Size-dependent optical properties of black carbon particles

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Black carbon (BC), a product of incomplete combustion, plays an important role in the earth's climate system through the absorption and scattering of solar radiation. Here, we report on measurements of light absorption and extinction by size-selected BC particles produced from both methane and ethylene flames and test the ability of various optical models to explain the observed optical properties. The fractal-like BC particles were size-selected with a differential mobility analyzer. Measurements were made on nascent soot particles and on particles that had been thermally denuded following coateing with either dioctyl sebacate or sulfuric acid. The coating+denuding process led to a collapse of the initially lacier particles towards more spherical shapes. Model-specific, wavelength-dependent refractive indices for the sampled BC particles have been derived by fitting the observed absorption and extinction cross-sections to both spherical particle Mie theory and Rayleigh-Debye-Gans theory; Mie theory is most commonly utilized by climate models to absorption and extinction cross-sections. In general, Mie theory can be fit well to the observations for particles with size parameters, x, less than ~1.9 (corresponding to a volume equivalent diameter of 160 nm at 532 nm), but for particles with larger x the calculated absorption cross-sections are systemically too low. In contrast, fitting to Rayleigh-Debye-Gans theory allowed for good model-measurement agreement for all particle diameters and wavelengths. These results indicate that the use of spherical particle Mie theory to describe the absorption behavior of BC particles with >160 nm VED (at 532 nm) will underestimate the absorption by these particles. Concurrent measurements of the dependence on particle size and morphology of the absorption Angstrom exponent and the single scattering albedo will also be discussed, along with preliminary results from a new series of experiments assessing the influence of non-absorbing coatings on the light absorption properties of BC-containing particles.