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The past few decades have seen a rapid development and progress in research on past and current hydrologic impacts of permafrost evolution. In permafrost area, groundwater is subdivided into two zones: supra-permafrost and sub-permafrost which are separated by permafrost. Knowledge of the sub-permafrost aquifers is often lacking due to the difficulty to access those systems. The few available data show that this aquifers are generally artesian below the continuous permafrost. In the literature, there are two plausible explanations for the relatively high pore pressures in the sub-permafrost aquifer; the recharge related to the ice sheet melting and the expulsion of water related to the ice expansion. In this study, we investigated areas where ice sheets have never developed like in the Paris basin region. The ice expansion induces also soil surface uplift.

Our study focuses on modifications of pore water pressure in the sub-permafrost aquifer and the soil surface motion during the permafrost development (freezing front deepening). To fill in the gaps to the field data availability, we developed an experimental approach. Experimental design was undertaken at the Laboratory M2C (Université de Caen-Basse Normandie, CNRS, France). The device consisted in a 2 m^2 box insulated at all sides except on the top where a surface temperature was prescribed. The box is filled with silty sand of which hydraulics and thermal parameters are known. Soil temperatures, pore water pressure and soil motion are continuously recorded at different elevations in the sand-box. We developed a two-dimensional transient fully coupled heat and water transport model to simulate thawing and freezing processes taking into account the phase change (Latent heat effects). The balance equations are solved using of a finite difference numerical scheme. Experimental results are used to verify the implementation of the hydro-mechanical processes in our numerical simulations.

Experimental and numerical approaches allowed us to verify and quantify the fact that the pressures induced by the ice volumetric expansion are translated into overpressure generated in sub-permafrost groundwater and a soil surface uplift.