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

Algorithm Theoretical Basis Document

Grid Top of Atmosphere and Surface Fluxes

(Subsystem 9.0)

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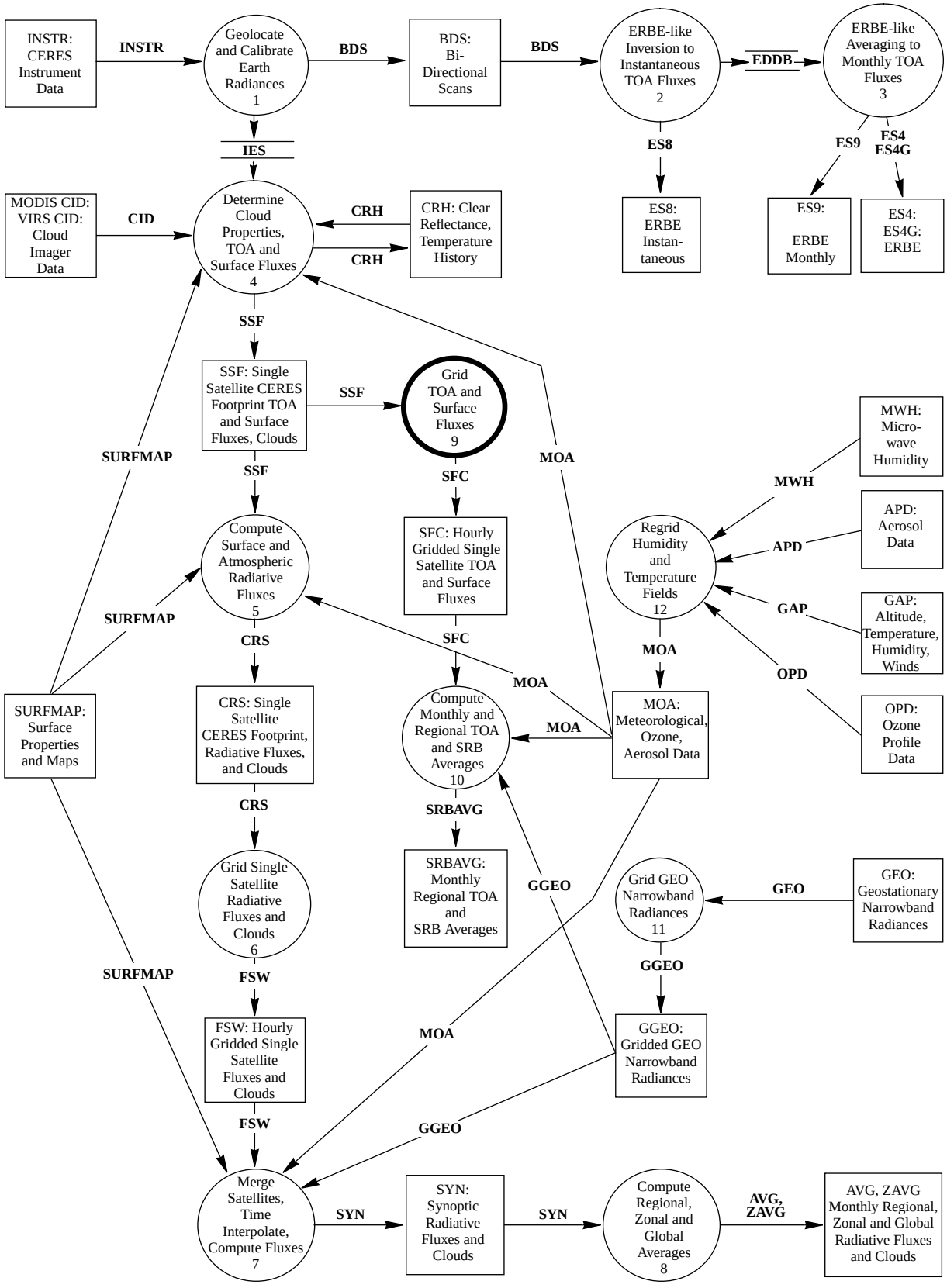
CERES Top Level Data Flow Diagram



Abstract

Subsystem 9 provides the transformation from instrument-referenced data to spatially averaged data. The gridding and spatial averaging subsystems perform two major functions. The first is to assign CERES footprints to the proper gridded regions. This assignment is based on the colatitude and longitude of the CERES footprint field of view at the top of the atmosphere. The second major function is to perform spatial averaging of the various radiative fluxes and column-averaged cloud properties over each region. This subsystem uses the SSF archival product from Subsystem 4.0 for input. A CERES footprint is assigned to the appropriate region of a 1^o x 1^o equal-angle grid. Fluxes and column-averaged cloud properties are spatially averaged over each region on an hourly basis. Subsystem 9.0 outputs the SFC archival data product, which includes radiative fluxes at the top of the atmosphere and the surface, column-averaged cloud properties, and angular model scene classes. After passing through this subsystem, the CERES data lose their traceability to specific CERES measurements.

9.0. Grid Top of Atmosphere and Surface Fluxes

9.1. Introduction

Gridding and averaging over regions for fluxes and other quantities is performed by Subsystems 6.0 and 9.0. Subsystem 9.0 (SFC) performs these functions for fluxes at the top-of-the-atmosphere and at the surface, and for column-averaged cloud properties. Input to the SFC subsystem is the SSF product (see Appendix A), and output is the SFC product (see Appendix B). Surface fluxes that are gridded and averaged in this subsystem have been calculated in Subsystem 4.0 from simple empirical algorithms, rather than from radiative transfer models, as is the case in Subsystem 6.0. The rationale and procedures for gridding and averaging are the same as for Subsystem 6.0, which grids and spatially averages the output of Subsystem 5.0, with the exception that the gridding is calculated on local time. Details of the averaging algorithms are presented in the ATBD for Subsystem 6.0.

Appendix A

Input Data Products

Grid TOA and Surface Fluxes (Subsystem 9.0)

This appendix describes the data products which are produced 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 for 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. Output Product Summary

Product Code		Name	Type	Frequency	Size, MB	Monthly Size, MB
CERES	EOSDIS					
SSF	CER11	Single Satellite TOA and Surface Fluxes, clouds	Archival	1/hour	237.6	176774.4

Single Satellite Footprint, TOA and Sfc Flux, Clouds (SSF)

EOSDIS Product Code: CER11

The Single Satellite CERES Footprint TOA and Surface Fluxes, Clouds (SSF) is produced from the cloud identification, convolution, inversion, and surface processing for CERES. Each SSF covers a single hour swath from a single CERES scanner (3 channels) mounted on one satellite. The product has a product header and multiple records of 113 parameters or 261 elements for each footprint.

The major categories of data output on the SSF are

- CERES footprint geometry and CERES viewing angles
- CERES footprint radiance and flux (TOA and Surface)
- CERES footprint area statistics and imager viewing angles
- CERES footprint clear area statistics
- CERES footprint cloudy area statistics for two out of four cloud height categories
  - Visible optical depth (mean and standard deviation)
  - Logarithm of visible optical depth (mean and standard deviation)
  - Infrared emissivity (mean and standard deviation)
  - Liquid water path (mean and standard deviation)
  - Ice water path (mean and standard deviation)
  - Cloud top pressure (mean and standard deviation)
  - Cloud effective pressure (mean and standard deviation)
  - Cloud effective temperature (mean and standard deviation)
  - Cloud effective height (mean and standard deviation)
  - Cloud bottom pressure (mean and standard deviation)
  - Water particle radius (mean and standard deviation)
  - Ice particle effective diameter (mean and standard deviation)
  - Particle phase (mean and standard deviation)
  - Vertical aspect ratio (mean and standard deviation)
  - Visible optical depth and IR emissivity (13 percentiles)
- CERES footprint cloud overlap conditions (4 conditions)

The SSF is an archival product that will be run daily in validation mode starting with the TRMM launch until sufficient data have been collected and analyzed to produce a production quality set of CERES Angular Distribution Models (CADM). It is estimated that at TRMM launch plus 18 to 24 months, the SSF product will be produced on a routine basis and will be archived within EOSDIS for distribution to the science community.

Level: 2
Type: Archival
Frequency: 1/Hour
Time Interval Covered
File: 1 Hour
Record: 1/100 Second

Portion of Globe Covered
File: Satellite Footprints
Record: One Footprint
Portion of Atmosphere Covered
File: Surface to TOA

Table A-2. Single Satellite Footprint (SSF)

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem
SSF_Header					
1 Day and Time at hour start		N/A	ASCII string	1	216A
2 Character name of satellite		N/A	ASCII string	1	64A
3 Character name of CERES instrument		N/A	ASCII string	1	32A
4 Character name of high resolution imager instrument		N/A	ASCII string	1	64A
5 Number of imager channels used		N/A	1 .. 20	1	16A
6 Central wavelengths of imager channels		µm	0.4 .. 15.0	20	32A
7 Earth-Sun distance		AU	0.98 .. 1.02	1	32A
8 Day and Time IES processed (SS1.0)		N/A	ASCII string	1	152V
9 Day and Time Imager Cloud properties processed (SS4-1 - 4.3)		N/A	ASCII string	1	152V
10 Day and Time Convolution of imager with CERES processed (SS4.4)		N/A	ASCII string	1	152V
11 Day and Time TOA and Surface Estimation processed (SS4.5 - 4.6)		N/A	ASCII string	1	152A
12 Number of Footprints in SSF product		N/A	0.. 245475	1	32A
SSF_Record					
Footprint Geometry					
Time and Position					
1 Time of observation	1	day	-0.01 ..1.01	1	64A
2 Radius of satellite from center of Earth at observation	2	km	6000..8000	1	64A
3 Colatitude of satellite at observation	3	deg	0..180	1	32A
4 Longitude of satellite at observation	4	deg	0..360	1	32A
5 Colatitude of Sun at observation	5	deg	0..180	1	32A
6 Longitude of Sun at observation	6	deg	0..360	1	32A
7 Colatitude of CERES FOV at TOA	7	deg	0..180	1	32A
8 Longitude of CERES FOV at TOA	8	deg	0..360	1	32A
9 Colatitude of CERES FOV at surface	9	deg	0..180	1	32A
10 Longitude of CERES FOV at surface	10	deg	0..360	1	32A
11 Scan sample number	11	N/A	1..660	1	16A
12 Packet number	12	N/A	0..32767	1	16A
13 Cone angle of CERES FOV at satellite	13	deg	0..90	1	32A
14 Clock angle of CERES FOV at satellite wrt inertial velocity	14	deg	0..360	1	32A
15 Rate of change of cone angle	15	deg sec^{-1}	-100 .. 100	1	32A
16 Rate of change of clock angle	16	deg sec^{-1}	-10 .. 10	1	32A
17 Along-track angle of CERES FOV at TOA	17	deg	0 .. 360	1	32A
18 Cross-track angle of CERES FOV at TOA	18	deg	-90..90	1	32A
19 X component of satellite inertial velocity	19	km sec^{-1}	-10 ..10	1	64A
20 Y component of satellite inertial velocity	20	km sec^{-1}	-10 ..10	1	64A
21 Z component of satellite inertial velocity	21	km sec^{-1}	-10 ..10	1	64A
CERES Viewing Angles					
22 CERES viewing zenith at TOA	22	deg	0 .. 90	1	32A
23 CERES solar zenith at TOA	23	deg	0 .. 180	1	32A
24 CERES relative azimuth at TOA	24	deg	0..360	1	32A
25 CERES viewing azimuth at TOA wrt North	25	deg	0..360	1	32V
Surface_Map Parameters					
26 Altitude of surface above sea level	26	m	-1000 .. 10000	1	32A
27 Surface type index	27	N/A	1 .. 20	8	16A
28 Surface type percent coverage	28	N/A	0 .. 100	8	16A
Scene_Type					
29 CERES SW ADM type for inversion process	29	N/A	0 .. 200	1	16A
30 CERES LW ADM type for inversion process	30	N/A	0 .. 600	1	16A
31 CERES WN ADM type for inversion process	31	N/A	0 .. 600	1	16A
Footprint Radiation					
CERES Filtered Radiances					
32 CERES TOT filtered radiance, upwards	32	W m^{-2} sr^{-1}	0..700	1	32I
33 CERES SW filtered radiance, upwards	33	W m^{-2} sr^{-1}	-10..510	1	32I
34 CERES WN filtered radiance, upwards	34	W m^{-2} sr^{-1}	0..50	1	32I
35 IES quality flags	35	N/A	see Table TBD	1	32A
CERES Unfiltered Radiances					
36 CERES SW radiance, upwards	36	Wm^{-2} sr^{-1}	-10 .. 510	1	32A
37 CERES LW radiance, upwards	37	Wm^{-2} sr^{-1}	0 .. 200	1	32A
38 CERES WN radiance, upwards	38	Wm^{-2} sr^{-1}	0 .. 50	1	32A
TOA and Surface Flux					
39 CERES SW flux at TOA, upwards	39	Wm^{-2}	0 .. 1400	1	32A
40 CERES LW flux at TOA, upwards	40	Wm^{-2}	0 .. 500	1	32A
41 CERES WN flux at TOA, upwards	41	Wm^{-2}	10 .. 400	1	32A
42 CERES downward SW surface flux, Model A	42	Wm^{-2}	0 .. 1400	1	32A
43 CERES downward LW surface flux, Model A	43	Wm^{-2}	0 .. 700	1	32A
44 CERES downward WN surface flux, Model A	44	Wm^{-2}	0 .. 700	1	32A
45 CERES downward nonWN surface flux, Model A	45	Wm^{-2}	0 .. 700	1	32A

Table A-2. Single Satellite Footprint (SSF) Continued

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	
46 CERES net SW surface flux, Model A	46	Wm^{-2}	0 .. 1400	1	32	A
47 CERES net LW surface flux, Model A	47	Wm^{-2}	-250 .. 50	1	32	A
48 CERES downward SW surface flux, Model B (TBD)	48	Wm^{-2}	0 .. 1400	1	32	A
49 CERES downward LW surface flux, Model B	49	Wm^{-2}	0 .. 700	1	32	A
50 CERES net SW surface flux, Model B (TBD)	50	Wm^{-2}	0 .. 1400	1	32	A
51 CERES net LW surface flux, Model B	51	Wm^{-2}	-250 .. 50	1	32	A
52 CERES spectral reflectivity	52	N/A	0 .. 1	6	32	I
53 CERES broadband surface albedo	53	N/A	0 .. 1	1	32	I
54 CERES LW surface emissivity	54	N/A	0 .. 1	1	32	I
55 CERES WN surface emissivity	55	N/A	0 .. 1	1	32	I
56 Imager-based surface skin temperature	56	K	175 .. 375	1	32	I
Full Footprint Area						
57 Number of imager pixels in CERES FOV	57	N/A	0 .. 9000	1	16	A
58 Imager percent coverage	58	N/A	0..100	1	16	A
59 Precipitable water	59	cm	0.001 .. 10	1	32	A
60 Shadowed pixels percent coverage (TBD)	60	N/A	0 .. 100	1	16	A
61 Notes on general procedure	61	N/A	TBD	1	16	A
62 Notes on Cloud Algorithms	62	N/A	TBD	1	16	A
63 Mean imager viewing zenith over CERES FOV	63	deg	0 .. 90	1	32	A
64 Mean imager relative azimuth over CERES FOV	64	deg	0 .. 360	1	32	A
65 Imager channel identifier	65	N/A	1 .. 20	5	16	A
66 5th percentile of imager radiances over CERES FOV	66	$W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$	TBD	5	32	V
67 Mean of imager radiances over CERES FOV	67	$W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$	TBD	5	32	A
68 95th percentile of imager radiances over CERES FOV	68	$W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$	TBD	5	32	V
Clear Footprint Area						
69 Sunglint percent coverage	69	N/A	0 .. 100	1	16	A
70 Snow/Ice percent coverage	70	N/A	0 .. 100	1	16	A
71 Smoke percent coverage	71	N/A	0 .. 100	1	16	A
72 Fire percent coverage	72	N/A	0 .. 100	1	16	A
73 Mean of imager radiances over clear area	73	$W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$	TBD	5	32	A
74 Stddev of imager radiances over clear area	74	$W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$	TBD	5	32	I
75 Total aerosol visible optical depth in clear area	75	N/A	0 .. 2	1	32	A
76 Total aerosol effective radius in clear area	76	µm	0 .. 20	1	32	A
Cloudy Footprint Area						
Cloud Category Arrays is Array[2] of:						
77 Cloud category area percent coverage	77	N/A	0 .. 100	2	16	A
78 Cloud category overcast percent coverage	78	N/A	0 .. 100	2	16	A
79 Cloud category broken percent coverage	79	N/A	0 .. 100	2	16	A
80 Mean of imager radiances for cloud category	80	$W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$	TBD	2 x 5	32	A
81 Stddev of imager radiances for cloud category	81	$W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$	TBD	2 x 5	32	I
82 Mean cloud visible optical depth for cloud category	82	N/A	0 .. 400	2	32	A
83 Stddev of visible optical depth for cloud category	83	N/A	TBD	2	32	A
84 Mean logarithm of cloud visible optical depth for cloud category	84	N/A	0 .. 6	2	32	A
85 Stddev of logarithm of visible optical depth for cloud category	85	N/A	TBD	2	32	A
86 Mean cloud infrared emissivity for cloud category	86	N/A	0 .. 1	2	32	A
87 Stddev of cloud infrared emissivity for cloud category	87	N/A	TBD	2	32	A
88 Mean liquid water path for cloud category	88	$g\ m^{-2}$	TBD	2	32	A
89 Stddev of liquid water path for cloud category	89	$g\ m^{-2}$	TBD	2	32	V
90 Mean ice water path for cloud category	90	$g\ m^{-2}$	TBD	2	32	A
91 Stdev of ice water path for cloud category	91	$g\ m^{-2}$	TBD	2	32	V
92 Mean cloud top pressure for cloud category	92	hPa	0 .. 1100	2	32	A
93 Stddev of cloud top pressure for cloud category	93	hPa	TBD	2	32	V
94 Mean cloud effective pressure for cloud category	94	hPa	0 .. 1100	2	32	A
95 Stddev of cloud effective pressure for cloud category	95	hPa	TBD	2	32	A
96 Mean cloud effective temperature for cloud category	96	K	100 .. 350	2	32	A
97 Stddev of cloud effective temperature for cloud category	97	K	TBD	2	32	A
98 Mean cloud effective height for cloud category	98	km	0 .. 20	2	32	A
99 Stddev of cloud effective height for cloud category	99	km	TBD	2	32	V
100 Mean cloud bottom pressure for cloud category	100	hPa	0 .. 1100	2	32	A
101 Stddev of cloud bottom pressure for cloud category	101	hPa	TBD	2	32	V
102 Mean water particle radius for cloud category	102	µm	TBD	2	32	A
103 Stddev of water particle radius for cloud category	103	µm	TBD	2	32	A
104 Mean ice particle effective diameter for cloud category	104	µm	TBD	2	32	A
105 Stddev of ice particle effective diameter for cloud category	105	µm	TBD	2	32	A

Table A-2. Single Satellite Footprint (SSF) Concluded

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	
106 Mean cloud particle phase for cloud category	106	N/A	0 .. 1	2	32	A
107 Stddev of cloud particle phase for cloud category	107	N/A	0 .. 1	2	32	V
108 Mean vertical aspect ratio for cloud category (TBD)	108	N/A	0 .. 1	2	32	A
109 Stddev of vertical aspect ratio for cloud category (TBD)	109	N/A	TBD	2	32	V
110 Percentiles of visible optical depth for cloud category	110	N/A	TBD	2 x 13	32	I
111 Percentiles of IR emissivity for cloud category	111	N/A	TBD	2 x 13	32	I
Overlap Footprint Area						
112 Number of imager pixels for overlap condition	112	N/A	0 .. 9000	4	16	A
113 Overlap condition weighted area percentage	113	N/A	0 .. 100	4	16	A

Total Meta Bits/File:	1704
Total Data Bits/Record:	**7744**
Total Records/File:	245475
Total Data Bits/File:	**1900958400**
Total MegaBytes / Hour	237.6
Total GigaBytes / Day	5.7

Appendix B

Output Data Products

Grid TOA and Surface Fluxes (Subsystem 9.0)

This appendix describes the data products which are used by the algorithms in this subsystem. The table 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 Product Summary

Product Code		Name	Type	Frequency	Size, MB	Monthly Size, MB
CERES	EOSDIS					
SFC	CER12	Gridded Single Satellite TOA and Surface Fluxes	Archival	1/Month	38.0	6847.2

Grid TOA and Surface Fluxes (Subsystem 9.0)

EOSDIS Product Code: CER12

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 .

Level: 3
Type: Archival
Frequency: 1/Month

Time Interval Covered
File: Month
Record: Hour

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

Portion of Atmosphere Covered
File: TOA and surface

Table B-2. Gridded Single Satellite TOA and Surface Fluxes and Clouds (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	
Description	Parameter Num	Unit	Range	Elements/ Record	Bits/ Elem	Elem Num
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

Table B-2. Gridded Single Satellite TOA and Surface Fluxes and Clouds (SFC) Concluded

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