



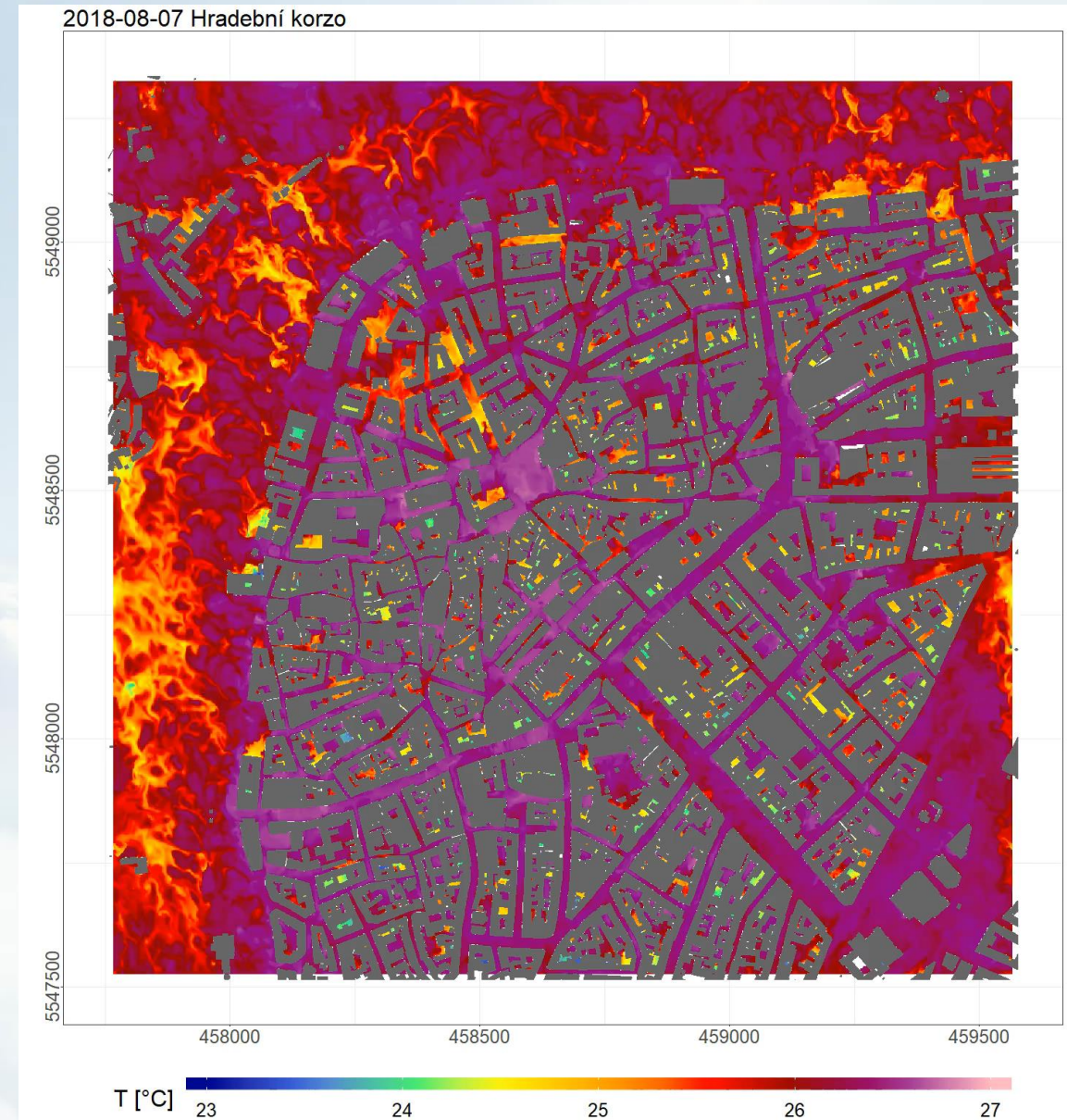
Street-level assessment of urban scenarios on thermal comfort and air quality

J. Resler, P. Krč, J. Geletič

Institute of Computer Science, The Czech Academy of Sciences, Prague, Czech Republic

Outline

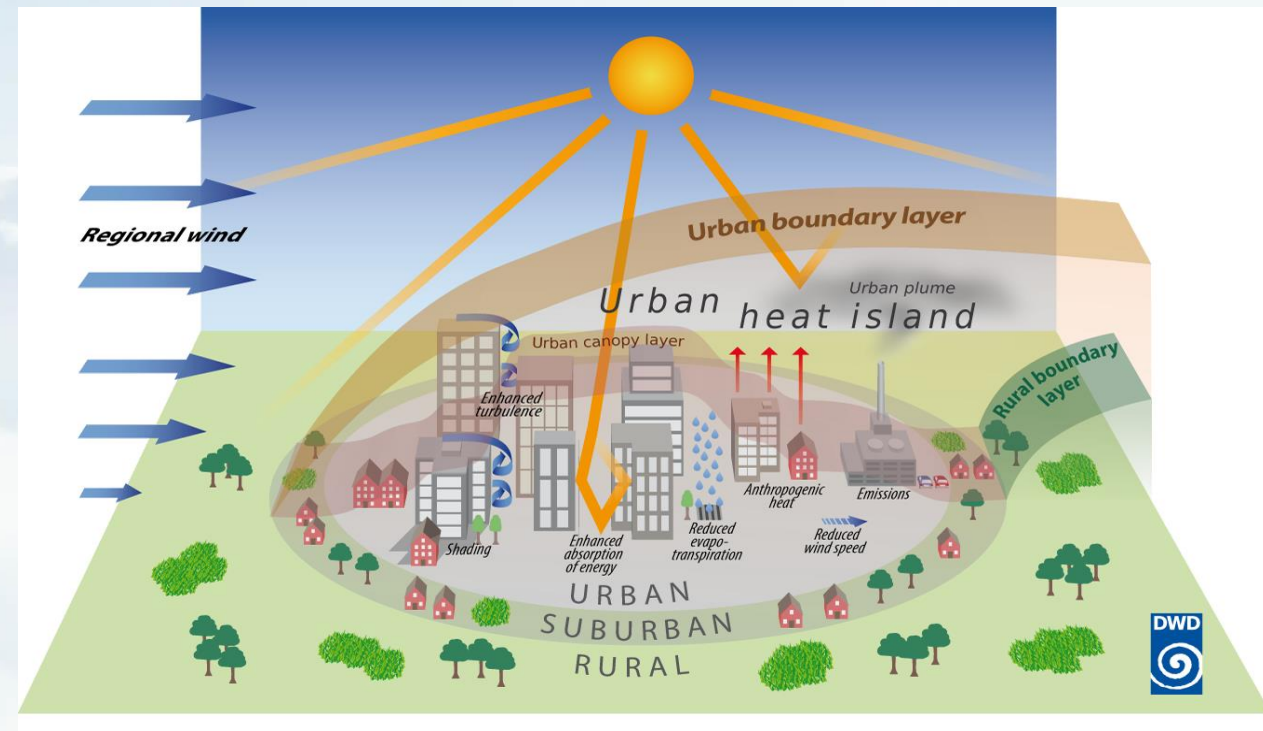
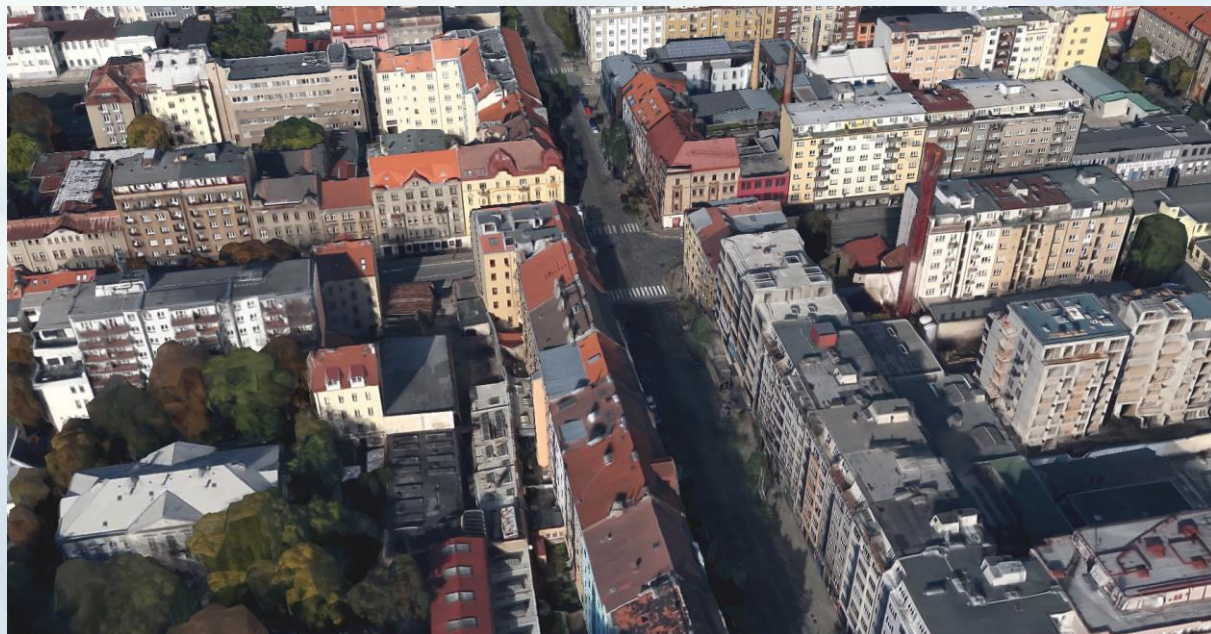
- Jaroslav Resler
 - Thermal comfort and air quality modelling
 - Modelling approaches, PALM-4U
 - How much complex model do we need?
 - Observation campaigns and model validation
- Jan Geletič
 - Input data for detailed modelling
 - How precise inputs we need?
- Pavel Krč
 - Use cases
 - Scenarios
 - Invitation to workshop (CAMP, 13:15)



Urban environment

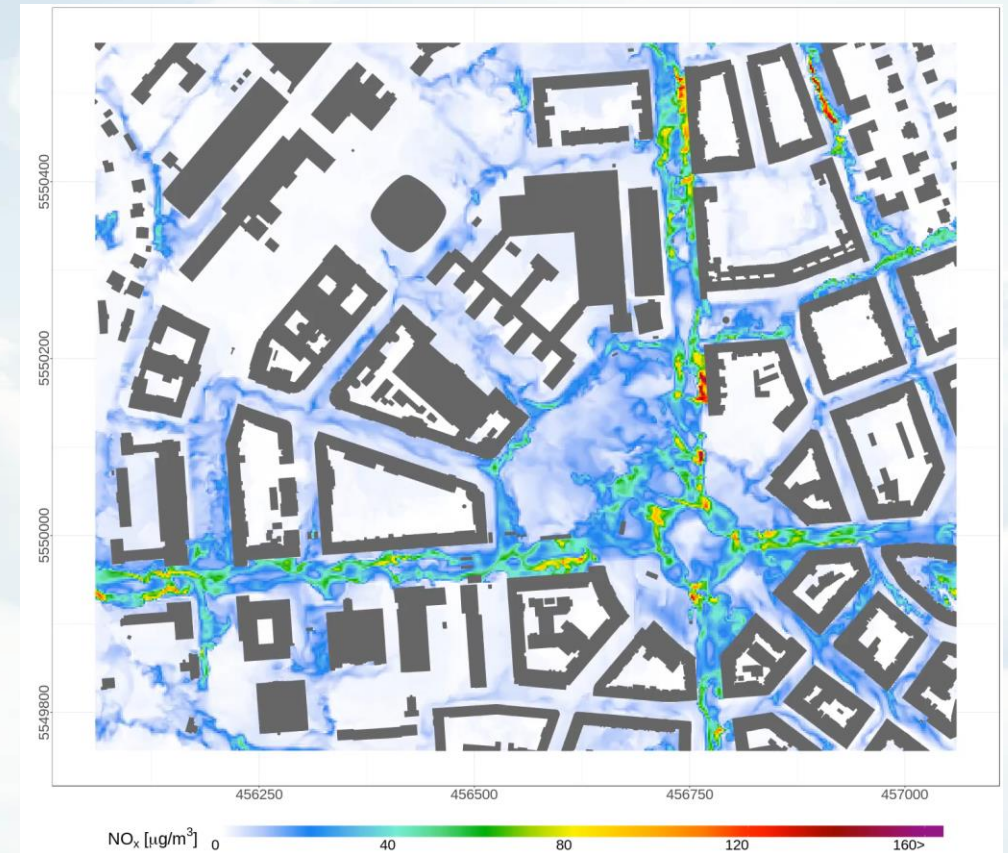
Urban Heat Island and Air Quality influences health and life quality in cities

- UHI mitigation measures <-> Air quality measures
- Integrated assessment of scenarios

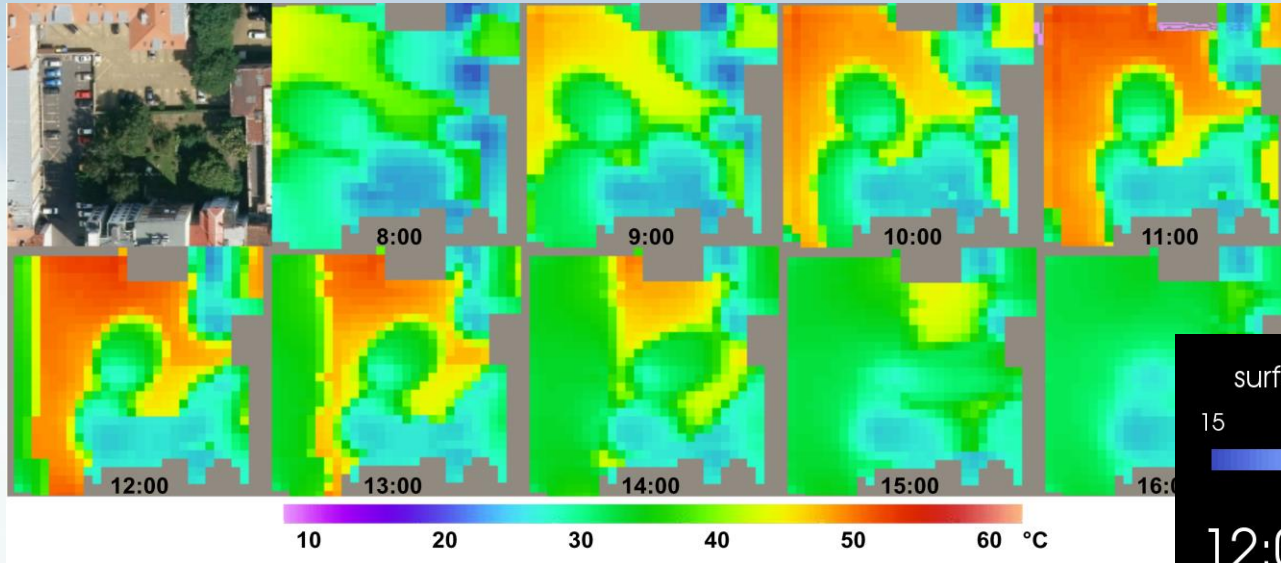


Modeling approaches

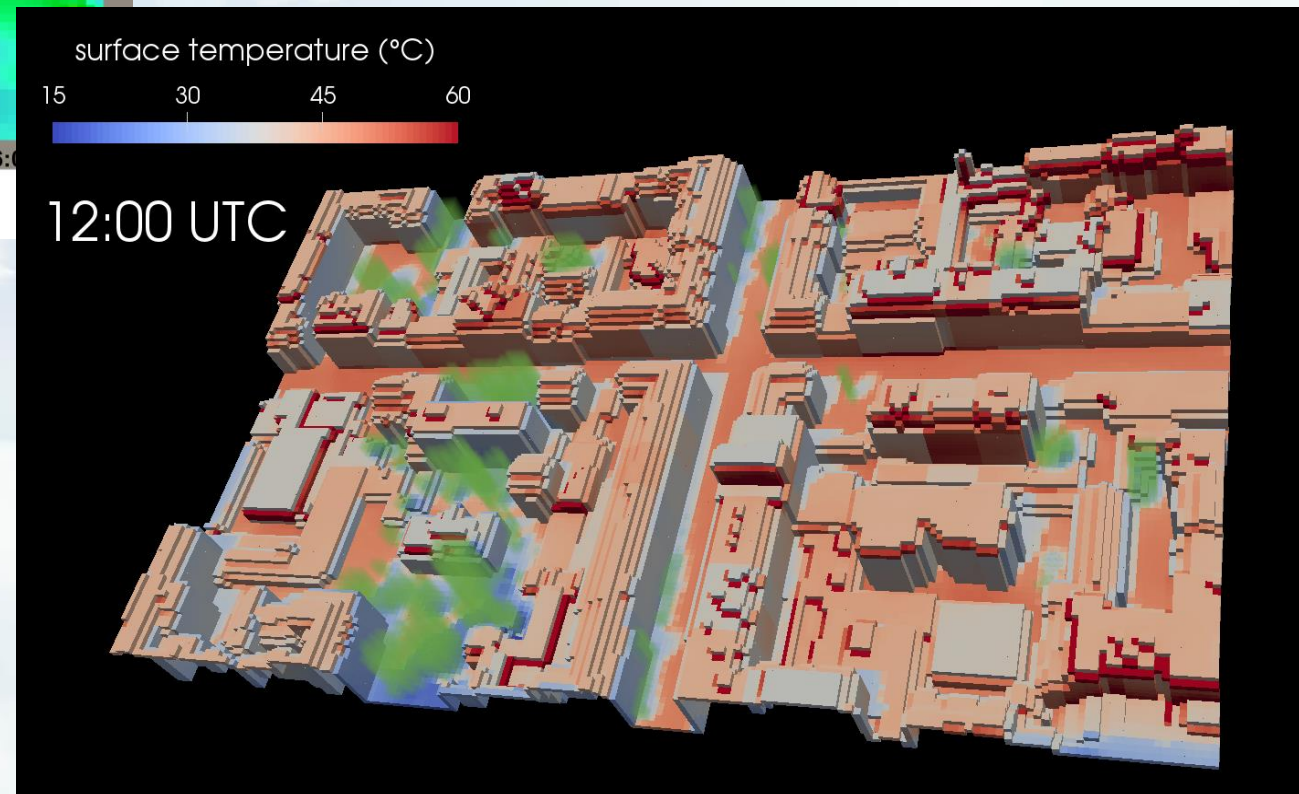
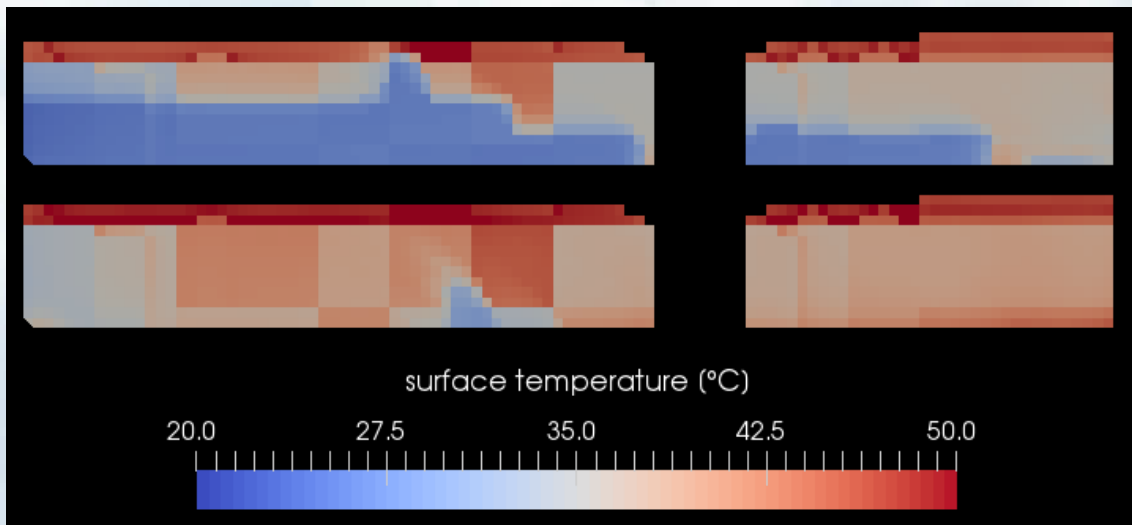
- Modelling approach can differ according information needed
 - Model resolution (covered area × level of detail)
 - Processes included in the model
- PALM-4U – complex street-level modelling
 - Turbulent dynamics (LES model)
 - Modelling of energy processes
 - Radiation transformation processes
 - Energy of buildings
 - Grounds modelling
 - Green areas, resolved trees
 - Anthropogenic heat
 - Air pollution processes
 - Biometeorological indices (MRT, PET, UTCI, PT)



Surface temperature



- Example simulation of Prague-Holesovice, 2.7.2015
 - Courtyard north-east corner of domain
 - East-facing wall in street at 06:00 and 08:00 UTC



Do we need a complex integrated model?

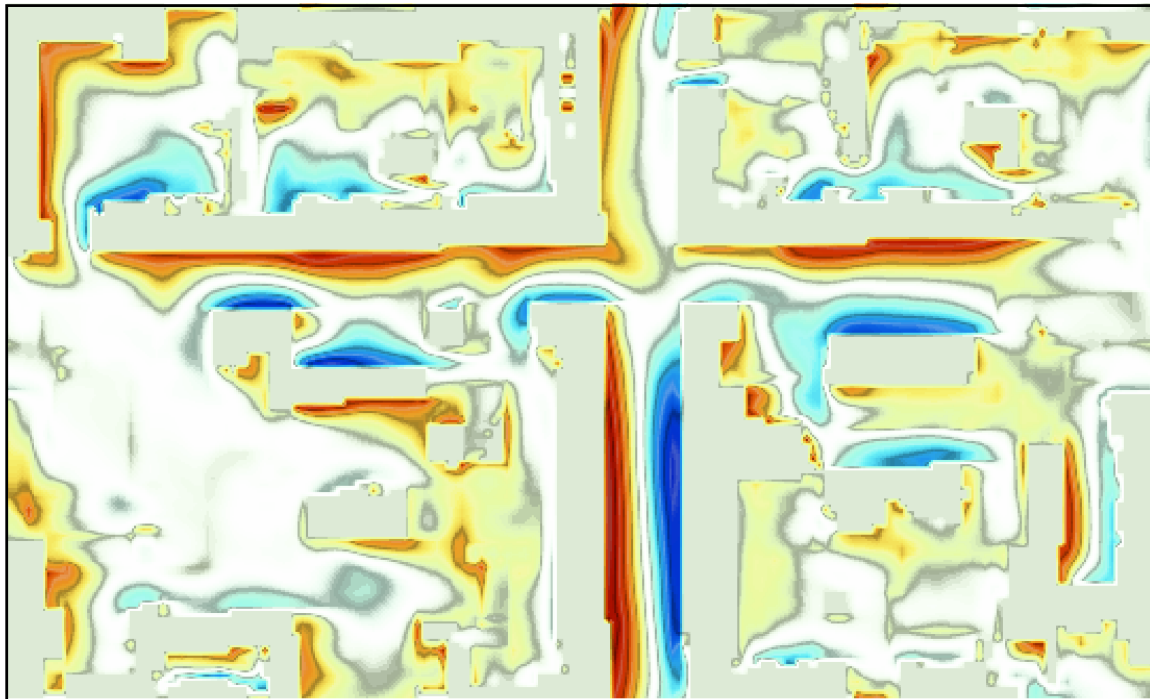
Air flow, energy processes and air pollution are strongly interconnected.

Example: dependence of the flow and air pollution on the energy processes

PALM noUSM, SHF

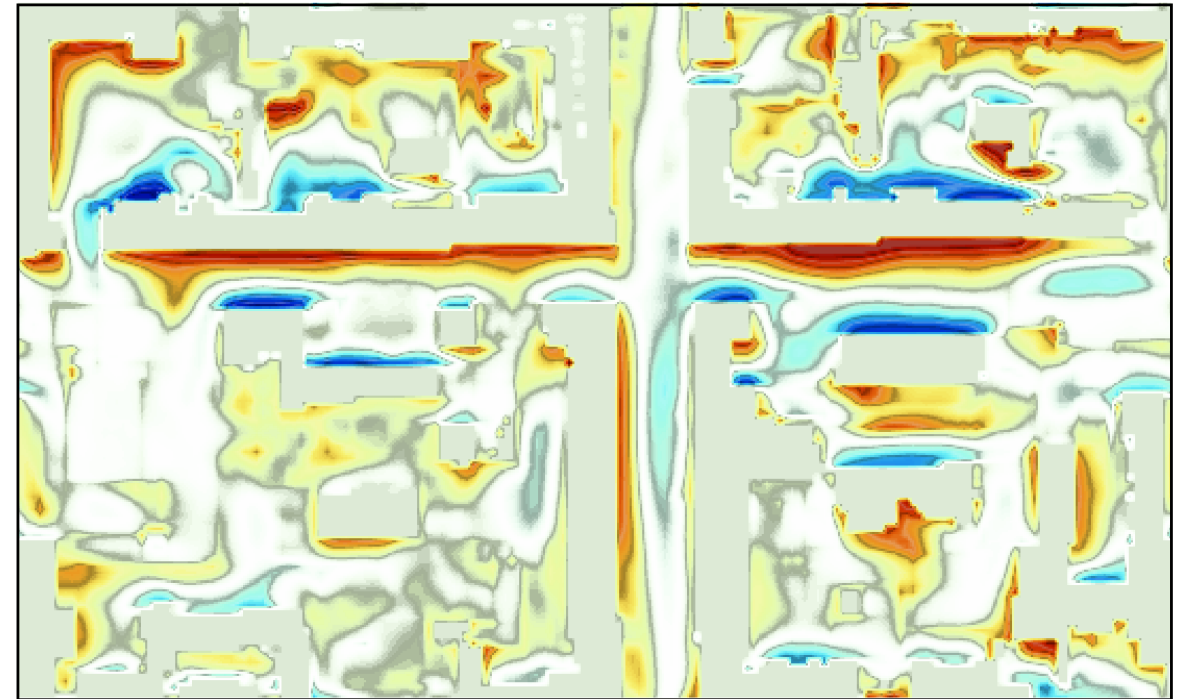
Vertical velocity at 10m AGL, 3 July 14:00 UTC

PALM USM



-1.5 0 1.0 (m/s)

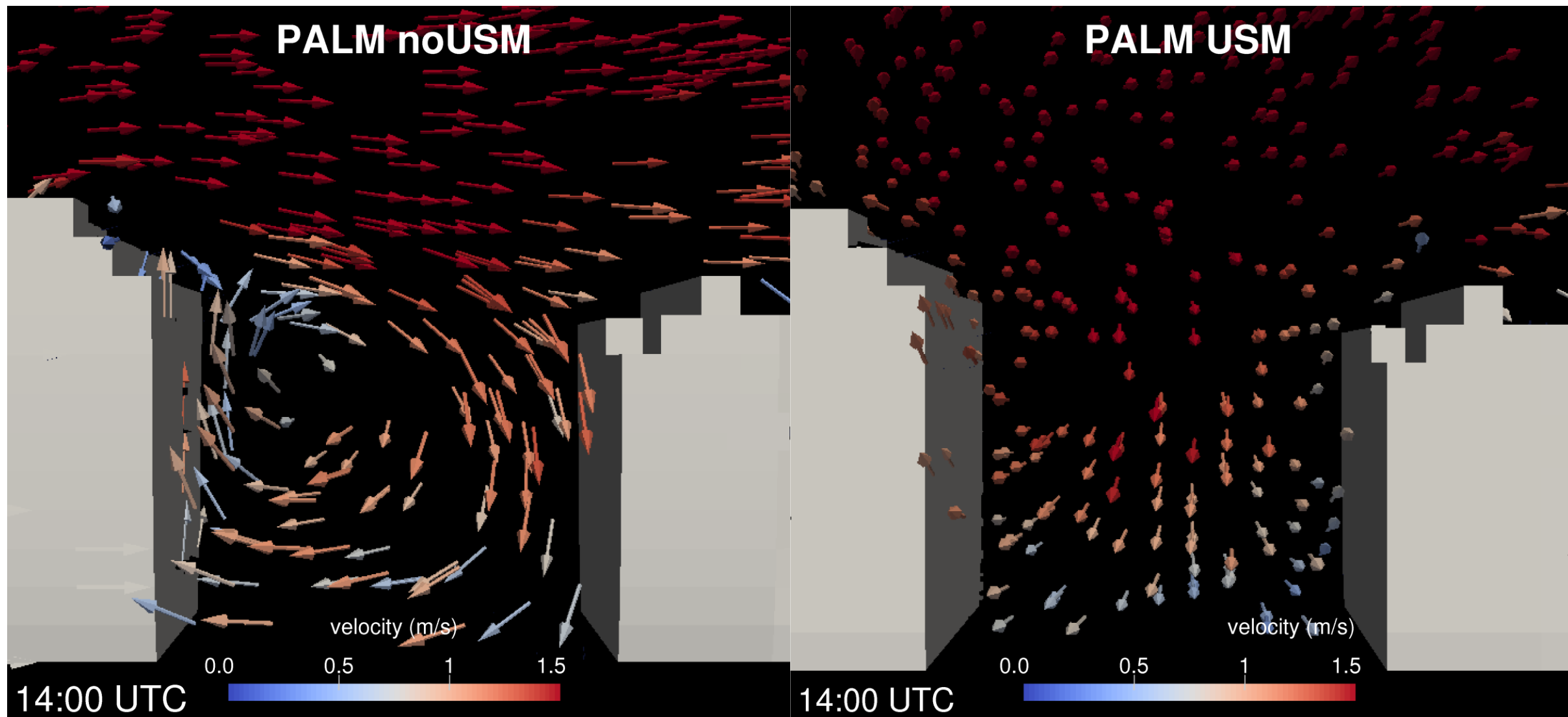
Constant averaged surface heat flux (left)



-1.5 0 1.0 (m/s)

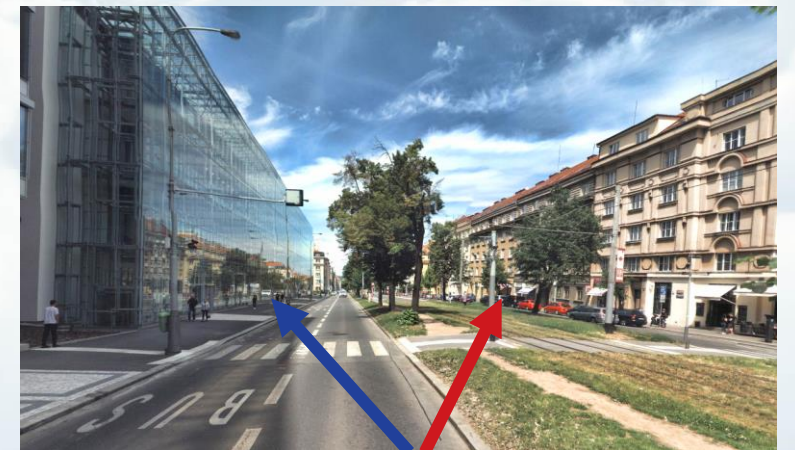
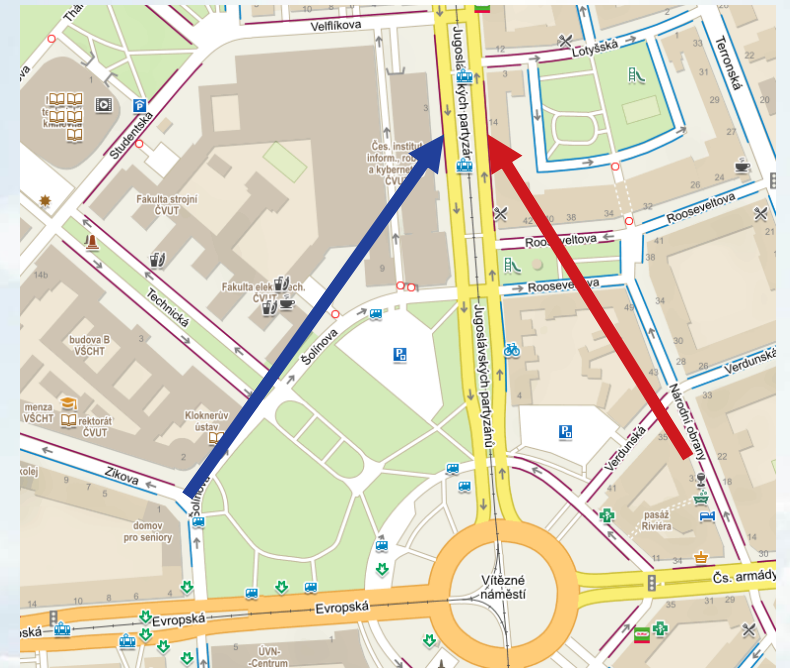
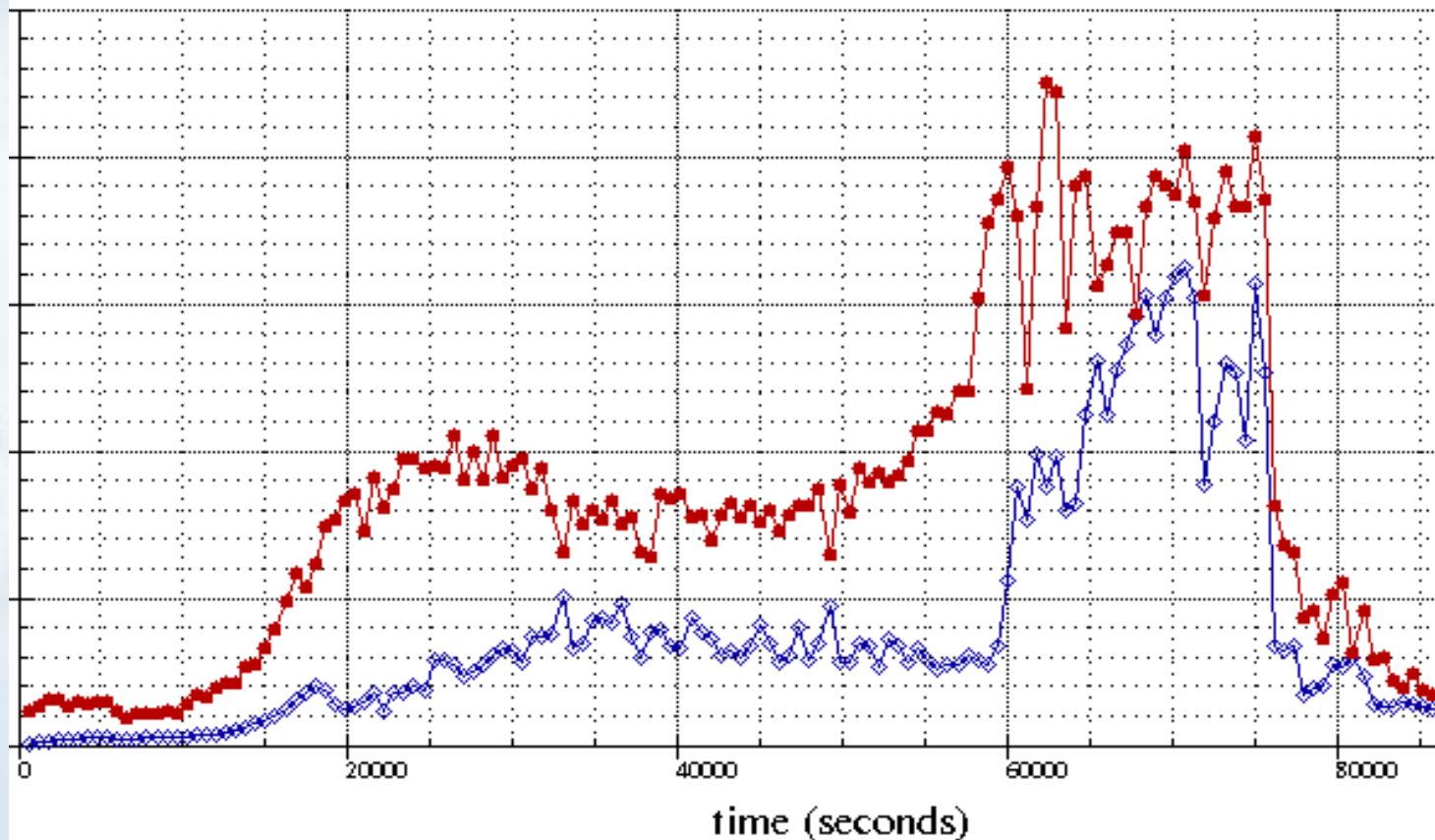
Heat flux calculated by USM (right)

Do we need a complex integrated model?



Why we need street-level model?

- Conditions in urban areas are local
 - Spatial and temporal variability
 - Dependency on local properties



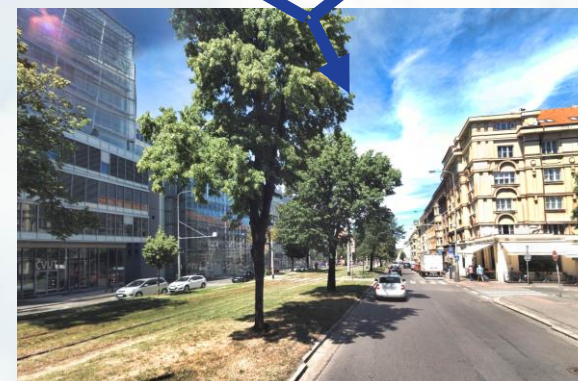
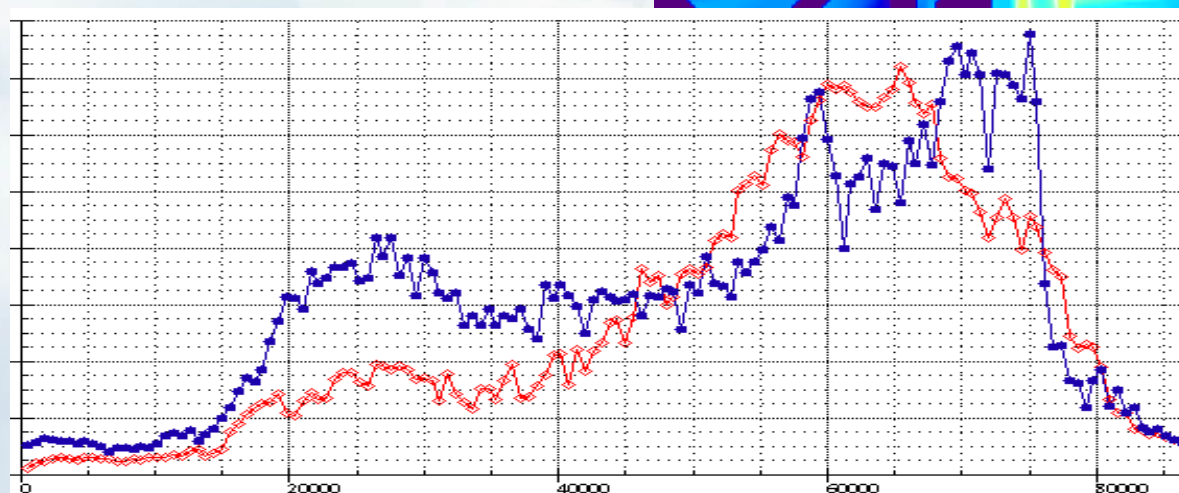
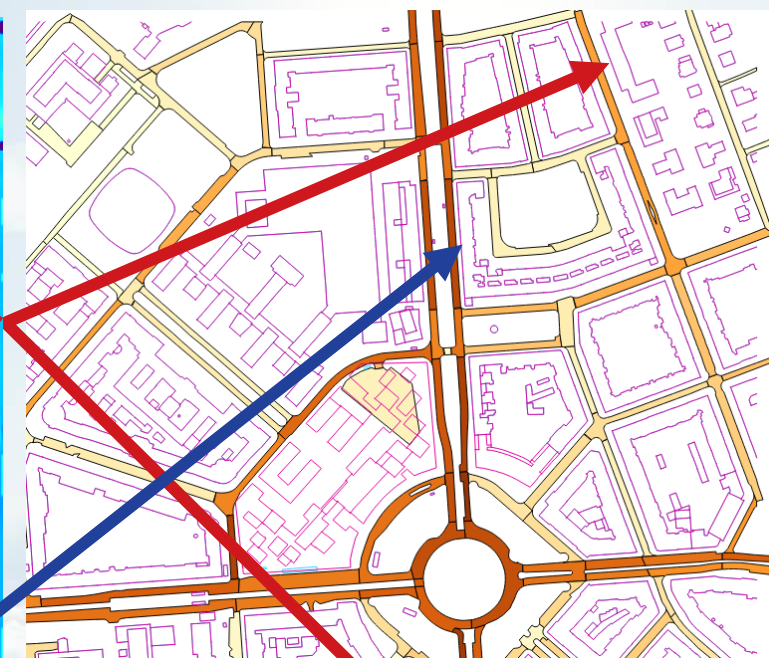
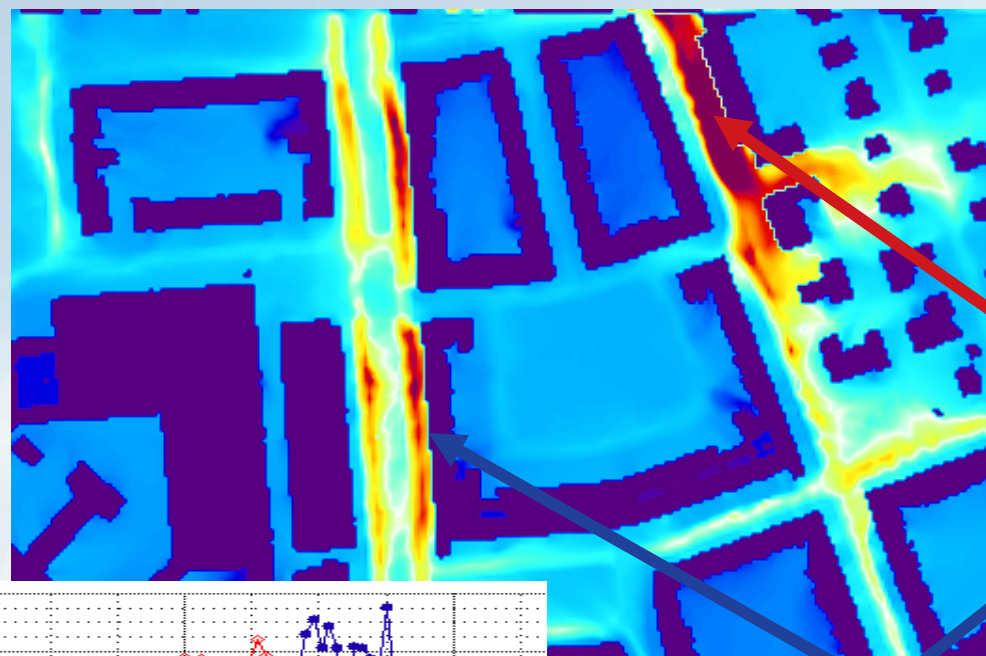
Do we need realistic modeling of trees?

Modelled concentration of NO_x

Daily total emission from transportation (right)

Concentrations at 15:00 (centre)

Diurnal course of the NO_x (bottom)

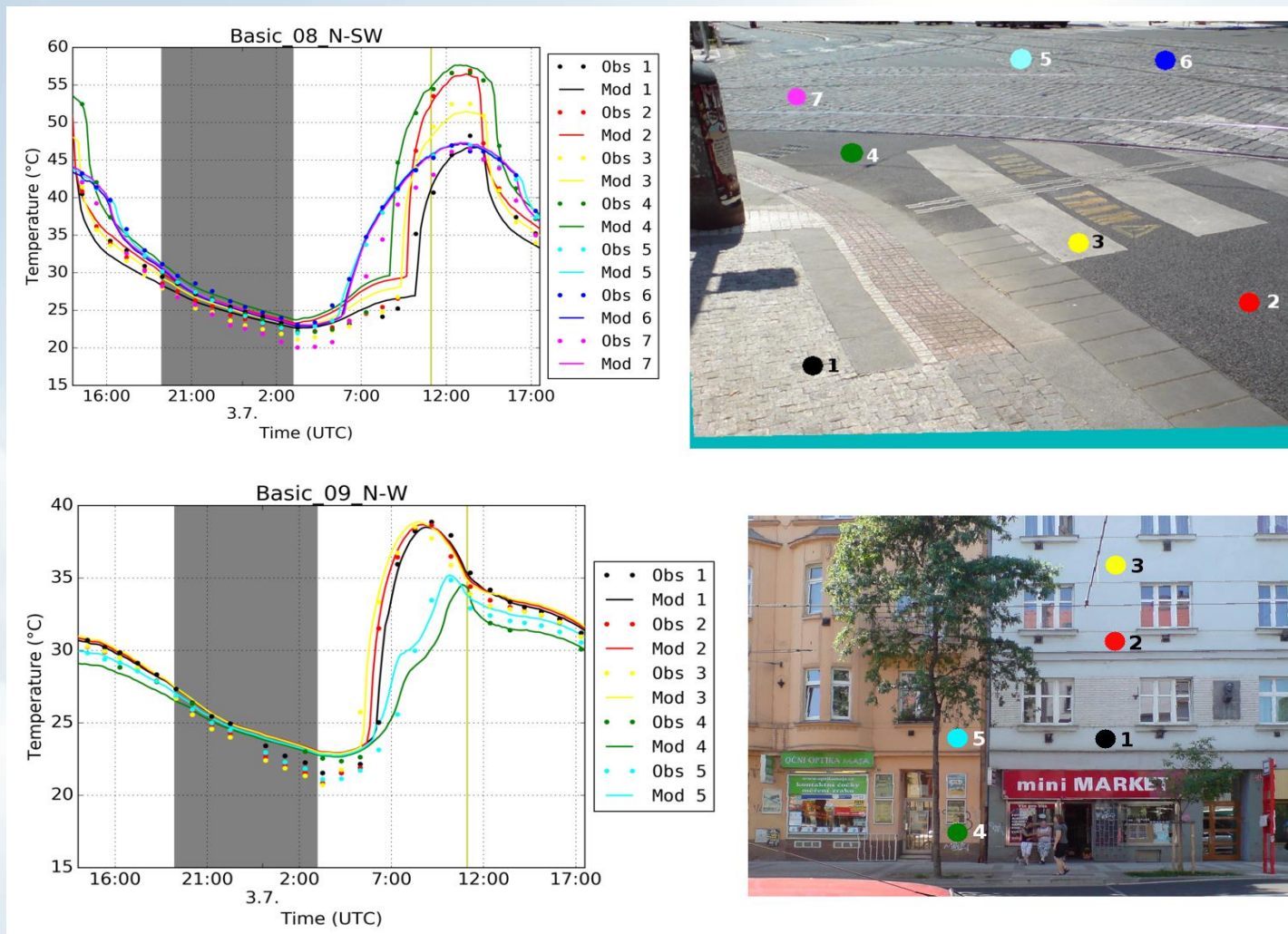


Sensitivity studies needed, two observation campaigns planned for summer and winter 2018.

How much can we trust the modelled results

Observation campaign with IR camera

- Heatwave episode (2.-3.7.2015)
- Prague-Holesovice area



Resler et al.: PALM-USM v1.0: A new urban surface model integrated into the PALM large-eddy simulation model
Geosci. Model Dev., 10, 3635-3659, <https://doi.org/10.5194/gmd-10-3635-2017>, 2017.

Observation campaign in Prague - Dejvice

Summer observations (10.7.-7.8.2018), winter observations (26.11.-6.12.2018)



Multidisciplinary cooperation

Cooperation in this research - projects:

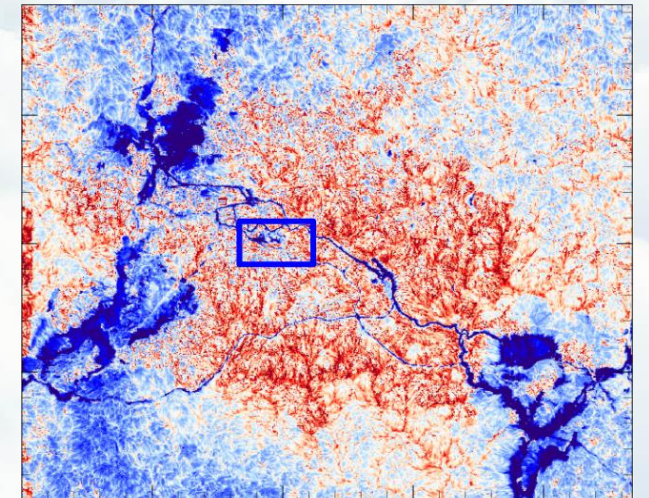
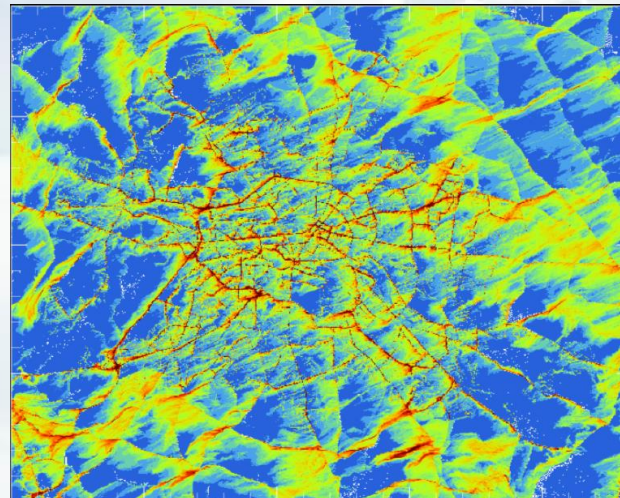
- Project UrbanAdapt (2014-2016)
- Project UrbiPragensi (2018-2020)
 - Charles Univ. in Prague
 - Institute of Computer Science Acad. of Sci.
 - Czech Hydrometeorological Institute
- Internal project support of Acad. of Sci.

Collaboration on practical applications:

- Prague Institute of Planning and Development
- Prague Municipality
- Operator ICT of Prague

International collaboration (research, model development:

- Germany - project MOSAIK, U2C
 - Universities (Hannover, Berlin, Hamburg,...)
 - KIT, DWD,...
- Finland
 - Finnish Meteorological Institute
 - University of Helsinki
- Austria (ZAMG) – in preparation





Jan Geletič

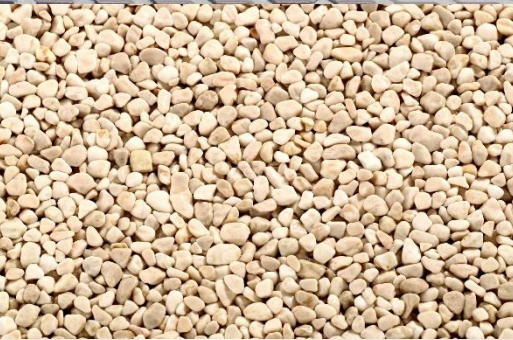
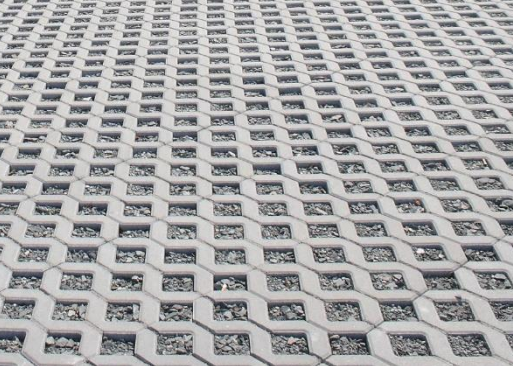
Input data, sensitivities

Input data

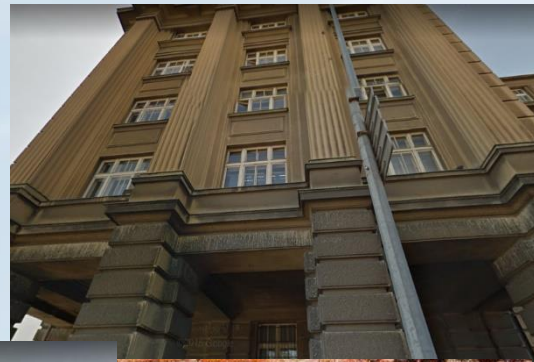
- Precise model outputs needs high quality data
- PALM-4U input data
 - Landcover
 - Buildings
 - Tree canopy
 - Meteorological conditions
 - Air pollutions etc.
- Important combination of multiple sources and data quality
- Sometimes are useful data „somewhere hidden“



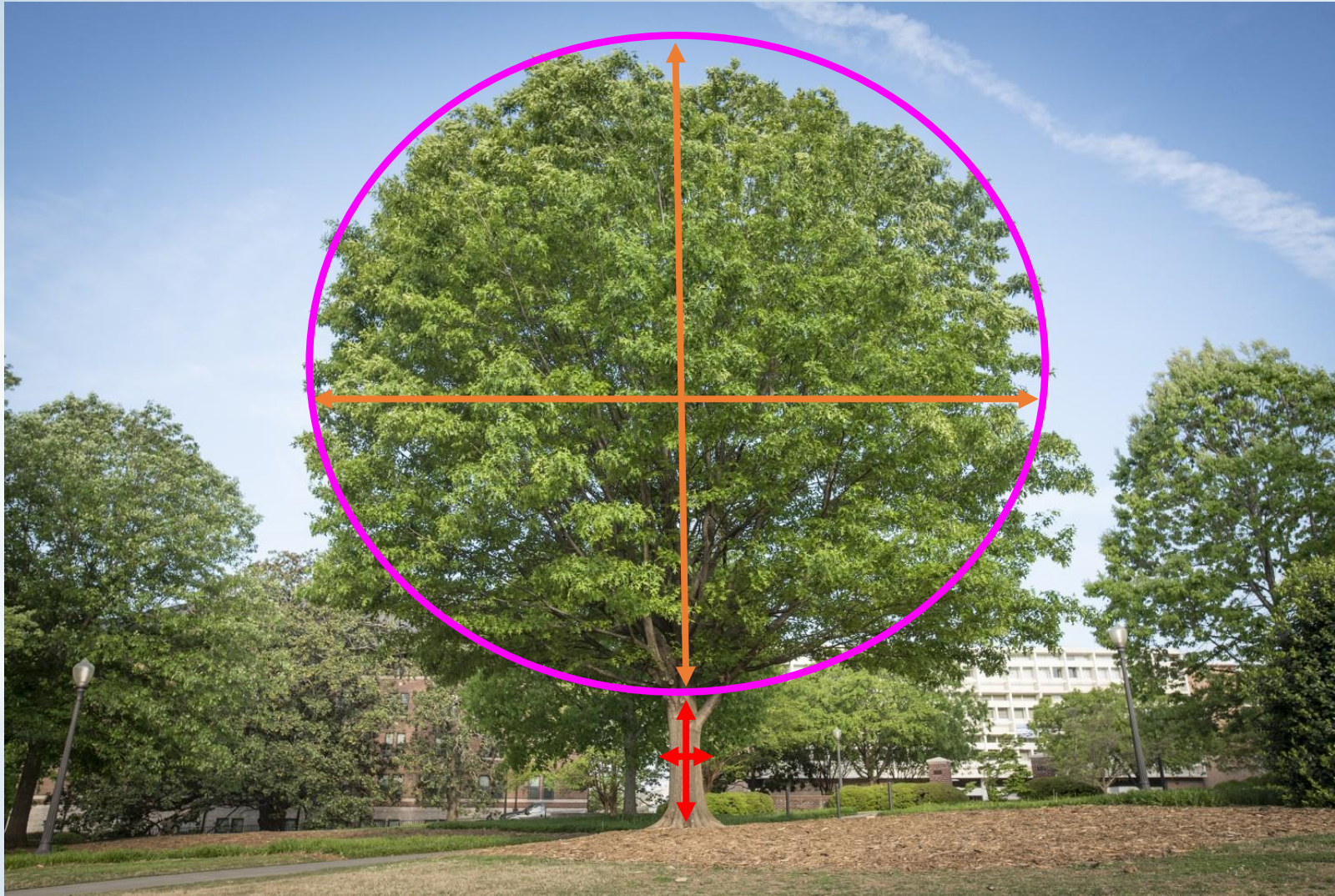
Input data - landcover



Input data - buildings



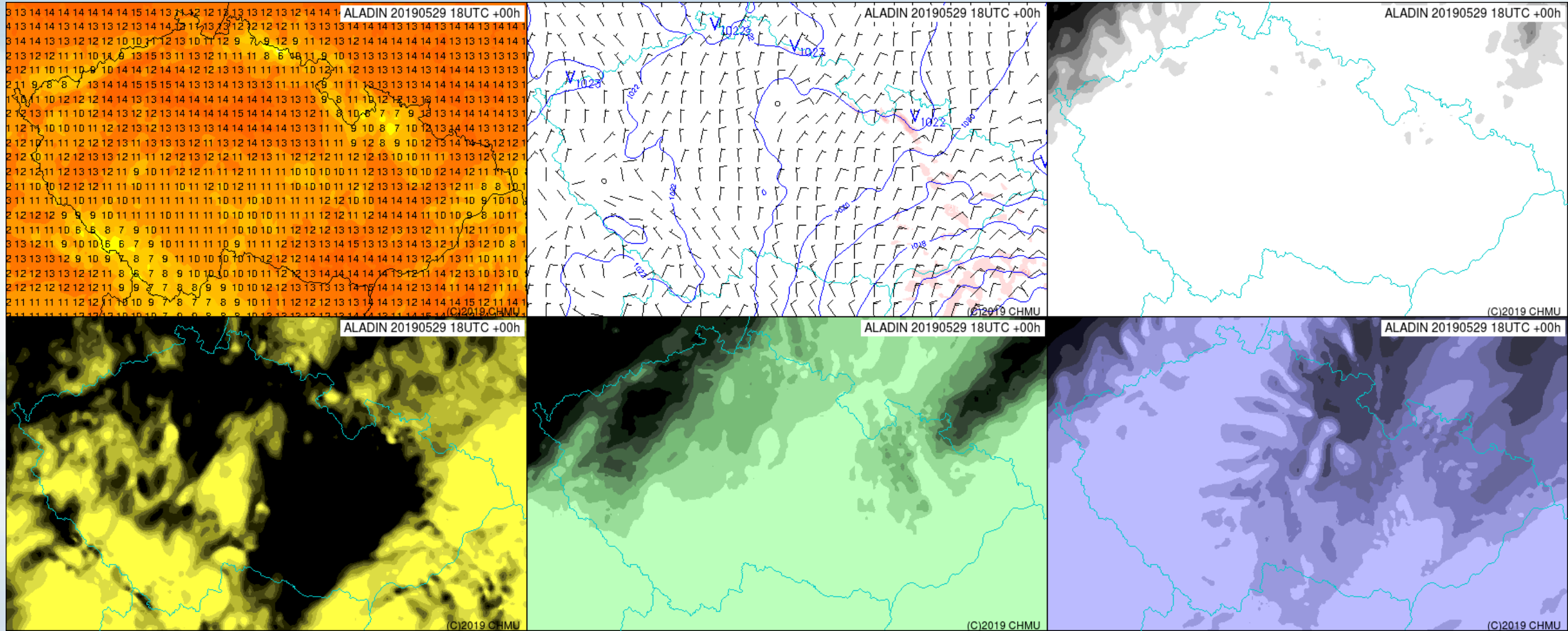
Input data – tree canopy



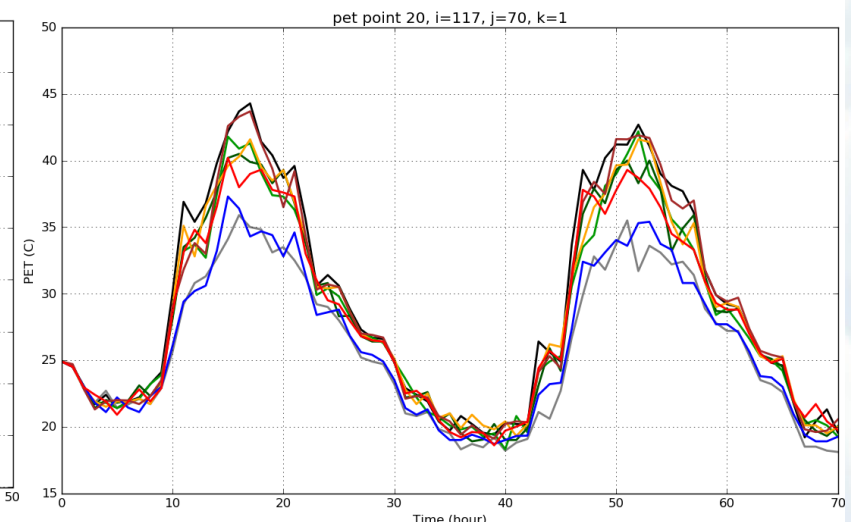
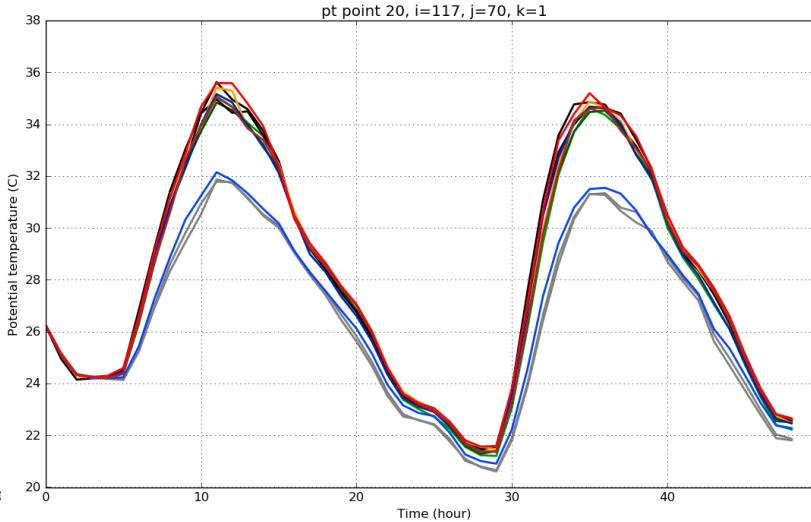
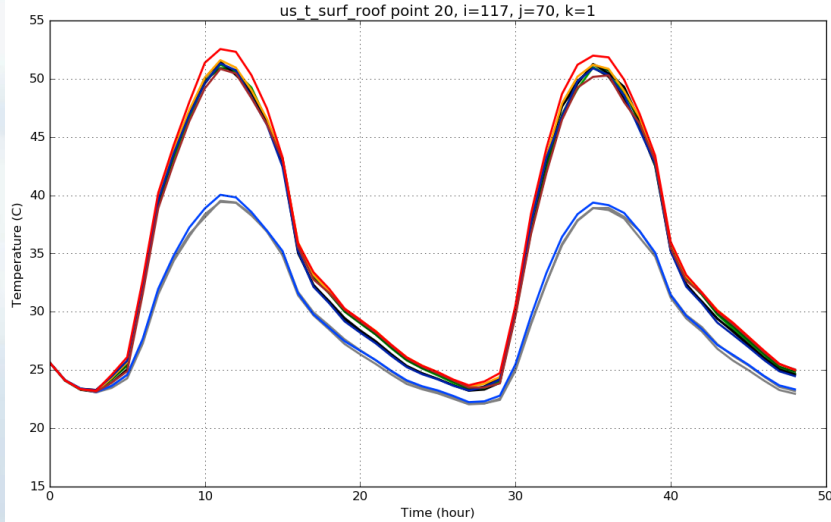
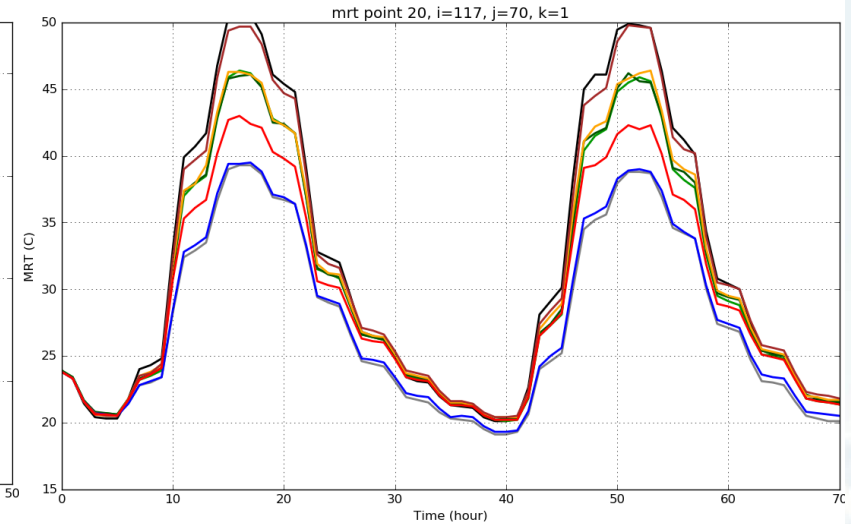
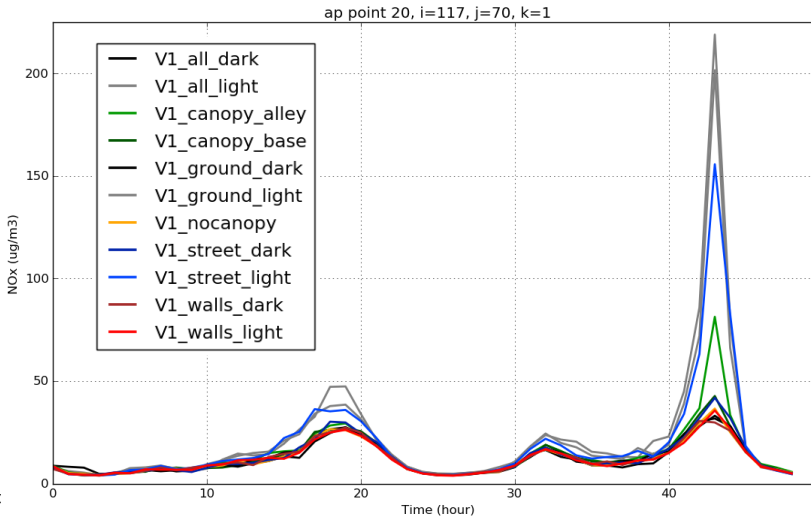
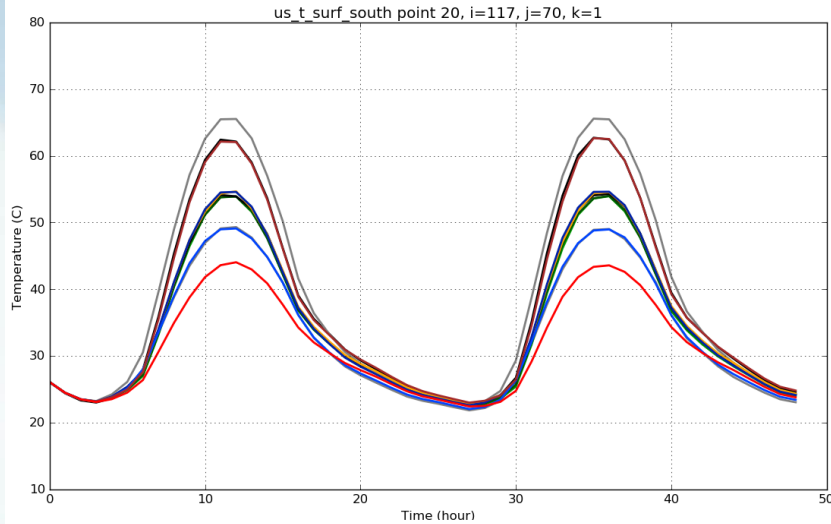
Properties:

- Tree height
 - Trunk height
 - Trunk radius
 - Crown height
 - Crown radius
 - Crown shape
 - Tree type
- > leaf area density (LAD)

Input data – meteorology, air pollution



Pavements – surface albedo sensitivity



A bright, sunny sky with white clouds and lens flare effects. The sun is in the upper right corner, creating a strong glow and lens flare patterns across the sky. The clouds are soft and white, filling the lower half of the image.

If you have any interesting data, we are
open for cooperation...



Pavel Krč

Use cases, scenarios

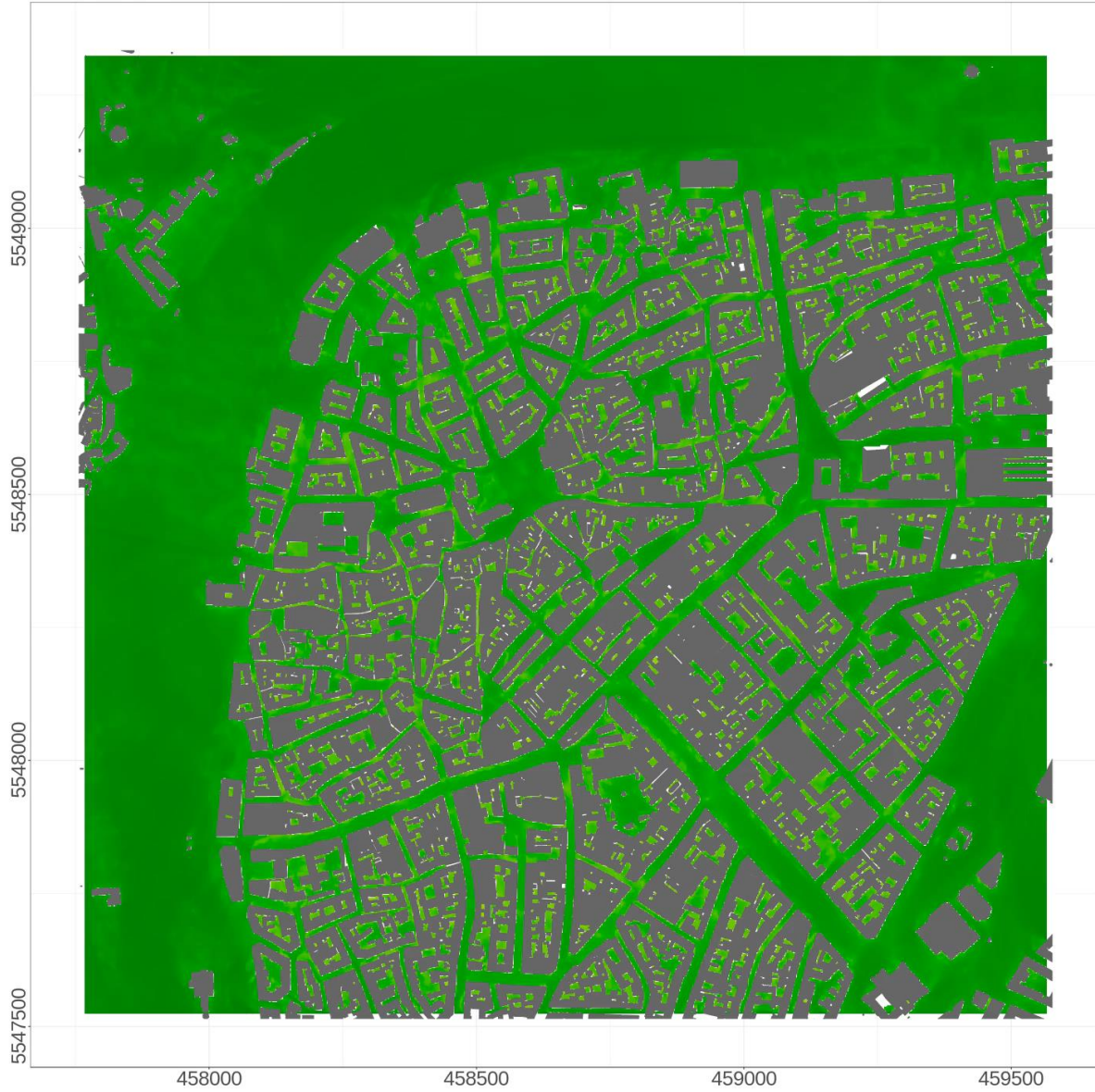
A complex urban area

Case study „Hradební korzo“

- Prague historical centre
- 3,2 km²
- 2m resolution
- 24 hour simulation
 - Summer scenario (heat-wave)
 - Winter scenario (inversion)
- Cooperation with IPR



2018-08-07 00:10 UTC

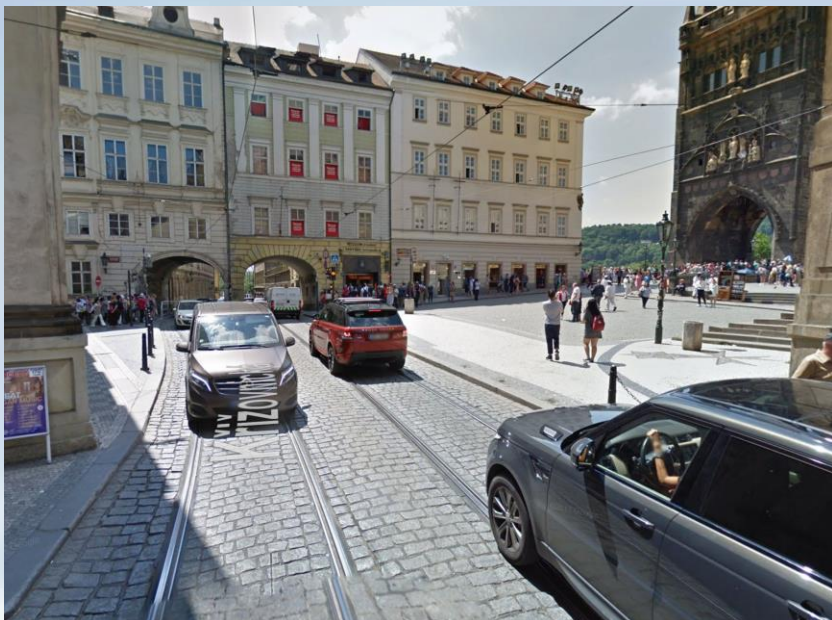


PET [°C] <10 20 30 40 50 60 70>

2018-08-07 00:10 UTC



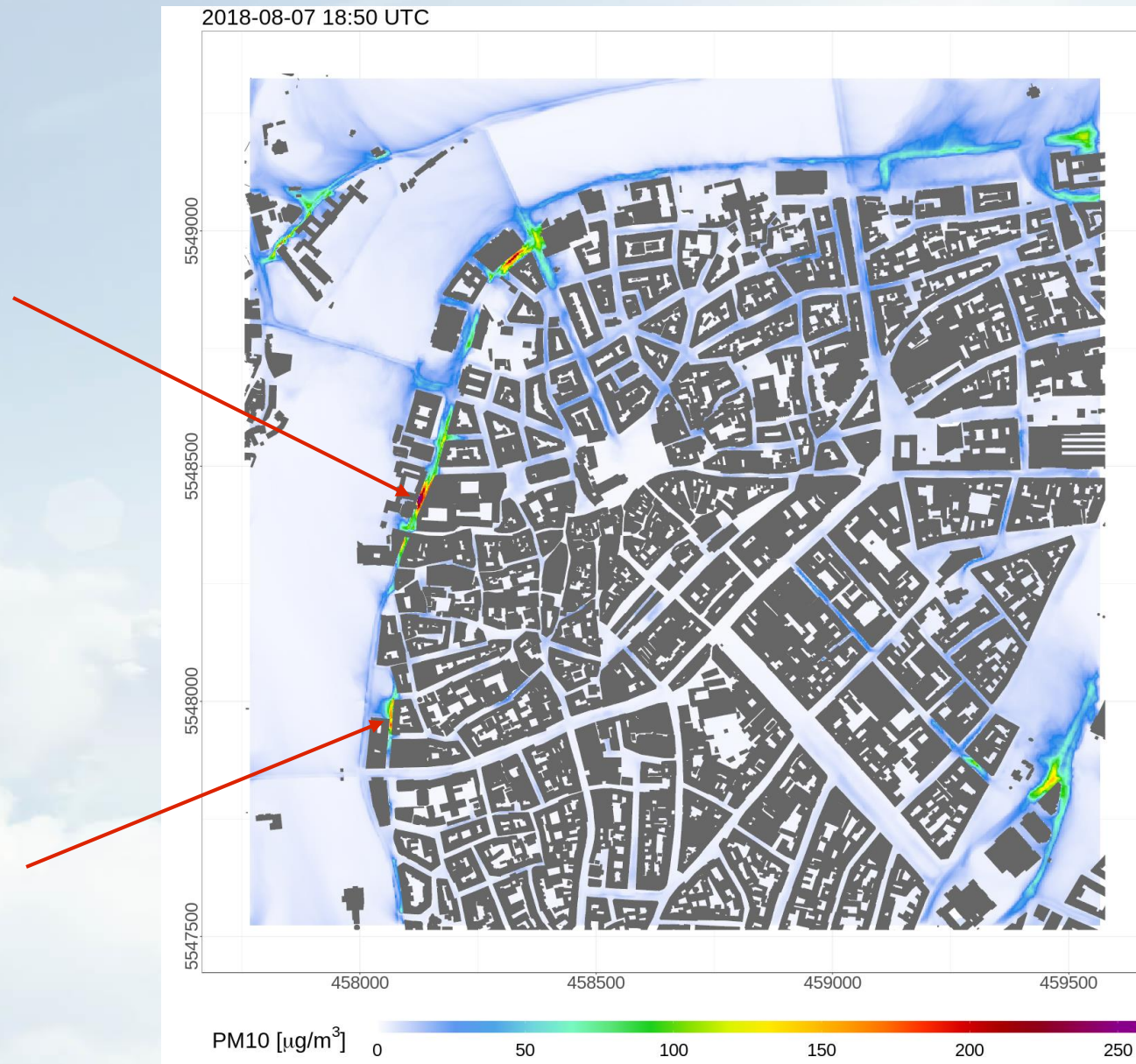
PM10 [µg/m³] 0 50 100 150 200 250



Křižovnické náměstí



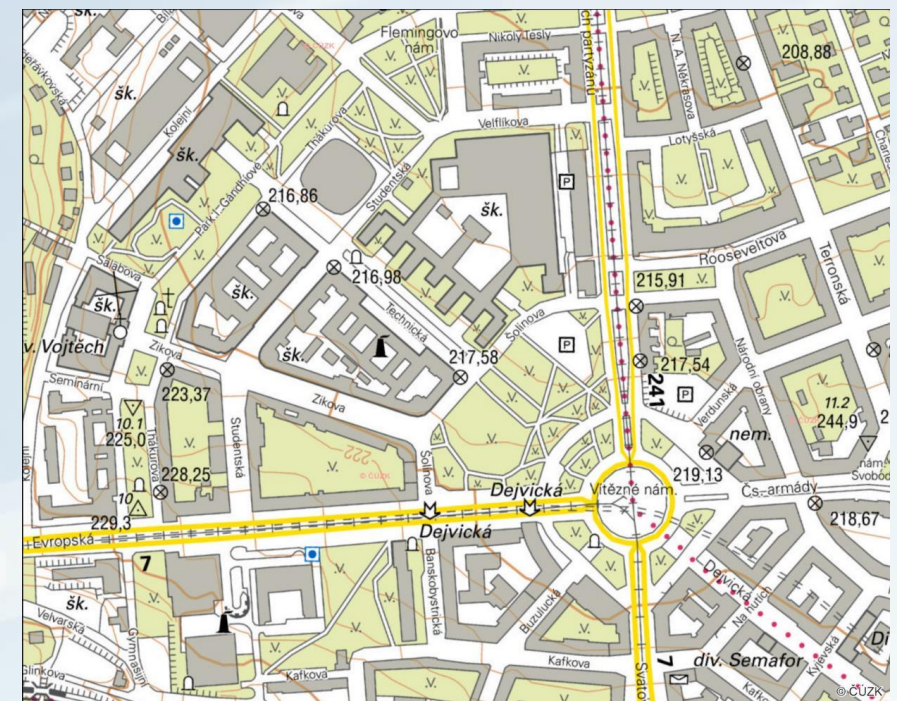
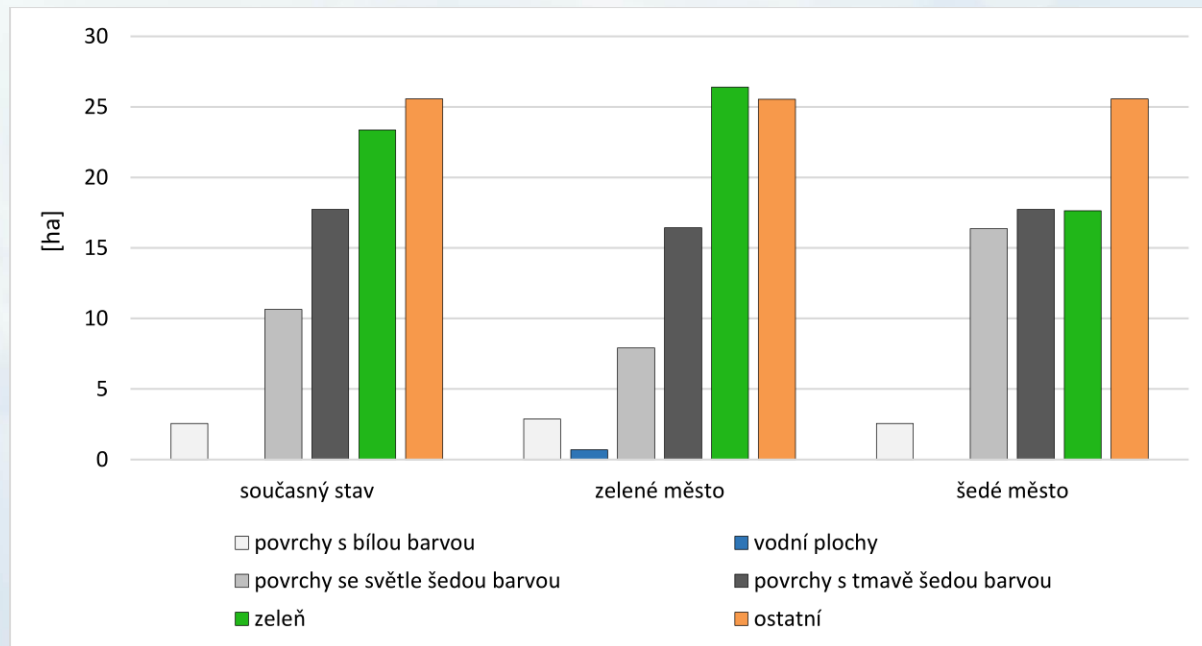
Divadelní



Particular urban scenarios

Prague-Dejvice area

- Green city scenario
- Grey city scenario



Landcover

Green city:

- New grass cover
- New ponds
- Bright pavements
- ~500 extra trees

Grey city:

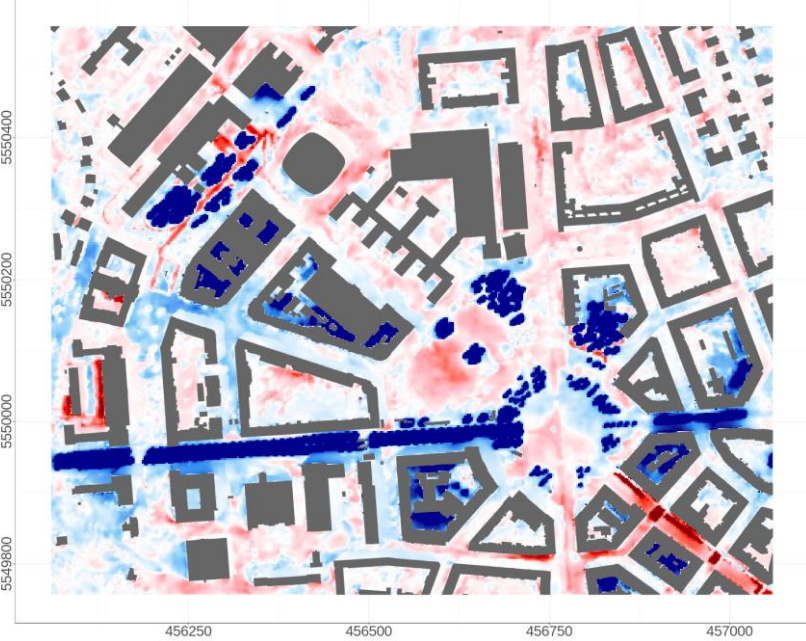
- Minimal grass cover
- ~500 fewer trees



15:00 CEST

2 hours after noon

2015-08-07 13:00 UTC



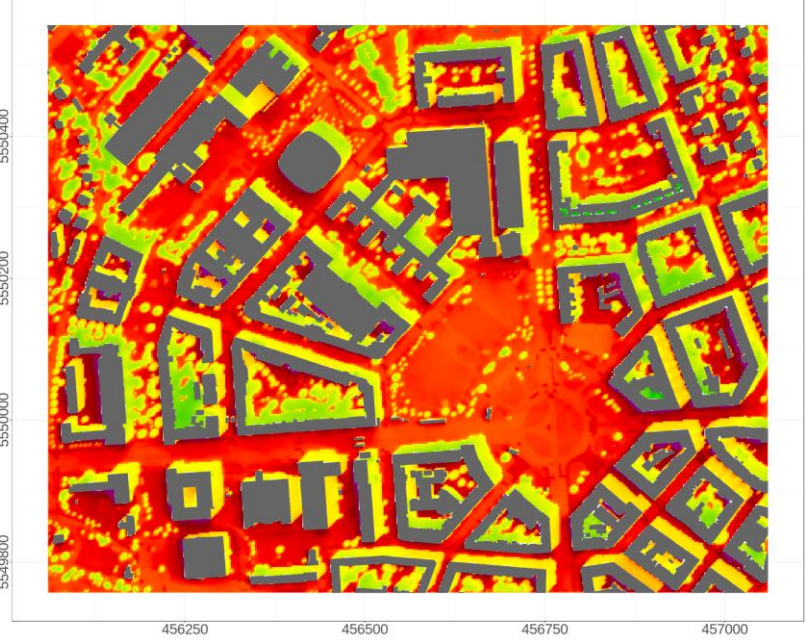
PET [°C] <-5 -4 -3 -2 -1 0 1 2 3 4 5>

2015-08-07 13:00 UTC



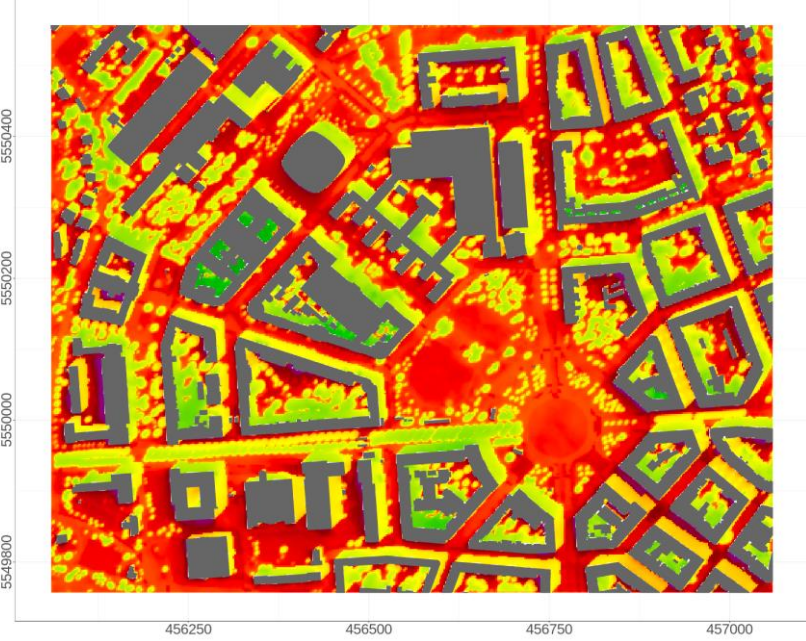
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2015-08-07 13:00 UTC



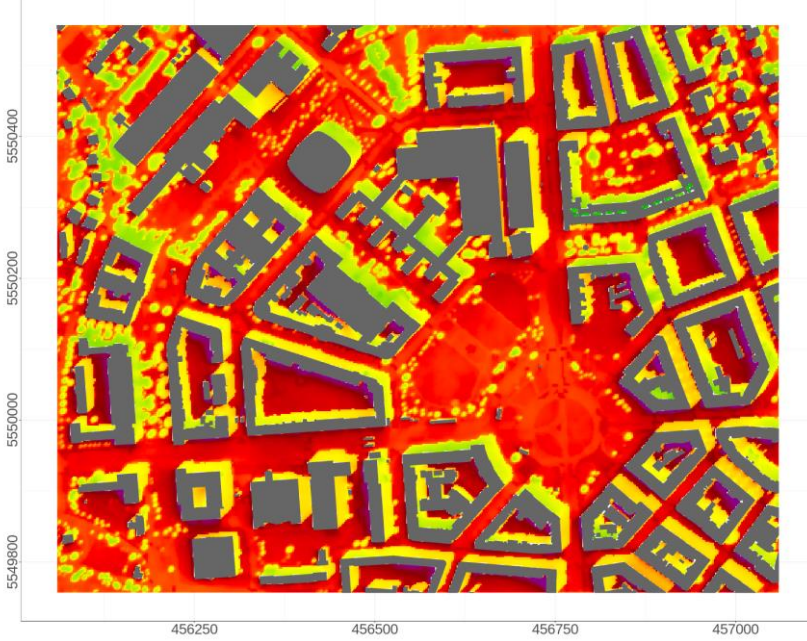
PET [°C] <20 30 40 50 60 70>

2015-08-07 13:00 UTC



PET [°C] <20 30 40 50 60 70>

2015-08-07 13:00 UTC

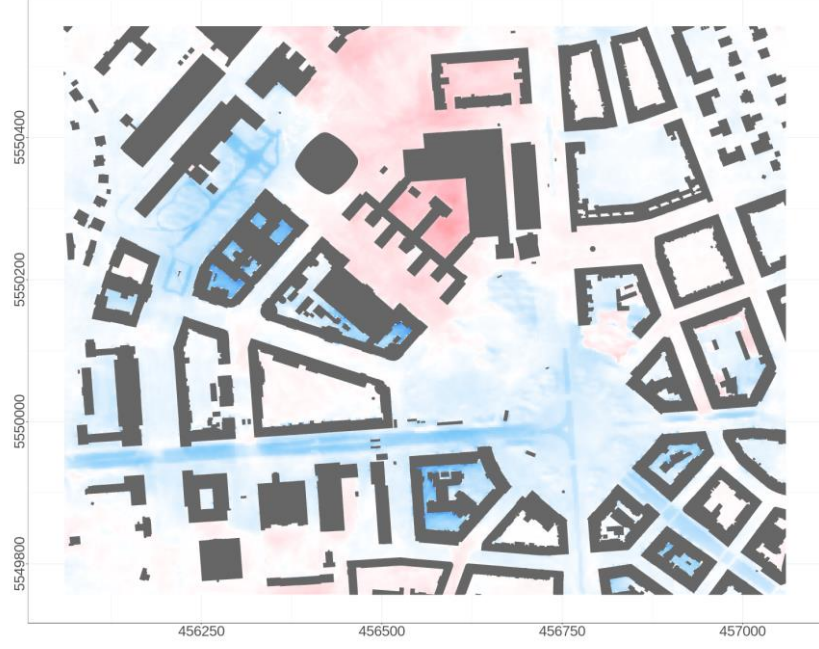


PET [°C] <20 30 40 50 60 70>

22:00 CEST

~2 hours after sunset

2015-08-07 20:00 UTC



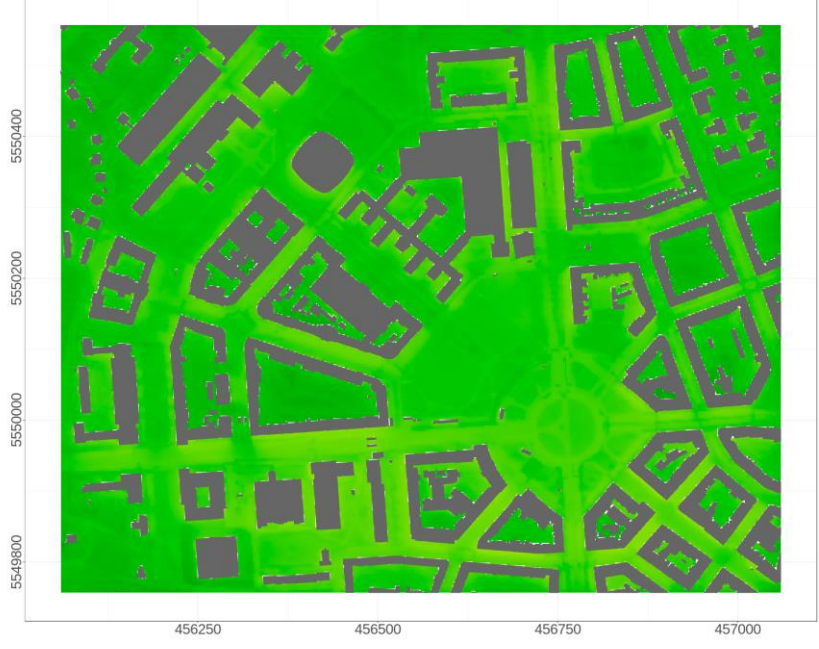
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2015-08-07 20:00 UTC



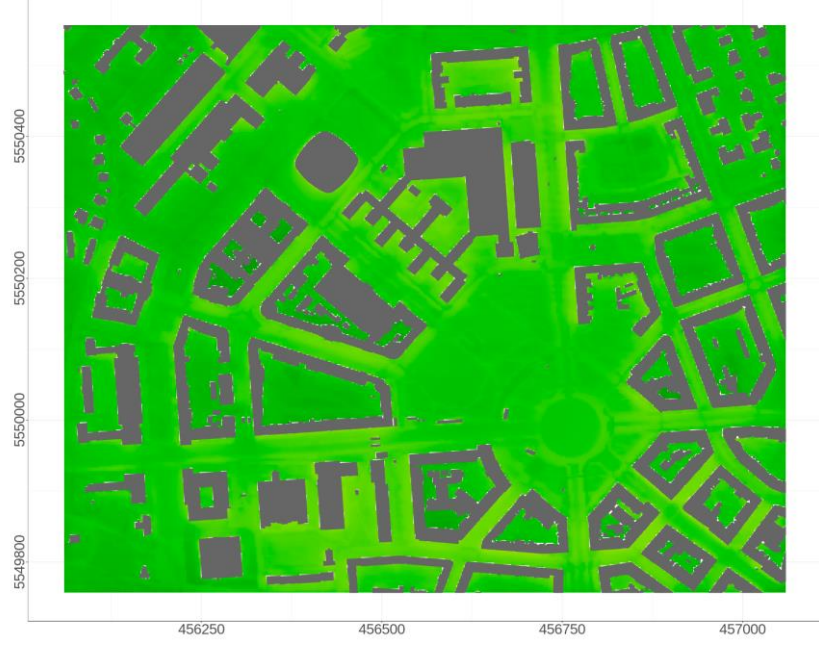
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2015-08-07 20:00 UTC



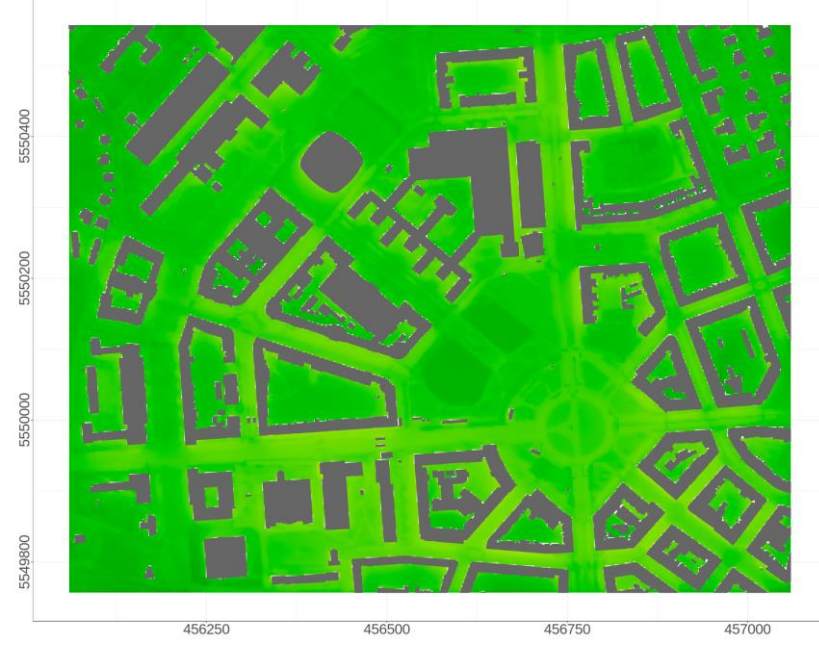
PET [°C] <20 30 40 50 60 70>

2015-08-07 20:00 UTC



PET [°C] <20 30 40 50 60 70>

2015-08-07 20:00 UTC

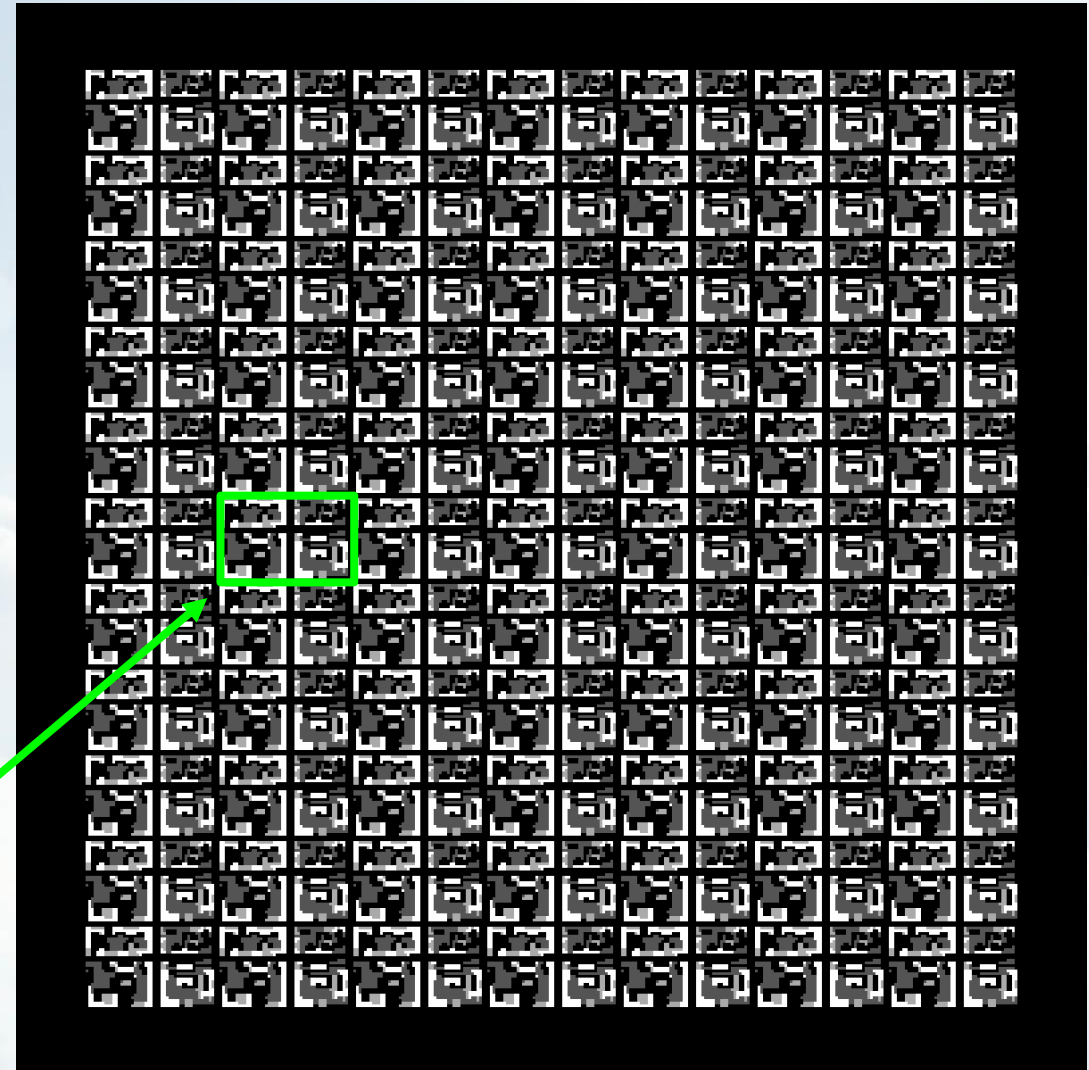
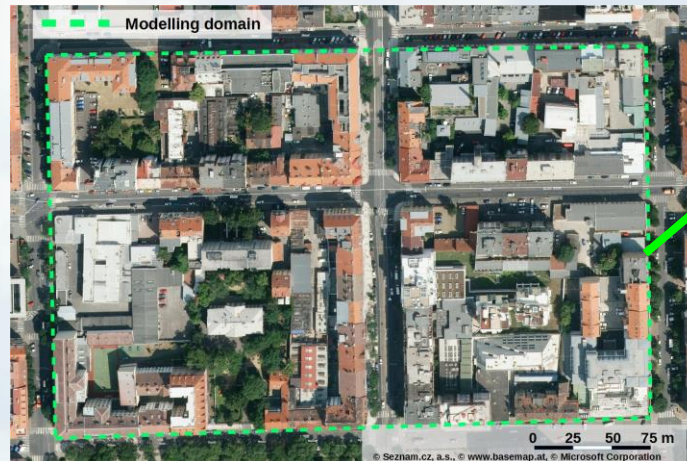


PET [°C] <20 30 40 50 60 70>

Generic urban development measures

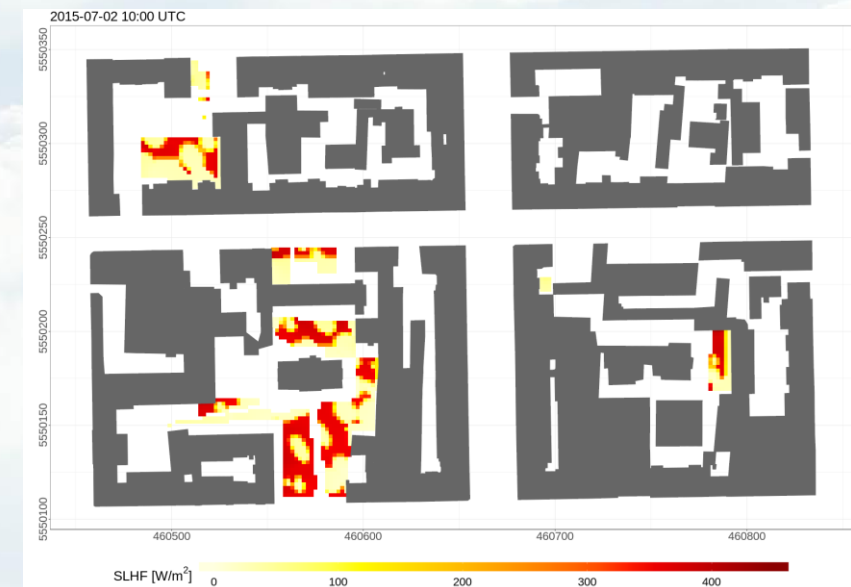
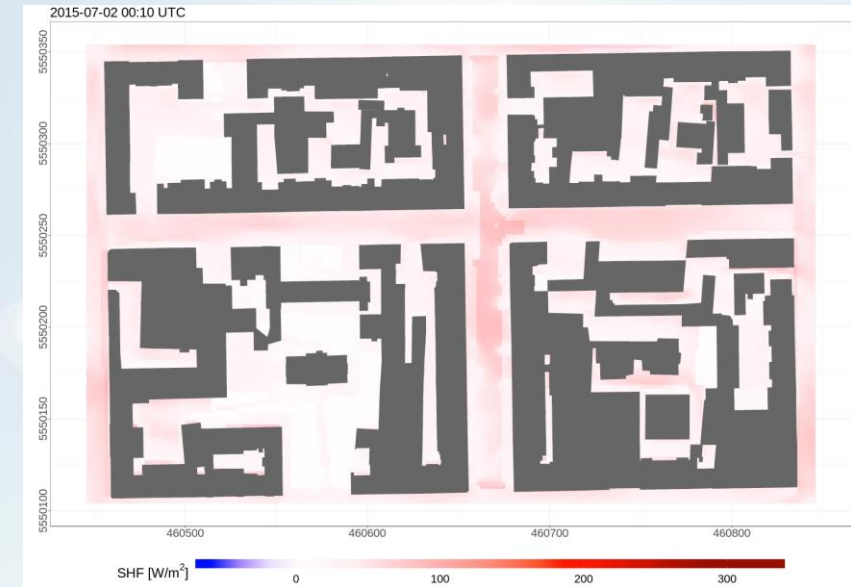
- Building height (street canyon ratio)
- Pavement surfaces
- Green tram tracks
- Insulated buildings
- Blue infrastructure
- Grey cities
- Green cities

7×11 raster

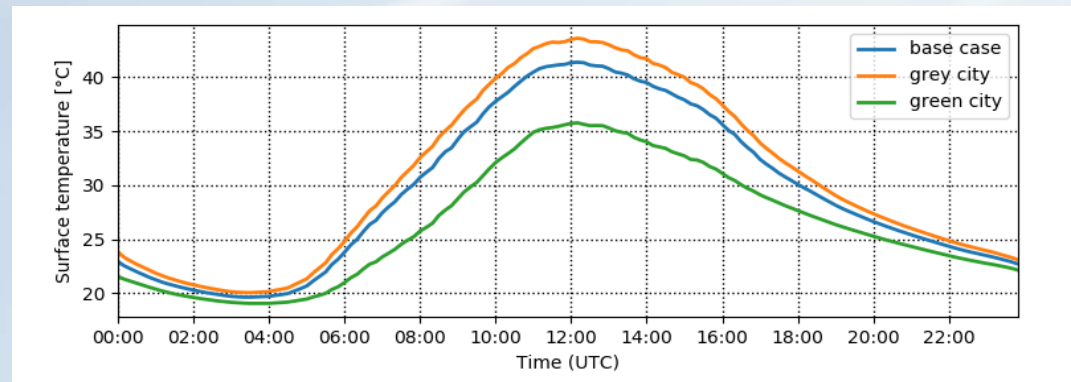


Data output & evaluation

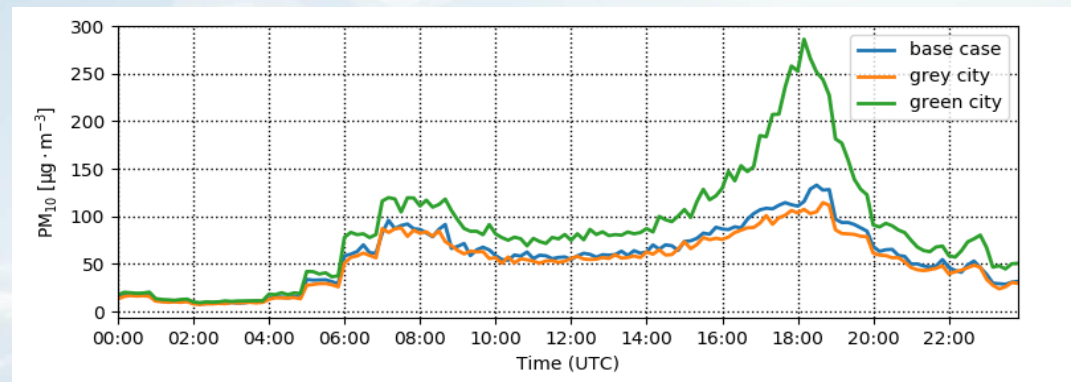
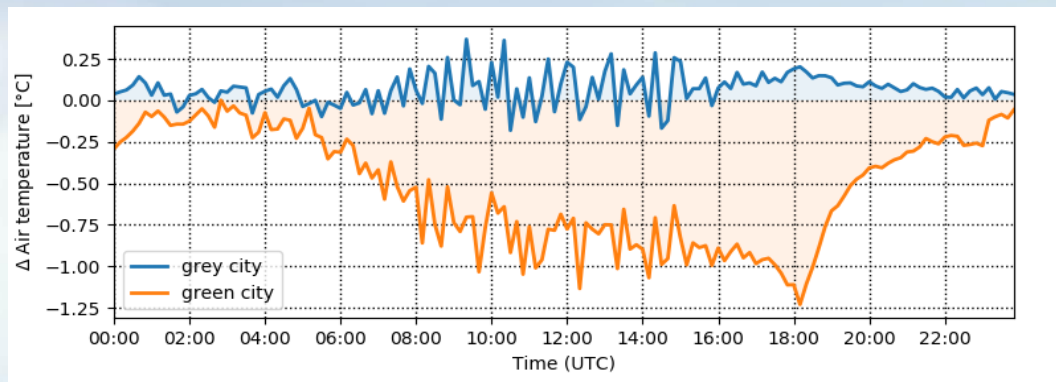
- Air temperature
- Biometeorological indices
 - MRT, PET, UTCI, PercT, wind comfort, ...
- Surface temperature
 - ground, walls
- Surface heat flux
- Latent heat (evapotranspiration)
- Air quality
 - SO_2 , NO_x , PM_{10} , $\text{PM}_{2.5}$, O_3 , VOC, ...



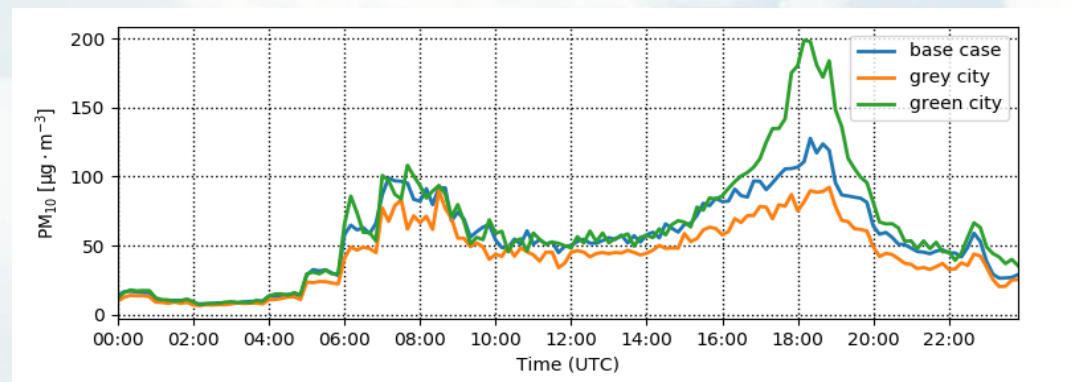
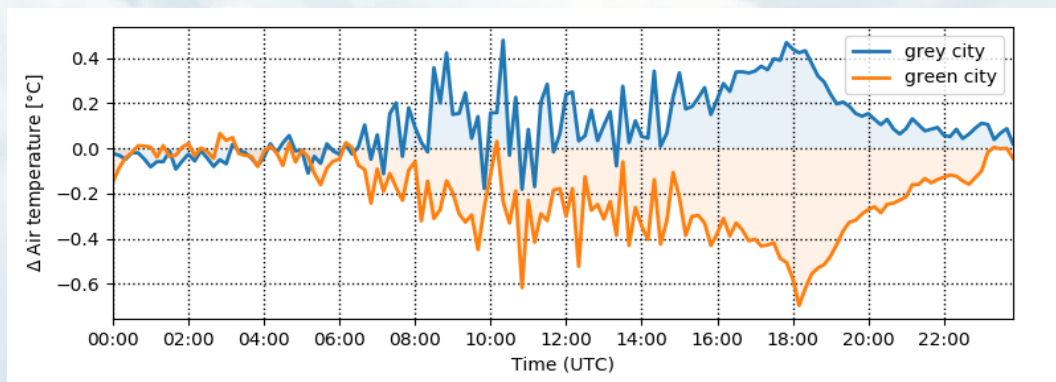
Green / grey city



Dělnická

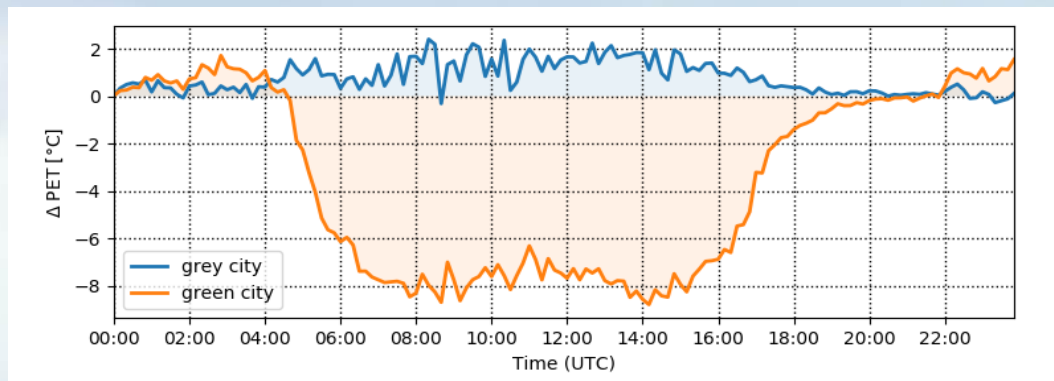


Komunardů

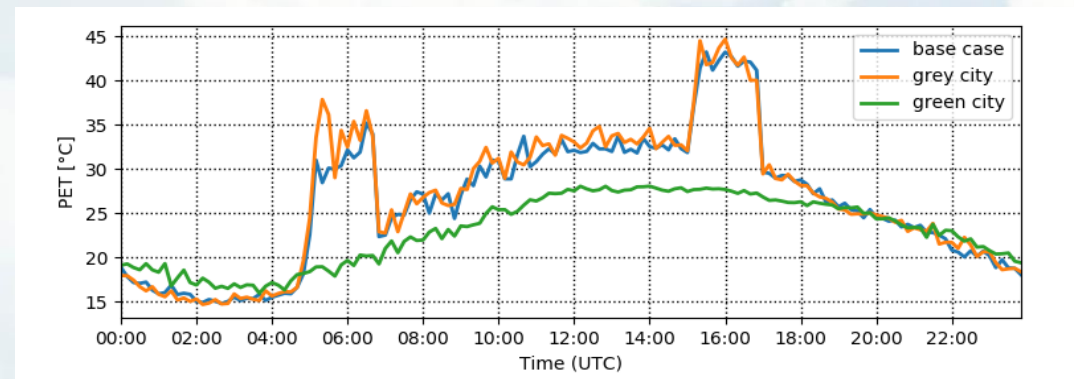
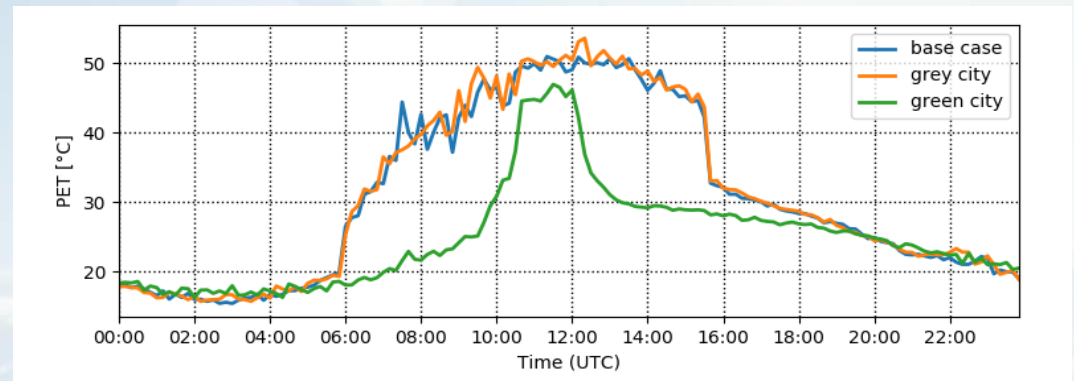
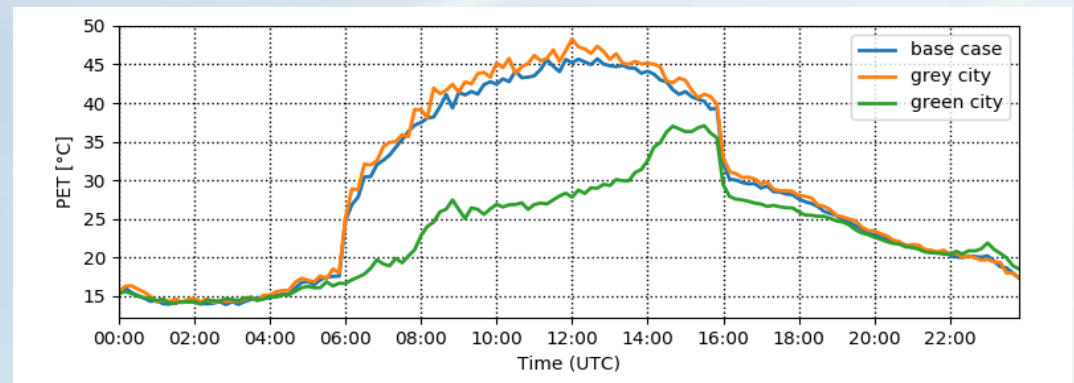
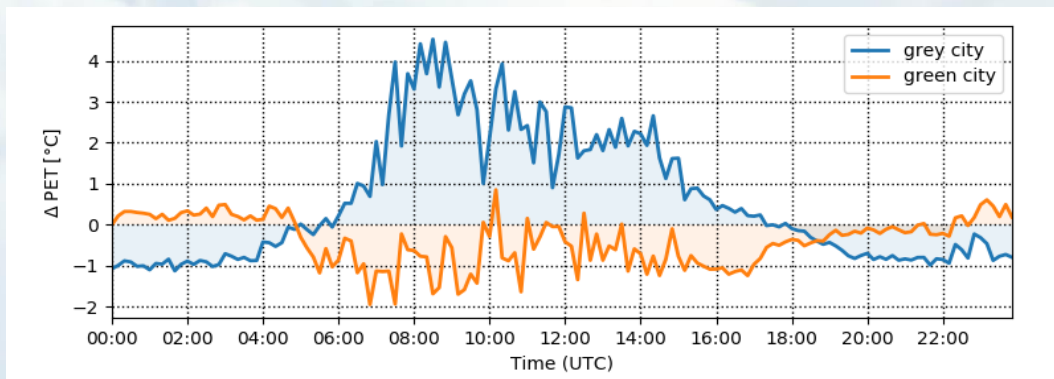


Green / gray

Dělnická



Komunardů



Thank you for your attention...

Invitation to workshop (CAMP, 13:15)

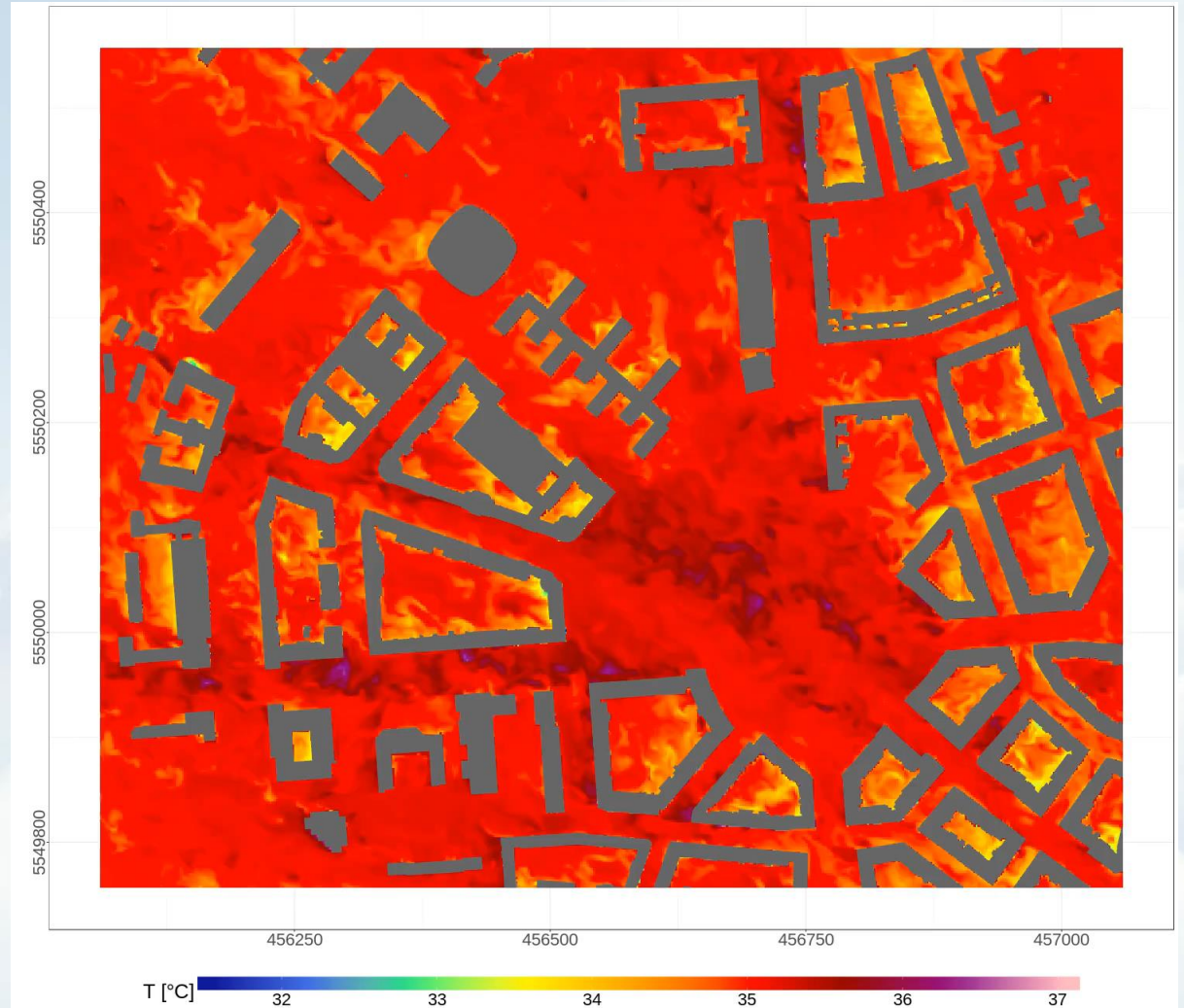
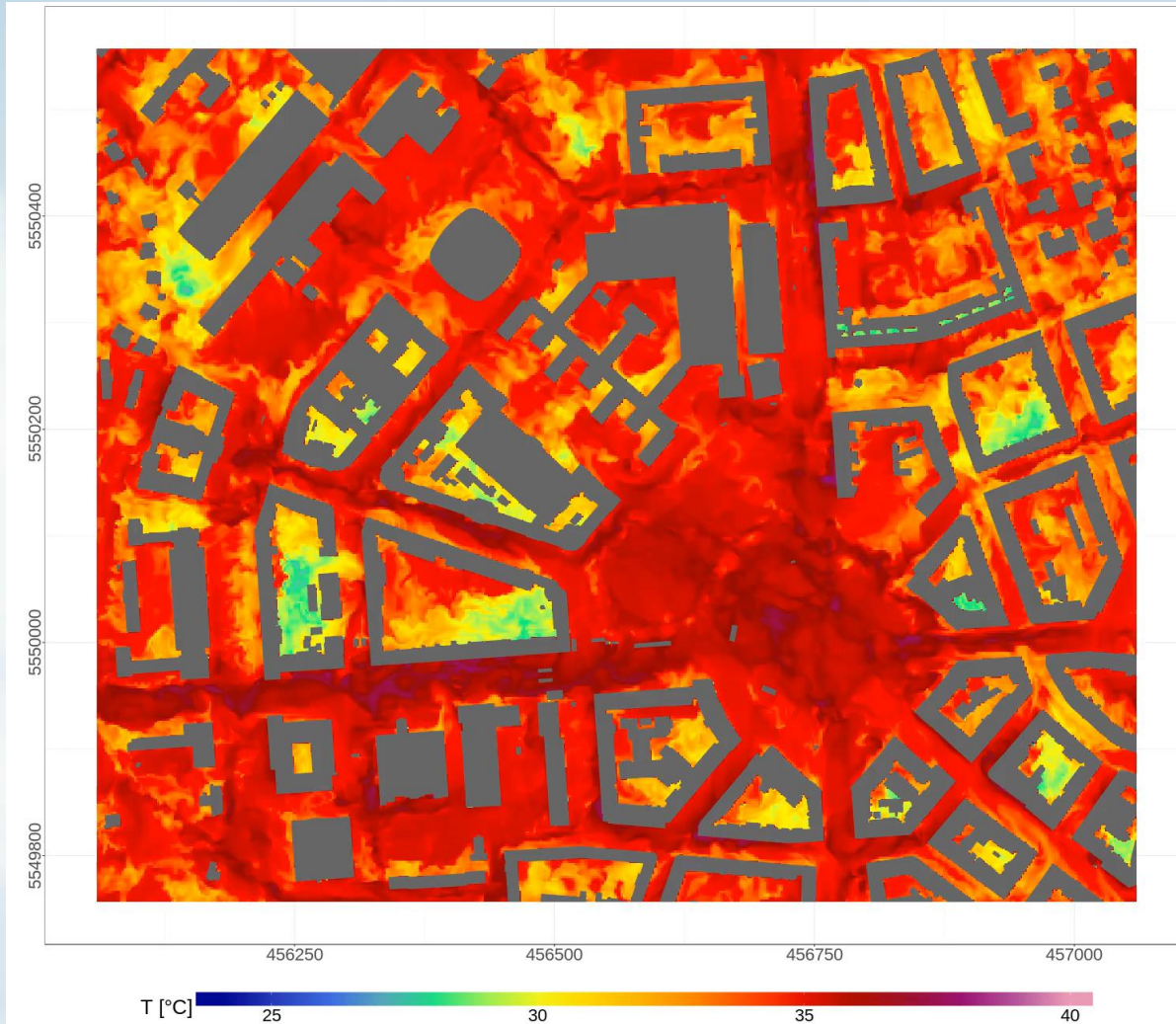
Contacts

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Pavel Krč: krc@cs.cas.cz

Jan Geletič: geletic@cs.cas.cz

Prague-Dejvice – first results (T_{air})



Simulation of air temperature in 1 m (left) and 17 m (right) on 7.8.2015 from 15:00 to 16:00 CET, speeded-up to 30 seconds