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An application of travel-time based surrogate model for hydraulic tomography

Yixuan Xing (1), Rui Hu (2), Quan Liu (1), and Thomas Ptak (1)

(1) University of Goettingen, Faculty of Geoscience and Geography, Applied Geology, Göttingen, Germany (xing.yx@gmx.de), (2) School of Earth Science and Engineering, Hohai University, Nanjing, China(rhu@hhu.edu.cn)

In recent years, hydraulic tomography has been widely applied for characterization of heterogeneous aquifer parameter distributions. Among them, the travel-time based inversion method has the characteristics of high computational efficiency. It is used to rapidly obtain the spatial distribution of hydraulic parameters by solving the eikonal equation with hydraulic travel time. However, similar with most other underdetermined problems, the shortcomings such as non-uniqueness and poor convergence of inversion results are difficult to avoid.

Nonlinear inversion methods that can effectively circumvent these shortcomings, such as simulated annealing and neural networks, have been often used in the field of geophysics. In this study, we established a nonlinear surrogate model with simplification of the mathematical relationship between observed data and aquifer parameters, in order to improve the efficiency of the hydraulic tomographical inversions.

In this contribution, instead of the ray tracing-based inversion of hydraulic travel time, the surrogate model is used to generate a mathematical mapping between hydraulic travel time and hydraulic diffusivity. Through the training of a large number of sample data of travel time, this model is utilized for hydraulic tomography based on a neural network approach. The inversion results for homogeneous and layered aquifers show that this new method provides good reliability and robustness. Next, by constructing a heterogeneous distribution of hydraulic parameters using geostatistical simulation, the feasibility of this method for characterizing complex aquifer structures will be further verified and applied for field experiments.