Datasets on extinction coefficients for free space optical link survey and optimization

Cheikh Amadou Bamba Dath *, Aliou Niane, Ndeye Arame Boye Faye, Modou Mbaye

Laboratoire Atomes Lasers, Faculté des Sciences et Techniques, Université Cheikh Anta Diop de Dakar (UCAD), Sénégal

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A B S T R A C T

Based on visibilities data recorded from 2004 to 2013, the minimum, maximum and mean values of extinction coefficients were determined and analyzed in a monthly basis, a yearly basis and also for the whole period of observation.

The extinction coefficients data are obtained for the 1330 and 1550 nm optical wavelengths and may be used inter alia for range and availability analyses of optical link for different weather conditions. The data are collected in the region of Dakar, but approach and model of investigation can be reproduced for other regions in Sahel, and in the World, for optical metrology and allied fields of study.

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Specifications table

Subject area Physics, Chemistry,
More specific subject area Free Optical communication, Optical signal metrology in atmosphere
Type of data Table (in word files), graphs, figures
How data was acquired Survey of visibilities data of Word meteorological station in Dakar, via free web portal

* Corresponding author.
E-mail address: cheikhamadou.dath@ucad.edu.sn (C.A.B. Dath).

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Data format  
Filtered, analyzed, and processed for 1330 nm and 1550 nm

Experimental factors  
Data of visibility are computed by using Beer Lambert Law of transmittance and with combination with the Kruse Model, in regard to obtain extinctions coefficients at 1330 nm and 1550 nm

Experimental features  
Extinctions value are obtained by using and analyzing visibility data, measured by transmissiometers or Diffusometer with error measurement of less than 1%. So, error induced in propagation can be neglected for free space optical communications purposes.

Data source location  
City of Dakar, in Senegal

Data accessibility  
Data is provided with this current article

Value of the data

- The present data will be of great usefulness and utility for the determination of optical signal range in atmosphere;
- The data will help to analyze the range and availability of free space optical systems over the time, as in a monthly, seasonal or yearly basis
- The data can be used for optical communication power budget modelling, forecasting and planning.
- The data can be used as support for comparison and survey of feasibility studies of optical applications in other regions, by professional and scientists.

1. Data

The datasets used in this work contain extinction coefficients for Dakar weather, from January 1, 2004 to December 31, 2013. The datasets are minimum, maximum and mean values of extinction coefficients at 1330 and 1550 nm, presented respectively in Tables 1–3. Also, lognormal approximations of monthly mean extinction coefficients presented in Table 4 and corresponding to 120 values of the ten years of observation are presented within two figures, noted Figs. 1 and 2. The extinction coefficients were estimated at both 1330 and 1550 nm by using a method called Kruse model. The data serve for survey, planning and optimization of free space optical communications systems and in general for optical metrology and spectroscopy in the near infra-red window.

The computed data, the modeling approach and the related precisions are described in this paper.

| Month | $\lambda = 1550$ | $\lambda = 1330$ |
|-------|-----------------|-----------------|
| Jan   | 0.330428811     | 0.382461926     |
| Feb   | 0.266951974     | 0.311463881     |
| Mar   | 0.403887066     | 0.464124991     |
| Apr   | 0.14553316      | 0.177576721     |
| May   | 0.155785113     | 0.190085955     |
| Jun   | 0.133151412     | 0.162468754     |
| July  | 0.121538445     | 0.148298839     |
| Aug   | 0.129754692     | 0.158324143     |
| Sept  | 0.13025311      | 0.158932303     |
| Oct   | 0.139928031     | 0.170737453     |
| Nov   | 0.144911223     | 0.176817847     |
| Dec   | 0.219545988     | 0.258104977     |
2. Experimental design, materials and methods

The extinction coefficients data are derived from visibility measurements, recorded for a period of ten years, from 2004 to 2013. So extinction coefficient depends on absorption and scattering of the propagating optical signal in the earth’s atmosphere [1–5].

Several following equations are used to obtain the extinction coefficient; before all, we have the atmospheric transmittance which is expressed by the beer-Lambert’s law [1,2,4]:

\[ \tau(L) = \frac{P(L)}{P(0)} = e^{(-\gamma(\lambda)L)} \]  

(1)

And \( \gamma(\lambda) \) is the extinction coefficient which is approximately taken to be equal to that produced only by the aerosols and is expressed as [3–6]:

\[ \gamma(\lambda) = \frac{3.912}{V} \left( \frac{\lambda_{\text{nm}}}{550} \right)^{-q} \]

(2)

Coefficient \( q \) has been established within many experimental studies and may take the values below, subject to the visibility range, according to KRUSE [1,4,6,7]

\[ q = \begin{cases} 
1.6 & \text{if } V > 50 \text{ km} \\
1.3 & \text{if } 6 \text{ km} < V < 50 \text{ km} \\
0.585V^{1/3} & \text{if } V < 6 \text{ km}
\end{cases} \]

(3)

### Table 2
Extinction coefficient computed for monthly mean of maximum visibility from 2004–2013.

| Month | \( \lambda = 1550 \) | \( \lambda = 1330 \) |
|-------|-----------------|-----------------|
| Jan   | 0.107648337     | 0.1313504       |
| Feb   | 0.104122496     | 0.127048238     |
| Mar   | 0.104122496     | 0.127048238     |
| Apr   | 0.104016031     | 0.126918332     |
| May   | 0.101626053     | 0.124002126     |
| Jun   | 0.100224314     | 0.12291752      |
| July  | 0.093413846     | 0.113981752     |
| Aug   | 0.097533728     | 0.119008752     |
| Sept  | 0.098477908     | 0.120160821     |
| Oct   | 0.098382668     | 0.120044611     |
| Nov   | 0.104550543     | 0.127570533     |
| Dec   | 0.106632787     | 0.130111246     |

### Table 3
Extinction coefficient computed for monthly mean of mean visibility from 2004–2013.

| Month | \( \lambda = 1550 \) | \( \lambda = 1330 \) |
|-------|-----------------|-----------------|
| Jan   | 0.133307881     | 0.16266         |
| Feb   | 0.124888337     | 0.152386        |
| Mar   | 0.125368959     | 0.152973        |
| Apr   | 0.116436699     | 0.142074        |
| May   | 0.114601447     | 0.139834        |
| Jun   | 0.111963016     | 0.136615        |
| July  | 0.109336049     | 0.13341         |
| Aug   | 0.108973761     | 0.132968        |
| Sept  | 0.110712607     | 0.135089        |
| Oct   | 0.112704877     | 0.13752         |
| Nov   | 0.115631937     | 0.141092        |
| Dec   | 0.121295352     | 0.148002        |
Visibility and extinction are here phenomenon varying with time and period [3, 4, 7, 8]. The datasets of extinction coefficients at 1330 and 1550 nm presented in the tables (Table 1–4), are obtained by adopting that Kruse model.

The data of Table 4 represent the average extinction coefficient for each month, over the period from 2004 to 2013, corresponding to the 120 monthly values over the ten years of observation [8].

### 2.1. Lognormal approximation and precision of data analyses for 1550 nm

A lognormal approximation of extinction coefficients data is performed at 1550 nm. A descriptive statistical analysis of the 120 values of extinction coefficient at the wavelength of 1550 nm is resumed in the Table 5.

The data are analyzed again, in regard to see what kind of distribution, they may follow, and to provide a tool which is easy to use by professionals and other non-technical people. The lognormal approximation proposed is fitted with very good precision [8].

### Table 4

| Extinction coefficient at $\lambda = 1550$ nm | Extinction coefficient at $\lambda = 1330$ nm |
|--------------------------------------------|---------------------------------------------|
| 0.124792891                                | 0.118644059                                 |
| 0.131995576                                | 0.111706771                                 |
| 0.14588105                                | 0.10635941                                   |
| 0.110325442                               | 0.10719098                                   |
| 0.101204967                               | 0.113210498                                  |
| 0.11198685                                | 0.10855618                                   |
| 0.108451674                               | 0.115373598                                  |
| 0.103439806                               | 0.118243579                                  |
| 0.103150424                               | 0.142704175                                  |
| 0.111380701                               | 0.122090688                                  |
| 0.115013709                               | 0.120757336                                  |
| 0.128769203                               | 0.12276743                                   |
| 0.17686164                                | 0.110737735                                   |
| 0.128189753                               | 0.109659684                                  |
| 0.124406991                               | 0.108819665                                  |
| 0.122514305                               | 0.11431365                                   |
| 0.118778017                               | 0.10997586                                   |
| 0.110854685                               | 0.11882283                                   |
| 0.110148764                               | 0.116526541                                  |
| 0.10659417                                | 0.124893397                                  |
| 0.111952641                               | 0.127829735                                  |
| 0.113929139                               | 0.119629368                                  |
| 0.116171639                               | 0.120456771                                  |
| 0.122390311                               | 0.123957306                                  |
| 0.120745009                               | 0.117058601                                  |
| 0.118440998                               | 0.116215966                                  |
| 0.13283739                               | 0.111236622                                  |
| 0.115032317                               | 0.107703491                                  |
| 0.112146408                               | 0.110693874                                  |
| 0.108916135                               | 0.112066722                                  |
| 0.101335401                               | 0.123356058                                  |
| 0.105156382                               | 0.118199339                                  |
| 0.108029346                               | 0.127933425                                  |
| 0.110923567                               | 0.12141412                                   |
| 0.11829571                               | 0.130744437                                  |
| 0.119182132                               | 0.117649535                                  |
| 0.145998086                               | 0.121477624                                  |
| 0.121986009                               | 0.112738501                                  |
| 0.125141216                               | 0.111947343                                  |
| 0.110733999                               | 0.111236622                                  |

$V$ is the atmospheric visibility which is measured by transmissiometers or diffusometers sensors. Visibility and extinction are here phenomenon varying with time and period [3, 4, 7, 8].

The datasets of extinction coefficients at 1330 and 1550 nm 1550 nm presented in the tables (Table 1–4), are obtained by adopting that Kruse model.

The data of the Table 4 represent the average extinction coefficient for each month, over the period from 2004 to 2013, corresponding to the 120 monthly values over the ten years of observation [8].

2.1. Lognormal approximation and precision of data analyses for 1550 nm

A lognormal approximation of extinction coefficients data is performed at 1550 nm. A descriptive statistical analysis of the 120 values of extinction coefficient at the wavelength of 1550 nm is resumed in the Table 5.

The data are analyzed again, in regard to see what kind of distribution, they may follow, and to provide a tool which is easy to use by professionals and other non-technical people. The lognormal approximation proposed is fitted with very good precision [8].
The values of the parameters of the lognormal approximation (3P) at 1550 nm are: \( \sigma = 0.40726; \)
\( \mu = -3.9384; \)
\( \gamma = 0.09615 \) and the number of bins used is 13; the cumulative distribution is fitted in the Fig. 1.

2.2. Lognormal approximation and precision of data analyses for 1330 nm

A lognormal approximation of extinction coefficients data at 1330 nm is also performed; a descriptive statistical analysis of data is resumed in the Table 6.
The values of the parameters of the lognormal approximation (3P) at 1330 nm are: $\sigma = 0.40726$; $\mu = -3.7394$; $\gamma = 0.11732$ [8]. The cumulative distribution function is presented in Fig. 2.

The goodness of the lognormal fit at the different wavelengths (1550 and 1330 nm) are estimated with very high precision (Table 7).

The goodness of lognormal (3P) fit for data at 1330 nm and 1550 nm are performed by using the method of Kolmogorov-Smirnov.

**Transparency document. Supporting information**

Transparency data associated with this article can be found in the online version at https://doi.org/10.1016/j.dib.2018.12.012.
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