Using Urban Climate Modelling to Support Climate Change Adaptation in Small- to Medium-sized Cities in Austria

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Introduction

Cities are particularly vulnerable to increasing temperatures from climate change because of the Urban Heat Island (UHI) effect (Oke, 1967). Increased temperatures in cities result from higher amounts of paved surfaces, a lack of vegetation and the concentration of urban structures. The UHI affects human health and well-being, and heat waves in urban areas have contributed to loss of life. For example, the heat wave in 2003 resulted in 30,000 deaths across Europe while mortality rates are predicted to increase in the future (UNEP, 2004 and Forzieri et al., 2017). Moreover, a recent study has found that if global temperatures increase by 4°C, a new super heatwave of 55°C may regularly impact many parts of the world, including Europe (Russo, et al. 2017). There are other negative effects of urban climate related to increasing air pollution and in the general reduction of thermal comfort (Harlan and Ruddell, 2011). The IPCC future climate scenarios indicate higher frequency and duration of heat waves in the coming decades, which will further increase health risk (Revi et al., 2014).

Large cities like Vienna have already investigated the UHI effect and developed climate change mitigation and adaptation strategies. However, there has been little work undertaken in small- to medium-sized cities in Austria, which are also affected by heat waves in the summer. Moreover, with increasing urbanization, urban planners in small- to medium-sized cities need solutions for mitigating the effects of UHI as their cities grow or change in the future. Hence, the overall aim of the ADAPT-UHI project is to support urban planners in decision making through the provision of climate services that can guide the development of strategies and action plans for climate change adaptation and mitigation. Three pilot cities are involved in the project: Mödling, Klagenfurt and Salzburg.

Methodology

The main methodology in the project involves the use of an urban climate model to simulate a range of current and future climate scenarios for each city. The model used in this project is called MUKLIMO_3 and has been developed by the German Meteorological Service. The model requires detailed information on the land cover and land use, the building geometry, the elevation, vegetated surfaces, tree heights, paved surfaces and other climate relevant information such as the green roof potential. Working closely with each of the three pilot cities, we collected the city-specific information needed to run the urban climate model. The models were then set up and calibrated by comparing the model results with available observations at nearby monitoring weather stations. To produce future scenarios, regional climate model data were downscaled using the EURO-CORDEX data as model inputs. The scenarios show climate indices related to extreme heat load, e.g., the number of summer days when the maximum temperature is equal to or exceeds 25 degrees Celsius. The climate indices in the present time period are then compared to scenarios in the future for 2021-2050 and 2071-2100 to see where the hotspots of increased number of summer days are located in the city. These are provided for two IPCC scenarios (RCP 4.5 and RCP 8.5) that consider different combinations of economic, technological, demographic and policy futures. There are two other components to the project: (i) the development of an Austrian-wide UHI risk index at a 1 km resolution and (ii) the development of green/blue quality maps for each of the pilot cities. The risk index involves combining data on thermal comfort with other variables such as populations at risk. The green/blue quality maps represent an inventory of green and blue areas in the city, including cooling and shadowing effects, which can be used as inputs to urban planning.

Results

The results from the urban climate model for Mödling, Klagenfurt and Salzburg were presented at meetings with the pilot cities. These results were based on a number of 'standard' adaptation scenarios that included decreasing the amount of impervious surfaces in the city, changing the vegetation, e.g. increasing the number of trees, adding new green areas, and modifications to buildings, e.g. adding green roofs, and increasing albedo of paved areas. Results for these scenarios were provided both as individual adaptation scenarios and as a combined scenario to show the effectiveness of each one in terms of decreasing the number of summer days as well as where these effects are visible within the city. These 'standard' scenarios were then modified to reflect more realistic city-specific urban planning, e.g., the addition of future urban developments to these scenarios such as new residential areas that are planned but have not yet been built, to aid in the development of climate adaptation and mitigation strategies. Results from the ongoing Austrian-wide UHI risk index analysis and the green/blue quality maps for each pilot city will also be shown where available.

Discussion

The results from the simulations carried out with the different future scenarios indicate a clear trend. There will be more urban heat islands, both in city centers and in sparsely populated areas of the city. Further construction and additional sealing of surfaces will aggravate this problem. However, the simulations have also shown that even small-scale adaptation measures can lead to climate improvements on a local level. The main challenge now is to show the advantages of these approaches to the representatives who are in charge of the cities.

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