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Sensitivity of rockfall frequency-magnitude and wall retreat rates to observation duration from TLS measurements

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Rockfalls are common in steep U-shaped valleys produced by glaciation. They contribute to valley erosion and pose substantial hazard to people, properties and infrastructure. In this study, we focus on the 5.2 km^2calcareous cliffs of the deglacited Lauterbrunnen Valley located in the Bernese Oberland, Switzerland. A time series of repeat terrestrial laser scan (TLS) measurements were collected during 21 field campaigns over a 5.2 year period from February 2012 to April 2017. We sample these measurements at two different time intervals (1.5 years and 5.2 years) to evaluate how the corresponding frequency-magnitude relationship changes.

Short-term average cliff retreat rates are similar for both time intervals (0.03 and 0.08 mm/yr for the east and west valley walls, respectively). However, there is a systematic decrease in the relative amount of smaller events (and consequently a lower power-law exponent of 1.64 ± 0.06) for the complete 5.2 year dataset. This may be explained by either natural stochastic variations or by undersampling from an increased measurement interval. Nevertheless, results from the 5.2 year dataset are in agreement within error with those from the 1.5-year period.

Finally, we determined a long-term (100-year average) eroded volume of 2.0 (+0.4 -0.3)$\cdot 10^3$ m^3/yr, corresponding to a long-term (power-law predicted) cliff retreat rate of 0.39 (+0.07 -0.06) mm/yr. This value is similar to the postglacial retreat rate of 0.27-0.36 mm/yr based on talus volumes as measured by TLS data of talus surfaces beneath the rockwalls. When compared with the present-day retreat rates of 0.03-0.08 mm/yr, the long-term rates are greater by a factor of >10. The undersampling of rockfall events in the 5.2 year time interval as well as lack of debuttressing and stress relaxation effects after glacial retreat may explain these differences. Furthermore, it is possible that higher rockfall activity after deglaciation is dampened by times of lower activity, and therefore, the postglacial retreat rates are averaged over the Holocene.