Use of BSRN data in the validation of NASA's Clouds and the Earth's Radiant Energy System (CERES) EBAF & SYN1deg data products

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- What are CERES and the EBAF & SYN1deg data products?
- How do we validate our products using BSRN data?
- Describe a study determining sensitivity of uncertainty (RMS) to spatial variability of surface sites. (Try to estimate global uncertainties at the surface.)

(All biases are based on Calculation – Observation)
Surface Validation: What are we validating?
Clouds & the Earth’s Radiant Energy System (CERES) (https://ceres.larc.nasa.gov/)

Broadband scanning radiometers
- On NASA TRMM, Terra, Aqua, NOAA Suomi NPP and JPSS1
- Radiance in three broad bands

<table>
<thead>
<tr>
<th>Channel</th>
<th>Wavelengths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shortwave</td>
<td>0.2 - 5 μm</td>
</tr>
<tr>
<td>Total</td>
<td>0.2 – 100 μm</td>
</tr>
<tr>
<td>Window</td>
<td>~8 - 12 μm</td>
</tr>
<tr>
<td>Longwave</td>
<td>Total - Shortwave</td>
</tr>
</tbody>
</table>

- Radiance is converted to irradiance using scene dependent Anisotropic Directional Models (ADMs)
- A CERES ‘footprint’ is approximately 30km at the surface for instrument nadir.
SYN1Deg

TOA CERES Observations &
Column Fluxes from Radiative Transfer Calculations

- Global; Gridded (1° x 1°); Hourly (Monthly)
- Upward & Downward irradiances provided at:
- 6 Levels (TOA, 70, 200, 500, 850 hPa and Earth’s surface)

SW Surface Down (Daily Avg)

LW Surface Down (Daily Avg)

- Clouds: Terra/Aqua MODIS Imagers, Geostationary imagers
- Atmosphere (P, T, q): GMAO GEOS5.4.1
- Aerosol: MODIS AOD assimilated by MATCH Chemical Trans Model
  - Langley Fu & Liou Radiative Transfer Model
EBAF TOA; EBAF-Surface
Provides TOA Observations & Surface RT Calculations

- Global; Gridded (1° x 1°); Monthly Mean
- Upward & Downward irradiances at:
- 2 Levels (TOA, Earth’s surface)

SW Surface Down (Monthly Avg)

LW Surface Down (Monthly Avg)

- TOA Observed CERES: “Balanced” by Ocean Heat storage
- “Filled” Clear sky by converting MODIS narrowband to broadband
- Surface irradiance is matched to TOA to balance over time
BSRN provides the backbone of our results.

- Key - established calibration requirements.
Surface Validation: Web-Tool

SYN1Deg

https://ceres-tool.larc.nasa.gov/cave/jsp/CAVE4Selection.jsp

EBAF-Surface

https://ceres-tool.larc.nasa.gov/cave/jsp/CAVEEBAF4Selection.jsp
Site Selection

Surface Site Description Page

PSU - Penn State, PA, USA (40.72, 282.07)
BOS - Boulder, CO USA (SURFRAD) (40.13, 254.76)
BOU - Boulder Tower, CO, USA (BSRN) (40.05, 254.99)
BON - Bondville, IL, USA (40.05, 271.63)
XIA - Xianghe, China (39.98, 116.38)
E09 - Ashton, Kansas, USA (37.13, 262.73)
CLH - Chesapeake Lighthouse, VA, USA (36.90, 284.29)
E11 - Byron, Oklahoma, USA (36.88, 261.72)
E12 - Pawhuska, Oklahoma, USA (36.84, 263.57)
COR - Desert Rock, NV, USA (36.62, 243.99)

Click icons on map to select/unselect individual stations or select ranges below.
CERES Validation

March - 2000 to February - 2016 (monthly)
Parameters

- TOA Fluxes
- Shortwave Global Flux Down
- Shortwave Global Flux Up
- Shortwave Direct Horizontal Flux
- Surface Fluxes
- Shortwave Diffuse Flux Down
- Total Shortwave Flux Down
- Longwave Global Flux Down
- Longwave Global Flux Up
- Auxiliary Data

Plot Type

- Time Series
- Scatter Plots

Temporal Resolution

- Monthly
- Daily
- 3-Hourly
- Hourly (Time Series only)

Time Range


From: 01 - 2005 (MM-YYYY) To: 01 - 2005 (MM-YYYY)

Email Address

david.a.rutan@nasa.gov

By providing your email address you will be informed of any future revisions of your download, product release, or related products.

Visualize Data | Get Data | Add to Cart

(for orders less than 2 GB) (registration required)
CERES Validation

Select a Date: Jan 2005

Parameter

January - 2005 (hourly)

BON (40.05, 27.63)
Bondville, IL, USA
Sc Longwave Flux Down (W m⁻²)

01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
150 200 250 300 350 400
A Note on Data Citation:

Surface Observed Fluxes

Surface observations from around the globe are collected here and made available as 1 hourly, 3 hourly, daily, and monthly averages. Original data sources and some site specific information, along with links to original data providers, can be found at the [CAVE web site](https://www.cave.larc.nasa.gov).

Product Attribution:
Many scientists around the globe work hard to provide reliable time series of observed surface fluxes. For a complete description of how to cite these data if used in a juried publication go to the [CAVE Reference page](https://www.cave.larc.nasa.gov).

Min Availability Filter (%):
Data contained in CAVE are there because of the hard labor of people maintaining instruments in difficult locations throughout the world. Therefore, if you use data contained in the CAVE data base in refereed journal articles please reference all original data sources used according to the following list.

Full policies of each agency are listed at the bottom of this page. One need only reference those data sets used:

- **DOE ARM Data:** (Acknowledgement)

  ARM data is made available through the U.S. Department of Energy as part of the Atmospheric Radiation Measurement Program.

- **NOAA Global Monitoring Division, SURFRAD, and Global Baseline Sites (GMD):** (Acknowledgement)

  These data are made available through the NOAA’s Earth System Research Laboratory/Global Monitoring Division - Radiation (G-RAD)

  Include for NOAA SURFRAD Data (Reference):


- **BSRN Data:** (Reference)


- **NREL SSV Data:** (Reference)


- **LaRC COVE Data:** (Reference)


- **WHOI PACS Data:** (Reference)


- **CERES SYN1Deg:** (Reference)

Surface Validation: Results
Longwave Surface Irradiance Down (SYN1Deg Ed4) (2000/02 - 2016/12)

Hourly

Land

Buoy

Monthly

Land

Buoy

y-Mean 319
x-Mean 318
Bias(y-x) 1
RMS 23
N 3849790

y-Mean 399
x-Mean 395
Bias(y-x) 3
RMS 22
N 768975

y-Mean 319
x-Mean 317
Bias(y-x) 1
RMS 10
N 5125

y-Mean 399
x-Mean 395
Bias(y-x) 3
RMS 11
N 1022

Langley Research Center Science Directorate

15th BSRN Workshop – 16-20, July 2018, Boulder, CO
Shortwave Surface Irradiance Down (SYN1Deg Ed4) (2000/02 - 2016/12)

Hourly

Monthly

Langley Research Center Science Directorate

15th BSRN Workshop – 16-20, July 2018, Boulder, CO
Surface Irradiance Down (EBAF-Surface Ed4)  
Land Sites (2000/02 - 2016/12)
A Word (?) About Buoys

SW Surface Bias (EBAF-Obs)

Foltz et al. (2013) established these errors due to dust accumulation on radiometers.

“B” in BSRN is:
Baseline: a specific value or values that can serve as a comparison or control.

Can BSRN establish a quality baseline for buoys?
Surface Validation: Spatial Uncertainty Analysis

(Not spatial representativeness in a grid box; but how does uncertainty change as we aggregate groups of sites over large areas?)
Calculate RMS over larger and larger groups of sites; randomly selecting groups 100 times.

Do land and buoy sites separately.

\[
F_{il(c) \text{om};o}(K) = \frac{1}{K} \sum_{1}^{K} F_{ilk}
\]

\[
\Delta F_{il}(K) = \Delta F_{il(calc)}(K) - \Delta F_{il(obs)}(K)
\]

\[
F_{x, \text{RMS}}(K) = \left[ \frac{1}{N} \sum_{i}^{N} \frac{1}{L} \sum_{l}^{L} [\Delta F_{il}(K)]^{2} \right]^{1/2}
\]

(\(x = 100\) realizations)

Total Sites = 36

When \(K = 4\) (# of sites per group)

Then \(L = 9\) (# of groups)

\(N = \# \text{ of months}\)

Replicate 100 Times (no Duplication)
Plot RMS as a function of increasing group size.

\[ \overline{F_{x,RMS}(K)}^2 = \Delta F_{x,bias}^2 + \frac{\Delta F_{x,random}^2}{K} \]

<table>
<thead>
<tr>
<th></th>
<th>Land (Wm(^{-2}))</th>
<th>Buoy (Wm(^{-2}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shortwave</td>
<td>Longwave</td>
</tr>
<tr>
<td>( \Delta F_{x,bias} )</td>
<td>3.2</td>
<td>3.1</td>
</tr>
<tr>
<td>( \Delta F_{x,random} )</td>
<td>9.6</td>
<td>7.9</td>
</tr>
</tbody>
</table>
Summary

- CERES EBAF & SYN1Deg along with surface observation can still be accessed at:
  
  https://ceres-tool.larc.nasa.gov/ord-tool

- BSRN data serves as the base upon which most of our validation and uncertainty analysis rests.

- It would be beneficial to have a baseline criteria for use of buoy data in validation processes.

- Uncertainty due to spatial variability in our surface validation sites shows:
  - Decrease is rapid for the land indicates higher spatial variability for these sites
  - Slower over ocean buoys:
    - Sites are primarily in tropics, less spatial variability in general
    - Fewer site with continuous time series adds to less reliable relationship.
Publications Using BSRN data


Thank all the site scientists and staff for all the hard work!