

## Reply

To the review #2 of Gavrilov et al: Comparisons of CH<sub>4</sub> satellite GOSAT and ground-based FTIR measurements near Saint-Petersburg (59.9\_N, 29.8\_E), October 2, 2013

**First of all, we greatly appreciate the referee's helpful comments and suggestions. We thank the referee for the time to improve our manuscript. We have carefully considered the referee's comments and will correct our manuscript as much as possible in the revised version. The following are our responses to the referee's comments (given below in bold font):**

The manuscript presented by Gavrilov et al. discusses comparisons of retrievals from ground-based mid infrared (MIR) Fourier transform spectra using solar absorption spectroscopy, with those retrieved from the space-based instrument, GOSAT. The main conclusion seems to be that the ground-based data from the Saint-Petersburg (Peterhof) site "could" agree with the GOSAT data. The manuscript introduces a site that could potentially provide interesting information for satellite validation, especially for methane. It does, however, seem to be undecided somewhat as to its focus. To be published in AMT, the "measurement technique" should be clearer - if the goal is to introduce the site (which I think would be sufficient and interesting for AMT), then this should be addressed in the abstract and title. Otherwise, there is nothing particularly novel about what is presented compared to other stations making NDACC style measurements. I could envisage the paper being published in AMT with a more clearly expressed scientific aim and emphasis on what about this study and/or site is novel.

**Indeed, one of goals of our paper is not "introduction", but "validation" of Saint-Petersburg measurement site. It is one of a very few sites of ground-based FTIR measurements in Russia, located at higher latitudes than most NDACC and TCCON stations, near megalopolis and seems to be important for scientific community. Unfortunately, we have no possibilities to move our devices to other places for comparisons and have no aircrafts for validation of our measurements. At present, the GOSAT data seem to be better validated than Saint-Petersburg ground-based measurements. Our paper is an experience to use satellite data for validation of unknown ground-based measurements. We do not know about other such experiences, at least for atmospheric CH<sub>4</sub>. This could be a technical novelty of our studies. We emphasized these statements in the paper. And changed the title and abstract.**

## General Comments

- As discussed above, I feel that the paper lacks a clear focus and novelty. This needs to be clarified. – **See our answer above.**

- There is a considerable amount of discussion and presentation of the differences between the satellite and ground-based X<sub>CH<sub>4</sub></sub> values that reads largely like a review of previous work. I feel that the value of your site could be examined in more detail by assessing something like inter-algorithm differences (from the GOSAT retrievals).–**We think, the value of our site**

**is more in its location than in inter-algorithm differences. Most of used algorithms are standard.**

- I'm missing a reference in your discussion to Sussmann et al, 2013 - regarding comparisons between MIR and NIR  $X_{CH_4}$  retrievals - something that is especially relevant considering previous published GOSAT comparisons focus on TCCON NIR data and you are presenting retrievals from the MIR. I realise you cite this paper in the introduction, but you never describe what it means for your work. - **The discussion to Sussmann et al, 2013 is extended (see close to "Conclusion").**

- In fact, the whole GOSAT validation literature review seems to have recent work simply appended to a previously written section referring to GOSAT V01.xx. While it is interesting to know what has changed between V01.xx and V02.xx at your site, and you should refer to how these differences compare to the rest of the globe (or at TCCON sites), I feel that the focus should be on the latest (and presumably best) product.

- **When we started our study, there were no publications about validations of GOSAT version V02.xx data. Therefore, we made analysis of GOSAT data V01.xx as well. We decided to keep this analysis, making its discussion shorter.**

- p7042, l9: "could agree" - this seems to be quite a weak conclusion of the work. What is perhaps more interesting is not whether or not they agree, but rather whether or not they can add additional value for GOSAT calibration or validation. The manuscript would be strengthened by taking this focus. It would require more assessment of the potential differences between Saint Petersburg and other sites currently used for GOSAT validation. - **We have no plans to improve GOSAT calibration and validation. We are more interested in validations (direct and indirect) of Saint-Petersburg measurements against other observational data. We emphasized the conclusion.**

- I would also like to see comparison of the Saint Petersburg measurements to model simulations, though I could be convinced that this is indeed outside the scope of the paper and leave this up to the editor to pass judgment. - **We think that comparisons of Saint-Petersburg measurements to model simulations are out the scope of this paper. Such comparisons were published for different gas species obtained with ground-based spectroscopic measurements near St. Petersburg (e.g. Makarova et al., Izvestiya, Atmospheric and Oceanic Physics, 2011, Vol. 47, No. 4, pp. 468-479; Makarova et al. Izvestiya, Atmospheric and Oceanic Physics, 2007, Vol. 43, No. 4, pp. 497-504). For  $CH_4$  such comparisons are making now and will be published later.**

- While the paper reads generally quite well, there are still some minor English language problems. I have endeavoured to highlight these in the technical comments, but a final proof-read by a native speaker would probably still be useful.

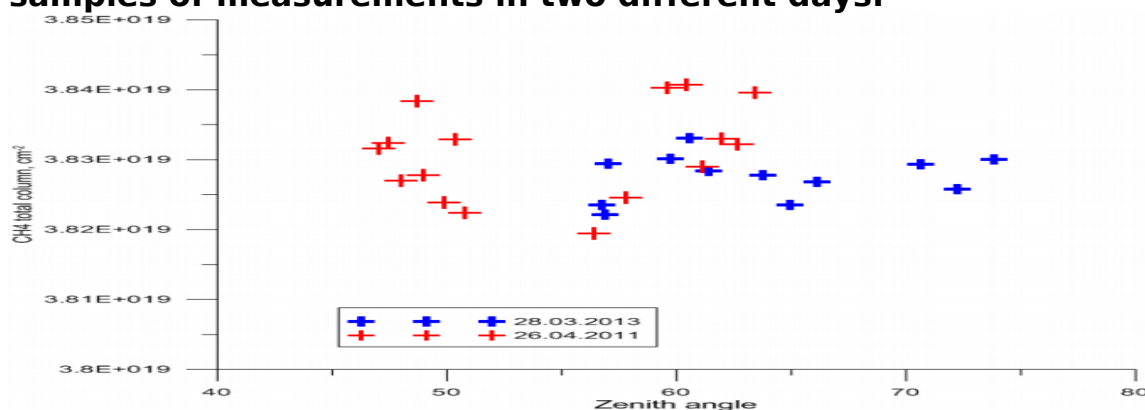
**The final version of the paper was corrected by a professional translator.**

## Technical Comments

- The title needs rewording. Something more like "Comparisons of CH<sub>4</sub> measurements from GOSAT and ground-based FTIR near Saint Petersburg (59.9N, 29.8E)" would sound better. Alternatively, to bring the focus on to the measurements described here, you could phrase it "CH<sub>4</sub> measurements near Saint Petersburg from a ground-based FTIR, and their comparison to GOSAT". – **The title is changed.**
- p7042, l5: "-13ppb less" - this is a tautology. Lose the minus sign. – **Corrected.**
- p7042, Intro: Numerous instances where acronyms need to be defined at their first use, rather than later. – **Corrected.**
- p7043, l2-3: the parties responsible for GOSAT also include the Japanese 'Ministry of the Environment' (MOE). – **Added.**
- p7043, l5: should also mention that these are 'dry-air' column average mole fractions. – **Mentioned.**
- p7043-7044, TCCON-GOSAT comparisons: this is an incomplete list of comparisons. The discussion later is much more detailed, and publications such as Butz, Schepers, etc. should also be mentioned here. – **The references are added.**
- p7044, l9: should mention that the NIES-GOSAT product is compared, otherwise it could be from any (or all) of the algorithms. – **Corrected.**
- p7044, l19: delete the before optical path differences. – **Corrected.**
- p7044, l20: "times of accumulation"? I assume you mean collection times. But in truth, I do not understand what you are adjusting here. Or is the sample rate simply chosen so that a single spectrum with 10 co-adds is collected in 12 minutes? – **Corrected.**
- p7044, l22: PROFFIT, not PFOFIT. Also, GFIT is not exclusively for TCCON - it can and does also do some MIR retrievals for NDACC. – **Corrected**
- p7044, l23: interpreting → interpretation (or better still would be a description of what the algorithms do - i.e. that they retrieve atmospheric column gas abundances via fitting the spectra...) – **Corrected.**
- p7044, l27: again, remove 'the' at the end of this line – **Corrected.**
- p7045, l4: consequent → subsequent? – **Corrected.**
- p7045, l8: Peterhof → Peterhof's – **Corrected.**
- p7045, l10: retrieving → retrieval – **Corrected.**
- p7045, l10-11: rearrange to "...are taken from Voejkovo, the nearest site of upper air soundings located 50km eastward of Peterhof" – **Corrected.**
- p7045, l13: at → by – **Corrected.**
- p7045, l19: "a long time" sounds strange to me. Maybe say "that have been recommended in the NDACC documentation for many years". A reference to back that up would be nice, however. Also here it should be mentioned that two of the microwindows used are shared between the Sussmann and Sepulveda approaches. – **Corrected.**
- p7045, l21: According to → Following – **Corrected.**

•p7045, l28: 'spectra series'? What does this mean? Also, it would be nice to see some evidence for your statement that variations do not generally exceed 1%. Perhaps a figure focussing on a short time series of retrievals.

**We removed “spectra series”). Below is a figure with two samples of measurements in two different days.**



**In the first day (blue crosses) daily variations are within 0.25%, in the second case (red crosses) the variations do not exceed 0.5%.**

•p7046, l10-13: either a formula or a reference for how the adjustment to dry-air would inspire confidence. – **In fact, we did not “adjust”, but calculated dry-air  $X_{CH_4}$  using standard formulae. We changed the text accordingly.**

•p7046, l13: "European Centre" is redundant (the EC from ECMWF stands for European Centre'). – **Corrected.**

•p7046, l15-17: Have you considered trying to obtain co-incidences using a dynamic tracer, such as potential temperature? Or increasing matches by requesting additional processing of GOSAT spectra by NIES? – **Not yet.**

**Thanks for the idea.**

•p7046, l23/Table 1: Table 1 should include the number of spectra (both GOSAT and ground-based) within each day, and shortly define that your differences are GOSAT - ground-based. – **The numbers of spectra are added to Tables 1 and 2.**

•p7047, first paragraph: I find it interesting that the GOSAT retrievals (V02.xx) show less variability than the ground-based retrievals. In fact, there seems to be minimal temporal variability in the GOSAT values over the whole time series. On the other hand, the ground-based (SPB) retrievals have several days with extremely low  $X_{CH_4}$ , like 2010-04. Have you investigated whether there are any prevailing conditions or reasons for this? While the long-term variability in the GOSAT data seems smaller, Figure 2 seems to suggest that in 2010 and 2012 the GOSAT scatter is at least as large as that from the SPB data. Have you thought about including some measure of shorter-term 'reproducibility', such as daily or weekly standard deviations? – **Thanks for interesting questions. We also all the time think about them. For other gases we observed dependences of their contents on the directions of wind, forest fires, etc (see, for example, papers by Makarova et al. mentioned previously). For CH<sub>4</sub> we also sometimes obtain dependences on meteorological conditions. At present, numbers of CH<sub>4</sub> measurements are not enough to make definite and reliable conclusions. We are going to continue these studies.**

- p7047, l9: How does the variability compare to desired figures necessary for satellite validation? - **It is difficult to say. In fact, satellite validation is not the main goal of our paper.**
- p7047, l27: respective →with respect (or relative) - **Corrected.**
- p7048, l6: ground-based is missing the final 'd' - **Corrected.**
- p7048, first paragraph of discussion: The argument for compatability of SPB with TCCON is somewhat weak. How does TCCON relate to the aircraft measurements to which you refer? - **Corrected.**
- p7049, l6: fraction →fractions - **Corrected.**
- p7049, l13: There should be a 'The' at the start of the sentence. - **Corrected.**
- p7049, l20: emission →emissions - **Corrected.**
- p7049, l17-23: given that local urban emissions could contribute 2% enhancement to the column, it's surprising that there seem to be unusual low days. Also, have you tried filtering for the data that are inuenced by local emissions (by wind direction or enhancements in other gases)? - **Peterhof is located not in the middle of the town, therefore, we may have clean air, depending on wind directions. This was analyzed in other our studies. Here we compare entire sets of the data without filtering.**
- p7049, l24-27: an order of magnitude is pretty large. How much do the biases vary when using different co-location criteria? How are the number of coincidences affected? - **Description of biases dependence on co-location criteria is extended.**

Yours sincerely.

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