

Interactive comment on “Nadir ozone profile retrieval from SCIAMACHY and its application to the Antarctic ozone hole in the period 2003–2011” by Sweta Shah et al.

Anonymous Referee #3

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The manuscript "Nadir ozone profile retrieval from SCIAMACHY and its application to the Antarctic ozone hole in the period 2003–2011" by S. Shah et al. presents an evaluation of several versions of Level1 SHIAMACHY nadir data that is done by validating Level 2 ozone profile retrievals. The approach for Level 1 evaluation presented in this paper might be promising, but it requires a deeper analysis in order to connect observed changes in the ozone profile retrievals to a specific calibration/adjustment applied to Level 1 data, which I believe is not completed in this study. The second portion of the paper is dedicated to a validation of the ozone profiles derived using latest Level 1 dataset (v8) against sonde observations. These ozone retrievals are also employed to look for inter-annual ozone variability over Antarctica. Unfortunately, the paper is

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not very well focused and covers a large number of topics, while none of them is fully investigated. The title of the paper, the abstract and conclusions do not reflect the content of the manuscript. This manuscript needs a major revision before publishing in the AMT.

General comments:

- The focus of the paper should be narrowed down. If the focus of the study is on evaluation of different Level1 data, than the part with the Antarctic ozone hole should be removed from the paper, the title needs to reflect the goal of the study, and appropriate changes should be made in the abstract and conclusions.

- In Introduction (page 2) authors presented a very "skewed" overview of the existing satellite methods of retrieving ozone profiles. Ozone profile retrievals derived from nadir SBUV/SBUV-2 sensors span for more than 40 years. There is also a number of limb ozone profile datasets, besides described SCHIAMACHY limb, with high vertical resolution, like MLS, MIPAS, OSIRIS and OMPS-LP, as well as from occultation instruments like ACE-FTS, GOMOS and SAGE II. Some of these datasets overlap with SCIAMACHY mission and can be used for validation in addition to sonde data.

- Section 3: I do not understand what had been done with the Slit Function in this study. Have you applied the SF corrections described in section 3 to Level 1 data before doing inversion? Did you apply these SF corrections to all 3 versions of Level 1 data? Or do you provide description of the SF corrections that had already been implemented in Level 1 data? Please, clarify that in the text.

- Figures 6 and 7 show differences with sondes for early and later years of SCHIAMACHY mission. It is obvious from these figures that the vertical pattern of differences has changed significantly (not just the absolute differences) over the instrument lifetime. It is not reflected in the discussion, however it is very important for any scientific application as it will lead to wrong conclusions. Obviously, such a change in the vertical pattern of differences points to a significant drift in O3 retrievals. Thus, you can

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not draw any reliable conclusions about inter-annual ozone variability over Antarctica using these O3 dataset. If the goal of the paper to look on effect of Level 1 adjustments, then it is worth to look at O3 time series at several levels to determine time-dependent changes and connect them to a drift in different spectral channels.

- Sections 4-6: All captions for figures and tables should be revisited and all data/lines should be clearly explained (see more below in "specific comments"). Many conclusions presented in these sections are not obvious for readers and more explanations and evidences are needed.

- Section 7 seems to be disconnected with the previous discussion. It is not clear what is the purpose of this section.

- It was mentioned several times in the text and in the abstract that the focus will be on the stratospheric ozone. And this would be a reasonable approach, since nadir sensors are not expected to produce high quality ozone profiles in the troposphere (especially relative to sonde measurements). It is not clear to me why results below 200-300 hPa are shown in the figures. Also several tables have extra lines to show statistics for the tropospheric values. It concerns me that some of the conclusions regarding to performances of different versions are based on the tropospheric results rather than stratospheric.

Specific comments:

- Section 2.2, page 6, lines 13-15: Since the vertical resolution of nadir measurements are limited they are sensitive to the a priori profiles as well as to assumed a priori and measurement covariance matrix. Please, specify which a priori data were used in the study, because Table 2 says that 3 different a priori data sets available in OPERA. Also, please, explain how matrices required for the Optimal Estimation were set in your study. Do Level 1 SHIAMACHY data come with the uncertainties that you use in the retrieval algorithm or do you have to assume these uncertainties? Are these measurement uncertainties the same for all Level 1 data sets that you tested here?

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- Figure 4. Please, specify in the caption what horizontal dashed lines represent. Are they shown here to make a connection between specific spectral ranges in radiances to altitude range in O3 profiles? It's also would be helpful to add the mean/median equatorial sonde profiles for 2003 and 2009 as a reference.

-Sections 4-6: Median values for biases and other characteristics are reported instead of mean values. Do you have a specific reason for using median values? Have you found many outliers or do you believe that the distribution of differences is mostly skewed to a particular direction, so the mean values are not representative? Please, explain that in the text.

- Section 5.2, lines 1-10: This part of the text is very confusing. Do you make a conclusion "This suggests that the quality of nadir L1 data is still poor" based on the fact that differences in tropospheric ozone are too large? This part needs to be revised.

- Appendix. The Averaging Kernels for nadir observations change significantly with latitude and season. Showing just one example of the AK is not sufficient. I would suggest to show DFS profiles for different latitude bands and seasons, and specifically for the Antarctic latitudes in Sep-Oct. I also believe that this discussion belongs to section 2.2 where you should describe the main characteristics of the SCHIAMACHY nadir ozone retrievals.

- Section 5.1: On my opinion authors didn't provide enough evidences and explanations to demonstrate that version v8 is any better than v7_mfac.

- Section 5.2: I believe that results presented in Fig. 7 and Table 5 are not enough to call this section 'Validation of v8'. For instance in section 7, authors speculate that on the days when the instrument was heated the measured radiances were affected. Have you tried to isolate and remove those days from your analysis? Do you see improvements/changes in the results?

- Section 6: The analysis shown in this section is insufficient. There are many total

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ozone observations available for the considered time period that can be used to validate integrated ozone columns instead of looking at the reanalysis data. Also, the statement in the conclusion "we investigated the Antarctic ozone profile behavior in the austral spring season" doesn't correspond to the work shown in Section 6. There are many satellite ozone observations that overlap (or partially overlap) with SCHIAMACHY mission like SBUV/2 NOAA-17, Odin OSIRIS, ACE-FTS, Aura MLS and MIPAS. Comparisons with these correlative measurements would help you to understand how well SCHIAMACHY nadir profiles can describe the vertical ozone distribution inside the ozone hole, and therefore if this dataset is suitable for studying inter-annual ozone variability over Antarctica. Without this extensive analysis it is not possible to claim that SCHIAMACHY nadir ozone profiles can be applied for the scientific analysis.

Minor correction/typos:

- Section 6 p 14 line 35 and page 15 lines 1-2: I don't see the cost function or # of iterations (that are not shown in Table 6!!!). Do you mean Table 7 here?
- page 5, line 29: Should be "This allows" instead of "This amounts"
- Table 2, Pressure grid- it would be useful to see the pressure grid used in your retrieval algorithm.
- Table 3. Please, in the Table caption make a connection to the corresponding Figure 4. Also, it's not clear what do you mean by # of pixels? Is it a number of profiles considered for this comparison? Why is it different for different versions of Level 1 data? Please, spell "n_inter" as "number of iterations" in the caption. Could you explain what does it mean "median n_iter for #pixels"? Do you mean median number of iterations for the considered pixels (Profiles)? It should be "Column 7: standard deviation of Column 6".
- Tables 4 and 5. Please, fix "Troposphere [1000-100] hPa" and "Stratosphere [100-10] hPa". The values shown in columns 6 and 7: are these biases for integrated

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stratospheric/tropospheric columns or mean over specified altitude range?

- Table 6: Please, clarify what quantities are shown in columns 2-4. Do they show min and max numbers of O3 profiles used to calculate the daily zonal mean value? It says "Column 5: Median uncertainty in stratospheric ozone column". Is it a correct label? What did you use to determine the tropopause pressures? Also why did you show total ozone values on Figure 8 and not stratospheric columns?

- Table 7. Please, explain what is "relative uncertainties in ozone layer per height". Section 6, Figure 8 and Table 6 show results for total ozone columns. The numbers for sigma shown in Tables 6 and 7 are not the same. Please, add clear explanation of results shown in these tables.

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