RALI-a multi-wavelength LIDAR for aerosol profiling in Romania

Anca Nemuc[1], Doina Nicolae[1], Emil Carstea[1], Camelia Talianu[1]

[1]National Institute for Optoelectronics (INOE), 409 Atomistilor Street,Magurele, Ilfov,Romania,

anca@inoe.inoe.ro

ABSTRACT

Atmospheric probing by LIDAR (LIght Detection and Ranging) is able to obtain time dependent, three dimensional pictures of aerosol distributions in any region of interest. Aerosols serve as valuable tracers of air motion. We have investigated tropospheric aerosols at the National Institute of Research and Development for Optoelectronics, located in Magurele, near Bucharest, Romania (44°21'N latitude, 26°02'E longitude, 90 m a.s.l.) and near the Black Sea coast, during 2008 up to now with a multi-wavelength Raman lidar system-RALI. The laser radiation is emitted at 1064, 532 and 355nm and collected at 1064, 532p, 532s, 355, 607, 387 (Nitrogen vibrational Raman backscatter) and 408nm (Raman excited water vapor line). We performed both systematic measurements on a regular schedule in the frame of EARLINET, the first aerosol lidar network on a continental scale and also during dust intrusion alerts. The use of several laser wavelengths has enabled us to observe variations in backscatter profiles depending on the particle origins.

RALI has proved to be a field-worthy, reliable and self contained system for monitoring and profiling the density and motion of aerosols in the air.

1. INTRODUCTION

Aerosols' impact on atmospheric systems and their role in global climate change is complex and not perfectly well-known.

LIDAR is a laser based system for atmosphere sounding, which allow suspended particulate(aerosol) detection along the sounding direction, with a very good precision and in a very short time (seconds).Lidar measurements of particle optical properties with high spatial and temporal resolution give detailed information on the occurrence, extent and development of aerosol structures. The determination of the extinction-to-backscatter ratio (the so-called lidar ratio) profile is possible using the Raman-lidar technique for the independent determination of the particle extinction and backscatter vertical profiles [1}[2].

One very important aspect that has to be considered is the accuracy of the measurements. Being part of a network give the advantage of participation at instruments validation campaign, which combined with the validation of algorithms, certifies that output data of a particular channel are quality assured.

2. METHODOLOGY

RALI (Raman Aerosol LIdar), the multiwavelength lidar system of National Institute of R&D for Optoelectronics, was set up, started working and included in EARLINET in June 2008. It is a state-of-the-art instrument, operating at seven wavelengths and with a maximum of 12 channels. The purpose of such a complexity consists in avoiding the non-determination in lidar equation and obtaining as much information as possible with the same transmitter and receiver. RALI is intended to measure aerosol optical coefficients up to the stratosphere, therefore is based on a short-pulses high power laser and a 400mm diameter telescope. A summary of apparatus' characteristics is shown below:

Transmitter:

- YAG:Nd laser, 10Hz, 330mJ total, 4ns, 3 harmonics (1064, 532, 355 nm output wavelengths)
- 2 exit axes: VIS+IR, UV
- beam expanders: 5x, 4x

Receiver:

- Cassegrain telescope, 400mm, 1mrad (initial), 4m focal length
- - 4 elastic channels (1064, 532p, 532c, 355nm), 2 Nitrogen vibrational Raman channels (607, 387nm) and water vapor channel (408nm)
- 1 channel analog only (1064nm), 1 channel photon counting only (408nm), 5 channels double detection
- 40MS/s, 12 bit acquisition

Profiles of backscatter and extinction coefficients of aerosols, needed for estimation of the radiative balance of the atmosphere, can be derived from elastic and Raman light scattering processes as was described in previous papers [6][7][8]. Therefore, using both types of channels it is possible to extract these parameters simultaneously. Advanced lidar systems with elastic and inelastic channels – such as RALI - delivers the same time elastic and inelastic Raman signals, which can be used into the inversion procedure to obtain all optical parameters, because they describe the same atmosphere.

Usually, Nitrogen molecules are used to obtain the Raman signal, because Nitrogen is considered a gas with constant concentration over time and has a proper Raman spectrum, easy to be separated from Rayleigh.

Microphysical properties of aerosols were also retrieved and studied using the inversion algorithm developed by us[6] but also following the procedures required in the EARLINET frame.

© Proceedings of the 8th International Symposium on Tropospheric Profiling, ISBN 978-90-6960-233-2
Delft, The Netherlands, October 2009. Editors, A. Apituley, H.W.J. Russchenberg, W.A.A. Monna

3. RESULTS

The tracer role of aerosols has been used in the vertical RCS(Range corrected Signal) profiles to determine the height of PBL and any distinct aerosol layers in the troposphere. The graphs underline not only the vertical distribution, but also their temporal evolution (figures 1 and 2) both near the Black Sea coast but also near Bucharest. Methodology used for atmospheric layering was described in details by Nemuc A.[9]

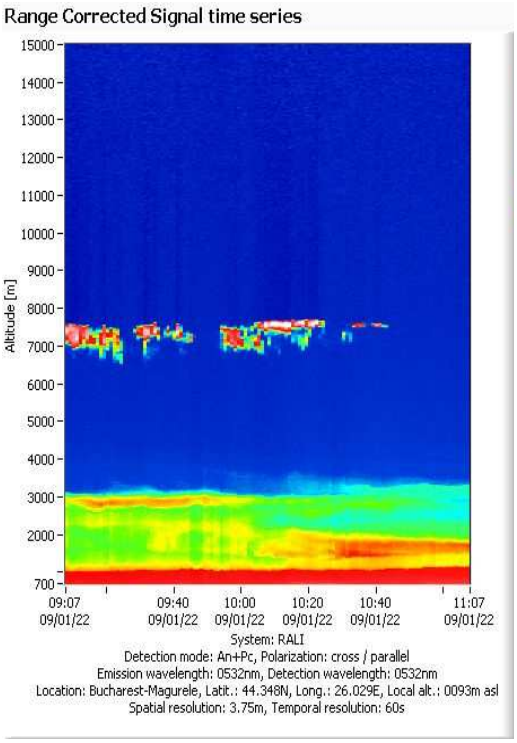

Figure 1. *1-minute resolution RCS (a.u.), vertical range 700m-15000m, starting at 9:07 UTC, on January 22, 2009; 532nm sounding wavelength; the layers detected using gradient method at ~800m and 3000m;a cirrus cloud at 7000m*

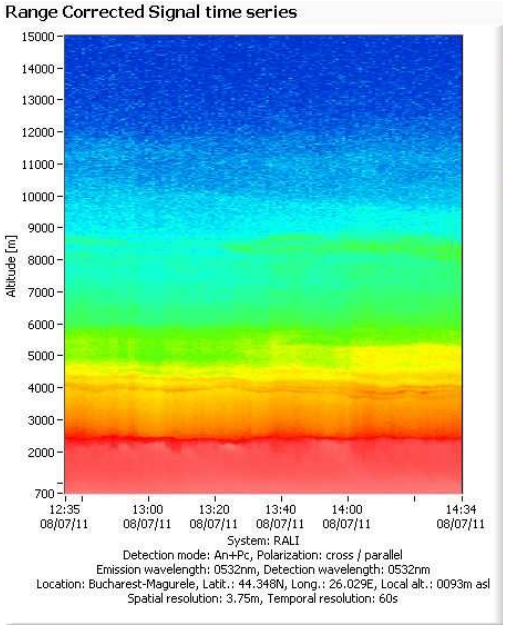

Figure 2. *Similar as in fig.1 but on July 11th , 2008 starting at 12:35 UTC, at Constanta, near Black Sea coast; layers detected at 2300m and 4300m*

4. CONCLUSIONS

LIDAR images (RCS signal) have shown the time evolution of the mixed layer depth and distinguished different atmospheric layers in different campaigns. From May 2008 up to now RALI system was suitable to detect and monitor aerosol layers' intrusion in Romania, from long range transport, but also to describe the optical and microphysical properties of the aerosol.

During May 2009, the instrument participated at the intercomparison campaign EARLI09, organized in the frame of EARLINET. This was an important opportunity to assess the performances of the Bucharest multiwavelength system, to optimize its operation and to test data handling procedures and programs. RALI worked without any hardware problems for the entire campaign, and demonstrated a good stability and accuracy.

AKNOWLEDGEMENTS

Supported by a grant from Norway through the Norwegian Co-operation Programme for Economic Growth and Sustainable Development in *Romania*

Supported by European Commission, FP6 RICA-CT-2006-025991 – EARLINET ASOS

European Commission, FP7-REGPOT-2008-1, project no. 229907, DELICE—Developing the emerging research potential of Romanian Lidar Centre

REFERENCES

[1] Measures R.M., , 1992, *Laser Remote Sensing. Fundamentals and Applications*, Krieger Publishing Company, Malabar, Florida

[2] Kovalev, V., and Eichinger, V., 2004, *Elastic lidar: Theory, Practice and Analysis Methods*, Wiley Interscience Publ., New York, USA

[3] Matthias V. et al., 2004, Aerosol lidar intercomparison in the framework of the EARLINET project. 1. Instruments, *Applied Optics*, Vol.43, No.4, pp. 961

[4] Bockmann C. et al., 2004,Aerosol lidar intercomparisons in the framework of EARLINET project 2.Aerosol backscatter algorithms, *Applied Optics*, Vol.43, No.4, pp. 977-989

[5] Pappalardo G. et al., 2004, Aerosol lidar intercomparison in the framework of the EARLINET project. 3. Raman lidar algorithm for aerosol extinction, backscatter, and lidar ratio, *Applied Optics*, Vol.43, No.4, pp. 5370

[6] Talianu C., D.Nicolae, J. Ciuciu , A. Nemuc , E. Carstea, L. Belegante, M. Ciobanu, 2007, *New Algorithm For The Retrieval Of Aerosol's Optical Parameters By Lidar Data Inversion*, ECMI Series Vol. 11, Springer, pp.55-62

[7] Nicolae D., C. Talianu, R.-E. Mamouri, E. Carstea, A. Papayannis, G. Tsaknakis, 2008, Air mass modification processes over the Balkans area detected by aerosol Lidar techniques,

J.Optoelectron.Adv. Mat. – Rapid communications Vol. 2, No. 6, pp. 405 – 412

[8] Nicolae D., C. Talianu, V. Babin, L. Belegante, 2008, Benefits and drawbacks of laser remote sensing in atmosphere science, *U.P.B. Sci. Bull.*, Series A, Vol. 70, No. 4, ISSN 1454-2331, pp. 5-14

[9] Nemuc A., D. Nicolae, C. Talianu, E.Carstea, C.Radu,2009, Dynamic Of The Lower Troposphere From Multiwavelength Lidar Measurements, 2009, Romanian Reports in Physics, Vol. 61, No. 2, P. 313–323