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Neural Network approach to assess the thermal affected zone around the injection well in a groundwater heat pump system

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ABSTRACT
The common use of well doublets for groundwater-sourced heating or cooling results in a thermal plume of colder or warmer re-injected groundwater known as the Thermal Affected Zone(TAZ). The plumes may be regarded either as a potential anthropogenic geothermal resource or as pollution, depending on downstream aquifer usage. A fundamental aspect in groundwater heat pump (GWHP) plant design is the correct evaluation of the thermally affected zone that develops around the injection well. Temperature anomalies are detected through numerical methods. Crucial elements in the process of thermal impact assessment are the sizes of installations, their position, the heating/cooling load of the building, and the temperature drop/increase imposed on the re-injected water flow. For multiple-well schemes, heterogeneous aquifers, or variable heating and cooling loads, numerical models that simulate groundwater and heat transport are needed. These tools should consider numerous scenarios obtained considering different heating/cooling loads, positions, and operating modes. Computational fluid dynamic (CFD) models are widely used in this field because they offer the opportunity to calculate the time evolution of the thermal plume produced by a heat pump, depending on the characteristics of the subsurface and the heat pump. Nevertheless, these models require large computational efforts, and therefore their use may be limited to a reasonable number of scenarios. Neural networks could represent an alternative to CFD for assessing the TAZ under different scenarios referring to a specific site.
The use of neural networks is proposed to determine the time evolution of the groundwater temperature downstream of an installation as a function of the possible utilization profiles of the heat pump. The main advantage of neural network modeling is the possibility of evaluating a large number of scenarios in a very short time, which is very useful for the preliminary analysis of future multiple installations. The neural network is trained using the results from a CFD model (FEFLOW) applied to the installation at Politecnico di Torino (Italy) under several operating conditions.