Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., author comment AC1
https://doi.org/10.5194/amt-2021-120-AC1, 2021

Reply on RC2

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Author comment on "The Berkeley Environmental Air-quality and CO_2 Network: field calibrations of sensor temperature dependence and assessment of network scale CO_2 accuracy" by Erin R. Delaria et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-120-AC1, 2021

We kindly thank the two reviewers for their constructive and thoughtful comments. We have incorporated the reviewers concerns into the revised manuscript as indicated below and in the document with tracked changes. Reviewer comments below appear in **bold** text and our responses are in standard font.

Response to Reviewer #2

Delaria et al present a paper on field calibrations of CO2-sensors and in particular on the correction of the temperature dependence of the sensors in a network. The authors state that temperature correction of individual sensors is necessary for achieving a good data quality. Individual sensor calibration can be done based on laboratory calibration which is, however, labor intensive and might defeat the purpose of using low-cost sensors. The authors therefore propose an in situ field calibration approach.

This is a well written and very relevant paper as dense sensor networks are promising for assessment, verification and tracking changes of urban CO2 emissions. This paper should be published in Atmospheric Measurement Techniques, however, I have a few issues that should be addressed:

- The authors mention that there is a temperature dependence in the residuals after correction of pressure and temperature effect according to the ideal gas law. This remaining temperature dependence varies for individual sensors in magnitude and sign. The authors do not provide any explanations or hypotheses on the causes of the temperature dependence, which would, however, be helpful for the reader.

We agree with the reviewer that it would be very helpful to know what the source of this temperature dependence is. We do not, however, try to discover or speculate as to the root cause of the problem, due to the limited availability of information on Vaisala operation from the manufacturing company. As we discuss, the problem may be more prevalent with older sensors. Our hypothesis is that it may have something to do the electrical control for separation of the optics in the Fabry-Perot interferometer, though this is purely speculation. We have added to the revised manuscript a description of the Vaisala principles of operation, in case the reader finds this useful. We leave it to the reader to form their own hypotheses.

- Figure 2 shows an example of the temperature dependence of a CO2 sensor. There is a very strong linear temperature dependence. Figure 3 shows another example of a strong and this time non-linear temperature dependence of opposite sign. In both examples, there is of course some variability in the derived temperature dependence, e.g. caused by comparison of CO2 as measured at two distant locations (deployment and reference site). However, this leads to some uncertainty in the parameter estimation for the temperature

correction. The authors therefore should provide uncertainty calculations for the temperature correction. I expect that at least for some sensors, the uncertainty in the parameter estimation for the temperature correction is around or larger than the ambitious data quality goal (1ppm). Actually, consideration of uncertainty in the data correction method is completely missing (also for drift correction) and should be included. Specifically, uncertainty considerations should be made for the calculations according to equations 6 and 8. It would then be interesting to see how the uncertainty of individual corrected CO2 sensors compares to the network error as estimated later in the paper. The strong temperature dependence of sensors as shown in Figs. 2-6 give the impression that the calculated network error is too optimistic.

- The authors claim, albeit implicitly, that field calibrations lead to similar performance than sensors calibrated in the laboratory. It would have been interesting to demonstrate this by deploying laboratory calibrated CO2 sensors and comparing the data postprocessed using the the two different calibration approaches. I know this is too much for now, but would be insightful in the future.

We agree that this would have been a great and very insightful experiment. Limitations with accessing sensors in the field due to the Covid-19 pandemic, and other time limitations, resulted in us unfortunately being unable to test sensor temperature dependence in the laboratory.

The following line edits have all been made unless otherwise indicated. We have commented where appropriate.

P5, L139/140: Sentence is linguistically not correct, please correct.

P6, L. 171: "… the either the …" correct.

P6, equations 4 and 5. med_mT is not defined. mT has been defined, but it has not been stated that med_mT is the median of the slope.

P7, L. 198: "… and without and adjustment …" delete second "and".

P8, L. 223. The authors mention that results were identical when using a multiplicative correction term. It is difficult to understand what this exactly means. How has a multiplicative correction term be determined, how does the equations look like? The authors should provide more details (e.g. in the supplementary Information).

This had been explained in more detail on L166.

P9, L. 265. The authors evaluated the network error based on a semivariogram. A sentence what a semi-variogram is and the underlying idea would be helpful.

We have added the equation for semivariance following suggestion by reviewer #1. ",…of gamma_nn vs distance,…" was also added to this sentence.

P11, equations 11 and 12. Notation can be improved, it is unclear which index is used for

summation.

P11, L. 324. It is not defind what "STP" stands for. Should be mentioned.

Variable had been defined in L102. A further definition of STP has been added to this line.

Fig 6a. The Picarro signal is not visible in the plot for 2018.

This has been fixed.

Figure S4. Missing data are filled with straight lines (orange and red), should be corrected.

This has been fixed.