Investigation of Modern Methods of Probabilistic Sensitivity Analysis of Final Repository Performance Assessment Models

D.-A. Becker, S. M. Spiessl
Gesellschaft fuer Anlagen- und Reaktorsicherheit (GRS) gGmbH, Germany

For deep geological repositories for radioactive waste, numerical performance assessment is a key process in all phases from site selection to licensing for closure. The release of contaminants to the biosphere for a number of conceivable scenarios has to be assessed in advance, which can only be done by modelling all relevant effects in an integrated, coupled model. Such computation models are typically rather complex, as they combine a lot of physical and chemical effects and influences from various processes in the underground. As a result, they often show a highly non-linear behaviour.

There are many parameters influencing the calculation results that are subject to essential uncertainties. By this reason, sensitivity analysis is an important tool for investigating the model behaviour. Sensitivity analysis is not only adequate for directing research activities, but can contribute essentially to a proper model understanding and even reveal errors in the model or the data.

In the past, there was a tendency to apply well-known standard methods of probabilistic sensitivity analysis to performance assessment models uncritically without thinking about their appropriateness. Although such a procedure often leads to a correctsensitivity estimation, it cannot be excluded that, in extreme cases, it can yield wrong or misleading results and jeopardise the benefit of sensitivity analysis. Therefore, a research programme was set up some years ago in order to investigate new developments in sensitivity analysis, their applicability to performance assessment model results and the benefit such methods can provide for repository safety assessment.The final goal of the investigations was to provide some guidance to a modeller for performing an effective and meaningful sensitivity analysis. In this talk we present an overview of the total project and the main outcomings.

Three performance assessment models were defined for hypothetical repositories for different kinds of radioactive waste in different geological formations. These models show different effects that are typical for their specific type, like output results widely spread over many orders of magnitude, occurrence of a considerable number of zero-runs, a two-split output distribution or an extremely non-linear, nearly non-continuous behaviour. For each model a set of uncertain input parameters was defined.An appropriate pdf was assigned to each parameter.

The models were calculated a high number of times using parameter samples of sizes between 1000 and 32000 that were drawn applying different sampling algorithms like Random sampling, Latin Hypercube sampling, Quasi-Random-LpTau sampling, FAST and EFAST sampling, and Random Balance Design (RBD) sampling. Different methods of sensitivity analysis were applied, including Standardised Regression and Rank Regression Coefficients (SRC/SRRC), (Extended) Fourier Amplitude Sensitivity Test (FAST/EFAST), Effective Algorithmfor Computing Global Sensitivity Indices (EASI), the State-Dependent Parameter (SDP) method as well as the Smirnov test. Some experiments were also done with correlated input parameters and transformation of model output. Moreover, graphical methods of sensitivity analysis, mainly the Contribution to Sample Mean (CSM) plot, were applied.

Sensitivity measures were calculated with each method for a number of points in time, so that the results could be plotted as time curves. The investigation of the results was oriented at the following questions:

- How robust are the results? Do the curves considerably change if a different sample of same size is used? How many runs are necessary to achieve stable curves?
- Do the different methods calculating variance-based sensitivity indices of first order produce similar results?
- Do the different sensitivity measures and graphical methods qualitatively agree about the main sensitivities?
- Are the sensitivity analysis results plausible and understandable?
- Are all sensitivities detected by the different methods?
- Which sampling algorithm seems best?
- Can the significance of sensitivity analysis be improved by transforming the model output to a more appropriate scale?

- How numerically effective are the different methods of sensitivity analysis?

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