Optimisation Techniques for Incompressible Flow Problems

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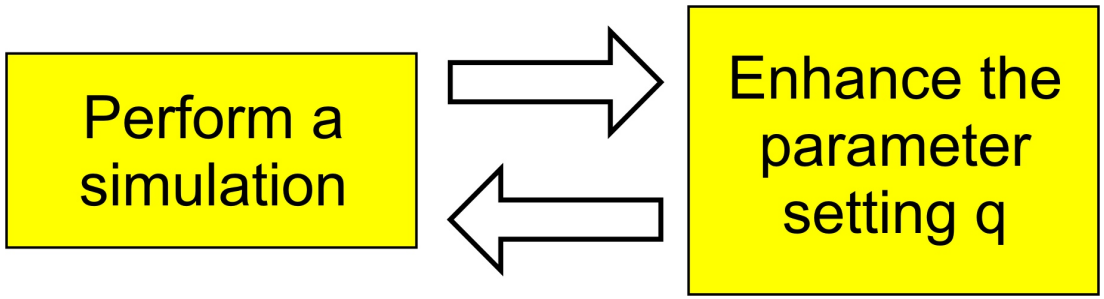
Content

What is Flow Control?

Formulate a minimisation problem with side constrains:

$$\min_q J(u(q), p(q), q) = \text{drag, lift,...}$$

$$\text{such that} \quad \text{Navier Stokes}(u, p) \text{ is fulfilled}$$



Background and Aims

Problems:

- Complex, general situations
  $\Rightarrow$ no gradient information available
- Behaviour even of simple algorithms in complex situations unknown

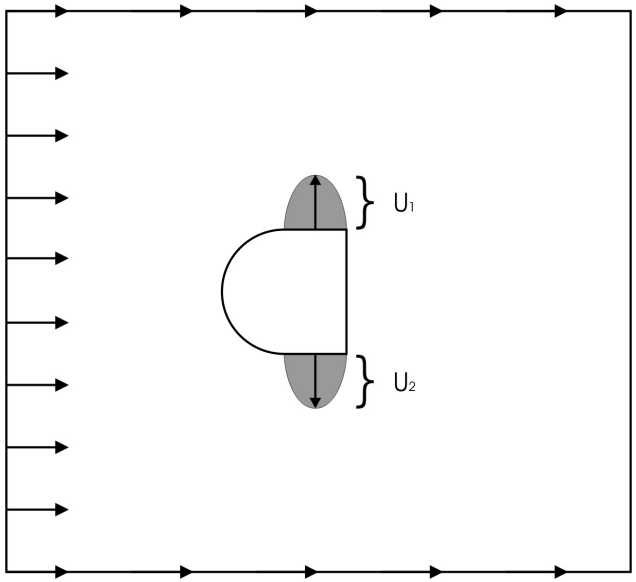
$\Rightarrow$ Test behaviour of simple algorithms

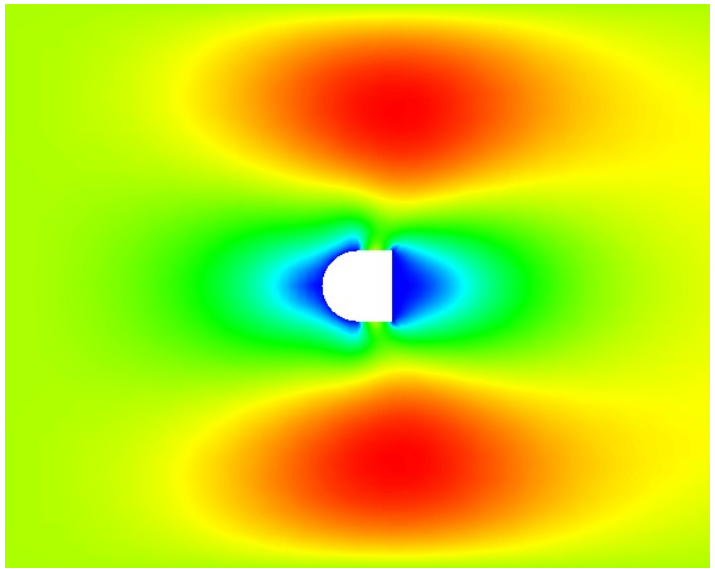
- derivative-free
- in complex situations
- with only few control variables

$\Rightarrow$ Provide accurate values for the optimiser

What is Flow Control?

Example: Boat-like object in a flow

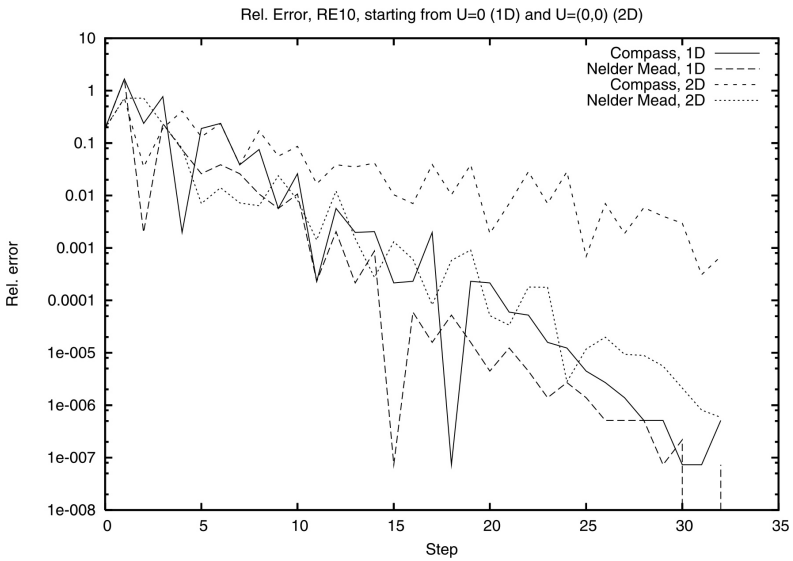


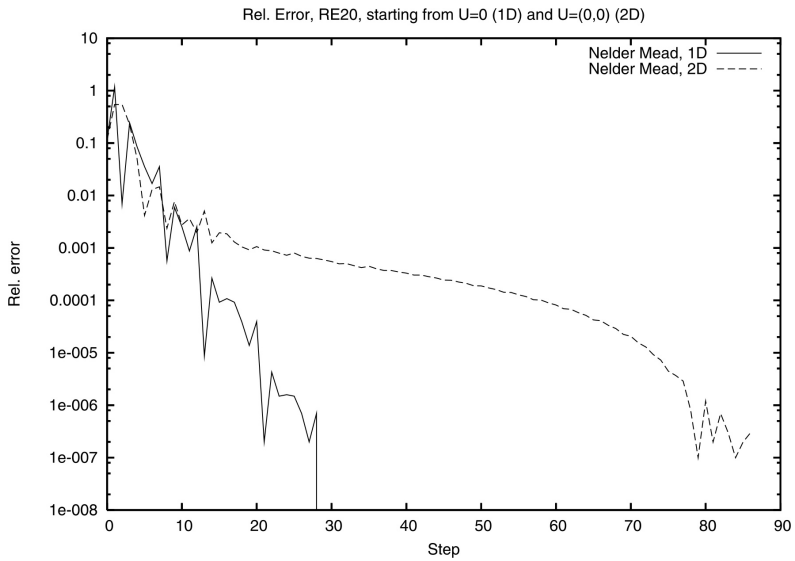


Aim: Find the best u_1, u_2 to minimise the *drag*.

Results for the example: 1D and 2D optimisation

Relative error: *Compass Search* against *Nelder Mead* in 2D





$\Rightarrow$ Compass / Nelder Mead similar in 1D

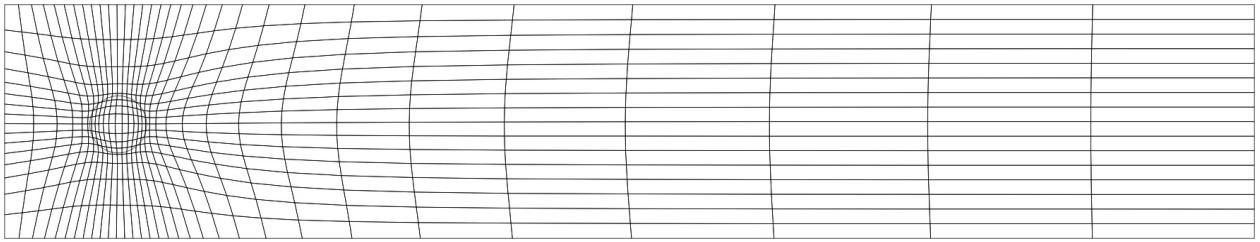
$\Rightarrow$ Nelder Mead scales better in 2D

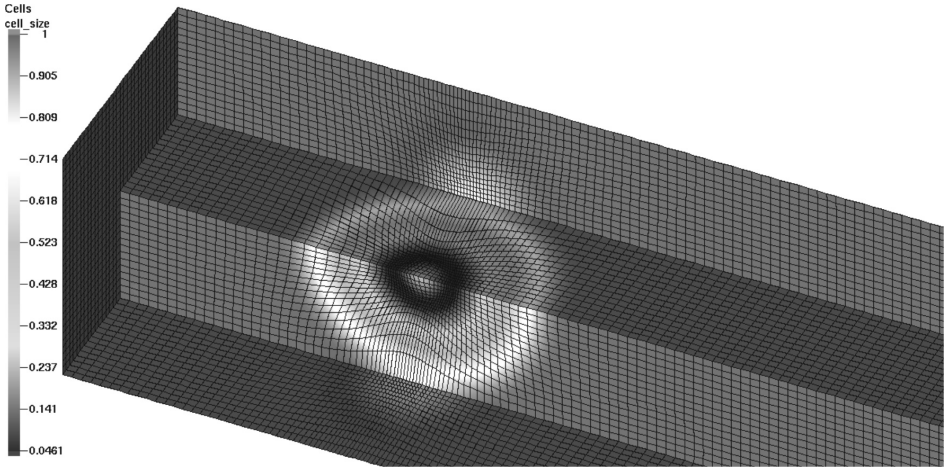
$\Rightarrow$ Nelder Mead may suffer from *simplex degeneration*

Accuracy and arbitrary geometries

Enhanced accuracy and support for arbitrary objects with

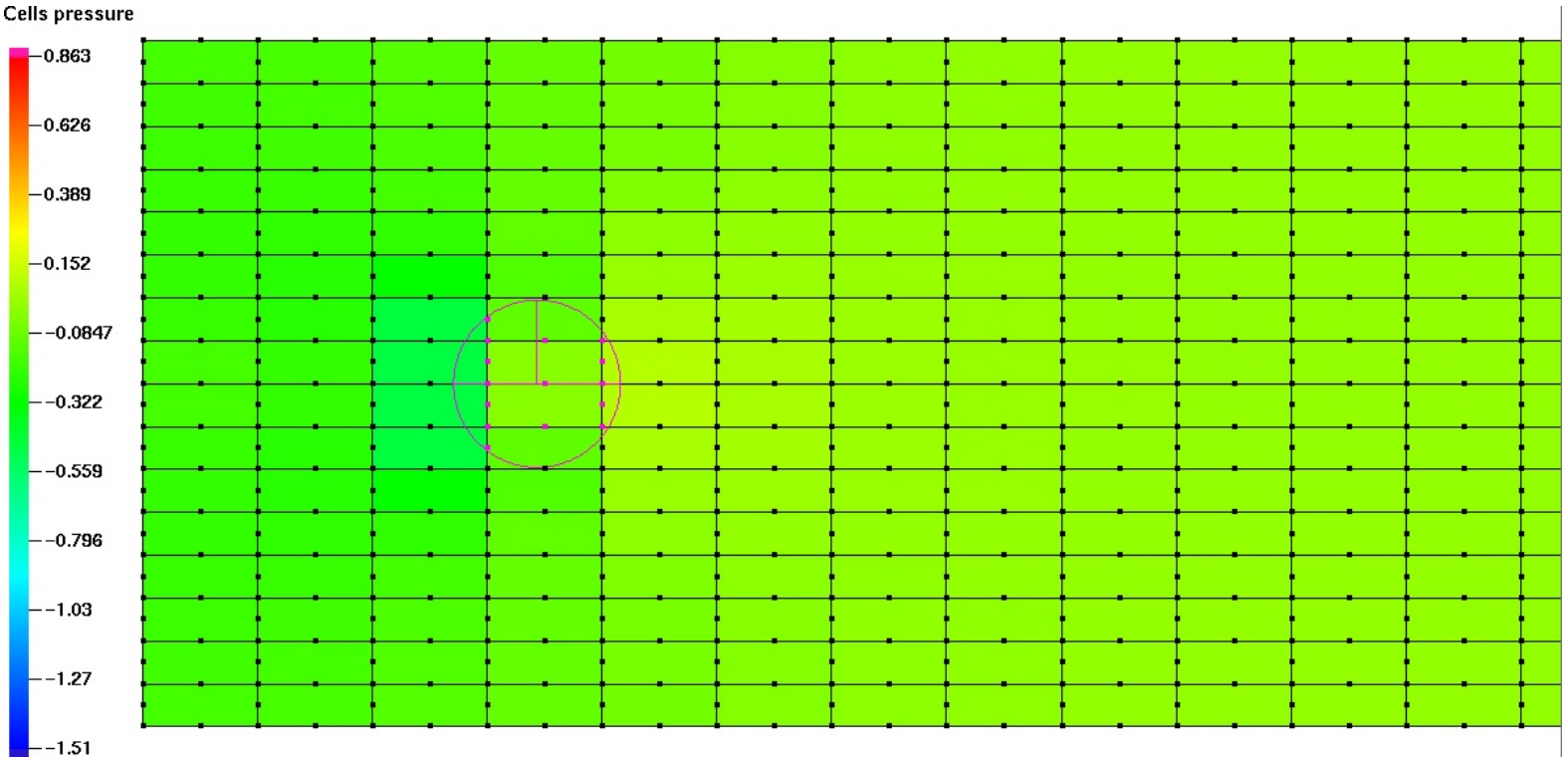
- Mesh deformation
- ALE method deformation
- Fictitious boundary technique





Methodical problems in the nonstationary case

Pressure fluctuations with Fictitious Boundary technique



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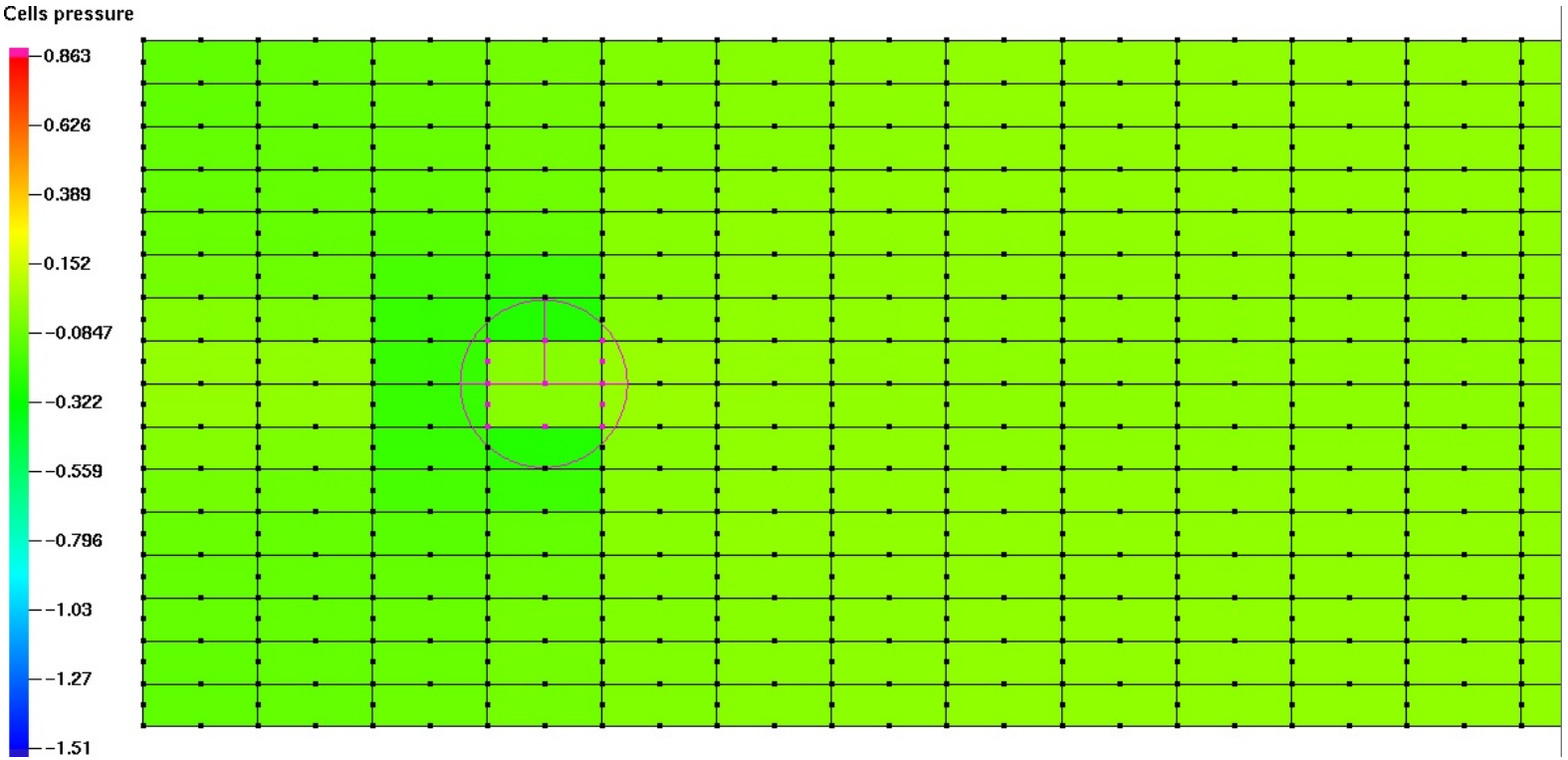

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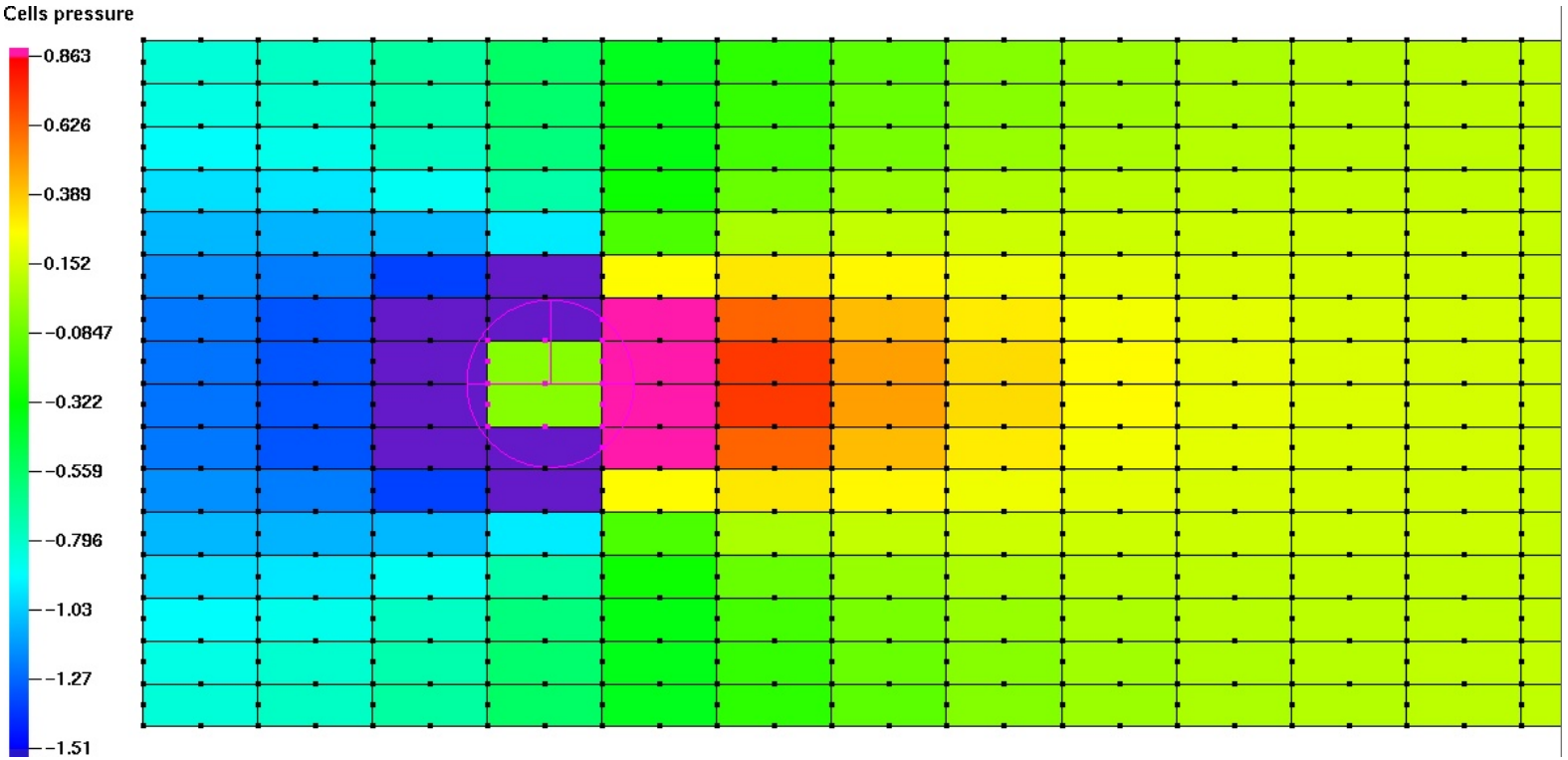

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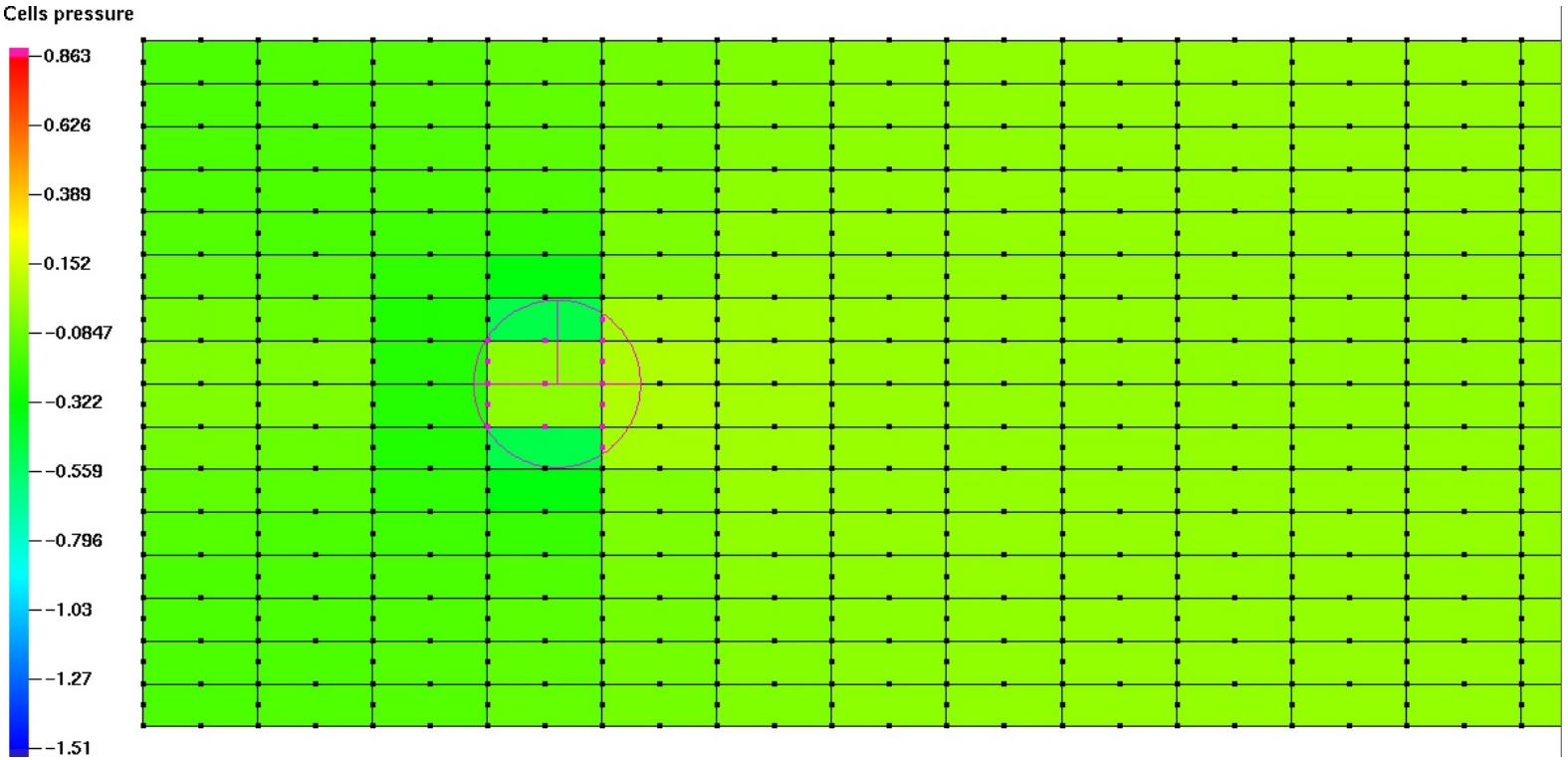
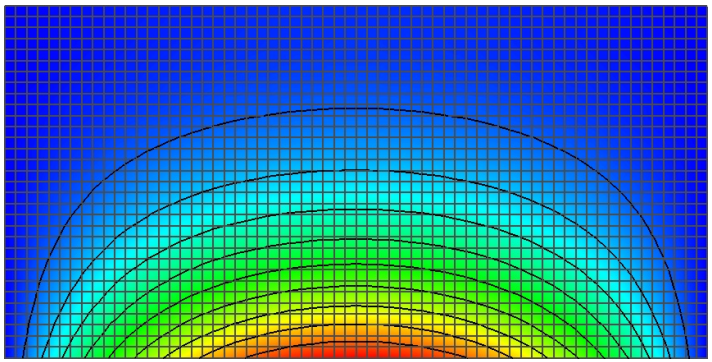


Open problems

- Get pressure fluctuations under control
  $\Rightarrow$ theoretically and practically
- Use other derivative-free optimisation algorithms (TRIOPT, DIRECT).
- Test the algorithms in the nonstationary case.

Methodical problems in the nonstationary case

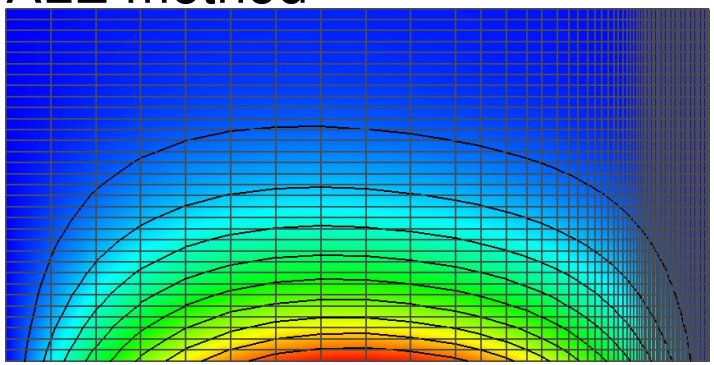
Nonstationary simulation, heat conduction equation



No deformation
after t=0.1 sec

$\Rightarrow$

ALE method



Nobile-method