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Interactive Comment

Interactive comment on "Ground-based remote sensing of HDO/H_2O ratio profiles: introduction and validation of an innovative retrieval approach" *by* M. Schneider et al.

M. Schneider et al.

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The authors appreciate all the comments made by the referees. Below they are answered in detail:

Response to Referee #1:
The Referee asks for potential applications of our retrieved HDO/H2O ratios. They doubt that the achieved precision is sufficient to apply the retrieved ratios for scientific studies.
(1) Our method allows the retrieval of middle/upper tropospheric HDO/H2O ratios from ground-based FTIR measurements with a precision of 50 % in the sense that

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50 % of the variability seen in the retrieved data is real and 50 % is erroneous. Standard approaches cannot retrieve middle/upper tropospheric HDO/H2O amounts at all. All the variability of their retrieved data is due to errors. Thus, our method is a significant improvement. Furthermore, we suggest that the precision of our method is sufficient and that the retrieved ratios are useful for scientific studies. In section 6 we showed that there exists a correlation between the origin of the detected airmass and the retrieved ratio. The outliers are statistically significant: The whole ensemble of midle/upper tropospheric HDO/H2O ratios has a mean and standard deviation of -223 +/- 61 per mil, while for a high latitude airmass it is typically below -350 per mil and for a tropical airmass above -100 per mil. This demonstrates that the achievable precision is sufficient to distinguish between different origins and thus different vertical transport processes or atmospheric conditions experienced by the detected water vapour amounts.
(2) An important potential application of middle/upper tropospheric HDO/H2O ratios as measured by our proposed method is the analysis of annual cycles at different measurement sites. Annual cycles of HDO/H2O ratios, which have a large day-to-day variability, can only be determined by continuous measurements. Ground-based FTIR measurements are performed continuously. This is the decisive advantage of our proposed method over more precise but sparsely performed balloon- or aircraft-based in-situ measurements. The Referee argues that in our measurements an artificial annual cycle could be introduced by the cycle of the typical solar elevation angle during the measurement. During winter we measure mainly at angles of 20-40° and during summer generally at elevation angles of 50-80° but also occasionally at low elevation angles. However, we find no correlation between elevation angle and retrieved HDO/H2O ratios, and consequently the observed annual cycle is not altered by changing elevation angles. We find that in 2005 and for the subtropical atmosphere on Tenerife Island the cycle of the ratio is not correlated to the temperature cycle. Therefore, we conclude that not the in-situ temperature but rather the origin of the airmass or transport processes determine the detected ratios. In future work

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the annual cycles retrieved for various measurement sites could help to constrain models (e.g. Schmidt et al., JGR, 110, D21314, 2005) and contribute to a better understanding of vertical water vapour transport, which is an important uncertainty in climate simulations.
We agree with all the specific comments of the Referee. They will be introduced in the revised manuscript version.

Response to Referee #2:
1) The Referee asks for the state vector. We will introduce a definition of the state vector in the revised manuscript: It consists of the vmr values of all absorbers and the temperature at 41 atmospheric levels and the spectral shift and ordinate scale in each microwindow.
2) The Referee would like to have a figure showing the averaging kernels of HDO/H2O. Typically the trace of the kernels (degree of freedom of measurements) is between 2.5 and 3. However, we didn't show averaging kernels on purpose: (a) tropospheric water vapor amounts vary over a range where the problem cannot be considered linear anymore. As a consequence the averaging kernels strongly depend on the actual atmospheric situation. (b) variability of water vapor is 10000 ppmv at the surface and 3-5 ppmv at the tropopause, i.e. it varies over nearly four orders of magnitude. This fact is not taken into account in the standard description of averaging kernels and thus their interpretation is not straight forward. Applying kernels on logarithmic scale would be an improvement, however, they still depend on the actual atmospheric state, i.e. they are largely variable. Instead of averaging kernels we decided to show the results of our simulations in form of correlation matrices (Fig. 6, Fig. 17). This gives, in our opinion, all necessary information about the achievable vertical resolution. It further allows to consider the impact of parameter errors on the vertical resolution, whereas the averaging kernel only present the situation in the absence of parameter errors. However, parameter errors have a large influence on the retrieval's sensitivity (compare Fig. 6 to Fig. 17) and should thus be considered when presenting the vertical

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resolution.

3) The Referee asks for the applied standard. It is SMOW. We will mention it in the revised manuscript.

4) We agree concerning the typo: it should be ratio instead of ration

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Interactive comment on Atmos. Chem. Phys. Discuss., 6, 5269, 2006.