



## ***Interactive comment on “MAX-DOAS observations of the total atmospheric water vapour column and comparison with independent observations” by T. Wagner et al.***

### **Anonymous Referee #1**

Received and published: 10 September 2012

### **General Comments:**

The paper presents a new approach to derive water vapour vertical columns from MAX-DOAS measurements in the yellow and red spectral range. The experimental setup and the retrieval method are clearly described. The resulting water vapour vertical columns are compared with different independent data sources (ground based and model data as well as satellite measurements). My main point of criticism is that the errors of the derived VCDs are not sufficiently discussed. Overall, the manuscript is well written and may be published in AMT after some corrections addressed below.

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## Specific Comments:

1. p. 6245/6246:

Why is a Fraunhofer reference spectrum required (except for maybe the Ring correction)? As stated in the first paragraph on page 6245, always the same Fraunhofer reference spectrum is used in this study. Therefore, it should cancel out in eq. (2), i.e. one could use the SCD instead of the DSCD. Please explain.

2. p. 6245, last paragraph:

As stated in this paragraph, H<sub>2</sub>O data are taken from the wavelength interval 608—680 nm and O<sub>4</sub> from 543—620 nm (with the argument that the scatter of the data is lower in these spectral ranges). As H<sub>2</sub>O and O<sub>4</sub> SCDs are determined from the same spectral analysis, wouldn't it be more consistent to use O<sub>4</sub> derived from the same spectral range as H<sub>2</sub>O for the correction described in section 2.5? As shown in Fig. 3 the DSCDs of O<sub>4</sub> (and also H<sub>2</sub>O) derived in the two spectral windows differ somewhat (not only by scatter, also by absolute values). Could this have an impact on the results?

3. p. 6247, 3rd paragraph:

As described in Wagner et al. (2003), the saturation correction is determined from numerical simulations. What assumptions on the atmosphere have been made in these simulations, and how dependent are the results described in the present manuscript on these (a-priori) assumptions? Furthermore, the factor 1.25 used in eq. (5) is determined from radiative transfer simulations. What assumptions have been made there, and what are the dependencies on these settings (e.g. atmospheric profiles, SZA)? Please justify that the statement that the retrieval does not depend on a-priori information (made several times in the paper) is still valid under these conditions.

4. p. 6247, last paragraph:

Looking at Fig. 4, the application of the O<sub>4</sub> correction using a 30% threshold

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seems to result in an exclusion of most of the data at lower relative azimuth angles, which corresponds to the morning data (as stated on p. 6248, l. 15/16). Could the exclusion of these data be an additional reason for the larger differences to the GOME-2 satellite data (overpass in the morning)?

5. p. 6252, l. 21–24:

*'While the diurnal variations of the DSCDs of  $H_2O$  and  $O_4$  still show some scatter, the radiance, the colour index, and the  $O_2$  DSCDs show a rather smooth variation (except towards the end of the day).'*

Looking at Fig. 9 (left), the variation of  $O_4$  seems even a bit smoother than the variation of  $O_2$ .

6. p. 6253, l. 9–11:

Has the categorisation of all 40000 measurements been done by visual inspection and, if yes, why? According to the description in Wagner et al., 2011, it should be possible to define an automatic procedure for this which would probably give more reproducible results and could be also applied to further MAX-DOAS data sets.

7. p. 6260, l. 25/26:

*'Our retrieval algorithm is fast and robust and can yield the  $H_2O$  VCD and associated uncertainties...'*

What are these uncertainties and how are they determined?

There is no discussion of errors except for the statement on p. 6256 l. 17/18 that *'the deviation of the measured  $O_4$  VCD from the true value is a good measure for the accuracy of the  $H_2O$  VCDs retrieved from MAX-DOAS'*. This is however a more qualitative statement, and it essentially means that the quality of the  $H_2O$  VCDs is similar to the performed  $O_4$  correction – shouldn't the quality be better after this correction?

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Please give an estimate of the error of the derived H<sub>2</sub>O VCDs, preferably split up into the different potential error sources including the error on the derived SCD from spectral fit and additional systematic errors due to assumptions in the saturation and/or O<sub>4</sub> correction (e.g. from assuming a constant true O<sub>4</sub> VCD or from assumptions in radiative transfer simulations).

8. Table 2 & Figs. 12–15:

The quantities  $\langle A/B \rangle$  and  $\langle A \rangle / \langle B \rangle$  given in Table 2 and Figs. 12–15 are not mentioned/discussed in the text.

### Technical Corrections:

1. p. 6252, line 4:

I suggest to make this a separate section (2.7) instead of a subsection of 2.6 as there is no other subsection.

2. p. 6258, line 5:

I suggest to make this a separate section instead of a subsection of 3.6 as there is no other subsection.

3. Fig. 2:

The titles of the two sub-figures do not match the wavelength axes.

4. Fig. 3:

Even when scaled to a full (portrait) page size the text in the sub-figures is barely readable. Please increase the font size.

5. Figs. 5 & 8:

Does Fig. 5 show a ratio of VCDs (as stated in the label of the y axis) or a ratio of the VCD ratios shown in the lower sub-figures of Fig. 4 (as stated in the caption)?

Please clarify and possibly adapt the y axis label. Probably the description / y axis label of the lower sub-figure of Fig. 8 needs to be adapted in a similar way.

6. Fig. 9:

There seems to be an additional blank in 'H<sub>2</sub> O' (top sub-figures). The font size of the 'Time' labels should be adjusted to the size of the y axes labels.

7. Fig. 15:

The 'layer height' text below each sub-figure is probably obsolete.

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