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Atmospheric Measurement Techniques Discussions

Interactive comment on "Temperature uniformity in the CERN CLOUD chamber" *by* Antonio Dias et al.

Anonymous Referee #1

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Review of
Dias et al.:
Temperature uniformity in the CERN CLOUD chamber

This manuscript describes the temperature calibration and measurements inside the CLOUD chamber at CERN. Using different temperature sensor arrays in the horizontal and vertical the uniformity of temperature inside the chamber is characterised.

I highly appreciate the effort to perform this kind of chamber characterisation, as the authors correctly state; temperature is a very important factor in cloud nucleation. Thus, I find this kind of manuscript very important and well suited for publication in AMT, however, this manuscript needs a thorough overhaul, as I will explain in the following.

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Major questions:
After reading the manuscript several times, now have the impression that during the calibration campaign only runs with steady flow conditions have been performed. Is this true? If so, why did you not perform evacuations for cloud formation as well? How much data (e.g. in hours, or if evacuations how many) did you take during the calibration campaign. How many hours did you measure in flow conditions during the data campaign? I think this information would be useful and should be added to the manuscript. Please clarify! In general, more information about the experiments performed during both campaigns might be helpful, maybe summarise the experiments in a table?

Why Pt100 sensors were chosen for the calibration strings? This is not motivated in the manuscript. However, as you state, they have a rather long response time (180 s), which seems insufficient for cloud experiments, where temperature drops much faster than this? How do you compare temperatures from the fast response sensors to these slow response sensors? Please explain!

Why do you average the data over 15sec? Does it make sense in case of the Pt100 with time constants around 180sec? On the other hand, 15secs smooth out fluctuations in the fast sensors responses. Do you also smooth data during evacuations?

I would like to see a schematic of CLOUD chamber that shows more detail, e.g. the "serpentine" pipe (page 3, line 71), regulation and gate valves (line 51), sampling ports for cloud measurements. Particularly the valve positions in respect to the temperature sensors would be good to know!

A large part of the introduction (i.e. from line 28) reads more like a potential chapter 2 "chamber operation" (or similar). I would expect more introduction about cloud chambers and the importance of temperature measurements, temperature stability e.g. what motivates your manuscript.

Calibration runs:
Are calibration and data runs performed at the same relative humidity? (Think of cloud formation, latent heat release...)
Are there calibration runs that were performed at data run like flow rate? You could simply let the instruments suck as well – higher flow rate might increase the temperature instability. Thus, it would be necessary to show. How are clouds formed in a calibration run? If clouds are only formed in expansions, what is the meaning of calibration runs for cloud studies in the chamber?
You only show examples of the measurements in the figures for the calibration campaign. Is there a way of showing all data in one plot? Are there any expansions made during the calibration campaign? As the calibration strings were only installed during the calibration campaign, this would need to mimic conditions as they would be during a measurement campaign. If not, what is the aim of the calibration campaign?
You state e.g. in line 148 that around 300 expansions have been performed in the latter campaign. I would expect something like scatterplots showing all data and median/average values (if necessary grouped into classes by speed of expansions to show all data. "Various experimental conditions" are mentioned in the abstract, not mentioned any further later on! What are these various conditions? They could be used to group data for plots. Where is the statistical analysis? What about significances?

Lab calibration:
You mention that the WIKA reference thermometer is calibrated in the temperature range 0-100°C. How to you use it at temperatures below freezing? What confidence do you have in its performance there?
You mention liquid nitrogen as calibration point for cold temperatures. Is it valid to assume linear calibration between -196.21°C and 0°C, why? How did you get calibration points at temperatures between -70°C and 0°C, i.e. at temperatures that would potentially be used for experiments in the chamber? (E.g. you could add one point by using

salt/ice mix and one point by using dry ice in a Dewar flask). How did you calibrate at 0°C, this is not mentioned in the text? Figure A2 is showing a very different behaviour of the sensors at 0°C compared to the water bath calibration points (which, as you state, start at 2°C). So, how trustworthy is the point at 0°C?
Why are the OS, TC and Pt strings not calibrated directly in the lab as well? How exactly is linear interpolation performed for the Pt string (page 8, line 237/238)? Elaborate!

Apart from these main points, I found several typos and grammar errors that give the impression that the manuscript was not properly proof read before submission. Please be mindful of the reviewers, it greatly enhances readability when a manuscript is properly proof read – reviewers are not copy editors.

Further comments:
Abstract:
Please, be precise!
Line 11: lower flow rate of 20l/min stated here, 10l/min stated later in the manuscript (line 68) – what is correct? Also, 210l/min said here but 200l/min (p6, line 182) in the conclusions.
Line 16: “a few times 0.01°C” – exactly how many degrees?
Line 18: “larger non-uniformities” – exactly how big?

Introduction:
Line 31/32: move “is added” to the end of the sentence.
Line 35: Maybe a reference to the CERN Proton Synchroton?
Line 41: space missing before and point missing after “(Voigtlander et al., 2012)”.
Line 42/43: “... (the small excess ensures...” better continue “ that no contaminant vapours enter...”
Line 44: Wilson chamber – is there a reference?

Section 2:
Line 70-74: As mentioned earlier, a schematic of the chamber showing the positions of the serpentine pipe and the inlets where the warm trace gases are injected would be desirable.
Line 78: space missing before "(Kirkby...)"

Section 3:
Line 112: "short term (>15s)" should be "<15s"?
Line 126: "experimental hall temperature" – wall temperature?
Line 129: "high flow flow" – remove one "flow"

Section 4:
Line 147: "The characteristic reheating time constant, .." – a verb is missing.
Line 167/170: References to Fig. 6c and Fig. 6d should be Fig. 10c and Fig. 10d?

Conclusions:
Line 181 "high flow flow"... as earlier, remove one flow.

Appendix:
This describes the calibration in detail. Isn't the temperature calibration a main point in this study? In that case, it should be found in the main manuscript.
Line 203: What is the uncertainty at temperatures below freezing?
Line 223: Figure A2 shows a calibration point at 0°C, however, you do not mention how you calibrated at this point (water bath from 2°C on)?

Figures:
Figure 1: typo - dessicated = desiccated
Check flow rates (here 20l/min and 210l/min)

Figure 4: How did you choose which sensors you show here? Motivate your choice. You could also show all other sensors in a supplement.

Figure 6: Mark which data points result from the calibration runs and which from data

campaign. What does 21% and 100% fan mean, please explain.

Figure 7: Is the right hand axis really showing pressure, or rather δp (i.e. overpressure in the chamber)?

Figure 10: same as Fig. 7.

Figure A4: You mention a malfunction of the PTH2 sensor, was this true for the whole campaign?

Figure A5: Were the OS4 and OS5 sensors replaced after the calibration campaign (as obviously they showed an unusual behaviour)?

Tables: Table 1: From this table one could think that the TC and PTH / OS and PTV sensors have the same position. It would be better to indicate the offset in the table, e.g. by saying "0 (-20)" in the Height column (TC and PTH), and accordingly for the radius column for the OS and PTV sensors.

Table A4: Why are PT4 and PT6 missing?

I recommend a thorough overhaul of the manuscript before resubmission and potential publication.

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