Geophysical Research Abstracts
Vol. 20, EGU2018-1643, 2018
EGU General Assembly 2018
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Thermal impact assessment of Groundwater Heat Pumps (GWHPs): modelling assumptions and key parameters

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The increasing diffusion of Groundwater Heat Pumps (GWHPs), especially for large buildings in urban areas, needs to be managed in order to avoid reciprocal impacts between neighbouring installations and on other water uses. For this reason, a thorough hydrogeological characterisation and a rigorous modelling of the subsurface thermal impact of GWHPs is required; however, this subject has been addressed by a few studies only, among which those reported in Refs. [1-4].
We present a comprehensive sensitivity analysis, based on numerical flow and heat transfer simulations carried out with the software FEFLOW, in order to assess how the thermal plume size is affected by the aquifer's hydrodynamic parameters, the subsurface thermal properties, the thickness of the vadose and saturated zones, and by the thermal load exchanged [5]. In particular, we addressed the plume length, width and their temporal evolution in the long term. The results of this analysis identify which parameters most affect the propagation of the thermal plume, and hence can most contribute to possible simulation errors if not properly assigned.
In addition, we addressed a number of different assumptions in the modelling of GWHPs. The heat exchange between the aquifer and the atmosphere strongly impacts on the plume length, and hence GWHPs should be modelled in 3D rather than 2D. Using the yearly average of a thermal load dramatically reduces calculation times, but may lead to a severe underestimation of the plume width. An acceptable estimation of the plume width can be performed with analytical formula by Banks [1], while this is not possible for the plume length.
This work, carried out in the framework of the GRETA project [6], provides a methodological basis for the assessment of the thermal footprint of GWHPs, and hence on their sustainability in densely inhabited areas.

References

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