Electromagnetic scattering by soot aerosols

Michael Kahnert[a,b,*] **and Franz Kanngießer**[b]

[a]*Research Department, Swedish Meteorological and Hydrological Institute, Folkborgsvägen 17, 601 76 Norrköping, Sweden*
[b]*Department of Space, Earth and Environment, Chalmers University of Technology, Maskingränd 2, 412 96 Gothenburg, Sweden*

[*]*Presenting author (michael.kahnert@smhi.se)*

Soot aerosols in the atmosphere are among the most important anthropogenic short-lived climate forcers that contribute to global warming. They can also cause respiratory health problems and degrade atmospheric visibility. The optical properties of these particles are of high interest in both climate modelling, remote sensing, and air-quality forecasting. However, modelling electromagnetic scattering by soot particles poses a formidable challenge on account of the particles' morphological complexity and variability. Newly formed soot particles typically form relatively lacy fractal aggregates composed of small, (nearly) spherical monomers of amorphous carbonaceous material. After atmospheric aging, the aggregates become more compact and hydrophilic. This can lead to condensation of liquid-phase material, resulting in soot aggregates encapsulated in a shell of sulfate, organic material, water, salt, or mixtures thereof.

Modelling studies on the optical properties of soot often focus on (i) assessments of the impact of specific morphological features on the optical properties (e.g., [1]); (ii) attempts to achieve closure of optical models and laboratory observations (e.g., [2]); and (iii) efforts to devise simple, yet accurate models that can be employed in environmental modelling and remote sensing (e.g., [3]). In this overview talk, the focus will be on the latter type, which, to a large extent, integrates results obtained from the former two types. The kinds of simplifications we can afford in a soot-optics model strongly depend on its intended use. Typically, we can introduce much more drastic simplifications in applications to climate modelling than in applications to remote sensing and chemical data assimilation. This will be illustrated in the talk by providing examples from each of these problems.

References

[1] Liu, L., Mishchenko, M. I., and Arnott, W. P., 2008: A study of radiative properties of fractal soot aggregates using the superposition *T*-matrix method. *J. Quant. Spectrosc. Radiat. Transfer* **109**, 2656–2663.

[2] Kahnert, M., 2010: On the discrepancy between modeled and measured mass absorption cross sections of light absorbing carbon aerosols. *Aerosol Sci. Technol.* **44**, 453–460.

[3] Kanngießer, F. and Kahnert, M, 2018: Calculation of optical properties of light-absorbing carbon with weakly absorbing coating: a model with tunable transition from film-coating to spherical-shell coating. *J. Quant. Spectrosc. Radiat. Transfer* **216**, 17–36.

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