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

Data Management System

ES-4 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).	Sec. 1.4
			• This document was converted from FrameMaker to Word. (12/03/2008)	All
			• The CERES Top Level Data Flow Diagram was modified. (12/03/2008)	Fig. 1-2
			• S(d) was modified to read S'(d) - added prime symbol - in two places in Item No. 5. (01/29/2010)	Table 4-4
			• Updated Website links. Some were modified to new sites and some were unlinked as the sites no longer exist. (06/19/2013)	Secs. 7.0 & 14.0

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Clouds and the Earth's Radiant Energy System (CERES) ES-4 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-4 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 regional, zonal, and global spatial averages from instantaneous scanner estimates at the top-of-the Earth's atmosphere which are averaged hourly, daily, and monthly.

The ES-4 product contains nine groups of spatial averages:

1. 2.5 Degree Regional
2. 5.0 Degree Nested Regional
3. 10.0 Degree Nested Regional

4. 2.5 Degree Zonal
5. 5.0 Degree Zonal
6. 10.0 Degree Zonal
7. 2.5 Degree Global
8. 5.0 Degree Global
9. 10.0 Degree Global

Each of these groups contains Monthly (Day), Monthly (Hour), Daily, and Monthly Hourly averages (see Figure 0-1) for clear-sky and total-sky parameters such as solar incidence, net radiant flux, longwave flux, shortwave flux, and albedo (see Table 1-2). The dots in Figure 0-1 indicate interpolated values which are also used in calculating the Daily Averages.

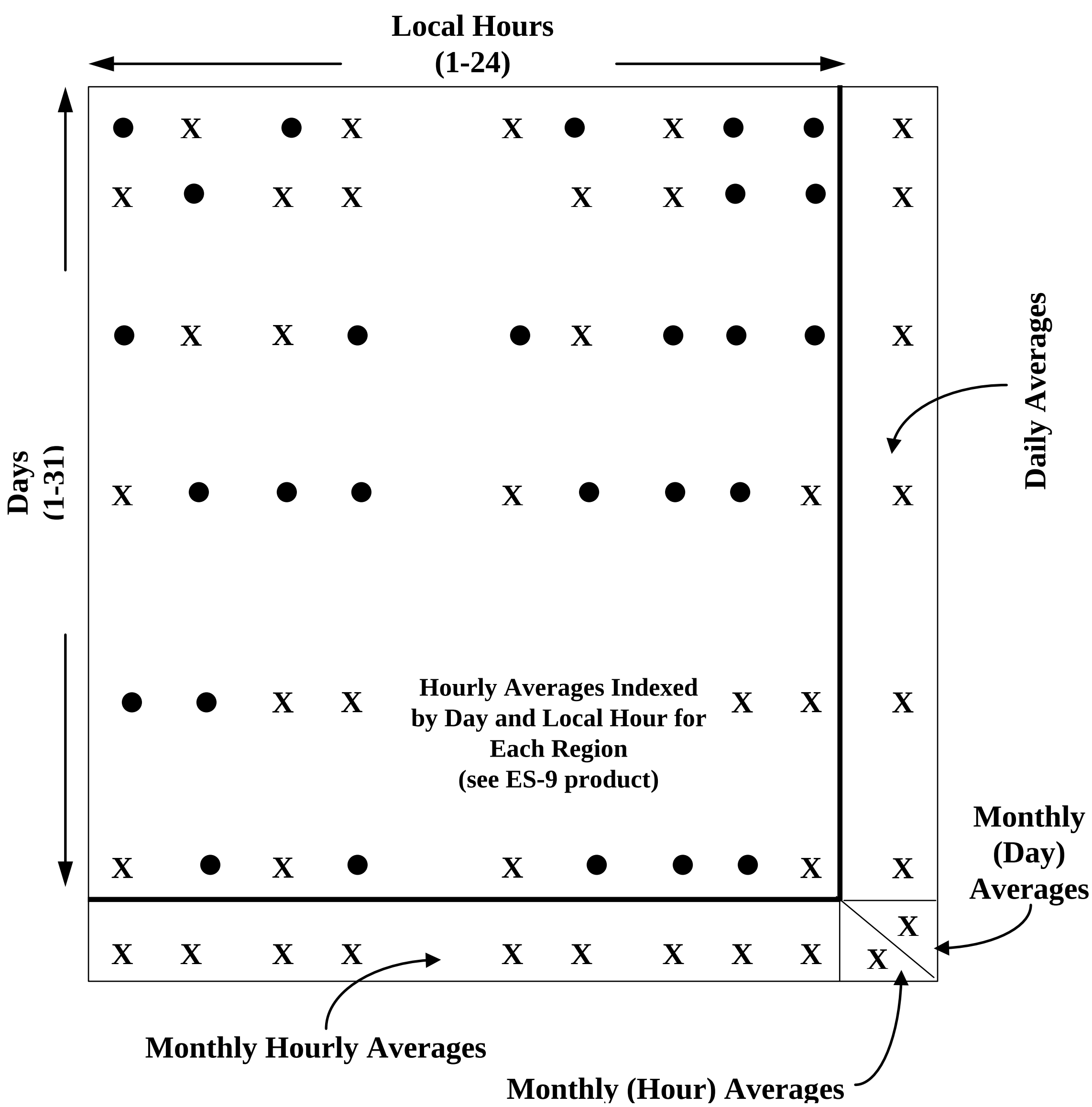

Figure 0-1. CERES Subsystem 3.0 Temporal Grid

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 a single instrument. The ES4 program uses the output data from EMTSA to produce geographical averages of radiant flux and albedo values.

Several levels of spatial averages are calculated based on the structure of the ERBE grid system. The first is on a regional level. Data values from higher spatial resolution regions are nested into lower spatial resolution regions. These regional averages constitute the first three (1-3) of the spatial groups listed in the Summary. Figure 1-1 shows which 2.5° and 5.0° regions are nested into 10.0° region 1.

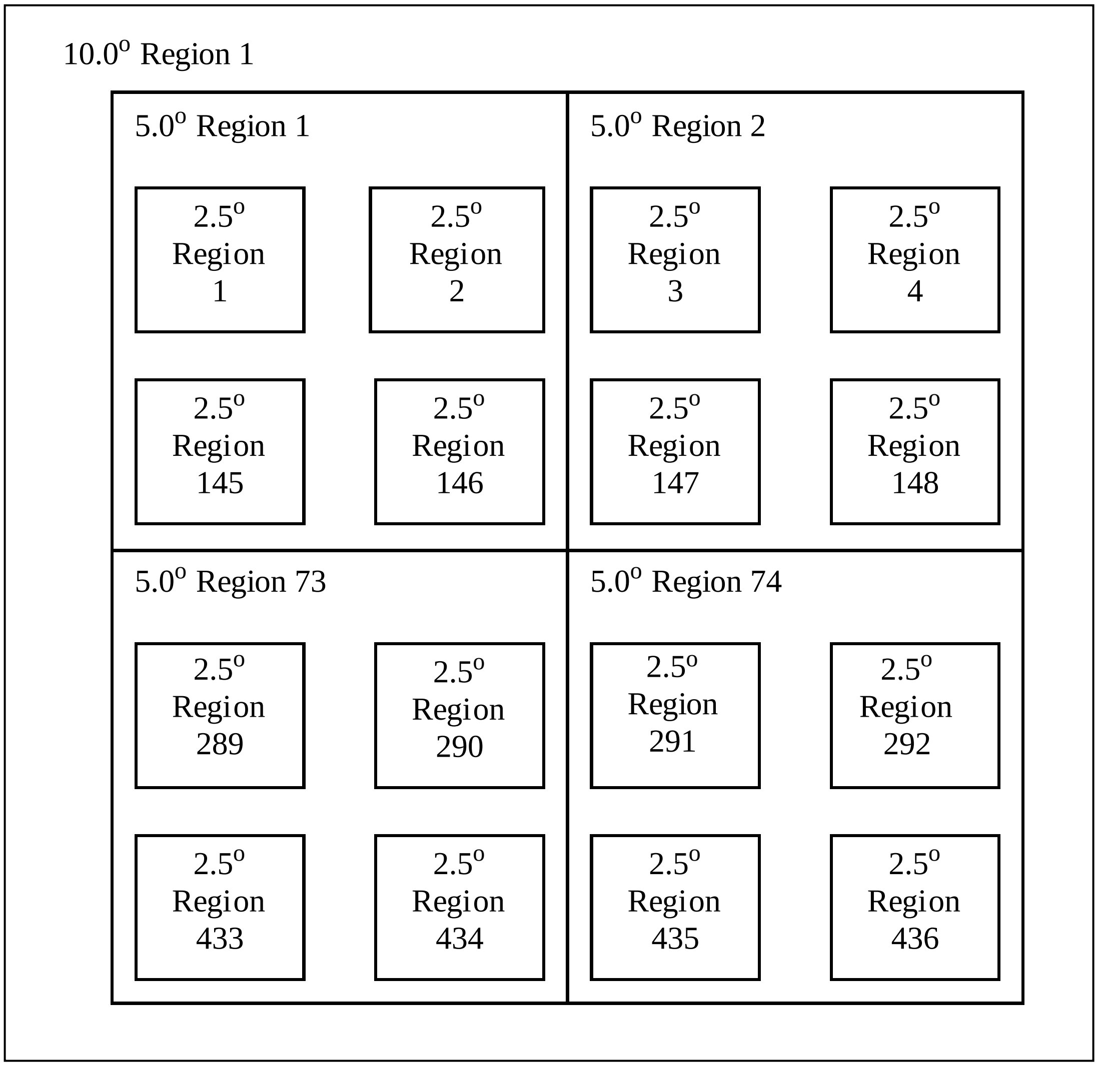

Figure 1-1. Nesting of Regions

The next level of averaging occurs across latitudinal bands. Data from all the regions in a 2.5°, 5.0°, or 10.0° latitudinal band are accumulated to produce 2.5°, 5.0°, and 10.0° zonal averages. These zonal averages constitute the next three (4-6) spatial groups listed in the Summary.

The final type of average is on a global level, where all the zonal averages for a given resolution are area weighted means. 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-4 filename is

CER_ ES4_Sampling-Strategy_Production-Strategy_XXXXXX.YYYYMM where

CER	Investigation designation for CERES,
ES4	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-4 data product is a Level-3 archival product that contains regional, zonal, and global averages. The scanner estimates at the TOA are arranged hourly, daily, and monthly. They are averaged spatially by regions and latitude zones and for the globe. The ES-4 product contains nine HDF vgroups (see Term-3). These vgroups correspond to the spatial averages listed in the Summary (also see Table 1-1). There are 10,368 2.5° regions for the ERBE-like data; therefore, there are 10,368 records in the 2.5° regional data set. The second set of data is the 2.5° nested to 5.0° regional data, which constitutes of 2,592 records. The third set of data is the 5.0° nested to 10.0° regional data, which constitutes 648 records. The fourth, fifth, and sixth sets of data are the 2.5°, 5.0°, and 10.0° zonally averaged data which constitute 72, 36, and 18 records, respectively. The seventh, eighth, and ninth sets of data are the 2.5°, 5.0°, and 10.0° global averages which are one record each and are based on 2.5° regional data, 5.0° regional data, and 10.0° regional data.

1.3 Objective/Purpose

The overall 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 1-2. Circles in the diagram represent algorithm

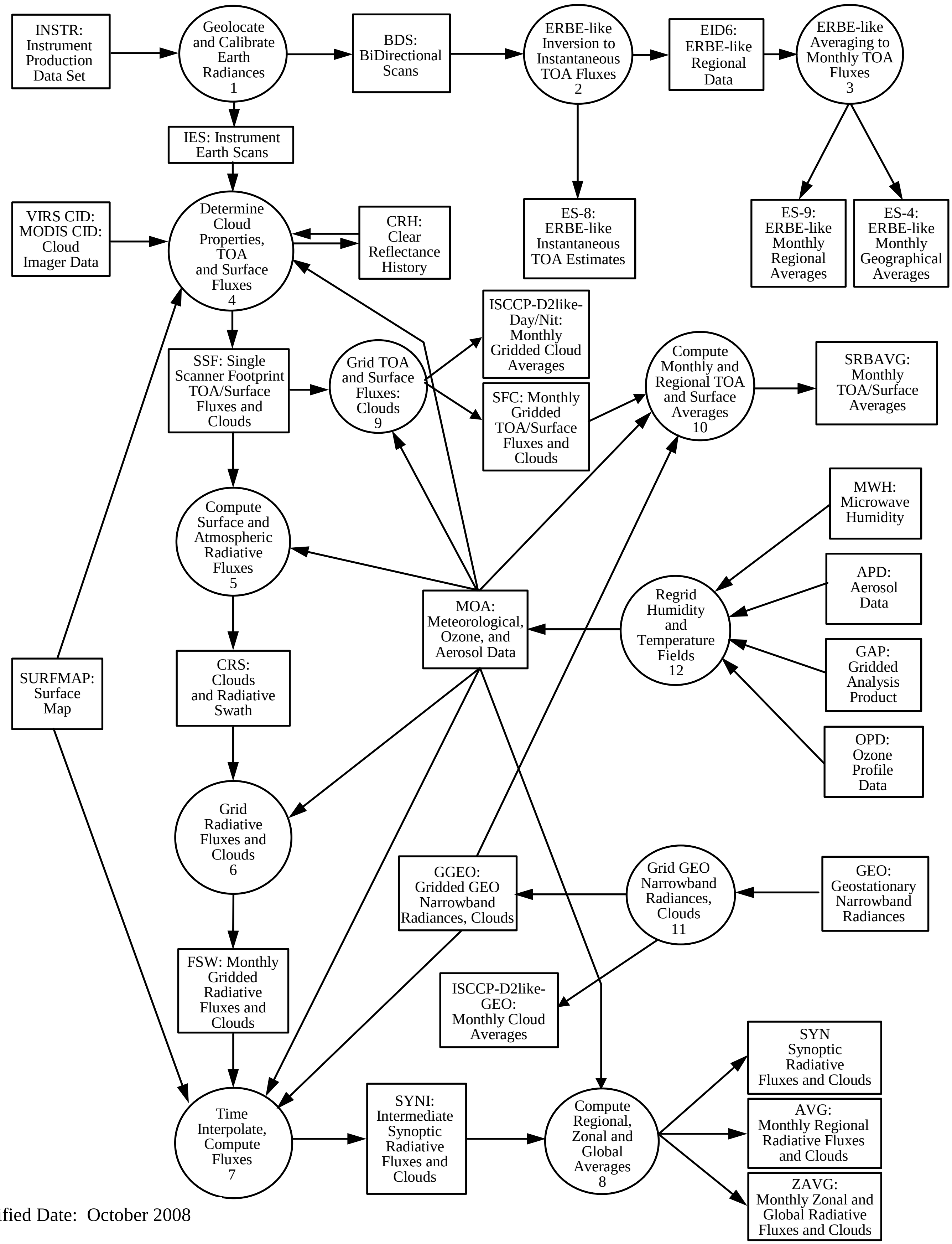

Figure 1-2. CERES Top Level Data Flow Diagram

processes which are called subsystems. Subsystems are a logical collection of algorithms which 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.

As shown in Figure 1-2, the ES-4 product is generated by the CERES ERBE-like Monthly Time and Space Averaging Subsystem (3.0). The input to Subsystem 3.0 is the ERBE-like daily, regional averages on the Subsystem 2.0 output product EID-6.

1.4 Summary of Parameters

The ES-4 data are organized spatially into vgroups (see Term-3) as shown in Table 1-1.

Table 1-1. ES-4 Vgroup Summary

Vgroup Number	Vgroup Name	Number of Records	Total Size (MB)
1	2.5 Degree Regional	10,368 (72 x 144)	19.232
2	5.0 Degree Nested Regional	2,592 (36 x 72)	4.808
3	10.0 Degree Nested Regional	648 (18 x 36)	1.202
4	2.5 Degree Zonal	72	0.134
5	5.0 Degree Zonal	36	.067
6	10.0 Degree Zonal	18	.033
7	2.5 Degree Global	1	.002
8	5.0 Degree Global	1	.002
9	10.0 Degree Global	1	.002
Total Product Size (MB)			**25.482**

Each vgroup contains science parameters written as Scientific Data Sets (SDSs) (see Term-1) that are averaged temporally. Table 1-2 shows the four temporal groups and the science parameters contained in each.

Table 1-2. Temporal Groups per Spatial Vgroup

Science Parameters	Monthly (Day) Averages	Monthly (Hour) Averages	Daily Averages	Monthly Hourly Averages
Total-sky Parameters	Table 4-4	Table 4-6	Table 4-8	Table 4-10
Solar incidence	X	X	X	X
Net radiant flux	X	X		
Longwave flux	X	X	X	X
Number of days of longwave flux				X
Number of hours of longwave flux			X	
Shortwave flux	X	X	X	X
Number of days of shortwave flux				X
Number of hours of shortwave flux			X	
Albedo	X	X	X	X
Geographic scene type	X	X	X	X
Longitude	X	X	X	X
Colatitude	X	X	X	X
Clear-sky Parameters	Table 4-5	Table 4-7	Table 4-9	Table 4-11
Solar incidence	X	X		X
Net radiant flux	X	X		
Longwave flux	X	X	X	X
Number of days of longwave flux				X
Number of hours of longwave flux			X	
Shortwave flux	X	X	X	X
Number of days of shortwave flux				X
Number of hours of shortwave flux			X	
Albedo	X	X	X	X
Geographic scene type	X	X	X	X

Table 1-2. Temporal Groups per Spatial Vgroup

Science Parameters	Monthly (Day) Averages	Monthly (Hour) Averages	Daily Averages	Monthly Hourly Averages
Longitude	X	X	X	X
Colatitude	X	X	X	X
the total number of science parameters per spatial vgroup is **67**.	**16**	**16**	**17**	**18**

1.5 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 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 1-2) 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 in the ES-9 and used to produce the ES-4 product which contains regionally, zonally, and globally averaged parameters.

1.6 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).

2.0 Investigators

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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 range 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-4 is shown in Table 4-1.

Table 4-1. ES-4 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-4 contains regional, zonal, and global averages on various temporal scales as described in this document's Summary. The CERES field of view of a nadir viewing measurement is 10 km for TRMM and 20 km for both EOS AM-1 and EOS PM-1.

4.1.3 Grid Description

Spatially, the ES-4 contains 2.5° regional and zonal data collected in the standard ERBE grid system, a 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).

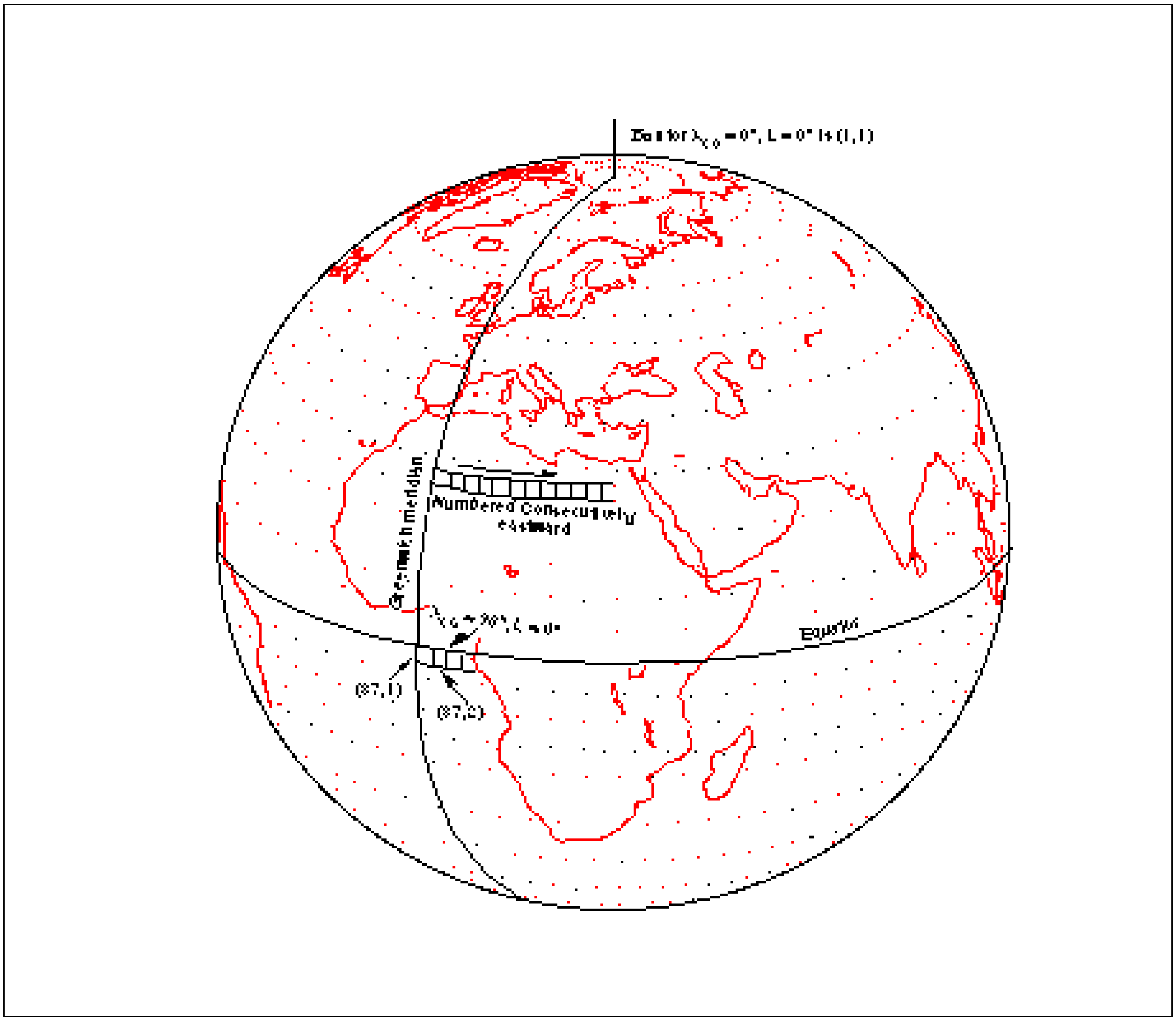


Figure 4-1. Layout of a 2.5° System

5.0° and 10.0° nested data are also contained on the ES-4. The 5.0° and 10.0° grid systems are designed similarly to the 2.5° grid 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
EOS PM	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-4 is a monthly data product that contains Monthly (Day), Monthly (Hour), Daily, and Monthly Hourly Averages (see Figure 0-1) for the month.

4.3 Parameter Definitions

The parameters contained on the ES-4 are listed by SDS Name and are defined in 4.3.1 in tables arranged according to the four temporal data classifications on the ES-4. Recall that these are,

1. Monthly (Day) Averages
2. Monthly (Hour) Averages
3. Daily Averages
4. Monthly Hourly Averages

There are tables for total-sky and clear-sky averages for each temporal group. A discussion of regional, zonal, and global averages, area weighting, polar day-night indicators, and albedo calculations follow in Sections 4.3.2 - 4.3.5.

4.3.1 ES-4 Parameter Definitions according to Temporal Classification

Table 4-4 through Table 4-12 in this section contain the definitions of each parameter on the ES-4. The arrangement of the tables containing the temporal vgroups is shown in Table 4-3. Table 4-12 gives definitions of SDSs containing geographical data. Section 16.3 contains the List of Symbols used in these tables.

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

Temporal Group	Total-Sky	Clear-Sky
Monthly (Day) Averages	Table 4-4	Table 4-5
Monthly (Hour) Averages	Table 4-6	Table 4-7
Daily Averages	Table 4-8	Table 4-9
Monthly Hourly Averages	Table 4-10	Table 4-11

Table 4-4. Monthly (Day), Total-sky Averagesa

Item No.	SDS Nameb	Monthly (Day), Total-sky Definitions	Units
1	Solar incidence	The monthly total integrated solar incidence for all days of the month.	W-hm^{-2}
2	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). $$\overline{M}_{NET}(d,h) = \left[(1-\bar{\alpha}(d\alpha)) \cdot \sum_{d=1}^{N} S(d)/24 \cdot N)\right] - \overline{M}_{LW}(d,h)$$	Wm^{-2}
3	Longwave flux	The monthly mean LW flux based on all extrapolated, interpolated, and modeled LW flux values for the month in this region. $$\overline{M}_{LW}(d,h) = \sum_{d=1}^{N}\sum_{h=1}^{24} M_{LW}(d,h)/(24 \cdot N)$$ where N = all days of month (see Reference 12).	Wm^{-2}
4	Shortwave flux	The monthly mean SW flux based on daily SW flux values, including “measurements” from the Inversion Subsystem (Reference 5) and modeled values, within this region. $$M_{SW}(d\alpha) = \bar{\alpha}(d\alpha) \cdot \sum_{d=1}^{N} S(d)/(24 \cdot N)$$ where N = all days of the month, $S(d)$ is the integrated daily solar incident radiation, and $\alpha(d\alpha)$ is defined in Item 5, Table 4-4.	Wm^{-2}
5	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}). $$\bar{\alpha}(d\alpha) = 24 \cdot \sum_{D_{SW}}^{N} M_{SW}(d) / \sum_{D_{SW}} S(d)$$ 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 0h0m0s 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. $$M_{SW}(d) = [S(d)/S'(d)] \cdot \sum_{b=1}^{24} M_{SW}(d,h)/24$$ where S'(d) and S(d) are the summed and integrated solar fluxes, respectively (also see Item 24, Table 4-8). Other equations used to calculate the albedo values in ES-4 may be found in 4.3.5 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.

b. Geographical Scene Type, Longitude, and Colatitude are also included as Monthly (Day), Total-sky parameters. These parameters are defined in Table 4-12, Geographical Data.

Table 4-5. Monthly (Day), Clear-sky Averages

Item No.	SDS Namea	Monthly (Day), Clear-sky Definitions	Units
6	Solar incidence	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.	$W\text{-}hm^{-2}$
7	Net radiant flux		Wm^{-2}
8	Longwave flux		Wm^{-2}
9	Shortwave flux		Wm^{-2}
10	Albedo		Unitless

a. Geographical Scene Type, Longitude, and Colatitude are also included as Monthly (Day), Clear-sky parameters. These parameters are defined in Table 4-12, Geographical Data.

Table 4-6. Monthly (Hour), Total-sky Averagesa

Item No.	SDS Nameb	Monthly (Hour), Total-sky Definitions	Units
11	Solar incidence	The monthly total solar incidence for all days of the month.	$W\text{-}hm^{-2}$
12	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. $$M_{NET}(mha) = \left(1-\overline{\alpha}(h)\right)\cdot\sum_{d=1}^{N} S(d)/(24\cdot N_{SW}) - M_{LW}(mha)$$ where mha = monthly hourly average, $\overline{\alpha}(h)$ is defined in Item 37, Table 4-10, S(d) *is the integrated daily solar incident radiation, and* $M_{LW}(mha)$ is defined in Item 13, Table 4-6.	Wm^{-2}
13	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, $$M_{LW}(mha) = \sum_{h=1}^{24} M_{LW}(h)/N_{LW}(mha)$$ (see Reference 12).	Wm^{-2}

Table 4-6. Monthly (Hour), Total-sky Averagesa

Item No.	SDS Nameb	Monthly (Hour), Total-sky Definitions	Units
14	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. $$\overline{M}_{SW} = \overline{\alpha} \cdot \sum_{d=1}^{N} S(d) / (24 \cdot N_{SW})$$ where N_{SW} = all days of the month, S(d) is the integrated daily solar incident radiation, and $\overline{\alpha}$ is defined in Item 15, Table 4-6.	Wm^{-2}
15	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-4 may be found in 4.3.5 of this document. $$\overline{\alpha} = 24 \cdot \sum_{D_{SW}} M_{SW}(d) / \sum_{D_{SW}} S(d)$$ 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.
b. Geographical Scene Type, Longitude, and Colatitude are also included as Monthly (Hour), Total-sky parameters. These parameters are defined in Table 4-12, Geographical Data.

Table 4-7. Monthly (Hour), Clear-sky Averages

Item No.	SDS Namea	Monthly (Hour), Clear-sky Definitions	Units
16	Solar incidence	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.	$W\text{-}hm^{-2}$
17	Net radiant flux		Wm^{-2}
18	Longwave flux		Wm^{-2}
19	Shortwave flux		Wm^{-2}
20	Albedo		Unitless

a. Geographical Scene Type, Longitude, and Colatitude are also included as Monthly (Hour), Clear-sky parameters. These parameters are defined in Table 4-12, Geographical Data.

Table 4-8. Daily, Total-sky Averagesa

Item No.	SDS Nameb	Daily, Total-sky Definitions	Units
21	Solar incidence	The integrated solar incidence for a day that includes at least one SW measurement.	W-hm^{-2}
22	Longwave flux	Daily LW flux consisting of measurements and extrapolated, interpolated, and modeled values.	Wm^{-2}
23	Number of hours of longwave flux	The number of hours with LW measurements for a day that includes at least one LW measurement.	hours
24	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. $$M_{SW}(d) = [S(d)/S^{\eta}(d)] \cdot \sum_{h=1}^{24} M_{SW}(d,h)/2$$ where S(d) and S^{η}(d) are the integrated and summed solar radiances, respectively (see Reference 12).	Wm^{-2}
25	Number of hours of shortwave flux	The number of hours with SW measurements for a day that includes at least one SW measurement. [N_{SW}(h)]	hours
26	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-4 may be found in 4.3.5 of this document.	Unitless

a. These quantities are calculated for each day in the month
b. Geographical Scene Type, Longitude, and Colatitude are also included as Daily, Total-sky parameters. These parameters are defined in Table 4-12, Geographical Data.

Table 4-9. Daily, Clear-sky Averages

Item No.	SDS Name[a]	Daily, Clear-sky Definitions	Units
27	Longwave flux	The total-sky values from Table 4-8 are repeated for clear-sky conditions; the solar incidence is not included as a Daily, Clear-sky Averages parameter. 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.	Wm^{-2}
28	Number of hours of longwave flux		hours
29	Shortwave flux		Wm^{-2}
30	Number of hours of shortwave flux		hours
31	Albedo		Unitless

a. Geographical Scene Type, Longitude, and Colatitude are also included as Daily, Clear-sky parameters. These parameters are defined in Table 4-12, Geographical Data.

Table 4-10. Monthly Hourly, Total-sky Averages[a]

Item No.	SDS Name[b]	Monthly Hourly, Total-sky Definitions	Units
32	Solar incidence	The integrated solar incidence over those days with SW data for a given hour.	$W\text{-}hm^{-2}$
33	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}
34	Number of days of longwave flux	The number of days that contain LW measurements for a given hour.	days
35	Shortwave flux	This is the monthly average SW flux at this hour and is only calculated based on days that had at least one SW measurement.	Wm^{-2}
36	Number of days of shortwave flux	The number of days that contain SW measurements for a given hour.	days
37	Albedo	The monthly hourly average albedo. The equations used to calculate the albedo values in ES-4 may be found in 4.3.5.	Unitless

a. These values are calculated for the month at each local hour.
b. Geographical Scene Type, Longitude, and Colatitude are also included as Monthly Hourly, Total-sky parameters. These parameters are defined in Table 4-12, Geographical Data.

Table 4-11. Monthly Hourly, Clear-sky Averages

Item No.	SDS Namea	Monthly Hourly, Clear-sky Definitions	Units
38	Solar incidence	The total-sky values from Table 4-10 are repeated for clear-sky as defined by the ERBE-like Inversion Subsystem.	W-hm^{-2}
39	Longwave flux		Wm^{-2}
40	Number of days of longwave flux		days
41	Shortwave flux		Wm^{-2}
42	Number of days of shortwave flux		days
43	Albedo		Unitless

a. Geographical Scene Type, Longitude, and Colatitude are also included as Monthly Hourly, Clear-sky parameters. These parameters are defined in Table 4-12, Geographical Data.

Table 4-12. Geographical Data

Item No.	SDS Name	Regional Geographical Definitions
44	Geographic scene type	For the “2.5 Degree Regional” vgroup an integer from 1-5 denoting the surface type for the region. The types are, 1 = ocean 2 = land 3 = snow 4 = desert 5 = land/ocean mix (coastal regions)a 127 = no data
45	Geographic scene type	For all vgroups, except “2.5 Degree Regional,” the value for the Geographical scene type is “1” if there are data available; otherwise, the value is “127.”
46	Longitude	The longitude of the center of the appropriate spatial entity.
47	Colatitude	The colatitude of the center of the appropriate spatial entity.

a. For the land/ocean mix, the corresponding directional models (clear, partly-cloudy, or mostly-cloudy over this scene) are linear composites of land and ocean models and not independent models.

4.3.2 Discussion of Regional, Zonal, and Global Averages

The ES-4 provides averages of radiant flux and albedo values using regional, zonal, and global data from the ERBE-like Monthly Time/Space Averaging Subsystem (Reference 3 from S-4 UG). This product is based on the ERBE S-4 and S-4G products (Reference X and Reference Y).

The ES-4 product contains data which are averaged to 2.5°, 5.0°, and 10.0° grid scales. The layout of a 2.5° system is given in Figure 4-1; the 5.0° and 10.0° systems are designed similarly. In this grid system, colatitude, θ, ranges from 0 at the North Pole to 180° at the South Pole, and longitude, φ, ranges from 0 at the Greenwich Meridian through 360°. The number of regions for each resolution is shown in Table 4-13.

Table 4-13. Number of Regions for 2.5°, 5.0°, and 10.0° Resolutions

Resolution	Number of Regions
2.5°	10,368
5.0°	2,592
10.0°	648

The 2.5° data are nested with *area weighting* to 5.0° and 10.0° regions, with four scanner 2.5° regions producing a 5.0° region and sixteen 2.5° regions producing a 10.0° region. This nesting is shown in Figure 1-1, and the *area weighting* is described in 4.3.3.

Equation 1 gives the formula for calculating weighted nested and global averages:

$$\overline{M} = \frac{\sum_{i=1}^{N} W_i M_i}{\sum_{i=1}^{N} W_i} \qquad (1)$$

where,

M = nested or global average flux value
N = number of regions included in nested or global average
W_i = area weighting factor
M_i = monthly means

Global averages are computed for each parameter over the entire globe.

The ES-4 product also contains averages over latitudinal bands or zones. The number of zones for each resolution is listed in Table 4-14.

Table 4-14. Number of Zones for 2.5°, 5.0°, and 10.0° Resolutions

Resolution	Total Number of Bands	Total Number of Regions in Each Band
2.5°	72	144
5.0°	36	72
10.0°	18	36

Table 1-1 provides a summary of the type of data available in the ES-4 output product. Processing is controlled by the lower resolution region numbers. A simple set of calculations can be used to derive the four higher resolution region numbers which will be nested into the lower resolution region (see Figure 1-1). The formulas for finding the four 2.5° region box numbers which are nested into a 5.0° region box are:

$$B_{2.5}(1) = 288\, INT\, [(B_5 - 1)/\, 72] + 2\, MOD\, [(B_5 - 1), 72] + 1 \qquad (2)$$

$$B_{2.5}(2) = B_{2.5}(1) + 1$$

$$B_{2.5}(3) = B_{2.5}(1) + 144$$

$$B_{2.5}(4) = B_{2.5}(1) + 145$$

where,

$B_{2.5}\,(N)$ = 2.5° region box number

B_5 = 5.0° region box number

The formulas for finding the four 5.0° region box numbers which are nested into a 10.0° region box are:

$$B_5(1) = 144\, INT\, [(B_{10} - 1)/\, 36] + 2\, MOD\, [(B_{10} - 1), 36] + 1 \qquad (3)$$

$$B_5(2) = B_5(1) + 1$$

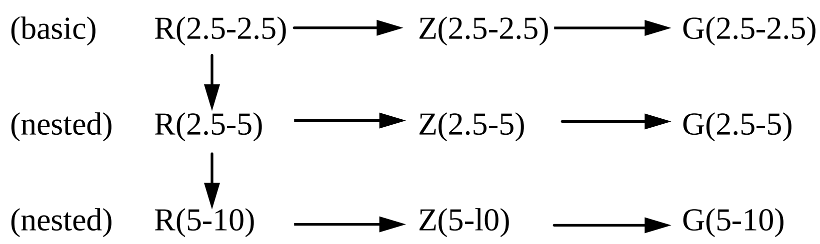
$$B_5(3) = B_5(1) + 72$$

$$B_5(4) = B_5(1) + 73$$

where,

B_{10} = 10.0° region box number

The 2.5° product is used to nest to the 5.0° product which is then used to nest to the 10.0° product. This process is done for each instrument and each combination of instruments. For each of these processes, separate zonal and global products are produced for each resolution,



where for any data product, R(r_1-r_2), r_1-r_2 designates the source and final product resolution.

So, for each instrument and combination of instruments, there are potentially three different global (monthly) averages of each calculated quantity. If there were no missing data on the high resolution grid, these numbers should be the same. However, missing data forces nesting procedures which can produce some discrepancies between the two products.

4.3.3 The Area Weighting Factors

Because the ERBE grid system divides the globe into regions which are defined by equal increments of latitude and longitude rather than equal areas, the nested averages must be normalized by weighting each region based upon its area. Since regions across a latitudinal band have the same area, only one weighting factor is needed for each latitudinal band. It also follows that since the area weighting factors across a latitudinal band are the same, the zonal averages do not have to be normalized. Equation 4 gives the formula for calculating the area weighting factors.

$$W_i = \frac{\pi R^2}{90}\,\Delta\theta \sin\left(\frac{\Delta\theta}{2}\right)\sin\theta_c \qquad (4)$$

where,

W_i = area of $\Delta\theta$ by $\Delta\theta$ region in km^2

$\Delta\theta$ = resolution in degrees (2.5^o, 5.0^o, 10.0^o)

R = distance from the center of the Earth to the top-of-the-atmosphere (km)

θ_c = colatitude in degrees of the center of the latitudinal band region

4.3.4 Polar Day-Night Indicators

Polar day-night indicators provided as input to the ES-4 Processor are used to identify those regions within approximately 23.5^o of the poles that experience continuous darkness or continuous daylight at certain times of the year. These regions are treated differently during processing from those which always experience day-night cycles.

In general, radiant flux values for regions not observed by the satellite are not accumulated as part of the averaging process. However, since it is known that the shortwave radiant flux is zero when there is no daylight, those unobserved regions which are in complete darkness for the entire month (i.e., near the polar regions at certain times of the year), will have the shortwave set to zero. The reason for doing this is to reduce the error in the zonal and global averaging process.

There is a direct relationship between the occurrence of polar night and the daily solar declination and the colatitude of a region. This can be used to determine whether or not that region is experiencing total darkness or has some daylight and which part of the month is affected. Of course, none of this has any effect on regions in latitudinal bands which are not near the north or south poles.

The criteria for setting the polar day-night indicators for latitudes in the northern hemisphere are:

1. April through August are daylight months.
2. For the other months (January through March and September through December), if the magnitude of the **negative** solar declination is greater than the center colatitude, then the region is in darkness for that day.
3. For months during which some days are in darkness and others are not: if the month is January through March, then the days before the flagged day are in darkness; if the month is September through December, then the days after the flagged day are in darkness.

The criteria for setting the polar day-night indicators for latitudes in the southern hemisphere are:

1. January, February, and October through December are daylight months.
2. For the other months (March through September), if the **positive** solar declination is greater than (180^o - center colatitude), then the day is in darkness.
3. For months during which some days are in darkness and others are not: if the month is March through May, then the days after the flagged day are in darkness; if the month is July through September, then the days before the flagged day are in darkness.

In order to clarify this concept, some tables are provided to illustrate the results of applying the logic described above. Table 4-15 shows which colatitudes are considered to be the northern and southern polar latitudes for each resolution. Table 4-16 shows the solar declinations for 1985, which was chosen as the example year. Table 4-17 shows the sunlit days for the northern and southern polar regions for the 2.5^o resolution. Table 4-18 gives a sample of the polar day-night indicator values for some latitudes at the 2.5^o resolution.

4.3.5 The Albedo Calculations

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

For Monthly (Day) Averages:

for individual regions:

$$albedo = \frac{\overline{M}_{SW} \cdot 24 \cdot NDAYS}{TSOLRD} \qquad (5)$$

for nested regions, zones, and the globe:

$$albedo = \frac{\sum_{regions} \overline{M}_{SW} \cdot 24 \cdot NDAYS}{TSOLRD} \tag{6}$$

where:

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 13)

NDAYS = The total number of days in the month

Table 4-15. Polar Colatitude Indicators and Center Colatitudes

2.5° RESOLUTION			5.0° RESOLUTION			10.0° RESOLUTION		
COLATITUDE INDICATORS	**CENTER COLAT (DEG)**	**HEMISPHERE**	**COLATITUDE INDICATORS**	**CENTER COLAT (DEG)**	**HEMISPHERE**	**COLATITUDE INDICATORS**	**CENTER COLAT (DEG)**	**HEMISPHERE**
1	1.25		1	2.50		1	5.00	North
2	3.75		2	7.50		2	15.00	
3	6.25		3	12.50				
4	8.75		4	17.50				
5	11.25	North	5	22.50	North			
6	13.75							
7	16.25							
8	18.75							
9	21.25							
						17	165.00	South
						18	175.00	
			32	157.50	South			
			33	162.50				
			34	167.50				
			35	172.50				
			36	177.50				
64	158.75							
65	161.25							
66	163.75							
67	166.25							
68	168.75	South						
69	171.25							
70	173.75							
71	176.25							
72	178.75							

Table 4-16. 1985 Solar Declinations

DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	-23.02	-17.17	-7.68	4.44	15.00	22.02	23.13	18.09	8.38	-3.08	-14.34	-21.76
2	-22.94	-16.89	-7.30	4.82	15.30	22.15	23.06	17.83	8.02	-3.47	-14.66	-21.92
3	-22.85	-16.60	-6.92	5.21	15.60	22.28	22.98	17.58	7.65	-3.86	-14.98	-22.06
4	-22.75	-16.30	-6.54	5.59	15.89	22.40	22.90	17.31	7.28	-4.24	-15.29	-22.20
5	-22.64	-16.00	-6.15	5.97	16.18	22.52	22.81	17.05	6.91	-4.63	-15.60	-22.33
6	-22.53	-15.70	-5.77	6.35	16.46	22.63	22.72	16.77	6.54	-5.01	-15.90	-22.46
7	-22.40	-15.39	-5.38	6.73	16.74	22.73	22.62	16.50	6.17	-5.40	-16.20	-22.58
8	-22.28	-15.07	-4.99	7.10	17.02	22.82	22.51	16.22	5.79	-5.78	-16.49	-22.69
9	-22.14	-14.75	-4.60	7.48	17.29	22.91	22.39	15.93	5.42	-6.16	-16.78	-22.79
10	-22.00	-14.43	-4.21	7.85	17.55	22.99	22.27	15.64	5.04	-6.54	-17.07	-22.89
11	-21.84	-14.11	-3.82	8.22	17.81	23.07	22.14	15.35	4.66	-6.92	-17.35	-22.98
12	-21.69	-13.78	-3.42	8.59	18.07	23.13	22.01	15.05	4.28	-7.30	-17.62	-23.06
13	-21.52	-13.44	-3.03	8.95	18.32	23.20	21.87	14.75	3.90	-7.67	-17.89	-23.13
14	-21.35	-13.11	-2.64	9.31	18.56	23.25	21.72	14.45	3.52	-8.05	-18.16	-23.20
15	-21.17	-12.77	-2.24	9.67	18.80	23.30	21.57	14.14	3.13	-8.42	-18.42	-23.25
16	-20.98	-12.42	-1.85	10.03	19.04	23.34	21.41	13.82	2.75	-8.79	-18.67	-23.30
17	-20.79	-12.07	-1.45	10.38	19.27	23.37	21.24	13.51	2.36	-9.15	-18.92	-23.35
18	-20.59	-11.72	-1.05	10.73	19.49	23.40	21.07	13.19	1.97	-9 52	-19.16	-23.38
19	-20.39	-11.37	-.66	11.08	19.71	23.42	20.90	12.86	1.59	-9.88	-19.40	-23.41
20	-20.18	-11.01	-.26	11.43	19.92	23.43	20.71	12.54	1.20	-10.24	-19.63	-23.43
21	-19.96	-10.65	.13	11.77	20.13	23.44	20.52	12.21	.81	-10.60	-19.86	-23.44
22	-19.73	-10.29	.53	12.11	20.33	23.44	20.33	11.87	.42	-10.96	-20.07	-23.44
23	-19.50	-9.92	.92	12.44	20.53	23.43	20.13	11.54	.03	-11.31	-20.29	-23.44
24	-19.27	-9.56	1.31	12.78	20.72	23.42	19.92	11.20	-.36	-11.66	-20.49	-23.42
25	-19.03	-9.19	1.71	13.10	20.90	23.40	19.71	10.85	-.75	-12.01	-20.70	-23.40
26	-18.78	-8.81	2.10	13.43	21.08	23.37	19.50	10.51	-1.14	-12.35	-20.89	-23.38
27	-18.52	-8.44	2.49	13.75	21.25	23.33	19.27	10.16	-1.53	-12.69	-21.08	-23.34
28	-18.26	-8.06	2.88	14.07	21.42	23.29	19.05	9.81	-1.92	-13.03	-21.26	-23.30
29	-18.00	-18.00	3.27	14.38	21.58	23.24	18.81	9.45	-2.31	-13.36	-21.43	-23.24
30	-17.73	-17.73	3.66	14.69	21.73	23.19	18.58	9.10	-2.69	-13.69	-21.60	-23.18
31	-17.45	-17.45	4.05	4.05	21.88	21.88	18.33	8.74	8.74	-14.02	-14.02	-23.12

Table 4-17. Sunlit Days for Northern and Southern Polar Regions

Year: 1985 Resolution: 2.5°

HEMISPHERE	COLAT INDICATOR	CENTER COLAT (DEG)	FIRST DATE FOR SUNLIGHT	LAST DATE FOR SUNLIGHT
North	1	1.25	3/18	09/26
	2	3.75	3/12	10/02
	3	6.25	3/05	10/09
	4	8.75	2/27	10/15
	5	11.25	2/20	10/22
	6	13.75	2/13	10/30
	7	16.25	2/05	11/07
	8	18.75	1/27	11/16
	9	21.25	1/15	11/27
South	64	158.75	7/17	5/26
	65	161.25	7/30	5/14
	66	163.75	8/08	5/05
	67	166.25	8/17	4/26
	68	168.75	8/24	4/19
	69	171.25	8/31	4/12
	70	173.75	9/07	4/05
	71	176.25	9/14	3/30
	72	178.75	9/20	3/23

Table 4-18. Polar Day-Night Indicator Values for 1985

		POLAR FLAG											
COLAT	**CENTER COLAT (DEG)**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
1	1.25	50	50	-18	0	0	0	0	0	26	50	50	50
3	6.25	50	50	-5	0	0	0	0	0	0	9	50	50
5	11.25	50	-20	0	0	0	0	0	0	0	22	50	50
7	16.25	50	-5	0	0	0	0	0	0	0	0	7	50
9	21.25	-15	0	0	0	0	0	0	0	0	0	27	50
64	158.75	0	0	0	0	26	50	-17	0	0	0	0	0
66	163.75	0	0	0	0	5	50	50	-8	0	0	0	0
68	168.75	0	0	0	19	50	50	50	-25	0	0	0	0
70	173.75	0	0	0	5	50	50	50	50	-7	0	0	0
72	178.75	0	0	23	50	50	50	50	50	-20	0	0	0

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:

for individual regions:

$$albedo = \frac{\overline{M}_{SW} \cdot 24 \cdot NDAYS}{TSOLRH} \tag{7}$$

for nested regions, zones, and the globe:

$$albedo = \frac{\sum_{regions} \overline{M}_{SW} \cdot 24 \cdot NDAYS}{\sum TSOLRH} \tag{8}$$

where:

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):

for individual regions:

$$albedo = \frac{\overline{M}_{SW} \cdot 24}{SOLARD} \tag{9}$$

for nested regions, zones, and the globe:

$$albedo = \frac{\sum_{regions} \overline{M}_{SW} \cdot 24}{\sum SOLARD} \tag{10}$$

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):

for individual regions:

$$albedo = \frac{\overline{M}_{SW} \cdot D_{SW}}{SOLARH} \tag{11}$$

for nested regions, zones, and the globe:

$$albedo = \frac{\sum_{regions} \overline{M}_{SW} \cdot D_{SW}}{\sum SOLARH} \tag{12}$$

for nested regions, zones, and the globe:

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

Table 4-19 lists the CERES ERBE-like default fill values. These are 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. The CERES default fill values are defined as follows:

Table 4-19. CERES Fill Values

Fill Value Name	Value	Fill Value Description
INT1_DFLT	127	default value for a 1-byte integer
REAL4_DFLT	3.4028235E+38	default value for a 4-byte real

4.5 Sample Data Record

A sample data granule containing five ES-4 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-4 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_ES4_version information.

5.0 Data Organization

The content of the ES-4 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-4 are defined with the bounding rectangle. The ES-4 Product Specific Metadata is shown in Table 5-2. The ES-4 Vgroup Summary is shown in Table 5-3.

Table 5-1. ES-4 Product Summary

HDF Name	Description	Number of Parameters	Nominal Size (MB)
CERES Baseline Header Metadata	See Table A-1	35	
CERES_metadata Vdata	See Table A-2	14	
ES-4 Product Specific Metadata	See Table 5-2	1	
ES-4 Vgroup Summary	See Table 5-3	9	25.482
ES-4 TOTAL SIZE (MB/Month)			**25.482**a

a. Counting overhead, each ES-4 is about 27 MB.

Table 5-2. ES-4 Product Specific Metadata

Item	Parameter Name	Records	Units	Range	Data Type
1	ES4BinaryProductionDate	1	N/A	N/A	ASCII string

Table 5-3. ES-4 Vgroup Summary

Vgroup Number	Vgroup Name	Description	Number of Records	Total Size (MB)
1	2.5 Degree Regional	See Table 5-4 - Table 5-11	10,368 (72 x 144)	19.232
2	5.0 Degree Nested Regional	See Table 5-12 - Table 5-19	2,592 (36 x 72)	4.808
3	10.0 Degree Nested Regional	See Table 5-20 - Table 5-27	648 (18 x 36)	1.202

Table 5-3. ES-4 Vgroup Summary

Vgroup Number	Vgroup Name	Description	Number of Records	Total Size (MB)
4	2.5 Degree Zonal	See Table 5-28 - Table 5-35	72	0.134
5	5.0 Degree Zonal	See Table 5-36 - Table 5-43	36	.067
6	10.0 Degree Zonal	See Table 5-44 - Table 5-51	18	.033
7	2.5 Degree Global	See Table 5-52 - Table 5-59	1	.002
8	5.0 Degree Global	See Table 5-60 - Table 5-67	1	.002
9	10.0 Degree Global	See Table 5-68 - Table 5-75	1	.002
Total Product Size (MB)				**25.482**

5.1 Data Granularity

All ES-4 data granules consist of no more than one month of data from one to three CERES instruments.

5.2 ES-4 Scientific Data Sets

The ES-4 contains SDSs written in HDF and organized by vgroups. These SDSs contain either 2-dimensional or 3-dimensional arrays. In 2-dimensional arrays, the first dimension corresponds to the colatitudinal zones in the given spatial resolution and the second dimension corresponds to the longitudinal zones in the given spatial resolution. In 3-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 colatitudinal zones in the given spatial resolution. The third dimension corresponds to the longitudinal zones in the given spatial resolution.

The following tables list the SDSs contained in each vgroup. The number of elements in each SDS is determined by the number of colatitudinal zones and longitudinal zones and may also be a function of the number of days in the month (31) or the number of hours in a day (24). CERES default values for 32-bit real numbers (3.4028235E+38) and 8-bit integers (127) 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 Table 5-4 - Table 5-75 is the index of the SDS in the HDF file.

Geographic scene type units for Table 5-4 - Table 5-11 are as follows: 1 = ocean, 2 = land, 3 = snow, 4 = desert, 5 = coast, and 127 = no data. For Table 5-12 - Table 5-75, geographic scene type units are: 1 = data available and 127 = no data available.

Table 5-4. 2.5° Regional Vgroup for Monthly (Day), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (0)	W-h/m^2	0 .. 500,000	72x144	32	40.5
Net radiant flux (1)	W/m^2	-200 .. 200	72x144	32	40.5
Longwave flux (2)	W/m^2	50 .. 450	72x144	32	40.5
Shortwave flux (3)	W/m^2	0 .. 1,400	72x144	32	40.5
Albedo (4)	unitless	0 .. 1	72x144	32	40.5
Geographic scene type (43)	See Section 5.2	1 .. 127	72x144	8	10.13
Longitude (44)	degrees	0 .. 360	72x144	32	40.5
Colatitude (45)	degrees	0 .. 180	72x144	32	40.5

Table 5-5. 2.5° Regional Vgroup for Monthly (Day), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (5)	W-h/m^2	0 .. 500,000	72x144	32	40.5
Net radiant flux (6)	W/m^2	-200 .. 200	72x144	32	40.5
Longwave flux (7)	W/m^2	50 .. 450	72x144	32	40.5
Shortwave flux (8)	W/m^2	0 .. 1,400	72x144	32	40.5
Albedo (9)	unitless	0 .. 1	72x144	32	40.5
Geographic scene type (43)	See Section 5.2	1 .. 127	72x144	8	10.13
Longitude (44)	degrees	0 .. 360	72x144	32	40.5

Table 5-5. 2.5° Regional Vgroup for Monthly (Day), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Colatitude (45)	degrees	0 .. 180	72x144	32	40.5

Table 5-6. 2.5° Regional Vgroup for Monthly (Hour), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (10)	$W\text{-}h/m^2$	0 .. 500,000	72x144	32	40.5
Net radiant flux (11)	W/m^2	-200 .. 200	72x144	32	40.5
Longwave flux (12)	W/m^2	50 .. 450	72x144	32	40.5
Shortwave flux (13)	W/m^2	0 .. 1,400	72x144	32	40.5
Albedo (14)	unitless	0 .. 1	72x144	32	40.5
Geographic scene type (43)	See Section 5.2	1 .. 127	72x144	8	10.13
Longitude (44)	degrees	0 .. 360	72x144	32	40.5
Colatitude (45)	degrees	0 .. 180	72x144	32	40.5

Table 5-7. 2.5° Regional Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (15)	$W\text{-}h/m^2$	0 .. 500,000	72x144	32	40.5
Net radiant flux (16)	W/m^2	-200 .. 200	72x144	32	40.5
Longwave flux (17)	W/m^2	50 .. 450	72x144	32	40.5

Table 5-7. 2.5° Regional Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Shortwave flux (18)	W/m^2	0 .. 1,400	72x144	32	40.5
Albedo (19)	unitless	0 .. 1	72x144	32	40.5
Geographic scene type (43)	See Section 5.2	1 .. 127	72x144	8	10.13
Longitude (44)	degrees	0 .. 360	72x144	32	40.5
Colatitude (45)	degrees	0 .. 180	72x144	32	40.5

Table 5-8. 2.5° Regional Vgroup for Daily, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (20)	$W\text{-}h/m^2$	0 .. 15000	31x72x144	32	1255.5
Longwave flux (21)	W/m^2	50 .. 450	31x72x144	32	1255.5
Number of hours of longwave flux (22)	hours	0 .. 24	31x72x144	8	313.87
Shortwave flux (23)	W/m^2	0 .. 1,400	31x72x144	32	1255.5
Number of hours of shortwave flux (24)	hours	0 .. 24	31x72x144	8	313.87
Albedo (25)	unitless	0 .. 1	31x72x144	32	1255.5
Geographic scene type (43)	See Section 5.2	1 .. 127	72x144	8	10.13
Longitude (44)	degrees	0 .. 360	72x144	32	40.5
Colatitude (45)	degrees	0 .. 180	72x144	32	40.5

Table 5-9. 2.5° Regional Vgroup for Daily, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Longwave flux (26)	W/m^2	50 .. 450	31x72x144	32	1255.5
Number of hours of longwave flux (27)	hours	0 .. 24	31x72x144	8	313.87
Shortwave flux (28)	W/m^2	0 .. 1,400	31x72x144	32	1255.5
Number of hours of shortwave flux (29)	hours	0 .. 24	31x72x144	8	313.87
Albedo (30)	unitless	0 .. 1	31x72x144	32	1255.5
Geographic scene type (43)	See Section 5.2	1 .. 127	72x144	8	10.13
Longitude (44)	degrees	0 .. 360	72x144	32	40.5
Colatitude (45)	degrees	0 .. 180	72x144	32	40.5

Table 5-10. 2.5° Regional Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (31)	$W\text{-}h/m^2$	0 .. 50000	24x72x144	32	40.5
Longwave flux (32)	W/m^2	50 .. 450	24x72x144	32	972.0
Number of days of longwave flux (33)	days	0 .. 31	24x72x144	8	243.0
Shortwave flux (34)	W/m^2	0 .. 1,400	24x72x144	32	972.0
Number of days of shortwave flux (35)	days	0 .. 31	24x72x144	8	243.0
Albedo (36)	unitless	0 .. 1	24x72x144	32	972.0

Table 5-10. 2.5° Regional Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Geographic scene type (43)	See Section 5.2	1 .. 127	72x144	8	10.13
Longitude (44)	degrees	0 .. 360	72x144	32	40.5
Colatitude (45)	degrees	0 .. 180	72x144	32	40.5

Table 5-11. 2.5° Regional Vgroup for Monthly Hourly, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (37)	W-h/m^2	0 .. 50000	24x72x144	32	40.5
Longwave flux (38)	W/m^2	50 .. 450	24x72x144	32	972.0
Number of days of longwave flux (39)	days	0 .. 31	24x72x144	8	243.0
Shortwave flux (40)	W/m^2	0 .. 1,400	24x72x144	32	972.0
Number of days of shortwave flux (41)	days	0 .. 31	24x72x144	8	243.0
Albedo (42)	unitless	0 .. 1	24x72x144	32	972.0
Geographic scene type (43)	See Section 5.2	1 .. 127	72x144	8	10.13
Longitude (44)	degrees	0 .. 360	72x144	32	40.5
Colatitude (45)	degrees	0 .. 180	72x144	32	40.5

Table 5-12. 5.0° Nested Regional Vgroup for Monthly (Day), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (46)	W-h/m^2	0 .. 500,000	36x72	32	10.13
Net radiant flux (47)	W/m^2	-200 .. 200	36x72	32	10.13
Longwave flux (48)	W/m^2	50 .. 450	36x72	32	10.13
Shortwave flux (49)	W/m^2	0 .. 1,400	36x72	32	10.13
Albedo (50)	unitless	0 .. 1	36x72	32	10.13
Geographic scene type (89)	See Section 5.2	1 .. 127	36x72	8	2.53
Longitude (90)	degrees	0 .. 360	36x72	32	10.13
Colatitude (91)	degrees	0 .. 180	36x72	32	10.13

Table 5-13. 5.0° Nested Regional Vgroup for Monthly (Day), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (51)	W-h/m^2	0 .. 500,000	36x72	32	10.13
Net radiant flux (52)	W/m^2	-200 .. 200	36x72	32	10.13
Longwave flux (53)	W/m^2	50 .. 450	36x72	32	10.13
Shortwave flux (54)	W/m^2	0 .. 1,400	36x72	32	10.13
Albedo (55)	unitless	0 .. 1	36x72	32	10.13
Geographic scene type (89)	See Section 5.2	1 .. 127	36x72	8	2.53
Longitude (90)	degrees	0 .. 360	36x72	32	10.13
Colatitude (91)	degrees	0 .. 180	36x72	32	10.13

Table 5-14. 5.0° Nested Regional Vgroup for Monthly (Hour), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (56)	W-h/m^2	0 .. 500,000	36x72	32	10.13
Net radiant flux (57)	W/m^2	-200 .. 200	36x72	32	10.13
Longwave flux (58)	W/m^2	50 .. 450	36x72	32	10.13
Shortwave flux (59)	W/m^2	0 .. 1,400	36x72	32	10.13
Albedo (60)	unitless	0 .. 1	36x72	32	10.13
Geographic scene type (89)	See Section 5.2	1 .. 127	36x72	8	2.53
Longitude (90)	degrees	0 .. 360	36x72	32	10.13
Colatitude (91)	degrees	0 .. 180	36x72	32	10.13

Table 5-15. 5.0° Nested Regional Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (61)	W-h/m^2	0 .. 500,000	36x72	32	10.13
Net radiant flux (62)	W/m^2	-200 .. 200	36x72	32	10.13
Longwave flux (63)	W/m^2	50 .. 450	36x72	32	10.13
Shortwave flux (64)	W/m^2	0 .. 1,400	36x72	32	10.13
Albedo (65)	unitless	0 .. 1	36x72	32	10.13
Geographic scene type (89)	See Section 5.2	1 .. 127	36x72	8	2.53
Longitude (90)	degrees	0 .. 360	36x72	32	10.13

Table 5-15. 5.0° Nested Regional Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Colatitude (91)	degrees	0 .. 180	36x72	32	10.13

Table 5-16. 5.0° Nested Regional Vgroup for Daily, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (66)	$W\text{-}h/m^2$	0 .. 15000	31x36x72	32	313.87
Longwave flux (67)	W/m^2	50 .. 450	31x36x72	32	313.87
Number of hours of longwave flux (68)	hours	0 .. 24	31x36x72	8	78.47
Shortwave flux (69)	W/m^2	0 .. 1,400	31x36x72	32	313.87
Number of hours of shortwave flux (70)	hours	0 .. 24	31x36x72	8	78.47
Albedo (71)	unitless	0 .. 1	31x36x72	32	313.87
Geographic scene type (89)	See Section 5.2	1 .. 127	36x72	8	2.53
Longitude (90)	degrees	0 .. 360	36x72	32	10.13
Colatitude (91)	degrees	0 .. 180	36x72	32	10.13

Table 5-17. 5.0° Nested Regional Vgroup for Daily, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Longwave flux (72)	W/m^2	50 .. 450	31x36x72	32	313.87
Number of hours of longwave flux (73)	hours	0 .. 24	31x36x72	8	78.47
Shortwave flux (74)	W/m^2	0 .. 1,400	31x36x72	32	313.87
Number of hours of shortwave flux (75)	hours	0 .. 24	31x36x72	8	78.47
Albedo (76)	unitless	0 .. 1	31x36x72	32	313.87
Geographic scene type (89)	See Section 5.2	1 .. 127	36x72	8	2.53
Longitude (90)	degrees	0 .. 360	36x72	32	10.13
Colatitude (91)	degrees	0 .. 180	36x72	32	10.13

Table 5-18. 5.0° Nested Regional Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (77)	$W\text{-}h/m^2$	0 .. 50000	24x36x72	32	10.13
Longwave flux (78)	W/m^2	50 .. 450	24x36x72	32	243.0
Number of days of longwave flux (79)	days	0 .. 31	24x36x72	8	60.75
Shortwave flux (80)	W/m^2	0 .. 1,400	24x36x72	32	243.0
Number of days of shortwave flux (81)	days	0 .. 31	24x36x72	8	60.75
Albedo (82)	unitless	0 .. 1	24x36x72	32	243.0

Table 5-18. 5.0° Nested Regional Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Geographic scene type (89)	See Section 5.2	1 .. 127	36x72	8	2.53
Longitude (90)	degrees	0 .. 360	36x72	32	10.13
Colatitude (91)	degrees	0 .. 180	36x72	32	10.13

Table 5-19. 5.0° Nested Regional Vgroup for Monthly Hourly, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (83)	W-h/m^2	0 .. 50000	24x36x72	32	10.13
Longwave flux (84)	W/m^2	50 .. 450	24x36x72	32	243.0
Number of days of longwave flux (85)	days	0 .. 31	24x36x72	8	60.75
Shortwave flux (86)	W/m^2	0 .. 1,400	24x36x72	32	243.0
Number of days of shortwave flux (87)	days	0 .. 31	24x36x72	8	60.75
Albedo (88)	unitless	0 .. 1	24x36x72	32	243.0
Geographic scene type (89)	See Section 5.2	1 .. 127	36x72	8	2.53
Longitude (90)	degrees	0 .. 360	36x72	32	10.13
Colatitude (91)	degrees	0 .. 180	36x72	32	10.13

Table 5-20. 10.0° Nested Regional Vgroup for Monthly (Day), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (92)	W-h/m^2	0 .. 500,000	18x36	32	2.53
Net radiant flux (93)	W/m^2	-200 .. 200	18x36	32	2.53
Longwave flux (94)	W/m^2	50 .. 450	18x36	32	2.53
Shortwave flux (95)	W/m^2	0 .. 1,400	18x36	32	2.53
Albedo (96)	unitless	0 .. 1	18x36	32	2.53
Geographic scene type (135)	See Section 5.2	1 .. 127	18x36	8	0.63
Longitude (136)	degrees	0 .. 360	18x36	32	2.53
Colatitude (137)	degrees	0 .. 180	18x36	32	2.53

Table 5-21. 10.0° Nested Regional Vgroup for Monthly (Day), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (97)	W-h/m^2	0 .. 500,000	18x36	32	2.53
Net radiant flux (98)	W/m^2	-200 .. 200	18x36	32	2.53
Longwave flux (99)	W/m^2	50 .. 450	18x36	32	2.53
Shortwave flux (100)	W/m^2	0 .. 1,400	18x36	32	2.53
Albedo (101)	unitless	0 .. 1	18x36	32	2.53
Geographic scene type (135)	See Section 5.2	1 .. 127	18x36	8	0.63
Longitude (136)	degrees	0 .. 360	18x36	32	2.53
Colatitude (137)	degrees	0 .. 180	18x36	32	2.53

Table 5-22. 10.0° Nested Regional Vgroup for Monthly (Hour), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (102)	W-h/m^2	0 .. 500,000	18x36	32	2.53
Net radiant flux (103)	W/m^2	-200 .. 200	18x36	32	2.53
Longwave flux (104)	W/m^2	50 .. 450	18x36	32	2.53
Shortwave flux (105)	W/m^2	0 .. 1,400	18x36	32	2.53
Albedo (106)	unitless	0 .. 1	18x36	32	2.53
Geographic scene type (135)	See Section 5.2	1 .. 127	18x36	8	0.63
Longitude (136)	degrees	0 .. 360	18x36	32	2.53
Colatitude (137)	degrees	0 .. 180	18x36	32	2.53

Table 5-23. 10.0° Nested Regional Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (107)	W-h/m^2	0 .. 500,000	18x36	32	2.53
Net radiant flux (108)	W/m^2	-200 .. 200	18x36	32	2.53
Longwave flux (109)	W/m^2	50 .. 450	18x36	32	2.53
Shortwave flux (110)	W/m^2	0 .. 1,400	18x36	32	2.53
Albedo (111)	unitless	0 .. 1	18x36	32	2.53
Geographic scene type (135)	See Section 5.2	1 .. 127	18x36	8	0.63
Longitude (136)	degrees	0 .. 360	18x36	32	2.53

Table 5-23. 10.0° Nested Regional Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Colatitude (137)	degrees	0 .. 180	18x36	32	2.53

Table 5-24. 10.0° Nested Regional Vgroup for Daily, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (112)	$W\text{-}h/m^2$	0 .. 15000	31x18x36	32	78.47
Longwave flux (113)	W/m^2	50 .. 450	31x18x36	32	78.47
Number of hours of longwave flux (114)	hours	0 .. 24	31x18x36	8	19.62
Shortwave flux (115)	W/m^2	0 .. 1,400	31x18x36	32	78.47
Number of hours of shortwave flux (116)	hours	0 .. 24	31x18x36	8	19.62
Albedo (117)	unitless	0 .. 1	31x18x36	32	78.47
Geographic scene type (135)	See Section 5.2	1 .. 127	18x36	8	0.63
Longitude (136)	degrees	0 .. 360	18x36	32	2.53
Colatitude (137)	degrees	0 .. 180	18x36	32	2.53

Table 5-25. 10.0° Nested Regional Vgroup for Daily, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Longwave flux (118)	W/m^2	50 .. 450	31x18x36	32	78.47
Number of hours of longwave flux (119)	hours	0 .. 24	31x18x36	8	19.62
Shortwave flux (120)	W/m^2	0 .. 1,400	31x18x36	32	78.47
Number of hours of shortwave flux (121)	hours	0 .. 24	31x18x36	8	19.62
Albedo (122)	unitless	0 .. 1	31x18x36	32	78.47
Geographic scene type (135)	See Section 5.2	1 .. 127	18x36	8	0.63
Longitude (136)	degrees	0 .. 360	18x36	32	2.53
Colatitude (137)	degrees	0 .. 180	18x36	32	2.53

Table 5-26. 10.0° Nested Regional Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (123)	$W\text{-}h/m^2$	0 .. 50000	24x18x36	32	2.53
Longwave flux (124)	W/m^2	50 .. 450	24x18x36	32	60.75
Number of days of longwave flux (125)	days	0 .. 31	24x18x36	8	15.19
Shortwave flux (126)	W/m^2	0 .. 1,400	24x18x36	32	60.75
Number of days of shortwave flux (127)	days	0 .. 31	24x18x36	8	15.19
Albedo (128)	unitless	0 .. 1	24x18x36	32	60.75

Table 5-26. 10.0° Nested Regional Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Geographic scene type (135)	See Section 5.2	1 .. 127	18x36	8	0.63
Longitude (136)	degrees	0 .. 360	18x36	32	2.53
Colatitude (137)	degrees	0 .. 180	18x36	32	2.53

Table 5-27. 10.0° Nested Regional Vgroup for Monthly Hourly, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (129)	W-h/m^2	0 .. 50000	24x18x36	32	2.53
Longwave flux (130)	W/m^2	50 .. 450	24x18x36	32	60.75
Number of days of longwave flux (131)	days	0 .. 31	24x18x36	8	15.19
Shortwave flux (132)	W/m^2	0 .. 1,400	24x18x36	32	60.75
Number of days of shortwave flux (133)	days	0 .. 31	24x18x36	8	15.19
Albedo (134)	unitless	0 .. 1	24x18x36	32	60.75
Geographic scene type (135)	See Section 5.2	1 .. 127	18x36	8	0.63
Longitude (136)	degrees	0 .. 360	18x36	32	2.53
Colatitude (137)	degrees	0 .. 180	18x36	32	2.53

Table 5-28. 2.5° Zonal Vgroup for Monthly (Day), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (138)	W-h/m^2	0 .. 500,000	72	32	0.28
Net radiant flux (139)	W/m^2	-200 .. 200	72	32	0.28
Longwave flux (140)	W/m^2	50 .. 450	72	32	0.28
Shortwave flux (141)	W/m^2	0 .. 1,400	72	32	0.28
Albedo (142)	unitless	0 .. 1	72	32	0.28
Geographic scene type (181)	See Section 5.2	1 .. 127	72	8	0.07
Longitude (182)	degrees	0 .. 360	72	32	0.28
Colatitude (183)	degrees	0 .. 180	72	32	0.28

Table 5-29. 2.5° Zonal Vgroup for Monthly (Day), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (143)	W-h/m^2	0 .. 500,000	72	32	0.28
Net radiant flux (144)	W/m^2	-200 .. 200	72	32	0.28
Longwave flux (145)	W/m^2	50 .. 450	72	32	0.28
Shortwave flux (146)	W/m^2	0 .. 1,400	72	32	0.28
Albedo (147)	unitless	0 .. 1	72	32	0.28
Geographic scene type (181)	See Section 5.2	1 .. 127	72	8	0.07
Longitude (182)	degrees	0 .. 360	72	32	0.28
Colatitude (183)	degrees	0 .. 180	72	32	0.28

Table 5-30. 2.5° Zonal Vgroup for Monthly (Hour), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (148)	W-h/m^2	0 .. 500,000	72	32	0.28
Net radiant flux (149)	W/m^2	-200 .. 200	72	32	0.28
Longwave flux (150)	W/m^2	50 .. 450	72	32	0.28
Shortwave flux (151)	W/m^2	0 .. 1,400	72	32	0.28
Albedo (152)	unitless	0 .. 1	72	32	0.28
Geographic scene type (181)	See Section 5.2	1 .. 127	72	8	0.07
Longitude (182)	degrees	0 .. 360	72	32	0.28
Colatitude (183)	degrees	0 .. 180	72	32	0.28

Table 5-31. 2.5° Zonal Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (153)	W-h/m^2	0 .. 500,000	72	32	0.28
Net radiant flux (154)	W/m^2	-200 .. 200	72	32	0.28
Longwave flux (155)	W/m^2	50 .. 450	72	32	0.28
Shortwave flux (156)	W/m^2	0 .. 1,400	72	32	0.28
Albedo (157)	unitless	0 .. 1	72	32	0.28
Geographic scene type (181)	See Section 5.2	1 .. 127	72	8	0.07
Longitude (182)	degrees	0 .. 360	72	32	0.28

Table 5-31. 2.5° Zonal Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Colatitude (183)	degrees	0 .. 180	72	32	0.28

Table 5-32. 2.5° Zonal Vgroup for Daily, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (158)	W-h/m^2	0 .. 15000	31x72	32	8.72
Longwave flux (159)	W/m^2	50 .. 450	31x72	32	8.72
Number of hours of longwave flux (160)	hours	0 .. 24	31x72	8	2.18
Shortwave flux (161)	W/m^2	0 .. 1,400	31x72	32	8.72
Number of hours of shortwave flux (162)	hours	0 .. 24	31x72	8	2.18
Albedo (163)	unitless	0 .. 1	31x72	32	8.72
Geographic scene type (181)	See Section 5.2	1 .. 127	72	8	0.07
Longitude (182)	degrees	0 .. 360	72	32	0.28
Colatitude (183)	degrees	0 .. 180	72	32	0.28

Table 5-33. 2.5° Zonal Vgroup for Daily, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Longwave flux (164)	W/m^2	50 .. 450	31x72	32	8.72
Number of hours of longwave flux (165)	hours	0 .. 24	31x72	8	2.18
Shortwave flux (166)	W/m^2	0 .. 1,400	31x72	32	8.72
Number of hours of shortwave flux (167)	hours	0 .. 24	31x72	8	2.18
Albedo (168)	unitless	0 .. 1	31x72	32	8.72
Geographic scene type (181)	See Section 5.2	1 .. 127	72	8	0.07
Longitude (182)	degrees	0 .. 360	72	32	0.28
Colatitude (183)	degrees	0 .. 180	72	32	0.28

Table 5-34. 2.5° Zonal Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (169)	$W\text{-}h/m^2$	0 .. 50000	24x72	32	0.28
Longwave flux (170)	W/m^2	50 .. 450	24x72	32	6.75
Number of days of longwave flux (171)	days	0 .. 31	24x72	8	1.69
Shortwave flux (172)	W/m^2	0 .. 1,400	24x72	32	6.75
Number of days of shortwave flux (173)	days	0 .. 31	24x72	8	1.69
Albedo (174)	unitless	0 .. 1	24x72	32	6.75

Table 5-34. 2.5° Zonal Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Geographic scene type (181)	See Section 5.2	1 .. 127	72	8	0.07
Longitude (182)	degrees	0 .. 360	72	32	0.28
Colatitude (183)	degrees	0 .. 180	72	32	0.28

Table 5-35. 2.5° Zonal Vgroup for Monthly Hourly, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (175)	$W\text{-}h/m^2$	0 .. 50000	24x72	32	0.28
Longwave flux (176)	W/m^2	50 .. 450	24x72	32	6.75
Number of days of longwave flux (177)	days	0 .. 31	24x72	8	1.69
Shortwave flux (178)	W/m^2	0 .. 1,400	24x72	32	6.75
Number of days of shortwave flux (179)	days	0 .. 31	24x72	8	1.69
Albedo (180)	unitless	0 .. 1	24x72	32	6.75
Geographic scene type (181)	See Section 5.2	1 .. 127	72	8	0.07
Longitude (182)	degrees	0 .. 360	72	32	0.28
Colatitude (183)	degrees	0 .. 180	72	32	0.28

Table 5-36. 5.0° Zonal Vgroup for Monthly (Day), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (184)	W-h/m^2	0 .. 500,000	36	32	0.14
Net radiant flux (185)	W/m^2	-200 .. 200	36	32	0.14
Longwave flux (186)	W/m^2	50 .. 450	36	32	0.14
Shortwave flux (187)	W/m^2	0 .. 1,400	36	32	0.14
Albedo (188)	unitless	0 .. 1	36	32	0.14
Geographic scene type (227)	See Section 5.2	1 .. 127	36	8	0.035
Longitude (228)	degrees	0 .. 360	36	32	0.14
Colatitude (229)	degrees	0 .. 180	36	32	0.14

Table 5-37. 5.0° Zonal Vgroup for Monthly (Day), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (189)	W-h/m^2	0 .. 500,000	36	32	0.14
Net radiant flux (190)	W/m^2	-200 .. 200	36	32	0.14
Longwave flux (191)	W/m^2	50 .. 450	36	32	0.14
Shortwave flux (192)	W/m^2	0 .. 1,400	36	32	0.14
Albedo (193)	unitless	0 .. 1	36	32	0.14
Geographic scene type (227)	See Section 5.2	1 .. 127	36	8	0.035
Longitude (228)	degrees	0 .. 360	36	32	0.14
Colatitude (229)	degrees	0 .. 180	36	32	0.14

Table 5-38. 5.0° Zonal Vgroup for Monthly (Hour), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (194)	W-h/m^2	0 .. 500,000	36	32	0.14
Net radiant flux (195)	W/m^2	-200 .. 200	36	32	0.14
Longwave flux (196)	W/m^2	50 .. 450	36	32	0.14
Shortwave flux (197)	W/m^2	0 .. 1,400	36	32	0.14
Albedo (198)	unitless	0 .. 1	36	32	0.14
Geographic scene type (227)	See Section 5.2	1 .. 127	36	8	0.035
Longitude (228)	degrees	0 .. 360	36	32	0.14
Colatitude (229)	degrees	0 .. 180	36	32	0.14

Table 5-39. 5.0° Zonal Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (199)	W-h/m^2	0 .. 500,000	36	32	0.14
Net radiant flux (200)	W/m^2	-200 .. 200	36	32	0.14
Longwave flux (201)	W/m^2	50 .. 450	36	32	0.14
Shortwave flux (202)	W/m^2	0 .. 1,400	36	32	0.14
Albedo (203)	unitless	0 .. 1	36	32	0.14
Geographic scene type (227)	See Section 5.2	1 .. 127	36	8	0.035
Longitude (228)	degrees	0 .. 360	36	32	0.14

Table 5-39. 5.0° Zonal Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Colatitude (229)	degrees	0 .. 180	36	32	0.14

Table 5-40. 5.0° Zonal Vgroup for Daily, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (204)	W-h/m^2	0 .. 15000	31x36	32	4.36
Longwave flux (205)	W/m^2	50 .. 450	31x36	32	4.36
Number of hours of longwave flux (206)	hours	0 .. 24	31x36	8	1.09
Shortwave flux (207)	W/m^2	0 .. 1,400	31x36	32	4.36
Number of hours of shortwave flux (208)	hours	0 .. 24	31x36	8	1.09
Albedo (209)	unitless	0 .. 1	31x36	32	4.36
Geographic scene type (227)	See Section 5.2	1 .. 127	36	8	0.035
Longitude (228)	degrees	0 .. 360	36	32	0.14
Colatitude (229)	degrees	0 .. 180	36	32	0.14

Table 5-41. 5.0° Zonal Vgroup for Daily, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Longwave flux (210)	W/m^2	50 .. 450	31x36	32	4.36
Number of hours of longwave flux (211)	hours	0 .. 24	31x36	8	1.09
Shortwave flux (212)	W/m^2	0 .. 1,400	31x36	32	4.36
Number of hours of shortwave flux (213)	hours	0 .. 24	31x36	8	1.09
Albedo (214)	unitless	0 .. 1	31x36	32	4.36
Geographic scene type (227)	See Section 5.2	1 .. 127	36	8	0.035
Longitude (228)	degrees	0 .. 360	36	32	0.14
Colatitude (229)	degrees	0 .. 180	36	32	0.14

Table 5-42. 5.0° Zonal Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (215)	$W\text{-}h/m^2$	0 .. 50000	24x36	32	0.14
Longwave flux (216)	W/m^2	50 .. 450	24x36	32	3.38
Number of days of longwave flux (217)	days	0 .. 31	24x36	8	0.84
Shortwave flux (218)	W/m^2	0 .. 1,400	24x36	32	3.38
Number of days of shortwave flux (219)	days	0 .. 31	24x36	8	0.84
Albedo (220)	unitless	0 .. 1	24x36	32	3.38

Table 5-42. 5.0° Zonal Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Geographic scene type (227)	See Section 5.2	1 .. 127	36	8	0.035
Longitude (228)	degrees	0 .. 360	36	32	0.14
Colatitude (229)	degrees	0 .. 180	36	32	0.14

Table 5-43. 5.0° Zonal Vgroup for Monthly Hourly, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (221)	W-h/m^2	0 .. 50000	24x36	32	0.14
Longwave flux (222)	W/m^2	50 .. 450	24x36	32	3.38
Number of days of longwave flux (223)	days	0 .. 31	24x36	8	0.84
Shortwave flux (224)	W/m^2	0 .. 1,400	24x36	32	3.38
Number of days of shortwave flux (225)	days	0 .. 31	24x36	8	0.84
Albedo (226)	unitless	0 .. 1	24x36	32	3.38
Geographic scene type (227)	See Section 5.2	1 .. 127	36	8	0.035
Longitude (228)	degrees	0 .. 360	36	32	0.14
Colatitude (229)	degrees	0 .. 180	36	32	0.14

Table 5-44. 10.0 Zonal Vgroup for Monthly (Day), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (230)	$W\text{-}h/m^2$	0 .. 500,000	18	32	0.07
Net radiant flux (231)	W/m^2	-200 .. 200	18	32	0.07
Longwave flux (232)	W/m^2	50 .. 450	18	32	0.07
Shortwave flux (233)	W/m^2	0 .. 1,400	18	32	0.07
Albedo (234)	unitless	0 .. 1	18	32	0.07
Geographic scene type (273)	See Section 5.2	1 .. 127	18	8	0.018
Longitude (274)	degrees	0 .. 360	18	32	0.07
Colatitude (275)	degrees	0 .. 180	18	32	0.07

Table 5-45. 10.0° Zonal Vgroup for Monthly (Day), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (235)	$W\text{-}h/m^2$	0 .. 500,000	18	32	0.07
Net radiant flux (236)	W/m^2	-200 .. 200	18	32	0.07
Longwave flux (237)	W/m^2	50 .. 450	18	32	0.07
Shortwave flux (238)	W/m^2	0 .. 1,400	18	32	0.07
Albedo (239)	unitless	0 .. 1	18	32	0.07
Geographic scene type (273)	See Section 5.2	1 .. 127	18	8	0.018
Longitude (274)	degrees	0 .. 360	18	32	0.07
Colatitude (275)	degrees	0 .. 180	18	32	0.07

Table 5-46. 10.0° Zonal Vgroup for Monthly (Hour), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (240)	W-h/m^2	0 .. 500,000	18	32	0.07
Net radiant flux (241)	W/m^2	-200 .. 200	18	32	0.07
Longwave flux (242)	W/m^2	50 .. 450	18	32	0.07
Shortwave flux (243)	W/m^2	0 .. 1,400	18	32	0.07
Albedo (244)	unitless	0 .. 1	18	32	0.07
Geographic scene type (273)	See Section 5.2	1 .. 127	18	8	0.018
Longitude (274)	degrees	0 .. 360	18	32	0.07
Colatitude (275)	degrees	0 .. 180	18	32	0.07

Table 5-47. 10.0° Zonal Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (245)	W-h/m^2	0 .. 500,000	18	32	0.07
Net radiant flux (246)	W/m^2	-200 .. 200	18	32	0.07
Longwave flux (247)	W/m^2	50 .. 450	18	32	0.07
Shortwave flux (248)	W/m^2	0 .. 1,400	18	32	0.07
Albedo (249)	unitless	0 .. 1	18	32	0.07
Geographic scene type (273)	See Section 5.2	1 .. 127	18	8	0.018
Longitude (274)	degrees	0 .. 360	18	32	0.07

Table 5-47. 10.0° Zonal Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Colatitude (275)	degrees	0 .. 180	18	32	0.07

Table 5-48. 10.0° Zonal Vgroup for Daily, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (250)	$W\text{-}h/m^2$	0 .. 15000	31x18	32	2.18
Longwave flux (251)	W/m^2	50 .. 450	31x18	32	2.18
Number of hours of longwave flux (252)	hours	0 .. 24	31x18	8	0.54
Shortwave flux (253)	W/m^2	0 .. 1,400	31x18	32	2.18
Number of hours of shortwave flux (254)	hours	0 .. 24	31x18	8	0.54
Albedo (255)	unitless	0 .. 1	31x18	32	2.18
Geographic scene type (273)	See Section 5.2	1 .. 127	18	8	0.018
Longitude (274)	degrees	0 .. 360	18	32	0.07
Colatitude (275)	degrees	0 .. 180	18	32	0.07

Table 5-49. 10.0° Zonal Vgroup for Daily, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Longwave flux (256)	W/m^2	50 .. 450	31x18	32	2.18
Number of hours of longwave flux (257)	hours	0 .. 24	31x18	8	0.54
Shortwave flux (258)	W/m^2	0 .. 1,400	31x18	32	2.18
Number of hours of shortwave flux (259)	hours	0 .. 24	31x18	8	0.54
Albedo (260)	unitless	0 .. 1	31x18	32	2.18
Geographic scene type (273)	See Section 5.2	1 .. 127	18	8	0.018
Longitude (274)	degrees	0 .. 360	18	32	0.07
Colatitude (275)	degrees	0 .. 180	18	32	0.07

Table 5-50. 10.0° Zonal Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (261)	$W\text{-}h/m^2$	0 .. 50000	24x18	32	0.07
Longwave flux (262)	W/m^2	50 .. 450	24x18	32	1.69
Number of days of longwave flux (263)	days	0 .. 31	24x18	8	0.42
Shortwave flux (264)	W/m^2	0 .. 1,400	24x18	32	1.69
Number of days of shortwave flux (265)	days	0 .. 31	24x18	8	0.42
Albedo (266)	unitless	0 .. 1	24x18	32	1.69

Table 5-50. 10.0° Zonal Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Geographic scene type (273)	See Section 5.2	1 .. 127	18	8	0.018
Longitude (274)	degrees	0 .. 360	18	32	0.07
Colatitude (275)	degrees	0 .. 180	18	32	0.07

Table 5-51. 10.0° Zonal Vgroup for Monthly Hourly, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (KB)
Solar incidence (267)	$W\text{-}h/m^2$	0 .. 50000	24x18	32	0.07
Longwave flux (268)	W/m^2	50 .. 450	24x18	32	1.69
Number of days of longwave flux (269)	days	0 .. 31	24x18	8	0.42
Shortwave flux (270)	W/m^2	0 .. 1,400	24x18	32	1.69
Number of days of shortwave flux (271)	days	0 .. 31	24x18	8	0.42
Albedo (272)	unitless	0 .. 1	24x18	32	1.69
Geographic scene type (273)	See Section 5.2	1 .. 127	18	8	0.018
Longitude (274)	degrees	0 .. 360	18	32	0.07
Colatitude (275)	degrees	0 .. 180	18	32	0.07

Table 5-52. 2.5° Global Vgroup for Monthly (Day), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (276)	$W\text{-}h/m^2$	0 .. 500,000	1	32	4
Net radiant flux (277)	W/m^2	-200 .. 200	1	32	4
Longwave flux (278)	W/m^2	50 .. 450	1	32	4
Shortwave flux (279)	W/m^2	0 .. 1,400	1	32	4
Albedo (280)	unitless	0 .. 1	1	32	4
Geographic scene type (319)	See Section 5.2	1 .. 127	1	8	1
Longitude (320)	degrees	0 .. 360	1	32	4
Colatitude (321)	degrees	0 .. 180	1	32	4

Table 5-53. 2.5° Global Vgroup for Monthly (Day), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (281)	$W\text{-}h/m^2$	0 .. 500,000	1	32	4
Net radiant flux (282)	W/m^2	-200 .. 200	1	32	4
Longwave flux (283)	W/m^2	50 .. 450	1	32	4
Shortwave flux (284)	W/m^2	0 .. 1,400	1	32	4
Albedo (285)	unitless	0 .. 1	1	32	4
Geographic scene type (319)	See Section 5.2	1 .. 127	1	8	1
Longitude (320)	degrees	0 .. 360	1	32	4
Colatitude (321)	degrees	0 .. 180	1	32	4

Table 5-54. 2.5° Global Vgroup for Monthly (Hour), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (286)	W-h/m^2	0 .. 500,000	1	32	4
Net radiant flux (287)	W/m^2	-200 .. 200	1	32	4
Longwave flux (288)	W/m^2	50 .. 450	1	32	4
Shortwave flux (289)	W/m^2	0 .. 1,400	1	32	4
Albedo (290)	unitless	0 .. 1	1	32	4
Geographic scene type (319)	See Section 5.2	1 .. 127	1	8	1
Longitude (320)	degrees	0 .. 360	1	32	4
Colatitude (321)	degrees	0 .. 180	1	32	4

Table 5-55. 2.5° Global Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (291)	W-h/m^2	0 .. 500,000	1	32	4
Net radiant flux (292)	W/m^2	-200 .. 200	1	32	4
Longwave flux (293)	W/m^2	50 .. 450	1	32	4
Shortwave flux (294)	W/m^2	0 .. 1,400	1	32	4
Albedo (295)	unitless	0 .. 1	1	32	4
Geographic scene type (319)	See Section 5.2	1 .. 127	1	8	1

Table 5-55. 2.5° Global Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Longitude (320)	degrees	0 .. 360	1	32	4
Colatitude (321)	degrees	0 .. 180	1	32	4

Table 5-56. 2.5° Global Vgroup for Daily, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (296)	$W\text{-}h/m^2$	0 .. 15000	31x1	32	124
Longwave flux (297)	W/m^2	50 .. 450	31x1	32	124
Number of hours of longwave flux (298)	hours	0 .. 24	31x1	8	31
Shortwave flux (299)	W/m^2	0 .. 1,400	31x1	32	124
Number of hours of shortwave flux (300)	hours	0 .. 24	31x1	8	31
Albedo (301)	unitless	0 .. 1	31x1	32	124
Geographic scene type (319)	See Section 5.2	1 .. 127	1	8	1
Longitude (320)	degrees	0 .. 360	1	32	4
Colatitude (321)	degrees	0 .. 180	1	32	4

Table 5-57. 2.5° Global Vgroup for Daily, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Longwave flux (302)	W/m^2	50 .. 450	31x1	32	124
Number of hours of longwave flux (303)	hours	0 .. 24	31x1	8	31
Shortwave flux (304)	W/m^2	0 .. 1,400	31x1	32	124
Number of hours of shortwave flux (305)	hours	0 .. 24	31x1	8	31
Albedo (306)	unitless	0 .. 1	31x1	32	124
Geographic scene type (319)	See Section 5.2	1 .. 127	1	8	1
Longitude (320)	degrees	0 .. 360	1	32	4
Colatitude (321)	degrees	0 .. 180	1	32	4

Table 5-58. 2.5° Global Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (307)	$W\text{-}h/m^2$	0 .. 50000	24x1	32	4
Longwave flux (308)	W/m^2	50 .. 450	24x1	32	96
Number of days of longwave flux (309)	days	0 .. 31	24x1	8	24
Shortwave flux (310)	W/m^2	0 .. 1,400	24x1	32	96
Number of days of shortwave flux (311)	days	0 .. 31	24x1	8	24
Albedo (312)	unitless	0 .. 1	24x1	32	96

Table 5-58. 2.5° Global Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Geographic scene type (319)	See Section 5.2	1 .. 127	1	8	1
Longitude (320)	degrees	0 .. 360	1	32	4
Colatitude (321)	degrees	0 .. 180	1	32	4

Table 5-59. 2.5° Global Vgroup for Monthly Hourly, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (313)	W-h/m^2	0 .. 50000	24x1	32	4
Longwave flux (314)	W/m^2	50 .. 450	24x1	32	96
Number of days of longwave flux (315)	days	0 .. 31	24x1	8	24
Shortwave flux (316)	W/m^2	0 .. 1,400	24x1	32	96
Number of days of shortwave flux (317)	days	0 .. 31	24x1	8	24
Albedo (318)	unitless	0 .. 1	24x1	32	96
Geographic scene type (319)	See Section 5.2	1 .. 127	1	8	1
Longitude (320)	degrees	0 .. 360	1	32	4
Colatitude (321)	degrees	0 .. 180	1	32	4

Table 5-60. 5.0° Global Vgroup for Monthly (Day), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (322)	$W\text{-}h/m^2$	0 .. 500,000	1	32	4
Net radiant flux (323)	W/m^2	-200 .. 200	1	32	4
Longwave flux (324)	W/m^2	50 .. 450	1	32	4
Shortwave flux (325)	W/m^2	0 .. 1,400	1	32	4
Albedo (326)	unitless	0 .. 1	1	32	4
Geographic scene type (365)	See Section 5.2	1 .. 127	1	8	1
Longitude (366)	degrees	0 .. 360	1	32	4
Colatitude (367)	degrees	0 .. 180	1	32	4

Table 5-61. 5.0° Global Vgroup for Monthly (Day), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (327)	$W\text{-}h/m^2$	0 .. 500,000	1	32	4
Net radiant flux (328)	W/m^2	-200 .. 200	1	32	4
Longwave flux (329)	W/m^2	50 .. 450	1	32	4
Shortwave flux (330)	W/m^2	0 .. 1,400	1	32	4
Albedo (331)	unitless	0 .. 1	1	32	4
Geographic scene type (365)	See Section 5.2	1 .. 127	1	8	1
Longitude (366)	degrees	0 .. 360	1	32	4
Colatitude (367)	degrees	0 .. 180	1	32	4

Table 5-62. 5.0° Global Vgroup for Monthly (Hour), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (332)	$W\text{-}h/m^2$	0 .. 500,000	1	32	4
Net radiant flux (333)	W/m^2	-200 .. 200	1	32	4
Longwave flux (334)	W/m^2	50 .. 450	1	32	4
Shortwave flux (335)	W/m^2	0 .. 1,400	1	32	4
Albedo (336)	unitless	0 .. 1	1	32	4
Geographic scene type (365)	See Section 5.2	1 .. 127	1	8	1
Longitude (366)	degrees	0 .. 360	1	32	4
Colatitude (367)	degrees	0 .. 180	1	32	4

Table 5-63. 5.0° Global Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (337)	$W\text{-}h/m^2$	0 .. 500,000	1	32	4
Net radiant flux (338)	W/m^2	-200 .. 200	1	32	4
Longwave flux (339)	W/m^2	50 .. 450	1	32	4
Shortwave flux (340)	W/m^2	0 .. 1,400	1	32	4
Albedo (341)	unitless	0 .. 1	1	32	4
Geographic scene type (365)	See Section 5.2	1 .. 127	1	8	1
Longitude (366)	degrees	0 .. 360	1	32	4

Table 5-63. 5.0° Global Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Colatitude (367)	degrees	0 .. 180	1	32	4

Table 5-64. 5.0° Global Vgroup for Daily, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (342)	W-h/m^2	0 .. 15000	31x1	32	124
Longwave flux (343)	W/m^2	50 .. 450	31x1	32	124
Number of hours of longwave flux (344)	hours	0 .. 24	31x1	8	31
Shortwave flux (345)	W/m^2	0 .. 1,400	31x1	32	124
Number of hours of shortwave flux (346)	hours	0 .. 24	31x1	8	31
Albedo (347)	unitless	0 .. 1	31x1	32	124
Geographic scene type (365)	See Section 5.2	1 .. 127	1	8	1
Longitude (366)	degrees	0 .. 360	1	32	4
Colatitude (367)	degrees	0 .. 180	1	32	4

Table 5-65. 5.0° Global Vgroup for Daily, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Longwave flux (348)	W/m^2	50 .. 450	31x1	32	124
Number of hours of longwave flux (349)	hours	0 .. 24	31x1	8	31
Shortwave flux (350)	W/m^2	0 .. 1,400	31x1	32	124
Number of hours of shortwave flux (351)	hours	0 .. 24	31x1	8	31
Albedo (352)	unitless	0 .. 1	31x1	32	124
Geographic scene type (365)	See Section 5.2	1 .. 127	1	8	1
Longitude (366)	degrees	0 .. 360	1	32	4
Colatitude (367)	degrees	0 .. 180	1	32	4

Table 5-66. 5.0° Global Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (353)	$W\text{-}h/m^2$	0 .. 50000	24x1	32	4
Longwave flux (354)	W/m^2	50 .. 450	24x1	32	96
Number of days of longwave flux (355)	days	0 .. 31	24x1	8	24
Shortwave flux (356)	W/m^2	0 .. 1,400	24x1	32	96
Number of days of shortwave flux (357)	days	0 .. 31	24x1	8	24
Albedo (358)	unitless	0 .. 1	24x1	32	96

Table 5-66. 5.0° Global Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Geographic scene type (365)	See Section 5.2	1 .. 127	1	8	1
Longitude (366)	degrees	0 .. 360	1	32	4
Colatitude (367)	degrees	0 .. 180	1	32	4

Table 5-67. 5.0° Global Vgroup for Monthly Hourly, Clear-sky Average

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (359)	$W\text{-}h/m^2$	0 .. 50000	24x1	32	4
Longwave flux (360)	W/m^2	50 .. 450	24x1	32	96
Number of days of longwave flux (361)	days	0 .. 31	24x1	8	24
Shortwave flux (362)	W/m^2	0 .. 1,400	24x1	32	96
Number of days of shortwave flux (363)	days	0 .. 31	24x1	8	24
Albedo (364)	unitless	0 .. 1	24x1	32	96
Geographic scene type (365)	See Section 5.2	1 .. 127	1	8	1
Longitude (366)	degrees	0 .. 360	1	32	4
Colatitude (367)	degrees	0 .. 180	1	32	4

Table 5-68. 10.0° Global Vgroup for Monthly (Day), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (368)	W-h/m^2	0 .. 500,000	1	32	4
Net radiant flux (369)	W/m^2	-200 .. 200	1	32	4
Longwave flux (370)	W/m^2	50 .. 450	1	32	4
Shortwave flux (371)	W/m^2	0 .. 1,400	1	32	4
Albedo (372)	unitless	0 .. 1	1	32	4
Geographic scene type (411)	See Section 5.2	1 .. 127	1	8	1
Longitude (412)	degrees	0 .. 360	1	32	4
Colatitude (413)	degrees	0 .. 180	1	32	4

Table 5-69. 10.0° Global Vgroup for Monthly (Day), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (373)	W-h/m^2	0 .. 500,000	1	32	4
Net radiant flux (374)	W/m^2	-200 .. 200	1	32	4
Longwave flux (375)	W/m^2	50 .. 450	1	32	4
Shortwave flux (376)	W/m^2	0 .. 1,400	1	32	4
Albedo (377)	unitless	0 .. 1	1	32	4
Geographic scene type (411)	See Section 5.2	1 .. 127	1	8	1
Longitude (412)	degrees	0 .. 360	1	32	4
Colatitude (413)	degrees	0 .. 180	1	32	4

Table 5-70. 10.0° Global Vgroup for Monthly (Hour), Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (378)	W-h/m^2	0 .. 500,000	1	32	4
Net radiant flux (379)	W/m^2	-200 .. 200	1	32	4
Longwave flux (380)	W/m^2	50 .. 450	1	32	4
Shortwave flux (381)	W/m^2	0 .. 1,400	1	32	4
Albedo (382)	unitless	0 .. 1	1	32	4
Geographic scene type (411)	See Section 5.2	1 .. 127	1	8	1
Longitude (412)	degrees	0 .. 360	1	32	4
Colatitude (413)	degrees	0 .. 180	1	32	4

Table 5-71. 10.0° Global Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (383)	W-h/m^2	0 .. 500,000	1	32	4
Net radiant flux (384)	W/m^2	-200 .. 200	1	32	4
Longwave flux (385)	W/m^2	50 .. 450	1	32	4
Shortwave flux (386)	W/m^2	0 .. 1,400	1	32	4
Albedo (387)	unitless	0 .. 1	1	32	4
Geographic scene type (411)	See Section 5.2	1 .. 127	1	8	1
Longitude (412)	degrees	0 .. 360	1	32	4

Table 5-71. 10.0° Global Vgroup for Monthly (Hour), Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Colatitude (413)	degrees	0 .. 180	1	32	4

Table 5-72. 10.0° Global Vgroup for Daily, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (388)	W-h/m^2	0 .. 15000	31x1	32	124
Longwave flux (389)	W/m^2	50 .. 450	31x1	32	124
Number of hours of longwave flux (390)	hours	0 .. 24	31x1	8	31
Shortwave flux (391)	W/m^2	0 .. 1,400	31x1	32	124
Number of hours of shortwave flux (392)	hours	0 .. 24	31x1	8	31
Albedo (393)	unitless	0 .. 1	31x1	32	124
Geographic scene type (411)	See Section 5.2	1 .. 127	1	8	1
Longitude (412)	degrees	0 .. 360	1	32	4
Colatitude (413)	degrees	0 .. 180	1	32	4

Table 5-73. 10.0° Global Vgroup for Daily, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Longwave flux (394)	W/m^2	50 .. 450	31x1	32	124
Number of hours of longwave flux (395)	hours	0 .. 24	31x1	8	31
Shortwave flux (396)	W/m^2	0 .. 1,400	31x1	32	124
Number of hours of shortwave flux (397)	hours	0 .. 24	31x1	8	31
Albedo (398)	unitless	0 .. 1	31x1	32	124
Geographic scene type (411)	See Section 5.2	1 .. 127	1	8	1
Longitude (412)	degrees	0 .. 360	1	32	4
Colatitude (413)	degrees	0 .. 180	1	32	4

Table 5-74. 10.0° Global Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (399)	$W\text{-}h/m^2$	0 .. 50000	24x1	32	4
Longwave flux (400)	W/m^2	50 .. 450	24x1	32	96
Number of days of longwave flux (401)	days	0 .. 31	24x1	8	24
Shortwave flux (402)	W/m^2	0 .. 1,400	24x1	32	96
Number of days of shortwave flux (403)	days	0 .. 31	24x1	8	24
Albedo (404)	unitless	0 .. 1	24x1	32	96

Table 5-74. 10.0° Global Vgroup for Monthly Hourly, Total-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Geographic scene type (411)	See Section 5.2	1 .. 127	1	8	1
Longitude (412)	degrees	0 .. 360	1	32	4
Colatitude (413)	degrees	0 .. 180	1	32	4

Table 5-75. 10.0° Global Vgroup for Monthly Hourly, Clear-sky Averages

SDS Name (Index)	Units	Range	Dimensions of SDS Elements	Bits per Element	SDS Size (Bytes)
Solar incidence (405)	$W\text{-}h/m^2$	0 .. 50000	24x1	32	4
Longwave flux (406)	W/m^2	50 .. 450	24x1	32	96
Number of days of longwave flux (407)	days	0 .. 31	24x1	8	24
Shortwave flux (408)	W/m^2	0 .. 1,400	24x1	32	96
Number of days of shortwave flux (409)	days	0 .. 31	24x1	8	24
Albedo (410)	unitless	0 .. 1	24x1	32	96
Geographic scene type (411)	See Section 5.2	1 .. 127	1	8	1
Longitude (412)	degrees	0 .. 360	1	32	4
Colatitude (413)	degrees	0 .. 180	1	32	4

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 Subsystem Architectural Design Document. (Reference 4)

6.3 Special Corrections/Adjustments

See CERES ATBD Subsystem 2.0 (Reference 4).

7.0 Errors

See the Data Quality Summary {URL=http://eosweb.larc.nasa.gov/project/ceres/ES4/disclaimer_CER_ES4.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 14).

8.0 Notes

9.0 Application of the Data Set

The ES-4 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, zonal, and global basis.

10.0 Future Modifications and Plans

Modifications to the ES-4 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, Virginia 23681-2199

13.0 Output Products and Availability

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

14.0 References

1. Clouds and the Earth's Radiant Energy System (CERES) Data Management System Software Requirements Document, ERBE-like Inversion to Instantaneous TOA Fluxes (Subsystem 2.0), Release 1 Version 1, November 1994 {URL = http://ceres.larc.nasa.gov/srd.php}.
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}.
4. Clouds and the Earth's Radiant Energy System (CERES) Algorithm Theoretical Basis Document, ERBE-like Inversion to Instantaneous TOA Fluxes (Subsystem 2.0), Rel. 2.2, June 2, 1997 {URL = http://ceres.larc.nasa.gov/atbd.php}.
5. ERBE Data Management System Reference Manual, Volume V(a) and V(b), Inversion, August 1987 {URL = http://}.
6. Clouds and the Earth's Radiant Energy System (CERES) Algorithm Theoretical Basis Document, ERBE-like Averaging to Monthly TOA Fluxes (Subsystem 3.0), Rel. 2.2, June 2, 1997 {URL = http://ceres.larc.nasa.gov/atbd.php}.
7. ERBE Data Management System Reference Manual, Volume VI, Daily Data Base, Monthly Time/Space Averaging, November 1986 {URL = http://}.
8. Clouds and the Earth's Radiant Energy System (CERES) Data Management System Data Products Catalog Release 3, Version 1, July 1998 {URL = http://ceres.larc.nasa.gov/dpc_current.php}.
9. TRW DRL 64, 55067.300.008E; In-flight Measurement Analysis (Rev. E), March 1997.
10. Clouds and the Earth's Radiant Energy System (CERES) Algorithm Theoretical Basis Document, Instrument Geolocate and Calibrate Earth Radiances (Subsystem 1.0), Release 2.2, June 1997 {URL = http://ceres.larc.nasa.gov/atbd.php}.
11. Brooks, D. R.; Harrison, E. F.; Minnis, P.; Suttles, J. T., and Kandel, R. S.: Development of Algorithms for Understanding the Temporal and Spatial Variability of the Earth's Radiation Balance. Reviews of Geophysics, Vol. 24, pp. 422-438, May 1986.
12. ERBE Data Management System, The Regional, Zonal, and Global Averages, S-4, User's Guides, June 1993.
13. 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.

14. 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-4 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 3, Table 4-4)
$M_{LW}(h)$	Monthly hourly average of longwave flux. (Item 33, Table 4-10)
$M_{LW}(mha)$	Monthly (Hour) longwave flux calculated from longwave monthly hourly averages. (Item 13, Table 4-6)
$\overline{M}_{NET}(d,h)$	Monthly net flux as calculated from regional longwave averages, $M_{LW}(d,h)$ over all hourboxes in the month. (Item 2, Table 4-4)
$M_{NET}(mha)$	Monthly net radiant flux based on monthly hourly averages (mha). (Item 12, Table 4-6)
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)
$\overline{M}_{SW}$	Monthly (Hour) mean shortwave flux. (Item 14, Table 4-6)
$M_{SW}(d)$	Daily average for the shortwave flux. (Item 24, Table 4-8)
$M_{SW}(da)$	Monthly mean shortwave flux based on daily shortwave flux values. (Item 4, Table 4-4)
$M_{SW}(d,h)$	Regional shortwave average flux for hourbox, (d, h).
$M_{SW}(h)$	Monthly hourly averages for the shortwave flux over the month.
N	Number of days in the month with any data.
N_{LW}	Number of days that contain at least one longwave measurement.

Symbol	Definition
$N_{LW}(mha)$	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 25, Table 4-8)
$S(d)$	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 5, Table 4-4)
$\overline{\alpha}(h)$	Monthly hourly average albedo. (Item 37, Table 4-10)

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

Table A-1. CERES Baseline Header Metadata

Item	Parameter Name	Units	Range	Data Type	No. of Elements
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	datetime	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
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

Table A-1. CERES Baseline Header Metadata

Ite m	Parameter Name	Units	Range	Data Type	No. of Elements
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)

Table A-2. CERES_metadata Vdata

Item	Parameter Name	Units	Range	Data Type
6	AutomaticQualityFlag	N/A	Passed, Failed, or Suspect	s(64)
7	AutomaticQualityFlagExplanation	N/A	N/A	s(256)
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)