POLLYNET - AN EMERGING NETWORK OF AUTOMATED RAMAN-POLARIZATION LIDARS FOR CONTINUOUS AEROSOL PROFILING

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ABSTRACT

POLLYnet is a network of portable, automated, and continuously measuring Raman-polarization lidars of type Polly operated by several institutes worldwide. The data from permanent and temporary measurement sites are automatically processed in terms of optical aerosol profiles and displayed in near-real time at polly.tropos.de. According to current schedules, the network will grow by 3-4 systems during the upcoming 2-3 years and will then comprise 11 permanent stations and 2 mobile platforms.

1 INTRODUCTION

Motivated by the urgent need for robust Raman-polarization lidars that are easy to operate and allow aerosol typing, an automated portable lidar system, called PollyXT, has been developed at the Leibniz Institute for Tropospheric Research (TROPOS) with international partners during the last decade [1, 2]. The aim was to develop a sophisticated automated Raman-polarization lidar for scientific purpose, but with the advantages of an easy-to-use and well-characterized instrument with same design, same automated operation, and same centralized data processing delivering near-real-time data products. By the end of the year 2016, ten Polly systems have been constructed and are employed worldwide. As the number of Polly lidars and measurement sites has increased, an independent, voluntary, international network of cooperating institutes, the so-called PollyNET [3], has evolved as an additional contribution to the worldwide aerosol observational efforts like for example the European Aerosol Research Lidar Network (EARLINET) and the Asian Dust Network (AD-NET). In this contribution, we present the basic idea behind PollyNET, its stations, the automated data analysis efforts and future plans.

2 POLLY LIDAR SYSTEMS

All Polly lidar systems are designed for automatic and unattended operation in 24/7 mode (continuously 24 h a day, 7 days per week). As the capabilities have continuously expanded, all lidars differ slightly from each other. Nevertheless, they feature a similar design, the same data format, and benefit from unified calibration and quality assurance routines. An overview of the different systems including their capabilities and different characteristics can be found in [2]. The latest developed PollyXT (with extended capabilities) is a so-called $3+2+2+1+2+2$ multiwavelengths lidar with near-range capabilities (3 elastic, 2 Raman, 2 depolarization, 1 water-vapor, 2 near-range elastic, and 2 near-
range Raman channels). The lidar emits light
at 1064, 532, and 355 nm at an energy of 180,
110, 60 mJ per pulse. The primary mirror of
the receiver unit has a diameter of 30 cm. The
data of all channels is acquired with a verti-
cal resolution of 7.5 m in temporal steps of 30 s
(laser repetition rate 20 Hz). Below about 600–
800 m above the lidar, the overlap of the laser
beam and the receiver field of view is incom-
plete and needs to be corrected. As a conse-
quence, a second detection unit together with
a near-range telescope was added to the system
to detect the elastic and inelastic backscatter in
the UV and VIS in the lowermost height range
above the system. As a result, the determined
overlap function of the far-range channels can
be verified and backscatter and extinction pro-
files can be obtained down to about 100 m a.g.l.
Further system details are given by [1] and [2].

3 POLLY\textsuperscript{NET}

Until now, the Leibniz Institute for Trop-
ospheric Research (TROPOS), the Finnish
Meteorological Institute (FMI), the National
Institute of Environmental Research in Ko-
rea (NIER), the Évora University in Por-
tugal (CGE), the University of Warsaw in
Poland (UW), the German Meteorological Ser-
cvice (DWD) and the National Observatory of
Athens in Greece (NOA) contribute actively to
Polly\textsuperscript{NET} by operating Polly systems. Each
group contributes with its expertise and knowl-
dge to the network and to joint scientific
projects.

Within Polly\textsuperscript{NET}, Polly lidar measurements
have been performed at 30 locations in Europe,
the Amazon rain forest, Southern Chile, South
Africa, India, China, Korea, Tajikistan, Israel
and over the Atlantic Ocean. Very different
aerosol types and aerosol mixtures have been
observed. An overview of findings from these
observations is given in [3].

Figure 1 shows the current and planned
measurement sites within Polly\textsuperscript{NET}. Curr-
rently, measurements are performed at Kuopi-
io, Finland (FMI); Leipzig, Germany; Limas-
sol, Cyprus; Haifa, Israel (TROPOS); War-
saw, Poland (UW), Hohenpeißenberg, Ger-
many (DWD); Evora, Portugal (CGE); and
Banegnyeong Island, Korea (NIER). Most of
these stations operate the lidar continuously.
Additionally, regular shipborne observations
are performed twice a year by TROPOS on-
board the German research vessel Polarstern
crossing the Atlantic Ocean latitudinal.

Data from the permanent locations as well as
from measurement campaigns are centrally col-
lected via internet, processed, and displayed in
near-real time at polly.tropos.de.

In future, new permanent stations are scheduled
for Cape Verde (TROPOS), Finokalia, Crete,
Greece (NOA), Cyprus (TROPOS), Tel Aviv,
Israel (TAU) and Dushanbe, Tajikistan (TRO-
POS).

4 AUTOMATED DATA ANALYSIS

Polly systems are designed to operate continu-
ously, i.e., accumulate up to 2880 raw files per
day. Naturally, a robust automatic data analysis
algorithm is necessary to make use of such
an amount of data. Thanks to equal system
setup and data format this could be achieved within PollyNET. The complete procedure for the automatic determination of aerosol optical profiles is illustrated in Fig. 2 and in detail described in [3].

After pre-processing including cloud-screening, optical profiles at 355, 532, and 1064 nm are calculated using the well-known retrieval algorithms with the help of an automated Rayleigh fit procedure for reference height finding. The choice between the preferred Raman method and the Klett method is based on the signal-to-noise ratio (SNR) in the channels detecting the Raman scattered light (387 and 607 nm). Then, either profiles of the backscatter and extinction coefficient (Raman method) or the backscatter coefficient only (Klett method) are determined. From the profile of the volume linear depolarization ratio and the backscatter coefficient profile, the particle linear depolarization ratio is calculated. For high quality in the depolarization measurements, the ∆90° calibration [4] is automatically performed three times a day since 2012 [2].

Finally, the vertical aerosol profiles (backscatter, extinction, and depolarization) are stored centrally and displayed at polly.tropos.de in near-real-time without any manual intervention. For research on aerosols only, a post-processing is applied, e.g., screening for cirrus clouds and discarding contaminated measurements. From those screened profiles, further studies like, e.g., a statistical analysis of the vertical aerosol distribution at the PollyNET stations can be performed. Such an analysis based on the backscatter coefficient profiles at 532 nm is shown for a nine-year data set of Leipzig in Fig. 3. In addition to the 16646 individual 30-min profiles, the mean (black), the median (blue), the 25- and 75 %-percentile (purple), and the 5- and 95 %-percentile (red) profiles are plotted. The median and extreme profiles may be of particular interest, if representative aerosol profiles at specific locations are needed as a priori input for models or data retrieval algorithms.
5 CONCLUSIONS AND OUTLOOK

A powerful global network of automated and continuous measuring Raman-polarization lidar systems has been established with Polly\textsuperscript{NET}. Permanent as well as temporary sites form a network of Polly instruments. The lidar data collected within Polly\textsuperscript{NET} since 2006 is analyzed with an automated data processing procedure. All analyzed data are shown online at polly.tropos.de and are available on demand for further use in agreement with the respective station representatives.

In future, Polly\textsuperscript{NET} will expand. New stations with new systems in Cape Verde, Cyprus, and Tajikistan are planned by TROPOS. NOA plans to install a permanent site in Crete. Also the data processing chain will be further developed and merged with ACTRIS (The European Research Infrastructure for the observation of Aerosol, Clouds, and Trace gases, www.actris.eu). E.g., the combination with Cloudnet (continuous measurements with cloud radar, microwave radiometer, and ceilometer, www.cloud-net.org) might be a powerful tool to investigate aerosol-cloud-interaction. A high-resolution target categorization based on absolute calibrated lidar signals as exemplary shown in Fig. 4 have been developed for such purposes [5].

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References


