Dear Editor,
Dear Authors,

Please find attached my review report.

Best regards,
Matthias Schneider

General comment:
The manuscript presents a new GOSAT retrieval for the estimation of the tropospheric water vapour isotopologue composition. The retrieval is very briefly presented and the data are briefly characterized. Furthermore, a brief empirical validation is performed by a comparison to water vapour isotopologue data produced from ground-based TCCON spectra.

Major comment:
Water isotopologue data obtained by space- or ground-based remote sensing techniques are potentially very useful for investigating the atmospheric water cycle, but respective measurements are very difficult. For this reason the remote sensing scientists' prime task should be to document the feasibility of the technique and the product quality in a detailed and extensive manner. In my opinion such documentation is a prerequisite for using the HDO/H2O data for scientific studies.
In this context, I would like to encourage the authors to perform a more detailed documentation of the feasibility of their retrieval and of the quality of their GOSAT and TCCON HDO/H2O data products. I think that the near infrared HDO/H2O remote sensing experts should undertake similar efforts as their colleagues did for middle infrared water isotopologue retrievals: in the middle infrared HDO/H2O can be well detected (strong and well isolated H2O and HDO lines) and there has been a lot of efforts for documenting the quality of this product (e.g., Schneider et al., 2006; Worden et al., 2006; Schneider and Hase 2011; Worden et al., 2011; Lacour et al., 2012; Schneider et al., 2012).

Specific comments:
(1) Estimation of leading error sources:
I would very much appreciate if the authors provided information on the different error sources (measurement noise, modeling of scattering, spectroscopic issues, etc.):
- What are the leading error sources?
- Are there especially favorable measurement conditions?
- Are there problematic measurement conditions?
- How do atmospheric humidity levels affect the retrieved HDO/H2O amounts?
- Etc.
When presenting complex data like HDO/H2O it is very desirable to document that the sensitivity and the uncertainty of the product is theoretically well understood. This would give confidence in the dataset. Furthermore, a rough knowledge of the uncertainty levels can avoid mis-/over-interpretations and thus strongly increase the scientific value of the dataset.

(2) Constraint of HDO/H2O, page 6361, line 19:
In the current manuscript version you say that you perform the retrievals without any "H2O-HDO side constraints (besides the similarity in the a priori profiles)". What you describe here as a kind of secondary order constraint is implicit in your retrieval setup

(hard constraint). I think it is a very strong constraint: (A) your kernels in Fig. 3 clearly show that the kernels of HDO and H2O are different, i.e. HDO-H2O constraint will definitively have an effect on your HDO/H2O result. (B) Near infrared spectra with a spectral resolution of 0.4cm-1 have a significant amount of information about the vertical distribution of water vapour (Schneider et al., 2011). Your constraint works against this information

(3) Sensitivity of your HDO/H2O retrieval, Fig. 3:
(A) Figure 3 shows that the sensitivities with respect to H2O and HDO are different. I think that this can cause significant artifacts in your retrieved HDO/H2O values and I would appreciate if you discussed this. For instance, imagine that there is a middle tropospheric increase of HDO and H2O, whereby HDO/H2O is not changed. However and according to Fig. 3, GOSAT will detect an increase in HDO/H2O (more sensitivity for HDO than for H2O).
(B) Actually it is not sufficient to only look on the H2O and HDO kernels, if you want to document your sensitivity with respect to HDO/H2O. There are also cross-correlations between the isotopologues. Furthermore, you might face the problem that the retrieved humidity and HDO/H2O states do not represent the same airmass, which makes an interpretation of the isotopologue data rather difficult. In Schneider et al. (2012) we show a procedure for documenting and correcting the cross-correlations between humidity and HDO/H2O and for adjusting the different sensitivities of humidity and HDO/H2O. The attached Appendix shows an example of the humidity and HDO/H2O sensitivities and the cross-correlations between humidity and HDO/H2O. The documentation is made for two different water vapour isotopologue retrieval setups applying a typical IASI spectrum: first, for our Schneider and Hase (2011) IASI retrieval setup, and second for a setup that is very similar to your GOSAT setup (scaling of prescribed H2O and HDO profiles). I hope that this example can encourage you to analyze the HDO/H2O sensitivity of your retrieval in more detail. In my opinion you should investigate (1) to what extent your humidity and HDO/H2O product represent the same airmass (HDO/H2O is scientifically most useful if it is provided together with humidity), and (2) to what extent your HDO/H2O product is affected by humidity interferences.
(C) The TCCON retrieval is similar to your GOSAT retrieval and the TCCON water isotopologue product faces the same problems.

(4) Uncertainty in the ECMWF and NCEP profiles (used as a priori profiles), page 6366, line 5:
What about uncertainties in the ECMWF H2O data and uncertainties in the NCEP H2O data (used by the TCCON retrieval)? Can you assess the difference between the actual H2O and the H2O state described by the ECMWF/NCEP data state (e.g., by means of the numerous radiosondes launched at the Lamont site)? Please also consider that tropospheric water vapour varies on very small scales, i.e., the radiosonde and the remote sensing instrument very likely detect airmasses that have significantly different water vapour profiles. According to the sensitivity studies as shown in the Appendix an incorrect a priori profile assumption can significantly affect your retrieved HDO/H2O. Can you estimate the importance of this?

(5) Comparison between GOSAT and TCCON, page 6366, line 25:
I am not very happy that you compare two retrieval products, whose HDO/H2O sensitivities and uncertainties are not theoretically documented (see my comment (1) and (3)). Both the GOSAT and the TCCON retrieval setup apply similar a priori

assumptions (e.g., a very similar HDO/H2O profile shape). At the same time it is not documented to what extent the retrieved HDO/H2O variability is, for instance, due to interferences from atmospheric humidity or uncertainties of the applied a priori profiles (ECMWF and NCEP for GOSAT and TCCON, respectively).
I am a bit concerned that the GOSAT and the TCCON retrievals suffer from a common artifact. For instance, both the GOSAT and TCCON retrieval might suffer from similar humidity interferences on HDO/H2O. Then in both datasets the observed HDO/H2O variations would actually and to a large extent reflect real atmospheric humidity variations. I am not sure if your Figs. 4-7 really demonstrate that your HDO/H2O products provide additional information to H2O.
SUGGESTION: Please perform the following and straightforward test. Plot the TCCON and GOSAT data in a {H2O vs. HDO/H2O}-plot. Such plots can nicely document the added value of HDO/H2O measurements (e.g., Noone et al., 2011; Risi et al., 2012; Schneider et al., 2012). Then investigate similarities in HDO/H2O anomalies (deviations for the mean {H2O vs. HDO/H2O} correlation). If you can show that GOSAT and TCCON reveal the same anomalies your study would be much more convincing.

(6) Comparison between GOSAT and SCIAMCHY, Figs. 8+9 and corresponding text:
Here I have the same concern as for the GOSAT versus TCCON comparison. Can you assure that you really compare HDO/H2O and not just H2O (H2O variability might widely determine your commonly retrieved HDO/H2O signal).

(7) Why don't you compare to existing global datasets with assessed quality?
I wonder why you chose to validate your global GOSAT dataset at a single TCCON station instead of validating it with respect to the MUSICA dataset. Within the European project MUSICA water isotopologue data are available for ten globally distributed sites (Schneider et al., 2012). Of course these data are also not perfect, but at least their quality has already been extensively documented in several different theoretical and empirical assessment studies (a very complex work which is still ongoing). I think that a comparison to this "reference" would be more convincing than your comparison study.

Technical corrections:
Page 6361, line 17:
"chose" -> "chosen"

Page 6362, line 5:
Shouldn't it be "Gaussian" instead of "gaussian"?

APPENDIX: Example for the sensitivity of a space-based remote sensing system with respect to tropospheric Humidity and δD

Here we present row kernels for Humidity and δD calculated from the H2O and HDO kernels according to Schneider et al. (2012). Our example retrieval uses a spectrum measured by the sensor IASI (not GOSAT). Principle characteristics of the IASI measurement:
- IASI is a thermal nadir sensor
- spectral resolution: 0.5cm^{-1}
- for our example retrieval we use a subtropical ocean pixel
- spectral retrieval window: 1190-1400cm^{-1}

Figure 1 shows the Humidity and δD kernels obtained by the Schneider and Hase (2011) IASI retrieval setup: simultaneous optimal estimation profile retrieval for H2O, HDO, and δD.
(1) We observe that the system's sensitivity wrt Humidity and δD is significantly different. While we can detect Humidity profiles between the lower and upper troposphere (kernel in the upper left graph) we only can measure mid-tropospheric δD (kernel in the lower right graph). Since the retrieved Humidity and δD do not represent the same airmass, a scientific interpretation of these data is very difficult.
(2) There are cross-correlations (depicted in the upper right and lower left graph). In particular important is the cross-correlation of Humidity on δD, meaning that humidity variations affect the retrieved δD values. Please note that the x-axes of the cross-correlation graphs are scaled by one order of magnitude in order to account for the differences in the variations of humidity and δD.
Please be informed that for this retrieval setup it is possible to adjust the Humidity and δD sensitivities and to correct a large part of the cross correlations by an a posteriori method (for more details see Schneider et al., 2012).

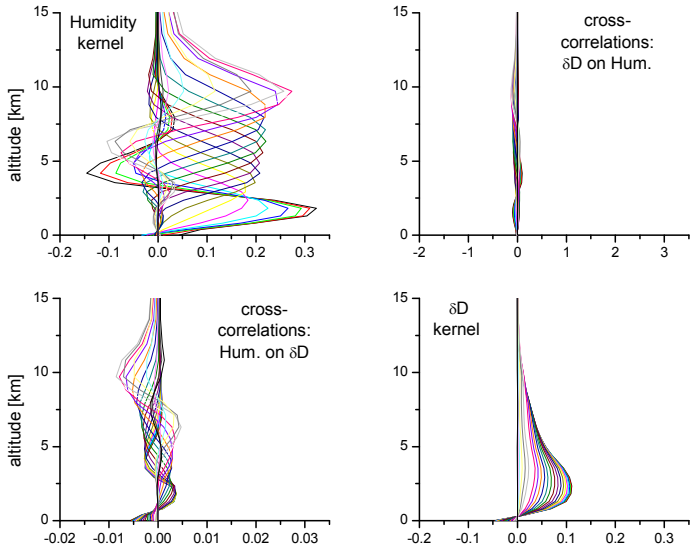

Fig. 1: Row kernels (on log scale) and cross-correlations for Humidity and δD obtained for IASI when applying the Schneider and Hase (2011) retrieval setup.

Figure 2 shows the same as Fig. 1 but applying the retrieval setup suggested by the authors for GOSAT and TCCON: scaling of a prescribed H2O and HDO profile.
(1) The Humidity sensitivity is now rather limited to the upper troposphere, while δD sensitivity is limited to the middle troposphere. There is few overlap between the Humidity and δD sensitivities.
(2) The cross-correlations of Humidity on δD become now significantly larger. Low upper tropospheric Humidity or high lower tropospheric Humidity artificially increase the retrieved column-averaged δD values.

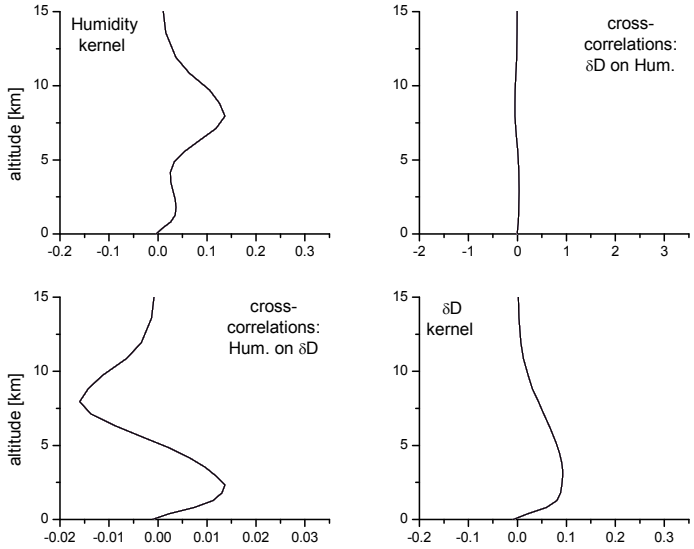

Fig. 2: Same as Fig. 1 but for a profile scaling retrieval (the setup suggested for GOSAT). Please not that like in Fig. 1 all row kernels corresponding to the different altitudes are depicted, but for a profile scaling retrieval they are all the same (and only one kernel is visible in the graph).

References:

Noone et al. (2011): http://www.agu.org/pubs/crossref/2011/2011JD015773.shtml

Lacour et al. (2012): http://www.atmos-chem-phys-discuss.net/12/13053/2012/acpd-12-13053-2012.html

Risi et al. (2012): http://www.agu.org/pubs/crossref/2012/2011JD016623.shtml

Schneider et al. (2006): http://www.atmos-chem-phys.net/6/4705/2006/acp-6-4705-2006.html

Schneider and Hase (2011): http://www.atmos-chem-phys.net/11/11207/2011/acp-11-11207-2011.html

Schneider et al. (2011): http://www.atmos-meas-tech.net/3/1785/2010/amt-3-1785-2010.html

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