We would like to thank all reviewers for the useful comments and suggestions, which definitely helped us to improve the quality of our manuscript. Hereby we provide a detailed response to the comments and questions raised by Prof. Alexei Korolev.

Reviewer's comment:

I have a serious concern regarding the parameterization of the ice-ice collisional breakup SIP solely based on CKE. Besides the CKE, the number of fragments generated after collision depends on the mechanical properties of the colliding particles. The mechanical properties of ice particles depend on the history of the environmental condition that this particle experienced in the past. Thus, for the sake of argument, assuming that the mass of the four graupel particles in the picture below is the same, their collision with other graupel will result in a different number of fragments, even though the CKE will be the same.

The morphology and mechanical properties of the graupel surface depend on many parameters such as DSD, LWC, T, P, vertical wind, the graupel's mass, and density. Within the same cloud, graupel may experience a variety of time histories of the above mentioned parameters, which can subsequently generate an infinite number of possible combinations of collisional events between graupel with different mechanical properties of surface ice but having the same CKE.

Authors' response:
We agree with these comments. It is evident that the number of fragments generated after collision depends on the mechanical properties of the particles and their environmental history, leading to different outcomes even with the same CKE. We now added to the results part this sentence 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* "

The reason we used a parameterization based solely on CKE was to easily compare our results with those of Takahashi. Certainly, such a parameterization is very bare, and several properties of the particles have to be included. We would like to stress out, however, that in laboratory experiments it is impossible to cover the whole life-cycle of a particle in a cloud. Therefore, we try to simulate the particles in terms of size, fragility, morphology, etc. In the current experiments we only used one fixed temperature (-15 °C), RH for generating the dendrites (about 115% over ice), two graupel sizes (2 and 4 mm), and three fall heights for different CKEs. Since the reviewers highlighted several constrains of our experiments, we added a separate section after Results and Discussion, in which we list and discuss such limitations.

Reviewer's comment:

In the frame of the present study, the fragment size distributions (FSD) and their dependence on CKE (Figs.11-13) were obtained for the graupel formed under approximately the same environmental conditions as described in section 2.

Therefore, the obtained parameterization (Eq.3) describes secondary ice production for the specific graupel generated in this lab setup, and it cannot be expanded to the entire variety of possible graupel-graupel collisions. This limitation of the obtained parameterization should be clearly stated in the paper in order to mitigate the use of the obtained SIP parameterization in cloud simulations.

Authors' response:

We agree with these concerns regarding the parameterization of ice-ice collisional breakup based solely on CKE. We change the simple Eq. 3 to the Phillips et al (2017) parametrization which is used by many microphysics schemes. Even if this parameterization is used to extend our results to several sizes of colliding graupel pairs, the parameters used for this one remains specific to the conditions of our laboratory experiment. This is why we now mention in line 326 that "*Since the results and parameters from Eq. 2 are obtained under high humidity around -14 °C, caution in their use is essential as they only correspond to the specific environmental conditions of our experiments. To further explore the effect of graupel surface properties on fragmentation by collision, rescaling the results (i.e., varying parameters from Eq. 2 based on temperature, humidity, and growth history) would be interesting. However, further experiments should be performed since only Takahashi et al .(1995) studied the effect of temperature on the number of fragments produced by collisions.*"

Reviewer's comment:

The relevance of the environmental conditions employed in the laboratory setup during the depositional growth of ice is another point of concern in this study. As described in section 2.2, that at the location of graupel, the supersaturation over ice and temperature varied in the ranges 20%<Si<27% and -15C<T<-13C, respectively. Such supersaturation over ice corresponds to up to 10% supersaturation of liquid. This is an overly high supersaturation, which normally does not occur in natural clouds, with the exception of short periods of time in vigorous updrafts. The mechanical properties of ice grown at high supersaturation are expected to be different as compared to growth at low supersaturation (e.g., below water saturation) due to an increased number of dislocations (hopper ice growth). The depositional growth of the graupel surface at lower and more realistic supersaturation is slower and may not develop protruding ice shapes (e.g., https://doi.org/10.1175/1520-0450(2004)043%3C0612:LAISOO%3E2.0.CO;2), which is expected to affect the FSD and SIP efficiency. The effect of high supersaturation and relevancy of the environmental condition should be discussed in the paper as well.

Authors' response:
The effect of our environmental conditions avec now added as mentioned in the first comment.

Furthermore, we added 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 at different humidity and temperature conditions."*

We also added to line 479: *"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:

Minor comment: Line 102: Rb4 => R4b

Authors' response:
Thank you, corrected.