

Enhanced Rockfall Activity from Periglacial Environments in the Swiss Alps Correlates with Warm Summer Temperatures over the Course of the 20th Century

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Trees located on slopes underneath rock cliffs are excellent recorders of spatio-temporal rockfall activity and can provide long-term, yet annually resolved information on possible changes in rockfall frequency and/or magnitude. Rockfall in mountains depends, among others, on freeze-thaw cycles and/or the melting of winter ice in clefts. Its temporal frequency and magnitude is likely to be altered at higher elevations as a result of ongoing climatic changes, even more so in environments controlled by permafrost. Here we focus on >100 years of rockfalls released from periglacial environments in the Swiss Alps. Based on the 400 time series of century-old larch (*Larix decidua* Mill.) trees, we demonstrate that rockfall activity has increased significantly between the end of the Little Ice Age and today, and that enhanced rockfall activity is clearly correlated with above-average summer temperatures (and therefore melting permafrost). Rockfall is most abundant when after several years with above-average summer temperatures and its activity exhibits a certain lag in the response, presumably as a result of inertia in permafrost bodies. With ongoing climate change, rockfall activity is expected to increase, and thereby creating critical situations in several parts of the Alps where rockfalls without historical precedents will likely affect transportation corridors and/or inhabited areas. Research on the evolution of rockfall processes from periglacial environments can help to reduce the risk emanating from new processes or process magnitudes, and - in combination with scenario-based process modeling - facilitate the planning of adequate countermeasures.