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Interactive comment on "Mapping carbon monoxide pollution from space down to city scales with daily global coverage" *by* Tobias Borsdorff et al.

Anonymous Referee #1

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General Comments

This brief manuscript reports early findings from CO retrievals by the TROPOMI instrument launched in late 2017. In that sense, the manuscript is similar to a GRL paper ('Measuring Carbon Monoxide With TROPOMI: First Results and a Comparison With ECMWF-IFS Analysis Data') recently published by Borsdorff et al. The main novel aspect of this new manuscript is an intercomparison with ground-based CO measurements from nine TCCON stations. The manuscript also presents several short 'case studies' demonstrating CO gradients associated with urbanization and long-range transport.

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Discussion paper

Readers of Atmospheric Measurement Techniques may find this paper interesting, although it contains little technical information. Since the recent GRL paper by Borsdorff et al. already demonstrated that the TROPOMI instrument and SICOR retrieval algorithm yield physically reasonable CO retrievals, this manuscript should really go into the quantitative use of the TROPOMI CO product in some depth. Without such detailed technical information, users will not be able to fully exploit this valuable new dataset. Some of this information is contained in the 2014 AMT paper by Borsdorff et al. ('Insights into Tikhonov regularization ...') and the 2016 AMT paper by Landgraf et al. ('Carbon monoxide total column retrievals from TROPOMI ...'), although the relevance of those theoretical papers to operational TROPOMI retrievals (which are inevitably more complicated to analyze than simulated retrievals) is unclear. Thus, as currently written, this paper lacks important information needed by potential users for quantitative applications.

For readers of AMT, the manuscript should specifically address the following questions.

- What do the operational TROPOMI total column AKs look like, and how do they vary (for example, with respect to solar and satellite zenith angle, CO concentration, etc.)?

- Do the operational total column AKs depart from unity (i.e., the 'ideal case') far enough to be significant to users? In other words, is the smoothing error for operational TROPOMI CO column retrievals significant or not?

- For the operational TROPOMI retrievals, what are typical statistics for 'smoothing error' and 'retrieval noise' (as determined by the retrieval algorithm)? Do these quantities vary, or can they be fairly represented as fixed values?

Minor Revisions and Technical Corrections

Somewhere, the manuscript should clearly define the relationship between 'total column density of CO', which would have units of molecules per area, and the 'dry air mixing ratio' with units of ppb. Which of these is the 'actual' TROPOMI CO product?

Exactly where and how is the conversion between these two quantities made?

p. 1, line 8 - The adjective 'game-changing' should probably be replaced with a more formal term like 'groundbreaking'.

p. 2, line 8 - Please include a number for typical background CO concentrations after 'low background concentration'.

p. 2, line 21 - The SICOR algorithm exploits a CO 'reference profile' which is scaled to produce the retrieved CO total column. Is this reference profile a fixed profile, or does it vary geographically and/or seasonally? What method was used to obtain the reference profile?

p. 3, line 10 - The text is not clear regarding the criteria for classifying 'clear' and 'cloudy' cases, and which cases are discarded entirely. For example, are all cases where cloud optical thickness > 0.5 OR cloud height < 5000 considered cloudy, or is it really where cloud optical thickness > 0.5 AND cloud height < 5000? Please clarify.

p. 3, line 16 - The striping issue should be discussed in more detail, with a specific example (including a figure) describing the problem and demonstrating the improvement associated with the method. Does the '5 %' value refer to the bias in CO or to the number of retrievals affected by the issue?

p. 3, Section 3.1 - This section does not include any discussion or consideration of the effects of the different total column averaging kernels for TROPOMI and TCCON. As a result, the influence of the retrieval vertical sensitivity and smoothing error can not be distinguished from other conceivable types of retrieval bias. Therefore, in the title of Section 3.1 (and elsewhere in the manuscript), I would use the term 'Intercomparison' rather than 'Validation'. In-situ profiles are typically needed for proper validation work since retrieval vertical sensitivity and smoothing error can be explicitly represented.

p. 3, line 29 - The handling of discrepancies between the TCCON station altitude and the assumed altitude (or surface pressure) in the TROPOMI retrievals requires more

explanation, preferably with an example. Is it possible to estimate an uncertainty (or an upper limit) for TROPOMI/TCCON intercomparisons due to this effect? How does this uncertainty vary among the different TCCON sites?

p. 4, line 17 - The text implies, but does not clearly state, that neither temporal nor spatial averaging is necessary to '... to distinguish the CO enhancement of 20 ppb of the total column from the surrounding background concentrations ...' Please clarify. An analysis of TROPOMI retrieval noise (random error) would be an essential part of this discussion.

p. 4, line 18 - The text '20 ppb of the total column' should be reworded since ppb is not the unit for total column.

p. 6, line 25 - 'retrieval' is misspelled

Figures 1 and 2 include many data points for days where TROPOMI data were available but TCCON were not, or vice-versa. Such data were not used to calculate TROPOMI/TCCON bias statistics. I would suggest revising the figures somehow to identify which points were actually used to calculate the bias statistics.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2018-132, 2018.