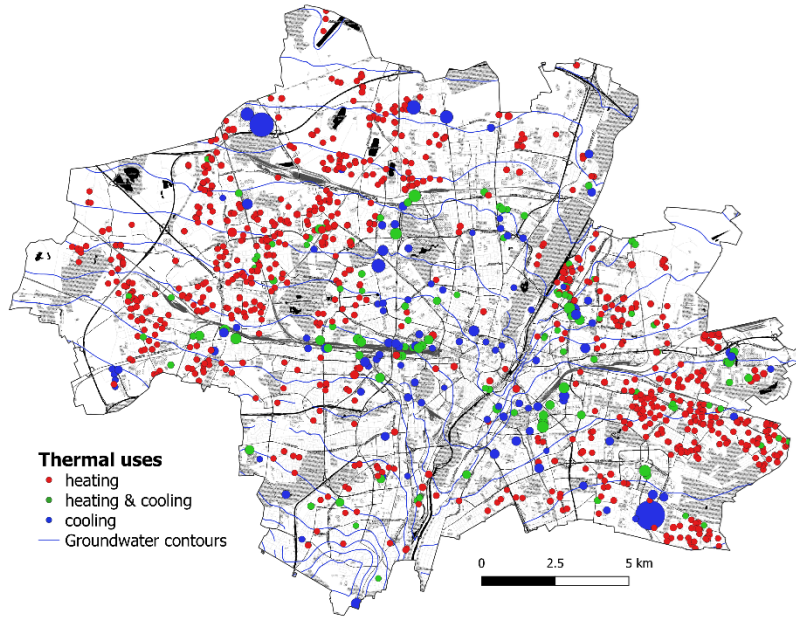


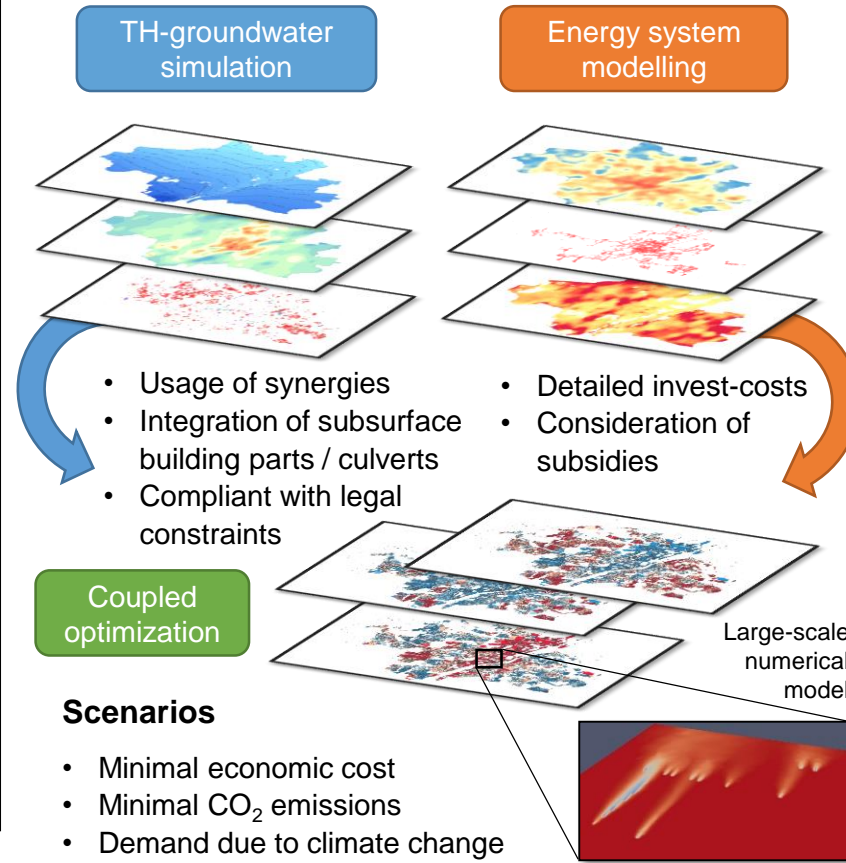
How to place systems for optimal use?

Munich's shallow quaternary gravel aquifer already hosts over **2800** thermal groundwater uses



We develop a **groundwater management tool** that tackles the dynamic complexity of urban aquifers by coupling groundwater simulation and energy system optimisation

City-wide optimisation

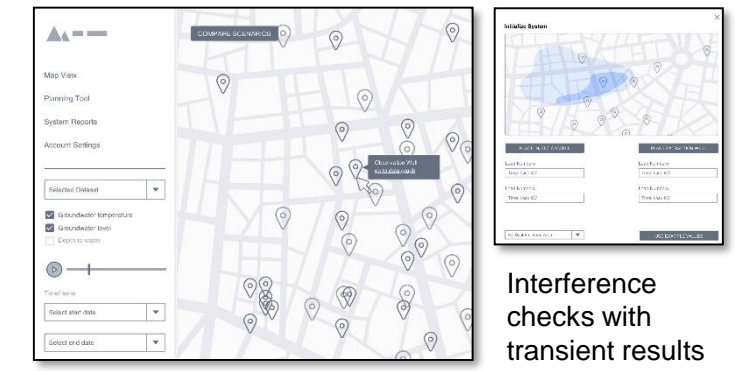


Management applications

- Information for initial planning tasks:
 - Approval evaluation of new thermal uses
 - Rated groundwater levels for excavations
- Integration in the city's licensing procedures
- Early evaluations for urban land-use planning

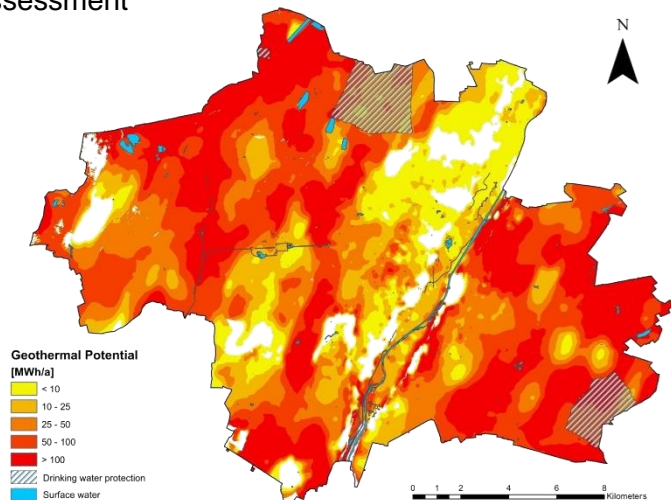
Web access and interactive planning

- Viewing / Download of results, e.g. current state calibration for detailed modelling tasks
- Submission of monitoring data for large systems



Technical coupling

The transition from a static to a dynamic potential assessment



preCICE Coupling library for high performance computing

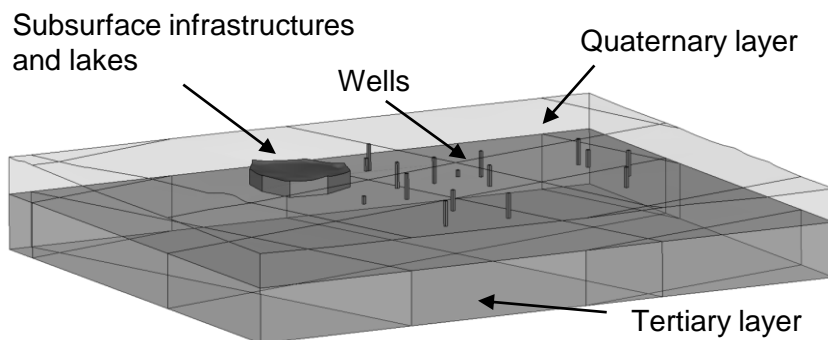
PFLOTRAN

Massively parallel subsurface finite-volume flow and heat transport solver

urbs

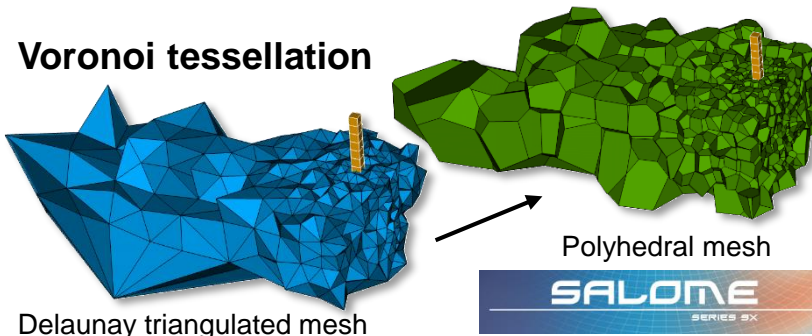
Linear optimiser that integrates legal constraints, energy demand and existing energy infrastructure

Modelling approach



- Integration of the vadose zone and the surface temperature via the top boundary
- Hydraulic / thermal integration of subsurface anthropogenic structures (i.e. tunnels, large sewers, etc.)

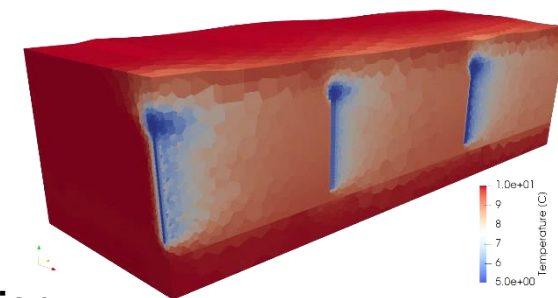
Voronoi tessellation



Outlook

- Hydraulic and thermal model calibration with a large observation database
- Transient simulation of the current state in a large-scale groundwater model
- Optimisation scenarios for minimising greenhouse gas emissions and economic cost

Injection well temperatures



Conclusion

- Optimisation coupling successfully tested on the SuperMUC-NG
- PFLOTRAN and PEST coupling successfully running on the SuperMUC-NG
- Parallel performance enhancement is ongoing