

Atmos. Meas. Tech. Discuss., referee comment RC2
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Comment on amt-2021-29

Anonymous Referee #2

Referee comment on "Retrieval of aerosol microphysical properties from atmospheric lidar sounding: an investigation using synthetic measurements and data from the ACEPOL campaign" by William G. K. McLean et al., Atmos. Meas. Tech. Discuss.,
<https://doi.org/10.5194/amt-2021-29-RC2>, 2021

Authors presented a study of aerosol microphysical retrievals from HSRL-2 instrument using both simulated data and real lidar measurements. The used iterative algorithm is based on Phillips-Tikhonov regularization. It is very unfortunate for the algorithm that quality of its results depends on the choice of prior and first guess. Retrieval errors increase when the prior deviates too much from the truth value that is a disadvantage for the real lidar data processing. At the moment, there is no way to have a good first guess for parameters like complex refractive index (especially, its imaginary part) or column number in the mass production mode.

Overall, this paper is well written and can be published after minor corrections:

- I would suggest renaming the "alpha" variable (mode component coefficient) in Eq. 2. Throughout the paper, "alpha" means aerosol extinction and only in Eq. 2 there is a confusing turn.

- There is no need to use blue color in figures at all. The blue curves in Fig. 3 can be dashed to be more friendly to people who have access only to black-and-white printer.

- Line 105 says:

"ii) Instead of performing a linear uncertainty/information content analysis, we apply an iterative retrieval scheme, that can be used to perform actual retrievals." The use of word "Instead" makes me think that the "iterative retrieval scheme" is somehow better compared to the "information content analysis" and have to replace the information content analysis. These two things are doing completely different job and can't be done instead of each other. I would say something like "Keeping in mind the results of uncertainty/information content analysis, we apply an iterative retrieval scheme..." to

avoid the negative connotations of the word "instead".

Now let's talk about the results of information content analysis.

Authors mentioned that " $3\beta + 2\alpha$ combination of measurements provides about 3-4 independent pieces of information" (line 100). Also, Authors are saying that "In addition to the underdeterminedness of the inversion problem, limitations to the forward model can further inhibit the retrieval of the microphysical properties" (line 165). At the same time "With this parameterization, the total number of parameters free to vary in the retrieval is six for each mode, thereby twelve in total for the bimodal setup we use" (line 150). Let's forget about dust and consider only spherical particles. Depolarization is zero and useless in this case. So, $3\beta + 2\alpha$ lidar measures 5 numbers that gives Authors only 3-4 independent pieces of information. At the bottom line, Authors would like to use 3-4 pieces of information to retrieve 12 independent parameters and it sounds like a miracle. It is clear that the inverse solution is not unique, and Authors experience massive issues in Their retrievals, but Authors don't want to talk about it. I would like Authors to directly acknowledge this issue in Their paper. It can be done by adding several solid sentences clearly discussing the non-uniqueness of inverse solution due to the simple 3-4/12 math and the ways that Authors offer to increase the information content. Iterative algorithm by itself is not increasing the information content at all.

I also would suggest:

Line 5

"high spectral resolution lidar (HSRL)" instead of "High Spectral Resolution Lidar (HSRL)"

Line 15

"higher aerosol optical depth (AOD)" instead of "higher AOD"

Line 20

- MAEs are shown for all the input parameters except effective variance. Effective variance also deserves to be shown here. Please show the effective variance in all the tables with results (if available).

- Please include also relative errors for effective radius and effective variance [0.038/??% (0.025/??%)].

Line 30

"Spectropolarimeter for Planetary Exploration (SPEX) and Research Scanning Polarimeter (RSP)" instead of "SPEX and RSP".

Line 50

"AOD and SSA" instead of "Aerosol Optical Depth (AOD) and Single Scattering Albedo (SSA)".

Line 60

- Acronym "POLDER" needs to be defined.
- "Measurements using HSRL techniques" instead of "Measurements using high spectral resolution lidar (HSRL) techniques".

Line 75

Acronym "ATLID" needs to be defined.

Line 90

"the $3\beta + 2\alpha$ setup" instead of "the $3\alpha + 2\beta$ setup".

Line 100

"used in MAP retrievals" instead of "used in Multi-Angle Polarimeter (MAP) retrievals".

Line 110

"during the ACEPOL campaign" instead of "during the Aerosol Characterization from Polarimeter and Lidar (ACEPOL) campaign".

Line 115

"onboard (CPL (McGill et al., 2002))" instead of "onboard (Cloud Physics Lidar (CPL) (McGill et al., 2002))".

Line 120

"(i.e. AOD)" instead of "(i.e. the aerosol optical depth (AOD))".

Line 220

"from HSRL measurements" instead of "from high spectral resolution lidar measurements".

Line 225

"and the RSP" instead of "and the Research Scanning Polarimeter (RSP)".

Figure 1

Please add the plots for effective variance and remove the redundant "Retrieval" in the right two columns to increase the font size. The font size in plots is normally 2 pt smaller compared to the main text.

Figure 3

"Metric" is redundant in the right column of plots and can be removed to increase the font size.

Tables 3-6

Effective variance is definitely missing here.