

## ***Interactive comment on “Vertical profiles of aerosol optical properties and the solar heating rate estimated by combining sky radiometer and lidar measurements” by Rei Kudo et al.***

**Anonymous Referee #2**

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This article describes an algorithm to retrieve aerosol properties from a combination of ground-based lidar and sun-photometer data. Authors suggest a novel approach, which suggests retrieving vertical profile of aerosol complex refractive index, which distinguishes the mentioned SKYLIDAR algorithm from other similar approaches. Also paper addresses the issue of computation of solar heating rate profiles based on the results of such combined retrievals. Mentioned issues are in a high interest of scientific community, and correspond well the scope of the AMT. Proposed approach was throughoutly tested on the several sets of synthetic data, in noisy and noise free conditions, applied to the real measurements with a proper comparison of the retrieved results with other methods.

C1

The paper is nice to read; compact and informative description of the work. However, I think that authors should've put more efforts to properly illustrate some of their results.

I think paper could be published after minor changes. Below I provide some issues that, in my opinion, should be resolved to improve the publication.

Technical comments:

Page 3 line 6. “profiles” instead of “profile”

Page 7 line 6. Although Lopatin et al. uses in his work spheroid model it wasn't author's personal contribution, I think a paper of Dubovik et al, 2006 on spheroids more corresponds to this reference.

Page 11 line 13. “are output” , doesn't sound like a proper sentence to me, consider adding additional verb, for e.g. “are produced at(as) output”

Page 12 line 23. “Eq.(23) can”, maybe it'll be better to replace it with “can(could) be” to maintain the passive voice like in the first part of the sentence.

Page 14 line 19. “The estimated real” I think adjective should be changed to “assumed” or “modelled”, since it is hard to tell what was expected and what was retrieved.

Page 16 line 17 & Page 17 line 8. Please, indicate the wavelength of the single scattering albedo at which the comparison was made. And were the wavelengths used for comparison the same?

Page 18 line 29. I think that vertical profile of spherical/non-spherical particles ratio was forgotten.

Page 19 line 21. “SKYR” instead of “SKR”

General comments:

Page 9 line 2. I would like to see more info on extrapolation, first the method and secondly it is not clear if optical properties (optical thickness and single scattering albedo)

C2

were interpolated too, or they were calculated following eq. 8,9 on the base of inter-extrapolated values of n and k.

Page 13 lines 6-14. It is not clear, how the transforming function was used. Was look-up-table used to overcome problems with possible zero and infinity values? If yes, what are the values of the LUT at 1.3 and 1.6? Also it is not clear if max and min values are actually reachable during retrieval (exact values). Please, provide more information on this in the text.

Page 14. I would like to see how the "TRUE" vertical profiles of refractive index were estimated. It's not straightforward how to get them from the mixtures of components with different n, k and vertical distribution profiles provided in the Table 1.

Page 14 line 25. Please, indicate which type of random noise distribution was used.

Page 15 lines 13-24. I would like to see a bit more of analysis of the sensitivity test results. Not only state the facts, but also add some discussion why in your opinion this happened:

1. "vertical profiles of refractive index and single scattering albedo of dust were reproduced well, but not those of transported pollution ". Could you provide a possible explanation why?
2. "The retrieval with and without HSRL data did not differ". Could you provide at least some explanation why there is no sensitivity to additional data for all types of aerosol?
3. Concerning oscillations, I think somehow it should be indicated that other methods like Chaikovsky et al, Lopatin et al. use additional smoothness constraints on aerosol vertical distributions to overcome observed oscillations. Maybe plan for implementation of such feature in the future work should be placed in conclusions.
4. At lines 13-14 it is claimed that size accurate retrieval of size distribution is enough to get extinction and asymmetry factor, but in the introduction (page 3 lines 6-7) it is indicated that refractive index reproduction is crucial to get asymmetry factor. It

C3

is a bit misleading; consider reformulating one of the phrases not to have a logical contradiction. Maybe a more general (for all aerosol types) conclusion about vertical refractive index retrieval and how it influences retrievals of optical parameters should be done, since it is a feature that distinguishes SKYLIDAR from other lidar-sunphotometer combination approaches.

Page 17. Comparisons of columnar properties. I think a brief description of the differences of first step of SKYLIDAR and SKYRAD.PACK is needed, since not everyone is well informed about SKYRAD.

Page 18. Summary It would be nice to see a list of future developments/improvements or plans for studies in the conclusions section. This will emphasize the methodology in the work: made tests>made conclusions>plans for further improvement.

Table 1. Could you add spherical/non-spherical to the description? And are dust and insoluble particles were considered to be 100% non-spherical? If not, please, provide a value.

Figures 4-9. My strongest belief that figures do not provide convincing illustrations that parameters are "retrieved well" as it was frequently stated in most of descriptions of the figures. I have several suggestions how this could be significantly improved:

1. It is really hard to analyze retrieval accuracy on the plot that is a bit bigger than a mail stamp. I suggest making the graphs bigger. I assume authors made plots that small to fit everything, so my suggestion will be to split every figure in two, showing physical and optical properties (extinction, ssa, and asymmetry factor) separately. 2. Statement that "vertical profiles of size distribution were estimated well" is supported by illustration of the SDs only at two altitudes! I suggest to put assumed and retrieved vertical profiles of C1 and C2. In my opinion it'll be much more illustrative and convincing. 3. I'm eager to see also the vertical profile of epsilon (spherical/non-spherical aerosol fraction), both modeled and retrieved.

C4

To sum the desired changes in graphs, I would like to see bigger plots that show all the parameters of aerosol model that are retrieved by the SKYLIDAR directly compared to the data that was used to produce the synthetic dataset. In my opinion these vertical profiles will be much more convincing and easy to understand, than trying to analyze the contents of Table 1. I hope same method that was used by authors to provide resulting vertical profiles for  $n$  and  $k$ , could be also applied to provide profiles of  $C1$ ,  $C2$  and  $\epsilon$ .

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