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Light scattering by ice crystals modelled using the Ray Tracing with Diffraction on Facets method

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The influence of cirrus clouds on the radiation balance is one of the greatest uncertainties in climate modelling. Aircraft or balloon based campaigns using optical particle imagers or replicator probes as well as cloud chamber experiments steadily increase the information available about ice crystal shape and size distribution. However, computations of light scattering properties for non-spheroidal particles based on exact methods like the SVM, T-matrix, Discrete Dipole Approximation and Discretized Mie Formalism are limited to size parameters of up to about 50 to 100. For moderate values of the size parameter the Finite Difference Time Domain method can be used but it too, puts severe demands on computational resources. Scattering data calculated using Yang's Improved Geometric Optics (IGO) method are only available for a restricted range of particle shapes, sizes and wavelengths.

We have developed a new method combining ray tracing with diffraction on facets, which is suitable for rapid computation of scattering by facetted particles of intermediate to large size parameters, where it approaches geometric optics (GO). Modelling of diffraction is based on the concept of energy flow lines. Each facet is treated as an aperture: When passing through a facet, a ray is bent towards the nearest edge by the far field deflection angle of an energy flow line through the same point. The present implementation of the model is based upon the GO code by Macke et al. Calculations were performed on a standard PC, where RTDF increased the computation time by only 27% when compared to GO. For small and large size parameters the model has been tested against the T-Matrix method, which is an exact method, the Separation of Variables method, and IGO, respectively. Comparisons with scattering data measured at single ice analogue crystals have been made. The model has been applied for interpretation of aircraft cirrus radiance data and of linear depolarization measurements.

Modelled 2D scattering patterns will be used for interpretation of nephelometric data.