*Supplement of*

# Enhanced Discrimination of Vertical Aerosol Types Based on Multi-Wavelength Mie–Raman–Fluorescence Lidar at a High-Altitude Background Site

**Yutong Tian et al.**

*Correspondence to*: Ting Yang (tingyang@mail.iap.ac.cn)

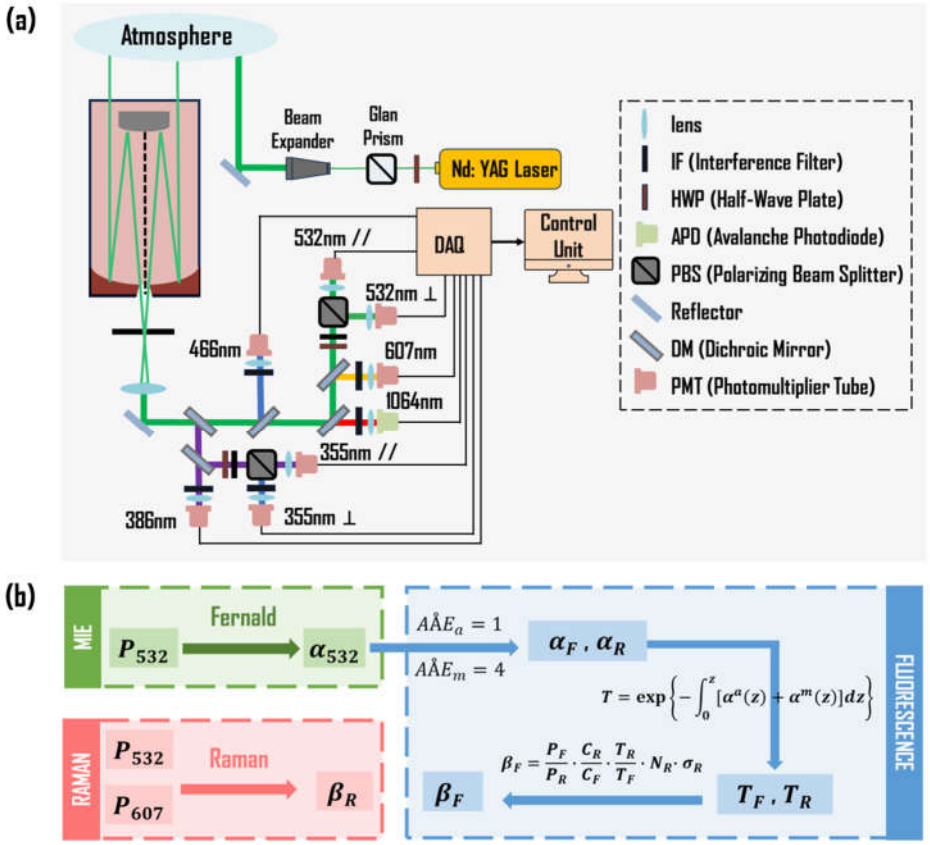


**Figure S1: Overview of the multiwavelength Mie–Raman–fluorescence lidar system. (a) Schematic diagram of the instrument configuration. b, Flowchart of the data processing workflow for the retrieval of aerosol optical parameters.**

**Table S1. Reference ranges of seven macroscopic optical parameters for Smoke, Urban, Pollen, and Dust aerosol types.**

| Type | $G_F$ ($10^{-4}$) | $PDR_{355}$ | $PDR_{532}$ | $BÅE_{532/1064}$ | $BÅE_{355/532}$ | $LR_{355}$ | $LR_{532}$ |
|---|---|---|---|---|---|---|---|
| Smoke | 2.5–4.5[a] | 0.01–0.05[b, c] | 0.025–0.07[d, e] | 1.1–1.5[e, f] | 0.6–1.9[e, f] | 40–76[b-e] | 30–85[b-e] |
| Urban | 0.2–0.8[a] | 0.008–0.014[c, g] | 0.02–0.12[c] | 0.4–1.4[c] | 0.4–2.0[c, h] | 45-60[c, g] | 28–55[c, g] |
| Pollen | 1–2.5[a] | 0.08–0.30[i, j] | 0.16–0.44[i, j, k] | 0.5–0.8[i] | −0.5–0.5 | 38-63[k] | 40–72[k] |
| Dust | 0.05–0.45[a] | 0.22–0.30[c, l] | 0.25–0.35[c, l] | 0.3–0.6 | −0.3–0.44[c] | 40–46[c, l] | 35–44[c, h, l] |

[a] (Veselovskii et al., 2024). [b](Haarig et al., 2018). [c](Floutsi et al., 2023). [d](De Rosa et al., 2022). [e](De Rosa et al., 2025). [f](Mylonaki et al., 2021). [g](Giannakaki et al., 2016). [h](Che et al., 2015). [i](Shang et al., 2020). [j](Bohlmann et al., 2021). [k](Bohlmann et al., 2019). [l](Hofer et al., 2020).

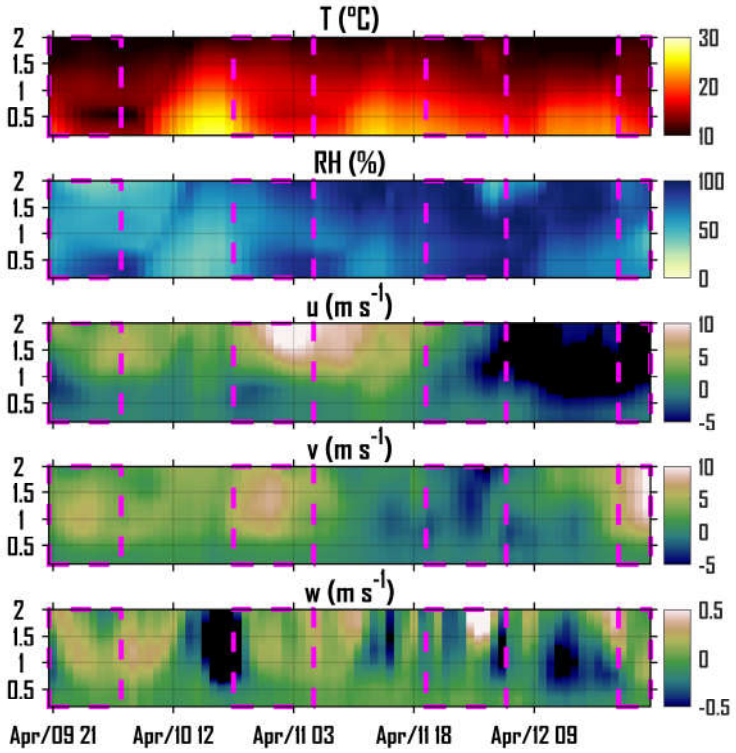


**Figure S2: Meteorological variables from April 9 to 12, 2023. The dashed box denotes the period coinciding with the retrieval dates.**

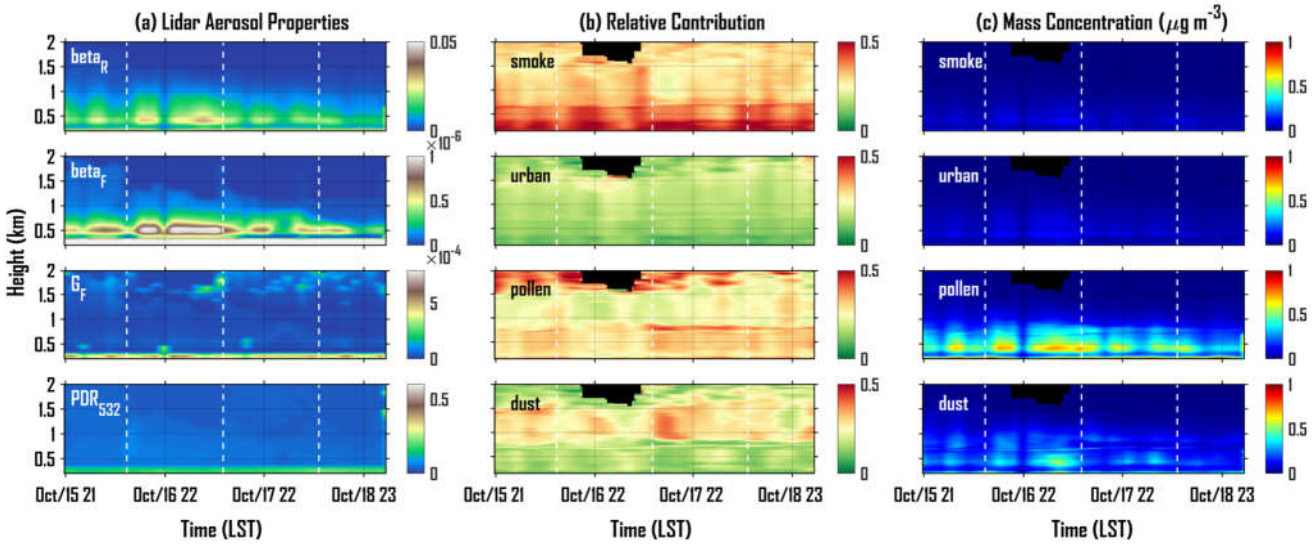


**Figure S3: Vertical profiles from October 15 to 18, 2023: (a) 532 nm backscatter coefficient ($\beta_R$, km$^{-1}$ sr$^{-1}$), fluorescence backscatter coefficient ($\beta_F$, km$^{-1}$ sr$^{-1}$), fluorescence capacity, and 532 nm depolarization ratio ($PDR_{532}$); (b) relative contributions of smoke, urban, pollen, and dust to ($\beta_R$); and (c) mass concentrations of the four aerosol types. White dashed lines indicate discontinuous intervals, as the data cover nighttime periods only.**

**References**


Bohlmann, S., Shang, X., Giannakaki, E., Filioglou, M., Saarto, A., Romakkaniemi, S., and Komppula, M.: Detection and characterization of birch pollen in the atmosphere using a multiwavelength Raman polarization lidar and Hirst-type pollen sampler in Finland, Atmos. Chem. Phys., 19, 14559-14569, 10.5194/acp-19-14559-2019, 2019.

Bohlmann, S., Shang, X., Vakkari, V., Giannakaki, E., Leskinen, A., Lehtinen, K. E. J., Pätsi, S., and Komppula, M.: Lidar depolarization ratio of atmospheric pollen at multiple wavelengths, Atmos. Chem. Phys., 21, 7083-7097, 10.5194/acp-21-7083-2021, 2021.

Che, H., Xia, X., Zhu, J., Wang, H., Wang, Y., Sun, J., Zhang, X., and Shi, G.: Aerosol optical properties under the condition of heavy haze over an urban site of Beijing, China, Environmental Science and Pollution Research, 22, 1043-1053, 10.1007/s11356-014-3415-5, 2015.

De Rosa, B., Amato, F., Amodeo, A., D'Amico, G., Dema, C., Falconieri, A., Giunta, A., Gumà-Claramunt, P., Kampouri, A., Solomos, S., Mytilinaios, M., Papagiannopoulos, N., Summa, D., Veselovskii, I., and Mona, L.: Characterization of Extremely Fresh Biomass Burning Aerosol by Means of Lidar Observations, 10.3390/rs14194984, 2022.

De Rosa, B., Amodeo, A., D'Amico, G., Papagiannopoulos, N., Rosoldi, M., Veselovskii, I., Cardellicchio, F., Falconieri, A., Gumà-Claramunt, P., Laurita, T., Mytilinaios, M., Papanikolaou, C.-A., Amodio, D., Colangelo, C., Di Girolamo, P., Gandolfi, I., Giunta, A., Lapenna, E., Marra, F., Petracca Altieri, R. M., Ripepi, E., Summa, D., Volini, M., Arienzo, A., and Mona, L.: Characterization of Fresh and Aged Smoke Particles Simultaneously Observed with an ACTRIS Multi-Wavelength Raman Lidar in Potenza, Italy, 10.3390/rs17152538, 2025.

Floutsi, A. A., Baars, H., Engelmann, R., Althausen, D., Ansmann, A., Bohlmann, S., Heese, B., Hofer, J., Kanitz, T., Haarig, M., Ohneiser, K., Radenz, M., Seifert, P., Skupin, A., Yin, Z., Abdullaev, S. F., Komppula, M., Filioglou, M., Giannakaki, E., Stachlewska, I. S., Janicka, L., Bortoli, D., Marinou, E., Amiridis, V., Gialitaki, A., Mamouri, R. E., Barja, B., and Wandinger, U.: DeLiAn – a growing collection of depolarization ratio, lidar ratio and Ångström exponent for different aerosol types and mixtures from ground-based lidar observations, Atmos. Meas. Tech., 16, 2353-2379, 10.5194/amt-16-2353-2023, 2023.

Giannakaki, E., van Zyl, P. G., Müller, D., Balis, D., and Komppula, M.: Optical and microphysical characterization of aerosol layers over South Africa by means of multi-wavelength depolarization and Raman lidar measurements, Atmos. Chem. Phys., 16, 8109-8123, 10.5194/acp-16-8109-2016, 2016.

Haarig, M., Ansmann, A., Baars, H., Jimenez, C., Veselovskii, I., Engelmann, R., and Althausen, D.: Depolarization and lidar ratios at 355, 532, and 1064 nm and microphysical properties of aged tropospheric and stratospheric Canadian wildfire smoke, Atmos. Chem. Phys., 18, 11847-11861, 10.5194/acp-18-11847-2018, 2018.

Hofer, J., Ansmann, A., Althausen, D., Engelmann, R., Baars, H., Fomba, K. W., Wandinger, U., Abdullaev, S. F., and Makhmudov, A. N.: Optical properties of Central Asian aerosol relevant for spaceborne lidar applications and aerosol typing at 355 and 532 nm, Atmos. Chem. Phys., 20, 9265-9280, 10.5194/acp-20-9265-2020, 2020.

Mylonaki, M., Giannakaki, E., Papayannis, A., Papanikolaou, C. A., Komppula, M., Nicolae, D., Papagiannopoulos, N., Amodeo, A., Baars, H., and Soupiona, O.: Aerosol type classification analysis using EARLINET multiwavelength and depolarization lidar observations, Atmos. Chem. Phys., 21, 2211-2227, 10.5194/acp-21-2211-2021, 2021.

Shang, X., Giannakaki, E., Bohlmann, S., Filioglou, M., Saarto, A., Ruuskanen, A., Leskinen, A., Romakkaniemi, S., and Komppula, M.: Optical characterization of pure pollen types using a multi-wavelength Raman polarization lidar, Atmos. Chem. Phys., 20, 15323-15339, 10.5194/acp-20-15323-2020, 2020.

Veselovskii, I., Barchunov, B., Hu, Q., Goloub, P., Podvin, T., Korenskii, M., Dubois, G., Boissiere, W., and Kasianik, N.: Retrieval and analysis of the composition of an aerosol mixture through Mie–Raman–fluorescence lidar observations, Atmos. Meas. Tech., 17, 4137-4152, 10.5194/amt-17-4137-2024, 2024.