

Charles University
Faculty of Mathematics and Physics
Dept. of Atmospheric Physics
V Holešovičkách 2, Prague
Czech Republic

URBANIZATION IN HIGH RESOLUTION RCM – DO WE NEED IT?

Tomáš Halenka, Michal Belda, Peter Huszár, Jan Karlický, Tereza Nováková

E-mail: tomas.halenka@mff.cuni.cz



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Motivation

World:

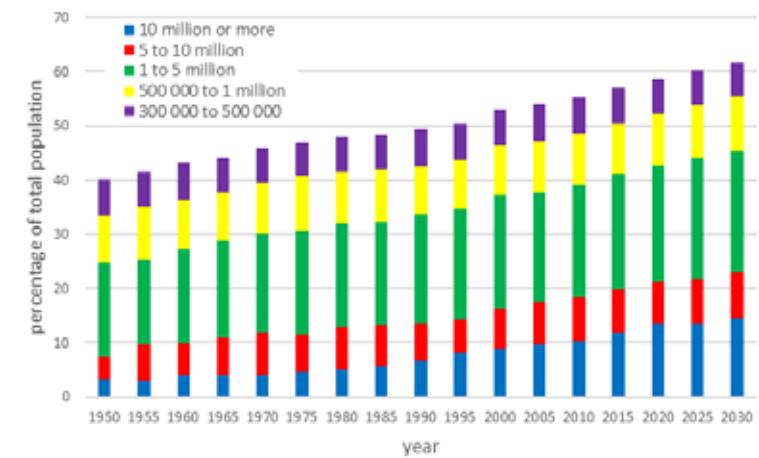
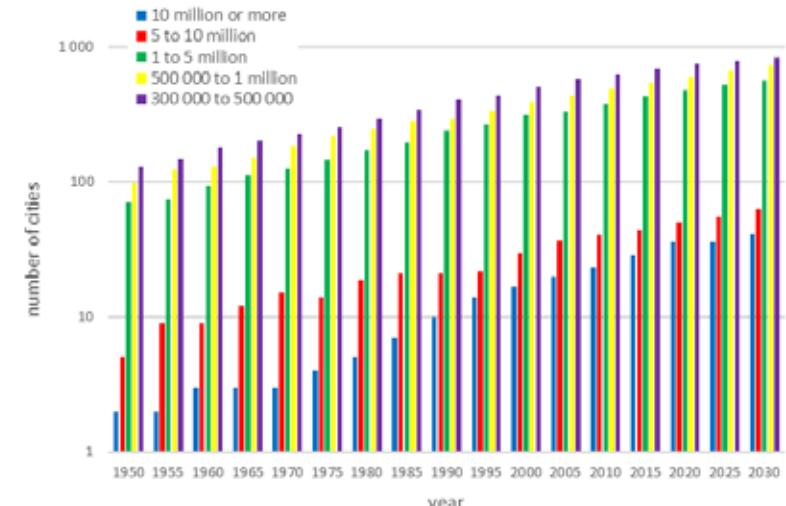
- From 2009 - more than 50% of the world's population living in cities (UN, 2009)
- less than 0.1% of the Earth's surface

Europe:

- 2008 - 73% of the population in cities
- mid 21th century - 84%, representing a rise from 531 to 582 millions (UN, 2008)

Clearly:

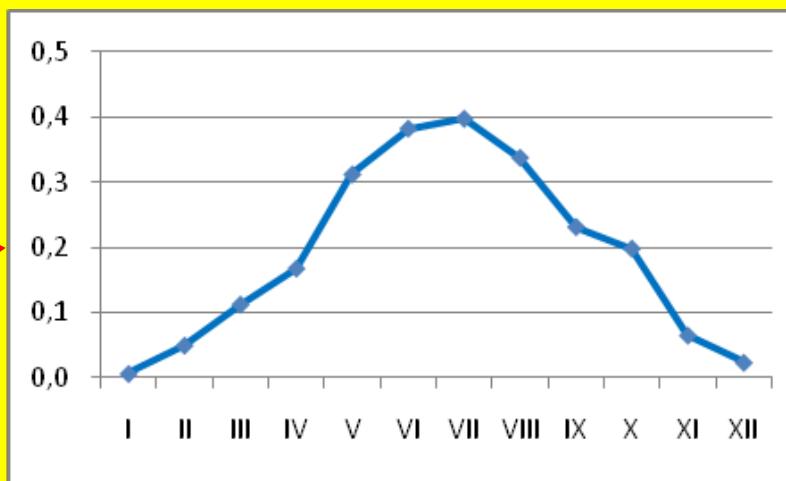
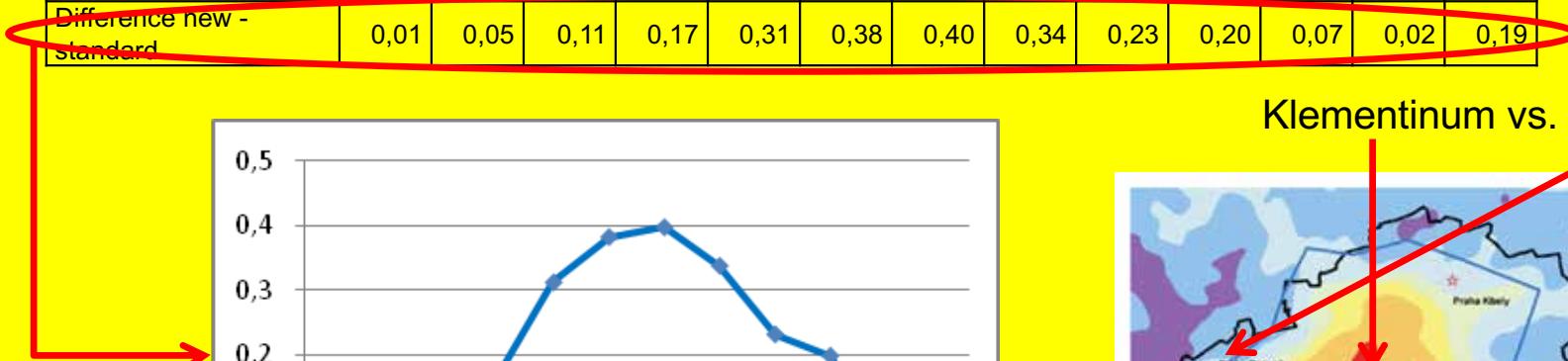
- Quite many atmospheric effects on population through the urban environment
- Especially thermal extreme weather effects like heat wave



Recent challenges in modeling of urban heat island ☆
Sustainable Cities and Society, Volume 19, 2015, 200–206
<http://dx.doi.org/10.1016/j.scs.2015.04.001>

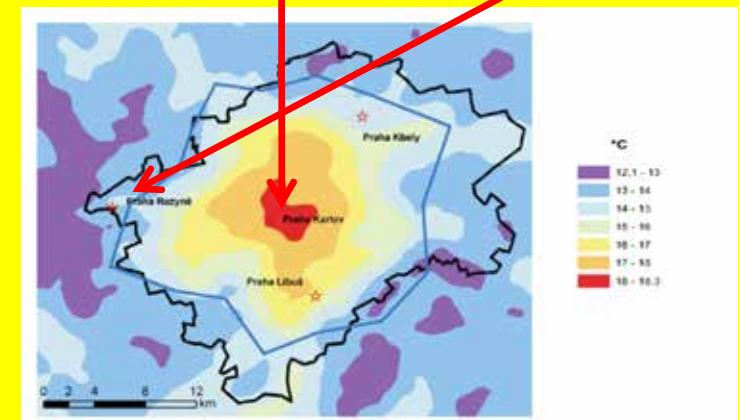
Prague heat island

period	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	YEAR
1961-2009	2,2	2,3	2,2	2,2	2,2	2,4	2,3	2,2	2,0	2,0	2,2	2,2	2,2
1961-1990	2,2	2,3	2,2	2,1	2,1	2,2	2,2	2,0	1,9	2,0	2,2	2,2	2,1
1991-2009	2,2	2,3	2,3	2,3	2,4	2,6	2,6	2,4	2,1	2,2	2,2	2,2	2,3
Difference new - Standard	0,01	0,05	0,11	0,17	0,31	0,38	0,40	0,34	0,23	0,20	0,07	0,02	0,19

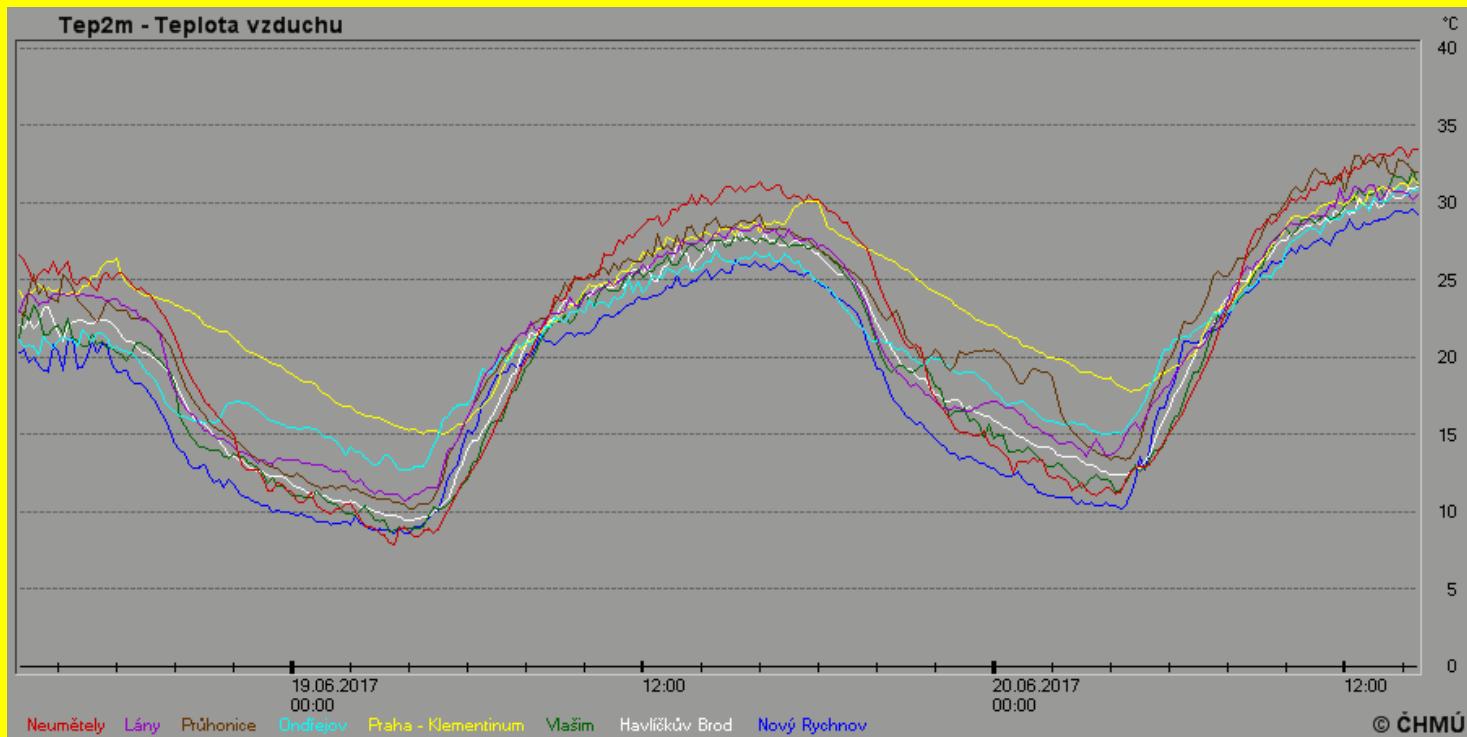


Pretel (2010)

Klementinum vs. Ruzyně



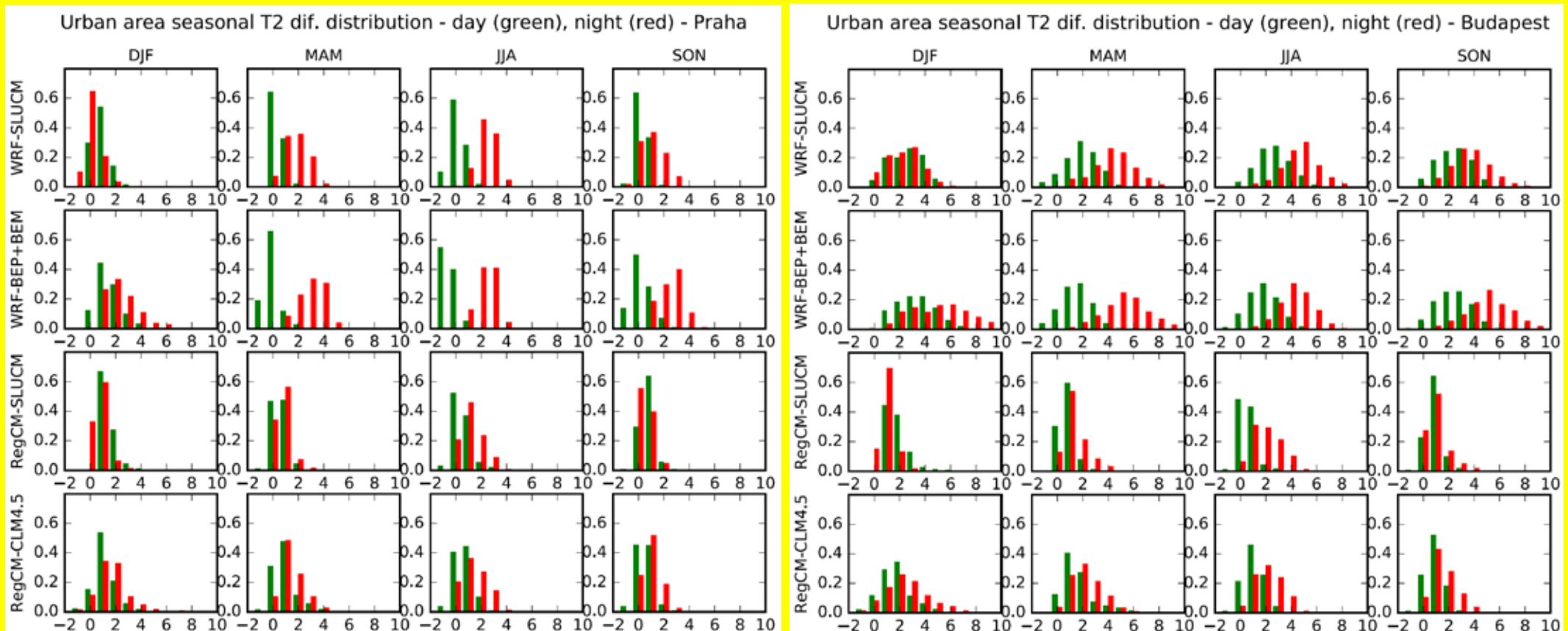
Example June 18-21, 2017



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UHI intensity Prague (day vs. night)



Karlicky et al. (ACP, 2018), you can see
our poster here as well (Halenka et al.,
No. 20, Thursday)

Project URBI PRAGENSI

- Urbanization of weather forecast
- Urbanization of air-quality forecast (connected to the above)
- Urbanization of climate change scenarios, the tool for efficiency assessment of adaptation or mitigation measures in strategic development plans
- Hot-spots simulations



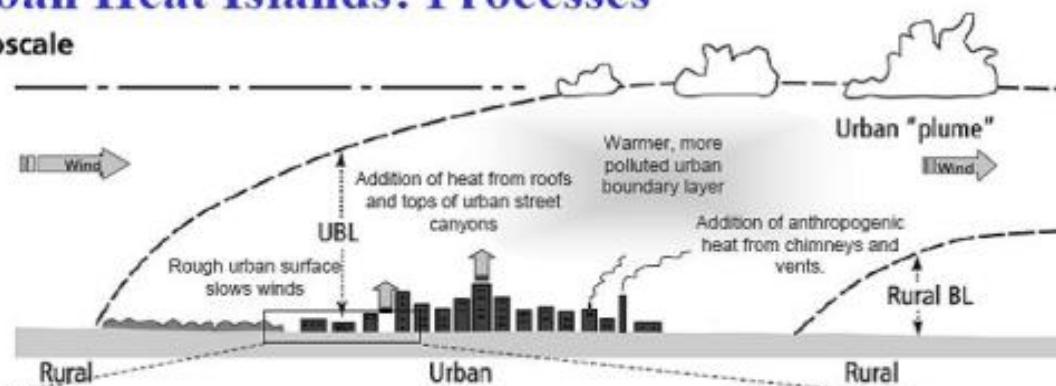
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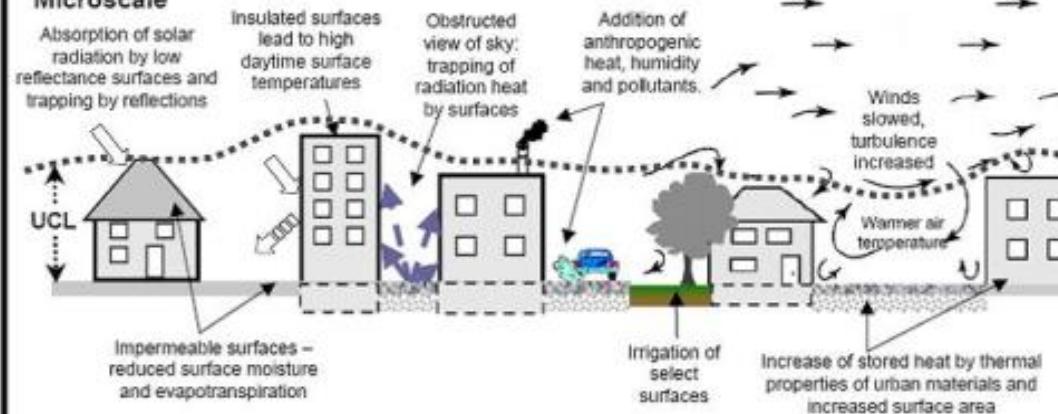
Atmospheric processes in urban canopy layer

Urban Heat Islands: Processes

Mesoscale



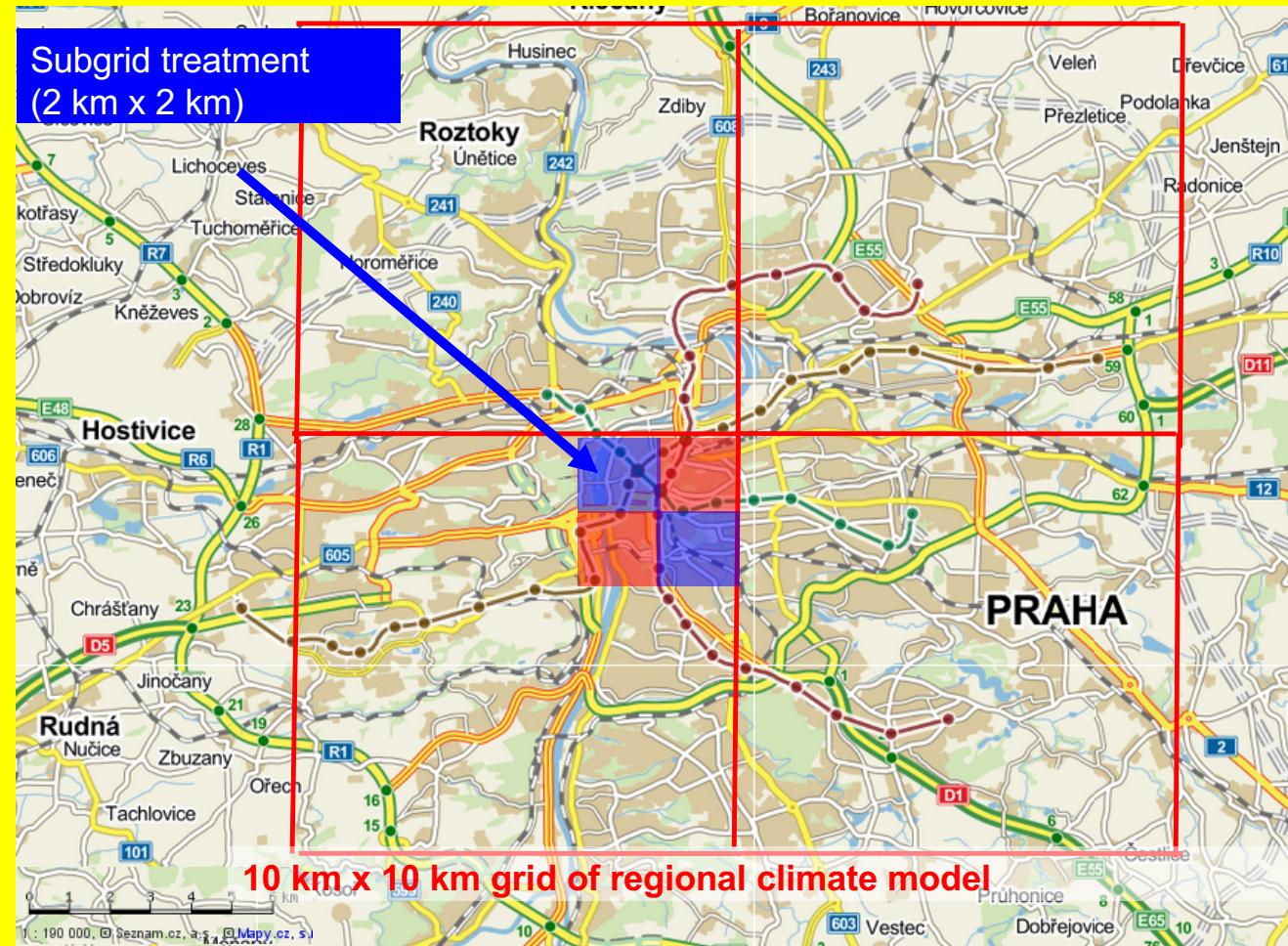
Microscale



Why urban parameterizations



Even further in very high-resolution



1 km resolution for weather and air quality forecast in URBI PRAGENSI

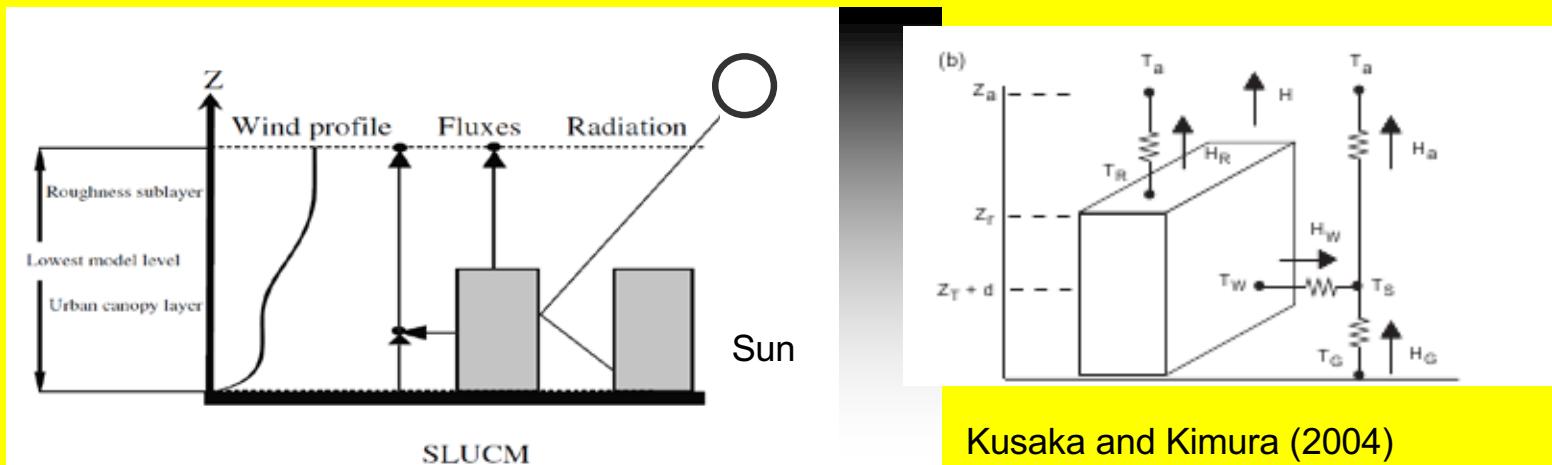
Modeling atmospheric process in urban canopy

- BULK – no special parameterization, but recognizing the land-use type (albedo, emissivity and other land surface parameterizations)
- SLUCM – single-layer urban canopy model
- MLUCM – multi-layer urban canopy model
- BEP-BEM – building environment parameterization – building energy model

Modeling atmospheric process in urban canopy

SLUCM (Single-Layer urban Canopy Model)

Kusaka et al. (2001), implementation into WRF Chen et al. (2010)

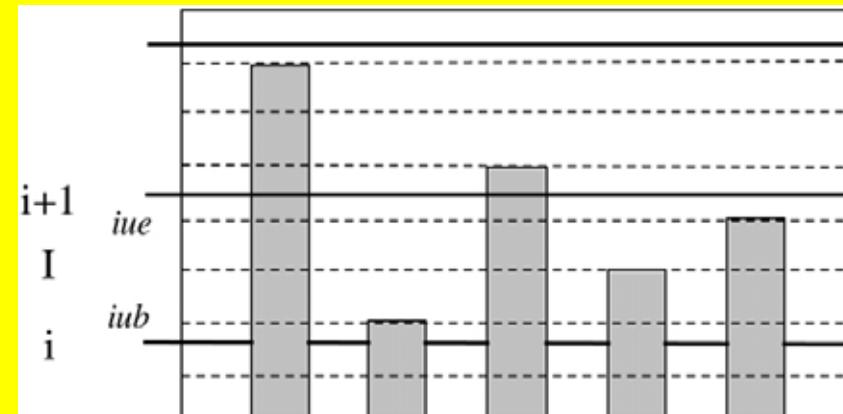


Modeling atmospheric process in urban canopy

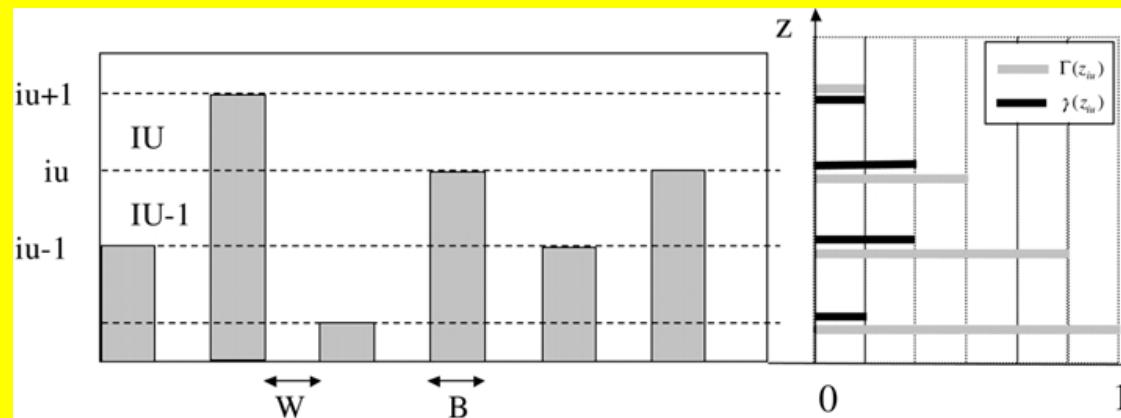
Possible urban surface parameterizations within WRF

MLUCM – fractional land-use in WRF?

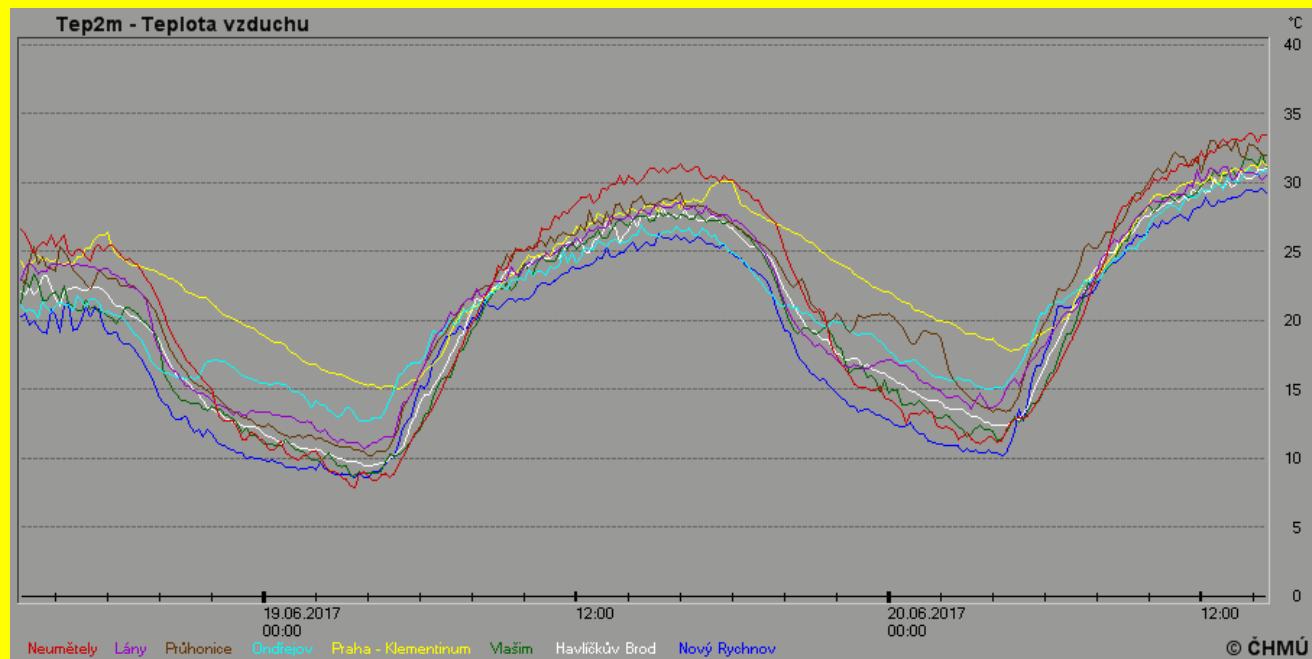
Martilli et al. (2001)
BEP-BEM in WRF



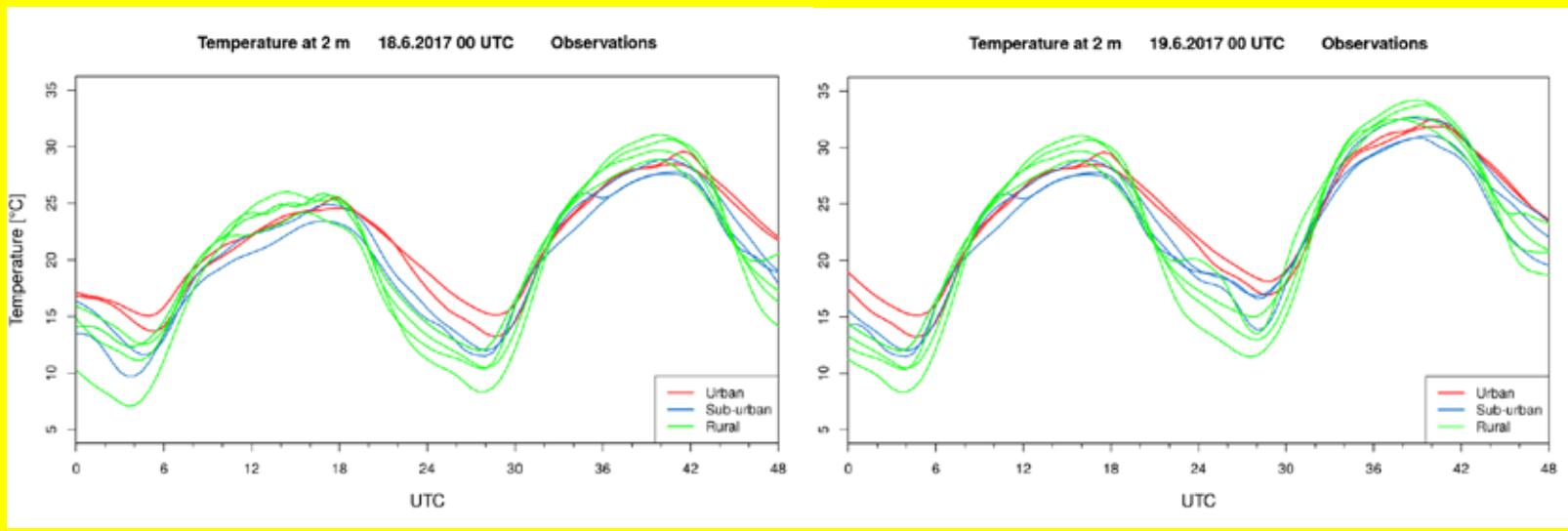
Schematic representation of the urban land unit.



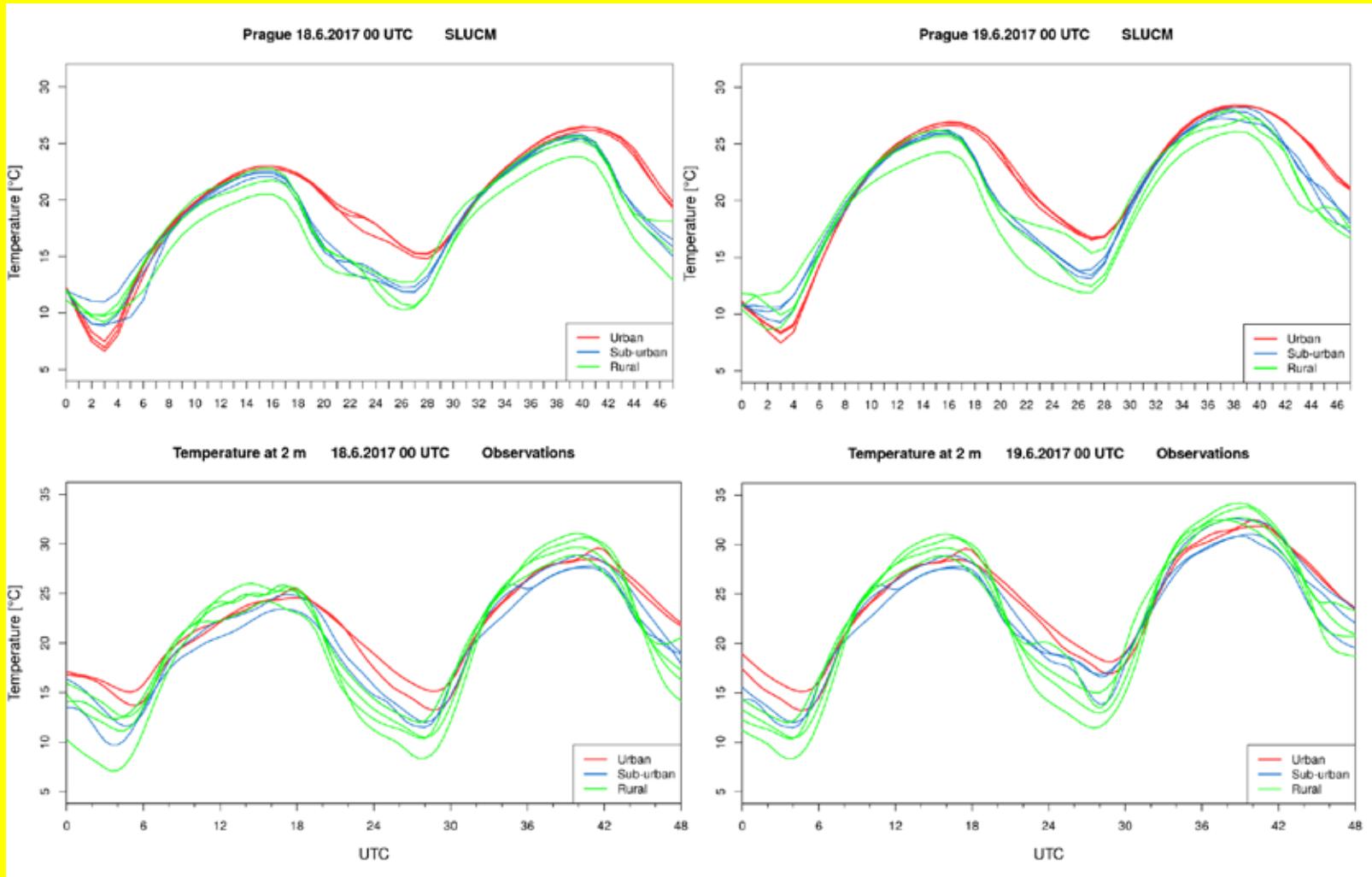
WRF forecast mode with SLUCM (3km)



WRF forecast mode with SLUCM (3km)

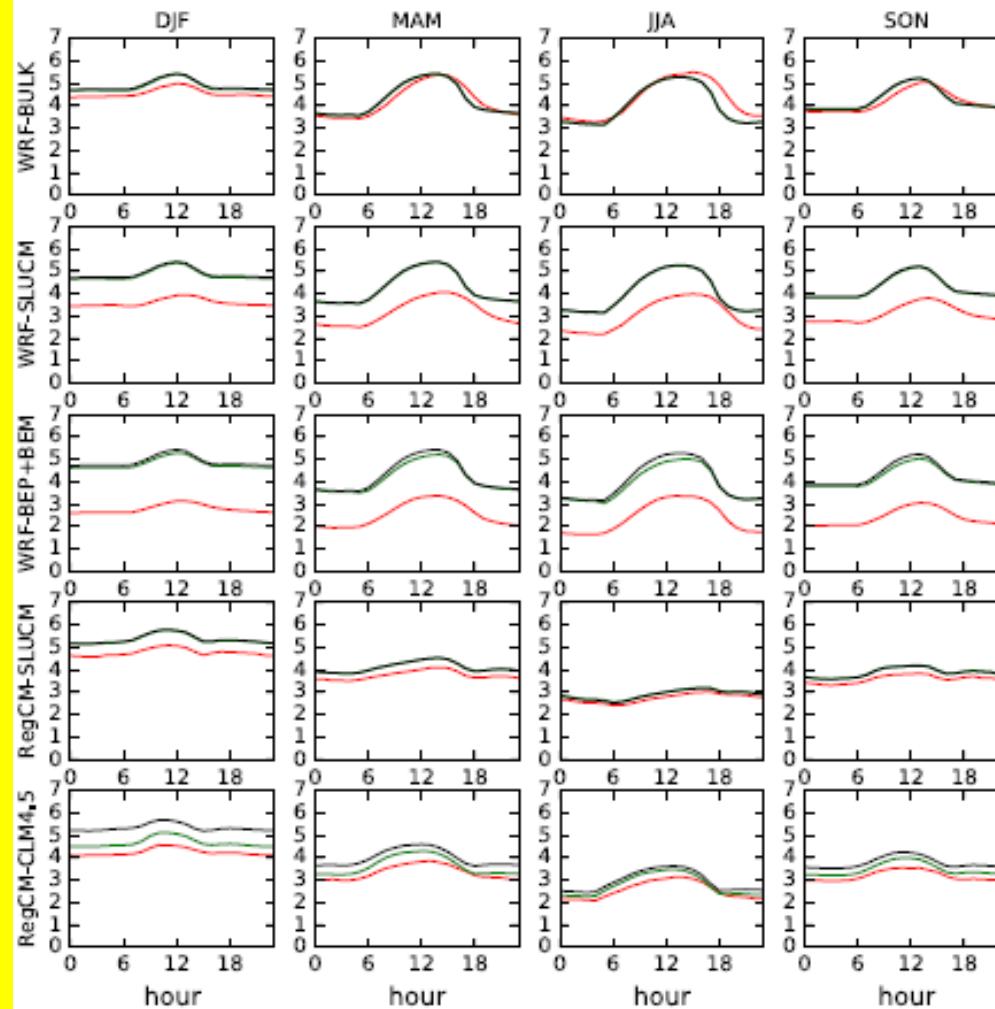


WRF forecast mode with SLUCM (3km)



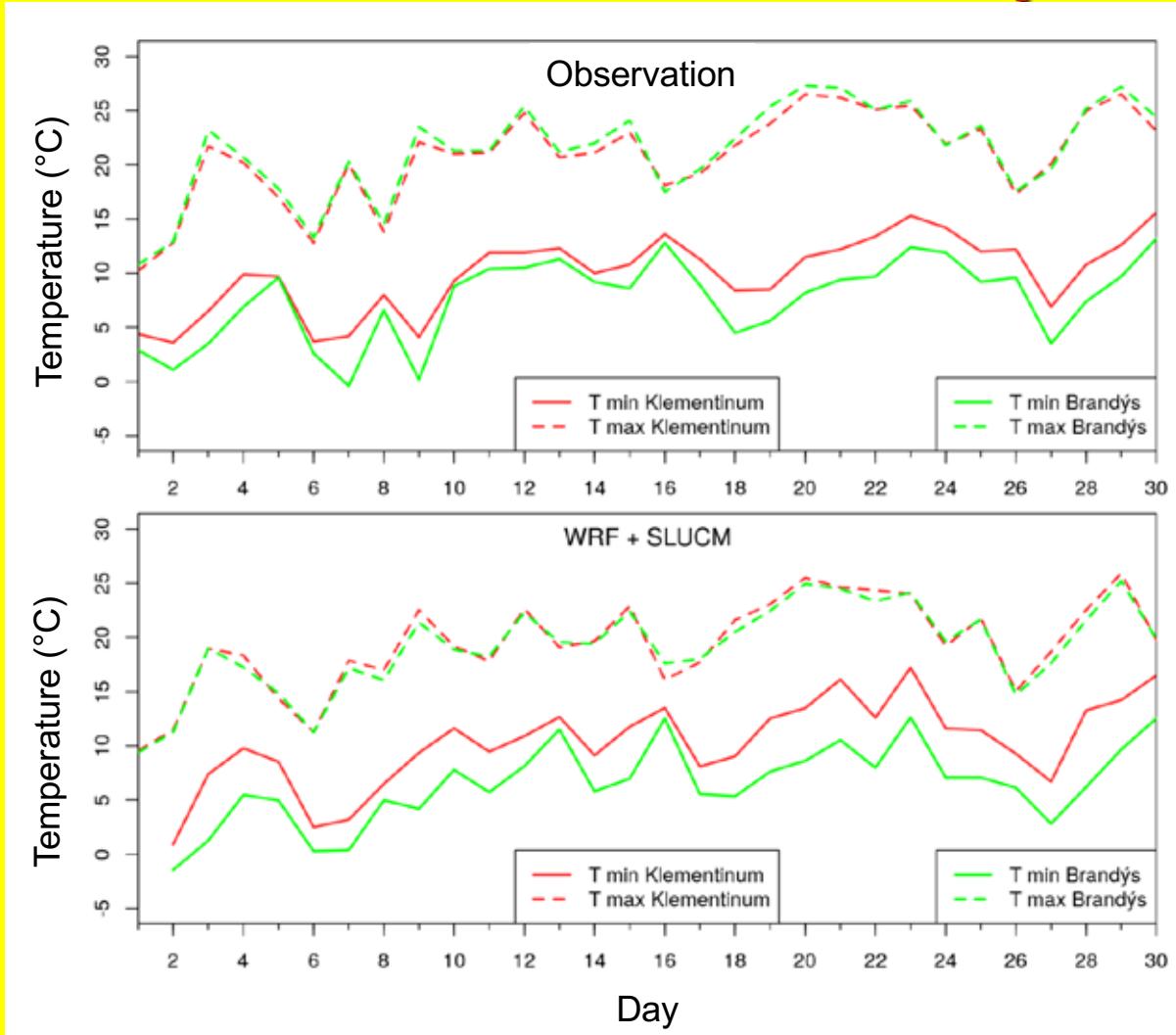
Wind

Urban area (red), near urban (green), all without urban LU (black) - Praha

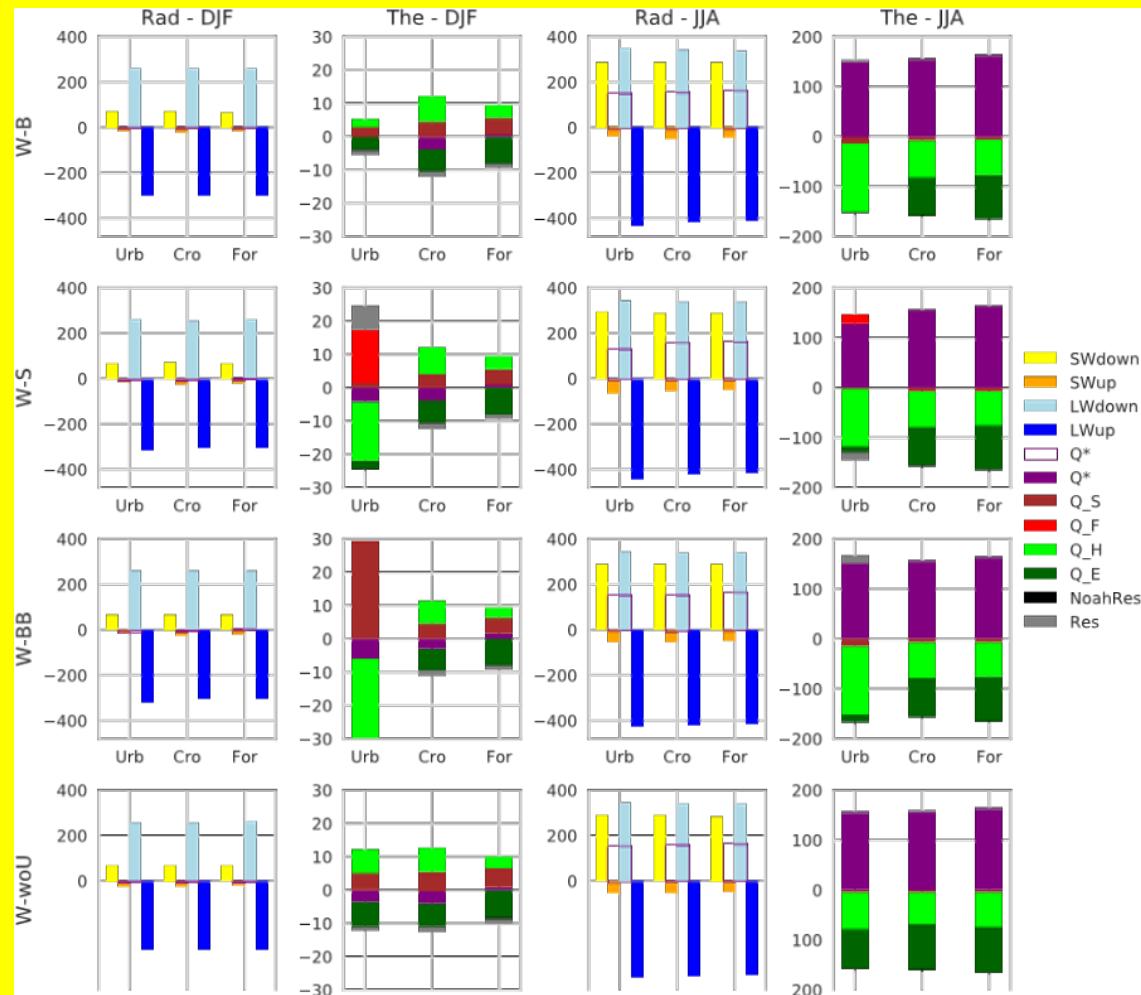


Karlicky et al. (ACP, 2018)

April 2018 – observation comparison

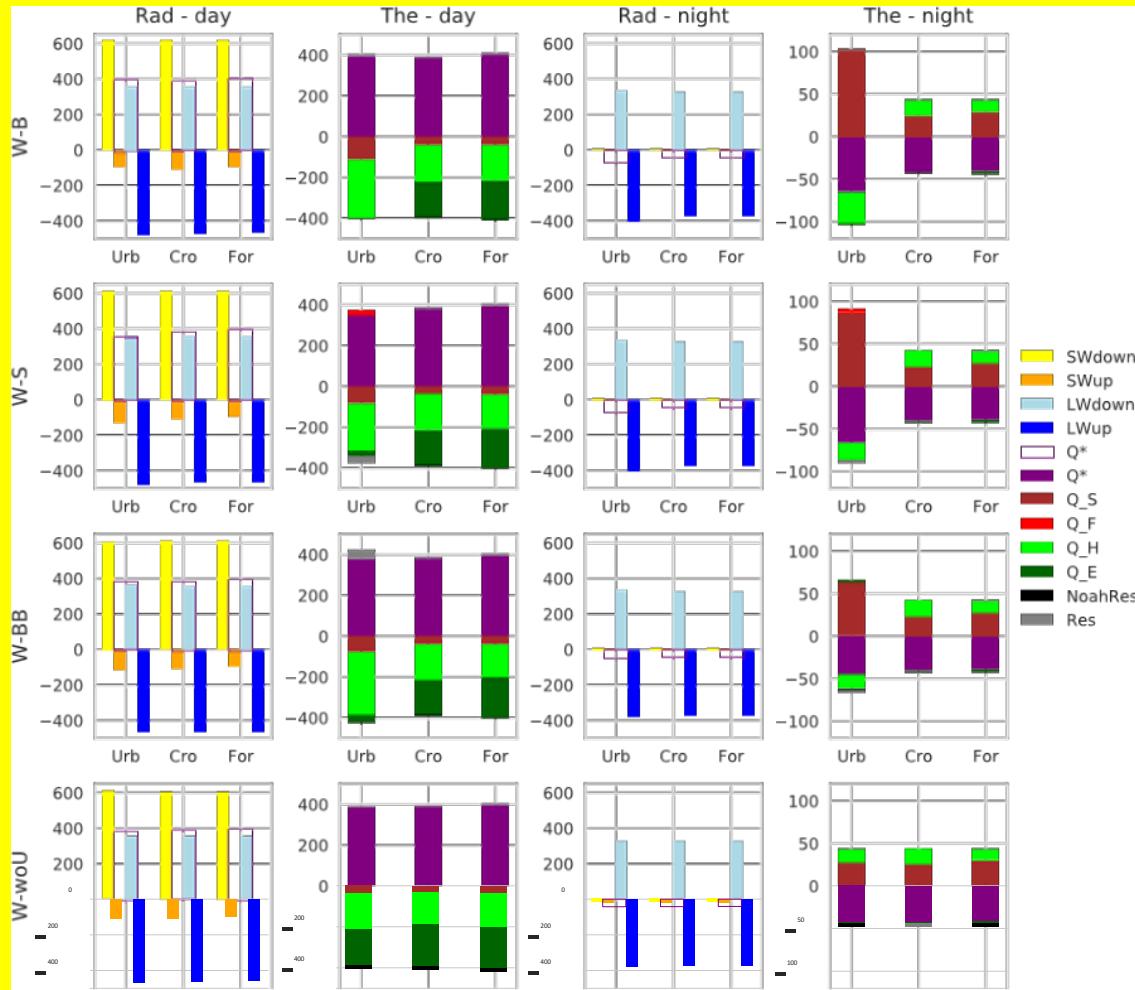


Energy budget comparison



- Christen and Vogt (2004) – Basel, JJA
 $(W\ m^{-2})$ /WRF:
 $SW_{\downarrow} = 264 / 288$
 $SW_{up} = -28 / -43$
 $LW_{\downarrow} = 355 / 345$
 $LW_{up} = -444 / 438$
 $Q^* = 146 / 151$

Energy budget comparison - summer



Christen and Vogt (2004) –
Basel, JJA
(W m⁻²) /WRF

– in day:

$$Q^? = 482 / 350$$

$$Q_S = -184 / -83$$

$$Q_H = 230 / 232$$

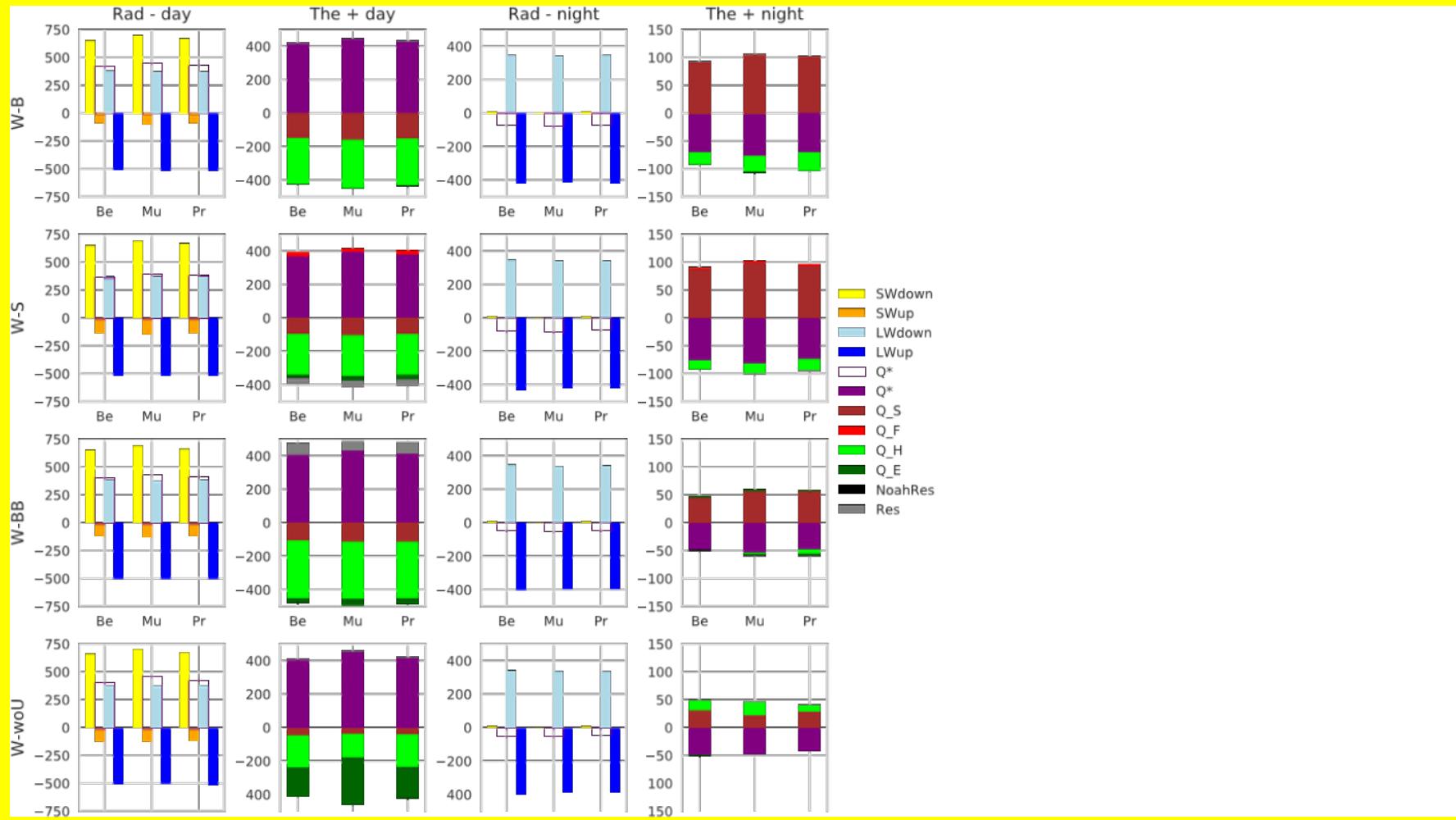
$$Q_E = 88 / 27$$

- in night:

$$Q^? = -65 / -66$$

$$Q_S = 80 / 87$$

Energy budget comparison – heat waves



Conclusions



- Urban surfaces have significant impact on the meteorological conditions and climate in Central Europe, with increasing effects on population
- Urban heat island effect clearly identified in simulations of 10 km resolution as well, mainly during summer and nighttime, especially significant under extreme weather like heat wave
- High-resolution achieved the city's scale, no excuse to neglect it in regional or very high resolution simulations, in assessment of extreme events impacts for adaptation or mitigation options analysis
- Higher complexity parameterization necessary to capture the effects fully, which might be important e.g. for air-quality issues

Further more detailed assessment within completed climate simulations of the project URBI PRAGENSI



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Acknowledgement



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THANKS FOR YOUR ATTENTION !



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