CHEMICAL ENGINEERING TRANSACTIONS, Volume 16, 2008
Guest Editor Eliseo Ranzi

Optical Properties of Aerosols from Lidar Data and Other Ground-based Instruments near Bucharest

Anca Nemuc*, J. Vasilescu*, L.Belegante*, C. Radu*
* National Institute for R&D of Optoelectronics- INOE
Atomistilor Street no. 409, P.O. Box MG-5, Bucharest-Magurele, Romania

The aerosols in the lower troposphere are one of the major issues studied by scientific community mainly because of their effect on human health and their role in climate change. They have also a determining effect on visibility and contribute to the soiling of monuments. Observations and model calculations show that the increase in the atmospheric aerosol burden is delaying the global warming expected from the increase in greenhouse gasses.
The aim of present paper is to analyze the aerosol characteristics of aerosol in 0-5 km altitude interval, at Magurele-Bucharest, Romania (44.35 N, 26.03 E) during 2007, using ground-based Lidar (Light Detection and Ranging) and Sun-photometer data. The optical thickness show seasonal variation resulting from different aerosol sources, long range transport and local atmospheric environment. Saharan dust and biomass burning can be identified using back trajectories analysis.

Introduction

Tropospheric aerosols have an important role in our climate for their contribution to cloud formations and sunlight attenuation affecting critically the global radiative balance. Depending on various generating sources, tropospheric aerosols may vary greatly in both time and space. To accurately study the optical properties of aerosols, governed by physical parameters such as particle density and size distribution, you need continuous observations both from satellite and ground based networks of instruments (Kaufman et al., 2002). The simplest, and in principle, the most accurate and easy to maintain monitoring systems are ground-based**.** Aerosol optical depth is the single most comprehensive variable to remotely assess the aerosol burden in the atmosphere from ground-based instruments. This variable is used in local investigations to characterize aerosols, assess atmospheric pollution and make atmospheric corrections to satellite remotely sensed data.
The Lidar provides vertical profiles characterizing optical properties of the aerosols, since the system is particularly sensitive to changes in atmospheric aerosol concentrations.
The July 2007 data base of aerosol properties at Magurele-Bucharest is used in this paper for aerosol characterization in the southeast part of Romania. Since July 2007, a Cimel sunphotometer included in the AERONET/PHOTONS network (Holben et. al, 2001) operates at our research institute location (44.35 N, 26.03 E). The site is in the south-east part of Europe, thus continental type aerosols are dominant, with industrial influences. However the most relevant in the characterization of aerosol properties in

Please cite this article as: Nemuc A., Vasilescu J., Belegante L. and Radu C., (2008), Optical properties of aerosols from lidar data and other ground-based instruments near bucharest, Chemical Engineering Transactions, 16, 67-72

this area is the desert dust events which distort the atmospheric composition. The Cimel monitoring database permits a first evaluation of values for aerosol properties in this area, and also the detection, characterization and evaluation of the desert dust events arriving at the station.

2. Instruments

2.1 Sunphotometer Data

AERONET is an international, global distributed network of automatic sun and sky scanning radiometers that routinely observe and transmit observations for processing and posting to the AERONET web site: http://aeronet.gsfc.nasa.gov and http://www-loa.univ-lille1.fr/photons/.
The Cimel sunphotometer provides aerosol optical properties, such as aerosol optical depth (AOD), Ångström parameters and column water vapor via direct sun measurements (at 340, 380, 440, 500, 670, 870, 940, 1020 nm), and inversion products (Dubovik et al, 2000a) derived from the direct sun and sky radiance measurements, such as aerosol size distribution, single scattering albedo and refractive index. These data are available for four narrow wavelength bands centered at 440, 670, 870 and 1,020 nm. The processing method involves fitting the multiangle multiwavelength observations with Mie scattering calculations.
Our instrument is calibrated using PHOTONS (http://www-loa.univ-lille1.fr/photons/) calibration facilities in Lille (LOA/USTL, France). This procedure yields to an estimated accuracy of 0.01-0.02 for the absolute AOD error (wavelength dependent) and 5% relative error for the radiance in the sky channels (Dubovik et al, 2000b).

2.2 Lidar

The Lidar system, in operation since July 2005 near Bucharest, is an aerosol backscatter lidar that provides elastic atmospheric returns at 1064 nm wavelength, up to 6 Km high with a spatial resolution of 6 m. Analysis of the lidar signal using Fernald-Klett method will yield vertical profiles of the backscattering coefficient (Nicolae and Cristescu, 2006).

3. Observations from July 6 to 31, 2007

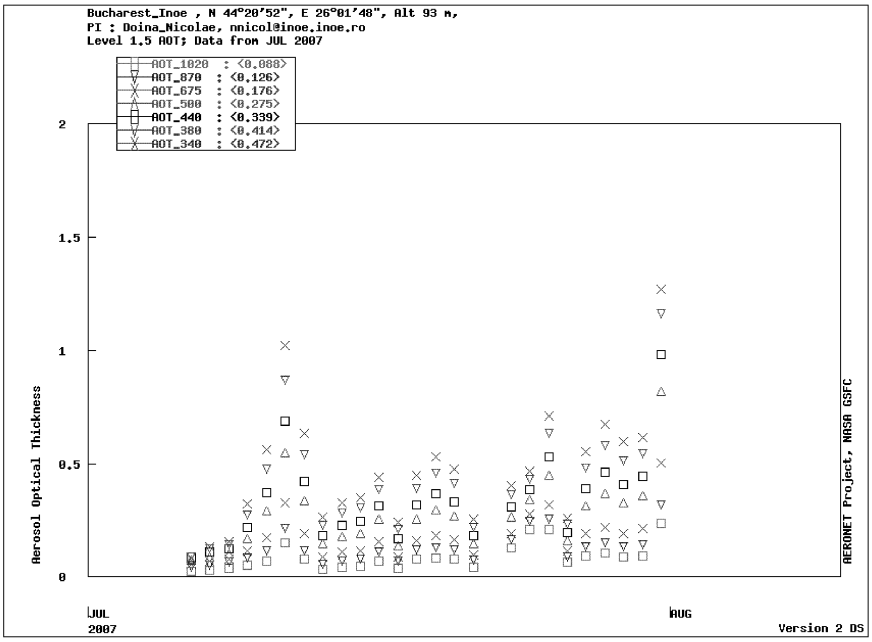

Fig.1 AOT sunphotometer observations during July 2007

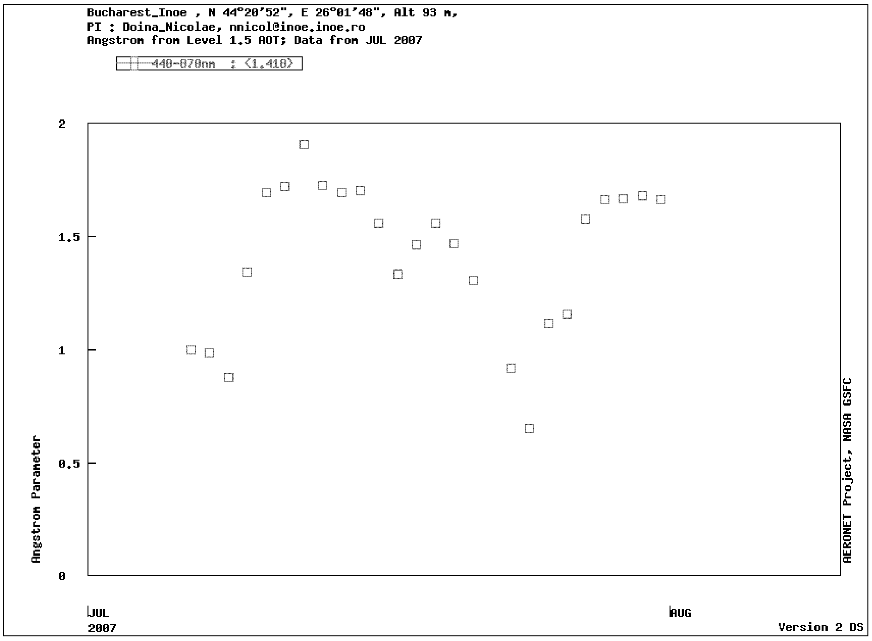

Fig 2. Ångström exponent derived from sunphotometer measurements during July 2007

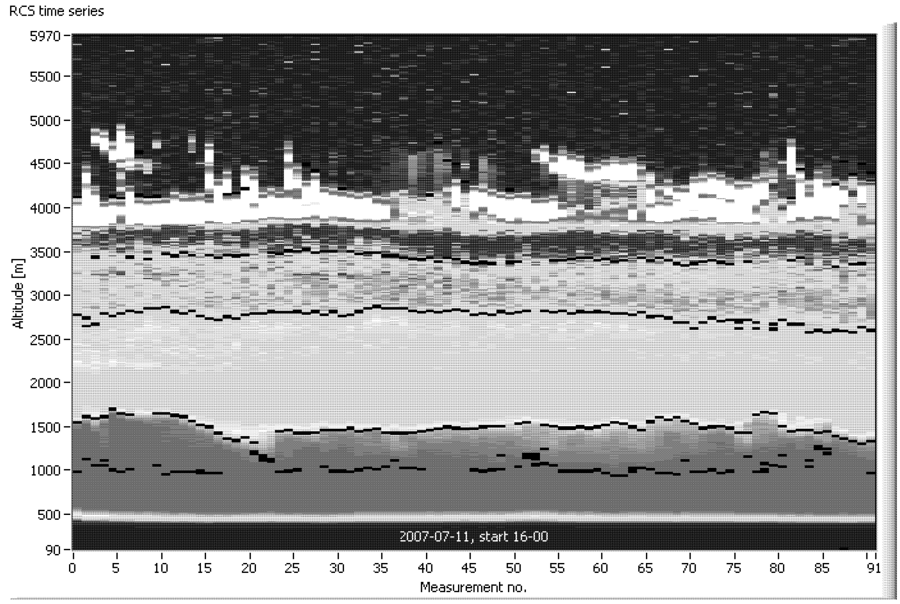

Fig.3 Range corrected signal from Lidar measurements on July 11th, 2007

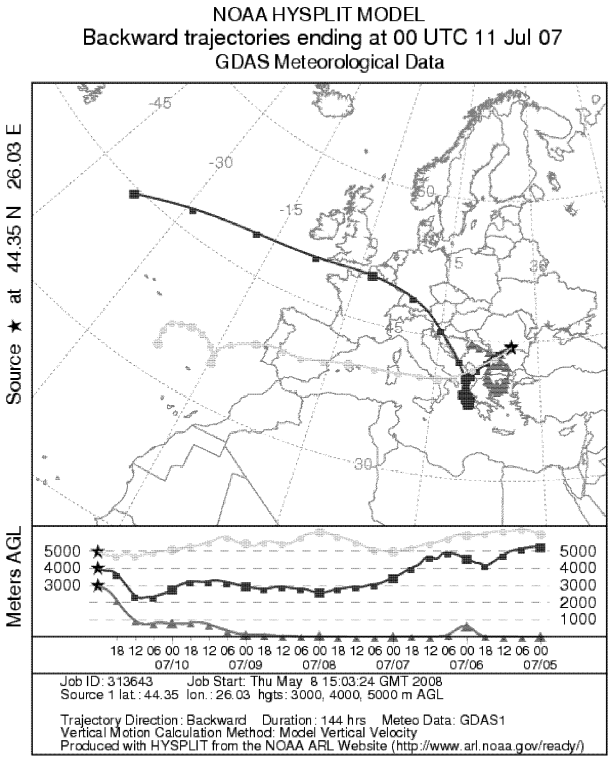

Fig.4 -7 day backward trajectories arriving at high altitudes over Romania on July 11th, 2007

The statistical results for aerosol optical depth and Ångström exponent for July 2007 give an average AOD of 0.275 with standard deviation (STD) of 0.008 at 500 nm and an average AOD of 0.088 (STD 0.003) at 1020 nm. The Ångström exponent is 1.41 (STD 0.09) (Fig. 1 and 2). For July 21, AOD has the lowest value of 0.146 at 500nm and low Ångström exponent of 0.919. Lidar analysis and Hyplit backtrajectories analysis of Radu et al., 2008 (presentation during this conference) confirmed smoke intrusions from large forest fires from Ukraine.

For July 11th 2007, we have mostly cloudy lidar observations (Fig. 3) but also stratified aerosol layers are observed above 1500 m asl (full-overlap lower altitude about 600m). According to the HYSPLIT back-trajectories (Draxler and Rolph, 2003) (Fig. 4) air masses arriving above Bucharest on July 11th have had a residence time over the Ocean. This is quite consistent with the observed AOD values, while the very high values of Ångström exponent are rather surprising for such maritime backtrajectories.

3. Conclusions

In this paper we present 2 case studies regarding the aerosol dynamics and characterization by the simultaneous and collocated measurements of a CIMEL sun photometer and a backscatter lidar. The observed AOD variations are consistent with the Lidar observations and with the back-trajectories of air masses.

The interpretation of the high Ångström exponents even when air masses were expected to bring aerosols of maritime type is not clear yet.

In situ analysis of particle size distribution and chemical analysis would be needed to help clarifying the likely origin of the predominant particles observed above Magurele-Bucharest. This issue shall be further investigated in upcoming campaigns.

As more data are available, the observed aerosol stratifications must also be further investigated, related both to the season and to the airmass origin. Starting June 2008 a Raman Lidar operating at different wavelengths along with a nephelometer will be set up for regular measurements in the frame of EARLINET-ASOS (European Aerosol Research Lidar Network-Advanced Sustainable Observation System). It may provide, together with the sunphotometer, a climatological approach to the aerosol properties in this region.

Acknowledements

References

Draxler, R. R. and Rolph, G. D., 2003: HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) Model access via NOAA ARL READY Website (http://www.arl.noaa.gov/ready/hysplit4.html), NOAA Air Resources Laboratory, Silver Spring, MD.

Dubovik, O., Holben, B. N., Eck, T. F., Smirnov, A., Kaufman, Y. J., King, M. D., Tanre, D. & Slutsker, I. , 2002, Variability of absorption and optical properties of key aerosol types observed in worldwide locations, J. Atmos. Sci. **59,** 590–608.

Dubovik, O., Smirnov, A., Holben, B. N., King, M. D., Kaufman, Y. J., Eck ,T. F., and Slutsker, I., 2000a.: Accuracy assessments of aerosol optical properties retrieved from AERONET sun and sky radiance measurements, J. Geophys. Res., 105, 9791–9806

Dubovik, O. & King, M. D., 2000b, A flexible inversion algorithm for retrieval of aerosol optical properties from Sun and sky radiance measurements J. Geophys. Res. 105, 20673–20696.

Holben, B. N., Tanre, D., Smirnov, A., Eck, T. F., Slutsker, I., Abuhassan, N., Newcomb, W. W., Schafer, J., Chatenet, B., Lavenue, F., 2001, An emerging ground-based aerosol climatology: Aerosol optical depth from AERONET, J.Geophys. Res. 106, 12067–12098.

Kaufman, Y. J., Tanre D., Boucher O., 2002, A satellite view of aerosols in the climate system, Nature, vol.419

Nicolae, D.N. and Cristescu C.P., 2006, Laser remote sensing of tropospheric aerosol, J.Optoelectron.Adv.Mater. **18**, pp.1781-1795