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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Simultaneous ground-based observations of O_3, HCl, N_2O, and CH_4 over Toronto, Canada by three Fourier transform spectrometers with different resolutions" *by* D. Wunch et al.

Anonymous Referee #1

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General comments:

The ground-based FTIR network of the NDACC provides a continuous and expanding dataset for trend evaluation as well as satellite validation. To ensure a homogeneous data set of high quality, the network strongly depends on various kinds of comparison exercises. This study presents for the first time a side-by-side intercomparison of ground-based FTIR spectrometers with significantly different spectral resolution.

Three FTIR spectrometers were used: The first instrument is a typical NDACC site

instrument which is operated at 250 cm max optical path difference (MPD). The second instrument offers 50 cm MPD and can also be operated on balloon platforms. The third instrument is a clone of the satellite-borne ACE-FTS and runs at 25 cm MPD. All instruments were fed by a common tracker to allow simultaneous recordings of solar spectra. From the available measurement set, total columns of O3, HCl, N2O and CH4 were retrieved and compared. In addition, synthetic spectra were generated and a sensitivity study of the retrievals wrt spectral resolution was performed on these grounds.

The agreement found for the retrieved total columns is within 3 % of the high-resolution reference instrument. Both the simulations as well as the campaign results indicate that 50 cm MPD are still sufficient for the retrieval of total columns, whereas the 25 cm MPD instrument lacks sensitivity at least in case of the stratospheric species. Since the NDACC recommends an MPD of at least 250 cm for FTIR network instruments, the results indicate that this requirement probably is too stringent. On the other hand, it turns out that correct assumptions concerning the instrumental line shape (ILS) of the instruments are of crucial importance, so this finding supports the NDACC recommendation of ILS monitoring by regular cell measurements.

Although the paper makes a significant contribution and is altogether clearly written, the investigation of effects of resolution and the discussion of results should be improved as detailed below. I recommend publication if the revisions recommended below are taken into account.

Specific comments:

Section 3, page 10889: "generated by FSCATM, a nonlinear forward model ... ." To my knowledge, there are no linear forward models around for the radiative transfer problem encountered here. The Lambert-Beer law introduces significant nonlinearity for all but the weakest (optically thin) spectral features.

Section 3, page 10889: "... a nonlinear forward model that uses an a-priori state

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estimate ... ." The term a-priori refers to the retrieval process. In the context of the description of the forward model, I suggest to avoid this term.

Page 10889: It might be advantageous to describe the forward model first and to discuss the retrieval procedure afterwards.

Page 10891: Please add details on gas cell used (pressure, length).

Page 10892: Concerning the set of simulated spectra, I do not fully understand which parameters generate the sample of 16 spectra for each choice of MPD. As far as I understand, noise has been added to each spectrum to generate the error bars given in Figs. 3 to 7.

However, it is not necessary to generate a manifold of spectra to determine the noise error in the retrieved column. Just generate a single noise-free synthetic spectrum and specify the assumed SNR in the retrieval process. The retrieval of this single spectrum will then yield the mean column, and the noise error covariance reported by the retrieval code can be used to calculate the noise error of the total column (this approach neglects the nonlinearity of the inversion problem, but is certainly feasible here).

Which conclusion can be drawn from the current simulation? I assume that the intention of the authors is to show that the ability to detect variability in total column decreases when MPD becomes too small. However, the outcome of the exercise is quite arbitrary, as it depends on the selection of the "same atmospheric conditions" (which are left unspecified?). If the climatological mean is selected here which is also used as a-priori in the retrievals, all retrievals will perfectly recover the original column. If a certain unique disturbance is chosen, the outcome might depend significantly on its assumed shape.

To make the simulation conclusive, I suggest to generate a set of spectra in accordance with the estimated variability of atmospheric conditions. The simulation would then

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lead to a definite conclusion: one would be enabled to specify which MPD (+ SNR combination) is required to follow the true variability of the total column to a certain extent. (Alternatively, there is a shortcut to reach this result by application of partial column sensitivities to the expected natural covariance of the trace gas profiles.)

Section 4, general: The results from the instruments are put together and are compared, but not too much effort is undertaken to shed light on the remaining discrepancies. As an example, with respect to CH4 results it is speculated that the current spectroscopic description generates the unexpected large discrepancies. This is probably right, but can be proven to some extent: e.g. cutting down the resolution of both the TAO-FTS and the U of T FTS spectra to PARIS-IR resolution should allow to retrieve compatible columns from all instruments.

Page 10898: The assumed SZA dependence of retrieved columns is rather significant. For example, according to Fig. 13, the TAO-FTS results differ by about 2.4 % between the two subsets. Let us assume the tracker offset amounts half the apparent diameter of the sun. Even this quite significant deviation would generate an airmass inconsistency of only 0.4 % at 45° SZA. Given the high solar elevations of the measurements, the observed discrepancies can hardly be ascribed to an SZA error. Are there other possible explanations?

Page 10898: I assume that x denotes the vector which collects the volume mixing ratios of the target gas in each model layer. Please clarify.

Page 10899: The vector rho should not be referred to as the atmospheric density or airmass. Its components are the partial columns of air molecules in each model layer.

Fig. 18: The figure caption is not a concise description of what is shown. I assume that the graph shows the response of the retrieved total column wrt a unity perturbation of volume mixing ratio in each model layer.

Technical corrections:

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Fig. 1: to which wave number region these results refer to?

Table 1 should also list the SNR achieved by each instrument (for typical spectra used in the analysis, in the spectral range of 2500 to 3000 cm-1)

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 10883, 2006.