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Evaluation of continuous and autonomous snow water equivalent measurements by a cosmic ray sensor on a Swiss glacier

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Snow water equivalent (SWE) measurements are crucial in many research fields such as avalanche prediction, flood prevention, runoff simulation, or ice sheet and glacier mass balance modeling. Despite the importance of accurate SWE measurements, continuous and autonomous measurements are difficult to obtain in high mountain regions at a high temporal resolution.

The cosmic ray sensor allows inferring SWE directly from neutron counts. Here, we present the analyses of continuous SWE measurements on a Swiss glacier (Glacier de la Plaine Morte). The measurements cover the two winter seasons of 2016/17 and 2017/18 which have been highly different in terms of amount and timing of snow accumulation. During these two winter seasons, the cosmic ray sensor has measured SWE reliably, and thus, we consider it a very robust method to monitor SWE at remote high alpine sites.

By combining the SWE values with snow depth measurements, we calculate the mean snow density of the snowpack at a daily resolution. The autonomous measurements of SWE, snow depth and density lie within $\pm 10\%$ of manual field measurements, which were obtained with snow pits and snow probings four, respectively six, times during the two winter seasons.

In a first application, we make use of the daily resolution to break down the winter season into days which are dominated by accumulation (solid precipitation, wind drift), ablation (wind drift, melt) or densification. Then, we determine the prevailing meteorological conditions (temperature, wind speeds, wind direction, and relative humidity) of these periods. Even though the two winter seasons were different in terms of amount and time evolution of SWE, the number of days with accumulation and densification processes remain similar for both winters.

In a second application, we compare daily SWE amounts to precipitation amounts of three nearby low-elevation stations in close vicinity to the glacier. The ratio of snow accumulation on the glacier over precipitation observed at the nearby station is only consistent for one station over different time scales (daily and monthly). For the other two stations, the variability is higher even though they are located at a similar distance to the glacier.