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

Algorithm Theoretical Basis Document

Monthly Regional, Zonal, and Global Radiation Fluxes and Cloud Properties

(Subsystem 8.0)

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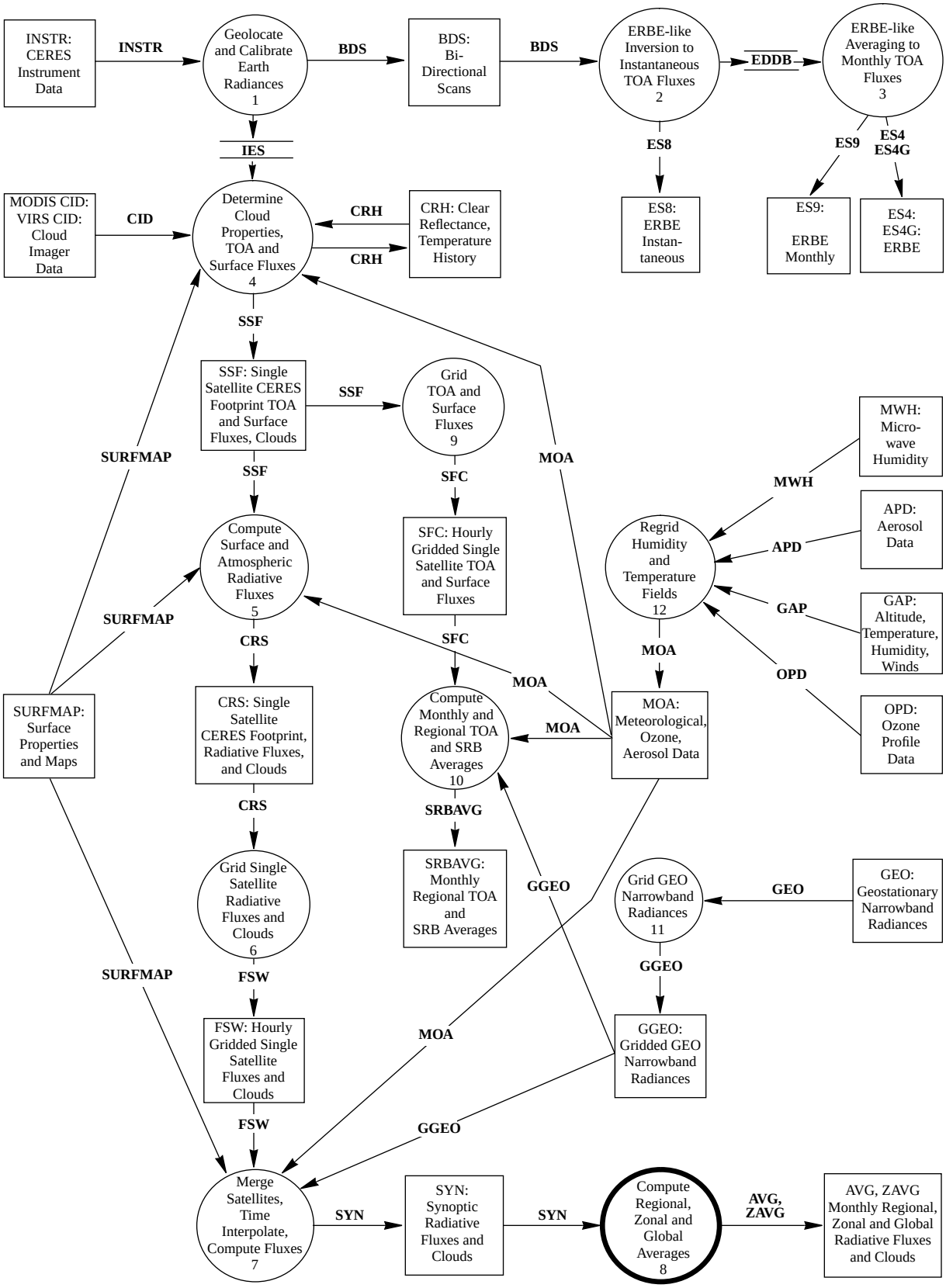
June 2, 1997

CERES Top Level Data Flow Diagram



Abstract

The CERES Data Management System produces regional, zonal, and global monthly and monthly-hourly means of the vertical structure of shortwave (SW) and longwave (LW) fluxes and cloud conditions. These means are first calculated on a regional basis from one month of synoptic maps. Regional means are then combined to obtain zonal and global averages.

The input to this subsystem is 1 month of 3-hourly synoptic maps in the form of the SYN data product. This data product contains top-of-the-atmosphere (TOA) LW and SW fluxes, TOA window radiances, upwelling and downwelling SW and LW flux at each standard CERES pressure level, and numerous cloud parameters for each region of the CERES global 1.0° equal-angle grid. Both total-sky and clear-sky fluxes are included. A complete description of the input data is provided in appendix A.

This subsystem produces two archived output products. The AVG product contains regional monthly and monthly-hourly means of the vertical structure of SW and LW fluxes and cloud conditions. The ZAVG product contains the same parameters averaged on zonal and global scales. Total-sky and clear-sky fluxes are provided at the TOA, the surface, and at each standard CERES pressure level. Cloud information including SW optical depth, emittance, liquid water path, cloud-top pressure, cloud-bottom pressure, cloud fractional area, cloud droplet radius, and the ice/water phase percentage is provided for each layer bounded by adjacent standard pressure levels. A complete description of the output data is given in appendix B.

The main steps of the monthly averaging process are

1. *Regionally sort the synoptically-ordered data.*
2. *Linearly average all flux data to produce monthly and monthly-hourly means.*
3. *Average the cloud properties using the proper weighting schemes.*
4. *Combine and average the regional means into zonal and global means.*

8.0. Monthly Regional, Zonal, and Global Radiation Fluxes and Cloud Properties

8.1. Algorithm Description

Zonal and global means are often used by meteorological researchers to study climate. Zonal quantities are useful in studying energy transport. Averaging on large spatial scales minimizes the effects of regional-scale anomalies in studying climate change and global dynamics. Global averages can be compared with other historical data sets derived from different regional scales to detect climate temperature trends and evaluate large-scale climate anomalies such as the effects of major volcanic eruptions.

The first step in the production of monthly means is the organization of the input data. The data are organized as files that each contain synoptic maps of the vertical structure of flux and cloud properties.

A separate data file exists for maps at 0, 3, 6, ..., 21 GMT for each day of the month. Each file contains data organized regionally on the CERES equal-angle grid. Sums of data values are maintained for each region and parameter simultaneously. The month of synoptic maps is simply read in sequential order.

The averaging process in this subsystem is extremely straightforward. The temporal interpolation necessary for calculating monthly means has already been performed in subsystem 7, providing a complete data set with uniform time sampling. In addition, the fluxes are also calculated in subsystem 7 at the levels at which they are averaged, so vertical interpolation is not required. Therefore, the monthly means of LW fluxes will be computed by simply averaging the month of synoptic data.

For SW fluxes, special consideration must be made to account for both the constantly changing solar conditions and the change of albedo as a function of solar zenith angle. All SW averages will use the same techniques described in subsystem 3 to correct mean fluxes to more accurately account for the contribution of the total integrated incident solar flux.

Data from each of the four cloud data structures described in subsystem 7 are compiled into monthly means. Monthly means for the cloud category properties and the cloud overlap statistics are averaged linearly using data from the synoptic grids. Monthly means for the angular model scene class data are compiled using only data from times of CERES observations. Column-weighted cloud properties are averaged using the proper weighting schemes as described in subsystem 6.

Since input data are only from 0, 3, 6, ..., 21 GMT, monthly-hourly means are produced for each parameter for only these times. This differs from the monthly-hourly products from SRBAVG which are calculated at all 24 hours based on local, not GMT, time.

Once regional means are computed for all parameters and all regions, these means are combined into zonal and global means. Area weighting factors are used to correct for the slight variation of grid box size with latitude.

8.2. Strategic Concerns

Monthly-hourly averages of LW and SW at the TOA from SRBAVG (the output from subsystem 10) will be compared with the results from averaging the eight synoptic maps to ensure that further interpolation to hourly maps is not required.

Simulations will be performed to determine the effects on the monthly mean SW fluxes of using only 3-hourly synoptic data. Additional time interpolation, similar to that used in the ERBE-like process of subsystem 3 may have to be employed to produce TOA SW flux estimates for all daylight hours before monthly means can be calculated. Studies will be performed to determine the best method for using the TOA SW estimates in an averaging scheme to produce monthly means of surface and atmosphere SW fluxes.

The decision to include additional time interpolation in this subsystem will also be affected by the handling of data gaps in subsystem 7.1. If restrictions are placed on the maximum time interval over which TOA flux estimates are calculated, then temporal data gaps may exist for some regions. If these gaps are common, then all parameters will be interpolated using the techniques used in subsystem 7.1.

Appendix A

Input Data Products

Compute Regional, Zonal and Global Averages (Subsystem 8.0)

This appendix describes the data products which are produced 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 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. Input Products Summary

Product Code		Name	Type	Frequency	Size, MB	Monthly Size, MB
CERES	EOSDIS					
SYN	CER07	Synoptic Radiative Fluxes and Clouds	Archival	Every 3 Hours	145.23	36016

Synoptic Radiative Fluxes and Clouds (SYN)

The Synoptic Radiative Fluxes and Clouds (SYN), a CERES archival product, is produced by the CERES Merge Satellites, Time Interpolate, Compute Fluxes Subsystem. Each SYN file contains regional longwave and shortwave radiative fluxes for the surface, internal atmosphere and TOA. The data are computed at 3-hour intervals on the CERES grid, and are based on measurements from multiple EOS CERES instruments. In addition to being an archival product, the SYN is used by the CERES subsystem, Compute Regional, Zonal and Global Averages.

The SYN contains averaged:

- Regional data
- Clear-sky area scene data
- Observed CERES TOA data
- Cloud category properties for four (low, lower middle, upper middle and high) cloud height categories
- Column averaged cloud properties for five (TOA SW, TOA LW, SFC LW, LWC and IWC) weighting schemes
- Overlap data for eleven (clear, low (L), lower middle (LM), upper middle (UM), high (H),
- H/UM, H/LM, H/L, UM/LM, UM/L, LM/L) cloud overlap conditions
- Angular model scene classes for the twelve ERBE scene types
- Surface radiative parameters
- Untuned radiative fluxes for both clear skies and total scene at the surface and the TOA
- Tuned radiative fluxes for both clear skies and total scene at the surface, 500hPa, the tropopause and the TOA
- Adjustment parameters for clear skies
- Adjustment parameters for four (low, lower middle, upper middle and high) cloud height categories

Level: 3
Type: Archival
Frequency: Every 3 Hours

Time Interval Covered
File: 3 Hours
Record: 3 Hours

Portion of Globe Covered
File: Global
Record: 1 CERES region

Portion of Atmosphere Covered
File: Surface, Internal and TOA

Table A-2. Synoptic Radiative Fluxes and Clouds (SYN)

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	Elem Num
Meta Data						
SYN Header FIle		N/A		1	380	
Regional Data						
Julian date at hour start	1	day	2449395 .. 2456000	1	32	1
Julian time at hour start	2	day	0 .. 1	1	32	2
Region number	3	N/A	1 .. 64800	1	32	3
Hour-box number	4	N/A	1 .. 744	1	32	4
Surface altitude above sea level, mean	5	m	-1000 .. 10000	1	32	5
Precipitable water	6	cm	0.001 .. 10.000	1	32	6
Cosine of solar zenith angle	7	deg	0 .. 1	1	32	7
Surface type percent coverage	8	N/A	0 .. 100	20	32	8
Clear-sky Area Data						
Snow/ice percent coverage	9	N/A	0 .. 100	1	32	28
Smoke percent coverage	10	N/A	0 .. 100	1	32	29
Fire percent coverage	11	N/A	0 .. 100	1	32	30
Total aerosol visible optical depth, clear area	12	N/A	0 .. 2	1	32	31
Total aerosol effective radius, clear area	13	N/A	0 .. 20	1	32	32
Observed CERES TOA Data for Clear-sky and Total-sky						
CERES SW flux, TOA, upwards, mean	14	W m^{-2}	0 .. 1400	2	32	33
CERES SW flux, TOA, upwards, std	15	W m^{-2}	TBD	2	32	35
CERES LW flux, TOA, upwards, mean	16	W m^{-2}	0 .. 1000	2	32	37
CERES LW flux, TOA, upwards, std	17	W m^{-2}	TBD	2	32	39
CERES WN flux, TOA, upwards, mean	18	W m^{-2}	10 .. 400	2	32	41
CERES WN flux, TOA, upwards, std	19	W m^{-2}	TBD	2	32	43
Albedo, TOA, mean	20	N/A	0 .. 1	2	32	45
Albedo, TOA, std	21	N/A	0 .. 1	2	32	47
Cloud Properties for 4 Cloud Height Categories (Cloud height categories are low, lower middle, upper middle and high)						
Overcast cloud area percentage	22	N/A	0 .. 100	4	32	49
Total cloud area percentage	23	N/A	0 .. 100	4	32	53
Cloud visible optical depth, mean	24	N/A	0 .. 400	4	32	57
Cloud vsible optical depth, std	25	N/A	TBD	4	32	61
Cloud infrared emissivity, mean	26	N/A	0 .. 1	4	32	65
Cloud infrared emissivity, std	27	N/A	0 .. 1	4	32	69
Cloud liquid water path, mean	28	g m^{-2}	0.001 .. 10.00	4	32	73
Cloud liquid water path, std	29	g m^{-2}	TBD	4	32	77
Cloud ice water path, mean	30	g m^{-2}	0.001 .. 10.00	4	32	81
Cloud ice water path, std	31	g m^{-2}	TBD	4	32	85
Cloud top pressure, mean	32	hPa	0 .. 1100	4	32	89
Cloud top pressure, std	33	hPa	TBD	4	32	93
Cloud effective pressure, mean	34	hPa	0 .. 1100	4	32	97
Cloud effective pressure, std	35	hPa	TBD	4	32	101
Cloud effective temperature, mean	36	K	100 .. 350	4	32	105
Cloud effective temperature, std	37	K	TBD	4	32	109
Cloud effective height, mean	38	km	0 .. 20	4	32	113
Cloud effective height, std	39	km	TBD	4	32	117
Cloud bottom pressure, mean	40	hPa	0 .. 1100	4	32	121
Cloud bottom pressure, std	41	hPa	TBD	4	32	125
Cloud liquid particle radius, mean	42	µm	0 .. 200	4	32	129
Cloud liquid particle radius, std	43	µm	TBD	4	32	133
Cloud ice particle effective diameter, mean	44	µm	0 .. 200	4	32	137
Cloud ice particle effective diameter, std	45	µm	TBD	4	32	141
Cloud particle phase, mean	46	N/A	0 .. 1	4	32	145
Cloud particle phase, std	47	N/A	0 .. 1	4	32	149
Vertical aspect ratio, mean	48	N/A	0 .. 1	4	32	153
Vertical aspect ratio, std	49	N/A	0 .. 1	4	32	157
Visible optical depth, 13 percentiles	50	N/A	TBD	52	32	161
Infrared emissivity, 13 percentiles	51	N/A	TBD	52	32	213

Table A-2. Synoptic Radiative Fluxes and Clouds (SYN) Continued

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	Elem Num
Column Averaged Cloud Properties for TOA-SW, TOA-LW, SFC-LW, LWC and IWC Weighting Schemes						
Overcast cloud area percentage	52	N/A	0 .. 100	5	32	265
Total cloud area percentage	53	N/A	0 .. 100	5	32	270
Cloud visible optical depth, mean	54	N/A	0 .. 400	5	32	275
Cloud vsible optical depth, std	55	N/A	TBD	5	32	280
Cloud infrared emissivity, mean	56	N/A	0 .. 1	5	32	285
Cloud infrared emissivity, std	57	N/A	0 .. 1	5	32	290
Cloud liquid water path, mean	58	g m^{-2}	0.001 .. 10.00	5	32	295
Cloud liquid water path, std	59	g m^{-2}	TBD	5	32	300
Cloud ice water path, mean	60	g m^{-2}	0.001 .. 10.00	5	32	305
Cloud ice water path, std	61	g m^{-2}	TBD	5	32	310
Cloud top pressure, mean	62	hPa	0 .. 1100	5	32	315
Cloud top pressure, std	63	hPa	TBD	5	32	320
Cloud effective pressure, mean	64	hPa	0 .. 1100	5	32	325
Cloud effective pressure, std	65	hPa	TBD	5	32	330
Cloud effective temperature, mean	66	K	100 .. 350	5	32	335
Cloud effective temperature, std	67	K	TBD	5	32	340
Cloud effective height, mean	68	km	0 .. 20	5	32	345
Cloud effective height, std	69	km	TBD	5	32	350
Cloud bottom pressure, mean	70	hPa	0 .. 1100	5	32	355
Cloud bottom pressure, std	71	hPa	TBD	5	32	360
Cloud liquid particle radius, mean	72	µm	0 .. 200	5	32	365
Cloud liquid particle radius, std	73	µm	TBD	5	32	370
Cloud ice particle effective diameter, mean	74	µm	0 .. 200	5	32	375
Cloud ice particle effective diameter, std	75	µm	TBD	5	32	380
Cloud particle phase, mean	76	N/A	0 .. 1	5	32	385
Cloud vertical aspect ratio, mean	77	N/A	0 .. 1	5	32	390
Cloud vertical aspect ratio, std	78	N/A	0 .. 1	5	32	395
Overlap Footprint Data for 11 Cloud Overlap Conditions (Cloud classes are clear, low (L), lower middle (LM), upper middle (UM), high (H), H/UM, H/LM, H/L, UM/LM, UM/L, and LM/L)						
Overlap condition weighted area percentage	79	N/A	0 .. 100	11	32	400
Angular Model Scene Classes for 12 ERBE Scene Types						
Fractional area coverage	80	N/A	0 .. 1	12	32	411
Albedo, mean	81	N/A	0 .. 1	12	32	423
Albedo, std	82	N/A	0 .. 1	12	32	435
Incident solar flux	83	W m^{-2}	TBD	12	32	447
Longwave flux, mean	84	W m^{-2}	TBD	12	32	459
Longwave flux, std	85	W m^{-2}	TBD	12	32	471
Surface Radiative Parameters						
Spectral reflectivity	86	N/A	0 .. 1	6	32	483
Broadband surface albedo	87	N/A	0 .. 1	1	32	489
LW surface emissivity	88	N/A	0 .. 1	1	32	490
WN surface emissivity	89	N/A	0 .. 1	1	32	491
Imager-based surface skin temperature	90	K	175 .. 375	1	32	492
Photosynthetically active radiation	91	W m^{-2}	0 .. 780	1	32	493
DIrect/diffuse ratio	92	N/A	0 .. 30	1	32	494
Atmospheric Flux Profile for Clear-sky and Total-sky (Atmospheric levels in profile are surface, 500hPa, tropopause and TOA)						
Number atmospheric levels	93	N/A	0 .. 4	1	32	495
Pressure, atmospheric levels	94	hPa	0 .. 1100	4	32	496
SW flux, atmospheric level, upwards, tuned	95	W m^{-2}	0 .. 1400	8	32	500
SW flux, atmospheric level, downwards, tuned	96	W m^{-2}	0 .. 1400	8	32	508
LW flux, atmospheric level, upwards, tuned	97	W m^{-2}	0 .. 1000	8	32	516
LW flux, atmospheric level, downwards, tuned	98	W m^{-2}	0 .. 1000	8	32	524

Table A-2. Synoptic Radiative Fluxes and Clouds (SYN) Concluded

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	Elem Num
Flux Adjustments (Tuned - Untuned) for Clear-sky and Total-sky at Surface and TOA						
Number of tuning iterations	99	N/A	0 .. 3	1	16	532
SW flux, surface, downwards, delta	100	W m^{-2}	0 .. 1400	2	32	533
SW flux, surface, upwards, delta	101	W m^{-2}	0 .. 1400	2	32	535
SW flux, TOA, upwards, delta	102	W m^{-2}	0 .. 1400	2	32	537
SW flux, TOA, downwards, delta	103	W m^{-2}	0 .. 1400	2	32	539
LW flux, surface, downwards, delta	104	W m^{-2}	0 .. 1000	2	32	541
LW flux, surface, upwards, delta	105	W m^{-2}	0 .. 1000	2	32	543
LW flux, TOA, upwards, delta	106	W m^{-2}	0 .. 1000	2	32	545
Adjustment Parameters for Clear Skies						
Adjusted precipitable water, delta	107	cm	0.001 .. 10.000	1	32	495
Adjusted surface albedo, delta	108	N/A	0 .. 1	1	32	496
Adjusted aerosol optical depth, delta	109	N/A	0.0 .. 2.0	1	32	497
Adjusted skin temperature, delta	110	K	TBD	1	32	498
Adjustment Parameters for 4 Cloud Height Categories						
Adjusted mean visible optical depth, delta	111	N/A	0 .. 400	4	32	499
Adjusted std visible optical depth	112	N/A	TBD	4	32	503
Adjusted mean cloud fractional area, delta	113	N/A	0 .. 1	4	32	507
Adjusted std cloud fractional area	114	N/A	0 .. 1	4	32	511
Adjusted mean cloud infrared emissivity, delta	115	N/A	0 .. 1	4	32	515
Adjusted std cloud infrared emissivity	116	N/A	0 .. 1	4	32	519
Adjusted mean cloud effective temperature, delta	117	K	0 .. 250	4	32	523
Adjusted std cloud effective temperature	118	K	TBD	4	32	527

Total Meta Bits/File:	380
Total Data Bits/Record:	18800
Total Records/File:	64800
Total Data Bits/File:	1218240000
Total Bits/File:	1218240380

Appendix B

Output Data Products

Compute Regional, Zonal and Global Averages (Subsystem 8.0)

This appendix describes the data products which are produced 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
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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					
AVG	CER08	Monthly Regional Radiative Fluxes and Clouds	Archival	1/Month	1230	1230
ZAVG	CER15	Monthly Zonal and Global Radiative Fluxes and Clouds	Archival	1/Month	3.45	3.45

Monthly Regional, Zonal, and Global Radiative Fluxes and Clouds (AVG/ZAVG)

The AVG/ZAVG product contains a monthly and monthly hourly averages of the TOA and surface LW and SW radiative fluxes, together with LW and SW fluxes at standard pressure levels in between. This final product also contains observed cloud and clear-sky properties at the standard one degree horizontal resolution.

AVG/ZAVG is an archival product produced for each spacecraft and for each combination of spacecraft. Initially at the TRMM launch, this product is produced in a validation mode every 3 months, or for 4 months a year. 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. Eighteen months after the TRMM launch, this product is archived and contains LW and SW fluxes at the tropopause and at 500 hPa pressure levels. Thirty-six months after the TRMM launch, this archived product contains LW and SW fluxes at 18 standard pressure levels. The pressure levels are in addition to fluxes at TOA and at the surface. In addition, the cloud and clear-sky properties are averaged between the 18 pressure levels, resulting in 17 vertical instances of the averaged cloud properties.

The major categories of data on the AVG/ZAVG are:

- Regional data
- Radiative fluxes for both clear-sky and total-sky at TOA.
- Cloud category properties for four (low, lower middle, upper middle and high) cloud layers.
- Adjustment parameters for four cloud layers.
- Column-averaged cloud properties for five (TOA SW, TOA LW, SFC LW, LWP, and IWP) weighting schemes.
- Adjustment parameters for five weighting schemes.
- Overlap data for eleven (clear, low (L), lower middle (LM), upper middle (UM), high (H), H/UM, H/LM, H/L, UM/LM, UM/L, LM/L) cloud conditions.
- Angular model scene classes.
- Atmospheric flux profile for clear-sky and total-sky.
- Flux adjustments for clear-sky and total-sky.
- Adjustment parameters for clear-skies.
- Surface data.

Level: 3

Type: Archival

Frequency: 1/Month

Portion of Globe Covered

File: Entire Globe

Record: 1 Degree Regions

Time Interval Covered

File: 1 Month

Record: 1 Month

Portion of Atmosphere Covered

File: Surface to TOA

Table B-2. Monthly Regional Radiative Fluxes and Clouds (AVG)

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	Elem Num
AVG						
AVG File Header		N/A	N/A	1	159232	
AVG Data						
REGIONAL DATA is Array[64800] of:						
Regional Parameters						
Region Number	1	N/A	1 - 64800	1	32	1
Surface altitude	2	km	-1000 - 10000	1	32	2
Precipitable water	3	cm	0.001 - 10.0	1	32	3
Surface type percent coverage	4	N/A	0.0 - 100.0	20	32	4
Clear-sky Area Scene Data						
Snow/Ice percent coverage	5	N/A	0.0 - 100.0	1	32	24
Smoke percent coverage	6	N/A	0.0 - 100.0	1	32	25
Fire percent coverage	7	N/A	0.0 - 100.0	1	32	26
Total aerosol visible optical depth, clear area	8	N/A	0.0 - 2.0	1	32	27
Total aerosol effective radius, clear area	9	N/A	0.0 - 20.0	1	32	28
TOA Fluxes for 2 Scene Classes						
Monthly-Hourly and Monthly TOA Fluxes is Array[9] of:						
(TOA hourly data are in elements 1-8, monthly data is in element 9)						
TOA flux is Array[3] of:						
Clear-Sky TOA Fluxes						
SW Flux at TOA: mean, std, num vals	10	Wm^{-2}	0.0 - 1400.0	27	32	29
LW flux at TOA: mean, std, num vals	11	Wm^{-2}	0.0 - 1000.0	27	32	56
Window flux: mean, std, num vals	12	Wm^{-2}	10.0 - 400.0	27	32	83
Total albedo: mean, std, num vals	13	N/A	0.0 - 1.0	27	32	110
Total-Sky TOA Fluxes						
SW Flux at TOA: mean, std, num vals	14	Wm^{-2}	0.0 - 1400.0	27	32	137
LW flux at TOA: mean, std, num vals	15	Wm^{-2}	0.0 - 1000.0	27	32	164
Window flux: mean, std, num vals	16	Wm^{-2}	10.0 - 400.0	27	32	191
Total albedo: mean, std, num vals	17	N/A	0.0 - 1.0	27	32	218
Fluxes levels						
Flux Levels Monthly-Hourly and Monthly Data is Array[9] of:						
(Flux monthly-hourly data are in elements 1-8, monthly data is in element 9)						
Atmospheric Flux Profile for 2 Scene Classes and 4 Layers						
Scene classes: clear-sky & total-sky, Layers: sfc, 500hPa, tropopause, & TOA is Array[24] of:						
Downward LW flux: mean, std dev, num vals	18	Wm^{-2}	0.0 - 1000.0	216	32	245
Upward SW flux: mean, std.dev, num vals	19	Wm^{-2}	0.0 - 1400.0	216	32	461
Downward SW Flux: mean, std dev, num vals	20	Wm^{-2}	0.0 - 1400.0	216	32	677
Upward LW flux: mean, std dev, num vals	21	Wm^{-2}	0.0 - 1000.0	216	32	893
Number of Atmospheric Layers	22	N/A	0 - 4	9	32	1109
Pressure, atmospheric layer	23	hPa	0 - 1100	36	32	1118
Flux Adjustments (Tuned - Untuned) for 2 Scene Classes and 2 Layers						
Scene classes,adj: clear-sky & total-sky is Array[2] of:						
Layer - surface is Array[3] of:						
Downward SW flux: mean, std, num days	24	Wm^{-2}	0.0 - 1400.0	54	32	1154
Downward LW flux: mean, std dev, num vals	25	Wm^{-2}	0.0 - 1000.0	54	32	1208
Upward SW flux: mean, std.dev, num vals	26	Wm^{-2}	0.0 - 1400.0	54	32	1262
Upward LW flux: mean, std dev, num vals	27	Wm^{-2}	0.0 - 1000.0	54	32	1316
Layer - TOA is Array[3] of:						
Upward SW flux: mean, std.dev, num vals	28	Wm^{-2}	0.0 - 1400.0	54	32	1370
Downward SW Flux: mean, std dev, num vals	29	Wm^{-2}	0.0 - 1400.0	54	32	1424
Upward LW flux: mean, std dev, num vals	30	Wm^{-2}	0.0 - 1000.0	54	32	1478
Clear-sky Adjustment Parameters						
Clear-sky Adj. Monthly and Monthly-Hourly Data is Array[9] of:						
(Clear-sky monthly-hourly data are in elements 1-8, monthly data is in element 9)						
Adjusted precipitable water: mean	31	cm	0.001 - 10.0	9	32	1532
Adjusted surface albedo: mean	32	N/A	0 - 1	9	32	1541
Adjusted aerosol optical depth: mean	33	N/A	0.0 - 2.0	9	32	1550
Adjusted skin temperature: mean	34	K	TBD	9	32	1559

Table B-2. Monthly Regional Radiative Fluxes and Clouds (AVG) Continued

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	Elem Num
Surface Data						
Surface Monthly-Hourly and Monthly Data is Array[9] of:						
(Surface monthly-hourly data are in elements 1-8, monthly data is in element 9)						
Photosynthetically active radiation	35	Wm^{-2}	0.0 - 780.0	9	32	1568
Direct/Diffuse ratio at surface: mean	36	N/A	0.0 - 30.0	9	32	1577
LW Surface Emissivity	37	N/A	0.0 - 1.0	9	32	1586
WN Surface Emissivity	38	N/A	0.0 - 1.0	9	32	1595
Imager-based surface skin temperature	39	K	175 - 375	9	32	1604
Monthly-Hourly and Monthly Cloud Information						
Monthly-Hourly data are in elements 1-8, Monthly data is in element 9 is Array[9] of:						
Angular Model Scene Types						
Angular Model Scene_Classes is Array[12] of:						
Fractional area coverage	40	Percent	0.0 - 100.0	108	32	1613
Albedo: mean, std	41	N/A	0.0 - 1.0	216	32	1721
Incident solar flux: mean, std	42	N/A	0.0 - 1400.0	216	32	1937
LW flux: mean, std	43	Wm^{-2}	0.0 - 400.0	216	32	2153
Column Averaged Cloud Properties						
Five weightings:TOA SW,TOA LW,SFC LW,LWP,and IWP is Array[5] of:						
Cloud Properties						
Overcast cloud area fraction	44	Percent	0.0 - 100.0	45	32	2369
Total cloud area fraction	45	Percent	0.0 - 100.0	45	32	2414
Cloud Property Stats is Array[3] of:						
Cloud effective pressure: mean, std, num vals	46	hPa	0.0 - 1100.0	135	32	2459
Cloud effective temperature: mean, std, num vals	47	K	100.0 - 350.0	135	32	2594
Cloud effective height: mean, std, num vals	48	km	0.0 - 20.0	135	32	2729
Cloud top pressure: mean, std, num vals	49	hPa	0.0 - 1100.0	135	32	2864
Cloud bottom pressure: mean, std, num vals	50	hPa	0.0 - 1100.0	135	32	2999
Cloud particle phase: mean, std, num vals	51	N/A	0.0 - 1.0	135	32	3134
Liquid water path: mean, std, num vals	52	$g\ m^{-2}$	0.001 - 1000.0	135	32	3269
Ice water path: mean, std, num vals	53	$g\ m^{-2}$	0.001 - 10.0	135	32	3404
Liquid particle radius: mean, std, num vals	54	micron	0.0 - 200.0	135	32	3539
Ice particle effective diameter: mean, std, num vals	55	micron	0.0 - 200.0	135	32	3674
Optical depth: mean, std, num vals	56	N/A	0.0 - 50.0	135	32	3809
Infrared emissivity: mean, std, num vals	57	N/A	0.0 - 2.0	135	32	3944
Cloud vertical aspect ratio: mean, std, num vals	58	N/A	TBD	135	32	4079
Adjustment Parameters for Column Averaged Data						
Five weights: TOA SW, TOA LW, SFC LW, LWP, AND IWP is Array[5] of:						
Adjusted cloud effective temperature: mean, std, num vals	59	K	0.0 - 250.0	135	32	4214
Adjusted optical depth: mean, std, num vals	60	N/A	0.0 - 400.0	135	32	4349
Adjusted cloud IR emissivity: mean, std, num vals	61	N/A	0.0 - 1.0	135	32	4484
Adjusted cloud fractional area: mean, std, num vals	62	N/A	0.0 - 1.0	135	32	4619
Monthly Only Cloud Information						
Cloud Category Properties						
Cloud Layers: H,UM,LM, & L is Array[4] of:						
Cloud Properties						
Overcast cloud area fraction	63	Percent	0.0 - 100.0	4	32	4754
Total cloud area fraction	64	Percent	0.0 - 100.0	4	32	4758
Cloud Property Stats is Array[3] of:						
Cloud effective pressure: mean, std, num vals	65	hPa	0.0 - 1100.0	12	32	4762
Cloud effective temperature: mean, std, num vals	66	K	100.0 - 350.0	12	32	4774
Cloud effective height: mean, std, num vals	67	km	0.0 - 20.0	12	32	4786
Cloud top pressure: mean, std, num vals	68	hPa	0.0 - 1100.0	12	32	4798
Cloud bottom pressure: mean, std, num vals	69	hPa	0.0 - 1100.0	12	32	4810
Cloud particle phase: mean, std, num vals	70	N/A	0.0 - 1.0	12	32	4822
Liquid water path: mean, std, num vals	71	$g\ m^{-2}$	0.001 - 1000.0	12	32	4834
Ice water path: mean, std, num vals	72	$g\ m^{-2}$	0.001 - 10.0	12	32	4846
Liquid particle radius: mean, std, num vals	73	micron	0.0 - 200.0	12	32	4858
Ice particle effective diameter: mean, std, num vals	74	micron	0.0 - 200.0	12	32	4870
Optical depth: mean, std, num vals	75	N/A	0.0 - 50.0	12	32	4882
Infrared emissivity: mean, std, num vals	76	N/A	0.0 - 2.0	12	32	4894
Cloud vertical aspect ratio: mean, std, num vals	77	N/A	TBD	12	32	4906

Table B-2. Monthly Regional Radiative Fluxes and Clouds (AVG) Concluded

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	Elem Num
Adjustment Parameters for 4 Cloud Layers						
Layers: H,UM,LM, & L is Array[4] of:						
Adjusted cloud effective temperature: mean, std, num vals	78	K	0.0 - 250.0	12	32	4918
Adjusted optical depth: mean, std, num vals	79	N/A	0.0 - 400.0	12	32	4930
Adjusted cloud fractional area: mean, std, num vals	80	N/A	0.0 - 1.0	12	32	4942
Adjusted cloud IR emissivity: mean, std, num vals	81	N/A	0.0 - 1.0	12	32	4954
Eleven Cloud Overlap Conditions						
Overlap condition weighted area fraction	82	N/A	0.0 - 1.0	11	32	4966

Total Meta Bits/Product:	**159232**
Total Bits/Record:	**159232**
Total Data Records/Product:	**64800**
Total Data Bits/Product:	**10318233600**
Total Bits/Product:	**10318392832**
Total Bytes/Record:	**19904**
Total Bytes/Product:	**1289799104**

Monthly Zonal and Global Radiative Fluxes and Clouds (ZAVG)

The Monthly Zonal and Global Radiative Fluxes and Clouds (ZAVG) product is a summary of the zonal and global averages of the radiative fluxes and cloud properties, probably most suitable for inclusion in the Earth Observing System Data and Information System (EOSDIS) Information Management System (IMS) as a browse product. This product is the CERES equivalent to the zonal averages and global averages in the ERBE S-4 product.

ZAVG is an archival product produced by the TISA subsystem for each instrument and for each combination of instruments. Initially at the TRMM launch, this product is produced in a validation mode every 3 months, or for 4 months a year. During the first 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. Eighteen months after the TRMM launch, this product is archived and contains LW and SW fluxes at the tropopause, and at 500 hPa pressure levels. Thirty-six months after the TRMM launch, this archived product will contain LW and SW fluxes at 18 standard pressure levels. The pressure levels are in addition to fluxes at TOA and at the surface. In addition, the cloud and clear-sky properties are averaged between the 18 pressure levels, resulting in 17 vertical instances of the averaged cloud properties. ZAVG contains one record of monthly and monthly hourly averages for each of the 180 latitudinal zones and one record of global averages.

The major categories of data on the ZAVG are:

- Regional data
- Radiative fluxes for both clear-sky and total-sky at TOA
- Cloud category properties for four cloud layers
- Column-averaged cloud properties for five weighting schemes
- Overlap data for eleven cloud conditions
- Angular model scene classes
- Adjustment parameters for four cloud layers
- Atmospheric profile for clear-sky and total-sky
- Flux adjustments for clear-sky and total-sky
- Surface data
- Adjustment parameters for clear-skies

Level: 3
Type: Archival
Frequency: Monthly

Portion of Globe Covered
File: Entire Globe
Record: Zonal and Global

Time Interval Covered
File: 1 Month
Record: 1 Month

Portion of Atmosphere Covered
File: Surface to TOA

Table B-3. Monthly Zonal and Global Radiative Fluxes and Clouds (ZAVG)

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	Elem Num
ZAVG						
ZAVG File Header		N/A	N/A	1	159040	
ZAVG Data						
ZONAL and GLOBAL DATA is Array[181] of:						
ZAVG Zone/Globe Parameters						
Zone/Globe Number	1	N/A	1 - 181	1	32	1
Surface type percent coverage	2	N/A	0.0 - 100.0	20	32	2
Snow/Ice percent coverage	3	N/A	0.0 - 100.0	1	32	22
TOA Fluxes for 2 Scene Classes						
Monthly-Hourly and Monthly TOA Fluxes is Array[9] of:						
(TOA hourly data are in elements 1-8, monthly data is in element 9)						
TOA flux is Array[3] of:						
Clear-Sky TOA Fluxes						
SW Flux at TOA: mean, std, num vals	4	Wm^{-2}	0.0 - 1400.0	27	32	23
LW flux at TOA: mean, std, num vals	5	Wm^{-2}	0.0 - 1000.0	27	32	50
Window flux: mean, std, num vals	6	Wm^{-2}	10.0 - 400.0	27	32	77
Total albedo: mean, std, num vals	7	N/A	0.0 - 1.0	27	32	104
Total-Sky TOA Fluxes						
SW Flux at TOA: mean, std, num vals	8	Wm^{-2}	0.0 - 1400.0	27	32	131
LW flux at TOA: mean, std, num vals	9	Wm^{-2}	0.0 - 1000.0	27	32	158
Window flux: mean, std, num vals	10	Wm^{-2}	10.0 - 400.0	27	32	185
Total albedo: mean, std, num vals	11	N/A	0.0 - 1.0	27	32	212
Fluxes levels						
Flux Levels Monthly-Hourly and Monthly Data is Array[9] of:						
(Flux monthly-hourly data are in elements 1-8, monthly data is in element 9)						
Atmospheric Flux Profile for 2 Scene Classes and 4 Layers						
Scene classes: clear-sky & total-sky, Layers: sfc, 500hPa, tropopause, & TOA is Array[24] of:						
Downward LW flux: mean, std dev, num vals	12	Wm^{-2}	0.0 - 1000.0	216	32	239
Upward SW flux: mean, std.dev, num vals	13	Wm^{-2}	0.0 - 1400.0	216	32	455
Downward SW Flux: mean, std dev, num vals	14	Wm^{-2}	0.0 - 1400.0	216	32	671
Upward LW flux: mean, std dev, num vals	15	Wm^{-2}	0.0 - 1000.0	216	32	887
Number of Atmospheric Layers	16	N/A	0 - 4	9	32	1103
Pressure, atmospheric layer	17	hPa	0 - 1100	36	32	1112
Flux Adjustments (Tuned - Untuned) for 2 Scene Classes and 2 Layers						
Scene classes,adj: clear-sky & total-sky is Array[2] of:						
Layer - surface is Array[3] of:						
Downward SW flux: mean, std, num days	18	Wm^{-2}	0.0 - 1400.0	54	32	1148
Downward LW flux: mean, std dev, num vals	19	Wm^{-2}	0.0 - 1000.0	54	32	1202
Upward SW flux: mean, std.dev, num vals	20	Wm^{-2}	0.0 - 1400.0	54	32	1256
Upward LW flux: mean, std dev, num vals	21	Wm^{-2}	0.0 - 1000.0	54	32	1310
Layer - TOA is Array[3] of:						
Upward SW flux: mean, std.dev, num vals	22	Wm^{-2}	0.0 - 1400.0	54	32	1364
Downward SW Flux: mean, std dev, num vals	23	Wm^{-2}	0.0 - 1400.0	54	32	1418
Upward LW flux: mean, std dev, num vals	24	Wm^{-2}	0.0 - 1000.0	54	32	1472
Clear-sky Adjustment Parameters						
Clear-sky Adj. Monthly and Monthly-Hourly Data is Array[9] of:						
(Clear-sky monthly-hourly data are in elements 1-8, monthly data is in element 9)						
Adjusted precipitable water: mean	25	cm	0.001 - 10.0	9	32	1526
Adjusted surface albedo: mean	26	N/A	0 - 1	9	32	1535
Adjusted aerosol optical depth: mean	27	N/A	0.0 - 2.0	9	32	1544
Adjusted skin temperature: mean	28	K	TBD	9	32	1553
Surface Data						
Surface Monthly-Hourly and Monthly Data is Array[9] of:						
(Surface monthly-hourly data are in elements 1-8, monthly data is in element 9)						
Photosynthetically active radiation	29	Wm^{-2}	0.0 - 780.0	9	32	1562
Direct/Diffuse ratio at surface: mean	30	N/A	0.0 - 30.0	9	32	1571
LW Surface Emissivity	31	N/A	0.0 - 1.0	9	32	1580
WN Surface Emissivity	32	N/A	0.0 - 1.0	9	32	1589
Imager-based surface skin temperature	33	K	175 - 375	9	32	1598

Table B-3. Monthly Zonal and Global Radiative Fluxes and Clouds (ZAVG) Continued

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	Elem Num
Monthly-Hourly and Monthly Cloud Information						
Monthly-Hourly data are in elements 1-8, Monthly data is in element 9 is Array[9] of:						
Angular Model Scene Types						
Angular Model Scene_Classes is Array[12] of:						
Fractional area coverage	34	Percent	0.0 - 100.0	108	32	1607
Albedo: mean, std	35	N/A	0.0 - 1.0	216	32	1715
Incident solar flux: mean, std	36	N/A	0.0 - 1400.0	216	32	1931
LW flux: mean, std	37	Wm^{-2}	0.0 - 400.0	216	32	2147
Column Averaged Cloud Properties						
Five weightings:TOA SW,TOA LW,SFC LW,LWP,and IWP is Array[5] of:						
Cloud Properties						
Overcast cloud area fraction	38	Percent	0.0 - 100.0	45	32	2363
Total cloud area fraction	39	Percent	0.0 - 100.0	45	32	2408
Cloud Property Stats is Array[3] of:						
Cloud effective pressure: mean, std, num vals	40	hPa	0.0 - 1100.0	135	32	2453
Cloud effective temperature: mean, std, num vals	41	K	100.0 - 350.0	135	32	2588
Cloud effective height: mean, std, num vals	42	km	0.0 - 20.0	135	32	2723
Cloud top pressure: mean, std, num vals	43	hPa	0.0 - 1100.0	135	32	2858
Cloud bottom pressure: mean, std, num vals	44	hPa	0.0 - 1100.0	135	32	2993
Cloud particle phase: mean, std, num vals	45	N/A	0.0 - 1.0	135	32	3128
Liquid water path: mean, std, num vals	46	$g\ m^{-2}$	0.001 - 1000.0	135	32	3263
Ice water path: mean, std, num vals	47	$g\ m^{-2}$	0.001 - 10.0	135	32	3398
Liquid particle radius: mean, std, num vals	48	micron	0.0 - 200.0	135	32	3533
Ice particle effective diameter: mean, std, num vals	49	micron	0.0 - 200.0	135	32	3668
Optical depth: mean, std, num vals	50	N/A	0.0 - 50.0	135	32	3803
Infrared emissivity: mean, std, num vals	51	N/A	0.0 - 2.0	135	32	3938
Cloud vertical aspect ratio: mean, std, num vals	52	N/A	TBD	135	32	4073
Adjustment Parameters for Column Averaged Data						
Five weights: TOA SW, TOA LW, SFC LW, LWP, AND IWP is Array[5] of:						
Adjusted cloud effective temperature: mean, std, num vals	53	K	0.0 - 250.0	135	32	4208
Adjusted optical depth: mean, std, num vals	54	N/A	0.0 - 400.0	135	32	4343
Adjusted cloud IR emissivity: mean, std, num vals	55	N/A	0.0 - 1.0	135	32	4478
Adjusted cloud fractional area: mean, std, num vals	56	N/A	0.0 - 1.0	135	32	4613
Monthly Only Cloud Information						
Cloud Category Properties						
Cloud Layers: H,UM,LM, & L is Array[4] of:						
Cloud Properties						
Overcast cloud area fraction	57	Percent	0.0 - 100.0	4	32	4748
Total cloud area fraction	58	Percent	0.0 - 100.0	4	32	4752
Cloud Property Stats is Array[3] of:						
Cloud effective pressure: mean, std, num vals	59	hPa	0.0 - 1100.0	12	32	4756
Cloud effective temperature: mean, std, num vals	60	K	100.0 - 350.0	12	32	4768
Cloud effective height: mean, std, num vals	61	km	0.0 - 20.0	12	32	4780
Cloud top pressure: mean, std, num vals	62	hPa	0.0 - 1100.0	12	32	4792
Cloud bottom pressure: mean, std, num vals	63	hPa	0.0 - 1100.0	12	32	4804
Cloud particle phase: mean, std, num vals	64	N/A	0.0 - 1.0	12	32	4816
Liquid water path: mean, std, num vals	65	$g\ m^{-2}$	0.001 - 1000.0	12	32	4828
Ice water path: mean, std, num vals	66	$g\ m^{-2}$	0.001 - 10.0	12	32	4840
Liquid particle radius: mean, std, num vals	67	micron	0.0 - 200.0	12	32	4852
Ice particle effective diameter: mean, std, num vals	68	micron	0.0 - 200.0	12	32	4864
Optical depth: mean, std, num vals	69	N/A	0.0 - 50.0	12	32	4876
Infrared emissivity: mean, std, num vals	70	N/A	0.0 - 2.0	12	32	4888
Cloud vertical aspect ratio: mean, std, num vals	71	N/A	TBD	12	32	4900
Adjustment Parameters for 4 Cloud Layers						
Layers: H,UM,LM, & L is Array[4] of:						
Adjusted cloud effective temperature: mean, std, num vals	72	K	0.0 - 250.0	12	32	4912
Adjusted optical depth: mean, std, num vals	73	N/A	0.0 - 400.0	12	32	4924
Adjusted cloud fractional area: mean, std, num vals	74	N/A	0.0 - 1.0	12	32	4936
Adjusted cloud IR emissivity: mean, std, num vals	75	N/A	0.0 - 1.0	12	32	4948

Table B-3. Monthly Zonal and Global Radiative Fluxes and Clouds (ZAVG) Concluded

Description	Parameter Number	Units	Range	Elements/ Record	Bits/ Elem	Elem Num
Eleven Cloud Overlap Conditions						
Overlap condition weighted area fraction	76	N/A	0.0 - 1.0	11	32	4960

Total Meta Bits/Product:	159040
Total Bits/Record:	159040
Total Data Records/Product:	181
Total Data Bits/Product:	28786240
Total Bits/Product:	28945280
Total Bytes/Record:	19880
Total Bytes/Product:	**3618160**

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