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Rainwater propagation through snow during artificial rain-on-snow events

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The mechanism of rainwater propagation and runoff generation during rain-on-snow (ROS) is still insufficiently known. Understanding rainwater behaviour within the natural snowpack is crucial especially for forecasting of natural hazards like floods and wet snow avalanches. In this study, rainwater percolation through snow was investigated by sprinkling the naturally stable isotope deuterium on snow and conduct hydrograph separation on samples collected from the snowpack runoff. This allowed quantifying the contribution of rainwater and snowmelt in the water released from the snowpack.

Four field experiments were carried out during the winter 2015 in the vicinity of Davos, Switzerland. A 1 by 1 m block of natural snow cover was isolated from the surrounding snowpack to enable a closed water balance. This experimental snow sample was exposed to artificial rainfall with 41 mm of deuterium enriched water. The sprinkling was run in four 30 minutes intervals separated by three 30 minutes non-sprinkling intervals. The runoff from the snow cube was monitored quantitatively by a snow lysimeter and output water was continuously sampled for the deuterium concentration. Further, snowpack properties were analysed before and after the sprinkling, including vertical profiles of snow density, liquid water content (LWC) and deuterium concentration.

One experiment conducted on cold snowpack showed that rainwater propagated much faster as compared to three experiments conducted on ripe isothermal snowpack. Our data revealed that sprinkled rainwater initially pushed out pre-event LWC or mixed with meltwater created within the snowpack. Hydrographs from every single experiment showed four pronounced peaks, with the first peak always consisted of less rainwater than the following ones. The partial contribution of rainwater to the total runoff consistently increased over the course of the experiment, but never exceeded 63 %. Moreover, the development of preferential paths after the first sprinkling period caused a quicker runoff response in subsequent periods.