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Please fill in your manuscript title.	Improving Capacity and Containment Modelling for CO_2 Storage Sites Utilizing Invasion Percolation

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Abstract

For successful deployment of subsurface storage of CO_2, it is critically important to understand and model how the CO_2 will behave and migrate in the subsurface post injection over decadal timescales and beyond. Such models drive confidence within organizations and with regulators that the injected CO_2 will remain securely stored within the storage formations. The objective of this paper is to show methods to improve this modelling throughout the life of the storage site.

This study utilizes modified invasion percolation to model the plume distribution, where it is assumed that viscous driving forces are negligible, and the flow of fluids is controlled by buoyancy (driving) and capillary (resistive) forces. This has been shown to be a reasonable assumption across the bulk of the injection formation in areas further away from the injection well. Using the invasion percolation approach means we can run simulations on much higher resolution earth models that capture the details of the geology and provide better understanding of plume distribution over longer time and length scales.

The Equinor operated Sleipner CO_2 storage site in the Norwegian North Sea provides an excellent benchmark to test modelling approaches to CO_2 migration. The 4D seismic monitoring affords researchers the ability to history match against the seismically calculated CO_2 plume distribution. Initial work by Lippard et al. 2008, investigated Darcy and Percolation models based on the 2006 data. Observations in the seismic show a layered plume where thin fractured shale intervals create capillary seals the injected CO_2 until capillary entry threshold pressures are breached and gravity/buoyancy segregates the plume.

The modelling approaches produce remarkable deviations on decadal modelling timescales. The Darcy flow model predicts continued vertical migration of the free CO_2 plume, whereas the invasion percolation method predicts local preservation of CO_2 beneath the intra-reservoir baffles beneath structural closures.

Invasion percolation methods provide an important solution to modelling challenges for CO_2 storage. Specifically, the method provides a unique simulation to understand migration at longer time scales and model migration around the innate heterogeneities of a storage reservoir, providing improved confidence around storage efficiency and seal/baffle integrity for better estimation of capacity and containment of potential and operational storage sites.

Existing approaches to modelling plume migration focus on Darcy-based simulations that cannot capture the details of the geology pertinent to modelling migration over longer time and length scales across the entirety of the storage formation. Through utilizing modified invasion percolation approaches, geoscientists can run multiple scenarios on high resolution models rapidly to understand plume distribution pre- and post-injection and add to the insights generated through traditional reservoir modelling approaches to CO_2 storage.