**Atmospheric
Measurement
Techniques
Discussions**

Interactive comment on "CH$_4$, CO, and H$_2$O spectroscopy for the Sentinel-5 Precursor mission: an assessment with the Total Carbon Column Observing Network measurements" *by* A. Galli et al.

Anonymous Referee #1

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This manuscript presents a simulation-based analysis of the effects of spectroscopic uncertainties on SWIR-based retrievals of CO and methane, in preparation for the future TROPOMI instrument. The topic of this work is certainly appropriate for AMT, and it is critical to perform studies such as this one before actually designing and building a new instrument. The paper is fairly well written overall, and I found the Conclusion section especially clear. As described below, however, there are two specific areas which I feel are relatively weak and should be revised. In addition, I have listed a number of minor comments which I feel should be addressed.

C655

Major Revisions

1. To quantify retrieval errors due to spectroscopy, simulated retrievals are compared to 'reference retrievals' produced with the GFIT package. Ideally, simulated retrievals (using the authors' retrieval algorithm) and GFIT-based retrievals would be identical for retrievals based on the same spectral range and resolution. Such tests were performed and are reported in Sec. 2.4. For CO, algorithm-related differences (biases and standard deviations) are on the order of a few percent. This seems acceptable, given that the natural variability of CO is much larger (CO concentrations can vary by a factor of two or more). However, for methane, the algorithm-related retrieval differences are up to 0.26% (the reported standard deviation at Park Falls). Since the natural variability of methane is only a few percent, this algorithm error seems very large, and will limit the interpretation of spectroscopic errors. The authors' statement on this matter that 'The small differences between our algorithm and GFIT may be explained by differences in averaging kernels and a priori profile for CH4 , CO, and H2O (smoothing and interference errors), and diferences in the H2O line list' is not supported by any analysis and therefore seems speculative. This part of the paper should be supported by stronger analysis, more conclusive evidence regarding the source of the differences, and should include comparisons of the a priori and averaging kernels for the two types of retrieval algorithms. 2. As discussed in Sec. 2.5, three statistics are employed to quantify how much retrieval performance is degraded by reduced spectral resolution. These statistics, presented in Tables 2 and 3, include the chi-square, standard deviation, and bias. The authors should also present the correlation coefficient as another important measure of retrieval performance. This statistic should also be presented and discussed for the analysis in the second paragraph of Sec. 3.1 (and shown in Fig. 7). The 'correlation strength' is mentioned in the fifth paragraph of Sec. 3.2 (i.e., the paragraph that starts with 'The CO bias would be ...',) but is not actually presented; the value should be given.

Minor Comments

p. 2133, Abstract - Retrievals based on ground-based measurements are fundamentally different from satellite-based retrievals. Please justify the use of simulations of ground-based retrievals to the design of a satellite instrument. For example, are ground-based and satellite-based retrievals equally sensitive to spectroscopic errors? Is this an implicit assumption?

p. 2134, Introduction - Please define spectral ranges corresponding to near-infrared and short-wave infrared.

p. 2134, l. 15. Suggest adding 'polar-orbiting' before ' ... series of satellites that monitor CH4 and CO ...'

p. 2134, l. 26. 'observations' should be singular.

p. 2135, l. 4. 'CO total columns ...' should be 'CO total columns and vertical profiles ...'

p. 2135, last paragraph. In discussion of SWIR-based products, mention than TIR-based products typically exhibit poor sensitivity to CO in the lower troposphere.

p. 2137, l. 15. Some discussion about the relative effects of scattering for TCCON-type ground-based retrievals and satellite-based retrievals would be helpful. Scattering from aerosols is a significant source of error for SWIR-based satellite retrievals of methane (and CO2), as shown by work done for the SCIAMACHY and GOSAT instruments.

p. 2139, l. 8. What would be the potential benefit (decreased residual) for retrieving CO and H2O as profiles, as is done for methane?

p. 2139, l. 11. What do the authors consider 'a meaningful profile'? DFS greater than 1, 2, 3 ...?

p. 2139, l. 21. How is the value of gamma determined? What is the value?

p. 2140, l. 9. Please include a brief description (one sentence) about the type of retrieval algorithm used in GFIT.

C657

p. 2140, l. 15. The statement that 'Similarly, the accuracy of retrieved CO columns from the 4209–4319 cm−1 spectral range by GFIT has also been conïñA̧rmed by validation with aircraft measurements' should include a supporting reference.

p. 2140, l. 22. What are the expected effects (on the retrieval results) of discarding window 1? Does this have any effect on the retrieval averaging kernels?

p. 2141, l. 8. The phrase 'consistent with' is not precise; what are the typical reported retrieval uncertainties for GFIT?

p. 2143, l. 16. Figure 7 appears out of sequence; shouldn't this be Figure 1?

p. 2143, l. 25. The meanings of 'pressure' and 'total pressure' in this paragraph (and the following two paragraphs on p. 2144) are not clear. Should both of these terms be replaced with 'surface pressure'?