Impact of model resolution on urban heat island simulation

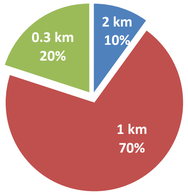
Gianluca Mussetti[1,2,3], D. Brunner[1], S. Henne[1], S. Schubert[4], J. Allegrini[2,3], J. Carmeliet[2,3]

[1] Laboratory for Air Pollution / Environmental Technology, Empa, Switzerland, [2] Laboratory for Multiscale Studies in Building Physics, Empa, Switzerland,
[3] Chair of Building Physics, ETH Zurich, Switzerland, [4] Geography Department, Humboldt University of Berlin, Germany

Introduction

- High resolution needed to resolve heterogeneity of urban surfaces, topography and their influence on heat fluxes and air flow
- Urban climate simulations are performed at various resolutions. However studies on the impact of model resolution are missing
- We performed urban climate simulations at various resolutions to analyze its influence on the UHI effect

Question: Is it worth to simulate at high resolution?



Horizontal model resolution used in 10 recent UHI studies over the last 5 years

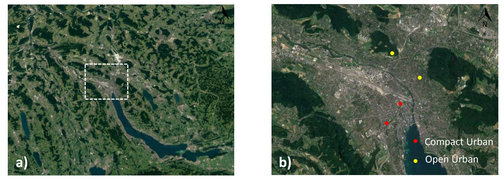
Method

The mesoscale NWP model COSMO in climate mode (CCLM) is used at various horizontal resolutions down to 250 m.

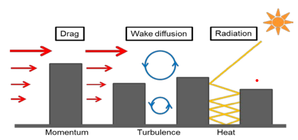
COSMO model (version 5.0)	Period	20 June – 8 July, 2015
	Horizontal resolution	1km, 500m, 250m
	Vertical resolution	76 levels
	Urban Canopy Model	Bulk (standard) DCEP (BEP type)
Input data	Boundary conditions	COSMO-2 analysis
	Urban fraction	Soil sealing 2 m res (EEA)
	Building data	LoD 1 building data (Local)
	Urban vegetation	LAI = 3, z0 = 0.1 m

CCLM is coupled to the Double Canyon Effect Parametrization (**DCEP**) model, which is a multi-layer urban canopy model based on the Building Effect Parameterization (BEP).

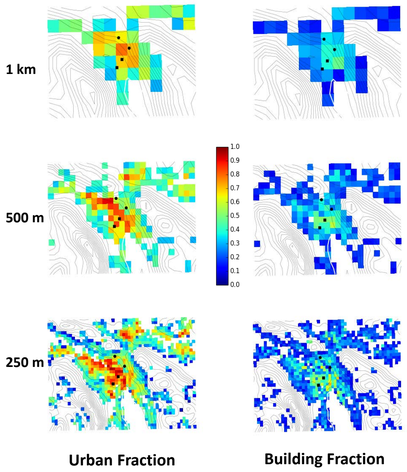
The simulations are performed for the medium-sized city of Zurich (Switzerland) for an intense heat wave event in summer 2015. The model results are evaluated using 2-m temperature (T2) data from urban surface observations.



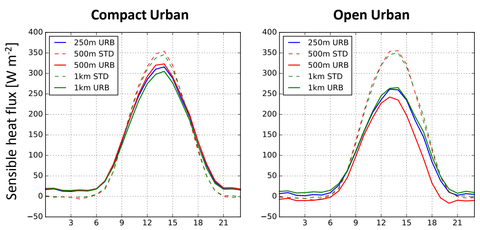
(a) Model domain and (b) details of the urban area of Zurich with the selected measuring stations.



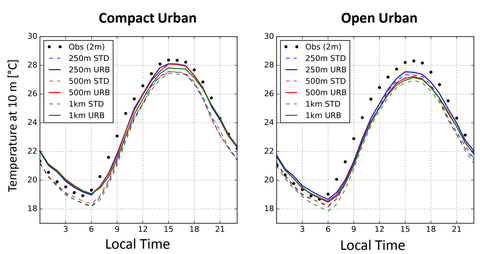
Urban canopy parameters are derived for the model domain at different resolutions.



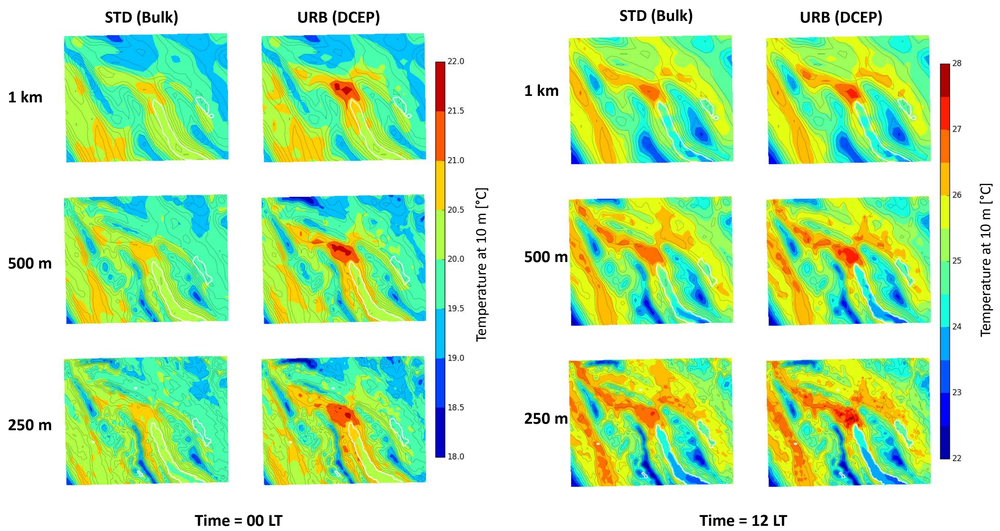
Results



Simulated average diurnal cycle of sensible heat flux at compact urban and open urban sites.



Measured and simulated average diurnal cycle of air temperature at different model resolutions at compact urban and open urban sites.



Simulated average spatial distribution of T (at 10 m) at (a) 00 local time and (b) 12 local time. Effects of DCEP urban parameterization on UHI are larger at night than during the day as expected. Effects of resolution are relatively minor.

Conclusion

- Night-time air temperature largely independent of model resolution
- Daytime air temperature shows a moderate dependence on resolution
- Intra-urban variability of air temperature better captured at high resolution
- Small-scale features related to topography and lake show up at higher resolution, UHI at outskirts more pronounced

Further information

Contact: Gianluca Mussetti, Email: gianluca.mussetti@empa.ch

We acknowledge the financial support from Empa. We thank MeteoSwiss for providing the COSMO-2 boundary conditions and the meteorological data. We thanks Hiroki Sayama from Tokyo Tech for contributing to the work and Antoine Berchet for helping with pre- and post-processing.