CERES CCCM Data Quality Summary

RelD1
Updated 9/30/2021

Investigation: **CERES**

Data Product: **CALIPSO Cloudsat**
CERES and MODIS (CCCM)

Data Set: **Aqua (Instruments: CALIPSO, CALIOP;**
CloudSat, CPR;
CERES, FM-3;
MODIS

Data Set Version: **RelD1 (907908)** **Release Date: September 29, 2021**

Subsetting Tool Availability: https://ceres.larc.nasa.gov/data/

The purpose of this document is to inform users of the accuracy of this data product as determined by the CERES Science Team. The document summarizes key validation results, provides cautions where users might easily misinterpret the data, provides links to further information about the data product, algorithms, and accuracy, and gives information about planned data improvements. This document also 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 needed by 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.

NOTE: To navigate the document, use Bookmarks in Adobe Reader.
Select "View > Show/Hide > Navigation Panes > Bookmarks."

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1.0 Nature of the CCCM Product

The CALIPSO-CloudSat-CERES-MODIS (CCCM) data set integrates measurements from the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP), CloudSat Cloud Profiling Radar (CPR), Clouds and the Earth's Radiant Energy System (CERES), and the Moderate Resolution Imaging Spectroradiometer (MODIS) data. The cloud and aerosol properties from CALIOP and cloud properties from the CPR are matched to a MODIS pixel and then an Aqua CERES footprint. The product contains only the CERES footprint in each scan that has the highest CALIPSO and CloudSat ground track coverage. The product consists of all cloud and aerosol properties derived from MODIS radiances included in the Single Scanner Footprint (SSF) product and computed irradiances included in the Cloud Radiative Swath (CRS) product. Two sets of SSF variables are including the CCCM data. One set covers the entire CERES footprint and the other set is only over CALIOP and CPR ground track. CERES derived top-of-atmosphere (TOA) shortwave, longwave and window irradiances by angular distribution models are also included. In addition, irradiance profiles computed by a radiative transfer model using MODIS, CALIOP, and CPR derived aerosol, clouds, and surface properties are included in the product. Furthermore, MODIS-derived cloud properties from the algorithm that incorporates CALIOP and CPR cloud information are also included. MODIS-derived cloud properties and TOA irradiances derived from CERES radiances are produced by the same algorithm that produces CERES SSF and CRS products. However, the CCCM product should not be considered as a climate data record since various input data product versions and algorithm modifications will occur along the course of the measurement period. The scan and packet numbers unique to the CERES footprint provide the means to match the data to other CERES products, although the CCCM product contains more near nadir CERES footprints compared with SSF and CRS products. The resulting HDF granule contains 24 hours of data.

2.0 Difference of the current version (RelD1 907908) from the previous version (RelB1 905906)

This version uses R05 CloudSat and version 4 CALIPSO data products, and MODIS derived cloud properties by an improved Ed4 CERES cloud algorithm and top-of-atmosphere (TOA) irradiances derived from Edition 4 CERES Angular Distribution Model (ADM). In addition, problems in the previous version (B1) have been corrected. The corrections include:

1) Liquid water content (LWC) and ice water content (IWC) derived from CloudSat below 3 km are corrected. LWC and LWC in the B1 version were 50% of the correct values.

2) Nighttime extinction coefficients profiles are included in CCCM-84.

Other improvements include:

1) Water clouds detected by horizontally averaging CALOP signal below 4 km are not included (i.e. only water clouds detected by CALIPO single shot are included, Figure 2-1. See also Ham et al. 2017).

2) Surface albedo consistent with CERES data products are used.

3) Time dependent solar constant based on Solar Radiation and Climate Experiment (SORCE) observations is used. 4) Significant improvements are made in merging CALIPSO/CloudSat and MODIS cloud properties. Details are described in Ham et al. (in preparation). As a result, agreements of TOA computed irradiance with CERES-derived irradiances are improved (Figure 2-2) over the RelB1 version (Figure 2-3).

5) The CloudSat 2C-ICE data product is added to the fine and used in irradiance computations.

6) The CALIPSO phase and GEOS-5.4.1 reanalysis temperature profiles are used to determine cloud phases.

7) The better agreement between observed and computed TOA irradiances in RelD1 over RelB1 is also contributed from changes in CERES-observed TOA irradiances (Figure 2-4). The new cloud algorithm in RelD1 gives better determination of angular distribution models (ADMs), which are used for converting radiances to irradiances.

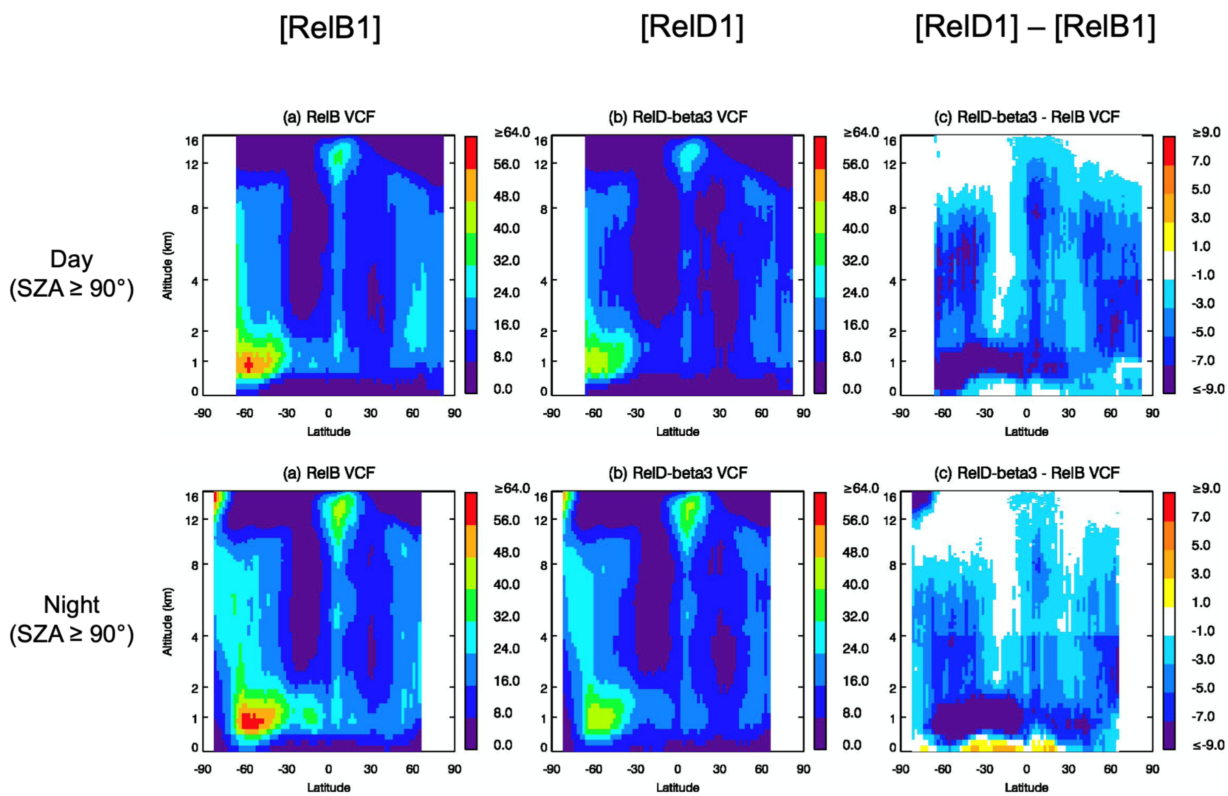

Figure 2-1. Volume cloud fraction obtained from RelB1 and RelD1 versions of CCCM product for July 2008. To the compute cloud fraction profile, cloud top (CCCM-13) and base heights (CCCM-15) of up to 16 cloud groups are used for each CERES footprint. The cloud fraction profiles are computed from 0 km to 20 km with a 0.16-km interval. The cloud base/top heights (CCCM-13 and CCCM-15) are obtained by combining CALIPSO and CloudSat cloud detections, as described in Kato et al. (2010).

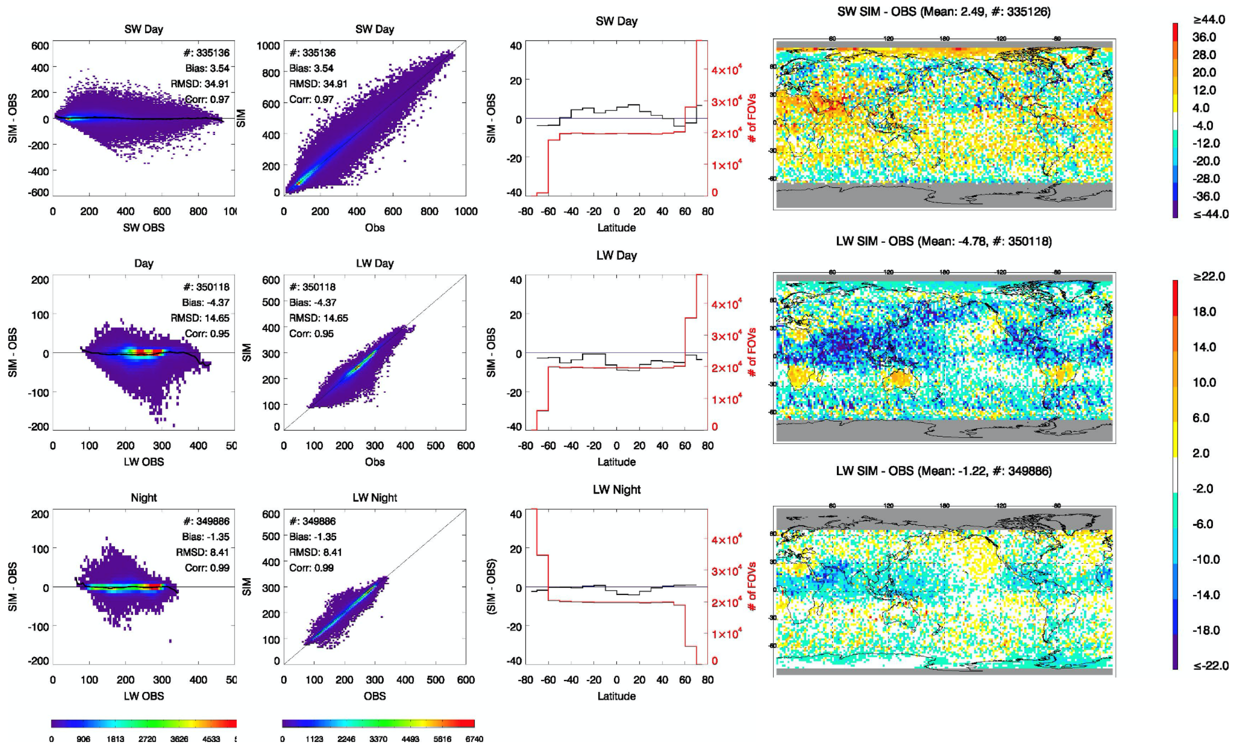

Figure 2-2. Comparison of computed top-of-atmosphere (Top) shortwave, (middle) daytime longwave, and (bottom) nighttime longwave irradiance with CERES-derived irradiance for July 2008 in RelD1 CCCM product. In this comparison, only CERES footprints with valid CALIPSO or CloudSat observations are used.

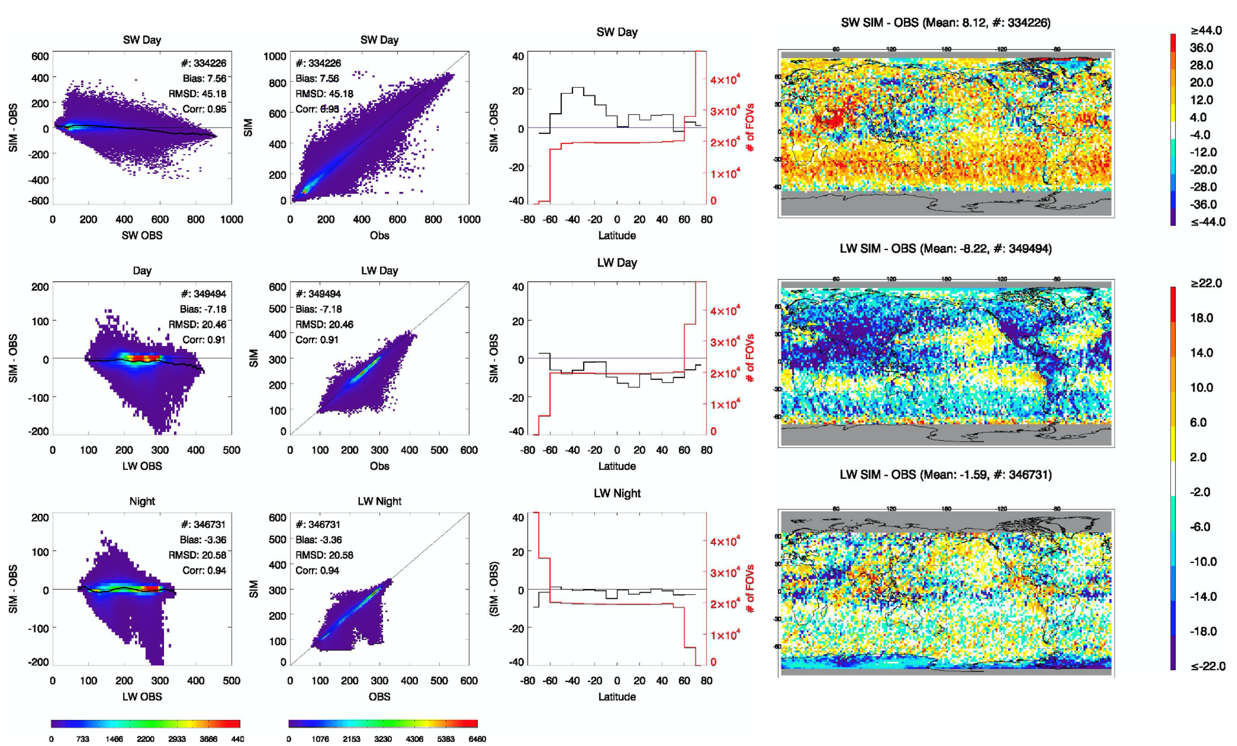

Figure 2-3. Same as Figure 2-2 but from RelB1 CCCM product.

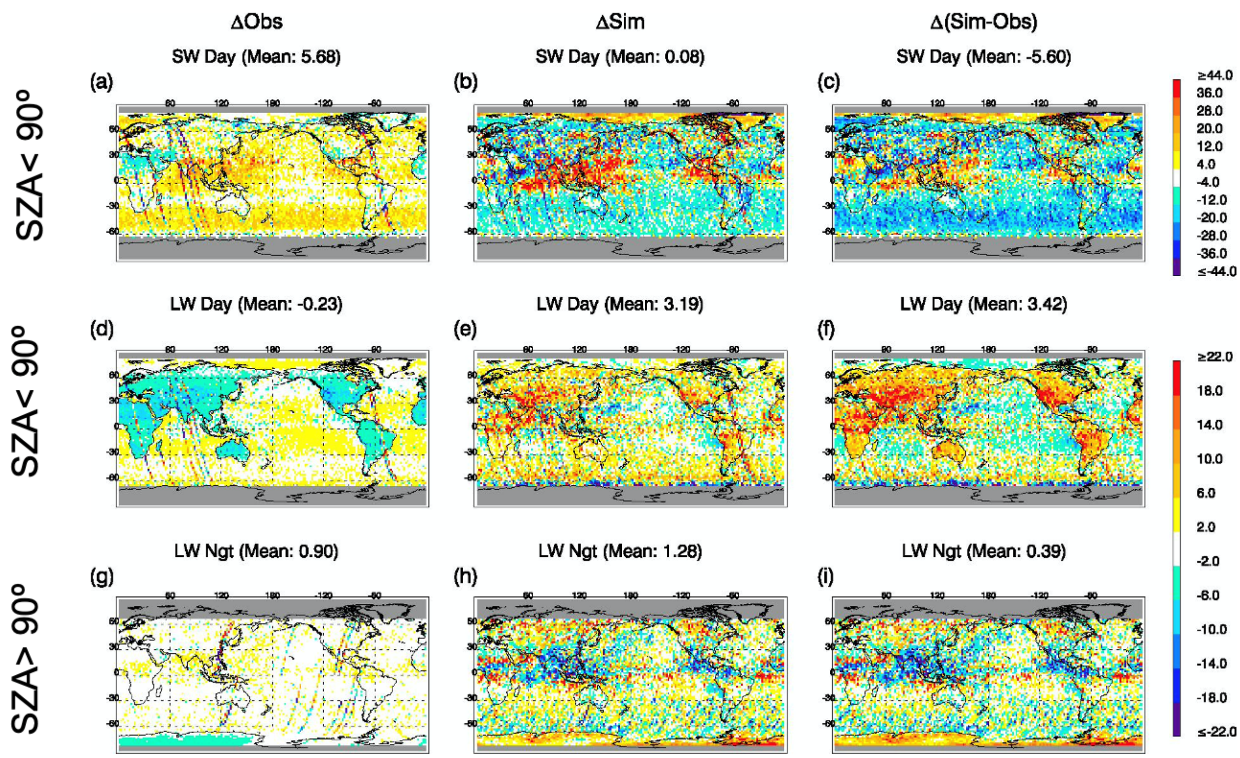

Figure 2-4. Changes of TOA irradiances from RelB1 to RelD1 versions for July 2008. The changes are made for (right) CERES-derived irradiances, (middle) computed irradiances, and (right) simulation biases.

3.0 Data Used for Producing CCCM Data (Version D1)

Data used for producing currently available CCCM version D1 data are:

- CALIPSO
    1. CALIPSO_VFM: CAL_LID_L2_VFM-Standard-V4-20.YYYY-MM-DDTHH-*hdf
    2. CALIPSO_05kmALay: CAL_LID_L2_05kmALay-Standard-V4-20.YYYY-MM-DDTHH-*hdf
    3. CALIPSO_05kmCLay: CAL_LID_L2_05kmCLay-Standard-V4-20.YYYY-MM-DDTHH-*hdf
    4. CALIPSO_05kmCPro: CAL_LID_L2_05kmCPro-Standard-V4-20.YYYY-MM-DDTHH-*hdf
- CloudSat
    1. CLOUDSAT_CLDCLASS:YYYYJDY*_CS_2B-CLDCLASS_GRANULE_P1_R05_E06_F01.hdf
    2. CLOUDSAT_CWC-RO:YYYJDY*_CS_2B-CWC-RO_GRANULE_P1_R05_E06_F01.hdf
    3. CLOUDSAT_2C-ICE: YYYJDY*_CS_2C-ICE_GRANULE_P1_R05_E06_F01.hdf
- MODIS (retrievals are done by the CERES cloud algorithm)
    1. MAC: MAC021S1.AYYYYJDY.HHMM.002.*hdf
    2. MAC_GEO: MAC03S1.AYYYYJDY.HHMM.002.*.hdf
    3. MAC_AEROSOL: MAC04S1.AYYYYJDY.HHMM.002.*.hdf
- CERES
    1. Aqua FM3 Edition4 (Cal/Val)

4.0 Cautions, Helpful Hints, and Known Problems:

- Users also need to read CALIPSO, CloudSat, CERES, and MODIS quality summary or similar documents before they analyze variables from those instruments.
  - **CALIPSO:** Data Quality Statements and user's guide (http://www-calipso.larc.nasa.gov/resources/calipso_users_guide/)
  - **CloudSat:** CloudSat Standard Data Products
  - **CERES and MODIS:** CERES SSF Aqua Edition2C Data Quality Summary
- CALIPSO, CloudSat and MODIS data are separated and stored by CERES footprints. For each CERES scan line, a CERES footprint that contains largest CALIPSO and CloudSat ground track was kept in CCCM.
- In order to use more reliable computed irradiances with valid CloudSat and CALIPSO measurements, CCCM-8 and CCCM-11 need to be checked whether these are at least greater than 90 and 28, respectively.
- Besides cautions related to variables mentioned in CALIPSO and CloudSat documents, other cautions in using variables in this product.

  - **Cloud property retrieval from MODIS radiances by the CERES cloud code (Edition 5 beta)**
    - When optically thick clouds (cloud top temperature less than 233 K) occur in a footprint, daytime cloud phase of all clouds within the footprint is sometimes all ice even when low-level clouds are present within the footprint.
    - Thick dust aerosols are often identified as clouds.
    - The algorithm uses a two-habit model (Liu et al. 2014) to retrieve ice cloud properties which is an improvement from the CERES Edition 4 cloud code that uses a single rough model.
    - Daytime cloud optical thickness over snow/ice regions is derived from combination of 1.6 μm and 1.24 μm channels while the CERES Edition 4 cloud code uses only 1.24 μm channel.
  - **CALIPSO CloudSat derived cloud fraction**
    - The sum of cloud group cloud fractions (cloud group area percentage coverage CCCM-12) or 100 minus cloud-free area percent coverage (CCCM-21) are the cloud fraction over a CERES footprint. When computing a cloud fraction averaged over an area and a time period, it is recommended to check the total number of good CloudSat profile (CCCM-8) and total number of good CALIPSO profile (CCCM-11). Because of a large sensitivity difference between CALIOP and CPR, when one of instruments is down, the cloud fraction is different from the value derived from both instruments.

- A smaller ice particle size (50% value of the correct value) was used in the irradiance computation. The impact is less than 1 Wm^{-2} in a monthly mean for most of regions (See Figure 4-1).

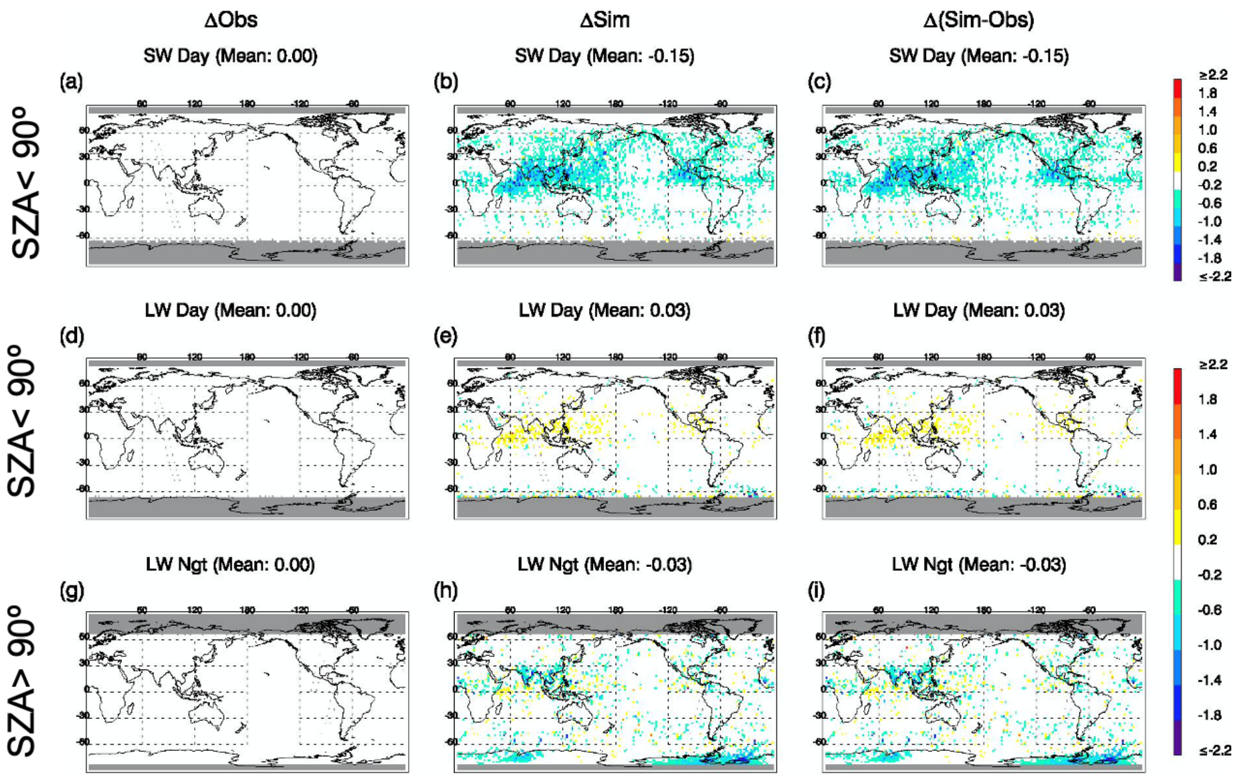

Figure 4-1. Estimated error in top-of-atmosphere (top) shortwave, (middle) daytime longwave, and (bottom) nighttime longwave irradiances due to the use of smaller ice particle size (50% value of the correct value). Because the asymmetry parameter is not very sensitive to particle size for a two-habit ice crystal model (Fig. 4 of Loeb et al., 2018), the impact is smaller than a hexagonal ice crystal model would have given.

5.0 Version history

March 2013: B1 version was released.

October 2021: D1 version was released.

6.0 References

Ham, S.-H., S. Kato, F. G. Rose, D. Winker, T. L'Ecuyer, G. G. Mace, D. Painemal, S. Sun-Mack, Y. Chen, and W. F. Miller (2017), Cloud occurrences and cloud radiative effects (CREs) from CERES-CALIPSO-CloudSat-MODIS (CCCM) and CloudSat radar-lidar (RL) products, J. Geophys. Res. Atmos., 122, doi:10.1002/2017JD026725.

Kato, S., S. Sun-Mack,W. F.Miller, F. G. Rose,Y.Chen, P. Minnis, and B. A. Wielicki, 2010: Relationships among cloud occurrence frequency, overlap, and effective thickness derived from CALIPSO and CloudSat merged cloud vertical profiles. J. Geophys. Res., 115, D00H28, https://doi.org/10.1029/2009JD012277.

Liu, C., P. Yang, P. Minnis, N. Loeb, S. Kato, A. Heymsfield, and C. Schmitt, 2014b: A two-habit model for the microphysical and optical properties of ice clouds. Atmos. Chem. Phys., 14, 13 719–13 737, https://doi.org/10.5194/acp-14-13719-2014.

Loeb, N. G., P. Yang, F. G. Rose, G. Hong, S. Sun-Mack, P. Minnis, S. Kato, S. Ham, W. L. Smith, S. Hioki, G. Tang, 2018: Impact of Ice Cloud Microphysics on Satellite Cloud Retrievals and Broadband Flux Radiative Transfer Model Calculations. J. Climate, 31(5), 1851–1864. doi: 10.1175/JCLI-D-17-0426.1.

7.0 Feedback and Questions

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

Document Creation Date: August 31, 2021

8.0 Document Revision Record

The Document Revision Record contains information pertaining to approved document changes. The table lists the Version Number, the date of the last revision, a short description of the revision, and the revised sections.

Document Revision Record

Version Number	Date	Description of Revision	Section(s) Affected
RelD1	09/29/2021	• Reformatted document.	All