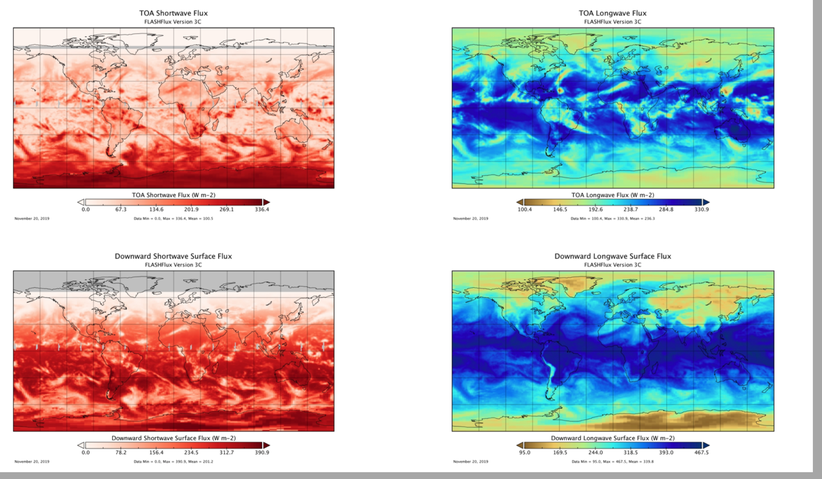
Validation of CERES Fast Longwave And SHortwave Radiative Flux (FLASHFlux)

Parnchai K. Sawaengphokhai[1], Paul W. Stackhouse, Jr.[2], David P. Kratz[2], Shashi K. Gupta[1], and Anne C. Wilber[1]
[1]Science Systems and Applications, Inc., Hampton, Virginia
[2]NASA Langley Research Center, Hampton, Virginia

Introduction : *The science, applied science and educational communities have a need for top-of-atmosphere (TOA) and surface radiative fluxes on a low latency basis (within about 7 days of observation). Applied science uses for surface fluxes include building energy performance monitoring and seasonal crop yield modeling. The Clouds and Earth's Radiant Energy System (CERES) FLASHFlux data products address this need by enhancing the speed of the CERES processing using a baseline spectral response and parameterized surface flux models to produce global fluxes within a week of satellite observations. The CERES FLASHFlux provides two data products: 1) an hourly [Level 2] Single Scanner Footprint (SSF) data separately for Aqua and Terra observations, and 2) a daily [Level 3] Time Interpolated and Spatially Averaged (TISA) 1°x1° gridded data that combines Aqua and Terra observations.*

FLASHFlux TISA and CERES EBAF (Energy Balanced and Filled) are used in the analysis of TOA anomalies for the annual "State of the Climate" report. We highlight the methodology use to merge the two data products by correcting the bias in FLASHFlux TISA and inter-calibrate to CERES EBAF. We also compare CERES FLASHFlux SSF overpass and TISA radiative flux products to a set of surface measurement sites that are globally distributed and assess agreement.

Level 3 Data product



FLASHFlux provides two data products. A Single Scanner Footprint (Level 2) data for each satellite observation and a one degree equal angle gridded (Level 3) data that combine observations from both satellites to estimate daily global radiative fluxes (shown above).

FLASHFlux data are often use by the renewable energy and agricultural communities. Through cooperation with the Prediction Of Worldwide Energy Resource (POWER) project, CERES FLASHFlux data is being used in crop yield modeling to energy monitoring. The number of unique users has grown over the years (see below).

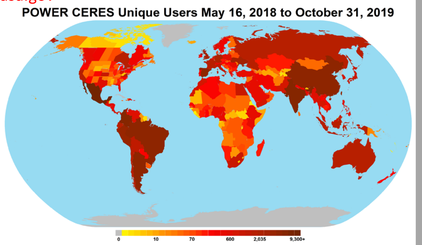
FLASHFlux data distribution through the POWER Web Portal

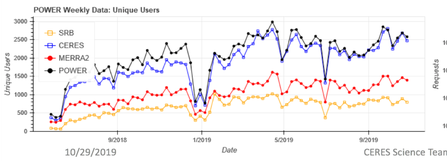
https://power.larc.nasa.gov

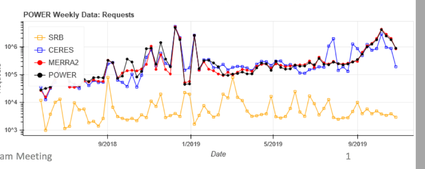
Metrics (2018/05/16 to 2019/10/31):

Source: CERES	Total	Monthly
Data Requests	34,159,018	2,006,520
Unique Users IPs	125,841	7,360
Latency < 2 Weeks	74.8%	74.9%

Source: All	Total	Monthly	CERES %
Data Requests	71,204,247	4,183,840	48.0%
Unique Users IPs	178,082	10,414	70.7%
Latency < 2 Weeks	82.6%	82.6%	



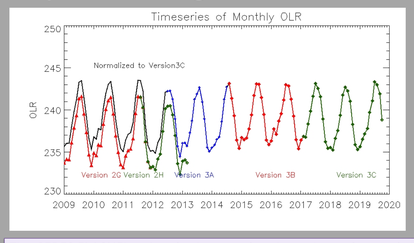


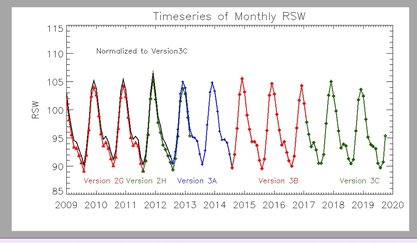


Acknowledgements: This work was funded by the NASA CERES Project, Norman Loeb PI. Data were obtained from the NASA Langley Research Center Atmospheric Science Data Center. Thanks go to John Kusterer, Tonya Davenport, Don Land and Fenny Wang for data production.

Annual State of the Climate: Since 2006, FLASHFlux data has been used to determine the Earth Radiation Budget at the Top of Atmosphere. While FLASHFlux data is not a climate dataset and long term analysis using only FLASHFlux data is highly discouraged, we can normalized FLASHFlux data to climate dataset such as CERES EBAF to assess most recent TOA flux variability in a long-term context. Below highlights the steps that we use to accomplish an early estimate of CERES EBAF fluxes.

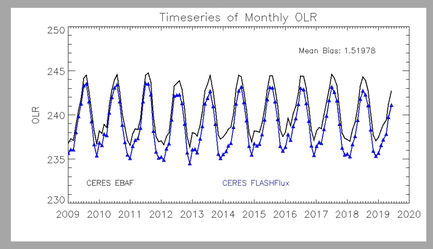
Step 1: Combining different FLASHFlux Versions

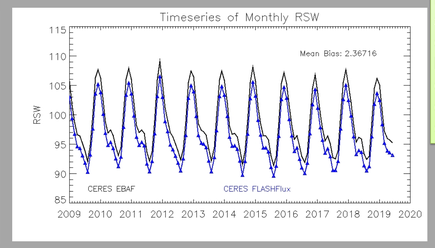




The CERES FLASHFlux data is always going through continuous improvement. Unlike formal CERES climate data products, FLASHFlux products are more operational in nature; therefore, are updated as changes to input data and algorithms are made. One such improvement is an update in the GEOS meteorology between Version 2 and Version 3. The updated meteorology caused a discontinuity in the data products and requiring a normalization to better ensure monthly global averaged consistency.

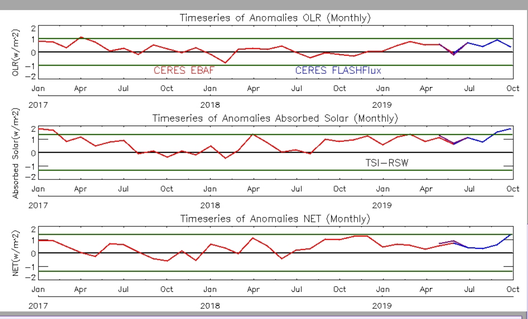
Step 2: Normalizing FLASHFlux data to CERES EBAF



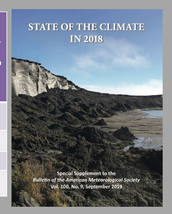


After producing a homogeneous FLASHFlux data product, we compare the TOA observation to the CERES EBAF data product. The difference in the observation can be attributed to many sources (Spectral response coefficients, meteorology, energy balancing, etc). To address the differences, we remove the mean bias from the overlapping period (Jan. 2009 to Jun. 2019) and use a linear fit to remove any seasonal dependencies.

Step 3: Deseasonalized anomalies



	Global-annual Mean Difference (W m^{-2})	2019 Anomaly (relative to Climatology) (W m^{-2})	Inter-annual variability (2001 to 2016) (W m^{-2})
OLR	0.30	+0.35	±0.55
TSI	0.0	-0.05	±0.15
RSW	-0.75	-1.00	±0.80
Net	0.45	+0.60	±0.80



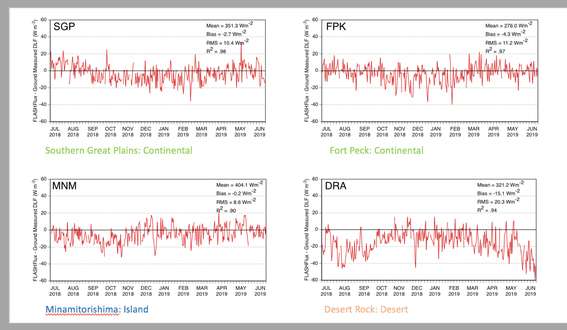
The normalized FLASHFlux data can now be used to extend the CERES EBAF observation. We use 18 years of CERES EBAF data to construct a monthly climatology. Removing the monthly climatology from the hybrid monthly timeseries provides the deseasonalized anomaly timeseries. Assessing this method by comparing estimated and actual EBAF flux anomalies, we determined that using this method provides an estimated flux anomaly within 0.2 Wm^{-2} uncertainty.

Global monthly mean deseasonalized time series was constructed from the CERES EBAF (Energy Balanced And Filled) Ed4 product for March 2000 to June 2019 and from the CERES Fast Longwave and Shortwave Radiative Fluxes (FLASHFlux) products for July 2019 to October 2019. A normalization procedure results in a 2-sigma monthly uncertainty of ±0.43, ±0.08, ±0.20 and ±0.50 Wm^{-2} for the OLR, TSI, RSW and total net radiation, respectively.

Conclusions:

- FLASHFlux data products contain the only publicly available global data set of shortwave and longwave surface fluxes within about 7 days of observation, which can be used to assess surface radiation budget variability in space and time.
- FLASHFlux surface fluxes show good agreement with ground measurements for TISA products and are reliable for uses in applied science through the POWER web portal.
- 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 provides a reliable estimate of future TOA CERES EBAF fluxes; this year the method projects a continued increased in the global net TOA flux through October.

Surface Sites Time Series Validation

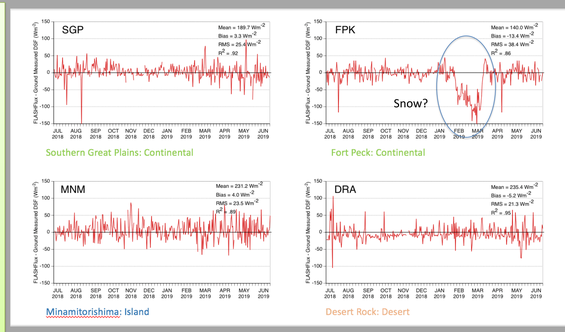


LW Surface Flux Validation

Difference time series plot of FLASHFlux data minus surface site measurements. Overall bias and variability are small except for the desert. We are assessing the causes for the large bias in the desert.

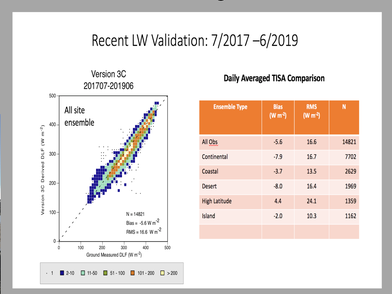
SW Surface Flux Validation

Difference time series plot of FLASHFlux data minus surface site measurements. Overall bias is small, but the variability can be quite large from day to day. Fort Peck shows a significant differences in late Jan to late March. We believe that coverage of the region is contributing to the larger differences.

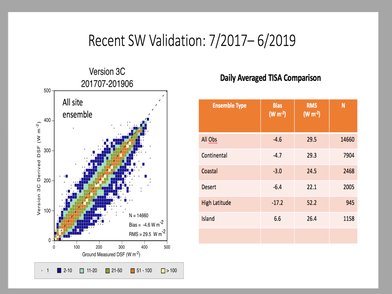


Validation of FLASHFlux Version3C TISA (Time Interpolated Space Averaged) Fluxes Daily Mean All-Sky [201707-201906]

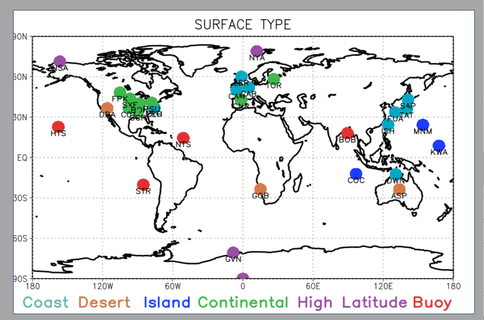
Downward Longwave



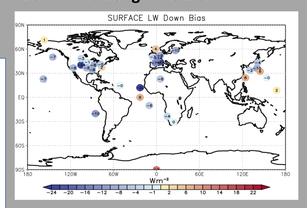
Downward Shortwave



Locations of Surface Validation Sites



Downward Longwave Bias



Downward Shortwave Bias

