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Different automatic Methods for estimating Snow Water Equivalent

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Snow Water Equivalent (SWE) is a key parameter in cryospheric sciences such as snow hydrology, avalanche formation, avalanche dynamics and snow climatology. SWE stands for the stored mass of water in the snow cover and is commonly calculated from the snow height and its corresponding density.

Since more than 70 years, the Swiss Federal Institute maintains a flat Alpine test site in the Davos area at Weissfluhjoch at an altitude of 2540 m above sea level. Over the years, new methods and instruments has been developed and tested here for snow and avalanche research. During the last four winters (2005-2008), 6 different methods of automatic SWE point-measurements have been tested at the Weissfluhjoch experimental site, namely:

1. Heated rain gauge (Type Joss-Tognini, MeteoSwiss),
2. Snow pillow hydrostatic pressure readings (Type Sommer, Austria),
3. TDR flat band cable readings (Prototype Snowpower, Sommer, Austria),
4. Laser optical distrometer (Type Ott Parsivel, Germany),
5. SNOWPACK SWE SLF-model output based on standard meteorological data, and
6. COSMO-CH7, meteorological forecast model by MeteoSwiss (as a "virtual sensor" of SWE estimation).

In this study, we first verified daily SWE amount (HNW) of the 6 automatic measurement methods against manual SWE reference measurements and present statistical parameters of the comparison. In order to classify the different sensors according to their reliability of the HNW data for applications in operational avalanche risk management, the probability of detection (POD) for different classes of daily new snow precipitation intensities is additionally calculated.

Second, we estimated the total SWE of the Snow cover either by the summation of automatic daily SWE measurement (a,d,e,f) or by direct reading of the total SWE (b,c). Reference readings here were the conventional measurements of total SWE by weighing the total amount of snow with a cylindrical tube in vertical columns during the bimonthly snow profiling procedure.

The results show that the HNW can be automatically estimated by a mean overall absolute accuracy of +/- 3.25 mm and a variable POD for every sensor and every class of HNW intensity.

Total amount of SWE at the end of the accumulation period can be estimated within an accuracy of about 5%-10%. As this accuracy is in the same range of the spatial variability of snow cover within the experimental site we conclude, that this value is the minimal possible technical accuracy for estimating the total amount of SWE in practical applications so far.

Some of the automatic methods open promising options for snow and avalanche research, allowing hourly readings and so temporal refinement. We discuss the advantages and disadvantages of the specific sensors tested in this study. This information provide a good base for cost effective decisions, e.g. if automatic SWE measurements should be integrated in snow networks or if a proper ground truth is needed for remote sensing control.