ERBE S10N_WFOV ERBS Edition2 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:	**Edition2**

The purpose of this document is: inform users of the changes in the 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 (including both long term stability of the ERBS WFOV nonscanner instruments and the effects of changes in the monthly mean algorithm to the original data), 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) consisted 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 radiometrically calibration results are described in Halyo et al. (1989) and Paden et al. (1990).

The quality of the reprocessed ERBE S10N_WFOV ERBS Edition2 data is comparable to the quality of the original 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 are in the monthly mean fluxes with (1) the incorporation of stochastic quality assurance algorithms for filtering out monthly-mean data with excessive temporal sample errors and (2) a self-consistent usage of the WFOV data in selecting scene-dependent directional models for temporal interpolation of the ERBE WFOV instantaneous gridded data.

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Nature of Data Product

The reprocessed ERBE S10N_WFOV ERBS Edition2 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 nonscannng wide field-of-view instruments aboard the Earth Radiation Budget Satellite. Instantaneous TOA fluxes from the ERBE/ERBS S7 product have been spatially averaged on a 5° and a 10° equal-angle grid 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 to November 1995, the newly reprocessed ERBE S10N_WFOV ERBS Edition2 dataset contains monthly mean data starting 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 Edition2 and Original Release

The major differences between Edition2 and the original release are in the treatment of monthly mean fluxes resulting from the following changes in the ERBE nonscanner monthly mean algorithm:

1. Incorporation of stochastic quality assurance algorithms for filtering out monthly mean data with excessive temporal sample errors:
    - During a comparison study between ERBE/ERBS nonscanner and ScaRAB scanner data (Bess et al., 1999), the ERBE team discovered that large regional errors can exist in the single satellite ERBE/ERBS WFOV nonscanner monthly mean dataset. These nonscanner errors were traced back to the temporal sampling noise associated with the precession of the ERBS satellite. The ERBE/ERBS orbit inclination of 57° results in a precession rate that passes through all local times in 72 days. Because of this precession, the temporal sampling and associated errors are rather complex. To minimize these errors in the WFOV nonscanner monthly mean data product, stochastic quality assurance algorithms were developed, removing regions with excessive temporal sampling error.
    - The stochastic algorithms were constructed by computing standard deviations of temporal sampling errors for monthly mean outgoing longwave and reflected solar radiant fluxes (OLR and RSR). These standard deviations are computed by considering day-to-day variability of regions as a function of latitude, temporal correlation of radiation, times of day and day of month at which the measurements are made, diurnal cycle of OLR and RSR radiation, and algorithms by which daily- and monthly-mean fluxes are computed.
    - The theoretical standard deviation of temporal sampling error for each regional box was computed for each month for OLR and RSR using historical ERBS scanner data. Monthly-mean temporal sampling error is considered to be excessive if the differences from theoretical standard deviation exceeds 12 Wm^{-2}; in this case the flux (OLR or RSR) is not listed in the S10N_WFOV monthly mean data product and an ERBE fill value for missing data is put in its place instead. Keep in mind that the stochastic quality assurance algorithms do not use any recorded flux values during the selection process; their decision is purely theoretical in nature. Complete details of these algorithms (Smith, 1997, 1998; Spangenberg et al., 1999) and results (Smith et al., 2000) can be found in the references listed on the bottom of this page.
2. Self-consistent use of WFOV data in selecting scene-dependent directional models for temporal interpolation of the ERBE WFOV instantaneous gridded data:
    - The original release of monthly mean ERBE/ERBS WFOV nonscanner data was made with the aid of ERBE/ERBS medium field-of-view (MFOV) measurements in selecting scene dependent directional models for temporal interpolation of ERBE/ERBS WFOV instantaneous gridded data. To create a self-consistent dataset, the ERBE team has decided to modify the original ERBE nonscanner temporal interpolation algorithm and use only ERBE WFOV measurement for performing this process. This modification completely eliminates the need of ERBE/ERBS MFOV measurements in the reprocessing of monthly mean ERBE/ERBS WFOV nonscanner data. The effects of this change to ERBS WFOV nonscanner data are small and they are outlined in the validation studies section below.
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:
    - There was a software bug in the original release of monthly mean ERBE nonscanner data. Some monthly mean shortwave albedos were assigned a zero value when there were no ERBE shortwave measurements during the month. These monthly mean shortwave albedos are now correctly assigned with the normal ERBE fill value of 32767. This correction only affects a small population of monthly mean shortwave albedo data, and has no effect on monthly mean longwave or shortwave flux data.

Cautions When Using Data

There are several cautions the ERBE Team notes regarding use of reprocessed monthly mean ERBE S10N_WFOV ERBS Edition2 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 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 a continuous climate time record study, 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.

Validation Study Results

The ERBE Team has performed initial validation and quality assurance processes on this data set. Specifically, the reprocessed ERBE S10N_WFOV ERBS Edition2 data were carefully checked by (1) the ERBE instrument working group for any long term drifts artifacts in the reprocessed dataset and (2) the ERBE time-space averaging working group for understanding differences between this reprocessed and the original dataset using direct comparison with data from November 1984 through November 1995.

1. The main validation results on long term stability and accuracy of ERBS WFOV instruments are:

    - Instrument gain and offset analyses show that the ERBS WFOV instrument has maintained a high level of precision over the 15 years data period. This high precision is achieved through ERBE in-flight calibration procedures which include solar constant monitoring every 2 weeks to verify stability of the gain, and internal blackbody calibration to verify instrument offset. These in-flight solar and internal calibration procedures were applied to remove instrument artifacts during the entire data period. For example, on-orbit, drifts or shifts in sensor gains/responses were derived at precision levels approaching 1 Wm^{-2} (0.1%) from observations of the sun's total solar irradiances (TSI) every 14 days on Wednesdays (Lee et al. 1993). The TSI can be characterized at levels better than 0.14 Wm^{-2} (0.01%), long-term TSI stability has been measured at the 0.1% level between 1978 and 2001 (Lee et al. 1995, Lee et al. 2000). The shortwave ACR offsets were derived from observations of the night side of the earth. The total ACR offsets were derived from observations of on-orbit, built-in blackbodies. The offsets were derived at the 1.5 Wm^{-2} precision level. Paden et al. (2000) analyzed the consistency of the resulting ERBS ACR WFOV earth irradiance data products. Analyses of the WFOV day-night longwave irradiances indicate that the ERBS WFOV measurements were consistent at precision levels approaching 1 Wm^{-2}.

    - Time series analyses of ERBS WFOV monthly mean tropical mean LW anomalies data do not show any relationship with those from instrument offsets (Wielicki et al, 1999); indicating that this monthly mean data product is free from instrument related artifacts.

    - Instantaneous comparisons with available independent scanner datasets, such as ERBE scanner, ScaRaB/Meteor scanner, CERES/TRMM scanner, and ScaRaB/Resurs scanner, show excellent agreement with ERBS nonscanner results between November 1984 and February 1999 (Green et al. 1990, Bess et al. 1997, 1999, Rutan et al. 1999, 2001); demonstrating accuracy at the level within 1 to 2%.

2. Major findings on effects of the new stochastic quality assurance algorithms include:

    - New stochastic quality assurance algorithms eliminate a higher percentage of regions in the 5° numerical filter dataset than the 10° shape factor dataset.

        - view affected LW regions over entire validation period for 5° numerical filter and 10° shape factor data .
        - view affected SW regions over entire validation period for 5° numerical filter and 10° shape factor data .

    - New stochastic quality assurance algorithms affect more high latitude regions than low latitude regions.

        - view affected SW regions over entire validation period for the 10° shape factor data showing this latitudinal effect .

    - The new stochastic quality assurance algorithms affect more shortwave data than longwave data.

        - view affected LW and SW regions over entire validation period for the 10° shape factor data showing this effect .

    For monthly mean WFOV longwave data stochastic quality assurance algorithms have a minor effect on the shape factor 10° data. Affected areas are concentrated at northern high latitude land regions. There are no effects over oceanic regions for shape factor longwave data. Similarly, stochastic quality assurance algorithms have minor effects on numerical filter 5° data. Affected areas include both land and ocean regions. Relative to the shape factor 10° dataset, more regions in the numerical filter 5° dataset are affected by the stochastic quality assurance algorithms; more latitude zones and more months are affected by the stochastic quality assurance algorithm. For monthly mean WFOV shortwave data stochastic quality assurance algorithms have a major effect over high latitude regions. Moderate to minor effects are noted at low latitude regions. Similar to longwave data, more regions in the numerical filter 5° dataset are affected by the stochastic quality assurance algorithms.

- The major effects of the new stochastic quality assurance algorithms are found in the months of January, February, March, July, August, and September.
  - view time series of affected LW zonal regions for 5° numerical filter data .
  - view time series of affected SW zonal regions for 5° numerical filter data .
  - view time series of affected LW regions for 10° shape factor data .
  - view time series of affected SW regions for 10° shape factor data .

3. A comparison was performed for those data regions that are not affected by the stochastic quality assurance algorithms to assess the effect due to changes resulted from the self-consistent use of WFOV data in selecting scene-dependend directional models for temporal interpolation of the ERBE WFOV instantaneous gridded data. The main results include:
   - Total-sky LW flux - There are no large biases in LW flux between Edition2 and the original release dataset, however, some regional differences do exist on a month-to-month basis.
     - view time series of LW differences for 5° numerical filter data .
     - view time series of LW differences for 10° shape factor data .
   - Total-sky SW flux - The Edition2 data is slightly darker (less than 2 Wm^{-2} on average) than the original release of nonscanner data. In addition, some regional differences do exist on a month-to-month basis.
     - view time series of SW differences for 5° numerical filter data .
     - view time series of SW differences for 10° shape factor data .

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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."

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Feedback:

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