

# ***Interactive comment on “Improving algorithms and uncertainty estimates for satellite NO<sub>2</sub> retrievals: Results from the Quality Assurance for Essential Climate Variables (QA4ECV) project” by K. Folkert Boersma et al.***

## **Anonymous Referee #1**

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Improving algorithms and uncertainty estimates for satellite NO<sub>2</sub> retrievals: Results from the Quality Assurance for Essential Climate Variables (QA4ECV) project, by K. F. Boersma et al.

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The manuscript summarizes the long-term effort in building a consistent, multi-decade record of NO<sub>2</sub> columns based on the practically all available data sets acquired from space. The article offers a plenitude of technical details aiming to improve the trace-

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ability of the described products as well as provides valuable recommendations that should help improving quality of the NO<sub>2</sub> retrievals. The article deserves a prompt publication.

I would like the authors to consider the following corrections/amendments:

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The main text:

I think that Section 2, especially Sect. 2.1, should be substantially shortened, since, by the author's remark, the survey's outcome was published elsewhere. I am not sure Fig. 1 adds any valuable content to the main objectives of the article. I would consider its removal. Section 2.1 could be shortened to 1-2 paragraphs by mentioning only the user's suggestions that have been implemented in the current version of the products). I would leave out all 'things-to-be-done' or 'things-to-be-considered'.

The same applies to Sect. 2.2 - I would concentrate exclusively on the already implemented items.

If the authors perceive the full review of the user's comments as very important, then I suggest moving it to Appendix.

Also, consider putting the text from p.8, l.25 through p.10, l.21 into a new Sect. 2.3, thus ascribing the current Sect. 2.3 to 2.4. This particular text, [p.8,l.25 - p.10,l.21], does not belong in Sect. 2.2.

The Footnote #2 to Table 1 does not help understand the meaning of the quoted 2%. Please either re-phrase or remove.

Table 2: is GOME v5 L1 used in the article different from the most recent L1 version described by Coldewey-Egbers et al. (AMTD, 2018)? Adding a footnote may help to remove the ambiguity. Also, Shah et al. (2018, AMT, 11, 2345) describes SCIAMACHY V8 while the authors use v7. This should be commented on just as well.

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p.15, l.5. OMI shows different degradation rates in radiances and irradiances. Moreover, various instrument-performance metrics show far superior stability than the quoted 2%. The wording should be changed to something like: "The OMI instrument produces stable (to ~2% over the mission time, in the row anomaly-free areas) L1B radiances".

p.15, l.11. '... directly from the Sun...'. Please re-phrase, since 'directly' does not apply to the sunlight presumably scattered by a peeling piece of insulation.

Fig. 2. The percentages shown at the upper axis do not correspond to the RA-marked areas in the plot. Either correct or clarify.

p.16, l.1. Replace 'detector degradation' by 'optical throughput changes in the irradiance channel'. The CCD detector does not change at the quoted rates.

p.18, l.9. In addition to the mentioned time-dependent slit-function changes, the GOME-2A slit function varies with the scan angle and along the orbit, though at a much lower level compared to the dominant long-term changes. Are these cross-track and along-orbit changes accounted for? Please comment on.

Figure 3. In the present format some details are inevitably lost due to the limited resolution of a printout. The same applies to the screen viewing, no matter the zoom. I may suggest: 1. Substantially enlarging the upper section. 2. Substantially overlapping two lower sections (these are practically the same) and expanding both of them at the same time.

p.23, l.4. Do you include or reject the RA-affected retrievals in your stats? Please clarify.

Fig. 4. Define the units of the color bars under both plots.

p.23, l.13. The intensity offset proves to be very important, so this particular subject deserves more detailed discussion, either in the main text or in a separate Appendix. In particular, the authors should provide a mathematical description and discuss the

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particulars of the 'best-practice' implementation of the offset. Indeed, the cited Müller et al. [2016] provides valuable information, but it is not possible to conclude which form of the intensity offset is considered as the best-practice by the authors. I suggest, besides providing mathematical description in the text, putting some specifics of the applied approach in Table 3. Currently the Table carries 'yes' or 'no' entries in the respective column. Does this mean that all 'yes' entries ascribe to the same intensity-offset mathematical form and implementation?

Table 4. Describe the 'undersampling' and 'Eta' corrections. These weren't mentioned in the text.

p.31, Footnote 6 : replace '...behavior of the red line...' by '...behavior of the black line...'

p.32, l.1. The 1st sentence mentions AMF\_strat in Fig.5, while Fig.5 caption says AMF\_total. Which one is true?

Table 5. If all listed values are derived on a pixel basis, then I would put a note in the caption and remove 'per pixel' from the fields. If not, then each field must carry either 'global' or 'per pixel' notation. Or, better yet, the table could be segregated into the 'pixel' and 'global' parts.

Fig. 9. All the colors but blue and light-blue are described in the caption. Either add these two descriptions or remove all and mention that additional info is provided in the figure legends.

Fig.13. The caption quotes  $P < 850$  hPa while the text (p. 50) says  $P < 875$  hPa. Which one applies?

p.52, l.7. The common Gauss-process error-combination formula gives ' $\sigma = \sqrt{\sum(\sigma_i^2)}$ '. The text mentions ' $\sigma = 1 / \sqrt{\sum(\sigma_i^2)}$ '. Please explain the difference.

Summary:

p.50 quotes -2% bias and 16% RMS, while Summary provides -2% and 13%, respectively. And, the same applies to DOMINO results: [+11% and 35%] in p.51 vs. [+11% and 28%] in Summary. Please clarify.

The list of references: a quick spot-check shows the cited in the text, but missing in the list - Boersma et al. [2004], Irie et al. [2009], Krotkov et al. [2016]. Thus, I suspect such omissions to be more numerable. Please double-check the list of references.

Also, please add letters b through f to the Boersma et al. [2017] works, to match the citations in the main text.

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Additional corrections:

p.23, l.15 - "... results in larger NO<sub>2</sub>..."

p.24, l.10 - "The inter-comparison of preferred-setting SCDs..."

p.29, l.4 - remove the 2nd 'agree reasonably well'

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