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Ray optics for absorbing ice crystals

Hannakaisa Lindqvist (1), Julia Martikainen (2), Jukka Räbinä (3), Antti Penttilä (2), Karri Muinonen (2,4)

(1) Finnish Meteorological Institute, Helsinki, Finland (hannakaisa.lindqvist@fmi.fi), (2) University of Helsinki, Finland, (3) University of Jyvaskyla, Finland, (4) Finnish Geospatial Research Institute, Masala, Finland

The optical properties of atmospheric ice crystals are traditionally solved using ray optics. At near-infrared wavelengths, the absorption of ice increases significantly. Because traditional ray optics solutions consider absorption within the crystals approximately, we here present our newly-published assessment of the effects rising from that simplification.

We have updated the ray-optics code SIRIS to take into account the propagation of light as inhomogeneous plane waves inside an absorbing particle. We have investigated the impact of this correction on the ray-optics computations for two example habits of ice particles through the near-infrared wavelengths, where the refractive index of ice has a high spectral dependence.

We show that the correction for the treatment of absorption systematically increases the single-scattering albedo throughout the near-infrared spectrum for both randomly-oriented, column hexagonal crystals and ice particles shaped like Gaussian random spheres. We also present results for the phase function and other scattering-matrix elements that show generally minor differences. We evaluate the correction for inhomogeneous waves through comparisons against an exact light scattering method (the discrete exterior calculus), and our comparisons agree that the consideration of the inhomogeneous waves brings the ray-optics solution generally closer to the exact result. Therefore, these results should be taken into account when considering the radiative properties of ice particles at near-infrared wavelengths.