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

Data Management System

Product Name (Acyonym) Collection Document

Release 1
Version 1

Primary Authors

SSAI people

Science Systems and Applications, Inc. (SSAI)
One Enterprise Parkway, Suite 200
Hampton, VA 23666

DMO people

NASA Langley Research Center
Climate Science Branch
Science Directorate
Building 1250
21 Langley Boulevard
Hampton, VA 23681-2199

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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
xx/xx/11	R1V1	xxx	• Initial draft document. •	All

Preface

The Clouds and the Earth's Radiant Energy System (CERES) Data Management System supports the data processing needs of the CERES Science Team research to increase understanding of the Earth's climate and radiant environment. The CERES Data Management Team works with the CERES Science Team to develop the software necessary to implement the science algorithms. This software, being developed to operate at the Langley Atmospheric Sciences Data Center (ASDC), produces an extensive set of science data products.

The Data Management System consists of 12 subsystems; each subsystem represents one or more stand-alone executable programs. Each subsystem executes when all of its required input data sets are available and produces one or more archival science products.

This Collection Guide is intended to give an overview of the science product along with definitions of each of the parameters included within the product. The document has been reviewed by the CERES Working Group teams responsible for producing the product and by the Working Group Teams who use the product.

Acknowledgment is given to *person1 and person2 (whoever helped with the logistics)* of Science Systems and Applications, Inc. (SSAI) for their support in the preparation of this document.

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Product Acronym (XYZ) Collection Document

Summary

The Clouds and the Earth’s Radiant Energy System (CERES) is a key component of the Earth Observing System (EOS) program. The CERES instrument provides radiometric measurements of the Earth's atmosphere from three broadband channels: a shortwave channel (0.3 - 5 μm), a total channel (0.3 - 200 μm), and an infrared window channel (8 - 12 μm). The CERES instruments are improved models of the Earth Radiation Budget Experiment (ERBE) scanner instruments, which operated from 1984 through 1990 on 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 Terra and Aqua EOS satellites carry two CERES instruments, one operating in a FAPS mode for continuous Earth sampling and the other operating in a 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, to define the physical properties of clouds, to define the surface radiation budget, and to determine the divergence of energy throughout the atmosphere. The CERES DMS produces products which support research to increase understanding of the Earth’s climate and radiant environment.

[Product Specific Information]

1.0 Collection Overview

1.1 Collection Identification

The *PSN* filename is

CER_*PSN*_Sampling-Strategy_Production-Strategy_XXXXXX.YYYYMM[DD][HH] where

CER	Investigation designation for CERES,
PSN	Product ID for the 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,
MM	2-digit integer defining data acquisition month, and
DD	2-digit integer defining the data acquisition day,
HH	2-digit hour integer which defines the data acquisition date *[Modify as needed for daily and monthly products.]*

1.2 Collection Introduction

[Product Specific Information]

1.3 Objective/Purpose

The overall science objectives of the CERES investigation are

1. For climate change research, provide a continuation of the ERBE record of radiative fluxes at the top of the atmosphere (TOA) that are analyzed using the same techniques used with existing ERBE data.
2. Double the accuracy of estimates of radiative fluxes at the TOA and the Earth's surface from existing ERBE data.
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.

The CERES Data Management System (DMS) is a software management and processing system which processes CERES instrument measurements and associated engineering data to produce archival science and other data products. The DMS is executed at the LaRC ASDC, which is also responsible for distributing the data products. A high-level view of the CERES DMS is illustrated by the CERES Top Level Data Flow Diagram shown in Figure 1-1.

Circles in the diagram represent algorithm processes called subsystems, which are a logical collection of algorithms that 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.

1.4 Summary of Parameters

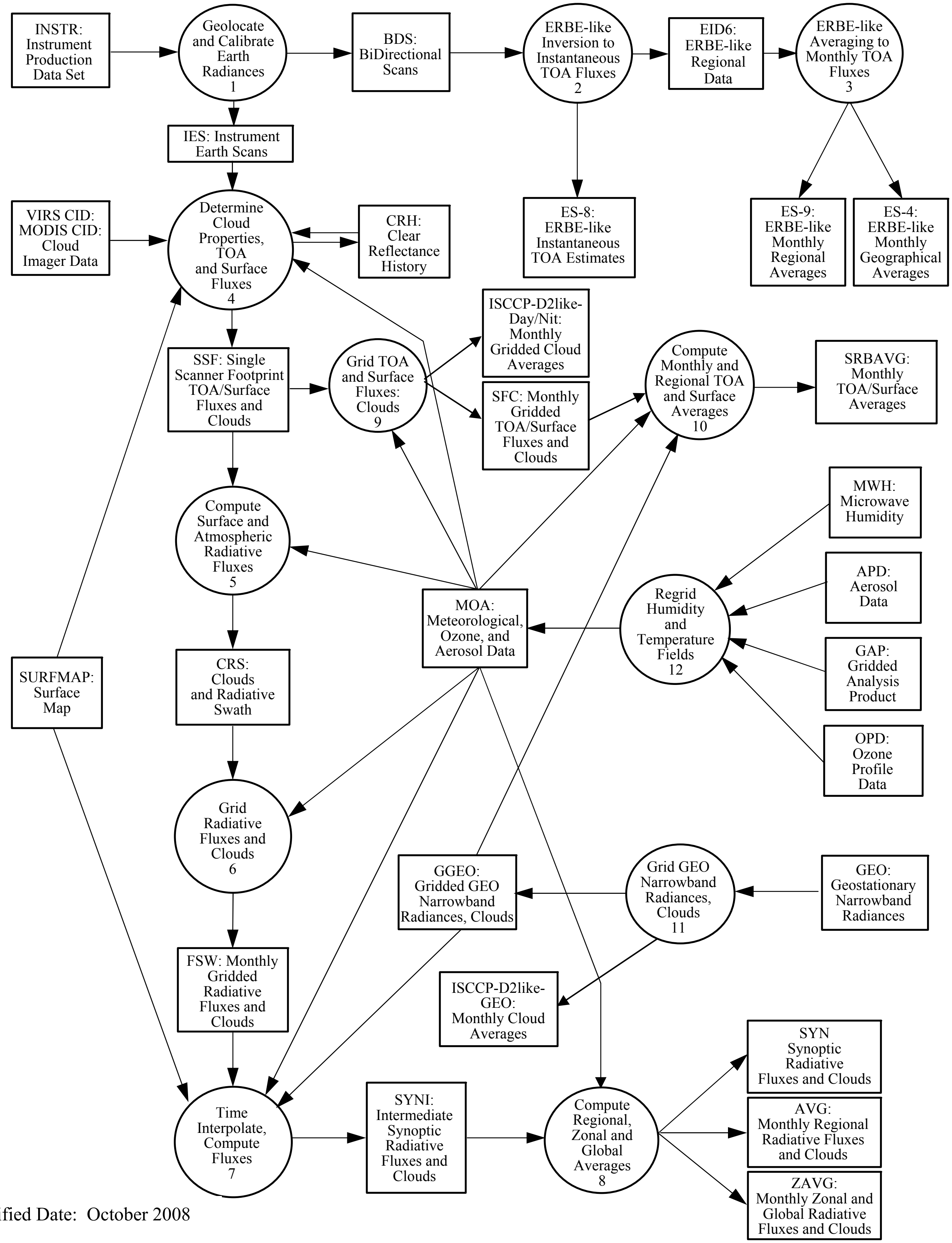
[Product Specific Information – could be table of parameters here instead of in Section 4]

1.5 Discussion

[Product Specific Information]

1.6 Related Collections

See the CERES Data Products Catalog (Reference 1) for a complete product listing.



Modified Date: October 2008

Figure 1-1. CERES Top Level Data Flow Diagram

2.0 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

2.1 Title of Investigation

Subsystem Name [Subsystem #]
e.g.,. Geolocate and Calibrate Earth Radiances (Subsystem 1.0)

2.2 Contact Information

Working Group Chair Name, Subsystem X Working Group Chair
Mail Stop 420
Atmospheric Sciences Research
21 Langley Boulevard
NASA Langley Research Center
Hampton, Virginia 23681-2199
Telephone: (757) 864-xxxx
FAX: (757) 864-7996
E-mail: p.q.name@larc.nasa.gov

3.0 Origination

The CERES data originate from CERES instruments on-board either the TRMM, Terra or Aqua EOS Earth-orbiting spacecrafts. Table 3-1 lists the CERES instruments and their host satellites.

Table 3-1. CERES Instruments

Satellite	CERES Instrument	
TRMM	PFM	
Terra	FM1	FM2
Aqua	FM3	FM4

The CERES instrument contains three scanning thermistor bolometer radiometers that measure the radiation in the near-visible through far-infrared spectral region. The shortwave detector measures Earth-reflected and Earth-emitted solar radiation and the window detector measures Earth-emitted longwave radiation in the water vapor window. The total detector measures total Earth-reflected and Earth-emitted radiation. The detectors are coaligned and mounted on a spindle that rotates about the instrument elevation axis. The resolution of the CERES radiometers is usually referenced to the optical FOV (See *Note TBD*).

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-viewing science measurements while the detectors rotate in the vertical (elevation scan) plane, and while the instrument horizontal (azimuth scan) plane is either fixed or rotating. 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 document, DRL 64, provided by the CERES instrument builder TRW (Reference 3), and the CERES ATBD for Subsystem 1.0 (Reference 4).

4.0 Data Description

4.1 Spatial Characteristics

4.1.1 Spatial Coverage

The XYZ collection is a global data set whose spatial coverage depends on the satellite orbit as shown in Table 4-1. *[Product Specific Information]*.

Table 4-1. *XYZ* Spatial Coverage

Spacecraft	Instrument	Minimum Latitude (deg)	Maximum Latitude (deg)	Minimum Longitude (deg)	Maximum Longitude (deg)	Spacecraft Altitude (km)
TRMM	PFM	-45	45	-180	180	350
Terra	FM1 & FM2	-90	90	-180	180	705
Aqua	FM3 & FM4	-90	90	-180	180	705

4.1.2 Spatial Coverage Map

[Product Specific Information – use postage stamp size images that links to full-sized images – recommendation from the ASDC – or delete if image is in ASDC HTML overview]

4.1.3 Spatial Resolution

[Product Specific Information]

4.1.4 Projection

[Applies to gridded data. Delete section from instantaneous products.]

4.1.5 Grid Description

[Applies to gridded data. Delete section from instantaneous products.]

4.2 Temporal Characteristics

4.2.1 Temporal Coverage

The XYZ temporal coverage begins after the spacecraft is launched, the scan covers are opened, and the early in-orbit calibration check-out is completed (see Table 4-2).

Table 4-2. *XYZ* Temporal Coverage

Spacecraft	Instrument	Launch Date	Start Date	End Date
TRMM	PFM	11/27/1997	12/27/1997	8/31/1998[a]
Terra	FM1 & FM2	12/18/1999	02/24/2000	TBD
Aqua	FM3 & FM4	05/05/2002	06/19/2002	TBD

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

[Product Specific Information]

4.2.2 Temporal Resolution

[Product Specific Information]

4.3 Data Characteristics

[Product Specific Information]

4.3.1 Parameter/Variable

[Product Specific Information] Table of parameters, units, ranges, …- similar to Table in Data Products Catalog. Describe the table and any hyperlinking. The *XYZ* metadata are listed in Appendix A.

4.3.2 Variable Description/Definition

[Product Specific Information - a detailed definition of each parameter. If the parameter is copied from a product produced by a previous subsystem, the producing subsystem will define the parameter. All users must have chance to review and approve the definitions. A parameter will be defined only once and will be pulled into each relevant document - the following parameters are examples from the BDS Guide, in which the parameters are grouped into 3 major divisions - 2 of those are shown as examples.]

4.3.2.1 Science Parameter Descriptions

The CERES science parameters are computed using the geodetic coordinate system. However, several parameters are computed in the geocentric coordinate system, and will specifically include the term "geocentric" in the parameter name. The geocentric parameters are used by the ERBElike Subsystems since ERBE products are archived in the geocentric coordinate system.

SCI-1 CERES Relative Azimuth at Surface

This parameter is the geodetic azimuth angle ϕ (See Figure 4-1) at the Earth point (See Term-4) of the satellite relative to the solar plane. (deg) [0 .. 360] {Section 5.2.1 Scientific Data Sets (SDS)}

The relative azimuth is measured clockwise in the plane normal to the geodetic zenith (See Term-9) so that the relative azimuth of the Sun is always 180^o. The solar plane is the plane which contains the geodetic zenith vector and a vector from the Earth point to the Sun. If the Earth point is north of the geodetic subsolar point (See Term-8) on the same meridian, then an azimuth of 90^o would imply the satellite is east of the Earth point.

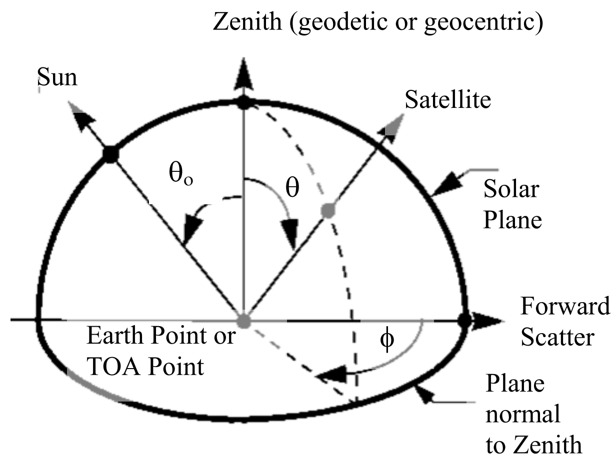


Figure 4-1. Viewing Angles at Surface or TOA

SCI-2 CERES Relative Azimuth at TOA - Geocentric

This parameter is the geocentric azimuth angle ϕ (See Figure 4-1) at the TOA point (See Term-14) of the satellite relative to the solar plane. (deg) [0 .. 360] {Section 5.2.1 Scientific Data Sets (SDS)}

The relative azimuth is measured clockwise in the plane normal to the geocentric zenith (See Term-7) so that the relative azimuth of the Sun is always 180^o. The solar plane is the plane which contains the geocentric zenith vector and a vector from the TOA point to the Sun. If the TOA point is north of the geocentric subsolar point (See Term-6) on the same meridian, then an azimuth of 90^o would imply the satellite is east of the target point.

SCI-3 CERES Solar Zenith at Surface

This parameter is the geodetic zenith angle θ_o (See Figure 4-1) at the Earth point (See Term-4) of the Sun. (deg) [0 .. 180] {Section 5.2.1 Scientific Data Sets (SDS)}

The geodetic solar zenith is the angle between the geodetic zenith (See Term-9) vector and a vector from the Earth point to the Sun.

SCI-4 CERES Solar Zenith at TOA - Geocentric

This parameter is the geocentric zenith angle θ_o (See Figure 4-1) at the TOA point (See Term-14) of the Sun. (deg) [0 .. 180] {Section 5.2.1 Scientific Data Sets (SDS)}

The geocentric solar zenith is the angle between the geocentric zenith (See Term-7) vector and a vector from the TOA point to the Sun.

SCI-5 CERES Viewing Zenith at Surface

This parameter is the geodetic angle θ (See Figure 4-1) at the Earth point (See Term-4) to the satellite. (deg) [0 .. 90] {Section 5.2.1 Scientific Data Sets (SDS)}

The geodetic viewing zenith is the angle between the geodetic zenith (See Term-7) vector and a vector from the Earth point to the satellite.

SCI-6 Clock Angle of CERES FOV at Satellite wrt Inertial Velocity

The clock angle (See Figure 4-2 and Figure 4-3) is the azimuth angle of the instrument view vector from the satellite to the Earth point (See Term-4) relative to the inertial velocity vector. (deg) [0 .. 360] {Section 5.2.1 Scientific Data Sets (SDS)}

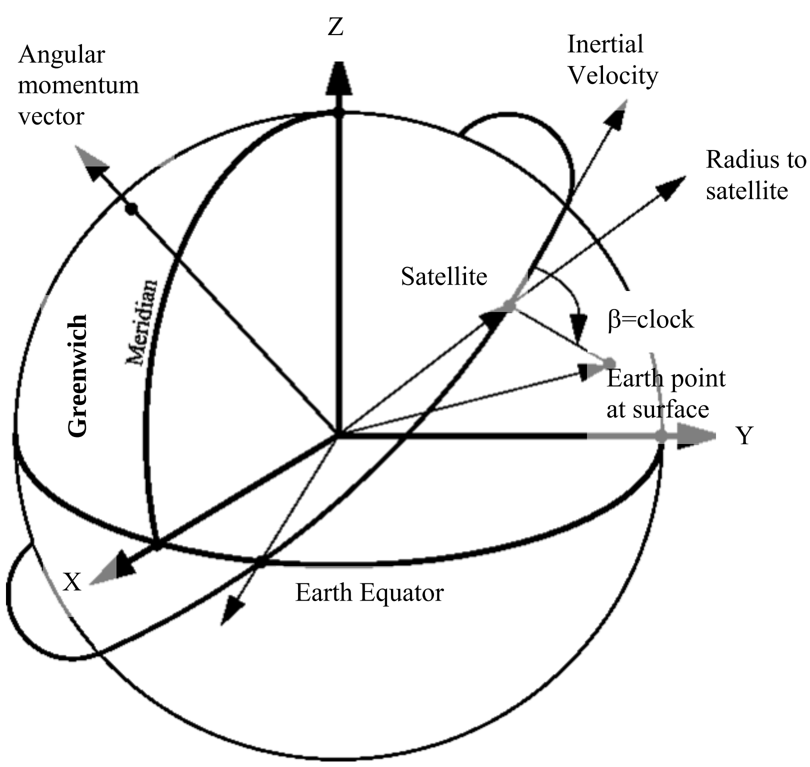


Figure 4-2. Clock Angle

The clock angle, along with the cone angle (See Figure 4-3 and SCI-7) define the direction of the instrument view vector to the Earth point.

The clock angle β is defined in a right-handed coordinate system centered at the satellite where z is toward the center of the Earth, x is in the direction of the inertial velocity vector, and y completes the triad.

When β = 270^{o,} the Earth point is on the same side of the orbit as the orbital angular momentum vector (See Figure 4-2). When β = 0^{o}, the Earth point is directly ahead of the satellite.

The toolkit call (See Reference 5) PGS_CSC_SCtoORB transforms the instrument view vector in spacecraft coordinates to (x,y,z) orbital coordinates and the clock angle is defined by

$$x/d = \cos\ \beta$$

and

$$y/d = \sin \beta$$

and

$$d = \sqrt{x^2 + y^2}$$

SCI-7 Cone Angle of CERES FOV at Satellite

The cone angle (See Figure 4-3) is the angle between a vector from the satellite to the center of the Earth and the instrument view vector from the satellite to the Earth point (See Term-2). (deg) [0 .. 90] {Section 5.2.1 Scientific Data Sets (SDS)}

The cone angle, along with the clock angle, (See Figure 4-2 and SCI-6) define the direction of the instrument view vector to the Earth point.

The toolKit call (See Reference 5) PGS_CSC_SCtoORB transforms the instrument view vector in spacecraft coordinates to (x,y,z) orbital coordinates (See SCI-6) and the cone angle is defined by z = cosα.

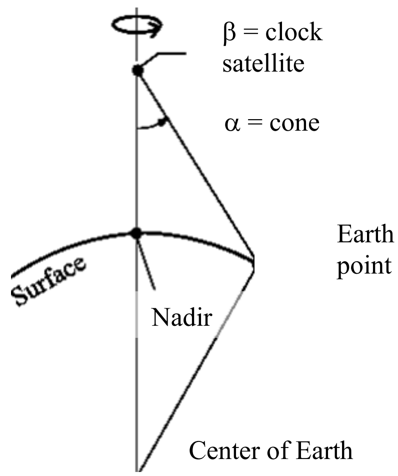


Figure 4-3. Cone and Clock Angles

4.3.2.2 Instrument Parameter Descriptions

[Bunch of parameters in alphabetical ordered related to the instrument or housekeeping parameters.]

INS-1 Elevation Offset Correction

This parameter indicates an internal count adjustment to compensate for the encoder position to actual gimbal position misalignment. This value will reflect the internal default value or the last update by the Set_Elevation_Offset_Correction command. The converted value is computed using DRL-64 (Reference 2) Algorithm Linear Coefficients. This value needs to be treated as a signed integer data representation. The default nominal unsigned and signed integer offset values for each instrument, as specified in the flight codes, are shown in Table B-4. (deg) [0 .. 360] {Section 5.2.2.1 Converted Instrument Status Data}

INS-2 Packet Data Version

This parameter indicates the flight code version burned into the Instrument's EPROMs. The default values for each of the instrument are shown below.

- **PFM (TRMM) = 4**
- **FM1/FM2 (EOS-AM) = 5**
- **FM3/FM4 (EOS-PM) = 6**

(N/A) [0..31] {Section 5.2.2.1 Converted Instrument Status Data}

4.3.3 Fill Values

Table 4-3 lists the default CERES Fill Values. These are used when data are missing, when there is insufficient data to make a calculation, or the data are suspect and there is no quality flag associated with the parameter. A value which has a corresponding flag need not be set to the CERES default value when the data value is suspect. Suspect values are values that were calculated but failed edit checks. The CERES default fill values are defined as follows:

Table 4-3. CERES Fill Values

Fill Value Name	Value	Fill Value Description*
INT1_DFLT	127	default value for a 1-byte integer
INT2_DFLT	32767	default value for a 2-byte integer
INT4_DFLT	2147483647	default value for a 4-byte integer
REAL4_DFLT	3.4028235E+38	default value for a 4-byte real
REAL8_DFLT	1.7976931348623157E+308	default value for a 8-byte real

* 1 byte = 8 bits

4.3.4 Data Types

[Include if relevant]
The following data types are used to represent numerical parameters in the *XYZ* product:

Table 4-4. Data Types and Formats

Data Type	Range	Format
Unsigned 8 Bit Integer	0..255	N/A
Signed 8 Bit Integer	-127..127	N/A
Unsigned 16 Bit Integer	0..65536	N/A
Signed 16 Bit Integer	-32767..32767	N/A
Unsigned 32 Bit Integer	0..4294967296	N/A
Signed 32 Bit Integer	-2147483648..2147483648	N/A
32 Bit Float	platform dependent	11.6
64 Bit Float	platform dependent	13.8

4.4 Sample Data Record

[Include 1 sample record with parameter labels or delete section.]

5.0 Data Organization

[Product Specific Information - discuss your HDF structures. e.g.]
This section discusses the organization of the BDS structures as written to the output data file. All BDS data products use Hierarchical Data Format (HDF) structures such as Vertex Data (Vdata) and Scientific Data Sets (SDSs). See the HDF User's Guide for additional information (Reference 6). BDS Metadata is implemented using the ECS ToolKit metadata routines (Reference 5), which are based on HDF Annotations.

5.1 Data Granularity

[Product Specific Information - e.g.]
All BDS data granules are stored in the HDF developed by the National Center for Supercomputing Applications (NCSA). The HDF permits aggregation of commonly used data structures within a single file, and a common, platform independent Application Programming Interface (API). The BDS product contains HDF SDSs and Vdata structures.

5.2 Data Format

[Product Specific Information - e.g.]
All BDS data granules are stored in the HDF developed by the National Center for Supercomputing Applications (NCSA). The HDF permits aggregation of commonly used data structures within a single file, and a common, platform independent Application Programming Interface (API). The BDS product contains HDF SDSs and Vdata structures.

5.2.1 Scientific Data Sets (SDS)

[An example from BDS]
A Scientific Data Set is an HDF structure capable of storing large quantities of a single data type. SDSs are organized by dimensions, and a single SDS can have up to 32 dimensions. Table 5-1 lists the parameters that are stored as SDSs. The entries in the Link and SDS Name columns are hyperlinked to a definition of the parameter. The HDF rank of all BDS SDSs is 2 (2-dimensional arrays). The size column specifies the dimensions where n is the number of packets. The HDF data type, the size of the SDS, and which products contain each SDS are also shown in the summary table. The key for the Product Types is in the summary table header.

Table 5-1. BDS Scientific Data Set (SDS) Summary

Link	SDS Name	Size	Data Type	Nominal Size MB	BDS Product Types (*)
(*) A=BDS, S=BDSS, D=BDSD, F=BDSF, G=BDSG, M=BDSM, P=BDSP					
SCI-1	CERES Relative Azimuth at Surface	660 x n	32 bit float		A, S, D, --, G, M, P
SCI-2	CERES Relative Azimuth at TOA - Geocentric	660 x n	32 bit float		A, S, D, --, G, M, P
SCI-3	CERES Solar Zenith at Surface	660 x n	32 bit float		A, S, D, --, G, M, P
SCI-4	CERES Solar Zenith at TOA - Geocentric	660 x n	32 bit float		A, S, D, --, G, M, P

5.2.2 Vertex Data (VData)

[An example]

A Vdata is an HDF structure that allows record-based storage of multiple parameters and/or multiple data types as shown in the example in Table 5-2. Vdata records are analogous to records found in relational database systems where a single record is composed of one or more data fields, and each data field can be represented by its own data type.

Table 5-2. Vdata Record Example

Field 1 Unsigned 16 bit Integer	**Field 2 32 bit Floats**		**Field 3 Signed 8 bit Integer**
Value	Value 1	Value 2	Value

Table 5-3 is a summary of the Vdata structures contained in the BDS products. Following the summary table are tables that list the components of each of the Vdatas. These tables represent the Vdata structures as written to the data products. The data descriptions are hyperlinked from the Parameter Name column in each of the tables.

Table 5-3. Vdata Summary

Vdata Name	Section Link	Records	Number of Fields	Nominal Size (MB)	BDS Product Types (*)
Converted Instrument Status Data	Sec. 5.2.2.1	n	25	1.1	A, S, D, F, G, M, P
Vdata Total Size				30.36	
(*) A=BDS, S=BDSS, D=BDSD, F=BDSF, G=BDSG, M=BDSM, P=BDSP					

5.2.2.1 Converted Instrument Status Data

BDS Product Types: BDS, BDSS, BDSD, BDSF, BDSM, BDSG, BDSP

This data set contains the converted values for instrument status parameters that have defined conversion algorithms. Packet status information that is not part of the raw digital status data block is also included in this data set.

Table 5-4. Converted Instrument Status Data Field Summary

Link	Field Num	Parameter Name	Order	Data Type
INS-1	1	Elevation Offset Correction	1	32 bit float
INS-2	21	Packet Data Version	1	Unsigned 16 bit integer
	Record Size (bytes)			92

6.0 Theory of Measurements and Data Manipulations

6.1 Theory of Measurements

See Reference 3 for the basic theory of measurements.

6.2 Data Processing Sequence

[Product Specific Information]
For detailed information see the Subsystem Architectural Design Document. (Reference 7)

6.3 Special Corrections/Adjustments

Algorithms not discussed in the ATBD are discussed in this section.

7.0 Errors

See CERES ATBD Subsystem Number. (Reference 4)
[may wish to include high level accuracy goals]

7.1 Quality Assessment

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

7.2 Data Validation by Source

See Subsystem *Subsystem Number* Validation Document. (Reference 8) for details on the data validation plans.

8.0 Notes

Note-1 Field-of-View (FOV)

Field-of-View and footprint are synonymous. The CERES FOV is determined by its PSF (See Note-1 and Term-1) which is a two-dimensional, bell-shaped function that defines the CERES instrument response to the viewed radiation field.

The resolution of the CERES radiometers is usually referenced to the optical FOV which is 1.3° in the along-track direction and 2.6° in the cross-track direction. For example, on TRMM with a satellite altitude of 350 km, the optical FOV at nadir is 8 × 16 km which is frequently referred to as an equivalent circle with a 10 km diameter, or simply as 10 km resolution. On EOS-AM with a satellite altitude of 705 km, the optical FOV at nadir is 16 × 32 km or 20 km resolution.

The CERES FOV or footprint size is referenced to an oval area that represents approximately 95% of the PSF response (See Note-2 and Term-1) for numerical representation of FOV). Since the PSF is defined in angular space at the instrument, the CERES FOV is a constant in angular space, but grows in surface area from a minimum at nadir to a larger area at shallow viewing angles (See SCI-7). For TRMM, the length and width of this oval at nadir is 19 × 15 km and grows to 138 × 38 km at a viewing zenith angle (See SCI-7) of 70°. For EOS-AM/PM, the length and width at nadir is 38 × 31 km and grows to 253 × 70 km at a viewing zenith angle of 70°.

Note-2 CERES Point Spread Function

Note-2.1 CERES Point Spread Function

The CERES scanning radiometer is an evolutionary development of the ERBE scanning radiometer. It is desired to increase the resolution as much as possible, using a thermistor bolometer as the detector. As the resolution is increased, the sampling rate must increase to achieve spatial coverage. When the sampling rate becomes comparable to the response time of the detector, the effect of the time response of the detector on the PSF must be considered. Also, the signal is usually filtered electronically prior to sampling in order to attenuate electronic noises and to remove high frequency components of the signal which would cause aliasing errors. The time response of the filter, together with that of the detector causes a lag in the output relative to the input radiance. This time lag causes the centroid of the PSF to be displaced from the centroid of the optical FOV. Thus, the signal as sampled comes not only from where the radiometer is pointed, but includes a "memory" of the input from where it had been looking. Another effect of the time response is to broaden the PSF, which will reduce the resolution of the measurement, increase blurring errors, and decrease aliasing errors.

Note-2.2 Geometry of the Point Spread Function

The scanner footprint geometry is given in Figure 8-1. The optical FOV is a truncated diamond (or hexagon) and is 1.3° in the along-scan direction and 2.6° in the across-scan direction. The

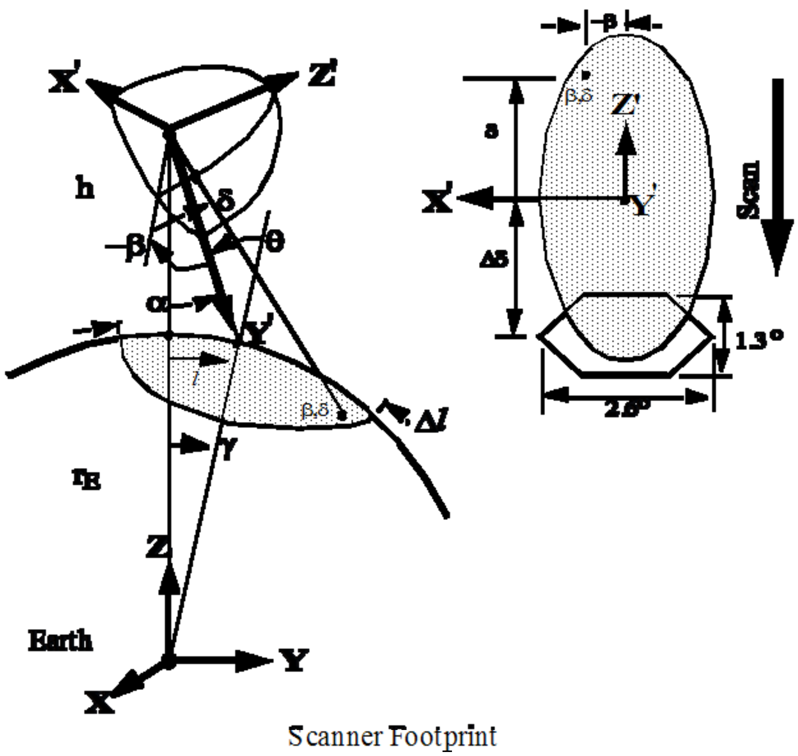


Figure 8-1. Scanner Footprint

effective FOV (or footprint) is given by the PSF and is shown as an ellipse. A point within the footprint is located by β and δ. The cone angle α (or nadir angle) determines the location of the footprint centroid on the Earth. If α = 0, the footprint is at nadir. The viewing zenith angle θ is a direct result of the satellite altitude h, the Earth radius r_E, and the cone angle α. The surface distance *l* and the Earth central angle γ between nadir and the centroid are also a result of the viewing geometry. In Figure 8-1 we have denoted the length of the FOV by Δ*l*.

Figure 8-3 gives three CERES FOVs. The shaded area is the optical FOV. Note that only half of the FOV is given since it is symmetrical about the scan line. The origin has been placed at the centroid of the PSF which trails the optical axis by about 1.5 degree. This is the lag that is inherent in the system. About the PSF centroid, the outline has been drawn on the 95-percent energy boundary. An angular grid, also has been drawn over the 95% energy FOV for weighting cloud parameters in a later process. All of the pertinent dimensions are given.

Note-2.3 Analytic form of the Point Spread Function

A full discussion of an analytic model of the point spread function and its development are given in Smith (See Reference 9). From Figure 8-1, we redraw half of the optical FOV in Figure 8-2

$$\delta_f'(\beta) = \begin{cases} -\alpha & 0 \le \beta < \alpha \\ -2\alpha + \beta & \alpha \le \beta < 2a \end{cases}$$

$$\delta_b'(\beta) = \begin{cases} \alpha & 0 \le \beta < \alpha \\ 2\alpha - \beta & \alpha \le \beta < 2a \end{cases}$$

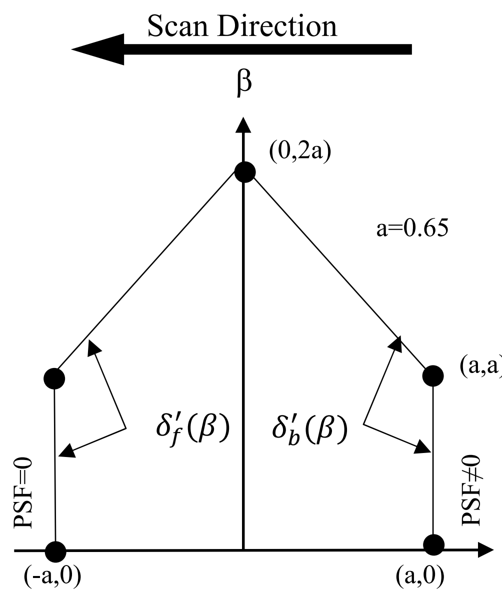


Figure 8-2. Optical FOV

where δ' is the along-scan angle and β is the cross-scan angle. Note that δ' points opposite the scan direction and increases toward the tail of the PSF (See Figure 8-3). The forward and back boundaries are given by $\delta'_f(\beta)$ and $\delta'_b(\beta)$, respectively. With these definitions the CERES PSF is written as

$$P(\delta', \beta) = \begin{cases} 0 & |\beta| > 2\alpha \\ 0 & \delta' < \delta'_f(\beta) \\ F[\delta' - \delta'_f(\beta)] & \delta'_f(\beta) \leq \delta' < \delta'_b(\beta) \\ F[\delta' - \delta'_f(\beta)] - F[\delta' - \delta'_b(\beta)] & (otherwise) \end{cases} \quad (1)$$

where

$$F(\xi) = 1 - (1 + a_1 + a_2)e^{-1.78348\xi}$$
$$+ e^{-3.04050\xi}[a_1 \cos(0.91043\xi) + b_1 \sin(0.91043\xi)] \quad (2)$$
$$+ e^{-2.20860\xi}[a_2 \cos(2.78981\xi) + b_2 \sin(2.78981\xi)]$$

and

$$a_1 = 5.83761 \quad a_2 = -0.18956$$
$$b_1 = 2.87362 \quad b_2 = 1.02431$$

where ξ is in degrees and (0.91043ξ) and (2.78981ξ) are in radians. The centroid of the PSF is derived in Smith (See Reference 10) and is 1.51° from the optical axis. This shift is denoted in Figure 8-3 and a new angle δ is defined relative to the centroid. To evaluate the PSF, determine δ and then set $\delta' = \delta + \delta_0$ where δ_0 is the shift (or offset) from the optical axis to the centroid.

The numerical values given in equation (1) are based on the following prelaunch calibration constants:

$f_c = 10.5263$ hertz	Characteristic frequency of the Bessel Filter
$\dot{\alpha} = 63.0$ deg/sec	Scan rate

Table 8-1. Detector Constant (τ seconds)

Instrument	Detector Channel		
	Total	Window	Shortwave
PFM	0.00860	0.00830	0.00815
FM1	0.00850	0.00795	0.00825
FM2	0.00800	0.00820	0.00820
FM3	N/A	N/A	N/A
FM4	N/A	N/A	N/A

The general form of equation (1) is given by

$$
\begin{aligned}
F(\xi) = \; & 1 - (1 + a_1 + a_2)e^{-\eta t} \\
& + e^{\mu_1 t}\,[a_1 \cos(\omega_1 t) + b_1 \sin(\omega_1 t)] \\
& + e^{\mu_2 t}\,[a_2 \cos(\omega_2 t) + b_2 \sin(\omega_2 t)]
\end{aligned}
\tag{3}
$$

where

$$t = \frac{2\pi f_c}{\dot{\alpha}}\,\xi$$

and where the complex roots of the 4-pole Besssel filter are

$$\nu_1 = -2.89621 + 0.86723i = \mu_1 + i\omega_1$$
$$\nu_2 = -2.10379 + 2.65742i = \mu_2 + i\omega_2$$

the residues of the Bessel filter are

$$u_1 = +1.66339 - 8.39628i$$
$$u_2 = -1.66339 + 2.24408i$$

and

$$\eta = \frac{1}{2\pi f_c \tau}$$

Note that ω_i, η, and t are non-dimensional so that $(\omega_i t)$ is in radians. The cone angle ξ has units of degrees. The complex variables p_i, v_i, u_i define a_i and b_i as

$$p_i = \frac{u_i}{\eta + v_i}, \quad a_i = 2\eta \, Re\left(\frac{p_i}{v_i}\right), \quad b_i = -2\eta \, Imag\left(\frac{p_i}{v_i}\right) \quad i = 1, 2$$

The centroid of the PSF can be derived from the analytic expression and is given by

$$\delta_0 = \dot{\alpha}\tau(1 + \eta) \tag{4}$$

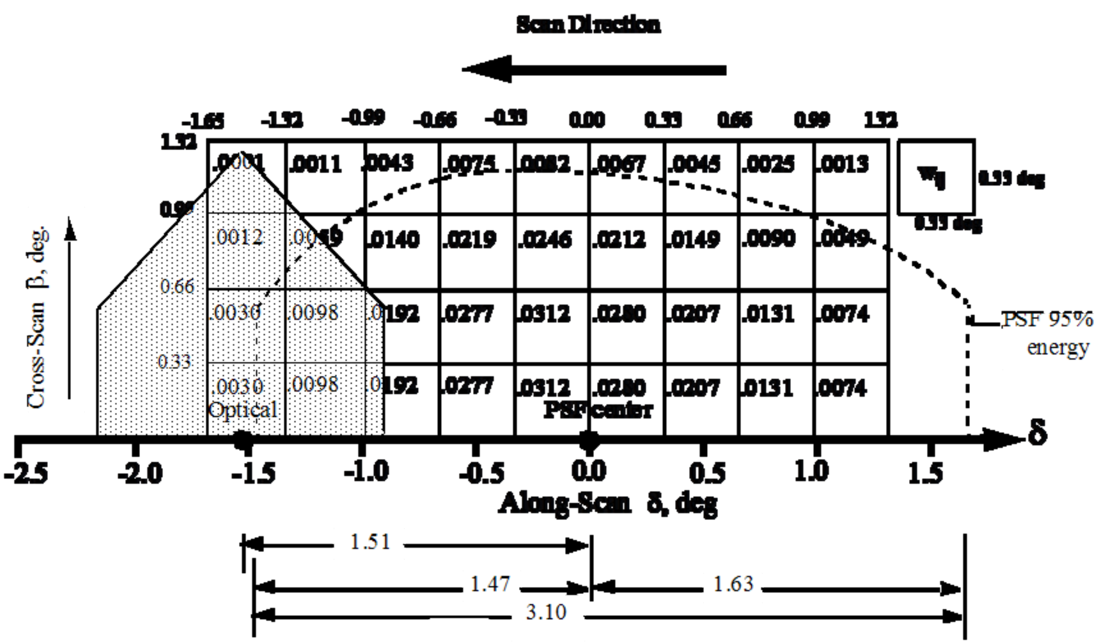


Figure 8-3. CERES Field-of-View Angular Grid

Note-3 Conversion of Julian Date to Calendar Date

The Julian Date is a time system that has been adopted by astronomers and is used in many scientific experiments. The Julian Date or Julian Day is the number of mean solar days since 1200 hours (GMT/UT/UTC/Zulu) on Monday, 24 November 4714 BCE, based on the current Gregorian calendar, or more precisely, the Gregorian Proleptic calendar. In other words, Julian day number 0 (zero) was Monday, 24 November 4714 Before Current Era (BCE), 1200 hours (noon). A new Julian day starts when the mean Sun at noon crosses the Greenwich meridian. This differs from Universal Time (UT) or Greenwich Mean Solar Time by 12 hours since UT changes day at Greenwich midnight. Table 8-2 below provides Julian day numbers which relate Universal Time to Julian date.

Important facts related to the Gregorian calendar are:

a) There is no year zero; year -1 is immediately followed by year 1.
b) A leap year is any year which is divisible by 4, except for those centesimal years (years divisible by 100) which must also be divisible by 400 to be considered a leap year.
c) A leap year has 366 days, with the month of February containing 29 days.
d) Year -1 is defined as a leap year, thus being also defined as containing 366 days, and being divisible by 4, 100, and 400.

Information on history, calendars, and Julian day numbers can be found in Blackadar's (Reference 10) "A Computer Almanac", and on the WWW (Reference 11).

The Julian day whole number is followed by the fraction of the day that has elapsed since the preceding noon (1200 hours UTC). The Julian Date JDATE can be represented as:

JDATE = JDay + JFract

where:

JDay = the integer Julian Day number and
JFract = the "fractional" Julian day (0 to 0.99...9)
(e.g. 245_0814.0 = 1200 or noon, 31 December, 1997 UT)

When the fractional part of the combined julian data is .0, it is noon or 1200 hours GMT and when the fraction part is .5, then it is midnight or 0000 hours GMT.

The calculation of GMT (YYYYMMDD-HH:MM:SS.SSS) from Julian date (JDATE) is performed using the following process.

1. The YYYYMMDD can be determined using Table 8-2 to find the year and the beginning of the month whose Julian Day occurs before the JDay integer value.
2. Calculate the number of days past the 0.5 day of the month via Table 8-2 which provides Julian day numbers which relate Universal Time to Julian date.

The GMT is determined by first computing the number of seconds in the day since midnight:

if	JFract > 0.5,
then	Seconds = 86400.0 * (JFract-0.5)
if	JFract <= 0.5,
then	Seconds = 86400.0 * (JFract+0.5)

Then compute HH, MM, and SS where:

HH = Int(Seconds/3600)
MM = Int(Seconds-(HH*3600.0)/60)
SS = Seconds-(HH*60.0 + MM)*60.0

As an example, if JD = 244_5733.5833, then the GMT date is computed using Table 8-2 by finding the closest beginning monthly calendar noon date, which is Feb 0.5, 1984 (UT).

(Feb 0.5) Jday
244 5731 < 244 5733.5833

JD = 244_5733.5833 is 2.5833 days past Feb 0.5, 1984 UT (i.e., past 1984 Jan 31^d 12^h 0^m 0^s) where 1984 Jan 31^d 12^h 0^m 0^{ss} = (244_5733-244_5731).

Beginning with the whole days portion of 2.5833 (i.e., 2), the GMT Date is 1984 Jan 31^d 12^h 0^m 0^s + 2 = 1984 Feb 2^d 12^h 0^m 0^s.

Next, since JFract (0.5833) is > 0.5, 12^h is added to the GMT Date, yielding: 1984 Feb 2^d 12^h 0^m 0^s + 12^h 0^m 0^s = 1984 Feb 3^d 0^h 0^m 0^s.

Finally, to get the GMT time and since JFract (0.5833) is > 0.5, the number of seconds = 86400 *(0.5833 -0.5) = 7197.12 yielding:

HH = 7197.12 / 3600 = 01.9992 = 01^h
MM = 7197.12 - ((1*3600) / 60) = 59.952 = 59^m
SS = 7197.12 - ((1*60) + 59)*60) = 57.12^s

Therefore, the GMT Date corresponding to the Julian Date 244_5733.5833 = 1984 Feb 3^d 1^h 59^m 57.12^s, which is UT = 1984 Jan 31^d 12^h 0^m 0^s + 2.5833 days.

Table 8-2. Julian Day Number

Year	Jan 0.5[a]	Feb 0.5	Mar 0.5	Apr 0.5	May 0.5	June 0.5	July 0.5	Aug 0.5	Sept 0.5	Oct 0.5	Nov 0.5	Dec 0.5
1980t	244_4239	_4270	_4299	_4330	_4360	_4391	_4421	_4452	_4483	_4513	_4544	_4574
1981	_4605	_4636	_4664	_4695	_4725	_4756	_4786	_4817	_4848	_4878	_4909	_4939
1982	_4970	_5001	_5029	_5060	_5090	_5121	_5151	_5182	_5213	_5243	_5274	_5304
1983	_5335	_5366	_5394	_5425	_5455	_5486	_5516	_5547	_5578	_5608	_5639	_5669
1984t	_5700	_5731	_5760	_5791	_5821	_5852	_5882	_5913	_5944	_5974	_6005	_6035
1985	244_6066	_6097	_6125	_6156	_6186	_6217	_6247	_6278	_6309	_6339	_6370	_6400
1986	_6431	_6462	_6490	_6521	_6551	_6582	_6612	_6643	_6674	_6704	_6735	_6765
1987	_6796	_6827	_6855	_6886	_6916	_6947	_6977	_7008	_7039	_7069	_7100	_7130
1988t	_7161	_7192	_7221	_7252	_7282	_7313	_7343	_7374	_7405	_7435	_7466	_7496
1989	_7527	_7558	_7586	_7617	_7647	_7678	_7708	_7739	_7770	_7800	_7831	_7861
1990	244_7892	_7923	_7951	_7982	_8012	_8043	_8073	_8104	_8135	_8165	_8196	_8226
1991	_8257	_8288	_8316	_8347	_8377	_8408	_8438	_8469	_8500	_8530	_8561	_8591
1992t	_8622	_8653	_8682	_8713	_8743	_8774	_8804	_8835	_8866	_8896	_8927	_8957
1993	_8988	_9019	_9047	_9078	_9108	_9139	_9169	_9200	_9231	_9261	_9292	_9322
1994	_9353	_9384	_9412	_9443	_9473	_9504	_9534	_9565	_9596	_9626	_9657	_9687
1995	244_9718	_9749	_9777	_9808	_9838	_9869	_9899	_9930	_9961	_9991	*_0022	*_0052
1996t	245_0083	_0114	_0143	_0174	_0204	_0235	_0265	_0296	_0327	_0357	_0388	_0418
1997	_0449	_0480	_0508	_0539	_0569	_0600	_0630	_0661	_0692	_0722	_0753	_0783
1998	_0814	_0845	_0873	_0904	_0934	_0965	_0995	_1026	_1057	_1087	_1118	_1148
1999	_1179	_1210	_1238	_1269	_1299	_1330	_1360	_1391	_1422	_1452	_1483	_1513
2000t	245_1544	_1575	_1604	_1635	_1665	_1696	_1726	_1757	_1788	_1818	_1849	_1879
2001	_1910	_1941	_1969	_2000	_2030	_2061	_2091	_2122	_2153	_2183	_2214	_2244
2002	_2275	_2306	_2334	_2365	_2395	_2426	_2456	_2487	_2518	_2548	_2579	_2609
2003	_2640	_2671	_2699	_2730	_2760	_2791	_2821	_2852	_2883	_2913	_2944	_2974
2004t	245_3005	_3036	_3965	_3096	_3126	_3157	_3187	_3218	_3249	_3279	_3310	_3340
2005	_3371	_3402	_3430	_3461	_3491	_3522	_3552	_3583	_3614	_3644	_3675	_3705
2006	_3736	_3767	_3795	_3826	_3856	_3887	_3917	_3948	_3979	_4009	_4040	_4070
2007	_4101	_4132	_4160	_4191	_4221	_4252	_4282	_4313	_4344	_4374	_4405	_4435
2008t	245_4466	_4497	_4526	_4557	_4587	_4618	_4648	_5679	_4710	_4740	_4771	_4801
2009	_4832	_4863	_4891	_4922	_4952	_4983	_5013	_5044	_5075	_5105	_5136	_5166

a. Jan. 0.5 (UT) is the same as Greenwich noon (12h) UT, Dec. 31. * These dates begin with 245 t Denotes leap years

9.0 Application of the Data Set

[Product Specific Information]

10.0 Future Modifications and Plans

Modifications to the *XYZ* product are driven by validation results and any EOS-AM related parameters. The ASDC provides users notification of changes.

11.0 Software Description

There is a C/Fortran90 read program that interfaces with the HDF libraries and a README file available from the LaRC ASDC User Services. The program was designed to run on a Unix workstation and can be compiled with a C/Fortran90 compiler.

[Correct for fortran or C] {Pointer to ASDC read program}

12.0 Contact Data Center/Obtain Data

EOSDIS Langley DAAC
USer and Data Service Office
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: http://eosweb.larc.nasa.gov/

13.0 Output Products and Availability

Several media types are supported by the Langley ASDC CERES Web Order Tool. Data can be downloaded from the Web or via FTP. Alternatively, data can be ordered on media tapes. The media tapes supported are 4mm 2Gb (90m), 8mm 2Gb (8200), 8mm 5Gb (8500), and 8mm 7Gb (8500c).

Data ordered via the Web or via FTP can be downloaded in either Uncompressed mode or in UNIX Compressed mode. Data written to media tape (in either Uncompressed mode or in UNIX Compressed mode) is in UNIX TAR format.

14.0 References

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2. TRW DRL 64, 55067.300.008E; In-flight Measurement Analysis (Rev. E), March 1997.
3. 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}.
4. Clouds and the Earth's Radiant Energy System (CERES) Algorithm Theoretical Basis Document, Subsystem *Name* (Subsystem *Number*), Release 2.2, *Month* 1997 {URL = http://ceres.larc.nasa.gov/atbd.php}
5. Release B SCF ToolKit User's Guide for the ECS Project, June 1998.
6. HDF User's Guide, Version 4.0, February 1996 (from NCSA) {URL = http://eosweb/HBDOCS/hdf.html}.
7. *Subsystem Name* (Subsystem *Number*) Draft Architectural Design Document Release 1.0, June 1996 {URL = http://ceres.larc.nasa.gov/sdd.php}.
8. *Subsystem Validation Plan Name* Release 1.1, March 1996 {URL = http://ceres.larc.nasa.gov/validation.php}
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10. Blackadar, Alfred, "A Computer Almanac," Weatherwise, Vol 37, No 5, October 1984, p. 257-260.
11. Jefferys, William H. "Julian Day Numbers" {URL = http://quasar.as.utexas.edu/BillInfo/JulianDatesG.html}.
12. Software Bulletin "CERES Metadata Requirements for LaTIS", Revision 1, January 7, 1998 {URL = http://ceres.larc.nasa.gov/sw_bull.php}.

15.0 Glossary of Terms

Term-1 CERES Point Spread Function

A Point Spread Function (PSF) is a two-dimensional bell-shaped function that defines the CERES instrument response to the viewed radiation field. Due to the response time, the radiometer responds to a larger FOV than the optical FOV and the resulting PSF centroid lags the optical FOV centroid by more than a degree of cone angle (See SCI-7) for normal scan rates (See Note-2).

Term-2 Earth Equator, Greenwich Meridian System

The Earth equator, Greenwich meridian system is an Earth-fixed, geocentric, rotating coordinate system with the X-axis in the equatorial plane through the Greenwich meridian, the Y-axis lies in the equatorial plane 90° to the east of the X-axis, and the Z-axis is toward the North Pole.

Term-3 Earth Surface

The surface of the Earth as defined by the WGS-84 Earth Model. The WGS-84 model of the Earth surface is an ellipsoid $\frac{x^2}{a^2} + \frac{y^2}{a^2} + \frac{z^2}{b^2} = 1$ where a = 6378.1370 km and b = 6356.7523 km (See Figure 15-2).

Term-4 Earth Point

The viewed point on the Earth surface (See Term-3), or the point at which the PSF centroid intersects the Earth surface.

Term-5 Field-of-View

The terms Field of View (FOV) and footprint are synonymous (See Note-1). The CERES FOV is determined by its PSF which is a two dimensional bell-shaped function that defines the CERES instrument response to the viewed radiation field.

The resolution of the CERES radiometers is usually referenced to the optical FOV and is 1.3° in the along-track direction and 2.6° in the cross-track direction. For TRMM with a satellite altitude of 350 km, the nadir optical FOV is 8 × 16 km which is frequently referred to as an equivalent circle with a 10 km diameter, or simply as 10 km resolution. For EOS-AM with a satellite altitude of 705 km, the optical FOV at nadir is 16 × 32 km or 20 km resolution.

The CERES footprint size is referenced as an oval area representing ~95% of the PSF response (See Note-1). Since the PSF is defined in instrument angular space, the CERES FOV is a constant in angular space, but grows in surface area from a minimum at nadir to a larger area at shallow viewing angles (See SCI-7). At nadir, this oval for TRMM is 19 × 15 km (EOS-AM is 38 × 31 km) and grows to 138 × 38 km (EOS-AM is 253 × 70 km) at a 70° viewing zenith angle.

The ToolKit routine PGS_CSC_GetFOV_Pixel returns the geodetic latitude and longitude of the intersection of the FOV centroid and the selected Model Surface. The returned longitudes are transformed from radians to degrees and then converted from to ±180° to 0° .. 360°. The returned geodetic latitudes are transformed from radians to degrees and then converted to geodetic colatitude using (90.0-latitude).

Term-6 Geocentric Subsolar Point

The point on a surface where the geocentric zenith (See Term-7) vector points toward the Sun (See Figure 15-1).

Term-7 Geocentric Zenith

A vector from the center of the Earth (See Figure 15-2) to the point of interest.

Term-8 Geodetic Subsolar Point

The point on a surface where the geodetic zenith (See Term-9) vector points toward the Sun (See Figure 15-1). Although the geocentric latitude θ_c and the geodetic latitude θ_d are equal, the geocentric subsolar point is different from the geodetic subsolar point.

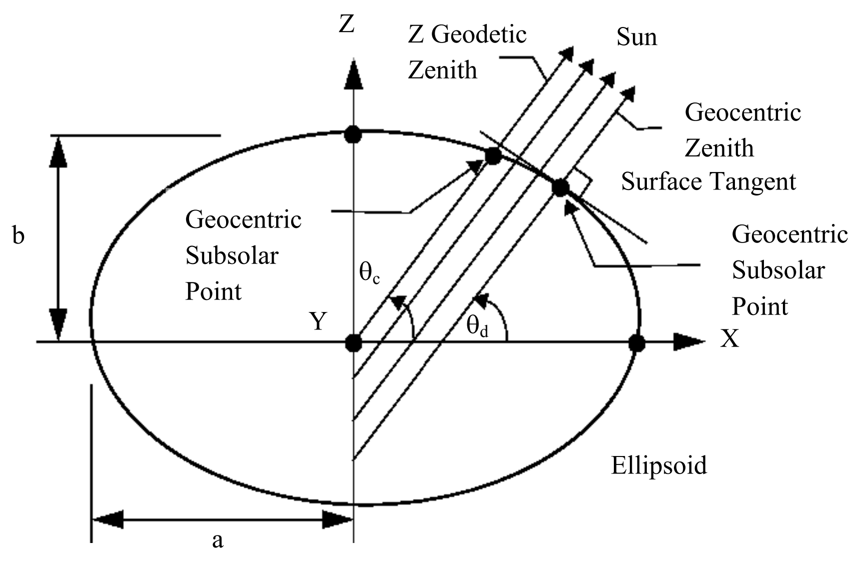

Figure 15-1. Subsolar Point

The ToolKit routine PGS_CBP_Earth_CB_vector calculates the Earth-Centered Inertial (ECI) position vector from the Earth to the Sun. A second ToolKit routine, PGS_CSC_ECItoECR, transforms the position vector to the ECR or Earth equator, Greenwich meridian rectangular coordinate system. From these coordinates, the geocentric colatitude and longitude of the Sun are calculated.

Term-9 Geodetic Zenith

The vector normal to an ellipsoid (See Figure 15-2) at a point on the surface. At a point on the surface the geocentric latitude θ_c and the geodetic latitude θ_d are related by $\tan\theta_c = \frac{b^2}{a^2}.\tan\theta_d$. We can determine the radial distance r as a function of the geocentric latitude θ_c by setting $x = r\cos(\theta_c)$, $y = 0$, $z = r\sin(\theta_c)$ in the ellipsoidal model and solving for r or

$$r = \frac{ab}{\sqrt{a^2\,sin^2\theta_c + b^2\,cos^2\theta_c}}$$

The semi-major axis (a) and the semi-minor axis (b) are defined by either the Earth Surface (See Term-3) or the TOA (See Term-13).

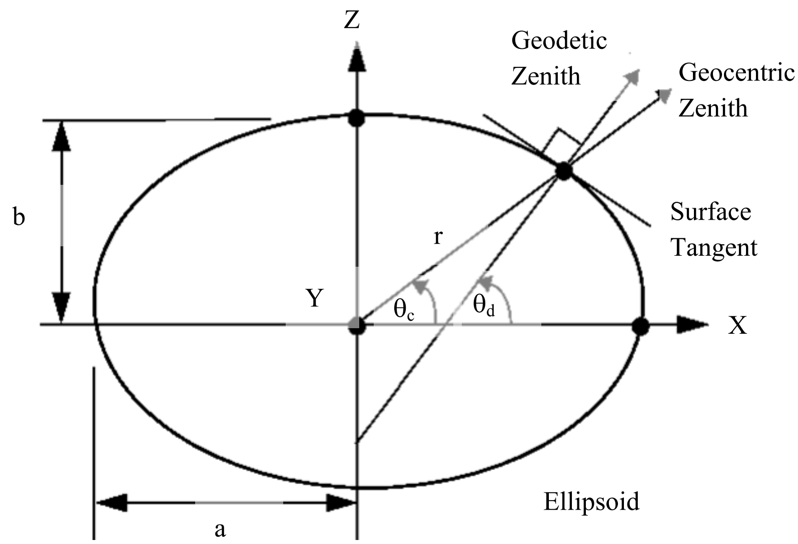

Figure 15-2. Ellipsoid Earth Model

Term-10 Julian Date

A continuous count of time in whole and fractional days elapsed at the Greenwich meridian since noon on January 1, 4714 BCE. (See Note-1)

Term-11 Subsatellite Point

The point on a surface below the satellite or the intersection point of a line dropped from the satellite through the surface (See Figure 15-3). The geocentric subsatellite point is on the radius vector to the center of the earth. The geodetic subsatellite point is on the geodetic zenith vector or the line dropped from the satellite is normal to the surface at the intersection point.

The ToolKit routine PGS_CSC_SubSatPoint returns the geodetic latitude and longitude of the subsatellite point. The returned longitudes are transformed from radians to degrees and then converted from to $\pm180^o$ to $0^o..360^o$. The returned latitudes are transformed from radians to degrees and then converted to colatitude using (90.0 - latitude).

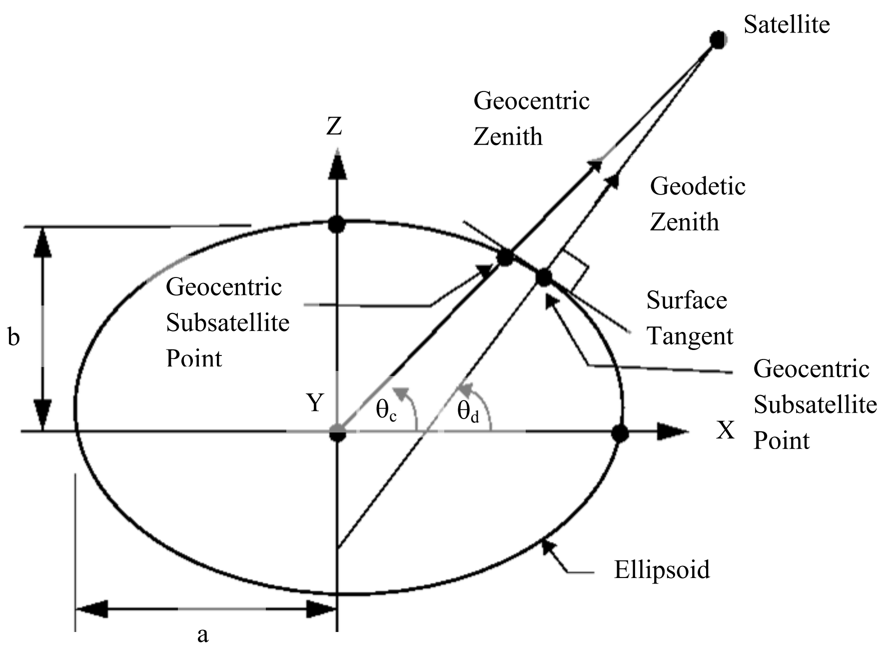

Figure 15-3. Subsatellite Point

Term-12 Target Point

The point at which the PSF (See Term-1) centroid intersects the TOA (See Term-13).

Term-13 Top-of-the-Atmosphere (TOA)

The TOA is a surface approximately 30 km above the Earth surface (See Term-3). Specifically, the TOA is an ellipsoid $\frac{x^2}{a^2} + \frac{y^2}{a^2} + \frac{z^2}{b^2} = 1$ where a = 6408.1370 km and b = 6386.651 km (See Figure 15-2).

Term-14 TOA Point

The viewed point at the TOA, or the point at which the PSF centroid intersects the TOA (See Term-13).

16.0 List of Acronyms

ADM	Angular Distribution Model
APID	Application Identifier
APD	Aerosol Profile Data
ATBD	Algorithm Theoretical Basis Document
AVG	Monthly Regional Radiative Fluxes and Clouds
AVHRR	Advanced Very High Resolution Radiometer
BCE	Before Current Era
BDS	BiDirectional Scan (data product)
CADM	CERES Angular Distribution Model
CER	CERES
CERES	Clouds and the Earth's Radiant Energy System
CID	Cloud Imager Data (data product)
CRH	Clear Reflectance History (data product)
CRS	Clouds and Radiative Swath (data product)
CW	Cable Wrap
DAAC	Distributed Active Archive Center
DAC	Digital to Analog Converter
DAO	Data Assimilation Office
DAP	Data Acquisition microProcessor
DMA	Direct Memory Access
DMS	Data Management System
ECR	Earth-Centered Rotating
EDDB	ERBE-Like Daily Database Product
EDOS	EOS Data Operations System
EOS	Earth Observing System
EOS-AM	EOS Morning Crossing Mission (Renamed Terra)
EOS-PM	EOS Afternoon Crossing Mission
EOSDIS	Earth Observing System Data and Information System
ERBE	Earth Radiation Budget Experiment
ERBS	Earth Radiation Budget Satellite
FAPS	Fixed Azimuth Plane Scan
FM	Flight Model
FOV	Field-of-View (See Term-5)
FSW	Monthly Single Satellite Fluxes and Clouds
GAP	Gridded Analysis Product
GB	Gigabyte
GEO	Geostationary Narrowband Radiances
GMS	Geostationary Meteorological Satellite

GGEO	Gridded Geostationary Narrowband Radiances
GOES	Geostationary Operational Environmental Satellite
H	High
HDF	Hierarchical Data Format
IES	Instrument Earth Scans (data product)
IGBP	International Geosphere Biosphere Programme
INSTR	Instrument
ISCCP	International Satellite Cloud Climatology Project
IWC	Ice Water Content
LaRC	Langley Research Center
LaTIS	Langley TRMM Information System
L	Low
LM	Lower Middle
LW	Longwave
LWC	Liquid Water Content
MAM	Mirror Attenuator Mosaic
MB	Megabyte
METEOSAT	Meteorological Satellite
MISR	Multi-angle Imaging SpectroRadiometer
MOA	Meteorological, Ozone, and Aerosols (data product)
MODIS	Moderate Resolution Imaging Spectrometer
MWH	Microwave Humidity (data product)
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
OPD	Ozone Profile Data (data product)
PFM	Prototype Flight Model (on TRMM)
PSA	Product Specific Attribute
PSF	Point Spread Function (See Term-1)
QA	Quality Assessment
RAPS	Rotating Azimuth Plane Scan
SARB	Surface and Atmospheric Radiation Budget
SBUV-2	Solar Backscatter Ultraviolet/Version 2
SDS	Scientific Data Set
SFC	Hourly Gridded Single Satellite TOA/Surface Fluxes and Clouds (data product)
SPS	Solar Presence Sensor
SRB	Surface Radiation Budget
SRBAVG	Surface Radiation Budget Average (data product)
SS	Subsystem
SSF	Single Satellite CERES Footprint TOA and Surface Fluxes, Clouds (data product)

SSM/I	Special Sensor Microwave/Imager
SURFMAP	Surface Map
SW	Shortwave
SWICS	Shortwave Internal Calibration Source
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 (See Term-13)
TOT	Total
TRMM	Tropical Rainfall Measuring Mission
UM	Upper Middle
URL	Uniform Resource Locator
UT	Universal Time
UTC	Universal Time Code
VIRS	Visible Infrared Scanner
WN	Window
ZAVG	Monthly Zonal and Global Average Radiative Fluxes and Clouds (data product)

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

Unit Definitions

Units	Definition
km sec^{-1}	kilometers per second
m	meter
mA	milliamp, milliamps
micron	micrometer, micron
msec	millisecond
mW $cm^{-2}sr^{-1}\mu m^{-1}$	milliWatts per square centimeter per steradian per micron
m sec^{-1}	meter per second
N/A	not applicable, none, unitless, dimensionless
percent	percent, percentage 0..100
rad	radian
sec	second
volt	volt, volts
W h m^{-2}	Watt hour per square meter
W^2 m^{-4}	square Watt per meter to the 4th
W m^{-2}	Watt per square meter
W $m^{-2}sr^{-1}$	Watt per square meter per steradian
W $m^{-2}sr^{-1}\mu m^{-1}$	Watt per square meter per steradian per micron
. ^{o}C	degrees centigrade
μm	micrometer, micron

17.0 Document Information

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17.3 Document Revision Date

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17.5 Citation

Please provide a reference to the following paper when scientific results are published using the CERES *XYZ* TRMM data:

"Wielicki, B. A.; Barkstrom, B.R.; Harrison, E. F.; Lee III,R.B.; Smith, G.L.; and Cooper, J.E., 1996: Clouds and the Earth's Radiant Energy System (CERES): An Earth Observing System Experiment, Bull. Amer. Meteor. Soc., 77, 853-868."

When Langley Atmospheric Sciences Data Center (ASDC) data are used in a publication, the following acknowledgment is requested to be included:

"These data were obtained from the NASA Langley Research Center EOSDIS Distributed Active Archive Center."

The Data Center at Langley requests two reprints of any published papers or reports which cite the use of data the Langley ASDC have distributed. This will help the ASDC to determine the use of data distributed, which is helpful in optimizing product development. It also helps the ASDC to keep product related references current.

17.6 Redistribution of Data

To assist the Langley ASDC in providing the best service to the scientific community, a notification is requested if these data are transmitted to other researchers.

17.7 Document Curator

The Langley ASDC Science, User & Data Services Office.

Appendix A
CERES Metadata

This section describes the metadata that are written to all CERES HDF products. Table A-1 describes the CERES Baseline Header Metadata that are written on both HDF and binary direct access output science data products. The parameters are written in HDF structures for CERES HDF output products and are written as 80-byte records for binary direct access output products. Some parameters may be written in multiple records. Table A-2 describes the CERES_metadata Vdata parameters which are a subset of the CERES Baseline Header Metadata and are also written to all CERES HDF output products. For details on CERES Metadata, see the CERES Software Bulletin "CERES Metadata Requirements for LaTIS" (Reference 12).

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 follows:

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, Diagnostic-Case, 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

Table A-1. CERES Baseline Header Metadata

Item	Parameter Name	Units	Range	Data Type	No. of Elements
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
22	GRingPointLatitude	deg	-90.0 .. 90.0	F11.6	5
23	GRingPointLongitude	deg	-180.0 .. 180.0	F11.6	5
24	GRingPointSequenceNo	N/A	0 .. 99999	I5	5
25	ExclusionGRingFlag	N/A	Y (= YES), N (= NO)	s(1)	1
26	CERWestBoundingCoordinate	deg	0.0 .. 360.0	F11.6	1
27	CERNorthBoundingCoordinate	deg	0.0 .. 180.0	F11.6	1
28	CEREastBoundingCoordinate	deg	0.0 .. 360.0	F11.6	1
29	CERSouthBoundingCoordinate	deg	0.0 .. 180.0	F11.6	1
26	CERGRingPointLatitude	deg	0.0 .. 180.0	F11.6	5
27	CERGRingPointLongitude	deg	0.0 .. 360.0	F11.6	5
28	GRingPointSequenceNo	N/A	0 .. 99999	I5	5
29	ExclusionGRingFlag	N/A	Y (= YES), N (= NO)	s(1)	1
30	AutomaticQualityFlag	N/A	Passed, Failed, or Suspect	s(64)	1
31	AutomaticQualityFlagExplanation	N/A	N/A	s(255)	1
32	QAGranuleFilename	N/A	N/A	s(255)	1
33	ValidationFilename	N/A	N/A	s(255)	1
34	ImagerShortName	N/A	VIRS, MODIS, TBD	s(20)	1
35	InputPointer	N/A	N/A	s(255)	800
36	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.

Table A-2. CERES_metadata Vdata

Item	Parameter Name	Units	Range	Data Type
1	ShortName	N/A	s(32)	1
2	RangeBeginningDate	1997-11-19 .. 2050-12-31	s(32)	2
3	RangeBeginningTime	00:00:00.000000Z .. 24:00:00:000000Z	s(32)	3
4	RangeEndingDate	1997-11-19 .. 2050-12-31	s(32)	4
5	RangeEndingTime	00:00:00.000000Z .. 24:00:00:000000Z	s(32)	5
6	AutomaticQualityFlag	Passed, Failed, or Suspect	s(64)	6
7	AutomaticQualityFlagExplanation	N/A	s(256)	7
8	AssociatedPlatformShortName	TRMM, EOS AM-1, EOS PM-1, TBD	s(32)	8
9	AssociatedInstrumentShortName	PFM, FM1, FM2, FM3, FM4, FM5, TBD	s(32)	9
10	LocalGranuleID	N/A	s(96)	10
11	LocalVersionID	N/A	s(64)	11
12	CERProductionDateTime	N/A	s(32)	12
13	NumberofRecords	1 .. 9 999 999 999	4-byte Integer	13
14	ProductGenerationLOC	SGI_xxx, TBD	s(256)	14

The *XYZ* Product Specific Attribute (PSA) metadata are listed in Table A-3. The definitions that are nearly identical for several parameters are defined only once, even though individually distinct parameters exist as shown in the table below.

Table A-3. *XYZ* Product Specific Metadata

Item	Parameter Name	Range	Data Type
15	Percent Total Channel Bad	0.0 .. 100.0	F11.6
16	Percent Window Channel Bad	0.0 .. 100.0	F11.6
17		Record Size (bytes) =nnn	

PSA-1 Percent Total Channel Bad
PSA-2 Percent Window Channel Bad

The percent of radiance samples that failed various edit checks and were then marked Bad during science processing.