Dependency of in-situ snow sampling accuracy on sampler cross-section

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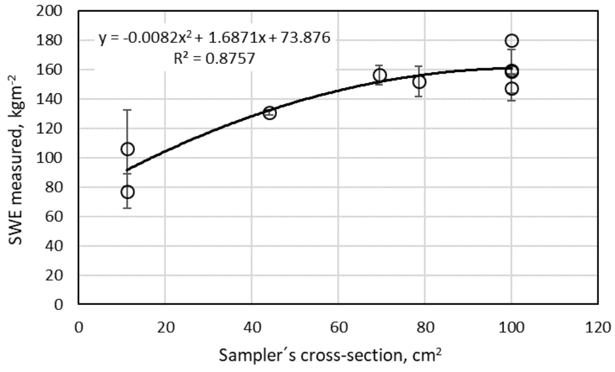
Snow sampling, either by pushing a tube through the entire snow pack or taking samples layer by layer, is widely applied to measure snow depth, density, and snow water equivalent (SWE), to collect snow water for chemical analyses of impurities etc. A comparative study of snow sampling methods was carried out on March 24, 2022 during the Nordic Snow Network (NordSnowNet) Snow Week in Sodankylä, Finland. The Nordic Snow Network (https://nordsnownet.fmi.fi/) is collaboration between with 5 national meteorological institutes and universities in Norway, Denmark, Finland, Sweden, Iceland, Estonia and Greenland. The network is focused on snow in Nordic and related Arctic areas and aims to link and make more visible existing snow research and snow data for researchers, data users and education communities.

Six groups from five countries (Estonia, Finland, Greenland, Iceland, and Sweden) participated with 12 different snow samplers, including 9 bulk tube samplers and 3 layer-wise box samplers. The cross-section area of samples varied from 11 to 100 cm^2, vertical sampling step from 5 cm layer-wise sampler to 100 cm long tubes. The samples were taken from snow pits in 55 – 65 cm deep snow cover in a flat area with sparse pine trees, with sampling sites at max. 10 m apart. Each tube sampling series consisted of 3 – 10 vertical columns for statistical validation, each of detail layer-wise box samplers was used for a single-column measurement.

The snowpack was relatively soft with two moderately hard crust layers and an ice layer in the middle of it. The density from tube sample measurements varied from 218 to 265 kgm^{-3}. For density cutters, the layer-wise densities varied from 240 to 307 kgm^{-3}. The measurement results of SWE, however, varied considerably depending on the sampling equipment used, from 77 to 180 kgm^{-2}, whereas the values within each particular series were rather stable: standard deviations 2 – 15, in one exceptional case 26 kgm^{-2}. A clear trend of lower SWE when sampling with a tube of smaller cross-section, was observed (Figure 1). Above cross-sections of 70 – 80 mm, the SWE value seems rather stable, thus the dependence is similar to a saturation curve.

The physical reason for the dependence of measured SWE on the cross-section of the sampler may lay in modification of the snow physical properties in the sampling process. In order to pass through snow, the sampler tube slightly compresses the snow inside, thus increasing drag force inside relative to the outer surface of the sampler, which causes the snow to partially clog in the tube. Then a fraction of snow on sampler´s path is pushed aside instead of getting inside the tube. Obviously, the drag force inside is stronger when the sampler is thinner. Considering the "saturation curve" behaviour, the cross-section of a cylindrical sampler above about 70 cm^2 seems large enough to not distort the SWE measurement result because the drag force difference is negligible.

More comparative studies are needed to prove this hypothesis and quantify the cross-section influence to the SWE result, depending on snow density and structure, and the properties of the sampler tube. As a thin sampler is often more practical, correction coefficients to SWE for different samplers may be needed.



Acknowledgement. This study is funded by Nordic Snow Network project under the Nordic Arctic Cooperation Programme, hosted by the Nordic Council of Ministers. We would like to thank Finnish Meteorological Institute personnel for their invaluable support during the NordSnowNet Snow Week.

Figure 1. Dependence of measured snow water equivalent on sampler´s cross-section. Error bars indicate the standard deviations of series consisting of multiple samples taken with the same sampler.