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Comparing the spatial variability of snow depth on glacierized and non-glacierized surfaces using a geostatistical approach

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Snow water storage is crucial for discharge generation in alpine headwater catchments. Hence, information on the snow pack and its spatial distribution and variation is of vital importance for the application of hydrological models. However, the assessment and quantification of the water equivalent stored in the snow cover is complicated due to several factors: i) wind or gravity driven relocation of snow results in heterogeneous spatial snow cover and snow depth patterns; ii) measuring snow characteristics (e.g. snow depth or snow water equivalent) and their spatial distribution is difficult in high alpine catchments and often limited to few point measurements only. Remote sensing can provide area-wide information on snow, but often the spatial resolution is too coarse and the temporal coverage is too low. Furthermore, sensors like MODIS or Landsat provide information on snow cover distribution only, but not on snow depth which is highly relevant for hydrological applications. Airborne Laser Scan (ALS) data can bridge this lack of information as there precise information on both distribution and depth of the snow cover is provided.

In this paper, we analyse the spatial distribution of snow depth using data from ALS flights in the glacierized parts of the Oetztal Alps, Austria. Snow depth is calculated from consecutive ALS flights at the beginning and the end of the snow accumulation period. The analysis of the spatial distribution of snow depth on both glacierized and non-glacierized surfaces is based on a geostatistical approach. From ALS snow depth data, six subsets (350 m x 350 m, 1 m raster width) were selected for the analysis: two subsets from Hintereisferner glacier, two subsets from Kesselwandferner glacier, and two subsets from adjacent, non- glacierized areas. In order to avoid biased results, the subsets from glacierized surfaces were chosen on areas without crevasses. The variability of snow depth is analysed with respect to surface properties (i.e. glacierized or non-glacierized) and the direction of highest variability (e.g. resulting from wind drift). The variogram analyses indicate that spatial variability of snow depth is much lower on the glacierized areas than on the non- glacierized areas, which is due to the smooth surface of the glacierized areas and the distance from obstacles (e.g. huge boulders) influencing the wind field. However, even on glacierized surfaces the spatial variability of snow depth can vary substantially

The high variability of snow depth (and hence snow water equivalent) on non-glacierized surfaces has to be taken into account when interpreting remote sensing snow data which does not include snow depth information, like MODIS or Landsat products. Assuming a homogenous snow depth will bias the estimated snow water equivalent and in consequence result in huge uncertainties with respect to runoff predictions.