

Interactive comment on “Development and characterization of an ice-selecting pumped counterflow virtual impactor (IS-PCVI) to study ice crystal residuals” by Naruki Hiranuma et al.

Anonymous Referee #2

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This manuscript has outlined the development and validation of a custom-built pumped counterflow virtual impactor (PCVI) that has a larger internal volume than commercial PCVIs and can accommodate a larger counterflow. This larger counterflow enables this manuscript's PCVI to have $D(50)$ cutoff sizes >10 micrometers (over twice that of the aforementioned commercial PVCIs), and is thusly termed "ice-selecting" due to its ability to reject large droplets found in mixed-phase clouds.

The development of the PCVI was guided by computation fluid dynamics simulations and the ice selecting PCVI (IS-PCVI) was validated in the laboratory by coupling it to the AIDA chamber. Validations included the determination of the cut sizes and transmission efficiency for droplets and pristine ice crystals, performance of the evaporation

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section downstream of the IS-PCVI, sampling particle concentrations in the pumped flow, discrimination of droplets and ice particles using a Particle Phase Discriminator, and determination of articles using OPC size distributions and a single particle mass spectrometer.

Overall, this is a well-written and well-organized manuscript with excellent scientific backing. It is well within the scope and quality of Atmospheric Measurement Techniques and would be a welcome addition to the ice nucleating particle literature. In particular, it addresses an increasing need for new instrumentation to sample ice crystals from mixed-phase clouds while rejecting large cloud droplets. I do, however, have several general, minor, and technical comments that should be addressed to increase the clarity and quality of the manuscript.

General Comments:

A discussion of the paper on the "Ice Selective Inlet" by Kupiszewski et al., [2015] is glaringly missing from the introduction section. The comment on Page 4, Line 1 that "this study presents the first application of a PCVI for analyzing only pristine ice crystals from a mixture of droplets and interstitial particles" should be re-phrased in light of the Kupiszewski paper.

Although some descriptions of the experiments labeled by CAMPAIGN_## are described in the experiment section and Table S2, it would be useful to re-described these experiments in the results section. At the least, describing the aerosol type would help prevent the reader from having to flip back and forth between the experiments, supporting information, and results section while reading the results section. This occurs specifically in sections 4.3, 4.5, 4.6, 4.7,

It should be made clear throughout the manuscript when CPC 2 has been corrected using Equation 6. Furthermore, it seems to the reviewer that the "corrected" CPC 2 should always be used when determining transmission efficiencies (Section 4.3, 4.6). Similarly, in Section 4.3, is the $(\text{OPC } 3)/(\text{OPC } 1)$ ratio on Page 4, Line 27 also corrected

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for the concentration factor due to the PCVI? Finally, in Section 4.6, is there an expected concentration factor for the pumped flow? That is, is it valid to assume that $(CPC\ 1) = (\text{corrected CPC 2}) + (CPC\ 3)$?

The reviewer was extremely happy to see the experiments in Section 4.8. It would be useful for the reader to know the efficiency of the miniSPLAT to see both the bacteria and BC. If either of those are not seen with unity efficiency, the concentrations should be corrected. Finally, can the authors postulate why the IS-PCVI seems to largely avoid the problems with wake capture, etc. that troubles the traditional PCVI as in the cited Pekour and Cziczo [2011] paper?

Minor Corrections:

Page 2, Line 8: Are "ice residual particles" always "leftover INPs?"

Page 2, Line 16: In the context of an "ice-selecting"-PCVI, it seems as if the statement "separating ice residuals from interstitial particles" would benefit from a small discussion on mixed-phase clouds and the relative size of droplets and ice particles.

Page 9, Line 22: TSI 3076 is an aerosol generator, please correct. Furthermore, is this CPC what is eventually termed "CPC 1?" If CPC 1 and CPC 2 are different models, is there a possibility that you could be over/underestimating your losses through the IS-PCVI due to different counting efficiencies?

Page 14, Line 7: A description of the dashed black line in Figure 6d should be added here. Furthermore, a discussion of why OPC 2 counts are much larger than the "corrected" CPC 2 counts should also be added.

Page 14, Line 24: It is interesting that the authors validated that the PCVI is "ice-selecting" by determining the TE of very large droplets. How prevalent would droplets of this size be for a normal AIDA chamber expansion? What about for ambient mixed-phase clouds?

Page 16, Line 7: It would be helpful to the reader to address the difference between

12a and 12b and define static vs. active sampling with the PVC1.

Figure 5: It might be more instructive to the reader to have the IFs directly on each figure.

Figure 14e: It is very difficult to determine the BC concentrations after the second injection. Would it be more useful to put these concentrations on a log scale?

Technical Corrections:

Page 1, Line 19: Change "in the controlled mixed-phase cloud system" to "in controlled mixed-phase cloud systems"

Page 1, Line 21: Delete "(CFD)" as it is not used in the remainder of the abstract

Page 2, Line 7: What does "their" correspond to?

Page 2, Line 21: Change "to collect" to "the collection of"

Page 3, Line 17: Delete "since"

Page 3, Line 20: Change "reduced the TE" to "reduced TE"

Page 4, Line 10: Unsure what "the application" refers to

Page 5, Line 5: Delete "the" in "equipped with the"

Page 5, Line 6: Delete "the" in "the 5-ohm heating wire"

Page 7, Line 7: Change "is used to seal" to "are used to seal"

Page 8, Line 18: Change "using first two" to "using the first two"

Page 8, Line 28: Change "investigate 'unintentional transmissions', as" to "investigate 'unintentional transmissions,' as"

Page 8, Line 31: Change "was to" to "were"

Page 9, Line 10: Does the author mean "tenths" or "tens?"

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Page 10, Line 7: Does the author mean "larger and" or "larger than?"

Page 17, line 23: Change "grown up to" to "grown to"

Page 17, line 24: Change "others is based" to "others based"

Page 18, line 2: Change "the layers of the T-controlled" to "layers of T controlled"

Page 18, line 10: Change "particles are analyzed with the single" to "particles were analyzed with a single"

Page 18, line 11: Delete "further"

Page 18, line 12: Change to either "using a single particle mass spectrometer" or "using single particle mass spectrometry"

References:

Kupiszewski, P., Weingartner, E., Vochezer, P., Schnaiter, M., Bigi, A., Gysel, M., Rosati, B., Toprak, E., Mertes, S. and Baltensperger, U.: The Ice Selective Inlet: A novel technique for exclusive extraction of pristine ice crystals in mixed-phase clouds, *Atmos. Meas. Tech.*, 8(8), 3087–3106, doi:10.5194/amt-8-3087-2015, 2015.

Interactive comment on *Atmos. Meas. Tech. Discuss.*, doi:10.5194/amt-2016-102, 2016.

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