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 #1

General comments: The authors present a study on the validation of TROPESS/CrIS carbon monoxide profiles. These TROPESS CrIS data retrieved using the MUSES algorithm with single field of view (FOV) radiances provide a better spatial resolution and allows to study plumes in more detail. Therefore, these CO profiles are very valuable when properly validated. In this paper, this data set is validated against in-situ data from aircraft observations. Averaging kernels are applied to take into account different vertical resolutions. The retrieved CO profiles agree well with the in-situ profiles. Therefore, I would recommend publishing this paper after minor revisions. The paper is well written and fits well to the scope of AMT. Please also 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:
- p. 7, line 238: Please provide a definition of 'retrieval quality of 1'.
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.

- p. 10: Is there a reason for limiting the study to 2 years of data?
Response:
This was due to the logistics and priorities of data processing. We decided to proceed with the study using only the 2 years that span both ATom and NOAA flights in order to make validation results available for this unique data set. Further validation over a longer time range and

extending the analysis to NOAA-20/CrIS will be the topics of future studies, as stated in the conclusions.

- p. 13&14: line 396 indicates a potential issue with water vapor: 'potentially indicating a TROPESS CrIS retrieval issue with water vapour or some other interferent'. On the other hand, Fig. 9 and lines 417 to 420 states the seasonal variations are well captured. In case of an H2O retrieval issue a seasonal variation of the difference between remote sensing and in-situ product is expected, at least outside the tropics. Can you elaborate a bit more on this and the seasonal dependence of the difference between TROPESS CrIS and in-situ data?

Response:

Since this bias latitude dependence is barely detectable, it is not likely that we have enough ATom coincidences by season to see the same effect that we see in the tropics for all data, so seasonal water vapor dependencies outside of the tropics will need to be studied more with the NOAA GML observations and more years of CrIS retrievals. The bias in the tropics could be similar to the water vapor dependence found for MOPITT (Deeter et al., 2019), but we will also need to consider the possible interference of N_2O (Gonzalez et al., 2021) when investigating this slightly higher bias. We have added more detail to this paragraph on the possible interferents that could contribute to a bias:

For example, Deeter et al. (2018) found that an empirical correction to MOPITT radiances resulting from a linear dependence on water vapor removed most of the latitude dependent bias in MOPITT CO profiles. Another gas interferent in the TIR CO band is N_2O and we will also need to consider the latitude dependent N_2O anomalies observed by ATom (Gonzalez et al., 2021) when assessing the contributions to this latitude dependence in TROPESS/CrIS CO bias.

Adding the reference:

Gonzalez, Y., Commane, R., Manninen, E., Daube, B. C., Schiferl, L. D., McManus, J. B., McKain, K., Hintsa, E. J., Elkins, J. W., Montzka, S. A., Sweeney, C., Moore, F., Jimenez, J. L., Campuzano Jost, P., Ryerson, T. B., Bourgeois, I., Peischl, J., Thompson, C. R., Ray, E., Wennberg, P. O., Crounse, J., Kim, M., Allen, H. M., Newman, P. A., Stephens, B. B., Apel, E. C., Hornbrook, R. S., Nault, B. A., Morgan, E., and Wofsy, S. C.: Impact of stratospheric air and surface emissions on tropospheric nitrous oxide during ATom, Atmos. Chem. Phys., 21, 11113–11132, https://doi.org/10.5194/acp-21-11113-2021, 2021.

- p. 18: I missed a comparison with validation results using different retrieval approaches, for example with the multiple FOVs retrieval.

Response:

Thank you for pointing out this oversight. We found a reference for NUCAPS/CrIS CO profile validation by Nalli et al. (2020). We thought the most appropriate place for a comparison with the reference for multiple FOV retrieval validation was in section 5.2 since Nalli et al. (2020) describe comparisons of the NUCAPS CO profiles with ATom in situ data. We now include the following text:

This TROPESS/CrIS CO bias also differs from Nalli et al. (2020) who examined the bias of NUCAPS profiles (including CO) with respect to ATom in situ profiles. That study, using the multiple FOV NUCAPS retrievals, found a small positive bias (~2%) for SNPP/CrIS CO with respect to ATom CO at all tropospheric vertical levels after applying their averaging kernels.

Adding the reference:

Nalli, N.R.; Tan, C.; Warner, J.; Divakarla, M.; Gambacorta, A.; Wilson, M.; Zhu, T.; Wang, T.; Wei, Z.; Pryor, K.; Kalluri, S.; Zhou, L.; Sweeney, C.; Baier, B.C.; McKain, K.; Wunch, D.; Deutscher, N.M.; Hase,

F.; Iraci, L.T.; Kivi, R.; Morino, I.; Notholt, J.; Ohyama, H.; Pollard, D.F.; Té, Y.; Velazco, V.A.; Warneke, T.; Sussmann, R.; Rettinger, M. Validation of Carbon Trace Gas Profile Retrievals from the NOAA-Unique Combined Atmospheric Processing System for the Cross-Track Infrared Sounder. *Remote Sens.* **2020**, *12*, 3245. https://doi.org/10.3390/rs12193245

Technical corrections:
- p. 1: TROPESS/CrIS in the title, TROPESS CrIS later in the text *Response: These are now consistently "TROPESS/CrIS".*
- p. 3, line 101: TROPOESS => TROPESS *Response: Fixed.*
- p. 5, Fig. 2: Some lines are hard to see *Response: By lines, we assume the referee means the state boundaries (solid) and the lat/lon boxes (dotted). Since these are only for reference and are not showing data, we decided to keep them as they are.*
- p. 8, Fig. 3: Axis scale is hard to read *Response: We have re-made this figure with larger font for the axes.*
- p. 9, line 323: I would suggest to add 'aircraft data' or similar: 'TROPESS CrIS CO comparisons with NOAA GML' => 'TROPESS CrIS CO comparisons with NOAA GML aircraft data' *Response: done.*
- l. 197: Calahorranol et al: 2018 => 2021 *Response: Fixed*
- l. 767 McMillam => McMillan *Response: Fixed*
- l. 876: a blank line is missing *Response: Fixed*