

Review of “Analyzing the chemical composition, morphology and size of ice nucleating particles by coupling a scanning electron microscope to an offline diffusion chamber”

General comments

In this study, the authors present an offline method for characterizing ice nucleating particles (INPs) by coupling an offline diffusion chamber, the FRankfurt Ice nucleation Deposition freezinG Experiment (FRIDGE), with a scanning electron microscope (SEM). The approach is potentially useful to provide comprehensive information of INPs, including their chemical composition, morphology, and size, and to improve the parameterization in the corresponding models. However, the advantages of combining the two instruments are not well demonstrated from the case study at JFJ. The FRIDGE-SEM coupling technique is not new and no convincingly new findings are shown in this study compared to the former studies at the JFJ. The methodology needs more details as intended to, in particular the coordinate system that allows for recovery of the particles, which is critical to determine whether particles are original or processed INPs. Statistical significance is also a big concern. It is unlikely to use the data present in this study to evaluate the INP-type-specific parameterizations in the model. In addition, the manuscript is not very well structured. The potential contribution of this study is within the scope of AMT. However, the current manuscript is behind publication quality due to the reasons as mentioned above. Therefore, I recommend that substantial revision needs to be done before considering publication.

Major Comments

The novelty of this study is supposed to be the technical details and direct measurement of INPs. However, it needs more details to convince the readers that the individual particles can be fully recovered after measurement cycle of the FRIDGE. Additional controlled experiments may need to be done and shown to prove that hypothesis. Otherwise, the SEM measurement would be on the IRs rather than original INPs.

It is good that comparisons with previous studies at JFJ are discussed. However, the authors may want to add more discussion on the differences and emphasize the new findings.

The results were based on 200 individual particles from 5-week measurement, and only half of the total analyzable area of each wafer was analyzed by SEM. The author should evaluate the statistical significance, discuss more about the representativity, uncertainty and limitations.

The structure of this manuscript needs revision. The introduction, method and results sections have several overlaps, which need to be improved. E.g., in the introduction section, L 126 to 130 belongs to method part; Section 2.6 Chemical classification should be merged into Section 3.4 INP chemistry or go to supporting information; Section 3.1 Sampling site needs to go to method and/or introduction; Section 3.3 Method evaluation needs to go to method section.

Minor Comments:

L33: Please remove “e.g.” from the citation and do it through the entire manuscript.

L41-42: What is the temperature range you mentioned? Please add the values and explain why the main focus has been on such range.

L44: Quantify the “small fraction”. How much%?

L46 & 51: Change “history within the atmosphere” to “atmospheric processing”

L60: Mineral dust is a good INP, rather than an important factor in ice nucleation.

L76-93: Please consider remove or shorten this part. Lab, field and model studies are the main approaches for atmospheric science. This is very basic and general, not specific for ice nucleation studies.

L103-104: The sentence is unclear. Please revise.

L105-106: It is unclear why the IR and INP are in the brackets. Please add more descriptions.

L111: What are the problems? Please elaborate.

L116-122: You might want to emphasize more on the advantages of EM over online measurement technique. For example, the morphology and quantitative results that SPMS generally does not provide without reference instrument. Note that SPMS can provide information of mixing state, which is not only obtained by the EM.

L131: I am not convinced that the particles characterized by SEM are INPs rather than IRs.

L133-148 Figure 1: It is unclear regarding the second and the third pictures, please consider adding B1, B2 and B3 for second and third pictures regarding the FRIDGE, C1, C2 and C3 for SEM. Please add the missing legends for the bars and pie chart. Please add missing units for the x-axes on the EDX spectra and the time series of INP conc., respectively. Please increase the resolution of the pictures, especially the scales and labels which are too vague for current version.

L174: Change “at” to “in”.

L205: Will measurement cycle change e.g., morphology or properties of particles? If no, you need to give the proof.

L204: Change “electron microscopy” to “EM”. The full name only needs to be mentioned when shown for the first time in the manuscript (from introduction section).

L223: What is ImageJ? Please explain.

L231: Consider changing “time-consuming” to “labour-intensive” or other more appropriate word. Please revise and give the approximation of the duration of such analysis.

L247: Give full name for “FEI”

L254: Remove the full name of SEM.

L267: How much is the uncertainty? Please give the value.

L294: How much smaller? Please give the value.

L302: “appearance”, do you mean morphology?

L305: Consider changing “excellent” to “efficient”

L374 Figure3: The scales and labels are too vague. Please increase the resolutions.

L437-438: Please separate the samples into cloudy and clear sky cases and discuss accordingly.

L440-444 Figure 6: Cloudy and clear sky cases should be separated.

L634-636: Consider archiving data in a reliable public data repository.