Requirements for a Smart Indicative Ambient Particulate Monitor (SIAPM)

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Limit values for PM10 and PM2.5 given by the world health organisation (WHO) are exceeded worldwide. Effective and efficient clean air strategies hast to be found and to be taken. One of the most important steps for a valuable source apportionment for particles are finding suitable measurement sites for the determination of hot-spots (traffic, industry), urban and regional background concentrations as well as impacts based on long range transports of particles. Another important point is a sufficient measurement quality for particulate matter (PM) to assess the contributions of different sources. In addition, a high time resolution down to minutes and seconds is required to combine particle measurements with meteorological data as well as with gaseous pollutants.

The PM source apportionment during the last decades has mostly been based on measurements carried out by local authorities with approved particle measurement devices. For recent years several small particle sensors has been developed and will be used in addition. Main advantages of these low cost sensors are higher densities of measurement sites as well as big data sets that can be achieved. Disadvantages of particle sensors in comparison to reference PM devices are a lower accuracies and influences on the measurement results due to humidity, changes of temperature and pollution of optics. Other problems that have been observed during our measurements in the frame of the SmartAQnet project [1] are based on unsteady particle properties as changes of refractive index or particle densities. These changes may influence PM measurements with particle sensors dramatically.

The overall strategy of GRIMM in the SmartAQnet project is to start with a scientific scout and to end with a smart indicative ambient air monitor in combination with PM reference technique. First step was using a small optical cell based on the nephelometer principle and improve this cell by using a mini-PC to control an intelligent heating, to run algorithms for PM determination, and handling drifts caused by air temperature changes or pollution of the optics.

In a second step inter-comparisons have been carried out at several locations with hot spot (traffic) or urban background characteristics in Augsburg. A local calibration procedure has been successfully developed by using reference devices of GRIMM, based on aerosol spectrometry. Local calibration means that the scientific scout will be calibrated locally by a PM reference device that is running simultaneously at a different measurement site. By evaluating many data sets it has been find out, that one reference device is capable to calibrate approx. 5 to 10 scientific scouts in parallel. The frequency that is required for local calibration as well as the maximum distance between scientific scout and reference device is depending on the characteristic of the measurement site as well as the pollution level and changes of the aerosol properties. Continuous PM measurements over several months and at different sites with time resolution of 5 minutes have also shown, that scientific scouts at traffic sites has to be calibrated approx. every 3-5 days whereas sites in urban background has to be calibrated only twice per month. New PM algorithms have been developed and successfully tested and allow local calibration for different PM fractions and consider drifts caused by changes of ambient air temperature or pollution of the optics.

Next steps are the improvement of the scientific scout by using a measurement cell with optical particle counting (OPC) and controlling all local calibrations via an intelligent data platform in the SmartAQnet project [1]. This way GRIMM targets to provide scalable smart measurement systems combining indicative and high-quality instrumentation for future networks.

References

[1] Matthias Budde, Till Riedel, Michael Beigl, Klaus Schäfer, Stefan Emeis, Josef Cyrys, Jürgen Schnelle-Kreis, Andreas Philipp, Volker Ziegler, Hans Grimm, Thomas Gratza (2017) SmartAQnet: Remote and In-Situ Sensing of Urban Air Quality, Proc. SPIE 10424, Remote Sensing of Clouds and the Atmosphere XXII, 104240C, doi:10.1117/12.2282698