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An innovative temperature monitoring approach to ensure the sustainable use of shallow geothermal energy on quarter scale

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Increasing the share of renewables in the heating sector is crucial to reduce CO_2-emissions. Using the shallow geological subsurface for heating and cooling is part of the solution. Especially the use of shallow geothermal energy for heating is widely applicable. An intensive but at the same time sustainable shallow geothermal use is essential to avoid interactions between geothermal users with a resulting decrease in system efficiency or competing use with other subsurface usages, e.g. groundwater provision. The intensive thermal use of the shallow subsurface is generally controlled by monitoring of subsurface or groundwater temperatures. Induced changes of subsurface or groundwater temperatures are required to not exceed specific thresholds over time. However, the urban subsurface is exposed to different sources of temperature impacts which need to be considered during the long term subsurface or groundwater temperature monitoring to determine absolute changes. This is especially true for new urban quarters. Elevated groundwater temperatures in densely populated areas in comparison to the rural surroundings, often referred to as groundwater urban heat islands, have been observed and investigated over decades. However, only little information is available about the formation of heat islands over time and yet, its effects are hardly considered in groundwater temperature monitoring practice. To overcome this lack of knowledge, this study follows an innovative approach by coupling simulated elevated groundwater temperatures for a densely settled quarter with empiric groundwater temperature data. Therefore, heat losses from buildings and their contribution to the formation of groundwater urban heat islands over time are analysed for a refurbished quarter with a building stock of 150 houses and intensive use of shallow geothermal energy in Cologne, Germany. To simulate heat losses from buildings, different scenario analyses with houses of varying insulation standards are performed using a building physics software. Obtained results were then implemented into a groundwater flow model to evaluate the impact on underground temperatures over time and compared with measured data of the same area. Simulation results reveal that the geothermal heating activities impact the groundwater temperatures more than the monitoring data suggests.