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Usage of the Reduced Basis Method and High-Performance Simulations in Geosciences

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The field of Computational Geosciences often encounters the "curse" of dimensionality, since it aims at analyzing complex coupled processes over a large domain in space and time. These high-dimensional problems are computationally intensive, requiring High-Performance Computing infrastructures. However, constructing parallelized problems is often not trivial. Therefore, we present a software implementation within the Multiphysics Object-Orientated Simulation Environment (MOOSE) offering a built-in parallelization.

Even with the computational potential of High-Performance Computers, it may be prohibitive to perform model calibrations or inversions for a reasonably large number of parameters, since the geoscientific forward simulations can be very demanding. Hence, one desires a method reducing the dimensionality of the problem while retaining the accuracy within a certain tolerance. Considering model order reduction techniques is a way to achieve this.

We present the Reduced Basis (RB) Method being such a Model Order Reduction Technique aiming at considerably reducing the number of degrees of freedom. We show how the reduction in the dimension results in a significant speed-up, which in turn allows one to perform sensitivity analyses and parameter estimations, to analyze more complicated structures, or to obtain results in real-time. In order to demonstrate the powerful combination of the Reduced Basis Method and High-Performance Computing, we investigate the method's of scalability and parallel efficiency, two measurements for the performance of clusters by using the example of a geothermal conduction problem.