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Atmospheric Measurement Techniques Discussions

Interactive comment on "A new electrodynamic balance design for low temperature studies" *by* H.-J. Tong et al.

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Response to the comments of Anonymous Referee #1

The authors present a new electrodynamic balance setup intended for studying evaporation rates and nucleation studies at low temperatures. The new design is based on previous designs, but offers an interesting approach for cooling and temperature control of the particle by a gas flow system. The authors describe their setup; explain the analytical capabilities for sizing the particle and detecting phase change and show two types of experiments performed with the setup. The first is the evaporation of single water droplets at different temperatures; the second are experiments exploring the heterogeneous ice freezing properties of washing water from birch pollen.

Response: We thank the referee for reviewing this paper and for providing great comments. We respond to each comment in detail below. We have highlighted the changes to the text (in yellow) and have attached the altered text as a supplement.

Referee comments 1: While the experiments look interesting and the new setup well designed, I feel what is severely missing in the present paper is an experiment characterizing the new setup in a quantitative manner. The experiment of the evaporating water droplets could serve as such, but the authors show only temperature dependent evaporation rates but point the reader to a forthcoming paper in which a quantitative comparison with theory is promised. In my opinion this is not acceptable. Without an experiment proofing that the new setup is capable of reproducing either a previous experiment of another setup, or that the results obtained with the new one can be modelled using established theory, the performance of the new setup remain unclear.

Response: We understand the reviewer's comment and we are sympathetic towards them. However, to model the evaporation rates one needs a value for the accommodation coefficient (alpha) of water vapour into liquid water. This value is highly controversial within the literature with alpha values reported within the last decades varying between ∼0.1-1 (e.g. Eames et al., 1997, Li et al., 2001, Winkler et al., 2004, Davies et al., 2014). This factor of ten presents a large uncertainty for the modelling of cloud water. Whilst it is possible for us to use the theoretical model of Davies et al. (2014) to calculate alpha from our measurements (and we have) we intend to perform more experiments over a wider range of conditions before we publish this result, hence the mention of the forthcoming paper. We believe that publication of this value before these further experiments have been performed would be premature and could further muddy the water in this controversial area. We further justify our approach by pointing out that we choose AMT for this initial paper because it was primarily to highlight our new CEDB approach not to provide new data.

However, we are mindful that the paper will benefit from more useful data that the community can utilize. Towards this aim we have much extended the amount of data presented on the freezing of droplets. In particular we show that the system accurately measures the homogenous freezing temperature (see discussion below). We hope this convinces the reviewer that the new CEDB can reproduce established results. This work has increased the author list.

Referee comments 2: There could be for example issues with temperature gradients, with temperature stability, with calibration etc.. I am not all thinking that these problems do exist, but the paper in the present form does show only that the setup behaves as expected qualitatively.

Response: We now provide more information about the measured temperature gradients within the cell (see Table 1 within the revised paper). The measured temperatures 2 mm away from the central null point are now detailed in the radial and in the positive and negative axial direction we measured more data points at various set temperatures and have updated the manuscript to highlight this (line 5-21 of page 9). The temperature stability in the cell is good. The temperature at the null point was measured between every data point. We found that the fluctuation of temperature is $<0.2\ ^{\circ}C$ once the temperature has reached equilibrium. This is now stated on p.8, line 3.

Referee comments 3: The second experiment presented, namely the freezing probabilities of the washing water from birch pollen can also not serve as a reference since there is too little known about the exact properties of this nuclei. I suggest that the authors either include the quantitative analysis of their evaporation data, or show another experiment to prove the capabilities of the new setup quantitatively.

Response: In order to quantify the performance of the CEDB, we made measurements of the homogeneous freezing temperature of pure supercooled water droplets (see Figure 2b). We found that homogeneous freezing occurs at temperatures below $-38\pm1\ ^{\circ}C$. This is in excellent agreement with the accepted literature value of $-38\ ^{\circ}C$ (Koop et al., 2000). Within the manuscript, we provide this information now on p. 10, line 9-13 and in Figure 5 (b). The paper already provided evidence of the accurate

quantification of particle size in Figure 2. Hence we demonstrate that the temperature and size measurement within the CEDB is reliable. We believe that our new CEDB is sufficiently characterised to demonstrate its suitability for quantitative ice nucleation studies. With this demonstration provided, we include the freezing studies on pollen washing water to provide an application of the CEDB to a current “hot topic” within atmospheric science literature namely the role of biomaterial in ice nucleation. We believe the data set is of high quality and of great interest to the community.

References:

Davies, J. F., Miles, R. E. H., Haddrell, A. E., and Reid, J. P.: Temperature dependence of the vapor pressure and evaporation coefficient of supercooled water. J. Geophys. Res. Atmos., 119, 10931-10940, 2014. Eames, I. W., Marr, N. J., and Sabir, H: The evaporation coefficient of water: a review. Int. J. Heat Mass Transfer. 40, 29639-2973, 1997. Koop, T., Luo, B., Tsias, A., and Peter T.: Water activity as the determinant for homogeneous ice nucleation in aqueous solutions. Nature, 406, 611-614, 2000. Li, Y. Q., Davidovits, P., Shi, Q., Jayne, J. T., Kolb, C. E., and Worsnop, D. R.: Mass and thermal accommodation coefficients of H2O(g) on liquid water as a function of temperature. J. Phys. Chem. A, 105, 10627-10634, 2001. Winkler, P., Vrtala, A., Wagner, P., Kulmala, M., Lehtinen, K., and Vesala, T.: Mass and thermal accommodation during gas-liquid condensation of water. Phys. Rev. Lett., 93, 075701, 2004.

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/7/C4229/2014/amtd-7-C4229-2014-supplement.pdf

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 7671, 2014.