State of CERES

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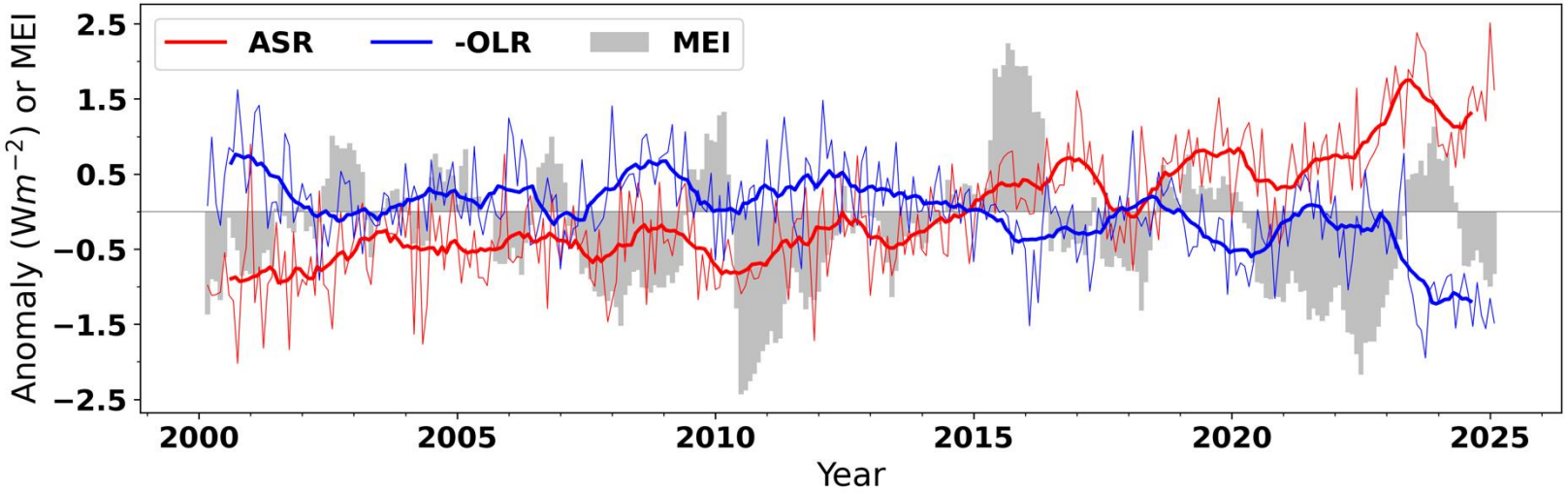
CERES Science Team Meeting, May 13-15, 2025
NASA Langley Research Center, Hampton, VA

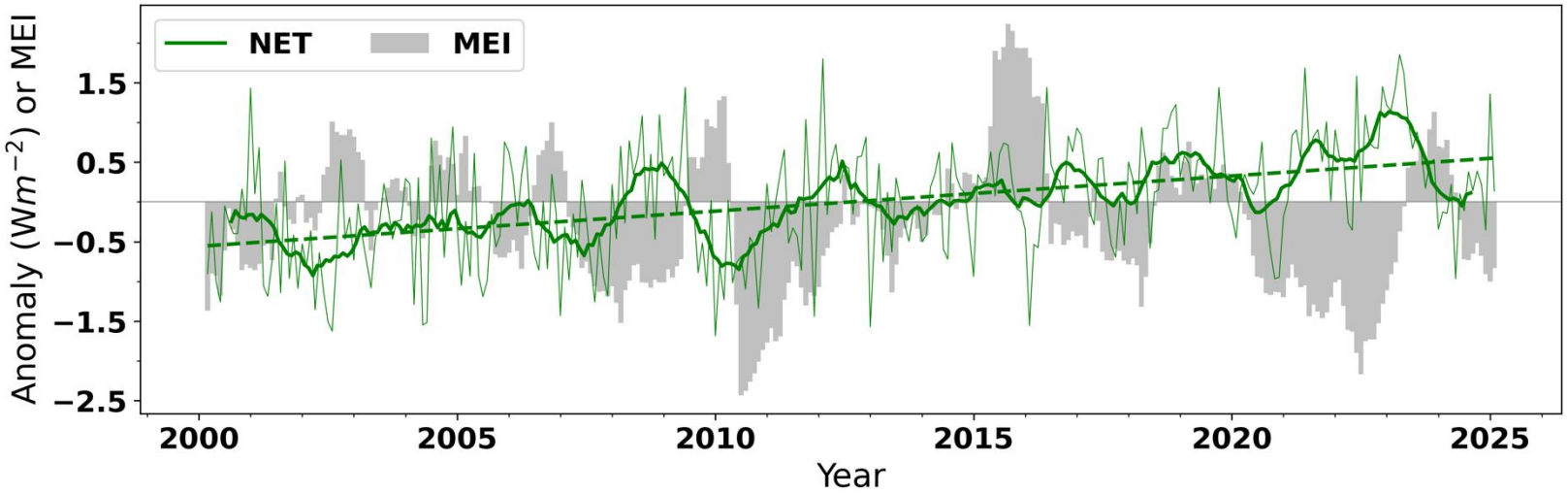
CERES Technical Meeting

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; 03/2000–02/2025)





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

ASR: 0.85 ± 0.22

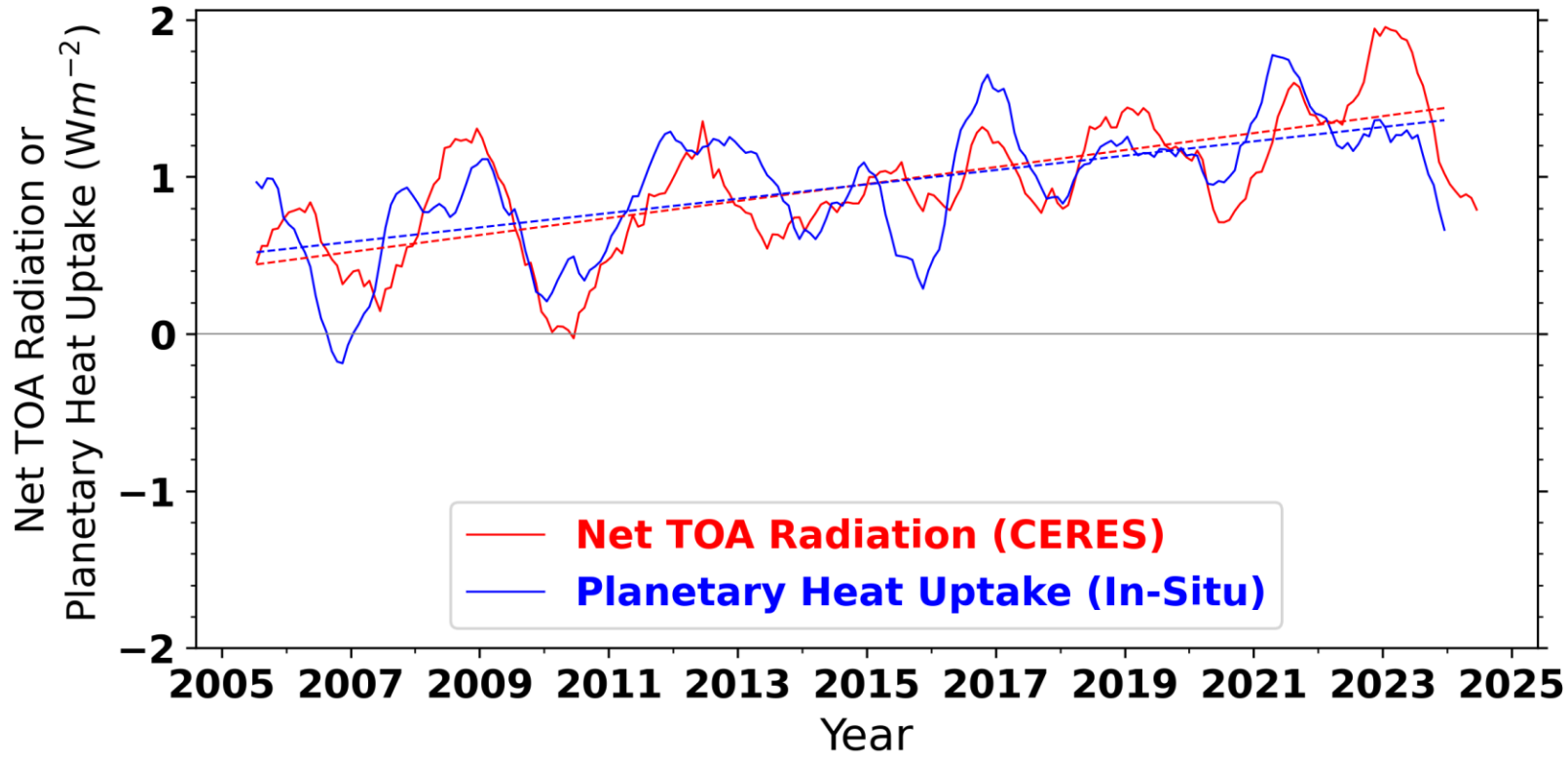
–OLR: –0.41 ± 0.23

NET: 0.44 ± 0.17

Congratulations CERES Team! A 25 Year ERB Record!!!

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

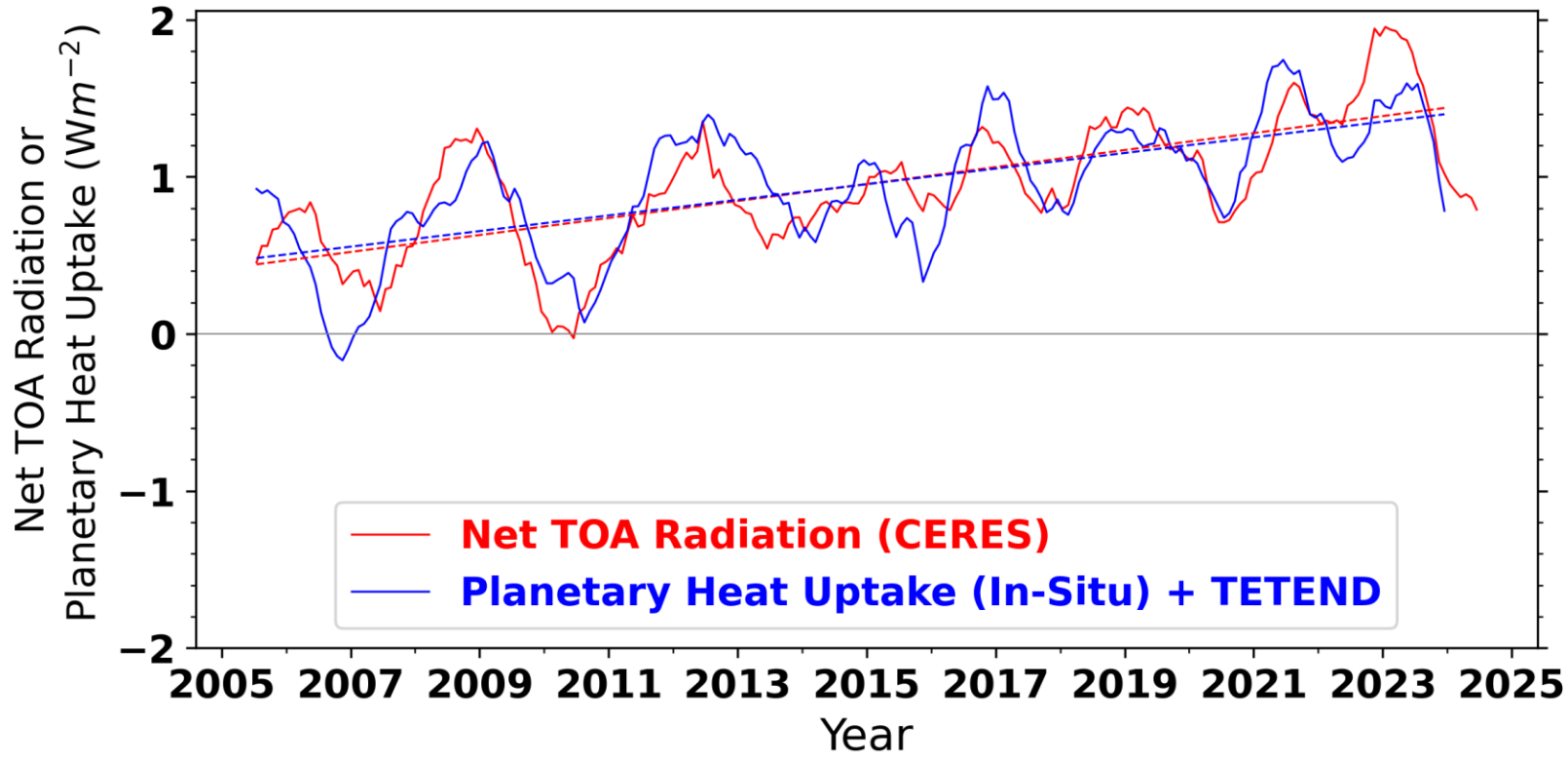
(CERES 02/2005-12/2024; In situ: 02/2005-06/2024)



	Trend (Wm^{-2} dec^{-1}) 02/2005-06/2024
CERES EBAF Ed4.2	0.54 ± 0.27
In-Situ	0.46 ± 0.26
Difference	0.08 ± 0.26
R	0.72

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

AGU Advances

COMMENTARY

10.1029/2024AV001636

Earth's Energy Imbalance More Than Doubled in Recent Decades

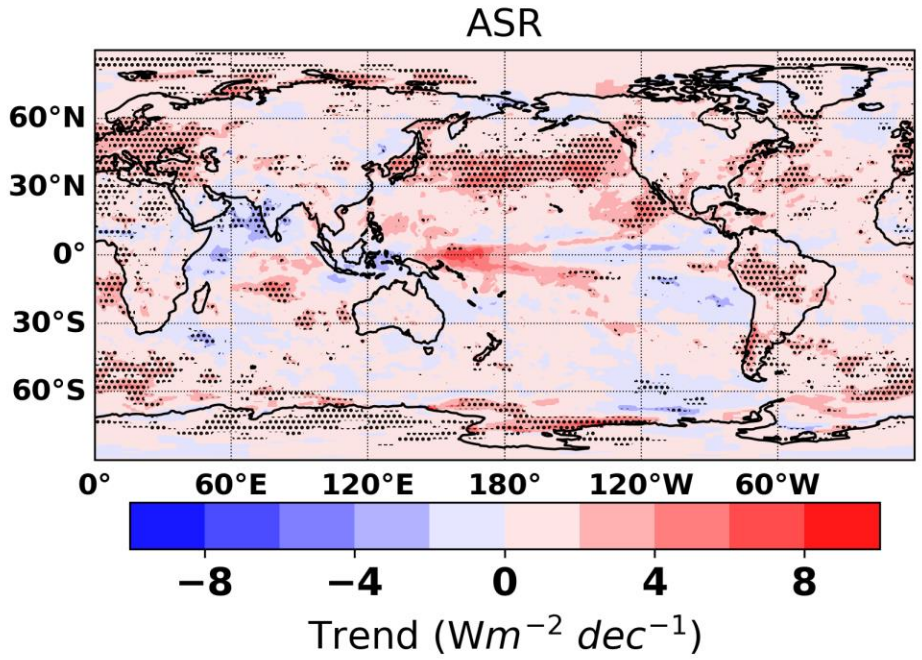
Thorsten Mauritsen[1], Yoko Tsushima[2], Benoit Meyssignac[3], Norman G. Loeb[4], Maria Hakuba[5], Peter Pilewskie[6], Jason Cole[7], Kentaroh Suzuki[8], Thomas P. Ackerman[9], Richard P. Allan[10], Timothy Andrews[2], Frida A.-M. Bender[1], Jonah Bloch-Johnson[11], Alejandro Bodas-Salcedo[2], Anca Brookshaw[12], Paulo Ceppi[13], Nicolas Clerbaux[14], Andrew E. Dessler[15], Aaron Donohoe[16], Jean-Louis Dufresne[17], Veronika Eyring[18], Kirsten L. Findell[19], Andrew Gettelman[20], Jake J. Gristey[21], Ed Hawkins[22], Patrick Heimbach[23], Helene T. Hewitt[24], Nadir Jeevanjee[19], Colin Jones[25], Sarah M. Kang[26], Seiji Kato[27], Jennifer E. Kay[28], Stephen A. Klein[29], Reto Knutti[30], Ryan Kramer[19], June-Yi Lee[31], Daniel T. McCoy[32], Brian Medeiros[33], Linda Megner[34], Angshuman Modak[35], Tomoo Ogura[36], Matthew D. Palmer[37], David Paynter[19], Johannes Quaas[38], Veerabhadran Ramanathan[39], Mark Ringer[2], Karina von Schuckmann[40], Steven Sherwood[41], Bjorn Stevens[26], Ivy Tan[42], George Tselioudis[43], Rowan Sutton[44], Aiko Voigt[45], Masahiro Watanabe[46], Mark J. Webb[2], Martin Wild[30], and Mark D. Zelinka[29]

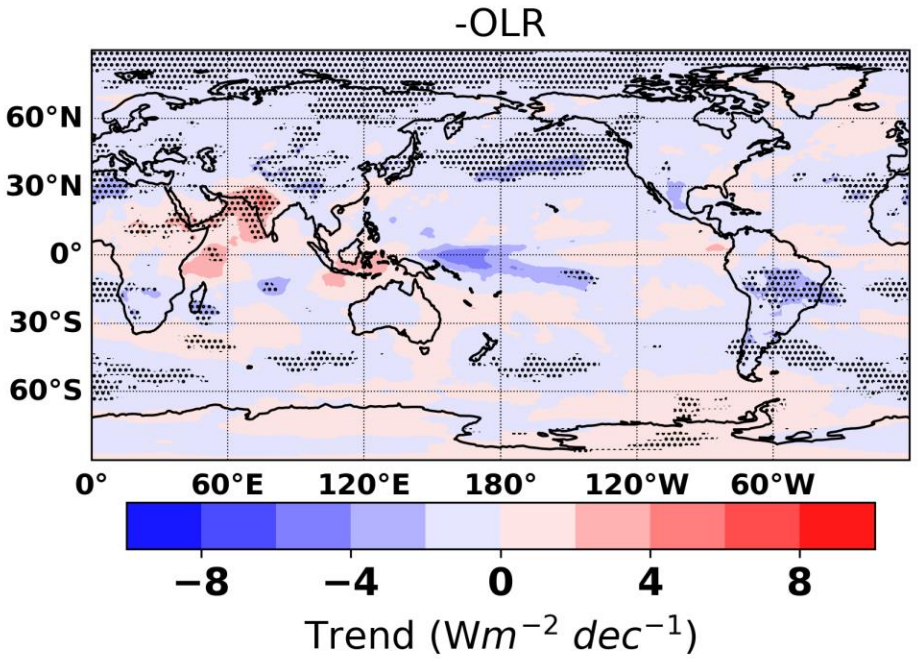
Peer Review The peer review history for this article is available as a PDF in the Supporting Information.

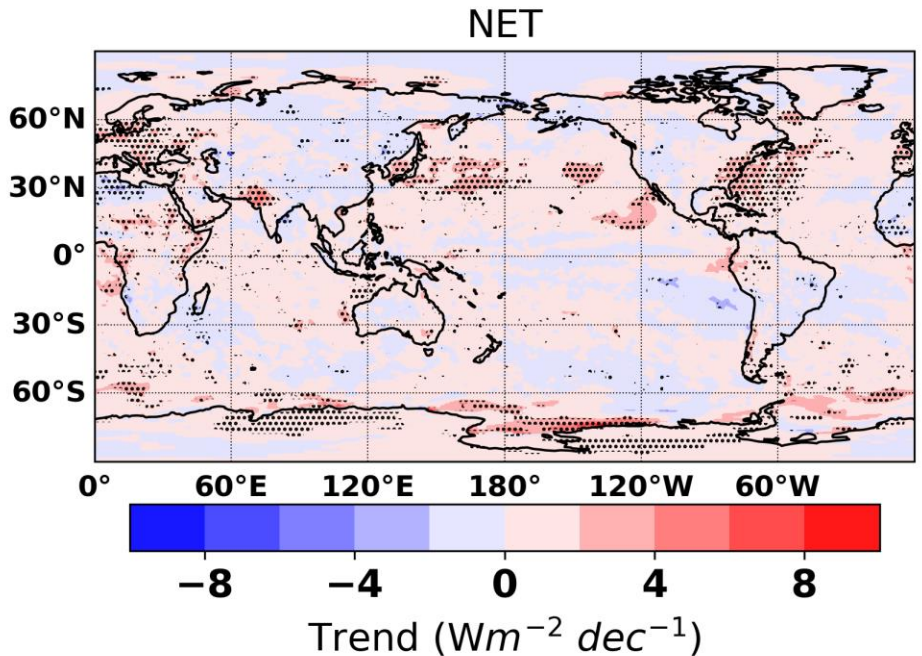
Key Points:

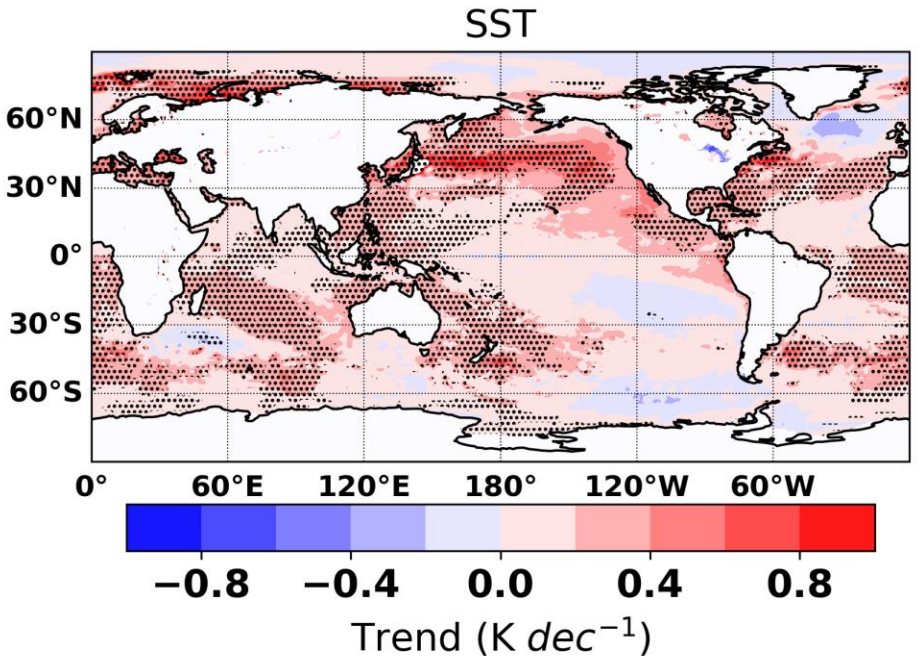
- Earth's energy imbalance more than doubled in recent decades
- The large trend has taken us by surprise, and as a community we should strive to understand the underlying causes
- Our capability to observe the Earth's energy imbalance and budget terms is threatened as satellites are decommissioned

Regional Trends in TOA Radiation and SST (03/2000–02/2025)

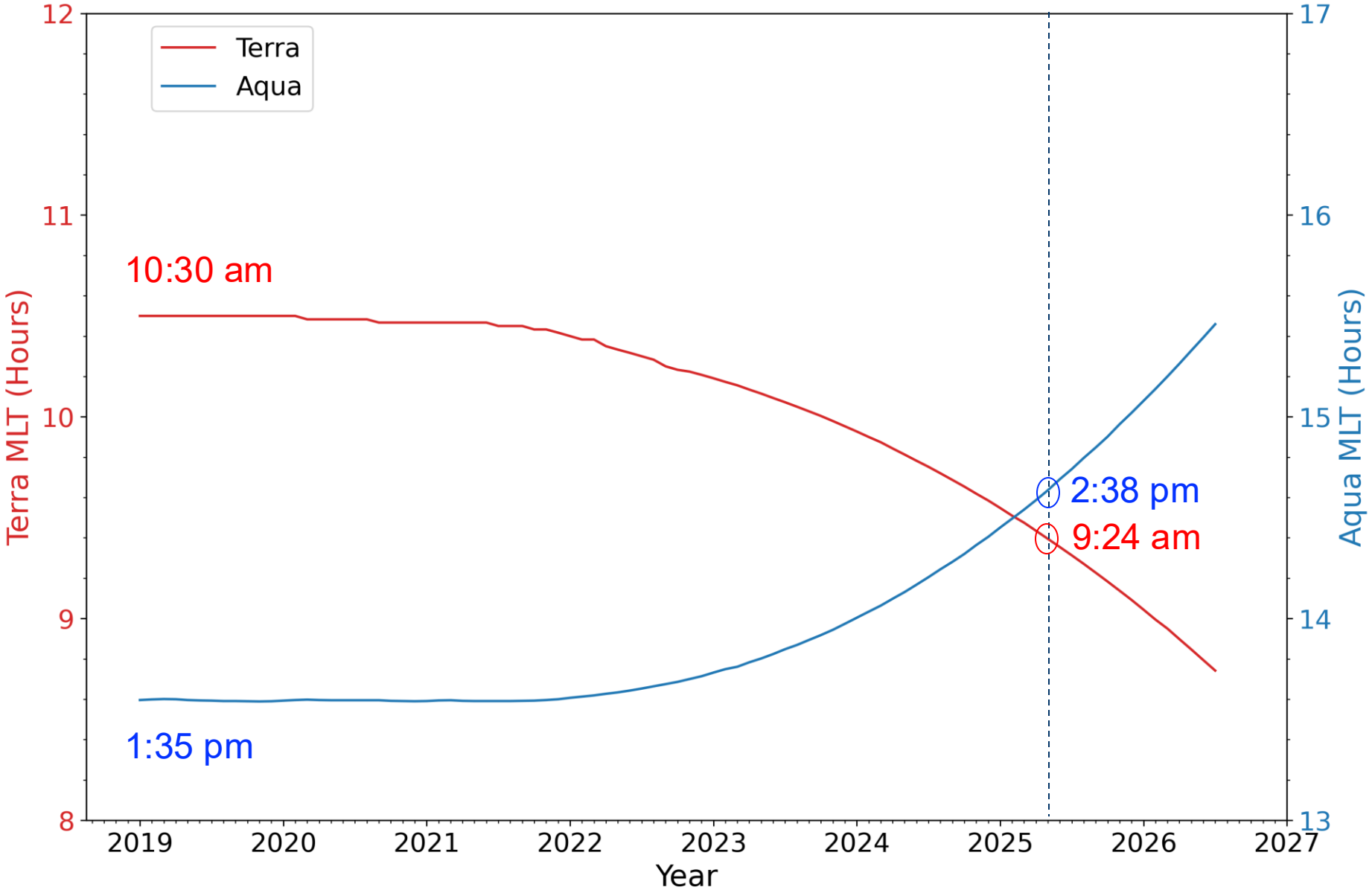






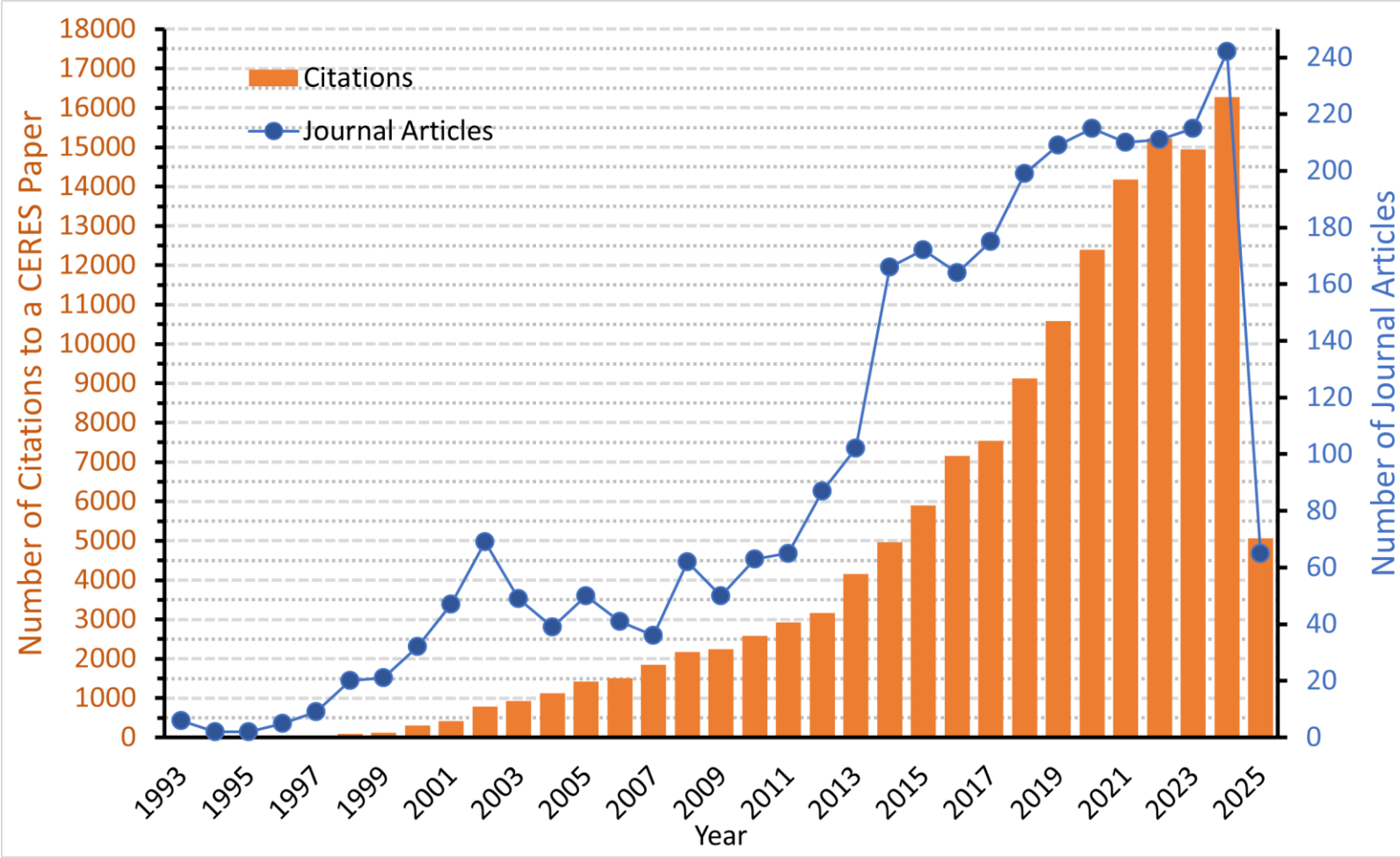


Terra and Aqua Mean Local Equatorial Crossing Times (MLTs)



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

CERES Journal Publications and Citation Counts
(For Papers Between 1993-2025; Updated April 30, 2025)



- Total number of peer-reviewed journal articles: 3,100
- Total number of citations to CERES papers: 149,260

(Compiled by Dennis Keyes)

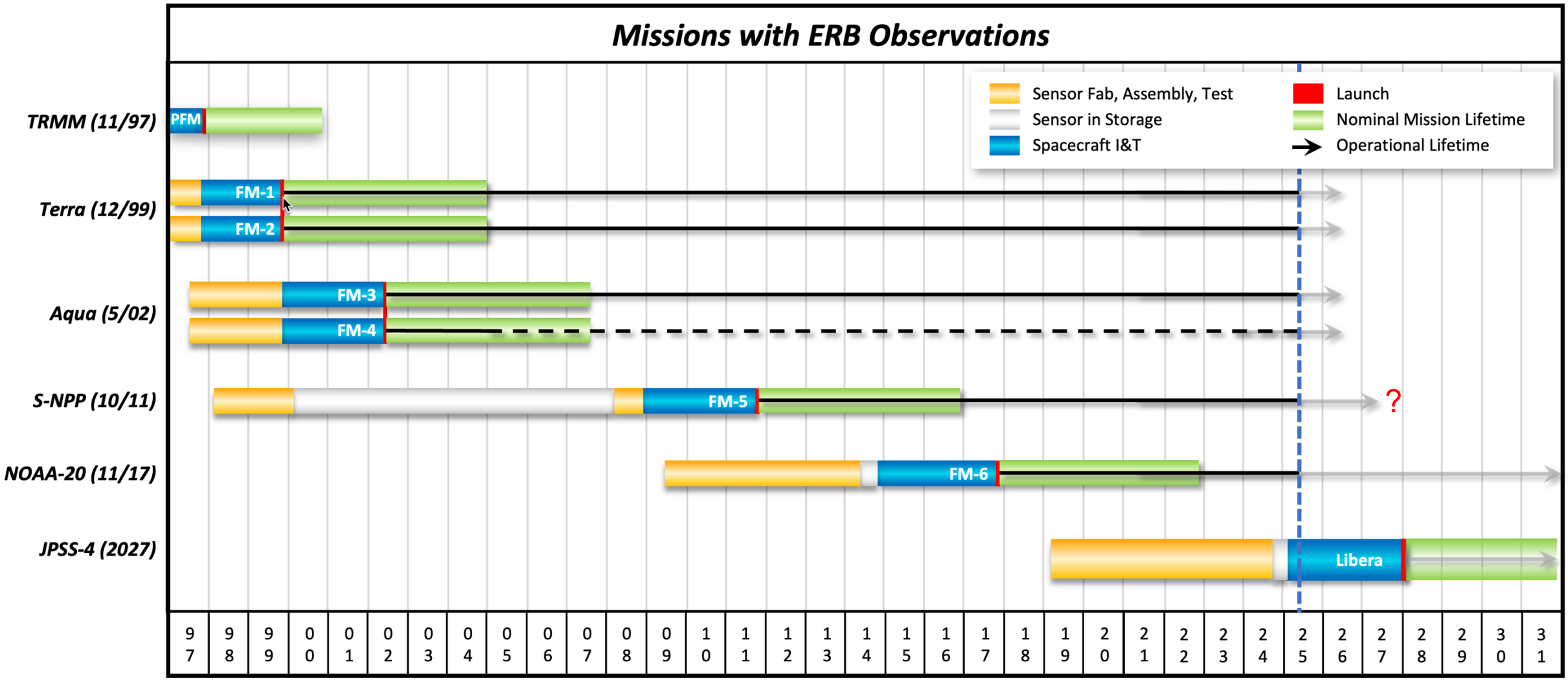
Number of Unique Users by CERES Data Product

(through May 8, 2025)

Level	Product	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1b	BDS	13	14	10	12	23	19	30	19	30	13
2	SSF	278	327	235	251	245	246	273	288	436	208
	FLASH_SSF	41	68	101	92	103	101	124	72	71	26
	CCCM	54	49	49	36	45	53	62	78	58	23
	ES8	15	15	10	8	11	8	14	8	37	18
	SSF-MISR	1	3	1	1	4	3	7	0	13	6
	CRS					2	1	4	20	37	7
3 & 3b	EBAF	783	935	928	995	1041	994	1196	1589	1747	681
	SYN1deg	494	607	639	754	854	858	918	984	1118	457
	SSF1deg	194	190	159	221	213	208	255	188	228	95
	CldTypHist	47	86	87	79	86	84	83	119	114	39
	FluxByCldTyp					50	62	67	94	65	35
	ES4	12	17	17	17	11	14	15	19	13	6
	ES9	5	8	6	6	8	5	8	6	7	3
	FLASH_TISA	36	52	65	81	131	107	116	95	90	45
	CRS1deg									61	8

FLASHFlux and SYN1deg via POWER since last year: **199K**

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 August 2026 (Aqua) and February 2027 (Terra)
- **CERES FM2/Terra turned off on January 11, 2025. FM1/Terra in RAP mode**
  - Degradation of Terra Solar Array power generation (loss of 5 of the 24 Shunts) required reduction in power demands to allow spacecraft to reach full charge every orbit.
  - Currently, Direct Broadcast is not available, CERES FM2 is off, and MOPITT sensor is off. Further degradation or shunt failures will result in further reduction of science.
- **New power availability analysis shows Aqua can operate until September 2027**
  - Would require revised budget to operate beyond August 2026.
- **End date of S-NPP is unknown. Ongoing topic of discussion (NASA and NOAA)**
- **CERES FM6/NOAA-20 is performing well**

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).

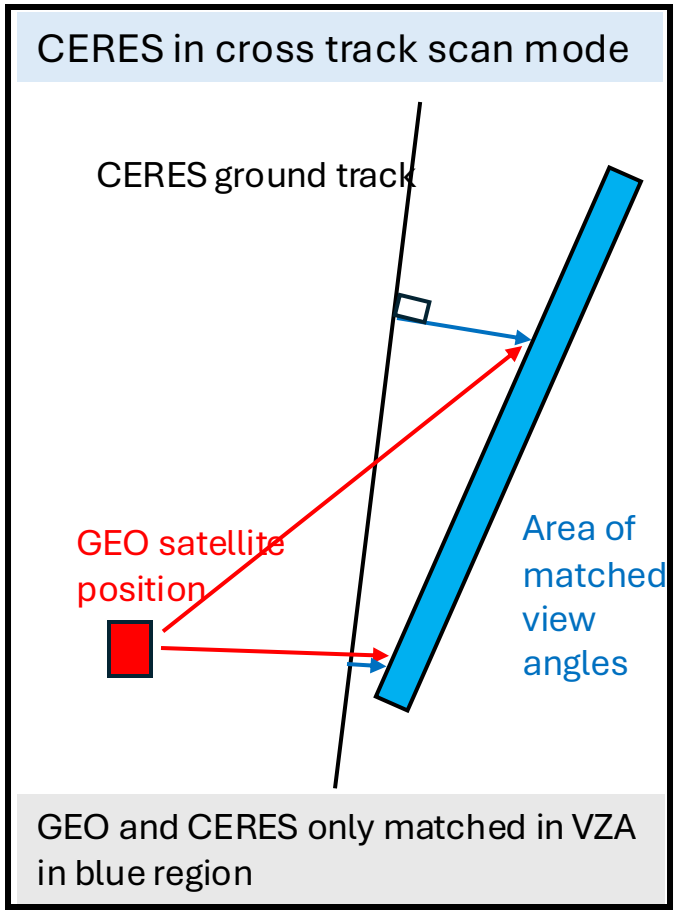
Planning for Libera

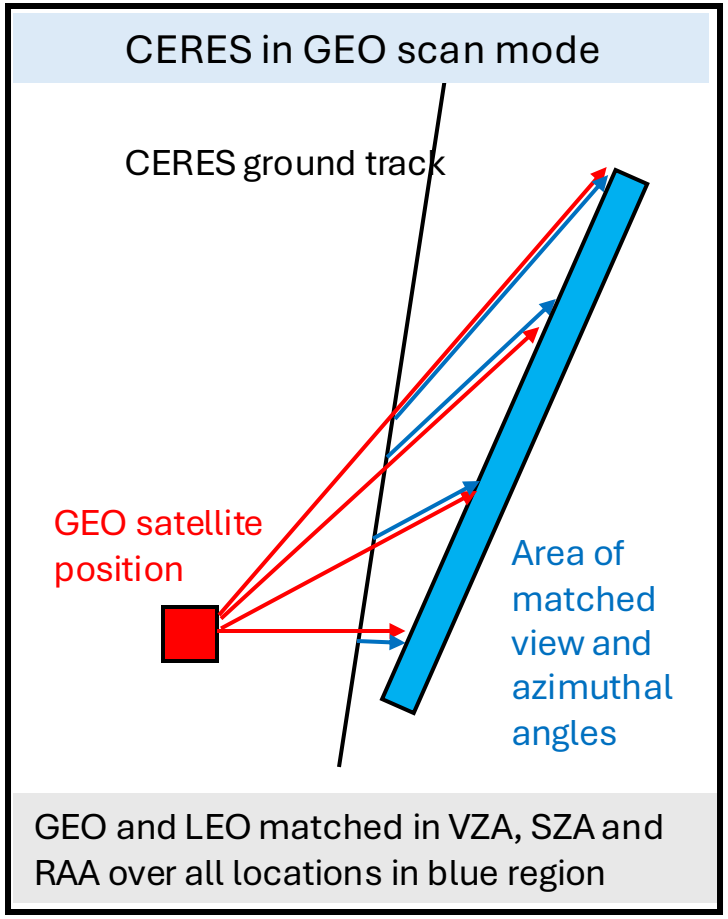
1) Bi-weekly meetings with Libera team, NASA HQ, ESSPO
2) Calibration WG meetings
3) DMT WG meetings
4) Periodic on-site visits at LASP by CERES Instrument WG
5) Intercalibration of CERES FM6 and Libera
6) New approach for inferring split SW fluxes from Libera measurements

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

GEOscan geometry

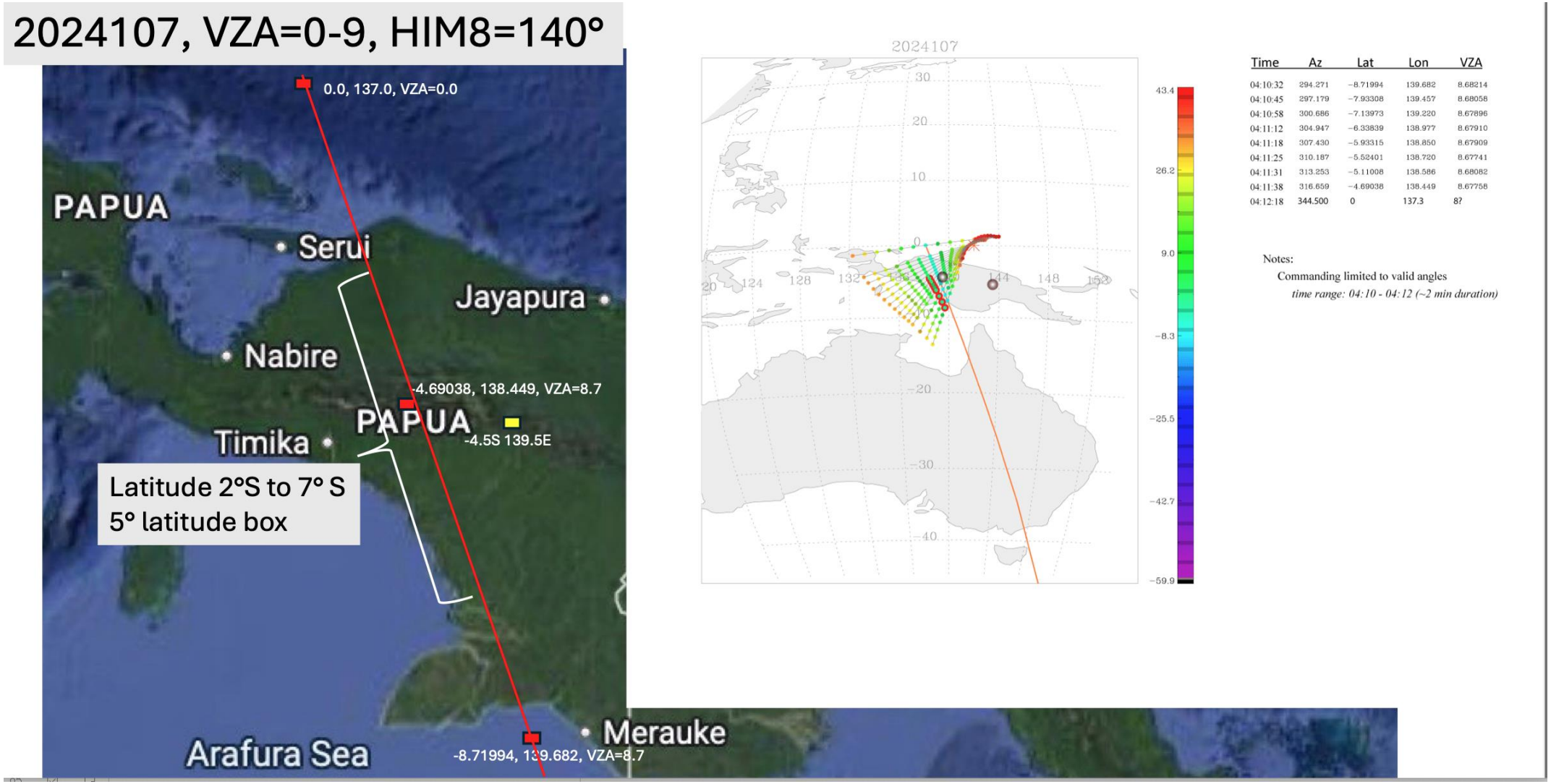




"Dry-Run" Using CERES S-NPP and NOAA-20

- Place CERES instruments on S-NPP and NOAA-20 in GEOscan mode as "dry-run" for FM6 and Libera
- Use STK software to generate a GEOscan simulator to determine frequency of angle-matched CERES/GEO data (Daniels)
- Use CERES Level 3 data products to evaluate candidate target regions for GEOscan (Doelling, Itterly)
  - Spatially homogeneous
  - Spectrally distinct targets
- Selected 2 daytime and 1 nighttime GEOscan targets
  - Papua New Guinea Cloudy Region (daytime)
  - Libya/Egypt Desert Region (daytime)
  - TBD (nighttime)

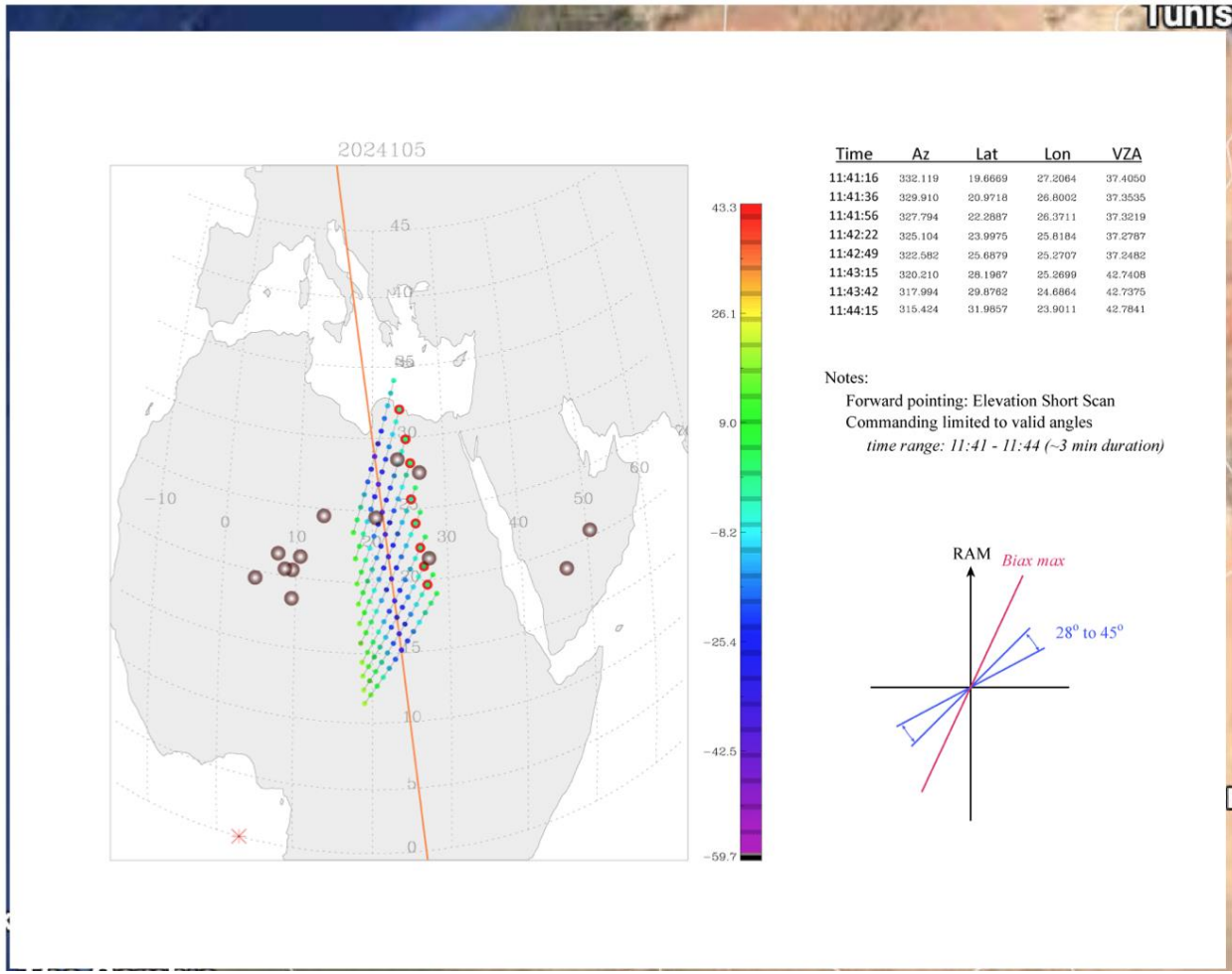
Papua New Guinea Cloudy Region



Typical cloud fraction ≈ 0.9; Albedo ≈ 0.4

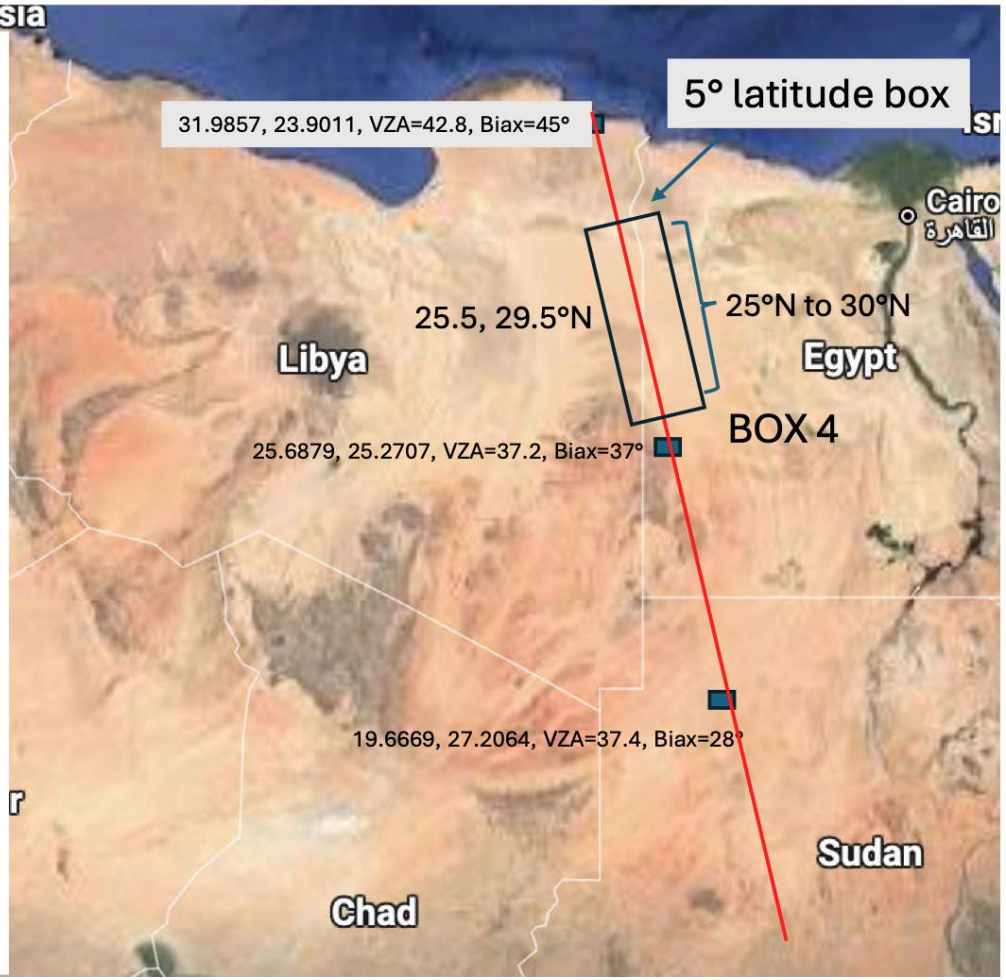
Libya/Egypt Desert Region

2024105, VZA=40, biax=40 , MET=0°



Time	Az	Lat	Lon	VZA
11:41:16	332.119	19.6669	27.2064	37.4050
11:41:36	329.910	20.9718	26.8002	37.3535
11:41:56	327.794	22.2887	26.3711	37.3219
11:42:22	325.104	23.9975	25.8184	37.2787
11:42:49	322.582	25.6879	25.2707	37.2482
11:43:15	320.210	28.1967	25.2699	42.7408
11:43:42	317.994	29.8762	24.6864	42.7375
11:44:15	315.424	31.9857	23.9011	42.7841

Notes:
Forward pointing: Elevation Short Scan
Commanding limited to valid angles
time range: 11:41 - 11:44 (~3 min duration)

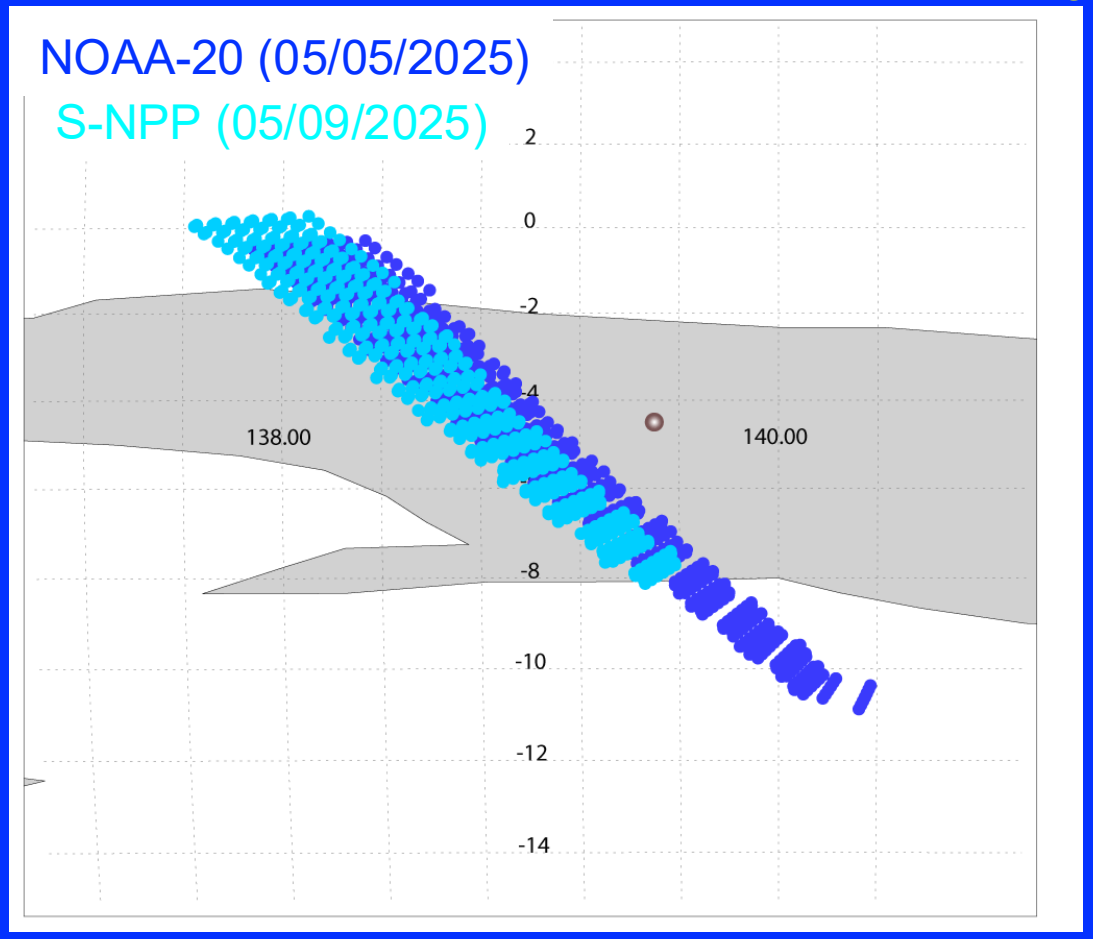


Typical cloud fraction between June and September < 5%; Albedo ≈ 0.35

Current Status of CERES S-NPP and NOAA-20 GEOScan

- Collected first samples on May 5 (NOAA-20) and May 9 (S-NPP)

CERES–GEO VZA Diff < 2°: Papua New Guinea Region



- Plan to continue routine GEOscan collections to determine how much sampling is necessary for accurate intercalibration

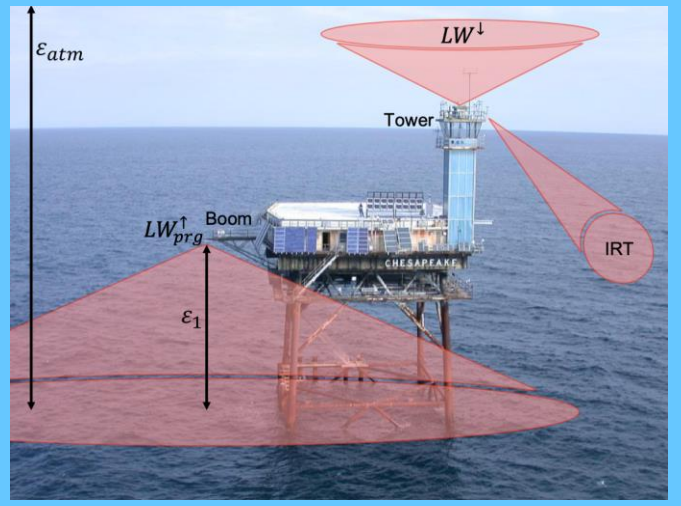
CRAVE — CERES Radiation Validation Experiment
https://science.larc.nasa.gov/CRAVE/

GRANITE ISLAND

- Ice build-up caused some data loss (~2 weeks) for all radiometric instruments over the winter.
- The solar tracker was turned off several times to prevent damage due to ice build-up, causing Direct and Diffuse to be unavailable, but Global and LW will be available.
- Both Temp/RH sensors failed in March. Air temp. data was replaced with the datalogger panel temp. and found to be a good proxy, but RH is likely lost until sensor can be replaced.
- A 2nd PAR will be added next trip for redundancy.
- Data range: 2018 July – 2025 April.

LaRC

- Normal operations.
- A 2nd PAR will be added this summer for redundancy.
- Data range: 2014 Dec. – 2025 Apr.



COVE (Legacy)

- Data range: 2000 May – 2016 November
- Journal article titled, "The Component Summation Technique for Measuring Upwelling Longwave Irradiance in the Presence of an Obstruction" was posted as a preprint and currently in AMT review.

Upcoming Conferences & Meetings of Interest

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

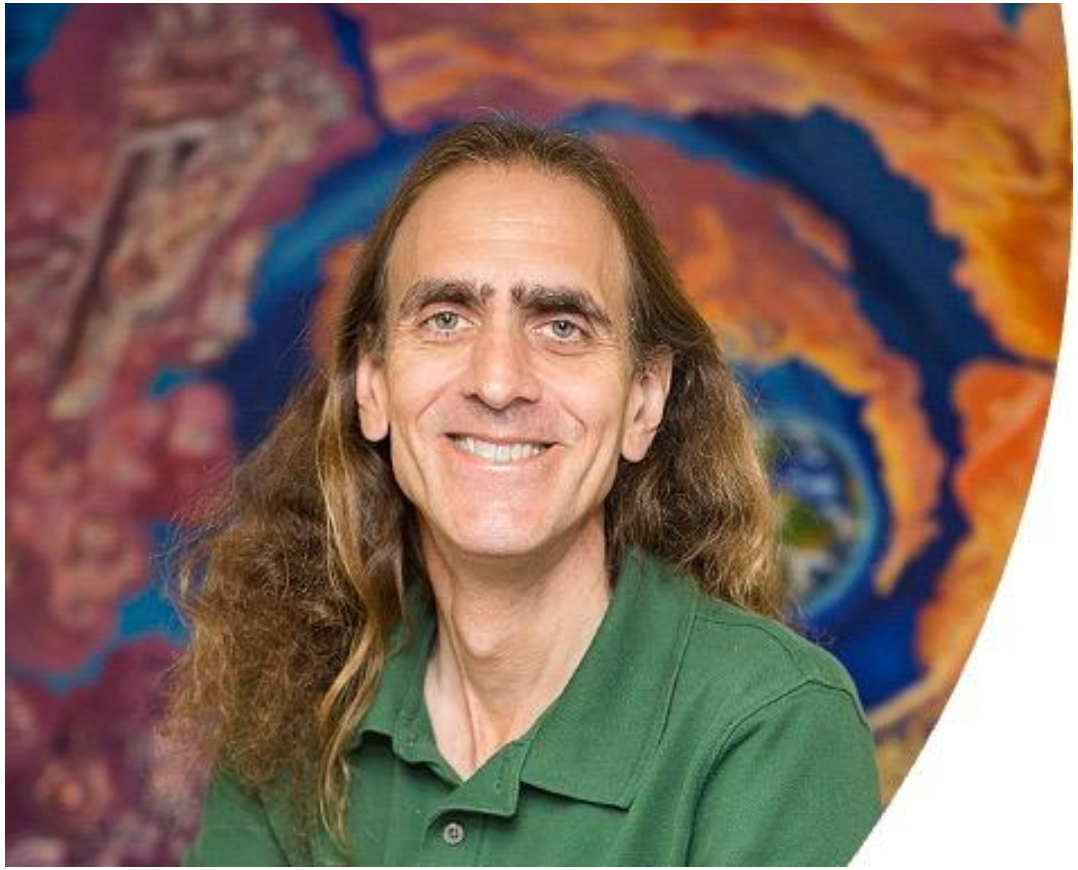
Gordon Conference
- July 20-25, 2025, Bates College, ME

Fall 2025 CERES Science Team Meeting
- October 28-30, 2025, NASA Langley Research Center, Hampton, VA

Fall AGU
- December 15-19, 2025, New Orleans, LA

AMS Annual Meeting
- January 25-29, 2026, Houston, TX

In Remembrance …



- David P. Kratz led what was known as the SOFA (Surface-Only Flux Algorithm) group for CERES until 2020 (group was absorbed into FLASHFlux).
- He led the validation, implementation and operationalization of the Langley Parameterized Flux (LPSA, LPLA) algorithms together with other surface flux estimates in the SSF.
- He also contributed by developing correlated-k coefficients and other spectroscopic analysis.