Numerical Modeling of Subsurface CO2-Storage

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Abstract

Storage of CO2 in the sub-surface is seen as a technology that could contribute to the generally accepted goal of a de-carbonized society. As real field experiments are hardly feasible, many current studies utilize the capabilities of numerical modelling.

Concerning the practical application of CO2 storage many questions are still unanswered. In the most favored scenario CO2 in supercritical state is pressed into a deep geological formation. Within the permeable layer CO2 will come to overlie brine and will start to dissolve into the deeper part by diffusion, which is influenced by convection.

Convection is a multi-physics phenomenon, in which flow and transport processes are coupled. For the coupling the fluid density is the crucial parameter. For the highly dynamic processes of CO2 storage, with high Rayleigh number, the initial phase with pure diffusion is followed by a convection phase. The latter can be sub-divided in an early stage with strong and increasing mass transfer; and a late stage, in which mass transfer is decreasing.

Using COMSOL Multiphysics® software we show that there are several pathways within the outlined time-line. We explore different disturbances in initial and boundary conditions, inhomogeneity and mesh dependencies. It is revealed that the onset convection is influenced severely by the numerical method (Figures 1, 2). However, once the convection stage is reached all solutions fluctuate irregularly around the same pathway. This is studied and demonstrated with respect to the temporal change of the overall mass transfer of CO2, represented by the Sherwood number. Figure 3 depicts mass transfer, simulated for permanent random disturbances, for 10 different realizations for each of three different mesh refinements.

Figures used in the abstract

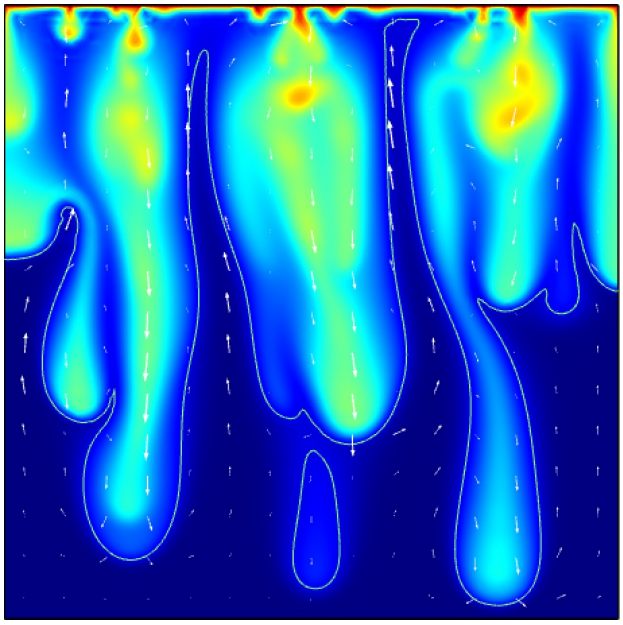

Figure 1: Oscillatory initial conditions, coarse mesh, t=0.0023.

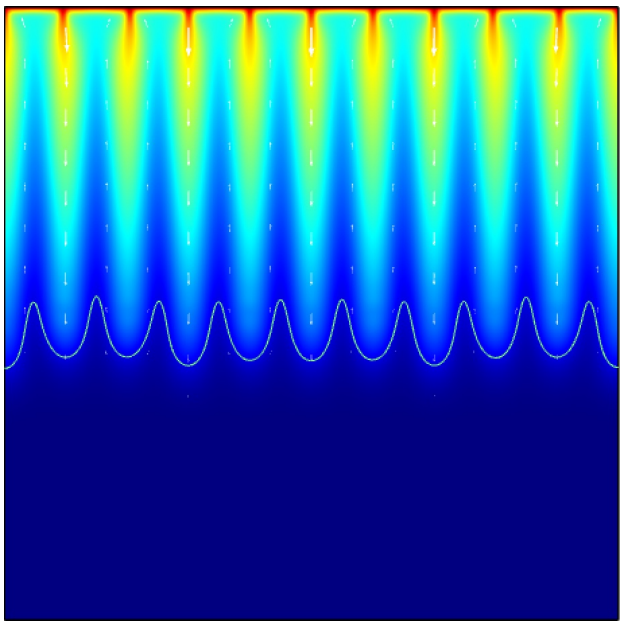

Figure 2: Oscillatory initial conditions, fine mesh, t=0.0023.

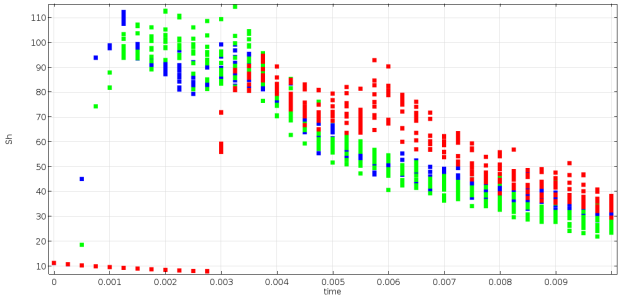

Figure 3: Mass transfer development, modelled with coarse (blue), medium (green) and fine (red) meshes.