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Floristic mapping as new proxy for the long-term urban heat island in Hamburg and comparison with annual characteristics of surface temperature

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The urban heat island (UHI) is still the most intensively studied feature in urban climatology. However, there is a certain restriction to provide data with spatial high resolution and long temporal coverage. Mobile platforms are costly to operate and therefore limited to a manageable number of occasions, although even literally the term urban climate suggests statistical considerations of longer periods. On the other hand, station measurements are very limited in spatial coverage and therefore not applicable to analyse spatial patterns and variations in temperature, which is critical in respect of adaption strategies against heat waves. Available measurements in Hamburg are further restricted in terms of quality and homogeneity.

Therefore, we tested a floristic mapping on a kilometre scale as a new proxy dataset for the long-term urban heat island. The basic assumption was that the species composition in a certain area yields information about the environmental and climatic (i.e. air temperature) conditions over a certain period. Several parameters (e.g. the percentage of thermophilic plant species) were derived from Ellenberg indicator values for temperature (EIT) of spontaneous vascular plant species. These parameters showed an almost radial pattern from the city centre which is in good agreement with conceptional heat island models. Further, the proxy data showed a high accordance with the available station data and significantly higher values for dense morphological structures with a high degree of soil sealing.

Although data from a floristic gradient certainly contains further factors, the results are promising for characterisation of long-term inner-urban temperature differences. Therefore, the pattern was used to compare different surface parameters, which are related to the UHI in the relevant literature. While the normalised difference vegetation index (NDVI) from Landsat data was best correlated with the pattern, parameters related to the urban morphology (e.g. building density or floor spacing) performed worse. Nightime city light data showed to be too smooth, while population density was too specific on a kilometre scale. Special attention was drawn to remotely sensed surface temperatures. While a single scene is only a snapshot at acquisition time, the cyclic variation in surface temperatures is controlled by thermal surface properties like the heat capacity. Therefore, an annual cycle of surface temperature was fitted to different Landsat scenes and two parameters (mean annual surface temperature MAST and yearly amplitude of surface temperature YAST) were extracted. Especially YAST shows a strong correlation with the derived heat island pattern. Furthermore, different local climate zones (local-scale regions of relatively homogeneous air temperature in the canopy layer) show different annual surface temperature parameters, which hence can be used for their classification.