Atmos. Chem. Phys. Discuss., 9, C10392–C10397, 2010
www.atmos-chem-phys-discuss.net/9/C10392/2010/

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Interactive Comment

Interactive comment on "The ground-based FTIR network's potential for investigating the atmospheric water cycle" *by* M. Schneider et al.

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Received and published: 2 February 2010

We are very grateful for the comment. The referee mentions a major handicap of the currently available HDO/H2O data: the different measurement techniques are insufficiently inter-validated. We share this opinion and think that an inter-comparison of the different techniques would be highly desirable (in-situ versus ground- and space-based HDO/H2O remote sensing). In this context we would like to inform that we have submitted a proposal to the European Research Council, which, among others, aims on removing the current HDO/H2O validation deficits.

Keeping this general agreement with the referee in mind, in the following we address the referee's questions/comments and explain where and why we disagree:

(1) The Referee suggests using a comparison between ground-based FTIR and satellite data as an independent method for validating:

We agree that comparing space- and ground-based remote sensing measurements would be an interesting exercise, but the space-based data cannot serve as reference data. The current space-based satellite data from TES and SCIAMACHY (Worden et al., 2006 and 2007; Frankenberg et al., 2009) have never been validated by a comparison to independent experiments. Worden at al., 2006 performs theoretical estimates and Worden et al., 2007 and Frankenberg et al. 2009 argue that the results being reasonable demonstrate the potential of the space-based techniques. For the ground-based FTIR technique the situation is very similar: Schneider et al., 2006b present an extensive theoretical error assessment and in this paper we demonstrate that the ground-based FTIR results are in agreement with the meteorological situations as given by the model.

Furthermore, the space-based data are limited to a certain altitude range (TES: middle troposphere, SCIAMACHY: surface layer), whereas the ground-based remote sensing technique is sensitive throughout the lower and middle troposphere.

As outlined above, inter-comparing the different HDO/H2O measurement technique is highly desirable. However, it is a big task and outside the scope of this paper, whose objective is to demonstrate the potential of the ground-based technique. The term "potential" implies that there is still a lot of effort necessary, among others an extensive empirical quality assessment of the data by inter-comparison studies.

(2) It is unclear whether the model is being used to validate the experimental data (including its assumption) or vice versa. The referee is concerned about a circular argument and that the agreement between measurement and model is artificial since both data sets are not independent:

The model is nudged towards horizontal wind fields and temperature profiles from re-analyses data, in order to reproduce short time scale and small scale dynamical features. The a priori data assumed for the retrieval of the ground-based FTIR data is a climatological mean HDO/H2O profile (the same for all retrievals) and a temperature profile from reanalysis data. Both nudged model and ground-based FTIR use reanalyses temperature profiles, and one might argue that this is the reason for the good agreement between the model and the measurement. However, it is important to state that the model and the measurement provide rather independent data sets:

First: The measurement is strongly independent on the a priori assumptions. As shown in Figure 3, below 10 km in Izana (and below 7 km in Kiruna) more than 75 % of the HDO/H2O variability produced by the retrieval comes from the measured spectra and is independent on the a priori assumptions. Furthermore and concerning the temperature profile, it is important to remark that we retrieve the temperature from the measured spectra. This approach strongly improves the quality of the FTIR H2O profiles (e.g. Schneider et al., 2006a) and the FTIR results are for the measured not the a priori assumed temperatures. Using the reanalyses temperature when performing the FTIR retrievals assure a quick convergence of the optimal estimation iteration process, but does not significantly affect the FTIR results.

Second: The model uses horizontally large scale components of wind fields and temperature profiles from reanalyses data (Yoshimura et al., 2008). Therefore it is not exactly the same temperature data as what FTIR a priori uses (local temperatures for the particular measurement site). Furthermore, the temperature nudging has a much weaker impact than the wind nudging in the model simulation. It is mainly used for stabilising the simulation (only planetary scale (>5000km) wave is needed). In other words, once the horizontal wind is constrained, temperature fields act more dependently. The opposite is not really true, i.e., wind fields would not be simulated well by constraining large scale temperature fields. Consequently, the simulated short-term moisture and isotope fields are dependent on the reanalyses wind fields but almost independent on the temperature fields.

Given the current lack of coincident in-situ and remote sensing measurements a com-

ACPD
9, C10392–C10397, 2010

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parison between model and measurement is the most effective validation method: Firstly, the model data are continuously available (large number of coincidences between measurement and model) and secondly, model and measurement data are rather independent. On the other hand, the number of coincidences between space- and ground-based measurements is significantly smaller and both measurement techniques have important similarities (e.g. apply similar spectroscopic signatures and similar retrieval techniques). Thirdly, the model produces data throughout the troposphere (even stratospheric simulations are available), whereas the space-based measurements are only sensitive to limited altitude ranges. For these reasons we perform a first validation of the ground-based FTIR data with model data and not with space-based data. The only reasonable explication for the good agreement between the measurements and the model (when assuring a correct modeling of the meteorology) is the ability of the measurement technique in capturing the real atmospheric variability. And vice versa: the fact, that the model – when assuring correct short-term and small scale meteorology – agrees with the measurements, demonstrates the ability of the model of correctly simulating the water transport pathways and the fractionation processes. The paper provides in deed both: a validation of the model and the measurement.

(3) The referee is concerned about the nudging and asks: "Why should nudging even be necessary if the model is a good one?":

Most of the variability in the HDO/H2O is small scale and short-term variability. An atmospheric general circulation model is not able to reproduce this variability (e.g. compare to weather prediction models, they need observational data to produce acceptable results). With non-nudged simulation data, we can only compare statistical information of the short-term variability for isotopes. Since it is not so easy to get representative statistical information from measurement data (due to data-missing, short period, etc.), it is a great step forward to use nudged model data to study detail mechanism of the isotopic variations. Moreover, since long term proxy data are usually precipitation-weighted mean, it is quite important to simulate short-term variability well as a base

ACPD
9, C10392–C10397, 2010

step. If we assure that the model's short-term and small scale dynamics agrees with the observations we get a good agreement with the measured HDO/H2O demonstrating that the water vapour transport pathways and the fractionation processes are well modeled (remember that we only nudge towards horizontal wind fields and temperature profiles not towards water vapour).

Concerning long-term issues, like the connection with the NAO index, nudging is also important since the free run model does not consider the complex interplay between atmosphere and ocean (which is thought to be the reason for the NAO). It would be interesting to investigate if a coupled ocean-atmosphere model can reproduce this strong connection to the NAO and other long-term climate signals.

(4) It is unclear whether the paper validates the experiment/model or whether the package of experimental data and model is being used to draw conclusions about the water cycle:

The paper addresses both issues: (a) it documents the quality of the FTIR HDO/H2O data (and the model) and (b) shows how this data can open up novel opportunities in water cycle research (e.g. investigating long-term aspects like the connection between the water cycle and atmospheric circulation patterns). The paper informs the scientific community about the ground-based FTIR long-term HDO/H2O data series and its unique possibility for water cycle research. It gives a first impression of what could be investigated with the long-term HDO/H2O data set covering all the globally distributed ground-based FTIR sites. As aforementioned the term "potential" in the title implies that there is still a lot of work to do: inter-comparing different techniques, evaluating HDO/H2O time series for other FTIR sites, etc. The paper demonstrates the possibility of the ground-based FTIR network. It is an important reference, but only a first step. We hope that the paper promotes the investigation of long-term water cycle aspects and that it helps us to get the funding necessary to exploit the whole potential of the FTIR network.

ACPD
9, C10392–C10397, 2010

(5) The referee suggests adding panels to Figures 1 and 2 demonstrating the mean and std of the measured and modeled data:

That's a good idea, we will do so!

(6) Thanks for the technical comments!

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 26199, 2009.

ACPD

9, C10392–C10397, 2010