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A reverse engineering approach to optimal design of site investigation schemes and monitoring networks

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Optimal design of experiments follows the goal to design investigation strategies such that maximum information towards a given scientific or modeling task is gained from a given limited budget for investigation. Looking at groundwater as a drinking water resource, its quality and safety is hard to assess and predict mainly because subsurface materials are heterogeneous, and normally there are too few data to resolve this heterogeneity and extract the necessary key properties of the system. Optimal design techniques have a vast potential to remedy this limitation. However, optimal design is currently heavily limited by its computer demands, especially when applied to complex large-scale problems such as stochastic groundwater quality models.

In this work, a re-formulation of optimal design theory within a new information-theoretic perspective will be shown. Instead of traditionally and tediously searching through all possible measurement locations and types to find the most informative ones, the direction of analysis will be reverted to directly identify the most informative ones in a single step. This will dramatically reduce the computational load, allowing to apply optimal design for larger, more complex and hence more realistic problems. At the same time, this avoids simplifications or linearizations that previously compromised the accuracy of optimal design analysis. Instead of giving in to computational restrictions, the new method will allow to tackle current, goal-oriented and application-driven research tasks. This poster shows the theoretic framework and a first application within the groundwater perspective as a proof of concept. In future the new method will then be exported as a valuable tool for many scientific disciplines that face similar uncertainties in heterogeneous or complex dynamic systems.