ERBE S10N_WFOV ERBS Edition3 Data Quality Summary

Investigation:	**ERBE**
Data Product:	**Scanner-Independent Wide Field-of-View Nonscanner Monthly Regional Averages (S10N_WFOV)**
Data Set:	**ERBS**
Data Set Version:	**Edition3**

The purpose of this document is to inform users of the changes in the latest reprocessed Earth Radiation Budget Experiment (ERBE; Barkstrom, 1984, Barkstrom and Smith, 1986) Earth Radiation Budget Satellite (ERBS) scanner-independent wide field-of-view (WFOV) nonscanner monthly mean data product (S10N), to briefly summarize key validation results, provide cautions when using the new data, provide helpful links to further information about the data product and algorithms, give information about planned data improvements, and register users. Registration will keep users informed of new validation results, cautions, or improved data sets that become available in the future. This document is a high-level summary and represents the minimum information that all scientific users of this data product should be familiar with. It is strongly recommended that users re-check this document for the latest status before publication of any scientific papers using this data product. This applies to both authors and reviewers of such research papers.

The ERBE nonscanner active-cavity radiometer (ACR) instrument package (Luther et al. 1986a, 1986b) consists of five ACR's: four earth-viewing ACR's and one ACR solar monitor (Lee et al. 1987). The ACR sensor packages were built and radiometrically calibrated on the International Practical Temperature Scale of 1968 (IPTR'68) by TRW. The shortwave WFOV ACR's measured earth-reflected total solar irradiances (TSI) in the 0.2 to 5.0 micron broadband spectral region while the total WFOV ACR measured both the earth-reflected TSI and the earth-emitted longwave irradiances in the 0.2 to 100 micron broadband region. The WFOV ACR's observed irradiances from the entire earth disc enclosed by a 2 angular degree space ring. The two remaining ACRS were shortwave and total medium field-of-view (MFOV) ACR's. The MFOV ACR's viewed earth irradiances from regions with earth-centered angles of 10 degrees. The ERBE nonscanner instrument calibration procedures and the initial 1984-1989 radiometrical calibration results are described in Halyo et al. (1989) and Paden et al. (1990).

The quality of the reprocessed ERBE S10N_WFOV ERBS Edition3 data is comparable to the quality of the original and the Edition2 release of ERBE S10N_WFOV ERBS data in terms of instantaneous gridded fluxes (Green and Smith, 1991, Green et al., 1990). The major differences between Edition2 and the original release can be found in the ERBE S10N WFOV ERBS Edition2 data quality summary or in the link to the section on "Algorithm Changes between previous Edition2 and Original Release" below. The difference between this latest Edition3 and the earlier Edition2 data is that this Edition3 data includes a minor correction for changes in satellite altitude over the first 15-year period. The Edition3 is an archived data product that is officially available from the Langley Atmospheric Science Data Center.

For this public release of the archived Edition3 data, the nonscanner reprocessing team will also include additional information concerning further revision to the archived Edition3 data to correct for a small drift in the shortwave sensor dome over the first 15-year period. This drift was discovered during the internal validation of the Edition3 data. Due to funding constraints that are beyond our control, and the desire to minimize further delay in the release of this reprocessed dataset, the nonscanner reprocessing team has decided to release the Edition3 data set at the Langley DAAC without further reprocessing to fix this small instrument problem. To account for this additional change, the nonscanner reprocessing team has released a set of interim Rev1 adjustments to the Edtion3 data set through a special ERBE interim Edition3_Rev1 website. Users of the Nonscanner Edition3 data should download these adjustments from this website and apply them directly to the official archived Edition3 data from the Langley Atmospheric Science Data center. To differentiate this interim release from the official archived release at the Langley DAAC, the revised Edition3 data with the shortwave sensor dome adjustment is officially referred to as the ERBE S10N_WFOV ERBS Edition3_Rev1 dataset. Please see sections on "User-applied Revision Adjustment to Archived Edition3 Data" and "Interim Edition3_Rev1 Website" for more details.

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Nature of Data Product

The reprocessed ERBE S10N_WFOV ERBS Edition3 data product contains temporally and spatially averaged shortwave (SW) and longwave

(LW) top-of-the-atmosphere (TOA) fluxes derived from one month of Earth Radiation Budget Experiment nonscanning wide field-of-view instruments aboard the Earth Radiation Budget Satellite. Instantaneous TOA fluxes have been spatially averaged on 5° and 10° equal-angle grids using numerical filter and shape factor techniques, respectively. ERBE scanner-independent temporal interpolation algorithms were applied to produce daily, monthly-hourly, and monthly mean fluxes from the instantaneous gridded data. The S10N_WFOV files contain both temporally averaged and instantaneous gridded mean values of TOA total-sky LW flux, total-sky SW flux, and total-sky albedo for each 5° and 10° region observed during the month. While the original release of the ERBE S10N_WFOV ERBS monthly mean dataset covered data between November 1984 and November 1995, the reprocessed ERBE S10N_WFOV ERBS Edition2 and later dataset contains monthly mean data from November 1984 to September 1999. On October 6, 1999, an anomaly occurred to the ERBS nonscanner instrument during its routine calibration operation and caused it to lose in-flight calibration capability. While the nonscanner continues to operate, taking scientific measurements, the data collected after September 1999 are currently being withheld until calibration capability can be re-established. These additional data months may be released at some future time pending available funding support.

For more detailed information regarding the original ERBE S10N data product, consult the ERBE Earth Radiant Fluxes and Albedo for Month Nonscanner (S10N) Langley DAAC Data Set Document.

Algorithm Changes between Previous Edition2 and Original Release

The major differences between previous Edition2 and the original release can be found in the Edition2 data quality summary and include:

1. Incorporation of stochastic quality assurance algorithms for filtering out monthly mean data with excessive temporal sampling errors

2. Self-consistent use of WFOV data in selecting scene-dependent directional models for temporal interpolation of the ERBE WFOV instantaneous gridded data

3. Minor correction associated with the assignment of ERBE fill value for missing data to some monthly mean shortwave albedo values in the original dataset

Algorithm Changes between New Edition3 and Previous Edition2 Release

The main difference between new Edition3 and previous Edition2 release is in the treatment of TOA radiative fluxes resulting from changes in the ERBE nonscanner processing algorithm to account for decay in satellite altitude over the data period.

1. During an instrument performance study, Lee et al. (2003) discovered that the ERBE nonscanner inversion algorithm did not correctly account for the decay in the ERBS altitude over its mission lifetime; this can have a small but significant effect on the reported decadal changes of nonscanner TOA fluxes. The ERBE nonscanner inversion algorithm is used to convert nonscanner measurements at satellite altitude (approximately 611 km at the start of the mission) to TOA measurements at a reference altitude of 30 km. While these altitude changes over the 15-year period are small (on the order of 25 km) and do not affect the overall quality of the large regional fluxes, they do, however, have significant effect on the smaller changes associated with the observed large scale decadal changes in Earth radiation budget (Wong et al., 2005).

2. This satellite altitude related problem is unique to the ERBS nonscanner instrument and does not affect the quality of the ERBS scanner data product. The nonscanner is a hemispheric instrument which views the entire Earth disk along with the small portion of the deep space surrounding the Earth itself. As the satellite altitude dropped over its mission, the small portion of the deep space partially viewed by the nonscanner began to be filled in by the Earth view itself, resulting in more energy being recorded by the nonscanner instrument. Since the original and the Edition2 release data did not account for these subtle altitude changes, there is a small effect of artificially increasing the reported longwave, shortwave, and net fluxes over the mission lifetime. Specifically, the overall effect of this altitude change is a small increase (~0.6%) in both longwave and shortwave radiation over the 15-year period.

3. To minimize errors in the ERBS nonscanner data product, an altitude correction algorithm to the Edition2 data was developed and applied to the entire Edition2 data set. The result is the new Edition3 data set.

4. The Edition3 data set is the official archived nonscanner data product and it is available at the Langley DAAC.

User-applied Revision Adjustment to the Archived Edition3 Data

The user-applied revision adjustment is a set of minor corrections that the user should apply to the archived Edition3 dataset to make the dataset current. This revision adjustment is used to correct an additional data issue that was discovered during the internal validation of the Edition3 dataset. Due to funding constraints that are beyond our control, and the desire to minimize further delay in the release of this reprocessed dataset, the nonscanner reprocessing team has decided to release the Edition3 data set at the Langley DAAC without further reprocessing to fix this data problem. To account for this additional change, the nonscanner reprocessing team has released a set of interim Rev1 adjustments to the Edtion3 data set through a special ERBE interim Edition3_Rev1 website. Users of the Nonscanner Edition3 data should download these adjustments from this website and apply them directly to the official archived Edition3 data from the Langley Atmospheric Science Data center. To differentiate this interim release from the official archived release at the Langley DAAC, the revised Edition3 data with this user-applied adjustment should always be referred to as the ERBE S10N_WFOV ERBS Edition3_Rev1 dataset.

The main difference between the interim Edition3_Rev1 and the archived Edition3 release is in the treatment of radiative fluxes resulting from

the slow drift of the nonscanner shortwave sensor dome over the 15-year period.

1. The ERBS nonscanner shortwave sensor appears to have a smaller instrument issue that has not been corrected during the instrument calibration process (Wong et al., 2005). This small shortwave instrument drift, on the level of 1% over the 15-year period, was discovered during the validation of the Edition3 data set. This type of small instrument drift is beyond the current ERBS nonscanner calibration capability and can only be corrected after major reprocessing. This shortwave drift is caused by non-uniform exposure of the nonscanner shortwave sensor dome to UV solar radiation during spacecraft sunrise and sunset over the 15-year period.

2. This shortwave sensor drift will affect both the TOA longwave and TOA shortwave data since the daytime longwave is derived from subtracting the daytime shortwave from the daytime total measurement.

3. The TOA Net radiation will not be affected since the changes in shortwave exactly cancel the longwave changes.

4. A set of adjustments (longwave and shortwave) for the shortwave sensor drift is developed from the Edition3 data set. These adjustments are available to the public through the interim Nonscanner Edition3_Rev1 webpage discussed in the next section. Users will need to download these adjustments and apply them directly to the Edition3 data set.

5. The Edition3 data will become Edition3_Rev1 data once the user applies these interim adjustments to the archived Edition3 data.

6. The Edition3_Rev1 is an interim release data set. This data set is not archived at the Langley DAAC.

Interim Edition3_Rev1 Website

The interim ERBS Nonscanner Edition3_Rev1 website is a temporary website setup by the ERBS nonscanner reprocessing team to communicate to the user community additional revisions that are not currently in the archived ERBE nonscanner data product available from the Langley DAAC. This website will remain open until the next major reprocessing of the nonscanner data. The information currently available from this website include:

1. Edition3_Rev1 adjustments for longwave and shortwave fluxes.

2. Special 36-day mean data for tropical regions between 20N and 20S, including tropical mean time series data.

3. Special 72-day mean data for tropical regions between 20N and 20S and near-global regions between 60N and 60S, including tropical mean and near-global mean time series data.

4. Subset of monthly mean regional data, including tropical mean and near-global mean time series data.

Cautions when Using Data

There are several cautions the ERBE Team notes regarding use of reprocessed monthly mean ERBE S10N_WFOV ERBS Edition3 and Edition3_Rev1 data:

1. Because of the 57° inclination orbit, the ERBE S10N_WFOV ERBS dataset only covers regions between 60°N and 60°S. Therefore global mean fluxes can not be produced by using this single satellite ERBE/ERBS data product alone.

2. In order to satisfy the needs of data users, original monthly mean ERBE/ERBS WFOV nonscanner data were released with both 5° numerical filter and 10° shape factor datasets. While 5° numerical filter data was designed to be a higher spatial resolution dataset, it also contained larger temporal sampling errors. The lower spatial resolution 10° shape factor data, on the other hand, was intended to be a dataset with smaller temporal sampling errors. With the incorporation of new stochastic quality assurance algorithms in Edition2 data filtering out WFOV nonscanner monthly mean data with temporal sampling errors larger than 12 Wm^{-2}, significantly more regions are missing from the monthly mean ERBE/ERBS WFOV nonscanner data product. This is especially true for the 5° numerical filter dataset.

3. In general, nonscanner temporal sampling errors tend to minimize in the tropics and increase poleward. Thus, more ERBE/ERBS nonscanner monthly mean regions are missing in higher latitudes.

4. Because of the larger magnitude and variability associated with the nature of shortwave flux and the imposed 12 Wm^{-2} temporal sampling error threshold, more ERBE/ERBS nonscanner monthly mean shortwave regions are missing. This is especially true over the summer hemisphere.

5. In general, months with the worst sampling errors include January, February, March for regions in the southern hemisphere and July, August, and September for regions in the northern hemisphere. Months with the least temporal sampling errors are April, May, June, October, November, and December. Thus, significantly more ERBE/ERBS nonscanner monthly mean regions are missing during those months with the worst sampling errors.

6. For monthly mean data, the ERBE Team recommends using the shape factor 10° WFOV nonscanner monthly-mean data over the

tropics where small temporal sampling errors minimize the occurrence of missing data due to activation of the stochastic quality assurance algorithms.

7. The archived Edition3 data from the Langley DAAC do not contain adjustments for the small shortwave sensor dome degradation due to non-uniform exposure to UV solar radiation during spacecraft sunrise and sunset. Users will either (1) need to apply these adjustments to the Edition3 data themselves by downloading the Edtion3_Rev1 adjustment coefficients from the interim Nonscanner Edition3_Rev1 website or (2) download the subsets of adjusted Edition3_Rev1 data from the same website.

8. Due to shifts in the local sampling time associated with the ERBS satellite precession cycle over the 15-year period and its interaction with ERBE monthly mean data processing, there will be aliasing of the diurnal cycle signal into the monthly mean data and that will artificially create a shift in the seasonal cycle of shortwave anomalies in the second half of the data record (Wielicki et al., 2002a). Therefore, the ERBE Team further recommends using 36-day mean and 72-day mean data for continuous climate time record study for the tropics and the extra-tropics, respectively. The 10-degree resolution ERBS WFOV tropical 36-day and near-global 72-day data are now available to the public through the interim ERBE Nonscanner Edition3_Rev1 website.

Validation Study Results

The ERBE Team has performed initial validation and quality assurance processes on this data set. Specifically, the new ERBE S10N_WFOV ERBS Edition3 and Edition3_Rev1 data were carefully checked by the ERBE nonscanner reprocessing team for other long-term instrument drift artifacts in the reprocessed dataset. In addition, a study was carried out to understand the differences between Edition3, Edition3_Rev1, and the earlier Edition2 dataset using direct comparison techniques. Validation results for previous Edition2 data are available from the ERBE Edition2 data quality summary.

1. The differences in the time series of Edition3 and Edition2 fluxes are consistent with the effects of satellite altitude changes over the ERBS mission period.

2. The changes in the time series of Edition3_Rev1 fluxes, relative to those from the Edition3 data, over the 15-year period are in agreement with the time series of the Edition3_Rev1 shortwave sensor dome adjustment.

3. The effects of Edition3 and Edition3_Rev1 changes on the reported decadal changes in tropical mean Earth Radiation Budget (Wielicki et al., 2002b) are summarized in the Table 1 below. Overall, the combined effects of these Edition changes modify the reported TOA LW decadal changes from +3.1 to +0.7, the reported TOA SW decadal changes from -2.4 to -2.1, and the reported TOA Net decadal changes from -0.7 to +1.4 Wm^{-2}, respectively.

Table 1. Decadal changes in tropical mean (20N to 20S) radiation budget between 1985-89 and 1994-97 period from ERBS Edition2, Edition3, and Edition3_Rev1 dataset

Data Source	TOA LW	TOA SW	TOA Net
ERBS Edition2	+3.1	-2.4	-0.7
ERBS Edition3	+1.6	-3.0	+1.4
ERBS Edition3_Rev1	+0.7	-2.1	+1.4

4. A comparison was performed using other publicly available climate data sets to access the quality of the revised Edition3_Rev1 data set. These include data from the ISCCP FD data product, the HIRS Pathfinder OLR data, and the AVHRR Pathfinder data set. The results of this comparison are:

    - The long-term time series analysis of radiative flux anomalies of tropical mean radiation budget is given in figure 1 below. Overall, there is very good agreement among ERBS Edition3_Rev1, ISCCP FD and HIR Pathfinder data sets. The time series of LW, SW, and Net from these three datasets follow each other in very similar patterns. The AVHRR pathfinder is the unadjusted dataset and contains significant artifacts from changes in instrument calibrations between NOAA satellites as well as slow changes in the data associated with drift of the satellite orbits. Thus the AVHHR pathfinder did not compare well with the other three data sets.

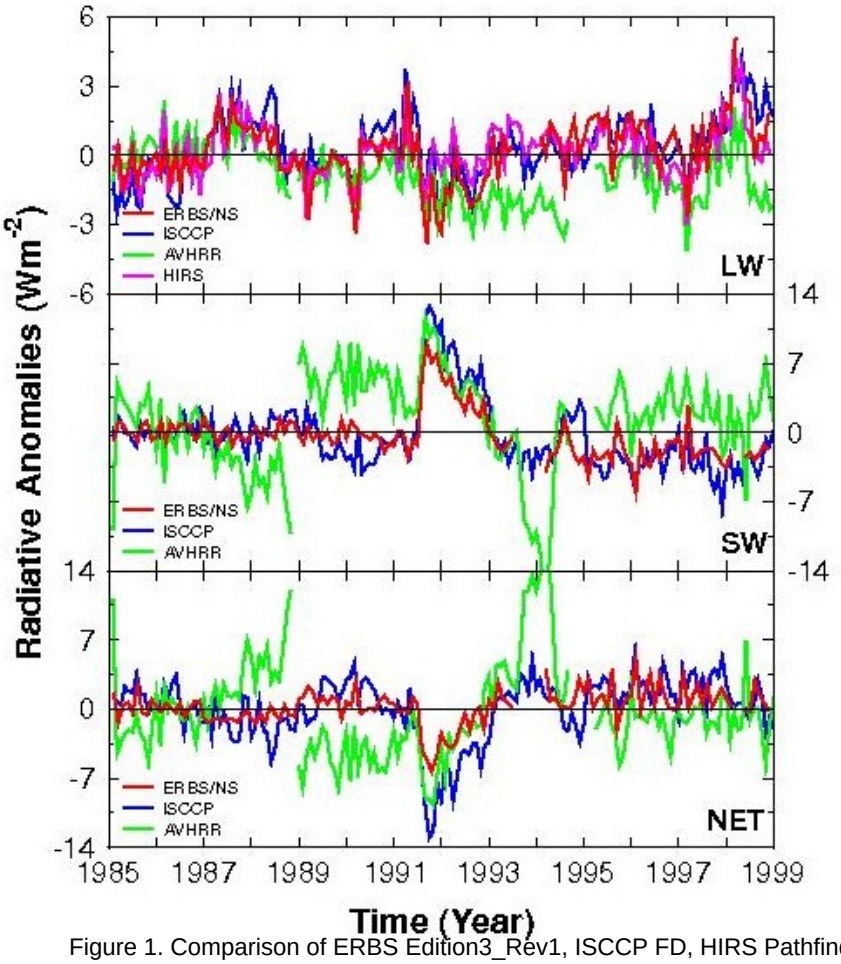

Figure 1. Comparison of ERBS Edition3_Rev1, ISCCP FD, HIRS Pathfinder OLR and AVHRR Pathfinder data.

- The decadal changes in tropical mean radiation budget are also in very good agreement between ERBS Edition3_Rev1, ISCCP FD, and HIRS Pathfinder OLR data set as given in Table 2 below. The unadjusted AVHRR Pathfinder data set, however, compared poorly with others due to problems noted earlier.

Table 2. Decadal changes in tropical mean (20N to 20S) radiation budget between 1985-89 and 1994-97 period from ERBS Edition3_Rev1, ISCCP FD, HIRS Pathfinder OLR, and AVHRR Pathfinder data set dataset

Data Source	TOA LW	TOA SW	TOA Net
ERBS Edition3_Rev1	+0.7	-2.1	+1.4
HIR Pathfinder	+0.2	n/a	n/a
AVHRR Pathfinder	-1.4	+0.7	+0.7
ISCCP FD	+0.5	-2.4	+1.8

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Expected Reprocessing

There are currently no plans for further reprocessing of the ERBE/ERBS nonscanner WFOV data. However, the ERBE team may reprocess this nonscanner data product in the future if further advancements in data calibration and processing techniques can be incorporated into the ERBE algorithm to remove known/discovered errors and to generate a consistent, long-term climate record.

Referencing Data in Journal Articles

The ERBE Team has gone to considerable trouble to remove major errors and to verify the quality of these data. **Please provide a reference to the following paper when you publish scientific results with the data:**

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

When data from the Langley Data Center are used in a publication, **we request the following acknowledgment be included:**

"These data were obtained from the Atmospheric Science Data Center at NASA Langley Research Center."

The Data Center at Langley requests a reprints of any published papers or reports or a brief description of other uses (e.g., posters, oral presentations, etc.) of data that we have distributed. This will help us determine the use of data that we distribute, which is helpful in optimizing product development. It also helps us to keep our product related references current.

Feedback:

For questions or comments on this ERBE Quality Summary, contact the User and Data Services staff at the Atmospheric Science Data Center.