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Geostatistical modeling of shallow open geothermal systems

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The design of shallow open geothermal systems depend on a comprehensive characterization of all those relevant, particularly hydraulic and thermal conductivities. Their distribution determines not only the technical design, but also the economic viability of such systems. This work analyses the effect of heterogeneity of hydraulic and thermal conductivities on the configuration of the heat plume.

Based on field data (Esseling site, Germany), several synthetic models with different degrees of logarithmic hydraulic conductivity variances are set up. Heterogeneous hydraulic conductivity fields are generated randomly by geostatistical tools using a sequential Gaussian simulation method. MT3DMS is selected as the subsurface heat transport simulation code. A comparison of modeling results under homogeneous and heterogeneous conditions is performed.

The results indicate that heterogeneity of hydraulic conductivity has a significant effect on the flow fields and heat plume configurations. For small variances of log K heterogeneity of hydraulic conductivity has minor effects, thus the aquifer can be regarded as a homogeneous model for practical purpose, while for large variances, heterogeneity should be taken into account as may have large influence on heat plume configurations. Moreover, in the area close to the source, the heterogeneity of hydraulic conductivity causes significant uncertainty on the heat plume configuration. Furthermore, the results show that the heterogeneity of thermal conductivity seems to have negligible influence on the temperature fields.