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Heterogeneous Domain Decomposition Methods for Coupled Hydrological Processes

The talk focusses on coupled nonlinear problems arising from the simulation of saturated-unsaturated fluid flow in porous media. It introduces an approach for the numerical solution of the Richards equation in heterogeneous soil which completely avoids linearization. This is achieved by applying Kirchhoff's transformation followed by convex minimization separately in subdomains with homogeneous soil. The coupling is induced by continuity of the pressure and the water flux across the interfaces and solved by the Dirichlet–Neumann or the Robin method. Here, convergence results in 1D as well as systematic numerical experiments in 2D, which show surprising similarities to linear cases, are presented.

Coupling of saturated-unsaturated groundwater flow with surface water is provided by mass conservation and hydrostatic pressure. For surface water reservoirs this coupling can be numerically realized since our solver for the Richards equation also determines the free boundary given by Signorini-type conditions on seepage faces around lakes. In addition, we introduce a solver of Dirichlet–Neumann type for the coupling of the Richards equation with the shallow water equations. Numerical results concerning the 2D-1D coupling are presented.

The talk is based on joint work with R. Kornhuber and O. Sander.