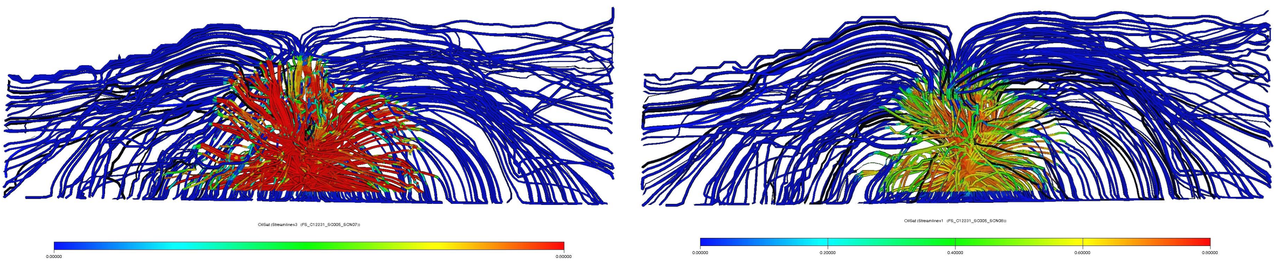

Figure 2: CO_2 saturation plotted on streamlines for linear relative permeabilities (left) and quadratic permeabilities (right).

viscosity 0.4 cP. The rock compressibility is set to $3 \cdot 10^{-7}$. For both fluids, we will use Corey-type relative permeability functions

$$k_{rCO_2} = (1 - S)^{\alpha}, \quad k_{rw} = S^{\alpha}, \qquad \alpha = 1, 2$$

where S denotes the saturation of brine normalized for end points 0.2 and 0.8.

3 Basic Flow Responses

In this section we will give a qualitative discussion of how some basic flow responses like the wave speeds of the plume migration, average aquifer pressure, mobile and residually trapped volumes, and plume sizes are affected by variations in the geological parameters.

3.1 Effect of relative permeability curvature

How the geological heterogeneity impacts the plume migration will depend upon the fluid model. We therefore start by discussing the choice of relative permeability functions. Previous studies have mainly looked at hysteresis and effects from saturation endpoints, see e.g., [7]. However, the curvature of relative permeability function will also play a significant role and in the following we will therefore consider both linear and quadratic relative permeability curves. In oil recovery processes, the efficiency of flooding increases by the higher viscosity of displacing fluid. For example in water-flooding, increasing the water viscosity using additives is a way to increase the process efficiency. For CO_2 storage, on the other hand, we are interested in mixing brine and CO_2 to increase the rate of dissolution; a lower viscosity of CO_2 compared to brine helps this aim.

With linear relative permeability and a CO_2 viscosity of tenth of the brine viscosity, there will be no sharp displacement front in the system and CO_2 invades the brine zone in a spectrum of rarefaction waves from zero to the maximum possible saturation (0.8 in our case). On the other hand, with quadratic relative permeability functions, there will be a sharp displacement front with a saturation around 0.4 followed by rarefactions.

To illustrate the different behavior of linear and quadratic relative permeabilities, we have picked one of the SAIGUP models which includes one shoreline lobe, medium level of barriers, high aggradation angle, up-dip progradation, and open faults. Figure 2 shows the CO_2 distribution resulting from the two different relative permeability functions. Although the streamline paths appear to be almost identical, there are significant differences in the extent of the plume and the saturation profile inside. With linear relative permeability and a CO_2 viscosity of tenth of the brine viscosity, there will be no sharp displacement front in the system and CO_2 invades the brine zone as a rarefaction fan from zero to the maximum possible saturation. In the left plot of Figure 2, this is observed as a spectrum of saturations ranging from zero to 0.8 and then a bank of constant saturation down to the injector (the red color region around the well). With quadratic relative permeabilities, on the other hand, there will be a sharp displacement front followed by a rarefaction fan. The front (with a saturation around 0.4) is recognizable followed by rarefactions down to the injector in the right plot of Figure 2.

In the simulation we observe that a significantly larger volume of injected CO_2 escapes through the down boundary in the quadratic case. The reason is that the mobility will be higher in the linear case and the wave speed at the tip of the rarefaction fan is significantly faster than the wave speed of the