State of CERES

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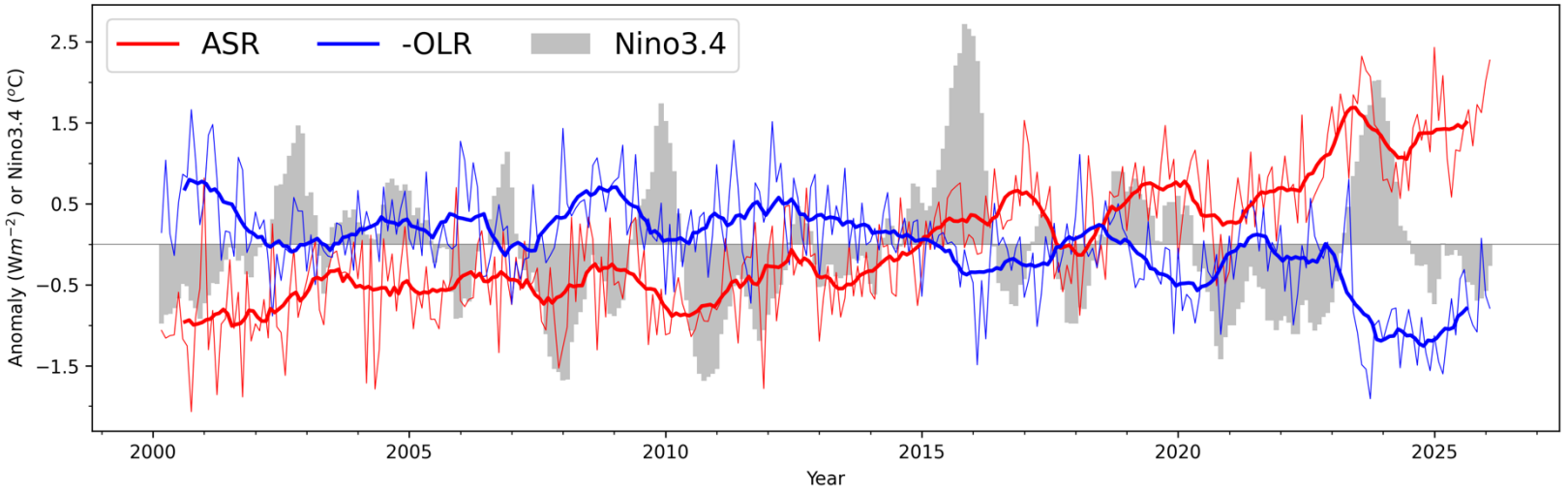
CERES Science Team Meeting, May 12-14, 2026
NASA Langley Research Center, Hampton, VA

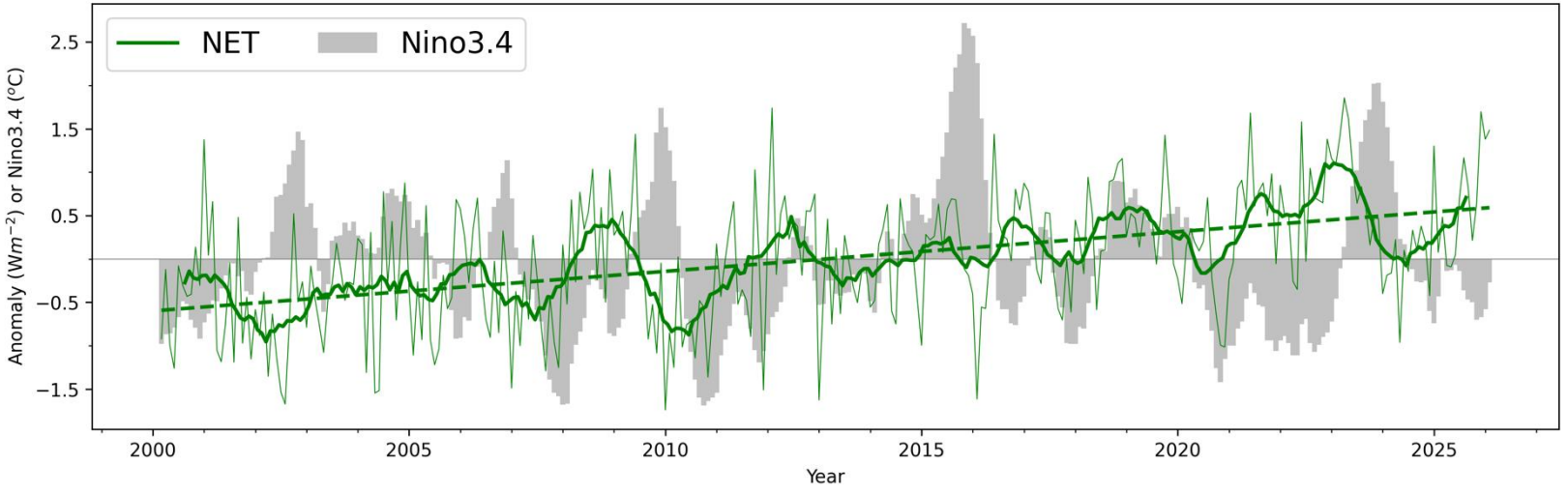
CERES Technical Meeting

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 Ed4.2.1; 03/2000–02/2026)





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

ASR: 0.89 ± 0.22

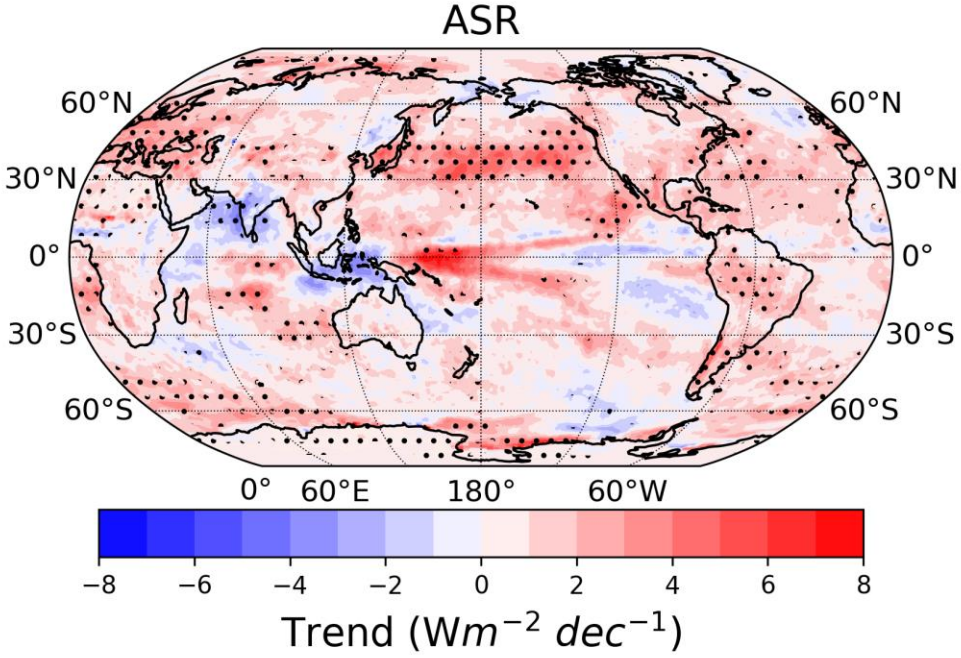
–OLR: –0.44 ± 0.23

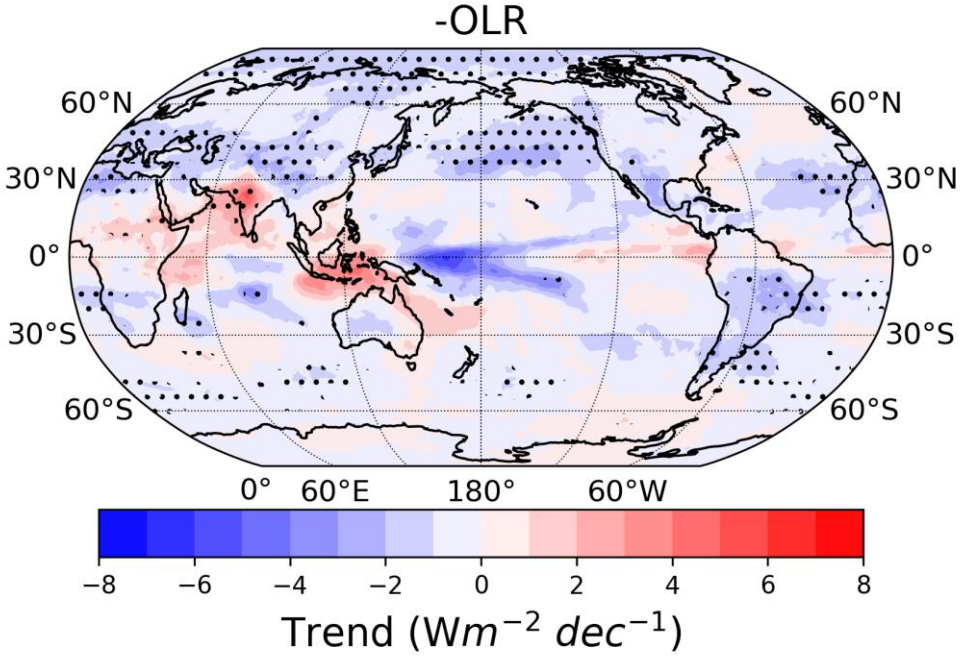
NET: 0.46 ± 0.16

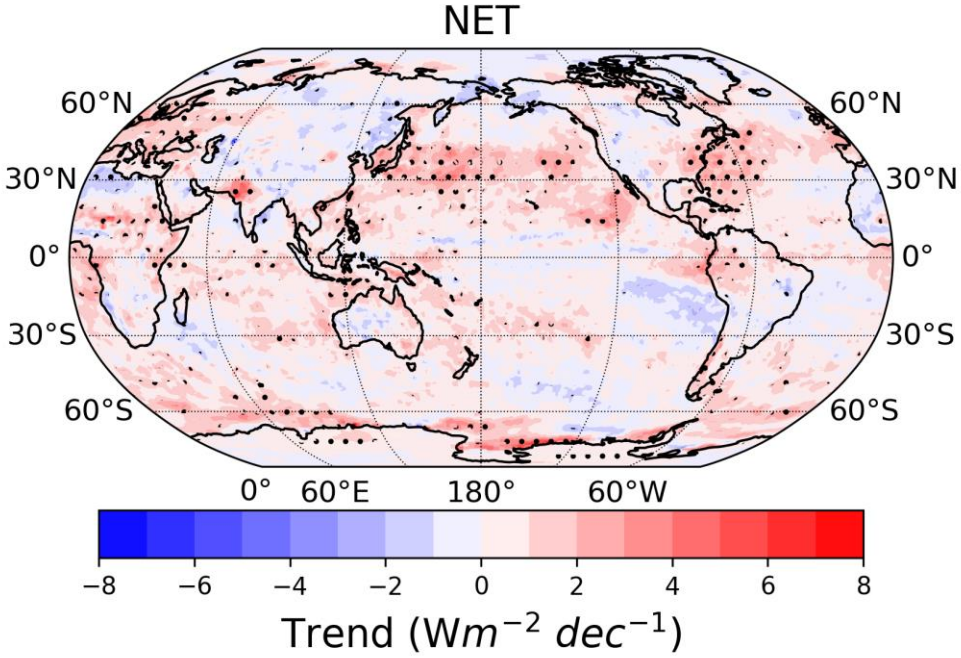
Units: Wm^{-2}	Solar Irradiance	ASR	–OLR	NET
03/2000-02/2010	340.14	240.73	–240.20	0.53
03/2016-02/2026	340.23	242.12	–240.87	1.25
Difference	0.090	1.39	–0.67	0.72

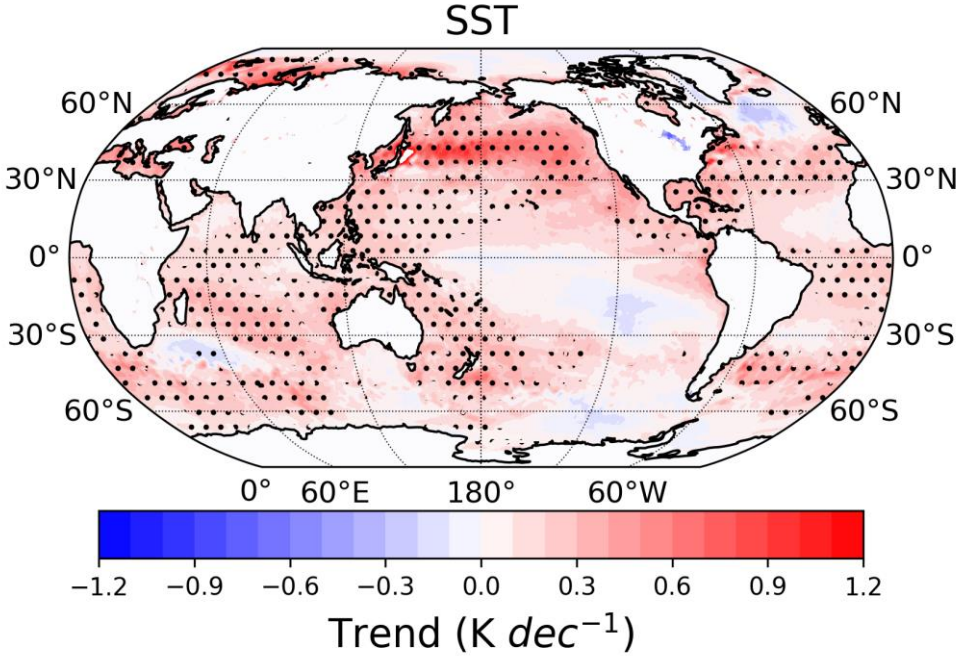
Doubling in EEI!

Trends in TOA Radiation and SST (03/2000–02/2026)









Earth’s Energy Imbalance (EEI) Workshop

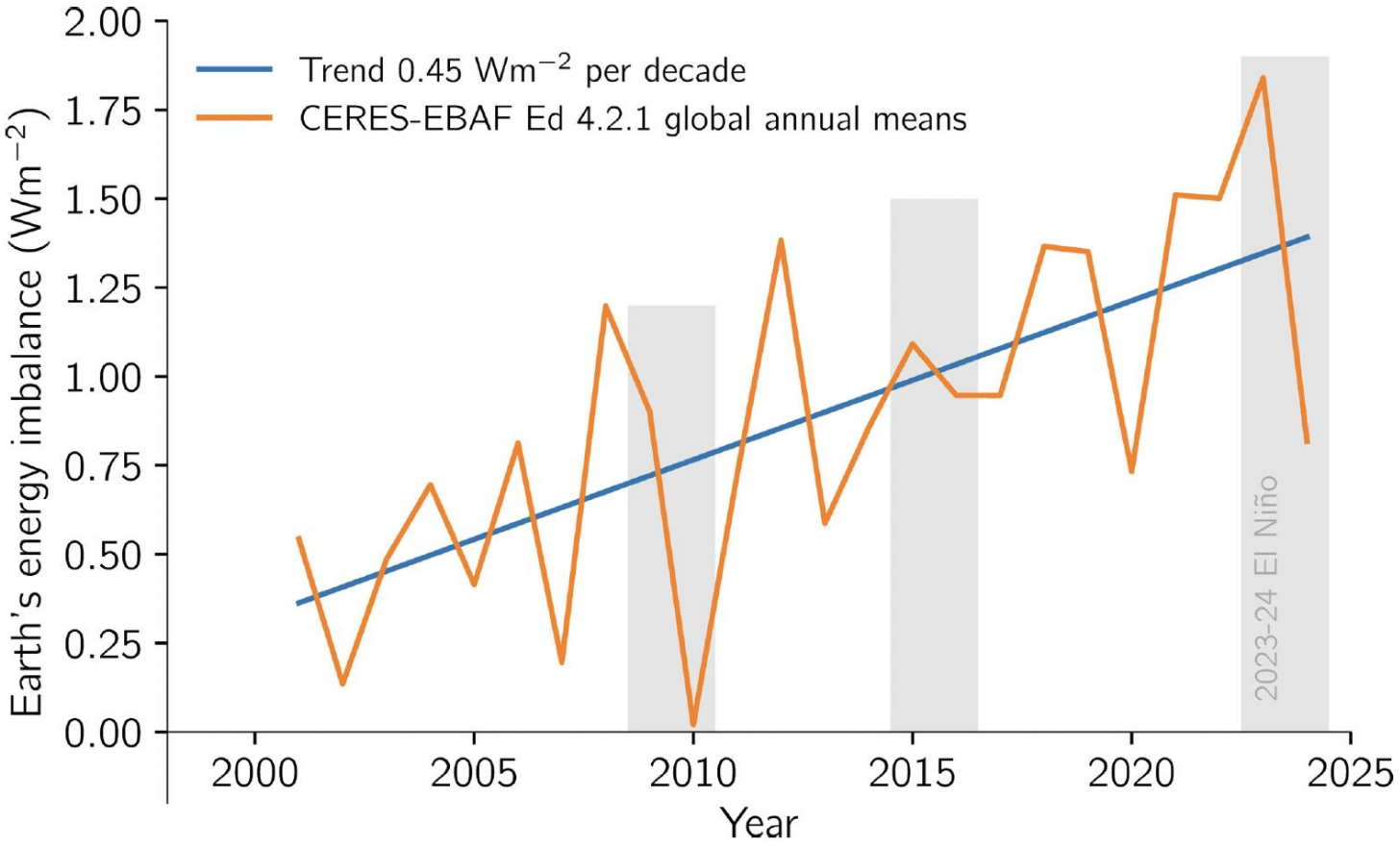
Schloss Ringberg, Germany

March 16-20, 2026

Host: Bjorn Stevens

- Approximately 45 participants from satellite, ocean, modeling and theoretical communities.
- Also included EarthCARE and ORCESTRA representatives.
- Venue: Schloss Ringberg Castle in Bavaria.

Earth's Energy Imbalance



0.45 Increasing trend in Earth's Energy Balance

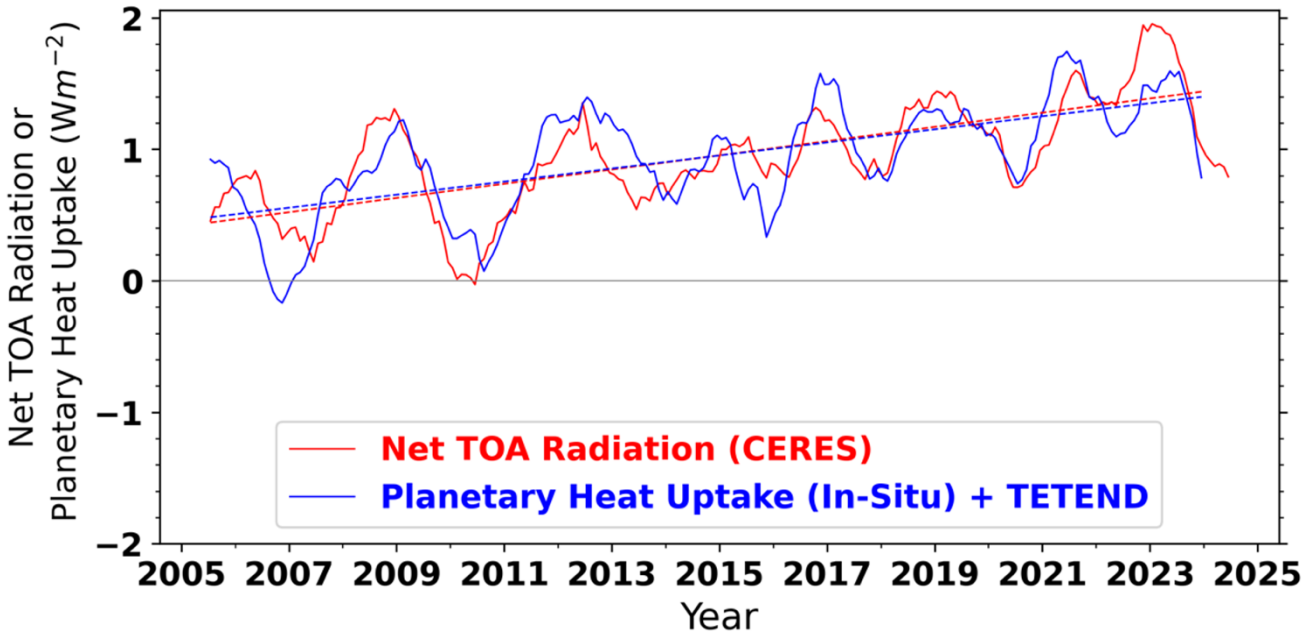
1. Do we believe the results?
2. If so, do we understand it?

High Level Statements

- **We have high confidence that EEI is increasing with a trend of in the range [0.3,0.5] Wm^{-2} dec^{-1} for 2005–2024.**
  - In-situ based estimates: 0.3 Wm^{-2} dec^{-1} [0.15 statistical uncertainty]; CERES and hybrid approach: 0.45 Wm^{-2} dec^{-1} [+/-0.2 statistical uncertainty]. They all agree within uncertainty. Hybrid method reproduces CERES interannual variability while in-situ only is very noisy.
  - It is urgent to reconcile the discrepancy between in-situ and hybrid OHU estimates.
  - Remaining concern about magnitudes of CERES ASR and OLR trends.

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

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



	Trend (Wm^{-2} dec^{-1}) 02/2005-06/2024
CERES EBAF Ed4.2	0.54 ± 0.27
In-Situ	0.50 ± 0.27
Difference	0.04 ± 0.21
R	0.82

High Level Statements

- Atmospheric General Circulation Model simulations initialized with observed sea-surface temperatures and sea-ice concentrations and historical forcing agents underestimate the observed EEI trend.
- Furthermore, the trend in climate forcing is approximately equal to the trend in EEI.
    - This would imply that equilibrium climate sensitivity (ECS) is much higher than what climate models project, perhaps as much as a factor of two or three larger.
- Workshop participants identified numerous possible reasons for the discrepancy and their implications considering present observations and understanding:

(1) Theory is inadequate **(5)**

(2) ECS is higher than we thought **(5)**

(3) Observed EEI trend is too large, which would imply that CERES is wrong, but this is unlikely to explain the full magnitude of the discrepancy **(0)**

(4) Climate forcing estimates are too small. Estimates of F, particularly the aerosol contribution, are still rather adhoc and based on models, so this requires additional critical inspection **(12)**

(5) The deviation from the expected forced response at equilibrium during the CERES period (e.g., due to a different SST pattern) is not well known **(8)**

High Level Statements

Looking forward:

- We see an opportunity to better partition the deep ocean contribution to the energy budget
- The partitioning in N (SW/LW, clear/cloud, regional & hemispheric) should help clarify the likelihood of some the above scenarios
- We see an increasing capacity and skill in attributing changes into specific process
- A concerted effort to develop a framework for reconciling the above issues would immensely be valuable
    - Propose a 5-year study (funded privately). Hire research fellows to advance understanding of EEI. Steering committee to oversee the research. Meet annually to track progress.
- Show importance of ongoing measurements (e.g., DEMETER) with stakeholders and public
    - Continuation of the ERB measurements beyond CERES and Libera is critically important
    - Currently there are no plans for ERB measurements after Libera

CERESMIP: Progress/Prospects

A CMIP6plus effort to focus on CERES data as a target for climate models

Goal: Reduce and/or understand the gap between climate models and CERES trends in EEI and SW/LW split

Update aerosol/SLCF/SST/sea ice forcings to best (CMIP7) estimates to 2023+

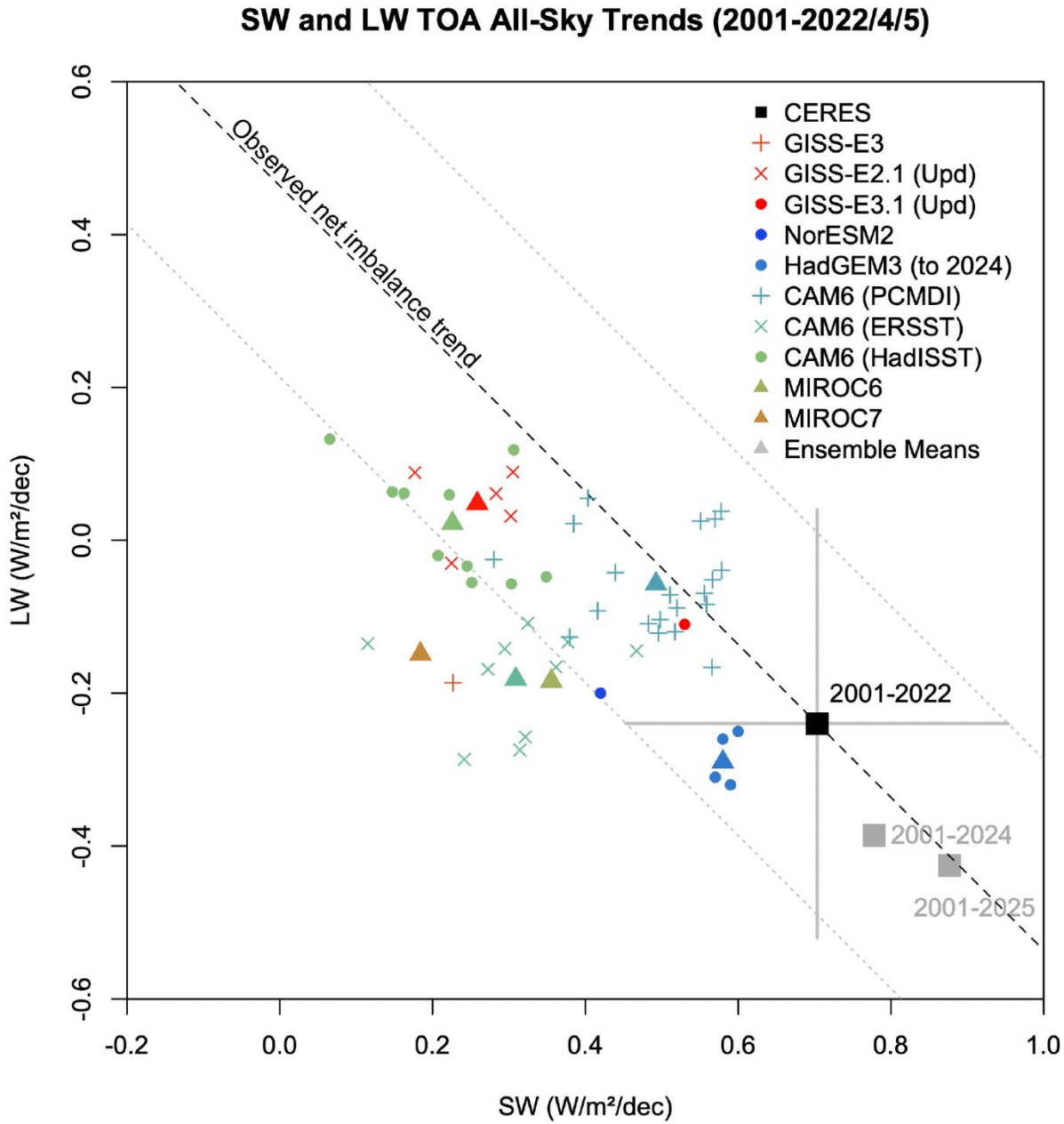
- Big changes in Chinese aerosols, IMO-regulations on shipping emissions
- SST/sea ice estimates (more warming in SH than previously, more SIC decrease post 2015)
- Single-forcing ensembles for attribution
- Protocol described in Schmidt et al. (2023)

New funding (~$500K) from Spark Climate Solutions to help focus

- Active international team (UKMO, NASA, NCAR, GFDL, ECMWF, NorESM, MIROC…)
- Multi-model approach critical
- Workshop planned in Vancouver (Dec, 2026).

CERESMIP: Initial results

- Many new AMIP-historical runs with updated forcings.
- Overall gap between models and CERES is smaller - but still significant
- Net is reasonable, SW trends still underestimated (by ~0.2 W/m^2/dec)
- Clear sensitivity to SST/SIC
- Models have varying skill!



CERESMIP: Plans

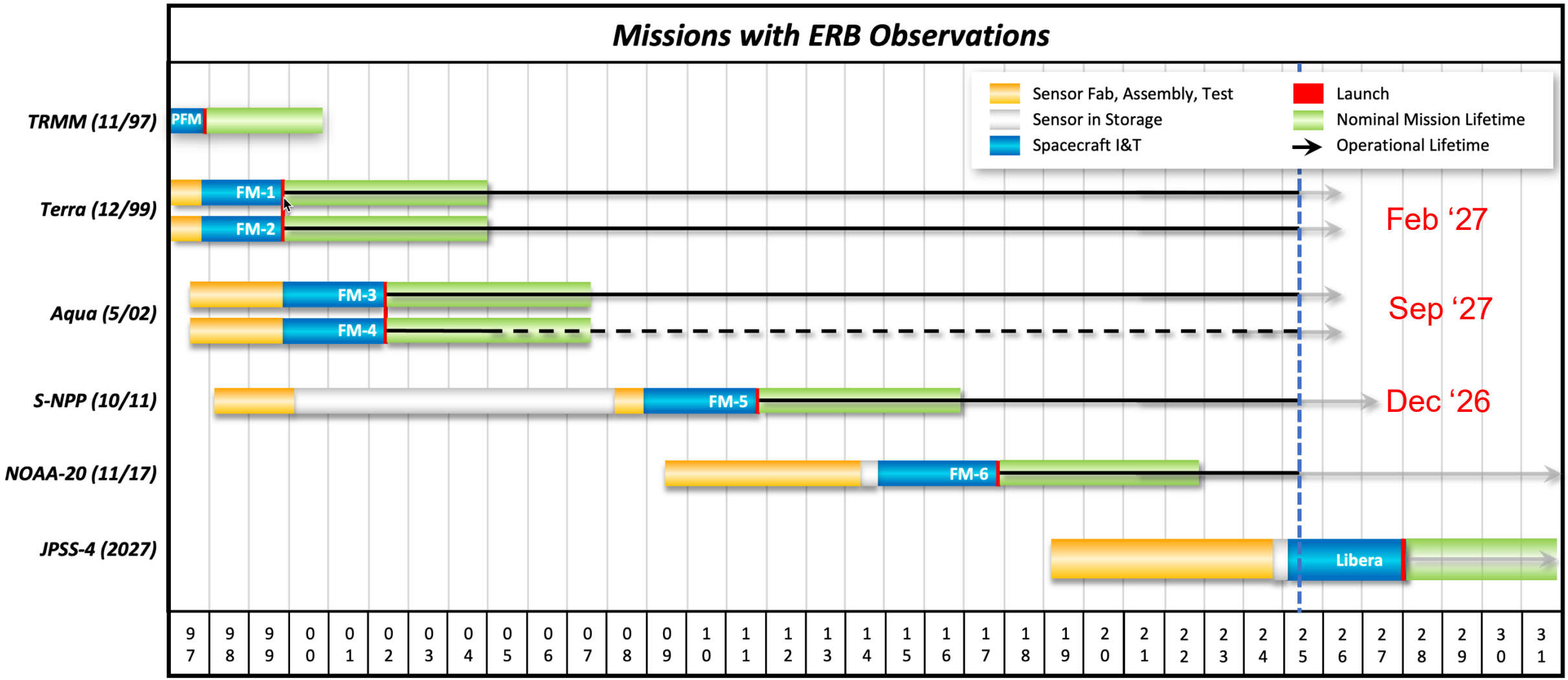
- Filling out experiment design (next few months)
- New models still welcome!
- Focused diagnostics (by end of year):
  - By forcing element (aer, ghg, sol, SST/SIC, etc.)
  - By hemisphere/region
  - By regime/cloud type
- Paper(s) will be in prep by end of year. Submission before March 2027.
- Subscribe to

  ceresmip-l@lists.nasa.gov

  for updates

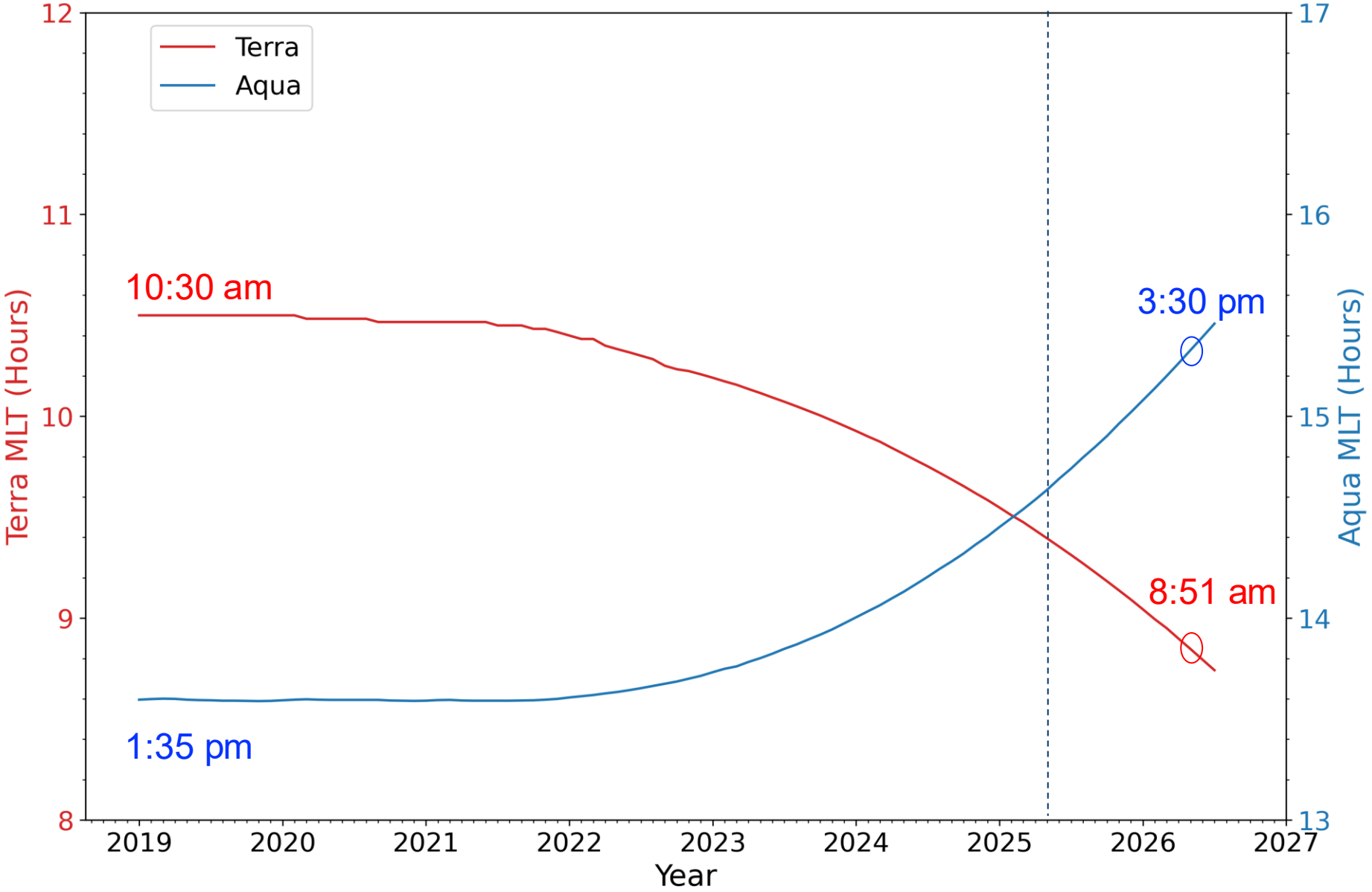
- Data will eventually be available on ESGF (cmip6plus/ceresmip)

Flight Schedules



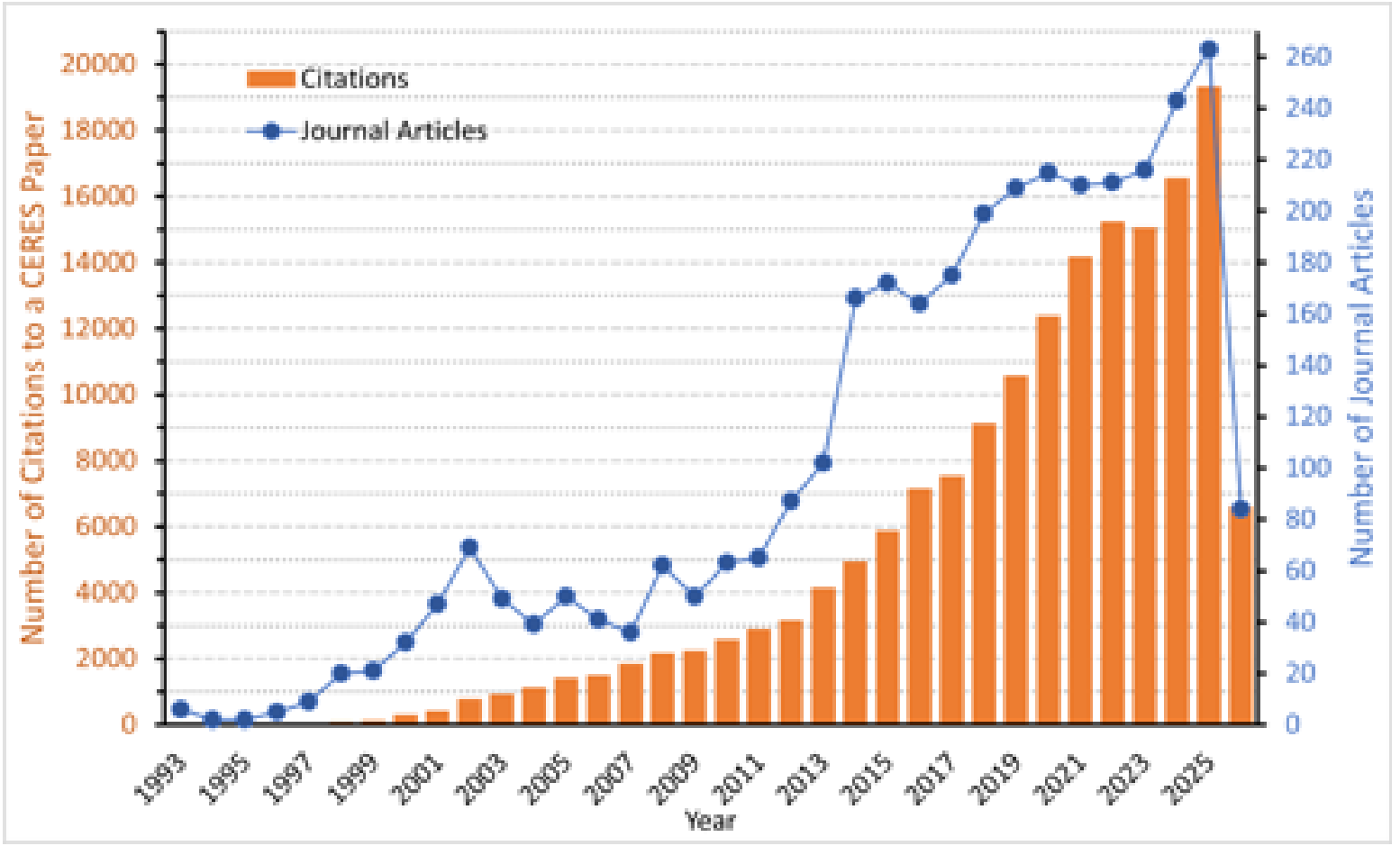
- Currently, 6 CERES instruments fly on 4 satellites: Terra (L1999), Aqua (L2002), SNPP(L2011), NOAA-20 (L2017)
- Libera scheduled for launch in 2027 on JPSS-4

Terra and Aqua Mean Local Equatorial Crossing Times (MLTs)



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

CERES Journal Publications and Citation Counts
(For Papers Between 1993-2026; Updated May 7, 2026)



- Total number of peer-reviewed journal articles: 3,384
- Total number of citations to CERES papers: 170,585

(Compiled by Dennis Keyes)

Number of Unique Users by CERES Data Product

(through April 30, 2026)

Level	Product	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
1b	BDS	14	10	12	23	19	30	19	30	44	19
2	SSF	327	235	251	245	246	273	288	436	476	223
	FLASH_SSF	68	101	92	103	101	124	72	71	64	27
	CCCM	49	49	36	45	53	62	78	58	62	29
	ES8	15	10	8	11	8	14	8	37	61	19
	SSF-MISR	3	1	1	4	3	7	0	13	10	7
	CRS				2	1	4	20	37	60	41
3 & 3b	EBAF	935	928	995	1041	994	1196	1589	1747	2010	862
	SYN1deg	607	639	754	854	858	918	984	1118	1299	587
	SSF1deg	190	159	221	213	208	255	188	228	249	73
	CldTypHist	86	87	79	86	84	83	119	114	124	32
	FluxByCldTyp				50	62	67	94	65	96	59
	ES4	17	17	17	11	14	15	19	13	14	6
	ES9	8	6	6	8	5	8	6	7	11	4
	FLASH_TISA	52	65	81	131	107	116	95	90	118	37
	CRS1deg								61	42	9

Planning for CERES Edition 5

1) Atmospheric reanalysis system

   - ECMWF ERA-5 T_s, T and q for standard CERES products
   - GMAO GEOS-IT aerosols for Fu-Liou based surface radiative fluxes in SSF (L2)
   - GMAO GEOS-IT for FLASHFlux

2) MODIS Collection 7. MODIS Level-1b is currently being reprocessed.

3) CERES production code improvements.

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

Planning for Libera

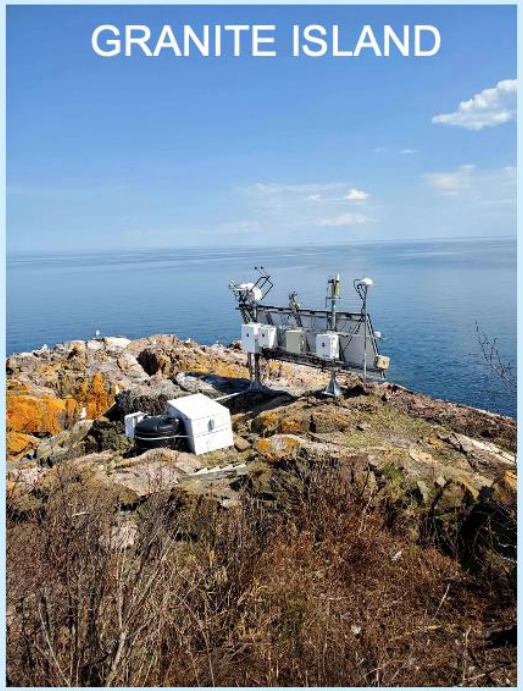
1) Bi-weekly meetings with Libera team, NASA HQ, ESSPO
2) Calibration WG meetings
3) DMT WG meetings
4) Periodic on-site visits at LASP by CERES Instrument WG
5) Intercalibration of CERES FM6 and Libera
6) New approach for inferring split SW fluxes from Libera measurements

Intercalibration of CERES FM6 and Libera

- ERB CDR requires overlap between successive instruments on different satellites
  - Ideally, this is achieved using measurements coincident in time, location, and viewing geometry (e.g., simultaneous nadir overpass (SNO) method)
- While NOAA satellites are in the same 1:30PM orbit and altitude, they are phased such that time-matched measurements are not possible
- An alternate approach is to use geostationary (GEO) imagers as “transfer radiometers” between ERB instruments on different NOAA satellites (e.g., FM6 and Libera)
- Place ERB instruments in GEOscan mode
  - Enables angle-matched ERB and GEO measurements

******See Presentation by Kyle Itterly on Thursday morning******

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



- Operations were normal until an island-wide internet failure in Jan 2026.
- Internet restored early May. Most instrumentation is okay, but the solar tracker and AERONET are unresponsive.
- Presented CRAVE and Granite Island to Northern Michigan University students and faculty Oct 2025.
- Data availability: 2018 Jul – 2025 Dec

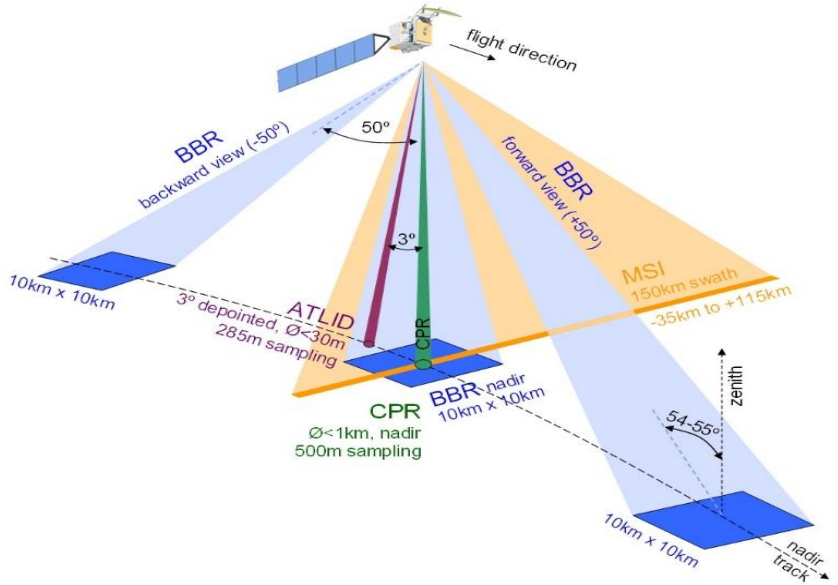
- Normal operations.
- In-house engineered automatic shade/unshade system enables autonomous SW calibrations.
- NMU summer internship completed its 7th year.
- Installed a 2nd PAR for redundancy.
- Data availability: 2014 Dec – 2026 Apr

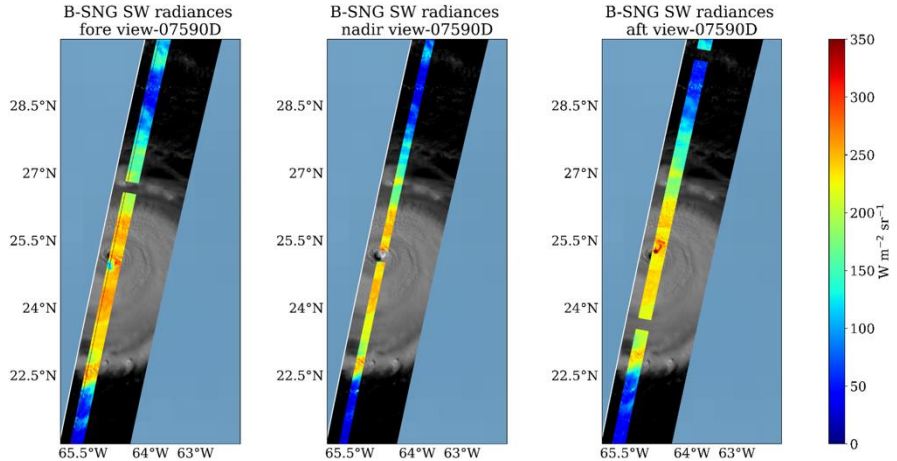
- Article “The Component Summation Technique for Measuring Upwelling Longwave Irradiance in the Presence of an Obstruction” published in Atmospheric Measurement Techniques (Oct 2025)
  DOI: https://doi.org/10.5194/amt-18-5939-2025
- Data availability: 2000 May – 2016 Nov

Publications			
	Total	2023-2026	2026 YTD
GI	24	13	3
LaRC	65	42	6
COVE	195	38	6

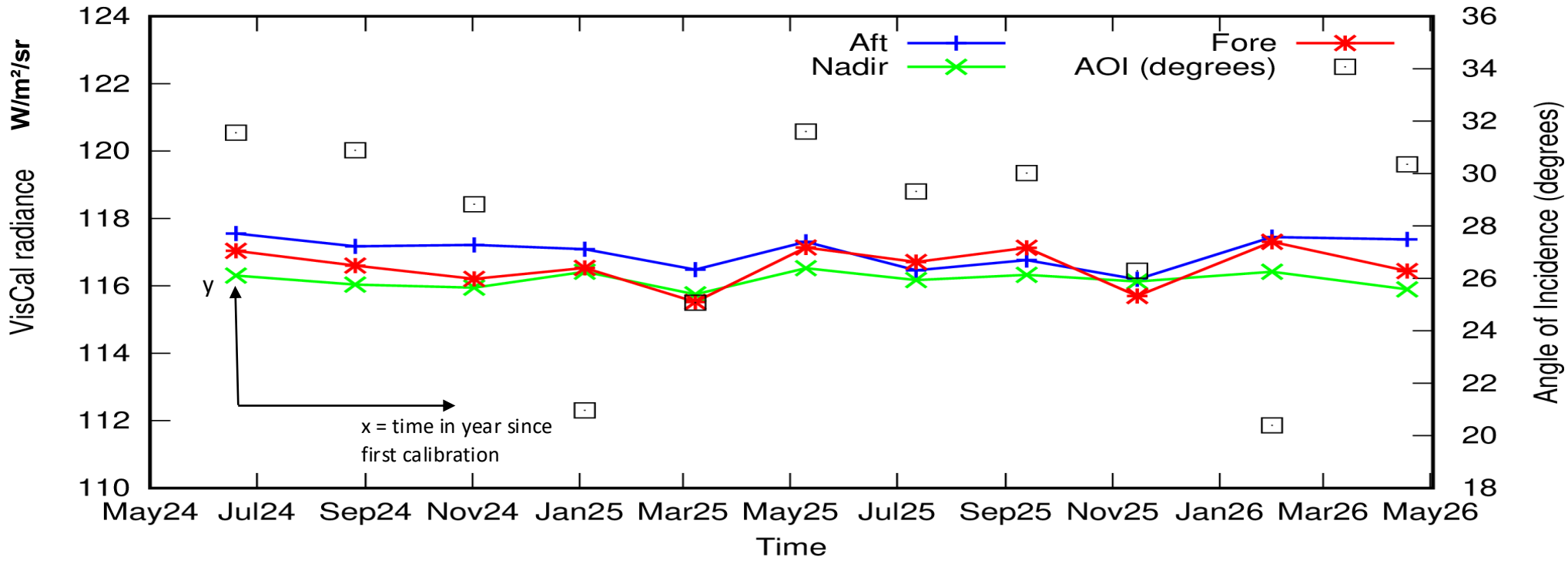
EarthCARE mission and the BBR

- EarthCARE (Earth Cloud Aerosol Radiation Explorer) is a process oriented mission (not long term monitoring).
- 4 instruments : cloud radar (CPR), lidar (ATLID), imager (MSI), and broadband radiometer (BBR).
- BBR primary for “closure” assessment: quantify how well we observe clouds and aerosols and model their effects on the radiation.
- Original mission lifetime was significantly extended (2034 or beyond) → BBR currently operated 5 days out of 20 (to protect rotating drum).
- Regular monitoring of the BBR wrt CERES FLASHflux (FM6) and SSF (FM6, FM3, FM1). Data compare well with CERES (within 1%-3%).
- Current attempts to use the solar diffuser for the (long term) monitoring of the SW channel of the 3 telescopes are encouraging. (see next slide)
- Overall the BBR instrument is working well and is stable.





BBR VisCal Observation (solar diffuser obs. ~ each 2 months)



Best fits (y=VisCalRad, x = time in year since "20240626"):

- **Aft : y = 117.15 (±0.26) – 0.16 (± 0.25)* x (RMSE=0.43 W/m²/sr)**
- **Nadir : y = 116.17 (±0.15) + 0.01 (± 0.14)* x (RMSE=0.24 W/m²/sr)**
- **Fore : y = 116.55 (±0.34) + 0.03 (± 0.33)* x (RMSE=0.56 W/m²/sr)**

(uncertainty at 1σ , no autocorrelation)

- **No significant drift / jump in signal between the campaigns so far**
- **The BRDF seems to correctly account for the dependency on the Angle Of Incidence (AOI) of the Sun on the diffuser.**

Upcoming Conferences & Meetings of Interest

2nd GEWEX Earth's Energy Imbalance Assessment Workshop

- June 1-5, 2026, Pasadena, CA

AMS Radiation Conference

- August 3-7, 2026, Madison, WI

Fall 2026 CERES Science Team Meeting

- TBD. Possibly in the UK, jointly with other science teams

Fall AGU

- December 7-11, 2026, San Francisco, CA
- Session: "Progress towards understanding the the growing Earth's Energy Imbalance"

AMS Annual Meeting

- January 10-14, 2027, Denver, CO