DYNAMIC MODELING OF SPEED PROFILES OF EXTREME DRY SNOW AVALANCHES

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ABSTRACT: We present an improved method for calculating the speed of extreme dry snow avalanches for land-use planning applications. This work is a response to the uncertainty surrounding the dynamics of entrainment of existing snowcover by a flowing avalanche. It is an attempt to reproduce, as simply as possible, observed avalanche behaviour that is most relevant for land-use planning; namely, the flow speed and depth in the runout zone. Complex models that attempt to account for all possible flow processes suffer from the necessity to speculate on the value of numerous physical parameters that cannot or have not been measured. The model presented here is controlled by a single, well-calibrated bulk physical parameter that describes the flow resistance. This approach eliminates the undesirable redundancy inherent in any multiple-parameter model, which is especially important when a physical model is used in a predictive application that involves the safety of people or structures.

The new method restricts the modeling domain to that which is most important in a hazard mapping context: the runout zone and a small portion of the track upslope. The model is calibrated with measured avalanche speed data, and therefore implicitly accounts for all entrainment upslope of the runout zone. The flow mass is discretized longitudinally in a Lagrangian reference frame. The flow width is variable, but must be prescribed in the model. This quasi two-dimensional approach has the flow length and depth as degrees of freedom. A frontal stopping position is specified as a model input, based on regional extreme runout data. This allows for quantification of the uncertainty in the predicted runout distance.

The model, well-constrained by measured avalanche data and employing a single bulk physical parameter, allows for confident calculation of speed profiles. Such profiles are necessary for hazard mapping applications which require impact pressure estimates. In this context, it is important for a model to reproduce the sharp deceleration of frontal speed observed in avalanche runout zones. For avalanche paths with known profiles and measured speed data, the new modeling approach produces speed profiles that agree well with observation.

KEYWORDS: dynamics, extreme events, land use planning, hazard mapping, avalanche speed

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