

We thank the reviewers for their suggestions, which certainly helped us improving the manuscript.

In the following,

- *Reviewers comments are shown in italic*
- Our responses by normal letters
- **Modifications in the text are highlighted in bold.**

Anonymous Referee #1

Received and published: 12 November 2015

The present paper describes the PollyNET performance on many campaigns for continuous aerosol profiling. There is a significative overall performance of these system and a criterious description on the dataset filtering aiming to provide good quality data. However I would like to see not only the system performance but also scientific results based on the observations, just mentioning typical and/or extraordinary aerosol optical properties is not sufficient in a journal as ACP. I strongly suggest a new section describing what WAS the current knowledge before the measuring campaign in each site and what became clear or new insights after Polly performed the measurements.

- The scope of the presented paper is the presentation/introduction into this new network. We present the overall strategy, peer-reviewed published results, data retrieval descriptions, and an overview of the network results. These may not be scientific highlights which are front breaking. However, we think that the presented results are of interest for the atmospheric science community. There are for example many modeling groups which are interested in the vertical aerosol distribution at the presented sites as there is almost no other information at these locations, especially, not on a long-term basis.
- From the measurements already performed there are more than 40 peer-reviewed papers, describing the location and the knowledge before the measurements and also intensively discuss the results. We cannot address this again and duplicating the information in this overviewing paper as it would increase the amount of information significantly, and thus the focus of the paper would get lost.
However, to make the focus of the paper clearer we have modified the introduction to state clearly that:
“The scope of this paper is to (a) introduce this network effort and its strategy, (b) review the scientific results obtained in the last decade, and (c) demonstrate the potential for future research. Here, a global statistical overview is provided, while intensified studies for each station are presented in specific publications.”
- Furthermore, as recommended, we have introduced a new subsection 3.5: **“Summarizing discussion”**. See more details in response to specific comment 4.
- We also have modified the title accordingly to make this message already visible in the title: **“An overview of the first decade of PollyNET: an emerging network of automated Raman-polarization lidars for continuous aerosol profiling”**

Other aspects is the timespan covered and the increase of performance of the Polly system. I believe that all improvements in hardware and software were incrementally added to the system but is somehow hard to follow which dataset had which improvement. In other words how the dataset and system setting were when a campaign was carried on in Manaus, for instance and which settings were present in Evora, at the present paper format is hard to follow.

- Thanks for this comment. To address this issue (also raised by reviewer 2), we have completely revised and updated Table 1. Now the configuration and thus the capabilities for each location are clearly stated.

Other points to consider are before publishing this paper are:

1. In the abstract the authors mention 532 nm measurements, but in the text 355 nm, 532 nm and 1064 nm were mentioned to be performed I believe an unified information should be given.

- We hope that it is now clear from the new Table 1 that the network has developed and capabilities are quite heterogeneous. Thus, it is not possible to present everything for each location. As Raman measurements obtained at 532 nm is the only common denominator for all locations, we decided to make the discussion on the vertical aerosol distributions for the different sites based on this wavelength. Thus, the information given in the abstract is correct, however, based on your comments, we tried to make it more clear and modified the abstract accordingly:

“All Polly lidars feature a standardized instrument design and apply unified calibration, quality control, and data analysis **but have different capabilities ranging from single wavelength to multiwavelength systems with near-range capabilities.**”

and

“The vertical aerosol distribution at the PollyNET locations is discussed on the basis of more than 55000 automatically retrieved 30-min particle backscatter coefficient profiles at 532 nm, **as this operating wavelength is available for all Polly lidar systems.**”

- Furthermore, as the presented algorithm is designed to calculate the optical properties for the different wavelengths independently, it is not possible to calculate the Angström exponents for selected sites straight forward as time periods for the profiles are different. This issue will be addressed in future, when the Polly activities merge more and more with EARLINET for which the same efforts are planned. The outlook was adapted accordingly.

2. In the text the limitations of other networks are limited in technical aspects and PollyNET claims to be the unique network to solve these flaws. I think this statement is too bold and scientifically not useful since each network has its own advantages and disadvantages but all together are meaningful both in TIME and SPACE since PollyNet would need to provide about 200 stations such as the AERONET stations in the globe to be the ultimate lidar network.

- It was not our intension to present PollyNET as the one and only network. Moreover, we see it as a further contribution to the efforts of worldwide aerosol profiling. PollyNET itself is also partly involved in EARLINET and has of course also limitations. We changed therefore the introduction accordingly to make this clearer and we also changed the title of the manuscript as already discussed above.

Added sentences before the introduction of the other network:

” **Comprehensive efforts have been made to establish ground-based research lidar networks.**”

- Furthermore, we have slightly rephrased several sentences in the introduction to not emphasize the limitations of a certain network but just deliver facts and stress the benefit from the existing networks.

3. Also there are many improvements in the Pollynet development were initiated within EARLINET protocol and good practice environment and despite the citations in the text more proper credit should be given.

- In the respective technical paper of the Polly lidars (Engelmann, AMTD, 2015), all the advantages taken from EARLINET and the fruitful discussions are properly acknowledged. We also think that we have properly acknowledged the benefit of PollyNET from EARLINET, and also in the outlook we stress that in future EARLINET and PollyNET will merge. However, to make it even more clear, we added to the introduction:

“EARLINET members have developed lidar techniques and algorithms in order to harmonize the lidar measurements, to setup quality standards, to perform systematic test routines, and to improve the lidar data evaluation (e.g., Böckmann et al., 2004; Pappalardo et al., 2004; Freudenthaler, 2008; Pappalardo et al., 2014; Wandinger et al., 2015; Freudenthaler, 2016; Bravo-Aranda et al., 2016; Belegante et al., 2016). Many of these efforts led also to a significant benefit for PollyNET.”

- Furthermore, we have acknowledged EARLINET now explicitly in the acknowledgements.

4. The data quality and data processing are known to be very carefully and with many details being taken into account however the way this paper is structured it looks more like a log book with their highlights given and a statistical approach should be give an aerosol typing in the way CALIOP/CALIPSO teams make should be performed otherwise the informations provided in this paper seem scattared without a BIG SCENARIO description should be given. Let us take the example of the greek site which is an ongoing project and take figure 6. What kind of information can be extracted from these plots ? For the lidar community perhaps it is useful but in the atmospheric science I see little contribution in this form of presenting the data.

- One of the main goals of this paper is to introduce the network. Therefore it might appear that it reads sometimes like a logbook, however, it is inevitable if one wants to explain the different system setups and briefly describe all measurement locations, which is certainly needed as the reviewer also stated in his/her general comments. Furthermore, the description is needed for future publications, which will be made with the use of PollyNET data.
- The benefit for future typing approaches is now discussed in a new subsection (3.5) and with an additional Figure (3) contrasting the different intensive properties obtained from the PollyNET observations. However, an automatic aerosol typing is a complete different and new topic as ground-based and satellite-based lidars (like Calipso) have completely different calibration procedures. However, this very interesting and potential topic will be investigated in future within the ACTRIS-2 Research Infrastructure effort as discussed in the outlook.
- We also believe that the data presented in Fig. 6 is of strong interest for the modelling community, which might need typical scenarios at different places or would like to test data assimilation procedures. Furthermore, it can be used to calculate average IN and CCN concentrations in the atmosphere as shown recently (e.g., Ansmann and Mamouri, ACPD) or give a general overview of the atmospheric conditions at a certain place. More important, it shows the potential in having continuous measurements at a certain location (not only for PollyNET). If one needs specific values, the data is of course available on request as stated in the manuscript. Thus, we think there is enough valuable information in Sec. 6. To make this clearer we added in the beginning of section 6 for motivation:

” Such knowledge of typical aerosol conditions might be used, e.g., for the estimation of the typical ice nucleus particle concentration in the whole troposphere (Mamouri and Ansmann, 2015) or to represent typical aerosol conditions in atmospheric models.”

5. Table 1 and Table 2 are very useful but need to be more carefully presented. For example 5_0:6 is not a good way of showing with the correct number of digits: either 5_1 or 5:0_0:6 please correct this and other cases in this table.

- Done

6. What about uncertainties in the plots and in the results presented ? It is true that this is not straightforward task however which improvements have been achieved along the Polly system development in the data SNR and corresponding effects on the optical parameters obtained throughout the data inversion process

- We have added error bars to Figure 5. For improvements concerning Polly system please refer to Engelmann, 2015, AMTD.

7. In the appendix A - Buchholtz 1995 is out of date there are more recent publications worth mentioning e.g. 10.1364/AO.51.002135. In equation A1 correct the superscript $_{atm}$ to $_{att}$.

- Thanks for the hint. However, as the molecular properties in for the data retrievals are calculated by the formulas given in Buchholtz 1995 we would like to leave the citation as it is. After reading the given new reference we might consider to change the molecular calculation in future.

8. Equation A10 has the indexes z_{ref} and z_{test} but there is no subscript in the variables ? Is that correct ?

- Thanks a lot for the hint, this was a mistake. Only z_{test} should have been used. That's now corrected.

9. Please rewrite equation A11 - if z_{test} is a variable of function X it should be explicitly shown or given in other relation on the right of the equation (A11).

- Thanks. We changed that.

10. Aren't error bars needed in plot 5 ?

- Figure 5 now shows error bars. For the sake of clarity only for the manual analysis. But errors for the automatic analysis are in the same order. This is stated in the caption

11. Finally, given the number and many affiliations in the author list. It is worth mentioning in which degree each group contributed to the knowledge acquired in the system deployment and/or data analysis and performance and scientific goals achieved by each group clearly stating so.

- The scope of this paper is to introduce an observational network that grew over the last decade. We decided to include all people, which have contributed to establish and maintain the stations,

operate the instruments, perform the measurements, analyse the collected data. Despite Polly systems being automated to the highest degree possible, the complexity of advanced lidars requires scientific personnel for operating the instruments and for assuring high quality of the measurements. Routine quality tests have to be performed and analyzed. During the measurement, signals have to be evaluated so that the lidars perform at a satisfactory level. For that reason all persons listed have significantly contributed to the data set used in this paper.

Anonymous Referee #2

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General comment

The manuscript presents the Polly lidar network, PollyNET. The paper presents an overview of the capabilities of the Polly lidar, describing the technical features and the automatic processing procedure developed for the network. It also presents a review of results, presented in previous publications based on the use of Polly lidar, and illustrates the automatic processing, using a study case. New results of the network are presented focusing on the analyses of the data gathered at different places. The variety of geographical location is used to offer a broad overview of the vertical structure of the aerosol in different regions, although using only graphical information on the visible channel, 532 nm. More detailed information is obtained from places with long-term monitoring, offering a seasonal characterization of the aerosol vertical profile.

The paper is well written and presents useful information on aerosol vertical profiling. The paper has enough quality and it is suitable for publication, after reviewing some aspects reflected in the detailed comments. Anyway, for the reasons I explain more in deep below, I think that the paper is more appropriate for Atmospheric Measurement Technology.

- We understand the reviewers concern, but think that the paper is appropriate for both, AMT and ACP. It's always a matter of the community which shall be reached and of the results presented. As non-lidar experts might not be interested in the data analysis details, the detailed description of this part was shifted to the appendix to show mostly only the atmospheric relevant results in the main body of the paper. We therefore think it is a solid basis for ACP, as the results presented could be used for e.g. calculate average IN and CCN concentrations in the atmosphere as shown recently (Mamouri and Ansmann, ACPD) or give a general overview of the atmospheric conditions at a certain place. In addition, as written in the response to reviewer 1, we added some more sentences in the introduction to make the scope of the paper clearer.

Added: "The scope of this paper is (a) to introduce this network, its strategy, (b) review the scientific results obtained in the last decade, and (c) demonstrate the potential for future research. Here a global statistical overview is provided, while intensified studies for each station are presented in specific publications."

Detailed comments

Presenting details on the instrumental features and the processing applied in a lidar network is interesting to the atmospheric community. In this sense, the manuscript offers a really interesting overview of the automatic procedures applied in the network for the processing of elastic and Raman signals. Particularly, the Appendix included in the manuscript is really useful for lidar researchers. Nevertheless, this emphasis on methodological aspects suggests that the manuscript would be more appropriate for Atmospheric Measurement Technologies.

- See comment above.

In section 2, after offering a short list of details on the first Polly system the authors include detailed information on the most recent version of Polly. Nevertheless, the results summarized in section 3 and the rest of analyses presented in the manuscript have been obtained with different versions of the system. In this sense, it is necessary to specify in Figure 1 the different versions of the system used in each place, specially indicating where are deployed the systems of the new configuration.

- Thanks very much for the valuable advice. We updated Table 1 accordingly so that it should be very clear now which system version and following which capabilities were available at the different locations.

Furthermore, considering the evolution of the Polly system along the last 10 years the authors must be careful with statements like the following, included in the abstract: "All Polly lidars feature a standardized instrument design and apply unified calibration, quality control, and data analysis."

- We agree to that and have slightly changed this sentence to: "All Polly lidars feature a standardized instrument design **with different capabilities ranging from single wavelength to multiwavelength systems**, and **now** apply unified calibration, quality control, and data analysis."

In section 3 the authors include a summary of previous results, presented in previous publications. This section must be merged with the analyses presented in section 6, supporting the results presented in this section with the results of particular studies developed in the different regions. In some sense, this would reinforce section 6, justifying some of the statements that are difficult to support only based on the analyses of the profiles of the backscatter coefficient at 532nm. That is, the information gained in previous studies on the aerosol properties analyzing multiespectral optical properties, will support better the discussion in section 6, if merged appropriately.

- We have discussed this idea already intensively during the preparation of the manuscript and were also considering this option seriously. However, as section 3 is a review of manually analyzed data and section 6 shows statistical results of automatically analyzed data, we think it would cause confusion when merging this two sections. Furthermore, the unique data set retrieved on a manual analysis basis is a very good motivation for the step forward towards automating the analysis. However, we have added a new subsection in section 3 as reviewer 1 suggested to discuss already there the potential for aerosol typing which we want to apply in future within the ACTRIS-2 Research Infrastructure not only to PollyNET but in principle to any lidar.

It is a pity that only section 5 offers an insight on the multiespectral and polarization capabilities of the system, but only at a place and applying it to a study case. It would be worthy to have some results that illustrate the whole capacity of the system at the network level, or at least covering the study case in various stations. Some discussion on this limitation of the manuscript is needed, especially considering that the manuscript is devoted to the network.

- After updating Table 1, it should be evident now that we have presented the backscatter at 532 nm because this is the only quantity available at all locations since the beginning. To make this more clear we have added:

“The vertical aerosol distribution at the PollyNET locations is discussed on the basis of more than 55000 automatically retrieved 30 min particle backscatter coefficient profiles at 532 nm, **as this operating wavelength is available for all lidar systems.** “

Routinely standardized depolarization measurements have just begun in 2012 and thus are not available for many locations. Of course we will consider these quantities during our ongoing work as written.

We have stated this in the section “future work” now explicitly:

“Moreover, the potential of the depolarization and spectral capabilities will be further exploited as well as the new possibilities which arise from the implementation of near-range channels in almost all systems.”

- Furthermore, we would not like to show more case studies from other places to not blow up the already quite extensive paper. We think that interesting case studies at various places can and will be used for own research and publications accordingly.

The way section 6 has been developed is appropriate to show the general overview of results in different regions, but seems too poor after showing all the capabilities of the more advanced version of the Polly system. In the end, it seems that only the information on 532 nm is available for a global analysis of the network data.

- See statement above. The reason for showing only 532 nm values should be now more obvious with the updated table 1.

Some formal questions are concerned with the size of diagrams shown in figures 6, 7. They are too small.

- Thanks for the notice. We have realized that the graphics department at Copernicus has changed the format probably due to the large size. During resubmission we will contact them directly to keep quality high and assure readability for everyone.

This kind of representation would be useful to offer a broad overview but it would be worthy to organize these figures in panels with larger diagrams, although this would require splitting them in several figures (panels). This will allow following the discussion more easily.

- We think that if the figures will be kept in vectorized form, unlimited zooming can be performed so that it should be readable for everyone. However, in case Copernicus states that it will not be possible due to size limitations, we will follow your advice and split the figures.

As I stated before, Appendix A is really worthy. Nevertheless, concerning the overlap treatment I expected some indications on how to use the new Poly design that includes near field measurements in 1 elastic and 1 Raman channel.

- Up to now the near range-channels are treated as separate channels and they undergo the same procedure as the far-range channels. However, in future we will investigate the possibilities of merging these channels automatically, e.g., like the method proposed for the EARLINET Single Calculus Chain (SCC, D’Amico, 2015, AMT).
We modified the outlook accordingly:

“Moreover, the potential of the depolarization and spectral capabilities will be further exploited as well as the new possibilities which arise from the implementation of near-range channels in almost all systems. These efforts will be done in close collaboration with EARLINET’s SCC development (D’Amico et al., 2015) and will lead to a further merging of PollyNET with EARLINET and Cloudnet in the framework of ACTRIS-2.”

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