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The potential of airborne laser scanning driven snow depth observations for modelling snow cover, snow water equivalent and runoff in high alpine catchments

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The use of remotely sensed snow cover extents in hydrological modelling of mountainous regions is a commonly applied technique in the last 20 years. Whilst at certain locations timeseries of snow depth (HS) measurements are available, at substantially fewer sites additional snow water equivalent (SWE) observations exist. Despite this, most hydrological applications characterize the snow cover by its SWE, but information on the areal distribution of the total stored water of a catchments snow cover is generally still rare.
In a highly glacierized sub-catchment of the Ötztal in the Austrian province of Tyrol, annual airborne laser scanning (ALS) measurement campaigns have been carried out since the glaciological year 2001/2002. ALS snow depth observations were made from a set of measurements made prior to the start of the snow season (September or October) which were subtracted from a second set made after the snow accumulated (May). Using a consistent ALS flight campaign setup, the vertical error of the resulting digital elevation models is about +/- 0.1 m. Difference layers, representing the depth of the catchments snow pack, have been obtained for the years 2001/2002, 2002/2003 and 2008/2009.
Recently, easy-to-use approaches for the conversion of snow depth measurements into snow water equivalent have been developed. A regression-approach from the Swiss Alps (Jonas et al. 2009) was checked for its applicability in the Tyrolean Alps using a set of HS and SWE measurements. An ALS difference layer (as described above) can be characterized as a set of HS measurements at every single square meter in the catchment and hence, using the regression parameters of the correlation of HS and snow density, this large number of measurements can be transformed to a “measured” SWE-layer. The runoff from the ALS-investigation-area is calculated using the spatially distributed energy balance model SES (Snow- and Icemelt Model). The SES model is a component of the flood forecasting system of the Tyrolean river Inn. Comparisons of the SWE-layers derived by SES and the corresponding measured SWE layers - representing snow accumulations of the three reference periods - show a great potential for recalibrations or updates of the snow-hydrological model.
Coupled with a depth-to-SWE conversion method, airborne laser scanning can be an ideal base for snow model calibrations, or even the assimilation of snow pack information for snow-hydrological model systems. The combination of these methods could highly improve the understanding of the distribution of SWE in alpine catchments and the ability to estimate local or regional snow and water resources.

Reference:
Jonas, T., Marty, C., Magnusson, J. (2009): Estimating the snow water equivalent from snow depth measurements in the Swiss Alps. Journal of Hydrology, Volume 378, Issues 1-2, 161-167.