We would like to thank all reviewers for the useful comments and suggestions, which definitely helped us to improve the manuscript. Hereby we provide a detailed response to the comments and questions raised by Reviewer #1.

Reviewer's comment:

I would suggest that highly dendritic growth on a graupel particle seen in fig 5b would not be observed in the real atmosphere. It would be difficult to obtain saturations above water saturation (~14% at -14C). At water saturation there would be droplets that would continue the riming.

For a realistic graupel with vapour grown surface ice I think that a superaturation with respect to ice but below water saturation is required.

Authors' response:

It is true that the saturations were high in our experiments which might result in more fragile dendritic structures due to fast growing of ice crystals. Thus, the number of fragments might be lower at lower supersaturations, i.e. under more common atmospheric conditions. We add the following text to line 321 "*The growth of dendrites on the graupel surface that occurs under high supersaturation conditions is faster than at low supersaturation, and therefore, may result in a more fragile ice crystal structure. This might lead to more fragments produced by graupel-graupel with dendrites collisions compared to ice crystals growing at lower humidity. Cloud graupel may experience several growth processes that influence their surface properties, making their fragility dependent on their growth history. Consequently, graupel collisions of the same size, with the same collision kinetic energy, can yield different fragment numbers due to their distinct surface properties*".

From Korolev et al, 2004 it seems to be apparent that frozen drops remain spherical during vapor deposition growth if the supersaturation is less than half of that of water. Hence, we can suppose that fragmentation by collision is less effective for ice crystals staying at low humidities and more efficient for ice crystals at higher humidities where the vapor growth enables the production of long branches. Therefore, we added a sentence to line 467 *"The dendritic crystals grown on the surface of graupel enables the production of many fragments during collisions, differing from a completely rimed surface. Future studies are required to investigate how this transition (observed in Korolev et al, 2004) can affect collision fragmentation under different humidity and temperature conditions. "*

Reviewer's comment:

It would be good to caveat the results for the dendrite-covered graupel vs graupel collisions.

Authors' response:

We added the following text to line 479 to caveat our results "*Nevertheless, it is important to note that the present conditions, characterized by high ice supersaturation and large particle size, may not be representative for most ice crystals in clouds. To overcome this limitation, it is necessary to conduct future experiments with technical improvements to explore collisions at lower ice supersaturation levels and with smaller aggregate sizes. We presume that our results are more representative for fragmentation occurring above water saturation, where fragile ice crystals tend to form. To apply our results to a microphysics scheme, it is crucial to consider these factors for precautionary purposes."*

Reviewer's comment:

Perhaps it would be possible to include the bare graupel-graupel collision results that were alluded to?

Authors' response:

We included the number of fragments generated by bare graupel-graupel collisions in Fig. 11b. We also added comments related to these results in the same section.

Reviewer's comment:

line 215: What was the 'glue' used for sticking? Were the crystals just brought together at ice saturation or slightly above? How long were the crystals allowed to sinter for? I imagine there will be sensitivity to this. In the results the production process for the aggregates is mentioned, but perhaps it is worth saying that this is something that could be explored more systematically in the future?

Authors' response:

The dendrites were glued by interlocking the branches of the crystals together like a natural aggregate of a cloud. This aggregation took place above the aquarium at a humidity close to that where the crystals therefore grew in an environment oversaturated with respect to the ice. We estimated that 20-60 crystals were used to form an aggregate.

We added '(*i.e. by interlocking the branches of the dendrites)*' to line 231.

It would be interesting to create a setup for the creation of aggregates in an automated way and by controlling various parameters, but this seems difficult to do. In future experiments, smaller aggregate sizes should be used to be closer to those encountered in the clouds as we mention in the revised manuscript at line 480: "*To overcome this limitation, it is necessary to conduct future experiments with technical improvements to explore collisions at lower ice supersaturation levels and with smaller aggregate sizes."*

Reviewer's comment:

line 302: Fig 12 I think needs a caveat to mention that these results are likely to be an upper bound because of the very high saturations the graupel were exposed to. Much more than is likely in a real cloud.

Authors' response:

In figure caption we added '*at high supersaturation'* for the caption of Fig. 11 and 12. Furthermore, we added the following text at line 321 "*The growth of dendrites on the graupel surface that occurs under high supersaturation conditions is faster than at low supersaturation, and therefore, may result in a more fragile ice crystal structure. This might lead to more fragments produced by graupel-graupel with dendrites collisions compared to ice crystals growing at lower humidity. Cloud graupel may experience several growth processes that influence their surface properties, making their fragility dependent on their growth history. Consequently, graupel collisions of the same size, with the same collision kinetic energy, can yield different fragment numbers due to their distinct surface properties*".

Reviewer's comment:

line 344: For fig. 14 graupel-snow collisions it may be appropriate to just suggest a mean and range (e.g. 200 splinters ranging from 100-400 to capture 95% of measurements. Hopefully, later experiments will provide enough data to parameterise the degree of separation effect. For models some average would likely be necessary to use.

Authors' response:

This is planned to be done in a future study where more collisions can be made for statistical significance. We also provide a fit of our experiments using Eq. 2 which can be taken as a means from all experiments. More data are needed to clearly parametrize the effect of edge/central collisions.

Reviewer's comment:

line 350: The size distribution of fragments is very welcome. For implementation in a model this would likely need to be scaled by the size of the snowparticle being collided with. In the first instance the use of 10mm snow aggregates could be used to scale the x axis (at least as an extra axis)?

Authors' response:

Yes, thank you for this suggestion! We added the following sentence to line 350: "*However, in a first instance, we suggest that the parameters μ and σ of the FSD can be interpolated or rescaled considering the size of the parent particle (2 mm graupel here and 10 mm snowflake in section 4.2)"*

Reviewer's comment:

line 354: Only 16 distributions in here so difficult to draw too many conclusions from the individual modes - apart from the mode at 50um being the size of the monomers.

Authors' response:

We agree. Therefore we added to line 391: '*However, only 16 FSD are presented here, more experiments have to be done to clarify the observation mentioned before*. '

Reviewer's comment:

line 368: This 50um mode is just the size of the monomers used to construct the aggregate, so unless Vardiman constructed their snow in the same way there is unlikely to have been a mode in those observations?

Authors' response:

We think that the monomers forming the initial snowflake are larger, they are rather millimeter-size crystals. The 50 µm fragments have no real structures, they are just irregular ice crystal fragments. Thus, 50 µm are probably coming from something else than the monomers. Vardiman used natural ice particles to do his experiments and used an old camera which probably didn't detected small fragments (e.g 50 µm diameter ice crystals) if they were present.

We added to line 402: 'This can be due to the detection method used in Vardiman (1978) which was probably not able to detect such small fragments, or due to the different particle and experimental setup used for collisions.'

Reviewer's comment:

line 401: Agreed. It would be great to see results for a range of graupel sizes and snow sizes to cover the phase space required in a numerical cloud model.

Authors' response:

Thank you for this motivating comment. We are planning to extend the experiment to other graupel and snow sizes. For that, it is necessary to improve the routine of our experiments to conduct a large number of collisions.