

Atmos. Meas. Tech. Discuss., referee comment RC1
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Comment on amt-2021-266

Anonymous Referee #1

Referee comment on "Simulation-aided characterization of a versatile water-based condensation particle counter for atmospheric airborne research" by Fan Mei et al., Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2021-266-RC1>, 2021

OVERALL COMMENT: The manuscript describes the results of the study on the performance of a commercially available versatile water-based condensation particle counter, vWCPC TSI 3789, at a range of pressure conditions down to 500 hPa. The reason behind it is to gain a better understanding of the instrument behavior in potential future airborne applications. The authors investigate the vWCPC counting efficiency and the cut off size, as well as the effect of the conditioner temperature, particle material and particle number concentration at a range of pressure conditions between 500 and 1000 hPa. This is done using both laboratory experiments and numerical simulations.

The topic fits well under into the scope of the AMT and I recommend the manuscript to be accepted after the following minor points have been addressed.

SPECIFIC COMMENTS:

Line 10-20: Abstract: The authors may add more information such as the d50 for the vWCPC used in this study; a range of pressure settings investigated; a range of particle number concentrations, and particle material used.

Line 14: authors may want to add e.g.: "under a large range of ambient pressure conditions"

Line 19: "chemical composition" of particles?

Section 1: Introduction: The authors mention that non-water-based CPCs have been investigated under low pressure conditions, however, the discussion on the outcome of these studies as well as deployment of these on aircrafts is not mentioned. It would be interesting to discuss why such studies were done more often for butanol-based CPCs or other CPCs rather than for WCPCs? In general, what are the main challenges for the implementation of CPCs on aircrafts, and what are specific challenges for WCPCs? Are health and safety concern the only advantage of the vWCPC over other CPCs in such applications? Some more discussion on that would add value to the manuscript.

Although the manuscript talks about the history of CPCs and WCPCs, the literature review says nothing about the state-of-the-art CPCs or CPC-based systems currently operating on aircrafts. I think more information that is currently provided could be discussed in the context of low-pressure applications. It would be interesting to see what is currently the state-of-the-art instrumentation (i.e. CPCs) - a good example could be NMASS instrument by Williamson et al. 2018.

Line 23-44: The authors describe the history of and some new developments in CPC instrumentation. Have any of these CPCs been used on aircraft platforms or was their performance studied under low pressure conditions? If yes, that would be interesting to highlight.

Line 56: delete the extra bracket

Line 71: The authors mention "comparable performance" - in terms of?

Line 71-75: The authors mention that non-water-based system have been characterized under low pressure conditions. I am currently missing information on the outcome of these studies.

Line 78: "pressure dependency of the counting efficiency" - what were the results?

Section 2.1 Instrument modification: The authors may consider "instrument description and modification" instead. Additional information on the instrument description could be helpful (such as the cut off size for certain particle material and temperature settings (e.g. default), detection of the maximum number concentration, default settings in terms of temperatures, new design of the growth tube.

Fig1: indicating which modifications were made as compared to the default unit could be helpful here?

Line 99: "each vWCPC" - how many were used in this study?

The authors may want to mention somewhere in the manuscript whether the vWCPC was operating with or without water fill bottle under low pressure conditions. This is usually what's being done for butanol-based systems (butanol fill bottle stays disconnected/autofill deactivated). If that was the case and vWCPC was operating without fill water bottle connected, please provide additional information e.g for how long, and how was it ensured that such configuration did not compromise the performance of the vWCPC. What was the stability of the detection efficiency when operating in such setting? This could be added to the result section or supplemental material.

Line 113: Information could be added on: the size ranges of particles used in this study, the particle material, range of pressures and number concentration investigated.

Line: 118: There is no information provided on the CPC 3775 used in this study. I suggest adding information on d_{50} , particle material, and working fluid. How does the response of these two models (vWCPC and 3775) compare without the constant pressure inlet? Maybe a plot could be added to a supplemental file?

Line 123- 129: seems like a mix of results or methods that doesn't really fit under the section "Experimental characterization set up". Please revise.

Fig.2: are these two dashed arrows that are going out of the atomizer correct? Please double check. Was either the atomizer used or tube furnace? If yes, then one line is incorrect. "Inlet pressure controller" or as in text "constant pressure inlet". Try using same name in both places to be consistent. Did you use a drier? I do not see it in the schematic. If not, please discuss why that was not the case.

Line 132-134: The information on the particle material could be somehow linked with line 113. "this study"? Please mention particles with various composition used and their size ranges. How the set up used in this study differs from other studies e.g. where butanol-based CPCs were used.

Section: 2.3 Numerical simulation: Currently it is unclear whether the approach described here is the one taken in this study, or it was used in previous studies. Please make links between information provided from other studies with the current study. The authors refer to Hering's research - what does that mean? How does the configuration and mentioned

dimensions compare to the one of this study?

Section 3: Results: the authors may consider: "Results and discussion"

The authors divide subsections into modelled (3.2) results but under this section one finds experimental results too (e.g. Fig.6). Please revise your subchapter titles/division.

Line 159-160: the authors could combine these two sentences into one

Line 157-158: please specify particle material and include "in diameter". Why these sizes were used?

Line 164: "lower than 500 hPa" - data below 500 hPa is currently not in the plot. However, the authors discuss the behavior below 500 hPa. Please revise this statement to match the data presented or add the data that supports that. The counting efficiency start decreasing below ~700 hPa. How does this compares with the results of the previous studies. Any potential explanation? There's no 100 nm data point at 920 hPa. Please double check or state the reason.

Line 198: please rewrite: "one 8 nm see particle grew to a smaller size"

Fig. 5. add the meaning of dashed lines in figure caption.

Line 214: this subsection is called "Modelled...", however it contains both simulated and experimental results. Please revise.

Line 217: add information for which particle size. Why did you choose 100 nm and not 15 or 25nm in diameter here?

Line 234: "low pressure conditions" – please be more precise

Line 235: the authors mention "saturation ratio over 1.3 and particles larger than 15 nm" however this is not what is presented in these figures (4,5,6). Please review the sentence/figures.

I am curious to know whether you tried any pressure setting below 500hPa in your study? If yes, what was the lowest pressure and what were the results?

Line 241: although it may be obvious to those who worked with CPCs, please briefly explain what the pulse height is

Line 243-244: add reference to the figure when describing the result

Line 252: please add ref to the fig in supplemental material

Fig.7 Y-axis label. Please change to "Counting efficiency" for consistency

Fig.S5: figure legends could be improved, currently displayed weird

Section: 3.4. "Chemical composition" – the authors refer to the particle material? Also this section could be made more concise.

Line 267-260: add reference to fig when describing these results.

Line 270: what kind of analysis?

Line 268 and 271: how to understand that counting efficiency statements "similar" and "affected" Please review this subsection.

Line 272: you mention sucrose and humic acid as particle material used. Please discuss why and what these two represent.

Wouldn't you expect that at 100 nm particle size these all particle material would be at 100% counting efficiency at ~900-1000 hPa? Why this is not the case e.g. for sucrose?

Fig. 8. Please add information in the caption on the size of these particles and their material.

Line 285-286: butanol-based CPC? Which model from which study? Please add a reference or additional information.

Line 287: please add ref to the figure.

Fig.9: In legend you state "30C TSI". Please specify for which particle material and pressure settings these results were obtained. Also why there is a difference in the slope between the results indicated as TSI and of this study? Do you have data points you could add for 30 C to see if your data agrees with the one referenced as TSI 30C?

The authors may consider adding a summary table in supplemental material that presents various temperature and pressure settings investigated, and resulting cut off sizes for certain particle material used.

It would be interesting to see if vWCPC flow rate (and so the instrument response) is influenced by the changing pressure. This CPC uses an internal pump, is that correct? What was the flow rate at various pressure settings? The authors may want to add a plot in the supplemental material.

Section 4. Conclusion: I suggest to revise this section. Currently some detailed information is missing and not all information that is given is clear. I would be interested to see what is the meaning of these results, and what's the outlook for operating the vWCPC on the aircraft? Do the authors have any recommendations? If yes, what would the optimal setting? Any suggestions for studying the performance of this CPC under 500 hPa? Is such study planned? Little is said about the advantage of the WCPC over other CPCs, and how these results compare to results from other studies. Any limitations or benefits over other studies could be mentioned too.

Line 301: "was modified to report environmental pressure"? Please review.

REFERENCES:

Williamson, C., Kupc, A., Wilson, J., Gesler, D. W., Reeves, J. M., Erdesz, F., McLaughlin, R., and Brock, C. A.: Fast time response measurements of particle size distributions in the 3–60 nm size range with the nucleation mode aerosol size spectrometer, *Atmos. Meas. Tech.*, 11, 3491–3509, <https://doi.org/10.5194/amt-11-3491-2018>, 2018.