USING WRF-CHEM WITH HIGH RESOLUTION EMISSION DATA TO MODEL THE EFFECT OF URBAN HEAT ISLAND MITIGATION STRATEGIES ON URBAN AIR QUALITY

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Summary

In 2050 the global fraction of urban population will increase to over 69%, which means that around 6.3 billion people are expected to live in urban areas. Cities are the predominant places for human beings to settle down, thus becoming more vulnerable to extreme weather events aggravating phenomena like heat stress and decreasing air quality. Finding mitigation strategies to counteract future air quality related problems and ways to sustain development is of great importance. In this study, the mesoscale numerical model WRF-Chem is used on regional scale to investigate the effect and the potential of urban planning strategies to mitigate air quality problems caused by the Urban Heat Island (UHI).

Introduction

UHI describes the tendency for an urbanized area, because of its radiative and geometrical features, to remain warmer than its rural surroundings and thus generating its own microclimate (Oke 1982). Additional heat generated by fuel combustion, air conditioning or other human activities as well as roughness effects caused by building structures, help to 'design' specific atmospheric dynamics resulting in modified urban rural circulation patterns (Arnfield 2003). UHI's raise demands of energy for air conditioning during summer periods and with power plants relying on fossil fuels, air pollutants and greenhouse gas emissions are increasing. Primary pollutants include SO2, NOx, PM or CO, which contribute to complex air quality problems such as ground level ozone (SMOG), fine PM or acid rain.

Methodology and Results

Time period August 11-18 2003 is used for the modelling. coupled to a land surface model (Noah LSM) and results compared with observation data. A sensitivity study reveals the highest R^2 = 0.72 (2m T_{pot}) for the multi-layer BEP approach, in turn used for further proceedings. By changing the land use characteristics, different scenario runs can be executed implying certain mitigation strategies. 4 case studies are presented: increasing of the albedo (Albedo; 0.7), decreasing of building density (Density; 20%) and replacing of urban land use by natural vegetation (Big Park/ Many Parks). Each scenario has an impact on UHI intensity, thus affecting the local surface- atmosphere exchange processes, as well as air quality. The albedo case offers the greatest potential with a decrease of urban-rural temperature difference of 1.7 °C (Tab. 1). Same scenario runs are executed with WRF-Chem, using 7km resolution emission inventory as chemical input data for a 3km resolution WRF-simulation. Correlation of modelling data (O3) with average of 5 observations for the time period reveal an R^2= 0.72. Figure 1 shows a snapshot for difference of O3 concentration between the urban base case (BEP) and the scenario case 'Big Park', for Aug 13 2003, 6pm. The decrease of urban surface ozone of up to 8 ppb accounts for approx. 10% reduction (82.9 ppb O3).

Scenario	Albedo	Density	Many Parks	Big Park	Real Case
Θ urban [°C]	31.5	32.4	32.5	32.3	33.1
Θ max [°C]	31.9	33	33.5	33.3	34.3
Std dev. [°C]	0.32	0.48	0.5	0.43	0.6
UHI; delta Θ	0.84	1.32	1.47	1.19	2.52

Tab.1 Urban Heat Island Intensity expressed as difference between average 2m temperature of urban area (Aug 13th 2003 6pm UTC)

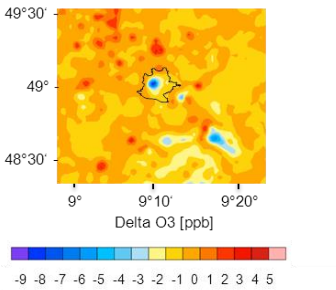

Fig 1:Difference of O3 between Base Case and 'Big Park' scenario for Aug 13 2003, 6pm

Conclusions

The results of the study reveal, that certain urban planning strategies are able to mitigate to negative effects coming along with urban heat island formation, both in cases of temperature and urban air quality. For further investigations, improving the modeling results by using 1km emission data is scheduled.

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