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Interactive comment on "Impact of land-water sensitivity contrast on MOPITT retrievals and trends over a coastal city" *by* Ian Ashpole and Aldona Wiacek

Anonymous Referee #2

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Ashpole and Wiacek analyze a MOPITT CO Level 3 (L3) pixel over one location – Halifax, Canada – and compare it to the Level 2 (L2) retrievals within the same 1 degree pixel. They use this coastal location to highlight instrument sensitivity differences between water and land that impact near-surface and profile analysis with the joint TIR-NIR product. The influence of different surface-types (land or water) on CO retrievals and the resulting trends is investigated. The authors find that sensitivity differences account for retrieval differences in JJA, but a CO gradient is likely the reason for differences in DJF. While the MOPITT team already provide recommendations to maximize information content for a studied region, Ashpole and Wiacek demonstrate the practical implications of retrieval differences. The study suggests L2 profile data over land is

more appropriate than L3 profile for the small region around the coastal city of Halifax, particularly for the lower troposphere. The authors present a valuable supplementary guide for users of the MOPITT product.

Overall the analysis shows attention to detail and generally good statistical practices. The manuscript is well written and language is clear with very few technical corrections. I have some recommendations for reducing verbosity. Additionally, I recommend the following major comments be addressed before the manuscript is considered for publication.

Major comments:

1. Section 3.2: In my opinion, the most logically inconsistent part of the manuscript is the comparison of all $L3_O$ pixels with $L3_L$ and $L3_W$. The surface pixel type (land, water or mixed) is given in the MOPITT level 3 product, and users should use information to filter data over such locations. I think the strength of this analysis would be to show that the improvement in information content if you use the L2 land data over coastal locations. Also - is there a difference between using L2 water and the L3 water retrievals, i.e. the extra days you gain from the "mixed" L3 pixel when creating $L3_W$. The authors need to clearly justify why they are comparing with the combination of L3 pixel-types, or alternatively compare against the water-only pixels from Level 3.

2. Trend analysis: The MOPITT profile layers are known to have drift (Deeter et al., 2017, doi:10.5194/amt-2017-71). Surface drift is about -0.7% per year, 800 hPa is -1% per year. The UT levels have positive drift - both the 400 and 200 hPa levels drift at greater than 1% per year. Drift should be corrected before trend analysis is performed. I did not see this mentioned in the manuscript.

3. Ordinary Least Squares analysis is highly susceptible to outliers and end points. End points may in particular be impacting the slope calculations for $L3_L$ data in JJA (Figure 10, bottom panel). Instead, I recommend that the trend analysis be performed with weighted least squares (WLS), weighted by the standard deviation, which is much

less susceptible to outliers. Additionally, the seasons that only have one day per 3 months can be de-weighted by using sufficiently large standard deviation.

4. Please mention somewhere (for example on P6, L189) why the analysis is statistically valid, even though only 7% of the potential DJF days and 17% of the potential JJA days have measured CO.

5. I am uncomfortable with the authors extending this analysis to other regions (e.g. P2, L35; P20, L605 to L607). Before extending these results to other coastal locations, other types of locations need to be analyzed (tropical, temperate). Please add a comment that recommends similar analysis be performed for other coastal sites before using MOPITT surface CO.

6. There was a change in MOPITT processing after the cooler failure in May 2001. Although a homogenized record is attempted, there remains a small step-change in data. I suggest to use data only from the latter part of the record starting August 2001, especially for the trend analysis where step changes could have large impact.

7. The authors have missed an opportunity to quantify the improvement in retrievals due to the inclusions of NIR between $L3_L$ and $L3_W$. In the JJA comparisons, when the CO gradients and a priori suggest there are no expected differences in the CO.

8. Figure 6 and associated discussion. I suggest to split the $logX_{true}$ - $logX_{ap}$ into different average profiles for land and water because Figure 7 suggests that in JJA both difference would be negative while for DJF, the land difference would be negative but the water would be positive. This would help support the overall argument that DJF sees real CO gradients, while JJA is impacted by sensitivity differences.

Minor comments:

P1, L9: Add latitude and longitude to location in abstract.

P1, L18 L30 and elsewhere in manuscript: Change "surface profile level" to just "surface level" - otherwise it should be "surface level of the profile".

P2, L41: Remove "primary" from "The primary target" because MOPITT only retrieves CO.

P2, L46: Add in a sentence about the secondary production of CO from VOCs.

P2, L48: "...since launch in December, 1999".

P4, L114 to 116: It is important to note here that the improved sensitivity occurs only over land for the joint TIR-NIR product. Also, largest difference would consequently be expected between land and water with the joint product, so the study presented in this manuscript is expected to show an upper bound on the differences in retrievals between land-types.

P4, L127: The simulation climatology resolution is $1.9° \times 2.5°$, not $1° \times 1°$.

P6, L172: Add degree symbols to the latitude and longitude locations.

P9, L274: I think it should be "MT and UT".

P10, L299: I was confused by "the widest part of each AK" - Did you mean in the X-direction or the Y-direction? Please clarify.

P11, L328: Do you mean differences in the MT?

P12, L346 to L347: Reword to be a little clearer, e.g. "The T_{skin} difference approaching $20°$ K between JJA $L3_L$ and DJF $L3_W$ likely..."

P12, L370: Reword to clarify, e.g. "Available CAMSRA data covers 2003-2016, so a subset of the available MOPITT data (2000-2017) are considered in simulation experiments."

P13, L377: Remove the "respectively" explanation in brackets because there is only one number.

P13, L378: "...sensitivity to $X_{true,sim}$ in $L3_L$ than $L3_W$:..."

P15, L463: Change all-caps TRUE.

C4

P16, L472 to L473: This is the first time the data is separated in this way ($L3_L > L3_W$ and $L3_W > L3_L$). Mention why this is necessary. Why is it not separated this way in the other sections - for example Figure 2 shows a mean response.

P16, L491 to L496: This description needs a little clarification. Could it be explained that the density of days where $L3_W < L3_L$ is higher at the beginning of the record, while the density of days where $L3_W > L3_L$ is higher at the end of the record for JJA. In DJF, the density of $L3_W > L3_L$ is consistent across the record.

P17, Section 3.2.1: Discuss/show p-values for all comparisons between means.

P18, L549: Consider discussing as "gradients for $L3_W$" etc. rather than introducing more acronyms. This would also help when reading Table 3 as the new acronyms are not used there.

P20, L604: "... before analysis of profile values in order to...".

P20, L605: "In particular, when investigating coastal cities, it is advised that retrievals over land..."

Table 3: Add units for m and SE.

Figure 4: Add error bars for standard deviation.

Figure 8: "Yearmean" is an unusual metric. I suggest "Center year".

Figure 9: What are the error bars?

Suggestions to reduce verbosity:

P5, L155: Remove end of sentence from "in the case of" onwards - redundant.

P8, L227-L228: Remove "For simulated..." onwards - redundant.

P12, L348 to L361: This is a repeat of earlier and later information. Consider whether any or all of it is really needed here.

P12, L366 to L369: Remove sentence starting "For each $L3_L$-$L3_W$..." because repeats information from the methods section and is not needed here. Can just start sentence on line 369 with "Recall that any differences..."

P13, L382 to L383: Ending of sentence starting "as would be expected from..." can be removed because it is a repeat of L378 to L380.

P13, L384 to L391: Unsure that this adds any important points to the discussion, consider removing or shortening.

P16, L496: "As we show in Section 3.2.2,..." - Is this really needed here, or could you leave it till Section 3.2.2.

P17, L510 to L511: Remove end of sentence beginning "primarily because..." - repeat of information in the beginning of the sentence.

P17, L511 to L514: Remove "Thus, there is..." - it is unnecessary.

P17, L524 to L526: Consider removing "(mean surface level..." to "...248 for $L3_O$)".

P19, L581 to L587: There is no significant difference between trends at 300 hPa , so there is no need to explain why they might be different. This paragraph just needs to mention the main point that trends at 300 hPa are positive.

Table 2: AK_{sfc} are in Figure 5 so can be removed. Consider adding other measures from Table 2 to Figure 5 and removing Table 2.