STEMM-CCS

Strategies for Environmental Monitoring of Marine Carbon Capture and Storage

News update

Spring 2017

STEMM-CCS field programme gets underway

The STEMM-CCS field programme gets underway this spring following an intensive 12 months of preparation and planning. The first research cruise, led by GEOMAR's Christian Berndt aboard the German vessel RV *Maria S. Merian* (pictured above), will depart from the dock outside the National Oceanography Centre in Southampton in late April, bound for the Southern Viking Graben (SVG) in the North Sea. Here, the team on board - comprising researchers from GEOMAR, University of Southampton, University of Tromso and the NOC - will use state-of-the-art seismic techniques to investigate the characteristics of sub-seafloor geological features known as chimney structures.

Chimney and pipe structures are common features on seismic reflection profiles from sedimentary basins such as the North Sea. They are thought to arise as a result of the movement of fluids through the sub-seafloor sediments during compaction, resulting in focused pathways for fluid flow. However, despite their common occurrence, very little is known about the characteristics of these chimneys, particularly their permeability relative to the surrounding rocks and how long they remain open as a conduit to gas or fluid after their formation. In the field of sub-seabed geological CO_2 storage, the distribution, orientation and permeability of subsurface fluid pathways such as chimneys have important implications for the integrity of a storage reservoir and therefore require careful investigation.

During the cruise the team will collect high-resolution 3D seismic data using the P-Cable array, very high resolution sub-bottom profiler data to image small-scale fracture networks in the top 20 metres of seafloor sediment, ocean bottom seismometer data for velocity analysis, and controlled source electromagnetic data (see below) to assess fracture anisotropy in the subsurface. All four data sets will be combined to create a geophysical model of the chimney structure and form the basis for permeability modelling after the data have been ground-truthed by drilling data, which will also be collected during the cruise. The rock drill, which will be precisely located on the chimney structure using the HyBIS robotic behicle (pictured right), will enable both geochemical/geophysical borehole logging and the recovery of up to 30m long sediment cores for further laboratory sampling and analysis.

Data collected during this cruise will be augmented by on-land chimney samples and data collected from a field study site in California (see article on page 3 in this newsletter).

This cruise is the first of five expeditions planned during the lifetime of the STEMM-CCS project. Later this year, another German cruise will visit the experimental site in the North Sea to start collecting environmental baseline data for the area, including sediment sampling and habitat mapping. A lander will be also deployed to collect basic information on salinity and temperature, currents, pH, phosphates and nitrates over an extended period. A third cruise, related to STEMM-CCS but funded and organised by the complementary CHIMNEY project, will carry out further geophysical experiments to determine the internal structure of a North Sea chimney in late summer 2017.

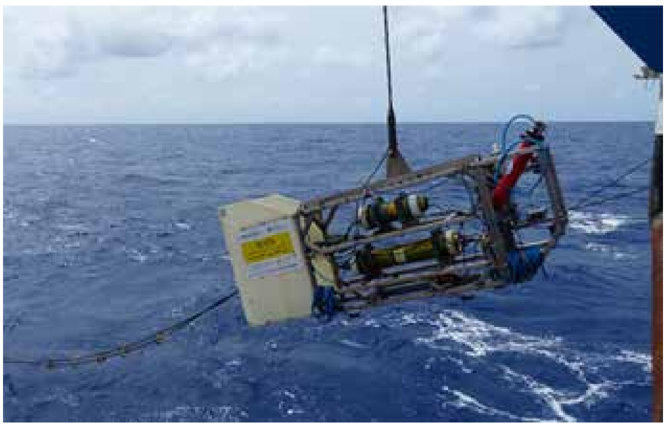
A further cruise focusing on geochemical characterisation will take place in summer 2018, leading up to the two main experimental cruises in late summer 2019, which will involve the UK research vessel RRS James Cook, and the German vessel RV Poseidon. These cruises will centre on the controlled release of CO_2 and monitoring of its impacts at the Goldeneye experimental site.

Above: the HyBIS robotic vehicle, equipped with cameras that will be used to precisely locate the rock drill over the chimney strucutre.

Using electromagnetics to determine sediment porosity and permeability

Electrical conductivity and electrical resistivity in sediments are mainly regulated by the amount of fluid electrolytes in the pore space (porosity) and the interconnectivity of the pores (permeability). Sediment grains are rather resistive compared to the conductive pore water (seawater) that resides in the spaces betwen sediment grains. Therefore the resistivity can serve as a proxy for porosity and permeability. The controlled source eletromagnetic method (CSEM) involves transmitting an electromagnetic field which is recorded by towed and ocean-bottom located receivers. The recorded field strength and arrival time of the signal at the receiver depend on the seabed resistivity structure.

Chimney structures are three dimensional (3D), and their geological formation may even cause them to be anisotropic, which means that their physical properties vary in different directions. For this reason, we design both the seismic and CSEM surveys in 3D.



Deep-towed electromagnetic instrument during deployment from a research vessel. Image courtesy B.Murton, NOC.

Investigating sandstone injectites in California

By Ben Callow, University of Southampton

During October 2016 Ben Callow and Professor Jon Bull (both University of Southampton) visited California to study field examples of sandstone injectites. It is hypothesised that sand injectites may be analogous to chimney structures, anomalies in seismic data common in many sedimentary basins which are generally believed to be the result of hydro-fracturing and fluid migration.

California is home to some of the largest onshore examples of sandstone injectites in the world, providing Ben and Jon with a unique opportunity to see these structures in the field. Although these structures are today observed onshore in California, around 20 million years ago in the Miocene, these structures would have been found hundreds of metres below the seafloor, and may be analogous to systems currently operating within sedimentary basins today.

Sand injectites are believed to form due to a large build up in pore pressure within unconsolidated sands. The overpressurisation causes the sands to penetrate upwards into the overlying mud rock units, forming structures that are observed on scales ranging from centimetre to kilometre in size.

Sand injectites are spectacular examples of fluid flow within the shallow sub-surface. A comprehensive understanding of fluid flow within the subsurface is critical for developing effective monitoring and mitigation strategies for CO_2 leakage at carbon capture and storage sites, hence the importance of the study.

Above: PhD student Ben Callow photographed sampling one of the smaller sandstone injectites found within the Panoche Hills

For the first half of the week Ben and Jon were very grateful to be shown examples of sand injectites in the Panoche Hills by Professor Andrew Hurst of the University of Aberdeen sandstone injection group. The evenings were spent at the local town of Los Banos where time was spent with Andrew and his research team.

The second half of the week saw Ben and Jon travel to the beautiful coastline of Santa Cruz, where more examples of sandstone injectites were observed. Fieldwork was undertaken at Yellowbank, Four Mile and Panther beaches, which Ben and Jon had to share with local surfers and sunbathers alike.

Above: Professor Jon Bull photographed above a large-scale sandstone injectite intruding vertically upwards through the horizontally bedded pale coloured mudstone layers, South of Yellowbank Creek beach

"The California trip was a fantastic introduction to my PhD and has opened my eyes to the breadth and depth of my chosen subject area" said Ben. "The experience has provided an excellent starting point for further research". The field excursion is an important starting point for Ben into further research of this subject area, which will make important contributions to STEMM-CCS research into leakage pathways through sub-seafloor strata. The information and samples collected during this trip will help further our understanding of these fluid flow features, and will be combined with seismic data collected from sub-seafloor chimney structures during the research cruise this spring (see lead story).

Jon and Ben would like to thank Professor Andrew Hurst and his field team from the University of Aberdeen, in particular Antonio Grippa, Gustavo Zvirtes and Giuseppe Palladino for their generosity and excellent company on the trip.

Partners gather in Kiel to mark end of first project year

After a busy first year of work, the STEMM-CCS project partners gathered in Kiel, Germany on 14-16 March 2017 for their first annual meeting. Hosted by GEOMAR at the Kunsthalle zu Kiel (Art Gallery, pictured below), more than fifty scientists, including PhD students, early career postdocs and members of the Stakeholder Advisory Board met to review the progress of the project to date and to discuss plans for the coming year.

The first day was devoted to bringing everyone up to speed on the work achieved so far in each area of the project. An overview of progress in each of the work packages demonstrated that the project is well on track.

On the second day, detailed presentations on specific aspects of the work were given, management issues were discussed and the young researchers in the project were given a slot to introduce themselves to the wider project team and showcase their research projects. An extended cruise planning session then provided the opportunity to discuss plans and arrangements for the upcoming research expeditions. In 2017, the STEMM-CCS cruise programme includes two research cruises: a geophysics and drilling cruise to survey and sample a chimney structure (see the lead story in this newsletter), and a biogeochemical baseline cruise which will involve sediment sampling and habitat mapping of the Goldeneye experimental area. A third cruise, related to STEMM-CCS but funded and organised by the complementary CHIMNEY project, will carry out further geophysical experiments to determine the internal structure of a North Sea chimney in late summer 2017.

Having worked up an appetite during these discussions and during the subsequent tour of the facilities at GEOMAR, the group adjourned to the Officer's Mess of Kiel's naval base, where an excellent conference dinner was enjoyed.

On the final day of the meeting, a half day workshop provided the opportunity to discuss specific technical aspects of the controlled CO_2 release experiment, which will take place at the Goldeneye experimental site in the summer of 2019.

Sampling design for baseline data acquisition

By Steve Widdecome, PML

In late November 2016, a group of 28 STEMM-CCS scientists gathered in the beautiful town of Olhão, a few kilometres to the south of Faro in Portugal. The reason for the meeting was to participate in a workshop entitled *"Sampling design for baseline data acquisition"*. The workshop gave participants an opportunity to discuss how environmental baseline surveys, suitable for geological CO_2 capture and storage (CCS) projects, should be conducted. The plan was that these discussions would ultimately lead to a detailed plan for the collection of seasonally and spatially explicit data in support of an effective environmental baseline for the seabed (and overlying water column) over the Goldeneye storage complex.

The first day of the workshop began with two talks to prompt thoughts about the actual purpose of an environmental baseline. First we heard from Marcella Dean, from Shell Global Solutions International, who gave us an operator's perspective of what she would consider to be an effective environmental baseline. This was followed by Dan Jones, of the National Oceanography Centre, who illustrated some previous examples of environmental baseline sampling designs taken from other industrial sectors.

Next up was Veerle Huvenne, also from the National Oceanography Centre, who explained how she and her colleagues had set up a data handling and aggregation framework by establishing a Geographic Information System (GIS) for the Goldeneye area. This involved some initial seafloor and sedimentary environment interpretation and will support future plans for habitat mapping. Veerle's talk was followed by a plenary discussion on what actually constituted our specific area of interest (geographic extent) that could be considered as in scope for a CCS baseline study (specifically for the Goldeneye area). Things we considered were: the spatial extent of the storage complex, likely CO_2 distribution in the complex, the spatial extent over which any leaked CO_2 will spread. It was concluded that this area of interest was different depending on which parameters you were measuring. The workshop agreed to allocate environmental parameters to one of three tiers which were defined as follows:

Tier 1 areas were those considered to have the highest probability of leakage (e.g. existing wells or identified faults) and were located above the expected storage site.

Tier 2 areas were those areas of seabed directly not close to potential leakage pathways but still above the maximum spatial extent of CO_2 storage.

Tier 3 was defined as the whole geological complex within which the predicted storage site is located.

After these discussions we had a session of talks which described some of the preliminary work already conducted within WP2. We heard from Joana Nunes (Plymouth Marine Laboratory) on the work she has done locating and collecting existing environmental data from the Goldeneye area. We heard from Anna Lichtschlag (National Oceanography Centre) on the sediment geochemistry and benthic-pelagic flux measurements that will be needed. Abdir Omar (Uni Research, Bergen) explained the carbonate chemistry of the northern North Sea (inc Goldeneye) as well as introducing the Cseep tracer approach. Guttorm Alendal (University of Bergen) ended the session by showing us his preliminary studies using Bayes theorem.

[continued over]

After a short break for a strong cup of coffee and a few minutes in which to catch some of the glorious Portuguese afternoon sun we completed day 1 with two talks that illustrated how we can use computer models to help quantify natural variability so as to distinguish between natural environmental changes and those caused by CO_2 leakage. First up Yuri Artioli (Plymouth Marine Laboratory) illustrated his work on the characterisation of baseline pH variability over multiple scales. This work included the identification of optimal sampling windows and the relationship between sampling frequency, detection threshold and maximising the true-positive : false-positive ratio. Then Gennadi Lessin (also of Plymouth Marine Laboratory) showed us how he used multivariate baseline characterisation to see which combinations of environmental variables (e.g. pCO_2, O_2 sat) can provide us with the best constraints on baseline variability.

At the end of day one a few brave souls took to the hotel's outdoor pool for a reinvigorating swim. Then it was off into Olhão for an evening meal and a chance to reflect on a full day of information and discussion.

Day 2 started with the final talk of the workshop as Gavin Tilstone (Plymouth Marine Laboratory) explained how remote sensing data could be used to appreciate seasonality and variability. He also updated us on progress towards delivering D2.2, *A generic method for the application of remote sensing in guiding CCS baseline data acquisition*.

For the remainder of Day 2 and the whole of Day 3 we split into 3 groups based on our specific areas of expertise; seabed habitat type and biology, sediment geochemistry and fluxes, pelagic biogeochemistry (including carbonate chemistry). Within these groups we used the information we had heard during the presentations, together with our combined expertise and experience to identify the key environmental parameters that need to be measured as part of a CCS baseline survey. Particular attention was paid to how such a baseline should deal with spatial and temporal variability in complex marine environments. These discussions prompted us to explore a variety of techniques including ecosystem modelling, remote sensing and the greater use of autonomous vehicles. In the end we identified over 200 potential parameters which will now be assessed for relevance, feasibility and application to produce a definitive list of required data. This list will be taken to the annual meeting in Kiel (March 2017) and will be used to inform our cruise fieldwork planning.

This workshop represented a first step in producing a detailed plan for the collection of seasonally and spatially explicit data in support of an effective environmental baseline for the seabed (and overlying water column) over the Goldeneye storage complex, as an example of best practice.

In addition to the hours of talks and discussions there was thankfully a little time for the workshop participants to enjoy the beautiful sites of Olhão and the surrounding area. The town sits on the world famous Ria Formosa and is home to an impressive variety of wading birds, including flamingos, storks, spoonbills, herons, grebes, egrets and many species of ducks and geese. All of these could be seen during an early morning or evening stroll to the nature reserve located to the south of the town or to the salt ponds to the north. Early in the morning was also a good time to see the spectacular bounty of fish and shellfish being sold at the local fish market. With access to such amazing ingredients it is not surprisingly that Olhão itself hosts a number of excellent restaurants and the food was amazing, especially the seafood. However, the biggest treat was at coffee break with the appearance of pasteis de nata - absolutely delicious little Portuguese custard tarts.

Above: The group enjoyed warm sunshine in between workshop sessions

The hunt for leaks and the need to avoid false alarms

Guttorm Alendal, University of Bergen

For CCS to be an effective technology the volume of CO_2 to be stored in geological formations will have to be substantial, hence a number of storage projects will be necessary. Storage projects will be designed to keep the stored CO_2 within the intended formations, and the formations and injection wells will be monitored by standard technologies to assure detection of unexpected events. However, there will always be some uncertainty that CO_2 may migrate toward the seafloor undetected. As a precaution the marine environment will have to be monitored for indications of a leak, which is also required by international regulations. Environmental monitoring also serves as an insurance against unjustified accusations on environmental adverse effects having other causes.

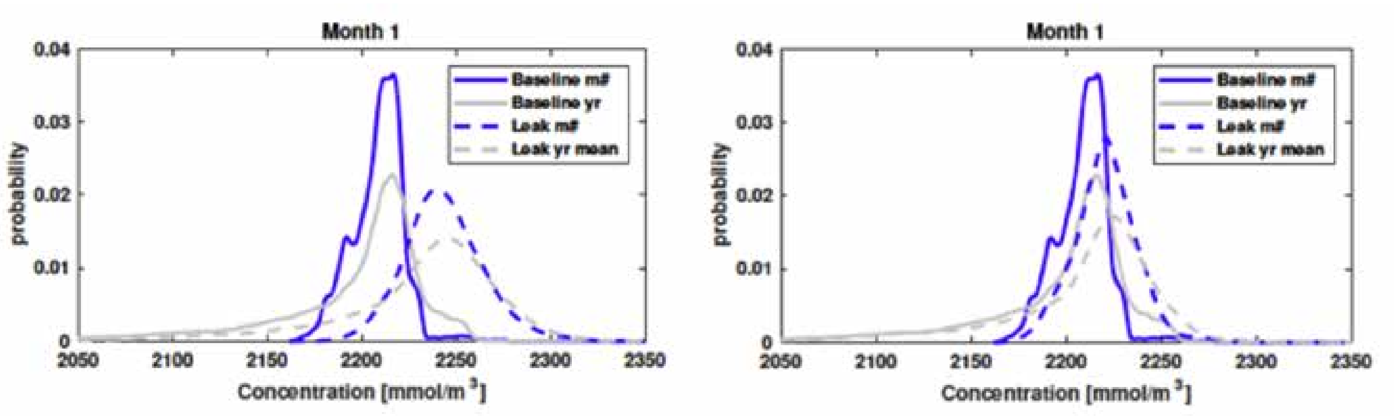
The area to be monitored will be large, the CO_2 might reach the seafloor far away from the injection site, and the signal of a leak may be camouflaged within the natural variability of the natural occurring gas seeps and CO_2 concentration. Marine waters are also notoriously hostile to instrumentation and marine operations are costly. False alarms may mobilise unnecessary additional resources, which may become costly and should be avoided. It is therefore important that the monitoring program is lean but still adequate to assure detection of signals from a leak.

A monitoring program will be based on identified probable leak locations and potential rates provided through a thorough characterisation of the storage site overburden. Secondly, an environmental baseline will have to be established in order to be able to detect a signal caused by a leak. The signal caused by a leak will have to be based on process models; it will not be possible to cover all scenarios or eventualities through in-situ experiments. Still, these models must be evaluated against laboratory experiments and in situ experiments like QICS and the planned 2019 experiment within the STEMM-CCS project.

The statistical baseline of important environmental parameters includes currents, natural gas seeps, and biogeochemical parameters such as bottom fauna and the varying CO_2 concentration. Long time series are important in order to capture natural variability, such as seasonal changes and long-term trends. In particularly it will be important to capture the expected acidification caused by increase of CO_2 concentration and changes caused by other human activities.

In STEMM-CCS, and the adjacent BayMoDe project funded by the Research Council of Norway (Climit program), we study the design of monitoring programs using methodology from Bayesian statistics. The theoretical framework offers quantification of uncertainties when classifying measurements

Illustration of the method:



The figure shows probability distribution functions for CO_2 concentration, i.e. the likelihood that a measurement will be at a given concentration (the x-axis). The continuous lines represent baseline, taken from the Plymouth Marine Laboratory hind cast, the blue line is for the month of January, while the grey line is the annual distribution. To achieve the staple lines, simulated signals from a leak have been added. The shift between the baseline and the leak location is what allows the classification of measurements. The left panel is at the leak, while the right panel is taken 1 km away. The shift is considerably smaller away from the seep, and hence to detect a longer time series will be necessary. The results are preliminary and should be used with care.

as taken under leak or non-leak conditions. Uncertainties are minimised and by using Bayesian decision theory the cost of the uncertainties, including false alarms, can be determined.

The preliminary studies performed so far have been based on hind cast simulations of the North Sea Environment from Plymouth Marine Laboratory, bubble plume model results from Heriot-Watt, and larger scale transport from Uni Research and University of Bergen. The aim is to have a framework ready to be tested during the 2019 Goldeneye experiment.

Further reading:

Ali A, HG Frøysa, H Avlesen, G Alendal (2016), Simulating spatial and temporal varying CO_2 signals from sources at the seafloor to help designing risk-based monitoring programs, Journal of Geophysical Research-Oceans 121 (1) 745–757.

Artioli Y, JC Blackford, M Butenschon, JT Holt, SL Wakelin, H Thomas, AV Borges, JI Allen (2012), The carbonate system in the North Sea: Sensitivity and model validation, J of Marine Systems 102-104.

Botnen H, A Omar, I Thorseth, T Johannessen, G Alendal (2015), The effect of submarine CO_2 vents on seawater: implications for detection of subsea Carbon sequestration leakage, Limnology and Oceanography 60 (2).

Dewar M, W. Wei, D. McNeil, B. Chen (2014), Small-scale modelling of the physiochemical impacts of CO_2 leaked from sub-seabed reservoirs or pipelines within the North Sea and surrounding waters, Mar. Poll. Bull.

Hvidevold, HK, G Alendal, T Johannessen, A Ali, T Mannseth, and H Avlesen (2015), Layout of CCS monitoring infrastructure with highest probability of detecting a footprint of a CO2 leak in a varying marine environment, Int. J. Greenhouse Gas Control, 37, 274–279.

Hvidevold HK, G Alendal, T Johannessen, A Ali (2016), Survey strategies to quantify and optimize detecting probability of a CO_2 seep in a varying marine environment, Env Modelling & Software 83 303–309.

STEMM-CCS convenes its first Science-Policy meeting

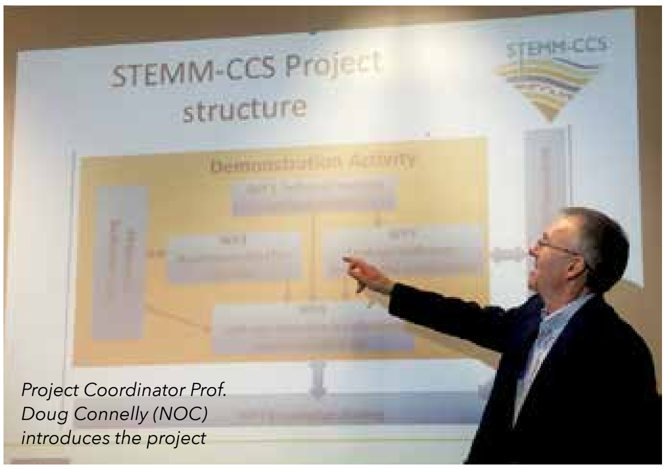
As part of our efforts to link research and policy and to provide policymakers and stakeholders with good and relevant scientific knowledge in support of policy developments, STEMM-CCS convenes an annual Science-Policy meeting comprising senior policymakers, stakeholders from industry and NGOs, representatives of international organisations, and leading scientists. The objective is to ensure that our results are brought promptly to the attention of policy makers in a forum where then can be discussed with all interested parties.

Three of these meetings will take place during the course of the project, and the first of the series took place in Brussels on 1 February 2017. The purpose of this first meeting was to introduce the project and its objectives to the meeting attendees, and to invite feedback from the audience on where STEMM-CCS results can be of use to different end-user sectors, and where there may be synergies with other initiatives or events in the CCS sector.

Attendees included representatives from the European Commission, the International Energy Agency's Greenhouse Gas R&D Programme (IEAGHG), the research community beyond STEMM-CCS, and the NGO sector.

The meeting programme comprised a series of presentations from STEMM-CCS lead scientists that showcased the major elements of the work programme, This was followed by a question and answer session, and opportunity for discussion on various topics, including the importance of establishing reliable environmental baselines, the potential secondary effects of CO_2 leakage, how different reservoir types present different technical challenges for secure CO_2 storage, and the need to consider timeframes and cost implications in the process of making recommendations for monitoring protocols.

A key topic of discussion was how STEMM-CCS can engage further with the community of CCS operators, and the need to establish stronger links with other CCS projects and research teams in Japan and the US. The results from STEMM-CCS will be highly relevant for both developing and ongoing offshore CCS projects, and the project is being observed with interest by a range of sectors.



Project Coordinator Prof. Doug Connelly (NOC) introduces the project

Development of a multi-scale, multi-phase prediction model for CO_2 leakage to the water column

Marius Dewar and Baixin Chen, Heriot-Watt University

At Heriot-Watt, we have been focusing on the development of a Multi-Scale Multi-Phase Prediction Model (MMPM) to show the effects of leakage at various scales in the North Sea Shelf's coastal waters, along with investigating the impacts on the seawater chemistry from bubble size distributions detected from leakage experiments within STEMM-CCS.

1. Development of a multi-scale multi-phase prediction model for CO_2 leakage

Our major contribution is to develop a Multi-Scale Multi-Phase Prediction Model for CO_2 leakage into the water column, both for the STEMM-CCS experiment, and further potential carbon storage leakage scenarios. Multi-scale allows the investigation in sizes from centimetres to hundreds of kilometres, and multi-phase investigates more than one fluid, such as the seawater and the CO_2. A two-phase (CO_2-seawater) small scale (<10 km) turbulent ocean model was previously developed, however lacks fluent communication with large scale dynamics (>10 km), including turbulent currents, salinity and temperature, along with the effects from ocean bathymetry surrounding the leakage site. Regional and coastal models are available (~102 – 103 km). However, these models are usually single-phase (seawater), and therefore a high level of modification is required in the model's coding and design to allow multi-phase flow for the bubble leakage.

One such model is The Unstructured Grid Finite Volume Community Ocean Model (FVCOM), which has the benefits of nesting various scales from the small scale (cm-km) to the ocean circulation scale (100 km+). A model has already been set for the North Sea region, known as the Scottish Shelf Model (SSM), shown in Figure 1a. This made FVCOM an ideal candidate for developing, with permission and programming support from both the FVCOM and SSM groups.

As the work is in progress, at present we have a physical model of a basic leakage developed and a nesting model constructed, where the bubbles leak, rise (at a set velocity) and dissolve (at a set rate) shown in Figure 1b as a test case; with the dissolved CO_2 flowing with the oceanic currents in a nested model (North Sea shelf coastal waters) shown in Figure 1c. We are currently working on programming of two-way nesting the multi-bubble plumes with the oceanic flows.

2. CO_2 bubble size distribution from sediment leakage

In addition to leakage rate, depth and currents, another contributor to impacts on the marine environment and ecosystem during a leakage is the bubble sizes forming on the seabed. In general, small bubbles dissolve faster and create a more localized impact than larger bubbles. Therefore, initial bubble sizes forming on the sediments are required for modelling, provided from either further models, observation data, or a combination of the two.

Optical visualization is one of the applicable techniques, taking photographs to measure bubble sizes. However, this presents a challenge when detecting the bubble plume in low visibility waters. Passive acoustic measurements are a suggested alternative for measuring bubble sizes forming, where, as a bubble breaks free from a surface, the bubble oscillates in simple harmonic motion to the bubbles natural frequency based on its dimensions.

We have investigated the applicability of these two techniques using data from the laboratory and the QICS in-situ observations in 2012, comparing what was recorded through passive acoustics and images simultaneously on the same camera, where the results suggest the preferred measurement techniques to be used in the design of the STEMM-CCS experiment.

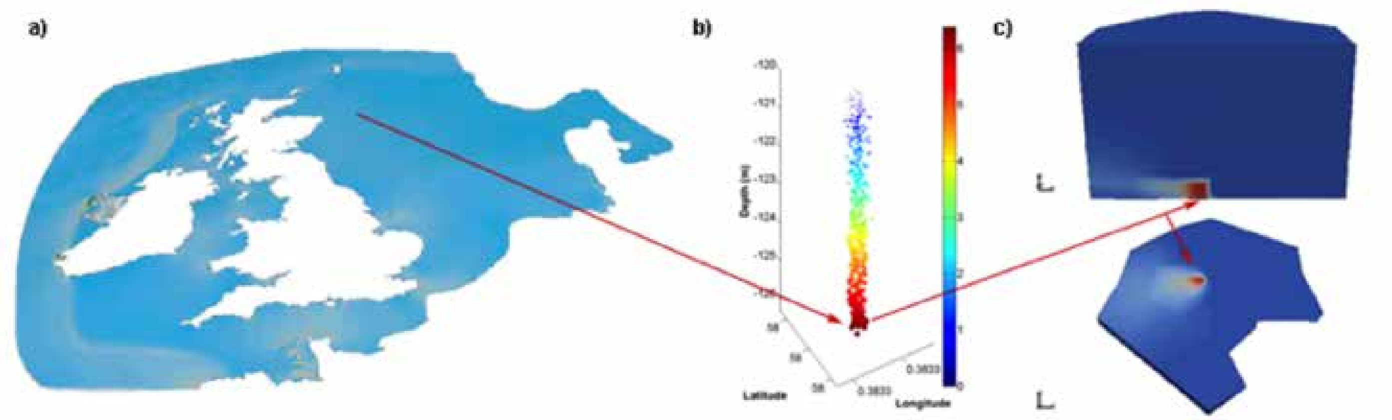
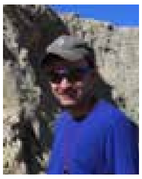


Figure 1. a) the Scottish Shelf Model domain; b) A bubble plume test case, with the bubble diameter shown in mm by both the colour map and the size of the marker; c) The CO_2 solution moving with the oceanic currents.

New faces in STEMM-CCS

The STEMM-CCS project community includes a number of PhD students and early career postdoctoral researchers who are working on a range of topics within the project. In many respects these researchers are the driving force in the project, contributing more than 20 person-years between them towards the achievement of the project's objectives. Here's a quick introduction to some of them and their research.



Ben Callow, PhD student, University of Southampton
Ben's PhD thesis seeks to characterise the permeability and structure of onshore and offshore chimney structures in order to quantify and assess the risk of CO_2 leakage from storage sites underlying these structures. The key aim of the project is to quantify the permeability and fully understand the dynamics and mechanisms of fluid flow through chimney structures, fracture networks and unconsolidated sediment.

Anita Flohr, Postdoctoral Researcher, University of Southampton
Anita's research interests are marine carbon and nutrient cycling with emphasis on inorganic carbonate chemistry, air-sea fluxes of climate relevant gases and the development of sensors and methods to study carbonate system dynamics. Anita's postdoctoral research will focus on assessing the applicability of natural and artificial tracers for the detection of CO_2 leakage.

Maribel García-Ibáñez, Postdoctoral Researcher, Uni Research
Maribel earned her PhD in Oceanography in 2015 at the University of Vigo, Spain. She has experience in investigations of marine biogeochemistry and measurements of carbon cycle parameters, and her research interest is the marine carbon cycle, particularly in the North Atlantic. In STEMM-CCS she will be working on C_{seep} tracers for the detection of CO_2 leakage.

Jens Karsten, Postdoctoral Researcher, GEOMAR
Jens carried out his PhD at GEOMAR whilst working on the ECO2 project. His expertise is in fluid migration in marine sediments, and the anaylsis and interpretation of seismic features. His postdoctoral research is focused on fluid flow analysis, chimney leakage potential and CO_2 plume modeling.

Bettina Schramm, PhD student, GEOMAR
Bettina is a geophysicist working on her PhD at GEOMAR. Her research is focused on the properties of chimney structures and fluid migration based on seismic refraction data. Her other research interests are gas hydrates, seismic interpretation and the evolution of lakes.

Mario Esposito, Postdoctoral Researcher, GEOMAR
Mario's research interests are marine biogeochemistry and chemical oceanography with focus on carbon cycling and inorganic nutrients dynamics. In STEMM-CCS, Mario's postdoctoral work will focus on the assessment of water column carbonate chemistry parameters and inorganic nutrients dynamics from discrete sampling and in-situ deployment of novel chemical sensors.

Espen Valberg, PhD student, University of Tromsø
The focus of Espen's PhD is the Vestnesa Ridge, on the western Svalbard margin - a prominent gas hydrate province containing evidence for active fluid flow through the sediments (e.g. chimney structures, seafloor pockmarks, gas leakage from the seafloor into the water column). Espen's work will focus on seismic and geological modelling of focused fluid flow structures in marine sediments in order to better understand this area.

Christoph Bottner, PhD student, GEOMAR
Christoph's PhD work will focus on the interpretation of the 3D seismic data collected during the PERMO cruise in spring 2017, and the development of numerical fluid flow modelling of a chimney. His work deals with a conceptual model of chimney structures for CO_2 leakage by evaluating reflection seismic data, numeric models and drilling logs.