Surface–Only Flux Algorithms Working Group Report

David P. Kratz\textsuperscript{1}, Shashi K. Gupta\textsuperscript{2},
Anne C. Wilber\textsuperscript{2}, Victor E. Sothcott\textsuperscript{2}

\textsuperscript{1}NASA Langley Research Center
\textsuperscript{2}Science Systems and Applications, Inc.

Twenty Eighth CERES–II Science Team Meeting
Goddard Space Flight Center
Greenbelt, Maryland
September 26–28, 2017
Algorithm Background

CERES uses several Surface–Only Flux Algorithms (SOFA) to compute SW and LW surface fluxes in addition to the more precise model used by SARB. The SOFA algorithms include:

<table>
<thead>
<tr>
<th></th>
<th>Model A</th>
<th>Model B</th>
<th>Model C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SW</strong></td>
<td>Clear Li et al.</td>
<td>LPSA</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>All-Sky --</td>
<td>LPSA</td>
<td>--</td>
</tr>
<tr>
<td><strong>LW</strong></td>
<td>Clear Inamdar and Ramanathan</td>
<td>LPLA</td>
<td>Zhou-Cess</td>
</tr>
<tr>
<td></td>
<td>All-Sky --</td>
<td>LPLA</td>
<td>Zhou-Cess</td>
</tr>
</tbody>
</table>

SOFA References:

- **SW A**: Li et al. (1993): *J. Climate*, 6, 1764-1772.
**Edition 4 Improvements to the Surface-Only Flux Algorithms**

**SW Model Improvements:**
1) Replacing the ERBE albedo maps with the Terra maps greatly improved the SW retrievals, most notably for polar regions.
2) Replacing the original WCP-55 aerosols properties with monthly MATCH/OPAC datasets while also replacing the original Rayleigh molecular scattering formulation with the Bodhaine et al., (1999) model significantly improved SW surface fluxes for clear conditions.
3) To account for the short term aerosol variability we have incorporated daily MATCH aerosol data into Edition 4A.
4) Using a revised empirical coefficient in the cloud transmission formula improved the SW surface fluxes for partly cloudy conditions.

**LW Model Improvements:**
1) Constraining the lapse rate to 10K/100hPa (roughly the dry adiabatic lapse rate) improved the derivation of surface fluxes for conditions involving surface temperatures that greatly exceeded the overlying air temperatures, see Gupta et al. (2010).
2) Limiting the inversion strength to −10K/100hPa for the downward flux retrievals provided the best results for cases involving surface temperatures that were much below the overlying air temperatures (strong inversions).

---

**Parameterized models for fast computation of surface fluxes for both CERES and FLASHFlux**

<table>
<thead>
<tr>
<th>Dataset</th>
<th>CERES 2B</th>
<th>CERES 4A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear-Sky TOA albedo Terra</td>
<td>48 month ERBE</td>
<td>70 month Terra</td>
</tr>
<tr>
<td>Clear-Sky TOA albedo Aqua</td>
<td>46 month Terra</td>
<td>70 month Terra</td>
</tr>
<tr>
<td>Clear-Sky Surf. albedo</td>
<td>46 month Terra</td>
<td>70 month Terra</td>
</tr>
<tr>
<td>TOA to Surface albedo transfer</td>
<td>Instantaneous</td>
<td>Monthly average</td>
</tr>
<tr>
<td>Cos (sza) dependence of Surface Flux</td>
<td>LPSA</td>
<td>Briegleb-type</td>
</tr>
<tr>
<td>Cloud Algorithm Terra</td>
<td>Terra Ed2</td>
<td>Terra/Aqua Ed4</td>
</tr>
<tr>
<td>Cloud Algorithm Aqua</td>
<td>Aqua Ed2</td>
<td>Terra/Aqua Ed4</td>
</tr>
<tr>
<td>SW aerosol dataset</td>
<td>WCP-55</td>
<td>MATCH/OPAC</td>
</tr>
<tr>
<td>Rayleigh Treatment</td>
<td>Original LPSA</td>
<td>Bodhaine et al (1999), JAOT,</td>
</tr>
<tr>
<td>Ozone Range Check</td>
<td>0 to 500 DU</td>
<td>0 to 800 DU</td>
</tr>
<tr>
<td>Twilight cutoff</td>
<td></td>
<td>New</td>
</tr>
<tr>
<td>Cloud transmission empirical coefficient</td>
<td>0.80</td>
<td>0.75</td>
</tr>
<tr>
<td>LW high temperature surface correction</td>
<td>No</td>
<td>Maximum Lapse Rate 10K/100hPa</td>
</tr>
<tr>
<td>LW Inversion correction</td>
<td>No</td>
<td>Maximum Inversion Strength -10K/100hPa</td>
</tr>
</tbody>
</table>

---

Climate Science Branch, NASA Langley Research Center
Validation of Surface Flux Algorithms

Improve, validate and maintain the CERES Edition 4A Surface–Only Flux Algorithms (SOFA) using the MODIS Collection 5 Imager Data
Surface Sites Available for Validation of Terra & Aqua Ed4A, and NPP Ed1A
CERES Terra Edition 4A LW Ground Validation (Global)

Clear–Sky


Climate Science Branch, NASA Langley Research Center
CERES Terra Edition 4A LW Ground Validation (Global)

All–Sky

CERES Aqua Edition 4A LW Ground Validation (Global)

Clear–Sky

Combined LW Ground Validation for Aqua (7/2002 through 2/2017).

Climate Science Branch, NASA Langley Research Center
Combined LW Ground Validation for Aqua (7/2002 through 2/2017).
CERES NPP Edition 1A LW Ground Validation (Global)
Clear–Sky

Combined LW Ground Validation for NPP (1/2012 through 3/2017).

Climate Science Branch, NASA Langley Research Center
CERES NPP Edition 1A LW Ground Validation (Global)  

All–Sky

Combined LW Ground Validation for NPP (1/2012 through 3/2017).
LW Surface Flux Results

The Terra, Aqua and NPP LW fluxes derived for Clear-Sky conditions show biases $\approx -4$ to $+8$ W/m$^2$ and uncertainties $\approx 12$ to 15 W/m$^2$.

The Terra, Aqua and NPP LW fluxes derived for All-Sky conditions show biases $\approx \pm 3$ W/m$^2$ and uncertainties $\approx 21$ to 23 W/m$^2$. 
CERES Terra Edition 4A SW Ground Validation (Global)
Clear−Sky

CERES Terra Edition 4A SW Ground Validation (Global)  
All-Sky

CERES Aqua Edition 4A SW Ground Validation (Global)

Clear-Sky

Combined SW Ground Validation for Aqua (7/2002 through 2/2017).
CERES Aqua Edition 4A SW Ground Validation (Global)

All–Sky

SWB

SWB Ground Validation for Aqua (7/2002 through 2/2017).

N = 115796
Bias = -3.6 W m\(^{-2}\)
R.E. = 91.8 W m\(^{-2}\)

Climate Science Branch, NASA Langley Research Center
CERES NPP Edition 1A SW Ground Validation (Global)
Clear–Sky

Combined SW Ground Validation for NPP (1/2012 through 3/2017).

Climate Science Branch, NASA Langley Research Center
CERES NPP Edition 1A SW Ground Validation (Global) All–Sky

SWB Ground Validation for NPP (1/2012 through 3/2017).

Climate Science Branch, NASA Langley Research Center
The Terra, Aqua and NPP SW fluxes derived for Clear-Sky conditions show biases $\approx -17$ to $-5$ W/m$^2$ and uncertainties $\approx 25$ to 40 W/m$^2$.

The Terra, Aqua and NPP SW fluxes derived for All-Sky conditions show biases $\approx -8$ to $-4$ W/m$^2$ and uncertainties $\approx 90$ W/m$^2$.

Our current effort is focused on finding methods to reduce the large uncertainties in the retrieved SW Cloudy Sky surface fluxes.
Conclusions for SOFA Ed4A algorithms

Validation studies have demonstrated that revisions to both the LW algorithms and the SW algorithms are working well, though further revisions to the cloud transmission method are underway to improve SW Model B.

An analysis of the LW and SW surface only flux algorithm results using the Edition 4A inputs, especially those from the Clouds Subsystem, has improved accuracies for most locations.

The Terra, Aqua and NPP flux retrievals show good agreement with the ground–based measurements.
MODIS Collections 5, 6 and 6.1 (future)

• For CERES Edition 4, which covered the timeframe from March 2000 through February 2017, MODIS Collection 5 was used for the imager data.

• For March 2017 forward, MODIS Collection 5 was no longer available, thus the need to upgrade to MODIS Collection 6.

• Uncompensated Crosstalk within the MODIS Water Vapor Channels 27, 28 & 29 on Terra produced spurious results for MODIS Collection 6, and thus, the need to upgrade to MODIS Collection 6.1 once that dataset becomes available.

• MATCH aerosols have also been improved significantly.
Difference between **Nighttime Cloud Fraction**; Terra MODIS Collection 6 minus Terra MODIS Collection 5
Comparison of Terra Longwave Surface Fluxes; MODIS Collection 6 minus MODIS Collection 5
Comparison of **Aerosol Optical Depths** using MATCH Aerosols from MODIS Collection 6 to MATCH Aerosols from MODIS Collection 5

Climate Science Branch, NASA Langley Research Center
Comparison of **Surface Shortwave Fluxes**
MODIS Collection 6 minus MODIS Collection 5

```
global = -1.91734  
60–90N = -0.17118  
60–90S = 0.023369  
20N–20S = -4.4085  
20–60N = -1.38386  
20–60S = -0.0816185
```

Aqua Ed4A MOD 06–05  
SWB Surface  
15 JAN 2017

---

Climate Science Branch, NASA Langley Research Center
Status of TSI composite data from WRC, SORCE(V15) and RMIB for the Timeframe of CERES Terra, Aqua & NPP

For CERES Ed 4A, all TSI data are offset to match SORCE TSI Version 15
Impact of 8/21/2017 Total Solar Eclipse on CERES data

17:15 UT  (11:15 CDT)
17:45 UT  (11:45 CDT)
18:15 UT  (12:15 CDT)
18:15 UT  (12:45 CDT)

See: http://cimss.ssec.wisc.edu/goes/blog/wp-content/uploads/2017/08/170821_g16_vegetation_b3_conus_anim.gif
Continental United States (CONUS) Sites Available for Validation of Terra & Aqua Ed4A, and NPP Ed1A
Data from ARM SGP MFRSRs showing the reduction in direct normal broadband radiation during the solar eclipse of 8/21/2017

Maximum eclipse was 89% at the SGP Central Facility in Lamont, OK

Image from ARM Facility News, September, 2017