Response to Reviewers

Dear Reviewers,

We are grateful for your comments and suggestions, which have helped us improve the manuscript. The necessary revisions have been implemented, which can be found in the attached file (highlighted in yellow). Below, we provide responses to your comments and suggestions, along with corresponding changes made in the revised manuscript, where applicable.

Sincerely,

On behalf of all authors,
Ayah Abu-Hani

Response to Reviewer #2

The manuscript presents a framework for the global machine learning (ML)-based calibration models for NO2 and NO electrochemical cells using data from low-cost sensor units (SUs) utilized in a previous study by Bigi et al. (2018). This study mainly focuses on calibration transferability among SUs when deployed at the same location (or with the same environmental conditions) and different locations (or with different environmental conditions), given that no explicit overlap exists between the training and testing data distributions. This approach uses a simple standardization to account for sensor-to-sensor variations. In addition, the author claims that a potential improvement in model transferability was achieved by using O3 from nearby regulatory air quality monitoring stations.

Thank you for taking the time to review our paper. We do appreciate your feedback and have carefully considered your comments. The manuscript is revised accordingly.

Minor comments:

Figures 1 and S2: Where are the central (median) lines in the Box plots? Please include the median line and mean (with a symbol) in the figures.

The figures are now modified as in the updated manuscript and Supplement (Fig.1 and Fig.S2).

Figure 4: What does the negative sensor voltage convey? No mention of this in the manuscript.

Thank you very much for your remark regarding negative sensor voltages. The caption of Fig.4 is now modified to highlight this point with a brief statement.

A more detailed explanation can be as follows:

The type of low-cost sensors in our study are electrochemical cells (ECs) on electronic sensor boards. In presence of the target gas, ECs produce a small electric current which is approximately proportional to the concentration of the target gas. The electronic sensor board amplifies this signal and converts it to a voltage, which is then the raw signal that we process.

However, the current of the EC is also affected by other ambient parameters such as temperature and humidity, which can cause the sensor output to drift. At low concentrations of the target gas, this electric current can also be slightly negative. Therefore, the electronic sensor board applies an electronic zero offset to the signal to ensure always a positive sensor output voltage.

The auxiliary electrode is affected by ambient parameters in the same way as the working electrode, however, it is not affected by the target gas, as it is not exposed to it.

An electronic zero offset is added to both working electrode and auxiliary electrode. Please note, that these electronic zero offsets are independent of each other, i.e. they are likely to be slightly different. If the zero offset of AE is significantly higher than the zero offset of WE, then WE-AE will be constantly negative. Furthermore, the chemical activity on auxiliary and working electrode may be different from each other, which could also lead to a negative sensor signal (WE-AE).

A more complete formula to calculate a compensated sensor signal would actually be (WE – WE_0) – (AE – AE_0) (or parametrized variations of this). However, as WE_0 and AE_0 are constants, applying "Z-score" after performing WE-AE, make WE_0 and AE_0 unimportant to apply.

Appendix A and Line 222: Although MAE was mentioned as one of the measures for quantifying the deviation between the calibrated values and their corresponding reference values, it was never discussed in the main manuscript. Tables S1-S6 and Figures S3-S6 are not referred to in the main manuscript.

Thank you for pointing this out. Our discussion is focusing on R^2 and RMSE, so, we have modified the manuscript accordingly (P.11, L.225). However, MAE results still exist in tables in the appendix in case they might be for interested researchers.

The manuscript is modified to refer to Figures S3-S6 (P.16, L.299) and Tables S1-S6 (P.12, L.241).

Line 232: RMSE units are missing.

Units are now added in the updated manuscript (P.11, L.335 & L.337).

Figure 9: In the caption, please include how the RMSE relative improvement (%) was estimated.

Thank you for the suggestion. The relative improvement was computed using the formula: [(new−old) / old × 100%]. The caption in the manuscript is modified accordingly (P.14, caption of Fig.9).

References

Bigi, A., Mueller, M., Grange, S. K., Ghermandi, G., and Hueglin, C.: Performance of NO, NO 2 low cost sensors and three calibration approaches within a real world application, Atmospheric Measurement Techniques, 11, 3717–3735, https://doi.org/10.5194/amt-11-3717- 2018, 2018.

Smith, K. R., Edwards, P. M., Ivatt, P. D., Lee, J. D., Squires, F., Dai, C., Peltier, R. E., Evans, M. J., Sun, Y., and Lewis, A. C.: An improved low-power measurement of ambient NO2 and O3 combining electrochemical sensor clusters and machine learning, Atmos. Meas. Tech., 12, 1325–1336, https://doi.org/10.5194/amt12-1325-2019, 2019.