Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2016-114-RC1, 2016

Atmospheric Measurement Techniques Discussions

Interactive comment on "Carbon monoxide total column retrievals from TROPOMI shortwave infrared measurements" *by* Jochen Landgraf et al.

Anonymous Referee #1

Received and published: 13 June 2016

Reviewer's comments on: "Carbon monoxide total column retrievals from TROPOMI shortwave infrared measurements" by J. Landgraf, et al.

General Comments

This manuscript by Landgraf et al. describes the retrieval algorithm designed to determine carbon monoxide (CO) total column values from TROPOMI shortwave-infrared (SWIR) spectra measured by the TROPOMI instrument. Overall, this manuscript will be valuable to users of TROPOMI CO products by providing a greater understanding of both the retrieval algorithm and the expected error characteristics of the CO retrieval products.

While the manuscript explains the essential details of the retrieval algorithm, I found it difficult to follow the data processing flow from its beginning to end. The algorithm in-

volves several steps of filtering and a variety of external data sources. I believe readers would benefit tremendously by the inclusion of a flowchart showing the different steps of retrieval processing and the various models and data sources that are exploited in operational data processing. This flowchart should appear in Section 2, before the sensitivity studies.

The presented theory of the retrieval algorithm is also somewhat confusing. Three different equations (Eqs. 6, 8, and 17) all reportedly describe the cost function of the TROPOMI CO retrieval algorithm. Even after reading the text a second time, it is unclear which of these cost functions is most relevant. It appears that Eq. 6 simplifies to become Eq. 8 as the result of forcing the DFS value to 1. If that is true, I would suggest deleting Eq. 6 entirely since it really is not relevant to the operational retrieval algorithm. Eq. 17 seems to only be applied when it is necessary to suppress singularities caused when the measurement is insensitive to specific elements of the state vector. Is that correct, or is Eq. 17 actually the "true" cost function for all retrievals? If Eq. 8 and Eq. 17 are used for different situations, then the authors should describe which cost function applies to which scenarios and how exactly that decision is made. If Eq. 17 is applied for all retrievals, then there is no obvious need to present Eq. 8.

The manuscript reports simulations of the effects of water and ice clouds on retrieval bias, but there seems to be no analysis of the effects of aerosols. Is this because aerosols have been shown to have negligible effect on CO retrievals, or is it simply because this effect has not yet been investigated?

Minor Revisions and Technical Corrections

p. 2, l. 38 - The MOPITT instrument observes CO using both thermal-infrared and SWIR bands.

p. 4, l. 75 - Please include reference and spell out the acronym 'SICOR'.

p. 7, l. 75 - For readers who are unfamiliar with the general topic of this paper, it

would be worthwhile to explain qualitatively how scattering can lead to either path-length shortening or path-length enhancement.

p. 7, l. 80 - Suggest deleting 'thoroughly'.

p. 7, l. 136 - Suggest rewriting sentence 'The fit window ... ' to emphasize the factors considered in the process of selecting the spectral window for CO retrievals.

p. 7, l. 161 - Please provide more detail with respect to the assumed cloud geometry; for example, what is meant by a 'triangular height profile'? Are single-scattering albedo and asymmetry parameter fixed or are they assumed to vary with height?

p. 7, l. 169 - Instead of 'microphysical properties', it appears that the authors mean 'optical properties'.

p. 7, l. 170 - References should be provided indicating that these are reasonable values for single-scattering albedo and asymmetry parameter for the CO spectral band; are these values appropriate for both clouds and aerosols?

p. 8, l. 207 - What is the 'vertical derivative operator' and what is its significance? Does this constraint essentially keep the shape of the profile fixed as the total column amount varies?

p. 8., l. 212 - What are the consequences of assuming a linear dependence of surface albedo on wavelength? Is this a reasonable approximation?

p. 9, l. 215 - The meaning of the sentence 'To account for the CO sensitivity ...' is unclear.

p. 10, l. 263 - In Eq. 17, it appears that the product Wx should be dimensionless. However, some of the elements of the state vector x (such as z_cld) are not dimensionless. Therefore, it appears that at least some of the diagonal elements of W should not be dimensionless either. So, shouldn't the diagonal elements of W depend on the units of the corresponding elements in x? The text states that the diagonal values of W are all

either 1 or 0, and no units are given.

p. 12, l. 298 - The listed telescope aperture is equivalent to 6 mmˆ2, which is surprisingly small. Is there a typo?

p. 14, l. 341 - For consistency with the order of panels in Fig. 5, consider discussing the results of the cirrus experiment after the middle-cloud experiment.

p. 14, l. 342 (and Fig. 5) - In both the left and right panels in Fig. 5, why are there no bias results reported in the lower right corners of the figures (i.e., the grey-colored area)? Are these cases filtered out somehow? Please explain this in the text and in the figure caption.

p. 14, l. 343 (and entire paragraph following this line) - While the rest of the manuscript was generally well written, I was unable to understand the material presented in this paragraph. I would suggest rewriting it. First, clearly describe the source of the retrieval error. Which implicit assumptions or approximations in the retrieval algorithm produce this error?

p. 19, l. 432. For the TROPOMI instrument, what are the design goals for radiometric offset error and multiplicative radiometric error?

p. 27. Conclusion. Please address the impact of aerosols. Are they unimportant, or has their effect on retrieval bias not yet been studied?

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