State of CERES

Norman G. Loeb
NASA Langley Research Center, Hampton, VA

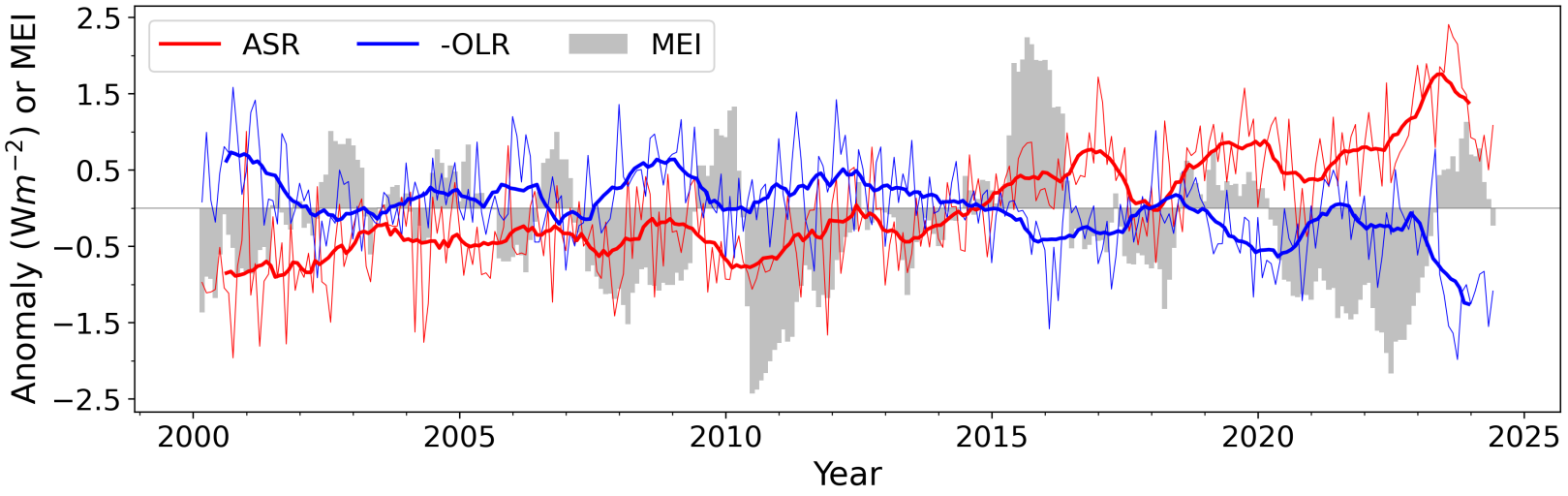
CERES Science Team Meeting, October 1-3, 2024
Lawrence Livermore National Laboratory, Livermore, CA

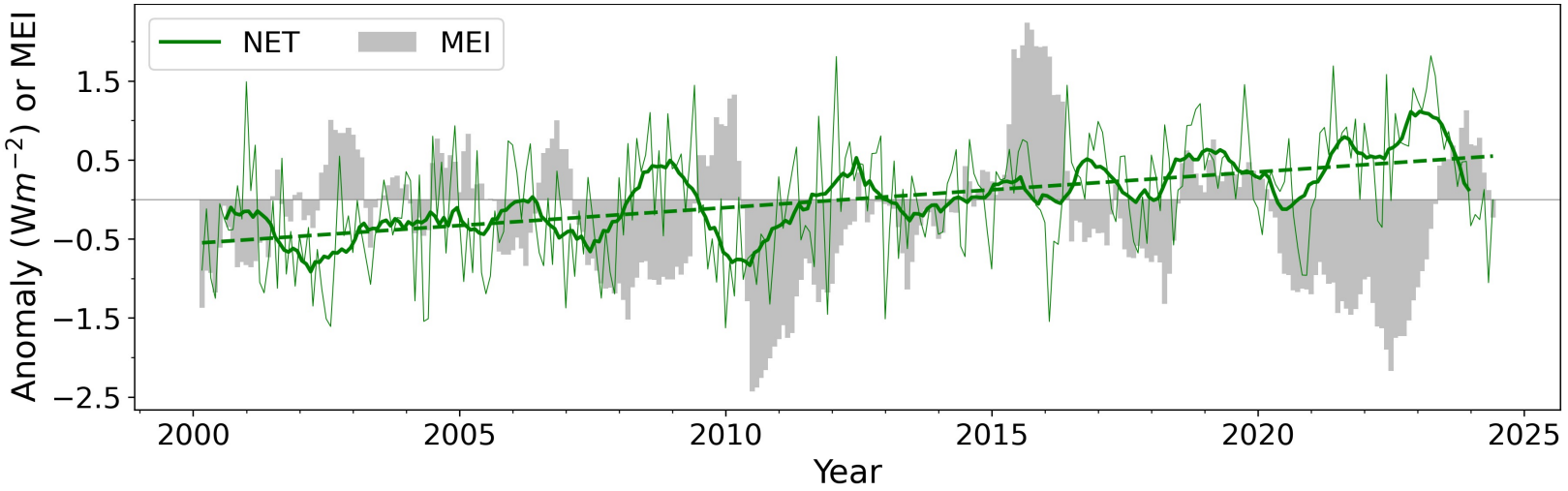
CERES Technical Meeting

Review Status of CERES Instruments and Data Products:

- State of CERES
- CERES Terra, Aqua, S-NPP, NOAA-20 Instrument Calibration Update
- MODIS & VIIRS Cloud Algorithm & Validation Status
- ADM, SARB and TISA Working Group Reports
- FLASHFlux Update
- Data Management Team Update

Global Mean All-Sky TOA Flux Anomalies (CERES EBAF Ed4.2; 03/2000–06/2024)





Trends (Wm^{-2} per decade; 2.5-97.5% CI)

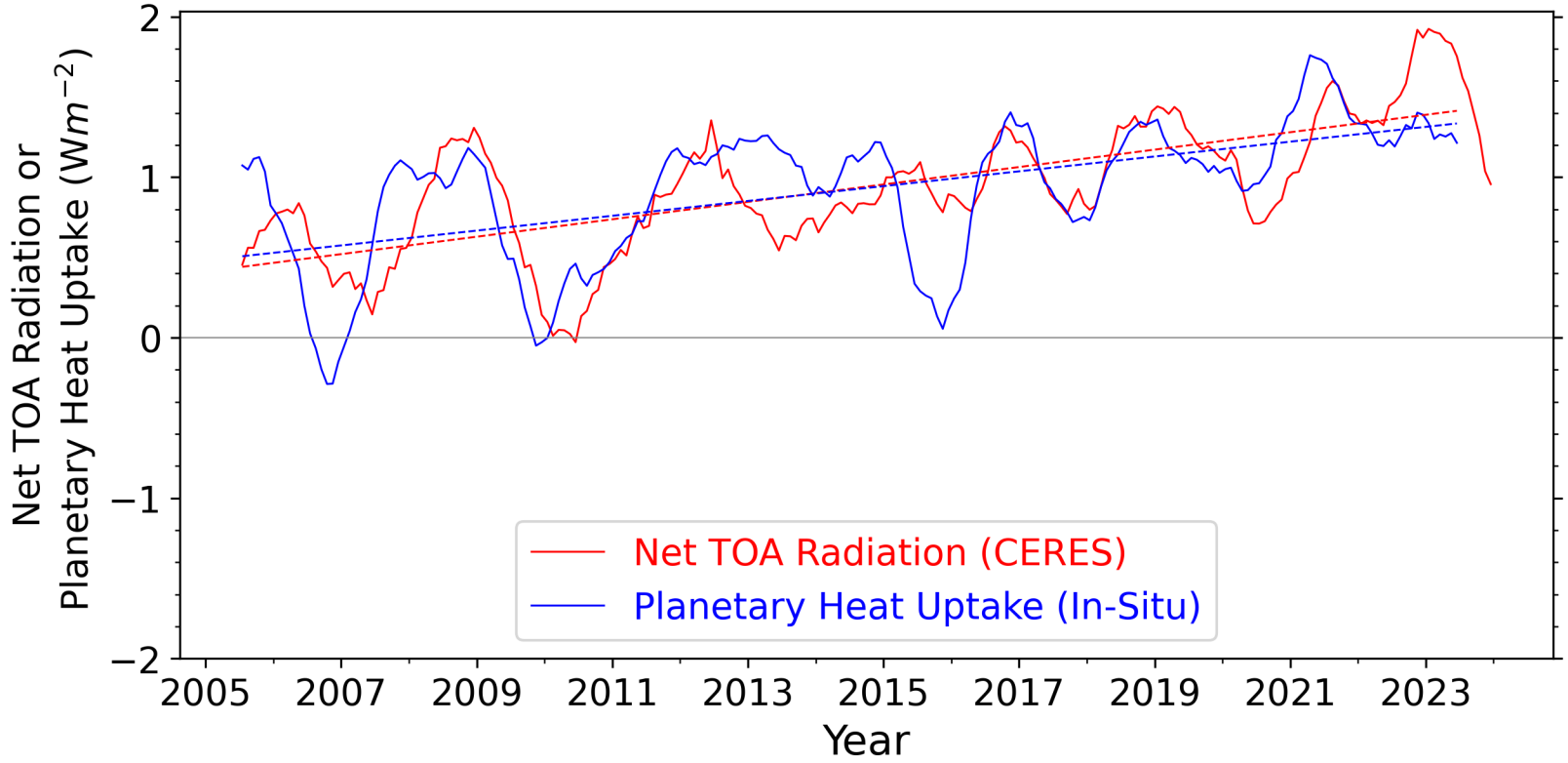
ASR: 0.81 ± 0.21

–OLR: –0.36 ± 0.20

NET: 0.45 ± 0.18

Annual Mean Net TOA Radiation & In-Situ Planetary Heat Uptake

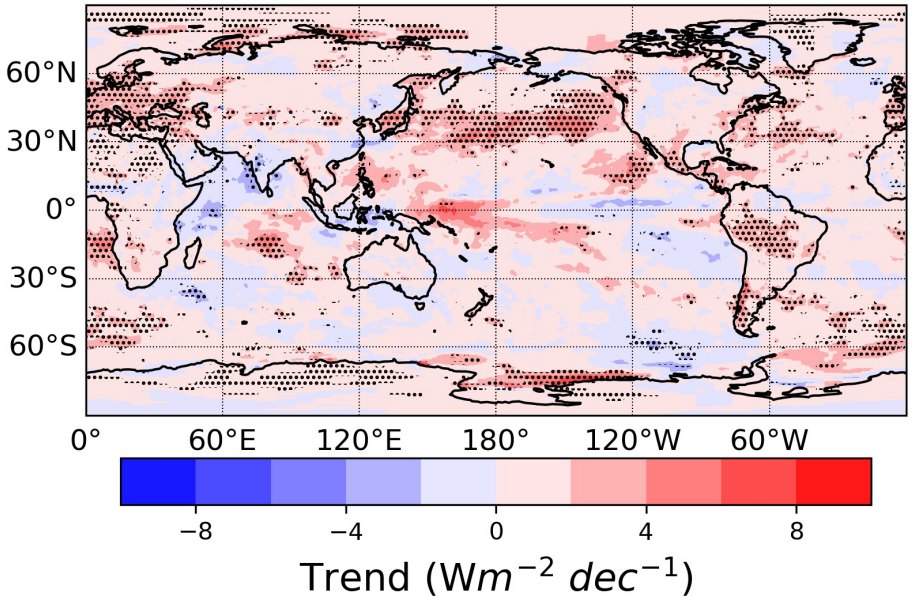
(CERES 02/2005-06/2024; In situ: 02/2005-12/2023)



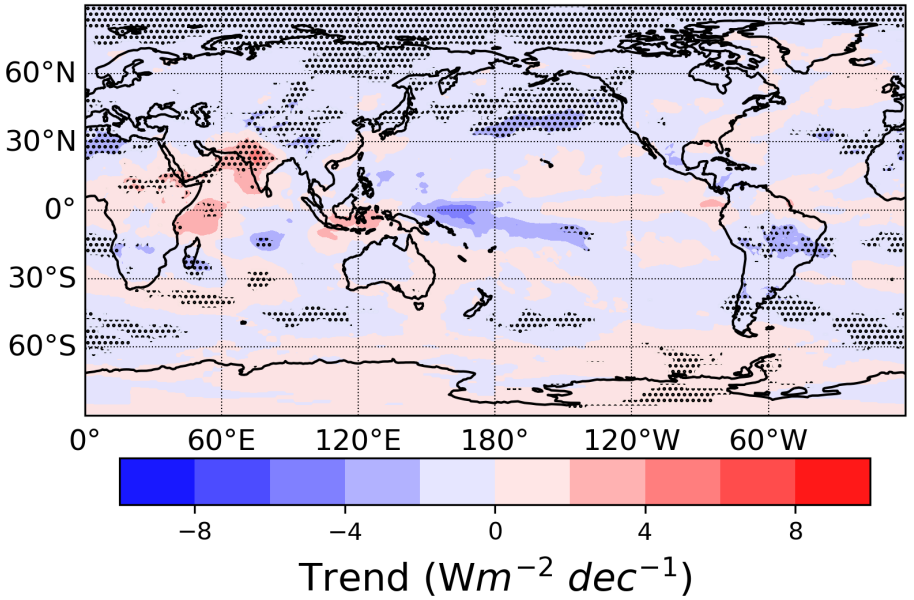
	Trend (Wm^{-2} dec^{-1}) 02/2005-12/2023
CERES EBAF Ed4.2	0.54 ± 0.28
In-Situ	0.46 ± 0.35
Difference	0.08 ± 0.30
R	0.68

Regional Trends in TOA Radiation and SST (03/2000–06/2024)

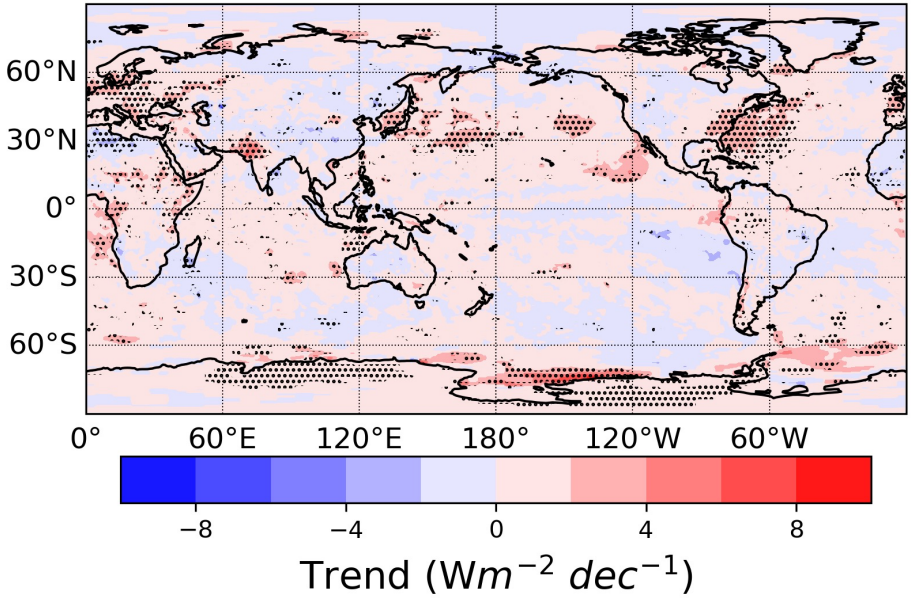
ASR



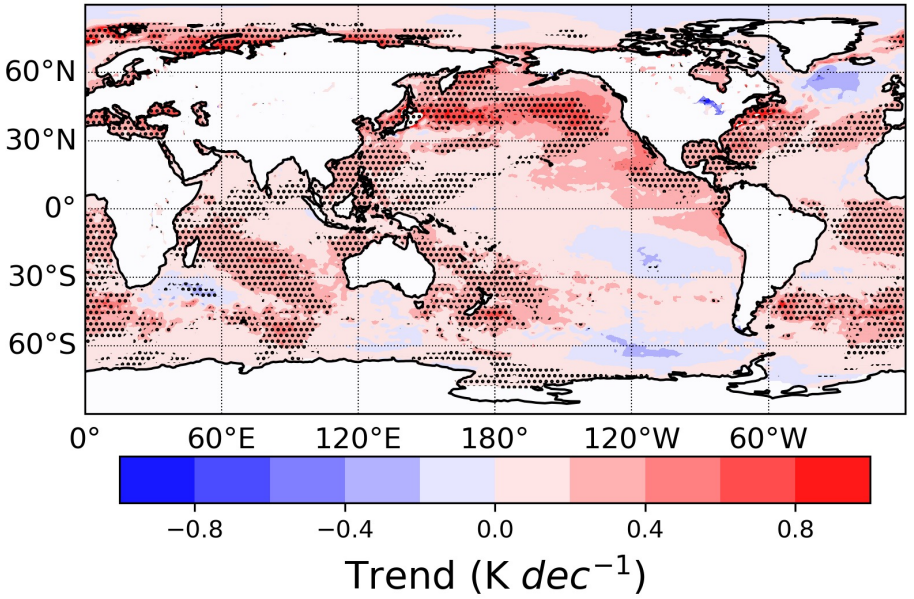
-OLR



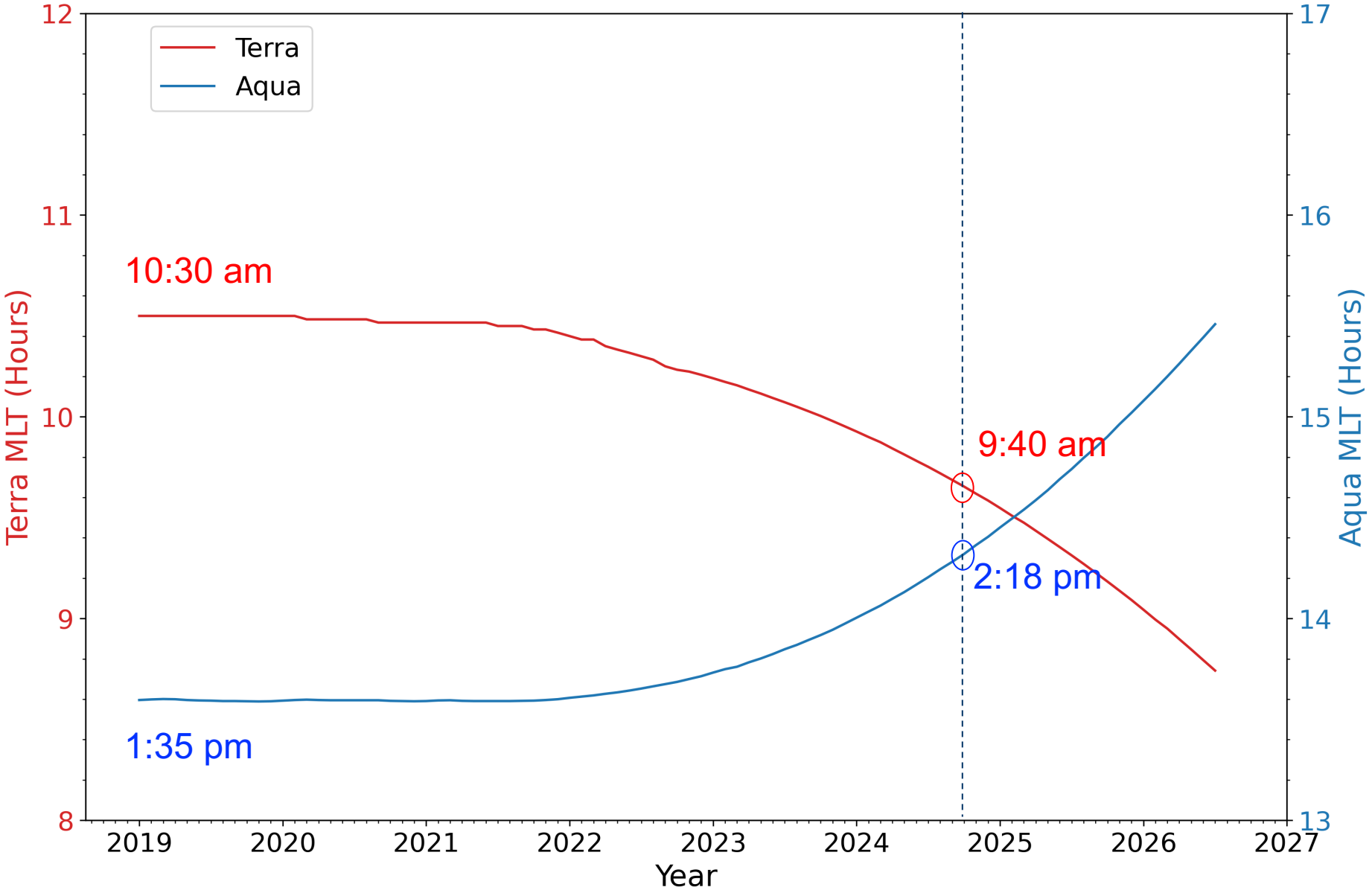
NET



SST



Terra and Aqua Mean Local Equatorial Crossing Times (MLTs)



- **MLT updates available at: https://terra.nasa.gov & https://aqua.nasa.gov**

Impact of MLT Drift on TOA Flux Anomalies

- Consider NOAA-20 SSF1deg and Terra SSF1deg for common period (05/2018-06/2024)
  - NOAA-20 has fixed MLT while Terra is drifting in MLT
  - Note: Aqua FM3 has been in RAP mode since 04/2023 & therefore isn't used here.
- SSF1deg uses simple diurnal correction (similar to ERBE)

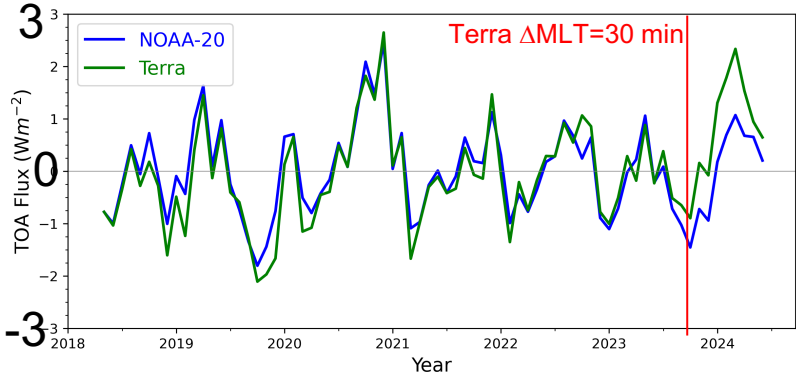
  SW: Converts observation to equivalent 24-h average using empirical models of albedo dependence on SZA assuming scene remains invariant throughout the day.

  LW: Linear interpolation of daytime and nighttime observations over ocean. Daytime and nighttime observations over land and desert are interpolated by fitting a one-half sine curve to the observations.

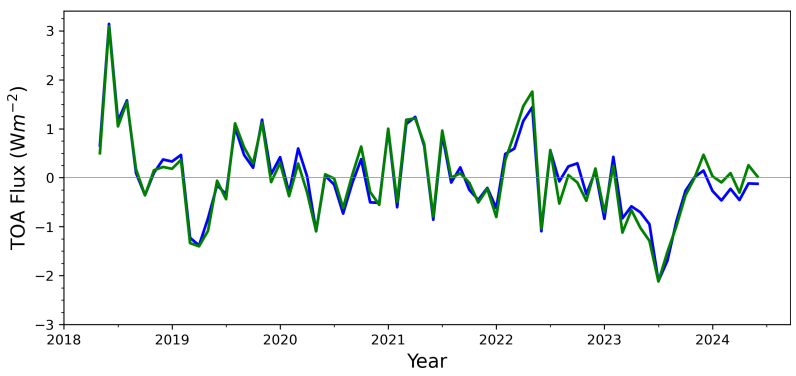
  - Highly sensitive to orbital drift.
- **Note:** EBAF accounts for diurnal variations and transitions from Terra+Aqua to NOAA-20 before MLT drift gets too large.

SW TOA Flux Anomalies for NOAA-20 (Fixed MLT) and Terra (Drifting MLT)

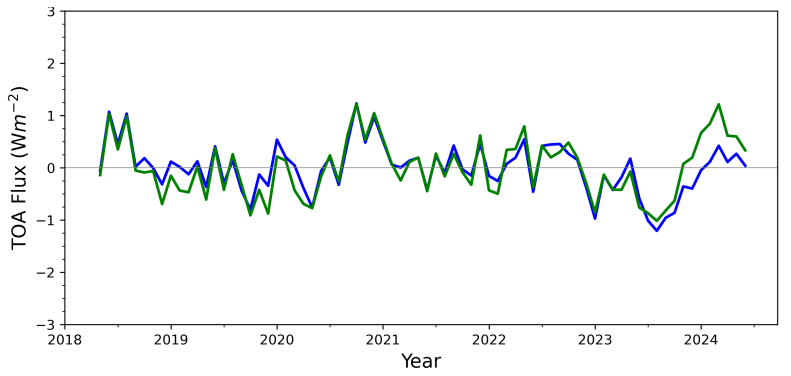
SH SW Anomalies



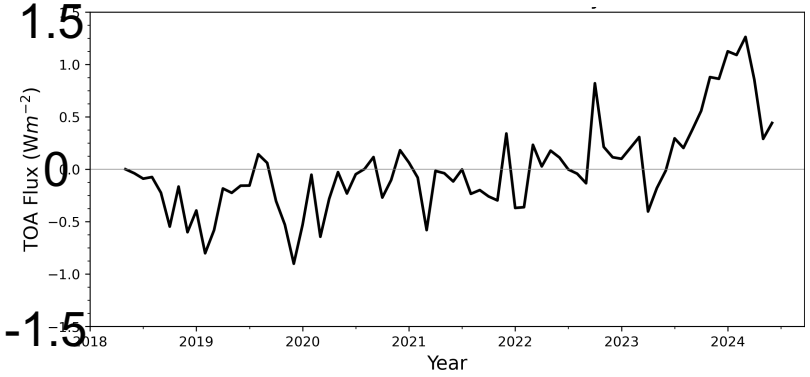
NH SW Anomalies



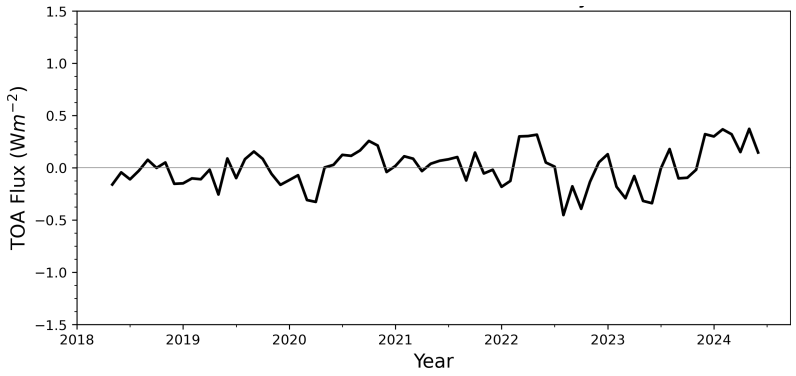
Global SW Anomalies



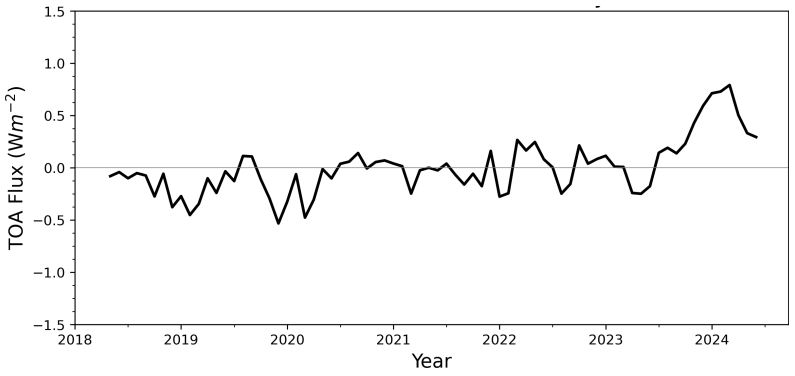
SH Ter-N20 SW Anomaly Diff



NH Ter-N20 SW Anomaly Diff

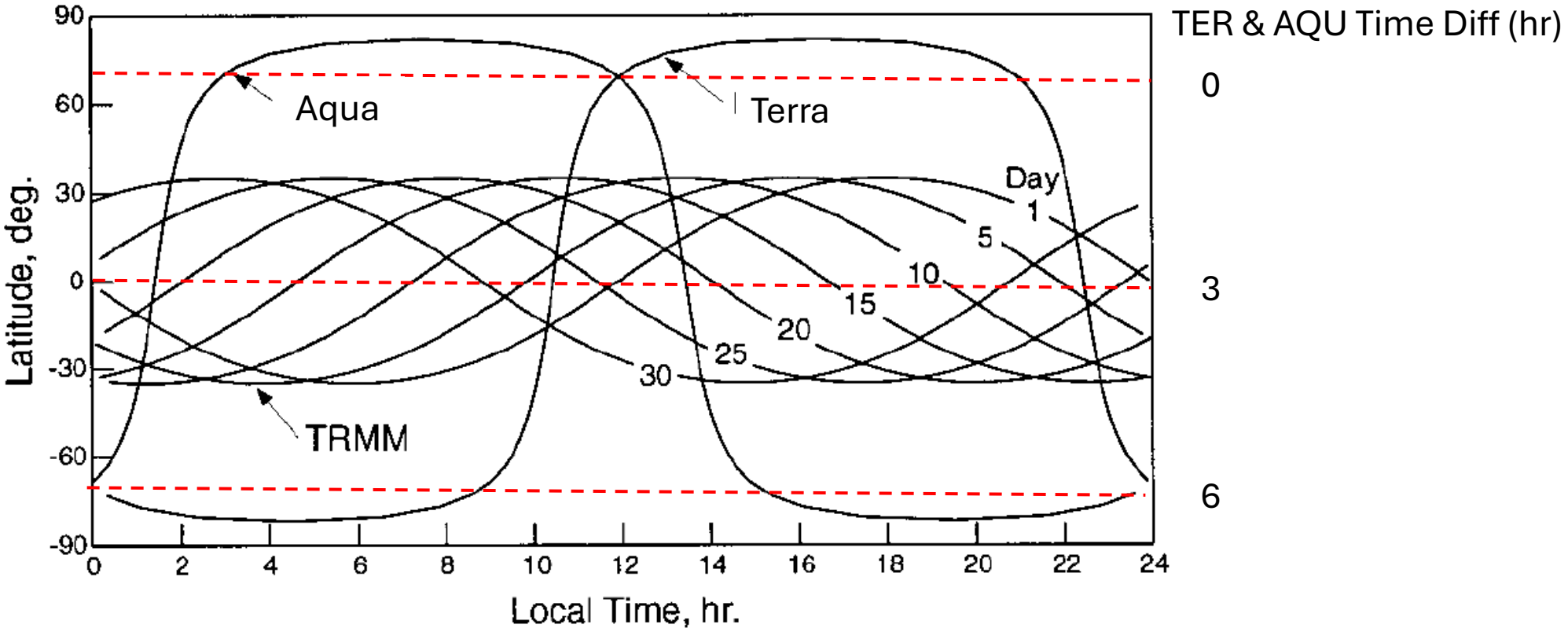


Global Ter-N20 SW Anomaly Diff



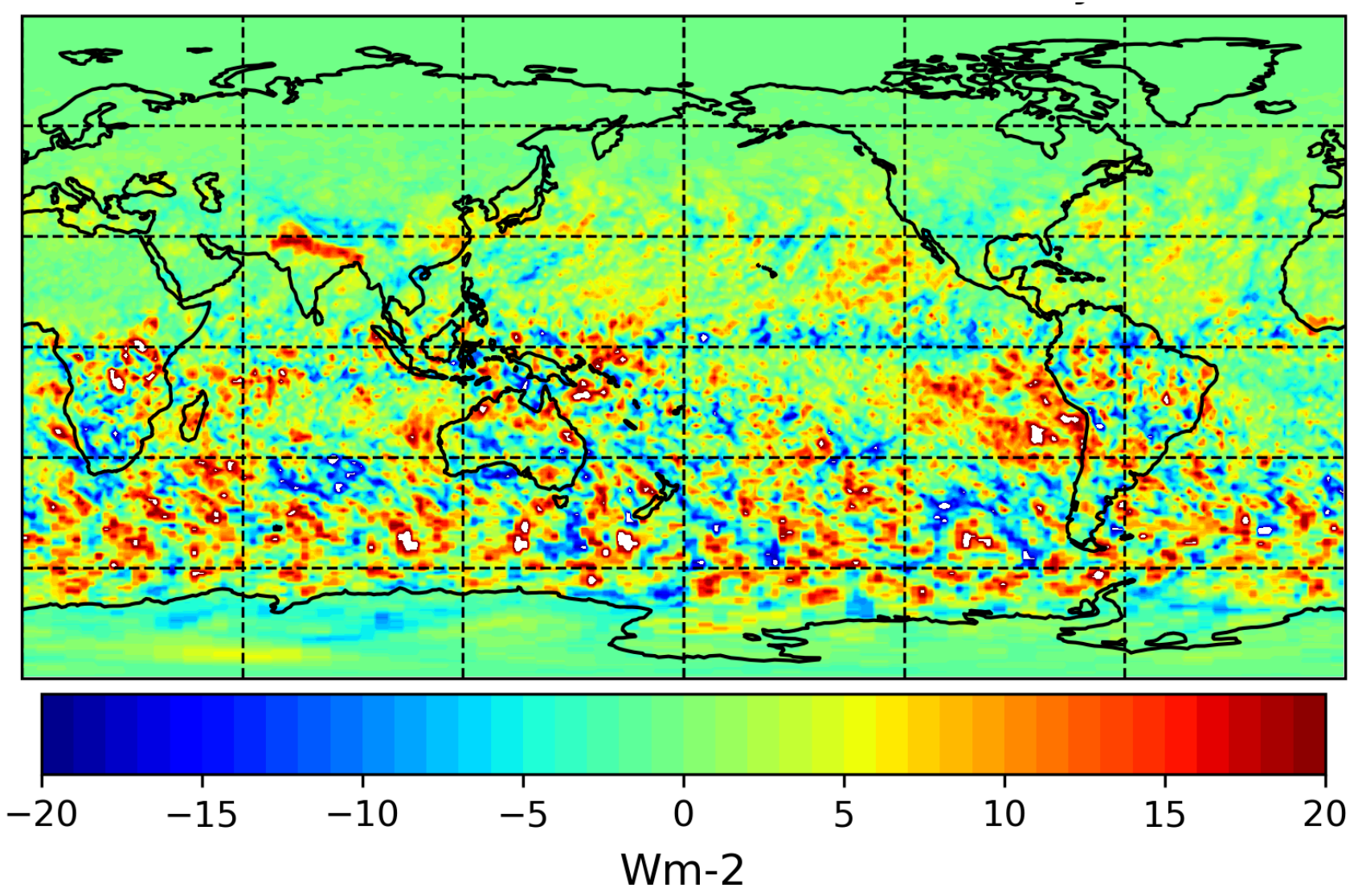
- Large Terra minus NOAA-20 SW anomaly difference in SH but not in NH. Why?

Temporal Coverage of Terra, Aqua and TRMM



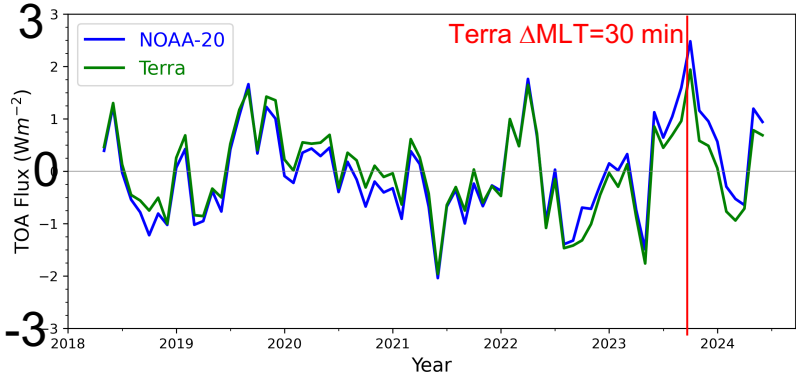
- Time separation between Terra and Aqua ground tracks is greater in SH than NH

Terra minus NOAA-20 SW TOA Flux Anomaly Difference (January 2024)

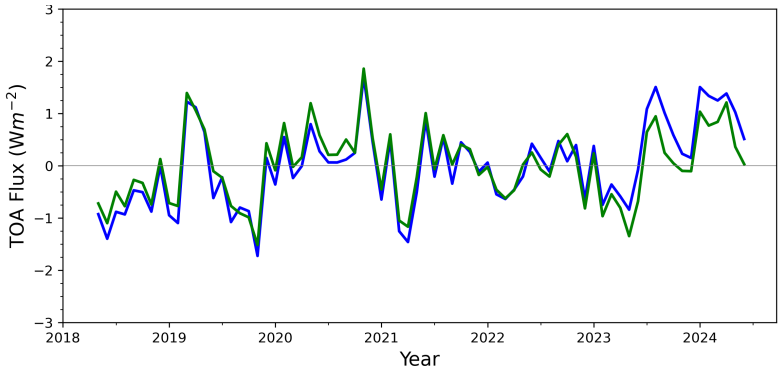


LW TOA Flux Anomalies for NOAA-20 (Fixed MLT) and Terra (Drifting MLT)

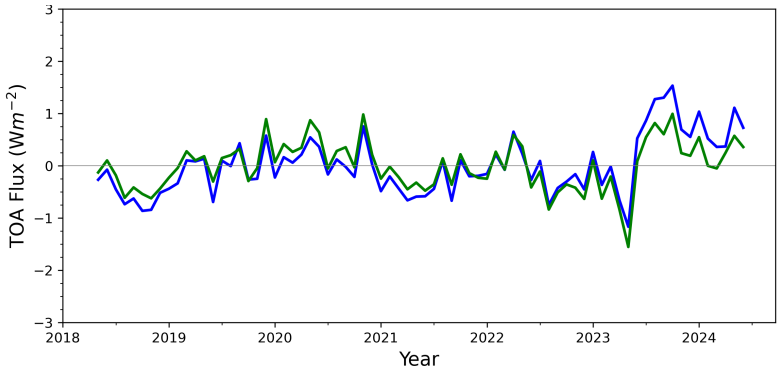
SH LW Anomalies



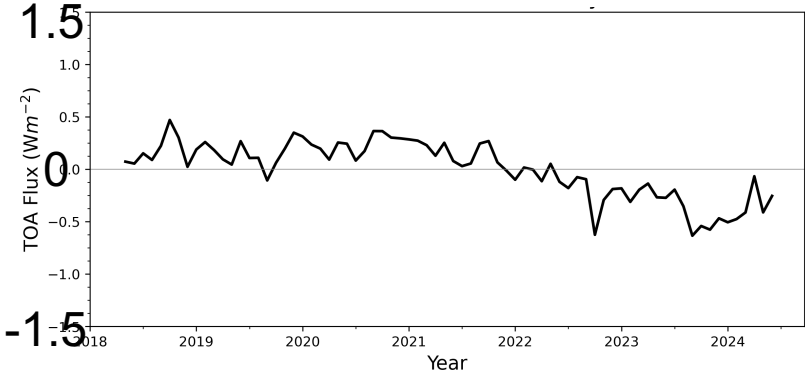
NH LW Anomalies



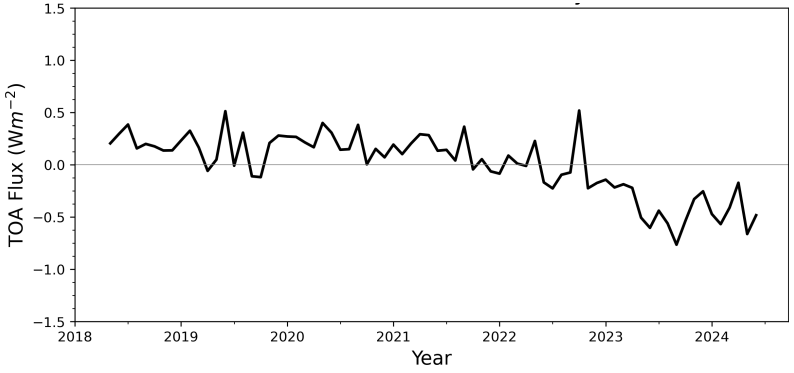
Global LW Anomalies



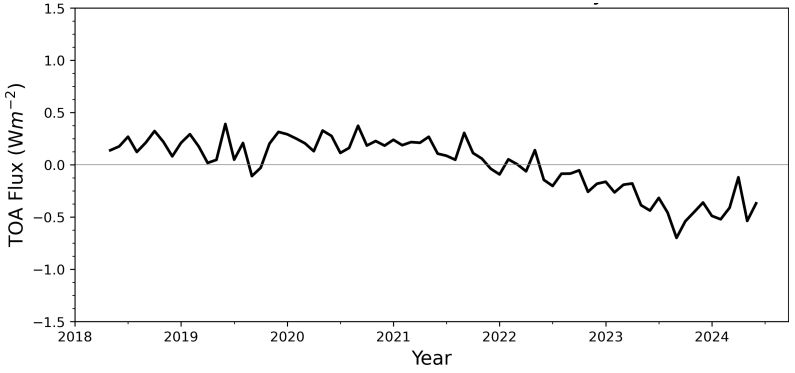
SH Ter-N20 LW Anomaly Diff



NH Ter-N20 LW Anomaly Diff

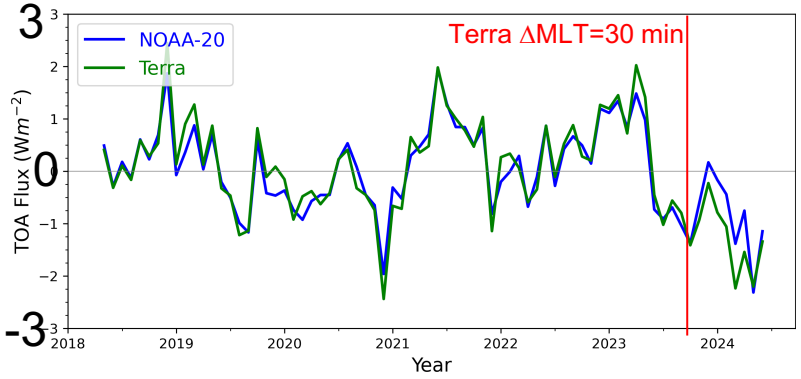


Global Ter-N20 LW Anomaly Diff

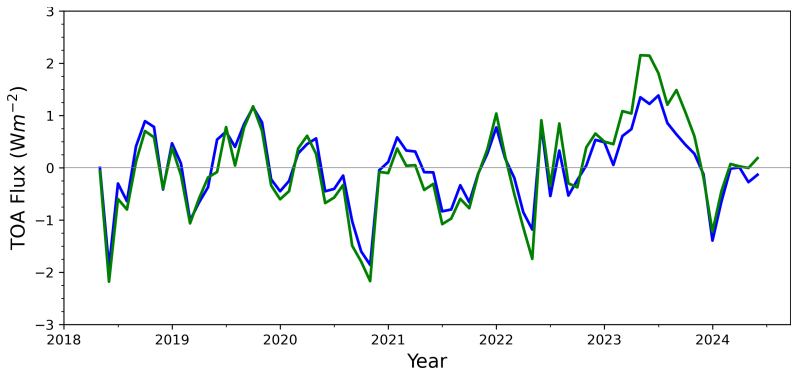


NET TOA Flux Anomalies for NOAA-20 (Fixed MLT) and Terra (Drifting MLT)

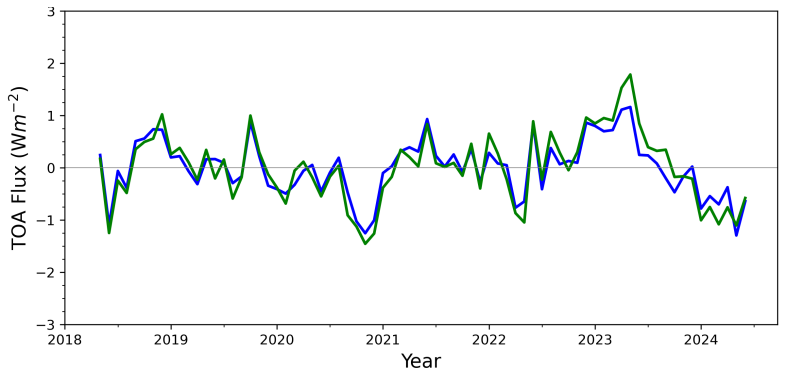
SH NET Anomalies



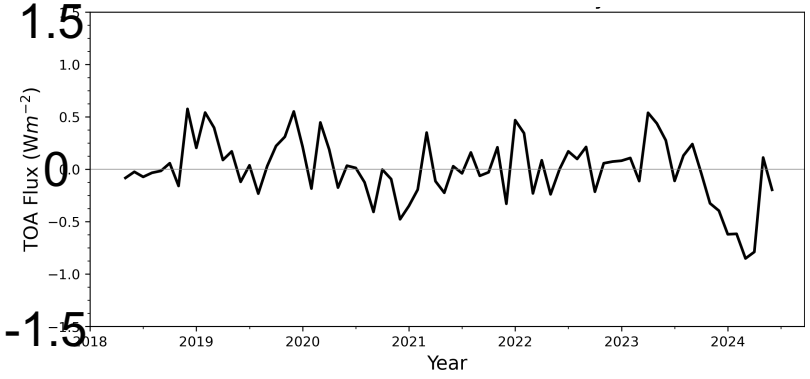
NH NET Anomalies



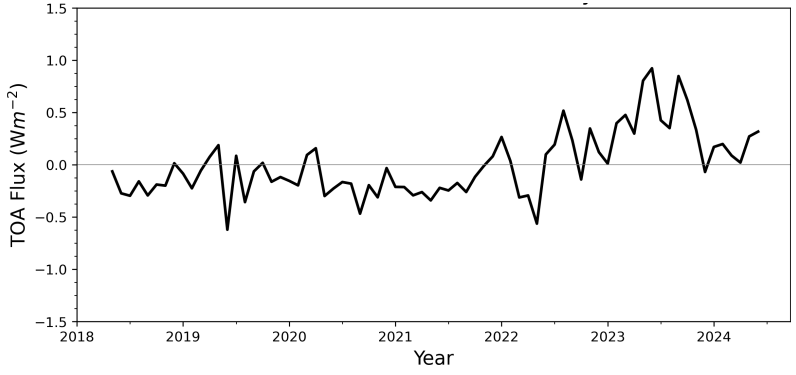
Global NET Anomalies



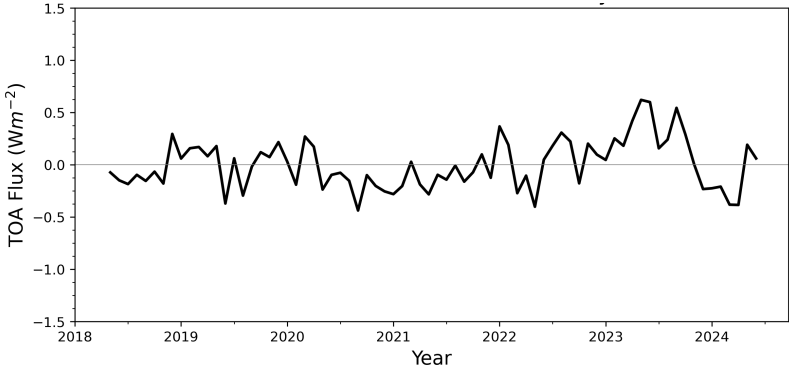
SH Ter-N20 NET Anomaly Diff



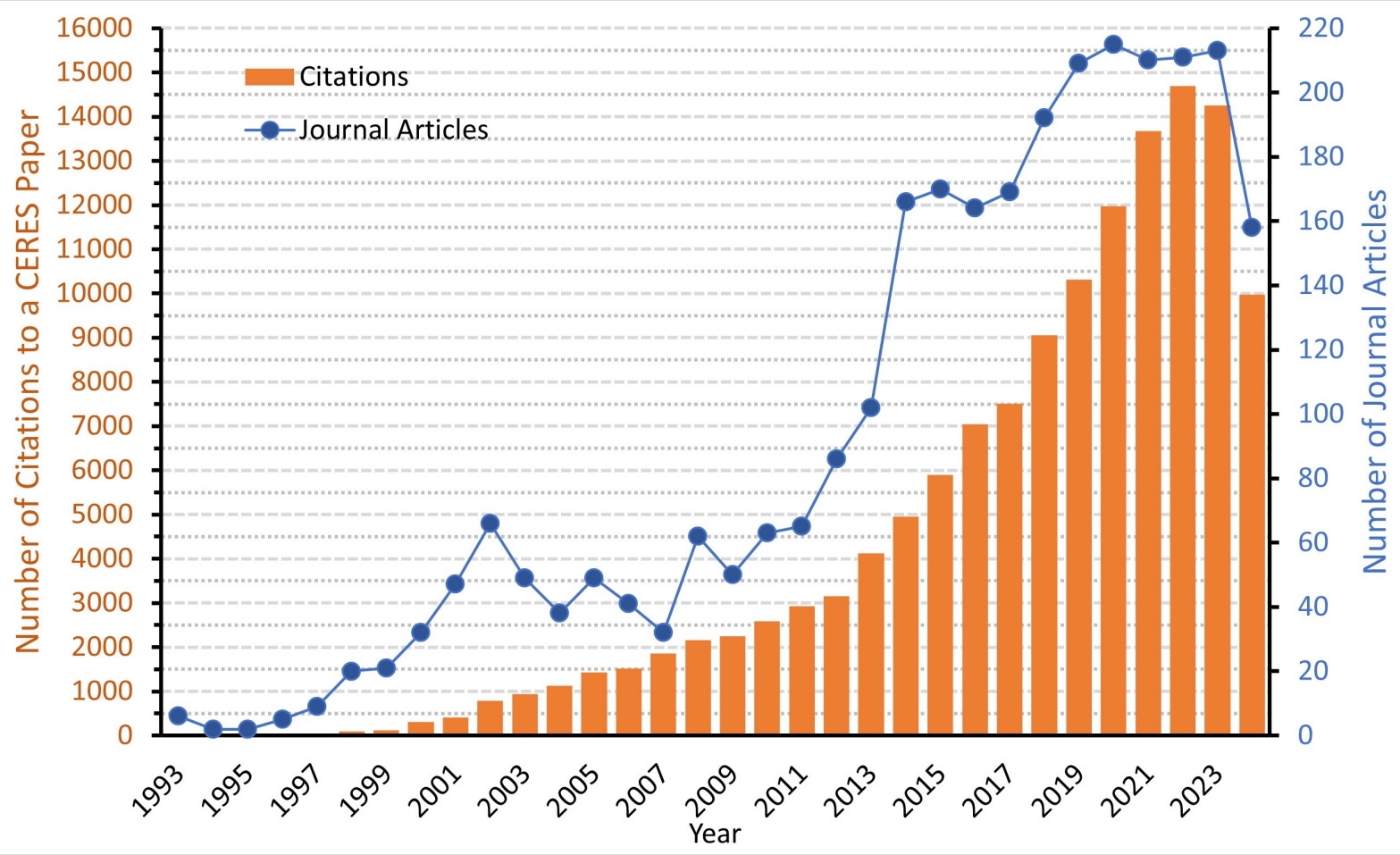
NH Ter-N20 NET Anomaly Diff



Global Ter-N20 NET Anomaly Diff



CERES Journal Publications and Citation Counts
(For Papers Between 1993-2024; Updated September 5, 2024)



- Total number of peer-reviewed journal articles: 2,924
- Total number of citations to CERES papers: 135,152

(Compiled by Dennis Keyes)

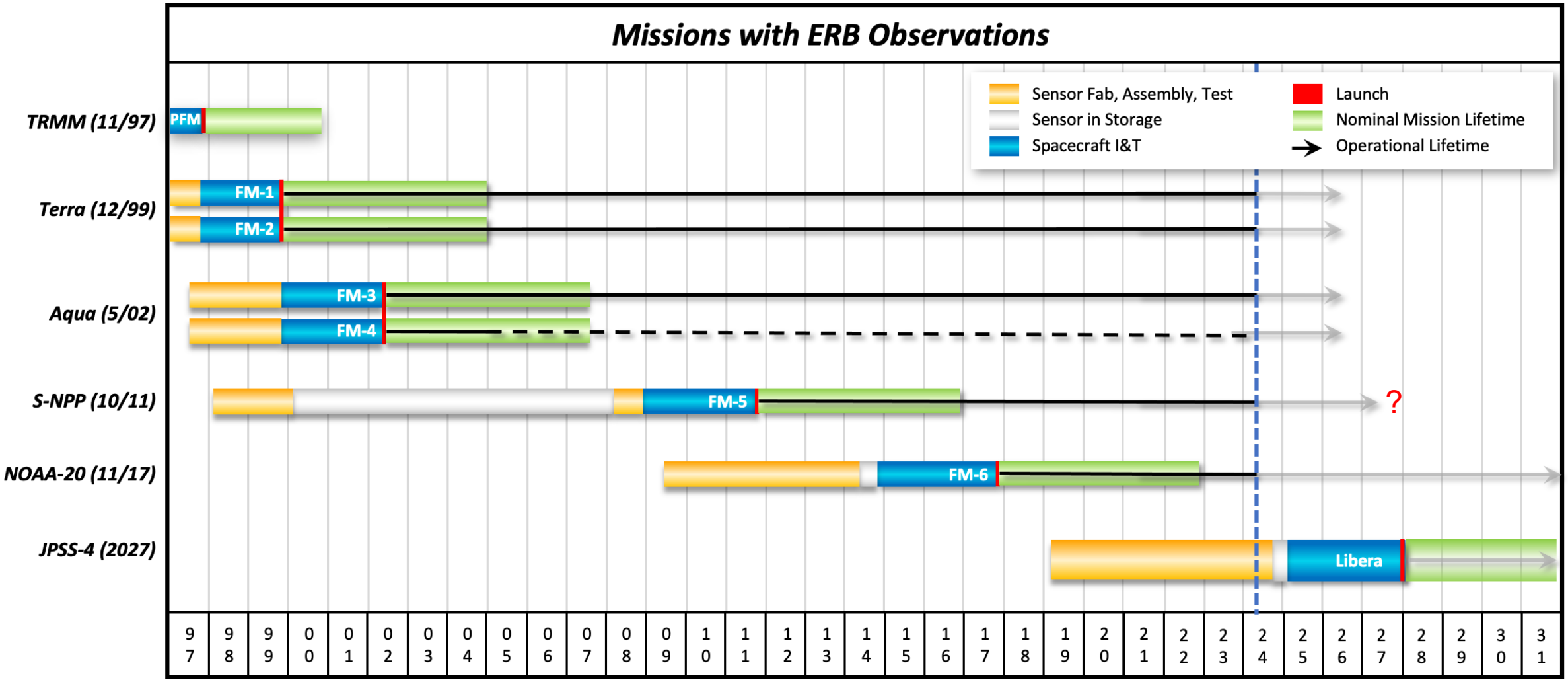
Number of Unique Users by CERES Data Product

(through September 15, 2024)

Level	Product	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
1b	BDS	11	13	14	10	12	23	29	31	14	14
2	SSF	253	278	327	235	251	245	266	272	276	408
	CCCM	55	54	49	49	36	45	58	64	75	26
	ES8	21	15	15	10	8	11	12	14	11	36
3 & 3b	EBAF	787	783	935	928	995	1041	1055	1202	1570	1185
	SYN1deg	438	494	607	639	754	854	886	923	973	794
	SSF1deg	160	194	190	159	221	213	226	261	177	162
	CldTypHist	40	47	86	87	79	86	94	83	116	77
	FluxByCldTyp						50	69	67	93	50
	ES4	13	12	17	17	17	11	17	16	15	11
	ES9	5	5	8	6	6	8	5	9	5	5

FLASHFlux via POWER since last year: **159K**

Flight Schedules



- Currently, 6 CERES instruments fly on 4 satellites: Terra (L1999), Aqua (L2002), SNPP(L2011), NOAA-20 (L2017)
- Libera scheduled for launch in 2027 on JPSS-4

Status of CERES Instruments on Terra, Aqua, S-NPP and NOAA-20

- 2023 Senior Review recommended extending Terra and Aqua for another 3 years
  - ➢ Anticipate end of science data collection in the latter part of 2026
- End date of S-NPP is unknown. Ongoing topic of discussion between NASA and NOAA
- CERES FM6 SW channel exhibited increased noise between November 2023-February 2024
  - ➢ Tiger team assembled to determine root cause
  - ➢ Problem appears to have gone away

Planning for CERES Edition 5

1) GMAO improvements to atmospheric reanalysis system.

   - CERES and GMAO hold Teams meetings every 3 weeks to gauge progress and provide ongoing validation results for GEOS-IT.

   - GEOS-IT reprocessing is up to date.

2) MODIS Collection 7. Release date for MODIS Level-1b is unknown. Requires approval by members of higher-level products.

3) CERES production code improvements.

4) CERES algorithm improvements (particularly those enabling a seamless transition across satellite platforms).

CERESMIP

- The Coupled Model Intercomparison Project (Phase 6) (CMIP6) protocol only uses observed forcings to 2014.
- However, climate variability since 2014 is quite pronounced and scientifically interesting (e.g., EEI and SST trends, PDO shifts, 2015/2016 El Nino, Marine Heat waves, etc.).
- In addition, many of the model inputs have been updated substantially since the CMIP6 inputs were defined.
- So why hasn't there been a coordinated effort to update climate model AMIP simulations?
- Gavin Schmidt (NASA GISS) is leading a new, relatively low cost, model intercomparison, CERESMIP, that will focus on the CERES period, with updated forcings to the end of 2021.
- The focus will be on atmosphere-only simulations, using updated SST, forcings and emissions from 1990-2021.
- The diagnostic focus will be on the EEI and atmospheric feedbacks, and so diagnostics should include output from the COSP simulator.
- A journal article describing CERESMIP has been published. https://doi.org/10.3389/fclim.2023.1202161
- New WCRP lighthouse activity on Explaining and Predicting Earth System Change (EPESC) with a focus on Earth's Energy Imbalance has been established.

CRAVE — CERES Radiation and Validation Experiment
https://science.larc.nasa.gov/CRAVE/

GRANITE ISLAND (GI)

- Solar tracker failed in mid-January (Lost dnSW direct and diffuse). Tracker replaced in late April.
- The site is back to full operations as of April 2024.
- Data availability: 2018 July – 2024 August.

Two recent conferences:

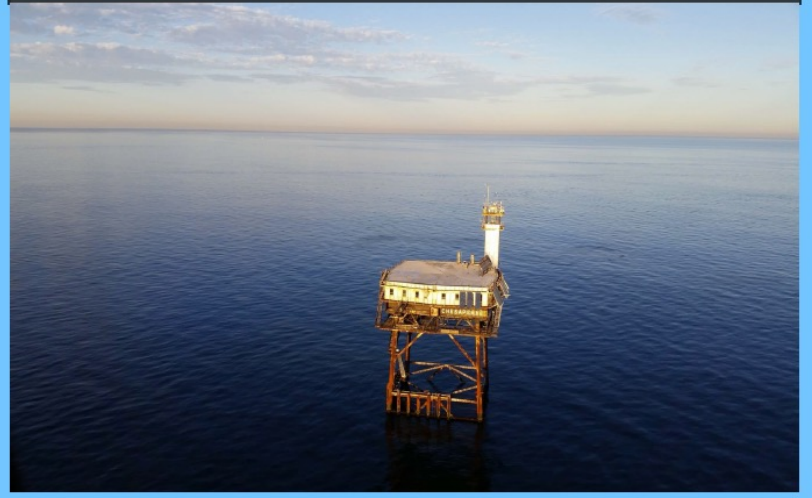
- 18th BSRN Scientific Review and Workshop
- AERONET Science and Application Exchange

LaRC

- Normal operations except AERONET removed for calibration and repair: ~March 4 – May 7, 2024.
- NMU Summer internship completed 6th year.
- Data availability: 2014 December – 2024 August.

COVE (Legacy)

- Data availability: 2000 May – 2016 November.



Publications		
	Total	N in last year
GI	10	6
LaRC	26	8
COVE	155	10

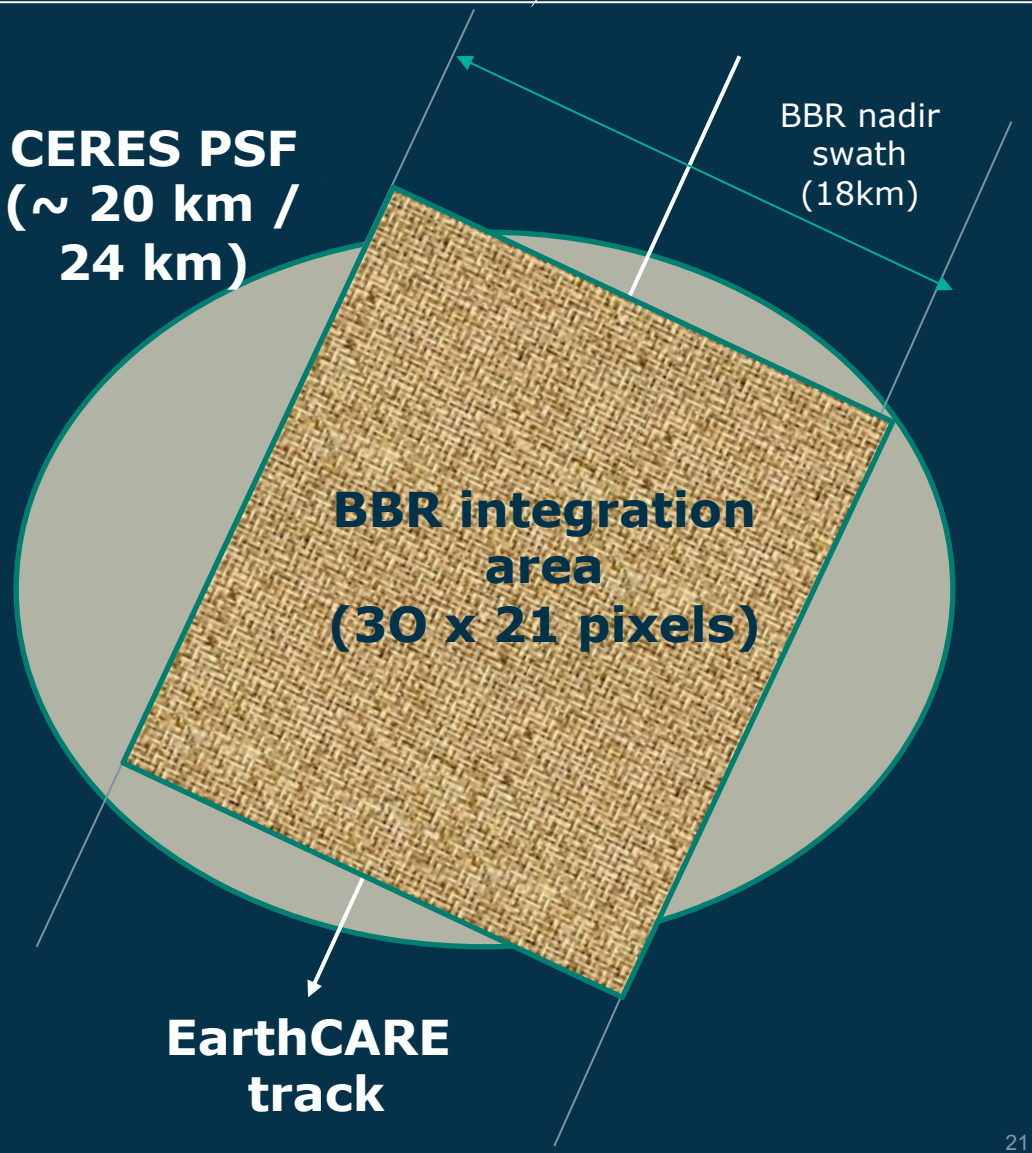
EarthCARE

- Launched on May 28, 2024
- All instruments performing nominally
- Public release of the level 1 is foreseen for early December, but the CERES team has access to the data for the Cal/Val activity

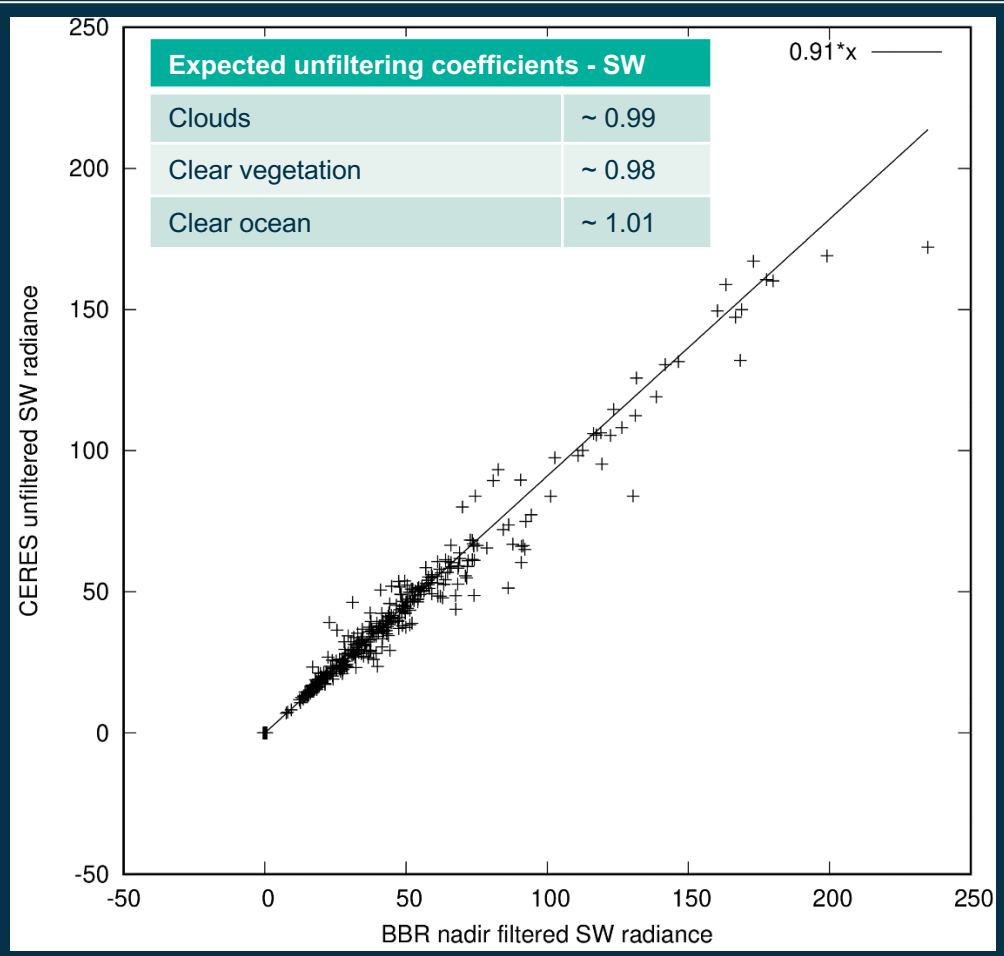
B-SNG intercomparison with CERES - method

- CERES = Cloud and Earth Radiant Energy System
- Level 2 SSF (Single Scanner Footprint) product
- Only FLASHFlux products available from across-track instrument on:
  - FM1 on Terra (morning)
  - FM6 on NOAA20 (afternoon)
- Point Spread Function of ~20 km (Terra, Aqua) or ~ 24 km (SNPP, NOAA20) -> larger than BBR swath (~18km)
- BBR integration area :

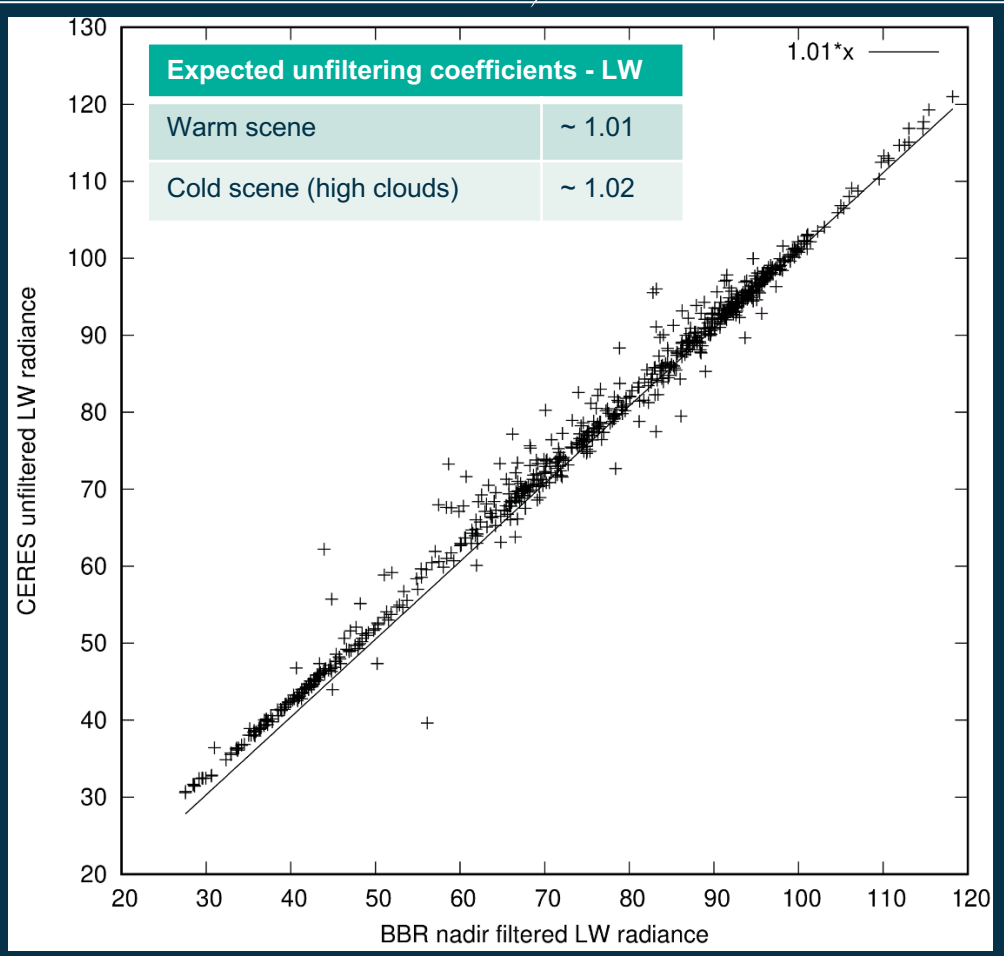
  30 (across track) x 21 (along-track)
- Collocation criteria
  - Time difference dt < 300 seconds
  - distance between PSF centers < 3km
  - VZA difference < 3°
- Dates : 10/08/2024 – 09/09/2024



B-SNG intercomparison with CERES - SW



- SW channel appears brighter than CERES of about 8% (after unfiltered)



- LW channel very consistent with CERES
- Very cold scenes too cold wrt CERES (only partly explained by the higher unfiltering factor)

DEMETER Instrument Incubator Program (IIP23) Proposal Selected

- PI: Anum Ashraf
- DEMETER = DEMonstrating the Emerging Technology for measuring the Earth's Radiation
  - Next-generation small satellite approach to sustain the Earth Radiation Budget Climate Data Record via a novel concept that reduces size, mass, cost, risk, and development time of Earth observing remote sensing platforms.
- Originally selected under IIP 2019
- IIP 2023 is a 2-year effort that matures all DEMETER subsystem assemblies to TRL 6 by demonstrating system-level performance in a representative operational environment.
- Additional funding over and above IIP23 allows DEMETER team to start mission maturation in addition to technology development

Upcoming Conferences & Meetings of Interest

Fall AGU
- December 9-13, 2024, Washington, DC

AMS Annual Meeting
- January 12-16, 2025, New Orleans, LA

EGU General Assembly
- April 27-May 2, 2025, Vienna, Austria

Spring 2025 CERES Science Team Meeting
- May 13-15, 2025, NASA Langley Research Center, Hampton, VA

ESA Living Planet Symposium
- June 23-27, 2025, Vienna, Austria