Clouds and the Earth's Radiant Energy System (CERES)

Algorithm Theoretical Basis Document

Monthly Regional TOA and Surface Radiation Budget

(Subsystem 10.0)

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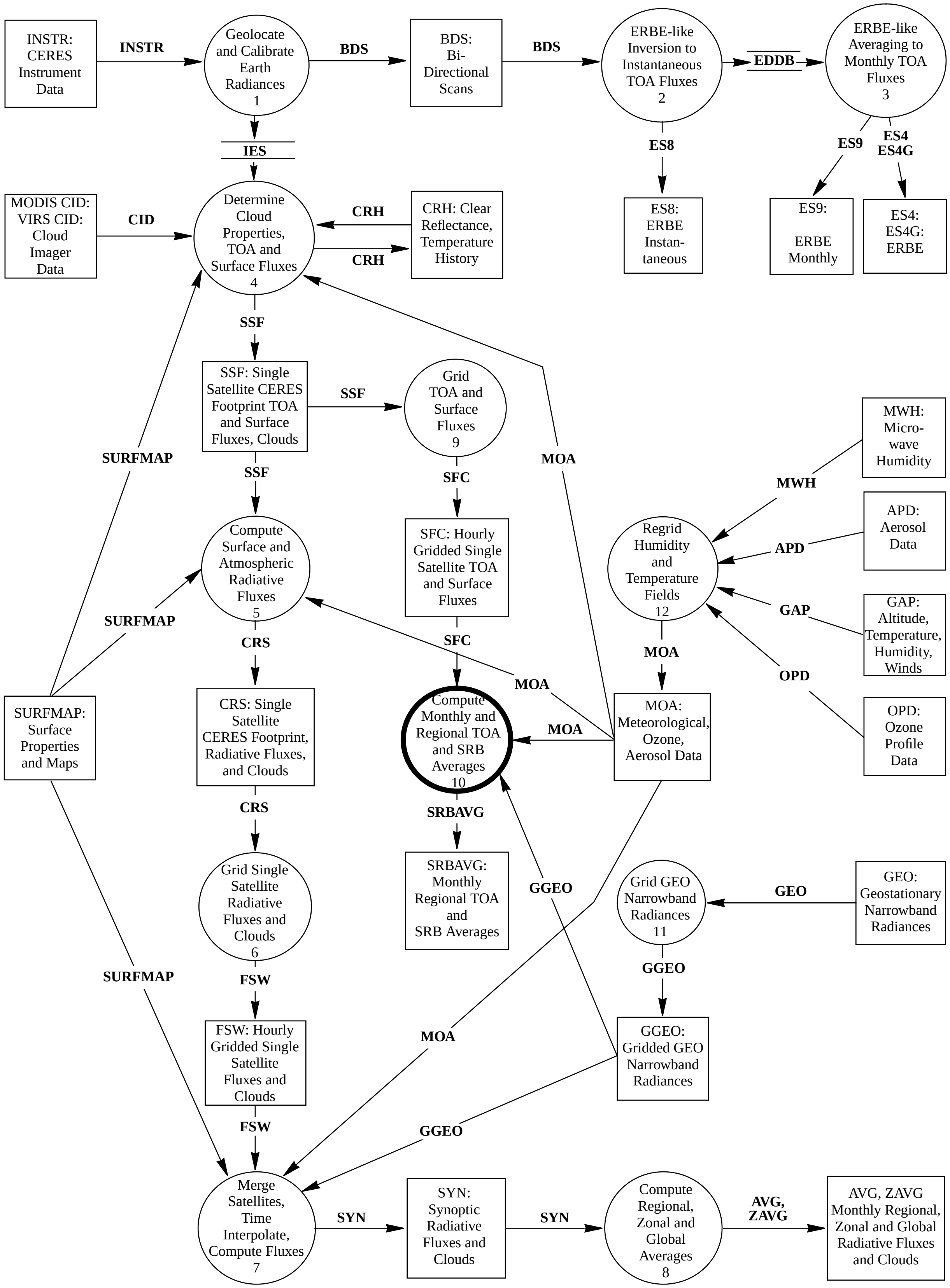
CERES Top Level Data Flow Diagram



Abstract

The CERES Data Management System computes averages of top-of-atmosphere (TOA) shortwave (SW) and longwave (LW) flux on regional, zonal, and global spatial scales. Separate regional averages are computed using the two methods discussed in subsystem 7. TOA flux estimates from both of the methods are used to produce estimates of surface flux at all temporal and spatial scales using the TOA-to-surface flux parameterization schemes for SW and LW described in subsystem 4.6.

The temporal interpolation process uses the gridded CERES SW and LW TOA fluxes and cloud information provided by the SFC data product. The SFC data contain spatial averages of one hour of CERES measurements on a 1.0° equal-angle grid. Gridded Geostationary satellite-derived narrowband radiances are provided by the GGEO data product. Additional input data include directional models of albedo, solar declination, and the coefficients necessary to produce surface flux estimates (see appendix A).

The TSA process produces monthly-hourly and monthly means of TOA and surface SW and LW flux on regional, zonal, and global spatial scales. Separate estimates are calculated for clear-sky and total-sky fluxes. In addition, means are computed and output using two different averaging techniques (see appendix B).

Temporal interpolation is accomplished by the two methods presented in subsection 7: (1) the ERBE-like method and (2) the geostationary data enhancement method. Using the hours with observations from the SFC product, time series of TOA total-sky and clear-sky fluxes are constructed for all hours of the month for each region.

Parameterization schemes are used to estimate surface fluxes from TOA data for all hours with TOA fluxes. Monthly and monthly-hourly means are calculated from the interpolated fluxes. The TOA and surface LW and SW fluxes are averaged on zonal and global scales.

10.0. Monthly Regional TOA and Surface Radiation Budget

10.1. Algorithm Description

10.1.1. Introduction

The goal of the CERES experiment is to accurately determine the components of the Earth's radiation budget and cloud parameters on regional, zonal, and global spatial scales. CERES will produce a large data set of highly accurate measurements of regional-scale incoming and outgoing radiant energy over the Earth. These measurements must be properly averaged in space and time. In addition, variations in Earth's climate can only be detected using stable, long-term global data sets. In order to accomplish the dual goals of a stable, long-term data set and averages produced using the most accurate techniques available, CERES will produce regional, zonal, and global means by both the ERBE-like technique and the geostationary data enhancement method (see subsection 7).

The ERBE-like interpolation (method 1) is used to provide a consistent data set for long-term climate studies. The results of this subsystem incorporate the improved CERES scene identification and angular distribution models (ADMs). The monthly averages from method 1 can be compared to similar results from the ERBE-like processing (subsystem 3) to evaluate the effect of these improvements on both TOA and surface fluxes. An output product based on using the geostationary-data-enhanced interpolation technique (method 2) is also included. The use of geostationary data in the interpolation process significantly improves the accuracy of the diurnal modeling. This not only provides the best possible monthly averages but also yields accurate hourly fluxes for use in detailed regional studies of radiation and clouds and for CERES Interdisciplinary Studies. The geostationary-data-enhanced interpolation technique depends on the availability of geostationary or polar orbiting narrowband radiance measurements. Data gaps due to satellite failures or spatial sampling patterns may pose problems when studying climate data on a global scale. Method 1 provides a consistent data set which can be used to evaluate zonal and global results from method 2. For regions where geostationary data are not available, only method 1 will be used.

A complete description of the methods used to produce the time series of TOA fluxes is included in subsystem 7. The major departure from the methods described there concerns the times to which the fluxes will be interpolated. The primary goal of the temporal interpolation described in subsystem 7 is to produce accurate estimates of cloud properties and TOA fluxes at specific synoptic times. For this subsystem, fluxes will be interpolated to all local hours of the month in order to produce a complete time series. In the following subsections, only the differences from the methods used in subsystem 7 will be described.

10.1.2. Sorting and Merging of Gridded Observations

This process is essentially identical to subsystem 7. The input data are derived from the SFC data product instead of the FSW. The other difference is that the data are sorted in terms of local time rather than GMT.

10.1.3. Regridding of Geostationary Data

This process is identical to subsystem 7.

10.1.4. Time Interpolation of Cloud Properties

The SFC data product contains fewer cloud data structures than the FSW. This subsystem will retain only the column-averaged cloud data (summarized in subsystem 6) and the Angular Model Scene Class data. The data in both of these structures are linearly interpolated to all local hours of the month, as described in subsystem 7. The complete time series of column-averaged data is used to compute monthly and monthly-hourly means. Monthly means of the Angular Model Scene Class data will be computed using only data from the times of CERES observations.

10.1.5. Time Interpolation of Total-sky LW Flux

The temporal interpolation of method 1 is identical to the technique described in subsystem 7. For method 2, all hours between the times of CERES observations must be filled with LW flux values. In order to accomplish this, the time series from the narrowband data is linearly interpolated between the synoptic times. This complete time series is then normalized to the CERES LW fluxes at the times of observation.

10.1.6. Time Interpolation of Clear-sky LW Flux

Only the ERBE-like process of method 1 is performed on clear-sky LW flux data. The half-sine fits and linear interpolation of method 1 model the clear-sky LW flux well when there is adequate sampling. No attempt will be made to produce clear-sky flux estimates at every hour. For all surface types, a fit is performed only during days with at least one daytime measurement and at least one nighttime measurement before and after the day. The monthly means will be computed only from these days. If this technique produces too many regions with no monthly clear averages, then a single diurnal model will be fit to monthly-hourly means of the data, as is done in the ERBE-like processing (subsystem 3).

10.1.7. Time Interpolation of Total-sky SW Flux

The albedos and scene fractions for each Angular Model Scene Class are used in method 1 to select ADMs to interpolate the data to hours between the observations (see subsystems 3 and 7). For method 2, these data are also used to select anisotropic factors used in the conversion of narrowband SW radiances into fluxes. A complete time series of simulated broadband fluxes is produced from the synoptic geostationary data using directional models selected using the interpolated angular model scene class data. An estimate of SW flux is then made for all daylight hours of all days within a region that contains at least one CERES observation by normalizing the time series of albedo produced from the geostationary data to the CERES observations. Only the days with observations will be used in the calculation of monthly mean fluxes.

10.1.8. Time Interpolation of Clear-sky SW Flux

Only the ERBE-like process of method 1 is performed on clear-sky SW flux data. Once again, only days with at least one clear-sky flux measurement are modeled and used in the computation of monthly means.

10.1.9. Time Interpolation of Window Radiance

This interpolation will be performed in the same manner as described in subsystem 7.

10.1.10. Surface SW and LW fluxes

An independent set of parameterized models has been developed for the calculation of LW and SW surface fluxes from the time series of TOA fluxes. These models are discussed in subsystem 4.6. The procedure used to incorporate these models into the averaging process begins with the modeling of the TOA fluxes as explained above. For every hour in which a TOA flux is calculated, the TOA-to-surface parameterization models are used to determine a corresponding surface flux. Monthly and monthly-hourly will be computed in the same manner as used for the TOA flux.

10.1.11. Computation of Monthly and Monthly-Hourly Means

Unlike subsystem 7, days with no clear-sky flux measurements are not modeled or used, and data used in monthly and monthly-hourly means are limited to data from days in which there is at least one CERES observation.

10.1.12. Computation of Zonal and Global Means

Zonal and global means of CERES 1.0 gridded TOA and surface LW and SW fluxes are calculated in the same manner as used with ERBE data (see subsystem 3). Area weighting factors are applied to account for the differences in the areas of regions in different latitude zones.

10.2. Implementation Issues

10.2.1. Strategic Concerns

Many of the strategic concerns of this subsystem are identical with those discussed in subsystem 7.1 and are not repeated here.

The total-sky LW TOA-surface parameterization requires cloud fraction and cloud base heights as input. For this subsystem, column-averaged cloud properties will be used. Simulations will be performed to test the accuracy of using these column-averaged properties. If the LW surface fluxes calculated with this method are insufficiently accurate, then the SFC input product may be changed to include layer cloud information in Release 4.

Since the TOA clear-sky LW flux will only be calculated on a monthly-hourly basis, the clear-sky LW TOA-surface parameterization may also be applied at this time-scale. A study will be performed on existing data sets to compare the difference in monthly mean surface clear-sky LW fluxes calculated on a daily and on a monthly-hourly basis. If the differences are unacceptable, then the clear-sky TOA will be interpolated to every hour of the month and the parameterization will be applied for all hours.

The input data stream for each month consists of gridded CERES observations for the times beginning with 0 GMT on the first day of the month to 24 GMT on the last. Since the temporal interpolation for this subsystem is performed in terms of local time, this can cause some loss of data at the beginning or end of the month depending upon the longitude of a particular region. This problem was handled in the ERBE processing by including “overlap” data files with observations from the last day of the previous month and the first day of the following month. A similar solution is being planned for CERES, but has not yet been implemented.

The output product does not contain daily means of fluxes, as in the ERBE-like product. The size of the SRBAVG data product is quite large compared with the ES9 ERBE-like product (see appendix B). The addition of daily means would increase the output product size. The needs of the Science Team and potential users will be assessed to see if daily means are required.

Appendix A

Input Data Products

Monthly and Regional TOA and SRB Averages (Subsystem 10.0)

This appendix describes the data products which are used by the algorithms in this subsystem. Table A-1 below summarizes these products, listing the CERES and EOSDIS product codes or abbreviations, a short product name, the product type, the production frequency, and volume estimates for each individual product as well as a complete data month of production. The product types are defined as follows:

Archival products: Assumed to be permanently stored by EOSDIS
Internal products: Temporary storage by EOSDIS (days to years)
Ancillary products: Non-CERES data needed to interpret measurements

The following pages describe each product. An introductory page provides an overall description of the product and specifies the temporal and spatial coverage. The table which follows the introductory page briefly describes every parameter which is contained in the product. Each product may be thought of as metadata followed by data records. The metadata (or header data) is not well-defined yet and is included mainly as a placeholder. The description of parameters which are present in each data record includes parameter number (a unique number for each distinct parameter), units, dynamic range, the number of elements per record, an estimate of the number of bits required to represent each parameter, and an element number (a unique number for each instance of every parameter). A summary at the bottom of each table shows the current estimated sizes of metadata, each data record, and the total data product. A more detailed description of each data product will be contained in a user's guide to be published before the first CERES launch.

Table A-1. Input Products Summary

Product code		Name	Type	Frequency	Size, MB	Monthly size, MB
CERES	EOSDIS					
MOA	CERX06	Meteorological, Ozone, and Aerosol Data	Archival	1/Hour	11.55	8591
GGEO	CERX14	Grid Geostationary Narrow-band Radiances	Interim	1/month	816.1	816.1
SFC	CER12	Gridded Single Satellite TOA and Surface Fluxes	Archival	1/Month	38.0	6847.2

Meteorological, Ozone, and Aerosol Data (MOA)

The CERES archival product Meteorological, Ozone, and Aerosol Data (MOA) is produced by the CERES Regrid MOA Subsystem. Each MOA file contains meteorological, ozone, and aerosol data for one hour, and is used by several of the CERES subsystems. Data on the MOA are derived from several data sources external to the CERES system, such as the Data Assimilation Office (DAO), NOAA, and various other meteorological satellites. These data arrive anywhere from four times daily to once a month, and have various horizontal resolutions. The Regrid MOA Subsystem interpolates the aerosol and ozone data horizontally to conform with the horizontal resolution of the meteorological data. Profile data are interpolated vertically to conform with CERES requirements. All data are temporally interpolated to provide data to the CERES processing system on an hourly basis.

The MOA contains:

- Surface pressure, geopotential height, skin temperature, and sea surface state
- Vertical profiles of temperature and humidity for 58 atmospheric levels
- Vertical profiles for 18 atmospheric levels below the tropopause of wind u-vector and v-vector data
- Tropospheric height
- Air mass index
- Column precipitable water based on humidity profiles
- Column precipitable water based on microwave measurements
- Column averaged relative humidity
- Vertical profile of ozone mixing ratios for 58 atmospheric levels
- Column ozone
- Aerosol optical depth

Level: 3
Type: Archival
Frequency: 1/Hour

Portion of Globe Covered
File: Global
Record: One region

Time Interval Covered
File: 1 hour
Record: 1 hour

Portion of Atmosphere Covered
File: Surface to TOA

Table A-2. Meteorological, Ozone, and Aerosol (MOA)

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	Elem Num
Header						
Date and Hour		N/A	ASCII string	1	216	
MOA Processing Date		N/A	ASCII string	1	216	
MOA Grid Index		N/A	1 .. 1	1	16	
Number of MOA Regions		N/A	13104 .. 13104	1	32	
Temperature, Humidity, and Ozone Profile Fixed Pressure Levels		hPa	0 .. 1100	55	32	
Wind Speed Profile Pressure levels		hPa	0 .. 1100	18	32	
Surface Data						
MOA Region Number	1	N/A	1 .. 13104	1	32	1
Surface Pressure	2	hPa	0 .. 1100	1	32	2
Surface Geopotential Height	3	m	-100 .. 10000	1	32	3
Surface Skin Temperature	4	K	175 .. 375	1	32	4
Flag, Sea Surface State	5	N/A	0 .. 9	1	32	5
Flag, Source Surface Data	6	N/A	TBD	1	32	6
Meteorological Profiles						
Temperature Profiles	7	K	175 .. 375	58	32	7
Specific Humidity Profiles	8	N/A	0 .. 100	58	32	65
Wind Profile, U-Vector	9	m sec^{-1}	-100 .. 100	18	32	123
Wind Profile, V-Vector	10	m sec^{-1}	-100 .. 100	18	32	141
Flag, Source Meteorological Profiles	11	N/A	TBD	1	32	159
Meteorological Column Data						
Tropospheric Height	12	hPa	150 .. 300	1	32	160
Air Mass Index	13	N/A	0 .. 10	1	32	161
Precipitable Water	14	cm	0.001 .. 10.000	1	32	162
Column Averaged Relative Humidity	15	N/A	0 .. 100	1	32	163
Microwave Precipitable Water	16	cm	0.001 .. 10.000	1	32	164
Microwave Precipitable Water, std	17	cm	TBD	1	32	165
Flag, Source Microwave Column Precipitable Water	18	N/A	TBD	1	32	166
Ozone Profile Data						
Ozone Mixing Ratio Profiles	19	g kg^{-1}	0.00002 .. 0.02	58	32	167
Flag, Source Ozone Profile Data	20	N/A	TBD	1	32	225
Column Ozone						
Column Ozone	21	du	0 .. 500	1	32	226
Flag, Source Column Ozone	22	N/A	TBD	1	32	227
Total Column Aerosol						
Optical Depth, Total Column	23	g m^{-2}	0 .. 2	1	32	228
Flag, Source Optical Depth, Total Column	24	N/A	TBD	1	32	229
Spares	25	N/A	TBD	2	32	230

Total Header Bits/File:	544
Total Data Bits/Record:	7392
Total Records/File:	13104
Total Data Bits/File:	96864768
Total Bits/File:	96865312

Gridded Geostationary Narrowband Radiances (GGEO)

The GGEO product is a single file containing a header record followed by multiple data records. The header record contains information to identify the product contents and version. These data are the CERES Data Product Code, the Data Starting and Ending Date, and the Product Creation Date and Time.

Each data record, called an hourbox, contains data particular to a single grid region and hour. The number of hourboxes on the file is constant and is determined by the number of data hours per day, the maximum number of days per month, and the number of regions in the grid (8 hours per day x 31 days per month x 64800 regions on globe = 16,070,400 hourboxes). Hourboxes for which there are no ISCCP data are filled with default values.

The data record (hourbox) contains 3 categories of data: Satellite and Hourbox ID information, Key Footprint Parameters, and Radiance Statistics.

- The **Satellite and Hourbox ID** information, as the name implies, identifies the hourbox, as well as the satellite which collected the data within the hourbox. Although there are many grid regions on the earth that are observed by more than one geostationary satellite, each hourbox contains only data from the closest observing satellite.
- The **Key Footprint Parameters** are data associated with the key footprint, the footprint which falls closest to the centroid of the region. These data are the time of the footprint and three angle measurements associated with the footprint: the cosine of the satellite zenith angle, the cosine of the solar zenith angle, and the relative azimuth angle.
- The primary data on the GGEO product are **Radiance Statistics**. These are visible and infrared radiance values averaged over a grid region every 3rd hour of each month. The statistics contain, in order, the calculated mean and variance, and the number of footprints used for the calculations.

Level: 3
Type: Ancillary
Frequency: Monthly

Portion of Globe Covered
File: Entire globe
Record: 1.0 degree equal angle regions

Time Interval Covered
File: Monthly
Record: Every third hour

Portion of Atmosphere Covered
File: TOA

Table A-3. Gridded Geostationary Narrowband Radiances (GGEO)

Description	Parameter Num	UnitRangeElements/Record	Bits/Elem	ElemNum	Bits/Rec
GGEO					
GGEO Header					
CERES Data Product Code		N/AN/A 1	32		32
Data Starting Date		N/AN/A 1	32		32
Data Ending Date		N/AN/A 1	32		32
Product Creation Date		N/AN/A 1	32		32
Product Creation Time		N/AN/A 1	32		32
GGEO Record					
Satellite and Hourbox ID					
Satellite Number	1	N/AN/A 1	32	1	32
Region Number	2	N/A1 .. 648001	32	2	32
Hour Number	3	N/A1 .. 7441	32	3	32
Key Footprint Parameters					
Time	4	hhmmss0 .. 235959132		4	32
Cos of Satellite Zenith Angle	5	N/A-1.0 .. 1.01	32	5	32
Cos of Solar Zenith Angle	6	N/A-1.0 .. 1.01	32	6	32
Relative Azimuth Angle	7	Degrees0.0 .. 180.0132		7	32
Radiance Statistics					
visible radiance: mean, var, num obs	8	W/m^2/SR0.0 .. 20.0332		8	96
infrared radiance: mean, var, num obs	9	$W/m^2/\mu m$/SR0.0 .. 600.033211			96

Total Meta Bits/File:	160
Total Data Bits/Record:	416
Total Records/File:	16070400
Total Data Bits/File:	6685286400
Total Bits/File:	6685286560
Total Data Bytes/Record:	52
Total Data Bytes/File	835660800
Total Files/Product:	1

Gridded Single Satellite TOA and Surface Fluxes (SFC)

The Monthly Gridded Single Satellite Fluxes and Clouds (SFC) archival data product contains hourly single satellite flux and cloud parameters averaged over 1.0 degree regions. Input to the SFC Subsystem is the Single Satellite CERES Footprint TOA and Surface Fluxes, Clouds (SSF) archival data product. Each SFC covers a single month swath from a single CERES instrument mounted on one satellite. The product has a product header and multiple records; each record contains spatially averaged data for an individual region.

The major categories of data output on the SFC are as follows:

- Region data
- Total-sky radiative fluxes at TOA and surface
- Clear-sky radiative fluxes at TOA and surface
- Column-averaged cloud properties
- Angular model scene classes
- Surface-only data

A complete listing of parameters for this data product can be found in Table A-4.

Level: 3
Type: Archival
Frequency: 1/Month

Portion of Globe Covered
File: Gridded satellite swath
Record: 1.0-degree equal-angle region

Time Interval Covered
File: Month
Record: Hour

Portion of Atmosphere Covered
File: TOA and surface

Table A-4. Gridded Single Satellite TOA and Surface Fluxes (SFC)

Description	Parameter Num	Unit	Range	Elements/ Record	Bits/ Elem	Elem Num
SFC Header						
CERES Data Product Code		N/A	N/A	1	32	
CERES Spacecraft Identification Code		N/A	N/A	1	32	
CERES Instrument Identification code		N/A	N/A	1	32	
Zone Number		N/A	1 .. 180	1	32	
Data Year		N/A	1996 .. 2099	1	32	
Data Month		N/A	1 .. 12	1	32	
Number of hours per region		N/A	0 .. 744	360	32	
Data Process Date		N/A	N/A	1	136	
SFC Record						
Spatially Averaged Region Parameters						
Time and Position Data						
Key Footprint Parameters						
Julian Time	1	Day	0.0 .. 1.0	1	32	1
Sun colatitude	2	Degrees	0.0 .. 180.0	1	32	2
Sun longitude	3	Degrees	0.0 .. 360.0	1	32	3
Relative azimuth angle at TOA	4	Degrees	0.0 .. 360.0	1	32	4
Cosine of solar zenith angle at TOA	5	N/A	0.0 .. 1.0	1	32	5
Spacecraft zenith angle	6	Degrees	0.0 .. 90.0	1	32	6
Region ID						
Region number	7	Dimensionless	1 .. 64800	1	32	7
Hour box number	8	Dimensionless	1 .. 744	1	32	8
Number of Footprints in region	9	N/A	1 .. 40	1	32	9
Number of imager pixels in CERES fov in the region	10	N/A	1 .. 360000	1	32	10
Other Regional Parameters						
Altitude of surface above sea level	11	m	-1000 .. 10000	1	32	11
Surface type percentage	12	Percent	0.0 .. 100.0	20	32	12
Snow/Ice percent coverage	13	Percent	0.0 .. 100.0	1	32	32
Precipitable Water	14	cm	0.0001 .. 10.0	1	32	33
Spatially Averaged Radiative Flux Parameters						
TOA Clear-Sky Fluxes is Array[3] of:						
Upward SW flux at TOA: mean, std, num obs	15	W m^{-2}	0.0 .. 1400.0	3	32	34
Upward LW flux at TOA: mean, std, num obs	16	W m^{-2}	100.0 .. 500.0	3	32	37
Upward LW window flux at TOA: mean, std, num obs	17	W m^{-2}	0.0 .. 800.0	3	32	40
Albedo: mean, std, num obs	18	Dimensionless	0.0 .. 1.0	3	32	43
TOA Total-Sky Fluxes is Array[3] of:						
Upward SW flux at TOA: mean, std, num obs	19	W m^{-2}	0.0 .. 1400.0	3	32	46
Upward LW flux at TOA: mean, std, num obs	20	W m^{-2}	100.0 .. 500.0	3	32	49
Upward LW window flux at TOA: mean, std, num obs	21	W m^{-2}	0.0 .. 800.0	3	32	52
Albedo: mean, std, num obs	22	Dimensionless	0.0 .. 1.0	3	32	55
Surface Clear-Sky Flux is Array[3] of:						
Downward SW flux, Model A: mean, std, num obs	23	W m^{-2}	0.0 .. 1400.0	3	32	58
Downward LW flux, Model A: mean, std, num obs	24	W m^{-2}	0.0 .. 700.0	3	32	61
SW net flux, Model A: mean, std, num obs	25	W m^{-2}	0.0 .. 1400.0	3	32	64
LW net flux, Model A: mean, std, num obs	26	W m^{-2}	-250.0 .. 50.0	3	32	67
Downward WN flux, Model A: mean, std, num obs	27	W m^{-2}	0.0 .. 700.0	3	32	70
Downward nonWN flux, Model A: mean, std, num obs	28	W m^{-2}	0.0 .. 700.0	3	32	73
Downward SW flux, Model B: mean, std, num obs	29	W m^{-2}	0.0 .. 1400.0	3	32	76
Downward LW flux, Model B: mean, std, num obs	30	W m^{-2}	0.0 .. 700.0	3	32	79
SW net flux, Model B: mean, std, num obs	31	W m^{-2}	0.0 .. 1400.0	3	32	82
LW net flux, Model B: mean, std, num obs	32	W m^{-2}	-250.0 .. 50.0	3	32	85
Surface Total-Sky Flux is Array[3] of:						
Downward SW flux, Model A: mean, std, num obs	33	W m^{-2}	0.0 .. 1400.0	3	32	88
Downward LW flux, Model A: mean, std, num obs	34	W m^{-2}	0.0 .. 700.0	3	32	91
SW net flux, Model A: mean, std, num obs	35	W m^{-2}	0.0 .. 1400.0	3	32	94
LW net flux, Model A: mean, std, num obs	36	W m^{-2}	-250.0 .. 50.0	3	32	97
Downward WN flux, Model A: mean, std, num obs	37	W m^{-2}	0.0 .. 700.0	3	32	100
Downward nonWN flux, Model A: mean, std, num obs	38	W m^{-2}	0.0 .. 700.0	3	32	103
Downward SW flux, Model B: mean, std, num obs	39	W m^{-2}	0.0 .. 1400.0	3	32	106
Downward LW flux, Model B: mean, std, num obs	40	W m^{-2}	0.0 .. 700.0	3	32	109
SW net flux, Model B: mean, std, num obs	41	W m^{-2}	0.0 .. 1400.0	3	32	112
LW net flux, Model B: mean, std, num obs	42	W m^{-2}	-250.0 .. 50.0	3	32	115

Table A-4. Gridded Single Satellite TOA and Surface Fluxes (SFC) Concluded

Description	Parameter Num	Unit	Range	Elements/ Record	Bits/ Elem	Elem Num
Emissivity						
LW surface emissivity	43	N/A	0 .. 1	1	32	118
WN surface emissivity	44	N/A	0 .. 1	1	32	119
Spatially Averaged Cloud Parameters						
Spatially Averaged Weighted Column						
Averaged Cloud Properties for 5 Weightings						
(Five Weightings: SW, LW TOA, SFC LW, LWP, IWP)						
Spatially Averaged Cloud Area Fractions						
Overcast percent coverage	45	Percent	0.0 .. 100.0	5	32	120
Total percent coverage	46	Percent	0.0 .. 100.0	5	32	125
Spatially Averaged Cloud Properties is Array[3] of:						
Cloud effective pressure: mean, std, num obs	47	hPa	0.0 .. 1100.0	15	32	130
Cloud effective temperature: mean, std, num obs	48	K	100.0 .. 350.0	15	32	145
Cloud effective altitude: mean, std, num obs	49	km	0.0 .. 20.0	15	32	160
Cloud top pressure: mean, std, num obs	50	hPa	0.0 .. 1100.0	15	32	175
Cloud bottom pressure: mean, std, num obs	51	hPa	0.0 .. 1100.0	15	32	190
Cloud particle phase: mean, std, num obs	52	Fraction	0.0 .. 1.0	15	32	205
Liquid water path: mean, std, num obs	53	kg m^{-2}	0.01 .. 1000.0	15	32	220
Ice water path: mean, std, num obs	54	kg m^{-2}	0.01 .. 1000.0	15	32	235
Liquid particle radius: mean, std, num obs	55	micron	0.0 .. 1000.0	15	32	250
Ice particle effective diameter: mean, std, num obs	56	micron	0.0 .. 100.0	15	32	265
Visible optical depth (linear): mean, std, num obs	57	Dimensionless	0.0 .. 50.0	15	32	280
Visible optical depth (logarithmic): mean, std, num obs	58	Dimensionless	0.0 .. 50.0	15	32	295
Infrared emissivity: mean, std, num obs	59	Dimensionless	0.0 .. 2.0	15	32	310
Cloud vertical aspect ratio: mean, std, num obs	60	Dimensionless	TBD	15	32	325
Spatially Averaged Angular Model Scene Type Parameters						
Angular Model Scene Type Parameters for 12 Scene Types						
Fractional area coverage	61	Percent	0.0 .. 100.0	12	32	340
Angular Model Scene Type Statistical Data is Array[2] of:						
Incident Solar Flux: mean, std	62	Dimensionless	0.0 .. 1400.0	24	32	352
Albedo: mean, std	63	Dimensionless	0.0 .. 1.0	24	32	376
LW flux: mean, std	64	W m^{-2}	0.0 .. 400.0	24	32	400

Total Meta Bits/File:	11848
Total Data Bits/Record:	13536
Total Records/File:	23572
Total Data Bits/File:	319070592
Total Bits/File:	319082440
Total Files/Product:	180
Total Meta Bits/Product:	2132640
Total Data Bits/Product:	57432706560
Total Bits/Product:	57434839200
Total MegaBytes/File:	38.04
Total GigaBytes/Product:	6.69

Appendix B

Output Data Products

Compute Monthly and Regional TOA and SRB Averages (Subsystem 10.0)

This appendix describes the data products which are produced by the algorithms in this subsystem. Table B-1 below summarizes these products, listing the CERES and EOSDIS product codes or abbreviations, a short product name, the product type, the production frequency, and volume estimates for each individual product as well as a complete data month of production. The product types are defined as follows:

Archival products: Assumed to be permanently stored by EOSDIS
Internal products: Temporary storage by EOSDIS (days to years)

The following pages describe each product. An introductory page provides an overall description of the product and specifies the temporal and spatial coverage. The table which follows the introductory page briefly describes every parameter which is contained in the product. Each product may be thought of as metadata followed by data records. The metadata (or header data) is not well-defined yet and is included mainly as a placeholder. The description of parameters which are present in each data record includes parameter number (a unique number for each distinct parameter), units, dynamic range, the number of elements per record, an estimate of the number of bits required to represent each parameter, and an element number (a unique number for each instance of every parameter). A summary at the bottom of each table shows the current estimated sizes of metadata, each data record, and the total data product. A more detailed description of each data product will be contained in a user's guide to be published before the first CERES launch.

Table B-1. Output Products Summary

Product code		Name	Type	Frequency	Size, MB	Monthly size, MB
CERES	EOSDIS					
SRBAVG	CER06	Monthly TOA and SRB Averages	Archival	1/Month	2367	2367

Monthly TOA and SRB Averages (SRBAVG)

The SRBAVG product contains monthly and monthly hourly regional, zonal, and global averages of the TOA and surface LW and SW fluxes and the observed cloud conditions for each one degree equal-angle region. This product differs from the AVG product in three ways. First, the surface fluxes have been calculated from the TOA fluxes using parameterizations provided by the science team, instead of using the models provided by the SARB subsystem. Secondly, no flux fields are calculated at levels between TOA and the surface. Lastly, the regional TOA fluxes are calculated using two methods.

SRBAVG is an archival product produced by Subsystem 10. There is one produced for each spacecraft and one for each combination. At the TRMM launch, this product will be produced in a validation mode for the first 18 months. During these 18 months, the CERES Science Team will derive a production quality set of Angular Distribution Models which are needed to produce the LW and SW instantaneous fluxes.

SRBAVG is composed of the following structures:

On a Regional, Zonal, and Global Basis:
- Regional Parameters
- Total Sky radiative fluxes at TOA and surface
- Clear Sky radiative fluxes at TOA and surface
- Angular model scene types
- Column-Averaged Cloud properties for five weighting schemes:
  (TOA SW, TOA LW, SFC LW, LWP and IWP)
- Surface data

Level: 3
Type: Archival
Frequency: 1/Month

Portion of Globe Covered
File: Entire Globe
Record: 1 Degree Regions

Time Interval Covered
File: Month
Record: Month

Portion of Atmosphere Covered
File: Surface and TOA

Table B-2. Monthly TOA and SRB Averages (SRBAVG)

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	Elem Num
SRBAVG						
SRBAVG File Header		N/A	N/A	1	305568	
SRBAVG Data						
REGIONAL DATA is Array[64800] of:						
SRBAVG Region Parameters						
Region Number	1	N/A	1 - 64800	1	32	1
Altitude of surface above sea level	2	m	-1000 - 10000	1	32	2
Surface type percent coverage	3	Percent	0.0 - 100.0	20	32	3
Snow/Ice Percent Coverage	4	Percent	0.0 - 100.0	1	32	23
Precipitable Water	5	cm	0.0001 - 10.0	1	32	24
SRBAVG_RECORD						
SRBAVG TOA Fluxes						
Monthly-Hourly and Monthly TOA Fluxes is Array[25] of: **(TOA hourly data are in elements 1-24, monthly data is in element 25)**						
TOA Flux Record is Array[3] of:						
Total-Sky TOA Fluxes - ERBE						
SW flux: mean, std, num obs	6	Wm^{-2}	0.0 - 800.0	75	32	25
LW flux: mean, std, num obs	7	Wm^{-2}	0.0 - 400.0	75	32	100
Window flux: mean, std, num obs	8	Wm^{-2}	0.0 - 800.0	75	32	175
Albedo: mean, std, num obs	9	N/A	0.0 - 1.0	75	32	250
Total-Sky TOA Fluxes - GEO						
SW flux: mean, std, num obs	10	Wm^{-2}	0.0 - 800.0	75	32	325
LW flux: mean, std, num obs	11	Wm^{-2}	0.0 - 400.0	75	32	400
Window flux: mean, std, num obs	12	Wm^{-2}	0.0 - 800.0	75	32	475
Albedo: mean, std, num obs	13	N/A	0.0 - 1.0	75	32	550
Clear-Sky TOA Fluxes						
SW flux: mean, std, num obs	14	Wm^{-2}	0.0 - 800.0	75	32	625
LW flux: mean, std, num obs	15	Wm^{-2}	0.0 - 400.0	75	32	700
Window flux: mean, std, num obs	16	Wm^{-2}	0.0 - 800.0	75	32	775
Albedo: mean, std, num obs	17	N/A	0.0 - 1.0	75	32	850
SRBAVG Surface Fluxes						
Monthly-Hourly and Monthly Surface Fluxes is Array[25] of: **(Surface flux hourly data are in elements 1-24, monthly data is in element 25)**						
Surface Fluxes Record is Array[3] of:						
Sfc_Down Total_Sky						
SW flux, Model A: mean, std, num obs	18	Wm^{-2}	0.0 - 1400.0	75	32	925
LW flux, Model A: mean, std, num obs	19	Wm^{-2}	0.0 - 700.0	75	32	1000
WN flux, Model A: mean, std, num obs	20	Wm^{-2}	0.0 - 700.0	75	32	1075
nonWN flux, Model A: mean, std, num obs	21	Wm^{-2}	0.0 - 700.0	75	32	1150
SW flux, Model B: mean, std, num obs	22	Wm^{-2}	0.0 - 1400.0	75	32	1225
LW flux, Model B: mean, std, num obs	23	Wm^{-2}	0.0 - 700.0	75	32	1300
Sfc_Net Total_Sky						
SW flux, Model A: mean, std, num obs	24	Wm^{-2}	0.0 - 1400.0	75	32	1375
LW flux, Model A: mean, std, num obs	25	Wm^{-2}	-250.0 - 50.0	75	32	1450
SW flux, Model B: mean, std, num obs	26	Wm^{-2}	0.0 - 1400.0	75	32	1525
LW flux, Model B: mean, std, num obs	27	Wm^{-2}	-250.0 - 50.0	75	32	1600
Sfc_Down Clear_Sky						
SW flux, Model A: mean, std, num obs	28	Wm^{-2}	0.0 - 1400.0	75	32	1675
LW flux, Model A: mean, std, num obs	29	Wm^{-2}	0.0 - 700.0	75	32	1750
SW flux, Model B: mean, std, num obs	30	Wm^{-2}	0.0 - 1400.0	75	32	1825
LW flux, Model B: mean, std, num obs	31	Wm^{-2}	0.0 - 700.0	75	32	1900
Sfc_Net Clear_Sky						
SW flux, Model A: mean, std, num obs	32	Wm^{-2}	0.0 - 1400.0	75	32	1975
LW flux, Model A: mean, std, num obs	33	Wm^{-2}	-250.0 - 50.0	75	32	2050

Table B-2. Monthly TOA and SRB Averages (SRBAVG) Continued

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	Elem Num
SW flux, Model B: mean, std, num obs	34	Wm^{-2}	0.0 - 1400.0	75	32	2125
LW flux, Model B: mean, std, num obs	35	Wm^{-2}	-250.0 - 50.0	75	32	2200
SRBAVG Surface Data						
Monthly-Hourly and Monthly Data is Array[25] of:						
(Surface hourly data are in elements 1-24, monthly data is in element 25)						
LW surface emissivity	36	N/A	0 - 1	25	32	2275
WN surface emissivity	37	N/A	0 - 1	25	32	2300
SRBAVG Cloud Properties						
Monthly-Hourly and Monthly Cloud Properties is Array[25] of:						
(Cloud hourly data are in elements 1-24, monthly data is in element 25)						
SRBAVG Angular_Model Scene_Types						
SRBAVG Angular_Model Scene_Types Record is Array[12] of:						
Fractional area coverage	38	Percent	0.0 - 100.0	300	32	2325
Albedo: mean, stdev	39	N/A	0.0 - 1.0	600	32	2625
Incident Solar Flux: mean, stdev	40	N/A	0.0 - 1400.0	600	32	3225
LW flux: mean, std	41	Wm^{-2}	0.0 - 400.0	600	32	3825
SRBAVG Weighted_Cloud Properties Record is Array[5] of:						
(Five weightings: TOA SW, TOA LW, SFC LW, LWP, & IWP)						
Cloud Area Fractions						
Overcast Cloud Area Fraction	42	N/A	0.0 - 100.0	125	32	4425
Total Cloud Area Fraction	43	N/A	0.0 - 100.0	125	32	4550
SRBAVG Column_Averaged Properties Record is Array[3] of:						
Mean, st dev, and num obs of effective pressure	44	hPa	0.0 - 1100.0	375	32	4675
Mean, st dev, and num obs of effective temperature	45	K	100.0 - 350.0	375	32	5050
Mean, st dev, and num obs of effective altitude	46	km	0.0 - 20.0	375	32	5425
Mean, st dev, and num obs of cloud top pressure	47	hPa	0.0 - 1100.0	375	32	5800
Mean, st dev, and num obs of cloud bottom pressure	48	hPa	0.0 - 1100.0	375	32	6175
Mean, st dev, and num obs of particle phase	49	fraction	0.0 - 1.0	375	32	6550
Mean, st dev, and num obs of liquid water path	50	$kg\ cm^{-2}$	0.01 - 1000.0	375	32	6925
Mean, st dev, and num obs of ice water path	51	$kg\ cm^{-2}$	0.01 - 1000.0	375	32	7300
Mean, st dev, and num obs of liquid particle radius	52	micron	0.0 - 1000.0	375	32	7675
Mean, st dev, and num obs of ice particle effective diameter	53	micron	0.0 - 200.0	375	32	8050
Mean, st dev, and num obs of VIS optical depth	54	N/A	0.0 - 50.0	375	32	8425
Mean, st dev, and num obs of infrared emissivity	55	N/A	0.0 - 2.0	375	32	8800
Mean, st dev, and num obs of vertical aspect ratio	56	N/A	TBD	375	32	9175
ZONAL AND GLOBAL DATA is Array[181] of:						
SRBAVG Zone Parameters						
Zone Number	57	N/A	1 - 181	1	32	9550
Surface type percent coverage	58	Percent	0.0 - 100.0	20	32	9551
Snow/Ice Percent Coverage	59	Percent	0.0 - 100.0	1	32	9571
SRBAVG_RECORD						
SRBAVG TOA Fluxes						
Monthly-Hourly and Monthly TOA Fluxes is Array[25] of:						
(TOA hourly data are in elements 1-24, monthly data is in element 25)						
TOA Flux Record is Array[3] of:						
Total-Sky TOA Fluxes - ERBE						
SW flux: mean, std, num obs	60	Wm^{-2}	0.0 - 800.0	75	32	9572
LW flux: mean, std, num obs	61	Wm^{-2}	0.0 - 400.0	75	32	9647
Window flux: mean, std, num obs	62	Wm^{-2}	0.0 - 800.0	75	32	9722
Albedo: mean, std, num obs	63	N/A	0.0 - 1.0	75	32	9797

Table B-2. Monthly TOA and SRB Averages (SRBAVG) Continued

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	Elem Num
Total-Sky TOA Fluxes - GEO						
SW flux: mean, std, num obs	64	Wm^{-2}	0.0 - 800.0	75	32	9872
LW flux: mean, std, num obs	65	Wm^{-2}	0.0 - 400.0	75	32	9947
Window flux: mean, std, num obs	66	Wm^{-2}	0.0 - 800.0	75	32	10022
Albedo: mean, std, num obs	67	N/A	0.0 - 1.0	75	32	10097
Clear-Sky TOA Fluxes						
SW flux: mean, std, num obs	68	Wm^{-2}	0.0 - 800.0	75	32	10172
LW flux: mean, std, num obs	69	Wm^{-2}	0.0 - 400.0	75	32	10247
Window flux: mean, std, num obs	70	Wm^{-2}	0.0 - 800.0	75	32	10322
Albedo: mean, std, num obs	71	N/A	0.0 - 1.0	75	32	10397
SRBAVG Surface Fluxes						
Monthly-Hourly and Monthly Surface Fluxes is Array[25] of:						
(Surface flux hourly data are in elements 1-24, monthly data is in element 25)						
Surface Fluxes Record is Array[3] of:						
Sfc_Down Total_Sky						
SW flux, Model A: mean, std, num obs	72	Wm^{-2}	0.0 - 1400.0	75	32	10472
LW flux, Model A: mean, std, num obs	73	Wm^{-2}	0.0 - 700.0	75	32	10547
WN flux, Model A: mean, std, num obs	74	Wm^{-2}	0.0 - 700.0	75	32	10622
nonWN flux, Model A: mean, std, num obs	75	Wm^{-2}	0.0 - 700.0	75	32	10697
SW flux, Model B: mean, std, num obs	76	Wm^{-2}	0.0 - 1400.0	75	32	10772
LW flux, Model B: mean, std, num obs	77	Wm^{-2}	0.0 - 700.0	75	32	10847
Sfc_Net Total_Sky						
SW flux, Model A: mean, std, num obs	78	Wm^{-2}	0.0 - 1400.0	75	32	10922
LW flux, Model A: mean, std, num obs	79	Wm^{-2}	-250.0 - 50.0	75	32	10997
SW flux, Model B: mean, std, num obs	80	Wm^{-2}	0.0 - 1400.0	75	32	11072
LW flux, Model B: mean, std, num obs	81	Wm^{-2}	-250.0 - 50.0	75	32	11147
Sfc_Down Clear_Sky						
SW flux, Model A: mean, std, num obs	82	Wm^{-2}	0.0 - 1400.0	75	32	11222
LW flux, Model A: mean, std, num obs	83	Wm^{-2}	0.0 - 700.0	75	32	11297
SW flux, Model B: mean, std, num obs	84	Wm^{-2}	0.0 - 1400.0	75	32	11372
LW flux, Model B: mean, std, num obs	85	Wm^{-2}	0.0 - 700.0	75	32	11447
Sfc_Net Clear_Sky						
SW flux, Model A: mean, std, num obs	86	Wm^{-2}	0.0 - 1400.0	75	32	11522
LW flux, Model A: mean, std, num obs	87	Wm^{-2}	-250.0 - 50.0	75	32	11597
SW flux, Model B: mean, std, num obs	88	Wm^{-2}	0.0 - 1400.0	75	32	11672
LW flux, Model B: mean, std, num obs	89	Wm^{-2}	-250.0 - 50.0	75	32	11747
SRBAVG Surface Data						
Monthly-Hourly and Monthly Data is Array[25] of:						
(Surface hourly data are in elements 1-24, monthly data is in element 25)						
LW surface emissivity	90	N/A	0 - 1	25	32	11822
WN surface emissivity	91	N/A	0 - 1	25	32	11847
SRBAVG Cloud Properties						
Monthly-Hourly and Monthly Cloud Properties is Array[25] of:						
(Cloud hourly data are in elements 1-24, monthly data is in element 25)						
SRBAVG Angular_Model Scene_Types						
SRBAVG Angular_Model Scene_Types Record is Array[12] of:						
Fractional area coverage	92	Percent	0.0 - 100.0	300	32	11872
Albedo: mean, stdev	93	N/A	0.0 - 1.0	600	32	12172
Incident Solar Flux: mean, stdev	94	N/A	0.0 - 1400.0	600	32	12772
LW flux: mean, std	95	Wm^{-2}	0.0 - 400.0	600	32	13372
SRBAVG Weighted_Cloud Properties Record is Array[5] of:						
(Five weightings: TOA SW, TOA LW, SFC LW, LWP, & IWP)						
Cloud Area Fractions						
Overcast Cloud Area Fraction	96	N/A	0.0 - 100.0	125	32	13972
Total Cloud Area Fraction	97	N/A	0.0 - 100.0	125	32	14097
SRBAVG Column_Averaged Properties Record is Array[3] of:						

Table B-2. Monthly TOA and SRB Averages (SRBAVG) Concluded

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	Elem Num
Mean, st dev, and num obs of effective pressure	98	hPa	0.0 - 1100.0	375	32	14222
Mean, st dev, and num obs of effective temperature	99	K	100.0 - 350.0	375	32	14597
Mean, st dev, and num obs of effective altitude	100	km	0.0 - 20.0	375	32	14972
Mean, st dev, and num obs of cloud top pressure	101	hPa	0.0 - 1100.0	375	32	15347
Mean, st dev, and num obs of cloud bottom pressure	102	hPa	0.0 - 1100.0	375	32	15722
Mean, st dev, and num obs of particle phase	103	fraction	0.0 - 1.0	375	32	16097
Mean, st dev, and num obs of liquid water path	104	g m^{-2}	0.01 - 1000.0	375	32	16472
Mean, st dev, and num obs of ice water path	105	g m^{-2}	0.01 - 1000.0	375	32	16847
Mean, st dev, and num obs of liquid particle radius	106	micron	0.0 - 1000.0	375	32	17222
Mean, st dev, and num obs of ice particle effective diameter	107	micron	0.0 - 200.0	375	32	17597
Mean, st dev, and num obs of VIS optical depth	108	N/A	0.0 - 50.0	375	32	17972
Mean, st dev, and num obs of infrared emissivity	109	N/A	0.0 - 2.0	375	32	18347
Mean, st dev, and num obs of vertical aspect ratio	110	N/A	TBD	375	32	18722

Total Meta Bits/Product:	305568
Total Bits/Record:	305568
Total Records/Product:	64981
Total Data Bits/Product:	19856114208
Total Bits/Product:	**19856419776**
Total Bytes/Product:	**2482052472**
Total Megabytes/Product:	**2367**

Appendix C

Nomenclature

Acronyms

ADEOS	Advanced Earth Observing System
ADM	Angular Distribution Model
AIRS	Atmospheric Infrared Sounder (EOS-AM)
AMSU	Advanced Microwave Sounding Unit (EOS-PM)
APD	Aerosol Profile Data
APID	Application Identifier
ARESE	ARM Enhanced Shortwave Experiment
ARM	Atmospheric Radiation Measurement
ASOS	Automated Surface Observing Sites
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
ASTEX	Atlantic Stratocumulus Transition Experiment
ASTR	Atmospheric Structures
ATBD	Algorithm Theoretical Basis Document
AVG	Monthly Regional, Average Radiative Fluxes and Clouds (CERES Archival Data Product)
AVHRR	Advanced Very High Resolution Radiometer
BDS	Bidirectional Scan (CERES Archival Data Product)
BRIE	Best Regional Integral Estimate
BSRN	Baseline Surface Radiation Network
BTD	Brightness Temperature Difference(s)
CCD	Charge Coupled Device
CCSDS	Consultative Committee for Space Data Systems
CEPEX	Central Equatorial Pacific Experiment
CERES	Clouds and the Earth’s Radiant Energy System
CID	Cloud Imager Data
CLAVR	Clouds from AVHRR
CLS	Constrained Least Squares
COPRS	Cloud Optical Property Retrieval System
CPR	Cloud Profiling Radar
CRH	Clear Reflectance, Temperature History (CERES Archival Data Product)
CRS	Single Satellite CERES Footprint, Radiative Fluxes and Clouds (CERES Archival Data Product)
DAAC	Distributed Active Archive Center
DAC	Digital-Analog Converter
DAO	Data Assimilation Office

DB	Database
DFD	Data Flow Diagram
DLF	Downward Longwave Flux
DMSP	Defense Meteorological Satellite Program
EADM	ERBE-Like Albedo Directional Model (CERES Input Data Product)
ECA	Earth Central Angle
ECLIPS	Experimental Cloud Lidar Pilot Study
ECMWF	European Centre for Medium-Range Weather Forecasts
EDDB	ERBE-Like Daily Data Base (CERES Archival Data Product)
EID9	ERBE-Like Internal Data Product 9 (CERES Internal Data Product)
EOS	Earth Observing System
EOSDIS	Earth Observing System Data Information System
EOS-AM	EOS Morning Crossing Mission
EOS-PM	EOS Afternoon Crossing Mission
ENSO	El Niño/Southern Oscillation
ENVISAT	Environmental Satellite
EPHANC	Ephemeris and Ancillary (CERES Input Data Product)
ERB	Earth Radiation Budget
ERBE	Earth Radiation Budget Experiment
ERBS	Earth Radiation Budget Satellite
ESA	European Space Agency
ES4	ERBE-Like S4 Data Product (CERES Archival Data Product)
ES4G	ERBE-Like S4G Data Product (CERES Archival Data Product)
ES8	ERBE-Like S8 Data Product (CERES Archival Data Product)
ES9	ERBE-Like S9 Data Product (CERES Archival Data Product)
FLOP	Floating Point Operation
FIRE	First ISCCP Regional Experiment
FIRE II IFO	First ISCCP Regional Experiment II Intensive Field Observations
FOV	Field of View
FSW	Hourly Gridded Single Satellite Fluxes and Clouds (CERES Archival Data Product)
FTM	Functional Test Model
GAC	Global Area Coverage (AVHRR data mode)
GAP	Gridded Atmospheric Product (CERES Input Data Product)
GCIP	GEWEX Continental-Phase International Project
GCM	General Circulation Model
GEBA	Global Energy Balance Archive
GEO	ISSCP Radiances (CERES Input Data Product)
GEWEX	Global Energy and Water Cycle Experiment
GLAS	Geoscience Laser Altimetry System

GMS	Geostationary Meteorological Satellite
GOES	Geostationary Operational Environmental Satellite
HBTM	Hybrid Bispectral Threshold Method
HIRS	High-Resolution Infrared Radiation Sounder
HIS	High-Resolution Interferometer Sounder
ICM	Internal Calibration Module
ICRCCM	Intercomparison of Radiation Codes in Climate Models
ID	Identification
IEEE	Institute of Electrical and Electronics Engineers
IES	Instrument Earth Scans (CERES Internal Data Product)
IFO	Intensive Field Observation
INSAT	Indian Satellite
IOP	Intensive Observing Period
IR	Infrared
IRIS	Infrared Interferometer Spectrometer
ISCCP	International Satellite Cloud Climatology Project
ISS	Integrated Sounding System
IWP	Ice Water Path
LAC	Local Area Coverage (AVHRR data mode)
LaRC	Langley Research Center
LBC	Laser Beam Ceilometer
LBTM	Layer Bispectral Threshold Method
Lidar	Light Detection and Ranging
LITE	Lidar In-Space Technology Experiment
Lowtran 7	Low-Resolution Transmittance (Radiative Transfer Code)
LW	Longwave
LWP	Liquid Water Path
MAM	Mirror Attenuator Mosaic
MC	Mostly Cloudy
MCR	Microwave Cloud Radiometer
METEOSAT	Meteorological Operational Satellite (European)
METSAT	Meteorological Satellite
MFLOP	Million FLOP
MIMR	Multifrequency Imaging Microwave Radiometer
MISR	Multiangle Imaging Spectroradiometer
MLE	Maximum Likelihood Estimate
MOA	Meteorology Ozone and Aerosol
MODIS	Moderate-Resolution Imaging Spectroradiometer
MSMR	Multispectral, multiresolution

MTSA	Monthly Time and Space Averaging
MWH	Microwave Humidity
MWP	Microwave Water Path
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NESDIS	National Environmental Satellite, Data, and Information Service
NIR	Near Infrared
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
NWP	Numerical Weather Prediction
OLR	Outgoing Longwave Radiation
OPD	Ozone Profile Data (CERES Input Data Product)
OV	Overcast
PC	Partly Cloudy
POLDER	Polarization of Directionality of Earth’s Reflectances
PRT	Platinum Resistance Thermometer
PSF	Point Spread Function
PW	Precipitable Water
RAPS	Rotating Azimuth Plane Scan
RPM	Radiance Pairs Method
RTM	Radiometer Test Model
SAB	Sorting by Angular Bins
SAGE	Stratospheric Aerosol and Gas Experiment
SARB	Surface and Atmospheric Radiation Budget Working Group
SDCD	Solar Distance Correction and Declination
SFC	Hourly Gridded Single Satellite TOA and Surface Fluxes (CERES Archival Data Product)
SHEBA	Surface Heat Budget in the Arctic
SPECTRE	Spectral Radiance Experiment
SRB	Surface Radiation Budget
SRBAVG	Surface Radiation Budget Average (CERES Archival Data Product)
SSF	Single Satellite CERES Footprint TOA and Surface Fluxes, Clouds
SSMI	Special Sensor Microwave Imager
SST	Sea Surface Temperature
SURFMAP	Surface Properties and Maps (CERES Input Product)
SW	Shortwave
SWICS	Shortwave Internal Calibration Source
SYN	Synoptic Radiative Fluxes and Clouds (CERES Archival Data Product)

SZA	Solar Zenith Angle
THIR	Temperature/Humidity Infrared Radiometer (Nimbus)
TIROS	Television Infrared Observation Satellite
TISA	Time Interpolation and Spatial Averaging Working Group
TMI	TRMM Microwave Imager
TOA	Top of the Atmosphere
TOGA	Tropical Ocean Global Atmosphere
TOMS	Total Ozone Mapping Spectrometer
TOVS	TIROS Operational Vertical Sounder
TRMM	Tropical Rainfall Measuring Mission
TSA	Time-Space Averaging
UAV	Unmanned Aerospace Vehicle
UT	Universal Time
UTC	Universal Time Code
VAS	VISSR Atmospheric Sounder (GOES)
VIRS	Visible Infrared Scanner
VISSR	Visible and Infrared Spin Scan Radiometer
WCRP	World Climate Research Program
WG	Working Group
Win	Window
WN	Window
WMO	World Meteorological Organization
ZAVG	Monthly Zonal and Global Average Radiative Fluxes and Clouds (CERES Archival Data Product)

Symbols

A	atmospheric absorptance
$B_\lambda(T)$	Planck function
C	cloud fractional area coverage
CF_2Cl_2	dichlorofluorocarbon
$CFCl_3$	trichlorofluorocarbon
CH_4	methane
CO_2	carbon dioxide
D	total number of days in the month
D_e	cloud particle equivalent diameter (for ice clouds)
E_o	solar constant or solar irradiance
F	flux
f	fraction
G_a	atmospheric greenhouse effect

g	cloud asymmetry parameter
H_2O	water vapor
I	radiance
i	scene type
m_i	imaginary refractive index
$\hat{N}$	angular momentum vector
N_2O	nitrous oxide
O_3	ozone
P	point spread function
p	pressure
Q_a	absorption efficiency
Q_e	extinction efficiency
Q_s	scattering efficiency
R	anisotropic reflectance factor
r_E	radius of the Earth
r_e	effective cloud droplet radius (for water clouds)
r_h	column-averaged relative humidity
S_o	summed solar incident SW flux
S_o'	integrated solar incident SW flux
T	temperature
T_B	blackbody temperature
t	time or transmittance
W_{liq}	liquid water path
w	precipitable water
$\hat{x}_o$	satellite position at t_o
x, y, z	satellite position vector components
$\dot{x}, \dot{y}, \dot{z}$	satellite velocity vector components
z	altitude
z_{top}	altitude at top of atmosphere
α	albedo or cone angle
β	cross-scan angle
γ	Earth central angle
γ_{at}	along-track angle
γ_{ct}	cross-track angle
δ	along-scan angle
ε	emittance
Θ	colatitude of satellite
θ	viewing zenith angle
θ_o	solar zenith angle

λ	wavelength
μ	viewing zenith angle cosine
μ_o	solar zenith angle cosine
ν	wave number
ρ	bidirectional reflectance
τ	optical depth
$\tau_{aer}(p)$	spectral optical depth profiles of aerosols
$\tau_{H_2O\lambda}(p)$	spectral optical depth profiles of water vapor
$\tau_{O_3}(p)$	spectral optical depth profiles of ozone
Φ	longitude of satellite
ϕ	azimuth angle
$\tilde{\omega}_o$	single-scattering albedo

Subscripts:

c	cloud
cb	cloud base
ce	cloud effective
cld	cloud
cs	clear sky
ct	cloud top
ice	ice water
lc	lower cloud
liq	liquid water
s	surface
uc	upper cloud
λ	spectral wavelength

Units

AU	astronomical unit
cm	centimeter
cm-sec^{-1}	centimeter per second
count	count
day	day, Julian date
deg	degree
deg-sec^{-1}	degree per second
DU	Dobson unit
erg-sec^{-1}	erg per second
fraction	fraction (range of 0–1)
g	gram
g-cm^{-2}	gram per square centimeter

$g\text{-}g^{-1}$	gram per gram
$g\text{-}m^{-2}$	gram per square meter
h	hour
hPa	hectopascal
K	Kelvin
kg	kilogram
$kg\text{-}m^{-2}$	kilogram per square meter
km	kilometer
$km\text{-}sec^{-1}$	kilometer per second
m	meter
mm	millimeter
μm	micrometer, micron
N/A	not applicable, none, unitless, dimensionless
$ohm\text{-}cm^{-1}$	ohm per centimeter
percent	percent (range of 0–100)
rad	radian
$rad\text{-}sec^{-1}$	radian per second
sec	second
sr^{-1}	per steradian
W	watt
$W\text{-}m^{-2}$	watt per square meter
$W\text{-}m^{-2}sr^{-1}$	watt per square meter per steradian
$W\text{-}m^{-2}sr^{-1}\mu m^{-1}$	watt per square meter per steradian per micrometer