Overview of OpenGeoSys High-Performance-Computing Applications

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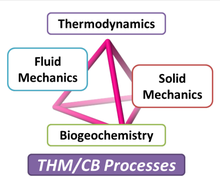
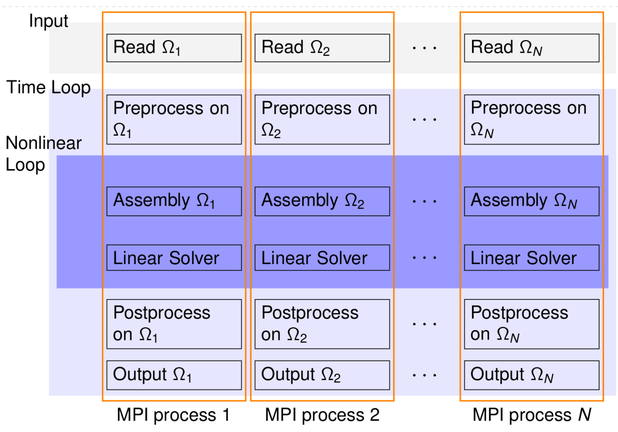
OpenGeoSys: High-Performance-Computing

OpenGeoSys

OpenGeoSys (OGS) is a scientific open source software for the development of numerical methods for the simulation of coupled thermo-hydro-mechanical-chemical (THMC) processes in porous and fractured media. OGS is fully parallelized using the distributed memory programming approach MPI (message passing interface).





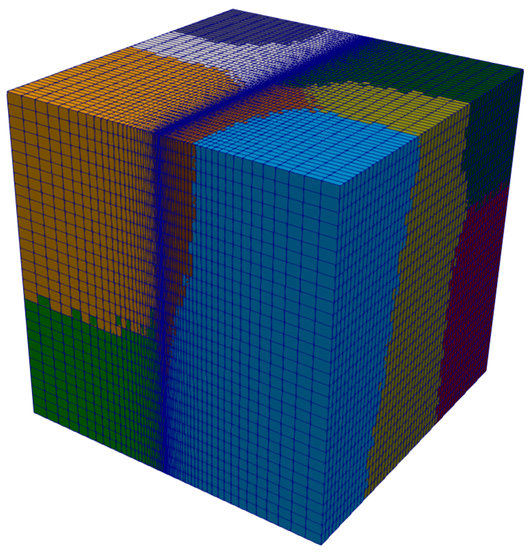
All parts of OGS-6 are parallelized

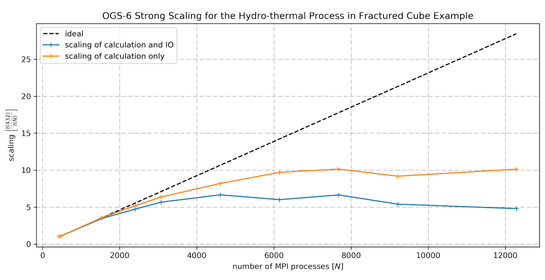
- Input (reading project data, read Ω_k)
- Time loop:
  - Preprocessing (possible data exchange)
  - Nonlinear solver (Picard / Newton)
    - Assembly (staggered, monolithic)
    - Linear solver (PETSc)
  - Postprocessing (secondary variable calculation, data exchange)
- Output

HPC Test: Fractured Cube

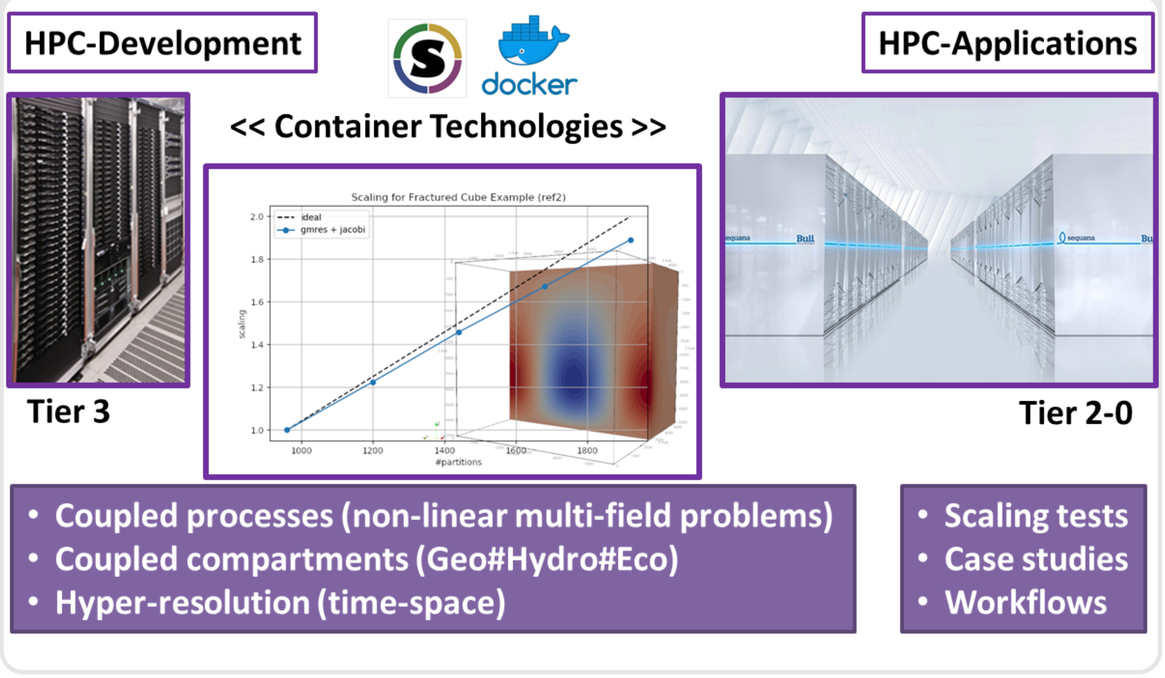
Simulation of a non-linear density driven flow process in a porous fractured cube

- Example of domain decomposition for a parallel run is shown on the right
- 4 different models from 107 000 nodes / elements (rev0) up to 55×10^6 nodes / elements (rev3) in the mesh
- 2 process variables (temperature and pressure) $\rightsquigarrow 110 \times 10^6$ unknowns
- Scalability results of the model rev3 are depicted below





HPC Concept



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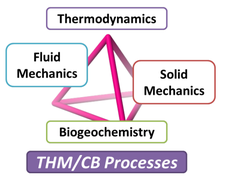
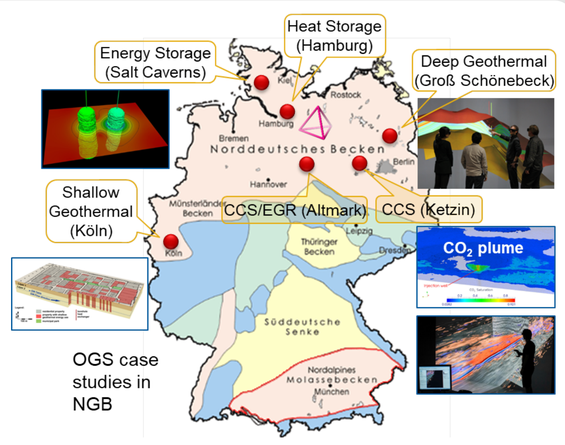
HPC Applications

North German Basin: OGS-HPC Applications

OpenGeoSys provides a large and flexible range for couplings of Hydro-Thermo-Mechanical-Chemical (THMC) processes for various geoscientific applications:

- HC: Seawater intrusion
- H/CB: Groundwater remediation
- TH(M): Shallow geothermal
- THM: Deep geothermal
- TM: (Very) deep geothermal
- (T)H^{2}M: CCS
- THM^{in}: Energy storage
- TH^{2}M/CB: Waste management
- THM: Fracture mechanics





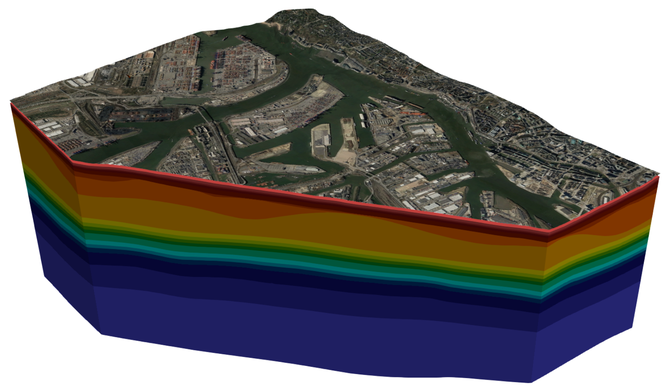
ANGUS-2: Hamburger Wärmespeicher

Hydro-Thermal Model

- 17 geological units
- Extent: 7419 m × 5078 m × 650 m
- 2 well points are included in the mesh

HPC

- 152 730 nodes / 284 121 elements
- 521 time steps
- Parallel simulation with 48 cores: 27 min



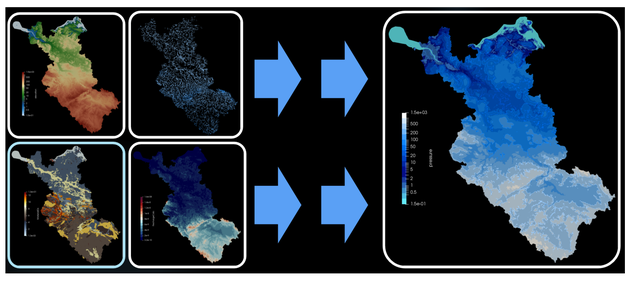
Elbe Catchment

Groundwater Flow Model

- 14 stratigraphic layers
- Extent: 637 km west-east, 690 km north-south

HPC

- 7 102 830 nodes / 14 190 644 elements
- Simulation of 1000 days realtime
- Parallel simulation with 48 cores: 27 min



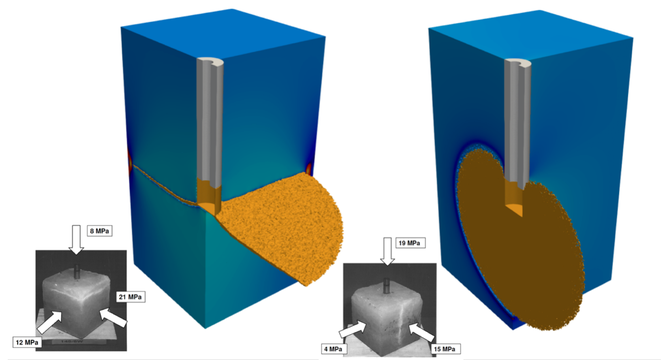
Subsurface Integrity Analysis

Crack Modeling using Phase Field

- The variational phase-field model has asserted itself as one of the most promising and reliable numerical tools to investigate crack propagation under complex conditions.
- Pre-existing fractures can be treated as an additional phase-field order parameter without the necessity of conforming meshes.
- Crack propagation by fluid injection through a hole drilled at the center.

HPC

- 21 729 300 dofs / 27 917 126 elements on 768 cores for 24 hours.



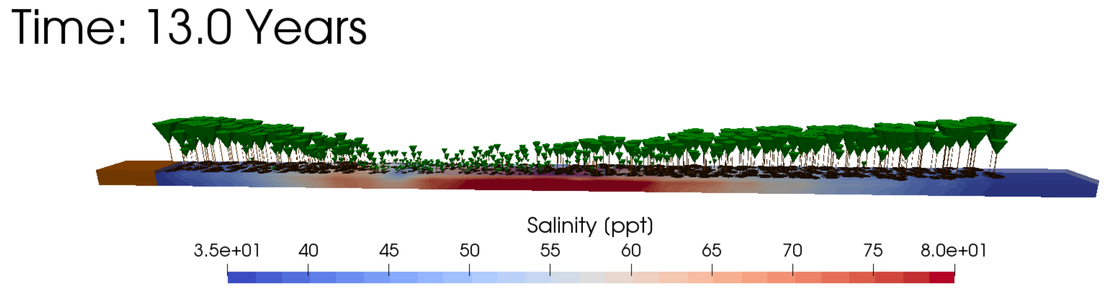
Ecosystem Dynamics in Changing Environments

Vegetation-Groundwater Feedback Model

- HC-Process: Porewater Salinity Dynamics
- Role of Feedbacks for Ecosystems Stability
- Understanding Processes Driving Mangrove Zonation

HPC

- 6500 Cells; 100 year real time (10^6 time steps)
- Extent: 120 m x 10 m
- Approximately 500 trees



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