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Retrieval of dust microphysical properties from multi-wavelength Mie-Raman-polarization lidar using different particle scattering models

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Mineral dust aerosol is a key atmospheric component impacting the Earth radiation budget, cloud microphysics and human health. While typing algorithms aiming at identifying dust layers based on measurements from Mie-Raman-polarization lidars have been reported [1], quantitative dust aerosol retrieval needs applicable physical models correctly describing the scattering properties of the non-spherical dust particles. Studies have shown compared to the sphere model, the spheroid model can reduce the fitting error and improve retrieval results of dust aerosols when applied to sun-sky photometer measurements [2]. However, discrepancies were found when it is used to reproduce lidar measurements [3,4]. A newly proposed scattering model, the irregular-hexahedral model [5], shows good potentials for reproducing lidar-measured quantities for dust aerosols. However, there are few direct applications of the irregular-hexahedral model to the retrieval process. Moreover, comparison between the spheroid and irregular-hexahedral models, with regard to both forward simulation and retrieval process, is also needed so as to provide insights into their capability of retrieving dust aerosols from lidar measurements.
In this study, firstly, we used the sphere, spheroid and irregular-hexahedral models respectively to compute the extinction (α), backscattering (β), lidar ratio (LR) and particle linear depolarization ratio (δ) of synthetic aerosol models. Simulation results show that the sphere and non-spherical models mainly differ in backscattering calculation and the two non-spherical models differ in LR and δ for particle effective radius greater than 1 μm. Then, we integrated the three scattering models into the BOREAL lidar-aerosol retrieval algorithm [6] to retrieve the synthetic aerosol models. A comparison of retrieval differences in particle size distribution (PSD) and refractive index (RI) indicates that: (1) there is a trend of underestimating particle size and it enlarges with the increase of the particle mode. Treating non-spherical particles as spherical ones corrects such underestimate to some extent, however, at the cost of deteriorating the RI retrieval; (2) besides the conventional 3β + 2α input, additional spectral depolarization measurements, 3δ, improve retrieval accuracies in both PSD and RI. In the next step, performance of the three scattering models in retrieving real dust measurements will be evaluated.

Keywords: dust aerosol retrieval, Mie-Raman-polarization lidar measurements, non-spherical scattering model

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