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Atmospheric Measurement Techniques Discussions

Interactive comment on "The operational methane retrieval algorithm for TROPOMI" *by* Haili Hu et al.

Anonymous Referee #1

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Reviewer's comments on: "The operational methane retrieval algorithm for TROPOMI" by H. Hu, et al.

General Comments

This manuscript by Hu et al. describes the retrieval algorithm designed to determine methane column-averaged dry air volume mixing ratio from TROPOMI spectra measured in two bands. Much of the first half of the paper (Sections 1 and 2) is background material and was presented previously in the paper by Butz et al. (2012). The new simulations and sensitivity studies presented in Sections 3 and 4 address the expected performance of the algorithm in 'real world' situations. A variety of degrading effects are considered, including aerosols, clouds, forward model error, instrument SNR, errors in assumed temperature and water vapor profiles, and calibration. Results of individual experiments are mainly evaluated in terms of (1) the overall fraction of 'valid' retrievals not rejected by filtering and (2) root-mean-square bias and precision statistics.

Overall, this paper will be quite valuable to future users of TROPOMI products wanting to understand how to properly interpret these products. For the most part, the analysis methods used are appropriate, and the results are properly interpreted. However, as described below, I believe the paper ignores at least one significant source of potential retrieval error, and also makes no attempt to analyze the scenarios which lead to rejected observations (i.e., in the filtering stage). In the revised manuscript, the authors should specifically address these issues, and discuss how these issues will affect potential users.

Surface albedo is strongly wavelength-dependent, for most (if not all) land surface types, however, the TROPOMI algorithm assumes a simple first-order spectral dependence across the NIR and SWIR bands. For example, green vegetation exhibits a sharp increase in reflectance near the TROPOMI NIR band (757-774 nm) and the reflectance of vegetation is likely not linear across this spectral band. Various types of minerals and soils also exhibit complex spectral dependence of surface reflectance in both the NIR and SWIR bands. Why was this effect not represented in the simulations?

As described in Section 2.3, filters are used to discard those observations where the reliability of the methane retrieval is expected to be poor. Globally, approximately one half of the observations will be rejected. This will include scenes where aerosols exhibit high optical depth, large particles, and are located at high altitude. Thus, it should be expected that rejected observations will not be random, but will probably occur much more frequently in certain geographical regions (and during certain seasons) compared to others. This is extremely important information for potential users and should be specifically addressed in the revised manuscript. Where will the TROPOMI methane retrieval algorithm generally be useful and where won't it be useful? For example, it appears that there are very few successful retrievals over China and India (in Fig. 7), but it is not clear if this might just be due to the lack of ensemble 'test profiles' located there. Maps of the locations of rejected retrievals should be shown.

Minor Revisions and Technical Corrections

p. 5, line 125. Does the entire forward model grid really change as p_sfc changes (in order to create 36 layers with equal pressure widths), or is there a fixed pressure grid above the surface?

p. 5, l. 139 (and following lines). Various assumptions are made in the aerosol model, including values for r_1, r_2, and the aerosol complex refractive index. How is it known that these are reasonable values?

p. 6, l. 157. Define 's' in Eq. 3.

p. 6, l. 161. What is the relationship between the 12-layer retrieval grid and the 36-layer forward model grid?

p. 6, l. 162. It appears that the retrieval algorithm simultaneously retrieves both methane and CO total column amounts. Is this CO total column value just a diagnostic for the methane retrieval, or is this the official TROPOMI CO product?

p. 8, l. 200. Suggest rewording phrase 'have sensitivity down to the ground'

p. 8, l. 211. Is there a reference for this equation for total column retrieval uncertainty? Please show how this equation was derived. As shown in Rodgers' book (Section 4.3, 'Best Estimate of a Function of the State Vector'), the measurement error for total column will involve the matrix Sx as well as the linear operator which relates the retrieved profile and the total column.

p. 8 l. 213. It should be noted somewhere that the simulations will not represent all types of forward model errors, such as errors in the underlying spectroscopic database.

p. 11, l. 251. Meaning of the phrase 'to better oppose them with the algorithm performance' is unclear to me.

p. 11, l. 256. Properties of the ensemble are very important to interpreting the simulation experiments. How are the ensemble profiles distributed geographically? What is the range of aerosol optical depths in the ensemble?

p. 11, l. 265. Clarify that simulations assume constant surface albedo within NIR and SWIR bands.

p. 12, l. 286. Are these SNR values really 'design goals' or are they based on actual instrument engineering data?

p. 13, Sec. 3.2.1, first paragraph. Is the a priori methane profile experiment really done using the 'latitudinal mean' (based on an average over all latitudes) or 'zonal mean' (based on an average over longitude)? In either case, please provide some more detail, such as the width of the latitude or longitude bins used to calculate the mean.

p. 21, Conclusion. The conclusion should include information about the filtering algorithm, and what scenarios (geographical regions and seasons) most often lead to filtered retrievals.

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