



Deriving snow hardness from density and its application to the 1-D snow cover model SNOWPACK

F. Monti and J. Schweizer

WSL Institute for Snow and Avalanche Research SLF, Davos Dorf, Switzerland (monti@slf.ch)

Estimating snow density (ρ_s) based on snow hardness and grain type is often exploited in snow science. In snow hydrology snow water equivalent (SWE) that strongly depends on ρ_s needs to be determined; in avalanche forecasting an appropriate calculation of ρ_s is crucial to assess the load on a possible weak layer. However, collecting ρ_s is time consuming and difficult to do for very thin layers, and thus a parameterisation of ρ_s on hand hardness is useful. On the other hand, the 1D snow cover model SNOWPACK derives snow hardness on simulated snow density. Recently, a new snow settling parameterization was introduced in the model which affects the simulation of density so that a new calibration is needed. We established a relation between ρ_s and hand hardness which is representative for various climatic regions of the European Alps. Two data sets including 14'455 dry-snow layers with measured density, grain type and hand hardness were used to relate density to hand hardness for the major grain types. The data were collected in the surroundings of Davos (Switzerland) and in the Veneto region (Italy), and cover different climatic regions and elevations. We applied least square and robust regressions to explore the data. The regression equations for both data sets were generally in reasonable agreement. The data collected in the Veneto region showed a higher variance than those of Davos; nevertheless the Veneto data was normally distributed and the mean values of ρ_s and hand hardness were highly correlated ($R^2 \geq 0.9$). Only for the grain type melt forms the correlation was lower. The linear relations were then used for the model calibration of SNOWPACK. First hardness simulations obtained with the different settings of the model are promising as simulated hardness is in fair agreement with observed values