1. TITLE

1.1 Data Set Identification

ISLSCP II Surface Radiation Budget (SRB) Radiation Data

1.2 Database Table Name(s)

Not applicable to this data set.

1.3 File Name(s)

The files in this data set for the International Satellite Land Surface Climatology Project (ISLSCP) Initiative II data collection contain radiation budget data at monthly, monthly-3-hourly (i.e. mean diurnal cycle), and 3-hourly temporal resolutions, and monthly cloud and meteorological parameter data**.** All monthly parameters include files with a monthly mean value, a monthly standard deviation, and monthly minimum and maximum values.

There are 30 *.zip files with this data set. The files are named **srb_var_1d_TF.zip**

Where

Srb=Surface Radiation Budget, var=variable, 1d (1-degree resolution), and TF=temporal frequency (monthly, diurnal, 3-hourly).

Variables and Temporal coverage are listed below. Refer to the companion file srb_radiation_1deg_documentation_readme.txt for information regarding the number of files per variable and temporal coverage.

File Abbrev.	Type of Data	Temporal coverage
calb	clear-sky surface albedo	Monthly

cdsf	clear-sky downward sw flux	Monthly, diurnal
dif	all-sky diffuse sw flux	Monthly; diurnal
dlf	all-sky downward lw flux	Monthly, diurnal, 3-hourly
dsf	all-sky downward sw flux	Monthly, diurnal, 3-hourly
nlf	all-sky net lw flux	Monthly, diurnal, 3-hourly
nsf	all-sky net sw flux	Monthly, diurnal
ntf	all-sky net total flux	Monthly, diurnal
par	all-sky par flux	Monthly, diurnal
sfal	all-sky surface albedo	Monthly
tin	toa insolation	Monthly, diurnal
trsf	toa reflected sw flux	Monthly, diurnal
ulf	surface upward lw flux	Monthly, diurnal
usf	surface upward sw flux	Monthly

File names

srb_nlf_1d_3hourly.zip

srb_nsf_1d_3hourly.zip

srb_dlf_1d_3hourly.zip

srb_dsf_1d_3hourly.zip

srb_calb_1d_monthly.zip

srb_cdsf_1d_monthly.zip

srb_dif_1d_monthly.zip

srb_dlf_1d_monthly.zip

srb_dsf_1d_monthly.zip

srb_nlf_1d_monthly.zip

srb_nsf_1d_monthly.zip

srb_ntf_1d_monthly.zip

srb_par_1d_monthly.zip

srb_sfal_1d_monthly.zip

srb_tin_1d_monthly.zip

srb_trsf_1d_monthly.zip

srb_ulf_1d_monthly.zip

srb_usf_1d_monthly.zip

srb_tin_1d_diurnal.zip

srb_cdsf_1d_diurnal.zip

srb_nlf_1d_diurnal.zip

srb_trsf_1d_diurnal.zip

srb_dif_1d_diurnal.zip

srb_nsf_1d_diurnal.zip

srb_ulf_1d_diurnal.zip

srb_dlf_1d_diurnal.zip

srb_ntf_1d_diurnal.zip

srb_usf_1d_diurnal.zip

srb_dlf_1d_diurnal.zip

srb_ntf_1d_diurnal.zip

srb_usf_1d_diurnal.zip

When expanded, the .zip files contain data files named by srb,variable,temporal frequency (monthly, diurnal, 3-hourly), and time stamp (e.g. year, month, day, and 3-hourly period). All files are named using the following naming convention:

srb_variable_XX_1d_YYYYMMDD_HH.asc

where

srb= "Surface Radiation Budget".

Variable= the variable name (See Section 8.2 for listing). The variable name can also include "_av" for mean, "_sd" for standard deviation, "_mn" for minimum, "_mx" for maximum data, or "_in" for instantaneous data.

XX= "av (average), "sd" for standard deviation, "mn" for minimum, or "mx" for maximum.

_1d_= the spatial resolution of the data: "1d" for 1-degree in both latitude and longitude.

YYYY= 4-digit year from 1986 to 1995.

MM= 2-digit month from 01 to 12.

DD= 2-digit day. A value of 00 means that the file is a monthly average.

HH= 2-digit hour (GMT) from 03 to 24 represents the time stamp corresponding to the parameter estimates. **NOTE***:** A value of 24 represents midnight of the current day, or hour 00 of the next day. The hour 00 is not used here for consistency with other ISLSCP2 data sets.

1.3.1 Monthly, Diurnal, and 3-hourly Files

Monthly Files

The individual monthly files are named **srb_*variable*_xx_1d_YYYYMM00.asc** where YYYY= 1986-1995, MM is the month from 01 to 12, and 00 denotes a monthly value.

Example file names:
srb_dlf_av_1d_19860100.asc
srb_dlf_mn_1d_19860100.asc
srb_dlf_mx_1d_19860100.asc
srb_dlf_sd_1d_19860100.asc

Diurnal Files

The individual diurnal files are named **srb_*variable*_xx_1d_YYYYMM00_hHH.asc** where YYYY= 1986-1995, MM is the month from 01 to 12, 00 denotes a monthly value, and HH is the time stamp.

Example file names:
srb_cdsf_av_1d_19860100_h00.asc
srb_cdsf_mx_1d_19860600_h09.asc
srb_cdsf_sd_1d_19860300_h12.asc

3-Hourly Files

The individual 3-hourly files are named **srb_*variable*_av_1d_YYYYMM00_hHH.asc**, where YYYY= 1986-1995, MM is the month from 01 to 12, 00 denotes a monthly value, and HH is the time stamp. The data are valid exactly at the given 3-hourly time stamp (i.e., 03, 06,...,24).

Example file names:

srb_nsf_av_1d_19860101_h00.asc
srb_nsf_av_1d_19860101_h06.asc
srb_nsf_av_1d_19860101_h15.asc

1.4 Revision Date of this Document

December 4, 2013

2. INVESTIGATOR(S)

2.1 Investigator(s) Name and Title

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NASA Langley Research Center

2.2 Title of Investigation

NASA/WCRP-GEWEX Surface Radiation Budget Project

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2.4 Data Set Citation

Stackhouse, P.W., and S. K. Gupta. 2013. ISLSCP II Surface Radiation Budget (SRB) Radiation Data. In Hall, Forrest G., G. Collatz, B. Meeson, S. Los, E. Brown de Colstoun, and D. Landis (eds.). ISLSCP Initiative II Collection. Data set. Available on-line [http://daac.ornl.gov/] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, USA. **http://dx.doi.org/10.3334/ORNLDAAC/1201**

2.5 Requested Form of Acknowledgment

Users of the International Satellite Land Surface Climatology (ISLSCP) Initiative II data collection are requested to cite the collection as a whole (Hall et al. 2006) as well as the individual data sets. Please cite the following publications when these data are used:

Hall, F.G., E. Brown de Colstoun, G. J. Collatz, D. Landis, P. Dirmeyer, A. Betts, G. Huffman, L. Bounoua, and B. Meeson, The ISLSCP Initiative II Global Data sets: Surface Boundary Conditions and Atmospheric Forcings for Land-Atmosphere Studies, *J. Geophys. Res.*, 111, doi:10.1029/2006JD007366, 2006.

Stackhouse, P. W., S. K. Gupta, S. J. Cox, M. Chiacchio, and J. C. Mikovitz, 2000: The WCRP/GEWEX Surface Radiation Budget Project Release 2: An assessment of surface fluxes at 1 degree resolution. In *IRS 2000: Current Problems in Atmospheric Radiation,* W. L. Smith and Y. M. Timofeyev, Eds., *International Radiation Symposium,* St. Petersburg, Russia, July 24-29, 2000.

Stackhouse, P.W., Jr., S. J. Cox, S. K. Gupta, J.C. Mikovitz, M. Chiacchio, 2003: The WCRP/GEWEX Surface Radiation Budget Data Set: A 1 degree resolution, 12 year flux climatology.

3. INTRODUCTION

3.1 Objective/Purpose

The objective of this project was to produce monthly, daily, 3-hourly, and monthly/3-hourly (diurnally resolved monthly averages) surface and top-of-atmosphere (TOA) radiation budget and cloud parameters over the globe at a 1 degree x 1 degree (latitude/longitude) spatial resolution for climate and other Earth science studies. The data are intended for use in evaluation of climate and data assimilation products and will provide diagnostic information on regional changes of surface radiation over a long time period that will be extended to present. The data also have demonstrated usefulness in interdisciplinary studies of land surface, biological, oceanographic, and cryospheric processes. The higher resolution products are compatible with many global scale models and with global products from new NASA Earth Observing System data sets like the Clouds and Earth's Radiant Energy System (CERES) measurements and analysis. These data sets were produced under the sponsorship of NASA and under the auspices of the World Climate Research Program (WCRP) Global Energy and Water Cycle Experiment (GEWEX) Surface Radiation Budget (SRB) project.

3.2 Summary of Parameters

This data set for the ISLSCP II data collection contains global Surface Radiation Budget (SRB) and a few TOA radiation budget parameters on a consistent 1-degree x 1-degree Earth grid. The parameters include downward, upward, and net SW and LW surface radiative fluxes (See Section 8.2 for complete listing of parameters). Fluxes were computed for all-sky and clear conditions enabling the estimates of cloud radiative forcing of the energy fluxes. These parameters are provided as monthly averages, monthly 3 hourly averages (i.e. monthly average for a particular 3 hourly time) and 3 hourly instantaneous fields. The number of parameters provided varies for each temporal average. Several estimates of the different components of the SW radiative flux including direct, diffuse and photosynthetically active radiation (PAR) are also provided. This data set also includes several cloud parameters (monthly only) and meteorological parameters such as the monthly surface skin temperature, and the monthly total column ozone and water vapor burdens. All monthly and monthly 3-hourly parameters except TOA insolation include files with a monthly mean value, a monthly standard deviation, and monthly minimum and maximum values.

3.3 Discussion

The SRB parameters were derived using radiative transfer based algorithms applied to cloud data provided by the International Satellite Cloud Climatology Project (ISCCP) (Rossow et al. 1996; Rossow and Schiffer. 1999). Radiance and cloud information were used from the ISCCP DX pixel data set. ISCCP provides a global mosaic of satellite Visible (VIS) and Infrared (IR) radiance and cloud information every three hours. The mosaic was completed by collecting measurements from the world's geosynchronous satellites (Geostationary Operational Environmental Satellite (GOES), Meteosat, and the Geostationary Meteorological Satellite (GMS)) and polar orbiting satellites. Geosynchronous overpasses were collected from the full earth scan of a particular geosynchronous satellite nearest to the 3-hourly time stamp (00, 03, 06, 09, 12, 15, 18, and 21Z). Polar orbiting satellite pixels were collected for an hour and half before and after the given time stamp. These data were combined to form the 3-hourly global mosaic using a hierarchy that prefers geosynchronous pixels from 55 degrees N to 55 degrees S and polar orbiter pixels to provide polar coverage and fill in gaps. Individual pixels were collected into a 1-degree based grid system. The grid system increased the longitudinal extent of the grid box in incremental steps towards the poles. The processing grid system mitigated the reduction of pixels occurring in grid boxes of equal angles and was easily replicated to the true 1-degree x 1-degree system that was used for the resulting data provided with this data set. The pixel radiances and cloud information were collected and averaged to the 1-degree x 1-degree resolution. It is important to note that the 3-hourly products included in this data set are considered instantaneous every 3 hours, although it should be noted that cloud fields north of 55 degrees and south of 55 degrees originated from times different from the time stamp.

Once the cloud properties were defined, they were input into the algorithms documented in Pinker and Laszlo (1992) for SW and Gupta et al. (1992) for LW. Meteorological profile information was developed at the processing grid resolution from the NASA Data Assimilation Office (DAO) Goddard Earth Observing System version 1 (GEOS-1) reanalysis (Schubert et al. 1993). The 6-hourly instantaneous fields were used and gridded to the processing grid. These were interpolated temporally to provide the estimates of 3-hourly meteorological fields. Ozone abundance is provided from Total Ozone Mapping Spectrometer (TOMS) and TIROS Operational Vertical Sounder measurements (TOVS) via the ISCCP data sets. Aerosol information was crudely included in the SW algorithm by assuming WCP-55 aerosol properties based on 3 surface types. Improvements to this treatment are currently being developed. Surface albedos are retrieved from clear-sky radiance information from ISCCP in the Pinker and Laszlo SW model assuming spectral variation based on the land cover information from Matthews (1985). Surface emissivity maps for LW calculations were created from International Geosphere-Biosphere Programme (IGBP) surface type maps (see Wilber et al. 1999).

4. THEORY OF ALGORITHM/MEASUREMENTS

There are many methods of deriving surface fluxes from satellite measurements (see Pinker et al., 1995). The first is an empirical method whereby satellite radiances are mapped directly to surface observations under various conditions. Semi-empirical methods involve the development of parameterizations from surface observations and/or radiative transfer which are applied to satellite measurements (Gupta et al., 2001). Radiative transfer type methods explicitly compute the radiative flux based upon a specification of atmospheric conditions (Zhang et al. 1995). The radiative transfer based techniques can also differ in the way that the satellite measurements are used. The Pinker/Laszlo algorithm used for this data set converts narrowband visible cloud and clear radiances to broadband radiances and then applies an angular distribution model (ADM) to convert this radiance to a top-of-atmosphere (TOA) albedo. The ADM's for these calculations were computed from ERBE (Earth Radiation Budget Experiment) data along with the narrowband-to-broadband conversions. First, surface albedos are retrieved using the meteorological inputs and assuming the background aerosol optical properties to match the clear-sky TOA albedo. The top-of-atmosphere albedos for the all-sky conditions are then matched using a radiative transfer model with the meteorological inputs. The advantage of this technique is that the resulting surface fluxes are consistent with the TOA albedos. Thus, the absorption of the solar radiation in the atmospheric column becomes the variable accounting for most errors in the surface fluxes. Also, the technique empirically accounts for cloud inhomogeneities by using the ERBE ADM's. The Zhang et al. (1995) technique uses retrievals of cloud properties (i.e., optical depths) using assumptions about cloud particle size distributions. Application of scattering theories provides the spectral dependencies of these cloud properties. Thus, using this technique, retrievals at the visible wavelength are extended to the broadband by using these cloud properties band-by-band with radiative transfer theory. This technique is very much dependent upon the accuracy of ISCCP radiance calibration and cloud identification.

For the LW region, clouds and boundary layer moisture tend to decouple the TOA emittance from the surface emittance. Thus, a different approach is required. Here, retrievals of cloud amount and cloud top temperature are merged with meteorological profile information to produce an estimate of the atmospheric properties. The Gupta et al. (1989) technique uses narrowband radiative transfer calculations and a large database of radiosonde profiles to develop parameterized relationships between surface fluxes and various atmospheric parameters. Clouds are treated as black body radiators that enhance the downward flux to the surface relative to the clear-sky. The enhanced flux is computed using parameterized relationship between an estimate of cloud base temperature and water vapor amount below the cloud base. These are discussed fully in Gupta et al. (1992, 1993).

5. EQUIPMENT

No instruments were directly used in the generation of this NASA/GEWEX SRB dataset. All inputs used were higher level products provided by other institutions. For example all satellite derived radiance and cloud data are from the ISCCP DX data set. Calibration information for ISCCP is available in Brest et al. 1997 or at http://isccp.giss.nasa.gov/docs/documents.html. GEOS-1 processing information is available in Schubert et al. (1993). Ozone data were taken from the Total Ozone Mapping Spectrometer (TOMS) data set. These are described above.

5.1 Instrument Description

5.1.1 Platform (Satellite, Aircraft, Ground, Person)

See above references for more information on higher level products.

5.1.2 Mission Objectives

See above references for more information on higher level products.

5.1.3 Key Variables

See above references for more information on higher level products.

5.1.4 Principles of Operation

See above references for more information on higher level products.

5.1.5 Instrument Measurement Geometry

See above references for more information on higher level products.

5.1.6 Manufacturer of Instrument

See above references for more information on higher level products.

5.2 Calibration

5.2.1 Specifications

5.2.1.1 Tolerance

See above references for more information on higher level products.

5.2.2 Frequency of Calibration

See above references for more information on higher level products.

5.2.3 Other Calibration Information

See above references for more information on higher level products.

6. PROCEDURE

6.1 Data Acquisition Methods

All input data sets were acquired by and archived at the Atmospheric Sciences Data Center (ASDC), NASA Langley Research Center (LaRC). All processing was also done at the ASDC. The ISCCP data were acquired from the NASA Goddard Institute for Space Studies (GISS).

6.2 Spatial Characteristics

6.2.1 Spatial Coverage

The spatial coverage is global.

6.2.2 Spatial Resolution

All output data sets are provided in an equal-angle Earth grid that has a spatial resolution of 1-degree x 1-degree in both latitude and longitude. Input data sets obtained at other resolutions were sampled to or re-gridded to an internal processing grid and these were converted to 1-degree x 1-degree. The internal processing grid is described briefly under the “The Cloud Retrieval Algorithm” in Section 9.1.1.

6.3 Temporal Characteristics

6.3.1 Temporal Coverage

All data sets provided cover the January 1986 to October 1995 (near 10 year) period. Note that November and December 1995 are NOT provided (See Section 9.1.1 for explanation).

6.3.2 Temporal Resolution

Different parameters are provided at different temporal resolutions. The temporal resolutions are monthly, monthly 3-hourly (diurnal cycle average) or 3-hourly.

7. OBSERVATIONS

7.1 Field Notes

Not applicable to this data set.

8. DATA DESCRIPTION

8.1 Table Definition with Comments

Not applicable to this data set.

8.2 Type of Data

8.2.1 Parameter/ Variable Name	8.2.2 Parameter/ Variable Description	8.2.3 Data Range	8.2.4 Units of Measurement	8.2.5 Data Source
Monthly Mean Fields (Radiation Budget)				
calb	Clear-sky surface albedo, monthly average, standard deviation, maximum and minimum	0-1	Unitless	Model computed
cdsf	Clear-sky downward SW flux, monthly average, standard deviation, maximum and minimum	0-500	W m-2	Model computed

dif	All-sky diffuse SW flux, monthly average, standard deviation, maximum and minimum	0-200	W m-2	Model computed
dlf	All-sky downward LW flux, monthly average, standard deviation, maximum and minimum	0-500	W m-2	Model computed
dsf	All-sky downward SW flux, monthly average, standard deviation, maximum and minimum	0-400	W m-2	Model computed,
nlf	All-sky net LW flux, monthly average, standard deviation, maximum and minimum	-120-0	W m-2	Model computed
nsf	All-sky net SW flux, monthly average, standard deviation, maximum and minimum	0-300	W m-2	Model computed
ntf	All-sky net total (SW+LW) flux, monthly average, standard deviation, maximum and minimum	0-200	W m-2	Model computed
par	All-sky PAR flux, monthly average, standard deviation, maximum and minimum	0-200	W m-2	Model computed
sfal	All-sky surface albedo, monthly average, standard deviation, maximum and minimum	0-1	Unitless	Model computed
Tin_avg	Monthly average TOA insolation,	0-500	W m-2	computed
trsf	TOA reflected SW flux, monthly average, standard deviation, maximum and minimum.	0-400	W m-2	Model computed
ulf	Surface upward LW flux, monthly average, standard deviation, maximum and minimum	0-600	W m-2	Model computed

usf	Surface upward SW flux, monthly average, standard deviation, maximum and minimum	0-300	Decimal Degrees	Model computed
Monthly Mean Fields (Clouds and Others)				
cldamt	Total cloud amount, monthly average, standard deviation, maximum and minimum	0-100	Percent	ISCCP
cldtopp	Cloud-top pressure, monthly average, standard deviation, maximum and minimum.	100-1000	nPa	ISCCP
cldtopt	Cloud-top temperature, monthly average, standard deviation, maximum and minimum	100-300	Degrees k	ISCCP
cwv	Column water vapor, monthly average, standard deviation, maximum and minimum	0-8	cm-2	re-analysis
ozone	Column ozone burden, monthly average, standard deviation, maximum and minimum	100-500	Dobson units	TOMS
skint	Surface skin temperature, monthly average, standard deviation, maximum and minimum	200-35-	Degrees k	ISCCP
tau	Cloud optical depth, monthly average, standard deviation, maximum and minimum	0-500	Unitless	ISCCP
water	Cloud liquid water path, monthly average, standard deviation, maximum and minimum	0-500	g m-2	ISCCP
Monthly-3-hourly (Mean Diurnal Cycle) Fields				
cdsf	Clear-sky downward SW flux, monthly/3-hourly average, standard deviation, maximum and minimum	0-800	W m-2	Model computed
dif	All-sky diffuse SW flux, monthly/3-hourly average, standard deviation, maximum and minimum	0-300	W m-2	Model computed
dlf	All-sky downward LW flux, monthly/3-hourly average, standard deviation, maximum and minimum	0-600	W m-2	Model computed

dsf	All-sky downward SW flux, monthly/3-hourly average, standard deviation, maximum and minimum	0-1000	W m-2	Model computed
nlf	All-sky net LW flux, monthly/3-hourly average, standard deviation, maximum and minimum	-180-0	W m-2	Model computed
nsf	All-sky net SW flux, monthly/3- hourly average, standard deviation, maximum and minimum	0-600	W m-2	Model computed
ntf	All-sky net total (SW+LW) flux, monthly/3-hourly average, standard deviation, maximum and minimum	0-300	W m-2	Model computed
par	All-sky PAR flux, monthly/3-hourly average, standard deviation, maximum and minimum	0-300	W m-2	Model computed
tin_av	Monthly/3-hourly average TOA insolation	0-1400	W m-2	Model computed
trsf	TOA reflected SW flux, monthly/3-hourly average, standard deviation, maximum and minimum	0-1000	W m-2	Model computed
ulf	Surface upward LW flux, monthly/3-hourly average, standard deviation, maximum and minimum	0-800	W m-2	Model computed
usf	Surface upward SW flux, monthly/3-hourly average, standard deviation, maximum and minimum	0-500	W m-2	Model computed
3-hourly Fields				
dlf_in	All-sky downward LW flux, instantaneous 3-hourly values	0-750	W m-2	Model computed
dsf_im	All-sky downward SW flux, instantaneous 3-hourly values	0-1200	W m-2	Model computed
nlf_in	All-sky net LW flux, instantaneous 3-hourly values	-300-0	W m-2	Model computed
nsf_in	All-sky net SW flux, instantaneous 3-hourly values	0-800	W m-2	Model computed

8.3 Sample Data Record

Not applicable to this data set.

8.4 Data Format

All of the files in the ISLSCP Initiative II data collection are in the Arc GIS ASCII grid format. The file format consists of numerical fields of varying length, which are delimited by a single space and arranged in columns and rows. The values for the binary land/water or land/ocean masks and the land outlines files are written as integers from 0 to 1. All values in the land/water/ocean fraction files are written as integers from 0 to 100. The values in the coordinate files are written as real numbers.

The files at different spatial resolutions each contain the following numbers of columns and rows:

1 degree: 360 columns by 180 rows

All files are gridded to a common equal-angle lat/long grid, where the coordinates of the upper left corner of the files are located at 180 degrees W, 90 degrees N and the lower right corner coordinates are located at 180 degrees E, 90 degrees S. Data in the map files are ordered from North to South and from West to East beginning at 180 degrees West and 90 degrees North. The files have all had the ISLSCP II land/water mask applied to them.

8.5 Related Data Sets

Additional ISLSCP II project information and data sets can also be obtained from the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC): http://daac.ornl.gov/ISLSCP_II/islscpii.html .

9. DATA MANIPULATIONS

9.1 Formulas

The reader is referred to Rossow *et al.* (1996), Pinker and Laszlo (1992), and Gupta *et al.* (1992) for details of the Cloud, SW and LW algorithms, respectively. A brief discussion is provided below.

9.1.1 Derivation Techniques/Algorithms

The Cloud Retrieval Algorithm:

Cloud and radiance information are taken from the NASA/GEWEX International Satellite Cloud Climatology Project (ISCCP) DX data set (Rossow *et al.* 1996; Rossow and Schiffer 1999). ISCCP produces calibrated, normalized radiances from geostationary (GOES, Meteosat, and GMS) and NOAA polar orbiting satellites for the period from **January 1985 through October 1995. November and December 1995 are not provided in this dataset because the GEOS-1 reanalysis ended in mid-November 1995.** A variety of cloud parameters are derived from the radiance information. The DX product contains information on each satellite image pixel. The pixel resolution is 30-km and 3 hours. Each pixel is judged to be clear or cloudy based on threshold analysis of the infrared and visible (if available) channels. Cloud properties including cloud top temperature, cloud top pressure, optical depth, liquid water path, and cloud water phase are derived for the cloudy pixels. Surface properties, including brightness temperature and reflectance, are derived for the clear pixels.

The NASA/GEWEX SRB project grids the DX pixel data onto a grid that is true 1-degree x 1-degree from 45 degrees N to 45 degrees S. Pole-ward of those latitudes in both hemispheres, the longitudinal size of grid boxes is increased progressively to 2 degrees, 4 degrees, 8 degrees, and 120 degrees. The latitudinal size remains 1-degree throughout. This is done so that grid boxes at higher latitudes will have sufficient number of DX pixels to ensure statistical integrity of the retrieved cloud properties. For each grid cell and each three-hour time period, a preferred satellite is chosen based primarily on favorable viewing geometry. Pixels are assigned to the proper grid cell. Cell properties are derived by averaging or summing pixel data as is appropriate. Both total cloud properties and layered cloud properties are derived. Properties such as cloud fraction, top temperature, top pressure, optical thickness, and liquid water path are made available.

The SW Technique:

The algorithm was developed at the University of Maryland by Drs. R.T. Pinker and I. Laszlo. It is a physical model based on radiative transfer calculations using the delta-Eddington approximation. The model uses ISCCP-DX data (Rossow et al. 1996) as the main input data set, with GEOS-1 water vapor and TOMS ozone as ancillary inputs.

The radiative fluxes at the lower and upper boundaries of the atmosphere are computed by determining the atmospheric transmission and reflection and the surface albedo pertaining to a particular satellite observation. The fluxes, namely, the TOA insolation (TOAINS), TOA reflected flux (TOAREF), surface downward SW flux (DSF), and surface upward SW flux (USF) in each of the five spectral intervals, namely, 0.2-0.4, 0.4-0.5, 0.5-0.6, 0.6-0.7, and 0.7-4.0 micrometer, spanning the 0.2-4.0 micrometer range, are computed from the following equations:

$$\mathrm{TOAINS} = \pi * F0 * \cos(\theta_0) \qquad \text{(A1)}$$

$$\mathrm{TOAREF} = \mathrm{TOAINS} * (\, R0\ (\theta_0) + r * \mathrm{TSP}) \qquad \text{(A2)}$$

$$\mathrm{DSF} = \mathrm{DSF(dir)} + \mathrm{DSF\ (dif)}$$

$$= \mathrm{TOAINS} * (\, T0\ (\mathrm{dir}, (\theta_0) + T0\ (\mathrm{dif}, (\theta_0) + r * \mathrm{RSP}) \qquad \text{(A3)}$$

$$\mathrm{USF} = \alpha(\mathrm{dir}) * \mathrm{DSF(dir)} + (\mathrm{dif}) * \mathrm{DSF(dif)} \qquad \text{(A4)}$$

where:

$$r = (\alpha(\mathrm{dir}, \theta_0) * T0(\mathrm{dir}, \theta_0) + \alpha(\mathrm{dif}, c) * T0(\mathrm{dif}, \theta_0)) / (1 - \alpha(\mathrm{dif}, \theta_0) * \mathrm{RSP} \qquad \text{(A5)}$$

In the equations above, θ_0 is the solar zenith angle, $\pi*F0\cos(\theta_0)$ is the extraterrestrial irradiance**,** $R0(\theta_0)$ and $T0(\theta_0)$ are the reflectivity and transmissivity of the atmosphere over a nonreflecting surface, respectively. The terms dir and dif refer to the direct and diffuse components of (1) the DSF (DSF(dir) and DSF(dif)), (2) the transmissivity (T0(dir, θ_0) and T0(dif, θ_0)), and (3) the surface albedo (α(dir) and α(dif)). RSP and TSP are the spherical reflectivity and transmissivity, respectively, representing the integrals of R0(θ_0) and T0(θ_0) over θ_0. The reflectivities R0(θ_0), RSP and transmissivities T0(dir, θ_0), T0(dif, θ_0), TSP (hereafter optical functions) are functions of the composition of the atmosphere: amount of water vapor, ozone, aerosol, and cloud.

To compute the above fluxes, the spectral surface albedos α(dir) and α(dif) and the optical functions are determined. The algorithm retrieves them from the satellite measured value of the TOA narrowband visible radiance and satellite-retrieved values of ozone and water vapor abundances, along with climatological values of aerosol optical depth based on surface type, by comparing the satellite radiances to a radiative model.

The radiative model contains spectral values of the optical functions precomputed for discrete values of the solar zenith angle as well as amounts of water vapor, ozone, aerosol, and cloud optical depth. It is currently based on the delta-Eddington approximation of the radiative transfer in a vertically inhomogeneous, scattering, and absorbing atmosphere. Also, satellite-measured narrowband radiances are transformed into broadband reflectances by applying narrow-to-broadband conversions (Laszlo *et al.* 1988) for clear ocean, land, desert, snow, and cloudy scenes as follows:

$$R\ (b, \theta, \theta_0\ \theta) = M * R\ (n, \theta, \theta_0, \varphi) + B \qquad \text{(A6)}$$

Where

$$R\ (n, \theta, \theta_0, \varphi) = (\pi * L\ \theta, \theta_0, \varphi))/(\pi * F0 * \cos(\theta_0)) \qquad \text{(A7)}$$

Here θ and φ are the satellite zenith angle and the relative azimuth angle, respectively. R(n, θ, θ_0, φ) is the narrowband bidirectional reflectance computed from the satellite measured narrowband radiance L (n, θ, θ_0, φ), and R (b, θ, θ_0, φ) is the broadband reflectance. M and B are the slope and intercept of the narrowband-to-broadband conversion, respectively. The broadband reflectance is then converted into a broadband albedo (A(b, θ_0)) using the anisotropic factors ($\chi(\theta, \theta_0, \varphi)$) of Suttles *et al.* (1988) as:

$$A(b, \theta_0) = R\ (b, \theta, \theta_0, \varphi)/\chi(\ \theta, \theta_0, \varphi), \qquad \text{(A8)}$$

and the TOA reflected broadband flux is derived as $\pi * F0 * \cos(\theta_0) * A(b, \theta_0)$.

The spectral surface albedos are determined as follows:

First, a broadband TOA upward flux is obtained from the narrowband clear-sky composite radiance in the ISCCP data as described above.

Next, a second broadband TOA upward flux is calculated by summing up the spectral fluxes obtained from (A2). The spectral surface albedos in the above computation are prescribed from the ocean and land albedo models of Briegleb et al. (1986) and the snow albedo model of Wiscombe and Warren (1980).

This flux is compared to that obtained above from ISCCP data. Agreement between the two fluxes is achieved by adjusting the spectral surface albedos by the same factor in all 5 intervals. These adjusted values constitute the retrieved values of spectral surface albedos.

The ISCCP data provides the needed satellite and clear/cloudy scene information. Surface type information (ocean, land, and desert) is based on the work of Matthews (1985). Once the surface albedo for the box is known, the optical functions for clear and cloudy conditions are determined by matching the broadband TOA albedos, derived from the clear and cloudy radiances of the ISCCP data, respectively, with TOA albedos in the radiative model of the surface-atmosphere system. Since the amounts of ozone, water vapor, and the surface albedo are given, the process requires searching through various values of the aerosol optical thickness for clear-sky conditions, and of the cloud optical thickness for cloudy-sky conditions until a match in the TOA albedos is found. The optical functions associated with the model that provide the best match are taken as the retrieved values. The retrieved optical functions, along with the surface albedos, are then used in equations (A1) through (A4) to compute the fluxes for clear (F(clear)) and cloudy (F(cloudy)) conditions. The all-sky flux, F(all-sky), is obtained by using the information on cloud cover:

$$\mathrm{DSF(all\text{-}sky)} = \left(\mathrm{N(clear)} * \mathrm{DSF(clear)} + \mathrm{N(cloudy)} * \mathrm{DSF(cloudy)} \right) / \left(\mathrm{N(clear)} + \mathrm{N(cloudy)} \right) \qquad \text{(A9)}$$

where

N((clear) and N(cloudy) are the number of clear and cloudy pixels from which the clear and cloudy ISCCP radiances are obtained. In addition to the total shortwave downward flux**,** results are given for the photosynthetically active radiation (PAR) 0.4-0.7 micron band. Diffuse fluxes are given, and follow from the selection of aerosol or cloud optical depth. The partitioning of direct and diffuse fluxes is quite sensitive to assumed optical properties and calculated optical thickness. This partitioning is not considered to be very reliable at this time.

The instantaneous fluxes, F (all-sky), computed above are integrated numerically for the daylight hours and divided by 24 hours to obtain a daily average. At times when no observations are available, the fluxes are interpolated from the preceding and following observations. Because of the finite number of observations available per day, the total daily flux obtained from numerically integrating the instantaneous fluxes is potentially inaccurate. Therefore, the daily total fluxes are adjusted by the ratio of the TOA incoming flux as obtained by an analytical integration to that computed from the numerical integration. To account for missing days in the monthly averages, first, an average TOA and surface albedo, and an average transmittance are computed from the daily average fluxes. The monthly mean TOA downward flux computed analytically (TOAINS (analytical)) is then multiplied by the average TOA albedo to yield the monthly mean of the TOA reflected flux. Similarly, the product of TOAINS (analytical) and the average transmittance gives the monthly mean DSF. The monthly mean USF is then obtained by multiplying monthly mean DSF by average surface albedo. The above procedure assumes that the days with observations are representative of the entire month. A similar process is followed in the calculation of monthly/3-hourly fluxes (monthly averages for each three hour period).

Table 9.1 - Input Parameters and their Primary Functions.

INPUT PARAMETER	**FUNCTION**
Clear-Sky	Radiance To get fluxes for clear-sky conditions
Cloudy-Sky Radiance	To get fluxes for cloudy-sky conditions
Clear-Sky Composite Radiance	To get surface albedo
Number of Clear Pixels	To weight clear-sky fluxes for all-sky conditions
Number of Cloudy Pixels	To weight cloudy-sky fluxes for all-sky conditions
Water Vapor and Ozone Amount	To select optical functions
Solar and Satellite Zenith	To select anisotropic correction factors and Relative Azimuth Angle
Latitude and Longitude	To select clear-scene type and surface albedo model
Satellite ID	To select appropriate narrow-to-broadband transformation
Snow Cover	To weight snow albedo

The LW technique:

All LW SRB parameters were computed using a fast parameterization based on detailed radiative transfer computations (Gupta 1989; Gupta et al. 1992). All cloud parameters used in LW flux computations were derived from ISCCP-DX data. Temperature and humidity profiles used were from the DAO reanalysis products (GEOS-1).

The downward LW flux (DLF) was computed as

$$DLF = F1 + F2 * AC , \tag{B1}$$

where

F1 is the clear-sky DLF, F2 is the cloud forcing factor, and AC is the fractional cloud cover. The net LW flux (NLF) was computed as

$$NLF = DLF - \varepsilon * \sigma * TS^{4} - (1 - \varepsilon) * DLF, \qquad (B2)$$

Where

ε is the emissivity of the surface (see Wilber *et al.* 1999), σ is the Stefan-Boltzman constant (σ =5.67E-08 W m^{-2} K^{-4}), and TS is the surface temperature.

Details of the development and application of the parameterizations of F1 and F2 in terms of the meteorological parameters are given in Gupta (1989) and Gupta et al. (1992). A very brief description of the parameterizations is presented here.
The clear-sky DLF (F1) is computed as

$$F1 = (A0 + A1 * V + A2 * V^2 + A3 * V^3) * TE^{3.7}, \qquad (B3)$$

Where

V = ln W, and W is the total water vapor burden of the atmosphere. TE is an effective emitting temperature of the lower troposphere, and is computed as

$$TE = KS*TS + K1*T1 + K2*T2, \qquad (B4)$$

Where

TS is the surface temperature, T1 is the mean temperature of the first atmospheric layer (surface to 800 hPa), and T2 is the same for the second layer (800 hPa to 680 hPa). KS, K1, and K2 are weighting factors with values of 0.60, 0.35, and 0.05 respectively.

The regression coefficients A0, A1, A2, and A3 have the following values:

A0 = 1.791E-07,
A1 = 2.093E-08,
A2 = -2.748E-09,
A3 = 1.184E-09.

The cloud forcing factor (F2) is computed as

$$\mathbf{F}2 = TCB^4 / (B0 + B1 * WC + B2 * WC^2 + B3 * WC^3), \qquad (B5)$$

Where

TCB is the cloud-base temperature, WC is the water vapor burden below the cloud base, and B0, B1, B2, and B3 are regression coefficients with the following values:

B0 = 4.990E+07,
B1 = 2.688E+06,
B2 = -6.147E+03,
B3 = 8.163E+02.

All fluxes represented here are in W m^{-2}, temperatures in degrees K, and water vapor burdens in kg m^{-2}. Cloud-base pressure is obtained by combining cloud-top pressure with climatological estimates of cloud thickness that depend upon cloud height and latitude. TCB and WC are computed from the meteorological data using the procedure described in Gupta (1989). The above equation for F2 is used as such when the pressure difference between the surface and cloud base is greater than 200 hPa. When the pressure difference is less than or equal to 200 hPa, a modified form of this equation, as described in Gupta et al. (1992), is used.

9.2 Data Processing Sequence

9.2.1 Processing Steps and Data Sets

The reader is referred to Pinker and Laszlo (1992), Gupta et al. (1992), and Rossow et al. (1996) for this information with regard to SW, LW, and cloud retrievals.

9.2.2 Processing Changes

The Pinker and Laszlo (1992) technique has replaced the Darnell et al. (1992) technique for deriving SW parameters. All results are now reported on a 1-degree x 1-degree grid.

9.2.3 Additional Processing by the ISLSCP Staff

The original data files submitted to the ISLSCP staff were in ASCII monthly files (the monthly, diurnal, and 3-hourly data were all in monthly files), where all the data were concatenated in a single file. These files were run through a program and broken up (every 180 lines were put into a new file) and the new files automatically named to the current naming scheme (see Section 1.3).

9.3 Calculations

9.3.1 Special Corrections/Adjustments

All computations were originally made on the NASA/GEWEX SRB grid which is described above in Section 9.1.1 within the cloud retrieval technique. Results were then projected on to a true 1-degree x 1-degree grid by replicating the values from each larger box at higher latitudes into all 1-degree x 1-degree boxes that fall within the larger box.

9.4 Graphs and Plots

The reader is referred to Pinker and Laszlo (1992), Gupta et al. (1999), and Rossow and Schiffer (1999).

10. ERRORS

10.1 Sources of Error

Errors in the fluxes come from the radiation modeling and from the meteorological data. Modeling errors are systematic and are generally small. Errors from meteorological data are both random and systematic. For a detailed analysis of errors the reader is referred to Pinker and Laszlo (1992), Gupta et al. (1993), and Rossow et al. (1996) for details.

10.2 Quality Assessment

10.2.1 Data Validation by Source

The SW and LW fluxes provided here were validated with surface measurements obtained from a large number of sites. See Stackhouse et al. (2000) and Gupta et al. (1999) for details. For validation information on cloud properties, the reader is referred to Rossow et al. (1996), Rossow and Schiffer (1999).

10.2.2 Confidence Level/Accuracy Judgment

While larger sources of errors are identified and quantified, smaller sources, e.g. the occurrence of fog, are difficult to quantify. These definitely contribute some positive bias to SW fluxes and negative bias to LW fluxes.

10.2.3 Measurement Error for Parameters and Variables

See Section 10.1.

10.2.4 Additional Quality Assessment Applied

Diurnal variations of both SW and LW fluxes were compared with surface observations and were found to be in good agreement.

11. NOTES

11.1 Known Problems with the Data

Quality of LW fluxes is affected by the low bias in surface skin temperature in the GEOS-1 data sets over high latitude land areas during winter months.

11.2 Usage Guidance

Errors in polar regions may be larger than those quoted in Section 10 because uncertainties in all input parameters are larger in the polar regions.

11.3 Other Relevant Information

None.

12. REFERENCES

12.1 Satellite/Instrument/Data Processing Documentation

None.

12.2 Journal Articles and Study Reports

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13. DATA ACCESS

13.1 Contacts for Archive/Data Access Information

The ISLSCP Initiative II data are available are archived and distributed through the Oak Ridge National Laboratory (ORNL) DAAC for Biogeochemical Dynamics at http://daac.ornl.gov.

13.2 Contacts for Archive

E-mail: uso@daac.ornl.gov
Telephone: +1 (865) 241-3952

13.3 Archive/Status/Plans

The ISLSCP Initiative II data are archived at the ORNL DAAC. There are no plans to update these data.

14. GLOSSARY OF ACRONYMS

ADM	Angular Distribution Model
ASDC	Atmospheric Sciences Data Center (LaRC)
CERES	Clouds and Earth’s Radiant Energy System

DAAC	Distributed Active Archive Center
DAO	Data Assimilation Office (NASA/GSFC)
DLF	Downward Longwave Flux
DODS	Distributed Oceanographic Data System
DSF	Downward Shortwave flux
ERBE	Earth Radiation Budget Experiment
GEOS-1	Goddard Earth Observing System model (Version 1)
GEWEX	Global Energy and Water-cycle Experiment (WCRP)
GISS	Goddard Institute for Space Studies (NASA)
GMS	Geostationary Meteorological Satellite
GOES	Geostationary Operational Environmental Satellite
GSFC	Goddard Space Flight Center (NASA)
IGBP	International Geosphere Biosphere Programme
ISCCP	International Satellite Cloud Climat Project
ISLSCP	International Satellite Land Surface Climatology Project
LaRC	Langley Research Center (NASA)
LW	Longwave
NASA	National Aeronautics and Space Administration
NLF	Net Longwave Flux
ORNL	Oak Ridge National Laboratory
PAR	Photosynthetically Active Radiation
SRB	Surface Radiation Budget
SW	Shortwave
TOA	Top-of-Atmosphere
TOAINS	Top-of-Atmosphere Insolation
TOAREF	Top-of-Atmosphere Reflected Flux
TOMS	Total Ozone Mapping Spectrometer
USF	Upward Shortwave Flux
WCRP	World Climate Research Program