Libera Mission Status Update: P. Pilewskie & Libera Team

CTIM Earth Views: Dave Harber, McKenzie Hawkins, Matt van den Heever and Matt Watwood

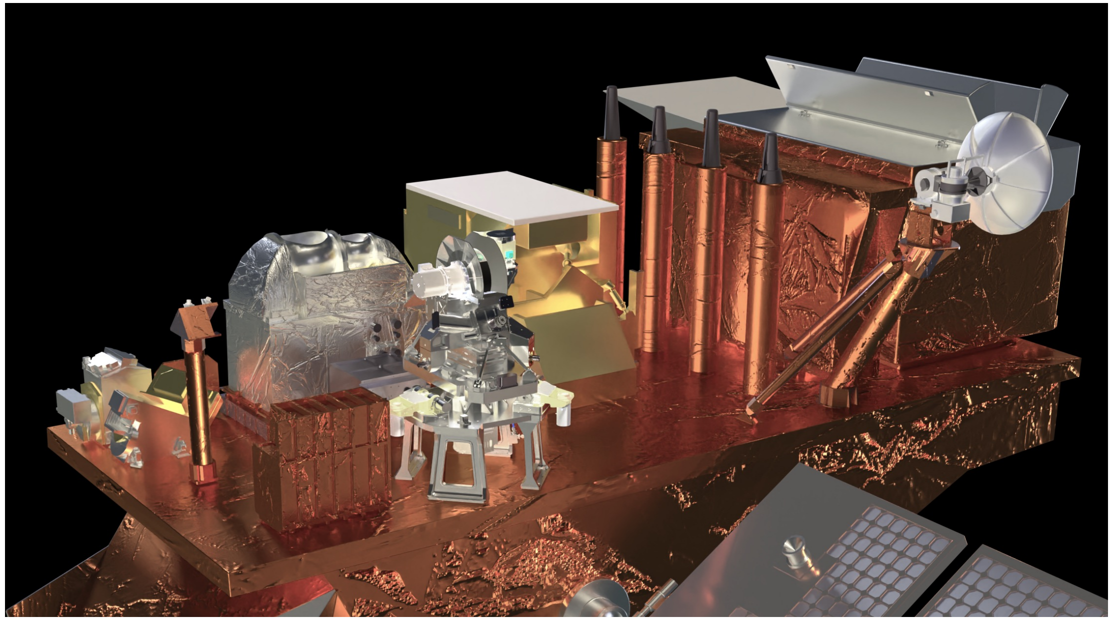
Ehrhard Raschke
1936-2023

IRC business meeting in 1976 in Garmisch

Summer 2021 in Hanau

Libera, NASA Earth Venture Continuity-1 Mission

'Li-be-ra, named for the daughter of Ceres in ancient Roman mythology



JPSS-4 Instruments

Libera **– Earth Radiation Budget**

ATMS - Advanced Technology Microwave Sounder

CrIS - Cross-track Infrared Sounder

VIIRS – Visible Infrared Imaging Radiometer Suite

OMPS – Ozone Mapping and Profiler Suite

Successful Critical Design Review 27-29 June 2023

Provides continuity of the Clouds and the Earth's Radiant Energy System (CERES) Earth radiation budget (ERB).

- Measures integrated shortwave (0.3–5 µm), longwave (5–50 µm), total (0.3–100+ µm) and ***(new) split-shortwave (0.7–5 µm) radiance*** over 24 km nadir footprint; ***uncertainty ~ 0.3%***
- ***Includes a wide FOV camera for scene ID and simple ADM generation to pave way for future free-flyer ERB observing system***

Innovative technology:

- ***Electrical substitution radiometers (ESRs) using vertically-aligned carbon nanotube (VACNT) detectors***

Primary operational modes:

- Cross-track and azimuthal scanning; on-board calibrators; solar and lunar viewing.

Flight:

- **JPSS-4, 2027 launch; 5-year mission**

Partners:

- LASP, Ball Aerospace, NIST Boulder, Space Dynamics Lab; CU, JPL, CSU, UA, UM, LBL

Libera Major Reviews and Key Milestones

Milestone	Acronym	Date	Convening Authority
Authorization to Proceed	ATP	6 Jul 20	-
System Requirements Review	SRR	22 Feb 21	SRB
Key Decision Point - B	KDP-B	30 Apr 21	SMD PMC
Preliminary Design Review	**PDR**	**8-10 Feb 22**	**SRB**
Key Decision Point - C	**KDP-C**	**Apr 22**	**SMD PMC**
Critical Design Review	**CDR**	**27-29 Jun 23**	**SRB**
Pre-Environmental Review	PER	Mar 24	SRB
Pre-Ship Review	PSR	Sep 25	SRB
Delivery to Spacecraft		Sep 25	-
Key Decision Point D	KDP-D	Nov 25	SMD PMC
Launch		2027	-
Key Decision Point E	KDP-E	2027	SMD PMC
Post Launch Assessment Review	PLAR	L+90d	SRB
Operational Transition Review	OTR	PLAR + 9mo	TBD

Decision to Integrate Libera onto JPSS-4 and Launch JPSS-4 Prior to JPSS-3

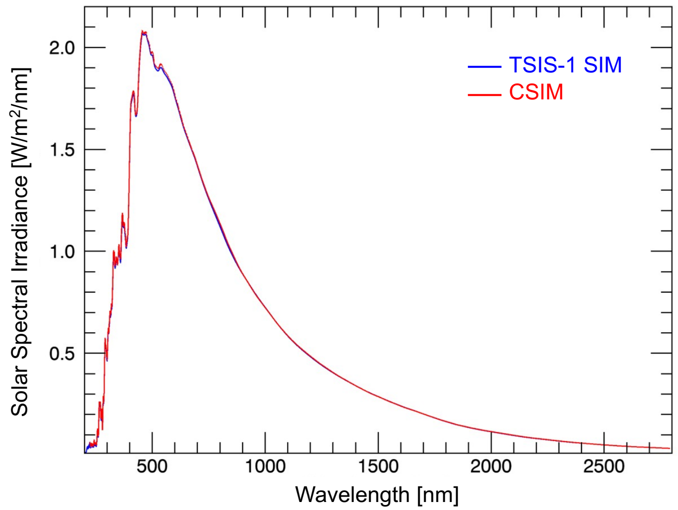
- Libera will be integrated onto JPSS-4.
  - Trade study performed by JPSS address risk for having a replacement JPSS spacecraft available, and in consideration of the delivery date of Libera
- JPSS-4 will be launched prior to JPSS-3.
  - There is no change to the Libera delivery date.
- Integration of Libera onto JPSS-3 involved removing JPSS-3 from storage, integrating Libera, conducting regression testing and returning the spacecraft to storage until the target JPSS-3 launch date.
- The current Libera delivery date of Aug. 2025 aligns with the planned flow of integration and testing of JPSS-4
- Reduces risk for Libera because design completion and analyses of the spacecraft will now include Libera in process of development and requires no special testing post storage.

Pre-launch Calibration and Characterization

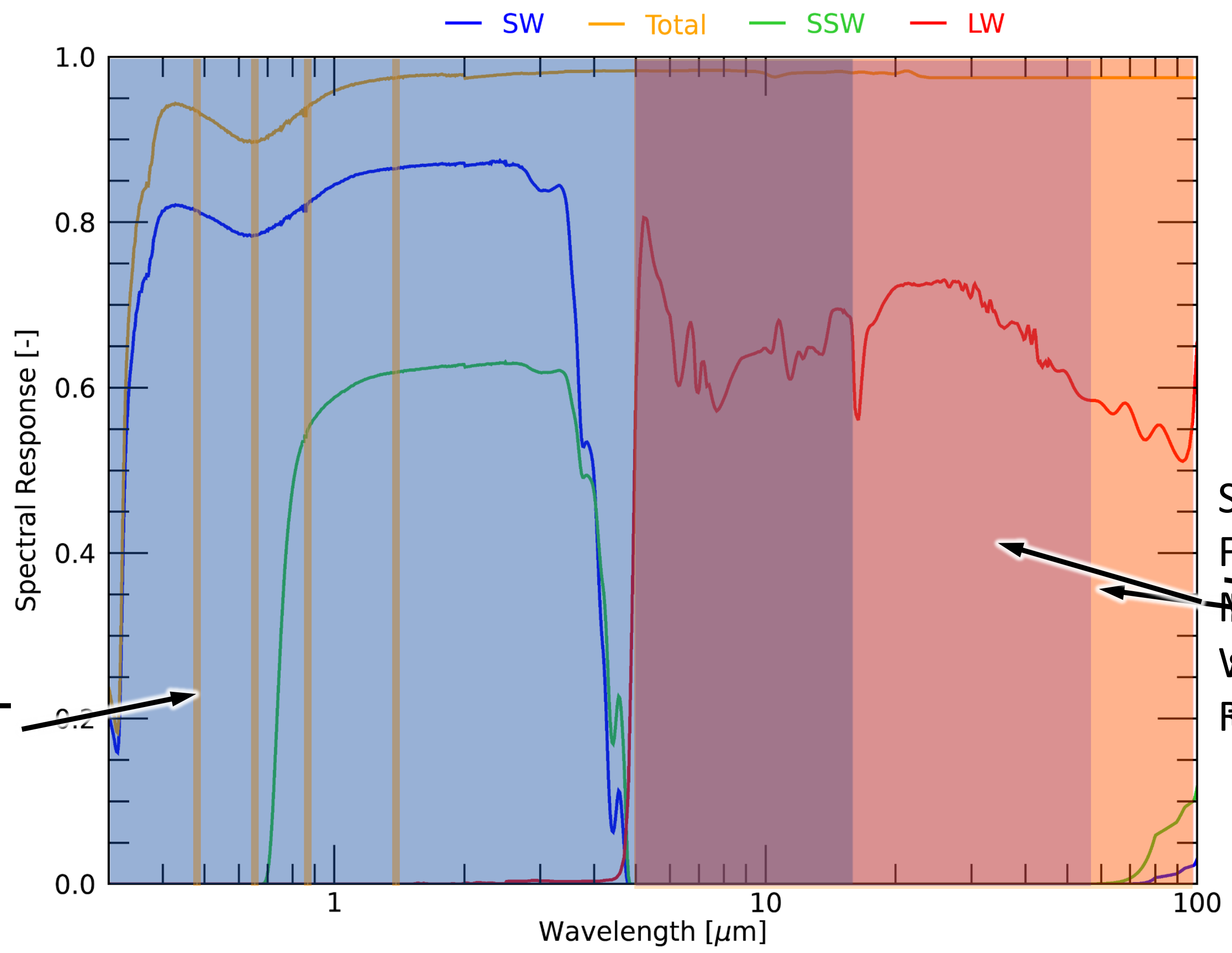
- Component-Level Characterizations
  - Properties of all optical surfaces (mirrors, filters, detectors) measured at NIST and PTB, Germany
  - Used in instrument model to generate expected spectral response functions
- Radiometer Calibrations
  - End-to-end channel calibration at LASP against NIST-traceable absolute radiance standard detector
  - Uses laser tie-points from 300 nm to 16 µm and broadband blackbody sources.
- System Level Validation
  - Integrated system transported to SDL for independent validation using SW & LW targets at a facility developed for RBI

Libera utilizes advanced carbon nanotube detector technology developed by LASP and NIST over a number of ESTO projects: BABAR ACT, CTIM-FD, CAESR, and CSIM-FD.

On-Orbit Demonstration of VACNT ESRs



Absolute Spectral Response Overview



Detector Based Laser Calibrations 0.3-16μm Wavelengths

SDL VIS/NIR APC Measurements

SDL FTS RSR Measurements

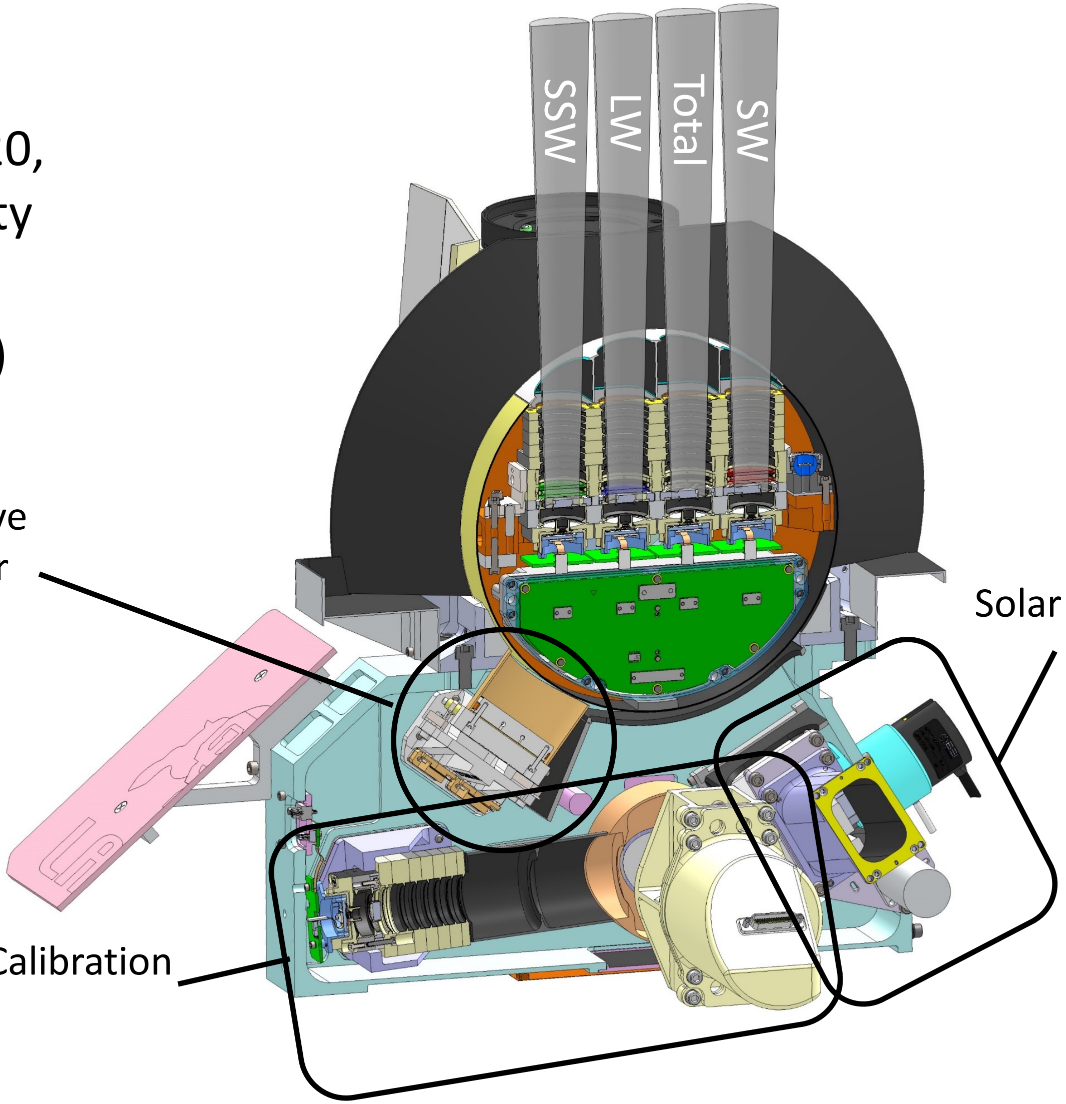
Blackbody Coverage 5-100μm Wavelength Range

- Blackbody Coverage 5-100μm

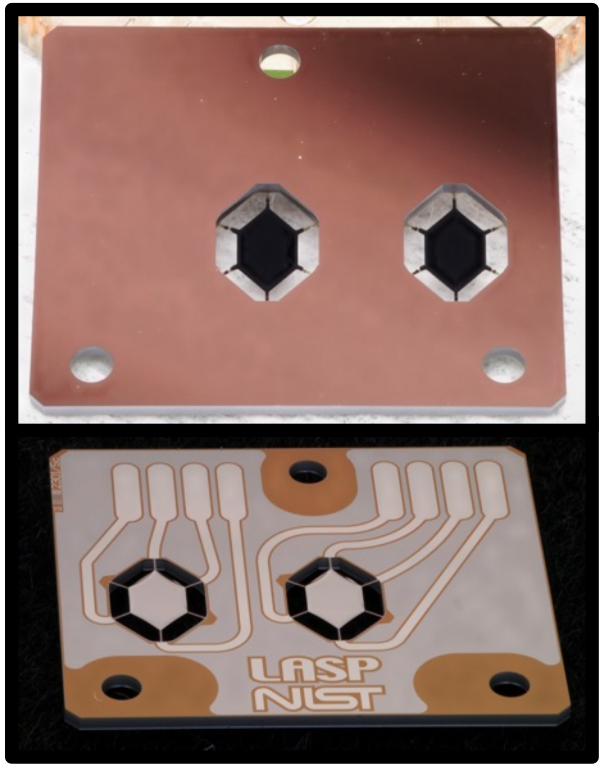
Covers entire reflected solar spectrum and >50% of the Earth blackbody emission.

On-Orbit Calibration and Validation

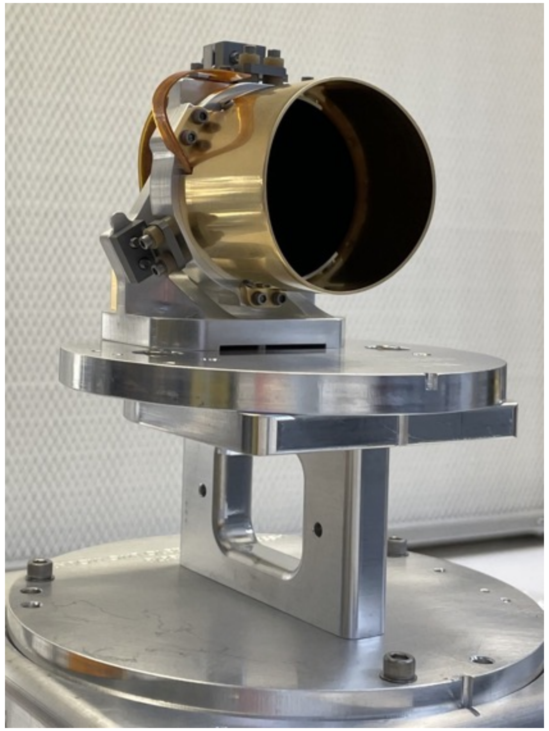
- Onboard calibration targets (daily)
  - ➢ Shortwave calibrator using LED sources (365, 405, 520, 635, 840, 1550 nm) and transmissive diffuser; stability tracked via a SW calibration radiometer
  - ➢ Longwave calibrator: flat-plate blackbody (310-335K) with VANTABLACK®S-IR coating, SI-traceable PRTs to NIST standards
- Solar calibrations (bi-monthly)
  - ➢ Spectralon reflective diffuser, three separate faces viewed bi-monthly/monthly/semi-annually for degradation tracking
- Lunar calibrations (~ 12-16 per year)

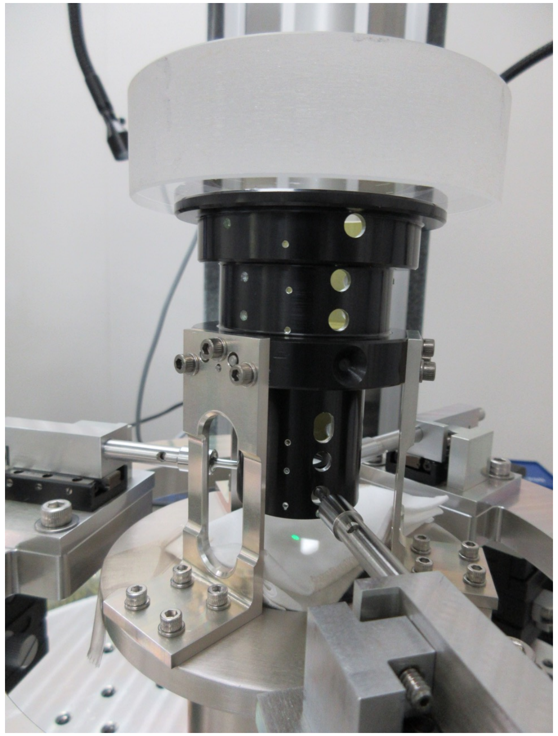


Libera Hardware

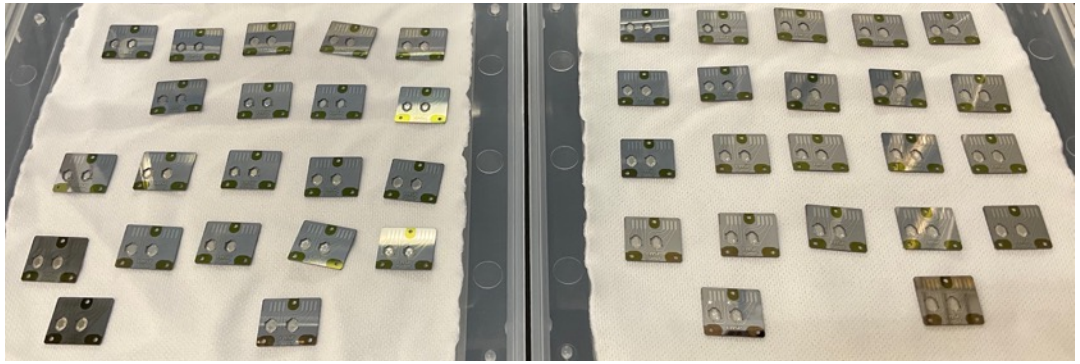


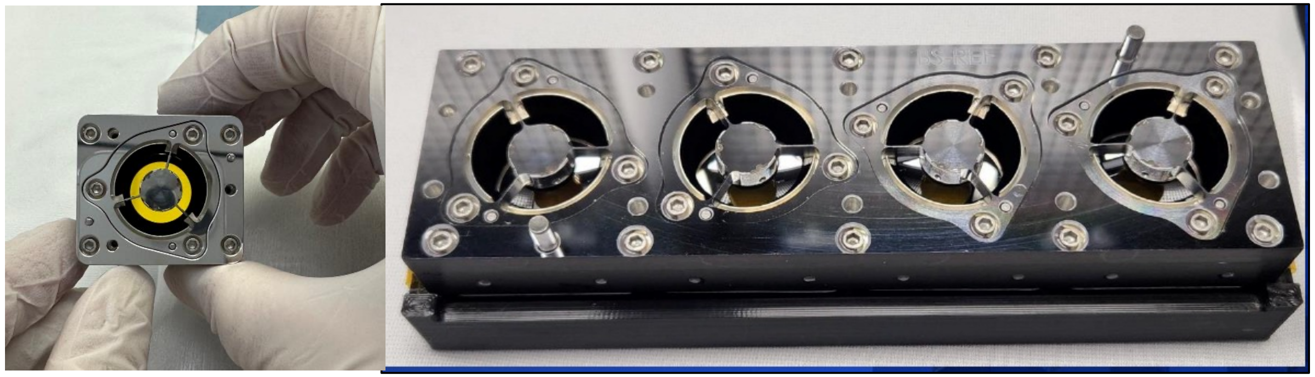
Detector Chips


LW Blackbody EDU


Camera Objective Lens integration

Transfer Radiometer




Telescope Bench Assembly

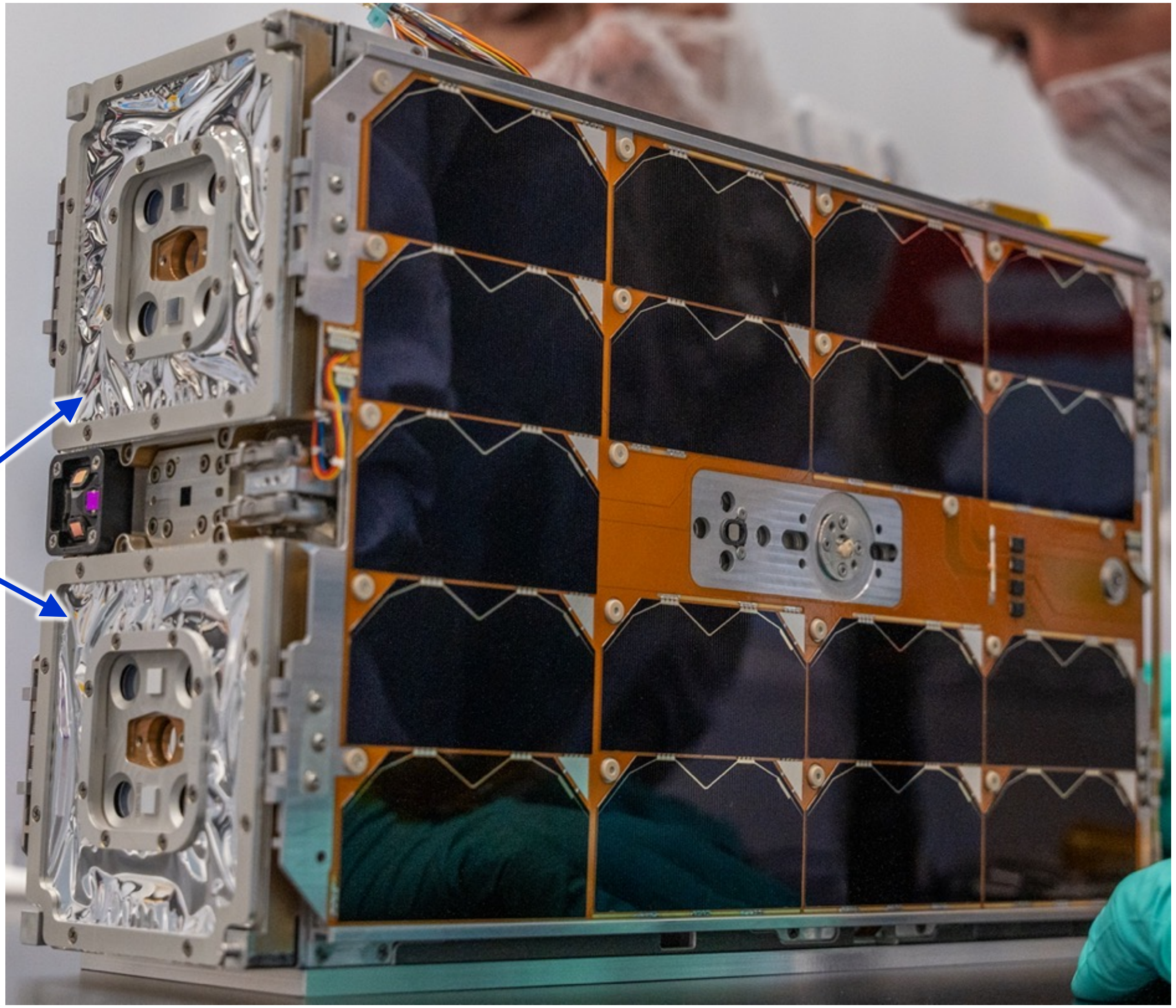
Compact Total Irradiance Monitor* (CTIM) *CubeSat

Principal Investigator: Dave Harber

- 6U CubeSat
- Dual 4-Channel Heads
  - ➢ Operated as two separate TSI instruments
  - ➢ This allows us to check short and long-term stability between heads
- Launch:
  - ➢ Virgin Orbit launch on July 1, 2022
  - ➢ Operations started August 2022

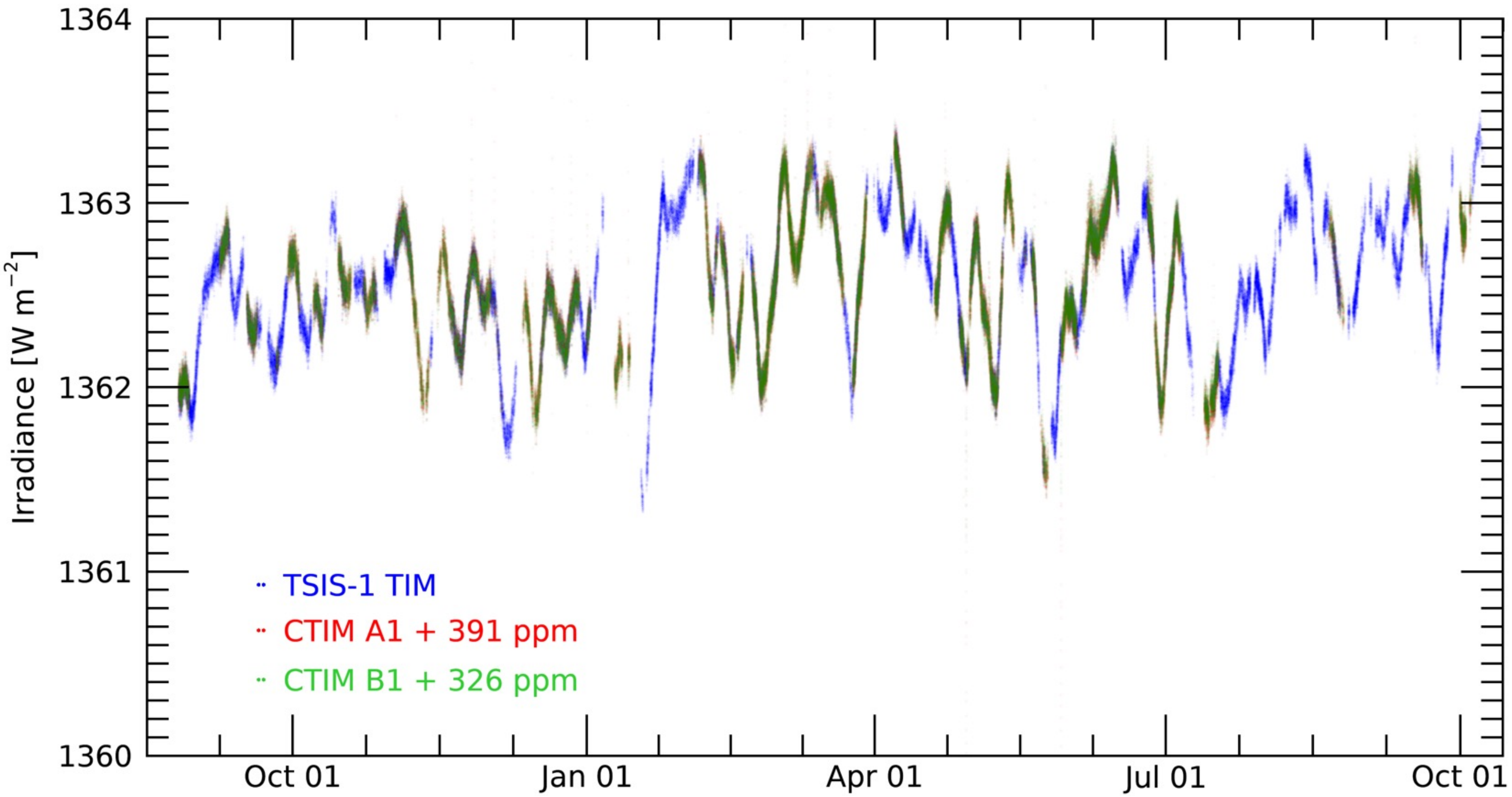
LauncherOne on Cosmic Girl

CTIM Prior to Launch Vehicle Integration



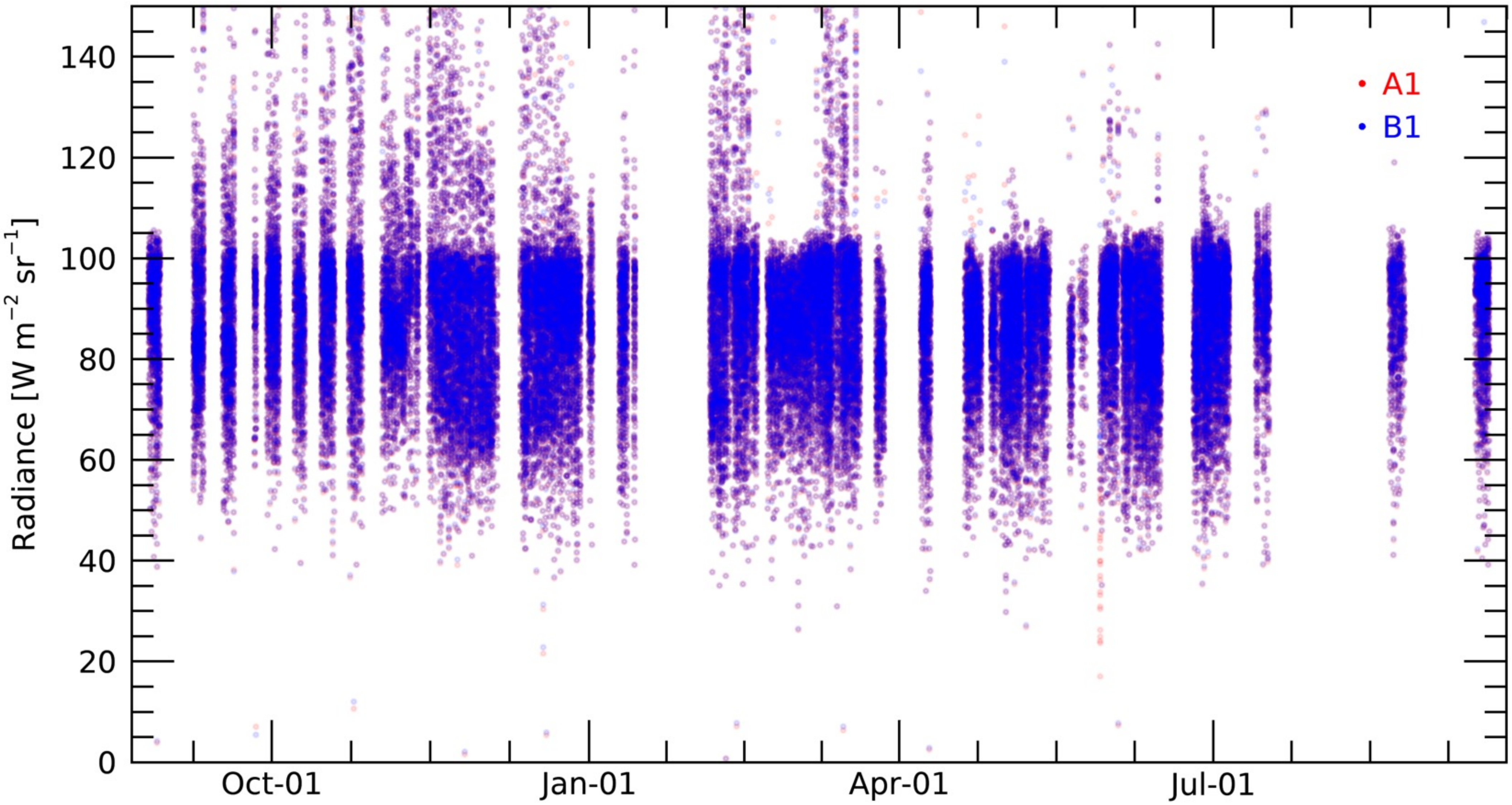
Corrected TSI Measurements

A1 is 391 ppm lower than TSIS-1 TIM, B1 is 326 ppm lower than TSIS-1 TIM

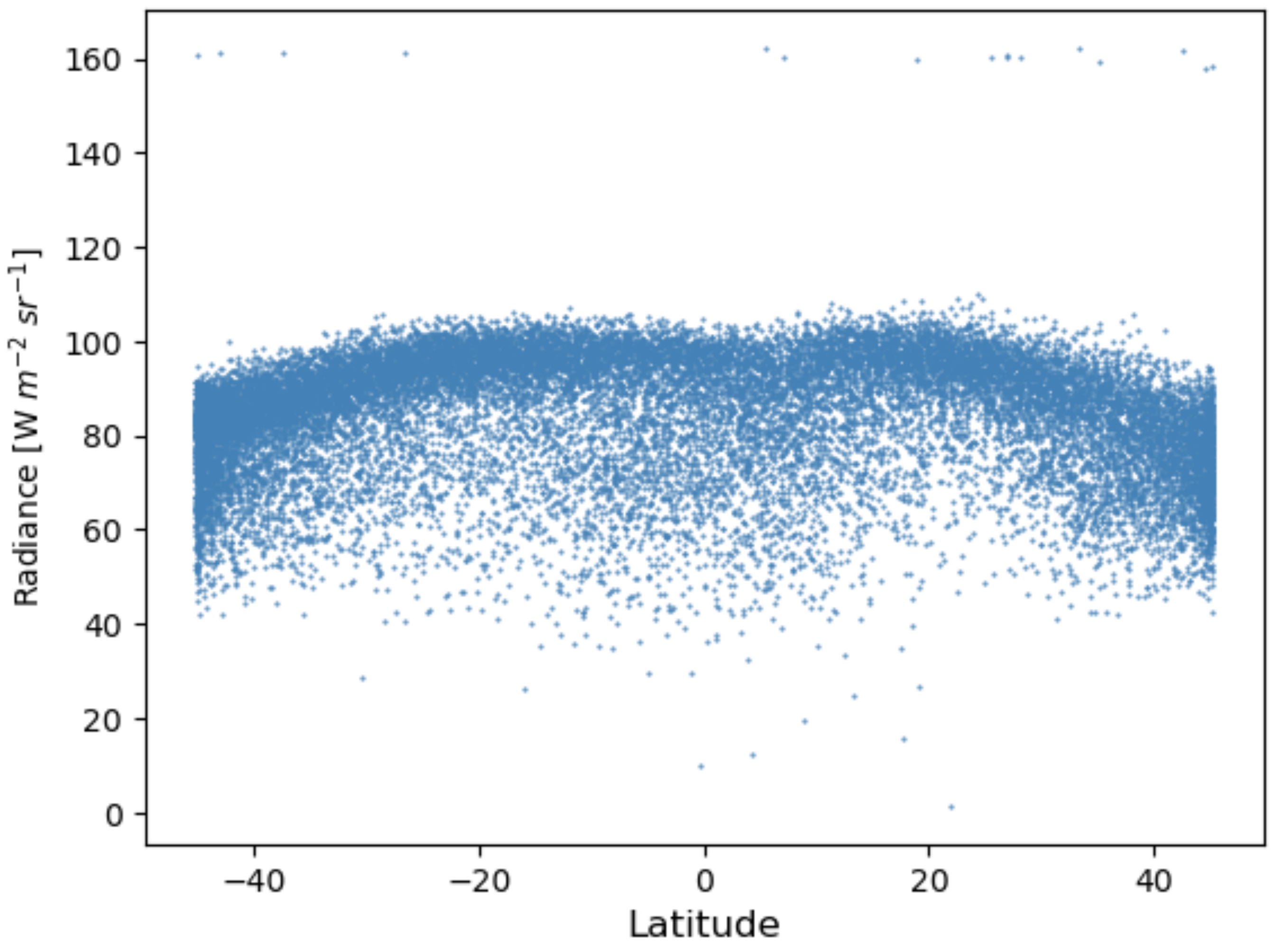


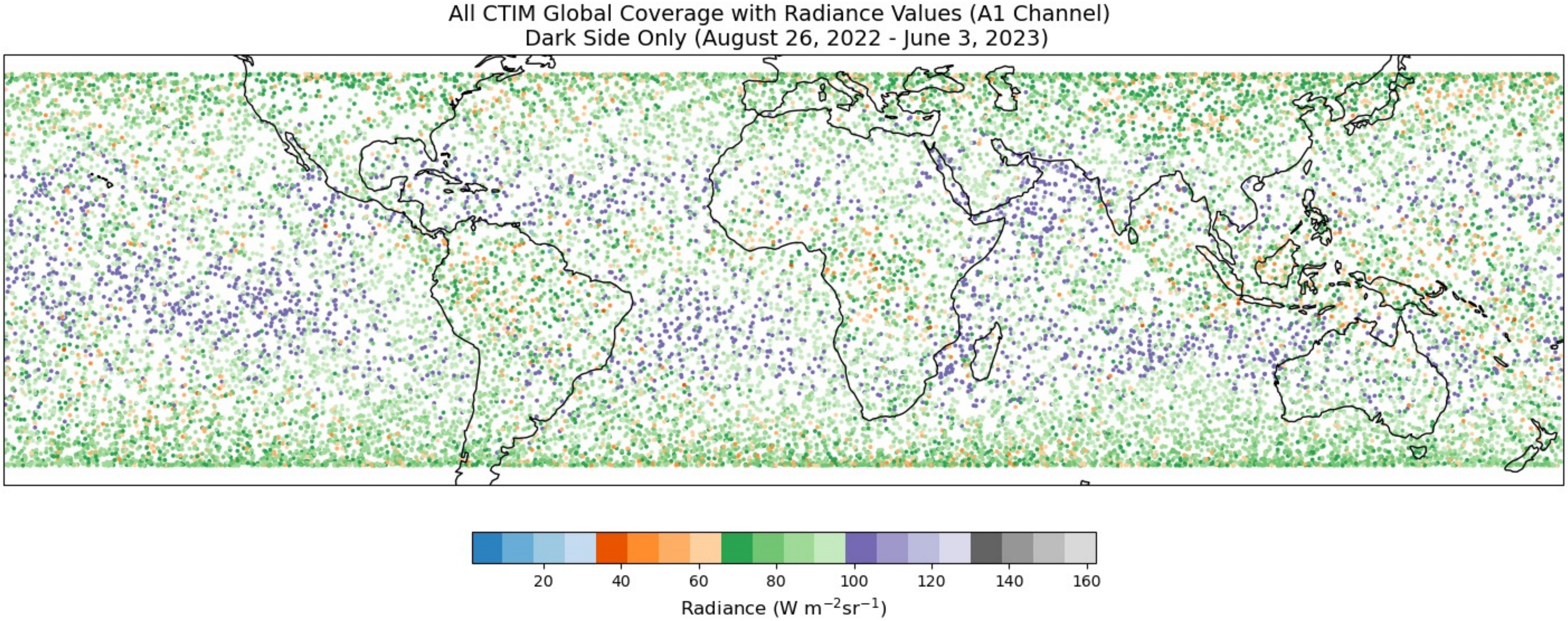
Measured Earth Radiance

Time series of CTIM A1 and B1 Earth Observations

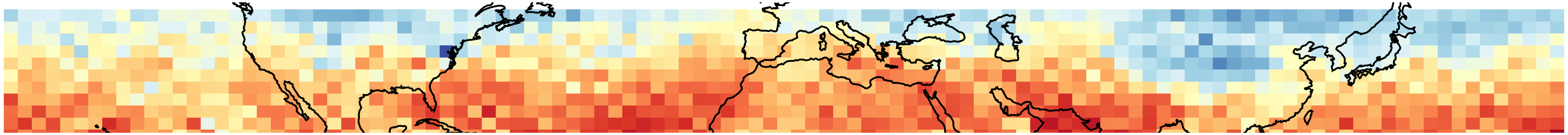


CTIM Radiance Over Latitude 26 Aug. 2022 – 3 June 2023

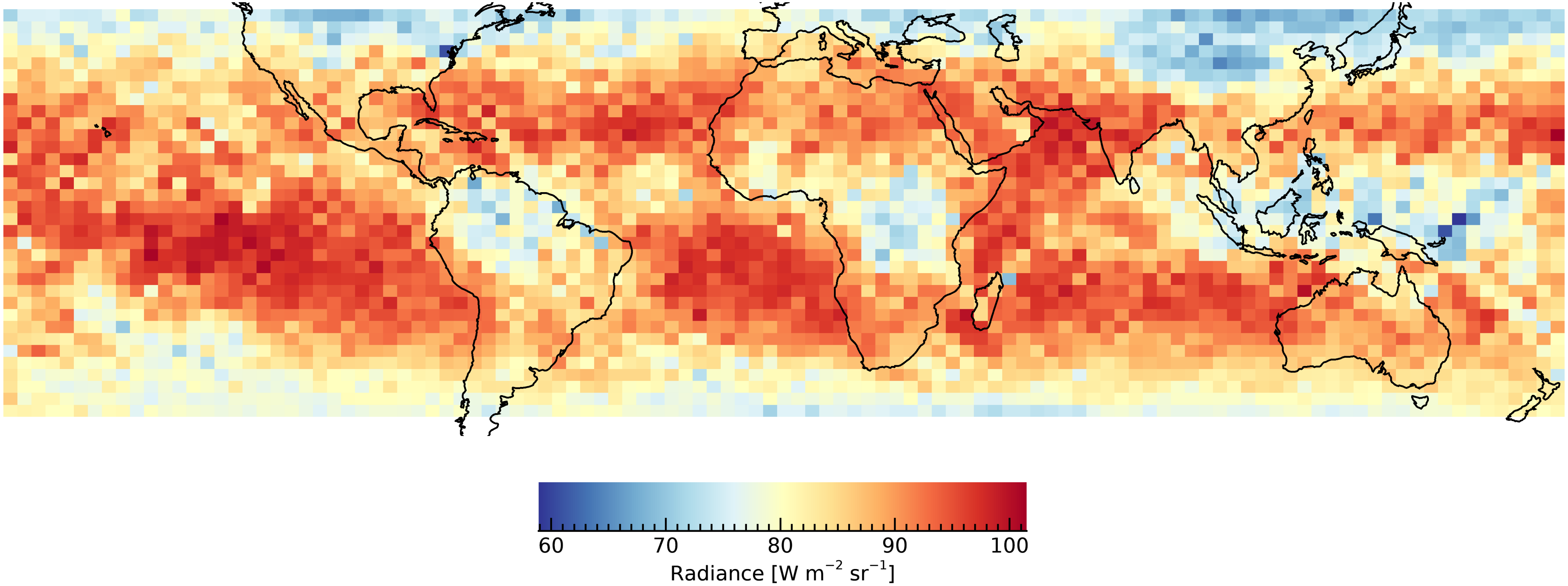


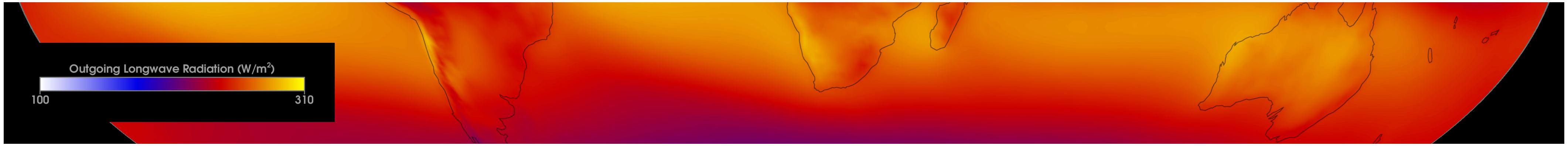

All CTIM Global Coverage with Radiance Values (A1 Channel)
Dark Side Only (August 26, 2022 - June 3, 2023)
20
40
60
80
100
120
140
160
Radiance (W m^{-2}sr^{-1})

CTIM Mean Radiance



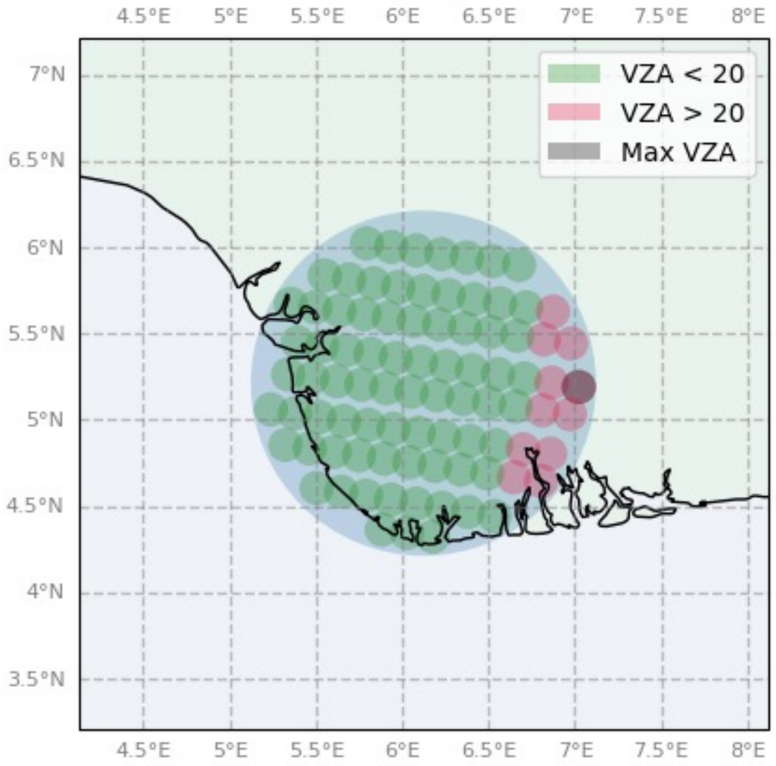
CTIM Mean Radiance 26 AUG 2022 –3 JUN 2033





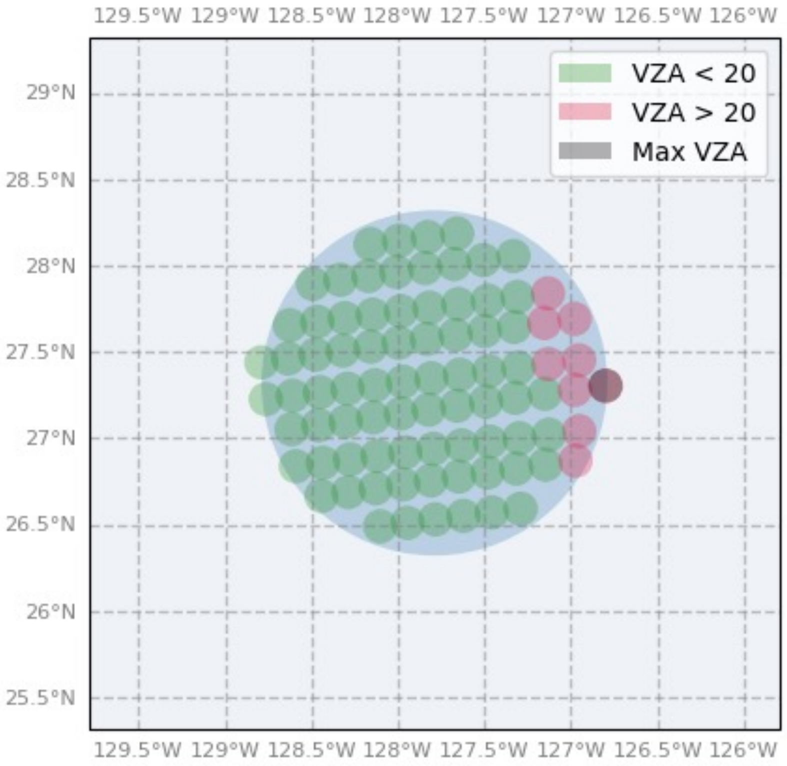
CERES-CTIM Overlap

Example of CERES Points Filling CTIM Footprint:
87 Aqua points



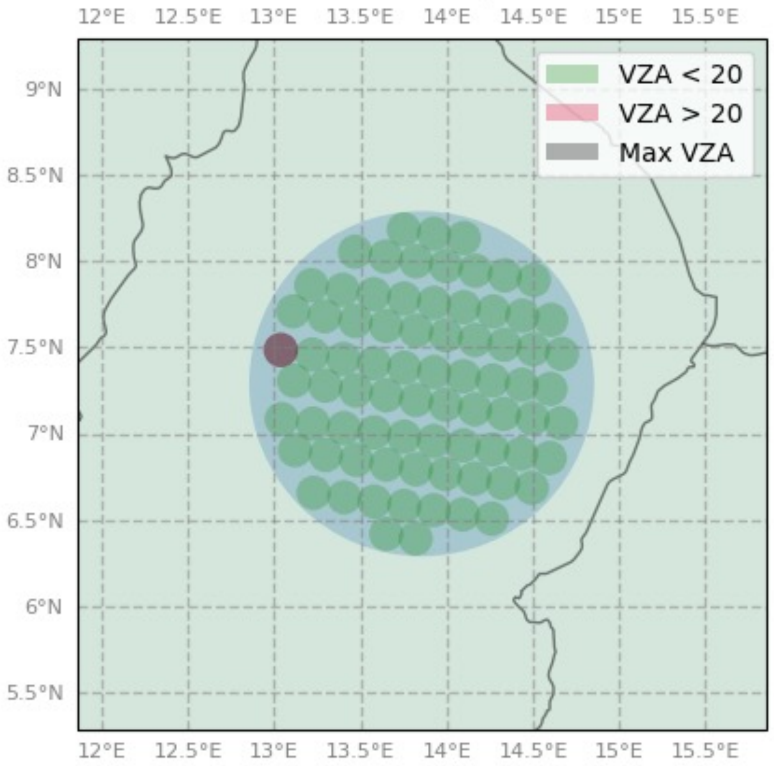
Maximum CERES VZA = 22.618002 degrees
# of CERES points with VZA < 20 = 76 points
# of CERES points with VZA > 20 = 11 points

Example of CERES Points Filling CTIM Footprint:
85 Terra points

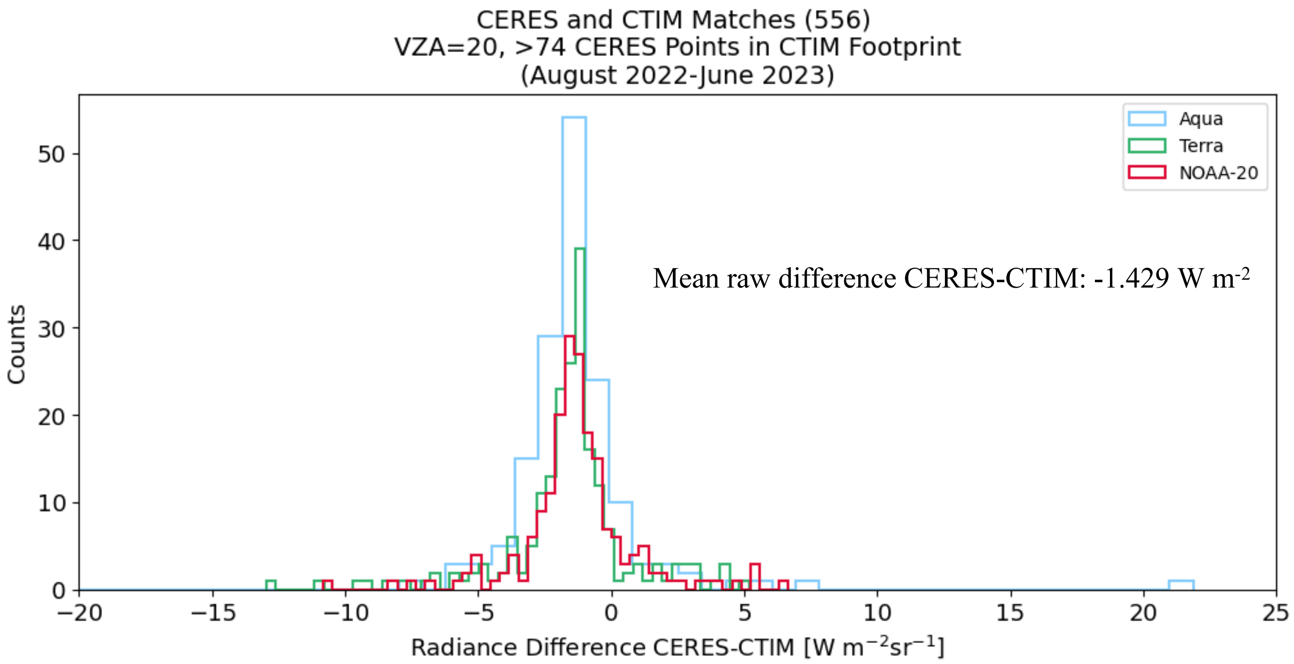


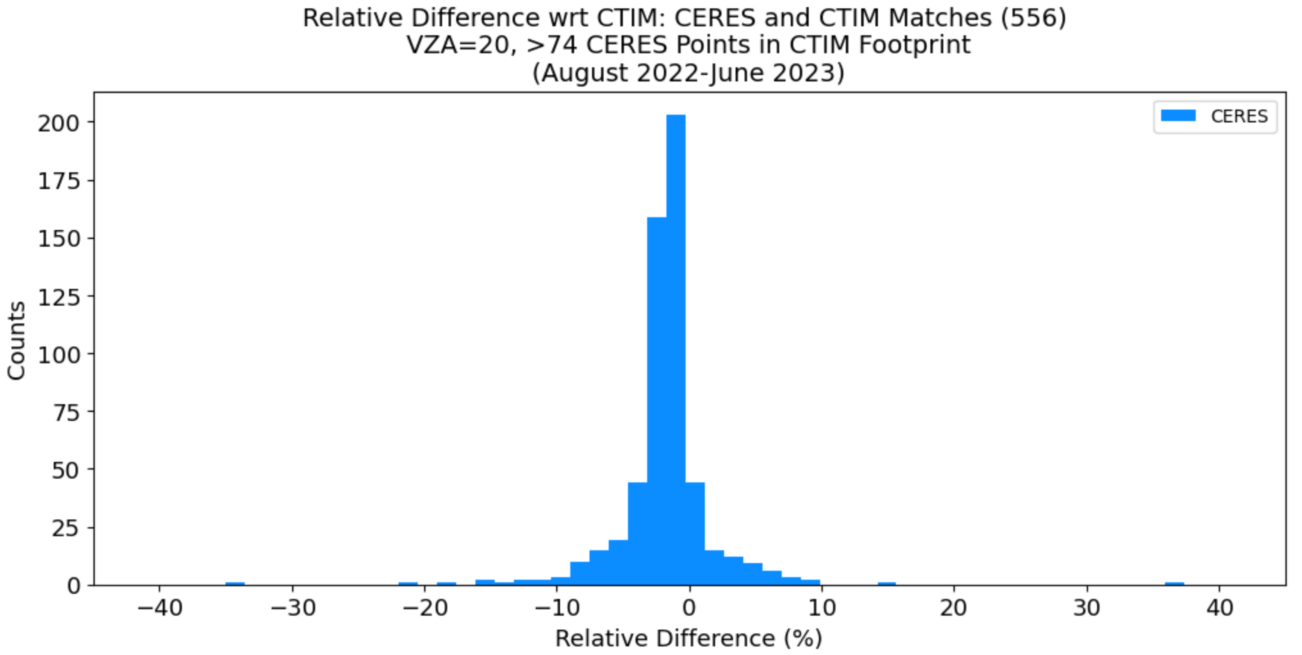
Maximum CERES VZA = 22.662287 degrees
# of CERES points with VZA < 20 = 76 points
# of CERES points with VZA > 20 = 9 points

Example of CERES Points Filling CTIM Footprint:
77 NOAA-20 points



Maximum CERES VZA = 20.14629 degrees
# of CERES points with VZA < 20 = 76 points
# of CERES points with VZA > 20 = 1 points





Relative Diffs wrt CTIM:

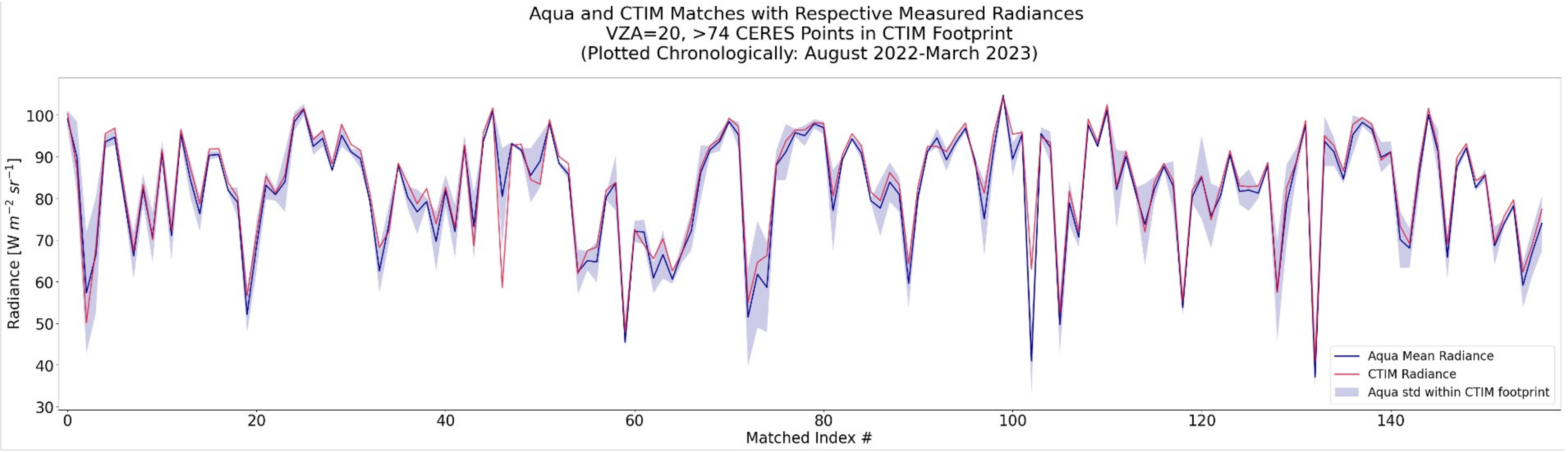
NOAA-20: -1.505%

Aqua: -1.734%

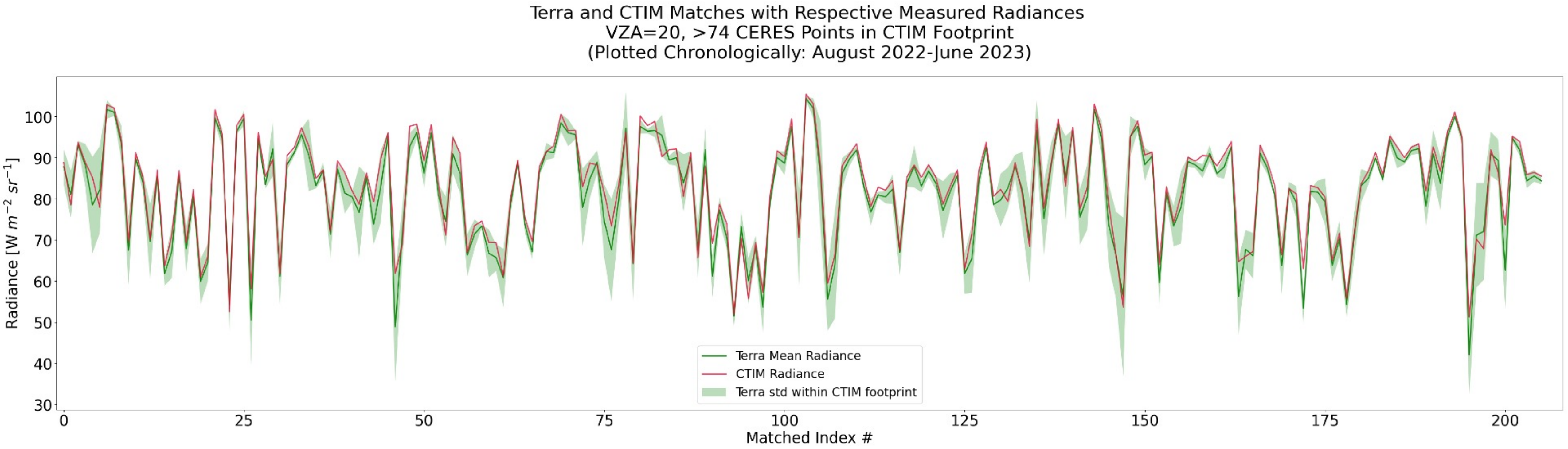
Terra: -2.020%

CERES: -1.760%

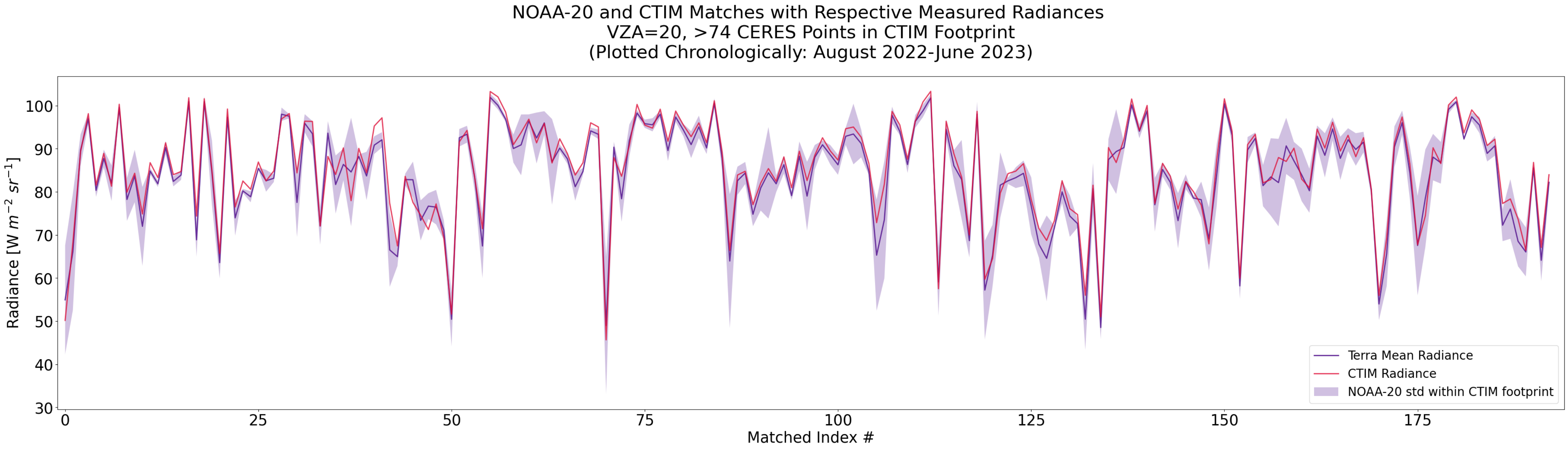
CERES Aqua & CTIM Time Series



CERES Terra & CTIM Time Series



CERES NOAA-20 & CTIM Time Series



Summary

Libera build phase has begun - on track for JPSS-4 late-2027 launch.

CTIM has collected some interesting data on Earth emission during eclipse. Looking forward to working with CERES team on comparison.

INTERNATIONAL RADIATION SYMPOSIUM 2024

17-21 June 2024 Hangzhou, China

http://www.irs2024.org

Thanks!