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InterFrost Project Phase 2: Updated experiment design for validation of Cryohydrogeological codes (Frozen Inclusion)

Christophe Grenier and the InterFrost Project (François Costard, Hauke Anbergen, Victor Bense, Quentin Chanzy, Ethan Coon, Nathaniel Collier, Michel Ferry, Andrew Frampton, Jennifer Frederick, Julio Gonçalvès, Johann Holmén, Anne Jost, Samuel Kokh, Barret Kurylyk, Jeffrey McKenzie, John Molson, Emmanuel Mouche, Laurent Orgogozo, Romain Pannetier, Eric Pohl, Agnès Rivière, Wolfram Rühaak, Johanna Scheidegger, Jan-Olof Selroos, René Therrien, Patrik Vidstrand, Clifford Voss)

LSCE/IPSL (CNRS-CEA-UVSQ), LSCE, Gif sur Yvette, France (christophe.grenier@lsce.ipsl.fr)

Recent field and modelling studies indicate that a fully-coupled, multi-dimensional, thermo-hydraulic (TH) approach is required to accurately model the evolution of permafrost-impacted landscapes and groundwater systems. However, the relatively new and complex numerical codes being developed for coupled non-linear freeze-thaw systems require validation. This issue was first addressed within the InterFrost IPA Action Group, by means of an intercomparison of thirteen numerical codes for two-dimensional TH test cases (TH2 & TH3). The main results (cf. Grenier et al. 2018 and wiki.lsce.ipsl.fr/interfrost) demonstrate that these codes provide robust results for the test cases considered.

The second phase of the InterFrost project is devoted to the simulation of a cold-room reference experiment based on test case TH2 (Frozen Inclusion). In a first implementation phase of the experimental setup, the initial frozen inclusion was inserted in the setup prior to the complete filling of the porous medium and the flow initiation. The thermal evolution of the system was monitored by thermistors located at the center of the initial inclusion and along the downgradient centerline. This setup provided optimal conditions to control the initial experiment geometries but resulted in slight differences in the initialization time for different experiments.

We present a second implementation strategy that considers "in place" generation of an initial frozen inclusion through a cooling coil. The initial frozen inclusion is obtained after the initial cooling time and its initial thermal state is measured by means of an array of thermistors. In a second step, the flow is initiated, and the thermal evolution is monitored through an array of 11 thermistors (within the initial position and downgradient). The experimental setup and monitoring results as well as preliminary simulation results are presented. Derived results and conclusions from this exercise form the basis for the next phase within the InterFrost validation exercise.

Grenier, C. et al. 2018. Groundwater flow and heat transport for systems undergoing freeze-thaw: Intercomparison of numerical simulators for 2D test cases. Adv. Wat. Res. 114: 196-218.