Surface and Atmosphere Radiation Budget (SARB)

Corrections to slides 8, 21, and 22 made on 9 May 2005

Clouds and the Earth’s Radiant Energy System (CERES)
Science Team Meeting (3-5 May 2005)
at Geophysical Fluid Dynamics Laboratory (GFDL), New Jersey

The Gang of Four:

T. P. Charlock (NASA LaRC)
Fred G. Rose (AS&M) - display of on line Fu-Liou broadband code
David A. Rutan (AS&M) - CAVE
Zhonghai Jin (AS&M) - Co-I talk on Thursday (snow trouble),
but GCM’ers should get his ocean surface albedo today.

Sent to CAVE for rendition:

Lisa H. Coleman, Thomas E. Caldwell, Scott Zentz (SAIC) - Data Management
Seiji Kato (H.U.) - fellow traveler in ADM group
David Fillmore and Bill Collins (NCAR) - MATCH
Wenying Su (H.U.) - surface UV and PAR algorithms

www-cave.larc.nasa.gov/cave/ or google “CERES CAVE”
CERES CRS: Surface and Atmosphere Radiation Budget (SARB) Product

- Tuned fluxes at all 5 levels
  - All-sky & Clear-sky, Up & Down,
  - SW and LW

- Surface & TOA also have Untuned fluxes
  - Fluxes with aerosols
  - Pristine fluxes (no aerosols)

- Aerosol forcing for all-sky & clear-sky

Tuning does NOT yield a perfect match to TOA observations.

Parameters adjusted when clear:
  - Skin temperature, aerosol AOT,
  - precipitable water (PW)

Parameters adjusted when cloudy:
  - LWP/IWP, cloud top temperature,
  - cloud fractional area within footprint
Welcome to the CAVE web site. Data collected in this effort are meant for use in validation studies of Clouds & The Earths 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

Global Coverage
Collocated CERES Observations
Continuous Surface Data Record
Atmospheric Profiles

Referencing CAVE data
Surface sites in CAVE surface validation program

- **ARM (22 Sites)**
  - SGP(20) & TWP(2)

- **SURFRAD (7 Sites)**
  - BON, DRA, FPK, GWN, PSU, TBL, SXF

- **CMDL (7 Sites)**
  - BAR, BER, BOU, KWA, SAM, MLO, SPL

- **BSRN (12 Sites)**
  - ASP, DAA, FLO, GVN, LAU, LIN, NYA, PAY, SBO, SYO, TAM, TAT

- **Other Sites (6 Sites)**
  - SSV, COV, KAS, SIR, VAS, CAB

[Map showing the distribution of the sites around the world]
### CAVE Surface Validation Untuned CRS 2001 (Ed 2B)

#### Down LW Flux at Surface

![Graph showing Down LW Flux at Surface](image)

#### Down SW Flux at Surface

![Graph showing Down SW Flux at Surface](image)

#### All Sky

<table>
<thead>
<tr>
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<th>Obs Mean</th>
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<th>Bias CRS-Obs</th>
<th>Std Dev</th>
<th>RMS</th>
<th>Diff Frc</th>
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#### Clear Sky MODIS

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Bias = (Untuned Calculations minus Observations)


CAVE surface radiometer “CVS” record.

TOA observations from CERES broadband instrument.

Aerosol forcing as all-sky computation with aerosols minus all-sky sky computation without aerosols.

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<td>10873</td>
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SW bias for ~1030 LST daylight overpass
Daily bias is smaller by factor of ~3
Clear sky insolation bias is only -0.4 Wm-2, much less than the clear sky aerosol forcing of -15.8 Wm-2.
Bias (calculated - observed) and Aerosol Forcing
Clear-sky SW insolation at SGP (2000-2001)

CRS Terra FM1/FM2 Edition 2B

Clear-sky Surface SW Insolation: Bias and Aerosol Forcing

Bias = Computed - Observed (Mean: 4.7 Wm-2)

Aerosol Forcing (Mean: -18.5 Wm-2)

2729 matchups of Terra and 20 SGP surface radiometers
Bias = (Untuned Calculations minus Observations)


CAVE surface radiometer “CVS” record.

TOA observations from CERES broadband instrument.

Aerosol forcing as all-sky computation with aerosols minus all-sky sky computation without aerosols.

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SW biases & RMS are mostly due to clouds (aka cloud forcing). Observations have ~ (13.1+10.7=23.8 24.8 Wm-2) more absorption by atmosphere, than do calculations.

Remember: This ~23.8 Wm-2 “anomaly” represents 1030 LST.
Bias = (Untuned Calculations minus Observations)


CAVE surface radiometer “CVS” record.

TOA observations from CERES broadband instrument.

Aerosol forcing as all-sky computation with aerosols minus all-sky sky computation without aerosols.

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Observations have -6.1 Wm-2 more downwelling LW than do calculations. This is mostly due to the input surface air temperature (GMAO). ECMWF was better. Cloud effects are “no problem” for LW here.
Q: What use is all this CERES SARB “in atmosphere” Wm\(^{-2}\) to a GCM?

A: If it’s sufficiently consistent with observations, it’s a gridded target for GCM validation; a shorthand over the cloud/aerosol properties. Translating \(\tau_{\text{model}}\) to \(\tau_{\text{satellite}}\) is awful. Translating Wm\(^{-2}\) is easy.

FSW: The hourly gridded CERES product
http://asd-www.larc.nasa.gov/sarb/Pindex.html
Tables/plots of official global product
(temporary password: “caveman”)

Currently Posted Files, Viewing and Downloading Enabled

*To make a new selection in a menu, first you MUST select CLEAR in order to reset menu to all available options.*

**If CLEAR does not reset box, then no other choices are available based on your previous selections.**

***You must make a selection in every menu in order to retrieve file***

****You can Right-Click on the filename (next page) to save file****

Product Description Page

What files are in the ASDC archives?

File Type: CLEAR Satellite: CLEAR Production Strat: CLEAR CCode: CLEAR
Year: CLEAR Month: CLEAR

RESET ALL SUBMIT
Cloud forcing to LW Convergence (Surface - 500 hPa) for March 2000

FSW: The hourly gridded CERES product
Bias at TOA (Untuned SW - Observed) for March 2000 as 24-hour mean

FSW: The hourly gridded CERES product

The computed SW reflects too much at TOA. This is a persistent problem.

Mean = 4.53
Stddev = 4.98
Count = 44012
All-Sky OLR Bias (Untuned - Observed) for March 2000 as 24-hour mean

\[ \text{(UT-OBS) LW TOA} \]
\[ \text{CER_FSWB_Terra-FM2-MODIS_Edition2C}_018020.200003 \]
\[ 200003\_all \]

![Map showing the All-Sky OLR Bias for March 2000 as 24-hour mean.]

- Mean: -0.56
- Stddev: 2.77
- Count: 44012
Adjustment to PW by SARB Tuning (March 2000)

Mean = 0.00
Stddev = 0.03
Count = 44012
Bias (Untuned - Observed) for Clear-sky OLR over Ocean

CER FSWB Edition 2C Terra FM1/FM2 and Aqua FM3/FM4

Start March 2000 ------- End March 2003
Bias (Untuned - Observed) for All-sky OLR

CER FSWB Edition 2C Terra FM1/FM2

OLR (Untuned Calculation - Observation) Wm-2

Terra FM2 (near start in spurts) has smaller bias

Start March 2000 --------- End March 2003
Bias (Untuned - Observed) for All-sky

CER FSWB Edition 2C Terra FM1/FM2

All sky TOA (Untuned Calculation - Observed) Wm-2

OLR All sky

SW All sky

Start: March 2000

End: March 2003
Bias (Untuned - Observed) for All-sky

CER FSWB Edition 2C Terra FM1/FM2   Aqua FM3/FM4

Start March 2000 ------- End March 2003
Bias (Untuned - Observed) over Ocean

Ice-free ocean calculation has no input from broadband instrument

CER FSWB Edition 2C Terra FM1/FM2  Aqua FM3/FM4

Start March 2000 --------- End March 2003
Bias = (Untuned Calculations minus Observations)


CAVE surface radiometer “CVS” record.

TOA observations from CERES broadband instrument.

Aerosol forcing as all-sky computation with aerosols minus all-sky sky computation without aerosols.

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Fractional Error in Reflected SW (Untuned-Observed)

TOA Albedo Bias (Untuned - Observed)

Overcast water clouds over ocean 55N-55S (AOT<0.2)


Fractional Error in Reflected SW (Untuned-Observed)

Albedo Bias (Untuned—Observed)

\[
\text{Fractional Error} = \frac{\text{Calculated-Observed}}{\text{Observed}}
\]

Cloud effective height

Fractional Error = (Calculated-Observed)/(Observed)
Theoretical ADM with COART:
A pure theory to theory look

Universe = 3 clouds with
tops at 1, 3, and 5 km

Produce single mean ADM
and apply it.

Errors for 1 km, 5 km clouds
significant for some angles
Q.: How do we reconcile the broadband heating rate, surface to TOA, on such scales?

A.: Look for cases where probability distribution function of transmission (surface to TOA) is consistent. Use the spatial distribution from satellite and temporal distribution from the surface.
Probability Distribution Function for Transmission (TOA to surface)

**SPACE**
A typical CERES FOV (or ARM gridbox) contains many MODIS (or GOES imager) pixels:

Imager gets cloud optical depth $\tau$ for each pixel:

This is an actual spatial probability distribution function (pdf) for TOA to surface transmissivity $T$ computed over SGP E-13 with the Fu-Liou code. The input cloud $\tau$ are from a single CERES FOV (Terra SSF Edition 2B) with MODIS radiances using the Minnis algorithm:

**TIME**
A surface radiometer (PSP) measures insolation. This can be expressed as a minute-by-minute time series of transmission $T$. The time series of yields a temporal probability distribution function (pdf) for TOA to surface transmissivity $T$.

Idealized PSP time series

Transmission

Time

This is the temporal probability distribution function (pdf) for $T$ over SGP E-13 for the 60 minute interval of the satellite observation on the left:

Real data matched in space (left) and time (right)
April 2 2001 C01
FOV Distances
(8.6, 12.9, 14.7) km

Observed PDFs of transmission at C01 ground site using from temporal records of four lengths

Computed spatial PDFs of transmission from three adjacent satellite FOVs

FOV#6 VZA 32.
TOAALB(Ut-Obs) −0.004

FOV#5 VZA 33.
TOAALB(Ut-Obs) 0.022

FOV#4 VZA 31.
TOAALB(Ut-Obs) −0.018

Trans Err: (.014, .051, .017)
Distrb Err: (.52, .85, .37)

Trans Err: (-.023, -.014, -.020)
Distrb Err: (.15, .12, .15)

Trans Err: (-.025, .011, -.023)
Distrb Err: (.10, .07, .18)

Trans Err: (.017, .019, .015)
Distrb Err: (.05, .12, .10)

CO1 ground site
15 min. interval

CO1 ground site
30 min. interval

CO1 ground site
60 min. interval

CO1 ground site
90 min. interval
Reduced Std Dev with preliminary algorithm
Bias (calculated - observed) and Aerosol Forcing
Clear-sky SW insolation at **Saudi Solar Village** (2000-2001)

CRS Terra FM1/FM2 Edition 2B

Clear-sky Surface SW Insolation: Bias and Aerosol Forcing

- **Bias = Computed - Observed** (Mean: -3.5 Wm$^{-2}$)
- **Aerosol Forcing** (Mean: -37.5 Wm$^{-2}$)

301 matchups of Terra and SSV surface radiometers
Aerosol Forcing to OLR and Bias for OLR and LW up at surface Clear-sky upwelling LW at **Saudi Solar Village** (2000-2001) 

CRS Terra FM1/FM2 Edition 2B

SSF retrieval of skin temperature does not include aerosol. Cloud WG has a strategy to build the needed algorithm.
All-sky SW Aerosol Forcing (TOA net - surface net)
Interannual changes as (Mar02-Mar03)

Aerosol single scattering albedo: tough problem. Big change from Ed2A to Ed2B. GISS has photopolarimeter to retrieve ssa... an issue for Coakley’s NPOESS meeting
Terra CERES FSW Edition 2B

All-sky SW aerosol forcing to atmosphere (day+nite)
(TOA net forcing - Surface net forcing on scale of 0-50 Wm$^{-2}$)

March 2000

Different winds over Africa in March 2000 pushed the warming dust further NW.

March 2002

Height of 1000 hPa in gpm (NCEP)

March 2003