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Determination of Turbidity Parameters over Ghardaia Site Using MODIS Data

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Abstract. In this work, three basic parameters for aerosol characterization, Aerosol Optical Thickness, Angstrom Exponent and Angstrom Coefficient are used for aerosol analysis. Their monthly average values are obtained from MODIS data for Ghardaia site. We have found that the transmission of solar radiation can reach 95 % and the 94% of the Angstrom exponent values lie between 1.2 and 1.27 and 70% of Angstrom coefficient lie between 0.019 and 0.062.

Key words: Aerosols, Optical Thickness, MODIS, turbidity parameters.

1. Introduction

The characteristics of the solar radiation on the ground depend on the measurement site. So, the design and installation of systems of solar energy conversion, the quality and amount of solar radiation at that location must be considered. During the propagation of solar radiation through the atmosphere can be effected by the atoms and molecules that compose it (ozone, water vapor, carbon dioxide,..) as well as from liquid aerosols and solid scattered or grouped in cloud.

Atmospheric aerosols are defined as suspended particles in the atmosphere in liquid or solid phase. The presence of aerosols in atmosphere can affect our weather and climate because they change the amount of sunlight reaching Earth’s surface [1]. Aerosol Optical Thickness (AOT, also called aerosol optical depth) is basically a measurement of transparency of the atmosphere. The larger the AOT at a particular wavelength, the less light of that wavelength reaches Earth’s surface. This information is important for determining the concentration, size distribution and variability of aerosols in the atmosphere.

The aerosols have different size distributions, shapes, and residence times. They originate from different sources such as gases condensation and action of wind on the Earth's surface. Aerosol size properties are one of the most important information for both modeling and experiments.

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They are tiny particles in the range 0.001 to 100 suspended in the atmosphere. In the other words, the Aerosol optical thickness (AOT) is a wavelength dependent measure of the total extinction of sunlight due to scattering and absorption by aerosols [2].

AOT is considered the most important unknown parameter in any atmospheric correction algorithm since it is used to solve the radiative transfer equation and remove atmospheric effects from satellite images [3].

Aerosols have an impact on human respiratory and global climate and weather changes [4]. In the case of climate and weather, the presence of solid particles in the Earth’s atmosphere has important consequences for the transmission of solar radiation and on the nature of the radiation regime at the ground. The absorption of solar energy by a layer of aerosol increases the radiative heating of the atmosphere and decreases the amount of energy available at the surface. Scattering by aerosol increases the amount of radiation which is reflected by the atmosphere into space and increases the downward flux of diffuse radiation at the Earth’s surface. In fact, there is a simple relationship between the aerosol optical thickness and the percentage of transmission which can be explained by this formula [5]:

$$transmission \quad (1)$$

Where is the aerosol optical thickness.

The Moderate Resolution Imaging Spectro-radiometer has two satellites, Terra and Aqua, where is making near-global daily observations of the

Earth in a wide spectral band (0.41–15 µm). These measurements are used to derive the characteristics of the atmosphere of the studied area. In this work we have focused on the spectral aerosol optical thickness and aerosol size parameters over land. Due to their variability, atmospheric aerosol monitoring is difficult and significant efforts to improve aerosol characterizations have included using in-situ measurements, ground-based remote sensing and satellite observations [6].

As mentioned before, the present paper study the characteristics of aerosol over Ghardaia site. After a brief introduction in section 1, the section 2 provides the site characterization and data used. Section 3 describes the two turbidity parameters (the Angstrom exponent α and the Angstrom coefficient β). In section 4, discussion of the obtained results is presented.

2. Site And Data Used

Our studied area is located in the center of the northern part of the Algerian Sahara about 600Km from the capital city (Figure 1). It is considered as arid and dry area. Its geographical coordinates are: 32°37'N in latitude and 3°77'E in longitude. This area is characterized by significant insolation rate [7]. The mean annual global solar radiation measured on a horizontal plane exceeds 6000 (Wh/m2) and the sunshine duration is more than 3000 (hours/year) [7].

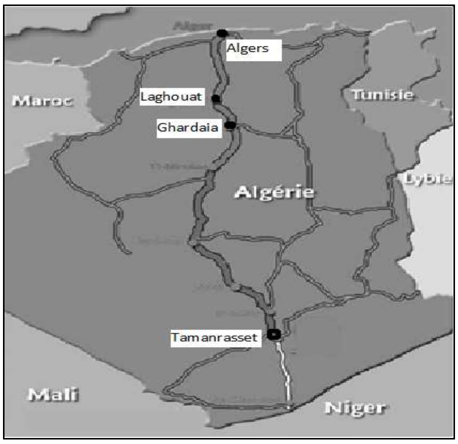

Fig. 1 Location of Ghardaia city

The winter in Ghardaia is described by an extreme cold due to windblown of snow from the highlands; sandstorms from the southwest. The end of winter is particularly troublesome, which is the result of extreme dustiness. The annual average values of temperature and humidity are respectively 27° and 25%. The monthly average values are between 13° and 43° for the temperature and between 10% and 46% for humidity. The predominant wind direction is south-west.

This study uses 1km resolution TERRA/MODIS of level 2 aerosol products (MOD04) of the year 2005. The level 2.0 MODIS data have been used to retrieve the AOT and consequently α, β values.

3. Aerosol Optical Thickness And Turbidity Parameters

Aerosol Optical Thickness (AOT) at wavelength λ is the standard parameter measured by Sun photometers. The aerosol optical thickness depends not only on aerosol characteristics (size distribution, refractive index, etc.) but also on aerosol total loading [8].

Angstrom suggested a single formula for aerosol scattering optical thickness evaluation generally known as Angstrom's turbidity formula given by the following [9]:

(2)

Where β is the Angstrom coefficient and α is the Angstrom exponent.

The Angstrom coefficient β is one of the most widely used indicator, because it represents the amount of aerosols in the atmosphere in the vertical direction [10]. In addition, it represents the combined effects of both scattering and absorption caused by aerosols [11][12]. The range of β parameter varies between 0.0 and 0.5 and it may exceed the value 0.5 for a highly charged atmosphere.

The Angstrom exponent α is a reliable index of the size distribution of these aerosols, which is a good indicator of the dominant size of the atmospheric particles [13][14]. This coefficient varies between 0 and 4.When the aerosol particles are very small, of the order of the air molecules, α takes value 4, and it approaches 0 for great particles. This indicator can be obtained by using the angstrom exponential formula (equation 2), which is giving by:

(3)

Where and represent the AOD values at the wavelengths of and , respectively.

4. Turbidity Parameters From MODIS Data

We have determined the terra MODIS Aerosol Optical Thickness (AOT) values and the corresponding turbidity parameters α and β using equations 2 and 3.For each acquired image by MODIS we extract the sub-image by introducing the geographic coordinates of Ghardaia (Figure 2).

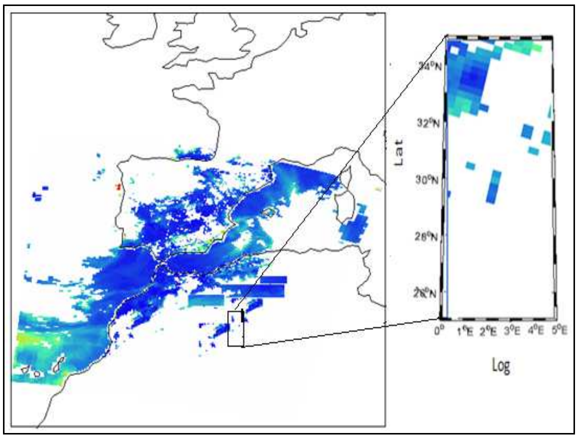

Fig. 2 Studied area

MODIS product images are stored in Hierarchical Data Format (HDF). HDF is a multi-object file format for sharing scientific data in multi-platform distributed environments. The number of acquired MODIS images is 0 to 3 images per day. The steps to determine the mean values of AOT are shown in the flowchart of Figure 3.

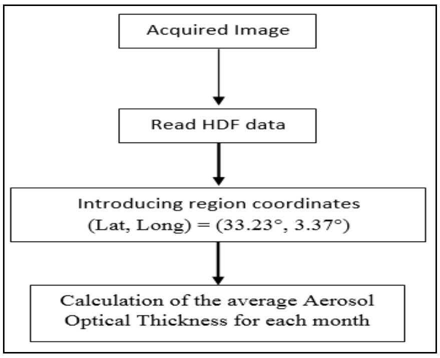

Fig. 3 Flowchart to determine the mean AOT from an acquired MODIS image

For the year 2005, the obtained mean value and standard deviation of AOT at two different wavelengths (0.47µm and 0.55µm) are given in Table 1.

Table 1 Monthly Average values and standard deviation of AOT

Month	Median of AOT		Standard deviation ofAOT	
	λ_1=0.47	λ_2=0.55	λ_1=0.47	λ_2=0.55
J-2005	0,052	0,043	0,068	0,056
F-2005	0,051	0,042	0,027	0,022
M-2005	0,157	0,129	0,066	0,055
A-2005	0,052	0,043	0,058	0,048
M-2005	0,047	0,039	0,035	0,029
J-2005	0,122	0,101	0,021	0,018
J-2005	0,149	0,122	0,002	0,001
A-2005	0,147	0,121	0,037	0,030
S-2005	0,154	0,126	0,160	0,138
O-2005	0,092	0,076	0,053	0,050
N-2005	0,050	0,041	0,055	0,045
D-2005	0,055	0,045	0,039	0,032

Figure 4 shows the evaluation of Aerosol Optical Thickness during the year 2005. We note for both wavelengths that aerosols concentration is more important in Mars and between June and October. This variation in values are explained by a hot summer climate and winds of the south sectors (Sirocco) that characterize the region of Ghardaïa. This kind of winds brings with them particles of dust and sand. The period of winter is characterized by rains that wash the atmosphere and this contribute to diminish the presence of Aerosols.

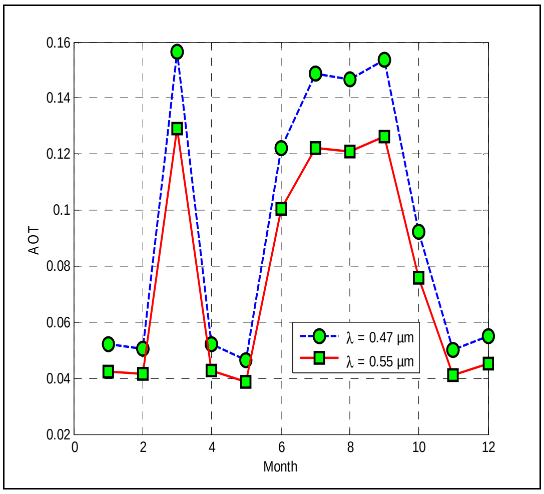

Fig. 4 Variation of AOT during 2005 for two wavelengths (0.47µm) and (0.55 µm).

A frequency distribution of AOT for 0.47 and 0.55 µm channels are shown on Figure 5. We observe that 95%of AOT values lines between 0.02 and 0.03. This implies that the transmission of solar radiation can reach 95% in earth surface according to equation 1.

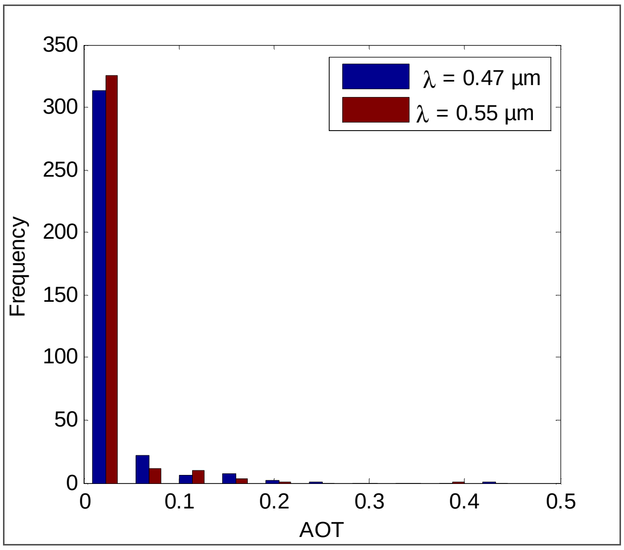

Fig. 5 Frequency distribution of AOT at the wavelength 0.47µm and 0.55 µm

Table 2 summarizes the Angstrom coefficient and Angstrom exponent values calculated using equation 2 and 3.The monthly average values for these parameters have been calculated. The results obtained MODIS data.

Table 2Monthly average values of α and β

Months	α	β	Number of measurements
J-2005	1,283	0,020	8
F-2005	1,249	0,020	5
M-2005	1,234	0,062	2
A-2005	1,246	0,020	3
M-2005	1,201	0,019	1
J-2005	1,246	0,048	1
J-2005	1,248	0,058	1
A-2005	1,241	0,058	2
S-2005	1,243	0,060	5
O-2005	1,245	0,036	4
N-2005	1,256	0,019	6
D-2005	1,277	0,021	9

A frequency distributions of α and β are shown on Figure 6. We observe that 94% of the Angstrom exponent values lie between 1.2 and 1.27 and 70% of Angstrom coefficient lies between 0.01 and 0.07.The maximum and the minimum values of α are 1.33 and 0.69 respectively. For those of the Angstrom coefficient are 0.27 and 0.01.

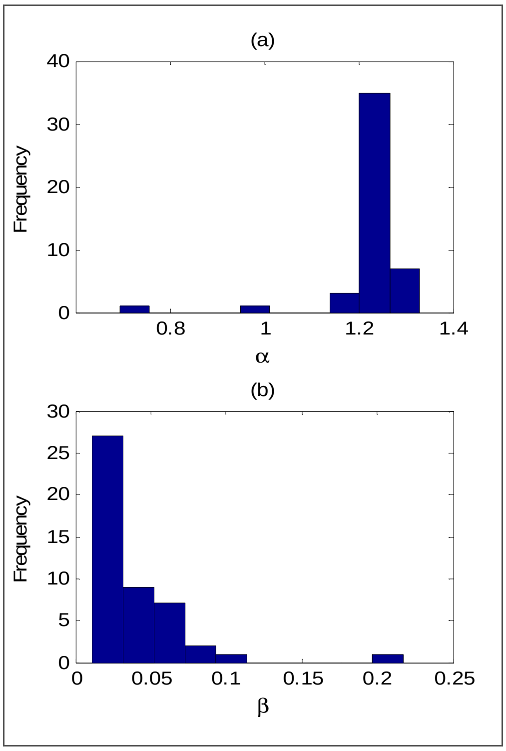

Fig. 6 (a) Frequency distribution of Angstrom exponent according to MODIS data of 2005, (b) Frequency distribution of Angstrom coefficient according to MODIS data of 2005.

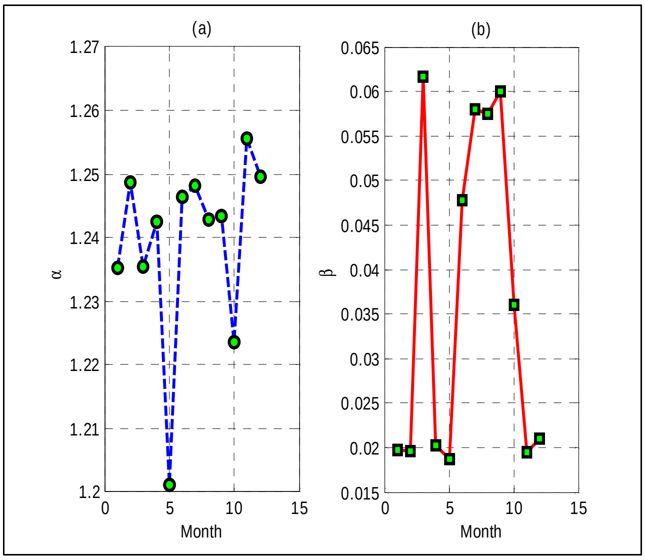

Fig. 7 (a) Angstrom exponent obtained from MODIS data, (b) Angstrom coefficient obtained from MODIS data.

Figure 7shows the variation of Angstrom coefficient and Angstrom exponent for MODIS data. The values of α show a variability from month-to-month with values ranging from 1.256 to 1.201. For those of β, they indicate higher turbidity values during summer and autumn months. The maximum and minimum values of β are 0.062 and 0.019 respectively. We can notice a significant value of β during March month. This is due to the lack or the small number of measurements during the month.

5. Conclusion

This work is devoted to calculate the turbidity parameters are obtained from the analysis of MODIS data of 12 months for year 2005 (Ghardaia area). We have found that the most dominant of optical thickness in study area lies between 0.02 and 0.03. This implies that the transmission of solar radiation can reach 95%. We have found also that the angstrom exponent values lies between 1.2 and 1.13 and for the turbidity factor, it lines between 0.02 and 0.07.

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