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

Data Management System

ES-9 Collection Guide

Release 1
Version 1

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Document Revision Record

The Document Revision Record contains information pertaining to approved document changes. The table lists the date the Software Configuration Change Request (SCCR) was approved, the Release and Version Number, the SCCR number, a short description of the revision, and the revised sections. The document authors are listed on the cover. The Head of the CERES Data Management Team approves or disapproves the requested changes based on recommendations of the Configuration Control Board.

Document Revision Record

SCCR Approval Date	Release/ Version Number	SCCR Number	Description of Revision	Section(s) Affected
xxxx	R1V1	xxxx	• The CERES Top Level Data Flow Diagram was modified (5/29/03).	Fig. 1-1
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Clouds and the Earth's Radiant Energy System (CERES) ES-9 Collection Guide

Summary

The Clouds and the Earth's Radiant Energy System (CERES) is a key component of the Earth Observing System (EOS) program. The CERES instrument provides radiometric measurements of the Earth's atmosphere from three broadband channels: a shortwave channel (0.3 - 5 µm), a total channel (0.3 - 200 µm), and an infrared window channel (8 - 12 µm). The CERES instruments are improved models of the Earth Radiation Budget Experiment (ERBE) scanner instruments, which operated from 1984 through 1990 on the National Aeronautics and Space Administration's (NASA) Earth Radiation Budget Satellite (ERBS) and on the National Oceanic and Atmospheric Administration's (NOAA) operational weather satellites, NOAA-9 and NOAA-10. The strategy of flying instruments on Sun-synchronous, polar orbiting satellites, such as NOAA-9 and NOAA-10, simultaneously with instruments on satellites that have precessing orbits in lower inclinations, such as ERBS, was successfully developed in ERBE to reduce time sampling errors. CERES continues that strategy by flying instruments on the polar orbiting EOS platforms simultaneously with an instrument on the Tropical Rainfall Measuring Mission (TRMM) spacecraft, which has an orbital inclination of 35 degrees. The TRMM satellite carries one CERES instrument while the EOS satellites carry two CERES instruments, one operating in a fixed azimuth plane scanning (FAPS) mode for continuous Earth sampling and the other operating in a rotating azimuth plane scanning (RAPS) mode for improved angular sampling.

To preserve historical continuity, some parts of the CERES data reduction use algorithms identical with the algorithms used in ERBE. At the same time, many of the algorithms on CERES are new. To reduce the uncertainty in data interpretation and to improve the consistency between the cloud parameters and the radiation fields, CERES includes cloud imager data and other atmospheric parameters. The CERES investigation is designed to monitor the top-of-atmosphere radiation budget as defined by ERBE, define the physical properties of clouds, define the surface radiation budget, and determine the divergence of energy throughout the atmosphere. The CERES Data Management System produces products which support research to increase understanding of the Earth's climate and radiant environment.

The ES-9 is one of the Clouds and the Earth's Radiant Energy System (CERES) science data archival products generated by the CERES ERBE-like Subsystem 3.0 (see Section 1.0). It is written in HDF and is a monthly product that contains 2.5° regional spatial averages from instantaneous scanner estimates at the top-of-the Earth's atmosphere which are averaged hourly, daily, and monthly.

The ES-9 product is created as an HDF file composed of vgroups (see Term-3) containing:

1. Regional Summary Data
2. Monthly (Day) Averages

3. Monthly (Hour) Averages
4. Daily Averages
5. Monthly Hourly Averages
6. Hourbox Data

The regional summary data group contains regional parameters such as longitude, colatitude, scene type, and number of hourboxes. These parameters remain the same regardless of the temporal group. The four temporal groups (Monthly (Day), Monthly (Hour), Daily, and Monthly Hourly averages (see Figure 0-1)) contain clear-sky and total-sky parameters such as solar incidence, net radiant flux, longwave flux statistics, shortwave flux statistics, and albedo (see Table 1-3). The dots in Figure 0-1 indicate interpolated values which are also used in calculating the Daily Averages. The hourbox data contain information about the individual hourboxes such as time of observation, longwave statistics, shortwave statistics, longitude, and colatitude.

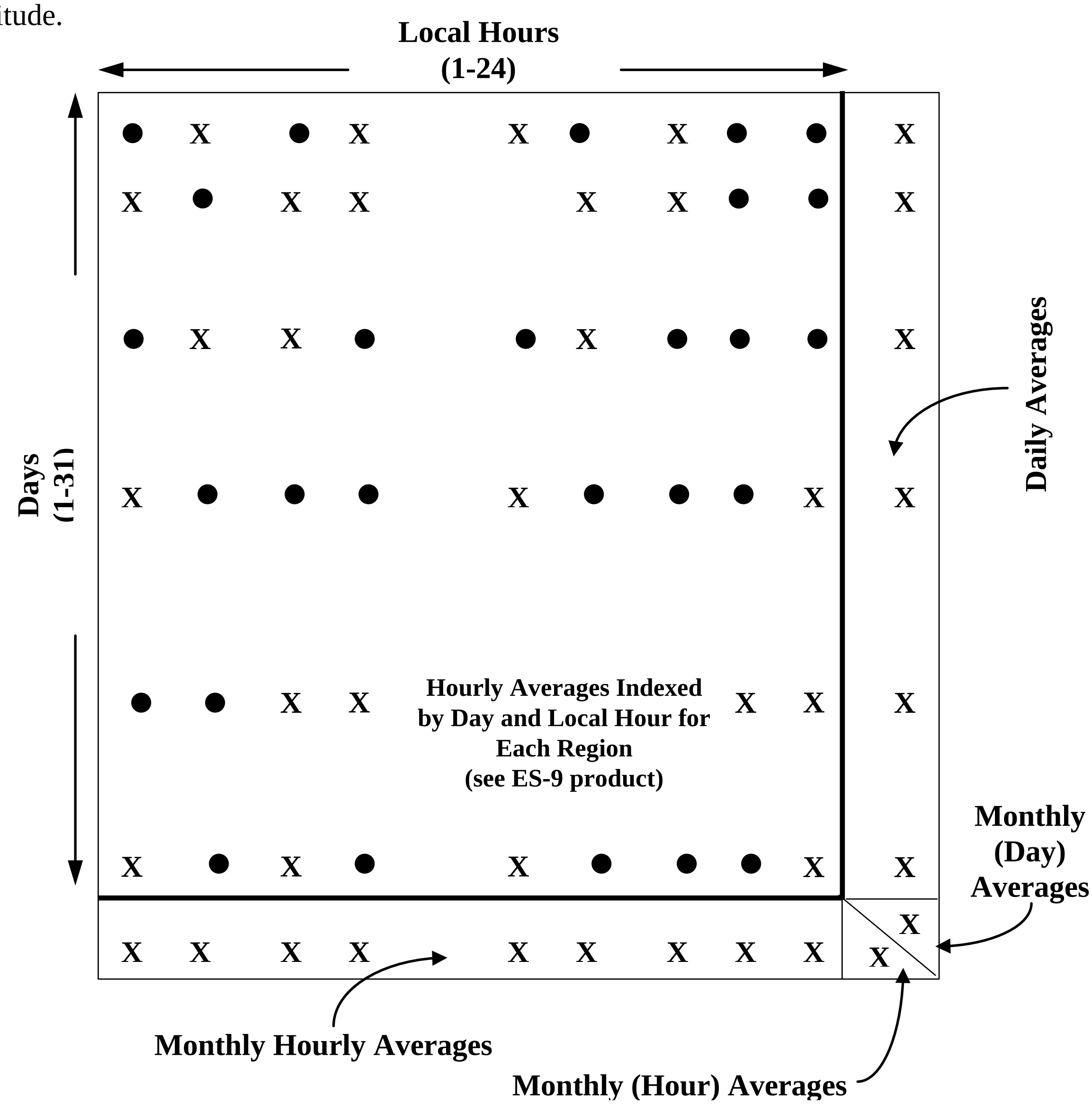

Figure 0-1. CERES Subsystem 3.0 Temporal Grid

1.0 Collection Overview

There are two ERBE-like subsystems; Subsystem 2.0 is the daily processor and Subsystem 3.0 is the monthly processor. The strategy for the ERBE-like subsystems is to process CERES data through the same processing system as ERBE with only minimal changes necessary to adapt to the CERES instrument characteristics. The ERBE-like Subsystem code was ported from the Control Data Corporation (CDC) cyber computers operating under NOS to run on a UNIX platform and was modified (see References 1 and 2) to process only data from scanning radiometers.

CERES Subsystem 2.0, ERBE-like Inversion to Instantaneous TOA, consists of the ERBE-like Inversion Processor.

The ERBE Inversion code was modified to account for the additional scanner samples from the CERES instrument, to process window channel radiometric measurements, and to produce tropical constants and 3-channel intercomparison results. This code converts filtered radiometric measurements in engineering units to instantaneous flux estimates at the top-of-atmosphere (TOA). The basis for this procedure is the ERBE processing system which produced TOA fluxes from the ERBE radiometers aboard the ERBS, NOAA-9, and NOAA-10 satellites over a 5-year period from November 1984 to February 1990. The ERBE inversion processing system is a mature set of algorithms that have been well documented and tested. An overview of the ERBE inversion algorithms is given by Smith et al., 1986 (see Reference 3). The CERES ERBE-like algorithms are documented in the CERES Algorithm Theoretical Basis Document (ATBD) for Subsystem 2.0 (see Reference 4). The applicable ERBE software is described in Reference 5.

CERES Subsystem 3.0, ERBE-like Averaging to Monthly TOA Fluxes, consists of the ERBE-like Daily Data Base (EDDB) processor, the ERBE-like Monthly Time/Space Averaging (EMTSA) processor, and the ERBE-like ES-4 output product code.

The EDDB processor collects and rearranges the time-referenced output data from Subsystem 2.0 into 36 regionally ordered latitudinal files for each instrument every month. EMTSA takes data from the latitudinal files and produces Daily and Monthly Hourly Averages and the averages of the Monthly Daily and Monthly Hourly Averages, of shortwave and longwave radiant fluxes for both clear-sky and total-sky at the top-of-atmosphere (TOA). The Monthly Hourly Average corresponds to estimates for one specific local hour which are averaged over the 31 days in the month. The averages of the Daily Averages are referred to as the Monthly (Day) Averages, and the averages of the Monthly Hourly Averages are referred to as the Monthly (Hour) Averages. The EMTSA calculations are performed at a 2.5° resolution for data from each instrument. The ES-4 software uses the output data from EMTSA to produce geographical averages of radiant flux and albedo values.

The algorithms for the ERBE-like Averaging to Monthly TOA Fluxes Subsystem are discussed in the CERES Algorithm Theoretical Basis Document (ATBD) for Subsystem 3.0 (see Reference 6). The applicable ERBE software is described in Reference 7.

1.1 Collection Identification

The ES-9 filename is

CER_ ES9_Sampling-Strategy_Production-Strategy_XXXXXX.YYYYMM where

CER	Investigation designation for CERES,
ES9	Product identification for the primary science data product (external distribution),
Sampling-Strategy	Platform, instrument, and imager (e.g., TRMM-PFM-VIRS),
Production-Strategy	Edition or campaign (e.g., At-launch, ValidationR1, Edition1),
XXXXXX	Configuration code for file and software version management,
YYYY	4-digit integer defining data acquisition year, and
MM	2-digit integer defining data acquisition month.

1.2 Collection Introduction

The ES-9 data product is a Level-3 archival product that contains 2.5° regional averages and the associated hourbox data. The scanner estimates at the TOA are arranged hourly, daily, and monthly. The ES-9 product contains six HDF vgroups (see Term-3) which are listed in Table 1-1. There are a total of 10,368 possible 2.5° regions for the ERBE-like data. Only regions with data will be contained on the ES-9. Therefore there are a maximum of 10,368 regions on an ES-9. The hourbox data contain measurements for each hour of each region for an entire month. If every region had measurements (10,368) and every hour of the month in that region contained measurements (744) then there would be 10,368 x 744 or 7,713,792 measurements of data for each hourbox SDS.

1.3 Objective/Purpose

The science objectives of the CERES investigation are

1. For climate change analysis, provide a continuation of the ERBE (Earth Radiation Budget Experiment) record of radiative fluxes at the top of the atmosphere (TOA) analyzed using the same techniques as the existing ERBE data.
2. Double the accuracy of estimates of radiative fluxes at the TOA and the Earth’s surface.
3. Provide the first long-term global estimates of the radiative fluxes within the Earth’s atmosphere.
4. Provide cloud property estimates which are consistent with the radiative fluxes from surface to TOA.

A high-level view of the CERES Data Management System (DMS) is illustrated by the CERES Top Level Data Flow Diagram shown in Figure 1-1. Circles in the diagram represent algorithm together convert input products into output products. Boxes represent archival products. Two parallel lines represent data stores which are designated as nonarchival or temporary data products. Boxes or data stores with arrows entering a circle are input sources for the subsystem, while boxes or data stores with arrows exiting the circles are output products.

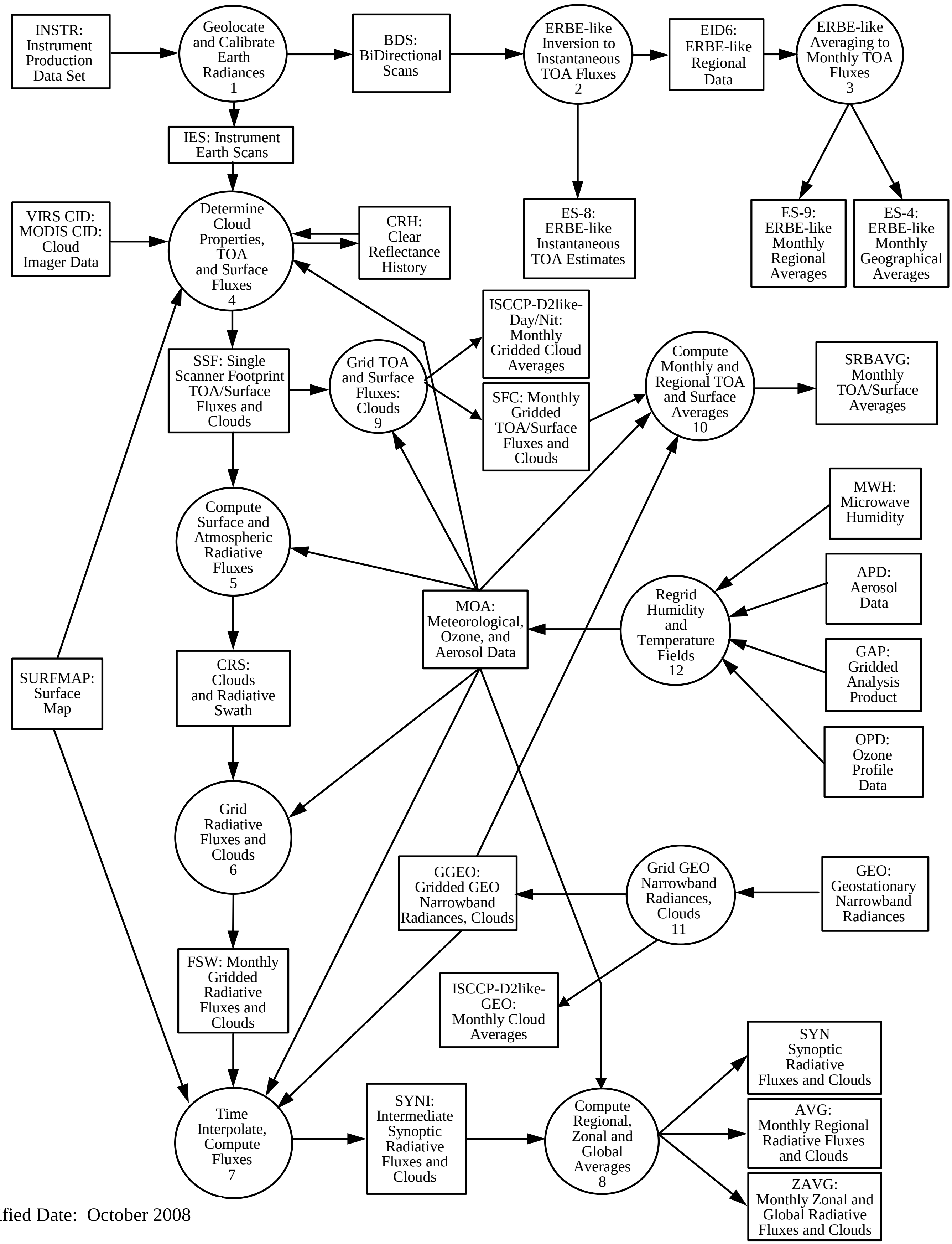

Figure 1-1. CERES Top Level Data Flow Diagram

As shown in Figure 1-1, the ES-9 product is generated by the CERES ERBE-like Monthly Time and Space Averaging Subsystem (3.0). The input to Subsystem 3.0 are the ERBE-like daily, regional averages on the Subsystem 2.0 output product EID-6.

1.1 Summary of Parameters

The ES-9 data are organized into vgroups (see Term-3) as shown in Table 1-1.

Table 1-1. ES-9 Vgroup Summary

Vgroup Number	Vgroup Name	Number of Records	Total Size (MB)
1	Regional Summary Data	10,368a	0.396
2	Monthly (Day) Averages	10,368a	1.107
3	Monthly (Hour) Averages	10,368a	1.107
4	Daily Averages	31 x 10,368a	34.330
5	Monthly Hourly Averages	24 x 10,368a	32.273
6	Hourbox Data	(10,368 x 744)b	1,029.902
Total Product Size (MB)			**1,099.115**

a. The actual size of the SDS will equal the number of 2.5° regions contained on the ES-9. 10,368 is the maximum number of regions.

b. The actual size of this SDS is equal to the sum of the number of hourboxes per region over all the regions contained on the ES-9. 10,368 is the maximum number of regions and 744 is the maximum number of hourboxes per region. Therefore the maximum number of elements for each SDS is 10,368 x 744 = 7,713,792.

The Regional Summary Data vgroup contains science parameters written as Scientific Data Sets (SDSs) (see Term-1) that are the same across all temporal averages. Table 1-2 shows the science parameters contained in this vgroup.

Table 1-2. Regional Summary Data

Parameter Name
See Table 5-4
Region number
Longitude
Colatitude
Geographic scene type
Scene fraction histogram (1)
Scene fraction histogram (2)
Scene fraction histogram (3)
Scene fraction histogram (4)

Table 1-2. Regional Summary Data

Parameter Name
Number of hourboxes
Start position of hourbox data

Each temporal vgroup contains science parameters written as SDSs (see Term-1) that are averaged temporally. Table 1-3 shows the four temporal groups and the science parameters contained in each.

Table 1-3. Temporal Vgroups for 2.5° Regions

Parameter Name	Temporal Vgroups			
	Monthly (Day) Averages	Monthly (Hour) Averages	Daily Averages	Monthly Hourly Averages
Total-Sky Parameters	See Table 5-5	See Table 5-7	See Table 5-9	See Table 5-11
Region number	X	X	X	X
Solar constant, distance corrected			X	
Solar incidence	X	X	X	X
Net radiant flux	X	X		
Longwave flux	X	X	X	X
Longwave flux minimum value	X	X	X	X
Longwave flux maximum value	X	X	X	X
Longwave flux standard deviation	X	X	X	X
Number of hours of longwave flux		X	X	
Number of days of longwave flux	X			X
Longwave sum of estimates				X
Longwave sum of estimates squared				X
Shortwave flux	X	X	X	X
Shortwave flux minimum value	X	X	X	X
Shortwave flux maximum value	X	X	X	X
Shortwave flux standard deviation	X	X	X	X
Number of hours of shortwave flux		X	X	
Number of days of shortwave flux	X			X
Shortwave sum of estimates				X
Shortwave sum of estimates squared				X
Albedo	X	X	X	X
Clear-sky Parameters	See Table 5-6	See Table 5-8	See Table 5-10	See Table 5-12

Table 1-3. Temporal Vgroups for 2.5° Regions

Parameter Name	Temporal Vgroups			
	Monthly (Day) Averages	Monthly (Hour) Averages	Daily Averages	Monthly Hourly Averages
Region number	X	X	X	X
Solar constant, distance corrected			X	
Solar incidence	X	X	X	X
Net radiant flux	X	X		
Longwave flux	X	X	X	X
Longwave flux minimum value	X	X	X	X
Longwave flux maximum value	X	X	X	X
Longwave flux standard deviation	X	X	X	X
Number of hours of longwave flux		X	X	
Number of days of longwave flux	X			X
Longwave sum of estimates				X
Longwave sum of estimates squared				X
Shortwave flux	X	X	X	X
Shortwave flux minimum value	X	X	X	X
Shortwave flux maximum value	X	X	X	X
Shortwave flux standard deviation	X	X	X	X
Number of hours of shortwave flux		X	X	
Number of days of shortwave flux	X			X
Shortwave sum of estimates				X
Shortwave sum of estimates squared				X
Albedo	X	X	X	X
Total parameters per temporal vgroup	28	28	28	34

The Hourbox Data vgroup contains science parameters written as SDSs. An hourbox must contain at least one good "measurement" to be included on the ES-9. Table 1-4 shows the science parameters contained in this group.

Table 1-4. Hourbox Data

Parameter Name
See Table 5-13
Region number
Longitude
Colatitude
Number of hourboxes

Table 1-4. Hourbox Data

Parameter Name
Hourbox number
Time of observation
Scene fraction (1)
Scene fraction (2)
Scene fraction (3)
Scene fraction (4)
Albedo factor (1)
Albedo factor (2)
Albedo factor (3)
Albedo factor (4)
Cosine of the solar zenith angle
Satellite zenith angle
Azimuth angle
Solar incidence
Longwave flux
Longwave flux minimum value
Longwave flux maximum value
Longwave flux standard deviation
Number of longwave flux estimates
Longwave flux maximum difference
Shortwave flux
Shortwave flux minimum value
Shortwave flux maximum value
Shortwave flux standard deviation
Number of shortwave flux estimates
Shortwave flux maximum difference
Clear-sky longwave flux
Clear-sky longwave flux standard deviation
Number of clear-sky longwave flux estimates
Clear-sky albedo standard deviation

1.2 Discussion

In Subsystem 2.0, data are processed in time-ordered sequence regardless of the location of the measurements. To obtain monthly averages of the radiometric measurements for geographic regions, the data must be made accessible by region. To accomplish this data transition, a Daily Data Base which contains data for an entire month is created to store the time-sequenced inverted data. The data base is comprised of 36 latitudinal data files and a housekeeping file. The housekeeping file provides the necessary information for accessing data from the data base. As each daily EID-6 file (regional averages) from the ERBE-like Inversion Subsystem is processed, individual records are written to one of the 36 latitudinal data files based on region number. After all EID-6 files are processed, a final sort is performed to each of the 36 latitudinal files.

The function of the ERBE-like Monthly Time/Space Averaging Subsystem is to produce daily and monthly averages of shortwave and longwave radiant flux and other parameters (see Table 1-3) on a regional basis. These calculations are made at the spatial resolution of a 2.5° region on the Earth's surface. The data are processed to produce Daily Averages, Monthly Hourly Averages (each hour averaged for all data during the month), and two grand monthly averages (averages of the Daily and Monthly Hourly Averages) for each geographic region. The averages are stored on the ES-9 and used to produce the ES-4 product which contains regionally, zonally, and globally averaged parameters.

1.3 Related Collections

The CERES DMS produces science data products or collections for use by the CERES Science Team, the Data Management Team, and for archival at the Langley Distributed Active Archive Center (DAAC). For a complete list of products, see the CERES Data Products Catalog (Reference 8).

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2.1 Title of Investigation

Clouds and the Earth's Radiant Energy System (CERES)
ERBE-like Subsystems (Subsystems 2.0 & 3.0)

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3.0 Origination

The CERES data originate from CERES instruments on-board either the TRMM or the EOS Earth-orbiting spacecraft. Table 3-1 lists the CERES instruments along with their host satellites.

Table 3-1. CERES Instruments

Satellite	CERES Instrument	
TRMM	PFM	
Terra	FM1	FM2
Aqua	FM3	FM4

3.1 Sensor and Instrument Description

The CERES instrument package contains three scanning thermistor bolometer radiometers classified by their broad-band spectral regions: total, window, and shortwave. The detectors measure the radiation in the near-visible through far-infrared spectral region. The shortwave detector measures Earth-reflected solar radiation in the wavelength region of 0.3 to 5.0 microns; the window detector measures Earth-emitted longwave radiation in the water vapor window wavelength region of 8.0 to 12.0 microns; and the total detector measures radiation in the wavelength region of 0.3 to 100 microns. The detectors are coaligned and mounted on a spindle that rotates about the instrument elevation axis. The field of view footprints of the CERES detectors are approximately 10- and 20-km at nadir for the instruments on the TRMM and EOS spacecraft, respectively.

The CERES instrument has an operational scanning cycle of 6.6 seconds and various scan elevation profiles. Radiometric measurements are sampled from the detectors every 0.01 seconds in all scanning profiles. The instrument makes Earth science measurements while the detectors rotate in the vertical (elevation scan) and horizontal (azimuth rotation). The instrument has built-in calibration sources for performing in-flight calibrations, and can also be calibrated by measuring solar radiances reflected by a solar diffuser plate into the instrument field of view. See the In-flight Measurement Analysis, DRL 64, provided by the CERES instrument builder TRW (Reference 9), and the CERES Algorithm Theoretical Basis Document (ATBD) for Subsystem 1.0 (Reference 10). Also, see the instrument, the sensor, and the platform Guides (TBD).

4.0 Data Description

4.1 Spatial Characteristics

4.1.1 Spatial Coverage

The CERES collection is a global data set whose spatial coverage depends on the satellite orbit. The spatial coverage of the data contained on the ES-9 is shown in Table 4-1.

Table 4-1. ES-9 Spatial Coverage

Spacecraft	Instrument	Minimum Latitude (deg)	Maximum Latitude (deg)	Minimum Longitude (deg)	Maximum Longitude (deg)	Spacecraft Altitude (km)
TRMM	PFM	-42.5	42.5	-180.0	180.0	350
Terra	FM1 & FM2	-90.0	90.0	-180.0	180.0	705
Aqua	FM3 & FM4	-90.0	90.0	-180.0	180.0	705

4.1.2 Spatial Resolution

The ES-9 contains 2.5° regional averages on various temporal scales as described in this document's Summary. It also contains hourbox information for each region which provides measurements for each hour there were data in a particular region. The CERES field of view of a nadir viewing measurement is 10 km for TRMM and 20 km for both Terra and Aqua.

4.1.3 Grid Description

Spatially, the ES-9 contains 2.5° regional data collected in the standard ERBE grid system, an Earth equatorial-Greenwich Meridian grid system composed of 2.5° equal-angle regions with colatitudinal indices (1-72) ranging 180° from north to south and longitudinal indices (1-144) that range from the Greenwich Meridian eastward through 360° (see Figure 4-1 and Appendix C in Reference 7).

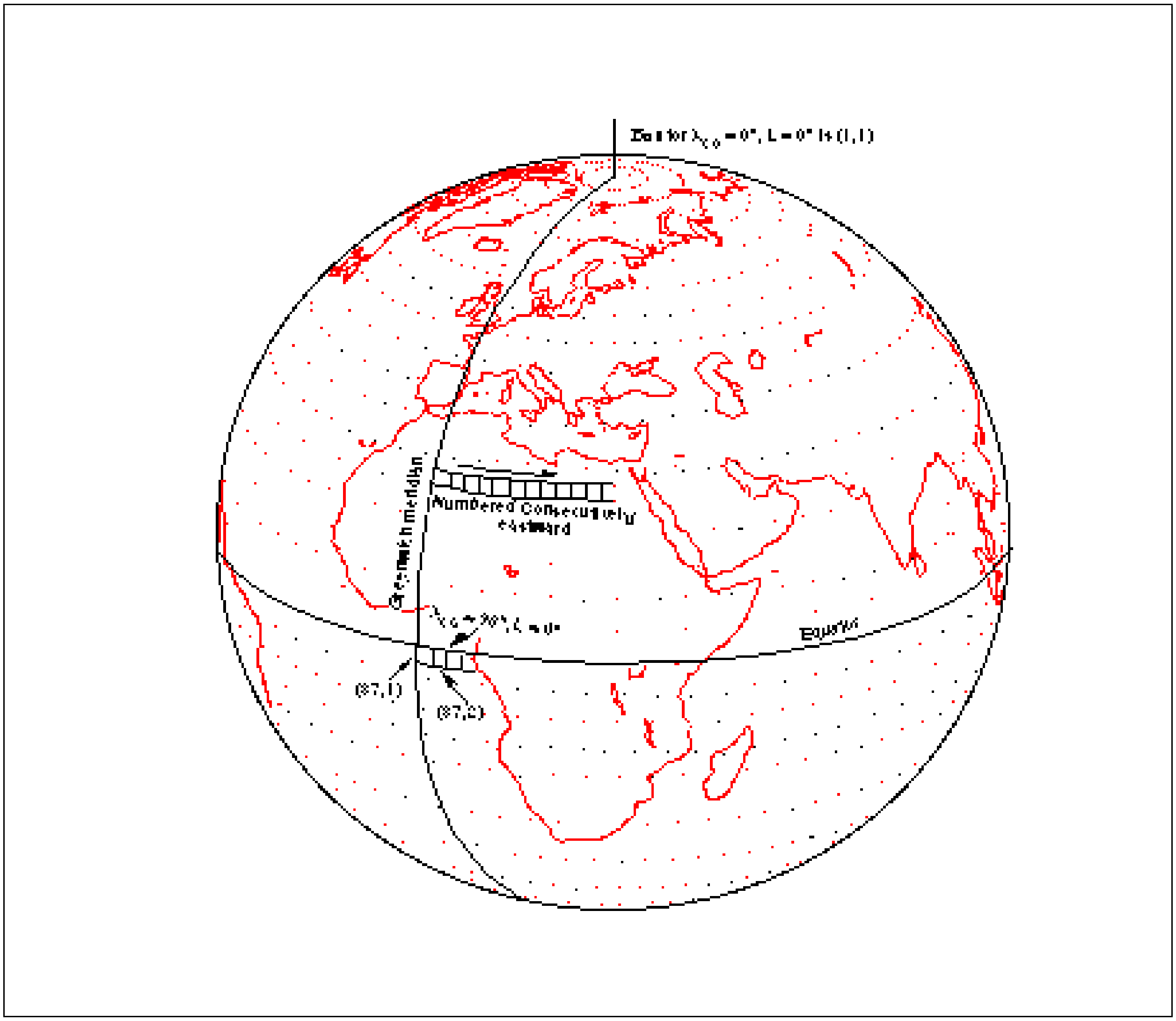

Figure 4-1. Layout of a 2.5° System

4.2 Temporal Characteristics

4.2.1 Temporal Coverage

CERES temporal coverage begins at different times depending upon when the spacecraft is launched, when the scan covers are opened after launch, and when early in-orbit calibration check-out is completed (see Table 4-2).

Table 4-2. CERES Temporal Coverage

Spacecraft	Instrument	Launch Date	Start Date	End Date
TRMM	PFM	11/27/1997	12/27/1997	8/31/1998a
Terra	FM1 & FM2	Expected mid-1999	TBD	TBD
Aqua	FM3 & FM4	Expected late-2000	TBD	TBD

a. The CERES instrument on TRMM has operated only occasionally since 9/1/98 due to a power converter anomaly.

4.2.2 Temporal Resolution

The ES-9 is a monthly data product that contains Monthly (Day) Averages, Monthly (Hour) Averages, Daily Averages, Monthly Hourly Averages, and Hourbox Data (see Figure 0-1) for the month.

4.3 Parameter Definitions

The parameters contained on the ES-9 are listed by SDS name and are defined in Section 4.3.1 in tables arranged according to the data classifications on the ES-9. These vgroups are listed below.

1. Regional Summary Data
2. Monthly (Day) Averages
3. Monthly (Hour) Averages
4. Daily Averages
5. Monthly Hourly Averages
6. Hourbox Data

There are tables for total-sky and clear-sky averages for each temporal group. A discussion of regional averages and albedo calculations follow in Sections 4.3.2 - 4.3.3.

4.3.1 ES-9 Parameter Definitions according to Temporal Classification

Tables 4-4 through 4-13 in this section contain the definitions of each parameter on the ES-9. The arrangement of the tables containing the summary data, temporal vgroups, and hourbox data is shown in Table 4-3. Section 16.3 contains the List of Symbols used in these tables.

Table 4-3. Location of ES-9 Parameter Descriptions

Temporal Group	Total-Sky	Clear-Sky
Regional Summary Data	Table 4-4	
Monthly (Day) Averages	Table 4-5	Table 4-6
Monthly (Hour) Averages	Table 4-7	Table 4-8
Daily Averages	Table 4-9	Table 4-10
Monthly Hourly Averages	Table 4-11	Table 4-12
Hourbox Data	Table 4-13	

Table 4-4. Regional Summary Data

Item No.	SDS Name	Regional Summary Data	Units
1	Region number	An integer from 1 to 10,368 denotes one of the 2.5 ° x 2.5 ° regions. Regions are numbered consecutively west to east with 144 per latitude band and 72 per longitude band.	number
2	Longitude	The longitude of the center of the region.	degrees
3	Colatitude	The colatitude of the center of the region.	degrees
4	Geographic scene type	An integer from 1 to 5 denoting the surface type of the region. The types are: 1. Ocean 2. Land 3. Snow 4. Desert 5. Land/Ocean mix (Coast)	N/A
5	Scene fraction histogram(1)	The sum of all scene fractions for one month for clear scenes.	N/A
6	Scene fraction histogram(2)	The sum of all scene fractions for one month for partly cloudy scenes.	N/A
7	Scene fraction histogram(3)	The sum of all scene fractions for one month for mostly cloudy scenes.	N/A
8	Scene fraction histogram(4)	The sum of all scene fractions for one month for overcast scenes.	N/A
9	Number of hourboxes	The number of hours in a month with estimates of any kind.	number
10	Start position of hourbox data	The starting position in the Hourbox Data SDS array that corresponds to the given region number.	number

Table 4-5. Monthly (Day), Total-Sky Averagesa

Item No.	SDS Name	Monthly (Day), Total-sky Definitions	Units
11	Region number	An integer from 1 to 10,368 denotes one of the 2.5 ° x 2.5 ° regions. Regions are numbered consecutively west to east with 144 per latitude band and 72 per longitude band.	number
12	Solar incidence	The monthly total integrated solar incidence for all days of the month.	W-hm^{-2}
13	Net radiant flux	The monthly net flux defined from albedo in Monthly Time/Space Averaging, the sum of integrated solar incidence over the entire month, and monthly net LW flux (see Reference 12). $$\bar{M}_{NET}(d,h) = \left[\left(1-\bar{a}(da)\right) \cdot \sum_{d=1}^{N} S(d)/(24 \cdot N)\right] - \bar{M}_{LW}(d,h)$$	Wm^{-2}
14	Longwave flux	The monthly mean LW flux based on all extrapolated, interpolated, and modeled LW flux values for the month in this region. $$\bar{M}_{LW}(d,h) = \sum_{d=1}^{N}\sum_{h=1}^{24} M_{LW}\ (d,h)/(24 \cdot N)$$ where N = all days of month (see Reference 12).	Wm^{-2}
15	Longwave flux minimum value	The minimum daily mean of the longwave flux for the month.	Wm^{-2}
16	Longwave flux maximum value	The maximum daily mean of the longwave flux for the month.	Wm^{-2}
17	Longwave flux standard deviation	The standard deviation for the longwave flux daily means for every day in the month.	Wm^{-2}
18	Number of days of longwave flux	The number of days with at least one longwave flux estimate.	days
19	Shortwave flux	The monthly mean SW flux based on daily SW flux values, including “measurements” from the Inversion Subsystem (see Reference 5) and modeled values, within this region. $$M_{SW}\ (da) = \bar{a}(da) \cdot \sum_{d=1}^{N} S(d)/24 \cdot N)$$ where N = all days of the month, $S(d)$ is the integrated daily solar incident radiation, and $\bar{a}(d\alpha)$ is defined in Item 24, Table 4-5.	Wm^{-2}

Table 4-5. Monthly (Day), Total-Sky Averagesa

Item No.	SDS Name	Monthly (Day), Total-sky Definitions	Units
20	Shortwave flux minimum value	The minimum daily mean for days with at least one shortwave flux estimate.	Wm^{-2}
21	Shortwave flux maximum value	The maximum daily mean for days with at least one shortwave flux estimate.	Wm^{-2}
22	Shortwave flux standard deviation	The standard deviation of daily means for days with at least one shortwave flux estimate	Wm^{-2}
23	Number of days of shortwave flux	The number of days with at least one shortwave flux estimate.	days
24	Albedo	The monthly mean albedo from daily values, based on the sum of all SW fluxes calculated for days with at least one SW measurement (D_{SW}). $$\bar{a}(da) = 24 \cdot \sum_{D_{SW}} M_{SW}(d) / \sum_{D_{SW}} S(d)$$ where S(d) = integrated solar flux (see Reference 12). The solar incidence is integrated from sunrise to sunset for each day with SW data, assuming a sun position for the day that is fixed at its position for $0^h0^m0^s$ UT. The summed SW flux for each day is multiplied by the ratio of the integrated to summed solar incidence for that day to provide some corrections to the summation error. $$M_{SW}(d) = [S(d)/S'(d)] \cdot \sum_{h=1}^{24} M_{SW}(d,h)/24$$ where $S'(d)$ and $S(d)$ are the summed and integrated solar fluxes, respectively (also see Item 75, Table 4-9). Other equations used to calculate the albedo values in ES-9 may be found in 4.3.3 of this document.	unitless

a. These are monthly means based on daily calculations of flux. For longwave quantities, the daily means are obtained from the extrapolation, interpolation, and diurnal modeling algorithms that operate on the existing longwave measurements. The extrapolation and interpolation algorithms will, in general, cross daily boundaries, but the longwave diurnal model applied to land scenes operates on a specific day. The shortwave quantities are based on calculations for specific days. The days are defined to be symmetric about local solar noon.

Table 4-6. Monthly (Day), Clear-sky Averages

Item No.	SDS Name	Monthly (Day), Clear-sky Definitions	Units
25	Region number	Clear-sky information for longwave (means and statistics defined in Reference 11) is calculated in the ERBE-like Inversion Subsystem and passed through Monthly Time/Space Averaging. The shortwave clear-sky values are calculated by Monthly Time/Space Averaging according to the distribution of cloud conditions as indicated by the scene fraction vector from the ERBE-like Inversion Subsystem.	number
26	Solar incidence		W-hm^{-2}
27	Net radiant flux		Wm^{-2}
28	Longwave flux		Wm^{-2}
29	Longwave flux minimum value		Wm^{-2}
30	Longwave flux maximum value		Wm^{-2}
31	Longwave flux standard deviation		Wm^{-2}
32	Number of days of longwave flux		days
33	Shortwave flux		Wm^{-2}
34	Shortwave flux minimum value		Wm^{-2}
35	Shortwave flux maximum value		Wm^{-2}
36	Shortwave flux standard deviation		Wm^{-2}
37	Number of days of shortwave flux		days
38	Albedo		unitless

Table 4-7. Monthly (Hour), Total-sky Averagesa

Item No.	SDS Name	Monthly (Hour), Total-sky Definitions	Units
39	Region number	An integer from 1 to 10,368 denotes one of the 2.5 ° x 2.5° regions. Regions are numbered consecutively west to east with 144 per latitude band and 72 per longitude band.	number
40	Solar incidence	The monthly total solar incidence for all days of the month.	W-hm^{-2}
41	Net radiant flux	The monthly net flux as calculated from albedo in Subsystem 3.0. The solar incidence is summed (not integrated) over the entire month; the monthly net LW flux is defined from days with at least one LW measurement. $$M_{NET}(mha) = \left(1 - \overline{a}(h)\right) \cdot \sum_{d=1}^{N} S(d)/(24 \cdot N_{SW}) - M_{LW}(mha)$$ where mha = monthly hourly average, $a(h)$ is defined in Item 111, Table 4-11, $S(d)$ is the integrated daily solar incident radiation, and $M_{LW}(mha)$ is defined in Item 42, Table 4-7.	Wm^{-2}
42	Longwave flux	The monthly mean LW flux based on extrapolated, interpolated, and modeled LW values only for days during the month that had at least one actual LW measurement. The monthly LW flux may be calculated from monthly hourly averages (mha) as, $$M_{LW}(mha) = \sum_{h=1}^{24} M_{LW}(h)/N\,(mha)_{LW}$$ (see Reference 12).	Wm^{-2}
43	Longwave flux minimum value	The minimum longwave flux for days with at least one longwave flux estimate.	Wm^{-2}
44	Longwave flux maximum value	The maximum longwave flux for days with at least one longwave flux estimate.	Wm^{-2}
45	Longwave flux standard deviation	The standard deviation of all monthly (hour) mean longwave fluxes for days with at least one longwave flux estimate.	Wm^{-2}
46	Number of hours of longwave flux	The number of hours with at least one longwave flux estimate.	hours
47	Shortwave flux	The monthly mean SW flux based on summing SW flux values over days with at least one SW measurement, and then over each local hour. $$\overline{M}_{SW} = \overline{a} \cdot \sum_{d=1}^{N} S(d)/(24 \cdot N_{SW})$$ where N_{SW} = all days of the month, $S(d)$ is the integrated daily solar incident radiation, and $\overline{a}$ is defined in Item 52, Table 4-7.	Wm^{-2}

Table 4-7. Monthly (Hour), Total-sky Averagesa

Item No.	SDS Name	Monthly (Hour), Total-sky Definitions	Units
48	Shortwave flux minimum value	The minimum monthly hourly mean shortwave flux, as calculated for days with at least one shortwave flux estimate. It can be zero if there is at least one nighttime hour during the month.	Wm^{-2}
49	Shortwave flux maximum value	The maximum monthly hourly mean shortwave flux, as calculated for days with at least one shortwave flux estimate.	Wm^{-2}
50	Shortwave flux standard deviation	The standard deviation of all monthly (hour) shortwave flux means including nighttime values. This value may be a large number without much physical significance.	Wm^{-2}
51	Number of hours of shortwave flux	The number of hours with at least one shortwave flux estimate.	hours
52	Albedo	The monthly mean albedo from monthly hourly values, based on the sum of all SW fluxes calculated. The equations used to calculate the albedo values in ES-9 may be found in 4.3.3 of this document. $$\bar{a} = 24 \cdot \sum_{D_{SW}} M_{SW}(d) / \sum_{D_{SW}} S(d)$$ where $S(d)$ is the integrated solar radiance and D_{SW} represents days with at least one SW measurement (see Reference 12).	unitless

a. The LW monthly means are based on values averaged over the month at each local hour. In general, they result in different values for the same quantity, compared to the Monthly (Day) means.

Table 4-8. Monthly (Hour), Clear-sky Averages

Item No.	SDS Name	Monthly (Hour), Clear-sky Definitions	Units
53	Region number	Clear-sky information for longwave (means and statistics defined in Reference 11) is based on values calculated in the ERBE-like Inversion Subsystem. The shortwave clear-sky values are calculated by Monthly Time/Space Averaging according to the distribution of cloud conditions as indicated by the scene fraction vector.	number
54	Solar incidence		$W\text{-}hm^{-2}$
55	Net radiant flux		Wm^{-2}
56	Longwave flux		Wm^{-2}
57	Longwave flux minimum value		Wm^{-2}
58	Longwave flux maximum value		Wm^{-2}
59	Longwave flux standard deviation		Wm^{-2}
60	Number of hours of longwave flux		hours
61	Shortwave flux		Wm^{-2}
62	Shortwave flux minimum value		Wm^{-2}
63	Shortwave flux maximum value		Wm^{-2}
64	Shortwave flux standard deviation		Wm^{-2}
65	Number of hours of shortwave flux		hours
66	Albedo		unitless

Table 4-9. Daily, Total-sky Averagesa

Item No.	SDS Name	Daily, Total-sky Definitions	Units
67	Region number	An integer from 1 to 10,368 denotes one of the 2.5° x 2.5° regions. Regions are numbered consecutively west to east with 144 per latitude band and 72 per longitude band.	number
68	Solar constant, distance corrected	The distance corrected solar constant for the day.	Wm^{-2}
69	Solar incidence	The integrated solar incidence for a day that includes at least one SW measurement.	$W\text{-}hm^{-2}$
70	Longwave flux	Daily LW flux consisting of measurements and extrapolated, interpolated, and modeled values.	Wm^{-2}
71	Longwave flux minimum value	The minimum longwave flux for the day.	Wm^{-2}
72	Longwave flux maximum value	The maximum longwave flux for the day.	Wm^{-2}
73	Longwave flux standard deviation	The standard deviation of all longwave fluxes for the day.	Wm^{-2}
74	Number of hours of longwave flux	The number of hours with longwave flux estimates for the day.	hours
75	Shortwave flux	The daily SW flux; i.e., the sum of all measured and modeled SW fluxes for every day with at least one SW measurement, corrected by the ratio of integrated to summed solar incidence. $$M_{SW}(d) = [S(d)/S^n(d)] \cdot \sum_{h=1}^{24} M_{SW}(d,h)/24$$ where $S(d)$ and $S^n(d)$ are the integrated and summed solar radiances, respectively (see Reference 12).	Wm^{-2}
76	Shortwave flux minimum value	The minimum shortwave flux for the day. This value will be zero for days with at least one nighttime hour.	Wm^{-2}
77	Shortwave flux maximum value	The maximum shortwave flux for the day.	Wm^{-2}
78	Shortwave flux standard deviation	The standard deviation of all shortwave flux values for the day. This value may be a large number without much physical significance for days having at least one nighttime hour.	Wm^{-2}

Table 4-9. Daily, Total-sky Averagesa

Item No.	SDS Name	Daily, Total-sky Definitions	Units
79	Number of hours of shortwave flux	The number of hours of shortwave estimates for the day.	hours
80	Albedo	The daily albedo is defined as the ratio of daily SW flux to the integrated daily solar incidence. The equations used to calculate the albedo values in ES-9 may be found in 4.3.3 of this document.	unitless

a. These quantities are calculated for each day in the month.

Table 4-10. Daily, Clear-sky Averages

Item No.	SDS Name	Daily, Clear-sky Definitions	Units
81	Region number	The total-sky values from Table 4-9 are repeated for clear-sky conditions. The LW clear-sky values passed from the ERBE-like Inversion Subsystem are supplemented with values determined in Subsystem 3.0 by linear interpolation, a half-sine model (daytime over land), or extrapolation. The SW values are calculated in Subsystem 3.0.	number
82	Solar constant, distance corrected		Wm^{-2}
83	Solar incidence		$W\text{-}hm^{-2}$
84	Longwave flux		Wm^{-2}
85	Longwave flux minimum value		Wm^{-2}
86	Longwave flux maximum value		Wm^{-2}
87	Longwave flux standard deviation		Wm^{-2}
88	Number of hours of longwave flux		hours
89	Shortwave flux		Wm^{-2}
90	Shortwave flux minimum value		Wm^{-2}
91	Shortwave flux maximum value		Wm^{-2}
92	Shortwave flux standard deviation		Wm^{-2}
93	Number of hours of shortwave flux		hours
94	Albedo		unitless

Table 4-11. Monthly Hourly, Total-sky Averagesa

Item No.	SDS Name	Monthly Hourly, Total-sky Definitions	Units
95	Region number	An integer from 1 to 10,368 denotes one of the 2.5 ° x 2.5° regions. Regions are numbered consecutively west to east with 144 per latitude band and 72 per longitude band.	number
96	Solar incidence	The integrated solar incidence over those days with SW data for a given hour.	$W\text{-}hm^{-2}$
97	Longwave flux	The monthly average LW flux at this hour and is only calculated based on days that had at least one LW measurement.	Wm^{-2}
98	Longwave flux minimum value	The minimum longwave flux for days with longwave flux estimates at the hour.	Wm^{-2}
99	Longwave flux maximum value	The maximum longwave flux for days with longwave flux estimates at the hour.	Wm^{-2}
100	Longwave flux standard deviation	The standard deviation for the longwave flux for days with longwave flux estimates at the hour.	Wm^{-2}
101	Number of days of longwave flux	The number of days with longwave flux estimates at the hour.	days
102	Longwave sum of estimates	The sum of actual longwave flux estimates at this hour. This value is intended for doing tests of statistical significance on diurnal variability.	Wm^{-2}
103	Longwave sum of estimates squared	The sum of actual longwave flux estimates squared at this hour. This value is intended for doing tests of statistical significance on diurnal variability.	$(Wm^{-2})^2$
104	Shortwave flux	The monthly average SW flux at this hour and is only calculated based on days that had at least one SW measurement.	Wm^{-2}
105	Shortwave flux minimum value	The minimum shortwave flux for the hour. This value will be zero for nighttime hours.	Wm^{-2}
106	Shortwave flux maximum value	The maximum shortwave flux for the hour.	Wm^{-2}
107	Shortwave flux standard deviation	The standard deviation for shortwave fluxes at this hour.	Wm^{-2}
108	Number of days of shortwave flux	The number of days with shortwave flux estimates for the hour.	days

Table 4-11. Monthly Hourly, Total-sky Averagesa

Item No.	SDS Name	Monthly Hourly, Total-sky Definitions	Units
109	Shortwave sum of estimates	The sum of actual shortwave flux estimates at this hour. This value is intended for doing tests of statistical significance on diurnal variability.	Wm^{-2}
110	Shortwave sum of estimates squared	The sum of actual shortwave flux estimates squared at this hour. This value is intended for doing tests of statistical significance on diurnal variability.	$(Wm^{-2})^2$
111	Albedo	The monthly hourly average albedo. The equations used to calculate the albedo values in ES-9 may be found in 4.3.3.	unitless

a. These values are calculated for the month at each local hour.

Table 4-12. Monthly Hourly, Clear-sky Averages

Item No.	SDS Name	Monthly Hourly, Clear-sky Definitions	Units
112	Region number	The total-sky values from Table 4-11 are repeated for clear-sky as defined by the ERBE-like Inversion Subsystem.	number
113	Solar incidence		$W\text{-}hm^{-2}$
114	Longwave flux		Wm^{-2}
115	Longwave flux minimum value		Wm^{-2}
116	Longwave flux maximum value		Wm^{-2}
117	Longwave flux standard deviation		Wm^{-2}
118	Number of days of longwave flux		days
119	Longwave sum of estimates	The total-sky values from Table 4-11 are repeated for clear-sky as defined by the ERBE-like Inversion Subsystem.	Wm^{-2}
120	Longwave sum of estimates squared		$(Wm^{-2})^2$
121	Shortwave flux		Wm^{-2}
122	Shortwave flux minimum value		Wm^{-2}
123	Shortwave flux maximum value		Wm^{-2}
124	Shortwave flux standard deviation		Wm^{-2}
125	Number of days of shortwave flux		days
126	Shortwave sum of estimates		Wm^{-2}
127	Shortwave sum of estimates squared		$(Wm^{-2})^2$
128	Albedo		unitless

Table 4-13. Hourbox Data

Item No.	SDS Name	Hourbox Data Definitions	Units
129	Region number	An integer from 1 to 10,368 denotes one of the 2.5 ° x 2.5° regions. Regions are numbered consecutively west to east with 144 per latitude band and 72 per longitude band.	number
130	Longitude	The longitude of the center of the region that this hourbox is in.	degrees
131	Colatitude	The colatitude of the center of the region that this hourbox is in.	degrees
132	Number of hourboxes	The number of hours in a month with estimates of any kind.	number
133	Hourbox number	An integer from 1-744 designating the local solar hourbox to which the estimate has been assigned. (Hours run from 1-24 on the first day of the month, 25-48 on the second day of the month, etc.) If this is a multiple instrument product, the hourbox number is adjusted by 1,000 times the number of instruments which have data for the region.	number
134	Time of observation	The Julian date and time at which the hourbox was observed.	days
135	Scene fraction(1)	The scene fraction values form a normalized vector giving the distribution of clear pixels inverted for this hourbox.	N/A
136	Scene fraction(2)	The scene fraction values form a normalized vector giving the distribution of partly cloudy pixels inverted for this hourbox.	N/A
137	Scene fraction(3)	The scene fraction values form a normalized vector giving the distribution of mostly cloudy pixels inverted for this hourbox.	N/A
138	Scene fraction(4)	The scene fraction values form a normalized vector giving the distribution of overcast pixels inverted for this hourbox.	N/A
139	Albedo factor(1)	The albedos for clear scene types within this hourbox.	N/A
140	Albedo factor(2)	The albedos for partly cloudy scene types within this hourbox.	N/A
141	Albedo factor(3)	The albedos for mostly cloudy scene types within this hourbox.	N/A
142	Albedo factor(4)	The albedos for overcast scene types within this hourbox.	N/A
143	Cosine of the solar zenith angle	The average cosine of the solar zenith angle in the range of 0-90 degrees for the pixels assigned to this hourbox. It is defined as 0 for all zenith angles greater than 90.	N/A
144	Satellite zenith angle	The average satellite viewing zenith angle for the pixels assigned to this hourbox.	degrees
145	Azimuth angle	The average relative azimuth angle (0 in the forward scattering direction) for the pixels assigned to this hourbox.	degrees
146	Solar incidence	The solar incidence for the local solar hourbox.	$W\text{-}h/m^2$
147	Longwave flux	The average longwave flux assigned to this local solar hourbox.	Wm^{-2}

Table 4-13. Hourbox Data

Item No.	SDS Name	Hourbox Data Definitions	Units
148	Longwave flux minimum value	The minimum longwave flux estimate for this local solar hourbox.	Wm^{-2}
149	Longwave flux maximum value	The maximum longwave flux estimate for this local solar hourbox.	Wm^{-2}
150	Longwave flux standard deviation	The standard deviation for longwave flux estimates for this local solar hourbox.	Wm^{-2}
151	Number of longwave flux estimates	The number of longwave flux estimates assigned to this local solar hourbox.	number
152	Longwave flux maximum difference	This value is used for processing multiple instrument products only and is the maximum difference between individual mean longwave fluxes. For single instrument products, these values are default.	Wm^{-2}
153	Shortwave flux	The average shortwave flux assigned to this local solar hourbox.	Wm^{-2}
154	Shortwave flux minimum value	The minimum shortwave flux estimate for this local solar hourbox.	Wm^{-2}
155	Shortwave flux maximum value	The maximum shortwave flux estimate for this local solar hourbox.	Wm^{-2}
156	Shortwave flux standard deviation	The standard deviation for shortwave flux estimates for this local solar hourbox.	Wm^{-2}
157	Number of shortwave flux estimates	The number of shortwave flux estimates assigned to this local solar hourbox.	number
158	Shortwave flux maximum difference	This value is used for processing multiple instrument products only and is the maximum difference between individual mean shortwave fluxes. For single instrument products, these values are default.	Wm^{-2}
159	Clear-sky longwave flux	The average clear-sky longwave flux estimate	Wm^{-2}

Table 4-13. Hourbox Data

Item No.	SDS Name	Hourbox Data Definitions	Units
160	Clear-sky longwave flux standard deviation	The standard deviation of the clear-sky longwave flux estimates	Wm^{-2}
161	Number of clear-sky longwave flux estimates	The number of clear-sky longwave flux estimates.	number
162	Clear-sky albedo standard deviation	The standard deviation of the clear-sky albedo.	unitless

4.3.2 Discussion of Regional Averages

The ES-9 provides averages of radiant flux and albedo values from the hourbox information obtained from the ERBE-like Inversion to Instantaneous TOA Subsystem. These hourboxes are then used to create regional averages in the ERBE-like Monthly Time/Space Averaging Subsystem. This product is based on the ERBE S-9 product (Reference 13).

The ES-9 product contains data averaged to 2.5^o grid scales. The layout of a 2.5^o system is given in Figure 4-1. In this grid system, colatitude, θ, ranges from 0^o at the North Pole to 180^o at the South Pole, and longitude, φ, ranges from 0 at the Greenwich Meridian through 360^o. There is a total of 10,368 regions on this resolution.

4.3.3 The Albedo Calculations

Albedos are calculated for Monthly (Day), Monthly (Hour), Daily, and Monthly Hourly Averages on a regional basis using the following equations:

For Monthly (Day) Averages:

$$albedo = \frac{\overline{M}_{SW} \cdot 24 \cdot NDAYS}{TSOLRD} \tag{1}$$

where:

$\overline{M}_{SW}$	=	Monthly mean shortwave flux based on daily calculations
TSOLRD	=	Total of monthly integrated solar incidence for all days of the month (see Reference 14)
NDAYS	=	The total number of days in the month

This equation involves the assumption, previously made in calculating monthly regional net flux, that the regional albedo, calculated with (in general) some missing days, is representative of the entire month. The assumption is necessary because each region will have (in general) its flux defined for a different number of days.

For Monthly (Hour) Averages:

$$albedo = \frac{\overline{M}_{SW} \cdot 24 \cdot NDAYS}{TSOLRH} \tag{2}$$

where:

$\overline{M}_{SW}$	=	Monthly mean shortwave flux based on monthly hourly calculations
TSOLRH	=	Total of monthly integrated solar incidence for all days of the month
NDAYS	=	The total number of days in the month

For Daily Averages (for each day):

$$albedo = \frac{\overline{M}_{SW} \cdot 24}{SOLARD} \tag{3}$$

where:

$\overline{M}_{SW}$	=	Daily shortwave flux
SOLARD	=	Daily integrated solar incidence

Given the hourly average shortwave flux and integrated solar incidence for a day, the albedo is defined as the total reflected energy divided by the total incident energy.

For Monthly Hourly Averages (for each hour of a given month):

$$albedo = \frac{M_{SW} \cdot D_{SW}}{SOLARH} \tag{4}$$

where:

$\overline{M}_{SW}$	=	Daily shortwave radiant flux for each hour of the month
SOLARH	=	Integrated solar incidence for the month
D_{SW}	=	Days with at least one shortwave measurement including those days of total darkness where shortwave is defined as 0

4.4 Fill Values

The CERES default fill value for the ES-9 product is the 32-bit real number default value (3.4028235E+38). This fill value is used when data are missing, when there is insufficient data to make a calculation, or the data are suspect and there is no quality flag associated with the parameter. A value which has a corresponding flag need not be set to the CERES default value when the data value is suspect. Suspect values are values that were calculated but failed edit checks.

4.5 Sample Data Record

A sample data granule containing 5 ES-9 regions is part of a package which also includes sample read software (in C), a Readme file, a postscript file describing granule contents, and an ASCII listing of the data in the sample granule (data dump). The sample ES-9 package can be ordered from the Langley DAAC (See Section 12.0). It is available from the Langley Web Ordering Tool and has the name format: CERES_Test_ES9_version information.

5.0 Data Organization

The content of the ES-9 is summarized in Table 5-1. The metadata structures contain information which need only be recorded once per monthly product. The CERES metadata are listed in Appendix A. Table A-1 shows the CERES Baseline Header Metadata, and Table A-2 shows the parameters in the CERES_metadata Vdata (See Term-2). Note that the CERES_metadata Vdata (See Term-2) is a subset of the CERES Baseline Header Metadata. As explained in Appendix A, the CERES Baseline Header Metadata includes either the bounding rectangle or GRing attributes. The spatial boundaries of the ES-9 are defined with the bounding rectangle. The ES-9 Product Specific Metadata is shown in Table 5-2. The ES-9 Vgroup Summary is shown in Table 5-3.

Table 5-1. ES-9 Product Summary

HDF Name	Description	Number of Fields	Nominal Size (MB)
CERES Baseline Header Metadata	See Table A-1	35	
CERES_metadata Vdata	See Table A-2	14	
ES-9 Product Specific Metadata	See Table 5-2	1	
ES-9 Vgroup Summary	See Table 5-3	6	1,099.115
ES-9 TOTAL SIZE (MB/Month)			**1,099.115**

Table 5-2. ES-9 Product Specific Metadata

Item	Parameter Name	Records	Units	Range	Data Type
1	ES9BinaryProductionDate	1	N/A	N/A	ASCII string

Table 5-3. ES-9 Vgroup Summary

Vgroup Number	Vgroup Name	Description	Number of Records	Maximum SDS Size (MB)
1	Regional Summary Data	See Table 5-4	10,368a x 10b	0.396
2	Monthly (Day) Averages	See Tables 5-5 - 5-6	10,368a x 28b	1.107
3	Monthly (Hour) Averages	See Tables 5-7 - 5-8	10,368a x 28b	1.107
4	Daily Averages	See Tables 5-9 - 5-10	10,368a x 31 x 28b	34.330
5	Monthly Hourly Averages	See Tables 5-11 - 5-12	10,368a x 24 x 34b	32.273
6	Hourbox Data	See Table 5-13	(10,368 x 744)c x 34b	1,029.902
Total Product Size (MB)				**1,099.115**

a. The actual first dimension of the SDS will equal the number of 2.5° regions contained on the ES-9.
b. This dimension represents the number of SDS parameters contained in the vgroup.
c. The actual first dimension of this SDS is equal to the sum of the number of hourboxes per region over all the regions actually contained on this ES-9, or it is equal to the sum of all “Number of hourboxes” from the Regional Summary Data vgroup. (10,368 is the maximum number of 2.5° regions, and 744 is the maximum number of hourboxes per region, so the maximum size of the first dimension for this SDS is 10,368 x 744 = 7,713,792.)

5.1 Data Granularity

All ES-9 data granules consist of no more than one month of data from one to three CERES instruments.

5.2 ES-9 Scientific Data Sets

The ES-9 contains SDSs written in HDF and organized by vgroups. These SDSs contain either 1-dimensional or 2-dimensional arrays. In 1-dimensional arrays, the dimension corresponds to the number of regions with data in the ES-9 product. In 2-dimensional arrays, the first dimension refers to one of two things. If this is Daily Averages, then the first dimension refers to the day of the month. If this is Monthly Hourly Averages, then the first dimension refers to the hour of the day. The second dimension corresponds to the number of regions with data in the ES-9 product.

The following tables list the SDSs contained in each vgroup. The number of elements in each SDS is determined by the number of regions with data in the ES-9 product and may also be a function of the number of days in the month (31) or the number of hours in a day (24). The number of elements in the Hourbox Data is determined by the number of regions with data and the number of hours with data for each region. CERES default values for 32-bit real numbers (3.4028235E+38) are used whenever there are missing data.

HDF files are arranged by index number starting at 0. The index number listed for each parameter in column one in Tables 5-4 - 5-13 is the index of the SDS in the HDF file.

Table 5-4. Regional Summary Data

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Region number (0)	N/A	1 .. 10,368	10,368	32	40.5
Longitude (150)	degrees	0 .. 360	10,368	32	40.5
Colatitude (151)	degrees	0 .. 180	10,368	32	40.5
Geographic scene type (1)	see footnoteb	1 .. 5	10,368	32	40.5

Table 5-4. Regional Summary Data

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Scene fraction histogram(1) (2)	N/A	0 .. 744	10,368	32	40.5
Scene fraction histogram(2) (3)	N/A	0 .. 744	10,368	32	40.5
Scene fraction histogram(3) (4)	N/A	0 .. 744	10,368	32	40.5
Scene fraction histogram(4) (5)	N/A	0 .. 744	10,368	32	40.5
Number of hourboxes (6)	N/A	1 .. 744	10,368	32	40.5
Start position of hourbox data (7)	N/A	0 .. 7,713,792	10,368	32	40.5

a. The actual size of the SDS will equal the number of 2.5° regions contained on the ES-9.
b. Geographic scene type units are as follows: 1 = ocean, 2 = land, 3 = snow, 4 = desert, and 5 = coast.

Table 5-5. Monthly (Day), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Region number (0)	N/A	0 .. 10,368	10,368	32	40.5
Solar incidence (8)	$W\text{-}hm^{-2}$	0 .. 500,000	10,368	32	40.5
Net radiant flux (9)	Wm^{-2}	-200 .. 200	10,368	32	40.5
Longwave flux (10)	Wm^{-2}	50 .. 450	10,368	32	40.5
Longwave flux minimum value (11)	Wm^{-2}	50 .. 450	10,368	32	40.5
Longwave flux maximum value (12)	Wm^{-2}	50 .. 450	10,368	32	40.5

Table 5-5. Monthly (Day), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Longwave flux standard deviation (13)	Wm^{-2}	0 .. 350	10,368	32	40.5
Number of days of longwave flux (14)	days	0 .. 31	10,368	32	40.5
Shortwave flux (15)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Shortwave flux minimum value (16)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Shortwave flux maximum value (17)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Shortwave flux standard deviation (18)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Number of days of shortwave flux (19)	days	0 .. 31	10,368	32	40.5
Albedo (20)	unitless	0 .. 1	10,368	32	40.5

a. The actual size of the SDS will equal the number of 2.5° regions contained on the ES-9.

Table 5-6. Monthly (Day), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Region number (0)	N/A	1 .. 10,368	10,368	32	40.5
Solar incidence (21)	$W\text{-}hm^{-2}$	0 .. 500,000	10,368	32	40.5
Net radiant flux (22)	Wm^{-2}	-200 .. 200	10,368	32	40.5
Longwave flux (23)	Wm^{-2}	50 .. 450	10,368	32	40.5
Longwave flux minimum value (24)	Wm^{-2}	50 .. 450	10,368	32	40.5
Longwave flux maximum value (25)	Wm^{-2}	50 .. 450	10,368	32	40.5
Longwave flux standard deviation (26)	Wm^{-2}	0 .. 350	10,368	32	40.5
Number of days of longwave flux (27)	days	0 .. 31	10,368	32	40.5
Shortwave flux (28)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Shortwave flux minimum value (29)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Shortwave flux maximum value (30)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Shortwave flux standard deviation (31)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Number of days of shortwave flux (32)	days	0 .. 31	10,368	32	40.5
Albedo (33)	unitless	0 .. 1	10,368	32	40.5

a. The actual size of the SDS will equal the number of 2.5° regions contained on the ES-9.

Table 5-7. Monthly (Hour), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Region number (0)	N/A	1 .. 10,368	10,368	32	40.5
Solar incidence (34)	$W\text{-}hm^{-2}$	0 .. 500,000	10,368	32	40.5
Net radiant flux (35)	Wm^{-2}	-200 .. 200	10,368	32	40.5
Longwave flux (36)	Wm^{-2}	50 .. 450	10,368	32	40.5
Longwave flux minimum value (37)	Wm^{-2}	50 .. 450	10,368	32	40.5
Longwave flux maximum value (38)	Wm^{-2}	50 .. 450	10,368	32	40.5
Longwave flux standard deviation (39)	Wm^{-2}	0 .. 350	10,368	32	40.5
Number of hours of longwave flux (40)	hours	0 .. 24	10,368	32	40.5
Shortwave flux (41)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Shortwave flux minimum value (42)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Shortwave flux maximum value (43)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Shortwave flux standard deviation (44)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Number of hours of shortwave flux (45)	hours	0 .. 24	10,368	32	40.5
Albedo (46)	unitless	0 .. 1	10,368	32	40.5

a. The actual size of the SDS will equal the number of 2.5° regions contained on the ES-9.

Table 5-8. Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Region number (0)	N/A	1 .. 10,368	10,368	32	40.5
Solar incidence (47)	$W\text{-}hm^{-2}$	0 .. 500,000	10,368	32	40.5
Net radiant flux (48)	Wm^{-2}	-200 .. 200	10,368	32	40.5
Longwave flux (49)	Wm^{-2}	50 .. 450	10,368	32	40.5
Longwave flux minimum value (50)	Wm^{-2}	50 .. 450	10,368	32	40.5
Longwave flux maximum value (51)	Wm^{-2}	50 .. 450	10,368	32	40.5
Longwave flux standard deviation (52)	Wm^{-2}	0 .. 350	10,368	32	40.5
Number of hours of longwave flux (53)	hours	0 .. 24	10,368	32	40.5
Shortwave flux (54)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Shortwave flux minimum value (55)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Shortwave flux maximum value (56)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Shortwave flux standard deviation (57)	Wm^{-2}	0 .. 1,400	10,368	32	40.5
Number of hours of shortwave flux (58)	hours	0 .. 24	10,368	32	40.5
Albedo (59)	unitless	0 .. 1	10,368	32	40.5

a. The actual size of the SDS will equal the number of 2.5° regions contained on the ES-9.

Table 5-9. Daily, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Region number (0)	N/A	1 .. 10,368	10,368	32	40.5
Solar constant, distance corrected (60)	Wm^{-2}	1,300 .. 1,450	31 x 10,368	32	1,255.5
Solar incidence (61)	$W\text{-}hm^{-2}$	0 .. 15,000	31 x 10,368	32	1,255.5
Longwave flux (62)	Wm^{-2}	50 .. 450	31 x 10,368	32	1,255.5
Longwave flux minimum value (63)	Wm^{-2}	50 .. 450	31 x 10,368	32	1,255.5
Longwave flux maximum value (64)	Wm^{-2}	50 .. 450	31 x 10,368	32	1,255.5
Longwave flux standard deviation (65)	Wm^{-2}	0 .. 350	31 x 10,368	32	1,255.5
Number of hours of longwave flux (66)	hours	0 .. 24	31 x 10,368	32	1,255.5
Shortwave flux (67)	Wm^{-2}	0 .. 1,400	31 x 10,368	32	1,255.5
Shortwave flux minimum value (68)	Wm^{-2}	0 .. 1,400	31 x 10,368	32	1,255.5
Shortwave flux maximum value (69)	Wm^{-2}	0 .. 1,400	31 x 10,368	32	1,255.5
Shortwave flux standard deviation (70)	Wm^{-2}	0 .. 1,400	31 x 10,368	32	1,255.5
Number of hours of shortwave flux (71)	hours	0 .. 24	31 x 10,368	32	1,255.5
Albedo (72)	unitless	0 .. 1	31 x 10,368	32	1,255.5

a. The actual size of the SDS will equal the number of 2.5° regions contained on the ES-9.

Table 5-10. Daily, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Region number (0)	N/A	1 .. 10,368	10,368	32	40.5
Solar constant, distance corrected (60)	Wm^{-2}	1,300 .. 1,450	31 x 10,368	32	1,255.5
Solar incidence (61)	$W\text{-}hm^{-2}$	0 .. 15,000	31 x 10,368	32	1,255.5
Longwave flux (73)	Wm^{-2}	50 .. 450	31 x 10,368	32	1,255.5
Longwave flux minimum value (74)	Wm^{-2}	50 .. 450	31 x 10,368	32	1,255.5
Longwave flux maximum value (75)	Wm^{-2}	50 .. 450	31 x 10,368	32	1,255.5
Longwave flux standard deviation (76)	Wm^{-2}	0 .. 350	31 x 10,368	32	1,255.5
Number of hours of longwave flux (77)	hours	0 .. 24	31 x 10,368	32	1,255.5
Shortwave flux (78)	Wm^{-2}	0 .. 1,400	31 x 10,368	32	1,255.5
Shortwave flux minimum value (79)	Wm^{-2}	0 .. 1,400	31 x 10,368	32	1,255.5
Shortwave flux maximum value (80)	Wm^{-2}	0 .. 1,400	31 x 10,368	32	1,255.5
Shortwave flux standard deviation (81)	Wm^{-2}	0 .. 1,400	31 x 10,368	32	1,255.5
Number of hours of shortwave flux (82)	hours	0 .. 24	31 x 10,368	32	1,255.5
Albedo (83)	unitless	0 .. 1	31 x 10,368	32	1,255.5

a. The actual size of the SDS will equal the number of 2.5° regions contained on the ES-9.

Table 5-11. Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Region number (0)	N/A	1 .. 10,368	10,368	32	40.5
Solar incidence (84)	$W\text{-}hm^{-2}$	0 .. 50,000	24 x 10,368	32	972.0
Longwave flux (85)	Wm^{-2}	50 .. 450	24 x 10,368	32	972.0
Longwave flux minimum value (86)	Wm^{-2}	50 .. 450	24 x 10,368	32	972.0
Longwave flux maximum value (87)	Wm^{-2}	50 .. 450	24 x 10,368	32	972.0
Longwave flux standard deviation (88)	Wm^{-2}	0 .. 350	24 x 10,368	32	972.0
Number of days of longwave flux (89)	days	0 .. 31	24 x 10,368	32	972.0
Longwave sum of estimates (90)	Wm^{-2}	0 .. 15,000	24 x 10,368	32	972.0
Longwave sum of estimates squared (91)	$(Wm^{-2})^2$	0 .. 5,000,000	24 x 10,368	32	972.0
Shortwave flux (92)	Wm^{-2}	0 .. 1,400	24 x 10,368	32	972.0
Shortwave flux minimum value (93)	Wm^{-2}	0 .. 1,400	24 x 10,368	32	972.0
Shortwave flux maximum value (94)	Wm^{-2}	0 .. 1,400	24 x 10,368	32	972.0
Shortwave flux standard deviation (95)	Wm^{-2}	0 .. 1,400	24 x 10,368	32	972.0
Number of days of shortwave flux (96)	days	0 .. 31	24 x 10,368	32	972.0

Table 5-11. Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Shortwave sum of estimates (97)	Wm^{-2}	0 .. 45,000	24 x 10,368	32	972.0
Shortwave sum of estimates squared (98)	$(Wm^{-2})^2$	0 .. 50,000,000	24 x 10,368	32	972.0
Albedo (99)	unitless	0 .. 1	24 x 10,368	32	972.0

a. The actual size of the SDS will equal the number of 2.5° regions contained on the ES-9.

Table 5-12. Monthly Hourly, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Region number (0)	N/A	1 .. 10,368	10,368	32	40.5
Solar incidence (100)	$W\text{-}hm^{-2}$	0 .. 50,000	24 x 10,368	32	972.0
Longwave flux (101)	Wm^{-2}	50 .. 450	24 x 10,368	32	972.0
Longwave flux minimum value (102)	Wm^{-2}	50 .. 450	24 x 10,368	32	972.0
Longwave flux maximum value (103)	Wm^{-2}	50 .. 450	24 x 10,368	32	972.0
Longwave flux standard deviation (104)	Wm^{-2}	0 .. 350	24 x 10,368	32	972.0
Number of days of longwave flux (105)	days	0 .. 31	24 x 10,368	32	972.0
Longwave sum of estimates (106)	Wm^{-2}	0 .. 15,000	24 x 10,368	32	972.0

Table 5-12. Monthly Hourly, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Longwave sum of estimates squared (107)	$(Wm^{-2})^2$	0 .. 5,000,000	24 x 10,368	32	972.0
Shortwave flux (108)	Wm^{-2}	0 .. 1,400	24 x 10,368	32	972.0
Shortwave flux minimum value (109)	Wm^{-2}	0 .. 1,400	24 x 10,368	32	972.0
Shortwave flux maximum value (110)	Wm^{-2}	0 .. 1,400	24 x 10,368	32	972.0
Shortwave flux standard deviation (111)	Wm^{-2}	0 .. 1,400	24 x 10,368	32	972.0
Number of days of shortwave flux (112)	days	0 .. 31	24 x 10,368	32	972.0
Shortwave sum of estimates (113)	Wm^{-2}	0 .. 45,000	24 x 10,368	32	972.0
Shortwave sum of estimates squared (114)	$(Wm^{-2})^2$	0 .. 50,000,000	24 x 10,368	32	972.0
Albedo (115)	unitless	0 .. 1	24 x 10,368	32	972.0

a. The actual size of the SDS will equal the number of 2.5° regions contained on the ES-9.

Table 5-13. Hourbox Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Region number (116)	N/A	1 .. 10,368	7,713,792	32	30,132.0
Longitude (148)	degrees	0 .. 360	7,713,792	32	3,0132.0
Colatitude (149)	degrees	0 .. 180	7,713,792	32	30,132.0
Number of hourboxes (117)	N/A	1 .. 744	7,713,792	32	30,132.0
Hourbox number (118)	N/A	1 .. 744	7,713,792	32	30,132.0
Time of observation (119)	days	2,449,340 .. 2,458,600	7,713,792	64	60,264.0
Scene fraction(1) (120)	N/A	0 .. 1	7,713,792	32	30,132.0
Scene fraction(2) (121)	N/A	0 .. 1	7,713,792	32	30,132.0
Scene fraction(3) (122)	N/A	0 .. 1	7,713,792	32	30,132.0
Scene fraction(4) (123)	N/A	0 .. 1	7,713,792	32	30,132.0
Albedo factor(1) (124)	N/A	0 .. 1	7,713,792	32	30,132.0
Albedo factor(2) (125)	N/A	0 .. 1	7,713,792	32	30,132.0
Albedo factor(3) (126)	N/A	0 .. 1	7,713,792	32	30,132.0
Albedo factor(4) (127)	N/A	0 .. 1	7,713,792	32	30,132.0
Cosine of the solar zenith angle (128)	N/A	0 .. 1	7,713,792	32	30,132.0
Satellite zenith angle (129)	degrees	0 .. 90	7,713,792	32	30,132.0
Azimuth angle (130)	degrees	0 .. 360	7,713,792	32	30,132.0
Solar incidence (131)	$W\text{-}hm^{-2}$	0 .. 1,450	7,713,792	32	30,132.0

Table 5-13. Hourbox Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Longwave flux (132)	Wm^{-2}	50 .. 450	7,713,792	32	30,132.0
Longwave flux minimum value (133)	Wm^{-2}	50 .. 450	7,713,792	32	30,132.0
Longwave flux maximum value (134)	Wm^{-2}	50 .. 450	7,713,792	32	30,132.0
Longwave flux standard deviation (135)	Wm^{-2}	0 .. 350	7,713,792	32	30,132.0
Number of longwave flux estimates (136)	N/A	0 .. 5,000	7,713,792	32	30,132.0
Longwave flux maximum difference (137)	Wm^{-2}	0 .. 450	7,713,792	32	30,132.0
Shortwave flux (138)	Wm^{-2}	0 .. 1,400	7,713,792	32	30,132.0
Shortwave flux minimum value (139)	Wm^{-2}	0 .. 1,400	7,713,792	32	30,132.0
Shortwave flux maximum value (140)	Wm^{-2}	0 .. 1,400	7,713,792	32	30,132.0
Shortwave flux standard deviation (141)	Wm^{-2}	0 .. 1,400	7,713,792	32	30,132.0
Number of shortwave flux estimates (142)	N/A	0 .. 5,000	7,713,792	32	30,132.0
Shortwave flux maximum difference (143)	Wm^{-2}	0 .. 1,400	7,713,792	32	30,132.0
Clear-sky longwave flux (144)	Wm^{-2}	50 .. 450	7,713,792	32	30,132.0
Clear-sky longwave flux standard deviation (145)	Wm^{-2}	0 .. 350	7,713,792	32	30,132.0

Table 5-13. Hourbox Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elementsa	Bits per Element	SDS Size (KB)
Number of clear-sky longwave flux estimates (146)	N/A	0 .. 5,000	7,713,792	32	30,132.0
Clear-sky albedo standard deviation (147)	unitless	0 .. 1	7,713,792	32	30,132.0

a. The actual size of this SDS is equal to the sum of the number of hourboxes per region over all the regions contained on this ES-9, or it is equal to the sum of all "Number of hourboxes" from the Regional Summary Data vgroup. 10,368 is the maximum number of 2.5° regions, and 744 is the maximum number of hourboxes per region, so the maximum number of elements in this SDS is 10,368 x 744 = 7,713,792.

6.0 Theory of Measurements and Data Manipulations

6.1 Theory of Measurements

See CERES ATBD Subsystem 3.0 (Reference 6).

6.2 Data Processing Sequence

The ERBE-like Monthly Time and Space Averaging Subsystem (3.0) takes time-sequenced, inverted data output from the ERBE-like Inversion Subsystem (2.0) and stores it in a regionally accessible data base which contains data for an entire month. A data base is created for each CERES instrument. This data base provides input for additional monthly processing which produces daily and monthly averages of shortwave and longwave radiant flux at the top-of-the-atmosphere on a 2.5° regional basis. The files are processed separately for each instrument to produce daily averages, monthly hourly averages (each hour averaged for all data during the month), and two grand monthly averages (averages of the daily and monthly hourly averages) for each geographic region. Determination of the averages requires the use of diurnal models which are input into the process. Further processing of the regional averages results in nested regional, zonal, and global averages.

In addition to processing the data for a single instrument, Subsystem 3.0 also provides the capability to combine data for up to three instruments.

For detailed information see the ATBD for Subsystem 3.0. (Reference 6)

6.3 Special Corrections/Adjustments

See CERES ATBD Subsystem 2.0 (see Reference 4).

7.0 Errors

See the Data Quality Summary {URL=http://eosweb.larc.nasa.gov/project/ceres/ES9/disclaimer_CER_ES9.html}.

7.1 Quality Assessment

Quality Assessment (QA) activities are performed at the Science Computing Facility (SCF) by the Data Management Team. Processing reports containing statistics and processing results are examined for anomalies. If the reports show anomalies, data visualization tools are used to examine those products in greater detail to begin the anomaly investigation. (See the QA flag description for this product.)

7.2 Data Validation by Source

See Subsystem 3.0 Validation Document (Reference 15).

8.0 Notes

9.0 Application of the Data Set

The ES-9 data product provides spatially and temporally averaged, level-3 data such as solar incidence, net flux, LW flux, SW flux, and albedo on a regional basis.

10.0 Future Modifications and Plans

Modifications to the ES-9 product are driven by validation results and any Terra related parameters. The Langley DAAC provides users notification of changes.

11.0 Software Description

There are Fortran and C read programs available at the Langley DAAC. The programs were designed to run on an Unix workstation and can be compiled with a Fortran 90 or C compiler.

12.0 Data Access

12.1 Contacts for Data Center/Data Access Information

EOSDIS Langley DAAC
NASA Langley Research Center
Mail Stop 157D
2 South Wright Street
Hampton, VA 23681-2199
USA
Telephone: (757) 864-8656
FAX: (757) 864-8807
E-mail: larc@eos.nasa.gov
URL:

12.2 Data Center Identification

EOSDIS Langley DAAC
NASA Langley Research Center
Hampton, VA 23681-2199

13.0 Output Products and Availability

{Section supplied by the DAAC - includes packaging for distribution}

14.0 References

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2. Clouds and the Earth's Radiant Energy System (CERES) Data Management System Software Requirements Document, ERBE-like Averaging to Monthly TOA Fluxes (Subsystem 3.0), Release 1 Version 1, January 1995 {URL = http://ceres.larc.nasa.gov/srd.php}.
3. Smith, G.L.; Green, R. N.; Raschke, E.; Avis, L. M.; Suttles, J. T.; Wielicki, B. A., and Davies, R.: Inversion Methods for Satellite Studies of the Earth's Radiation Budget: Development of Algorithms for the ERBE Mission. Reviews of Geophysics, Vol. 24, No. 2, pp. 407-421, May 1986 {URL = http://asd-www.larc.nasa.gov/bib/rngreen.html}.
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14. Brooks, D. R. and P. Minnis, “Comparison of Longwave Diurnal Models Applied to Simulations of the Earth Radiation Budget Experiment,” Journal of Climate and Applied Meteorology, 23, 155-160, 1984.

15. Clouds and the Earth’s Radiant Energy System (CERES) Validation Plan, ERBE-like Averaging to Monthly TOA Fluxes (Subsystem 3.0), Release 3.0, February 1999 {URL = http:/ceres.larc.nasa.gov/validation.php}.

15.0 Glossary of Terms

Term-1 Scientific Data Set

A Scientific Data Set (SDS) is an HDF structure. It is a collection (or grouping) of parameters that have the same data type such as 8, 16, or 32-bit integers or 32, or 64-bit floating point numbers. The ES-8 SDS's each contain only one parameter. The SDS is an array of values and for ES-8 this corresponds to a two dimensional array of all values of a certain parameter for a day. The dimensions of the array correspond to the number of footprints (660) within a record (scan cycle) and the number of records within the granule. In general, an SDS is a multi-dimensional array. It has dimension records and data type which describe it. The dimensions specify the shape and size of the SDS array. Each dimension has its own attributes.

Term-2 Vertex Data

A Vertex data (Vdata) set is an HDF structure. It is a collection (or grouping) of parameters that have different data types such as 8, 16, or 32-bit integers, floating point numbers, text, etc. In general, Vdata is a table of parameters of varying data type. Specifically stated, a Vdata is a customized table, comprised of a collection of similar records (rows) whose values are stored in one or more fixed length fields (columns) where individual fields can have their own data type. The ES-8 contains 20 record-level parameters, each of which is written into a separate Vdata. Therefore, an ES-8 record-level Vdata contains a single field (column) which has multiple values (rows) such that one value exists for each record (scan cycle) within the granule. The ES-8 also contains a CERES_metadata Vdata which contains numerous parameters (columns) and each parameter has only one value per granule. A Vdata is uniquely identified by a name, a class, and individual field names. The Vdata class identifies the purpose or use of its data.

Term-3 Vgroup

A vgroup is a structure designed to associate related data objects. The general structure of a vgroup is similar to that of the UNIX file system in that the vgroup may contain references to other vgroups or HDF data objects just as the UNIX directory may contain subdirectories or files.

16.0 Acronyms and Units

16.1 CERES Acronyms

ADM	Angular Distribution Model
APD	Aerosol Profile Data
ATBD	Algorithm Theoretical Basis Document
AVG	Monthly Regional Radiative Fluxes and Clouds
AVHRR	Advanced Very High Resolution Radiometer
BDS	Bidirectional Scan
CADM	CERES Angular Distribution Model
CERES	Clouds and the Earth's Radiant Energy System
CID	Cloud Imager Data
CRH	Clear Reflectance History
CRS	Clouds and Radiative Swath
DAAC	Distributed Active Archive Center
DAO	Data Assimilation Office
DMS	Data Management System
EDDB	ERBE-Like Daily Database Product
EMTSA	ERBE-like Monthly Time/Space Averaging
EOS	Earth Observing System
EOS-AM	EOS Morning Crossing (Ascending) Mission
EOS-PM	EOS Afternoon Crossing (Descending) Mission
EOSDIS	Earth Observing System Data and Information System
ERBE	Earth Radiation Budget Experiment
ERBS	Earth Radiation Budget Satellite
FOV	Field-of-View
FSW	Monthly Single Satellite Fluxes and Clouds
GAP	Gridded Analysis Product
GB	Giga Byte
GEO	Geostationary Narrowband Radiances
GGEO	Gridded GEO Narrowband Radiances
GMS	Geostationary Meteorological Satellite
GOES	Geostationary Operational Environmental Satellite
H	High
HDF	Hierarchical Data Format
IES	Instrument Earth Scans
IGBP	International Geosphere Biosphere Programme
IMS	Information Management System
INSTR	Instrument

ISCCP	International Satellite Cloud Climatology Project
IWC	Ice Water Content
LaRC	Langley Research Center
L	Low
LM	Lower Middle
LW	Longwave
LWC	Liquid Water Content
MB	Mega Byte
METEOSAT	Meteorological Satellite
MISR	Multi-angle Imaging SpectroRadiometer
MOA	Meteorological, Ozone, and Aerosols
MODIS	Moderate Resolution Imaging Spectrometer
MWH	Microwave Humidity
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
OPD	Ozone Profile Data
PSF	Point Spread Function
QA	Quality Assessment
RAPS	Rotating Azimuth Plane Scan
SARB	Surface and Atmospheric Radiation Budget
SBUV-2	Solar Backscatter Ultraviolet/Version 2
SFC	Monthly Gridded Single Satellite TOA and Surface Fluxes and Clouds
SRB	Surface Radiation Budget
SRBAVG	Monthly Averages for Top-of-Atmosphere and Surface Radiation Budget
SSF	Single Satellite CERES Footprint TOA and Surface Fluxes, Clouds
SSM/I	Special Sensor Microwave/Imager
SURFMAP	Surface Map
SW	Shortwave
SYN	Synoptic Radiative Fluxes and Clouds
TBD	To be determined
TISA	Time Interpolation and Spatial Averaging
TMI	TRMM Microwave Imager
TOA	Top-of-the-Atmosphere
TRMM	Tropical Rainfall Measuring Mission
UM	Upper Middle
URL	Uniform Resource Locator
VIRS	Visible Infrared Scanner
WN	Window
ZAVG	Monthly Zonal and Global Radiative Fluxes and Clouds

16.2 CERES Units

Unit Definitions

Units	Definition
AU	Astronomical Unit
cm	centimeter
count	count, counts
day	day, Julian date
deg	degree
deg sec^{-1}	degrees per second
du	Dobson units
fraction	fraction 0..1
g kg^{-1}	gram per kilogram
g $^{m-2}$	gram per square meter
hhmmss	hour, minute, second
hour	hour
hPa	hectoPascals
in-oz	inch-ounce
K	Kelvin
km	kilometer, kilometers
km sec^{-1}	kilometers per second
m	meter
mA	milliamp, milliamps
micron	micrometer, micron
msec	millisecond
mW $cm^{-2}sr^{-1}\mu m^{-1}$	milliWatts per square centimeter per steradian per micron
m sec^{-1}	meter per second
N/A	not applicable, none, unitless, dimensionless
percent	percent, percentage 0..100
rad	radian
sec	second
volt	volt, volts
W h m^{-2}	Watt hour per square meter
W^2 m^{-4}	square Watt per meter to the 4th
W m^{-2}	Watt per square meter
W $m^{-2}sr^{-1}$	Watt per square meter per steradian
W $m^{-2}sr^{-1}\mu m^{-1}$	Watt per square meter per steradian per micron
°C	degrees centigrade
μm	micrometer, micron

16.3 ES-9 Symbols

These are symbols used in the tables describing parameter definitions in Section 4.3.1. The symbols are in the following order: lowercase English, uppercase English, and lowercase Greek.

Symbol	Definition
d	Day
da	(from) Daily average
h	Hour
mha	(from) Monthly hourly average
$s(d)$	Integrated daily solar incident radiance.
D_{LW}	Days that contain at least one longwave measurement.
D_{SW}	Days that contain at least one shortwave measurement.
M_{LW}	"Instantaneous regional estimates" of longwave flux used as input to Subsystem 3.0 for modeling monthly net radiant flux values. This is the average regional longwave flux for whatever day and hour into which the "instantaneous" regional estimates of longwave flux fall. (see Reference 11)
$M_{LW}(d,h)$	Regional longwave average flux for hourbox, (d, h).
$\overline{M}_{LW}(d,h)$	Monthly longwave flux as calculated from regional longwave averages, $M_{LW}(d,h)$, overall hourboxes in the month. (Item 14, Table 4-5)
$M_{LW}(h)$	Monthly hourly average of longwave flux. (Item 97, Table 4-11)
$M_{LW}(mha)$	Monthly (Hour) longwave flux calculated from longwave monthly hourly averages. (Item 42, Table 4-7)
$\overline{M}_{NET}(d,h)$	Monthly net flux as calculated from regional longwave averages, $M_{LW}(d,h)$, over all hourboxes in the month. (Item 13, Table 4-5)
$M_{NET}(mha)$	Monthly net radiant flux based on monthly hourly averages (*mha*). (Item 41, Table 4-7)
M_{SW}	"Instantaneous regional estimates" of shortwave flux used as input to Subsystem 3.0 for modeling monthly net radiant flux values. (see Reference 11)
M_{SW}	Monthly (Hour) mean shortwave flux. (Item 47, Table 4-7)
$M_{SW}(d)$	Daily average for the shortwave flux. (Item 75, Table 4-9)
$M_{SW}(da)$	Monthly mean shortwave flux based on daily shortwave flux values. (Item 19, Table 4-5)
$M_{SW}(d,h)$	Regional shortwave average flux for hourbox, (d, h).
$M_{SW}(h)$	Monthly hourly averages for the shortwave flux over the month.

Symbol	Definition
N	Number of days in the month with any data.
N_{LW}	Number of days that contain at least one longwave measurement.
$N_{LW}(mha)$	Number of longwave monthly hourly averages, i.e. if for hour h, any day in the month contains longwave data, $M_{LW}(d,h)$, this hour is included in the count.
N_{SW}	Number of days that contain at least one shortwave measurement.
$N_{SW}(h)$	Number of hours with shortwave measurements for a day that includes at least one shortwave measurement. (Item 79, Table 4-9)
$S(d)$	Summed daily solar incident radiance.
$\overline{\alpha}(da)$	Monthly albedo as calculated from daily shortwave averages, $M_{SW}(d)$, and solar incoming radiation, $S(d)$, for only those days D_{SW} which contain one or more shortwave measurement. (Item 24, Table 4-5)
$\overline{\alpha}(h)$	Monthly hourly average albedo. (Item 111, Table 4-11)

17.0 Document Information

17.1 Document Revision Date

April 1998 - Original Version
June 1998 - Revision

Appendix A
CERES Metadata

This section describes the metadata that are written to all CERES HDF products. Table A-1 describes the CERES Baseline Header Metadata that are written on both HDF and binary direct access output science data products. The parameters are written in HDF structures for CERES HDF output products and are written as 80 byte records for binary direct access output products. Some parameters may be written in multiple records. Table A-2 describes the CERES_metadata Vdata parameters which are a subset of the CERES Baseline Header Metadata and are also written to all CERES HDF output products.

Table A-1 lists the item number, parameter name, units, range or allowable values, the data type, and the maximum number of elements. Note that there are two choices for parameters 22-25 and two choices for parameters 26-29. The choices depend on whether the product is described by a bounding rectangle or by a GRing. Abbreviations used in the Data Type field are defined as

s	=	string	date	=	yyyy-mm-dd
F	=	float	time	=	hh:mm:ss.xxxxxxZ
I	=	integer	datetime	=	yyyy-mm-ddThh:mm:ss.xxxxxxZ

Table A-1. CERES Baseline Header Metadata

Item	Parameter Name	Units	Range	Data Type	No. of Elements
1	ShortName	N/A	N/A	s(8)	1
2	VersionID	N/A	0 .. 255	I3	1
3	CERPGEName	N/A	N/A	s(20)	1
4	SamplingStrategy	N/A	CERES, TRMM-PFM-VIRS, AM1-FM1-MODIS, TBD	s(20)	1
5	ProductionStrategy	N/A	Edition, Campaign, DiagnosticCase, PreFlight, TBD	s(20)	1
6	CERDataDateYear	N/A	1997 .. 2050	s(4)	1
7	CERDataDateMonth	N/A	1 .. 12	s(2)	1
8	CERDataDateDay	N/A	1 .. 31	s(2)	1
9	CERHrOfMonth	N/A	1 .. 744	s(3)	1
10	RangeBeginningDate	N/A	1997-11-19 .. 2050-12-31	date	1
11	RangeBeginningTime	N/A	00:00:00.000000Z .. 24:00:00:000000Z	time	1
12	RangeEndingDate	N/A	1997-11-19 .. 2050-12-31	date	1
13	RangeEndingTime	N/A	00:00:00.000000Z .. 24:00:00:000000Z	time	1
14	AssociatedPlatformShortName	N/A	TRMM, AM1, PM1, TBD	s(20)	1 - 4
15	AssociatedInstrumentShortName	N/A	PFM, FM1, FM2, FM3, FM4, FM5, TBD	s(20)	1-4
16	LocalGranuleID	N/A	N/A	s(80)	1
17	PGEVersion	N/A	N/A	s(10)	1
18	CERProductionDateTime	N/A	N/A	dateti me	1
19	LocalVersionID	N/A	N/A	s(60)	1
20	ProductGenerationLOC	N/A	SGI_xxx, TBD	s(255)	1
21	NumberofRecords	N/A	1 .. 9 999 999 999	I10	1
22	WestBoundingCoordinate	deg	-180.0 .. 180.0	F11.6	1
23	NorthBoundingCoordinate	deg	-90.0 .. 90.0	F11.6	1
24	EastBoundingCoordinate	deg	-180.0 .. 180.0	F11.6	1
25	SouthBoundingCoordinate	deg	-90.0 .. 90.0	F11.6	1
26 22	GRingPointLatitude	deg	-90.0 .. 90.0	F11.6	5
27 23	GRingPointLongitude	deg	-180.0 .. 180.0	F11.6	5
28 24	GRingPointSequenceNo	N/A	0 .. 99999	I5	5

Table A-1. CERES Baseline Header Metadata

Item	Parameter Name	Units	Range	Data Type	No. of Elements
29 25	ExclusionGRingFlag	N/A	Y (= YES), N (= NO)	s(1)	1
30	CERWestBoundingCoordinate	deg	0.0 .. 360.0	F11.6	1
31	CERNorthBoundingCoordinate	deg	0.0 .. 180.0	F11.6	1
32	CEREastBoundingCoordinate	deg	0.0 .. 360.0	F11.6	1
33	CERSouthBoundingCoordinate	deg	0.0 .. 180.0	F11.6	1
34 26	CERGRingPointLatitude	deg	0.0 .. 180.0	F11.6	5
35 27	CERGRingPointLongitude	deg	0.0 .. 360.0	F11.6	5
36 28	GRingPointSequenceNo	N/A	0 .. 99999	I5	5
37 29	ExclusionGRingFlag	N/A	Y (= YES), N (= NO)	s(1)	1
38	AutomaticQualityFlag	N/A	Passed, Failed, or Suspect	s(64)	1
39	AutomaticQualityFlagExplanation	N/A	N/A	s(255)	1
40	QAGranuleFilename	N/A	N/A	s(255)	1
41	ValidationFilename	N/A	N/A	s(255)	1
42	ImagerShortName	N/A	VIRS, MODIS, TBD	s(20)	1
43	InputPointer	N/A	N/A	s(255)	800
44	NumberInputFiles	N/A	1 .. 9999	I4	1

Table A-2 describes the CERES_metadata Vdata parameters which are written to all CERES HDF output science products. The table lists the item number, parameter name, units, range or allowable values, and the parameter data type where s(x) denotes a string of x characters.

Table A-2. CERES_metadata Vdata

Item	Parameter Name	Units	Range	Data Type
1	ShortName	N/A	N/A	s(32)
2	RangeBeginningDate	N/A	1997-11-19 .. 2050-12-31	s(32)
3	RangeBeginningTime	N/A	00:00:00.000000Z .. 24:00:00:000000Z	s(32)
4	RangeEndingDate	N/A	1997-11-19 .. 2050-12-31	s(32)
5	RangeEndingTime	N/A	00:00:00.000000Z .. 24:00:00:000000Z	s(32)
6	AutomaticQualityFlag	N/A	Passed, Failed, or Suspect	s(64)
7	AutomaticQualityFlagExplanation	N/A	N/A	s(256)

Table A-2. CERES_metadata Vdata

Item	Parameter Name	Units	Range	Data Type
8	AssociatedPlatformShortName	N/A	TRMM, EOS AM-1, EOS PM-1, TBD	s(32)
9	AssociatedInstrumentShortName	N/A	PFM, FM1, FM2, FM3, FM4, FM5, TBD	s(32)
10	LocalGranuleID	N/A	N/A	s(96)
11	LocalVersionID	N/A	N/A	s(64)
12	CERProductionDateTime	N/A	N/A	s(32)
13	NumberofRecords	N/A	1 .. 9 999 999 999	4-byte integer
14	ProductGenerationLOC	N/A	SGI_xxx, TBD	s(256)