

## ***Interactive comment on “Ice multiplication from ice-ice collisions in the high Arctic: sensitivity to ice habit, rimed fraction and the spectral representation of the colliding particles” by Georgia Sotiropoulou et al.***

**Anonymous Referee #1**

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The manuscript titled: “Ice multiplication from ice-ice collisions in the high Arctic: sensitivity to ice habit, rimed fraction and the spectral representation of the colliding particles” by Sotiropoulou et al., discussed the impacts of adding secondary ice production (SIP) process into the LES model and its influence on Arctic cloud properties. The authors conducted several sensitivity tests to investigate the influence of ice habit, rimed fraction, and threshold value in cloud ice and snow autoconversion process on the SIP and cloud features.

General comments:

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1. Comparison between the simulated ice number and observed ice number should be included in the study since this is the aim of this study. If the observation data for ice number is not available for this case, the author should use a different case that has this useful observation data. Otherwise, it is hard to justify if the modification in the model leading in the right direction. Lacking this comparison makes the paper less convincing to readers.
2. The scientific contribution is not significant enough for this paper. The implementation of the secondary ice production processes to the model is clearly shown in your previous paper. Just several sensitivities tests are not enough to support a whole research story. More deep analysis should be conducted, like give a physically-based explanation of changes in LWP and IWP, not only just describe the figures feature.
3. The “spectral representation” in the title and “Sensitivity to the representation of the ice particle spectrum” in Page 12 (Line 401) are confused to readers. The representation of the ice particle spectrum indicates the size distribution function, just as the authors described in the paper Line 153 “size distributions are defined by generalized Gamma functions”. I think the author did a sensitivity test about the threshold value in the cloud ice and snow autoconversion process, not about the size distribution function. I suggest modifying the title and the subtitle.

Minor comments:

1. Page 3 (Line 100) what is the uncertainty range of the instrument and the observation data?
2. Page 10 (Line 325) “Planar ice is expected to generate more fragments per collision compared to plates if the diameter of the particles and the collisional kinetic energy are the same(see equations 6-7 in Appendix B). ” you mean “dendrites ice is expected to generate more fragments per collision compared to plates”?
3. Page 10 (Line 309) “while the ICNC enhancement from break-up is shown in the

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Supplementary Information (Text S2, Fig. S2)" I think a X-Y Figure (similar as Figure 2) shows the total ice enhancement is quite important, this figure should be shown in the main text. I also suggest adding a figure shows the comparison between the observed ice number and simulated ice number concentration.

4. Page 10 (Line 330) "This variability indicates that precipitation processes (i.e. the precipitation sink) are more effective". Author indicated that the decrease of cloud ice in Figure 3b is due to precipitation sink, but why the graupel number still increase in Figure 3d? considering the graupel has a larger fall speed parameter, should precipitate more quickly compared with cloud ice.
5. Page 32 (Line 1000) In Table 1, the parameters  $a_v$  for graupel is set to be 199.05 in the model. However, the  $a_v$  is usually set to be 19.3 for graupel, and is 114 for hail (Morrison et al., 2009). So, 200 seems too large for me, is any citation here to support that the Arctic graupel has big value  $a_v$ ?
6. Page 36 (Line 1070) In Figure 2, does this mean observed LWP and IWP does not change during this time period? This figure is kind of confused, I suggested use time-series of observed LWP and IWP with uncertainty.
7. Page 36 (Line 1070) From Figure 2, the simulated LWP decreased by 50 g m<sup>-2</sup>, but IWP only increased by 5 g m<sup>-2</sup>. Does this means the total condensation is decreased? Or precipitation is increased?
8. Page 37 (Line 1095) Figure 3e does not have a black line, does this mean control simulation do not has snow?
9. Page 37 (Line 1095) Figure 3 shows graupel is the dominant ice-phase particles, it is 2 orders of cloud ice and is 3-4 orders of snow. Is that true for Arctic cloud? Graupel is the dominant ice particles in the Arctic cloud? Or it is a model dependent result? I think snow and cloud ice should have the largest fraction of total ice.

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