CERES Surface-Only Algorithm Studies: Constraining Overestimation of Downward Longwave Flux (DLF) in Simple Surface Flux Models

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Background

• CERES uses several simple surface flux models for computing SW and LW surface fluxes in addition to the detailed model used by SARB. This presentation is on simple LW models.

• Two LW models are in use from the beginning. A third brought in recently and tested offline; to be used in Edition-3 processing. These models are designated as: A, B, and C.

• Validation of SSF fluxes provided many insights and revealed some flaws. Present work is an attempt at mid-course adjustment based on what we have learned.

• All three models overestimate DLF for some footprints at the high end of DLF range.
Overestimation of DLF Over Desert Regions
Overestimation of DLF Over Desert Regions
All-Sky (Aqua-2A; July 2002 - March 2005)
Plan and Hypothesis

• Determine the cause, develop a remedy, and test it for Model B. Apply the same or similar remedy to Models A and C.

What in the model could be causing it?

• Effective Emitting Temperature:
  \[ T_{\text{eff}} = 0.60 \, T_s + 0.35 \, T_1 + 0.05 \, T_2 \]
  \( T_s \) - Surface skin temperature
  \( T_1 \) - Average temperature for Sfc. - 800 mb layer
  \( T_2 \) - Average temperature for 800 - 680 mb layer

• Works well when \( T_s, T_1, \) and \( T_2 \) conform to nominal lapse rates.

• When \( T_s >> T_1 \) (and \( T_2 \)), it results in overestimation of DLF.
Hypothesis (contd.)

Where on Earth could this be happening?

• Mostly over dry/arid regions during hot times of the day.

Methodology

• Selected two sites for study:

  Alice Springs, Australia - Dry/Arid
  Goodwin Creek, MS (USA) - Moderate/Humid

• Performed flux computations using a stand-alone version of the model on a 3-hourly time resolution for all months of 2000.

• Compared model-derived DLF with ground-based observations for the above sites obtained from BSRN.
Model-Derived vs. Ground-Measured (BSRN) DLF
(Current version of the model)

Alice Springs

Significant overestimation over Alice Springs; almost none over Goodwin Creek

Goodwin Creek

N = 2587
Mean X = 343.9
Mean Y = 354.7
Mean Bias = 10.8
Random Error = 30.4

N = 2900
Mean X = 347.3
Mean Y = 348.6
Mean Bias = 1.3
Random Error = 26.8
Severe overestimation during DJF; slight underestimation during JJA
Further Analysis of Alice Springs Overestimation

• Points with overestimation of > 100 Wm$^{-2}$
  
  32 points during the year (16 in Jan; 20 in DJF)
  
  Mean = 120 Wm$^{-2}$; Range: 100-160 Wm$^{-2}$
  
  $T_s$: Mean = 324.3 K; Range: 302-336 K
  
  $P_s$: Mean = 939 mb; Range: 935-946 mb
  
  $T_{800}$: Mean = 292.1 K; Range: 284.7-297.7 K
  
  $T_s - T_{800}$: Mean = 32.2 K; Range: 17.0-40.3 K

• $T_s - T_{800}$ should be about 10 K, but no more than 15 K

• Decided that lapse rates > 10K/100mb in the lower layer are too steep, and need to be adjusted.

• Adjusted skin temperature to not exceed 10K/100mb limit.
Results From the Modified Computation

Alice Springs

- N = 2587
- Mean X = 343.9
- Mean Y = 345.3
- Mean Bias = 1.4
- Random Error = 24.2

Goodwin Creek

- N = 2900
- Mean X = 347.3
- Mean Y = 346.7
- Mean Bias = -0.6
- Random Error = 25.8

Bias for Alice Springs - reduced greatly; Change for Goodwin Creek - minimal
CERES Model-B Computation With Modified Scheme  
(Aqua All-Sky Results: Jul 2002 and Jan 2004)

<table>
<thead>
<tr>
<th>Method</th>
<th>N</th>
<th>Mean X</th>
<th>Mean Y</th>
<th>Mean Bias</th>
<th>Random Error</th>
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<tbody>
<tr>
<td>Current</td>
<td>1877</td>
<td>297.0</td>
<td>294.4</td>
<td>-2.6</td>
<td>25.1</td>
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<tr>
<td>Modified</td>
<td>1877</td>
<td>297.0</td>
<td>292.0</td>
<td>-5.0</td>
<td>23.2</td>
</tr>
</tbody>
</table>
CERES Model-C Computation With Modified Scheme
(Aqua All-Sky Results: Jul 2002 and Jan 2004)

**Current**

- \( N = 1864 \)
- Mean X = 295.8
- Mean Y = 296.2
- Mean Bias = 0.4
- Random Error = 23.9

**Modified**

- \( N = 1864 \)
- Mean X = 295.8
- Mean Y = 288.6
- Mean Bias = -7.2
- Random Error = 21.4
Monthly Temperature Adjustment and Frequency

Temperature Adjustment - January

Adjustment Frequency - January

Temperature Adjustment - July

Adjustment Frequency - July

Climate Science Branch, NASA Langley Research Center
Summary

• Determined the cause of DLF overestimation: Occurs when skin temperature ($T_s$) is much higher than atmospheric temperatures.

• Developed a method for detecting this condition and constraining $T_s$ prior to using it in DLF computation. Constrained $T_s$ is not used for upward flux computation.

• Tested the method with Model-B for all months of 2000 using the stand-alone version and for two months using the CERES version.

• Applied the same method to CERES version of Model-C and tested for the same two months. Testing currently underway for Model-A.

• This method significantly improves Model-B and -C results. Ready to be implemented in Edition-3 $\beta$-testing and final processing.
Weighting Function for DLF Reaching the Surface

(U.S. Standard Atmosphere - 50 mb Layers)
Surface and Atmospheric Temperatures Over Sea of Japan
January 2000
Monthly Average Temperature Adjustment - January
Monthly Average Temperature Adjustment - July