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Atmospheric Chemistry and Physics Discussions

Interactive comment on "HDO measurements with MIPAS" *by* J. Steinwagner et al.

Anonymous Referee #1

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General

In this paper the authors present a method allowing one to derive the atmospheric HDO fractionation from the measurements acquired by the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) operating on the ENVISAT satellite. The presented method is tested on both simulated and real observations, showing the enormous potentiality of MIPAS measurements. The results of the method are presented along with a comprehensive error analysis, making the work globally convincing. Exhaustive scientific interpretation of the results is demanded to a future publication.

The approach and formulas used are scientifically sound, the presentation is clear although not always concise, therefore I recommend the paper also for publication on ACP. Please find below a list of specific comments. Among them there is only one important issue (specifically marked) that the authors should try to address before final

publication, other points should help improving the paper.

Specific comments

1. Page 932, line 5: I think the meaning of $\delta\vec{D}$ should be explained also in the abstract. This notation may not be clear to readers not familiar with isotope fractionation terminology.

2. Page 934, line 5: In order to avoid ambiguities I would specify here that you are speaking about the FWHM of the unapodized and apodized instrument line shapes respectively.

3. Page 934, line 10: I suggest to provide here the exact definition of the MIPAS scan range and sampling step (e.g. give directly the tangent altitudes as 6, 9, ..., 42, 47, 52, 60, 68 km).

4. Page 934, line 23: The most recent update of the MIPAS - dedicated spectroscopic database is described in J.-M. Flaud et al. 'MIPAS database: Validation of HNO_3 line parameters using MIPAS satellite measurements', Atmos. Chem. Phys., 6, 5037-5048, 2006. I think this is relevant because later (Page 936, line 1) you state that you also retrieve HNO_3 to minimize the error due to its spectral interference.

5. Page 935, line 16: please state explicitly what type of regularization matrix $\mathbf{R}$ you are using. Are you constraining the profile values or only the shape? Or both? If you constrain the profile shape, which operator do you use? Discrete first derivative? (i.e. $\mathbf{R} = \gamma \mathbf{L}_1^t \mathbf{L}_1$?)

6. Page 935, line 9: There is no nominal MIPAS tangent point at 11 km. Maybe you meant 12 km ?

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7. Page 936, lines 19, 20: time and geolocation of the measurements selected for testing are already given at line 11, same page.

8. Page 936, line 27: Figure 3. It would be nice if you could include an additional panel in Fig. 3, showing the vertical resolution (FWHM of the averaging kernels (AKs)) as a function of altitude, for both HDO and H_2O profiles. The plots of the AKs are quite crowded and it is difficult to establish how similar are the two sets (in fact they seem quite different ...). I understand that this is a critical issue, as the subsequent analysis of $\delta\vec{D}$ errors is based on the assumption that the AKs of H_2O and HDO are identical. However, even if the two vertical resolutions are not identical, if you add the mentioned plot one can at least judge on its own what can be achieved with your approach.

9. Page 939, Eq. (6): the 'transpose' operation should be applied to the rightmost term in parenthesis (not to the parenthesis on the left as it is now).

10. Page 939, lines 21, 24: The sensitivity test of Sect. 5.2.4 shows for a particular case, the smoothing introduced by the broad averaging kernels of the inversion system. Sect. 5.2.4 does not address the smoothing error, simply because (as you state above) $\mathbf{S}_e$ is not known. I would rephrase the first part of this sentence.

11. Page 940, lines 17,18: I would expect the retrieval of H_2O made in this work to be more precise than the conventional H_2O retrieval. This is because in this work the vertical resolution of H_2O is degraded (wrt to the conventional case) to match the resolution of the HDO retrieval. Is this correct ? Therefore, I would expect dedicated water retrievals to have a smaller smoothing error and a larger noise error.

12. Page 942, line 2: Figure 5a. Here is my main concern. The behavior of $\delta\vec{D}$ versus altitude reflects the 'W'-shape of the retrieved HDO profile (Fig. 2a). Are you sure that this 'W'-shape is not an artifact introduced by the combined use of

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an extremely fine (overambitious) vertical retrieval grid (1 km step) and a relatively strong regularization (maybe with the $\mathbf{L}_1$ discrete first derivative operator) leading to 6-8 km vertical resolution ? I would have used a coarser retrieval grid (e.g. 3 km step similar to the MIPAS sampling) or, alternatively, a high-order regularizing operator, extending the smoothness constraint over large altitude ranges. This puzzling doubt could be removed with a sensitivity test (like the ones presented in Sect. 5.2.4) in which both the HDO and H_2O profiles are perturbed smoothly, so that the retrieval is in principle able to recover properly the true profiles. In this test, differences between retrieved and true profiles within error bars would definitely rule out the hypothesis of artifact. If you have already done such a test you could just mention it somewhere in the paper.

13. Page 942, Eq. (15): the linearization cannot be operated about $\vec{x} = 0$ as in this point there is a singularity of Eq.s (13) and (14). I guess here you meant to do an expansion about the retrieved values of HDO and H_2O and you actually used these values for the calculation of the expressions in Eq.s (13) and (14). Therefore both in Eq. (15) and at line 20 you should replace $\vec{x}$ with the related increment with respect to the retrieved value.

14. Page 943, Eq. (15): the 'transpose' should be applied to the rightmost $\mathbf{J}$, not to the leftmost, as it is now.

15. Page 943, Eq. (18): I tried to derive this expression and a factor f multiplying everything seems missing. Please make sure that you used the correct expression for the calculations shown in the paper.

16. Page 944, lines 25, 26. Here I feel again the need of an additional panel in Fig. 3 showing the vertical resolutions of the retrieved profiles.

17. Page 945, lines 9, 10: please specify whether you apply the perturbations to the atmosphere used to generate synthetic observations or to the initial guess

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profiles.

18. Page 947, Eq.s (19) and (20): both σ_{ens} and σ_{mean} depend on the altitude index i, therefore I suggest to make explicit this dependence also in the symbols used (e.g. you could use $\sigma_{\mathrm{ens},i}$ and $\sigma_{\mathrm{mean},i}$).

19. Page 951, line 9: 'δ values ...' please make sure to use the same symbol '$\delta\vec{D}$' throughout the whole paper (see also caption of Fig. 7).

20. Page 952, line 24: 'Lopez-Puerta' $--> $ 'Lopez-Puertas'

21. Page 953, line 28: Reference incomplete.

22. Page 965, caption of Fig. 6. Please state explicitly the meaning of both solid and dashed lines.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 931, 2007.