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Interactive comment on "Validation of MOPITT Carbon Monoxide (CO) retrievals over urban regions" *by* W. Tang et al.

Anonymous Referee #1

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The focus of this paper is a comparison of the latest MOPITT CO V8 retrievals with aircraft measurements. The authors use aircraft profiles that have not been previously used for comparisons with MOPITT, including profiles around urban regions. A variety of sensitivity tests are also performed to see how specific parameters affect the comparison. Overall I think the paper is well written and sound, and though I have numerous comments they are mostly minor.

General comments

G1: Even though the word "validation" or a variant has been used frequently in these contexts in the literature, "comparison" would nearly always be a better choice. "Validation" has a positive connotation which to me makes it sound like nothing new can be learned, and like the result is already known before the study. However, there is almost

always something new that can be learned and new ways to improve the retrievals. In addition the aircraft measurements themselves are not perfect as the authors point out, with limited measurement altitudes and possible inhomogeneities. Please try to limit use of the word "validation" or a variant to five or fewer instances throughout the entire paper. I include some suggestions for rephrasing in the technical comments, but I do not have a technical comment for each instance.

G2: Sometimes it is not always clear when all data from the listed flights are used in a comparison and when it is just urban areas like the title implies. Please clarify throughout (especially Sect. 4) if comparisons are from just urban or if they include both urban and non-urban.

Specific comments:

S1 - p1l1: Suggest the title be changed to be more descriptive, e.g., "Comparisons of MOPITT carbon monoxide retrievals with aircraft measurements, focusing on urban regions"

S2 - p1l21: list date range of campaigns (2011-2016)

S3 - p1l22: Please specify biases here refer to both urban and non-urban.

S4 - p1l22: Why is V8N disregarded in the abstract? Low DFS?

S5 - p2l30: specify the other levels

S6 - p2l48: Surely MOPITT itself is not doing the CO retrievals, but rather a team at NCAR? Suggest updating to: "Observations from the Measurements...satellite have been used for retrieving..."

S7 - p2l51-52: Similar to last comment, I think MOPITT just makes the measurement and NCAR provides the product. Suggest update to: "...products, a multispectral TIR-NIR product is also produced, which..."

S8 - p4l109: I think it would help to update to "quantities in the state vector."

S9 - p5l142: Similar to S6 & S7 – "There are 121 profiles over four urban regions from DISCOVER-AQ."

S10 - p5l145: "…campaign obtained 45 profiles in total sampled over…"

S11 - p6l161: I'm curious, why not just take the aircraft data as high as it goes and then use the model for the rest? Why include more interpolation with a Pinterp parameter than needed?

S12 - p6l169: This is a little circular, comparing MOPITT retrievals with data that assimilated another version of MOPITT retrievals. It would be helpful to let readers know here that you do not compare with these higher levels later, and that they are expected to have a minimal impact on the lower levels you use in the comparison.

S13 - p6l173: Is this mass weighted? If not add in "unweighted averaging"

S14 – p7l176: Please clarify, are these MOPITT profiles with the center point in the radius, or the entire footprint in the radius?

S15 - p7l181-183: Please clarify that these are not the profiles, but rather the state vectors. (You could also remind readers the state vectors and profiles are related by log10).

S16 – p7l197: Specify, what does "uniformly weighted" mean here? In pressure? For MOPITT, isn't the surface level an exception to "uniformly"?

S17 – p7l198: "vertical and horizontal" here is a little confusing (at first I thought it was in km, but realized it is variation in CO). You could reword to "The standard deviation of the original aircraft CO observations in each MOPITT layer are also shown, which is due to horizontal and vertical variability in CO."

S18 - p7l201: Numerically, what is the xtransformed and xrtv difference?

S19 - p8l207: Even if it was not the focus, MOPITT has been compared against other observing systems in urban regions prior to this paper. For example, Buchholz (doi:

10.5194/amt-10-1927-2017) compared MOPITT observations with ground-based observations in urban areas including Toronto and Bremen.

S20 - p9l238: Does this range of percentages include the 900 hPa and 700 hPa layers not shown? Why did you decide not to show these layers? Presumably you already did most the work for their comparison too.

S21 - p9l239: Why wasn't V8N also included? Low DFS? Coverage over land only?

S22 – p9l239: Consider changing "lower" to "smaller." I initially interpreted "lower" to mean "less than" (or more negative), but I think you mean "closer to zero." Same comment for "higher" on line 241.

S23 - p9l240: Is "-0.2" supposed to be "-2.0" based on Table 2?

S24 – p9l242: It looks like you can omit "generally" here, as it appears to be true for all (unless 700 hPa and 900 hPa are exceptions).

S25 - p9l244-246: This line is hard to read because of the number density, and the information is already in Table 2. I suggest omitting it completely.

S26 – p9l247: If you specified for T and J, then you could remove "generally" on this line.

S27 – p9l259: I suggest "at 600 hPa" -> "at the 600-500 hPa layer" (same for line 261). Otherwise it sounds like the comparison is at a specific level.

S28 – p11l295: Consider rewording "this validation of MOPITT at higher CO concentrations…" which sounds like it is the process does not work as well, rather than the results being further off.

S29 – p12l335: Quantitatively how much larger are the "larger biases"?

S30 – p12l339: This is repetitive with a sentence a few lines up (line 329). Can you just separate out a paragraph for DISCOVER-AQ CA so you do not have to mention it

6 times?

S31 - p12l344: "Previous MOPITT evaluation results," are these previous studies? Could you cite a few examples?

S32 - p13l376: Does this section and 4.4 use both urban and non-urban observations?

S33 - p13l380: Please be quantitative with "long enough lifetime" and include a reference.

S34 - p14l394: What is the L3 grid size?

S35 – p15l422: "MOPITT biases" -> "MOPITT mean biases"

S36 – p15l422: Please provide a reference for "10% required accuracy"

S37 – p16l453: Do you know about how many profiles go into each grid cell for Level 3? If it's 1x1 degrees then a 100 km radius is larger. In this case the overall agreement may actually be worsened further by too few MOPITT soundings (if this is what you mean by "which is unlikely to happen when generating L3").

S38 – p16l463-468: These 2 sentences are very late in the paper. They should be earlier, like in Section 2.2.

S39 – p16l468-476: This discussion on NO2 variability from GeoTASO to try to constrain CO variability seems irrelevant and late in the paper. I think the whole thing should be omitted.

S40 – p17l480: All the references to data should be split out into a "Data availability" section. See "Manuscript Composition" here: https://publications.copernicus.org/for_authors/manuscript_preparation.html.

S41 – p17l480: Best practice is for all data to be in a public repository. If this is not possible, then please provide contact information for how the aircraft data can be obtained including ARIAs and A-FORCE.

C5

S42 – p17l480: Include a last access data with all URLs.

S43 – p17l481-482: These seem like 2 references to the same MOPITT data? Which one should readers use?

S44 – p17l493: An "Author Contribution" section is needed: https://publications.copernicus.org/for_authors/manuscript_preparation.html.

S45 – p24Table1: Could you please include the accuracy of CO from aircraft measurements somewhere?

S46 – p24lTable1: For better traceability, please list the CO scale the aircraft measurements were tied to (e.g., WMO-CO-X2004, WMOCO-X2014, WMO-CO-X2014A, CSIRO…).

S47 – p26: (No response requested) – Figure 1 is well done and has high information content

S48 – p27l776-777: I don't understand "vertical and horizontal variability" here. Does "horizontal" somehow correspond to how many km were flown? Or are these just the standard deviations of aircraft profiles. If so, then just say "are the standard deviations of the original aircraft observations."

S49 – p27l777-778: I guess this is why the black and orange traces do not always match. Optionally consider plotting at layer centers (shifting up by about 50 hPa).

S50 – p29l793: Please define Delta log(VMR) here and explicitly include the base of the logarithm.

S51 – p30l803: Should "Figure 2" be "Figure 4"?

S52 – p31l810: Numerically, what are considered "outliers"? Please also add to captions of Figures 8-11. Or just reference the caption the Figure 6 so it is less repetitive.

S53 – p33lFigure8: Are these MOPITT biases compared with aircraft still? So the "200

C6

hPa" values are the same as yellow values in Figure 6? Please specify or optionally consider showing as a % bias compared with the baseline "200 hPa" results.

S54 – p33lFigure8: Please clarify that you are using "all" observations (both urban and non-urban).

S55 – p34Figure9: Optionally consider comparing against 100 km.

S56 – p35Figure10: Optionally consider comparing against 12 hours.

S57 – Figure S3: It would help to remind readers that "in situ" is a combination of aircraft and models since values at 1050 hPa do not make much physical sense. (As a side observation it is interesting that MOPITT is so insensitive).

S58 – Figure S5: Could you please provide more detail in the caption? Consider marking the level of highest aircraft measurements (presumably this is why there are straight lines).

Technical comments:

T1 - p1l17: "The performance of the" could be omitted (and update has -> have)

T2 - p1l19-20: E.g., validate -> compare, using -> with

T3 - p1l25: suggest "performance" -> "agreement" and adding "with aircraft measurements" after V8T

T4 - p2l32: "allowed maximum" -> "maximum allowed" and "as criteria" -> "criterion"

T5 - p2l34-35: suggest "hence few MOPITT retrievals are included in the comparison."

T6 - p2l36: "overall smaller" -> "smaller overall"

T7 - p2l40: "retrievals that result for comparison." -> "retrievals for the comparison."

T8 - p3l58: "the most recently"

T9 - p3l83-84: suggest "...we compare MOPITT version...regions with aircraft profiles

made over..."

T10 - p3l83: "version" is lowercase here but capitalized on p2l55. Please be consistent throughout.

T11 - p4l100: "retrievals" -> "observations"

T12 - p4l111: "The two" -> "These two"

T13 - p5l124: "determined" -> "considered"

T14 - p5l128-130: move/modify "the profiles over urban and non-urban areas are similar" to right after "We also notice..."

T15 - p5l139: omit "different instruments" (it's implied)

T16 - p6l148: "Only few" -> "Few"

T17 - p6l162: omit "below" (I initially was confused because I thought "below" meant lower pressure/higher altitude)

T18 - p6l174-175: "We have investigated the..."

T19 - p7l179: "have been further" -> "are"

T20 - p7l186: "If fewer than five MOPITT retrievals are co-located with an in-situ profile, the..."

T21 - p7l187-191: I think it would be clearer if you reordered the description. a) In situ profile individually applied to AK and prior of each MOPITT retrieval to get xtranformed. b) xtransform averaged as log10. c) Corresponding MOPITT profile retrievals also averaged

T22 - p7l200: "variability" -> "standard deviation"

T23 - p7l202 & 203: omit "retrieval" (the size does not depend on the retrieval algorithm, but is inherent in the MOPITT observation system)

T24 - p8l205: omit "very"

T25 - p8l207: "validated" -> "compared with aircraft observations"

T26 - p8l209-210: "…show a sensitivity analysis in Section 4 to provide…"

T27 - p8l211: omit "validation"

T28 - p8l215: maybe "validation" -> "comparison with aircraft profiles"

T29 - p8l224: "against observations" -> "against in situ observations"

T30 - p9l236: "Corresponding results" -> "These comparisons"

T31 - p9l244: "three levels" -> "three levels in Table 2"

T32 – p9l251: "…in terms of higher correlation coefficients and smaller biases…"

T33 - p9l253: "provide" -> "evaluate", "evaluation against" -> "retrievals during", "campaigns" -> "campaigns with results"

T34 - p9l264: "in more favorable weather conditions" -> "during times with greater vertical mixing"

T35 - p9l271: "xin-situ, the" -> "xin-situ over non-urban areas, the"

T36 - p9l291: "concentrations all" -> "concentration for all"

T37 - p9l292: "For both" -> "For the higher 50% of measured mixing ratios both" and omit "if only the upper 50% of measured mixing ratios are considered"

T38 - p12l335-336: Suggest omitting "The validation results", and the second "validation" and changing "are" -> "does", "different for" -> change

T39 - p12l347: "the radius" -> "a radius"

T40 - p12l350: "close" -> "similar"

T41 - p13l356: "a smaller number of included" -> "including fewer"

T42 - p13l359: "a a more more" -> "a more"

T43 - p13l367: "especially" -> "including"

T44 - p14l399: "Level 3" -> "the Level 3"

T45 - p14l411: omit "process"

T46 – p15l423: suggest "overall" -> "mean"

T47 – p15l424: "to 3.5% for different levels"

T48 – p15l429: "to" -> "into"

T49 – p15l431: "compared with low"

T50 – p15l440: "as co-location criteria" -> "as a co-location criterion"

T51 – p15l441: "where a" -> "where only a"