

Enhancing Lidar and Polarimeter Synergy through Improved Particle Shape Modeling

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Recently launched missions offer novel data from advanced Earth observing sensors, including SPeXone and HARP2 on PACE, and the ATLID high spectral resolution lidar on the EarthCARE satellite. The increased information content in these observations represents a significant step forward in our ability to remotely sense aerosols from space, but complete utilization of this new information will require advancements in retrieval approaches. In this presentation, we explore how common forward modeling assumptions, particularly those regarding particle shape, impact the accuracy of resulting aerosol products. Retrieval sensitivity is assessed via synthetic studies, and performance is evaluated using real data from the CAMP2Ex and ORACLES campaigns. Our retrievals and radiative transfer simulations employ an enhanced version of the Generalized Retrieval of Aerosol and Surface Properties (GRASP) algorithm capable of simulating distributions of spheres, spheroids, and hexahedral particles from the TAMUdust2020 database. We find that the magnitudes of retrieval errors stemming from these forward model assumptions exhibit strong non-uniformity, varying significantly depending on the specific measurement combination and the target geophysical variable. As noted in prior work, lidar depolarization is particularly sensitive to the choice of particle shape, and we find that hexahedra generally yield synergistically retrieved properties (e.g., particle size and spectral absorption) more consistent with canonical literature values for dust than spheroids do. We also observe that, relative to typical measurement uncertainties, differences in predicted polarimetric DoLP between hexahedral and spheroidal dust models substantially exceed the corresponding differences in total intensity. This suggests the exact choice of nonspherical particle shape is more critical for retrievals of polarimetric observations than for heritage retrievals utilizing only intensity. Furthermore, we demonstrate that pairing total and/or polarimetric radiances with even conventional backscatter lidar profiles can provide enhanced constraints on the lidar ratio and yield accurate, mode-resolved aerosol extinction profiles in relatively simple scenes. This finding emphasizes the benefit of pairing passive observations with upcoming active instruments, such as NASA's planned FALCON lidar slated for launch around 2029.

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