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

ON THE URBAN EFFECTS IN HIGH RESOLUTION WEATHER FORECAST AND REGIONAL CLIMATE SIMULATIONS

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

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

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URBI PRAGENSI

PRA HA
PRA GUE
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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:

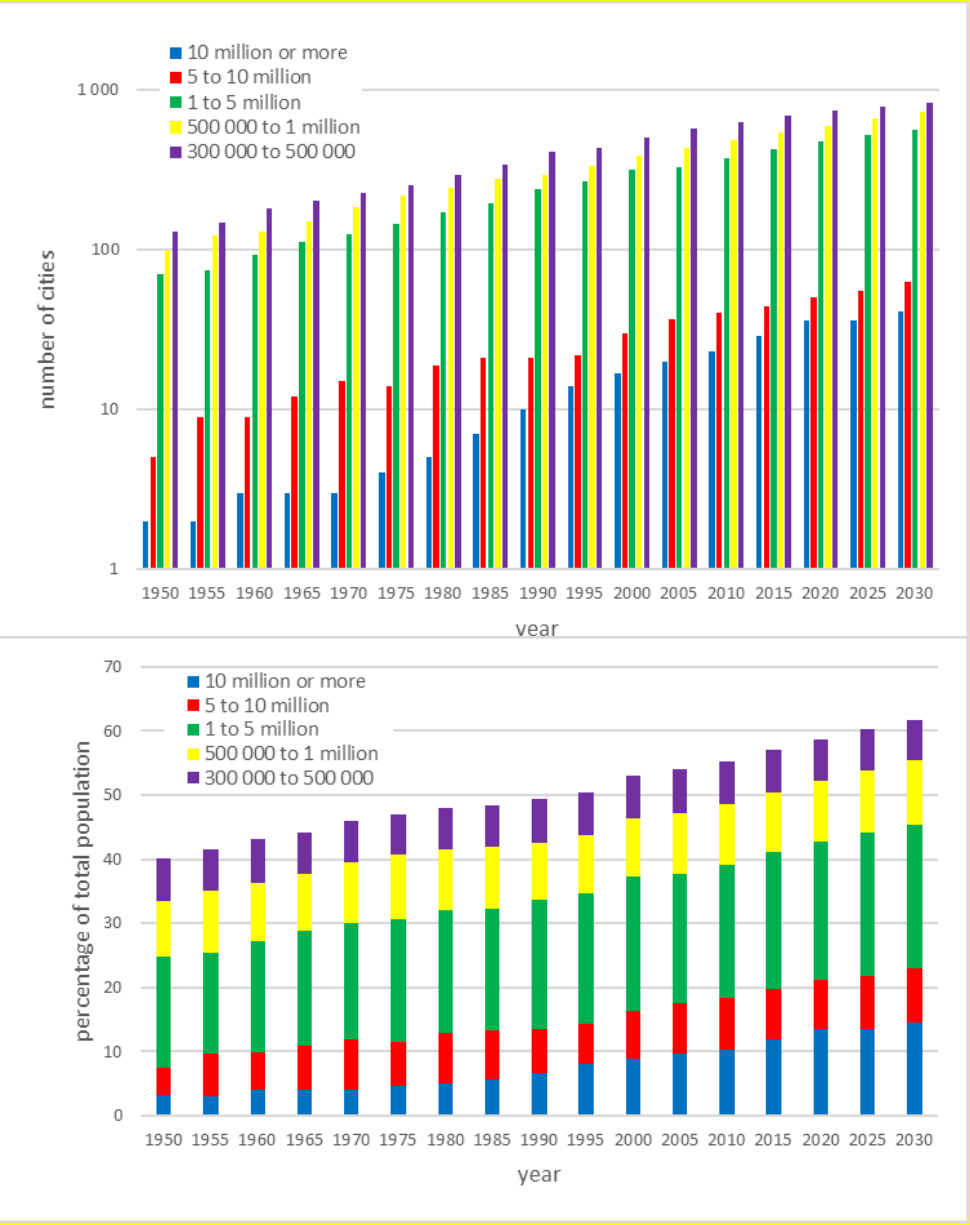
- 2008 - 73% of the population in cities
- mid 21th century - 84%, representing a rise from 531 to 582 millions (UN, 2008)

Clearly:

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

Scientific question:

- Do we need urban parameterization in RCM simulations?



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

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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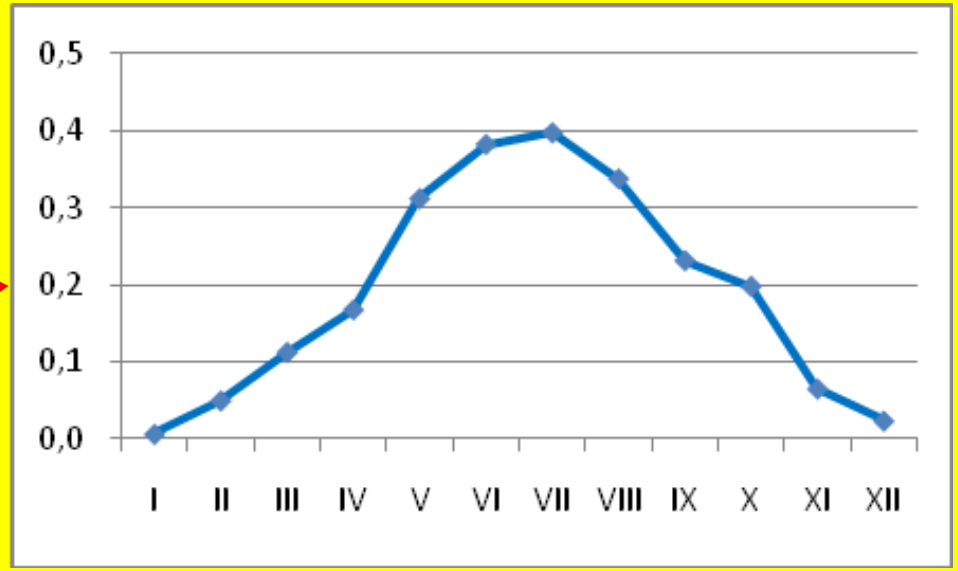
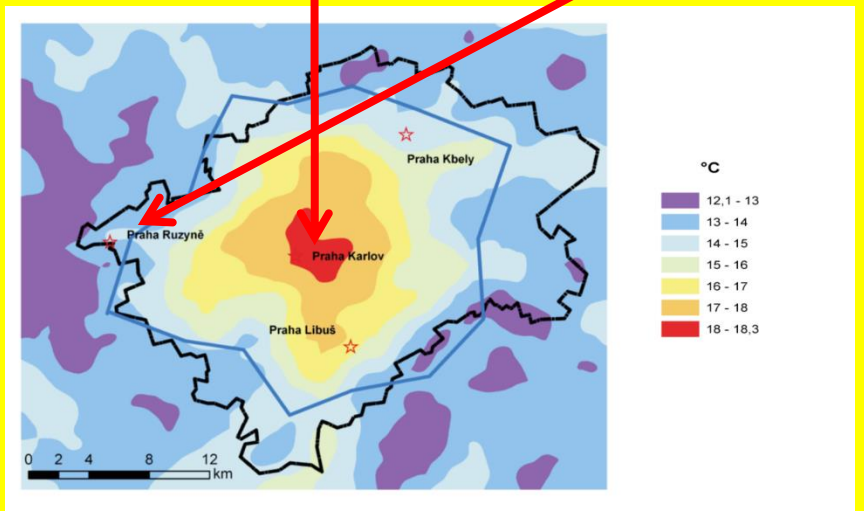
Prague heat island

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)

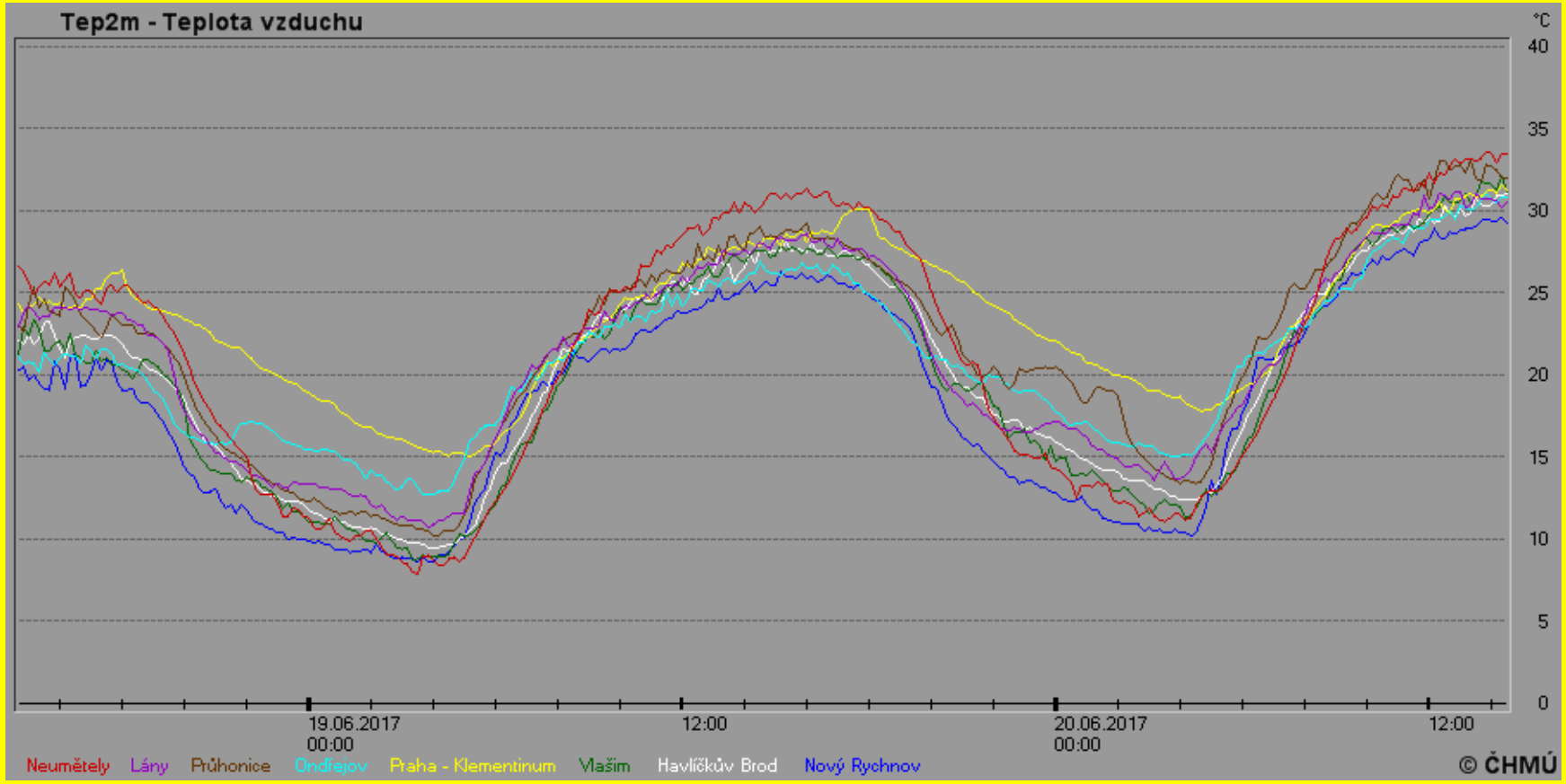
Klementinum vs. Ruzyne



CENTRAL EUROPE
COOPERATING FOR SUCCESS.

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Example June 18-21, 2017



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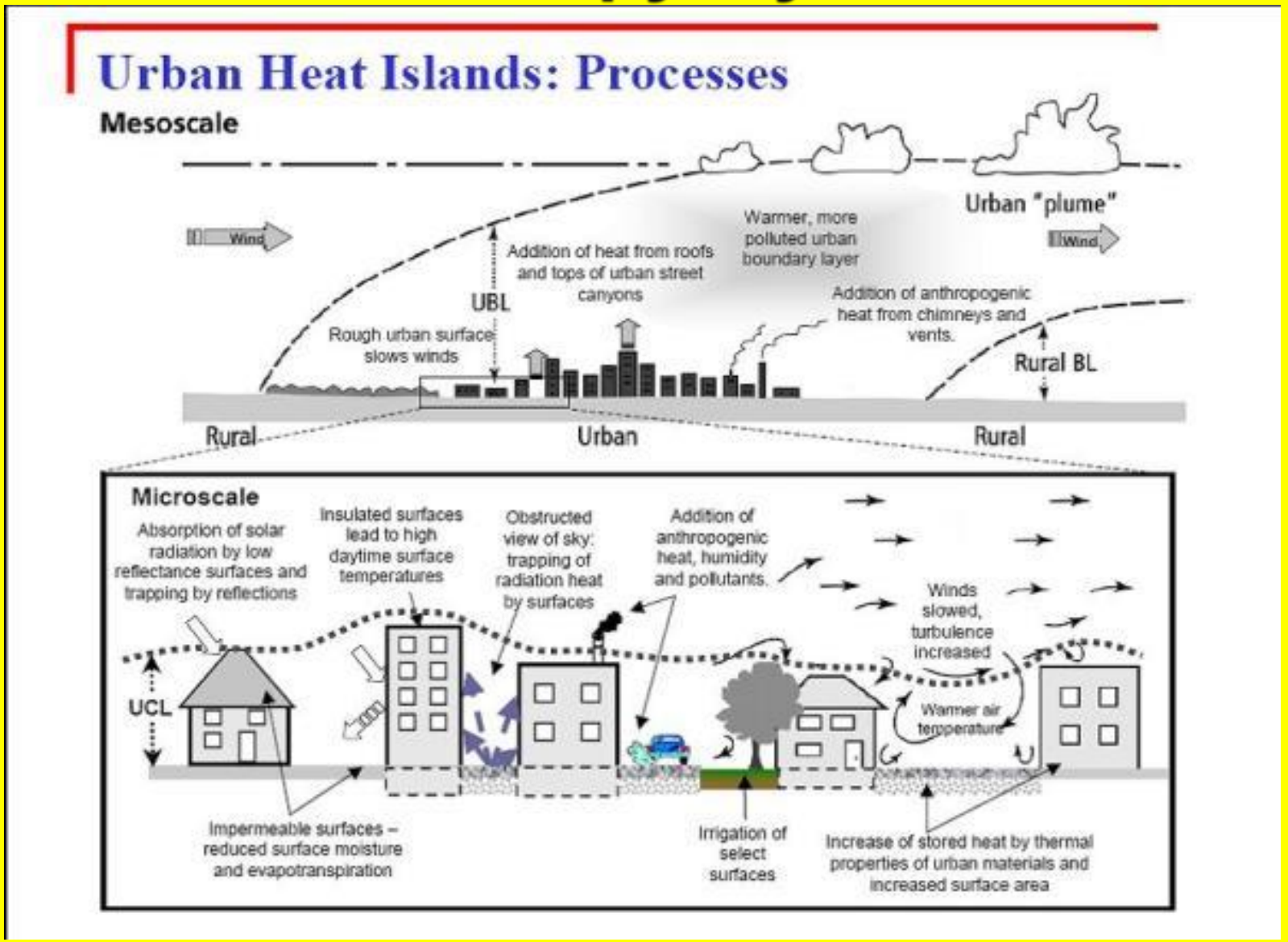
Atmospheric processes in urban canopy layer

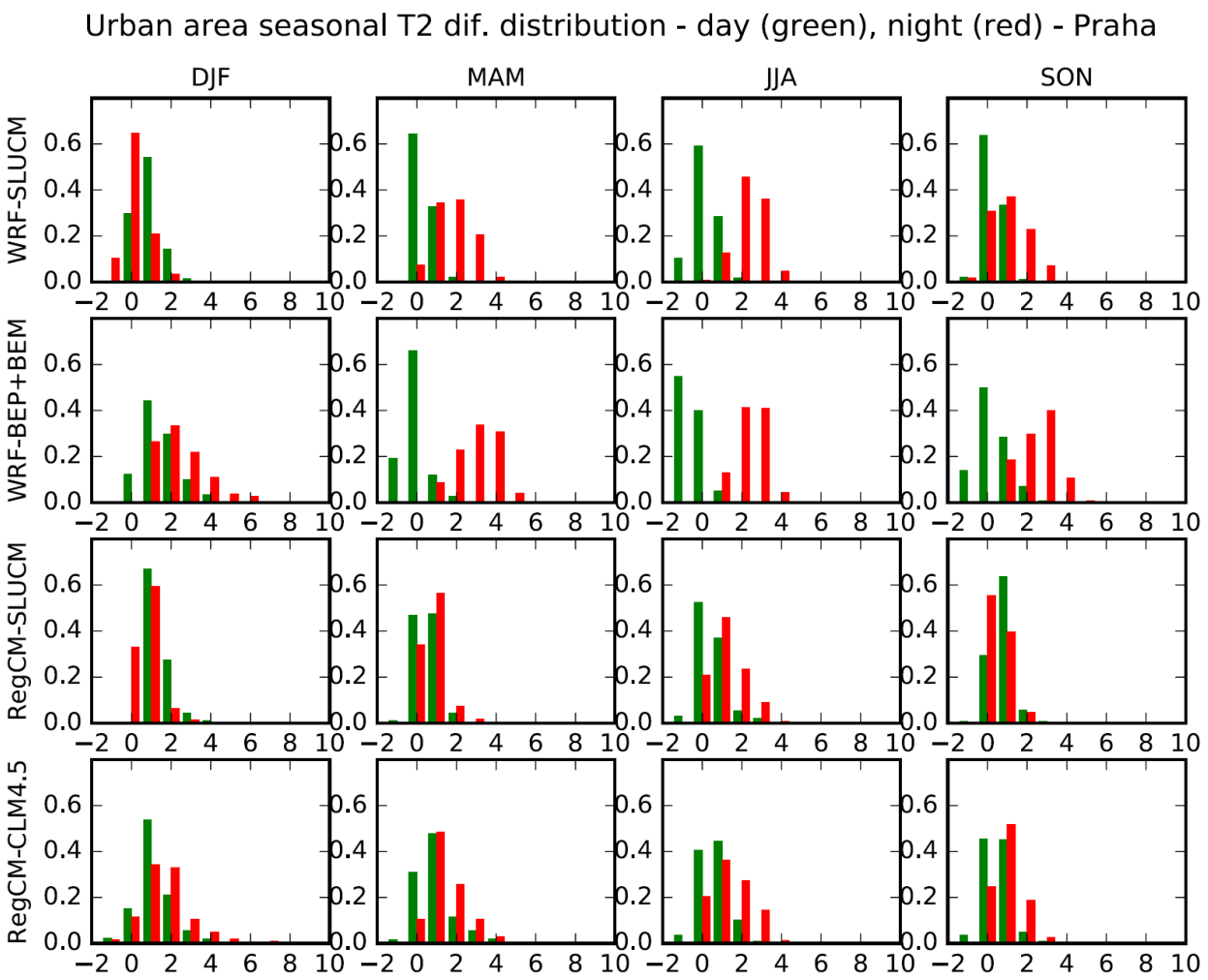


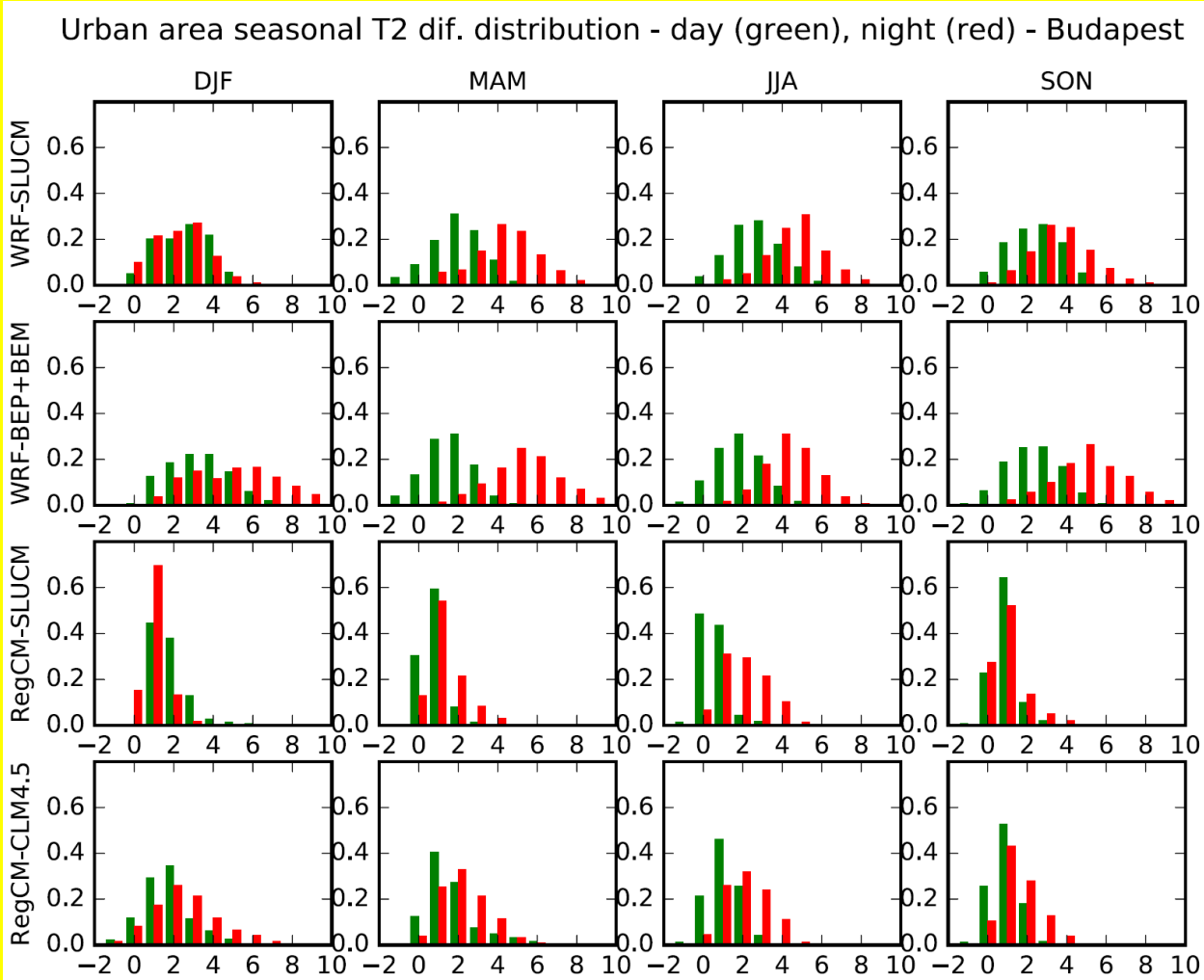
Modeling atmospheric processes in urban canopy

- 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

Tests in RegCM and WRF at 10 km resolution

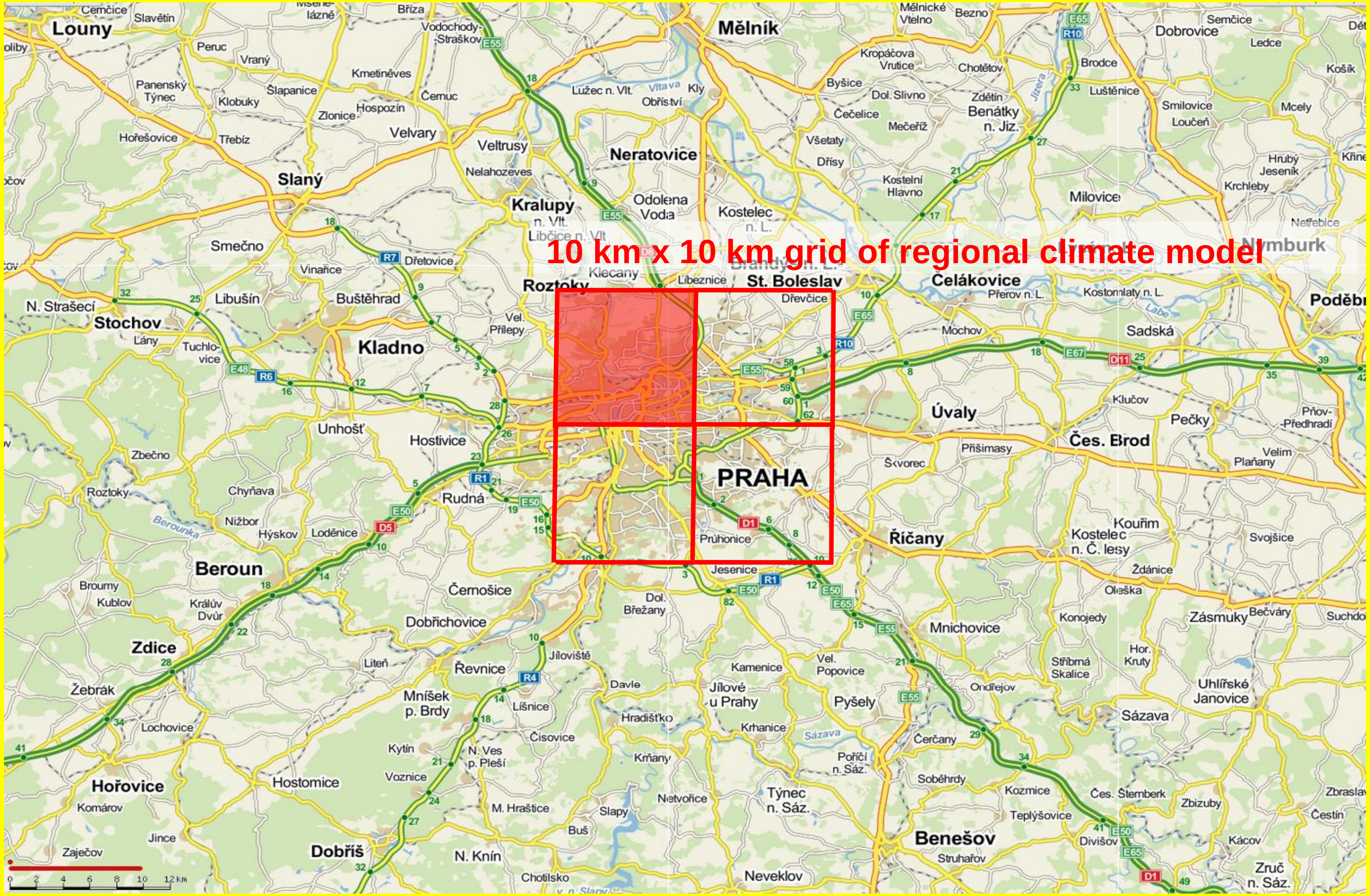
UHI intensity Prague (day vs. night)



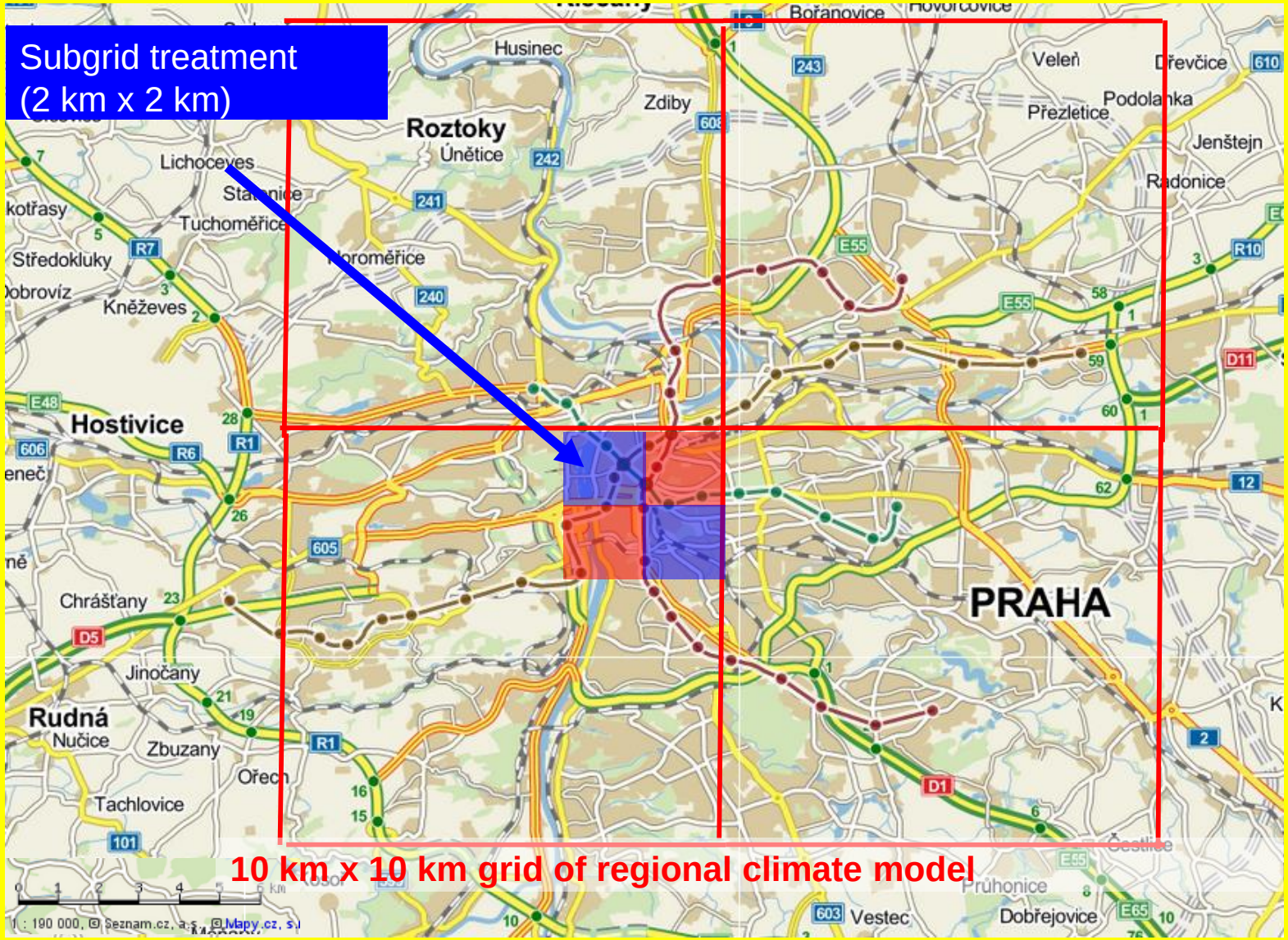


Karlicky et al. (ACP, 2018), you can see our poster here as well (Halenka et al., **PA43G-1193**, Thursday)

Why urban parameterizations

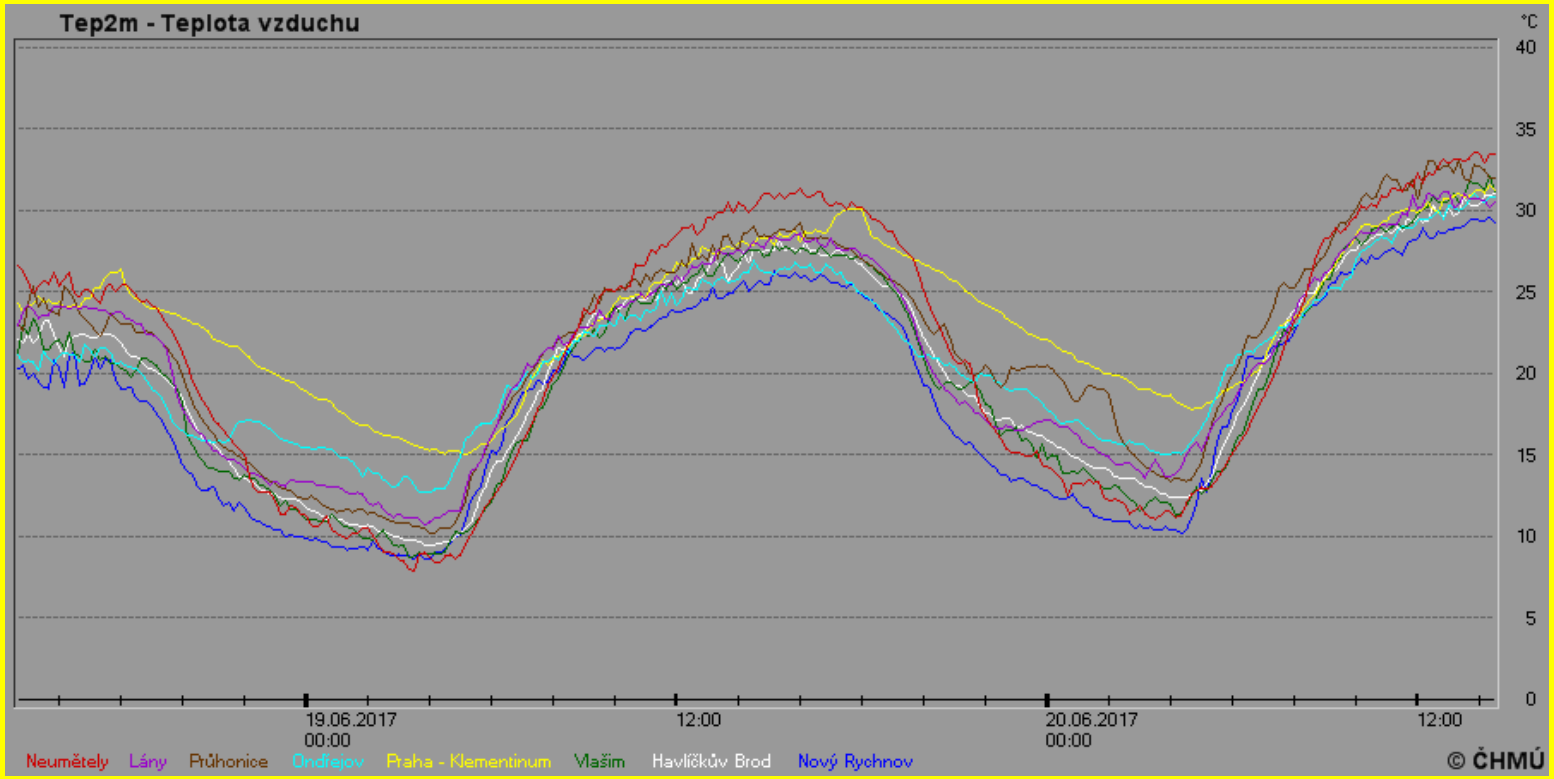


Even further in very high-resolution

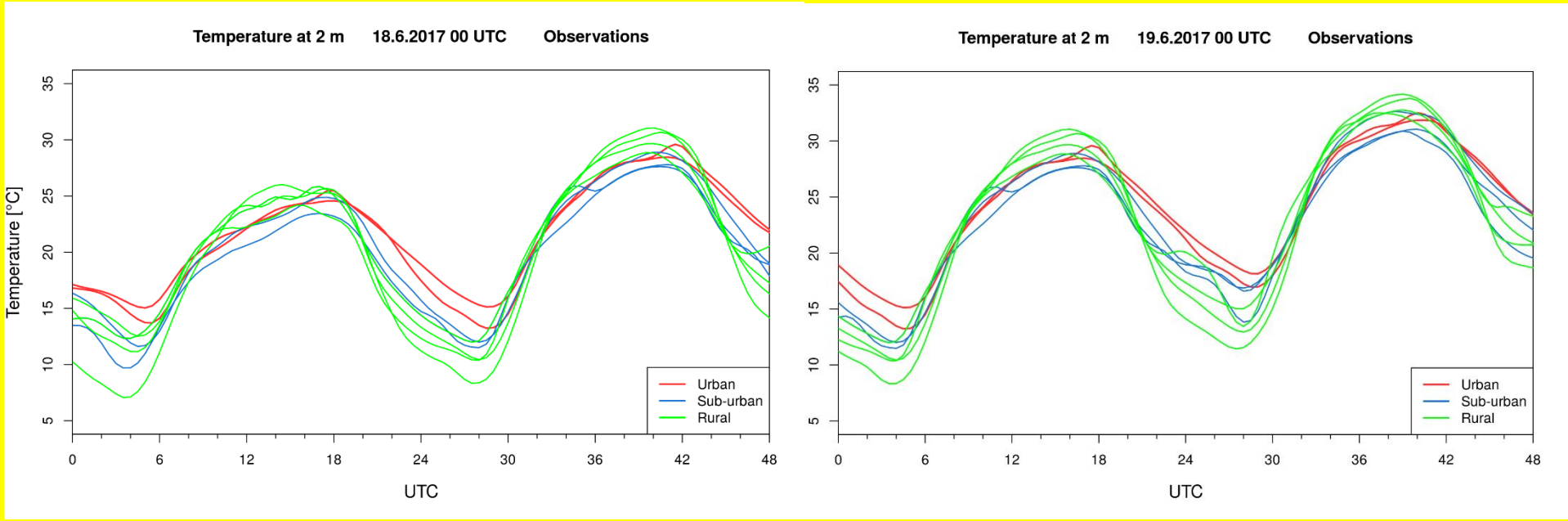


1 km resolution for weather and air quality forecast in URBI PRAGENSI

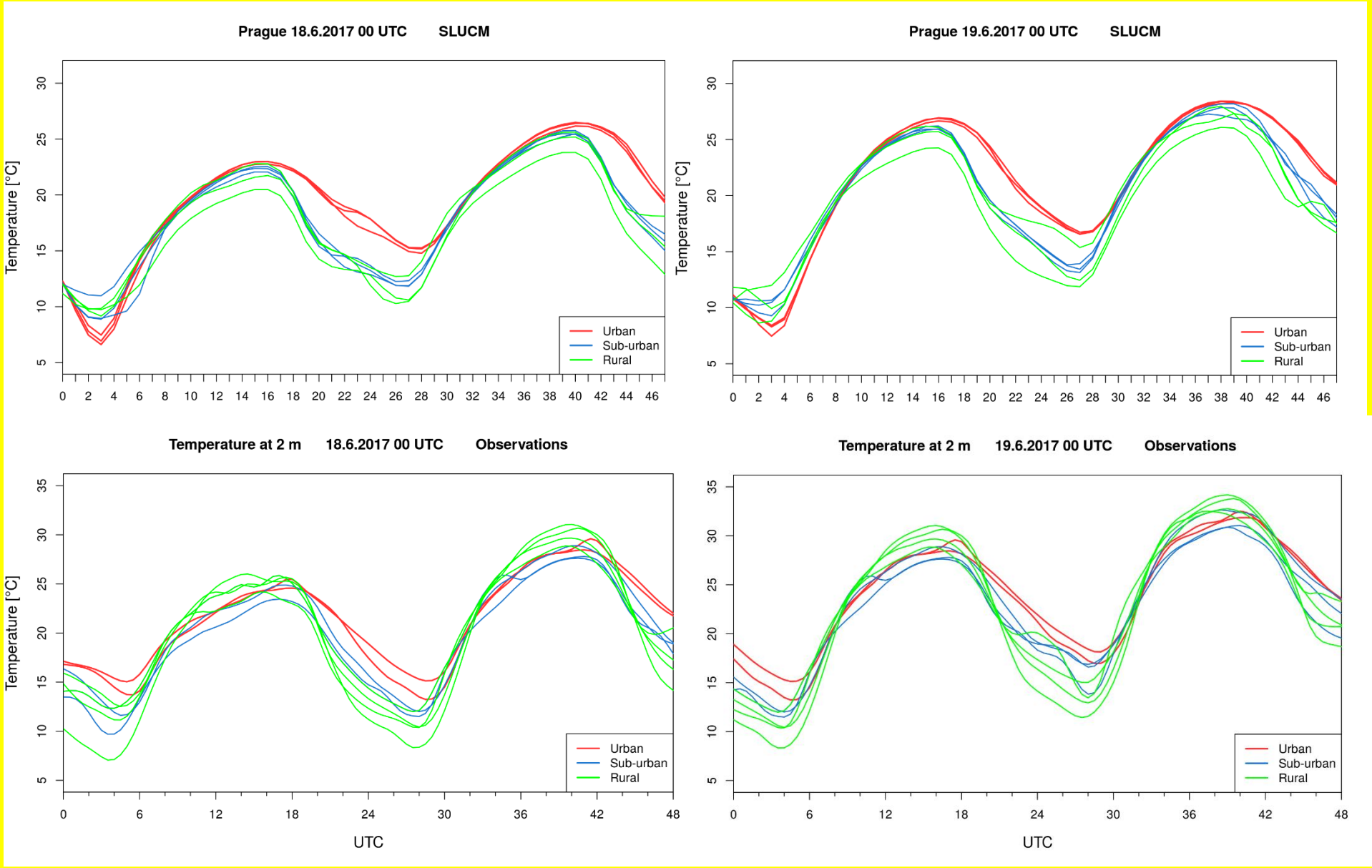
WRF forecast mode with SLUCM (3km)



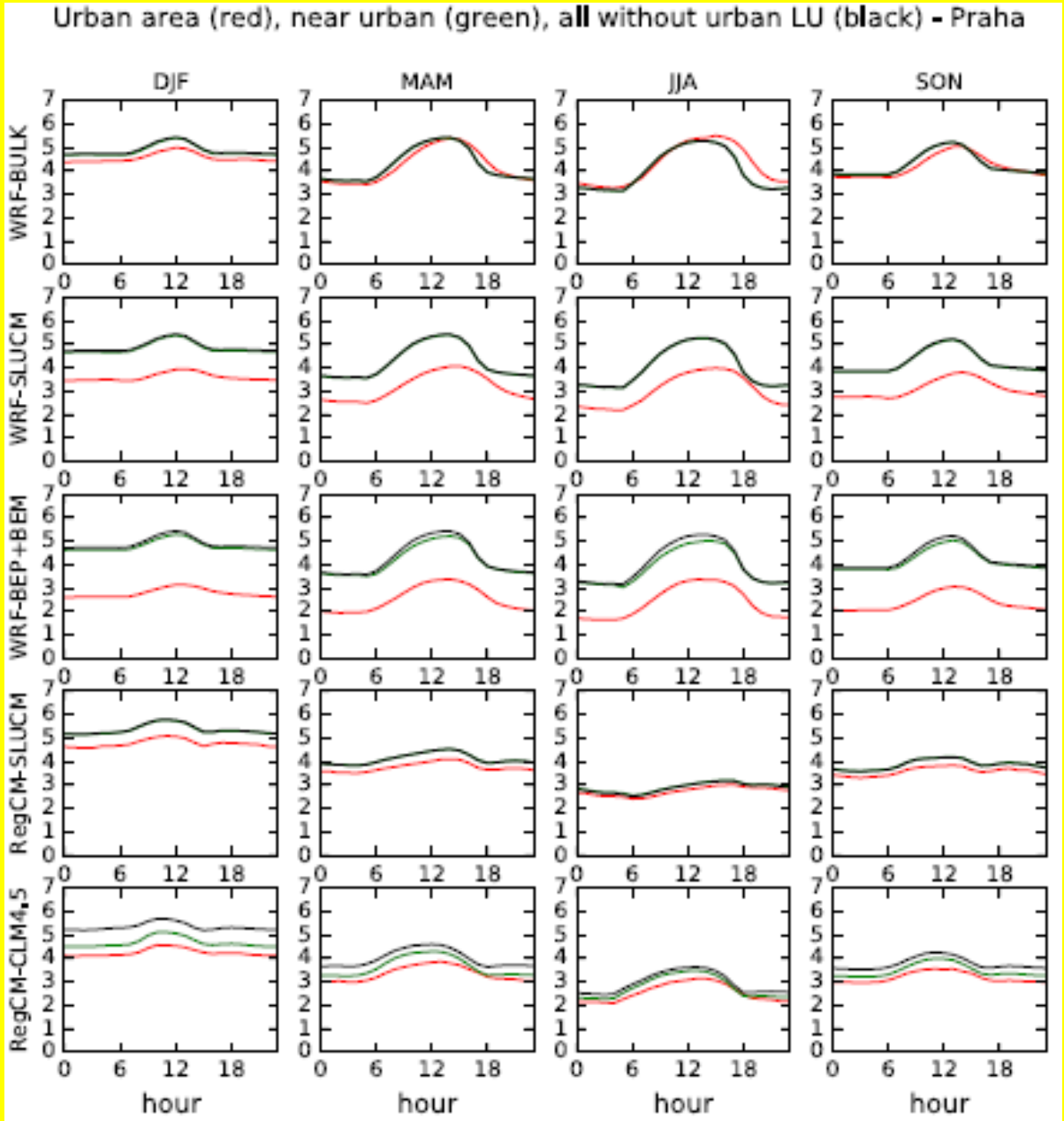
WRF forecast mode with SLUCM (3km)



WRF forecast mode with SLUCM (3km)

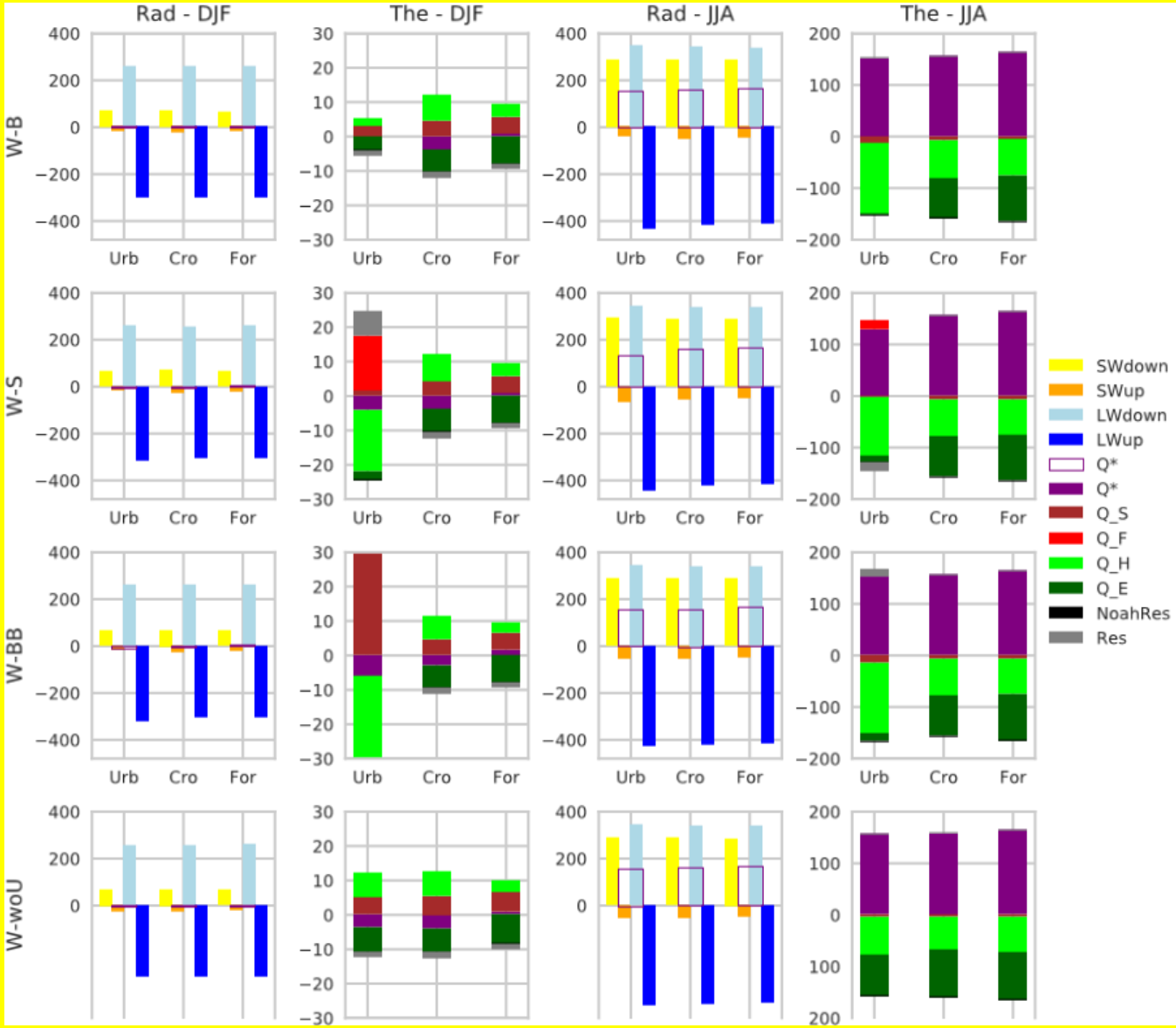


Wind – 10 km comparison experiment



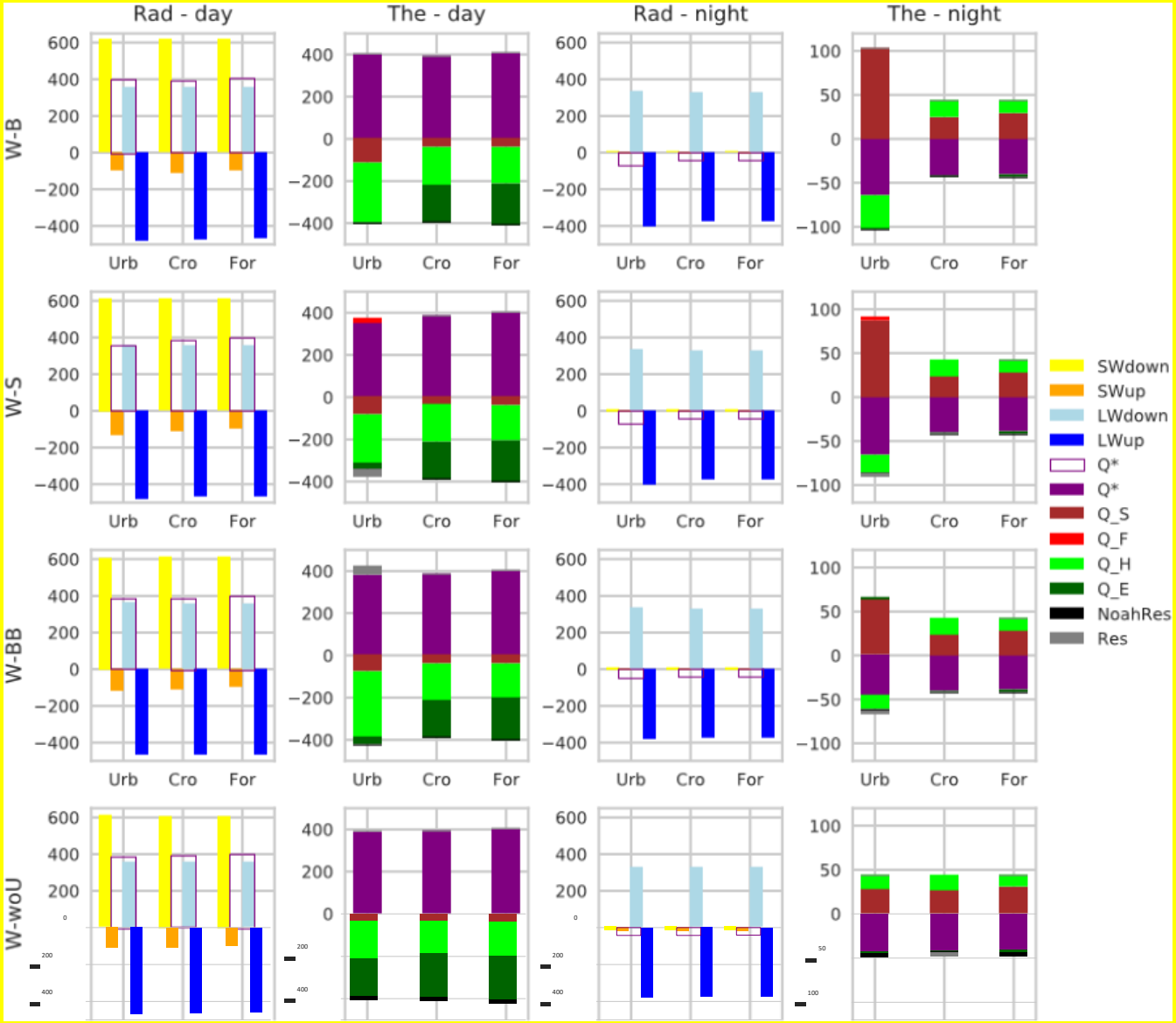
Karlicky et al. (ACP, 2018)

Energy budget comparison



- Christen and Vogt (2004) – Basel, JJA ($W\,m^{-2}$) /WRF:
  SW↓ = 264 / 288
  SWup = -28 / -43
  LW↓ = 355 / 345
  LWup =-444 / 438
  $Q^{\star}$ = 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

-

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 at 3 km resolution within the project URBI PRAGENSI

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Summary, Outcomes – FPS on urbanization

As cities are becoming one of the most vulnerable environments under climate change, increasing effort dedicated to these aspects is becoming highly relevant to the CORDEX community, and to enhance the discussion on climate change interaction with urban environment within the wider CORDEX community in a more coordinated fashion is necessary, especially when aiming higher resolution in up-to-date CORDEX simulations

A clear option, consistent with CORDEX structure, is **to develop an FPS on urbanization**, which is expected going across the CORDEX domains considering a few selected big cities (even megacities) in interested CORDEX domains.

This could be seen to be supported by – and contributing to –

- Special IPCC Assessment Report planned for cities after AR6,
- WCRP Grand Challenges – Weather and Climate Extremes – on local scale, and
- SDG (Sustainable Development Goal) on sustainable cities (#11), climate action (#13) and health (#3)

Basics of foreseen FPS on urbanization and regional climate change

Scientific aims:

- To investigate the interaction of urban environment with local climate change for selected big cities based on coordinated ensemble simulations using urbanized CORDEX RCMs
- To assess the options for urbanization in regional climate simulations for further use in CORDEX simulations in high resolution
- To better understand the urban environment vulnerability in changing world as well as its effects on climate change impact in the cities

Specific tasks:

- Overview of the urban effects incorporation in high resolution regional climate models used in CORDEX and possible options for that
- Analysis of results available (EuroCORDEX 0.11, CORDEX-CORE 0.22, CP simulations within FPS Convection, EUCP CP simulations, …)

Phase 1

- Coordinated (CP) experiments with urbanization for selected cities
- Sensitivity experiments for different options and settings

Phase 2*

- Coupling to CTM
- Climate services for health effects, city management and planning, etc.

Phase 3*

Interested? Contact tomas.halenka@mff.cuni.cz

* Not necessarily so strictly separated – on-line vs. off-line coupling, etc.

Acknowledgement

The work recently supported within OP-PPR URBI PRAGENSI - [illegible] weather forecast, air quality prediction and climate scenarios for Prague CZ.07.1.02/0[illegible]0000383, OP-PPR project Proof of Concept UK, CZ.07.1.02/0.0/0.0/16_023/0000108, O[illegible]nosti a komerčního potenciálu výsledků výzkumu Univerzity Karlovy, started under supp[illegible]ject "Development and Application of Mitigation and Adaptation Strategies and Measures fo[illegible]g the Global Urban Heat Island Phenomenon" within the framework of EC Operation Pro[illegible]l Europe (3CE292P3), using the previous development achieved under EC FP6 STREP C[illegible]nder support by EC FP7 Project MEGAPOLI (Megacities and regional hot-spots air qualit[illegible] grant agreement no.: 212520.

THANKS FOR YOUR ATTENTION !

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