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

Algorithm Theoretical Basis Document

Grid Geostationary Narrowband Radiances

(Subsystem 11.0)

Takmeng Wong[1]
Patrick Minnis[1]
David F. Young[2]
Gary G. Gibson[2]
Maria V. Mitchum[1]
Joseph C. Stassi[3]
Alice Fan[3]

[1]Atmospheric Sciences Division, NASA Langley Research Center, Hampton, Virginia 23681-0001
[2]Analytical Services & Materials, Inc., One Enterprise Parkway, Suite 300, Hampton, Virginia 23666
[3]Science Applications International Corporation (SAIC), Hampton, Virginia 23666

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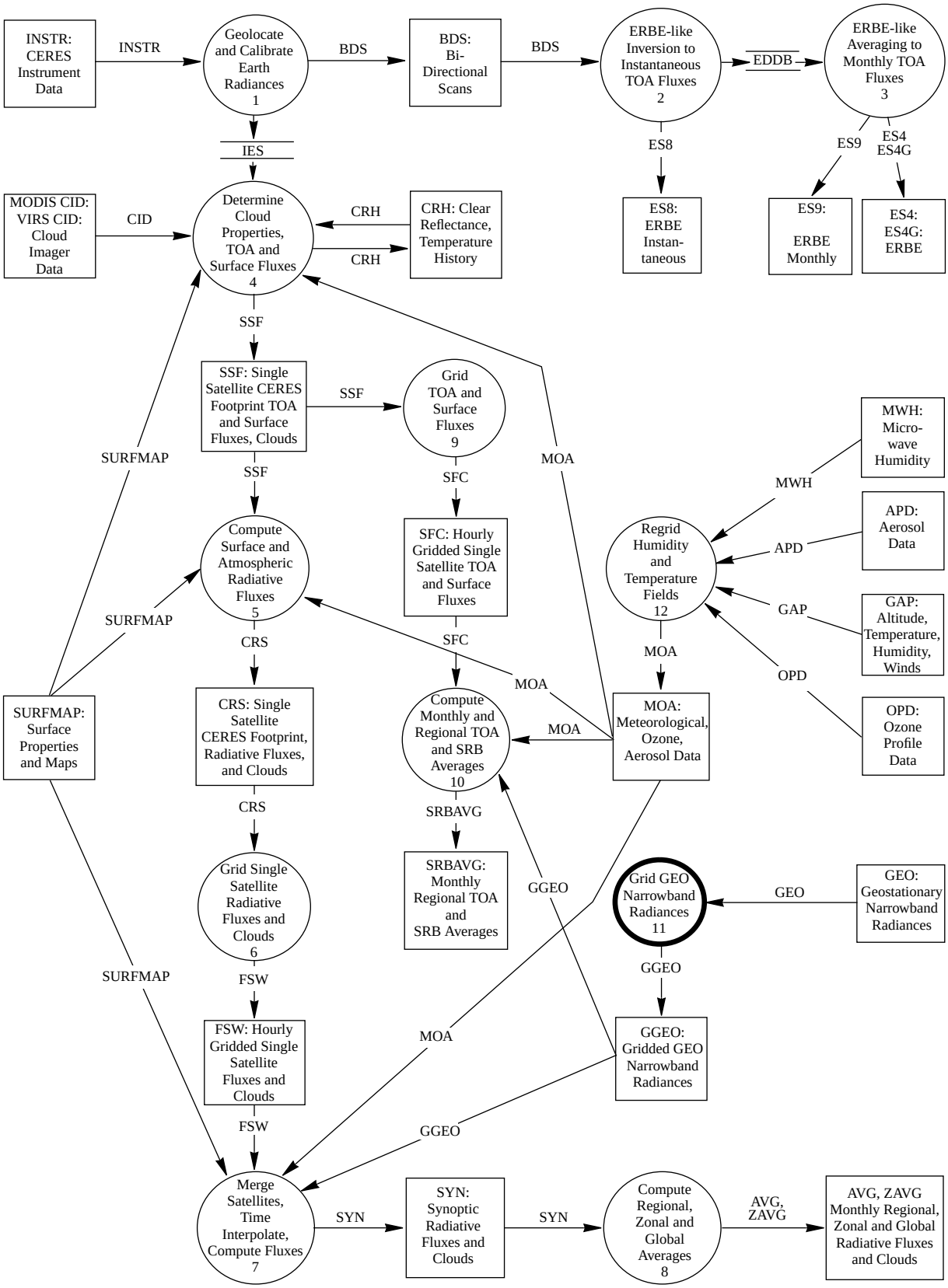
CERES Top Level Data Flow Diagram



Abstract

This subsystem, Grid Geostationary Narrowband Radiances, provides two functions for the CERES data system. First, it gives the transformation from geostationary-based data to CERES-based data by assigning each geostationary narrowband radiance to the appropriate region of the CERES 1-degree equal-angle grid. Second, this subsystem performs spatial averaging of the geostationary data over each CERES gridded region. The resultant data are used as input to (1) CERES subsystem 7 (Time Interpolation and Synoptic Flux Computation for Single and Multiple Satellites) and (2) CERES subsystem 10 (Monthly Regional TOA and Surface Radiation Budget).

The chief input product for this subsystem is narrowband visible (VIS) and infrared (IR) radiances from geostationary satellites. These data have a spatial and temporal resolution of 10 km and 3-hours, respectively.

The output data product of this subsystem contains gridded 1-degree equal-angle regional geostationary satellite narrowband VIS and IR radiances at a 3-hourly temporal resolution.

11.0. Grid Geostationary Narrowband Radiances

11.1. Introduction

The Cloud and the Earth's Radiant Energy System (CERES) broadband instrument will be flying on three different satellites. In order to assist the diurnal modeling of the top-of-atmosphere (TOA) fluxes and to minimize the temporal sampling errors in the CERES monthly mean TOA fluxes products, the CERES Data Management System will produce grid-averaged geostationary narrowband visible (VIS) and infrared (IR) radiances.

11.2. Data Description

Currently, this subsystem will use geostationary satellite data collected by the International Satellite Cloud Climatology Project (ISCCP). The ISCCP B1 dataset consists of un-intercalibrated radiances at a resolution of approximately 10 km. These data are navigated and subsampled to a nominal resolution of 30 km to produce the B2 dataset. After completion of cross-calibration procedures, the B2 data are calibrated to yield the B3 dataset which is used to produce ISCCP cloud products. The processing of the geostationary data from initial collection to the B3 product requires 1 to 2 years depending on the efficiency of the calibration effort. Although the B2 and B3 products are more convenient, the B1 dataset is used in the CERES system because it meets the strict scheduling requirements of the CERES project and provides the spatial coverage and resolution necessary for accurate gridded geostationary radiance averages. The B1 data are usually available 2 months after collection and have the highest resolution of any ISCCP product. The B2 data generally become available a few months after the B1 data but suffer from reduced resolution. The diminished sampling introduces an uncertainty of ~ 15% and 2% in the average VIS and IR radiances, respectively, for the nominal 1-degree CERES grid boxes. The uncertainty is even greater at higher latitudes where the grid box area decreases. These levels of uncertainty are unacceptable. The current CERES Time Interpolation and Spatial Averaging (TISA) algorithms do not require intercalibrated geostationary radiances so the additional information from the B3 data is not necessary. In addition, the long delay encountered with the B3 data precludes their use in the CERES

algorithms, especially during validation periods. The B1 data are the only data sufficient for meeting CERES' requirements.

At the present time, the B1 geostationary (GEO) data are available from four different satellites; METEOSAT, GOES-EAST, GOES-WEST, and GMS at 3-hourly intervals nominally at 0, 3, 6, ..., 21 GMT. Since these GEO datasets are neither intercalibrated nor navigated to a common data format, each data will have its own calibration and navigation information coded in the native format (see Appendix A for details). Thus, separate algorithms are developed by CERES to read, navigate, and calibrate each of the four GEO data sets independently. Intercalibration of these data sets is not performed at the present time since cross-calibration is not a required element in the current CERES TISA algorithms. Once these data are successfully read into the CERES processing system, they will be gridded and averaged into the standard CERES 1-degree equal-angle grid system. The outputs consist of means and statistics of VIS and IR narrowband radiances for each of the CERES 1-degree grid boxes and each of the 3-hourly synoptic times. This final product represents a major input source for both subsystems 7 and 10.

11.3. Algorithm Description

The functions of the Grid Geostationary Narrowband Radiances (GGEO) subsystem are very similar to those of Subsystem 6. The first is the gridding function, in which individual GEO measurements are assigned to the appropriate CERES region or grid box. The second is the averaging function, in which spatial averages of VIS and IR narrowband radiances are computed. The algorithms used to perform these functions are described below.

11.3.1. Gridding Algorithm

The gridding algorithm used in the GGEO Subsystem is exactly the same as for the FSW product. Details of this algorithm are presented in the ATBD for Subsystem 6.0, section 6.2.1.

11.3.2. Spatial Averaging Algorithms

11.3.2.1. Time and geometry data. Using the technique outlined in Subsystem 6.0, section 6.2.2.1, this subsystem will use the key footprint for calculating the time and geometry data for each CERES grid box. The key footprint for the geostationary data is defined by the GEO measurement that is closest to the centroid of the CERES 1-degree equal-angle grid box. The cosine of the satellite zenith angle, the cosine of the solar zenith angle, and the relative azimuth angle for the footprint are calculated based on the time of the key footprint, the location of the key footprint (latitude and longitude), and the position of the sub-satellite point.

11.3.2.2. Spatial averaging . The spatial averaging algorithms for calculating mean and statistics for GEO radiances are exactly the same as those used for the FSW product. Specifically, all GEO measurements located within a CERES grid box are averaged together to obtain a regional mean value. Additional details of these algorithms are described in ATBD Subsystem 6.0, section 6.2.2.2.

11.4. Procedural Considerations

11.4.1. Routine Operations Expectations

The gridding and spatial averaging functions are performed for each GEO data file. The input data is a 3-hourly product. The output GGEO data is a 3-hourly data product arranged sequentially in time for the entire month period.

11.4.2. Exception Handling Strategy: Missing Data, Invalid Data

Geostationary data sets are commonly known to have missing data. In order to properly handle these situations, routine limit checks will be made to make sure that data are within reasonable limits. Data that are outside these limits will be excluded from further processing and a diagnostic report will be issued. These data will also be noted on the quality control (QC) reports generated by the subsystem.

11.5. Strategic Concerns

Major strategic concerns for this subsystem involve the possible future use of geostationary cloud products in Release 4 for assisting CERES temporal interpolation of cloud parameters. The current GGEO subsystem is only designed to perform gridding and averaging of un-intercalibrated geostationary satellite narrowband radiances. Intercalibration between different GEO satellite sensors is not performed at this time since cross-calibration of different GEO data sets is not a required element for the current CERES TISA algorithms. However, cross-calibration between these data sets will become an important issue for deriving geostationary cloud products from a subset of CERES cloud algorithms. Studies are currently underway to define these cross-calibration requirements and procedures using VIRS and MODIS channels. In addition, spatial averaging algorithms similar to those used in Subsystem 6.0 will have to be incorporated into the GGEO subsystem for averaging of these cloud data. Changes will have to be made to the GGEO data structures to accommodate the additional cloud parameters. Furthermore, studies are also underway to examine possible use of polar orbiter narrowband VIS and IR data to fill in data gaps due to incomplete geographical sampling by the geostationary satellites.

Appendix A

Input Data Products

Grid Geostationary Narrowband Radiances (Subsystem 11.0)

This appendix describes the data products which are used by the algorithms in this subsystem. The table below summarizes these products, listing the CERES and EOSDIS product codes or abbreviations, a short product name, the product type, the production frequency, and volume estimates for each individual product as well as a complete data month of production. The product types are defined as follows:

Ancillary products: Non-CERES data needed to interpret measurements

Table A-1. Input Products Summary

Product Code		Name	Type	Frequency	Size, MB	Monthly Size, MB
CERES	EOSDIS					
GEO	CERX09	Geostationary Narrowband Radiances	Ancillary	8/day	30.6	7600

Geostationary Narrowband Radiances (GEO)

Currently, CERES will use geostationary satellite data collected by the International Satellite Cloud Climatology Project (ISCCP).

The ISCCP B1 dataset consists of a narrowband infrared channel radiance (near 10.8 micrometer) and a narrowband visible channel radiance (near 0.68 micrometer). The radiances are sampled at about 10-km resolution every 3 hours. These data are in the form of eight or ten-bit counts that can be converted to radiances using either nominal, normalized, or updated calibration formulae.

There are four sets of B1 data currently available. Others may be added in the future as other satellites are launched. The four sets currently available are

1. GMS in GMS format
2. METEOSAT in METEOSAT format
3. GOES-8 in Canadian format
4. GOES-9 in McIDAS format

These data will be provided by EOSDIS which will acquire them from NOAA, the designated archive center for ISCCP B1 data. The data volume is as follows:

1. GMS: eight 3480 cartridges
2. METEOSAT: eight 3480 cartridges
3. GOES-8: fifteen 3480 cartridges
4. GOES-9: seven 3480 cartridges

Each 3480 cartridge holds about 200 MB, so the data volume will be about 7.6 GB per month. NOAA will package these data in 8-mm tape format.

Level: 1B
Type: Ancillary
Frequency: every third hour

Time Interval Covered
File: 1 hour
Record: Instantaneous

Portion of Globe Covered
File: 1 hemisphere
Record: 10 km footprint

Portion of Atmosphere Covered
File: TOA

Appendix B

Output Data Products

Grid Geostationary Narrowband Radiances (Subsystem 11)

This appendix describes the data products which are produced by the algorithms in this subsystem. Table B-1 below summarizes these products, listing the CERES and EOSDIS product codes or abbreviations, a short product name, the product type, the production frequency, and volume estimates for each individual product as well as a complete data month of production. The product types are defined as follows:

Archival products: Assumed to be permanently stored by EOSDIS
Internal products: Temporary storage by EOSDIS (days to years)

The following pages describe each product. An introductory page provides an overall description of the product and specifies the temporal and spatial coverage. The table which follows the introductory page briefly describes every parameter which is contained in the product. Each product may be thought of as metadata followed by data records. The metadata (or header data) is not well-defined yet and is included mainly as a placeholder. The description of parameters which are present in each data record includes parameter number (a unique number for each distinct parameter), units, dynamic range, the number of elements per record, an estimate of the number of bits required to represent each parameter, and an element number (a unique number for each instance of every parameter). A summary at the bottom of each table shows the current estimated sizes of metadata, each data record, and the total data product. A more detailed description of each data product will be contained in a user's guide to be published before the first CERES launch.

Table B-1. Output Products Summary

Product code		Name	Type	Frequency	Size, MB	Monthly size, MB
CERES	EOSDIS					
GGEO	CERX14	Gridded Geostationary Narrowband Radiances	internal	1/month	816.1	816.1

Gridded Geostationary Narrowband Radiances (GGEO)

The GGEO product is a single file containing a header record followed by multiple data records. The header record contains information to identify the product contents and version. These data are the CERES Data Product Code, the Data Starting and Ending Date, and the Product Creation Date and Time.

Each data record, called an hourbox, contains data particular to a single grid region and hour. The number of hourboxes on the file is constant and is determined by the number of data hours per day, the maximum number of days per month, and the number of regions in the grid (8 hours per day x 31 days per month x 64800 regions on globe = 16,070,400 hourboxes). Hourboxes for which there are no ISCCP data are filled with default values.

The data record (hourbox) contains 3 categories of data: Satellite and Hourbox ID information, Key Footprint Parameters, and Radiance Statistics.

- The **Satellite and Hourbox ID** information, as the name implies, identifies the hourbox, as well as the satellite which collected the data within the hourbox. Although there are many grid regions on the earth that are observed by more than one geostationary satellite, each hourbox contains only data from the closest observing satellite.
- The **Key Footprint Parameters** are data associated with the key footprint, the footprint which falls closest to the centroid of the region. These data are the time of the footprint and three angle measurements associated with the footprint: the cosine of the satellite zenith angle, the cosine of the solar zenith angle, and the relative azimuth angle.
- The primary data on the GGEO product are **Radiance Statistics**. These are visible and infrared radiance values averaged over a grid region every 3rd hour of each month. The statistics contain, in order, the calculated mean and variance, and the number of footprints used for the calculations.

Level: 3
Type: Ancillary
Frequency: Monthly

Portion of Globe Covered
File: Entire globe
Record: 1.0 degree equal angle regions

Time Interval Covered
File: Monthly
Record: Every third hour

Portion of Atmosphere Covered
File: TOA

Table B-2. Gridded Geostationary Narrowband Radiances (GGEO)

Description	Parameter Num	Unit	Range	Elements/ Record	Bits/ Elem	Elem Num	Bits/ Rec
GGEO							
GGEO Header							
CERES Data Product Code		N/A	N/A	1	32		32
Data Starting Date		N/A	N/A	1	32		32
Data Ending Date		N/A	N/A	1	32		32
Product Creation Date		N/A	N/A	1	32		32
Product Creation Time		N/A	N/A	1	32		32
GGEO Record							
Satellite and Hourbox ID							
Satellite Number	1	N/A	N/A	1	32	1	32
Region Number	2	N/A	1 .. 64800	1	32	2	32
Hour Number	3	N/A	1 .. 744	1	32	3	32
Key Footprint Parameters							
Time	4	hhmmss	0 .. 235959	1	32	4	32
Cos of Satellite Zenith Angle	5	N/A	-1.0 .. 1.0	1	32	5	32
Cos of Solar Zenith Angle	6	N/A	-1.0 .. 1.0	1	32	6	32
Relative Azimuth Angle	7	Degrees	0.0 .. 180.0	1	32	7	32
Radiance Statistics							
visible radiance: mean, var, num obs	8	$W/m^2/SR$	0.0 .. 20.0	3	32	8	96
infrared radiance: mean, var, num obs	9	$W/m^2/\mu m/SR$	0.0 .. 600.0	3	32	11	96

Total Meta Bits/File:	160
Total Data Bits/Record:	416
Total Records/File:	16070400
Total Data Bits/File:	6685286400
Total Bits/File:	6685286560
Total Data Bytes/Record:	52
Total Data Bytes/File	835660800
Total Files/Product:	1

Appendix C

Nomenclature

Acronyms

ADEOS	Advanced Earth Observing System
ADM	Angular Distribution Model
AIRS	Atmospheric Infrared Sounder (EOS-AM)
AMSU	Advanced Microwave Sounding Unit (EOS-PM)
APD	Aerosol Profile Data
APID	Application Identifier
ARESE	ARM Enhanced Shortwave Experiment
ARM	Atmospheric Radiation Measurement
ASOS	Automated Surface Observing Sites
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
ASTEX	Atlantic Stratocumulus Transition Experiment
ASTR	Atmospheric Structures
ATBD	Algorithm Theoretical Basis Document
AVG	Monthly Regional, Average Radiative Fluxes and Clouds (CERES Archival Data Product)
AVHRR	Advanced Very High Resolution Radiometer
BDS	Bidirectional Scan (CERES Archival Data Product)
BRIE	Best Regional Integral Estimate
BSRN	Baseline Surface Radiation Network
BTD	Brightness Temperature Difference(s)
CCD	Charge Coupled Device
CCSDS	Consultative Committee for Space Data Systems
CEPEX	Central Equatorial Pacific Experiment
CERES	Clouds and the Earth’s Radiant Energy System
CID	Cloud Imager Data
CLAVR	Clouds from AVHRR
CLS	Constrained Least Squares
COPRS	Cloud Optical Property Retrieval System
CPR	Cloud Profiling Radar
CRH	Clear Reflectance, Temperature History (CERES Archival Data Product)
CRS	Single Satellite CERES Footprint, Radiative Fluxes and Clouds (CERES Archival Data Product)
DAAC	Distributed Active Archive Center
DAC	Digital-Analog Converter
DAO	Data Assimilation Office

DB	Database
DFD	Data Flow Diagram
DLF	Downward Longwave Flux
DMSP	Defense Meteorological Satellite Program
EADM	ERBE-Like Albedo Directional Model (CERES Input Data Product)
ECA	Earth Central Angle
ECLIPS	Experimental Cloud Lidar Pilot Study
ECMWF	European Centre for Medium-Range Weather Forecasts
EDDB	ERBE-Like Daily Data Base (CERES Archival Data Product)
EID9	ERBE-Like Internal Data Product 9 (CERES Internal Data Product)
EOS	Earth Observing System
EOSDIS	Earth Observing System Data Information System
EOS-AM	EOS Morning Crossing Mission
EOS-PM	EOS Afternoon Crossing Mission
ENSO	El Niño/Southern Oscillation
ENVISAT	Environmental Satellite
EPHANC	Ephemeris and Ancillary (CERES Input Data Product)
ERB	Earth Radiation Budget
ERBE	Earth Radiation Budget Experiment
ERBS	Earth Radiation Budget Satellite
ESA	European Space Agency
ES4	ERBE-Like S4 Data Product (CERES Archival Data Product)
ES4G	ERBE-Like S4G Data Product (CERES Archival Data Product)
ES8	ERBE-Like S8 Data Product (CERES Archival Data Product)
ES9	ERBE-Like S9 Data Product (CERES Archival Data Product)
FLOP	Floating Point Operation
FIRE	First ISCCP Regional Experiment
FIRE II IFO	First ISCCP Regional Experiment II Intensive Field Observations
FOV	Field of View
FSW	Hourly Gridded Single Satellite Fluxes and Clouds (CERES Archival Data Product)
FTM	Functional Test Model
GAC	Global Area Coverage (AVHRR data mode)
GAP	Gridded Atmospheric Product (CERES Input Data Product)
GCIP	GEWEX Continental-Phase International Project
GCM	General Circulation Model
GEBA	Global Energy Balance Archive
GEO	ISSCP Radiances (CERES Input Data Product)
GEWEX	Global Energy and Water Cycle Experiment
GLAS	Geoscience Laser Altimetry System

GMS	Geostationary Meteorological Satellite
GOES	Geostationary Operational Environmental Satellite
HBTM	Hybrid Bispectral Threshold Method
HIRS	High-Resolution Infrared Radiation Sounder
HIS	High-Resolution Interferometer Sounder
ICM	Internal Calibration Module
ICRCCM	Intercomparison of Radiation Codes in Climate Models
ID	Identification
IEEE	Institute of Electrical and Electronics Engineers
IES	Instrument Earth Scans (CERES Internal Data Product)
IFO	Intensive Field Observation
INSAT	Indian Satellite
IOP	Intensive Observing Period
IR	Infrared
IRIS	Infrared Interferometer Spectrometer
ISCCP	International Satellite Cloud Climatology Project
ISS	Integrated Sounding System
IWP	Ice Water Path
LAC	Local Area Coverage (AVHRR data mode)
LaRC	Langley Research Center
LBC	Laser Beam Ceilometer
LBTM	Layer Bispectral Threshold Method
Lidar	Light Detection and Ranging
LITE	Lidar In-Space Technology Experiment
Lowtran 7	Low-Resolution Transmittance (Radiative Transfer Code)
LW	Longwave
LWP	Liquid Water Path
MAM	Mirror Attenuator Mosaic
MC	Mostly Cloudy
MCR	Microwave Cloud Radiometer
METEOSAT	Meteorological Operational Satellite (European)
METSAT	Meteorological Satellite
MFLOP	Million FLOP
MIMR	Multifrequency Imaging Microwave Radiometer
MISR	Multiangle Imaging Spectroradiometer
MLE	Maximum Likelihood Estimate
MOA	Meteorology Ozone and Aerosol
MODIS	Moderate-Resolution Imaging Spectroradiometer
MSMR	Multispectral, Multiresolution

MTSA	Monthly Time and Space Averaging
MWH	Microwave Humidity
MWP	Microwave Water Path
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NESDIS	National Environmental Satellite, Data, and Information Service
NIR	Near Infrared
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
NWP	Numerical Weather Prediction
OLR	Outgoing Longwave Radiation
OPD	Ozone Profile Data (CERES Input Data Product)
OV	Overcast
PC	Partly Cloudy
POLDER	Polarization of Directionality of Earth's Reflectances
PRT	Platinum Resistance Thermometer
PSF	Point Spread Function
PW	Precipitable Water
RAPS	Rotating Azimuth Plane Scan
RPM	Radiance Pairs Method
RTM	Radiometer Test Model
SAB	Sorting by Angular Bins
SAGE	Stratospheric Aerosol and Gas Experiment
SARB	Surface and Atmospheric Radiation Budget Working Group
SDCD	Solar Distance Correction and Declination
SFC	Hourly Gridded Single Satellite TOA and Surface Fluxes (CERES Archival Data Product)
SHEBA	Surface Heat Budget in the Arctic
SPECTRE	Spectral Radiance Experiment
SRB	Surface Radiation Budget
SRBAVG	Surface Radiation Budget Average (CERES Archival Data Product)
SSF	Single Satellite CERES Footprint TOA and Surface Fluxes, Clouds
SSMI	Special Sensor Microwave Imager
SST	Sea Surface Temperature
SURFMAP	Surface Properties and Maps (CERES Input Product)
SW	Shortwave
SWICS	Shortwave Internal Calibration Source
SYN	Synoptic Radiative Fluxes and Clouds (CERES Archival Data Product)

SZA	Solar Zenith Angle
THIR	Temperature/Humidity Infrared Radiometer (Nimbus)
TIROS	Television Infrared Observation Satellite
TISA	Time Interpolation and Spatial Averaging Working Group
TMI	TRMM Microwave Imager
TOA	Top of the Atmosphere
TOGA	Tropical Ocean Global Atmosphere
TOMS	Total Ozone Mapping Spectrometer
TOVS	TIROS Operational Vertical Sounder
TRMM	Tropical Rainfall Measuring Mission
TSA	Time-Space Averaging
UAV	Unmanned Aerospace Vehicle
UT	Universal Time
UTC	Universal Time Code
VAS	VISSR Atmospheric Sounder (GOES)
VIRS	Visible Infrared Scanner
VISSR	Visible and Infrared Spin Scan Radiometer
WCRP	World Climate Research Program
WG	Working Group
Win	Window
WN	Window
WMO	World Meteorological Organization
ZAVG	Monthly Zonal and Global Average Radiative Fluxes and Clouds (CERES Archival Data Product)

Symbols

A	atmospheric absorptance
$B_\lambda(T)$	Planck function
C	cloud fractional area coverage
CF_2Cl_2	dichlorofluorocarbon
$CFCl_3$	trichlorofluorocarbon
CH_4	methane
CO_2	carbon dioxide
D	total number of days in the month
D_e	cloud particle equivalent diameter (for ice clouds)
E_o	solar constant or solar irradiance
F	flux
f	fraction
G_a	atmospheric greenhouse effect

g	cloud asymmetry parameter
H_2O	water vapor
I	radiance
i	scene type
m_i	imaginary refractive index
$\hat{N}$	angular momentum vector
N_2O	nitrous oxide
O_3	ozone
P	point spread function
p	pressure
Q_a	absorption efficiency
Q_e	extinction efficiency
Q_s	scattering efficiency
R	anisotropic reflectance factor
r_E	radius of the Earth
r_e	effective cloud droplet radius (for water clouds)
r_h	column-averaged relative humidity
S_o	summed solar incident SW flux
S_o'	integrated solar incident SW flux
T	temperature
T_B	blackbody temperature
t	time or transmittance
W_{liq}	liquid water path
w	precipitable water
$\hat{x}_o$	satellite position at t_o
x, y, z	satellite position vector components
$\dot{x}, \dot{y}, \dot{z}$	satellite velocity vector components
z	altitude
z_{top}	altitude at top of atmosphere
α	albedo or cone angle
β	cross-scan angle
γ	Earth central angle
γ_{at}	along-track angle
γ_{ct}	cross-track angle
δ	along-scan angle
ε	emittance
Θ	colatitude of satellite
θ	viewing zenith angle
θ_o	solar zenith angle

λ	wavelength
μ	viewing zenith angle cosine
μ_o	solar zenith angle cosine
ν	wave number
ρ	bidirectional reflectance
τ	optical depth
$\tau_{aer}(p)$	spectral optical depth profiles of aerosols
$\tau_{H_2O\lambda}(p)$	spectral optical depth profiles of water vapor
$\tau_{O_3}(p)$	spectral optical depth profiles of ozone
Φ	longitude of satellite
ϕ	azimuth angle
$\tilde{\omega}_o$	single-scattering albedo

Subscripts:

c	cloud
cb	cloud base
ce	cloud effective
cld	cloud
cs	clear sky
ct	cloud top
ice	ice water
lc	lower cloud
liq	liquid water
s	surface
uc	upper cloud
λ	spectral wavelength

Units

AU	astronomical unit
cm	centimeter
cm-sec^{-1}	centimeter per second
count	count
day	day, Julian date
deg	degree
deg-sec^{-1}	degree per second
DU	Dobson unit
erg-sec^{-1}	erg per second
fraction	fraction (range of 0–1)
g	gram
g-cm^{-2}	gram per square centimeter

$g\text{-}g^{-1}$	gram per gram
$g\text{-}m^{-2}$	gram per square meter
h	hour
hPa	hectopascal
K	Kelvin
kg	kilogram
$kg\text{-}m^{-2}$	kilogram per square meter
km	kilometer
$km\text{-}sec^{-1}$	kilometer per second
m	meter
mm	millimeter
μm	micrometer, micron
N/A	not applicable, none, unitless, dimensionless
$ohm\text{-}cm^{-1}$	ohm per centimeter
percent	percent (range of 0–100)
rad	radian
$rad\text{-}sec^{-1}$	radian per second
sec	second
sr^{-1}	per steradian
W	watt
$W\text{-}m^{-2}$	watt per square meter
$W\text{-}m^{-2}sr^{-1}$	watt per square meter per steradian
$W\text{-}m^{-2}sr^{-1}\mu m^{-1}$	watt per square meter per steradian per micrometer