Geophysical Research Abstracts
Vol. 19, EGU2017-18678, 2017
EGU General Assembly 2017

Long-term trends and spatial variability of shallow groundwater temperatures beneath Bratislava

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Shallow groundwater temperatures are closely linked to surface temperatures. In recent years several studies have shown that the effects from atmospheric warming can be observed in rural groundwater temperature measurements. However, urban groundwater temperatures are different. Especially shallow aquifers show temperatures that change with the evolution of a city. Temperatures are locally variable and regionally higher when compared to undisturbed rural environments. For several cities, particularly in cold and temperate climate zones, pronounced subsurface urban heat islands have been reported with groundwater temperatures that are increased by several degrees compared to their rural surrounding. Heat release from basements and other urban infrastructure has been identified as a major heat source, superposing the effects from atmospheric warming. A major challenge still is to distinguish between the anthropogenic urban effects and the influence from climate change.
In our study, we focus on the conditions in the city of Bratislava in Slovakia, where productive aquifers are hosted by the sediments in the Danube river valley. At selected wells, long-term groundwater temperature measurements have been recorded since the year 2002. These temperature time series are measured in shallow depth and therefore show substantial seasonal variations. Each temperature time series is compared to satellite-derived land surface temperature trends, and a clear correlation is found that supports the strong coupling between atmospheric, land surface and groundwater temperatures. Additionally, it is now possible to analyze the main differences between these two temperature trends for all selected wells and relate them to location specific cases of urban infrastructure that influence groundwater temperatures but not land surface temperatures.