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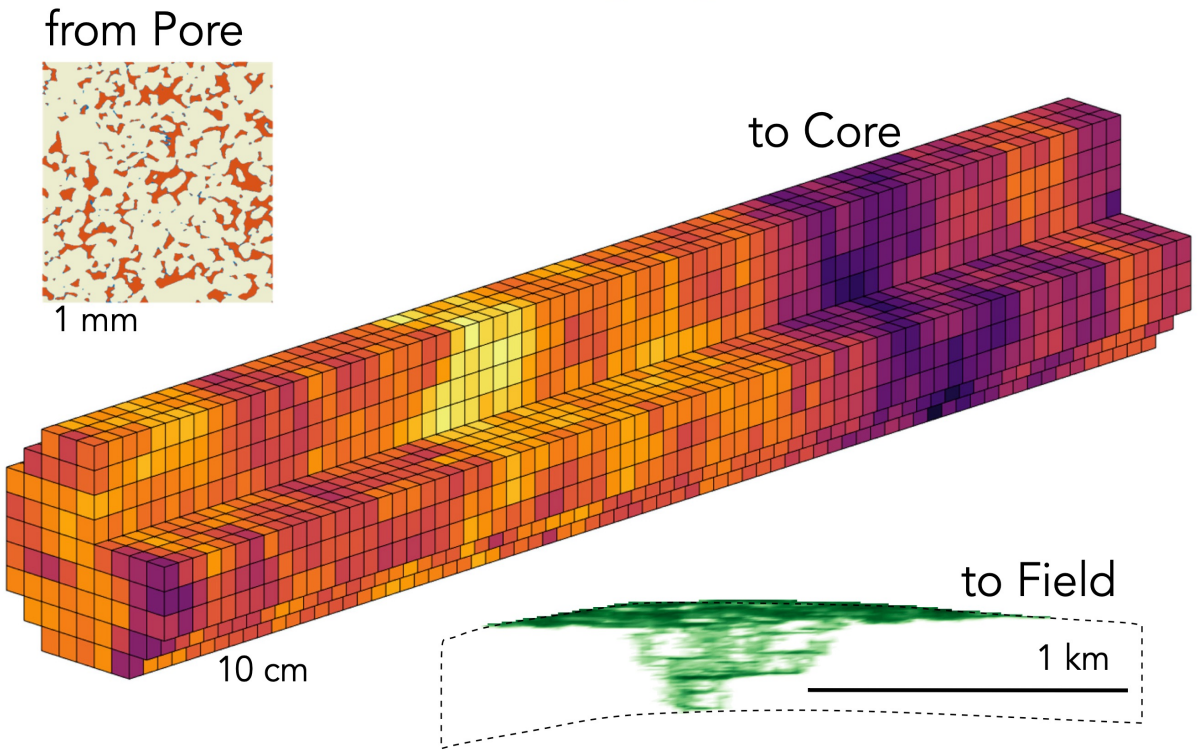
Department of Earth Science and Engineering
Subsurface CO_2 Research Group

StrataTrapper



EGU25-4162

Max ELIZAREV, Sam Krevor, Ann Muggeridge

Capillary heterogeneity upscaling using macroscopic percolation

code advances and field-scale dynamic CO_2 storage simulations

Sharing is encouraged

Capillary Heterogeneity
as flow driving force

StrataTrapper

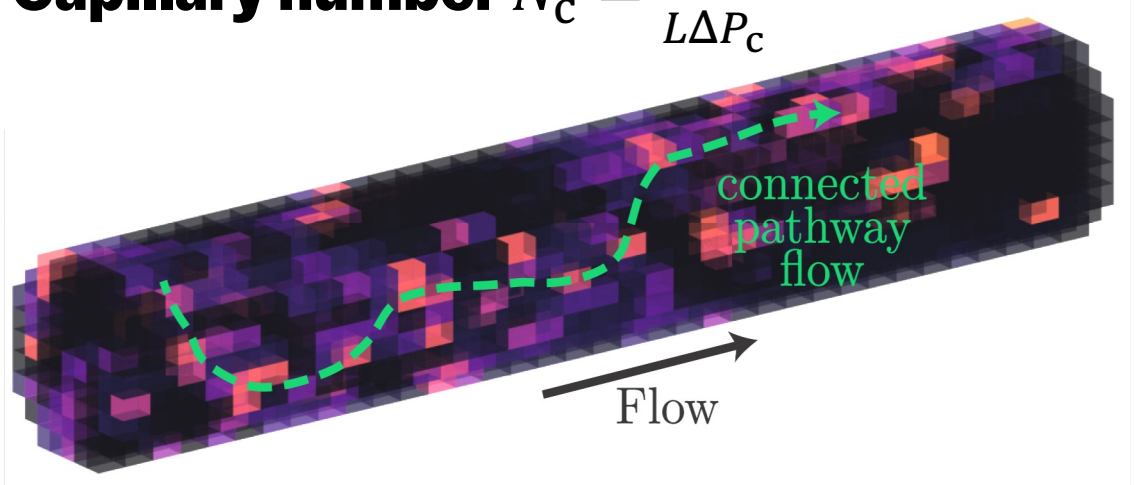
has largely been ignored
through practical scaling arguments

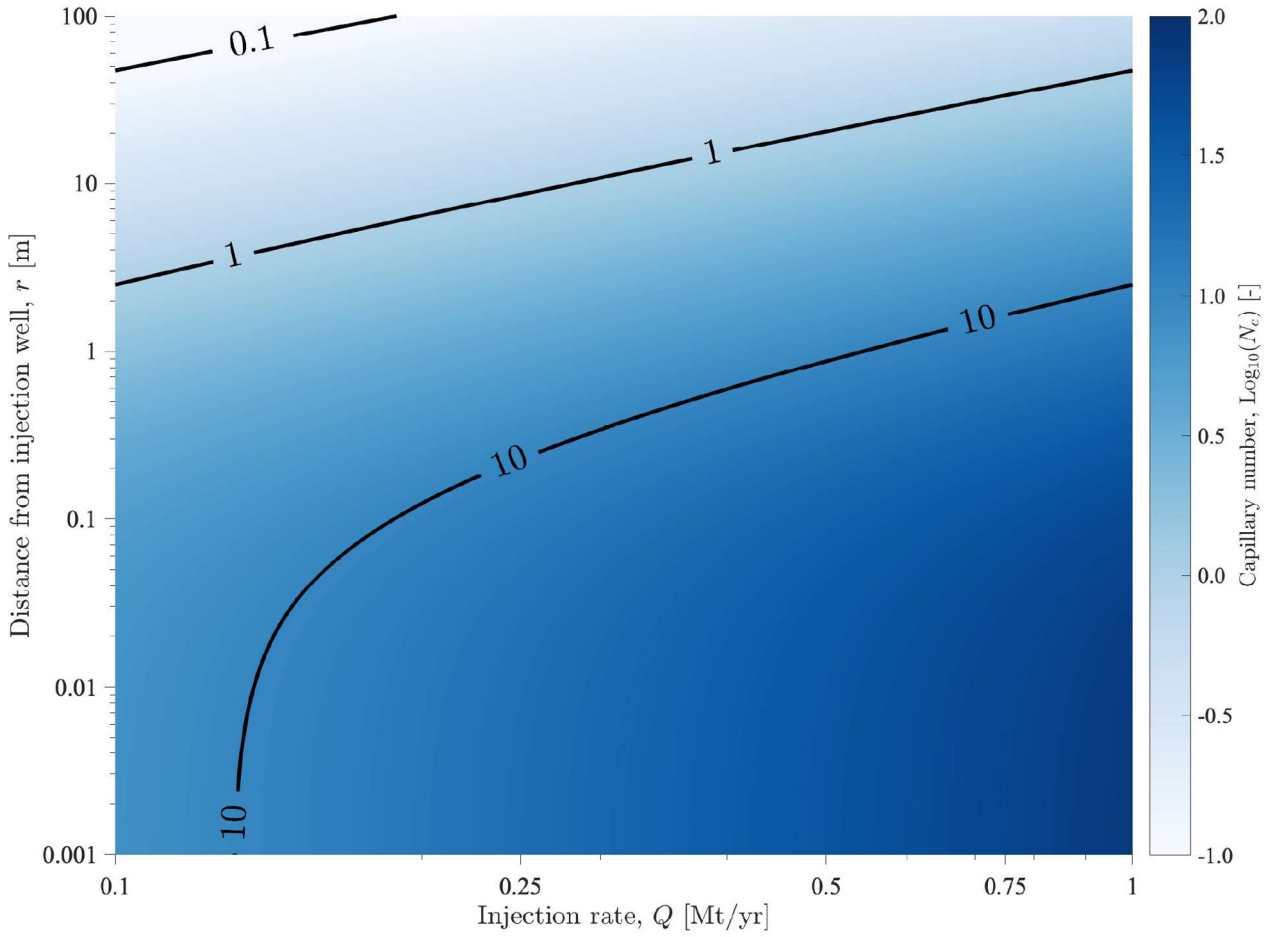
$$\nabla \cdot \left(\lambda_T \nabla P_{CO_2} + \lambda_g \nabla h - \lambda_w \nabla P_c\right) = 0$$

Capillary heterogeneity

$$P_c(S_w, \varphi, K) = \gamma \cos\theta \; J(S_w) \sqrt{\frac{\varphi}{K}}$$

Capillary number $N_c = \frac{H\Delta P}{L\Delta P_c}$





← Wenck (2023), ↑ Jackson & Krevor (2020)

Macroscopic Invasion Percolation

as upscaling method

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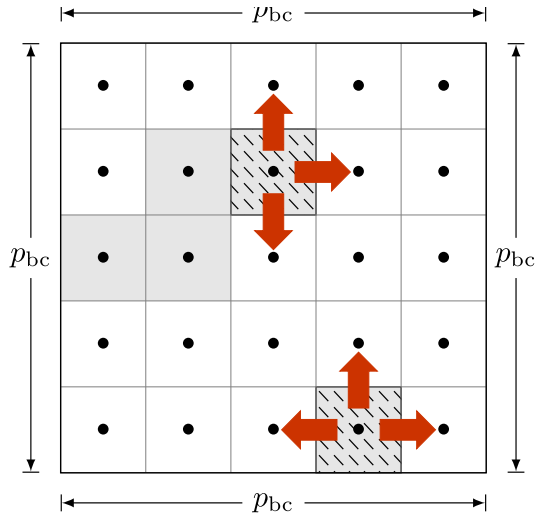
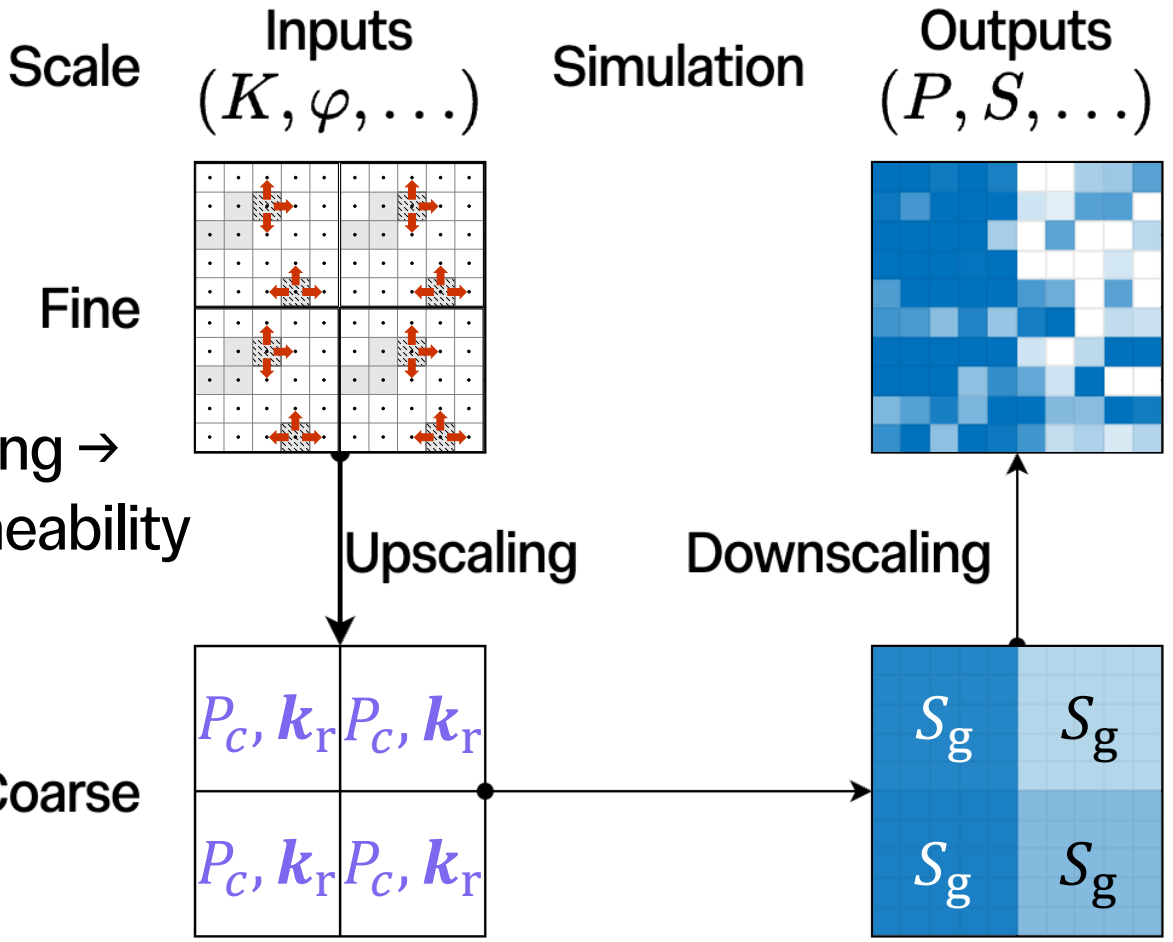


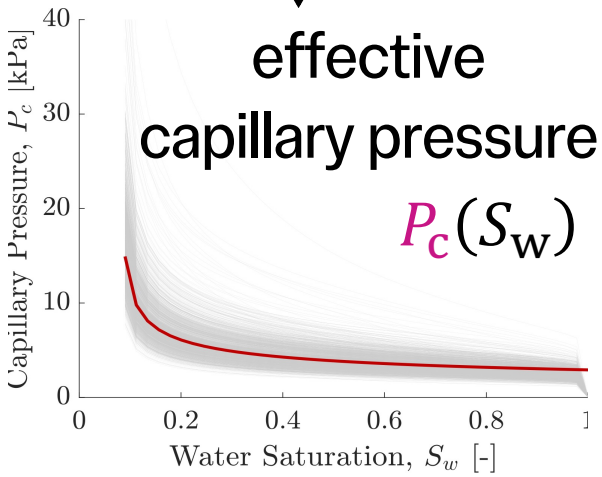
Figure 2. Schematic of percolation for capillary pressure upscaling

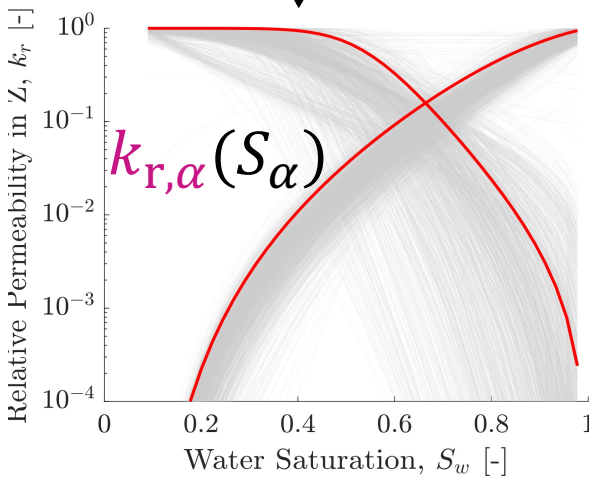
entry pressure controls fine-scale S_g



numerical core flooding → effective phase permeability

effective capillary pressure $P_c(S_w)$





↖ Wolff et al. (2013), ← Wenck et al. (2025)

StrataTrapper

MATLAB package for MIP upscaling

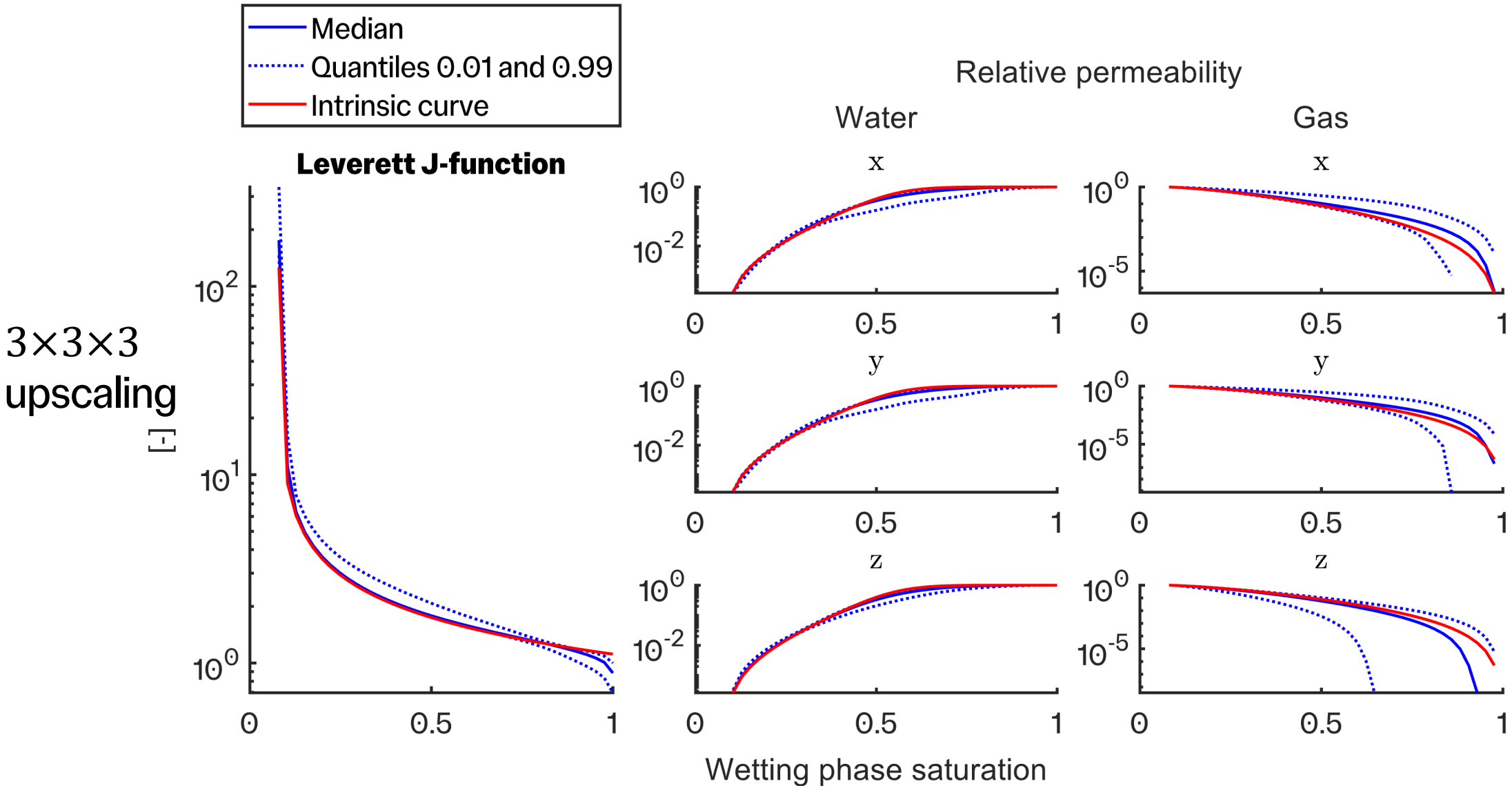
github.com/Imperial College London/ StrataTrapper

```
params = Params(krw,krg,cap_pressure,rho_gas,rho_water);

options = Options().save_mip_step(true); % new release v0.12.0
options.hydrostatic_correction = false;
                                % ↓ EGRID improted with MRST
strata_trapped = strata_trapper(grid, sub_rock, params, ...
    options=options, mask=mask, parfor_arg = 36 );

plot_result(strata_trapped);

ogs_export(strata_trapped); % PFLOTRAN-OGS input deck
```

Endurance CO_2 storage (ref.: Northern Endurance Partnership)

Upscaled flow functions `plot_result(strata_trapped)`

StrataTrapper



Endurance CO_2 storage (ref.: Northern Endurance Partnership)

MIP-based vs conventional upscaling

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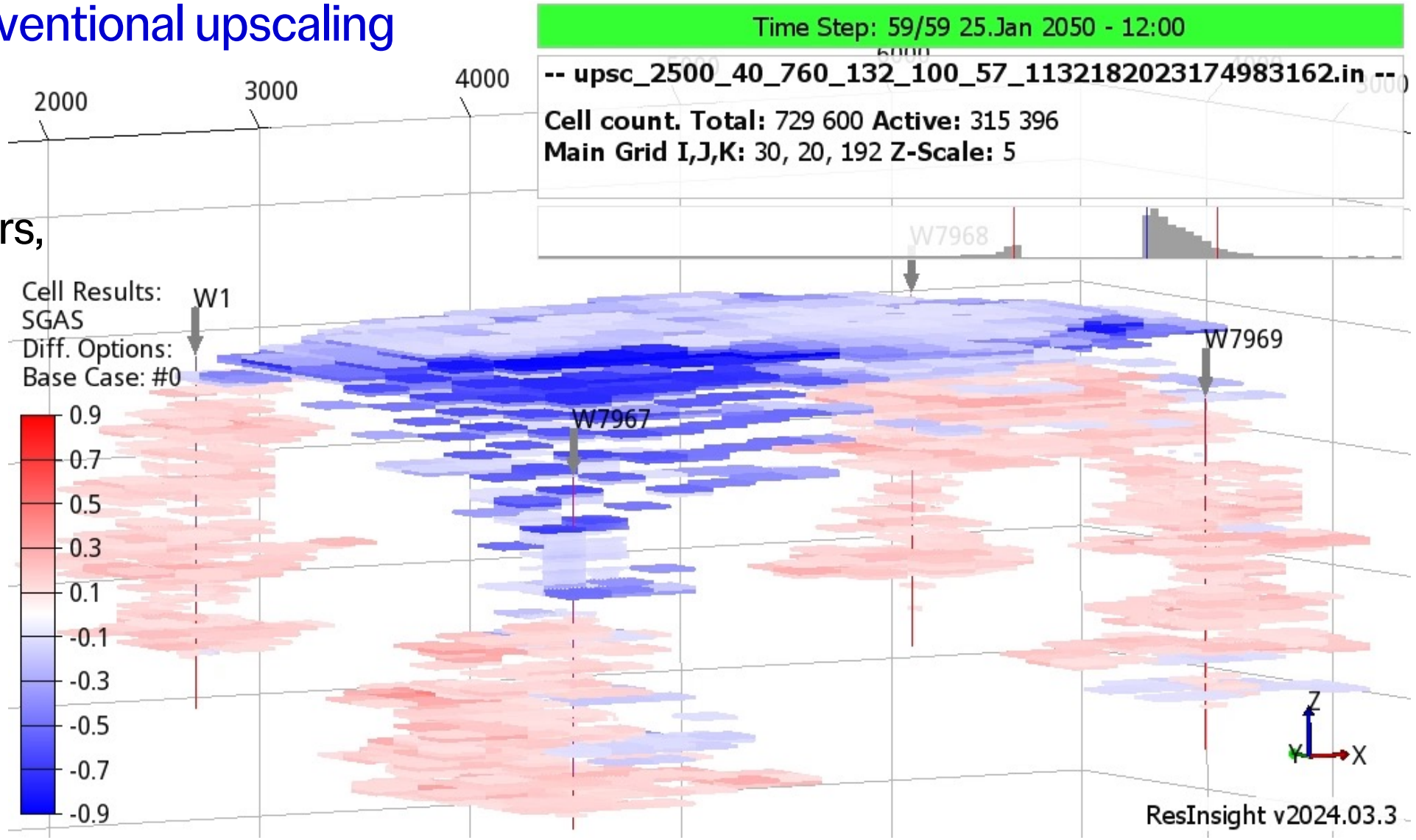
injection: 25 years,
monitoring: 25 years,
4 wells

3×3×3
upscaling



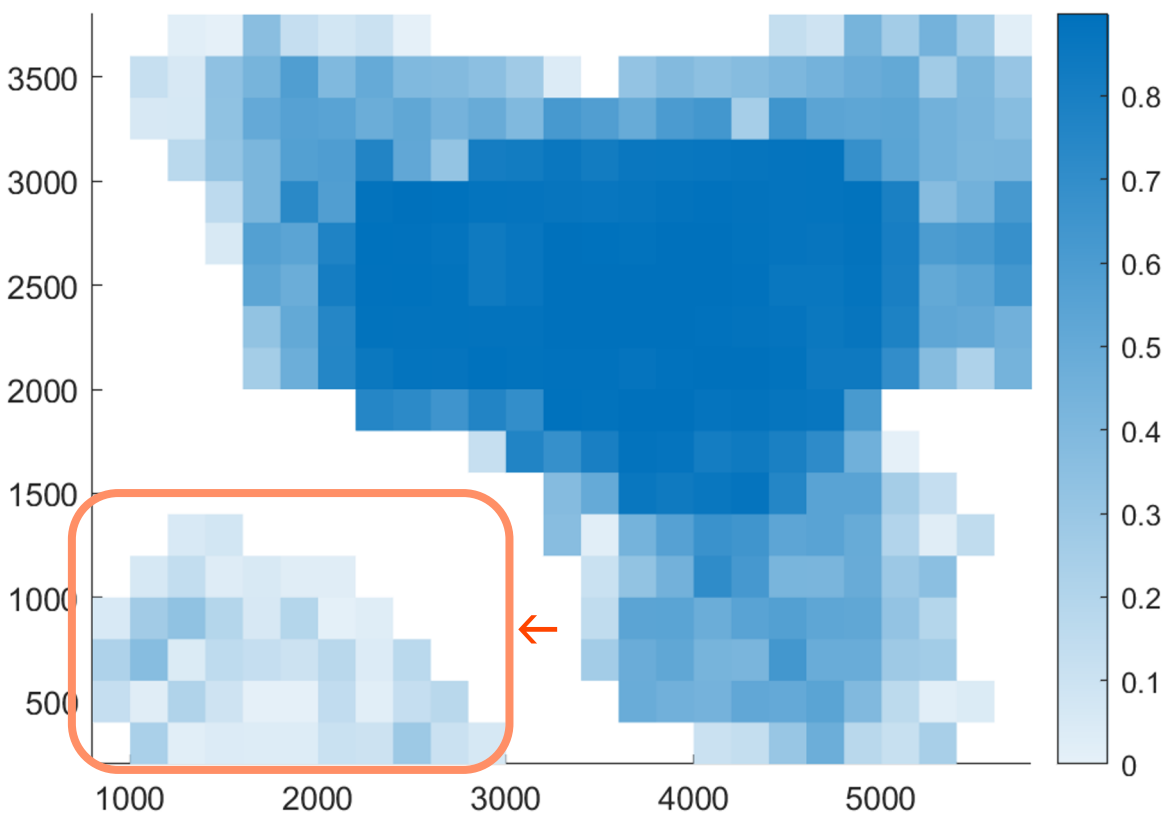
more at: Wenck et al. (2025), Elizarev et al. (2024), StrataTrapper-models on GitHub

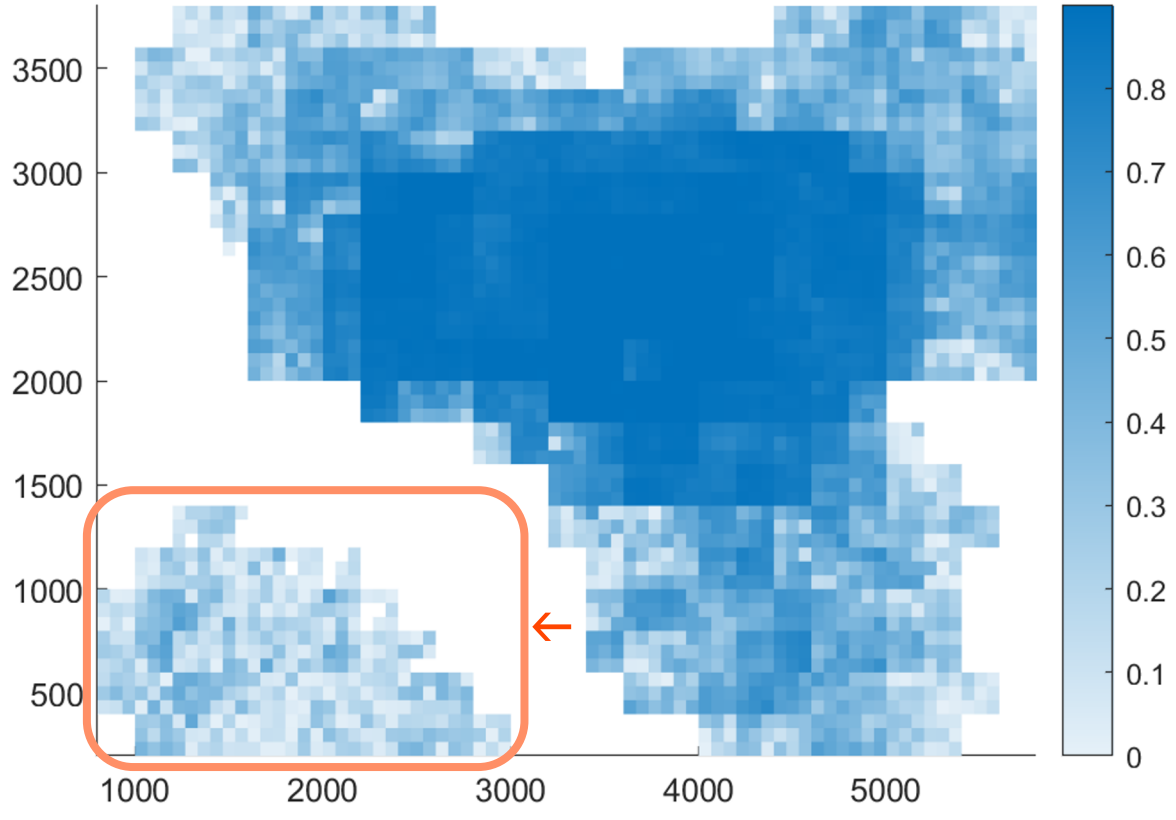
Endurance CO_2 storage (ref.: Northern Endurance Partnership)

Downscaled gas saturation

StrataTrapper

final timestep, top-down view

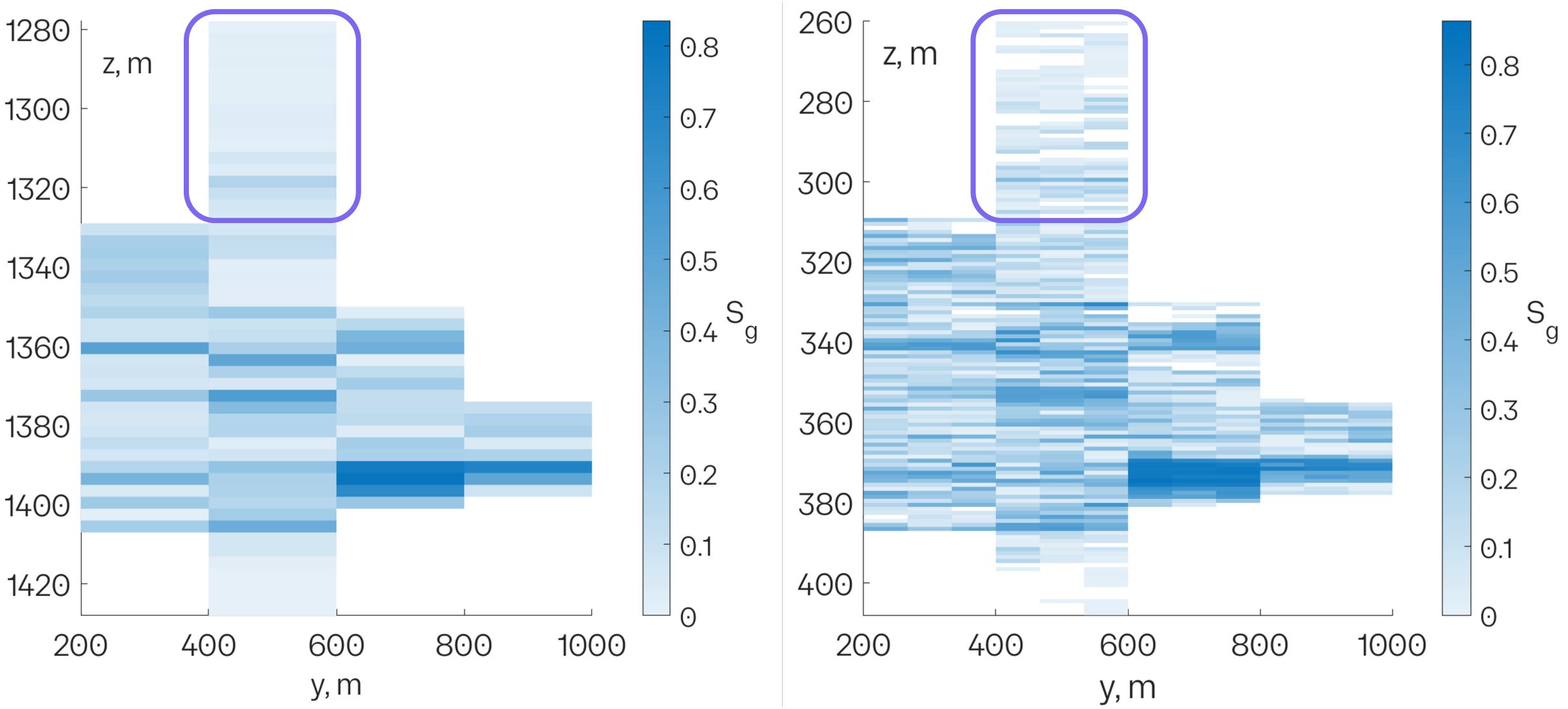




Endurance CO_2 storage (ref.: Northern Endurance Partnership)

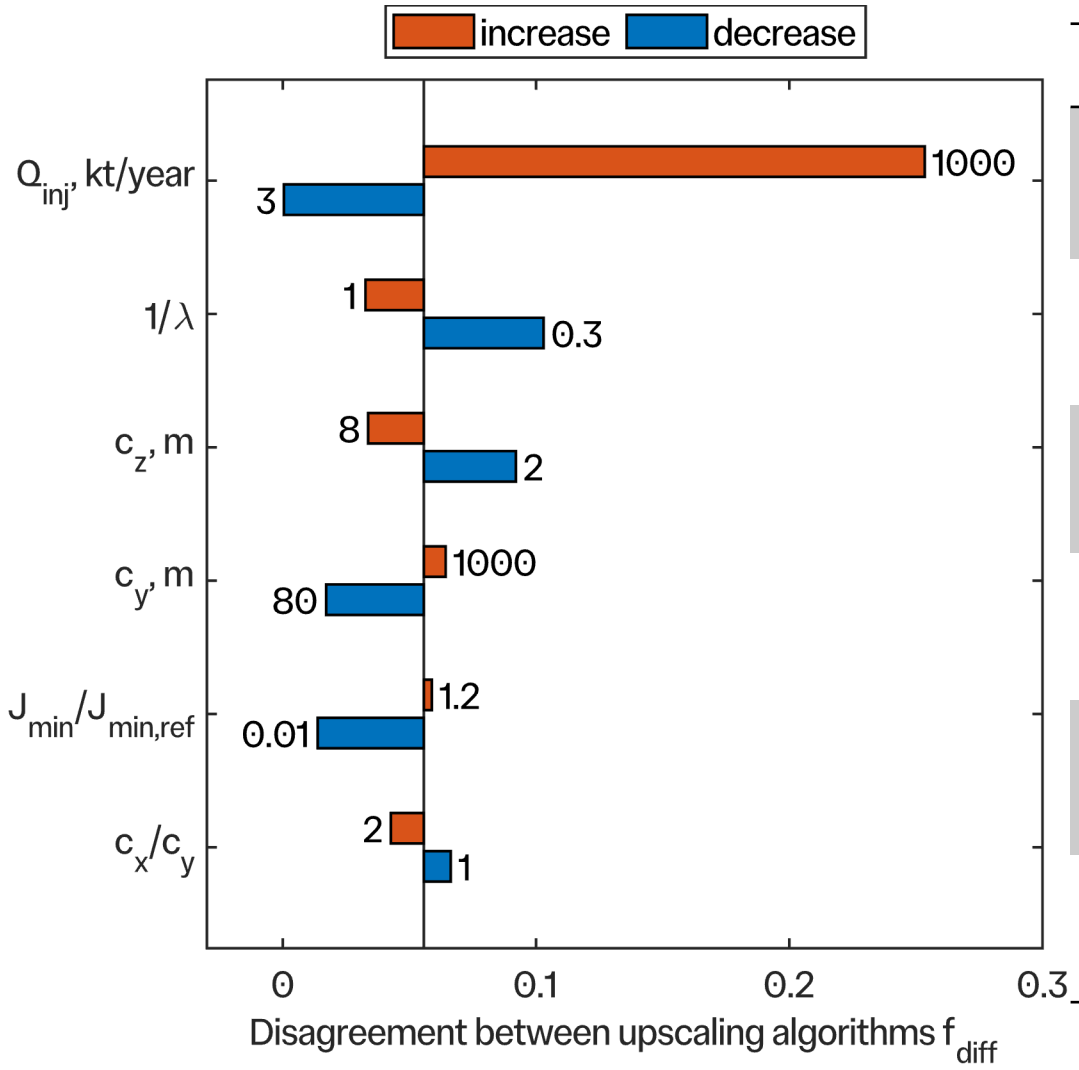
Downscaled gas saturation

8 years of injection, side view



Endurance CO_2 storage (ref.: Northern Endurance Partnership)

Comparative sensitivity analysis: CO_2 boundary proximity



	Base value	Range	Units	Name
Q_{inj}	250	$[3, 1000]$	$\frac{\text{kt CO}_2}{\text{year}}$	Well injection rate
$1/\lambda$	$1/1.75$	$[0.3, 1]$	1	Leverett J-function shape
c_{z}	4	$[2, 8]$	m	z correlation length
c_{y}	760	$[80, 1000]$	m	y correlation length
$\frac{J_{\text{min}}}{J_{\text{min,ref}}}$	$\frac{0.032}{0.032}$	$[0.01, 1.2]$	1	Leverett J-function minimum
$c_{\text{x}}/c_{\text{y}}$	$\frac{1000}{760}$	$[1, 2]$	1	x-to-y corr. len. ratio

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THANK YOU!

GitHub.com/Imperial College London
/StrataTrapper

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code advances and field-scale dynamic CO_2 storage simulations

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