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Groundwater Temperature in the Limmat Valley Aquifer, Zurich

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In metropolitan areas, the thermal environment is strongly influenced by the effects of urbanization. Urban climate is often described by Urban Heat Islands (UHIs), which are also observed in the shallow subsurface. On the one hand, these temperature anomalies may put sustainable development of urban ground at a risk, but on the other hand, enhanced ground temperatures represent potential energy reservoirs. In this contribution, we focus on the role of hydrogeological conditions for the development subsurface UHIs.

As a study case, the Limmat valley forming the city center of Zurich is chosen. The Limmat valley is filled with widely heterogeneous, high-conductive moraine deposits, which host groundwater reaching close to the urban surface. By rigorous temperature-depth metering of the Limmat valley aquifer since the summer of 2013, and by compiling previously measured data, the intensity of Zurich's subsurface UHI is examined. This is done with respect to its special hydrogeology, which is dominated by large-scale infiltrations from the rivers Limmat and Sihl. These generate seasonal temperature variations in the groundwater, with increasing amplitudes in the vicinity of the rivers. The seasonal groundwater temperature changes in the Limmat valley are assessed by complementing measurements from summer and winter.

The measurements reveal that groundwater temperatures in Zurich are generally high. Across the Limmat valley, values of beyond 13°C are regionally observed, which is around 4 K higher than annual surface air temperature and around 3 K higher than groundwater temperature in the rural surrounding. Though, urbanization is interpreted as a secondary factor (1-1.5K), as the river infiltration naturally causes high groundwater temperatures in the Limmat valley. In the permeable gravel, the temperature-depth-profiles measured in city wells often show little fluctuation. This may be due to horizontal and vertical mixing of the groundwater, and reflects the dominant role of advective heat transport. However, this is different at locations where hydraulic conductivity is small, and accordingly groundwater flow velocity is only minor. We find increasing temperatures towards the ground surface, showing that here heat is accumulated. This leads to maximum groundwater temperatures of 27°C at certain wells. These observations point out that there is a strong coherence between hydrogeological parameters and subsurface temperature in Zurich.