

The STEMM-CCS online monitoring and decision support tool



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

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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 <u>tools and</u> <u>techniques</u> 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





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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Tool requirements

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





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



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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 (<u>www.stemm-ccs.eu/monitoring-tool</u>)



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



Tool structure – "The Monitoring Tasks"	STEMM-CCS
Strategies for Environmental Monitoring of Marine Carbon Capture and Storage	
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	





Tool structure – "The Monitoring Tasks" STEMM-CCS Strategies for Environmental Monitoring of Marine Carbon Capture and Storage	STEMM-CCS
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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.

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Example "Leakage Detection" General Recommendations



Leakage Detection			\$
3.0			
25			<u></u>
20			
1.5			
1.0			
0.5			
0 Active Acoustics (EK60) Active Acoustics (SBP) Benthic Chamber C-seep GEC	AR Leak Model Microprofiler	Multipurpose VCTD Passive Acoustics	pH Eddy Covariance Traditional CTD
Mandatory Measurements In line with CCS Directive requirements, some of the mandatory requirements for this monitoring after CO ₂ injection) are summarised in the table below. Further information about these mandator	task (irrespective of the methods ch y requirements can be viewed by cliv	osen) during the operational lifetime ol cking the titles.	f a CCS storage complex (i.e. before, during and/or
Measurement	Pre-I	njection During Opera	tion Post-Injection
Overburden and seabed characterisation	√ Re	quired -	-
Potential leakage pathway mapping	√ Re	quired -	-
Seabed chemical characterisation	√ Re	quired	✓ Required
Assessment of water column physics	√ Re	quired v Required	✓ Required
Assessment of water column carbonate chemistry dynamics	√ Re	quired v Required	✓ Required
Assessment of other key water column chemistry and biology parameters			





Example "Leakage Detection" General Recommendations



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30			
20			1
1.0			
Mandatory Measurements			
In line with CCS Directive requirements, some of the mandatory requirements for this monitoring task (irrespective of the meth after CO ₂ injection) are summarised in the table below. Further information about these mandatory requirements can be viewed	nods chosen) during the ope d by clicking the titles.	rational lifetime of a CCS storage com	plex (i.e. before, during and/or
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Example "Benthic Chamber"





Suitability scoring

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Method Scoring: Benthic Chamber				Lookago rata
CO ₂ leakage rate and nature of leakage	High (Bubbles)	Low to High (Bubbles)	✓ Low (Bubbles and Dissolved)	LeakageTate
Cost of measurement	√ high	medium	low	Time
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	TI R Coverage
			Final Score: 1.8	

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STEMM-CCS Example – "Comparison Mode" Monitoring Methods -Comparison Mode 3.0 2.5 2.0 1.5 1.0 0.5 Microprofiler Active Acoustics (EK60) Active Acoustics Multipurpose VCTD Passive Acoustics pH Eddy Covariance Traditional CTD C-seep Method Comparison Method Time Cost Leakage rates Spatial Extent Technical Readiness Score Low (Bubbles and Dissolved) C-seep 0-1 medium medium in development 2.2 Passive Acoustics 0-1 low Low to High (Bubbles) commercially available 2.6 medium Benthic Chamber 3+ high Low (Bubbles and Dissolved) low commercially available 1.8 commercially available Active Acoustics (SBP) 0-1 high Low to High (Bubbles) high 2.4 GEOMAR Leak Model 2 Low (Bubbles and Dissolved) 2.4 low high in development



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xample –	"С	omp	parison Mo	de"		3
onitoring Methods					-% Com	parison Mode
Active Acoustics (EK60) Active Acoust	ICS (SBP) Bet	thic Chamber	C-seep GEOMAR Leak Model Microprofit	er Multipurpose VCTD Passive Act	Dustics pH Eddy Covariance Tradition	al CTD
lethod	Time	Cost	Leakage rates	Spatial Extent V	Technical Readiness	Score
stine Acoustics (SPP)	0-1	high	Low to High (Bubbles)	high	commercially available	2.4
icuve Acoustics (SBI)		100000	Low (Bubbles and Dissolved)	high	in development	24
EOMAR Leak Model	2	low				2.1
EOMAR Leak Model	2 0-1	nedium	Low (Bubbles and Dissolved)	medium	in development	2.2
GEOMAR Leak Model	2 0-1 0-1	low medium low	Low (Bubbles and Dissolved) Low to High (Bubbles)	medium medium	in development commercially available	2.2





"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 (<u>http://www.stemm-ccs.eu</u>)
- β-version currently available under: <u>http://www.stemm-ccs.eu/monitoring-tool</u>
- Reminder: Questionnaire and feedback: <u>https://forms.gle/RyCjdfqJCDspeqz48</u> or Chris Pearce / Anna Lichtschlag



new injection site, on the assumption that injection is expected to start within the next 2 years and very background little water chemistry data is available for the site.



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





