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A laboratory-based characterization of capillary barriers and preferential flow in snow

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Liquid water percolation in snow is a complex process, which is characterized by high spatial and temporal heterogeneity. Several strategies have been considered in the past to simulate the vertical profile of liquid water content in snow, since this information has important impacts on runoff prediction and avalanche forecast. Examples are the use of Darcy's law and/or Richards Equation. In this context, a frequent assumption is that the effects of gravitational gradients on the flow are predominant over capillary gradients, which can be therefore neglected as a first approximation. As a result, the physical characterization of several capillary-related processes in snow is still low. An example are capillary barriers: their occurrence in snow is well known, but this knowledge is still mostly qualitative. An additional complication is that measuring liquid water content in snow is usually very difficult and this hampers a more comprehensive investigation on these processes. Here, we present and discuss the results of nine experiments in a cold laboratory where dyed water was supplied to layered snow samples. All samples were characterized by a finer-over-coarser transition between layers of different grain size. By means of visual inspection, liquid water content measurements and cross-sectioning, the properties of capillary barriers and associated preferential flow were investigated. Results show that both are relevant processes ruling the time of arrival of water at sample base. Peaks in liquid water content at the inter-layer boundary reach 33 – 36 vol%. We also observe that heterogeneity of flux increases with grain size, while no clear dependency on external supply rate is found. Finally, the dynamics of each sample were replicated using SNOWPACK and a water scheme that bases on van Genuchten formulation. Results of this comparison are discussed in view of existing theory.