CERES FLASHFlux Status:

Near-Real Time Surface Radiative Fluxes and Meteorology for Research and Applications

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Jason Barnett, Booz-Allen-Hamilton

Tonya Davenport, Lindsay Parker and the Atmospheric Science Data Center Team (SSAI)
FLASHFLUX: Schematic of Current 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

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

**POWER Web Portal** (power.larc.nasa.gov)

Push subscription

Local Use (DPO)

ASDC Order As Needed

Processed Nightly from DPO

**DSSAT format**

**RETScreen format**
FLASHFlux Status

- **Continuing production with v3B (since August 2014)**
  - FLASHFlux SSF available via CERES subsetter and ASDC through 8/28
  - FLASHFlux TISA available from ASDC and specialized formats through POWER web portal (power.larc.nasa.gov) through 8/26
  - TISA netCDF files production continued
  - **Big Issue:** Terra safe mode data drop out from 2/18 – 2/25

- **Version 3B Validation**
  - Processed and compared to latest validation from BSRN, ARM & buoy

- **Flux Anomalies from the 2015-2016 El Nino**
  - “State of Climate 2015” submitted
  - Differences between July 2015 and July 2013

- **Applied Science Usage: Expansion to GIS**
  - Agricultural and Energy usage showed continued growth since May (1100+ users, 400,000+ orders per, 21+ GB per month)
  - First efforts to serve CERES using GIS tools for FLASHFlux and SYN1Deg
FLASHFlux .netCDF Format
(from Panoply – 4/11/16)

US Frontal System
Recent SW Validation: 8/2014 – 1/2016

Version 3B Derived DSF (W m\(^{-2}\))

Ground Measured DSF (W m\(^{-2}\))

Daily Averaged TISA Comparison

<table>
<thead>
<tr>
<th>Ensemble Type</th>
<th>Bias (W m(^{-2}))</th>
<th>RMS (W m(^{-2}))</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Obs</td>
<td>-4.4</td>
<td>34.0</td>
<td>14987</td>
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<tr>
<td>Continental</td>
<td>-2.5</td>
<td>25.7</td>
<td>5525</td>
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<tr>
<td>Coastal</td>
<td>-2.6</td>
<td>23.8</td>
<td>4464</td>
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<tr>
<td>Desert</td>
<td>-3.6</td>
<td>22.2</td>
<td>1518</td>
</tr>
<tr>
<td>High Latitude</td>
<td>-56.6</td>
<td>95.0</td>
<td>892</td>
</tr>
<tr>
<td>Island</td>
<td>2.3</td>
<td>26.5</td>
<td>916</td>
</tr>
<tr>
<td>Buoy</td>
<td>8.2</td>
<td>31.6</td>
<td>1672</td>
</tr>
</tbody>
</table>
Recent LW Validation: 8/2014 –1/2016

Version 3B
201408-201601

All site ensemble

Daily Averaged TISA Comparison

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<thead>
<tr>
<th>Ensemble Type</th>
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<tr>
<td>All Obs</td>
<td>-4.2</td>
<td>15.4</td>
<td>14866</td>
</tr>
<tr>
<td>Continental</td>
<td>-9.4</td>
<td>17.4</td>
<td>5310</td>
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<tr>
<td>Coastal</td>
<td>-1.8</td>
<td>11.8</td>
<td>4468</td>
</tr>
<tr>
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<td>-2.4</td>
<td>15.6</td>
<td>1491</td>
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<tr>
<td>High Latitude</td>
<td>5.8</td>
<td>20.4</td>
<td>1309</td>
</tr>
<tr>
<td>Island</td>
<td>-1.5</td>
<td>9.9</td>
<td>860</td>
</tr>
<tr>
<td>Buoy</td>
<td>-5.0</td>
<td>13.7</td>
<td>1428</td>
</tr>
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</table>

N = 14866
Bias = -4.2 W m⁻²
R.E. = 14.8 W m⁻²
State of Climate 2015: Global TOA Fluxes

Monthly averaged FLASHFlux normalized and appended to EBAF

Annual averaged flux anomalies for 2015, relative to 2014, 2013 and EBAF climatology

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<td>±0.50</td>
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<tr>
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<td>+0.10</td>
<td>±0.20</td>
</tr>
<tr>
<td>RSW</td>
<td>-0.75</td>
<td>-0.45</td>
<td>-0.55</td>
<td>±0.40</td>
</tr>
<tr>
<td>Net</td>
<td>+0.50</td>
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<td>+0.35</td>
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<th>Global-annual Mean Difference (2015 minus 2013) (Wm$^{-2}$)</th>
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<th>2015 Anomaly (relative to climatology) (Wm$^{-2}$)</th>
<th>Interannual variability (2001 to 2014) (Wm$^{-2}$)</th>
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WHOI OAflux Latent & Sensible Heat fluxes + CERES FLASHFlux year-to-year difference for radiative fluxes

Figure 1. (a) The 2015 surface heat flux (Qnet) anomalies relative to the 5-year (2010-2014) mean. Positive (negative) values denote ocean heat gain (loss). (b), (c), and (d) are the 2015-2014 difference anomalies in Qnet, surface radiation (SW+LW, and turbulent heat fluxes (LH + SH), respectively. Positive (negative) anomalies denote that the ocean gains (loses) more heat in 2015 than in 2014. LH+SH are produced by the OAFlux high resolution satellite-based analysis and SW+LW by the NASA FLASHFlux project.
2015 El Nino: 2015 - 2013

global = 1.34022
60–90N = 1.32168
60–90S = -1.25604
20–60N = 1.87749
20–60S = 0.253149
20N–20S = 2.27353

LW Up Surf (Wm⁻²) Diff Mean 2015–2013
2015 El Nino: 2015 - 2013

Cloud Fraction Diff

Mean 2015 - 2013

global = -0.135397
60-90N = 2.06199
20-60N = -0.248374
60-90S = 0.104356
20N-20S = -0.826933
20-60S = 0.257364
Near total SW/LW cancellation over W. Pacific, but strong positive net difference in E. Pacific and up W. coast of US.
At surface, some partial SW/LW cancellation in each region, but SW change appears to dominate; note.
Tropical Surface Net SW Flux Changes

Tropical Pacific SW net

Central Pacific SW net

Eastern Pacific SW net

Western Pacific SW net

Flux (w/m²)

Days


Flux (w/m²)

Days

Flux (w/m²)

Days

Flux (w/m²)

Days
Tropical Surface Net LW Flux Changes

Positive change means LW net is less negative

Tropical Pacific LW net

Central Pacific LW net

Eastern Pacific LW net

Western Pacific LW net
Tropical Surface Total Net Flux Changes

Tropical Pacific Surface Net

Central Pacific Surface Net

Eastern Pacific Surface Net

Western Pacific Surface Net
Using ArcGIS To Enhance Applied Science Usage of Data Products

ASDC Geospatial Portal

Featured Maps and Apps

- 22 Year Averages of Surface Meteorology and Solar
- Daily Averaged Surface Meteorology and Solar
- POWER SSE Web App

The Atmospheric Science Data Center (ASDC) at NASA Langley Research Center is responsible for the processing, archiving, and distribution of NASA Earth science data in the areas of radiation budget, clouds, aerosols, and tropospheric chemistry.

The Data Center was established in 1991 to support the Earth Observing System (EOS) as part of NASA’s Earth Science Global Change Research Program, and is one of several Distributed Active Archive Centers (DAACs) sponsored by NASA’s Earth Observing System Data and Information System (EOSDIS).

GEOPLATFORM.gov

CERES Science Team Meeting
SSE-GIS Beta v1.0.3

- Nearing public release of SSE-GIS
- Provides users an opportunity interact with time series data sets of energy related data sets using web based GIS services from ESRI
- Services are hosted from ASDC servers
- Users can display maps, work with multiple layers, obtain data tables and geotiff files of the parameters
Progress Toward CERES GIS Support

- Published four CERES SYN1DEG ArcGIS Image Services in the development environment. Allows users to 1) access the data via a REST endpoint/protocols, via JSON REST response, 2) utilize online web mapping application development tools via the ArcGIS API for JavaScript, 3) consume the services directly into ArcGIS Desktop and custom applications for further visualization and analysis.

- Data served directly from the CERES SYN1Deg Native NetCDFs:
  - SFC COMP LW DOWN ALL DAILY
  - SFC COMP SW DOWN ALL DAILY
  - SFC COMP SW DOWN CLR DAILY
  - TOA COMP SW DOWN ALL DAILY

- The 2 systems purchased by CERES have had systems software installed and are integrated into the WebRA production environment. Each server has 2 Intel Xeon E5-2643 v3 Processors (20M cache, 3.40 Ghz, 6 cores), 2.4TB of storage, 256 GB RAM (DDR4-2133MHz).

- A process was developed for integrating the machines into the production architecture for dedicated hosting of geospatial web services for CERES data products.

- These systems will be added to the ArcGIS cluster for dedicated hosting of CERES data product geospatial web services.
Progress Toward CERES GIS Support

ArcGIS REST Services Directory

Home > services > cere

JSON | SOAP

Folder: cere

Current Version: 10.4

View Footprints In: ArcGIS Online map viewer

Services:

- cere/arcgis_arcgis_CERES_SYN1degDayEd3A_sfc_comp_lw_down_all_daily (ImageServer)
- cere/arcgis_arcgis_CERES_SYN1degDayEd3A_sfc_comp_sw_down_all_daily (ImageServer)
- cere/arcgis_arcgis_CERES_SYN1degDayEd3A_sfc_comp_sw_down_clr_daily (ImageServer)
- cere/arcgis_arcgis_CERES_SYN1degDayEd3A_toa_comp_sw_down_all_daily (ImageServer)

Supported Interfaces: REST SOAP Sitemap Geo Sitemap
Image Services directly ingested into ArcGIS geospatial software for further analysis and visualization such as time slider visualization.
Future Plans

- Reprocess Terra gap period to evaluate Aqua only fluxes => current FLASHFlux TISA code cannot run without at least some of both Terra and Aqua
- FLASHFlux TISA netCDF to be made compliant => add to CERES subetter
- Meteorological input migration from GEOS 5.9.1 to 5.12.4 => the replacement of FP-IT
- Upgrade CERES Ed 4 underway
- Begin work on NPP FLASHFlux SSF
- Planning for loss of Terra: began strategy to process and use GEO data for FLASHFlux production; will ensure more consistency between FF and TSI
Summary and Conclusions

• **FLASHFlux 3B**
  – Continuing production and validation for v3B; surface site
  – Working to add TISA products to CERES subsetter
  – 2015 El Nino anomalies proving very significant

• **FLASHFlux Applications:**
  – Continued growth of usage of FLASHFlux through POWER project
  – Developing GIS tools for CERES/POWER and with ASDC

• **FLASHFlux publications:**
  – 2015 SotC reports submitted
  – TISA paper next (renewable energy journal?)

• **Future Versions**
  – Must adapt MOA to accept FP-IT (GEOS 5.12.4)
  – Will coordinate with Clouds and Inversion teams to adapt to Ed 4
  – Begin work on NPP SSF production system as new modules arrive
FLASHFlux Web Sites:

http://flashflux.larc.nasa.gov
POWER makes ASCII time series data from FLASHFlux and FP-IT available for:

1) “Sustainable Building” => energy performance modeling
2) “Agroclimatology” => data format according to DSSAT crop modeling format

Average Usage Per Month

<table>
<thead>
<tr>
<th>Type</th>
<th>Monthly Users</th>
<th>Monthly Orders</th>
<th>Monthly Data Vol (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainable Buildings</td>
<td>788</td>
<td>275,600</td>
<td>5.6</td>
</tr>
<tr>
<td>Agroclimatology</td>
<td>405</td>
<td>128,600</td>
<td>15.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1192</strong></td>
<td><strong>404,200</strong></td>
<td><strong>21.3</strong></td>
</tr>
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State of Climate 2014 Results


**Year-to-year global changes 2014 vs. 2013**

<table>
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<th>One year change (2014 minus 2013) (W m⁻²)</th>
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**Global-monthly average flux anomalies**

Fig. 2.34. Time series of global-monthly mean deseasonalized anomalies (W m⁻²) of TOA Earth radiation budget for (top) OLR, (middle) absorbed shortwave (TSI–RSW), and (lower) total net (TSI–RSW–OLR) from Mar 2000 to Dec 2014. Anomalies are relative to the calendar month climatology derived for 2001–13. The time series shows the CERES EBAF Ed2.8 1Deg data (Mar 2000–Oct 2014) in red and the CERES FLASHFlux version 3B data (Nov–Dec 2014) in blue; see text for merging procedure. (Source: CERES EBAF Ed2.8 1Deg and the FLASHFlux version 3B.)
Cloud and Up LW Differences July 2015 - 2013

Cloud

Surface LW UP

FLASHFlux Cloud Fraction
JULY 2015

FLASHFlux Cloud Fraction
JULY 2015–2013

FLASHFlux SFC LW UPWARD
JULY 2015

FLASHFlux SFC LW UPWARD
JULY 2015–2014

4/26/2016
CERES Science Team Meeting
LW Differences July 2015 - 2013

FLASHFlux TOA LW JULY 2015

FLASHFlux TOA LW JULY 2015–2013

FLASHFlux SFC LW DOWNWARD JULY 2015

FLASHFlux SFC LW DOWNWARD JULY 2015–2013
Surface Net Differences July 2015 - 2013

SW Surface Net

LW Surface Net

FLASHFlux SFC SW NET
JULY 2015

FLASHFlux SFC LW NET
JULY 2015

FLASHFlux SFC SW NET
JULY 2015-2013

FLASHFlux SFC LW NET
JULY 2015-2013
Total Net Differences July 2015 - 2013

TOA

FLASHFlux TOA TOTAL NET
JULY 2015

FLASHFlux TOA TOTAL NET
JULY 2015–2013

Surface

FLASHFlux SFC NET TOTAL
JULY 2015

FLASHFlux SFC NET TOTAL
JULY 2015–2013
2015 Tropical Pacific Anomalies to Date
(20N-20S, 120E-100W)

Timeseries of Monthly OLR (Tropics)

Timeseries of Monthly OLR (Tropics Anomalies)

MEI Index
2015 Tropical Pacific Anomalies to Date
(20N-20S, 120E-100W)

Timeseries of Monthly RSW (Tropics)

Timeseries of Monthly RSW (Tropics Anomalies)
Enhancing Applied Science Usage with ArcGIS

**ArcGIS Capabilities**
- High quality viewing (Desktop/Mobile) and printing
- Data Extraction/Subsetting => Python code to support a variety of data formats from ASCII, to .netCDF, to geoTIF
- Simultaneous Dataset Visualization (Swiping)
- Temporal Visualization (time slider)
- Custom Color Ramps
- Pixel/Attribute Value Identification at Selected Location
- Python code to support computation of on-the-fly parameter computation

**Technologies**
- Esri ArcGIS Server & Portal
- OPeNDAP
- PostgreSQL & PostGIS

**Connectivity**
- Climate.gov
- GEOSS (AIP-8)