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Long-range transported Canadian biomass-burning aerosol observed over Sofia, Bulgaria

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Studying biomass-burning aerosols is essential for assessing their impact on climate, air quality, and human health due to their complex interactions with atmospheric processes and radiation. Annually, huge amounts of biomass-burning aerosols are released into the atmosphere as a result of large-scale seasonal wildfires, particularly in regions of the United States and Canada. These aerosols are frequently subjected to long-range atmospheric transport, often reaching Europe. The 2023 wildfire season in Canada was the most extensive and prolonged on record, with exceptionally high emissions of biomass-burning particles from mid-April to late October. These emissions considerably deteriorated the air quality both locally and across large portions of the Northern Hemisphere.

In this work, we present results of a multi-sensor study of long-range-transported smoke aerosols originating from Canadian wildfires observed over Sofia, Bulgaria, in October 2023. The measurements were conducted at the Sofia aerosol remote sensing station (42.653N, 23.387E, 610 m ASL) located within the Institute of Electronics at the Bulgarian Academy of Sciences (IE –BAS) in the southeastern part of the city. The station is contributing to several international networks, including the European Aerosol Research LIdar NETwork (EARLINET), the AErosol RObotic NETwork (AERONET), the program E-Profile, and the Pan-European research infrastructure ACTRIS (The Aerosol, Clouds and Trace Gases Research Infrastructure). A comprehensive set of ground-based remote sensing instruments (lidar, ceilometer, and sun photometer) was employed in the investigations, supported by model, forecast, satellite and meteorological data. The source and type of the detected aerosols are confirmed through air mass backward trajectory analysis and global satellite-based fire maps. The optical and microphysical characteristics of the registered aerosol layers, such as the backscatter coefficients, backscatter-related Ångström exponents (BAE) and volume linear depolarization ratio were vertically profiled with a high range resolution by lidar. The registered high BAE values of the order of 1.5–2 indicate a dominance of fine, submicron particles in the smoke layers. In support of the lidar data, the sun-photometer-provided columnar optical and microphysical characteristics show that the contribution of the fine-mode aerosols to the total aerosol optical depth is more significant than that of the coarse-mode particles. The low depolarization ratios observed by both lidar and photometer indicate that the smoke particles were mostly spherical. Additionally, the experimental data revealed coarse-aerosol presence within the local planetary boundary layer, likely associated with regional continental sources. The results presented contribute to a deeper understanding of the dynamics and impacts of long-range biomass-burning aerosol transport in the context of European air quality and atmospheric composition.

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