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Aerosols in the Atmosphere

Analysis of aerosol scattering coefficient measurements between 2006 and 2008 at El Arenosillo station

Análisis de medidas del coeficiente de dispersión de aerosoles entre 2006 y 2008 en la estación de El Arenosillo

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ABSTRACT:

Aerosol scattering properties have been measured over two years (January 2006 to May 2008) at the monitoring station ESAT-El Arenosillo as part of the development of the "Laboratorio de Medida de Aerosoles" in situ into the scientific collaboration between INTA National Institute of Aerospace Technique of Spain) and "Atmospheric Optics Group of the University of Valladolid (GOA-UVA). This station belonging to INTA is located in the coastal area of the province of Huelva (Southwestern of Spain). Light scattering coefficient σ_{sp} and hemispheric back-scattering coefficient σ_{bsp} were measured using a 3-wavelengths (450, 550 and 700 nm) integrating nephelometer of TSI Model 3563, under specified GAW dry conditions. Ångström exponent α has been also derived from the spectral scattering dependence and the hemispheric backscatter fraction b from the ratio σ_{bsp}/σ_{sp}. All these parameters have been carefully analyzed to investigate their general characteristics and features, as annual, seasonal and diurnal variability.

Keywords: Atmospheric Aerosol, Scattering, Measurement, Nephelometer.

RESUMEN:

De enero de 2006 a Mayo de 2008 se llevó a cabo la medida de las propiedades dispersoras o de "scattering" de los aerosoles en la estación ESAT-El Arenosillo como parte del desarrollo del "Laboratorio de medida de aerosoles" in situ dentro de la colaboración científica entre el INTA (Instituto Nacional de Técnica Aeroespacial) y el Grupo de Óptica Atmosférica de la Universidad de Valladolid (GOA-UVA). Esta estación perteneciente al INTA esta ubicada en el área costera de la provincial de Huelva, en el sur-oeste de España. El coeficiente de dispersión o "scattering" σ_{sp} y el coeficiente hemisférico de "back-scattering" o retrodispersión σ_{bsp} se han medido con un nefelelómetro integrador de la marca TSI, Modelo 3563, que tiene 3 longitudes de onda de trabajo, 450, 550 y 700 nm. Las medidas se han realizado en condiciones "secas" de acuerdo a las especificaciones GAW. De estos parámetros se deriva el exponente de Ångström, α, debido a la dependencia espectral de σ_{sp} y la fracción de "backscattering" b que se define como σ_{bsp}/σ_{sp}. Todos estos parámetros han sido cuidadosamente analizados para investigar sus características generales, como su variabilidad anual, estacional o diaria.

Palabras clave: Aerosol Atmósferico, Medidas, Scattering, Nefelómetro.

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1. Introduction

Measuring aerosol scattering properties is a necessary task in atmospheric aerosol studies in order to establish the characterization of a given area o region, in our case the area under study is the coastal area in Southwestern Spain, known as the Cadiz Golf. This geographical area is affected by a great variety of air masses with the predominance of Atlantic oceanic air masses but also with the frequent occurrence of those from continental and desert African origins [1]. Local pollution due to the nearby Palos-Huelva industrial belt has its influence on surface aerosol measurements.

The area is well characterized in term of columnar aerosol properties [2-5] and different studies have been also carried out based on "in situ" aerosol measurements, as particulate

matter concentration and chemical composition [6,7], size particle distributions [8,9]), absorption coefficients and BC concentration [10-12]. Hence "in situ" aerosol scattering properties [13] is the necessary complement to the above data and information. However, the values of all these parameters are very variable depending on the urban or rural location of the station because of the strong influence of local conditions, such as traffic in urban area and breeze system, the latter being particularly important in this area. The prevailing wind directions are NE and SW, perpendicular to the Atlantic coast line.

2. Instrument and data description

The σ_{sp} and σ_{bsp} coefficients were measured between January 2006 and May 2008 at ESAT-El Arenosillo station (belonging to INTA) located in the south Atlantic coast of Spain (37.1*N*, 6.7*W*) in the province of Huelva. These measurements were performed by means of a 3-wavelengths (450, 550 and 700 nm) TSI Model 3563 integrating nephelometer [13]. The system is located in a little home-laboratory with an 8 meter inlet above the ground and 3 meters above the forest canopy with a particle collecting efficiency of 50% for an aerodynamic radius of 10 μm (more details about the collecting system is given in [13]).

The 10 minutes average measurements were corrected for calibration drift, quality controlled based on local meteorological conditions (precipitation and RH<50%), and finally corrected for instrumental angular truncation of scattering signal using the α parameter value which has been derived from the spectral scattering dependence [14]. The measurements followed the recommendations and protocols of GAW. The so obtained database contained a total of 79303 values, from which 37000 were considered as dry data, as shown in Fig. 1. The lacks in the data are due to instrument breakdown and other different incidences at the El Arenosillo station.

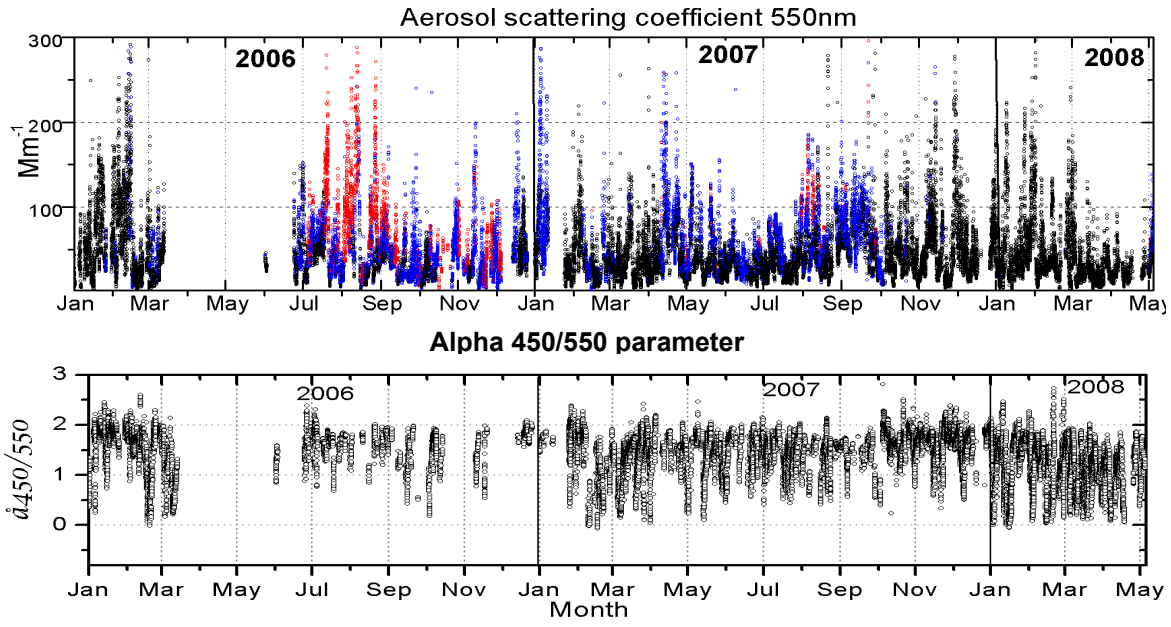

Fig. 1: 10 minutes average sampling measurements of the scattering coefficient σ_{sp}, and the Ångström coefficients, α, for the whole study period, from January 2006 to May 2008. The black dots represent data with relative humidity RH<55%, blue dots are data with RH <70%, and the red dots those with RH >70%.

TABLE I

Statistical parameters of scattering and backscattering coefficients based on hourly average data for the 2006-2008 period, in two different seasons (warm and cold) at El Arenosillo.

(a) Scattering [Mm^{-1}]	Cold station			Warm station			Whole period		
λ [nm]	**450**	**550**	**700**	**450**	**550**	**700**	**450**	**550**	**700**
N	5540	5540	5504	2179	2179	1837	7719	7719	7341
Average	71.4	52.3	36.7	51.6	39.1	30.1	65.8	48.6	35.0
Std	57.1	40.9	27.5	37.8	27.0	19.6	53.1	38.0	25.9
Maximum	428	358	284	449	366	281	449	366	284
Minimum	4.12	2.51	1.24	9.83	7.47	5.81	4.12	2.51	1.24
Median	54.4	40.0	28.6	42.8	33.0	26.2	50.2	37.8	27.8
10^{th} percentil	19.5	15.4	12.0	20.5	16.3	12.9	19.8	15.7	12.3
90^{th} percentil	149	107	70.7	89.1	65.6	49.4	132	95.0	65.6
(b) Backscatter [Mm^{-1}]									
N	5245	5245	5209	1664	1664	1344	6909	6909	6553
Average	7.95	6.29	5.46	5.40	4.31	3.99	7.34	5.81	5.16
Std	5.86	4.75	4.15	2.92	2.25	2.09	5.41	4.36	3.86
Maximum	44.6	38.1	35.3	34.0	26.9	26.3	44.6	38.1	35.3
Minimum	0.78	0.52	0.35	1.09	0.86	0.89	0.78	0.52	0.35
Median	6.22	4.96	4.32	4.74	3.83	3.54	5.77	4.59	4.14
10^{th} percentil	2.47	2.05	1.84	2.49	2.04	1.87	2.47	2.04	1.84
90^{th} percentil	15.9	12.3	10.4	8.99	7.03	6.43	14.2	11.0	9.52

TABLE II

Statistical parameters of hourly alpha for the whole period of study.

	Mean	STD	Median	P90	P10
450/550 nm	1.44	0.46	1.56	1.90	0.74
450/700 nm	1.35	0.53	1.48	1.95	0.53
550/700 nm	1.29	0.62	1.40	2.01	0.36

3. Results

Hourly data were calculated providing 66.6% of the measurements were available. The statistical analysis based on hourly data allows the general characterization of the scattering aerosol optical properties by the representative values over the area of study, which can be seen in Table I for the whole period and for the cold and warm periods. For the whole period the average and standard deviation for σ_{sp} (550) was 48.6 ±38.0 Mm^{-1} a value which is the same as that obtained considering daily mean values (48.5±32.6). The median is 37.8 Mm^{-1}, thus a lower value which indicates that most frequent values are below the mean value, as it found observing the distribution of the frequency of occurrence (histogram not shown). The 90th and 10th percentiles of σ_{sp} (550) are 101.7 and 15.4 Mm^{-1} respectively and the maximum and minimum values are 366 and 2.5 Mm^{-1} respectively.

The seasonal analysis was performed considering only a cold (October to March) period and a warmer (April to September) period (see Table I) as the data seem to indicate a clear differentiation. The two years of data are not enough to provide a good seasonal evaluation. Table I shows larger values for all the parameters during the cool season than in warm months.

The backscattering coefficient at 550 nm shows an average value of 5.8±4.3 for the whole measurement period and 6.3 ±4.7 Mm^{-1} for the cold season and 4.3 ±2.2 Mm^{-1} for the warn season (Table Ib). Also the median presents lower values than the mean.

For the entire database, the hourly average and standard deviation for the parameter α(450/700) was 1.35±0.53. Other values taking other pair of wavelengths are shown in Table II. Lowest values of α around 0.5 are coincident

with high turbidity measurements (values about 150 Mm^{-1} and higher) which are associated with the presence of desert dust aerosols.

The analysis of the daily cycle is also carried out (figures not shown) where the highest values of σ_{sp} appear between 12:00-15:00 GMT during warm months, and this maximum shifts to 00:00 GMT for cold months while a minimum appears around 17:00 GMT. The diurnal cycle of α also shows notable differences depending on the season: the high average values observed in the afternoon in the warm season contrast with the low averages in the cold season. Further information about the analysis of this data can be seen in [13]. Finally the hemispheric backscatter fraction *b* for 550 nm has a mean value of 0.12±0.02.

4. Conclusions

The values and variability of the scattering properties measured under dry conditions at El Arenosillo station characterize this local zone as typical coastal and rural [6,7] with predominance of relatively low values, which are influenced by the anthropogenic emission of the industrial type sources around the city of Huelva. These in situ aerosols are frequently affected by the arrival of desert dust aerosols and also by local re-circulations in summer. However most of the data affected by desert dust aerosols has been removed of the analysis because of the high humidity into the nephelometer (most of them in summer months). The diurnal cycles of σ_{sp} and α do not follows the typical diurnal cycles of thermodynamic variables as temperature or relative humidity, instead they appear to be governed by seasonal regimes of land-sea breeze.

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