



Assurance offshore CO₂ monitoring, a cross-disciplinary approach.

Guttorm Alendal¹, Jerry Blackford², Stefan Carpentier³, Dorothy J. Dankel¹, Marius Dewar², Sufyan El Droubi⁴, Bjarte Fagerås⁵, Sarah E. Gasda⁶, Anna Olyenik¹, Abdirahman Omar⁶, Rajesh Pawar⁷, Katherine Romanak⁸, Darren Snee², Sigrid E. Schütz¹, and Parisa Torabi¹

¹University of Bergen, Department of Mathematics, Norway (guttorm.alendal@uib.no)

²Plymouth Marine Laboratory (UK)

³TNO (The Netherlands)

⁴University of Dundee, (UK)

⁵Reach Subsea (Norway)

⁶NORCE (Norway)

⁷Los Alamos National Laboratory (USA)

⁸University of Texas at Austin (USA)

Formulating appropriate monitoring programs for offshore geological CO₂ storage projects, from either a regulatory or operator viewpoint, is difficult to achieve without a properly quantified cost-benefit analysis of what that monitoring could and should achieve. In addition, communicating risks and uncertainties is a challenge for offshore storage projects, and tools assisting in dialogue with stakeholders, governments and public at large will be of value.

The monitoring programs will have a role in communicating risks and benefits for storage projects and assure against unjustified accusations for having adverse environmental effects but cannot be seen in isolation from the multi-leveled CCUS (Carbon Capture, Usage and Storage) management systems.

Evaluations of CO₂ storage monitoring techniques usually aim to determine the suitability to user-defined project scenario (e.g., IEAGHG monitoring selection tool, <https://ieaghg.org/ccs-resources/monitoring-selection-tool>) or to assess the availability of sensors that can measure variables that are likely to fluctuate under a seepage scenario, or processes that are sensitive to CO₂-related stress. Less focus has been on how they perform relative to regulatory requirements, cost efficiency, and user friendliness.

We can use observations and models to characterise the natural variability of the marine system, or the noise from which an anomalous signal must be detected. We can use models to simulate hypothetical leak events thereby defining the monitoring target(s). We have algorithms that assess the cost-benefit of a range of anomaly criteria – i.e., a signal that would provoke a more concerted

monitoring campaign and finally algorithms that can derive the optimal deployment strategy – i.e., where to monitor and when. The challenge is to collate these abilities into a coherent whole, which then allows the presentation of an evaluated monitoring system that can be judged against regulatory and societal expectations.

We outline the approach chosen in the ACTOM project (<https://actom.w.uib.no>) to develop procedures for design and execution of appropriate, rigorous, and cost-effective monitoring of offshore carbon storage, aligning industrial, societal, and regulative expectations with technological capabilities and limitations.

The ACTOM toolbox is capable of simulating “what if” seep scenarios, as well as monitoring deployments, that can be used to deliver environmental impact assessments as required under the CCS (Carbon Capture and Storage) and EIA directives. As a result, recommended monitoring strategies could be delivered autonomously and be dependent on established generic operational marine simulation models, both factors reducing costs.

We will demonstrate use of the toolbox on three sites in the Gulf of Mexico, in southern North Sea and off the coast of Norway, each with distinctive features and availability of data.