Interactive comment on "Improvement of the retrieval algorithm for GOSAT SWIR XCO2 and XCH4 and their validation using TCCON data" by Y. Yoshida et al.

Anonymous Referee #1

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The paper "Improvement of the retrieval algorithm for GOSAT SWIR XCO2 and XCH4 and their validation using TCCON data" of Yoshida et al., submitted for publication in AMT, covers an important topic highly relevant for AMT. The paper is very well written, with good Figures and Tables, and contains important and interesting new material not published so far. I strongly recommend publication after the (mostly) minor items listed below have been addressed by the authors.
First of all I would like to congratulate the authors for this manuscript which documents the significant progress which has been made concerning improvements of the official retrieval algorithm of GOSAT. I am confident that this paper is a key reference for user of GOSAT data products.

> => Thank you for your careful reading of our paper and providing constructive comments. The followings are our reply to your comments. The revised part is marked with "double line (~~—~~: removed)" or "under bar (___: added)".

My main point is the following: The abstract lists the mean systematic biases relative to TCCON. While it is good to know that also this error has been improved, it is not of critical importance for the surface flux inverse modeling applications, as constant biases can relatively easily be accounted for. What is more critical are regional biases. This is not mentioned in the abstract but in the text on page 963 line 10 and following. There is it mentioned that a "relative regional-scale accuracy" of 1.05 ppm has been achieved for XCO2 and 6.8 ppb for XCH4. This should be highlighted in the abstract as this is directly related to GOSAT requirement of 1% relative accuracy. Seems this requirement has been met with the described version of the L2 products. If yes, this should be mentioned in the paper including a more detailed discussion. I also recommend to shown in Table 2 which numbers result from computing the standard deviation of the biases at the various TCCON sites as an estimate of relative accuracy. The mean bias is reported in that table but not the standard deviation, which I think is more important. In this context it would also be important to discuss the validation results in the context of publications describing similar efforts but using other algorithms. Do the various algorithms / products agree or not? This needs to be discussed.

> => We added averages and standard deviations of the mean station bias in Table 2 and Table 1 in supplement.
> Although TCCON data is most important to validate satellite data, its coverage is limited. We added Eureka and Karlsruhe TCCON sites in our comparison. Additional comparison using aircraft data (Inoue et al., 2013), other satellite data, model data, etc. is needed to evaluate the global accuracy of GOSAT data. It might be a rush decision to conclude the achievement of GOSAT requirement at this time.
> Since each publication used different coincidence criteria, observation period, and number of TCCON sites, publication-based comparison is unfavorable. Algorithm intercomparison over TCCON sites with common criteria was already done by Oshchepkov et al. (2013) and beyond of the scope of this paper. At least, various algorithms agree over TCCON sites.

Concerning Table 2: Please add if the averages have been obtained by weighting with N or not. Please also explain why the Ns are different for the same TCCON site when different versions of the TCCON data have been used for comparison.

> => As mentioned above, we added the average of the mean station bias (no-weighing with N).

Therefore, we didn't add additional explanation about N-weighting.
The number of TCCON data depends on its quality control. In GGG2012, the a priori profiles, spectroscopy, and solar model/linelist were updated, and site-to-site consistency became better. It is reasonable to change the number of retrieved data according to the retrieval algorithm update, therefore, no comments were added.

Page 954, line 17: “are therefore” -> “is therefore”.

=> Done.

Page 957, line 5-6: “and we assumed there to be no-aerosols”. Please replace by, e.g., “and we assumed aerosol free conditions for these scenarios” (or equivalent).

=> Done.

Page 958, line 17: Please quantify “small changes in the viewing angle”.

=> We quantified the pointing anomaly as follows.

The pointing anomaly was corrected by shifting the pointing angle and this made small changes in the viewing angle (~0.5 deg. for along-track direction and ~0.3 deg. for cross-track direction) and, as a result, the airmass value (~0.01).

Eq. (3): Are “ao, a1, and a2” three constant values ? If yes please report the numbers.

=> We added following table.

Table. Empirical noise coefficients. The coefficients of each spectral window were preliminary evaluated from the relationships between SNR and the mean-squared values of the residual spectra. For details, see text in Section 3.2.

		a_0	a_1	a_2
O_2 sub-band	land, Gain H	1.095	-9.616×10^{-5}	1.246×10^{-5}
	land, Gain M	0.8903	3.925×10^{-3}	2.633×10^{-6}
	ocean	1.027	1.137×10^{-3}	1.096×10^{-5}
CO_2 sub-band	land, Gain H	1.163	-6.922×10^{-4}	8.207×10^{-6}
	land, Gain M	0.8956	9.440×10^{-4}	5.801×10^{-6}
	ocean	1.064	4.094×10^{-4}	9.595×10^{-6}
CH_4 sub-band	land, Gain H	1.115	-1.003×10^{-3}	8.121×10^{-6}
	land, Gain M	1.240	-1.844×10^{-3}	8.871×10^{-6}
	ocean	0.986	2.413×10^{-4}	1.163×10^{-5}
SCO_2 sub-band	land, Gain H	0.995	3.151×10^{-4}	1.505×10^{-5}
	land, Gain M	0.393	3.193×10^{-3}	1.302×10^{-5}
	ocean	0.912	8.419×10^{-4}	1.875×10^{-5}

Page 961, line 8-9: Replace “does not refer the sun-glint flag” by “does not use the sun-glint flag” or equivalent.

=> Done.

Page 961, line 25: “strictest : : : filter is the AOD”: What about cirrus ?

=> As written in Section 3 (p.958, l.8), we selected the cloud-free measurements and retrieved under the assumption of cloud-free atmosphere. Therefore, cirrus affects the pre-screening result, not the post-screening result. The fraction of pre-screened measurements is roughly consistent with the clear-sky occurrence (p.961, l.12).
We applied three cloud detection methods: (i) TANSO-CAI cloud flag test, (ii) TANSO-CAI spatial coherence test only over ocean, and (iii) TANSO-FTS 2-μm-band test to detect elevated clouds (Yoshida et al. 2011). Note that we don't distinguish cirrus from other cloud types. The TANSO-CAI cloud flag test categorizes ~80% of measurements as cloudy, while the TANSO-FTS 2-μm-band test categorizes ~40%.

Page 962, line 10: “other month” -> “other months”.

=> Done.

Page 962, line 12: Please add “CO2 emissions due to” before “fossil fuel consumption”.

=> According to the comment by Referee #2, we removed this sentence.

Page 964, line 22: “in cloud-free scenes” -> “for cloud-free scenes”.

=> Done.

Page 965: “there still remain the : : : differences” -> “Differences due to : : : still remain” or so.

=> Done.

Page 965, line 6: “More : : : analysis : : : is needed”

=> Done.

Page 965, line 13: “Ha Tran”? Please check.

=> It is correct. Dr. Ha Tran provided the code.