Contribution of tree-impact data and tree-ring analyses to rockfall risk assessments: a case study from the Swiss Alps

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INTRODUCTION

Acquisition of reliable data on past events is fundamental for a reliable and comprehensive assessment of natural hazard risks, but in the case of rockfall, historical records are often missing completely or at best fragmentary. Traces of past events in tree-ring series and impacts on stem surfaces have been investigated intensively within the last decades. They have shown to provide valuable data on the spatial and temporal occurrence of past events of a wide variety of natural hazard processes, amongst others rockfall. The present study is based on findings of work of Trappmann et al. (2014), which demonstrated that the determination of rockfall frequencies can be improved on the basis of tree impact analyses combined with rockfall modeling techniques. The present paper extends this work and shows how a rockfall risk assessment can be improved by combining modeling approaches with data from rockfall-impacted trees.

METHODS

Rockfall hazards along a 1631m-long section of the road connecting Sion and Arolla (Evolène, Swiss Alps) were assessed using an approach that couples tree impact data and rockfall modeling with the three-dimensional, process-based rockfall model Rockyfor3D (Dorren, 2015). Based on data from 1260 investigated trees and 488 detected rockfall impacts, the model was calibrated and validated in a first step by comparing observed rockfall frequencies in trees with simulated numbers of rock passages (Fig. 1). Simulated passages derived from the calibrated model were then transformed into real rockfall frequencies, by combining the temporal information obtained from the tree impacts. This allows the identification of distinct road sections with varying rockfall activity.

EXPECTED RESULTS

In a next step we focus on the potential of past rockfall impact records in trees for analysis of rockfall risks. Trees are expected to provide valuable data in several steps of the risk analysis. First, they can provide the spatial extent of past events and thus assist in the definition of realistic scenarios. Secondly, rockfall models can be calibrated using detailed tree impact data. In turn, calibrated models can deliver even more reliable (and more realistic) energies of falling rocks and their spatial probability of occurrence with higher confidence in scenario-based simulations. Thirdly, rockfall impacts in trees can form the basis for the definition of the temporal occurrence probability of rockfalls in the different scenarios. The temporal occurrence is one of the most determining variables in the risk calculation, as is the event magnitude or intensity. In contrast to previous work on the case-study slope, a detailed quantitative risk analysis will be performed, including the analysis of direct rockfall impacts to moving vehicles, impacts of vehicles on deposited rocks, and costs of road clearance and restoration. This allows monetizing rockfall risks and expressing these in expected damage costs per year for different road sections as well as for the road section as a whole.

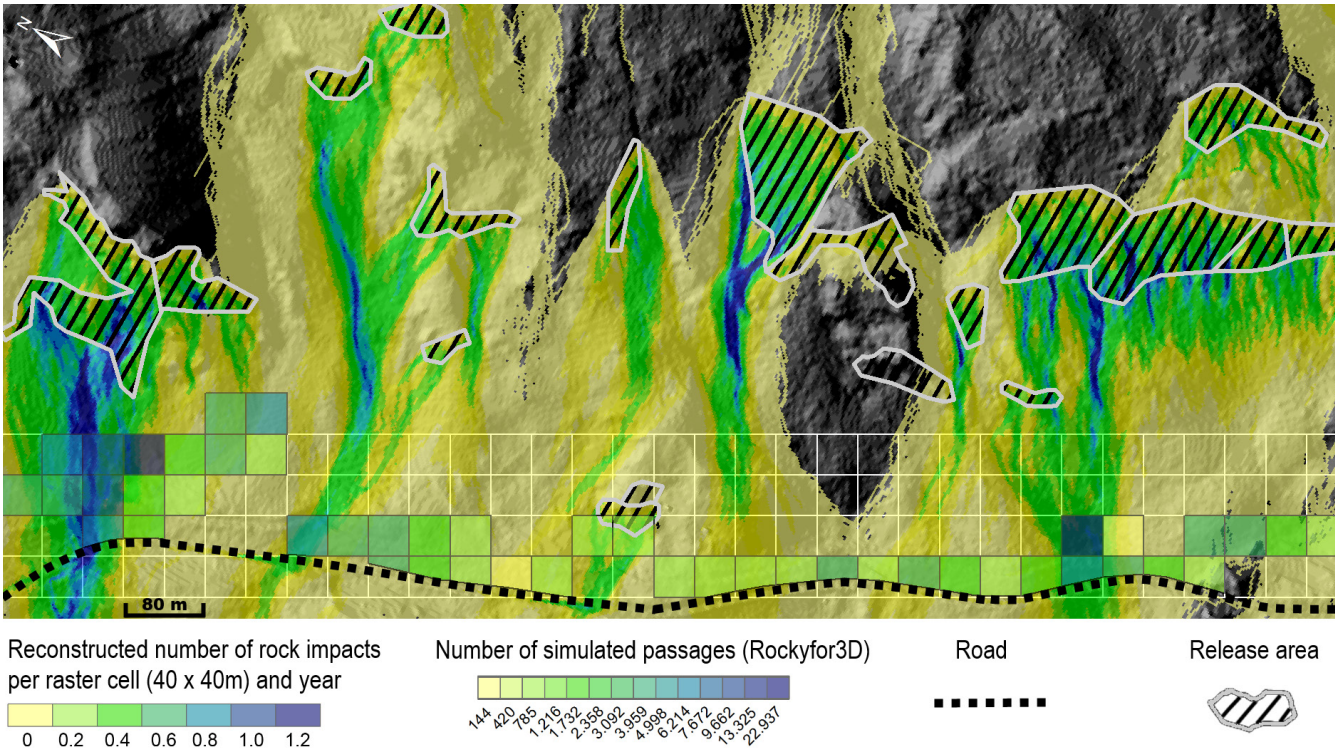

Figure 1. Simulated number of passages (obtained from Rockyfor3D) overlain by rockfall frequency as observed on trees given as rock passages per year for raster cells of 40 x 40m. Values represent the upper class limits (adapted from Trappmann et al., 2014).

REFERENCES

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KEYWORDS

dendrogeomorphology, tree ring, rockfall, simulation, quantitative risk assessment

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