UiO-NGI CCS Seminar

28 Nov 2022

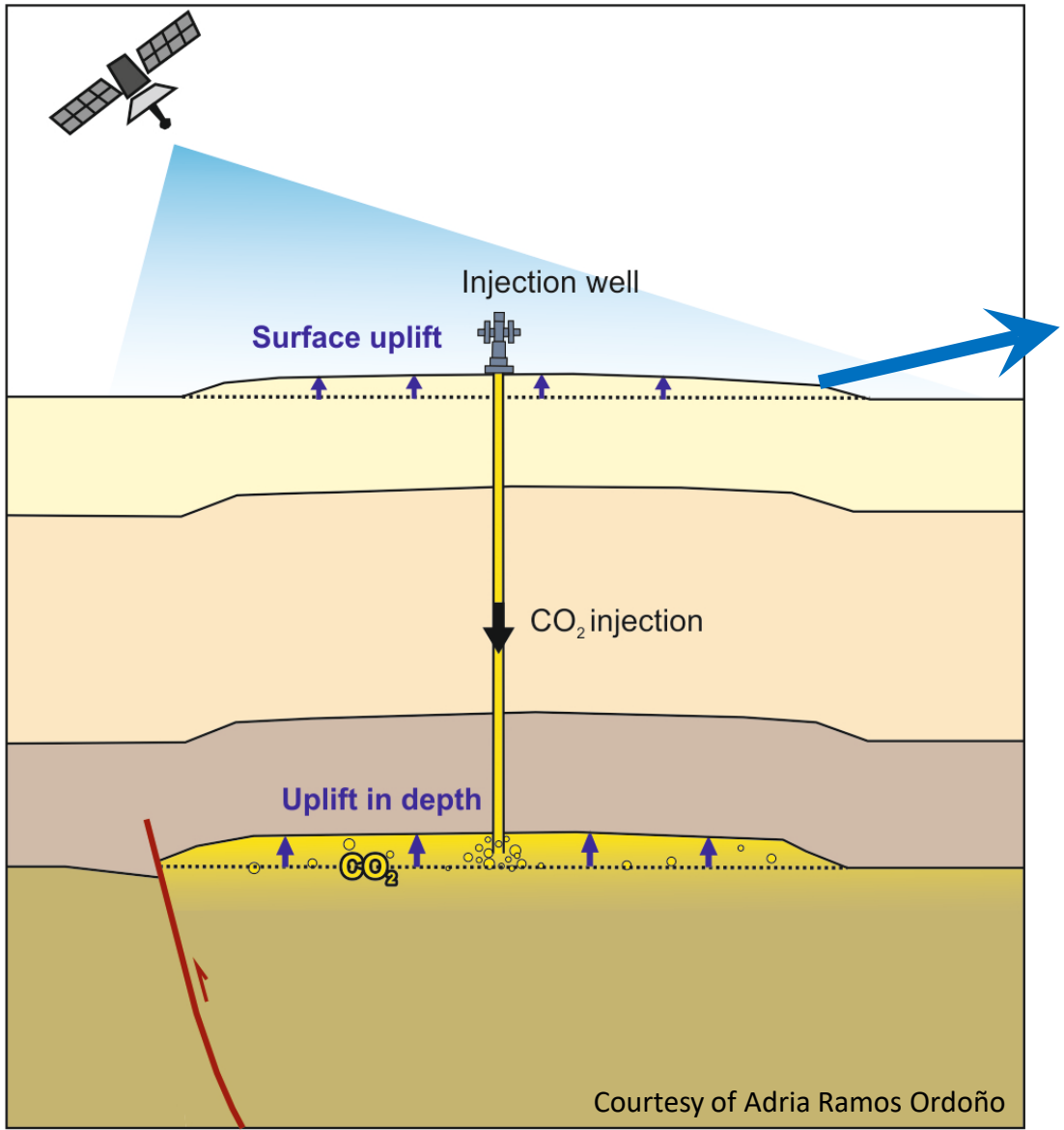
https://sense-act.eu/

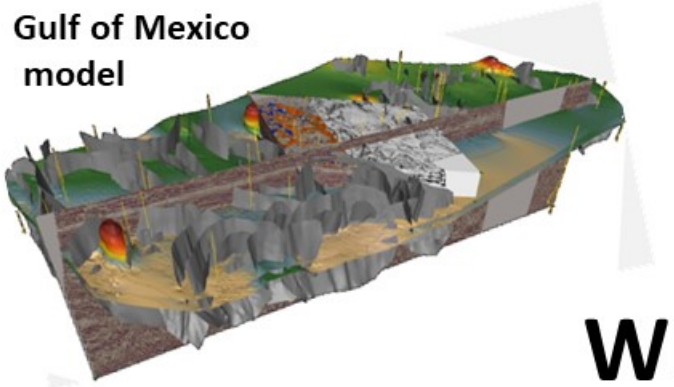
ACT2: 2019- 2022

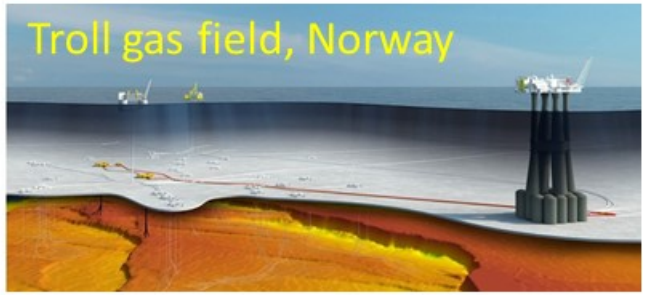
Value of ground deformation for geomechanical monitoring of CO_2 storage site

Bahman Bohloli, Joonsang Park and the SENSE Team

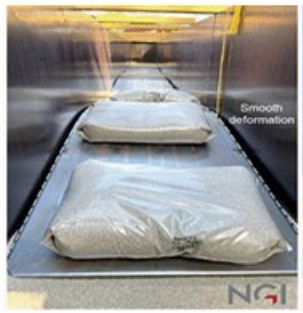
SENSE project narrative (1)



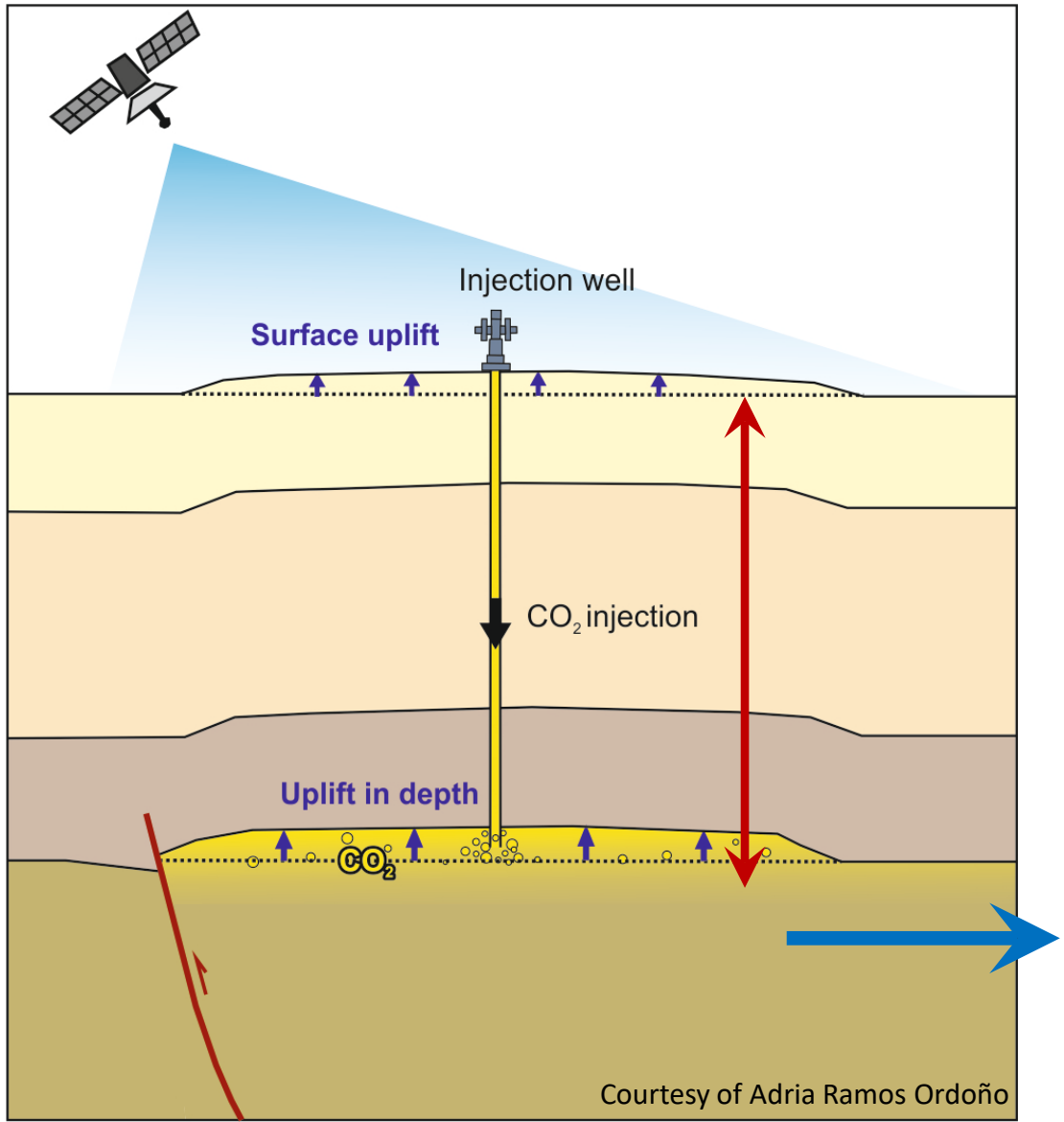




WP1

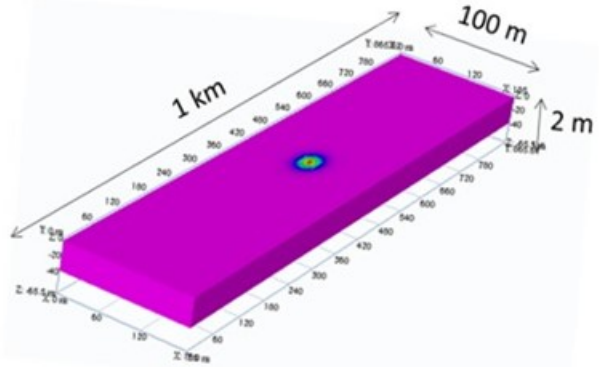


SENSE project narrative (2)

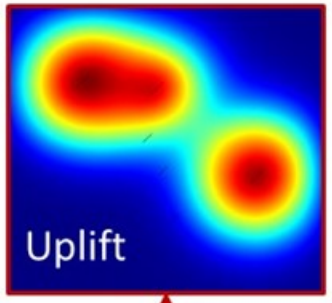


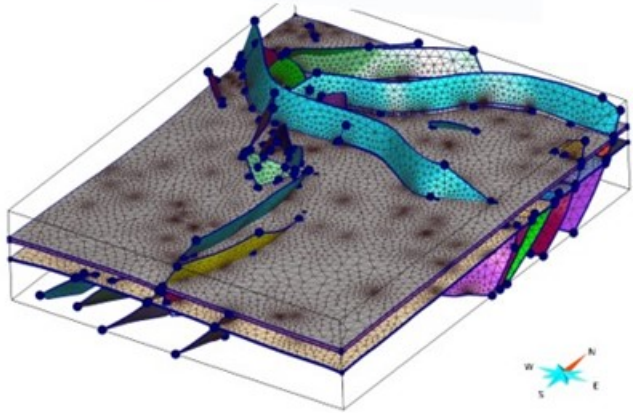
Numerical simulations & inversion studies

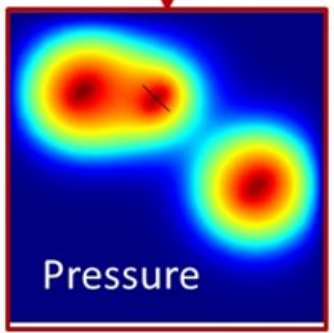
WP2 & 3

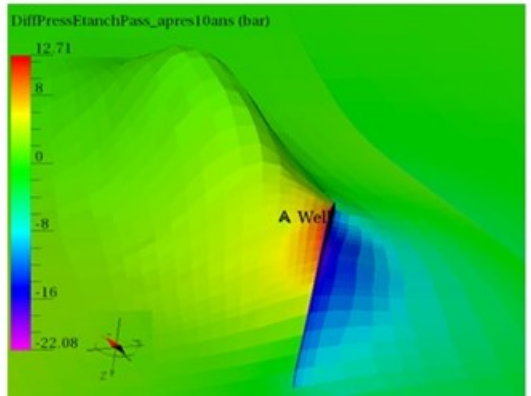


Inversion & Machine Learning

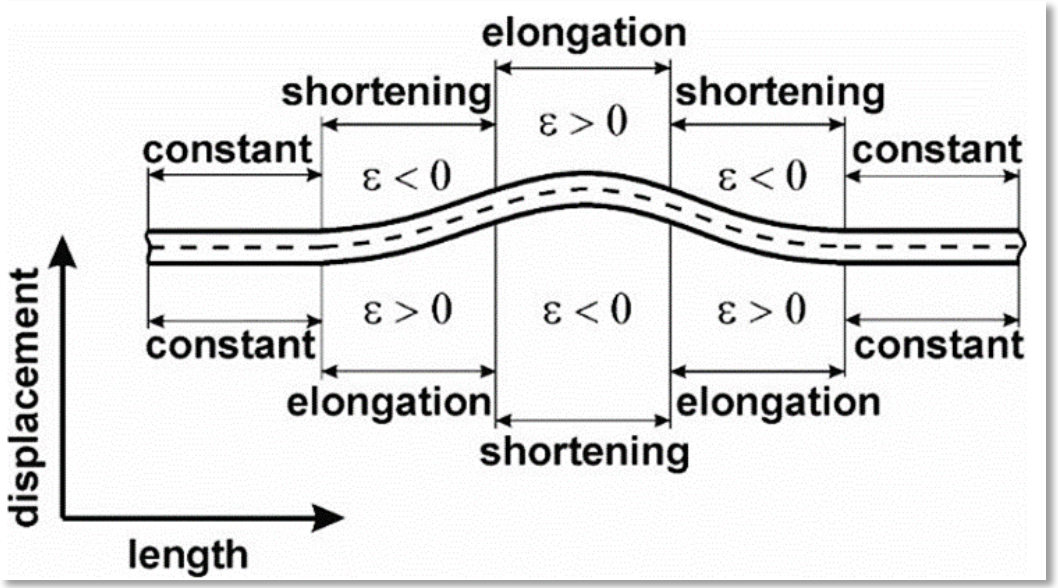




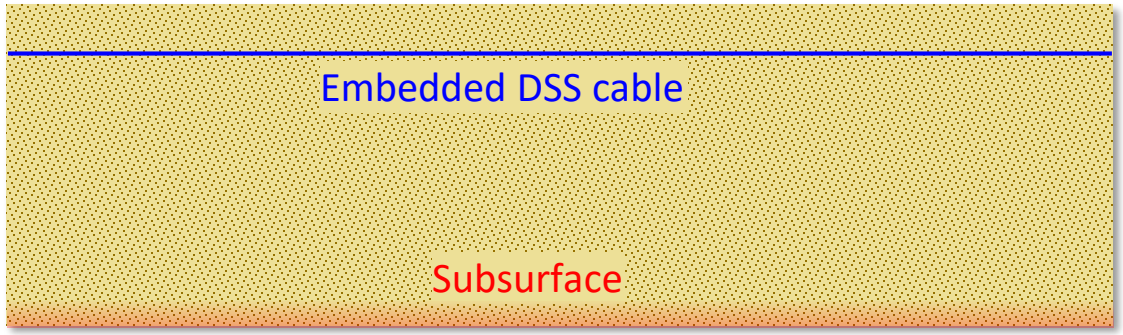




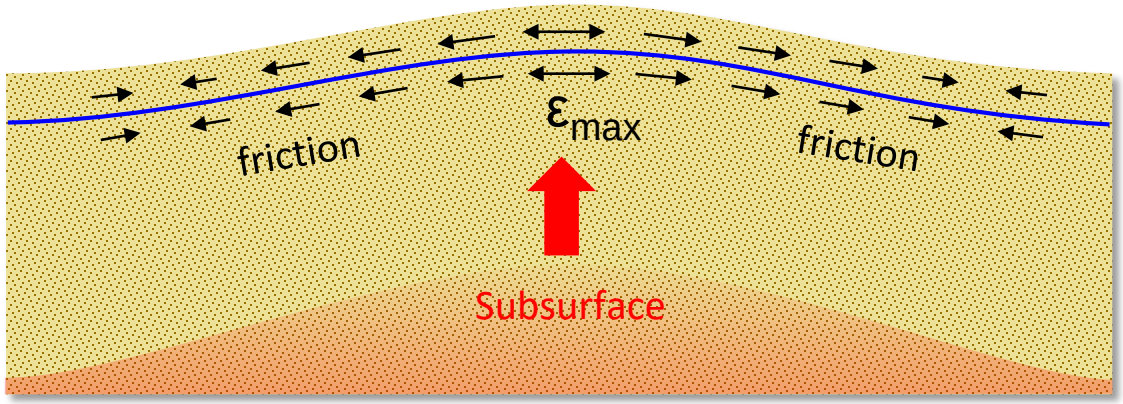
Principle of deformation measurement by Distributed Strain Sensing (DSS) fiber optic cables



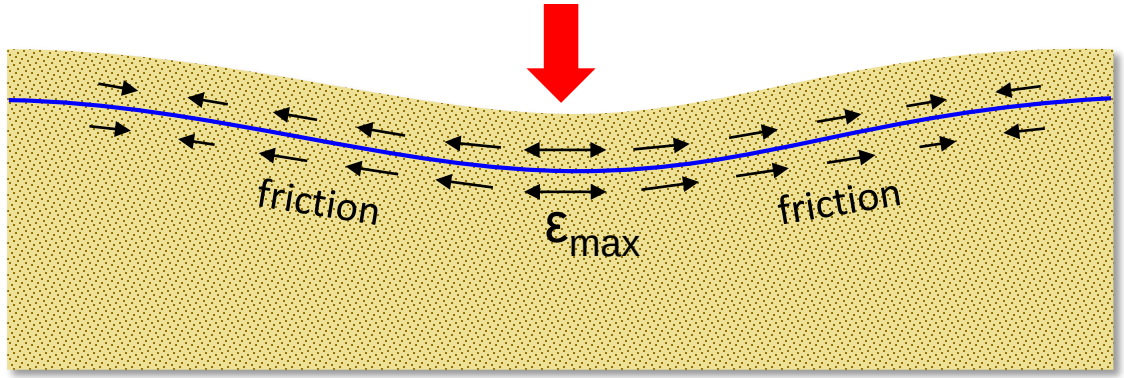
Baseline



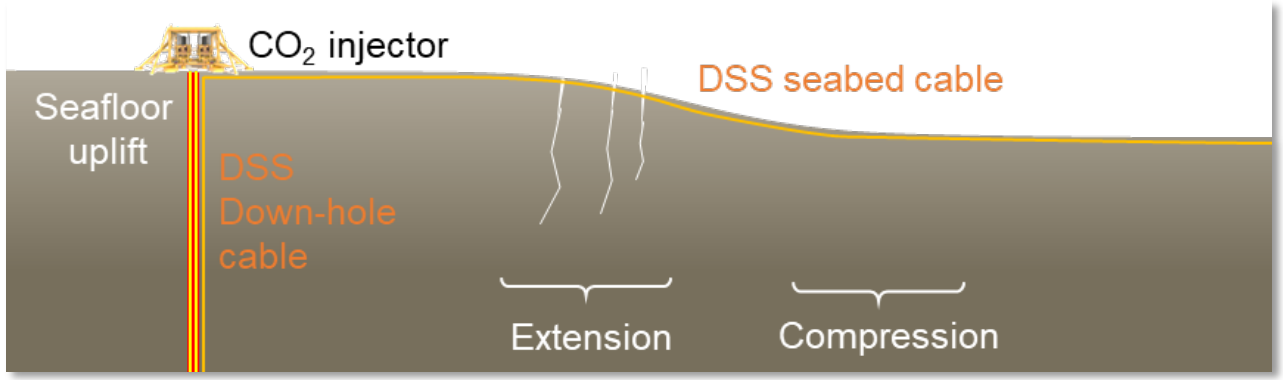
Ground Uplift



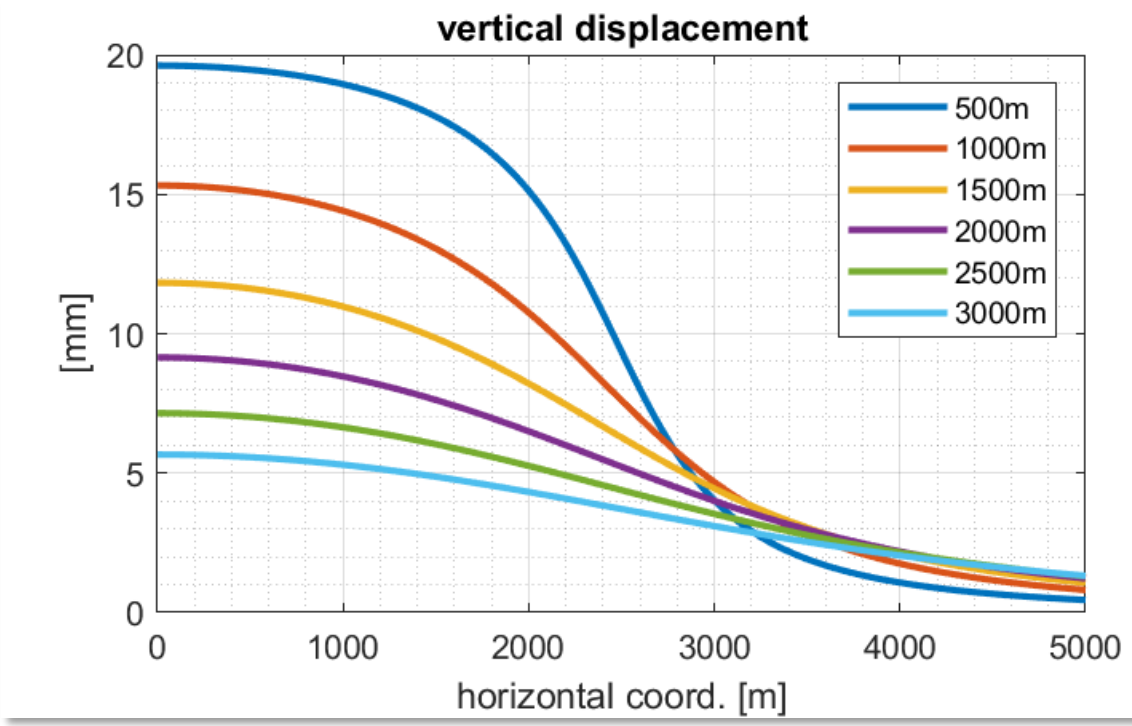
Subsidence/Settlement

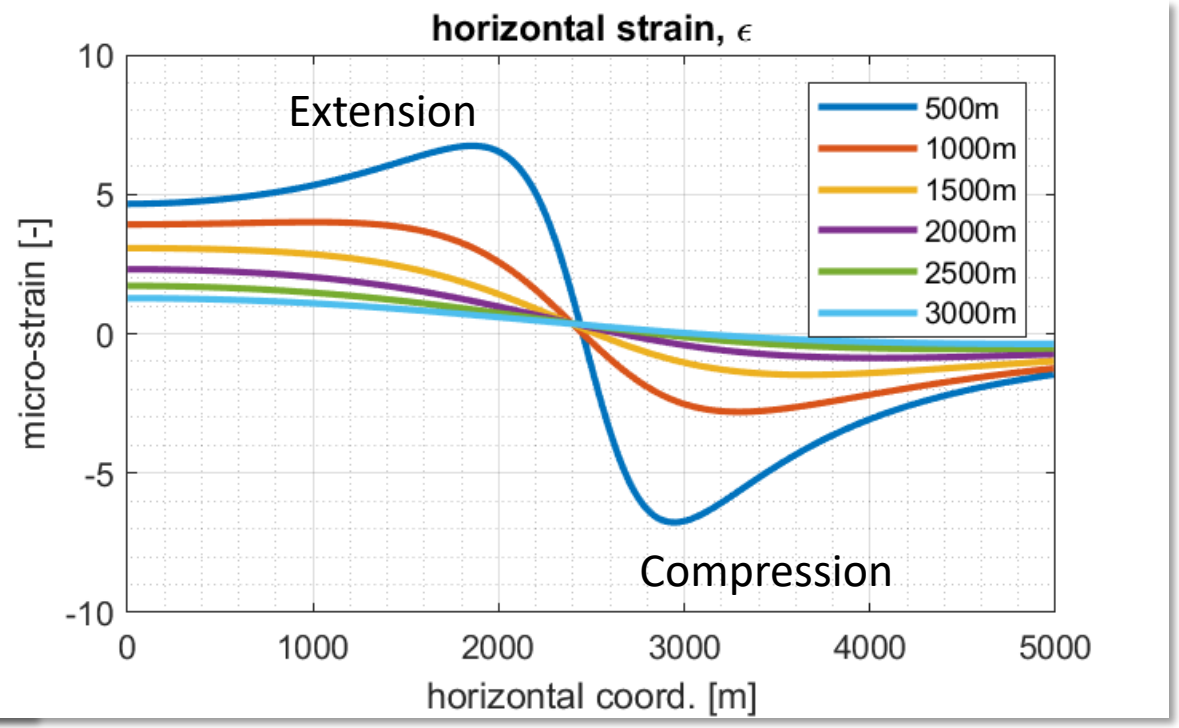


Estimation of seabed deformation



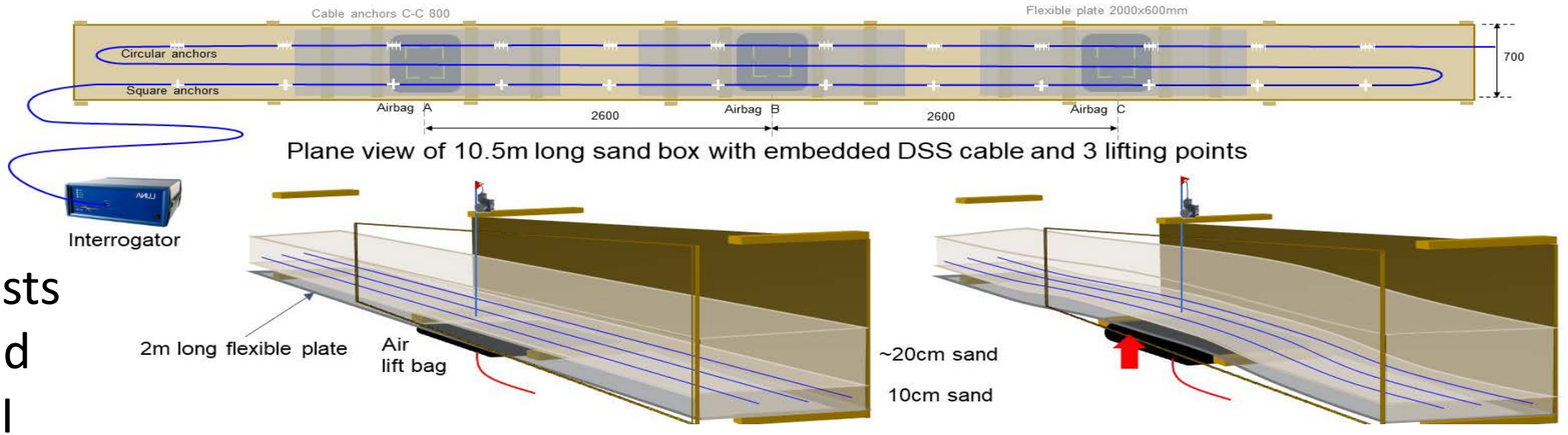
Vertical seabed displacement and horizontal strain calculated for a **100m thick 1 MPa pressure anomaly** with **2500m radius** at different reservoir **depths (500-3000m):**

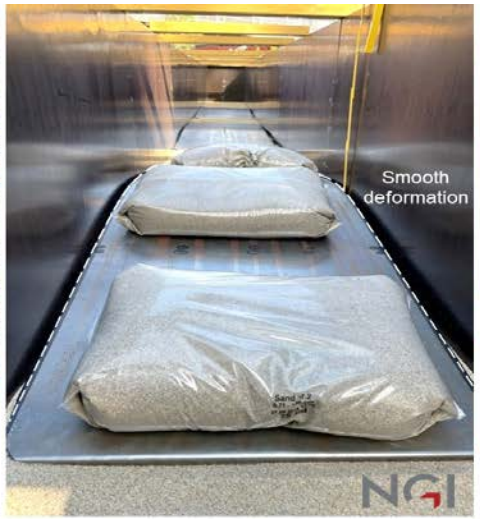


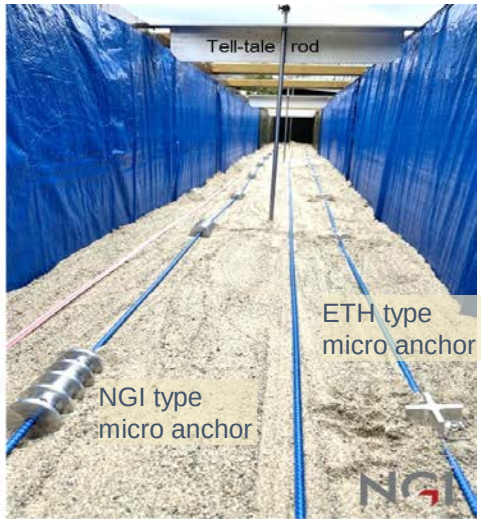


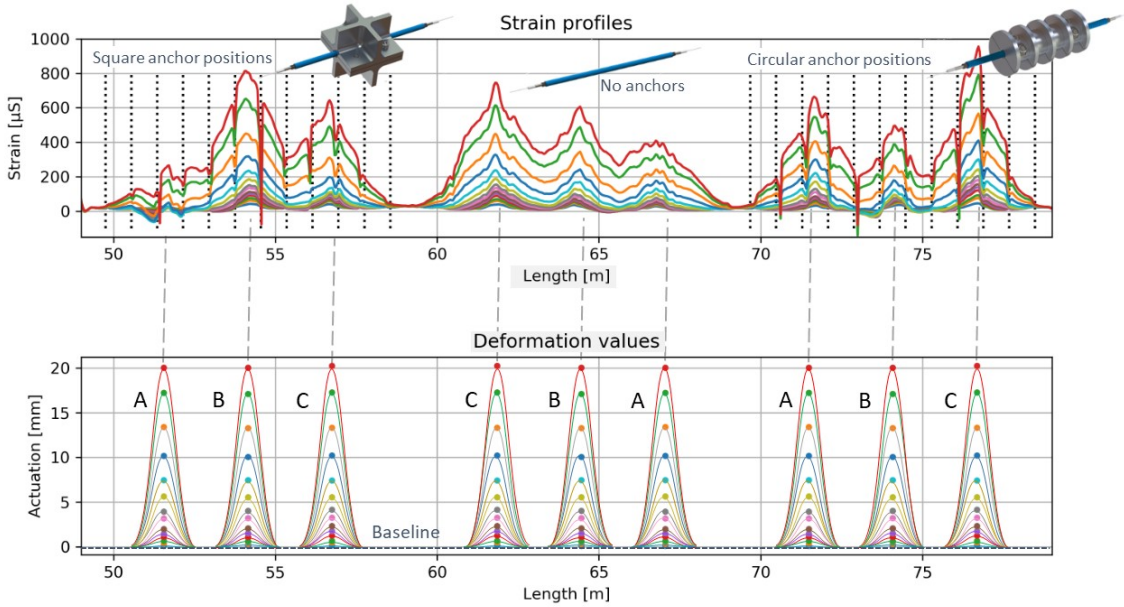
Advancing measurment techniques in lab (WP1)-Norway

Large scale tests in a sand box-NGI









Advancing measurment techniques in nearshore (WP1)-Germany

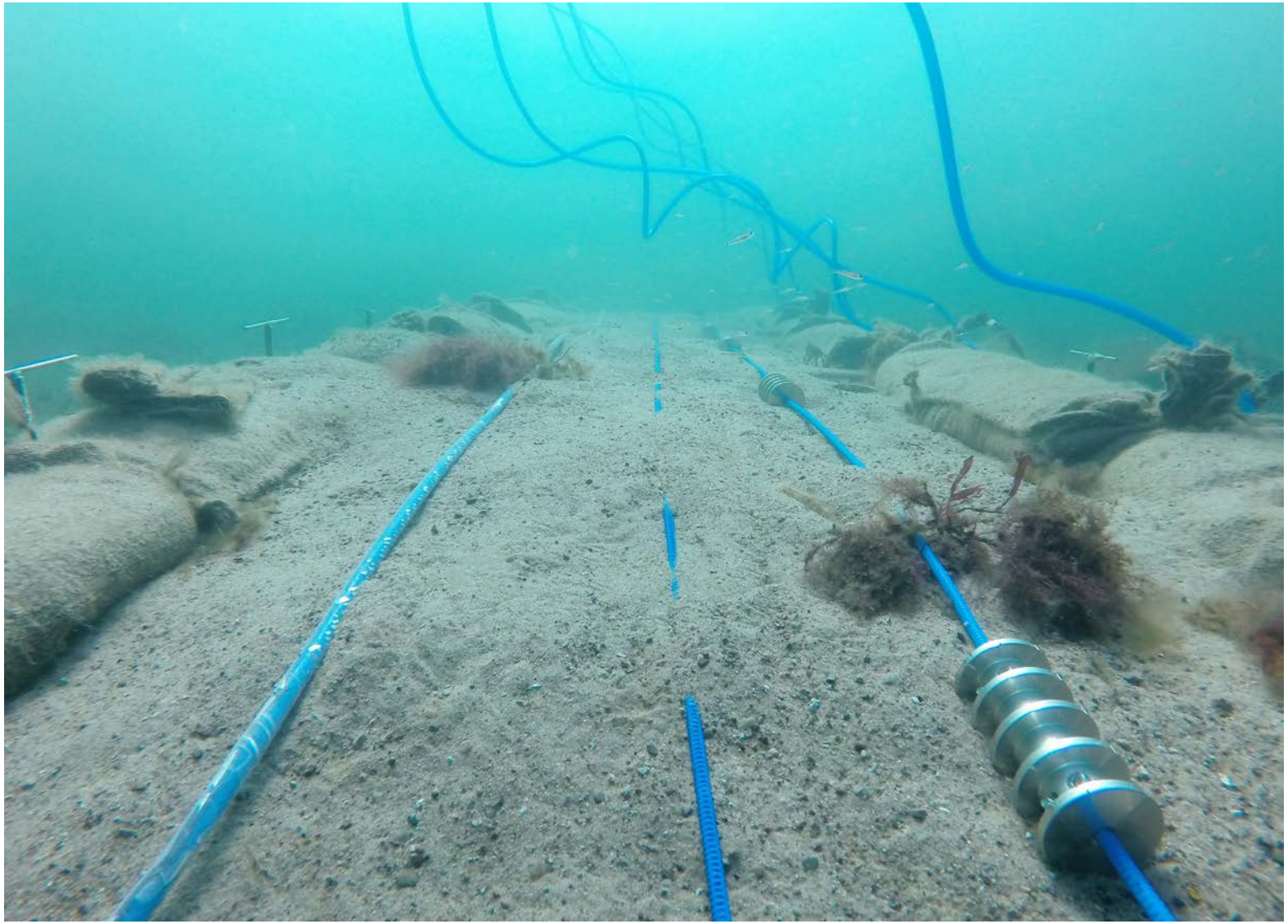
~300 m

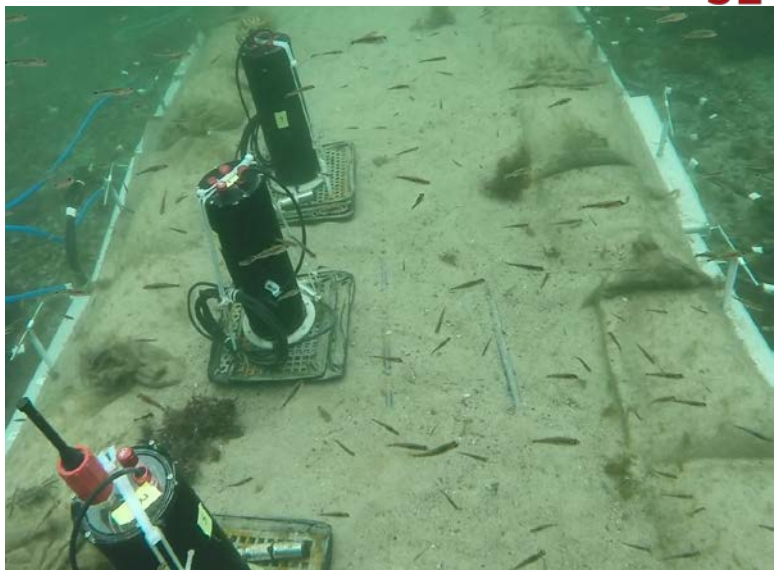
~300 m

Test area with adjustable "seabed"

Fiber optics cable test at Boknis Eck

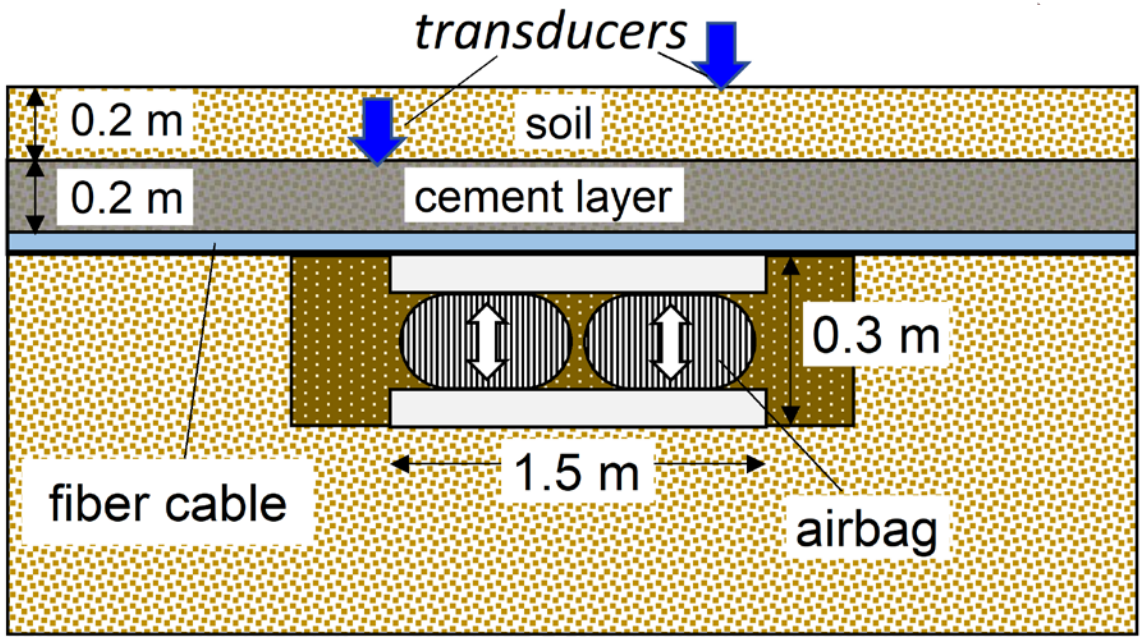
Strain sensing fiber optic cable tests at Boknis Eck, Germany

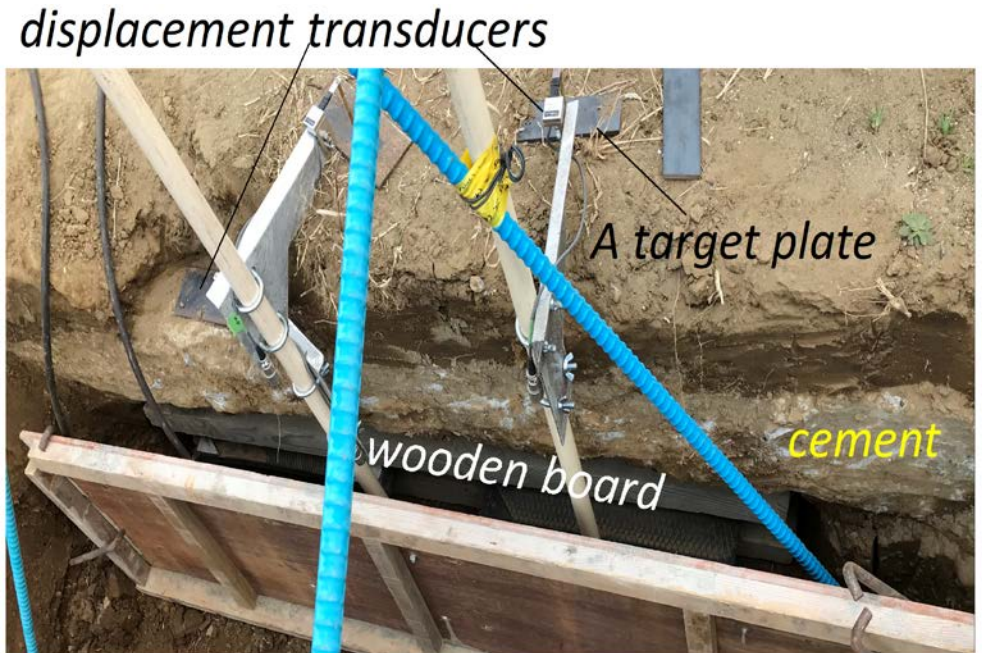


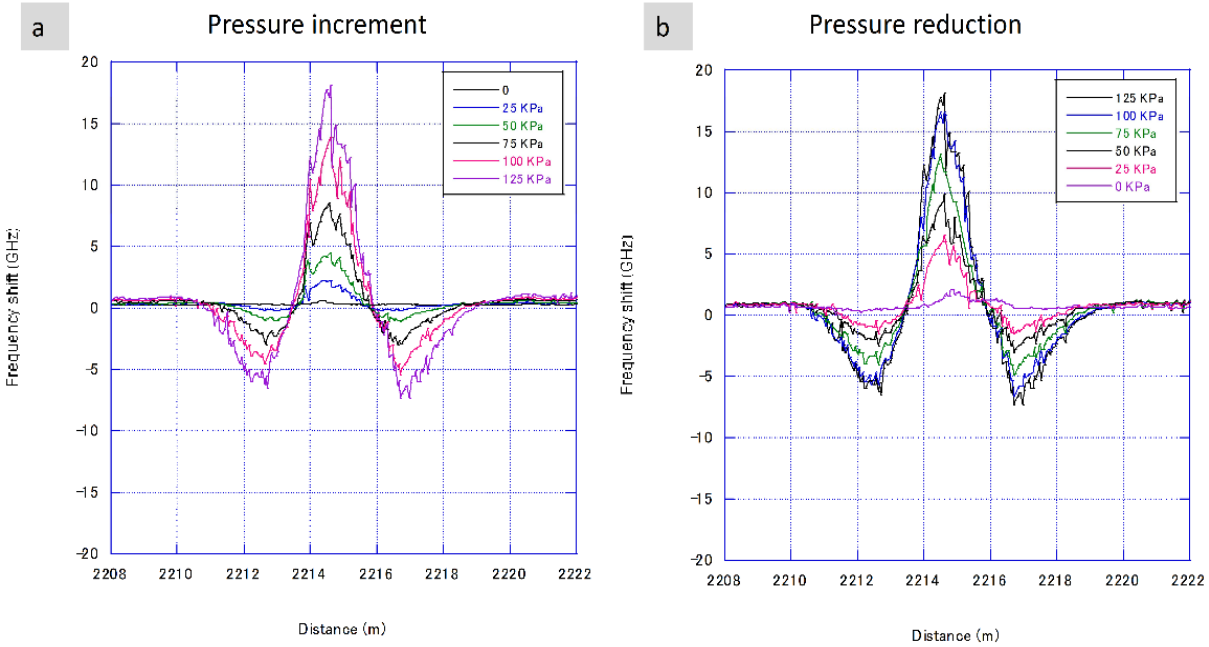


Although nearshore tests were challenging, similar ground deformation sensitivity of micro-strain was demonstrated.

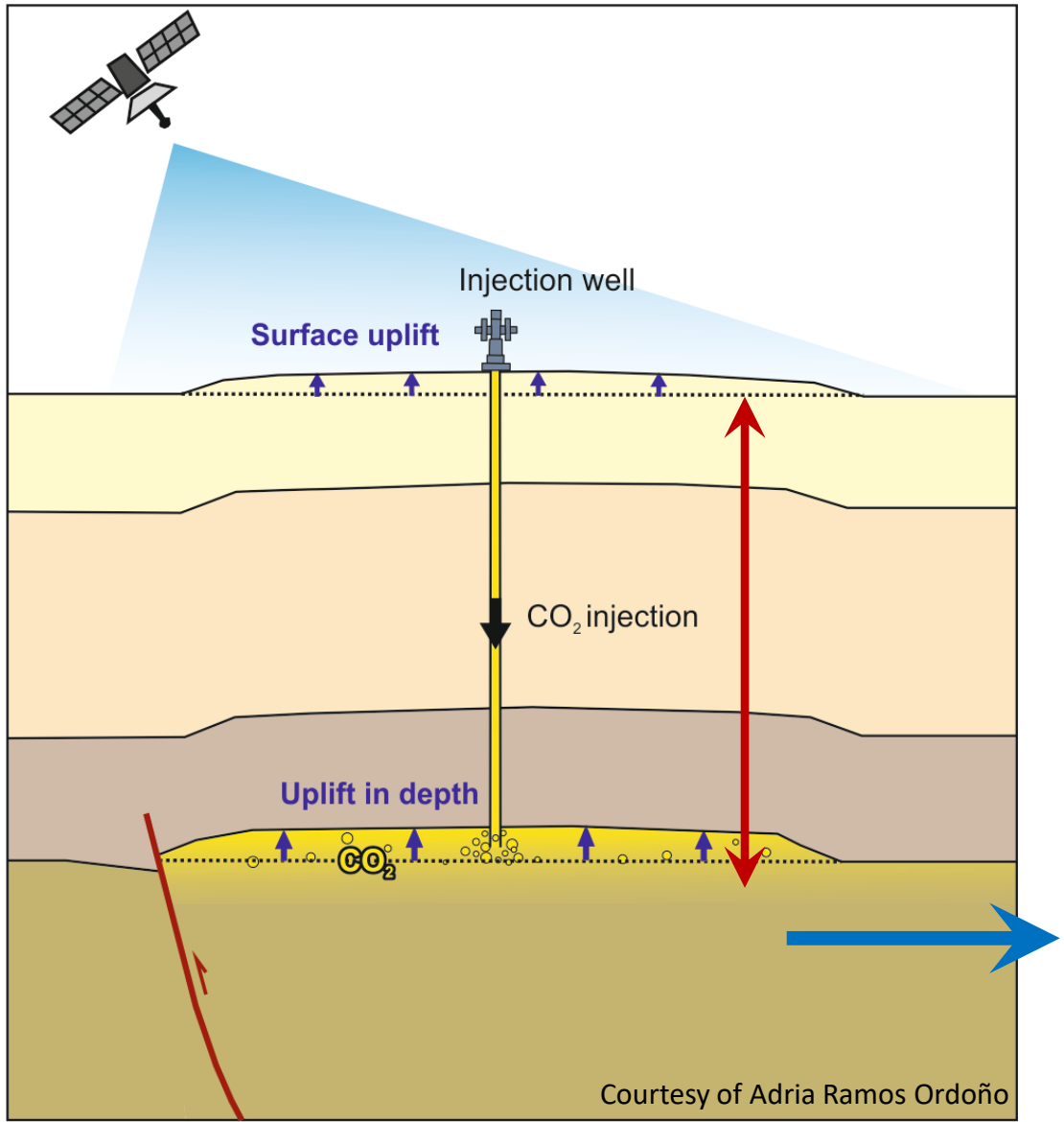
Advancing measurment techniques- full scale tests in Japan





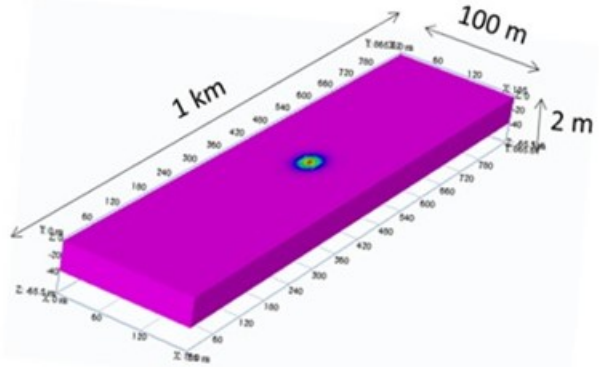


SENSE project narrative (2)

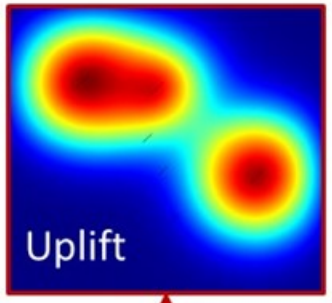


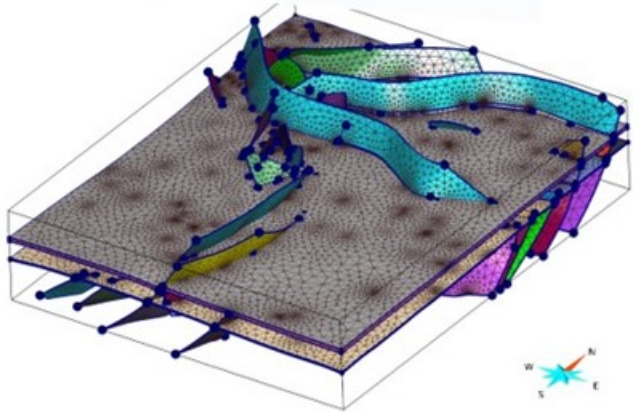
Numerical simulations & inversion studies

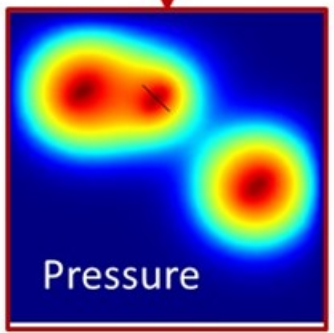
WP2 & 3

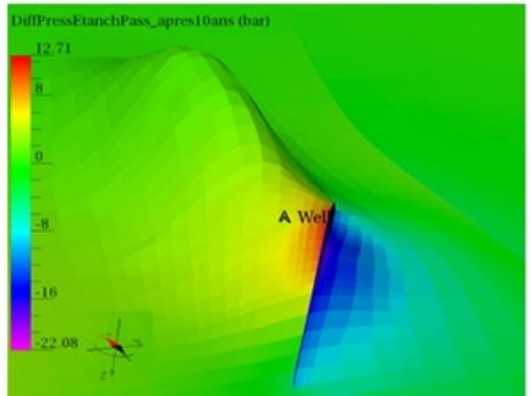


Inversion & Machine Learning



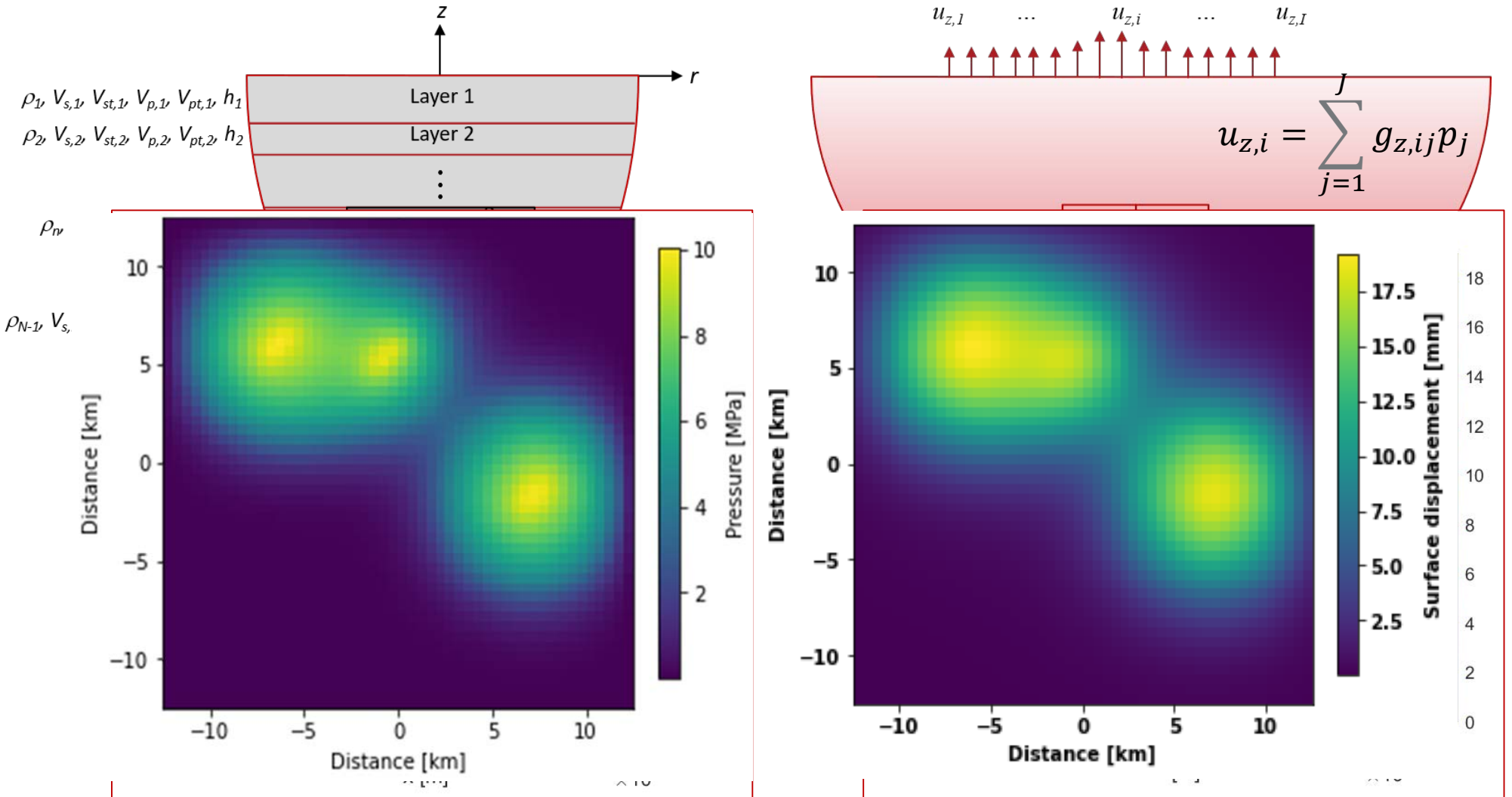






How reservoir deformation is transferred to the surface?

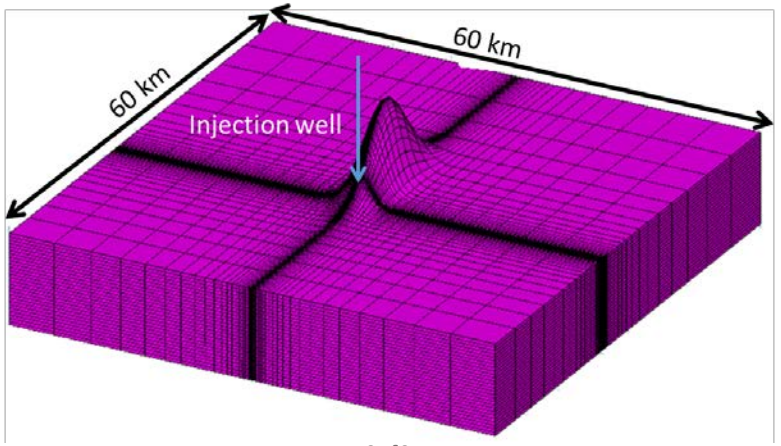
Analytical solution: Geertsma Generalized Solution (Park et al. 2021)- provides fast & accurate ground deformation calculation for **arbitrary geometry, thickness, pressure compartments, layering**, etc.



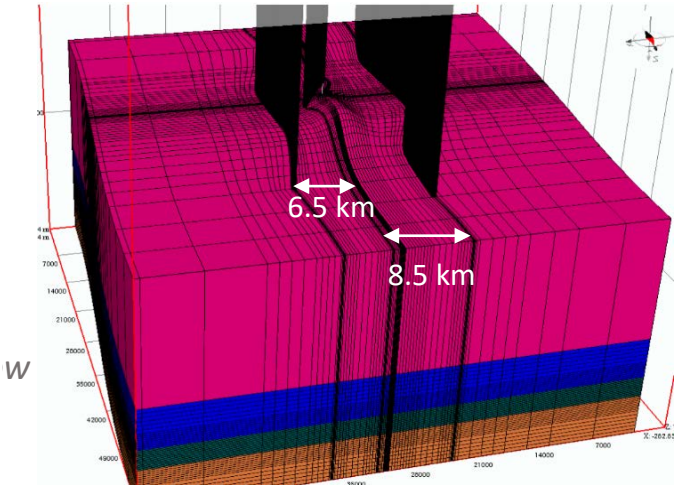
How reservoir deformation is transferred to the surface?

Geomechanical simulation: impact of geo- structures and lithology on ground uplift

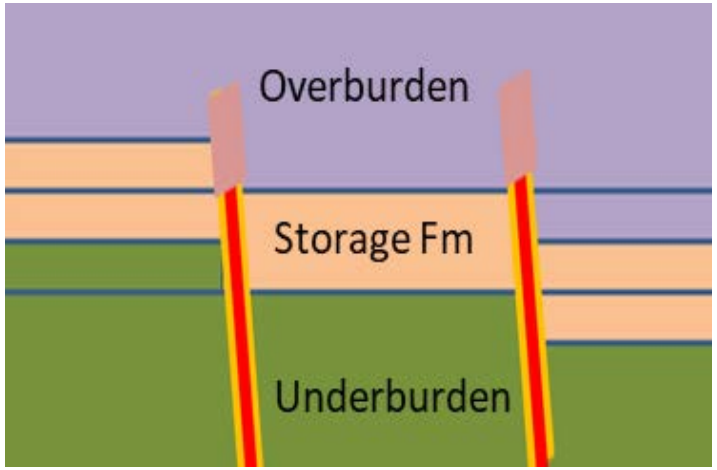
- Reservoir at a 1600 m depth, 50 m thick
- 2800 t/d injection, 160 bar/40°C conditions, injection controlled by a 50 bar overpressure
- Injection well: 6 km from anticline summit
- Depth, thickness of storage formation and overburden are scenario-dependent.

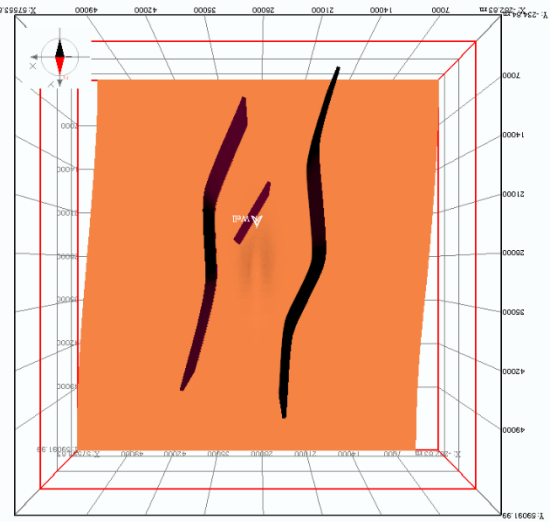


Anticline trap



Anticline trap with sealing or draining faults

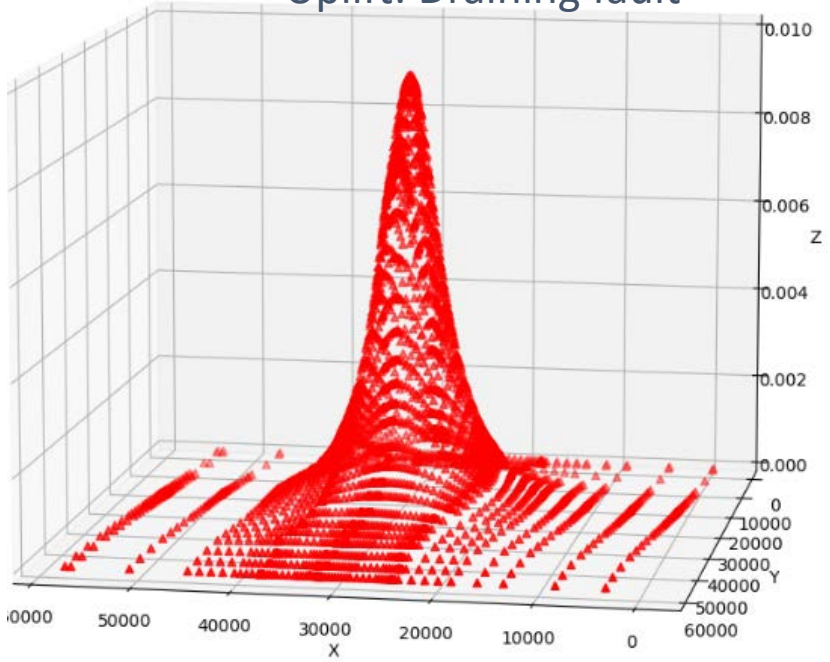




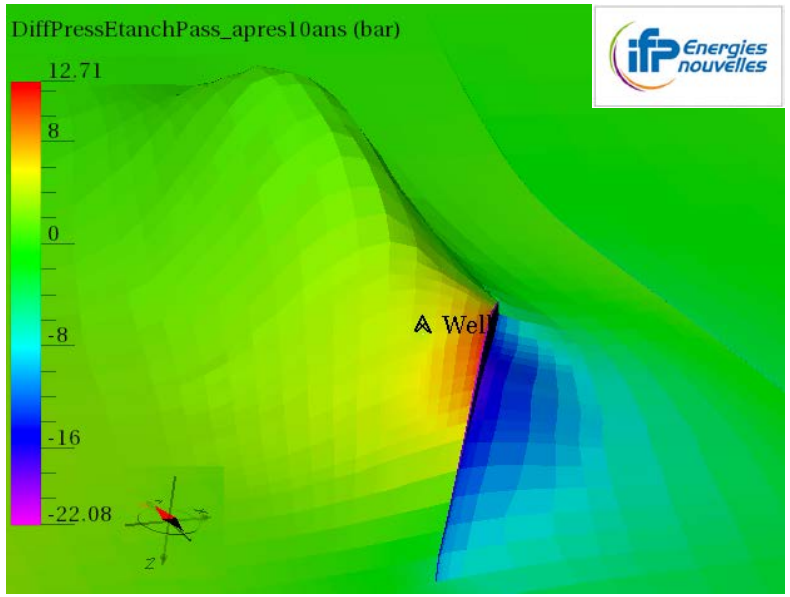
Impact of fault permeability of ground uplift

Anticline trap with draining and sealing faults

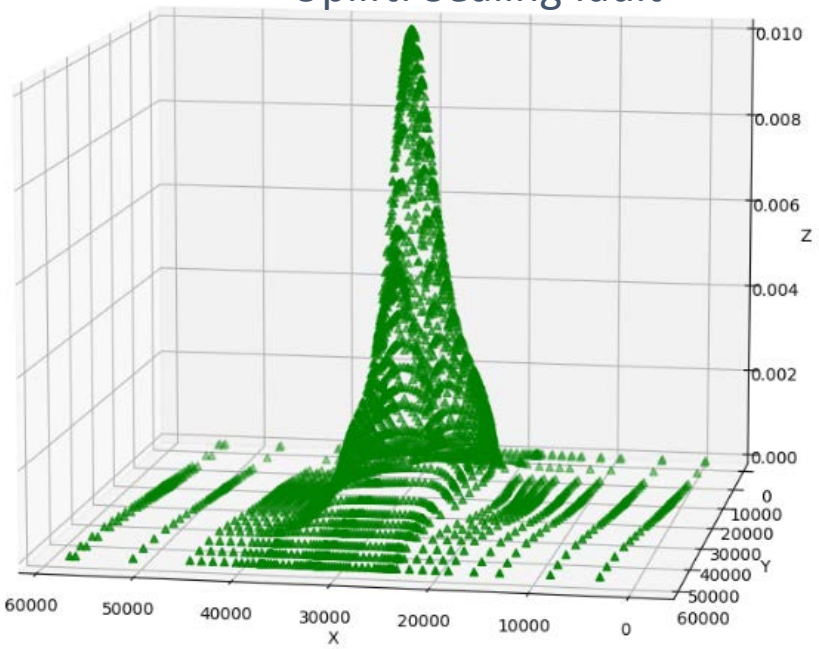
Uplift: Draining fault



Pressure difference
Draining & Sealing Faults scenarii [bar]

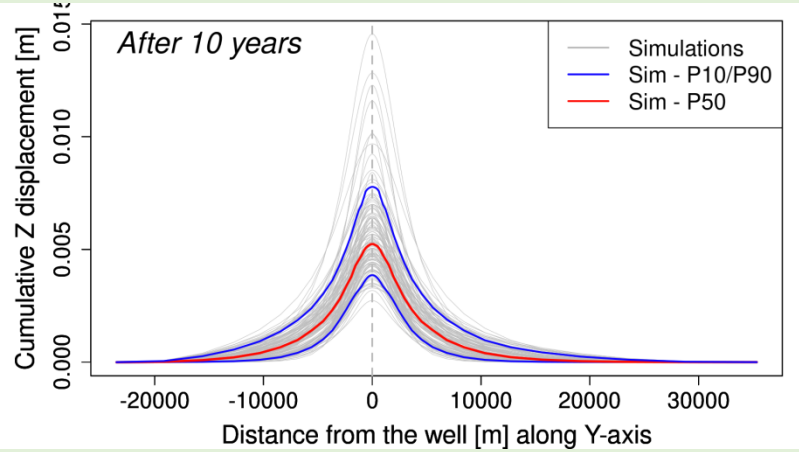


Uplift: Sealing fault



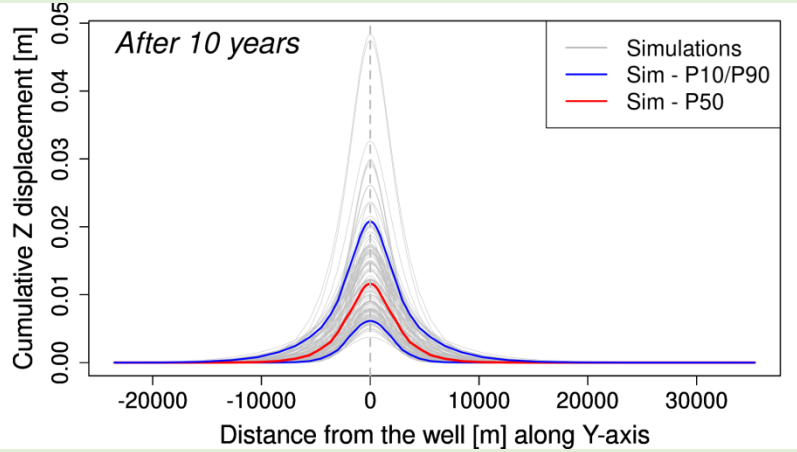
Impact of lithology and strucures on ground deformation

Carbonate



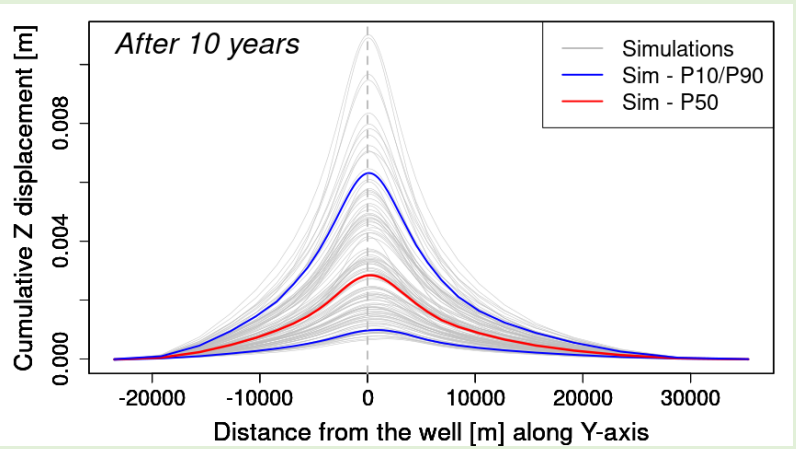
Uplift ca 2-15 mm in 10 years

Sandstone I



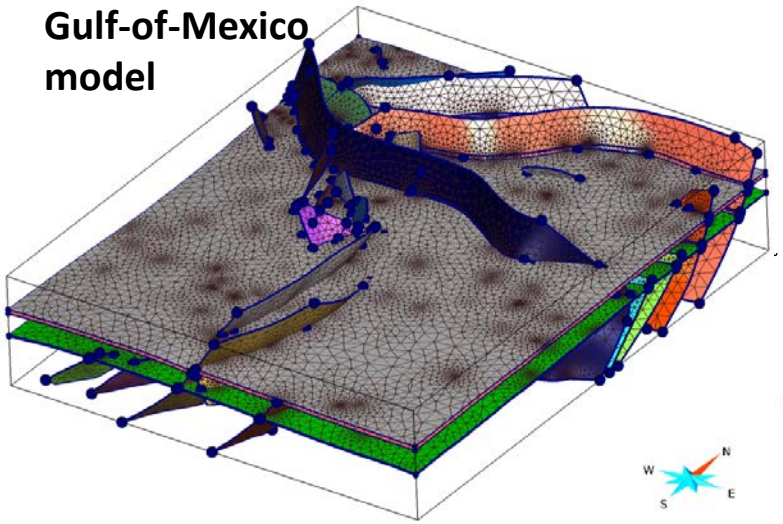
Uplift ca 5-50 mm in 10 years

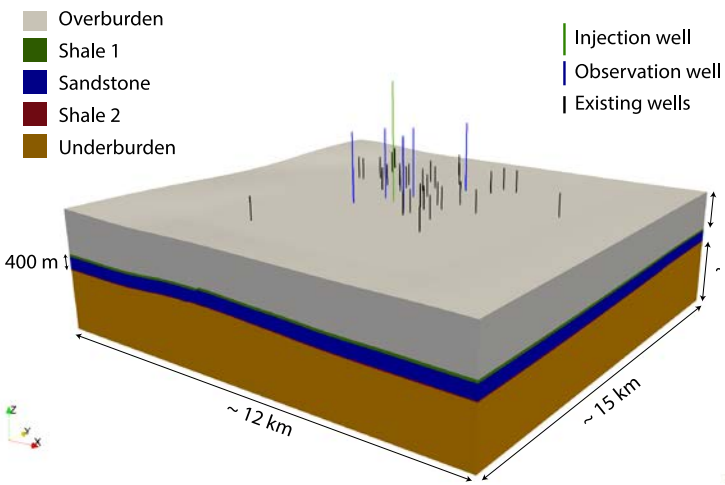
Sandstone II



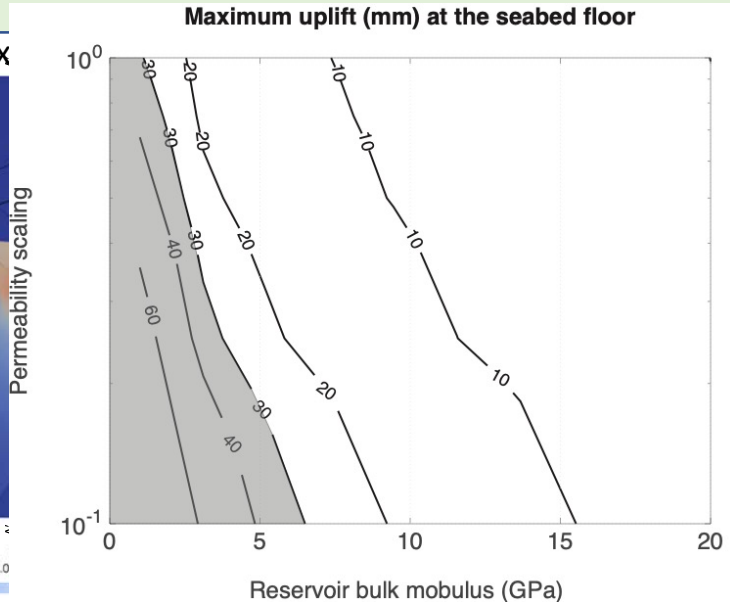
Max. uplift <10 mm in 10 years

Gulf-of-Mexico model





Reservoir ex



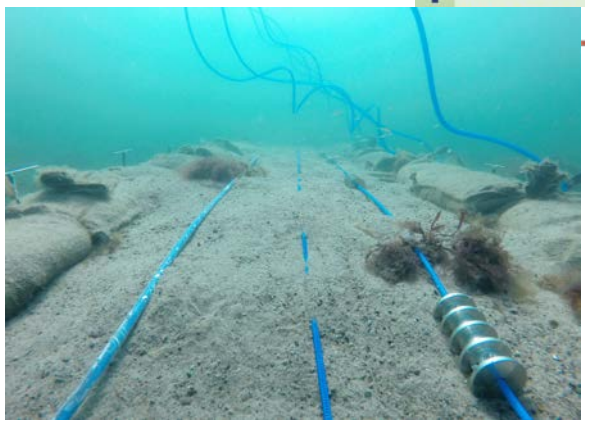
Conclusions (1)

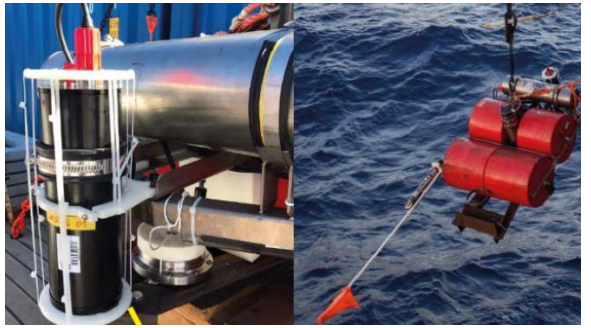
Technology development

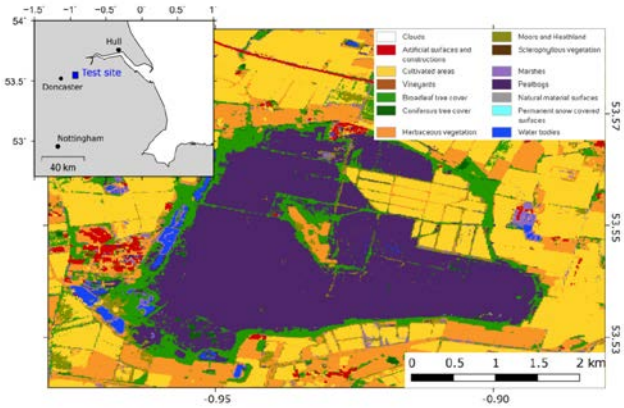
- Strain sensing fiber optics:
  - **world-class** technology for strain measurement with **µ strain accuracy**
  - Fit for deformation **hotspots** (not suitable for all cases)
  - Can be implemented at **surface & downhole**
  - **limitations**: high costs to cover large areas, data processing, etc.)

- Ocean bottom landers: **pressure + tiltmeter + temp**.

- Satellite InSAR data: more **affordable data** for ground monitoring through **automatic data processing**





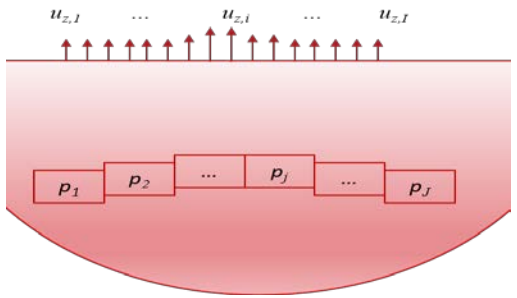


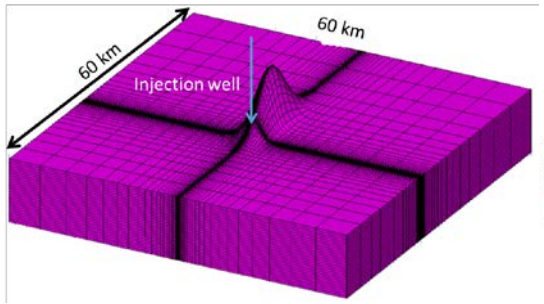
Conclusions (2)

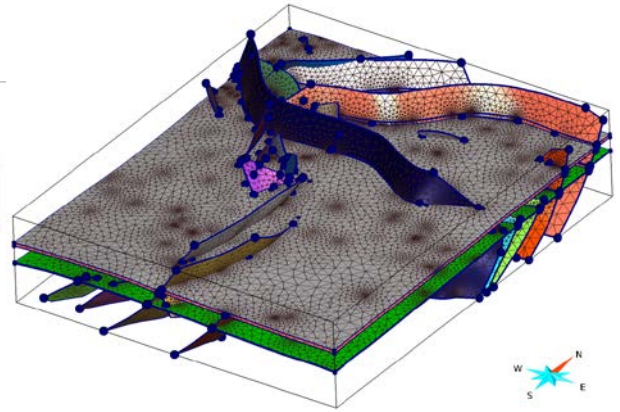
Models and workflows for CO2 storage site monitoring:

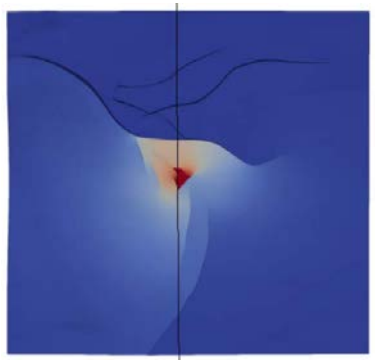
- **Geertsma** Generalized analytical solution for **fast calculation** of deformation
- **Inversion** of deformation from pressure and **machine learning** algorithms
- **Numerical simulation** of both **deep** & **shallow** formations (geotechnical depth)

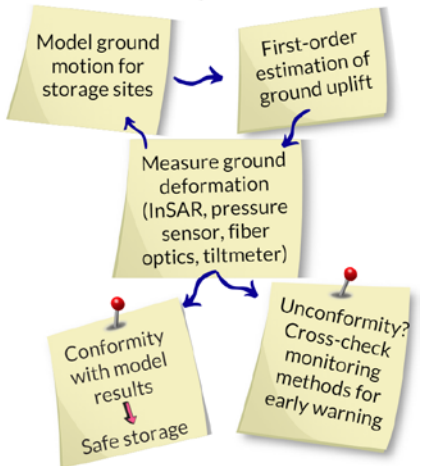
- **Geomechanical modelling** of Gulf of Mexico and synthetic cases show the **shape of deformation** at surface **reveals reservoir performance, sealing, draining**, and other properties of reservoire & overurden.











Thank you

@SenseAct

Sense-ACT

SENSE (Assuring integrity of CO_2 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.