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Comment

# ***Interactive comment on “A feasibility study for the retrieval of the total column precipitable water vapor from satellite observations in the blue spectral range” by T. Wagner et al.***

**T. Wagner et al.**

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Reply to anonymous Referee #1

General Comments: In the paper by Wagner et al. an interesting new approach to derive total column water vapour from measurements in the blue spectral range (around 440 nm) is described. This method complements already existing retrievals for other wavelength ranges and especially allows to derive water vapour information from sensors like OMI, which do not measure in the red, NIR or MW region. I recommend publication in AMT after some corrections suggested below. One general deficiency of

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the work is in my opinion that no VCDs are calculated (only SCDs). Since the AMFs depend on the spectral region, it is difficult to (quantitatively) judge upon the differences between the retrieval results based on SCDs alone. In this context, I would like to have some more quantitative information about potential systematic errors of the new (VCD) product related to e.g. insufficient knowledge of atmospheric conditions. However, as already mentioned in the title, the paper by Wagner et al. is only a feasibility study, therefore it would be sufficient to give some estimates here.

Author Reply: First of all we want to thank the reviewer for the positive assessment of our work! We agree that it would be good to compare the retrieval results from the blue spectral range with those from the red spectral range not only for SCDs but also for VCDs. However, as mentioned in our manuscript, we think that this should be the subject of a forthcoming study. In the revised version of our manuscript we add some more quantitative information as suggested by the reviewer. First, we investigated the uncertainties of the spectral retrieval in more detail and added the results of sensitivity studies varying several parameters of the spectral retrieval. In summary, varying the settings of the spectral retrieval can lead to small systematic differences (between  $-1.29 \times 1022$  and  $1.24 \times 1022$ ). To date it is not possible to identify the optimum settings for the spectral retrieval. This should be subject to futures validation studies after H<sub>2</sub>O VCDs have been calculated from the retrieved H<sub>2</sub>O SCDs. We added the results of the sensitivity studies at the end of section 2.

In addition we quantified the uncertainties of the air mass factors in both spectral ranges for different surface albedos and cloud fractions. These uncertainties are calculated for variations of the surface albedo of 1% (absolute uncertainty). Especially over ocean, the uncertainties in the blue spectral range are much smaller than in the red spectral range. Over land, the uncertainties are similar, except over deserts, where the uncertainties in the red spectral range are smaller. We added this information at the end of section 3 and in the new table 3.

Specific Comments:

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1. list of advantages of new method on p. 3645/3646: “Many of the advantages mentioned here are supported by plots/text later in the paper. Maybe one should mention this.

Author Reply: We added a statement at the end of the introduction that ‘Most of these points are confirmed by the results presented in sections 3 and 4.’

“The statement that ‘the retrieved H<sub>2</sub>O data sets are more consistent, especially across land-ocean boundaries’ should be justified a bit more. How ‘inconsistent’ are the current red/NIR retrievals over land/ocean boundaries, i.e. how large is the typical systematic error of these retrievals and how does it compare to the uncertainties of the new method?

Author Reply: We added the following text to the manuscript: ‘Here it should be noted that the albedo dependence on the retrieved H<sub>2</sub>O VCDs can in principle be corrected if accurate knowledge about the surface albedo, cloud properties and H<sub>2</sub>O profile is available. However, usually this is not the case, and especially in the retrievals in the red spectral range, the associated uncertainties are rather high (see section 3).’

At the end of section 3 we added a paragraph about the uncertainties of the air mass factor calculations in both spectral ranges caused by uncertainties of the surface albedo. We also added a new table 3 summarising these uncertainties.

2. p. 3647, l. 5: Current HITRAN version is HITRAN2008 (with some updates). Why has HITRAN2004 be used?

Author Reply: We investigated the effect of the choice of cross sections. If we replace the H<sub>2</sub>O cross section by the HITRAN 2009 version, a difference of the H<sub>2</sub>O SCDs of  $-0.23 \times 10^{22}$  is found. This difference is much smaller than the typical fit error. We added this information at the end of section 2.

3. p. 3647, l. 11: A polynomial degree of 5 seems quite high for a 20 nm spectral region. Doesn’t this interfere e.g. with ozone structures which also look quite smooth

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there (as shown in Fig. 2)?

Author Reply: We investigated the effect of different degrees of the polynomial on the fit results (see also first point above). Using different polynomial degrees (3 and 4) causes differences between  $-0.15e22$  and  $1.24e22$  compared to the standard retrieval (using a polynomial degree of 5). These differences are smaller than typical fit errors. We added this information at the end of section 2.

4. p. 3648, l. 14/15: 'Here we calculate AMFs to explore the measurement sensitivity for various measurement conditions.' As I interpret eq. (1) and the later discussion, a higher AMF corresponds to a higher sensitivity. Maybe one should mention this here. This would also be the place to give an estimate for the uncertainties of the VCDs resulting from the radiative transfer calculations / AMFs (see also general comments).

Author Reply: We added the following information to the text (see also first point above): Here it should be noted that a) a higher AMF indicates a higher sensitivity of the measurement, and b) that higher AMF lead to smaller uncertainties of the H<sub>2</sub>O VCDs calculated from the retrieved H<sub>2</sub>O SCDs (see also discussion at the end of this section and table 3).

5. Section 4.1, Fig, 5: Is Greenland really a representative region for a comparison? As shown in Fig. 3, the surface albedo is very high there. Wouldn't it be better – if possible – to choose a different set of orbits where the overlap region between GOME-2 and OMI is over land but not over ice/snow?

Author Reply: Greenland and ocean were chosen as examples with high and low surface albedos, respectively. We agree with the reviewer that it would be good to add another example for observations over land. Therefore we added another comparison over eastern Europe, for which the results are similar to those over the southern ocean. We added the additional comparison to Figs. 5, 8 and table 2. The results are discussed in section 4.1.

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6. Section 4.2 / Fig. 9: Please explain how the maps of the daily data have been generated. Have they been gridded/averaged at regions where more than one measurement is available (e.g. at higher latitudes)?

Author Reply: We added the following information to section 4.2.: For both daily and monthly maps the measurements are averaged on  $0.5^\circ \times 0.5^\circ$  grid.

Technical Corrections:

1. Acknowledgements: I assume ‘ERS-2’ should be replaced by ‘METOP’.

Author Reply: Corrected

2. Table 1: In the caption italic text is mentioned whereas in the table there is only roman text (also for the red spectral range).

Author Reply: We removed this part of the caption.

In the caption replace ‘AMF’ by ‘AMFs’ in caption (two times).

Author Reply: Corrected

3. Table 2: ‘DSCDs’ should probably read ‘SCDs’.

Author Reply: Corrected

4. Fig. 2: I suggest to include plots of the complete measured spectra in Fig. 2, not only the fit results and residuals. This could maybe also help to justify the need for a polynomial of degree 5 (see above).

Author Reply: We included the measured spectra in all figures as suggested. (note that during updating the figure we found two mistakes in the numbers given on the right side of the figures: For the weak H<sub>2</sub>O absorption in the OMI spectrum (bottom left) the radiance was changed from  $4.4e13$  to  $3.4e13$ , and the H<sub>2</sub>O SCD was changed from  $3.4e22$  to  $3.9e22$ ).

The effect of the degree of the polynomial is discussed at the end of section 2 (see

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above).

5. Fig. 4: Please provide the unit for the shown H<sub>2</sub>O profiles.

Author Reply: The black lines indicate relative H<sub>2</sub>O concentration profiles with a scale height of 2 km. We mention this in the text now.

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