Status of the Edition 4β Surface-Only Flux Algorithms

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\textsuperscript{2}Science Systems and Applications, Inc.

Nineteenth CERES-II Science Team Meeting

Hampton, Virginia
7 May 2013
CERES uses several surface-only flux algorithms to compute SW and LW surface fluxes in conjunction with the detailed model used by SARB. These algorithms include:

**LPSA/LPLA:**

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<th>Model A</th>
<th>Model B</th>
<th>Model C</th>
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<td>SW</td>
<td>Clear</td>
<td>Li et al.</td>
<td>LPSA</td>
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<td>All-Sky</td>
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<td>LPSA</td>
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<tr>
<td>LW</td>
<td>Clear</td>
<td>Inamdar and Ramanathan</td>
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References:

  
Background (Page 2)

- The SOFA LW & SW Models are based on rapid, highly parameterized TOA-to-surface transfer algorithms to derive surface fluxes.

- LW Models A & B as well as SW Model A were incorporated at the start of the CERES project.

- SW Model B was adapted for use in the CERES processing shortly before the launch of TRMM.

- The Edition 2B LW & SW surface flux results underwent extensive validation (See: Kratz et al. 2010).

- The ongoing validation process has already led to improvements to the LW models (Gupta et al., 2010).

- LW Model C has been introduced in Edition 4 processing to maintain two independent LW algorithms after the CERES Window Channel is replaced in future versions of the CERES instrument.
Recent Improvements to the Surface-Only Flux Algorithms

**SW Model Improvements:**
1) Replacing the ERBE albedo maps with 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 4.
4) Using a revised empirical coefficient in the cloud transmission formula has improved the SW surface fluxes for partly cloudy conditions.
5) Work continues on the improvement of the cloud transmission method for the new Edition 4 clouds.

**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).

**SW and LW Model Improvements:**
1) The availability of ocean buoy measurements is expected to allow for improved surface flux retrievals by providing validation over ocean regions.

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

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<td>Monthly average</td>
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<td>Terra/Aqua Ed4</td>
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Status of Edition 4β LW Models A, B and C

Effect of Temperature Constraints on the calculation of downward LW fluxes for cases involving super-adiabatic lapse rates and extreme temperature inversions.
Daytime and Nighttime Surface Temperatures
[MOA (SSF-59)] Terra Edition 4β 7/1/2002

Climate Science Branch, NASA Langley Research Center
Monthly mean (solid line) atmospheric temperature profiles from 2 m above surface to 30 km above MSL over the South Pole (The dashed lines show the 10\textsuperscript{th} and 90\textsuperscript{th} percentiles of temperature at each height). Figure adopted from Hudson and Brandt (2005), \textit{J. Climate}, \textbf{18}, 1673-1696.
Comparison of input temperatures in SOFA LW Models for calculating downward LW fluxes to the surface

- $T_s$ (MOA SSF-59) versus $T_s$ (Constrained MOA SSF-59b)
- $T_s$ (MOA (SSF-59)) versus $T_s$ (CWG SSF-79)
- $T_s$ (Constrained MOA SSF-59b) versus $T_s$ (Constrained CWG No SSF#)

Climate Science Branch, NASA Langley Research Center
Daytime and Nighttime Surface Temperatures
[MOA (SSF-59)] Terra Edition 4β 7/1/2002

July 1, 2002

MOA Surface Temperatures

Climate Science Branch, NASA Langley Research Center
Daytime and Nighttime Surface Temperatures
[Constrained MOA (SSF-59b)] Terra Edition 4β 7/1/2002

July 1, 2002

Constrained MOA Surface Temperatures

Climate Science Branch, NASA Langley Research Center
Difference in Daytime and Nighttime Surface Temperatures
[Constrained MOA (SSF-59b) minus MOA(SSF-59)]
Terra Edition 4β 7/1/2002

Differences off the eastern coasts of S.A. & Africa are associated with Ocean Currents
Daytime and Nighttime Surface Temperatures
[CWG (SSF-79)] Terra Edition 4β 7/1/2002

July 1, 2002

MOA Surface Temperatures

Climate Science Branch, NASA Langley Research Center
Difference in Daytime and Nighttime Surface Temperatures
[CWG (SSF-79) minus MOA(SSF-59)]
Terra Edition 4β 7/1/2002
Daytime and Nighttime Surface Temperatures
[Constrained MOA (SSF-59b)] Terra Edition 4β 7/1/2002
Difference in Daytime and Nighttime Surface Temperatures
[Constrained CWG minus Constrained MOA(SSF-59b)]
Terra Edition 4β 7/1/2002

July 1, 2002

Climate Science Branch, NASA Langley Research Center
Surface Sites Available for Validation of Ed 4\(\beta\)

- 48.31N, 105.10W Fort Peck, MT
- 40.72N, 77.93W Penn State, PA
- 40.05N, 88.37W Bondville, IL
- 34.25N, 89.87W Goodwin Creek, MS
- 36.60N, 97.48W SGP ARM
- 45.03S, 169.7E New Zealand
- 44.81N, 5.1E Carpentras, FR
- 46.82N, 6.9W Payene, Switzerland
- 52.22N, 14.1W Lindenberg, Germany
- 32.30N, 64.77W Bermuda
- 8.72N, 167.72E Kwajalein
- 2.06S, 147.42E Manus
- 0.52S, 166.9 E, Nauru
- 36.05N, 140.13E Tatano
- 36.9N, 75.71W Ches Light
- 60.13N, 1.2E Lerwick, UK
- 71.33N, 156.61W Barrow, AK
- 90.00S, 0.00 South Pole
- 69.00S, 39.58E Syowa
- 70.65S, 8.25W Georg von Neumayer
- 78.9N, 11.95E Ny Alesund
- 23.70S, 133.87E Alice Springs
- 22.78N, 5.52E Algeria
- 24.91N, 46.4E Saudi Solar Village
- 30.67S, 24.0W, De Aar

Climate Science Branch, NASA Langley Research Center
LWA ($T_{s,\text{con}}$ MOA) & ($T_{s,\text{con}}$ CWG) versus Ground Truth

LWA Ts MOA vs Ground

LWA Ts CWG vs Ground

N = 136
Bias = -7.7 W m$^{-2}$
$\sigma = 16.5$ W m$^{-2}$

N = 136
Bias = -7.4 W m$^{-2}$
$\sigma = 16.7$ W m$^{-2}$

Constrained Near-Surface Air Temperatures

Climate Science Branch, NASA Langley Research Center
LWB ($T_{s,\text{con}}$ MOA) & ($T_{s,\text{con}}$ CWG) versus Ground Truth

**LWB $T_s$ MOA vs Ground**

- $N = 1297$
- Bias = 2.2 W m$^{-2}$
- $\sigma = 21.0$ W m$^{-2}$

**LWB $T_s$ CWG vs Ground**

- $N = 1297$
- Bias = 0.8 W m$^{-2}$
- $\sigma = 21.0$ W m$^{-2}$

Constrained Near-Surface Air Temperatures

Climate Science Branch, NASA Langley Research Center
LWC ($T_{s,\text{con}}$ MOA) & ($T_{s,\text{con}}$ CWG) versus Ground Truth

LWC $T_s$ MOA vs Ground

- $N = 1291$
- Bias = -0.1 W m$^{-2}$
- $\sigma = 21.5$ W m$^{-2}$

LWC $T_s$ CWG vs Ground

- $N = 1291$
- Bias = -1.3 W m$^{-2}$
- $\sigma = 21.4$ W m$^{-2}$

Constrained Near-Surface Air Temperatures

Climate Science Branch, NASA Langley Research Center
Difference in Daytime and Nighttime Cloud Base Pressure
Terra Edition 4β2 minus Terra Edition 4β1 7/1/2002

July 1, 2002

MOA Surface Temperatures

Climate Science Branch, NASA Langley Research Center
Difference in Daytime and Nighttime Cloud Fractions
Terra Edition 4β2 minus Terra Edition 4β1 7/1/2002

July 1, 2002

Climate Science Branch, NASA Langley Research Center
Results of Recent LW Model Improvements

The CWG skin temperatures have a significantly greater dynamic range than the MOA surface temperatures. The use of the CWG skin temperatures will, therefore, tend to have a wider range of fluxes at the surface. Constraining the CWG and MOA surface temperatures using the SOFA methods, however, tends to yield comparable results.

For the condition involving surface temperatures that greatly exceed the overlying air temperatures, constraining the lapse rate to 10K / 100hPa (roughly the dry adiabatic lapse rate) has significantly improved the results for both MOA and CWG $T_S$, see Gupta et al. (2010).

For conditions involving surface temperatures that are much below the overlying air temperatures (strong inversions), limiting the inversion to a maximum of 10K / 100hPa for the downward flux calculations provides the best results for all conditions for both MOA and CWG $T_S$.

Edition 4β inputs into the LW model are providing the expected results.
Simultaneously replacing the original WCP-55 aerosols with the MATCH aerosols, and the original Rayleigh molecular scattering formulation with an improved Rayleigh molecular scattering formulation has significantly improved the surface SW flux calculations for clear through partly cloudy sky conditions.

To account for the short term variability of aerosol properties, we have incorporated the daily aerosol properties into SW Model B.

Results for the mostly cloudy to overcast conditions showed some improvement by revising the $a_0$ coefficient but strongly suggest that further work on the cloud transmittance calculation is necessary. Our attention is currently focused on developing a lookup table method to account for the cloud transmittance.
Cloud Transmission as a Function of Total Cloud Cover Percent (Tccp); range of Total Cloud Optical Depth (Tcod) is 0 to > 50
Cloud Transmission as a Function of Total Cloud Optical Depth (Tcod); range of Total Cloud Cover Percent (Tccp) is 0 to 100
Lookup table to compute the SW Cloud Transmission as a function of total cloud optical depth (Tcod) and total cloud cover percent (Tccp)

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Results of Recent SW Model Development
(Course of Action for the Future)

The present look-up table was developed using parameters using daily averaged, SYN 1°x1° gridded data for the year 2004.

These parameters include: 1) All-Sky Surface SW Fluxes, 2) Clear-Sky Surface SW Fluxes, 3) Total Cloud Amounts, and 4) Total Cloud Optical Depths.

An underestimation of the surface fluxes were realized when cloud transmission values derived from this daily-gridded data were applied to the instantaneous footprint level computation.

The reasons of this underestimation are under investigation.
Conclusions for SOFA Ed4β algorithms

Validation studies have shown that revisions to both the LW algorithms and the SW algorithms (for clear to partly cloudy conditions) appear to be working well, though further revisions to the cloud transmission method and/or overcast albedo method are needed for SW Model B.

A preliminary analysis of the LW and SW surface only flux algorithm results using the Edition 4β inputs, especially those from the Clouds Subsystem, indicate improved accuracies for most locations.
CERES Journal Publication Citations

For all publications whether funded by CERES or using CERES data, please include the word “CERES” in the keyword list as this will facilitate listing your publication in the CERES formal publication web-page list (http://ceres.larc.nasa.gov/docs.php).

When any paper, technical report, or book chapter has either been accepted for publication or been published, please notify the CERES group of this publication by contacting Anne Wilber at (anne.c.wilber@nasa.gov).
### CERES Journal Publication Citation Values (1/1/2013)

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Citation c₁ = # of citations for papers published in that year.

Citation c₂ = # of citations in ISI for papers published in all years using a specified set of categories.

Citation c₃ = renormalized # of citations for papers published in all years so that the total number of citations in c₃ = c₁
Backup Slide showing Ocean Currents:
Explains surface flux differences observed in slide 12 off the Eastern coasts of South America & Africa.

http://www.physicalgeography.net/fundamentals/8q_1.html