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Effects of urban planning measures on regional air quality in a central European city – A WRF-Chem modelling study

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In 2050 the global fraction of urban population will increase to over 69%, which means that around 6.3 billion people are expected to be living in urban areas. Cities are the predominant places for human settlement, thus becoming more vulnerable to extreme weather events aggravating phenomena like heat stress and air pollution. Finding mitigation strategies to counteract future air quality related problems and ways to sustain development is of great importance. The Urban Heat Island (UHI) describes the tendency for an urbanized area, because of its radiative and geometrical features, to remain warmer than its rural surroundings and thereby generating its own microclimate. UHI's raise the energy demands of air conditioning during summer periods and with power plants relying on fossil fuels, air pollutants and greenhouse gas emissions are increasing. Primary pollutants, including SO_2, NO_x, PM and CO, contribute to complex air quality problems such as ground level ozone (SMOG), fine PM or acid rain.

In this study, the mesoscale numerical model WRF-Chem is used on a regional scale to investigate the effect and the potential of urban planning measures to mitigate air quality problems caused by the Urban Heat Island.

For this reason, a multi-layer urban canopy model is coupled to WRF and applied for the city of Stuttgart, to conduct high resolution modelling runs for different urban planning scenarios. Furthermore, the chemical part WRF-Chem is used to assess the effect of these scenarios on air quality. The urban area of Stuttgart is situated in complex terrain, with a caldera-like area that increases the risk of high air pollution and heat stress, especially during periods of weak winds and reduced circulation, which reinforces the formation of strong inversion layers.

Through GIS-based manipulation of land use data or transformation of surface parameters in the urban canopy model, the effect of high reflective surfaces or urban greening on air temperature, urban heat island and air quality is investigated. To account for an extreme scenario, the period of the European Heat Wave in July and August 2003 is chosen for the modelling. According to the Intergovernmental Panel on Climate Change (IPCC), these periods are more likely to occur in the future, thus becoming a challenge for urban planning.

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