Rapid Prototyping of Subsurface CO2 Sequestration with Flow Diagnostics

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S2202. Rapid Prototyping of Subsurface CO2 Sequestration with Flow Diagnostics

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Traditional reservoir modelling workflows are often too restrictive for substantial modifications to the underlying geological hypotheses, and therefore restrict the breadth of interpretations considered in subsurface evaluation (Bentley and Smith, 2008). Emerging geoengineering challenges associated with the energy transition, such as carbon dioxide sequestration, hydrogen storage, and aquifer thermal energy storage, require extensive study of geological heterogeneity and its impact on storage and flow properties from sparse data (e.g. Alshakri et al., 2023; Jackson et al., 2022).

We propose an alternative and complementary approach, referred to as rapid reservoir modelling (RRM), that aims to address the drawbacks of conventional modelling methods. RRM differentiates itself by using sketch-based interface and modelling (SBIM) technology that constructs 3D surfaces from simple 2D sketches and geologically consistent surface-interaction operators that allow for fast and intuitive subsurface modelling. (Jacquemyn et al., 2021b). Here, we further advance RRM capabilities by connecting on-the-fly flow diagnostics (FD) computations to streamline and enhance the prediction of subsurface flow (Petrovskyy et al., 2023). The application of FD methods is particularly efficient when ranking and comparing model ensembles (Watson et al., 2022). FD brings the prototyping approach of SBIM into the dynamic space of injection/production and well patterns.

Our FD implementation enables the specification of custom open-boundary conditions that are usually closed in previous FD studies, rapid and on-demand grid resampling for higher accuracy of calculations, and an interactive graphical interface to navigate and specify the well placements and perforation directly in 3D. We demonstrate the FD dynamic modelling approach using a model of deep water slope channels (Jacquemyn et al., 2021). Specifically, we study the impact of well placement on the viscous-to-gravity force balance during the active CO2 injection phase, to illustrate how different offtake well placements influence the viscous flow regime. FD calculations acquire fast and informative flow prediction in a matter of seconds. Such calculations facilitate rapid prototyping, screening, and ranking of reservoir models. The FD computation may serve as the guide and first-order approximation to inform expensive full-physical modelling and simulation.