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Investigating performance of using snow depth data to minimize the error in winter precipitation measurements

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The European Alps hold the densest network of automatic weather stations (AWS) in mountain regions of the world. Thanks to the efforts of national weather- and hydrological services, avalanche warning services, and various research institutions, the overall number of AWS has increased significantly in recent years and particularly stations using sophisticated instrumentation to record snow parameters at high elevations are becoming more and more ubiquitous. In Austria, the Zentralanstalt für Meteorologie und Geodynamik (ZAMG) has mounted optical snow depth sensors (SHM30) to 82 stations of its operational network. The sensor is based on laser technology and has a markedly higher accuracy of a few millimetres, compared to the centimetre scale-accuracy of ultra-sonic sensors, which are more commonly used for operational snow depth observation.
Within the pluSnow project snow depth changes measured using the optical sensor where compared to precipitation measurements from pluviometers, taking into account undercatch correction, snow settling and new snow density estimates. In general, a high correlation between precipitation and the height of new snow could be detected using hourly data.
To compare the water equivalent of snowfall and the heights of new snow, the density of the new snow has to be estimated. For hourly values, we calculated the density of the new snow from combined measurements of snow water equivalent and snow depth, and compared the results to density estimates using existing formulas. We found the average density of the new snow for hourly snowfall data to be 68 $\pm$ 9 kgm-3, which is distinctly lower than the approximation of 100 kgm-3 often used for daily snowfall amounts. Variations in new snow density could not be explained in a satisfactory manner using meteorological data measured at the same location.
A comprehensive comparison between the water equivalent of new snow and precipitation measurements corrections as suggested by the WMO over a large set of automatic weather stations shows that the difference between snow depth changes and precipitation data is very specific for the individual stations and correlations vary accordingly. Applying the SNOWGRID snow cover model with different correction formulas to adjust precipitation input shows that the applied precipitation corrections are useful to correct for undercatch at some of the stations, but are not necessary at other stations, and may not explain the observed difference between precipitation and heights of new snow especially particularly at higher elevation stations.
The results can be used to improve snow model performance considering a bias-correction in winter precipitation input at distinct observation sites and are relevant in a general sense to operational hydrological and meteorological services.