Geophysical Research Abstracts
Vol. 16, EGU2014-15799, 2014
EGU General Assembly 2014

On the urban land-surface impact on climate over Central Europe

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For the purpose of qualifying and quantifying the impact of cities and in general the urban surfaces on climate over central Europe, the surface parameterization in regional climate model RegCM4 has been extended with the Single Layer Urban Canopy Model (SLUCM) for urban and suburban land surface. This can be used both in dynamic scale within BATS scheme and in a more detailed SUBBATS scale to treat the surface processes on a higher resolution subgrid. A set of experiments was performed over the period of 2005-2009 over central Europe, either without considering urban surfaces and with the SLUCM treatment. Results show a statistically significant impact of urbanized surfaces on temperature (up to 1.5 K increase in summer), on the boundary layer height (ZPBL, increases up to 50 m). Urbanization further influences surface wind with a winter decrease up to -0,6 m s-1 and both increases and decreases in summer depending the location with respect to cities and daytime (changes up to 0.3 ms-1). Urban surfaces significantly reduce evaporation and thus the humidity over the surface. This impacts in our simulations the summer precipitation rate showing decrease over cities up to – 2 mm day-1. We further showed, that significant temperature increases are not limited to the urban canopy layer but spawn the whole boundary layer. Above that, a small but statistically significant temperature decrease is modeled.

The comparison with observational data showed significant improvement in modeling the monthly surface temperatures in summer and the models better describe the diurnal temperature variation reducing the afternoon and evening bias due to the UHI development, which was not captured by the model if one does not apply the urban parameterization. Sensitivity experiments were carried out as well to quantify the response of the meteorological conditions to changes in the parameters specific to the urban environment such as street width, building height, albedo of the roofs, anthropogenic heat release etc. and showed that the results are rather robust and the choice of the key SLUCM parameters impacts the results only slightly (mainly temperature, ZPBL and wind velocity).

Further, the important conclusion is that statistically significant impacts are modeled not only over large urbanized areas (cities), but the influence of cities is evident over remote rural areas as well with minor or without any urban surfaces. We show that this is the result of the combined effect of the distant influence of surrounding cities and the influence of the minor local urban surface coverage.