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A study of T- matrix optical scattering modelling for mixed phase Polar Stratospheric Clouds

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Scattering codes are used to study the optical properties of Polar Stratospheric Clouds (PSC). Particle backscattering and depolarization coefficients can be computed with available scattering codes once the particle size distribution (PSD) is known and a suitable refractive index is assumed. However, PSCs often appear as external mixtures of Supercooled Ternary Solution (STS) droplets, solid Nitric Acid Trihydrate (NAT) and possibly ice particles, making questionable the assumption of a single refractive index and a single morphology to model the scatterers.
Here we consider a set of fifteen coincident measurements of PSCs above McMurdo Station, Antarctica, by ground-based lidar and balloon-borne Optical Particle Counter (OPC), and in situ observations taken by a laser backscattersonde and OPC during four balloon stratospheric flights from Kiruna, Sweden. This unique dataset of microphysical and optical observations allows to test the performances of optical scattering models when both spherical and aspherical scatterers of different composition and, possibly, shapes are present.
We consider particles as STS if their radius is below a certain threshold value Rth and NAT or possibly ice if above it. The refractive indices are assumed known from the literature. Mie scattering is used for the STS, assumed spherical, while scattering from NAT particles, considered as spheroids of different Aspect Ratio (AR), is treated with T-Matrix results where applicable, and of geometric-optics-integral-equation approach where the particle size parameter is too large to allow for a convergence of the T-matrix method.
The parameters Rth and AR of our model have been varied between 0.1 and 2 micrometers and between 0.3 and 3, respectively, and the calculated backscattering coefficient and depolarization were compared with the observed ones. The best agreement was found for Rth between 0.5 and 0.8 micrometers, and for AR less than 0.55 and greater than 1.5.
To further constrain the variability of AR within the identified intervals we have sought an agreement with the experimental data by varying AR on a case-by-case basis, and further optimizing the agreement by a proper choice of AR smaller than 0.55 and greater than 1.5, and Rth within the interval 0.5 and 0.8 micrometers. The ARs identified in this way cluster around the values 0.5 and 2.5.
The comparison of the calculations with the measurements is presented and discussed. The results of this work help to set limits to the variability of the dimensions and asphericity of PSC solid particles, within the limits of applicability of our model based on the T-matrix theory of

scattering and on assumptions on a common particle shape in a PSD and a common threshold radius for all the PSDs.