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Evaluation of spatial variability of snow cover duration in a small alpine catchment using automatic photography and terrain-based modeling

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Snow cover plays a major role in the water and energy balance of alpine environments and is essential for various processes such as runoff, snow avalanches and permafrost distribution. Maps of snow cover represent an important basis for the assessment of spatial and temporal variability of the snow covered area (SCA) and can be used as validation data for distributed hydrological modeling. Terrestrial monitoring of the SCA by automatic photography is especially suitable for repeated local-scale investigations in mountainous regions, since satellite remote sensing products that meet the requirements regarding spatial and temporal resolution are generally rather costly.

An automatic camera system, consisting of a standard digital camera and a timer control unit in a weatherproof case, was installed in the upper part of a small NW-facing cirque (Hinteres Langtalkar) in the Hohe Tauern range (Central Eastern Alps). Photographs were taken on a daily basis from September 2006 to August 2008. 439 of these oblique photographs were selected to generate high resolution (1 m) orthophotos of a 0.16 km^2 large area, of which 3.8 % are hidden due to terrain effects. Since unbalanced illumination of the scenery complicates automated classification approaches, an empirical threshold method was used to discriminate snow covered areas from snow free areas pixelwise. Snow cover duration and snow cover depletion patterns during the two-year period were analyzed with respect to data from an in-situ automatic weather station and DEM-derived terrain parameters.

Because of the limited vertical extent of the investigated area (2690-3010 m a.s.l.) elevation has no significant influence on the spatial variability of snow cover duration. Our results suggest that slope is the determining factor at the study site as mean snow cover duration decreases rapidly with slopes steeper than 30°. Influence of aspect (as expressed by potential direct solar radiation) and curvature is less pronounced and presumably obscured by the effect of slope. Analysis of our images shows that late-lying snow patches are formed by the deposits of avalanches flowing from the cirque headwall. Records from the nearby observatory at Hoher Sonnblick (3106 m a.s.l.) indicate that maximum snow depth at the end of the snow accumulation season varies by a factor of two for the two observed years. However, spatial patterns of snow cover depletion and duration of the snowmelt period are very similar (116 and 122 days). Beyond the analysis presented here, the data set of detailed snow cover maps has a strong potential to be employed in further applications, e.g. calibration of process-based models of snow deposition, snow transport and snowmelt.