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Beam Tracing with Diffraction

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It is well accepted that uncertainties still persist regarding the quantitative contribution of ice clouds to the radiative balance of the Earth [1]. Techniques for modelling the interaction of light with ice crystals found in these clouds have helped reduce this uncertainty; however techniques such as the discrete dipole approximation (DDA) [2] and T-matrix [3] are computationally expensive for particles with large size parameters. Despite the success of geometric optics (GO) and its variants for modelling electromagnetic scattering by such ice crystals, their accuracy is still limited by their use of approximations of phenomena associated with physical optics, for example, diffraction. Advances in GO methods have been proposed resulting in hybrid physical - geometric optics models, for example [4,5] which consider diffraction on facets and on equivalent circular areas respectively; alternative hybrid methods have been discussed in [6,7].
The Beam Tracing with Diffraction (BTD) code developed at the University of Hertfordshire is a new hybrid model for numerical determination of the phase matrix elements. The model considers the propagation of electromagnetic beams as they propagate through smooth polyhedral particles with complex refractive indexes by way of Snell's law and Fresnel's equations, in a manner similar to geometric optics. The beams are split as they propagate through the crystal according to the regions that they illuminate on the crystal's surface. Phase tracing allows for consideration of interference between scattered beams, the intensity of which is redistributed through the use of Kirchhoff's approximation for far-field diffraction. The diffraction integral is evaluated over the area illuminated by an exiting beam, that is, one which has either undergone external reflection or transmission following a number of internal reflections. External diffraction is evaluated by considering diffraction on upward facing facets, which act as diffracting apertures. We present results acquired from using this method in the form of 2-dimensional scattering patterns along with 1-dimensional, azimuthally averaged phase functions. Results are compared to exact methods.

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