Assuring integrity of CO_2 storage sites through ground surface monitoring (SENSE)

https://sense-act.eu/

Integrated Geotechnology

17 August 2020

Online

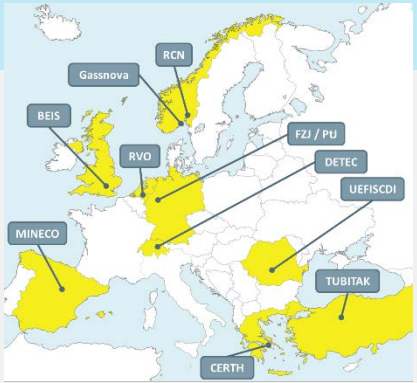
ACT – Accelerating CCS Technologies

ACT1: Projects Started Sept 2017

10 funding agencies from **9** countries

8 new projects started in 2017

€36M from ACT of which ~€11.9M from the EC



ACT2: Projects Started ~Sept 2019

- Funding agencies from **11** countries
- 12 new projects started in 2019
- €31M from ACT, No EC money

ACT3: Call

- Funding agencies from **14** countries/regions
- Pre-proposals due **10 Nov 2020**
- Info: http://www.act-ccs.eu/

New members: Nordic Energy Research

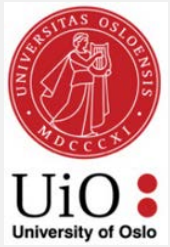
State of Alberta

SENSE –an overview

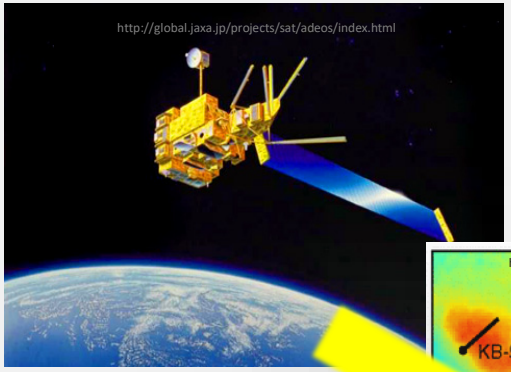
SENSE consortium & budget

Total budget: 4.5 m€

ACT contribution: 2.7 m€

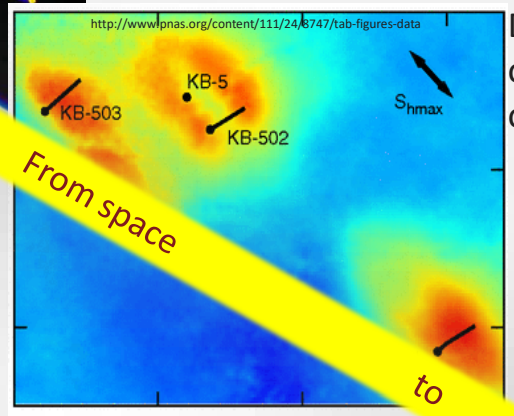


SENSE project concept



Satellite for monitoring ground motion onshore

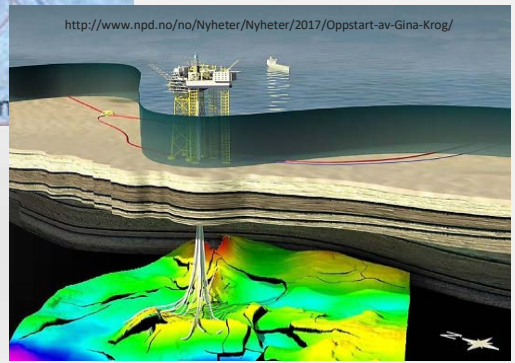
Objective: Measure displacement at ground surface/seafloor to understand geomechanics behaviour of a deep CO2 storage reservoir.



Demonstration of concept onshore

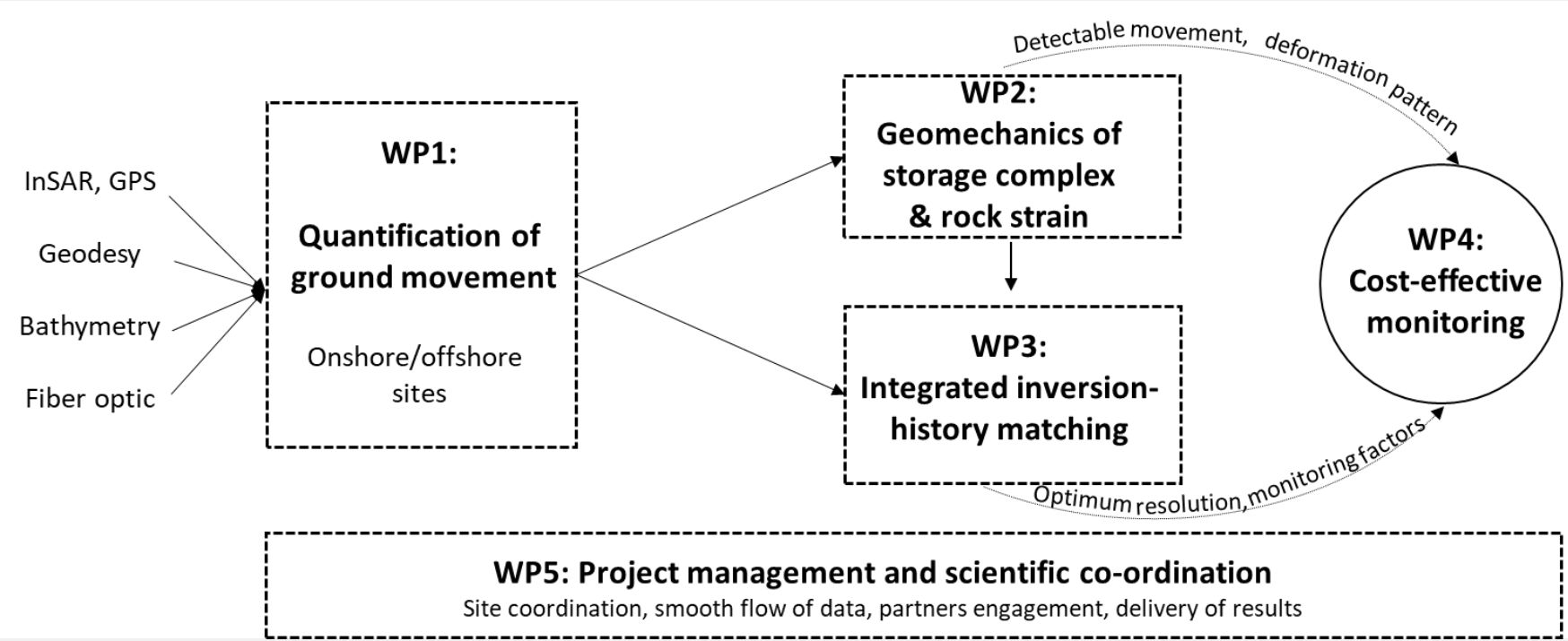
From space to the subsurface

Demonstration offshore



Geomechanical modelling, inversion- history matching
→ subsurface management & **containment assurance**

Project structure



WP1: Four field cases

SENSE works with data from 4/5 field cases:

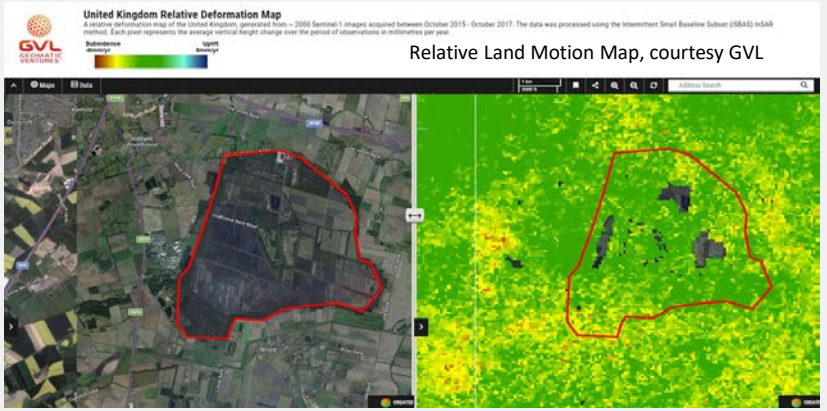
#1: Hatfield Moors, onshore UK

#2: Bay of Mecklenburg, Offshore Germany

#3: In Salah/Troll subsidence data

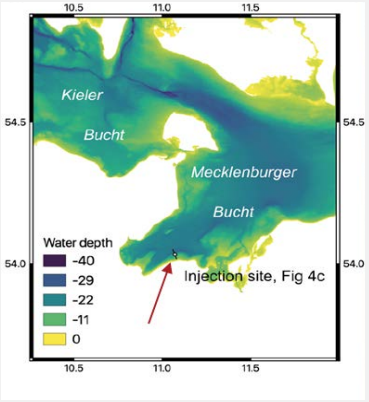
#4: Gulf of Mexico

#1



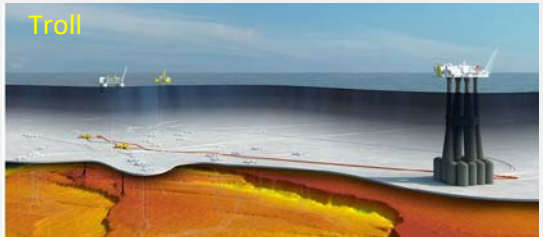
Relative Land Motion Map, courtesy GVL

#2



#4

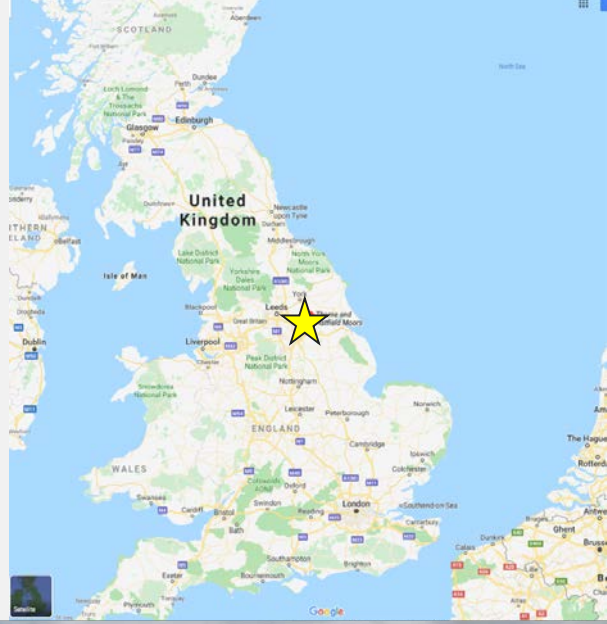
#3



NGI

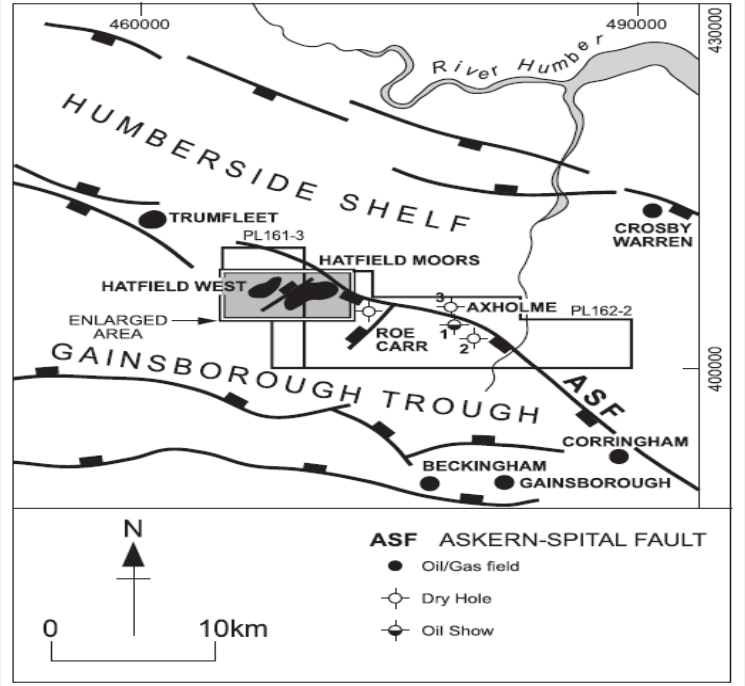
Site #1: Hatfield Moors, onshore UK

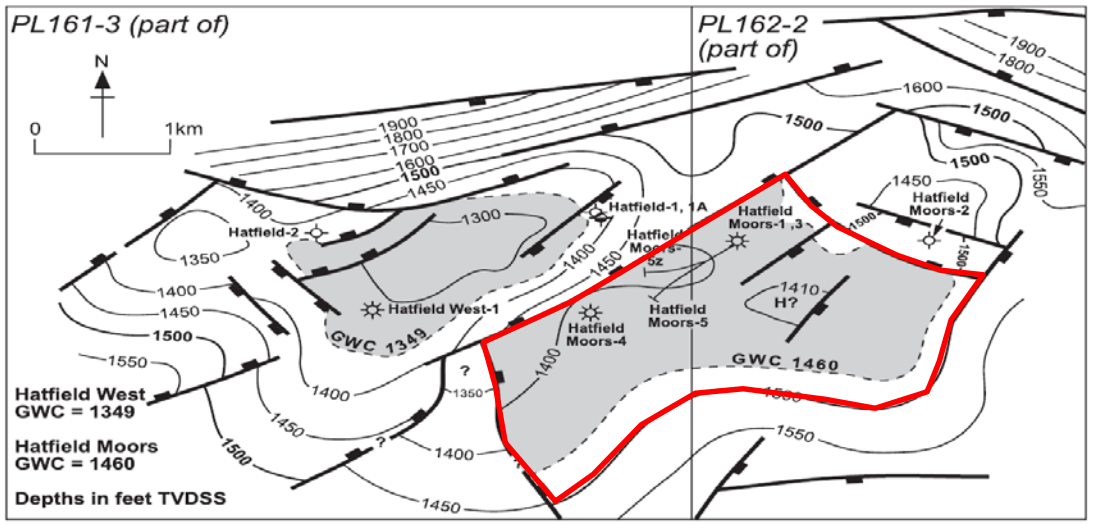
- Natural gas storage site (depth 450 m)
- operated by Scottish Power
- Reservoir is underneath a National Nature reserve (wetlands area – thick peat surface cover)



Site #1: Hatfield Moors - Geology

- Faulted anticlinal structure within the Gainsborough half-graben
- Westphalian B Oaks Rock Sandstone reservoir



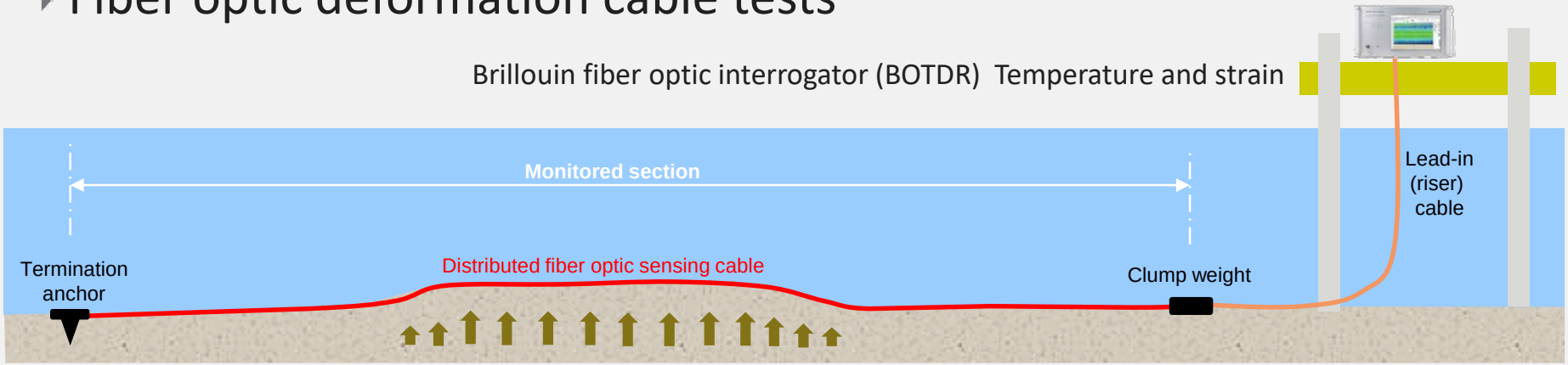


Figures reproduced from Ward et al. (2003)

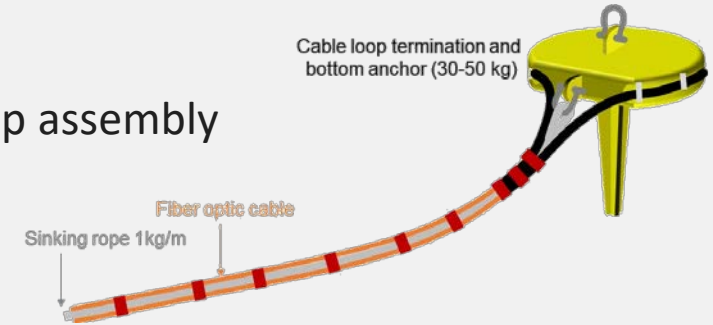
Site #2: Bay of Mecklenburg, offshore Germany

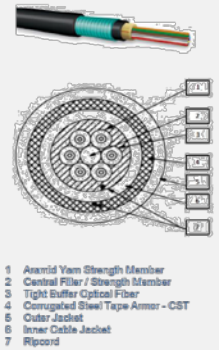
Fiber optic deformation cable tests

Brillouin fiber optic interrogator (BOTDR) Temperature and strain



Cable loop assembly

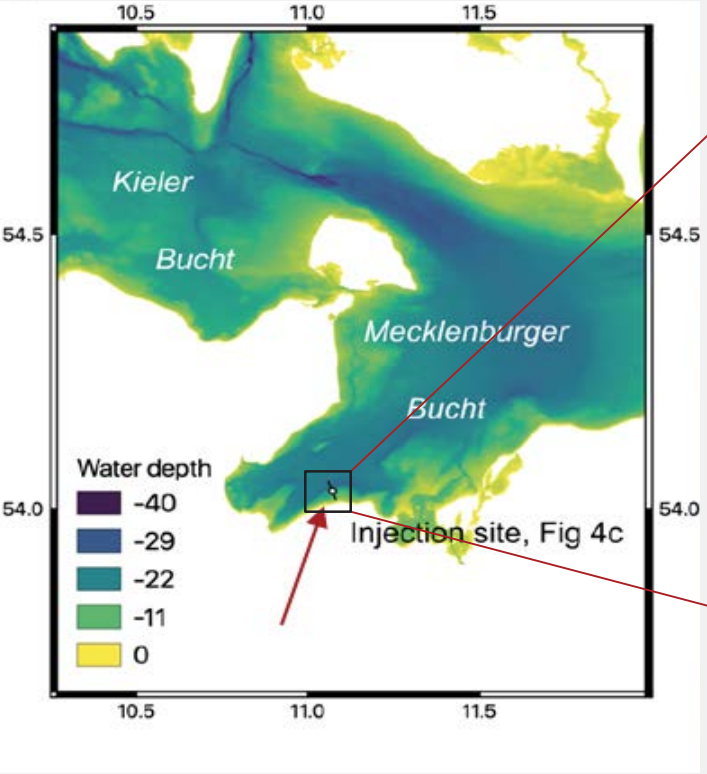




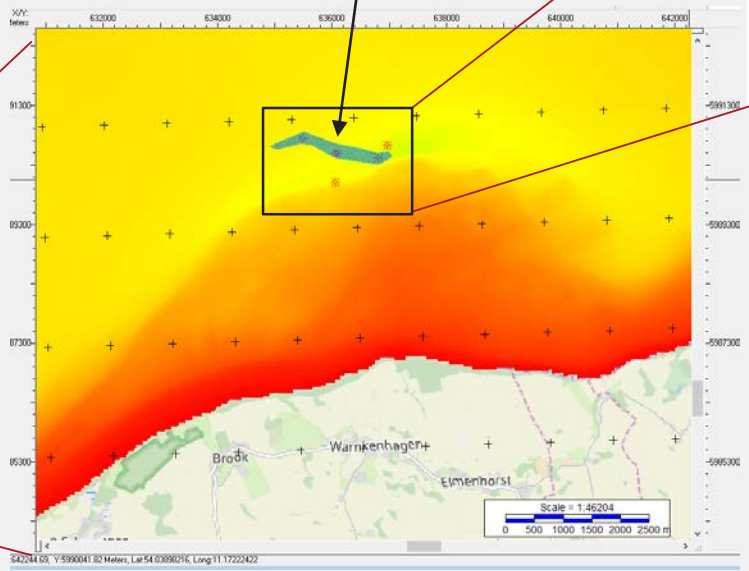
Cable section across the monitored section must lay fixed to the seabed

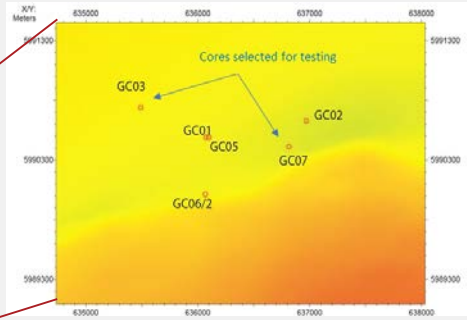
- Weighted by lead rope
- Buried ?
- Trenched ?
- Scour ?
- Onshore tests ?

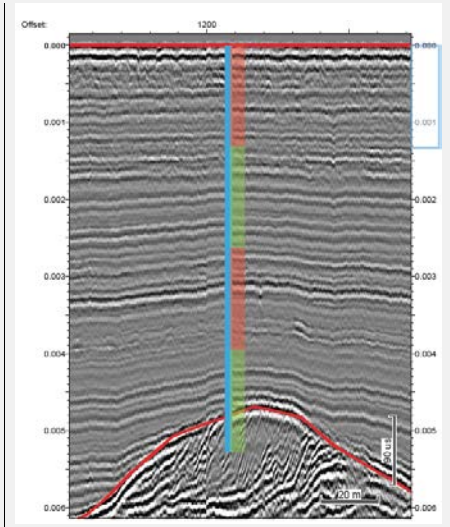
Site #2: Bay of Mecklenburg, offshore Germany



Sand body overlain by clay

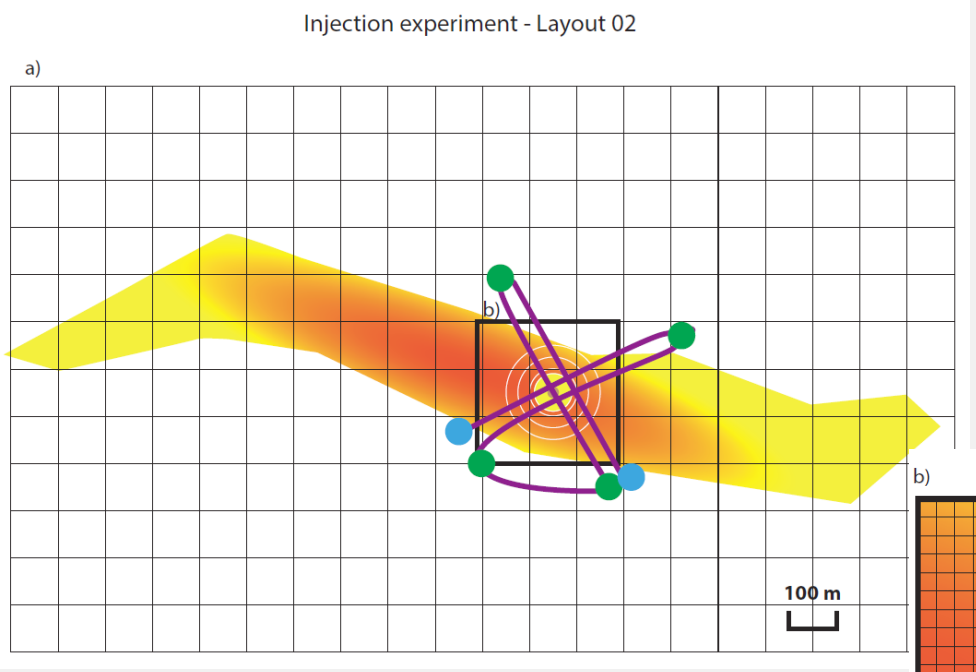


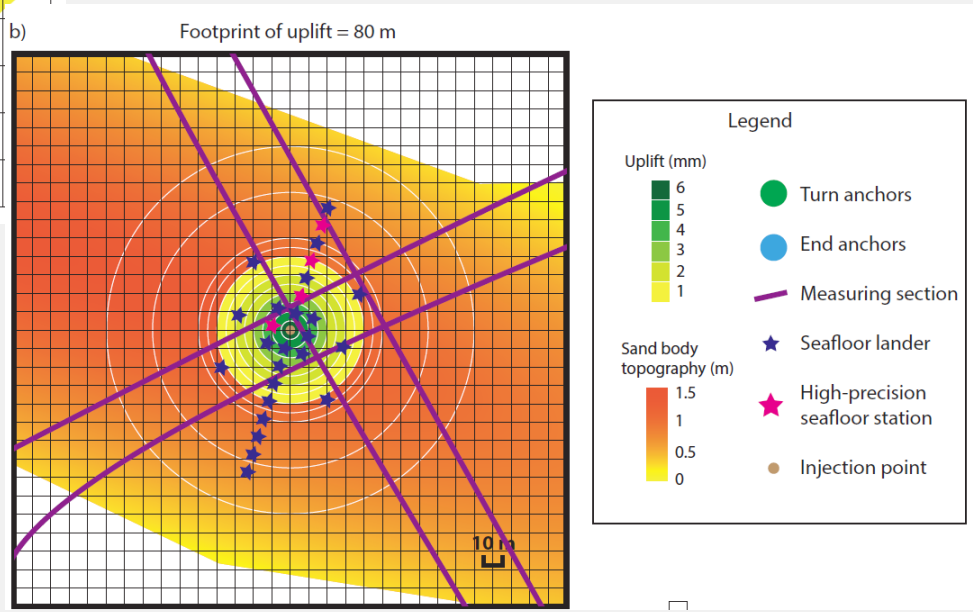




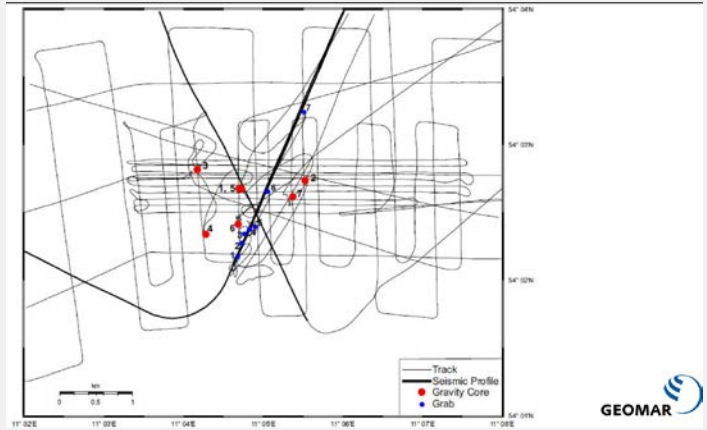
Seismic profile GC03

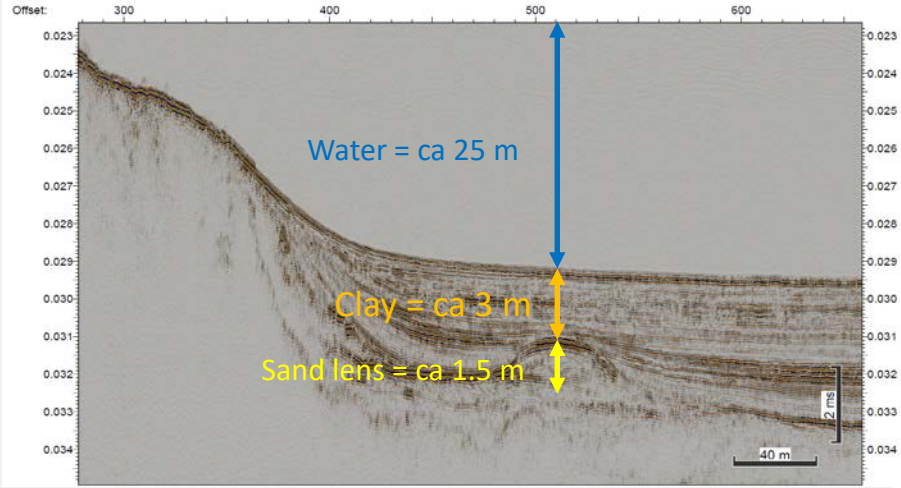
Preliminary fibre optics monitoring array- Bay of Mecklenburg

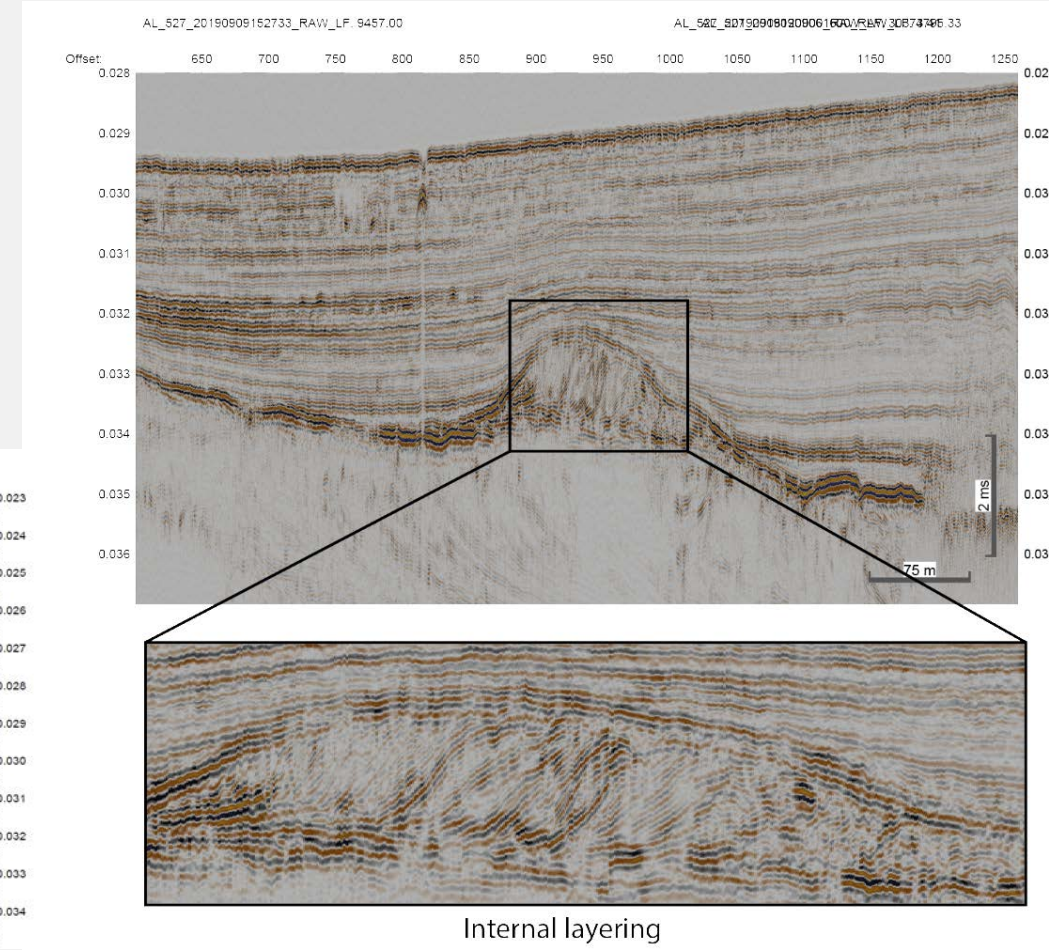




Site #2: Bay of Mecklenburg-geophysical survey







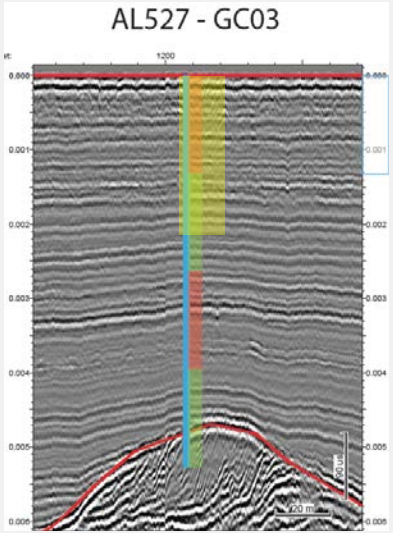
Gravity core sample-Bay of Mecklenburg

Lab tests conduted on samples from Bay of Mecklenburg

Undrained Shear Strength- Results from Fall Cone Tests

Determination of undrained shear strength of **undisturbed (Cufc)** and remoulded (Curfc) specimens of fine grained soils by the fall cone method, performed according to NS-EN ISO 17892-6:2017 and Norwegian standard NS 8015:1988. Cone penetration range in ISO 17892-6 is 4-20 mm. Sensitivity (St) is according to Norwegian standard NS 8015:1988.

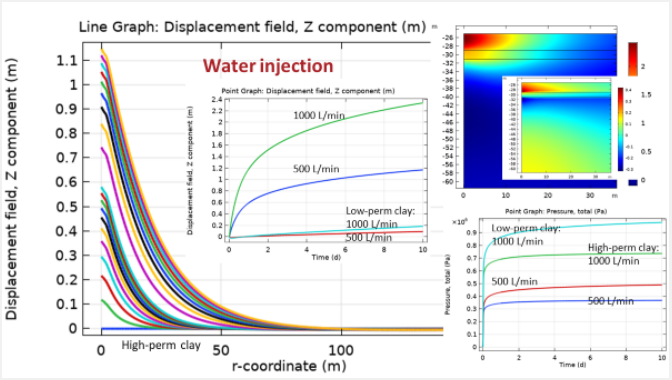
Sample identification					Fall cone				ISO 17892-6		Norwegian correlation		
Borehole	Tube	Part	Test	Depth	undisturbed		remoulded						
					mass	i	mass	i	cufc	curfc	cufc	curfc	St
				[m]	[g]	[mm]	[g]	[mm]	[kPa]	[kPa]	[kPa]	[kPa]	[kPa]
AL527-03	1			0.12	60	9.1	10	6.0	1.9	0.7	2.9	1.1	3.0
AL527-03	1			0.57	60	8.0	60	12.0	2.5	1.1	3.7	1.7	2.0
AL527-03	2			1.12	60	5.9	60	11.0	4.6	1.3	6.8	2.1	3.0
AL527-03	2			1.74	60	5.6	60	9.5	5.1	1.8	7.5	2.7	3.0



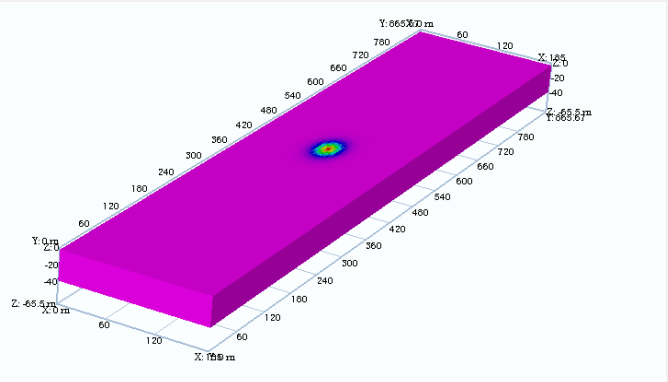
Site #2: Geomechanical modelling of gas injection

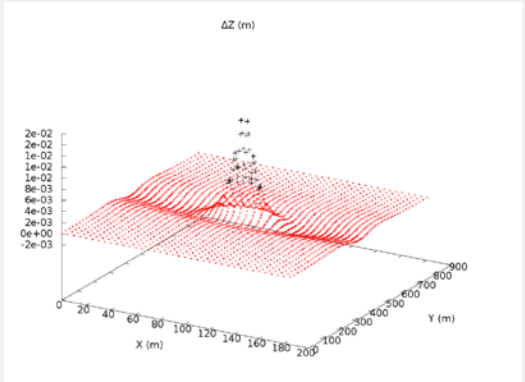
- Objective: Understanding the mechanism of surface movement through conceptual and coupled flow-geomechanics models
- Use of rock physics models developed by SENSE partners
- Use of reduced dimension models

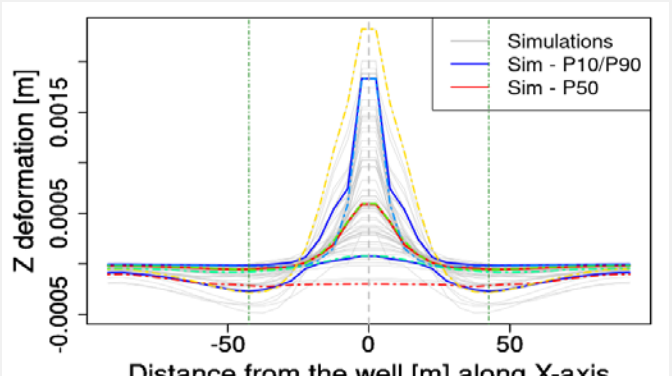
NGI simulation



IFPEN Simulation





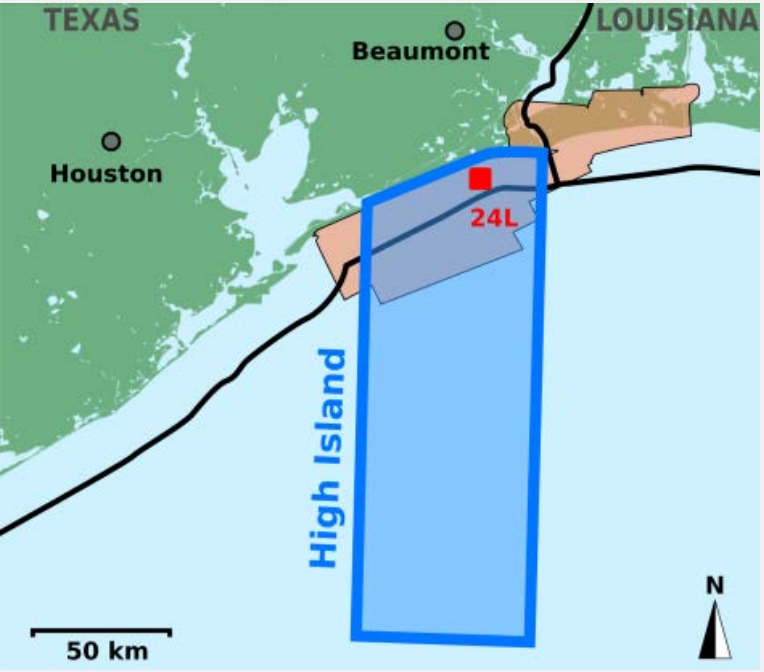


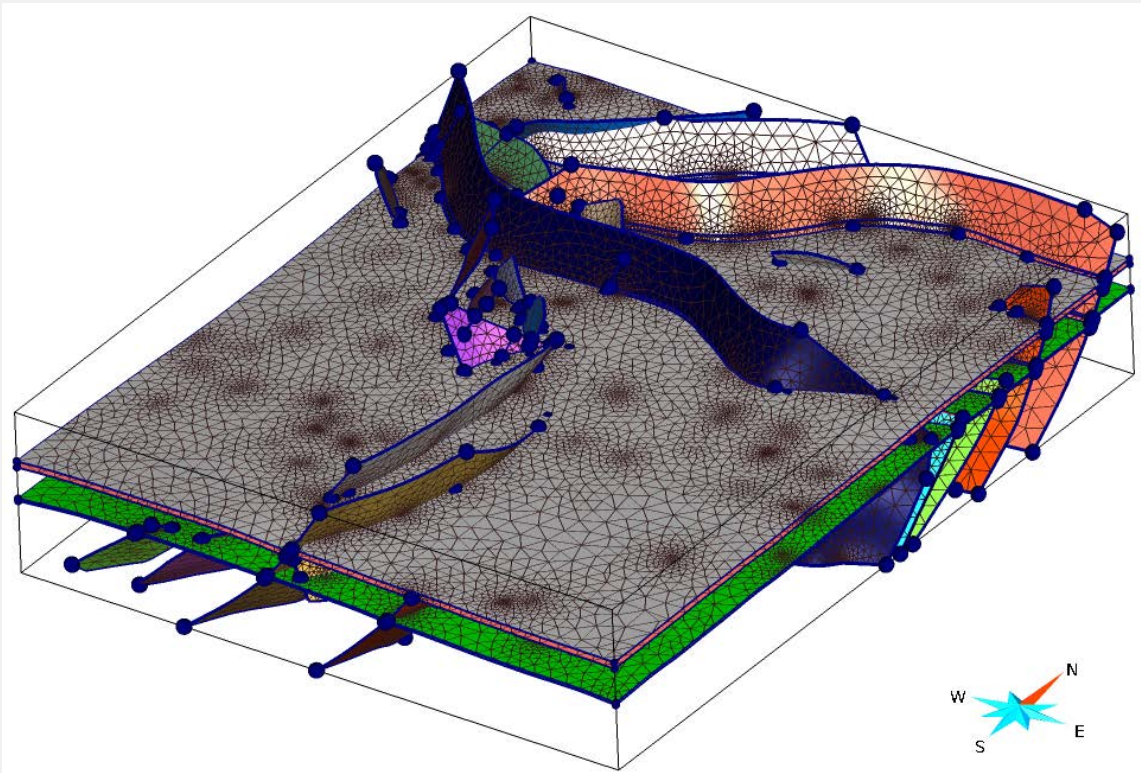
Site #2: Gas-Injection plan

- Cruise AL527 in September 2019
- Site selection
- Coring performed
- Shipment of cores to Oslo
- Lab testing

- New injection (air in sand), likely summer 2021

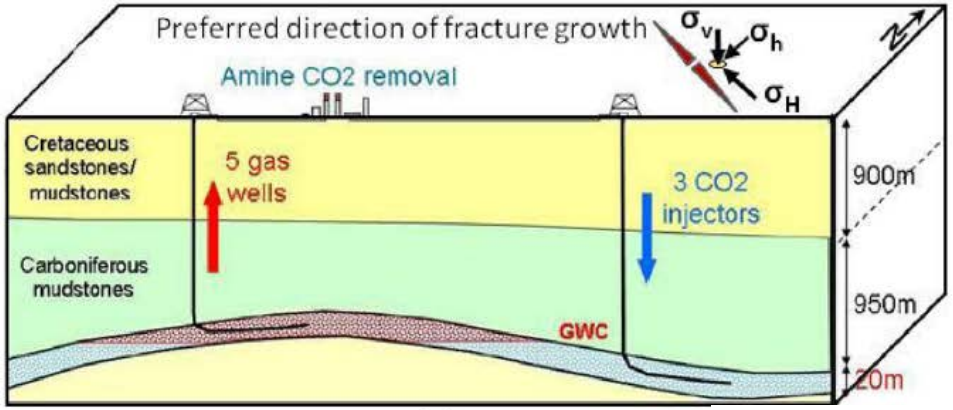
Site #4: Gulf of Mexico
Meshing suitable for multiphysics simulations



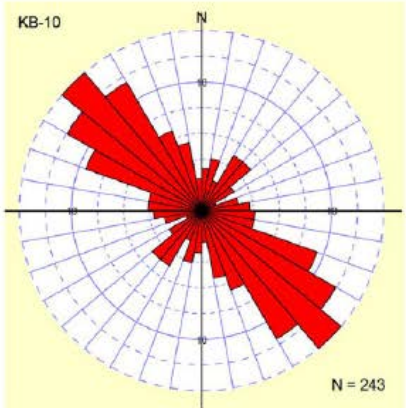


SENSE –In Salah case study (Site #3)

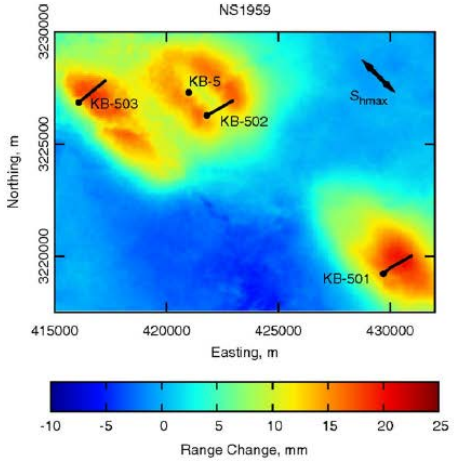
In Salah CO_2 storage site, Algeria



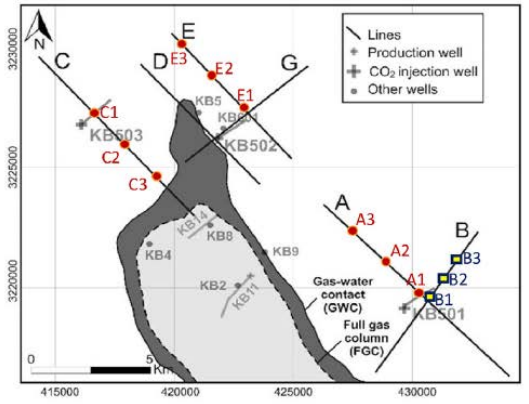
(a)



Surface heave due to CO_2 injection-pressure build-up

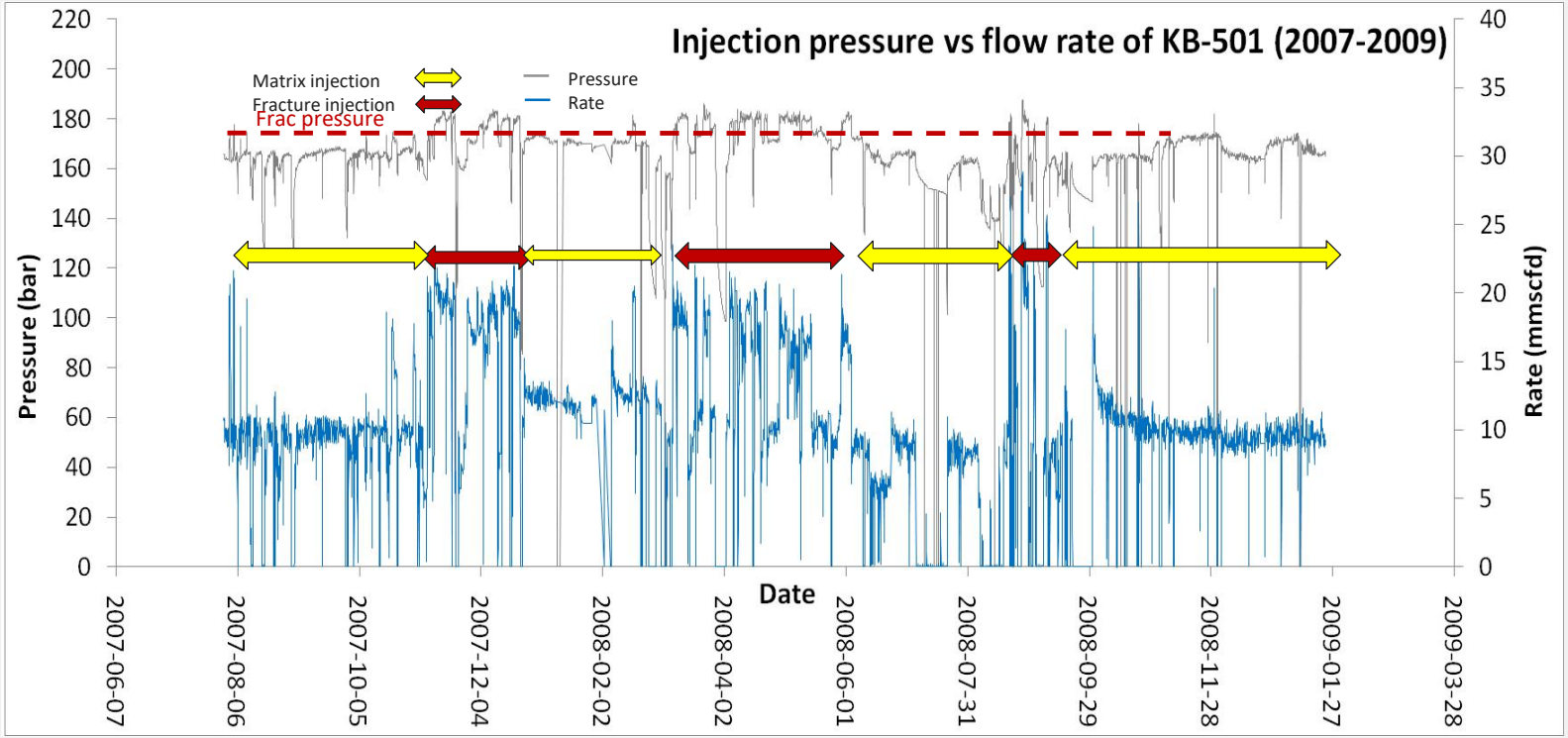


(a)

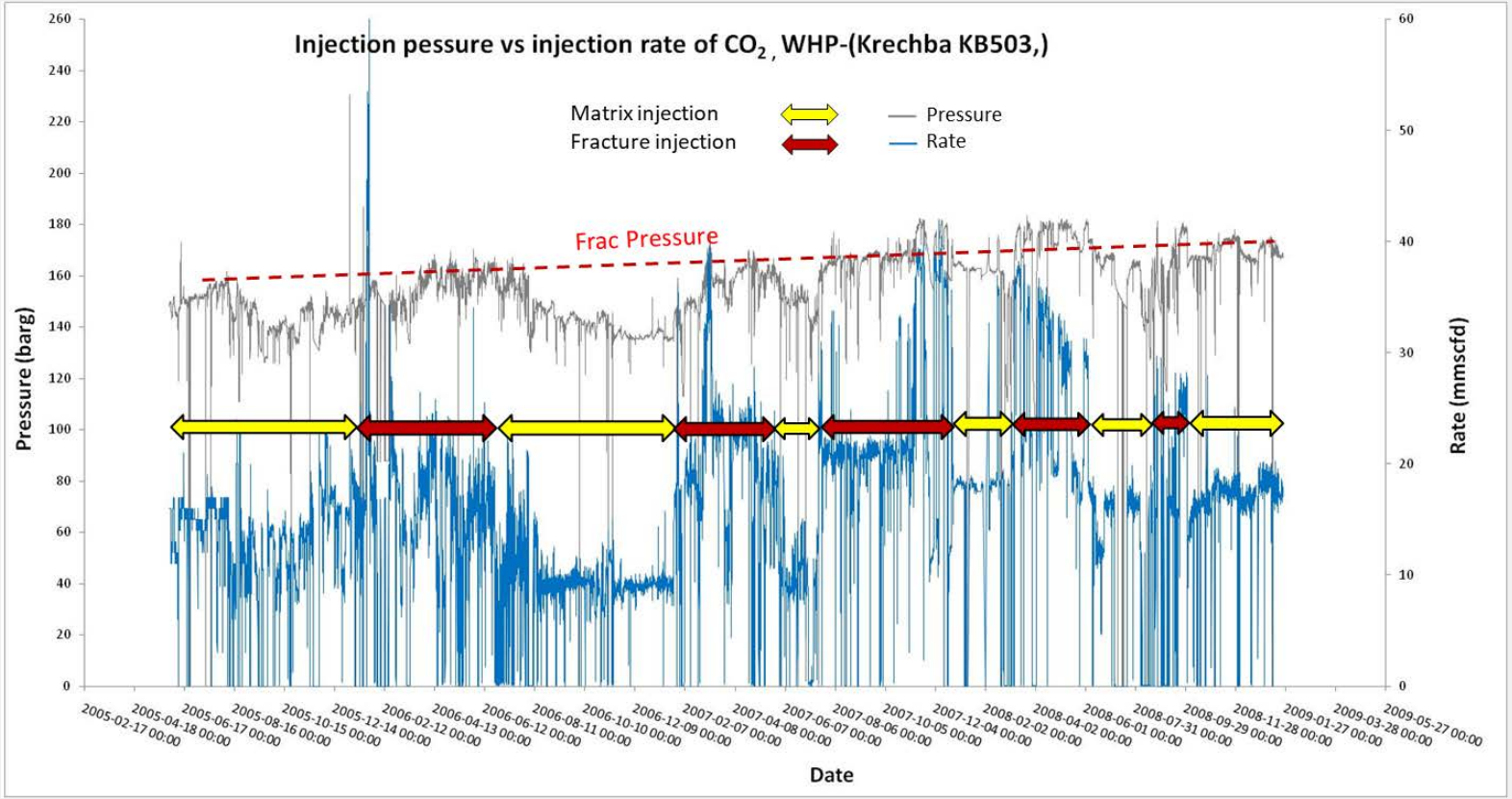


(b)

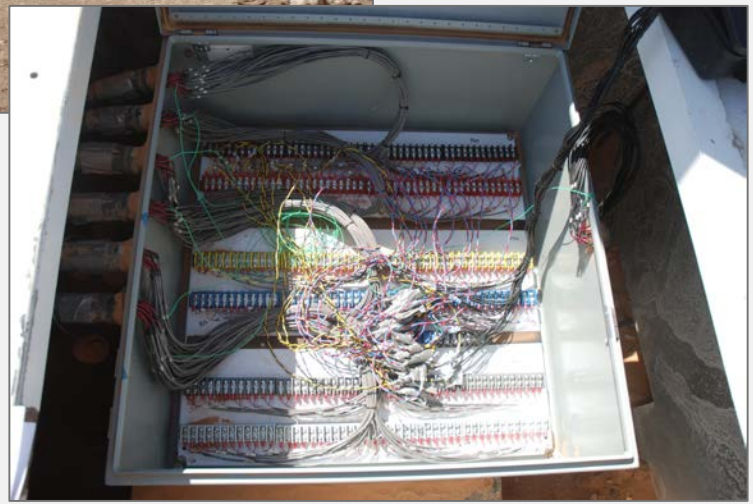
In Salah: Fracture pressure from injection time series

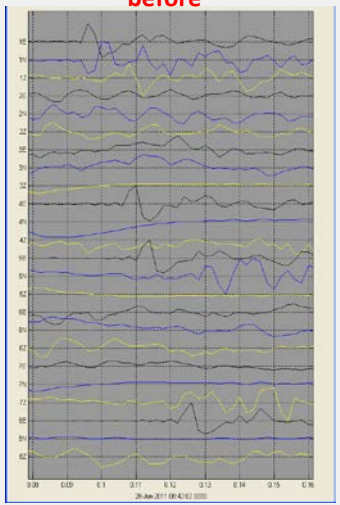


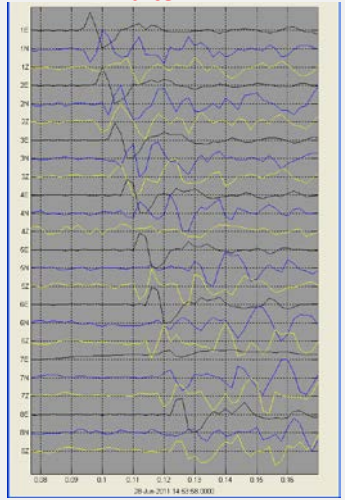
Well KB503: Several fracture injection periods. Fracture pressure increases wih time.



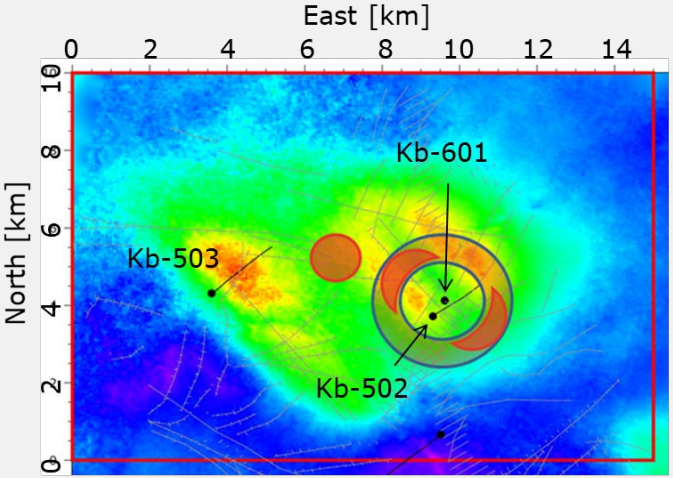
In Salah-field work: microsesimic array

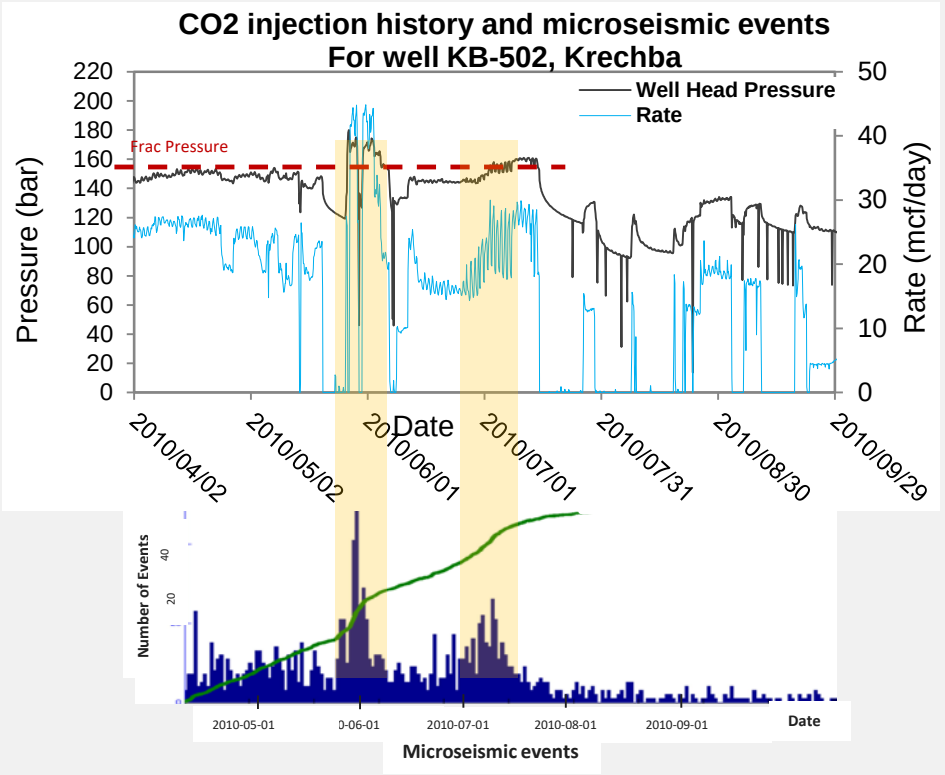




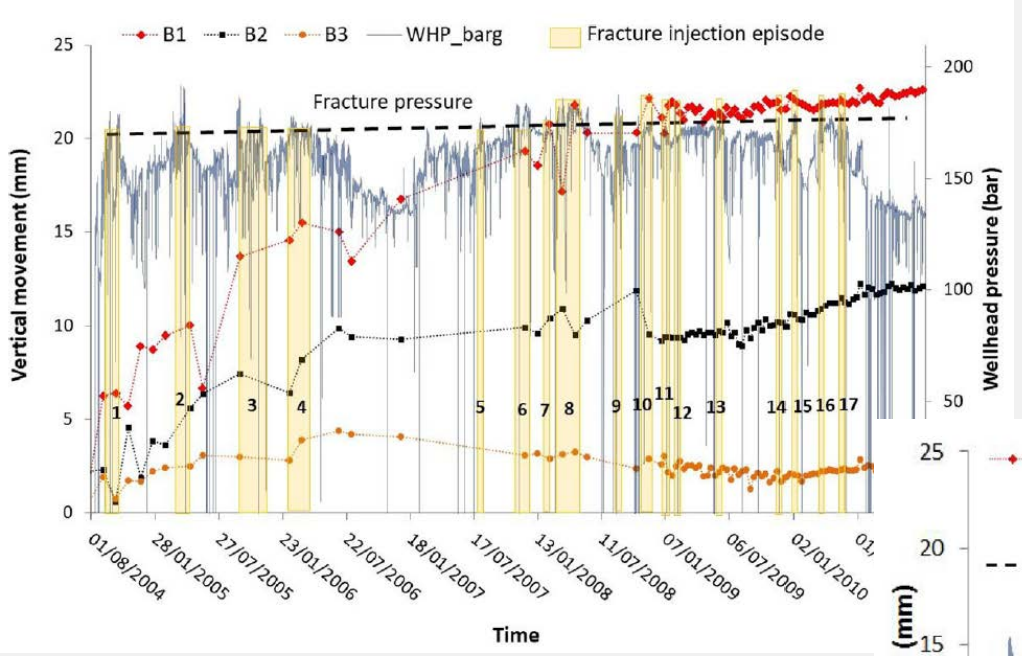


Correlation of fracture episodes with microseismic events

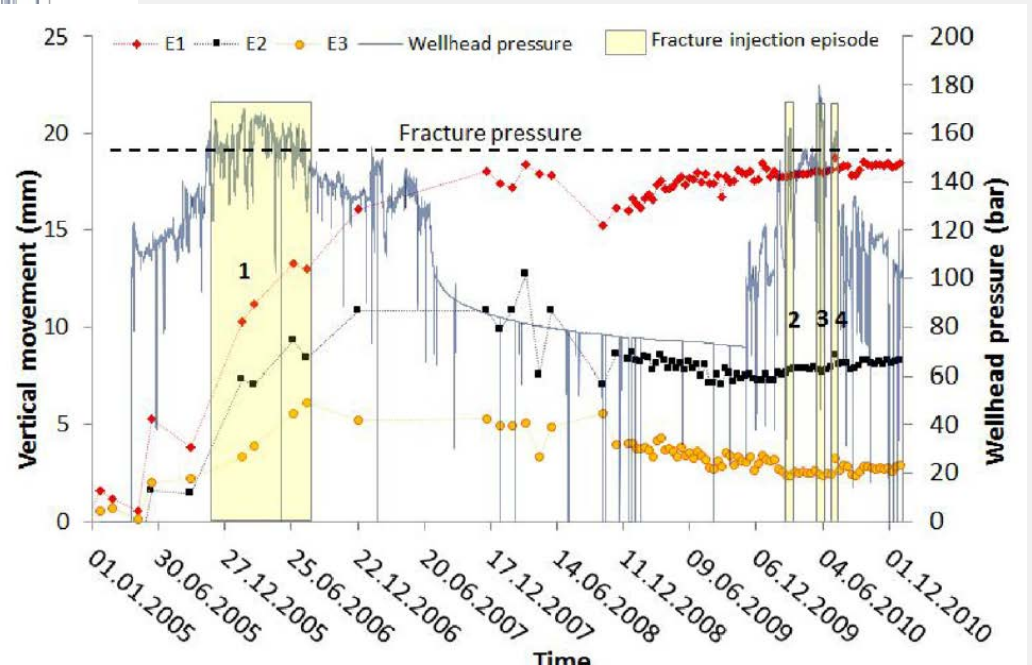




In Salah surface heave 2004-2010



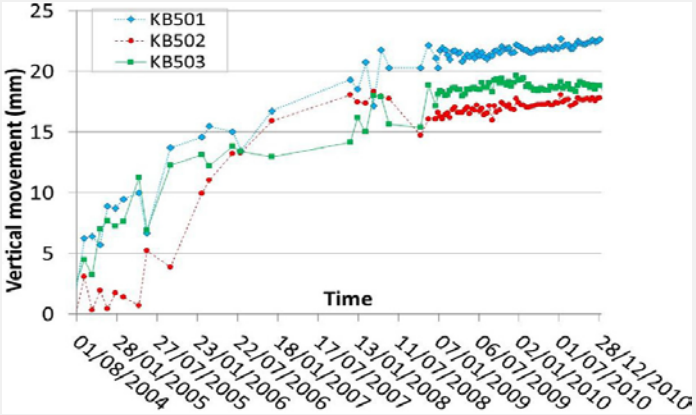
Well KB501

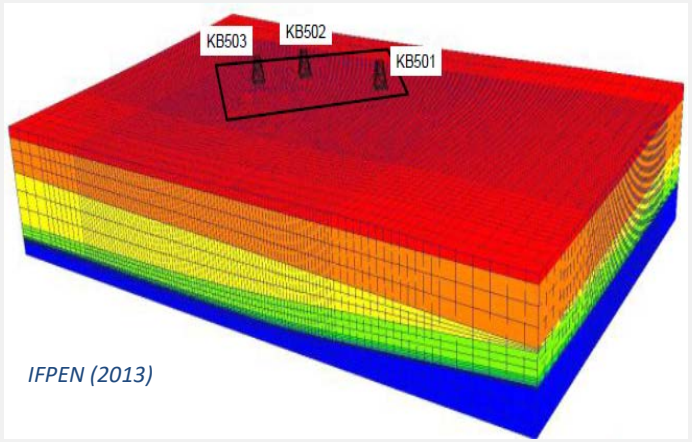


Well KB502

In Salah-modelling surface heave

Observation





IFPEN (2013)

Model

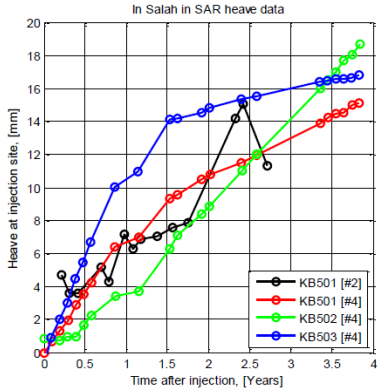


Figure 3. Measured heave data at the injection wells from two different references: #2, Rutquist et. al. 2009 and #4, Onuma et. al. 2009.

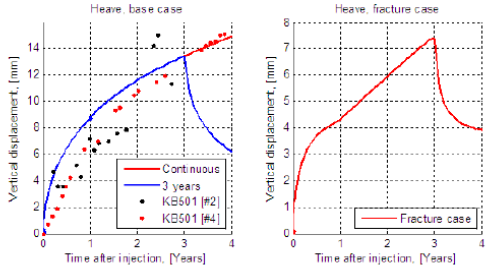
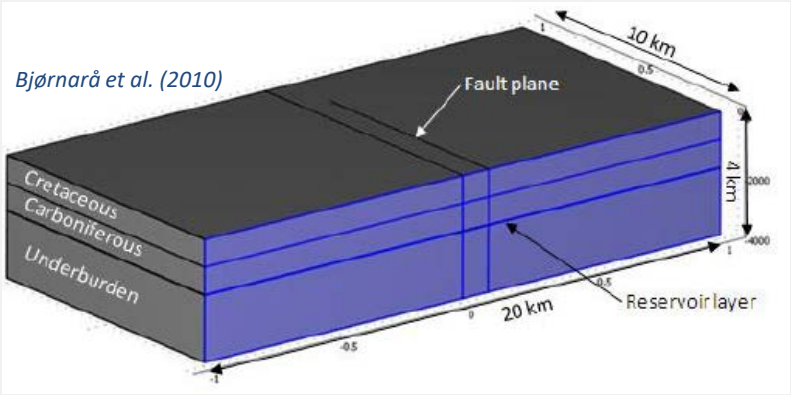
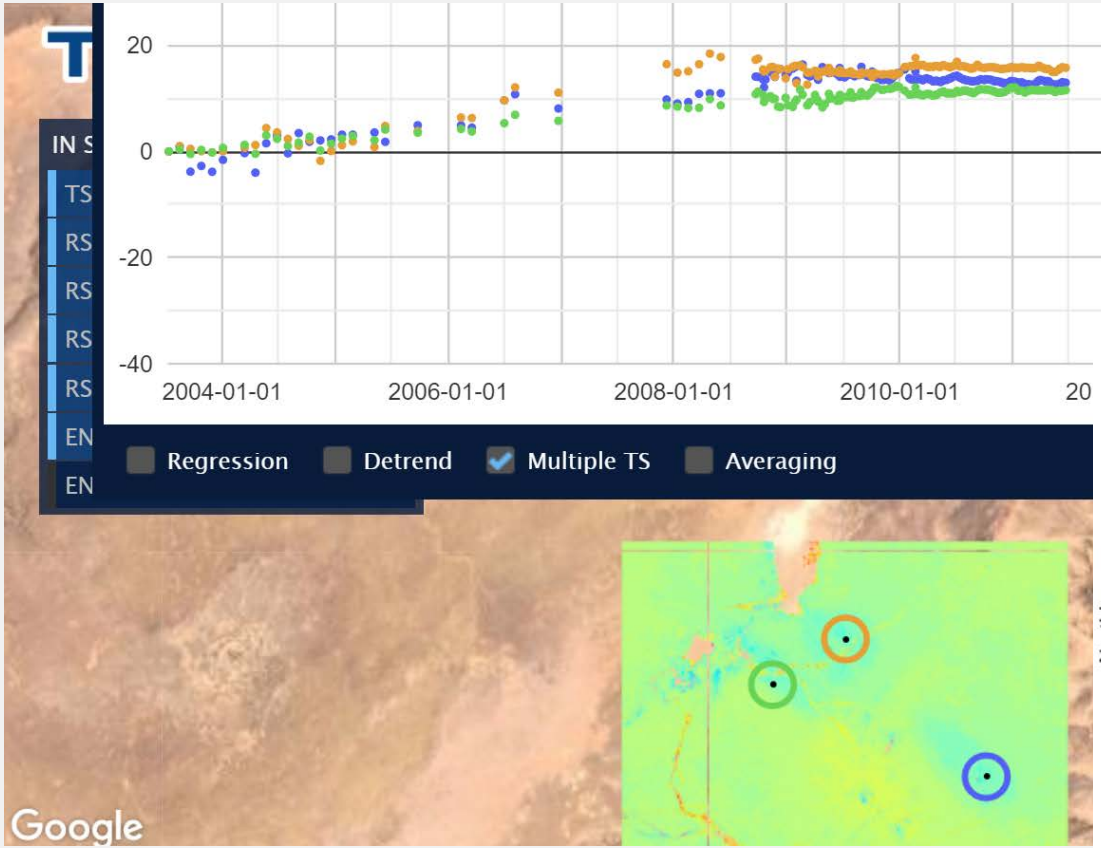


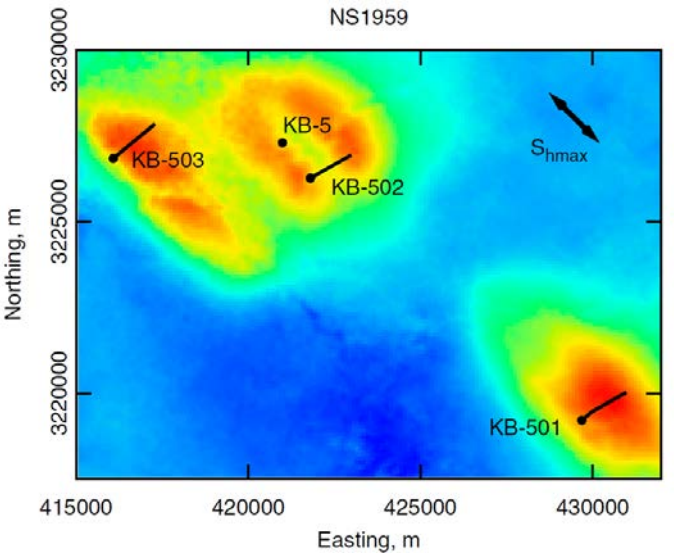
Figure 4. Left: Close-up (0-4 years after injection) of surface heave (modeled Base case; line) compared with measured data for injection well KB501 (dots). Red curve is from continuous injection and blue curve when injection is stopped after 3 years. Right: Close-up (0-4 years after injection) of surface heave (Fracture case).

Bjørnarå et al. (2010)



In Salah-new InSAR data (post-injection)





SENSE in media

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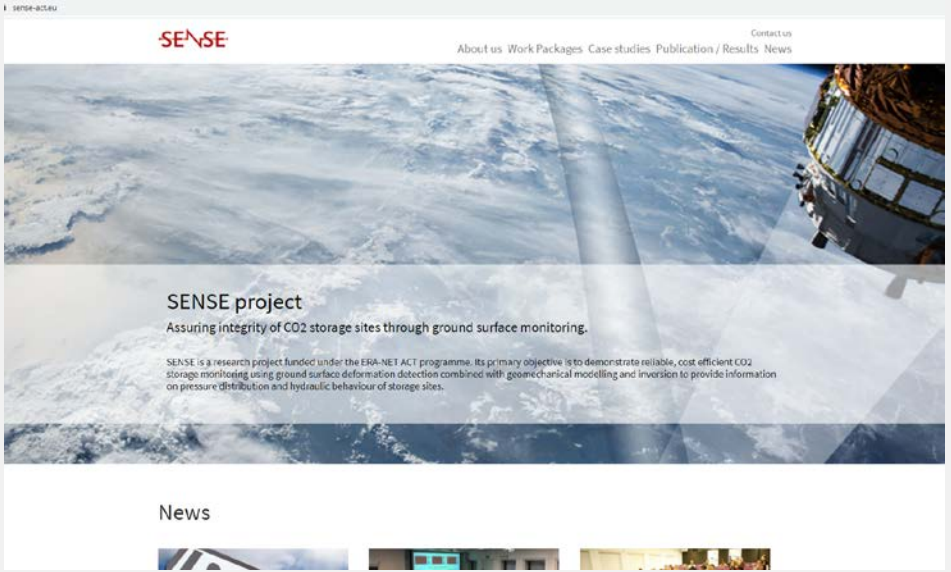

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