

Answer to M. Sipilä (Referee)

Thanks to Mikko Sipilä for his helpful comments and remarks. We tried to consider them all. Detailed response to each point is given below.

-In abstract you could mention the working fluid used in the FCPC.

- Okay, we added this information in the abstract.

-p.5910, l.18-20. We have been running a mixing type CPC continuously over time range of months in atmospheric conditions. Some of the first results are published by Vanhanen et al., AS&T 45:4, 533-542, 2011.

-Thanks for this remark. I read this very new paper. Basically a similar approach is used but with a different goal: We want to measure faster and you go to smaller sizes. But it is really interesting that different goals can be reached by the same principle of turbulent mixing. Also good to see, that your instrument worked stable over days under atmospheric conditions. We added this information in the introduction.

We added:

'Vanhanen et al. (2011) used the principle of particle growth due to turbulent mixing with a saturated gas flow to measure aerosol particles down to 1 nm. During a field study over several days its functionality for ambient measurements has been demonstrated.'

- Swagelok-T is used as a mixer. Its heat conductivity is quite high and the mixing is not possibly very adiabatic. Thus the working fluid would not necessarily supersaturate in the mixing process but only in the condenser. It probably does not deteriorate instruments operation in this case, but only the idea of activation by adiabatic mixing. Also, the aerosol flow is not temperature controlled, and thus the only reasonable operation mode in ambient measurements would be such that activation takes place in condenser.

- right, we do not control or measure the temperature of the aerosol flow. However, assuming a temperature of the sample flow of 15-30°C which was the case in our measurements so far, the activation will definitely not take place in the mixing chamber, so it will be in the condenser. However, this should not make a difference, just if the activation takes place earlier there is more time for the particles to grow. Reviewer 3 also noticed that our FastCPC is not a real mixing type CPC, since we actively cool in the condenser unit. Thus, we changed the nomenclature and talk about a FastCPC only.

-What is the length of the condenser tube? Flow is quite high so to effectively use the vapour for growing the particles it should be reasonably long.

- The length is 65 mm. We started with a larger inner diameter resulting in a higher response time. In order to reduce the response time we reduced the inner diameter. 3 mm was tried firstly and worked quite well and the flow inside is still laminar. Thus, the condenser fulfills all requirements we had and obviously it is long enough. Maybe a longer residence time would lead to a lower detection limit? However, our first priority was to realize a short response time and we optimized everything in that way.

-p.5914, l.16 & p.5915, l.12. Is it meaningful to give std in absolute numbers as the deviation must be concentration dependent? Maybe rather std of normalized difference?

-That's true. In fact, there was a mistake and the standard deviation presented here is the square root of the mean error. Thus, it is dimensionless and independent on the concentration. However, maybe it is too confusing using this error. I leave it out at this point.

-What is the maximum concentration that FCPC can reliably measure, and what kind of processing (for accounting e.g. coincidence) is needed? In fig 6 it seems that 10^8 is quite abundant concentration. Is it real or can it be related to any saturation problem in droplet counting?

- Good question, we made another measurement in the laboratory to compare real and measured number concentrations. We used the same calibration setup and adjusted different concentrations. Results are plotted in the new figure ?? In addition, a function was fitted according to Eq. 2 from Hermann and Wiedensohler (2001). This allows to correct the number concentration for the coincidence effect leading to an underestimation of the true particle concentration. However, since this does not play any role in the investigation of the step function, we did not correct the number concentration here. This additional information demonstrates nicely the ability of the FCPC for high concentration measurements and the applicability of commonly used coincidence corrections.

We added a new subsection:

Particle coincidence

The calibration setup was used to investigate also the effect of coincidence on the measured number concentration measured by the new FCPC. For this purpose 30-nm particles were generated with different number concentrations between 100 and 58,000 cm⁻³. FCPC and EM measured in parallel at each selected concentration, while the EM is considered to give the true particle number concentration N_{true} . The relation between true and measured number concentration influenced by coincidence is given in the CPC-manuals (e.g. TSI Operation and service manual for CPC 3771/3772) as:

$$N_{true} = N_{meas} \exp(N_{true} * c).$$

Here, c is the coincidence parameter which is given by the product of the volume flow rate and the residence time within the viewing volume of the CPC optics. The measurement results from EM and FCPC are displayed in Fig. 4. To correct measured data for coincidence a function is fitted to the measurement points according to Hermann and Wiedensohler (2001), resulting in a c of $2.1 * 10^{-6} \text{ cm}^{-3}$. To calculate c from theory we use the volume flow rate of 0.3 l min^{-1} and the residence time in the viewing volume of $0.35 \mu\text{s}$ (cf. TSI Operation and service manual for CPC 3771/3772) resulting in a theoretical value for c of $1.75 * 10^{-6} \text{ cm}^{-3}$ which is close to the value obtained from measurements above. This demonstrates that the coincidence of the FCPC, because of its low volume flow rate, is lower than for the unsheathed commercial CPCs such as TSI 3772 and the operation range can be easily extended to concentrations up to 60,000 cm⁻³.