Geophysical Research Abstracts
Vol. 20, EGU2018-13422, 2018
EGU General Assembly 2018

A model for water flow in macroporous soils under freezing and thawing conditions

Mats Larsbo (1), Roger Holten (2), Ole Martin Eklo (2), Marianne Stenrod (2), and Nick Jarvis (1)

(1) Swedish University of Agricultural Sciences (SLU), Soil and Environment, Uppsala, Sweden (mats.larsbo@slu.se), (2) Norwegian Institute of Bioeconomy Research (NIBIO), Division of Biotechnology and Plant Health

Freezing and thawing have large effects on water flow in soils since ice may block a large part of the pore space and thereby prevent infiltration and flow through the soil. This, in turn, may have consequences for contaminant transport. For example, transport of solutes contained at or close to the soil surface can be rapidly transported through frozen soils in large pores that were air filled at the time of freezing. Accounting for freezing and thawing could potentially improve model predictions used for risk assessment of contaminant leaching. A few numerical models of water flow through soil accounts for freezing by coupling Richards' equation and the heat flow equation using of the generalized Clapeyron equation, which relates the capillary pressure to temperature during phase change. However, these models are not applicable to macroporous soils.

The objective of this study was to develop and evaluate a dual-permeability approach for simulating water flow in soil under freezing and thawing conditions. To achieve this we extended the widely used MACRO-model for water flow and solute transport in macroporous soil. Richards' equation and the heat flow equation were loosely coupled using the Clapeyron equation for the soil micropore domain. In accordance with the original MACRO model, capillary forces were neglected for the macropore domain and conductive heat flow in the macropores was not accounted for. Freezing and thawing of macropore water, hence, were solely governed by heat exchange between the pore domains. This exchange included a first-order heat conduction term depending on the temperature difference between domains and the diffusion pathlength (a proxy variable related to the distance between macropores) and convective heat flow.

As far as we know, there are no analytical solutions available for water flow during freezing and thawing and laboratory data is limited for evaluation of water flow through macropores. In order to evaluate the new model approach we therefore first compared simulation results of water flows during freezing for the micropore domain to existing literature data. Our model was shown to give similar results as other available models. We then compared the first-order conductive heat exchange during freezing to a full numerical solution of heat conduction. Finally, simulations were run for water flow through frozen soil with initially air-filled macropores for different boundary conditions. Simulation results were sensitive to parameters governing the heat exchange between pore domains for both test cases.