M.Sc. Thesis

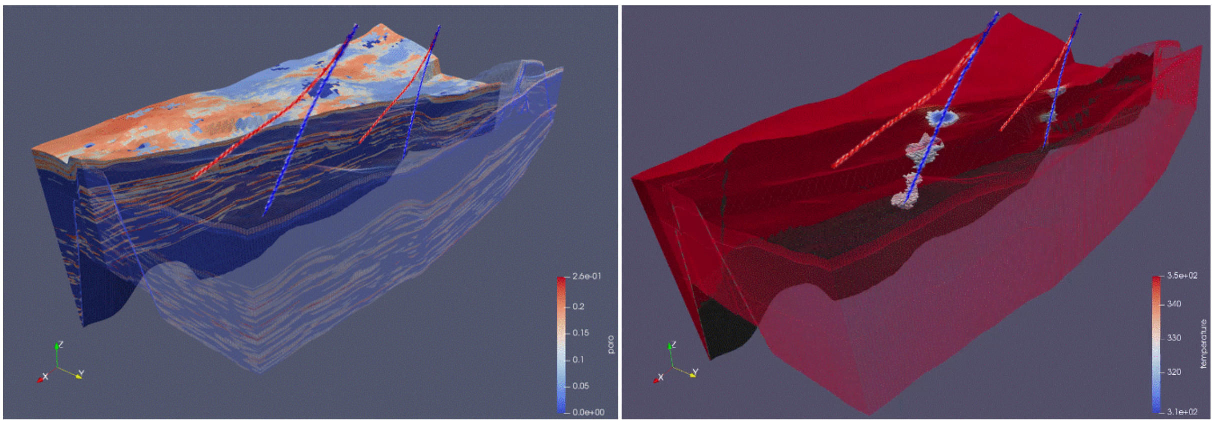
Title: Realistic Computational Prototyping for Applied Electromagnetics.

Who supports you:
Artur Palha, a.palha@tudelft.nl (EWI, DIAM, Numerical Analysis)
Denis Voskov, d.v.voskov@tudelft.nl (CEG, GSE, Reservoir Engineering)
Ilshat Saifullin, I.S.Saifullin@tudelft.nl (CEG, GSE, Reservoir Engineering)

Research line: Preconditioning and linear solvers for flow problems.

General description:

Subsurface reservoirs are used for various applications relevant to the energy transition toward zero-carbon energy sources. They can serve as a direct source of energy (geothermal production), cyclic energy storage required by renewable energy production technologies (sun and wind), and sequestration of "energy waste" (carbon dioxide sequestration). Making optimal use of subsurface reservoirs is a great challenge for both academia and society. Open-DARTS (https://gitlab.com/open-darts/open-darts) is a numerical framework capable of modeling and optimizing energy transition applications relevant to subsurface reservoirs. Open-DARTS modeling results can be directly used for more efficient energy production, risk assessment in energy transition applications and various legislative initiatives.



The goal of this project is to improve the efficiency of Open-DARTS by developing and integrating an open-source CPR (Constrained Pressure Residuals) preconditioner, [1, 2, 3], in order to improve the convergence of available algebraic iterative solvers. CPR preconditioner is a two-stage preconditioner that is based on the idea that the solution of coupled systems of equations is mainly determined by the solution of the elliptic part (in the case of reservoir modelling, the pressure system). The focus of this preconditioning approach is to reduce the original coupled iterative problem into two simpler problems (stages). The first stage computes an approximate solution for the pressure using, for example, efficient Algebraic Multigrid (AMG) methods, which are effective at handling the elliptic nature of the pressure problem. The second stage focuses on extracting the full solution.

Goals of project:

In the specifics, the project consists of:

Develop open-source CPR implementations and apply them in open-DARTS

- Utilize open-source iterative solvers and preconditioners (e.g., Hypre, PetSC)
- Benchmark implementation for practical problems against the in-house version (both CPU and GPU)
- Test for energy-transition applications including conductive-dominated problem

References

[1] K. Stüben, Tanja Clees, H. Klie, B. Lu, and M. F. Wheeler, *Algebraic Multigrid Methods (AMG) for the Efficient Solution of Fully Implicit Formulations in Reservoir Simulation*, SPE Reservoir Simulation Symposium, 2007
doi:https://doi.org/10.2118/105832-MS

[2] J. R. Wallis, R. P. Kendall, and T. E. Little, *Constrained Residual Acceleration of Conjugate Residual Methods*, SPE Reservoir Simulation Symposium, 1985.
doi: https://doi-org.tudelft.idm.oclc.org/10.2118/13536-MS

[3] S. Nardean, M. Feffonato, and A. Abushaikha, *Block constrained pressure residual preconditioning for two-phase flow in porous media by mixed hybrid finite elements,* arXiv, 2023.
doi: https://doi.org/10.48550/arXiv.2303.13415