Medições de longo termo, in situ à superfície, de propriedades ópticas dos aerossóis em Évora, Portugal

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Introduction

The evaluation of the direct effect of aerosols on climate (due to their interaction with solar and terrestrial radiation via scattering and absorption processes) requires quantitative information on their optical properties. Long term measurements at different locations are necessary for characterizing both the aerosol field and climatology in order to decrease the uncertainties in radiative forcing estimations. Spectral scattering coefficients, $\sigma_{sp}(\lambda)$, are measured at Évora Geophysics Centre's (CGE) Observatory since 2002, with an Integrating Nephelometer (TSI-3563) at the wavelengths λ = 450, 550 and 700 nm. The Ångstrom exponent, α, which is related to size distribution, was calculated with the wavelengths of 450 and 700 nm:

$$\alpha = -\frac{\log(\sigma_{sp}(700)) - \log(\sigma_{sp}(450))}{\log(700) - \log(450)} \qquad \text{(eq. 1)}$$

Measurements of absorption coefficient, $\sigma_{ap}(\lambda)$, at 670 nm, were performed since 2007 with a Multi-Angle Absorption Photometer (Thermo Scientific, Model 5012).

Évora is a small sized city (~60000 inhabitants) located on the south-western sector of the Iberian Peninsula. It's surrounded by a rural area of low population density. No major polluting industries are present in the area; therefore the local anthropogenic production is essentially related to traffic and biomass burning for heating during the colder fall and winter periods. The aerosol load is frequently of moderate to low magnitude, hence the site is suitable for monitoring long-range transported particles from other regions, namely dust from Sahara and pollution from major industrial/urban areas or due to forest fires (Elias et al., 2006; Pereira et al., 2008).

Data and methodology

Scattering coefficients data are based on nephelometer's measurements performed during the years of 2002 to 2008, while absorption coeficient's measurements started in 2007 and extend until 2009. Hourly values of the measured properties are used for calculating other longer term statistical quantities in order to obtain aerosol description and climatology for the site.

Results, discussion and conclusions

Figure 1 shows the time evolution of $\sigma_{sp}(550)$, α and $\sigma_{ap}(670)$ hourly values. Monthly average values of the same quantities are shown in figure 2. Table 1 accounts for the seasonal averages, considering winter (DJF), spring (MAM), summer (JJA) and fall (SON).

	$\sigma_{sp}(550)$ (Mm^{-1})	**α**	**$\sigma_{ap}(670)$ (Mm^{-1})**
Winter	53.5±46.1	1.6±0.5	12.0±11.5
Spring	34.7±27.1	1.2±0.5	7.0±5.8
Summer	47.1±66.3	1.4±0.4	5.7±3.8
Autumn	36.9±30.6	1.4±0.5	9.7±8.9
All data	42.5±46.0	1.4±0.5	8.5±8.2

Table. 1.- Seasonal average values (± standard deviation) of $\sigma_{sp}(550)$, α and $\sigma_{ap}(670)$.

A seasonal variation of the scattering and absorption coefficients is observed with higher values in winter; this is likely due to the combined effect of biomass burning due to heating added to the usual traffic and a low mixing layer height). Also the summer peak observed only for $\sigma_{sp}(550)$ is mainly related to forest fires aerosols transported to the site; the highest hourly values ever observed at the CGE observatory (~ 2000 Mm^{-1}) were measured under these conditions. However, the number of forest fires (and burnt areas) decreased dramatically since 2007; thus, since the measurements of σ_{ap}(670nm) started in 2007 extreme values were rarely observed in the summers of 2007 to 2009. The values of α indicate that the aerosol population is, in general, clearly dominated by sub-micrometer particles. The winter and summer peaks are a sign of the input of these small particles related with biomass burning as abovementioned.

Figure 3 shows the daily evolution of $\sigma_{sp}(550)$ and $\sigma_{ap}(670)$ considering the days with normal human activities (working days, from Monday to Friday) as well as Sundays. The morning and afternoon peaks are clearly visible and are related with the traffic rush hours; no morning peak is observed when only

Sundays are considered because the city is usually quiet in these periods. The lower values measured during the night and middle afternoon reflect the decrease in the local production and the aerosol mixing and dilution in the afternoon well developed boundary layer.

Besides the daily patterns of $\sigma_{sp}(550)$ and $\sigma_{ap}(670nm)$, which are related in particular with local features, emphasis is also given to the magnitude and type of transported aerosols to the site. For this purpose the measured optical properties were related to back-trajectories (Rolph, 2003; Draxler and Rolph, 2003), calculated at 12:00 (at 500 m) and one per day. In order to keep temporal consistency between the trajectories arrival and measured optical properties, hourly values of $\sigma_{sp}(550)$, $\sigma_{ap}(670)$ and α at 13:00 (i. e. between 12:00 and 13:00) were used. In this analysis the trajectories were classified as follows (figure 4): the Atlantic originated ones (by far the most frequent) were distinguished to take in account the fact of arriving Évora following a "straight" path with minimum continental influence (maritime) or traversing portions of the Iberian Peninsula (maritimeIB); this includes trajectories entering from the northern IB or with circulations within IB before reaching Évora. Three other types of trajectories-from Europe, Africa and Iberian (re circulations within IB) were also defined. Figure 5 shows the relative frequency distributions of $\sigma_{sp}(550)$, $\sigma_{ap}(670)$ and α according to the different air mass types. The values of $\sigma_{sp}(550)$ are s**y**stematically low (and narrow distributed) for trajectories representing maritime air masses but as soon as the air masses acquire continental influence (i.e. become maritimeIB) not only a large portion of $\sigma_{sp}(550)$ values increase significantly but also the distribution of α shifts towards larger values and values <1 become much less frequent. This indicates that the maritime influence (coarse particles) has been lost and continental influence has increased. When the trajectories are from Europe or Iberia $\sigma_{sp}(550)$ and α also experience higher values. In the latter situation (Iberian) the values of $\sigma_{sp}(550)$ are consistently higher likely because this regime with low advection conditions might lead to the accumulation of particles in the atmosphere. In the case of trajectories from North Africa the values of $\sigma_{sp}(550)$ are high but the Angstrom exponent does not comprise only low values (due to coarse dust). This means that when trajectories have African origin desert dust particles usually doesn't dominate the aerosol at the ground or aren't even present and the higher aerosol loads **c**ould be caused by anthropogenic particles. The $\sigma_{ap}(670)$ distribution appears to have a weaker dependence on the trajectory types, suggesting that black carbon is mainly of local origin.

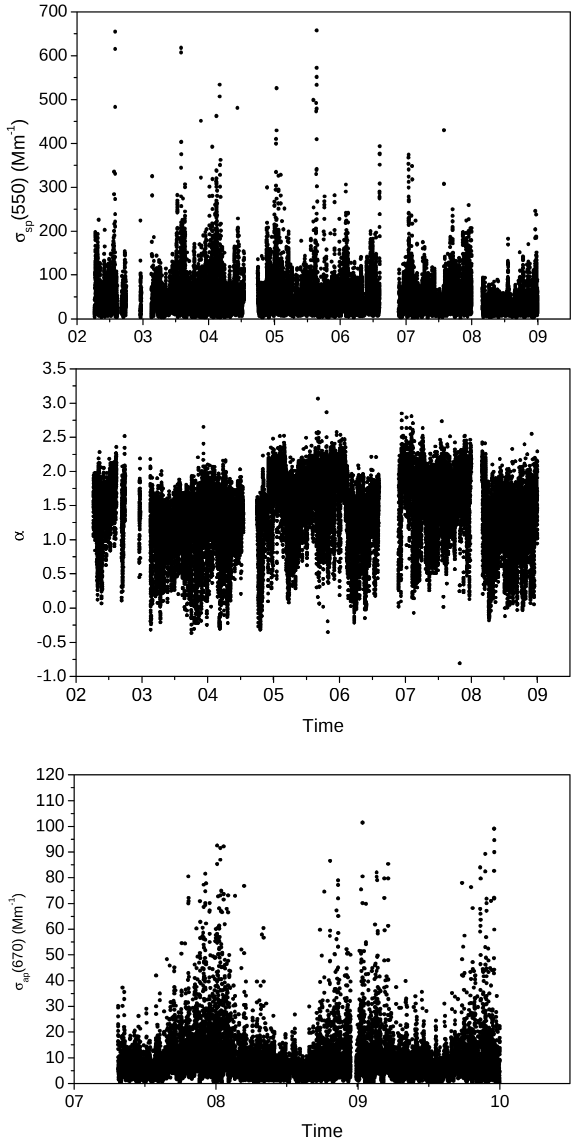
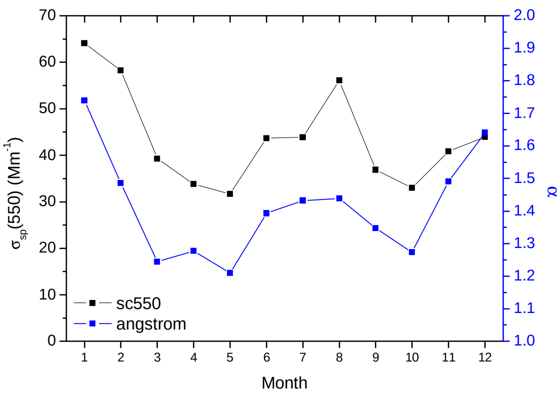


Fig. 1.- Time series with the hourly values of $\sigma_{sp}(550)$ (top), α (middle) and $\sigma_{ap}(670)$ (bottom).



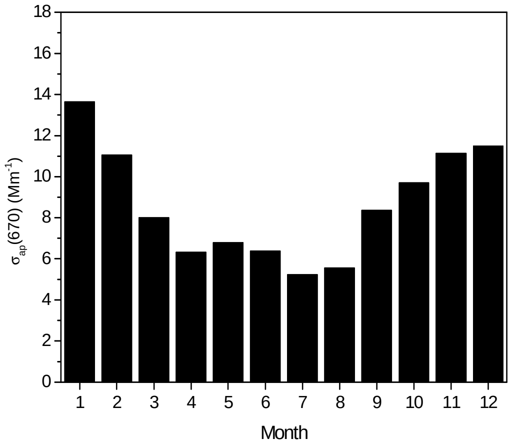


Fig. 2.- Monthly variation of $\sigma_{sp}(550)$ and α (top) and $\sigma_{ap}(670)$ (bottom).

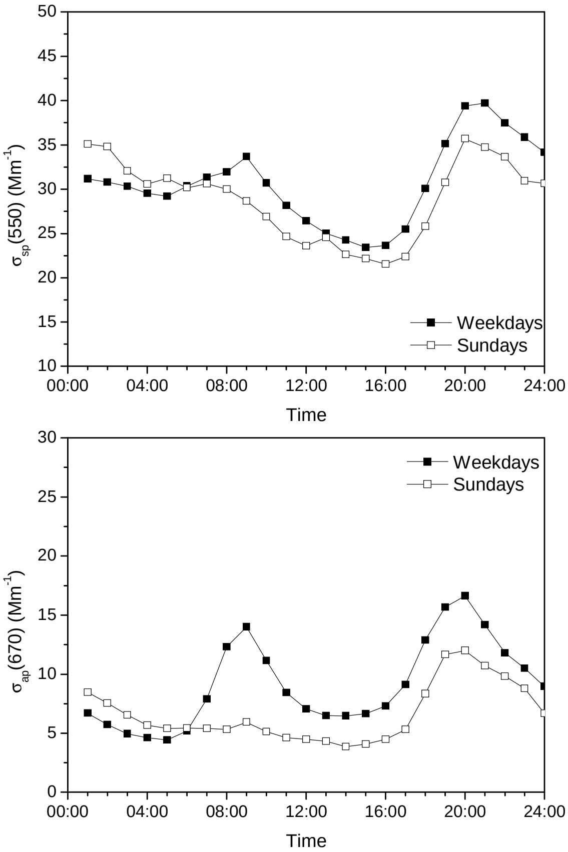


Fig. 3.- Daily evolution of σ_{sp}(550nm) (top) and σ_{ap}(670nm) for working days and Sundays (bottom).

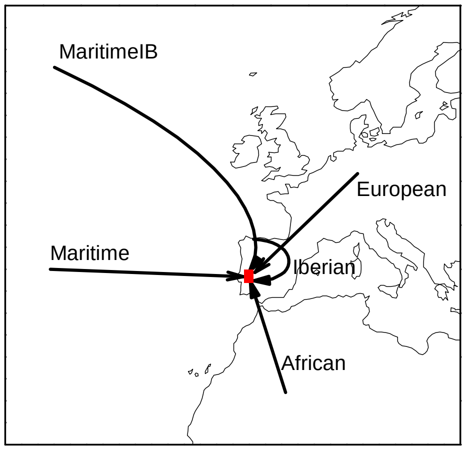


Fig. 4.- Pictorial representation of different trajectories paths arriving Évora (at 500m height).

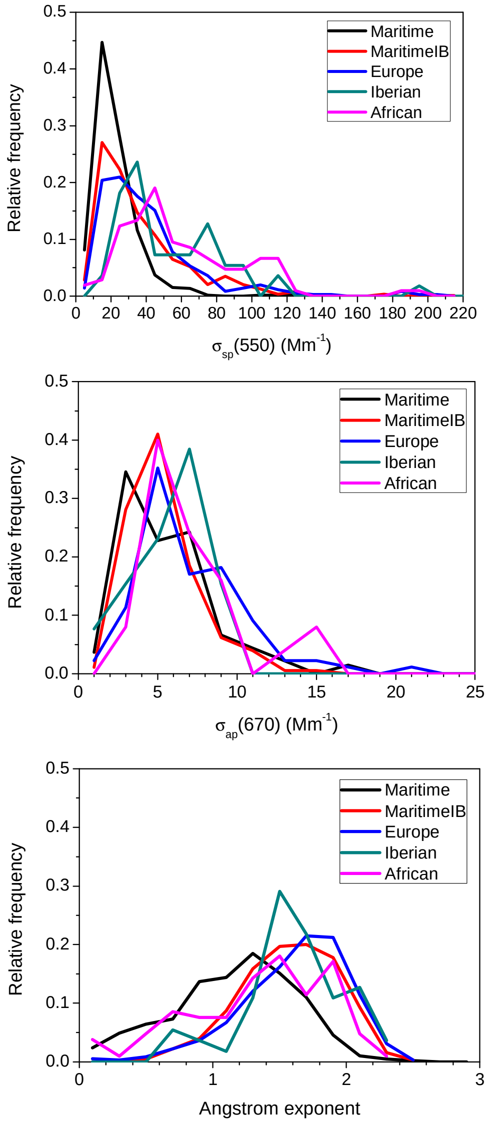


Fig. 5.- Relative frequency distribution of $\sigma_{sp}(550)$ (top), $\sigma_{ap}(670)$ (middle) and α (bottom) for different types of back-trajectories.

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