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Characterization by AERONET Sun Photometer of Aerosol Events with High Aerosol Optical Depth and Ångström Exponent over Sofia, Bulgaria

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The aerosol particles in the atmosphere strongly influence the energy exchange between the Sun and the Earth's atmosphere and surface. Thus, they could significantly impact multiple atmospheric phenomena, the climate, and the living conditions on the Earth. Also, the fine (submicron) fraction of the aerosol ensembles, the so called fine dust particles (FDP), may be especially harmful to the human health. The anthropogenic and biomass-burning (BB) smoke FDP are characterized as well by high light absorptivity and take an active part in the solar energy redistribution. The permanent monitoring and studying of the aerosol properties and dynamics contribute to the better understanding of many atmospheric processes, including the climate change, and assist the authorities in urban areas in being timely informed of dangerous FDP concentration rise above the permissible levels.

The main purpose of the present work is to describe and analyze the results of two-year passive optical remote sensing of the atmospheric aerosol field over Sofia, Bulgaria, and characterize mainly the aerosol situations by a strongly prevailing fine particle fraction of a relatively high concentration.

The analysis of aerosol situations over Sofia is based on a wide set of columnar aerosol characteristics evaluated automatically by AErosol RObotic NETwork (AERONET) algorithms using results of specific automatic procedures of measuring the direct sun/moon irradiance and the sky radiance by a Cimel CE318-TS9 sun/sky/lunar photometer. The sun photometer has been functioning since 5 May 2020 in the Sofia Site in the Institute of Electronics, Bulgarian Academy of Sciences that is contributing to AERONET and is involved in European Aerosol Research Lidar Network (EARLINET) and Aerosol, Clouds and Trace Gases Research Infrastructure (ACTRIS) activities.

The main aerosol characteristics employed in the analysis are the aerosol optical depth (AOD) and the Ångström exponent (AE), the volume size distribution (VSD) and the single-scattering albedo (SSA) of the aerosol particles. The particle sphericity factor (SF), depolarization ratio (DR) and the real part of the refractive index n_r are also considered.

The analysis performed shows that aerosol situations with a strongly prevailing fine particle fraction (around 100 nm in size) with a relatively high concentration (AOD > 0.3), sphericity factor (SF ~ 99%) and low depolarization ratio (DR ~ 0.002) take place mainly in the summer and early autumn, when the wildfire activity is maximum. Because of their small sizes, the scattering from such particles decreases rapidly with the light wavelength, λ, and faster than the absorption.

Correspondingly, the AE is large > 1.6-1.7 and the SSA is sharply decreasing with λ, beginning from 0.85 – 0.95 at λ = 440 nm. The relative occurrence of BB aerosol situations is estimated to be 9.1%.

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