Earth Radiation Budget Experiment (ERBE) Solar Monitor Irradiance Langley ASDC Data Set Document

Summary:

This document describes the Solar Monitor Irradiance data set and provides the user with the necessary information to use the Earth Radiation Budget Experiment (ERBE) data for scientific research studies.

The solar monitor channel of the nonscanner instrument measures the total output of radiant heat and light from the sun. The ERBE nonscanner solar calibrations are performed by commanding the elevation beam to the solar calibration position (i.e. solar ports) which allows the earth-viewing detector modules to view space just above the Earth's limb. The solar ports restrict the detectors from viewing the Earth or spacecraft structure and are aligned with the instrument head is then commended to rotate to the proper azimuth angle. The angle is determined from updated spacecraft ephemeris data and is stored in instrument memory prior to initiating the solar calibration sequence. Once the instrument is in position, the sun passes through the Earth detectors, SMA, and SAS fields-of-view.

The sequence of events associated with solar calibrations positions the instrument in elevation and azimuth, starts the SMA shutter cycle (32 second open - 32 seconds closed) and turns on the detector bias heaters. The solar monitor shutter enables more precise solar measurements to be obtained because the zero reference can be obtained 32 seconds before and after the sun-view. This automatic solar calibration sequence is initiated via a single ground system command issued 28 minutes and 48 seconds prior to the sun passing through the center of the instrument fields-of-view. The Earth-viewing channels are elevated to the solar-viewing position early in the sequence to allow them to be radiometrically "chopped" (referenced) against the absolute zero irradiance of space both before and after the solar viewing event. By taking advantage of this chopping in the data analysis, an exceptionally accurate solar measurement can be made.

During normal mission operations, the ERBE nonscanner instrument is positioned for solar-viewing approximately every 14 days. Beginning in late January, 1985 and continuing throughout the normal mission life of both spacecraft, solar observations are scheduled within one hour of each other for each respective spacecraft (ERBS, NOAA-9, and NOAA-10).

Table of Contents:

1. Data Set Overview:

Data Set Identification:

Earth Radiation Budget Experiment (ERBE) Total Solar Irradiance (from the Earth Radiation Budget Satellite (ERBS) in Native (NAT) Format (ERBE_TSI_ERBS_NAT), ERBE_TSI_ERBS_NAT)

Data Set Introduction:

See Summary.

Objective/Purpose:

The objectives of the ERBE solar monitors are:

1. To monitor any changes in the response of the Earth-viewing detectors due to instrument degradation.
2. To monitor the total energy input of the sun to the Earth/atmosphere system for Earth radiation budget studies and climate studies.

Summary of Parameters:

The solar monitor channel of the nonscanner instrument collects about 20 minutes of usable data during solar calibration periods which may occur as often as once a week or during special periods daily. Out of these 20 minutes or so of data, between 1 to 4 irradiance values are computed and averaged giving one irradiance value per day. All of the data are ordered chronologically and contain the following:

- Date - year/month/day
- Time - hour:minutes:seconds
- Total solar irradiance - Watts/square meter
- Standard deviation - Watts/square meter

Discussion:

The goal of the ERBE is to produce monthly averages of longwave and shortwave radiation parameters on the Earth at regional to global scales. Preflight mission analysis lead to a three-spacecraft system to provide the geographic and temporal sampling required to meet this goal. Three nearly identical sets of instruments were built and launched on three separate spacecraft. These instruments differ principally in the spacecraft interface electronics and in the field-of-view limiters for the nonscanner instruments required because of differences in the spacecraft orbit altitudes.

The ERBS spacecraft was launched by Space Shuttle Challenger in October 1984 and was the first spacecraft to carry ERBE instruments into orbit. The ERBS was designed and built by Ball Aerospace Systems under contract to NASA Goddard Space Flight Center (GSFC), and ERBS was the first spacecraft dedicated to NASA science experiments to be launched by the Space Shuttle. The ERBS carries the Stratospheric Aerosol and Gas Experiment II (SAGE II) in addition to the ERBE instruments. The Payload Operation and Control Center (POCC) at GSFC directs operations of the ERBS spacecraft and the ERBE and SAGE II instruments, employing both ground stations and the Tracking and Data Relay Satellite System (TDRSS) network. Spacecraft and instrument telemetry data are received at GSFC where the data are processed by the Information Processing Division that provides ERBE and SAGE II experiment tapes to the NASA Langley Research Center (LaRC).

NASA tracks the ERBS spacecraft. The tracking data are provided to GSFC where orbit ephemeris data are calculated and provided (on either magnetic tape or via Internet file transfer) to LaRC.

Related Data Sets:

There are no data sets related to this data set.

2. Investigator(s):

Investigator(s) Name and Title:

Mr. Robert B. Lee III
Senior Scientist
NASA Langley Research Center

Title of Investigation:

Earth Radiation Budget Experiment (ERBE) Total Solar Irradiance

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3. Theory of Measurements:

The theory behind the measurements made to collect the ERBE data is non-trivial and well beyond the scope of this document. However, interested readers are referred to Ref. 1.

4. Equipment:

Sensor/Instrument Description:

Collection Environment:

The ERBE solar monitor instrument was designed to collect data for one year but had a goal of two years. The instrument continues to collect data.

The ERBS satellite was launched on October 5, 1984 into a precessing 57 degree inclined orbit with a semi-major axis of 6988 km and a mean altitude of 610 km with a 98 minute nodal period.

Source/Platform:

The Solar monitor instrument is on the ERBS satellite.

Source/Platform Mission Objectives:

ERBS was the first spacecraft dedicated to NASA science experiments to be launched by the Space Shuttle. ERBS carries SAGE II instruments in addition to the ERBE instruments.

Key Variables:

Total Solar irradiance, Date, Time, Standard deviation

Principles of Operation:

The ERBE is a multisatellite system designed to measure the Earth's radiation budget. The ERBE instruments fly on a mid-inclination NASA satellite, (ERBS). The satellite carries a nonscanner instrument package consisting of two channels which measure shortwave reflected radiances (0.2-5.0 microns) and three which measure the total wavelengths (0.2-50.0 microns) which includes the solar monitor.

The nonscanner instrument package contains four Earth-viewing channels and a solar monitor. The solar monitor is a direct descendant of the Solar Maximum Mission's Active Cavity Radiometer Irradiance Monitor detector. Because of the concern for spectral flatness and high accuracy, all five of the channels on the nonscanner package are active cavity radiometers.

Sensor/Instrument Measurement Geometry:

The solar monitor assembly is fixed at at 78 degree solar calibration position.

Manufacturer of Sensor/Instrument:

The ERBE instruments were developed by TRW, Inc.

Calibration:

Specifications:

Not obtainable.

Tolerance:

This information is not available.

Frequency of Calibration:

In-flight solar calibrations of the nonscanners were normally performed on a bi-weekly basis. During periods of special operation (SOLCON experiment, ect) solar monitor calibrations were done as frequently as every day, for to 14 orbits.

Other Calibration Information:

The ERBE instruments were developed by TRW, Inc. Laboratory calibrations of the ERBE scanner, nonscanner, and solar monitor instruments were completed in the TRW calibration facility at Redondo Beach, California in 1984. The fundamental standards used for the ERBE instruments were the International Pressure and Temperature Standard of 1968 (IPTS-68) and the World Radiation Reference (WRR). The TRW master reference blackbody (MRBB) was calibrated using these, and the MRBB was subsequently used to transfer the calibrations to the internal blackbody (IBB) and to the shortwave channels via an integrating sphere. The results of the calibrations were reported in detail in TRW calibration documents.

In-flight calibrations are performed in order to maintain the accuracy of radiometric measurements by accounting for internal instrument component parametric changes brought about by the spacecraft's environmental variables. In-flight calibrations of the nonscanners were also normally performed on a bi-weekly basis. These included internal calibrations, space looks, and solar calibrations. Internal calibrations consist of cycling of IBB temperatures (total sensors) and shortwave internal calibration source (SWICS) voltages. Space looks consist of observations of "cold" space, both before and after solar calibrations. Solar calibrations consist of measurements made while the solar disc is within the instrument's FOV.

5. Data Acquisition Methods:

Each of the satellites carrying ERBE instruments carries a pair of instrument packages. The first package is a scanner instrument. The second instrument package is a nonscanner for obtaining large-scale Earth fluxes and solar irradiance measurements. The nonscanner has four Earth-viewing channels and a solar monitor. Observations of the sun check the stability and precision of the instruments while in flight.

6. Observations:

Data Notes:

Not obtainable.

Field Notes:

Not obtainable.

7. Data Description:

Spatial Characteristics:

Spatial Coverage:

Even though the Earth-viewing detectors have spatial coverage on the Earth, the solar monitor does not view the Earth at any time.

Spatial Coverage Map:

This information is not available.

Spatial Resolution:

The solar monitor instrument has an unencumbered FOV which observes the entire solar disk during solar observation periods.

Projection:

This information is not available.

Grid Description:

This information is not applicable.

Temporal Characteristics:

Temporal Coverage:

The solar instrument collects about 20 minutes of usable data during bi-weekly solar calibration periods.

Temporal Coverage Map:

Temporal Resolution:

The solar data results in the computation of from 1 to 3 solar irradiance values per 20 minutes of usable data which are averaged to produce a single irradiance value.

Data Characteristics:

Parameter/Variable:

Total Solar Irradiance

Variable Description/Definition:

In this section, each data item in a record is defined. Each definition begins with the "Record Index" and the parameter name. This heading is followed by a brief description of the parameter. The range of possible values is denoted by brackets. Some definitions are followed by notes which list more detailed information about the data item.

1. Date

   Year/Month/Day

2. Time

   The Time consists of the Hour:Minute:Second of the sun-view in the middle of the measurement cycle.

3. Total Solar irradiance (Watts/square meter)

   The average power received on a unit area at the mean Earth/Sun distance.

4. Standard deviation (Watts/suare meter)

   The standard deviation of from 1 to 4 irradiance values during the day.

Unit of Measurement:

Units of measurement for the calculated and measured science variables for the solar irradiance data product can be found in the Variable Description/Definition.

Data Source:

The solar monitor channel of the nonscanner collects about 20 minutes of usable data during solar calibration periods. The ERBS total solar irradiance product consists of the irradiance values computed from data taken during each solar calibration period of the day.

Data Range:

Sample Data Record:

```
YR/MO/DY HR:MN:SC          IRR       STD
84/10/25 15:24:45         1364.8     0.1
```

```
84/10/26 10:44:49          1365.4    0.2
84/10/29 11:21:05          1365.2    0.0
```

8. Data Organization:

Data Granularity:

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

Each granule contains six months of data. There are also granules that consist of all data collected for this data set.

Data Format:

All data granules are in ASCII format.

9. Data Manipulations:

Formulae:

Derivation Techniques and Algorithms:

There are a number of steps in the processing of the ERBE data. The mathematics involved in each of these steps is beyond the scope of this document. However, interested readers are referred to Reference 1.

Data Processing Sequence:

Processing Steps:

The Langley Research Center (LaRC) has the responsibility of processing and validating all science data from the ERBE mission and of distributing the resulting data products to the science community. The ERBE data processing system at LaRC uses a modular software subsystems approach to process the ERBE data, starting with the input telemetry and ephemeris data from Goddard Space Flight Center (GSFC) and ending with the production of the required science data products.

The first step in this processing procedure is to ingest 24 hours of telemetry data from the ERBS spacecraft into the front-end processing subsystem of the Data Processing System. The data are organized into a format that is common to data from GSFC. Extensive data quality editing and evaluation are performed, including the checking of quality flags appended by the tracking networks and processing systems at GSFC. The operational status of the instruments is determined, and all instrument housekeeping data and selected spacecraft housekeeping measurements are converted to engineering units and edited. Pointing vectors for the optical axes of the detectors are calculated.

At the next processing stage, the raw measurements for each radiometric detector are averaged for each 16 second record and statistical values stored. Sun view and reference view records are then distinguished and converted to irradiances. The conversion algorithms employ calibration coefficients that are based primarily on ground-based calibration data, but which are updated with results from in-flight calibrations as needed. An archival product from the solar monitor measurements is then produced to provide time histories of solar irradiance values. All archival data products are distributed first to the ERBE Science Team for review and validation and then to LaRC ASDC for archival.

Processing Changes:

There are no plans for reprocessing.

Calculations:

Special Corrections/Adjustments:

Calculated Variables:

Graphs and Plots:

There is a browse product available for each granule in this data set.

10.Errors:

Sources of Error:

Quality Assessment:

Data Validation by Source:

Confidence Level/Accuracy Judgement:

Measurement Error for Parameters:

Additional Quality Assessments:

Data Verification by Data Center:

The Langley ASDC performs an inspection process on this data received by the data producer via ftp. The ASDC checks to see if the transfer of the data completed and were delivered in their entirety. An inspection software was developed by the ASDC to see if the code was able to read every granule. The code also checks to see if every parameter of data falls within the ranges which are included in the granule. 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 ASDC.

11. Notes:

Limitations of the Data:

There are no known limitations or unreliable aspects in the algorithms implemented to generate the ERBE science data.

Known Problems with the Data:

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

Usage Guidance:

Any Other Relevant Information about the Study:

None.

12. Application of the Data Set:

Measurements of the total solar irradiance provide one of the important elements of Earth's radiation budget. They also provide possibilities for "climate experiments" by allowing the sensitivity of the radiation budget to various forcings to be studied empirically. One of those forcings is the variation in the Suns total energy output which drives our climate system.

13. Future Modifications and Plans:

Additional granules will be added to the archive list as data become available.

14. Software:

Software Description:

Sample read software is available for this data set. This code is written in C. A makefile and a readme file are also available to work with the code and data.

Software Access:

The software can be obtained through the Langley ASDC. Please refer to the contact information below. The software can also be obtained at the same time the user is ordering this data set.

15. Data Access:

Data Center Identification and Contact Information:

Langley ASDC User and Data Services Office
NASA Langley Research Center
Mail Stop 157D
Hampton, Virginia 23681-2199
USA
Telephone: (757) 864-8656
FAX: (757) 864-8807

E-mail: support-asdc@earthdata.nasa.gov

Procedures for Obtaining Data:

Data, programs for reading the data, and user's guides can be obtained through the EOSDIS Langley ASDC on-line system which will allow users to search through the data inventory and place orders on-line.

Langley ASDC User and Data Services Office
NASA Langley Research Center
Mail Stop 157D
Hampton, Virginia 23681-2199
USA
Telephone: (757) 864-8656
FAX: (757) 864-8807
E-mail: support-asdc@earthdata.nasa.gov
URL: http://eosweb.larc.nasa.gov

The Langley ASDC User and Data Services staff provides technical and operational support for users ordering data.

Select this text for information on the Langley Information Management System which provides an interface to order data from the Langley ASDC.

Data Center Status/Plans:

On a regular basis, individual ERBE data granules are reviewed by local members of the ERBE Science Team. Upon Science Team approval, the ERBE Data Management Team releases the data granule to the LaRC ASDC for archive.

16. Output Products and Availability:

There is a browse image for each granule of data archived at the Langley ASDC.

17. References:

1. R. B. Lee III, B. R. Barkstrom, and R. D. Cess, "Characteristics of the Earth Radiation Budget Experiment Solar Monitors," Appl. Optics, 26 (15) 3090-3096, 1987.

2. R. B. Lee III, M. A. Gibson, N. Shivakumar, R. S. Wilson, H. L. Kyle, and A. T. Mecherikunnel, "Solar Irradiance Measurement: Minimum Through Maximum Solar Activity," Metrologia, Vol. 28, pp. 265-268, 1991.

3. R. B. Lee III, B. R. Barkstrom, M. R. Luther, R. D. Cess, Solar Irradiance Measurements Using the Earth Radiation Budget Experiment Solar Monitors, Proceedings of the Sixth Conference on Atmospheric Radiation, American Meteorological Society, pp. J5-J8, 1986.

4. R. B. Lee III, M. A. Gibson, R. S. Wilson, S. Thomas, "Long-term Total Solar Irradiance Variability During Sunspot Cycle 22" Journal of Geophysical Research, Vol. 100, No. A2, pp. 1667-1675, February 1, 1995.

5. Sorlie, S., February 1993. "Langley DAAC Handbook." NASA Langley Research Center, Hampton, Virginia.

18. Glossary of Terms:

EOSDIS Glossary.

19. List of Acronyms:

EOSDIS Acronyms.

ASDC - Atmospheric Science Data Center
DAAC - Distributed Active Archive Center
EOSDIS - Earth Observing System Data and Information System
ERBE - Earth Radiation Budget Experiment
ERBS - Earth Radiation Budget Satellite

FOV - Field-of-View
GOES - Geostationary Operational Environmental Satellite
GSFC - Goddard Space Flight Center
HIRS - High-Resolution Infrared Radiometer Sounder
IBB - Internal Blackbody - used, in flight, to calibrate the ERBE sensors
IPTS-68 - International Pressure and Temperature Standard of 1968
IMS - Information Management System
LaRC - Langley Research Center
MFOV - Medium Field-of-View
MRBB - Master reference blackbody
NASA - National Aeronautics and Space Administration
NESDIS - National Environmental Satellite and Data Information Service
NOAA - National Oceanic and Atmospheric Administration
NOAA-9 - National Oceanic and Atmospheric Administration Operational Weather Monitoring Satellite number 9
NOAA-10 - National Oceanic and Atmospheric Administration Operational Weather Monitoring Satellite number 10
NORAD - North American Aerospace Defense Command
NSSDC - National Space Science Data Center
POCC - Payload Operation and Control Center
SAGE II - Stratospheric Aerosol and Gas Experiment II
SMA - Solar Monitor Assembly
SAS - Solar Aspect Sensor
SOCC - Satellite Operations and Control Center (NOAA)
SWICS - shortwave internal calibration source
TDRSS - Tracking and Data Relay Satellite System
TIROS - Television Infrared Radiometer Orbiting Satellite
URL - Uniform Resource Locator
UT - Universal Time
WFOV - Wide Field-of-View
WRR - World Radiation Reference

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