Lidar Measurements over the City of Sofia

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Abstract – **In this paper some results from measurements of aerosol layers in the atmosphere are presented. High repetition CuBr-laser is used in the aerosol lidar, made in the Institute of Electronics at the Bulgarian Academy of Sciences.**

Keywords – **Lidar, Aerosol layers in Atmosphere, Laser Radars.**

I. Introduction

The lidar methods for measurement of the aerosol content in the atmosphere are a powerful up-to-date means of control and analysis of the state of the environment. The aerosol lidars allow real-time tracking and mapping of the movement of aerosol fields over vast territories, without introducing additional perturbation flows in the natural evolution of the transportation processes. For quantitative analysis of the concentrations and chemical composition of aerosols, lidar measurements are being successfully combined with other conventional measurement methods, which allow assessment of the characteristics of the aerosol field at a local scale and subsequent calibration of the data from aerosol lidars. In the meantime, new mobile aerosol lidar systems are being developed (airborne and spaceborne lidars) that significantly increase the maximal spatial dimensions of the analyzed objects. Networks of lidar stations are being set up to research the climatologic characteristics and trans-continental transportation of aerosol layers (EARLINET, Asian lidar network).

In this paper we present some results from measurements of aerosol layers in the atmosphere, made using a high-repetition aerosol lidar. The lidar is constructed and functioning in the Institute of Electronics at the Bulgarian Academy of Sciences. Our previous measurements [1] with a lidar station of this type were aimed at mapping of aerosol fields over a vast region. The measurements were carried out in horizontal directions relative to the ground surface. A standard algorithm for determination of the extinction coefficient of the atmosphere from the lidar data was used [2]. Subsequently the data for the aerosol fields were recalculated for determination of the mass concentrations of dust contaminants after calibration of the lidar with local sampling devices.

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II. The Lidar

Currently the lidar is part of the European scientific research lidar network (EARLINET) for study of climatologic characteristics of the atmospheric aerosols. This network comprises 22 lidar stations situated in a number of European countries: Germany, France, Italy, Great Britain, Spain, Portugal, Greece, Bulgaria, Belarus, Switzerland, Sweden, Poland, Slovenia. EARLINET was a 3-years long project under the 5-th Framework Programme of the Commission for scientific research in the European Union. Our lidar participated in the measurements under two work programmes of the project:

- WP2-Regular measurements – with the goal to establish a comprehensive climatological database of the vertical distribution of aerosol over stations of the network.
- WP7-Observation of special events – observation of specifically high aerosol loads in the lower troposphere, resulting from extreme dust events (transport of Saharan dust, break of forest/industrial fires, intense photoshemical smog episodes, volcano eruption etc.).

For participation in the EARLINET project both the installations and methodology of the lidar were modified. The improvements of the apparatuses allowed for really all day long lidar measurements. The installation of a narrow diaphragm and additional filtering optics contracted the range of vision of the receiving telescope to 0,2 mrad and decreased significantly the registration of the parasitic background daylight in the atmosphere. The usage of a laser with high-frequency of repetition of the impulses, 14 kHz, allows registration of the reflected signals with photomultiplier in photon counting mode for the whole way of sounding. The technical characteristics of the lidar are shown in Table 1.

Table 1. Technical characteristics of the lidar

CuBr-vapor laser	Mean power: 3 W Wavelength: 510 nm, 578 nm Divergence: 3 mrad
Collimator	Output divergence: 0.6 mrad
Telescope	Focus length: 1000 mm Aperture: 200 mm
Photon detector	Photomultiplier EMI9863QB100 in photon counting mode
Acquisition system	Digital correlator “Malvern” K7023 Range resolution: 150 m Multichannel regime: 70 chnls/samples/
Computer	Pentium 4

The measurements under WP2 were carried out regularly twice a week, at noon and sunset on Monday, and at sunset on Thursday. The measurements under WP7 were carried out upon notification by the programme coordinator for upcoming dust events above the territory of Sofia, based on satellite observations and weather forecasts. The lidar profiles of the laser emission, backscattered in the atmosphere were registered with accumulation time of 1 min. for every sample. In addition, averaging was performed by summation of the data of 30 profiles, thus the effective measurement time for each profile amounting to 30 min. The data processing and calculation of the extinction coefficient of the atmosphere were made by a computer programme in Matlab environment, developed in the Institute of Electronics at BAS. The programme implements an algorithm for lidar data processing by Fernald's method [3].

III. Results

The figures presented below show two types of aerosol layers distribution in the atmosphere. The measurement of 21.10.2002 (Fig. 1) is under WP2 programme, in a day with clear atmosphere, therefore no significant aerosol layers are observed in height, except the Planetary Bounder Layer (PBL) aerosol layer at 1-1,5 km, existing predominantly due to anthropogenic factors. The measurement of 15.07.2002 (Fig. 2) is under WP7 programme, when aerosol layers of Sahara dust have reached Sofia. An increase of the height to 2 km is distinctly observed for the ground aerosol layers. It is due to the sedimentation of aerosol particles from the upper aerosol layer. An additional layer at height 3-3,5 km is also observed, which is most probably in result of the transportation of Sahara dust. The low optical density and relative stability over time are typical for this aerosol layer, which in addition to the prognostic information bear out the conclusion that this is an aerosol layer containing Sahara dust.

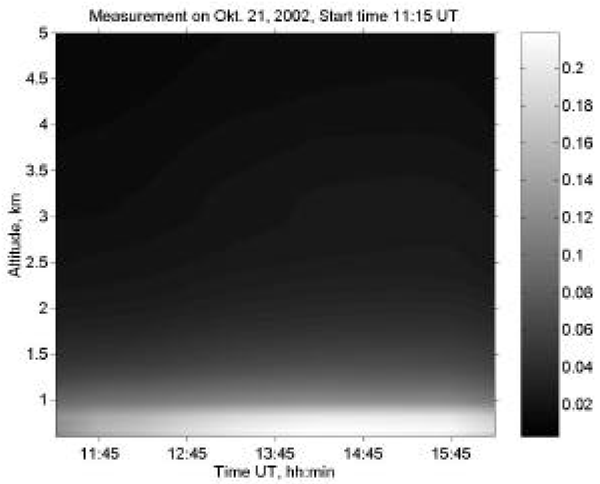

Fig. 1. Lidar measurement in circumstances of clear atmosphere. The scale in the right gives the values of the extinction coefficient in km^{-1}.

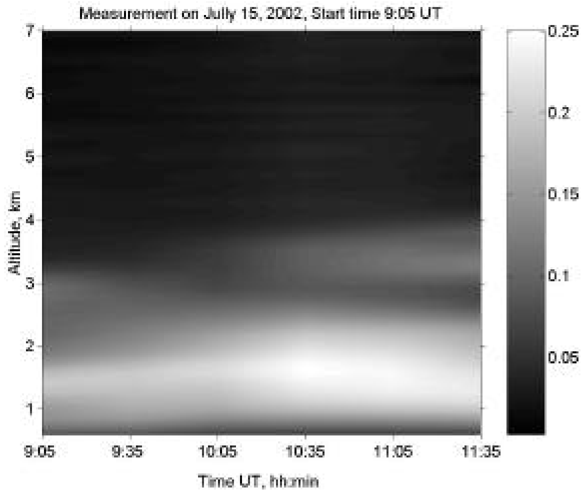

Fig. 2. Lidar measurement in circumstances of multiple aerosol layers in the atmosphere. The scale in the right gives the values of the extinction coefficient in km^{-1}.

IV. Conclusion

The data of presented measurements are stored in the database that has been established by the EARLINET project. This database is now growing continuously and is of very high scientific interest, because it is by far the most comprehensive quantitative data set on the vertical distribution of aerosols on a continental scale.

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