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Atmospheric Measurement Techniques Discussions

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Interactive comment

Interactive comment on "Performance of NO, NO_2 low cost sensors and three calibration approaches within a real world application" *by* Alessandro Bigi et al.

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One issue the paper should address is the relationship between the manufacturers' specifications and in field performance. What is the same, what different?

The information provided by the sensor manufacturer (Alphasense) is not extensive, especially regarding the long-term use of these sensors in ambient conditions. The results presented in our study refer to the operation of these sensors in varying ambient conditions for about half a year. It is not clear to what extent the information provided by the manufacturer can be compared to our results because the test settings may differ. Therefore, we prefer to refrain from detailed comparisons. However, we present

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Discussion paper

in detail the ambient conditions encountered by the sensors during the campaign and provide measures for the accuracy achieved during the calibration and the consecutive deployment period. Further details on the performance are now added in page 11 and 12 of the enclosed latexdiff manuscript. This independent information will support users in deciding if the performance of such sensors is sufficient for their applications.

The field is very fast moving. I recognize that much of this work was done prior to Kim et al. (2018). However that paper was posted on AMT before submission of this one and it reports results that are relevant. For example, that the Alphasense NO2-B43F sensor has cross-sensitivity to CO2 and not to NO. They also report a measurement of temporal drift that could be a point of comparison. AMTD Interactive comment Kim, J., Shusterman, A. A., Lieschke, K. J., Newman, C., and Cohen, R. C.: The BErkeley Atmospheric CO2 Observation Network: field calibration and evaluation of low-cost air quality sensors, Atmos. Meas. Tech. Discuss., in review, 2018.

Results from Kim et al. (2018) and from our study cannot be compared on a one to one level as the performed approaches differ. The results in our study were derived from field deployment where the sensors were operated next to reference instruments, while Kim et al (2018) performed a remote calibration. Moreover, contrarily to Kim et al. (2018), we do not present in our study results obtained in the lab. We included Kim et al. (2018) in the discussion about sensor characteristics together with other relevant studies that contribute to this important topic (paragraph 3.1, page 9 of the enclosed latexdiff manuscript).

The paper should describe an intrinsic noise level and how the authors prevent the methods from overfitting.

The +/-2 σ noise level was estimated under field conditions during the deployment period (and not the calibration period) using the estimates by the Random Forest algorithm. It includes modelling effects, effects related to the differences in measurement principles between sensor and reference instrument, sampling effects and effects from the small differences in measurement location. The noise resulted 1-2 ppb larger than the 2σ noise derived by Kim et al. (2018) under lab conditions. This information is now added in the revised manuscript (page 12 of the enclosed latexdiff manuscript).

The ambient conditions the sensors encountered during calibration and deployment periods differ. This approach was selected to be able to detect deficiencies in the calibration models. The application of the sensor model during the deployment period led to reasonable results. Therefore, we conclude that the models do not suffer from large overfitting. It is worth noting that the consistency of Random Forest algorithm, i.e. its minimum generalization error, is theoretically supported in Breiman et al. (2001). Possibly, the sensor models could be further simplified by omitting less important variables. However, in this case the impact of particular conditions on the sensor signal might have to be investigated in a more controlled environment.

The paper speaks to interurban gradients. Is the discussion any different than simply describing the detection limit of the sensors?

The detection of inter-urban gradient and the detection limit of the units are tightly connected, but there are important differences: the latter detection is based on the probability density function of the sensor's response and how this compares to the true concentration; the former detection is associated to the combination of the response by two similar sensors and therefore to their combined probability density functions. We also believe that Figure 10 brings significant added values compared to other plots in the manuscript and not immediately available from e.g. Figure 9 and S27 of the original manuscript:
– it is based upon all sensor units, therefore it includes the variability due to hardware and to the deployment site
– it is of immediate use for planning spatial monitoring of NO, NO2 using by this class of sensors in urban areas (within a realistic framework of field calibration including relocation)

– it synthesizes the limitations and the potential of these devices for their application in urban environments (several representative European cities).

In the conclusions, it would help if the authors offered some opinions about directions for use of this class of electrochemical sensors. Something in the form that synthesizes their results along with those that are in the overview presented in their introduction.

We partly rearranged the final part of the Conclusions to better synthesize the results (including noise) and to better highlight our view about the directions of most suitable use for this class of sensors (see pages 13-14 in the enclosed latexdiff manuscript).

Minor Comments
- P9 L19: the bracket has to be closed.
- P11 L27, Figure 10 caption: “blue dots” should be replaced by “red dots.”
- Appendix A, Equations A6: typographic errors.
Thanks, these typos are now fixed.

References

Breiman, L. Random Forests. Machine learning, 2001, 45(1), 5–32.

Kim, J.; Shusterman, A. A.; Lieschke, K. J.; Newman, C. Cohen, R. C. The BErkeley Atmospheric CO2 Observation Network: field calibration and evaluation of low-cost air quality sensors Atmospheric Measurement Techniques, 2018, 11, 1937-1946

Please also note the supplement to this comment:
https://www.atmos-meas-tech-discuss.net/amt-2018-26/amt-2018-26-AC1-supplement.pdf

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