FLASHFlux TISA Terra+Aqua Version2 Data Quality Summary

Investigation:	**FLASHFlux**
Data Product:	**Time Interpolated and Spatially Averaged (TISA)**
Data Sets:	**Terra+Aqua (Instruments: CERES-FM1 or CERES-FM2, CERES-FM3 or CERES-FM4, MODIS)**
Data Set Family:	**Version2**
Data Set Versions:	**Version2D, Version2E, Version 2F, Version2G, Version 2H**

The Fast Longwave and SHortwave Flux (FLASHFlux) project is based upon the algorithms developed for and data collected by the Clouds and the Earth's Radiant Energy System (CERES) project. CERES is currently producing world-class climate data products derived from measurements taken aboard NASA's Terra and Aqua spacecrafts. While of exceptional fidelity, CERES data products require a considerable amount of processing to assure quality and verify accuracy and precision. The result is that CERES data are typically released more than six months after acquisition of the initial measurements. For climate studies, such delays are of little consequence especially considering the improved quality of the released data products. There are, however, many uses for the CERES data products on a near real-time basis. These include CERES instrument calibration and subsystem quality checks, CloudSat operations, seasonal predictions, land and ocean assimilations, support of field campaigns, outreach programs such as S'COOL, and application projects for agriculture and energy industries.

The FLASHFlux project was envisioned as a conduit whereby CERES data could be provided to the community within a week of the initial measurements, with the trade-off that some degree of fidelity would be exacted to gain speed.

The purpose of this document is to inform potential users of the FLASHFlux data of the differences between the FLASHFlux and CERES data products. This document also provides potential users with information concerning the difference between versions within the Version2 family. This document provides the data users with cautions where they could possibly misinterpret the data; links to further information about the data product, algorithms, and accuracy; and information about planned changes. Even though the FLASHFlux endeavor intends to incorporate the latest input data sets and improvements into its algorithms, there are no plans to reprocess the FLASHFlux data products once these modifications are in place. Thus, in contrast to the CERES data products, the FLASHFlux data products are **not** to be considered of climate quality. Users seeking climate quality should instead use the CERES data products.

The FLASHFlux **Version2** data sets refer to all files within the Version2 family. When changes are made that may noticeably affect one or more output parameters, the letter which follows the version number is changed (e.g., Version5D, Version5E, and Version5F would all belong to the Version5 family of TISA files). All files with the same number belong in the same version family, regardless of the letter that follows. Substantial changes will result in a version number change, which also changes the version family. By definition, adding or removing TISA parameters will always result in a version number/family change. Every TISA version family has its own Data Quality Summary. Note that a change in the input (SSF) version will result in a change to TISA version. Typically, an SSF letter change will result in a TISA letter change and an SSF version number (family) change will result in a TISA version number change. However, the TISA version letter or number may also change independently of the SSF.

Please note, this document is a high-level summary and represents the minimum information for scientific users of this data product. We strongly urge authors, researchers, and reviewers of research papers to periodically re-check this URL for the latest status of this Data Set Version and particularly before publication of any scientific papers using the data.

Table of Contents

Nature of the TISA Product

FLASHFlux will typically choose to process the Terra and Aqua instruments that are in the crosstrack scan mode. To determine operations on a given day from any previous month, refer to the CERES Operations in Orbit. FLASHFlux TISA is a combination of daily and hourly products produced by combining Terra and Aqua data and interpolating inside a 3-day window.

The daily and hourly parameters on the TISA is listed on the Level 3 FLASHFlux Data Sets page. Only the daily averaged flux products have been fully validated so far. Efforts are currently underway to validate the hourly averaged flux products, and when completed will be noted in this document.

This Data Quality Summary is written for all TISA files within the Version2 family.

When referring to a FLASHFlux data set, please include FLASHFlux, the specific data set version or the data set version family, and the data product. Multiple files that are identical in all aspects of the filename except for the 6 digit configuration code (number to the left of the data date) differ little scientifically. Thus, users may analyze FLASHFlux data from the same data set version and data product without regard to configuration code. If all the files come from one data set version, refer to the data set using that specific data set version. For example, users working only with Version2G files should refer to "FLASHFlux Version2G TISA." If the files are from numerous data set versions of the same family, then refer to the data set as "FLASHFlux Version2 TISA.".

Users should analyze FLASHFlux data sets from different version families separately.

Similarities between FLASHFlux and CERES

Both FLASHFlux and CERES make use of the same SW Model B and LW Model B algorithms. These models are also named Langley Parameterized SW Algorithm (LPSA) and Langley Parameterized LW Algorithm (LPLA) respectively. Hence, both FLASHFlux and CERES rely on similar input data sets from the meteorological products and MODIS.

Differences between FLASHFlux and CERES

- FLASHFlux will provide high quality data sets to the community within a week of the initial measurements. The FLASHFlux data sets will **not** be reprocessed into consistent time series records.
- FLASHFlux input data sets and algorithms will change as improvements become available.
- FLASHFlux TISA processes very shortly after the data date, and therefore, there may be gaps. Please consult the FLASHFlux data tables to learn of abnormalities of missing data in the production (FLASHFlux Processing Metadata). Also, FLASHFlux TISA is a daily product derived by combining inputs from both Terra and Aqua while CERES TISA is a monthly product derived for each satellite separately.
- CERES produces a non-GEO product and a GEO product by bringing in geostationary satellite data to improve temporal sampling characteristics. So far, FLASHFlux is a non-GEO product only.
- CERES Rev1 corrections are included in the special set of correction coefficients used by FLASHFlux and should **not** be applied again by the user.
- Data from only one Terra and one Aqua instrument are processed each day. The selected instrument is typically in the crosstrack mode of operation. When possible, the data from the same instrument are processed for the entire month. To determine the mode of operations for each instrument in previous months, users should refer to CERES Operations in Orbit. Available data from the Terra and Aqua instrument are combined in the TISA product.

Data Sets within the Version2 family

Note: Versions preceding Version2D are considered beta level products and are not suitable for publication.

Version2D

- Version2D is the first non-Beta FLASHFlux TISA dataset produced.
- This version uses as inputs collection 5 MODIS data and Meteorology, Ozone, and Aerosol (MOA) data produced with GMAO's GEOS-5.1.0 product.
- Unlike CERES, FLASHFlux TISA products are derived only with SW and LW Models B. Fluxes derived with corresponding Models A are set to default because both of those models work for clear skies only and hence provide sparse global coverage.
- Valid data dates: January 1, 2008 - August 31, 2008.

Version2E

- Version2E uses as inputs collection 5 MODIS data and Meteorology, Ozone, and Aerosol (MOA) data produced with GMAO's GEOS-5.2.0 product. Information about the GEOS-5.2.0 is found at the GMAO web site.
- Valid data dates: September 1, 2008 - June 30, 2009.

Version2F

- A small error was discovered in the values of the spectral correction coefficients that are used for unfiltering measured radiances. Those coefficients have now been corrected and are used for Version2F. The use of corrected coefficients has resulted in a 0.01%

increase for both Terra and Aqua TOA SW fluxes and a 3.6% increase for Aqua window fluxes. Terra window fluxes are not affected. This change has gone into effect starting July 1, 2009.
- Valid data dates: July 1, 2009 - July 31, 2010.

Version2G

- New snow/ice maps (16-mesh) obtained from NSIDC were implemented in cloud retrieval and MOA processing. A script that designated the backup MOA input files was corrected to read the appropriate files for stratospheric water vapor, Pinker/Stowe aerosols and ozone for each month. Another error found with initialization in the MOA code was corrected though this did not affect FLASHFlux results.
- Three subroutines in the cloud code dealing with transition between polar and non-polar algorithms and ozone absorption were replaced by revised versions.
- A code error affecting computation of TOA SW flux in the inversion subsystem was corrected. A script error that had resulted in the reading of an ancillary file for the month of August, regardless of the month being processed, was corrected to read the ancillary file for the current month being processed. This ancillary file contains precomputed values for the angular distribution models for land surfaces.
- Clear-sky TOA and surface albedo files based on 70 months of Terra observations were substituted for ones based on 46 months of Terra observations which had been used in all earlier versions of FLASHFlux TISA processing. These changes have gone into effect starting January 1, 2009.
- Valid data dates: January 1, 2009 - Decmber 31, 2011.

Version2H

- Processing for this version was moved from a SGI system to an IBM system. Differences between these platforms and their accompanying compilers gave rise to small differences but those were always within +/- 1 Wm^{-2} range.
- A small error found in the order of compilation of a number of subroutines in the cloud subsystem was corrected. This correction resulted in small changes in retrieved cloud properties and gave rise to a 2-3 Wm^{-2} increase in downward LW fluxes over some ocean regions.
- Valid data dates: January 1, 2012 - Present.

Cautions and Helpful Hints

- FLASHFlux only produces data sets for one crosstrack CERES instrument from each satellite. The instrument in crosstrack mode for a satellite may change over time. Instrument operation modes typically change at a monthly boundary and are seldom made in the middle of a month. When a failure or anomaly is detected, the instrument FLASHFlux processes may abruptly switch in the middle of a month.

- Users should **not** apply the Rev1 user applied revisions discussed in the CERES Data Quality Summaries to any FLASHFlux data set. As Rev1 scaling factors become available, they will be included in the FLASHFlux data sets via the set of correction coefficients used to unfilter the CERES radiances.

- Users should note that only the daily averaged flux products have been fully validated. Efforts are currently underway to validate the hourly averaged flux products, and when completed will be noted in this document.

- Users who need to know whether the hour box data was extrapolated, interpolated, or associated with an actual observation should consult the Quality Assurance byte in the Quality Assurance Vgroup. The bit definitions are as follows:

  if actual observation, bit0 == 0:
    - bit1: Was there an Aqua observation?, 0=no, 1=yes
    - bit2: Was an Aqua observation used?, 0=no, 1=yes
    - bit3: Was there a Terra observation?, 0=no, 1=yes
    - bit4: Was a Terra observation used?, 0=no, 1=yes

  if interpolated or extrapolated, bit0 == 1:
    - bit1: Was there an earlier observation?, 0=no, 1=yes
    - bit2: Was there a later observation?, 0=no, 1=yes
    - bit3: Which spacecraft was the earlier observation from?, 0=Aqua, 1=Terra
    - bit4: Which spacecraft was the later observation from?, 0=Aqua, 1=Terra

      It should be noted that in the above situation (bit0 == 1), if bit1=0, then bit3 will not have a meaningful value. Similarly, if bit2=0, then bit4 will not have a meaningful value.

- The Model B surface flux parameters have been validated for the Version2 family of data sets. These surface fluxes are computed for all-sky conditions.

- Comparison of the near-surface and skin temperatures between GEOS-5.1.0 and GEOS-5.2.0 shows differences over ice surfaces such as over Greenland and Antarctica. There may be discontinuities over these surfaces from August 31, 2008 version 2D (using GEOS-5.1.0) and September 1, 2008 version 2E (using GEOS-5.2.0) that exceed ± 10 K. User caution is advised.

- The nomenclature used to describe the fluxes in the SSF data are as follows: Total = Shortwave + Longwave; Net = Down - Up; and

All-sky = Clear-sky + Cloudy_sky. The HDF output files often refer to the All-sky case as Tot-sky or Total-sky, which means Clear-sky + Cloudy-sky, rather than Shortwave + Longwave.

Accuracy and Validation

Validation of the FLASHFlux results is actively being pursued. The accuracy of FLASHFlux results will be documented as they become available. Please see the FLASHFlux home page for more information.

Overview of the Fast Algorithms

SW Model B Algorithm (LPSA)

The Langley Parameterized Shortwave Algorithm (LPSA) described in Gupta et al. (2001) was developed to provide a fast radiative transfer method to derive the Earth's shortwave (SW) surface radiation budget. Both CERES and FLASHFlux projects use this algorithm for deriving instantaneous Single Scanner Footprint (SSF) and Time Interpolation and Spatial Averaging (TISA) data products. This algorithm is also used by WCRP/GEWEX Surface Radiation Budget (SRB) project for deriving global surface insolation products. The LPSA consists of physical parameterizations that account for the attenuation of solar radiation in simple terms separately for clear and cloudy atmospheres.

LW Model B Algorithm (LPLA)

The Langley Parameterized Longwave Algorithm (LPLA) is a fast parameterization derived from an accurate narrowband radiative transfer model (Gupta 1989; Gupta et al. 1992). The LPLA is also used by both CERES and FLASHFlux projects for deriving SSF and TISA products and by WCRP/GEWEX SRB project for deriving global LW fluxes. The LPLA computes downward LW flux (DLF) in terms of an effective emitting temperature of the atmosphere, the column water vapor, the fractional cloud amount, and the cloud-base height for each footprint. The effective emitting temperature and column water vapor are computed from temperature and humidity profiles available from the MOA database. Fractional cloud amount and cloud-base height are available from the CERES cloud subsystem. Recent validation of LPLA products by Kratz et al. (2010) indicated significant overestimation of downward LW fluxes when surface skin temperature greatly exceeded near-surface air temperature. As a result, an improvement has been implemented in LPLA to better handle downward longwave fluxes for very high surface skin temperature conditions that commonly occur over daytime dry/arid regions (Gupta et al., 2010).

Future Changes

FLASHFlux will not be able to hold the TISA processing constant. As inputs and algorithms change, the quality of the data product will also change. Minor changes that do not impact the science will be denoted by an increase in the 6 digit configuration code that appears just before the data date and hour. Changes that impact the science enough to be noted will result in a letter change within the data set version. Major changes will result in a change to the data set family.

The following are expected to have an impact on the FLASHFlux TISA products:

1. The FLASHFlux products will be made available via the improved CERES ordering tools that will provide for subsetting, interactive graphics and ascii data retrievals.
2. CERES provides updated Terra and/or Aqua unfiltering coefficients.
3. The next version of LPSA will replace the WCP-55 aerosol parameters with MATCH aerosol optical depths (Collins et al., 2001) and OPAC single scattering albedos and asymmetry parameters (Hess et al., 1998).
4. The next version of the LPSA will also replace the original LPSA Rayleigh scattering formulation with a Rayleigh scattering formulation based upon the work of Bodhaine et al. (1999).
5. To capture transient events, we plan to incorporate near real-time MODIS aerosol optical depths into the LPSA.
6. The next version of LPLA will take into account severe LW surface flux underestimations caused by strong, but shallow temperature inversions.
7. More advanced versions of the emissivity maps are under development and will use wind speed data over water surfaces, and ASTER and MODIS retrievals over land surfaces.
8. Improve the spatial resolution to at least 0.5 X 0.5 degrees

Referencing Data in Journal Articles

The FLASHFlux and CERES Teams have gone to considerable trouble to remove major errors and to verify the quality and accuracy of this data. Please provide a reference to the following papers when you publish scientific results with the CERES data:

Wielicki, B. A., B. R. Barkstrom, E. F. Harrison, R. B. Lee III, G. L. Smith, and J. E. Cooper, 1996: Clouds and the Earth's Radiant Energy System (CERES): An Earth Observing System Experiment, ***Bull. Amer. Meteor. Soc.***, **77**, 853-868.

Stackhouse, P. W., D. P. Kratz, G. R. McGarragh, S. K. Gupta, and E. B. Geier, 2006: Fast Longwave and Shortwave Radiative Flux (FLASHFlux) Products From CERES and MODIS Measurements. 12th Conference on Atmospheric Radiation, American Meteorological Society, Madison, Wisconsin, 10-14 July 2006.

When Langley Atmospheric Science Data Center (ASDC) data are used in a publication, **we request the following acknowledgment be included:**

"These data were obtained from the NASA Langley Atmospheric Science Data Center."

The Langley ASDC requests two reprints of any published papers or reports which cite the use of data that we have distributed. This will help us determine the use of data that we distribute, which is helpful in optimizing product development. This also helps us to keep the product related references current.

References Cited

1. Bodhaine, B. A., N. B. Wood, E. G. Dutton, and J. R. Slusser, 1999: On Rayleigh Optical Depth Calculations. ***J. Atmos. Oceanic Tech.***, **16**, 1854-1861.

2. Collins, W. D., P. J. Rasch, B. E. Eaton, and B. V. Khattatov, 2001: Simulating Aerosols Using a Chemical Transport Model with Assimilation of Satellite Aerosol Retrievals: Methodology for INDOEX. ***J. Geophys. Res.***, **106**, 7313-7336.

3. Gupta, S. K., 1989: A Parameterization for Longwave Surface Radiation From Sun-Synchronous Satellite Data. ***J. Climate***, **2**, 305-320.

4. Gupta, S. K., W. L. Darnell, and A. C. Wilber, 1992: A Parameterization of Longwave Surface Radiation From Satellite Data: Recent Improvements. ***J. Appl. Meteorol.***, **31**, 1361-1367.

5. Gupta, S. K., D. P. Kratz, P. W. Stackhouse, and A. C. Wilber, 2001: The Langley Parameterized Shortwave Algorithm (LPSA) for surface radiation budget studies (Version 1.0). ***NASA/TP-2001-211272***, 31 pp.

6. Gupta, S. K., D. P. Kratz, P. W. Stackhouse, A. C. Wilber, T. Zhang, and V. E. Sothcott, 2010: Improvement of Surface Longwave Flux Algorithms Used in CERES Processing. ***J. Appl. Meteor. Climatol.***, **49**, 1579-1589. doi: 10.1175/2010JAMC2463.1

7. Hess, M., P. Koepke, and I. Schult (1998): Optical Properties of Aerosols and Clouds: The Software package. ***Bull. Amer. Meteor. Soc.***, **79**, 831-844.

8. Kratz, D. P., S. K. Gupta, A. C. Wilber, and V. E. Sothcott, 2010: Validation of the CERES Edition 2B Surface-Only Flux Algorithms, ***J. Appl. Meteor. Climatol.***, **49**, 164-180, doi:10.1175/2009JAMC2246.1.

Feedback and Questions

For questions or comments on the FLASHFlux Quality Summary, contact the User and Data Services staff at the Atmospheric Science Data Center.

Document Creation Date: August 15, 2006
Modified: Jun 2008; Oct 2008; Apr 2009; Jul 2009; Feb 2011; Feb 2012
Most Recent Update: February 10, 2012