the ENERGY lab

PROJECT FACTS

Carbon Sequestration

Inexpensive Modeling and Uncertainty Assessment of CO_2 Plume Migration

Background

The U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) is currently funding research aimed to advance state-of-the-art technologies that address geologic storage of carbon dioxide (CO_2) in multiple formation types and across all phases of CO_2 geologic storage operations.

Geologic storage involves the injection of CO_2 into underground formations that have the ability to securely contain it over long periods of time. Research efforts are currently focused on several geologic storage formation types: several clastic and carbonate types, coal, organic rich shale, and basalt formations. These formations contain different fluids such as saline water and oil and natural gas. A principal element of DOE's Carbon Sequestration Program is Core Research and Development (R&D), and one of the R&D focus areas—geologic storage—is aimed at addressing the challenges of CO_2 storage in these formations.

Critical challenges identified in the geologic storage focus area include CO_2 well bore integrity, geochemical and mechanical responses, fluid flow and containment, and development of mitigation technologies. This study is exploring ways to predict the location of the CO_2 as it is being injected into a formation.

Project Description

The University of Texas at Austin (UT Austin) is developing a prototype modular computational approach for monitoring the location of the CO_2 plume as it moves through the subsurface during the injection process—the period when the CO_2 is pumped through an injection well into the targeted rock formation. The approach utilizes project injection rate and pressure data as a basis for the modeling input. This enables modeling and monitoring capabilities at negligible incremental cost because injection rate and pressure data will be recorded for operational reasons in every sequestration project. Quantifying uncertainty is valuable for monitoring, verification, and accounting activities, but is often difficult to achieve with traditional approaches that include parameter

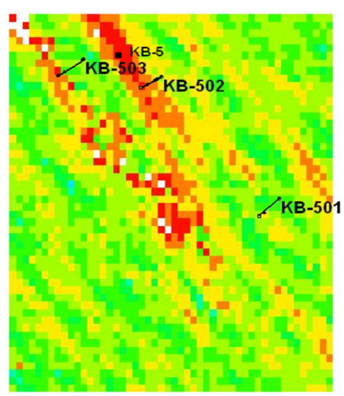

Figure 1 – Composite sampling models shown in final cluster showing large

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PARTNERS

None

PROJECT DURATION

Start Date
10/1/2010

End Date
9/30/2013

COST

Total Project Value
$1,265,621

DOE/Non-DOE Share
$1,011,664 / $253,957

U.S. DEPARTMENT OF ENERGY

estimation or from direct observation. A goal of the modular computational approach is to take advantage of the inherent geologic basis of the approach, so that other types of data, such as surface deflection or seismic imaging, can be easily included with the rate/pressure data to reduce the uncertainty of the inferred plume location.

The injection data are used to model spatial distributions of subsurface features for a range of hypothetical storage formations (formation rock types and conditions) to delineate the impact of large-scale heterogeneities (baffles, sealing faults, and zones of high permeability) on injection characteristics (rates and pressures). A random walker algorithm is being developed as a fast transfer function that simulates the physics of CO_2 injection and migration with sufficient fidelity for the purposes of model discrimination, reducing overall run time. A method to quantitatively measure similarity between model responses is also being developed. These components are then integrated into a software module that takes injection data and a suite of plausible geologic models as inputs and produces a probabilistic assessment of the plume location. The deviation from the expected plume location and the degree of confidence in the deviation will then be quantified.

The resulting software will be tested on synthetic data sets and validated with field data obtained from external CO_2 injection projects such as the In Salah Injection Project in Algeria and the various injection projects being performed by the seven DOE-funded Regional Carbon Sequestration Partnerships.

Goals/Objectives

The overall goal of this project is to develop a prototype of a new computational approach for predicting the location of CO_2 plumes during injection that is based on pressure and injection rate data. Key research objectives include (1) implementing a novel Bayesian probabilistic approach for geological model selection using injection data and other information, (2) developing modular software that can be readily integrated with existing injection flow simulators, (3) demonstrating and verifying that approach on field datasets, and (4) quantifying the uncertainty in the plume location.

Benefits

This effort will increase the fundamental understanding of processes associated with CO_2 injection in geologic formations by demonstrating a quantitative link between inexpensive, routinely measured injection data and large-scale features of CO_2 plume migration. The tool can be easily extended to include other sources of monitoring data such as seismic imaging and surface deflection. The modular implementation of the software will be readily integrated with existing technologies for monitoring and performance prediction. The project will produce a low-cost, easily implemented early warning system for unanticipated deviations in plume migration. This will enable operators and regulators to deploy expensive, higher resolution plume monitoring methods in a more cost-effective and targeted way. Additionally, the method provides a quantitative estimate of the uncertainty in plume location, allowing for more informed decisions about whether to acquire additional data or alter injection strategies.

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