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Regional modeling of urban climate: the impact of physical process representation

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The urban heat island (UHI) is a relatively old concept and has been widely studied using both observational and modeling approaches. However, urban canopies impact the meteorological conditions in the planetary boundary layer (PBL) and above in many other ways, e.g. urban breeze circulation can form, enhanced drag causes intensification of the turbulent diffusion leading to elevated PBL height, reduced evaporation results in decreased absolute humidity, changes in cloudiness etc.

A well established regional model representation of these phenomena is crucial for both mitigation and adaptation in areas affected by intense urbanization and climate change. There are however large uncertainties how the underlying physical processes are represented in numerical models, i.e. what models are used along with which parameterizations and parameters.

Here we perform a regional multi-model analysis over central Europe using the Regional Climate Model (RegCM4) and Weather Research and Forecast (WRF) regional models with different configurations representing different PBL treatment, convection parameterization, surface layer physics, microphysics and urban canopy models. Model results are extensively compared to surface measurements as well as satellite observation of surface temperatures. We analyse the model results mainly in terms of the urban-rural contrast which is a measure of the difference between the urban core value and the vicinity (with respect to the particular city) for selected meteorological parameters. Our results show substantial impact of the choice of the model as well as the choice of parameterization on the intensity of UHI and other meteorological effects. The urban-rural difference of PBL height and average wind speed between urban areas and their vicinity is affected the most, controlled by the boundary layer physics parameterization.

Our simulations confirm the large uncertainty in how models resolve the meteorological features specific to urbanized areas and this has to be taken into account when designing different strategies for urban planning and multimodel approaches should be preferred.