Simplified geological assumptions allow the use of established analytical solution of the flow governing equations. Neuman and Witherspoon [11] presented solutions that are useful for determining the hydrolic properties of leaky confined aquifer systems. They assumed that the aquifer is homogeneous, isotropic, and of uniform thickness. Moreover, they assumed the extents of the aquifer to be infinite. Chabora and Benson [6] used the analytical solution provided in [11] to study the leakage of the stored CO_2 through the cap-rock by measuring the pressure build-up in the aquifer. They performed sensitivity analysis on the pressure variation by changing the formation parameters and injection criteria. Chabora and Benson found a correlation between the pressure build-up values in the medium and the specifications of aquifer and injection operations. This correlation gives insight in the design and monitoring phases of the storage operations. Such pressure monitoring approaches are based on geological simplifications.

Injection causes pressure evolution in the domain that starts by transient pressure build-up near the injector. As the injection proceeds, the injected CO_2 invades larger region in the domain. The two phase region grows in size and the injected CO_2 moves in both vertical and horizontal directions within the aquifer. In the vertical direction, the CO_2 moves upward due to the buoyancy forces and in the horizontal direction, the influx from the injector pushes the CO_2 through the two phase zone. When the pressure pulse imposed by the injector reaches the boundaries of the domain, the average pressure in the aquifer increases in a quasi-steady state trend. Pressure build-up development in the medium, in particular the transient pressure changes, can be influenced dramatically by geological heterogeneities. This study aims to evaluate the importance of sophisticated geological modeling in simulating the pressure variation in the domain.

We perform detailed pressure analysis by simulating the flow within the SAIGUP geological setup. Our study demonstrates the value of realistic geological modeling in designing CO_2 storage operations and monitoring the pressure development in the aquifer.

Spatial pressure distribution in the aquifer depends on the domain extents. The available volume for CO_2 storage in closed or semi-closed systems with limited domain extents is mostly provided by medium compressibility in response to formation pressure build-up. Moreover, the cap-rock and structural traps that are supposed to be sealing allow the CO_2 to leak with a rate that depends to the pressure build-up in the aquifer.

Birkholzer et al. [3] investigated the influence of domain size on pressure rise in the medium due to CO_2 injection. They assumed homogeneous aquifer to study the pressure development in various model sizes, ranging from 10 to 100 km. They simulated CO_2 injection over 30 years in 250 m of formation with a rate of 120 kg/s. They performed sensitivity analysis with focus on the plume migration and the evolution of pressure build-up in the aquifer. In addition to the model extent, various hydrological properties are examined in [3] to study the impact on CO_2 storage capacity.

The results in [3] suggest that the storage capacity in closed and semi-closed aquifers is controlled by the operational pressure constraints and it is much smaller than the capacity of large aquifers.

The simulation results in [3] show that the region of evaluated pressure is much larger than the CO_2 plume size. In the model with 20 km domain extent, a substantial pressure increase from hydrostatic is observed with 45 bar rise at the model boundaries. They used closed boundary condition in the model that causes a global pressurizing in the medium. A