A commercially available water-based CPC (MAGIC CPC) is tested over a range of pressures to characterize its performance for use on aircraft, specifically IAGOS. The CPC is tested with both hygroscopic and hydrophilic aerosols and compared with a butanol CPC (GRIMM-CPC). The study, once the concerns mentioned below are addressed, represents a substantial contribution to scientific progress in enabling airborne measurement of aerosol concentrations without the use of toxic or high GHG potential working fluids.

The manuscripts describe in detail testing the water-based CPC in comparison to a reference electrometer and a Grimm-CPC over a pressure range 200-700 hPa. While much of the method and experimental set up are well described and justified, there are a number of aspects which need more full explanation or justification:

- Humified air appears to be added after the DMA, changing the humidity from 5 % to 30 %. Do the particles grow after the DMA size selection because of this? What was the residence time between the DMA and the CPCs and electrometer?

  ANSWER:

  The Humidity is added after the DMA. This should be below the efflorescence. We wanted to show We wanted to test, if "low" humidity can have an impact on aerosol activation for particle counters. The mixing chamber is flushed every 3-4 seconds. Particle grow due to humidification after size selection has no effect on the results.

- In figure 1, what is flowing in through the two valves in the bottom section, and the flow controller in the top middle? Is it zero-air? Filtered lab air? Something else?

  ANSWER:

  It is aerosol-filtered air.

- What are the flow rates and line lengths between the DMA outlet and CPC and electrometer inlets? Were diffusion losses the same in all 3 lines?

  ANSWER:

  The Diffusion losses are assumed to be the same. The flexible conductive sampling tubing length from the line to the instruments is 25 cm to instrument that drew 0.6 l/min and adjusted proportionally to instruments with a different flow.

- The authors discuss how the water-based CPCs respond differently to particles depending on their chemical composition, hence testing both soot and ammonium sulphate. It has previously shown that water-based CPC cut-off diameters can be substantially larger for organic aerosols e.g. (Hering et al., 2005) (by one of the co-authors). Why did the authors choose not to examine organics given their atmospheric relevance?

  ANSWER:

We did not have the appropriate set-up for organic aerosols. **However, pure soot is hydrophobic and ammonium sulfate is highly hydrophilic, atmospheric organic aerosols should be in between. While pure organics can may be poorly detectable with water CPCs contaminates in even slightly aged particles usually make them detectable with water.**

- Section 3 describes how the CPC increases laser power and decreases the detector threshold "until only the detector threshold is the only limit of signal detection" (page 5, line 132) . I think there may be a slight wording issue here, and beyond that, how is it ascertained when this limit is reached?

  ANSWER:

  We will include a more detailed description in the supplementary. Since the stray light reaching the photodetector is proportional to laser power, the firmware automatically adjusts both the laser power and detector offset with pressure. The specific relationship between laser power and detector offset are set at the factory and vary from instrument to instrument. To operated the MAGIC 210-LP at pressures lower than then it was designed for, voltage offset and detector thresholds had to be determined experimentally below 300 hPa. At 250 hPa, we found that the required laser power was so high that the electronics was incapable of zeroing out the baseline voltage. Aerosol Dyanmics has corrected this in the MAGIC-250-LP.

- Section 3, page 5, line 139 suggests that CPC overheating in hot ambient conditions could be addressed be maintaining a constant delta T between condenser and saturator, instead of trying to keep each at fixed settings. However, in the previous lines the need to keep the initiator below 45C and the condenser between 2 and 4C because of manufacturer specifications. Do these limits not mean that a constant delta T can therefore not be maintained?

  ANSWER:

  That is correct during a "heatwave" for the low pressure settings, that's why we increased the temperatures of all stages by 3K and were the behaviour of the instrument did not change. For Example: The Conditioner with 5°C and the Moderator with 7°C. 45C was an overly conservative value originally (and mistakenly) specified by Aerosol Dynamics. The boiling point of water at 150 hPa is 52.5 degC. At 200 hPa it is 59 degC. The difference between the conditioner and initiator set point is what determines the D50.

  For Ambient Conditions (Pressures around 1000hPa) the Temperature stages are normally operated not with fixed values but with relative temperature settings.

- Section 3, page 5, line 146 mentions a look-up table for laser power as a function of ambient pressure. Was this something provided by the manufacturer or produced in this study?

  ANSWER:

  The manual is provided by the manufacturer. The Look-up table is implemented in the software.

- Section 3, page 6, line 155 to 164 discussed the need to vary the detector offset setpoint from 250 mV to 400 mV. It is not clear to me whether a single detector offset setpoint works for the full pressure range from ground to 200 hPa. Some clarification needed here.

  ANSWER:

  It varies with pressure and is determined by firmware. We will expand this section and put it into the supplementary

- Fig 4 – why are there no error bars? The choice of 500 mW laser power seems well justified for the 250-700 hPa pressure range. Why was the lower limit of 200 hPa not tested here? Similarly, what about pressure greater than 700 hPa? Will this setting work to ground level? The authors mention that for 250 hPa and adjustment of the dectector offset was needed from 205 mV to 400 mV. Can this be done automatically in flight? Is there a loss of data while this change is made?

  ANSWER:

  I simply forgot the error bars. The lower limit of 200 hPa was than tested with the optimized parameters and at all pressure levels up to ground level. This can be done automatically be done by an external command, but with well adjusted parameters, there is no need for that.

- Fig 5 shows an extended soot size distribution including measurements from another paper by the same 1st Was this size distribution measured with the same experimental set up? If not, what makes it certain that the same size distribution occurred in these experiments as the other Weber et al. 2022 paper?

  ANSWER:

  It was measured with the same experimental set-up

- Page 7 Line 181 claims “Using ammonium sulphate as a particle material, the instruments respond with an excellent agreement with the FCE reference instrument, with a slope of 1.0 ±0.05 regardless of the inline pressure.” Do the authors mean that a linear fit was performed for each pressure, and all of them had a slope of 1.0 ±0.05 individually? Or was the fit made of the aggregate data over all pressures? It needs to be clearer what was done. If only the aggregate fit was done, the data at higher pressures might make the agreement seem more robust than it really is at low pressure. This graph also lacks uncertainties. Later, around line 220 the authors discuss that both

CPCs see up to 15% fewer particles than the electrometer. This seems to contradict the "excellent agreement with the FCE reference instrument".

ANSWER:

The 15% fewer particles is exclusively for particles lower than a certain size. We will rephrase the slope-statement.

- Section 3, page 9, line 220 discusses that the undercounting of the CPCs relative to the electrometer for soot particles may be due to an error in the multiple charge correction because the size distribution was not measured above about 150 nm. But in fig 5, the size distribution is presented using a different study up to 1mm and clearly covering the bulk of the generated mode. Can this extended size distribution not be used to better calculate the multiple charge correction and correct this undercounting?

ANSWER:

This can be tried. We used the measured size distribution for all calculations. We could not measure the complete combustion soot particles size distribution; The approximation could be an issue; nevertheless, it gave consistent results when checked at lower pressure ranges.

- In the conclusions, page 11 line 262, it is mentioned that 5 units were examined. This is the first mention of this (would be better in the methods description). It is not clear whether the data presented are from all 5 units, or just 1 CPC. This needs clarification, and the claim that "factory settings for all 5 units" were satisfactory down to 200 mb needs to be supported by data.

ANSWER:

We will mention this earlier. The data shown are from one unit. All Units must have corrected settings to work down to 200 hPa.

- Section 3 analyses a number of different aspects of instrument performance, and clarity might be improved by introducing subsections.

ANSWER:

Thanks for the advice

Many of the conclusions drawn in this manuscript are well justified, but the following do not seem well supported:

- The experiments performed in this study cover the pressure range of 700-200 hPa. Why was 700 hPa chosen as the lower limit? The title suggests that the study only is interested in "cruising pressure levels" in which case the lower cut off of 700 hPa is well justified. This should be made clearer also in the text. The question of instrument performance between 700 hPa and ground seems to be left unanswered. The

conclusion, page 11 line 278 claims “This pressure range covers the operational conditions present during IAGOS aircraft flights.” Do IAGOS flights only use data at pressures lower than 700 hPa?

ANSWER:

We performed ambient aerosol/pressure measurements and saw no differences as in earlier studies provided by Hering. Because this does not increase the gain of knowledge we did not show these and the 700 hPa measurement data is sufficient as a comparison.

- Section 3 line 205 claims fig 8 shows the counting efficiencies of the MAGIC CPC and GRIMM CPC are nearly identical for pressure above 250 hPa. This is hard to see from the graphs, and from the fits shown, they seem to have different cut off diameters, so then the behaviour is quite different. I’m not sure what was meant here, and it may be that different plots are needed to show it well.

ANSWER:

We will rephrase it, to state that 700 and 500 hPa data is meant here.

- Figure 8 – it is very hard to distinguish the multiple shades of green or blue from each other in these plots, both for the points and the error bars. It makes it hard to determine if the conclusions drawn e.g. about the stability of the G-CPC efficiency curve over the examined pressure range, are valid. The order of the legends makes the plots very confusing to read. The D50 lines are very confusing. They appear to not pass through any of the presented fits. How are they determined? And why do they not pass through the fit lines?

ANSWER:

That is my fault. There used to be more fitting curves and I erased those, to make the figures clearer. The D50 matched back then, I will correct it.

- Fig 9 appears to show a trend with ambient pressure of the CPC number concentrations to that measured by the electrometer, but this is obscured by the choice of a linear scale, the hard-to-distinguish colours, the lack of error bars and the confusing ordering of the legend. Until this is corrected, it is not possible to determine whether the claims made around line 205 are justified.

ANSWER:

We will be more colour friendly and add some. Error bars will be added as well.

- Page 11 line 249 “Overall, the agreement between values derived directly from the experiment and values deduced from the fitting procedure is high.” What objective metric is this based on?

ANSWER:

The difference between those values is within the uncertainty (which is one half width of the electrostatic mobility)

- Conclusions, page 11 line 265 “the manufacturer has modified the firmware and design of the MAGIC 210-LP to improve the performance at high altitudes and to better accommodate the automatic adjustments in the laser and detector settings with operating pressure.” It is unclear what aspects of “performance” have been enhanced since this study was made, and also which of the laser power and offsets that were tested and adjusted in this study are now different in the instrument settings. The whole concept of what works with the CPC settings and what needs adjusting by the user, and what is adjusted automatically vs needing to be adjusted by the user as the pressure changes needs to be much more clearly addressed.

  ANSWER:

  To operated the MAGIC 210-LP at pressures lower than then it was designed for, voltage offset and detector thresholds had to be determined experimentally Based on this study, Aerosol Dynamics Inc. has updated their low pressure CPCs to operate down to 200 hPa.

- Conclusions, page 11 line 258 “excellent overall performance compared to a standard butanol CPC” need to be more specific. The shift in D50 with hygroscopicity should be mentioned, also the shifting D90 with changing pressure.

  ANSWER:

  We will rephrase this accordingly

Some of the terminology, wording and presentation used is confusing to the reader, and needs adjusting:

- Abstract, line 21 “the D50 cut-off diameter did not differ significantly for particle sizes around 10 nm” – does this mean the D50 cut-off diameter was stable at around 10 nm over the tested pressure range?

  ANSWER:

  The D50 cut-off diameter did not differ significantly for particle sizes around 10 nm at all pressure ranges.

  We wanted to set the focus on the D90 parameter.

- Section 3, line 182 references the “Sky CPC”, which is otherwise referred to as the G-CPC. It would be clearer to use consistent terminology.

  ANSWER:

  Acknowledged

- Introduction, line 26 “adverse effects that particles can have on climate change” seems a bit confused, suggest revision. It makes more sense with reference to air quality, which is listed later.

  ANSWER:

  We will change that order

- Introduction, line 54 “It comprises”, unclear if referring to this study or IAGOS. Suggest it is better to be specific than let the reader infer from the following text.

  ANSWER:

  It should refer to the new IAGOS package. We will rephrase “it”

- Section 3 line 154: “lowed”?

  ANSWER:

  lowered

- Section 3, line 207 describes the increase in CPC cut off for soot particles as occurring “as soon as an ambient pressure of 200 hPa is reached”, this makes it sound like a sudden transition, whereas in reality it will be a gradual shift with decreasing pressure. The text should be changed to more accurately reflect this.

  ANSWER:

  Thanks for the advice

- Page 9 line 226, the sentence “Looking at the D50 Value of Tables 1 and 2, both Instruments have the same range of particle diameter of 5 nm for ammonium sulphate” is unclear and needs revision

  ANSWER:

  Acknowledged

- Tables 1 and 2 – what are A, B and Bb? These do not seem to be defined anywhere.

  ANSWER:

  Those are the Fitting Parameters mentioned in Equation 1 (Bb is a spelling mistake)

- Conclusions, page 11 line 259 “LP” acronym needs definition, and why is it only introduced here and not earlier?

  ANSWER:

  MAGIC-LP (Low Pressure). We will rephrase it.

Overall relevant work seems well referenced. I suggest the following additions/corrections:

- Introduction, line 42 – the more relevant reference is again Williamson et al. (2018), which describes the referenced flourinert based CPC in detail, as opposed to a combined payload including that CPC that is described in the current reference.

ANSWER:

Will be included

References:

Hering, S. V., Stolzenburg, M. R., Quant, F. R., Oberreit, D. R., & Keady, P. B. (2005). A Laminar-Flow, Water-Based Condensation Particle Counter (WCPC). *Aerosol Science and Technology*, *39*(7), 659-672. https://doi.org/10.1080/02786820500182123

Williamson, C., Kupc, A., Wilson, J., Gesler, D. W., Reeves, J. M., Erdesz, F., McLaughlin, R., & Brock, C. A. (2018). 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*(6), 3491-3509. https://doi.org/10.5194/amt-11-3491-2018