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Scaling of spatial snow depth distribution parameters for large-scale model applications

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Snow depth distribution is extremely heterogeneous in mountainous terrain where the snow cover is typically influenced by large spatial gradients of incident radiation, precipitation and wind. Small-scale snow depth variations play a key role in large-scale models such as hydrologic catchment or land-surface models. Due to computational constraints, small-scale distributed modeling is, in general, rarely feasible for large regions. However, information about small-scale (sub-grid) snow coverage is essential for instance to accurately represent snow melt rates for large grid sizes.

Past research has shown that for rather homogeneous landscape units the pre-melt spatial distribution of snow depth can be approximated by a log-normal distribution. However, this may no longer be valid for snow distributions over landscape units covering complex terrain. Seasonally recurring snow accumulation patterns have been reported, mostly shaped by precipitation, radiation and wind. Which process dominates, strongly depends on the considered scale. We focus on large heterogeneous landscape units on the order of a few kilometers, typically employed by hydrologic and land-surface models. In order to characterize the impact of topographic parameters on pre-melt sub grid snow depth distribution, we analyzed a new, highly resolved data set acquired at peak of winter. Snow depth data with 2 m horizontal resolution was obtained from an opto-electronic scanning data set (Sensor ADS 80, Leica Geosystems) in a large catchment located above Davos, in the eastern Swiss Alps. Sub-grid snow distribution parameters were found to scale with topographic descriptors such as mean slope and standard deviation of the summer digital elevation model. Our results suggest that parameterizations of the snow-covered fraction can be enhanced if terrain parameters are included.