Long-Term Seismic Monitoring of CO2 Sequestration Projects for 50-100 Years

David Lumley[1]

[1]University of Texas at Dallas

November 22, 2022

Abstract

Large-scale injection of carbon dioxide (CO2) into the earth started in the 1980's for enhanced oil recovery (EOR). Geological sequestration (injection and storage) of industrial CO2 to reduce greenhouse gas emissions began in the 1990's using saline aquifers and depleted hydrocarbon reservoirs. Today the two processes are being co-optimized as Carbon Capture, Use and Storage (CCUS). As a result, the time-lapse seismology community has gathered about 20-30 years of experience monitoring CO2 injection projects of various types and sizes, primarily using controlled active seismic sources and Large-N receiver arrays. To help achieve IPCC projections of 2C global temperature change versus CO2 emissions, society would need to scale up current CO2 injection rates by a factor of 250x from 40 Megatons to 10 Gigatons, per year. CCUS regulations for Monitoring and Verification requirements are in various stages of development around the world, including the EU CCS Directive, US EPA, and international ISO standards. A typical commercial-scale CCUS project injects $>$ 1 Mt CO2/yr for $>$ 20 years. After CO2 injection ceases, the project operator must further monitor the post-injection CO2 plume behavior to establish regulatory compliance for 20-50 years in order to "handover" the project to the regulator. After handover, the regulator is then responsible for monitoring the post-injection plume stability for another 20-30 years (in the US there is no handover, the operator maintains all project and monitoring responsibilities). These CCUS requirements imply that we will need to monitor CO2 projects, both during and after injection, for 50-100 years or more. We simply do not have experience in the time-lapse seismology community with such long-term monitoring periods, in terms of data acquisition, processing, imaging, and minimizing environmental footprint and costs. It would certainly not be practical nor affordable to conduct a full-scale 4D seismic survey every year, for 100 years. These long-term monitoring requirements thus present both challenges and new research opportunities. I will present some experimental results I have obtained over the past decade to help develop long-term, near real-time, continuous monitoring of CO2 injection projects using ambient seismic noise (ASN).

Long-Term Seismic Monitoring of CO2 Sequestration Projects for 50-100 Years

David Lumley, University of Texas at Dallas

Large-scale injection of carbon dioxide (CO2) into the earth started in the 1980's for enhanced oil recovery (EOR). Geological sequestration (injection and storage) of industrial CO2 to reduce greenhouse gas emissions began in the 1990's using saline aquifers and depleted hydrocarbon reservoirs. Today the two processes are being co-optimized as Carbon Capture, Use and Storage (CCUS). As a result, the time-lapse seismology community has gathered about 20-30 years of experience monitoring CO2 injection projects of various types and sizes, primarily using controlled active seismic sources and Large-N receiver arrays.

To help achieve IPCC projections of 2C global temperature change versus CO2 emissions, society would need to scale up current CO2 injection rates by a factor of 250x from 40 Megatons to 10 Gigatons, per year. CCUS regulations for Monitoring and Verification requirements are in various stages of development around the world, including the EU CCS Directive, US EPA, and international ISO standards. A typical commercial-scale CCUS project injects > 1 Mt CO2/yr for > 20 years. After CO2 injection ceases, the project operator must further monitor the post-injection CO2 plume behavior to establish regulatory compliance for 20-50 years in order to "handover" the project to the regulator. After handover, the regulator is then responsible for monitoring the post-injection plume stability for another 20-30 years (in the US there is no handover, the operator maintains all project and monitoring responsibilities).

These CCUS requirements imply that we will need to monitor CO2 projects, both during and after injection, for 50-100 years or more. We simply do not have experience in the time-lapse seismology community with such long-term monitoring periods, in terms of data acquisition, processing, imaging, and minimizing environmental footprint and costs. It would certainly not be practical nor affordable to conduct a full-scale 4D seismic survey every year, for 100 years. These long-term monitoring requirements thus present both challenges and new research opportunities. I will present some experimental results I have obtained over the past decade to help develop long-term, near real-time, continuous monitoring of CO2 injection projects using ambient seismic noise (ASN).