FLASHFlux Working Group Status: Operations with GEOS-IT and moving to GEO

Paul Stackhouse (NASA LaRC)

PC Sawaengphokhai (ADNet), Hunter Winecoff (AS&M), and Jay Garg (ADNet)

CERES Team members: Walt Miller (ADNet) and Pam Mlynczak (AMA)

POWER Team: A Jason Barnett, Claire Baldacci, Bradley MacPherson, Christopher Higham (Booz-Allen-Hamilton)

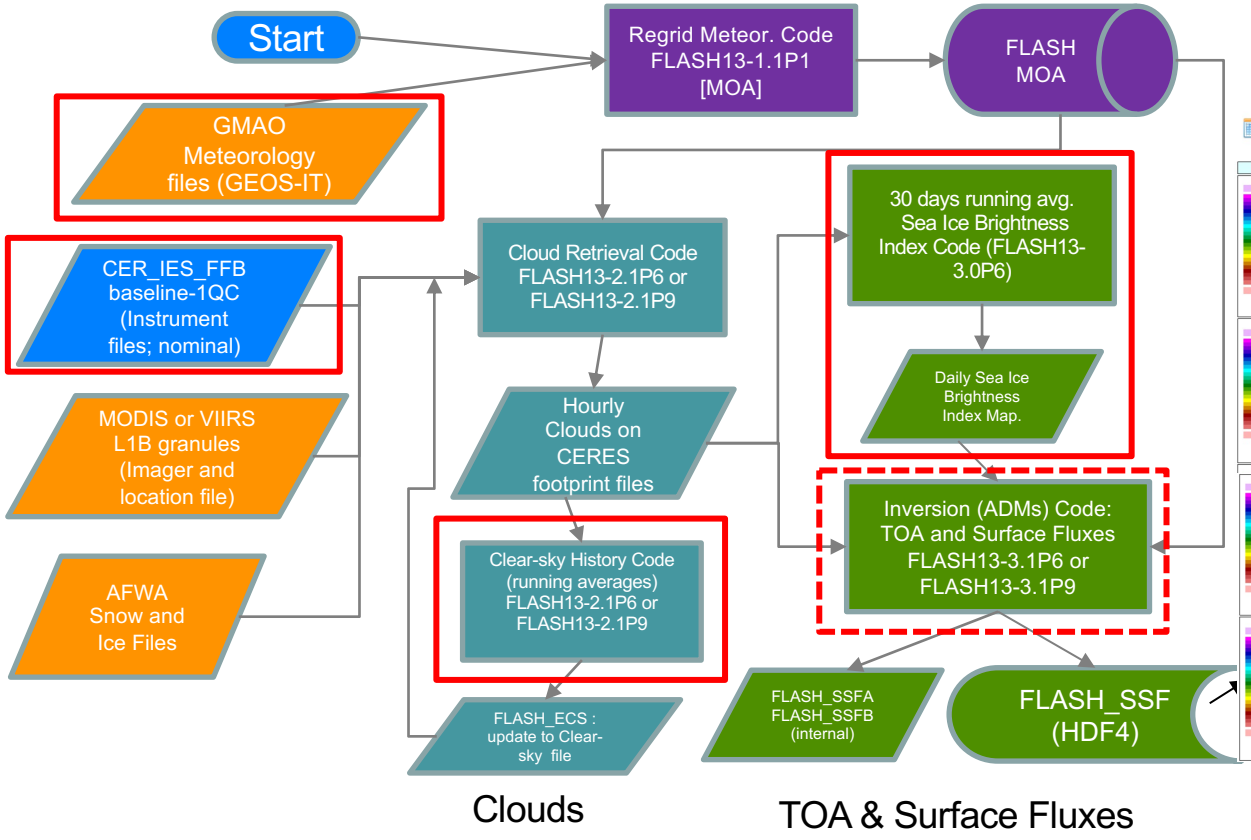
CERES FLASHFlux Overview

- ***FLASHFlux Overview***
  - Uses CERES based production system through inversion (w/ quarterly calibration updates projected forward)
  - Running 3-day TISA utilizing morning and afternoon orbiters
- ***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.

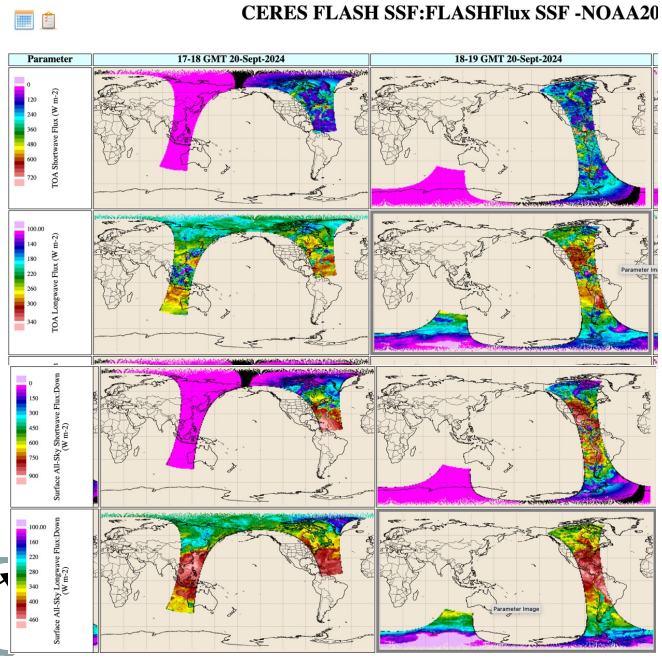
FLASHFlux Operational Status

- ***FF Production status:***
  - Current Status (since 10/1/2023; overlaps previous version through 3/24):
    - SSF Terra (V4B): 9/27/24; SSF NOAA-20 (V1B): 9/28/24
    - TISA V4C (Terra+NOAA-20): 9/26/24
  - Updated calibration coefficients received & promoted as cc change effective 7/1/24 (next update scheduled for 10/1/24)
- ***Important Activities since last CERES Meetings:***
  - Maintain production and update validation
  - Continue developing new footprint flux algorithms utilizing a NN/ML approach
  - Continue developing a FF TISA that utilizes GEO data from SatCORPS and leverages code structures of CERES Ed5 TISA (i.e., global by hour processing)

FLASHFlux SSF Data Flow



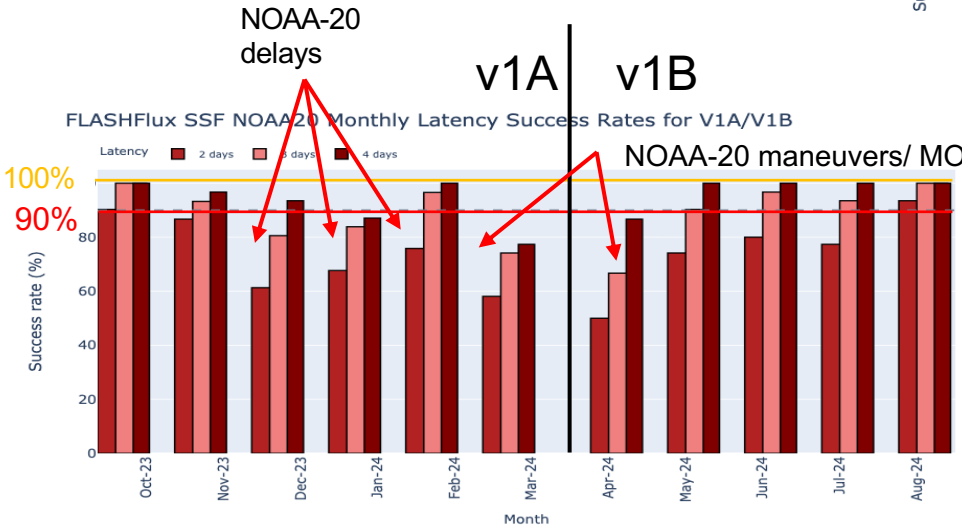
Sample Data from 9/20/24

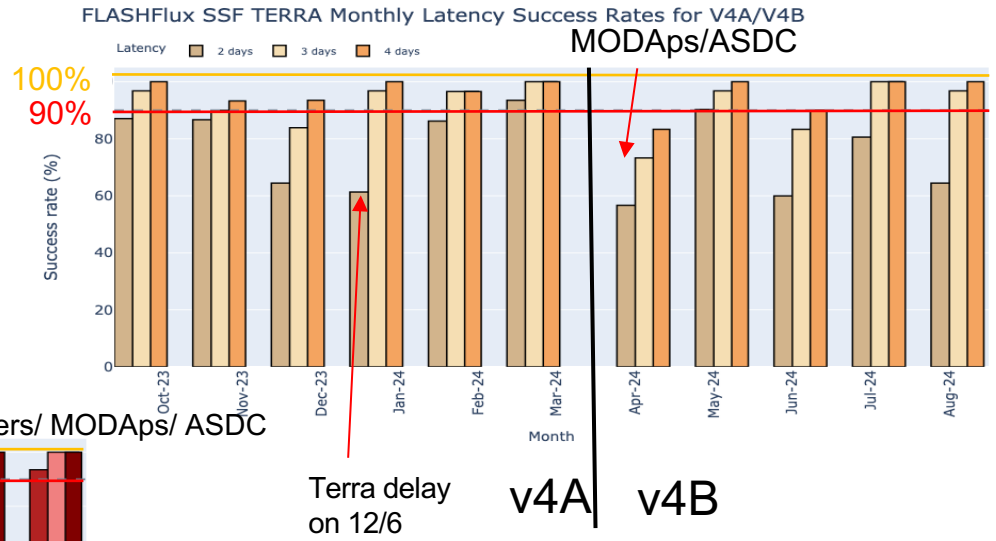


FLASHFlux SSF Latency Assessment

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





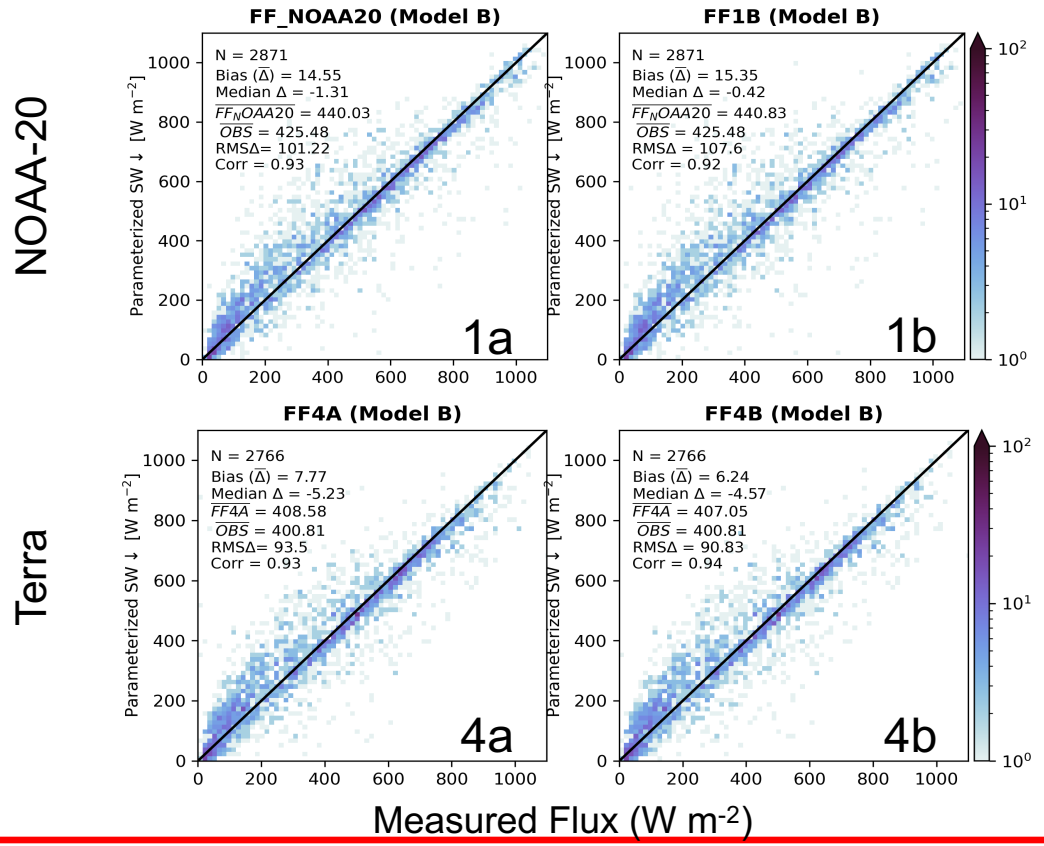
Latency for August 2024:
Terra SSF: 100% at 3 days
NOAA-20 SSF: 100% at 4 days

FF SSF SW Flux Validation: 10/2023-4/2024

Overpass SW flux validation with BSRN measurements:

- Left FLASHFlux SSF with previous version (w/ FP-IT)
- Right FLASHFlux SSF (Current Version w/ GEOS-IT)
- Top NOAA-20, Bottom Terra

- SW fluxes Bias/RMS slightly worse with GEOS-IT; Terra better
- SW NOAA-20 has much larger biases than Terra
  - NOAA-20: bias, RMS < 4%, 26%
  - Terra: bias, RMS < 2%, 23%

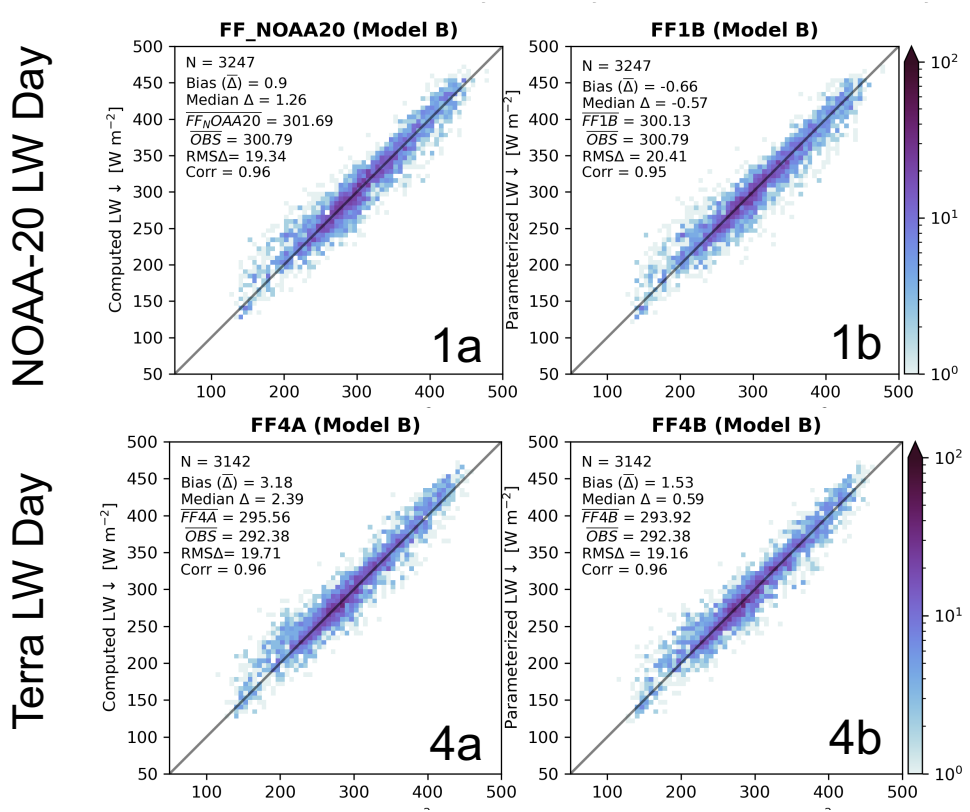


FF SSF LW Flux Day Validation: 10/2023-4/2024

Overpass LW daytime flux validation with BSRN measurements:

- Left FLASHFlux SSF Previous Version (with FP-IT)
- Right FLASHFlux SSF Current Version: (with GEOS-IT)
- Top NOAA-20, Bottom Terra

FLASHFlux LW Daytime NOAA-20 and Terra radiative fluxes show consistency between FP-IT/GEOS-IT: biases < 0.2%; RMS's < 7%

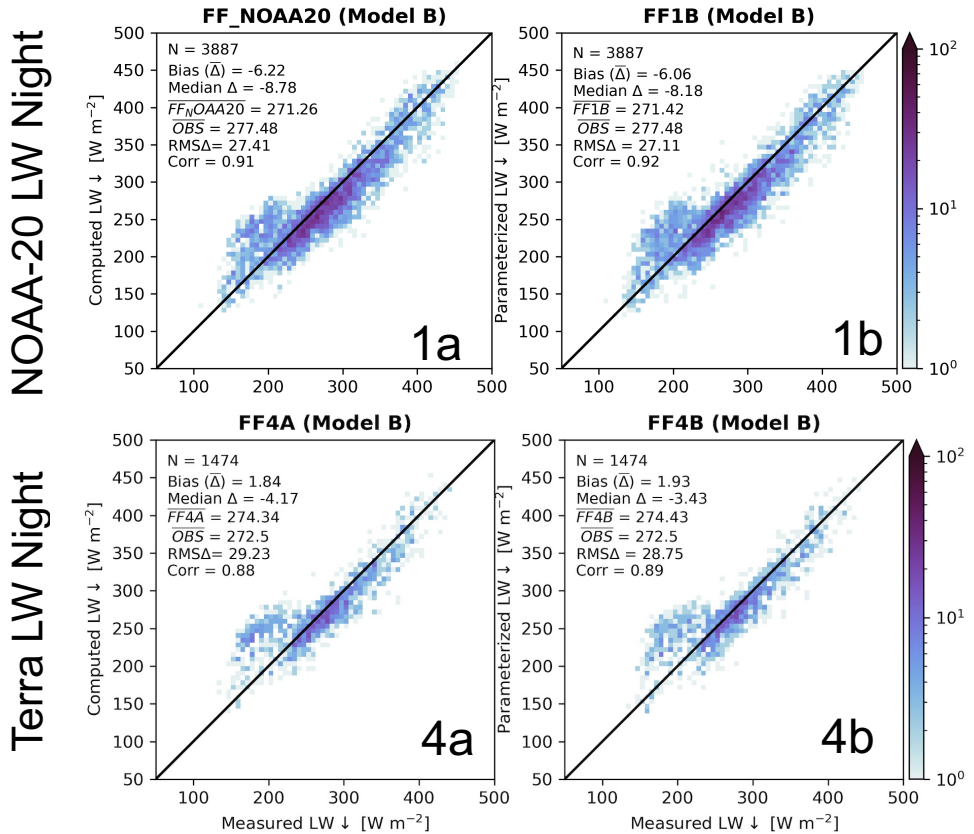


FF SSF LW Flux Night Validation: 10/2023-12/2023

Overpass LW daytime flux validation with BSRN measurements:

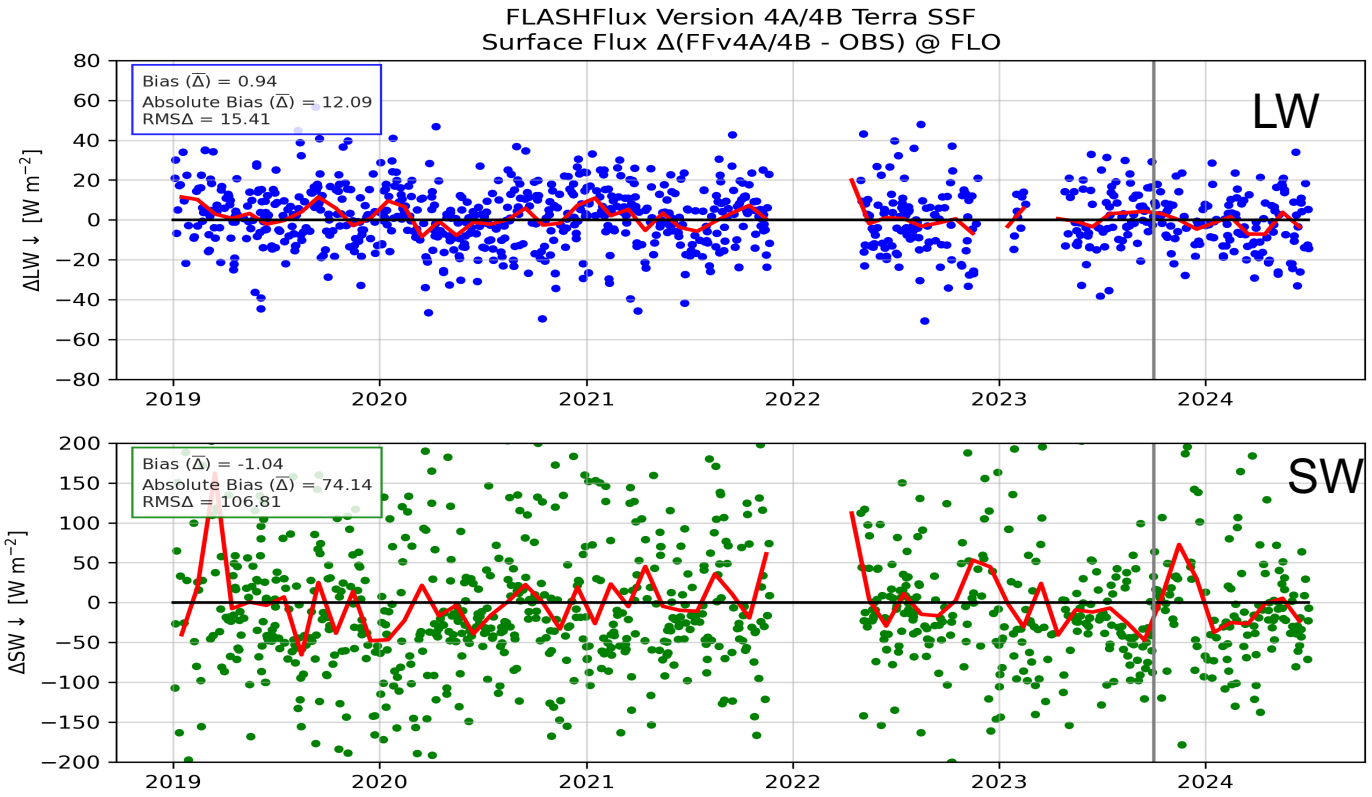
- Left FLASHFlux SSF Previous Version (with FP-IT)
- Right FLASHFlux SSF Current Version: (with GEOS-IT)
- Top NOAA-20, Bottom Terra

FLASHFlux LW Daytime NOAA-20 and Terra radiative fluxes show consistency between FP-IT/GEOS-IT: biases < -2.2%; RMS's < 10%



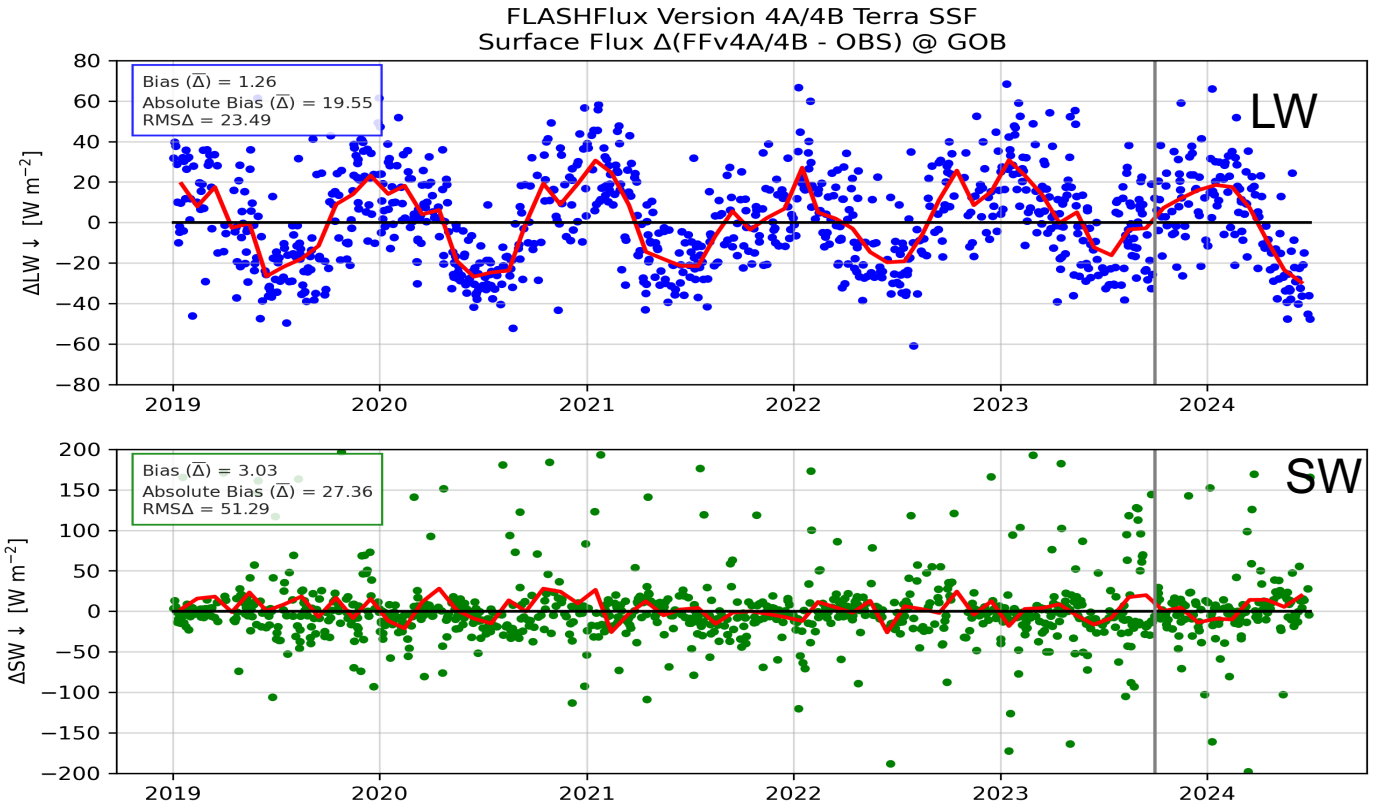
FLASHFlux Terra SSF Validation (through 4/2024)

- Terra SSF flux differences with BSRN at overpass time (even as it drifts)
- Site is: Florianapolis, Brazil
- Red lines are 30 day averages



FLASHFlux Terra SSF Validation (through 4/2024)

- Terra SSF flux differences with BSRN at overpass time (even as it drifts)
- Site is: Gobabeb, Namib Desert, Namibia
- Red lines are 30 day averages



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:

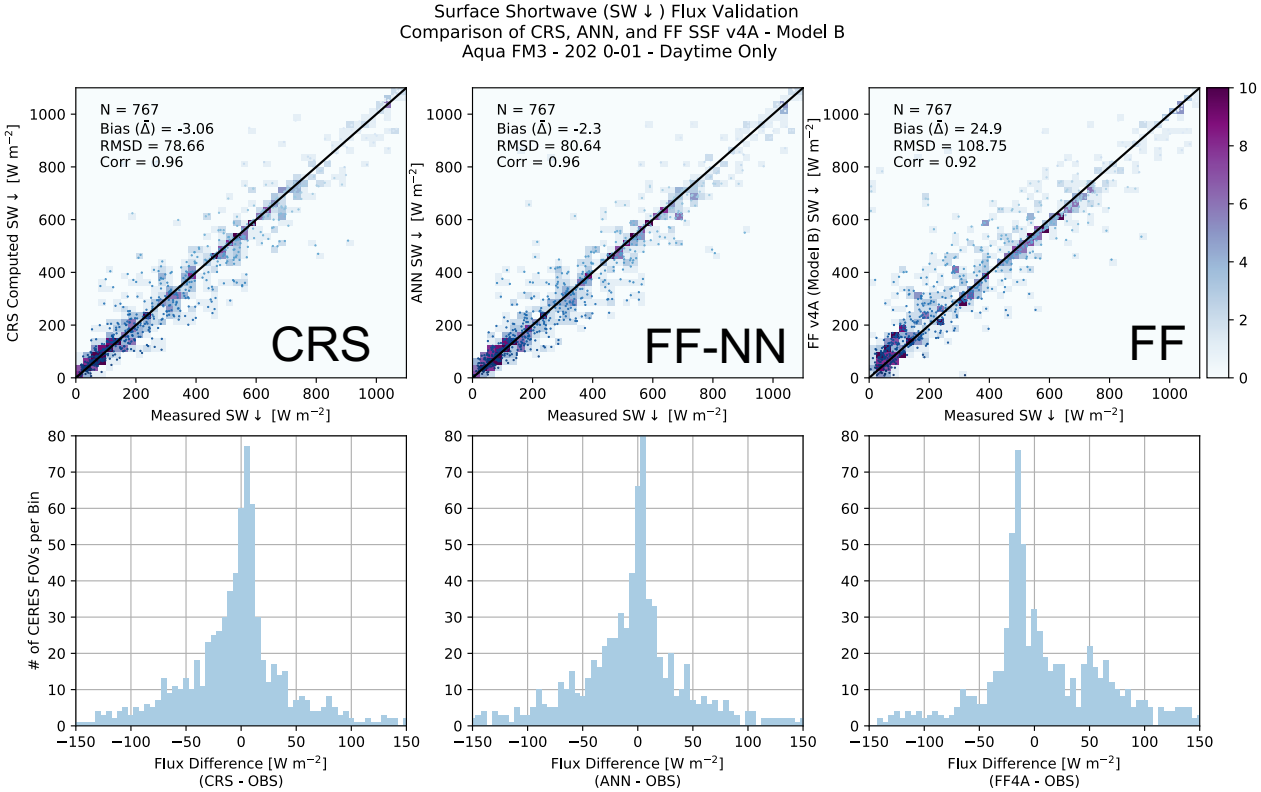
- Use NN/ML methods to devise algorithms that approximate surface fluxes for each footprint to replace old LPSA and LPLA estimates:
  - Produce SW, LW for all-sky, clear-sky ”clouds removed”
  - Estimate surface up, down, net within FF SSF:
  - Using CRS Ed4 used for training since uses full Fu/Liou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

Progress to date:

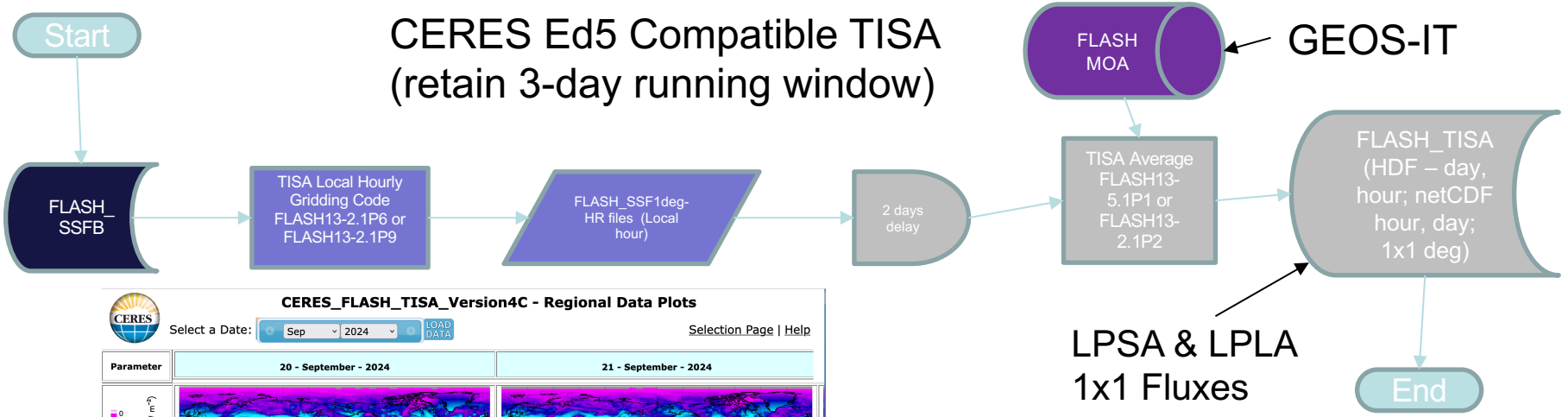
- Developed framework; but revised parameter selection criteria since May; also fixed bug that resulted in missing data days
- Re-running test simulations with CRS training data sets and parameters
  - Adding surface overhead albedo parameter for additional testing for all-sky SW, LW
- Coding to train/run other flux components

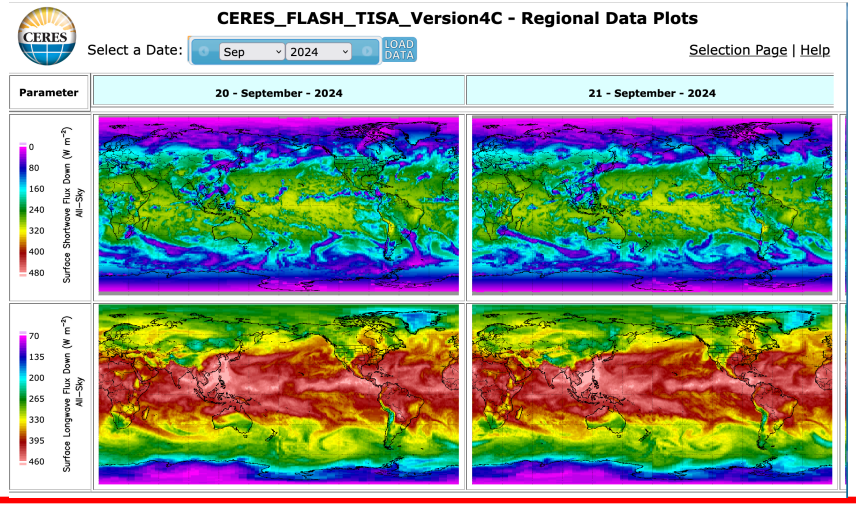
SSF Flux Algorithm Updates: NN SW & LW

- Latest run for surface all-sky SW down
- Aqua for Jan 2023
- Trained with Terra CRS 2020



FLASHFlux TISA Data Flow: Current



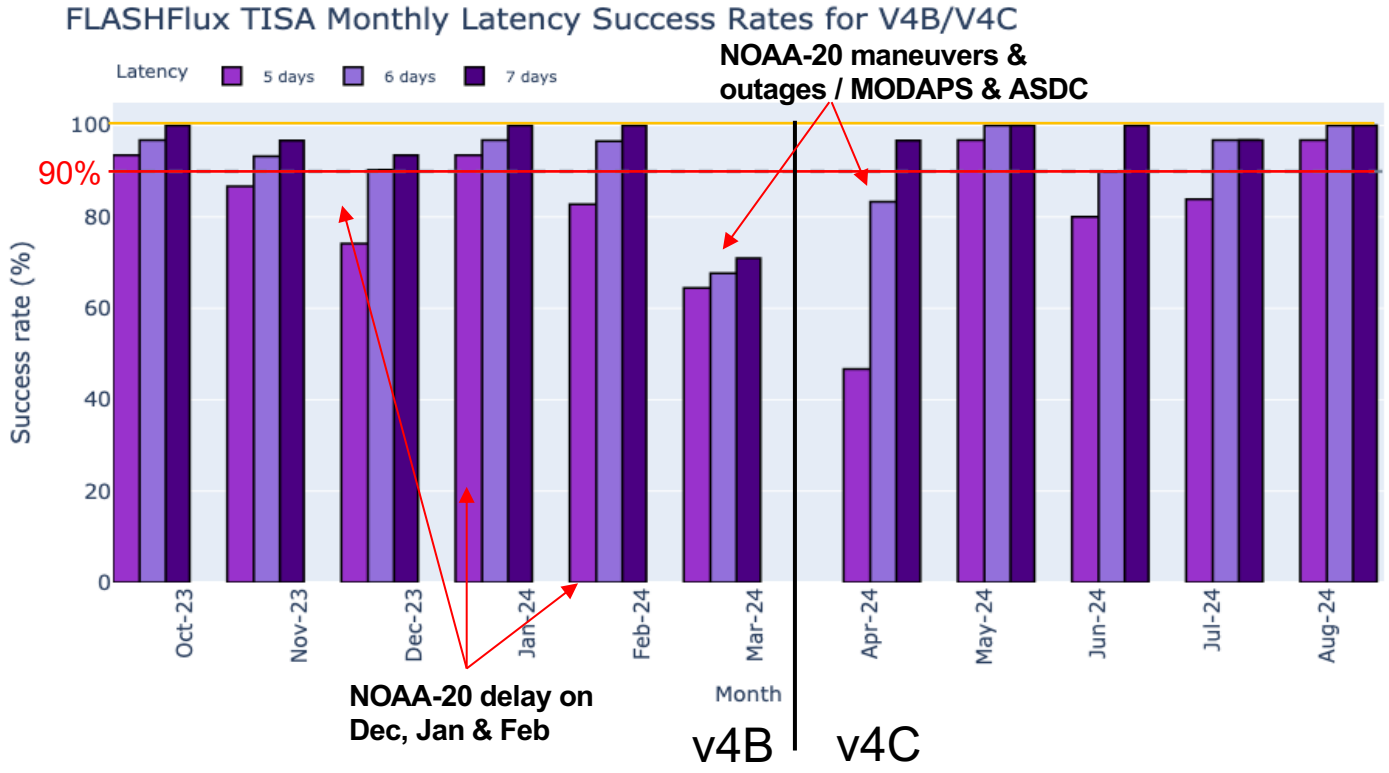


FLASHFlux TISA: Latency Statistics (v4B/v4C)

v4A success rates for TISA to be archive in 5, 6 or 7 days after observation

v4C began production in March 2024

August 2024 100% processed by day 6 after RT (> 95% by day 5)



FLASHFlux TISA Application: Updated Anomalies

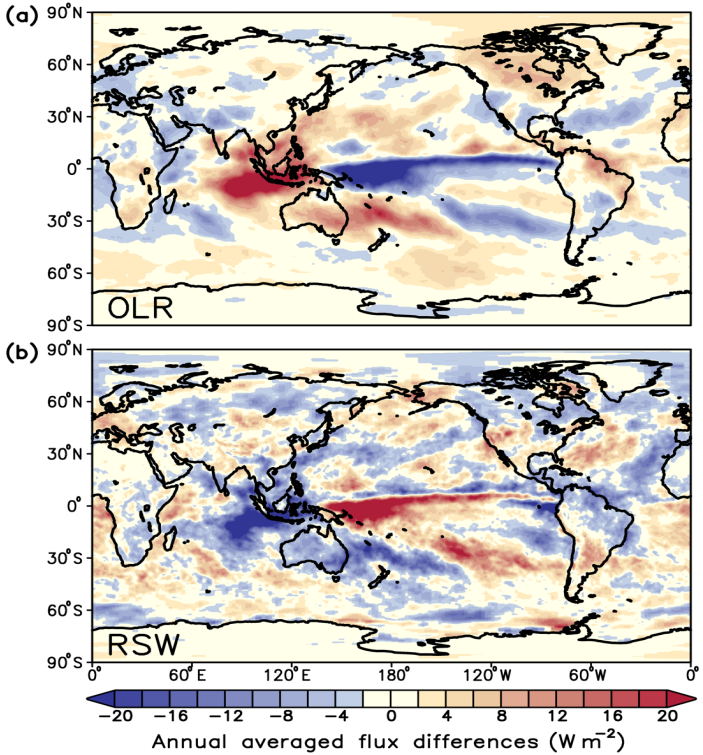


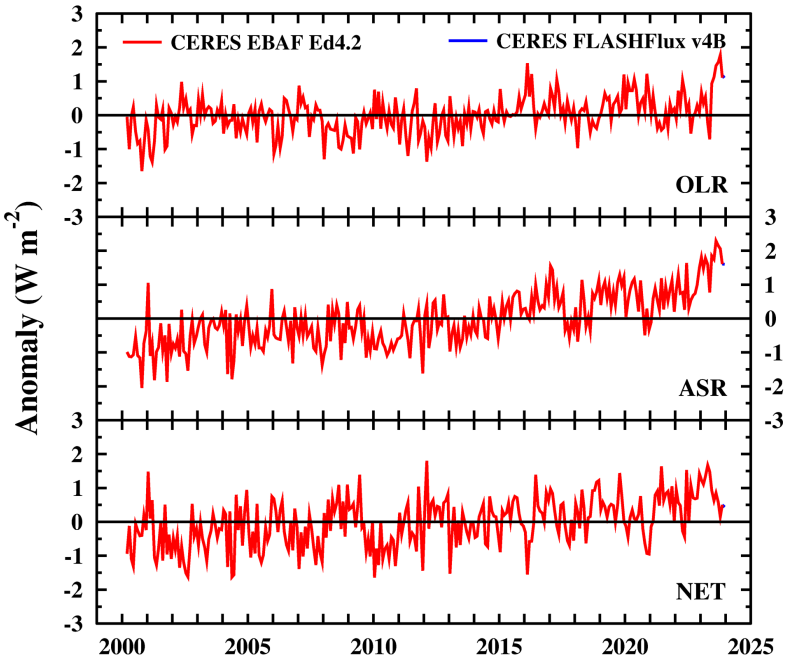
Table 2.f.1.1. *Global annual mean TOA radiative flux changes between 2022 and 2023, the 2023 global annual mean radiative flux anomalies relative to their corresponding 2001–22 mean climatological values, and the 2-sigma interannual variabilities of the 2001–22 global annual mean fluxes (all units in W m^{-2}) for the outgoing longwave radiation (OLR), total solar irradiance (TSI), reflected shortwave (RSW), absorbed solar radiation (ASR, determined from TSI-RSW) and total net fluxes. All flux values have been rounded to the nearest 0.05 W m^{-2} and only balance to that level of significance.*

	One Year Change (2023 minus 2022) (W m^{-2})	2023 Anomaly (Relative to Climatology) (W m^{-2})	Climatological Mean (2001–22) (W m^{-2})	Interannual Variability (2001–22) (W m^{-2})
OLR	+0.60	+0.85	240.35	±0.65
TSI	+0.10	+0.25	340.20	±0.15
RSW	−0.80	−1.50	99.00	±1.05
ASR	+0.90	+1.75	241.20	±1.05
Net	+0.30	+0.90	0.85	±0.85

Stackhouse *et al.*, 2024, published in BAMS State of the Climate Special Issue

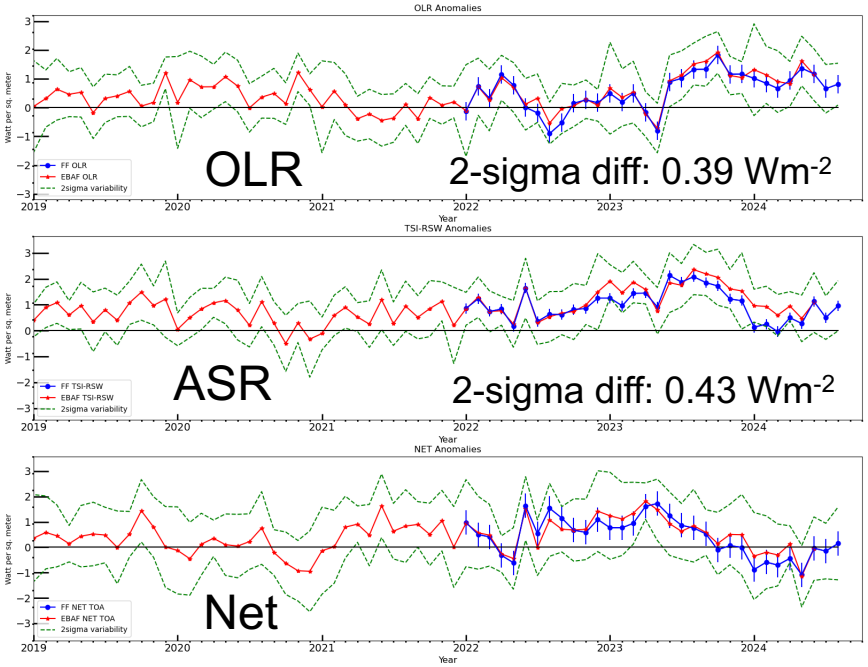
FLASHFlux TISA Application: Updated TOA Anomalies

TOA Flux Anomalies (through 2023)



Stackhouse *et al.*, 2024, BAMS SotC

TOA Flux Anomalies (updated through 8/24)



Includes TISA 4B/4C transition;
EBAF base period 01/2001 to 12/2023

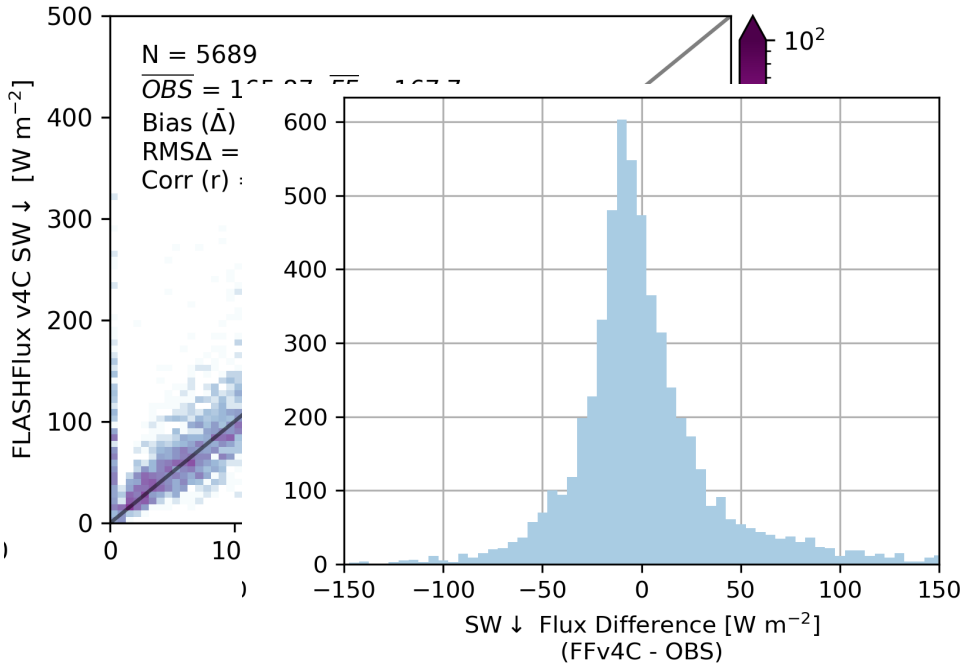
FLASHFlux TISA Validation: SW Surface Fluxes

- Ensemble FLASHFlux Version4C SW Daily Average Comparisons to Surface Measurements (10/2023-6/2024)

- SW fluxes show very consistent statistical quality relative to surface measurements:
  - Bias Diff: < 1.1%
  - RMS Diff: < 25%

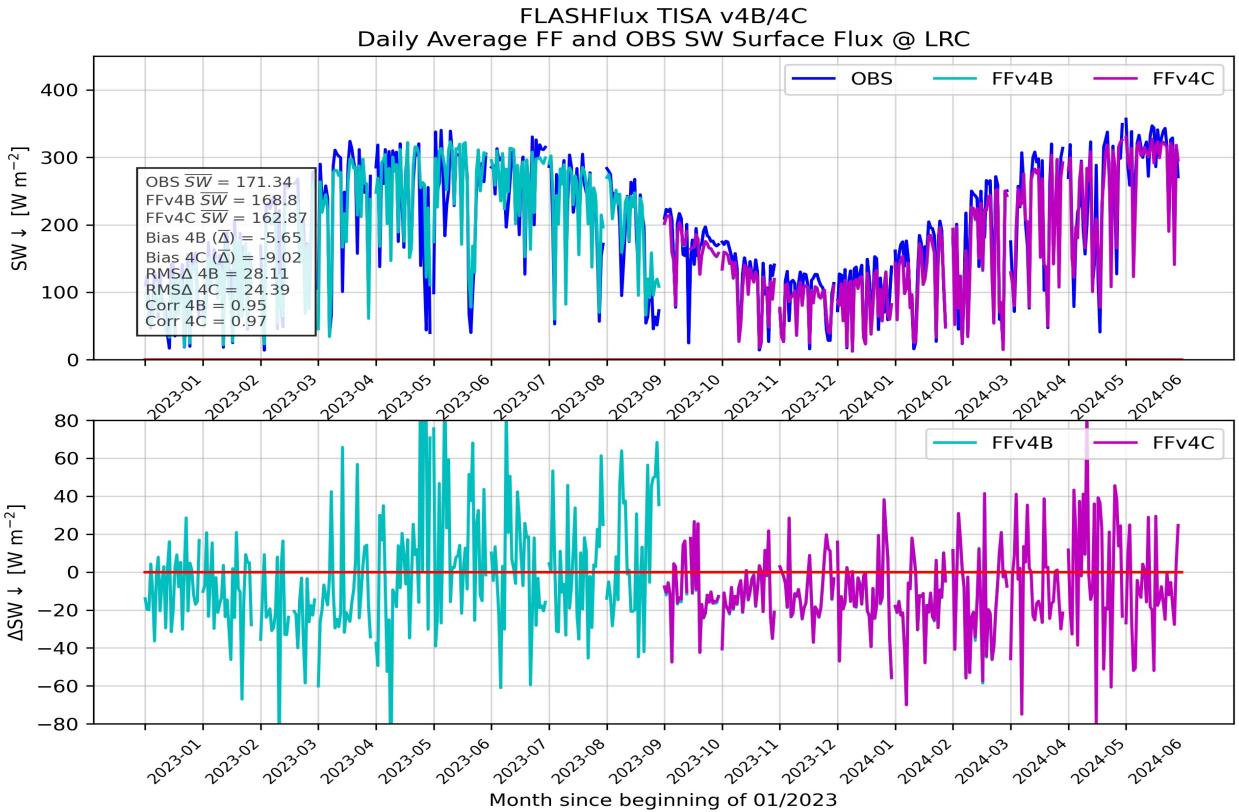
- Histograms show peaked, relatively symmetric distributions, but systematically skewed negative for all climate types.

TISA v4C (GEOS-IT) Daily Averages vs BSRN



Time Series Validation: SW

- Example time series comparison against SW measurements from the LRC site
- Here negative bias is evident, but that varies site to site
- There is no discernable difference between 4B and 4C; no “drift” in fluxes yet evident through June 2024



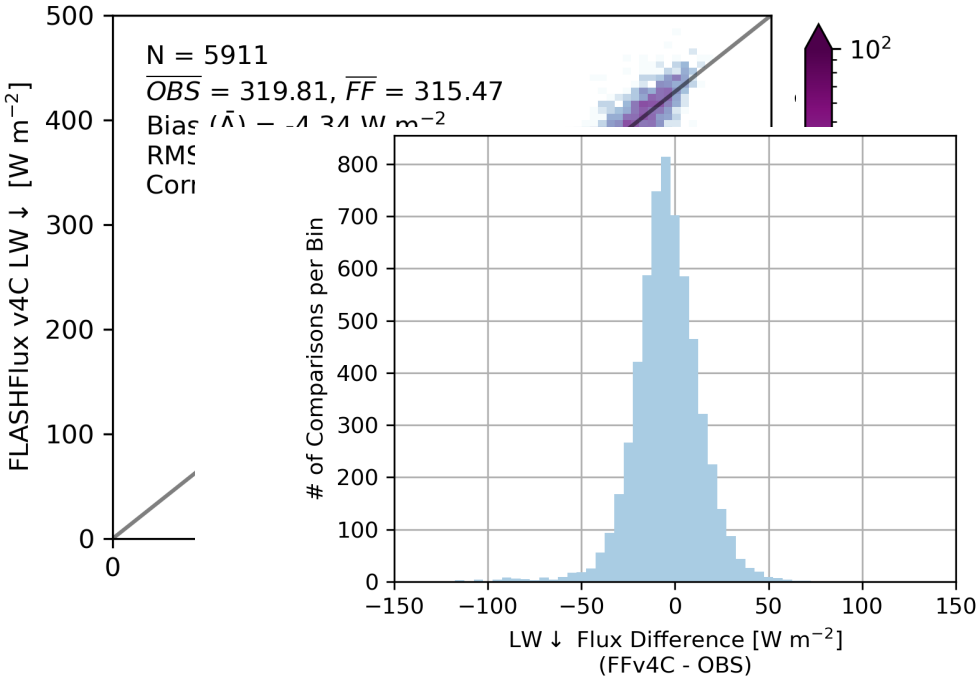
FLASHFlux TISA Validation: LW Surface Fluxes

- Ensemble FLASHFlux Version4B vs 4C LW Daily Average Comparisons to Surface Measurements (10/2023-1/2024)

- LW fluxes show very consistent statistical quality relative to surface measurements:
  - Bias Diff: < -1.4%
  - RMS Diff: < 5.9%

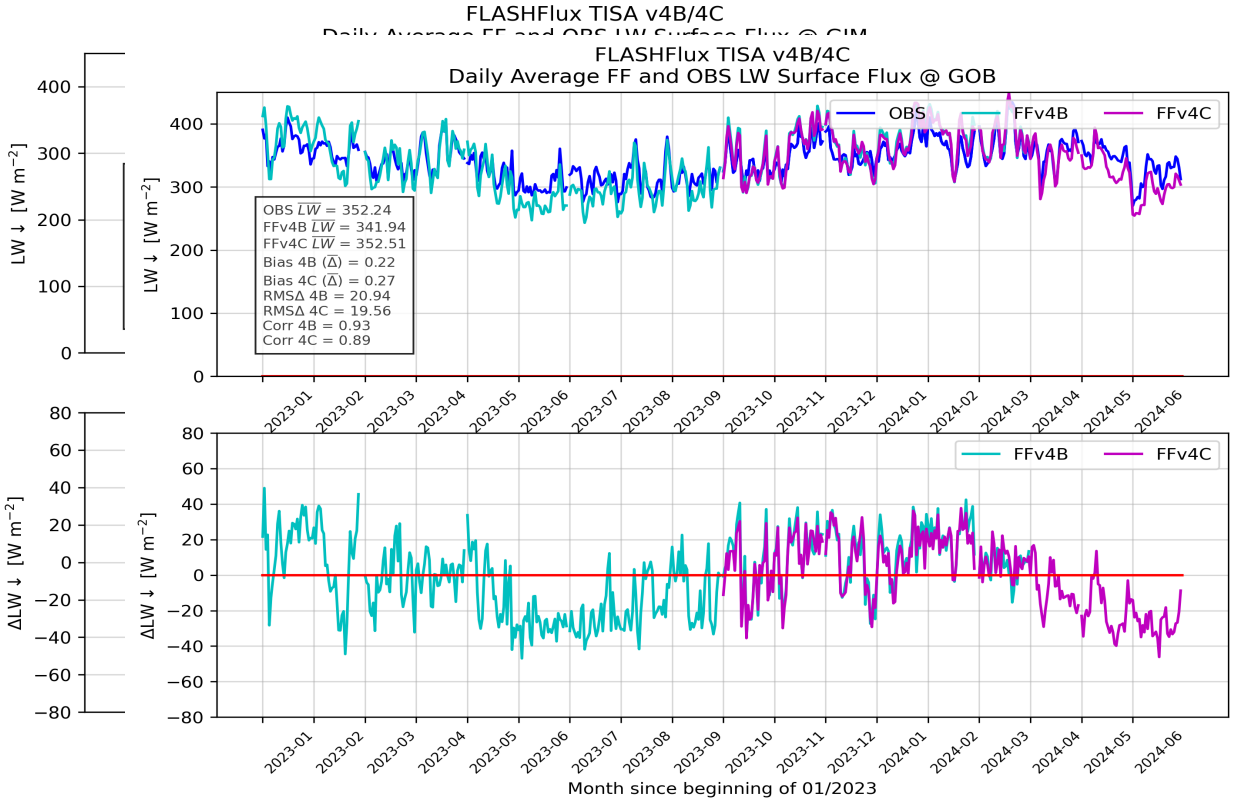
- Histograms show peaked, relatively symmetric distributions, median bias is negative for LW; slightly improved negative shoulder

TISA v4C (GEOS-IT) Daily Averages vs BSRN

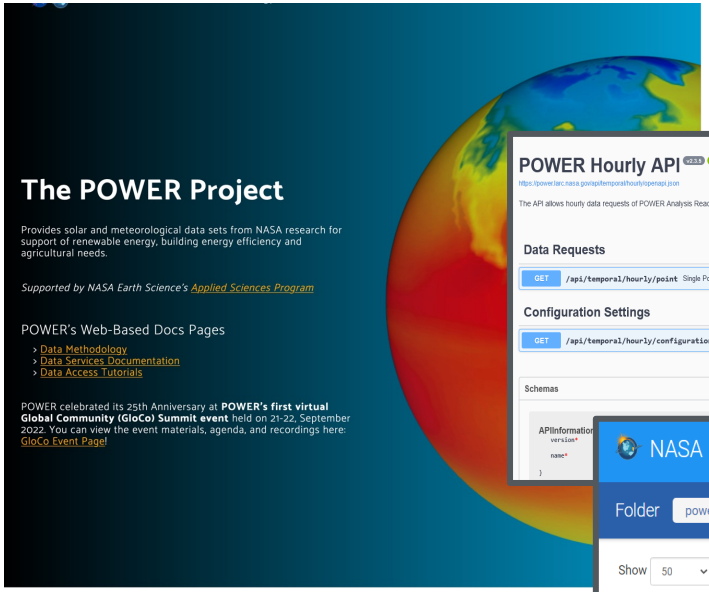


Time Series Validation: LW

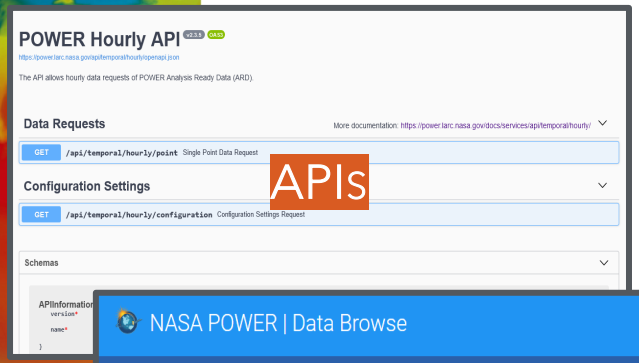
- Example time series comparison against LW measurements from the GIM site through 6/’24
- Some day-to-day variability in differences; similar to other sites
- For v4C (GEOS-IT) there does seem to be at least a seasonal cycle bias; there could be a drift but it will take a few more months to determine this.

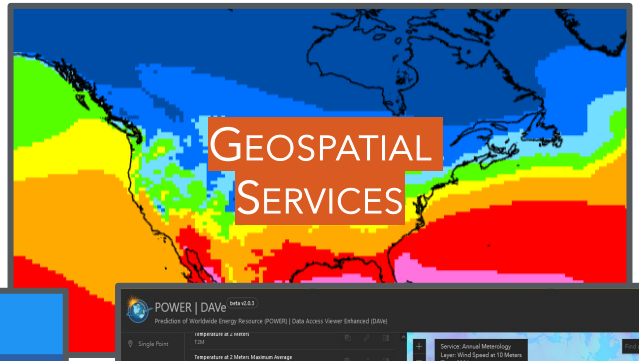


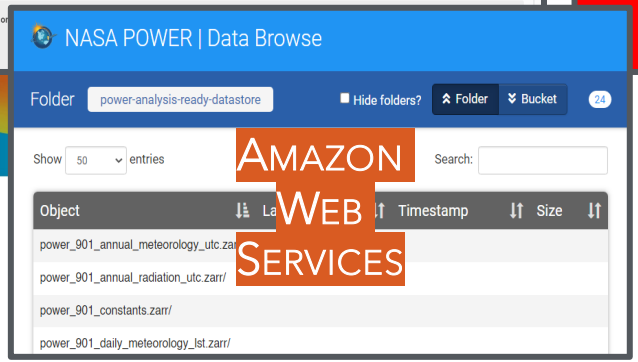
FLASHFlux TISA Application: Accessibility Through POWER

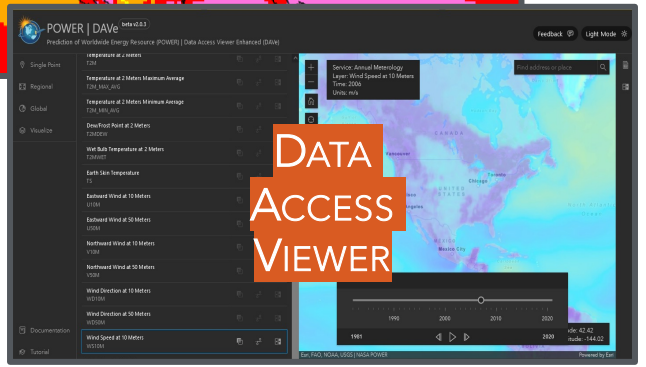


Different users require different ways to access the same data









https://power.larc.nasa.gov

Creating **trusted, value-added, easy-to-use** Application Ready Data & **Services**

FLASHFlux TISA & SYN1Deg Usage via POWER Web Services Portal (2023/09/01 to 2024/08/31)

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

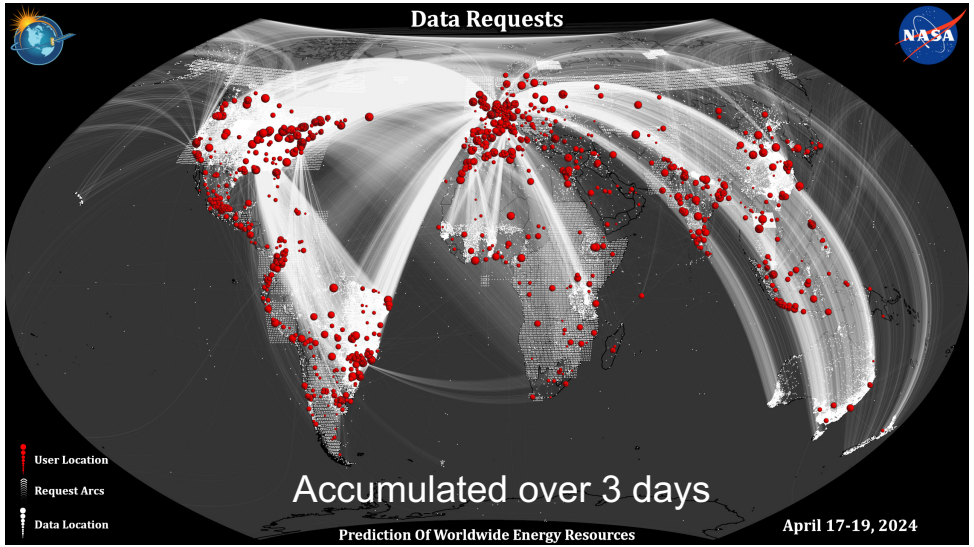
	Total	Monthly	Avg. Last 3 Months
Unique Users IPs	~51.6 K (15%)	~5.5 K (17%)	~4.7 K (16%)
Requests	~51.9 M (36%)	~4.3 M (36%)	~4.7 M (35%)

CERES Data Orders Delivered via POWER including SYN1Deg and FLASHFlux data

	Total	Monthly	Avg. Last 3 Months
Unique Users IPs	~159.3 K (49%)	~15.3 K (49%)	~15.2 K (51%)
Requests	~ 74.3 M (51%)	~6.2 M (51%)	~7.7 M (58%)

(includes SYN1Deg from Sep 2001 through latest month released)

Dot density map showing locations of users (red) and data request locations (white). Brighter colors show larger frequency at that location.

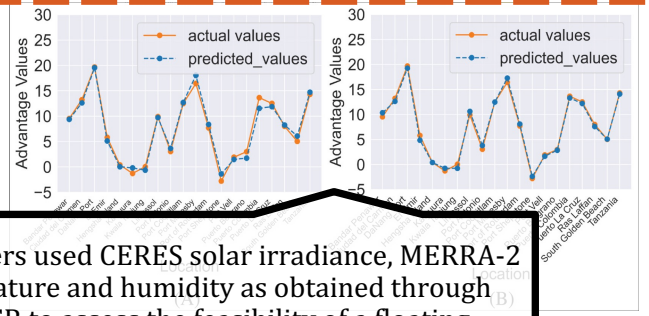


FF data requests up by about 15% since last report.

Total FF+ SYN1Deg requests up by about 38% since last report

CERES Through POWER: Floating Solar Photovoltaics

#1: *"Offshore floating photovoltaics system assessment in worldwide perspective"*



Researchers used CERES solar irradiance, MERRA-2 temperature and humidity as obtained through POWER to assess the feasibility of a floating photovoltaics (FPV) project to identify optimal locations in multiple offshore locations.

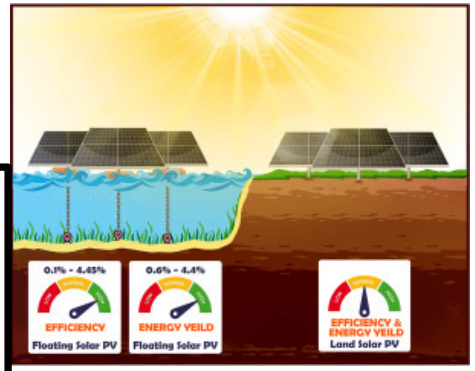
Source

#2: *Design of floating solar PV system for typical household on Debre Mariam Island*

Article assesses floating solar photovoltaic (PV) system designs for a typical household on Debre Mariam Island in Ethiopia using CERES solar irradiance and other variables obtained through POWER .

Source

#4: *Techno-economic and environmental estimation assessment of floating solar PV power generation on Akosombo dam reservoir in Ghana*

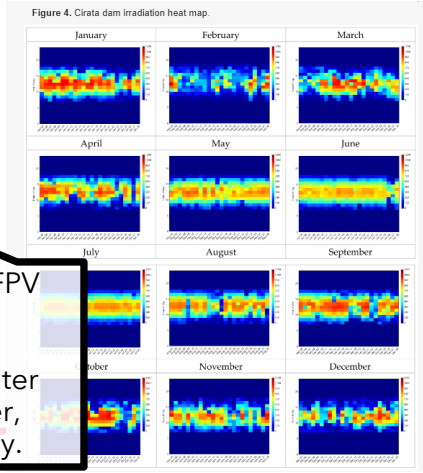


Using the decision support tool RETScreen Expert that uses key solar irradiance from POWER, researchers assess the viability of deploying FPV power generation on the Akosombo dam reservoir in Ghana, supplementing hydropower production

Source

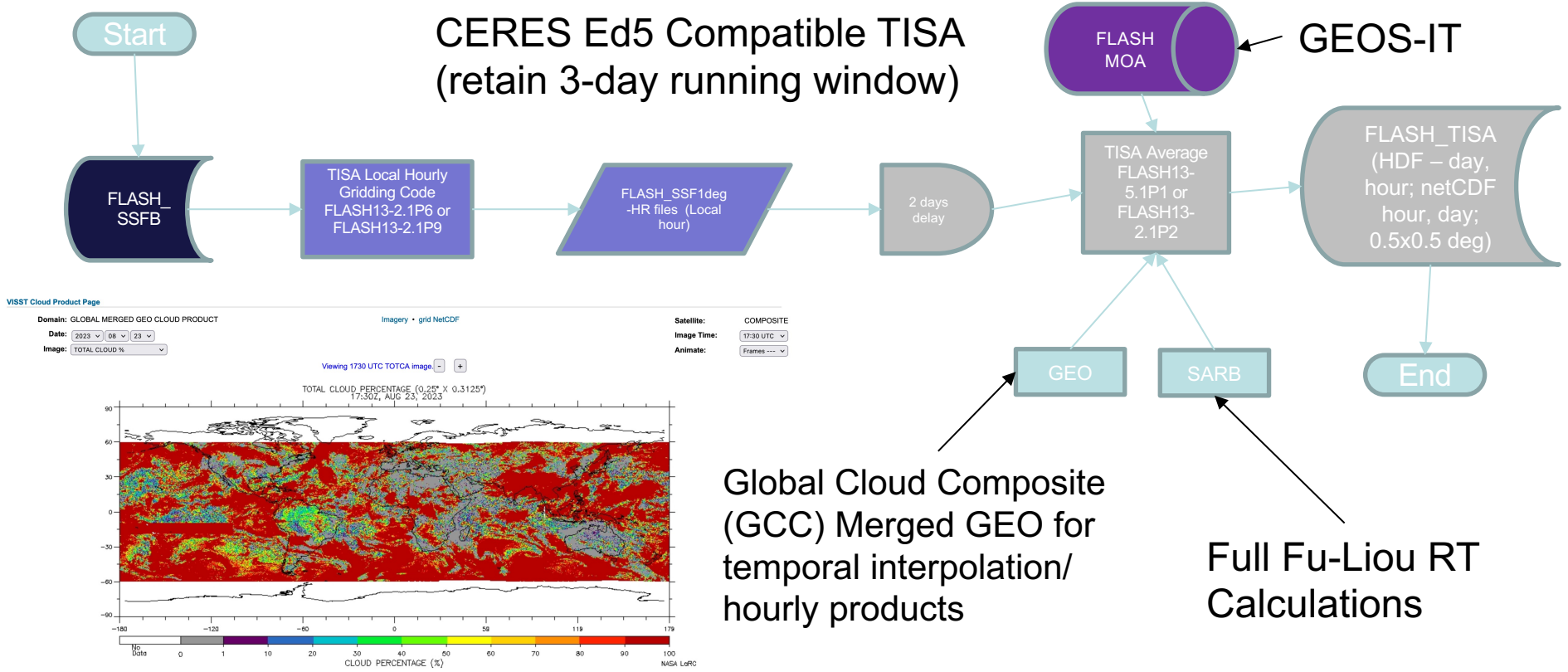
#4: *Cooling Effect on the Floating Solar PV: Performance and Economic Analysis on the Case of West Java Province in Indonesia"*

Source

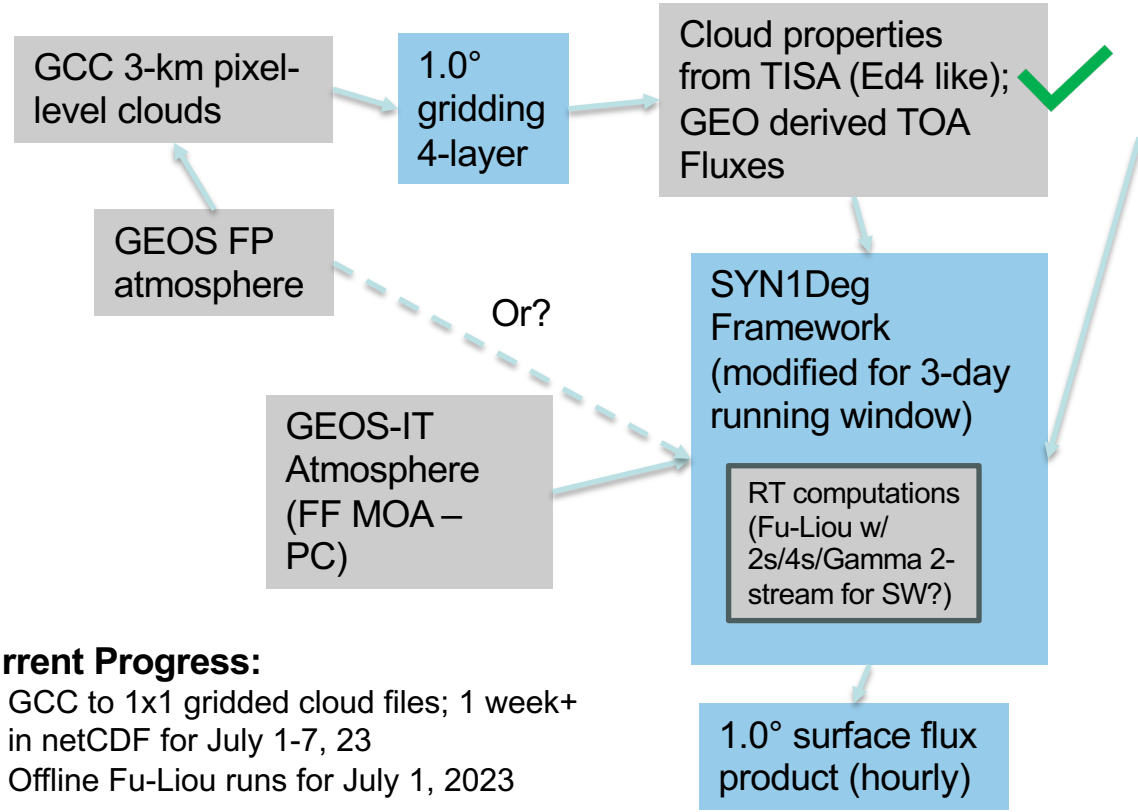


Researchers assess FPV performance and additionally how deployment over water keeps panels cooler, increasing efficiency.

Future FLASHFlux TISA Data Flow: Adding GEO



Adding GEO to FF TISA: SatCORPS GCC into FLASHFlux



IGBP, altitude, water %, sibi, snow, surface BRDF spectral albedo, aerosols, etc (for testing use various CERES inputs as it; will work to create at low latency later)

Current Progress:

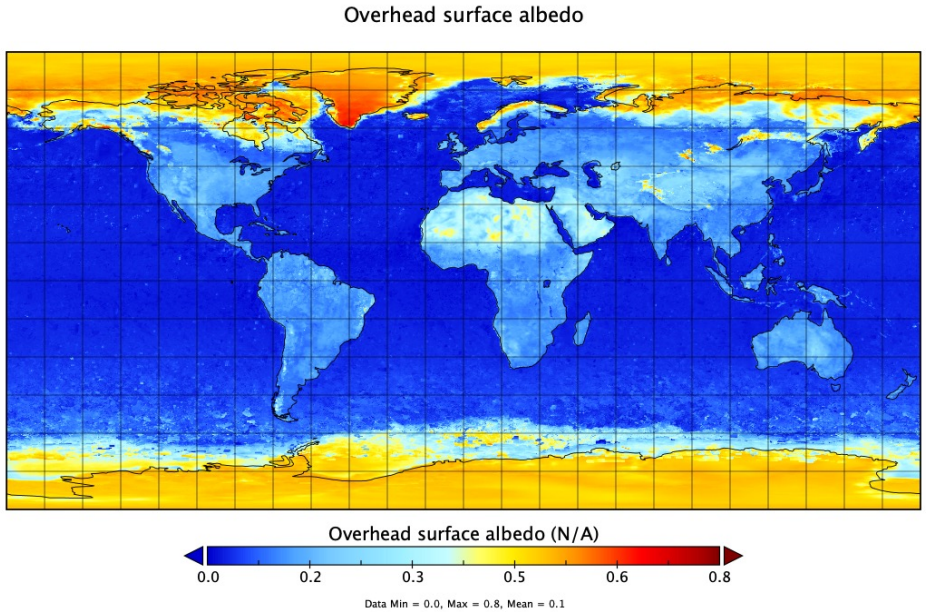
1. GCC to 1x1 gridded cloud files; 1 week+ in netCDF for July 1-7, 23
2. Offline Fu-Liou runs for July 1, 2023

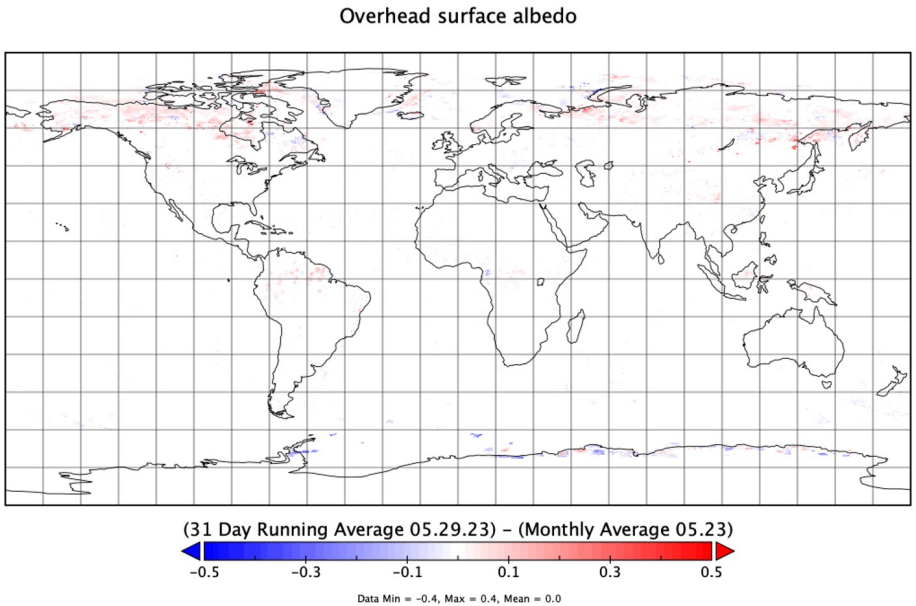
Progress:

1. Completed cloud gridding code – targeting Ed4 clouds (4 layers) since code exists. **Done**
2. Align all inputs to correct data structures: **Ongoing**
3. Configure SYN1Deg like code with 3-day running window, global by hour; determine options for running F/L: **Ongoing**
4. Offline global by time F/L code running for testing. **Running**
5. Assess GEOS-FP vs GEOS-IT: **Ongoing**

Running Overhead Surface Albedo Histories

Albedo required for Fu/Liou computations (SAH files); but can't wait for monthly boundaries; running for previous 31-days

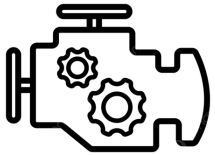




June 1, 2023

General Schedule for GEO to FF Production

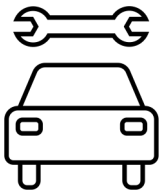
Stage 1: FF SYNi_Map Pipeline



Target Completion Date: Jan/Feb

- ❑ Test clouds gridding code with SatCORPS GCC (Arun/Bao)
- ❑ FLASH MOA reader (PC/Fu-Lung)
- ❑ MATCH/GEOS-IT Aerosols?
- ❑ Other Inputs: Albedo/reflectance map, etc.
- ❑ SYNi & Offline codes for GEO
  - ❑ Change SYNi to SYNi_map to process global hour grid structure
  - ❑ Clouds (Ed4) initialization & input for Fu-Liou.
  - ❑ Input parameter initialization for Fu-Liou (consistent with new structure)
  - ❑ Test Fu-Liou code (4-layer, 1 deg.) (Fu-Lung) new inputs GEO + NOAA-20
  - ❑ Test period/assess
- ❑ Integration with N20 (FF_SFCHourly or modified SSF1deg?) => leverage existing TSI codes

Stage 2: Production Code

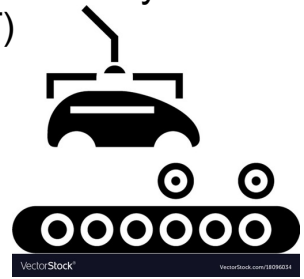


Target Completion Date: Apr/May

- ❑ Develop Processing Control file scripts.
- ❑ Create metadata (ASDC approve)
- ❑ Create new PGE(s)
- ❑ Develop production rules
- ❑ Develop Test Plans and Operator Manuals.
- ❑ Test code
- ❑ Validate results
- ❑ Produce Data Quality Summary

- ❑ Validate Catalyst results
- ❑ Create new product entry on EarthData

Stage 3: Catalyst Production (DMT)



Target Completion Date: June/July

- ❑ New PGE Catalyst code
- ❑ Develop new Production Requestor PGE
- ❑ Testing/Validation of test plans
- ❑ Test Catalyst production
- ❑ Promote to production for test period

Send to ASDC

FLASHFlux Summary

- ***Production with SSF for Terra (v4b), NOAA-20 (1b) and TISA (v4C) Continues***
  - FF NOAA-20 V1B SSF (9/27/24) and Terra V4B (9/28/24) with GEOS-IT
  - TISA V4C Terra/NOAA-20 through 9/26/24
  - New FF Gain+Spectral coefficients beginning Oct 1st, 2024.
- ***Validation and Assessment Relative to BSRN/Buoy***
  - CERES and FLASHFlux SSF through June 2024; SW biases larger; GEOS-IT min impact
  - TISA v4C daily averages through Oct-Jun 2024 (9 months); low overall biases but depends on surface sites; some LW improved; more data needed to establish LW drift
- ***FLASHFlux Modernization and Updates***
  - ML based algorithms for future FF SSF data products: Goal Operational Mar 2025
  - Migrate configuration to NOAA-20 + GCC GEO & F/L Fluxes: Goal Operational July 2025
- ***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: ~159K unique IPs; > 73M orders; orders >35% FF
  - 2023 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

Acknowledgements for to other CERES Team members contributing to FLASHFlux Data products and updates:
Katie Dejwakh, Dave Doelling, William Smith Jr,
Arun Gopalan, Baojuan Shan, Fu-Lung Chang, Nelson Hillyer, and others (ADNet)

Extras

TISA Flux Algorithm Updates: Incorporating GEO

Justification:

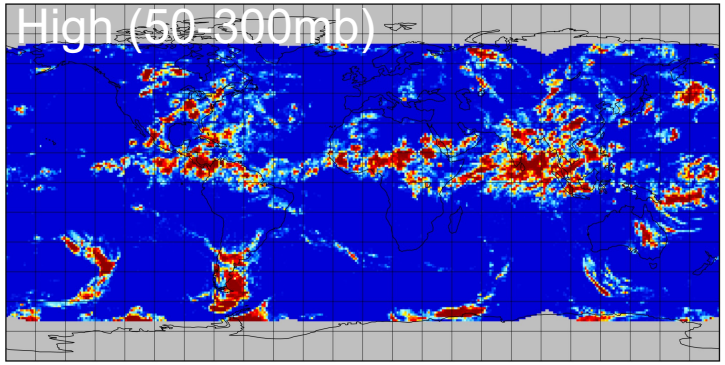
- Aqua and Terra are drifting and will be turned off
- Currently have replaced Aqua with NOAA-20, but still using Terra
- Once TERRA is turned off, there will be no morning, evening samples for the diurnal models to estimate the daily averages; the primary product
- Concurrently, users are asking for hourly flux data at lower latency to be more consistent with the SYN1Deg hourly products
- If the GEO that CERES already processes for the SYN1Deg can be processed within the latency, then this provides the extra samples needed to improve daily and also provides the opportunity to provide CERES consistent fluxes at the hourly temporal resolution at lower latency.

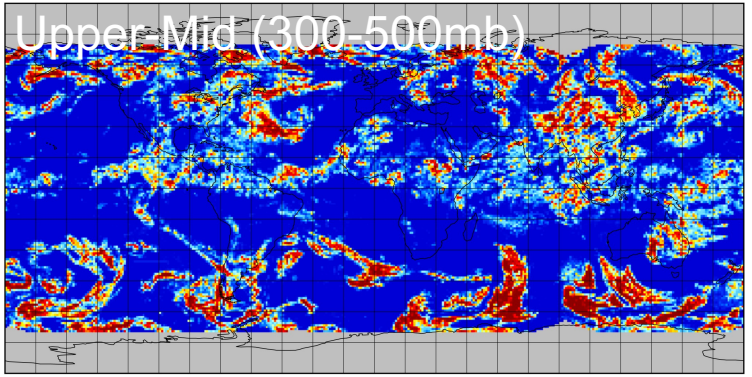
Objectives:

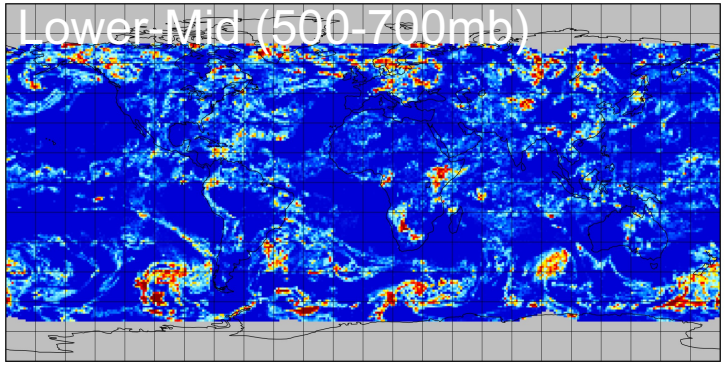
- Work with SatCORP/Clouds group and the TSI group to develop a new lower latency pipeline to enable the production of fluxes more consistent with CERES SYN1Deg
- Leverages SatCORP groups existing work and automated QC
- Leverages TSI group's objective to restructure CERES production code for Ed5

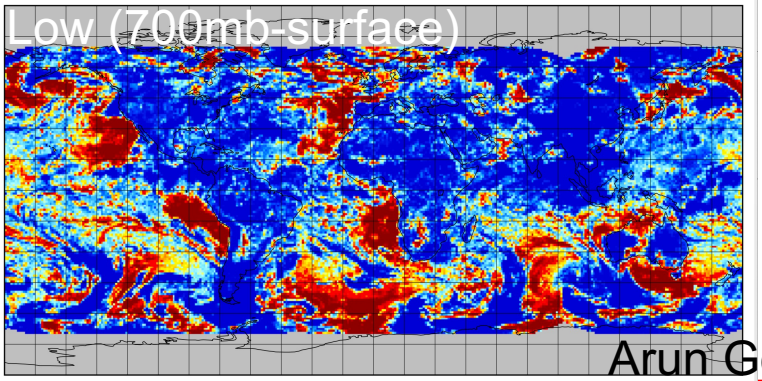
Adding GEO to FF TISA: Gridded GCC Cloud Properties

From Global Cloud Composite, Gridded Cloud Fraction at 1^0 X 1^0, Hour 1 of 24, 7/2/23







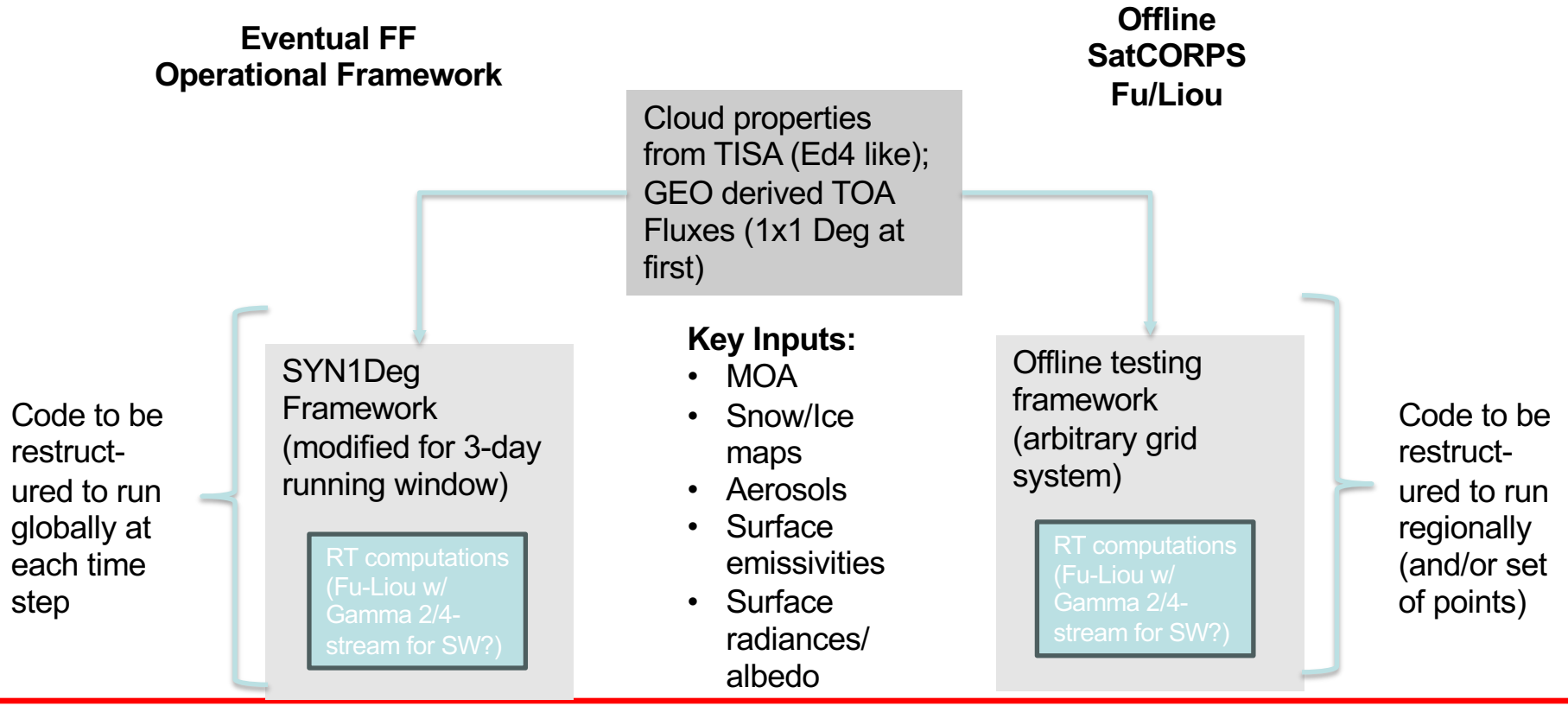


Cloud fraction at 4 levels (%)
0.0 20.0 40.0 60.0 80.0 100.0

Arun Gopalan

Cloud fraction at 4 levels (%)
0.0 20.0 40.0 60.0 80.0 100.0

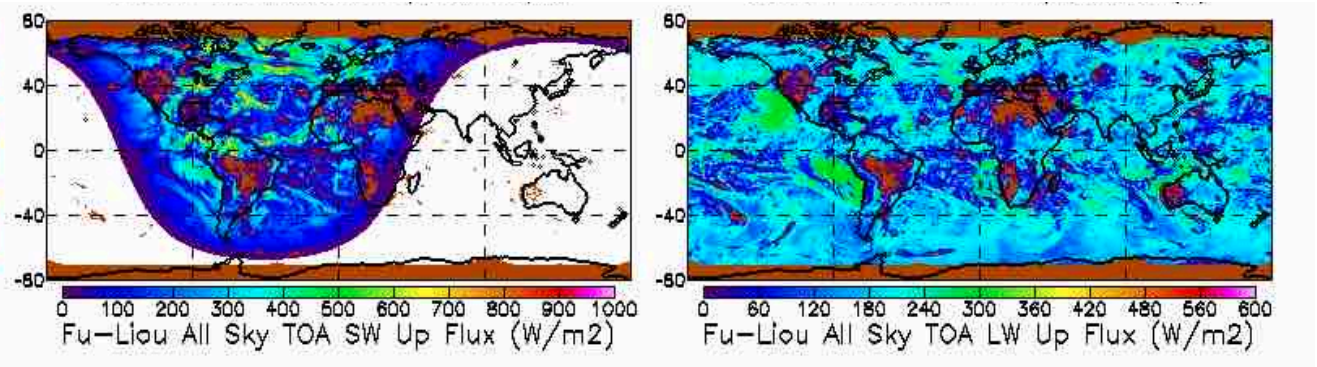
Strategic Fu/Liou Development Activities

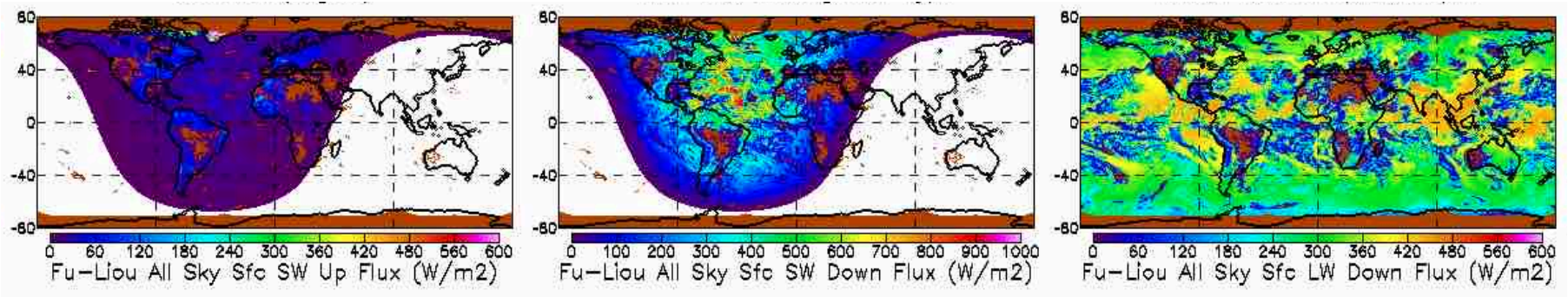


Adding GEO to FF TISA: Offline 1st Fluxes

Offline runs will be compared to SARB-like runs

July 1, 2023
15 UT





Fu-Lung Chang