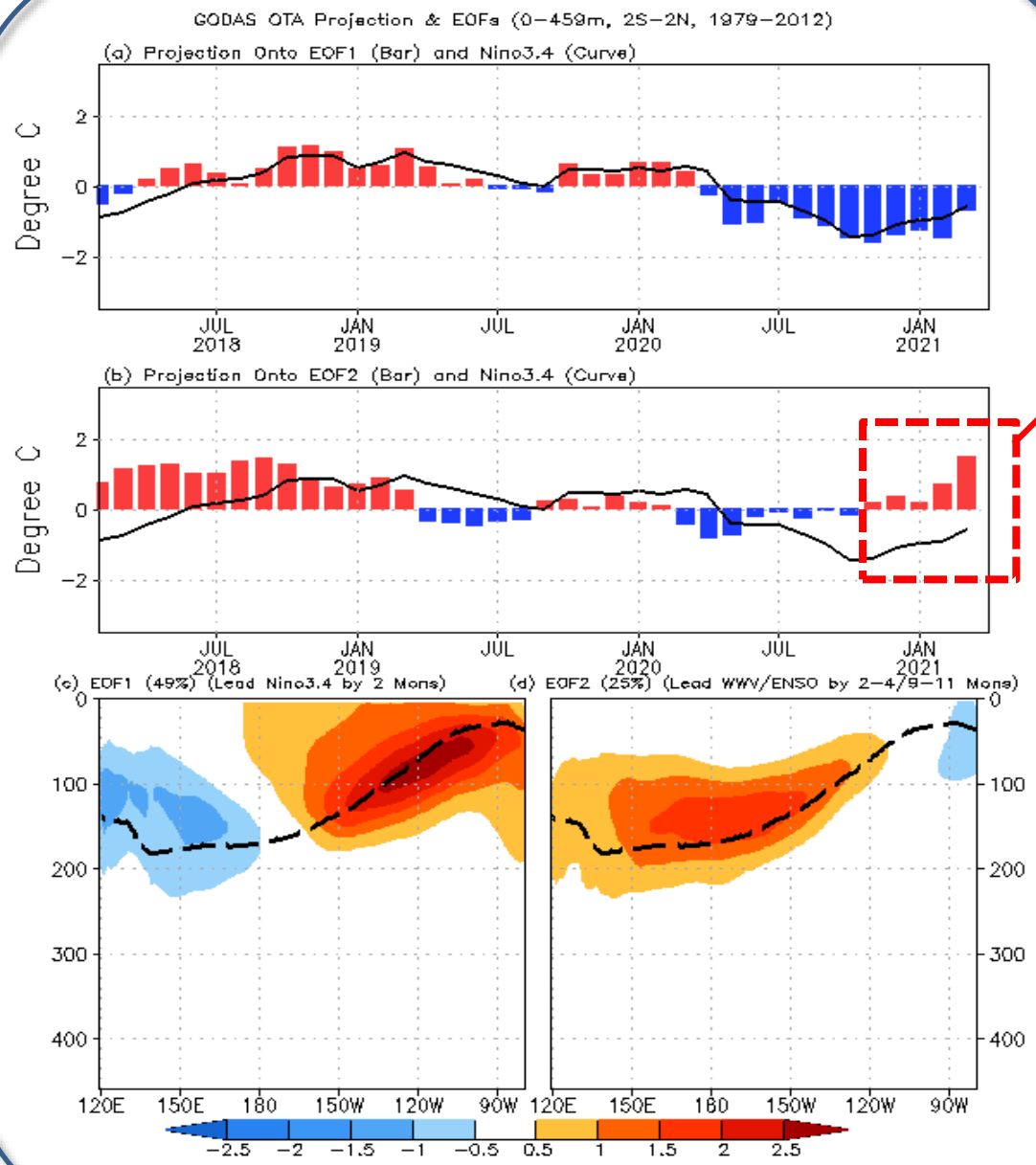
Monthly SSS Anomaly Evolution over Equatorial Pacific

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, west of 140° E, negative SSS signal continues; positive SSS signal also continues between 140° E and 170° W; while negative SSS signal continues east of 160° W.



Equatorial Sub-surface Ocean Temperature Monitoring



- The equatorial Pacific has been in a recharge phase since Nov 2020.

- Projection of ocean temperature anomalies onto EOF1 and EOF2; EOF1: Tilt/dipole mode (ENSO peak phase); EOF2: WWV mode.

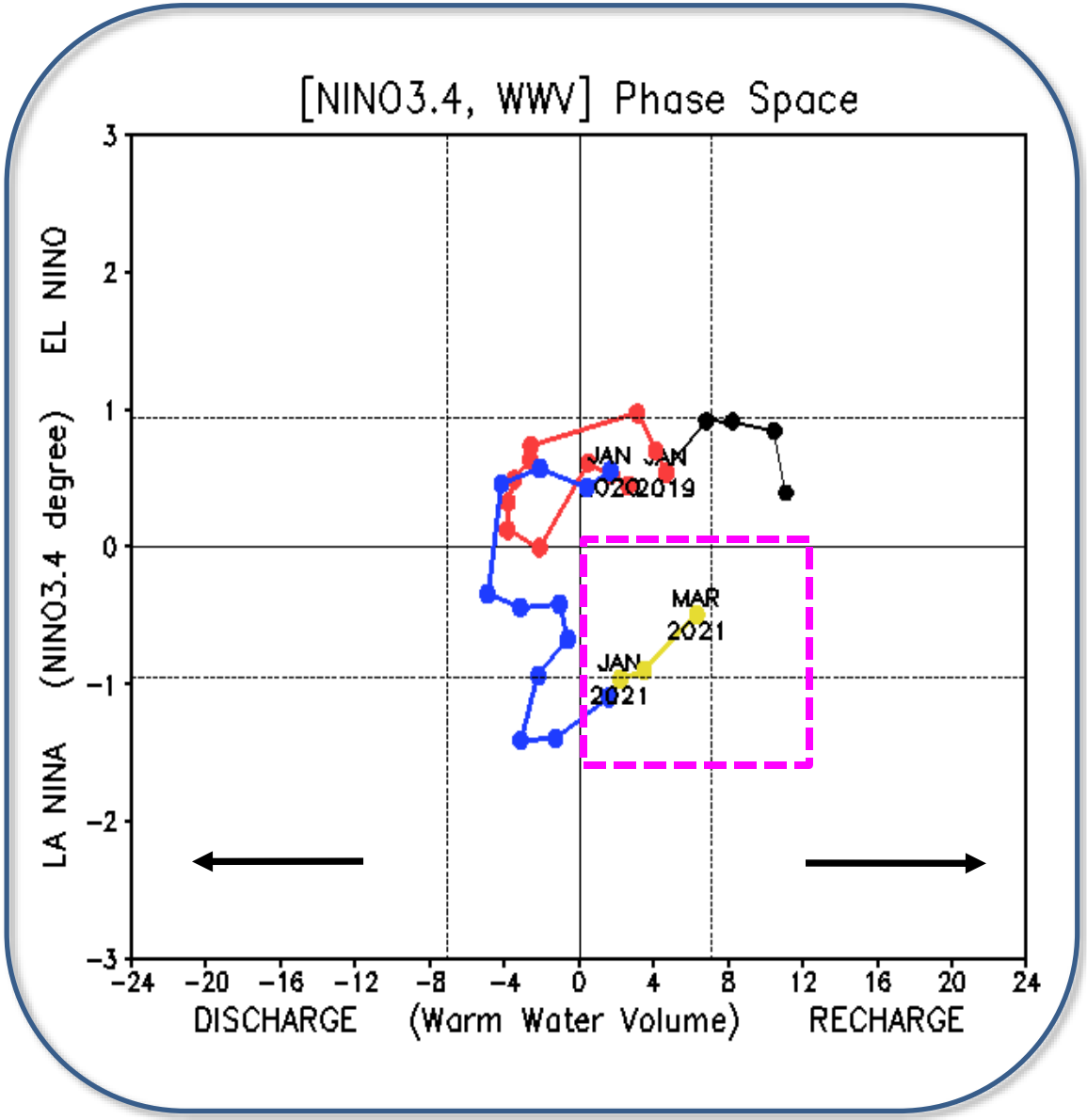
- Recharge/discharge oscillation (ENSO transition phase); Recharge process: heat transport from outside of equator to equator; Negative -> positive phase of ENSO

- For details, see: Kumar A, Z-Z Hu (2014) DOI: 10.1007/s00382-013-1721-0.

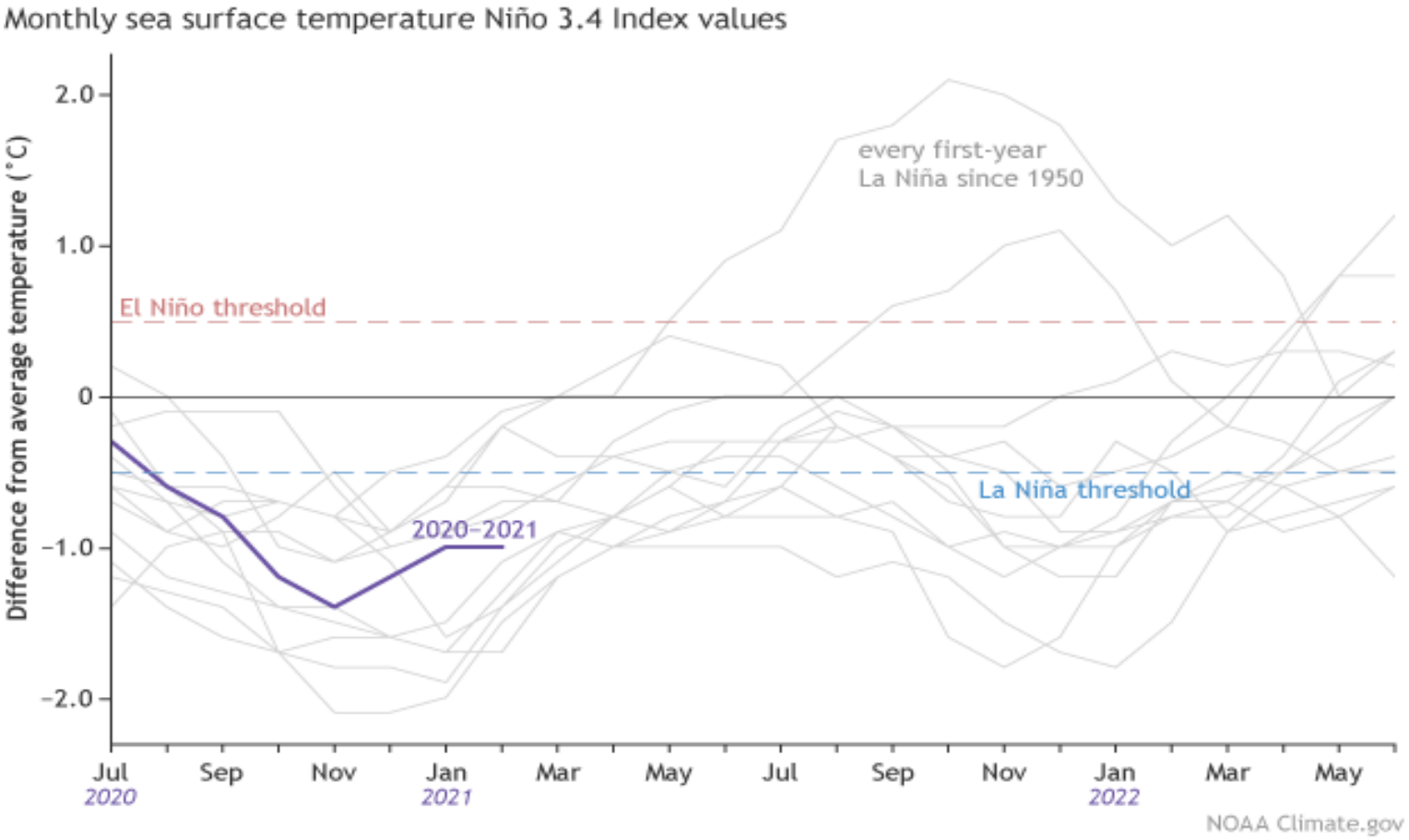
Warm Water Volume (WWV) and Niño3.4 Anomalies

- Equatorial Warm Water Volume (WWV) was in a recharge phase in Jan-Mar 2021.

-As WWV is intimately linked to ENSO variability (Wyrtki 1985; Jin 1997), it is useful to monitor ENSO in a phase space of WWV and Niño3.4 (Kessler 2002).
- Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.



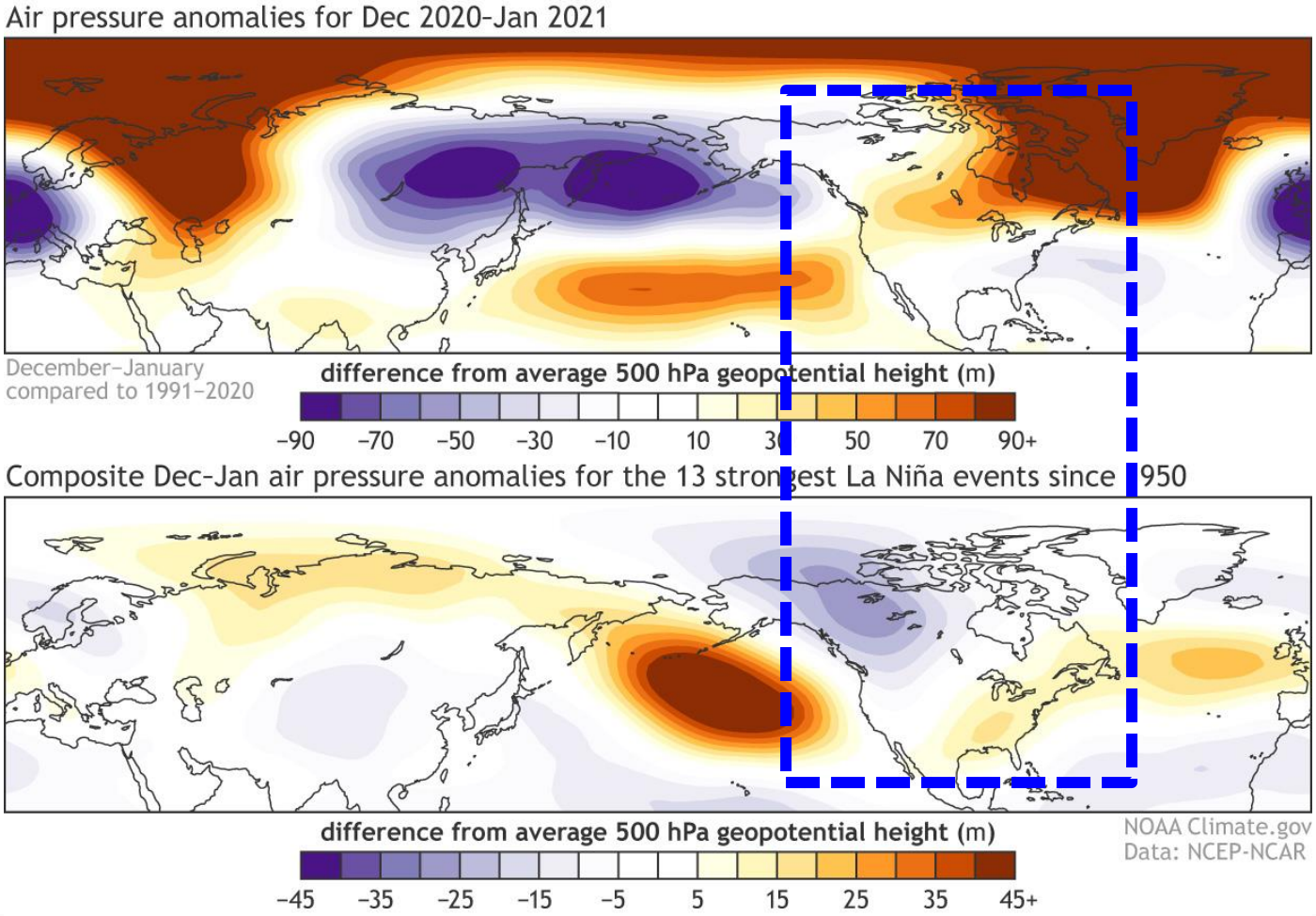
Phase diagram of Warm Water Volume (WWV) and Niño3.4 indices. WWV is the average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN] calculated with the NCEP's GODAS. Anomalies are departures from the 1991-2020 base period means.



- Monthly sea surface temperature in the Niño 3.4 region of the tropical Pacific for 2020-21 (purple line) and all other years starting from first-year La Niña winters since 1950. Climate.gov graph based on ERSSTv5 temperature data.

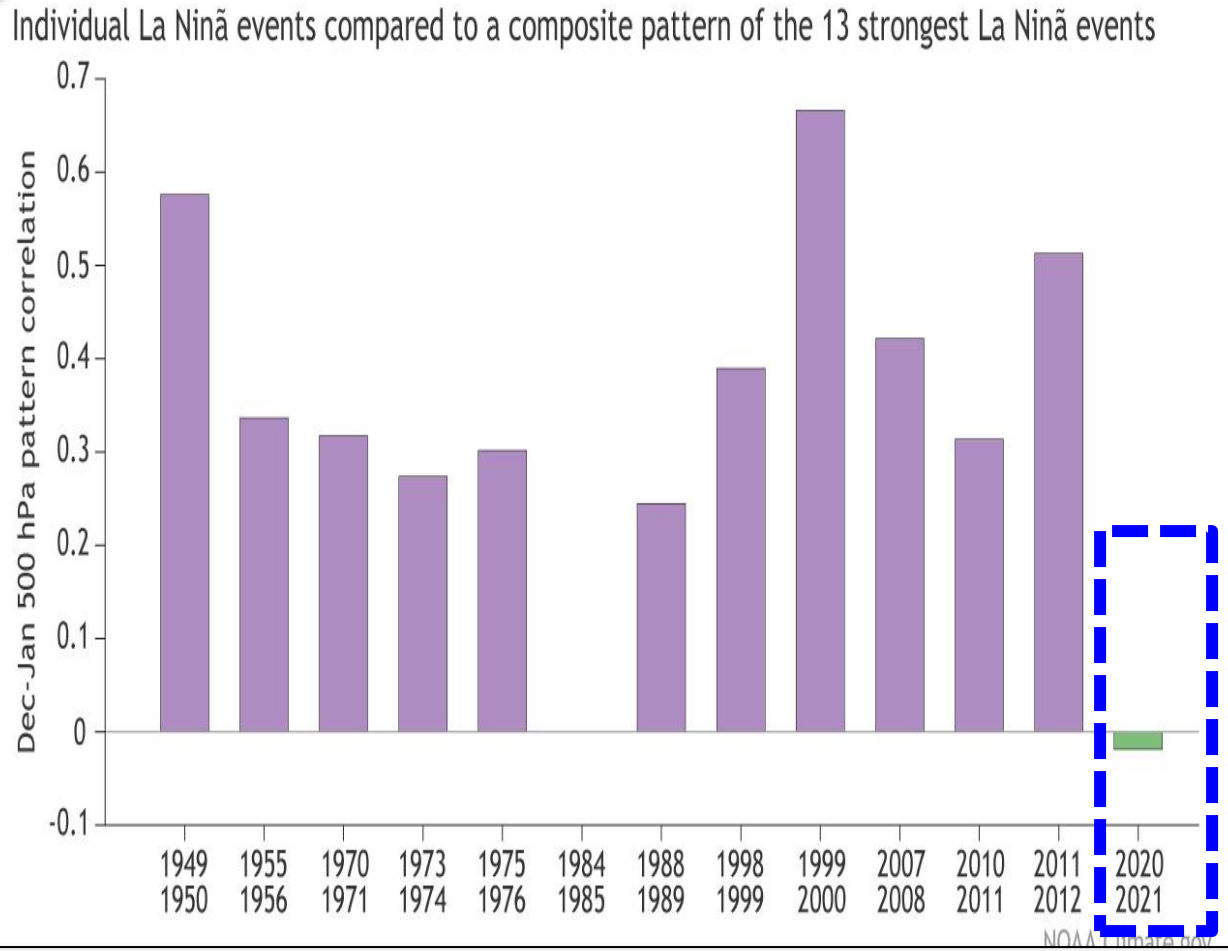
Dr. Nat Johnson; GFDL

https://www.climate.gov/news-features/blogs/enso/march-2021-enso-update-fine-feathered-friends



Did the Northern Hemisphere get the memo on this year's La Niña? ***(Dr. Nat Johnson; GFDL)***

https://www.climate.gov/news-features/blogs/enso/did-northern-hemisphere-get-memo-years-la-ni%C3%B1a

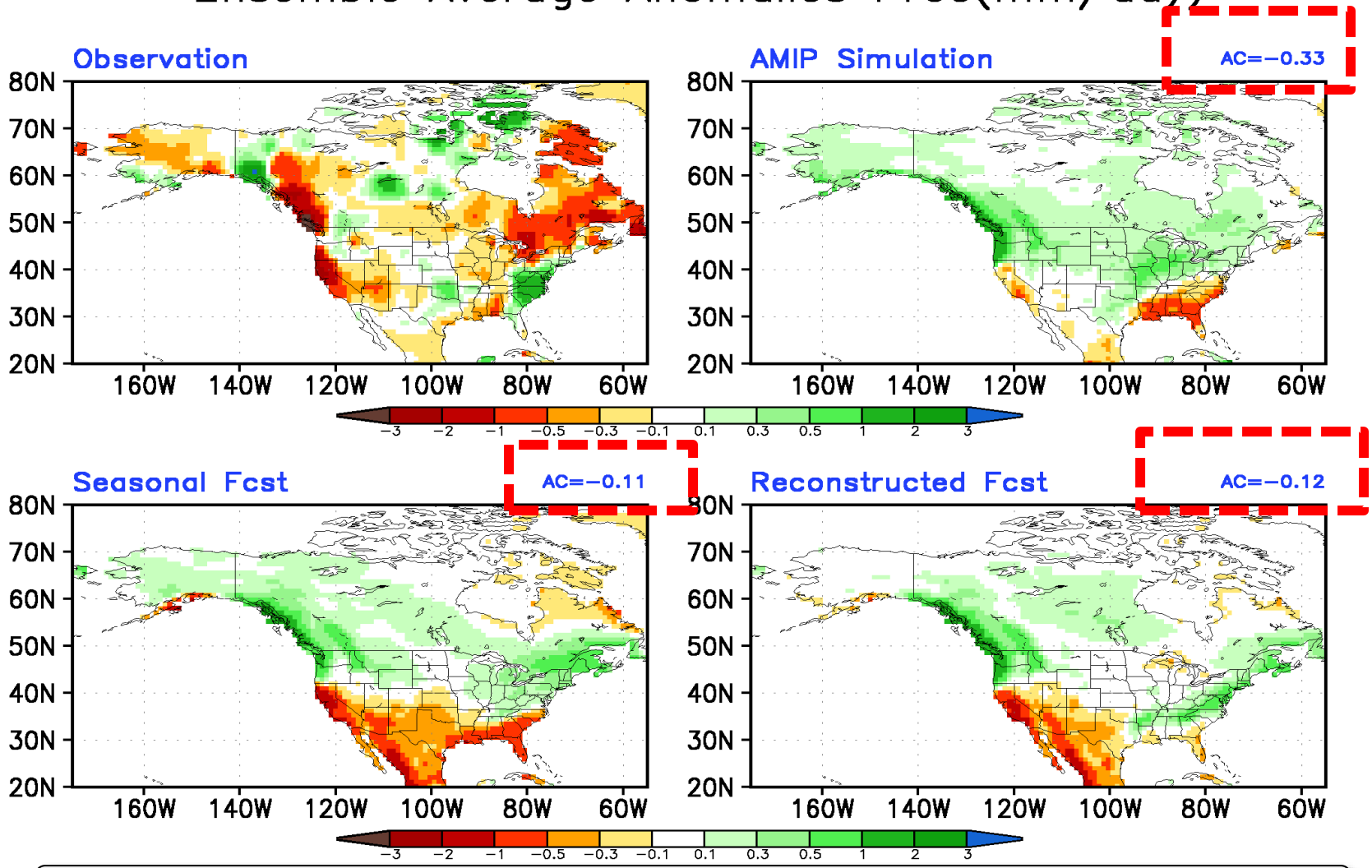


•Pattern correlations between the individual La Niña and average La Niña December – January 500 hPa geopotential height anomalies north of 15° N for the 13 strongest La Niña episodes since 1950.

Did the Northern Hemisphere get the memo on this year's La Niña? (*Dr. Nat Johnson; GFDL*)

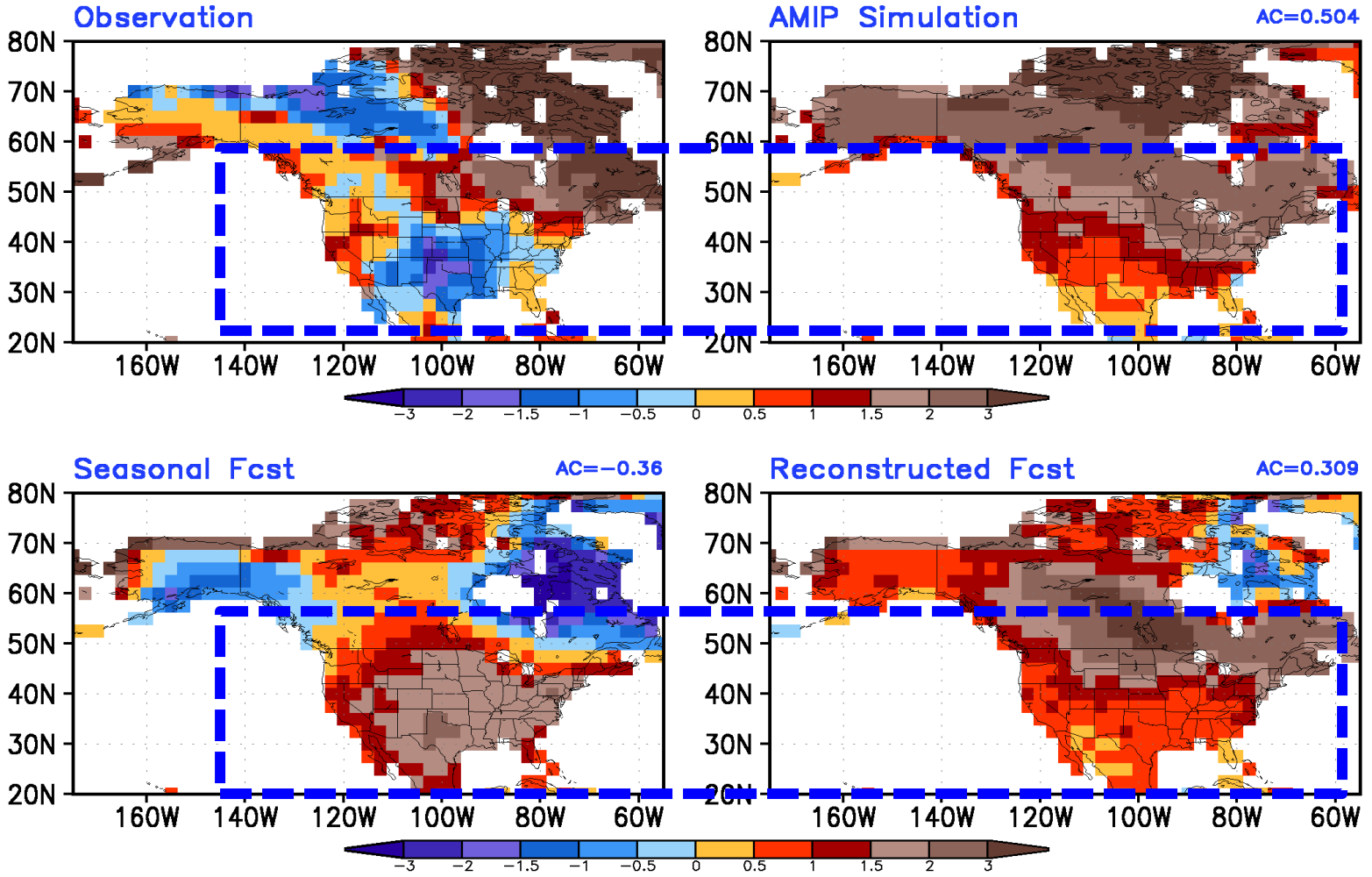
https://www.climate.gov/news-features/blogs/enso/did-northern-hemisphere-get-memo-years-la-ni%C3%B1a

DJF2020/2021 Observed & Model Simulated/Forecast Ensemble Average Anomalies Prec(mm/day)



https://www.cpc.ncep.noaa.gov/products/people/mchen/AttributionAnalysis/

DJF2020/2021 Observed & Model Simulated/Forecast Ensemble Average Anomalies T2m(K)



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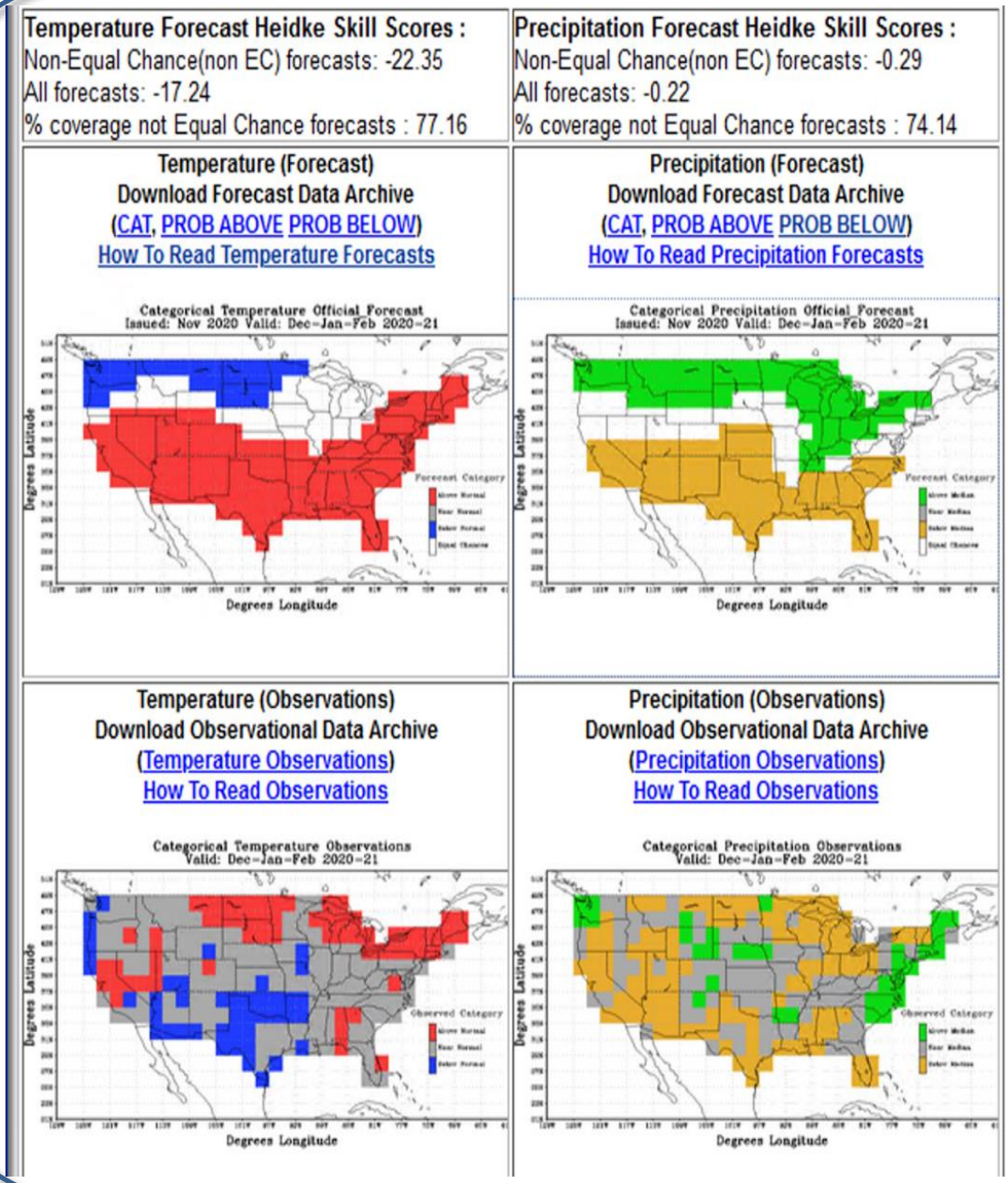
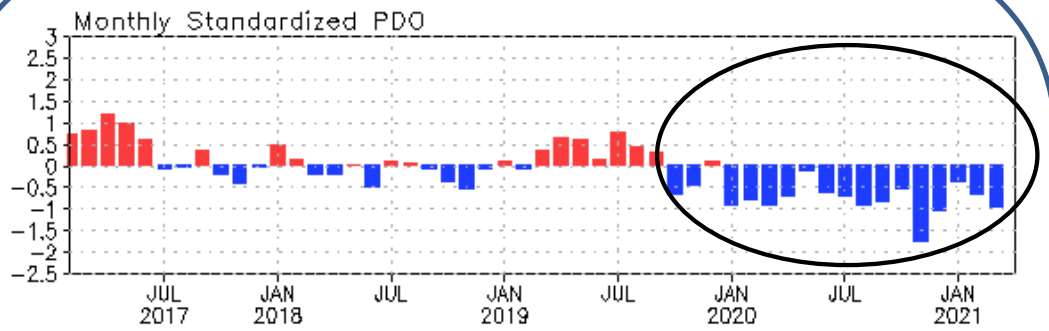


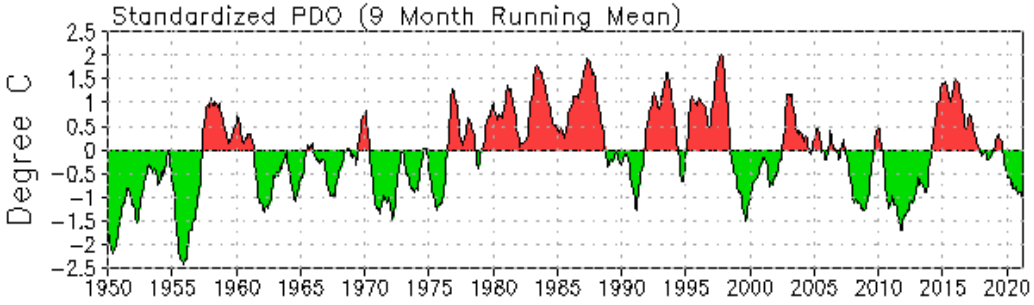
- **2020/21 DJF Temperature Forecast Heidke Skill Scores :**
  Non-Equal Chance(non EC) forecasts: -22.35
  All forecasts: -17.24
  % coverage not Equal Chance forecasts: 77.16

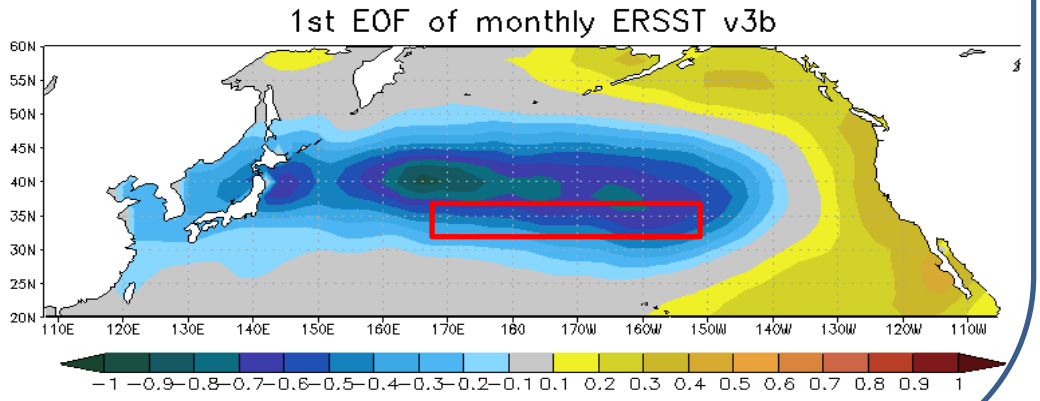
- **Precipitation Forecast Heidke Skill Scores :**
  Non-Equal Chance(non EC) forecasts: -0.29
  All forecasts: -0.22
  % coverage not Equal Chance forecasts : 74.14

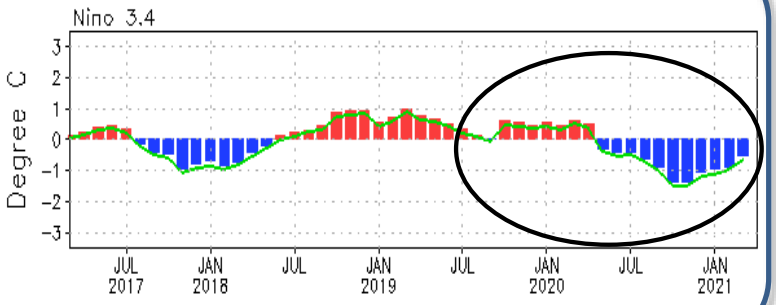
North Pacific & Arctic Oceans

Pacific Decadal Oscillation (PDO) Index







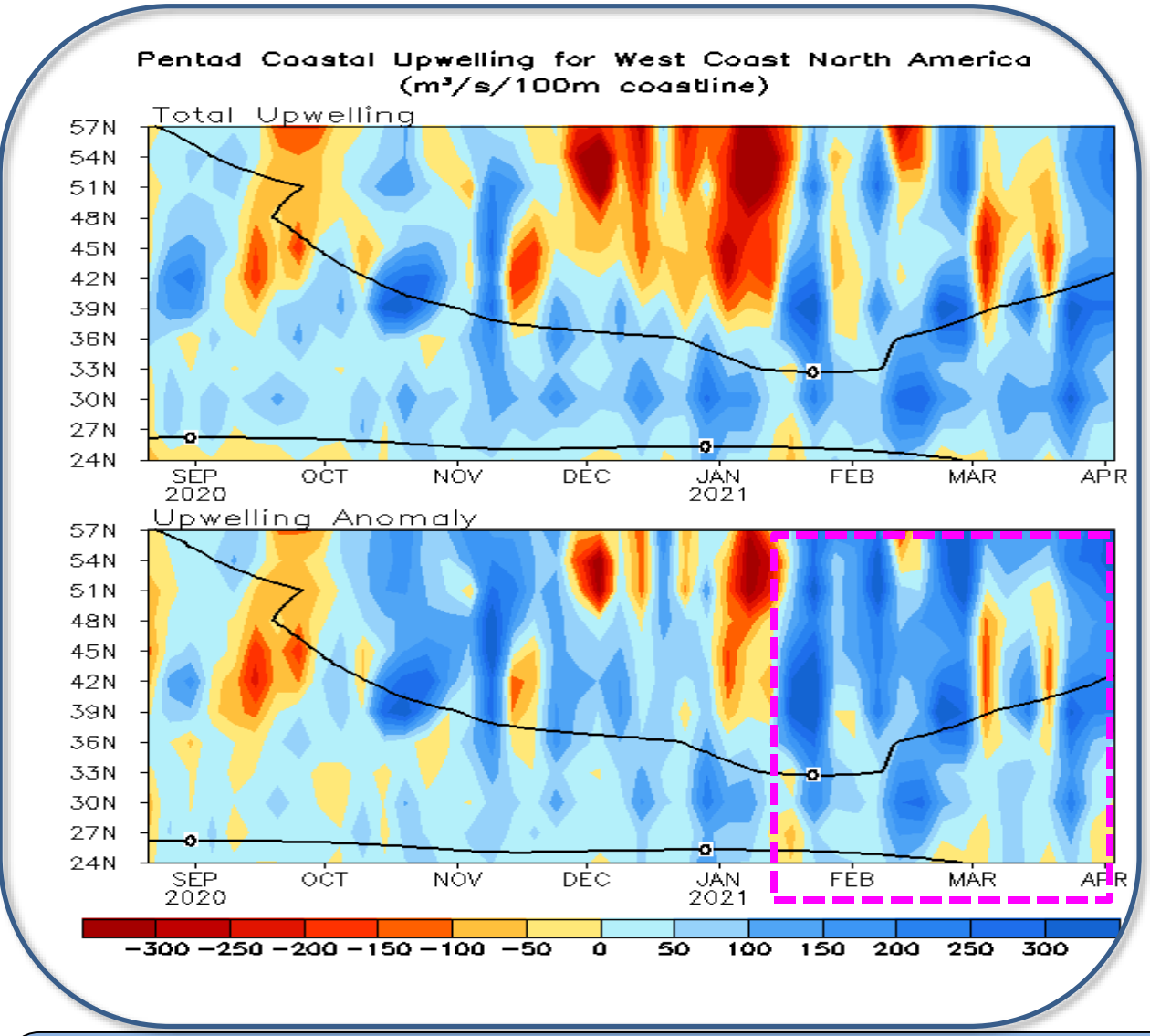


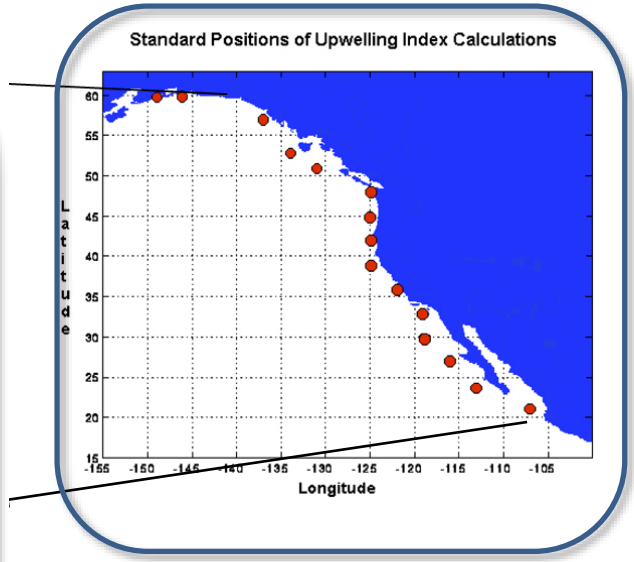
- The negative phase of PDO has persisted since Jan 2020 with PDOI = -1.0 in Mar 2021.

- Statistically, ENSO leads PDO by 3-4 months, through teleconnection via atmospheric bridge, with El Niño (La Niña) associated with positive (negative) PDO Index.

• PDO 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

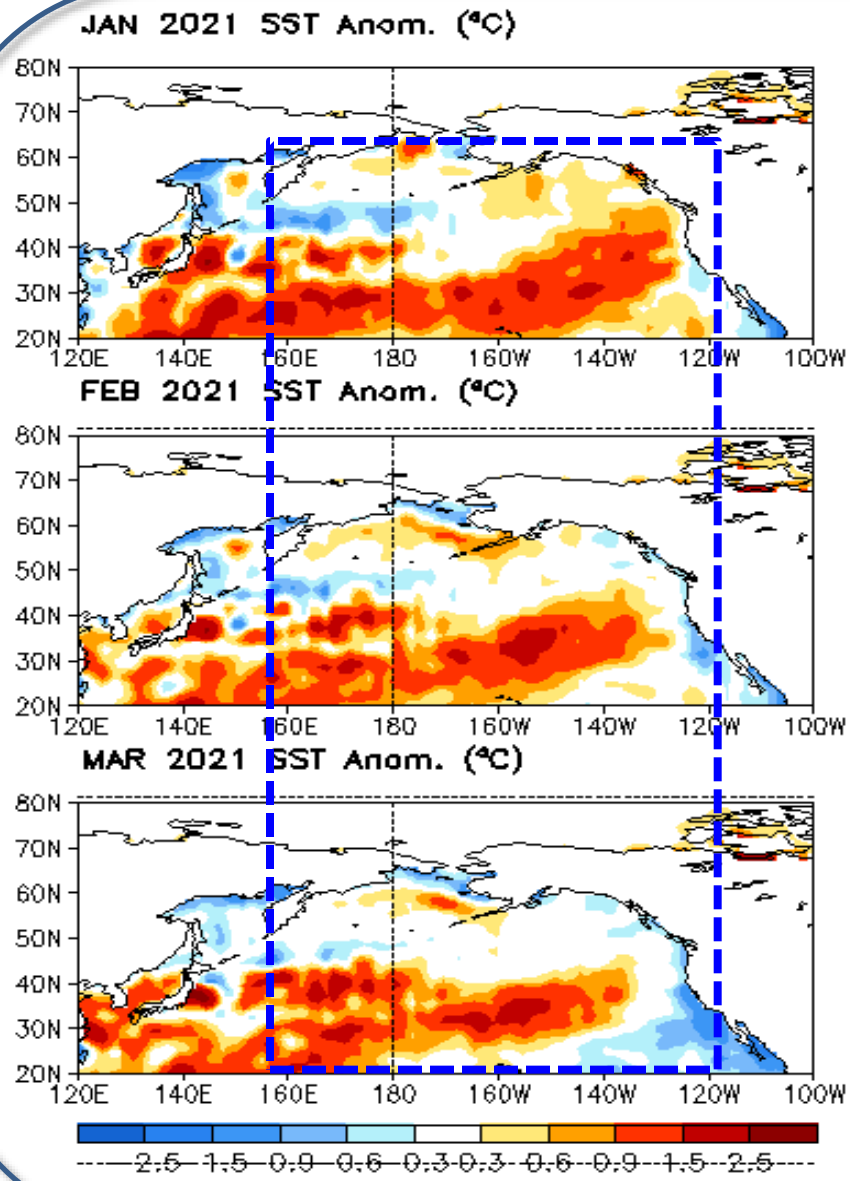


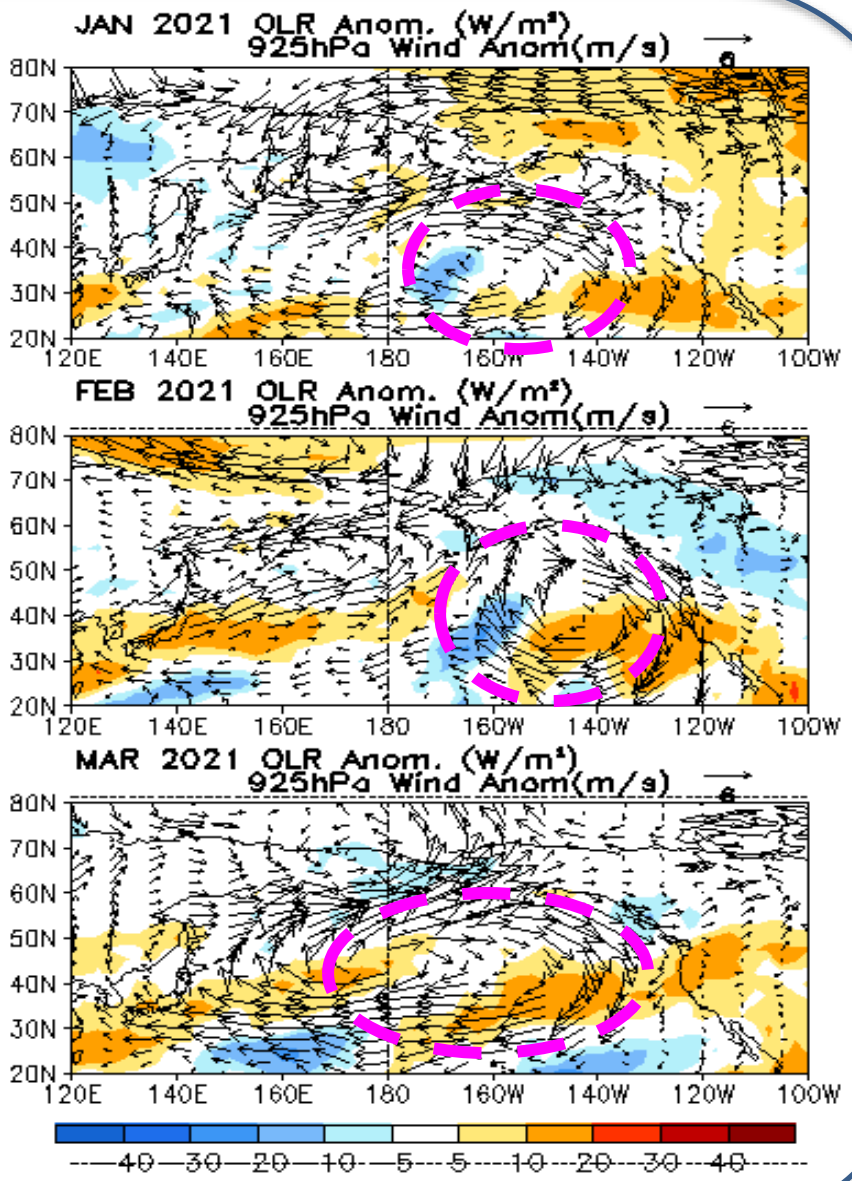


- Coastal anomalous upwelling has been present north of 27ºN since 2nd half of Jan 2021.

(top) Total and (bottom) anomalous upwelling indices at the 15 standard locations for the western coast of North America. derived from the vertical velocity of the NCEP's GODAS 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 1991-2020 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.

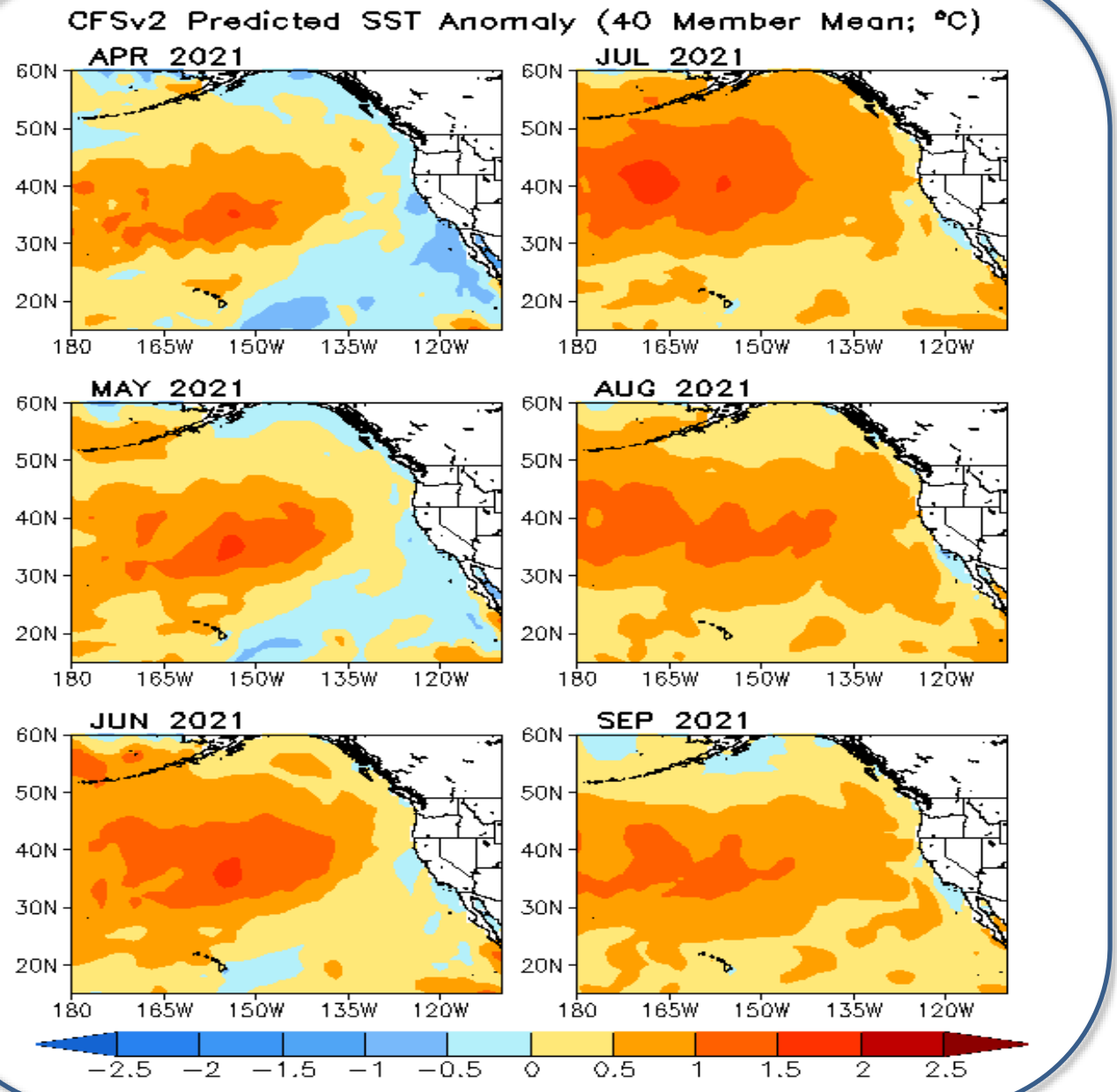
Latest 3-month North Pacific SST, OLR & uv925 anomalies





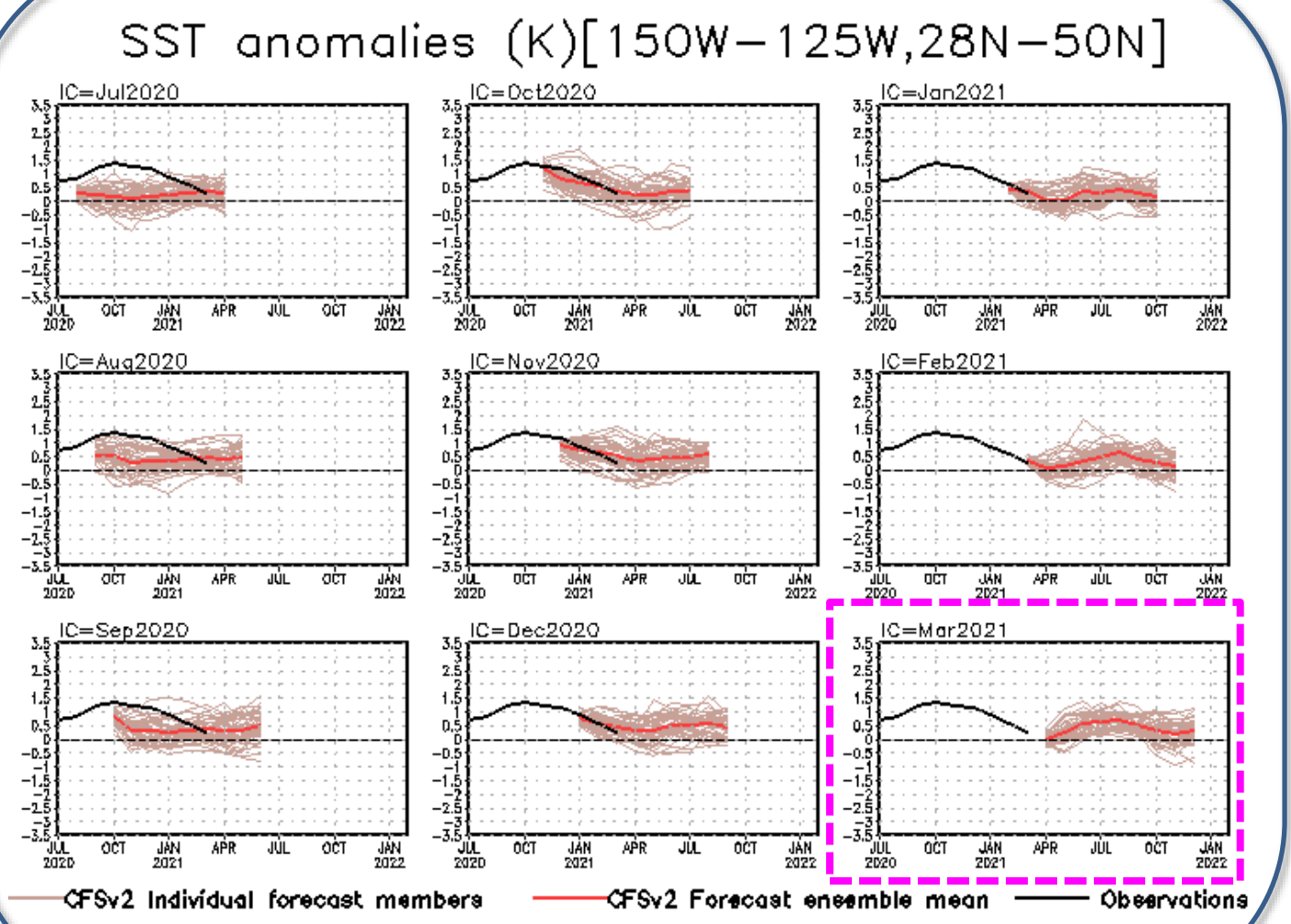
Data source: NCEP/NCAR Reanalysis 1

CFSv2 NE Pacific Marine Heatwave Predictions



- Latest CFSv2 predictions suggest that the current warm state will continue in the next 6 months.

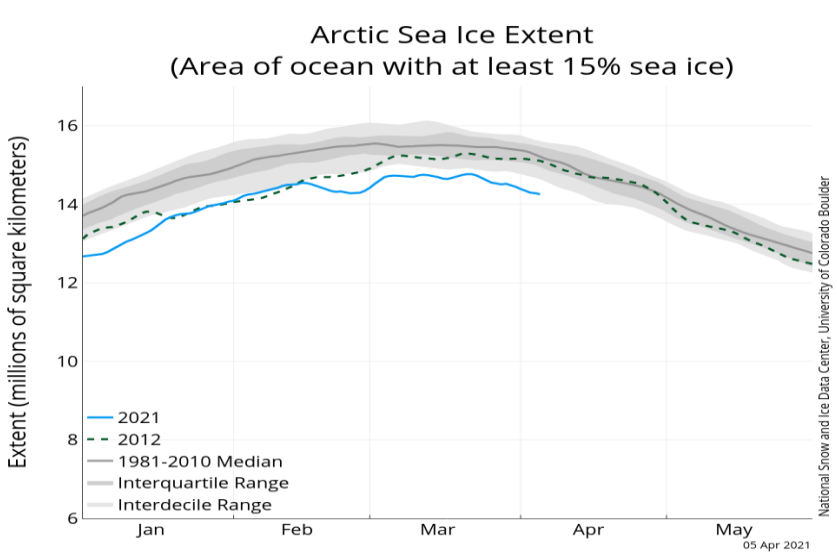
CFSv2 NE Pacific Marine Heatwave Index Predictions

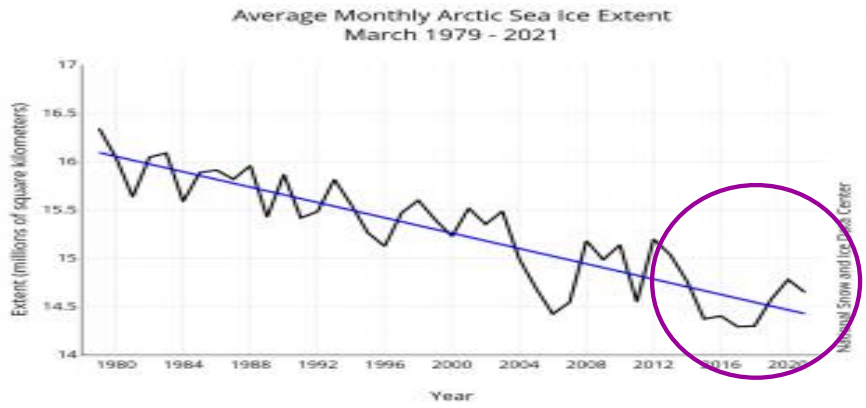


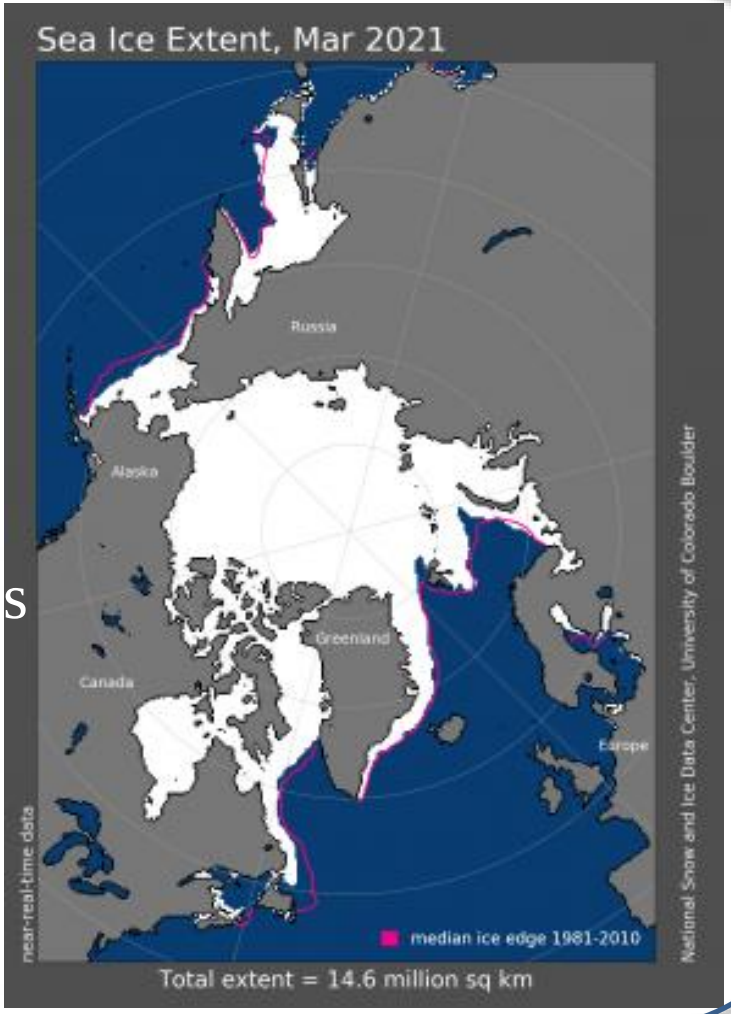
- Earlier CFSv2 predictions underestimated the strength of NP Marine Heatwave;
- Latest CFSv2 predictions call above-normal SSTs in 2021.

CFS NE Pacific 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 1991-2020 base period means.

Arctic Sea Ice; NSIDC (http://nsidc.org/arcticseaicenews/index.html)

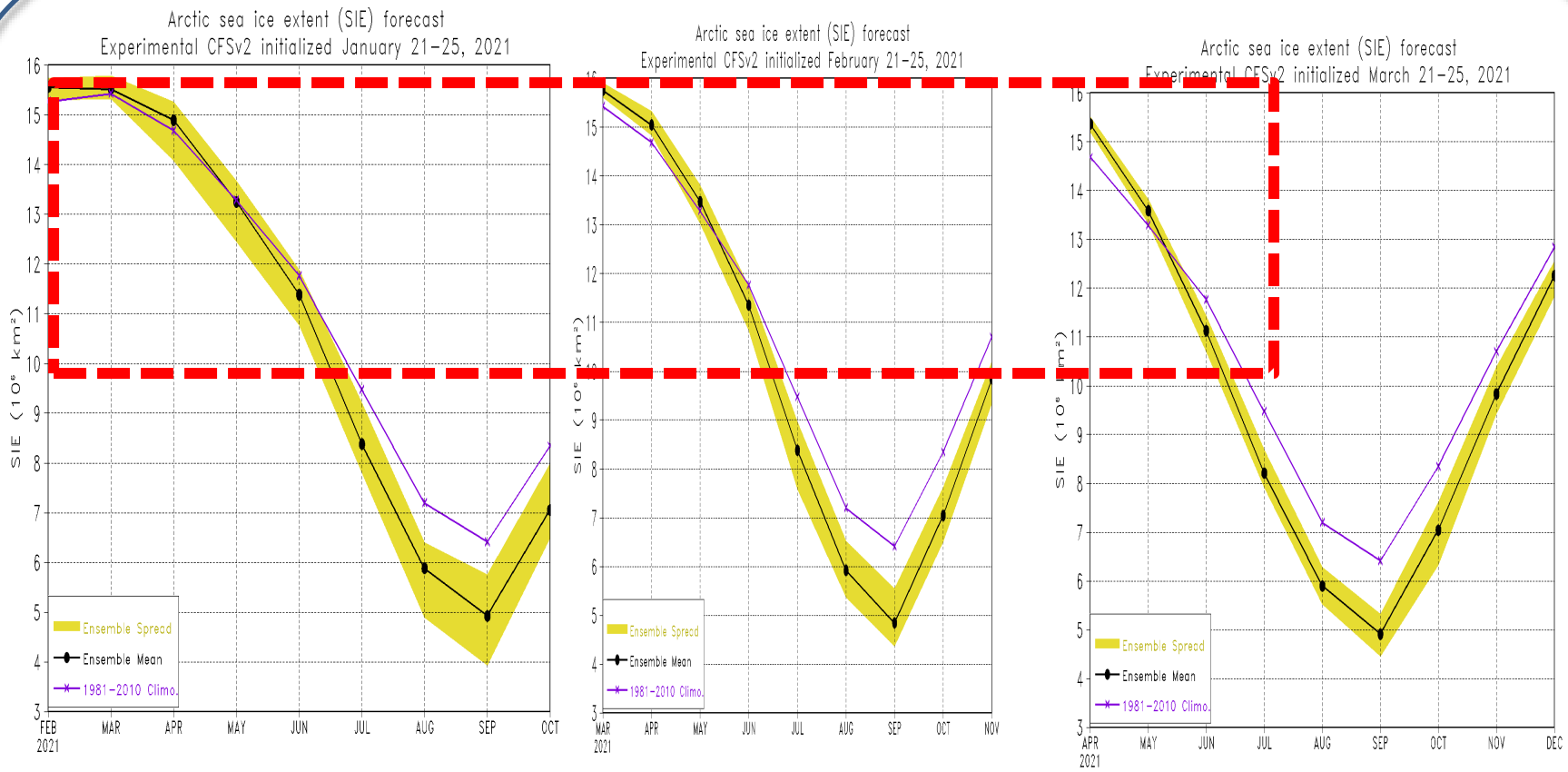






- The seasonal maximum in the sea ice extent was observed on 21 March 2021.
- The sea ice extent averaged for Mar 2021 was the 9th lowest in the satellite record.
- Through 2021, the linear rate of decline for Mar sea ice extent is 2.6% per decade.

NCEP/CPC Arctic Sea Ice Extent Forecasts

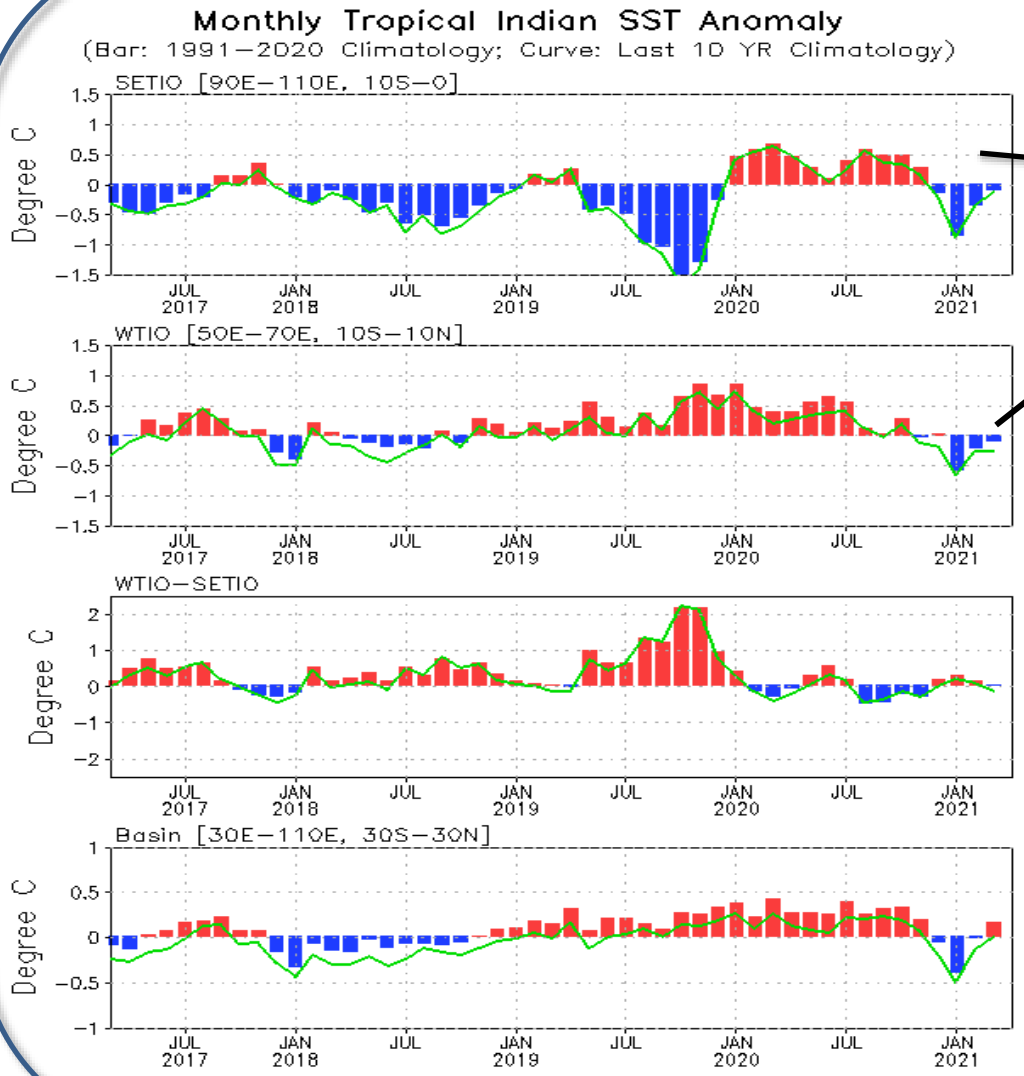


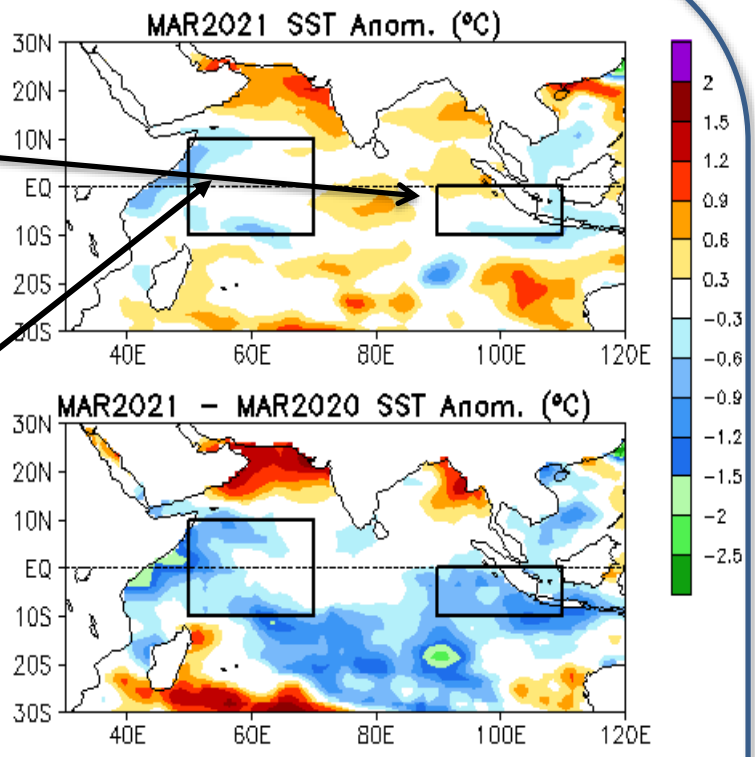
For ICs in Jan-Mar 2021, NCEP/CPC predicted a near-normal sea ice extent during spring & early summer 2021.

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

Indian Ocean

Evolution of Indian Ocean SST Indices

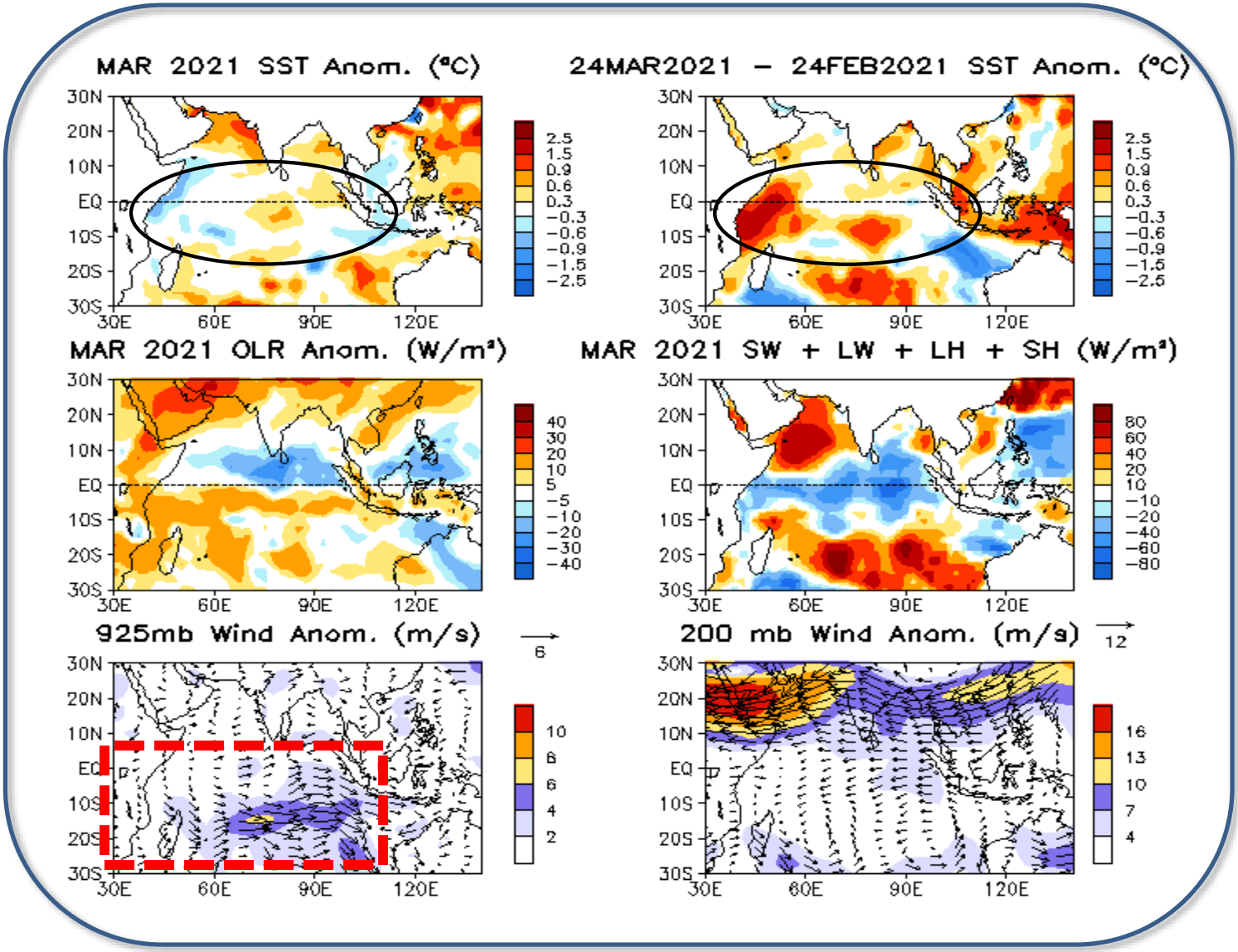




- Overall, SSTAs were small in the tropical Indian Ocean in Mar 2021.

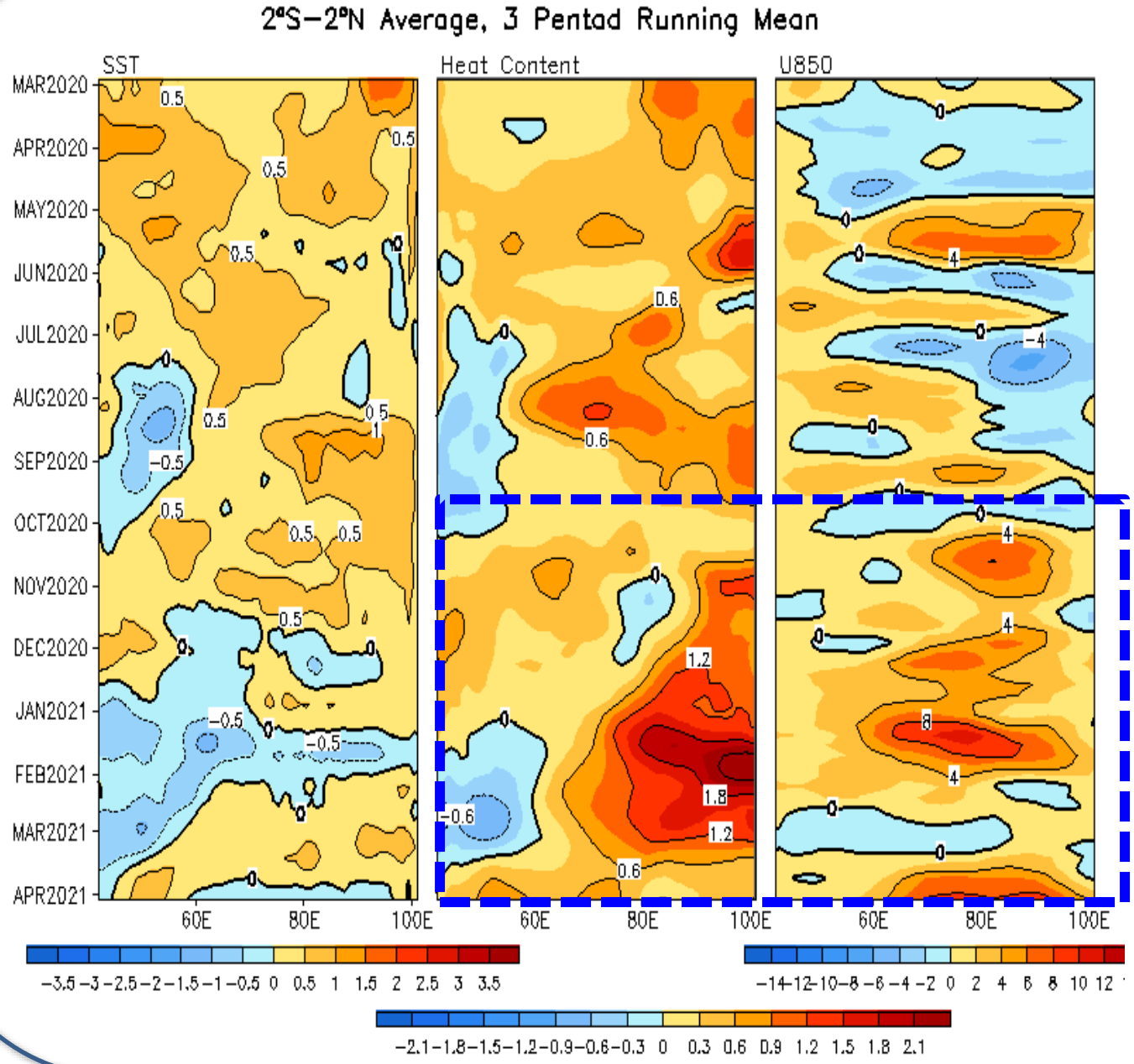
Indian Ocean Dipole region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (OC) for the SETIO [90ºE-110ºE, 10ºS-0] and WTIO [50ºE-70ºE, 10ºS-10ºN] regions, and Dipole Mode Index, defined as differences between WTIO and SETIO. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1991-2020 base period means.

Tropical Indian: SSTA, SSTA Trend, OLR, heat flux uv925-mb & uv200 anomalies



- SSTAs were small and the tendencies were mostly positive in the tropical Indian Ocean.

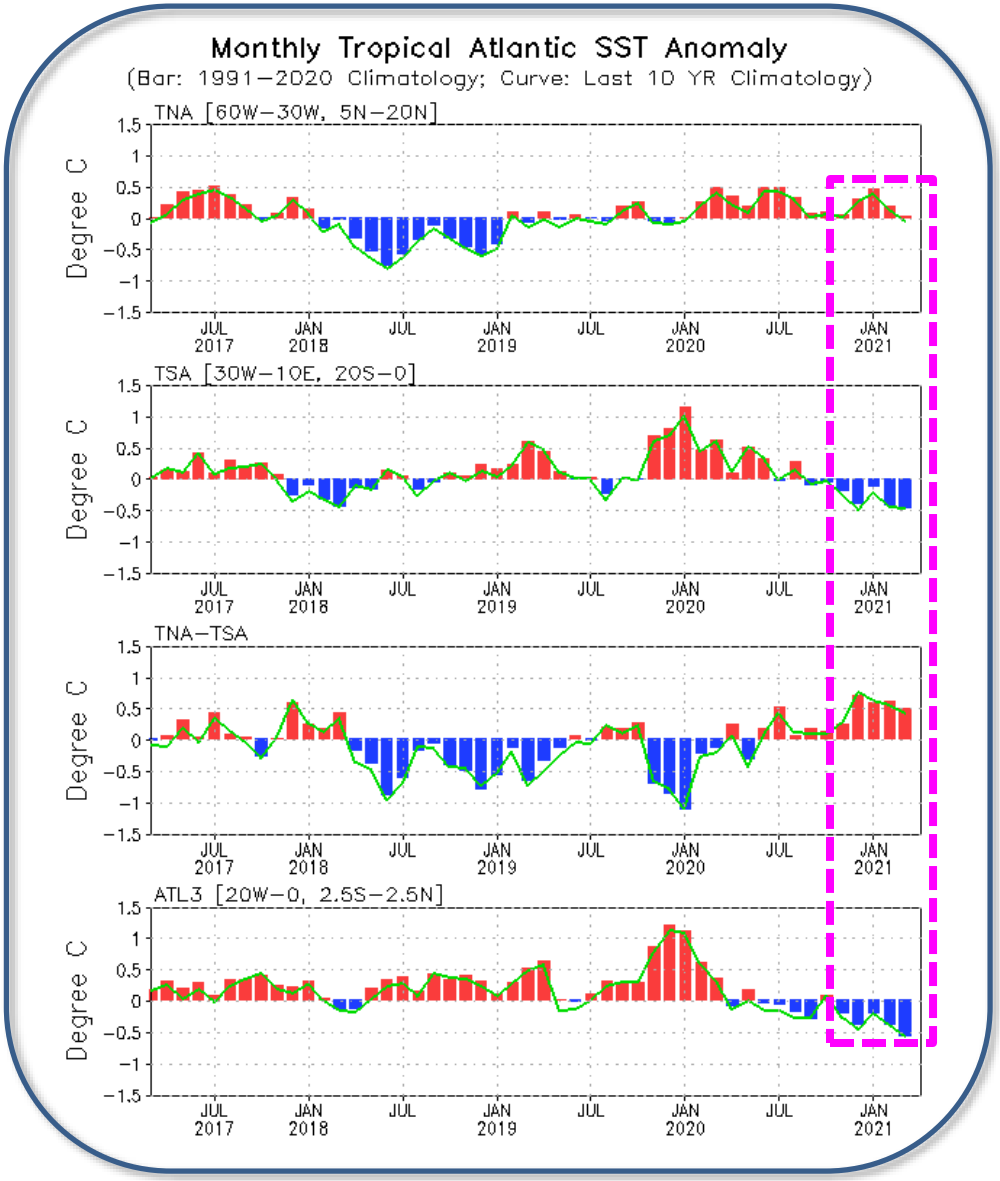
SSTAs (top-left), SSTA tendency (top-right), OLR anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the 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 1991-2020 base period means.

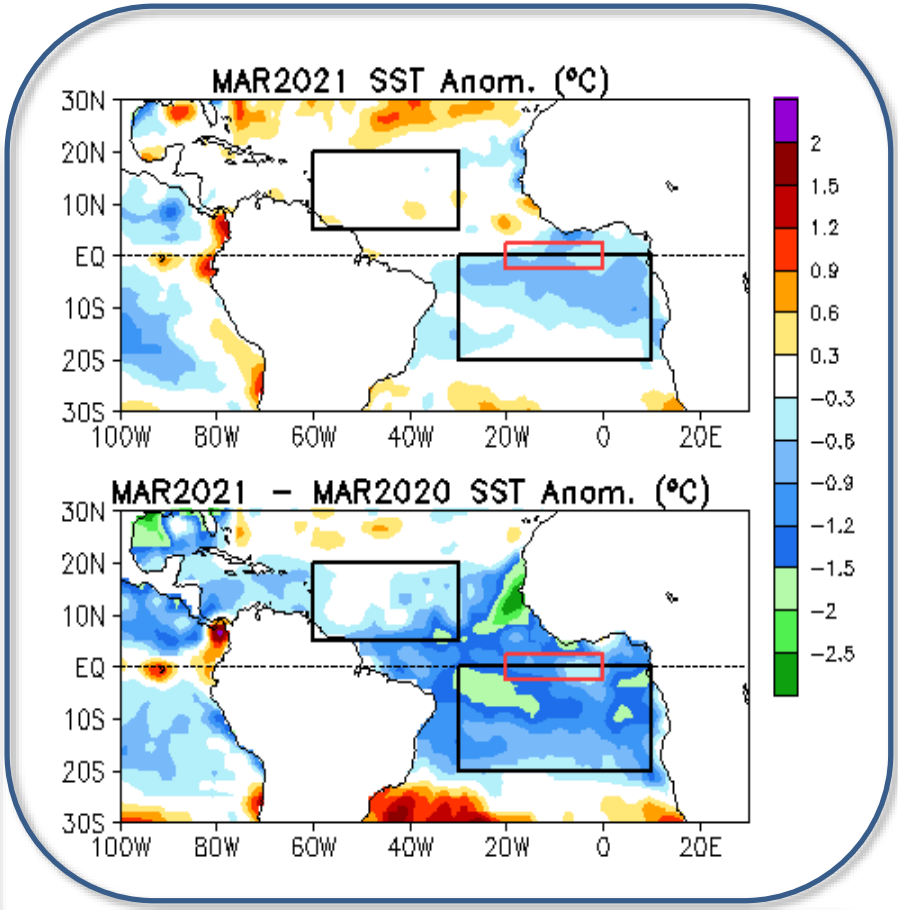


- Westerly wind anomaly in the equatorial Indian Ocean led to the subsurface warming in the eastern Indian Ocean.

Tropical and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

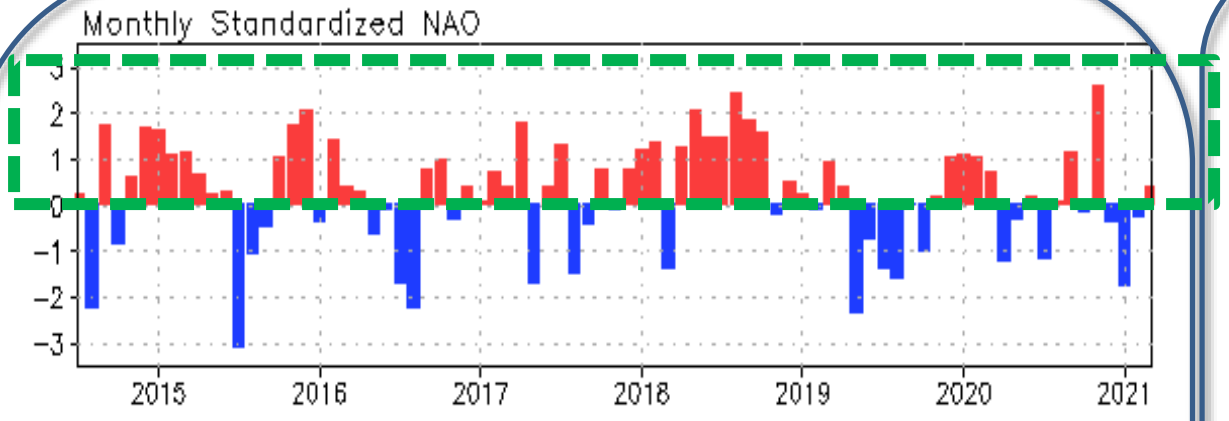


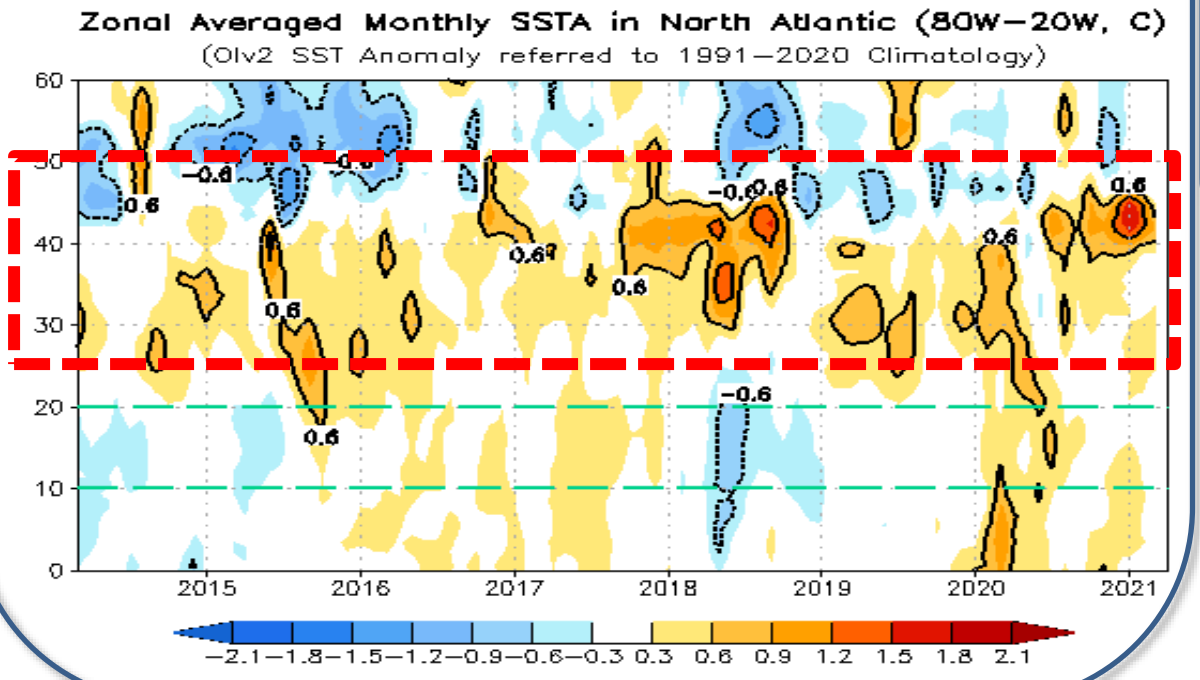


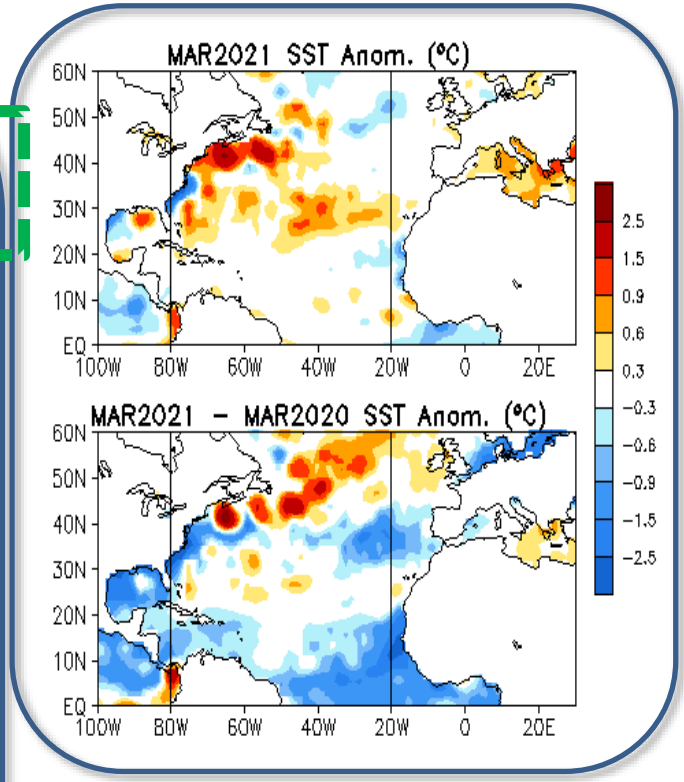
- Positive (negative) SSTAs in the tropical North (South) Atlantic feature a positive phase of the Atlantic meridional dipole mode during Dec 2020-Mar 2021.

Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (^{O}C) for the TNA [60^{O}W-30^{O}W, 5ºN-20^{O}N], TSA [30^{O}W-10^{O}E, 20^{O}S-0] and ATL3 [20^{O}W-0, 2.5^{O}S-2.5^{O}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 1991-2020 base period means.

NAO and SST Anomaly in North Atlantic





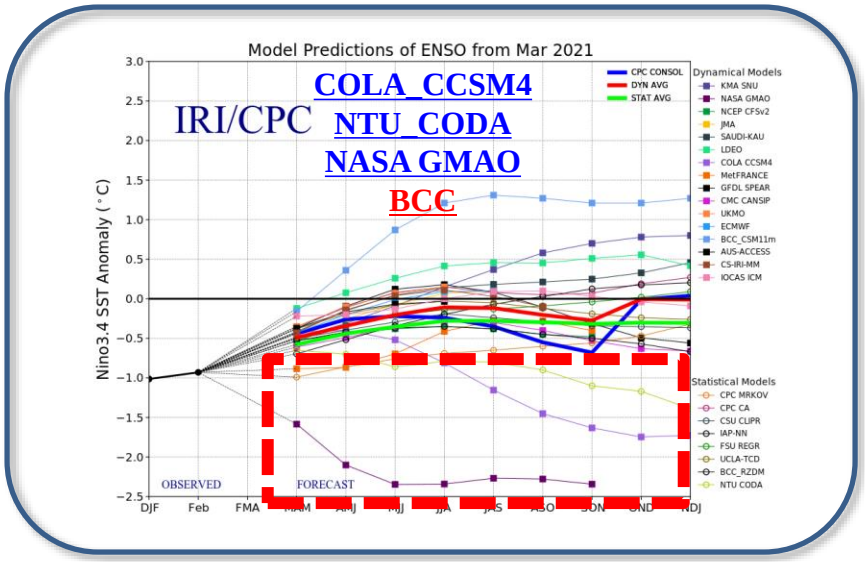


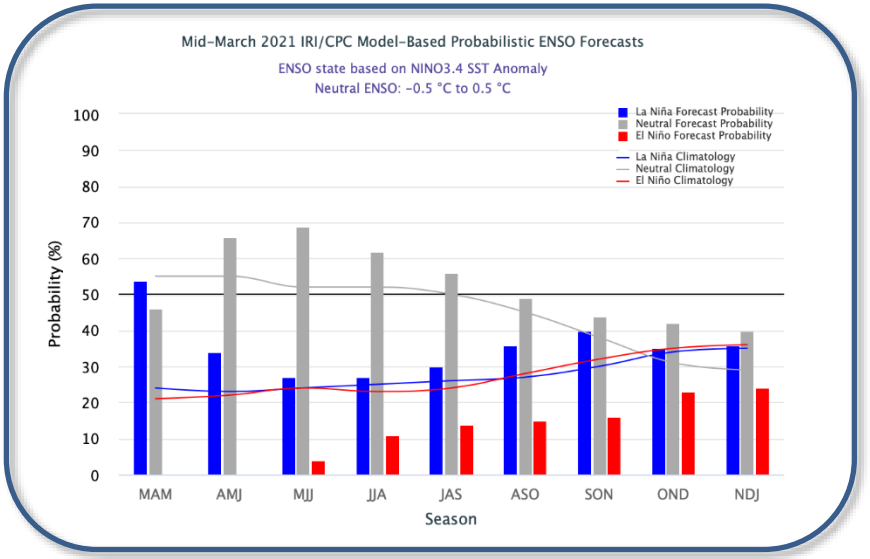
- NAO was in a positive phase in Mar 2021 with NAOI= 0.36.
- The prolonged positive SSTAs in the middle latitudes were evident, due to the domination of the positive phase of NAO during the last 5-6 years.

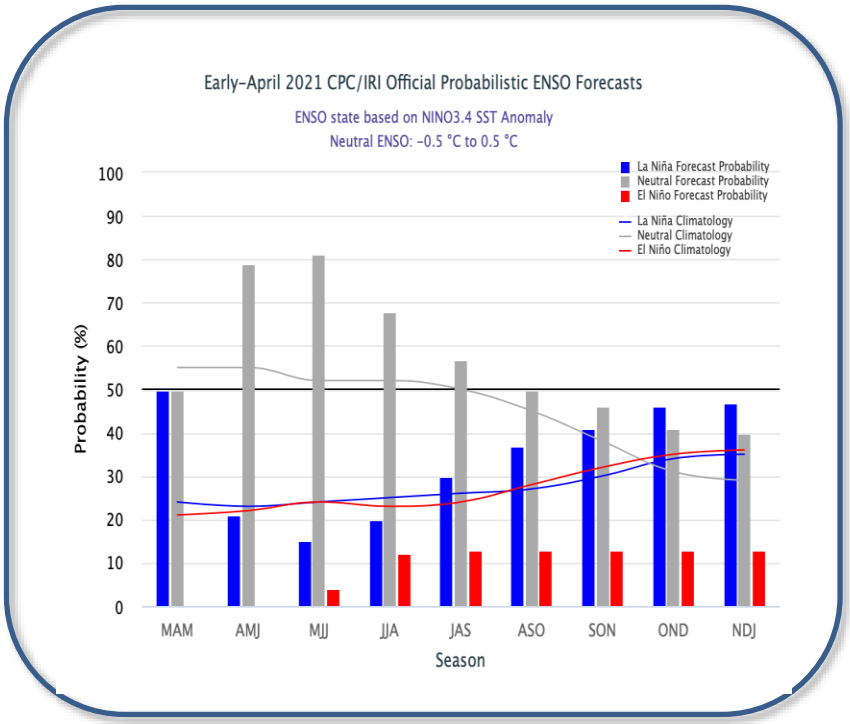
Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20^{O}N-90^{O}N (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80ºW and 20ºW (bottom). SST are derived from the NCEP OI SST analysis, and anomalies are departures from the 1991-2020 base period means.

ENSO and Global SST Predictions

IRI/CPC Niño3.4 Forecast





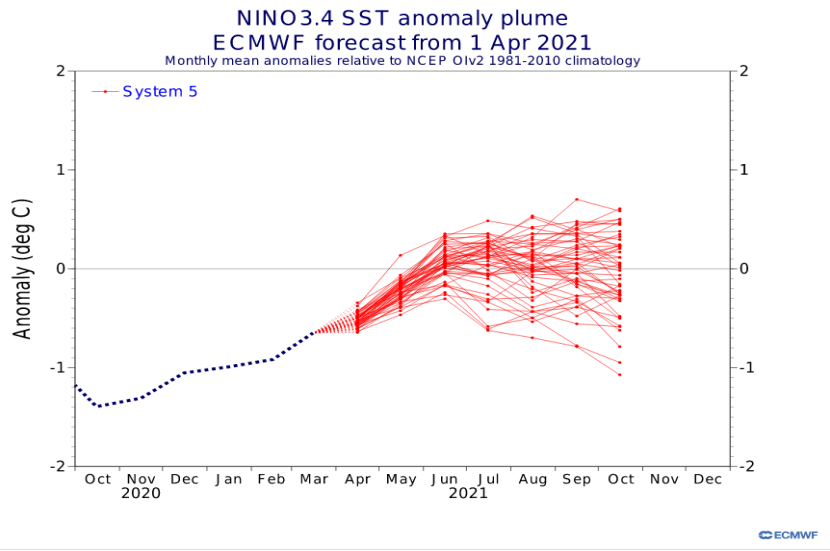


- ENSO Alert System Status: La Niña Advisory

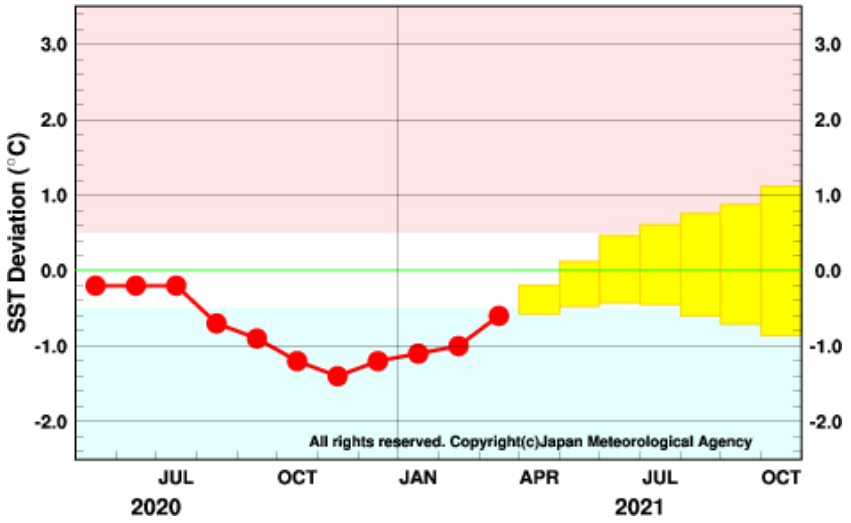
- Synopsis: *A transition from La Niña to ENSO-Neutral is likely in the next month or so, with an 80% chance of ENSO-neutral during May-July 2021.*

Individual Model Niño3.4 Forecasts

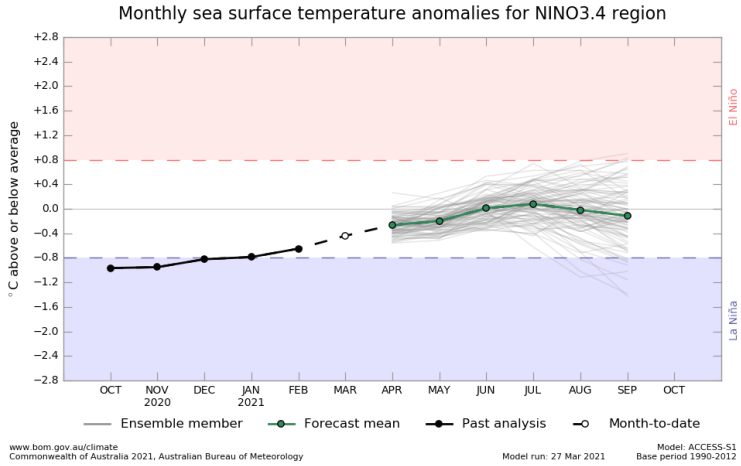
EC: IC= 01 Apr, 2021



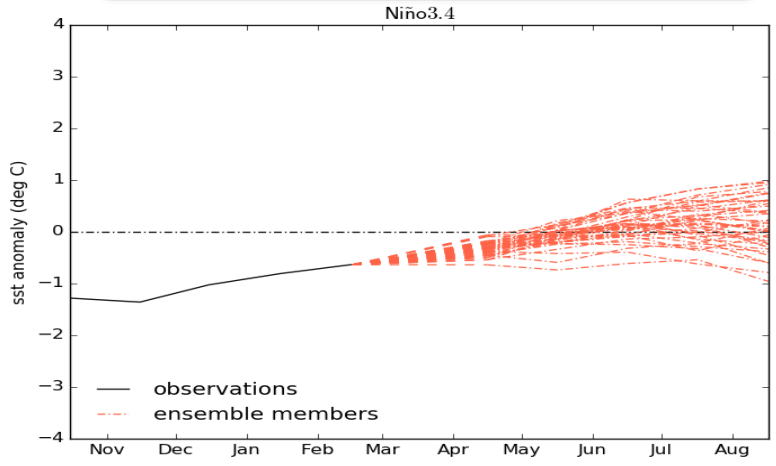
JMA: Updated 9 Apr, 2021



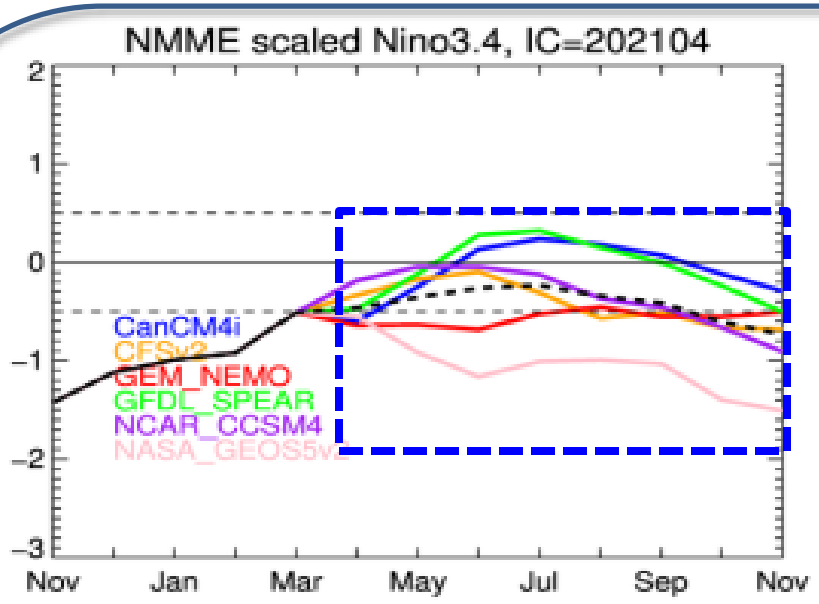
BOM: Updated 27 Mar, 2021

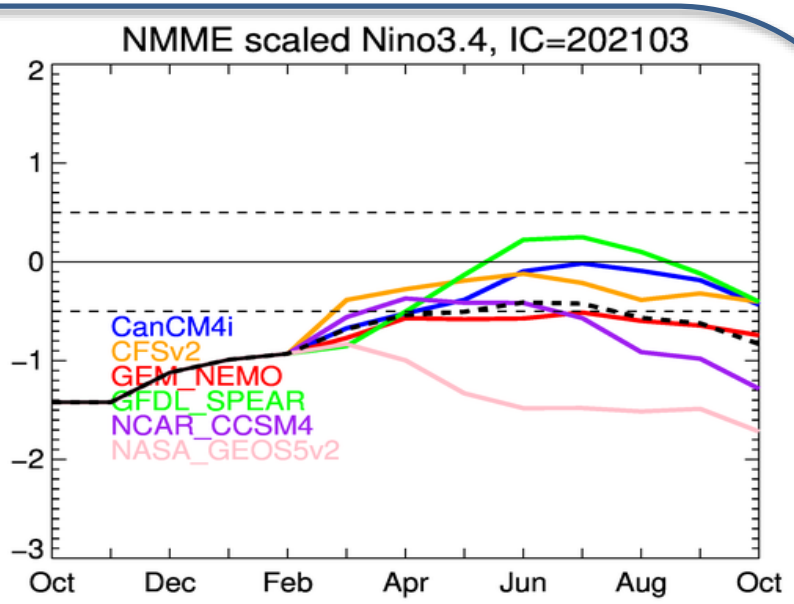


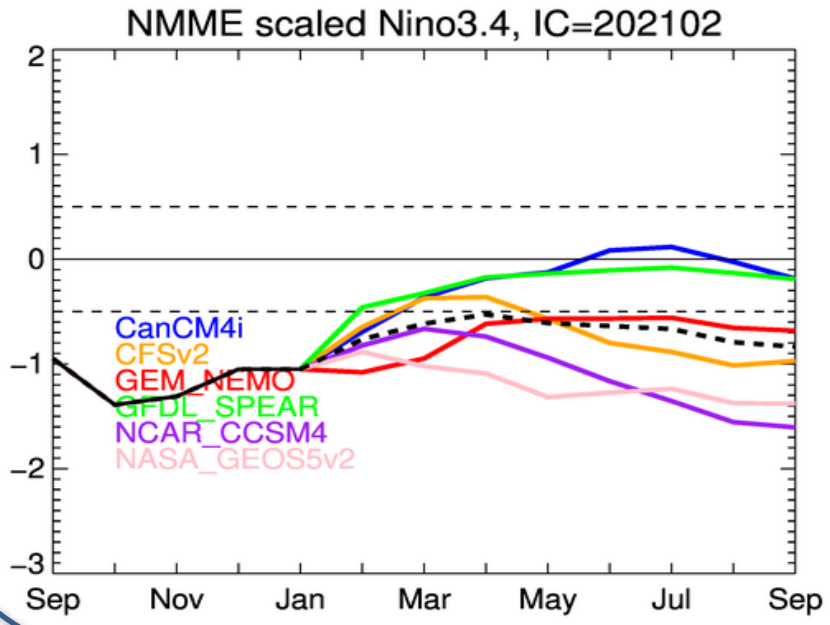
UKMO: Updated 11 Mar, 2021

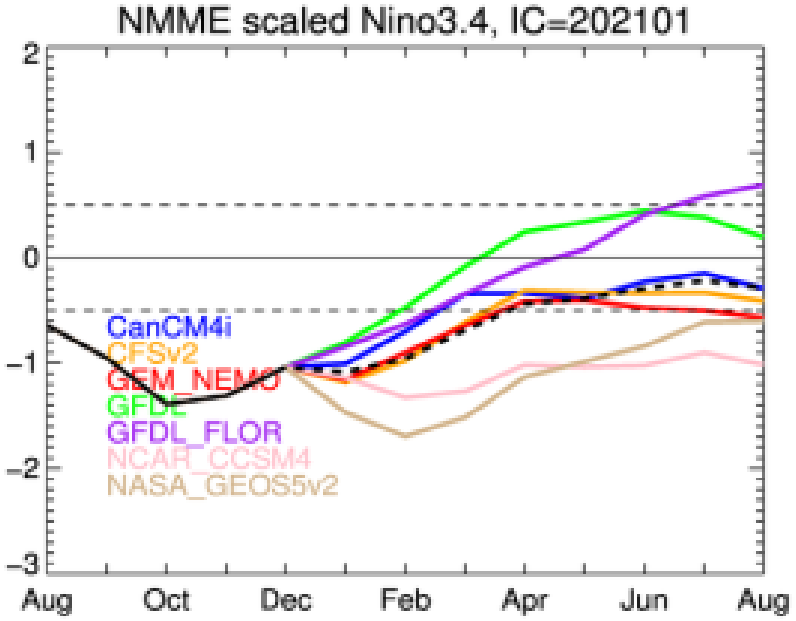


NMME forecasts with the latest 4-month initial conditions

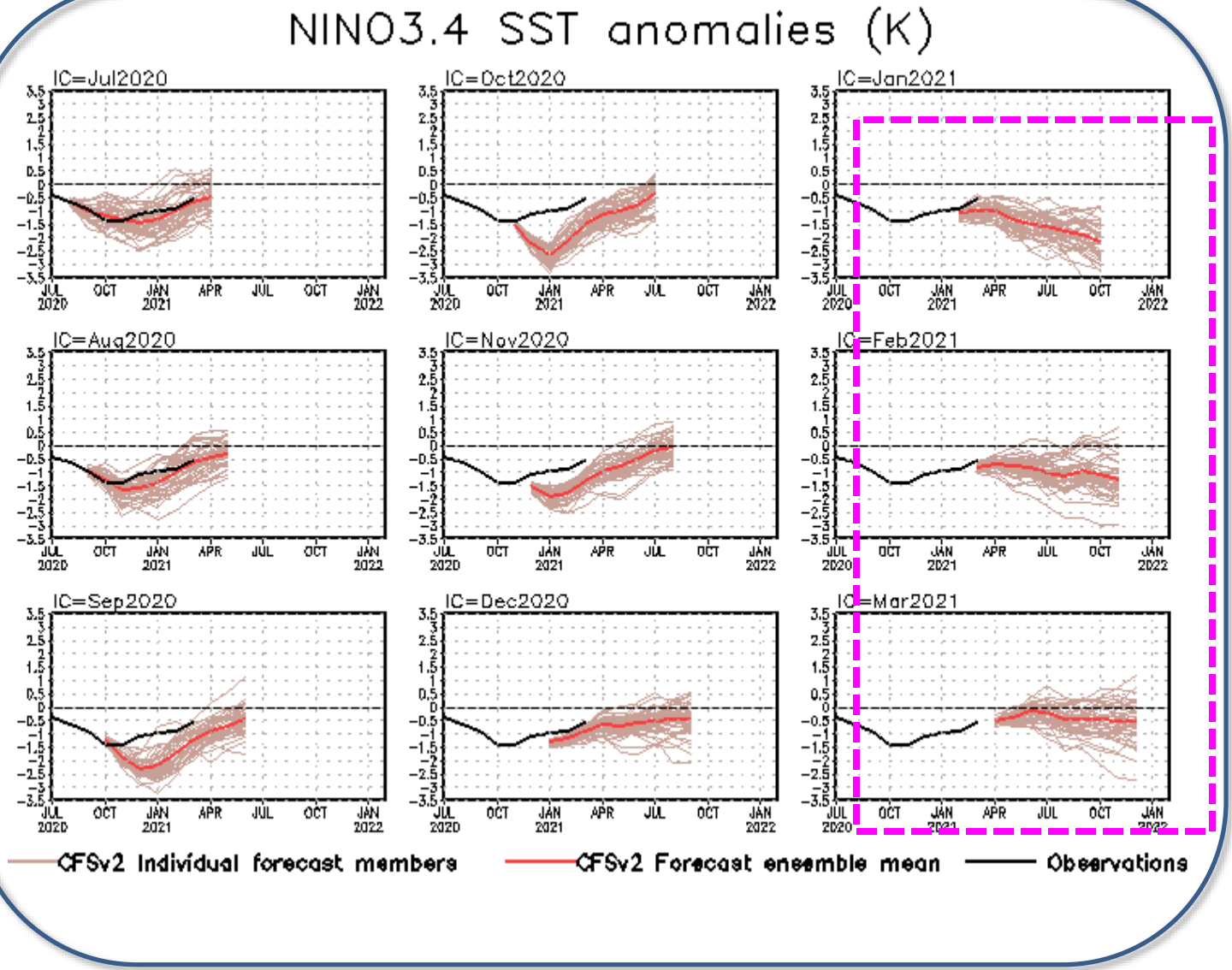








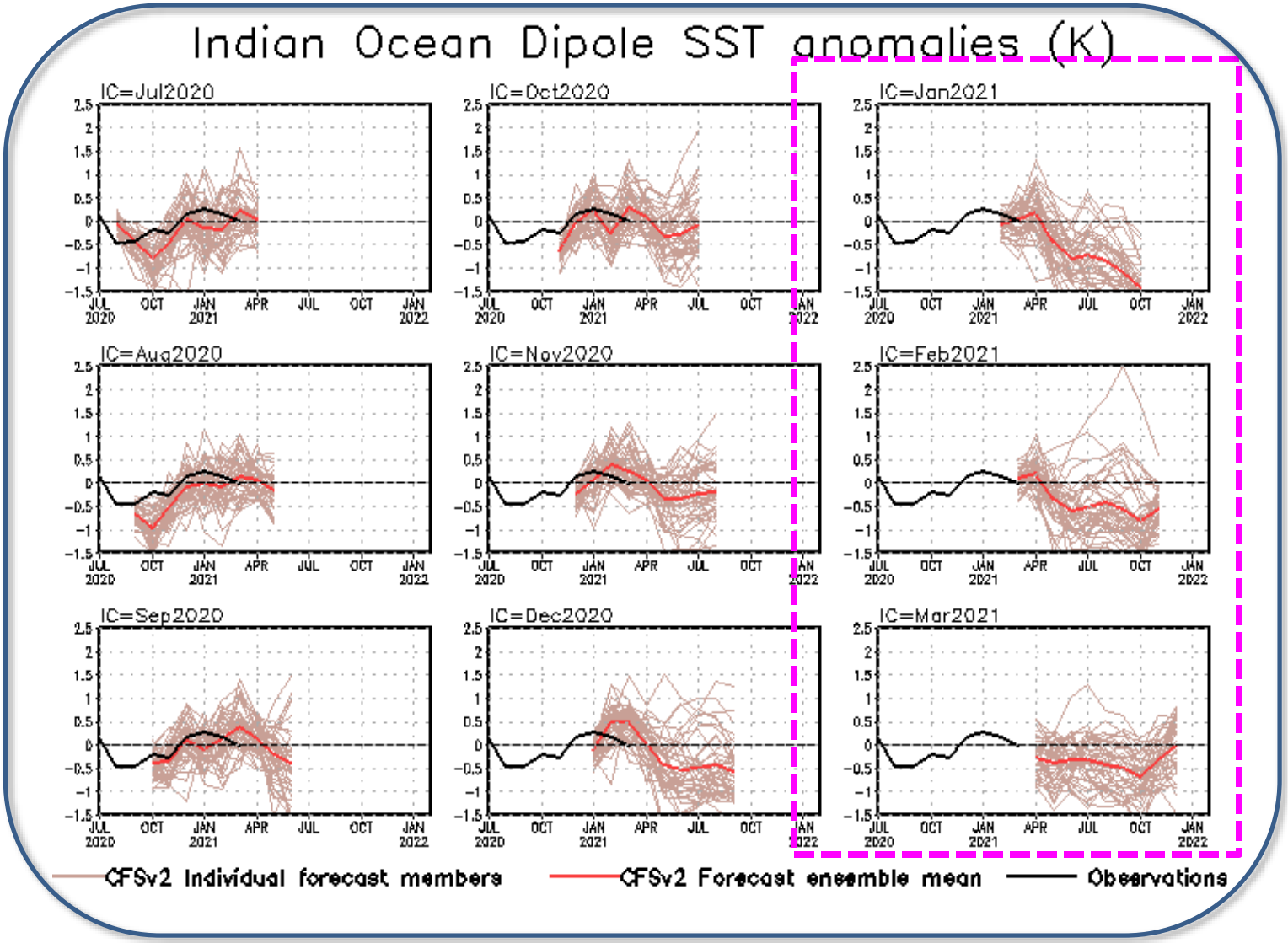
CFSv2 Niño3.4 SST Predictions



- CFSv2 oceanic IC reset on 15Jan2021 led to strong cooling tendencies in the predictions with ICs in Jan 2021.

CFS Niño3.4 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 1991-2020 base period means.

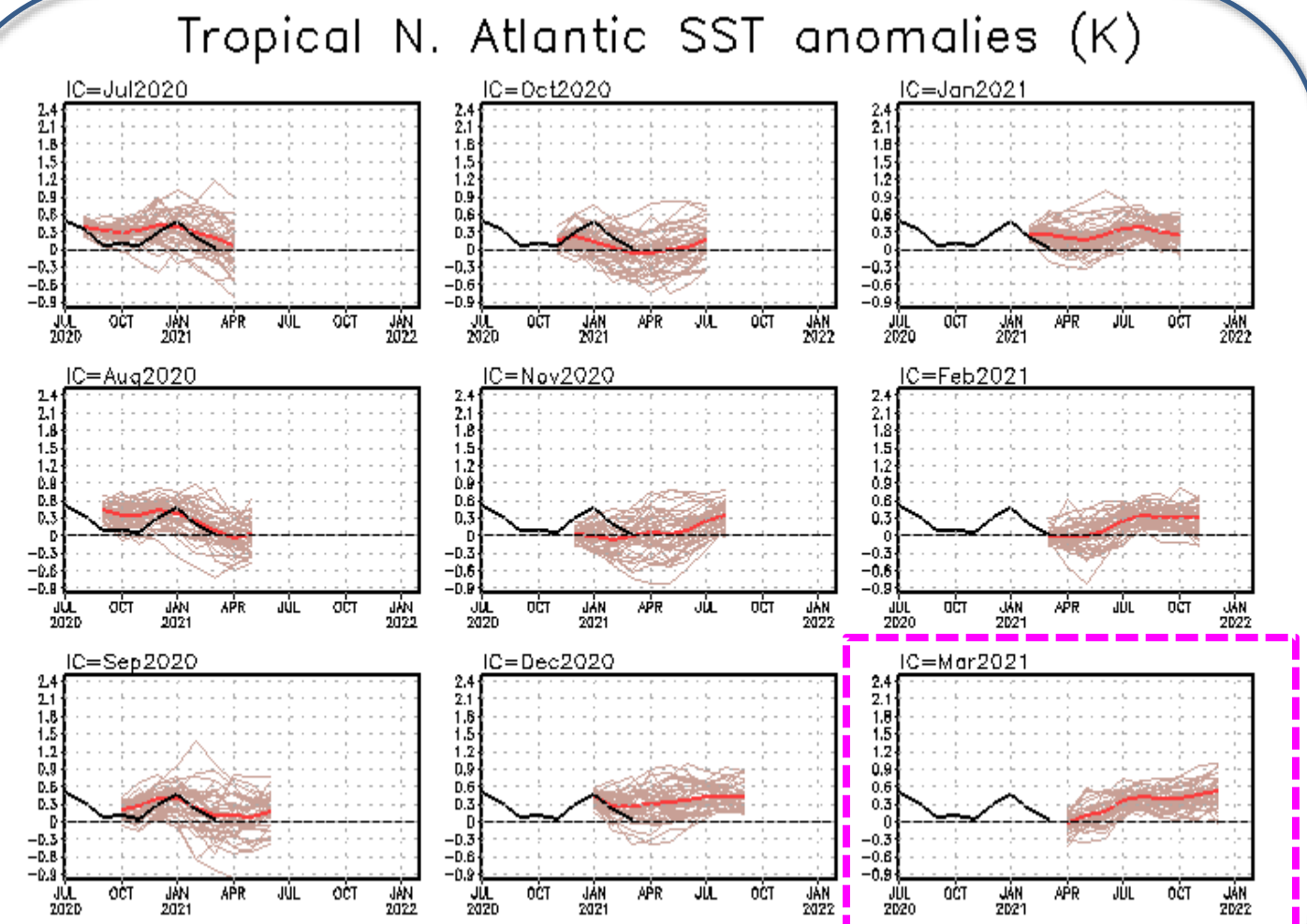
CFSv2 DMI SST Predictions



- Latest CFSv2 predicts a negative phase of IOD in 2021.

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 1991-2020 base period means.

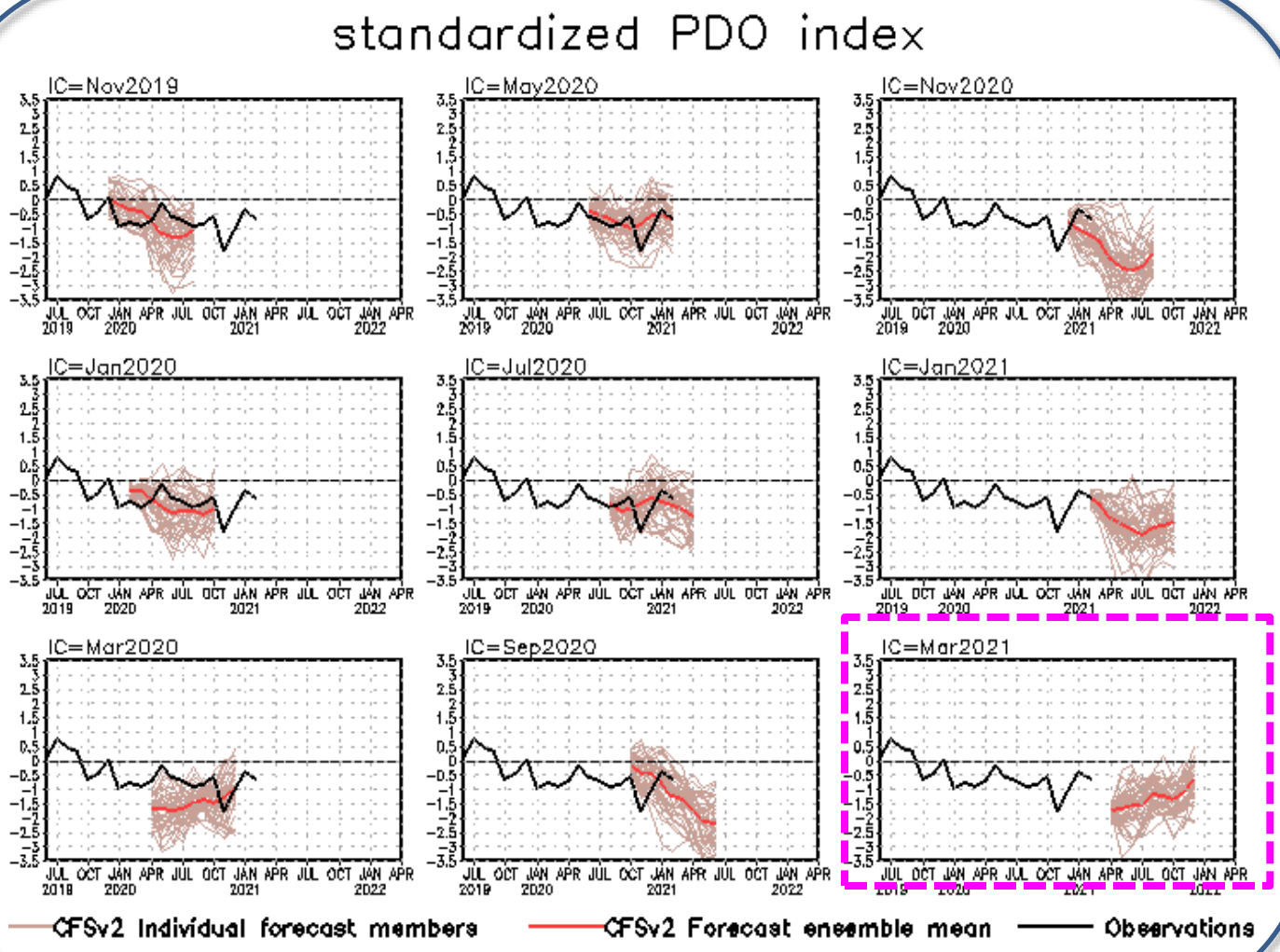
CFSv2 Tropical North Atlantic (TNA) SST Predictions



- Latest CFSv2 predictions call for above normal SSTs in the tropical N. Atlantic in 2021 hurricane season.

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 1991-2020 base period means. TNA is the SST anomaly averaged in the region of [60oW-30oW, 5oN-20oN].

CFSv2 Pacific Decadal Oscillation (PDO) Index Predictions



- CFSv2 predicts a negative phase of PDO in the coming seasons.

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 1991-2020 base period means. 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.

Acknowledgements

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

- Drs. Li Ren and Pingping Xie provided the BASS/CMORPH/CFSR EVAP package

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

Please send your comments and suggestions to:

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Jieshun.Zhu@noaa.gov

Data Sources (climatology is for 1991-2020)

- **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

Backup Slides

Global Sea Surface Salinity (SSS): Anomaly for March 2021

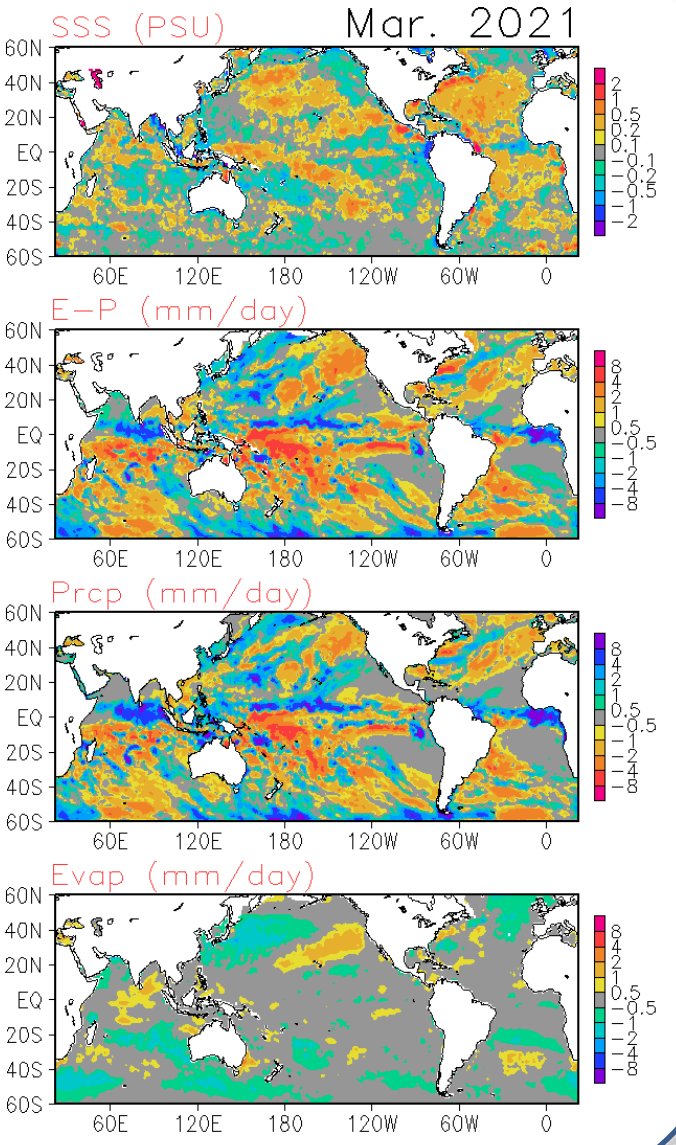
New Update: The NCEI SST data used in the quality control procedure has been updated to version 2.1 since May 2020;

Positive SSS anomaly continues in the western equator Pacific Ocean and SPCZ region, which is likely caused by the reduced precipitation. Positive SSS anomalies continue and expand in the central N. Pacific ocean. Positive SSS anomaly along the Equatorial Indian Ocean is likely due to decreased precipitation. Positive SSS anomalies continue and strengthen between equator and 40° N in the North Atlantic Ocean. Such positive salinity anomaly is possibly caused by decreased precipitation.

SSS : Blended Analysis of Surface Salinity (BASS) V0.Z
(a CPC-NESDIS/NODC-NESDIS/STAR joint effort)
ftp.cpc.ncep.noaa.gov/precip/BASS

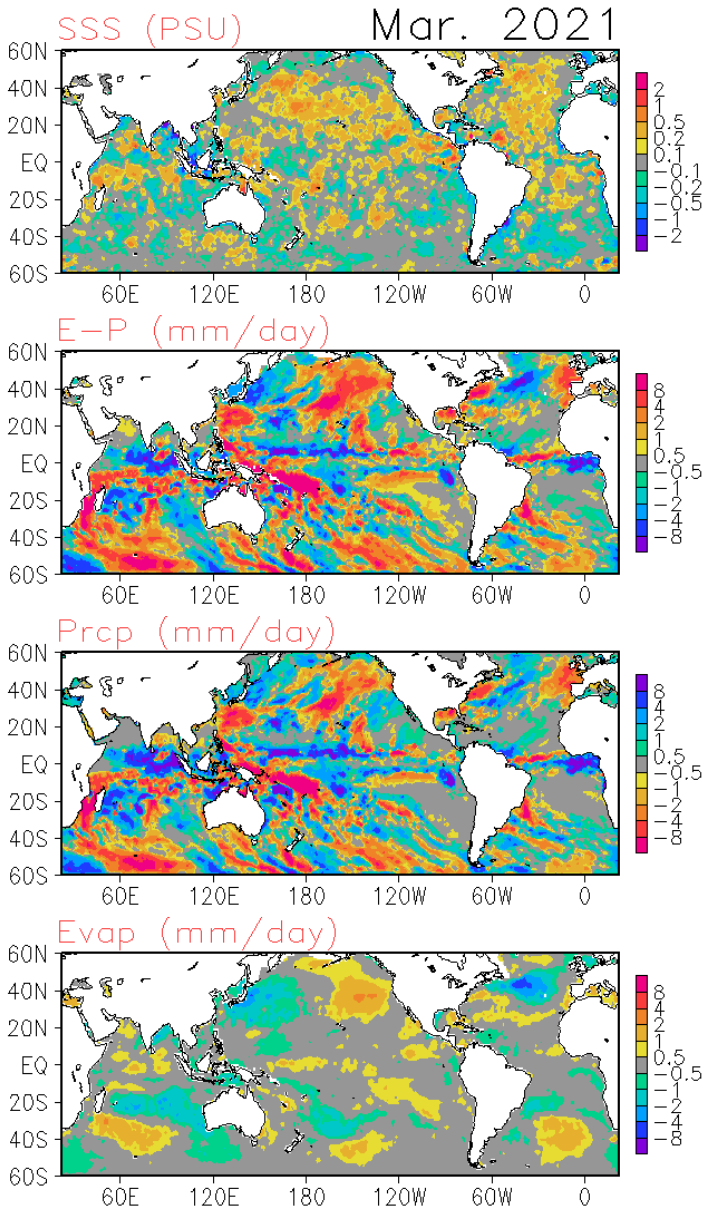
Precipitation: CMORPH adjusted satellite precipitation estimates

Evaporation: Adjusted CFS Reanalysis



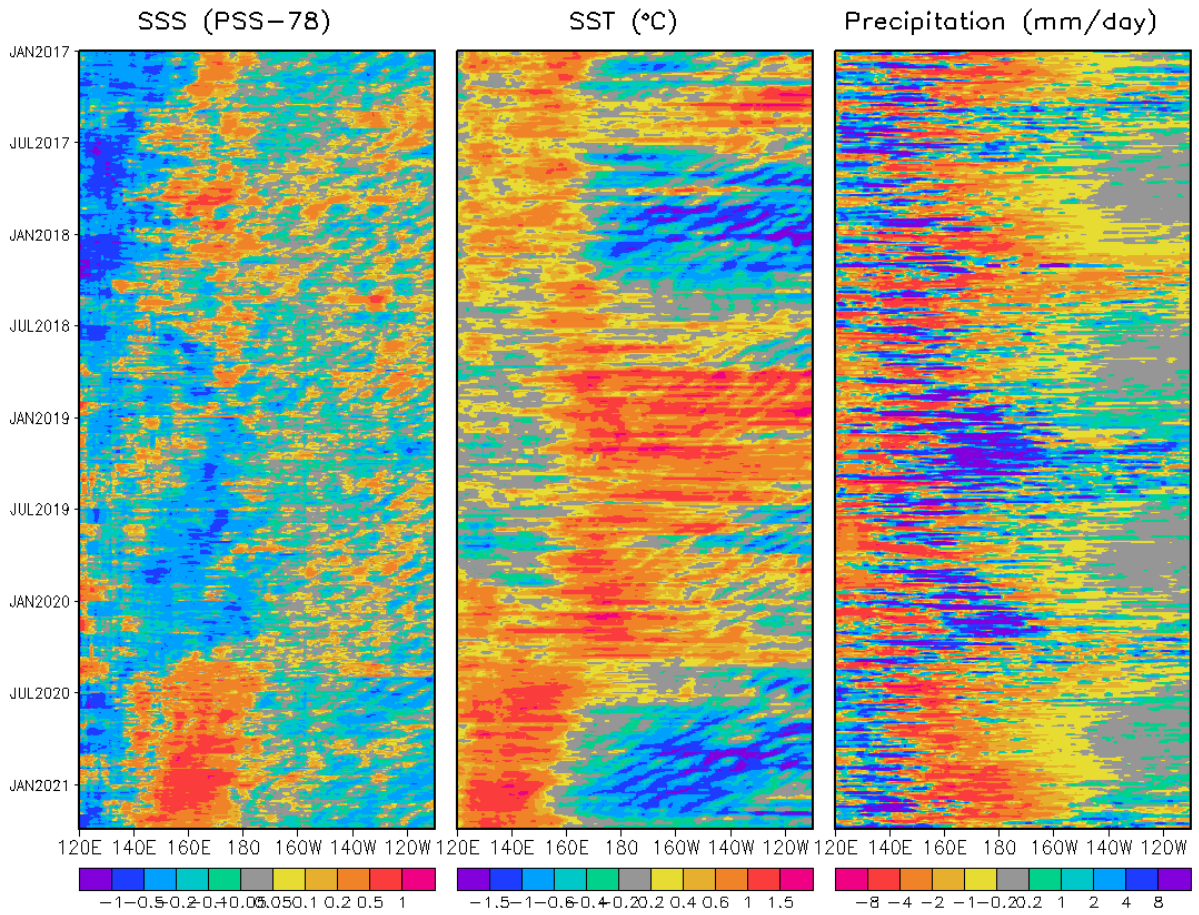
Global Sea Surface Salinity (SSS): Tendency for March 2021

Compared with last month, SSS increased between equator and 40° N in the North Pacific Ocean. SSS increased in the Indian Ocean along and little south of Equatorial Indian Ocean, which is likely caused by reduced precipitation. SSS in the North Atlantic Ocean increased in most area between 30° S and 40° N with stronger signals in the North Atlantic ocean.

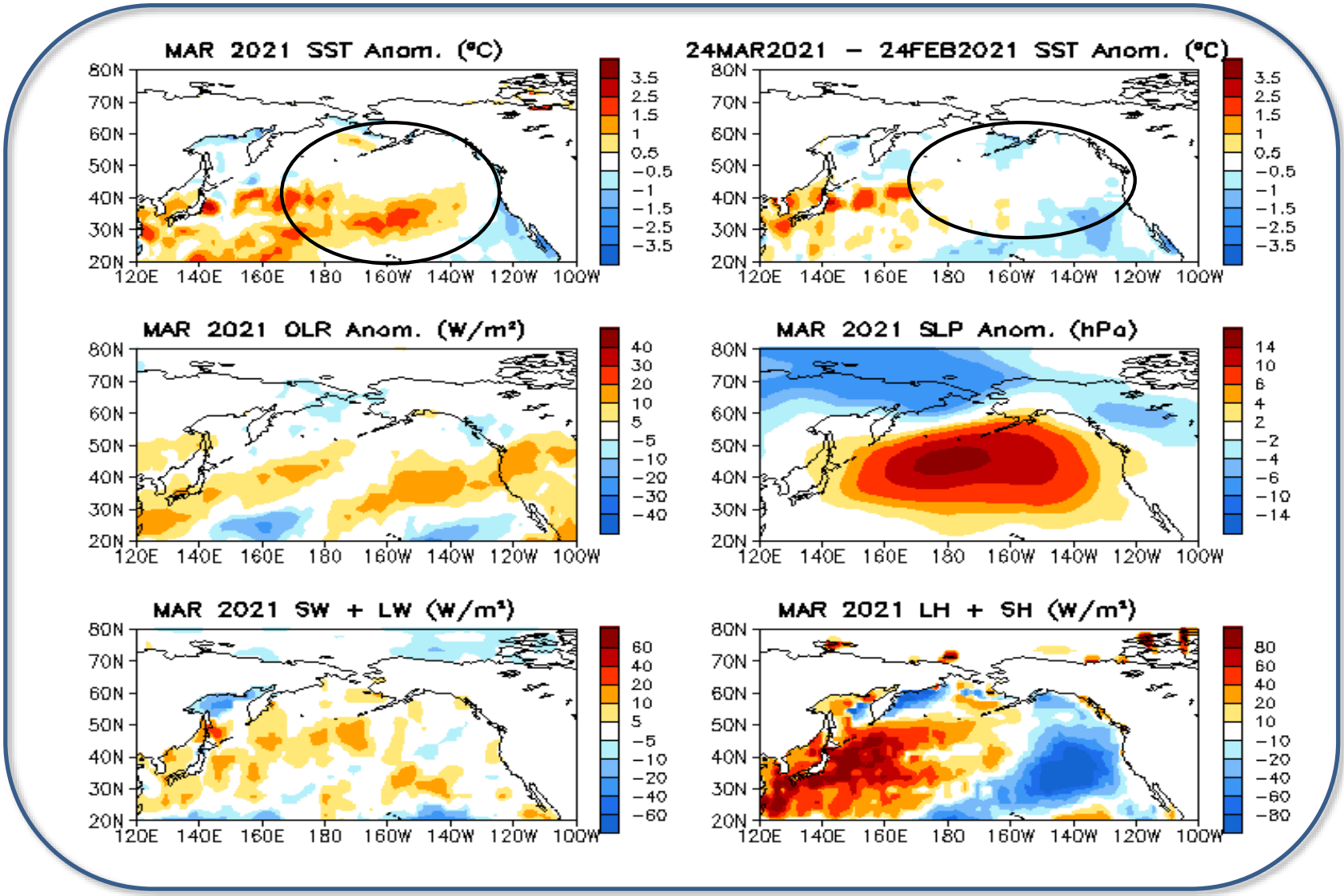


Pentad SSS Anomaly Evolution over Equatorial Pacific

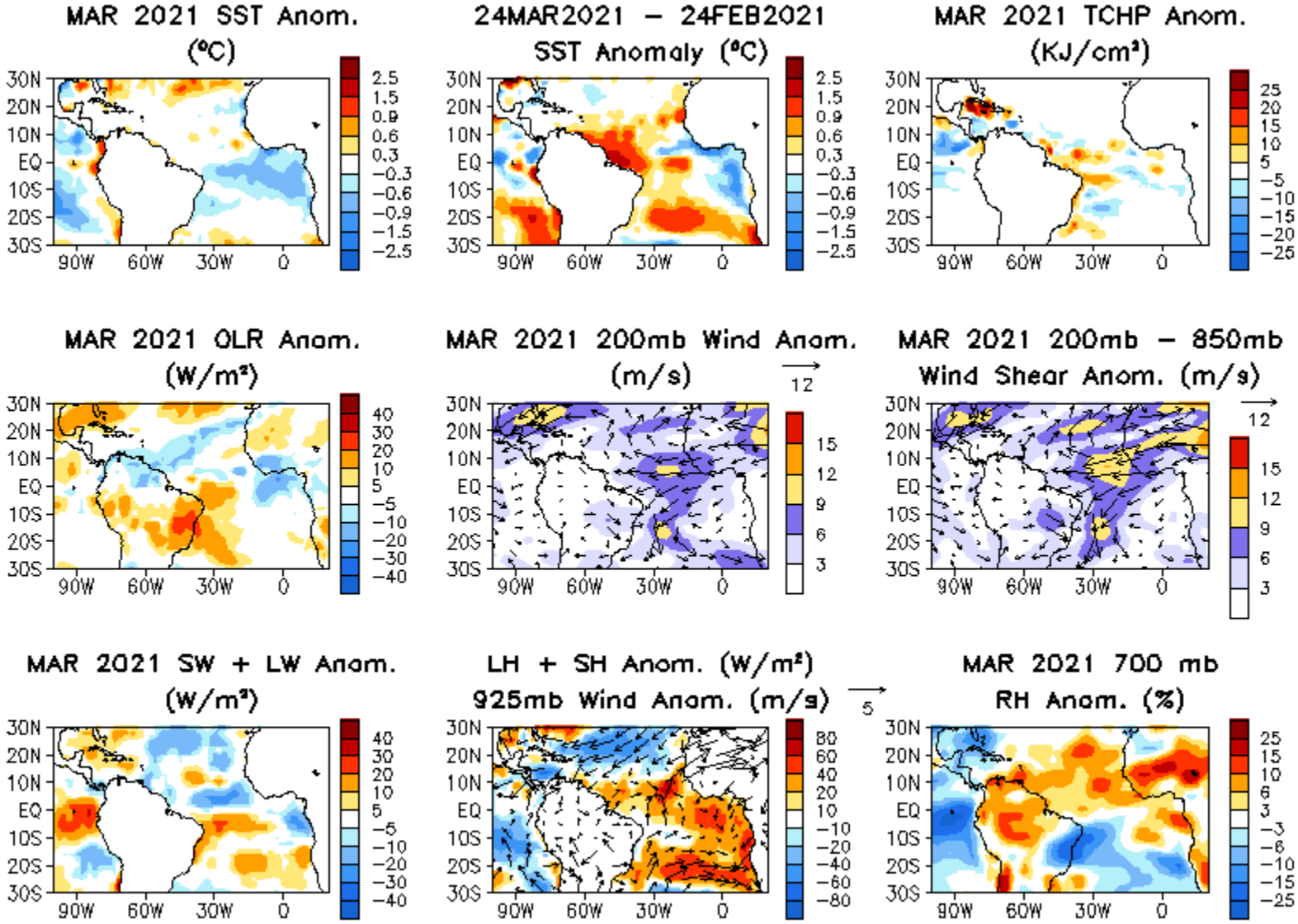
Figure caption:
Hovemoller diagram for equatorial (5° S-5° N) 5-day mean SSS, SST and precipitation anomalies. The climatology for SSS is Levitus 1994 climatology. The SST data used here is the OISST V2 AVHRR only daily dataset with its climatology being calculated from 1985 to 2010. The precipitation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

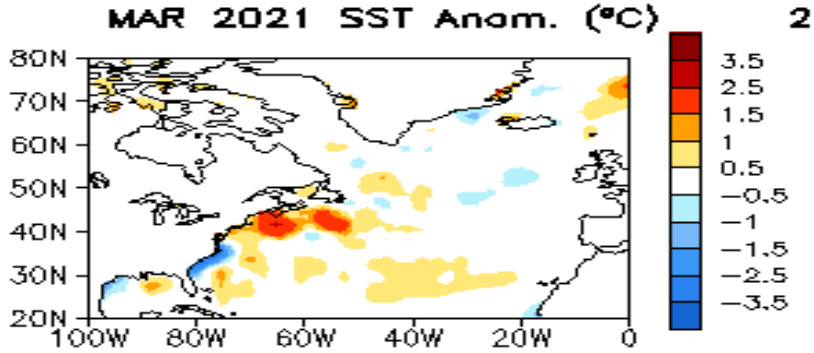


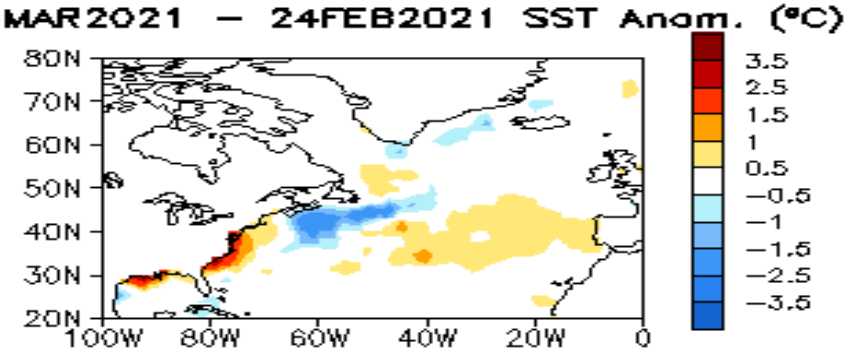
North Pacific & Arctic Ocean: SSTA, SSTA Trend, OLR, SLP, Heat Flux Anomalies

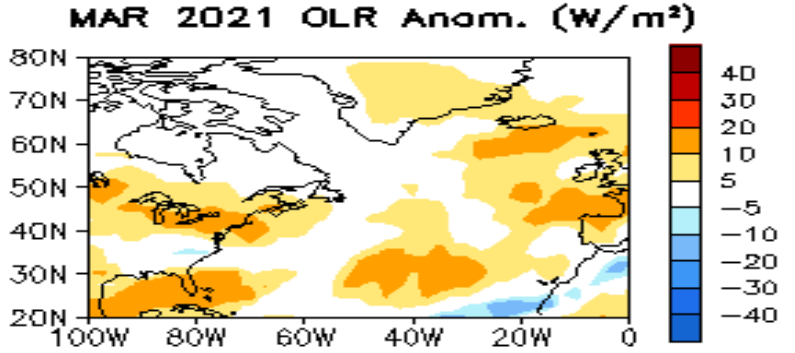


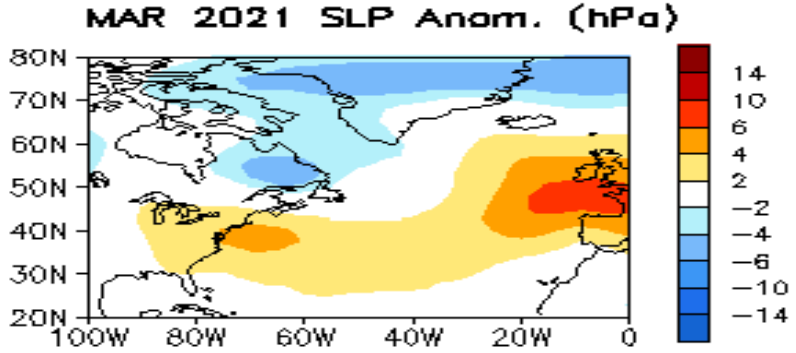
Sea surface temperature (top-left; NCEP OI SST Analysis), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) (middle-left; NOAA 18 AVHRR IR), sea surface pressure (middle-right; NCEP CDAS), sum of net surface short- and long-wave radiation (bottom-left; positive means heat into the ocean; NCEP CDAS), sum of latent and sensible heat flux (bottom-right; positive means heat into the ocean; NCEP CDAS). Anomalies are departures from the 1991-2020 base period means.

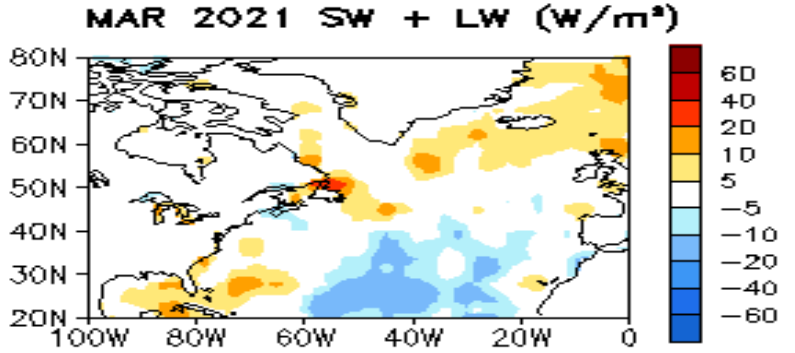

MAR 2021 SST Anom. (°C)
24MAR2021 – 24FEB2021 SST Anomaly (°C)
MAR 2021 TCHP Anom. (KJ/cm²)
MAR 2021 OLR Anom. (W/m²)
MAR 2021 200mb Wind Anom. (m/s)
MAR 2021 200mb – 850mb Wind Shear Anom. (m/s)
MAR 2021 SW + LW Anom. (W/m²)
LH + SH Anom. (W/m²)
925mb Wind Anom. (m/s)
MAR 2021 700 mb RH Anom. (%)
30N
20N
10N
EQ
10S
20S
30S
90W
60W
30W
0

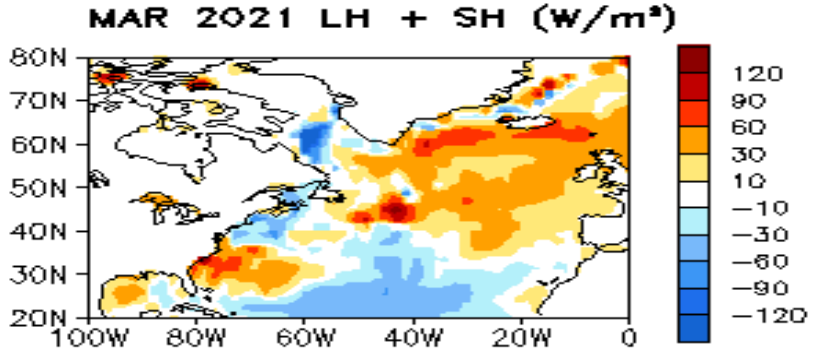

MAR 2021 SST Anom. (°C)
80N
70N
60N
50N
40N
30N
20N
100W
80W
60W
40W
20W
0
3.5
2.5
1.5
1
0.5
−0.5
−1
−1.5
−2.5
−3.5

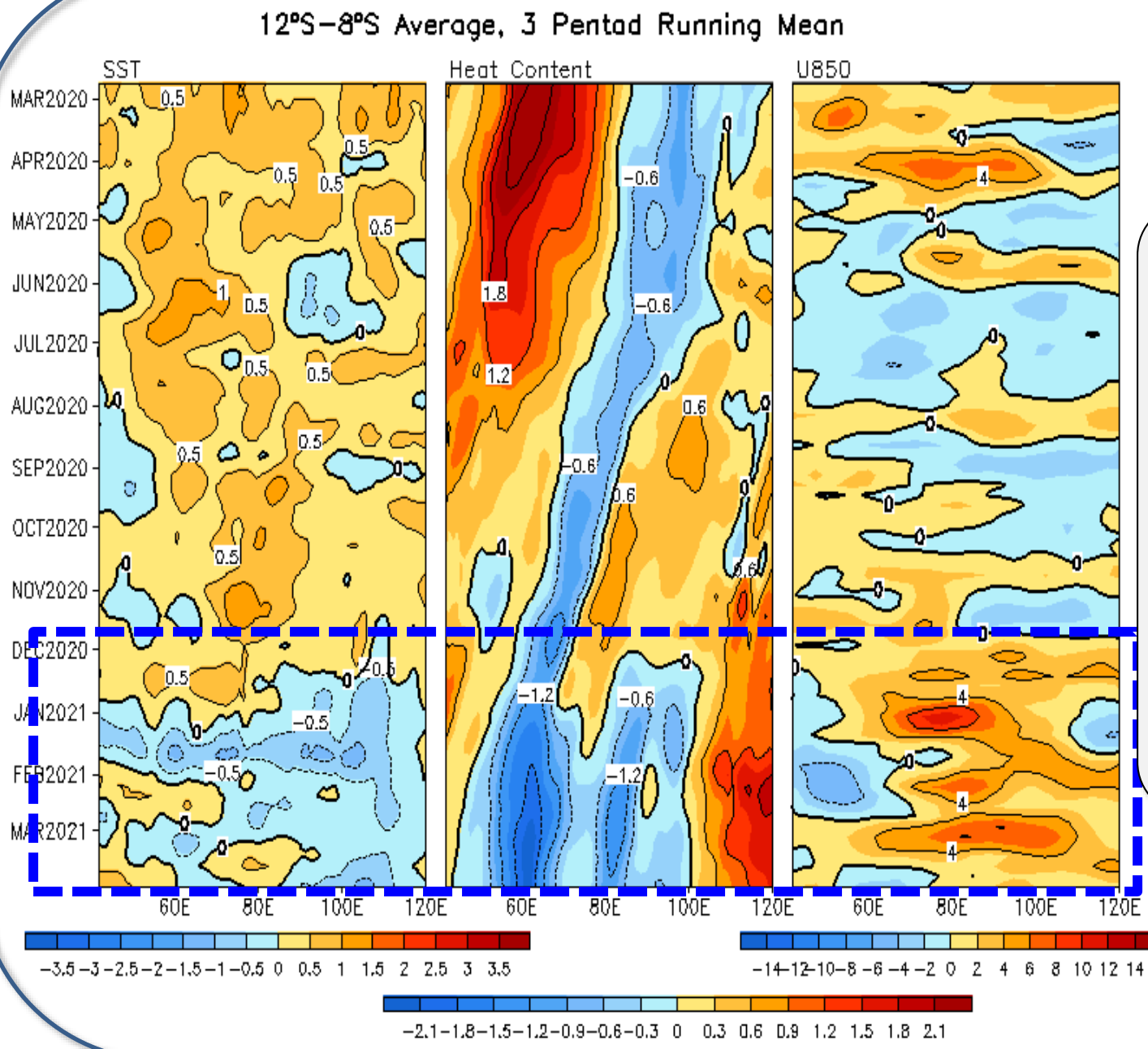

24MAR2021 − 24FEB2021 SST Anom. (°C)
80N
70N
60N
50N
40N
30N
20N
100W
80W
60W
40W
20W
0
3.5
2.5
1.5
1
0.5
−0.5
−1
−1.5
−2.5
−3.5


MAR 2021 OLR Anom. (W/m²)
80N
70N
60N
50N
40N
30N
20N
100W
80W
60W
40W
20W
0
40
30
20
10
5
−5
−10
−20
−30
−40


MAR 2021 SLP Anom. (hPa)
80N
70N
60N
50N
40N
30N
20N
100W
80W
60W
40W
20W
0
14
10
6
4
2
−2
−4
−6
−10
−14


MAR 2021 SW + LW (W/m²)
80N
70N
60N
50N
40N
30N
20N
100W
80W
60W
40W
20W
0
60
40
20
10
5
−5
−10
−20
−40
−60


MAR 2021 LH + SH (W/m²)
80N
70N
60N
50N
40N
30N
20N
100W
80W
60W
40W
20W
0
120
90
60
30
10
−10
−30
−60
−90
−120



- Westerly wind anomaly persisted in the tropical Indian Ocean, leading to the subsurface warming in the eastern and cooling in the western Indian Ocean.

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