Atmospheric
Measurement
Techniques

Open Access

EGU

Discussions

Interactive comment on "Methane cross-validation between three Fourier Transform Spectrometers: SCISAT ACE-FTS, GOSAT TANSO-FTS, and ground-based FTS measurements in the Canadian high Arctic" *by* G. Holl et al.

G. Holl et al.

kwalker@atmosp.physics.utoronto.ca

Received and published: 8 March 2016

1 Introduction

We thank the anonymous reviewer #1 for their feedback. Below, we include the comments indicated by the anonymous reviewer along with our response.

2 Anonymous Referee #1

Holl et al. provide a comprehensive account of measurement intercomparison between three remote sensing Fourier transform infrared spectrometers. Measurements of atmospheric methane from two satellite-based instruments and one ground-based instrument are cross-validated at one location in the Arctic. The authors investigate differences for profiles as well as for partial columns, taking into account the information content measured by each instrument.

The paper meticulously describes the methodology, drawing on previous work in the field. Writing style is clear and concise, and includes rigorous analysis and sound statistical interpretation. The subject matter is relevant to the scope of AMT. Subsequent to addressing or responding to the minor comments below, I recommend that the manuscript be accepted for publication in AMT.

We would like to thank Anonymous Referee #1 for their encouraging remarks about our manuscript.

Specific Comments:
Page 13202, Line 21: While it was the aim that MOPITT measure methane, there is no operational methane product, due to several radiance-based issues, some of which are described in Pfister et al. (2005).

We have removed the reference to MOPITT from the introduction.

Page 13203, Lines 23-26: I would like to see a bit more detail describing the coming sections rather than just "Results, Discussion, Conclusions".

Particularly, I think more specific details are needed about Sections 3, 4 and 5.

We have expanded the description of coming sections for sections 3 and 4. We do not think more detail is needed when referring to section 5 (conclusions).

Page 13204, Line 21: Discuss what pressure range is covered by the 47 levels. This will help prime the reader for the following sentences where selection of the pressure and temperature profiles is explained.

We added the pressure values to the article (91×10^3 to 8×10^{-3} Pa).

Page 13205, Lines 12-20: The vertical resolution of ACE is first described as 4km, but then later described as being retrieved on a 1 km altitude grid. How do these reconcile?

ACE profiles are retrieved on a higher vertical grid than the vertical resolution of the instrument, i.e. the retrieval is oversampled. We have added a note on this in the article, to avoid confusion.

Page 13208, Lines 22-24: It is unclear why a different spatial extent is used to compare ACE-FTS and TANSO-FTS instead of using the same radius around the PEARL-FTS station.

We chose a larger spatial extent for ACE/TANSO in order to get a larger sample size and better statistics. We have added the rationale to the text.

Page 13209, Line 11, and Line 18: Averaging kernels (AK) and a priori do not need to be interpolated because you smooth the interpolated higher resolution measurement with the lower resolution AK and a priori. This only requires interpolation of the higher resolution profile onto the lower resolution grid.

Averaging kernels and a priori information as we obtained them are not necessarily on the same vertical grid as the measurements themselves. Therefore, we do need to interpolate them before we can apply subsequent processing.

Page 13211, Line 7: I would argue that the coincidence error could still be important, but the error cannot be reduced by taking into account collocation distance.

Although we understand the point Reviewer #1 is making, we respectfully disagree. The coincidence error should be expected to get larger as distance and time difference increase, and smaller as they decrease, reducing to zero for the theoretical case where distance and time difference are zero. Therefore, if we reduce the distance and time difference but we do not observe a decrease in the error, then the error cannot be dominated by the coincidence error. We have rephrased the relevant text to make this point more clearly.

Section 2.7: It would be useful to mention within the partial column calculation methodology section at what point averaging kernels are applied. It seems as though sometimes they are smoothed (section 3.5) and other times not (e.g. Figure 5).

Smoothing is applied in any figure or table comparing two instruments. Figures 4 and 5 each look only at a single dataset, rather than at the differences between two

datasets. Therefore, smoothing is not relevant for Figures 4 and 5. We have added a note explaining this to Section 3.2 ("Vertical resolution and information content").

> *Page 13213, Line 14: Mention typical choices for f and c. Also mention that criteria for choosing f and c are shown later in section 3.2 and vary between instruments.*

At the end of the paragraph, we have added text to indicate typical choices, with a reference to Sect. 3.2 for specific criteria.

> *Page 13215, Lines 5 to 17: This methodology is not really about "choosing a closest profile". Rather, it is calculating a representative covariance matrix for several sets of retrievals, defined as likely to have an equivalent error covariance.*

This is true. We have adapted the description to describe a representative covariance matrix, rather than "closest profile".

> *Page 13224, Paragraph on lines 6-21: Can the comparison of V2.2 and V3.0 in Waymark et al. (2013) be used to lend any insight on whether the differences found relative to De Mazière et al. (2008) are expected?*

Waymark et al. (2013), Figure 2 contains comparisons between V2.2 and V3.0 for methane retrievals. However, this figure contains results from all latitudes. Therefore, it is difficult to gain insight from this for Arctic validation.

> *Table 2, Figure 17 cation, Page 13222, Line 15 and elsewhere: The altitude range for the comparison of PEARL-FTS and TANSO-FTS partial*

> *columns is defined at the lower boundary by TANSO to be 5.2 km according to page 13218 line 18. However, elsewhere in the discussion this lower boundary is 5.3 km.*

ACE-TANSO comparisons are down to 5.2 km, PEARL-TANSO comparisons are down to 5.3 km, as shown in Table 2. The difference between 5.2 km and 5.3 km in different collocation pairs is due to slightly different vertical grids, interpolation, and rounding. We have added a remark clarifying this at the end of Sect. 3.2.

> *Figure 1 Caption: Collocation is shown as 12 h of PEARL, but in the text on page 13208, line 8, the text says collocations are within 24 h.*

The collocation time in the caption of Figure 1 was erroneous. We have fixed this, 24 h is correct.

> *Figure 8: What causes the horizontal lines in the lower 10 km of the PEARL-FTS sPV plot?*

We are not sure why those horizontal lines appear in the left panel of Figure 8. Although it would be interesting to investigate the answer, we consider it is not required for the purpose of the present study.

> *Figure 17 and discussion on page 1322, Lines 15-17: There are 4 points which look to be outliers on this plot. Outliers can greatly influence linear regression. Was linear regression without the outliers performed to make sure these points do not have a major effect on the result?*

Although we are not convinced that the data points that deviate from the bulk are technically outliers (they might correspond to physically real situations), we have repeated the regression while removing any data points that deviate from the median by more than 5 times the median absolute deviation.

Figure 1 (shown at end of response) shows a repetition of Figure 17 from the manuscript, but with suspected outliers removed as described. The new prediction band lies slightly higher than the old one, but there is still considerable overlap between the two. Therefore, we conclude that those data points (which may or may not be outliers) do not significantly affect the regression. In the manuscript, we have replaced Figure 17 by the new figure and adapted the text accordingly.

> *Technical Corrections: The paper is well written and there are only minor technical corrections. Below are some suggested grammatical changes and areas to include additional information.*
> *Page 13200, Line 16: An additional collocation criterion*

Fixed.

> *Page 13201, Line 6: The phrase "expressed in absolute or relative terms" is indicated in the brackets, but I cannot see where any absolute terms are recorded within the bracketed values (e.g. -1.6 is not an absolute value)*

Right — what we meant was a proportional value (a percentage) and a value in methane units. Clarified that we mean partial column units vs. percentages instead.

> *Page 13201, Line 15: third largest contributing*

Fixed.

> *Page 13202, Line 7: process of verifying that*

Fixed.

> *Page 13203, Lines 11: A more appropriate term to use instead of "A special case of" may be "A sub-category of" or "One type of". Th subsequent sentences do not go into how occultation measurements are "special" compared to other types of limb measurements.*

Replaced "A special case" by "One type".

> *Page 13204, Line 16: The retrieval strategy*

Fixed.

> *Page 13204, Lines 21 and 24: I would clarify that "below 10 Pa" and "Above 10 Pa" means at altitudes above and below 10 Pa, because 100 Pa $>$ 10 Pa can also be interpreted as an "above" relationship.*

Fixed.

> *Page 13207, Line 7: Are the pressure level ranges of "94 to 56 Pa" meant to be pressure level width ranges?*

Fixed to read "94 kPa to 56 Pa".

> *Page 13210, Line 20: I would avoid using "He proposes" and instead use "They propose".*

The referred article has a single male author, so "He proposes" is grammatically correct.

> *Page 13211, Line 14: Explicitly state at which level sPV is investigated.*

Added.

> *Page 13216, Line 7: above in Section 2.*

Added.

> *Page 13219, Line 18: and implies that showing*

Fixed.

> *Page 13221, Line 6: It would be useful to make a reference to Figure 2, that shows TANSO-FTS contains almost no information above 15 km.*

Reference to Fig. 2 added.

> *Page 13221, Line 7: FTS tends to be very similar to TANSO-FTS*

Fixed.

> *Page 13221, Line 22: Change "0" to "zero"*

Fixed.

> *Page 13223: Some of the information in the sentence lines 3-5 is repeated on lines 6-8. I suggest consolidating these two sentences.*

Fixed.

> *Table 1 Caption, 4th sentence: There are two row headings including "primary" so indicate the "No. primary" row.*

Fixed.

> *Figure 6 and 7: The x-axis tickmarks and labels would be better in the middle of the bar-chart columns.*

We have redrawn Figures 6 and 7 with xticks shifted to the right by 0.05. The updated figures are included in the new version of the manuscript.

> *Figures 9, 11 and 13: Consider making the units of the x-axis ppbv to be consistent with Figures 10, 12 and 14*

We believe it is clear that ppm is parts per million and ppb is parts per billion. It is natural that differences are shown in a smaller unit than the total amount. The alternative would mean adding a 10^{-3} to the x-axis of Figures 9, 11, and 13 — we do not believe that would be a significant improvement over the current version.
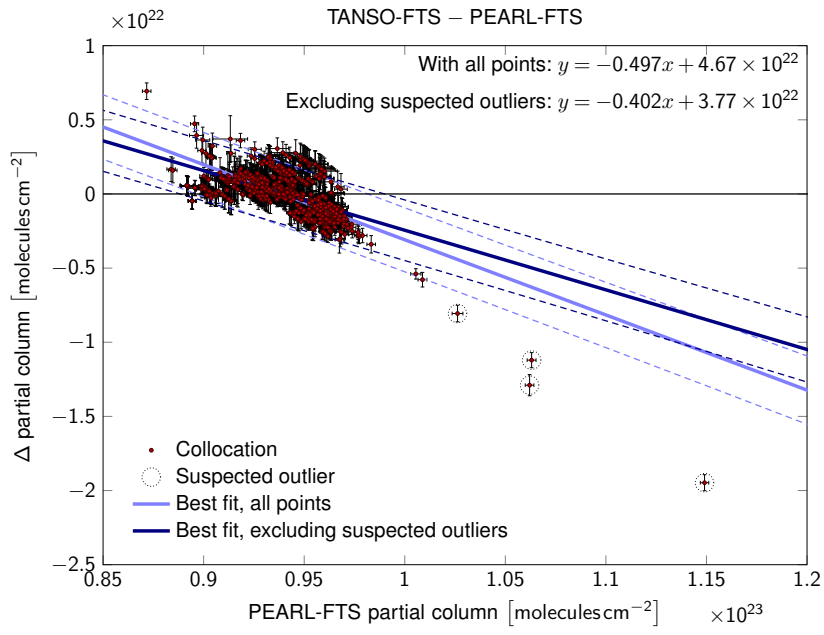
Fig. 1. Repetition of Figure 17 from the manuscript, but for the linear regression, excluding any data points that deviate from the median by more than 5 times the median absolute deviation.