CRS Issues and Plans
(but fasten seat belts for Fred’s talk on SYNI)
Surface and Atmosphere Radiation Budget (SARB)

Clouds and the Earth’s Radiant Energy System (CERES)
Science Team Meeting at Williamsburg, Virginia (2-4 May 2006)

T. P. Charlock (NASA LaRC)
Fred G. Rose (AS&M) algorithm development
David A. Rutan (AS&M) CAVE validation
Zhonghai Jin (AS&M) coupled ocean atmosphere radiative transfer
  Seiji Kato (H.U.) - modification of LaRC Fu-Liou code
Wenying Su (H.U.) - surface UV and PAR algorithms
Lisa H. Coleman, Thomas E. Caldwell, Scott Zentz (SAIC) - Data Management

David Fillmore and Bill Collins (NCAR) aerosol assimilation

SARB/SOFA Working Group Wed. AM:
SOFA Issues (Kratz), ARM Collaboration (Rutan), Ocean albedo update (Jin)

www-cave.larc.nasa.gov/cave/ or google “CERES CAVE”
MODIS ~1km pixels provide
Cloud properties (almost always)
Aerosol AOT (sometimes)
Land skin temperature (if clear)

SARB vertical profile at ~2,000,000 CRS footprints/day
Gridded SYNI, which has surface UV, etc., coming soon (90 min.)

NCEP O3(z)
Mostly from SBUV/2

GEOS4 T(z), q(z), surface wind
Wind speed affects ocean surface albedo

MATCH aerosols
Always used for SSA & g
Used for AOT if no MODIS AOT

~20-50 km

Large CERES footprint for TOA flux

Surface

~70 hPa (altitude ~18 km)

MODIS ~1km pixels provide

www-cave.larc.nasa.gov/cave/ or google “CERES CAVE”
Welcome to the CAVE website. Data collected in this effort are meant for use in validation studies of Clouds & The Earth's Radiant Energy System (CERES) instruments operating on the Tropical Rainfall Measurement Mission (TRMM) and Earth Observing Systems (EOS) Terra (soon Aqua) satellites.

Important Change to CAVE Surface flux, Aerosol, Meteorology (SAM) Files

Please Read for Details
# TOA Flux Validation

**Instantaneous Footprint Results**

Terra, 70 Months of CRS Ed2B, “clear” - imager

<table>
<thead>
<tr>
<th></th>
<th>All Sky</th>
<th>Clear Sky</th>
<th>Clear-Pristine</th>
<th>SW CNA*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LW</td>
<td>SW</td>
<td>LW</td>
<td>SW</td>
</tr>
<tr>
<td>ARM/SGP</td>
<td>+2</td>
<td>+2</td>
<td>+0</td>
<td>-1</td>
</tr>
<tr>
<td>Island Sites</td>
<td>-2</td>
<td>+17</td>
<td>-4</td>
<td>+7</td>
</tr>
<tr>
<td>Polar Sites</td>
<td>+3</td>
<td>+16</td>
<td>-2</td>
<td>+6</td>
</tr>
<tr>
<td>SURFRAD</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>+0</td>
</tr>
<tr>
<td>European</td>
<td>+2</td>
<td>+8</td>
<td>-0</td>
<td>-2</td>
</tr>
<tr>
<td>Validation Sites</td>
<td>+1(8)</td>
<td>+11(27)</td>
<td>-1(5)</td>
<td>-0(6)</td>
</tr>
</tbody>
</table>

*Difference model run with clouds and aerosols and model run with clouds, no aerosols. (SW is daytime only, LW is day and night.)
Surface Flux Validation

Instantaneous Footprint Results
Terra, 70 Months of CRS Ed2B, (“clear” – imager)

<table>
<thead>
<tr>
<th>Downward Untuned Surface Flux Biases (Model-Obs)(W/m2)</th>
<th>SFC Aerosol Forcing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clear-Pristine</td>
</tr>
<tr>
<td></td>
<td>LW</td>
</tr>
<tr>
<td>All Sky</td>
<td>Clear Sky</td>
</tr>
<tr>
<td>LW</td>
<td>SW</td>
</tr>
<tr>
<td>ARM/SGP</td>
<td>-7</td>
</tr>
<tr>
<td>Island Sites</td>
<td>-3</td>
</tr>
<tr>
<td>Polar Sites</td>
<td>-4</td>
</tr>
<tr>
<td>SURFRAD</td>
<td>-8</td>
</tr>
<tr>
<td>European</td>
<td>-6</td>
</tr>
<tr>
<td>Validation Sites</td>
<td>-6 (23)</td>
</tr>
</tbody>
</table>

*Difference model run with clouds and aerosols and model run with clouds, no aerosols. (SW is daytime only, LW is day and night.)
Rutan’s presentation in SARB/SOFA WG tomorrow uses Kato-Rose analysis of ARM radar and SSF clouds.
One month comparison of BBHRP with CRS Terra Ed2B
Full report by Rutan in tomorrow’s WG session

ARM Broadband Heating Rate Profile BBHRP (Mlawer et al.)
RRTM radiative transfer code
Uplooking active and passive sensors in narrow FOV
Aerosol SSA by tuning diffuse MFRSR
Surface albedo from downlooking MFRSR tower

<table>
<thead>
<tr>
<th></th>
<th>Longwave Bias (RMS) (W/m²)</th>
<th>Shortwave Bias (RMS) (W/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Sky</td>
<td>Clear Sky</td>
</tr>
<tr>
<td>BBHRP</td>
<td>+10(21)</td>
<td>+3(9)</td>
</tr>
<tr>
<td>CRS</td>
<td>-5(15)</td>
<td>-7(18)</td>
</tr>
<tr>
<td>BBRHP</td>
<td>+1(4)</td>
<td>+1(4)</td>
</tr>
<tr>
<td>CRS</td>
<td>-3(7)</td>
<td>-7(11)</td>
</tr>
<tr>
<td>N samples</td>
<td>72</td>
<td>24</td>
</tr>
</tbody>
</table>

Table 1. Model biases with respect to observations for LW & SW flux up at the top of atmosphere and LW & SW flux down at the surface.
Relative Bias of SW at TOA — Deseasonalized

Calculations reflect more than observations and may be closer to planetary balance with OLR.

Clear Ocean
Rayleigh, sea surface, AOT

All sky Globe
MODIS clouds

Dashes: Ed2B calculations, observations
Circles: FM2
Others: FM1

Solid: Ed2B calculations, Rev1 observations

March 2000 to May 2005

(Untuned - Observed) / Observed
Clear ocean SW at TOA: Multi-stream COART would reduce SZA-dependent bias now seen in 2-stream CRS Ed2B, but slightly increase the domain mean bias.
Bias of LW at TOA ---- Deseasonalized

Raw means of FOVs (no grid) Terra CRS Ed2B
CO2, N2O, CH4 and CFCs constant in Ed2B calculation

All-sky OLR Day

Asterisks: All-sky 8–12um Window Day+Nite

Dashes: Clear-sky OLR Day+Nite

Circles: FM2
Others: FM1

Bias for daytime OLR has a trend. It may flag an instrument drift.
Observed OLR = [ Total (SW+LW) channel – SW channel ]

March 2000 to May 2005
OLR bias = Untuned-Observed

Day (April 2002)

Nite (April 2002)
Calculations show possible effect of effect of aerosols on relative bias. Say cloud tau=20, where relative bias above is 0.03 or about 20 Wm-2 for cosSZA=0.8. Aerosol (AOT=0.2) would then increase TOA by only 1.3 Wm-2. But “double counting” of aerosols at small cloud tau could be important. AOT effect on cloud retrieval needed.
Relative SW Blas at TOA for Overcast at SGP

Terra CRS Ed2B 2000–2005 at 20 ARM sites

Cloud 1: Liquid

Cloud 1: Ice

(Exact wording and data are not provided, as the image is not a text document.)
Low and moderate optical depth clouds are a problem over land, too.
These clouds are essentially black. The OLR bias for clouds is too large in this daytime-only plot.
Bias of Computed Flux for Overcast at SGP

Terra CRS Ed2B 2000–2005
20 ARM sites

Solid: SW up at TOA

Dashed: OLR

Circles: SW down at SFC

Both water and ice clouds
<table>
<thead>
<tr>
<th></th>
<th>CLEAR</th>
<th>PARTLY CLOUDY</th>
<th>OVERCAST</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW up TOA</td>
<td>-1 (4)</td>
<td>-3 (25)</td>
<td>19 (29)</td>
</tr>
<tr>
<td>SW down SFC</td>
<td>3 (22)</td>
<td>14 (117)</td>
<td>8 (95)</td>
</tr>
<tr>
<td>OLR</td>
<td>1 (4)</td>
<td>2 (10)</td>
<td>7 (12)</td>
</tr>
<tr>
<td>LW down SFC</td>
<td>-13 (21)</td>
<td>-8 (21)</td>
<td>-4 (17)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>Day only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>~1030 LST</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No nite</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>samples</td>
</tr>
</tbody>
</table>

Bias of Computed Flux for Partly Cloudy at SGP

- Circles: SW down at SFC
- Dashed: OLR
- Solid: SW up at TOA
- Both water and ice clouds

BIAS (RMS)

Terra CRS Ed2B 2000–2005
20 ARM sites
Minnis SSF cloud retrieval uses lapse rate adjustment to GEOS4 to improve characterization of marine boundary layer. The retrieved cloud temperature is fairly independent of GEOS4. Cloud top pressure is also retrieved.

Terra CRS Edition 2B SARB uses GEOS4 for $T(z)$ and $q(z)$, assigning the SSF cloud to the GEOS4 profile using cloud top pressure.

Here test new method. Use SSF cloud temperature explicitly and adjust the GEOS4 lapse rate using Cloud WG concepts.
**Standard** Ed2B method:

Bias / Std (Wm-2)
1.04 / 8.58 Edition 2B

*Bias/Std values for globe
Plots show only NH*

**Test** with new SARB placement of SSF cloud and sounding adjustment:

Bias / Std (Wm-2)
-0.65 / 7.42 Test version
**COVE Beach Cleanup of SSF and CRS for Aqua**

<table>
<thead>
<tr>
<th>Bias</th>
<th>RMS</th>
<th>Std (Wm-2)</th>
<th>Decembers of 00-04 (Terra Ed2B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>34</td>
<td>42</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>18</td>
<td>11</td>
<td><strong>December 02</strong> (SCF run of Aqua)</td>
</tr>
</tbody>
</table>

This is a CERES map of IGBP types near Tidewater, Virginia. The area within the magenta rectangle appears to contain 3 tiles (with each tile 10 minutes by 10 minute) of IGBP type 12 (cropland). This wrecks Terra CRS Edition 2B validation at COVE, which is the sole site with surface radiometers deployed over water that subscribe to BSRN protocols. For Aqua CRS Val processing, this has “COVE Beach Problem” been cleaned up.
Kato and Rose revise LaRC Fu-Liou code again for Edition 3. A band that spanned 0.7-1.3 micron is now split into 3 parts for more rigorous treatment of the overlapping absorption by water vapor and cloud particles.

The new way reduces absorption by the atmosphere for ice clouds; a large effect at high optical depths.

Will be tested with CAVE “Grand Time Series” (GTS).
This summary from last meeting still holds for Terra CRS Edition 2B:

SARB calculations are noisy (compared with data) and they:

- reflect more SW at TOA than observed by CERES (~3-5%) --- ocean
- transmit more SW to surface for all-sky (~2%) & clear-sky (0-1%) --- land
  Aerosol forcing has some credibility
- less surface LW down than PIR (~10 Wm-2)
- more daytime OLR than CERES (0-2 Wm-2)
Summary for this meeting:

Parallel assessment of Edition 2B CRS bias w.r.t. CERES TOA calibration continues.

Changes to Aqua maps will allow better use of COVE for validation.

New Grand Time Series (GTS) resource allows multi-year re-runs with new data sources and code for CAVE sites.

Revised radiative transfer for Edition 3. Expect more bias for a domain where Ed2B calculations and observations agree.

Cloud tests also underway for Edition 3.