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Urban heat islands in the subsurface

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During the last hundred years, urban heat island effect and climate change have not only caused surface temperature increase in most urban areas, but also enhanced the subsurface temperature by several degrees. This phenomenon yields aquifers with elevated temperature, which are attractive thermal energy reservoirs. Meanwhile, geothermal energy has become increasingly popular, because it offers a number of advantages over traditional energy sources based on fossil fuels. As a renewable energy source, it is clean and safe for the surrounding environment, and it also contributes to reduction of CO2 emissions. Therefore, to estimate the regional potential geothermal energy content in densely populated urban areas is necessary. The current study presents extensive field studies in two cities, Cologne (Germany) and Winnipeg (Canada). The results reveal high subsurface temperature distributions in the centers of both cities and indicate a warming trend of up to 5 °C. The case-specific potential heat content in urban aquifers and available capacities for space heating are quantified. The results show, for example, that by decreasing the 20 m thick urban aquifer's temperature by 2 °C, the amount of extractable geothermal energy beneath Cologne could be used for residential heating of the whole city for at least 2.5 years. The geothermal potential in other cities such as Shanghai and Tokyo is shown to supply heating demand even for decades. Furthermore, different types of shallow geothermal systems that could be used to extract the geothermal energy in urban aquifers are discussed.