Effective monitoring of long-term site stability for transparent carbon capture and storage hazard assessment (ENSURE)

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Microseismic monitoring of CO_2 storages

Status

- A long-established method for the surveillance of subsurface activities.
- Seismicity shows where fluid pathways and stress transfer are generated by the injection.

Challenges

- Microseismic for CCS monitoring has a mixed acceptance level.
- Often insufficient aperture or sensitivity (e.g., InSalah).
- Estimation of more advanced earthquake source parameters is often hampered by limited data.
- Challenging to compare the effectiveness of microseismic monitoring for seal verification between sites.

Developments

- Big success stories (e.g., Decatur, Quest)
- Distributed Acoustic Sensing (DAS) looks promising for microseismic monitoring but is still in an early stage

Project aim

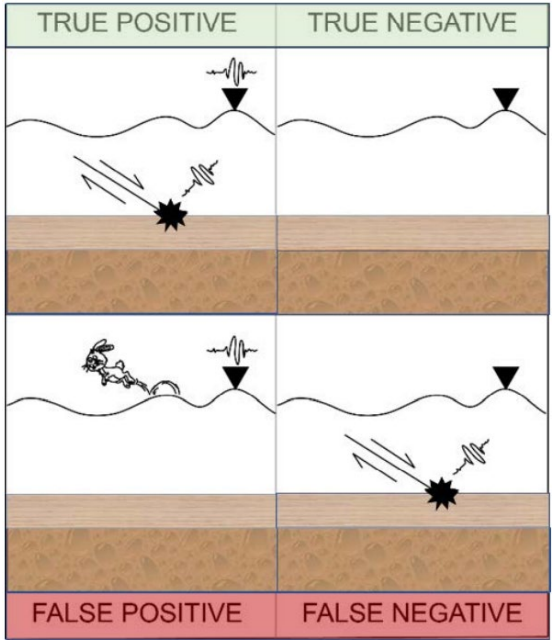
Progression of microseismic monitoring technologies to become a

- robust
- cost-effective
- publicly accepted

tool for seal integrity verification in large-scale CO_2 sequestration.

Main objectives

- Recommendations for design of fit-for-purpose and cost-effective networks. **(WP1)**
- Improved understanding of the seismodynamic behavior and identification of most relevant seismological parameters for long-term seal stability assessment. **(WP2)**
- Recommendations on how to share complex information and educate on real versus perceived risks of induced seismicity. **(WP3)**



Innovation potential

- First of its kind **data-driven** study to quantitatively assess and optimize microseismic monitoring for CCS seal integrity verification.

- Access to unprecedented monitoring infrastructure:
  - surface/downhole geophones
  - in-well/surface DAS cables
  - within one site and across different sites and plays

- New insight into the detectability of microseismic events with fiberoptic DAS and investigation of optimized fit-for-purpose array configurations.

- Innovative methods to analyse acquisition footprint on seismological parameters.

- International comparison on conditions and strategies for enhancing public acceptance by sociological surveys.

Consortium partners

➢ **9 partners from 7 countries**

- Norway: NORSAR, ASN
- Canada: Shell Canada: Quest operated by Shell Canada, University of Alberta
- France: TotalEnergies one Tech
- UK: bp
- Italy: INGV
- US: MRCI
- Netherlands: Shell Global Solutions International

ENSURE CO_2

Case study sites

Project timeline

We are here

Project content			Year 1				Year 2				Year 3			
WP	Description	Tasks	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
WP1			WP1: Success factors for validation of seal integrity											
	New data acquisition	T1.1												
	Compilation catalogs	T1.2												
	Differences betw. sites	T1.3												
WP2					WP2: Advanced microseismic interpretation									
	Model influence	T2.1												
	Source parameters	T2.2												
	Correlation w. injection	T2.3												
WP3			WP3: Effective communication strategies											
	Design & conduct survey	T3.1												
	Data analysis	T3.2												
	Recommendations	T3.3												

★ Milestone
☆ Deliverable

Webpage: https://www.norsar.no/ensure_en

WP 1

- Field scale testing with new acquisition
- Development of novel analysis tools (e.g. noise assessment)
- Compare sensor technologies and network setup

WP 2

- What seismological parameters should be communicated?
- Which analyses should be performed?
- Influence of network properties

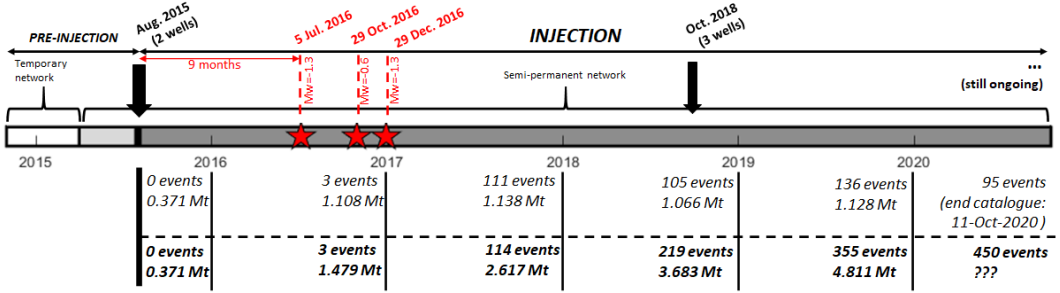
WP 3

- How to communicate?

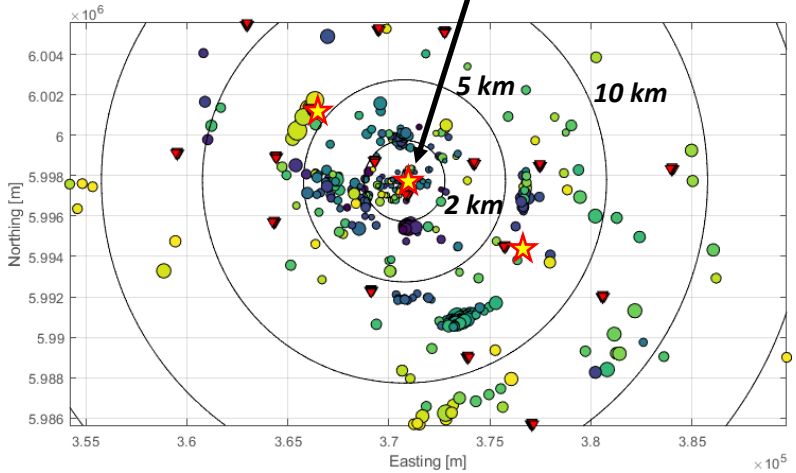
First results – Quest

- CO_2 injection in Alberta, Canada: ~1Mt/y in 3 wells
- Operated by Shell Canada

- Microseismic events
- Injection wells
- Surface node arrays



Downhole geophone array & DAS



- All events in the Precambrian basement

(From O'Brien, GHGT, 2018)

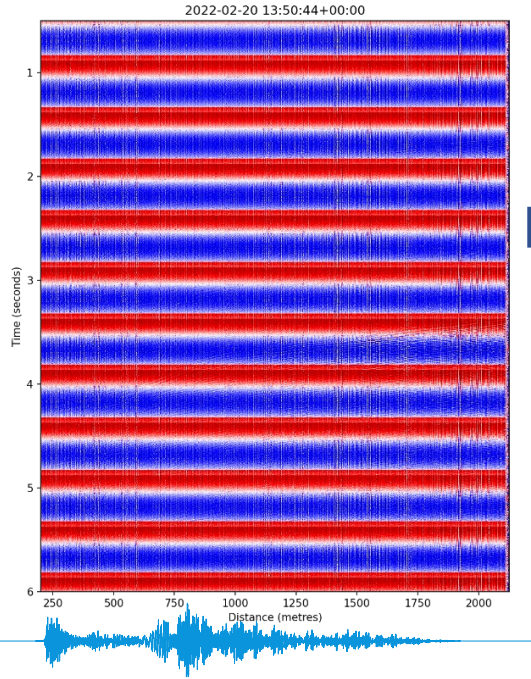
- First 400 events until Oct. 2020

First results – Quest

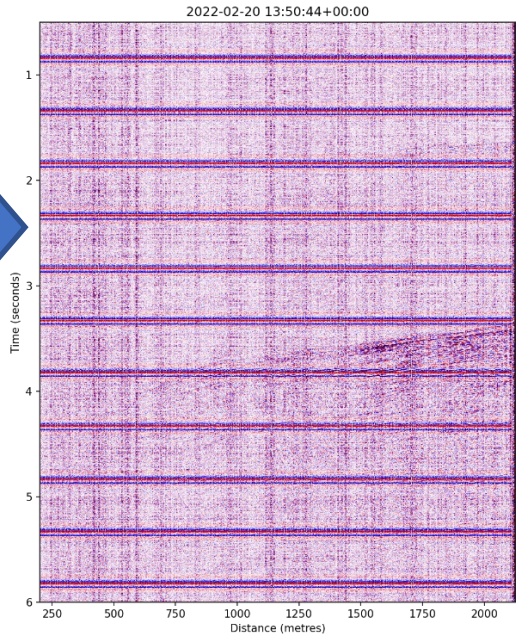
- DAS data recorded on ASN OptoDAS interrogator in the 2 km deep central injection well
- Acquisition started in February and still ongoing

Magnitude 0.8

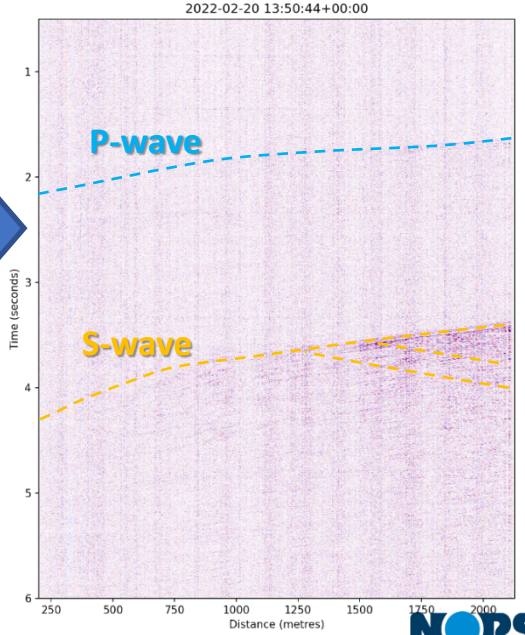
Raw data



10-100Hz bandpass filter



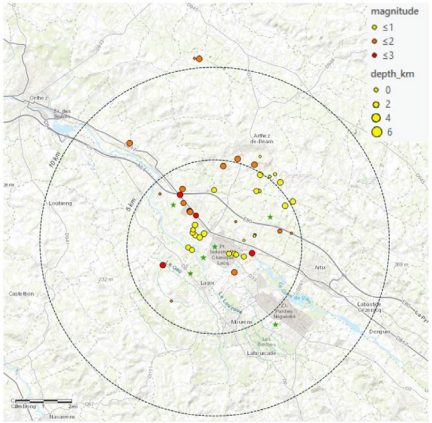
singular value decomposition

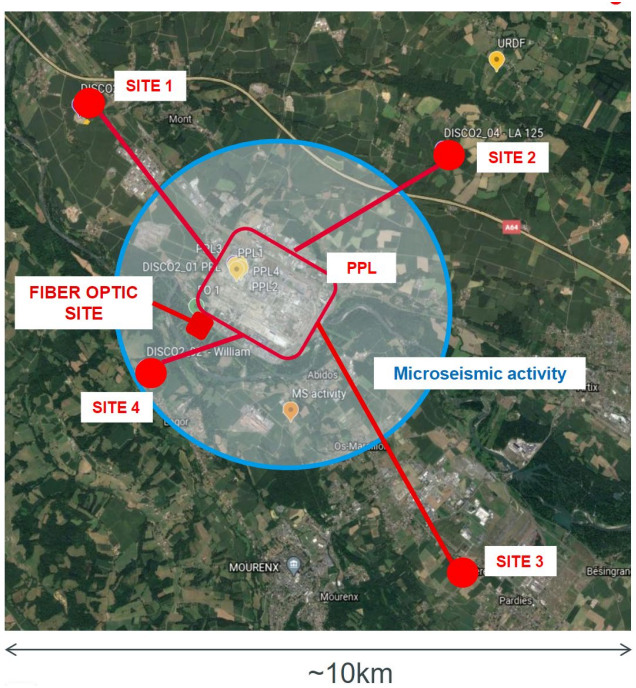


First results – Southern France

- Monitoring network in a seismically active area (induced seismicity) with several types of instrumentation:
  - Broadband sensor (1)
  - 3C 1-Hz geophones (4)
  - Vertical 5-Hz geophone strings (16)
  - DAS (in a pond) with different types of cables
- 47 events located using conventional sensors
- Operated by TotalEnergies

The $DISCO_2$ site is located SW of France (former Lacq production site)

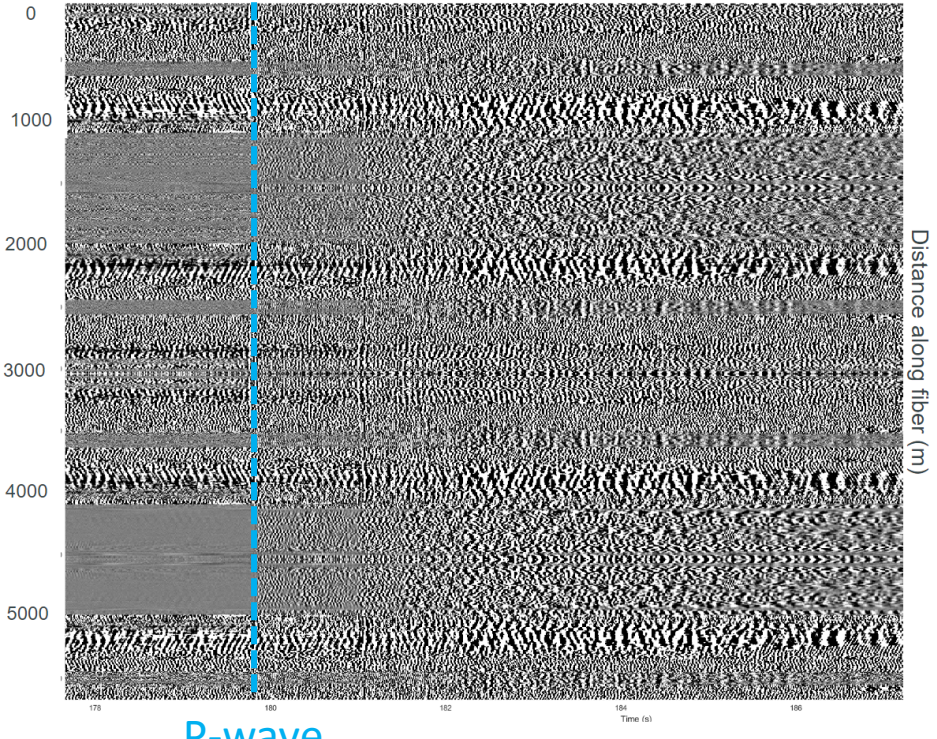




First results – Southern France

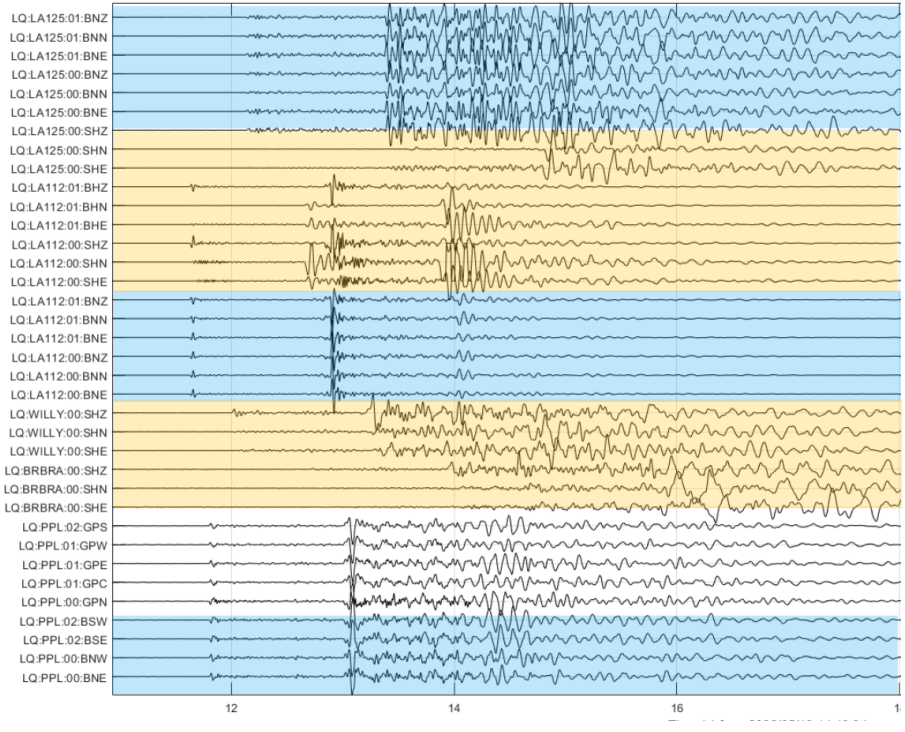
2,5 ML @ 4,4 km

DAS



P-wave

geophones



Strings of 5Hz-1C Geophones	1Hz-3C Sensors	4m-buried 5Hz-1C Geophones

Outlook

- Finalize WP3 survey questionnaire
- Continue with data integration and data acquisition as part of WP1
- Starting up WP2 with initial modelling to analyze the network footprint

Acknowledgement

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