A calibrated 3D thermal model of urban heat fluxes into the shallow subsurface

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The growth of urban populations, combined with the limited availability of above-ground space, is resulting in the increased use of underground structures as living spaces, e.g. residential basements. Such subsurface structures constitute continuous sources and sinks of heat to and from the surrounding underground environment, particularly if maintained at comfortable temperatures. In heavily populated cities and city-centres, underground temperature increases due anthropogenic heat fluxes are well-established, known as the urban underground heat island effect. Due to limited availability of long-term underground temperature data, models looking at subsurface temperature changes caused by man-made structures are difficult to calibrate. However, accurately accounting for the underground thermal climate is essential in ensuring efficient heating and cooling of underground structures as well as correctly estimating the geothermal potential in areas affected by the heat fluxes. The work to be presented explores the impact of temperature-maintained subsurface structures on the thermal climate of the shallow subsurface by developing a 3D finite element model of the Cardiff (UK) city-centre, using COMSOL Multiphysics. The model takes into account conductive and convective heat transfer between the ground and basements as well as geological features and existing hydraulic head measurements. Calibration of the model is performed using time-series temperature data, collected over several years by monitoring boreholes distributed throughout the modelled domain, provided by the British Geological Survey. This constitutes an important step towards accurately characterising the effects of underground urban heat islands and better understanding the human impact on the below ground thermal climate.