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Can the total snow amount in an Alpine catchment be estimated from flat field snow measurements?

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Knowledge on total snow volume or snow water equivalent (SWE) stored in alpine areas is highly important for many hydrological applications. Therefore it is an important question, whether the total snow volume and total SWE of a catchment can be estimated by simply using a single snow depth point measurement from a flat field.
There are two main factors on which total snow volume depends on: First the average snow depth of the catchment and second the area which is covered with snow. Especially in the melting season the increasing difference between total area and snow covered area can cause major errors in snow volume estimation. Once the volume is known, an estimation of mean density is required to convert to total SWE.
To approach our question we did a comparison of total snow volume and SWE extrapolated from snow depth measured with automatic flat field snow stations on the one hand, with total snow volumes and SWE gained from terrestrial laser scanning surveys on the other hand. The study uses three automatic weather and snow stations, situated in and nearby the Albertibach catchment area, a small, high alpine mountain valley located in the Davos mountains (Swiss Alps). Station Wannengrat3 (WAN3), a completely equipped meteorological and snow flat field station is located in an altitude of 2360m in the center of the catchment. The IMIS-snow stations Weissfluhjoch Versuchsfeld (WFJ) and Hanengretij (DAV3) are situated nearby but outside the investigation area: WFJ (2540 m) is located about 3 km in north eastern, DAV3 (2450 m) about 1.5 km in southern direction of the catchment area.
To obtain comprehensive snow depths in the area of investigation we used a long range laser scanner. Laser data from four field campaigns starting with the end of accumulation season (April 26th 2008) and ending with the ablation of the investigation area (June 10th 2008) are available. Snow depths can be obtained by the laser scanner by measuring the snow surface and subtracting it from the digital elevation model obtained from a summer scan. As vertical snow depth was calculated (vertical with respect to a flat base) it had to be transferred with a trigonometric function to values vertical to the slope. The size of the snow covered area was gained from orthophotos taken during the laser survey. To transfer snow depth to SWE we took several manual snow density measurements spread over the area of investigation for each field day. We compared snow volumes and SWE obtained with the two methods mentioned above for every scan day.
Results show significant differences between the three flat-field snow stations. At the time of maximum snow depth WAN3 measured a snow depth similar to the average from the laser scanner. It has to be pointed out, however, that this station is exposed to wind and hence wind erosion can take place here. Both other stations are sheltered from wind erosion and overestimate snow depth, snow volume and SWE significantly. During the ablation period, the snow stations showed a stronger decrease in snow depth than the whole catchment area as measured with the laser scanner. This results in an underestimation of the snow volume and SWE by WAN3 which increases in time. At the other two stations the overestimation decreased until they turned to an underestimation of the snow volume at the end of the melting season.
We finally conclude that (i) None of the snow stations provided a representative snow depth measurement at least not for the whole ablation period (ii) The snow station on which erosion takes place (WAN3) was more representative than the sheltered stations at the end of the accumulation season (iii) For all flat-field stations the ablation was increasingly overestimated with time in comparison to the real ablation in the whole catchment.