Interactive comment on "Overview of SLOPE I and II campaigns: aerosol properties retrieved with lidar and sun-sky photometer measurements" by Jose Antonio Benavent-Oltra et al.

Anonymous Referee #3 Received and published: 20 April 2021.

We would like to acknowledge the work done by the referee in the revision of our manuscript. We appreciate his/her effort and contributions to improve the quality of the paper. Our responses to the reviewer's comments are detailed below. Our answers to reviewer are shown in bold and the changes inserted in the manuscript are noted here in italic and between quotation marks. The changes in the new version of the manuscript are noted in blue.

Reviewer's comment

Author's response

Changes in the manuscript.

General comments:

This paper addresses an evaluation of the aerosol property profiles retrieved from GRASP algorithm and which uses as inputs lidar and sun-photometer (SPM) measurements versus in-situ measurements. The in-situ measurements were carried out at Sierra Nevada Station (SNS) and on board of an aircraft. The work presents different relevant aspects that show its importance and novelty. This is the first time that GRASP algorithm using as inputs lidar and SPM measurements (GRASP) has been evaluated for absorption coefficient in a long-term comparison. In addition the work have dealt with the complexity of comparing different techniques (remote and in-situ) which also cover different ranges in the Earth-atmosphere system (surface and almost full troposphere). The results presented here show a good agreement between the optical properties from techniques and larger discrepancies in the volume size distribution when fine particles are dominant. So after these comments I conclude that the paper is very interesting, well written and show the capability of GRASP approach to retrieve vertical information of aerosol properties based on this long-term study. I consider that this work is appropriated for Atmospheric Chemistry and Physics and it should be published after some minor corrections.

The point-to-point responses to the Referee #3's comments are summarized below:

Specific comments:

Line 23 -26: Sentence needs rewording.

We have rewritten this sentence as follows:

(sect. Abstract, line 24-27): "In this work, we use the in-situ measurements of these campaigns to evaluate aerosol properties retrieved by GRASP code (Generalized

Retrieval of Atmosphere and Surface Properties) combining lidar and sun-sky photometer measurements."

Lines 65 - 69: If you have elastic and inelastic signals you can also calculate the backscatter coefficient using the Raman techniques, which present the advantage that you don't need any assumption of LR. So please be more precise in this sentence, it sounds that you only can calculate the backscatter coef. using klett method.

We agree with the referee and we have rewritten this sentence as follows to be more precise:

(sect. 1, line 67-73): "Basic lidar systems only have information on the backscatter elastic signals which allow the retrieval of aerosol backscatter coefficient (β) vertical profiles by the Klett–Fernald method (Fernald et al., 1972; Fernald, 1984; Klett, 1981, 1985) assuming a constant aerosol lidar ratio (LR). However, advanced lidar systems provide information on the backscatter elastic and inelastic signals allowing the retrieval of vertical profiles of aerosol backscatter and extinction (α) coefficients by the Raman technique (e.g. Ansmann et al., 1992; Whiteman et al., 1992)."

Line 75: replace "retrievals" by "retrieval".

Corrected

Lines: 100 – 104: Confusing sentence: I imagine that you mean that the combination of SPM and ceilometer allows obtaining less optical properties than using multi-wavelength lidars, but the sentence should be more explicit. The authors refer "long-term vertical profiles" from the combination of SPM and ceilomter, it is difficult to know what you mean.

We agree with the referee that this sentence is confusing and we have rewritten this sentence as follow:

(sect. 1, line 108-112): "This is the first long-term evaluation of GRASP that combines sun-sky photometer and multi-wavelength lidar measurements to retrieve profiles of aerosol intensive properties separately for both fine and coarse modes instead of only one mode such as using ceilometer measurements (e.g., Román et al., 2018; Titos et al., 2019)."

Line 207: d.o.o. : Can you say what it means for the first time that is cited in the manuscript?

Aerosol d.o.o." is the name of an Slovenian company. d.o.o. is the Slovenian equivalent to LLC (limited liability company) in English.

Line 208: Please, replace "de" by "the".

Corrected

Methodology. General comments: I recommend to put the description of GRASP in a subsection, for example 3.1, in order to put it at the same level than aircraft data section. In addition, I suggest including in this section a paragraph talking about the lidar inversions. I guess that you are using the Klett algorithm to obtain the backscatter profiles, but it should be indicated. If this is the case, the assumed lidar ratio and the criteria for choosing those values should be discussed.

Following reviewers' suggestion we have put the description of GRASP in the subsection 3.1..

As stated on section 3.1. Line L250-254, the lidar data used in each GRASP retrieval is the normalized backscattered range corrected signal profiles. In this sense, the LR necessary for Klett algorithm are not necessary to be assumed for GRASP inputs. The description of the lidar data used in this work was described in the last paragraph of this new subsection.

Lines 235-236: This sentence should be clarified. The sentence mixes GRASP and LIRIC algorithms, with an inversion method (for lidar measurements, which is not indicated) with a measurement technique (in-situ). It should be more elaborated to make it more understandable.

We agree with the reviewer that this sentence should be clarified. Therefore, we have rewritten this sentence to make it more understandable and we added it in the 1.Introduction section where we think is the best section to show this information:

(sect. 1, line 90-94): "The aerosol properties retrieved by GRASP have been evaluated in previous works using as reference the volume concentration provided by LIRIC algorithm (differences ~20%; Benavent-Oltra et al., 2017), the backscatter and extinction coefficients calculated with Klett-Fernald and Raman methods (differences below 30%; Benavent-Oltra et al., 2017, 2019; Tsekeri et al., 2017)".

Results. General comments: The statistical analysis should be better described. The number of the cases (profiles) used for the different analyses is not mentioned at any time.

Following reviewers' suggestion we have added the following sentences:

(sect. 4.1.1, line 282-284): "The number of coincident GRASP retrievals with in-situ measurements are 231, 202, 154 and 151 for volume concentration, σ_{sca}, σ_{abs} and α coefficients, respectively."
(sect. 4.2.2, line 420-422): "As we commented in section 3.1., a total of 286 GRASP retrievals passed the filter imposed. For the statistical overview, we compare point by point the 60 altitudes log-spaced of each aerosol property profiles."

Lines 276 – 277: Please rephrase the sentence. You could write something like: "The aerosol volume concentration at SNS were calculated for the 0.05 – 0.5 and 0.5 – 10 μm radius size ranges for the fine and coarse modes, respectively.

We agree with the reviewer and we have rewritten this sentence as the reviewer indicates.

Lines 317 – 318: It should be mentioned that is at 532 nm. Why is it not calculated for other wavelengths? How is it calculated the extinction from in-situ? Did you use the sum of the scattering and absorption from different in-situ instrument? This should be indicated in the manuscript, perhaps in the methodology section.

We agree with the reviewer and we have added the wavelength in the new manuscript version:

(sect. 4.1.2, line 331): "*... for extinction coefficient* at 532 nm *showed in…*"

We have only shown the extinction at 532 nm because is the closest wavelength to those of the aethalometer (520 nm) and nephelometer (550 nm). The extinction has been calculated as the sum of the scattering and absorption coefficients measured by the nephelometer and aethalometer, respectively.. To clarify this, we have added the following sentence in the new manuscript version:

(sect. 4.1.2 line 331-333): "The in-situ extinction coefficient at 532 nm is the sum of the scattering and absorption coefficients interpolated to 532 nm using the Ångström exponent law."

Figure 6: For clarity, it should be helpful to indicate the year for each plot of the figure.

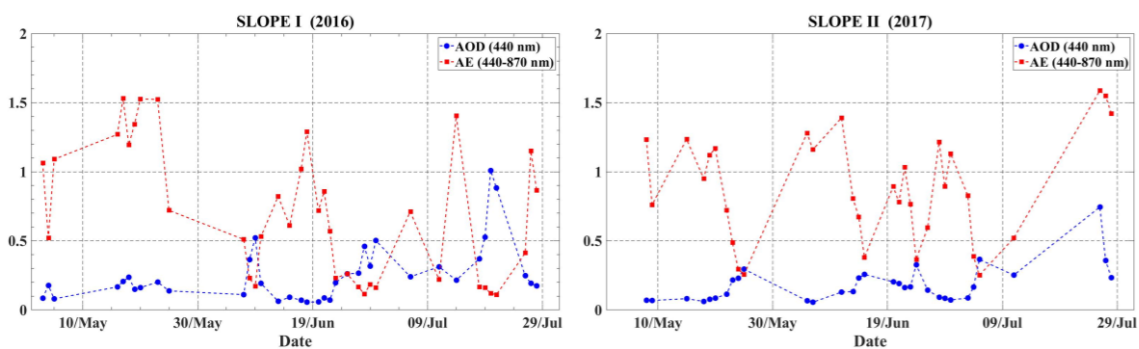**We agree and therefore we have included the year in each plot title.**

Figure 1. Temporal evolution of aerosol optical depth (AOD) at 440 nm and Ångström exponent (440–870 nm) retrieved by GRASP during (**a**) SLOPE I and (**b**) SLOPE II campaigns.

Lines 408 – 409: "The decays do not reveal any decoupled layer with altitude": This statement is difficult to corroborate when all the profiles are plotted. I guess that for some individual profiles decoupled layers of the Planetary Boundary Layer could be present.

We agree with the reviewer that for averaged profiles is difficult to corroborate this statement and we have decided to remove this sentence.

Lines 420: Comment: The shape of the profiles does not look like exponential.

We specially acknowledge this comment since it is a mistake. We have rewritten it as follows:

(sect. 4.2.2, line 437-438): "This behaviour of σ_{sca} profile has been previously observed in other statistical lidar studies (e.g. Titos et al., 2019)."

Line 471: "For intensive optical properties, …". Do you mean "extensive" ?

Yes, we have corrected it.