Bremen, January 16, 2023

Letter to the Editor of paper amt-2022-258

Dear Joanna,

on behalf of all co-authors I have prepared this document, which provides the point-by-point responses to the suggestions of reviewer #2. The corresponding changes (and very few other minor stylistic revisions of the text) made in the manuscript are highlighted in the attached track-changes file.

Best regards,

Oliver

Response to referee comments on revised paper amt-2022-258

Below we give answers and clarifications to all comments made by the reviewer #2 (repeated in italics).

Minor comments

Reviewer: *1) In light of your recent publication on using ICESat-2 for TROPOMI retrievals, it would be interesting for readers to know if there is any significant difference between GLO-90 and ICESat-2 over Greenland. Please add a statement that puts the current algorithm update (GLO-90) into context with the retrievals you obtained with ICESat-2: Is GLO-90 the recommended DEM for retrieving methane over Greenland? This section may naively come across as if Hachmeister et al. was now outdated with respect to the DEM data source; please clarify.*

Authors: There is a similar improvement over Greenland when using GLO-90 or ICESat-2 instead of GMTED2010. If it is (only) about Greenland, you can use both DEMs. The added value of GLO-90 is its global consistency, which additionally permits to resolve further potential DEM inaccuracies and related retrieval biases elsewhere. This has been clarified.

Reviewer: *2) Is the spectral range of the TROPOMI WFMD fitting windows specified anywhere in the text of the manuscript (has it changed since v1.2?)? Please clarify. If the fitting windows are identical to the spectral range(s) shown in Fig. 5 [a,b], please discuss in the manuscript why you do not use the whole CH_4 absorption band (as measured by TROPOMI) in your fits. The fact that these spectral windows are relatively narrow may explain why WFMD is less susceptible to some of the observed albedo bias features in comparison to the operational TROPOMI retrievals, which cover a wider spectral range. Lower order polynomials can approximate albedo-induced structures in the spectral baseline well, if the spectral range is sufficiently small and the spectral signature of the surface reflectance is of a broadband nature (i.e. variations on the scale of 10s of nanometres). Please consider adding a statement about this in the manuscript, for example in line 146-147. The way this sentence is written, appears to suggest that there is something fundamental about either algorithm that leads to better or worse retrieval quality. Please rephrase to emphasise that it is the choice of spectral windows that has a significant impact on different aspects of the retrieval; among them spectral information content, the ability of spectral albedo features to affect retrieved methane concentrations, etc..*

Authors: The spectral fitting windows are unchanged since v1.2 and span the spectral range shown in Figure 5. They were optimised based on an error analysis (also including typical spectral albedo scenarios) of simulated measurements. It has been found that systematic errors are minimised if we do not use the whole CH_4 absorption band as measured by TROPOMI. This finding and the connection between choice of fitting windows and spectral albedo biases is discussed in a new paragraph starting in line 146:

"Overall, the changes due to the adjustment of the polynomial degree seem to be less significant for TROPOMI/WFMD than for RemoTeC. The lower susceptibility of TROPOMI/WFMD to some of the observed spectral albedo bias features is primarily attributed to the narrower

spectral fitting windows in comparison to the RemoTeC retrievals, which cover a wider spectral range. If the spectral range is sufficiently small, it is easier to approximate albedo-induced structures in the spectral baseline by lower degree polynomials. To retrieve CH_4 and CO simultaneously as accurately as possible, the TROPOMI/WFMD spectral fitting windows were optimised based on an error analysis of simulated measurements (also including spectral albedo scenarios of typical surface types) resulting in the windows 2311–2315.5 nm and 2320–2338 nm (Schneising et al., 2019). For instance, it was identified that it is beneficial with regard to systematic errors to exclude the strong methane absorption lines between the two fitting windows, although the associated loss of spectral information may lead to a slightly increased random error."

Reviewer: *3) You could consider moving section 3.4.1 to the appendix to make the main body of the manuscript more compact.*

Authors: Although section 3.4.1 is of technical nature, we prefer to keep it in the main text because it facilitates the understanding of what follows and thus enables a linear flow of reading without scrolling back and forth. We would like to reserve the appendix for brief additional information that is not absolutely necessary for understanding the main text.

Technical suggestions

Reviewer: *1) Line 225: "blocky" -> "discontinuous"*

Authors: Has been changed.

Reviewer: *2) Caption Fig. 1 "Juli" -> "July"*

Authors: Has been corrected

Reviewer: *3) Fig. 2: What temporal range of TROPOMI data was used for this plot? Please add in caption.*

Authors: The temporal range (2018-2020) is added to the caption.

Reviewer: *4) Please mention in the caption of Figure 5 that XCO images show yearly averages (which year(s)?).*

Authors: All maps in Figure 5 (including XCO) show a single satellite overpass from the same day. This is clarified in the caption.