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Interactive comment on "A new lidar inversion method using a surface reference target. Application to the backcattering coefficient and lidar ratio retrievals of a fog-oil plume at short-range" *by* Florian Gaudfrin et al.

Anonymous Referee #1

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In this paper, the authors include the surface reflectance in the lidar equation and derive its inversion. The derivation of the inversion itself is new as far as I can tell. Section 2 includes the standard volumetric lidar equation with an additive term which was already derived in (Kavaya et al. AO 1983) or similar derivations (Josset et al. OE 2010). The inclusion of an additive term is trivial. The meaning of the equation and what is being done with it (determination of instrumental constant, lidar ratio retrieval) is not new either. This has been proposed and done by (O' Connor JAOT 2004, Hu IEEE GRSL 2007) with a different kind of target (water clouds). With a surface reference

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target there's relevant discussions by (Josset et al. IEEE GRSL 2010, IEEE TGRS 2018). However, I believe there is value in the formal derivation of the inversion and that the methodology could be applied to a standardized calibration of lidar systems with more descriptions of the field experiment. I suggest a major review. The changes are suggest are not necessarily difficult to implement but I would like the authors to think carefully and take the time needed to present a significantly revised version of the manuscript.

Major comments: - Several key references are missing. This paper seems surprisingly out of context of relevant research. The inclusion of these references could strengthen its content. - - The description of the experiment (section 5) lacks details. It makes it harder to understand the domain of validity and application of the methodology. - - I believe that several statements made in the paper are wrong (see some minor comments). These statements are mostly in the context and perspectives so they do not directly impact the core of the presented work. It could be related to the lack of references.

Minor comments: p.2 line 27 I would suggest to add more references on lidar calibration based on molecular backscattering. One recent example related to the CALIPSO lidar would be (Kar et al. AMT 2018).

p.2 line 52 "It is worth indicating that coupling lidar and sunphotometer measurements is possible only daytime while Raman measurements are carried out preferentially at nighttime in order to increase the SNR."

This is correct but the statement does not apply to the work of (Hu et al. IEEE GRSL 2007, etc). Please rephrase after more references are added to the manuscript.

p. 3 line 76 I'm not sure that I understand why the SRT is assumed to be Lambertian here. As far as I can tell, the formalism you derive is valid for any surface reflectance. It is a wrong assumption to make that natural surfaces are Lambertian, please include (Breon et al. JGR 2002) in the references. Limiting the formalism to Lambertian sur-

faces seriously limits the usefulness of this research. If one of the equation explicitly requires the surface to be Lambertian. Please state it explicitly in the manuscript.

Eq. 1 I don't understand why Fcor is not applied to the volumetric target. Please clarify.

Eq. 1 Fcor definition is on page 4, please define quantities the first time they are used.

p.4 line 105 the statement is confusing (beta missing, definition of the lidar ratios lines 91 and 92 ok).

p.5 In Eq (8) it could help to clarify that Y(rs) = 0 (only surface at rs).

Eq (9) clarify that it applies only before the surface.

About my two previous comments: in general, it is not very clear that there are two separate domains (as a function of range) for the equation.

p. 6 I'm not sure if there's a typo in Eq (13) or if I'm missing something. Please rephrase the comment right before Eq (13). It could help to clarify the matter.

p. 16 line 242 How do you know the reflectance of the Lambertian surface ? More detail are needed to describe this experiment (see major comment). Please expand this section.

line 243 "than 100 signals in 0.1s (1 kHz)"

This is redundant. Please remove or rephrase.

p. 19 line 287 "Indeed, BRDF are often considered as Lambertian for natural targets (surface roughness, vegetation...), so it can be replaced by SRT reflectance."

I believe it is a wrong assumption, I'm again referring to (Breon et al. JGR 2002). Recent research could imply that using reference measurements out of the hotspot would be ok for a lidar (Josset et al. IEEE TGRS 2018) but please rephrase this statement.

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