Groundwater flow and solute transport modelling in coupled permafrost-hydrogeological systems

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There is a need for improved mechanistic understanding and quantification of permafrost and active layer change and its interactions with changes in subsurface water flow and solute transport. This is not only important for understanding dissolved carbon transport in the context of climate change, but also for understanding effects of anthropogenic pollution induced by increased arctic activity (Elberling et al., 2010; Jessen et al., 2014).

In this contribution subsurface solute transport in a degrading permafrost system is studied using a physically-based numerical model of coupled cryotic and hydrogeological flows combined with a particle tracking method (Frampton and Destouni, 2015). Changes in subsurface water flows and solute transport travel times are analysed for different modelled geological configurations during a 100-year warming period. For all simulated cases, the minimum and mean travel times increase non-linearly with warming irrespective of geological configuration and heterogeneity structure. These travel time changes depend on combined warming effects of increase in pathway length due to deepening of the active layer, reduced transport velocities due to a shift from horizontal saturated groundwater flow near the surface to vertical water percolation deeper into the subsurface, and pathway length increase and temporary immobilization caused by cryosuction-induced seasonal freeze cycles.

References:

Elberling, B., Christiansen, H.H., Hansen, B.U., 2010. High nitrous oxide production from thawing permafrost. Nat. Geosci. 3, 332–335. doi:10.1038/ngeo803

Frampton, A., Destouni, G., 2015. Impact of degrading permafrost on subsurface solute transport pathways and travel times. Water Resour. Res. doi:10.1002/2014WR016689

Jessen, S., Holmslykke, H.D., Rasmussen, K., Richardt, N., Holm, P.E., 2014. Hydrology and pore water chemistry in a permafrost wetland, Ilulissat, Greenland. Water Resour. Res. 50, 4760–4774. doi:10.1002/2013WR014376