SpeicherCITY

Workshop „Aquifer Storage for Germany“

Optimisation of design and operational parameters at the example of ATES Adlershof based on Reduced Order Models (ROM)

and more

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Federal Ministry of Education and Research

GFZ Helmholtz-Zentrum für Geoforschung

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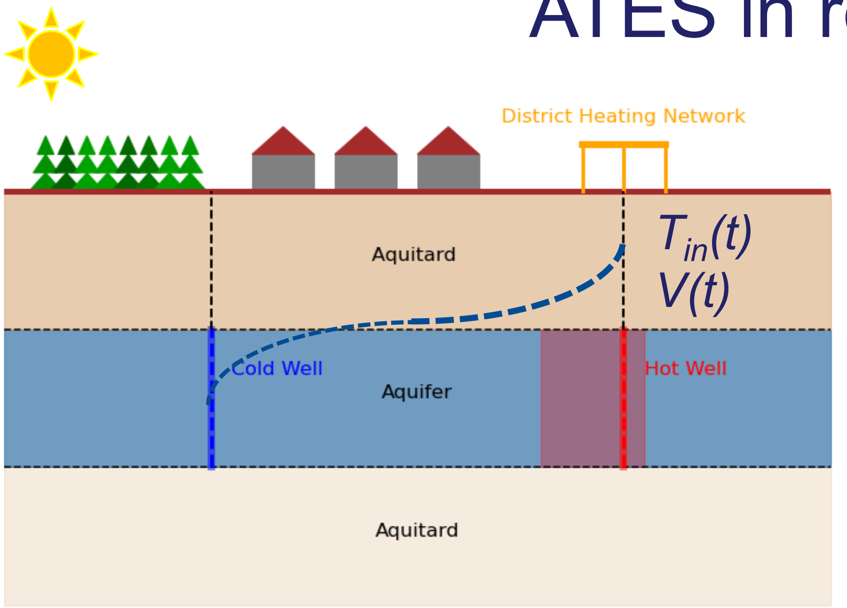
ATES in real aquifers



M2.1	Matrix of system parameters for all sites under consideration, including a comparison with the expectation spaces
M2.2	Creation of the concept models with the relevant system parameters
M2.3	Recommendation for action for in-service monitoring of ATES

- Temporal dynamics
- Spatial variability
- Conceptual uncertainty etc.

What are the primary controls on ATES in the subsurface?

Advection-Dispersion Equation

$$R_T \frac{\partial T}{\partial t} + \boldsymbol{v}\nabla T - \nabla \cdot (\boldsymbol{D}\nabla T) = 0$$

- Energy exchange between aqueous and solid phase
- Requires a 3D vector field of velocity
- Large CPU times to solve the ADE+ (numerical dispersion, oscillations, time-space resolution)
- Parameters, Parameters
- Computational effort vs. Nonlinearity –> ensemble-based solutions

? How ATES functions and what are the controlling parameters

? How to make it simple enough but still informative

Objective

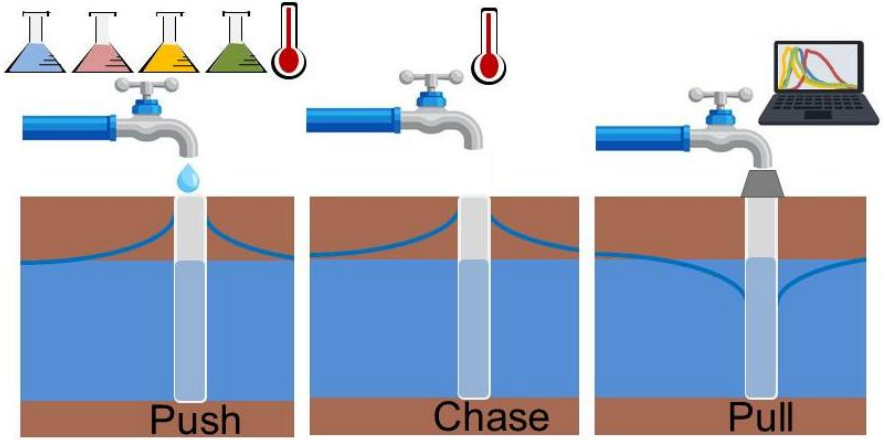
- A conceptually simplified yet precise description of ATES
- Try to avoid spatially variable 3D description

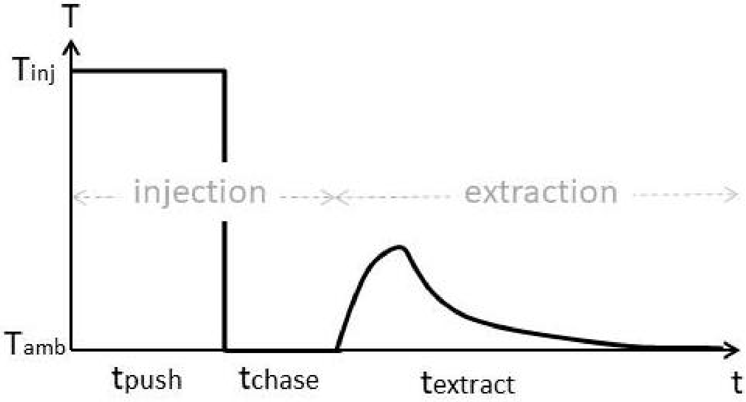
3D → 1D

$$R_T \frac{\partial T}{\partial t} + \boldsymbol{v}\nabla T - \nabla \cdot (\boldsymbol{D}\nabla T) = 0 \qquad \frac{\partial T}{\partial t} + \frac{A}{rR_T}\frac{\partial T}{\partial r} - \left(\frac{A\alpha_T}{rR_T} + \frac{D_T}{R_T}\right)\frac{\partial^2 T}{\partial r^2} = 0$$

ADE → surrogate (regression or classification)

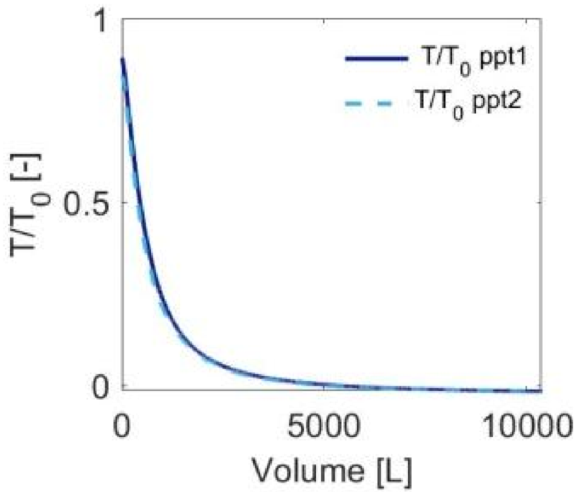
Push pull tests for parameter inference

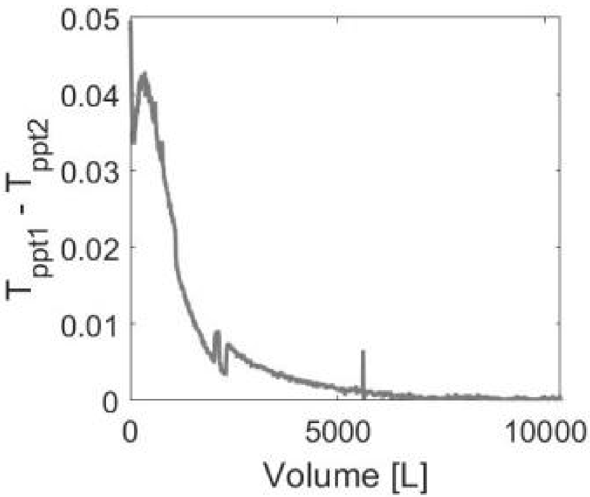




Regression surrogate model of 1D ADE for plausible parameter combinations

Multitracer push-pull test in Horonobe, Japan





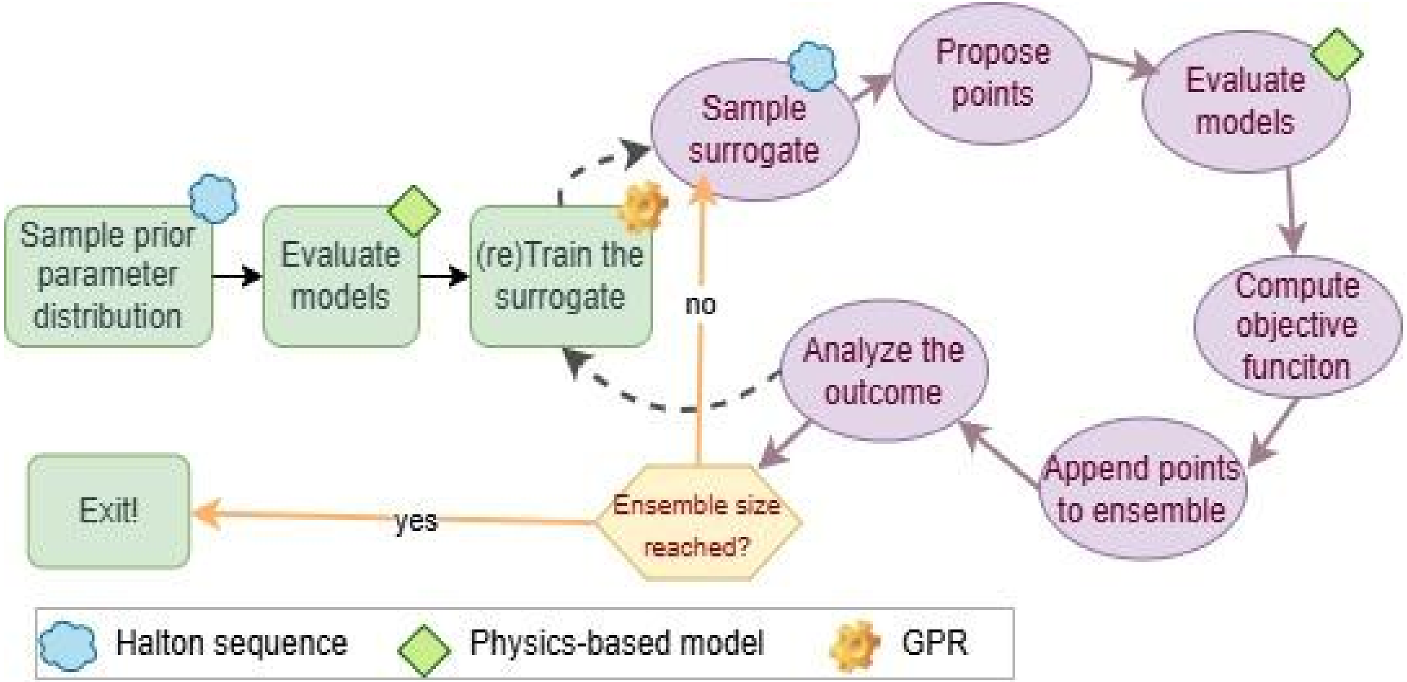
Tracers:

- Uranine
- Lithium
- Iodide
- Heat

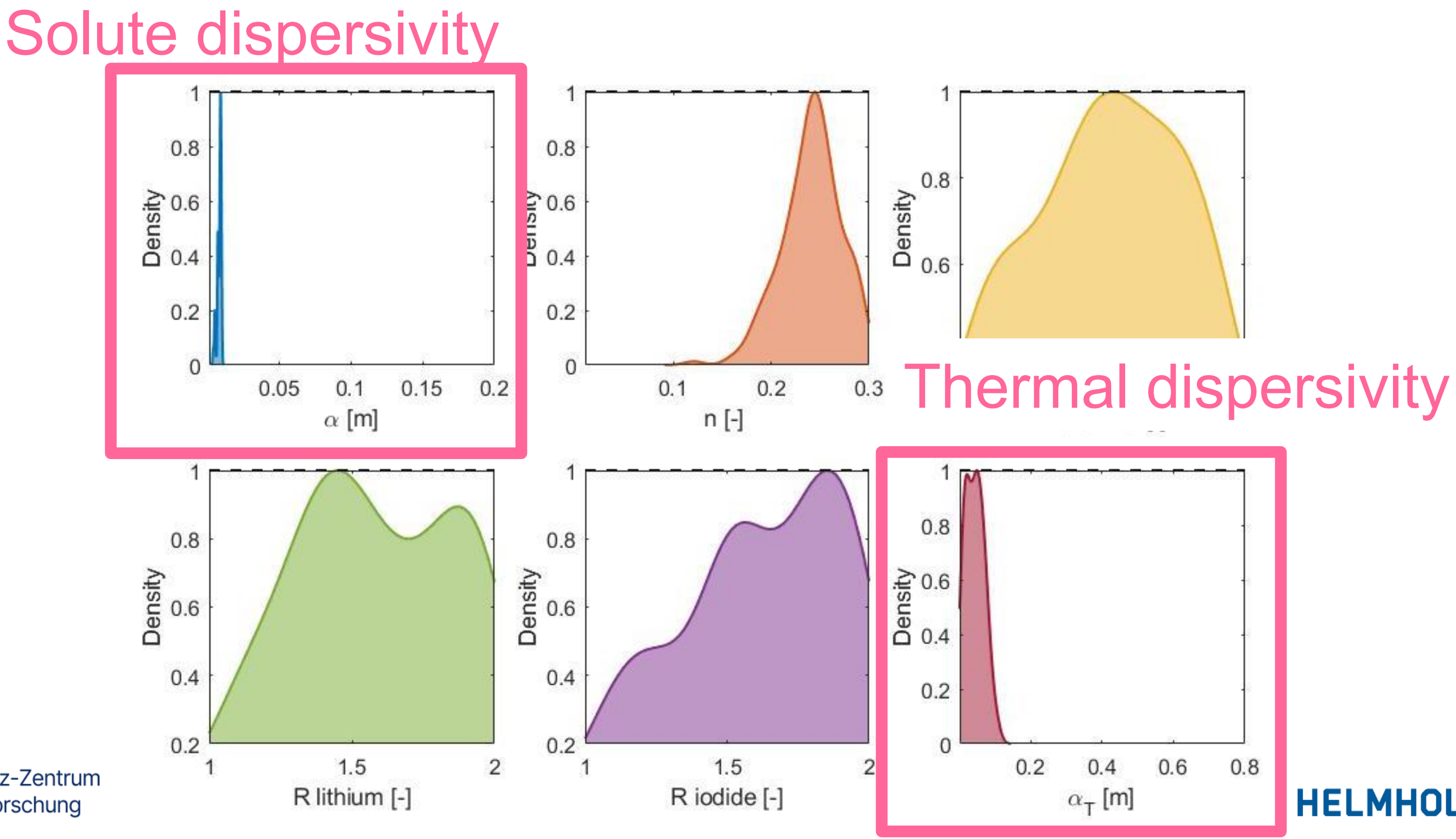
Sorptive and non-sorptive scenario

Regression surrogate model of 1D ADE for plausible parameter combinations

Multitracer push-pull test in Horonobe, Japan

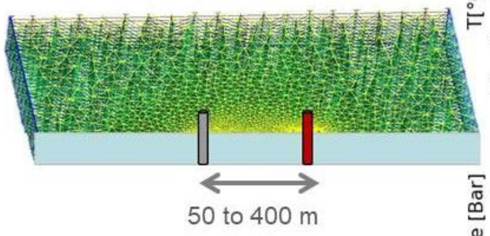


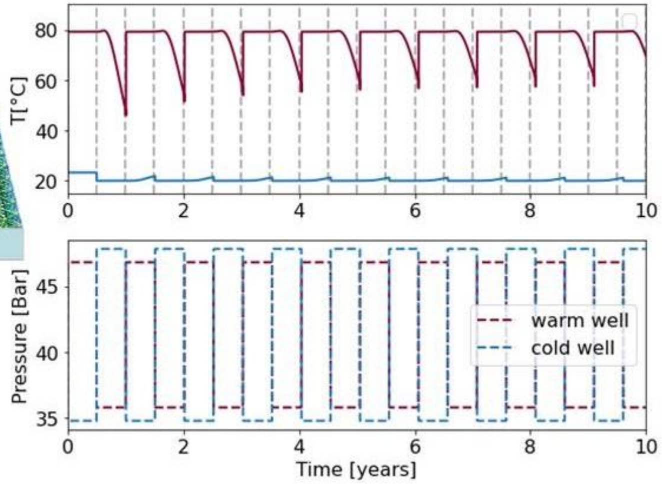
Regression surrogate model of 1D ADE for plausible parameter combinations

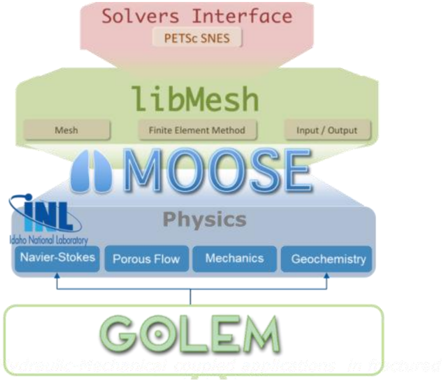


Well placing effect on the long-term ATES functioning

Classification surrogate model for ATES in Berlin Adlershof for optimal design

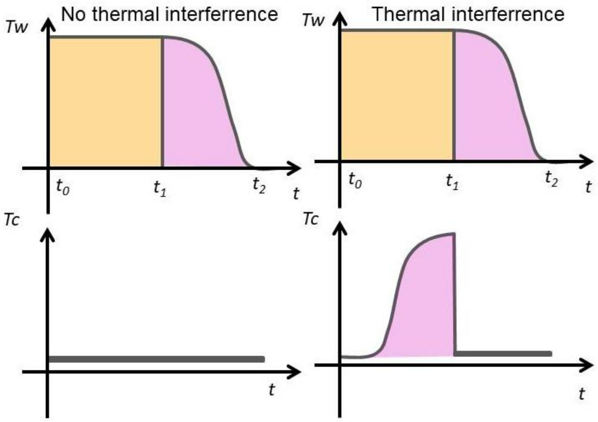


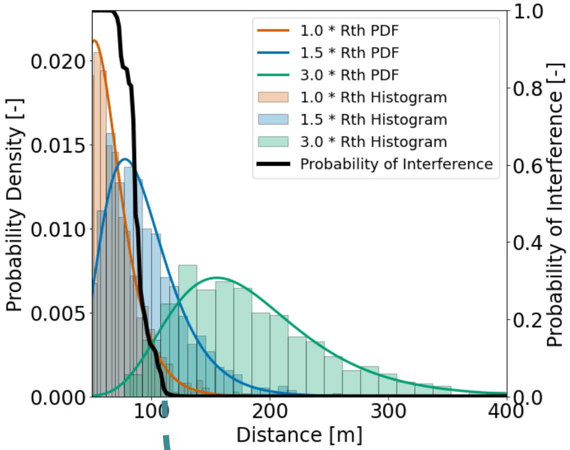




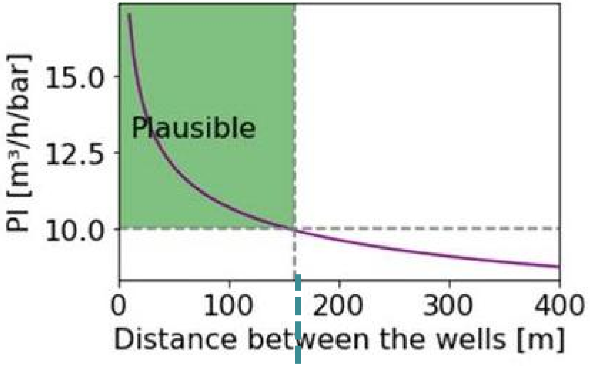
Well placing effect on the long-term ATES functioning

Thermal limit





Hydraulic limit



120-170 m

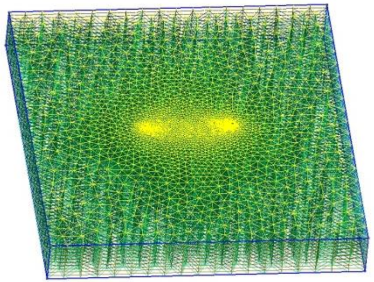
Coupled surface-subsurface modelling

Coupling of the district heating network simulation (TRNSYS – TUD) with the subsurface simulation (MOOSE-GOLEM)

Created with Canvas AI

$Tc, Tw, \dot{v}$

Tw, Tc

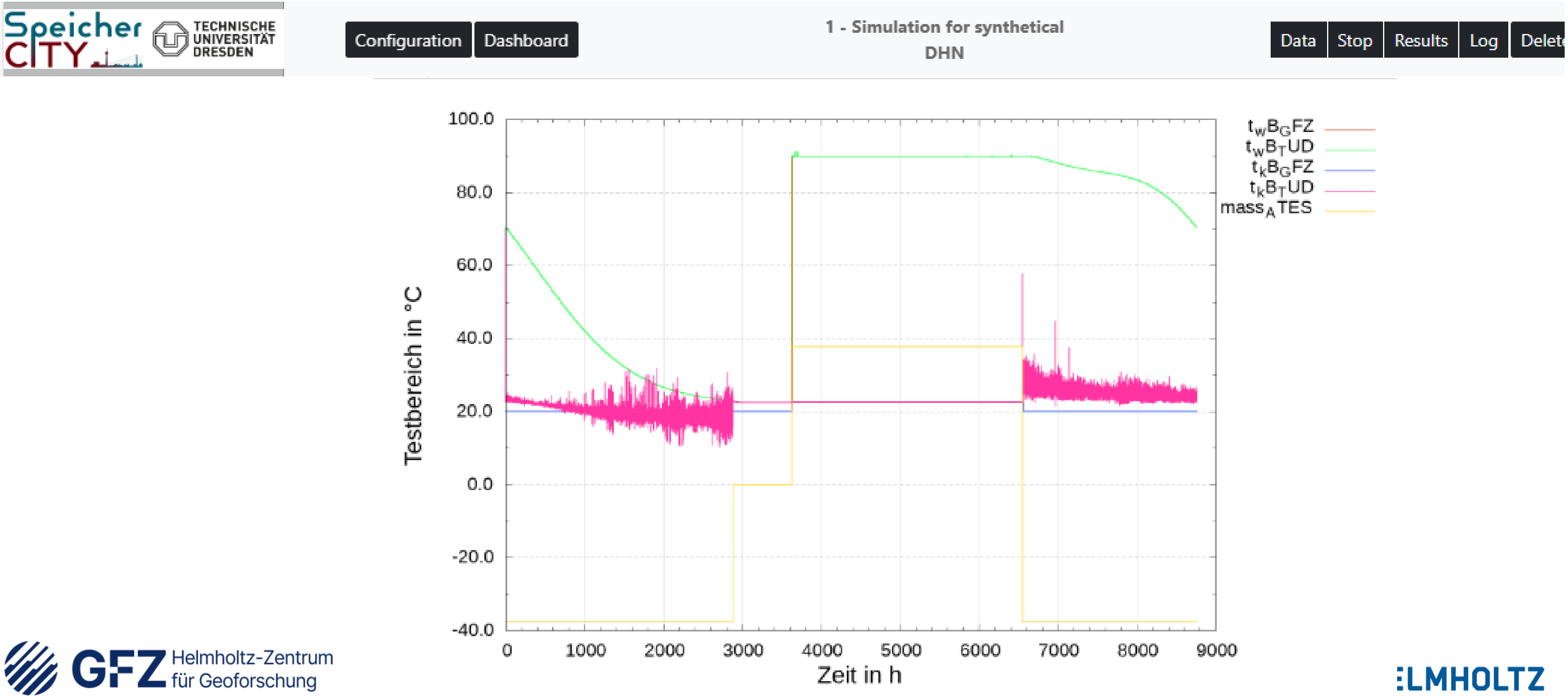


District heating network simulation

Server
TU Dresden

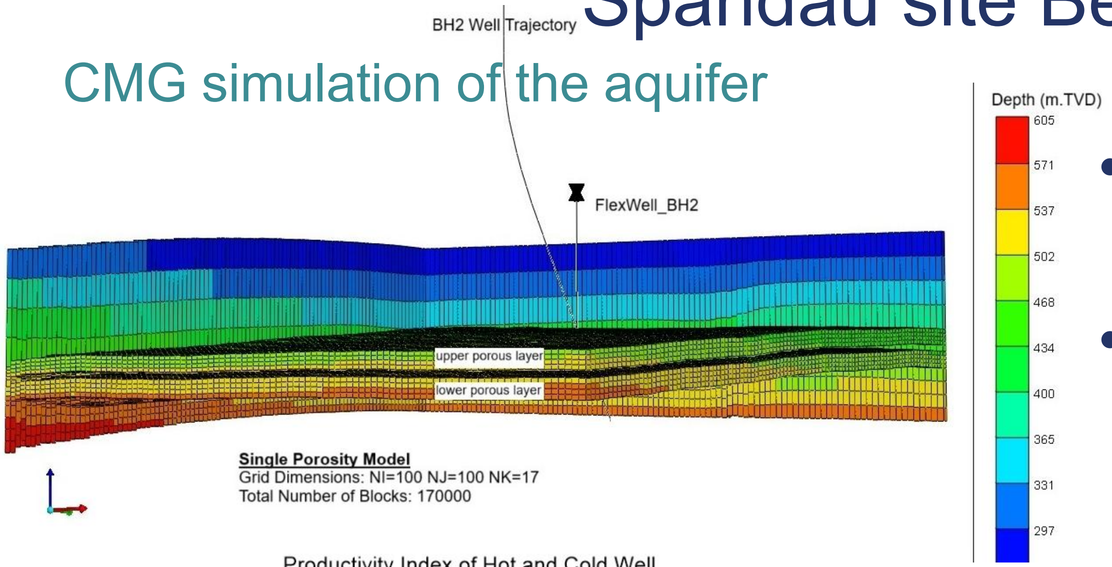
TH-Simulation of ATES

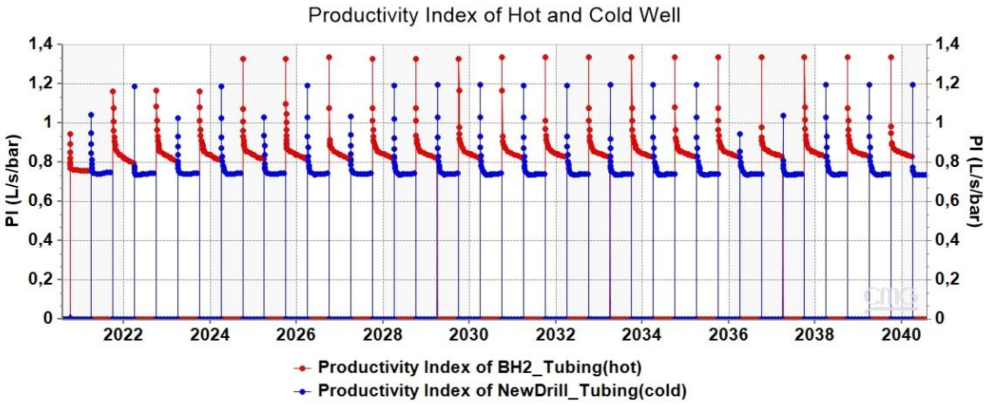
Coupled surface-subsurface modelling



Spandau site Berlin

CMG simulation of the aquifer





- Model validation with pumping tests to match permeability and productivity index.
- Sensitivity analysis:
  - High permeability and longer perforation enhance well performance.
  - Temperature differences impact flow resistance and therefore PI.

MSs Work of Yuxuan Liu

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Progress

- ✓ Milestone 1. A matrix of relevant system parameters for both sites including sensitivity assessment
- ✓ The developed methodology is general, application to other sites possible

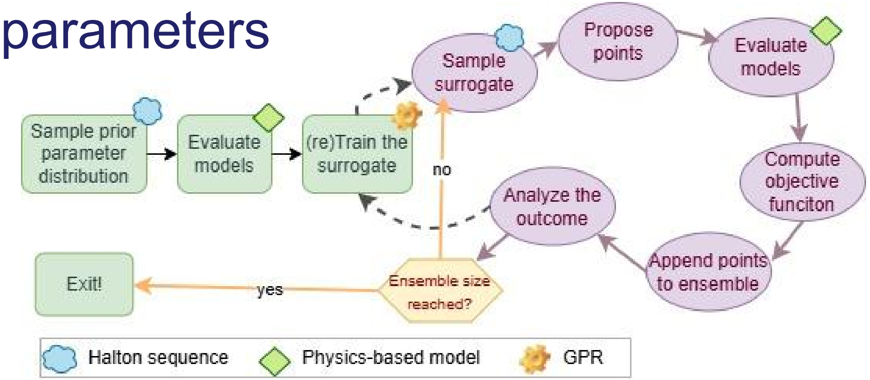
- ✓ Milestone 2. 1D – 3D conceptual models with a framework for inversion to determine system parameters
- ✓ Application to the push-pull tests in Horonobe, Japan
- ✓ Application to Adlershof site and Spandau

- ➢ Milestone 3. Recommendations for action for in-service monitoring of aquifer storage systems are formulated in Hintergrund Paper

- ✓ **Bonus.** Weak coupling scheme implemented accounting for an in-depth technical implementation of Adlershof ATES site

Take homes

- Reduced-order models are a helpful speed-up to create an ensemble of physics-based models
- A physics-based model does not need to include all processes and parameters – figuring out controlling parameters



- To which extend does aquifer heterogeneity play a significant role?
  – conditions/scheme for including it or not

Thank you!

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