A simulation method for estimating the accuracy of aerosol source apportionment by dual wavelength optical absorption measurement

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Aerosol source apportionment is one of the outstanding challenges for environmental monitoring. Aerosols from different sources usually have distinct chemical and physical properties. There are various methods for aerosol source apportionment but among them size distribution or optical absorption measurements are among the simplest yet remarkably accurate ones especially compared to laborious chemical analysis. In many cases the wavelength dependence of the optical absorption coefficient (*OAC*) can be accurately characterised by the so called Absorption Angström Coefficient (*AAE*). The fact that both size distribution and *AAE* are source dependent (Favez *et al* 2009) provides us an opportunity for using the former one as a calibration method for the latter one (Utry *et al* (2014), Favez *et al* (2010)).

The proposed simulation method can be used to estimate the accuracy of source apportionment in case of a dual wavelength photoacoustic system and whenever aerosol dominantly originating from two distinct sources. It has two steps. During the first one parameters of a calibration curve (Ajtai *et al* (2015) which correlates the photacoustically measured *AAE* with the relative strength of the two sources determined by an independent method (e.g. chemical or size distribution analysis) are calculated. In the measurement step the parameters are used to estimate the ratio of source strengths from the PA measurement. The noise of the PA measurements and the limited source strength ratio range on which the calibration can be implemented leads to certain inaccuracy in the source strength ratio estimates. The relative error of the estimated source strength ratios is used to qualify the simulated PA systems.

We applied the proposed method to a concrete case when simulation was performed on data collected during an urban measurement under wintry conditions when traffic and wood burning were the dominant aerosol sources and we examined that how the selection of the two measurement wavelengths from a pool of commercially available lasers influences the accuracy of the source strength ratio determination. Source strengths were represented by N_{ff} and N_{wb}, i.e. the number concentration within the 20 nm and 100 nm mode corresponding to fossil fuel and wood burning, respectively.

We evaluated the simulation results repeated for each of the possible wavelength pairs by setting 10% to be an acceptable accuracy limit of the source strength ratio determination. Based on the results of the simulation 405 nm and 808 nm lasers were found to be the best choices for building a dual wavelength photoacoustic system for aerosol source apportionment.

Type	Wavelength (nm)	Output power (mW)
Nd:YAG	266	7
Nd:YAG	355	14
Nd:YAG	532	70
Nd:YAG/diode	1064	350
diode	405	70
diode	808	350

Table 2. Wavelengths and output powers of lasers used in our simulations

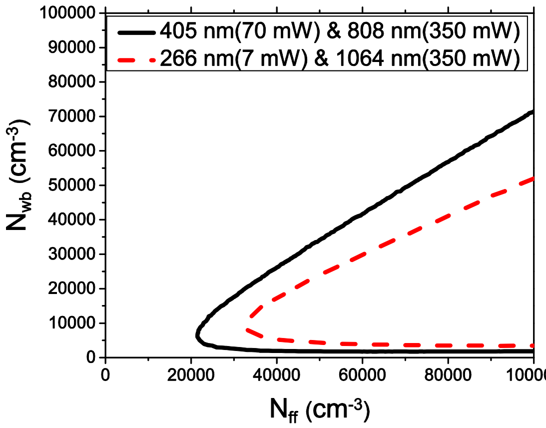

Figure 1. Contour lines corresponding to 0.1 relative errors on the $N_{ff} - N_{wb}$ plane.

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