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Comparison of heat mitigation effects of blue roofs and green roofs on building wall temperature and thermal outdoor comfort based on scenario analyses using 3D microclimate modelling for a dense urban district

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Heat stress is a major challenge in urban areas, especially in cities which are affected by the urban heat island effect. Adaptation measures are a key strategy to mitigate future heat and health consequences in the context of climate change. To improve both indoor and outdoor microclimatic conditions and thermal comfort, nature-based solutions like roof greenings or wet roofs are implemented as they do not require additional space in dense urban environments. However, cooling effects of evaporation- and transpiration-based adaptation measures are limited by water availability to enable latent heat flux and reduce sensible and wall heat flux during extreme prolonged heat events. Water storage systems like rainfed cisterns can supply water for roof greenings or wet roofs during hot periods, but also store storm water to reduce flooding risks. While individual green roofs or blue roofs only show small local cooling potentials in their direct surrounding of their installation, scaling such measures for a larger proportion of buildings can cause significant cooling effects for the entire air volume of a city. This research aims to simulate heat mitigation effects of blue and green roofs on building wall temperature and thermal outdoor comfort using the physically-based microclimate model ENVI-met. A 16-ha 3D gridded model domain of a dense urban district in the city of Cologne/Germany was parameterized using remote sensing data and field observations. The model is validated based on a quality-controlled, densely-distributed microclimate measurement network with 59 sensors which was setup in the study area. A new model parameterization for wet roofs was developed. Scenario analyses are performed to scale these measures up to an implementation on all 338 buildings in the model domain (100%). Statistically significant average cooling effects of -0.52 K and up to -2.67 K on air temperature and -3.85 K and up to -29.03 K on building roof wall temperature were found for blue roofs in relation to the reference run of the status-quo. For roof greenings, average cooling effects of -0.76 K and up to -3.01 K for air temperature and -12.82 K and up to -39.45 K for wall temperature were determined. Cooling effects of green roofs on outdoor air temperature are strongest during daytime, and for wet roofs strongest in the evenings. Green roofs also have a higher wall cooling potential than blue roofs during daytime. However, roof greenings only show small effects on wall temperatures during nighttime, while blue roofs slightly heat up walls in nighttime. In future research, climate change adaptation and heat mitigation potentials of

combining blue and green roofs with other nature-based and technical solutions in the street canyons will be analysed.