Bayesian Evidential Learning Approach to Uncertainty Quantification in THM Model of Geothermal Energy Extraction in Deep Mines

Zhang, Le; Daniilidis, Alexandros; Dieudonné, Anne-Catherine; Hermans, Thomas

DOI
10.5194/egusphere-egu24-10336

Publication date
2024

Document Version
Final published version

Citation (APA)
Zhang, L., Daniilidis, A., Dieudonné, A.-C., & Hermans, T. (2024). *Bayesian Evidential Learning Approach to Uncertainty Quantification in THM Model of Geothermal Energy Extraction in Deep Mines*. Abstract from EGU General Assembly 2024, Vienna, Austria. https://doi.org/10.5194/egusphere-egu24-10336

EGU24-10336, updated on 12 Sep 2024
https://doi.org/10.5194/egusphere-egu24-10336
EGU General Assembly 2024

Bayesian Evidential Learning Approach to Uncertainty Quantification in THM Model of Geothermal Energy Extraction in Deep Mines

Le Zhang[1,2], Alexandros Daniilidis[2], Anne-Catherine Dieudonné[2], and Thomas Hermans[1]
[1]Department of Geology, Ghent University, Belgium
[2]Faculty of Civil Engineering and Geosciences, Delft University of Technology, The Netherlands

Utilizing existing deep mining systems for geothermal extraction not only facilitates the development of geothermal systems but also helps meeting the cooling requirements for deep mining operations. In this study, a thermo-hydro-mechanical model of geothermal extraction in deep mines is developed to investigate the evolution of mine galleries stability and temperature, and the temperature changes in geothermal production wells. The uncertainty in system responses is predicted through the Bayesian Evidential Learning framework.

Due to our limited understanding of the material properties and the scarcity of measurement data, uncertainties emerge in the forward simulations. Ideally, a comprehensive uncertainty analysis would be conducted to predict all possible outcomes and assess any risks. However, In light of the intractability of performing comprehensive uncertainty analyses in scenarios with vast unknown data, particularly due to the computational overhead of multiple inverse problem-solving, we employ the Bayesian Evidential Learning framework, which provides a feasible and rapid alternative for approximating prediction post-distributions and choosing the most informative data sets. Before implementing BEL, we employed Latin Hypercube Sampling to create 500 sets of realizations for forward simulations, and subsequently utilized global sensitivity analysis to evaluate the data's informational value, aiming to diminish the uncertainty in predictions. In this paper, the BEL framework is utilized to achieve two: firstly, to stochastically predict the responses of the system (stability and temperature) within the BEL framework, using machine learning to discover direct correlations between predictors (sensitive parameters) and targets (system responses). Subsequently, newly collected data can be utilized to predict the approximate posterior distributions of the corresponding gallery stability, temperature, and production well temperature, thus circumventing traditional data inversion steps. This framework can be adjusted to accommodate any predictions related to subsurface conditions; hence, our second goal involves predicting the system's long-term responses within the BEL based on short-term data collection, forecasting posterior distributions from the acquired short-term data, and validating the efficacy of this approach.

Our study indicates that in practical engineering, by (1) obtaining data of material properties and (2) key responses of short-term simulation, it is possible to predict the critical responses of the

system in long-term geothermal extraction, thereby maximizing the information content of any measurement data while minimizing budget constraints and computational costs.