Clouds and the Earth's Radiant Energy System

(CERES)

Data Management System

**ES-9 Collection Guide**

**Release 1**

**Version 1**

**Primary Authors**

*Lee-hwa Chang, Jason A. Halvorson, Edward A. Kizer, John L. Robbins*

Science Applications International Corporation (SAIC)

One Enterprise Parkway, Suite 300

Hampton, VA 23666-5845

*James F. Kibler, David F. Young*

NASA Langley Research Center

Climate Science Branch

Science Directorate

Building 1250

21 Langley Boulevard

Hampton, VA 23681-2199

January 2003

Document Revision Record

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

| Document Revision Record | | | | |
| --- | --- | --- | --- | --- |
| SCCR Approval Date | Release/ Version  Number | SCCR  Number | Description of Revision | Section(s) Affected |
| xxxx | R1V1 | xxxx | The CERES Top Level Data Flow Diagram was modified (5/29/03). | Fig. 1-1 |
|  |  |  | This document was converted from FrameMaker to Word. (06/11/2008) | All |
|  |  |  | The CERES Top Level Data Flow Diagram was modified. (06/11/2008) | Fig. 1-1 |
|  |  |  | S(d) was modified to read S’(d) - added prime symbol - in two places in Item No. 24. (01/29/2010) | Table 4-5 |
|  |  |  | 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 |

[Summary 1](#_Toc216072595)

[1.0 Collection Overview 3](#_Toc216072596)

[1.1 Collection Identification 4](#_Toc216072597)

[1.2 Collection Introduction 4](#_Toc216072598)

[1.3 Objective/Purpose 4](#_Toc216072599)

[1.1 Summary of Parameters 6](#_Toc216072600)

[1.2 Discussion 9](#_Toc216072601)

[1.3 Related Collections 10](#_Toc216072602)

[2.0 Investigators 11](#_Toc216072603)

[2.1 Title of Investigation 11](#_Toc216072604)

[2.2 Contact Information 11](#_Toc216072605)

[3.0 Origination 12](#_Toc216072606)

[3.1 Sensor and Instrument Description 12](#_Toc216072607)

[4.0 Data Description 13](#_Toc216072608)

[4.1 Spatial Characteristics 13](#_Toc216072609)

[4.1.1 Spatial Coverage 13](#_Toc216072610)

[4.1.2 Spatial Resolution 13](#_Toc216072611)

[4.1.3 Grid Description 13](#_Toc216072612)

[4.2 Temporal Characteristics 14](#_Toc216072613)

[4.2.1 Temporal Coverage 14](#_Toc216072614)

[4.2.2 Temporal Resolution 15](#_Toc216072615)

[4.3 Parameter Definitions 15](#_Toc216072616)

[4.3.1 ES-9 Parameter Definitions according to Temporal Classification 15](#_Toc216072617)

[4.3.2 Discussion of Regional Averages 31](#_Toc216072618)

[4.3.3 The Albedo Calculations 31](#_Toc216072619)

[4.4 Fill Values 32](#_Toc216072620)

[4.5 Sample Data Record 32](#_Toc216072621)

[5.0 Data Organization 34](#_Toc216072622)

[5.1 Data Granularity 35](#_Toc216072623)

[5.2 ES-9 Scientific Data Sets 35](#_Toc216072624)

[6.0 Theory of Measurements and Data Manipulations 49](#_Toc216072625)

[6.1 Theory of Measurements 49](#_Toc216072626)

[6.2 Data Processing Sequence 49](#_Toc216072627)

[6.3 Special Corrections/Adjustments 49](#_Toc216072628)

[7.0 Errors 50](#_Toc216072629)

[7.1 Quality Assessment 50](#_Toc216072630)

[7.2 Data Validation by Source 50](#_Toc216072631)

[8.0 Notes 51](#_Toc216072632)

[9.0 Application of the Data Set 52](#_Toc216072633)

[10.0 Future Modifications and Plans 53](#_Toc216072634)

[11.0 Software Description 54](#_Toc216072635)

[12.0 Data Access 55](#_Toc216072636)

[12.1 Contacts for Data Center/Data Access Information 55](#_Toc216072637)

[12.2 Data Center Identification 55](#_Toc216072638)

[13.0 Output Products and Availability 56](#_Toc216072639)

[14.0 References 57](#_Toc216072640)

[15.0 Glossary of Terms 59](#_Toc216072641)

[16.0 Acronyms and Units 60](#_Toc216072642)

[16.1 CERES Acronyms 60](#_Toc216072643)

[16.2 CERES Units 62](#_Toc216072644)

[16.3 ES-9 Symbols 63](#_Toc216072645)

[17.0 Document Information 65](#_Toc216072646)

[17.1 Document Revision Date 65](#_Toc216072647)

[Appendix A CERES Metadata A-1](#_Toc216072648)

Figure 0-1. CERES Subsystem 3.0 Temporal Grid 2

[Figure 1‑1. CERES Top Level Data Flow Diagram 5](#_Toc200937850)

[Figure 4‑1. Layout of a 2.5 System 14](#_Toc200937851)

[Table 1‑1. ES-9 Vgroup Summary 6](#_Toc200870082)

[Table 1‑2. Regional Summary Data 6](#_Toc200870083)

[Table 1‑3. Temporal Vgroups for 2.5° Regions 7](#_Toc200870084)

[Table 1‑4. Hourbox Data 8](#_Toc200870085)

[Table 3‑1. CERES Instruments 12](#_Toc200870086)

[Table 4‑1. ES-9 Spatial Coverage 13](#_Toc200870087)

[Table 4‑2. CERES Temporal Coverage 15](#_Toc200870088)

[Table 4‑3. Location of ES-9 Parameter Descriptions 16](#_Toc200870089)

[Table 4‑4. Regional Summary Data 16](#_Toc200870090)

[Table 4‑5. Monthly (Day), Total-Sky Averagesa 17](#_Toc200870091)

[Table 4‑6. Monthly (Day), Clear-sky Averages 19](#_Toc200870092)

[Table 4‑7. Monthly (Hour), Total-sky Averagesa 20](#_Toc200870093)

[Table 4‑8. Monthly (Hour), Clear-sky Averages 22](#_Toc200870094)

[Table 4‑9. Daily, Total-sky Averagesa 23](#_Toc200870095)

[Table 4‑10. Daily, Clear-sky Averages 25](#_Toc200870096)

[Table 4‑11. Monthly Hourly, Total-sky Averagesa 26](#_Toc200870097)

[Table 4‑12. Monthly Hourly, Clear-sky Averages 28](#_Toc200870098)

[Table 4‑13. Hourbox Data 29](#_Toc200870099)

[Table 5‑1. ES-9 Product Summary 34](#_Toc200870100)

[Table 5‑2. ES-9 Product Specific Metadata 34](#_Toc200870101)

[Table 5‑3. ES-9 Vgroup Summary 34](#_Toc200870102)

[Table 5‑4. Regional Summary Data 35](#_Toc200870103)

[Table 5‑5. Monthly (Day), Total-sky Averages 36](#_Toc200870104)

[Table 5‑6. Monthly (Day), Clear-sky Averages 38](#_Toc200870105)

[Table 5‑7. Monthly (Hour), Total-sky Averages 39](#_Toc200870106)

[Table 5‑8. Monthly (Hour), Clear-sky Averages 40](#_Toc200870107)

[Table 5‑9. Daily, Total-sky Averages 41](#_Toc200870108)

[Table 5‑10. Daily, Clear-sky Averages 42](#_Toc200870109)

[Table 5‑11. Monthly Hourly, Total-sky Averages 43](#_Toc200870110)

[Table 5‑12. Monthly Hourly, Clear-sky Averages 44](#_Toc200870111)

[Table 5‑13. Hourbox Averages 46](#_Toc200870112)

[Table A‑1. CERES Baseline Header Metadata A-2](#_Toc200870242)

[Table A‑2. CERES\_metadata Vdata A-3](#_Toc200870243)

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

ES-9 Collection Guide

Summary

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

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

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

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

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

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

**Local Hours  
(1-24)**

**Daily Averages**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**X**

**Monthly (Hour) Averages**

**Monthly  
(Day)  
Averages**

**Hourly Averages Indexed by Day and Local Hour for Each Region  
(see ES-9 product)**

**X**

**Monthly Hourly Averages**

**X**

**X**

**X**

**X**

**X**























































**Days**

**(1-31)**

|  |
| --- |
| Figure 0-1. CERES Subsystem 3.0 Temporal Grid |

Figure 0-1. CERES Subsystem 3.0 Temporal Grid

# Collection Overview

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

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

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

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

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

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

## Collection Identification

The ES-9 filename is

CER\_ ES9\_Sampling-Strategy\_Production-Strategy\_XXXXXX.YYYYMM where

CER Investigation designation for CERES,

ES9 Product identification for the primary science data product (external  
 distribution),

Sampling-Strategy Platform, instrument, and imager (e.g., TRMM-PFM-VIRS),

Production-Strategy Edition or campaign (e.g., At-launch, ValidationR1, Edition1),

XXXXXX Configuration code for file and software version management,

YYYY 4-digit integer defining data acquisition year, and

MM 2-digit integer defining data acquisition month.

## Collection Introduction

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

## Objective/Purpose

The science objectives of the CERES investigation are

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

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

Grid TOA

and Surface

Fluxes:

Clouds

9

ERBE-like

Averaging to

Monthly TOA

Fluxes

3

Grid GEO

Narrowband

Radiances,

Clouds

11

GEO:

Geostationary

Narrowband

Radiances

Time  
Interpolate,  
Compute  
Fluxes

7

Grid

Radiative

Fluxes and

Clouds

6

MOA:

Meteorological,

Ozone, and

Aerosol Data

ES-8:

ERBE-like

Instantaneous  
TOA Estimates

ERBE-like

Inversion to

Instantaneous

TOA Fluxes

2

Regrid

Humidity

and

Temperature

Fields

12

BDS:

BiDirectional

Scans

SRBAVG:

Monthly

TOA/Surface Averages

SYNI:

Intermediate

Synoptic

Radiative

Fluxes and Clouds

Compute

Monthly and

Regional TOA

and Surface

Averages

10

Determine

Cloud

Properties, TOA

and Surface Fluxes

4

Geolocate

and Calibrate

Earth

Radiances

1

SSF: Single

Scanner Footprint TOA/Surface Fluxes and Clouds

CRS:   
Clouds

and Radiative

Swath

VIRS CID:

MODIS CID:

Cloud

Imager Data

SURFMAP:

Surface

Map

INSTR:

Instrument

Production Data Set

EID6:

ERBE-like Regional Data

AVG:

Monthly Regional

Radiative Fluxes

and Clouds

ZAVG:

Monthly Zonal and Global Radiative Fluxes and Clouds

Compute

Regional,

Zonal and

Global

Averages

8

GGEO:

Gridded GEO

Narrowband

Radiances, Clouds

FSW: Monthly

Gridded Radiative Fluxes and

Clouds

IES: Instrument

Earth Scans

CRH:

Clear

Reflectance

History

GAP:

Gridded Analysis Product

OPD:

Ozone

Profile

Data

MWH:

Microwave

Humidity

APD:

Aerosol

Data

SFC: Monthly

Gridded TOA/Surface

Fluxes and Clouds

ES-9:

ERBE-like

Monthly Regional Averages

ES-4:

ERBE-like  
Monthly Geographical Averages

Compute

Surface and

Atmospheric

Radiative

Fluxes

5

SYN

Synoptic

Radiative

Fluxes and Clouds

ISCCP-D2like-Day/Nit:

Monthly Gridded Cloud Averages

ISCCP-D2like-GEO:

Monthly Cloud Averages

Modified Date: October 2008

Figure 1‑1. CERES Top Level Data Flow Diagram

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

## Summary of Parameters

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

Table 1‑1. ES-9 Vgroup Summary

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

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

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

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

| Table 1‑2. Regional Summary Data |
| --- |
| Parameter Name |
| See Table 5‑4 |
| Region number |
| Longitude |
| Colatitude |
| Geographic scene type |
| Scene fraction histogram (1) |
| Scene fraction histogram (2) |
| Scene fraction histogram (3) |
| Scene fraction histogram (4) |
| Number of hourboxes |
| Start position of hourbox data |

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

| Table 1‑3. Temporal Vgroups for 2.5° Regions | | | | |
| --- | --- | --- | --- | --- |
| Parameter Name | | Temporal Vgroups | | | |
| Monthly (Day) Averages | Monthly (Hour)  Averages | Daily Averages | Monthly Hourly  Averages | |
| Total-Sky Parameters | | See Table 5‑5 | See Table 5‑7 | See Table 5‑9 | See Table 5‑11 | |
| Region number | | X | X | X | X | |
| Solar constant, distance corrected | |  |  | X |  | |
| Solar incidence | | X | X | X | X | |
| Net radiant flux | | X | X |  |  | |
| Longwave flux | | X | X | X | X | |
| Longwave flux minimum value | | X | X | X | X | |
| Longwave flux maximum value | | X | X | X | X | |
| Longwave flux standard deviation | | X | X | X | X | |
| Number of hours of longwave flux | |  | X | X |  | |
| Number of days of longwave flux | | X |  |  | X | |
| Longwave sum of estimates | |  |  |  | X | |
| Longwave sum of estimates squared | |  |  |  | X | |
| Shortwave flux | | X | X | X | X | |
| Shortwave flux minimum value | | X | X | X | X | |
| Shortwave flux maximum value | | X | X | X | X | |
| Shortwave flux standard deviation | | X | X | X | X | |
| Number of hours of shortwave flux | |  | X | X |  | |
| Number of days of shortwave flux | | X |  |  | X | |
| Shortwave sum of estimates | |  |  |  | X | |
| Shortwave sum of estimates squared | |  |  |  | X | |
| Albedo | | X | X | X | X | |
|  | |  |  |  |  | |
| **Clear-sky Parameters** | | See Table 5‑6 | See Table 5‑8 | See Table 5‑10 | See Table 5‑12 | |
| Region number | | X | X | X | X | |
| Solar constant, distance corrected | |  |  | X |  | |
| Solar incidence | | X | X | X | X | |
| Net radiant flux | | X | X |  |  | |
| Longwave flux | | X | X | X | X | |
| Longwave flux minimum value | | X | X | X | X | |
| Longwave flux maximum value | | X | X | X | X | |
| Longwave flux standard deviation | | X | X | X | X | |
| Number of hours of longwave flux | |  | X | X |  | |
| Number of days of longwave flux | | X |  |  | X | |
| Longwave sum of estimates | |  |  |  | X | |
| Longwave sum of estimates squared | |  |  |  | X | |
| Shortwave flux | | X | X | X | X | |
| Shortwave flux minimum value | | X | X | X | X | |
| Shortwave flux maximum value | | X | X | X | X | |
| Shortwave flux standard deviation | | X | X | X | X | |
| Number of hours of shortwave flux | |  | X | X |  | |
| Number of days of shortwave flux | | X |  |  | X | |
| Shortwave sum of estimates | |  |  |  | X | |
| Shortwave sum of estimates squared | |  |  |  | X | |
| Albedo | | X | X | X | X | |
| **Total parameters per temporal vgroup** | | 28 | 28 | 28 | 34 | |

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

| Table 1‑4. Hourbox Data |
| --- |
| Parameter Name |
| See Table 5‑13 |
| Region number |
| Longitude |
| Colatitude |
| Number of hourboxes |
| Hourbox number |
| Time of observation |
| Scene fraction (1) |
| Scene fraction (2) |
| Scene fraction (3) |
| Scene fraction (4) |
| Albedo factor (1) |
| Albedo factor (2) |
| Albedo factor (3) |
| Albedo factor (4) |
| Cosine of the solar zenith angle |
| Satellite zenith angle |
| Azimuth angle |
| Solar incidence |
| Longwave flux |
| Longwave flux minimum value |
| Longwave flux maximum value |
| Longwave flux standard deviation |
| Number of longwave flux estimates |
| Longwave flux maximum difference |
| Shortwave flux |
| Shortwave flux minimum value |
| Shortwave flux maximum value |
| Shortwave flux standard deviation |
| Number of shortwave flux estimates |
| Shortwave flux maximum difference |
| Clear-sky longwave flux |
| Clear-sky longwave flux standard deviation |
| Number of clear-sky longwave flux estimates |
| Clear-sky albedo standard deviation |

## Discussion

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

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

## 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).

# Investigators

Dr. Bruce A. Wielicki, CERES Principal Investigator

E-mail: B.A.Wielicki@LaRC.NASA.Gov

Telephone: (757) 864-5683

FAX: (757) 864-7996

Mail Stop 420

Atmospheric Sciences Competency

Building 1250

21 Langley Boulevard

NASA Langley Research Center

Hampton, VA 23681-2199

## Title of Investigation

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

ERBE-like Subsystems (Subsystems 2.0 & 3.0)

## Contact Information

David F. Young, Subsystem 3.0 Working Group Chair

E-mail: D.F.Young@LaRC.NASA.Gov

Telephone: (757) 864-5740

Dr. Takmeng Wong, Subsystem 3.0 Working Group Science and Validation Advisor

E-mail: Takmeng.Wong@LaRC.NASA.Gov

Telephone: (757) 864-5607

FAX: (757) 864-7996

Mail Stop 420

Atmospheric Sciences Competency

Building 1250

21 Langley Boulevard

NASA Langley Research Center

Hampton, VA 23681-2199

Edward A. Kizer, Subsystem 3.0 Software and Data Management Lead

E-mail: E.A.Kizer@LaRC.NASA.Gov

Telephone: (757) 827-4883

FAX: (757) 825-4968

Science Applications International Corporation (SAIC)

One Enterprise Parkway, Suite 300

Hampton, VA 23666-5845

# 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 |

## Sensor and Instrument Description

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

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

# Data Description

## Spatial Characteristics

### Spatial Coverage

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

Table 4‑1. ES-9 Spatial Coverage

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

### Spatial Resolution

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

### Grid Description

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

|  |
| --- |
|  |

Figure 4‑1. Layout of a 2.5 System

## Temporal Characteristics

### Temporal Coverage

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

Table 4‑2. CERES Temporal Coverage

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

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

### Temporal Resolution

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

## Parameter Definitions

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

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

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

### ES-9 Parameter Definitions according to Temporal Classification

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

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

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

Table 4‑4. Regional Summary Data

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

| Table 4‑5. Monthly (Day), Total-Sky Averagesa | | | |
| --- | --- | --- | --- |
| Item  No. | SDS Name | Monthly (Day), Total-sky Definitions | Units |
| 11 | Region number | An integer from 1 to 10,368 denotes one of the 2.5° x 2.5° regions. Regions are numbered consecutively west to east with 144 per latitude band and 72 per longitude band. | number |
| 12 | Solar  incidence | The monthly total integrated solar incidence for all days of the month. | W-hm-2 |
| 13 | Net radiant flux | The monthly net flux defined from albedo in Monthly Time/Space Averaging, the sum of integrated solar incidence over the entire month, and monthly net LW flux (see Reference 12). | Wm-2 |
| 14 | Longwave flux | The monthly mean LW flux based on all extrapolated, interpolated, and modeled LW flux values for the month in this region.  where N = all days of month (see Reference 12). | Wm-2 |
| 15 | Longwave flux minimum value | The minimum daily mean of the longwave flux for the month. | Wm-2 |
| 16 | Longwave flux maximum value | The maximum daily mean of the longwave flux for the month. | Wm-2 |
| 17 | Longwave flux standard deviation | The standard deviation for the longwave flux daily means for every day in the month. | Wm-2 |
| 18 | Number of days of longwave flux | The number of days with at least one longwave flux estimate. | days |
| 19 | Shortwave flux | The monthly mean SW flux based on daily SW flux values, including “measurements” from the Inversion Subsystem (see Reference 5) and modeled values, within this region.  where N = all days of the month, is the integrated daily solar incident radiation, and () is defined in Item 24, Table 4‑5. | Wm-2 |
| 20 | Shortwave flux minimum value | The minimum daily mean for days with at least one shortwave flux estimate. | Wm-2 |
| 21 | Shortwave flux maximum value | The maximum daily mean for days with at least one shortwave flux estimate. | Wm-2 |
| 22 | Shortwave flux standard deviation | The standard deviation of daily means for days with at least one shortwave flux estimate | Wm-2 |
| 23 | Number of days of shortwave flux | The number of days with at least one shortwave flux estimate. | days |
| 24 | Albedo | The monthly mean albedo from daily values, based on the sum of all SW fluxes calculated for days with at least one SW measurement (DSW).  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.  where and are the summed and integrated solar fluxes, respectively (also see Item 75, Table 4‑9). Other equations used to calculate the albedo values in ES-9 may be found in 4.3.3 of this document. | unitless |

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

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

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

| Table 4‑7. Monthly (Hour), Total-sky Averagesa | | | |
| --- | --- | --- | --- |
| Item  No. | SDS Name | Monthly (Hour), Total-sky Definitions | Units |
| 39 | Region  number | An integer from 1 to 10,368 denotes one of the 2.5° x 2.5° regions. Regions are numbered consecutively west to east with 144 per latitude band and 72 per longitude band. | number |
| 40 | Solar  incidence | The monthly total solar incidence for all days of the month. | W-hm-2 |
| 41 | Net radiant flux | The monthly net flux as calculated from albedo in Subsystem 3.0. The solar incidence is summed (not integrated) over the entire month; the monthly net LW flux is defined from days with at least one LW measurement.  where = monthly hourly average, is defined in Item 111, Table 4‑11, is the integrated daily solar incident radiation, and is defined in Item 42, Table 4‑7. | Wm-2 |
| 42 | Longwave flux | The monthly mean LW flux based on extrapolated, interpolated, and modeled LW values only for days during the month that had at least one actual LW measurement. The monthly LW flux may be calculated from monthly hourly averages as,  (see Reference 12). | Wm-2 |
| 43 | Longwave flux minimum value | The minimum longwave flux for days with at least one longwave flux estimate. | Wm-2 |
| 44 | Longwave flux maximum value | The maximum longwave flux for days with at least one longwave flux estimate. | Wm-2 |
| 45 | Longwave flux standard deviation | The standard deviation of all monthly (hour) mean longwave fluxes for days with at least one longwave flux estimate. | Wm-2 |
| 46 | Number of hours of longwave flux | The number of hours with at least one longwave flux estimate. | hours |
| 47 | Shortwave flux | The monthly mean SW flux based on summing SW flux values over days with at least one SW measurement, and then over each local hour.  where = all days of the month, is the integrated daily solar incident radiation, and is defined in Item 52, Table 4‑7. | Wm-2 |
| 48 | Shortwave flux minimum value | The minimum monthly hourly mean shortwave flux, as calculated for days with at least one shortwave flux estimate. It can be zero if there is at least one nighttime hour during the month. | Wm-2 |
| 49 | Shortwave flux maximum value | The maximum monthly hourly mean shortwave flux, as calculated for days with at least one shortwave flux estimate. | Wm-2 |
| 50 | Shortwave flux standard deviation | The standard deviation of all monthly (hour) shortwave flux means including nighttime values. This value may be a large number without much physical significance. | Wm-2 |
| 51 | Number of hours of shortwave flux | The number of hours with at least one shortwave flux estimate. | hours |
| 52 | Albedo | The monthly mean albedo from monthly hourly values, based on the sum of all SW fluxes calculated. The equations used to calculate the albedo values in ES-9 may be found in 4.3.3 of this document.  where is the integrated solar radiance and represents days with at least one SW measurement (see Reference 12). | unitless |

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

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

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

| Table 4‑9. Daily, Total-sky Averagesa | | | |
| --- | --- | --- | --- |
| Item  No. | SDS Name | Daily, Total-sky Definitions | Units |
| 67 | Region  number | An integer from 1 to 10,368 denotes one of the 2.5° x 2.5° regions. Regions are numbered consecutively west to east with 144 per latitude band and 72 per longitude band. | number |
| 68 | Solar  constant,  distance  corrected | The distance corrected solar constant for the day. | Wm-2 |
| 69 | Solar  incidence | The integrated solar incidence for a day that includes at least one SW measurement. | W-hm-2 |
| 70 | Longwave flux | Daily LW flux consisting of measurements and extrapolated, interpolated, and modeled values. | Wm-2 |
| 71 | Longwave flux minimum value | The minimum longwave flux for the day. | Wm-2 |
| 72 | Longwave flux maximum value | The maximum longwave flux for the day. | Wm-2 |
| 73 | Longwave flux standard deviation | The standard deviation of all longwave fluxes for the day. | Wm-2 |
| 74 | Number of hours of longwave flux | The number of hours with longwave flux estimates for the day. | hours |
| 75 | Shortwave flux | The daily SW flux; i.e., the sum of all measured and modeled SW fluxes for every day with at least one SW measurement, corrected by the ratio of integrated to summed solar incidence.  where and are the integrated and summed solar radiances, respectively (see Reference 12). | Wm-2 |
| 76 | Shortwave flux minimum value | The minimum shortwave flux for the day. This value will be zero for days with at least one nighttime hour. | Wm-2 |
| 77 | Shortwave flux maximum value | The maximum shortwave flux for the day. | Wm-2 |
| 78 | Shortwave flux standard deviation | The standard deviation of all shortwave flux values for the day. This value may be a large number without much physical significance for days having at least one nighttime hour. | Wm-2 |
| 79 | Number of hours of shortwave flux | The number of hours of shortwave estimates for the day. | hours |
| 80 | Albedo | The daily albedo is defined as the ratio of daily SW flux to the integrated daily solar incidence. The equations used to calculate the albedo values in ES-9 may be found in 4.3.3 of this document. | unitless |

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

Table 4‑10. Daily, Clear-sky Averages

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

| Table 4‑11. Monthly Hourly, Total-sky Averagesa | | | |
| --- | --- | --- | --- |
| Item  No. | SDS Name | Monthly Hourly, Total-sky Definitions | Units |
| 95 | Region  number | An integer from 1 to 10,368 denotes one of the 2.5° x 2.5° regions. Regions are numbered consecutively west to east with 144 per latitude band and 72 per longitude band. | number |
| 96 | Solar  incidence | The integrated solar incidence over those days with SW data for a given hour. | W-hm-2 |
| 97 | Longwave flux | The monthly average LW flux at this hour and is only calculated based on days that had at least one LW measurement. | Wm-2 |
| 98 | Longwave flux minimum value | The minimum longwave flux for days with longwave flux estimates at the hour. | Wm-2 |
| 99 | Longwave flux maximum value | The maximum longwave flux for days with longwave flux estimates at the hour. | Wm-2 |
| 100 | Longwave flux standard deviation | The standard deviation for the longwave flux for days with longwave flux estimates at the hour. | Wm-2 |
| 101 | Number of days of longwave flux | The number of days with longwave flux estimates at the hour. | days |
| 102 | Longwave sum of estimates | The sum of actual longwave flux estimates at this hour. This value is intended for doing tests of statistical significance on diurnal variability. | Wm-2 |
| 103 | Longwave sum of estimates squared | The sum of actual longwave flux estimates squared at this hour. This value is intended for doing tests of statistical significance on diurnal variability. | (Wm-2)2 |
| 104 | Shortwave flux | The monthly average SW flux at this hour and is only calculated based on days that had at least one SW measurement. | Wm-2 |
| 105 | Shortwave flux minimum value | The minimum shortwave flux for the hour. This value will be zero for nighttime hours. | Wm-2 |
| 106 | Shortwave flux maximum value | The maximum shortwave flux for the hour. | Wm-2 |
| 107 | Shortwave flux standard deviation | The standard deviation for shortwave fluxes at this hour. | Wm-2 |
| 108 | Number of days of shortwave flux | The number of days with shortwave flux estimates for the hour. | days |
| 109 | Shortwave sum of estimates | The sum of actual shortwave flux estimates at this hour. This value is intended for doing tests of statistical significance on diurnal variability. | Wm-2 |
| 110 | Shortwave sum of estimates squared | The sum of actual shortwave flux estimates squared at this hour. This value is intended for doing tests of statistical significance on diurnal variability. | (Wm-2)2 |
| 111 | Albedo | The monthly hourly average albedo. The equations used to calculate the albedo values in ES-9 may be found in 4.3.3. | unitless |

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

| Table 4‑12. Monthly Hourly, Clear-sky Averages | | | |
| --- | --- | --- | --- |
| Item  No. | SDS Name | Monthly Hourly, Clear-sky Definitions | Units |
| 112 | Region  number | The total-sky values from Table 4‑11 are repeated for clear-sky as defined by the ERBE-like Inversion Subsystem. | number |
| 113 | Solar  incidence | W-hm-2 |
| 114 | Longwave flux | Wm-2 |
| 115 | Longwave flux minimum value | Wm-2 |
| 116 | Longwave flux maximum value | Wm-2 |
| 117 | Longwave flux standard deviation | Wm-2 |
| 118 | Number of days of longwave flux | days |
| 119 | Longwave sum of estimates | The total-sky values from Table 4‑11 are repeated for clear-sky as defined by the ERBE-like Inversion Subsystem. | Wm-2 |
| 120 | Longwave sum of estimates squared | (Wm-2)2 |
| 121 | Shortwave flux | Wm-2 |
| 122 | Shortwave flux minimum value | Wm-2 |
| 123 | Shortwave flux maximum value | Wm-2 |
| 124 | Shortwave flux standard deviation | Wm-2 |
| 125 | Number of days of shortwave flux | days |
| 126 | Shortwave sum of estimates | Wm-2 |
| 127 | Shortwave sum of estimates squared | (Wm-2)2 |
| 128 | Albedo | unitless |

| Table 4‑13. Hourbox Data | | | |
| --- | --- | --- | --- |
| Item  No. | SDS Name | Hourbox Data Definitions | Units |
| 129 | Region  number | An integer from 1 to 10,368 denotes one of the 2.5° x 2.5° regions. Regions are numbered consecutively west to east with 144 per latitude band and 72 per longitude band. | number |
| 130 | Longitude | The longitude of the center of the region that this hourbox is in. | degrees |
| 131 | Colatitude | The colatitude of the center of the region that this hourbox is in. | degrees |
| 132 | Number of hourboxes | The number of hours in a month with estimates of any kind. | number |
| 133 | Hourbox number | An integer from 1-744 designating the local solar hourbox to which the estimate has been assigned. (Hours run from 1-24 on the first day of the month, 25-48 on the second day of the month, etc.) If this is a multiple instrument product, the hourbox number is adjusted by 1,000 times the number of instruments which have data for the region. | number |
| 134 | Time of observation | The Julian date and time at which the hourbox was observed. | days |
| 135 | Scene  fraction(1) | The scene fraction values form a normalized vector giving the distribution of clear pixels inverted for this hourbox. | N/A |
| 136 | Scene  fraction(2) | The scene fraction values form a normalized vector giving the distribution of partly cloudy pixels inverted for this hourbox. | N/A |
| 137 | Scene  fraction(3) | The scene fraction values form a normalized vector giving the distribution of mostly cloudy pixels inverted for this hourbox. | N/A |
| 138 | Scene  fraction(4) | The scene fraction values form a normalized vector giving the distribution of overcast pixels inverted for this hourbox. | N/A |
| 139 | Albedo  factor(1) | The albedos for clear scene types within this hourbox. | N/A |
| 140 | Albedo  factor(2) | The albedos for partly cloudy scene types within this hourbox. | N/A |
| 141 | Albedo  factor(3) | The albedos for mostly cloudy scene types within this hourbox. | N/A |
| 142 | Albedo  factor(4) | The albedos for overcast scene types within this hourbox. | N/A |
| 143 | Cosine of the solar zenith angle | The average cosine of the solar zenith angle in the range of 0-90 degrees for the pixels assigned to this hourbox. It is defined as 0 for all zenith angles greater than 90. | N/A |
| 144 | Satellite zenith angle | The average satellite viewing zenith angle for the pixels assigned to this hourbox. | degrees |
| 145 | Azimuth angle | The average relative azimuth angle (0 in the forward scattering direction) for the pixels assigned to this hourbox. | degrees |
| 146 | Solar incidence | The solar incidence for the local solar hourbox. | W-h/m2 |
| 147 | Longwave flux | The average longwave flux assigned to this local solar hourbox. | Wm-2 |
| 148 | Longwave flux minimum value | The minimum longwave flux estimate for this local solar hourbox. | Wm-2 |
| 149 | Longwave flux maximum value | The maximum longwave flux estimate for this local solar hourbox. | Wm-2 |
| 150 | Longwave flux standard deviation | The standard deviation for longwave flux estimates for this local solar hourbox. | Wm-2 |
| 151 | Number of longwave flux estimates | The number of longwave flux estimates assigned to this local solar hourbox. | number |
| 152 | Longwave flux maximum difference | This value is used for processing multiple instrument products only and is the maximum difference between individual mean longwave fluxes. For single instrument products, these values are default. | Wm-2 |
| 153 | Shortwave flux | The average shortwave flux assigned to this local solar hourbox. | Wm-2 |
| 154 | Shortwave flux minimum value | The minimum shortwave flux estimate for this local solar hourbox. | Wm-2 |
| 155 | Shortwave flux maximum value | The maximum shortwave flux estimate for this local solar hourbox. | Wm-2 |
| 156 | Shortwave flux standard deviation | The standard deviation for shortwave flux estimates for this local solar hourbox. | Wm-2 |
| 157 | Number of shortwave flux estimates | The number of shortwave flux estimates assigned to this local solar hourbox. | number |
| 158 | Shortwave flux maximum difference | This value is used for processing multiple instrument products only and is the maximum difference between individual mean shortwave fluxes. For single instrument products, these values are default. | Wm-2 |
| 159 | Clear-sky longwave flux | The average clear-sky longwave flux estimate | Wm-2 |
| 160 | Clear-sky longwave flux standard deviation | The standard deviation of the clear-sky longwave flux estimates | Wm-2 |
| 161 | Number of clear-sky longwave flux estimates | The number of clear-sky longwave flux estimates. | number |
| 162 | Clear-sky albedo standard deviation | The standard deviation of the clear-sky albedo. | unitless |

### Discussion of Regional Averages

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

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

### The Albedo Calculations

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

For Monthly (Day) Averages:

|  |  |  |
| --- | --- | --- |
|  |  | (1) |

where:

= Monthly mean shortwave flux based on daily calculations

TSOLRD = Total of monthly integrated solar incidence for all days of the month (see Reference 14)

NDAYS = The total number of days in the month

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

For Monthly (Hour) Averages:

|  |  |  |
| --- | --- | --- |
|  |  | (2) |

where:

= 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):

|  |  |  |
| --- | --- | --- |
|  |  | (3) |

where:

= 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):

|  |  |  |
| --- | --- | --- |
|  |  | (4) |

where:

= Daily shortwave radiant flux for each hour of the month

SOLARH = Integrated solar incidence for the month

= Days with at least one shortwave measurement including those days of total darkness where shortwave is defined as 0

## Fill Values

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

## Sample Data Record

A sample data granule containing 5 ES-9 regions is part of a package which also includes sample read software (in C), a Readme file, a postscript file describing granule contents, and an ASCII listing of the data in the sample granule (data dump). The sample ES-9 package can be ordered from the Langley DAAC (See Section 12.0). It is available from the Langley Web Ordering Tool and has the name format: CERES\_Test\_ES9\_version information.

# Data Organization

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

Table 5‑1. ES-9 Product Summary

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

Table 5‑2. ES-9 Product Specific Metadata

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

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

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

b. This dimension represents the number of SDS parameters contained in the vgroup.

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

## Data Granularity

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

## ES-9 Scientific Data Sets

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

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

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

| Table 5‑4. Regional Summary Data | | | | | |
| --- | --- | --- | --- | --- | --- |
| SDS Name  (Index) | Units | Range | Dimensions  of SDS  Elementsa | Bits per  Element | SDS  Size  (KB) |
| Region number  (0) | N/A | 1 .. 10,368 | 10,368 | 32 | 40.5 |
| Longitude  (150) | degrees | 0 .. 360 | 10,368 | 32 | 40.5 |
| Colatitude  (151) | degrees | 0 .. 180 | 10,368 | 32 | 40.5 |
| Geographic scene type  (1) | see  footnoteb | 1 .. 5 | 10,368 | 32 | 40.5 |
| Scene fraction histogram(1)  (2) | N/A | 0 .. 744 | 10,368 | 32 | 40.5 |
| Scene fraction histogram(2)  (3) | N/A | 0 .. 744 | 10,368 | 32 | 40.5 |
| Scene fraction histogram(3)  (4) | N/A | 0 .. 744 | 10,368 | 32 | 40.5 |
| Scene fraction histogram(4)  (5) | N/A | 0 .. 744 | 10,368 | 32 | 40.5 |
| Number of hourboxes  (6) | N/A | 1 .. 744 | 10,368 | 32 | 40.5 |
| Start position of hourbox data  (7) | N/A | 0 .. 7,713,792 | 10,368 | 32 | 40.5 |

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

b. Geographic scene type units are as follows: 1 = ocean, 2 = land, 3 = snow, 4 = desert, and 5 = coast.

| Table 5‑5. Monthly (Day), Total-sky Averages | | | | | |
| --- | --- | --- | --- | --- | --- |
| SDS Name  (Index) | Units | Range | Dimensions  of SDS  Elementsa | Bits per  Element | SDS  Size  (KB) |
| Region number  (0) | N/A | 0 .. 10,368 | 10,368 | 32 | 40.5 |
| Solar incidence  (8) | W-hm-2 | 0 .. 500,000 | 10,368 | 32 | 40.5 |
| Net radiant flux  (9) | Wm-2 | -200 .. 200 | 10,368 | 32 | 40.5 |
| Longwave flux  (10) | Wm-2 | 50 .. 450 | 10,368 | 32 | 40.5 |
| Longwave flux  minimum value  (11) | Wm-2 | 50 .. 450 | 10,368 | 32 | 40.5 |
| Longwave flux  maximum value  (12) | Wm-2 | 50 .. 450 | 10,368 | 32 | 40.5 |
| Longwave flux  standard deviation  (13) | Wm-2 | 0 .. 350 | 10,368 | 32 | 40.5 |
| Number of days of  longwave flux  (14) | days | 0 .. 31 | 10,368 | 32 | 40.5 |
| Shortwave flux  (15) | Wm-2 | 0 .. 1,400 | 10,368 | 32 | 40.5 |
| Shortwave flux  minimum value  (16) | Wm-2 | 0 .. 1,400 | 10,368 | 32 | 40.5 |
| Shortwave flux  maximum value  (17) | Wm-2 | 0 .. 1,400 | 10,368 | 32 | 40.5 |
| Shortwave flux  standard deviation  (18) | Wm-2 | 0 .. 1,400 | 10,368 | 32 | 40.5 |
| Number of days of  shortwave flux  (19) | days | 0 .. 31 | 10,368 | 32 | 40.5 |
| Albedo  (20) | unitless | 0 .. 1 | 10,368 | 32 | 40.5 |

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

| Table 5‑6. Monthly (Day), Clear-sky Averages | | | | | |
| --- | --- | --- | --- | --- | --- |
| SDS Name  (Index) | Units | Range | Dimensions  of SDS  Elementsa | Bits per  Element | SDS  Size  (KB) |
| Region number  (0) | N/A | 1 .. 10,368 | 10,368 | 32 | 40.5 |
| Solar incidence  (21) | W-hm-2 | 0 .. 500,000 | 10,368 | 32 | 40.5 |
| Net radiant flux  (22) | Wm-2 | -200 .. 200 | 10,368 | 32 | 40.5 |
| Longwave flux  (23) | Wm-2 | 50 .. 450 | 10,368 | 32 | 40.5 |
| Longwave flux  minimum value  (24) | Wm-2 | 50 .. 450 | 10,368 | 32 | 40.5 |
| Longwave flux  maximum value  (25) | Wm-2 | 50 .. 450 | 10,368 | 32 | 40.5 |
| Longwave flux  standard deviation  (26) | Wm-2 | 0 .. 350 | 10,368 | 32 | 40.5 |
| Number of days of  longwave flux  (27) | days | 0 .. 31 | 10,368 | 32 | 40.5 |
| Shortwave flux  (28) | Wm-2 | 0 .. 1,400 | 10,368 | 32 | 40.5 |
| Shortwave flux  minimum value  (29) | Wm-2 | 0 .. 1,400 | 10,368 | 32 | 40.5 |
| Shortwave flux  maximum value  (30) | Wm-2 | 0 .. 1,400 | 10,368 | 32 | 40.5 |
| Shortwave flux  standard deviation  (31) | Wm-2 | 0 .. 1,400 | 10,368 | 32 | 40.5 |
| Number of days of  shortwave flux  (32) | days | 0 .. 31 | 10,368 | 32 | 40.5 |
| Albedo  (33) | unitless | 0 .. 1 | 10,368 | 32 | 40.5 |

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

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

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

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

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

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

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

Table 5‑9. Daily, Total-sky Averages

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

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

Table 5‑10. Daily, Clear-sky Averages

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

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

| Table 5‑11. Monthly Hourly, Total-sky Averages | | | | | |
| --- | --- | --- | --- | --- | --- |
| SDS Name  (Index) | Units | Range | Dimensions  of SDS  Elementsa | Bits per  Element | SDS  Size  (KB) |
| Region number  (0) | N/A | 1 .. 10,368 | 10,368 | 32 | 40.5 |
| Solar incidence  (84) | W-hm-2 | 0 .. 50,000 | 24 x 10,368 | 32 | 972.0 |
| Longwave flux  (85) | Wm-2 | 50 .. 450 | 24 x 10,368 | 32 | 972.0 |
| Longwave flux  minimum value  (86) | Wm-2 | 50 .. 450 | 24 x 10,368 | 32 | 972.0 |
| Longwave flux  maximum value  (87) | Wm-2 | 50 .. 450 | 24 x 10,368 | 32 | 972.0 |
| Longwave flux  standard deviation  (88) | Wm-2 | 0 .. 350 | 24 x 10,368 | 32 | 972.0 |
| Number of days of  longwave flux  (89) | days | 0 .. 31 | 24 x 10,368 | 32 | 972.0 |
| Longwave sum of  estimates  (90) | Wm-2 | 0 .. 15,000 | 24 x 10,368 | 32 | 972.0 |
| Longwave sum of  estimates squared  (91) | (Wm-2)2 | 0 .. 5,000,000 | 24 x 10,368 | 32 | 972.0 |
| Shortwave flux  (92) | Wm-2 | 0 .. 1,400 | 24 x 10,368 | 32 | 972.0 |
| Shortwave flux  minimum value  (93) | Wm-2 | 0 .. 1,400 | 24 x 10,368 | 32 | 972.0 |
| Shortwave flux  maximum value  (94) | Wm-2 | 0 .. 1,400 | 24 x 10,368 | 32 | 972.0 |
| Shortwave flux  standard deviation  (95) | Wm-2 | 0 .. 1,400 | 24 x 10,368 | 32 | 972.0 |
| Number of days of  shortwave flux  (96) | days | 0 .. 31 | 24 x 10,368 | 32 | 972.0 |
| Shortwave sum of  estimates  (97) | Wm-2 | 0 .. 45,000 | 24 x 10,368 | 32 | 972.0 |
| Shortwave sum of  estimates squared  (98) | (Wm-2)2 | 0 .. 50,000,000 | 24 x 10,368 | 32 | 972.0 |
| Albedo  (99) | unitless | 0 .. 1 | 24 x 10,368 | 32 | 972.0 |

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

| Table 5‑12. Monthly Hourly, Clear-sky Averages | | | | | |
| --- | --- | --- | --- | --- | --- |
| SDS Name  (Index) | Units | Range | Dimensions  of SDS  Elementsa | Bits per  Element | SDS  Size  (KB) |
| Region number  (0) | N/A | 1 .. 10,368 | 10,368 | 32 | 40.5 |
| Solar incidence  (100) | W-hm-2 | 0 .. 50,000 | 24 x 10,368 | 32 | 972.0 |
| Longwave flux  (101) | Wm-2 | 50 .. 450 | 24 x 10,368 | 32 | 972.0 |
| Longwave flux  minimum value  (102) | Wm-2 | 50 .. 450 | 24 x 10,368 | 32 | 972.0 |
| Longwave flux  maximum value  (103) | Wm-2 | 50 .. 450 | 24 x 10,368 | 32 | 972.0 |
| Longwave flux  standard deviation  (104) | Wm-2 | 0 .. 350 | 24 x 10,368 | 32 | 972.0 |
| Number of days of  longwave flux  (105) | days | 0 .. 31 | 24 x 10,368 | 32 | 972.0 |
| Longwave sum of  estimates  (106) | Wm-2 | 0 .. 15,000 | 24 x 10,368 | 32 | 972.0 |
| Longwave sum of  estimates squared  (107) | (Wm-2)2 | 0 .. 5,000,000 | 24 x 10,368 | 32 | 972.0 |
| Shortwave flux  (108) | Wm-2 | 0 .. 1,400 | 24 x 10,368 | 32 | 972.0 |
| Shortwave flux  minimum value  (109) | Wm-2 | 0 .. 1,400 | 24 x 10,368 | 32 | 972.0 |
| Shortwave flux  maximum value  (110) | Wm-2 | 0 .. 1,400 | 24 x 10,368 | 32 | 972.0 |
| Shortwave flux  standard deviation  (111) | Wm-2 | 0 .. 1,400 | 24 x 10,368 | 32 | 972.0 |
| Number of days of  shortwave flux  (112) | days | 0 .. 31 | 24 x 10,368 | 32 | 972.0 |
| Shortwave sum of  estimates  (113) | Wm-2 | 0 .. 45,000 | 24 x 10,368 | 32 | 972.0 |
| Shortwave sum of  estimates squared  (114) | (Wm-2)2 | 0 .. 50,000,000 | 24 x 10,368 | 32 | 972.0 |
| Albedo  (115) | unitless | 0 .. 1 | 24 x 10,368 | 32 | 972.0 |

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

| Table 5‑13. Hourbox Averages | | | | | |
| --- | --- | --- | --- | --- | --- |
| SDS Name  (Index) | Units | Range | Dimensions  of SDS  Elementsa | Bits per  Element | SDS Size  (KB) |
| Region number  (116) | N/A | 1 .. 10,368 | 7,713,792 | 32 | 30,132.0 |
| Longitude  (148) | degrees | 0 .. 360 | 7,713,792 | 32 | 3,0132.0 |
| Colatitude  (149) | degrees | 0 .. 180 | 7,713,792 | 32 | 30,132.0 |
| Number of hourboxes  (117) | N/A | 1 .. 744 | 7,713,792 | 32 | 30,132.0 |
| Hourbox number  (118) | N/A | 1 .. 744 | 7,713,792 | 32 | 30,132.0 |
| Time of observation  (119) | days | 2,449,340 .. 2,458,600 | 7,713,792 | 64 | 60,264.0 |
| Scene fraction(1)  (120) | N/A | 0 .. 1 | 7,713,792 | 32 | 30,132.0 |
| Scene fraction(2)  (121) | N/A | 0 .. 1 | 7,713,792 | 32 | 30,132.0 |
| Scene fraction(3)  (122) | N/A | 0 .. 1 | 7,713,792 | 32 | 30,132.0 |
| Scene fraction(4)  (123) | N/A | 0 .. 1 | 7,713,792 | 32 | 30,132.0 |
| Albedo factor(1)  (124) | N/A | 0 .. 1 | 7,713,792 | 32 | 30,132.0 |
| Albedo factor(2)  (125) | N/A | 0 .. 1 | 7,713,792 | 32 | 30,132.0 |
| Albedo factor(3)  (126) | N/A | 0 .. 1 | 7,713,792 | 32 | 30,132.0 |
| Albedo factor(4)  (127) | N/A | 0 .. 1 | 7,713,792 | 32 | 30,132.0 |
| Cosine of the solar  zenith angle  (128) | N/A | 0 .. 1 | 7,713,792 | 32 | 30,132.0 |
| Satellite zenith angle  (129) | degrees | 0 .. 90 | 7,713,792 | 32 | 30,132.0 |
| Azimuth angle  (130) | degrees | 0 .. 360 | 7,713,792 | 32 | 30,132.0 |
| Solar incidence  (131) | W-hm-2 | 0 .. 1,450 | 7,713,792 | 32 | 30,132.0 |
| Longwave flux  (132) | Wm-2 | 50 .. 450 | 7,713,792 | 32 | 30,132.0 |
| Longwave flux  minimum value  (133) | Wm-2 | 50 .. 450 | 7,713,792 | 32 | 30,132.0 |
| Longwave flux  maximum value  (134) | Wm-2 | 50 .. 450 | 7,713,792 | 32 | 30,132.0 |
| Longwave flux  standard deviation  (135) | Wm-2 | 0 .. 350 | 7,713,792 | 32 | 30,132.0 |
| Number of longwave  flux estimates  (136) | N/A | 0 .. 5,000 | 7,713,792 | 32 | 30,132.0 |
| Longwave flux  maximum difference  (137) | Wm-2 | 0 .. 450 | 7,713,792 | 32 | 30,132.0 |
| Shortwave flux  (138) | Wm-2 | 0 .. 1,400 | 7,713,792 | 32 | 30,132.0 |
| Shortwave flux  minimum value  (139) | Wm-2 | 0 .. 1,400 | 7,713,792 | 32 | 30,132.0 |
| Shortwave flux  maximum value  (140) | Wm-2 | 0 .. 1,400 | 7,713,792 | 32 | 30,132.0 |
| Shortwave flux  standard deviation  (141) | Wm-2 | 0 .. 1,400 | 7,713,792 | 32 | 30,132.0 |
| Number of shortwave  flux estimates  (142) | N/A | 0 .. 5,000 | 7,713,792 | 32 | 30,132.0 |
| Shortwave flux  maximum difference  (143) | Wm-2 | 0 .. 1,400 | 7,713,792 | 32 | 30,132.0 |
| Clear-sky longwave flux  (144) | Wm-2 | 50 .. 450 | 7,713,792 | 32 | 30,132.0 |
| Clear-sky longwave flux  standard deviation  (145) | Wm-2 | 0 .. 350 | 7,713,792 | 32 | 30,132.0 |
| Number of clear-sky  longwave flux estimates  (146) | N/A | 0 .. 5,000 | 7,713,792 | 32 | 30,132.0 |
| Clear-sky albedo  standard deviation  (147) | unitless | 0 .. 1 | 7,713,792 | 32 | 30,132.0 |

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

# Theory of Measurements and Data Manipulations

## Theory of Measurements

See CERES ATBD Subsystem 3.0 (Reference 6).

## Data Processing Sequence

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

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

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

## Special Corrections/Adjustments

See CERES ATBD Subsystem 2.0 (see Reference 4).

# Errors

See the Data Quality Summary {URL=http://eosweb.larc.nasa.gov/project/ceres/ES9/disclaimer\_CER\_ES9.html}.

## 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.)

## Data Validation by Source

See Subsystem 3.0 Validation Document (Reference 15).

# Notes

# Application of the Data Set

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

# Future Modifications and Plans

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

# 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.

# Data Access

## 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:

## Data Center Identification

EOSDIS Langley DAAC

NASA Langley Research Center

Hampton, VA 23681-2199

# Output Products and Availability

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

# 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](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](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](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](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](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](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. ERBE Data Management System, Earth Flux and Albedo, (Scanner) S-9, User’s Guides, December 1994.
14. Brooks, D. R. and P. Minnis, “Comparison of Longwave Diurnal Models Applied to Simulations of the Earth Radiation Budget Experiment,” Journal of Climate and Applied Meteorology, 23, 155-160, 1984.
15. Clouds and the Earth’s Radiant Energy System (CERES) Validation Plan, ERBE-like Averaging to Monthly TOA Fluxes (Subsystem 3.0), Release 3.0, February 1999 {[URL = http:/ceres.larc.nasa.gov/validation.php](http://ceres.larc.nasa.gov/validation.php)}.

# 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.

# Acronyms and Units

## 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

## 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-2sr-1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 |
| W2 m-4 | square Watt per meter to the 4th |
| W m-2 | Watt per square meter |
| W m-2sr-1 | Watt per square meter per steradian |
| W m-2sr-1m-1 | Watt per square meter per steradian per micron |
| °C | degrees centigrade |
| m | micrometer, micron |

## ES-9 Symbols

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

| **Symbol** | **Definition** |
| --- | --- |
|  | Day |
|  | (from) Daily average |
|  | Hour |
|  | (from) Monthly hourly average |
|  | Integrated daily solar incident radiance. |
|  | Days that contain at least one longwave measurement. |
|  | Days that contain at least one shortwave measurement. |
|  | “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) |
|  | Regional longwave average flux for hourbox, (*d, h*). |
|  | Monthly longwave flux as calculated from regional longwave averages, , overall hourboxes in the month. (Item 14, Table 4‑5) |
|  | Monthly hourly average of longwave flux. (Item 97, Table 4‑11) |
|  | Monthly (Hour) longwave flux calculated from longwave monthly hourly averages. (Item 42, Table 4‑7) |
|  | Monthly net flux as calculated from regional longwave averages, , over all hourboxes in the month. (Item 13, Table 4‑5) |
|  | Monthly net radiant flux based on monthly hourly averages (*mha*). (Item 41, Table 4‑7) |
|  | “Instantaneous regional estimates” of shortwave flux used as input to Subsystem 3.0 for modeling monthly net radiant flux values. (see Reference 11) |
|  | Monthly (Hour) mean shortwave flux. (Item 47, Table 4‑7) |
|  | Daily average for the shortwave flux. (Item 75, Table 4‑9) |
|  | Monthly mean shortwave flux based on daily shortwave flux values. (Item 19, Table 4‑5) |
|  | Regional shortwave average flux for hourbox, (*d, h*). |
|  | Monthly hourly averages for the shortwave flux over the month. |
|  | Number of days in the month with any data. |
|  | Number of days that contain at least one longwave measurement. |
|  | Number of longwave monthly hourly averages, i.e. if for hour *h*, any day in the month contains longwave data, , this hour is included in the count. |
|  | Number of days that contain at least one shortwave measurement. |
|  | Number of hours with shortwave measurements for a day that includes at least one shortwave measurement. (Item 79, Table 4‑9) |
|  | Summed daily solar incident radiance. |
|  | Monthly albedo as calculated from daily shortwave averages, , and solar incoming radiation, , for only those days which contain one or more shortwave measurement. (Item 24, Table 4‑5) |
|  | Monthly hourly average albedo. (Item 111, Table 4‑11) |

# Document Information

## Document Revision Date

April 1998 - Original Version

June 1998 - Revision

CERES Metadata

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

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

s = string date = yyyy-mm-dd

F = float time = hh:mm:ss.xxxxxxZ

I = integer datetime = yyyy-mm-ddThh:mm:ss.xxxxxxZ

| Table A‑1. CERES Baseline Header Metadata | | | | | |
| --- | --- | --- | --- | --- | --- |
| Item | Parameter Name | Units | Range | Data Type | No. of Elements |
| 1 | ShortName | N/A | N/A | s(8) | 1 |
| 2 | VersionID | N/A | 0 .. 255 | I3 | 1 |
| 3 | CERPGEName | N/A | N/A | s(20) | 1 |
| 4 | SamplingStrategy | N/A | CERES, TRMM-PFM-VIRS, AM1-FM1-MODIS, TBD | s(20) | 1 |
| 5 | ProductionStrategy | N/A | Edition, Campaign, DiagnosticCase, PreFlight, TBD | s(20) | 1 |
| 6 | CERDataDateYear | N/A | 1997 .. 2050 | s(4) | 1 |
| 7 | CERDataDateMonth | N/A | 1 .. 12 | s(2) | 1 |
| 8 | CERDataDateDay | N/A | 1 .. 31 | s(2) | 1 |
| 9 | CERHrOfMonth | N/A | 1 .. 744 | s(3) | 1 |
| 10 | RangeBeginningDate | N/A | 1997-11-19 .. 2050-12-31 | date | 1 |
| 11 | RangeBeginningTime | N/A | 00:00:00.000000Z .. 24:00:00:000000Z | time | 1 |
| 12 | RangeEndingDate | N/A | 1997-11-19 .. 2050-12-31 | date | 1 |
| 13 | RangeEndingTime | N/A | 00:00:00.000000Z .. 24:00:00:000000Z | time | 1 |
| 14 | AssociatedPlatformShortName | N/A | TRMM, AM1, PM1, TBD | s(20) | 1 - 4 |
| 15 | AssociatedInstrumentShortName | N/A | PFM, FM1, FM2, FM3, FM4, FM5, TBD | s(20) | 1-4 |
| 16 | LocalGranuleID | N/A | N/A | s(80) | 1 |
| 17 | PGEVersion | N/A | N/A | s(10) | 1 |
| 18 | CERProductionDateTime | N/A | N/A | 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 |
| 34 26 | CERGRingPointLatitude | deg | 0.0 .. 180.0 | F11.6 | 5 |
| 35 27 | CERGRingPointLongitude | deg | 0.0 .. 360.0 | F11.6 | 5 |
| 36 28 | GRingPointSequenceNo | N/A | 0 .. 99999 | I5 | 5 |
| 37 29 | ExclusionGRingFlag | N/A | Y (= YES), N (= NO) | s(1) | 1 |
| 38 | AutomaticQualityFlag | N/A | Passed, Failed, or Suspect | s(64) | 1 |
| 39 | AutomaticQualityFlagExplanation | N/A | N/A | s(255) | 1 |
| 40 | QAGranuleFilename | N/A | N/A | s(255) | 1 |
| 41 | ValidationFilename | N/A | N/A | s(255) | 1 |
| 42 | ImagerShortName | N/A | VIRS, MODIS, TBD | s(20) | 1 |
| 43 | InputPointer | N/A | N/A | s(255) | 800 |
| 44 | NumberInputFiles | N/A | 1 .. 9999 | I4 | 1 |

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

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