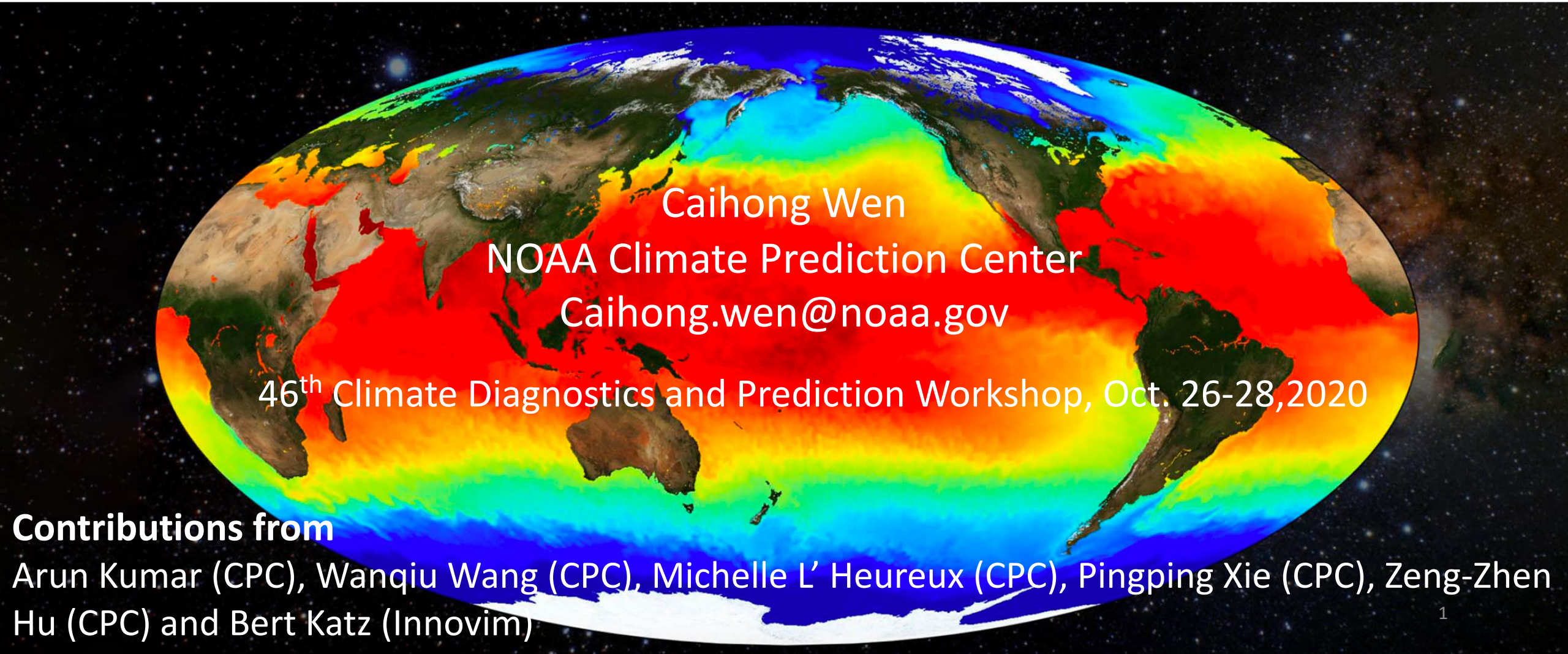
Communicating Uncertainty in SST Analyses



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46th Climate Diagnostics and Prediction Workshop, Oct. 26-28,2020

Contributions from
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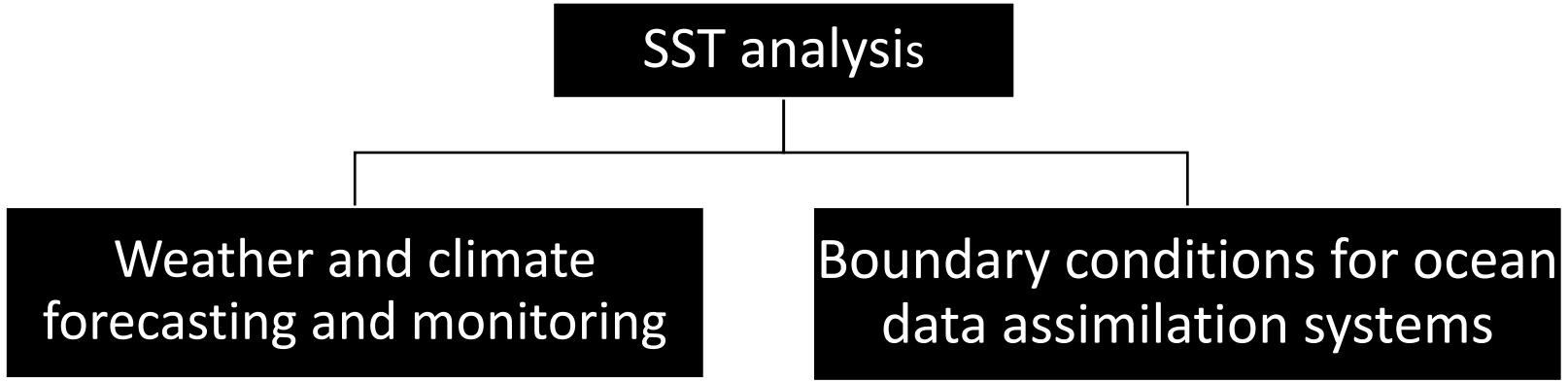


---------- “Why is the CFSR analysis much colder than other SST products in the tropical Atlantic?

---------- “ I saw a large difference between SST anomaly on the CPC website and another website. Is this unusual?

---------- “ Which of the SST product have the best quality?”

Purpose:

- Understand uncertainty among SST analysis products
- Explore the potential impacts of replacing SST nudging source on CFSR and CFSv2 forecasts

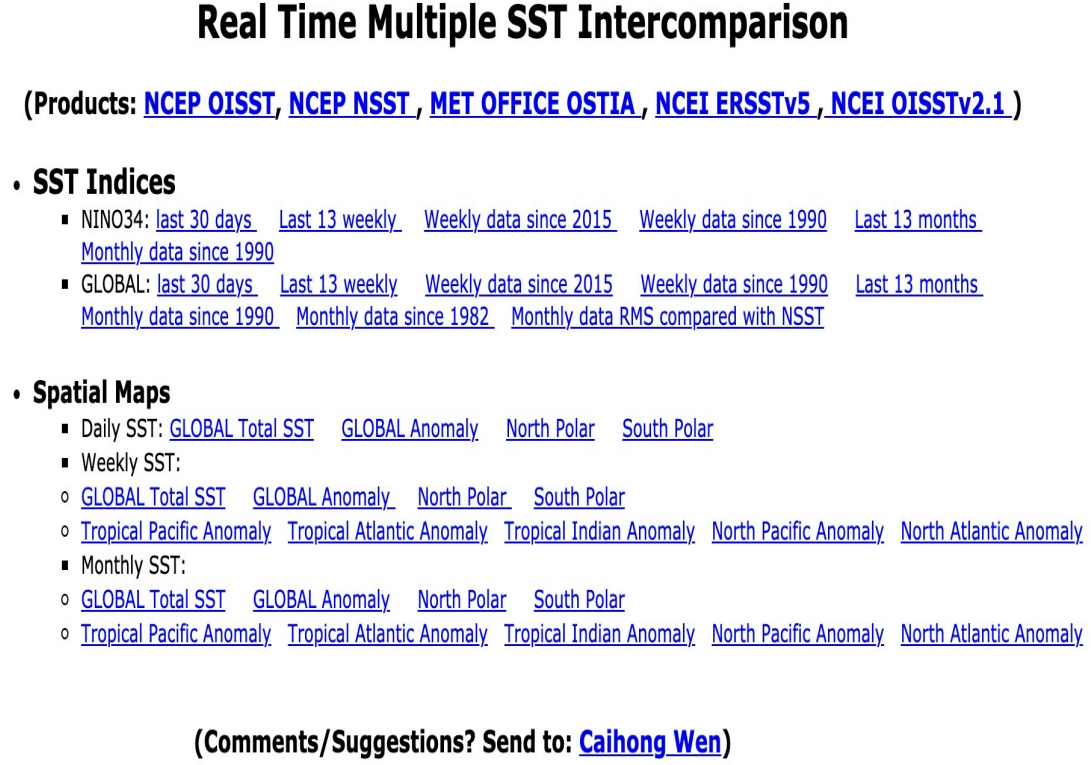
SST Analysis Products

	Spatial resolution	Temporal resolution	Coverage period	Usage examples
NCEP OISST, or NOAA OIv2 (**OISST**)	1° x 1°	Weekly	Nov,1982-present	CPC operational products (weekly ENSO update, Ocean briefing, etc.)
NCEI ERSSTv5 (**ERSST**)	2° x 2°	Monthly	1854-present	ENSO Diagnostic Discussion
NCEI Daily OISSTv2.1 (**OISSTv2.1**)	0.25° x 0.25°	Daily	Sep,1981-present (1981-2015 is identical with Daily OISSTv2)	SST analysis for CFSR until Feb. 11, 2020; CFSv2 forecast validation, CPC ENSO products
NCEP NSST (**NSST**)	0.083° x 0.083°	Daily	Jul, 2015 - present	SST analysis for CFSR since Feb. 11, 2020
Met Office OSTIA (**OSTIA**)	0.05° x0.05°	Daily	1985-present	EMC model validation

Note: OISST, ERSST and OISSTv2.1 represent SST at ~0.2 m, while NSST and OSTIA represent foundation SST at 10m.

Real Time Multiple SST Intercomparison Web page

- Realtime updates for daily, weekly, monthly comparison
- Variables include total SST and SST anomaly
- Reference climatology : 1991-2020
- Plots of SST indices
- Plots of spatial distribution



Real Time Multiple SST Intercomparison

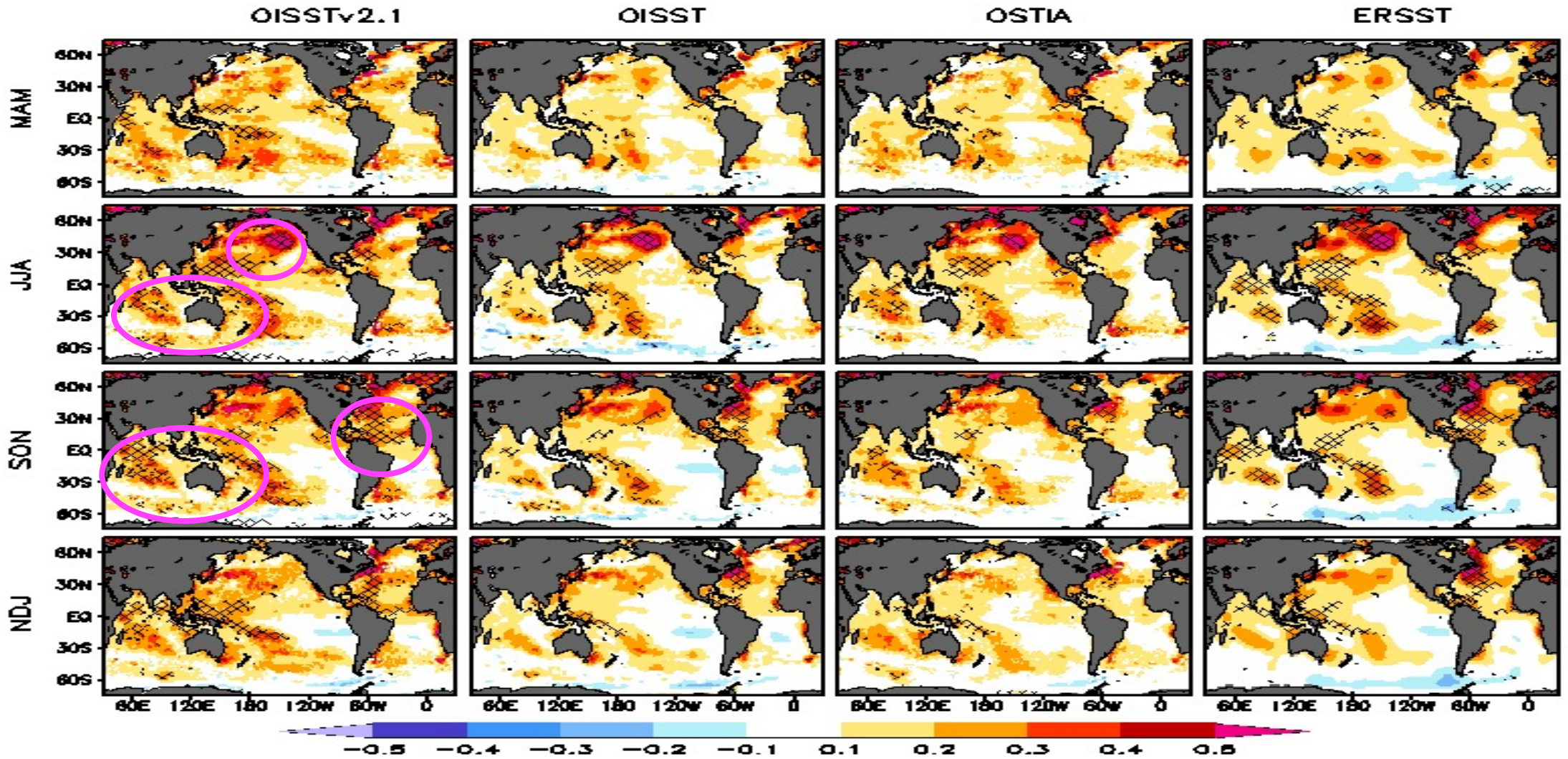
(Products: NCEP OISST, NCEP NSST , MET OFFICE OSTIA , NCEI ERSSTv5 , NCEI OISSTv2.1)

- **SST Indices**
  - NINO34: last 30 days Last 13 weekly Weekly data since 2015 Weekly data since 1990 Last 13 months Monthly data since 1990
  - GLOBAL: last 30 days Last 13 weekly Weekly data since 2015 Weekly data since 1990 Last 13 months Monthly data since 1990 Monthly data since 1982 Monthly data RMS compared with NSST
- **Spatial Maps**
  - Daily SST: GLOBAL Total SST GLOBAL Anomaly North Polar South Polar
  - Weekly SST:
    - GLOBAL Total SST GLOBAL Anomaly North Polar South Polar
    - Tropical Pacific Anomaly Tropical Atlantic Anomaly Tropical Indian Anomaly North Pacific Anomaly North Atlantic Anomaly
  - Monthly SST:
    - GLOBAL Total SST GLOBAL Anomaly North Polar South Polar
    - Tropical Pacific Anomaly Tropical Atlantic Anomaly Tropical Indian Anomaly North Pacific Anomaly North Atlantic Anomaly

(Comments/Suggestions? Send to: Caihong Wen)

https://origin.cpc.ncep.noaa.gov/products/GODAS/multiSST_body.html

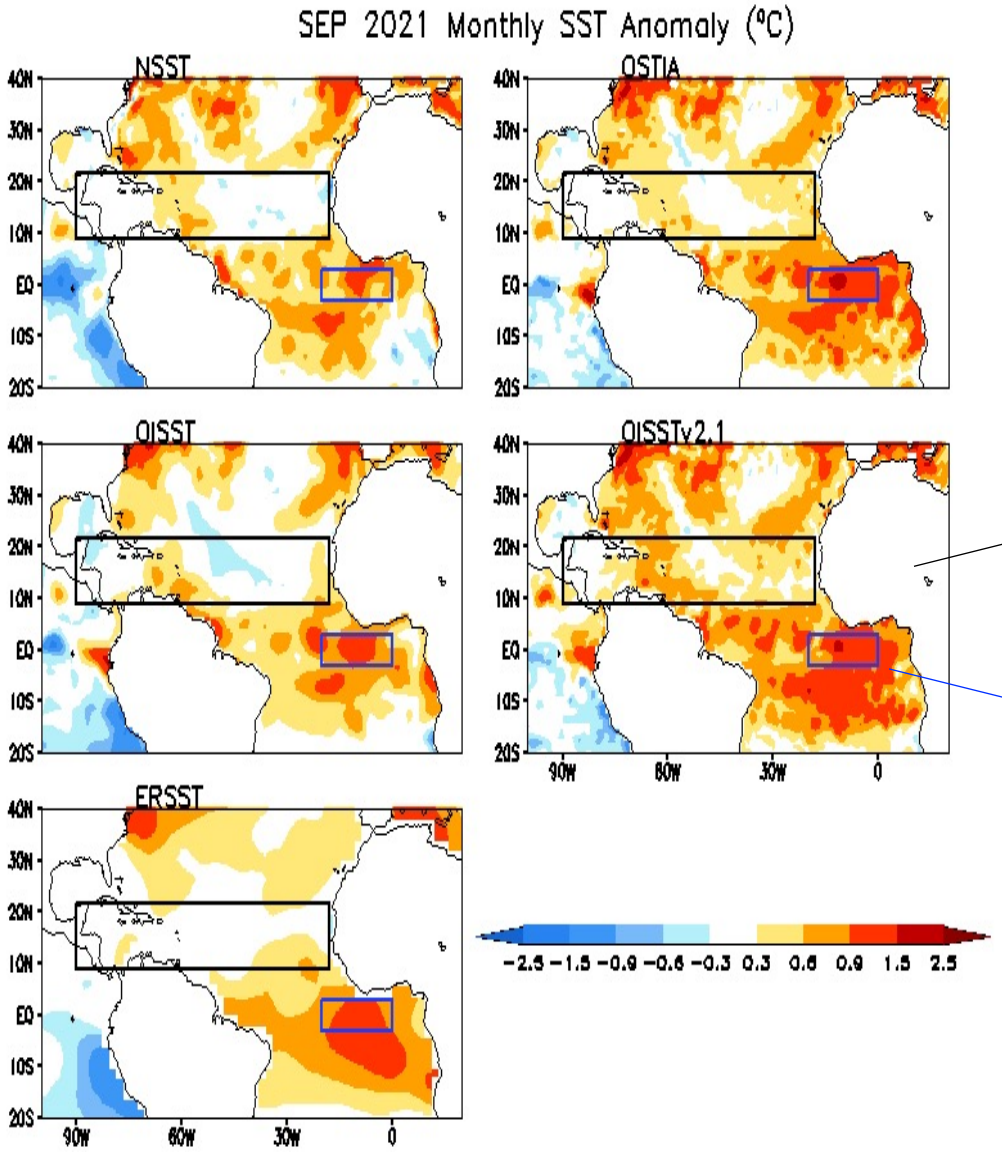
Seasonal Climatology Differences : 1991-2020 minus 1981-2010

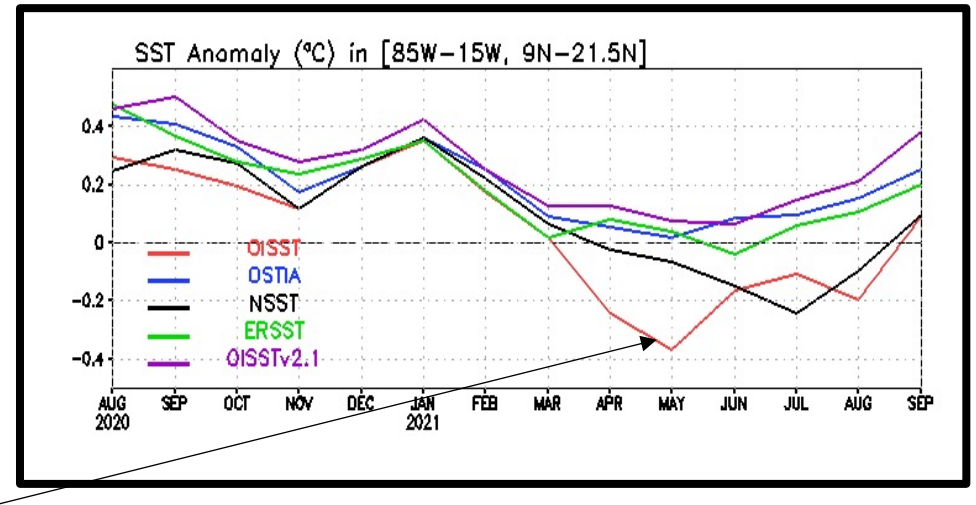


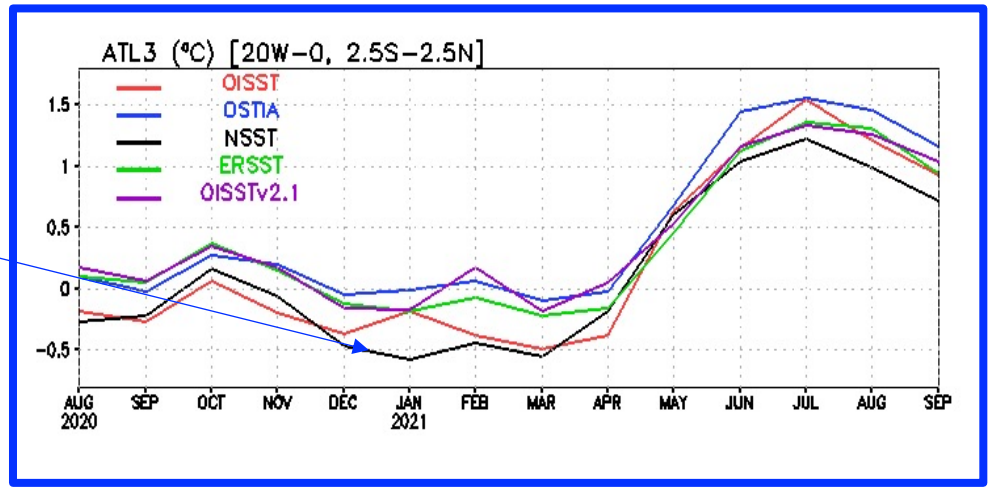
(Hatched areas are significant at 95% statistical significance level)

New climatology is significantly warmer than the old one near the Indo-Pacific , northeastern Pacific, and north Atlantic oceans during summer-fall seasons.

Comparison of monthly mean SST data sets: Tropical Atlantic Ocean

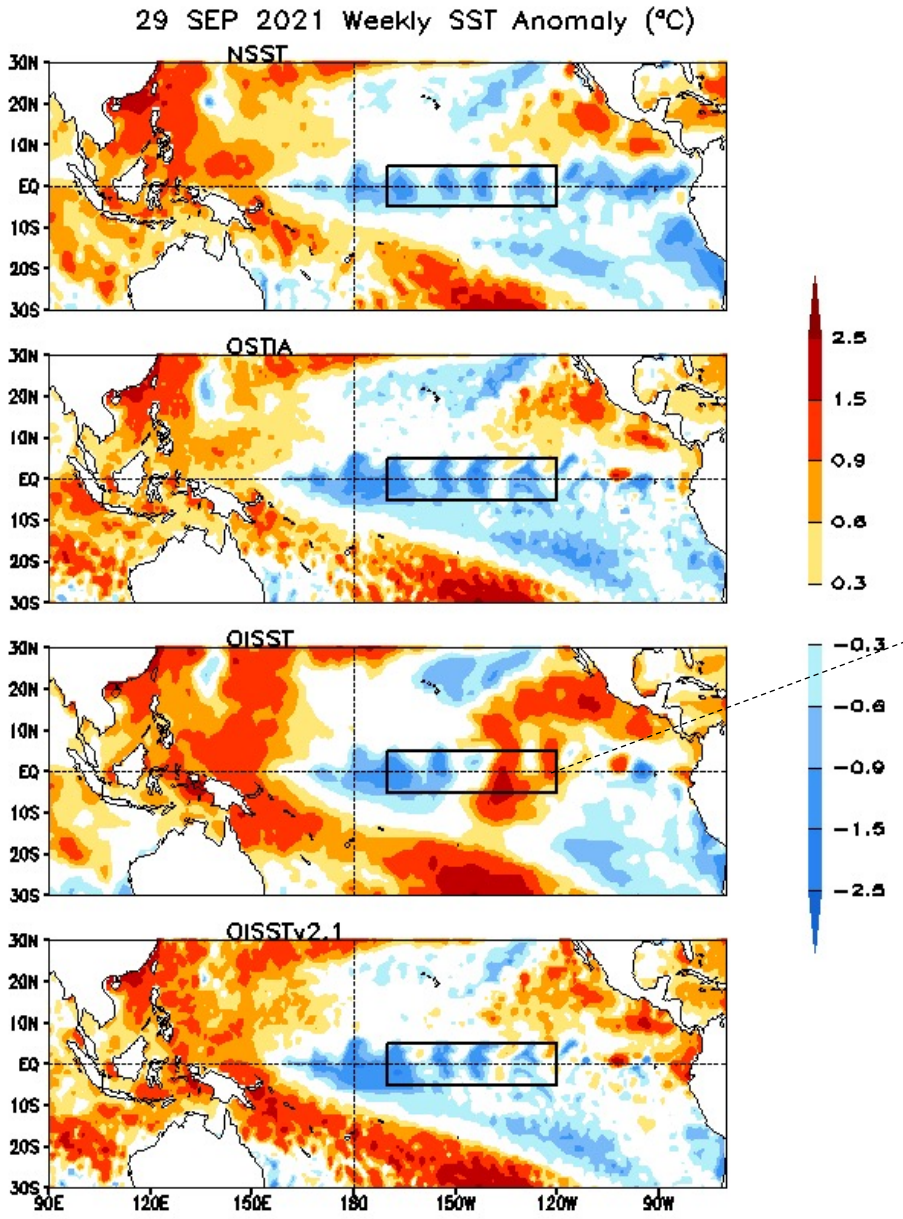


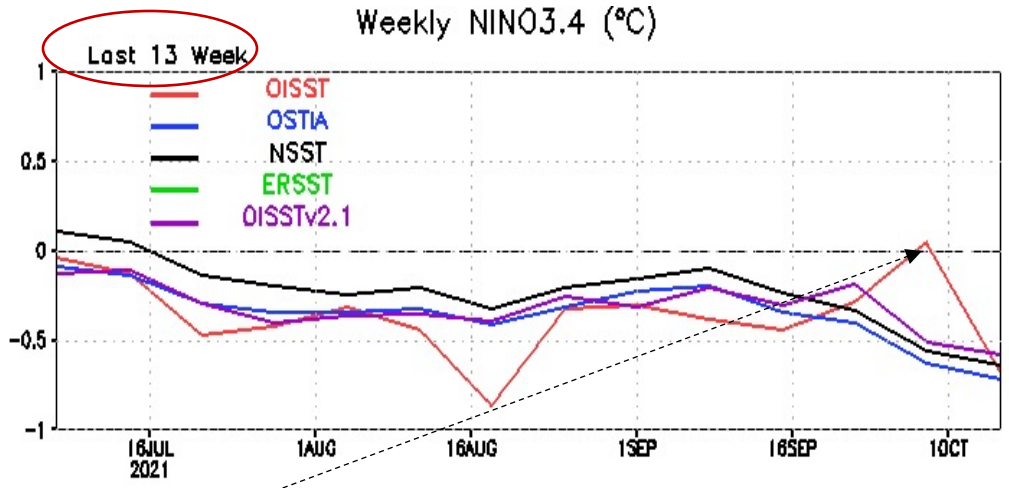


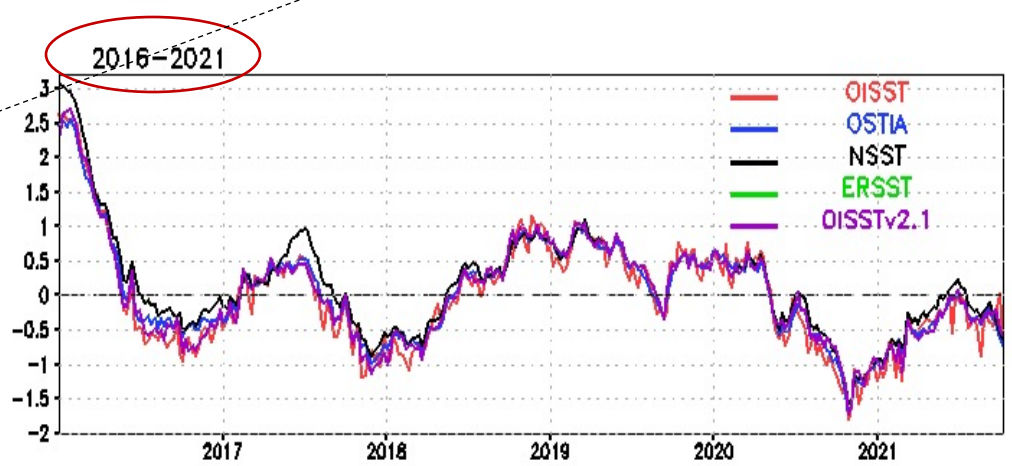


Uncertainty among SST data sets varies with time and locations

Comparison of weekly SST data sets: Tropical Pacific Ocean

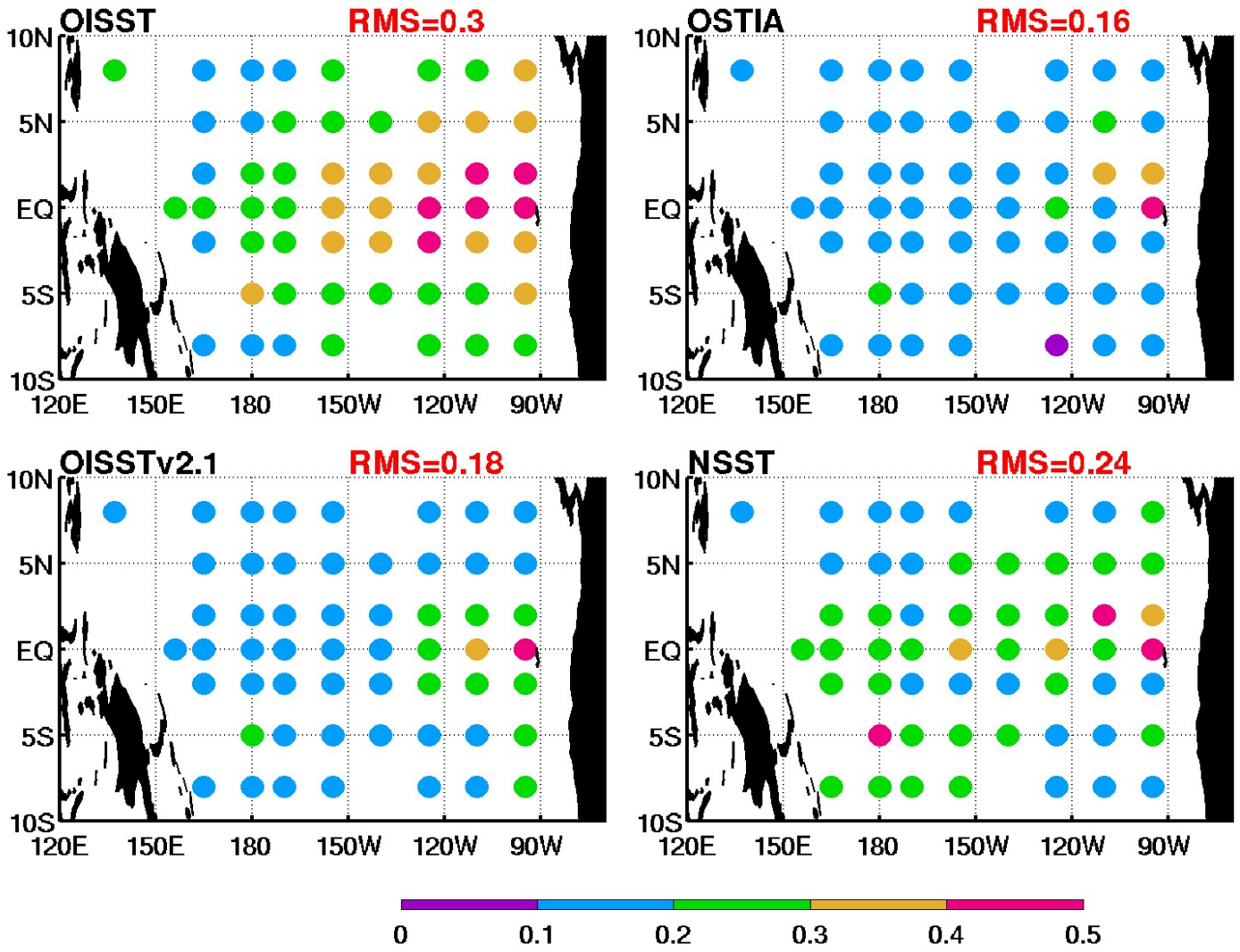






- NCEP OISST exhibits pronounced fluctuations since 2016.

Root-mean-square error (RMS,℃) of weekly SST against TAO buoys

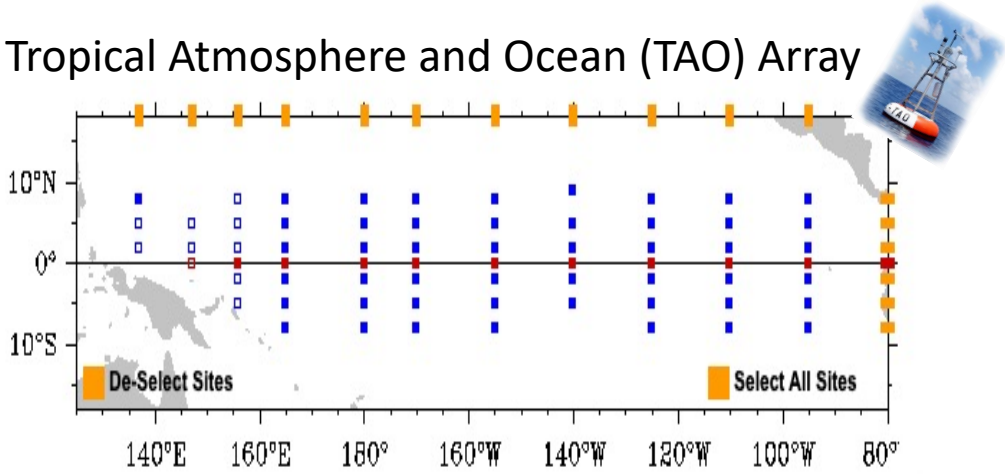


Analysis period : Jan,2016 – Sep, 2021

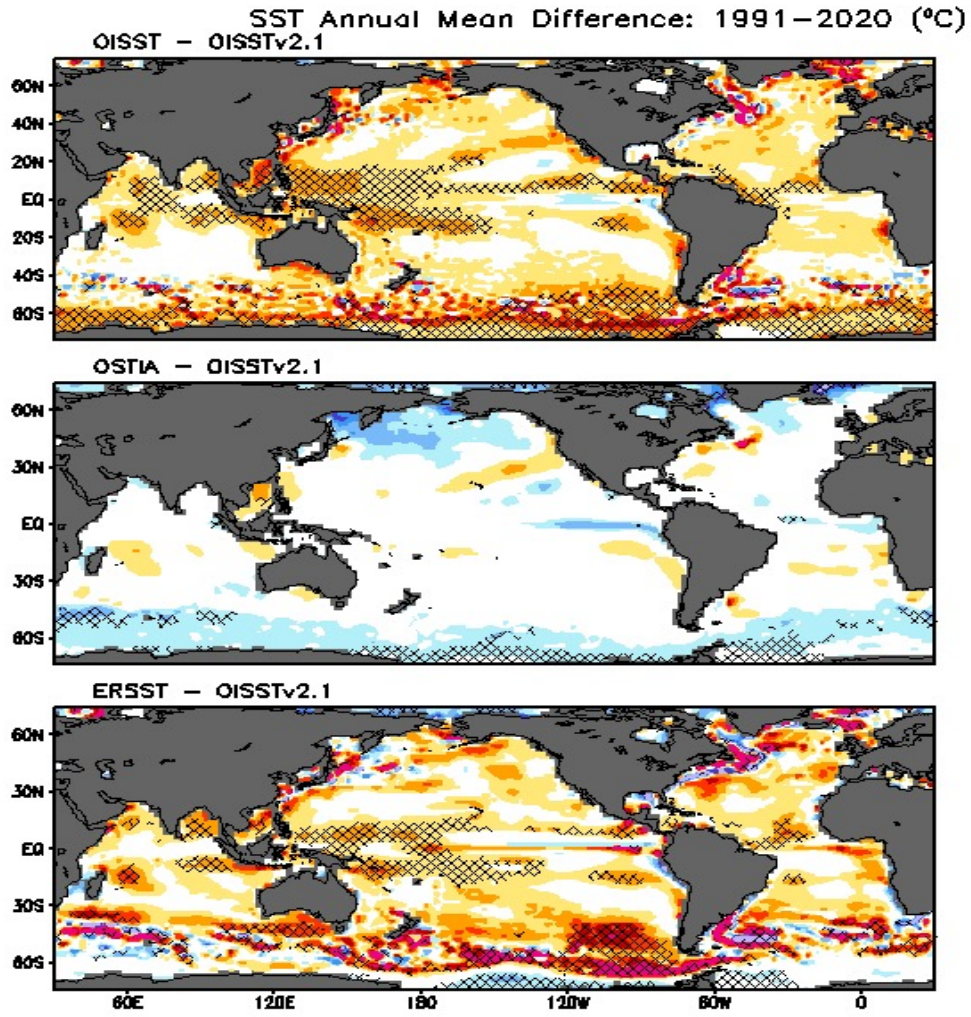
Red number: area RMS average

- NCEP OISST has largest analysis errors.
- OSTIA and OISSTv2.1 are closer to TAO buoys.
- CPC ENSO products are now using NCEI OISSTv2.1 since Oct.11, 2021.

Tropical Atmosphere and Ocean (TAO) Array



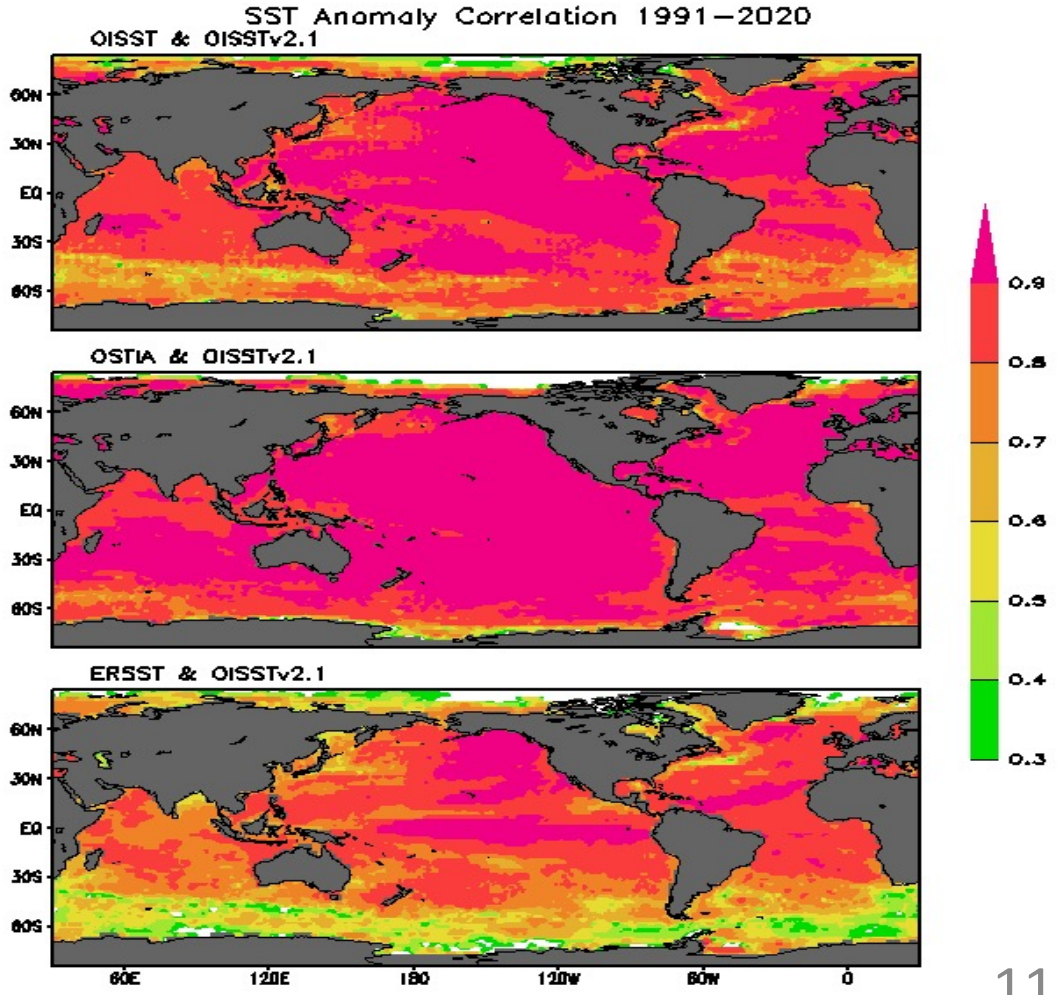
Uncertainty/consistency among SST analyses (Benchmark : OISSTv2.1)



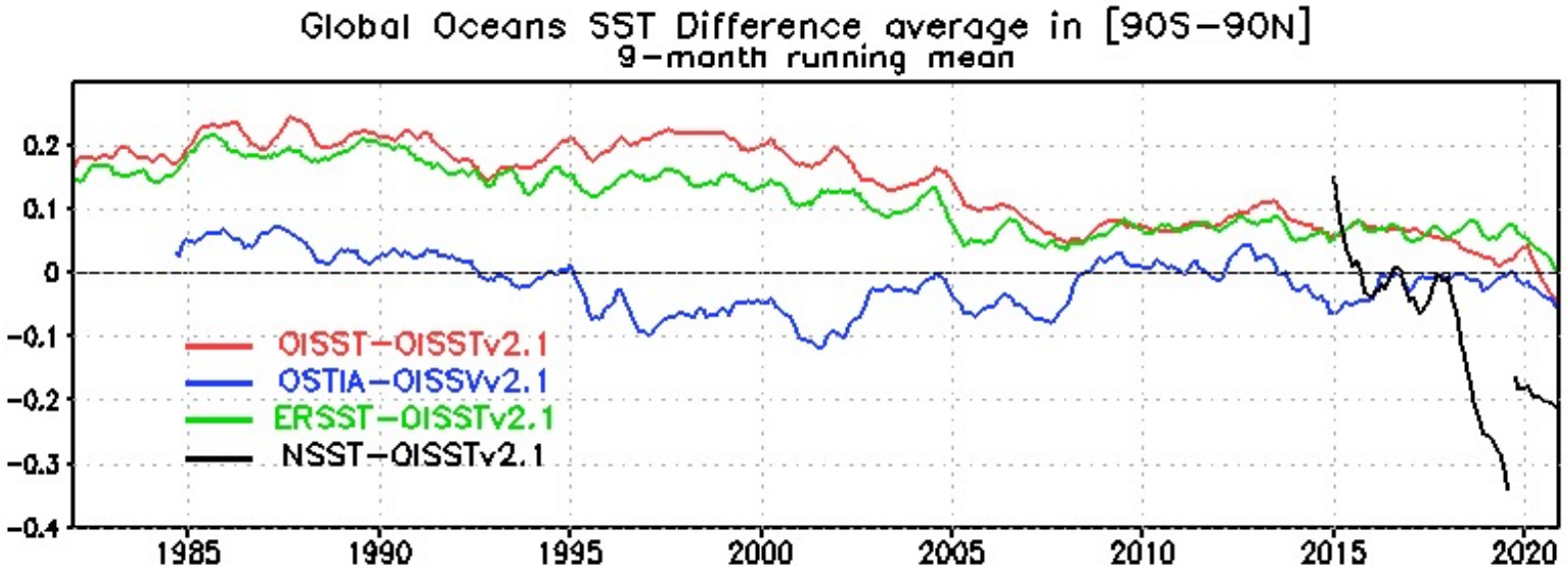
(Hatched areas are significant at 95% statistical significance level)

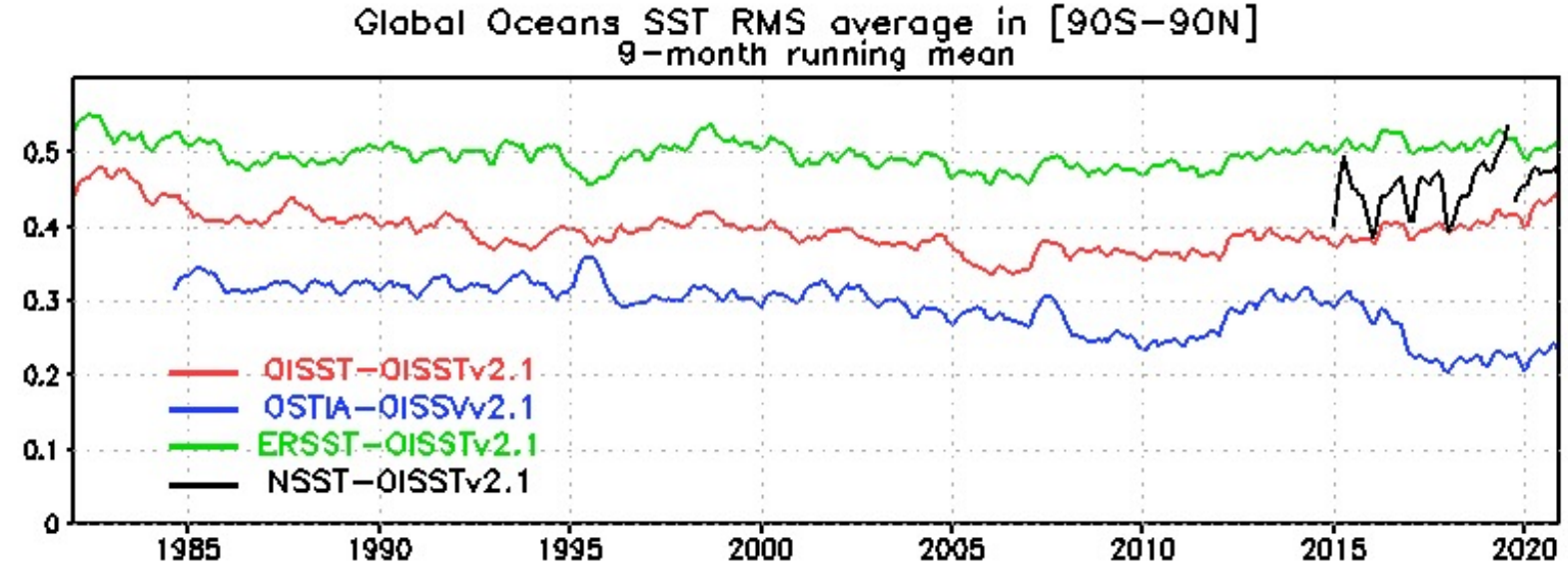
Both NCEP OISST and ERSST are significantly warmer than OISSTv2.1 near the ITCZ and high-latitude of southern hemisphere.

OSTIA has very high correlation (>0.9) with OISSTv2.1 in most of regions.



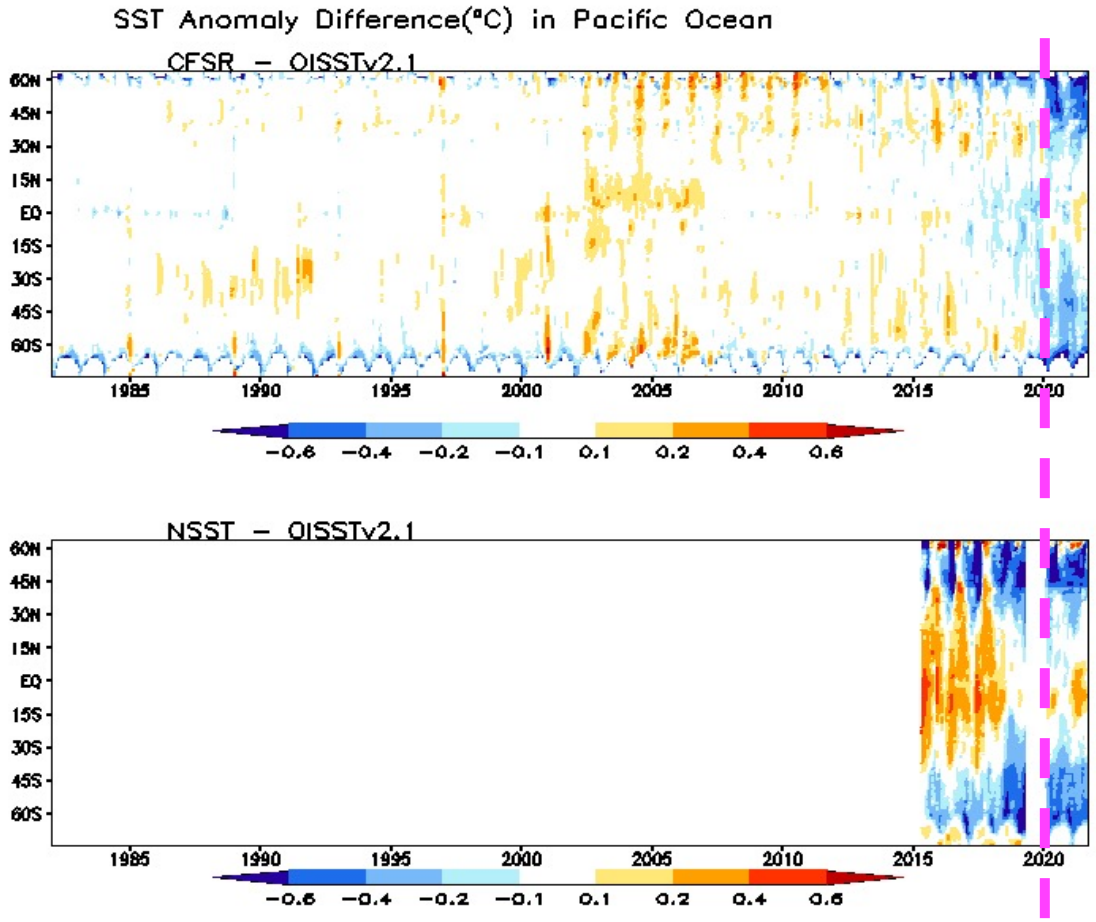
Uncertainty/consistency among SST analyses (Benchmark : OISSTv2.1)

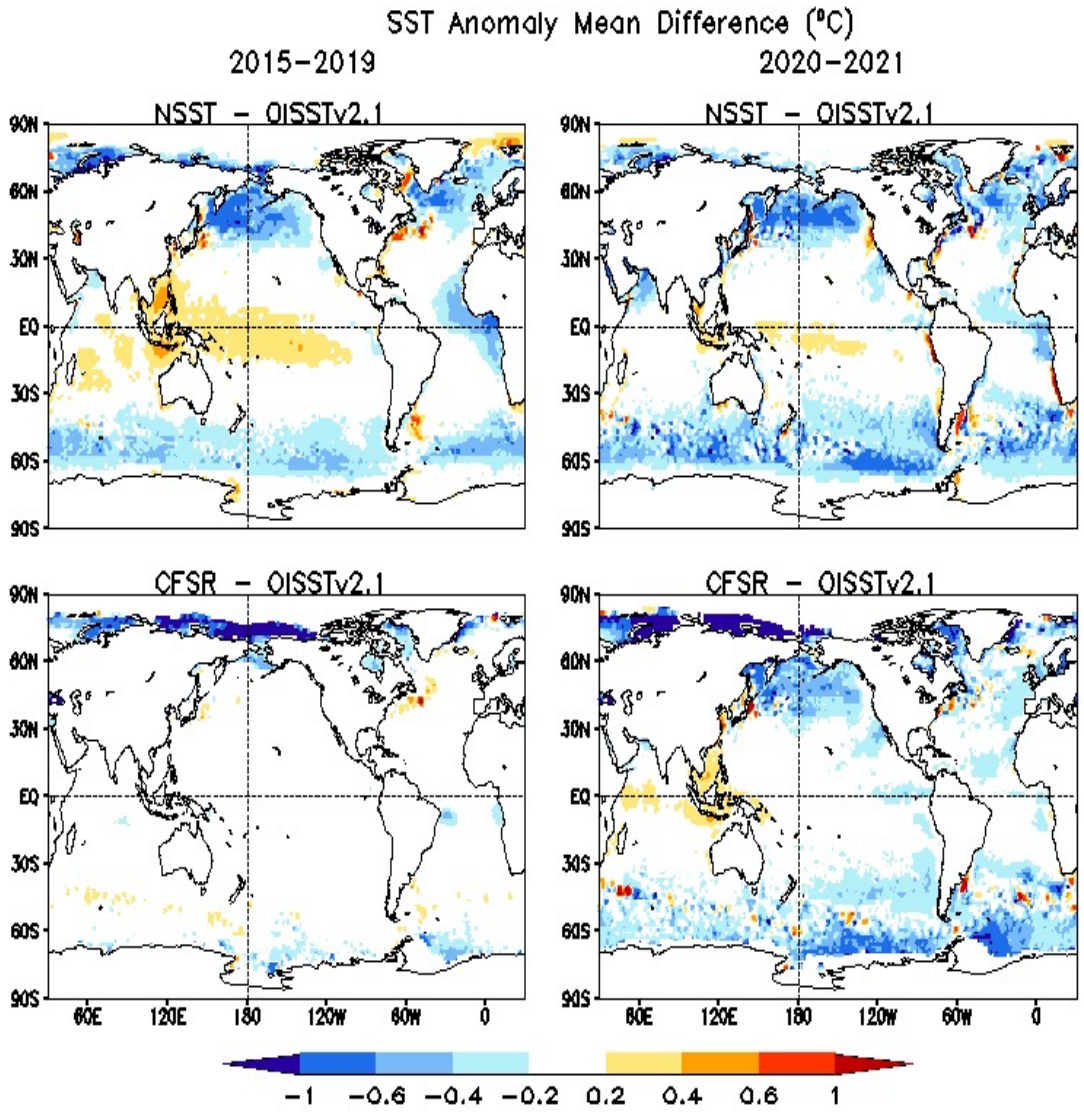




- OSTIA resemble more closely to OISSTv2.1 in recent years.
- NSST is colder than other SST products.

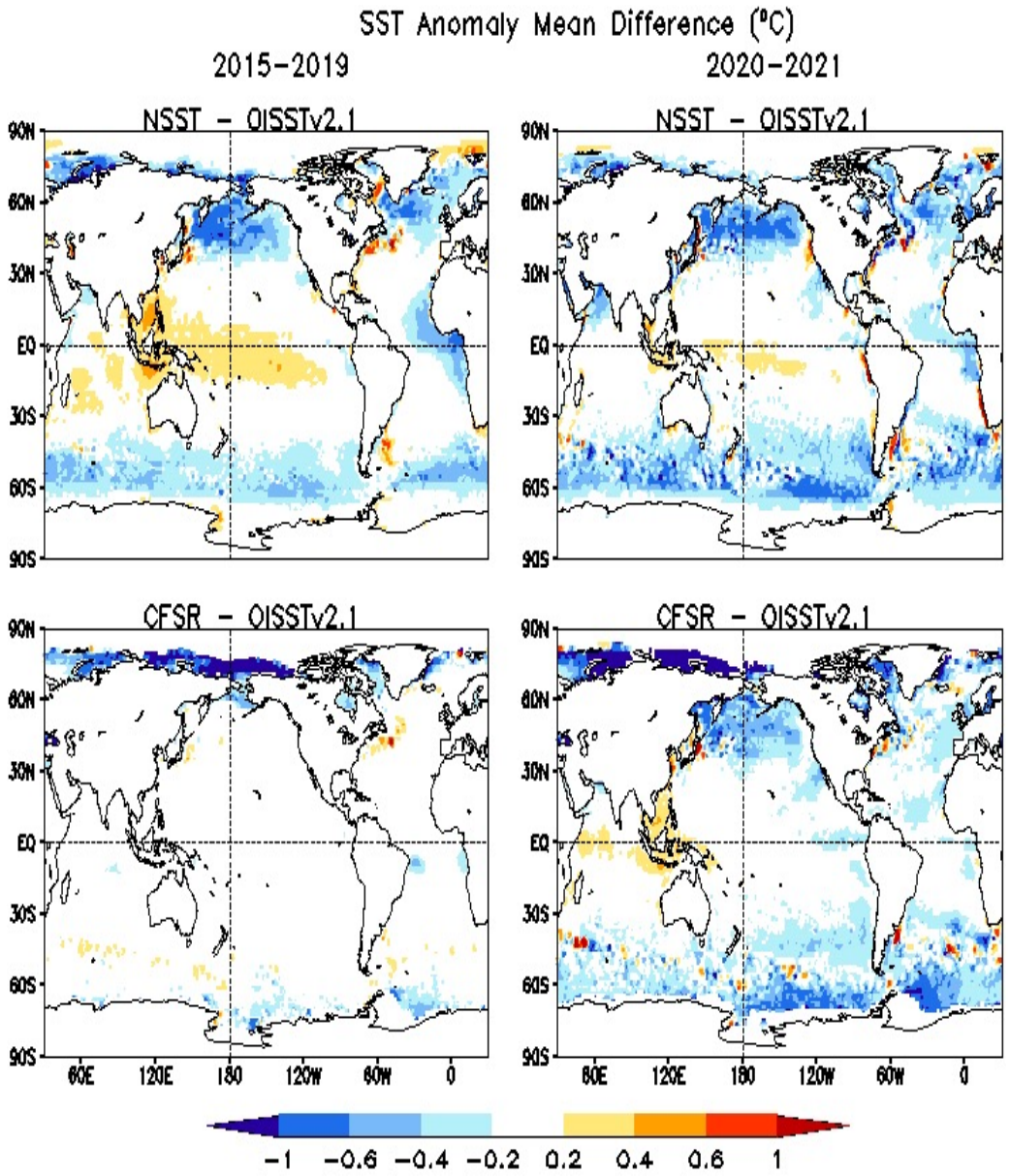
Impact of replacing OISSTv2 by NSST on CFSR





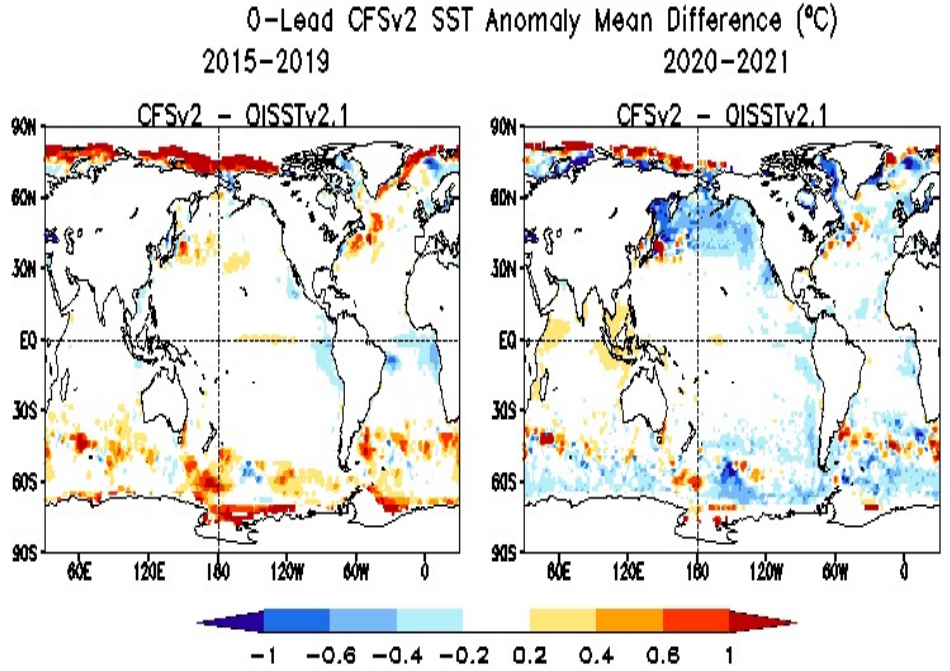
CFSR has systematic cold bias in mid-to-high latitude since 2020, consistent with the timing of OISSTv2 replacement by NSST.

Potential Impact of NSST bias on 0-lead CFSv2 forecast



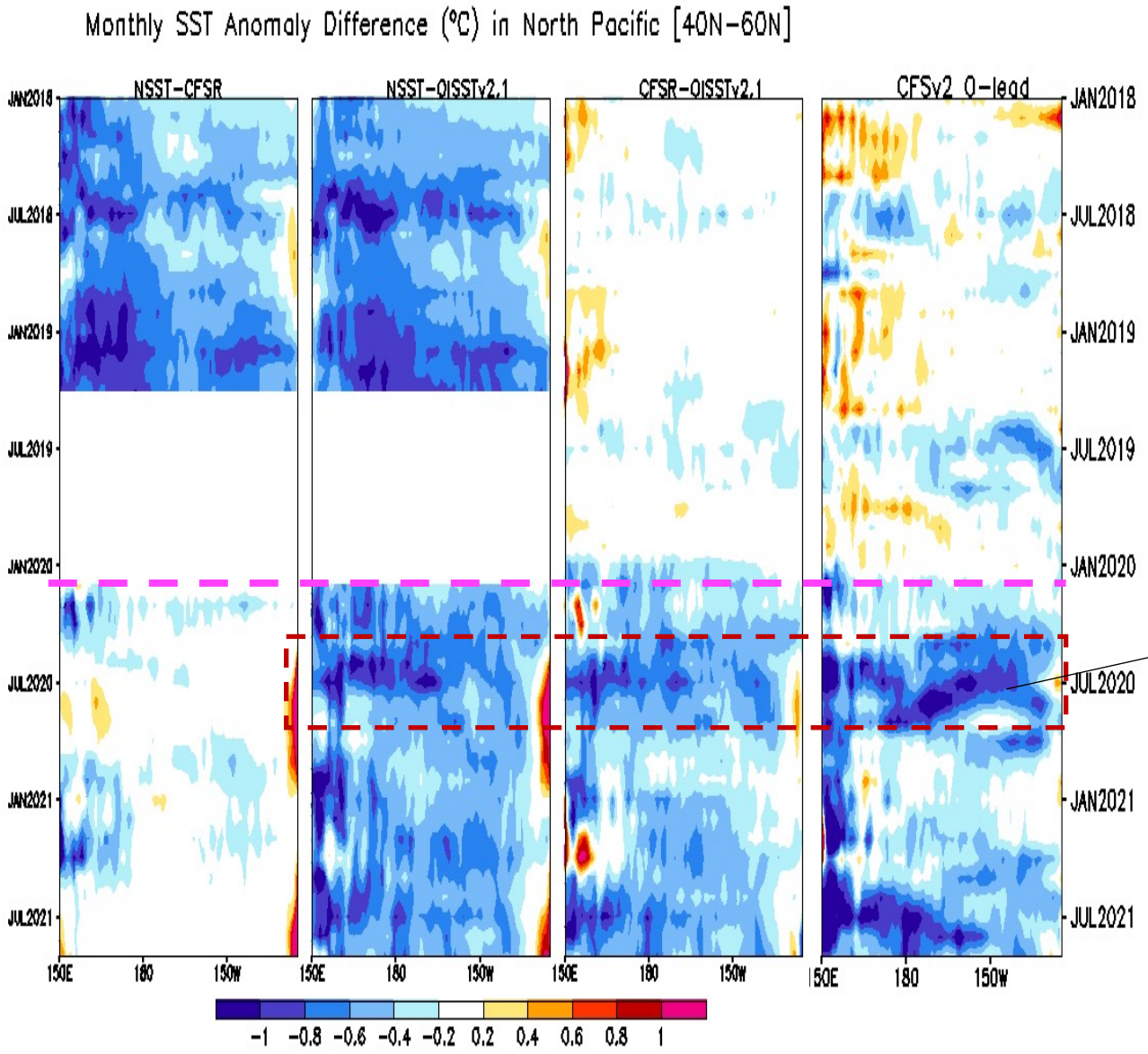
Boundary forcing bias

CFSR

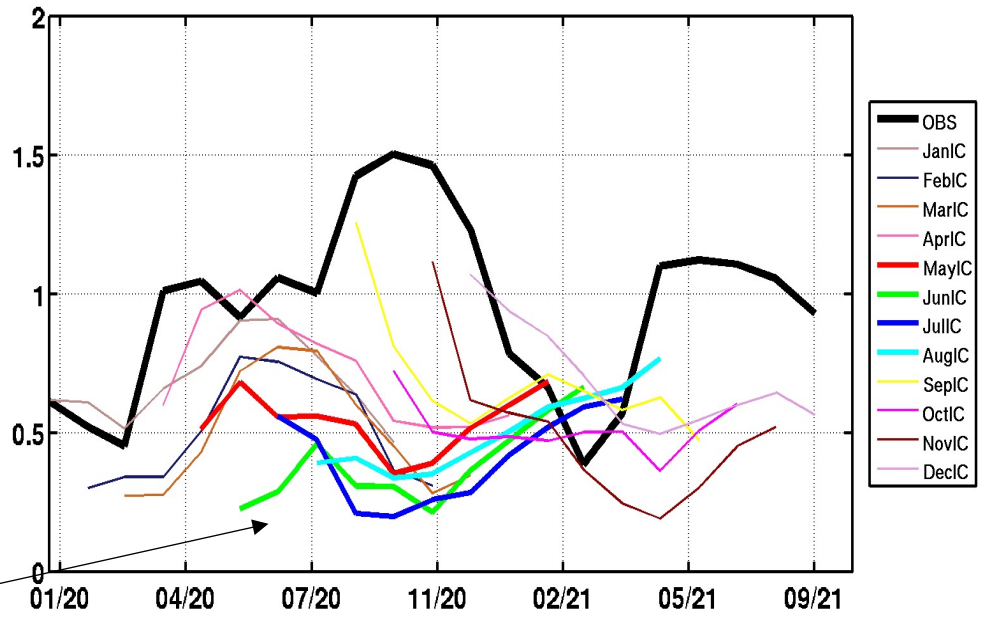


Oceanic IC bias

Potential Impact of NSST bias on CFSv2 forecast : North Pacific



Pacific "Blob" region [150W-125W, 35N-50N]

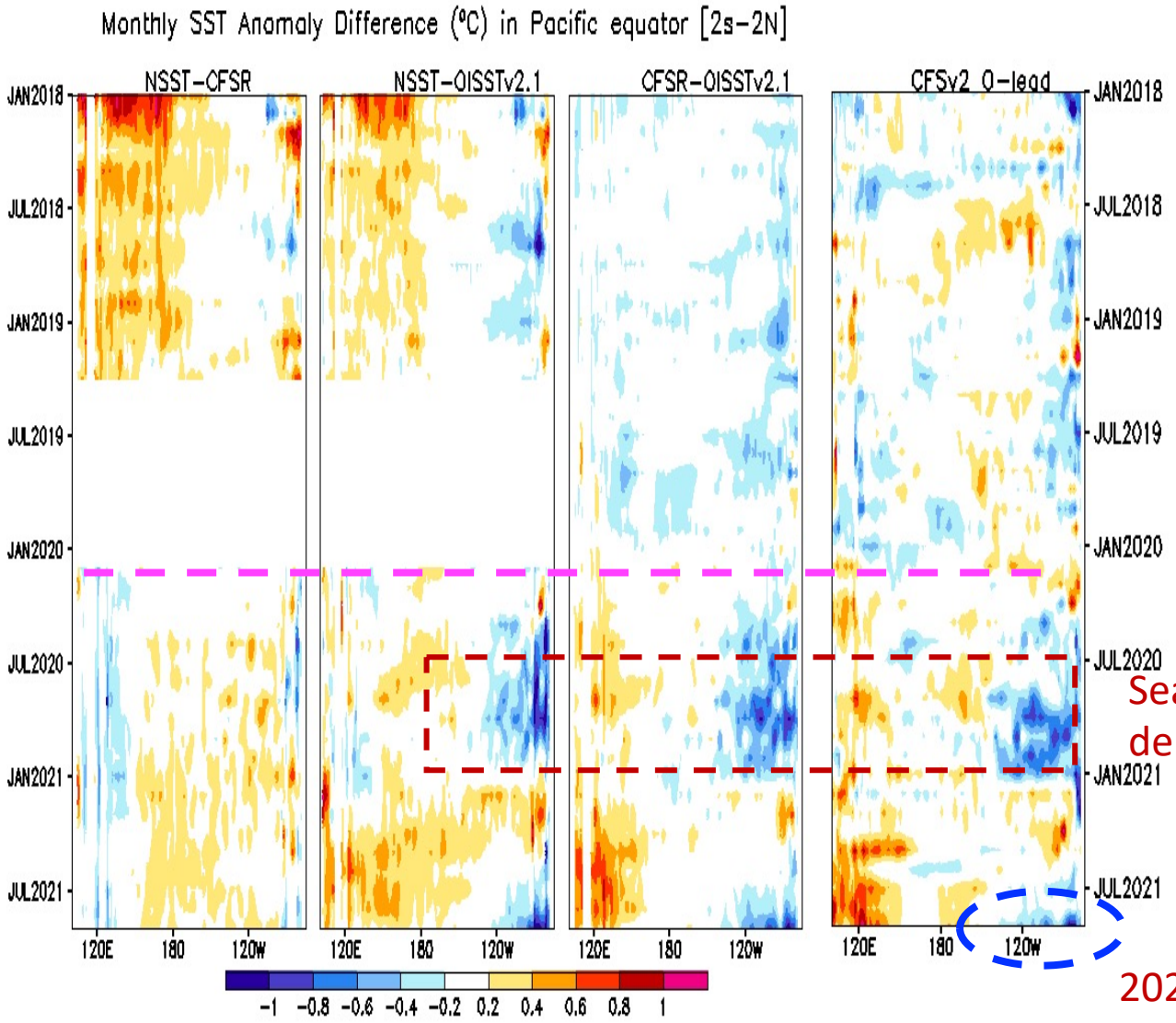


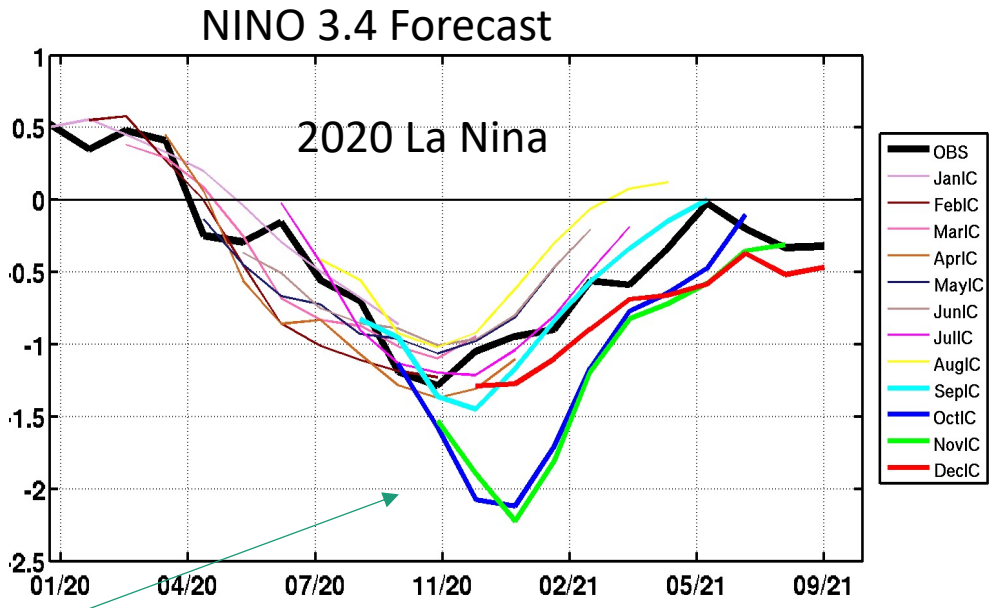
Seasonal dependency

Large cold CFSR SST bias in 2020 summer contribute to failure of warm event prediction in fall season.

Bias pathway : NSST ⇨ CFSR ⇨ CFSv2

Potential Impact of NSST bias on CFSv2 forecast : ENSO





Seasonal dependency

2021 La Nina?

Large cold CFSR SST bias in the eastern Pacific during Sep- Oct 2020 is consistent with overshooting La Nina forecast initiated with Oct., Nov. condition.

Bias pathway : NSST ⇨ CFSR ⇨ CFSv2

Summaries:

- SST are significantly warmer in the Indo-Pacific, northeastern Pacific and north Atlantic regions during 1991-2020 than those in 1981-2010.

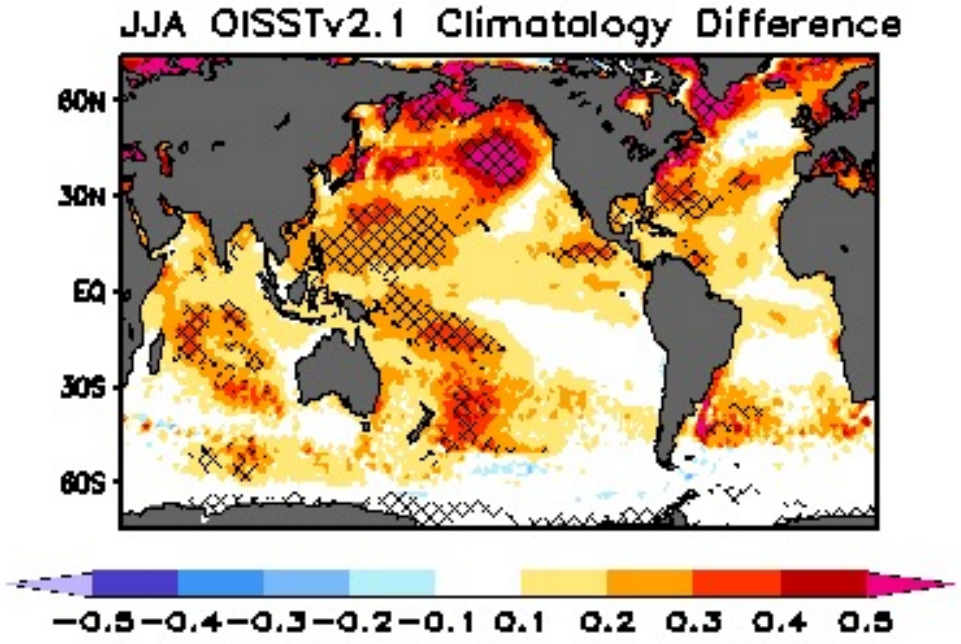
- Uncertainty among SST data sets varies with time and locations. OSTIA and OISSTv2.1 are consistent with each other and have the smaller analysis error in the tropical Pacific. ERSST and NCEP OISST are significantly warmer than OISSTv2.1/OSTIA near ITCZ and the high-latitudes of southern hemisphere.

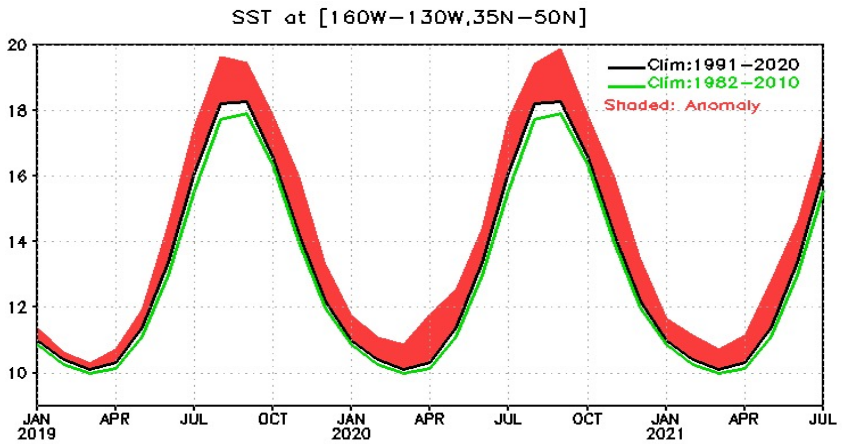
- NSST is much colder than other SST products in the high latitudes. The replacement of NSST as SST nudging analysis gives rise to the systematic cold bias in CFSR since 2020.

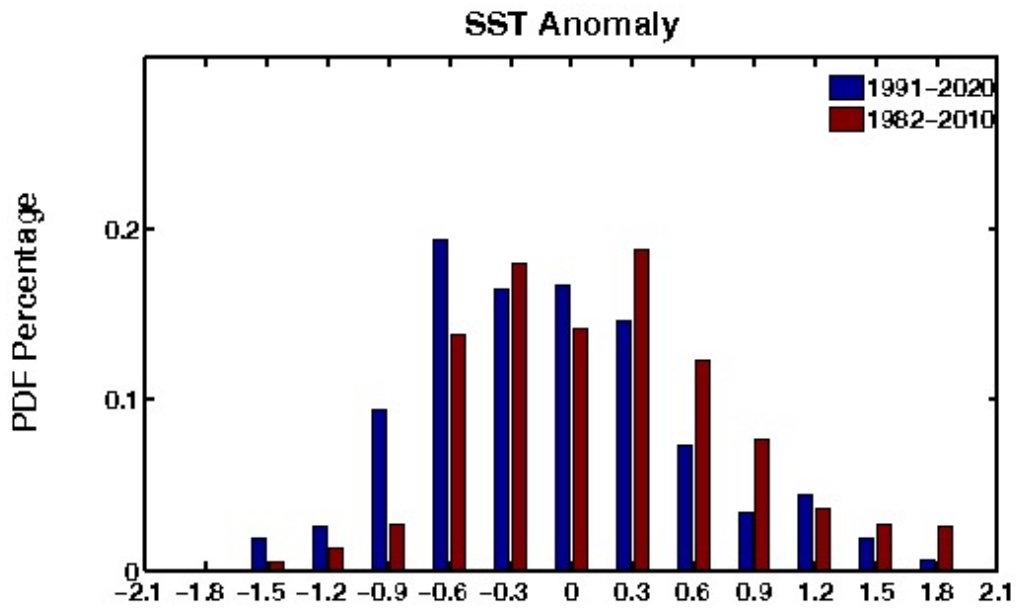
- Bias pattern in 0-lead CFSv2 forecasts resembles closely with that in CFSR. We need to be cautious when interpreting CFSv2 forecasts at regions where large NSST bias are identified.

Back up slides

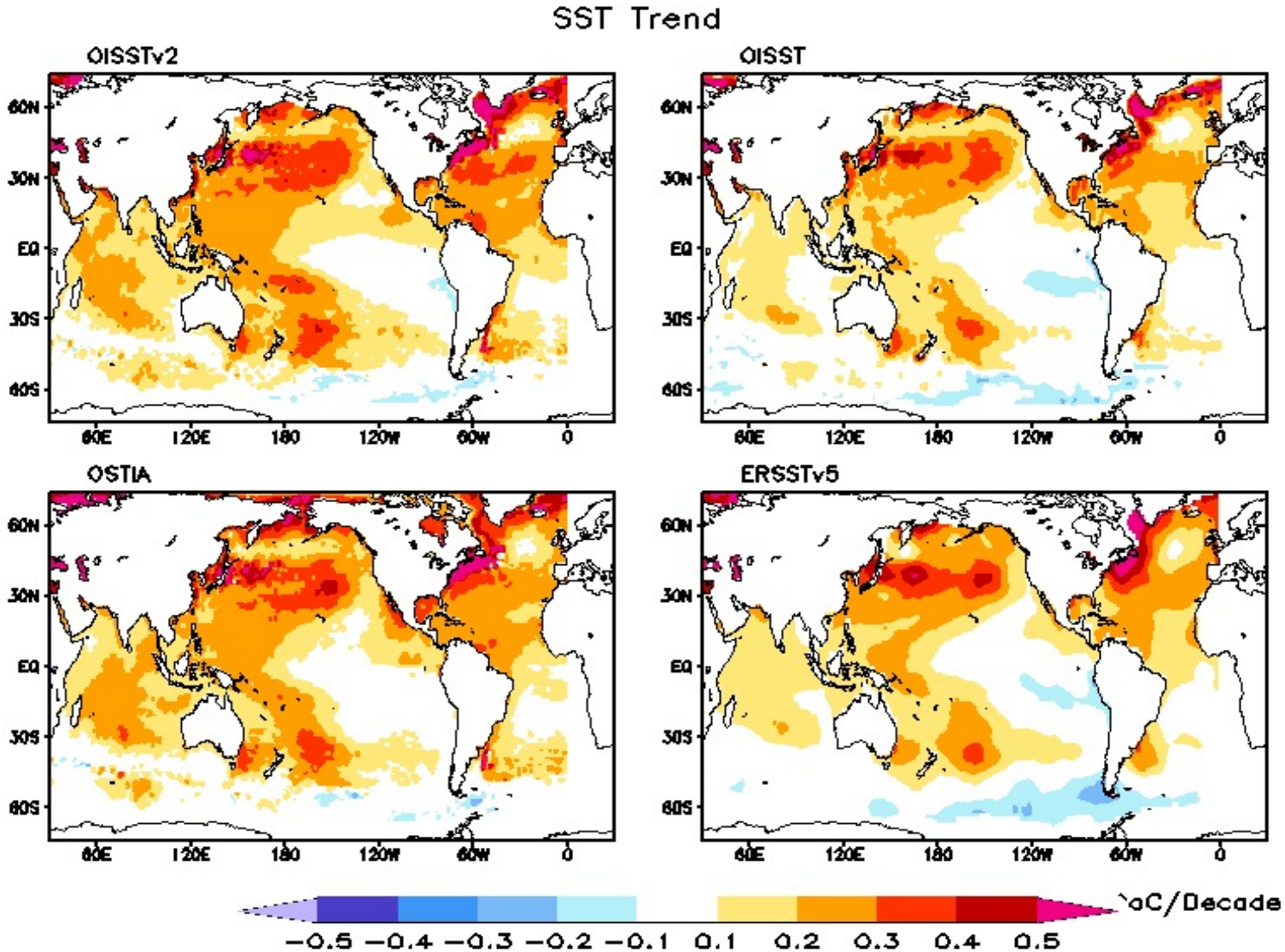
OISST seasonal Difference

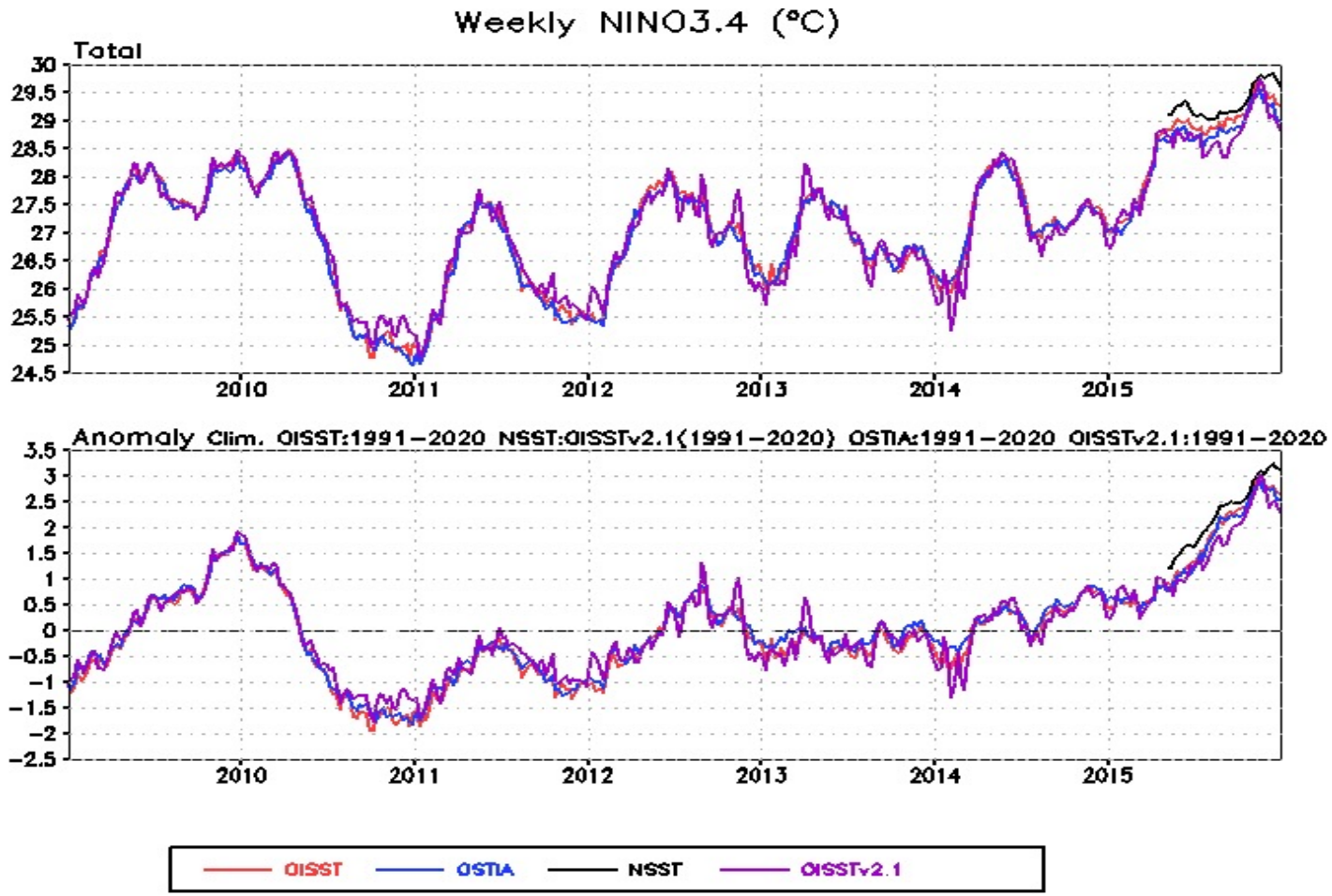


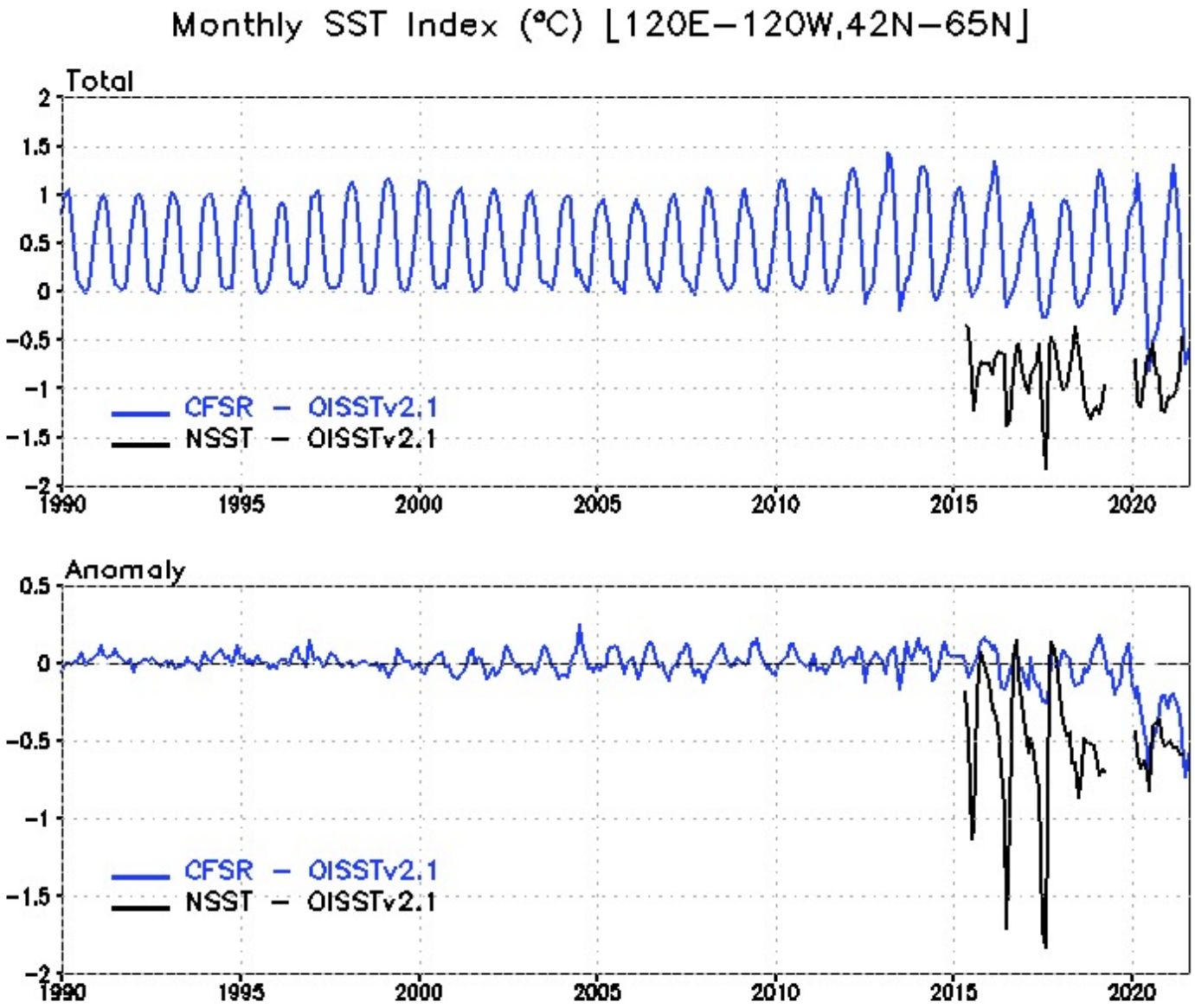


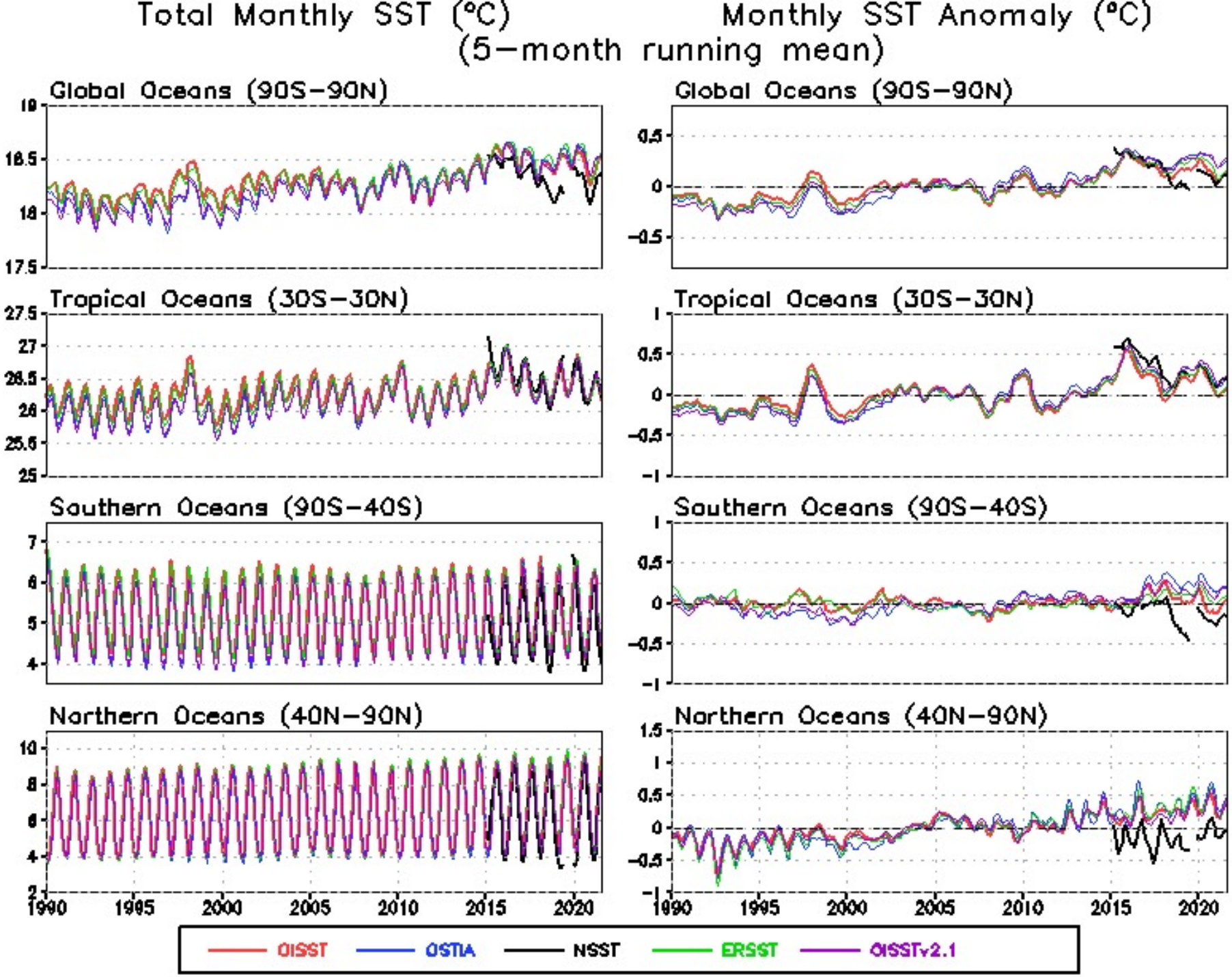


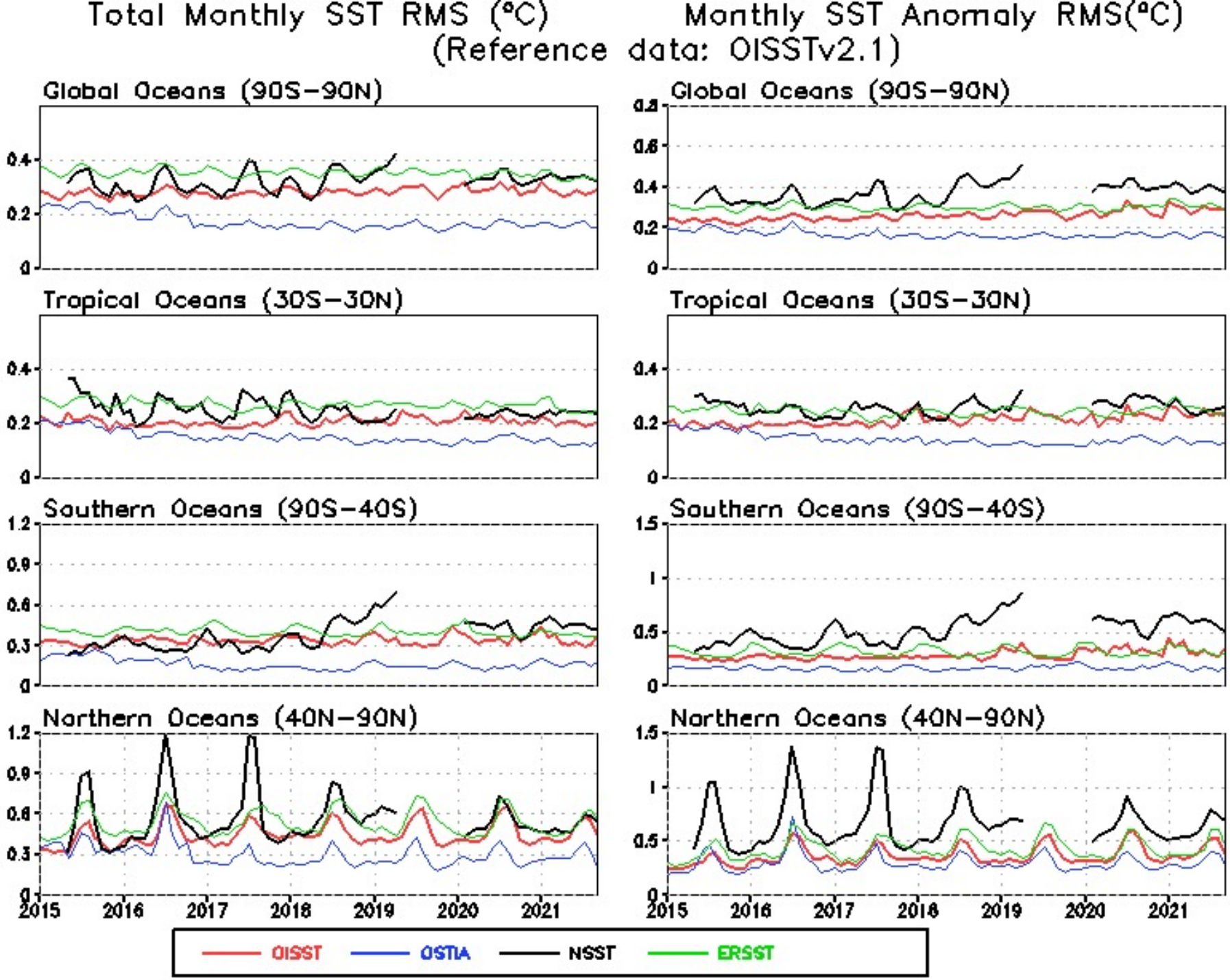
Trend


SST Trend
OISSTv2
OISST
OSTIA
ERSSTv5
60N
30N
EQ
30S
60S
60E
120E
180
120W
60W
0
°C/Decade
−0.5 −0.4 −0.3 −0.2 −0.1 0.1 0.2 0.3 0.4 0.5

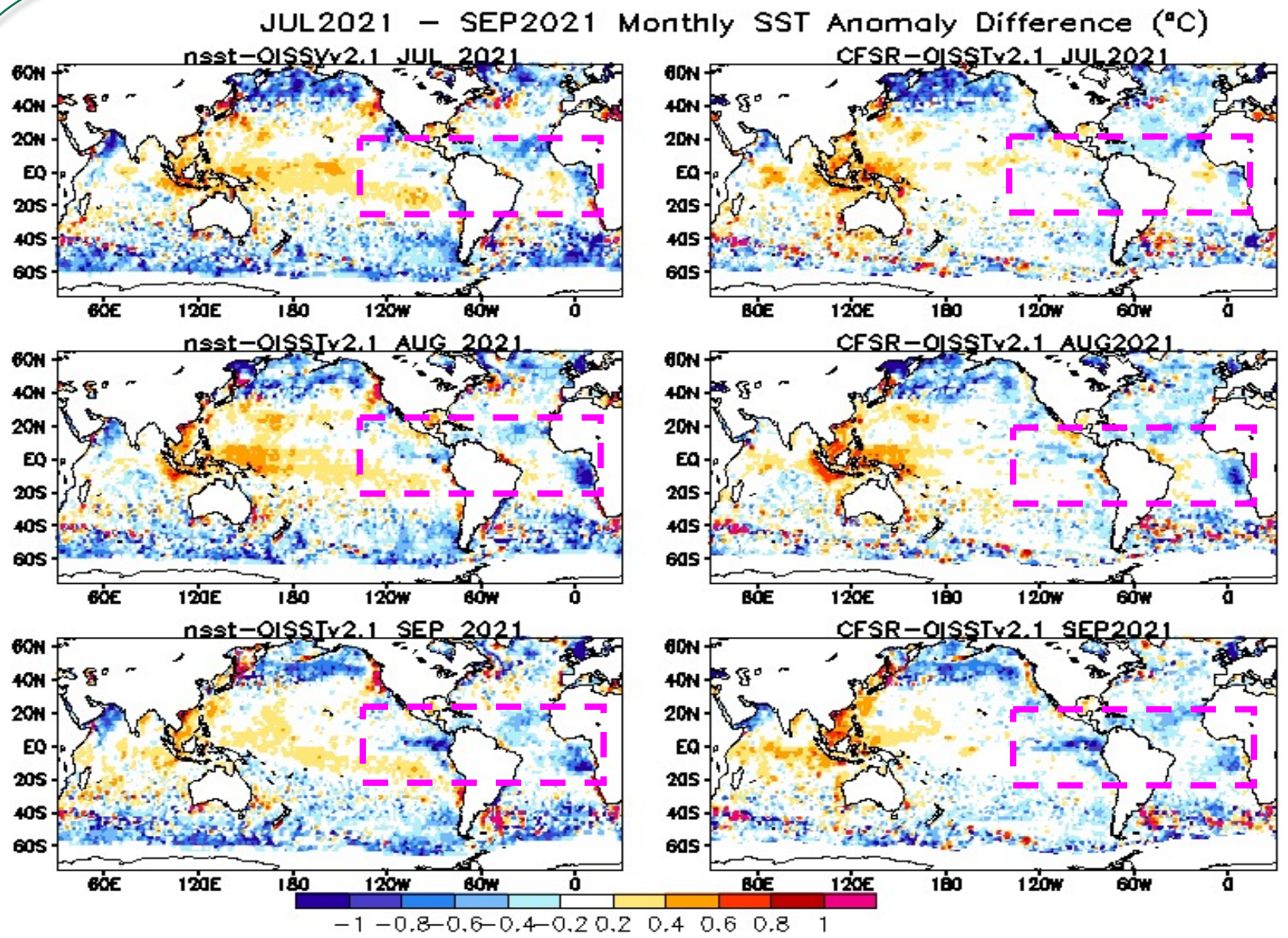

Weekly NINO3.4 (°C)
Total
30
29.5
29
28.5
28
27.5
27
26.5
26
25.5
25
24.5
2010
2011
2012
2013
2014
2015
Anomaly Clim. OISST:1991–2020 NSST:OISSTv2.1(1991–2020) OSTIA:1991–2020 OISSTv2.1:1991–2020
3.5
3
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
2010
2011
2012
2013
2014
2015
OISST
OSTIA
NSST
OISSTv2.1


Monthly SST Index (°C) [120E–120W,42N–65N]
Total
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
1990
1995
2000
2005
2010
2015
2020
CFSR – OISSTv2.1
NSST – OISSTv2.1
Anomaly
0.5
0
−0.5
−1
−1.5
−2
1990
1995
2000
2005
2010
2015
2020
CFSR – OISSTv2.1
NSST – OISSTv2.1


Total Monthly SST (°C)
(5-month running mean)
Monthly SST Anomaly (°C)
Global Oceans (90S-90N)
Global Oceans (90S-90N)
Tropical Oceans (30S-30N)
Tropical Oceans (30S-30N)
Southern Oceans (90S-40S)
Southern Oceans (90S-40S)
Northern Oceans (40N-90N)
Northern Oceans (40N-90N)
1990
1995
2000
2005
2010
2015
2020
OISST
OSTIA
NSST
ERSST
OISSTv2.1


Total Monthly SST RMS (°C)
Monthly SST Anomaly RMS(°C)
(Reference data: OISSTv2.1)
Global Oceans (90S–90N)
Tropical Oceans (30S–30N)
Southern Oceans (90S–40S)
Northern Oceans (40N–90N)
2015
2016
2017
2018
2019
2020
2021
OISST
OSTIA
NSST
ERSST

Potential Impact of NSST bias on CFSv2 Predictions



Bias pathway : NSST ⟶ CFSR ⟶ CFSv2