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Demonstration of a city-scale geothermal resource assessment using a statistical archetypes-based approach

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Growing demand for space in urban areas is accelerating the utilisation of the shallow subsurface for residential and commercial spaces, transport systems, industrial processes, and energy applications. The associated underground infrastructure can act as a source and sink of heat within the subsurface, altering the ambient temperature of the soil. The extent and magnitude of such a temperature anomaly is affected by the type and density of the structures in the ground, the environmental hydraulic conditions governing groundwater flow, and the geological properties impacting conductive heat transfer. As a result, temperature distributions will vary spatially beneath a given city, thereby also affecting the geothermal potential available for heating and cooling. Knowledge on where the greatest geothermal potential lies within a city can be crucial for large-scale planning of geothermal systems, and incorporating these within building and district-level systems.

We present a methodology to map the geothermal potential under cities, extending on a recently developed and published large-scale subsurface temperature modelling methodology, which statistically identifies commonalities in how natural and anthropogenic features affect subsurface heat transfer and creates subsurface archetypes. The extension entails incorporating ground heat exchanging structures, e.g. boreholes, within the archetypes to further subdivide existing thermal archetypes into geothermal archetypes and thus enable comparison of the relative performance of a ground heat exchanger in different areas of a city. The methodology is applied to the city of Cambridge, UK to generate a map of geothermal potential. Additionally, the demand for the city, computed using field data, is mapped to produce a demand-to-capacity map of the city. By exploring different exploitation scenarios of the geothermal potential, i.e. first-come-first-served vs. co-ordinated, we further determine the ability of the resulting deployment patterns to meet likely changes in future demand under the effects of climate change.