

General comments

The paper is a Measurement report on urban vertical profiles of atmospheric CO₂ and CH₄ in situ measurements. The measurements were collected during 11 intensive period covering days, roughly every month. The platforms used alternate UAV (sampling air directly injected in a Picarro) and touristic tethered balloon. The data is commented through a general overview of the dataset, through examples of daily boundary layer development and its link to vertical profiles of trace gas species, and finally through a case study of the influence of nearby coal plant exploiting high resolution WRF simulation.

The collection of vertical profiles in repeated intensive periods is certainly valuable and such measurements could ultimately contribute to a better quantification of urban emissions.

Here, a few case studies are selected and analyzed. The strategy behind the selection of the case studies is not really explained. The results on BLH development are in essence short pedagogical illustrations of expected atmospheric behavior; they do not bring novel information.

Since the manuscript is intended as a measurement report, not a full research paper, thorough analysis of all the collected cases is not required nor needed. General description of the observations was included along with several cases chosen that are interesting from pollution transport modelling point of view.

As a part of general description of the obtained data and a background upon which pollution plumes events were observed, BL diurnal dynamics was analyzed. As this part may seem unnecessary and bookcase to a reader accustomed to the subject, valuable conclusions are reached: 1) validity of the utilized methods is proved, 2) a baseline diurnal variability of the BLH to investigate events upon is established. Furthermore, an assumption of “standard” BLH diurnal course should not be done freely. It may not be that be obvious in urban areas, and in a complex terrain even more so. In fact, observation of any bookcase features in real atmosphere is quite rare and worth showing.

The profiles with CO₂ enhancements are left half unexplained, even after mobilizing a high-resolution simulation. The couple of CH₄ profiles are simply introduced in a figure but no fair analysis is offered.

The shallow and descriptive analysis of the case studies falls short of demonstrating the value of vertical profiles for urban GHG emission research.

The presented manuscript is meant to be a measurement report, not a research article. The main scope is to present the dataset together with the general background of greenhouse gases measurements in urban areas and a summary of the key findings. According to the ACP Measurement report description¹, this type of publication may include the results of more limited scope than in research articles.

Given the lack of novelty extracted from the data reported here, this paper could be reworked to improve the case studies and their interpretation, and to be considered for submission as a dataset description paper than as an ACP measurement report.

In our opinion, scarcity of this type of data, collected regularly over an entire year in an urban area, and on top of that, in the city which is located in a concave terrain, makes them more than desired by the modelling community. They provide a mean to verify modelled BL dynamics in

complex urban areas. The unexpected added value of encountered plumes was analyzed in detail. While this is true that the extensive dataset description does not belong to a research paper, the detailed analysis of cases which is supported by atmospheric modelling, does not belong to a dataset description paper either. This is why a measurement report is the best choice in this case.

Specific comments

L7 Abstract: indicate maximum altitude reached for each platform?

Max altitude information added.

Introduction: I find the introduction theoretical and generic. It could be reinforced on developing a more solid argument for the vertical measurements reported here and lay the ground for the selected case studies (e.G. CO2 point sources in a mixture of urban emissions).

The introduction is supposed to introduce the reader, who is not necessarily familiar with the field, into the research problem. It is impossible to do without theoretical and generic sentences. The section was supplemented by a justification on the need of vertical profiles of GHGs.

L31 I suggest to replace ‘development’ by ‘validation’.

Changed

L31 : ‘and also in the calibration and validation of satellite-borne measurements’ – this is true only for profiles that span full troposphere and lower stratosphere

This aspect is included in the discussion.

L34-47 It is not immediately clear what is the point of this paragraph. Please highlight to the reader the relevance of this paragraph

The paragraph was extended.

L38 ‘The variability... ‘ - this is relevant for CO₂, but other GHG (CH₄) deserve a significantly different description.

The sentence “variability of GHG fluxes is linked to land use and land cover” is true for both CO₂ and CH₄. Human activities releasing GHGs is also true for both gases. The differences are highlighted in following sentences. The paragraph was rewritten.

L50-52: please also include vertical profiles from tall towers, and aircores in the discussion

Profiles from tall towers were already included – see Richardson et al. 2017, aircore systems were added to the discussion.

L55 in this case UAV with discrete sampling should be differentiated from aircore sampling in their ability to achieve detailed vertical resolution

corrected

L140 please provide this literature review and the other reason for this choice

(McKinney et al. 2019, doi:10.5194/amt-12-3123-2019, Hedworth et al. 2022, doi: 10.3390/drones6090253) The text has been extended “Furthermore, since the air inlet was located above the balloon gondola, during the descent measured air might be contaminated with the passengers breathing”.

L157 the paper should briefly mention how is the WMO calibration scale propagated to the working standards

A sentence was added: For maintaining the WMO scale the laboratory is participating in a periodic intercomparison exercises.

L159 for the 200 m tubing is a flush pump used or is the Picarro pump sufficient?

modified

L254+ what are the meaningful spatial resolution (if applicable) of land surface databases? Is it relevant and justified to use 200m/1s resolution for the simulation? Given the reason for modelling given at L77 this complex model configuration is maybe an oversize solution?

Modified. The resolution of emission databases is insufficient to be able to resolve point sources, especially in highly heterogeneous urban environment. Parametrization of unresolved features usually leads to increased uncertainty of the model. The complex model configuration is a part of extensive analysis that should not be in a data description paper, but it certainly does belong to a measurement report, as was argued in the answer to general comments. The modeling system was designed as a part of other task and is the subject of a separate publication. Here we used this system as designed to support the interpretation of observed CO₂ enhancements observed at high altitudes.

Figure 2 could be more interesting to replace daily means in panels B by an envelope extending from daytime mean to nighttime means daily values.

The figure has been modified

Figure 3. Maybe averaged profiles per period of the day and per season could be more explicit?

The authors carefully considered the different methods of presentation of the profile data to make them as readable as possible. The averaging option was also considered, but due to different flights altitude and inhomogeneous temporal coverage the averaging was not possible (it produces artefacts and make the data not representative). We realize that figures can be difficult to interpret at first glance, but in our opinion this method is the most appropriate.

L292 I would not describe the interpretation of this figure as ‘easily’ identified – given the density of the figure the wording sounds a little bit ironic.

The paragraph was rewritten, the sentence in question was rephrased.

L293 please define SBL determination in this context and describe the data stratification that was performed to arrive at these mean values.

The text has been modified

Section 3.2 is interesting as academic illustrations but it is unclear what is the added value of this description. The selected academic examples are not put in the perspective of new information that would be expected from such a paper.

Establishing a background BL dynamics for the dataset is important for the following case studies. On top of that, observation of “academic” weather features in real atmosphere is not that common as it may appear.

Figure 4 – too many profiles: the visual clutter and the colors make it challenging to follow the interpretation. Given the title of section 3.2.1, why show all day’s measurements? Top row in the figure do not bring information.

The colors for all the figures were adjusted according to ACP accessibility guidelines. Small daytime variations in measured parameters are still variations and not showing them would be an omission. In this case, also valuable information can be obtained: for example, the highest wind speed in the whole profile was measured at 14:56UTC (around 17:00 local time), late afternoon when a short-time increase of wind speed is often reported in the area by aviation users and weather office forecasters. This is a time when daytime turbulence starts to decline and a gradual decrease of wind speed should be observed. This feature is worth investigating further and may potentially be beneficial for the local weather forecasting (information obtained directly from the aviation forecasting office).

L326-327 : are these the only two flights where this enhancement has been observed? Or are they just selected examples? How are they selected? How representative are they?

Our intention is not a full analysis of all of the events, as this is a measurement report, and not a comprehensive research article. These two events presented in the main text are the most clearly observed plumes that have been encountered – in two out of 12 measurement campaigns. Others were not that clear, but still noticeable – for example, CO₂ peaks at 19:41UTC in April (Fig. S7), or CH₄ peaks at 250 m agl at 02:15 UTC in June (Fig. S9).

L345 remind what different tagged tracer were included.

See section 2.4 line 270

Figure 6 why not also show CH₄?

CH₄ plume was not detected in the campaign 5, see Figure S13. Campaign 7 CH₄ plumes are presented in Figure 8.

Figure 7 so the likelihood of source receptor relationship is fairly well established for this case, but how useful is it? it would be interesting to show also the simulation using total CO₂ emissions next to the power plant tagged tracer

The purpose of presenting the figure 7 was to confirm the origin of CO₂ enhancement observed in the vertical profiles. While the manuscript is focused on the presentation of the dataset, the additional model analysis (being the subject of the separate paper) were not consider by authors here.

L349 So what may have caused this enhancement, comparable in importance to the other one associated to the power plant? How would that be processed? What other important sources are influencing the measurements in this dataset?

There are several possible CO₂ emission sources located in the urban areas which may influence the observed CO₂ molar fraction. Observed CO₂ enhancements located far above the inversion layer clearly seen in the profiles had to be attributed to one of industrial high emission sources existing nearby. It has been confirmed by numerical simulation presented on fig.7.

L350-355: is it possible that the choice of 200m spatial resolution is not appropriate or running out of control? How sensitive is the simulation to injection height? Injection velocity and gas temperature?

The detailed investigation of model configuration and performance is out of the scope of this measurement report.

L360 could the same information be obtained with a simpler approach?

Probably yes, although the results of simplified analyses based on e.g. Gaussian plume models could also be questioned due to a number of simplifications in this method. Since the authors had the opportunity to use a high-resolution model developed in other studies, they used it to demonstrate the origin of the observed plume.

L364 what is a quasi gaussian plume here?

We agree that quasi gaussian term is not precisely used here (it is rather referring to the approximation of the probability distribution rather than gas plume shape. The term was removed from the text.

Fig 8 why not also show CO₂ here?

The CO₂ was presented and discussed on previous section (Fig. 6). It was decided to separate CO₂ and CH₄ cases into separate sections to make the text more clear and better organised.

Section 3.3.1: there is no articulated information in this section, I suggest to remove it completely.

The information we convey here is that while for CO₂ it was relatively easy to locate the plume sources, it is not that obvious for CH₄ – this GHG is more complicated in this regard as there are numerous possible sources, and more sophisticated data are required to identify them in the specific events.

L375-378 I find this statement poorly supported by the current text. However I assume that deeper work on the interpretation of the dataset may ultimately support such a finding.

Observational data, especially these describing “standard” dynamics of the weather parameters, are extremely valuable for validating of model performance.

L380-381 Same as above, I find this statement poorly supported by the text.

The sentence was supplemented by highlighting a need for more sophisticated data in case of methane plumes source identification.

Conclusion: I suggest to finish the conclusion with some opening toward potential applications and suggestions rather than on an 'impossible' measurement (I agree that reporting negative findings is useful for the community but maybe elsewhere in the conclusion). Maybe further research using different anemometer would solve the problem? or ground based lidar if available?

A recommendation of using different wind direction measurement methods was added. “Impossible” was rephrased to “unreliable”. This report describes in detail the methodology of the measurements, hence any recommendations, including those coming from a negative experience, should be emphasized.

Editorial

L32 : all 'these' components- not 'the'?

done

L57ff : this paragraph is challenging to read. I encourage the authors to review the logic, and to simplify with shorter sentences

Paragraph modified

L361 maybe this section should be numbered 3.4? why is the CH4 case study numbering one level lower than CO2?

done