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Effects of water coating on optical scattering properties of fractal soot aggregates.

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Optical scattering properties of hygroscopic atmospheric aerosols can be affected by changes in ambient relative humidity that lead to a layer of water coating the aerosols. We report on numerical simulations of the effect that a coating of water on the constituent monomers of fractal soot aggregates has on the single-scattering properties of the aggregates. A cluster-cluster aggregation algorithm is used to numerically generate fractal aggregates. Comparisons are made between scattering calculations using the analytical Core-Mantle Generalized Multi-particle Mie (CMGMM) method and two approximate methods. The approximate methods involve computation of an equivalent homogeneous aggregate, by either the Maxwell-Garnett or the Bruggeman effective medium theory, to which the Generalized Multi-particle Mie method is applied. The methods are compared on the basis of their representations of the extinction and absorption cross sections, the single-scattering albedo, and the phase matrix of water-coated fractal aggregates: the comparisons are made at the two wavelengths (0.628 and 1.1) corresponding to peaks in the shortwave and longwave terrestrial spectra. A range of coating thicknesses and aggregate "sizes," is considered, where by "size" is meant the number of monomers in the aggregate. Results reported for aggregates are ensemble averages taken over different realizations of the cluster algorithm at each aggregate size.

Water coating of the fractal aggregates is shown by the analytic CMGMM method to increase the extinction and absorption cross sections, the single-scattering albedo, and the forward scattering, and to decrease the backward scattering. In modeling this result, the Maxwell-Garnett theory is found to be clearly superior to the Bruggeman theory, the former giving quite accurate approximations to the scattering properties of the aggregates with water-coated monomers (differences from analytic calculations typically less than 0.5%), while the latter overestimates the extinction and absorption cross sections and underestimates the single-scattering albedo (involving differences from analytic calculations on the order of 5%).