



Norwegian Embassy
The Hague



Ministerie van Economische Zaken
en Klimaat

Assuring integrity of CO₂ storage sites through ground surface monitoring (SENSE)

Results and highlights

Bahman Bohloli and the SENSE team

CCUS Conference Rotterdam

8-10 June 2022

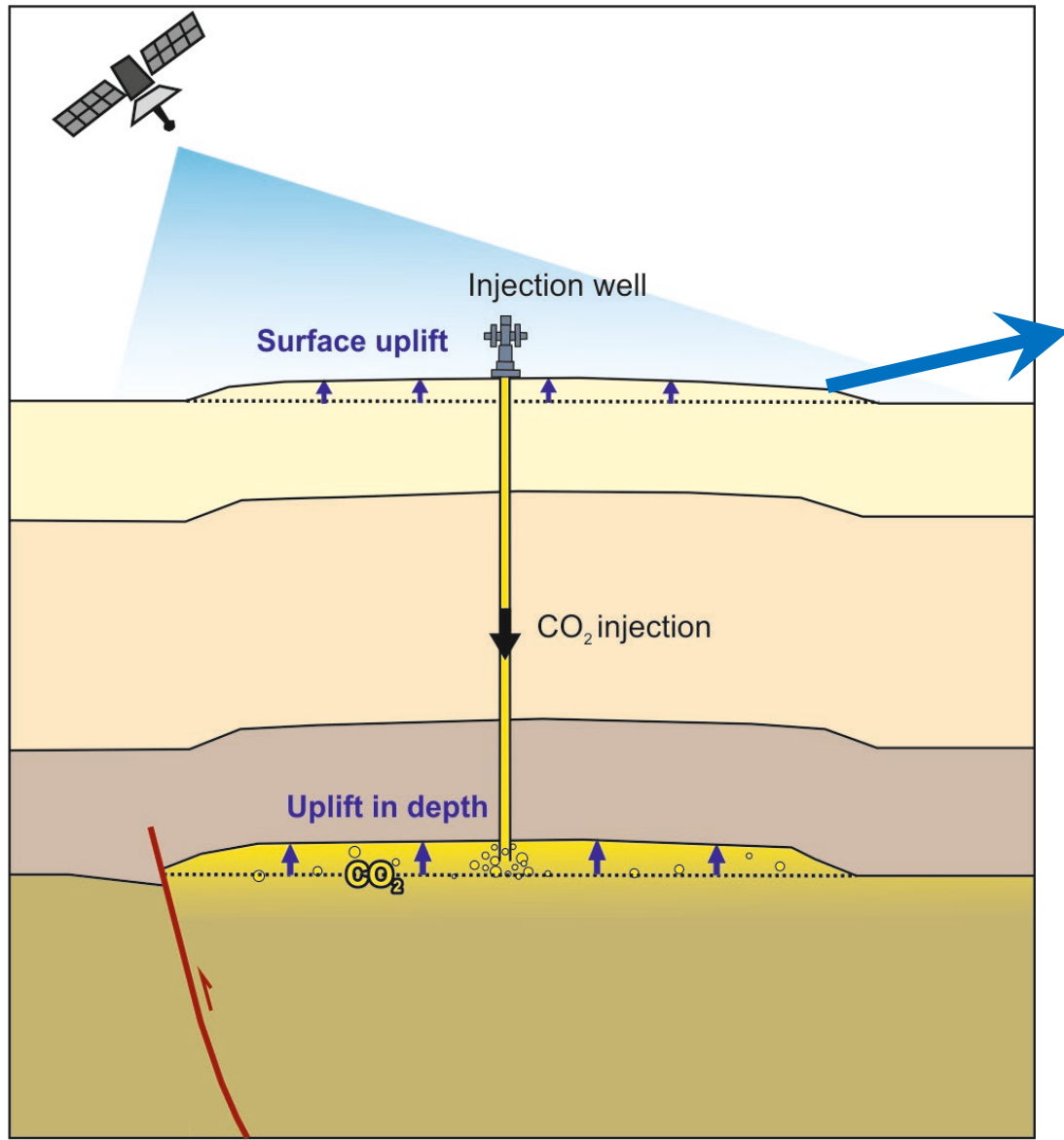


Outline

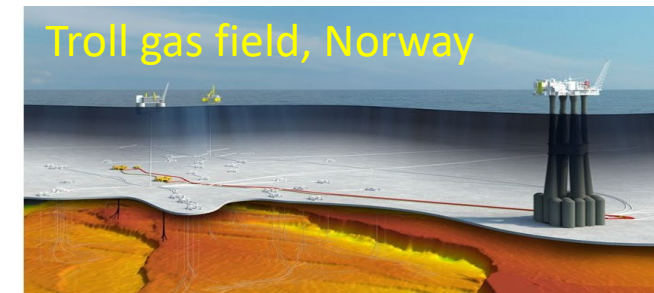
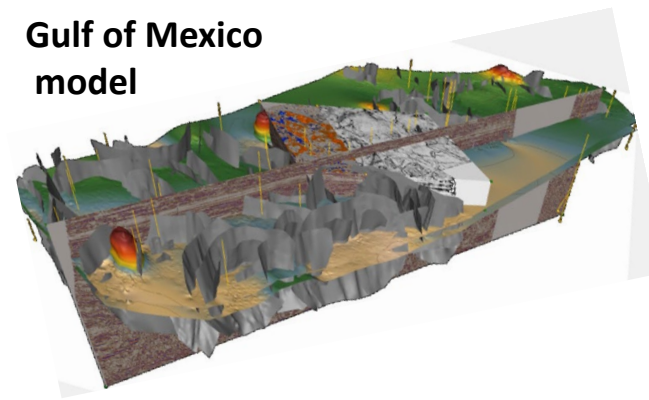
- SENSE project narrative
- Achievements and Highlights
- Dissemination activities
- Summary

SENSE project narrative

Case studies

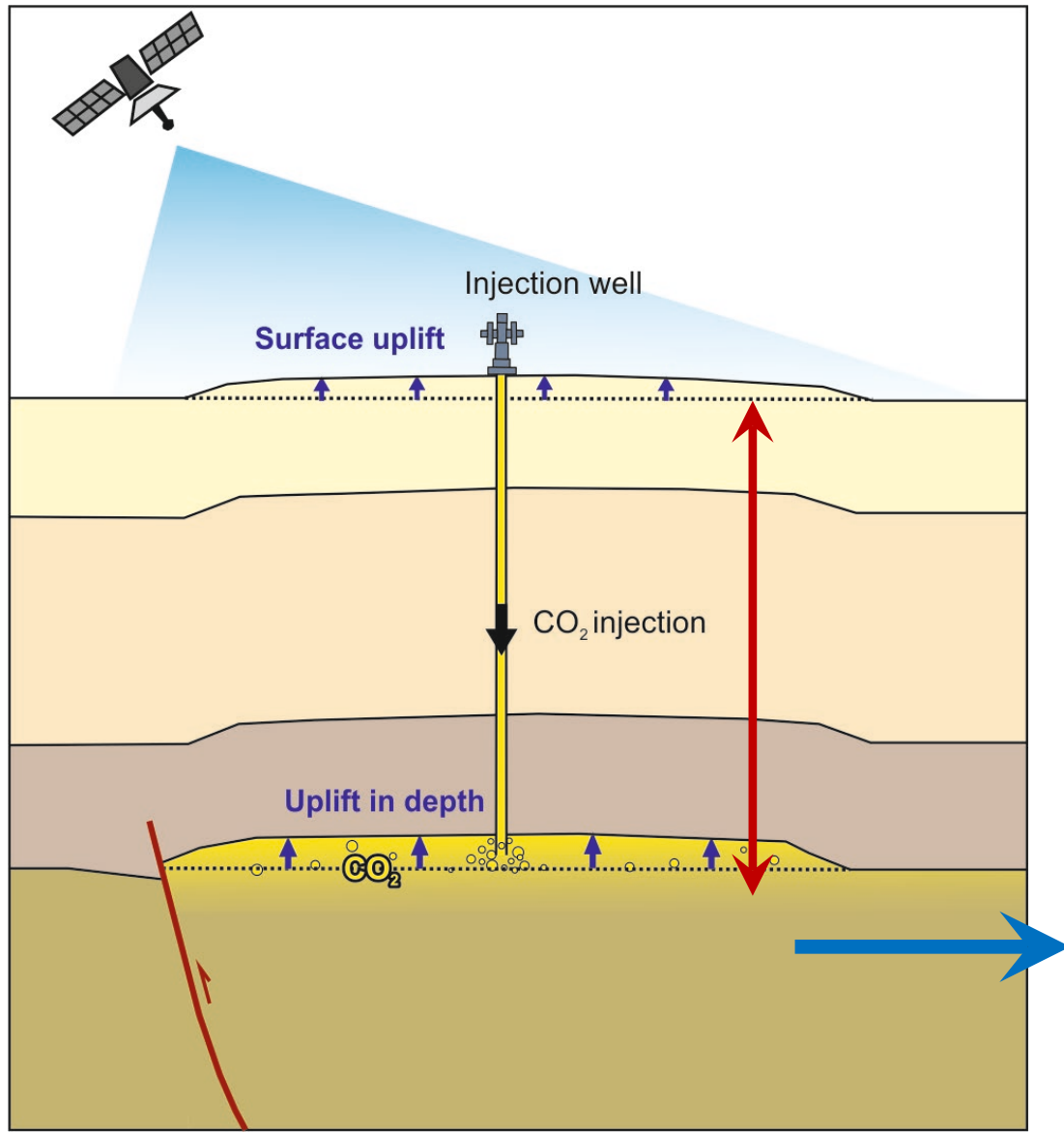


Gulf of Mexico
model

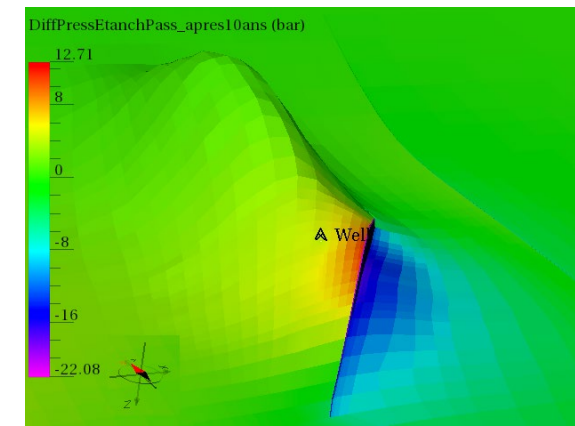
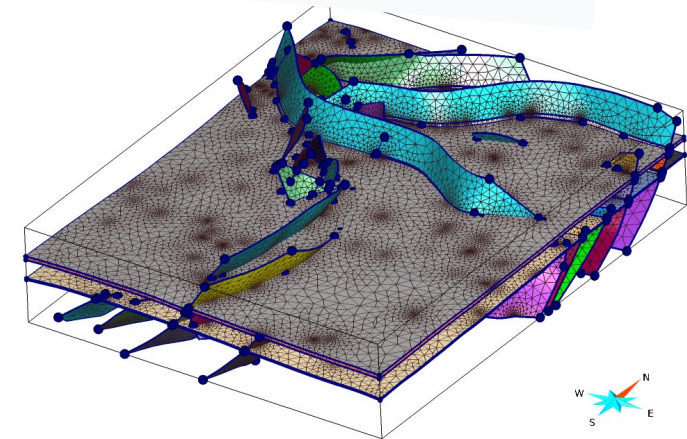
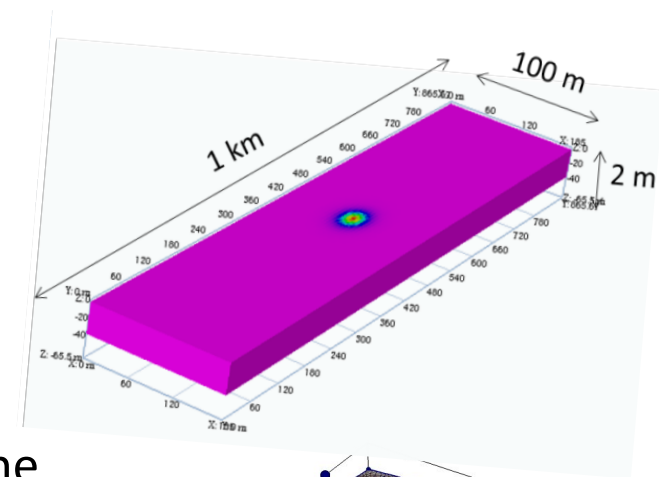
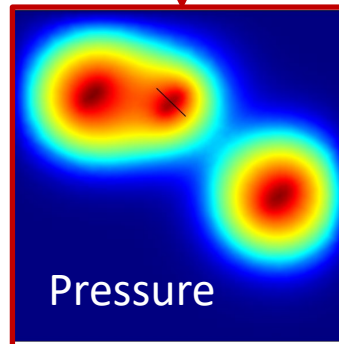
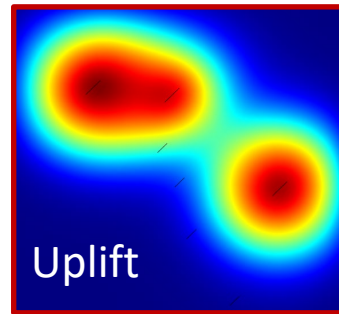


SENSE project narrative

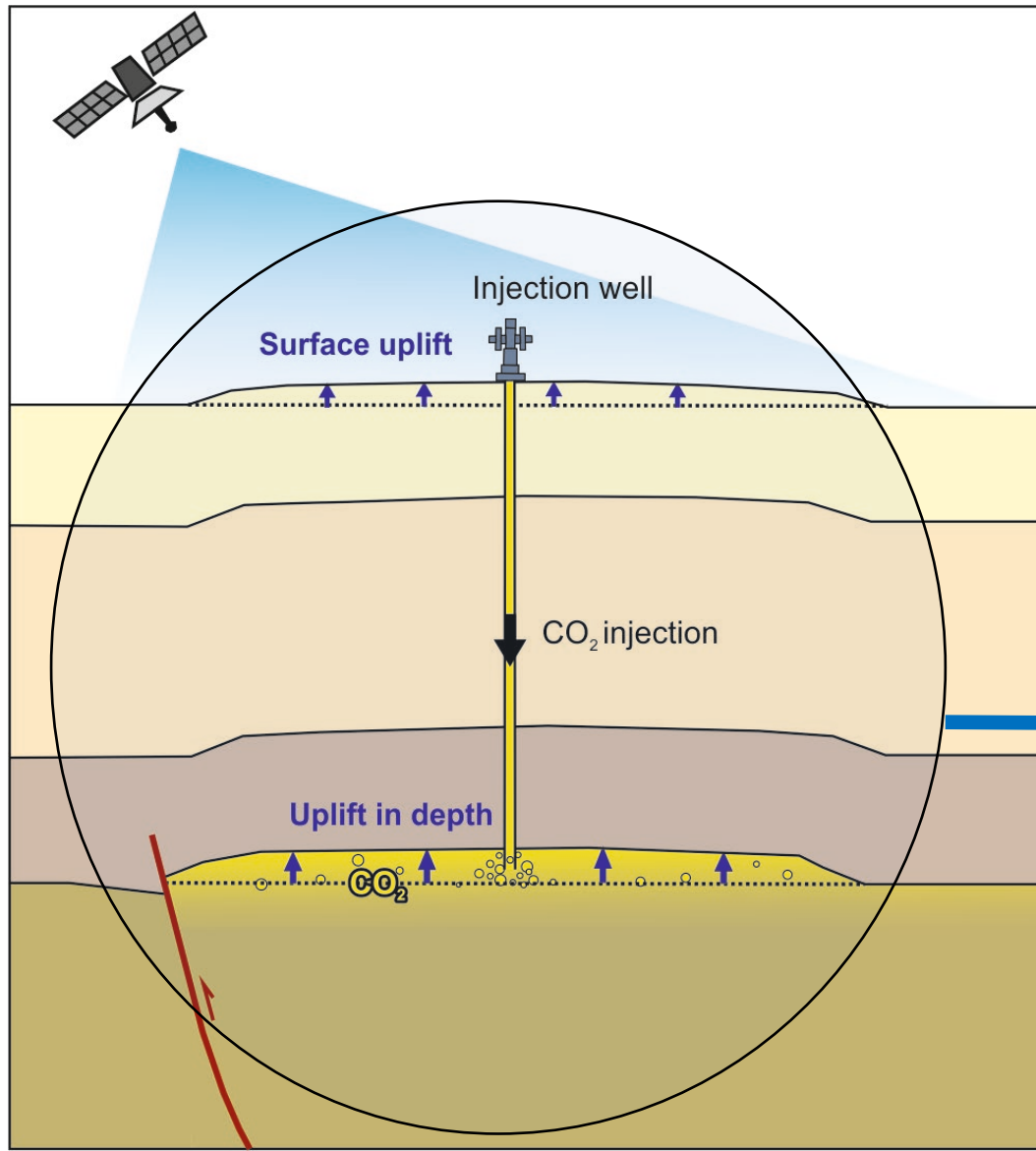
Numerical simulations



Inversion & Machine Learning

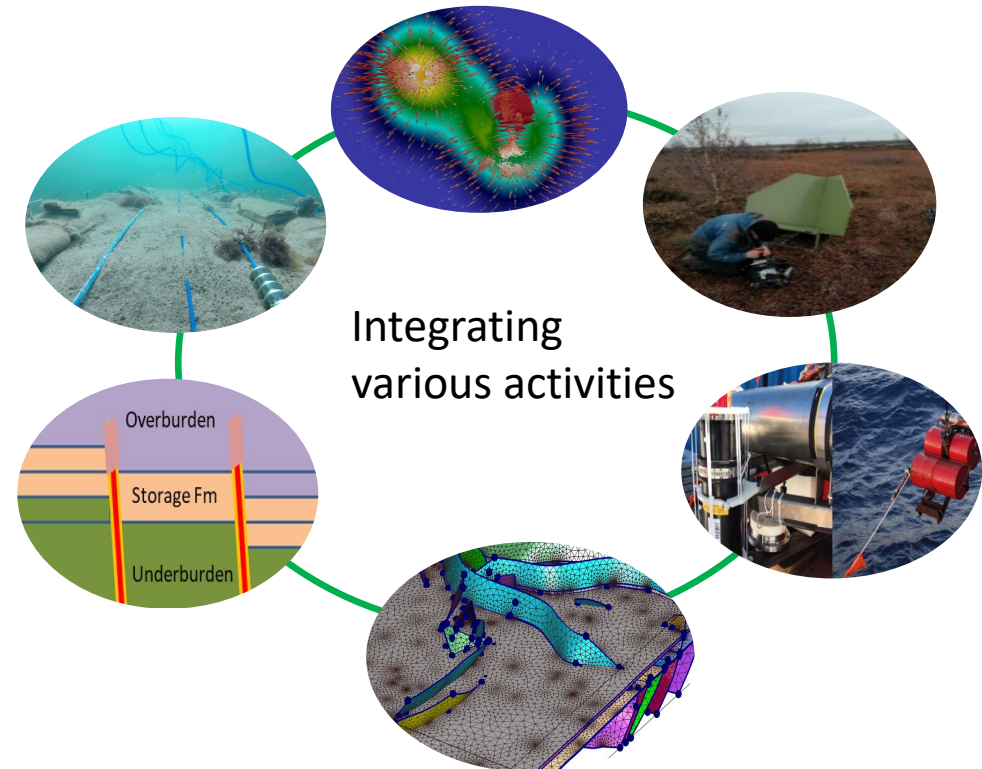


SENSE project narrative



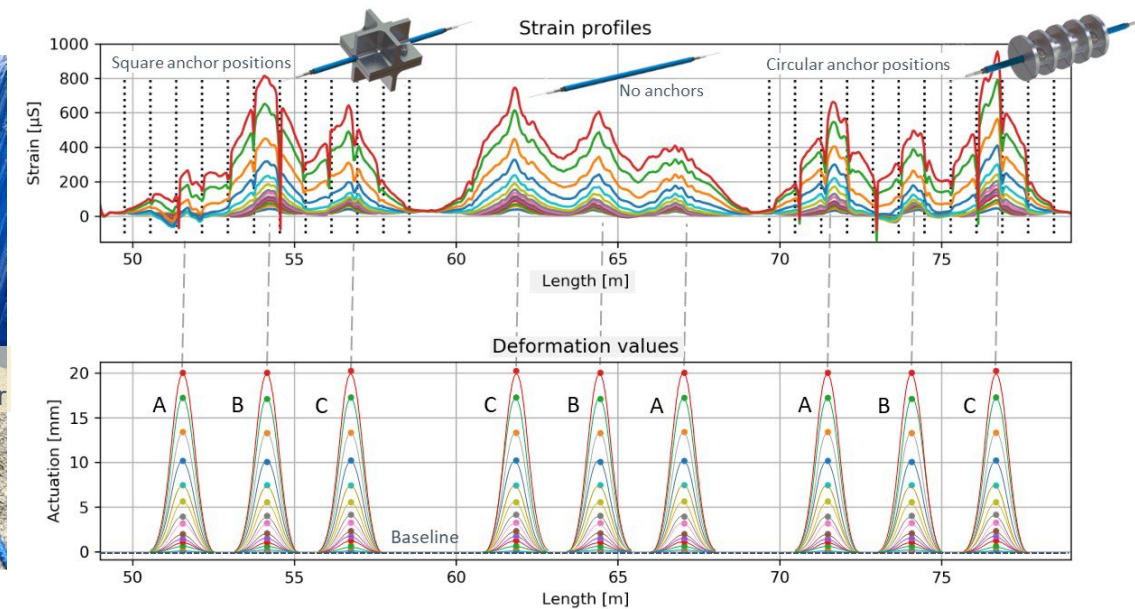
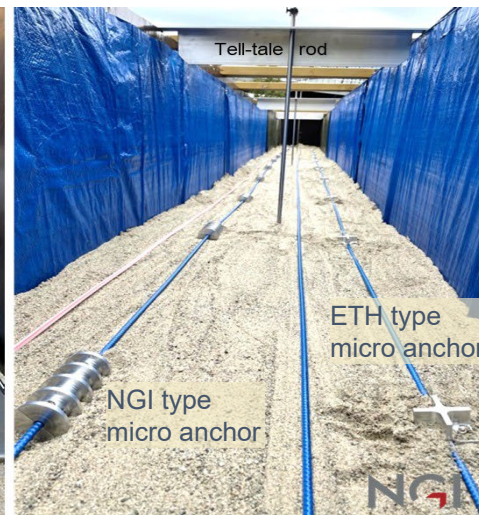
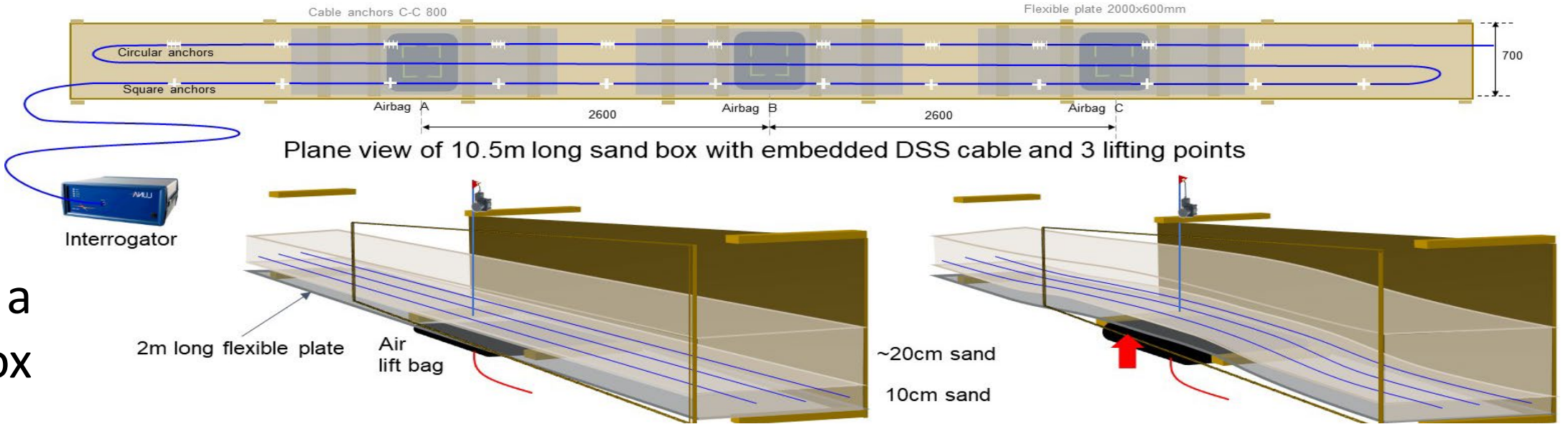
Integration (WP4)

Value of ground deformation for monitoring; tools, methodologies, etc.

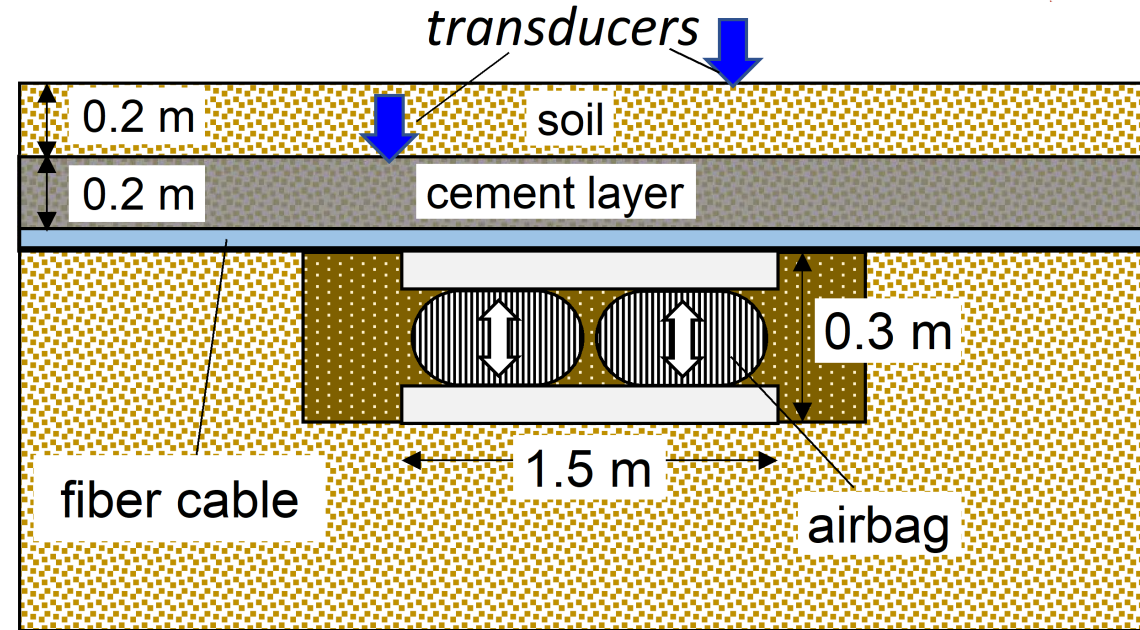


Q1: Advancing measurement techniques in lab (WP1)-Norway

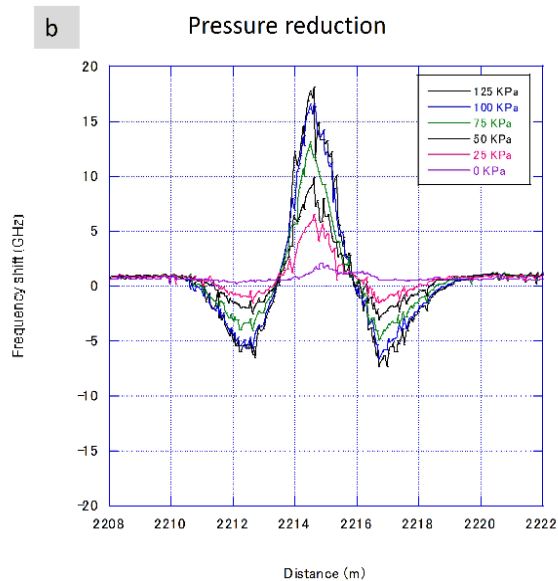
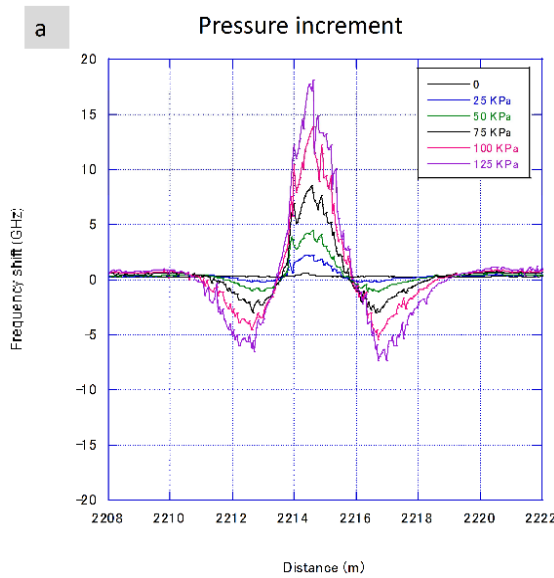
Large
scale
tests in a
sand box



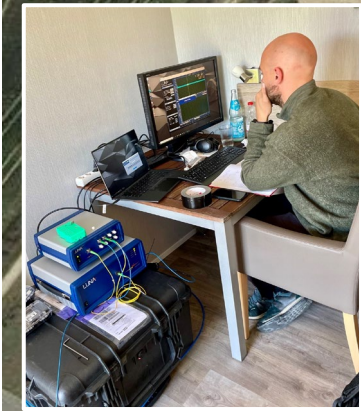
Q1: Advancing measurement techniques- field scale (WP1)-Japan



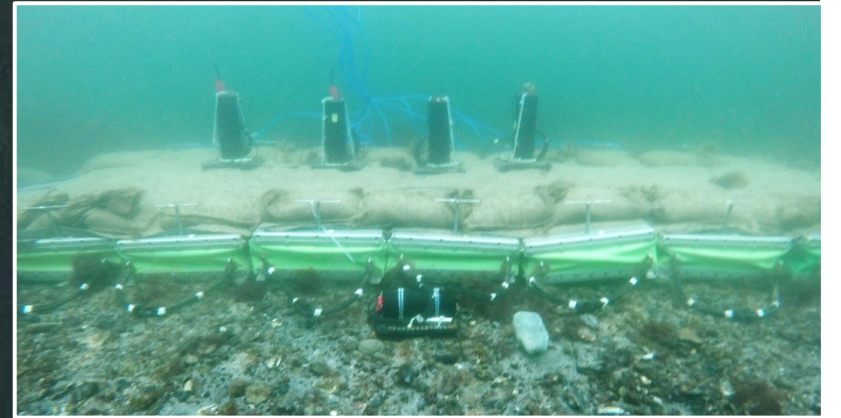
displacement transducers



Q1: Advancing measurement techniques in field (WP1)-Germany



Test area with adjustable "seabed"



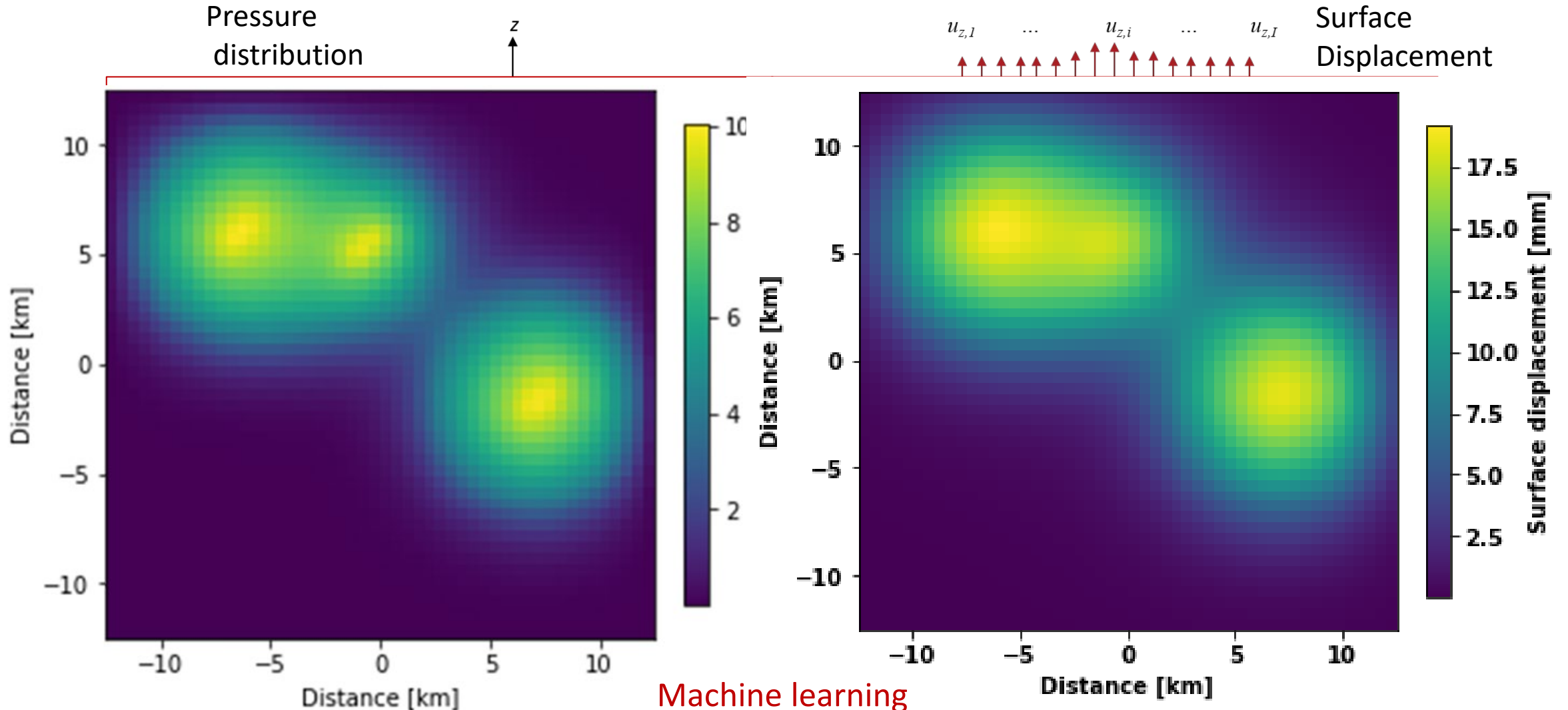
~300 m

Fiber optics cable test at Boknis Eck

Although nearshore tests were challenging, similar ground deformation sensitivity as in the sandbox was demonstrated.

Q2: How reservoir deformation is transferred to the surface? (WP2)

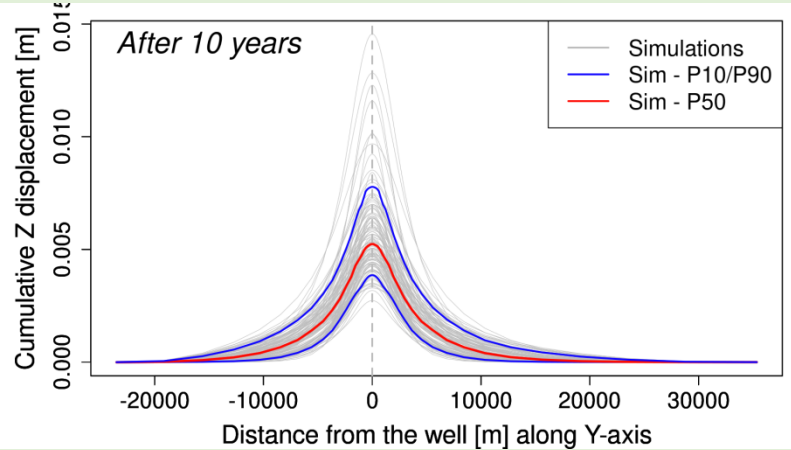
We introduced a new analytical solution (Geertsma Generalized Solution) published in Park et al. (2021)- *fast calculation method with good accuracy*



Q2: How reservoir deformation is transferred to the surface?

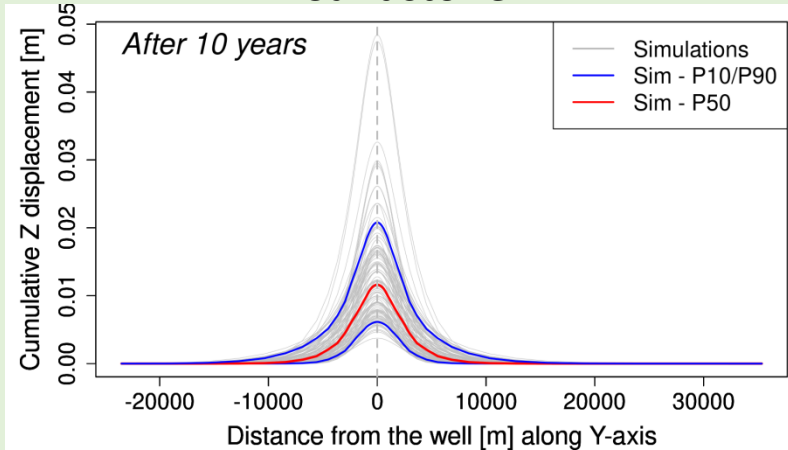
Numerical simulation of various types of reservoirs and uplift response

Carbonate



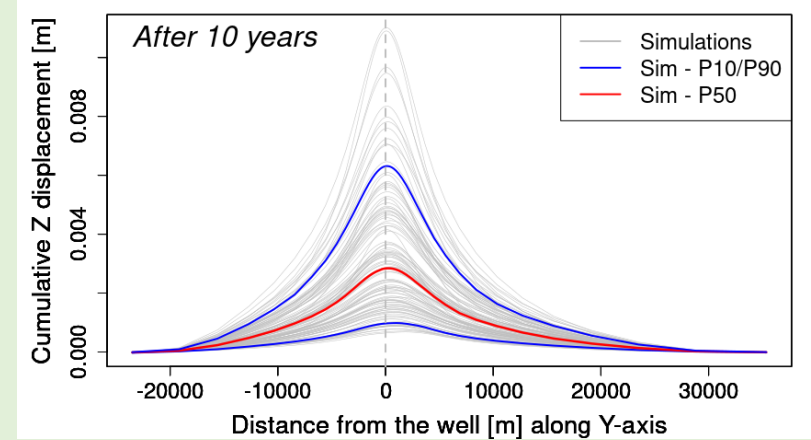
Uplift ca 2-15 mm in 10 years

Sandstone I



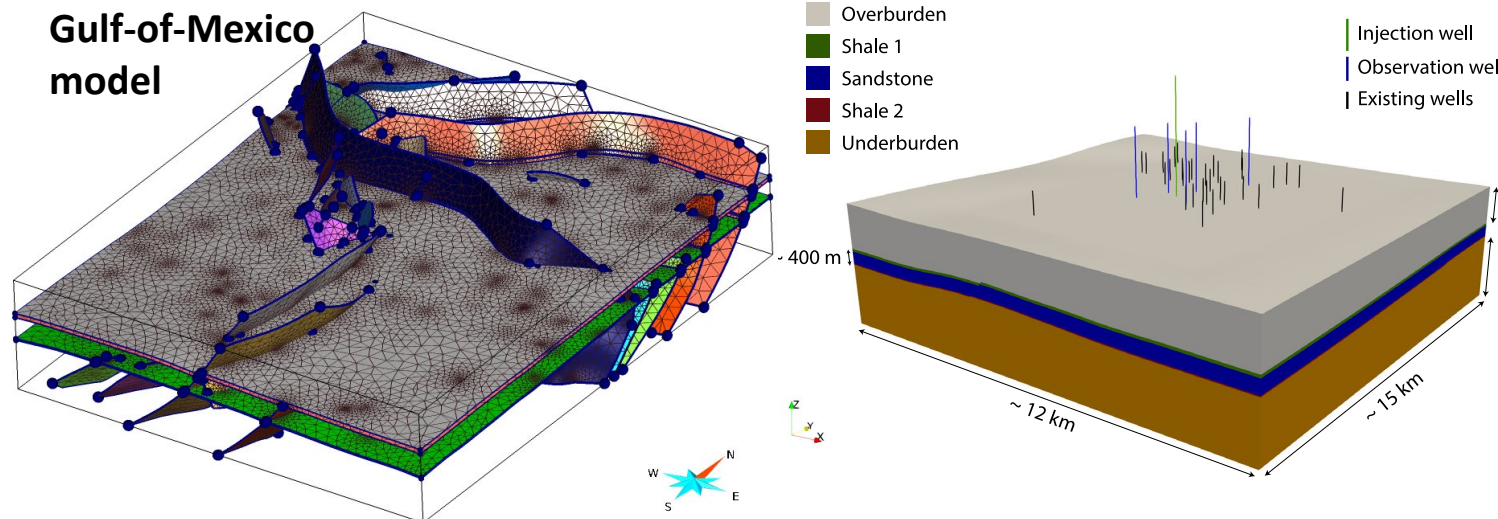
Uplift ca 5-50 mm in 10 years

Sandstone II

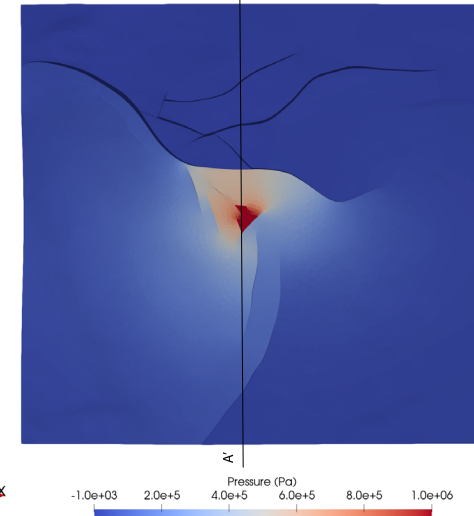


Max. uplift <10 mm in 10 years

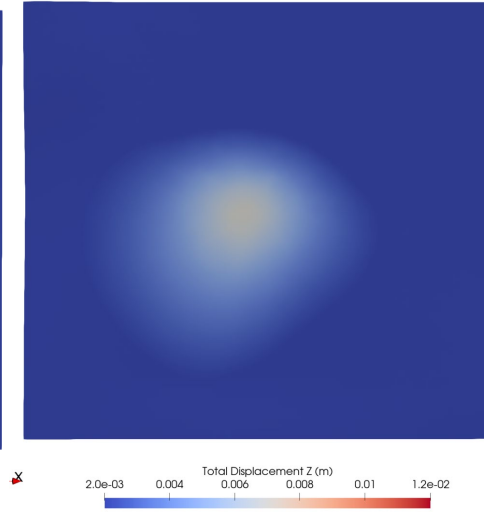
Gulf-of-Mexico model



Reservoir excess pressure

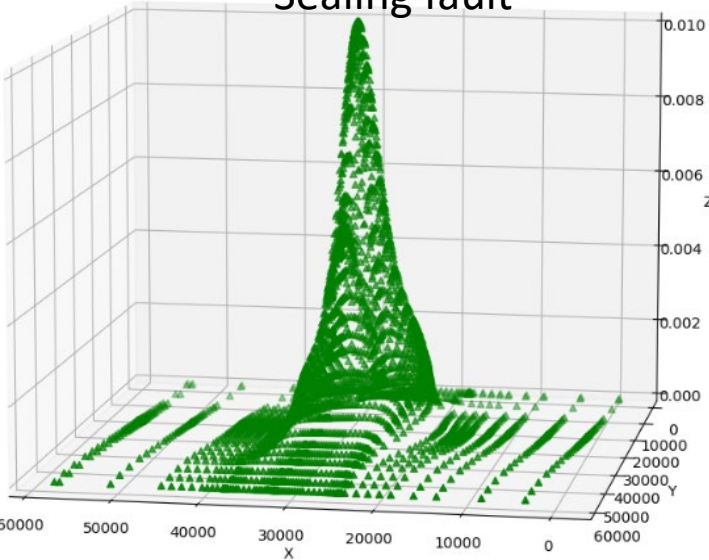


Seabed deformation

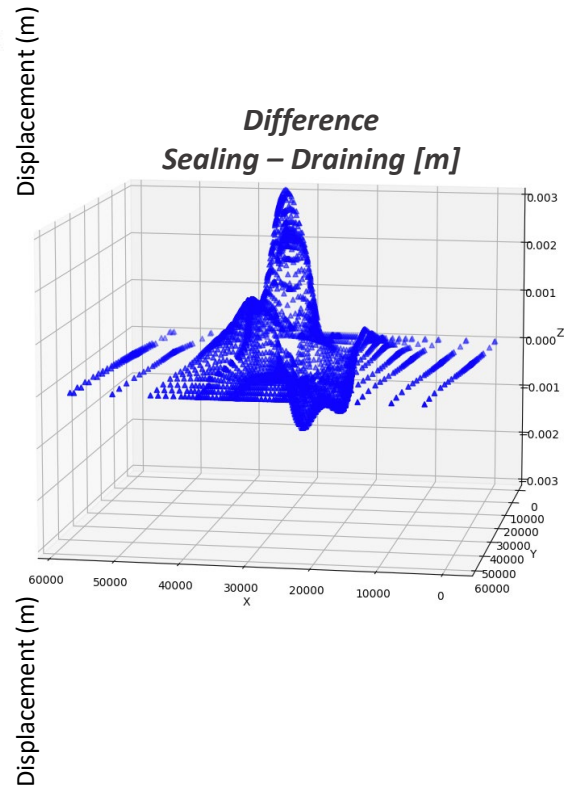
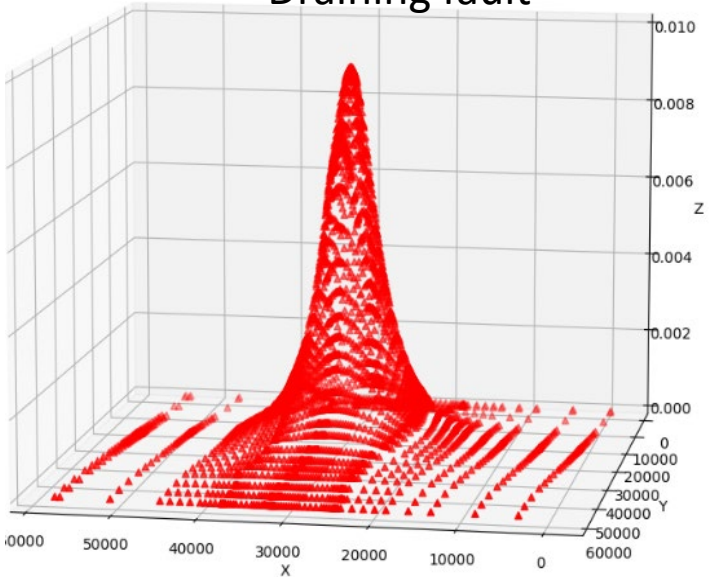


Q2: How reservoir deformation is transferred to the surface- Impact of faults

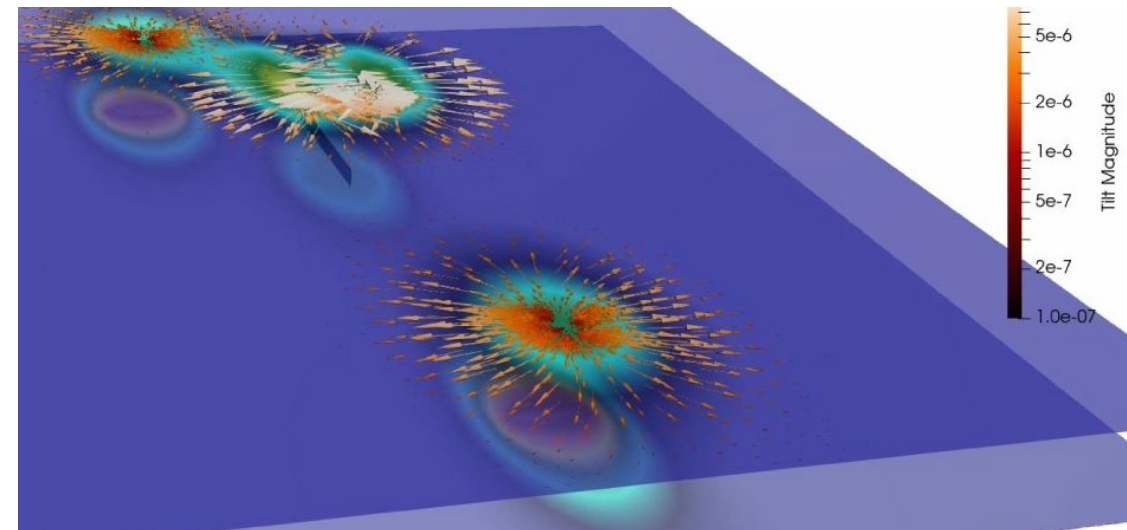
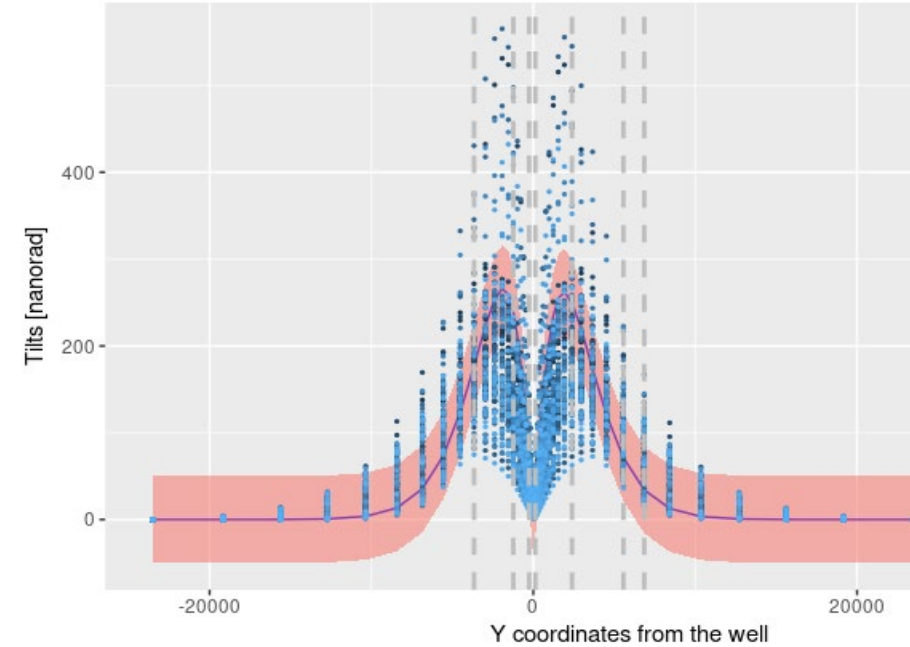
Sealing fault



Draining fault

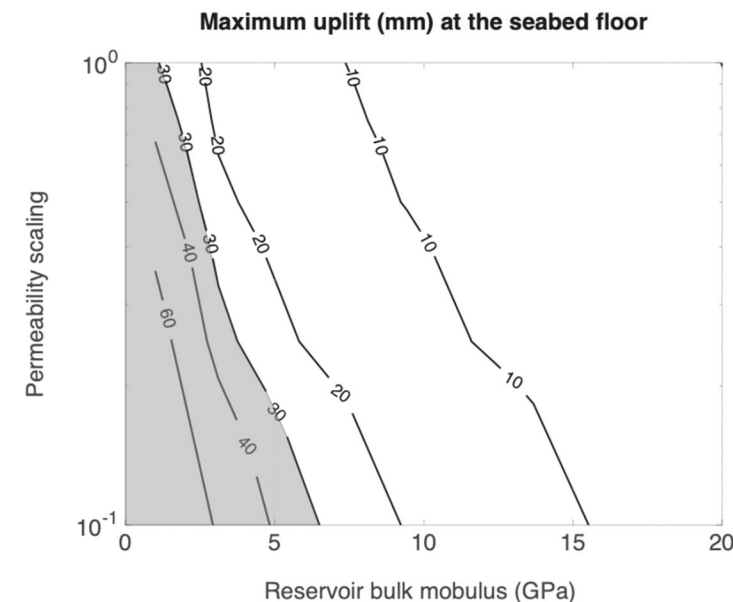
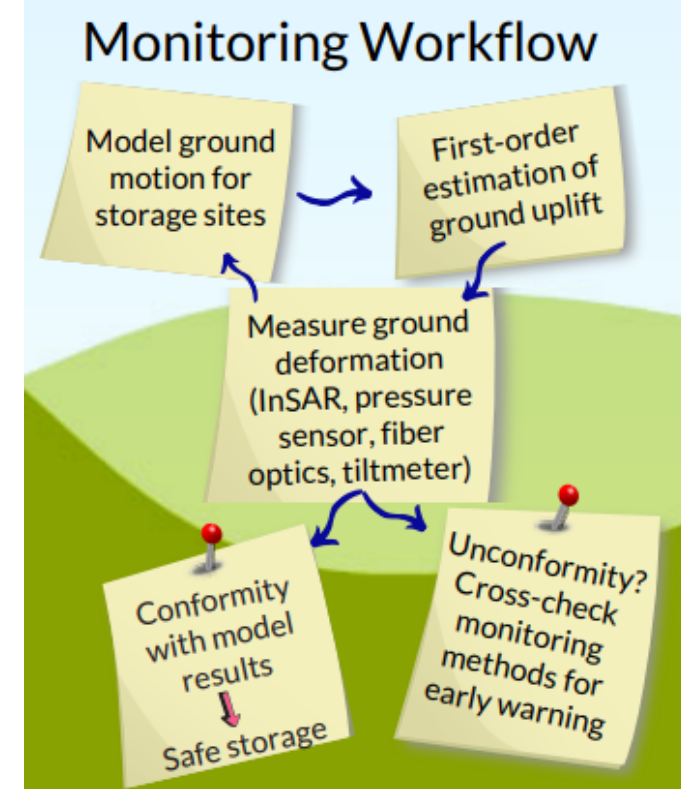


Optimize monitoring survey



Q3: Integration - Contribution to CO₂ storage monitoring

- Ground deformation as a cost-effective monitoring:
 - Offshore
 - Norwegian Continental Shelf (NCS): We have developed routines, codes and inversion techniques that work well to model & estimate deformation at Troll field. It will likely work for Northern Lights storage site too.
 - US Gulf Coast: Simulations that estimate deformation and uplift and suggest the range of deformation → *fiber optics may be more feasible* to monitor deformation
 - Onshore:
 - In Salah & UK analogue gas storage site, Hontomin: automatic InSAR processing → reduces monitoring cost, robust numerical simulations
 - Suggest tiltmeter for monitoring deformation hot spots
 - Integration of deformation with microseismic (MS & deformation are linked).



Dissemination activities

Deliverable	Quantity
Journal papers	6
Conference articles	25
Project reports	4
Outreach to industry, the public, Professional societies, regulators	24
Total	59

Collaboration with ACT projects: DIGIMON, ACTOM (joint meetings, plan for joint events during 2022)

Actualidad

DETALLES POR PROFESIONALES DE PRESTIGIOSAS UNIVERSIDADES EUROPEAS Y ORIENTALES

Con gran éxito culminó en Los Queñes taller de Geología

Compliendo con las medidas sanitarias, Evento logró congregarse a miembros de la comunidad, organizaciones locales, visitantes y personal de la Osmi.




El taller se realizó en un espacio al aire libre, donde se abordaron temas de geología y monitoreo de sitios de almacenamiento de CO2. Los participantes, que incluyeron a miembros de la comunidad local y personal de la Osmi, disfrutaron de una jornada de aprendizaje y networking.



2022-01-11

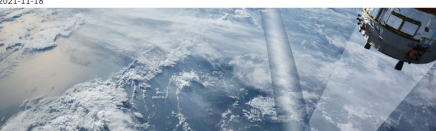
Assuring integrity of CO₂ storage sites through ground surface monitoring (SENSE)



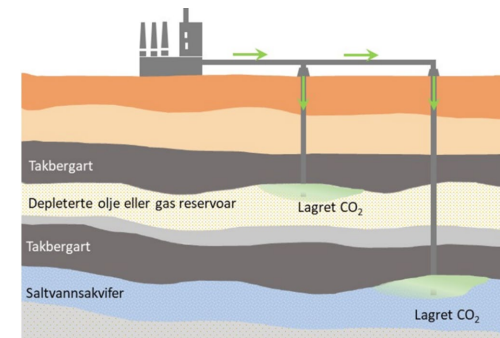
SENSE the surface to manage subsurface

SENSE has held its first webinar

2021-11-18



SENSE webinar no 1: InSAR data and theoretical aspects



Accelerating CCS Technologies

Monitoring CO₂ Storage Sites SENSE Webinar #2 - 25 January 2022

a) Ground deformation monitoring using fiber optics
By Dr Zhiu Xue, Chief Researcher, Research Institute of Innovative Technology for the Earth (RIITE, Japan), General Manager (Technical Division), Geological Carbon Dioxide Storage Technology Research Association

b) Ground deformation monitoring onshore and offshore
By Mr Per Sparrevik, Technical Expert (Norwegian Geotechnical Institute (NGI - Norway) and Dr Jens Karlens, Posiboc Researcher, GEOMAR (Germany)

Event Information:
When: 25 January 2022 at 11:00-12:00 Central European Time (CET)
Where: Online via Teams
Registration via link:
Welcome to join us and hear about the latest advances on CO₂ storage site monitoring & SENSE project <https://zenodo.org/>

Accelerating CCS Technologies

Monitoring CO₂ Storage Sites SENSE Webinar #3 - 18 February 2022

a) Hydro-mechanical simulation of ground deformation due to fluid injection - synthetic cases
By Dr Sarah Bouquet, Research Engineer, IFPEN - France, Geoscience Division

b) Seismicity monitoring at onshore CO₂ geological storage sites
By Dr Almudena Sánchez de la Muela, researcher, Fundación Ciudad de la Energía - CIUDEN, Spain

Event Information:
When: 18 February 2022 at 11:00-12:00 Central European Time (CET)
Where: Online via Teams
Registration via link:
Welcome to join us and hear about the latest advances on CO₂ storage site monitoring & SENSE project <https://zenodo.org/>



EAGE

14th October 2021 – Carbon Capture and Storage

Carbon Capture and Storage in Norway - a geomechanics perspective

By Bahman Bahli and Elin Skurtveit (Norwegian Geotechnical Institute)

Online meeting with dinner afterwards in Prague office of Seditek s.r.o.

Event Information:
When: 14th October 2021 at 16:30 Central Euro Time (CEST)
Where: Online and in Prague (Seditek s.r.o., Kubusova 8, Prague)
Zoom Meeting ID: 850 8360 2205 | Passcode: 321650

Fortell om din forskning!

FORMIDLINGS-KONKURRANSEN 2022





Acknowledgement

SENSE

<https://sense-act.eu>

CLIMIT



SENSE (Assuring integrity of CO₂ storage sites through ground surface monitoring) project No. 299664, has been subsidized through ACT (EC Project no. 691712) by Gassnova, Norway, United Kingdom Department for Business, Energy and Industrial Strategy, Forschungszentrum Jülich GmbH, Projektträger Jülich, Germany, The French Agency for the Environment and Energy Management, The United States Department of Energy, and State Research Agency, Spain. Additional support from Equinor and Quad Geometrics and permission to use data from the Krechba Field by In Salah Gas JV are appreciated. Scientific Advisory Board of SENSE (Giovanni Bertotti-TU Delft, Lyesse Laloui-EPFL, Vit Hladik-Czech Geological Survey) is acknowledged.

