

Technical Note on CERES EBAF Ed2.8 TOA Incident Shortwave Radiation (rsdt)

1. Intent of This Document and POC

1a) This document is intended for users who wish to compare CMIP5/IPCC historical climate model output with satellite-derived observations. Users are not expected to be experts in satellite-derived Earth system observational data. This document summarizes essential information needed for comparing this dataset to climate model output. References are provided at the end of this document to additional information.

This NASA dataset is provided as part of an experimental activity to increase the usability of NASA satellite observational data for the modeling and model analysis communities. This is not a standard NASA satellite instrument product, but does represent an effort on behalf of data experts to identify a product that is appropriate for routine model evaluation. The data may have been reprocessed, reformatted, or created solely for comparisons with climate model output. Community feedback to improve and validate the dataset for modeling usage is appreciated. Email comments to HQ-CLIMATE-OBS@mail.nasa.gov.

Dataset File Name (as it appears on the ESGF):

rsdt_CERES-EBAF_L3B_Ed2-8_200003-201310.nc

1b) Technical point of contact for this dataset:

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2. Data Field Description

CF variable name, units:	TOA Incident Shortwave Radiation (rsdt), $W\ m^{-2}$
Spatial resolution:	1°x1° latitude by longitude
Temporal resolution and extent:	Monthly averaged from 03/2000 to 10/2013
Coverage:	Global

3. Data Origin

The CERES science team provides monthly regional mean TOA incident shortwave radiation derived from daily Total Solar Irradiance (TSI) data using various sources (Table 1). For March 1- June 30, 2013, a TSI composite from the Laboratory for Atmospheric and Space Physics (LASP) is used (Kopp and Lean, 2011). The first part of this composite (March 1-February 24, 2003) is based upon data from the World Radiation Center (WRC), Davos. Between February 25-June 30, 2013, TSI is from the Total Irradiance Monitor (TIM) instrument aboard the Solar Radiation and Climate Experiment (SORCE) satellite, launched on January 25, 2003, in a 645 km, 40° orbit. The TIM instrument measures the absolute intensity of solar radiation, integrated over the entire solar disk and the entire solar spectrum. For July 1, 2013-present, TSI is based upon the RMIB TSI composite (Mekaoui and Dewitte 2008), which uses DIARAD/VIRGO data (Dewitte et al. 2004).

Adjustments are made to the different TSI datasets in order to ensure a seamless record across transitions from one dataset to another (for specific details, please see Table 1). The daily total

solar irradiance (TSI) values used to compute monthly TSI are available at the following web site:

http://ceres.larc.nasa.gov/science_information.php?page=TSIdata

On rare occasions when the daily flux is missing, it is linearly interpolated from the nearest daily measurements.

A plot of the combined daily TSI is shown in Figure 1. The corresponding EBAF Ed2.8 global monthly mean solar incoming flux is shown in Figure 2 with deseasonalized values in Figure 3.

Table 1. TSI data sets used in CERES EBAF Ed2.8

Period	TSI Source
March 1, 2000 – February 24, 2003	From Dr. Greg Kopp of LASP, University of Colorado, Boulder, who had extracted it from a composite dataset from the World Radiation Center (WRC), Davos. The file used, "composite_d41_62_0906.dat" was downloaded from the ftp site: ftp://ftp.pmodwrc.ch/pub/data/irradiance/composite . Dr. Kopp had offset WRC-Composite time series to match with the SORCE version available at the time (V-09). We offset the WRC-Composite time series further to match with SORCE V-15 data following the procedure suggested by Dr. Kopp. According to this procedure, the offset between the SORCE time series and another one is determined by comparing the two time series for the period 25Feb2003 to 31Dec2003.
February 25, 2003 – June 30, 2013	SORCE TIM V-15 (Kopp and Lean 2011)
July 1, 2013 -- present	A composite data set available from the Royal Meteorological Institute of Belgium (RMIB) (Mekaoui and Dewitte 2008). It is based on the DIARAD/VIRGO data set (Dewitte et al. 2004) and absolutely calibrated according to Dewitte et al. 2013. This data set was radiometrically scaled to SORCE TIM V-15 using an offset, which was determined over a 5-year period (01Mar2003 - 29Feb2008).

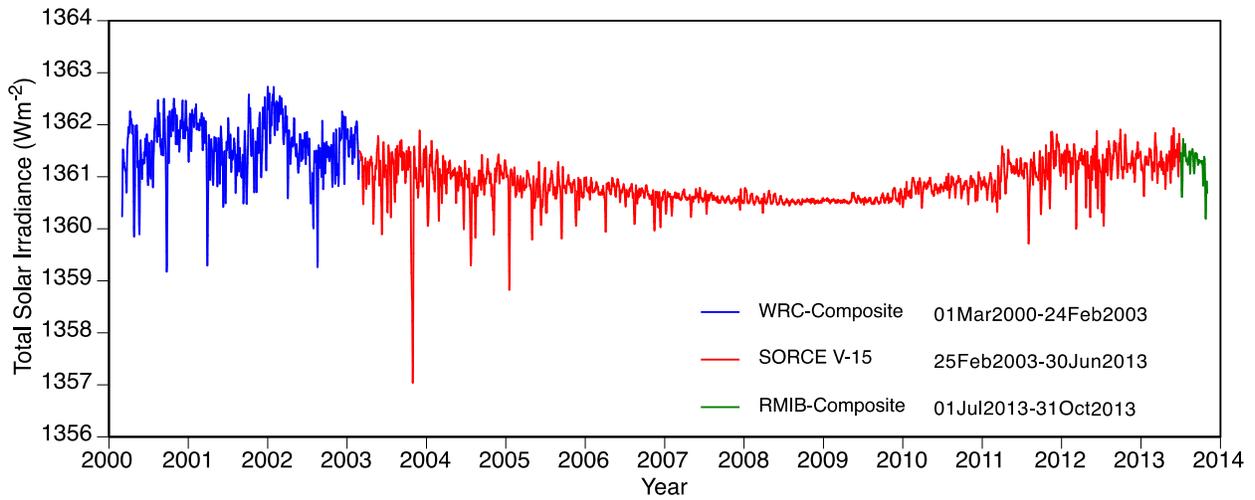


Figure 1. Daily total solar irradiance (TSI) used in EBAF Ed2.8 from March 2000 through October 2013 (W m^{-2}).

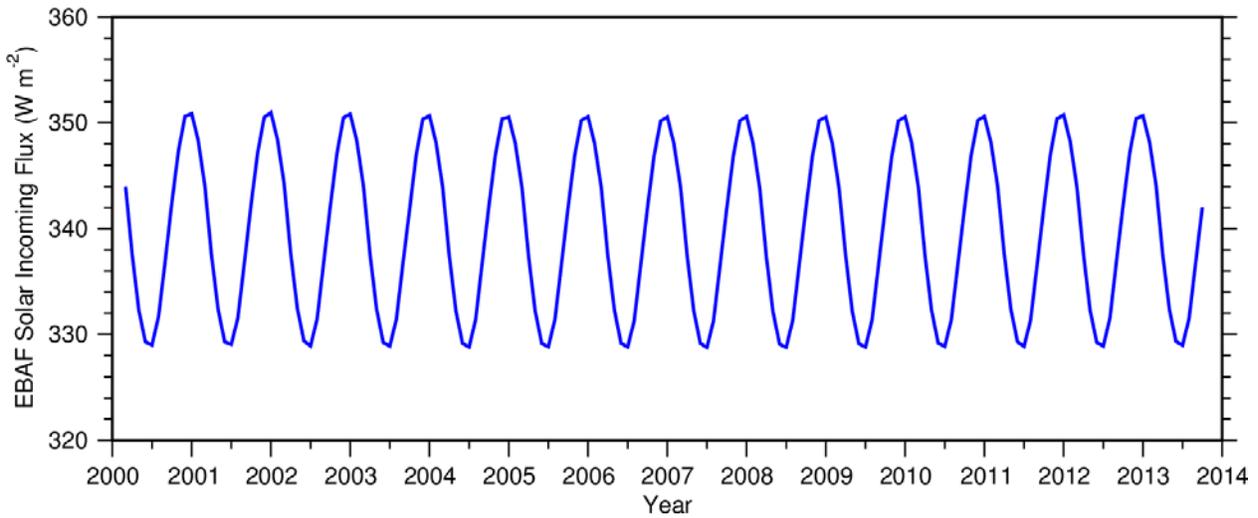


Figure 2. Global monthly mean solar incoming flux in EBAF Ed2.8 from March 2000 through October 2013 (W m^{-2}).

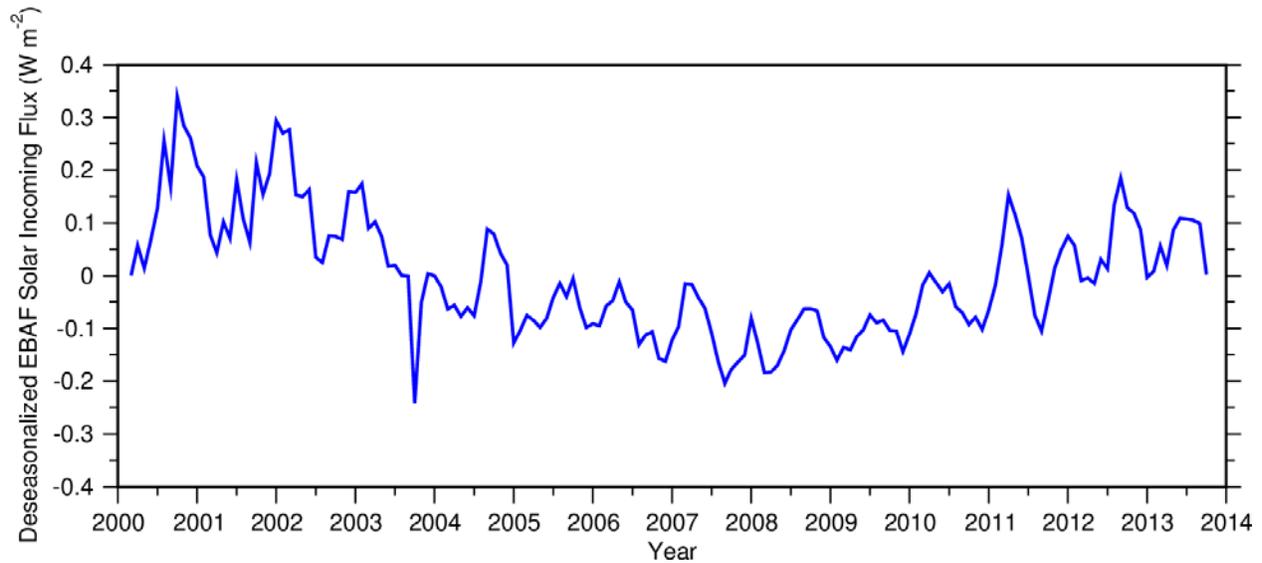


Figure 3. Deseasonalized global monthly mean solar incoming flux in EBAF Ed2.8 from March 2000 through October 2013 (W m^{-2}).

To compute the solar incoming irradiance for a given region as a function of time, CERES uses JPL DE200 to compute the daily earth-sun distance and the Consultative Committee for Space Data Systems CCSDS 301.0-B-2 (1994) almanac to compute the daily solar declination angle and sidereal day or right ascension or hour angle. The CCSDS database can be downloaded at <http://public.ccsds.org/publications/SilverBooks.aspx> and the JPL DE200 at <http://heasarc.nasa.gov/listserv/heafits/msg00050.html>. The regional solar zenith angle or solar insolation is then computed analytically, as referenced in Liou (1980).

CERES uses geodetic weighting to average the zonal fluxes into a global mean. This assumes the earth is an oblate spheroid with an equator radius of 6378.137 km and polar radius of 6356.752 km. This increases the annual global incoming solar flux by 0.29 W m^{-2} over weighting assuming a spherical earth (Loeb et al. 2009).

4. Validation and Uncertainty Estimate

The TIM Total Solar Irradiance (TSI) measurements monitor the incident sunlight to the Earth's atmosphere using an ambient temperature active cavity radiometer. Using electrical substitution radiometers (ESRs) and taking advantage of new materials and modern electronics, the TIM measures TSI to an estimated absolute accuracy of 350 ppm (0.035%). Relative changes in solar irradiance are measured to less than 10 ppm/yr (0.001%/yr), allowing determination of possible long-term variations in the Sun's output (Kopp et al. 2005).

5. Considerations for Model-Observation Comparisons

The solar incoming TOA flux is derived from daily SORCE TIM measurements, which have an average annual flux of $\sim 1361 \text{ W m}^{-2}$, vary with time, and take into account the solar sunspot cycle with an amplitude of $\sim 0.1\%$.

6. Instrument Overview

The first paragraph under section 3 gives an overview of the SORCE TIM instrument.

7. References

The full version of CERES EBAF Ed2.8 is available from the following ordering site:

http://ceres.larc.nasa.gov/order_data.php

Dewitte, S., D. Crommelynck, and A. Joukoff, 2004: Total solar irradiance observations from DIARAD/VIRGO. *J. Geophys. Res.*, **109**, A02102, doi:10.1029/2002JA009694.

Dewitte, S., E. Janssen, and S. Mekaoui, 2013: Science results from the Sova-Picard total solar irradiance instrument, *AIP Conf. Proc.*, **1531**, 688-691, doi:10.1063/1.4804863.

Kopp, G. and G. Lawrence, 2005: The Total Irradiance Monitor (TIM): Instrument design. *Sol. Phys.*, **230**, 91-109.

Liou, Kuo-Nan, 1980: *An introduction to atmospheric radiation*. Academic Press, 392 pp.

Loeb, N. G., B. A. Wielicki, D. R. Doelling, G. L. Smith, D. F. Keyes, S. Kato, N. Manalo-Smith, T. Wong, 2009: Toward optimal closure of the Earth's top-of-atmosphere radiation budget. *J. Climate*, **22**, 748-766, doi:10.1175/2008JCLI2637.1.

Mekaoui, S., and S. Dewitte, 2008: Total Solar Irradiance measurement and modelling during cycle 23, *Sol. Phys.*, **247**, 203-216.

8. Dataset and Document Revision History

Rev 0 – 09 Aug 2011 – This is a new document/dataset

Rev 1 – 05 Mar 2012 – Updated to Edition2.6r. EBAF Ed2.6r corrects a code error in the calculation of global mean quantities in EBAF Ed2.6. Also updates temporal extent to 06/2011 from 12/2010.

Rev 2 – 06 Jun 2012 – Updated temporal extent to 12/2011 from 06/2011.

Rev 3 – 01 Nov 2012 – Updated temporal extent to 06/2012 from 12/2011.

Rev 4 – 28 Aug 2013 – Updated to Edition2.7. No change from Edition2.6r. Updated temporal extent to 02/2013 from 06/2012.

Rev 5 – 18 Sep 2013 – Updated temporal extent to 04/2013 from 02/2013.

Rev 6 – 26 Mar 2014 – Updated to Edition2.8. Incoming solar irradiances are from SORCE TIM TSI V-15 for March 2000-June 2013, followed by RMIB from July 2013 onwards. Updated temporal extent from 4/2013 to 10/2013.