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Cosmic-ray neutron sensing of snow water equivalent in heterogeneous alpine terrain

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Low-energy cosmic-ray neutrons show a high sensitivity to hydrogen pools and thus to water. Apart from soil moisture, cosmic-ray neutron sensing (CRNS) was shown to be a promising method for monitoring snow at intermediate scale. The practical knowledge is however limited to rather shallow and homogeneous snow.

To better understand the signal in heterogeneous alpine sites, a field campaign with accompanying point-scale snow sampling and spatially distributed terrestrial laser scanning (TLS) was conducted in the Austrian Alps. Therein, the main scope was to evaluate the characteristics of CRNS for monitoring a mountain snowpack in a wetter and more complex environment. During the experiment, the study site experienced a peak snow accumulation in terms of snow water equivalent (SWE) of up to 600 mm. The spatial structure of the snow accumulation patterns was highly heterogeneous in space and time. Unlike the conventional point-scale snow measurements, the function between snow on the ground and low-energy neutrons was constant over three winter seasons with contrasting wind directions and spatial snow patterns. At the measurement site located at around 2500 m a.s.l. the representative footprint of the CRNS measurement is in the range of 230 to 270 m.

In addition to the empirical result from the field campaign, the URANOS neutron transport model was set up to provide insights into the characteristics of CRNS in the presence of a complex snowpack. In a first step, the data gaps in the TLS based SWE maps were filled by an interpolation scheme based on a multi-linear regression between the laser-scan measurements and different terrain variables. This resulted in a seamless 1 x 1 km domain of the snow layer, which was used as a boundary condition in URANOS. With this heterogeneous snow layer, the neutron counts from the field campaign could be reproduced well. In contrast, a baseline scenario with homogeneously distributed snow showed a lower degree of agreement.

Based on the results of both the empirical field campaign and the neutron modelling, this contribution gives insights into the interactions between low-energy neutrons and complex snow cover as it is common to most mountain environments.