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CALIBRATION OF OPTICAL COUNTERS AND CLOSURE WITH NEPHELOMETER MEASUREMENTS AT THE ARM SITE

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ABSTRACT

Recent studies show that optical counters based upon measurement of the single scattering of visible light not only undersize particles, but that the maximum undersizing occurs in the region where particle diameters are comparable to the wavelength of light used (0.628 mm). One purpose of this study is to theoretically model such refractive-index related-phenomenon, focusing on the Passive Cavity Axial Spectrometer Probe (PCASP) manufactured by the Particle Measuring System, Inc. (PMS). This is achieved by modeling the diameter ratio as a function of indicated diameter, Id (Id refers to the diameter measured by optical counters based upon the standard calibration; the diameter ratio is defined as the ratio of measured diameter to the real diameter). The simple model agrees with the limited measurements available and clearly demonstrates the occurrence of a minimum in the diameter ratio at a particle diameter of 0.5-0.6 mm. Existing theoretical response functions are compared in terms of the modeled diameter ratio as a function of Id. A new formulation is proposed which includes the existing response functions as special cases. The refractive index effect, nominal effect (defined as undersizing caused by phenomena other than refractive index), and the size truncation effect in calculating light scattering coefficients are estimated to be 36.6%, 7.2% and 4.6% for a typical aerosol. A closure experiment is conducted using aircraft data collected during the April 1997 Intensive Observation Period at the ARM site in OK. It is found that the naïve application of Mie theory to PCASP-measured size distributions generally underestimates light scattering coefficients compared to light scattering coefficients measured simultaneously with an integrating nephelometer, and that the underestimation increases with increasing measured light scattering coefficients. The agreement between measured and calculated light scattering coefficients is significantly improved by applying our new calibration scheme to the PCASP measurements. This study suggests two methods for estimating the refractive index of ambient aerosol particles. Implications of this study for estimating aerosol shortwave aerosol radiative forcing are discussed.