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Sustainable operation of a large BHE field considering groundwater flow and land cover changes

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Shallow geothermal energy has been widely used for heating and cooling buildings by combining borehole heat exchangers (BHEs) with heat pumps. In recent years, how to maintain the efficiency and sustainability of large BHE systems has received increasing attention. An effective way to address this issue is to develop site-specific models to accurately predict the economy, thermal efficiency, and environmental impacts of geothermal systems. However, site characteristics are often simplified or even ignored, such as complex groundwater flow induced by subsurface heterogeneity and non-homogeneous surface heat transfer due to various land covers. In this study, a BHE system model was developed based on collected site characteristics and thermal measurements during system operation. Firstly, groundwater flow in a heterogeneous subsurface was considered in the developed model, according to the regional hydrogeologic conditions and borehole logs. In addition, complex surface heat transfer influenced by solar radiation and land cover characteristics was incorporated. Thermal parameters of different land cover types are considered as time-varying parameters to account for neighboring land use changes. Finally, the hydraulic parameters in the developed model were calibrated by comparing simulations with the groundwater temperatures observed in the boreholes. Next, we plan to further validate the prediction capability of the developed model based on recent temperature observations. We will then discuss the importance of site characteristics in assessing the thermal efficiency and environmental impacts of the BHE system by comparing the results with those of simplified models. Forecasts of system economics for the next ten years will also be made based on the developed model and possible thermal energy management strategies.