Urban air quality measurements in Finland and China using a PPS-M sensor

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Concern regarding the harmful health effect of airborne particles has increased the demand for observations and data on the concentrations of harmful aerosol particles. Current methods for observations of the number concentration of harmful particles have yet to become affordable enough to allow the construction of dense measurement stations that would provide data on the high spatial resolution required for effective measures to lower population exposures. A promising, economically affordable and operationally robust method for harmful aerosol measurements are diffusion charging-based aerosol sensors, such as the Pegasor PPS-M (Lanki et al., 2011 Rostedt et al., 2014).

We deployed the PPS-M particle sensor in two Finnish stationary urban air quality measurement stations, one located in the roadside environment and the other in residential area, and in a mobile laboratory (Järvinen et al., 2015). Additionally, two other sensors were installed in a highly-polluted megacity setting in Beijing, China, over a longer time period to evaluate the instruments response in varying aerosol loadings. Because the response of the PPS-M depends on the size distribution of the ambient aerosol, we compared the PPS-M with a range of other particle instrumentation, including and ELPI, MSP Wide Range Particle Spectrometer (WPS), NSAM, CPC, and $PM_{2.5}$ from TEOM.

In addition to studying the PPS-M data, we also performed measurements in which the PPS-M was set up to operate with variable trap voltages applied. The instrument trap voltage is known to affect the particle size-dependent response function, and therefore our aim was to investigate the differences in the PPS signal with different PPS-M trap voltages, and explore the possibilities of using this information to gain insight in on the size distribution using only the PPS-M instrument.

For Finnish measurements, the PPS-M was found to correlate very well with both condensation sink values and lung-deposited surface area, while less correlation was found for mobile measurements. The difference in the response can be attributed to variance of the size distributions between the observations.

For Beijing, the analysis of the size distribution data showed that the aerosol size distribution was highly variable in the Beijing air. k-means clustering of the normalized size distribution data showed that at times, the aerosol was loaded with fresh nanosized particles, while at times the aerosol was clearly dominated by the accumulation size. The variability in the size distribution was also reflected in the PPS-M response, which varied with the aerosol size distribution.

Using the data with variable trap voltages, we were able to develop a calibration expression for total particulate volume and number. Using only the signal of the PPS-M, using the signal ratio at different trap voltages, we could significantly improve the correlation between the PPS-M and WPS number concentration observations. Overall, the PPS-M was found to be applicable as a megacity aerosol sensor, and the variable trap voltage method, while reducing the time resolution of the instrument, produced information on the average size of particles. As the diffusion charging-based sensors such as the PPS-M are fairly inexpensive when compared to other instruments, operate well also on very polluted environments, and require comparatively low maintenance, this potentially improves their attractiveness as components of urban air quality monitoring networks in polluted urban areas.

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