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Effect of temperature and soil-rock characteristics on permafrost distribution and hydrology

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In the present study, we perform numerical modelling to address the effects of soil and rock characteristics, in terms of hydraulic and thermal properties, on permafrost development and groundwater flow subject to annual variations in climate forcing. We utilize a two-dimensional model domain describing a typical Scandinavian soil-rock setting with specified, temporally varying, surface temperature and groundwater recharge. Specifically, the temperature follows a sine curve with an annual average of -1 degrees Celsius, while the recharge is zero during freezing temperatures and has a constant value, relevant for typical mean annual recharge, during positive temperatures.

The groundwater flow model DarcyTools (Svensson, 2010; Vidstrand et al., 2013) is used. DarcyTools simulates coupled saturated/unsaturated flow and heat transport; permafrost development is modelled in a simplified manner by assigning low permeability values in regions with negative temperatures. This is achieved by adopting a permeability reduction factor which depends on an ice-content function and material properties; the ice content function in turn depends on modelled temperature and a freezing parameter that depends on in-situ conditions.

Different combinations of rock and soil characteristics are investigated. Results show that differences in thermal properties between different soil/rock units have the largest influence on permafrost development and hence also on groundwater flow in permafrost regions. Specifically, if prevalent soil/rock units have similar thermal properties, while having different hydraulic properties, there is limited effect on permafrost development compared to the case where also thermal properties vary between units. The results mechanistically show that, for a given temperature, permafrost will develop more readily and to greater extent in a peat soil than in a mineral soil due to the fact that peat has thermal properties different from mineral soils and rock.

The results also have implications for carbon release in regions with thawing permafrost. They indicate that permafrost in peat is more resilient to warming than permafrost in mineral soils. On-going simulations are performed to further test this indication.

References:

Svensson, U., 2010. Darcy Tools version 3.4, Verification, validation and demonstration. SKB R-10-71, Svensk Kärnbränslehantering AB, Stockholm, Sweden.

Vidstrand, P., Follin, S., Selroos J. O., Näslund, J. O., Rhén, I., 2012. Modeling of groundwater flow at depth in crystalline rock beneath a moving ice sheet margin, exemplified by the Fennoscandian Shield, Sweden, Hydrogeology Journal, DOI 10.1007/s10040-012-0921-8.