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Atmospheric Measurement Techniques Discussions

Interactive comment on "GARRLiC and LIRIC: strengths and limitations for the characterization of dust and marine particles along with their mixtures" *by* Alexandra Tsekeri et al.

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Both active and passive remote sensing instruments have their own advantages and disadvantages in terms of the vertically-resolved retrievals of the aerosol microphysical parameters. It is clear that the combination of active/passive technologies is absolutely necessary in order to improve the quality of retrievals. Alexandra Tsekeri and coauthors are moving in that direction. Finokalia lidar station is famous to have a unique geographical location allowing observation of the different combinations of the aerosol particles from Central Europe and Africa/Sahara. It is nice to get a reminder that Finokalia station is operational and actively delivering the valuable scientific data related

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to the dust and marine aerosols. The paper in overall is very well written. It is pleasure to read the text. The wording and grammar are close to be perfect. I recommend to accept this manuscript for the publication after a few minor corrections.

REPLY: We thank the reviewer for his/her kind words!

General comments:

1. After reading the paper I got an impression that there is some kind of luck that GARRLiC and LIRIC algorithms work and result in a reasonable aerosol microphysical retrievals. Here is the list of introduced assumptions to support this impression:

A) "The volume concentration below the lowest height of the lidar signals is considered to be constant" (page 4, line 9) It is very difficult to imagine the constant volume concentration in the first few hundreds meters above the ground. Please keep in mind that the comparisons with in situ are performed using the near-surface data.

B) The Raman signals from the lidar are such a useful piece of information about aerosols, but not used in the retrievals at all (see Fig. 1). There is only a plan to use the extinction optical coefficients in future.

C) "GARRLiC ... is able to retrieve only one refractive index for each mode." (page 16, line 14) "considering refractive index to be constant along the atmospheric column" (page 4, line 6) The assumption of only one refractive index per profile is very damaging for the whole idea of vertically-resolved microphysical retrievals. The aerosols of different nature (thus, different refractive indexes) are often reside in a different layers of the same vertical profile. Please consider in your future studies to eliminate this assumption.

D) Some additional difficulties on the top of that: - "In addition, as seen in Fig. 7a, most of the aerosol load is located below 1 km, where the lidar incomplete overlap region is located, which challenges even more the combined lidar/sun-photometer retrieval." (page 14, line 1) As a result, there is a nice agreement between GARRLiC and LIRIC

in terms of volume concentration (see Fig. 10a), very strong disagreement between GARRLiC and LIRIC in terms of ambient PM10 (up to 3-4 times or so, see Fig. 10b.right above 1 km), and than finally fair agreement between GARRLiC, LIRIC, and in situ in terms of dry PM10 (see Fig. 10b.right below 1 km). All these sudden turns are really thrilling! Please provide some explanation in the text.

REPLY: GARRLiC and LIRIC have their limitations in successfully characterizing the particle microphysical property profiles, as the reviewer points out. We have clearly stated this in the paper, e.g. in pg. 4, lines 26-30: "Both algorithms work well for individual aerosol components or mixtures of (mainly) fine (e.g. pollution) and (mainly) coarse (e.g. dust) particles, but they should not be able to fully characterize the mixture components in case of more than one fine or coarse mode in the mixture, as in smoke/pollution or dust/marine mixture cases.". Going through the reviewer's individual points:

A) We changed the text (pg. 4, lines 12-13): "The concentrations are considered constant below the lowest height of the lidar signals, which may introduce errors in the retrieved profiles (e.g. Tsekeri et al., 2013)."

B) The Raman signals are very useful for the retrieval, but they are not available for the day-time retrievals considered here, as of yet.

C) GARRLiC retrieves one refractive index for each mode: in case of two modes in the profile, the total refractive index may change along the column. We changed the text so as to highlight this point (pg. 4, lines 9-11): "Although in GARRLiC the microphysical properties are considered to be constant along the column for each mode, the total values change along the column in case of two modes with different properties." Moreover, we added a comment for the change in profile properties due to the particle hygroscopic growth, following the advice of reviewer #1 (pg. 4, lines 18-22): "In case of multi-mode aerosol mixtures and/or change of microphysical properties with height due to particle hygroscopic growth (e.g. Tsekeri et al., 2017) an inherent deficiency

of both algorithms is the number of aerosol modes retrieved, with LIRIC considering three modes (fine particles, coarse spherical and coarse non-spherical particles) and GARRLiC considering two modes (fine and coarse particles)."

D) We do not agree with the reviewer that there is nice agreement between GARRLiC and LIRIC in terms of volume concentration in Fig. 10a, for the retrieval below 1 km. More specifically, GARRLiC retrieves ∼100% more coarse particle volume concentration than LIRIC below 1 km. Concerning the disagreement in the ambient PM10: The ambient PM10 profile in Fig. 10c is the sum of fine and part of the coarse particle volume concentration, multiplied by the corresponding densities. The small and large differences seen below and above 1 km, respectively, are due to the differences in particle densities, with the fine particles to have a density of 1.8 g cmˆ(-3), which is 40% larger than the coarse particle density of 1.25 g cmˆ(-3).

2. GARRLiC and LIRIC algorithms are based on the usage of pre-calculated AERONET products. Without going too much into a details, they sound almost like a twins or, at least, share some part of the software code. For the final users at the lidar stations it is not convenient to have several twins-like algorithms in a package. It is confusing to have similar results for the one group of microphysical parameters and different results for the other group of parameters. Is there a plan to come up with the best way on how to combine the lidar/sun-photometer data that will merge/replace GARRLiC and LIRIC in a single algorithm? It is highly desirable if authors will share their vision regarding this issue in a paragraph of text.

REPLY: We are not aware of any future plans for combination/merging of GARRLiC and LIRIC algorithms. The algorithms are not as similar as the reviewer states here, as proven from the results shown for the three cases in the paper. For example, GARRLiC does not use any pre-calculated AERONET products. To avoid confusion, we highlighted this in the text by adding the following description for GARRLiC (pg. 4, lines 5-7): "The algorithm does not use the AERONET products, but it instead calculates the size distribution, spherical particle fraction and spectral complex refractive index,

separately for fine and coarse particles."

Specific comments:

1. Page 4. Line 4: "The algorithm calculates the size distribution, spherical particle fraction and spectral complex refractive index, separately for fine and coarse particles, considering them constant along the atmospheric column, and the volume concentration profiles of fine and coarse particles." This sentence is quite unclear and ambiguous. Please consider to split it into two simpler sentences.

REPLY: We did it. See comment above.

2. Page 11. Line 11 "m." instead of "m:"

REPLY: We changed the text accordingly.

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