CERES FLASHFlux Status:
Near-Real Time Surface Radiative Fluxes and Meteorology for Research and Applications

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CERES FLASHFlux Overview

- **FLASHFLUX =** Fast Longwave And SHortwave Radiative Fluxes from CERES and MODIS
- **FLASHFlux Objectives:**
  - Provide TOA and surface radiative fluxes within one week of observation for scientific and applied science uses:
    - Level 2 – SSF for Terra and Aqua; currently through 4/19/14
    - Level 3 – TISA, Terra+Aqua,1°x1°; currently through 4/16/14
  - Scientific, Educational and Applied Science use examples:
    - CloudSat and Megha-Tropiques (SSF)
    - Annual “State of the Climate” report on radiative budgets (TISA)
    - CERES S’COOL, NASA Earth Observatory (TISA)
    - LaRC POWER (TISA): Building energy monitoring through (RETSCreen); Crop modeling systems such as APSIM (CSIRO)
  - Demonstrate processing system pushing data products to research and applications uses
    - Push subscription from ASDC to NASA Earth Observatory for Education
    - Pull from ASDC by CloudSat and Megha-Tropiques missions
    - Direct usage via DPO at NASA LaRC: CERES team, POWER
FLASHFlux Data Flow (v3A)

Official FLASHFlux data products highlighted with black box

Legend
- MOA (SS1)
- Clouds (SS2)
- Instantaneous Fluxes (SS3)
- Time and Space gridding (SS4)
- Time and Space averaging (SS5)
- User Data and Interfaces (SS6)

State of Climate Analysis
FLASHFlux SSF Data Products

Processed through about 4/19/2014

https://eosweb.larc.nasa.gov/project/ceres/flashflux-l2_table
FLASHFlux TISA Data Products

FLASHFlux TISA
Version 3A
Products
(Terra+Aqua;
Daily; 1°x1° resolution;
Processed through about 4/9/2014)

https://eosweb.larc.nasa.gov/project/ceres/flashflux-tisa_table
Finding FLASHFlux from CERES Data Ordering Page (HDF Only)

### CERES Data Products

To subset, visually browse, and download CERES data products in netCDF format, click "Browse & Subset.

For more information and documentation on a specific product, click on the "Data Product" name. Or as a quick reference, click on the 

Access to the complete CERES archived HDF data products.

**Level 3A:** Spatially (regional, global, etc.) and temporally (daily, monthly, etc.) averaged fluxes where the net flux has been energy balanced.

**Data Product (Information & Documentation)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Resolution</th>
<th>Version/Availability</th>
<th>Order Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBAP-TOA (Monthly and climatological averages of TOA fluxes, all-sky fluxes, and cloud radiative effect (CRE), where the TOA net flux is constrained to the ocean heat storage)</td>
<td></td>
<td></td>
<td>✓</td>
<td>Order via ASDC</td>
</tr>
<tr>
<td>EBAP-Surface (Monthly and climatological averages of net surface fluxes, all-sky fluxes, and cloud radiative effect (CRE), consistent with the CERES EBAP-TOA fluxes)</td>
<td></td>
<td></td>
<td>✓</td>
<td>Order via ASDC</td>
</tr>
</tbody>
</table>

**Level 3B:** Spatially (regional, global, etc.) and temporally (daily, monthly, etc.) averaged fluxes and clouds.

**Data Product (Information & Documentation)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Resolution</th>
<th>Version/Availability</th>
<th>Order Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYN/AVHRR (CERES instantaneous footprints and temporally interpolated TOA fluxes, MODIS clouds and aerosols)</td>
<td></td>
<td></td>
<td>✓</td>
<td>Order via ASDC</td>
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<tr>
<td>SFP (CERES instantaneous footprints and temporally interpolated TOA fluxes, MODIS clouds and aerosols)</td>
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<td></td>
<td>✓</td>
<td>Order via ASDC</td>
</tr>
<tr>
<td>DISCAP-02H (CERES instantaneous footprints and temporally interpolated TOA fluxes, MODIS clouds and aerosols)</td>
<td></td>
<td></td>
<td>✓</td>
<td>Order via ASDC</td>
</tr>
</tbody>
</table>

**Level 2:** CERES instantaneous footprint level (20 km nominal) fluxes and cloud properties.

**Data Product (Information & Documentation)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Resolution</th>
<th>Version/Availability</th>
<th>Order Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>NET (CERES observed TOA fluxes, MODIS clouds and aerosols, and uncorrected surface fluxes)</td>
<td></td>
<td></td>
<td>✓</td>
<td>Order via ASDC</td>
</tr>
<tr>
<td>Aqua Data Quality Summary/R</td>
<td></td>
<td></td>
<td>✓</td>
<td>Order via ASDC</td>
</tr>
</tbody>
</table>

Note: The Browse & Subset ordering tool will query for temporal and spatial resolutions.

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**4/24/2014**

**CERES Science**
SSF Paper Published

- Published in the Journal of Applied Meteorology and Climatology in April issue.
- Highlights the production and validation of the FLASHFlux SSF data product.
- Compares well with CERES SSF data product.
- TISA paper in progress.
FLASHFlux TISA Validation

SW SURFRAD Measurements Only (2008-2012)

Version 2H

Comparison of FLASHFlux and BSRN Data from 2008-01 to 2012-12

- Bias = -5.2537 (W m\(^{-2}\))
- RMS = 35.3875 (W m\(^{-2}\))
- \(\rho = 0.9372\)
- \(n = 34.9985 (W m^{-2})\)
- \(|\text{BSRN} = 185.4242 (W m^{-2})\)
- \(|\text{FLASH} = 180.1610 (W m^{-2})\)
- \(N = 12709\)

Histogram of FLASHFlux-BSRN SWDW Differences from 2008-01 to 2012-12

- Skewness = 1.2148
- Kurtosis = 12.0762
- N = 12709

The red curve is a normal distribution with 0 mean and the same standard deviation as the dataset.

Daily Mean SURFRAD DIR+DIF
Comparison of FLASHFlux and BSRN Data from 2013-01 to 2013-12

Bias = -6.2486 (W m$^{-2}$)
RMS = 37.5691 (W m$^{-2}$)
$n = 0.0247$
$m = 37.0532 (W m$^{-2}$)
\$\bar{L}_{\text{BSRN}} = 179.6376$ (W m$^{-2}$)
\$\bar{L}_{\text{FLASH}} = 173.3892$ (W m$^{-2}$)
$N = 2542$

Histogram of FLASHFlux-BSRN SWDW Differences from 2013-01 to 2013-12

Daily Mean SURFRAD DIR+DIF

Skewness = 1.4390
Kurtosis = 14.4492
$N = 2542$

The red curve is a normal distribution with 0 mean and the same standard deviation as the dataset.
FLASHFlux TISA Validation

LW SURFRAD Measurements Only (2008-2012)

Version 2H

FLASHFlux-BSRN LWDW Flux Comparison from 2008-01 to 2012-12

Bias = -3.1584 (W m⁻²)
RMSE = 12.5332 (W m⁻²)
ρ = 0.9908

<table>
<thead>
<tr>
<th>Bias</th>
<th>RMSE</th>
<th>ρ</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3.1584</td>
<td>12.5332</td>
<td>0.9908</td>
</tr>
</tbody>
</table>

FLASHFlux-BSRN LWDW Differences from 2008-01 to 2012-12

Daily Mean SURFRAD DIR+DIF

Skewness = -0.1812
Kurtosis  = 0.5457

The red curve is a normal distribution with 0 mean and the same standard deviation as the dataset.

N = 12624
FLASHFlux TISA Validation

LW SURFRAD Measurements Only (2013)

Version 3A

FLASHFlux-BSRN LWDW Flux Comparison from 2013-01 to 2013-12

Bias = -7.0625 (W m⁻²)
RMS = 13.7174 (W m⁻²)
σ = 11.7499 (W m⁻²)
\( \mu _{BSRN} = 308.0163 \) (W m⁻²)
\( \mu _{FLASH} = 300.9338 \) (W m⁻²)
N = 2547

Daily Mean SURFRAD DIR+DIF

The red curve is a normal distribution with 0 mean and the same standard deviation as the dataset.

Histogram of FLASHFlux-BSRN LWDW Differences from 2013-01 to 2013-12

Skewness = -0.2647
Kurtosis = 2.2812
N = 2547
FLASHFlux TISA v2H v v3a

SW Surface Downward Flux

LW Surface Downward Flux

Comparison of FLASHFlux V2H (OLD) and V3A (NEW) at SURFRAD Sites from 2012-07 to 2012-12

SURFRAD Sites: FPE, PSU, BOS, BON, DRA, GCR.

Daily Mean
• CERES FLASHFlux contributed to the special annual BAMS report on the “State of the Climate in 2012”.

• Issue appeared in Aug. 2013, providing estimates of changes in year to year Global Earth Radiation Budget for the first time.

• These data were extended and normalized relative to the CERES EBAF 2.6r products for this report.
CERES FLASHFlux TOA flux variability for 2013 for BAMS “State of the Climate” report:

- TSI for SORCE had to be normalized relative to RMIB
- Overlap with EBAF from July 2012 to June 2013 used to adjust FLASHFlux TOA 3A fluxes
- $2\sigma$ monthly uncertainty (W m$^{-2}$) = ±0.34, ±0.05, ±0.84 and ±0.93 Wm$^{-2}$ for the OLR, TSI, RSW and NET radiation
- Global annual average anomalies and variability (in $2\sigma$):

<table>
<thead>
<tr>
<th></th>
<th>One year change (2013 minus 2012) (Wm$^{-2}$)</th>
<th>2013 anomaly (relative to climatology) (Wm$^{-2}$)</th>
<th>Interannual variability (2001 to 2012) (Wm$^{-2}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLR</td>
<td>+0.25</td>
<td>−0.05</td>
<td>±0.50</td>
</tr>
<tr>
<td>TSI</td>
<td>+0.00</td>
<td>+0.05</td>
<td>±0.20</td>
</tr>
<tr>
<td>RSW</td>
<td>+0.45</td>
<td>+0.20</td>
<td>±0.40</td>
</tr>
<tr>
<td>Net</td>
<td>−0.70</td>
<td>−0.10</td>
<td>±0.70</td>
</tr>
</tbody>
</table>
State of the Climate 2013 Analysis

Radiative Flux Anomalies (Wm\(^{-2}\))

- CERES EBAF Ed2.7
- CERES FLASHFlux

OLR
TSI-RSW
NET

Time (Year)


5/7/2013
CERES Science Team Meeting
Lisan Yu (WHOI), OAFlux
With FLASH-Flux net surface flux changes 2013-2012
APSIM (The Agricultural Production Systems sIMulator)

- internationally recognized as a highly advanced simulator of agricultural systems.
- DSSAT based formatted model
- Run for crop systems in West, East and Southern Africa
- FLASHFlux surface fluxes are “gold standard” of surface irradiance estimates for these regions (surface measurements are too poorly calibrated and/or maintained)
- Also uses surface temperature and other parameters from GEOS FP-IT

Results complements of John Hargreaves, CSIRO
CERES FLASHFlux Energy Usage: RETScreen Performance Plus

**RETScreen Performance Plus**
*(imbedded in RETScreen Suite)*

- Internationally recognized for monitoring, targeting and verification of clean energy technologies in operational building systems
- Special ASCII time series format used for SW + meteorological parameters from GEOS FP-IT
- RETScreen reports at least 20,000 users worldwide with most using the NASA data sets from FLASHFlux production
- Example usage includes Weston Bakeries (Wonder Bread), Ford Motor Company, Property management firms, government buildings (i.e., NASA), etc.
Future Upgrades and Challenges

• **Update to v3B**
  – Correct production code anomaly in SSF surface fluxes
  – Update calibration (working with CERES Instrument team)
  – Daily FF TISA TOA and surface fluxes to netCDF format to support inclusion in CERES subsetter (increase visibility)

• **Continued refinement of algorithms:**
  – Improve near-real time surface albedo to reflect surface condition (support for ARISE – Arctic radiation experiment)
  – Aerosols: evaluation FP-IT compared to “Fast-MATCH”

• **Future Upgrades**
  – CERES Ed 4 Clouds (MODIS Collection 6) and Inversion
  – Improve consistency between CERES algorithms and FLASHFlux (TISA/SYN)
  – Develop FLASHFlux NPP SSF data product stream

• **Continued/improved support for applications (Solar industry, Agriculture, Building assessment)**
Summary and Conclusions

• **FLASHFlux 3A**
  – Continuing production and validation
  – New version featuring netCDF delivered soon
  – Improving/upgrading algorithms will work with TISA team to increase similarity to current CERES products
  – Will coordinate with Clouds and Inversion teams to adapt to Ed 4
  – Plan to begin work on NPP SSF production system as new modules arrive

• **FLASHFlux Applications:**
  – Expanding usage for Energy applications using RETScreen and other clean energy applications
  – Also noting expanded usage in building infrastructure risks applications

• **FLASHFlux publications:**
  – SSF published; TISA paper next (renewable energy journal?)
  – 2013 SotC reports submitted
FLASHFlux Web Sites:

http://flashflux.larc.nasa.gov
Backup Slides
• **NASA CASI:**
  – NASA has instituted a Climate Adaptation Science Investigation (CASI) team to assess NASA building infrastructure risks to potential changes in climate.
  – Part of the assessment is a review of energy performance of buildings under varying meteorological conditions.
  – LaRC’s team is assessing 4 buildings for team and with the intent to provide tutorial for other centers.
  – Analysis uses RETScreen Performance Plus tool.
  – Data sets from CERES FLASHFlux production allow computation of parameters to near-real time.
TABLE 1. Difference between the FLASHFlux and CERES LW TOA fluxes (FLASHFlux – CERES) for clear-sky and cloudy-sky conditions based on the Terra and Aqua measurements at the overpass times. The seven scene types are representative of the earth’s surface and consist of subgroups derived from the 20 IGBP surface types. The first column represents the scene type. The second and fourth columns represent the systematic differences (bias) and the third and fifth columns represent the RMSs between the FLASHFlux and CERES model-derived fluxes for the clear- and cloud-sky cases, respectively.

<table>
<thead>
<tr>
<th>Terra Type</th>
<th>Clear sky</th>
<th>Cloudy sky</th>
<th>Clear sky</th>
<th>Cloudy sky</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bias (W m⁻²) (%)</td>
<td>RMS (W m⁻²) (%)</td>
<td>Bias (W m⁻²) (%)</td>
<td>RMS (W m⁻²) (%)</td>
</tr>
<tr>
<td>Forest</td>
<td>−0.7 (−0.3)</td>
<td>1.1 (0.4)</td>
<td>−2.2 (−1.0)</td>
<td>6.2 (2.7)</td>
</tr>
<tr>
<td>Grassland</td>
<td>−1.2 (−0.4)</td>
<td>3.2 (1.1)</td>
<td>−2.3 (−1.0)</td>
<td>10.4 (4.4)</td>
</tr>
<tr>
<td>Cropland–urban</td>
<td>−0.9 (−0.3)</td>
<td>1.4 (0.5)</td>
<td>−2.4 (−1.0)</td>
<td>6.6 (2.9)</td>
</tr>
<tr>
<td>Bright desert</td>
<td>−3.1 (−1.0)</td>
<td>4.2 (1.4)</td>
<td>−2.1 (−0.8)</td>
<td>11.0 (4.2)</td>
</tr>
<tr>
<td>Tundra–barren</td>
<td>−1.6 (−0.5)</td>
<td>3.1 (1.0)</td>
<td>−1.9 (−0.8)</td>
<td>9.5 (3.9)</td>
</tr>
<tr>
<td>Water</td>
<td>−1.0 (−0.3)</td>
<td>1.4 (0.5)</td>
<td>−2.1 (−0.8)</td>
<td>5.4 (2.2)</td>
</tr>
<tr>
<td>Snow–ice</td>
<td>−2.4 (−1.3)</td>
<td>3.8 (2.1)</td>
<td>−1.7 (−0.9)</td>
<td>6.9 (3.8)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aqua Type</th>
<th>Clear sky</th>
<th>Cloudy sky</th>
<th>Clear sky</th>
<th>Cloudy sky</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bias (W m⁻²) (%)</td>
<td>RMS (W m⁻²) (%)</td>
<td>Bias (W m⁻²) (%)</td>
<td>RMS (W m⁻²) (%)</td>
</tr>
<tr>
<td>Forest</td>
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<td>1.3 (0.5)</td>
<td>−2.5 (−1.1)</td>
<td>6.8 (3.0)</td>
</tr>
<tr>
<td>Grassland</td>
<td>−1.5 (−0.5)</td>
<td>3.3 (1.1)</td>
<td>−2.7 (−1.1)</td>
<td>7.7 (3.2)</td>
</tr>
<tr>
<td>Cropland–urban</td>
<td>−1.1 (−0.4)</td>
<td>1.6 (0.6)</td>
<td>−2.7 (−1.2)</td>
<td>6.9 (3.0)</td>
</tr>
<tr>
<td>Bright desert</td>
<td>−3.4 (−1.1)</td>
<td>4.3 (1.4)</td>
<td>−2.7 (−1.0)</td>
<td>7.5 (2.8)</td>
</tr>
<tr>
<td>Tundra–barren</td>
<td>−1.8 (−0.6)</td>
<td>2.9 (1.0)</td>
<td>−2.7 (−1.1)</td>
<td>9.3 (3.7)</td>
</tr>
<tr>
<td>Water</td>
<td>−0.6 (−0.2)</td>
<td>1.0 (0.3)</td>
<td>−1.6 (−0.6)</td>
<td>4.6 (1.9)</td>
</tr>
<tr>
<td>Snow–ice</td>
<td>−1.4 (−0.8)</td>
<td>3.0 (1.8)</td>
<td>−1.7 (−1.0)</td>
<td>9.2 (5.1)</td>
</tr>
</tbody>
</table>
### CERES vs FLASHFlux SSF TOA Fluxes

**Table 2.** As in Table 1, but for the SW.

<table>
<thead>
<tr>
<th>Terra Type</th>
<th>Clear sky</th>
<th>Cloudy sky</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bias (W m(^{-2})) (%)</td>
<td>RMS (W m(^{-2})) (%)</td>
</tr>
<tr>
<td>Forest</td>
<td>-0.1 (-0.1)</td>
<td>1.7 (1.3)</td>
</tr>
<tr>
<td>Grassland</td>
<td>0.2 (0.1)</td>
<td>1.8 (1.0)</td>
</tr>
<tr>
<td>Cropland–urban</td>
<td>0.1 (0.1)</td>
<td>2.0 (1.3)</td>
</tr>
<tr>
<td>Bright desert</td>
<td>1.1 (0.4)</td>
<td>3.1 (1.0)</td>
</tr>
<tr>
<td>Tundra–barren</td>
<td>0.5 (0.3)</td>
<td>3.1 (1.4)</td>
</tr>
<tr>
<td>Water</td>
<td>-0.5 (-0.6)</td>
<td>2.3 (2.6)</td>
</tr>
<tr>
<td>Snow–ice</td>
<td>0.4 (0.1)</td>
<td>7.3 (2.7)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aqua Type</th>
<th>Clear sky</th>
<th>Cloudy sky</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bias (W m(^{-2})) (%)</td>
<td>RMS (W m(^{-2})) (%)</td>
</tr>
<tr>
<td>Forest</td>
<td>-1.2 (-1.0)</td>
<td>3.9 (3.0)</td>
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<td>Grassland</td>
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<td>Water</td>
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<td>2.8 (3.3)</td>
</tr>
<tr>
<td>Snow–ice</td>
<td>-5.4 (-2.0)</td>
<td>9.0 (3.3)</td>
</tr>
</tbody>
</table>
CERES FLASHFlux: Schematic Mapping to Current Example Uses

**Educational Uses**
- NASA Earth Observatory
- CERES S’COOL

**Scientific Uses**
- CERES Calibration
- Annual “State of Climate” Report
- Field Campaigns
- Mission: CloudSat and Megha-Tropiques

**Applied Science Uses**
- Building Energy Monitoring with RETScreen Performance Plus: NASA CASI team and general worldwide usage
- Agricultural Crop Projections: NASA APIAS, general worldwide usage

**Push subscription**
- CERES FLASHFlux SSF (Lev 2) & TISA (Lev 3) Data Products (ASDC Archive)

**Local Use (DPO)**
- ASDC Order As Needed

**Processed Nightly from DPO**
- POWER Web Portal
  - RETScreen format
  - DSSAT format

5/7/2013
CERES Science Team Meeting