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Atmospheric Measurement Techniques Discussions

Interactive comment on "Validation of the CrIS Fast Physical NH_3 Retrieval with ground-based FTIR" *by* Enrico Dammers et al.

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We would like to thank Referee #2 for his/her time, constructive and helpful comments and suggestions. Note, throughout the document R1 stands for reviewer 1, and figures named R1.x point to the x'th figure in "Reply to comments, Referee #1.

General Comments:

1. One particular issue that could hamper the interpretation of the results is the potentially limited information content captured by the CrIS retrievals. The current DOFS cut off is taken at >0.1, which entails that some measurements are/could be heavily dominated by the a-priori. The authors allude that particularly measurements with low NH3 concentrations could be effected. One way to at least give some information on

this is to replot Fig2, whereby each measurement is coloured related to its (average) DOFS.

The artificial DOF cut off was chosen to remove observations without information. We added colouring to the scatterplot indicating the average DOF for each CrIS observation, with the colour bar ranging from 0.1 to more than 1.1. See the reply to the comments of ref #1 for a distribution of the DOF for all observations used in this study. Added "The colouring on the scatter indicates the mean DOF of each the CrIS coincident data." to the caption of Figure 2.

2. Another way to test whether observed differences between CrIS and FTIR are driven by differences in a-priori rather than the actual retrieval, is to (prior to mapping CrIS to FTIR –see eq(1)) conform the CrIS retrieval to the FTIR a-priori as in Rodgers (2000): x(CrIS,ftir apriori corrected)=x(CrIS) +[A(CrIS)-I]*[apriori(CrIs)-apriori(ftir)].

That is a great question and it is something we have tried before submitting. A posteriori switching out the CrIS a-priori for the FTIR a-priori essentially brings us closer to what we want, validating just the observations without an effect from the a-priori. The problem however is the non-linearity in the retrievals (Kulawik et al., 2008). The resulting retrieved profile is not always near/comparable to the initial a-priori shape and amplitude (which in itself shows that the initial choice of a-priori does not greatly influence the retrieval), which makes an a posteriori switch of the a-priori profile troublesome. Without a repeat of the CrIS retrievals it is not possible to distinguish between the effect of the a priori on the retrieval and the effect of the a posteriori switch. The study by Kulawik et al., (2008) showed that the effect does not have to be major as long as the a priori is representative of the final retrieved profile. This however is not always the case in our retrievals. To illustrate we give a number of examples. Fig R2.1 to R2.4 show the effect for a range of atmospheric ammonia concentrations at a variety of sites, starting with situations with medium to large concentrations for Pasadena (Fig R2.1, which is Figure 5 in the main manuscript), Bremen (Fig R2.2) and Toronto(Fig R2.3). Furthermore we added a figure showing the situation when there is not much

ammonia i.e. Wollongong (Fig R2.4). In the case of Pasadena the difference is only small with a few percent change in the concentrations of the individual layers. For Bremen the difference is larger near the surface, corresponding to the higher concentration levels. Especially near the surface the concentration change is high following the abrupt difference in the a priori shape, which does not have the sharp peak like the CrIS a priori. In the case of Toronto the effect is in the order of 10%, although concentrations around 750hPa, turn negative. In the Wollongong example the relative difference is large, as the retrieved concentrations are low. The large difference shows that a change of 1-2 ppb in the a priori shape and amplitude cannot be seen as a small enough difference to permit an a posteriori change. âĂČ

3. In any case, the authors need to look deeper into the possible effects of the DOFS on the bias.

We looked into the effects of the DOF, but decided to not put any further emphasis on it in the main manuscript. Essentially most (>80%) of the observations have a DOF between 0.9 – 1.1. From the remaining 20 % the larger number are above >0.7 leaving a small set of observations ($\sim$10%) with a DOF <0.7. Figure R2.5 shows a scatterplot similar to Figure 2 in the main manuscript but now with only observations with a DOF <0.9. As one can see there is no clear relation visible between the amount of scatter and the DOF. About 20% of the observations (N=45 in total) used for Figure 2 have a DOF < 0.9. Table R1(supplement) shows the mean difference and mean relative difference for the observations with a DOF<0.9. For comparability we added the full set of observations to the table, coloured in red. The observations with small DOFs usually are observations with a relatively low ammonia concentration. This makes that we can only really compare the lower range of total columns to our earlier results as there are only 6 observations with a total column > 10 x 1015 molecules cm-2. The observations smaller than > 10 x 1015 molecules cm-2 have a MD of 2.6 with a std of 4.1 which is comparable to the complete set with 3.3 (std = 4.1). Similarly the MRD is 33.0 %(std = 54.9%) which is also in the same range as the original set's 30.2% (std = 38.0%)).

A few outlying values are observed in Fig R2.5 which show more of a dependency to location than to DOF, as illustrated in Fig R2.6. All of the larger retrieved total columns (both FTIR and CrIS, >10 x 1015 molecules cm-2) are observations from the Toronto measurement site. As noted in the main manuscript the Toronto results are influenced by the local conditions, which increase the heterogeneity in the region. The site is located within the city, further away from the main sources surrounding the city. Furthermore Toronto is located at the edge of Lake Ontario, which increases the differences as for days with wind originating from the south one can expect clean air observed by the FTIR, where the satellite observes the emitted ammonia of the sources outside the city. Similarly for conditions with wind from the north one can expect

4. A second general comment is the error analysis which could be improved. The document either misses a general statement that all presented errors correspond with the 1-sigma standard deviation or it sometimes needs to be more specific when it uses the term 'error' as it sometimes relates to the standard deviation on the bias and sometimes on the bias itself. That said, 1-sigma standard deviations often tell little with regards to the statistical significance of an observed difference. For instance one claim made by the authors is that in the 0.5-1.0 e16 bin CrIS is significantly higher. This is likely to be true but from the article alone I cannot verify this. In Figure 4 the observed binned biases are shown with their standard deviations. A much better metric to show statistical significance would be the 95 or 99% confidence interval on the mean. This goes for all metrics where statistical significance is claimed or investigated.

Some parts are indeed confusing. We cleaned up the text and added a few sentences to clarify what error we are talking about. We define two types of errors, 1. Estimated errors: FTIR & CrIS retrieval & prior knowledge and 2. the actual errors i.e. the mean and mean relative differences that come out of the comparison. In the case of Figure 4, we edited the figure to include the 95 % confidence level as the number of observations were not included. Throughout the text we left it at standard deviation. Optionally one could calculate it directly from the standard deviation and the number of observations.

Line 296: edited caption, “total estimated error” Line 305: removed “significantly” Line 363, 365: added , N = 229) Line 365, 364: added “std =” in between brackets” Line 403: added “estimated” to “estimated error” Line 460: changed “bias” to “actual error” Line 538: added “estimated” Line 527, 529, 530, 531: added “std =” in between brackets Line 582: changed “bias” to “actual error” Caption Fig 4. Added “The number of observations in each set is shown in the bottom panel.”

Specific comments:

5. L155: A list of the dominant interfering species would be useful here

L155: Changed “i.e. interfering species” to “(i.e. major interfering species such as H2O, CO2, and O3)”

6. L165: A representation of the used collocation area would be useful in this figure.

Adjusted Figure 1 to include 2 circles with radii of 25 and 50 km. Added a second sentence to the caption of figure 1: “The two circles show the collocation area when for radii of 25 and 50 km.”

7. L305: show the error (be more specific= standard deviation is better)

L305: Added “total” to indicate it is not a standard deviation of the observations. The bars indicate the mean total error of the combined observations.

8. L319: Pasadena looks worse at elevated values

L319: Removed Pasadena.

9. L320: in, and low bias (“in” is obsolete)

L320: removed “in”

10. L465: red diamond -> red square

Changed “diamond” to “square in all bar plot figures.

11. L468: Summary of the errors. . . Could be interpreted as the uncertainty on the biases, not the actual absolute and relative bias.

Caption figure 7: Changed “summary of the errors” to “Summary of the absolute and relative bias”. L580: Caption Fig. A5. Similarly changed to “Summary of the absolute and relative bias”

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/amt-2017-38/amt-2017-38-AC2-supplement.pdf

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Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2017-38, 2017.

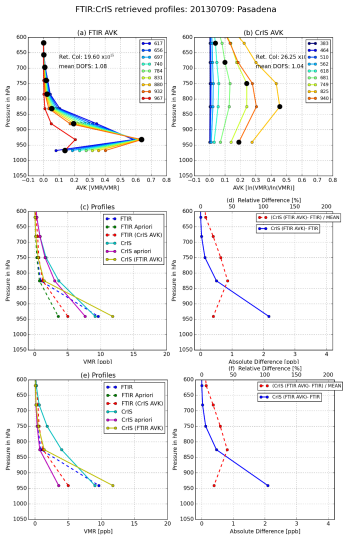

Fig. 1. Example of the effect of switching out the CrIS a priori for the FTIR a priori to the CrIS Retrieved profile, for an FTIR profile matched with a CrIS profile measured around the Pasadena site. For the

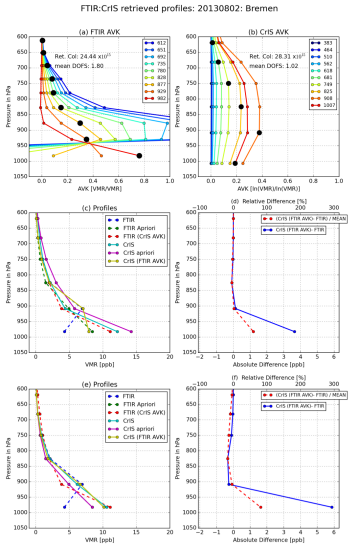

Fig. 2. Example of the effect of switching out the CrIS a priori for the FTIR a priori to the CrIS Retrieved profile, for an FTIR profile matched with a CrIS profile measured around the Bremen site. For the f

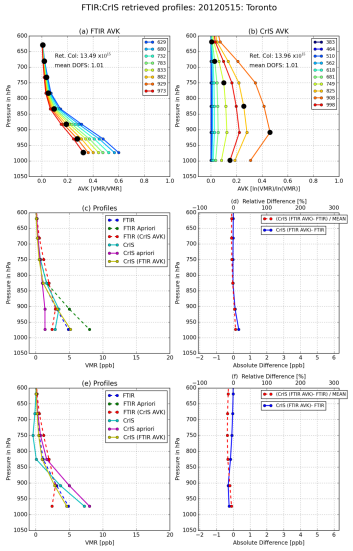

Fig. 3. Example of the effect of switching out the CrIS a priori for the FTIR a priori to the CrIS Retrieved profile, for an FTIR profile matched with a CrIS profile measured around the Toronto site. For the

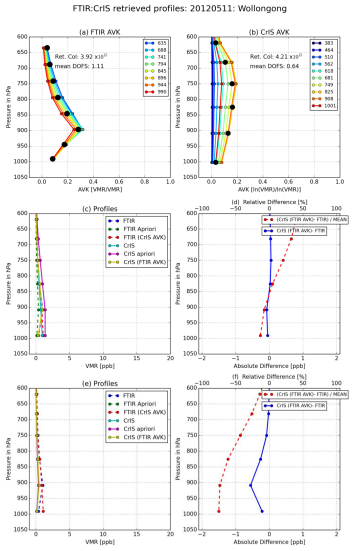

Fig. 4. Example of the effect of switching out the CrIS a priori for the FTIR a priori to the CrIS Retrieved profile, for an FTIR profile matched with a CrIS profile measured around the Wollongong site. For t

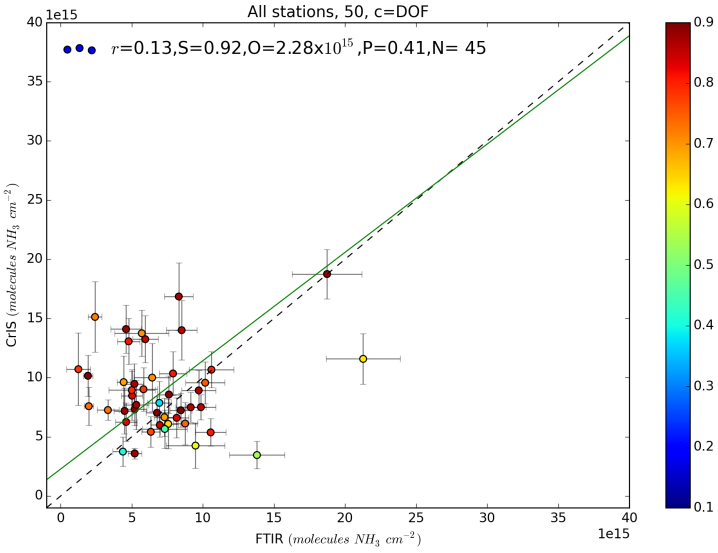

Fig. 5. Correlation between the FTIR and CrIS total columns using the coincident data from all measurement sites for all CrIS observations with a mean DOF < 0.9. The horizontal and vertical bars show the tota

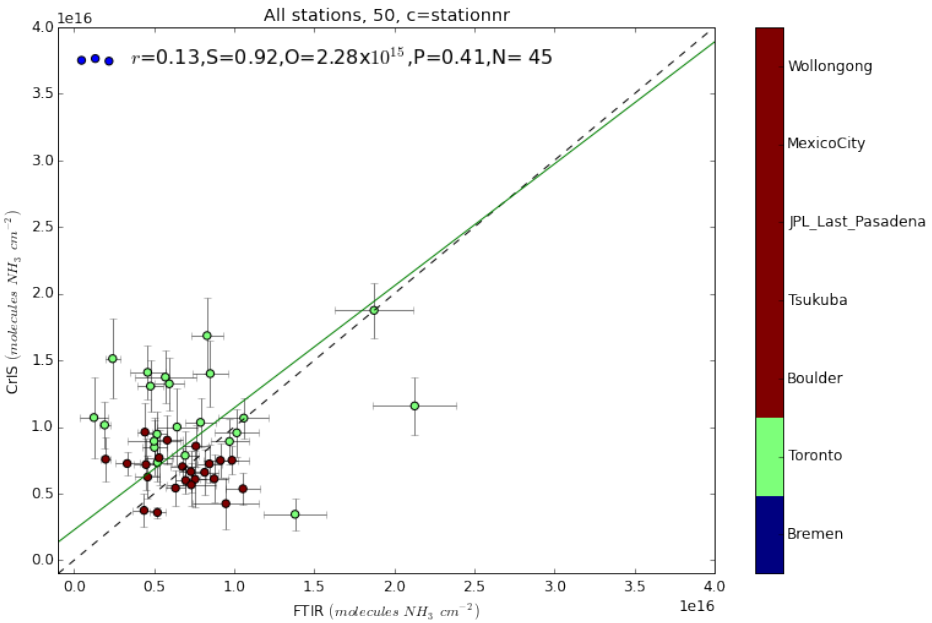

Fig. 6. Correlation between the FTIR and CrIS total columns using the coincident data from all measurement sites for all CrIS observations with a mean DOF < 0.9. The horizontal and vertical bars show the tota