

Characterization of irregularly shaped dust particles for lidar applications

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Irregularly shaped particles such as mineral dust, stratospheric smoke or complex ice crystals challenge the retrieval of microphysical properties from remote sensing observations. In the case of mineral dust, the introduction of spheroids [1] was a big step forward compared to the use of spherical particles. It led to a significantly better description especially for passive remote sensing where the scattering angles are usually below 140° . However, in the case of active remote sensing with lidar, which requires the scattering properties at a scattering angle of 180° , the spheroidal geometry could not properly reproduce the spectral backscattering properties, especially in the case of the linear depolarization ratio [2]. More complex particle shapes have been proposed in the literature, including those by Gasteiger et al. [3], Bi et al. [4], and Saito et al. [5]. The first one compared well to lidar observations close to the Sahara [3], but the discrete dipole approximation is computationally expensive for large size parameters. The super-spheroids [4] are versatile in their shape, even including concave shapes, but are rotationally symmetrical. The irregular hexahedra [5] are non-symmetrical, but they have smooth surfaces as the other shape models as well. These shapes do not perfectly mimic the small-scale irregular geometries of real dust particles shown in microscopic images. As a first step forward to a more realistic mineral dust morphology model, we will present surface-roughened irregular hexahedral particles [6]. Numerical calculations are done using the invariant-imbedding T-Matrix (IITM) [7] and improved geometric optics method (IGOM) [8] up to a size parameter of 1000. The ultimate goal is to develop a particle shape model, which accurately describes the size-dependent spectral behavior of the backscattering properties of mineral dust.

This task cannot be achieved with modelling efforts alone. To constrain the optical models, we need to measure the depolarization ratio of size-segregated, well-characterized mineral dust particles in exact backscattering direction (180°) at several wavelengths in the laboratory. The Optical Lab for Lidar Applications (OLALA) aims to achieve exactly this mission. The effort was started in 2023 at the Leibniz Institute for Tropospheric Research in Leipzig. To date, we have established a working setup at 532 nm, which has been tested with several particle types, including Arizona Test Dust and local soil dust. In the fine mode (diameter $< 1 \mu\text{m}$), an increasing depolarization ratio with particle size was found for all irregularly shaped particles [9]. Further developments to extend the setup to 355 and 1064 nm are ongoing, as well as the measurements of several natural desert dust samples. In contrast to previous laboratory work [10-12], OLALA provides a much finer size resolution, which is well suited to constrain the optical models, not only the surface roughened irregular hexahedra, but any other model as well.

In this talk, we summarize our efforts in the laboratory and particle shape modelling with the goal of an improved description of irregularly shaped mineral dust particles in lidar observation. The

combination of laboratory work, modelling efforts and remote sensing observations fits perfectly in the scope of the MIRA (Models, In situ and Remote sensing of Aerosols) collaboration.

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