Intercomparisons and Aerosol Calibrations of 12 Commercial Integrating Nephelometers of Three Manufacturers

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ABSTRACT

This study determined measured and Mie-calculated angular signal truncations for total and backscatter TSI, Inc., nephelometers, as a function of wavelength and for particles of known size and composition. Except for the total scattering channels, similar agreements as in a previous study of measured and calculated truncations were derived for submicrometer test aerosols. For the first time, instrument responses were also determined for supermicrometer test aerosols up to 1.9 μm in geometric mean diameter. These supermicrometer data confirm the theoretical predictions of strong angular truncations of the total scatter signals in integrating nephelometers due to the limited range of measured forward scattering angles. Truncations up to 60% were determined for the largest measured particles. Rough empirical truncation corrections have been derived from the calibration data for Radiance Research and Ecotech nephelometers for which no detailed response characteristics exist. Intercomparisons of the nephelometers measuring urban atmospheric aerosols yield average deviations of the slope from a 1:1 relation with a TSI reference nephelometer of less than 7%. Average intercepts range between +0.53 and -0.19 Mm^{-1}. For the Radiance Research and Ecotech nephelometers ambient regressions of the Radiance Research and Ecotech instruments with the TSI nephelometer show larger negative intercepts, which are attributed to their less well characterized optics.

1. Introduction

First Lieutenant R. G. Beuttell invented the integrating nephelometer during World War II (Beuttell and Brewer 1949). This instrument optically integrates scattered light in an ingenious way from a volume of air over a wide range of scattering angles to derive the scattering coefficient, ideally over the full necessary range of scattering angles from 0° to 180°. Electronically operated integrating nephelometers have been used widely in visibility monitoring and atmospheric research since the 1950s (Ruppersberg 1959). Many modifications and a large number of applications of this type of instrument emerged over the past 50 yr. Relevant for the present investigation is the addition of a backscatter shutter to measure hemispheric backscatter coefficients (Waggoner et al. 1972). A review of this type of instrument was prepared by Heintzenberg and Charlson (1996). With increasing attention to possible radiative forcing of climate by anthropogenic aerosols (Charlson et al. 1991) this instrument gained a central

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