**Answers to referee 2 comments:**

**The study addresses a critical gap in air quality monitoring by evaluating cost-effective alternatives to expensive Condensation Particle Counters (CPCs) for monitoring particle number concentrations (PNC). The use of two distinct sites (Traffic and Urban Background) and a 7.5-month duration provides a comprehensive dataset for evaluating sensor performance under varying environmental conditions. Comparing multiple AQ Urban units (7 in total) and two different reference CPC models ensures that the findings are not biased by a single instrument. Reference size distribution measurements complement the AQ Urban unit measurement series to explain differences in readings relative to the reference CPCs. The presentation of the results is OK. Nevertheless, an uncertainty analysis including influences from particle size and concentration ranges, as well as ambient conditions (humidity, temperature, dilution) and a robust definition of outliers is missing. What is hard to follow are the arguments regarding the size distribution to sensor cut-off size characteristics, partly because the Figures in the supplemental materials are missing, and partly because the explanation of the conversion from escaping current to particle number concentration and average particle size (Count Mean Diameter) in the experimental section is missing.**

Answer:

There was no side-by-side comparison of Airmodus A20 and TSI 3756 CPCs.

Accuracy information has been added to the manuscript.

The accuracy of Airmodus A20 CPC is < 10 % up to PNC 30 000 p cm$^{-3}$. For the TSI 3756 CPC the accuracy is about 5 % when the total particle concentration is below 50 000 p cm$^{-3}$. The accuracy of the DMPS-CPC system is about ±10 %. The changes in the instrument flow rates were mainly caused by the changes in air pressure. The dilution at the Traffic Supersite was applied using a bridge dilution. The laboratory test showed that the accuracy of the bridge diluter was 2 %. In the field measurements, the bridge diluter may be prone to contamination, and the dilution ratio is not constant throughout the measurements. The change in the dilution ratio is determined after the measurement, and the measurement data is corrected using a moving correction for the dilution. If estimating the propagation error using a maximum 10 % error for CPC and 10 % error for the bridge diluter, then the total error is around 15 %.

The flow rates of the CPCs were constantly checked, together with draining of butanol, to avoid interference of condensed water. For DMPS silica gel was changed when needed and the flow rate was adjusted if the deviation was > 1 %. The CPCs and DMPS-CPC system were placed inside the measurement station, so the instruments were in stable condition (temperature and relative humidity). It can be assumed that the temperature and relative humidity of the sample entering the CPCs and DMPS-CPC systems were quite constant during the measurements. The AQ Urban sensors on the other hand were placed outside the container, but the temperature was set to be 40 °C above the ambient temperature in AQ Urban instruments so especially RH should not have affected measured PNC.

The differences in the measured PNC between CPCs and AQ Urban sensors may partly be explained with the instrument accuracy itself. However, larger differences between the measured PNC between CPCs and AQ Urban sensors are caused by the different cut-off sizes and different detection efficiency slopes near the cut points. The AQ Urban cutoff is shallower than CPC as it is defined by the zeroth order mobility analyzer versus heterogeneous nucleation in CPC. The CPC used at the UB supersite had a cut-off size of 7 nm which is closer to the lower measurement range of AQ Urban sensor. The concentration of particles < 10 nm is also relatively low at this site. This means that the two instruments measure more closely similar size particles at the UB Supersite than at the Traffic Supersite where the used CPC had a cut-off diameter of 5.4 nm and the heavily trafficked site has high concentration of particles < 10 nm.

The outliers measured during the instrument comparison period are omitted from the boxplot figures (Figs. 1, 2 and 4) to make the figures layout clearer. This information has been added to the text (line 133) and to the figure captions for figures 1,2 and 4. Below are the boxplot figures with the outliers which show that the outliers measured with all the instruments (different AQ Urban sensors and CPCs).

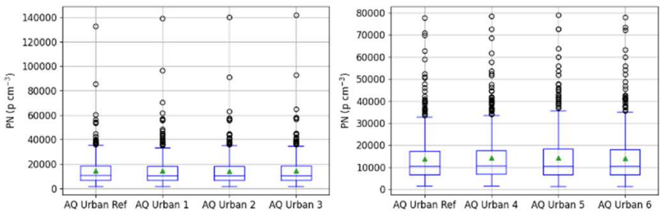



Figure 1 with the outliers.

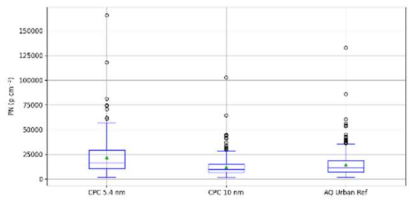



Figure 2 with outliers.

The outliers in boxplot figures are defined so that outliers are the measurement values having (in this case concentration) values larger than upper quartile (Q3) plus 1.5 times the difference between upper quartile (Q3) and lower quartile (Q1).

The correlation plots in Figs. S1 and S3 and the time series of AQ Urban sensors (Fig. S2) show that the high PNC are measured with all instruments which indicate that the high PNC are real and not an instrument artifact during the instrument comparison period except for AQ Urban sensor 4 (Fig. S1b) which shows few points that deviate from the linear correlation. In the manuscript, it is mentioned in figure captions that the outliers corresponding to high concentrations are not shown in the figures. In the discussion of correlations (Fig. S1), the few deviant measurement points are also mentioned.

During the 7.5-month measurement period high concentrations were also measured and again the outliers (high concentrations) were omitted from the figure to make it clearer. Below is Figure 4 with the outliers. However, these are real measurement results measured with AQ Urban sensor and CPCs. Much higher PN concentrations were measured at the Traffic Supersite which is due to the higher emission of motor vehicles in this site. The discussion of the deviation of measured concentrations between AQ Urban sensors and CPCs at both sites is discussed further in the manuscript (Starting from line 233 in the original manuscript and now starting from line 268)

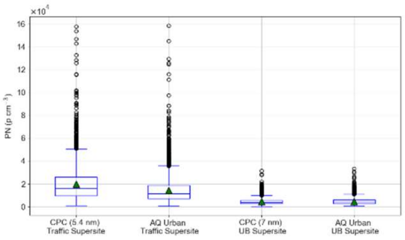



Figure 4. with outliers.

The description of how the AQ Urban sensor determines the count median diameter has been modified in the experiment section as below.

The AQ Urban sensor determines count median diameter (CMD) indirectly by measuring the electrical current produced when particles are diffusion-charged. The determination of CMD is based on the calibration of the instrument and the assumption that the aerosol size distribution is lognormal. The instrument estimates the CMD by continuously stepping between a low and variable, high voltage settings; the median particle size is determined by the cutoff voltage of the half-maximum signal compared to the low cutoff signal. Using this mean particle diameter and assuming a lognormal particle size distribution with fixed standard deviation the instrument calculates the PNC (Janka and Saukko, 2017).

The count median diameter (CMD) plots are added in the supplement and the figure numbering has been changed that it is in agreement of the order how figures are referenced in the text (now Figure S6).

**Line 69: Is LDSA a concentration?**

Answer: Yes, it is concentration. The unit is Lung Deposited Surface Area per unit volume of air.

**Figure 5: How are the differences in the CPC readings between the two sites?**

Answer: The plot showing the measured PNC with CPCs at the two sites has been added to Figure 5b.

**Line 237: Is there an explanation for the opposite behavior of the slope in the correlation regarding high PM2.5 values at traffic/background sites?**

Answer: Discussion about the effect on PM2.5 concentration and particle number size distributions is discussed in the following paragraphs, starting from line 279. In the text, it has been added "The following paragraphs discuss more detailed the effect of particle size distribution and $PM_{2.5}$ concentration on the measured PNC with AQ Urban sensor".

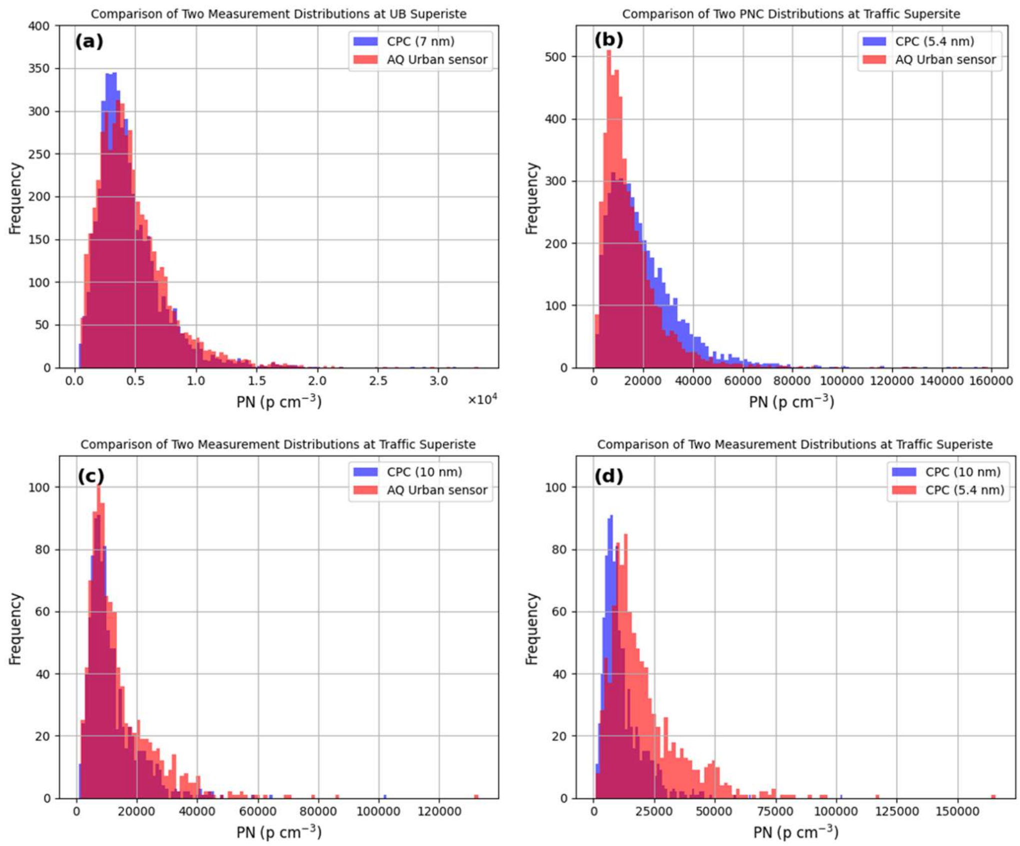
**Figure 6: The slopes between the linear correlations are different by approx. 20%, but much larger (factor of 2) for many measurement points (also at low PM2.5 values). What are the implications for AQ monitoring in terms of measurement uncertainty?**

Answer: Based on this study, the two reasons for the deviation of PNC measured with AQ Urban sensor compared to those measured with CPS were connected to two factors. First, the different lower cut-off sizes of the used CPCs (5.4 and 7 nm) compared to the AQ Urban sensor. The CPC used at the UB Supersite had a cut-off size 7 nm which is closer to the lower particle size than the AQ Urban detects. Also, the concentration of particles < 10 nm is quite low at the UB Supersite, so it can be assumed that AQ Urban and CPC both "see" the same particle population. At the UB Supersite on the other hand the bimodal nature of the accumulation mode was more pronounced, and the existence of large size particles affected more to the estimation of count median diameter of AQ Urban sensor. This was seen with a higher deviation of PNC measured with AQ Urban sensor compared to those measured with CPC at UB Supersite.

At the Traffic Supersite the used CPC detects particles down to 5.4 nm and in this environment the concentration of particles < 10 nm is high due to the heavily trafficked street. Due to this, the AQ Urban sensor shows lower concentrations compared to the CPC, especially when the PNC is high.

Below are figures showing the distributions of measured PNC with different instruments. The PNC concentrations are quite similar during the 7.5-month measurement period at the UB supersite since the detection limit of AQ Urban and the CPC were quite similar, and the ultrafine particle concentrations were lower at this site. At the Traffic Supersite there was clearly underestimation of PNC with AQ Urban sensor when concentrations were higher, due to the higher fraction of ultrafine particles (below 10 nm). It seems also that some overestimation of PNC was seen when concentrations were low. During low PNC concentrations, the uncertainties related to bimodal size distribution could be more evident, explaining this result. The figure showing the comparisons of measured PNC distributions has been also added to the supplement (Fig. S9) and text relating the distributions are added in the manuscript (lines 307-321).

The aim of this study was to show if AQ Urban sensor can be used to monitor PNC for particles above 10 nm (based on the WHO regulations). In this study, the PNC measured with AQ Urban sensors were compared to the CPCs that are continuously used at the measurement sites (with cut-offs 5.4 nm and 7 nm). For this reason, there were some additional deviations observed in PNC, especially at the Traffic Supersite. As a summary of Fig. 6 it can be seen that AQ Urban sensors perform well in long-term monitoring of PNC, but the short-term concentration can have some uncertainty in cases when the concentrations are low, or the particle size distribution is strongly bimodal. As discussed in the manuscript, these points should be considered when measuring PNC with electrical particle sensors. But, in conclusion, AQ Urban sensors can be used for monitoring purposes for PNC above 10 nm in different environments.




**Line 315: What would be the suggested max. deviation to be well-suited for AQ monitoring?**

Answer: According to Directive (EU) 2024/2881, PNC monitoring is regulated at rural and urban background supersites and at “hotspot” sites with high ultrafine particle (UFP) concentrations. The directive regulates the PNC measurement for particles above 10 nm in diameter. However, no clear quality requirements are not stated for the measurements. In addition to air quality measurements with reference-level instruments, also less expensive indicative instruments can be used to complement the regional coverage of the measurements. For indicative measurements higher inaccuracies can be allowed even more than 20% on yearly averages and even higher inaccuracy for daily and hourly averages. The use of diffusion based AQ Urban sensors in Helsinki Metropolitan area shows that they are well suited to long-term monitoring of PNC. The reliability of AQ Urban sensors has been good so the temporal coverage e.g. in yearly averages has been excellent.