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Causes of snow instability variations at the basin scale

Benjamin Reuter, Bettina Richter, and Jürg Schweizer
WSL Institute for Snow and Avalanche Research SLF, Davos Dorf, Switzerland (reuter@slf.ch)

The alpine snow cover accumulates layers during characteristic meteorological events. The so formed stratigraphic features of the snowpack are known to influence avalanche release processes, such as failure initiation or crack propagation. Synoptic scale meteorological processes are altered by the underlying terrain, which causes micro-meteorological differences at smaller scales, such as the basin scale, for instance. Such micro-meteorological effects of complex snow surfaces were successfully modeled suggesting that the time is ripe to investigate their influence on snow instability. In other words, we aim at identifying the causes of spatial snow instability variations at the scale of a small basin. Over the past years we have compiled several field data sets for a small basin above Davos (Eastern Swiss Alps) covering 400 m by 400 m and consisting of snow penetration resistance profiles collected with the snow micro-penetrometer, terrain data and terrestrial laser scans. Each dataset holds about 150 vertical profiles sampled semi-randomly in the basin and captures the situation of a specific day, hence a particular avalanche situation. At those 150 point measurements the criteria for failure initiation and crack propagation were calculated and their spatial structure was analyzed. Eventually, we were able to model the distribution of snow instability in the basin by external drift kriging. We based the regression models on terrain and snow depth data. Slope aspect was the most prominent driver, but the number of significant covariates depended on the situation. Our results further suggest that the observed differences were caused by external influences possibly due to meteorological forcing as their residual autocorrelation ranges were shorter than the ones of the terrain. Repeating the geostatistical analysis with snow cover model output as covariate data, we were able to identify the causes of the snow instability patterns observed at the basin scale. The most prominent differences were related to variations in slab layer properties and caused by preferential deposition of precipitation and differences in energy input at the snow surface.