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Macro-scale constitutive relationships for CO_2 migration in heterogeneous geological formations

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Numerical models have been developed and applied to migration of geological stored carbon dioxide for site performance and risk assessment studies at the reservoir scale. However, due to the restriction in computational time and resources, reservoir scale models have limitations in accounting for the multi-scale heterogeneities. In order to address the heterogeneity issues, appropriate upscaling methods are needed. In this study, we present macro-scale capillary pressure – relative permeability – saturation relationships for grid-block properties used in the full-scale modeling. We develop a macroscopic percolation model for the upscaling procedures. The macro-scale constitutive relationships are obtained through simulation procedures of CO_2 displacing brine in a porous domain with spatially correlated random permeability fields. Sensitivity of the derived constitutive relationships to the statistical parameters representing the local heterogeneity is shown. Comparison of the percolation-based method to other approaches is demonstrated.