

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

Anonymous Referee #2

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The manuscript by Tack et al. “Assessment of the TROPOMI tropospheric NO₂ product based on airborne APEX observations”, is well-written with a solid methodology. The accommodating figures are of excellent quality and easy to understand. The study assesses the quality of the TROPOMI NO₂ observations and compares them to high-resolution aircraft-borne remote sensing observations over two Belgian cities. The impact of spatial smoothing and NO₂ a priori is estimated and discussed in great detail. Overall, I think this is a great fit for the TROPOMI special issue in AMT and I would recommend publication. I have some minor comments and suggestions that should be addressed.

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General comments

p.3 l. 31: Is this really the first? Around the same time: Evaluating Sentinel-5P TROPOMI tropospheric NO₂ column densities with airborne and Pandora spectrometers near New York City and Long Island Sound, Laura M. Judd et al.; <https://doi.org/10.5194/amt-2020-151>; I would suggest deleting this comment and possibly include a reference to this paper within the manuscript.

p. 4 l. 16: The TROPOMI tropospheric columns are up to ~12km. There is NO₂ above 6.5km, the NO₂ profile is not 0. Over cities and enhanced areas this will not be a big factor, but this should be discussed and mentioned. A typical amount of NO₂ from 6.5 to 12km over Belgium would be useful to mention – maybe using CAMS or TMP.

p. 4/5 I think the cloud fraction should be mentioned. It's mentioned that for the flights it was mainly clear sky, but what is the range of the cloud fractions for the TROPOMI observations? Some of this could be of course due to aerosols, but I think it would be good to know the cloud fraction (nitrogen dioxide window) assumed in the TROPOMI retrieval. I just noticed this is mentioned later in Sect. 4.3.3, but it would be good to include it in this section.

p.10 l. 1 Could the difference of the AMF come from the different height? APEX is from the surface to 6.5km; for TROPOMI it's higher.

Sect 4.3.2 Albedo: the TROPOMI AMF could be re-calculated using the APEX albedo and the impact can be directly estimated. I think the study would benefit from looking at the impact of correcting for the albedo. I'm not sure if this would be possible to do within a reasonable amount of time, if this is too time consuming, just mention it at least.

Sect. 4.3.2: The albedo is wavelength dependent; albedos at 3 different wavelengths are compared. How big is the impact of the wavelengths difference? This should be discussed, e.g. look at the OMI albedo and include the relative difference for these

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different wavelengths (over Brussels and Antwerp).

p. 13, l. 16: it could be due to meteorology; e.g. lower wind speeds can increase the VCD enhancement even though emissions do not increase VCDs can be higher for stagnant winds, there could also be factors that potentially increased the lifetime of NO_x (e.g. OH, O₃, and NO_x concentration) for that particular day. I think meteorology should be mentioned as a potential influence; look at the wind speeds and direction for these days (the wind speed is definitely lower). If both TROPOMI and APEX observed higher VCDs on June 29, this would not be due to the APEX instrument troubles.

p. 22, l. 21: Can you really conclude this if your comparison is done over a small area and over a short time period, seasons are not considered (e.g. snow)? Re-phrase this, or add “over Belgium in the summer time.”

Specific/technical comments

p.1 l. 24-26: “When the absolute value . . ., when comparing APEX NO₂ VCDs with TM5-MP based and CAMS-based NO₂ VCDs, respectively.” I suggest re-wording this sentence, e.g.: The absolute difference is on average xx molec cm⁻² (16%) and xx molec cm⁻² (9%) compared to . . .

p.1 l. 26: Which accuracy requirement; maybe change it to “mission accuracy requirement”

p.1 l. 29-30; suggest re-wording: Something like: The current TROPOMI data underestimate localized enhancements and overestimate background values by approximately 1-2x 10¹⁵ molec cm⁻² (10- 20%).

p.3 l. 13: “studied in Sect. 6” change to “see Sect. 6”

p.4 l. 4 Air pollution levels over Belgium. . . Do you have a reference that can be included here?

p.6, l. 16 VNIR; this should be defined, maybe in the previous sentence were the two

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channels are mentioned

p.7 l. 28, mention the height of the layers (between surface and xx km)

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