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Hyperbolic Systems for Strongly Coupled Multi-Phase Flow and Transport in the Sub-Surface

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Multiphase flow and transport in porous media typically is simulated by solving an elliptic or parabolic flow equation together with hyperbolic transport equations. In case of tight coupling, either a fully implicit solution algorithm is required, or very small time steps have to be employed, if a sequential algorithm is used. Here, a new solution approach is presented, which relies on a coupled hyperbolic system of conservation laws. Latter can efficiently be solved with an explicit finite volume method, which is advantageous in many ways, since all operations are local. The hyperbolic system is based on the isothermal Euler equations with momentum source terms accounting for resistance due to the porous medium as well as for buoyancy. Further, to account for saturation transport, the system was augmented by an additional hyperbolic equation. If the parameters are chosen such that the Mach number is much less than one and inertia remains small compared to the momentum source term, the obtained results converge to the same solutions as obtained with a classical reservoir simulator. To compute the numerical fluxes, a characteristic based approximative Riemann solver was developed and 2nd order accuracy in space and time is achieved by piecewise linear reconstruction. As demonstrated with numerical experiments, the devised method is very promising and well suited for massive parallel computations.

Participation

In-Person

References

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