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On the role of tree-ring analysis for the characterization of debris-flow torrents and the design of structural and non-structural mitigation measures

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Debris flows represent a major threat in many parts of the Alps, where their repeated occurrence regularly causes fatalities or major damage to infrastructure and transportation corridors. Information on past events, return periods, volumes, spatial patterns or triggers of past debris flows, therefore, are of crucial importance for the assessment of hazards and risks as well as for the conceptualization and the design of structural and non-structural measures. This is primarily the reason why a great deal of attention is commonly directed towards the analysis and documentation of processes in the aftermath of widespread flooding and debris-flow events.

However, only a very limited number of torrents and gullies have been monitored over sufficiently long periods of the past. Similarly, archival records on former debris-flow events remain fragmentary. As a consequence, only little information is normally available on the characteristics or behavior of past events at basin scale, despite recognition that individual debris-flow events possess much greater erosive and hazard potential than flood processes.

In several catchments of the Valais Alps (Switzerland), dendrogeomorphological techniques were applied to absolutely date past debris-flow activity with, at least, yearly precision. The method of dendrogeomorphology benefits from the fact that trees and shrubs growing in temperate climates form annual increment rings and that any kind of geomorphic disturbance (e.g., injury, stem burial or tilting, decapitation, erosion of root mass) remains recorded in the tree-ring series. In addition to the reconstruction of minimum frequencies that normally cover several centuries, it is sometimes

even possible to approximate volumes that were transported during past debris-flow events. The analysis of the spatial distribution of trees that were disturbed during individual events in the past may also help the identification of preferential breakout locations of past debris-flow surges. The additional knowledge that tree-ring analysis may furnish to magnitude-frequency relationships or the spatial patterns of past events may therefore serve the delimitation of hazard zones for landuse planning as well as for the design of appropriate structural mitigation measures. Finally, data obtained by means of dendrogeomorphological methods may also be used to feed or even improve modelling approaches at basin-scale level.

In a similar way, the high-resolution event series (i.e. monthly resolution) obtained in certain catchments further allow a coupling of frequency data with meteorological records of local weather stations. Through the identification of meteorological conditions that have prevailed during past events, critical weather regimes or precipitation thresholds can be defined and used for early warning purposes.