URS-MEQUR

Probabilistic integrity analyses for a generic high-level radioactive waste repository

BGR B3.5 Geotechnische Sicherheitsnachweise
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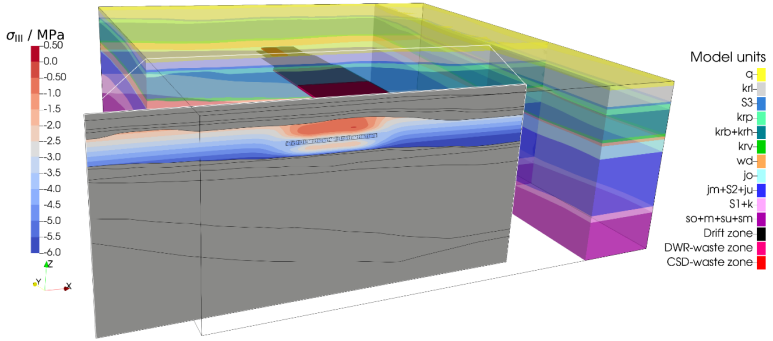
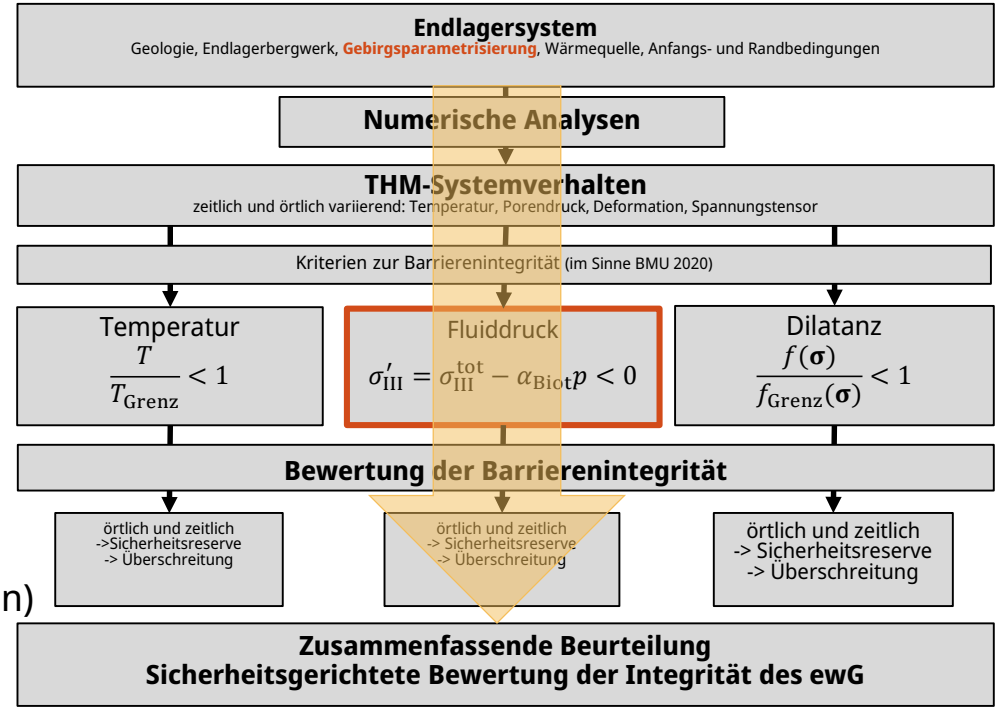
Case study: Integrity analyses in clay rock

- Integrity analyses in the project ANSICHT for the generic model “NORD”

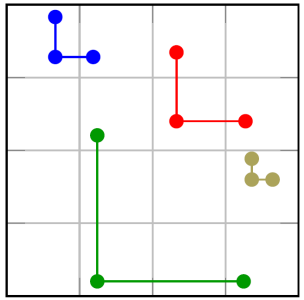


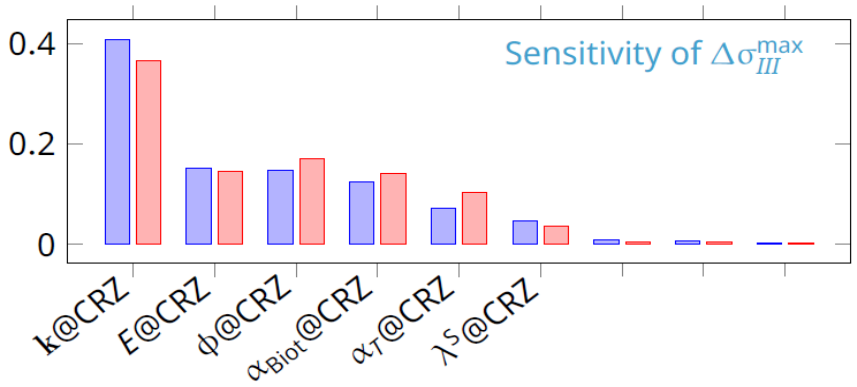
- OGS-6
- THM-coupled system response (Richards equation)
- Focus on temperature-induced increase in pore pressure with very low permeability



Model reduction - Global sensitivity analysis

- 9 rock parameters for each of the 11 homogenous model units:
  Young`s modulus, permeability , thermal conductivity, …
- 2 parameters describe the stochastic characteristics of the liquid phase
- ⇒ **101 stochastics dimensions in total**
- Uniform distributions on wide intervals are estimated from the literature and expert knowledge.





- Comparison Sobol-Indices and Morris-Screening
- Scalar index for comparison ⇒ Integration of spatially-resolved indicators over CRZ.

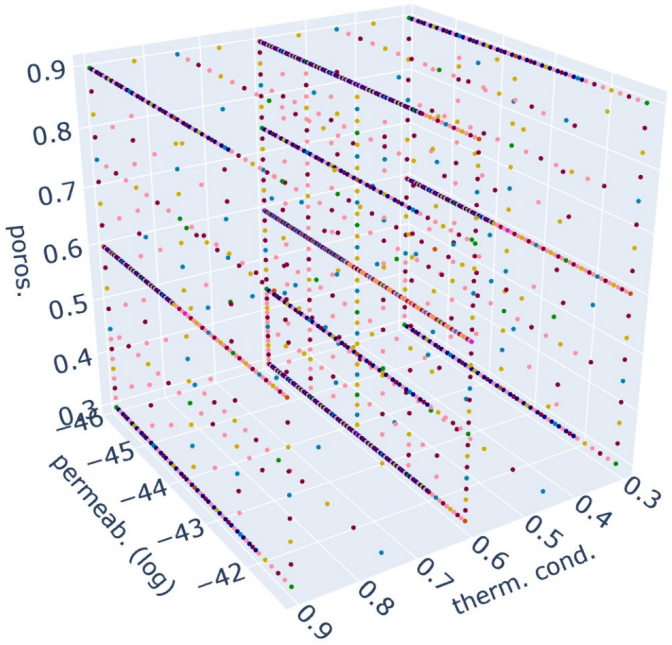
⇒ Total-Sobol and Morris sensitivities are in good agreement with each other and with our understanding of the system.

⇒ Model reduction with minimum loss of global variance.

Sparse-grid surrogate model

- Reduced stochastic model enables training of a surrogate model for the physical state space (THM response)
  - => approx. 35 000 OGS simulations (<1 day)
  - Complexity grows with number of dimensions: $O(N(\log N)^{d-1})$
- Efficient interpolation of complete OGS-6 THM simulation results for arbitrary points in the state space (in ~1/10 s).
  - No data reduction!
- Enables integration of arbitrary stochastic quantities for arbitrary evalution types by Monte Carlo integration on surrogate

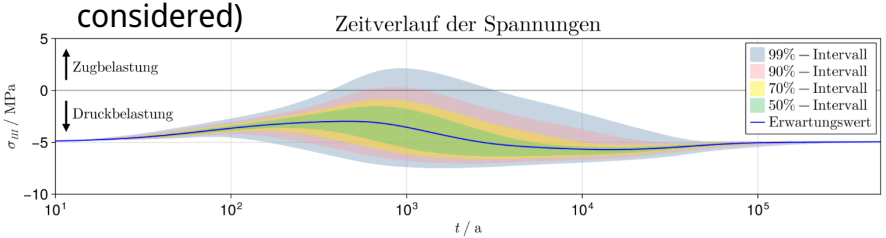
⇒ Surrogate model integration needed since compuation of tails of output distribution requires a high number of snapshots



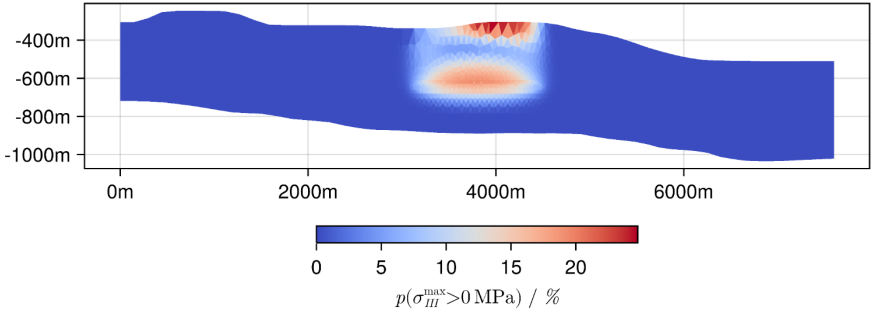
Comprehensive evaluation of integrity under uncertainty

Stochastic evaluations of the fluid pressure criterion:

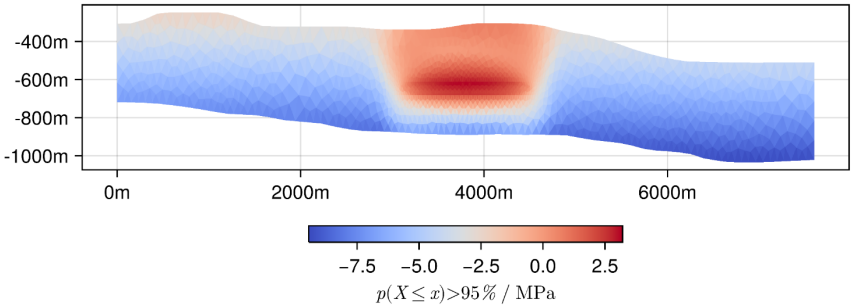
- Fluid pressure criterion => no tensile stresses allowed
- Time curves for characteristic locations above the storage area with confidence intervals
- Spatial distribution for „worst-case“ integrity criteria (for each point in the CRZ the worst indicator value in time is considered)



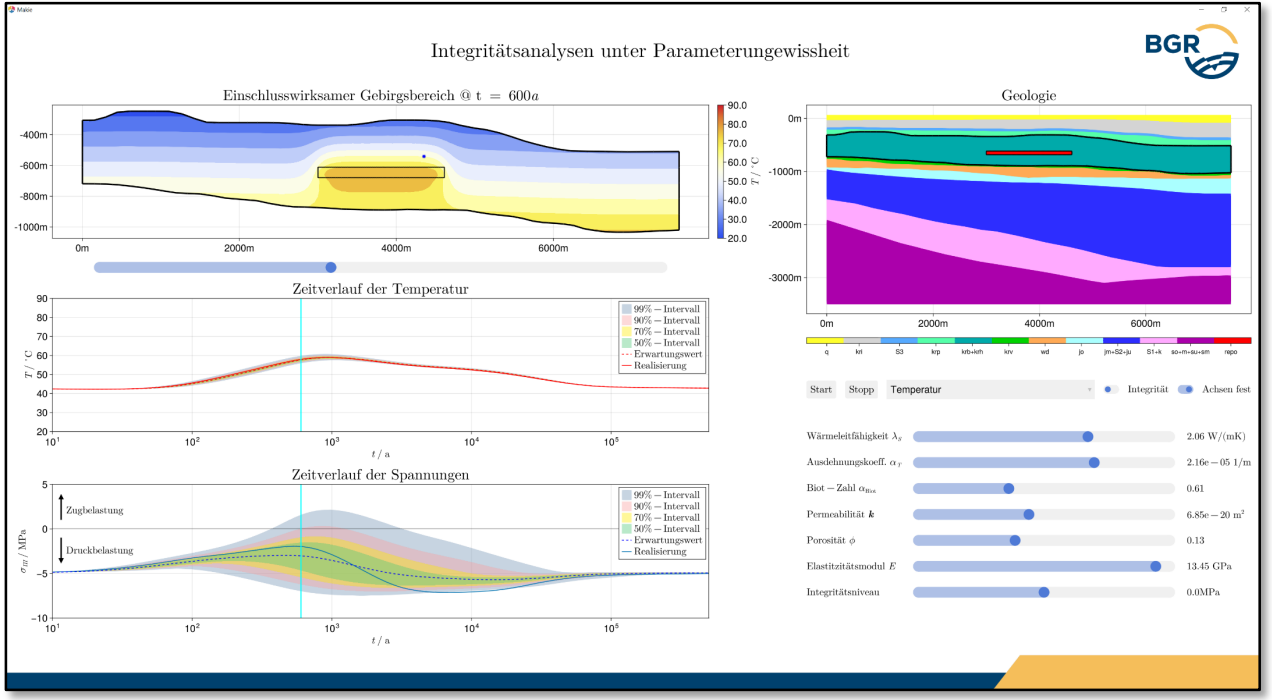
Probability of fluid pressure criterion violation



Spatial distribution of 95% percentile of worst-case fluid pressure

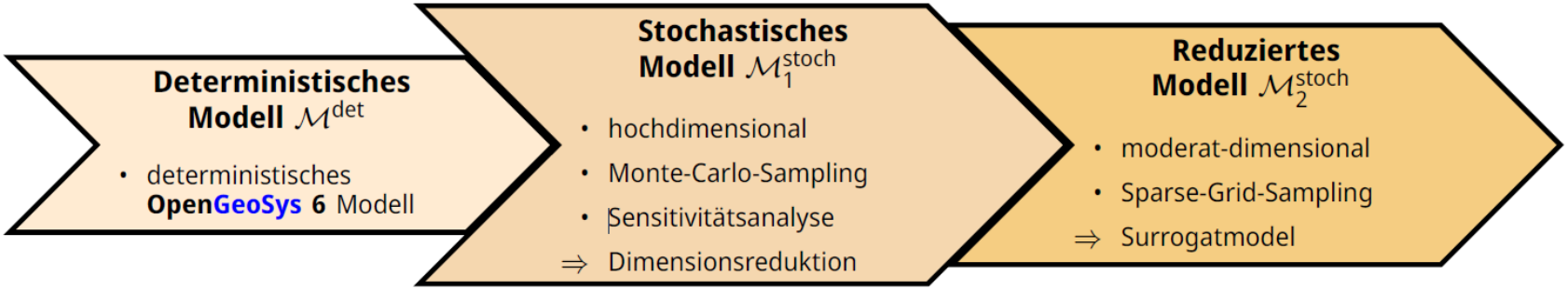


Investigating the state space: interactive representation of variability



Numerische Integritätsanalysen unter Parameterungewissheit

- Mehrstufige Verfahren zur Quantifizierung des Einflusses von Parameterungewissheiten



- Open-source HPC-Toolbox zur Quantifizierung von Ungewissheiten implementiert in julia.
- Anwendung für das generische Endlagersystem Ansicht Nord
- Ergebnisse auch stark vom Initialzustand abhängig, der hier nicht variiert wird.

Referenzen

- Maßmann, J.; Thiedau, J.; Bittens, M.; Kumar, V.; Tran, T. V.; Morel, C. G.; Kneuker, T. & Schumacher, S. (2022): *ANSICHT-II – Methode und Berechnungen zur Integritätsanalyse der geologischen Barriere für ein generisches Endlagersystem im Tongestein.* Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Ergebnisbericht; Hannover. DOI: 10.25928/n8ac-y452
- Reinhold, K.; Jahn, S.; Kühnlenz, T.; Ptock, L. & Sönnke, J. (2013): E*ndlagerstandortmodell Nord - Teil I: Beschreibung des geologischen Endlagerstandortmodells*. Projekt ANSICHT. BGR, Technischer Bericht; Hannover.
- Bittens, M. & Gates, R. L. (2023): *DistributedSparseGrids.jl: A Julia library implementing an Adaptive Sparse Grid collocation method.* Journal of Open Source Software, 8, 83. DOI: 10.21105/joss.05003.
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