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Integrating a deep-averaged fluid propagation model in a hierarchical Bayesian framework for avalanche predetermination: Monte Carlo calibration, predictive simulations and pressure computations

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For a few years, methods inspired by hydrological modelling associated with Monte Carlo simulations have been proposed to address the issue of avalanche predetermination. Enough fictitious events are generated in order to compute the probability distributions of the variables of interest, mainly runout distances and pressure fields. A questionable assumption is the choice of appropriate distributions for the different variables, which generally comes rather from practical reasons than from physical considerations. Moreover, the propagation model must match a compromise between the precision of the description of the avalanche flow, computation times and inference feasibility. Bayesian modelling is an interesting option to overcome the technical difficulties associated with the probabilistic calibration of a complex numerical model on real data.

In this work we use the general Bayesian framework proposed in other papers associated with an iterative estimation procedure to infer the joint posterior distribution of the unknown quantities given the available data. The propagation model is a deep-averaged fluid description of the avalanche flow based on Saint Venant equations. The obtained point estimates are then used to compute the distributions of the variables of interest for hazard mapping: runout distance, velocity, flow depth, Froude number, etc. Finally, recent advances in the quantification of impact pressures are used to com-

pute a pressure distribution taking into account the rheology of snow. In particular, this allows high pressures to be simulated for avalanches characterized by low Froude numbers. The method is illustrated with a case study and real avalanche data from the French Alps.