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Interactive comment on "Comparison of formaldehyde tropospheric columns in Australia and New Zealand using MAX-DOAS, FTIR and TROPOMI" *by* Robert G. Ryan et al.

Anonymous Referee #1

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The study of Ryan et al. (2020) presents time-series of formaldehyde tropospheric columns from two ground-based MAX-DOAS stations, located in Australia and New Zealand, and their comparisons with ground-based FTIR and satellite (mainly TROPOMI) data. This paper is relevant for a publication in AMT, because the monitoring of biogenic VOCs, especially in such a region that was lacking of such measurements, is of great importance for our understanding of the complex tropospheric chemistry. The paper provides information on the observed amounts of HCHO in this region, and on the seasonal cycles, both important for modelers. The MAX-DOAS data are compared carefully with FTIR and TROPOMI data, and the paper demonstrates the improvement of the TROPOMI HCHO data compared to the OMI satellite. The paper

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Discussion paper

is also very well-structured and clear. Therefore, I recommend the publication of this paper in AMT, with a few minor comments, suggestions and questions (listed below) that should / could be addressed for some clarification.

I) Specific comments/suggestions:

- It could be nice to add a Table summarizing the main results discussed in the paper: the 2 ground-based MAX-DOAS data, with mean values, and seasonal amplitudes, and their error budget. I don't see any random and systematic uncertainty numbers given in the paper for MAX-DOAS, while I see error bars in e.g. the scatter plots (with Deming fit that is using the MAX-DOAS uncertainty). It would be clearer in a Table. Then, possibly in the same Table (or another one), the different comparisons results (slope, R2, Diff+/-Std, ErrTC,...), as in Table A1 first 3 lines: I think these lines deserve to be in the main text, not in the Appendix.

- Sect. 3.1, discussion Lauder vs Melbourne: I understand that the authors want to focus on the "background" explanation (normal conditions) of HCHO. However (suggestion), a discussion on the added possible impact of biomass burning could be interesting as well (e.g. the peak in January 2018 seen at both stations might be related to fires?). Can plumes be observed from TROPOMI this month passing over Melbourne and Lauder as well on specific days? Also, maybe a Google Earth-type map (or a vegetation map found elsewhere) could help for the discussion on the different type of vegetation (forest / agriculture,...), e.g. in replacement of Fig. 1?

- Sect.3.2, scatter plots: I do not understand the correspondence between the slope provided in the scatter plots and the red line: in Fig. A1, the slope of the red lines look larger than 1 to me, while the number given are 0.64 and .0.71. Could you explain?

- p.12, l.248: calculation of the error on the differences: in the EMAX_DOAS and EFTIR total uncertainty, do you include the smoothing error? It should be included for your comparisons of FTIR and original DOAS data (Rodgers and Connor, 2003, Eq. 13). And for comparisons of FTIR and smoothed DOAS data, then it becomes Eq.30 of

Rodgers and Connor (2003). It would be nice to have separate information on random and systematic part of the uncertainties. (of DOAS, and of the comparisons). However, the systematic part of the smoothing might be negligible in your case compared to the other sources, but it should be better to check and say it.

- p.14, l.278-298, discussion on Fig.7: may the enhanced TROPOMI HCHO columns on the east be (also) due to transport pathways from the polluted city?

- p.14, 290-292, averaging of averaging kernels: it is usually preferred to make all smoothing part before with individual data and ak, and then average the smoothed results. (cf von Clarmann, T. and Glatthor, N. , AMT, 2019). Maybe low impact in your case, did you check?

- p.16, l.318 - p.17, l.333: discussion comparisons DOAS-TROPOMI: maybe these results (slope, diff, seasonal cycle comparisons Fig.8, ...) should be put in perspective with previous TROPOMI HCHO validation (Vigouroux et al. 2020), especially for similar stations (in HCHO amounts). Do these studies agree? Maybe the public routine validation report (not peer-reviewed) that can be found here: http://mpc-vdaf.tropomi.eu/index.php/formaldehyde can also help with MAX-DOAS / TROPOMI comparisons made at a few stations, but the sites used there are more polluted sites.

- p.17, l.340-342: the TROPOMI a priori profiles are also from chemical transport model. Did you compare the ones used for TROPOMI and for OMI retrievals? Are they so much different? A possibility to learn about the improvement made from OMI to TROPOMI would be to ask the satellite data providers (e.g. Isabelle De Smedt, BIRA-IASB).

- P.18, l. 376: "This would begin to address the current Northern-Hemispheric bias in satellite validation studies". I do not understand this sentence, sorry. Which Northern-Hemispheric bias? Which molecule? How the data in Australasia can help addressing a bias in Northern Hemisphere? Please, clarify.

II) Minor or technical comments:

- abstract, p.1, l.5 + Sect.2.3, p7, l.139 + Sect.3.1,p.9,l.193 + Sect.conclusions,p.17,l.352: the numbers given for the mean columns at Lauder are not consistent in these sections.

- abstract, p.1, l.12: I would define the partial columns.

- p.2, l.51: uses (not use)

- p.4, l.101-102: remove one of the two "however".

- p.6, legend box inserted in Fig.3(a): it is written Retrieved (blue) and Measured (Red). I guess "model" is the "Retrieved"? Maybe use the same terminology in legend of Fig.3 (and text) and the legend box in Fig.3a.

- p.6, l.129: have, not had.

- p.6, l.131: "$2°$ the lowest possible elevation angle at Lauder": it is written $1°$ in the Sect. 2.1. (p.4,l.86). One should be corrected.

- p.7, l.159: The 2% random error for FTIR measurement: is it the value for the specific day 8th January 2018 or for the mean of FTIR data? It is a low value compared to the 6% given in Vigouroux et al., 2018. If this is the value for the specific day, maybe give the total column value as well or the random error in absolute values.

- p.8, l.164: "in October 2017, and is a low..." (add and ?)

- p.8, l.179: "(Gonzalez Abad et al. 2015) and are..." (add and ?)

- p.9,l.199: I would change for: "...as Melbourne is a large city, and/or to higher biogenic VOC..." (a combination of both being likely)

- p. 12, l.245: You should specify how the percentage is calculated (mean(relative diff) or mean(absolute diff)/mean(levels)), and specify what is levels: DOAS ?FTIR? mean of both?,...

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- p.17, l. 327 "The majority of. . .. line": English?

- p.18, l. 365: slope=0.61 (and not 0.81, right ?)

- p.18, l.374: "could contribute" (not could be contributed)

- p. 21, Figure A4, legend: Remove one of two repeated sentences.