

Interactive comment on “The portable ice nucleation experiment PINE: a new online instrument for laboratory studies and automated long-term field observations of ice-nucleating particles” by Ottmar Möhler et al.

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Received and published: 11 December 2020

Author comment in response to the comments provided by Referee #4

We thank referee #4 for her/his effort in reading and commenting our manuscript. In the following, we repeat the referee's comments (italics), give point-by-point answers, and suggest manuscript revisions based on the referee's comments and our answers. Respective reference will be given to the line numbers of manuscript version 1.

Referee comment:

C1

The knowledge of ice nucleating particles and their impacts on clouds was restricted by the development of measurement techniques and instruments. This manuscript presents a new instrument based on expansion chamber for both laboratory studies and field observations to measure ice nucleating particles. The authors successfully demonstrate the applicability of their new instrument to be compared with AIDA and deployed in a field campaign. Different from the commonly used Continuous Flow Diffusion Chamber (CFDC), PINE is truly the first commercial instrument capable of automated long-term continuous observation, and its development provides an excellent complement to enrich measurement methods. This research aligns well with the scope of AMT. The manuscript is well written and easy to follow, thus should be acceptable for publication after considering following minor comments:

Referee comment:

P2 Line28: The abbreviation “(INPs)” should not be linked directly after “. . . atmospheric aerosol particles”. Moreover, two sets of parentheses are used instead of one. For example, “. . . atmospheric aerosol particles (INPs) (Vali et al., 2015)”.

Answer:

Thanks for noting this. We suggest to reformulate lines 27/28 as follows:

“In the absence of homogeneous freezing, the cloud ice phase is initiated in various ways by ice nucleating particles (INPs), a very small fraction of atmospheric aerosol particles (Vali et al., 2015).”

Referee comment:

P2-3: The need for promoting INP monitoring was put forward until P3 Line 63, and the new methods and instruments for INP measurements were discussed from P3 Line 90. Please consider adding more descriptions and comparisons of existing instruments, especially the most commonly used CFDC, and simplifying the context on INP.

Answer:

C2

Referees #1 and #3 have also suggested similar revisions to the introduction. We have removed some parts and in particular revised lines 84 to 100 (see our answers to referees #1 and #3). We have in particular added reference to recent developments of by Bi et al. (2019) and Brunner and Kanji (2020), and for other instruments like CFDCs we referred the reader to the paper by DeMott et al. (2018).

Referee comment:

P9 Line275: A parenthesis is missed.

Answer:

Yes, added.

Referee comment:

P12-14: PINE-c performed the field measurements to demonstrate its capability, however, the comparisons with AIDA and performance tests were conducted by the prototype version PINE-1A. PINE-c is a further developed version with major upgrades in chamber type, cooling system, controlled temperature range, particle detector, and so on. So direct characterizations and tests of the performance of PINE-c would be helpful.

Answer:

This is a good point. Unfortunately, there was time for only a few test runs of PINE-c at the AIDA (Aerosol Interaction and Dynamics in the Atmosphere) cloud chamber facility, before the instrument had to be delivered for participation in the ARM-SGP field campaign. Meanwhile, three more instruments of type PINE-c have been built, and two of them are currently extensively tested and operated at the AIDA facility (see for instance the new Figure A6 in the appendix) and also next to the PINE-1A version. A more comprehensive comparison of PINE-c with other methods and instruments will be the subject of upcoming publications.

C3

Referee comment:

Figure 7: Please notice the superscript of the unit, "... 5 l min⁻¹".

Answer:

Yes, corrected.

References:

Bi, K., G. R. McMeeking, D. Ding, E. J. T. Levin, P. J. DeMott, D. Zhao, F. Wang, Q. Liu, P. Tian, X. Ma, Y. Chen, M. Huang, H. Zhang, T. Gordon, and P. Chen, 2019: Measurements of ice nucleating particles in Beijing, China. *Journal of Geophysical Research: Atmospheres*, 124, 8065–8075. <https://doi.org/10.1029/2019JD030609>

Brunner, C. and Kanji, Z. A.: Continuous online-monitoring of Ice Nucleating Particles: development of the automated Horizontal Ice Nucleation Chamber (HINC-Auto), *Atmos. Meas. Tech. Discuss.*, <https://doi.org/10.5194/amt-2020-306>, in review, 2020.

DeMott, P. J., Möhler, O., Cziczo, D. J., et al.: The Fifth International Workshop on Ice Nucleation phase 2 (FIN-02): laboratory intercomparison of ice nucleation measurements, *Atmos. Meas. Tech.*, 11, 6231–6257, <https://doi.org/10.5194/amt-11-6231-2018>, 2018.

Interactive comment on *Atmos. Meas. Tech. Discuss.*, doi:10.5194/amt-2020-307, 2020.

C4