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Networks of Air Quality Sensors and Their Use for High-resolution Mapping of Urban Air Quality

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One of the most promising applications of low-cost sensor systems for air quality is the possibility to deploy them in relatively dense networks and to use this information for mapping urban air quality at unprecedented spatial detail. More and more such dense sensor networks are being set up worldwide, particularly for relatively inexpensive nephelometers that provide $PM_{2.5}$ observations with often quite reasonable accuracy. However, air pollutants typically exhibit significant spatial variability in urban areas, so using data from sensor networks alone tends to result in maps with unrealistic spatial patterns, unless the network density is extremely high. One solution is to use the output from an air quality model as an a priori field and as such to use the combined knowledge of both model and sensor network to provide improved maps of urban air quality. Here we present our latest work on combining the observations from low-cost sensor systems with data from urban-scale air quality models, with the goal of providing realistic, high-resolution, and up-to-date maps of urban air quality.

In previous years we have used a geostatistical approach for mapping air quality (Schneider et al., 2017), exploiting both low-cost sensors and model information. The system has now been upgraded to a data assimilation approach that integrates the observations from a heterogeneous sensor network into an urban-scale air quality model while considering the sensor-specific uncertainties. The approach further ensures that the spatial representativity of each observation is automatically derived as a combination of a model climatology and a function of distance. We demonstrate the methodology using examples from Oslo and other cities in Norway. Initial results indicate that the method is robust and provides realistic spatial patterns of air quality for the main air pollutants that were evaluated, even in areas where only limited observations are available. Conversely, the model output is constrained by the sensor data, thus adding value to both input datasets.

While several challenging issues remain, modern air quality sensor systems have reached a maturity level at which some of them can provide an intra-sensor consistency and robustness that makes it feasible to use networks of such systems as a data source for mapping urban air quality at high spatial resolution. We present our current approach for mapping urban air quality with the help of low-cost sensor networks and demonstrate both that it can provide realistic results and that the uncertainty of each individual sensor system can be taken into account in a robust and meaningful manner.

Schneider, P., Castell N., Vogt M., Dauge F. R., Lahoz W. A., and Bartonova A., 2017. Mapping urban air quality in near real-time using observations from low-cost sensors and model information. Environment international, 106, 234-247.