Sección Especial: 37th AMASON / Special Section: 37th AMASON
Aerosols in the Atmosphere

Preliminary characterization of columnar aerosol properties (AOD-AE) at the Saharan Tamanrasset (Algeria) station

Caracterización preliminar de las propiedades del aerosol en columna (EOA-EA) en la estación sahariana de Tamanrasset (Argelia)

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ABSTRACT:

A Cimel sun photometer has been in operation at Tamanrasset station since late 2006. In this study, more than two years of aerosol measurements have been analyzed from October 2006 to January 2009. Two parameters, aerosol optical depth (AOD) and Ångström exponent (AE), have been used for this preliminar characterization. At this station, the mean AOD is 0.25±0.15 and the mean AE is 0.48±0.23. Both time series data show a clear seasonal cycle. A dry-cool season (fall and winter time), characterized by low AOD and high AE values, and a wet-hot season (in spring-summer), with strong and frequent mineral dust storms, giving high AOD and low AE values, are observed at Tamanrasset. Both, AOD and AE values show the behaviour of a station where desert mineral dust is the prevailing aerosol defining the characteristic of the site. However a significant number of episodes with AE values around 1 together with AOD greater than 0.2 have been found, what suggests the presence of pollution derived aerosols.

Keywords: Aerosol Optical Depth, Ångström Exponent, Desert Mineral Dust.

RESUMEN:

Desde finales de 2006, un fotómetro solar Cimel está en funcionamiento en la estación de Tamanrasset. En el presente estudio han sido analizados más de dos años de medidas de aerosoles, realizadas entre octubre de 2006 y enero de 2009, y han sido usados dos parámetros, el espesor óptico de aerosoles (EOA) y el exponente de Ångström (EA), para esta caracterización preliminar. En esta estación el promedio de EOA es 0.26±0.15 y el de EA es 0.45±0.20, aunque ambas series de datos muestran un claro ciclo estacional. Dos tipos de estaciones han sido observadas en Tamanrasset, una seca y fría (en otoño e invierno) caracterizada por valores bajos de EOA y altos de EA, y otra húmeda y cálida (en primavera y verano), de fuertes y frecuentes tormentas de polvo mineral, con valores altos de EOA y bajos de EA. Los valores tanto del EOA como del EA muestran el comportamiento propio de una estación en la que el polvo mineral desértico es el aerosol dominante, aunque existe un significativo número de episodios con valores de EA en torno a 1 y EOA mayores que 0.2 los cuales sugieren la presencia de aerosoles derivados de la polución.

Palabras clave: Espesor Óptico de Aerosoles, Exponente de Ångström, Polvo Desértico Mineral.

REFERENCIAS Y ENLACES / REFERENCES AND LINKS

[1]. Intergovernmental Panel on Climate Change (IPCC). <u>*Climate Change 2007: The Physical Science Basis*</u> , Cambridge University Press, New York, USA (2007).

[2]. J. M. Prospero, P. Ginoux, O. Torres, S. E. Nicholson, T. E. Gill, "Environmental characterization of global sources of atmospheric soil dust identified with the NIMBUS 7 Total Ozone Mapping Spectrometer (TOMS) absorbing aerosol product", *Rev. Geophys.* **40**, 2-1 – 2-31 (2002).

[3]. O. Dubovik, M. D. King, "A flexible inversion algorithm for retrieval of aerosol optical properties from Sun and sky radiance measurements", *J. Geophys. Res.* **105**, 20673–20696 (2000).

[4]. http://aeronet.gsfc.nasa.gov

[5]. V. E. Cachorro, P. M. Romero, C. Toledano, E. Cuevas, A. M. de Frutos, "The fictitious diurnal cycle of aerosol optical depth: A new approach for "in situ" calibration and correction of AOD data series", *Geophys. Res. Lett.* **31**, L12106 (2004).

[6]. S. Basart, C. Pérez, E. Cuevas, J. M. Baldasano, G. P. Gobbi, "Aerosol characterization in Northern Africa, Northeastern Atlantic, Mediterranean Basin and Middle East from direct-sun AERONET observations", *Atmos. Chem. Phys*. **9**, 8265–8282 (2009).

1. Introduction

Last years scientific studies of the influence of atmospheric aerosols on climate have broaden the knowledge about its climate forcing. However, large uncertainties still exist about the radiative forcing of this type of particles [1].

Mineral dust is one of the main sources of aerosols in the atmosphere and the Saharan desert is the largest and quasi-permanent dust source in the world. Saharan dust usually affects Mediterranean and European countries and it can even be transported to the Caribbean area across the North Atlantic Ocean [2]. On the other hand, the physical and chemical properties of mineral aerosol depend on the dust source region and therefore it is important the characterization of mineral dust close to the sources [3].

Within this framework, at the end of September 2006 a Cimel sunphotometer was set up at Tamanrasset (Algeria) by the Izaña Atmospheric Research Center (AEMET) in collaboration with l'Office Nationale de la Météorologie (Algeria). This station was integrated in the AERONET network as a strategic site within the Global Atmospheric Watch (GAW) programme for its situation in the heart of the Sahara, and, a priori, representative of pure desert dust, free of industrial activities.

This work provides a preliminar analysis of more than two years of aerosol measurements at Tamanrasset focused in the characterization of the aerosol optical depth (AOD) and the Ångström exponent (AE) as basic parameters for aerosol description.

2. Results

2.a. Cimel data sets

From October 2006 to January 2009 a data set of level 2.0 (cloud screened and quality-assured) aerosol measurements at Tamanrasset is available at AERONET database [4]. However, around six months of data in 2008 did not achieve this level 2.0. A detailed analysis of data shows a strong fictitious diurnal cycle within this six months dataset. A part of the problem is the regular maintenance schedule followed for the photometer which is not sufficient for sites which receive intense dust intrusions on a frequent basis. In future work the KCICLO method [5] will be used to correct the calibration factor and upgrade this dataset. In this preliminary characterization the level 1.5 data are used to fill these six months gap in level 2.0.

A statistical summary of the spectral AOD and the AE is summarized in Table I. The mean AOD is 0.25±0.15 and the mean AE is 0.48±0.23. Both, AOD and AE values show the behavior of a station where desert mineral dust is the prevailing aerosol.

TABLE I

Five AOD channels and AE statistics evaluated from AERONET level 2 daily and monthly mean values for this dataset at Tamanrasset.

PARAMETER(nm)	AOD(1020)	AOD(870)	AOD(675)	AOD(440)	AOD(380)	AE(440-870)
MEAN	0.198	0.209	0.226	0.249	0.263	0.480
STD. DEV.	0.138	0.142	0.147	0.148	0.150	0.226
MAXIMUM	2.110	2.159	2.206	2.180	2.165	1.570
MINIMUM	0.003	0.006	0.010	0.016	0.021	-0.002
MEDIAN	0.219	0.235	0.258	0.282	0.292	0.459

However, the frequency histograms (Fig. 1 and Fig. 2) show that a 60% of AOD measurements are below 0.15 (cumulative frequency at Fig. 1) but about a 85% of the AOD values are above 0.15 at those stations located southward of Saharan sources [6]. It means significant less AOD at Tamanrasset than a priori expected. On the other hand a discussion on pollution derived aerosols observed at Tamanrasset is introduced in section 2.c.

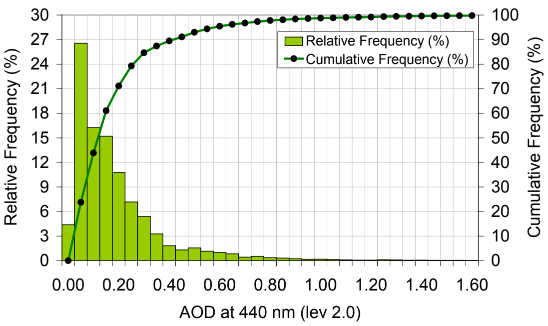

Fig. 1: Frequency histogram of AOD at 440 nm at Tamanrasset.

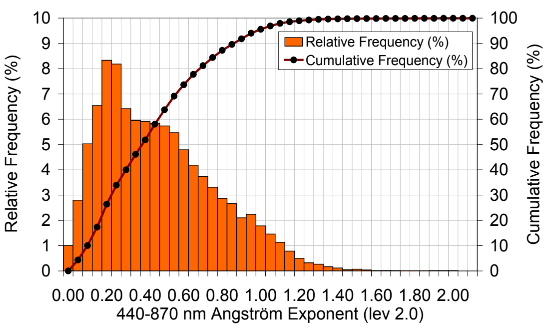

Fig. 2: Frequency histogram of Ångström exponent at Tamanrasset.

2.b. Temporal evolution of AOD and Ångström exponent

The temporal evolution of the whole data set is presented in Fig. 3. Both time series data, AOD and AE, show a clear seasonal cycle (Fig. 3 and Fig. 4). A dry-cool season (fall and winter time) is characterized by low AOD (~0.10) and high AE values (~0.70), and a wet-hot season (in spring-summer), with strong and frequent mineral dust storms, giving high AOD (~0.40) and low AE values (~0.30), are observed at this station. The spring-summer season is driven by a strong and thick convective boundary layer over Tamanrasset which has been analysed using the rawinsonde dataset (Fig. 5).

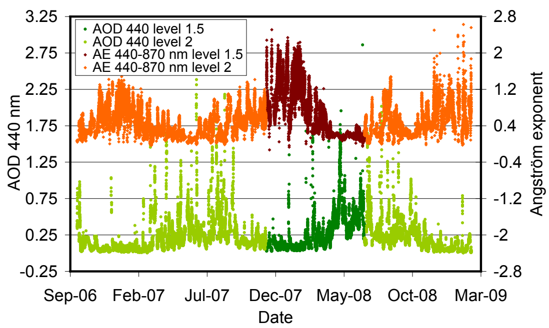

Fig. 3: Temporal evolution for AOD at 440 nm and for 440-870 nm AE (all points values).

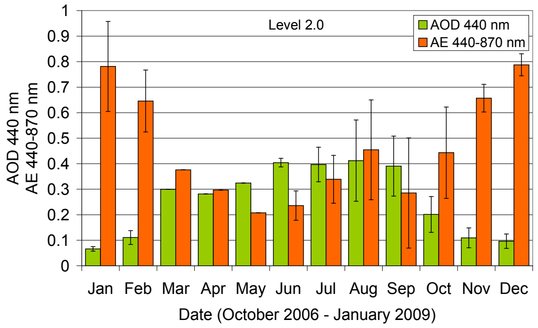

Fig. 4: Monthly means of AOD at 440 nm and Ångström exponent at Tamanrasset, calculated using the AERONET level 2 monthly mean values. Error bars indicate standard deviation. Only one month level 2.0 data are available on March, April and June.

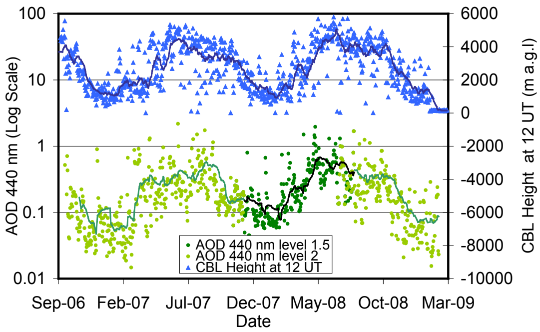

Fig. 5: Temporal evolution for AOD at 440 nm (daily mean values) and for the Convective Boundary Layer height (CBL) determined from the 12 UTC soundings in Tamanrasset. Solid lines are the corresponding moving averages.

2.c. Aerosol types

Apart from the mineral dust presence there are two kind of scenarios to be analysed: high turbidity events not related to desert mineral dust but linked to pollution derived aerosols, and clean air masses events during fall and winter time. The Gobbi's graphical method is used in this task to discriminate different aerosol types and the HYSPLIT back trajectories are used to analyse the origin of the air masses arriving to Tamanrasset.

The presence of pollution derived aerosols is suggested for a significant number of episodes with Ångström exponent values around 1 together with AOD greater than 0.2 (green boxes in Fig. 6). One of these episodes was observed in August'07. The corresponding HYSPLIT back-trajectories (Fig. 7) show air masses coming far from the north-east of Tamanrasset where important gas well flares are in operation.

On the other hand, the presence of no dust loaded air masses during the dry-cool season is suggested for the high frequency of AOD below 0.15 (Fig. 1 and Fig. 2).

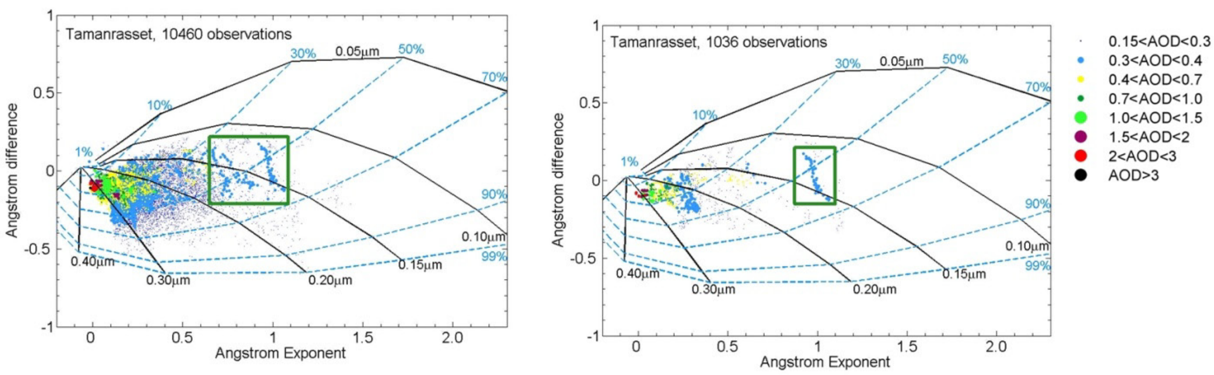

Fig. 6: Ångström exponent difference, δα=α(440,675)–α(675,870), as a function of the 440–870 nm Ångström exponent and AOD at 440 nm (color code) evaluated using the AERONET level 2 all points values. The first graph is for the whole dataset. The second graph is only for measurements from August'07.

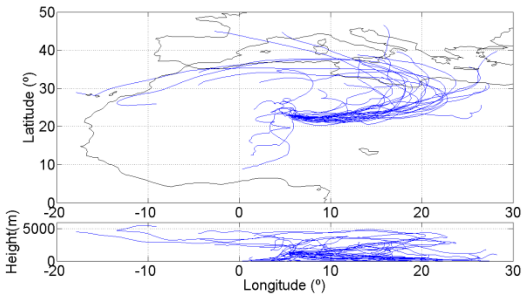

Fig. 7: HYSPLIT five days back-trajectories over Tamanrasset at 1377 m a.g.l. on August'07. Similar results are found at 3000 and 4000 m a.g.l.

3. Conclusions

A preliminar characterization of the Tamanrasset station have been provided based on more than two years of aerosol measurements. In this period, six months of data do not achieve the level 2.0 from AERONET but the level 1.5 has been used to fill the data set. The results agree on a station where desert mineral dust is the prevailing aerosol with a strong seasonal cycle, linked to the CBL. Mineral dust storms are frequent in summer time while low AOD and high AE values are observed in winter time. Finally, high turbidity events related to pollution derived aerosols have been found and will be studied in detail in future works.

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