Review of: Mapping the spatial distribution of NO_2 with in situ and remote sensing instruments during the Munich NO_2 imaging campaign (Kuhlmann et al., 2021)

The manuscript discusses results from the Munich NO_2 imaging campaign (MuNIC) where nitrogen dioxide (NO_2) near-surface concentrations (NSC) and vertical column densities (VCD) were measured with several stationary, mobile and airborne in situ and remote sensing instruments. The measurements have been intercompared with a focus on one day where also airborne APEX measurements were performed. Also a mass-balance approach is discussed to estimate NOx emissions of two CHP plants from the APEX observations. The scientific content of the paper fits well within the scope of AMT. The manuscript is well-written and generally well-structured. Therefore, I recommend its publication in AMT. However, a number of revisions (detailed below) need to be conducted in the paper before publication.

General comments

main comment: the different types of measurements are discussed in full detail. However, the study is very short on the actual comparison of airborne and in-situ observations and understanding of the relationship between VCDs and NSCs, while this is put forward as one of the main drivers of this study. It would also help the reader to more extensively explain why the relation NSC - VCD is not trivial and what are the main parameters affecting this relation, etc. As sect. 3.5 is not comparing with airborne data, mobile in-situ and remote sensing data could be better exploited by also taking into account measurements at other days than 7 July 2016, to see if findings are consistent or impacted by certain environmental parameters (I understood the campaign took place in the first two weeks of July). Also the LP-DOAS is described in this work but the data is not really exploited. This comment is linked to the following two comments.

p.3 l. 52: '…and to advance the understanding on the relationship between VCDs and NSCs in Munich, Germany' → This is actually not well developed in this work. You could elaborate on the reasons why the relation is non-trivial. What is impacting it? etc.

p.3 l. 56: '…analysis the consistency of in situ and airborne NO2 observations' → in-situ and airborne observations have not been compared in this work but mentioned here as an objective.

p.15 l.330: Key highways and key intersections/roundabouts could be identified in previous studies. In some cases a clear distinction could be made between the NO_2 field upwind and downwind of the line source.

p.17 l.357: It is not fully clear how you compute the ratios: so basically it is giving the percentage of the VCD which is in the 1 m partial column at the surface? The percentage seems (very) low. Is this also a correct definition for the near-surface layer or NO_2 NSC?

Minor comments

p.2 l.31: What you also might mention as an option is putting in-situ monitors on mobile platforms such as trams, buses, taxi cabs, etc. There are also some examples in the literature of putting in-situ monitors on Google street view cars, e.g. Apte JS, Messier KP, Gani S, Brauer M, Kirchstetter TW, Lunden MM, Marshall JD, Portier CJ, Vermeulen RCH, Hamburg SP. High resolution air pollution mapping with Google Street View cars: Exploiting big data. Environ. Sci. Tech, 2017.

p.5 l.77: The data is probably available per minute (for scientific use), but averaged per hour?

p.5 l.96: Please specify if a profiling is performed in each of the 7 azimuth directions or only in one main direction?

p.6 l.119: You might specify the major changes/updates of v2 compared to v1.

p.6 l.127: As I understand here, you used a different reference for each flight line. However, as the along-track drift was small for this flight you probably could use one reference for all flight lines?

p.7 l.148: if the spatial resolution is 80 m x 60 m, why do you upsample to 10 m?

p.8 l. 181: not fully clear: I assume integration time for 1 spectrum is shorter than 30 or 60 seconds, but you probably average an amount of spectra. Please clarify what is your integration time (for 1 spectrum) and total measurement time.

p.9 l.194: Please clarify here already that the instruments point towards the sun during measurements.

Section 3.1: Please reformulate 3.1 title to something more specific, something like 'campaign day with APEX overpass'

p.10 l.235: The absence of photolysis in the evening/night plays an important role as well.

p.10 l.248: The DoF should be taken into account to get an idea on how much layer information can be extracted

p.10 l.255: It would help the reader to clarify that the 2 sec. measurements are very sensitive to local effects, e.g. diesel truck next to the mobile in situ instrument.

Fig. 3: The stations of Landshuter Allee and Stachus were closely crossed by the mobile in situ. It would be nice to add the LfU station measurement to the time series (b) and/or (c) and the time of co-located measurement.

p.14 l. 320: Not clear to me why it is mentioned that uncertainties of the reference SCD is negligible. VCD errors from mobile measurements can be substantial (20-30%).

p.16 l.347: It is rather due to the relatively high uncertainty of both types of measurements, not only the airborne measurements.

Technical corrections

p.2 l.26: Because of these localized emissions **and the relatively short lifetime of NO_2**,...

p.5 l.76: Fig. or Figure. Please make it consistent throughout the work.

p.9 l.206: R. in R. Richter can be removed?

p.9 l.212: an hand-held → a hand-held

Figure 2 and other plots: indicate time is in UTC on the axis, in a similar way like done in S2 and S3.

p.23 l.495: …and the detection of emission plumes from larger point sources **and cities.**

p.23 l.499: shows → show