CCUS: 3999159

CCS Predictive maintenance using active focused seismic monitoring

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Abstract

One of the most critical aspects of a CCS MMV (Monitoring, Measurement, and Verification) plan is determining the frequency of monitoring a CCS field with active seismic methods. Deviating from regular time-lapse measurements, this study presents an innovative surveillance approach for CCS

This paper explores how combining the predicted extension of CO_2 plumes (i.e., a dynamic model) and focused monitoring can provide a nimble and efficient response to this question. By analyzing the output of the dynamic model, we can identify where and when to focus seismic monitoring, thereby validating the primary reservoir hypothesis while excluding worst-case scenarios and assessing identified risks. This trigger technology can be implemented frequently and provide critical information to trgiger if models are prove to be wrong, model updates or the acquisition of more expensive data such as walk-away VSPs, 4D seismic images…

The same method can be used for multiple flow scenarios check, and to monitor some identified risks for CCS containment (fault, abandoned wells, fractured areas). When synergized with micro-seismic, it can be used using micro-seismic antennae as receivers, and has the ability to be quickly mobilized to focus a monitoring on an unexpected microseismic ‘active’ area in order to check the presence or absence of CO_2 in this area.

Objectives and Scope:
One of the most critical aspects of a CCS MMV (Monitoring, Measurement, and Verification) plan is determining the frequency of monitoring a CCS field with active seismic methods. This paper explores how combining the predicted extension of CO2 plumes (i.e., a dynamic model) and focused monitoring can provide a nimble and efficient response to this question. By analyzing the output of the dynamic model, we can identify where and when to focus seismic monitoring, thereby validating the primary reservoir hypothesis while excluding worst-case scenarios and assessing identified risks.

Methods, Procedures, Process:
Several key decisions in CCS, including prospect identification, final investment decision, risk assessment, and permit applications, rely on flow models even before the first molecule of CO2 is injected (figure 1). Utilizing the flow model outputs, which encompass stochastic simulations, we can simulate various scenarios of CO2 plume expansion and determine the expected pressure and CO2 saturation for each cell within the model at each modeled time step under various scenarios. Employing a petro-elastic model, we can define a detection threshold to map the "actively detected CO2 plume" using this information. This allows us to identify crucial areas in both space and time where CO2 detection is pivotal for confirming or refuting the main hypotheses and key CCS risks (figure 2). Focusing seismic measurements on these areas, often referred to as "Spots," provides a swift and flexible model validation solution.

Results, Observations:
Focused seismic monitoring using single source/receiver locations has been successfully employed both onshore and offshore for CO2 detection. This paper demonstrates how targeted seismic monitoring can be utilized to frequently assess the flow model and risk hypotheses, potentially triggering more environmentally, socially, and economically costly measures if the model proves inaccurate. This "triggering monitoring" approach is designed to enhance the value of information of conventional imaging-based seismic solutions, such as full 4D seismic or walk-away VSP as you trigger them only when needed.

Figure 1. Subsurface apriorism. For Final Investment decisions, CCS stakeholders relies on the same “digital twins”

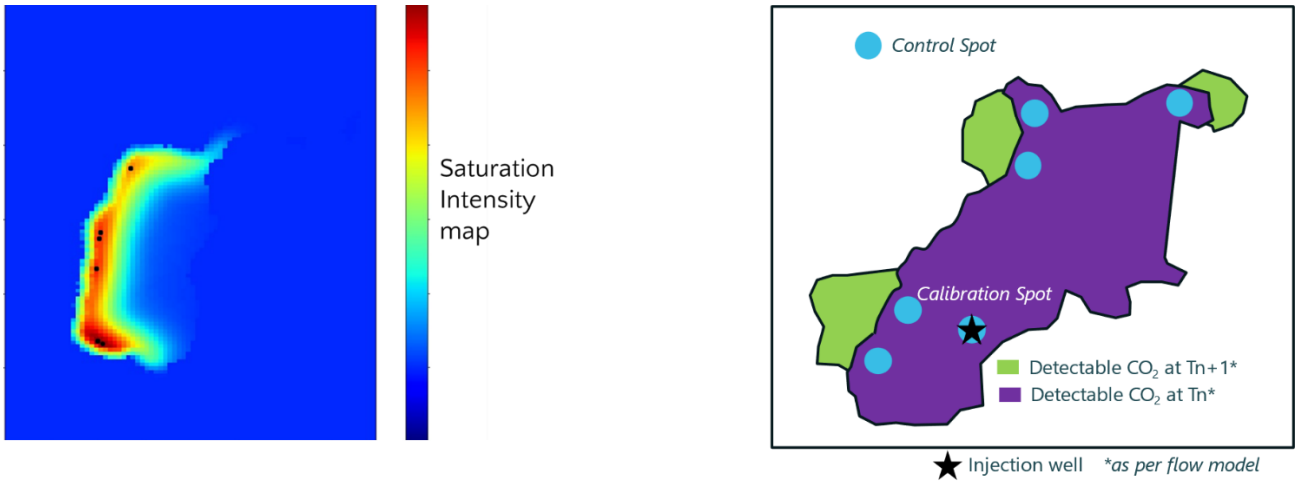

Figure 2. Conformance Spot illustration

Significance/Novelty:
The concept of predictive maintenance offers a tool for regularly verifying and updating complex 3D simulation model through a cost-effective focused seismic monitoring approach. This method can be applied to verify injection locations, track the speed of the plume migration, or detect CO2 appearances in vital areas of the storage complex, including spill points, old exploration wells or secondary storage formations in the overburden.