

UPDATE ON MODELING THE CO₂ PLUME AT SLEIPNER

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Pittsburgh, Aug. 29 2019

Background

- Equinor has injected CO₂ into a saline aquifer at the Sleipner site since 1996 (~0.9 Mt/year)
- Extensively monitored from the beginning, including a series of time-lapse seismics
- Initial benchmark simulation model released in 2011, which received significant attention
- An updated and significantly expanded benchmark model released this year, and shared on the CO2DataShare web portal.



Adapted from OpenStreetMap

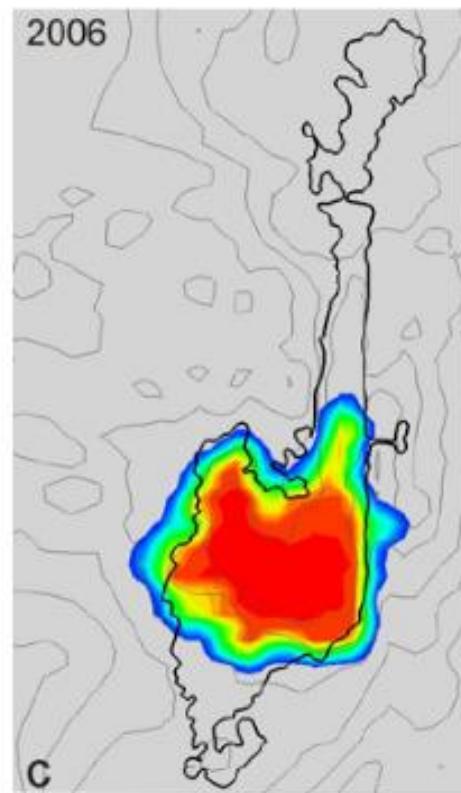
Brief history of CO₂ plume modelling at Sleipner

Layer 9 models

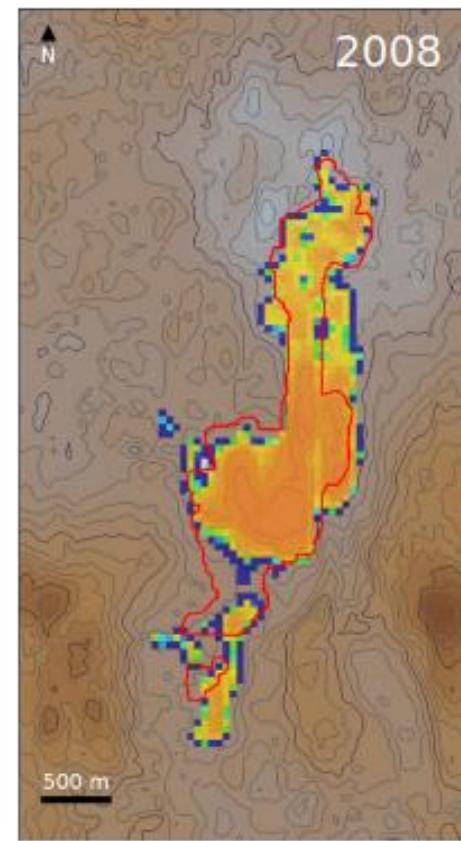
Early 5-layer model



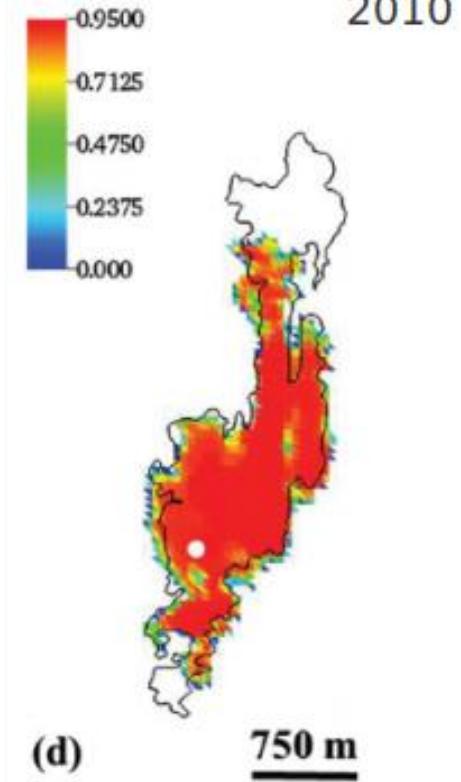
Lindeberg et al. 2000



Chadwick & Noy (2010)



Cavanagh (2013)

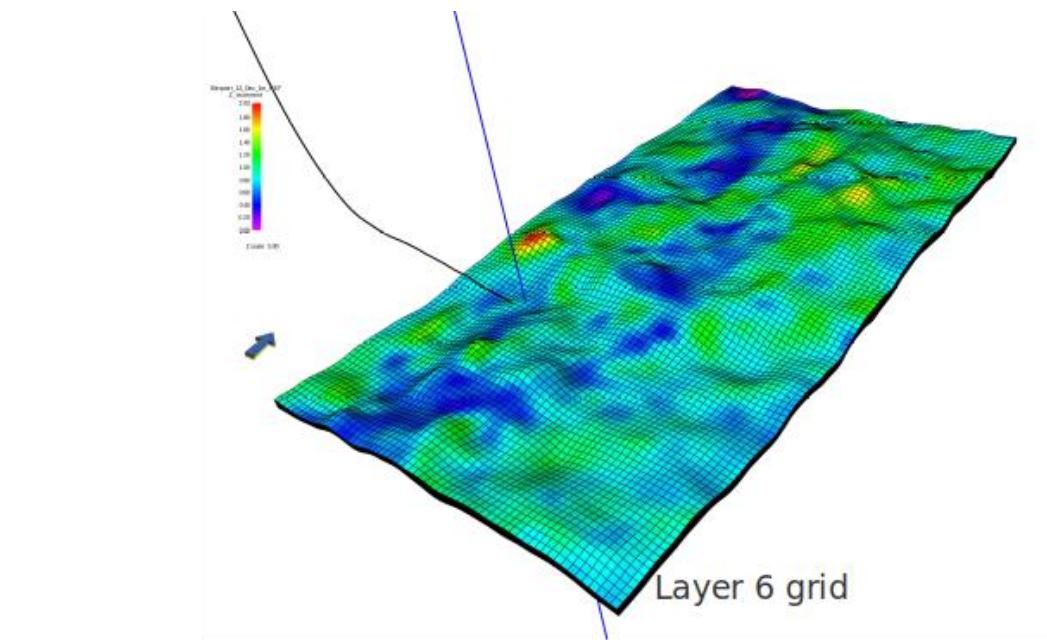
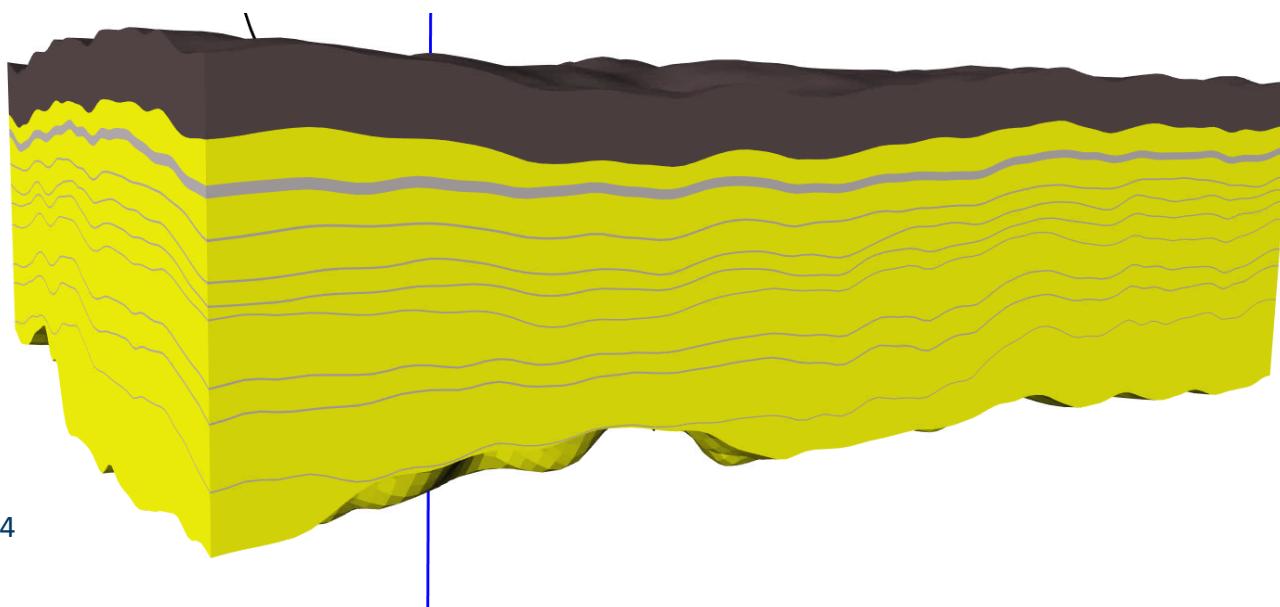


(d)

Williams & Chadwick, 2017

The Sleipner 2019 Benchmark Model

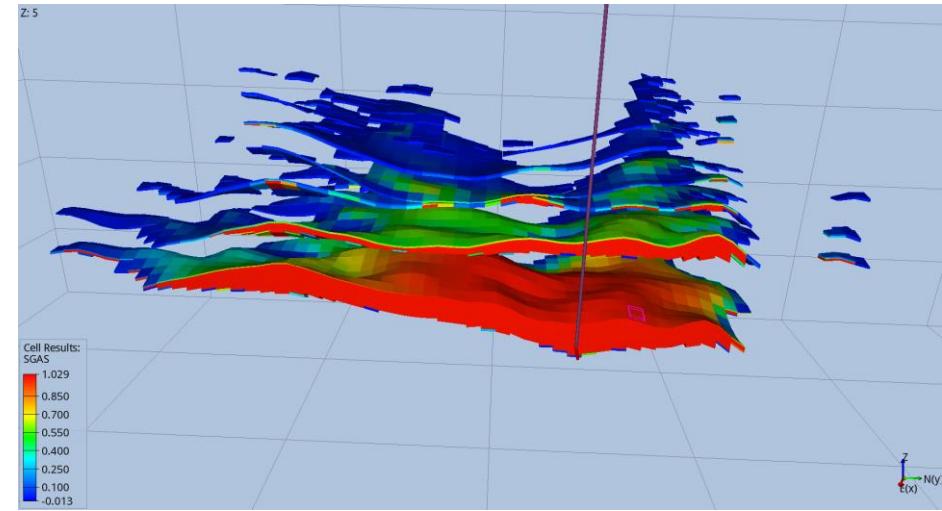
- Simulation grid (3.2 km x 5.9 km x 300 m); approx. ~ 2 million cells
- Petrophysical parameters (constant per layer)
- Well data
- Velocity maps
- Depth-converted surfaces
- Plume outline in all layers (development over time)
- Assumed intra-layer leakage points
- Seismic data to be released in separate data package



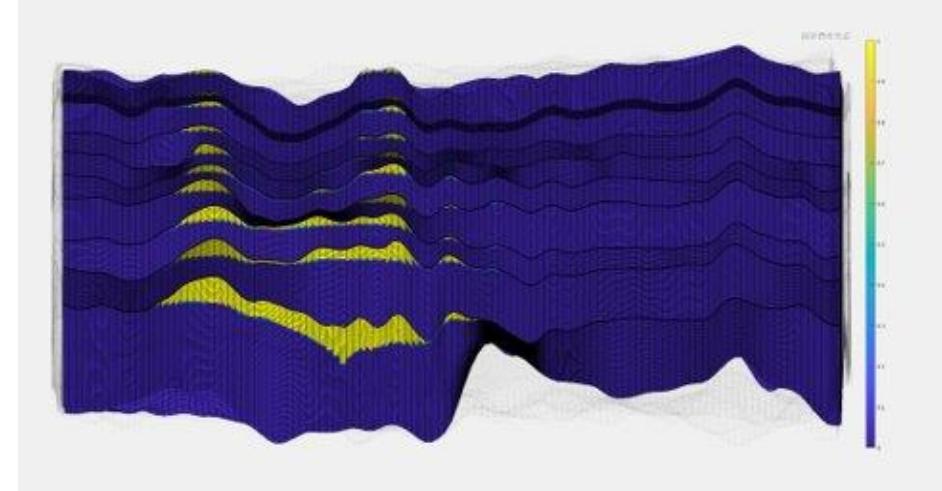
Model built by Andrea Callioli Santi (Equinor/Sintef)

Initial simulation experiences

- Some observations from preliminary testing by SINTEF Digital on the new Benchmark Model
- Computationally demanding – 2 million cells. Model simplification essential for practical study.
- Significant model reduction possible without practical loss in information
- Diffuse flow through shale layers hard to model correctly. Transmissibilities must be significantly adjusted to match reality.
- Diffuse flow may also lead to numerical issues when upscaling.
- Feedback from geologists suggest diffuse flow may be⁵ unimportant here anyway.



Full 3D sim. (OPM): ~1.9 million cells, 17 hours – 8 processors



VE sim (MRST) ~75 000 cells, 3 minutes,
single processor

Gassnova initiative

- Industry needs better confidence in their simulation approaches for CCS. Emerging projects have challenges to predict long-term plume development.
- Important questions: injection capacity, storage capacity, CO₂ migration
- Gassnova now invites interested parties to participate in a **CO₂ plume dynamics modeling challenge**, based on the 2019 Sleipner Benchmark Model.
- Purpose of the initiative:
 - Assess existing simulators/simulation methods/approaches for modeling plume developments
 - Improve predictions and determine where further development are most needed
 - Compare findings from different modeling groups
- Commercial/academic institutions may apply for up to 200 kNOK (22 kUSD), with own-effort contribution from 30% to 50%
- Non-Norwegian institutions are also invited to participate



GASSNOVA

- State enterprise; part of the funding system for state-financed CCS R&D in Norway
- Heads the CLIMIT secretariat
- Grants financial support for development, demonstration and piloting projects in CCS

CO₂ plume dynamics modeling challenge - timeline

- Gassnova call open until the end of 2019, applications evaluated continuously.
- Initial kickoff workshop or webinar to be organized in January 2020
- Final workshop organized towards the end of the summer.
- Final outcome: Summary report, or joint academic paper



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