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Modelling Meltwater Infiltration and Refreezing in Snow under Non-Isothermal Conditions

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The flow of meltwater through snow, acknowledged as a porous medium, is a crucial hydrological process essential for predicting the cryosphere's response to climate change. This work aims to model the intricate coupling between meltwater infiltration and the non-equilibrium thermodynamics of ice-melt phase change at the Darcy scale. The proposed model consists of the Richards' equation for infiltration, and evolution equations for ice and water temperature fields, which account for the thermal budget resulting from melt refreezing. Additionally, the model takes into account variations in porosity within the ice structure. The study presents numerical results from simulations conducted on 2D models of snowpacks with distinct initial levels of dryness and varying physical setups, which examine the mechanics of infiltration and alteration of the porosity structure due to refreezing. The implementation employs the PorePy and PyGeoN Python libraries.