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Atmospheric Measurement Techniques Discussions

Interactive comment on "A study of synthetic $^{13}CH_4$ retrievals from TROPOMI and Sentinel 5/UVNS Part 1: non scattering atmosphere" *by* Edward Malina et al.

Anonymous Referee #1

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This manuscript by Malina at al. examines whether S5P/TROPOMI and S5 can retrieve 13CH4 with sufficient precision to differentiate CH4 source contributions. Carbon isotope measurement in CH4 could provide useful information on the atmospheric CH4 budget and the changing CH4 sources/sinks that are not fully understood. Therefore, data availability of 13CH4 measurements are highly anticipated but challenging for carbon cycle science community.

The information Content (IC) analysis approach in the study is similar to the one presented by Malina et al. (ATM, 2018) for GOSAT-2. Both are feasibility tests to these new/future satellites. Both studies applied IC analysis to the synthetic measurements,

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assuming clear sky condition (non scattering atmosphere). One of the main differences between GOSAT-2 and S5P/S5 is resolution due the different spectrometers (resolutions), FTS (0.2 cm-1) and push broom spectrometer (0.45 cm-1).

The paper would be interesting for the readers of Atmospheric Measurement Techniques, in particular for those studying GHG from the space. This kind of feasibility test is essential before handling real data and contribute to exploring the possibilities in coming satellites. However, the paper needs to be improved. There are missing information and editorial errors (missing words, incomplete sentences, and so on), and inconsistencies with figures. Some figures are not clear.

The paper potentially contributes to the GHG community. However, at this stage, I recommend major modification for further consideration.

Major comments

Overall, the manuscript has a lack of information and consistency in figures. Please check the figures (including captions) and descriptions in the main text. Figures should be self-descriptive. Also, the figure legends should not overlap/distract the plots (see more in the specific comments).

In Introduction, the authors said ‘the key questions becomes whether SNR or spectral resolutions is the key limiting factor in the retrieval of methane isotopologues”. At the end of Sect. 4.5, the authors conclude that "SNR is more important... than spectral resolution". However, this comes from the comparison between SWIR1 and SWIR3. SWIR1 has higher SNR than SWIR3, but they both have the same spectral resolution, which is lower than GOSAT-2. Before the conclusion, a discussion on spectral resolution vs SNR should be given.

Definition of latitude bands (low-latitude, mid-latitude and, high-latitude) should be given before the results are presented (from Section 3 onward). Alternatively, specific regions should be referred to. Otherwise, readers might be lost. For example, in low-

and mid-latitudes, the regional differences (between desert areas and non-temperate areas, inland and islands, etc) are more evident than the latitudinal characteristics.

Specific comments

- Page 7, L4 'This paper builds on this study'. These two "this" must refer to different studies. Please rephrase this sentence.

- Page 9, L7: "The spectral fit quality is good, with a chi-square value equal to 1". How was the chi-square value of 1 derived? Fig. 1 reads chi-square of 1.15, not 1.

- Page 10, L1: "disagree with the 'truth', notably the methane lines at 1670 nm". However, no such disagreement is seen in the top panel in Fig. 1.

- Page 10 L3: Please specify more of "complex behaviour" about the cause of difference?

- Figure 1: Caption reads "-1.4S, -47.81W for a day in January 2015". However the middle panel shows "Measured, 16/7/2015, 51.63 39.39". They should be consistent. No right-hand scale in the bottom panel, which is mentioned in the caption.

- Figure 2: Overlapped legends are destructive. Please move them outside the panels (same for Figs. 8 and 12). Four colours indicate different regions, but it is hard to distinguish them. It would be more informative if the legends include the representing regions (not only latitude-longitude information).

- Figure 3: To see the overall performance, it would be helpful to have a total number of the measurement (before measurements with DFS (<1) have been filtered out).

- Page 11, L15: 'almost 3000 additional valid retrievals, which is roughly 30% of the ensemble'? This statement is not clear. What do the authors mean by "3000 additional"?

- Figure 4: 'lobal' should be 'Global'?

- Page 12, L11: what 'show'? The subject of the sentence is missing.

- Page 12, L13: the last sentence seems incomplete.

- Table 3: The units should be given for 13CH4 and d13C intercept and sigma, separately (same for Table 4).

- Figures 5, 6 and 11: Please give the units for x-axis and y-axis. Also, for Figs 5 and 6, please describe in the caption which parameters perturbed are.

- Figure 6: Is the caption correct?

- Page 16, L29: ILSF should be spelled out.

- Page 22, L4: SWIR3 should be SWIR1?

- Page 23, L1: “Radiometric offset errors are not significant in the SWIR3 as opposed to the SWIR1 band’. More explanation and possible reasons for or discussion on this difference should be given.

- Page 27, L34: What is "the L-curve method"? It should be introduced before being mentioned in the Discussion section.

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