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Assessing past debris-flow dynamics on a forested cone using tree rings

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Debris flows and related phenomena represent an important earth-surface shaping process in mountain regions. Repeated deposition of material at the mouth of gullies or the base of slopes leads to the formation of characteristic debris-flow cones. Increasing anthropogenic activity repeatedly interferes with torrential activity which in turn may enhance existing hazards and risks. In order to perform a reliable assessment of hazards, detailed information on previous debris-flow activity in the torrent is of crucial importance. As archival data is often fragmentary or sometimes completely missing, data on past events needs to be elaborated. Trees represent an excellent natural archive as they record environmental disturbances such as mass movements in their tree-ring series.
We report here on results obtained from 220 trees heavily affected by debris-flow activity in the Birchbach torrent, Valais Alps, Switzerland. The analysis of 328 tree-ring samples allowed reconstruction of 47 debris-flow events between 1752 and 2007. In combination with a detailed geomorphic maps and the positioning of the trees showing growth disturbances in a specific event year, the spatial behavior of flows could be determined. The spatial distribution of damaged trees reconstructed for past events indicates that the main channel did not significantly change over the investigated time period, but that two secondary channels were sometimes activated during events. In addition, the age of lobate deposits was assessed by coupling the data of survivor trees growing inside the deposits with the age of successor trees colonizing them. Based on our data, we believe that most of the events did affect only small parts of the cone. In contrast, it seems that at least one important event between 1917 and 1920 would have eliminated large parts of the forest. Results obtained in this study considerably help understanding the dynamics of the torrent and can therefore be used for the assessment of hazard and risk.