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AEROSOL SCATTERING COEFFICIENTS AT DIFFERENT HUMIDITIES

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INTRODUCTION

The Beer-Lambert law describes the light attenuation during its travel through an absorbing and/or scattering medium. The spatial attenuation rate is called the extinction coefficient σ_{ext}, which is separated into four components: gas absorption σ_{ag}, gas scattering σ_{sg}, particle absorption σ_{ap}, and particle scattering σ_{sp}. For visible wavelengths, light scattering by atmospheric aerosols σ_{sp} dominates the extinction. Therefore, σ_{sp} is an important index for atmospheric scattering process. The aerosol-causing scattering process has the essential determinants composed of the aerosol size distribution and refractive index.[McCartney 1976] Both of them are related to aerosol water contents. This study evaluates the measurements from a nephelometer in relation to this issue.

METHODS

Figure 1 shows the experimental setup used to measure the scattering coefficient as a implicit function of aerosol water content by means of several dilution ratios of aerosol number concentration. A Collison aerosol generator produced a polydisperse sodium bromide aerosol that was partially dried by dilution air stream free of particles. The size-resolved particle number concentration is measured by TSI Model 3934 scanning mobility particle sizer, SMPS, while the scattering coefficients are measured by TSI Model 3563 integrating nephelometer. Both of the sample streams are drawn from the same cross-section in the dilution chamber, this design provides the same bases to correct the sampling error. The temperature and relative humidity of the stream were measured using the built-in sensors in nephelometer. The heater is set off to minimize the heat interference on sampling stream measured in the nephelometer.

Experiments were performed at a small temperature interval from 292.5 K to 295.5 K. The nephelometer flow rate was maintained at 30 $Lmin^{-1}$. The flow rate of dilution air was manipulated at 30, 35, 40, 45, and 50 $Lmin^{-1}$, respectively. At each dilution ratio, scattering coefficients were measured, as well as size distributions of particles. By considering the inlet and transmission efficiencies corresponding to both SMPS and nephelometer[Willeke and Baron 1993], the particle size distribution measured by SMPS is corrected to yield a result comparable to its nephelometer-caught counterpart. Further calculation of σ_{sp} is also appropriate on this base. From this particle size information, σ_{sp} can be estimated as:

$$\sigma_{sp} = \frac{\pi}{4}\sum_{i}^{m} d_{p,i}^2 Q_{s,i} n_i$$

For our calculations, particle size distributions are divided into 102 size bins with center diameter ($d_{p,i}$) ranging from 16.0 nm to 604.3 nm. The aerosol scattering efficiency, $Q_{s,i}$, is estimated following the approach of Bohren and Huffman (1983) under the assumption that particles are spherical. The refractive index of particle is calculated by assuming each particle is an internal mixture of sodium bromide and water.

Dilution air flow rate (Lmin^{-1})	Measured σ_{sp} (m^{-1})	Calculated σ_{sp} (m^{-1})
50	1.03×10^{-3}	1.23×10^{-3}
45	1.19×10^{-3}	1.33×10^{-3}
40	1.32×10^{-3}	1.47×10^{-3}
35	1.42×10^{-3}	1.51×10^{-3}
30	1.62×10^{-3}	1.86×10^{-3}

Table 1. Comparison between calculated and measured aerosol scattering coefficients.

CONCLUSIONS

Table 1 compares the modeled and measured scattering coefficients as a function of dilution ratio for a wavelength of 550 nm. Though the particle water content can't be directly measured in this study, the relative humidity readings hint its variation with surroundings. Overall, the modeled σ_{sp} values are within 20% deviation of their measured counterparts. The particle scattering coefficient is properly calculated by suggested approach to only some extent.

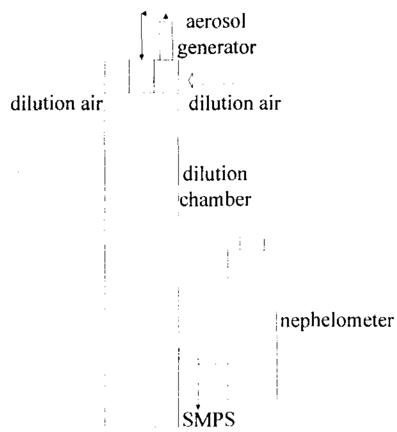

Figure 1. Experimental setup.

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