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Frequency and magnitude reconstructions on sites influenced by debris flows and snow avalanches using tree-ring series and physically-based process models

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Dendrogeomorphic analysis of 372 Norway spruce (Picea abies (L.) Karst.) trees of the Reiselehnrinne (Tyrol, Austria) allowed reconstruction of past avalanche and debris-flow activity for the last 140 years. Determination of event years was performed by analyzing the (i) number and (ii) intensity of growth disturbances within tree-ring series and (iii) the spatial distribution of affected trees. Differentiation of debris-flow from snow avalanche events was based on (iv) the intra-annual position of scars, callus tissues or tangential rows of traumatic resin ducts and on (v) the spatial distribution of trees with simultaneous reactions in the tree-ring series. We introduced a weighting factor to substantiate the dating of past events in a comprehensive way and to compare individual events as to their intensity and total number of tree-ring responses. The accuracy of the dendrogeomorphic assessment was evaluated by comparing the reconstructed event frequency with event chronologies available for the Reiselehnrinne. The use of different avalanche and debris-flow simulation models (RAMMS, SAMOS, TopRunDF) furthermore allowed assignment of magnitude and intensity to particular events reconstructed with tree-ring series. We demonstrate that the coupling of dendrogeomorphic data with physically-based process modelling may assist in a detailed determination of magnitude-frequency relations of snow avalanches and debris flows at the local scale and over several centuries.