

## ***Review 2 of Secondary ice production during the break-up of freezing water drops on impact with ice particles***

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I appreciate the authors' efforts to revise the manuscript and find that I understand the proposed mechanism and setup much better now. For example, the paragraph in lines 35-41 is now quite helpful to understand the difference between mode 1 and mode 2 drop freezing and fragmentation, and addition of mechanism 'phase labels' to Figures 3 and 4 is nice. I also appreciate mention of experimental challenges and future work in Section 5. I have a series of minor comments and edits after my second read-through, but otherwise support publication of the manuscript.

### **Comments**

Abstract - The abstract starts brusquely. I would add an initial contextual sentence about the importance of secondary ice processes and the contribution of these experiments to better understanding their mechanisms.

Lines 51-64 – These paragraphs seem to me to fit better after line 23. Then you have discussed the general importance of secondary ice, first to understand discrepancies between INP and ICNC and second to explain persistent generation of ice in thin mixed-phase clouds. After that, you present rime-splintering as the most widely employed and studied mechanism and finish by suggesting that this new mode 2 drop freezing and fragmentation could also be important.

Lines 95-96 – Is a more convincing argument here for the relevance of this impact velocity that the mixed-phase region, at least of deep convective clouds where liquid and ice hydrometeors grow to the large sizes here, are highly turbulent? And impact velocities within the turbulent eddies could be quite large?

Discussion – I would also add one introductory sentence here to help the reader orient, something like “We discuss some aspects of the experimental setup that may affect the occurrence and rate of secondary drop production and freezing here.”

### **Minor Edits**

Line 29 – I would remove “than rime-splintering”, as the sentence reads more cleanly then. You could also specify that the variation in “quantification between laboratory studies” is quantification *of ice fragment generation rates and temperature dependence in these rates*.

Line 68 – drops *that* freeze

Line 98 – (Locatelli and Hobbs 1974) adjust parentheses

Line 106-107 – You already defined  $D$  within  $We$  and  $Re$  above, but it is perhaps worth reiterating here that you define the length scale in these dimensionless number to be the water drop diameter prior to impact.

Lines 131-133 – I asked why these filaments are only produced at colder temperatures, and I feel it would be worthwhile to mention the point you made about increased viscosity and surface tension of supercooled water explicitly, e.g. “where no ejection of filament-like structures was observed, *perhaps due to lower viscosity and surface tension of water at these temperatures*”

Figure 6 caption – “The error bars represent the standard error *in freezing fraction or secondary drop number for the* temperature intervals...” Quite minor but just for clarity

Line 167 – “on an elevated ice surface” From this description, it sounds like the setup in Schreimb et al. 2018 also used a flat surface for impact (an icy one not glass). But later it is stated that “when a flat surface... is not present, secondary drops are still formed.” Could you clarify?

Line 189 – “we expect the irregular shape of an ice particle to *enhance* the fragmentation mechanisms” ?

Line 246 – “freezing fraction of the secondary drops” Omit “*ice*”, right?

Lines 261-262 – suggested rewording to avoid a run-on “We measure about 10 secondary drops per collision. Schreimb et al. 2017 observed on the order of tens of drops per collisions for impacts on an elevated ice surface. Finally, Rozhkov et al. 2002 observed hundreds of drops for impacts on steel disks...”