Run-out prediction for small and medium scale dense flow avalanches - evaluation of ELBA+ and calibration of the Alpha-Beta model.

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INTRODUCTION

Avalanches pose a major threat to settlements and infrastructure in alpine regions. For regional planning, maximum runout lengths are among the most valuable information, as hazard zones are confined by the expected maximum reach of extreme events. As shown in the winter 2009, not only large avalanche tracks can be a problem. The smaller ones, which have not received too much attention yet, can cause considerable damage as well.

BACKGROUND

Two different approaches are pursued to estimate avalanche runout lengths. The empirical approach regards correlations between topographic parameters and maximum runout length. The most common tool is the Alpha-Beta model (4) which predicts avalanche path inclination based on the avalanche track‘s slope. The model only needs a terrain profile along the avalanche path to be applicable. The so-called β-point which defines the end of the avalanche track is defined by the slope angle falling below 10°.

The deterministic approach focuses on avalanche dynamics in order to determine the maximum reach of avalanches. ELBA+ is a 2-dimensional model deterministic model which utilizes a modified Voellmy-Fluid implemented into a finite difference scheme. Default parameters are used to define the coefficients of dry friction μ and turbulent friction ξ.

Both the Alpha-Beta-model and ELBA+ have been calibrated and evaluated with avalanches featuring a large fall height and a big release volume (1, 4, 5).

In this study, small and medium avalanches are defined by a release volume between 2000 and 50000 m^3 and fall heights between 100 and 500 m.

METHODS

Empirical approach

Application of the existing Alpha-Beta equations to avalanches with fall heights lower than 500 m does not lead to accurate results. Therefore the Alpha-Beta-model was calibrated to the characteristics of short-slope avalanches in the Eastern Alps performing a least-squares regression analysis. The underlying dataset consists of 44 recorded extreme avalanche events with a mean fall height of 330 m. Prior to the calibration of the model, the positioning of the β-point was investigated.

DETERMINISTIC APPROACH

Many years of practical experience showed that the accuracy of the predicted runout length of large avalanches simulated with ELBA+ needs to be improved (2). The reason is still unknown and could possibly be related to the underlying physical model, which determines ξ as a function of the avalanche‘s velocity. In order to test if better results can be provided when applied to small- and medium-scale avalanches, 25 recorded extreme events with a mean release volume of 19000 m^3 were simulated with ELBA+.

The simulations were performed using the default friction parameters. Snow erosion was considered assuming entrainment of 30 cm along the track.

RESULTS

Empirical approach

In accordance with the findings of earlier work on the topic (3), lower fall heights seem to result in proportionally longer runout lengths.

Positioning of the β-point was examined by a best-fit analysis. The best results could be obtained by leaving the β-point at a slope angle of 10°.

A simple linear model represented by the equation

$\alpha = 0.884\,\beta - 0.226°$ (R^2=0.80, S=2.53°)

is proposed.

Deterministic approach

Using default parameters and reconstructed release volumes, simulated runout lengths tend to be too short compared with recorded avalanche reach. Furthermore it could be observed that ELBA+ responds sensitively to changes of the underlying DTM's resolution. Higher resolution often leads to longer runout lenghts and higher velocities. This leads to the assumption that poor results are not restricted to large-scale avalanches. A re-examination of ELBA+'s finite difference scheme is suggested since the inaccurate results might be attributed to the numerical model rather than the nature of the modified Voellmy-fluid.

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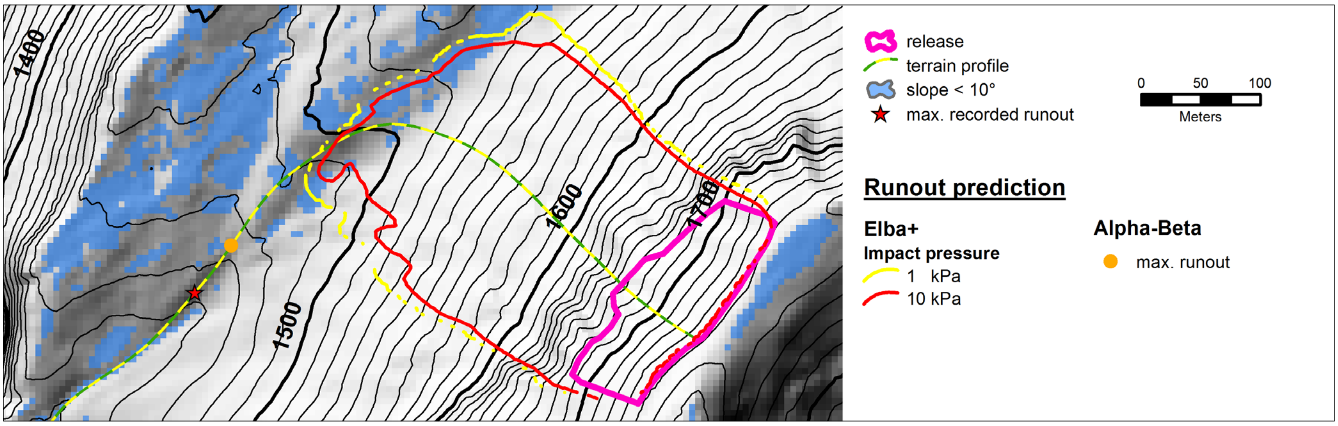

Figure 1. Deterministic calculation of a small scale avalanche using ELBA+ and maximum estimated runout based on Alpha-Beta. The avalanche's release volume amounts to approximately 14700 m³. The red and yellow perimeters outline the impact pressure extents (red: 10 kPa, yellow: 1 kPa) calculated using default parameters. The red asterisk labels the maximum recorded runout. Both ELBA+ and Alpha-Beta underestimate the runout length.

KEYWORDS

small-scale avalanche; avalanche simulation; runout prediction; ELBA+;Alpha-Beta

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