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Groundwater life expectancy simulations in strongly coupled density-dependent flow above a salt dome

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In the overburden of salt domes, salt is dissolved by groundwater, resulting in groundwater flow under highly variable water densities. Density-dependent flow is therefore important in assessing potential migration pathways for radionuclides accidentally released from high-level nuclear waste repositories located in salt domes. Groundwater life expectancy has been established as a safety indicator for radionuclide travel times and is therefore of particular interest.

The objective of this study is to numerically investigate and understand the effects of uncertain transport parameters on density-dependent flow above a salt dome. The effects of density-dependent flow and salt transport, along with the transport parameters on the groundwater life expectancy are investigated numerically using the FEM code Saltflow. Groundwater life expectancy can be directly simulated using an advection-dispersion equation. The life expectancy depends on the transport parameters in two ways, first via the flow velocities calculated in the density-dependent flow simulation which depend on the dispersion terms, and second directly for the calculation of the life expectancy. This suggests a strong and also highly non-linear dependence of life expectancy on the transport parameters.

Preliminary results support this interpretation. Longitudinal macrodispersivity shows a considerable influence on groundwater life expectancy. Strongly non-linear results are also obtained depending on the transverse vertical dispersivity. Increasing the transverse dispersivity up to a certain threshold leads to an increase of the maximum life expectancy in the model domain. Above this threshold, which depends on the longitudinal dispersivity, the maximum life expectancy decreases. Life expectancy also strongly increases with a decreasing diffusion coefficient. These results highlight the importance of considering uncertainty in the transport parameters when numerically evaluating groundwater life expectancy in density-dependent flow in the context of nuclear waste disposal.