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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Retrieval of ammonia from ground-based FTIR solar spectra" *by* E. Dammers et al.

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We would like to thank Referee #1 for his/her time, constructive and helpful comments and suggestions.

1) Pg 23283, line 20 to Pg 23284 line 12: It terms of satellite validations you mention IASI, but you might also want to mention the potential for the FTIR to provide direct profile comparisons similar to recent satellite/aircraft validation studies (e.g. Shephard et al., "2015, Tropospheric Emission Spectrometer (TES) satellite validations of ammonia, methanol, formic acid, and carbon monoxide over the Canadian oil sands AMTD).

We added the following sentence as a pointer to the potential of the FTIR observations as a validation tool for nh3-profile observations. "A recent study by Shephard et

al. (2015b) shows the potential of an instrument that can be used for profile comparisons. In the study instruments on an aircraft were used measure a vertical profile of NH3 which were used as a validation tool for the NH3-profile observations of TES." Added the reference: "Shephard, M. W., McLinden, C. A., Cady-Pereira, K. E., Luo, M., Moussa, S. G., Leithead, A., Liggio, J., Staebler, R. M., Akingunola, A., Makar, P., Lehr, P., Zhang, J., Henze, D. K., Millet, D. B., Bash, J. O., Zhu, L., Wells, K. C., Capps, S. L., Chaliyakunnel, S., Gordon, M., Hayden, K., Brook, J. R., Wolde, M., and Li, S.-M.: Tropospheric Emission Spectrometer (TES) satellite validations of ammonia, methanol, formic acid, and carbon monoxide over the Canadian oil sands, Atmos. Meas. Tech. Discuss., 8, 9503-9563, doi:10.5194/amtd-8-9503-2015, 2015b."

We also changed the already included Shephard et al (2015) reference to (2015a) in the introduction(Page 23283, line 24, added 2015a (was missing)) and the reference list(Page 23302, Line 18): "Shephard, M. W. and Cady-Pereira, K. E.: Cross-track Infrared Sounder (CrIS) satellite observations of tropospheric ammonia, Atmos. Meas. Tech., 8, 1323-1336, doi:10.5194/amt-8-1323-2015, 2015b."

2) Pg 23289, lines 7-10: Can more justification be provided for there being no correlations between the layers? For example, is the vertical resolution comparable to the number of vertical retrievals levels? Looking at the averaging kernels they appear to be relatively smooth indicating that there might appear to be significant interlayer correlations. The resolution of the retrieved profile is not the same as the number of the vertical layers. The resolution of the profile is given by the AVK. The AVK reflect the fact, that the information content in the measurement is not high enough to retrieve more than one or two independent layers in case of NH3. From the FTIR measurements one cannot draw the conclusion, that there are interlayer correlations just because the AVK indicate this.

3) Pg 23290, lines 22-23 and Pg 23294 lines 22-23: It probably not completely accurate to say that 1 DOFS means that only total columns can be retrieved. It can be stated that with 1 DOFS only one piece of information can be obtained, but this is not necessary

ACPD
15, C8090–C8094, 2015

over the whole column unless the retrieval is equally sensitive over the whole column. For example, the retrieval might be mostly sensitive over a certain region of the profile so the 1 DOFS might refer to more of a partial column, etc. Changed page 23290, lines 22-23, removed “which means that only total columns can be retrieved.” Added “with almost no vertical information available”. Page 23294, lines 22-23, changed” only the total columns can be retrieved” to “there is not enough information to discriminate individual layers”

4) Pg. 23291, line 15-17: To reduce some of the propagation errors due to NCEP temperature uncertainties, is it possible to also perform a temperature retrieval using the CO2 lines with or before the NH3 retrievals? I am not proposing it is to be done here for the results in this paper, but rather just a comment (maybe in the future). It would be possible to do this if one had a band of CO2 in the spectral window, because you can get the temperature from the relative size of the CO2 lines. The one line in our micro windows is not enough.

5) Pg. 23294, lines 27-29 and Pg 23295 lines 1-7: To help demonstrate the information content that goes along with the sensitivity of these low values at Jungfraujoch it would be good to also provide the average DOFS with the average retrieved values. Added the average DOFS, For Bremen: Page 23294, line 13, added “, with a mean DOFS 1.9” For Jungfraujoch: Page 23294, line 14 , added”, with a mean DOFS 1.0”

6) Pg. 23295 lines 23-29 Pg. 23296 line 1: When providing background information on emission inventories you might want to also mention top-down constraints being provided by satellites (e.g. Zhu et al., 2013, Constraining U.S. ammonia emissions using TES remote sensing observations and the GEOS-Chem adjoint model, ACP), and the potential of using both FTIR and satellite observations in conjunction with chemical transport model inversions to improve emission estimates. We’ve added a few words to point out earlier studies and use of ammonia remote sensing for emission estimate purposes: Added “Satellite observations in combination with chemical transport models (CTM) have been used to provide a top-down constraint on ammonia emissions

ACPD
15, C8090–C8094, 2015

(e.g. Zhu et al., 2013).” In between “. . . the performance of air quality models (Skjoth et al., 2011).” And “Similar to satellite”. Added to Page 23296 line 3:” and satellite” in between “,FTIR total columns in combination with surface” and “observations could provide the means to evaluate the emission”

Added “Zhu, L., Henze, D. K., Cady-Pereira, K. E., Shephard, M. W., Luo, M., Pinder, R. W., Bash, J. O. and Jeong, G. R.: Constraining U.S. ammonia emissions using TES remote sensing observations and the GEOS-Chem adjoint model, J. Geophys. Res. Atmos., 118(8), 3355–3368, doi:10.1002/jgrd.50166, 2013.” To the reference list

Edits: 1) One overall grammar correction is often there should be a “,” before the word “but” We added a “,” to the following lines: Page 23282, line 27, Page 23283, line 5, Page 23283, line 16, Page 23284, line 15.

2) Pg 23282, line 7: missing the “a” between “is major” Added “a”

3) Pg 23282, lines 10-12: Might want to remove “Recently” as the reference is from 2008. Removed “Recently”

4) Pg 23282, line 28: change “and” to “with”? Changed “and” to “with” and removed “are” from the sentence.

5) Pg 23283, line 1: might want to put brackets around the“e.g. many . . . 4 weeks” Added brackets.

6) Pg 23283, line 22-23: missing reference for CrIS As stated in the answer to question 1 we added the reference.

7) Pg 23284, lines 4-5: If you like you can make this statement more general by just stating that satellite data is on order the order of 10’s of kilometers. Changed the sentence to: “whereas satellite observations have a footprint on the order of tens of kilometres.”

8) Pg 23284, line 18-19: the molecule names (e.g. Carbon Dioxide) don’t need to be

ACPD

15, C8090–C8094, 2015

capitalized in the sentence. Removed the capital letters.

9) Pg 23285, line 12: change “and a HgCdTe” to “with a HgCdTe” Changed to “with a HgCdTe”.

10) Pg 23288, line 15: should use “signal-to-noise ratio” for the “SNR” Changed “SNR” to “signal-to-noise ratio”, also changed the “SNR” in the header of table 2 to “Signal-to-noise ratio (SNR)”

11) Pg 23293, line 9-11: units on the error numbers. Added "molecules NH3 cm-2” behind the error number.

12) Pg 23293, line 11: put a “,” before “which” Added the “,”

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