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Development and application of protocols for CO■ detection in marine environments

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Development and application of protocols for CO_2 detection in marine environments

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Introduction

In industrial-scale marine Carbon Capture and Storage (CCS) operations, detecting CO_2 and associated gas leaks remains a major challenge for Measurement, Monitoring, and Verification (MMV) due to large survey areas, natural variability, and limited measurement sensitivity. Reliable monitoring requires a combination of dynamic platforms (e.g., ships, remotely or autonomously operated vehicles) and stationary platforms (e.g., buoys, landers), along with emerging technologies. Many of these methods require specialized expertise for deployment and data interpretation, and several are not yet commercially available, presenting scientific and technological opportunities. Effective MMV in shallow marine environments demands robust and cost-effective methods to detect, attribute, and quantify (DAQ) potential leaks. While several techniques have been proposed in the literature, most are still under development, with Technology Readiness Levels (TRLs) of 2 or lower. Site-specific strategies are therefore essential. This study will test and compare various DAQ approaches ranging from sub-millimeter to kilometers, in the context of a CO_2 injection experiment led by PETROBRAS. The experiment is placed in a saline aquifer near Barra do Furado (RJ), at injection depth of 1200 m and about 300 m inland from the ocean, with an injection rate projection of 200,000 m³/day and a total of 200,000–300,000 tonnes of CO_2. The project will evaluate the advantages, limitations, costs, spatiotemporal resolution, readiness levels, and leak detection sensitivity of the methods. These results will support the deployment of a CCS hub for industrial CO_2 capture in southern Brazil and help assess environmental impacts and validate monitoring sensors.

Method and/or Theory

The project involves environmental monitoring in the coastal zone and continental shelf near the Barra do Furado Station, where a CO_2 storage facility will be installed. Activities include high-resolution 3D seismic data acquisition, deployment of seafloor sensors, seasonal sampling of sediments, water, and organisms, and a controlled CO_2 leak experiment. Monitoring will be continuous (sensors and buoy), seasonal (biogeochemical sampling), and semiannual (bathymetry and sonar imaging). All collected data will feed into real-time tracking dashboards.

Results and Conclusions

The project aims to assess MMV methodologies for detecting, attributing, and quantifying CO_2 leaks in shallow marine environments by testing emerging technologies and sensors at **multiple spatial scales**. It will compare these approaches in terms of sensitivity, **cost-effectiveness**, resolution, and TRLs, and will develop a site-specific MMV strategy **tailored to the injection site**. Anticipated outcomes include sensor validation and a **deeper understanding** of environmental impacts before and after CO_2 injection. These findings will provide technical support for the advancement of **a CCS hub for industrial CO_2 capture in southern Brazil** and help assess environmental impacts and validate monitoring sensors.