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# *Interactive comment on* "An instrument for quantifying heterogeneous ice nucleation in multiwell plates using infrared emissions to detect freezing" *by* Alexander D. Harrison et al.

**H. Grothe (Referee)**

grothe@tuwien.ac.at

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This is a well-written paper with an interesting experimental approach that fits perfectly well into the journal Atmospheric Measurement Techniques. The authors describe an instrument for quantifying heterogeneous ice nucleation: the InfraRed-Nucleation by Immersed Particles Instrument (IR-NIPI). They use multiwell plates and an infrared camera for detection of the freezing process. For comparison, they have investigated homogeneous ice nucleation of ultrapure water, and the heterogeneous freezing of two mineral dust samples. The manuscript should be published in AMT after major revisions.

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Discussion paper

General comments

In line 72, the authors claim "Here we propose a new technique,...". Unfortunately, this is not entirely true. A quick literature research shows that there are other instruments with very similar approaches. In particular, I would like to mention the set-ups of Zaragotas et al. and of Kunert et al. It is good scientific practice to search, to describe, and to discuss the findings of other scientists when presenting a new set-up. I expect that the authors make up the leeway in the revised version of the manuscript.

Concerning the set-up of Kunert et al., I could not find any peer-reviewed publication, but I have been the organizer of two ice workshops (Kunert 2016b, 2017b) and the convener of two EGU General Assembly sessions (Kunert 2016a, 2017a) and a speaker at the INUIT Final Conference and 2nd Atmospheric Ice Nucleation Conference (Kunert 2018), where this research has been presented. At all these meetings, also the authors were present and in the case of the latter have even been the organizers. Therefore, the Twin-plate ice nucleation assay (TINA) with infrared detection by Kunert et al. is well-known to them and should be described in their manuscript for comparison with IR-NIPI.

In line 48, the authors list some droplet freezing assay experiments but the list is rather incomplete, e.g. Häusler 2018 is missing. I strongly recommend a table with all technical parameters of each experiment listed, e.g. number of observed volumes, volume of the droplets, homogeneous ice nucleation temperature, etc. Finally, for all experiments a discussion of the pros and cons in comparison to IR-NIPI should be added.

Instead, the authors compare only their own set-ups, i.e. $\mu$L-NIPI and IR-NIPI. However, the volume of the respective droplets is very different, $1\mu$L versus $50\mu$L, respectively. This is not only important for homogeneous ice nucleation, which shows strong volume dependence, but also is important for heterogeneous ice nucleation because larger volumes carry more INPs and the abundance of efficient INPs rises. The authors have discussed this only partly and a more elaborated discussion might be necessary.

In particular, I miss plots of the homogeneous freezing events and a detailed study of the freezing of single droplets (marked with numbers on a picture of the multiwell assay). I also recommend adding the diameter of the droplets to the volume to make the study more comparable to other studies.

The authors make the point that their set-up is more sensitive for low concentrations of INPs, which is particularly true for strong INPs. However, they don't mention the disadvantage of their set-up, which is that they cannot easily measure weak INPs. In the atmosphere, the number of strong INPs is extremely low, which makes $\mu$L-NIPI a valuable technique. However, often strong INPs are entirely missing and weak INPs will be much more abundant. Therefore, the authors should discuss the limitations of their set-up and should also show experiments at the detection threshold and should investigate proxies for weak INPs e.g. cellulose or soot. Also I miss biological INPs or proteins and polysaccharides been emitted by biological sources. Therefore, beside ns values of solid INPs also nm values of soluble INPs should be measured and discussed.

Specific comments

Where is the homogeneous freezing temperature (T50) of ultrapure water in your IR-NIPI set-up?

Have you quantified the effect of the walls of the multiwall plates on the freezing process?

Line 99: Also indicate the formula for nm and add respective water soluble samples.

Line 182: "standard deviation $\pm 0.5^\circ$C"

Line 190: "after the first equilibrium step at +5$^\circ$C"

How is the temperature uncertainty in the range between -20$^\circ$ and -30$^\circ$ C ?

You have only used ultrapure water for temperature calibration. How about other sam-

ples such as aqueous salt solutions, higher alcohols or alkanes?

Line 215: What kind of filter has been used for purification?

A figure, similar to that in fig. 7B, should be plotted also for feldspar samples including comparison data from other groups.

In figures 2, 3, 4, and 7 capital letters have been used in the graph but small letters have been used in the figure caption, respectively.

References

Häusler, T., Witek, L., Felgitsch, L., Hitzenberger, R., Grothe, H.: Freezing on a Chip - A New Approach to Determine Heterogeneous Ice Nucleation of Micrometer-Sized Water Droplets, Atmosphere 9 (4), 140, 2018.

Kunert, A. T., Scheel, J. F., Helleis, F., Klimach, T., Pöschl, U. and Fröhlich-Nowoisky, J.: New High-Performance Droplet Freezing Assay (HP-DFA) for the Analysis of Ice Nuclei with Complex Composition, in EGU General Assembly Conference Abstracts, vol. 18, pp. EPSC2016-6293., 2016a.

Kunert, A. T., Scheel, J. F., Helleis, F., Klimach, T., Pöschl, U. and Fröhlich-Nowoisky, J.: TINA: A New High-Performance Droplet Freezing Assay for the Analysis of Ice Nuclei with Complex Composition, in 4th Workshop - Microphysics of Ice Clouds., 2016b.

Kunert, A. T., Lamneck, M., Gurk, C., Helleis, F., Klimach, T., Scheel, J. F., Pöschl, U. and Fröhlich-Nowoisky, J.: TINA, a new fully automated high-performance droplet freezing assay coupled to a customized infrared detection system, in EGU General Assembly Conference Abstracts, vol. 19, p. 13571., 2017a.

Kunert, A. T., Lamneck, M., Gurk, C., Helleis, F., Klimach, T., Scheel, J. F., Pöschl, U. and Fröhlich-Nowoisky, J.: TINA, a new fully automated high-performance droplet freezing assay coupled to a customized infrared detection system, in 5th Workshop - Microphysics of Ice Clouds., 2017b.

Kunert, A. T., Lamneck, M., Helleis, F., Scheel, J. F., Pöschl, U. and Fröhlich-Nowoisky, J.: TINA: Twin-plate ice nucleation assay with infrared detection for high-throughput droplet freezing experiments, in INUIT Final Conference and 2nd Atmospheric Ice Nucleation Conference., 2018.

Zaragotas, D., Liolios, N. T. and Anastassopoulos, E.: Supercooling, ice nucleation and crystal growth: A systematic study in plant samples, Cryobiology, 72(3), 239–243, 2016. http://dx.doi.org/10.1016/j.cryobiol.2016.03.012

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Interactive comment

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