EUROPEAN AEROSOL RESEARCH LIDAR NETWORK – ADVANCED SUSTAINABLE OBSERVATION SYSTEM (EARLINET-ASOS)

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ABSTRACT

EARLINET, the European Aerosol Lidar Research Network, is the first aerosol lidar network, established in 2000, with the main goal to provide a comprehensive, quantitative, and statistically significant data base for the aerosol distribution on a continental scale.

The EARLINET-ASOS (Advanced Sustainable Observation System) EC Project, starting on the EARLINET infrastructure, will contribute to the improvement of continuing observations and methodological developments that are urgently needed to provide the multi-year continental scale data set necessary to assess the impact of aerosols on the European and global environment and to support future satellite missions.

1. INTRODUCTION

The present knowledge of the aerosol distribution is far from sufficient to properly estimate the role of aerosols in changes of the global and regional environmental conditions and climate. Improving the observation system for aerosols will contribute to almost all areas of societal benefits listed in the GEOSS Implementation Plan. Since it is in particular the information on the vertical distribution that is lacking, advanced laser remote sensing is the most appropriate tool to close the observational gap.

EARLINET-ASOS, starting on the European Aerosol Research Lidar Network (EARLINET) infrastructure, consisting of 20 lidar stations distributed over Europe, will contribute to the improvement of the network.

The main objective is to improve the EARLINET infrastructure resulting in a better spatial and temporal coverage of the observations, continuous quality

control for the complete observation system, and fast availability of standardized data products. This will be reached by strengthening the co-operation among the partners with several networking activities: exchange of expertise with the main goal of defining and disseminating best practice and knowledge; quality assurance program for both algorithms and instruments for assessing and assuring common high quality standards; optimization of instruments for achieving a better temporal coverage and standardization of performance; optimization of data processing with the goal of establishing an automatic processing from raw data to final products; establishing a database provided with an user interface for dissemination of data.

The expected outcome is the most comprehensive data source for the 4-D spatio-temporal distribution of aerosols on a continental scale.

2. EARLINET

EARLINET is a coordinated network of stations using advanced lidar methods for the vertical profiling of aerosols [1]. At present, more than 20 stations distributed over Europe (see Figure 1) are part of the network.

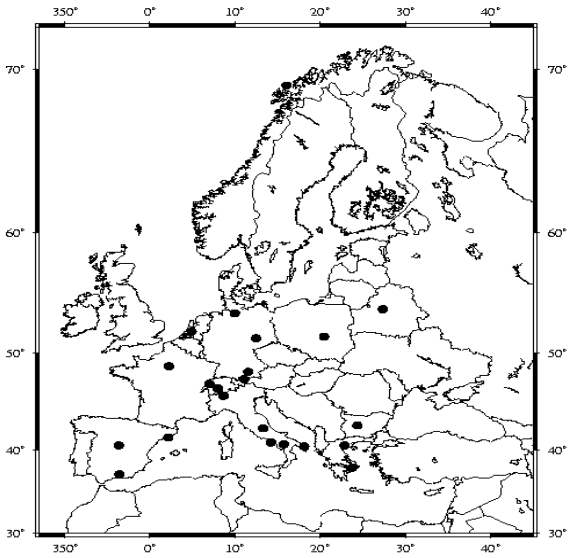

Figure 1. Map of Europe with the distribution of all the EARLINET lidar stations.

The network activity is based on scheduled measurements, a rigorous quality assurance program addressing both instruments and evaluation algorithms, and a standardised data exchange format.

In order to collect unbiased data, all the network stations perform measurements simultaneously at three fixed dates a week. Additional network measurements are performed to address specifically important processes that are localised either in space or time, like Saharan dust outbreaks, forest fires, volcanic eruptions, photochemical smog.

Special care has been taken to assure data of highest possible quality. Therefore all network stations participated in inter-comparisons both at instrument and algorithm levels with standardised procedures [2-4].

The EARLINET database represents the largest database for the aerosol distribution on a continental scale. At present, it contains more than 20000 aerosol profiles in terms of extinction, backscatter and lidar ratio, whereas lidar ratio data have been retrieved from simultaneous and independent lidar measurements of aerosol extinction and backscatter.

All the files are divided in different categories related to regular (scheduled measurements three times per week) and special observations: climatology (regular measurements); cirrus; diurnal and seasonal cycle of aerosols in the boundary layer; volcanic eruptions; forest fires; observations of photochemical smog episodes in large cities; observations in rural and urban context; Saharan dust; stratospheric aerosols. EARLINET data have already conducted to a first statistical analysis of the aerosol optical properties over Europe [5], climatological studies [6-9], studies on Saharan dust events [10-12], volcanic eruptions [13], bio-mass burning [14], long range transport [15] and solar aerosol radiative forcing [16]. Moreover, microphysical retrieval algorithms [17,18] were developed and tested extensively with synthetic data and as well with first real measurement data. From optical lidar and sun photometer data, respectively, microphysical properties as effective radius, total surface-area and volume concentration, complex refractive index and single scattering albedo can be retrieved.

3. EARLINET-ASOS

EARLINET is continuing its activity and further lidar stations are going to join the network. In particular, within the EARLINET-ASOS (Advanced Sustainable Observation System) 5-year project, started on 1 March 2006, EARLINET will enhance the operation of the network.

The main objectives of the EARLINET-ASOS project are:

- to extend the development of the European Aerosol Research Lidar Network as a world-leading instrument for the observation of the 4-dimensional spatio-temporal distribution of aerosols on a continental scale, resulting in accurate, well-defined, and easily accessible data products for use in science and environmental services.
- to enhance the operation of the network to foster aerosol-related process studies, validation of satellite sensors, model development and validation, assimilation of aerosol data into operational models, and to build a comprehensive climatology of the aerosol distribution.

This will be reached by defining and using common standards for instruments, operation procedures, observation schemes, data processing including advanced retrieval algorithms, and dissemination of data.

To facilitate the verification of achievements more specific technical objectives are defined:

a) Maintain quality assurance for all the stations at the highest possible level. This includes spreading of good practice for system control and operation as well as end-to-end checks of performance.

b) Establish common standards for advanced aerosol lidar instruments with improved temporal coverage, operation procedures, data processing, and retrieval of optical, microphysical, and other derived parameters.

c) Extend an observation scheme of regularly scheduled measurements and additional measurements for special purposes towards better temporal coverage.

d) Collect data, including auxiliary data, in a comprehensive data base and implement a user interface providing fast and easy access to well structured data for both internal and external users, e.g., atmospheric researchers, global and regional climate modellers, satellite community, and environmental agencies.

e) Establish a platform for cooperation and coordination with the relevant observation and user communities, and serve as a nucleus for a world-wide aerosol lidar network.

EARLINET-ASOS is organized in the following networking activities:

Quality assurance
This will be implemented by defining standardized tools for internal quality checks at both instrument and inversion algorithm levels, by providing assistance to the participating stations to apply these tools to their instruments and procedures, and by compiling the different system and subsystems setups at individual stations.

Optimization of instruments
Starting from individual solutions found at the different partner stations, an optimal approach to the instrumentation both at the system and at the subsystem level will be defined. Emphasis will be made on automation, for extended temporal coverage, and standardization, for improved interoperability in future networks.

Optimization of data processing
The main objective of this activity is to provide all partners with the possibility to use a common single processing chain for the evaluation of their data, from raw signals to final products. Raw signals may come from different types of system, final products are profiles of optical properties like backscatter and extinction and, as far as instrument properties permit, microphysical properties.

Database construction and operation
The aim is building a common database that is automatically and continuously updated through a software system which automatically collects the data products provided by the individual stations and makes them available to the community; in addition to the continuously updated quality-controlled lidar data, the database will include auxiliary data allowing to search for data meeting specified criteria. It will be accessible through a web-based interface to provide easy access to data products for internal and external users.

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REFERENCES

1. Bösenberg, J., et al., A European Aerosol Research Lidar Network to Establish an Aerosol Climatology. MPI-Report 348, Max-Plank-Institut für Meteorologie, Hamburg, 2003.

2. Matthias V., et al., Aerosol lidar inter-comparison in the framework of the EARLINET project. 1 - Instruments, *Appl. Opt*., 43, N. 4, 961-976, 2004.

3. Böckmann, C. et al., Aerosol lidar intercomparison in the framework of EARLINET. 2. Aerosol backscatter algorithms, *Appl. Opt*., 43, 4, 977-989, 2004.

4. Pappalardo, G. et al., Aerosol lidar intercomparison in the framework of the EARLINET project. 3 - Raman lidar algorithm for aerosol extinction, backscatter and lidar ratio, *Appl. Opt*., 43, N. 28, 5370-5385, 2004.

5. Matthias, V. et al., The vertical aerosol distribution over Europe: statistical analysis of Raman lidar data from 10 EARLINET stations, *J. Geophys. Res.*, 109, D18201, doi: 10.1029/2004JD004638, 2004.

6. Matthias V., Bösenberg J., Aerosol climatology for the planetary boundary layer derived from regular lidar measurements, Atmospheric Research, 63, 221-245, 2002.

7. Pappalardo G., et al., One year of tropospheric lidar measurements of aerosol extinction and backscatter, Annals of Geophysics, 46, N.2, 401-413, 2003.

8. Mattis I., et al., Multiyear aerosol observations with dual-wavelength Raman lidar in the framework of EARLINET. Journal of Geophysical Research 109, 10.1029/2004JD004600, 2004.

9. Amiridis V. et al., Four-year aerosol observations with a Raman lidar at Thessaloniki, Greece, in the framework of European Aerosol Research Lidar Network (EARLINET), *J. Geophys. Res.*, 110, D21203, doi: 10.1029/2005JD006190, 2005.

10. Ansmann, A., et al., Long-range transport of Saharan dust to northern Europe: The 11-16 October 2001 outbreak with EARLINET. *J. Geophys. Res.*, 108, 4783, doi: 10.1029/2003JD003757, 2003.

11. De Tomasi F. et al., Raman lidar monitoring of extinction and backscattering of African dust layer and dust chacterization", Appl. Optics 42, 1699-1709, 2003.

12. Balis, D.S. et al., Optical properties of Saharan dust layers as detected by a Raman lidar at Thessaloniki, Greece, *Geophys. Res. Lett.*, 31, L13104, doi:10.1029/2004GL019881, 2004.

13. Pappalardo, G. et al., Raman lidar observations of aerosol emitted during the 2002 Etna eruption, *Geophys. Res. Lett.*, 31, L05120, doi:10.1029/2003GL019073, 2004.

14. Balis D.S, et al., Raman lidar and sunphotometric measurements of aerosol optical properties over Thessaloniki, Greece during a biomass burning episode, Atm. Env., 37,32, 4529-4538, 2003.

15. Wandinger, U., et al., Air-mass modification over Europe: EARLINET aerosol observations from Wales to Belarus, *J. Geophys. Res.*, 109, doi: 10.1029/2004JD005142, 2004.

16. Wendisch M. et al., Potential of lidar backscatter data to estimate solar aerosol radiative forcing, *Appl. Opt*., 45, N. 4, 770-783, 2006.

17. Böckmann, C., I. Et al., Microphysical aerosol parameters from multiwavelength lidar, J. Opt. Soc. Am. A, 518-528, 2005.

18. Müller, D., et al., Closure study on optical and microphysical properties of an urban/arctic haze plume observed with Raman lidar and Sun photometer. J. Geophys. Res., 109, 2003JD004200, 2004.