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Impact of different urban structures on the microclimate in the city of Dresden, Germany

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Heat island intensity of cities and, therefore, urban warming mainly depends on the density of urban structures and sealing of urban areas. Against the background of a probable increase of summer temperature in Central Europe, actual urban planning strategies should consider the importance of open areas and vegetation in the centre of cities for the urban microclimate. This study deals with the interaction between open areas and vegetation structures in the urban micro climate of Dresden. Investigations are embedded in the project "city nature and open area structures under climate change" of the German Federal Agency for Nature Conservation which aims to demonstrate impacts of different urban structures based on climatic factors and to identify their capability for adaptation.

Main topic of this research is the determination of the capabilities of given and potentially vegetated areas and open areas in the inner city of Dresden to attenuate microclimatic extremes. The diversity of impacts of vegetated and open areas on the urban microclimate is presented by mobile bicycle measurements and model simulations. Simulations were carried out with the coupled vegetation-boundary layer model HIRVAC-2D and the three-dimensional microclimate model ENVI-met. Model output was compared to measurements of air temperature and air humidity on sunny days in the year 2009 to quantify cooling effects of vegetated areas for summer heat periods.

ENVI-met is designed to simulate the surface-plant-atmosphere interactions in urban environment and allows the derivation of bioclimatic factors like Predicted Mean Vote (PMV) for different urban structures. PMV describes the thermal perception of a human body which can result in cold or heat stress. Simulations with ENVI-met were carried out to define the cooling effects of urban areas and to estimate microclimate effects on humans.

HIRVAC quantifies the interactions of urban structures with the atmospheric boundary layer depending on area and volume density of vegetation considering the weighted urban surface types in the investigated area (e.g. grass covered areas, forested and sealed surfaces). Model results of HIRVAC were used to derive an easy manageable analytic function which shows the interactions between urban structure parameters and microclimatic quantities.

Interactions of different urban structures and microclimate were determined by temperature differences to a reference area and by the distribution of PMV. Model output of temperature and PMV showed clearly the effects of vegetated areas in Dresden and therewith the impact to the thermal environment of humans. For example, the largest park of the city indicated a temperature drop of about 4°C compared to the surrounding with less vegetation. PMV inside the park showed distinct lower values (pleasant thermal environment for humans) compared to the sealed areas in the vicinity. The measurement campaign confirms the model results and verifies the cooling effects of vegetated areas.