Deconvolution well-test algorithms for monitoring carbon storage reservoir performance

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Abstract

Well-based monitoring using pressure and temperature gauges is a cost-effective way to characterize subsurface reservoirs and track their performance over time. By providing continuous monitoring with time, gauge data complements geophysical approaches—e.g. 3D/4D seismic—that have low repeat frequency but broader spatial coverage. Indeed, effective use of pressure monitoring could allow for longer periods between repeat geophysical surveys, substantially lowering project costs. Recent innovations in distributed sensing using fiber are also opening up new possibilities when using pressure and temperature data to characterize reservoir performance.

In this paper, we discuss recent progress in the development of welltest methods based on deconvolution principles. The advantage of deconvolution methods is that they can be applied to real-time injection data without the need for dedicated shut-in periods. Further, they may be readily applied to datasets spanning months or years, providing information about reservoir heterogeneity in a zone of influence that may extend many kilometers from the well itself. This contrasts with more traditional well-test methods that typically only probe the near-wellbore region because of a limited shut-in duration. In this paper, we describe the underlying algorithms as well as demonstrate their application using down-hole gauge data from the Snøhvit CO\textsubscript{2} storage project.

The analysis and processing of CO\textsubscript{2} gauge data is non-trivial, however, due to complex equation-of-state behavior and the important role of temperature uncertainties. To address these challenges, we are developing a new open-source software package, the Cypress Analysis Toolkit, whose goal is to provide a general-purpose platform for analyzing reservoir time series data using various algorithms (Figure 1). The toolkit is flexibly designed to support research-and-development work, but is also sufficiently easy to use to be of interest to practitioners. We describe capabilities related to bottomhole pressure estimation, well-test analysis, fracture pressure identification, and related workflows.

**Figure 1**: Screenshot of the Cypress Analysis Toolkit, an open-source platform for analysis of CO₂ gauge data using novel algorithms.