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HIGHLY EFFICIENT TOOL FOR PROBABILISTIC RISK ASSESSMENT of CCS JOINT WITH INJECTION DESIGN

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Summary. The potential of large-scale industrial CO_2 injection as an interim solution will vastly depend on our ability to quantify its uncertainties and risks. Current numerical simulation models are inadequate for stochastic simulation techniques, because they are too expensive for repeated simulation. Even single deterministic simulations require parallel high performance computing. Because the involved multiphase flow processes of CO_2 in porous media have a significantly nonlinear character, the problem is too non-linear for quasi-linear and other simplified stochastic tools. As an alternative approach, we propose a massive stochastic model reduction which is based on the probabilistic collocation method. The model response surface is projected onto a higher-order orthogonal basis of polynomials, allowing for non-linear propagation of model uncertainties onto the predicted leakage risk. The variable parameters include uncertain model parameters, such as porosity, permeability, etc. and a list of design parameters (injection rate, depth, etc.). The chosen degree of the polynomial balances between computational effort and accuracy. The proposed stochastic approach was validated through Monte Carlo simulation using a common 3D Benchmark [1]. The reasonable compromise between computational efforts and precision was reached with 2^{nd} order polynomials. In this case study, our proposed approach yields a computational speed-up of 100: 1000 Benchmark runs for Monte Carlo evaluation are comparable to 10 Benchmark runs using the probabilistic collocation method. At the same time, our collocation methodology is an integrative powerful tool for optimizing design variables and uncertain variables into one approach (via integrative response surfaces). Thus the design tasks explicitly includes uncertainty, leading to robust designs with minimum failure probability over the entire range of uncertainty.

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