FLASHFlux Working Group Status: Progress toward NN/ML SSF and GCC TISA

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Fu-lung Chang (AMA), Arun Gopalan (AMA), and Baojuan Shan (ADNet)

POWER Team: ***Christopher Higham, Bradley MacPherson, Amanda Merritt, Zoe Waring and A. Jason Barnett (Booz-Allen-Hamilton)***

CERES FLASHFlux Overview

- ***FLASHFlux Overview***
  - Uses CERES based production system through inversion (w/ quarterly calibration updates projected forward)
  - Running 3-day TISA utilizing afternoon orbiter (NOAA-20 only)
- ***FLASHFlux Latency Objectives***
  - SSF products within 3-4 days
  - Global 1x1 daily averages from FF TISA; goal: 5-7 days latency
- ***FLASHFlux Uses***
  - Primarily used for applied science and education (i.e., POWER and Globe Clouds)
  - Supports also QC for selected missions (e.g., NOAA NESDIS, EarthCare)
  - TOA gridded fluxes; normalized to TOA EBAF for annual “State of the Climate” assessments.

FLASHFlux Operational Status

- ***FF Production status:***
  - Current Status:
    - SSF NOAA-20 (V1B): 10/21/26
    - TISA: NOAA-20-only v1A: 10/19/26
  - Updated calibration coefficients received & promoted as cc change effective 10/1/26 (next update scheduled for 1/1/27)
- ***Important Activities since last CERES Meetings:***
  - Maintained production and updated validation for old and new versions
  - Revised and retrained NN/ML for SW surface flux downward flux for all-sky and clear-sky conditions; sensitivity study on training periods (Kuan-Man's talk).
  - Revised offline F/L with new Ed5 solar zenith angle, MOA and other updates; global hourly TOA and surface radiative fluxes using SatCORPS GCC data

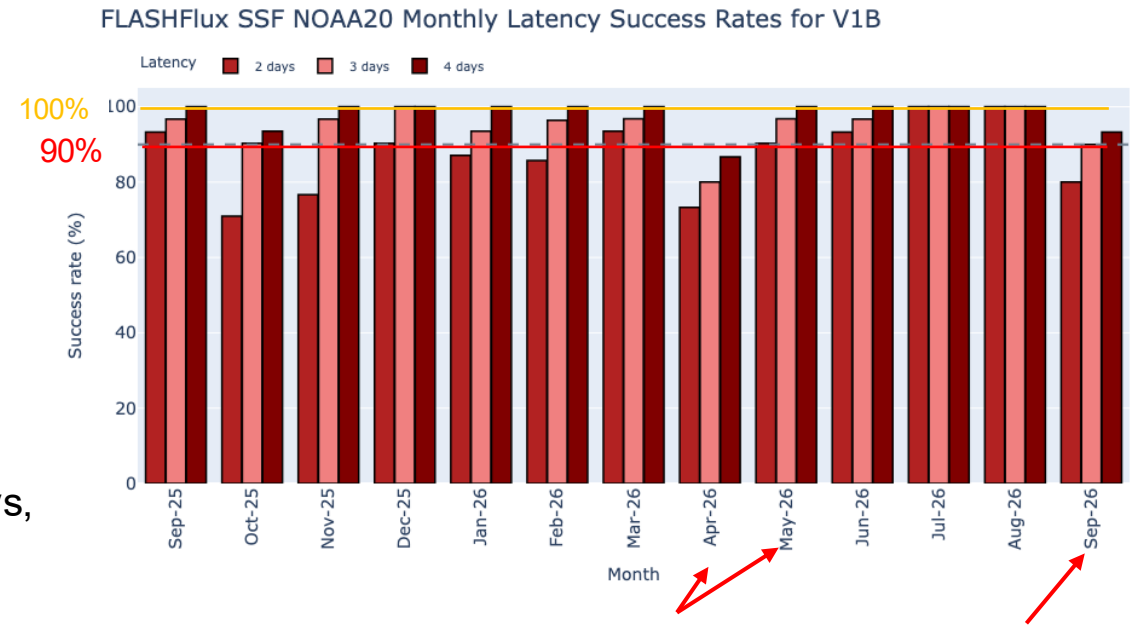
FLASHFlux SSF Latency Assessment

Success rate (%) of time data archived within 2, 3, or 4 days of observation

Lags are sometimes due to maneuvers/satellite issues, ASDC updates/outages, ASDC Dropbox/Darkhorse, GSFC LAADS and/or SIPS

Latency for August 2026:
100% of products archived at 3 days,
100% by 4 days

Latency for September 2026:
90% of products archived at 3 days,
93% by 4 days



Multiple outages for hardware migration/software upgrades at ASDC, sporadic VIIRS/CERES gaps

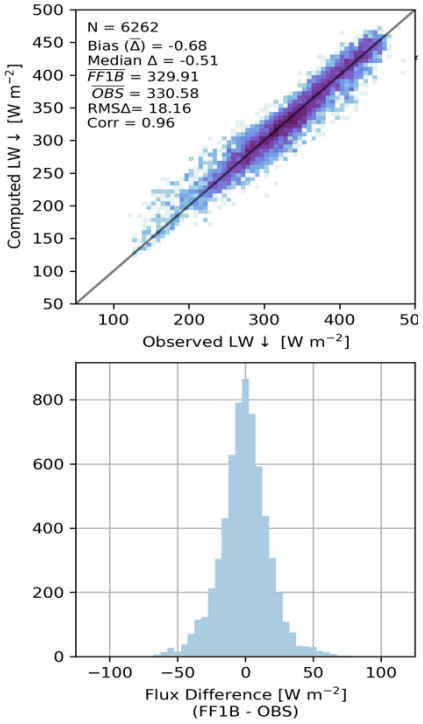
NOAA-20 SSF LW Flux Day Validation:
7/2025 - 6/2026

Overpass NOAA-20 LW daytime flux validation with BSRN measurements:

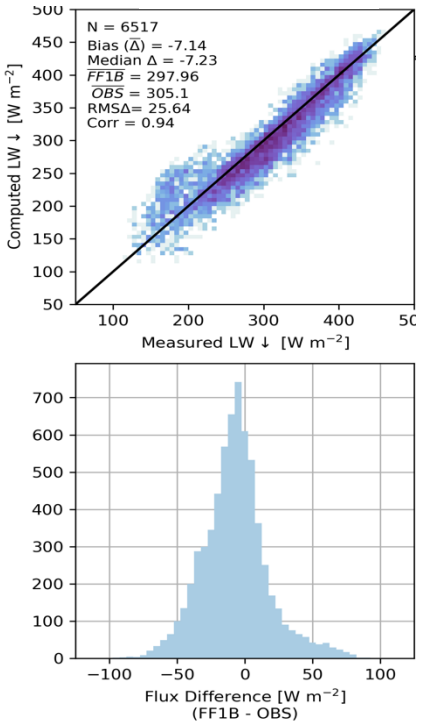
- Left: FF SSF V1B Daytime: <1% bias, < 6% RMS
- Right: FF SSF V1B Nighttime: ~ 2.3% bias, ~8.5% RMS

FF LW down (FF V1B, Model B, 7/25 – 6/26)

Daytime



Nighttime

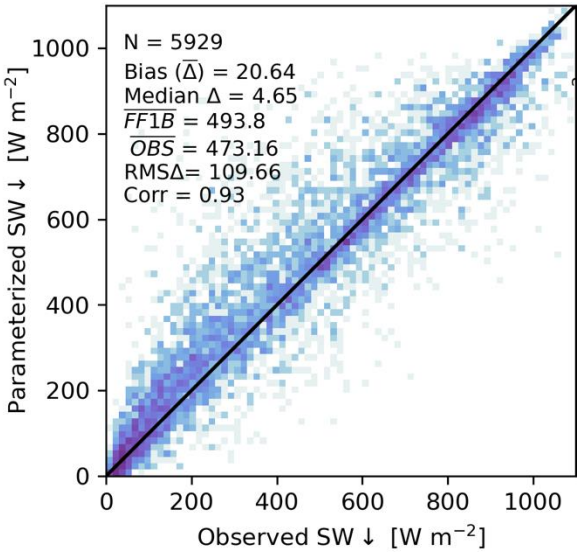


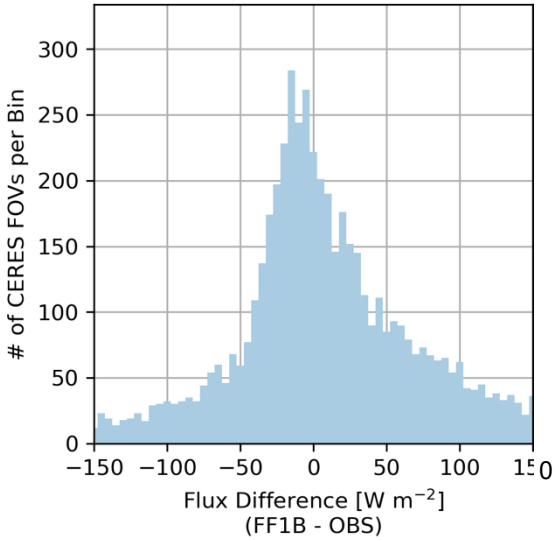
NOAA-20 SSF SW Flux Validation:
7/2025 - 6/2026

Overpass NOAA-20 SW daytime flux validation with BSRN measurements:

- Right: FLASHFlux SSF V1B scatter plot: ~4.3% bias, ~23% RMS
- Left: FLASHFLux SSF V1B difference histogram
  - asymmetric
  - shows median < 0

FF Surface SW down
(NOAA-20; FF V1B, Model B)





SSF Flux Algorithm Updates: NN SW & LW

Justification:

- FF footprint fluxes have been used both scientifically and for applications
- Current LPSA/LPLA algorithms older methods, hard to update; separate from Fu/Liou

Objectives:

- Use NN/ML methods to devise algorithms that approximate surface fluxes for each footprint to replace old LPSA and LPLA estimates:
  - Produce SW, LW for all-sky, clear-sky ”clouds removed”; surface up, down and net
  - Use CRS Ed4 used for training since uses full Fu/Liou RT
  - Compare and assess relative to CRS outside of training period & surface measurements

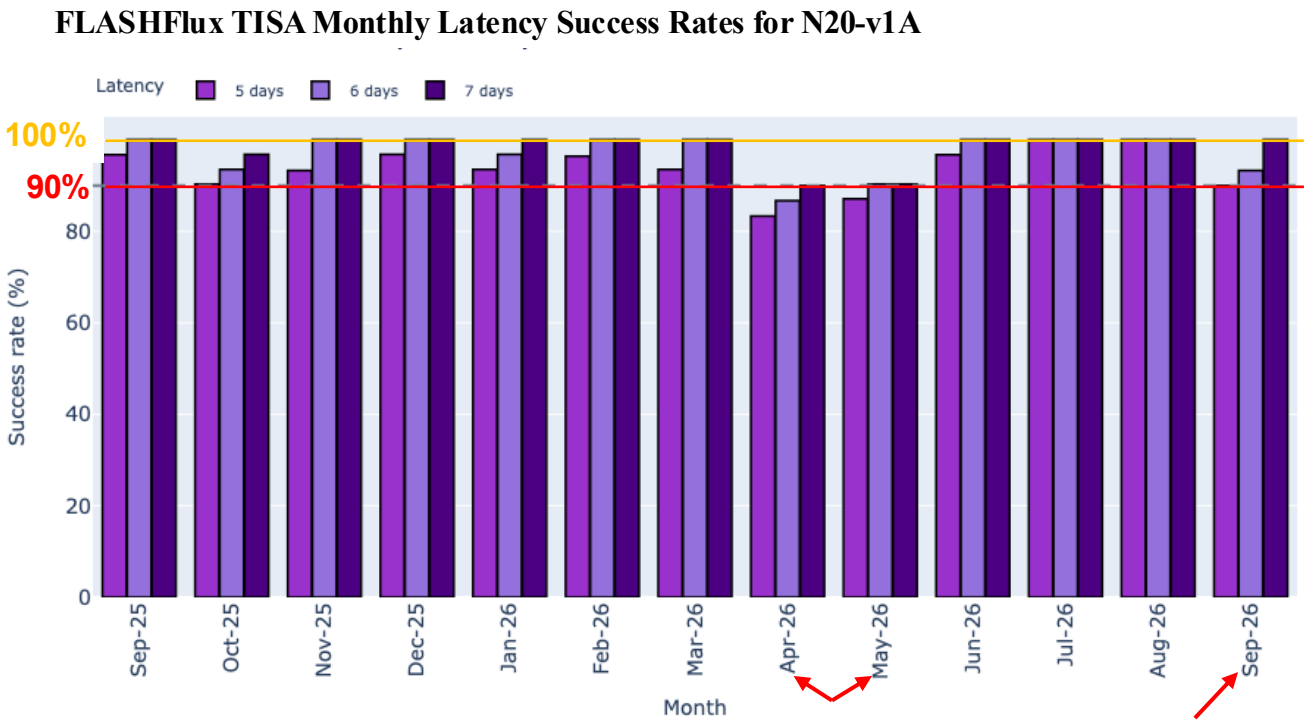
Progress since May 2026:

- *Continued working with surface SW fluxes only since LPSA is showing largest errors*
- Revised and retrained to improve coefficients; first cut validation
- See Kuan-Man Xu’s presentation (next)

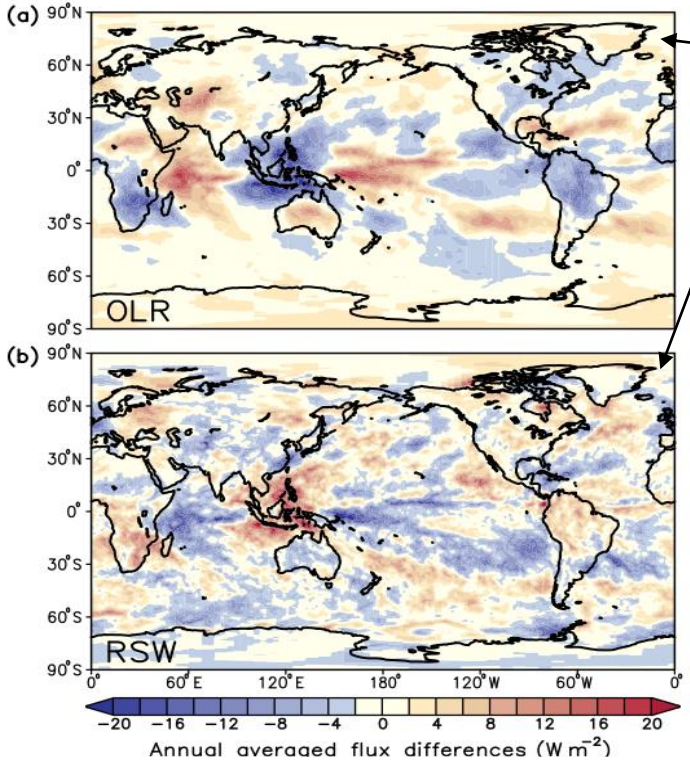
FLASHFlux TISA: Latency Statistics (N20v1A)

N20 v1A success rates for TISA to be archived in 5, 6 or 7 days after observation

Sept. 2026: 100% released by day 7 after obs (~ 93% by day 5); last 3 months 100% released by 6 days.



FLASHFlux TISA Application: Updated Anomalies



Global map of annual mean (a) OLR and (b) RSW for 2025 minus 2024

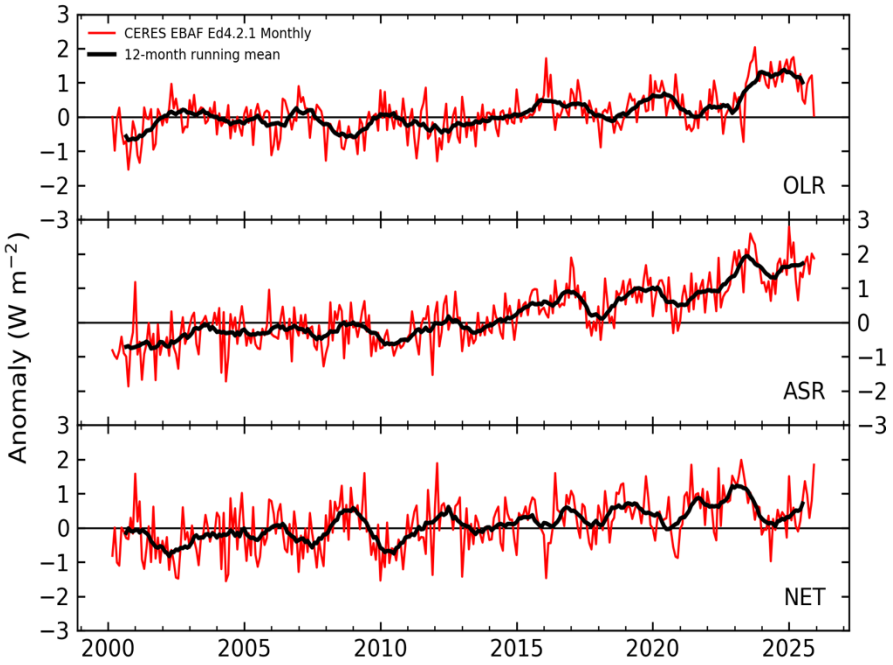
Global annual mean top-of-atmosphere (TOA) radiative flux means, changes, anomalies, and the 2-sigma interannual as shown. All flux values have been rounded to the nearest 0.05 W m^{-2} and only balance to that level of significance.

Global	One Year Change (2025 minus 2024) (W m^{-2})	2025 Anomaly (Relative to 2001–20) (W m^{-2})	Climatological Mean (2001–20) (W m^{-2})	Interannual Variability (2001–20) (W m^{-2})
OLR	-0.25	+1.00	240.35	±0.65
TSI	-0.05	+0.25	340.15	±0.15
RSW	-0.45	−1.45	99.05	±0.95
ASR	0.40	+1.70	241.10	±0.90
Net	+0.65	+0.70	0.80	±0.80

Stackhouse *et al.*, 2026, BAMS State of the Climate Special Issue

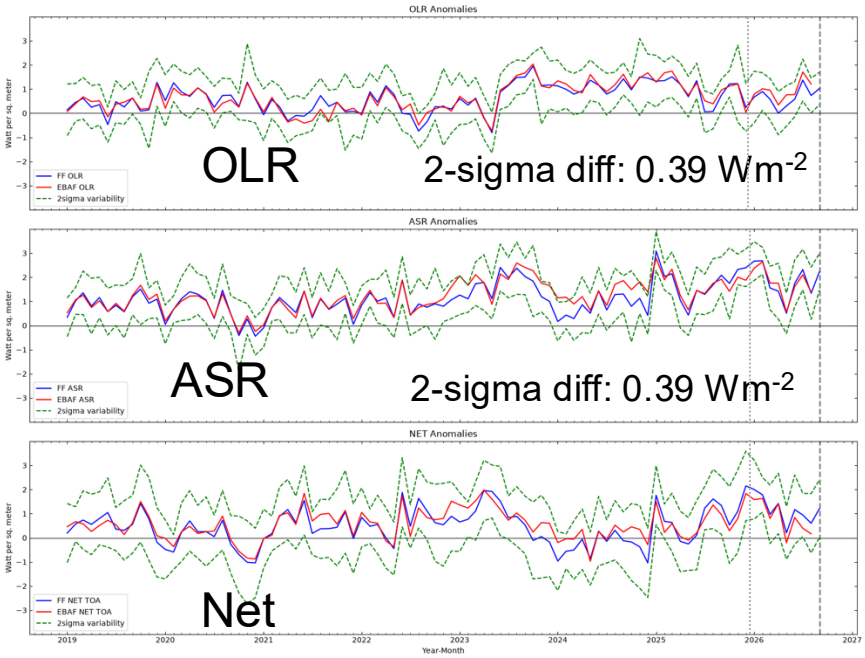
FLASHFlux TISA Application: Updated TOA Anomalies

TOA Flux Anomalies (through 2025)



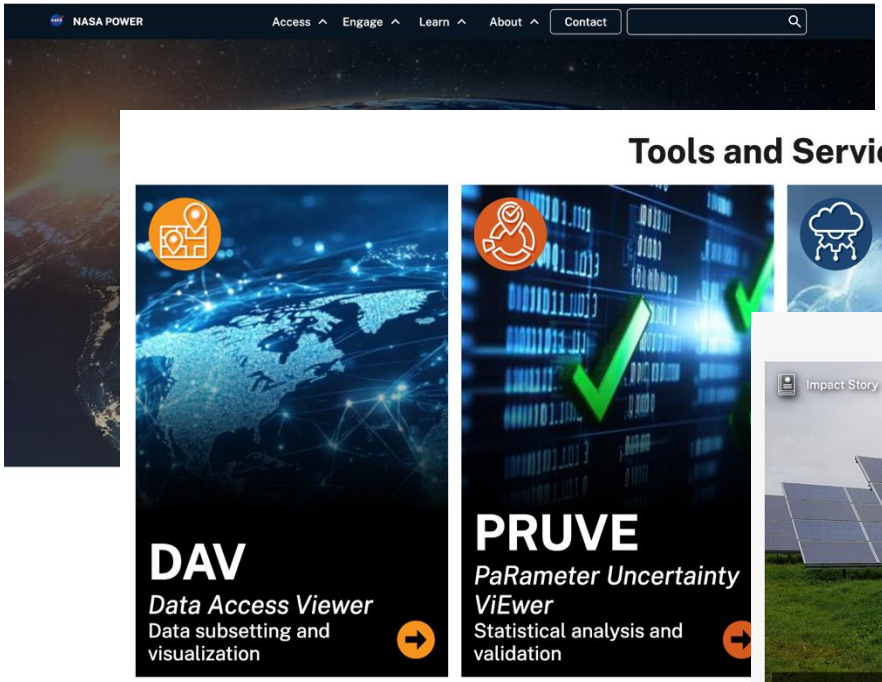
Stackhouse *et al.*, 2026, BAMS SotC

TOA Flux Anomalies (updated through 9/26)



Includes TISA NOAA20 from 1/2024 transition;
EBAF base period 01/2001 to 12/2020

FLASHFlux (& SYN1Deg) Applications through POWER Web Services



POWER continually updates with CERES Data Products for Energy, Infrastructure and Agricultural Applications

Data Accessible via Numerous Optional Pathways and Formats

https://power.larc.nasa.gov

User Impact: Electryone AI

Smart Battery Optimization Creates Affordable Energy with POWER Data

- Electryone AI, founded in the United Kingdom, pulls POWER's hourly solar irradiance data to help people optimize their smart battery charging and solar power usage.
- Customers using Electryone AI software save on average more than $600 on their electric bill.

"Seamless and free access to high-quality data was very critical for us…Without data like POWER data, we wouldn't be able to boost our operations and figure out how to make a commercial product."

- Electryone AI CEO and Co-Founder



Image Credit: Electryone AI

FLASHFlux TISA & SYN1Deg Usage via POWER Web Services Portal (2025/10/01 to 2026/09/30)

CERES Data Orders Delivered via POWER < 3 weeks latency (FLASHFlux Data)

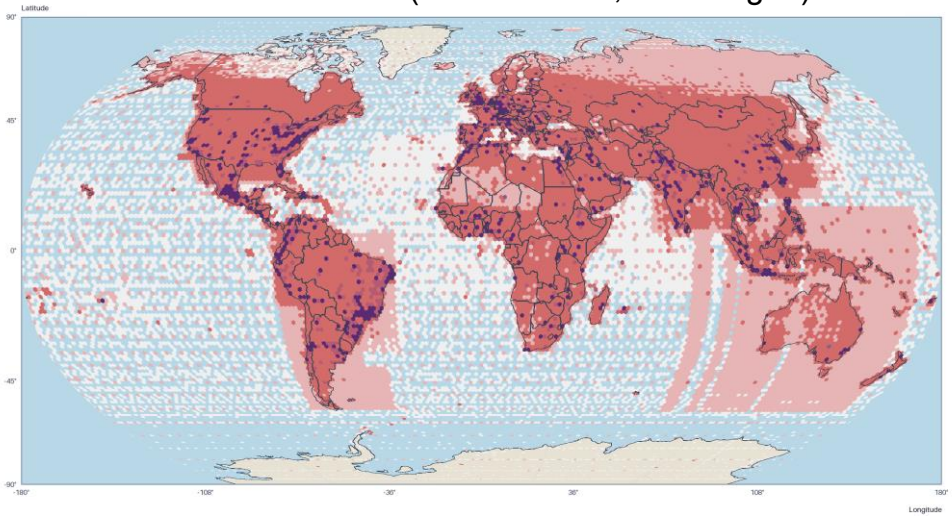
	Total	Monthly	Avg. Last 3 Months
Unique Users IPs	~368.2 K (26%)	~34.8 K (25%)	~78.8 K (32%)
Requests	~128.7 M (34%)	~10.7 M (34%)	~18.8 M (41%)

CERES Data Orders Delivered via POWER including SYN1Deg and FLASHFlux data

	Total	Monthly	Avg. Last 3 Months
Unique Users IPs	~836.0 K (58%)	~80.2 K (58%)	~119.7 K (49%)
Requests	~228.3 M (60%)	~19.0 M (60%)	~26.0 M (57%)

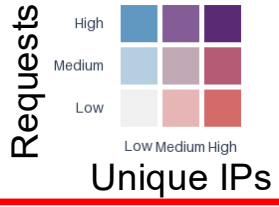
(includes SYN1Deg from through latest month released)

POWER API Metrics (10/19 – 10/21; 100 km grid)



Period totals

Coordinate-valid point requests	5,104,628
Distinct GeoIP client IPs	113,366



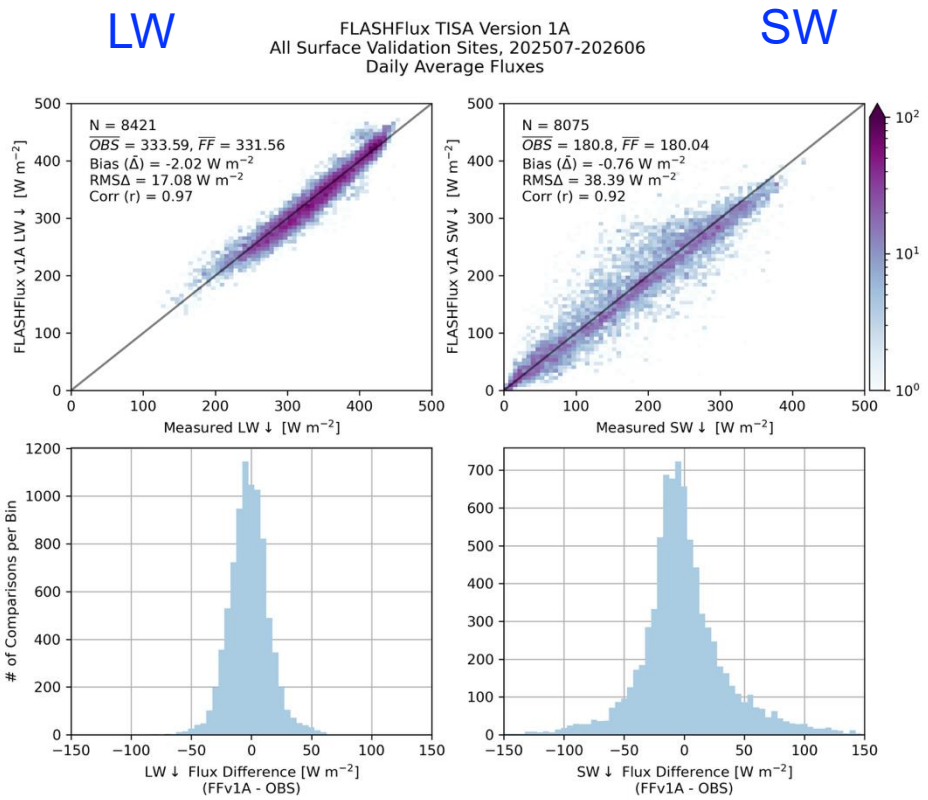
Bivariate map showing POWER API request activity by user location, with color indicating the combined frequency of distinct client IP locations and coordinate-valid point requests.

FLASHFlux TISA Validation: NOAA-20 TISA

- Ensemble FLASHFlux TISA (NOAA20-only) Daily Average Comparisons to Surface Measurements (7/2025-6/2026)

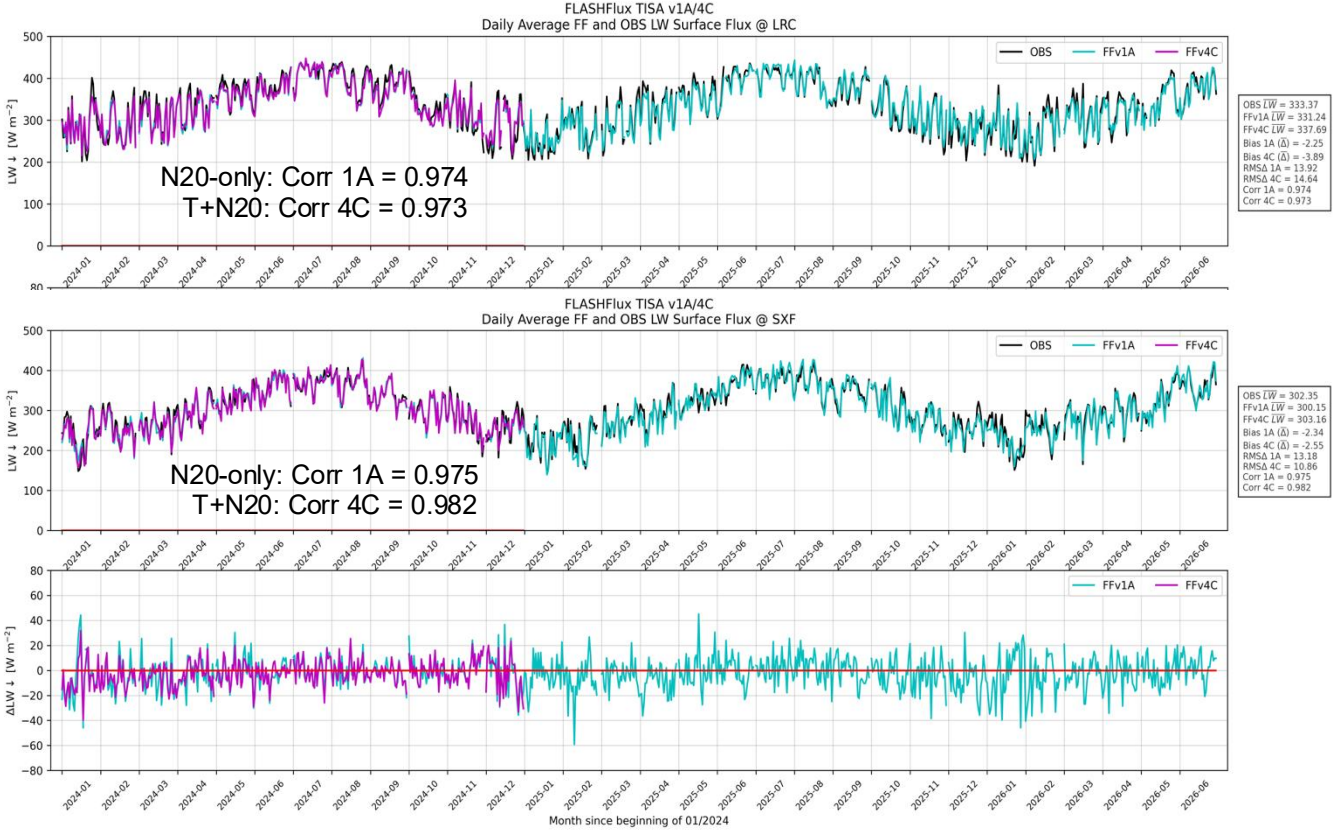
- LW & SW fluxes consistent quality relative to surface measurements:
  - Bias Diff: LW & SW ~ -0.5 - -1%
  - RMS Diff: LW ~ 5.1%; SW ~ 22%

- Histograms show peaked, relatively symmetric distributions, median bias is negative for both SW & LW; SW broader distribution with larger outliers



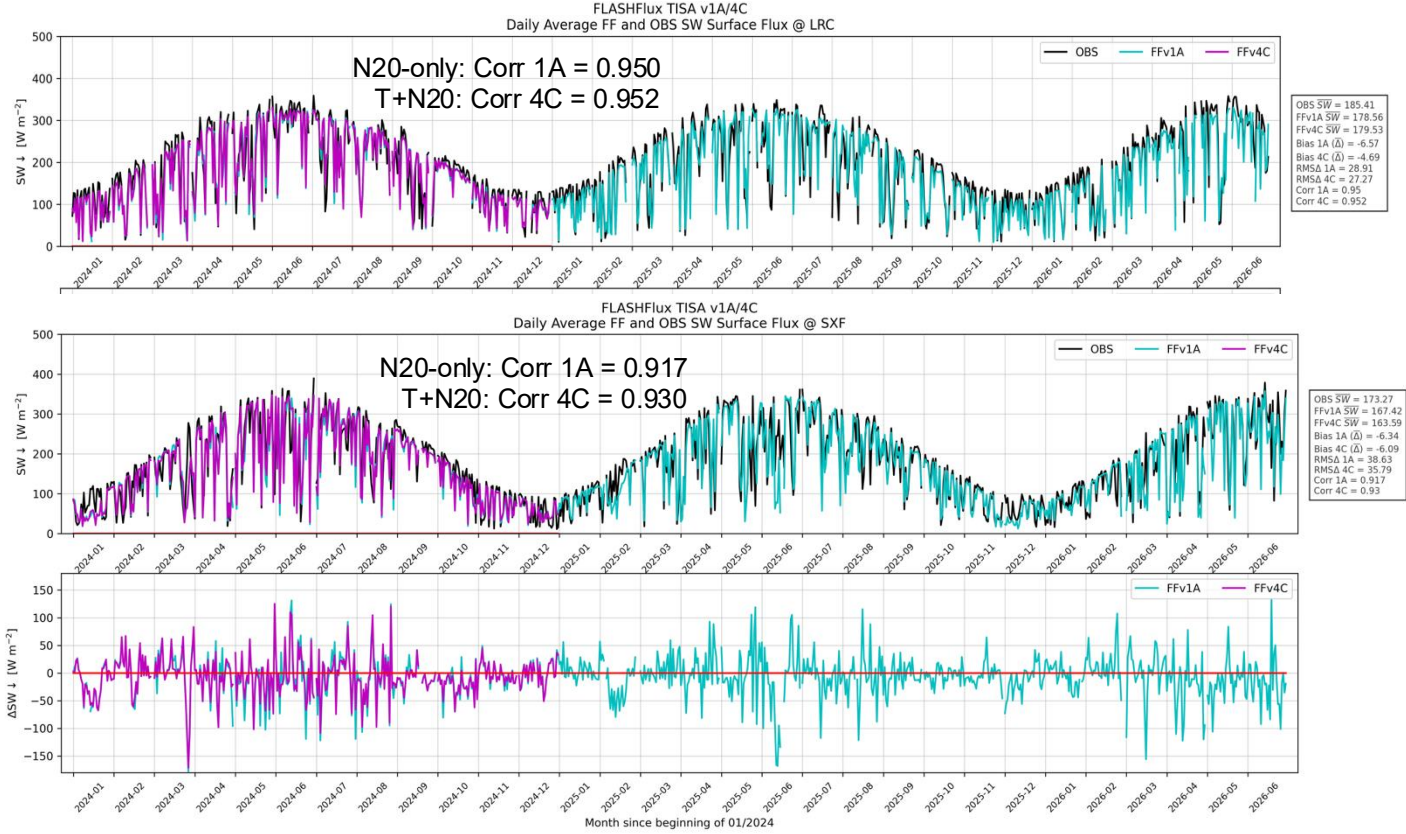
Time Series Validation: LW

- Example time series comparison against LW LRC and BOS BSRN sites
  - FF T+N20 v4C
  - FF N20-only v1A
- Although day-to-day variability is smaller, there still seems to be more noise in the N20-only version.
- RMS's (correlations) are increased (decreased), but to a lesser extent
- No LW drifts currently observed.



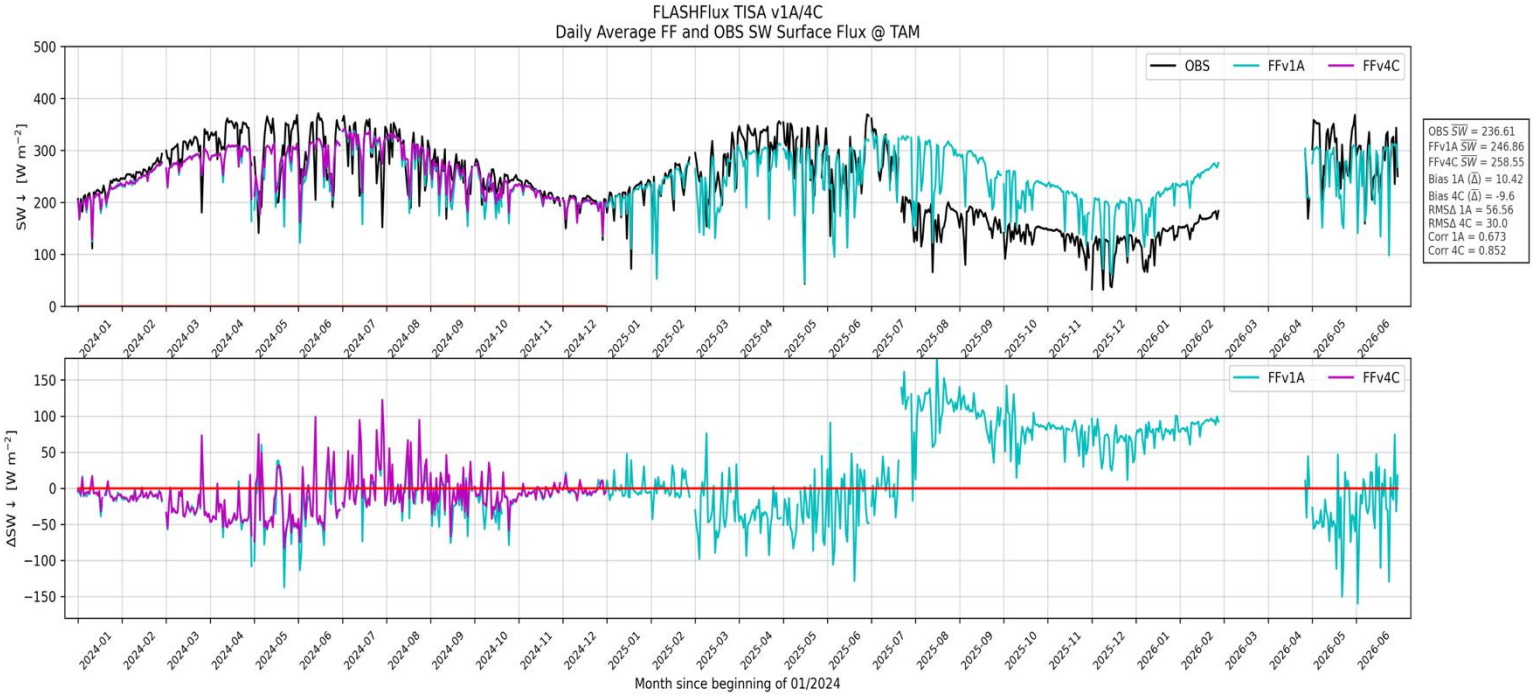
Time Series Validation: SW

- Example time series comparison against SW measurements from the LRC & SXF BSRN sites for:
  - FF T+N20 v4C
  - FF N20-only v1A
- Biases occur for periods but these vary site to site.
- However, RMS's (correlations) are increased (de-creased) at every site.
- No SW long-term drifts currently observed.



Time Series Validation: SW

- SW measurements from the TAM BSRN site for:
  - FF T+N20 v4C
  - FF N20-only v1A
- SW measurements large discontinuity
- FF remained consistent
- TAM SW measurements past July 2025 are not usable



GEO to FLASHFlux TISA

Why GEO?

- Losing Terra removed an early sample to better anchor daily average; NOAA-20 daily averages show similar biases but are more noisy less correlated in locations.
- Applied user demand for hourly global fluxes at low latency (within 1 week)

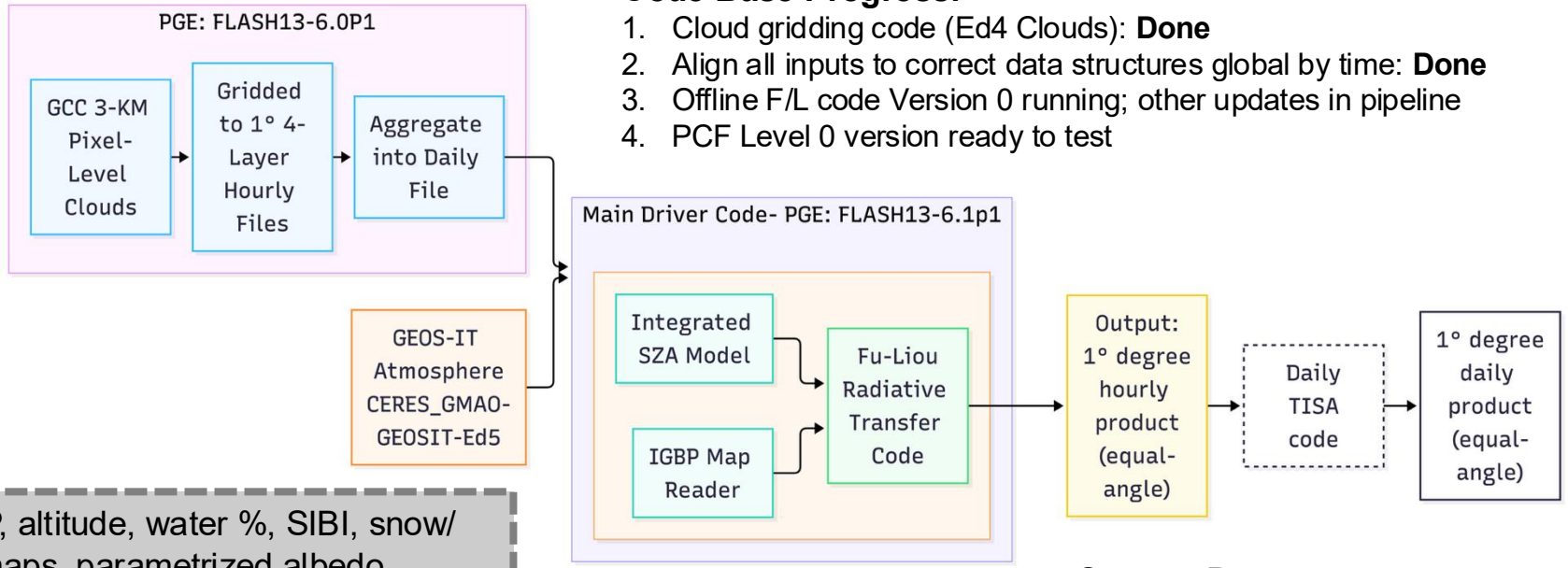
Key Inputs:

- Global Cloud Composite from SatCORPS Group (NRT global fused 3 km cloud): using GCC v2b for 4 mid-seasonal months: Oct 2025; Jan, April and July 2026
- Key Edition 5 inputs (i.e., IGBP) and algorithms (i.e., improved hourly weighted TSI solar fluxes; TISA architecture – global hour by hour processing)
- Meteorological Profiles and Surface Met from GEOS-IT (low-latency within 2 days)

Two Prong Development for Sustained Improvement

1) Offline Fu/Liou driver code development => testbed for updates; version 0 is now running and is being used to test new updates
2) Preparation for script based production (PCF, for eventual CATALYST production); requires formal documentation and metadata; data reformatting, timing decisions and other requirements

Adding GEO to FF TISA: Current Progress



Code Base Progress:

1. Cloud gridding code (Ed4 Clouds): **Done**
2. Align all inputs to correct data structures global by time: **Done**
3. Offline F/L code Version 0 running; other updates in pipeline
4. PCF Level 0 version ready to test

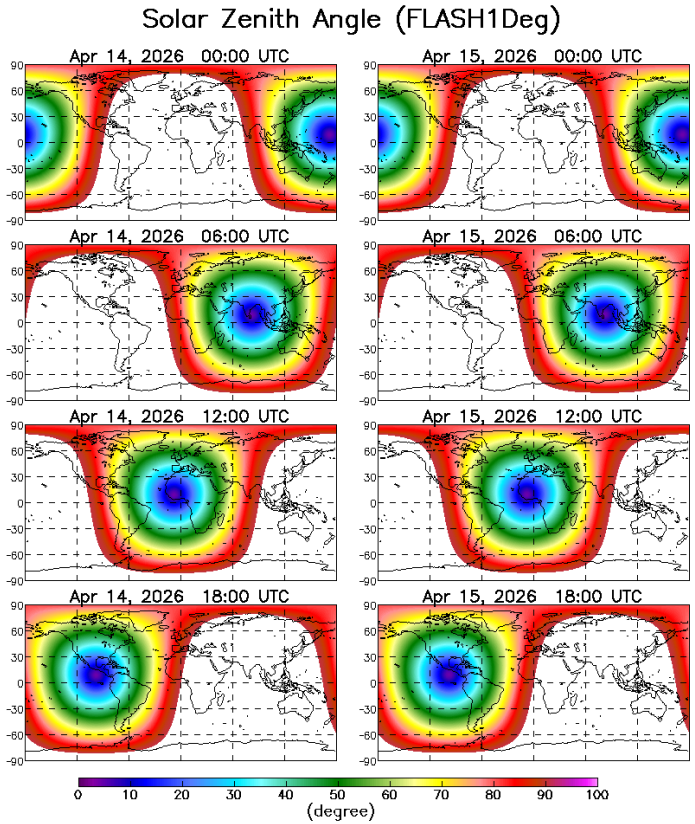
IGBP, altitude, water %, SIBI, snow/ice maps, parametrized albedo, aerosols, etc (for testing use various CERES inputs as it; will work to create at low latency later)

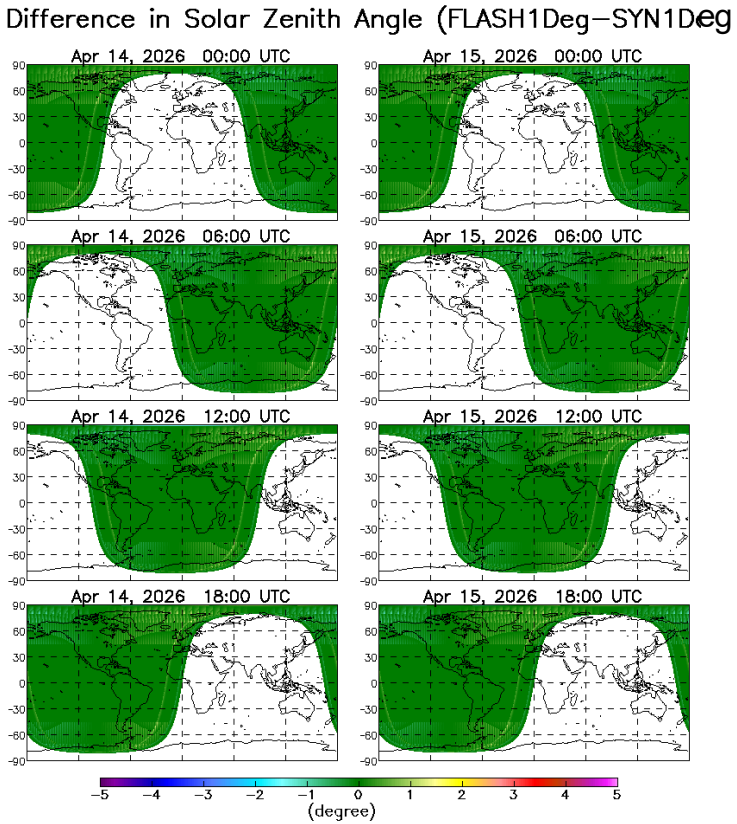
Current Progress:

1. Offline Fu-Liou runs for days April 2026 with w/ GCC version 2B
2. Test PCF by running 1 week in production test run environment.

Adding GEO to FF TISA: Integrated Solar Zenith Angle

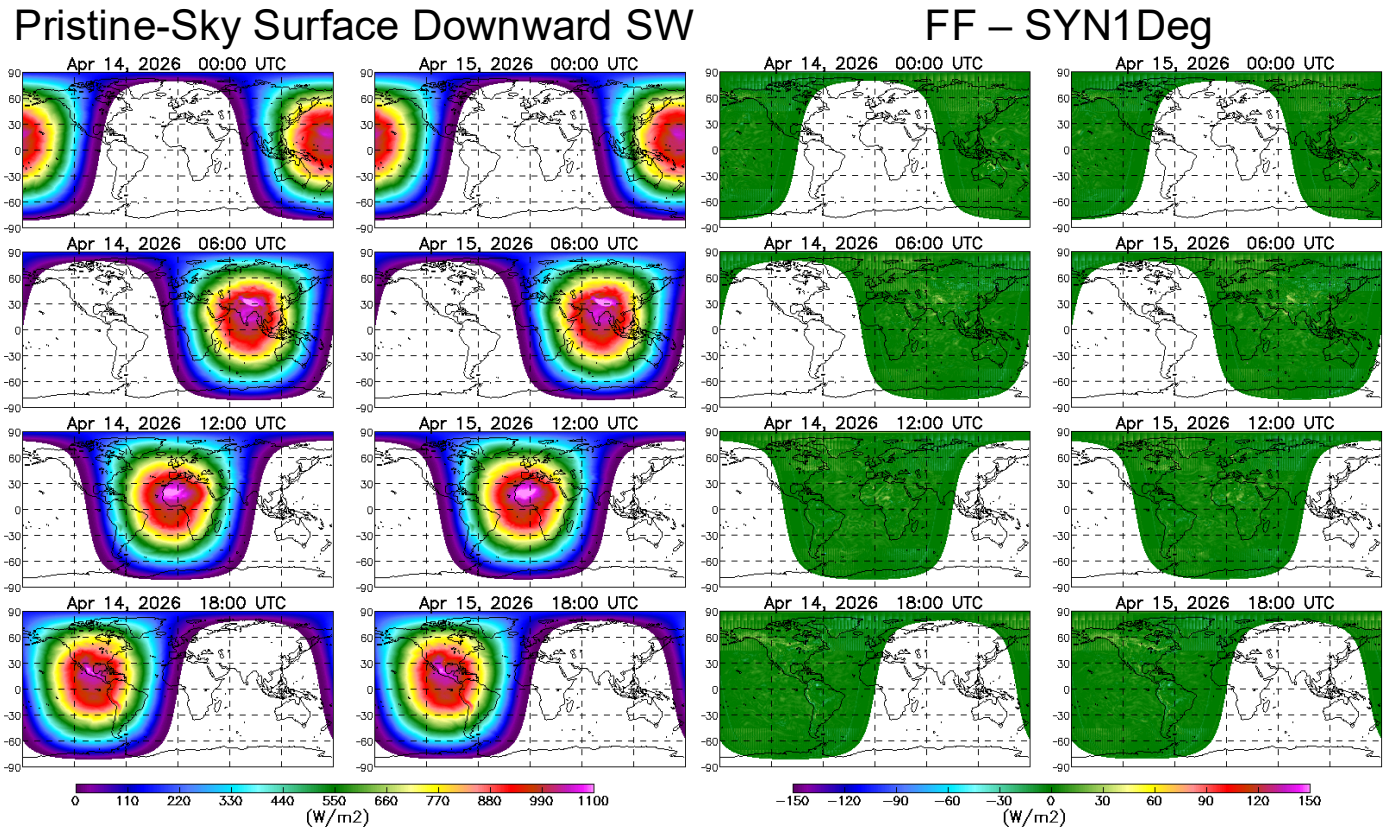
- Worked with TISA team to adapt Ed5 SZA hour integration hour into code
- Allows for simple flux sum to derive daily averages
- Impacts hour TSI and thus surface down clear-sky fluxes





Adding GEO to FF TISA: Pristine-sky Surf SW Dn

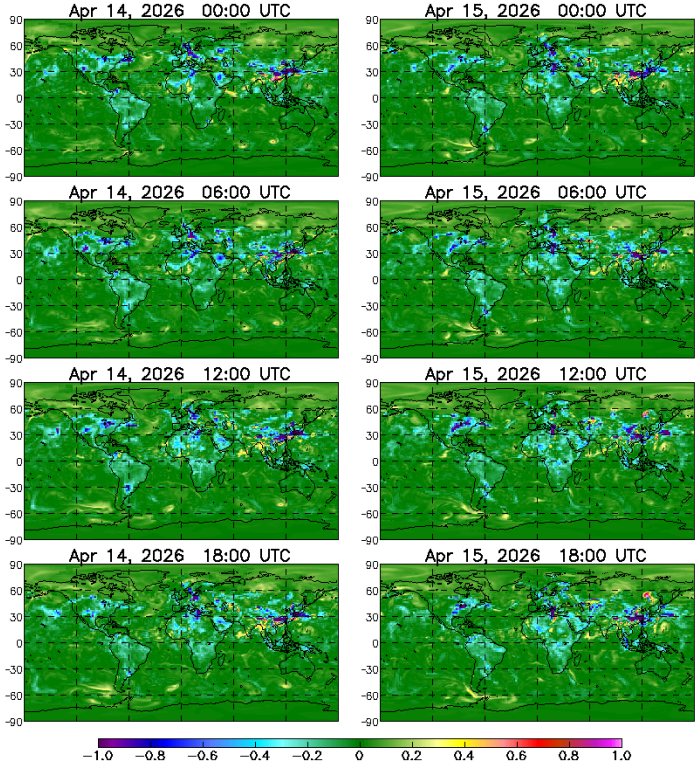
- Hourly Pristine-sky Surface SW down flux and flux differences relative to SYN1Deg
- Shows consistency w/ SYN1Deg but now independent
- Note: some differences due to grid and also to difference between MERRA2 and GEOS-IT



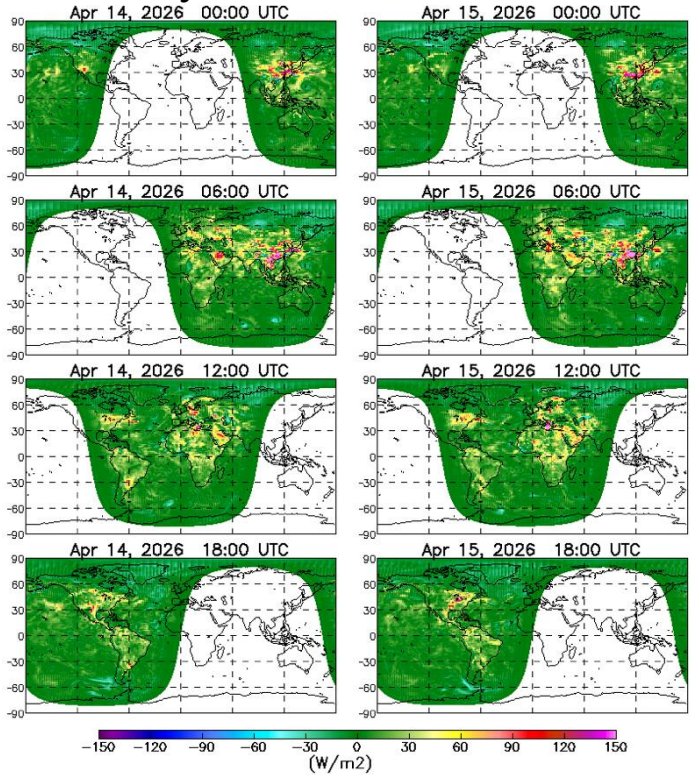
Adding GEO to FF TISA: AOD and Clear-sky SW

- Aerosol optical Depth (AOD) is currently uses GEOS-IT w/ parameterized scattering optical properties
- Current land FF AOD < SYN1Deg
- Result: FFCS Hour Surf SW flux > SYN1Deg

AOD Difference

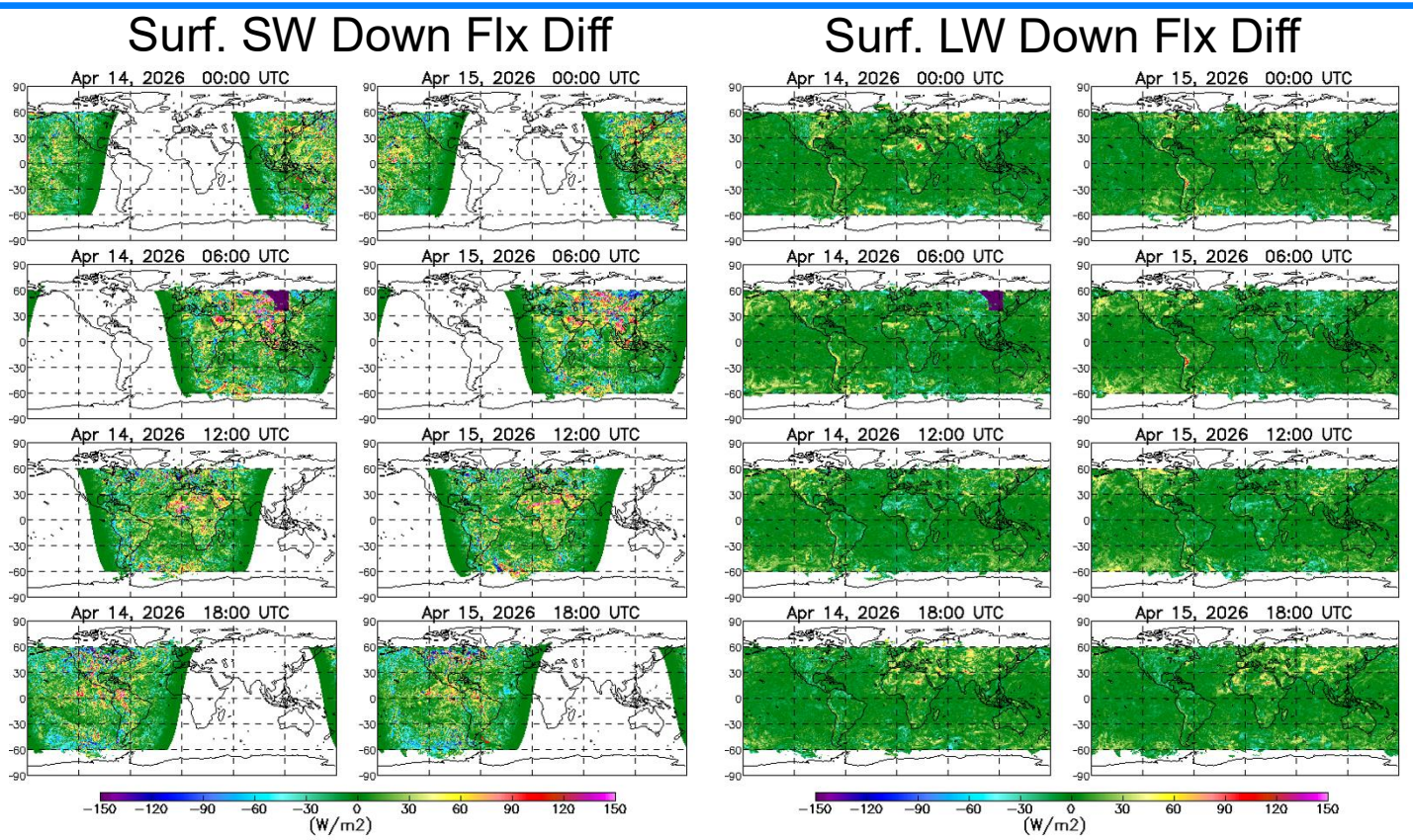


Clear-sky Surf SW Dn Difference



Adding GEO to FF TISA: All-sky SW & LW

- Version 0 All-sky surface downward SW & LW fluxes
- GEO-only clouds processed for this version
- Mostly positive SW differences noted; more mixed in LW



Adding GEO to FF TISA: Next Steps

Off-line Code Plans:

Version 0: Continue improvement testing for surface albedo, aerosol and cloud properties

- Improve land & snow/ice partial coverage albedo estimates
- Assess cloud properties; particularly LEO
- Assess aerosol optical properties

Online (Script-based) Plans:

- Version 0: Use scripting system to run at least 4 months with GCC v2B; assess with surface measurements
- Version 1: Update with key improvements above as necessary to improve surface fluxes (at or better current daily average quality)
- Deliver to production for implementation

FLASHFlux Summary

- ***Production with SSF for NOAA-20 only (1b) and TISA (v1A) Continues***
  - FF NOAA-20 V1B SSF (10/19/26) and Terra V4B (2/13/25 - end) with GEOS-IT
  - TISA NOAA-20-only V1A through 10/17/26
  - New FF Gain+Spectral coefficients beginning Oct 1st, 2026.
- ***Validation and Assessment Relative to BSRN/Buoy***
  - FLASHFlux NOAA-20 SSF V1B through March 2025; SW biases consistent, but high
  - TISA Terra+NOAA-20 V4C compared to NOAA-20-only V1A daily averages from Jan-Dec 2024 (12 months); biases slightly worse for SW/LW; RMS's higher and correlation lower for N20-only
- ***FLASHFlux Modernization and Updates***
  - ML based algorithms for future FF SSF data products: Goal Operational Spring 2027
  - Migrate configuration to NOAA-20 + GCC GEO & F/L Fluxes: Goal Operational Summer 2027
- ***FLASHFlux Information & Data Provision Through ...***
  - CERES web site and subsetter both SSF and TISA, ASDC (via EarthData) and POWER
    - FF+Syn1 POWER Distribution in last year: ~836K unique IPs; ~ 228M orders; orders >41% FF
  - 2025 BAMS State of the Climate TOA Flux reports published

FLASHFlux Web Sites & Acknowledgments

https://ceres.larc.nasa.gov/data/#fast-longwave-and-shortwave-flux-flashflux

Data also served through
https://power.larc.nasa.gov