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Atmospheric Measurement Techniques Discussions

Interactive comment on "Continuous standalone controllable aerosol/cloud droplet dryer for atmospheric sampling" *by* S. Sjogren et al.

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We thank the referee (R) for constructive and thoughtful comments, which we address below.

General:

R: "...needs revisions in structure and content."

Answer: We agree. We will change the outline as the referee proposes, in order to improve the organization and readability. Also referee 1 commented on this topic. New outline for section 2:

2. Materials and methods

2.1 Design Criteria

2.1.1 Diffusion/impaction losses

2.1.2 Electrostatic losses

2.1.3 Residence time

2.2 Design - Generation of dry air

2.3 Aerosol particle transmission characterisation

2.4 Ambient measurements

R: "equations 5 6 that better fit into the methodology..."

A: We will move these equations, and the surrounding explaining text into methods section (best would be into new section 2.3).

R: "writing and content ... more succinct..."

A: Indeed, we expect, as the referee, that the above restructuring helps in improving these issues, as well as reformulating unspecific wording to more precise expressions.

Specifically the following are addressed:L. 8 p. 5474 "aligned". As the referee points out this is unspecific. Will be changed to: "When the dryer is used in the DAA the flow field arrangement allows cloud droplets to be transported vertically into the cross-section between the two membranes, ..."

In addition to the problems explicitly pointed out by the referee, the language has been changed on the following places:

P 5470 L23: "... and monitor its properties."

P5470 L26: "An automatically..."

5472 L21 “The DAA requires typical cloud droplets to be transported by a flow vertically into and inside the dryer. . .”

5476 L24: “constantly at the minimum time interval.”

5480 L8-L12: “The lines to guide the eye are based on the assumption of a logarithmic dependence of RH along the dryer (Bierwerth, 2001). The sample flow between two concentric membranes is surrounded by two closed loop drying flows, the outside flow-rate being 10 L min-1 and the inside 4.7 L min-1. The total flow thus is approximately three times as large drying airflow as sample flow.”

L17: “and the ratio was 1.5 (implying that the inner flow should have been set higher)”

5481 L12, inserted “RHdried”

L16-L17: “. . .be defined primarily in order to deal with situations when the outdoor part of the instrument is warmer than the indoor part. In this study we considered . . .”

5483 L23: “A dryer designed for continuous. . .”

Specific comments

R: P. 5471, l. 23, ". . .leakage. . . closed loop design?"

A: We meant that the closed loop set-up of the dry airflows prevents gas transfer from the dry airflows to the sample flow or vice versa. Of course, as in any system, if the closed loops are not of good quality and leaking, then there is a leak. This is not appropriate, and we took care this was not the case. We will add this distinction in text. The referee further indicates if there are other solutions possible, and it is conceivable that for example a flow-through dry air system can be used, however, contrary to a closed loop system, the pressure drop can induce a constant transfer of gas through the membrane. We have not evaluated that potential effect, and we have not seen that described in the literature.

R: "p. 5471-5472 text after l. 19 should be at beginning"

A: We started with the general description of the dryer principle, followed by the design criterion and continued with the specific dryer used in our instrumentation. The text after l.19 will be moved upwards to after p. 5471 l.24, so that the new order will be: principle, specific dryer, criterion, and ending with determination of membrane area.

R: "p. 5474, reference Ogren or Rood"

A: We assume the referee means e.g. Ogren et al., CVI, 1985. This will be added. Could the referee please send, via the editor, more specifically, which articles the referee means, then we would be pleased to add these.

R: ”pg. 5476 Generation of dry air”

A: This section is moved to a subsection in section 2. The generation of dry air can be done in various ways, with same drying results (assuming same dry air generation capacity).

R: Ln. 15 pg. 5479, ”bends”

A: The two ”90° bends” were only used in the experimental set-up, shown in Fig. 3. They contribute to the model of the experimental set-up, for super-micron sizes. This will be clarified in text, on p. 5479, l. 15 and added earlier in section methods as well.

R: ” Ln. 13 pg. 5481, state the average Temperature with the RH measurement.”

A: The average ambient temperature was 9.2 degree C. The average temperature in the station was 22.8 degree C. Will be added in text. See also comment Fig. 5 below.

R: ” pg. 5483 Discussion, does the inlet RH affect the transmission efficiency?” and Fig. 4.

A: The inlet (ambient) RH (and T) influences the transmission in two ways. Firstly, increasing RH (as well as decreasing temperature, by itself) increases the time required to dry a given cloud droplet (specified on P5475 L19-22). This might increase losses due to impaction, however only for (larger) super-micron drops not being sufficiently dried. Secondly, increasing specific RH, increases the load on the dry air regeneration system (it thus requires switching more often), thus reduces the effective time measurements can be done. The second effect is more of a technical design issue to solve, and the first one is used a criterion during the development of the dryer, as detailed on P5472 L1-7. In caption (Fig. 4) will be added “These experiments were performed with dry conditions, < 30% RH.”

R: ” Fig. 1, Functionality of parts upstream of dryer not clear. Also, why is this (fairly complicated) design preferred over a traditional annular dryer design?”

A: This study focus on the dryer design. The dryer was used in the droplet aerosol analyzer (DAA), and in order to show a more complete view, the DAA inlet was included in Fig. 1. The inlet is described in Frank et al., 2004, which will be added as reference. In order to sample homogeneously charged cloud droplets, at a flow rate of 5.7 L min-1, an annular slit was designed with an outer excess flow and an inner excess flow, set separately. In order to dry this airflow, still including the cloud droplets and at ambient RH, the dryer requires the same dimensions, situated precisely below. See also comment L. 8 p. 5474 "aligned" above.

R: ”Fig. 2, point out cross flow which results in the shown decrease in drying flow RH from top to bottom.”

A: The sample flow was 5.5 L min−1, outer drying flow 10 L min-1 and inner drying flow 4.7 L min-1. This will be added to Fig. 2.

R: Fig. 2. ”How was the sample flow point at 0.25 m measured ? what are the typical RH uncertainties? Also state roughly temperature range at which the experiment was performed.”

A: The sample flow RH inside the dryer was measured by inserting a tube in that location and extracting a flow (corresponding to tube diameter) to a Rotronic sensor (HygroClip S) just outside the dryer. We considered that the temperature was similar

for all material used in this experiment, and the temperature was 21 degrees C (air-conditioned lab). The typical accuracy of the Rotronic sensors (HygroClip S) were 1.5 %RH and 0.3 K. This technical information will be added in text.

R: "Fig. 3, Confusing, Not enough detail for publication, e.g. was the DMA aerosol flow 4.7 lpm."

A: We apologize. The DMA in panel B used 2.2 L min-1 sample aerosol flow and 9.8 L min-1 sheath flow. Missing in Fig. 3 panel B is a low pressure-drop filter used after the DMA (downstreams Ni 63) to dilute the DMA sample flow. Referee 1 also pointed out this error. Fig. 3. will be corrected.

R: Fig. 4. “RH affects transmission”

A: See comment above, pg. 5483 Discussion. In caption will be added “These experiments were performed with dry conditions, < 30% RH.”

R: Fig. 5. ”Temperature and upstream RH/T conditions”

A: The temperature in the measurement station was in the range 12-34 degrees C and ambient temperature range was -2.6-28 degrees C and ambient RH range was 9.5-100%. This will be added in caption.

Technical corrections

R: Ln. 6, Abstract, define "highly charged"

A: In our application the largest droplet size investigated is charged to 2.0x10ˆ2 charges, and has a distribution, so that charges up to 5x10ˆ2 charges are of relevance, and could be detected. Highly charged will be defined as 5x10ˆ2 charges in text.

R: Ln. 12, Abstract, missing word before 4.6 x....

A: Will insert in text ”. . .measured to be. . .”. Similar on p. 5481 l. 1 and in conclusions.

R: Table 1, confusing names "Inner Tube", "Outer Tube", "Sample air space", maybe just "inner drying flow, outer drying flow and sample flow"

A: Will add names: inner flow, outer flow, sample flow.

References

Frank G. P., Sven-Inge Cederfelt, Bengt G. Martinsson, Characterisation of a unipolar charger for droplet aerosols of 0.1–20 um in diameter, Journal of Aerosol Science, Volume 35, Issue 1, January 2004, Pages 117–134

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Ogren, J. A., Heintzenberg, J. and Charlson, R. J. 1985. In-situ sampling of clouds with a droplet to aerosol converter. Geophys. Res. Lett. 12, 121–124.

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 5469, 2012.