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Low-Cost CCS Monitoring with Sparse Data Acquisition

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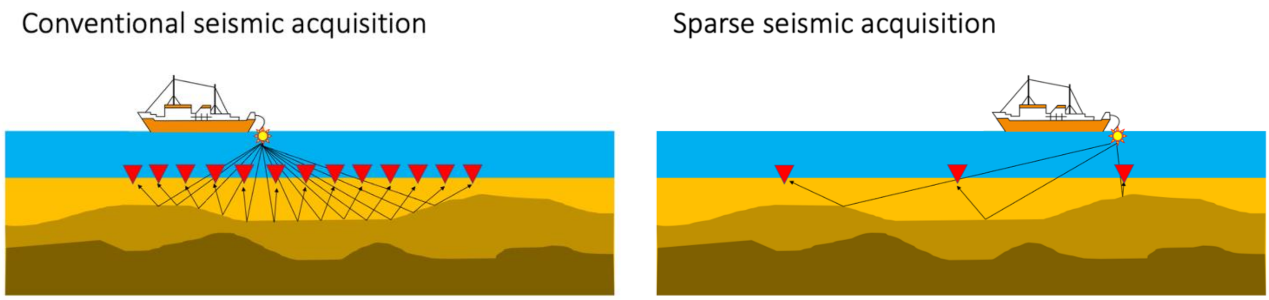
One of the key requirements for Carbon Capture and Storage projects is to verify and monitor during and post the injection phase. Although there are many geophysical techniques to characterise and monitor the subsurface, none are as capable in generating reliable and high-resolution subsurface information as seismic surveying. Time-lapse seismic imaging has been widely used for both exploration purposes and CCS monitoring purposes. The acquired data are processed to understand how the injected CO_2 distributes in the reservoir and if the CO_2 moves over time. Conventional wisdom is that high resolution seismic images require dense data acquisition. However, survey costs are the main driver for high costs and techniques allowing monitoring using sparse data, and hence cheaper surveys, are a promising solution. In the case of CCS monitoring, in which there may be little to no revenue generation, developing low-cost acquisition and seismic monitoring capability is critical.



Here we present preliminary results of a time-lapse imaging technique, pre-stack Image Domain Wavefield Tomography (IDWT). IDWT exploits the effect of kinematic changes in the subsurface. The presence of CO_2 In the reservoir, and the effect of reservoir pressure on the overburden stress-state, lead to changes in the seismic wave velocity in the reservoir and the overburden. These velocity changes would result in an apparent depth (or time) shift when migrating the data. In IDWT the objective function tries to minimize the shift between baseline and monitor migrations by optimising the monitor velocity model. Unlike post-stack IDWT, pre-stack IDWT method measures depth-shifts in pre-stack migrated gathers. This is beneficial in the case of sparse surveys in which either source or receiver gathers (a choice) can still appear dense allowing reliable measurement of time-shifts between monitor and baseline.

This study is particularly focussed on evaluating the monitoring efficacy and cost-savings in the context of a Danish hydrocarbon field that is a prospective future repository of CO_2. We selected Tyra Field, a gas condensate field in the Danish sector of the North Sea. The chalk reservoir lies at approximately 2000 meter depth, the geological structures and overburden are typical of the Danish North Sea. We use field data and seismic images to build a representative model and simulate CCS and subsequent leakages scenario. This way we retain full control and verification capability over our experiments.

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