Measuring Aerosol Scattering and Absorption - Limitations of the Extinction-Minus-Scattering Method

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Aerosols from biomass burning represent a significant source of particles in the atmosphere. An accurate measurement of the optical properties of these aerosols is critical for measuring their effect on climate, since they represent a large uncertainty. Optically dark aerosols, such as soot, affect the climate system by both cooling (due to scattering) and by warming (due to absorbing), depending on the aerosol's size, composition, and shape. The aim of this work is to quantitatively determine the absorption and scattering cross-sections, single scattering albedo, and angstrom coefficient of soot. Particle extinction (absorption + scattering) was measured with a cavity ring-down spectrometer (CRDS), scattering was measured with an integrating nephelometer, and a condensation particle counter (CPC) measured particle number density. In this work, we perform an assessment of the contributions to systematic and random errors for CRDS, nephelometer, and combined measurements. Extinction cross section measurements are limited by the accuracy of the CPC and, to a lesser extent, measurement variability and cell geometry. Statistical fluctuations of aerosol particles, recapturing of forward-scattered light, laser mode noise, and laser bandwidth effects are negligible. For nephelometer measurements, scattering cross section errors are mostly limited by CPC counting accuracy and the truncation angle correction factor. A comparison between CRDS, nephelometery, and Mie Theory predictions for non-absorbing polystyrene latex spheres shows mean measured cross section values at 584 nm to have an excellent agreement, though all were systematically larger than predicted values. The resulting effects of propagated errors on the accuracy of absorption cross section and single scattering albedo are discussed along with preliminary measurements on absorbing polystyrene.