ATMOSPHERIC SCIENCE DATA CENTER

CERES TRMM-PFM-VIRS Edition2A SSF Surface Fluxes - Accuracy and Validation

One of the principal objectives for the CERES data products is to provide improved estimates of surface fluxes (net and downward) for shortwave (SW) and longwave (LW) radiation. To achieve this objective, considerable effort has been focused upon obtaining consistent fluxes at the surface, within the atmosphere, and at the top of the atmosphere, all of which are produced as part of the CERES CRS data product using the Edition2A SSF as input data. Initial CRS surface fluxes, however, will not be available until Spring 2002. A second effort, therefore, uses much simpler algorithms either:

- to directly tie surface fluxes to broadband CERES TOA fluxes such as in Li et al. (1993) and Darnell et al. (1992) for SW fluxes, and Inamdar and Ramanathan (1997) for clear-sky LW surface fluxes.
- or to use simple radiative parameterizations (Gupta 1989 and Gupta, Darnell, and Wilber 1992) to estimate surface fluxes, especially for the case of surface downward LW fluxes which are effectively decoupled from the TOA fluxes for cloudy sky conditions.

These simpler SSF surface flux parameterizations are, therefore, more comparable to results used in past analyses of surface radiation data sets based on ERBE or geostationary data. In general, however, they are not expected to be as precise as the CERES CRS surface fluxes, though they do represent an independent method to get to the more difficult surface flux estimates.

The CERES SSF data product provides 4 surface flux algorithm results:

1. Shortwave Flux Model A, Clear-sky only
   - Net surface fluxes use Li et al. (1993).
   - Downward surface fluxes use Li et al. (1993) for net and Li and Garand (1994) for surface albedo.
2. Shortwave Flux Model B, Clear and All-sky
   - Net and downward surface fluxes use the Langley Parameterized Shortwave Algorithm (LPSA) (Darnell et al. 1992; Gupta et al. 1999).
3. Longwave Flux Model A, Clear-sky only
   - Net and downward surface fluxes uses Inamdar and Ramanathan (1994).
4. Longwave Flux Model B, Clear and All-sky
   - Net and downward surface fluxes use the Langley Parameterized Longwave Algorithm (LPLA) (Gupta 1989 and Gupta, Darnell, and Wilber 1992).

For the Edition2A surface fluxes, clear-sky has been defined as a CERES footprint with an imager determined cloud cover percentage less than 5.0%; however, for this validation study, clear-sky is defined as a CERES footprint with an imager determined cloud cover percentage less than 0.1%. This latter cutoff is for consistency with the angular distribution models.

The SSF surface fluxes are being validated using both theoretical analyses and simultaneous matching of satellite data to a range of surface sites. Preliminary results are discussed in the sections which follow.

The CERES SSF surface flux estimates were obtained using Tropical Rainfall Measuring Mission (TRMM) satellite data for January through August of 1998. The coincident surface fluxes were then gathered from the 21 sites of the Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) network, the 6 sites of the Climate Modeling and Diagnostic Laboratory (CMDL) network, and the 4 sites of the Baseline Surface Radiation Network (BSRN). Unless otherwise noted, surface site fluxes are 1 minute averages and are compared to the CERES footprint which includes the surface site.

Clear-sky Shortwave Downward Flux Validation: Model A and B

For the shortwave, two models have been used to produce the surface fluxes. Both of these shortwave models are part of our validation effort; however, Model A produces fluxes only for clear-sky conditions while Model B produces fluxes for both clear and all-sky conditions.

As can be seen in the following tables for the clear-sky cases, the shortwave models are found to be in reasonably good agreement with the surface measurements at the ARM/CART SGP sites. At the CMDL and BSRN sites, however, errors between the surface fluxes derived from satellite data and the measured surface fluxes are larger by factors of 1.5 to 2. These discrepancies are under investigation.

Downward Shortwave Model A Comparisons, Clear-Sky, 1 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation

ARM Central Facility	50	24.8 W m^{-2}	32.5 W m^{-2}	21.3 W m^{-2}
Arm Extended Facilities	853	32.2 W m^{-2}	43.1 W m^{-2}	28.7 W m^{-2}
BSRN Facilities	53	42.6 W m^{-2}	56.3 W m^{-2}	37.3 W m^{-2}
CMDL Facilities	37	46.2 W m^{-2}	63.4 W m^{-2}	44.0 W m^{-2}

Downward Shortwave Model B Comparisons, Clear-Sky, 1 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	50	-19.9 W m^{-2}	23.6 W m^{-2}	12.7 W m^{-2}
Arm Extended Facilities	853	-11.7 W m^{-2}	23.0 W m^{-2}	19.8 W m^{-2}
BSRN Facilities	53	-12.0 W m^{-2}	28.3 W m^{-2}	25.9 W m^{-2}
CMDL Facilities	37	10.9 W m^{-2}	43.6 W m^{-2}	42.8 W m^{-2}

Preliminary results are presented for the all-sky Model B case. To reduce the considerable variance introduced by broken cloud fields, the surface data have been averaged over the 60 minutes centered on the time of the satellite overpass. Note, the variance introduced by broken cloud fields is far greater than that introduced by the temporal averaging. Other discrepancies which contribute to the variance are still under investigation.

Downward Shortwave Model B Comparisons, All-Sky, 60 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	140	-6.2 W m^{-2}	47.7 W m^{-2}	47.4 W m^{-2}
Arm Extended Facilities	2062	12.9 W m^{-2}	71.5 W m^{-2}	70.3 W m^{-2}
BSRN Facilities	147	12.9 W m^{-2}	62.1 W m^{-2}	60.9 W m^{-2}
CMDL Facilities	354	35.8 W m^{-2}	93.9 W m^{-2}	87.0 W m^{-2}

Clear-sky Longwave Downward Flux Validation: Model A

Longwave Model A uses CERES-derived window and non-window TOA fluxes as well as the meteorological profiles to obtain surface fluxes for clear sky conditions. As demonstrated by the following table, the results from longwave model A are found to be in good agreement with the surface measurements for all the sites that were considered.

Downward Longwave Model A Comparisons, Clear-Sky, 1 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
BSRN Facilities	39	0.3 W m^{-2}	23.5 W m^{-2}	23.5 W m^{-2}
CMDL Facilities	70	-9.7 W m^{-2}	14.4 W m^{-2}	10.7 W m^{-2}

Theoretical studies and validation studies employing data from Central Equatorial Pacific Experiment (CEPEX), reported by Inamdar & Ramanathan (1997), are consistent with our results. The parameterization over the land surfaces have been developed using limited set of emissivity data available from IRIS measurements aboard NIMBUS 4 (Prabhakara & Dalu 1976). Other possible sources of errors are:

1. Specification of the true radiating temperature (especially land surfaces);
2. Errors in scene identification;
3. Emissions from aerosols in the boundary layer. For example, sensitivity studies have shown that thick haze in the boundary layer (visibilities less than 15 km) can increase the downward emissions by about 3 - 5 W m^{-2}.

All-sky Longwave Downward Flux Validation: Model B

Longwave model B uses the meteorological profiles and CERES VIRS-derived cloud properties, but not the CERES-derived TOA fluxes, to obtain surface fluxes for clear and all-sky conditions. As demonstrated by the following tables, the results from longwave model B are found to be in good agreement with the surface measurements at all the sites.

Downward Longwave Model B Comparisons, Clear-Sky, 1 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	125	-1.9 W m^{-2}	17.6 W m^{-2}	17.5 W m^{-2}
Arm Extended Facilities	1962	-4.8 W m^{-2}	19.8 W m^{-2}	19.2 W m^{-2}
BSRN Facilities	253	-13.4 W m^{-2}	21.3 W m^{-2}	16.6 W m^{-2}
CMDL Facilities	97	-9.6 W m^{-2}	15.4 W m^{-2}	12.1 W m^{-2}

Downward Longwave Model B Comparisons, All-Sky, 1 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	315	-0.1 W m^{-2}	18.9 W m^{-2}	18.9 W m^{-2}
Arm Extended Facilities	4607	-2.1 W m^{-2}	20.7 W m^{-2}	20.6 W m^{-2}
BSRN Facilities	711	-8.5 W m^{-2}	21.6 W m^{-2}	19.9 W m^{-2}
CMDL Facilities	784	-7.3 W m^{-2}	16.1 W m^{-2}	14.3 W m^{-2}

The error statistics given in the above tables, especially for the ARM central facility and extended facilities represent realistic estimates of the instantaneous errors present in the retrieved fluxes. Nevertheless, while the results are very encouraging, it is critical that longer term comparisons be made to improve the statistics of the results and to resolve outstanding issues.

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