Quantification of the Urban Heat Island effect using paired station data in the Middle East and North Africa region

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The urban heat island (UHI) is a well-known effect where the temperature is higher in a city compared to a rural area, defined as the temperature difference between an urban and a rural location. This is a challenging phenomenon because it exacerbates the heat stress on human health in addition to the on-going global warming. It is therefore important to understand temporal changes in the UHI effect in a warming climate. To examine the UHI effect intensity and variability, we use 40 years (1980-2019) of observational data (daily maximum, minimum, and mean temperature) from the Global Summary of the Day (GSOD), consisting of about 1000 stations of varying temporal extend, spanning the Middle East and North Africa (MENA) region where a faster warming rate has occurred than the other regions globally.

The challenge in using data with such spatial and temporal extend is the need to allow for heterogeneities between each of the two stations used to define an urban-rural pair. For instance, one has to allow for the distance between the pair, elevation differences, spatial changes in urbanization as well as the distance from the coast. Here a new method is proposed based on flexible statistical methods (Generalized Additive Models –GAMs) to quantify the temporal trend in the UHI effect while allowing for the aforementioned characteristics using regression splines of appropriately defined variables.

A composition of high-resolution satellite geospatial information related to urbanisation properties and population data was utilized from the Global Human Settlement (GHSL-SMOD), in order to characterise the stations in terms of their urbanization type. This was also used to quantify changes in the extend of urbanisation in an area surrounding the rural stations. Results indicate a consistently upward trend of the UHI effect, particularly at night time (Tmin), across all four seasons.