The impact of pre-project data quality and quantity on developing environmental monitoring strategies for offshore carbon storage: case studies from the Gulf of Mexico and North Sea

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Abstract

Environmental monitoring of offshore geological carbon storage sites presents several techno-economic and legal challenges to be considered when designing monitoring strategies. The optimal plan should simultaneously address operational, regulatory, and societal expectations. Despite the many recent advances in marine monitoring technology, stakeholders outside of academia struggle to assimilate the wealth of data and knowledge available in data warehouses, in the literature and to implement available algorithms and programs to utilize them. Recently the ACTOM project has worked to develop a semi-automated toolbox into a streamlined and easily accessible software for designing optimal monitoring strategies for offshore storage. The ACTOM toolbox equips operators with the ability to plan strategies under site-specific conditions and provides regulators a reliable and independent assessment of proposed monitoring strategies from license applicants. In addition to the tool assisting in the technical design of monitoring programs, it can be used as a tool in communicating with governments and the public in view of Marine Spatial Planning and Responsible Research and Innovation. The scenarios studied show how policies, legal constraints, and potential conflict with other offshore activities might influence a monitoring program, including the risk of making the monitoring program too costly.

The ACTOM toolbox is designed to provide value over a range of field cases with diverse subsurface geology and environmental marine characteristics. Whereas the end product of the toolbox is to aid users in defining a monitoring plan that will satisfy local stakeholders, one intermediate outcome from our study is to understand how data quality and availability as well as site variability will affect the development of the monitoring plan. For this assessment we collect and use available data from three representative sites as input to the toolbox: the Gulf of Mexico and northern and southern North Sea to visualize how the output from the semi-automated planning toolbox works in practice. Although these sites all lie along continental margins in mature petroleum provinces, their respective environments

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and associated data availability are unique. As such, a comparison of the toolbox application is a useful exercise for not only the software developers but also for future end users.

Figure 1: The environmental data needed as input to the ACTOM toolbox.

The toolbox requires multiple sources of site-specific data for input as shown in Figure 1. These include 1) subsurface geophysical/geological data, 2) hydrodynamic data, and 3) marine biogeochemical data. In many cases, pre-existing data are sparse or even missing. Therefore, as a sensitivity analysis, this study explores the impact of data availability on the resulting monitoring plan.

The first challenge of applying the toolbox is to map the areas of variable risk for CO$_2$ reaching the sediment surface. Ideally, quantification of risk should involve interpretation and analysis of CO$_2$ injection and migration in the storage reservoir, which in turn depends on having access to data and models of each CO$_2$ storage reservoir and the resources to carry out a detailed risk assessment. In practice, this step can be resource intensive, and the value of a detailed approach should be evaluated. Indicators of potential leakage pathways such as faults or chimneys are commonly characterised using seismic surveys. However, geophysical data taken from 3D seismic surveys of the shallow subsurface is not always available and is expensive to acquire and process. In addition, the state-of-the-art in leakage modelling may not be sufficiently reliable to support such risk analyses. Still, some form of risk analysis is required for site selection and development. In this study, we test the level of detail required in the risk map to produce meaningful and acceptable offshore monitoring plans for the selected sites. The added impact of geological architecture and structural elements like faults, stratigraphic traps, spill points etc. is also considered.

In an ideal setting, hydrodynamic and marine biogeochemical data can be readily attained from calibrated high-resolution models and simulations, combined with available in-situ measurements. The process of identifying data availability, and later gather and pre-processing the data, will have to be site specific. It might be necessary to set up a biochemical general circulation model for the area, which can be a considerable task. However, such model systems are often used in regional weather forecasts, in climate research, and as part of marine research and management.

This study demonstrates the toolbox using a real-world case studies and assesses the impact of data availability on the outcome of the tool promotes the added value of toolbox functionality with regards to optimized strategies that account for geologic risk, cost-benefit, and maximum effect. The technical details of the toolbox, and its component will be presented in another contribution to GHGT-16, here we will demonstrate the preparation steps for the three sites, and how the toolbox can address regional concerns and be tuned to local characteristics. We note that the intention is not to replicate or influence monitoring strategies at these sites as this type of assessment would require more detailed preparation, involving site operators and stakeholders. However, we can assess the effect of pre-project data availability on the monitoring outputs of the tool.

*This work is part of the project ACTOM, funded through the ACT programme (Accelerating CCS Technologies, Horizon2020 Project No 294766).*

**Keywords:** Offshore storage; Environment; Monitoring; Assurance