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Assessing the Uncertainty Impact of CERES Fast Longwave And SHortwave Radiative Flux (FLASHFlux) Level 3 Product with and without Terra Observations.

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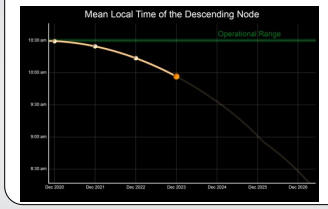
Introduction

The Clouds and Earth's Radiant Energy System (CERES) project provides satellite-based observations of how Earth's energy flows are varying in time and space and how clouds and aerosols are affecting the Earth's radiation budget. Nominally, CERES data products require months of validation and calibration before releasing a climate quality data. The Fast Longwave And SHortwave radiative Flux (FLASHFlux) data product was developed to provide data for applied science research involving the renewable energy and agricultural sectors within a week of observation. FLASHFlux achieves this by using simplified calibration, an operational meteorological product from Global Monitoring and Assimilation Office (GMAO), and a surface parameterizations model. The CERES FLASHFlux provides two data products: 1) an hourly Level 2 Single Scanner Footprint (SSF) data separately for Terra and NOAA-20 observations. 2) a daily Level 3 Time Interpolated and Spatially Averaged (TISA) gridded data that combines NOAA-20 and Terra observations on a one-degree equal angle grid.

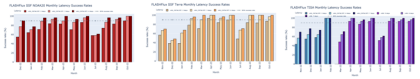
FLASHFlux TISA data product interpolate on a diurnal model that assumes a satellite equilateral crossing time of 10:30 AM and 1:30 PM from Terra and Aqua, respectively. Aqua was replaced by NOAA-20 starting on September 2022. Terra is planned to be replace by the Satellite ClOud and Radiation Property retrieval System (SatCORPS) soon. We are currently using the Terra observations as it continues to drift. We assess the impact of FLASHFlux TISA data when Terra is removed. An uncertainty estimate of the Top-Of-Atmosphere (TOA) fluxes are given of FLASHFlux Terra-Aqua_Version4A, Terra-NOAA20_Version4B, and NOAA20_Version4B in comparison to the CERES EBAF and SYN1deg. In addition, we compare FLASHFlux Version4B and Version4B (NOAA20 only) surface radiative fluxes to ground base measurements to determine the impact of running without Terra data.

Terra Orbital Drift

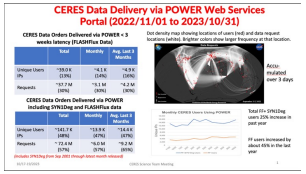


Terra is currently in orbital drift away from mean local crossing time of 10:30 AM. CERES FLASHFlux current gridding and averaging window box works on a 15 minutes window. Therefore, the drift will impact the flux averages.

FLASHFlux Latency and Usage

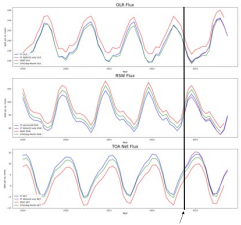


FLASHFlux mission is to provide TOA and Surface Fluxes as soon as feasible. The objective is a 3 days delay of SSF Level 2 product and a 7 days delay of TISA Level 3 product from the time of measurement. Above is the latency metric of NOAA-20 SSF, Terra SSF, and TISA (Terra-Aqua in blue and Terra-NOAA20 in purple) data products (from left to right). FLASHFlux was able to meet this objective for 90% of the time for most months.



The TISA data is provided to the Prediction of Worldwide Energy Resources (POWER) where it is being use for building energy assessment, Solar renewable maintenance, and other agricultural needs.

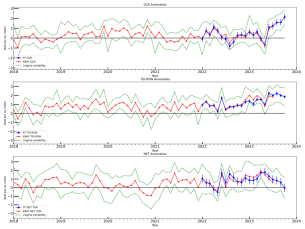
TOA Comparison



NOAA-20 only TISA Starts

We assessed FLASHFlux Level3 TISA TOA data running in NOAA-20 only mode. NOAA-20 only is from Oct 2022 to Oct 2023. The difference between NOAA-20 only mode and TISA Version4B is -0.05, -0.27, 0.32 W m^{-2} for OLR, RSW and TOA Net, respectively. Note: the EBAF curves include a scaling balance net flux relative to independent ocean heat content estimates (Loeb et al., 2018), while the other plots do not contain this adjustment.

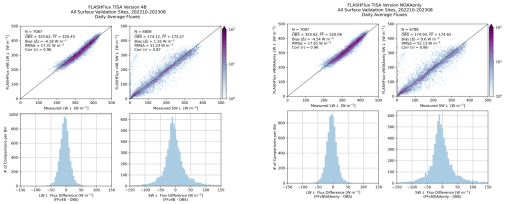
Earth's Radiation Budget



Climate is controlled by the amount of sunlight absorbed by Earth and the amount of infrared energy emitted to space. These quantities–together with their difference–define Earth's radiation budget (ERB). The Clouds and the Earth's Radiant Energy System (CERES) project provides satellite-based observations of ERB and clouds.

Each year, CERES FLASHFlux extend the CERES Energy Balanced and Filled (EBAF) data record to analyze the anomalies of the ERB for the State of the Climate report (https://doi.org/10.1175/BAMS-D-20-0104.1). Above is the global TOA anomalies using CERES EBAF up to July 2023 and extended using FLASHFlux to October 2023.

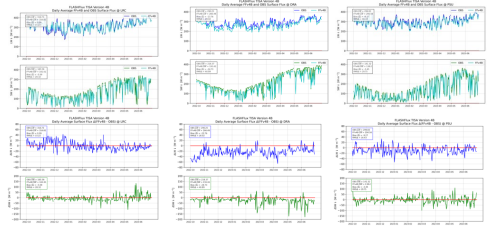
Surface Validation



Version 4B NOAA-20 only

In the case where Terra observation data are no longer viable, we ran FLASHFlux Version4B offline with only NOAA-20 data from October 2022 to August 2023 to produce the TISA gridded surface products. The results above highlight the LW and SW downward fluxes compared to an ensemble of measurements from the Baseline Surface Radiation Network. Version4B (left) refers to FLASHFlux Version4B that blends Terra and NOAA-20. NOAA-20 only (right) refers to FLASHflux Version4B using only NOAA-20 observation. Both the LW and SW surface downward fluxes agree similarly with the surface measurements, with the SW showing a slight improvement.

Surface Validation – Time series



Day to day variability can be useful to determine the stability of the observation and its impact on the algorithm. Above are 3 surface sites (Langley Research Center, Hampton, VA; Desert rock, NV; Penn State University, PA) that we use to determine FLASHFlux Version 4B Terra-NOAA20 TISA performance over time.

After March 2023, we noticed a larger variability in the differences of SW surface flux compares to surface observation. We believe that these differences may be due in part to Terra drifting in time within and across the TISA algorithm averaging boxes. This feature is currently under investigation.

Conclusions

- FLASHFlux TISA Version 4B with NOAA-20 only compares well within 0.5 Wm^{-2} of globally averaged TOA fluxes to the FLASHFlux TISA Version4B data product.
- Relative to an ensemble surface sites, FLASHFlux Version 4B TISA from October 2022 to August 2023 shows statistically negligible differences when running in Terra-NOAA20 mode versus running in NOAA-20 only mode.
- FLASHFlux TISA Version 4B SW downward surface fluxes shows larger day to day variability relative to surface sites after March 2023; we are assessing whether the NOAA-20 only mode impacts this result as we study the impact of drift in Terra equator overpass time.
- FLASHFlux shows good agreement with ground measurements for TISA products and are reliable for uses in applied science through the POWER web portal.
- In the past year, data requested from an average of nearly 4,100 monthly unique IPs (a proxy for users) with about 30% of all data orders requesting low latency solar irradiance estimates, shows the importance of FLASHFlux data products to the community.
- The methods use to create a hybrid CERES FLASHFlux and CERES EBAF timeseries provide a result that is within 0.2 Wm^{-2} uncertainty.
- FLASHFlux data is available from the CERES website (https://ceres.larc.nasa.gov/data/#flashflux-gridded-fluxes-level-3)

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