Geophysical Research Abstracts
Vol. 16, EGU2014-1590, 2014
EGU General Assembly 2014

Simplified Predictive Models for CO_2 Sequestration Performance Assessment

Srikanta Mishra (1), Priya RaviGanesh (1), Jared Schuetter (1), Douglas Mooney (1), Jincong He (2), and Louis Durlofsky (2)

(1) Battelle Memorial Institute, Columbus, OH, United States (mishras@battelle.org), (2) Stanford University, Stanford, CA, United States

We present results from an ongoing research project that seeks to develop and validate a portfolio of simplified modeling approaches that will enable rapid feasibility and risk assessment for CO_2 sequestration in deep saline formation. The overall research goal is to provide tools for predicting: (a) injection well and formation pressure buildup, and (b) lateral and vertical CO_2 plume migration. Simplified modeling approaches that are being developed in this research fall under three categories: (1) Simplified physics-based modeling (SPM), where only the most relevant physical processes are modeled, (2) Statistical-learning based modeling (SLM), where the simulator is replaced with a "response surface", and (3) Reduced-order method based modeling (RMM), where mathematical approximations reduce the computational burden. The system of interest is a single vertical well injecting supercritical CO_2 into a 2-D layered reservoir-caprock system with variable layer permeabilities.

In the first category (SPM), we use a set of well-designed full-physics compositional simulations to understand key processes and parameters affecting pressure propagation and buoyant plume migration. Based on these simulations, we have developed correlations for dimensionless injectivity as a function of the slope of fractional-flow curve, variance of layer permeability values, and the nature of vertical permeability arrangement. The same variables, along with a modified gravity number, can be used to develop a correlation for the total storage efficiency within the CO_2 plume footprint.

In the second category (SLM), we develop statistical "proxy models" using the simulation domain described previously with two different approaches: (a) classical Box-Behnken experimental design with a quadratic response surface fit, and (b) maximin Latin Hypercube sampling (LHS) based design with a Kriging metamodel fit using a quadratic trend and Gaussian correlation structure. For roughly the same number of simulations, the LHS-based meta-model yields a more robust predictive model, as verified by a k-fold cross-validation approach.

In the third category (RMM), we use a reduced-order modeling procedure that combines proper orthogonal decomposition (POD) for reducing problem dimensionality with trajectory-piecewise linearization (TPWL) for extrapolating system response at new control points from a limited number of trial runs ("snapshots"). We observe significant savings in computational time with very good accuracy from the POD-TPWL reduced order model – which could be important in the context of history matching, uncertainty quantification and optimization problems. The paper will present results from our ongoing investigations, and also discuss future research directions and likely outcomes.

This work was supported by U.S. Department of Energy National Energy Technology Laboratory award DE-FE0009051 and Ohio Department of Development grant D-13-02.