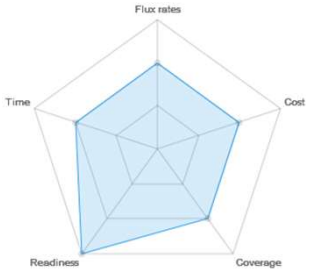
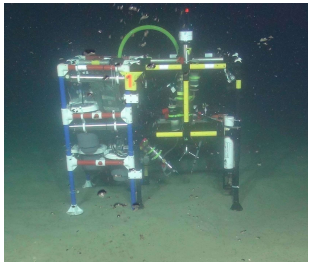
The STEMM-CCS online monitoring and decision support tool





Method	Cost ▼
GEOMAR Leak Model	low
Passive acoustics	low
C-seep	medium
Active Acoustics (SBP)	high
Benthic Chamber	high

Anna Lichtschlag, Chris Pearce, Mikael Suominen

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 654462

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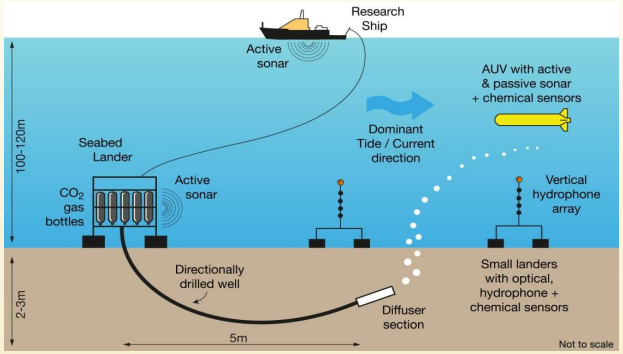
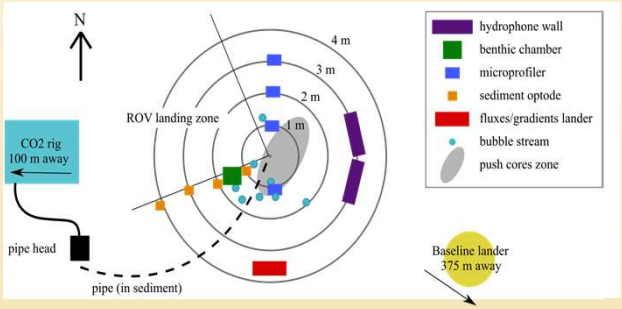
Aim of the STEMM-CCS online monitoring and decision support tool

- To make “lessons learned” during the STEMM-CCS project accessible to a wider audience

- To help users to select the most appropriate **tools and techniques** to set up the legally required monitoring programme for an offshore CCS storage complex in terms of:

  1. Characterization of injection site (environmental point of view)
  2. Detection, quantification and source attribution in case of a leakage
  3. Environmental impact assessment





http://www.stemm-ccs.eu/monitoring-tool

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Tool requirements

- Publically accessible
- Easy to use for non-experts
- Examples of monitoring data
- Specific recommendations
- Cost-benefit analyses

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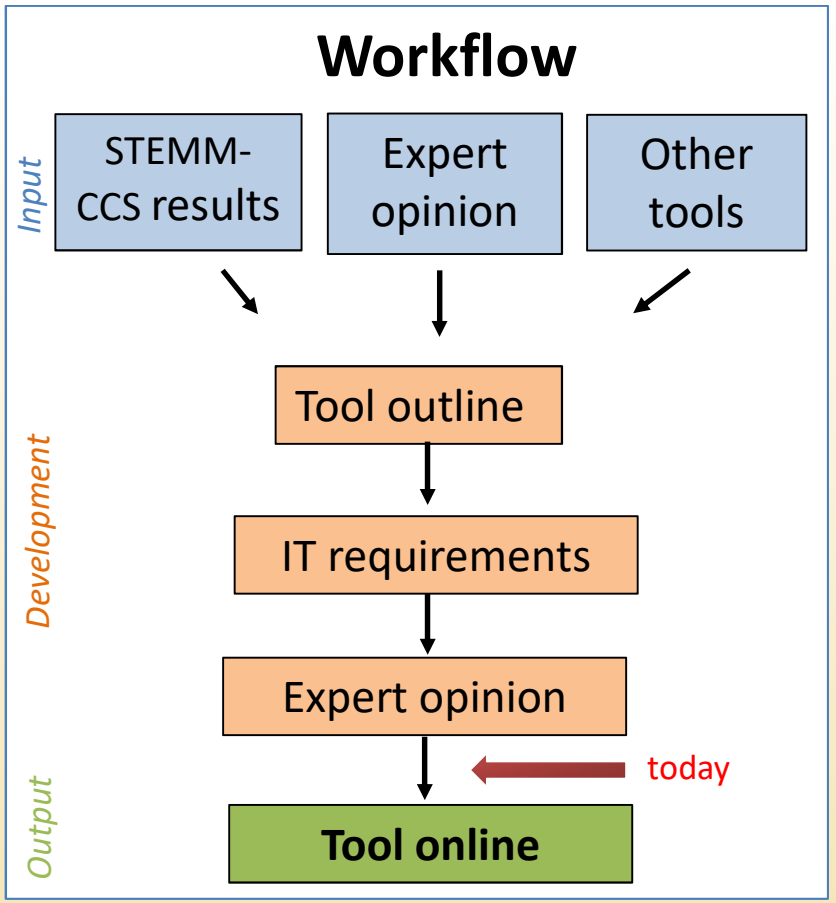

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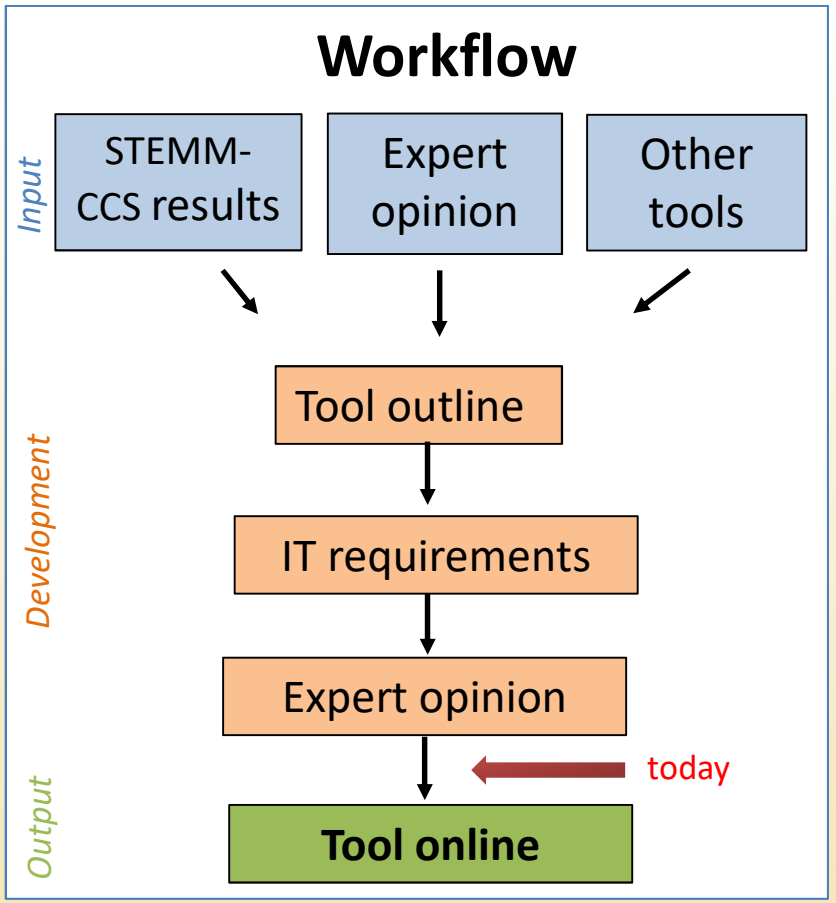
Current limitations

- Mainly tools and techniques tested during STEMM-CCS (valid 2019)
- Majority of examples are from North Sea
- Simplification
- Currently not working in Internet Explorer 11



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Technical Background

- Written in a bootstrap framework to provide responsive design, to improve its usability on small screens (typically mobile devices)
- Main body of the tool is a single HTML page that makes asynchronous requests to scripts on the server to get information on the method(s) selected and render it appropriately
- Hosted on STEMM-CCS homepage (www.stemm-ccs.eu/monitoring-tool)

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Tool structure – "The Monitoring Tasks"

http://www.stemm-ccs.eu/monitoring-tool

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Tool structure – "The Monitoring Tasks"

STEMM-CCS Online Monitoring and Decision Tool

- Purpose of the Tool
- Description

Monitoring Tasks

- Characterisation of Injection Site
- Leakage Detection
- Source Attribution
- Leakage Quantification
- Environmental Impact Assessment

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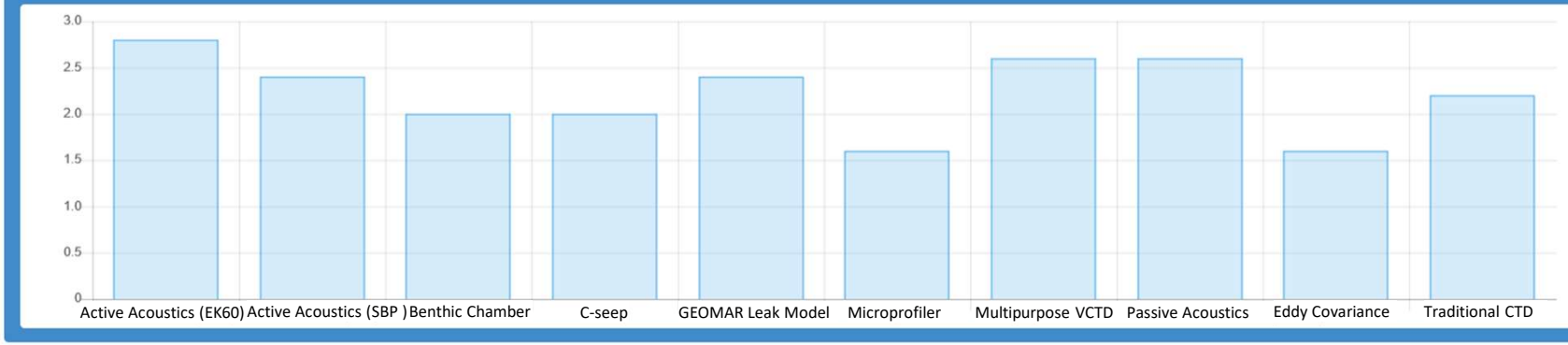
Example "Leakage Detection"

Leakage Detection

In line with the CCS Directive, any CCS storage complex monitoring strategy needs to assess whether any migration or leakage or CO_2 is occurring within the surrounding area. Such strategies need to accommodate the fact that CO_2 leakage may occur from a single point source or as more diffuse discharge over a larger area, and similarly that the leaking CO_2 may be present in form of CO_2 gas bubbles or dissolved into the interstitial waters of the sediments and overlying water column. Given these complexities, a number of different methods and techniques for detecting CO_2 leakage under varying scenarios were tested through the STEMM-CCS project, with their relative performance and individual merits summarised below.

Methods Tested

Comparison Mode



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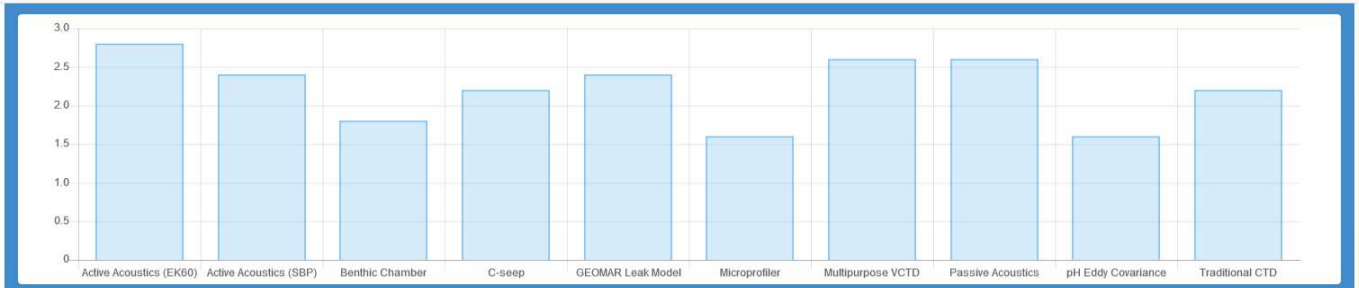
Example “Leakage Detection”
General Recommendations

Leakage Detection



Mandatory Measurements

In line with CCS Directive requirements, some of the mandatory requirements for this monitoring task (irrespective of the methods chosen) during the operational lifetime of a CCS storage complex (i.e. before, during and/or after CO_2 injection) are summarised in the table below. Further information about these mandatory requirements can be viewed by clicking the titles.

Measurement	Pre-Injection	During Operation	Post-Injection
Overburden and seabed characterisation	✓ Required	-	-
Potential leakage pathway mapping	✓ Required	-	-
Seabed chemical characterisation	✓ Required	✓ Required	✓ Required
Assessment of water column physics	✓ Required	✓ Required	✓ Required
Assessment of water column carbonate chemistry dynamics	✓ Required	✓ Required	✓ Required
Assessment of other key water column chemistry and biology parameters	✓ Required	✓ Required	✓ Required

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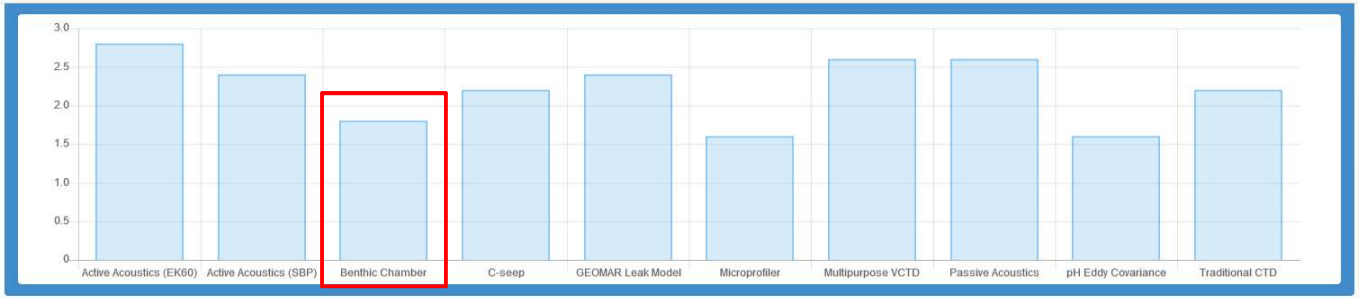

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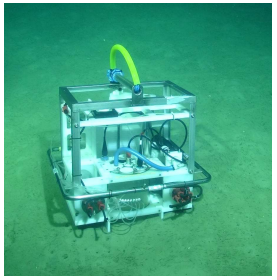
Example "Benthic Chamber"

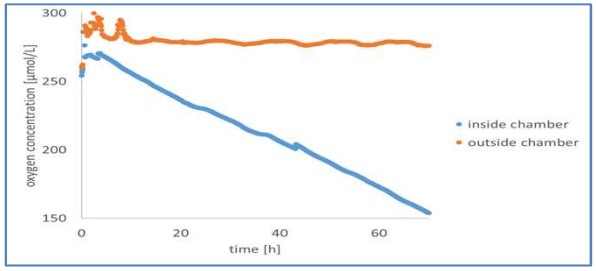
Method explanation



Including:

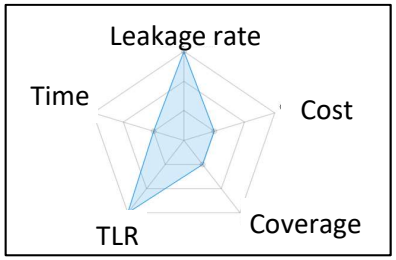
- Mode of operation
- Photograph
- Certainty of results

Data example



Suitability scoring

Method Scoring: Benthic Chamber			
CO_2 leakage rate and nature of leakage	High (Bubbles)	Low to High (Bubbles)	✓ Low (Bubbles and Dissolved)
Cost of measurement	✓ high	medium	low
Spatial extent (coverage) of measurement	✓ low	medium	high
Technical readiness level of the method	in development	near market	✓ commercially available
Time needed to obtain final results (in months)	✓ 3+	2	0-1
			Final Score: 1.8



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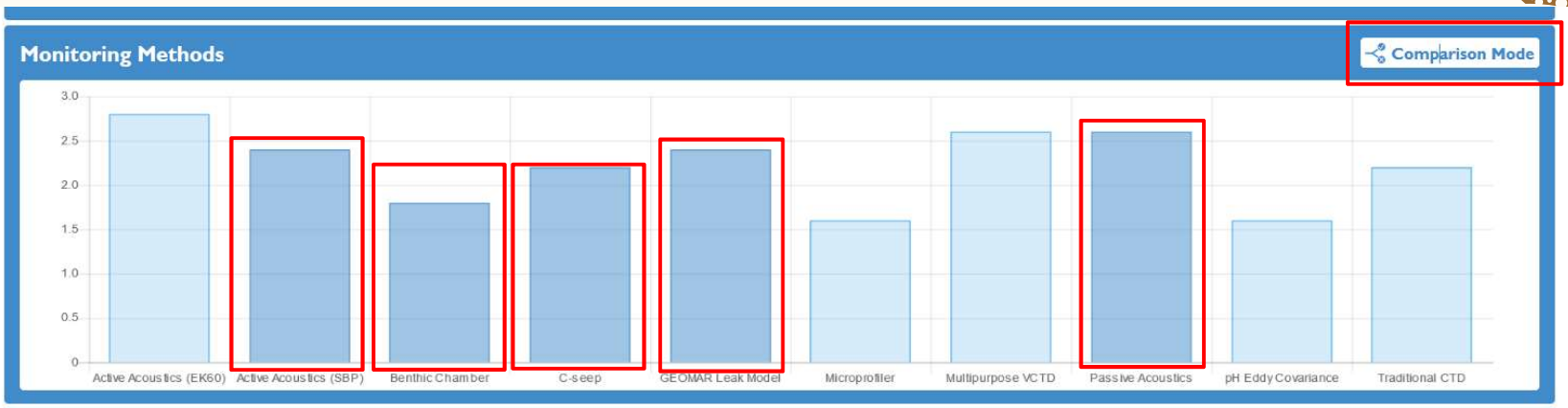
Example – "Comparison Mode"



Method Comparison

Method	Time	Cost	Leakage rates	Spatial Extent	Technical Readiness	Score
C-seep	0-1	medium	Low (Bubbles and Dissolved)	medium	in development	2.2
Passive Acoustics	0-1	low	Low to High (Bubbles)	medium	commercially available	2.6
Benthic Chamber	3+	high	Low (Bubbles and Dissolved)	low	commercially available	1.8
Active Acoustics (SBP)	0-1	high	Low to High (Bubbles)	high	commercially available	2.4
GEOMAR Leak Model	2	low	Low (Bubbles and Dissolved)	high	in development	2.4

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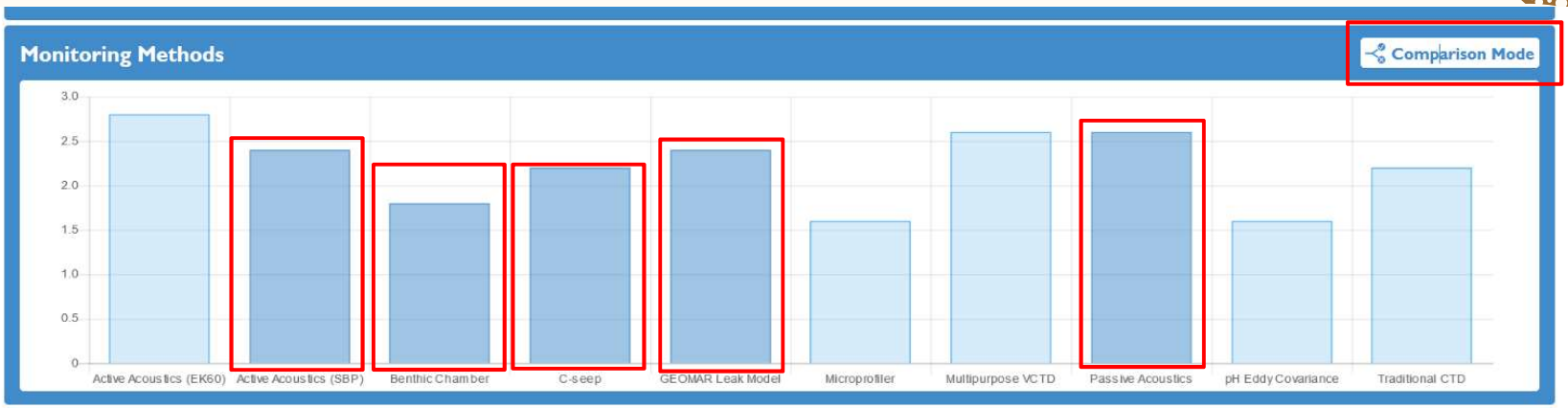

Method Comparison

Method	Time	Cost	Leakage rates	Spatial Extent ▼	Technical Readiness	Score
Active Acoustics (SBP)	0-1	high	Low to High (Bubbles)	high	commercially available	2.4
GEOMAR Leak Model	2	low	Low (Bubbles and Dissolved)	high	in development	2.4
C-seep	0-1	medium	Low (Bubbles and Dissolved)	medium	in development	2.2
Passive Acoustics	0-1	low	Low to High (Bubbles)	medium	commercially available	2.6
Benthic Chamber	3+	high	Low (Bubbles and Dissolved)	low	commercially available	1.8

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“Recommendations ”

Recommendations for application of C-seep

The method requires data for any two of the four measurable parameters of the CO_2-system (DIC, TA, pH, and pCO_2), salinity, temperature, and nutrients or dissolved oxygen. Additionally, a site-specific model for the drivers of the natural DIC variability is required.

Recommendations for application of Benthic Chamber

Equipment needs to be deployed in the immediate vicinity of a suspected carbon dioxide source (but not immediately above bubble gas sources).

Recommendations for application of GEOMAR Leak Model

Simulation of data acquired with a towed Multipurpose Video-CTD including a short-response-time pH sensor combined with field measurements of water currents (ADCP) were applied previously to estimate total flow rate at distributed multiple carbon dioxide sources at the natural seep site offshore Panarea Island (Gros et al., 2019). Combination of model with different sets of field data could be envisioned but may require modification of the source code.

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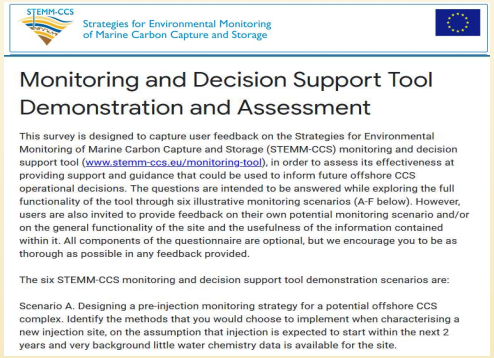
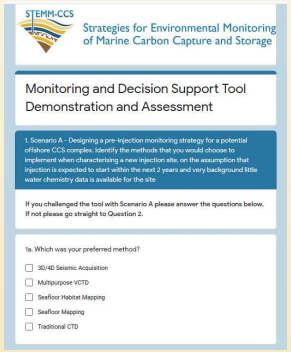
Sources and resources

- Final version publically available by end of February 2020: access via the STEMM-CCS webpage (http://www.stemm-ccs.eu)
- β-version currently available under: http://www.stemm-ccs.eu/monitoring-tool
- Reminder: Questionnaire and feedback: *https://forms.gle/RyCjdfqJCDspeqz48 or Chris Pearce / Anna Lichtschlag*





- **Input from many STEMM-CCS partners and institutions and IT NOC (THANKS!)**

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