# Dense avalanche friction coefficients: influence of physical properties of snow

The values of the Voellmy friction parameters of 735 historical avalanches that have occurred along 26 paths in the Chamonix valley, France, since 1958 are back-analyzed with a depth-averaged hydraulic model, including sub-models for erosion, entrainment and deposition. For each path, the longitudinal and crosswise topographic profiles were derived from a high-resolution digital elevation model acquired by laser scanning. The initial snow depth and snow cohesion, as well as various physical properties of snow, were computed from numerical simulations of the detailed snowpack model Crocus fed by the SAFRAN meteorological analysis. For each event, the full ranges of the two friction parameters were scanned and the pairs of friction parameters for which the run-out altitude is found close enough to the observed one (with an uncertainty of +/- 5 m) were retained. Statistical class analysis was used to investigate the correlation between the obtained friction coefficients and the snow physical properties. No evident trend with the snow parameters was found for the inertial friction coefficient. For the static friction coefficient, an increasing trend with temperature and density was observed, as well as a decreasing trend with liquid water content and initial snow depth. Although modeling assumptions and limitations regarding data and the calibration procedure should be kept in mind, these trends are worth noting, allowing avalanche simulations to be refined to take into account prevailing weather and snow conditions.

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