

Lidar-Polarimetric Synergistic Retrieval of Wildfire Smoke: 3D Plume and Nonspherical Particle Effects

Feng Xu^{a,*}, Tianfeng Pan^a, Benting Chen^a, and Olga V. Kalashnikova^b

^a*School of Meteorology, University of Oklahoma, 120 David L Boren Boulevard, Norman, OK73072, United States*

^b*Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA91109, United States*

*fengxu@ou.edu

Wildfire smoke aerosols exhibit strong spatial heterogeneity, complex particle morphology, and pronounced three-dimensional (3D) plume structures, posing significant challenges for remote sensing. Multi-angle polarimetric observations provide useful constraints on retrieving absorption and microphysical properties of smoke particles but typically rely on plane-parallel radiative transfer and simplified particle shape assumptions (e.g., spheres or spheroids) [1]. These approximations can introduce biases when applied to highly inhomogeneous wildfire plumes. In this study, we quantify the impact of 3D plume structure and particle shape assumptions on polarimetric aerosol retrievals, highlighting their influence on retrieved optical and microphysical properties. Building on a lidar-polarimetric synergistic retrieval framework [2] that jointly constrains aerosol vertical distribution and microphysics, we demonstrate how lidar observations provide critical information on profiled smoke particle properties that is not accessible from passive measurements alone. The algorithm is tested using the polarimetric and lidar data acquired by instruments deployed during the FIREX-AQ [3] and ACEPOL [4] field campaigns. We underscore the importance of accounting for 3D radiative effects and particle morphology and highlight lidar-polarimetric synergy as a promising pathway for improved characterization of complex smoke plumes.

References

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