EARLINET – LIDAR ALGORITHM INTERCOMPARISON

C. BÖCKMANN[1], U. WANDINGER[2], A. ANSMANN[2], J. BÖSENBERG[3], V. AMIRIDIS[4], A. BOSELLI[16] A. DELAVAL[5], F. DE TOMASI[6], M. FRIOUD[7], M. IARLORI[12], L. KOMGUEM[8], S. KREIPL[9], G. LARCHEVĘQUE[10], V. MATTHIAS[3], A. PAPAYANNIS[11], F. ROCADENBOSCH[13], J. SCHNEIDER[14], V. SHCHERBAKOV[15] and M. WIEGNER[17]

[1] Institut für Mathematik, Universität Potsdam,
Am Neuen Palais 10, 14469 Potsdam, Germany.

[2]Institut für Troposphärenforschung, Leipzig, Germany.
[3]Max-Planck-Institut für Meteorologie, Hamburg, Germany.
[4]Laboratory of Atmospheric Physics, Aristotelian University of Thessaloniki, Greece.
[5]Institute Pierre Simone Laplace, Paris-Jussieu, France.
[6]Dipartimento di Fisica and I.N.F.M. Unità di Lecce, Italy.
[7]Observatory of Neuchâtel, Switzerland.
[8]Physics Department, University of Wales, Aberystwyth, United Kingdom.
[9]Fraunhofer-Institut für Atmosphärische Umweltforschung, Garmisch-Partenkirchen, Germany.
[10]Lidar Group, École Polytechnique Fédérale de Lausanne, Switzerland.
[11]Physics Department, National Technical University of Athens, Greece.
[12]Department of Physics, Università degli Studi, L'Aquila, Italy.
[13]Universitat Politecnica de Catalunya, Barcelona, Spain.
[14]Leibniz-Institut für Atmosphärenphysik an der Universität Rostock e.V., Germany.
[15]Institute of Physics, National Academy of Sciences of Belarus, Minsk, Belarus.
[16]I.N.F.M. and Dipartimento di Scienze Fisiche Università di Napoli, Italy.
[17]Meteorologisches Institut der Universität München, Germany.

Keywords: aerosol climatology, optical properties, lidar, remote sensing.

INTRODUCTION

EARLINET is a joint project of 19 European lidar groups to establish a quantitative comprehensive statistical data base of both horizontal and vertical distribution of aerosols on a continental scale. The objectives are reached by implementing a network of 21 stations distributed over most of Europe, using advanced quantitative laser remote sensing (multispectral backscatter lidar mostly combined with Raman lidar) to measure directly the vertical distribution of aerosol. Special care was and will be taken to assure data quality. A basic exercise to test performances is the comparison of the algorithms used to calculate the optical parameters from the lidar signals. Therefore, an intercomparison of algorithms applied by different lidar groups to retrieve the backscatter-coefficient profile of aerosols was organized as a part of EARLINET. Using their individual algorithms, all participating groups processed synthetic lidar data sets. The outcome of this algorithm intercomparison permits one to test the numerical correctness and accuracy of the algorithms as well as the experiences of the groups and the limits of the method with respect to the unknown input parameters.

METHOD AND RESULTS

Most of the lidar inversion algorithms are based on the works of Fernald (1984) and Klett (1985). Because two unknowns, particle extinction and particle backscattering, influence the measured elastic backscatter signal, the algorithm considers a linear relationship between the extinction and the backscatter coefficient, the extinction-to-backscatter or lidar ratio. This input quantity is unknown in principle, because it depends on the actual physical and chemical properties of the atmospheric particles. In addition, a reference value is needed for the inversion, which usually is set into a height region, where Rayleigh scattering dominates the measured signal. Rayleigh scattering is calculated from temperature and pressure values of a radiosonde ascent or a standard atmosphere.

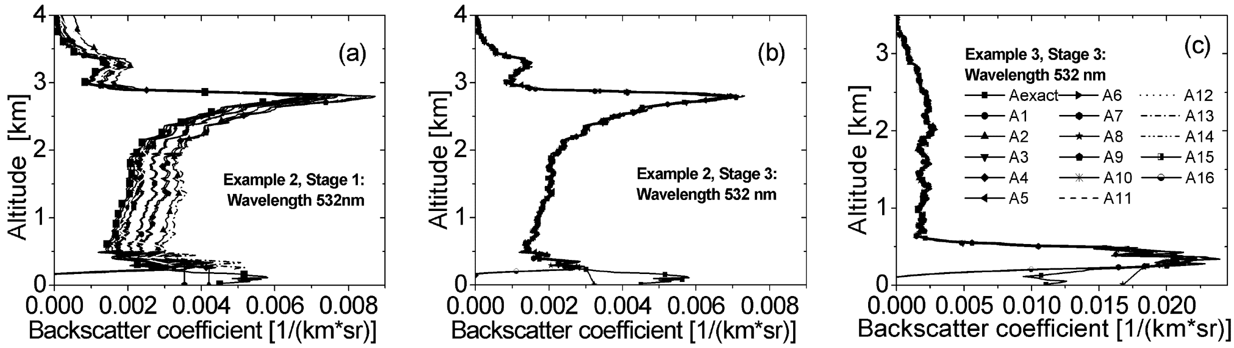

Figure 1: Backscatter coefficients at 532 nm calculated by the groups A1–A16 in comparison to the correct solution for (a) simulation case 2, stage 1, (b) simulation case 2, stage 3, and (c) simulation case 3, stage 3.

The synthetic data were calculated with a sophisticated lidar simulation model. Three different sets of elastic backscatter signals at wavelengths of 355, 532, and 1064 nm for realistic atmospheric conditions were computed. For the first example, the input profiles of extinction coefficient and lidar ratio were provided to the participants to allow an exercise with known solutions. Examples 2 and 3 were used for the intercomparison. In example 2, a wavelength-dependent extinction-coefficient profile was assumed and the lidar ratio was dependent on wavelength but constant with height. In contrast, for example 3 a height-dependent but wavelength-independent lidar ratio was used.

The intercomparison was executed in three stages. The first stage was the most realistic and difficult one, because the input parameters were unknown. Therefore, not only the correctness and accuracy of the algorithm was proved but also the experience in estimating the lidar ratio and choosing the reference value. Figure 1(a) shows the backscatter-coefficient profiles at 532 nm for simulation case 2 obtained by the different groups in stage 1. The deviations from the correct solution were between 0% and 100%. In the second stage the lidar ratio was known, and in the third stage both input values were given to the participants. Thus, the final stage proves definitively the numerical correctness, i.e., the accuracy and stability of the algorithms. The results of stage 3 for simulation cases 2 and 3 are shown in Fig. 1(b) and (c), respectively.

The algorithm intercomparison showed that in general the data evaluation schemes of the different groups work well. Differences in the solutions can mainly be attributed to differences in the estimate of the input parameters. If the input parameters are known, remaining errors are of the order of a few percent. The unknown lidar ratio had the largest influence on the solutions. To overcome this problem, independent measurements of the particle extinction coefficient with the Raman method are or will be performed at most of the network stations.

ACKNOWLEDGEMENTS

This work is supported by the European Commission under grant EVR1-CT1999-40003.

REFERENCES

Fernald, F.G. (1984). Analysis of Atmospheric Lidar Observations: Some Comments. *Appl. Opt.*, **23**, 652.

Klett, J.D. (1985). Lidar Inversion with variable backscatter/extinction ratios. *Appl. Opt.*, **24**, 1638.