Manuscript acp-2020-294 – Author's replies to reviewers

*We thank gratefully the editor and two anonymous referees for careful reading and comments. Below are the referee's comments in **black**, and replies from the authors in **blue**. Please note that page and line numbers given below refer to the revised version of the manuscript without tracked-changes.*

Anonymous Referee #1

The authors have responded adequately to my remarks in the previous review, but to my main remark No. 4 in what respects the statistical uncertainty of RALMO measurements. In the revised manuscript the authors state (page 4, lines 2-4 of the revised manuscript): "The mean statistical uncertainties associated with the retrieval of βaer at 355 nm from Raman inversion techniques are typically estimated as 15 % in the PBL (Pappalardo et al., 2004)". However, the reference (Pappalardo et al., 2004) supposed to sustain this uncertainty value does not deal with instruments, but with the performance of algorithms faced to synthetic lidar data mimicking an instrument output. The quoted 15% figure refers to the typical statistical error yielded by the different algorithms when dealing with simulated raw signals coming from a typical atmospheric profile and with a given amount of noise yielding a mean signal-to-noise ratio of ~ 70 in the PBL. The mean statistical uncertainty cannot be based on this reference and the sentence must be removed of modified. I suspect, based on RALMO characteristics, that the typical uncertainty for the retrieval of βaer in the PBL from its nighttime data will be lower than 15%.

The reviewer is right that the 15% uncertainty estimated by Pappalardo et al. (2004) only accounts for errors related to the data processing algorithms, and does not represent the mean statistical uncertainty of the instruments. Therefore, as suggested, we removed this statement from the manuscript.

Other minor issues are:

1. The authors use throughout the paper the same symbol, Δβaer, to denote both the absolute difference and the relative difference between the aerosol backscatter coefficient retrieved from a lidar measurement and from COBALD. But in Eq. (3) Δβaer is defined unambiguously as absolute error. I suggest that for relative error another symbol is used. I'm sorry I didn't notice this in my previous review.

Done: a new symbol ($\Delta\beta_{aer}^{rel}$) was introduced to denote the relative differences in aerosol backscatter coefficient. For consistency, new symbols were also introduced to denote the relative mean deviation (δ_{rel}) and relative standard deviation (σ_{rel}) of $\Delta\beta_{aer}$. These new symbols are now used consistently throughout the manuscript, figures and tables.

2. On page 14, lines 17-18 of the revised manuscript, the authors say, referring to the larger spread of relative β_{aer} differences above 3 km between CHM15K and COBALD compared to the relative differences between CHM15K and RALMO: "This again denotes the lower signal-to-noise ratio of CHM15K with respect to RALMO at high altitudes". But couldn't it be due also to the smaller values of β_{aer}^{COB} in the denominator when computing the relative error?

It is true that, for a given difference $\Delta\beta_{aer}$, the lower absolute β_{aer} signal at 940 nm compared to 455 nm leads to larger relative differences ($\Delta\beta_{aer}^{rel}$) for CHM15K – COBALD than for RALMO – COBALD. The statement has been modified in order to include this consideration: "This is due to the low signal-to-noise ratio of CHM15K at high altitudes, together with the lower absolute β_{aer} signal at 940 compared to 455 nm" (Page 14, Lines 17-19).

Anonymous Referee #2

I am happy that the authors addressed all the previously raised issues and now the manuscript is ready for publication.

Some typos in the manuscript should corrected.
Some images are not in high-res, with very small fonts hard to read.

Done: a careful grammar check of the entire manuscript was performed, and the quality of the figures was improved. In particular, a larger font size is now used in Figures 2, 3, 4, 7, 10 to improve readability, and the aspect ratio of Figures 5, 7, 8, 10 was optimized in order to enhance the resolution in pdf format. We will make sure during proofreading that all figures are reproduced in high resolution in the final layout of the paper.

I would add in the introduction some references about similar campaigns between ceilometers and lidars, e.g:

Tsaknakis, G., et al. "Inter-comparison of lidar and ceilometer retrievals for aerosol and planetary boundary layer profiling over Athens, Greece." Atmospheric Measurement Techniques 4.6 (2011): 1261-1273.

Madonna, F., et al. "Intercomparison of aerosol measurements performed with multi-wavelength Raman lidars, automatic lidars and ceilometers in the framework of INTERACT-II campaign." Atmospheric Measurement Techniques 11.4 (2018).

Done: references to Tsaknakis et al. (2011) and Madonna et al. (2018) were added to the introduction (Page 2, Line 22) and conclusions (Page 17, Lines 13-14). We thank the reviewer for this comment.