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Impact of land cover on avalanche hazard: how forest cover changes affect return periods and dynamical characteristics simulated by a statistical-numerical avalanche model.

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Land cover and particularly forests have significant impact on snow avalanche initiation and propagation. Mountain forests can prevent avalanche initiation by stabilizing the snow in release areas, and potentially decelerate an avalanche, thus reducing runout distances. Interaction between forests and avalanches is recognized in avalanche modelling mostly by increasing friction parameters. For instance, the dry –Coulomb friction μ of the Voellmy friction law is thought to summarize snow properties, whereas the velocity-dependent friction ξ aims at representing the roughness of the path potentially related to land cover properties. In this work, we hypothesize on the temporal variability of both friction factors, inherited from their dependability on land cover, particularly the forest fraction, namely the aerial percentage of the terrain covered by forests within the extension of the avalanche path. Specifically, we show how the evolution of the forest fraction within the avalanche path affects the return period of runout distances and further dynamical characteristics of simulated avalanches. First, a Bayesian statistical-dynamical model is used to model avalanche frequency and magnitude on the selected path. The two processes are independently modelled, and the joint posterior distribution is estimated using a sequential Metropolis-Hastings algorithm. The forest-avalanche interaction is represented by increasing the total basal friction within the Voellmy friction law (TBF). Accordingly, to increase TBF, the velocity-dependent friction (turbulent friction) ξ is gradually decreased, whereas the dry –Coulomb friction μ is increased. To that end, ξ is assumed to be exponentially decaying with the forest fraction and is modelled as such. The dry –Coulomb friction μ is assumed to be normally distributed with parameters characterizing its dependency on the release abscissa, mean release depth and the forest fraction. Then, the return period for runout distances and the whole distribution of velocities, flow depths and pressures corresponding to any return periods is computed for different forest fractions representing the true forest evolution within the studied path. Results for a typical avalanche path of the French Alps notably show that, logically, the larger the forest fraction, the higher the return period, but only for runout distances exceeding a given threshold. Future work will include the explicit calibration of the forest cover dependency within the statistical-dynamical approach.