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Urban modelling for Budapest using the Weather Research and Forecasting model

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The population of Earth is continuously growing, and due to urbanisation it is quite concentrated in metropolitan areas. Overall, cities cover almost 2% of the global surface causing several environmental and social issues. These artificial surface covers significantly modify the surface energy exchange processes through modification of naturally covered lands resulting in altered local wind and temperature patterns because of the presence of buildings. The architectures' three-dimensional extensions certainly affect the incoming radiation, the sky-view factors as well, as the 3D wind fields, resulting in specific local microclimate at each metropolitan area. The increased temperature in the central built-up areas and the cooler surrounding of the cities lead to the urban heat island phenomenon, which is widely studied both with observations and numerical models. The Weather Research and Forecasting (WRF) mesoscale model coupled to multilayer urban canopy parameterisation is used to investigate this phenomenon for Budapest and its surroundings. Before starting the simulations, the detailed surface has to be set up according to the actual conditions, for which CORINE and OpenStreetMap databases are used, both including buildings, different land use categories, and waterbodies. The new land use distribution serving as input for WRF runs distinguishes three urban categories: (i) low-intensity residential, (ii) high-intensity residential, and (iii) commercial/industrial. For the simulations the initial meteorological fields are derived from the publicly available GFS (Global Forecast System) outputs. Simulations are completed for one-week-long periods in summer and winter in 2015, for which we selected periods with the atmospheric conditions of weak wind and clear sky. In order to keep the stability of the simulations, the entire downscaling is carried out in several steps using gradually smaller domains embedded to each other. Thus, three embedded target areas have been determined for this modelling study, the 15 000 km^2 large external area covers the whole Pannonian region with 10 km horizontal resolution, whereas the 7200 km^2 large innermost domain covers Budapest and its surroundings with 1 km grid resolution. The calculated skin temperature over Budapest is compared to remotely sensed measurements derived from satellites Aqua and Terra in order to estimate the temporal and spatial bias values, which later can be used to improve the WRF model and the essential settings to describe the urban environment in case of the Budapest agglomeration area with even finer resolution than used here.