Surface Radiation Budget (SRB) Langley DAAC Data Set Document

Summary:

This is Version 1.0 of a new interim product with parameters obtained from a variety of sources. As such, it is expected that revisions will be necessary as corrections are received from various users. The general approach is to use the ISCCP C1 data supplemented by the ERBE results as input to SRB satellite algorithms to estimate various surface parameters. Where possible, the satellite-estimated fluxes are compared with surface-measured ground truth. Using the ISCCP 3-hourly parameters as input, SRB results were generated using two different algorithms. The two methods use different approaches. Both methods apply spectral and angular corrections (based on ERB and results) which are not included in the original ISCCP C1 data. The user may have increased confidence in the SRB results for those cells wherein the two methods obtain values that differ slightly. The Pinker Algorithm (developed jointly by Drs. R. T. Pinker and I. Laszlo from the University of Maryland) is a physical model which uses an iterative procedure based on delta-Eddington radiative transfer calculations. The Staylor algorithm (developed by Mr. W. F. Staylor from the NASA Langley Research Center) is a parameterized physical model in which both cloud and aerosol transmission characteristics have been separately tuned to historic data at various locations around the globe. The monthly-averaged radiative fluxes are based on the monthly average of 24-hr daily averages, but certain other items are simple linear averages of values during daylight hours.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

SRB_DAILY:	Surface Radiation Budget (SRB) Daily Shortwave Parameters in Hierarchical Data Format (SRB_DAILY)
SRB_MONTHLY:	Surface Radiation Budget (SRB) Monthly Shortwave Parameters in Hierarchical Data Format (SRB_MONTHLY)

Data Set Introduction:

See Summary.

Objective/Purpose:

Summary of Parameters:

Discussion:

Related Data Sets:

ISCCP-C1:	ISCCP C1 3-Hourly Data
ERBE-S4:	ERBE Monthly Regional Averages

2. Investigator(s):

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Title of Investigation:

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3. Theory of Measurements:

4. Equipment:

Sensor/Instrument Description:

Collection Environment:

Source/Platform:

Source/Platform Mission Objectives:

The mission objectives of SRB are to use the ISCCP C1 data supplemented with ERBE data as input to the SRB satellite algorithms to estimate various top-of-atmosphere and surface parameters. Where GEBA data are available and determined by Satellite Data Analysis Center (SDAC) to be accurate, it is compared with both algorithm's calculation of downward shortwave irradiance at the surface.

Key Variables:

The NOAA spacecraft are a series of satellites in 870 km (nominal) circular, near-polar, sun-synchronous orbits with an inclination angle of approximately 99 degrees (retrograde) to the equator. They cross the equator during local morning and afternoon (and corresponding night times), with an orbital period of approximately 102 minutes. Each sequential orbit covers adjacent longitudes near the equator and overlapping longitudes near the poles. The Advanced Very High Resolution Radiometer (AVHRR) on-board this series is composed of up to five spectral channels with a nadir resolution of 1.1 km. In addition, temperature sounding and ozone observations are made by the TIROS (Television and Infrared Operational Satellite) Operational Vertical Sounder (TOVS) and are used in the ISCCP analysis of B3 data.

The Geostationary Operational Environmental Satellite (GOES) series consist of spin-stabilized spacecraft in geostationary circular orbit located over 75 degrees west longitude for GOES-East (5 & 7), and 135 degrees west longitude for GOES-West (6). The GOES-6 satellite was routinely moved to provide better coverage of seasonal weather events until its failure on 1/21/89. The GOES-7 satellite is now utilized in this manner. Data are collected in the visible and infrared bands by the Visible Infrared Spin-Scan Radiometer (VISSR). The visible channel detector consists of eight identical photo-multiplier tubes that scan the Earth in parallel, producing a visible channel resolution of 0.9 km. The IR detector produces a resolution of 8 km.

The Meteorological Satellite (Meteosat) series are operated by the European Space Agency and are in geostationary circular orbit over the equator centered at the Greenwich meridian (0 degrees E longitude), with the exception of METEOSAT-3. METEOSAT-3 is now centered at 50 degrees west and is functioning as a replacement for GOES-7 which was moved westward in response to the failure of GOES-6. The Multispectral Imaging Radiometer (MIR) on METEOSAT-2, -3, -4, and -5 collect data over the Earth in three spectral regions, one in the visible and two in the infrared. The satellite scans the Earth from east to west and, if the water vapor channel (6.7 um) is turned off, is capable of producing a resolution of 2.5 km.

The Geostationary Meteorological Satellites (GMS) are a series of satellites operated by the Japan Meteorological Agency. They are located in geostationary circular orbit over the equator centered at 140 degrees east longitude. The VISSR on board the GMS satellite collects data with four identical detectors operating in parallel, producing a resolution of 1.25 km.

Principles of Operation:

NOAA/ AVHRR:

The AVHRR is a four or five channel scanning radiometer that operates in the visible, near-infrared, and far-infrared regions. The fifth channel was added on the AVHRR/2 instrument flown on NOAA-7, -9, -11 and -12. Scanning is provided by an elliptical beryllium mirror rotating at 360 rpm about an axis parallel to the Earth. A two stage radiant cooler is designed to provide a basic temperature of 95 degrees K for the IR detectors. The telescope is an 8-inch afocal, all-reflective system, with polarization of less than 10 percent. Instrument operation is controlled by 26 commands and monitored by 20 analog housekeeping parameters.

GOES/VISSR:

The VISSR instrument operates in the visible region of 0.55 to 0.75 micrometers, and in the infrared region of 10.5 to 12.6 micrometers. Each of the eight photo-multiplier tubes on the visible detector is 0.025 X 0.021 microradians (mrads), with a dynamic range of 3-100albedo. The infrared portion of the instrument consists of two detectors cooled to 95 degrees K, with an instantaneous field-of-view (IFOV) of 192 X 192 mrads. The VISSR telescope has an aperture of 40 cm and a focal length of 291 cm, and routes the IR wavelengths to separate detectors. The video analog output of all detectors is transmitted to the VISSR Digital Multiplexer (VDM) where it is sequentially sampled every 2 microseconds by the visible channel and every 8 microseconds by the IR channel.

METEOSAT/MIR:

The Multispectral Imaging Radiometer (MIR) sensor on METEOSAT is a scanning radiometer which provides images in the visible and thermal IR regions of the spectrum. The instrument produces images of the full Earth disc viewed from a geostationary orbit. A reduced image format, corresponding to a limited band across the Earth's disc, may be selected by telecommand. The optical reflector system of the radiometer includes a movable Ritchey-Chretien telescope with primary and secondary mirrors. This includes a mirror located in the center of the primary mirror inclined at 45 degrees to the optical axis, four folding mirrors, and a separation mirror for diverting light to the visible sensor.

The optically-collected visible and IR signals are converted into analog electric signals by five detectors. These are divided into two subsets, two visible and three IR. The detectors are distributed across the focal plane of the radiometer and as a result of the relative displacement of the detectors in this plane, their respective fields-of-view (FOV) do not coincide but are displaced relative to each other.

The two visible detectors are positioned in the focal plane of the primary telescope. Their instantaneous FOV at the Earth's surface (2.5 square km) is determined by their physical size (250 X 250 micrometers sensitive area) and the telescope's focal length (3650 millimeters). While the visible detectors function properly at ambient temperatures, the three IR detectors must be cooled to less than 95 degrees K.

Each IR detector is 70 square micrometers and generates an instantaneous 5 km square FOV at the subsatellite point. One visible channel is time sharing with the water vapor channel so that the resolution of the visible image changes depending on the choice of channels.

GMS/VISSR:

The GMS Visible and IR Spin-Scan Radiometer (VISSR) is very similar to the scanning radiometers carried on Synchronous Meteorological Satellite (SMS) and GOES (1 through 3) satellites except for some modifications to stepping gears and detector portions; the number of steps in the scan is 2500 for the IR detector on GMS versus 1821 for GOES.

Sensor/Instrument Measurement Geometry:

The following table lists the measuring geometry characteristics for the satellites employed by the SRB program:

Satellite	Scan System	Scan Direction	Image Viewing
NOAA	Cross-track scan mirror	Moving south to north, scanning west to east	55.4 degrees
GOES	Spacecraft spin motion plus scan mirror	Stepping north to south, scan west to east	20 x 20 degrees
METEOSAT	Spacecraft spin motion plus scan mirror	Stepping south to north, scan east west	18 x 18 degrees
GMS	Spacecraft spin motion plus scan	Stepping north to south, scan west	18 x 18 degrees

	mirror	to east	
ERBS			

Manufacturer of Sensor/Instrument:

Calibration:

Specifications:

Tolerance:

Frequency of Calibration:

Other Calibration Information:

5. Data Acquisition Methods:

6. Observations:

Data Notes:

SATELLITE DATA GAPS

On a given day, time, and location, one or more parameters may be missing from either the ISCCP C1 or ERBE data used as inputs to the SRB algorithms. ISCCP missing data is caused by gaps in the operational satellite data being used to create the C1 product. Both the Pinker and Staylor algorithms use automated gap-filling techniques to compensate for voids in either the ISCCP or ERBE input data. Each algorithm uses a different technique which may cause notable differences between the two algorithms for one or more of the output parameters. (Details concerning the gap-filling techniques for each algorithm can be found in listings of the Fortran code supplied with each month's SRB data package.) These large differences occur infrequently and should not be of general concern. The user should be alert to the possibility of their existence, however. Whenever a parameter seems "out-of-line" with historical values, exceeds expected max or min values, or is significantly different from results of the other algorithm, it is recommended that the user examine other supporting parameters in the monthly file to determine the cause of the erratic behavior. Monthly-file parameters 9 through 22 and 42 through 50 should be useful. Examination of the daily files for the month may also be useful. If a cause for the abnormal value cannot be found or supported by other results from literature, the most likely problem is a combination of data gaps which cannot be properly handled by the automated procedures. In such a case, that value should be considered as missing data. Automated procedures are seldom successful in accounting for all possible combinations of data gaps or errors in input data.

REPROCESSING OF DATA MONTHS

September 1988 and November 1988 have been reprocessed due to errors found in an input file for the Staylor algorithm. Only parameters that have Staylor output have been affected. September 1988 was reprocessed on September 17, 1993, and November 1988 was reprocessed on November 22, 1993. The SRB version number now listed in the README files for these months is 1.1.r1. Users should obtain this new release for these two months. The new release is consistent with Version 1.1 for all other data months.

RECREATION OF HDF FILES

All of the monthly and daily HDF files from March 1985 through December 1988 (excluding the quarterly months - January, April, July and October) have been recreated to correct an error found in the listing of the processing date. The processing date month was listed as "00". This revision, Version 1.1.r2 updates the processing date of these data months to that listed in the respective README file originally released. For simplicity, all of the HDF file versions have been changed to 1.1.r2, including the quarterly months. Please note that the information contained in parameters 1 through 51 for the monthly files, and parameters 1 through 9 for the daily files, has not been changed. If the user does not have a need for the processing date as part of the HDF file, then it is not necessary to obtain Version 1.1.r2 for these months.

Refer to the README.MMMYY file for further information.

Field Notes:

7. Data Description:

Spatial Characteristics:

Spatial Coverage:

The SRB data package provides global coverage.

ISCCP

Satellite	Sensor	Longitude Range	Latitude Range
NOAA-7,8,9,10,11,12	AVHRR	Global	Global (1)
GOES-5(E)	VISSR	15 W to 135 W	60 N to 60 S
GOES-6(W)	VISSR	75 W to 165 E	60 N to 60 S (2)
GOES-7(E)	VISSR	15 W to 135 W	60 N to 60 S (3)
METEOSAT-2,3,4,5	MIR	60 W to 60 E	60 N to 60 S (4)
GMS-1	VISSR	160 W to 80 E	60 N to 30 S
GMS-2,3,4	VISSR	160 W to 80 E	60 N to 60 S

1. Global coverage over a period of approximately 24 hours.
2. For better coverage of seasonal weather events, GOES-6 was moved to 98 W on August 30, 1984; to 108 W on November 22, 1984; back to 98 W on July 28, 1986; and to 135 W from April 1987 until its failure on January 21, 1989.
3. For better coverage of seasonal weather events, GOES-7 is positioned between 98 W and 108 W, with a position of 98 W during the tropical convective season. This regular change in positions will occur until GOES-I becomes operational, approximately late 1993.
4. METEOSAT-3 was positioned to 50 deg W in early August 1991 to supplement the coverage of GOES-7. This move was necessary in order to provide coverage of Atlantic weather events during the absence of a GOES East Satellite.

ERBE

Satellite	Sensor	North	South	East	West
ERBS	Nonscanner	67.5	67.5	180	180
ERBS	Scanner	67.5	67.5	180	180
NOAA-9	Nonscanner	90	90	180	180
NOAA-9	Scanner	90	90	180	180
NOAA-10	Nonscanner	90	90	180	180
NOAA-10	Scanner	90	90	180	180

Spatial Coverage Map:

A map is not available.

Spatial Resolution:

The SRB data package uses the ISCCP C1 equal-area map grid consisting of 6596 cells covering the entire globe. The C1 data set is on an equal-area grid (the dimension of a cell at the equator is about 280 km X 280 km).The spatial resolution of the ERBE data set is 2.5 degrees X 2.5 degrees on an equal-angle grid. The ERBE dataset is converted to equal-area resolution using a weighting technique.

Projection:

Grid Description:

Temporal Characteristics:

Temporal Coverage:

The SRB data package will consist of monthly data sets covering a twelve year period from July 1983 through 1995. The ISCCP data are planned to cover the twelve year period from July 1983 to 1995. The overall coverage of each of the satellites and sensors participating in the SRB are listed below:

Satellite	Sensor	SRB Start Date*	SRB End Date*
NOAA-7	AVHRR	07/01/83	02/09/85
NOAA-8	AVHRR	09/20/83	06/24/84
NOAA-9	AVHRR	01/09/85	11/08/88
NOAA-10	AVHRR	11/10/86	09/16/91
NOAA-11	AVHRR	10/18/88	ongoing
NOAA-12	AVHRR	09/16/91	ongoing
GOES-5	VISSR	07/01/83	07/30/84
GOES-6	VISSR	07/01/83	01/21/89
GOES-7	VISSR	04/26/87	ongoing
METEOSAT-2	MIR	07/01/83	08/11/88

METEOSAT-3	MIR	08/11/88	01/25/91
METEOSAT-4	MIR	05/19/89	ongoing
METEOSAT-5	MIR	08/01/91	ongoing
GMS-1	VISSR	01/21/84	06/29/84
GMS-2	VISSR	07/01/83	09/27/84
GMS-3	VISSR	09/27/84	12/04/89
GMS-4	VISSR	12/04/89	ongoing
ERBS	ERBE-Scanner	11/05/84	02/28/90

*Note: Some gaps exist between start and end dates.
**NOAA-D was launched on May 14, 1991. NOAA-D became NOAA-12 and replaced NOAA-10 as the morning satellite.

Temporal Coverage Map:

A map is not available.

Temporal Resolution:

The SRB data package represents global, merged results from a variety of data sources (listed previously). Fifty parameters are reported as monthly averages, eight parameters are reported as daily averages.

Data Characteristics:

Parameter/Variable:

Fifty-eight quantities are reported for the SRB Shortwave Data Package (excluding data date and processing date). There are 50 monthly average quantities and 8 daily average quantities. The principle parameters in the data package are Pinker and Staylor (SRB satellite algorithms) calculated irradiances for the surface and top-of-atmosphere. Ground truth values for downward shortwave irradiance and an accuracy assessment are also included. SRB uses the same equal area grid system as that used by ISCCP for its C1 products. The equal-area grid contains 6596 cells covering the globe; where a cell is approximately 280km X 280km at the equator. Ground truth values for downward shortwave irradiance and an accuracy assessment are also included.

The SRB Shortwave Data Package parameters and their units are listed below.

DEFINITIONS OF SRB PARAMETERS AND CODES

A. Definition Of 52 Items In Monthly Binary File: srb_monavgs_yymm. Cell information including both ISCCP and ERBE-derived properties:

1. CELL NUMBER (beginning at Greenwich south pole circling east), DIMENSIONLESS.
2. ISCCP LATITUDE INDEX, DIMENSIONLESS.
3. ISCCP LONGITUDE INDEX, DIMENSIONLESS.
4. LATITUDE OF CELL CENTER, DEGREES.
5. LONGITUDE OF CELL CENTER, DEGREES.
6. ISCCP SURFACE TYPE CODE (ISCCP parameter 11 for daytime), DIMENSIONLESS.

Code	Surface Type
1	Water
2	Land
3	Coastal

7. ISCCP PRINCIPAL SATELLITE CODE (ISCCP parameter 12), DIMENSIONLESS. Satellite codes used by SRB are:

Code	Satellite	Code	Satellite	Code	Satellite	Code	Satellite
11	NOAA-7	**31**	GOES-5	**41**	METEOSAT-2	**51**	GMS-1
61	NOAA-8	**21**	GOES-6	**42**	METEOSAT-3	**52**	GMS-2
12	NOAA-9	**32**	GOES-7	**43**	METEOSAT-4	**53**	GMS-3
62	NOAA-10			**44**	METEOSAT-5	**54**	GMS-4

13	NOAA-11
63	NOAA-12

8. NUMBER OF GROUND TRUTH SITES IN CELL, DIMENSIONLESS (GEBA Subset).
9. NUMBER OF DAYS OF MISSING ISCCP RADIANCE DATA THAT WERE FILLED, DAYS (STAYLOR VALUE).

   This number allows the user to know how much radiation data for this cell are based on real ISCCP data and how much are based on fill values obtained by interpolation. The PINKER ALGORITHM also fills over gaps of missing data.

10. STAYLOR SNOW/ICE COVER, PERCENT OF MONTH.

    This is the percentage of time when snow/ice cover is greater than 10 percent and the surface temperature (ISCCP PARAMETER 115) is less than 285 DEG K over a 5-day period. The value is calculated as a percentage of days when actual data are available. Thus, data gaps are assumed to have the same snow/ice frequency as data days. When average surface temperature is greater than 285 DEG K over a 5-day period, Staylor assumes that the snow/ice cover has melted and modifies ISCCP PARAMETER 13 to zero snow/ice cover.

11. NUMBER OF ISCCP ALL-SKY PIXELS (linear average of daylight values of ISCCP parameter 5 over the month).
12. NUMBER OF ISCCP CLOUDY-SKY PIXELS (linear average of daylight values of ISCCP parameter 6 over the month).
13. ISCCP DAYLIGHT CLOUD FRACTION, DIMENSIONLESS (SRB ITEM 12/SRB ITEM 11).
14. ISCCP CLOUDY-PIXEL CLOUD OPTICAL DEPTH, DIMENSIONLESS (linear average of daylight values of ISCCP parameter 85 over the month).
15. ISCCP SURFACE PRESSURE, MB (linear average of daylight values for ISCCP parameter 114 over the month).
16. ISCCP SURFACE TEMPERATURE (TOVS SOUNDER PRODUCT), DEG K (linear average of daylight values for ISCCP parameter 115 over the month).
17. ISCCP SURFACE TEMPERATURE (ISCCP CLOUD-IMAGER PRODUCT), DEG K (linear average of daylight values for ISCCP parameter 89 over the month).
18. ISCCP TOTAL COLUMN PRECIPITABLE WATER, CM (linear average of the daylight sum of ISCCP parameters 127, 128, 129, 130, and 131 over the month).
19. ISCCP TOTAL COLUMN OZONE, DOBSON UNITS (linear average of daylight values of ISCCP parameter 132 over the month).
20. ISCCP CLEAR-SKY COMPOSITE TOP-OF-ATMOSPHERE REFLECTANCE, DIMENSIONLESS (linear average of daytime values of ISCCP clear-sky composite scaled radiance divided by solar zenith angle [ISCCP parameter 110/isccp parameter 14], See WMO/TD-No. 58, Revised August 1987, page 16 for discussion).
21. ERBE ALL-SKY, TOP-OF-ATMOSPHERE SW NET IRRADIANCE, W/M**2.
22. ERBE CLEAR-SKY, TOP-OF-ATMOSPHERE SW NET IRRADIANCE, W/M**2.

    Downward SW surface irradiance:

23. PINKER ALL-SKY DOWNWARD SW SURFACE IRRADIANCE, W/M**2 (average of 24-hr values over the month).
24. STAYLOR ALL-SKY DOWNWARD SW SURFACE IRRADIANCE, W/M**2 (average of 24-hr values over the month).
25. GEBA SUBSET ALL-SKY DOWNWARD SW IRRADIANCE GROUND TRUTH, W/M**2.

    Other parameters used to estimate downward SW surface irradiance:

26. PINKER SURFACE PRESSURE, MB (assumed value).
27. STAYLOR SURFACE PRESSURE, MB (assumed value).
28. PINKER TOP-OF-ATMOSPHERE DOWNWARD SW IRRADIANCE, W/M**2 (average of 24-hr values over the month).
29. STAYLOR TOP-OF-ATMOSPHERE DOWNWARD SW IRRADIANCE, W/M**2 (average of 24-hr values over the month).

    Calculated parameters (without validation):

30. PINKER SURFACE DOWNWARD SW DIRECT/ DIFFUSE RATIO (linear average of daylight values over the month).
31. PINKER CLEAR-SKY DOWNWARD SW SURFACE IRRADIANCE, W/M**2 (average of 24-hr values over month).
32. STAYLOR CLEAR-SKY DOWNWARD SW SURFACE IRRADIANCE, W/M**2 (average of 24-hr values over month).
33. PINKER DOWNWARD SW SURFACE "CLOUD FORCING" IRRADIANCE, W/M**2 (SRB item 23-SRB item 31).
34. STAYLOR DOWNWARD SW SURFACE "CLOUD FORCING" IRRADIANCE, W/M**2 (SRB item 24-SRB item 32).
35. PINKER SW SURFACE ALBEDO, DIMENSIONLESS (Surface Upward/Surface Downward).
36. STAYLOR SW SURFACE ALBEDO, DIMENSIONLESS (analysis of ERBE data).
37. PINKER ALL-SKY SURFACE SW NET IRRADIANCE, W/M**2. (Surface Downward/Surface Upward)
38. STAYLOR ALL-SKY SURFACE SW NET IRRADIANCE, W/M**2 (Downward (1-surface albedo)).
39. PINKER ALL-SKY, TOP-OF-ATMOSPHERE SW NET IRRADIANCE, W/M**2.
40. PINKER CLEAR-SKY, TOP-OF-ATMOSPHERE SW NET IRRADIANCE, W/M**2.
41. PINKER ATMOSPHERE SW ABSORBED IRRADIANCE, W/M**2 (SRB item 39 - SRB item 37).

    Diagnostic parameters:

42. PINKER MINUS STAYLOR ALL-SKY DOWNWARD SW SURFACE IRRADIANCE,W/M**2 (SRB item 23- SRB item 24).
43. GEBA SUBSET GROUND TRUTH MINUS PINKER ALL-SKY DOWNWARD SW SURFACE IRRADIANCE, W/M**2 (SRB item 25 -

SRB item 23).

44. GEBA SUBSET GROUND TRUTH MINUS STAYLOR ALL-SKY DOWNWARD SW SURFACE IRRADIANCE, W/M**2 (SRB item 25 - SRB item 24).
45. PINKER MINUS STAYLOR CLEAR-SKY DOWNWARD SW SURFACE IRRADIANCE, W/M**2 (SRB item 31 - SRB item 32).
46. PINKER MINUS STAYLOR SURFACE SW CLOUD FORCING IRRADIANCE, W/M**2 (SRB item 33- SRB item 34).
47. PINKER MINUS STAYLOR SW SURFACE ALBEDO, DIMENSIONLESS (SRB item 35 - SRB item 36).
48. PINKER MINUS STAYLOR ALL-SKY SURFACE SW NET IRRADIANCE, W/M**2 (SRB item 37 - SRB item 38).
49. PINKER MINUS ERBE ALL-SKY, TOP-OF-ATMOSPHERE SW NET IRRADIANCE, W/M**2 (SRB item 39 - SRB item 21).
50. PINKER MINUS ERBE CLEAR-SKY, TOP-OF-ATMOSPHERE SW NET IRRADIANCE, W/M**2 (SRB item 40 - SRB item 22).
51. DATA DATE, MMYY.
52. PROCESSING DATE, DDMMYY.

NOTE: A value of -1000 means that no data are available for this item.

B. DEFINITIONS OF 10 ITEMS IN DAILY BINARY FILE
srb_dayavgs_yymm

1. CELL NUMBER (beginning at Greenwich south pole circling east, 1-6596, Dimensionless.
2. DAYLIGHT CLOUD FRACTION, DIMENSIONLESS (linear average of daylight values of ISCCP parameter 6/ linear average of daylight values of ISCCP parameter 5).
3. PINKER ALL-SKY DOWNWARD SW SURFACE IRRADIANCE, W/M**2.
4. STAYLOR ALL-SKY DOWNWARD SW SURFACE IRRADIANCE, W/M**2.
5. PINKER CLEAR-SKY DOWNWARD SW SURFACE IRRADIANCE, W/M**2.
6. STAYLOR CLEAR-SKY DOWNWARD SW SURFACE IRRADIANCE, W/M**2.
7. PINKER ALL-SKY, TOP-OF-ATMOSPHERE SW NET IRRADIANCE, W/M**2.
8. PINKER TOP-OF-ATMOSPHERE DOWNWARD SW IRRADIANCE, W/M**2.
9. DATA DATE, MMYY.
10. PROCESSING DATE, DDMMYY.

NOTE: A value of -1000 means that no data are available for this item.

Variable Description/Definition:

Unit of Measurement:

Data Source:

SRB has a variety of data sources. The primary source is the ISCCP C1 monthly data set. The ISCCP product provides input for the Staylor and Pinker satellite algorithms. ERBE data are also used - as input to the models, as well as for top-of-atmosphere (TOA) irradiance comparisons with the Pinker Model output. The Swiss Federal Institute of Technology, Zurich, provides ground-truth fluxes from GEBA. These data are used for validation of the Pinker and Staylor calculated downward shortwave surface irradiances.

Data Range:

Sample Data Record:

8. Data Organization:

Data Granularity:

A general description of data granularity as it applies to the IMS appears in the EOSDIS Glossary.

Data Format:

All data are written in Hiearchical Data Format (HDF).

9. Data Manipulations:

Formulae:

Derivation Techniques and Algorithms:

DESCRIPTION OF PINKER METHOD:

The algorithm was developed at the UNIVERSITY OF MARYLAND by R. T. Pinker and I. Laszlo who supplied this ASCII character documentation. It is a physical model based on radiative transfer calculations using the delta- Eddington approximation. The model is an improvement on earlier concepts (Pinker and Ewing, 1985) and is more fully described in Pinker and Laszlo (1992).

Conceptual Framework:

Reflectivity (R), transmissivity (T), and absorptivity (A), of the atmosphere (clear or cloudy) can be determined by the following set of optical parameters: optical depth (TAU); single scattering albedo (OMEGA); and phase function/asymmetry parameter (g). It has been demonstrated that a reverse application, i.e., the retrieval of these parameters from the measurements of R, T and A is also possible, namely, that information on optical depth can be recovered from satellite data and that the visible albedo provides the most sensitive measure of optical depth. Using similar concepts, a low resolution spectral model in the 0.2-4.0 micrometer range, was formulated for computing T from satellite observations of top of the atmosphere (TOA) reflectivity (R); if the transmissivity (T), of the atmosphere is known, one can also compute the downwelling radiation at the surface.

The method is based on relating the broadband (0.2-4.0 micrometer) transmissivity, T, (ratio of the irradiance at the surface to that at TOA) to the broadband TOA reflectivity, R, (ratio of the reflected flux at TOA to the TOA irradiance). Once the relationship, T = f(R) is known, T (and the surface irradiance, SWDN) can be computed by using R as determined from the satellite measured narrowband radiance. Three major steps are involved. First, relationships of the type T = fi(R), i = 1, ... N, representing N realistic atmosphere/surface conditions are established through radiative transfer computations of transmitted and reflected radiation. Each of the N different conditions is characterized by a specific surface albedo, given amounts of absorbing gases (ozone; water vapor) and scatterers (molecules; aerosols; cloud droplets). Next, a broadband TOA albedo, RSAT, is determined from the satellite measurement. Finally, the relationship, T = fs(R), pertaining to the atmosphere/surface condition (S), that existed when the satellite measurement was taken, is selected from the results of the first step, and an estimate of T (and SWDN) is obtained by matching the satellite derived broadband albedo, RSAT, to an albedo (R) computed in the first step. The first step has to be performed only once and the results of the radiative transfer computations can be stored in a data library. Steps 2 and 3 have to be executed for each satellite observation.

Atmospheric Radiative Transfer Component:

The reflected and transmitted radiation are computed for a plane-parallel, vertically inhomogeneous, scattering and absorbing atmosphere in five spectral intervals (0.2-0.4, 0.4-0.5, 0.5-0.6, 0.6-0.7, 0.7-4.0 micrometer) using the delta-Eddington approximation of radiative transfer. The rationale for the selection of the delta-Eddington approach, and the accuracy of this method are discussed in Pinker and Ewing (1985). The atmospheric radiative transfer model accounts for 1) absorption by ozone and water vapor; 2) multiple scattering by molecules; 3) multiple scattering and absorption by aerosols and cloud droplets and 4) multiple reflection between the atmosphere and the surface. It has five or six layers, depending on the aerosol profile considered, and on whether a cloud is present. The parameterizations used in the atmospheric radiative transfer model will be described in what follows.

Ozone and Water Vapor Absorption:

Scattering of radiation is weak at high altitudes where much of the absorption by ozone takes place. It is therefore assumed that ozone is concentrated in a single, pure absorbing layer at the top of the atmosphere. The fraction of the incident solar radiation absorbed by ozone in this layer (A), is computed following Lacis and Hansen (1974):

A = A(x) + R(THETA0)*A(x) (1)

where THETA0 is the solar zenith angle, R(THETA0) is the reflectivity of the atmosphere-surface system below the absorbing ozone layer, and x is the relative optical ozone pathlength. The first term represents the absorption of the downwelling direct radiation, while the second one gives the absorption of the upwelling diffuse radiation. Ozone absorption is accounted for in the 0.2-0.4 micrometer (UV) and in the 0.5-0.6 micrometer (VIS) spectral intervals (Lacis and Hansen, 1974):

AUV = (1.082*x)/((1+(138.6*x))**0.805) + (0.0658*x)/(1+((103.6*x)**3)) (2)

AVIS = (0.02118*x)/(1+(0.042*x)+(0.000323*(x**2))) (3)

The absorption by water vapor, Awv, in the 0.7-4.0 micrometer band is computed in terms of the discrete probability distribution (p(kn)) of the absorption coefficients (kn) following Lacis and Hansen (1974):

Awv(Y(L)) = 1-summation from n=1 to n=8 of (p(kn)*e**(-kn*Y(L))) (4)

Here Yl is the effective water vapor amount (temperature and pressure scaled amount) in the Lth atmospheric layer. The total amount of ozone and the effective water vapor amount in each layer of the atmosphere were obtained from detailed data on ozone and water vapor densities, temperature and pressure at 31 levels of the Standard Atmospheres (tropical, mid-latitude summer and winter, subarctic summer and winter) (Kneizys et al., 1980).

Rayleigh Scattering:

Molecular scattering is accounted for in the first four spectral intervals 0.2-0.4; 0.4-0.5; 0.5-0.6; and 0.6-0.7 micrometer. For Rayleigh scattering OMEGA = 1 and g = 0. The Rayleigh scattering optical depth of a layer, dTAU, between levels L and L-1 (Penndorf, 1957) is expressed as:

DTAU = 27.019*t*((1+(0.5*(z(L-1)+z(L)))/6371)**2)*(1+29/18r) /(1+r)(p(L)-p(L-1)) (5)

where: z(L), z(L-1) - heights (km) at levels L and L-1
p(L), p(L-1) - pressures (mb) at levels L and L-1
r - relative humidity in the layer
t - a function of wavelength, depolarization factor and the refractive index of the air.

Equation (5) includes corrections for humidity and the variation of gravitation with altitude. For the four spectral intervals between 0.2-0.7 micrometer, the parameter t was computed with the ATRAD model (Wiscombe et al., 1984).

Aerosol Extinction:

Four atmospheric aerosol profiles (MAR-I, MAR-II, CONT-I and CONT-II) of the Standard Radiation Atmosphere (SRA) (WCP-55, 1983) have been incorporated into the solar model. They depict typical maritime conditions, dust outbreaks over oceans, average rural-continental aerosol atmosphere and desert atmosphere under conditions of heavy haze, respectively. Depending on the aerosol profile selected, the atmosphere is divided into five (CONT-I, CONT-II and MAR-I) or six (MAR-II) layers. For each layer, the aerosol models give the extinction coefficients, SIGMALAMBDA, single scattering albedos, OMEGA, and asymmetry parameters, gLAMBDA, as functions of wavelength, LAMBDA, and aerosol type (continental, maritime, background stratospheric and upper atmospheric).

Cloud Extinction:

The cloud parameterization of Stephens et al. (1984) for two broad spectral intervals in the shortwave region (0.2-0.75 micrometer and 0.75-4.0 micrometer) was adopted. It is expressed in terms of optical thickness, TAU, single scattering albedo, OMEGA, and backscattered fraction of monodirectional incident radiation BETA(MU0), as a function of the cosine of the solar zenith angle, MU0. In the solar model the radiative transfer is treated in the framework of the delta-Eddington approximation; the optical properties are described by the optical depth, TAU, the single scattering albedo, OMEGA, and the asymmetry parameter, g. In order to implement the cloud parameterization of Stephens into the delta- Eddington scheme, it is necessary to relate BETA(MU0) to g.

The single scattering albedos and the asymmetry parameters to be used in the delta-Eddington approximation have been derived iteratively so that they yield reflectance, R, and absorption, A, of clouds as given by the Stephens' parameterization scheme. This method allows the inclusion of aerosols in the atmospheric column. The parameterization of Stephens does not account for aerosol extinction. Because it was assumed by Stephens that the cloud does not absorb in the visible spectrum, the ability to include aerosol extinction is important. In all the radiative transfer computations, the spectral interval was (0.2-4.0 micrometer), to be compatible with the parameterization of Stephens.

Surface Reflectivity:

The ocean- and land-albedo models of Briegleb et al., (1986) were adopted to prescribe the surface reflectance as a function of solar zenith angle, THETA0, and wavelength, LAMBDA. In the land-albedo models each surface is considered to consist of two components (ak, where k = 1,2) with fractions f and (1-f):

a(THETA0,LAMBDA) = f*a(1,THETA0,LAMBDA) + (1-f)*a(2,THETA0,LAMBDA) (6)

The albedo of each component is given as a function of the solar zenith angle, the albedo for THETA0 = 60 degrees, a0, and an empirical parameter, (dk, where k = 1,2), (Dickinson, 1983):

a(k,THETA0,LAMBDA) = a(k,60 degrees,LAMBDA) *(1+d(k))/(1+2*d(k)*cos(THETA0)). (7)

In the surface albedo models a0 is specified for 4 spectral intervals in the shortwave band with boundaries at 0.2, 0.5, 0.7, 0.85 and 4.0 micrometer, as well as the values of dk and the fractions f for each component. The above parameters and the surface reflectivities based on surface and aircraft measurements are specified for ten surface types (Briegleb et al., 1986). It is assumed that land surface albedos are the same for both the direct and the diffuse components of the solar irradiance.

The ocean-albedo for direct solar radiation is obtained from the following expression (Briegleb et al., 1986):

adir(THETA0) = (2.6/((((cos(THETA0))**1.7)+0.065)) +(15(cos(THETA0)-0.1)*(cos(THETA0)-0.5) *(cos(THETA0)-1)) (8)

For diffuse irradiance, a constant albedo value, adif, of 6 105s used.

A surface albedo is derived from the satellite measurements at clear sky, using the actual values of ozone and water vapor amounts and aerosol climatology. This value is then used as a scaling factor. This scaling procedure retains the spectral and angular characteristics of the surface model of Briegleb et al. (1986), but yields a broadband albedo which is consistent with satellite observations. This procedure will accommodate future developments of global scale surface reflectance models, as might result from the EOS mission.

Further details about the model and its implementation can be found in Pinker and Laszlo (1992).

Description of Staylor Method:

The algorithm was developed at NASA LANGLEY RESEARCH CENTER by W. F. Staylor who supplied this ASCII-character documentation. It is an empirical/physical model that utilizes ISCCP-C1 data (Schiffer and Rossow, 1983) as its primary input data. The model is a modified version of an earlier model by Darnell et al. (1988), hereafter D88, that utilized TOVS meteorological data (Smith et al., 1979) and Heat Budget Product radiance data (Gruber, 1978) as input data to estimate surface insolation.

The current insolation model uses a broadband shortwave approach which assumes that insolation at the surface for all-sky conditions (clear and cloudy), ISASi, can be related as the product of insolation at the top of the atmosphere, ITOAi, clear-sky atmospheric transmittance, TA, and cloud transmittance, TC,

ISASi = ITOAi*TA*TC . (1)

This is an instantaneous expression (i) and it is assumed that TA and TC are independent. ITOAi is given by

ITOAi = S*cos(theta) (2)

where S is the Earth-Sun distance-corrected solar flux and theta is the solar zenith angle.

Atmospheric transmittance can be expressed as:

TA = (1+0.065*PS*AS+2*J*AS)*exp(-TAU,theta) (3)

where PS is the surface pressure, AS is surface albedo, J is an aerosol parameter, and TAU,theta is the effective clear-sky atmospheric optical depth. The first term in brackets relates the atmospheric backscattering of surface reflected flux (treated as negative optical depth in D88). The 0.065 coefficient is the average of values given by Lacis and Hansen (1974) and Hoyt (1978). Surface albedo will be treated later (see SURFACE ALBEDO). In Fig. 2 of D88, it was found that TAU,theta and the optical depth at zero degrees solar zenith angle, TAU,zero, were related as:

TAU,theta = TAU,zero*(sec(theta))**N (4)

and the power, N, could be calculated as:

N = 2.1*(log(TAU,70.5 deg)-log(TAU,0 deg)). (5)

Vertical optical depth (theta = 0 degrees) is defined as:

TAU,zero = -ln(1-ALPHA,zero) (6)

where ALPHA,zero is the effective downward attenuation factor for solar energy due to all absorption and scattering processes (clear-sky only). ALPHA, zero is the summation of six components given as:

ALPHA,zero = ALPHA,WV + ALPHA,OZ + ALPHA,02 +ALPHA,CO2 +ALPHA,RAY + ALPHA,AER (7)

Lacis and Hansen (1974) gave equations for the broadband absorptions of water vapor and ozone which are approximated here as:

ALPHA,WV = 0.100*(WV)**0.27 (8)

and

ALPHA,OZ = 0.037*(OZ)**0.43 (9)

Yamamoto (1962) gave equations for the broadband absorptions of oxygen and carbon dioxide which are approximated here as:

ALPHA,O2 = 0.002*(PS)**0.87 (10)

and

ALPHA,CO2 = 0.006*(PS)**0.29 (11)

Rayleigh attenuation was estimated by Lacis and Hansen (1974) as:

ALPHA,RAY = 0.035*PS (12)

Aerosol attenuation was based on WCP models (WCRP, 1983) given here as:

ALPHA,AER = J/2 + K (13)

The J term is equal to aerosol optical depth times the quantity one minus the asymmetry factor and K is equal to the optical depth times the quantity one minus the single-scattering albedo. Values for J and K are given in Table 1 for five surface types.

It should be noted that the Rayleigh and aerosol attenuation terms are concerned only with backscattering and/or absorption, but not with forward scattering of flux which reaches the surface.

With values of S, PS, AS, WV, OZ, J, K, and TC (see INPUT DATA), one could compute the instantaneous insolation at the surface as a function of theta using equations (1) through (13). Computation of the daily insolation (d) involves the time integration of the instantaneous insolation (i) from sunrise (sr) to sunset (ss) which can be approximated as:

ISASd = S*TC*(1 + 0.065*PS*AS+2*J*AS) *integral(exp(-TAU,theta)*cos(theta)*dt) taken over sr to ss (14)

where PS, AS, S, J, and TC are assumed to be constant for a region during the course of each day. Equation (14) can be evaluated as:

ISASd = S*H*TC*(1 + 0.065*PS*AS+2*J*AS) *exp(-TAU,zero*(UE)**-N) (15)

where H is the daily vertical Sun fraction and UE is the effective daily cosine of the solar zenith angle. Both H and UE are defined in Table 2.

Cloud transmittance is based on a threshold technique (D88, Fig. 7) given by:

TC = 0.O5 +0.95*(Ro-Rm)/(Ro-Rc) (16)

where Ro, Rc and Rm are the TOA reflectances for overcast, clear-sky and measured conditions, respectively. The coefficients 0.05 and 0.95 (rather than 0 and 1) simply relate the observation that for totally overcast days (Rm=Ro) cloud transmittance is about 5 percent, not zero. Each of the three reflectance terms in equation (16) is a daily value obtained by weighting the ISCCP 3-hourly instantaneous values with the cosine of the solar zenith angle, UO. The measured value, for instance, would be

Rm = summation Rmi*UO/summation UO (17)

Instantaneous overcast reflectances are estimated from a model by Staylor (1985) as:

Roi = D1/(UO*UV) + (D2/(UO*UV))*((UO*UV) /(UO + UV))**2 (18)

where UV is the cosine of the viewing zenith angle and D1 and D2 are ISCCP satellite coefficients given in Table 3. These coefficients are determined from ISCCP data from a number of non-snow, totally overcast regions with mean cloud optical depths greater than 80 for each satellite every month. A linear regression of (Roi*UO*UV) versus (((UO*UV)**2)/((UO + UV)**2)) is performed to determine D1 and D2.

Clear-sky reflectances are determined by one of several methods depending on the surface type and snow cover. For ocean regions, which cover the majority of the Earth's surface,

Rci = D3 + D4*((UO*UV)**-0.75) (19)

where D3 and D4 are ISCCP satellite coefficients, given in Table 3, that were determined from a number of totally-clear ocean regions for each satellite every month. A linear regression of (Rci) versus ((UO*UV)**- 0.75) is performed to determine D3 and D4. For land regions where there is no snow or where the snow cover does not change by more than 10 during the month, daily Rc values are computed from the clear-sky pixels and the minimum value for the month is used for the entire month. If the snow cover changes more than 10 0uring the month (determined for 5- day intervals), the above procedure is still used, but is applied to several shorter time intervals.

Measured instantaneous reflectances, Rmi, are the pixel-weighted average of the clear and cloud pixel reflectances which are then UO-weighted to produce the daily Rm values (equation 17). If only a single Rmi value exists for a day (average of about four for the ISCCP geostationary satellites), a value of Rm can be computed for that day. But if no Rmi value exists for a day (occurs most frequently in regions of polar satellite coverage), a fill value is provided by one of two methods. If an Rm value exists for an adjacent longitudinal region for that day, it is used. If it does not exist, the previous day's value of Rm is used. This procedure is expanded spatially, then temporally until a non-fill value of Rm is found.

Surface Albedo:

A daily surface albedo value for all-sky conditions, AS, is needed for the computation of insolation (equation 15), and it is also used in the computation of surface absorbed insolation which is given by:

IAASd = ISASd*(1-AS) (20)

The all-sky albedo is estimated as

AS = Aso + (Asc - Aso)*(TC)**2 (21)

where Aso is the daily overcast albedo and Asc is the daily clear-sky albedo. Because of the difficulty of obtaining consistent surface albedos using the visible (0.5 - 0.7 micron: GOES, GMS, NOAA) and near- infrared (0.7 - 1.1 micron; METEOSAT) radiances from ISCCP, daily clear-sky albedo results from Staylor and Wilber (1990) were used which were based on broadband ERBE scanner data. Daily overcast albedos are estimated to be equal to the instantaneous clear-sky albedos for a solar zenith angle of 53 degrees (cosine = 0.6) as that is approximately the effective downward zenith angle of diffuse rays from clouds. For oceans,

Aso = 0.065, (22a)

and for land

Aso = 1.1*Asc*(UE)**0.2 (22b)

Input Data

ISCCP data sets contain data bytes (B) for 132 parameters which are given once every 3 hours (0, 3, 6, 9, 12, 15, 18, 21 GMT). Surface pressure is given in millibars (1000 mb = sea level pressure) and is converted to atmospheres as

PS = B114/1000 (23)

Precipitable water vapor is given in centimeters for each of 5 layers and converted to total burden in precipitable centimeters as

WV = B127 + B128 + B129 + B130 + B131 (24)

Ozone is given in Dobson units and converted to atmosphere-cm as

OZ = B132/1000 (25)

The cosine of the solar zenith angle, UO, is B14/100 and the cosine of the viewing zenith angle, UV, is B15/100. Snow coverage in percent is B13. Total number of pixels in a region is B5, and the number of those which are cloudy is B6. Mean scaled reflectance (Rmi*UO) for the cloudy pixels is B104, and mean scaled reflectance for the clear pixels is B107.

Solar declinations and Earth-Sun distances were obtained from the Naval Observatory Almanac for each day. A solar flux of 1365 W/m2 was used for an Earth-Sun distance of 1AU. As mentioned previously, surface albedos were derived from ERBE scanner data (Staylor and Wilber, 1990).

Table 1: Aerosol Models

Surface	J	K
Ocean	0.06*UE	0.008*UE
Land	0.12*UE	0.035*UE
Coastal	0.09*UE	0.020*UE
Desert	0.20*UE	0.040*UE

Table 2: Definition of Insolation Parameters

F/G > 1 no sunset	1 > F/G > -1 sunrise and sunset	F/G < -1 Nsunrise
H = F	(1/PI)*(F*arccos(-F/G)**2)**0.5)	0
UE = F	F + G*(G-F/2*G)**0.5	-

F = sin(ELAT)*sin(SDEC)
G = cos(ELAT)*cos(SDEC)
ELAT = Effective latitude of a region, area-centered
SDEC = Solar declination

Table 3: ISCCP Satellite Coefficient (Applicable from April 1985 to January 1986)

Satellite	Code	D1	D2	D3	D4
NOAA-9	12	0.023	3.08	-0.007	0.040
GOES-6 (west)	21	0.000	3.40	0.002	0.038
METEOSAT-2	41	0.004	3.35	-0.010	0.040
GMS-3	53	0.005	3.38	-0.012	0.040

Data Processing Sequence:

Processing Steps:

The SRB data set processing steps include:

1. Executing the ISCCP C1 READ program which reads the ISCCP C1 data from tape, unpacks the necessary parameters, and stores them on disk.
2. Reformatting ERBE data to ISCCP grid.
3. Executing the Pinker and Staylor satellite algorithms.
4. Executing various support programs which put the appropriate parameters in data-ready format for global-map picture generation.
5. Executing the program which puts the data month into hierarchical data format (HDF).

Processing Changes:

None.

Calculations:

Special Corrections/Adjustments:

The GEBA ground truth sites in the SRB data package are a subset of all GEBA sites around the globe. Only those sites which are most accurate (GEBA category 88) and believed most representative of the large-scale ISCCP cell have been retained. Data from ground-truth sites which are either in mountains, near mountain coastlines, or in ISCCP cells labeled COASTAL were removed because of potential local topography effects.

ERBE data were transformed from an equal-angle grid to an equal-area grid system using a weighting technique.

Calculated Variables:

Graphs and Plots:

10. Errors:

Sources of Error:

Quality Assessment:

Data Validation by Source:

SRB results are dependent on the absolute accuracy of ISCCP C1 data radiances which are input to the shortwave algorithms. Algorithm output has been checked to validate results against output provided by the Pinker and Staylor research groups.

Confidence Level/Accuracy Judgement:

ISCCP

ISCCP performs an absolute calibration of the polar orbiter instrument with an uncertainty of less than 7 percent (see WMO/TD-No. 266, Revised March 1991, pp 25). ISCCP also normalizes the visible-wavelength channel of each geostationary satellite to that of the NOAA polar orbiter to within plus or minus 5 percent (see WMO.TD-No. 266, Revised March 1991, pp 25). After normalization, the polar orbiter absolute calibration is transferred to each geostationary satellite. Both the Staylor and Pinker methods have satisfied the ICRCCM Model-Validation Tests using standard atmospheric profiles. For this SRB application, they use ISCCP scaled-radiance, cloud, precipitable water, and ozone parameters, as well as some ERBE data for input. The Pinker Algorithm assumes accurate satellite calibration by ISCCP. The Staylor Algorithm uses a relative threshold technique and is somewhat insensitive to satellite calibration errors.

GEBA

Caution is required when comparing cell-averaged, ground-truth values with satellite estimates. Of the ISCCP cells which contain GEBA SUBSET sites, approximately 75 percent contain only one GEBA site per ISCCP cell. In such a case, an intercomparison of satellite results with ground-truth values assumes that the fluxes averaged over a month over the entire cell is the same as the monthly average of the fluxes over the ground truth site. That may not be true if either the meteorology or solar exposure varies over the cell. Thus, even a GEBA category 88 site in near-flat topography may still not be representative of an ISCCP cell if it is in a polluted, obstructed, or frequently-foggy area relative to the rest of the cell. In some cases (much of Europe and a few other locations), there are multiple ground sites per ISCCP cell, and the cell-averaged ground truth values can be used with more confidence. Another issue is that satellite estimates are based on the solar radiation between 0.2-4.0 (Pinker) or 0.2-5.0 (Staylor) micrometers. The ground truth measurements are for the wavelength interval of 0.3-3.0

micrometers. This spectral mismatch means that satellite-estimated downward irradiance should be approximately one percent higher than ground measurements on a clear day. On an overcast day with a cloud optical depth = 10, the differences due to spectral mismatch is less than 0.02 percent based on high- resolutions spectral calculations supplied by the UNIVERSITY OF MARYLAND. Thus, there could be positive bias between 0 and 1 percent (depending on monthly-averaged cloud cover) when satellite estimates of downward irradiance are compared with ground truth.

Measurement Error for Parameters:

Additional Quality Assessments:

Data Verification by Data Center:

The Langley DAAC performs an inspection process on data received by the data producer via ftp. The DAAC checks to see if the data transfer completed and the data were delivered in their entirety. An inspection software was developed by the DAAC to make sure every granule is readable. The code also checks to see if every data value falls within the range specified by the data producer. This same code extracts the metadata required for ingesting the data into the IMS. If any discrepancies are found, the data producer is contacted. The discrepancies are corrected before the data are archived at the DAAC.

11. Notes:

Limitations of the Data:

Known Problems with the Data:

Usage Guidance:

The SRB product is intended to provide users a time series of radiation budget parameters for the period spanning July 1983 through 1995.

Any Other Relevant Information about the Study:

12. Application of the Data Set:

13. Future Modifications and Plans:

14. Software:

Software Description:

Software Access:

15. Data Access:

Contact Information:

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Mail Stop 157D
Hampton, Virginia 23681-2199
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Telephone: (757) 864-8656
FAX: (757) 864-8807
E-mail: support-asdc@earthdata.nasa.gov

Procedures for Obtaining Data:

Data Center Status/Plans:

16. Output Products and Availability:

The total SRB data package for each month consists of 5 files. The first file is the ASCII header file, named README.MMMYY. The second and third files are ASCII showing Fortran listings of the Pinker and Staylor algorithms (PINKER.FOR and STAYLOR.FOR, respectively). The fourth and fifth files are binary data files in HDF format. The fourth file is the monthly binary file and presents monthly average gridded values for 52 different items in each cell (srb_monavgs_yymm). The fifth file is the daily binary file and presents 24-hr daily average values for 10 key items in each cell (srb_dayavgs_yymm). This package is currently stored on the Langley DAAC IMS system and can be retrieved through electronic mail (INTERNET).

SRB_DAILY

The Surface Radiation Budget (SRB) Daily Averages data set is available from the Langley DAAC in Hierarchical Data Format (HDF).

SRB_MONTHLY

The Surface Radiation Budget (SRB) Monthly Averages data set is available from the Langley DAAC in Hierarchical Data Format.

SRB CD

The Surface Radiation Budget CD-ROM is available from the Langley DAAC. **Currently Unavailable**

17. References:

1. Brest, C. L. and W. B. Rossow. 1991. Radiometric Calibration and Monitoring of NOAA AVHRR Data for ISCCP, Int. J. Remote Sensing, In Press.

2. Gautier, C. and R. Frouin. 1988. Sensitivity of Satellite-Derived Net Shortwave Irradiance at the Earth's Surface to Radiometric Calibration. In Proc. 4th International Colloquium on Spectral Signatures of Objects in Remote Sensing, Aussois, France, January 18-22, 1988, ESA SP-287; ESA Paris, 179-183.

3. Rossow, W. B., L. C. Gardner, P-J. Lu, and A. W. Walker. 1988. International Satellite Cloud Climatology Project (ISCCP) Description of Reduced Resolution Data. WMO/TD-No. 266, World Meteorological Organization, Geneva.

4. Rossow, W. B., C. L. Brest, and L. C. Garder. 1989. Global, Seasonal Surface Variations form Satellite Radiance Measurements. J. Climate 2(3): 214-247.

5. Sellers, P. J., S. I. Rasool, and H. -J. Bolle. 1990. A Review of Satellite Data Algorithms for Studies of the Land Surface. Bull. Amer. Meteor. Soc. 71 (10): 1429-1477.

6. Staylor, W. F., and A. C. Wilber. 1990. Global Surface Albedos Estimated from ERBE Data. In Proc. AMS 7th Conference on Atmospheric Radiation, San Francisco, California, July 23-27, 1990, 231-236.

7. *Also, see next reference:*

8. Staylor, W. F., and A. C. Wilber. 1990. Global surface albedos estimated from ERBE data. Proceedings of AMS Conf. on Atmospheric Radiation, July 23-27, 1990, San Francisco, CA, pp 231-236.

9. Suttles, J. T., R. N. Green, P. Minnis, G. L. Smith, W. F. Staylor, B. A. Wielicki, I. J. Walker, D. F. Young, V. R. Taylor, and L. L, Stowe. 1988. Angular Radiation Models for Earth-Atmosphere System, Volume I-Shortwave Radiation. NASA RP-1184; NASA Langley Research Center, Hampton, VA 23665-5225.

10. WCRP. 1988. International Satellite Cloud Climatology Project (ISCCP) Working Group on Data Management, Sixth Session. Ft. Collins, CO, June 16-18, 1987, WMO/TD-No. 210,Geneva.

11. Whitlock C. H., W. F. Staylor, J. T. Suttles, G. Smith, R, Levin, R. Frouin, C. Gautier, P. M. Teillet, P. N. Slater, Y. J. Kaufman, B. N. Holben, W. B. Rossow, C., Brest, and S. R. LeCroy. 1990a. AVHRR and VISSR Satellite Instrument Calibration Results for both Cirrus and Marine Stratocumulus IFO Periods. In Proc. FIRE Science Meeting, Vail, Co., July 11-15,1988, NASA CP-3083, NASA Langley Research Center, Hampton, VA 23665-5225, 141-146.

12. Whitlock, C. H., W. F. Staylor, W. L. Darnell, M-D. Chou, G. Dedieu, P. Y. Deschamps, J. Ellis, C. Gautier, R. Frouin, R. T. Pinker, I. Laslo, W. B. Rossow, and D. Tarpley. 1990b. Comparison of Surface Radiation Budget Satellite Algorithms for Downwelled Shortwave Irradiance With Wisconsin FIRE/SRB Surface Truth Data. In Proc. AMS 7th Conference on Atmospheric Radiation, San Francisco, California, July 23-27, 1990, 237-242.

13. Briegleb, B. P., P. Minnis, V. Ramanathan and E. Harrison. 1986. Comparison of regional clear-sky albedos inferred from satellite observations and model calculations. J. Climate Appl. Meteor. 25:214-226.

14. Kneizys, F., E. Shettle, W. Gallery, J. Chetwynd, L. Abreu, J. Selby, R. Fenn and R. McClatchey, 1980: Atmospheric transmittance/radiance: Computer code LOWT RAN5. Rep. AFGL-Tr-80-67, Air Force Geophysics Laboratory, Hanscomb AFB, MA, 127 pp.

15. Lacis, A. A. and J. E. Hansen, 1974. A parameterization for the absorption of solar radiation in the earth's atmosphere. J. Atmos. Sci. 31:118-133.

16. Pinker, R. and J. Ewing, 1985. Modeling surface solar radiation: Model formulation and validation. J. Climate Appl. Meteor. 24:389-401.

17. Pinker, R. T. and I. Laszlo. 1992. Modeling surface solar irradiance for satellite applications on a global scale. J. Appl. Meteor., February issue. Stephens, G. L., S. Ackerman and E. Smith. 1984. A shortwave parameterization revised to improve cloud absorption. J. Atmos. Sci. 41:687-690.

18. WCP-55. 1983. World Climate Research report of the experts meeting on aerosols and their climatic effects. Williamsburg, Virginia, 28-30 March 1983, A. Deepak and H. E. Gerber, Eds. 107 pp.

19. Wiscombe, W. J., R. M. Welch and W. D. Hall, 1984. The effects of very large drops on cloud absorption. Part I: Parcel models. J. Atmos. Sci. 41:1336-1355.

20. Darnell. W. L., W. F. Staylor, S. K. Gupta, and F. M. Denn, 1988. Estimation of surface insolation using Sun-synchronous satellite data. J. Clim. 1:820-835.

21. Hoyt, D. V., 1978. A model for the calculation of solar global insolation. Sol. Energy 21:27-35.

22. Lacis, A. A., and J. E. Hansen. 1978. A parameterization for the absorption of solar radiation in the Earth's atmosphere. J. Atmos. Sci. 31:118-133.

23. The Astronomical Almanac, Nautical Almanac Office, U. S. Naval Observatory, Washington, D. C., 1985, 1980.

24. Schiffer, R. A., and W. B. Rossow, 1983. The International Satellite Cloud Climatology Project (ISCCP): The first project of the World Climate Research Programme. Bull. Amer. Met. Soc. 64:779-784.

25. Smith, W. L., H. M. Woolf, C. M. Hayden, D. Q. Wark, and L. M. McMillin. 1979. The Tiros-N operational vertical sounder. Bull. Amer. Met. Soc. 60:1177-1187.

26. Staylor, W. F. 1985. Reflection and emission models for clouds derived from Nimbus 7 Earth radiation budget scanner measurements. JGR 90:8075-8079.

27. WCRP, 1983: Experts meeting on aerosols and their climate effects. A. Deepak and H. E. Gerber editors, WCP-55, 107 pp.

28. Yamamoto, G. 1962. Direct absorption of solar radiation by atmospheric water vapor, carbon dioxide, and molecular oxygen. J. Atmos. Sci. 19:182-188.

29. Sorlie, S., February 1993. Langley DAAC Handbook. LaRC DAAC, NASA Langley Research Center, Hampton, VA.

18. Glossary of Terms:

EOSDIS Glossary.

19. List of Acronyms:

EOSDIS Acronyms

ERBE: The Earth Radiation Budget Experiment is a multisatellite system designed to measure the Earth's radiation budget. The ERBE instruments fly on a low inclination NASA satellite and two sun-synchronous NOAA satellites. Each satellite carries both a scanner and a nonscanner instrument package.
Select this text to link to the ERBE Data and Documentation.

GEBA: Global Earth Budget Archive

ISCCP: International Satellite Cloud Climatology Project (ISCCP)
Select this text to link to the ISCCP Data and Documentation.

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