Nonlinear Solvers for Variably Saturated Subsurface Flow

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Accurate simulation of water resource management problems requires the solution of large problems with many spatial zones. In the case of variably saturated flow problems, we need to develop scalable and highly efficient algorithms for solving the large nonlinear systems of equations that arise from the discretization of Richards' equation, a nonlinear, parabolic equation modeling the flow of water through a porous media filled with both air and water.

One approach to solving these systems is to apply a Newton method which requires a linear Jacobian system solve within each iteration. Although Newton's method can have very fast convergence properties, it can run slowly if the linear system solver is not efficient. Another approach uses a modified Picard solver. Since the Picard method relies on fixed point iteration theory, its convergence is slower than Newton's method, but each iteration requires a simpler linear system to solve.

In this presentation, we will discuss the Richards' equation model, overviewing its properties and common discretization. We then discuss the application of Newton-Krylov and accelerated modified Picard methods for solution of the nonlinear discretized systems. Some comments will be made on the KINSOL nonlinear solver package developed at LLNL and it use for solving such systems. Lastly, we remark on uses of the variably saturated subsurface flow model in coupled subsurface-land surface flow simulations.

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