Submitted Abstract

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Abstract

Simulation tools for snow avalanches are often applied in a deterministic manner, i.e. yielding a single simulation result. However, numerical modelling results have inherent uncertainties originating from different sources. For one, due to limitations in process understanding as well as constraints on available input data, the chosen set of equations itself might not fully represent the physical processes at work. When solving the mathematical model with numerical methods, simulation results provide only an approximation to the true solution, based on the type of method, associated parameters and its implementation. Furthermore, data on the initial state or boundary conditions can suffer from uncertainties which propagate through the model.

Performing probabilistic simulations is an approach to quantify uncertainties in modelling results and also to asses the range of uncertainties introduced by different sources.

Here we present an uncertainty assessment of avalanche simulations using the open-source framework AvaFrame. We analyze uncertainty introduced by two different sources: a) a parameter related to the numerical implementation and b) the uncertainty in input data propagating through the numerical model.

For this purpose, we employ the dense flow snow avalanche simulations module (com1DFA) and vary the initial particle distribution (case a) and the release snow thickness (case b), which mainly define the avalanche release. Uncertainties in the resulting flow variables are quantified using the statistical module (ana4Stats) and visualized with probability maps. Converting the simulation results into an avalanche path following coordinate system (ana3AIMEC module), allows us to compare and to determine the likely range in scalar indicators like peak pressure-based runout length or maximum peak flow thickness and velocity. Combining these analysis tools, we can also compare the magnitudes of uncertainties introduced by different sources.

On the basis of these two examples, we showcase how AvaFrame can be used as a tool i) to study the effect of variations in numerical and input parameters and the resulting uncertainty bounds as well as ii) to include information on uncertainty within simulation result visualisations.