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Atmospheric Measurement Techniques Discussions

Interactive comment on "Comparison of the GOSAT TANSO-FTS TIR CH_4 volume mixing ratio vertical profiles with those measured by ACE-FTS, ESA MIPAS, IMK-IAA MIPAS, and 16 NDACC stations" *by* Kevin S. Olsen et al.

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1 Anonymous Referee #1

1.1 General comments

> This paper describes a comparison of CH_4 profiles retrieved from the GOSAT TANSO-FTS TIR with measurements by ACE-FTS, ESA MIPAS, IMK-IAA MIPAS, and NDACC. Although this manuscript presents results

> that would be of interest to readers of AMT, I found some of the authors' explanations difficult to follow. Therefore, some revisions are needed before it can be accepted for publication.

We thank the reviewer for their careful review. We will address each specific comment and try to clarify our manuscript as well as possible. Our aim was to provide a clear and concise description of our methods and focus on our results, which we also believe are of interest to the community.

A complete list of changes is included as a supplement to this authors' response to anonymous referee #1.

1.2 Specific comments

1. p1, line14-15: "with and without smoothing" p9, line13: "To reduce biases caused by over-counting, when comparing TANSO-FTS to MIPAS, and by smoothing, when comparing TANSO-FTS to ACE-FTS,. . ." What is "smoothing" in this study? Please add a detailed description in Abstract and text to help the readers. Additionally, the authors should explain why they show correlation results based on both smoothed CH_4 profiles (Fig. 8) and unsmoothed CH_4 profiles (Fig. 9). What can we learn from this comparison?

Smoothing is a general term used to describe an operation that reduces the magnitude or frequency of fine-scale structure in a signal. When comparing two atmospheric remote sensing instruments with different vertical resolutions, the instrument with finer vertical resolution will have more fine-scale structure in its retrieved profiles. Likewise, an instruments whose retrieval has less of a dependence on the a priori may also have more fine-scale structure in its retrieved profiles. The instrument with lower vertical resolution or more dependence on the a priori will have retrieved vertical profiles that look "smoother." In order to compare the results of two instruments that are intrinsically different, we apply smoothing to that with finer resolution in order to account for these instrumental differences. Our objective is not to compare the results from two different instruments, but to ask, if one of our instruments had the same vertical resolution, information content, and dependence on the TANSO-FTS a priori, would the retrievals for that instrument agree with those from TANSO-FTS. The process, as described by Rodgers and Connor (2003), is standard practice when validating remote sensing vertical profiles of trace gas VMRs. The purpose of smoothing and the method used are described in Sect. 6.1. At the first mention of "smooth" in the abstract, the sentence has been extended to include a brief description of the purpose of smoothing. In the introduction, a few sentences were added to describe the need for smoothing and refer to Sect 6.1 for the method.

The reason we present results with and without smoothing is that a data user may not apply smoothing to the ACE-FTS, NDACC, or MIPAS results. The objective of validation is not necessarily to measure the magnitude of the differences between the two instruments' retrievals, but to do so in the context of the sensitivity and information content of the instrument being validated. These results may be of interest to data users, so they have been included.

2. p7, line13: "internal variability for each instrument" Due to insufficient description, I don't understand the meaning of "internal variability" in Sect. 3 and Fig. 1. Green lines (TANSO-FTS) in Fig. 1 show the difference between the GOSAT TANSO-FTS CH_4 retrievals and the a priori profiles. On the other hand, blue lines (MIPAS) are the difference between IMK-IAA MIPAS and ESA MIPAS. I don't understand how were the internal variabilities of ACE-FTS (p7, line25-33) and NDACC (p8, line9-15) evaluated. Does "the variability of NDACC data" mean the difference between NDACC CH_4 profile and TANSO-FTS CH_4 pro-

file? In addition, can the authors explain the reason why they were compared in the same figure despite a different definition?

Several changes have been made to the internal variability section to address your concerns. This study is not central to the paper, but we feel that it is important to provide context for the main results. The internal variability is the difference between measurements within each instruments data set, loosely defined (too much so, we agree). Due to the different measurement techniques (especially the data acquisition rate of ACE-FTS compared to TANSO-FTS and MIPAS), a single method to estimate this variability was not used. Furthermore, there were other calculations of interest to us, for instance, the IMK and ESA data products for MIPAS allow us to directly compare different retrievals made from the same observations, something we cannot with ACE-FTS or NDACC. The measurements compared in this study are made at different times and locations, sampling different air-masses, and are subject to noise, and considering the internal variability of each instrument addresses the magnitude of the effects caused by these differences. Several changes were made to make the purpose of this study clear and we have tried to eliminate our usage of the term "internal variability" since we are presenting different measurements. Changes were also made to the caption of Fig. 1 to reflect this.

The reason each variability profile is placed on the same figure is because they are to be qualitatively compared and we see no reason to unnecessarily create extra figures and paper length.

3. p8, line20-27: "coincidence criteria" There is a lack of explanation why the coincident criteria were set as "within 12 hours and within 500km" for ACE-FTS and NDACC and set as "within 3 hours and within 300km" for the MIPAS data. For example, did the authors examine latitudinal and longitudinal dependence of TANSO-FTS data within 500km or 300km? I would show the spatial variations of TANSO-FTS CH_4 in

the colocation circle at a particular height (the upper or middle troposphere). In addition, can the authors discuss the validity of their method by comparing the coincidences (e.g., statistics for match-upped data) in present study to those in the previous validation papers on the GOSAT data.

The coincidence criteria were used to try to optimize the number of coincidences with TANSO-FTS, increasing the small number of NDACC and ACE-FTS coincidences, and reducing the large number of MIPAS coincidences. Because MIPAS makes measurements much more frequently, we have the freedom to demand much tighter coincidences in space and time. At the beginning of Sect. 4, where "coincident criteria" is used, this is made explicitly clear with the statements: "Due the coverage and data collection rates of each instrument, different coincidence criteria were used. In the case of ACE-FTS, which only records two occultations per orbit, and NDACC stations, which are stationary, the objective of the coincidence criteria was to maximize the number of measurements used. Conversely, in the case of MIPAS, which makes frequent observations, the objective was to reduce the number of potential coincident measurements." Furthermore, we point out: "...for MIPAS–TANSO-FTS coincidences within 12 hours and 500km, we find approximately 180,000 coincidences per month."

The TANSO-FTS data are collected with a high frequency in a sweeping pattern along the satellite ground track. The high inclination of 98° provides a near-polar orbit. The result is high-density, near-global coverage, with more observations near the poles because the satellite ground tracks are more tightly spaced at higher latitudes. Reducing the spatial dependence of the coincidence criteria will have a different effect on each satellite. The impact will be larger on ACE-FTS because its measurements over the tropics are very sparse, but for ACE-FTS we used the wider criteria. A way to avoid this difference in sample sizes between the tropics and poles is to use a degrees-latitude criteria. The result is that over

the poles we are comparing measurements that are very close together, while those over the tropics may be separated by hundreds to thousands of kms, which would have a larger negative impact on our study.

The criteria used match other validation studies that use ACE-FTS, NDACC, and MIPAS data, and also the validation studies of CH_4 for each instrument. These are, however, far too numerous to list here. Coincidence criteria for primary CH_4 validation studies have been added to the text.

The reviewer asks whether we can compare coincidence statistics to previous validation papers on the GOSAT data. Only one previous validation paper on TANSO-FTS TIR data is in press: Saitoh et al. (2015) compares the CO_2 data product to aircraft measurements. They use very tight criteria (100 km and 2 hr) and consider only 140 coincident profiles. However, this study is not comparable with ours since the aircraft flights are in-situ measurements, rather than remote sensing, so a tighter coincident criteria is needed. The TANSO-FTS SWIR XCH_4 data product was validated by Inoue et al. (2014) that included the ACE-FTS instrument. However, they use climatological data, not coincidences.

4. p16, line31-34 "We also compared the differences shown in Fig. 10 to TANSO-FTS retrieval parameters: land or sea mask, sunglint flag, incident angle, both along the scan path and GOSAT track path, and observation mode (see Kuze et al., 2009). We found no biases in our coincident TANSO-FTS dataset related to any of these parameters, or whether the observation was made during night or day." Can the authors show the features of the GOSAT TANSO-FTS biases related to land or sea mask and the other parameters in the previous section (or in Appendix)? It is not appropriate to discuss these important points without showing here.

The reviewer asks us to show the features of the GOSAT TANSO-FTS biases related to land or sea mask." However, there were no biases to show. We understand the reviewers comment that it may be inappropriate to have mentioned investigating these quantities without explicitly showing the results. Our objective is to show due diligence on our part. We are not making strong statements about the effects of any of these quantities on the TANSO-FTS data, and that is not the purpose of this paper. We feel that it may be detrimental to our manuscript to include several more figures and significantly increase its length, while not significantly adding to the conclusions of our work. An appendix may be created showing the relationships of our results to the ancillary data in the GOSAT data files (eight additional figures) at the discretion of the editor.

1.3 Minor revisions

1. p4, line32: “the Halogen Occultation Experiment” âĂŤ> “the Halogen Occultation Experiment (HALOE)”

change made, thank you

2. p7, line38: “the IMK-IAA data has” âĂŤ> “the IMK-IAA data have”

changed “has” to “have” for the plural of “data”

3. p12, line23: “have a much smaller affect on” âĂŤ> “have a much smaller effect on”?

this is certainly a case where the noun “effect” is correct

4. p15, line34: The Pearson correlation coefficient R2 of NDACC (0.9929) is different from that shown in Fig. 8.

thank you, this is a typo. The figure is correct, R^2 is computed during the generation of the figure. We also changed the order of the list to match the order of the panels of the figure

5. p19, line13: Please update information on Bader et al., 2016, ACPD.

updated the reference.

6. p19, line10: in reference list of Côté et al. (1998), “formulations” âĂŤ> “formulation”

corrected the typo in the title

7. p20, line19: Please update information on Errera et al., 2016, AMTD.

updated the reference

8. p21, line33: in reference list of Picone et al. (2002), “1486” → “1468”

changed the page number from 1486 to 1468

9. p21, line11: in reference list of Raspollini et al. (2014), “Annal. Geophys.,” → “Ann. Geophys.,”

corrected the journal abbreviation

10. p28: a legend of Fig. 2, “NDDAC” → “NDACC”

corrected the typo. Similar to the next two items, axis labels indicating cardinal direction are missing from manuscript version downloaded from the AMTD website

11. p34: In Figs. 8 and 9, “x” of “y = mx+b” is not printed. In addition, “R” of “R2” is not printed.

during the technical review of this manuscript, this problem was mentioned. However, this issue did not exist on our copies of the submitted manuscript. We have downloaded copies from the AMTD website, and, sure enough, characters have been stripped from the figure. This is not an issue we can change, but will have a special note to the editors upon re-submission and ensure that the correct figure ends up in the compiled document. Thank you for pointing this out

12. p35: In Fig. 10, the unit of “Latitude” is not printed.

similar as for Fig. 9, the degree symbol appears in our submitted manuscript and figure files. We will discuss with the editors and ensure this symbol appears in a future version

Please also note the supplement to this comment:
https://www.atmos-meas-tech-discuss.net/amt-2017-6/amt-2017-6-AC1-supplement.pdf

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Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2017-6, 2017.