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DOI

[10.13140/RG.2.2.28532.32641](https://doi.org/10.13140/RG.2.2.28532.32641)

Publication date

2023

Document Version

Final published version

Citation (APA)

de Jonge-Anderson, I., Ramachandran, H., Geiger, S., Nicholson, U., & Doster, F. (2023). *Storage Efficiency and Reduced Complexity Modelling*. Poster session presented at Energy Group - CO2 Storage Efficiency, London, United Kingdom. <https://doi.org/10.13140/RG.2.2.28532.32641>

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Storage Efficiency and Reduced Complexity Modelling

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Motivation

- It is difficult to forecast CO₂ storage efficiency without running computationally-expensive and time-consuming reservoir simulations.
- It's a key parameter in assessing the capacity of a CO₂ storage site.

Goal

- Develop a workflow for estimating CO₂ storage efficiency using reduced complexity modelling.
- Apply this workflow to a simple case study offshore Malaysia.

Area of interest

- Real data from the Malay Basin, offshore Peninsular Malaysia.
- Small area mapped using 3D seismic data.

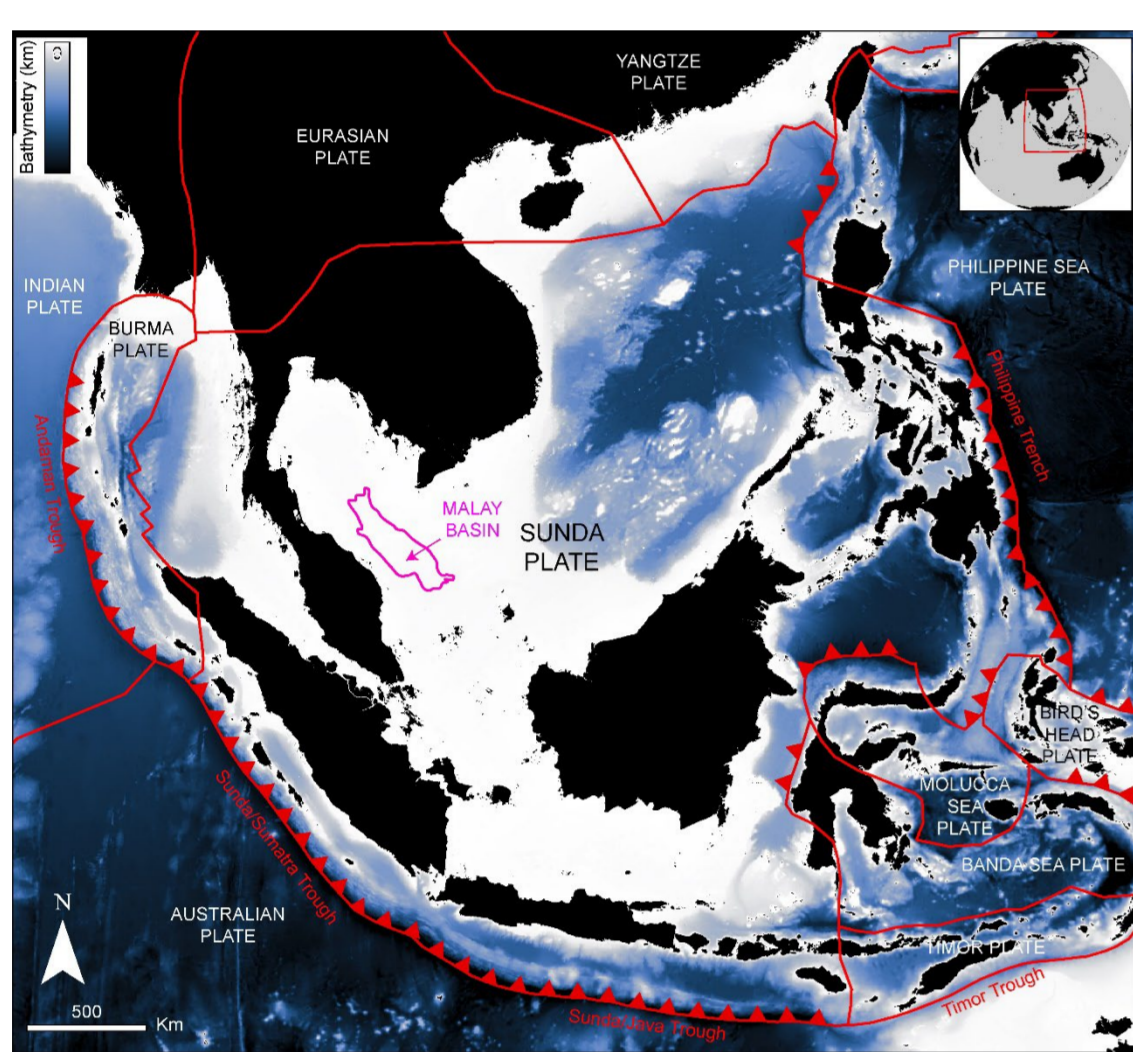


Fig.1 The Malay Basin lies on the Sunda Shelf offshore Peninsular Malaysia

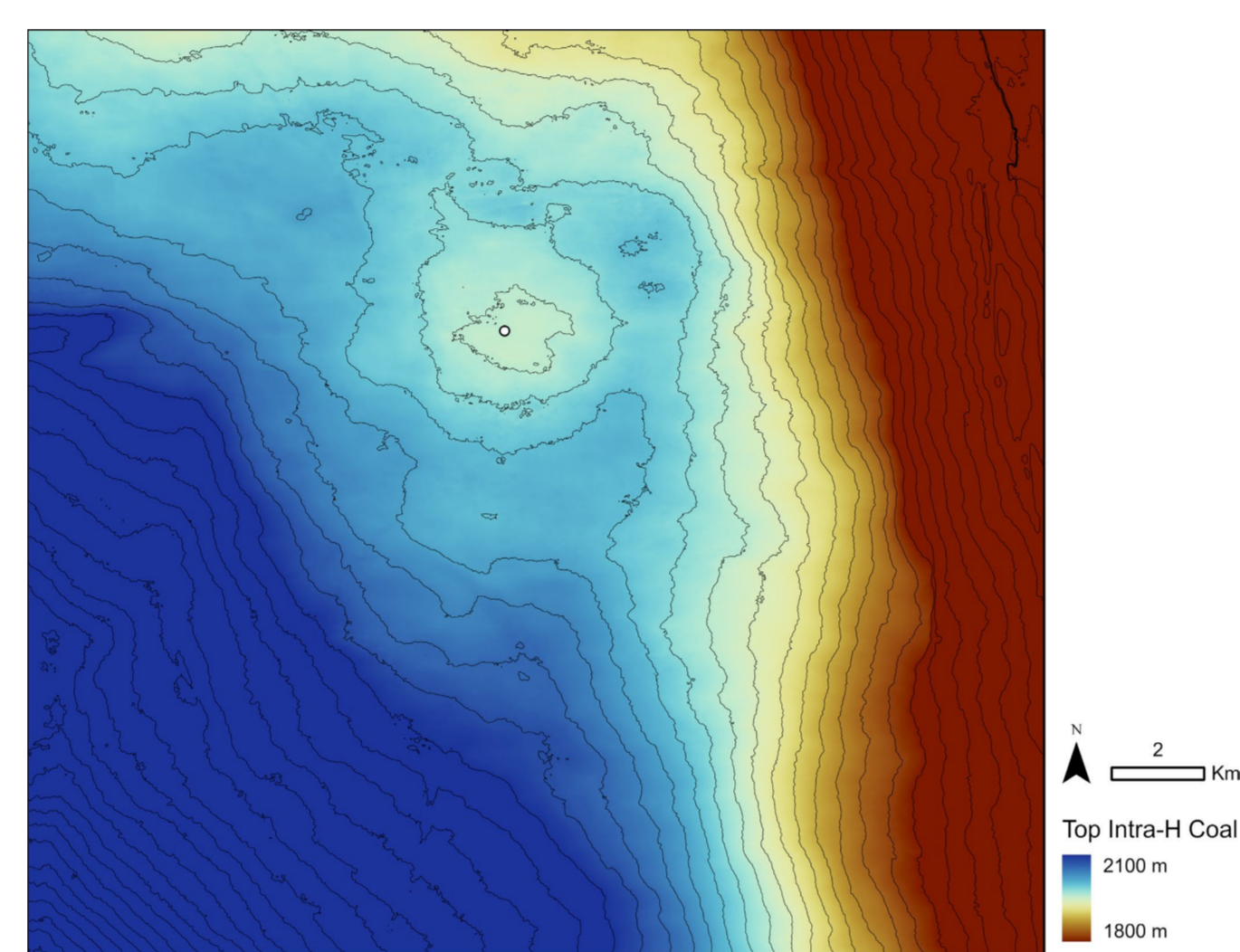


Fig.2 Area of interest is a gently dipping (downdip to west) aquifer with a small anticline. (Grid size 200 m x 200 m)

Structural trapping, spill-point analysis

- Simple 3D grid made with dimensions 200 m x 200 m x 200 m.
- Grid is loaded into MRST-CO₂Lab and trapping analysis is first used to identify traps, spill pathways and filling regions.

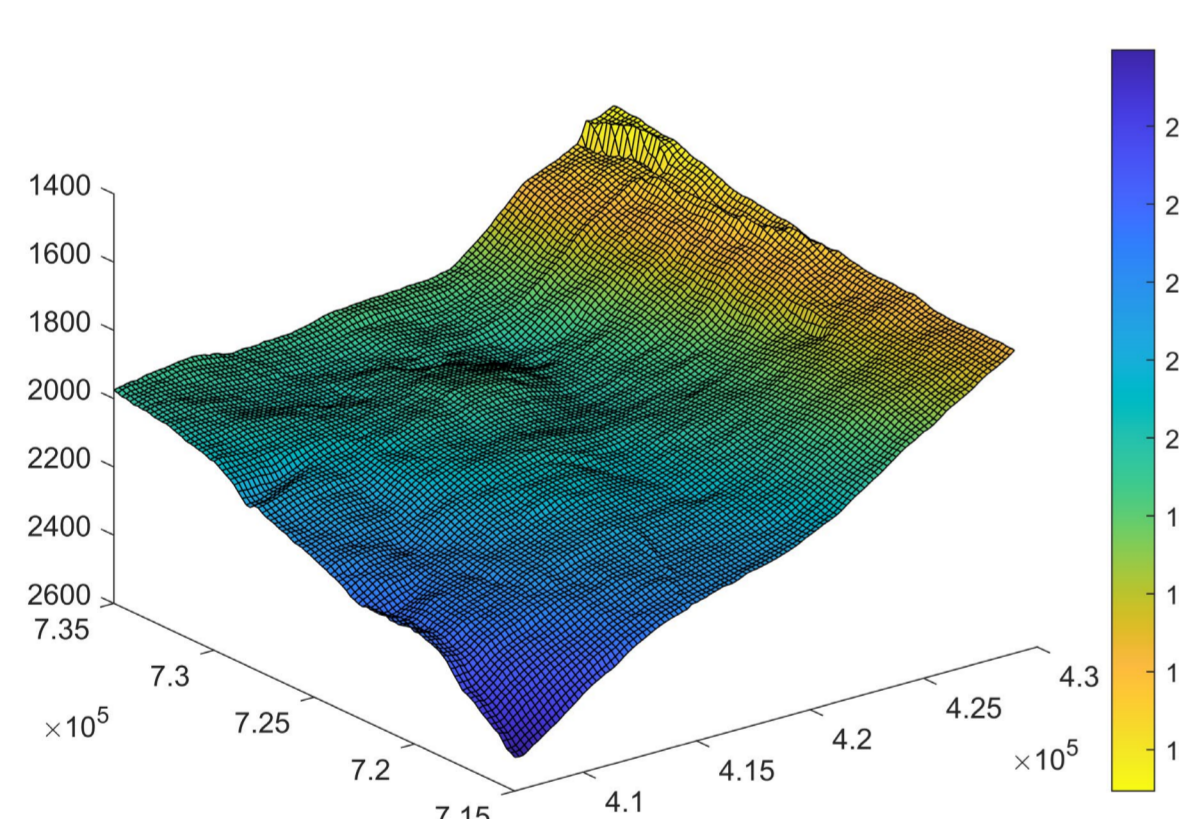


Fig.3 Top reservoir surface used for the static trapping analysis

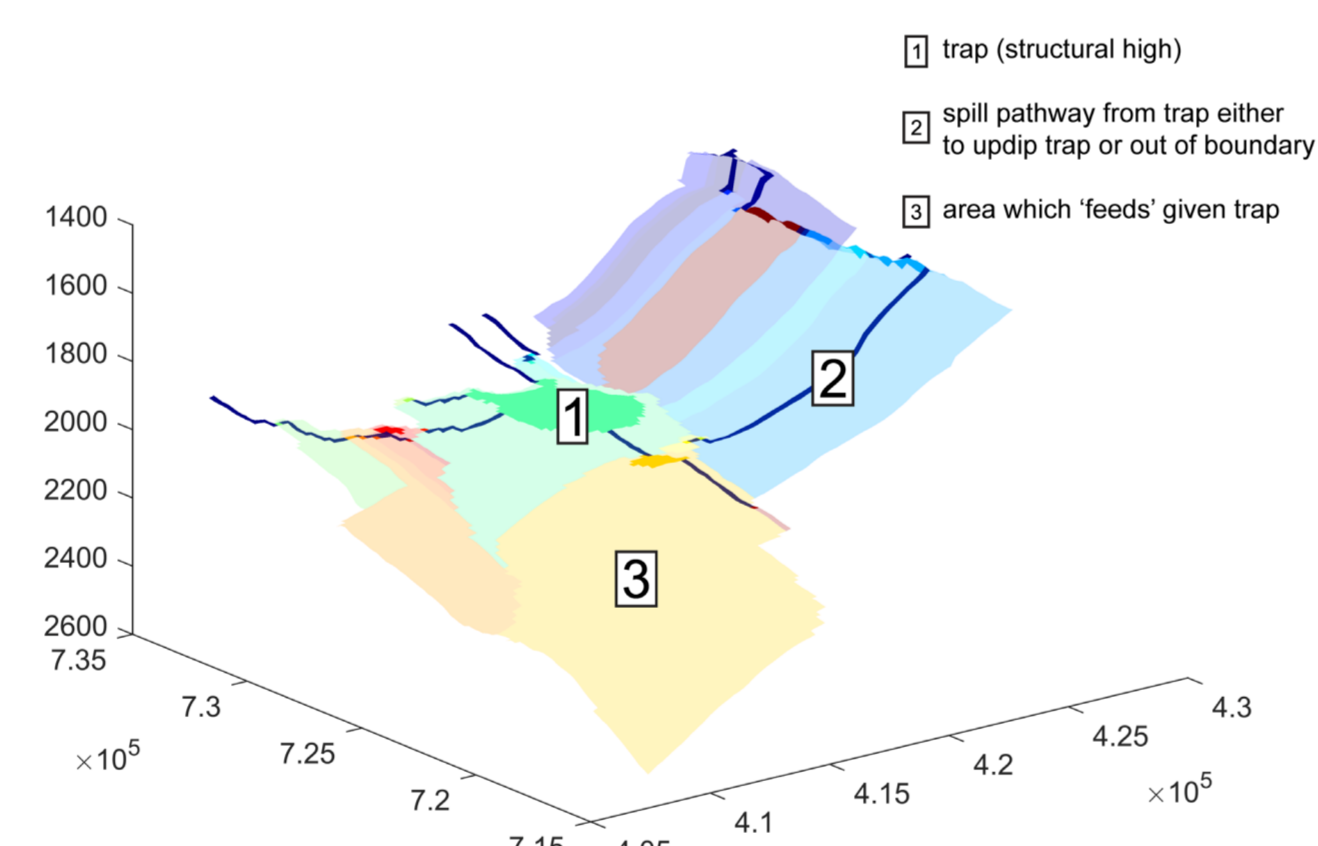


Fig.4 Traps, trap regions and spill pathways identified from structural grid

- Trap analysis then used to identify "chains" of traps – giving insight into how CO₂ could migrate and be stored within traps over long time scales.
- These chains can be used to identify prospective injection locations.

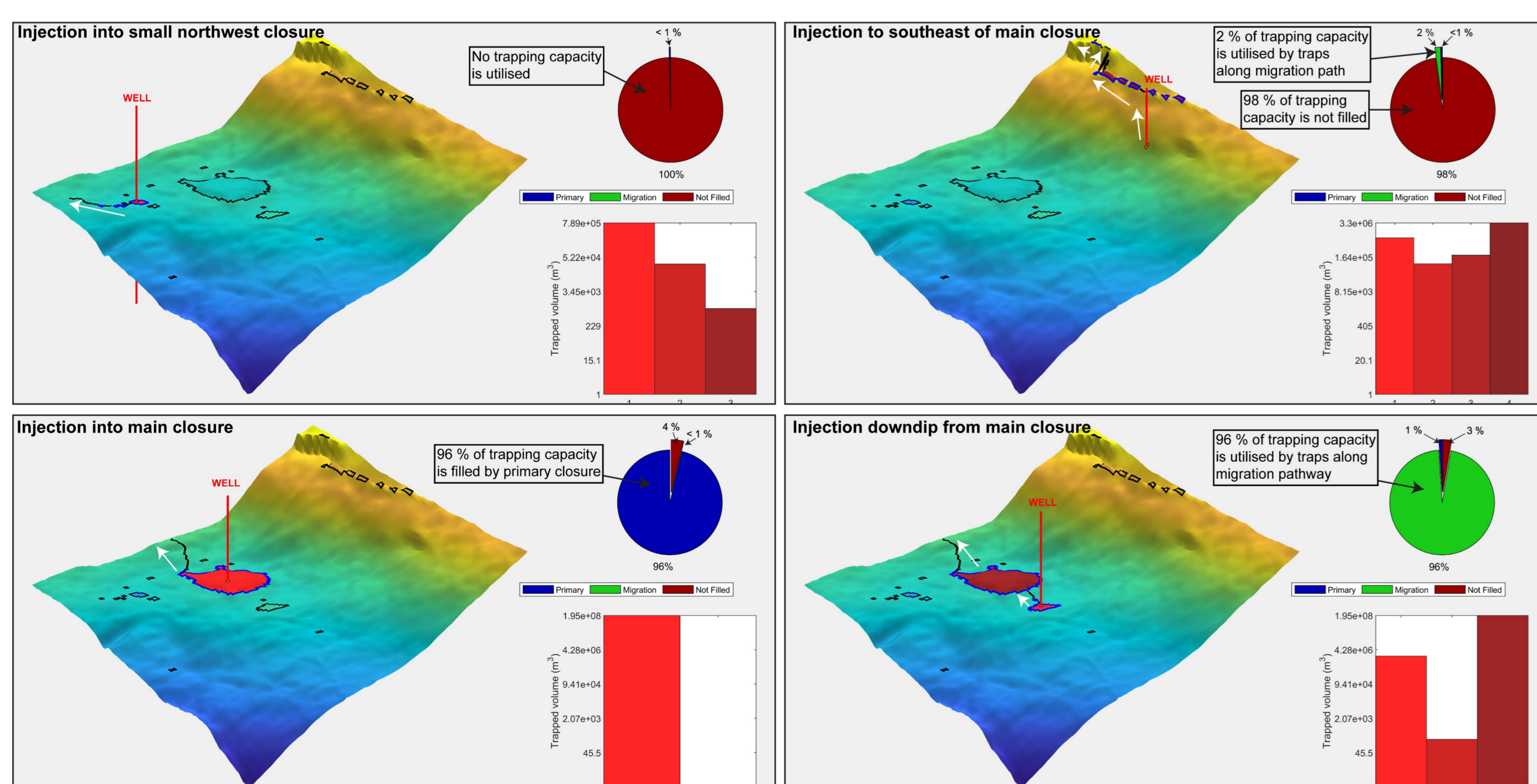


Fig. 5 Trapping scenarios for four different well locations

Storage efficiency from static trapping analysis

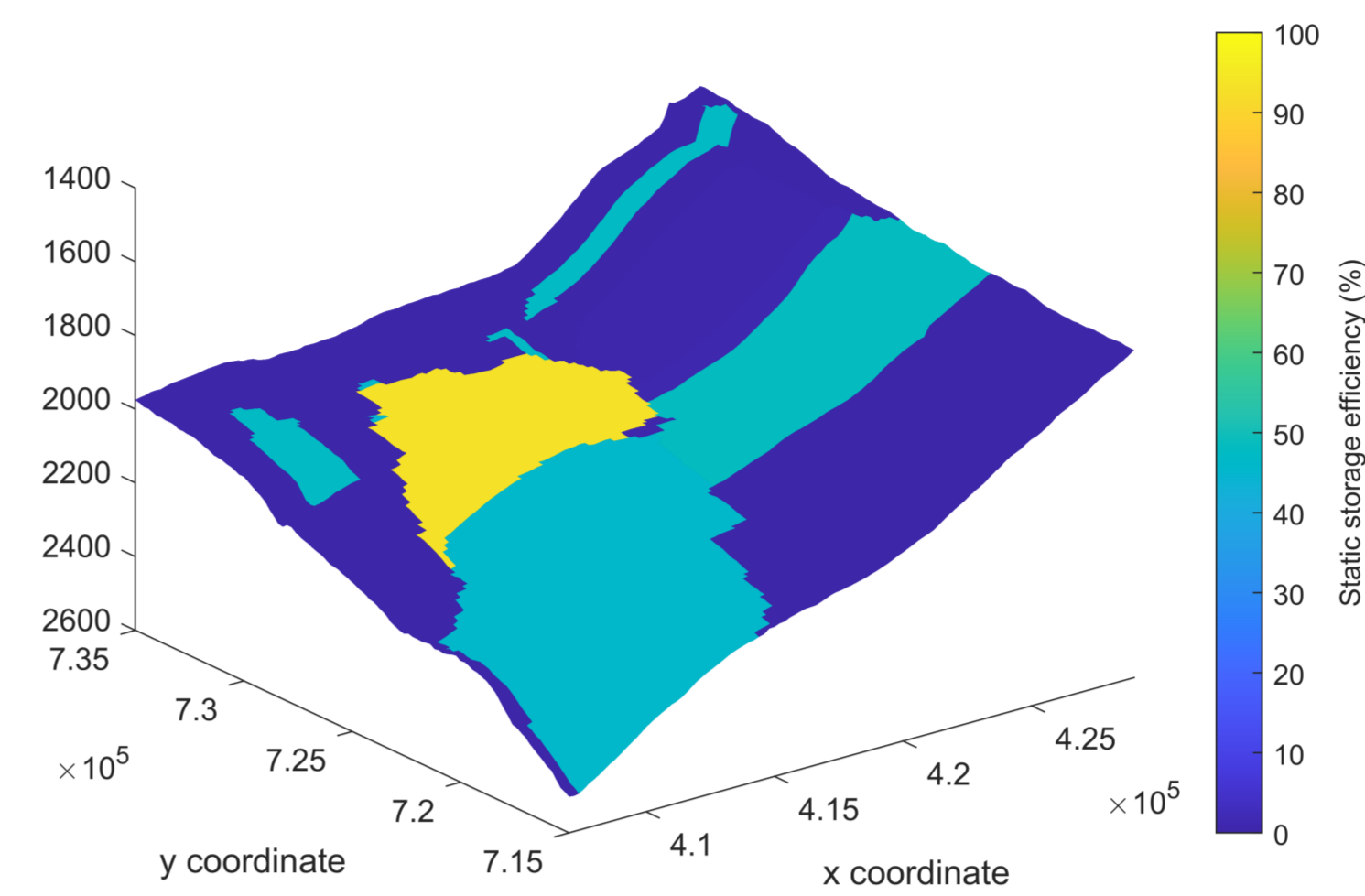


Fig.6 Static storage efficiency across the structural grid.

- Traps and migration pathways used to get initial look at best injection location.
- For each cell, the total trapped volume of its trapping chain is first calculated.
- Then, storage efficiency is calculated as:

$$\frac{V_c}{V_g} \times 100$$

- Where V_c is the storage volume within the trapping chain and V_g is the total volume of the grid.
- Highlights where a good well placement could be, but efficiency factors are very high (no petrophysics or fluid behaviour considered).

Storage efficiency using vertical-equilibrium models

- Assumes that the flow system is in vertical equilibrium so that the vertical distribution of fluid phases can be determined from analytical expressions.
- Considered a reasonable assumption for CO₂ migrating through a relatively homogenous aquifer.
- Porosity and permeability cubes made using a gaussian distribution.
- 50 years of injection at 3 Mt/year, followed by 950 years of migration.
- More than 400 simulations (30 sec/simulation) across grid.
- CO₂ saturation is mapped, and storage efficiency calculated as:

$$\frac{V_{CO_2}}{V_p} \times 100$$

- Where V_{CO_2} is the pore volume saturated by CO₂ and V_p is the pore volume.
- Highlights ideal well location, with much smaller storage efficiencies (< 1 %).

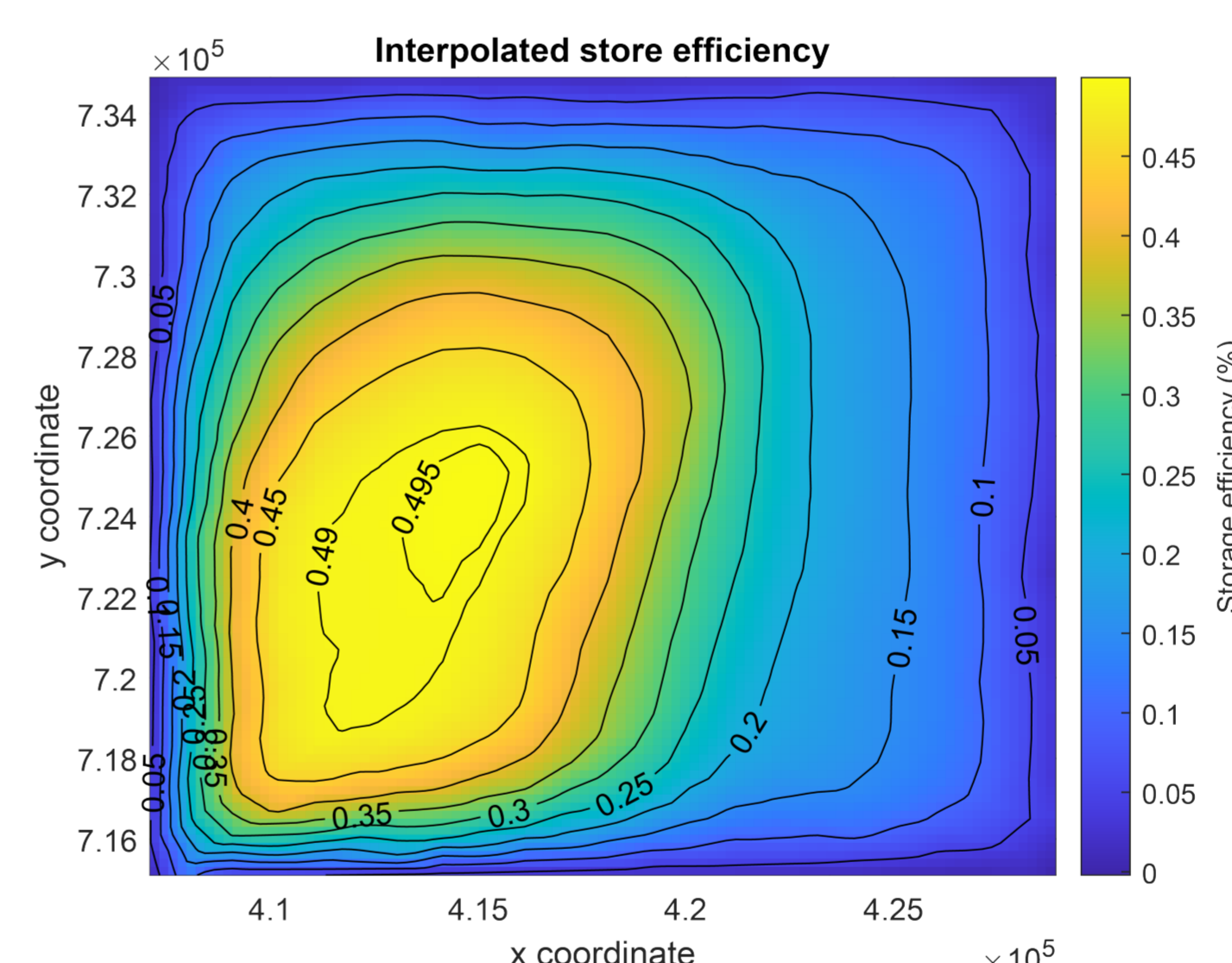


Fig.7 Map of storage efficiency based on > 400 VE simulations

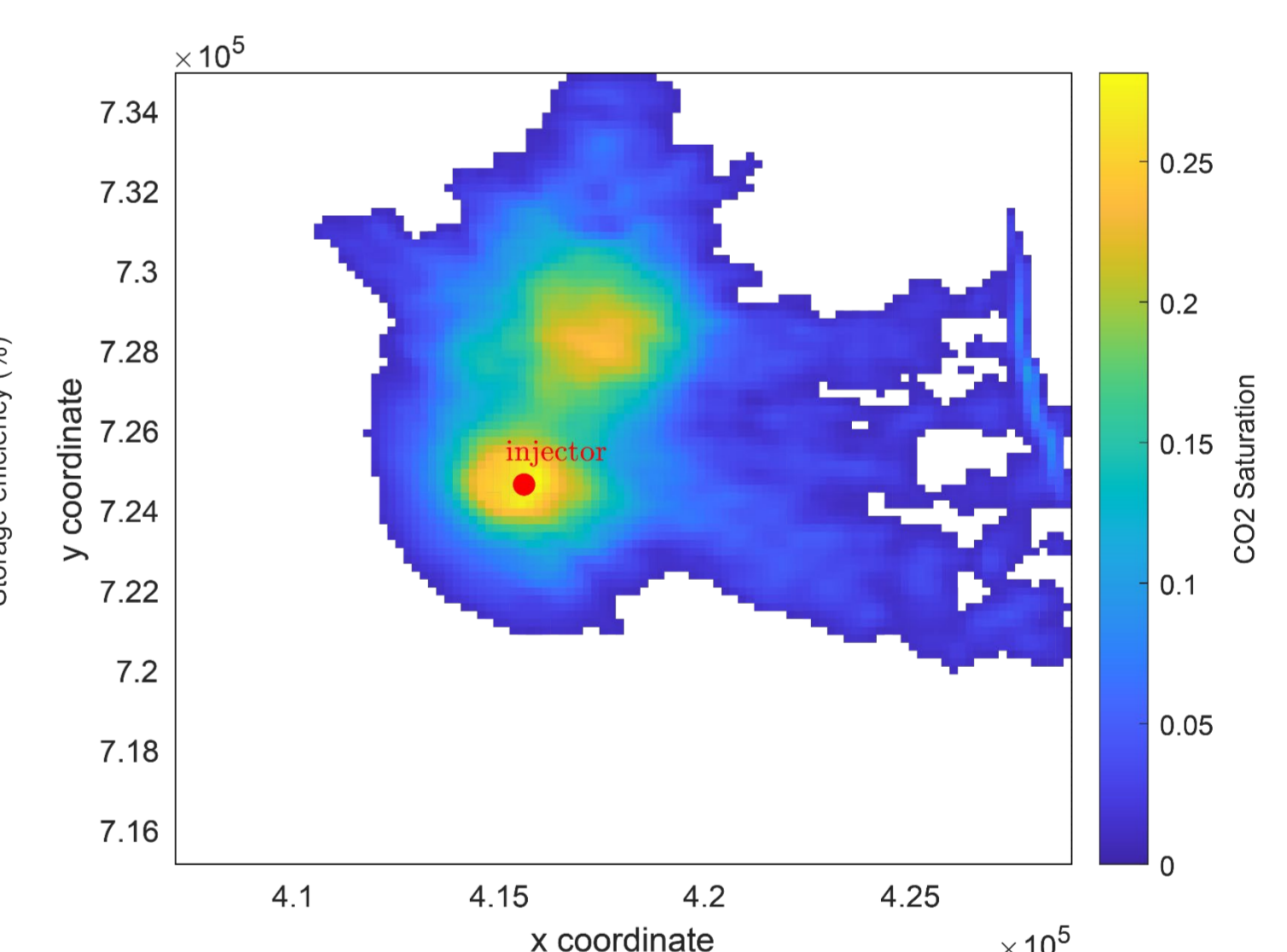


Fig.8 CO₂ saturation (after 1000 years) for the optimal well location

Summary

- Reduced complexity modelling allows quick insights into storage efficiency of a given storage site and provides the middle ground between simple volumetric assessments and 3D simulations
- Different levels of complexity allow to investigate ranges of storage efficiencies at different stages along the development phase.
- While the locations of efficient well placement are similar between the two methods above, the large difference in efficiency factor highlights the need for refinement.
- Small computational costs and limited number of parameters allow for uncertainty assessment of storage efficiency, exploring different injection strategies and value-of-information assessments at different development stages.

Acknowledgements

We thank Petronas and the Petronas GTC for providing access to data and funding Iain and Hari's positions.