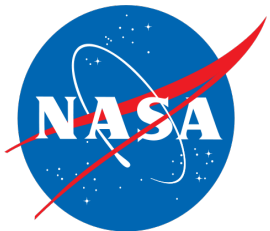# Edition 4.2 EBAF: Surface

Seiji Kato[1], Fred G. Rose[2], Norman G. Loeb[1],

David A. Rutan[2], Seung Hee Ham[2], and Tyler J. Thorsen[1]

[1]NASA Langley Research Center

[2]Science System & Applications Inc.

CERES Science Team Meeting
May 9-11, 2023

Edition 4.2 algorithm change from Edition 4.1

- Only MODIS and VIIRS retrieved cloud properties are used. (i.e. No cloud properties derived from geostationary satellites is used.)

- MERRA-2 provides temperature and humidity profiles and skin temperature. However, MODIS and VIIRS cloud properties are derived using GEOS-5.4.1.

- Climatological adjustment is applied to Terra only (March 2000 through June 2002) and NOAA20 only (April 2022 onward) periods.
  - Climatologically adjusted flux $\hat{F}_x$ for Terra only and NOAA20 only periods is the Terra+Aqua climatological mean flux + anomalies derived from Terra or NOAA20.

$$\hat{F}_x^t = \bar{F}_x^{ta} + \Delta F_x^t \quad \text{and} \quad \hat{F}_x^{n20} = \bar{F}_x^{ta} + \Delta F_x^{n20}$$
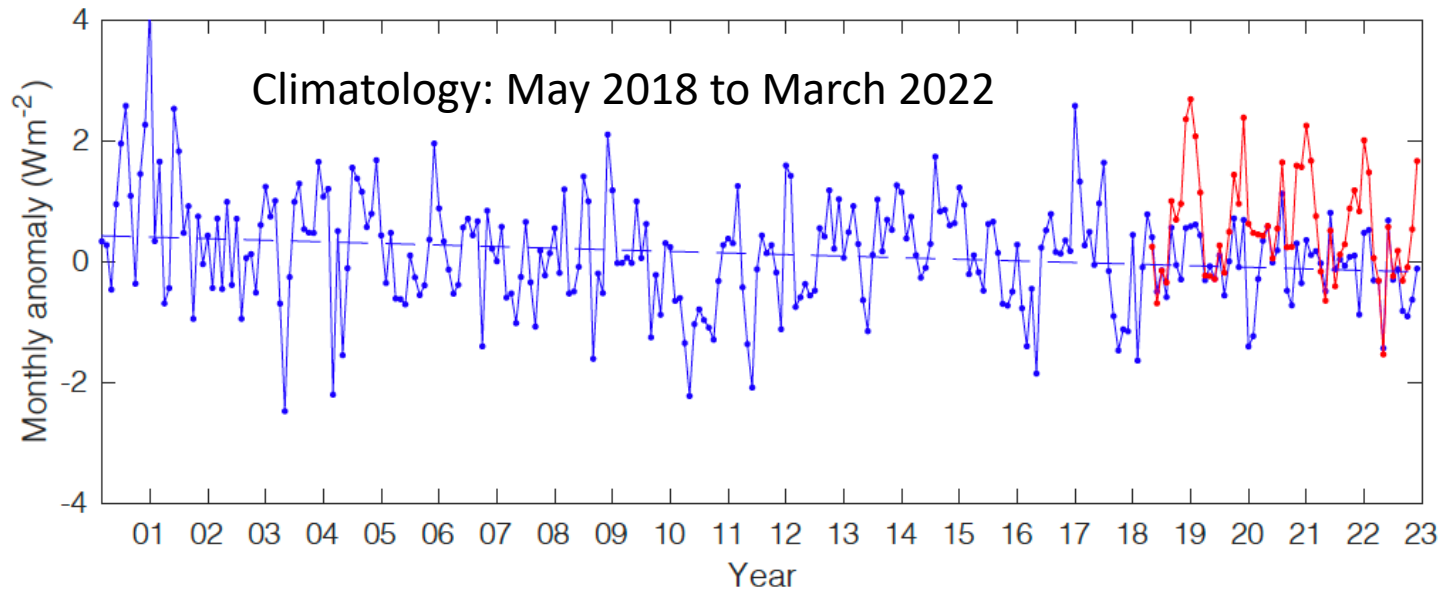
Global monthly mean all-sky surface downward shortwave irradiance
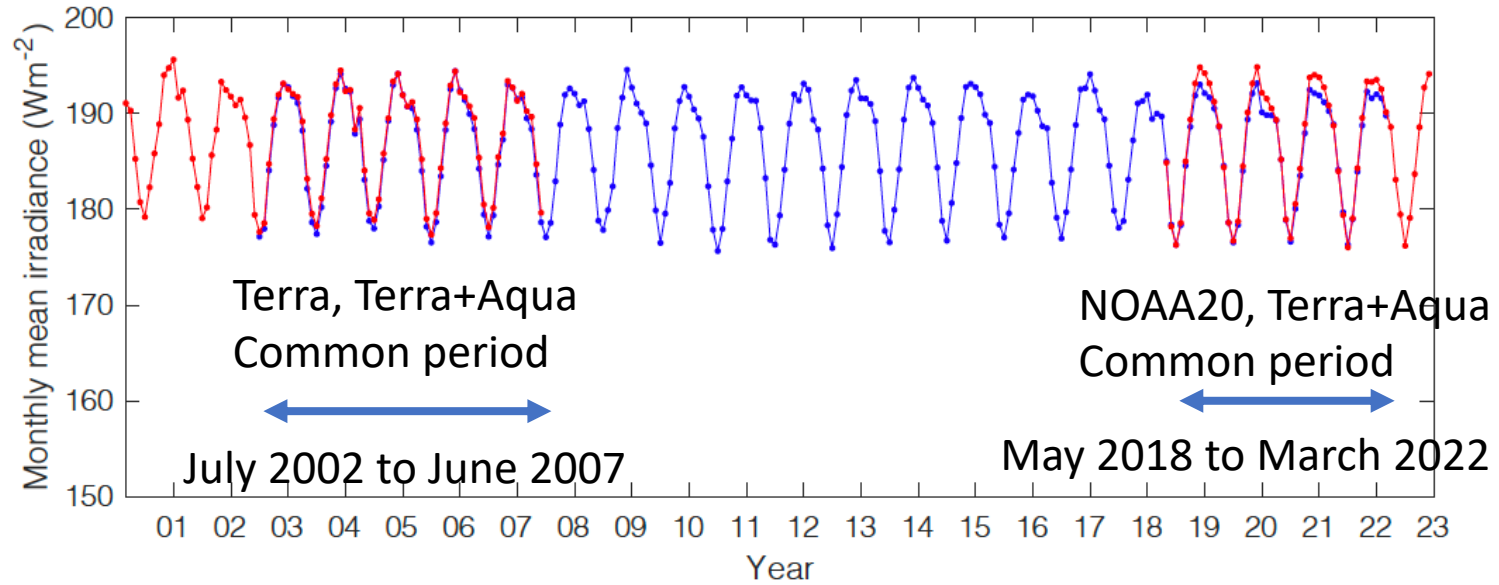
Red:
No climatological adjustment

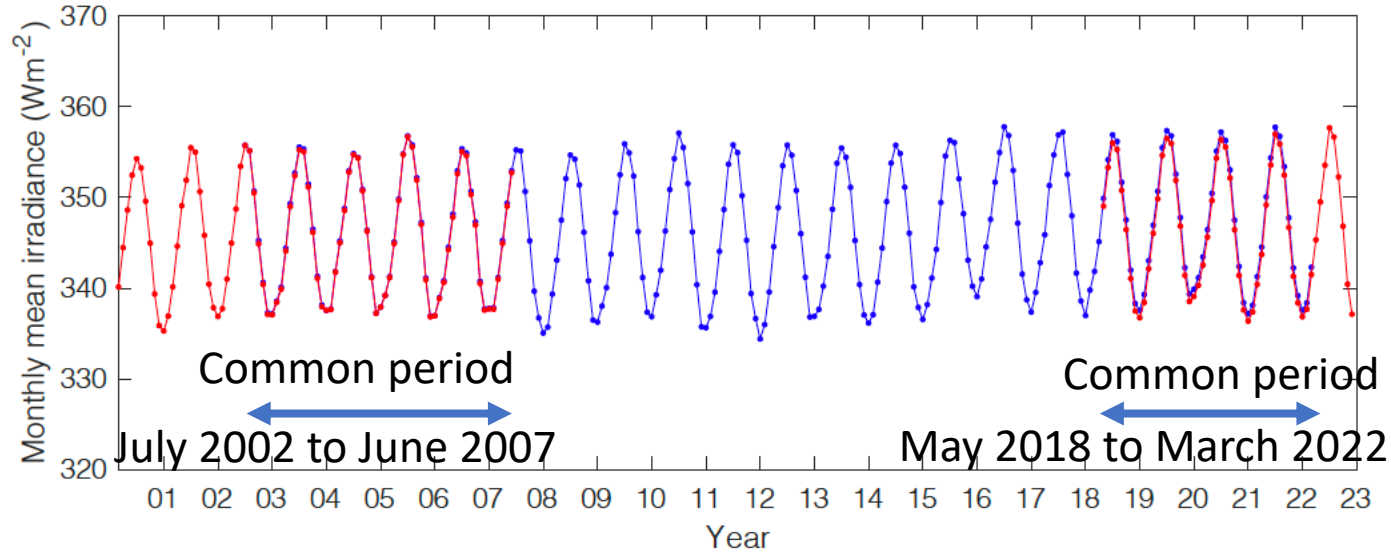$$\hat{F}_x^{n20} = \bar{F}_x^{n20} + \Delta F_x^{n20}$$
$$= \bar{F}_x^{ta} + [(\bar{F}_x^{n20} - \bar{F}_x^{ta}) + \Delta F_x^{n20}]$$

Blue:
Climatological adjustment to NOAA 20 data

$$\hat{F}_x^{n20} = \bar{F}_x^{ta} + \Delta F_x^{n20}$$

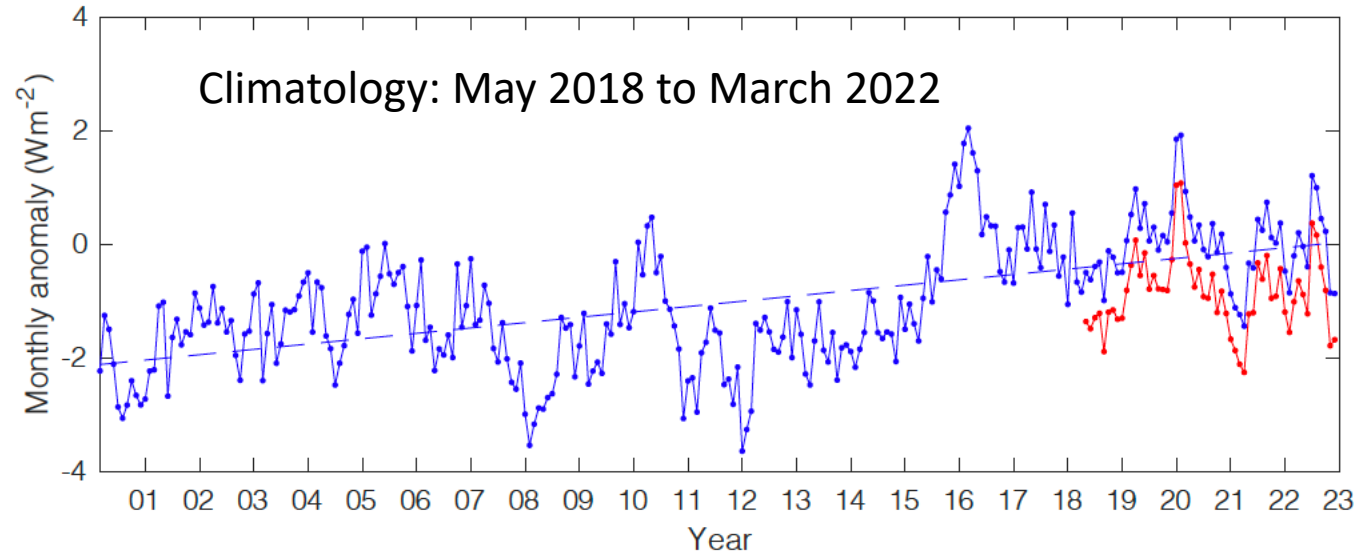# Global monthly mean all-sky surface downward longwave irradiance

Red:

No climatological adjustment

$$\hat{F}_x^{n20} = \bar{F}_x^{n20} + \Delta F_x^{n20}$$
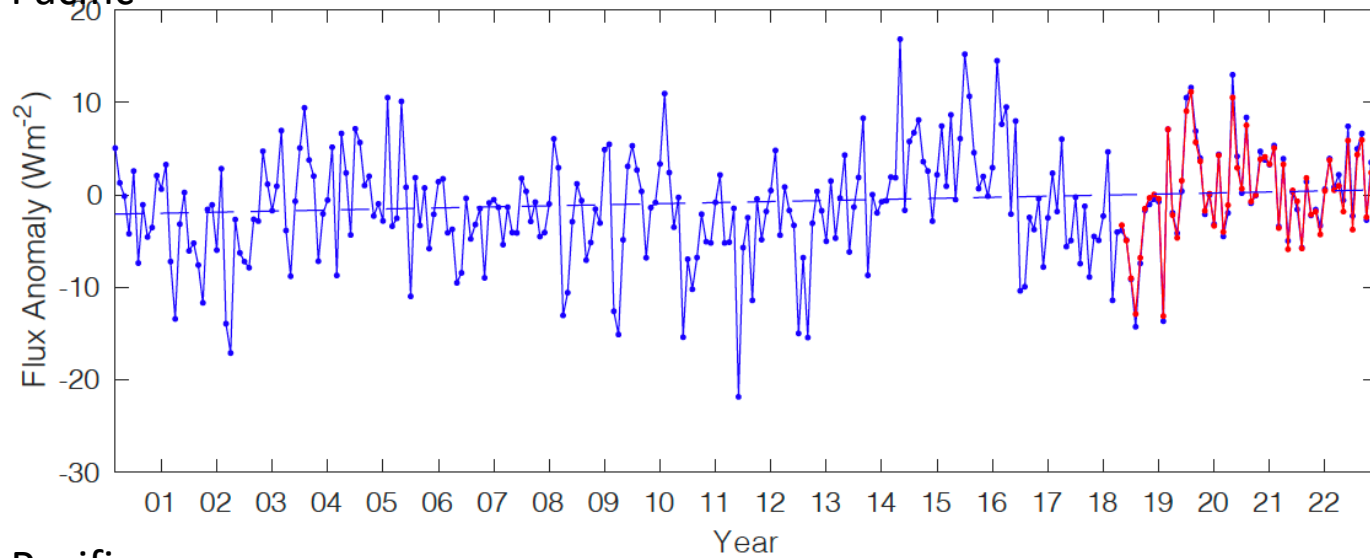$$= \bar{F}_x^{ta} + [(\bar{F}_x^{n20} - \bar{F}_x^{ta}) + \Delta F_x^{n20}]$$

Blue:

Climatological adjustment to NOAA 20 data
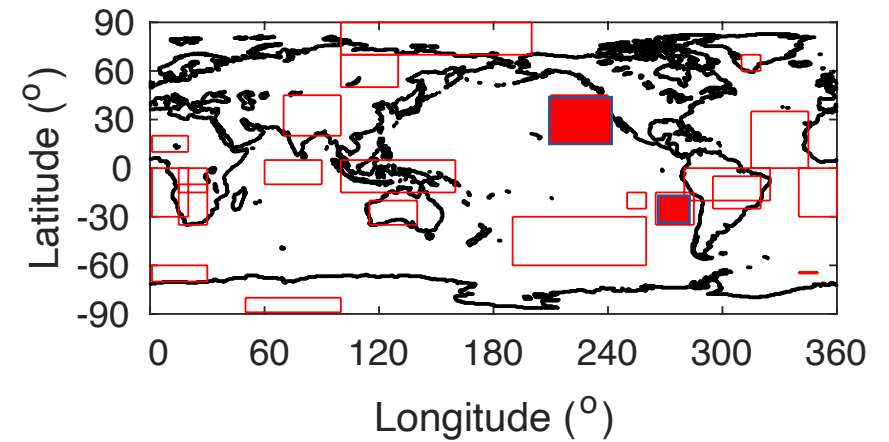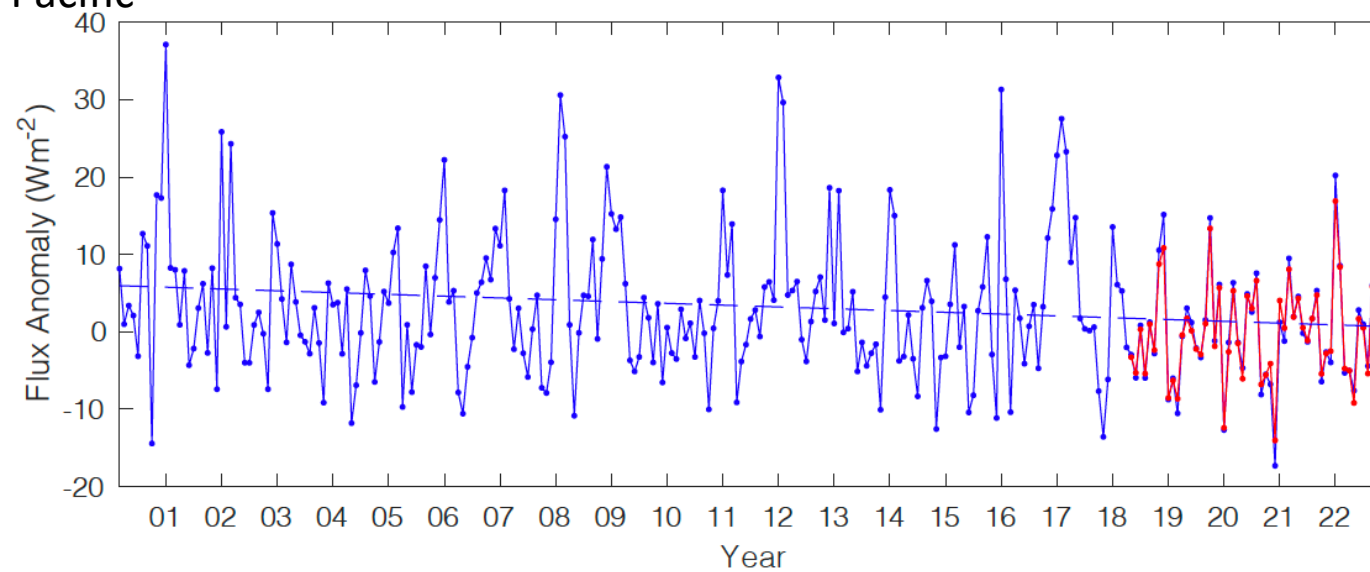
$$\hat{F}_x^{n20} = \bar{F}_x^{ta} + \Delta F_x^{n20}$$

Regional downward shortwave irradiance

Northeast Pacific

Southeast Pacific

— Edition 4.2 EBAF Terra&Terra+Aqua&NOAA20
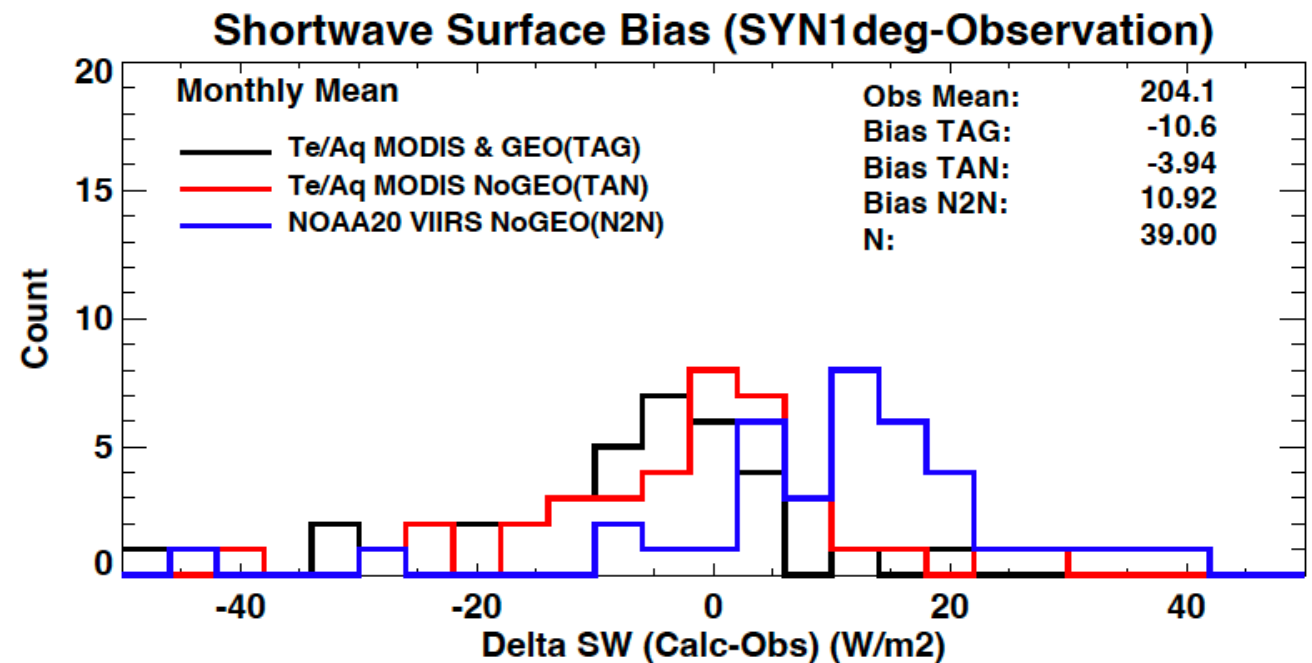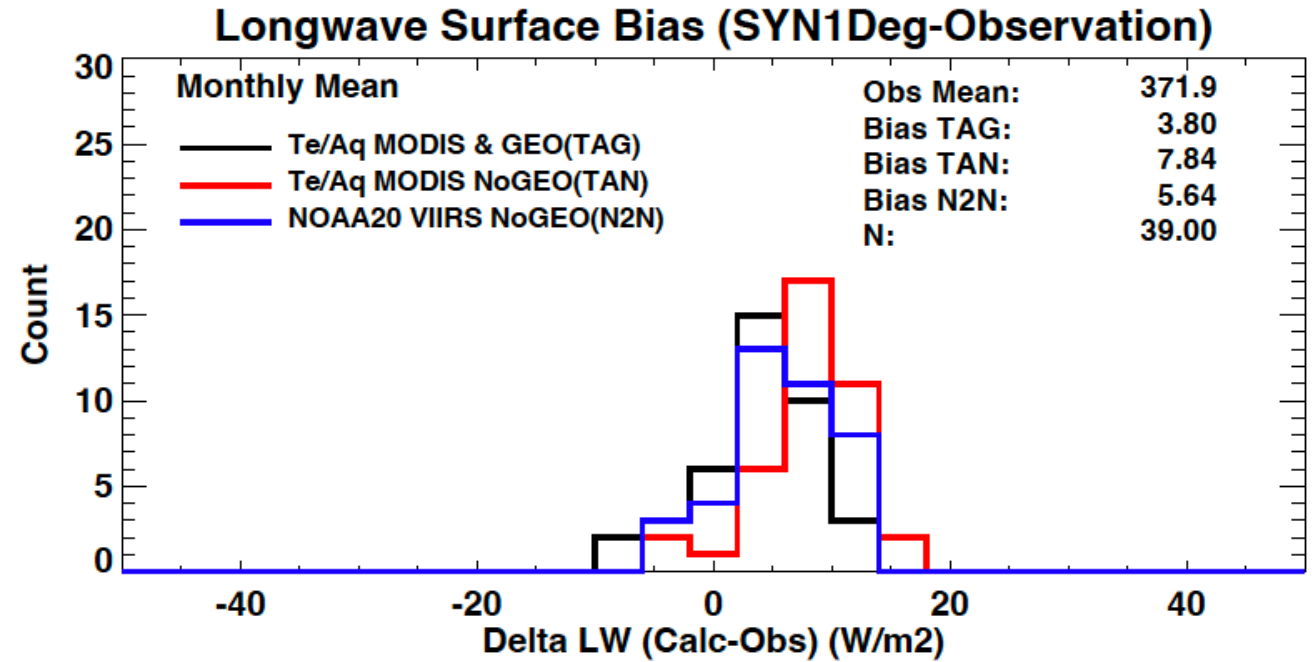
— Edition 4 SYN1deg NOAA20

Standard deviation and RMS difference tables

Region	Standard deviation (Wm^{-2})		RMS difference (Wm^{-2})		Correlation coefficient	
	Terra common period	NOAA 20 common period	Terra common period	NOAA 20 common period	Terra common period	NOAA 20 common period
Downward shortwave irradiance						
Global	0.612	0.500	0.120	0.163	0.986	0.950
NE Pacific	5.55	5.65	0.611	0.433	0.993	0.997
SE Pacific	7.93	7.25	1.07	1.26	0.988	0.992
Downward longwave irradiance						
Global	0.551	0.688	0.078	0.053	0.991	0.997
NE Pacific	2.70	2.44	0.114	0.124	0.999	0.999
SE Pacific	3.59	3.22	0.209	0.187	0.998	0.998

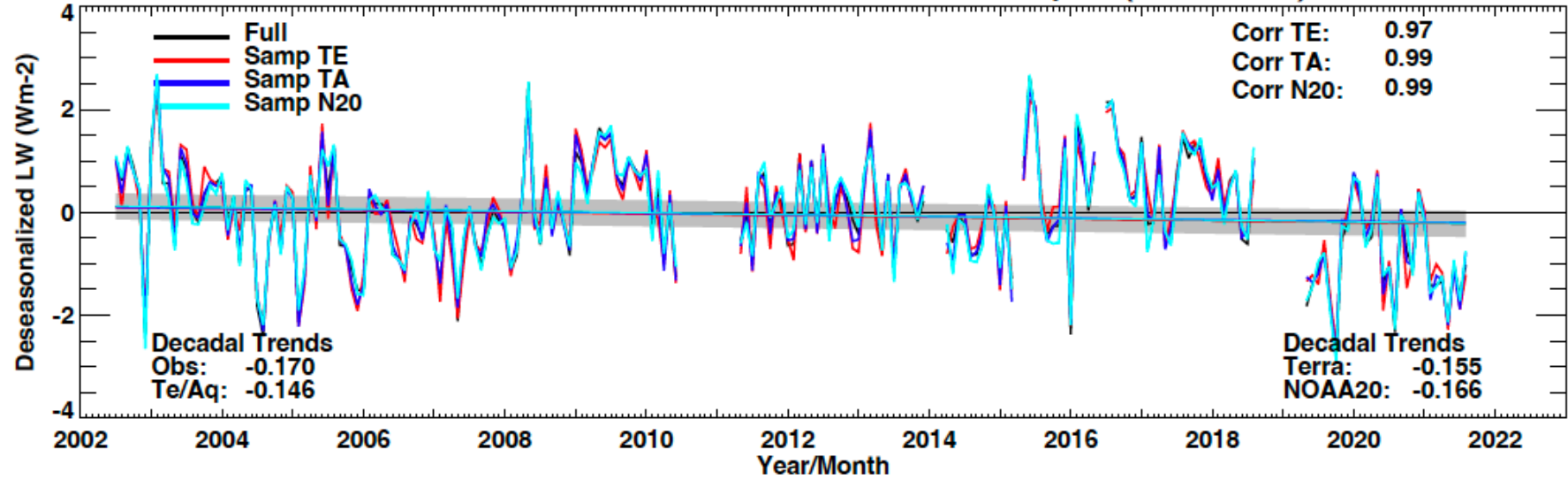# Evaluation of climatological adjustment concept with surface observations

SYN1deg Edition 4 WHOI Stratus buoy data

Longwave Surface Bias (SYN1Deg-Observation)

Monthly Mean

- Te/Aq MODIS & GEO(TAG)
- Te/Aq MODIS NoGEO(TAN)
- NOAA20 VIIRS NoGEO(N2N)

Obs Mean:	371.9
Bias TAG:	3.80
Bias TAN:	7.84
Bias N2N:	5.64
N:	39.00

Delta LW (Calc-Obs) (W/m2)

Shortwave Surface Bias (SYN1deg-Observation)

Monthly Mean

- Te/Aq MODIS & GEO(TAG)
- Te/Aq MODIS NoGEO(TAN)
- NOAA20 VIIRS NoGEO(N2N)

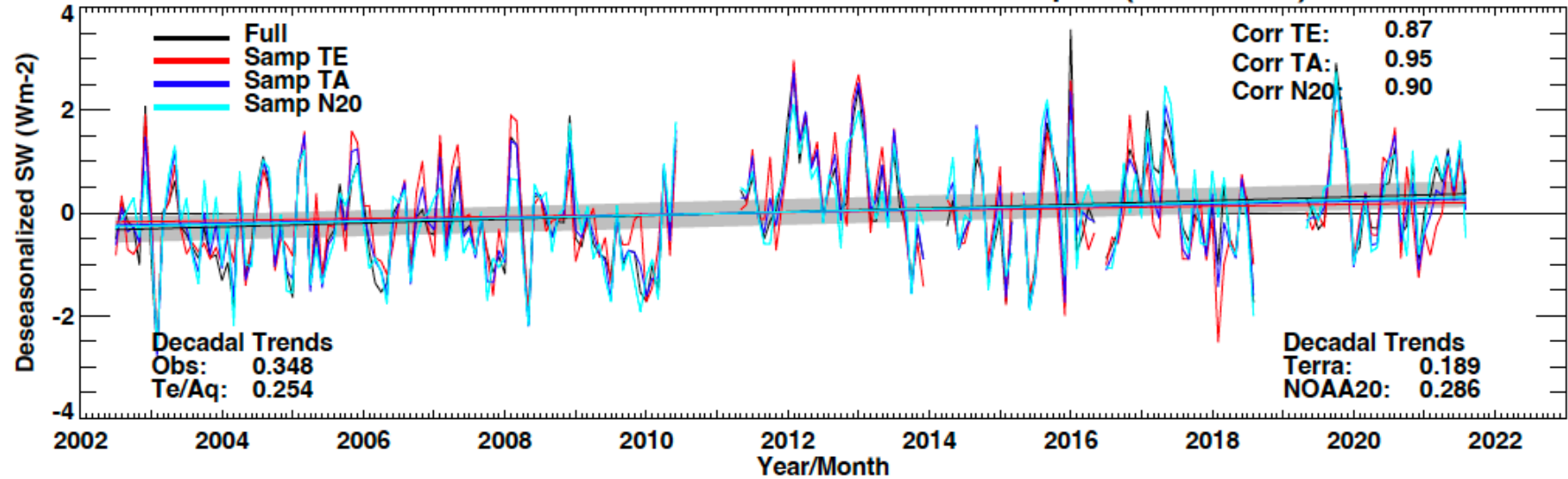|	
Obs Mean:	204.1
Bias TAG:	-10.6
Bias TAN:	-3.94
Bias N2N:	10.92
N:	39.00

Delta SW (Calc-Obs) (W/m2)

Full: All observations
TE: Terra overpass time
TA: Terra+Aqua overpass time
N20: NOAA20 overpass time

STRATUS Buoy (WHOI)

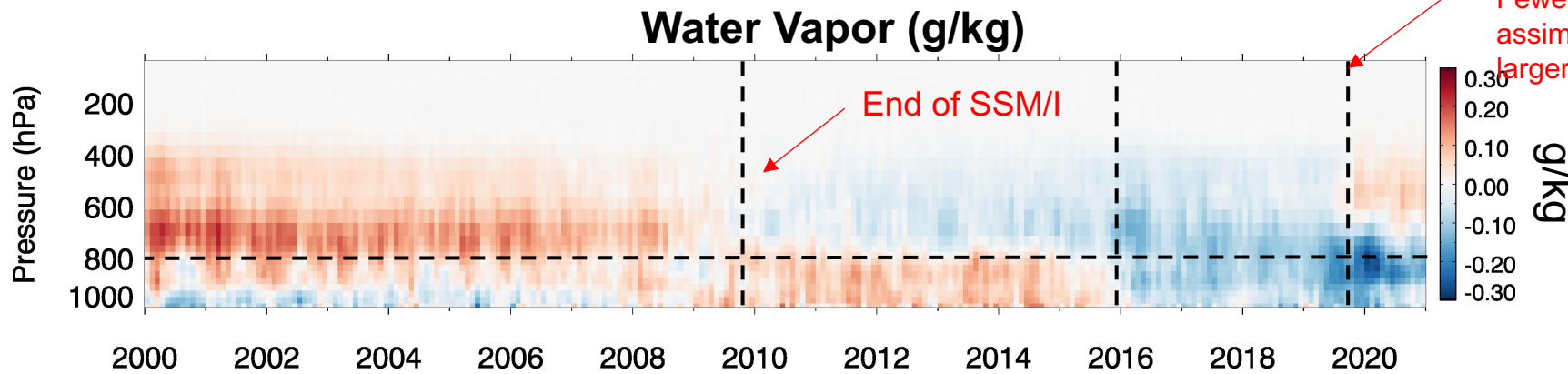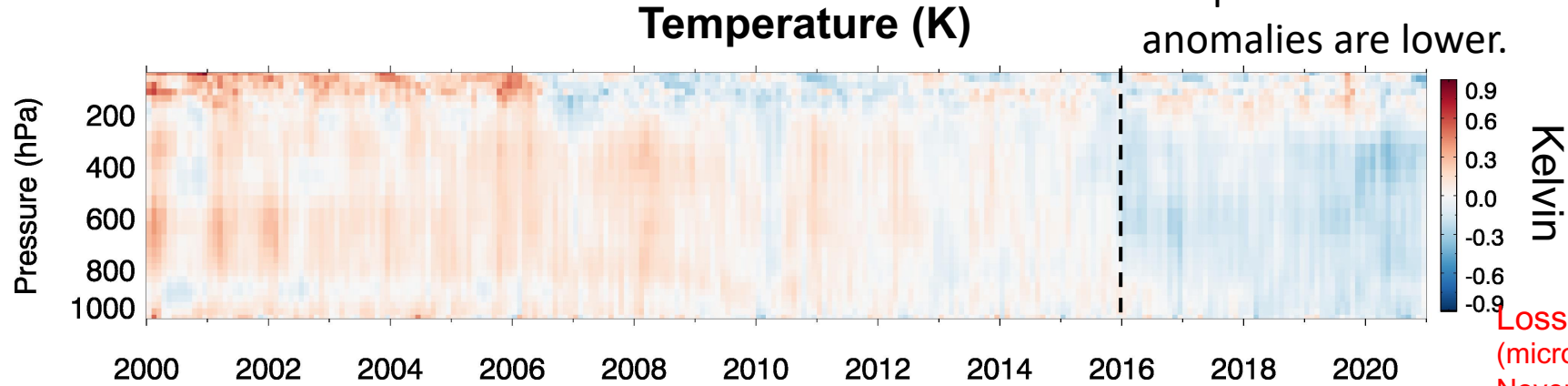Deseasonalized LW Surface Observations & Sampled (Normalized)

Corr TE: 0.97
Corr TA: 0.99
Corr N20: 0.99

Decadal Trends
Obs: -0.170
Te/Aq: -0.146

Decadal Trends
Terra: -0.155
NOAA20: -0.166

Deseasonalized SW Surface Observations & Sampled (Normalized)

Corr TE: 0.87
Corr TA: 0.95
Corr N20: 0.90

Decadal Trends
Obs: 0.348
Te/Aq: 0.254

Decadal Trends
Terra: 0.189
NOAA20: 0.286

Difference from Edition 4.1

Area weighted; climatology is obtained using 2003-2020

[G-5.4.1 Anomalies] – [ERA-5 Anomalies]

After 2016, GEOS-5.4.1 temperature and humidity anomalies are lower.

Temperature (K)

Pressure (hPa)

Kelvin
0.9
0.6
0.3
0.0
-0.3
-0.6
-0.9

2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020

Loss of MHS (microwave humidity sounder) November 2019 Fewer instruments are assimilated so that the impact is larger in GEOS-5.4.1

Water Vapor (g/kg)

Pressure (hPa)

End of SSM/I

g/kg
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30

2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020

Tropical standard ATM Water vapor mixing ratio @ 400 hPa
~0.6 g/kg
~20 to 30% drift

- The differences between G541 and ERA5 are similar to those between G541 and MERRA-2.
- This implies that the differences are mainly driven by G541 problems.

Total area clear-sky downward longwave

(Total area)

Clear-sky LW down

Correction to GEOS-5.4.1 temperature and humidity profiles were made after November 2019.

The effect on the mitigation of MHS loss is limited.
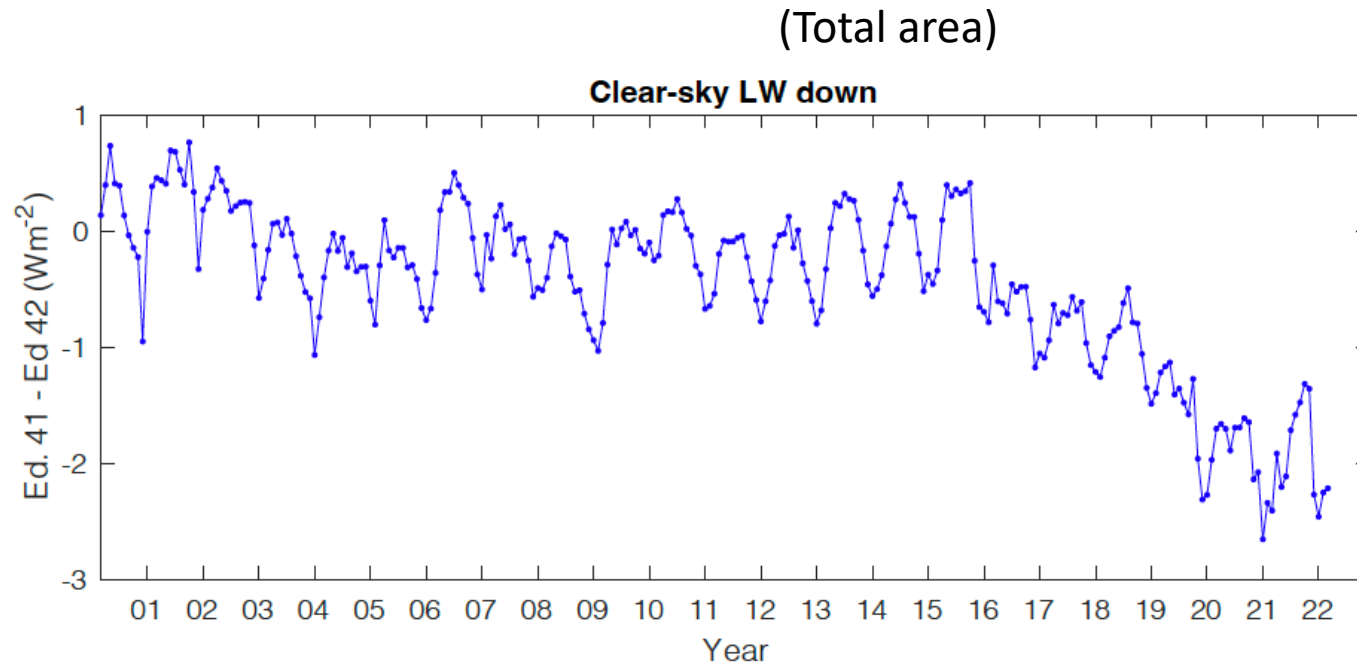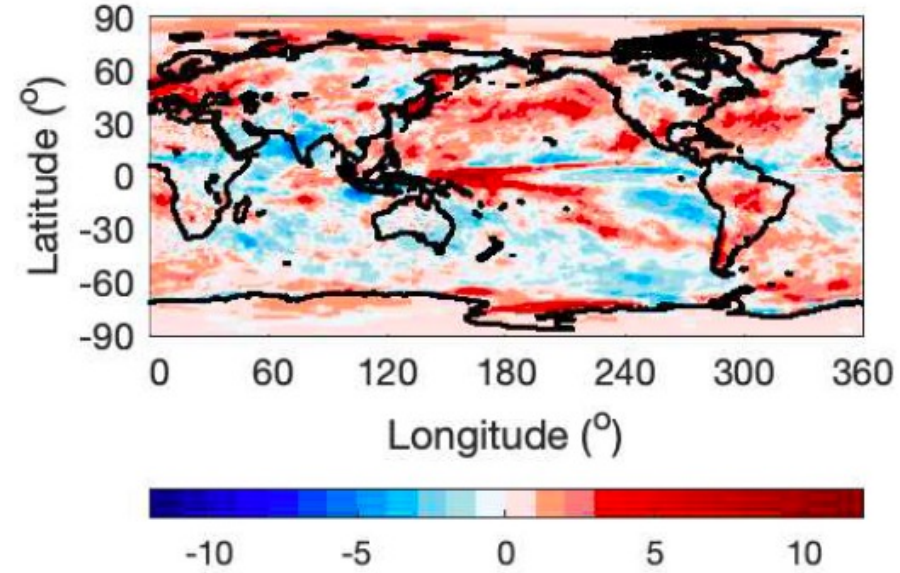
Blue: Edition 4.1
Red: Edition 4.2
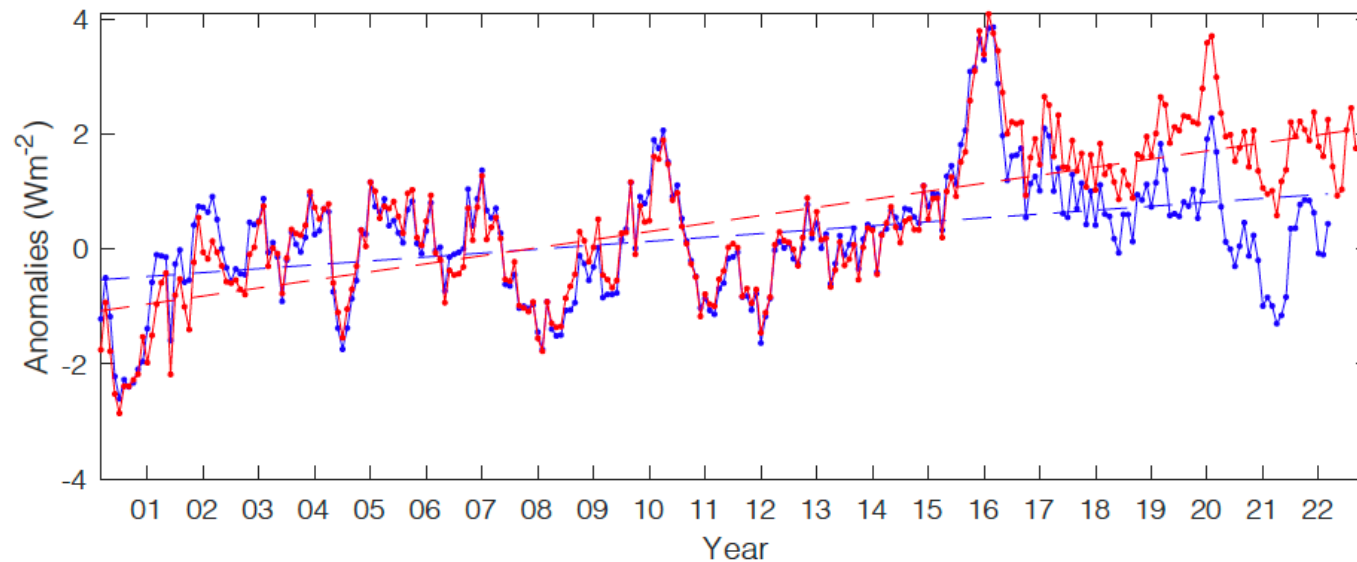
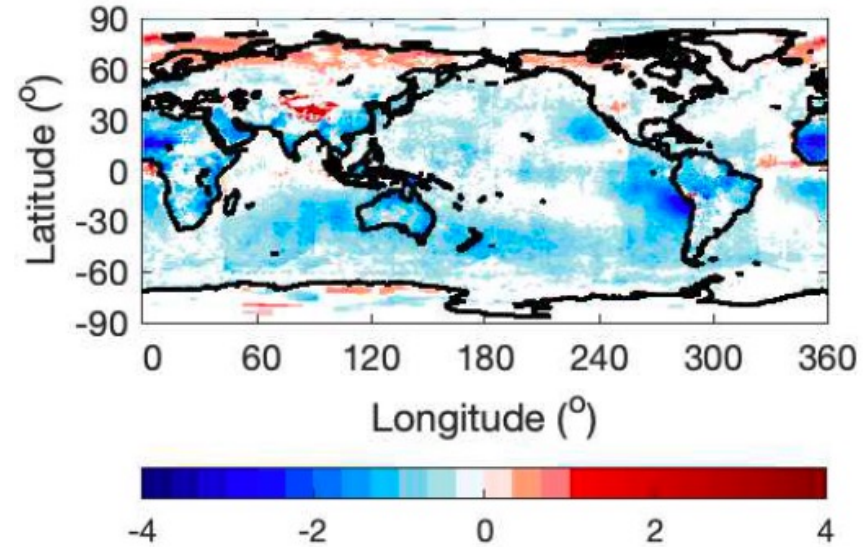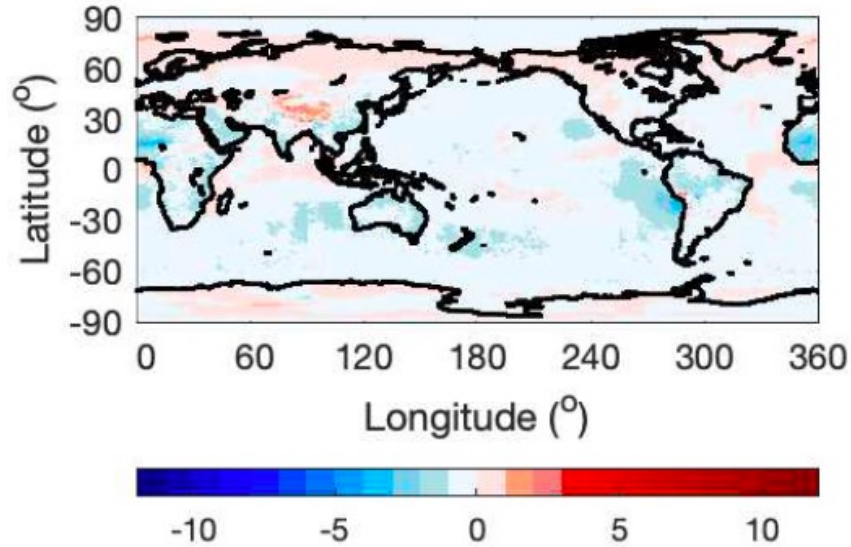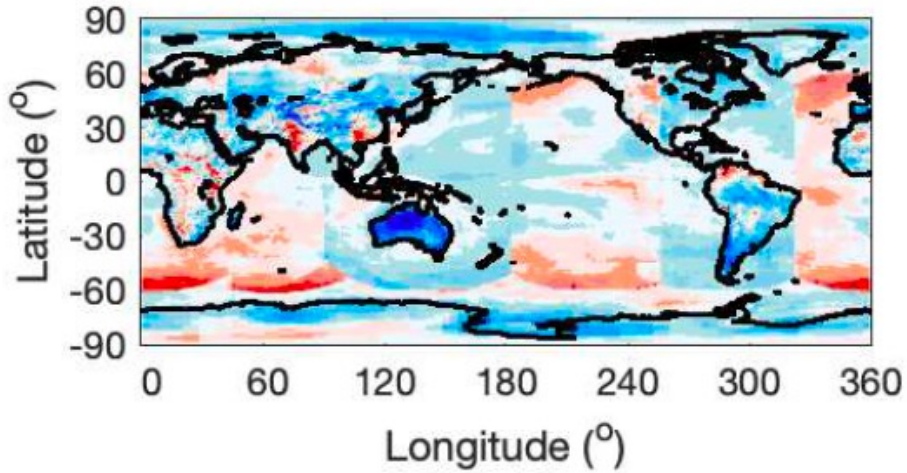# Surface shortwave net irradiance trends (Wm^{-2} dec^{-1}) 20003 - 202212
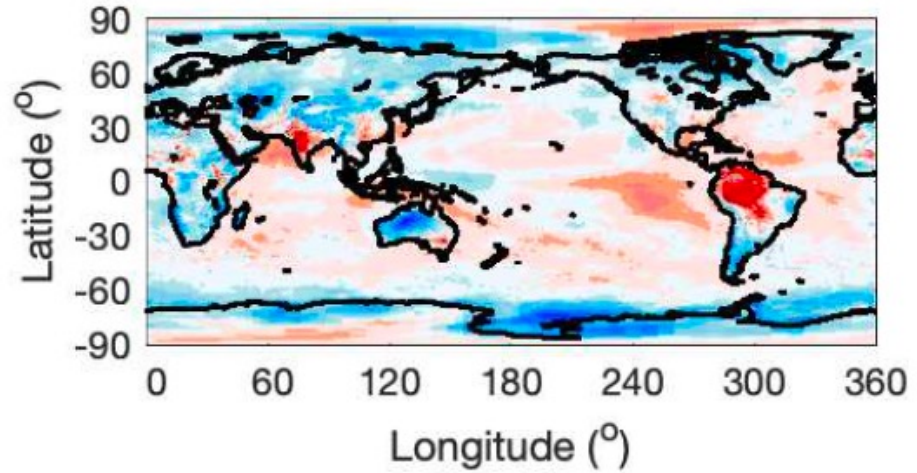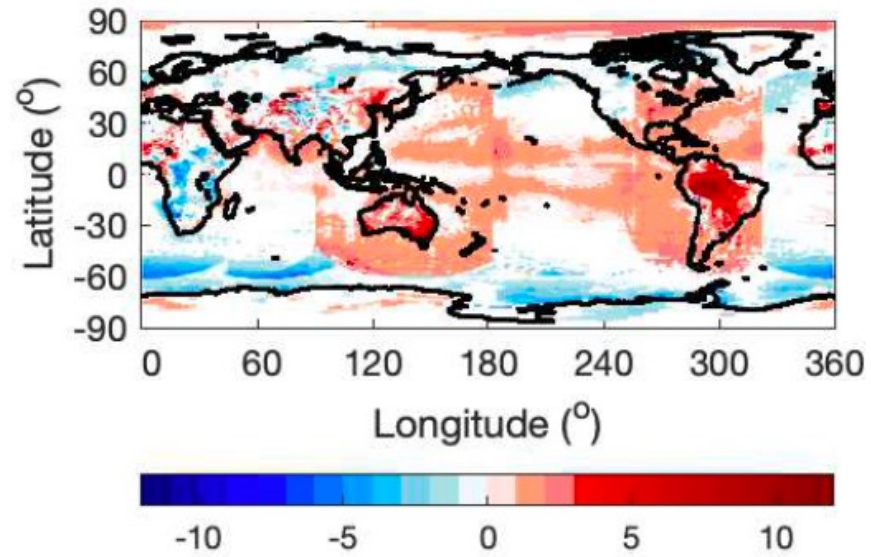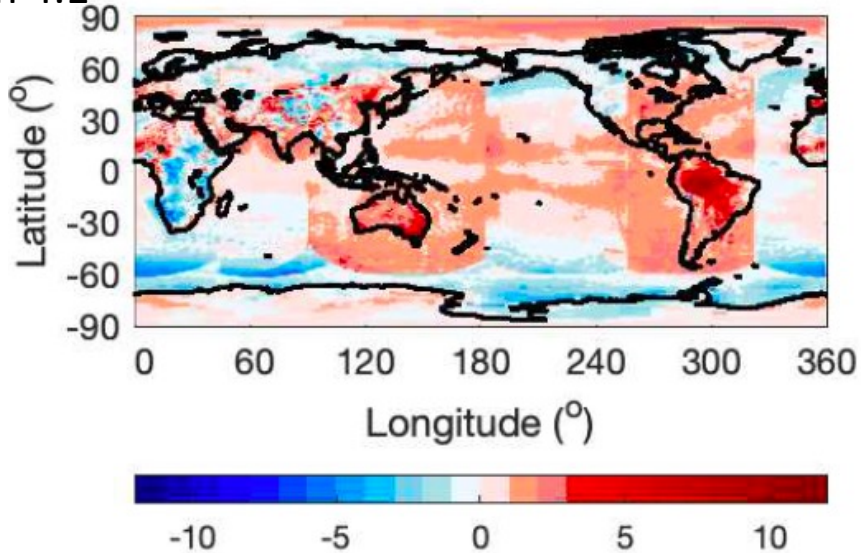
Edition 4.1
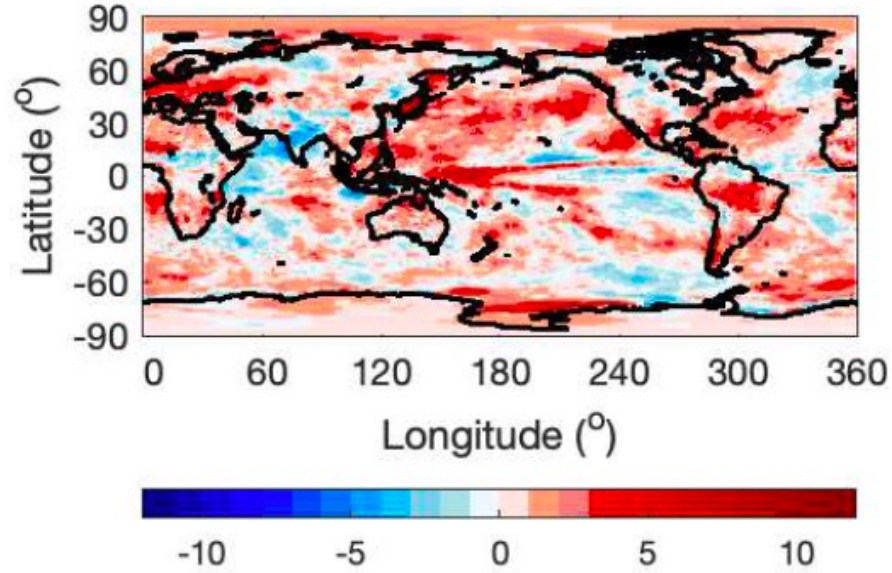
Edition 4.2

Edition 4.2 – Edition 4.1

Regions with a difference outside the 5% - 95% confidence interval

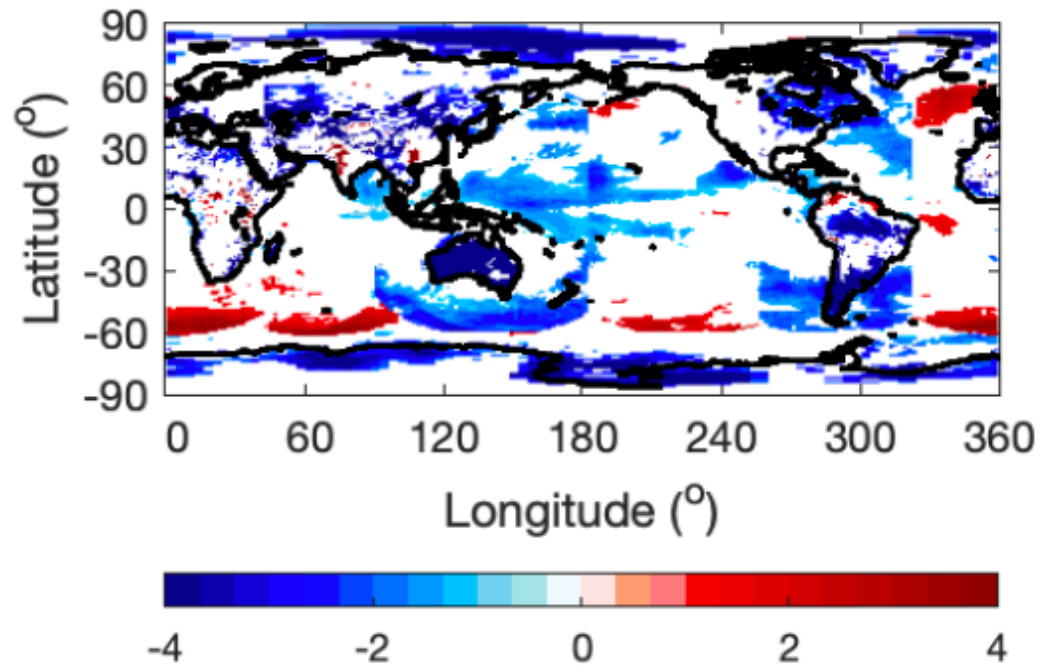# Surface longwave net irradiance trends (Wm^{-2} dec^{-1})

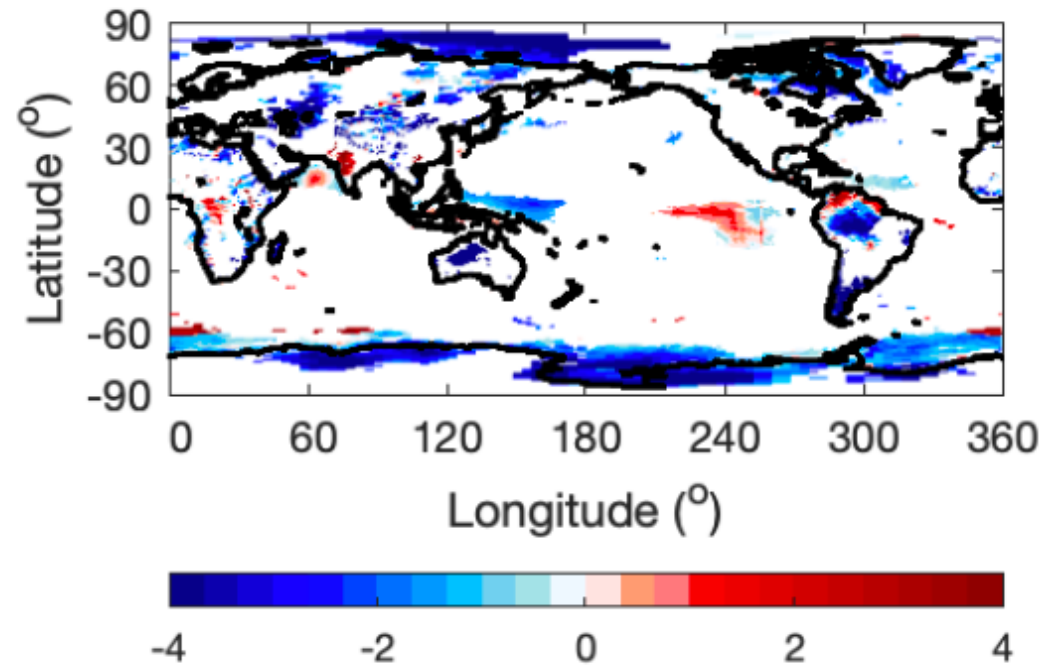Edition 4.1

Edition 4.2

Edition 4.2 – Edition 4.1

Regions with a difference outside the 5% - 95% confidence interval

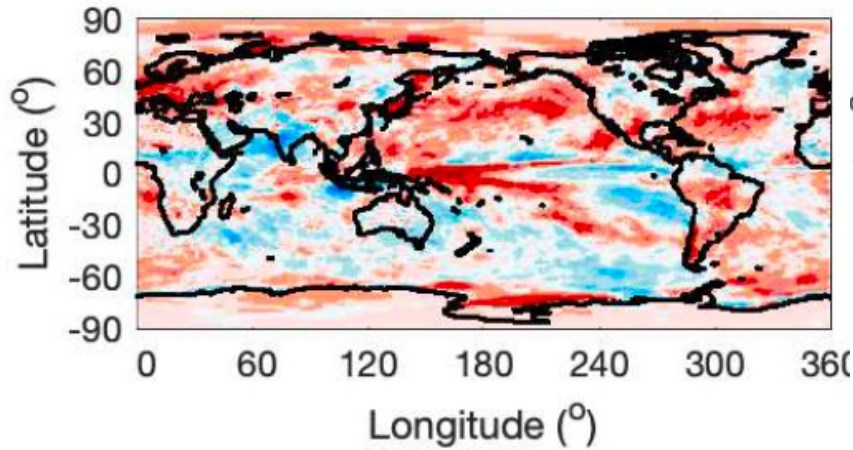# Net longwave irradiance trend (Wm^{-2} dec^{-1})
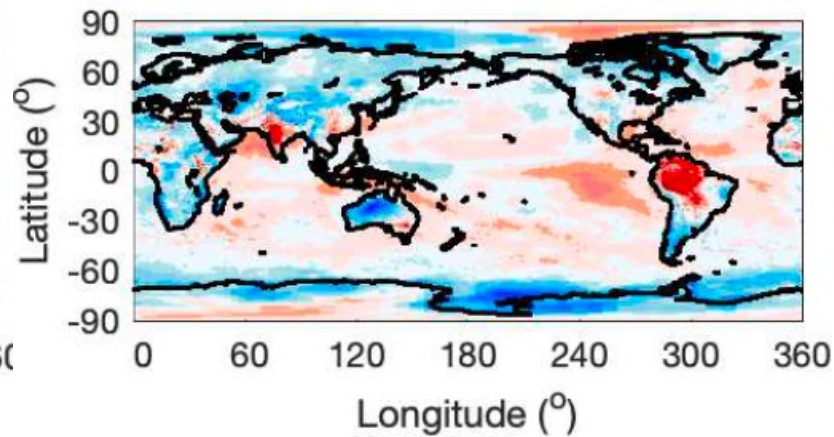
Edition 4.1

Edition 4.2

Regions with a trend over March 2000 to December 2022 outside the 5% - 95% confidence interval

Trends of net surface irradiances in the period from March 2000 through December 2022
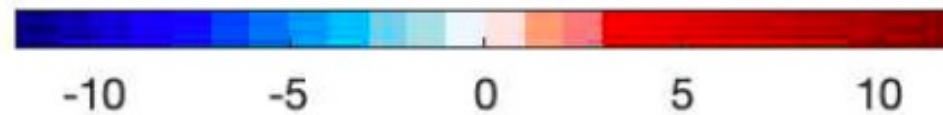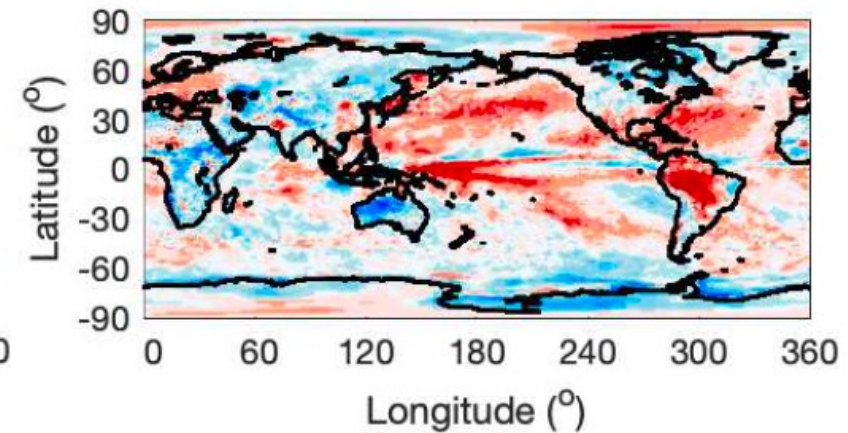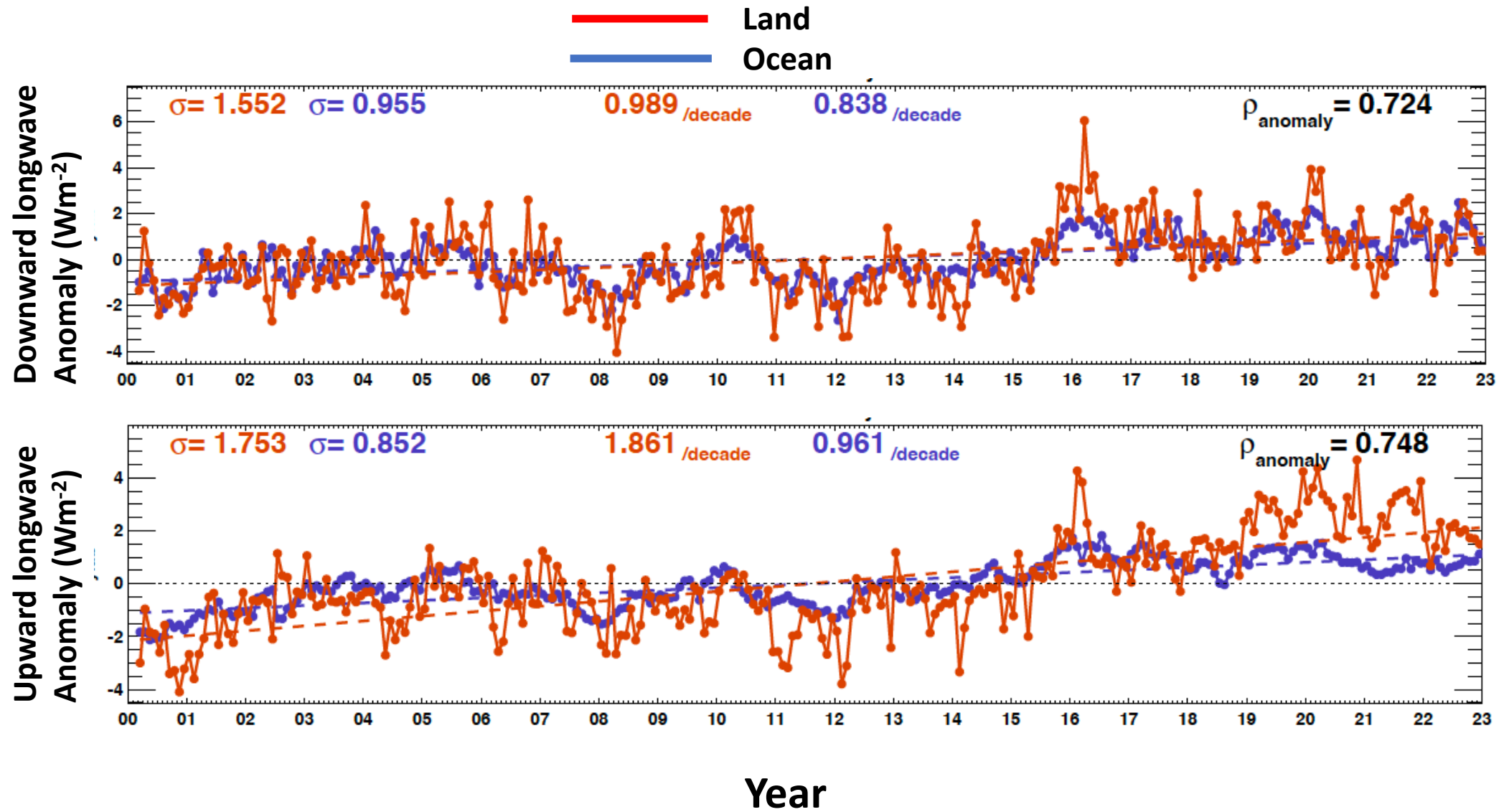

NET SW trend

NET longwave trend

NET total trend

Wm⁻² dec⁻¹

Net total trend: Ocean trend is dominated by SW and land trend is dominated by LW

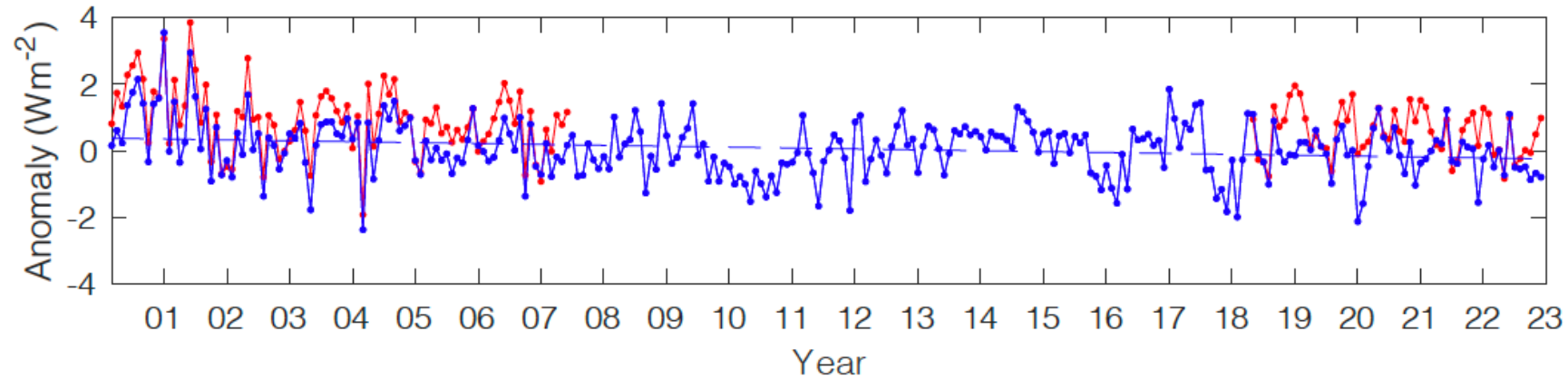# All-sky longwave irradiance trend over land and ocean

Summary

- Surface irradiances for Edition 4.2 EBAF are computed using only MODIS and VIIRS derived cloud properties (i.e. no geostationary satellite derived clouds).

- Cloud properties derived from one orbit (i.e. Terra only or NOAA20 only) are sufficient to derive surface irradiance anomalies.

- Uncertainty in Edition 4.2 surface irradiance anomalies is significantly smaller than the uncertainty in Edition 4.1 surface irradiance anomalies.

- Negative total area clear-sky upward shortwave irradiances occur in both TOA and surface near the boundary of daytime and nighttime.

Back-ups

Input datasets

Algorithms and tools
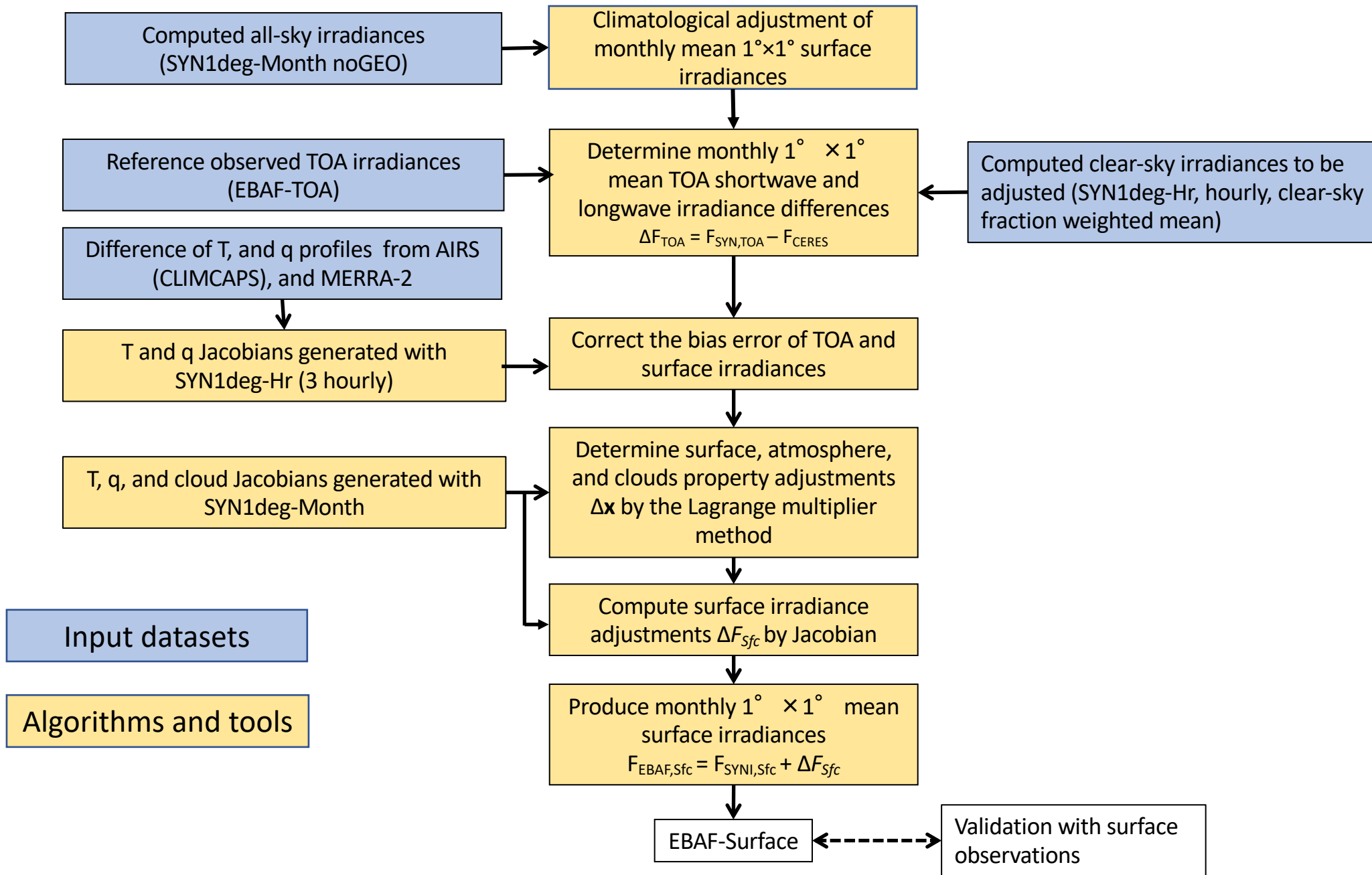
Anomaly time series with and without climatological adjustment: global monthly anomalies