Intercomparison of identical cost-effective particulate matter monitors

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Low-cost particulate matter (PM) sensors are more and more often employed for measuring the fractional mass concentrations of aerosols smaller than 10 and 2.5 µm (i.e., PM_{10} and $PM_{2.5}$), which in turn can be utilized for assessing air quality (AQ). Due to their low cost and compact size, these sensors are excellent candidates for forming dense monitoring networks, thus increasing the spatiotemporal resolution of the measurements. This, in turn, allows for a better understanding of the effects of AQ on human health and climate (Koehler, K. A. and Petters T. M., 2015), especially in highly diverse and variable environments (e.g., inside cities).

Despite latest developments, the performance of low-cost AQ sensors still remains inferior to that of standard/laboratory grade instruments, as pointed out by numerous field studies (e.g., Liu et al., 2020; Stavroulas et al., 2020; kang et al., 2021). This is mainly due to compromises made in their design and technology for achieving compact and low-cost solutions.

Certain limitations of low-cost PM sensors (e.g., inaccurate results at high relative humidity conditions, passive or weak sample flow system, limited use only to direct sampling, electronics/software related uncertainties, *etc.;* Karagulian et al., 2019) can be overcome by embedding them in cost-effective integrated instruments. The latter include Optical Particle Spectrometers that employ modified low-cost PM sensors, pumping systems the improve stability, and user-friendly interfaces having networking capabilities and software for data analysis. Our group has developed such a cost-effective PM monitor, the improved performance and increased applicability of which have been demonstrated at laboratory conditions (Bezantakos et al., 2021).

As a next step here we built and tested 10 identical cost-effective PM monitors (cf. Fig. 1) to form the basis of a dense observational network. We evaluate their performance under real-life conditions by carrying out collocated in-situ measurements with reference/laboratory grade PM instruments. The observations took place in the diverse and variable urban environment of Nicosia (CY). The performance of the cost-effective monitors was evaluated in terms of i) their detection and sizing efficiency (i.e., by comparing the measured sized distributions with those obtained from reference/laboratory grade instruments; i.e., TSI 3330 and PALAS FIDAS 200E), and ii) in terms of the PM_{10} and $PM_{2.5}$ fractional mass concentrations, using the dichotomous tapered element oscillating microbalances (ThermoFisher TEOM-FDMS 1405) as a reference.

Fig. 1: Picture of six of the cost-effective PM monitors built for measuring the size distribution of aerosol particles having sizes larger than ca. 400 nm.

Our results highlight the advantages of integrating low-cost optical sensors in cost-effective monitors, for use in dense networks for PM observations. In addition, the successful implementation of a such a network is demonstrated.

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