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Atmospheric Measurement Techniques Discussions

Interactive comment on "Integration and calibration of NDIR CO_2 low-cost sensors, and their operation in a sensor network covering Switzerland" *by* Michael Mueller et al.

Anonymous Referee #2

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Review of "Integration and calibration of NDIR CO2 low-cost sensors, and their operation in a sensor network covering Switzerland" for AMT, by Mueller et al.

The manuscript describes the calibration, deployment, data processing, and data quality filtering for a network of low-cost sensors deployed in Switzerland. The authors have put a large amount of effort into this process and clearly a lot of careful thought into achieving the most high-quality data product one can get from these sensors, and this is to be applauded. This should be published in AMT, as this information provided here can guide many researchers across the world interested in deploying low-cost CO2 sensors. My main issue is with the final pronouncement of the uncertainty of the

sensor data, which is stated to be 20 ppm at 2-sigma but not explained. Many different statistics are shown in the paper, but it's not clear which one is being used to assess the overall possible accuracy of the sensor network. Otherwise, all my comments are minor and only needed for clarification.

Comments:

L10: LP8 should be defined (a commercial low-cost non-dispersive infrared (NDIR) CO2 sensor)

fig S6-S9: caption or legend should explain gray vs. black points.

P2L9: awkward wording. should read "..is crucial for both high data quality and reliable and cost-efficient operation"".

P2L19: what constellation? perhaps the authors meant "a low-cost sensor network".

P2 L28 comma should be period?

P3, lines 2: Earlier (P2 L39) both the HPP and the LP8 were described as "low-cost", which are you referring to here?

Same comment P3 L18. Perhaps it would be better to not describe the HPP's as low-cost on P2 L39 (medium-cost instead, perhaps), to avoid this confusion, as I believe this refers to the LP8 (next sentence makes that clear).

Fig. 2, it is hard to see where the LP8 resides within the white box. could a second panel be added here with a schematic? I still wonder about response time. It is hard to see what kind of opening there is.

Eq 1-4: chi_co2 is not defined at all here. Presumably mole fraction, from equation 2. should be stated along with units. And this of course is not the dry mole fraction, right? Please state this.

p5 L6: Here CO2,wet is the same as chi_co2 above? keep consistent.

P5 L6, only this dilution effect is needed to account for water vapor? Is there no additional effect of water on the measurement (as there is in CRDS for example)? Perhaps point to Fig. 3 here which shows that there is no RH dependence below the threshold RH.

P5,L11 CO2 mole fraction (not concentration?)?

P5, L17 - which of these two is used finally, eq 4 or 5? [Later this explained, that both are used and evaluated - perhaps note this here to avoid confusion].

Table 1 - is the altitude the altitude of the sensor above sea level (i.e. elevation + height of sampling pole), or the elevation of the site? It would be useful to have both. Perhaps this is addressed later, but were the LP8's colocated on the same sampling line as the high-precision instruments (either next to the sampling inlet or pulling from the same line?).

Section 2.4 title should be "data" not "date". P6 L20 = all sensor units or just the LP8 units?

P6 L30 - Reference to Section 3.3 would be nice here for the reader to know it's coming.

P7L10 - to ask my previous question again, out of curiosity, how was the "in parallel" achieved? The LP8 sensor units do not draw air in through an inlet, so presumably the inlet to the Picarro was located very close to the opening in the LP8 sensor box?

P7, L21, I'm not super clear on this f(t) step function. Perhaps a figure illustrating how it's determined during calibration?

P7 L18, How is this uncertainty of the pressure interpolation known? (has this pressure been evaluated against a measurement somewhere)?

P8L14: should be "an LP8".

Section 3.5 (and maybe elsewhere): please be consistent between CO2,cal and CO2,CAL (case of subscript).

Also, clarify this quantity relative to the equations earlier (page 4 & 5): is this CO2, dry from p5, line 6, which is derived from Co2,wet as computed using equations 4 or 5 (which one?), where in those equations it is referred to as x_co2?

Perhaps remind the reader here that CO2,CAL is the calibrated value using the laboratory calibration from the chamber and co-location experiments where the parameters to those equations (4 &5) were determined.

p11L15, does this include night-time periods, or only 13-17?

p11, L20 Can the authors include a figure of this time series? It would be nice to see if drift is typically long-time scale monotonic drift, or if it is variable in time from one to the next windy period, indicating that the drift may not be captured by this method due to the (in)frequency of windy periods? Or to show if maybe a linear fit in time to this offset might work better?

p12 L15 remind us what this is in local time?

p12 Fig 6 & text, this is a nice analysis to indicate the accuracy of your calibration during windy periods. Although would the authors expect many of the LP8 sites to behave more like HAE, as they are often found in urban areas at low height?

p12 L18 - is this what is meant by this sentence, that some of the LP8 sites are treated a bit differently with additional filtering prior to comparing w/ high-precision sites? Perhaps another sentence would explain this better - time filter on wind direction?

P13 L33 awkward phrasing. Perhaps, "like that encountered indoors, and does not include a pressure correction" (or the effect of pressure in the calibration).

P13 L34: "not accurate enough" is not really quantitative - one could say that 20 ppm is not accurate enough either. Rephrase perhaps, that it is not as accurate as can be achieved with this sensor as you show in (a) and (b)?

Fig 9: indicate that the different colours represent different individual sensors when all

are co-located (this took me a while to realize from the legend).

P16 L12: "long-term accuracy", what quantity exactly is being reported here? The range of the deviations from the reference instrument after drift correction? Accuracy is not supposed to be a quantity, it is qualitative, like "good" or "bad". I think here it should state "error" or even better, explain the exact quantity that is calculated here. (mean difference, range of differences over all the sensors, etc.). Later references to accuracy are valid (e.g. " the accuracy can be improved".. etc. is fine).

p19 L25: relation should read "relationship"

p21 L9: This is misleading - the calibrations themselves did not account for RH dependence; rather the water vapor correction was applied, and the comparison with high-precision data showed the RH dependence was not there until a threshold was reached. Perhaps cite Fig. 3 here.

P21 L34. The authors have done such a great amount of work to evaluate these sensors, that to boil it all down to this range seems to do it diservice. Please state what this number is and how it was calculated.

P21 L37: And where is this 20ppm shown? It is not clear where this comes from at 2-sigma - is it from the RMSE shown in the figures?

P22 L1: last sentence is awkward.

Data Availability: I encourage the authors to ensure the data is full available prior to publication. That is my understanding of the rules of this journal.

SI, page 11 there is a non-English word there!!

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