EGU21-6131
https://doi.org/10.5194/egusphere-egu21-6131
EGU General Assembly 2021

Comprehensive global sensitivity analysis of a repository model using different types of transformations and metamodeling techniques

Sabine M. Spiessl[1], Dirk-A. Becker[1], and Sergei Kucherenko[2]
[1]Gesellschaft für Anlagen- & Reaktorsicherheit GRS gGmbH, Braunschweig, Germany (sabine.spiessl@grs.de)
[2]Imperial College London, London, UK

Due to their highly nonlinear, non-monotonic or even discontinuous behavior, sensitivity analysis of final repository models can be a demanding task. Most of the output of repository models is typically distributed over several orders of magnitude and highly skewed. Many values of a probabilistic investigation are very low or even zero. Although this is desirable in view of repository safety it can distort the evidence of sensitivity analysis. For the safety assessment of the system, the highest values of outputs are mainly essential and if those are only a few, their dependence on specific parameters may appear insignificant. By applying a transformation, different model output values are differently weighed, according to their magnitude, in sensitivity analysis. Probabilistic methods of higher-order sensitivity analysis, applied on appropriately transformed model output values, provide a possibility for more robust identification of relevant parameters and their interactions. This type of sensitivity analysis is typically done by decomposing the total unconditional variance of the model output into partial variances corresponding to different terms in the ANOVA decomposition. From this, sensitivity indices of increasing order can be computed. The key indices used most often are the first-order index (SI1) and the total-order index (SIT). SI1 refers to the individual impact of one parameter on the model and SIT represents the total effect of one parameter on the output in interactions with all other parameters. The second-order sensitivity indices (SI2) describe the interactions between two model parameters.

In this work global sensitivity analysis has been performed with three different kinds of output transformations (log, shifted and Box-Cox transformation) and two metamodeling approaches, namely the Random-Sampling High Dimensional Model Representation (RS-HDMR) [1] and the Bayesian Sparse PCE (BSPCE) [2] approaches. Both approaches are implemented in the SobolGSA software [3, 4] which was used in this work. We analyzed the time-dependent output with two approaches for sensitivity analysis, i.e., the pointwise and generalized approaches. With the pointwise approach, the output at each time step is analyzed independently. The generalized approach considers averaged output contributions at all previous time steps in the analysis of the current step. Obtained results indicate that robustness can be improved by using appropriate transformations and choice of coefficients for the transformation and the metamodel.

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