Intercomparison of 21 aerosol lidar systems in the frame of EARLINET

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ABSTRACT

EARLINET is an European aerosol lidar network consisting of 19 lidar groups. Several steps were taken in order to guarantee the quality of the deliverables to the common database. In this part of the quality assurance program 21 lidar systems were compared at system level. Two or more lidar systems were placed close to each other at a time, and the retrieved aerosol backscatter coefficient profiles from simultaneous measurements at the same or similar wavelengths were compared considering predefined quality criteria. Most of the discovered discrepancies could be eliminated during the comparison campaigns; a few systems had to be modified to meet the requirements.

1. INTRODUCTION

19 lidar groups are forming the European project EARLINET (European Aerosol Research Lidar NETwork) to establish an aerosol climatology¹:². Within this framework, much effort has been spent to assure the quality of the measured data
at the different stations. Comparisons of the algorithms used to calculate the backscatter coefficient from the lidar signals and of the algorithms used to calculate aerosol extinction profiles from Raman measurements have been carried out. In this paper we report on the comparison of the lidars at system level, in which up to now 21 different lidar systems have been compared between 1998 and 2001.

2. METHODS

Most of the lidar systems used within the EARLINET project are based on Nd:YAG lasers emitting at least at two of the wavelengths 355 nm, 532 nm and 1064 nm. Three excimer-based systems are emitting only one wavelength at 351 nm. Most systems include Raman channels in the UV and some also in the visible, which provides independent measurements of the aerosol extinction. About half of the lidar systems are mobile, and some groups own mobile systems in addition to the stationary. However, at the time of the intercomparisons only one transportable Raman system was available, and therefore all intercomparisons except one concern backscatter.

The first intercomparison of four German systems took place in August 1998 in the frame of the German Lidar Network. Within EARLINET most of the intercomparisons have been completed in two main experiments in fall 2000. Five systems were compared in September 2000 in Palaiseau, France. The mobile Munich lidar traveled to Italy and Greece in September and October 2000 and was compared to six EARLINET stations in those countries. Additional intercomparisons of just two systems, with one of them being already approved, were performed in Hamburg, Munich and Aberystwyth.

![AFS Intercomparison Lindenberg 1998/08/11](image1)

![EARLINET Intercomparison Lecce 2000/10/05](image2)

**Figure 1:** Intercomparison of the lidar aerosol backscatter profiles at 351 nm and 355 nm. Left: MPI (Hamburg), IFT (Leipzig), and MIM (Munich) in Lindenberg on August 11, 1998. The error bars show the limits of the allowed mean deviation of the profiles. Right: MIM (Munich) and Lecce in Lecce on October 17 and 18, 2000.
For the comparisons, simultaneous measurements of aerosol particle backscatter profiles have been accomplished on several days and under different meteorological conditions. The profiles of the backscatter coefficient were calculated by each group separately using proven algorithms with common reference values and lidar ratios. This allows to test the whole procedure of determining aerosol backscatter profiles from the measurement itself to the calculated profile.

The common quality criteria for the comparisons had been defined in advance considering the goals of the project as well as the possible differences due to the temporal and spatial variability of the atmosphere during the comparison measurements. Different criteria were selected for the different wavelengths and for heights with high and low aerosol load. For example, at 355 nm the limits for the mean deviation of the backscatter coefficient with high aerosol load were set to 20% or $5 \times 10^{-7}$ (m*sr)$^{-1}$, whichever is the larger, and to $5 \times 10^{-7}$ (m*sr)$^{-1}$ with low aerosol load.

### 3. RESULTS

Examples of the results are displayed in Fig. 1 and Fig. 2. Fig. 1, left side, shows measurements at 351 and 355 nm of the MPI (Hamburg), IFT (Leipzig) and the MIM (Munich) systems, which were compared already in August 1998 in the frame of the preceding German Lidar Network. The systems agreed perfectly in the PBL and quite well above. The error bars show the limits of the allowed mean deviation of the profiles. In Fig. 1, right side, the MIM (Munich) and the Lecce systems are compared with measurements from August 5, 2000, with a just as good agreement. The measurements in Fig. 2 were taken on two different days during the intercomparison campaign at Palaiseau, in Sept. 2000, showing rather
different aerosol distributions. In these cases, the agreement can also be regarded as excellent; even the Micro Lidar from Observatory Neuchatel, for which some daytime problems due to its very low pulse energy had been anticipated, performed very well up to 3000 m (Fig. 2, left side).

On the other hand problems occurred for several lidar systems especially in the near range. These problems could mainly be assigned to detector saturation and to incomplete overlap, and had been solved within a short time. One system had and two others have to be compared a second time after changes in the configuration in order to obtain better results also in the boundary layer.

In general the mean mutual deviations of the systems stay well within the 20 % limits in regions with high aerosol, mostly even within ± 10%. In regions with low aerosol, the mean deviations are in almost all cases smaller than $2 \times 10^{-7}$ (m*sr)$^{-1}$.

4. SUMMARY

Intercomparison experiments including a set of 21 aerosol lidar systems in whole Europe have successfully been performed. In most cases the lidar derived aerosol backscatter profiles agreed well within the limits of the EARLINET quality criteria. In some cases shortcomings were identified and corrected, and in two cases the final comparisons are under way. This intercomparison of the lidar systems and the concurrent revision of the inversion algorithms are prerequisites for the reliability of the common data base for the establishment of an aerosol climatology.

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REFERENCES