An optimal inverse method with regularization for retrieving dust aerosol microphysical properties from extinction, backscattering and depolarization lidar measurements

Yuyang Chang*[, a], Qiaoyun Hu[a] and Philippe Goloub[a]

[a]*Laboratoire d'Optique Atmosphérique, Centre National de la Recherche Scientifique (CNRS), Université de Lille, Villeneuve d'Ascq, 59650, France*

**Presenting author (yuyang.chang@univ-lille.fr)*

Lidar observations provide unique height-resolved information on mineral dust aerosols. Inversion of lidar measurements into microphysical properties improves knowledge of dust evaluation, transport, and distribution, which is crucial for better understanding the effects of dust aerosols on Earth's radiative budget. However, the generalized lidar-aerosol retrieval algorithm developed by the Laboratoire d'Optique Atmosphérique (LOA) tends to underestimate the mode of large particles due to the limited sensitivity of the measurements [1]. Hence, we propose an optimal inverse method with Tikhonov regularization that utilizes *a priori* information to better constrain the retrieved dust particles in two ways: (1) it helps select an initial point of the iteration not far from the optimal solution, and (2) together with the adjustable regularization parameter, it serves as a regularization term for the ill-pose inverse problem.

Our approach retrieves parameterized particle size distribution and complex refractive index from the spectral extinction (α), backscattering (β), and depolarization (δ) measurements of Mie-Raman-polarization lidars [2]. The optical and microphysical properties of dust particles are linked by the Spheroid model [3]. A comparison with the generalized retrieval method [1] demonstrates that the new method effectively corrects the underestimation of the volume concentration and effective radius of large particles. Furthermore, the regularization strategy significantly reduces the influence of measurement noise. Based on the new method, we also examine the information content of different combinations of the lidar measurements. Preliminary results indicate that incorporating 3δ (355, 532 and 1064 nm) into the conventional 3β (355, 532 and 1064 nm) + 2α (355 and 532 nm) greatly enhances the information on effective radius and real refractive index, while including the third α (at 1064 nm) does not yield significant improvement. In the next step, we will apply the new method to real lidar measurements on dust aerosols, of which the results will be compared with those derived from joint remote sensing retrieval or in-situ measurements for further validation.

References

[1] Chang, Y.; Hu, Q.; Goloub, P.; Veselovskii, I.; Podvin, T. Retrieval of Aerosol Microphysical Properties from Multi-Wavelength Mie–Raman Lidar Using Maximum Likelihood Estimation: Algorithm, Performance, and Application. *Remote Sens.* **2022**, *14*, 6208.

[2] Hu, Q.; Wang, H.; Goloub, P.; Li, Z.; Veselovskii, I.; Podvin, T.; Li, K.; Korenskiy, M. The Characterization of Taklamakan Dust Properties Using a Multiwavelength Raman Polarization Lidar in Kashi, China. *Atmospheric Chem. Phys.* **2020**, *20*, 13817–13834.

[3] Dubovik, O.; Sinyuk, A.; Lapyonok, T.; Holben, B.N.; Mishchenko, M.; Yang, P.; Eck, T.F.; Volten, H.; Muñoz, O.; Veihelmann, B.; et al. Application of Spheroid Models to Account for Aerosol Particle Nonsphericity in Remote Sensing of Desert Dust. *J. Geophys. Res. Atmospheres* **2006**, *111*.

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