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Heat transport modelling using the multi-species transport model MT3DMS

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Due to the mathematical similarities between heat and mass transport, the USGS multi-species transport model MT3DMS, originally developed for solute transport, is applied to simulate heat transport for ground source heat pump (GSHP) systems. Although in several studies solute transport models were successfully applied for simulating heat transport, they lack of providing any rigorous verification of this approach. We provide a comprehensive verification of applying MT3DMS (Version 5.2) for two-dimensional and three-dimensional heat transport simulations of shallow geothermal systems. Closed systems are considered for three generic scenarios that are distinguished by their Péclet number. Two verification approaches are employed: First, numerical results are compared with solute and heat transport analytical solutions. For 2D scenarios, line-source analytical solutions for heat transport simulation are applied. For 3D scenarios, planar-source analytical solutions based on classical solute transport equations are considered. Second, MT3DMS results are compared with simulations by the finite element code FEFLOW. The overall agreements of MT3DMS with the analytical solutions and FEFLOW for the various scenarios are satisfying. Differences are mostly due to the impossibility to represent the boundary conditions of the analytical solutions (line source), and the inherent differences of the numerical methods used by each code. Overall, this study reveals that MT3DMS is suitable to simulate heat transport of shallow geothermal systems, while offering insight into the application constraints.