CERES Terra Edition2B CRS
Data Quality Summary

Investigation:	**CERES**
Data Product:	**Clouds and Radiative Swath (CRS)**
Data Set:	**Terra (Instruments: CERES-FM1 or CERES-FM2, MODIS)**
Data Set Version:	**Edition2B**

The purpose of this document is to inform users of the accuracy of this data product as determined by the CERES (Wielicki et al., 1996) Science Team. This document briefly summarizes key validation results, provides cautions where users might easily misinterpret the data, provides links to further information about the data product, algorithms, and accuracy, and gives information about planned data improvements. This document also automates registration in order to keep users informed of new validation results, cautions, or improved data sets as they become available.

This document is a high-level summary and represents the minimum necessary information for scientific users of this data product.

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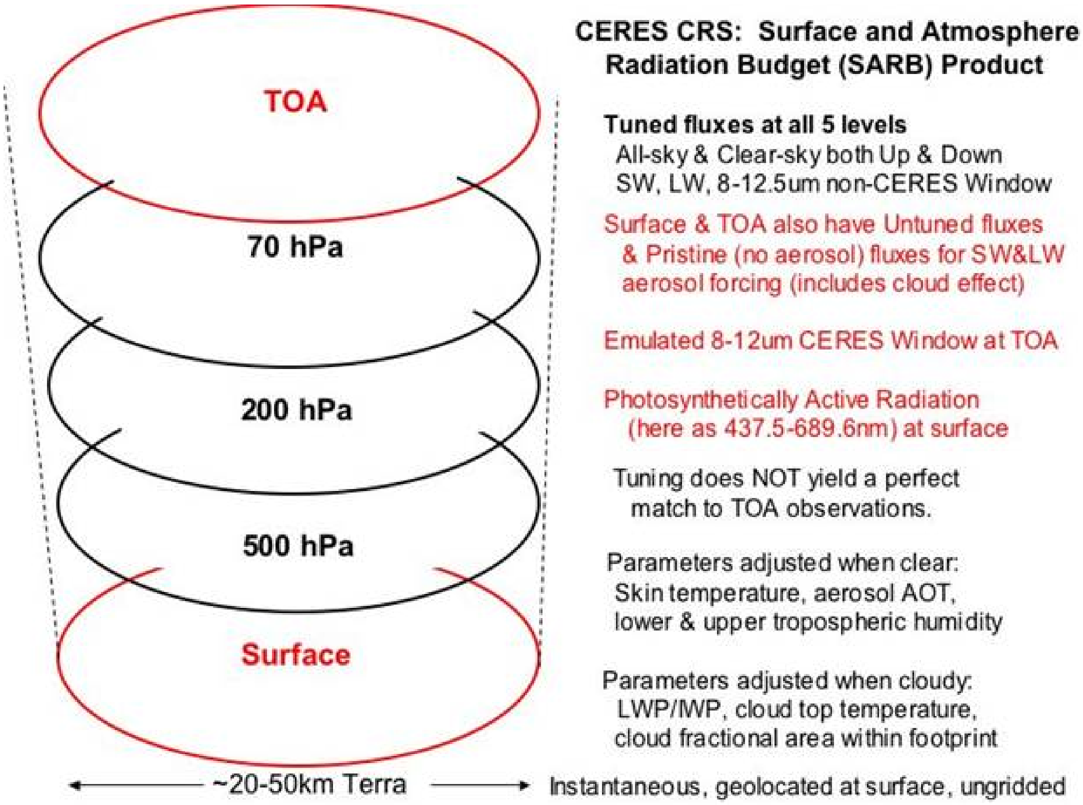


Figure 1: CERES Surface and Atmosphere Radiation Budget (SARB) product

Nature of the CRS Product

Introduction

The CRS product (Figure 1) is designed for studies which require fields of clouds, humidity and aerosol that are consistent with radiative fluxes from the surface to the Top Of the Atmosphere (TOA); for example, studies of cloud and aerosol forcing at both TOA and surface, or investigations of possible errors in retrievals of TOA fluxes, cloud properties, surface skin temperature, etc. It is quite a task to manipulate the huge files of this ungridded dataset, which spans the globe with about 100 megabytes per day. Potential users are strongly encouraged to visit the CAVE web site which is a gateway to a point and click version of the radiative transfer code used here; user-friendly time series of subset (small) files at a few locations; validation at ~50 independent ground-based sites (ARM, BSRN, and SURFRAD); and an ocean albedo look up table (LUT) for GCMs. A subsequent gridded form of CRS will have the name "FSW". Potential users may also benefit from the CERES Archival Data website when attempting to determine the CERES data product of interest.

CRS software is developed and managed by the CERES Surface and Atmospheric Radiation Budget (SARB) Working Group (WG); the above "CAVE" URL is an operating environment for the WG and its users. Like its parent Single Scanner Footprint (SSF), CRS corresponds to an instantaneous CERES broadband footprint. The footprint has nominal nadir resolution of 20 km for half power points but is larger at other view angles (Figure 2). The major inputs (Figure 3) to the CRS software are the instantaneous scene identification, cloud and aerosol properties from the MODIS cloud imager pixels (resolution ~1 km), and TOA radiation (from the CERES instrument) contained on the respective SSF footprint; along with 6-hourly gridded fields of temperature, humidity, wind, and ozone, and climatological aerosol data contained on the Meteorological, Ozone, and Aerosol (MOA) product. MOA includes meteorological data provided by GEOS4 and the Stratospheric Monitoring Group Ozone Blended Analysis (SMOBA, Yang et al., 2000) ozone profiles from NCEP. Aerosol information is taken from MODIS and from the NCAR Model for Atmospheric Transport and Chemistry (MATCH, an assimilation that here also employs MODIS, Fillmore et al. 2005, Collins et al. 2001). The CRS product contains the SSF input data; through-the-atmosphere radiative flux profiles calculated by SARB algorithms that partially constrain to CERES TOA observations; adjustments to key input parameters (i.e., optical depth for cloudy footprints and skin temperature for clear footprints); and diagnostic parameters. CRS fluxes are produced for shortwave (SW), longwave (LW), the 8.0-12.0 µm window (WN), both upwelling and downwelling at TOA, 70 hPa, 200 hPa, 500 hPa, and the surface (Figure 3). To permit the user to infer cloud forcing and direct aerosol forcing, we include surface and TOA fluxes that have been computed for cloud-free (clear) and aerosol-free (pristine) footprints; this accounts for aerosol effects (SW and LW) to both clear and cloudy skies.

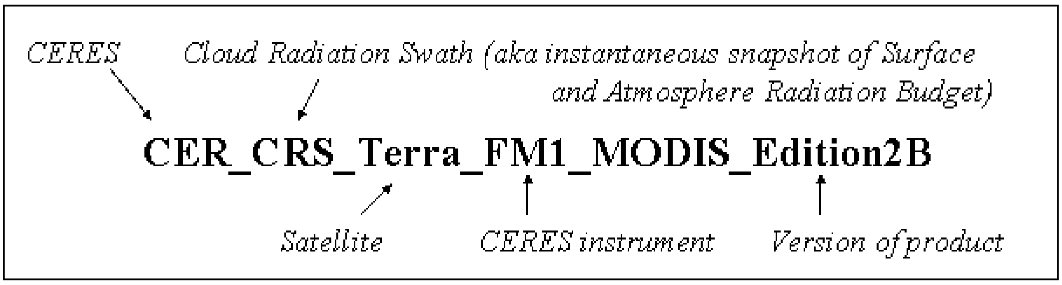
Terra CRS Edition 2B is an advance on Terra CRS Edition 2A. The aerosols used to compute SARB are the main differences between the two editions. Desert dust in Terra CRS Edition 2A absorbed SW too strongly; Terra CRS Edition 2B uses improved optical properties of dust, courtesy of A. Lacis at NASA GISS. All 7 types of aerosol in Terra CRS Edition 2A were distributed with altitude using a respective global mean scale height for the type. Terra CRS Edition 2B changes the vertical distributions of the aerosols every day over the whole globe. The vertical distribution of aerosols - especially relative to those for clouds - affects both the SW and LW forcing of aerosols. Aerosol forcing in Terra CRS Edition 2A is briefly described by Charlock et al. (2005).

The user can refer to the application of the earlier TRMM SARB product in the following: where Charlock et al. (2002) compare time series of computed fluxes at TOA with CERES observations to illustrate how the flux profiles are related to the tropical circulation. Rutan et al. (2002) point out that the present results do not support "anomalous absorption" of SW by clouds. Rose and Charlock (2002) note further advances in the radiative transfer code which are used in this Terra product (but not in TRMM). The surface insolation in TRMM CRS has a larger bias with respect to independent ground-based measurements, than does the surface insolation in Terra CRS; this is due to both the advances in the radiative transfer code and the introduction of satellite retrievals of aerosols over land in Terra.

A full definition of each parameter will be contained in the CRS Collection Guide, which has not been written yet. The present lengthy document should make the definitions clear to a reader having the CRS Data Product Catalog in hand. Informal extensions to the CRS Data Quality Summary will be posted under "CRS Advice" at the CAVE web site.

The SSF parent of this data set is CER_SSF_Terra-FM1-MODIS_Edition2B and CER_SSF_Terra-FM2-MODIS_Edition2B. The first few hundred parameters on a CRS file are duplicates of SSF. (See SSF Data Products Catalog (PDF).) Before using these parameters, please consult the SSF Quality Summary. Definitions of these parameters are available in the SSF Collection Guide.

When referring to a CERES data set, please include the satellite name and/or the CERES instrument name, the data set version, and the data product. Multiple files which are identical in all aspects of the filename except for the 6 digit configuration code (see Collection Guide - when available) differ little, if any, scientifically. Users may, therefore, analyze data from the same satellite/instrument (here Terra/CERES/MODIS), data set version (here Edition2B), and data product (here CRS) without regard to configuration code. This CRS data set may be referred to as "CERES Terra Edition2B CRS".



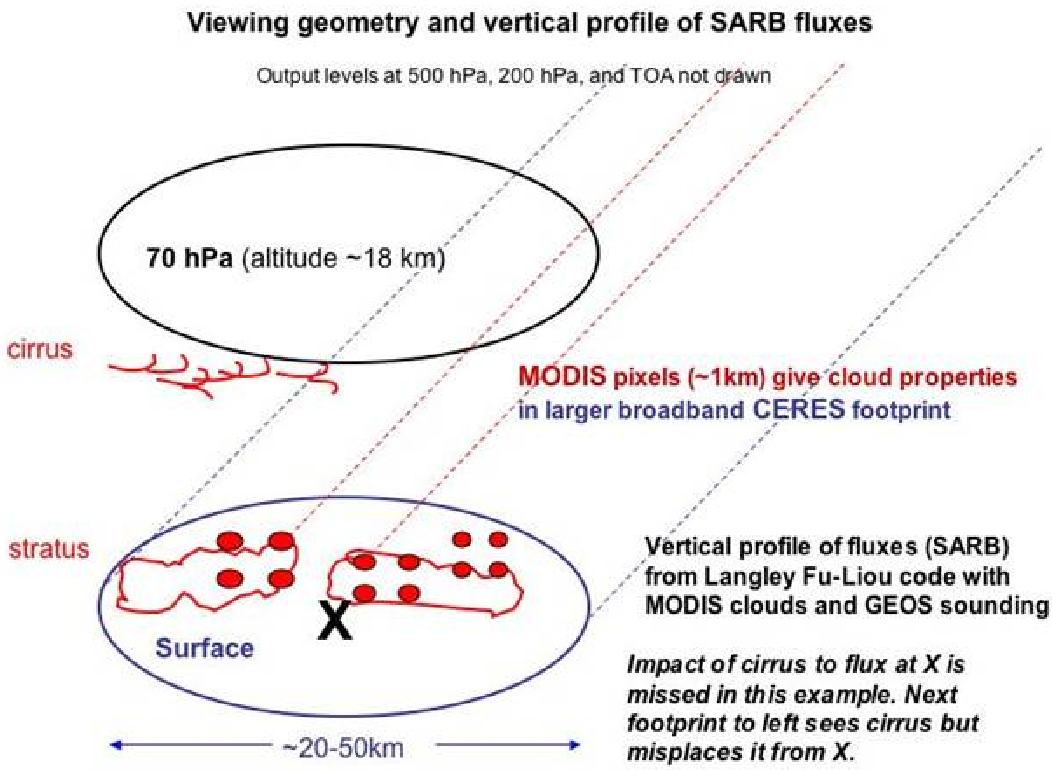


Figure 2: Typical viewing geometry showing small MODIS pixels within large CERES footprints

Constrainment (tuning)

In short, the SARB flux profile in the CRS product is the output of a highly modified Fu and Liou (1993) radiative transfer code. The code is run at least twice for each broadband CERES footprint, in order to adjust inputs that determine the vertical profile of radiative fluxes. The constrainment (or tuning) algorithm does NOT yield a perfect match to CERES broadband observations at TOA. Constrainment (Rose et al. 1997; Charlock et al. 1997) is an approach to minimize the normalized, least squares differences between (1) computed TOA parameters and adjusted values for key inputs and (2) observed TOA parameters and initial values for key inputs. The algorithm assigns an a priori numerical "sigma" (uncertainty) to each TOA parameter and key input parameter. The "sigmas" for TOA parameters (first group in Table 1) are the anticipated rms differences between observations based on the core CERES instrument and the outputs of radiative transfer calculations. The sigmas for key input parameters (the second and third groups labeled "cloud" and "other" in Table 1) are the anticipated rms differences between the initial (untuned) and final values of those key input parameters (tuned).

The inputs for radiative transfer calculations are depicted in Figure 3. The initial values of cloud parameters are taken from the SSF; they are narrowband imager-based retrievals of cloud properties. Initial values of other key input parameters such as PW and UTH are based on GEOS4. Aerosol information is taken from MODIS when available for the instantaneous CERES footprints. If the MODIS instantaneous AOD is not available for the footprint, we interpolate AOD from a file of the MODIS Daily Gridded Aerosol for the calendar month of processing. When cloudiness in the footprint exceeds 50%, or when there is no MODIS AOD, we use AOD from the NCAR Model for Atmospheric Transport and Chemistry (MATCH).

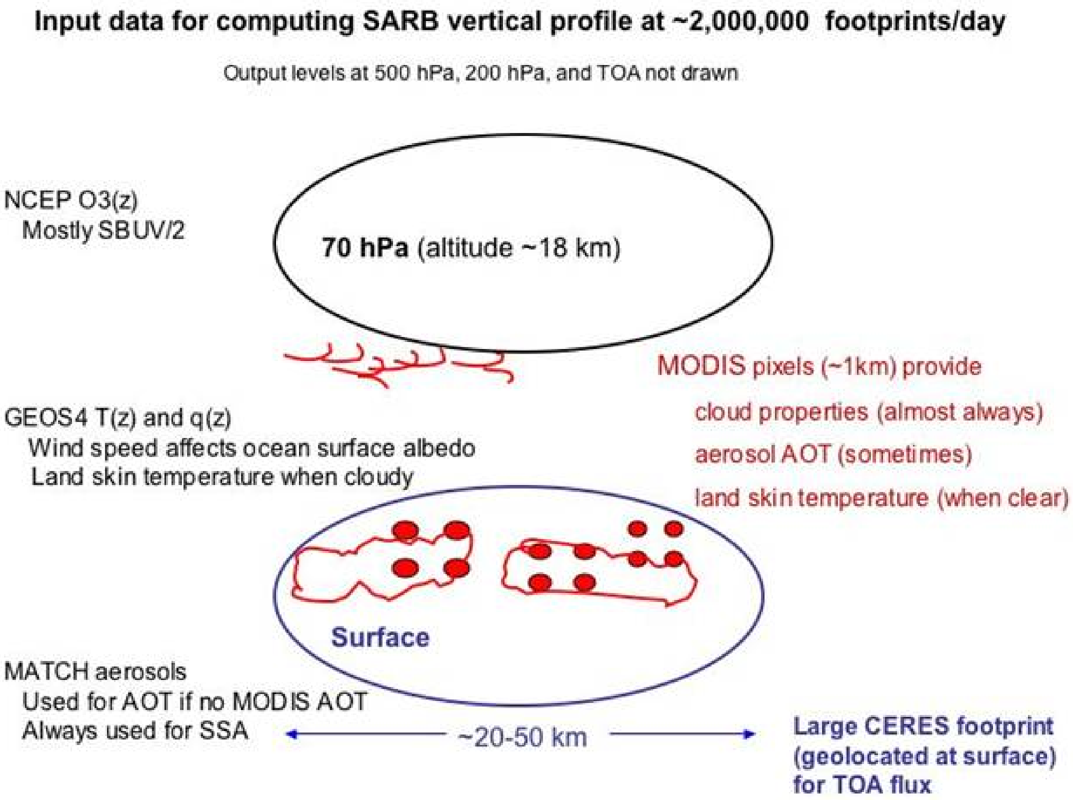


Figure 3: Inputs for determining the Surface and Atmosphere Radiation Budget (SARB)

If the reported fraction of cloudiness on the SSF file exceeds 0.05, the values of the third group of "other" (Table 1) parameters are frozen. The cloud optical depth, cloud fractional area, and cloud top height (second group in Table 1) are adjusted instead. Cloud optical depth is modified by adjusting liquid water path (LWP) or ice water path (IWP), rather than droplet or crystal size.

If the reported fraction of cloudiness on the SSF file is less than 0.05, the cloud parameters (second group in Table 1) are frozen, and the constrainment algorithm adjusts parameters from the third ("other") group in Table 1. For such clear and almost clear footprints over the ocean (note "ocean" column at the bottom of Table 1), the constrainment adjusts the surface skin temperature, lower tropospheric humidity (LTH), upper tropospheric humidity (UTH), and aerosol optical depth (AOD). For such clear and almost clear footprints over land, the surface albedo is also adjusted; and the sigma (a priori uncertainty) for skin temperature is increased, causing a larger adjustment in skin temperature over land than over ocean. The SARB algorithm does not adjust temperature above the surface.

Every CRS footprint has TOA parameters (first box in Table 1) with observed values taken from SSF, tuned values for the fluxes, and adjustments to the fluxes from the constrainment process. Every CRS footprint has input values for cloudy parameters (second box in Table 1) which are taken from SSF and "other" parameters (third box in Table 1); and it has slots for the adjustments to each of these parameters by the constrainment process. This is summarized in Figure 1. For a discussion of observed TOA parameters (first box in Table 1) or unadjusted cloudy or clear parameters (second and third boxes in Table 1), note the SSF Quality Summary. A single SSF FOV can consist of a fraction which is free of clouds, a second fraction with cloud 1, and a third fraction with cloud 2; clouds 1 and 2 would have different distributions of optical depth, different altitudes of top and base and particle size; clouds 1 and 2 could have different phases. A single SSF FOV may also consist of clear sky only; clear sky and cloud 1 only; or cloud 1 only. At present, clouds 1 and 2 do not overlap.

What is the implication of an assigned sigma of 1.0% for broadband LW flux versus 2.0% for window WN flux versus 5.0% for filtered window radiance (top group in Table 1)? Among those 3 parameters, broadband LW flux (OLR) has the smallest sigma. Thus OLR is the tightest constraint among those 3 parameters. Adjustable parameters like cloud optical depth and surface skin temperature are pulled more toward new values causing a better match between computed and observed OLR (sigma 1%), than they are pulled to new values causing a better match between computed and observed filtered window radiance (sigma 5%). The large sigmas of 5% for the broadband LW and filtered window radiances in Table 1 in fact produce hardly any adjustments in direct response to the radiances. The smallest sigmas (1%) are assigned to broadband reflected SW and to broadband LW fluxes, as they are the primary earth radiation budget (ERB) observables. If we had less confidence in the inversion from radiance ($Wm^{-2}sr^{-1}$) to flux (Wm^{-2}) on the CERES SSF record, the sigmas of broadband LW flux and broadband LW radiance could hypothetically be reversed. There is no sigma for reflected SW radiance because our fast radiative transfer code does not simulate SW radiance.

Table 1: The a priori uncertainty ("sigma") for each adjustable parameter in the constraint (tuning) algorithm that produces the Surface and Atmosphere Radiation Budget (SARB) for CERES footprints

Observed by CERES at TOA (SSF record)			
TOA parameters	**Sigma (%)**	**Minimum sigma (MKS)**	**Parameter**
	1.0 %	2.0 Wm^{-2}	reflected SW flux
	1.0 %	2.0 Wm^{-2}	broadband LW flux
	2.0 %	1.0 Wm^{-2}	window WN flux
	5.0 %	0.3 Wm^{-2} sr^{-1}	broadband LW radiance
	5.0 %	0.3 Wm^{-2} sr^{-1}	filtered window radiance
From MODIS imager (SSF record)			
Cloud parameters	**Sigma**		**Adjustable parameter**
	0.15		d ln(τ) τ = cloud optical depth
	2.0		cloud top temperature
	0.05		total cloud fraction in footprint
	0.025		fraction swap of 2 types in footprint (i.e., increase Cu and decrease Ci)
From various sources			
Other parameters	**Ocean**	**Land**	**Adjustable parameter**
	1.0 K	4.0 K	surface skin temperature
	0.15	0.10	d ln(PW) PW: surface to 500 hPa
	0.15	0.10	d ln(UTH) upper tropos. humidity
	0.002	0.015	surface albedo
	0.50	0.10	d ln(τ) τ = aerosol optical depth

Definitions of SW, LW, and Window

CERES geophysical products define SW (shortwave or solar) and LW (longwave or thermal infrared) in terms of physical origin, rather than wavelength. We refer to the solar energy which enters and exits (overwhelmingly by reflection) the earth-atmosphere system as SW. LW is regarded as the thermal energy which is emitted by the earth-atmosphere system. There is no wavelength of demarcation, for which all radiation at shorter (longer) wavelengths is called SW (LW). Thus defined, roughly 1% of the incoming SW at TOA is at wavelengths longer than 4 µm. A small amount of radiation from the sun enters the troposphere at 10 µm. This too is regarded as SW, and we strive to account for it in successive SW products. Less than 1 Wm^{-2} of OLR is at wavelengths below 4 µm. If the radiation was originally emitted by a thermal process in the earth-atmosphere system, we regard it as LW, even if it is subsequently scattered. When a small amount of thermal radiation is emitted from the surface of the Sahara at 6 µm, and a portion of that is scattered upward to space through a cirrus cloud, said portion is regarded as LW. The 8.0-12.0 µm window (WN) products are a repository of the thermal radiation in the window. We strive to eliminate any signal of solar contamination in an 8.0-12.0 µm window or broadband LW product.

The official CERES window (WN) spans 8.0 µm to 12.0 µm (1250 cm^{-1} to 833.333 cm^{-1}). The TOA observed SSF window products use this interval, as do the TOA emulated window product. CRS users should be aware that the vertical profiles of window flux use a DIFFERENT spectral interval, 8.0 µm to 12.5 µm (1250 cm^{-1} to 800 cm^{-1}), as explained in the next section.

Radiative Transfer Code

CRS uses a fast, plane parallel correlated-k radiative transfer code (Fu and Liou, 1993, Fu et al., 1997, 1999) which has been highly modified. It is referred to as the "Langley Fu-Liou code". An economical 2 stream calculation is used for SW. The LW calculation employs a 2/4 stream version, wherein the source function is evaluated with the quick 2-stream approach, while radiances are effectively computed at 4 streams. Constituents for the thermal infrared include H2O, CO2, O3, CH4 and N2O. A special treatment of the CERES 8.0-12.0 µm window includes CFCs (Kratz and Rose, 1999) and uses the Clough CKD 2.4 version of the H2O continuum (the original Fu-Liou employed the Roberts continuum). In collaboration with Dr. Qiang Fu, the Fu-Liou code was modified to include 10 separate bands between 0.2-0.7 µm to better account for the interaction of Rayleigh scattering, aerosols, and absorption by O3 and a minor band of H2O. In cooperation with Dr. Seiji Kato, we have included the HITRAN2000 data base for the determination of correlated k's in the SW (Kato et al., 1999). We make a first order accounting for the inhomogeneity of cloud optical thickness (using the gamma weighted two stream approximation of Kato et al., 2005) in the SW; the gamma distribution is parameterized with the logarithmic mean and standard deviation of the cloud optical depth from SSF. The original code included SW from 0.2 to 4 µm. In addition, we cover the SW at wavelengths larger than 4 µm by simply stuffing the solar insolation beyond 4 µm into a near IR band with strong absorption by H2O. Downwelling solar photons at wavelengths larger than 4 µm are then mostly absorbed by the model before reaching the middle troposphere. Scattering by cloud particles, aerosols, and a non-black surface is parameterized in LW, as well as SW. For example, the desert surface has reduced thermal emission as it is non-black. As its emissivity is less than unity, the reduction in upward LW emitted by the surface is partly compensated by reflection of the downwelling LW to the surface. The code has been extended with a new band to cover thermal emission from 2200-2850 cm^{-1}.

The Fu-Liou code covers the window with 3 bands from 8.0 µm to 12.5 µm (1250 cm^{-1} to 800 cm^{-1}); vertical profiles of window flux use this interval. A different window interval, 8.0 µm to 12.0 µm (1250 cm^{-1} to 833.333 cm^{-1}), is used for TOA observations on SSF and for the formal TOA emulations. The 8.0 µm to 12.0 µm TOA window parameters on SSF are emulated (modeled) as follows with the Langley Fu-Liou code. First, the code produces window radiance and flux for 8.0 µm to 12.5 µm at TOA; the modeled radiance and flux constitute a theoretical Angular Distribution Model (ADM relating radiance to flux) for the footprint. Second, a straightforward parameterization based on MODTRAN4 is then applied; the inputs are view zenith angle and radiance. The parameterization maps the 8.0 µm to 12.5 µm Fu-Liou radiance to an "unfiltered" (geophysical) 8.0 µm to 12.0 µm emulated radiance and also to a "filtered" 8.0 to 12.0 µm emulated radiance. Recall that the spacecraft itself observes a filtered radiance, a signal which includes the effect of the spectral response of the instrument. It is the task of SSF to account for the spectral response and produce an unfiltered radiance. In the second step here, the spectral response (filter function) of the instrument is modeled, producing an emulated filtered window radiance. Third, the theoretical ADM (based on 8.0 µm to 12.5 µm) converts the unfiltered 8.0 µm to 12.0 µm emulated radiance into an emulated window flux. The unfiltered, emulated window radiance is not archived.

While the original Fu-Liou code offered empirical droplet size spectra based on early field campaign data, we now use theoretical, gamma distributions for the radii of cloud water droplets (Hu and Stamnes, 1993), consistent with the Minnis et al. (2002) retrievals on CERES SSF input stream. The code treats all ice cloud crystals as randomly oriented hexagons characterized by a generalized effective diameter D_{ge}. The SSF cloud retrievals also assume randomly oriented hexagons but express them as effective diameter D_e. Caution is advised when interpreting CRS results for ice clouds, as both the input cloud retrievals (SSF) and the radiative transfer calculations do not account for the enormous variation of crystal shapes found in nature.

The typical CRS calculation uses 30 atmospheric layers with fixed thickness layers of 10 hPa and 20 hPa nearest the surface. The remainder are placed on a sliding scale following the input value for surface pressure. Additional layers, at levels "custom made" for each footprint, are inserted in the radiative transfer calculation for cloud top and cloud bottom. Edition2B CRS places the cloud top as per the pressure top retreived by SSF. The SSF estimate for cloud geometrical thickness is used to specify cloud bottom.

Reflection of SW by Surface

The spectral dependence of surface reflectivity for land surface albedos are specified according to the CERES Surface Properties maps (from CERES/SARB Surface Properties web site) following Rutan and Charlock (1997 and 1999). CRS uses the Wilber et al. (1999) surface LW spectral emissivity maps (which are available at the same URL). Both SW and LW surface maps are keyed to International Geophysical Biospherical Project (IGBP) land types. For the category of Permanent Snow and Ice, the spectral shape of reflectance is taken from a model by Jin et al. (1994) assuming 1000 µm snow grains; a grain size of 50 µm is assumed for the spectral shape of fresh snow. The spectral shape of sea ice also employs Jin et al. (1994).

Ocean spectral albedo is obtained using a look up table (LUT) based on discrete ordinate calculations with a sophisticated coupled ocean atmosphere radiative transfer code (Jin et al., 2002, Jin and Stamnes, 1994). Inputs to the look-up table for ocean spectral albedo include cosine of the solar zenith angle (cosSZA), wind speed (from GMAO), chlorophyll concentration (which has a minor effect on broadband flux), and SW optical depth of clouds and aerosols (from SSF) for the respective spectral interval. There is an empirical correction for surface foam based on wind speed.

For clear footprints over land during daytime, the broadband surface albedo is explicitly retrieved using TOA observations and iterations of the Langley Fu-Liou code with the constrainment algorithm; the broadband albedo is then simply a ratio of upwelling to downwelling SW at the surface. When a CRS footprint contains clouds, the broadband surface albedo is assumed using the Surface Albedo History (SAH) procedure. The SAH algorithm is run at the start of each month of CRS processing. SAH identifies the clear SSF footprints during the month with the most favorable geometry for the retrieval of surface albedo: those with large values of cosSZA. SAH uses a quick table look-up to the Langley Fu-Liou code that relates TOA albedo, surface albedo, cosSZA, precipitable water (PW), and aerosol optical depth (AOD). Using the footprint AOD (from MODIS or the MATCH aerosol assimilation), the look-up retrieves a first guess surface albedo for the month. This first guess surface albedo corresponds to a clear SSF/CRS footprint. The monthly value for the first guess surface albedo is then written to a SAH file for each of the 10 by 10 minute gridded tiles, whose center points are contained in the clear footprint. Each 10 by 10 minute gridded tile of land is thus given an initial broadband surface albedo for the month. The SAH albedo is stored internally as a reference value A_o using the Dickinson (1982) relationship

$A(cosSZA) = A_o(1 + d)/(1 + 2d\ cosSZA)$

where d is specified for each IGBP type and A_o is the albedo at cosSZA of 0.5. The look-up, first guess values of A_o for the various 10 by 10 minute tiles are then available to construct a fixed broadband surface albedo as an input for radiative transfer calculations with any cloudy footprint, for which we assume A(cosSZA=0.5). The quality of the surface albedo retrieval depends heavily on the value of the observed TOA flux reported on SSF, and on the realism of simulation of AOD and the CRS assignment of the corresponding single scattering albedo (see next section). The most reliable CRS values of surface albedo are expected for clear footprints under high sun, in regions and seasons with low AOD.

When a land surface broadband albedo for all-sky conditions is not available from the Surface Albedo History (SAH) resouce, a default broadband surface albedo is then assigned using the CERES Surface Properties maps (from www-surf.larc.nasa.gov/surf) keyed to the IGBP land types. At a given location, the surface albedeo then changes only with the effective SZA (the Dickinson relationship above). The effective SZA varies with both season and cloudiness.

The Photosynthetically Active Radiation (PAR) product, which is generated only at the surface, is simply the SW output from 437.5 to 689.6 nm, rather than the traditional PAR interval of 400-700 nm. To date, we have not compared this non-traditional PAR with any surface observations.

Treatment of Aerosols

Each footprint accounts for the effect of aerosols on SW fluxes, LW fluxes and 8.0-12.0 µm window fluxes at all levels, and on broadband LW and filtered window radiance at TOA. Aerosol information is taken from MODIS (MODIS Atmospheres MOD04 product described by Kaufman et al., 1997) when available for the instantaneous CERES footprints. Over the ocean, MOD04 is used for 7 wavelengths; the AOD is interpolated to the remainder of the spectrum using the selected aerosol type, as specified below. Over land, MOD04 provides AOD at 3 wavelengths, and the MOD04 Angstrom exponent is used to guide the extension over the spectrum. If MOD04 instantaneous AOD is not available for the footprint, we temporally interpolate from a file of the MODIS Daily Gridded Aerosol as noted earlier. When footprint cloudiness exceeds 50%, or when there is no MODIS AOD, we use AOD from the NCAR Model for Atmospheric Transport and Chemistry (MATCH, an assimilation that here also employs MODIS, see Fillmore et al., 2004 and Collins et al., 2001). MOD04 does not span the entire globe; it does not include the cryosphere and most deserts, for example. When AOD is taken from MATCH, we assume it for one wavelength only, 0.63µm. MATCH provides aerosols on a daily basis over the globe for all sky conditions. Sources of aerosol in MATCH include formation from industrial emissions (as a climatology). More timely MATCH AOD inputs include MOD04-based retrievals over clear regions; and an algorithm for wind-blown dust. MATCH itself accepts the NCEP analysis as an meteorological input. MATCH advects aerosols and removes aerosols with wet (cloudy) and dry (deposition) processes.

While AOD is based on either MOD04 (a satellite retrieval) or MATCH (a model), aerosol type is always taken from MATCH. Aerosol type here guides the selection of the asymmetry factor (g) and the single scattering albedo (SSA). CRS distributes the MATCH aerosols into 7 types: small desert dust, large desert dust, black carbon (soot), soluble organic carbon, insoluble organic carbon, sulfate, and sea salt. In the earlier Terra CRS Edition 2A, the spectral single scattering albedos and asymmetry factors are assumed from the Tegen and Lacis (1996) and OPACS-GADS (Hess et al., 1998; d'Almeida et al., 1991) models. The present Edition 2B uses a revised treatment of desert dust, courtesy of Dr. Andrew Lacis at NASA GISS (personal communication), which has reduced absorption in SW (Charlock et al., 2005). The earlier Terra CRS Edition 2A placed each of the 7 aerosol types in the vertical column using their respective global mean scale heights; the present Edition 2B uses explicit height profiles from MATCH which are typically different for each aerosol type, each day, and each location. The height profile effects the LW forcing, which can be significant regionally for larger aerosol particles like dust and sea salt, at both surface and TOA. The vertical placement of aerosols relative to clouds can have a strong effect on the absorption of SW by dust, black carbon, and insoluble organic carbon. The 7 aerosol types are treated as external mixtures, as are aerosols and clouds.

Recent studies with the fairly reliable inversions of ground-based AERONET data (i.e., Dubovik et al., 2002) suggest that absorption of SW by desert dust has a strong regional dependence which cannot be explained by simple differences in size distribution alone. CRS does not account for such regional dependence, nor does it account for the effect of internal mixing of constituents like sulfate and black carbon. Such internal mixtures can increase absorption by a factor of two or more (Fuller et al., 1999).

Comparison of computed radiation with observations at TOA

CERES measurements of radiances ($Wm^{-2}sr^{-1}$) at satellite altitude are reported on the SSF file, a key source for the computed radiation fields reported here on CRS. Observed broadband SW, broadband LW (OLR) and window (8-12 µm) fluxes (irradiances in Wm^{-2}) at the top of the atmosphere (TOA) reference level are inverted from measured radiances at the respective footprints; this is done on SSF by means of Angular Distribution Model (ADM) statistics from many footprints with similar characteristics (Loeb et al., 2000). SSF also has CERES' own, purpose-built cloud retrievals (Minnis et al., 2002) from small MODIS pixels within each large broadband footprint; the MODIS data used for cloud retrievals are a spatial subset (1 of every 8 pixels). Terra CRS is based on a routine subset of every second SSF footprint. There are actually two distinct CERES instruments on Terra (called FM1 and FM2) and two on Aqua (FM3 and FM4). CRS is generally processed for the CERES instrument which is on a cross track scan; the cross track scans are used to map the globe. On a typical day, the second CERES instrument will have a different scan pattern (i.e., Rotating Azimuth Plane Scan or RAPS), in order to build up ADM statistics or gather data for other studies. To determine which CERES instrument is operating in a particular scan pattern on a given day, refer to CERES Operations in Orbit. Terra passes the equator around 1030 local (day) and 2230 local (night).

Table 2 compares CRS calculations with SSF observations; these are raw comparisons of footprints for one day and have not been gridded to correctly represent particular regions of the globe. A raw comparison gives equal weight to footprints regardless of view zenith angle (VZA); a footprint at large VZA covers more geographical area than does one at nadir. Further, the scan pattern of CERES causes the raw statistics of Table 2 to be over-weighted at higher latitudes; a point near either pole is more frequently sampled than is a point near the equator. The SW statistics in Table 2 represent daylight data only; the LW statistics cover day and night. For reflected SW in January 2001, untuned calculations have a bias of 10.5 Wm^{-2} (the calculations reflect about 4% more than the observations) and a standard deviation of 21.6 Wm^{-2}. We regard the mean untuned bias for SW as quite good; it attests to the high quality of the cloud retrievals used to compute CRS. The substantial standard deviation of 21.6 Wm^{-2} is primarily due to the simplifications of the 2-stream calculation, the noise of obtaining the observed flux with a statistical ADM, the 1 in 8 spatial subsampling of MODIS in the SSF cloud retrieval (the input for the 2-stream calculation), and the noise in the cloud retrieval.

The bias for untuned OLR in January 2001 (Table 2) is unusually good at only 0.3 Wm^{-2} (standard deviation: 8.0 Wm^{-2}). Application of the constrainment (which also yields the reported fluxes within the atmosphere) reduces the daylight SW bias from the untuned 10.5 Wm^{-2} to the tuned 2.4 Wm^{-2}, but slightly increases the day plus night OLR bias 0.4 Wm^{-2}. Why has the OLR bias increased with tuning? Table 2 does not give separate day and night values for OLR bias. Day OLR bias for untuned (tuned) is 1.0 Wm^{-2} (0.8 Wm^{-2}); night OLR bias for untuned (tuned) is -0.5 Wm^{-2} (0.0 Wm^{-2}). The small value of day plus night OLR bias (0.3 Wm^{-2}) is a fortuitous result of the compensation of the day and night biases. (Our raw statistics do not have 50% day and 50% night, so the day and night values are equally weighted). The day tuned OLR bias (0.8 Wm^{-2}) has hardly budged from the untuned bias (1.0 Wm^{-2}), because the day tuning, which also adjusts SW (from the huge untuned bias of 10.5 Wm^{-2} to the tuned 2.4 Wm^{-2}) by reducing cloud optical depth (Table 1), pulls some cloud property adjustments in the opposite direction.

What about catching climate change with either observations or calculations? Or producing a set of TOA observations that are closer to the near annual mean balance between incoming and outgoing predicted by climate theory? While the ungridded approach in Table 2 is not entirely appropriate for this, there are still a few hints. Note that the observed value of daytime reflected SW decreased, as if the planet darkened, from 252.4 Wm^{-2} in January 2001 to 251.5 Wm^{-2}in January 2003. But the corresponding biases of untuned SW increased from 10.5 Wm^{-2} to 13.1 Wm^{-2}, as if the planet *brightened*. It should be noted that the untuned SW calculations are partly based on the CERES observations over land, where observations of clear sky scenes are used to retrieve surface albedo. But over ice-free ocean, the untuned fluxes are virtually independent of the values reported by the CERES broadband instrument, as ocean surface albedo is based on Jin et al. (2004). The untuned SW biases for ocean only (not in Table 2) are 11.4 Wm^{-2} in January 2001 versus 15.0 Wm^{-2} January 2003 (as if the planet brightened). While some of the biases in the calculations are large, trends in the calculations should not be summarily dismissed. The large discrepancies of computed and observed SW flux at a given time, and the smaller differences in trends of computed and observed SW, are being studied actively by the CERES Science Team.

Table 2: Raw statistics of TOA parameters for CRS Terra Edition 2B

Observations use cross track FM1	January 2001	January 2003
SW reflected in Wm^{-2}	252.4	251.5
Untuned bias (std. dev.)	10.5 (21.6)	13.1 (21.9)
Tuned bias (std. dev.)	2.4 (9.3)	2.9 (9.5)
OLR in Wm^{-2}	221.8	223.1
Untuned bias (std. dev.)	0.3 (8.0)	0.4 (7.8)
Tuned bias (std. dev.)	0.4 (4.5)	0.6 (4.3)
Window 8-12µm in Wm^{-2}	56.7	57.1
Untuned bias (std. dev.)	0.7 (3.6)	0.7 (3.6)
Tuned bias (std. dev.)	0.8 (2.3)	0.8 (3.6)
LW broadband radiance in $Wm^{-2}sr^{-1}$	72.5	72.9
Untuned bias (std. dev.)	-0.2 (2.6)	-0.2 (2.5)
Tuned bias (std. dev.)	-0.1 (1.5)	-0.1 (1.5)
SW statistics are daylight-only samples Other statistics are 24-hour samples Bias = (Computed) - (Observed by FM1)		

Comparison with Surface Observations

Retrievals of surface flux are here compared with surface-based observations which are available online through the CERES "ARM" Validation Experiment (CAVE) web site. CAVE (Rutan et al., 2001) provides high quality surface data at over 50 sites worldwide. About half of the sites are part of the ARM Southern Great Plains (SGP) network (Stokes and Schwartz, 1994. Many CAVE sites, such as the SGP Central Facility, and NOAA SURFRAD (Augustine et al., 2000) and CMDL stations, subscribe to the rigorous BSRN observing protocol (Ohmura et al., 1998). Each CAVE surface observation (CAVE Obs) is expressed as a 15-minute mean. We represent the surface flux over the large span of the satellite footprint by using an adjusted time mean of the point surface SW observation. While computed surface SW fluxes in the CRS record are "instantaneous" at their respective SZAs, we have adjusted observed SW surface fluxes in Table 3 with the formula

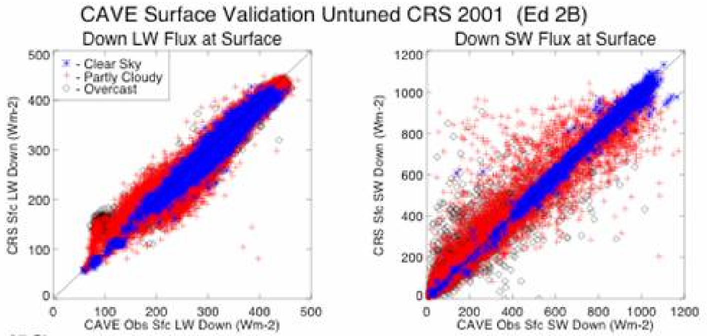
Obs SW flux in Table 3 = (CAVE Obs SW flux)*[cos(SZAceres)]/[15 min. mean cos(SZA)]

This converts the 15 minute mean observation to a value that represents the surface flux for the satellite observation. While observed values of TOA radiation are indeed used in constrainment (tuning), as explained earlier, measured values of surface radiation are NOT used for input or for constrainment (tuning). Hence the comparison of fluxes at the surface in Table 3 below is a "cold" test. To avoid excess representation of SGP in summary Table 3 below, we use only 5 of the SGP sites; this sample of sites is dubbed CAVE Validation Sites (CVS). While more representative than "all CAVE", CVS is hardly a fair global mean. Table 3 covers all months during 2001 excepting February. The six matrices represent all-sky (total-sky) conditions, conditions identified as clear using MODIS, conditions identified as clear using both MODIS and the surface-radiometer-based Long and Ackerman (L/AA) time series method, overcast conditions as per MODIS, and overcast as per both MODIS and the surface radiometers. Each matrix gives six fluxes; LW down at the surface (LW Dn Sfc), LW up at the surface (LW Up Sfc), SW down at the surface (SW Dn Sfc), SW up at the surface (SW Up Sfc), LW up at TOA (the OLR), and SW up at TOA. Columns give the observed mean, number of samples (N), the bias, standard deviation (as in Table 2), rms, modeled cloud forcing (computed total sky flux minus computed clear sky), and modeled aerosol forcing.

The third row of the first matrix in CVS Table 3 gives an observed insolation (SW Dn Sfc) of 444.3 Wm^{-2} for a 11204 samples (N) and has a bias of 13.1 Wm^{-2}. The computed mean insolation is approximately 3% larger than the measurements. The insolation bias of 13.1 Wm^{-2} represents only the daytime overpass at ~1030 local time, which is fairly high sun. The corresponding 24 hour mean insolation bias for the same sites would be reduced by a factor of 2 *at least*. Because the insolation can have a large spatial variation over a the 20-50 km CERES footprint, the rms error is much larger at 94.5 Wm^{-2}. Biases for the other all-sky fluxes are small, except for the reflected SW at the surface; here the error is large, simply because the albedo beneath a tower of height 10 m is unlikely to represent that of the CERES footprint. In particular, note the second matrix for clear footprints, whose final column gives the clear-sky aerosol forcing (-15.8 Wm^{-2}) as the difference of the computed clear sky flux (with aerosols) and the computed pristine flux (no aerosols). This estimate of surface aerosol forcing should be compared with the small bias for computed clear insolation (-0.4 Wm^{-2}). It appears that the estimate of mean aerosol forcing to clear sky insolation is reasonably accurate for the CVS sample. For cloudy sky, nature appears to absorb a few Wm^{-2} more than is predicted by the code. Finally, we note a fairly disappointing bias of -8.8 Wm^{-2} for downward LW at the surface under clear conditions.

Table 3 was taken directly from the CAVE web site. Analogous tables, for both tuned and untuned fluxes, are available at the CAVE URL for *each site and each month.* We stress that absolutely no surface radiometric data are used to compute untuned or tuned fluxes; ground-based radiometry is used for validation only; tuning is founded on satellite data. Users will find that untuned fluxes generally have smaller biases with respect to ground-based measurements, than do tuned fluxes.

We regard the calculations in Terra CRS Edition 2B as an advance over the earlier Edition 2A, which had a coarse, global mean profile for all aerosols; a crude allocation for the size distribution of desert dust; and an older treatment of single scattering albedo for desert dust. Desert dust accounts for a lion's share of global mean aerosol forcing. Saudi Solar Village is one site in the CVS sample that is strongly affected by desert dust. In the earlier Edition 2A, the bias for untuned surface insolation under clear skies was -52.3 Wm^{-2} at Saudi Solar Village in 2001; in Edition 2B, this bias is more respectable at -13.7 Wm^{-2}.



All Sky

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Mod Frc All-Clr	Forcing All-CNA
LW Dn Sfc	286.0	22420	-6.1	23.6	24.4	28.1	1.1
LW Up Sfc	353.5	10938	-3.6	25.1	25.4	--------	--------
SW Dn Sfc	444.3	11204	13.1	93.6	94.5	-113.9	-9.7
SW Up Sfc	112.8	5152	-18.4	51.2	54.4	--------	--------
LW Up TOA	218.8	22885	1.4	8.6	8.8	-20.7	-0.4
SW Up TOA	261.0	10873	10.7	26.1	28.2	80.7	3.4

Clear Sky MODIS

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Dif Bias CRS-Obs	AOT Frc Clr-Prs
LW Dn Sfc	291.5	3500	-8.7	14.2	16.7	--------	2.9
LW Up Sfc	400.0	2263	-0.7	20.7	20.7	--------	--------
SW Dn Sfc	726.1	1801	-0.4	30.5	30.5	--------	-15.8
SW Up Sfc	154.1	1048	-22.7	28.6	36.5	--------	--------
LW Up TOA	274.8	3597	-0.3	5.2	5.2	--------	-1.1
SW Up TOA	196.5	1844	-0.2	5.7	5.7	--------	5.9

Clear Sky MODIS & L/AA

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Dif Bias CRS-Obs	AOT Frc Clr-Prs
LW Dn Sfc	283.9	569	-12.5	14.4	19.0	--------	1.7
LW Up Sfc	439.3	497	-0.7	20.3	20.3	--------	--------
SW Dn Sfc	702.9	567	-0.3	19.1	19.1	--------	-14.1
SW Up Sfc	148.4	489	-20.4	24.0	31.5	--------	--------
LW Up TOA	285.0	574	0.6	5.5	5.5	--------	-0.8
SW Up TOA	174.6	572	-0.2	5.7	5.7	--------	4.4

Overcast MODIS

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Mod Frc All-Clr	Forcing All-CNA
LW Dn Sfc	313.2	4732	-7.7	24.2	25.4	45.2	0.4
LW Up Sfc	339.1	2328	1.5	22.3	22.4	--------	--------
SW Dn Sfc	241.3	2552	23.8	99.8	102.6	-274.4	-4.8
SW Up Sfc	73.8	1203	-10.6	52.3	53.3	--------	--------
LW Up TOA	178.0	4825	1.5	10.0	10.1	-55.5	-0.1
SW Up TOA	390.6	2508	15.9	28.3	32.5	204.8	0.3

Overcast MODIS & L/AA

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Mod Frc All-Clr	Forcing All-CNA
LW Dn Sfc	349.1	870	-5.1	15.0	15.8	52.8	0.3
LW Up Sfc	364.0	676	5.1	19.9	20.6	--------	--------
SW Dn Sfc	212.3	868	29.0	106.4	110.2	-406.1	-5.4
SW Up Sfc	46.9	647	-4.0	53.2	53.3	--------	--------
LW Up TOA	186.8	863	4.5	10.3	11.2	-60.7	-0.1
SW Up TOA	478.0	871	12.2	27.7	30.3	318.9	-0.2

Table 3: Comparison of untuned SARB (computed fluxes) with ground-based (Sfc) radiometric measurements and CERES (TOA) observations for 2001. Table and figures taken directly from www-cave.larc.nasa.gov/cave/ homepage, which has them for each site and each month.

User Applied Revisions for Current Edition

The purpose of User Applied Revisions is to provide the scientific community early access to algorithm improvements which will be included in the future Editions of the CERES data products. The intent is to provide users simple algorithms along with a description of how and why they should be applied in order to capture the most significant improvements prior to their introduction in the production processing environment. ***It is left to the user to apply a revision to data ordered from the Atmospheric Science Data Center.*** Note: Users should never apply more than one revision. Revisions are independent.

CRS Edition2B-Rev1

The end product of Terra CRS Edition2B, is a "tuned" flux, which has been constrained to more closely approach CERES observations at TOA by modifying inputs like cloud optical depth, surface albedo, etc. Tuned CRS fluxes are hardly ever equal to observed SSF fluxes. Untuned CRS fluxes can be obtained by subtracting the "adjustment" from the "tuned" flux; the tuned fluxes and the adjustments are archived. Over land and over the cryosphere, even the untuned fluxes are affected by the CERES TOA observations of SW, as they are used to estimate surface albedo. Over the ice-free ocean, CERES TOA SW observations do not affect untuned CRS calculations. In the mean over Ice-free ocean, CRS untuned SW calculations at TOA are closer to the Rev1 corrected observations, than they are to original SSF observations.

The CERES Science Team has approved a table of scaling factors known as Rev1. When a user orders a CRS file, an SSF file will come automatically attached; the file has SSF parameters first, then CRS parameters. The broadband SSF observations should be corrected as per user revision instructions.

This revision is necessary to account for spectral darkening of the transmissive optics on the CERES SW channels. By June 2005, this darkening has reduced the average global all-sky SW flux measurements by 1.1 and 1.8 percent for Terra FM1 and FM2 data respectively. A complete description of the physics of this darkening appears in the CERES BDS Quality Summaries under the Expected Reprocessing section. After application of this revision to the Edition2B CRS data set, users should refer to the data as Terra Edition2B-Rev1 CRS.

Cautions and Useful Hints

- Terra CRS Edition2B has a sporadic bug relating to the input for AOD. Terra CRS Edition2F and Aqua Edition2B/2C do not have this bug. When the bug is active, there can be signicant error in the computed flux. As noted in the section Treatment of Aerosols, AOD for a footprint is taken from one of following soures: (1) an instantaneous retrieval by either MOD04 or CERES within the footprint, (2) an interpolation by CRS of the MODIS Daily Gridded value, or (3) the MATCH assimilation. Some of the interpolations of the MODIS Daily Gridded value (2) are faulty. The defect is due to CRS software (and not the MODIS Daily Gridded files provided by GSFC). To avoid the bug entirely, do not use footprints having a value of 500 or greater for SDS Terra-232 ("Aerosol and surface albedo sources"); those footprints use the CRS interpolation of MODIS Daily Gridded AOD. Most footprints with values of 500 or greater for Terra-232 are okay; but some have wild numbers for AOD.

  The sporadic consequences of the AOD bug in Terra CRS Edition2B are apparent in Figure 4, which covers clear-sky fields of view (FOV or footprint) over ice-free ocean. "AOT" in Figure 4 denotes AOD (aerosol optical depth) at 550nm. Several years of monthly-averged data are plotted. The bug-free AOD from Terra CRS Edition2F and Aqua Edition2B/2C are shown for comparison. In Figure 4, Terra CRS Edtiion2B ends in month 74 (April 2006), and Terra CRS Edition2F starts in month 75 (May 2006). Note the large, odd values of AOD in Terra CRS Edition2B for a few months before and after month 70 (December 2005); and also in month 39 (June 2003).

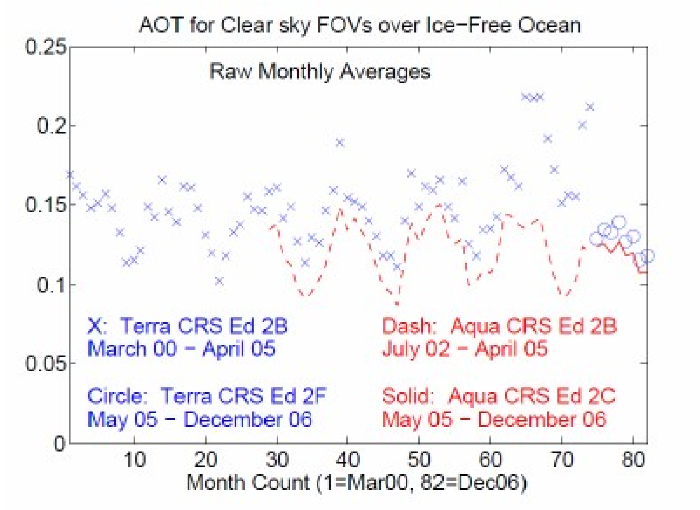


Figure 4: AOT for Clear sky FOVs over Ice-Free Ocean

Table 4: Relative bias of untuned calculation for SW reflected at TOA.
Terra CRS Edition 2B clear-sky ocean, daytime only.
CERES observations not adjusted by Rev1 or Beta15.

Date	Observed (W/m**2)	Relative Bias	AOD/source	N
20051015	86.1	16.8 %	0.30 / Interpolated	8565
20051015	84.5	7.4 %	0.17 / All sources	25931
20051020	85.2	18.6 %	0.33 / Interpolated	7714
20051020	84.6	8.0 %	0.19 / All sources	23008
20041006	85.6	2.6 %	0.15 / Interpolated	12692
20041006	83.6	3.4 %	0.13 / All sources	21750
20041011	86.9	6.6 %	0.20 / Interpolated	15205
20041011	85.2	6.2 %	0.17 / All sources	25613

Faulty AOD in the clear-sky ocean domain of Figure 4 can have a sharp impact on the computed SW at TOA. This is illustrated by the dashed lines in the right panel of Figure 5, where the untuned bias for Terra CRS Edition2B over clear ocean sharply increases about month 70 (December 2005). Similar features are noted in the right panel when official Rev1 adjustments to observations are made (the solid line with MattewsBeta15 is an unofficial test). The left panel of Figure 5 for all-sky ocean indicates that clouds can mask some of the impact of a faulty AOD. The AOD bug is diagnosed further in Table 4, which covers two days during October 2005 (when the bug is notable on the monthly scale of Figure 4) and two days during October 2004 (which appears as "bug free" in a monthly-average gloss).

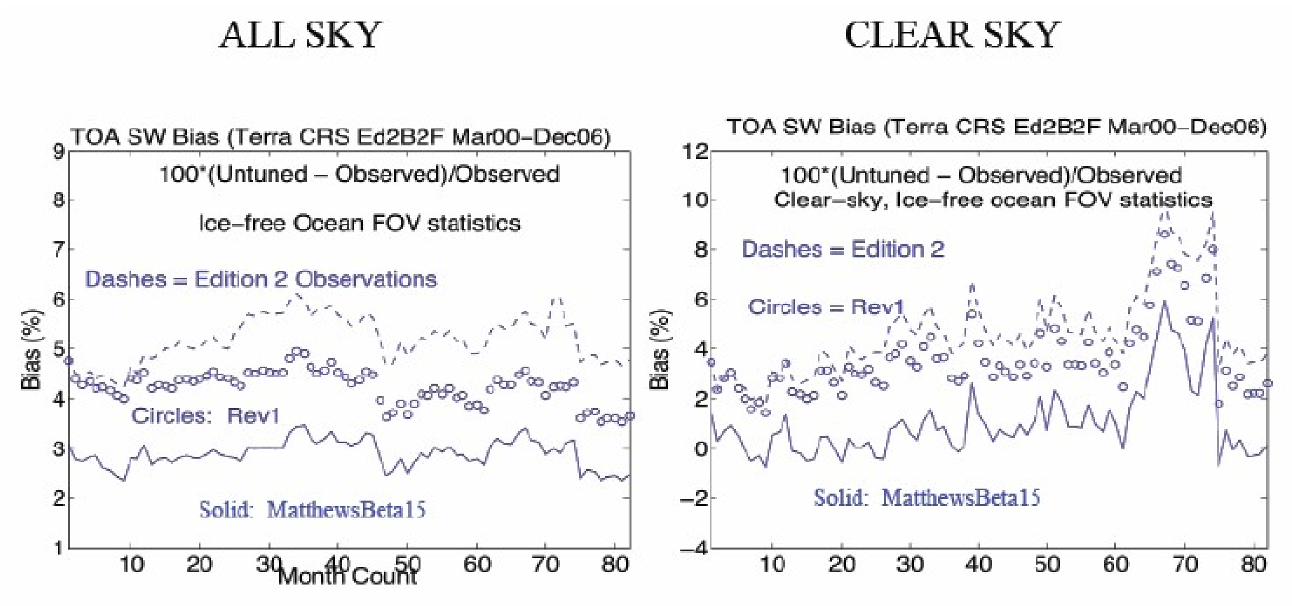


Figure 5: Relative Bias of Calculated SW at TOA for Ice-free Ocean
Compute monthly average, deseasonalize, then form bias.
March 2000 (month 1) to April 2006 (month 74): Edition2B
May 2006 (month 75) to December 2006 (month 82): Edition2F

Figure 6 indicates that the AOD bug affects land sites, too, but to varying degrees. "AOT" in Figure 6 denotes AOD (aerosol optical depth). Monthly averaged biases for the untuned clear-sky SW insolation at the ARM Southern Great Plains (SGP is blue in Figure 6) show little apparent effect due to the use of interpolated MODIS Daily Gridded AOD (the large bias in month 48 is explained by unusually inhomogeneous snow cover for a few days in February 2004). But for 25 other CAVE sites (red), the solid lines (using interpolated MODIS Daily Gridded) have much more bias than the dashed lines (using other sources for AOT).

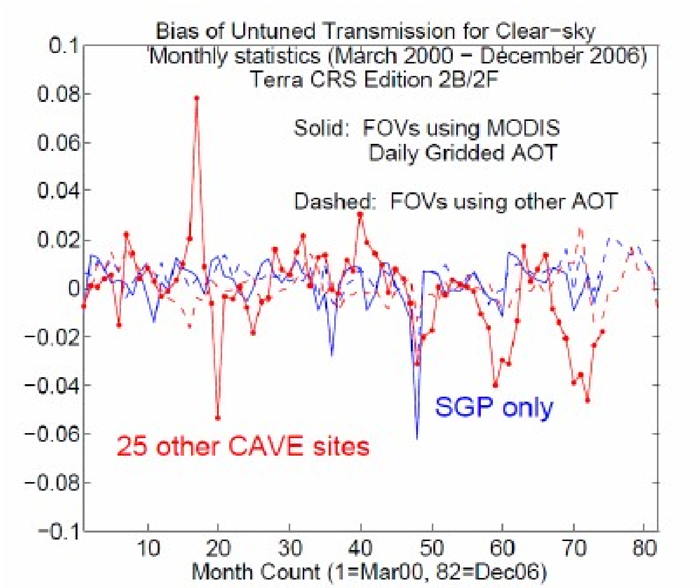


Figure 6: Bias of Untuned Transmission for Clear-sky

Table 5: Comparison for May 2006: Terra CRS Edition 2B (has bug) versus *Terra CRS Edition 2F (no bug)*.
Edition 2B uses MODIS Collection 4 aerosols and CRS employs an in-house interpolation of MODIS AOD for some footprints.
Edition 2F uses MODIS Collection 5 aerosols and does not employ the interpolation of AOD mentioned above

Quantity	Domain			
	Globe		Ocean	
	All Sky	Overcast	All Sky	Clear Sky
Observed upwelling SW at TOA (W/m**2)	119.0	153.8	102.6	42.2
	119.2	*154.2*	*102.8*	*42.5*
Relative bias of untuned TOA calculation	3.0 %	3.0 %	5.6 %	8.4 %
	2.3 %	*2.8 %*	*4.7 %*	*2.7 %*
AOD for untuned calculation	0.17	0.14	0.14	0.21
	0.12	*0.12*	*0.11*	*0.13*
Tuned calculation of SW insolation (W/m**2)	240.2	149.4	247.2	392.8
	242.0	*149.8*	*248.4*	*397.1*

Table 5 compares monthly averaged results from Terra CRS Edition2B (which allows the use of interpolated MODIS Daily Gridded AOD) and Terra CRS Edition2F (which uses only instantaneous retrievals of AOD or values from MATCH) for the same month, May 2006. The bug is not found in Terra CRS Edition2F. Edition 2B and 2F differ on yet other accounts: Edition 2B (2F) uses MODIS collection 4 (5) radiances for retrievals of both clouds and AOD. Edition 2F also uses an upgraded algorithm for the retrieval of AOD (MODIS Atmosphere Team). These "other accounts" explain the very small differences in the CERES observed TOA fluxes (see first two rows of Table 5, where Edition 2F uses italic font). The last column of Table 5 shows a much reduced bias for untuned SW over clear ocean in Edition 2F (8.4%) versus Edition 2B (2.7%). While Editions 2B and 2F differ less for all-sky fields, there are still some differences for overcast sky in Table 5.

- Bug in All-Sky Land Surface Albedo for All-sky

A bug has been found in the Terra CRS Edition2B land surface albedo for all-sky conditions from June 2001 to March 2003. Terra CRS Edition2F and Aqua CRS Edition2B/2C do not have this bug. All-sky (ie., cloudy) surface albedo for a footprint is typically obtained from the Surface Albedo History (SAH), which stores surface albedo retrieved for that location under clear conditions during that month. For most of the land footprints during June 2001 to March 2003 (and apparently during this interval only), the SAH albedos did not load into the Terra CRS Edition2B processing stream. Lacking the SAH resource, land broadband surface albedos for all-sky conditions were then obtained by the default procedure described at the end of the section Reflection of SW by Surface. This bug does not affect surface albedos for clear-sky footprints, which are retrieved using the procedure described in Rutan et al. (2009).

The bug in all-sky surface albedo has a strong impact on land footprints with large surface albedo (as an accurate value for this quantity is then more critical for reflected flux) and limited cloud forcing (where errors in surface albedo are not masked by cloud effects). Tamanrasset Algeria in the Saharan Desert is such a location. Note the all-sky surface albedo at Tamanrasset produced by the June 2001 to March 2003 bug in Figure 7. The consequences for the computed all-sky TOA albedo at Tamanraseet are even more conspicuous (Figure 8). The impact on computed all-sky TOA albedo over the ARM SGP sites, where surface reflection is smaller and cloud forcing is larger, is muted by comparison (Figure 9). For the mean of global land footprints, the surface albedo bug increases the relative bias in the untuned, computed all-sky SW flux at TOA (Figure 10).

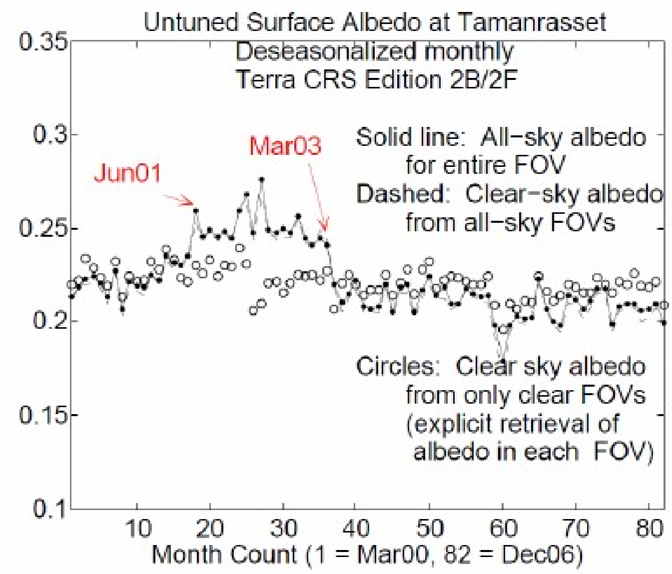


Figure 7: Untuned Surface Albedo at Tamanrasset

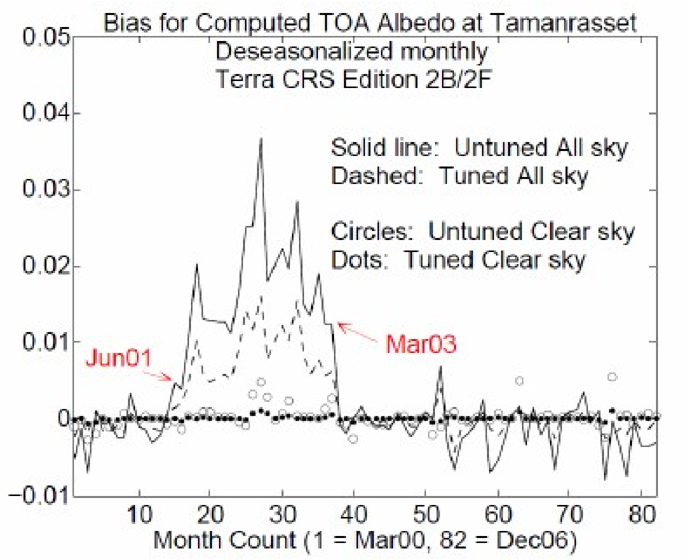


Figure 8: Bias for Computed TOA Albedo at Tamanrasset

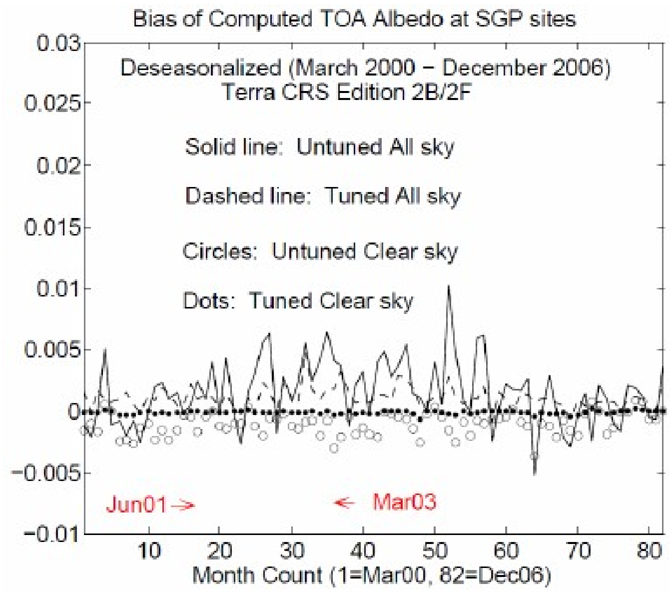


Figure 9: Bias of Computed TOA Albedo at SGP Sites

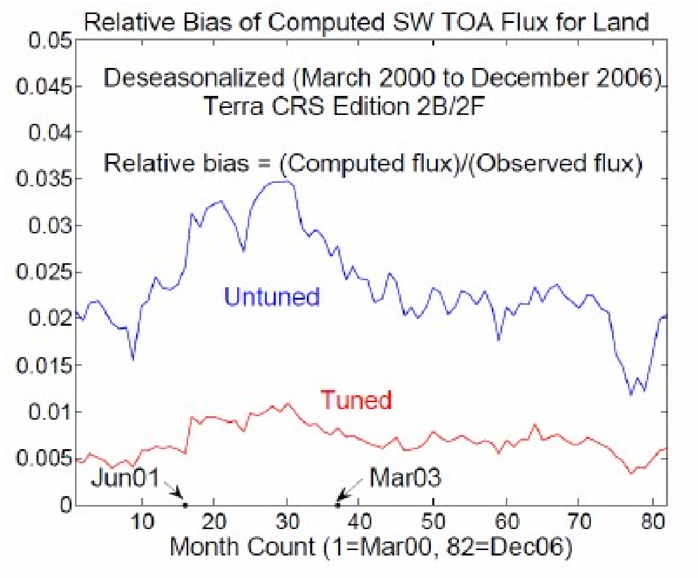


Figure 10: Relative Bias of Computed SW TOA Flux for Land

- The Langley Atmospheric Science Data Center (ASDC) offers a capability to subset CERES HDF files on request. Terra Edition2B and Edition2F CRS for data dates July 2005 through December 2007 cannot be subset due to a missing Vdata parameter. The problem is expected to be corrected for data dates 2008 forward. Aqua CRS data sets do not seem to be affected by the subset bug. ASDC and CERES are working on this problem. We have no evidence of special errors in the formal science data products of CRS files that do not subset by this means.

- Informal additions to this document will be posted at the CAVE web site under "CRS Advice".

- The ratio of direct to diffuse SW flux at the surface is one product in the CRS record. A bug in the code yielded incorrect ratios beneath ice clouds. The total surface insolation (sum of the direct and diffuse) is NOT affected by this bug. The direct/diffuse ratios for clear skies and for liquid phase clouds are okay. The bug has been corrected in the current "point and click" Langley Fu-Liou code on the CAVE URL. Unfortunately, the (ice-cloud direct/diffuse ratio) bug will occur in all CRS Terra Edition 2B files. CRS provides the SARB as ungridded snapshots for the time of satellite overpass. The bug will not affect a subsequent generation of SYN products containing gridded SARB fluxes representing 3-hourly "synoptic" time means.

Accuracy and Validation

Accuracy and validation discussions are found in the following sections of Nature of the CRS Product.

- Comparison of computed radiation with observations at TOA
- Comparison with Surface Observations

References

- List of CERES CRS References

Expected Reprocessing

In the longer term, yet more advanced versions of CRS are expected. A future run will use a "frozen" NWP analysis. There will be advances in the TOA fluxes. SSF will use new techniques to identify multilayer clouds. For an indefinite time, however, we anticipate continuing, significant uncertainties in CRS products for

- surface SW and atmospheric absorption of SW because of mixed phase clouds (land and sea), aerosol single scattering albedo (land and sea) and AOD (land);
- LW fluxes at the surface and at 500 hPa because of multiple layer clouds (land and sea).

Referencing Data in Journal Articles

The CERES Team has gone to considerable trouble to remove major errors and to verify the quality and accuracy of this data. **Please provide a reference to the following paper when you publish scientific results with the CERES Terra Edition2B CRS data:**

Wielicki, B. A., B. R. Barkstrom, E. F. Harrison, R. B. Lee, G. L. Smith, and J. E. Cooper, 1996: Clouds and the Earth's Radiant Energy System (CERES): An Earth Observing System Experiment. Bull. Amer. Meteor. Soc., 77, 853-868.

When Langley ASDC data are used in a publication, **we request the following acknowledgement be included:** "These data were obtained from the NASA Langley Research Center EOSDIS Distributed Active Archive Center."

The Langley ASDC requests two reprints of any published papers or reports which cite the use of data that we have distributed. This will help us determine the use of data that we distribute, which is helpful in optimizing product development. It also helps us to keep our product references current.

Feedback

For questions or comments on the CERES Quality Summary, contact the User and Data Services staff at the Atmospheric Science Data Center.

Informal contact to the SARB WG is accessible by selecting "The Group" at the CAVE web site.

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