Review of “Characterization of a self-sustained, water-based condensation particle counter for aircraft cruising pressure level operation” by Weber et al.

The present manuscript deals with the performance of a new commercial condensation particle counter aimed for the automated operation onboard passenger aircraft. In a laboratory simulation of the flight conditions, the performance was characterized. The thorough characterization of such an instrument for standard operational use is an important task, and it may serve as reference for the deployment of this instrument at other locations. The manuscript shows the results of these calibration measurements and discusses deviates as function of thermodynamic conditions. It generally shows the suitability of the instrument for the intended use, onboard the IAGOS container.

The manuscript is suitable for the publication in AMT, but requires some clarification and corrections. A grammar check for punctuation is suggested.

Remarks/Questions

Abstract: It should be mentioned in the abstract that the instrument was modified after this investigation. Also, maybe a recognizable instrument version of MAGIC should be given to avoid misunderstandings of the applicability.

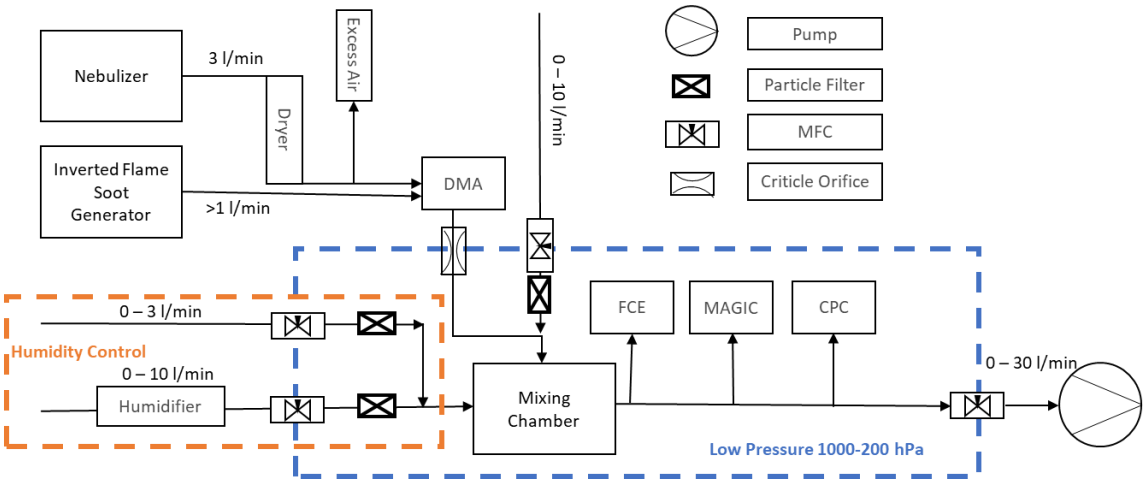
ANSWER:

> **We will add the information: We used the MAGIC-210-LP Version. Currently, the manufacturer produces the MAGIC -250-LP as an updated version, which incorporated insights from this study.**

Figure 1: Many arrows are not straight, which is inadequate for a scheme. What is the difference between the line from the top labeled ‘flow control’ and the line from the left without label above the humidifier? If the butterfly symbolizes a MFC, why is the additional ‘flow control’ needed? G-CPC should be explained in the caption. Flow rate ranges (and pressure ranges) should be given for all flows, not only for one. Also the pump symbol should be in the legend for sake of completeness. A better match to ‘Humidifier’ would be ‘Dryer’ instead of ‘Dehydration’. The caption has an unmatched parenthesis.

ANSWER:

> **You are right, this graph needed more love, so we added a few things:**



110-125: I can't make much sense of this section. It is too short to give a real explanation of what was done in this previous work of Bundke et al. 2015. And it doesn't make sense showing a curve from the previous work and then stating, that another curve has ben used. Or is there a different physical meaning between xi and eta?

This section should be thoroughly reworked. Either extend it to give a short explanation what was actually done in which step, or remove it, refer to the literature (and in case, state what was different to the previous approach).

ANSWER:

We moved this section to the supplementary and expanded it. By using a diffusion charger, the particles may carry multiple charges passing the DMA and may then be counted multiple times by the FCE. To correct the FCE count, the number concentrations are multiplied by a size-dependent correction factor calculated by using the size distribution measurement.

148-163: This seems to be one of the key achievements. But we learn here for the first time, that MAGIC is actually not specified for < 300 hPa, which might be on of the motivations of that study. Therefore, the problem should mentioned in the introduction. Also, some more information on the optimization procedure would therefore be useful (plots). E.g., at which laser voltages and which sensor thresholds / offsets the system operated with what efficiency?

ANSWER:

We mentioned in the Conclusion that it is necessary to test a MAGIC-LP 210, when operating at 500 hPa or below. Since the manufacturer settings my not be optimizes for this. The manual states an automatic adjustment for the laser power and the detector characteristics down to 300 hPa. We will mention this in the introduction as well.

From 155-157 we learn that detector offset and threshold are different properties, but the

expressions are used before. Maybe a sketch of the instrument and its logic would help here following the explanation. Are offset and threshold applied to the same reference potential or do they apply to different part of the electronics?

ANSWER:

We will include a more detailed description in the supplementary.

Figure 1 shows an idealized signal from the optics electronics. The analog signal is compared to the "detector threshold" (normally 250mV) which produces a digital pulse that increments a counter in the microcontroller.

The "baseline voltage", i.e. the signal with no particles present, could be above or below 0 volts due to imperfection in the optics and electronics, as shown in Figure 2. There is always some stray light that reaches the photo detector, and all operational amplifiers have some non-zero offset. To compensate, a "detector offset" is add to the analog signal to adjust the baseline voltage to zero.

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. To compensate the detector threshold was increased above the factory setting of 250mV (figure 3).

Note: due to specifics of the electronics a larger firmware setting for the detector lowers the baseline. Also the digital pulse are 0-5V; the height was reduced in the figures for clarity.

Based on this study, Aerosol Dynamics Inc. has updated their low pressure CPCs to operate down to 200 hPa.

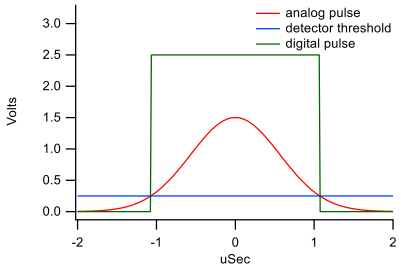


Figure 1: Ideal signal from one particle passing through the optics detector

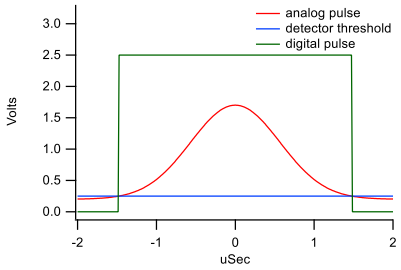


Figure 2: Effect of imperfections in optics and electronics on the baseline voltage.

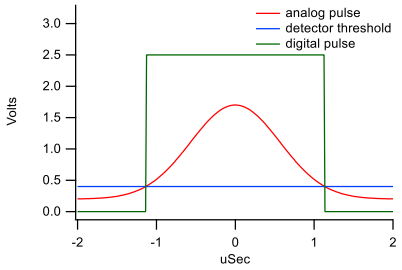


Figure 3: Detector threshold is increased to compensate for inability of the electronics to completely cancel out the baseline signal at lowest pressure.

165: Without further explanation, Fig. 5 should be in the method section describing the aerosol generation. What means 'the particle mobility sizes were measured to 138 nm'? There is a size distribution displayed – the maximum of the soot distribution? Why is the size resolution as a result suitable for the cut-off characterization? Y axis: In Fig. 3, the symbol was used, but here a description instead of N_FCE. Unify (Applies also to other plots).

ANSWER:

In order to achieve a high resolution at smaller particle sizes, we started at 138 nm. It seems like an odd number, but it is even in the voltage settings. The full range size distribution was measured by the identical measurement set-up but for another study and used here, for the sake of completeness.

179: Fig. 6: The D50 apparently doesn't match the fit curve. Which data does D50 refer to? Is the fit curve in this case then suitable? Same applies to Fig. 8

ANSWER:

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

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Minor remarks/Corrections

39: Reference format

Thanks

42: Reference format

Acknowledged

44: ‘limited’: Chose another wording. Being a greenhouse gas might be unfavorable, but it not really a limitation (compared to a flammable material onboard aircraft). And water vapor is a greenhouse gas, too, though of course weaker.

It has a very high greenhousegas potential. Another point is, that FC43 reaches its best performance at low pressures and is not suitable at ambient pressures.

46: Doesn’t the reference belong to the second statement after it?

Will be relocated

70: Reference format

OK

75: Remove ‘as well’?

As well will be removed

101: What happened to 2.1 and 2.2?

Good Question; I update this

102: Multiply charged?

Acknowledged

103: It is not an error of the DMA, as it simply selects according to charge-to-size ratios (or effective mobility). It’s an error of the data interpretation by assuming a unique effective-mobility/size relationship. The effect of course is correctly described, but I suggest a more careful wording.

You are right

104: ‘This effect…’ These different sizes?

Thanks for the suggestion

109: Figure 2 is not referenced (or referenced as Figure 3). Figure 2 doesn't add much information over the text. Remove.

Will be moved and explained in the Supplementary

112: While for N_FCE is quite clear, what it should be, the symbol is not explained above. This equation has no number, but the next one ha. Why?

Will be moved and explained in the Supplementary

121: '_' before Xi

Will be moved and explained in the Supplementary

122: Reference format

Acknowledged

130: 'pressure detection': barometer / pressure sensor is measuring

Acknowledged

131: 'until only the detector threshold is the only limit of signal detection': unclear. Reword.

And why is the threshold decreased, if the laser power increases? One would expect that also the 'background' light intensity would increase, and therefore the threshold should be increased.

The detector offset adjusts for non-ideal electronics and optics so that the signal without any particles present is at zero volts. The detector offset decreases the baseline level. We rework this and put it in the supplementary. The detector threshold is the voltage level that is used to determine if a particle is in the laser beam.

143: 'optimised' should be explained in the caption

Acknowledged, with the best fitting Laser and Detector Settings

144: 'droplets, which need to be counted.' ?

Acknowledged

146: If there is a 1-sec average, what is the actually reading frequency?

Actually this is not quite right. The absolute pressure is measured once per second, and adjusts the laser power and threshold each second. The averaging time between one second and 30 minutes is for particle concentration.

146: 1-sec averaged à 1 s average or one-second average

One-second moot, changing to 1-Hz pressure reading

146: It seems that [standard] laboratory ?

?

171-173: Quirky. Rephrase.

Acknowledged

173: corrected -> multiple-charge-corrected

Acknowledged

174: concerning -> with respect to

Acknowledged

174:remove multi-charged

Acknowledged

175: FEC -> FCE

Acknowledged

179: different

Acknowledged

181: The material ammonium sulfate should be mentioned in the text before the curves are discussed.

Acknowledged

198: dryer

Acknowledged

200: Fig. 8: The pressure levels should be sorted ascendingly. D50 is one time after, one time before fits.

Acknowledged

210: Fig. 9: The pressure levels should be sorted ascendingly.

Acknowledged

218: ‘square of the Pearson correlation coefficient’ or ‘coefficient of determination’ – but where is it?

Acknowledged. As can be seen is very misleading.

234: affinity -> disinclination / repugnance

The detection limits increased when we switched to soot, because of its lower activation affinity.”240: Table 2: Bb -> B ?

Indeed

250-252: As long as there is not bypass sampling in used.

Sure

253: Bundke et al. 2015

Acknowledged

257: Header has no number

Acknowledged

260: ‘We recommend, testing’ remove comma

Acknowledged

263: “It is noted that since this study, the manufacturer has modified…” That should maybe be noted with a remark at the according plots, otherwise a reader might overlook that the plots are no longer applicable to the current instrument generation.

Acknowledged

265: So are the manufacturer setting acceptable now for this pressure range?

For the MAGIC-LP 250 Units, yes.

267: “Its well-engineered water recycling mechanism…” That information is new. Its relevance for the section is unclear.

It is relevant for the continuous operation on IAGOS aircraft packages.

266: “operates without loss in performance” The manuscript dealt with the details of exactly this performance loss, so this general statement doesn’t seem to be suitable for the conclusion section.

This effects only particles with a small diameter. Those are effected with line loss anyway. We will state this in the Supplementary

269: “To evaluate …” from here a summary start, which should be at the beginning of the last section.

Acknowledged

276: Solubility is probably not a directly relevant property here.

Acknowledged

277-278: “… Its well-engineered water recycling mechanism.” Unclear. Rephrase

Acknowledged

278: “For pressures below 200 hPa, the efficiency of the MAGIC 210-LP can reach 100% linearity…” No data for this pressure range were shown in the manuscript, so the conclusion is a bit surprising. Or is this referring to pressure altitudes? Avoid ‘can’.

Acknowledged. We meant at 200 hPa

296: Some of the references don’t seem to be managed by a citation system, what would berecommended. Some dois are given as http-reference, some only numerically. Unify.

Acknowledged

300: Details of publication missing?

Indeed

303: doi is missing a ‘w’

Oh

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