

Please find our responses embedded below in *blue italics*.

Best regards,
Helen Worden & co-authors

Reviews of amt-2022-128

“TROPESS/CrIS carbon monoxide profile validation with NOAA GML and ATom in situ aircraft observations”

Anonymous Referee #2

General comments This study presents the results of validating TROPESS/CrIS carbon monoxide (CO) profiles against in-situ aircraft observations. The authors demonstrate the significance of high-resolution spaceborne CO observations and present a data quality assessment. In particular, Section 6 assists readers in how interpreting the TROPESS/CrIS data in detail. This information is essential for users applying this data to their studies. The manuscript fits the scope of the journal and is well written. I believe it can be more readable with a bit of clarification and elaboration. Therefore, I would recommend publishing this manuscript after minor revisions. Please see specific comments below.

Response:

We thank the referee for their time and effort to review the paper and valuable comments that have helped to improve the manuscript.

Specific comments

- Section 1 (Introduction): In general, more clarifications would be appreciated on the definitions of MUSES and TROPESS. Although detailed information is given in Section 2, please consider elaborating briefly on the description of the two terms (i.e., MUSES and TROPICS) in Section 1. My main questions are: Is it correct that MUSES is the algorithm name and TROPESS is the product name?

Response:

That is correct, MUSES is the algorithm name and TROPESS is the new processing system and product. We agree this is a bit confusing and we have modified and added the following to Section 1, 3rd paragraph:

The CrIS CO products evaluated here use the MUSES (MULTi-SpEctra, MUlti-SpEcies, MUlti-Sensors) algorithm (Fu et al., 2016, 2018, 2019) and are processed with the TROPESS (TRopospheric Ozone and its Precursors from Earth System Sounding), Science Data Processing System (Bowman et al., 2021). TROPESS is a NASA project that provides a framework for consistent data processing of ozone and ozone precursors across different satellite instruments.

- o More specifically, on Lines 84–87: (1) Please provide full names for the abbreviations MUSES and TROPESS here. MUSES’ full name is provided in Line 91, after its first appearance in Line 84. TROPESS’ full name is only given in the abstract or after the conclusion section. (2) Please consider moving a part (or the entirety) of the descriptions of MUSES (Lines 99–106) and TROPESS (Lines 94–98) above Line 84.

Response:

We have re-ordered the text for clarity and acronyms are now defined when first used in both the abstract and main text. We also moved some of the MUSES description in Sec. 1 to Sec. 2.1.

- Line 238: Please provide a definition of the quality flag used here.

Response:

We have added the following paragraph to Sec. 2.1 (TROPESS retrieval approach):

The TROPESS CO products have quality flags for screening cases that did not converge or that have unphysical results. This screening checks the magnitude and spectral structure of radiance residuals, cloud retrieval characteristics, and deviation of surface emissivity from a priori values. Specifically, retrievals with good data quality of 1 have: radiance residual standard deviation less than 12 times the radiance error, an absolute value of the radiance residual mean less than 0.7 times the radiance error, KdotDL (the normalized dot product of the Jacobians and the radiance residual) less than 0.8, LdotDL (the normalized dot product of the radiance and the residual) less than 0.6, cloud top pressures below 90 hPa, mean cloud optical depths less than 50, cloud variability (variation with respect to wavenumber) less than 3, and mean surface emissivity that did not change by more than 0.06. These threshold values are based on comparisons with in situ data and other satellite data to determine when retrievals are valid.

- Lines 329–332 and 378–380: The fact that MOPITT shows different patterns is mentioned twice in this manuscript without describing the causes. Could you provide possible reasons (e.g., differences in instruments or algorithms)?

Response:

We have added the following text to Sec. 5.1:

Since TROPESS and MOPITT retrievals both use optimal estimation algorithms and a similar prior CO error covariance, this different vertical bias pattern is most likely due to instrument differences. MOPITT uses gas filter correlation radiometry instead of spectroscopy to detect CO absorption in the atmosphere with corresponding differences in vertical sensitivity that are determined from gas cell pressure rather than spectral resolution. After accounting for retrieval differences in a priori profiles and covariances between MOPITT and IASI (another FTS instrument), George et al. (2015) find a similar positive bias for MOPITT in the upper troposphere.

With corresponding new reference:

George, M., Clerbaux, C., Bouarar, I., Coheur, P.-F., Deeter, M. N., Edwards, D. P., Francis, G., Gille, J. C., Hadji-Lazaro, J., Hurtmans, D., Inness, A., Mao, D., and Worden, H. M.: An examination of the long-term CO records from MOPITT and IASI: comparison of retrieval methodology, *Atmos. Meas. Tech.*, 8, 4313–4328, <https://doi.org/10.5194/amt-8-4313-2015>, 2015.

- Lines 458 and 507: The phrases “what we expect for an optimal estimation” (Line 458) and “the expected behavior for optimal estimation retrievals” (Line 507) sound vague. Please elaborate on these sentences.

Response:

We have made the first sentence more explicit by using Equation 1 instead of “optimal estimation” as well as a better connection to the following text that explains why it is “expected”. For conclusion #7, we now have:

Comparisons of computed observational errors and standard deviations of retrieval-aircraft comparison differences show expected vertical behavior and demonstrate significant improvement over the standard deviation of prior-aircraft differences in vertical ranges with higher retrieval sensitivity.

Technical corrections

- Line 78: CO₂ to CO₂ *Response: Fixed.*
- Lines 85, 197, and 452: Please remove a comma before a parenthesis when presenting a reference (e.g., Hegarty et al., (2022) to Hegarty et al. (2022)). *Response: Fixed.*
- Line 147: x to x *Response: Fixed.*
- Line 188 and Table 1: How about replacing °E with °W since all longitude values are negative? *Response: Good suggestion. Done.*
- Line 433: Fig. 10 to Figure 10 *Response: Fixed.*
- Line 450: A period missing (differences As expected to differences. As expected) *Response: Fixed.*