Clouds and the Earth's Radiant Energy System (CERES) ERBE-like Monthly Geographic Averages (ES-4) Data Set Abstract
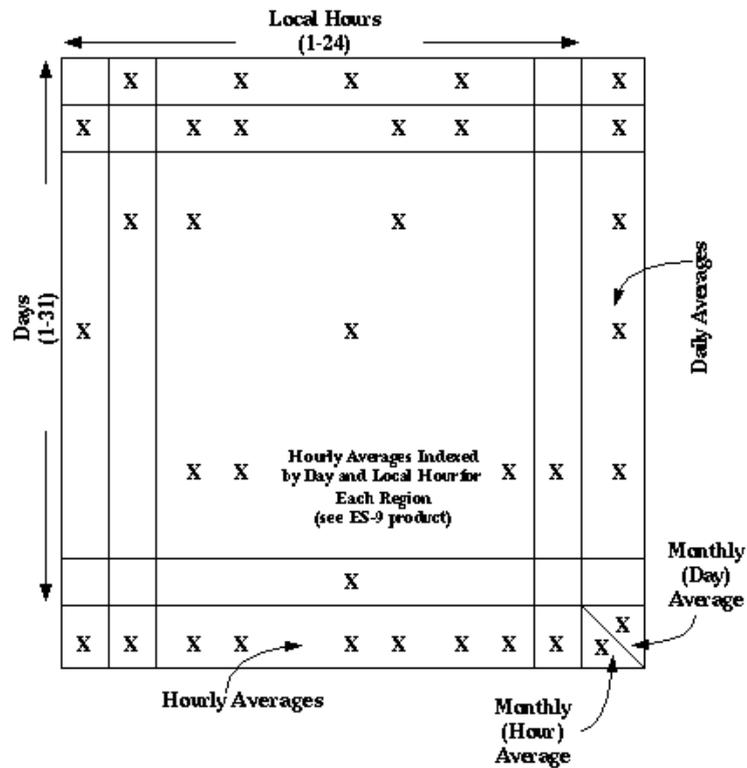
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Data Set Description:

The ERBE-like Monthly Geographical Averages (ES-4) product contains a month of space and time averaged Clouds and the Earth's Radiant Energy System (CERES) data for a single scanner instrument. The ES-4 is also produced for combinations of scanner instruments. For each observed 2.5-degree spatial region, the daily average, the hourly average over the month, and the overall monthly average of shortwave and longwave fluxes at the Top-of-the-Atmosphere (TOA) from the CERES ES-9 product are spatially nested up from 2.5-degree regions to 5- and 10-degree regions, to 2.5-, 5-, and 10-degree zonal averages, and to global monthly averages. For each nested area, the albedo and net flux are given. For each region, the daily average flux is estimated from an algorithm that uses the available hourly data, scene identification data, and diurnal models. This algorithm is "like" the algorithm used for the Earth Radiation Budget Experiment (ERBE).

The ES-4 archival data product is created as an HDF file with nine vgroups of spatial averages:

1. 2.5 Degree Regional
2. 5.0 Degree Nested Regional
3. 10.0 Degree Nested Regional
4. 2.5 Degree Zonal
5. 5.0 Degree Zonal
6. 10.0 Degree Zonal
7. 2.5 Degree Global
8. 5.0 Degree Global
9. 10.0 Degree Global

There are 10,368 2.5-degree regions for the ERBE-like data; therefore, there is a maximum of 10,368 records in the 2.5-degree regional data set. The second set of data is the 2.5-degree nested to 5-degree regional data, which constitutes a maximum of 2,592 records. The third set of data is the 5-degree nested to 10-degree regional data, which constitutes up to 648 records. The fourth, fifth, and sixth sets of data are the 2.5-, 5-, and 10-degree zonally averaged data which constitute 72, 36, and 18 records, respectively. The seventh, eighth, and ninth sets of data are the 2.5-, 5-, and 10-degree globally averaged data which constitutes 1 record each. Each geographic vgroup contains Monthly (Day), Monthly (Hour), Daily, and Hourly averages (see figure below) for clear-sky and total-sky parameters such as solar incidence, net radiant flux, longwave flux, shortwave flux, and albedo.

Local Hours
(1-24)

Days
(1-31)

Daily Averages

Hourly Averages Indexed by Day and Local Hour for Each Region (see ES-9 product)

Monthly (Day) Average

Hourly Averages

Monthly (Hour) Average

Additional information about the format and content of the ES-4 can be found in the CERES Data Products Catalog. Details concerning the science parameters and how they are calculated can be found in the CERES Algorithm Theoretical Basis Document for Subsystem 3.0 and in the ES-4 Collection Guide.

Summary of Changes:

The CERES Data Management Team and the Atmospheric Science Data Center (ASDC) at Langley use a Sampling Strategy, a Production Strategy, and a Configuration Code (CCode) to track versions of CERES archival data products. In general, minor reprocessing changes are tracked by increasing the Configuration Code while major reprocessing changes result in a new Production Strategy. The Sampling Strategy identifies the satellite(s) and instrument(s) which acquired the data in the product.

A summary of changes made to the ES-4 HDF product is shown in the following table.

Modification History for: NPP | Aqua | Terra | TRMM | Terra+Aqua | TRMM+Terra

Modification History of the CERES ES-4 NPP Archival Product

Sampling Strategy and Production Strategy	CCode	Available at ASDC	Impact on the ES-4 Product
NPP-FM5_Edition1 [3]	100103	Dec 2013	• First application of time-varying gains to FM5 data. • Initiated by instrument PGE update using this CCode.
NPP-FM5_Edition1-CV [3]	300303	Aug 2013	• No science impact. • Reprocessed entire FM5 data set due to spikes detected in initial Instrument data (BDS), which translated into fill values in downstream products. • Fixed by Instrument PGE update using this CCode.
NPP-FM5_Edition1-CV [3]	300301	Sep 2012	• No science impact. • Migration of software to IBM P6 and x86 platforms.
NPP-FM5_Edition1-CV [3]	300300	Sep 2012	• Initial delivery.
Availability: (1) Validation version only available to CERES analysts; (2) restricted to CERES Science Team; (3) public			

Modification History for: NPP | Aqua | Terra | TRMM | Terra+Aqua | TRMM+Terra

Modification History of the CERES ES-4 Aqua Archival Product

Sampling Strategy and Production Strategy	CCode	Available at ASDC	Impact on the ES-4 Product
Aqua-Xtrk_Edition4 [3]	400403	Nov 2013	• Uses new set of Spectral Correction Coefficients similar to Edition3's.
Aqua-Xtrk_Edition3 [3]	300303	Aug 2013	• No science impact. • Reprocessed data from 201210 due to incorrect scan time initialization detected in initial C++ Instrument data stream (BDS). • Fixed by Instrument PGE update using this CCode.
Aqua-Xtrk_Edition3 [3]	300301	Nov 2012	• No science impact. • Migration of software to IBM P6 and x86 platforms.
Aqua-Xtrk_Edition3 [3]	300300	Nov 2011	• Uses new set of Aqua channel-degradation-corrected Edition3 EID6s and CXDRs from subsystem 2.0. • Processes only data that is in cross-track scan mode on day-to-day basis, selecting the Aqua instrument for each day based on the daily Aqua x-track database.
Aqua-FM3_Edition1-CV [3]	300303	Aug 2013	• No science impact. • Extension of 300301 data set following upstream Instrument PGE update (see NPP-FM5_Edition1-CV entry above with this CCode).
Aqua-FM3_Edition1-CV [3]	300301	Sep 2012	• No science impact. • Migration of software to IBM P6 and x86 platforms.
Aqua-FM3_Edition1-CV [3]	300300	Nov 2011	• No science impact. • Migration of software to IBM P6 platform.
Aqua-FM3_Edition2 [3] Aqua-FM4_Edition2 [3] Aqua-FM3_Edition1-CV [3]	025033	Oct 2010	• No science impact. • Migration of software to IBM P4 platform.

Modification History of the CERES ES-4 Aqua Archival Product

Sampling Strategy and Production Strategy	CCode	Available at ASDC	Impact on the ES-4 Product
Aqua-FM4_Edition1-CV [3]			
Aqua-FM3_Edition1-CV [3] Aqua-FM4_Edition1-CV [3]	024030	Apr 2006	• No science impact. • Reprocessed to use all available input.
Aqua-FM3_Edition1-CV [3] Aqua-FM4_Edition1-CV [3]	024029	Apr 2006	• Eliminated data affected by Solar Heating.
Aqua-FM3_Edition1 [3] Aqua-FM4_Edition1 [3]	024026	Mar 2005	• Instrument Subsystem code changes result in less radiances processed. The worst case is 1.5% less records for a day and 0.1% for a month compared with 024025 processing.
Aqua-FM3_Edition2 [3] Aqua-FM4_Edition2 [3]	024025	Jun 2004	• (FM3) Corrected SW part of Total Channel spectral response. • (FM4) Corrected SW part of Total Channel spectral response.
Aqua-FM3_Edition1 [3] Aqua-FM4_Edition1 [3]	024025	May 2004	• No science impact.
Aqua-FM3_Edition2 [3] Aqua-FM4_Edition2 [3]	024024	Feb 2004	• Instrument calibration updates for both FM3 and FM4 instruments. • (FM3) Corrected SW part of Total Channel spectral response. • (FM4) Corrected SW part of Total Channel spectral response.
Aqua-FM3_Edition1 [3] Aqua-FM4_Edition1 [3]	024024	Feb 2004	• Instrument calibration updates for both FM3 and FM4 instruments.
Aqua-FM3_Edition1 [3] Aqua-FM4_Edition1 [3]	023023	Sep 2003	• No science impact.
Aqua-FM3_Edition1 [3] Aqua-FM4_Edition1 [3]	023022	Aug 2003	• Release of Aqua Edition1.
Availability: (1) Validation version only available to CERES analysts; (2) restricted to CERES Science Team; (3) public			

Modification History for: NPP | Aqua | Terra | TRMM | Terra+Aqua | TRMM+Terra

Modification History of the CERES ES-4 Terra Archival Product

Sampling Strategy and Production Strategy	CCode	Available at ASDC	Impact on the ES-4 Product
Terra-Xtrk_Edition4 [3]	400403	Nov 2013	• Uses new set of Spectral Correction Coefficients similar to Edition3's except for the TOT channel offset: instead of being in the spectral response function, it was put back into the gain.
Terra-Xtrk_Edition3 [3]	300303	Aug 2013	• No science impact. • Reprocessed data from 201210 due to incorrect scan time initialization detected in initial C++ Instrument data stream (BDS). • Fixed by Instrument PGE update using this CCode.
Terra-Xtrk_Edition3 [3]	300301	Nov 2012	• No science impact. • Migration of software to IBM P6 and x86 platforms.
Terra-Xtrk_Edition3 [3]	300300	Nov 2011	• Uses new set of Terra channel-degradation-corrected Edition3 EID6s and CXDRs from subsystem 2.0. • Processes only data that is in cross-track scan mode on day-to-day basis, selecting the Terra instrument for each day based on the daily Terra x-track database.

Modification History of the CERES ES-4 Terra Archival Product

Sampling Strategy and Production Strategy	CCode	Available at ASDC	Impact on the ES-4 Product
Terra-FM1_Edition1-CV [3] Terra-FM2_Edition1-CV [3]	300303	Aug 2013	• No science impact. • Extension of 300301 data set following upstream Instrument PGE update (see NPP-FM5_Edition1-CV entry above with this CCode).
Terra-FM1_Edition1-CV [3] Terra-FM2_Edition1-CV [3]	300301	Sep 2012	• No science impact. • Migration of software to IBM P6 and x86 platforms.
Terra-FM1_Edition1-CV [3] Terra-FM2_Edition1-CV [3]	300300	Nov 2011	• No science impact. • Migration of software to IBM P6 platform.
Terra-FM1_Edition2 [3] Terra-FM2_Edition2 [3] Terra-FM1_Edition1-CV [3] Terra-FM2_Edition1-CV [3]	025033	Oct 2010	• No science impact. • Migration of software to IBM P4 platform.
Terra-FM1_Edition1-CV [3] Terra-FM2_Edition1-CV [3]	024030	Apr 2006	• No science impact. • Reprocessed to use all available input.
Terra-FM1_Edition1-CV [3] Terra-FM2_Edition1-CV [3]	024029	Apr 2006	• Eliminated data affected by Solar Heating.
Terra-FM1_Edition2 [3] Terra-FM2_Edition2 [3]	024026	Mar 2005	• Instrument Subsystem code changes result in less radiances processed. The worst case is 1.5% less records for a day and 0.1% for a month compared with 024025 processing. • Linerally dropped FM2's SW channel spectral response by 0.25% from Dec03 level. Each month Jan04 to Nov04 has a 0.25%/11 drop from the preceeding month.
Terra-FM1_Edition1 [3] Terra-FM2_Edition1 [3]	024026	Mar 2005	• Instrument Subsystem code changes result in less radiances processed. The worst case is 1.5% less records for a day and 0.1% for a month compared with 024025 processing.
Terra-FM1_Edition1 [3] Terra-FM2_Edition1 [3] Terra-FM1_Edition2 [3] Terra-FM2_Edition2 [3]	024025	May 2004	• No science impact.
Terra-FM1_Edition1 [3] Terra-FM2_Edition1 [3]	024024	Feb 2004	• No science impact.
Terra-FM1_Edition2 [3] Terra-FM2_Edition2 [3]	023023	Sep 2003	• (FM2) Corrected SW Channel spectral response.
Terra-FM1_Edition1 [3] Terra-FM2_Edition1 [3]	023023	Sep 2003	• No science impact.
FM1+FM2_Edition1 [2]	023022	Jul 2003	• No science impact.
Terra-FM1_Edition2 [2] Terra-FM2_Edition2 [2]	023021	Jul 2003	• (FM2) Corrected SW Channel spectral response.
Terra-FM1_Edition1 [3] Terra-FM2_Edition1 [3]	023021	Jul 2003	• No science impact.
Terra-FM1_Edition2 [3] Terra-FM2_Edition2 [3] FM1+FM2_Edition2 [3]	021020	Sep 2002	• Instrument calibration updates for both FM1 and FM2 instruments. Snow map algorithm correction. • Recovery of missing Edition1 data. • (FM1) Corrected SW part of Total Channel spectral response. • (FM2) Corrected SW part of Total Channel spectral response.

Modification History of the CERES ES-4 Terra Archival Product

Sampling Strategy and Production Strategy	CCode	Available at ASDC	Impact on the ES-4 Product
Terra-FM1_Edition2 [3] Terra-FM2_Edition2 [3] FM1+FM2_Edition2 [3]	021019	Aug 2002	• Instrument calibration updates for both FM1 and FM2 instruments. Snow map algorithm correction. • (FM1) Corrected SW part of Total Channel spectral response (FM1) Corrected SW Channel spectral response. • (FM2) Corrected SW part of Total Channel spectral response.
Terra-FM1_Edition1 [3] Terra-FM2_Edition1 [3] FM1+FM2_Edition1 [3]	021019	Aug 2002	• Instrument calibration updates for both FM1 and FM2 instruments. • Recovery of missing Edition1 data. • Snow map algorithm correction.
Terra-FM1_Edition1 [3] Terra-FM2_Edition1 [3] FM1+FM2_Edition1 [3]	019018	Nov 2001	• No science impact.
Terra-FM1_Edition1 [2] Terra-FM2_Edition1 [2] FM1+FM2_Edition1 [2]	018016	Apr 2001	• Applied HDF Compression.
Terra-FM1_Edition1 [3] Terra-FM2_Edition1 [3] FM1+FM2_Edition1 [3]	017015	Nov 2000	• Release of Terra Edition1. • Slope/intercept Spectral Correction code updated to apply 2nd order polynomial fits for the window channel and for shortwave cloudy cases, and to perform interpolation of unfiltered radiances. • Provided new day and night spectral correction coefficients for FM1 and FM2.
Availability: (1) Validation version only available to CERES analysts; (2) restricted to CERES Science Team; (3) public			

Modification History for: NPP | Aqua | Terra | TRMM | Terra+Aqua | TRMM+Terra

Modification History of the CERES ES-4 TRMM Archival Product

Sampling Strategy and Production Strategy	CCode	Available at ASDC	Impact on the ES-4 Product
TRMM-PFM_Edition2 [3]	021019	Aug 2002	• Snow map algorithm correction. • Recovery of missing Edition1 data.
TRMM-PFM_Edition2 [3]	019018	Nov 2001	• No science impact.
TRMM-PFM_Edition1 [2]	016014	Sep 2000	• No science impact.
TRMM-PFM_Edition2 [2]	015013	Apr 2000	• Change Spectral Correction Algorithm to use slope intercept method. • Change LW TOA flux upper limit from 400 W/m² to 450 W/m². • New structure for ES-4 HDF products. Also, changed from HDF-EOS to HDF. • Modified slope intercept method (2nd (+) order curve fit) used in the Spectral Correction Algorithm. • New day & night Spectral Correction Coefficients for PFM, FM1, & FM2.
TRMM-PFM_Edition2 [2]	014012	Mar 2000	• No science impact.
TRMM-PFM_Edition1 [3]	009001	Oct 1998	• Both crosstrack and rotating azimuth measurements included in monthly averages.
TRMM-PFM_Edition1 [2]	008000	Aug 1998	• Changed HDF parameter names.
TRMM-PFM_Edition1 [2]	007000	Jun 1998	• Began generating ES-4 HDF product.

Modification History of the CERES ES-4 TRMM Archival Product

Sampling Strategy and Production Strategy	CCode	Available at ASDC	Impact on the ES-4 Product
Availability: (1) Validation version only available to CERES analysts; (2) restricted to CERES Science Team; (3) public			

Modification History for: NPP | Aqua | Terra | TRMM | Terra+Aqua | TRMM+Terra

Modification History of the CERES ES-4 Terra+Aqua Archival Product

Sampling Strategy and Production Strategy	CCode	Available at ASDC	Impact on the ES-4 Product
Terra+Aqua_Edition4 [3]	400403	Nov 2013	• Uses new set of Spectral Correction Coefficients similar to Edition3's except for Terra's TOT channel offsets: instead of being in the spectral responses, they were put back into the gains.
Terra+Aqua_Edition3 [3]	300303	Aug 2013	• No science impact. • Reprocessed data from 201210 due to incorrect scan time initialization detected in initial C++ Instrument data stream (BDS). • Fixed by Instrument PGE update using this CCode.
Terra+Aqua_Edition3 [3]	300301	Aug 2012	• No science impact. • Migration of software to IBM P6 and x86 platforms.
Terra+Aqua_Edition3 [3]	300300	Nov 2011	• Uses new set of Terra and Aqua channel-degradation-corrected Edition3 DES9s from 3.1P1.
FM1+FM3_Edition2 [3] FM1+FM4_Edition2 [3]	024025	Jun 2004	• (FM3) Corrected SW part of Total Channel spectral response • (FM4) Corrected SW part of Total Channel spectral response
FM1+FM3_Edition2 [3] FM1+FM4_Edition2 [3]	024024	Feb 2004	• (FM3) Corrected SW part of Total Channel spectral response • (FM4) Corrected SW part of Total Channel spectral response
FM1+FM2+FM3+FM4_Edition1 [3]	023023	Sep 2003	• No science impact.
FM1+FM2+FM3+FM4_Edition1 [3]	023022	Aug 2003	• No science impact.
Availability: (1) Validation version only available to CERES analysts; (2) restricted to CERES Science Team; (3) public			

Modification History for: NPP | Aqua | Terra | TRMM | Terra+Aqua | TRMM+Terra

## Modification History of the CERES ES-4 TRMM+Terra Archival Product

Sampling Strategy and Production Strategy	CCode	Available at ASDC	Impact on the ES-4 Product
PFM+FM1_Edition2 [3] PFM+FM2_Edition2 [3] PFM+FM1+FM2_Edition2 [3]	021020	Sep 2002	• Instrument calibration updates for both FM1 and FM2 instruments. • Snow map algorithm correction. • Recovery of missing Edition1 data.
PFM+FM1_Edition1 [3] PFM+FM2_Edition1 [3] PFM+FM1+FM2_Edition1 [3]	019018	Nov 2001	• No science impact.

Modification History of the CERES ES-4 TRMM+Terra Archival Product

Sampling Strategy and Production Strategy	CCode	Available at ASDC	Impact on the ES-4 Product
PFM+FM1_Edition1 [3] PFM+FM2_Edition1 [3] PFM+FM1+FM2_Edition1 [3]	017015	Nov 2000	• New slope/intercept spectral correction coefficients for PFM. Slope/intercept Spectral Correction code updated to apply 2nd order polynomial fits for the window channel and for shortwave cloudy cases, and to perform interpolation of unfiltered radiances. • Provided new day and night spectral correction coefficients for FM1 and FM2.
Availability: (1) Validation version only available to CERES analysts; (2) restricted to CERES Science Team; (3) public			

Examples of Data:

Six quality control images (gif files) are generated and made available on the Web for each ES-4. These images are for albedo, shortwave, and longwave (clear-sky and total-sky for each). Examples for each of these from the January 1998 TRMM data set follow.

	Albedo	Shortwave	Longwave
All-Sky			
Clear-Sky			
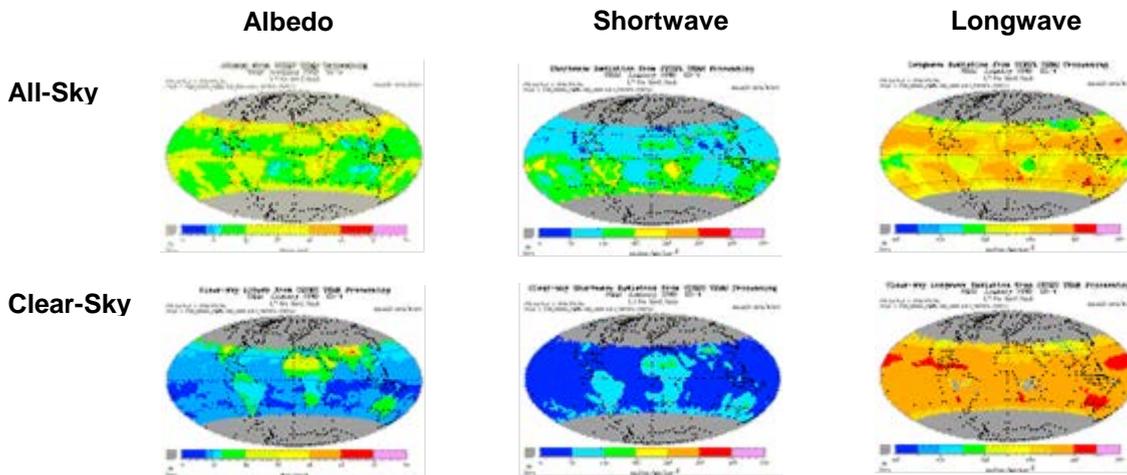
Additional images and ancillary data sets (such as Directional Models) are available from the CERES ERBE-like Data Validation - Public Page.

References:

1. Clouds and the Earth's Radiant Energy System (CERES) Data Management System Software Requirements Document, ERBE-like Inversion to Instantaneous TOA Fluxes (Subsystem 2.0), Release 1 Version 1, November 1994.

2. Clouds and the Earth's Radiant Energy System (CERES) Data Management System Software Requirements Document, ERBE-like Averaging to Monthly TOA Fluxes (Subsystem 3.0), Release 1 Version 1, January 1995.

3. Smith, G.L.; Green, R. N.; Raschke, E.; Avis, L. M.; Suttles, J. T.; Wielicki, B. A., and Davies, R.: Inversion Methods for Satellite Studies of the Earth's Radiation Budget: Development of Algorithms for the ERBE Mission. Reviews of Geophysics, Vol. 24, No. 2, pp. 407-421, May 1986.

4. Clouds and the Earth's Radiant Energy System (CERES) Algorithm Theoretical Basis Document, ERBE-like Inversion to Instantaneous TOA Fluxes (Subsystem 2.0), Rel. 2.2, June 2, 1997.

5. ERBE Data Management System Reference Manual, Volume V(a) and V(b) (PDF), Inversion, August 1987.

6. Clouds and the Earth's Radiant Energy System (CERES) Algorithm Theoretical Basis Document, ERBE-like Averaging to Monthly TOA Fluxes (Subsystem 3.0), Rel. 2.2, June 2, 1997.

7. ERBE Data Management System Reference Manual, Volume VI (PDF), Daily Data Base, Monthly Time/Space Averaging, November 1986.

8. Clouds and the Earth's Radiant Energy System (CERES) Data Management System Data Products Catalog.

9. TRW DRL 64, 55067.300.008E; In-flight Measurement Analysis (Rev. E), March 1997.

10. Clouds and the Earth's Radiant Energy System (CERES) Algorithm Theoretical Basis Document, Instrument Geolocate and Calibrate Earth Radiances (Subsystem 1.0), Release 2.2, June 1997.

11. Brooks, D. R.; Harrison, E. F.; Minnis, P.; Suttles, J. T., and Kandel, R. S.: Development of Algorithms for Understanding the Temporal and Spatial Variability of the Earth's Radiation Balance. Reviews of Geophysics, Vol. 24, pp. 422-438, May 1986.

12. ERBE Data Management System, The Regional, Zonal, and Global Averages, S-4, User's Guides, June 1993.

13. Brooks, D. R. and P. Minnis, "Comparison of Longwave Diurnal Models Applied to Simulations of the Earth Radiation Budget Experiment," Journal of Climate and Applied Meteorology, 23, 155-160, 1984.

14. Clouds and the Earth's Radiant Energy System (CERES) Validation Plan, ERBE-like Averaging to Monthly TOA Fluxes (Subsystem 3.0), Release 3.0, February 1999.

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Acknowledgement:

The requested form of acknowledgment for any publication in which these data are used is:

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

The Langley Data Center requests a reprint 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 the Data Center determine the use of data distributed, which is helpful in optimizing product development. It also helps us to keep our product related references current.

Reference:

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

Wielicki, B. A., B. R. Barkstrom, E. F. Harrison, R. B. Lee III, G. L. Smith, and J. E. Cooper, "Clouds and the Earth's Radiant Energy System (CERES): An Earth Observing System Experiment," *Bull. Amer. Meteor. Soc.*, **77**, 853-868, 1996.

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