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Bayesian inference in mass flow simulations - from back calculation to prediction

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Mass flow simulations are an integral part of hazard assessment. Determining the hazard potential requires a multidisciplinary approach, including different scientific fields such as geomorphology, meteorology, physics, civil engineering and mathematics. An important task in snow avalanche simulation is to predict process intensities (runout, flow velocity and depth, ...). The application of probabilistic methods allows one to develop a comprehensive simulation concept, ranging from back to forward calculation and finally to prediction of mass flow events. In this context optimized parameter sets for the used simulation model or intensities of the modeled mass flow process (e.g. runout distances) are represented by probability distributions. Existing deterministic flow models, in particular with respect to snow avalanche dynamics, contain several parameters (e.g. friction). Some of these parameters are more conceptual than physical and their direct measurement in the field is hardly possible. Hence, parameters have to be optimized by matching simulation results to field observations. This inverse problem can be solved by a Bayesian approach (Markov chain Monte Carlo). The optimization process yields parameter distributions, that can be utilized for probabilistic reconstruction and prediction of avalanche events. Arising challenges include the limited amount of observations, correlations appearing in model parameters or observed avalanche characteristics (e.g. velocity and runout) and the accurate handling of ensemble simulations, always taking into account the related uncertainties. Here we present an operational Bayesian simulation framework with r.avaflow, the open source GIS simulation model for granular avalanches and debris flows.