1. TITLE

1.1 Data Set Identification

Earth Radiation Budget Experiment (ERBE) Monthly Albedo, 1986-1990

1.2 File Name(s)

The following files are included in this data set:

erbe_albedo_orig_YYYYMM00.asc: 50 files with the original ERBE monthly clear-sky top of atmosphere albedos (unitless) at a 2.5 degree resolution (lat/long.). Here YYYY is the year from 1986 to 1990 and MM is the month from 01 to 12. The 00 means that this is a monthly average. ***NOTE**: March through December 1990 data are NOT available.

erbe_albedo_1deg_YYYYMM00.asc: Same as above but for 1 degree spatial resolution (lat/long.).

1.3 Revision Date of this Document

November 19, 2009

2. INVESTIGATOR(S)

2.1 Investigator(s) Name and Title

Dr. Bruce R. Barkstrom
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NASA Langley Research Center

2.2 Title of Investigation

Earth Radiation Budget Experiment (ERBE).

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2.4 Data Set Citation

Barkstrom, B.R. 2009. ISLSCP II Earth Radiation Budget Experiment (ERBE) Monthly Albedo, 1986-1990. In Hall, Forrest G., G. Collatz, B. Meeson, S. Los, E. Brown de Colstoun, and D. Landis (eds.). Data set. Available on-line [http://daac.ornl.gov/] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/957

2.5 Requested Form of Acknowledgement

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 Datasets: Surface Boundary Conditions and Atmospheric Forcings for Land-Atmosphere Studies, *J. Geophys. Res.*, 111, doi:10.1029/2006JD007366, 2006.

Barkstrom, B. R., 1984. The Earth Radiation Budget Experiment (ERBE*). Bull. Amer. Meteorol. Soc.*, 65:1170-1185.

3. INTRODUCTION

3.1 Objective/Purpose

The goals of the Earth Radiation Budget Experiment (ERBE) are (1) to understand the radiation balance between the Sun, Earth, atmosphere, and space and (2) to establish an accurate, long-term baseline data set for detection of climate changes. Earth Radiation Budget (ERB) data are fundamental to the development of realistic climate models and to the understanding of natural and anthropogenic perturbations of the climate system. As part of ERBE, measurements of broadband shortwave radiation reflected from the Earth-atmosphere system were obtained, from which top of atmosphere albedo values were calculated. In addition, values from scenes determined to be free of clouds were analyzed separately and clear-sky albedos were derived.

3.2 Summary of Parameters

For this study, only the clear-sky albedos are included. The ERBE data sets for the International Satellite Land Surface Climatology Project (ISLSCP) Initiative II contain global, top of atmosphere, clear sky albedo data from January 1986 to February 1990. The original ERBE albedo data at 2.5 degree spatial resolution were re-gridded to a 1 degree spatial resolution by the ISLSCP II staff. Both the original data at 2.5 degree resolution and the 1 degree data set are provided.

3.3 Discussion

Clear-sky albedos were obtained from the scanning radiometer instruments on Earth Radiation Budget Experiment. For details on the ERBE satellites, instruments, and data analysis techniques, the user is referred to Barkstrom et al. (1990), Harrison et al. (1990), and Harrison et al. (1993).

The 1 degree ISLSCP II version of this data set was produced to provide consistency in spatial resolution with all other data sets in the ISLSCP II data collection. This data set was produced by simply replicating the value of every 2.5 degree cell in the original data set 25 times to a 0.5 degree resolution, and then aggregating the 0.5 degree cells back up to the 1 degree product. This product does not really add any additional or new information to the original data.

4. THEORY OF ALGORITHM/MEASUREMENTS

The Earth Radiation Budget Experiment (ERBE) was the first Earth radiation budget instrument flown simultaneously on multiple satellites to provide the necessary temporal sampling for studying the diurnal variations of regional broadband radiative parameters over the Earth. Identical ERBE instruments were launched on a dedicated NASA satellite (the Earth Radiation Budget Satellite, or ERBS) by the Space Shuttle Challenger in October 1984, and two NOAA operational satellites launched in December 1984 and November 1986. The high-resolution ERBE scanning radiometers were used to determine regional scale radiative parameters. The ERBS obtained 5 years of scanner data; each of the NOAA satellites provided about 2 years of scanner data.

The ERBE data processing system performs three major tasks:

1) Converts telemetry data to calibrated radiation measurements at the instruments.

2) Relates the satellite measurements to radiative fluxes at the top of the Earth's atmosphere using angular dependence models (Smith et al., 1986).
3) Averages the measurements over various space and time scales (Brooks et al., 1986).

The ERBE scanners observe pixels with a nadir size of 35-50 km depending on the satellite. Each 2.5 degree x 2.5 degree grid box of the original ERBE data contained approximately 100 pixels. These pixels are classified as four types: clear, partly cloudy, mostly cloudy, and overcast. A maximum likelihood estimation technique is used to identify cloud-free scenes (Wielicki and Green, 1989). Clear-sky radiative fluxes at each hour in a grid box are calculated as the averaged fluxes of the clear pixels, which are then converted from radiance measurements through the ERBE angular-directional models (Suttles et al., 1988).

5. EQUIPMENT

5.1 Instrument Description

The ERBE scanner (Kopia, 1986) has three spectral channels, 0.2-5.0 μm (Shortwave, SW), 5-50 μm (Longwave, LW), and 0.2-50 μm (total), to provide consistency checks and redundancy. The scanner spatial resolution at nadir, the point on the Earth directly below the spacecraft, is about 40 km. The ERBE scanner is accurate, well calibrated, and stable.

5.1.1 Platform (Satellite, Aircraft, Ground, Person)

ERBE scanning radiometers were flown on three satellites: ERBS in a 57-deg inclined orbit and NOAA-9 and NOAA-10 in sun synchronous orbits at 14:30 and 07:30 equatorial crossing times, respectively.

5.1.2 Mission Objectives

The goal of ERBE is to understand the radiation balance between the sun, earth, atmosphere, and space, and to establish an accurate baseline data set for detection of climate changes.

5.1.3 Key Variables

The ERBE scanner measures reflected radiation from the Earth in three spectral channels.

5.1.4 Principles of Operation

See Kopia (1986).

5.1.5 Instrument Measurement Geometry

The ERBE scanner operates in a cross track mode, covering viewing zenith angles from nadir to the limb. In the processing, only viewing zenith angles less than 70 degrees are considered.

5.1.6 Manufacturer of Instrument

TRW, Redondo Beach, CA.

5.2 Calibration

Ground calibration sources consist of a reference blackbody and an integrating sphere in a vacuum chamber. In flight, an internal blackbody, evacuated tungsten lamps, and observations of the Sun are used to check the stability and precision of the instruments.

5.2.1 Specifications

5.2.1.1 Tolerance

See http://asd-www.larc.nasa.gov/erbe/erbescanner.html.

5.2.2 Frequency of Calibration

See http://asd-www.larc.nasa.gov/erbe/erbescanner.html.

5.2.3 Other Calibration Information

See http://asd-www.larc.nasa.gov/erbe/erbescanner.html

6. PROCEDURE

6.1 Data Acquisition Methods

The ERBE scanner data are available from the NASA Langley Research Center (LaRC) Distributed Active Archive Center (DAAC). The data can be accessed at the following web site: http://eosweb.larc.nasa.gov/PRODOCS/erbe/table_erbe.html.

6.2 Spatial Characteristics

6.2.1 Spatial Coverage

ERBS scanner data provide coverage from 70 degrees S to 70 degrees N latitude. The NOAA satellites have complete global coverage. The spatial coverage of all the data layers in this data set is global (both land and ocean). Some missing data are present, primarily at the north and south poles. All files are gridded to a common equal angle latitude/longitude global 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.

6.2.2 Spatial Resolution

The spatial resolution of the original ERBE gridded albedo data set is 2.5 degrees (lat/long) while the individual measurements have a resolution of about 40 km at nadir. A re-gridded version at 1 degree(lat/long) spatial resolution is also provided in the ISLSCP II data collection.

6.3 Temporal Characteristics

6.3.1 Temporal Coverage

January 1986 through February 1990.

6.3.2 Temporal Resolution

Monthly mean.

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
Albedo (Original Resolution)	Monthly, top of atmosphere, clear sky albedo derived from ERBE data at a 2.5 degree resolution. Albedo is the fraction of incident solar radiation that a surface reflects.	Min=0 Max=1 Missing data=-99	Unitless*	ERBE
Albedo (1 degree resolution)	Monthly, top of atmosphere, clear sky albedo at a 1 degree resolution.	Min=0 Max=1 Missing data=-99	Unitless*	Computed from original resolution data

*Albedo units are non-dimensional, a fraction between 0 and 1.

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 standard ARC GIS ASCII GRID format. The file format consists of six lines of header information followed by numerical fields of varying length, which are delimited by a single space and arranged in columns and rows. The 2.5 degrees original ERBE S4G data sets are organized with 144 columns (i.e. pixels) and 72 total rows (i.e. lines). The 1 degree resolution data sets contain 360 pixels per line and 180 lines. All values are written as real numbers. Missing values are assigned the value of -99 on all data layers.

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 files are ordered from North to South and from West to East beginning at 180 degrees West, 90 degrees North.

WARNING: The 1x1 degree data product is recommended for browse use only. These data files were created from the original 2.5 x 2.5 degree map files. Thus the data values at specific pixels may not be exact. Use this data with caution and always refer to the original 2.5-degree data files for specific information.

8.5 Related Data Sets

There are multiple albedo data sets in the ISLSCP Initiative II data collection, each with specific temporal and/or spatial attributes. Users should refer to the overview document for albedo as well as Hall et al. (2006) for a more in depth discussion of these products. Other albedo data sets in this collection include an albedo product for February and July 1995 from the Advanced Very High Resolution Radiometer (AVHRR), a 5-year AVHRR albedo climatology produced by NOAA-NESDIS (National Environmental Satellite Data and Information Service), and a snow-free albedo produced using the FASIR-NDVI (Fourier-Adjusted, Sensor and Solar zenith angle corrected, Interpolated, Reconstructed-Normalized Difference Vegetation Index) data set.

9. DATA MANIPULATIONS

9.1 Formulas

For details of the ERBE data processing algorithm, the user is referred to Barkstrom and Smith (1986), Smith et al. (1986), Brooks et al. (1986), Suttles et al. (1988, 1989), and the ERBE S4G Data and Information site: http://eosweb.larc.nasa.gov/PRODOCS/erbe/table_erbe.html

9.1.1 Derivation Techniques/Algorithms

Clear-sky albedo is calculated from ERBE measurements. For a clear-sky shortwave measurement, the clear-sky albedo is defined as the ratio of the outgoing shortwave to the incoming solar flux. For that day, clear-sky albedos at other hours are filled-in using the ERBE directional models. Using only the days with clear-sky measurements, the monthly average clear-sky albedo is determined.

9.2 Data Processing Sequence

Top-of-atmosphere monthly mean albedo is derived from shortwave (0.2-5 μm) radiances measured by the ERBE scanners (Kopia, 1986) on the ERBS and NOAA-9 spacecraft.

9.2.1 Processing Steps and Data Sets

See Barkstrom and Smith (1986) and Barkstrom et al. (1989).

9.2.2 Processing Changes

See http://eosweb.larc.nasa.gov/PRODOCS/erbe/table_erbe.html.

9.2.3 Additional Processing by the ISLSCP II Staff

The ISLSCP II staff has processed all original ERBE files at 2.5 degree resolution from their original format to the ASCII or text format. A data set at 1 degree resolution has also been produced from the original resolution ERBE data. This was done by forcing the 2.5 degree data into a 0.5 degree global grid, in other words replicating the original value 25 times for each grid cell. The 0.5 degree files were then aggregated to a 1 degree global grid by averaging the 4 0.5 degree cells falling on each 1 degree box. Missing data cells were ignored in the calculations.

WARNING: The 1x1 degree data product is recommended for browse use only. These data files were created from the original 2.5 x 2.5 degree map files. Thus the data values at specific pixels may not be exact. Use this data with caution and always refer to the original 2.5-degree data files for specific information.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

See http://eosweb.larc.nasa.gov/PRODOCS/erbe/table_erbe.html.

9.4 Graphs and Plots

None.

10. ERRORS

10.1 Sources of Error

Errors in clear-sky albedo come from cloud contamination of the scene, instrument errors, sampling errors, and uncertainties in models used in processing.

10.2 Quality Assessment

10.2.1 Data Validation by Source

The earth's radiation budget is not easy to measure, even indirectly. The ERBE Science Team has relied on consistency and measurement intercomparisons for validation. Fortunately, ERBE data also provide a number of these checks. These criteria provide a way of judging the consistency of the various parameters in the data processing system.

10.2.2 Confidence Level/Accuracy Judgment

The user is referred to Harrison et al. (1990) for a discussion of ERBE error sources. Also see http://eosweb.larc.nasa.gov/PRODOCS/erbe/table_erbe.html.

10.2.3 Measurement Error for Parameters and Variables

Random error is about 0.01. Values may also be overestimated slightly due to cloud contamination. (See Harrison et al., 1990).

10.2.4 Additional Quality Assessment Applied

None.

11. NOTES

11.1 Known Problems with the Data

There are no known problems or inconsistencies in the ERBE data.

11.2 Usage Guidance

Errors in the polar regions may be larger than those quoted in Section 10 due to the inability to reliably distinguish between clouds and snow.

Users should understand that the original spatial resolution of the ERBE S4G data is 2.5 degrees. The 1 degree version of this data set produced by the ISLSCP II staff was produced to provide consistency in spatial resolution with all other data sets in the ISLSCP II data collection. This data set was produced by simply replicating the value of every 2.5 degree cell in the original data set 25 times to a 0.5 degree resolution, and then aggregating the 0.5 degree cells back up to the 1 degree product. This product does not really add any additional or new information to the original data.

11.3 Other Relevant Information

The clear sky albedos, estimated from ERBE, generally are a higher than albedos calculated for a molecular atmosphere with best estimates of surface albedos (over the oceans surface albedos are low and fairly well known). Some of this difference is likely due to aerosol effects not included in the calculation and some due to the fact that ERBE may designate scenes as clear when they have a small amount of subpixel cloudiness in their view.

12. REFERENCES

12.1 Satellite/Instrument/Data Processing Documentation

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Smith, G. L., R. N. Green, E. Raschke, L. M. Avis, J. T. Suttles, B. A. Wielicki, and R. Davies. 1986. Inversion methods for satellite studies of the Earth's radiation budget: Development of algorithms for the ERBE mission. *Rev. Geophys.*, 24:407-421.

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Wielicki, B. A. and R. N. Green, 1989. Cloud identification for ERBE radiative flux retrieval. *J. Appl. Meteorol.*, 28:1133-1146.

12.2 Journal Articles and Study Reports

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Zhang, M. H., R. D. Cess, T. Y. Kwon, and M. H. Chen, 1994. Approaches of comparison for clear-sky radiative fluxes from general circulation models with Earth Radiation Budget Experiment data. *J. Geophys. Res.*, 99:5515-5523.

13. DATA ACCESS

13.1 Data Access Information

The ISLSCP Initiative II data are archived 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.

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14. GLOSSARY OF ACRONYMS

DAAC	Distributed Active Archive Center
EOS	Earth Observing System
ERB	Earth Radiation Budget
ERBE	Earth Radiation Budget Experiment
ERBS	Earth Radiation Budget Satellite
GSFC	Goddard Space Flight Center (NASA)
ISCCP	International Satellite Cloud Climatology Project
ISLSCP	International Satellite Land Surface Climatology Project

LaRC	Langley Research Center (NASA)
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
ORNL	Oak Ridge National Laboratory