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Modeling liquid water transport in snow under rain-on-snow conditions considering preferential flow

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Rain-on-snow (ROS) has caused severe flood events in Europe in the recent past. Thus, precisely forecasting snowpack runoff during ROS events is very important. Data analyses from past ROS events have shown that the release of snow cover runoff is often delayed relative to the onset of rainfall. This delay is influenced by the refreeze of liquid water inside the snowpack, as well as by the water transport mechanisms. Water percolation in turn depends on snow grain size but also on the presence of structures such as ice lenses or capillary barriers. Further, during sprinkling experiments, preferential flow was found to be a main mechanism to determine the generation of snow cover runoff. However, current 1D snow cover models are not capable of addressing this phenomenon correctly.

For this study, the detailed physics-based snow cover model SNOWPACK has been extended with a water transport scheme accounting for preferential flow. The implemented Richards′ Equation solver was modified based on a dual-domain approach to simulate water transport under preferential flow conditions. This transport model is used to simulate liquid water transport within the snow cover during ROS events. To validate the presented approach, we used an extensive data set of approximately 100 historic ROS events at different locations between 950 m and 2540 m elevation in the Alps. The data set comprises meteorological and snow cover measurements as well as snow lysimeter runoff data. Additionally, experimental sprinkling of dye tracer colored water was conducted on snow cover, where runoff was measured by snow lysimeters. The model was tested under a variety of ROS events including cold, ripe, stratified and homogeneous initial snow cover conditions. Preliminary results show an improvement in temporal runoff representation as well as in total runoff amount for several ROS events.