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Comment

## ***Interactive comment on “Performance of diethylene glycol based particle counters in the sub 3 nm size range” by D. Wimmer et al.***

**D. Wimmer et al.**

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RC: The above manuscript deals with the laboratory calibration of two types of condensa-

tion particle counters for very small particles (below 3 nm diameter). As new particle formation is still a paramount topic in atmospheric aerosol research (cf. Kulmala et al., Science, 2013, which, by the way could be cited in the introduction), in particular because of the recent technical developments, the presented work is of interest for atmospheric researchers and should be published after minor revision. Generally, the manuscript looks like there where several independent calibration efforts done, which were combined afterwards to one manuscript. I'm missing the thread, making clear,

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why which calibration was done. However, I know from own experience that such a patchwork is often forced by limited time, hence I don't blame the authors too much for that. Nevertheless, they could provide some reasons.

AC: There are several reasons for the indepent calibrations. The sulphuric acid and WOX calibrations were done in Frankfurt first, we then wanted to explore the effect of the particle composition of the test aerosol on the counting efficiency including a high resolution DMA and an API-TOF which was only available in Helsinki. Furthermore by performing several calibrations we wanted to make sure that the counting efficiency fuctions of the CPC did not change with time.

Kulmala et al is now cited.

RC: - p 2152 | 17: if you speak about a higher mixing ratio, please provide at least two flows here, e.g., the saturator flow and the aerosol flow.

AC: -p 2152 | 17 : a higher saturator flow means higher mixing ratios. The aerosol flow on the other hand stays constant at 2.5 lpm. We clarified this point revised manuscript,

RC: - p 2154 | 3: "exiting the capillary" is true for the specific CPC type used in the present study, however, Eqn. 1 is of more general nature and holds true for other CPCs without capillary too. So please remove the "capillary"

AC: -p 2154 | 5: ok deleted capillary in the revised manuscript

RC: - p 2154 | 5: usually, the term "counting efficiency" is used for the overall efficiency of a CPC, not only for the detection efficiency

AC: we thank the referee for his suggestion and will stick to the term counting efficiency in the revised manuscript.

RC: p 2154 | 8: please remove "i.e." because for instance the chemical composition of a particle is not automatically determined by the particle size

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AC: ok done in the revised manuscript

RC: p 2154 l 19: here I miss a paragraph describing the contents of the manuscript. This paragraph follows later at the end of Sec. 2. It should be moved from Sec. 2 to the end of the Introduction (Sec. 1)

AC: done

RC: - p 2155 l 9: I'm not a native speaker, but "after" feels for me more related to time, I suggest to use "downstream" or something similar instead.

AC: done

RC: - p 2155 l 17: please replace "Thus" with "Usually".

AC: done

RC: - p 2155 l 24: please remove "aim to", because you characterized the CPCs.

AC: done

RC- p 2156 l 5: please add "diameter" behind "3 nm".

AC : done

RC: - p 2156 l 3: publication year is missing for the "Iida et al." reference.

AC: ok, corrected

RC: - p 2156 l 15: experimental work performed by you should be described in past time not in perfect time, please replace "have been" with "were". This is of course relevant for the rest of the manuscript too.

AC: done

RC: - p 2157 l 12: please replace "set-up" with "DEG CPC" because this is more specific.

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AC: done

RC: - p 2158 | 7: the scanning mode of the PSM, how fast is it? Please provide numbers and a reference.

AC: one scan takes 4 minutes, this information is included in the revised manuscript

RC: - p 2158 | 18: please don't use "various" or similar expression, be more specific, in this case e.g. "three" or "four" gives detailed information.

AC: done

RC:- p 2158 Sec 3.3: you used four different generators and two different DMAs to calibrate four, more or less, different CPCs. The reader is quickly lost in knowing which instrument was calibrated with which set-up. Please provide a matrix-type table indicating to the reader which set-up was used for which CPC. This would help a lot when reading the results section later on. Furthermore, it is not clear why you did they not use only one or two generators with one DMA? Please provide some arguments/reasons, why you used different instruments, what are the advantages, what are the disadvantages of the used generators and the DMAs?

AC: there is a table now in the revised manuscript. We assumed that the schematics of the different setups given in Fig 3 is good enough. We used several different setups in order to study the influence of different test-aerosol on the counting efficiency functions. This is discussed in detail in Kangasluoma et al 2013. We rephrased the point in the revised manuscript and give reference to Kangasluoma et. al.

RC: - p 2159 | 2: the air from the laboratory likely contains traces of ammonia which would quickly react with your sulfuric acid particles. Please comment on that (to the reader, not to me).

AC: we made our point a bit more clear in the revised manuscript

RC: - p 2160 | 3: the whole description of the electrometers is not a "result"; please

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move to the “experimental” section.

AC: done, a new subsection is included in the revised manuscript

RC: - p 2160 | 5: “inter-comparison showed that..” should be rephrased, what you likely meant is that the two instruments agreed within 0.5-1%, but this is not what the current sentence says.

AC: done

RC: - p 2160 | 13: the reference for the fitting curve: please cite the original article, not the one citing the one citing the original article, i.e. Wehner et al., 2011 should be replaced by Stolzenburg and McMurry, 1991 (which was cited by Wiedensohler et al., 1997 which then was cited by Wehner et al., 2011). Same on page 2161.

AC: done

RC: - p 2160 | 13: please replace “error” with “uncertainty”.

AC: done.

RC: - p 2160 | 15: what does “the high resolution DMA has a (size? time?) resolution of about 20” mean? 20% or 20 nm or...? Please specify.

AC: it means the reciprocal of the normalized full width at half height, a citation and comment is included in the revised manuscript

RC: - p 2161 | 1: Fig. 5 shows the overall “counting efficiency”, not only the “detection” efficiency.

AC: we will stick to the term counting efficiency in the revised manuscript.

RC: - p 2161 | 6: Fig. 5 and 6 show two data sets for the counting efficiency of the DEG CPC1 for negatively charged sulfuric acid particles using the nano-DMA. What’s the difference in the data? And why are they displayed in two separate figures? Please clarify and combine the data into one figure.

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AC: It's not the same plot, in figure 5 the sulphuric acid particles are only used for sizes bigger than 5 nm, whereas in Fig 6 the whole counting efficiency curve was measured with sulphuric acid particles only.

RC: - p 2161 | 24: please provide a reason why the lower cut-off diameter of the DEG CPC1 is shifted towards smaller particle sizes in Fig. 7a.

AC: We do not know the exact reason why the cut-offs have shifted between the sulfuric acid particles used in Fig 6 and the salts used in Fig 7. It is an experimental finding which has also been found by other authors (Lida et al. 2009).

RC: - p 2161 | 27: where are the data for the DEG CPC1 in Fig. 7B?

AC: -p 2161 | 27: we didn't measure it, due to time limitations and instrumental problems

RC: - p 2162 | 12 : what does "cleaned carefully" mean? Heating the tubes for several hours? Or purging? What did you try to do and how successful was it? Please let the reader know this important information.

AC: we added a citation to Kangasluoma where there is a more detailed description of the whole setup and also we added one sentence in the revised manuscript

RC: - p 2162 | 22: please replace "being activated" with "activate"

AC: done

- p 2162 | 22: I don't understand the sentence "Therefore clusters with higher organic impurity...". Please rephrase it to make it clearer.

AC: -p 2163 | 17: We rephrased the paragraph in the revised manuscript.

RC: - p 2162 | 28: please remove "Whereby".

AC: done

RC: - p 2163 | 5: the last sentence of this paragraph is too long, please make it two

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sen- tences.

AC: done

RC: - p 2163 | 15: please replace “ at smaller sizes earlier than the” with “already at smaller sizes compared to the” or something similar

AC: done

RC: p 2163 | 17: the argument starting with “Another effect might be....”. I don’t think that an inhomogeneous saturation ratio profile in the condenser is of much importance for the differences between the used DEG CPC and the PSMs. First, the used DEG CPCs have a capillary and a sheath flow around the aerosol flow leading to a relatively flat supersaturation profile experienced by the particles (cf. Stolzenburg and McMurry, 1991). Secondly, you have shown that accounting for the diffusive particle losses inside your DEG CPC leads to a similar steepness in the counting efficiency curve as for the PSM. Hence you don’t need a second effect. I suggest to remove this argument.

AC: we thank the referee for the suggestion and agree. The argument has been removed.

RC: - p 2164 | 2: please replace “to the CPC” with “by the CPC”.

AC: done

RC: - p 2164 | 23: first sentence in this paragraph (“As the internal”) is incomplete, please check.

AC: the sentence has been re-phrased

RC: - p 2166 | 4: please be more specific and replace “variety”.

AC: done

RC: - p 2166 | 9: please replace “efficiencies” with “efficiency diameters”.

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AC: done

RC:- p 2166 | 10: please make it “differ” because the given statement is still valid.

AC: done

RC: - p 2166 | 15: “corrections are considerably reduced”. First, it is not a problem if a correction is small or large, as long as you know it exactly. What you probably meant is that the “uncertainties associated with the corrections are considerably reduced”. Secondly, what does “considerably” mean? By a factor of two? Or even ten?

AC: - p 2166 | 15: The point is that the corrections are based on certain assumptions and by direct measurements at least some of the errors which are caused by assumptions are reduced, of course the ‘amount’ of the corrections depends on various factors, eg in how far one can be sure about the measured growth rates.

RC - p 2166 | 25: please add the new Kulmala et al., 2013 reference.

AC: done

Figures: RC: Fig. 3: these sketches are too small, please make them larger.

AC: the figures are bigger in the revised manuscript

RC:Fig. 4: please provide error bars for the particle diameter (x-axis), e g., the DMA transfer window width.

AC: x-axis error bars are omitted for the sake of clarity. The x-axis error bars are mainly determined by the DMA transfer function width. These are discussed, for example by Jiang et al., 2011. The resolution for the n-DMA is 5 and of the high resolution DMA is 20 (as pointed out in the manuscript), respectively. Both numbers are derived from the mobility of the electrosprayed mobility standard.

RC:Fig. 5: why did you stop the WO<sub>x</sub> measurements at 4 nm? It seems to me that the WO<sub>x</sub> data points lead to a curve with a maximum counting efficiency clearly below

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100%. Please comment and let the reader know it too.

AC: -Fig. 5: the WO<sub>x</sub> stops at 4 nm, because with the applied settings of the high resolution DMA, one cannot go higher than 4 nm, we will add the explanation to the revised manuscript.

RC: Fig. 7: please enlarge the three graphs, the curves are hard to see.

AC: done

RC: Fig. 8: figure caption: please specify the CPC type in the last sentence, the curve is not valid for every CPC.

AC: done

RC: Fig. 10: for very high concentrations the blue data points in the insert deviate from the one to one line. Could a different coincidence behavior be the reason for this? Are the values corrected for coincidence. Please give a statement in the text

AC: -Fig. 10 Coincidence could be the explanation for the observed deviation. The PSM data is corrected for coincidence the DEG CPC has a dilution unit, so it needs rather high particle concentrations before coincidence corrections are necessary. A statement about the coincidence corrections has been added to the revised manuscript.

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Interactive comment on Atmos. Meas. Tech. Discuss., 6, 2151, 2013.

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