Geophysical Research Abstracts
Vol. 21, EGU2019-8538, 2019
EGU General Assembly 2019

Numerical modelling to assess the energy efficiency of shallow geothermal installations

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In recent years, so-called energy geostructures have gained increasing popularity among both academics and professionals in Europe. They typically consist of closed-loop heat exchanger systems embedded in geotechnical structures, which serve the double purpose of supporting soil and/or the overlying structure and providing sustainable energy for heating and cooling of buildings. Such installations allow significant cost savings compared to traditional borehole heat exchangers, as they do not require ad-hoc excavations. However, their non-standard geometry and peculiar boundary conditions means that established calculation tools (e.g. simplified analytical models) are not suitable to predict their energy performance. In this work, a numerical finite element model able to carry out both thermal and thermo-mechanical analyses of energy geostructures is described, and validated against field data. The model is then used to carry out parametric studies to assess the energy efficiency of three different types of geothermal installations, namely: rotary bored energy piles, continuous flight auger energy piles and energy walls. It emerges that different thermal design criteria should be used for different energy geostructures, in order to maximise the geothermal exchanged power. Guidelines are also provided aimed at improving the energy efficiency of such installations by acting on parameters that are relatively easy to engineer, without altering the structural and geotechnical design arrangements.