

Combined Lidar-Polarimeter Aerosol Retrievals using Spheroidal and Hexahedral Particle Shape Models with Data from the ORACLES Field Campaigns

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Accurate retrievals of aerosol geophysical variables are crucial to better constrain climate change projection estimates and formulate effective policies for a sustainable future. The accuracy of the retrieved microphysical and optical properties relies on the assumptions and methods adopted in the retrieval algorithms. Lidars and Multi-Angle Polarimeters (MAPs) together offer an attractive synergistic opportunity, as their measurements are highly complementary. MAP's column-effective radiometric and polarimetric intensities, paired with vertically resolved information on backscattering, extinction, and depolarization at high spatial resolution, can significantly increase the available information content in an observed scene. We compared the performance of combined lidar-polarimeter retrievals using Generalized Retrieval of Aerosol and Surface Properties (GRASP) on scenes dominated by dust aerosol—observed by Research Scanning Polarimeter (RSP) and Second-generation High Spectral Resolution Lidar (HSRL-2) instruments during ORACLES field campaigns—to single-sensor retrievals using RSP and HSRL-2 independently. Additionally, for each instrument setup, we compared the differences between the spheroid and hexahedra shape models from the TAMUdust2020 database to represent dust.

Our findings indicate that incorrect assumptions about aerosol morphology primarily affect the retrieval of single-scattering albedo and size distribution, while Aerosol Optical Depth (AOD) is less impacted. We found that the spheroid model largely underestimates the size of dust particles for HSRL and RSP+HSRL retrievals and produces significantly different size values compared to those retrieved from RSP. Conversely, the hexahedral shape model not only produces more consistent retrievals of size and refractive indices across all instrument setups but also yields reasonable values for both. We will discuss how these biases in the retrievals are rooted in the fundamental physics of spheroids being unable to reproduce real measurements of dust from Lidar and Polarimeters. This work highlights the need for better representation of shape in retrieval models for dust to take full advantage of advanced retrieval setups such as Lidar+MAP combinations.