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Scattering and absorption properties of frozen hydrometeors for passive and active microwave satellite snowfall retrieval

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In passive and active microwave satellite snowfall retrieval algorithms the scattering properties of frozen hydrometeors as snowflakes and ice crystals at centimeter and millimeter wavelengths are fundamental. It is still common practice to approximate the arbitrarily shaped particles as equal volume ice spheres to avoid computationally intensive scattering calculations, the more so as even the number of possible ice crystal shapes is enormous - not to mention the proverbial diversity of snowflake shapes.

In relevant literature it has been reported that the scattering and absorption cross sections of randomly oriented ice crystals do not depend on the specific particle shape but on the specific ice volume for size parameters x <2.5 (x=$2\pi a/\lambda$, were a is the radius of an equal volume sphere and λ is the wavelength of the incoming wave). However, other studies show that even at a size parameter x = 1 the approximation by an equal volume ice sphere can lead to a noticeable error.

The present study aims to review the existing results. For this reason single scattering parameters like scattering cross section and absorption cross section have been calculated for of a variety of frozen hydrometeors up to 300 GHz frequency – encompassing the range of frequencies typical for microwave satellite snowfall retrieval. The calculations have been carried out by a software tool using the Discrete Dipole Approximation (DDA). The crystals have been approximated very precisely with numbers of dipoles per wavelength about 10 times more than common criteria for the applicability of the DDA suggest.

The results show that especially the aspect ratio of the particle determines up to what size parameter the approximation by an equal volume sphere is acceptable. The study results also show that the scattering parameters of ice crystals can vary up to 150 % and more, from those of equal volume ice spheres for frequencies up to 300 GHz.