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Interactive comment on "Enhanced rockwall retreat and modified rockfall magnitudes/frequencies in deglaciating cirques from a 6-year LiDAR monitoring" *by* Ingo Hartmeyer et al.

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Dear Georgina Bennett,

thank you for your constructive and insightful comments which we feel helped to improve the manuscript.

We (i) uploaded a revised version of the manuscript (changes highlighted and commented), (ii) posted a new author's comment to inform on minor general amendments in the manuscript, and (iii) below provide a point-by-point response to all your comments.

Our response is structured as follows: (1) referee comment, (2) author's response and (3) changes in manuscript text.

(1) Sometimes it is difficult to distinguish results presented in the two different papers. Perhaps make it clear briefly in the introduction the key findings and differences between these. (2) To highlight the distinctions of the companion papers we (i) expanded the abstract, (ii) summarized the key findings of the companion paper in the introduction (Sect. 1), and (iii) slightly modified the conclusions (Sect. 6). (3) The summary given in the introduction reads as follows: This paper is closely linked to a companion paper (Hartmeyer et al., 2020) which identified significant glacial thinning (0.5 m a-1) adjacent to the monitored rockwalls and found elevated rockfall activity in the freshly deglaciated terrain. 60 % of the rockfall volume detached from less than ten vertical meters above the glacier surface. High rates 10-20 m above the glacier indicate enhanced rockfall activity over tens of years following deglaciation. Rockfall preconditioning probably starts inside the Randkluft (void between cirque wall and glacier) where sustained freezing and ample supply of liquid water causes enhanced physical weathering and high plucking stresses. As the glacier is wasting down strong temperature variations will induce pronounced thermal stress in the first-time exposed rock, cause rock fatigue and lead to the formation of a deep active layer, all of which will exert significant destabilizing effects in glacier-proximal areas.

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(1) You emphasize differences in the rates of cirque retreat in this paper but need to visualize how your rates compare to others and why they might differ. You mention that it is hard to compare rates over different spatial and temporal scales. Perhaps you could produce a figure or table comparing rates collected over similar spatial and temporal scales and perhaps a bit more discussion on why these might differ and why yours are so high. (2) We added a table listing cirque wall retreat rates from various studies and tried better distinguishing between retreat rates from cirques and from other arctic/alpine environments in the text. We also expanded the text to include

potential causes for the elevated retreat rates observed.

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(1) You seem to find a more elongated cirque geometry than the normal due to the effect of cataclinal back walls on erosion rates. Again, it would be interesting to see a plot visualizing the shape of this cirque in comparison to others, perhaps as a function of geological structure wherever this information is available? (2) Based on literature data we compared length/width ratios of cirques investigated here and those of other studies. We also added a plot visualizing the elongated shape of the monitored cirques and extended the review on structural controls of cirque shape. (3) The text now reads: Length/width (L/W) ratios of both cirques (1.5 for E cirque, 1.2 for W cirque) exceed most L/W ratios given in the literature. In an extensive review of 25 different cirque inventories containing over 10,000 cirques from around the world, Barr and Spagnolo (2015) found a mean L/W ratio of 1.03 indicating that the majority of cirques is almost perfectly circular in shape. Deviations from circularity have mostly been attributed to glaciation history (review in Barr and Spagnolo, 2013) but geological structure is considered an important factor, too: In the Western Alps and in the uplands of North Wales cirques that cut along geological strike are more elongated than those cutting across strike (Federici and Spagnolo, 2004; Bennett and Glasser, 2009), in the Carpathians the dipping of bedding planes significantly influences cirque shape (Mindrescu and Evans, 2014), and in the French Pyrenees bedrock characteristics are considered key controls of cirque shape in anisotropic schists (Delmas et al., 2015).

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(1) There is some information on uncertainties in the power law distributions e.g. resulting from inclusion or not of the largest rockfalls, that should be presented in the results section and relevant figure. (2) The respective paragraphs have been transferred to the results section (Sect 4.4).

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(1) You also lack quantification of error in your rockfall volumes i.e. the propagation of alignment errors between 1-2 cm. These should ideally be propagated into volume error following the method used in Bennett et al. 2012. (2) Rockfall volume errors are discussed in the companion paper. We modified the text and added a cross-reference. Based on your suggestion the alignment error has now been integrated. (3) For each distance measurement the algorithm calculates the local confidence interval (at one sigma level), which was added to the alignment error and propagated into the volume error. Full details on rockfall volume computation and error quantification are provided in Hartmeyer et al., 2020. In addition to rockfall volume and its associated uncertainty a suite of morphometric parameters including slope aspect, gradient and elevation above glacier surface was determined for each rockfall source area.

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