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Comparing simulated and manual snow profiles to derive thresholds for modeled snow instability metrics

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Numerical snow cover models enable simulating present or future snow stratigraphy based on meteorological input data from automatic weather stations, numerical weather prediction or climate models. To assess avalanche danger for short-term forecasts or with respect to long-term trends induced by a warming climate, the modeled vertical layering of the snowpack has to be interpreted in terms of mechanical instability. In recent years, improvements in our understanding of dry-snow slab avalanche formation have led to the introduction of new metrics describing the fracture processes leading to avalanche release. Even though these instability metrics have been implemented into the detailed snow cover model SNOWPACK, validated threshold values that discriminate rather stable from rather unstable snow conditions are not readily available. To overcome this issue, we compared a comprehensive dataset of almost 600 manual snow profiles with simulations. The manual profiles were observed in the region of Davos over 17 different winters and include stability tests such as the Rutschblock test as well as observations of signs of instability. To simulate snow stratigraphy at the locations of the manual profiles, we obtained meteorological input data by interpolating measurements from a network of automatic weather stations. By matching simulated snow layers with the layers from traditional snow profiles, we established a method to detect potential weak layers in the simulated profiles and determine the degree of instability. To this end, thresholds for failure initiation (skier stability index) and crack propagation criteria (critical crack length) were calibrated using the observed stability test results and signs of instability incorporated in the manual observations. The resulting instability criteria are an important step towards exploiting numerical snow cover models for snow instability assessment.