The properties of the seasonal mountain snow cover are spatially variable. The spatial variability of weak and slab layer properties, is believed to affect the avalanche formation process. To quantify spatial variations and their structure at slope scale, spatially distributed measurements were carried out on 23 slopes above tree line near Davos, Switzerland. The SnowMicroPen (SMP), a constant speed penetrometer was used for high resolution resistance probing in a partly randomized grid pattern. In addition, manual snow cover observations, stability tests and manual snow profiles were performed within each grid.

The SMP resistance signal was analyzed to derive an estimate of snow stability. A stability algorithm was developed by comparing 71 SMP force-distance profiles to the corresponding manual profiles including stability tests. The algorithm identifies a set of four potentially weak layers by taking into account changes in structure and rupture strength of micro-structural elements that make up snow layers as derived from the SMP signal. In 90% of the cases one of the four potentially weak layers proposed by the algorithm coincided with the failure layer observed in the stability test. For fully automatic picking of the critical layer, an agreement with the failure layer observed in the stability test was reached in 58% of the cases. To derive a stability classification, weak layer as well as slab layer properties were analysed. These predictor variables allow one to classify the SMP signal into two stability classes of poor and fair-to-good with an accuracy of about 75% (cross-validated) when compared to observed stability.

The spatial variation of weak layer and slab properties were characterized using non-spatial as well as spatial statistics. The non-spatial analysis showed that the investigated weak layers were spatially continuous, i.e. were identified in almost all SMP signals, and that weak layer properties showed fewer variations than slab layer properties. A large fraction of the spatial variability of slab layer properties was caused by linear spatial trends suggesting the importance of meteorological conditions during and after deposition as driving agents for spatial variability. In most cases, the geostatistical analysis suggested that no range of autocorrelation existed, neither for the slab layers nor for the weak layers. Nevertheless, slab layers exhibited a spatial structure, i.e. a range, more often than the corresponding weak layers. Weak layers showed generally less variance than the slab layers. Spatial range could not be related to slope stability and therefore the effect of the scale of variation on slope stability remains unknown for the time being.

Grids with low median compression test scores showed less variation than grids of intermediate or high compression test scores. The variation of the layer properties was positively correlated with the variation of the compression test scores. In other words, stability increased with increasing variation - suggesting that variable layer properties are rather related to stable conditions.

No firm conclusions can be drawn based on the limited dataset that could be collected in this study. Nevertheless, a hypothetical concept is suggested how spatial variability might be considered for slope stability estimation. The hypothesis is that spatial variations of weak layer and slab layer properties are only relevant if the variations at the slope scale are around the threshold of rather stable to rather unstable conditions. As this hypothetical concept could not sufficiently be supported by observations, it should be considered as preliminary.