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Simulation of capillary overshoot in snow with a non-equilibrium Richards equation model combined with a trapping model for the water phase

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The timing and magnitude of snowmelt discharge and subsequent runoff is controlled by both matrix and preferential flows of water through snowpacks. Matrix flow can be estimated using Richards equation, and recently, preferential flow in snowpacks been represented in 2D and 3D models. A challenge for representing preferential flow through porous media is capillary overshoot and soil studies have developed sophisticated and largely realistic approaches to represent this, but it has not been addressed in snowpack water flow models. Here, a 1D non-equilibrium Richards equation model is implemented with dynamic capillary pressure, and then combined with a new concept of entrapment of liquid water within the pore space. This new model was capable of quantitatively simulating capillary overshoot as estimated by published capillary pressure measurements in snow samples of various grain sizes under different rates of liquid water infiltration. Three model parameters were calibrated and their impacts on model outputs were evaluated. This improvement is a substantial step towards better understanding and simulating physical processes occurring while liquid water percolates an initially dry snowpack.