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Modeling of far-field pressure plumes and brine migration for CO_2 geological storage

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Carbon sequestration in deep saline aquifers involves injection of large volumes of CO_2 which causes pressure increase in the reservoir formations. Recent work shows that the region of pressure increase can reach distances from the injection well that are far beyond the CO_2 plume itself. The adverse far-field impacts (e.g., for near-surface fresh-water aquifers) of the pressure build-up and brine migration can become a limiting factor for CO_2 storage capacity. It is therefore needed to carefully examine the evolution and impact of the pressure plume and far-field brine migration caused by commercial scale CO_2 injection under different conditions. Given the large size of the domains of interest, this poses a challenging modeling and parameter estimation problem, including issues of parameter upscaling. This study investigates the effect of several factors on the size of the propagating pressure plume and the magnitude of the pressure build-up. These factors include: (i) formation geometry and boundary conditions; (ii) depth-dependent formation material properties; and (iii) brine leakage through fractures zones and/or faults in the overlying units. For the reservoir formation we consider both generic and site-specific large-scale models, the latter based on data from formations in the Baltic Sea region. Numerical simulations for these large-scale models are conducted using both the full multiphase flow modeling approach and more simplified single-phase approaches. The simulation results are also discussed in terms of comparison to simple analytical and semi-analytical solutions.