

# SAFARI 2000 AERONET-derived Diffuse Spectral Irradiance for Eight Core Sites

## Abstract

This data set contains monthly mean values of diffuse irradiance fraction [ $f(E_{diff})$ , or ratio of diffuse-to-total irradiance] at ground level for a 30-degree solar zenith angle and in seven spectral bands (MODIS bands 1-7) as well broadband visible (400-700 nm), near-infrared (700-3000 nm) and shortwave (400-3000 nm). Values are provided for eight SAFARI 2000 core sites, including Ghanzi/Okwa River Crossing, Maun (Main and Floodplain Towers), Pandamatenga, and Tshane, Botswana; Skukuza, South Africa; Etosha National Park, Namibia; and Mongu, Zambia. The fractions were estimated with the 6S radiative transfer model, given the mean aerosol optical depth (AOT) values from AERONET sunphotometer measurements. Where sunphotometers were not deployed at a SAFARI 2000 core site, the "nearest neighbor" sunphotometer data were used. A rough estimate of the likely spatial extrapolation error is provided. These data can be used to estimate typical surface albedo ("blue sky" conditions) from the theoretical "black-sky" and "white-sky" albedo values provided in the MODIS albedo product (MOD43), as well as in other applications.

## Background Information

**Investigator:** Jeffrey L. Privette (Jeff.Privette@nasa.gov)

**Project:** SAFARI 2000  
Southern Africa Validation of EOS (SAVE)

**Data Set Title:** SAFARI 2000 AERONET-derived Diffuse Spectral Irradiance for Eight Core Sites

**Site:** Southern Africa  
**Westernmost Longitude:** 15° 54' 52" E  
**Easternmost Longitude:** 31° 29.8128' E  
**Northernmost Latitude:** 15° 26.33093' S  
**Southernmost Latitude:** 25° 01.1832' S

## Data Set Citation:

Privette, J. L. 2005. SAFARI 2000 AERONET-derived Diffuse Spectral Irradiance for Eight Core Sites. Data set. Available on-line [<http://daac.ornl.gov/>] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

## Data File Information

The data for all eight sites are contained in one ASCII file (diffuse\_irradiance.csv), with the sites in alphabetical sequence. The data file provides the ratio of diffuse (atmospherically-scattered) irradiance to total irradiance, both at ground level, for the eight sites in southern Africa. Mean values are provided for each of 12 months in 10 spectral bands between 0.4 and 4.0 microns. There is also a file showing the original layout of the data set (diffuse\_irradiance.pdf).

### Data Format:

In the single data file, the data are organized in eight ASCII matrices, corresponding to eight unique sites, of diffuse irradiance fraction for 10 bands (rows) and 12 months (columns). Each site's data matrix contains the site's country (e.g., Botswana), the site's name (e.g., Ghanzi/Okwa River Crossing), the IGBP land classification of the site (e.g., open shrublands), the site's geographic coordinates (in degrees and decimal minutes, e.g., 22° 24' 33" S), the "nearest neighbor" AERONET sunphotometer site's name and geographic coordinates (e.g., AERONET SITE: Etosha\_Pan(7), Latitude: -19.1750, Longitude: 15.9144), and the distance between the SAFARI 2000 Core Site and AERONET sunphotometer site (e.g., Distance: 701.52 km).

### Sample Data Record:

Country	Site Name	IGBP Class	Lat.	Lon.	Closest AERONET Site	Other Close Site	Band #	JAN	FEB	MAR ...
Botswana	Ghanzi/Okwa River Crossing	Open shrublands	22° 24' 33" S	21° 42' 47" E	Etosha_Pan(7), Latitude: -19.1750, Longitude: 15.9144, Distance: 701.52 km	1 other site was within 10 degrees (883) of closest AERONET site; Epsilon between the two sites: 0.01359	1	0.103	0.103	0.103 ...

Notes: The data are monthly mean values of diffuse irradiance fraction [f(Ediff), or ratio of diffuse-to-total irradiance] at ground level. The other monthly mean values follow in subsequent columns and the other nine bands follow in subsequent rows. IGBP = International Geosphere Biosphere Programme.

**Spectral Bands in this Data Set:**

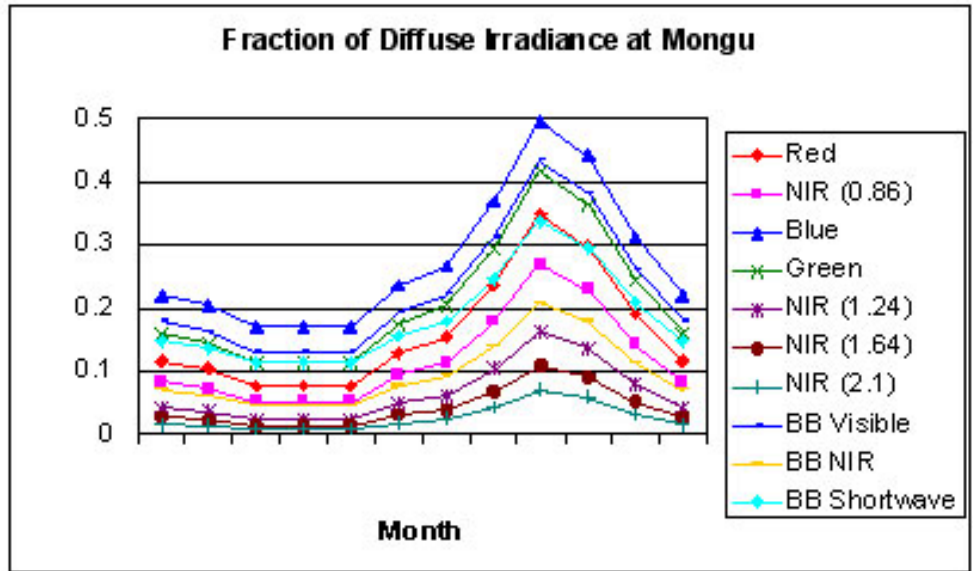
Band Number	Lower and Upper Bandpass Cutoffs (FWHM)
1	0.620-0.670 (red)
2	0.841-0.876 (nir)
3	0.459-0.479
4	0.545-0.565
5	1.230-1.250
6	1.628-1.652
7	2.105-2.155
BB 8	0.400-0.700 (vis)
BB 9	0.700-4.000 (nir)
BB 10	0.250-4.000 (sw)

where BB = broadband (i.e., not a MODIS band), vis = visible, nir = near-infrared, and sw = shortwave radiation.

**Parameter Table for Data File (diffuse\_irradiance.csv):**

Variable	Description	Units	Instrument	Range
Diffuse Irradiance Fraction [f (Ediff)]	Ratio of diffuse-to-total irradiance, in 10 different bands and for 12 months	unitless	CIMEL sunphotometer for AOT, 6S radiative transfer model for f (Ediff)	0-0.5
Epsilon	Estimate of spatial extrapolation error	unitless	N/A	0.03

**Example of Data Output:**



**Study Area**

**Spatial Coverage:**

Country	Site Name	IGBP Class	Lat	Long
Botswana	Ghanzi/Okwa River Crossing	Open shrublands	22° 24' 33" S	21° 42' 47" E
Botswana	Pandamatenga	Savannas	18° 39' 19" S	25° 30' 1" E
Botswana	Tshane	Open shrublands	24° 9' 51" S	21° 53' 34" E
Botswana	Maun, Botswana, Main Tower	Grasslands	19° 54' 55.656" S	23° 33' 37.692" E
Botswana	Maun, Floodplain Tower	Grasslands	19° 39.35' S	23° 20.92' E
Namibia	Etosha National Park	Grasslands	19° 10' 30" S	15° 54' 52" E
South Africa	Skukuza, Kruger National Park	Savannas	25° 01.1832' S	31° 29.8128' E
Zambia	Mongu	Savannas	15° 26.33093' S	23° 15.15477' E

NOTE: As climatology data, the data are likely suitable for general use over larger areas.

## Temporal Coverage:

The diffuse fraction data are monthly means, computed for a 30-degree solar zenith angle. The native resolution of the AERONET sunphotometer data varies, but is typically less than 1 hour.

## Data Application and Derivation:

### Typical Application of Data:

This data set was primarily created to facilitate determination of approximate “blue sky” spectral or broadband albedo (i.e., albedo for a typical non-cloudy day) from the MODIS black-sky (theoretical no-atmosphere case) and white sky (theoretical perfectly diffuse case) remote sensing products. A general equation often used to determine blue sky albedo is:  
$$\text{Blue\_sky\_alb} = \text{Black\_sky\_alb} * (1-f(\text{Ediff})) + \text{White\_sky\_alb} * f(\text{Ediff}).$$
The data can be used for many other applications (e.g., radiation budget and analysis of vegetation productivity under typical sky conditions).

### Theory of Measurements:

Details on sunphotometer use and determination of the AOT values are found Holben and Eck (2004). The climatology was developed from statistical analysis of AOT values collected over multiple years. Additional details are available at the AERONET web site (<http://aeronet.gsfc.nasa.gov/>).

Here we describe only the determination of  $f(\text{Ediff})$  from the AOT climatology.

### Processing Steps:

1. The AERONET climatology data set, available from <http://aeronet.gsfc.nasa.gov>, included monthly average AOT and their corresponding Angstrom Coefficients (alphas) for each month. Measured values for 500 nm were then converted to their expected values at 550 nm using Angstrom's Law.
2. If a site was missing data for only 1 or 2 consecutive months, the values for those months were filled in through simple linear interpolation, and the months filled in were then appended to the site name (i.e., "SANTA\_CRUZ(7,8)" had months 7 & 8 filled in).
3. The AOTs are converted to fraction of diffuse skylight [ $f(\text{Ediff})$ ] in 10 spectral bands using 6S modeling results generated and compiled into a look-up table by Feng Gao of Boston University. The look-up table contains 6S results for 10 spectral bands at 50 AOT values (0.0, 0.2, ... , 0.98), and for 90 solar zenith angles (0, 1 ... , 89), but for the purposes of this data set, only an solar zenith angles of 30 degrees was used.

4. Using a Great Circle calculation, the nearest AERONET site to the given SAFARI 2000 core site is found and a table of the fractions of diffuse skylight is generated for each month along with some estimated error values. These data can provide realistic estimates of diffuse irradiance as required to determine blue sky (actual) albedo from the MODIS "black sky" and "white sky" albedo products (MOD43).

5. An estimation of error over distance was also calculated for each AERONET site. The monthly AOTs at one site were compared to those of all other sites to produce a single epsilon value for each pair of sites. Of those pairs whose distance was less than 1300 km (~10 degrees), a simple regression (x: distance, y: epsilon), along with a sum of squared errors, was calculated.

6. For some AERONET sites, there were no other sites within range to calculate these error estimates. In the case where there was only 1 other site within range, the distance between those 2 sites and the epsilon of that pair are given. For the sites with 2 or more pairs, the distance between the AERONET and the SAFARI 2000 core site is used to calculate the estimated epsilon based on the slope and intercept generated by the regression for that AERONET site. The number of sites used to generate the regression, and the SSE of the regression are also given.

## **Quality Assessment:**

### **Error Sources:**

There are errors in the AERONET AOT and angstrom values and in all calculations. Use data as gross estimates and with caution. Mostly likely, the greatest and most difficult to estimate errors is due to extrapolating AERONET data using just physical distance (i.e., nearest neighbor approach). No interpolation procedures were attempted. Ideally, one would know something about the landcovers, aerosol regimes, and topography; however, those considerations were not used here.

### **Limitations of the Data:**

These data should not be compared from site to site. In fact, two or more sites may have exactly the same values if the nearest AERONET site to each is the same. Further, one should check the location of the AERONET site vs. the SAFARI 2000 core site to assess likely aerosol regime differences. For example, it would be unwise to use data collected over an industrial site if one is estimating  $f(E_{diff})$  from an upstream "clean" rural site, even if the physical distance between them is small.

**Known Problems with the Data:**

None.

**Validation by Submitter of Data:**

These data have not been validated, and likely will not be; however, no problems are known to exist. The PI has subjectively reviewed some trends in the data (e.g., spectral trends, trends due to fire seasonality) and the data seem plausible. Users should check with PI before using the data to assure that no issues have arisen since the writing of this document.

**Confidence Level or Accuracy Judgment:**

The epsilon error estimate should be taken as a very rough value. It is more qualitative than quantitative.

**Measurement Error for Parameters:**

As given in data set.

**Additional Information About This Data Set:****Field Collection Environment:**

Please see documentation for Holben and Eck (2004).

**Field Sensor or Instrument Descriptions:**

Please see documentation for Holben and Eck (2004).

**Sensor or Instrument Measurement Geometry:**

Please see documentation for Holben and Eck (2004).

**Manufacturer of Sensor or Instrument:**

Cimel Electronique  
172, rue de Charonne 75011  
Paris, France  
Phone: 331 43487933  
Fax: 331 43486261

## **Calibration:**

Please see documentation for Holben and Eck (2004).

## **Additional Sources of Information**

This data set was provided by Jeffrey Privette of NASA's Goddard Space Flight Center. The AERONET climatology were processed by Brent Holben of NASA's GSFC, and were converted to diffuse irradiance by Seth Hoffman of SAIC, Inc.

## **Related Data Sets**

Holben, B. N. and T. F. Eck. 2004. SAFARI 2000 AERONET Ground-based Aerosol Data, Dry Season 2000. Data set. Available on-line [<http://www.daac.ornl.gov>] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

Privette J. L. and M. Mukelabai. 2005. SAFARI 2000 Surface Irradiance Measurements, Mongu Tower Site, Zambia, 2000-2002. Data set. Available on-line [<http://daac.ornl.gov/>] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

Privette, J. L., M. Mukelabai, and C. Pietras. 2004. SAFARI 2000 AOT and Column Water Vapor, Kalahari Transect, Wet Season 2000. Data set. Available on-line [<http://daac.ornl.gov/>] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

Privette J. L., M. Mukelabai, N. Hanan, and Z. Hao. 2005. SAFARI 2000 Surface Albedo and Radiation Fluxes at Mongu and Skukuza, 2000-2002. Data set. Available on-line [<http://daac.ornl.gov/>] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

Tsay S. C. and J. Q. Li. 2004. SAFARI 2000 Surface Atmospheric Radiative Transfer (SMART), Dry Season 2000. Data set. Available on-line [<http://daac.ornl.gov/>] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

## **References**

Privette, J. L., M. Mukelabai, Z. Hao, and C. B. Schaaf. 2004. Validation of the MODIS albedo product in African savannas and woodlands. IEEE Geosciences and Remote Sensing, submitted.



Holben, B. N., D. Tanre, A. Smirnov, T. F. Eck, I. Slutsker, N. Abuhassan, W. W. Newcomb, J. S. Schafer, B. Chatenet, F. Lavenu, Y. J. Kaufman, J. V. Castle, A. Setzer, B. Markham, D. Clark, R. Frouin, R. Halthore, A. Karneli, N. T. O'Neill, C. Pietras, R. T. Pinker, K. Voss, and G. Zibordi. 2001. An emerging ground-based aerosol climatology: aerosol optical depth from AERONET. J. Geophys. Res. 106(D11): 12067-12097.

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