Saf. Nucl. Waste Disposal, 2, 93–94, 2023
https://doi.org/10.5194/sand-2-93-2023


SaND
Safety of Nuclear Waste Disposal
Open Access



# Methods for the quantification of uncertainties in thermo–hydro–mechanical simulations for safety analyses and influence of modelling decisions

**Thomas Nagel[1], Maximilian Bittens[2], Jörg Buchwald[3], Aqeel A. Chaudhry[1], Oliver G. Ernst[4], Werner Gräsle[2], Feliks Kiszkurno[3,1], Kata Kurgyis[1], Jobst Maßmann[2], Sibylle Mayr[2], Jan Thiedau[2], and Chao Zhang[4]**

[1]Geotechnical Institute, Technische Universität Bergakademie Freiberg, 09559 Freiberg, Germany
[2]Geotechnical Safety Analyses, Federal Institute of Geosciences and Natural Resources – BGR, 30655 Hanover, Germany
[3]Department of Environmental Informatics, Helmholtz Centre for Environmental Research GmbH – UFZ, 04318 Leipzig, Germany
[4]Numerical Analysis, Technische Universität Chemnitz, 09107 Chemnitz, Germany

**Correspondence:** Thomas Nagel (thomas.nagel@ifgt.tu-freiberg.de)

Received: 28 March 2023 – Revised: 13 June 2023 – Accepted: 14 June 2023 – Published: 6 September 2023

**Abstract.** The simulation of thermal, hydraulic, and mechanical coupled processes can be a decisive factor in the integrity assessment of geotechnical and geological barriers. Modelling decisions, such as the representation of heterogeneity and the constitutive models used, significantly impact the simulation outcome (Wagener and Pianosi, 2019). Furthermore, numerical inputs to the simulation, i.e. material parameters and boundary conditions, are subject to uncertainty. This results in a lower confidence level of the outcome, even if the overall simulation framework is well validated.

To derive robust conclusions from such analyses, it is important to quantify the relative impact of modelling decisions and inputs on certain quantities of interest. Parameter uncertainties can be quantified by their forward propagation through the discretized problem (Helton, 1994), providing a natural frame of reference for quantifying structural uncertainty (Bond et al., 2007), such as the representation of heterogeneity, and for model validation. This contribution will focus on the latter aspects.

We present research on workflows for the unification of evaluating uncertainty in experimental data and certain modelling decisions. We first focus on parameter uncertainty quantification and the resulting conclusions concerning the chosen modelling approach. Hereafter, scale questions are addressed in the context of heterogeneity and anisotropy, based on selected case studies. We close by discussing two example applications, namely one at the Underground Research Laboratory (URL) scale (Mount Terri Full-Scale Emplacement (FE) experiment) and one at the repository scale (ANSICHT Ton Nord model).

This work is done as part of the Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz (BGE URS) research cluster.

**Financial support.** Financial support for this work has been provided by the Bundesgesellschaft für Endlagerung (BGE), the German federal company for radioactive waste disposal, in the framework of the URS project.

## References

Bond, C. E., Gibbs, A. D., Shipton, Z. K., and Jones, S.: What do you think this is? "Conceptual uncertainty" in geoscience interpretation, GSA Today, 17, 4–10, https://doi.org/10.1130/GSAT01711A.1, 2007.

Helton, J. C.: Treatment of Uncertainty in Performance Assessments for Complex Systems, Risk Anal., 14, 483–511, https://doi.org/10.1111/j.1539-6924.1994.tb00266.x, 1994.

Wagener, T. and Pianosi, F.: What has Global Sensitivity Analysis ever done for us? A systematic review to support scientific advancement and to inform policy-making in earth system modelling, Earth-Sci. Rev., 194, 1–18, https://doi.org/10.1016/j.earscirev.2019.04.006, 2019.