CERES ES8 NPP Edition1 Data Quality Summary

Investigation:	**CERES**
Data Product:	**ERBE-like Instantaneous TOA Estimates (ES8)**
Data Set:	**NPP (Instruments: FM5)**
Data Set Version:	**Edition1**

The purpose of this document is to inform users of the accuracy of this data product which has been determined by the CERES Team. This document briefly summarizes key validation results, provides cautions where users might easily misinterpret the data, provides helpful links to further information about the data product, algorithms, and accuracy, gives information about planned data improvements, and, finally, automates registration in order to keep users informed of new validation results, cautions, or improved data sets as they become available.

This document is a high-level summary and represents the minimum information for scientific users of this data product. It is strongly suggested that authors, researchers, and reviewers of research papers re-check this document for the latest status before publication of any scientific papers using this data product.

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1.0 Nature of the ES8 Product

This document discusses the NPP ERBE-like Science Product [ES8] data set version Edition1. Additional information is in the Description/Abstract Guide. The files in this data product contain one day (24 hours) of filtered and unfiltered radiances, top-of-the- atmosphere (TOA) fluxes, and scene identification. Each radiance and its associated viewing angles are located in colatitude and longitude at a reference level of 30 km. The unfiltering algorithm produces radiances for three spectral bands for each measurement point or footprint: the longwave (LW) band measures energy emitted by the Earth's surface and atmosphere predominantly from wavelengths >5 microns, the shortwave (SW) band measures reflected sunlight primarily from wavelengths <5 microns, and the window (WN) band measures energy emitted mostly from the Earth's surface over the wavelength range from about 8 microns to about 12 microns. Radiances are converted to fluxes at the TOA for the SW and LW bands. For the WN band, only filtered and unfiltered radiances are recorded on this product.

The data are organized in time of observation. The principal scan mode is the Fixed Azimuth Plane (FAP) mode.

A full list of parameters on the ES8 is contained in the CERES Data Product Catalog (PDF) and a full definition of each parameter is contained in the ES8 Collection Guide.

When referring to a CERES data set, please include the satellite name and/or the CERES instrument name, the data set version, and the data product. Multiple files which are identical in all aspects of the filename except for the 6 digit configuration code (see Collection Guide) differ little, if any, scientifically. Users may, therefore, analyze data from the same satellite/instrument, data set version, and data product without regard to configuration code. The current data set may be referred to as "CERES NPP FM5 Edition1 ES8."

2.0 Processing Updates in Current Edition

The CERES NPP Edition1 data product is based on analysis of CERES NPP FM5 instrument calibration information collected up to this point. The primary goal of this edition is to provide the most accurate and consistent data product to the users by removing all known instrument related artifacts from the CERES instrument on the NPP spacecraft. This is in contrast to the CERES NPP Edition1-CV product, which is produced using only static calibration coefficient with no temporal correction. The corrections implemented in the CERES NPP Edition1 BDS and ERBE-Like ES8 products consist of:

- Corrections for on-orbit derived changes in radiometric gains calibration coefficients based on the on-board calibration sources as described in the CERES BDS NPP Edition1 Data Quality Summary.

3.0 Data Accuracy Table

The ES8 products contain estimates of instantaneous filtered radiance, unfiltered radiance, TOA flux, and scene type. The nature of an estimate is that it is uncertain with a bias error and a random error about the bias which can be measured by its standard deviation. Thus, an understanding of the uncertainty in an instantaneous estimate must consider both biases and standard deviations. Often the uncertainty is given in terms of the RMS error which includes both the bias and standard deviation.

Uncertainties in the filtered radiances are given in Table 3-1. The total (TOT) channel errors are given separately for night and day since daytime TOT contains both shortwave and longwave radiance while nighttime contains only longwave. The filtered radiances are determined from the instrument counts by multiplying by a gain. If this gain is in error, then the filtered radiances appear to be biased. The measurements are also subject to random measurement noise. All of these errors are combined and given as RMS errors.

Table 3-1. Uncertainty of Filtered Radiances

		Systematic Bias Error (Accuracy)			Mean Zero Random Error Standard Deviation (Precision)		Instantaneous RMS error
Instrument Channel	Typical Value[a] $Wm^{-2}sr^{-1}$	Instrument Requirements[b] 1 std dev	Ground Cal. Gain error[c] 3 std dev	Instrument Drift over 6 months	Instrument Requirements[b] 3 std dev	Instrument Noise[d] 1 std dev	
SW	43	1.0%	1.0%	0%	1%	0.3%	0.45%
TOT-day	119	0.5%	0.5%	0%	1%	0.1%	0.19%
TOT-night	64	0.5%	0.1%	0%	0.5%	0.1%	0.11%
WN	4.4[e]	0.3 $Wm^{-2}sr^{-1}$	1.0%[f]	0%	-	0.5%	1.0%

a. Median nadir values for six months Feb-July 2012
b. Lee et al., *J. Atmos. Oceanic Technol*, **13**, 1996
c. Estimated from validation studies
d. Determined from space view
e. $Wm^{-2}sr^{-1}\mu m^{-1}$
f. See the CERES BDS NPP Edition1 Data Quality Summary

Uncertainties in the unfiltered radiances are given in Table 3-2. The unfiltered radiances are linearly related to the filtered radiances by coefficients which are denoted "Spectral Correction Coefficients" (SCC). These are mean coefficients and introduce random error. The nighttime unfiltered LW radiance is determined from the TOT filtered channel radiance at night. The daytime longwave, however, is derived from the TOT, SW and WN filtered radiances.

Table 3-2. Uncertainty of Unfiltered Radiances

Spectral Band	Typical Value[a] $Wm^{-2}sr^{-1}$	Spectral Correction Bias Error	Spectral Correction Random Error 1 std dev	Instantaneous RMS error
SW	56	0	0.4%	0.6%
LW-day	79	0	0.1%	0.2%
LW-night	75	0	0.1%	0.15%
WN	5.5[b]	0	0.6%	1%

a. Median nadir values for six months Feb-July 2012
b. $Wm^{-2}sr^{-1}\mu m^{-1}$

Uncertainties in the TOA fluxes are given in Table 3-3. The fluxes are derived by multiplying radiance by π and dividing by an anisotropic factor from the Angular Distribution Models (ADM). These ADMs are mean models and introduce random error which is the dominant error for flux.

Table 3-3. Uncertainty of TOA Flux

Spectral Band	Typical Value[a] Wm^{-2}	ADM Bias Error[b]	ADM Random Error[c] std dev	Instantaneous RMS error
SW	209	1.0%	12%	12.1%
LW-day	238	0.5%	5%	5.0%
LW-night	226	0.5%	5%	5.0%

a. Median nadir values for six months Feb-July 2012
b. Suttles, et al., *J. Appl. Meteor.*, **31**, 1992
c. Wielicki, et al, *Bull. Amer. Meteorol. Soc.*, **76**, 1995

4.0 Differences between CERES and the ERBE Scanner

1. The resolution of CERES-NPP is 24 km at nadir, and the resolution of ERBE-ERBS is 40 km at nadir so that the surface area observed from ERBS is 2.78 times larger than the area observed from CERES-NPP.
2. The longwave channel on ERBE was replaced by an 8 to 12 micron window channel on CERES.
3. The data rate on ERBE was 30 measurements per second. The data rate on CERES is 100 measurements per second.
4. The ERBE S8 data product was about 36 MB in size. The CERES ES8 data product is about 290 MB.
5. ERBS has an orbital inclination of 57°. NPP is in a 1:30 p.m. sun-synchronous orbit.
6. ES8 Edition1 uses a different unfiltering algorithm (Loeb et al., 2000) than ERBE (Green and Avis, 1996).

5.0 Caution When Using Data

There are several cautions the CERES Team notes regarding the use of the CERES NPP Edition1 ES8 data:

- CERES-NPP is observing more clear sky than ERBE due in part to the difference in footprint size. The resolution of CERES-NPP is 24 km at nadir and the resolution of ERBE-ERBS is 40 km at nadir so that the surface area observed by ERBS is 2.78 times larger than the area observed by CERES-NPP.
- The ERBE scene identification algorithm (Maximum Likelihood Estimator, MLE) in conjunction with the ERBE angular distribution models (ADMs) are known to erroneously produce albedo growth from nadir to the limb. The ERBE ADMs are probably insufficiently limb-darkened in longwave and insufficiently limb-brightened in shortwave. The CERES-NPP fluxes also have these biases with viewing zenith angle.
- Data users are strongly urged to examine the flags for each footprint in order to determine if the data for that footprint are good or bad. "Scanner Operation Flag Word" (see ES8 Collection Guide)

6.0 Validation Study Results

The validity of the filtered radiances, unfiltered radiances, TOA fluxes, and identified scene types has been examined with various validation studies and quality checks. These validations also show that the gains need to be adjusted from the static Edition1-CV value. The gains are adjusted on a monthly basis (see CERES BDS NPP Edition1 Data Quality Summary).

6.1 Unfiltered Radiances

The unfiltered radiances are linear functions of the filtered radiances where the coefficients are the Spectral Correction Coefficients (SCC). The SCCs are based on the spectral response of the instrument channel, S^i_λ, where λ is wavelength and i = SW, TOT, WN for shortwave, total, and window channel, respectively. The S^i_λ has been measured as part of the instrument calibration and characterization. The SCCs are based on a database of spectral radiances from typical surfaces, such as ocean, land, desert, snow, and cloud. The methodology used in producing NPP Edition1 unfiltered radiances is the same as that used in the CERES TRMM Edition2 ES8 product and is outlined in Loeb et al. (2000). This method differs from that used on ERBE. To unfilter SW radiances, the ERBE unfiltering algorithm used a theoretical ratio between unfiltered and filtered radiances defined at various angles in overcast and cloud-free conditions over ocean, land, desert and snow. Interpolation between these theoretical ratios was used to determine coefficients under partly and mostly cloudy conditions. The ERBE approach has been shown to produce large errors when applied to CERES due to the differences between the CERES and ERBE spectral response functions (see Loeb et al., 2000).

6.2 Theory

To estimate uncertainties in instantaneous unfiltered radiances for each channel, the unfiltering algorithm was used to estimate radiances from approximately 10,000 theoretical test cases representative of clear and cloudy conditions over ocean, land and snow. The test calculations were determined from MODTRAN + DISORT radiative transfer calculations at high spectral resolution and represent a wide range of cases.

Errors in instantaneous SW unfiltered radiances from FM5 are found to be <0.5% (relative). By comparison, uncertainties in PFM instantaneous unfiltered SW radiances were generally <1%. The reduction in error was particularly marked for clear oceanic scenes because the FM5 spectral response functions are flatter than PFM at wavelengths between 0.3-0.4 microns.

In contrast, the theoretical results revealed slightly larger uncertainties in unfiltered LW radiances from FM5 compared to PFM. For most scenes, FM5 uncertainties remain less than 0.4% (relative) compared to 0.2% for PFM. However, for extremely cold clouds (e.g. deep convective clouds), uncertainties in FM5 unfiltered radiances can reach 1% for both daytime and nighttime conditions.

In the WN channel, all three instruments showed very small uncertainties in unfiltered radiances (<0.2%) for all scenes.

7.0 References

Green, R. N., and L. M. Avis, 1996: Validation of ERBS Scanner Radiances. *J. Atmos. and Ocean. Tech*., **13**, 851–862.

Lee, R. B., B. R. Barkstrom, G. L. Smith, J. E. Cooper, L. P. Kopia, R. W. Lawrence, S. Thomas, D. K. Pandey, and D. A. Crommelynck, 1996: The Clouds and the Earth's Radiant Energy System (CERES) Sensors and Preflight Calibration Plans. *J. Atmos. Oceanic Technol.*, **13**, 300–313.

Loeb, N. G., K. J. Priestley, D. P. Kratz, E. B. Geier, R. N. Green, B. A. Wielicki, P. O. Hinton, and S. K. Nolan, 2001: Determination of Unfiltered Radiances from the Clouds and the Earth's Radiant Energy System Instrument. *J. Appl. Meteor.* **40**, 822–835.

Suttles, J. T., B. A. Wielicki, and S. Vemury, 1992: Top-of-Atmosphere Radiative Fluxes: Validation of ERBE Scanner Inversion Algorithm Using Nimbus-7 ERB Data. *J. Appl. Meteor.*, **31**, 784–796.

Wielicki, B. A., E. F. Harrison, R. D. Cess, M. D. King, and D. A. Randall, 1995: Mission to Planet Earth: Role of Clouds and Radiation in Climate. *Bull. Amer. Meteor. Soc.*, **76**, 2125–2153.

8.0 Expected Reprocessing

At this time, there are no scheduled revisions of the NPP Edition1 ES8 data. The CERES Team will continue detailed examination and documentation of the ground calibration and characterization data, as well as the in-flight calibration opportunities. The current Edition1 dataset will be reprocessed into a validated/archived/publishable Edition2 data some times in the future. Notification of any changes will be sent to registered users.

9.0 Referencing Data in Journal Articles

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 data:**

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

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 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 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.

10.0 Feedback

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

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