Optimal design of pressure-based, leakage detection monitoring networks for geologic carbon sequestration repositories

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Abstract

Monitoring of leakage at geologic carbon sequestration (GCS) sites requires the capability to intercept and resolve the onset, location, and volume of leakage in a timely manner. Pressure-anomaly monitoring represents one of the few monitoring technologies that possess such capabilities. To fully leverage the strength of pressure monitoring while meeting cost constraints, optimization of network design is necessary. This study presents an optimization method for designing cost-effective GCS monitoring networks under model and parameter uncertainty. A binary integer programming problem (BIPP) is formulated to minimize both the total volume of leakage and the number of uncovered potentially leaky locations. The BIPP is demonstrated for selecting optimal monitoring locations in both homogeneous and heterogeneous formations. The sensitivity of monitoring design to a number of model and design parameters is investigated, while model structure and parameter uncertainties are incorporated through user-specified scenarios. Results suggest that the BIPP is a viable approach for identifying optimal sensing locations even when the number of design variables is relatively large (~105). The BIPP is general and can be readily used to facilitate the design of performance-based GCS monitoring networks.