Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2017-136-AC1, 2017

Atmospheric Measurement Techniques Discussions

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.

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Received and published: 24 November 2017

Response to Anonymous Referee #1

We thank the referee for the constructive comments and address them point-by-point. The comment is copied below in normal font, and the response is in italics.

The paper has been re-organized in order to make the focus on SCIAMACHY L1 evaluation clearer: the part on the Antarctic ozone hole has been removed from the paper, and the Appendix has been incorporated into the main text. A new figure showing profiles of the DFS for all seasons and two representative years has been included.

The text has been revised throughout the paper. The textual changes are indicated in colored text in the manuscript version showing differences.

Specific comments

1. The coverage of this manuscript is too broad to provide clear and satisfactory discussions: Topics addressed are L1 version intercomparison, instrument slit function retrieval, ozonesonde validation, satellite intercomparison (e.g. GOME-2), stratospheric, tropospheric, and total ozone (despite different claims, see below), Antarctic ozone depletion, averaging kernel shape and smoothing ... As a result, the manuscript's title is unsatisfactory for its content, and vice-versa. Narrowing down the focus of the text would allow for appropriate coverage of these promising subjects and could strongly improve its scientific quality. The overall readability of the manuscript could be (strongly) improved: - Word order mixing - Lack of use of definite and indefinite articles - It is difficult to derive the number of L1 versions that is actually studied from abstract and introduction, and to which of those the instrument slit function retrieval is applied. - Lack of a clear story-telling framework. - Untidy scientific formulations: "each nadir state is an area on the Earth's surface" (page 3, line 19-20), mixing of "degradation" and "degradation correction" which are quite different, "collocated geolocations indicating the location" (Figure 5 caption), "the median values of the quantity in the table conversions" (page 11 line 3), "[AK smoothing] gives a smoothed sonde profile which is more suitable to compare with the profile retrieved from the satellite instrument and influences the results" (page 11, lines 11-12), Table captions are typically too brief to be clear ...

   Author Response:
   We have narrowed down the focus of the article to the SCIAMACHY L1 version evaluation, through intercomparison of L2 retrievals and L2 validation. Slit func-

tion retrieval has been moved to the Discussion as it is not used in the version comparison but is still a part of the calibration of the L1 data. The title has been changed appropriately. We have extensively adjusted the text for better formulation and readability; the many changes are indicated in colored text.

2. Page 6, line 14-15: "An inversion [...] is carried out until convergence is reached or until the maximum number of iterations is reached." What is the effect of the difference between the two options on the quality of the retrieval outcome?

   Author Response:
   Convergence is defined as when the difference between the cost function between two iterative solutions are less than a few percent. This typically happens before 10 iterations. If it exceeds 10 iterations, the retrieval is considered unsuccessful. This is now clarified in the text; see also Table 2.

3. Page 7-9, Section 3: The instrument slit function calibration parameters are well-explained, but their application is not: Is the slit function retrieval part of the OPERA retrieval? Why is it not applied to L1 v7 data to compare directly with v7_mfac? Why is their no squeeze in Channel 1? How can the retrieval start from 260 nm, if only data starting from 265 nm are considered? Why is the Channel distinction different in the text (at 308 nm) and in Table 1 (314 nm)? Please clarify.

   Author Response:
   We have moved the Slit function section to the Discussion section in the new organization of the paper. Slit function retrieval is not a part of the OPERA retrieval used in this paper. The reason is that the slit function correction is of the order of 10 times smaller than the degradation correction, so slit function correction currently does not contribute much to the improvement of the data quality; this is now explained in the Discussion. There is no SF squeeze in channel 1, because adding squeeze does not improve the slit function retrieval there. The retrieval indeed starts at 265 nm. The division of 308 nm corresponds only to

the slit function retrieval. SF retrieval on Channel 1 from 265-308 nm gives the lowest residuals rather than taking 265-314 nm. Taking the 308-330 nm spectra in Channel 2 gives the lowest residuals. This is now explained in the Slit function part in the Discussion section.

4. Figure 4: Why show results for a narrow tropical band if the later focus is on the Antarctic ozone hole?

   Author Response:
   We have removed the Antarctic ozone hole analysis from the paper, as the focus of this paper is the L1 data quality analysis.

5. Starting from Section 5, reference is made to the "ESA CCI" requirements (including reference to a non-existent Section 4.3 on page 13, line 5). From the website link (page 12, line 17) and paper content, it is understood that the Ozone-CCI project is intended, but any clarification on the project or motivation for its reference is lacking. The comparison with GOME-2 results obtained by van Peet et al. (2014) in the last paragraph of Section 5.3 seems to be of marginal support for the general discussion. The added value of the discussion in Section 7 is poor. This section could be redistributed over the previous sections the keep relevant information together.

   Author Response:
   We have corrected "ESA CCI", with which we mean the ESA Ozone-CCI project. From this project we take the required accuracy requirements for satellite ozone profile measurements. We corrected the section reference. The Discussion section (now Sec. 5) has been expanded to include two topics related to L1 data calibration: degradation and slit function retrieval and their relative importance in retrieving L2 ozone profiles. We have removed the discussion about the Antarctic ozone, so the text is only pertaining to L1 data evaluation.

6. It is agreed with the associate editor that a discussion of the nadir ozone pro-

file retrieval's averaging kernels is of importance for understanding the retrieved product. The single-pixel example (without discussion) and single-sentence conclusion on the effect of smoothing provided in Appendix A however are unsatisfactory: "The validation results are clearly less noisy and smoother for the case where the AK was applied to the ozone sondes." A lot more information on the retrieval performance can be derived from the averaging kernels.

Author Response:
We agree that the averaging kernel is an important concept in ozone profile retrieval. Therefore the AK is discussed in the retrieval algorithm part (Sec 2.2) with one graphical example (Fig. 2). In Sec. 4 we added more text on the application of the AK for validation, with one graphical example of its impact on the validation (Fig. 8). We have added a new figure, Fig. 4, showing the DFS profiles for different seasons for the years 2003 and 2009.

Technical corrections

1. Abstract, line 7: "focus on stratospheric ozone" and page 3, line 6 "we will focus exclusively on the study of ozone in the stratospheric region" does not match the many tropospheric and total column discussions appearing in the text.

   Author Response:
   We corrected the main text. Please note that due to reorganization of the paper the part on total columns has been removed.

2. Page 2, line 11: "their geographical coverage is limited to approximately 300 stations worldwide" is exaggerated. It's rather about half of that.

   Author Response:
   We corrected this in the Introduction, and added a reference to a publication on ozone networks.

3. Page 5, line 3-4: The statement on L1c data reproduction comes out of thin air. Please clarify.

   Author Response:
   We now clarify the L1c data reproduction in the beginning of Sec 2.1.

4. Page 5, line 8: The (van Soest et al., 2005) reference for L1 v7.04–W data release in 2012 seems unfitting.

   Author Response:
   We removed the reference.

5. Figure 2: dashed lines, mean or median, explain order indication, "residuals for 300 spectra" in contrast with "each curve is a residual for one solar spectrum" in text (page 8, line 18)

   Author Response:
   This is now Fig. 9. The meaning of dashed lines is now explained. We only show representative residuals for 300 spectra in the figure for clarity without overloading the size of the file. These 300 spectra are representative for the mission lifetime from 2002-2012. We explain this in the text belonging to the figure.

6. Page 6, line 6-7: Provide proper definition and explanation for DFS. The current phrasing is vague.

   Author Response:
   DFS is now explained in Sec. 2.2. In the new Fig. 4 the DFS is now shown for different seasons and years.

7. Page 10, lines 5-6: The text provides conflicting information on the years that are covered in this section's discussion.

Author Response:
We try to make it clear that the Slit function retrieval is done for 2002-2012, however the ozone validation and retrieval is done for 2003-2011 depending on the dataset version. The reasons are also explained.

8. Page 12, line 6: Interpercentiles are indicated as errors, but in fact are (random) uncertainties on the relative differences.

   Author Response:
   Agreed. Text is corrected in Sect. 4.1.

9. Page 12, line 33: “solar azimuth angle” should be “solar zenith angle”

   Author Response:
   Corrected.

10. Section 6: Table numbers seem to be wrong.

    Author Response:
    Corrected.

11. Journal names in the References section are sometimes wrong (ACP and AMT are mixed) and both abbreviations and full names are used.

    Author Response:
    Consistent journal names are now used in the References, and mistakes have been corrected.