ACTRIS TNA Activity Report

High altitude aerosol in situ characterization in synergy with LIDAR vertical profiles, *SYNERGY*

Nadège Montoux

- Introduction and motivation

  Aerosols monitoring is of high relevance for studying pollution spread and climate evolution. The Puy de Dôme (PdD) station includes instruments to characterize in situ aerosol physico-chemical properties (size distribution, optical properties, hygroscopicity, ...) at 1465 m a.s.l. Eleven kilometers far from the station, a 355 nm aerosol lidar with Raman capability (Clermont-Ferrand (CL) lidar) has been performing optical measurements in clear sky conditions since 2009. Aerosol optical properties obtained from the lidar alone (with the Raman channels) and from the lidar coupled with a CIMEL sunphotometer can be compared. The synergy between in-situ and lidar measurements allow the retrieval of aerosol mass vertical profiles over the whole atmosphere in order to study events like dust, volcanic eruptions or pollution transport (Freney et al., 2011 ; Hervo et al., 2012). In addition, integrating the CL lidar data will contribute to long-term climate monitoring programs such as the EARLINET and ACTRIS networks. In order to perform these research activities with the quality assurance required by the EARLINET community, training at a state-of-art atmospheric research infrastructure including expert support and know-how transfer was necessary and strongly beneficial to retrieve aerosols optical properties from the lidar data.

- Scientific objectives

  The first objective of this training activity was to learn how to calculate from raw lidar data:
  - aerosol extinction and backscatter using only elastic channels during day-time measurements with assumption of a well-known ratio between extinction and backscatter coefficients,
  - aerosol extinction and backscatter using both elastic and Raman channels during night-time measurements with no assumption of the ratio between extinction and backscatter coefficients.

  The second objective was to get familiar with using the Single Calculus Chain (SCC) developed by some groups of the EARLINET community. The aim of the SCC is to provide a tool for processing all the different lidar data of the EARLINET community in the same manner to get consistent aerosol optical properties.

- Reason for choosing station

  The CNR-IMAA Atmospheric Observatory (CIAO) has a long experience in lidar remote sensing: instrumentation design and development, quality check, retrieval algorithms and data analysis. In addition, this group is one of the three main groups involved in the SCC development and is in charge of the SCC web interface.

- Method and experimental set-up

  The training activities were divided into three parts.

  The first part was dedicated to quality assurance. The following points were discussed in order to constantly check instrumental problems and ensure, thus, high-quality measurements in the future:
  - tests on the optical, electronic and hardware parts of the lidar (for example, tests on the quality of the polarization splitter, on the electronic delay between emission and acquisition),

- optimization of the telescope and laser beam positions to allow coverage at low altitude ranges (~1000 m asl). The method for optimizing the alignment was shown on the Potenza EArlinet Raman Lidar (PEARL) at CIAO,
- regular quality check of the system and the data acquisition (for example, telecover test, dark measurement, Rayleigh fit),
- adjustment of the lidar acquisition to avoid distortion on the signals (for example, high-voltage of the photomultipliers, neutral density filters add).

The second part of the training was dedicated to aerosol extinction retrieval using the N_2 Raman channel. Basic Raman scattering as well as applications on the CIAO measurements were shown.
The last part of the training was dedicated to the SCC description (input file requirements, modules included in the chain, and output files provided by the SCC) as well as web interface use.

- Preliminary results and conclusions

The training was very successful and now allows us to optimize the altitude range of our measurements and to avoid spurious effects in our measurements. Most of the tests have been implemented on the CL lidar and the configuration of the system and the parameters for the data acquisition have been optimized.
Routines have been developed to calculate aerosol extinction and backscatter for day-time and night-time measurements. To check the quality of the routines developed, CIAO provided synthetic lidar data used by the EARLINET community to check the agreement of all the algorithms developed by each station (Pappalardo et al., 2008). The results of this intercomparison are shown in Figure 1. The developed algorithm shows good agreement with the one developed by CIAO. The small differences can probably be explained by different choices of vertical averaging between both algorithms and will be investigated further.

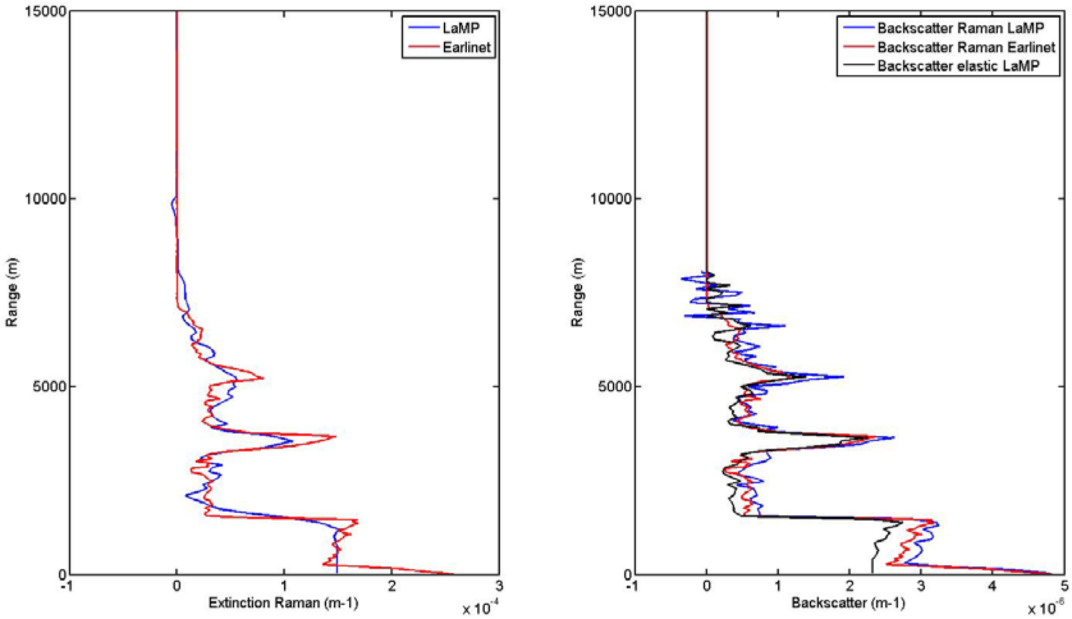

Figure 1: (Left) Aerosol extinction and (Right) aerosol backscatter obtained from synthetic lidar data simulated at 355 nm. Red curve: result from the CIAO algorithm taken as reference. Blue curve: result from the algorithm developed during and after the training using the Raman and elastic channels. Black curve: same as blue curve but using only elastic channels.

CL processing routines are now used to process the data acquired during the last EMEP campaign (8 June – 17 July 2012).
In the framework of an EARLINET operational exercise and a ChArMEx pre-campaign, 72-hour continuous lidar measurements were performed by 11 stations including Clermont-Ferrand from 9

July 6:00 UTC until 12 July 6:00 UTC. This provided a good opportunity to check the improvements of the lidar configuration made since the training activity at CIAO. Unfortunately, during this exercise no dust were observed above Clermont-Ferrand and the sky was most of the time cloudy by low-level clouds (~2 km high). The raw data files were converted into SCC netcdf input files and 59 of the 72 hourly files submitted to the Potenza centralized server were processed successfully.

- Outcome and future studies

Further optimization of the lidar setup, like use of plates in the optical box of the lidar to check improvements of the depolarization measurements and to have a better estimate of the depolarization factor of the system, are planned before the end of 2012. In addition, an intercomparison campaign with the mobile lidar of the Munich group is considered in 2013. This campaign could also help to improve our knowledge of spurious effects affecting the lidar signals that have never been addressed before.

The processing of all data acquired since 2009 is ongoing and aerosol extinction and backscatter data will be submitted to ACTRIS/EARLINET before the next report in 2013.

Moreover, continuous aerosol in-situ measurements at PdD station as well as CIMEL and lidar measurements will allow to compare aerosols properties retrieved in the same altitude range (~1465 m asl) and to study future events like dust, volcanic eruptions or pollution transport.

Long term analysis of the optical properties at the PdD station will be performed. The aerosol hygroscopic growth and its impact on optical properties and especially lidar ratio will be investigated.

- References

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