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Uncertainty in air quality observations using low-cost sensors

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Air pollution poses a threat to human health, and the WHO has classified air pollution as the world's largest single environmental health risk. In Europe, the majority of the population lives in areas where air quality levels frequently exceed WHO's ambient air quality guidelines.
The emergence of low-cost, user-friendly and very compact air pollution platforms allowing observations at high spatial resolution in near real-time, provides us with new opportunities to simultaneously enhance existing monitoring systems as well as enable citizens to engage in more active environmental monitoring (citizen science). However the data sets generated by low-cost sensors show often questionable data quality. For many sensors, neither their error characteristics nor how their measurement capability holds up over time or through a range of environmental conditions, have been evaluated.
We have conducted an exhaustive evaluation of the commercial low-cost platform AQMesh (measuring NO, NO_2, CO, O_3, PM10 and PM2.5) in laboratory and in real-world conditions in the city of Oslo (Norway). Co-locations in field of 24 platforms were conducted over a 6 month period (April to September 2015) allowing to characterize the temporal variability in the performance. Additionally, the field performance included the characterization on different monitoring urban monitoring sites characteristic of both traffic and background conditions. All the evaluations have been conducted against CEN reference method analyzers maintained according to the Norwegian National Reference Laboratory quality system.
The results show clearly that a good performance in laboratory does not imply similar performance in real-world outdoor conditions. Moreover, laboratory calibration is not suitable for subsequent measurements in urban environments. In order to reduce the errors, sensors require on-site field calibration. Even after such field calibration, the platforms show a significant variability in the performance due to changes in the environmental conditions.
Currently there is a lack of testing to ensure adequate sensor performance prior to marketing such instruments. Even when manufacturers provide detailed specification sheets, there is little guarantee that the specifications can actually be met in real-world conditions. Data quality is a pertinent concern, especially when citizens are collecting and interpreting the data by themselves. Poor or unknown data quality can lead to incorrect or inappropriate decisions. We present the experiences gained within the EU project CITI-SENSE, where low-cost sensors are one of the tools employed to empower citizens in air quality issues.