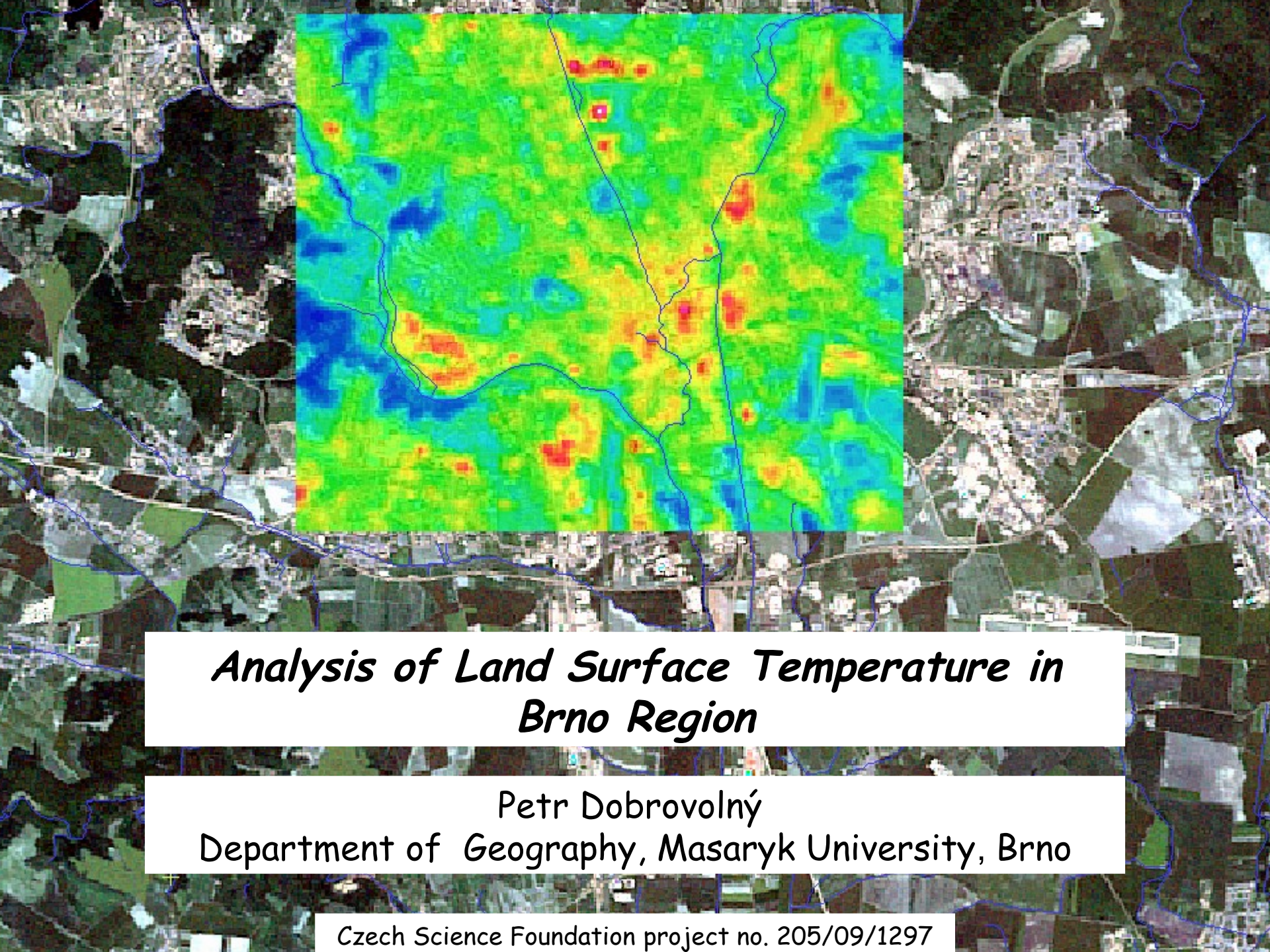


Analysis of Land Surface Temperature in Brno Region

Petr Dobrovolný
Department of Geography, Masaryk University, Brno

Czech Science Foundation project no. 205/09/1297

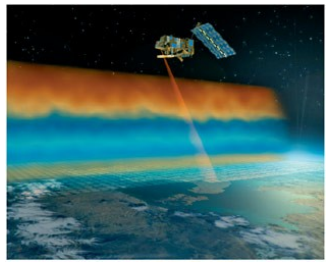
Outline

1. Motivation
2. Multilevel approach and UHI as an example
3. Air temperature variability
4. Land Surface Temperatures derived from satellite measurements
5. Spatial variability of Land Surface Temperatures w.r.t. land cover types
6. Summary and outlook

Motivation

Are we able to detect any signal of higher temperatures within a city compared to its neighborhoods?

- **Urban** build-up areas can be considered as a **hierarchical system** of several levels.
- Such system is typical with a **considerable** temporal and spatial **differentiation** of fields of meteorological elements.
- **Data of different resolution** in time and space can be successfully used to analyze spatial and temporal variability of climate in urban environment.

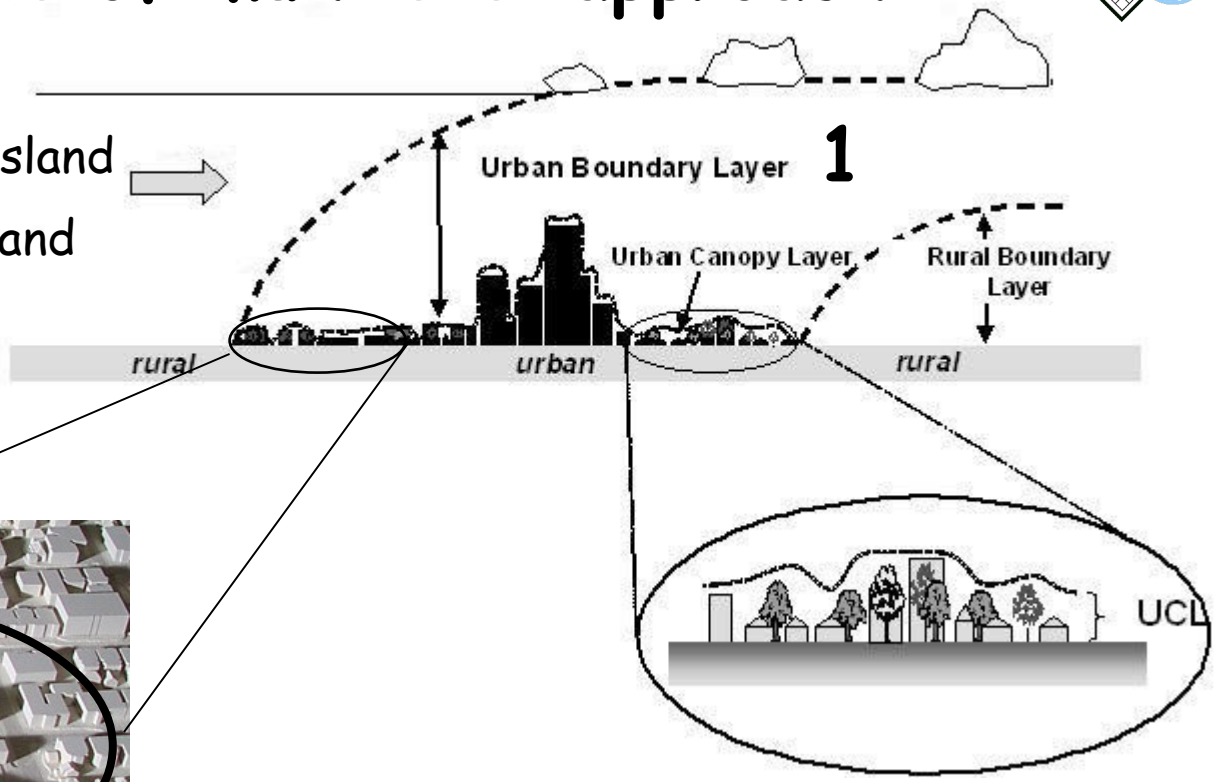


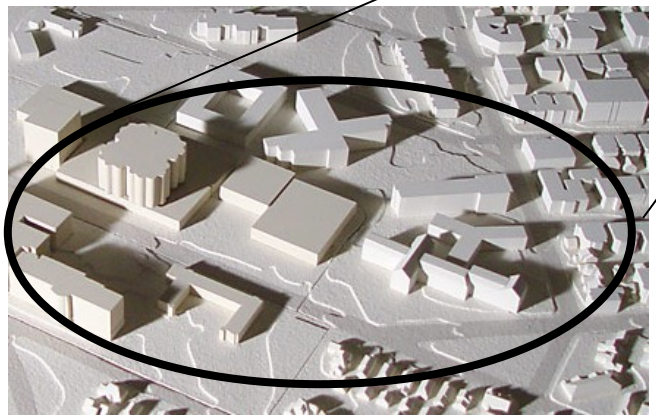
Project no. 205/09/1297 **Multilevel analysis of the urban and suburban climate taking medium-sized towns as an example** (2009-2012)

UHI as an example of multilevel approach

1. Boundary layer urban heat island
2. Canopy Layer urban heat island
3. Surface urban heat island

(adapted from Oke 1976)





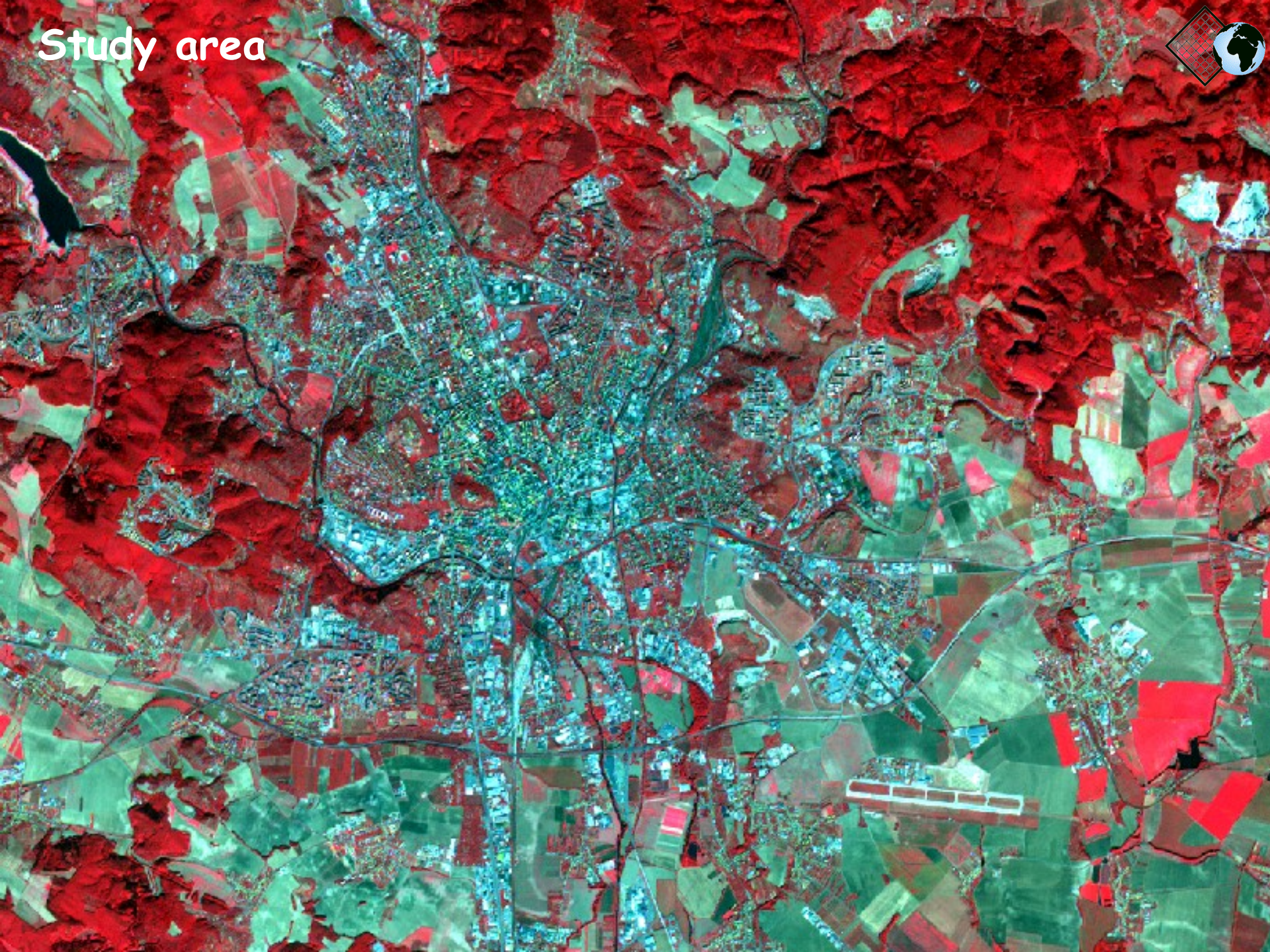
3

Methods of remote sensing

2

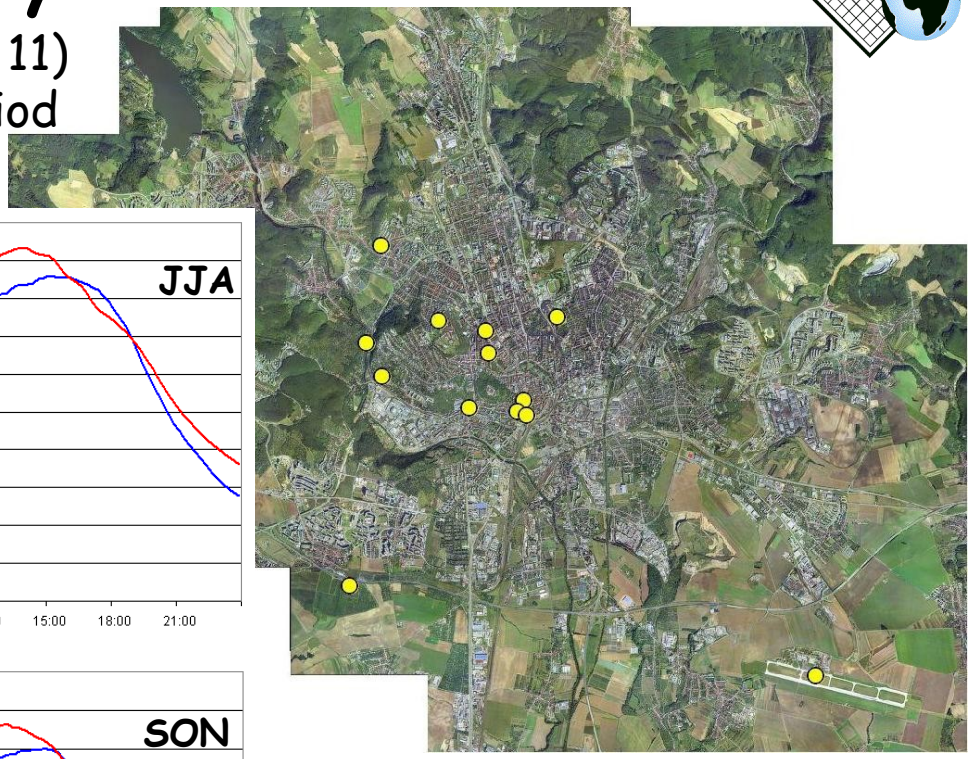
Special-purpose measurements

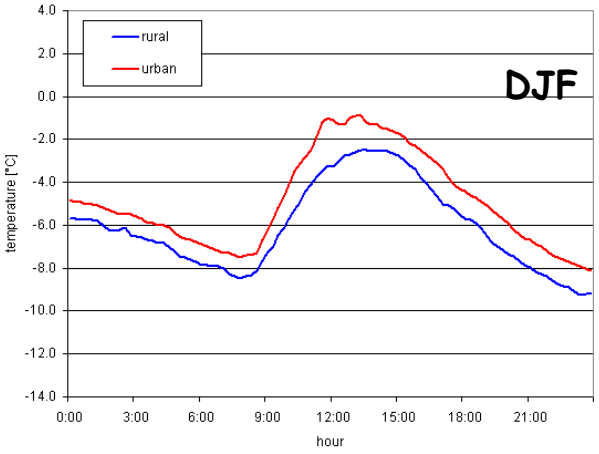
Study area

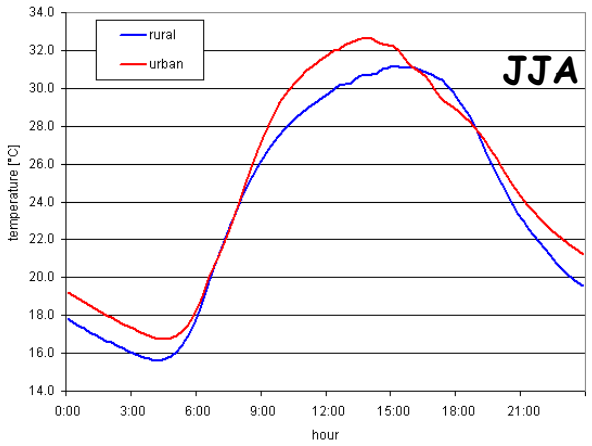


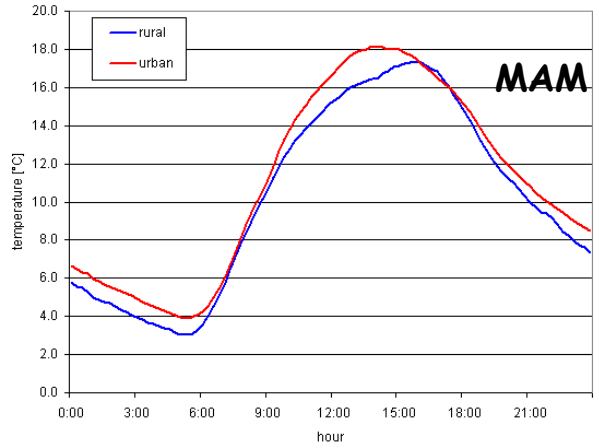
Air temperature variability

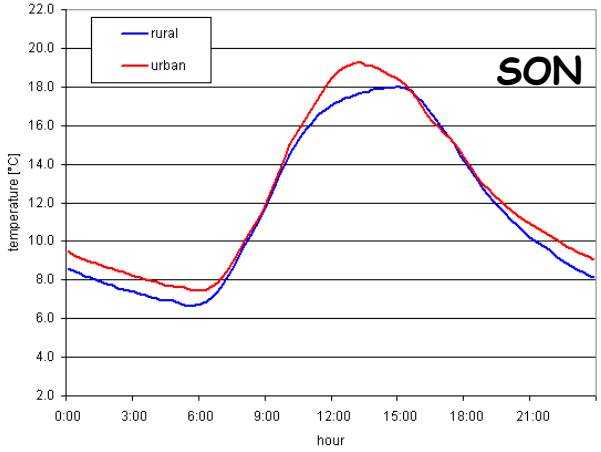
69 days (DJF 4, MAM 19, JJA 35, SON 11) with „radiation" weather type in the period 1 Jan. 2009 – 31 Jul. 2010







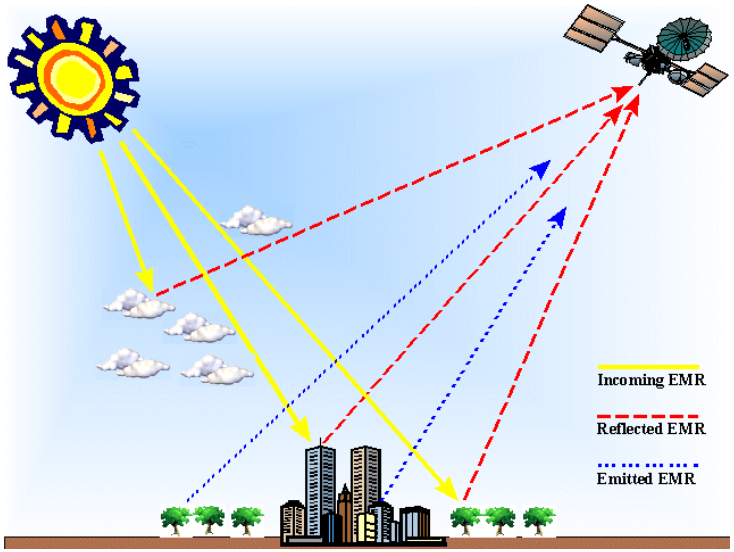


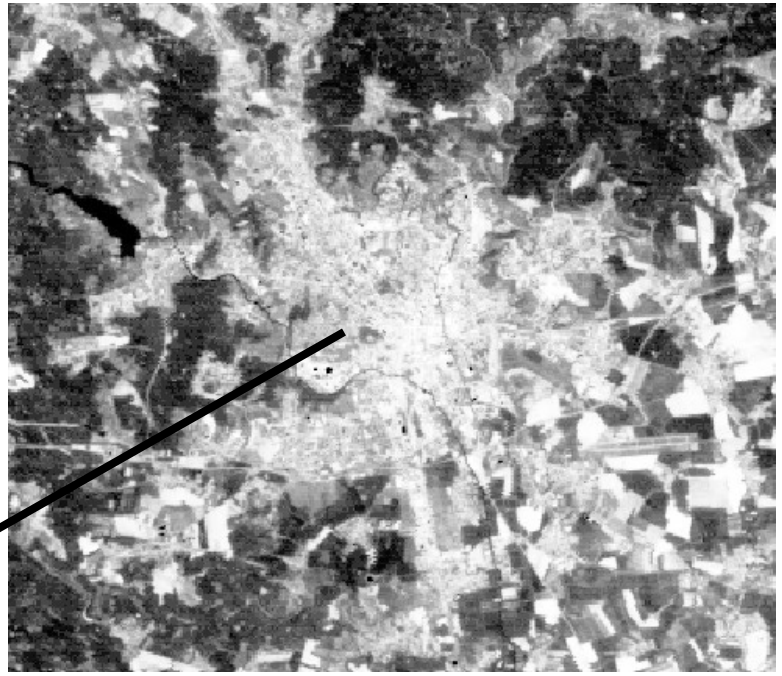


- In winter urban stations are all day 1–2 °C warmer compared to rural stations
- Maximum temperature occurs 1–1.5 hr earlier at urban stations

- Temperature differences between urban and rural stations show a clear daily cycle with maximum at mid-day (more than 2°C in summer).
- Urban – rural T differences are minimal in morning (7–8) and evening (17–19 hours).

Land Surface Temperatures - LST





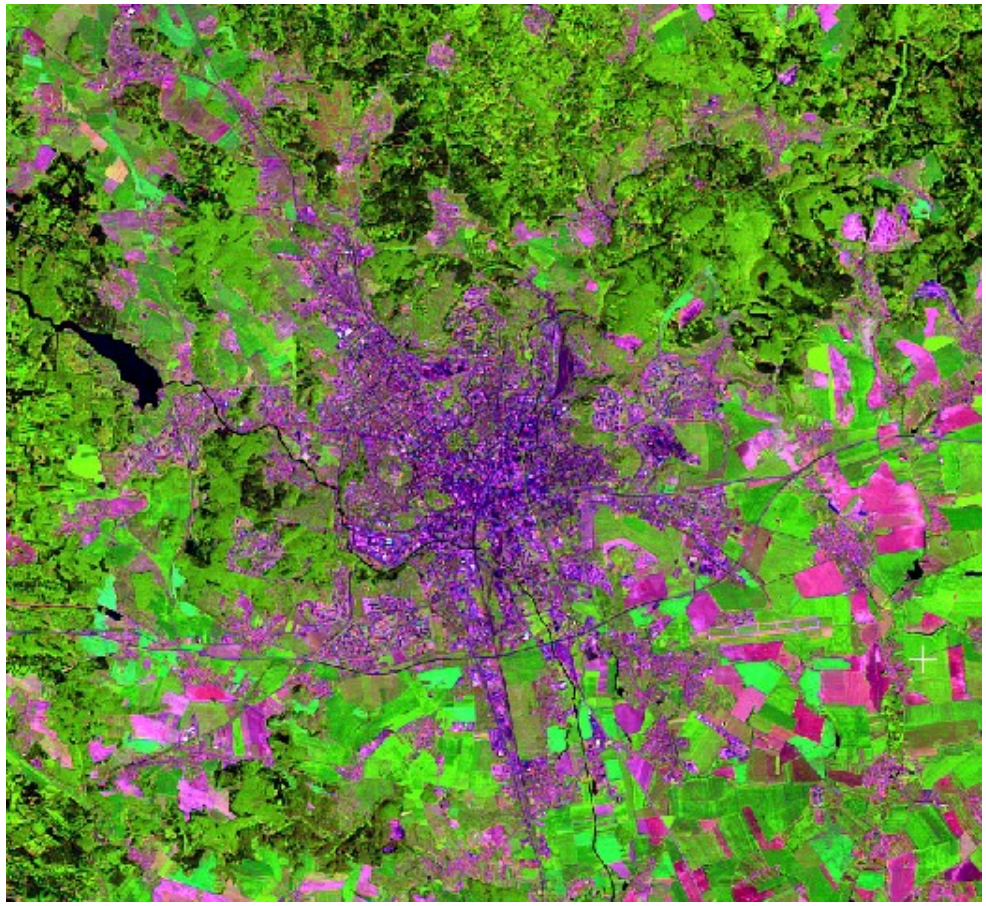
Digital Numbers

```
131 131 132 132 140 140 144
131 131 132 132 140 140 144
129 129 128 128 132 132 135
129 129 128(128)132 132 135
131 131 131 131 132 132 132
131 131 131 131 132 132 132
135 135 131 131 135 135 134
```

DN = f(LST)

Data description

- LANDSAT 7 satellite
- Scanner ETM+
- date 24 May 2001
- time 9:35:02 GMT
- Thermal band 10.4–12.5 µm
- Spatial resolution 60 m



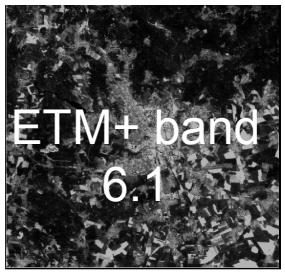
Typical radiation type of weather

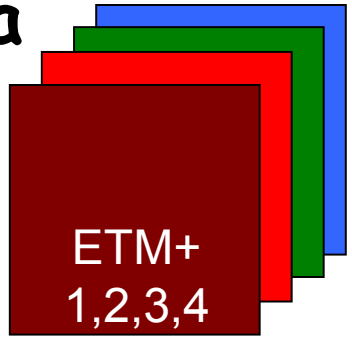
Synoptic situation NEa

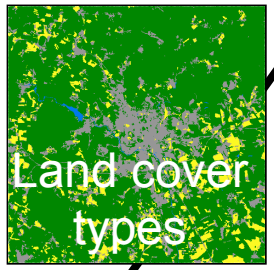
T_{min} 8.4°C T_{max} 23.3°C T_{mean} 17.6°C $T_{ground\ min}$ 5.0°C

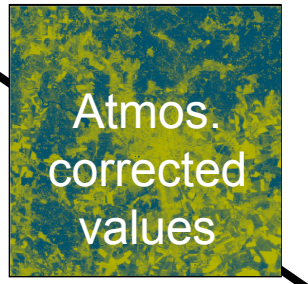
LST derivation from LANDSAT data

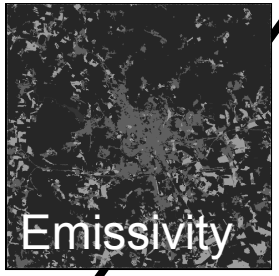
$$L_{\text{sensor},\lambda} = \left[\varepsilon_\lambda B_\lambda(T_s) + (1-\varepsilon_\lambda)L^{\downarrow}_{\text{atm},\lambda}\right]\tau_\lambda + L^{\uparrow}_{\text{atm},\lambda}$$





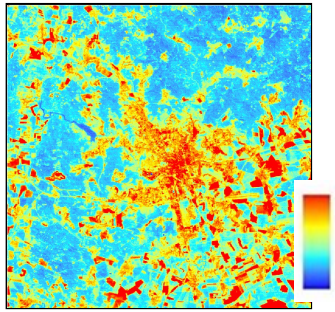






Atmospheric correction

Emissivity correction



Land Surface Temperature

Atmospheric correction

http://atmcorr.gsfc.nasa.gov/

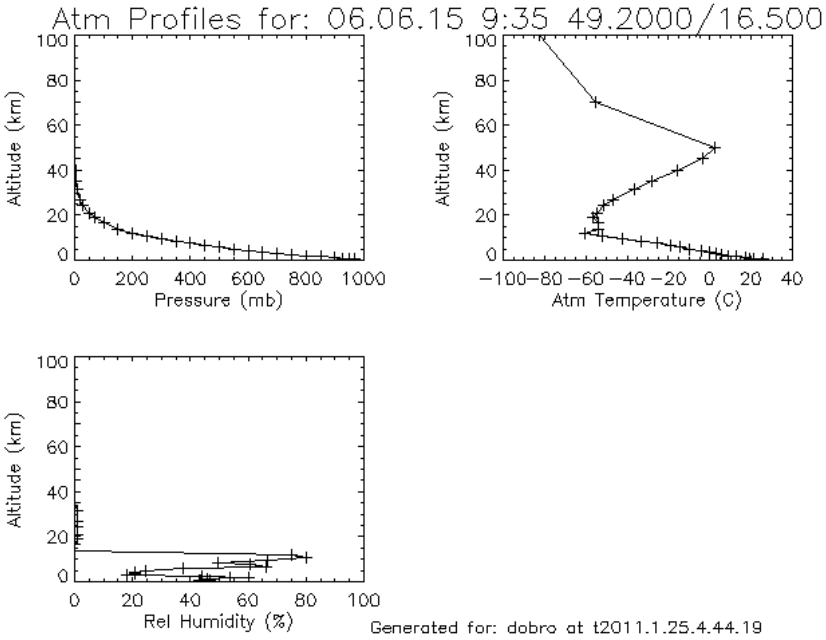
(Barsi et al. 2005)

MODTRAN model provides following parameters:

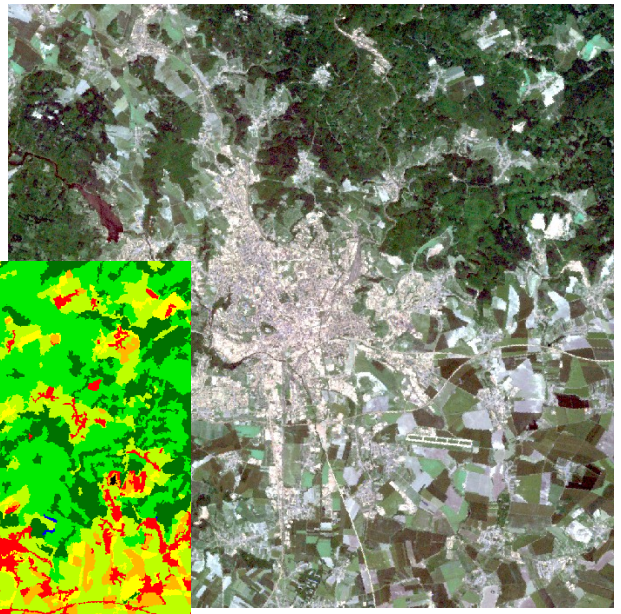
- transmissivity
- upwelling radiance
- downwelling radiance

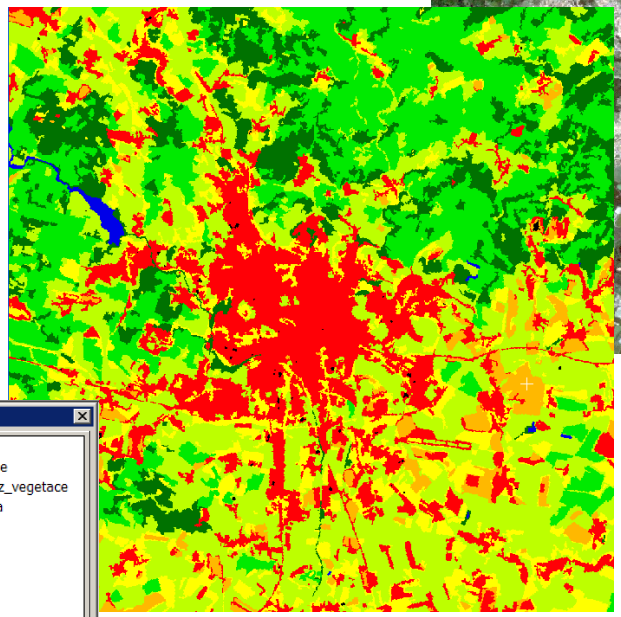
Atmospheric Correction Parameter Calculator

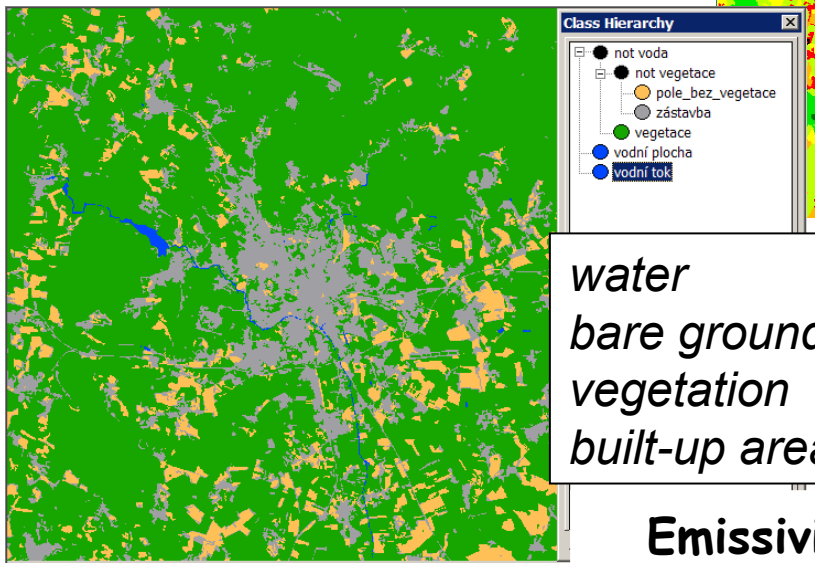
```
Date (yyyy-mm-dd):                          2006-06-15
Input Lat/Long:                               49.200/   16.500
Profile lat/long:                             49.000/   16.000
GMT Time:                                    9:35
L5 Spectral Response Curve from handbook
Mid-latitude summer standard atmosphere
User input surface conditions
Surface altitude (km):          -999.000
Surface pressure (mb):          -999.000
Surface temperature (C):      -999.000
Surface relative humidity (%):      -999.000

Band average atmospheric transmission:     0.79
Effective bandpass upwelling radiance:     1.55 W/m^2/sr/um
Effective bandpass downwelling radiance:   2.54 W/m^2/sr/um
```



Emissivity correction





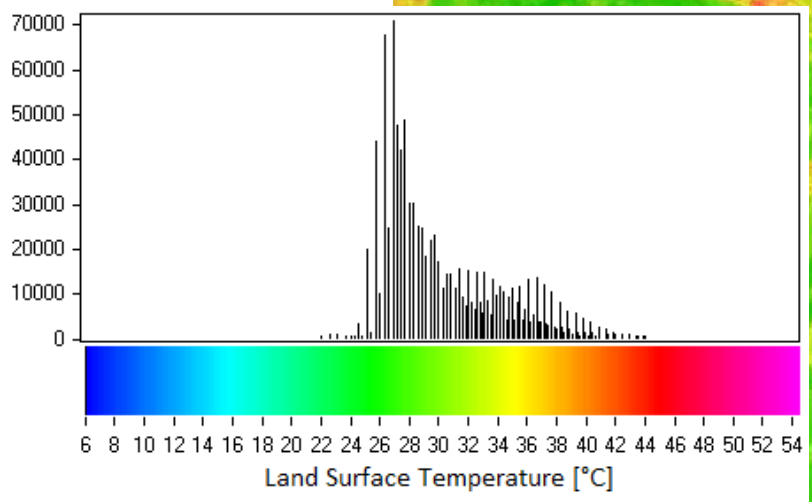


water	***0,98***
bare ground	***0,97***
vegetation	***0,94***
built-up area	***0,925***

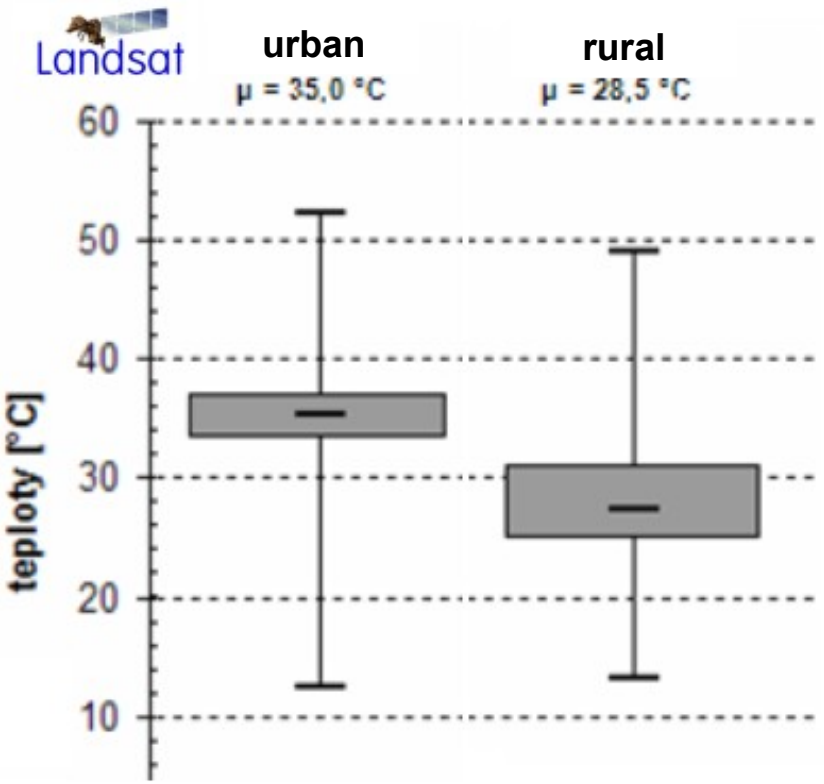
Emissivity values (Snyder et al. 1998)

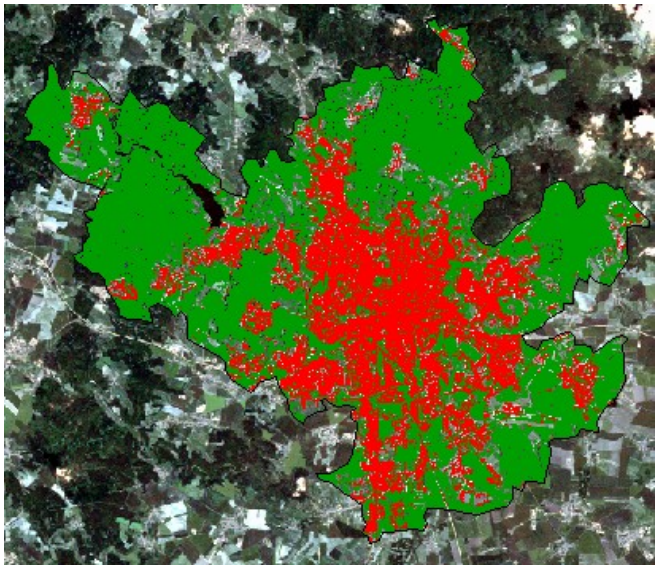
This is a weak point of mono window algorithms

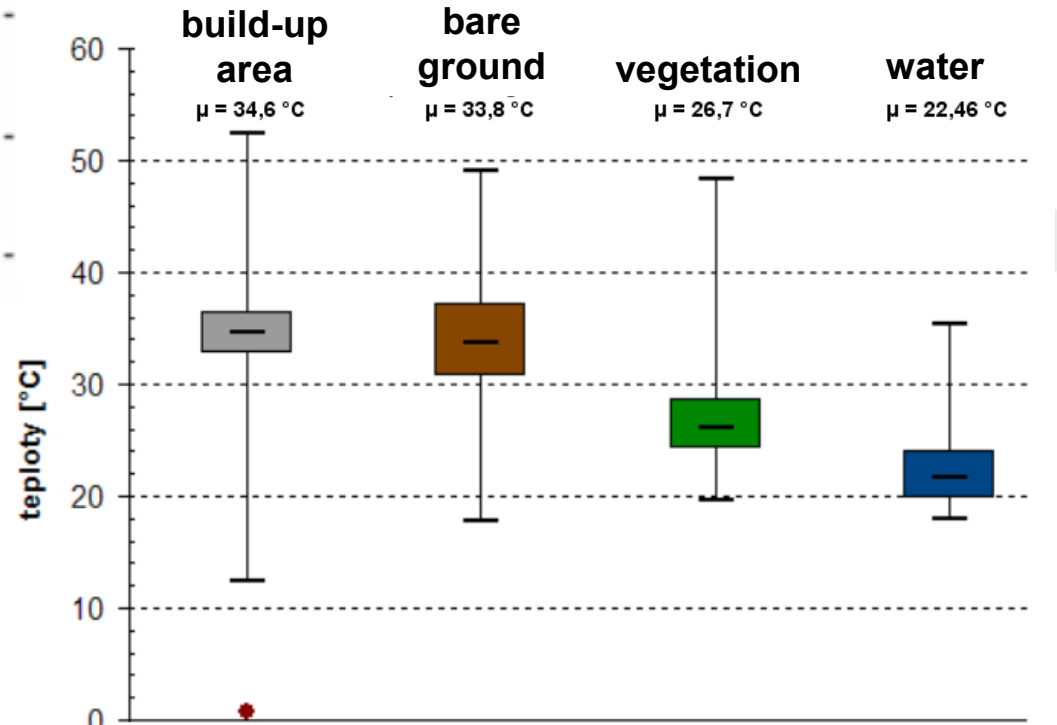
Land Surface Temperatures, Brno, 15 June 2006



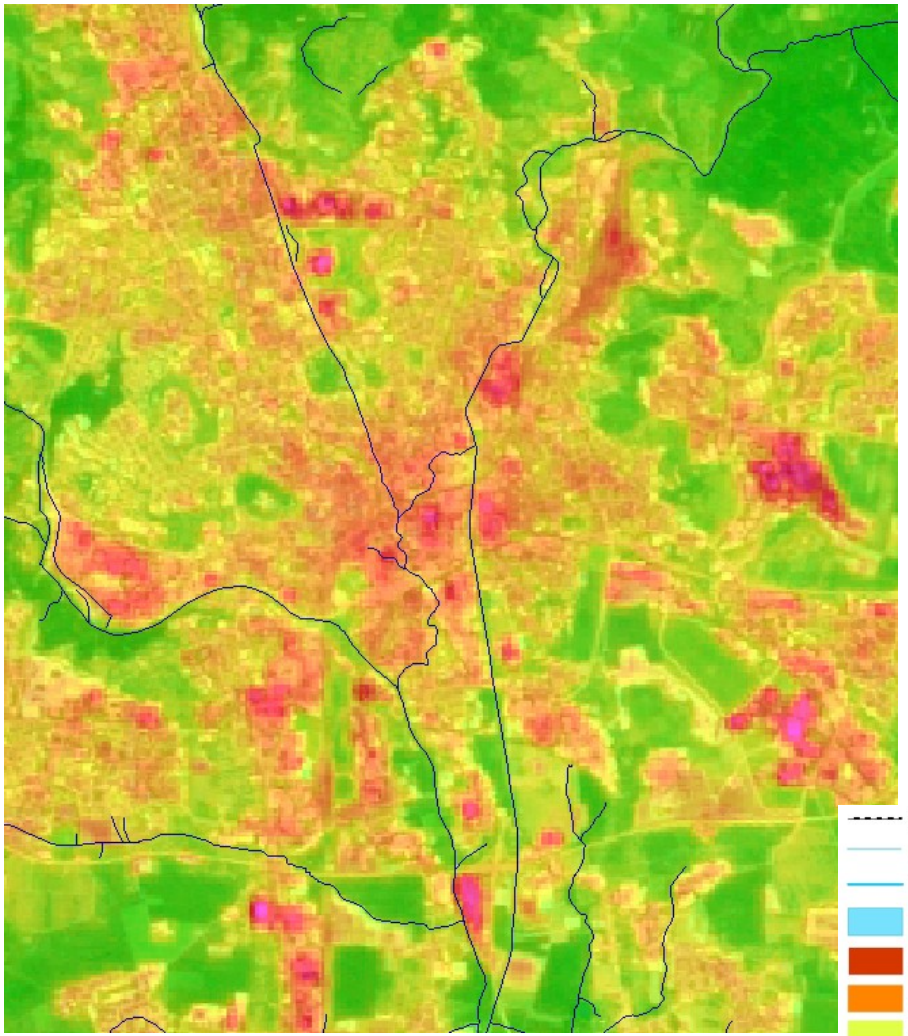
LST of different land cover types

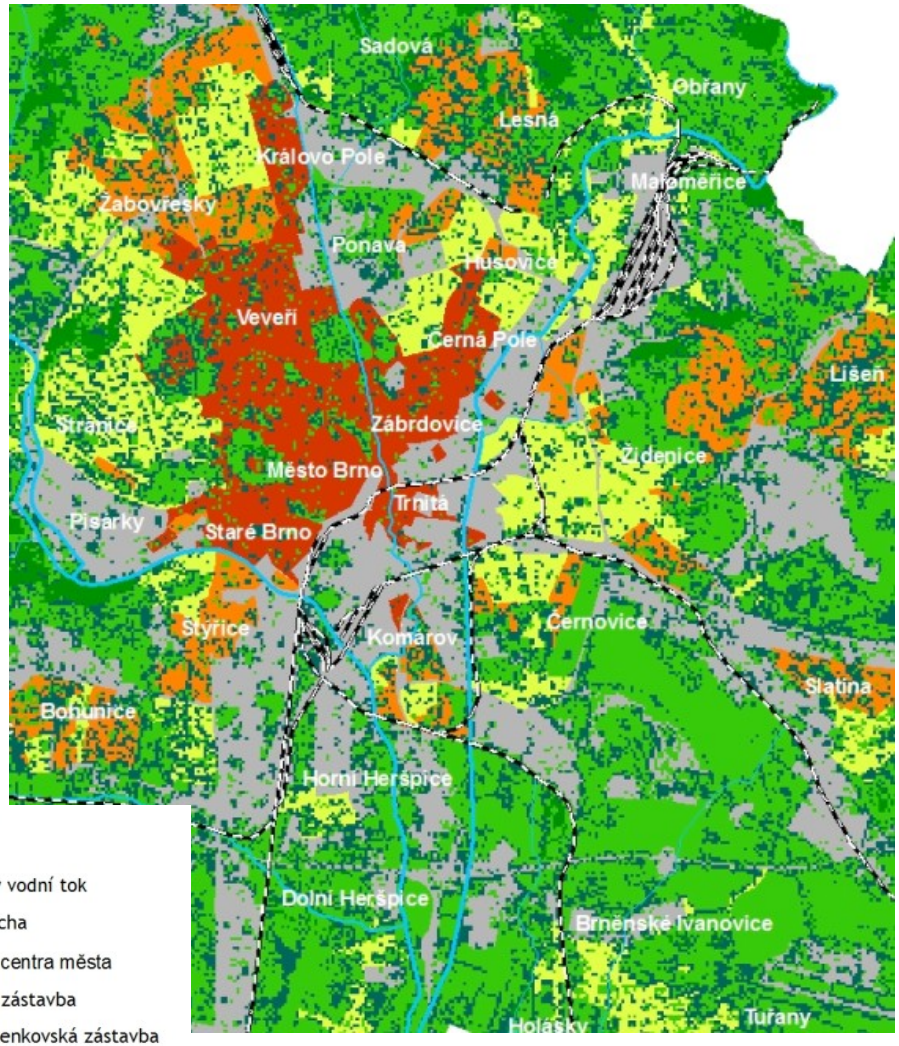






LST for different types of built-up area





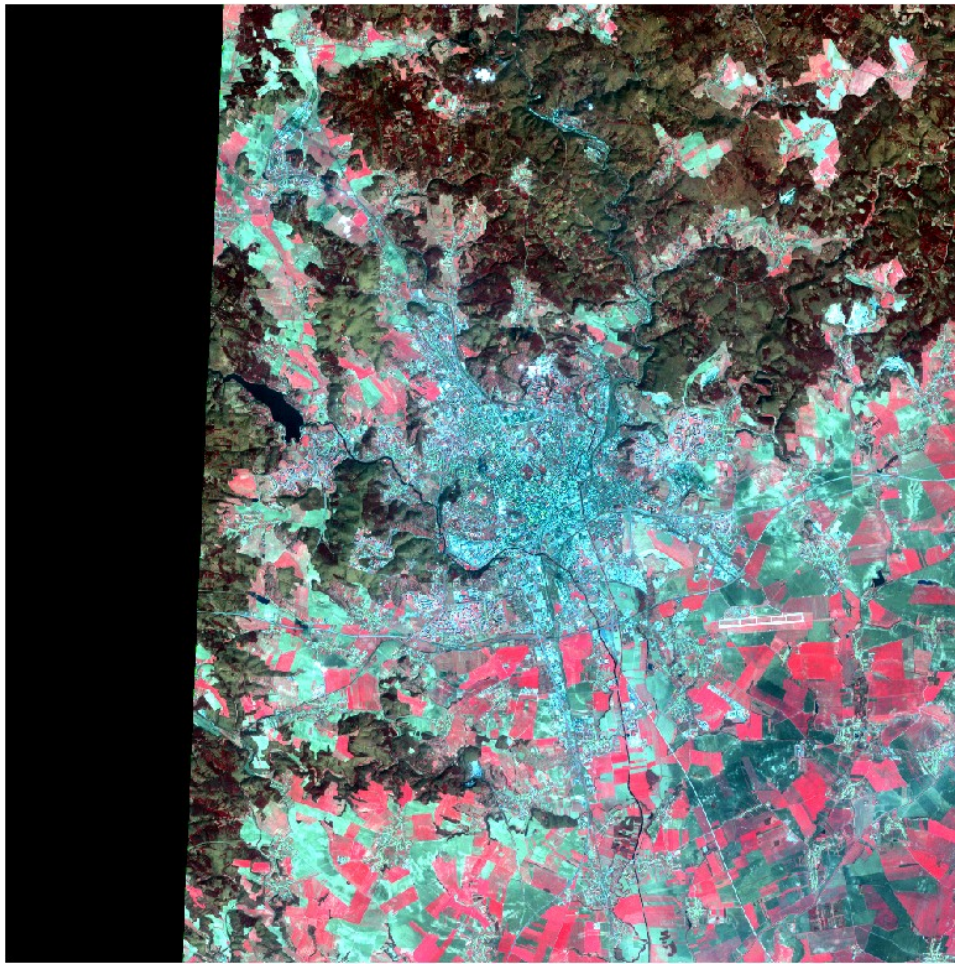
železnice
vodní tok
významný vodní tok
vodní plocha
zástavba centra města
panelová zástavba
vilová a venkovská zástavba
průmyslová a nákupní zástavba
les
ostatní vegetace
nezařazeno

Helena RYBÁKOVÁ, BRNO 2008
Souřadný systém S-JTSK
©ARC ČR 500, DIBAVOD, DMÚ 25

Other RS data - „multispectral" algorithms

- TERRA satellite
- scanner ASTER
- date 2 April 2002
- time 9:57:53 GMT
- 5 thermal bands (10–14)

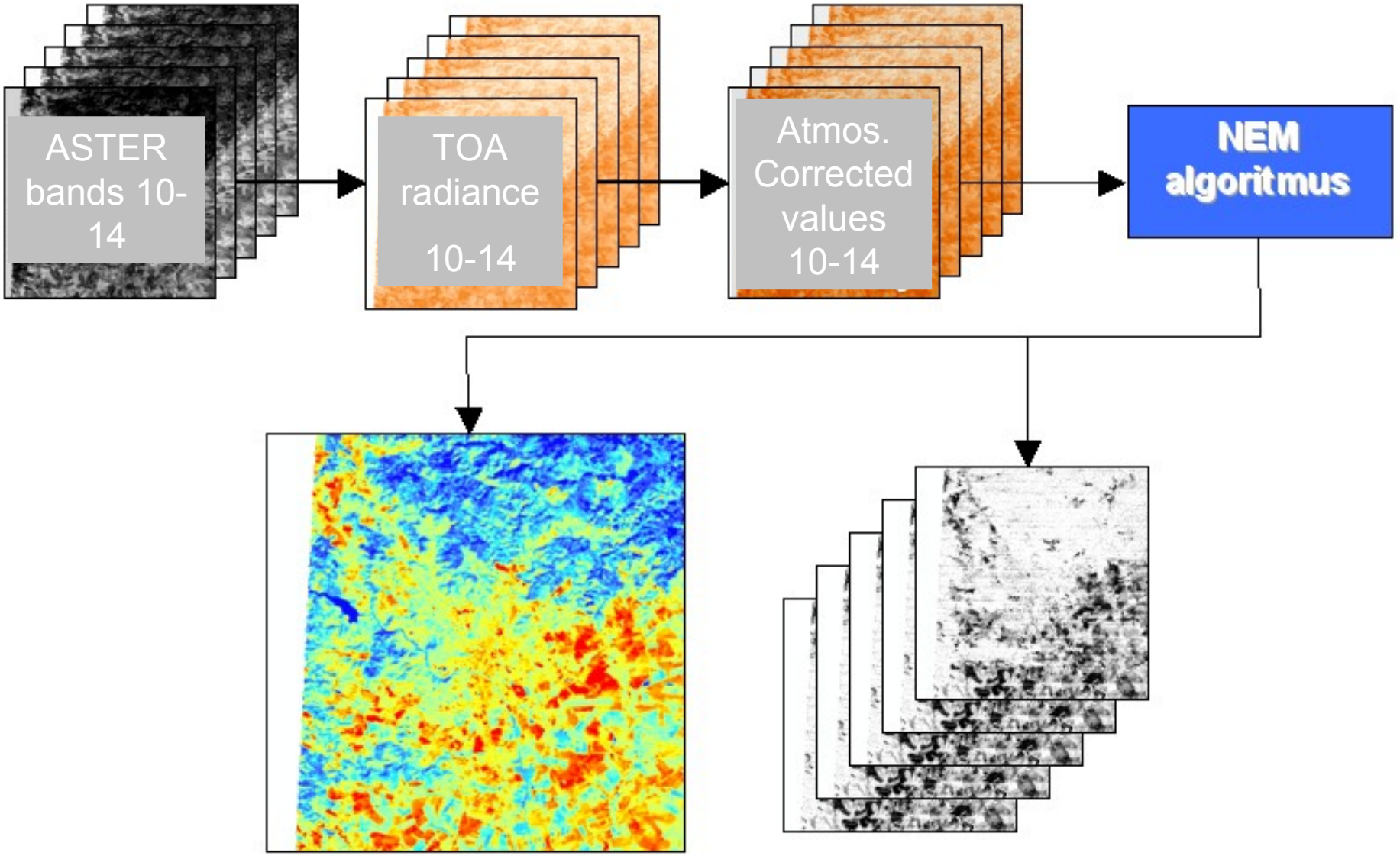
  wavelengths 8.125– 11.65 μm
- spatial resolution 90 m



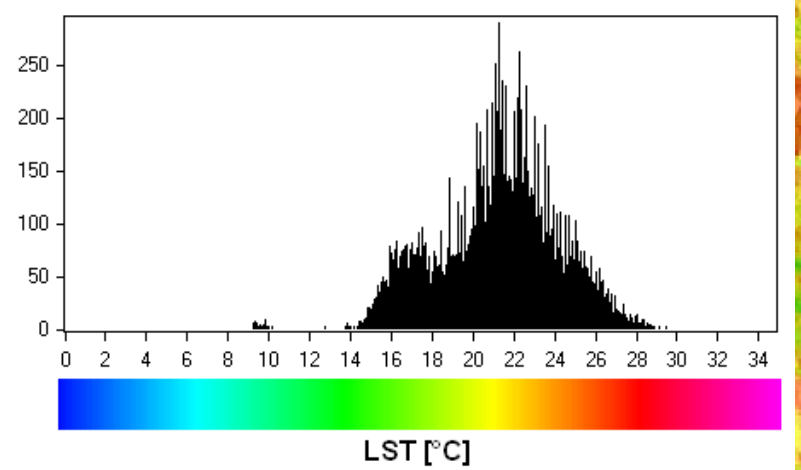
Synoptic situation SEa

T_{min} 7.8°C T_{max} 16.8°C T_{mean} 11.3°C $T_{ground\ min}$ 6.4°C

LST derivation from ASTER data



Land Surface Temperatures, Brno, 2 April 2002

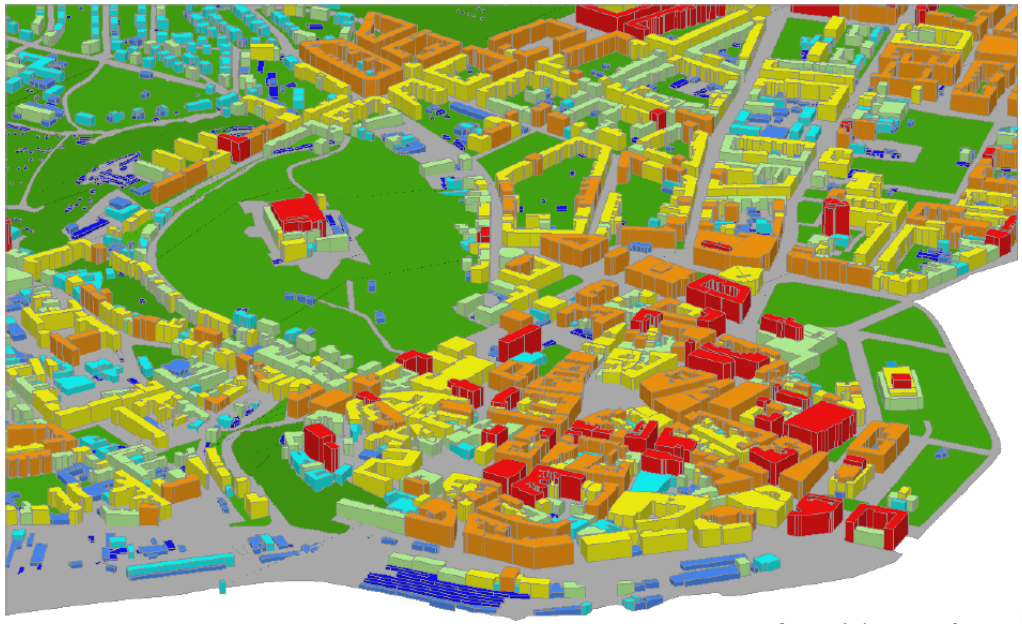


Summary

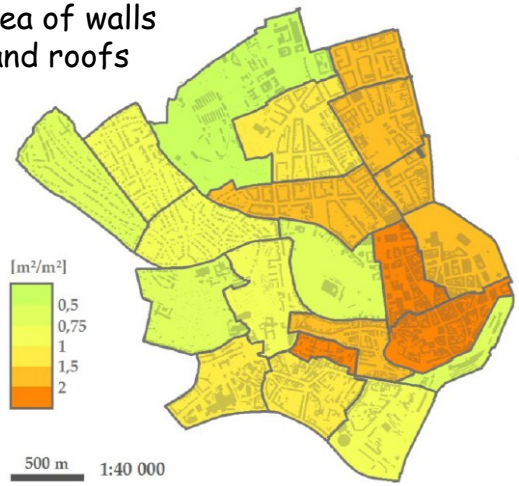
- Different approaches for construction of LST fields have been tested using ETM+ and ASTER thermal imagery
- LSTs in urban areas can reach 35 – 50 °C. However, LST of areas with a dense vegetation cover vary around 25 °C (based on 6 different satellite scenes acquired from April to September)
- LSTs of industrial areas and large shopping centers are significantly higher compared to other build-up areas
- LSTs of bare ground in southern part of the study area are comparable to those of urban surfaces
- Two different data sources and two different methods provide very similar spatial distribution of LST within a city centre

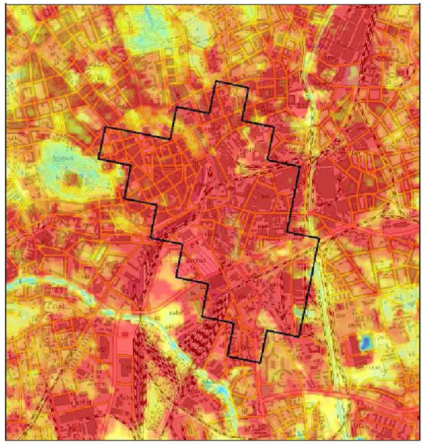
Outlook

Various parameters derived from 3D model of buildings and from Digital Elevation Model explain spatial variability of land surface temperatures.

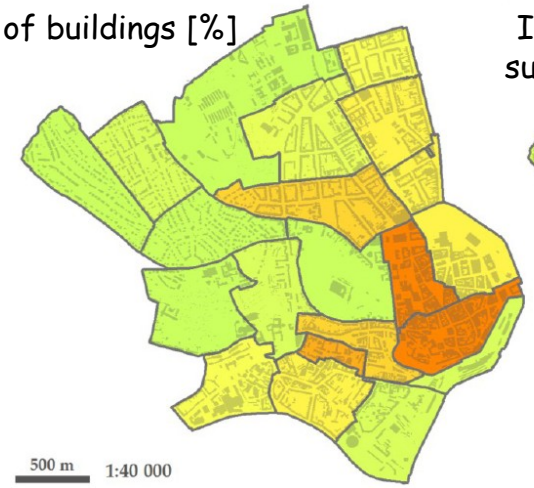


Area of walls and roofs

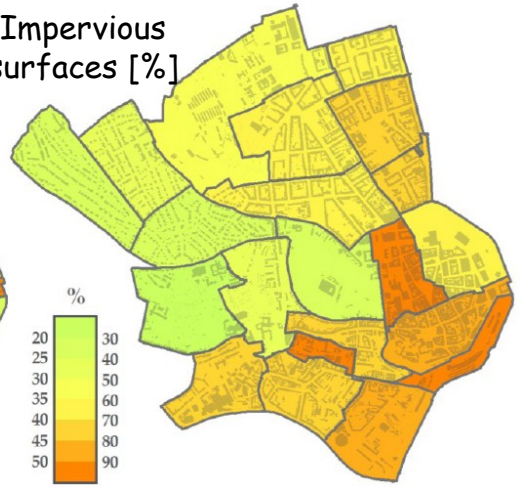


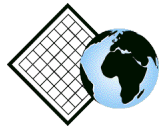


Area of buildings [%]



Impervious surfaces [%]





Thank you for your attention