How to determine if a CO_2 storage site is performing as expected – quantitative conformance tools developed by the Pre-ACT project

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EU CCS Showcase Event

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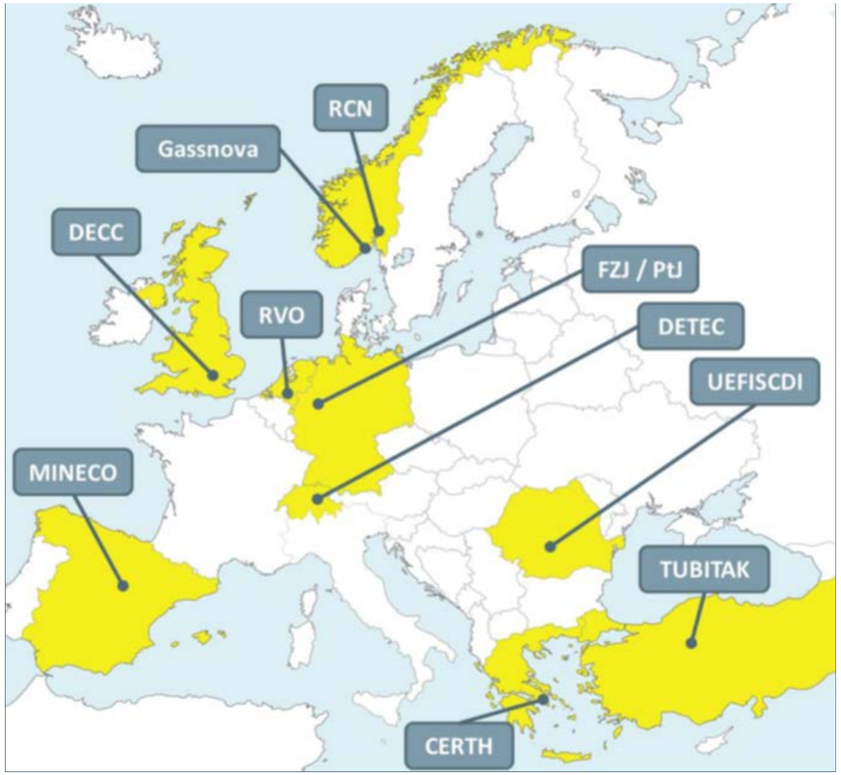
Background

- ACT (Accelerating CCS Technologies) call 2016
- We wanted to identify and address main storage-related challenges for **accelerated deployment of CCS** in collaboration with industry.
- Focus on crucial storage **challenges:**

  capacity, confidence, and cost

- Least common denominator: **pressure**



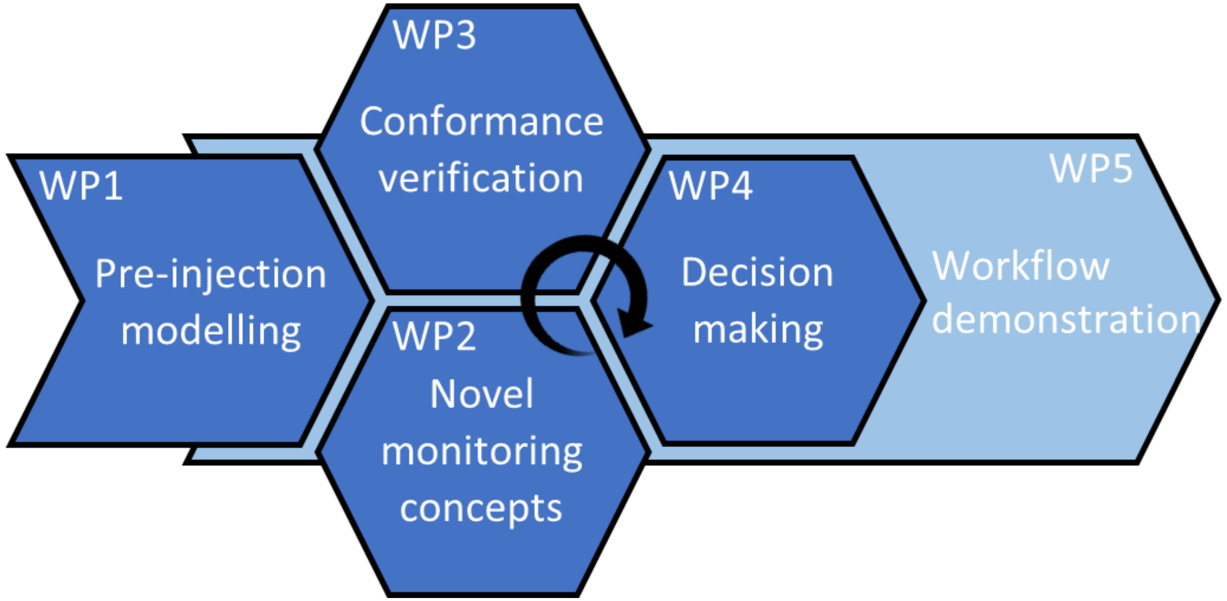
→ **Pressure control and conformance management for safe and efficient CO_2 storage - Accelerating CCS Technologies (Acronym: Pre-ACT)**

Pre-ACT

- Pressure control and conformance management for safe and efficient CO_2 storage - Accelerating CCS Technologies
- 3 year project
- Research and industry partnership with a focus on North Sea storage

The Pre-ACT approach

- Answering to industry needs
- **Learning from demonstration, pilot, and field lab data**
- Deliverables with focus on industry uptake



RE-VITALISATION AND UPGRADE

Development and testing of technologies and equipment required for large-scale CCS applications in a rapid and cost efficient manner

ECCSEL INFRASTRUCTURE

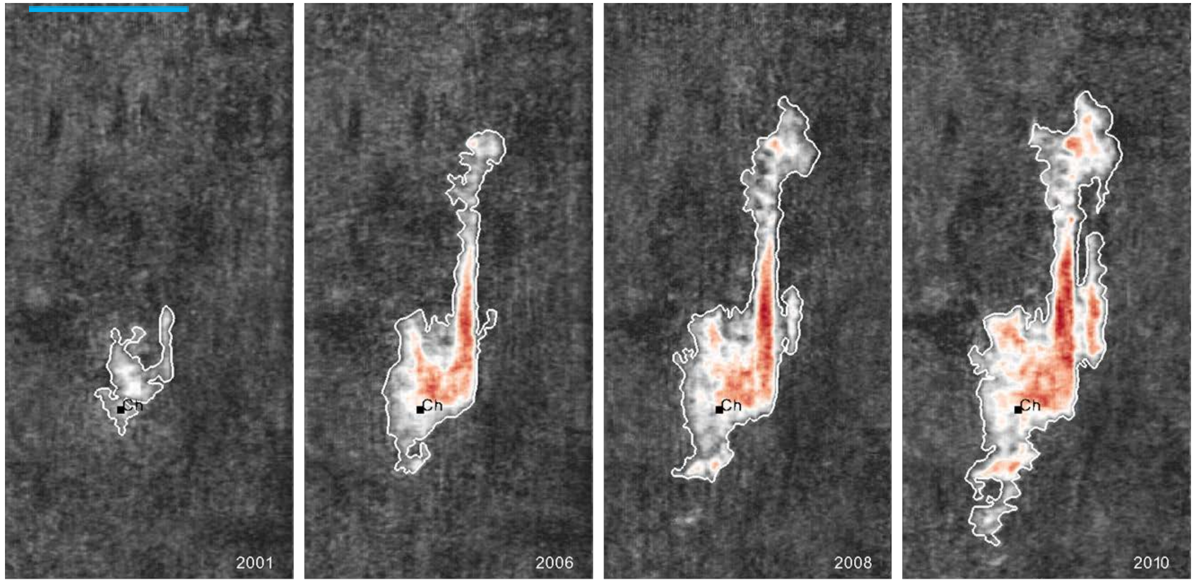
- European Carbon dioxide Capture and Storage Laboratory Infrastructure
- Opening access for CCS researchers to a top quality European research infrastructure
- Nine European countries

SINTEF

Saturation, pressure and conformance

- Large scale CO_2 injection generates widespread changes in the subsurface.
- The consequences can be imaged or appraised with active and passive geophysical measurements and downhole monitoring.
- But what controls the size and scale of the subsurface anomalies?
- And what can a point measurement say about the entire storage reservoir?
- How can limited geophysical measurements demonstrate conformance of a storage site?

Conformance: history matching



- CO_2 migration can be accurately imaged with geophysical data.
- Flow simulations, based on the best estimates of reservoir parameters, allow prediction to be made.
- But results do not always match!

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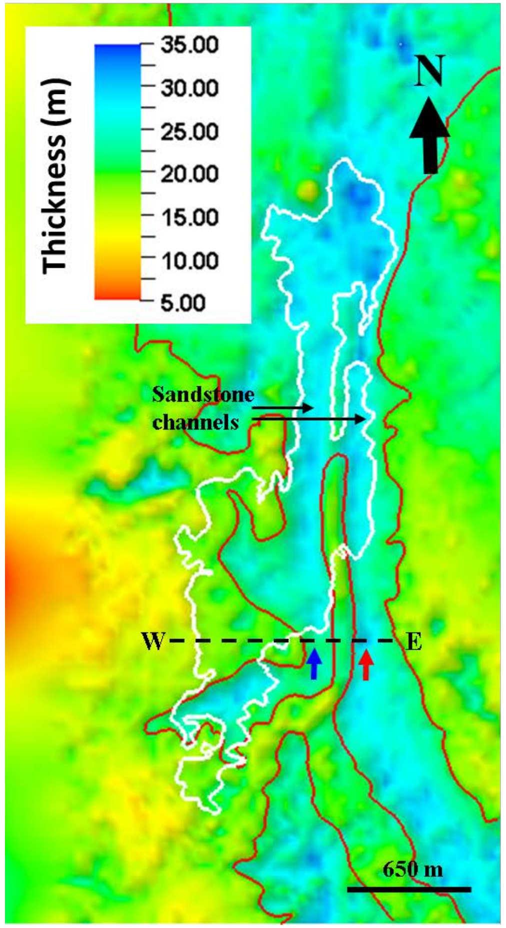
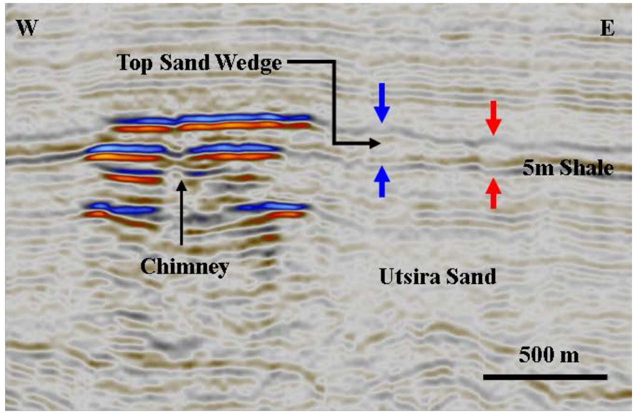
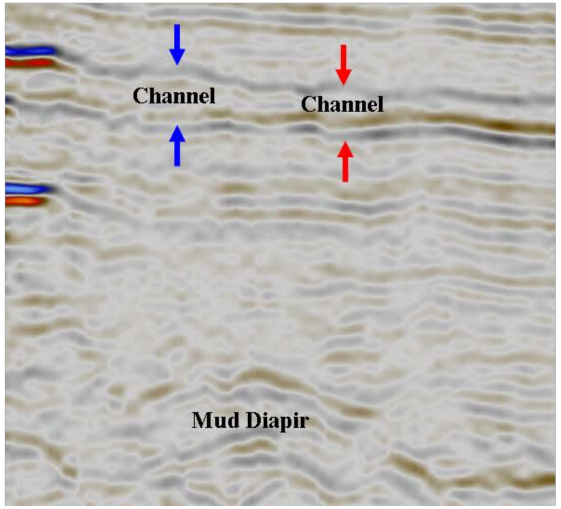
Sleipner – top sand wedge

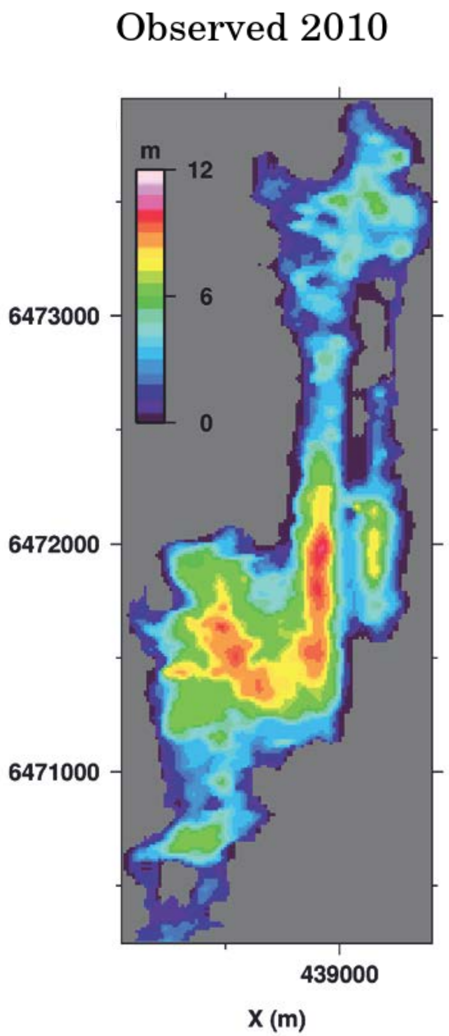
- Additional data, or understanding, allows a new model to be developed.
- Here higher resolution seismic has allowed channel structures to be imaged.

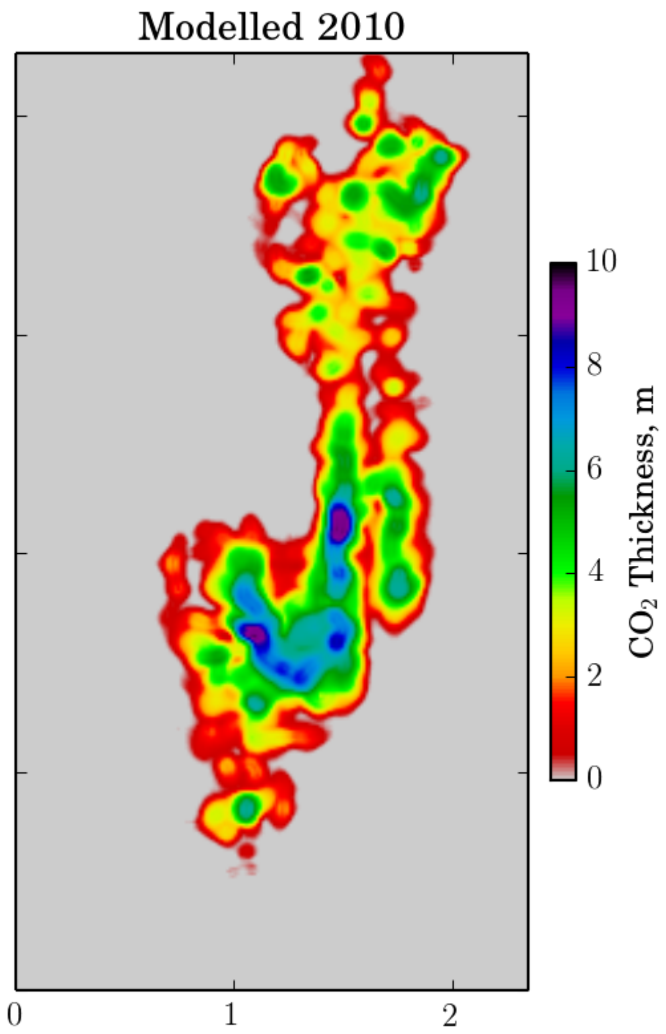






High permeability channel





Conformance

- Conformance assessment
  - Definition of conformance is case-specific (e.g., pressure limits, CO_2 containment)
  - Observed behaviour (measurements) in compliance with expected behaviour (model predictions) and regulations
  - Conformance statements must account for uncertainties (model and measurements)
- Monitoring strategies to improve conformance assessment
  - Well measurements (e.g., bottom-hole pressures, flow rates)
  - Field-wide geophysical surveys (e.g., time-lapse seismic)

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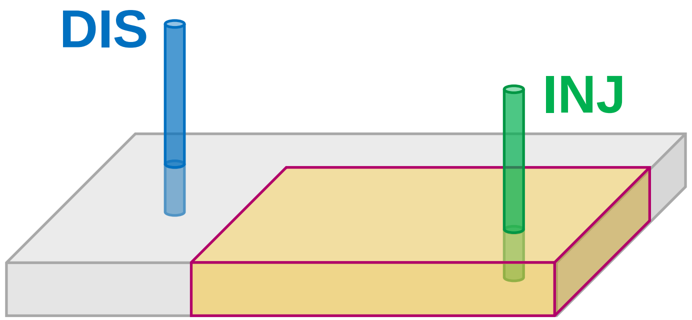
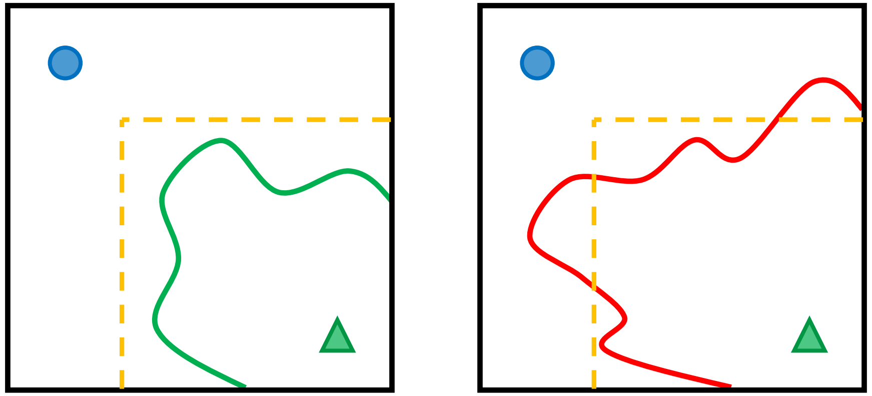
Case study

- Injected CO_2 must remain within regulatory/safety bounds
  - Quantity of interest: conformance verification at the end of injection period (t = T)



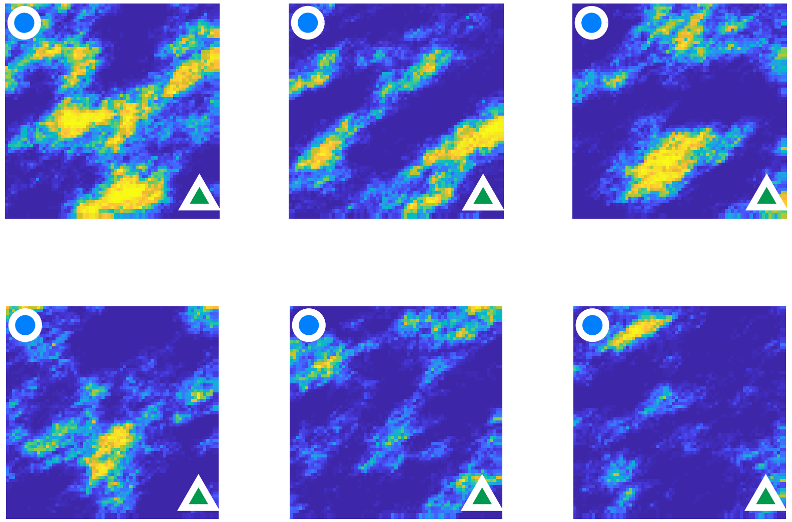


- Monitoring alternatives:
  - Time-lapse survey during interval t = [0,T]
  - How to design the configuration of such a survey?
  - Which configuration is most useful to improve conformance verification

Value of information

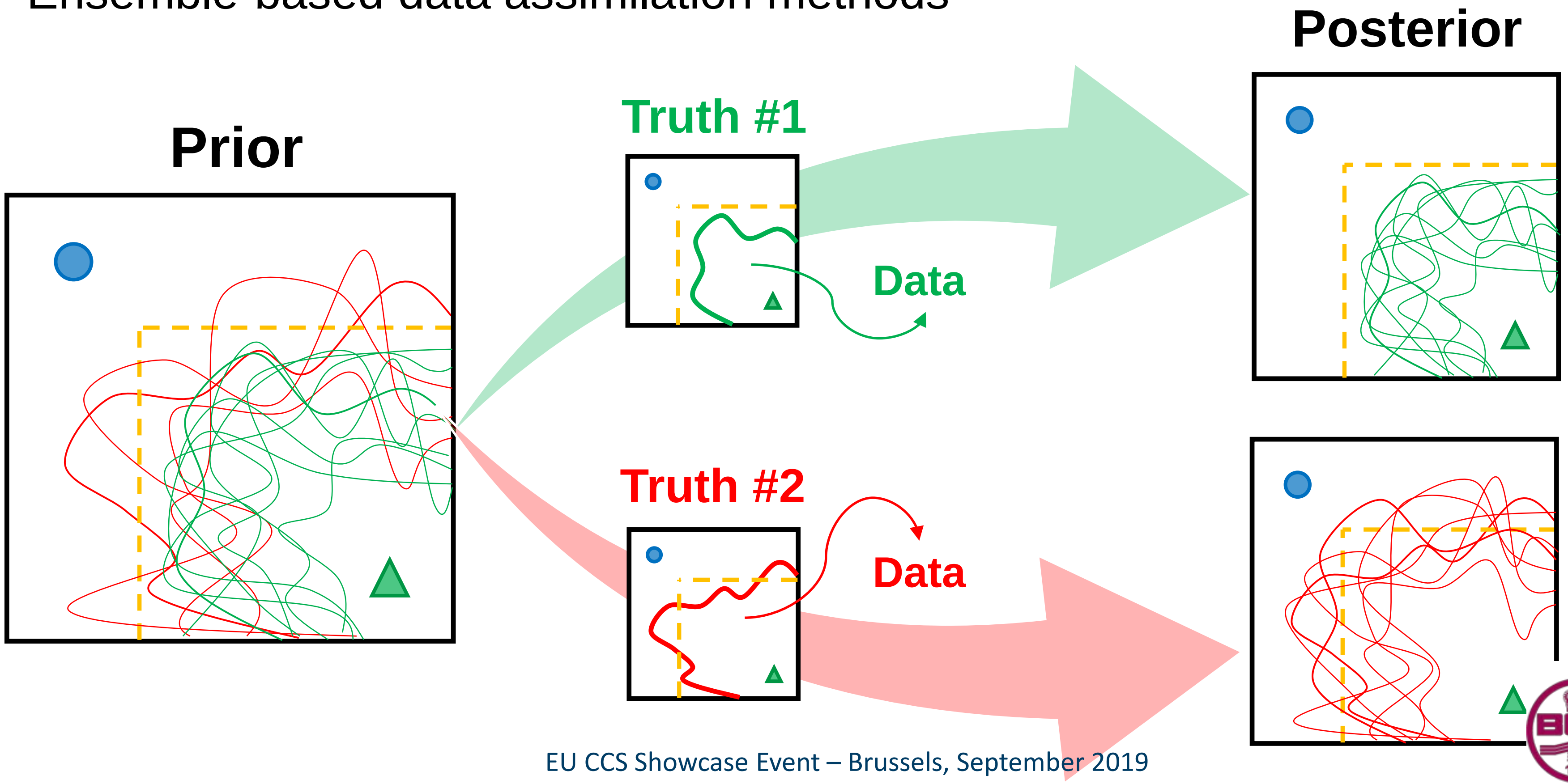
Geological uncertainty

- Geological structures influence propagation of CO_2 plume (e.g., heterogeneities in rock properties)
  - Ensemble of model realizations to characterize geological uncertainty
  - Ensemble of model predictions → Probabilistic conformance assessment



History matching

- Incorporate data measured during CO_2 injection to update model realizations
  - Ensemble-based data assimilation methods



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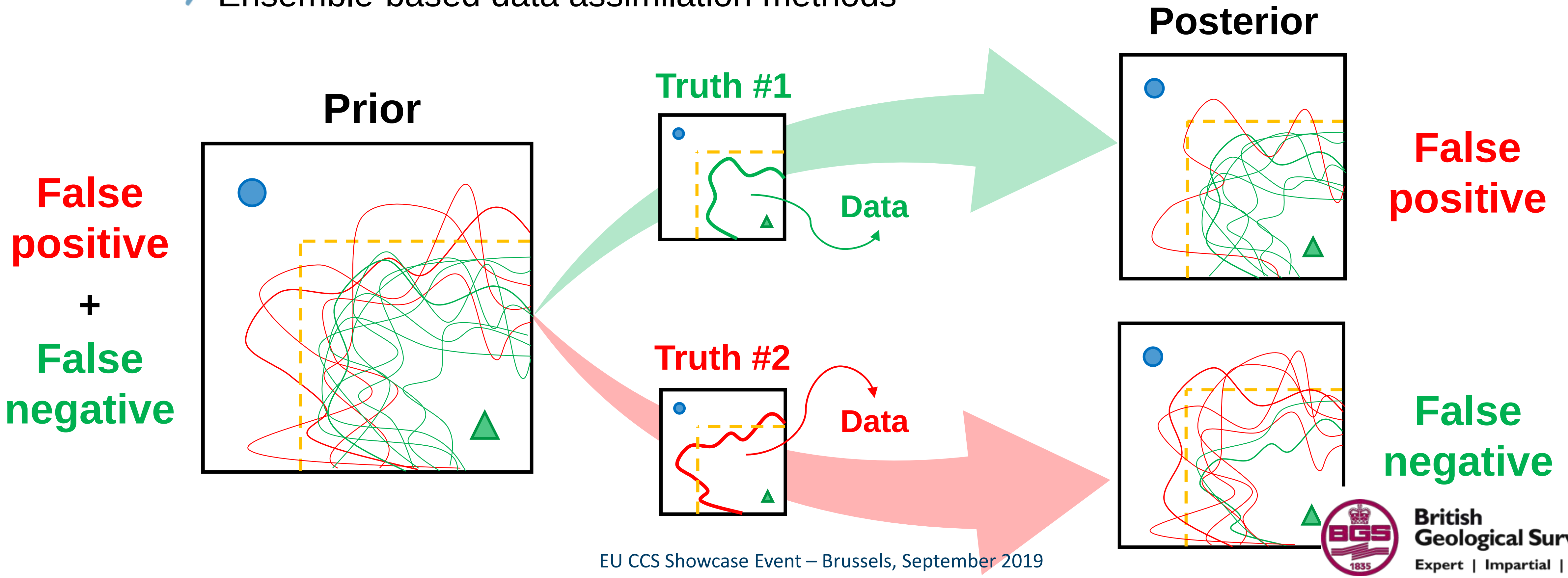
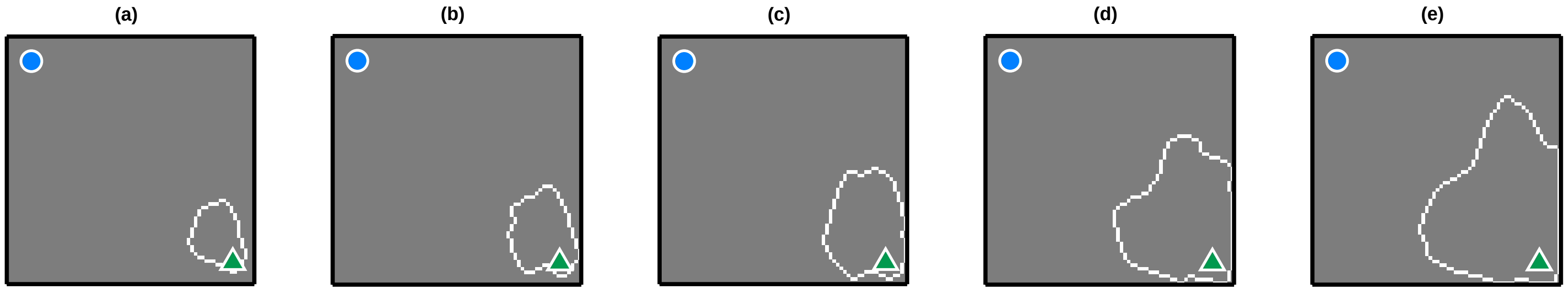
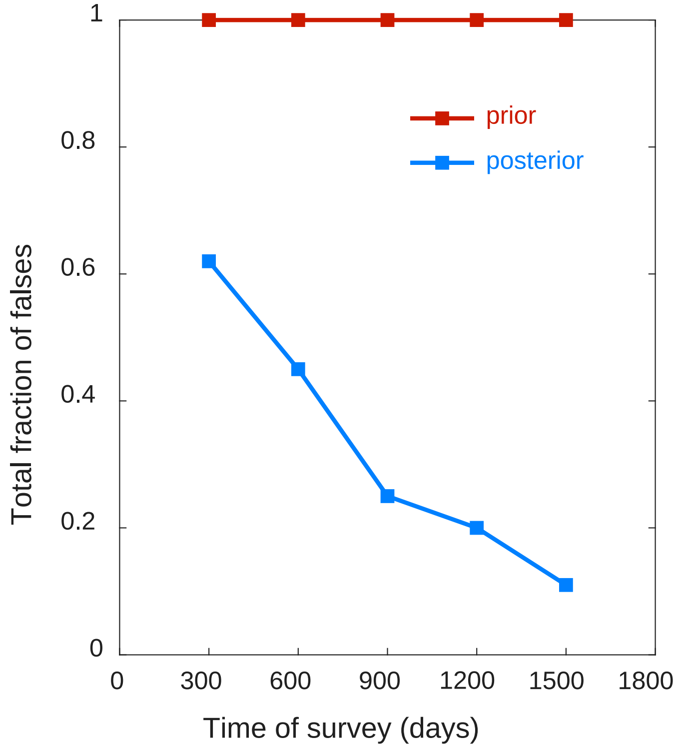


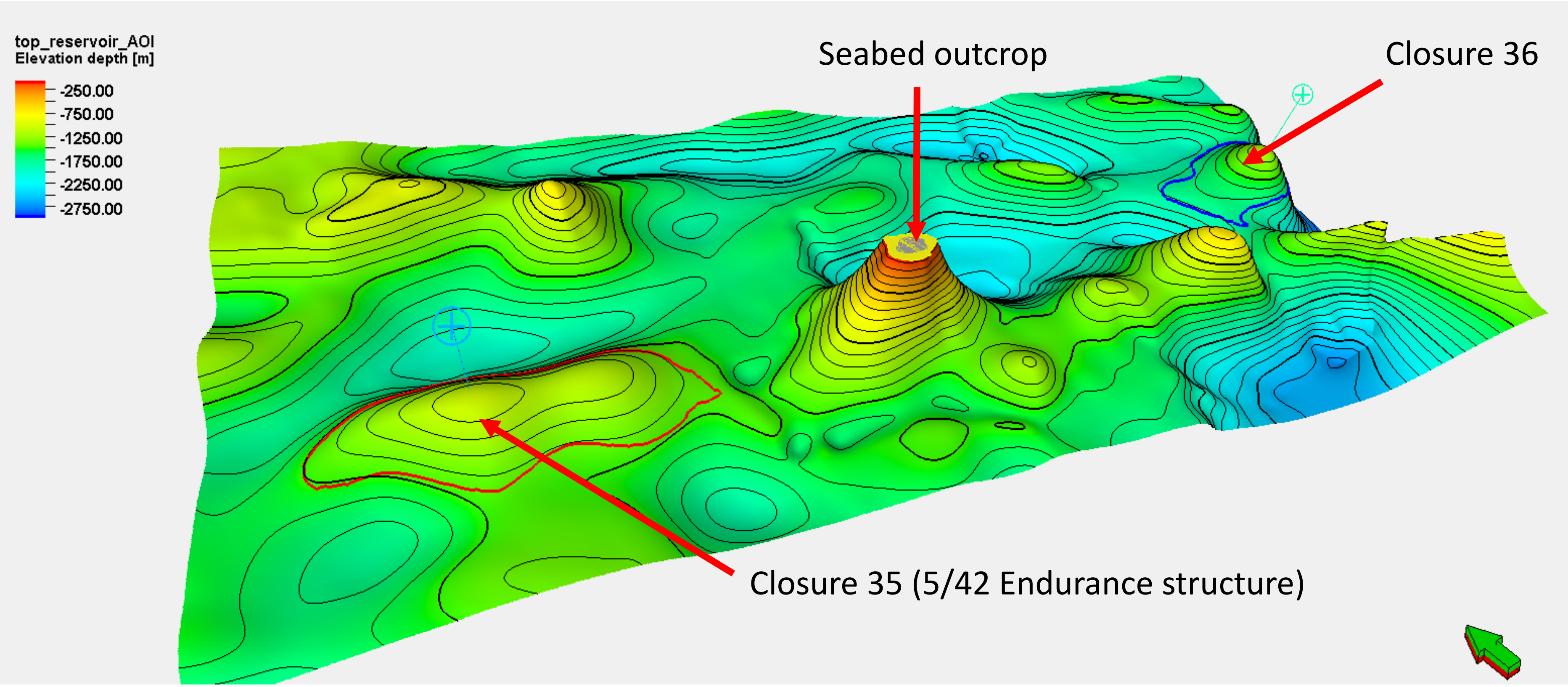
Survey considerations



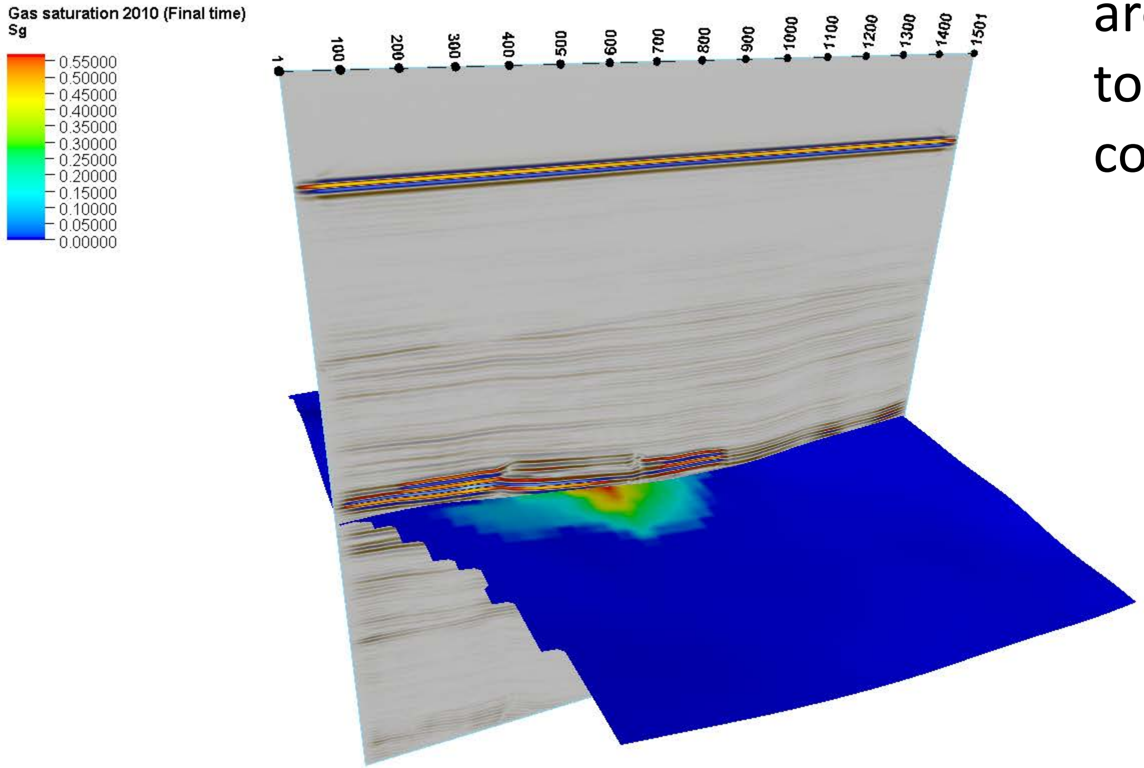
- Varying time of acquisition



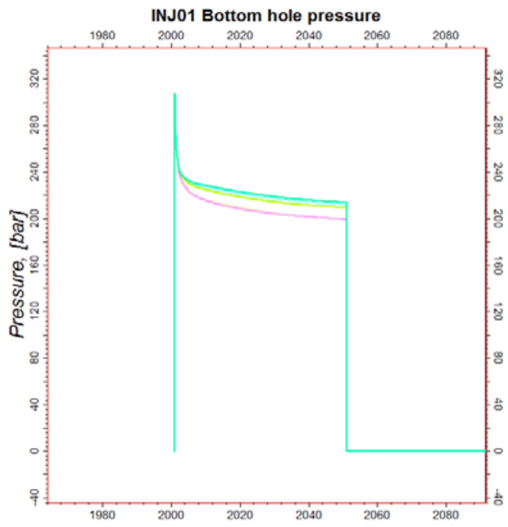
Case studies

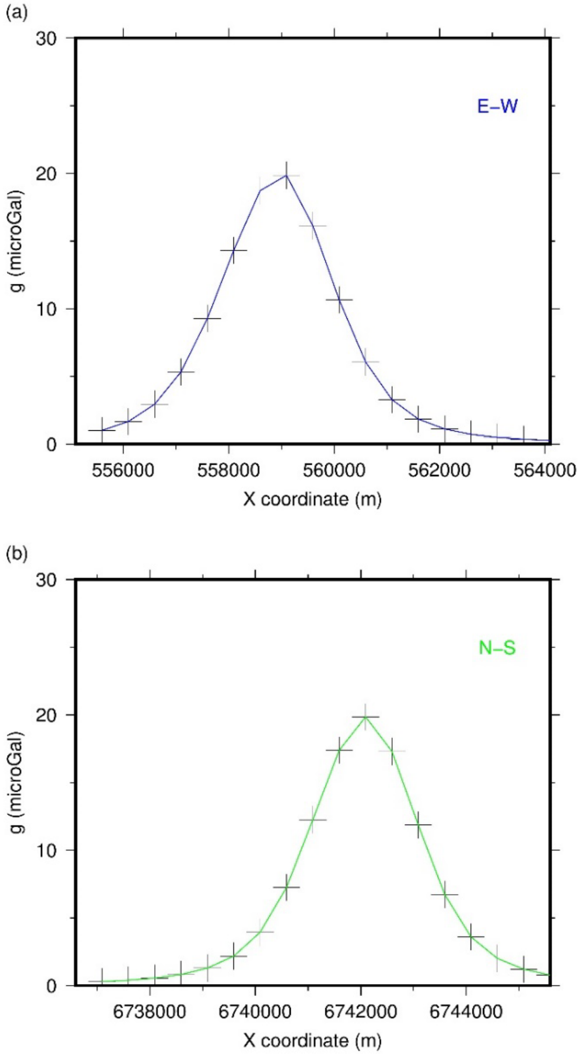


Create synthetic data for assessment



Seismic plume footprint, downhole pressure, gravity data are modelled for all realisations to feed into the Pre-ACT conformance assessment tool.





Next steps

- Apply full Pre-ACT conformance assessment to three case studies
- Assessment of downhole pressure data and ability to infer regional response
- Assess different monitoring techniques relative to ability to demonstrate conformance – this is a key output from the conformance tool.

Acknowledgements

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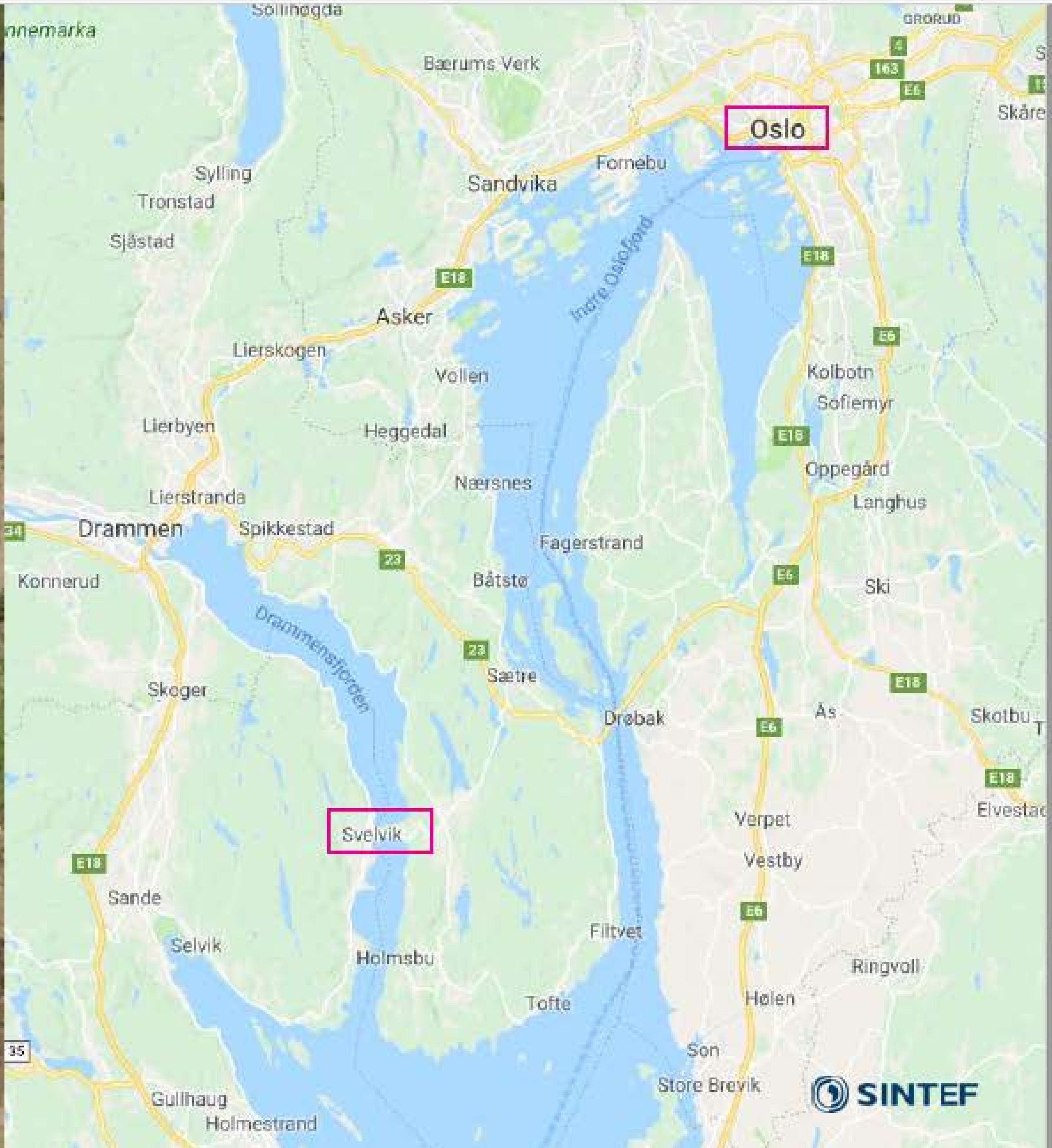

SVELVIK FIELD LAB CO_2

RE-VITALISATION AND UPGRADE

INJECTION WELL

Convert Svelvik #2 into an injection well for water and CO_2 injection @ 64 – 65 m

MONITORING WELLS

Drilling and instrumentation of four vertical 100 m deep wells for cross-well monitoring