RR: Reviewer's response

AR: Author's response

Reviewer 1 comments:

RR:

Review to "Performance analysis of the NanoScan SMPS and the Mini WRAS Ultrafine Aerosol Particle Size Spectrometers"

The authors present performance evaluations of two portable instruments against reference instrumentation for the measurement of particle number size distributions (PNSD) and total particle number concentration (PNC) during the workshop conducted at the World Calibration Center for Aerosol Physics (WCCAP) in Leipzig, Germany, in January 2020. The performances and uncertainties of the NanoScan SMPS (TSI, model 3910), and the Mini WRAS (Grimm, model 1371) were investigated against the WCCAP Mobility Particle Size Spectrometers (MPSS) and Condensation Particle Counters (CPC) using ambient aerosols and lab-generated PSL and NaCl particles. The inter-comparisons were performed both before and after the service and maintenance, and recommendations of timely service, maintenance and calibration were proposed, which will be instructive to the users. The manuscript is easy to follow and fits the scope of Atmospheric Measurement Techniques. However, I feel that the authors could provide more detailed work to demonstrate how service and maintenance improve the performance of the instruments, which will serve as valuable guidance for both existing and potential users. The reviewer recommends accepting this manuscript after addressing the following comments.

AR: Authors thank the reviewer for providing comments for improvement of the manuscript (MS).

Major comments:

RR:

1) The NanoScan SMPS and the Mini WRAS are portable and easy to use. But considering their inferiorities in both the time and size resolution, they may not be a great choice for mobile-platform measurement. Both the NanoScan SMPS and the Mini WRAS are not considered as fast (i.e., time resolution of 60 s). The new generation SMPS (e.g., TSI model 3938) can provide fast scan measurements (e.g., 15s and below, https://tsi.com/products/particle-sizers/scanning-mobility-particle-sizer-spectrometers/general-scanning-mobility-particle-sizer-(smps)-3938/).

AR: Authors agree with the reviewer that the TSI model 3938 can provide fast ultrafine particle measurements compared to NanoScan SMPS and Mini WRAS spectrometers.

TSI model 3938 is a more expensive research instrument and is less mobile, while portable instruments such as the NanoScan SMPS and the Mini WRAS are less advanced, however, can be well suited for mobile measurements (because of the light-weight) and especially point source identification. TSI model 3938 spectrometer is manufactured for different purposes, such as fast scans of particle number size distributions with relatively high particle number concentrations.

The purpose of this workshop was to identify the performance of the NanoScan SMPS and the Mini WRAS compared to high-end instruments such as the regular research mobility particle size spectrometers from different manufacturers or in this case to the reference mobility particle size spectrometer (MPSS) of the World Calibration Center.

RR:

2) If possible, I recommend the authors provide performance evaluations of the instruments based on their factory calibration, and analyze how the performance would change during long-term operations, such that the users could have a professional application note to follow.

AR:

Authors thank the reviewer for the suggestion. It is worth mentioning here that the factory calibration is somewhat different than the tests performed here. The units under test had a different history and different status of service and time since the last calibration. A defined use would be necessary to really be able to compare before and after a certain time of use. The "long-term operation" of the NanoScan SMPS is fine for e.g. daily use for several hours. However, the instrument is not designed for 24/7 (ambient) operation and therefore it is not advertised and should probably not be promoted with a performance test for this application. Isopropanol CPCs are rather suited for short-term measurements and not for continuous monitoring.

RR:

3) The author claimed that the TSI NanoScan SMPS instruments were significantly improved after service and maintenance, based on the comparisons of ambient PNSD measurement before and after maintenance. However, it is noticeable that the ambient PNSD of the two measurement periods are quite different. If the comparison is demonstrated by relative errors (i.e., concentration ratios), I suspect the relative error may still be comparable.

AR: Authors thank the reviewer for the valuable suggestion.

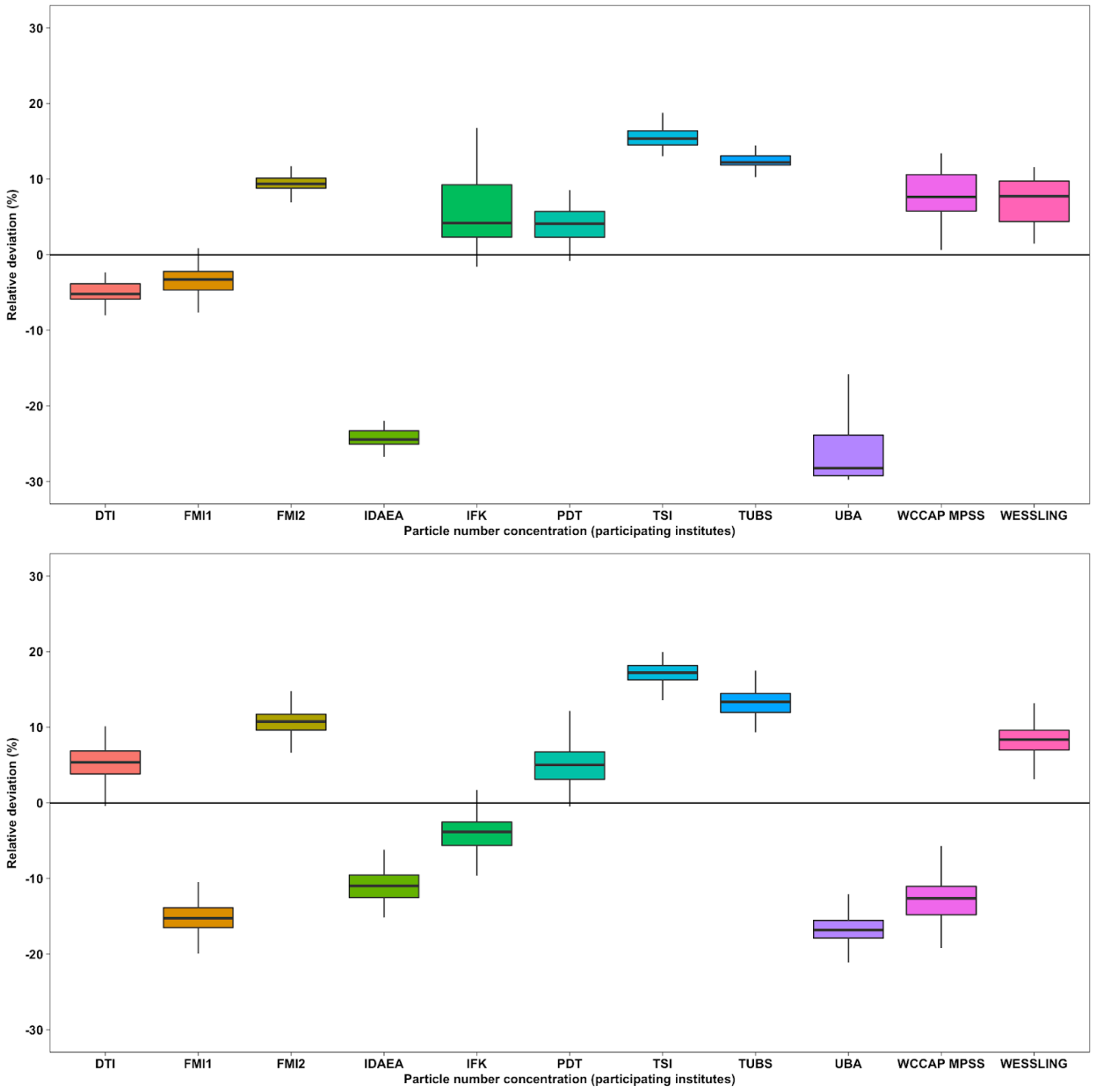

Figure 1: Relative deviation of the calculated total number concentration for the measured distribution relative to the average ambient aerosol distribution.

Here, in figure 1 (a) possible outliers have been identified. From figure 1(b), we suggest that maintenance of the instruments makes sense as all instruments are in the ±20% range.

RR:

4) By comparing Fig. 2 and Fig. 3, I am wondering why the TSI NanoScan SMPS failed to capture the size distribution of particles in the ultrafine mode from the PSL solution, but got reasonably good agreements when measuring ambient aerosols of the similar size range (i.e., 10 ~ 50 nm). Same for the GRIMM Mini WRAS (except for the one from UNICATT).

AR: TSI NanoScan SMPS and GRIMM Mini WRAS spectrometers cannot resolve the monodisperse peaks of single and doubly charged PSL particles due to the limited size resolution (cannot be changed by the user). The ambient particle number size distribution is broad and for PSL, it is quasi monodisperse. Therefore, almost all instruments failed to capture the PSL particle size distribution. If by chance a PSL size corresponding to the bin mid-point diameter would be chosen, the instrument would be able to resolve a monodisperse peak but that would be a special case.

RR:

5) If possible, please clarify how the sizing-relevant parameters (e.g., flow and/or voltage) look like before and after maintenance, especially the NanoScan SMPS from FMI2 which behaves quite differently after maintenance. I think that may help guide the users on how often to service the instrument.

AR:

The information related to flow has already been provided in supplementary tables before and after the maintenance period. However, there was no maintenance done on the voltage (HV of the DMA). For FMI2 instruments, the cyclone and charger are cleaned during servicing and maintenance day. In addition, wick and filters are changed.

RR:

6) With respect to the WCCAP MPSS, the NanoScan SMPS underestimated the PNC in the ultrafine aerosol mode for the intercomparison of ambient measurement, but overestimated the PNC when testing the polydisperse NaCl particles. Do the authors have any explanations for that?

AR: The NanoScan SMPS underestimated the PNC in the ultrafine aerosol mode when compared with WCCAP MPSS for ambient measurement. There is no obvious reason for this. We assume that the inversion matrix (unipolar charging) might be the reason for this discrepancy.

Minor comments:

RR:

1) Table 1 row 1: Please also specify the particle counting technique of the NanoScan SMPS.

AR: This is corrected in the revised MS.