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Lidar Investigation and Mapping of Aerosol Loadings above Sofia, Bulgaria

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Atmospheric aerosols, both natural and anthropogenic, have strong direct or indirect effects on the regional and global climate, air quality and human health. Their impacts depend mainly on the aerosol composition, particle size, and chemical-physical properties. The lidar technique is an effective instrument for near real-time observations of the aerosol mass stratification and optical parameters with high spatial and temporal resolutions over long distances and large areas.

The Sofia lidar station (located at the Institute of Electronics, Bulgarian Academy of Sciences) has participated in coordinated measurements of the European Aerosol Research Lidar Network (EARLINET) since 2002, and is currently part of the Aerosols, Clouds, and Trace gases Research InfraStructure (ACTRIS). The station's lidar systems perform systematic vertical monitoring of various type of aerosols (Saharan dust, volcanic ash, fire smoke, as well as marine, anthropogenic and mixed aerosols) in the atmosphere above Sofia, as well as near-ground aerosol mapping over urban areas.

In this work, we report results of studies of different types of atmospheric aerosols present above Sofia by using a Nd:YAG-laser-based lidar emitting at 1064 nm and 532 nm. The results are presented in terms of vertical profiles of the atmospheric backscatter coefficient and color maps of range-corrected lidar signals in height-time coordinates, which illustrate the aerosol density spatial distribution and temporal evolution. The retrieved backscatter profiles at the two lidar wavelengths are used to calculate the corresponding profiles of the backscatter-related Ångström exponent as a qualitative indicator of the dominant particle-size fractions in the aerosol fields observed.

Results are reported on lidar observations of extraordinary in altitude (up to 15 km) aerosol layers above Sofia that consisted predominantly of Saharan mineral dust partly mixed with other aerosol types, as well as of a wintertime Saharan dust intrusion, the latter a rare and atypical until recently for the region. Data are also presented from lidar monitoring of atmospheric smoke aerosols resulting from a local fire burning forest areas close to Sofia. Finally, results of near-surface atmospheric measurements and aerosol lidar mapping over broad urban and sub-urban areas of Sofia City are displayed and discussed. To identify the type and origin of the aerosols in the layers registered by the lidar, modeling and forecasting data from online accessible resources are used, such as the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model and the dust forecast models provided by the SDS-WAS (Sand and Dust Storm Warning Advisory and Assessment System) Regional Node for Northern Africa, Middle East and Europe. Conclusions are drawn confirming the high efficiency of the lidar technology for rapid and reliable monitoring of airborne aerosol pollutions of different type and assessing their environmental and social impacts.

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