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Simulating flow and solute transport in subsurface environments: From pore-scale to beyond

Research of the multi-scale, multi-phase, and multi-processes system is of great interest in understanding subsurface environments. However, the coupled flow and transport processes are complex yet challenging for model development and utilization. There have been numerous object-oriented and easy-to-use models/codes across scales to facilitate consistency, continuity, and reproducibility in subsurface research. In addition, pioneer efforts on upscaling also inspire the development of hybrid multi-scale models. It is then critical to intercompare codes and approaches for their evaluation or validation, and propel discussions for optimizing the codes and the development of the next-generation numerical approaches. In this talk, we present a suite of at-scale and multi-scale models that we developed and utilized in recent years for simulating flow and transport processes, with intercomparison and benchmarking cases, including: (1) pore-scale models for simulating flow, solute transport and biofilm growth in porous media; (2) Darcy-scale models for simulating thermo-hydrological processes in frozen soils; (3) regional-scale groundwater models for simulating groundwater-surface interactions; (4) hybrid multi-scale models (pore- to Darcy-scale) for numerical upscaling.

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