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# Massive parallel simulation of large scale subsurface flow

Olaf Ippisch, Markus Blatt, and Peter Bastian

University of Heidelberg, Interdisciplinary Center for Scientific Computing, Parallel Computing, Heidelberg, Germany (olaf.ippisch@iwr.uni-heidelberg.de)

Simulation of subsurface flow is crucial for the prediction and control of groundwater production, the assessment of water contamination and becomes more and more important for flood and climate prediction.

We implemented the highly scalable simulation program $\mu\varphi$ (muPhi) for the solution of Richards' equation. The code is capable to describe saturated and unsaturated subsurface flow. A cell-centred Finite-Volume scheme is used for the spatial discretisation, an implicit Euler scheme for the time discretisation and an incomplete Newton-scheme for the linearisation of the non-linear equations. The linear equation system is solved with the iterative solver template library (ISTL) developed by our group in the framework of the DUNE-Project. A CG or BiCGstab solver with an algebraic multigrid preconditioner allows the efficient and scalable solution of huge systems on massively parallel computers.

We tested the simulation code with realistic three-dimensional saturated and unsaturated subsurface flow problems on Europe's fasted supercomputer JUGENE and also with a 48-core off-the-shelf server. The results demonstrate excellent scalability up to JUGENE's 294'912 cores. A groundwater flow problem with an anisotropic autocorrelated random permeability field with a range of 9 orders of magnitude and 150 billion unknowns can be solved in less than 15 minutes. This allows the solution of large scale subsurface flow problems with high spatial resolution.