Using DAS-to-Geophone Conversion Data for Monitoring CO_2 Sequestration

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Abstract

Carbon capture and storage (CCS) or CO_2 sequestration is part of the solution to meet climate targets through the process of capturing CO_2 and then storing it underground in viable geological formations. Subsurface monitoring of CO_2 storage is essential for a CCS project, with the objective of assuring storage safety. Seismic imaging plays a crucial role in monitoring during and after the CO_2 injection by observing the subsurface CO_2 plume size and its migration.

Recent advances in distributed acoustic sensing (DAS) offer an cost-effective way for seismic acquisition that can potentially overcome the limitations associated with geophones, especially in the downhole setting. For example, DAS can be used to acquire vertical seismic profile (VSP) in a large spatial coverage while providing high temporal and spatial sampling resolutions.

However, different measuring mechanisms lead to differences (e.g., phase and noise level) between DAS and geophone signals. As a result, directly applying seismic imaging techniques, e.g., reverse time migration (RTM), which are traditionally developed based on common geophone data, to image DAS data could generate misleading results.

In this study, we use a field VSP data from the Containment and Monitoring Institute to evaluate the potential of using DAS imaging in particular, for monitoring subsurface CO_2 sequestration. Results demonstrate that DAS can provide comparable structural images of the subsurface as conventional geophones do while providing extended spatial coverage with a finer sampling interval. Meanwhile, uncertainties related to the phase and structural depth exist in imaged results of original DAS data as opposed to the image of geophone data. To mitigate the uncertainties in DAS imaging results, we proposed two conversion methods (both physics based and machine learning based) to transform DAS data to geophone data. Then, those well-established techniques like RTM can be leveraged on DAS-to-geophone conversion data. In this way, DAS imaging not only can accurately and robustly capture the wavefield characteristic but also can enhance spatial resolution and coverage for monitoring CO_2 sequestration.