

Interactive comment on “Assessment of the TROPOMI tropospheric NO₂ product based on airborne APEX observations” by Frederik Tack et al.

Anonymous Referee #1

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General Comments about the manuscript in discussion titled, ‘Assessment of the TROPOMI tropospheric NO₂ product based on airborne APEX observations’ by Tack et al., 2020. This manuscript is a well thought out analysis which uses the airborne instrument, APEX, to evaluate tropospheric NO₂ columns from TROPOMI over two major Belgian cities, Antwerp and Brussels. This work does a great job in assessing the impact of spatial resolution between the observations and a lot of detailed analysis on spatial smearing and found that the NO₂ tropospheric NO₂ product is within the precision and accuracy requirements. Overall, the analysis is quite detailed and very fitting for publication within AMT. I recommend publishing after the proper addressing a couple specific concerns pertaining to details about the APEX retrieval and some other

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minor comments.

Specific Comments: There is concern about the assumption of vertical NO₂ profile in the APEX retrieval as well mixed profile of NO₂ through the boundary layer. There have been many observations and analysis in the literature proving that NO₂ is rarely ‘well-mixed’ in an urban environment (e.g., <http://dx.doi.org/10.1002/2015JD024203>). (1) There appears to be modeled high resolution model data available from the regional CAMS model that likely at last has some more realistic weighting of NO₂ nearer to the surface (negative vertical gradient in the boundary layer). The analysis would be strengthened if results were also shown with those a priori in the APEX retrieval. (2) Alternatively or in addition, the analysis would also be strengthened if there was some background on the validation of APEX NO₂ observations or perhaps independent validation with measurements from the MAX-DOAS measurements mentioned in this analysis. It is hard to evaluate TROPOMI bias if the reference measurement is not validated itself.

There are some missing details about the APEX NO₂ tropospheric column algorithm. Please add discussion about the reference spectra (i.e., is there one per flight? One overall? Where is it? I saw the comment that it was estimated using a mobile MAX-DOAS) also please add some text that discusses how APEX tropospheric vertical columns are computed (e.g., is it similar to Sect. 3.2.2 and 3.3 in Lamsal et al. <http://dx.doi.org/10.1002/2016JD025483> ?)

How is sigmaAMF_APEX computed?

It is interesting in Table 4 how the bias/slopes are different between the two cities. Antwerp has a lower slope for all three column comparisons as well as a larger negative bias. Any comment on this?

On page 5, there is discussion about AOT measurements. Were any observed in Antwerp or only in Brussels?

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In Figure 15 and Sect. 6.2: why does the color bar go to zero if the background is 3×10^{15} and the detection limit is assumed at 5.1×10^{15} ? I am not sure if this is an oversight or if the section needs some clarifying discussion about the interpretation of this figure.

Page 1 Line 31 and generally in the paper: These biases are for these Belgian cities but are stated as general results for 'urban areas'. Could these results perhaps be different in other cities?

Technical Comments: Page 1: Line 23: You refer to the slope of 0.93 after the introduction of the CAMS profile, however the original slope is not listed. Please add this to the abstract to be consistent.

Page 3 Line 1: please add the TROPOMI resolution sooner than is mentioned in page 3 line 15 as it is referenced in relation to other missions.

Page 3: Please consider swapping the placement of the second and third paragraphs in this page (Paragraph 2 being 'In this study...' and Paragraph 3 being 'Richter et al.'). It would improve flow as it talks about the challenges then state how this study addresses those challenges

Page 3 Line 31: There is this reference also in AMTD. <https://amt.copernicus.org/preprints/amt-2020-151/> Perhaps make the statement more defining to the region studied or other details. Or remove/edit accordingly.

Page 5 Line 30: AURA should be Aura. It is not an acronym. Same with PANDORA->Pandora.

Page 7 Line 13-14: 'is based' is used twice in one sentence.

Page 9 Final paragraph: This figure shows the difference in Box AMFs based on albedo, and therefore belongs better in the next section rather than Sect. 4.3.1 about A priori NO₂ profiles.

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Page 12: Line 20: Word Choice: refer to Antwerp and Brussels as regions or cities, rather than separate campaigns.

Figure 7: please point out the airport for ease of identifying when discussed in the text on Page 13

Page 14 Line 21-22: It is premature to make a statement about the error bars in Figure 8 since the figure is not introduced until a couple pages later. I suggest removing that sentence here.

Page 18 Lines 15-23: Please clarify this discussion on how the temporal variability between TROPOMI overpasses is computed, especially with the differences in pixel footprints. It is hard to follow what those statistics are referring to and how they are computed.

Page 19 Line 10: delete 'allow to'

Figure 1: Adding a label for Stabroek as the other ground site where meteorology is measured in Antwerp could be helpful.

Figure 13: Please make the red dots more visible. (Perhaps white like in other Figures). Also in the caption write what they are. And as a suggestion, pull the color bar legend out of panel (a) and make larger since it refers to all four maps.

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