Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2016-65-RC1, 2016

Atmospheric Measurement Techniques Discussions

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 #1

Received and published: 22 April 2016

The paper describes a retrieval scheme where passive and active ground-based measurements are combined with the aim of retrieving vertical profiles of aerosol optical properties, which are then used to infer solar heating rate profiles. The algorithm has been tested on a number of synthetic scenarios – displaying a good capability to retrieve most of the considered aerosol properties when the aerosol load is not too small – and then applied to real measurements. AOT and SSA and asymmetry factors retrieved on real measurements show good agreement with those retrieved using an existing algorithm, and direct comparisons between retrieved surface solar irradiances and corresponding pyranometer measurements also show good agreement. I think the paper is generally well written and fits the scope of AMT. I do not have major criticism

towards the presented work, but I would just like to suggest a number of minor revisions the Authors may want to take into consideration before the manuscript is published.

1. Since I did not know about SKYRAD.PACK before reading this paper, I had to look it up in order to understand what you mean. I think this is not a good feature in an abstract, so you may want to spend at least a couple of words to explain what SKYRAD.PACK is. For example, you may say something like "We then compared the optical properties retrieved with the SKYLIDAR algorithm to those produced with the more established scheme SKYRAD.PACK".

2. P2, L15. By Mie lidar you mean the basic, conventional lidar, right?

3. P4, L6. "langley method" -> "Langley method".

4. P4, L15. It may be worthwhile to remind the reader that $\cos^2(\theta_0)$ and $\sin^2(\theta_0)$ in the expression of the scattering angle appear because we are in the almucantar plane, where $\theta = \theta_0$.

5. P5, L26. I do not agree on the fact that your algorithm is a maximum likelihood method, because you have a priori constraints and the pdf you maximize is an a posteriori one. Therefore it would be more proper to say that your algorithm is a maximum a posteriori (MAP) scheme. I am aware that other papers about aerosol retrievals claim that the method you present is maximum likelihood, but if one wants to keep consistency with standard statistical terminology (which I think would be a good thing) I am almost certain that it is not. To the best of my knowledge, maximum likelihood methods seek the maximum of $P(\mathbf{y}^{mea}|\mathbf{y}(\mathbf{x}))$, which is different from $P(\mathbf{y}(\mathbf{x})|\mathbf{y}^{mea})$ (Lehmann and Casella, 1998; Robert, 2007), and usually need a sample of independent and identically distributed realizations of the observation vector $\mathbf{y}^{mea}$, which are rarely available in remote sensing, unless you repeat the measurement of the full vector $\mathbf{y}^{mea}$ multiple times under

identical conditions and use all the repeated measurements to build a joint pdf that you later maximize with respect to $\mathbf{x}$. This remark may seem pedantic, but the difference between MAP and maximum likelihood has some remarkable consequences. For instance, maximum likelihood estimates are invariant to reparameterizations (i.e., if $\mathbf{x}_0$ is the optimal estimate of $\mathbf{x}$ then $g(\mathbf{x}_0)$ is the optimal estimate of $g(\mathbf{x})$ for any bijective function g), whereas MAP estimates are not. MAP estimates are numerically equal to maximum likelihood if a flat (improper) prior is used, but of course being numerically equal does not mean that they are the same thing.

6. P6, L6. If $\mathbf{W}$ is the covariance matrix then its diagonal elements are the squares of the standard errors in the measurements (not the errors themselves) and in equation (4) you should replace $\mathbf{W}^2$ with $\mathbf{W}$. If, instead, the diagonal elements of $\mathbf{W}$ are the errors then it is correct to keep $\mathbf{W}^2$ in eq. (4) but you should say that $\mathbf{W}^2$ (not $\mathbf{W}$) is the covariance matrix.

7. P6, L15 and eq. (5) and (6). I do not find the notation very clear. Wouldn't it be better to just say that $\mathbf{y}_{mea}$ contains τ_{ext}^{mea} at all wavelengths, I^{mea} at all wavelengths and scattering angles and δ_{ave}^{mea} at 532 nm? Or, if you want to use an equation, you may use the more established notation

$$\mathbf{y}^{mea} = [\tau_{ext}^{mea}(\lambda_1), \ldots ..., \tau_{ext}^{mea}(\lambda_n), I^{mea}(\Theta_1, \lambda_1), I^{mea}(\Theta_2, \lambda_1), \ldots$$

$$\ldots, I^{mea}(\Theta_m, \lambda_n), \delta_{ave}^{mea}(532\,\text{nm})]$$

or you can summarize the content of the vector in a table. Similarly, in eq. (6) wouldn't it be clearer if you just state that x contains real and imaginary part of refractive index at all SKYR wavelengths plus all the other parameters?

8. P9, equations. Again, the notation of the formulas looks a bit confusing to me. The suggestions I would give you are similar to those given in the previous point.

9. P11, eq.(21). $\mathbf{W}$ and $\mathbf{W}_a$ should be uppercase. Please re-check whether there should be $\mathbf{W}^2$ or $\mathbf{W}$ depending on the choice you make about the meaning of $\mathbf{W}$ (see point 6).

10. P12, L24. "In actuality" -> "Actually" or "Eventually".

11. P13, L27. It is not clear to me what does "the broadband wavelength regions of solar radiation" mean.

12. P13, L28. "The wavelengths of the optical properties" -> "The wavelengths at which the optical properties ... are obtained".

13. P14, L2. Which kind of interpolation did you use to compute the refractive index between 532 and 1064 nm? I guess linear is enough for the real part, but what about the imaginary part?

14. P15, L2. "other than" -> "except" (it sounds clearer).

15. P15, L3. Is the size distribution only retrieved at 540 and 3540 m? Is that enough to call that a "profile of the aerosol size distribution"? Furthermore, you assume a bimodal lognormal size distribution and – if I understood correctly – you fit mode radii and widths for the entire column in step 1, whereas in step 2 you keep those values fixed but update C_1 and C_2 per layer. Then, I guess, your estimate of the aerosol size distribution profile is controlled by these two parameters, right? Wouldn't it be more informative to compare and plot the profiles of $C_1(z)$ and $C_2(z)$?

16. P15, L7. "plotted" -> "shows"; "the aerosol optical thickness of" -> "an aerosol optical thickness of".

17. P15, L8-9. You say the profiles of the refractive index were not estimated well, but doesn't that only apply to the imaginary part? You may want to specify that.

18. P19, L21. SKR -> SKYR ?

REFERENCES

Lehmann, E.L., and Casella, G., “Theory of Point Estimation”, II edition, Springer Texts in Statistics, 1998

Robert, C. P., “The Bayesian Choice. From Decision-Theoretic Foundations to Computational Implementation”, Springer Texts in Statistics, 2007

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2016-65, 2016.