Abstract

Determination of the properties of particles suspended in the atmosphere is important in the context of their impact on the Earth's climate system. Aerosols that absorb solar radiation are of particular interest to scientists due to causing local warming of the atmosphere at the altitude of their occurrence. Aerosols from the biomass burning in open fires of natural communities (smoke), due to their high content of black carbon (mainly soot), show such properties.

This doctoral dissertation, as the first scientific work of this kind, presents a comprehensive characterization of biomass burning aerosols over Poland.

The data used for the analysis was obtained by the means of the modern 12-channel Polly^{XT}-UW aerosol-depolarization-Raman lidar operating at the RS-Lab (Remote Sensing Laboratory) of the Institute of Geophysics, Faculty of Physics, University of Warsaw. High-quality lidar measurements are performed accordingly to the recommendations of the EARLINET network being part of the pan-European research infrastructure ACTRIS. They allow the determination of optical properties (such as particle backscattering coefficient β, particle extinction coefficient α, particle linear depolarization coefficient δ) and water vapor mixing ratio wv. Based on the sets of these physical quantities, it enables to retrieve the microphysical properties of observed atmospheric aerosols (such as aerosol particle size distribution *PSD*, composite refractive index m, single scattering albedo *SSA*) by the means of the mathematical inverse methods.

In the presented work it was undertaken to determine, on the basis of existing lidar observations, the physical and chemical characteristics of biomass burning aerosol observed over Warsaw. The analysis considered the sources and directions of the inflow of aerosol particles and discusses cases of inflow over Warsaw of aerosols from biomass burning from natural sources, such as forest, grassland and peatland fires. The observed

aerosols differed in terms of the place of emission (e.g., Western Europe, North America), the residence time of the aerosol in the atmosphere (from one to several days), and the height of suspension in the boundary layer and in the free troposphere (within the altitude range of ~ 1 - 8 km). The study was supported by calculations and analysis of the backward trajectories, the aerosol transport model outputs, and the satellite data.

The values of optical and microphysical properties of biomass burning aerosol vary depending on the residence time in the atmosphere and the source of origin. Depending on the area of origin, different types of biomass burning aerosols inflowing over Warsaw can be distinguished. The inflow of those different types depends on the prevailing synoptic situation.

In the dissertation, special attention was given to the methodology of the retrieval of a set of optical properties of aerosols $(3\beta+2\alpha+2\delta)+wv$ from lidar measurements and microphysical properties of aerosols retrieved from the obtained sets of optical properties $(3\beta+2\alpha)$ using mathematical inverse methods with regularization. Such studies are sparse in the world, and this topic has not been explored so far in scientific papers on aerosols in Poland.

The vast amount of selected cases of biomass burning aerosols inflow over Warsaw was analyzed in detail. Due to the fact that some of these analyses have been already published in the papers co-authored by the doctoral student (listed in points 1-4), in this dissertation attention has been focused on the results not yet published (point 5).

1) Analyses of PollyXT-UW data in Warsaw with respect to other stations being part of the PollyNET lidar network. Publication: Baars et al. 2016.
2) A case study of the long-range transport of aged biomass burning aerosols from Canadian forest fires over Warsaw on July 8-10, 2013. Publications: Janicka et al, 2016; Markowicz et al, 2016; Ortiz-Amezcua et al, 2017; Janicka et al, 2017.
3) The analysis of a complex aerosol structure containing smoke from biomass combustion from several European sources mixed with anthropogenic pollutants, observed in Warsaw on August 9-11, 2015 in the vicinity of a quasi-stationary atmospheric front during a heat wave conditions. Fine-scale analysis of microphysical properties performed for the complex aerosol structure occurring on

August 9-11, 2015. Publications: Janicka et al., 2018; Janicka and Stachlewska, 2019; Janicka et al., 2020.

4) The analysis of the influence of aerosols from biomass burning from Ukraine and Portugal on the parameters of the atmospheric boundary layer in the situation of a high pressure system over Central Poland on August 25-27, 2016. Publication: Stachlewska et al., 2018.
5) Comparative analysis presenting the state of knowledge accumulated in own research on biomass burning aerosols observed over Warsaw. Compilation of optical and microphysical quantities characterizing aerosols based on measurements from the long period 2013-2020.

An important part of the dissertation work was creation of the universal tools for visualization and comparative analysis of lidar profiles, i.e., the *PROfiler tool* developed solely by the dissertation author.