Monitoring Methods Optimization: PIDAS

Project Description

The objective of this three-year project (October 2013 to September 2016) is to develop a pressure-based inversion and data assimilation system (PIDAS) for detecting CO_2 leakage pathways from geologic carbon sequestration (GCS) formations. The capability to accurately identify pathways by which stored CO_2 could leak, has leaked, or is leaking from the targeted storage formation(s) is of critical importance to GCS site operators and regulators.

Although many monitoring, verification, and accounting (MVA) techniques have been devised, pressure-based monitoring technology remains the most sensitive and reliable technique for early leakage detection. It has consistently received the highest rank in terms of benefit-cost ratio and provides the greatest potential for leak detection over medium to large footprints. To achieve the optimal use of pressure-based technology in monitoring operations, further theoretical, experimental, and field validation is needed.

Objectives

The major research objectives of PIDAS are to

- Demonstrate the utility of the proposed well testing technique for leakage detection through integrated theoretical and numerical analysis, laboratory experiments, and field tests.
- Develop effective data assimilation and inversion algorithms for identifying leakage pathways by using data generated during well testing.
- Design optimal well testing strategies and publish a best-practice manual for maximizing the utility of the developed PIDAS tool for early leakage detection.

Methods

The PIDAS project focuses on developing and demonstrating a harmonic well testing technique for leakage detection. A harmonic well test is a well testing technique in which periodic flow rates are applied to an active well (i.e., pulser) continuously until a periodic steady-state condition is established. At this point in time the pressure response is recorded at a monitoring well (i.e., responder).

Body of stainless steel tank (1-m diameter and 0.5-m height) for performing laboratory harmonic well testing

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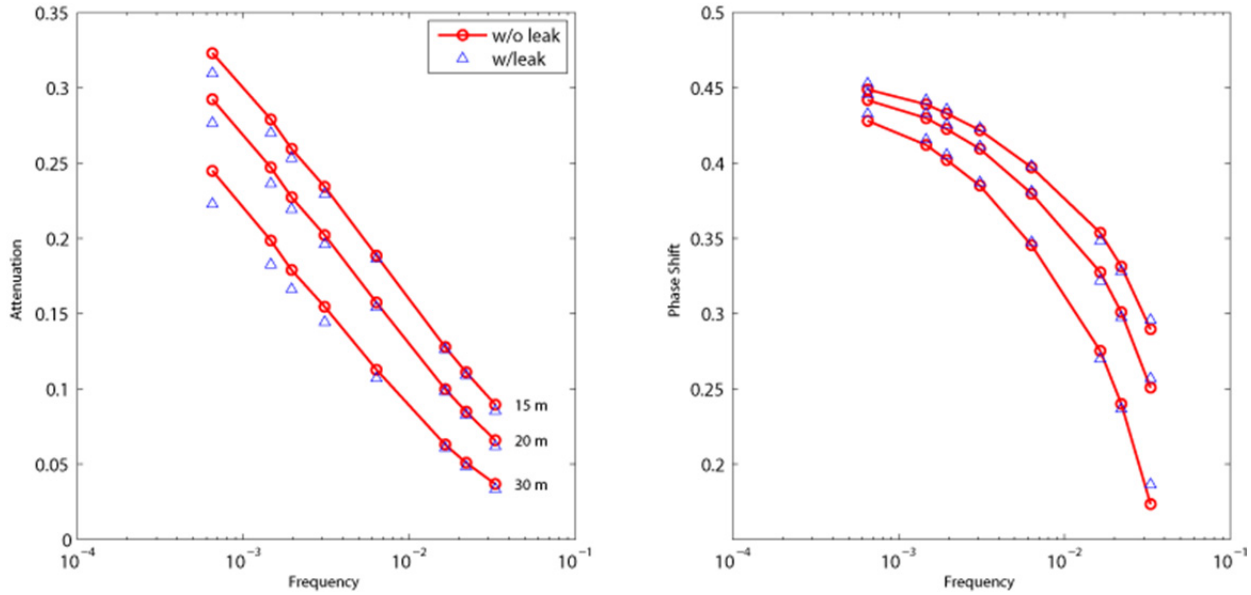
Accomplishments

PIDAS is a multipronged research effort that includes numerical modeling, laboratory testing, and field demonstration. Major accomplishments to date include

- Performed numerical simulation of harmonic well testing in single-phase and multiphase settings and for different leakage scenarios.
- Designed and manufactured a stainless steel tank (see photo) for performing laboratory validation of the harmonic well test.



Magnitude and phase shift of observed pressure signals are shown as a function of leak locations (measured from the injector) and pulse durations (*x*-axis). The pressure signals are converted to the frequency domain. The leak appears as apparent deviations rom the baseline. The leak scenario was simulated by allowing the leaking well to flow when pressure exceeded a certain threshold (e.g., above-zone pressure).

Selected Citations

Sun, A. Y., and Nicot, J.-P., 2012, Inversion of pressure anomaly data for detecting leakage at geologic carbon sequestration sites: Advances in Water Resources, v. 44, p. 20–29.

Sun, A. Y., Nicot, J.-P., and Zhang, Xiaodong, 2013, Optimal design of pressure-based, leakage detection monitoring networks for geologic carbon sequestration repositories: International Journal of Greenhouse Gas Control, v. 19, p. 251–261.

Sun, A. Y., Zeidouni, M., Nicot, J.-P., Lu, Zhiming, and Zhang, D., 2013, Assessing leakage detectability at geologic CO2 sequestration sites using the probabilistic collocation method: Advances in Water Resources, v. 56, p. 49–60.

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