

Interactive comment on “Quantification and parameterization of non-linearity effects by higher order sensitivity terms in scattered light Differential Optical Absorption Spectroscopy” by Jānis Puķīte and Thomas Wagner

Anonymous Referee #2

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This manuscript presents an in-depth characterization of non-linear effects seen in scattered light measurement retrievals, specifically using the DOAS method, caused by the presence of strong absorbers and/or under specific measurements geometries, e.g., limb measurements. The authors provide a systematic and detailed overview of these effects, through simulated measurements, and compare several current methods used to overcome these effects with a standard analysis procedure which does not account for them. They, then, present a new two step retrieval algorithm to derive spatial distributions of trace gases in the presence of strong absorbers (O₃) which accounts for these non-linear effects. The presented method has the benefit of being more time

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efficient and carrying a lower data processing burden as some of the other currently used methods. This new method is characterized using both simulated measurements and real measurements from SCIAMACHY for the derivation of vertical profiles of O₃, NO₂, and BrO. The real data provides the opportunity to compare vertical profiles with other previously reported measurement taken concurrently with the SCIAMACHY data.

This manuscript as well written and falls well within the scope of AMT. I recommend publication after the following comments are addressed.

General Comments:

Throughout the manuscript the authors present quantitative characterizations of the impacts for neglecting or incompletely accounting for the non-linear effects of a strong absorber (O₃) under simulated limb measurements; however, no quantitative criteria is presented for determining when such a non-linear regime is entered, e.g., optical depths for strong absorbers. Is it possible for the authors to comment and include such information in the manuscript? This could be included early in the manuscript to provide a framework for the regime to which the rest of the presented work pertains. This seems to be an important aspect for measurement geometries and/or scenarios where it is unclear whether or not the non-linear effects of strong absorbers will impact retrievals in such a way as to significantly contribute to uncertainties in the derived quantities (typically VCDs and/or vertical distributions).

Specific comments:

Page 9 lines 4-12: Describes the simulated OD contributions from the different order terms from the Taylor series expansion shown in Fig. 1 for a specific measurement geometry. Are the authors able to comment on the compatibility of the wavelength dependence of the simulated ODs of the higher order terms with actual measurement residual ODs for this measurement scenario? For example, are measurements available (for conditions similar to the simulated scenario) which show the residual structure containing a clear signature of the higher order terms that are neglected during analy-

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sis. Especially for terms such as the second order self-correlative O3 term, which has a simulated OD that is as large as the first order BrO term.

Page 16 lines 9-18: Can the authors comment on the reason for using such specific wavelengths for the light path difference calculations presented in this section?

Page 24 lines 23-25: This sentence is rather vague in the characterization of the impact of including 3rd order O3 terms in the DOAS fit (while not using those terms in the RTM calculations) and whether the statement applies to all three molecules mentioned or only NO2. Can the authors quantify the agreement between the profile retrieved by the iterative approach and the true profile in this retrieval scenario, and clarify to which molecules these statements apply?

Technical comments:

Page 9 line 20 – Remove comma after “OD”.

Page 18 line 8 – Sentence starts with “10 mio light path trajectories”, seems to be typographical error.

Page 18 lines 10 and 16 – “Fig.” should be changed to “Figure”

Page 19 line 1 – Remove “how” from this sentence.

Page 21 line 5 – This refers to Table 3 for the retrieval settings - should it be Table 2 instead?

Page 22 line 4 – “result” should be “results”

Page 28 line 18 – Remove right parentheses after “absorption”.

Page 30 line 4 – There is no right parentheses, and the end of the sentence “. . .Eq. 1 i.a. According. . .” should be corrected.

Fig. 3 caption – UV is already mentioned in the first line (which is a general description of the figure), but only the top panel contains the UV absorbers and the bottom panel

contains VIS absorbers.

Figure 18 – Is it possible to move the legend elsewhere (outside of the figure area perhaps) which would help with the readability of this figure.

Figure 19 – The bottom axis labels are cut off in this figure.

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