Benefits of Global Sensitivity Analysis and Reduced Order Modeling for Basin-Scale Process Simulations

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Geophysical process simulations pose several challenges including the determination of i) the rock properties, ii) the underlying physical process, and iii) the spatial and temporal domain that needs to be considered.

Often it is not feasible or impossible to include the entire complexity of the given application. Hence, we need to evaluate the consequences of neglecting certain processes, properties, etc. by using, for instance, sensitivity analyses. However, this evaluation is for basin-scale application non-trivial due to the high computational costs associated with them. These high costs arise from the high-dimensional character of basin-scale applications in the parameter, spatial, and temporal domain.

Therefore, this evaluation is often not performed or via computationally fast algorithms as, for example, the local sensitivity analysis. The problem with local sensitivity analyses is that they cannot account for parameter correlations. Thus, a global sensitivity analysis is preferential. Unfortunately, global sensitivity analyses are computationally demanding.

To allow the usage of global sensitivity analysis for a better evaluation of the changes in the influencing parameters, we construct in this work a surrogate model via the reduced basis method.

The reduced basis method is a model order reduction technique that is physics-preserving. Hence, we are able to retrieve the entire state variable (i.e. temperature) instead of being restricted to the observation space.

To showcase the benefits of this methodology, we demonstrate with the Central European Basin System how the influences of the thermal rock properties change when moving from a steady-state to a transient system.

Furthermore, we use the case study of the Alpine Region to highlight the influences of the spatial

distribution of measurements on the model response. This latter aspect is especially important since measurements are often used to calibrate and validate a given geological model. Thus, it is crucial to determine which amount of bias is introduced through our commonly unequal data distribution.