URBAN CLIMATOLOGY

5. Urban Remote Sensing

Paper to read

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2007 Urban Remote Sensing Joint Event

Application of satellite Remote Sensing for Urban Risk Analysis: a case study of the 2003 extreme heat wave in Paris

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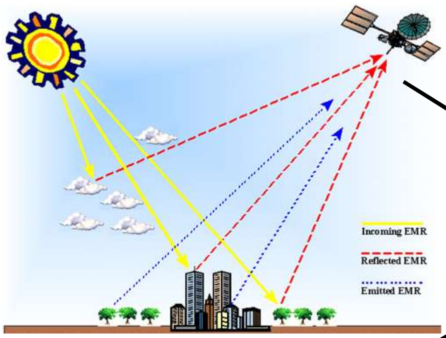
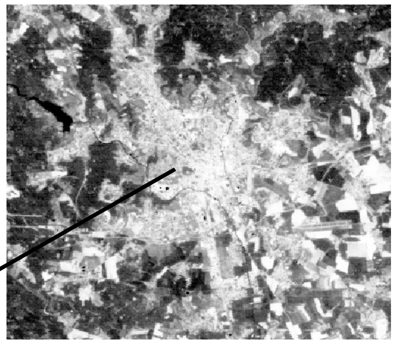
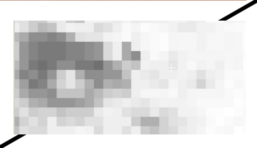
https://is.muni.cz/auth/el/sci/podzim2022/ZX601/um/67875456/05_Dousset-URS-07.pdf

5.1 Remote Sensing Principles





thermal imagery

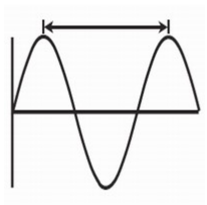


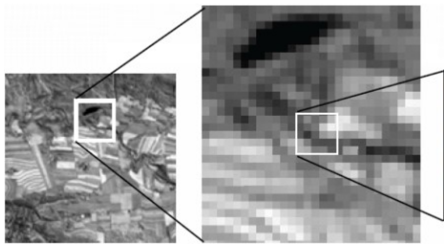
Digital Numbers

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

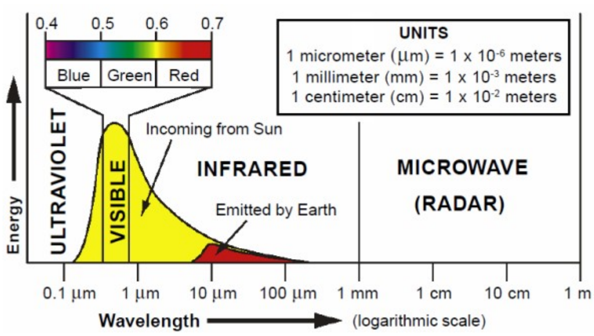
→ DN = f(LST)

5.1 Remote Sensing Principle





115	111	71	67	74
111	89	52	77	95
87	66	74	87	80
89	64	102	125	90
70	65	113	144	119



http://www.remote-sensing.net/concepts.html

5.1 Remote Sensing Principle

Stefan-Boltzmann law: The thermal energy radiated by a **blackbody** is proportional to the fourth power of the absolute temperature:

$$M = \sigma T^4$$

M - thermal energy
T - absolute temperature
σ - the Stefan–Boltzmann constant

Real surfaces

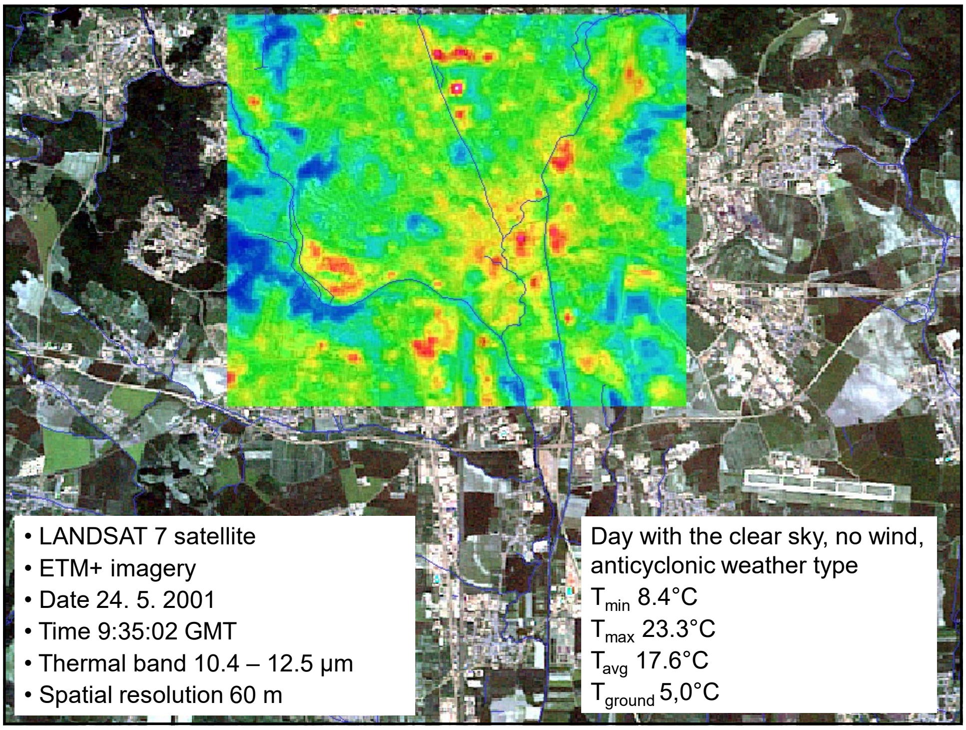
$$M = \varepsilon \sigma T^4$$

ε - emissivity

Emissivity is the measure of an object's ability to emit infrared energy. Emitted energy indicates the temperature of the object. Emissivity can have a value from 0 (shiny mirror) to 1.0 (blackbody). Most organic, painted, or oxidized surfaces have emissivity values close to 0.95.

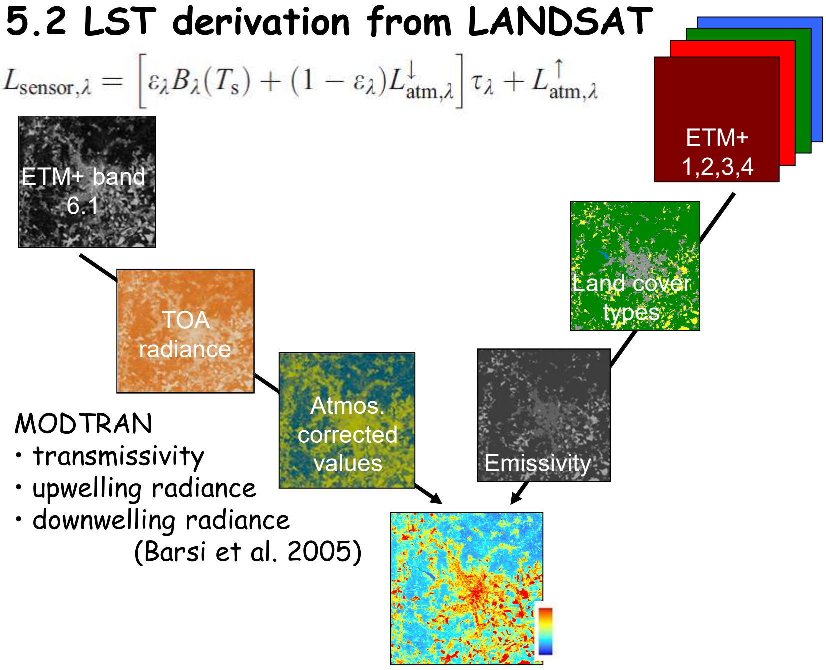
There are at least **two problems** in urban remote sensing:

1) How to determine emissivity of real surfaces in highly heterogeneous urban environment
2) How to recalculate LST - Land Surface Temperature to air temperature



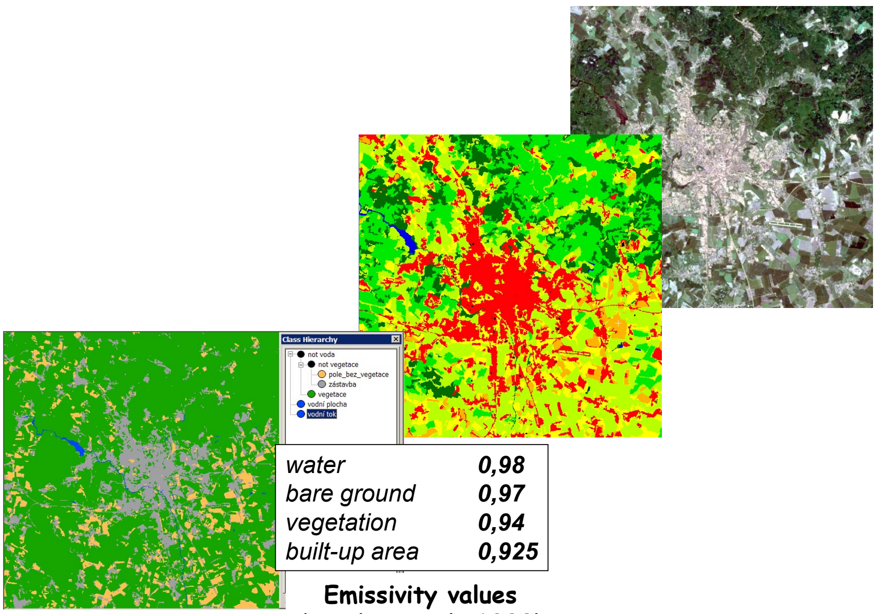
5.2 LST derivation from LANDSAT

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



Land surface Temperature

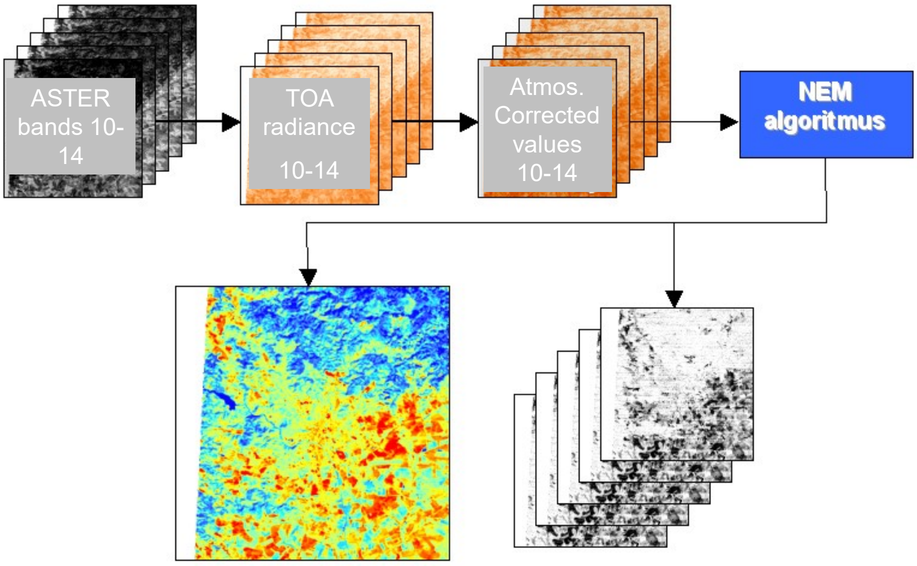
Emissivity map of basic land cover types



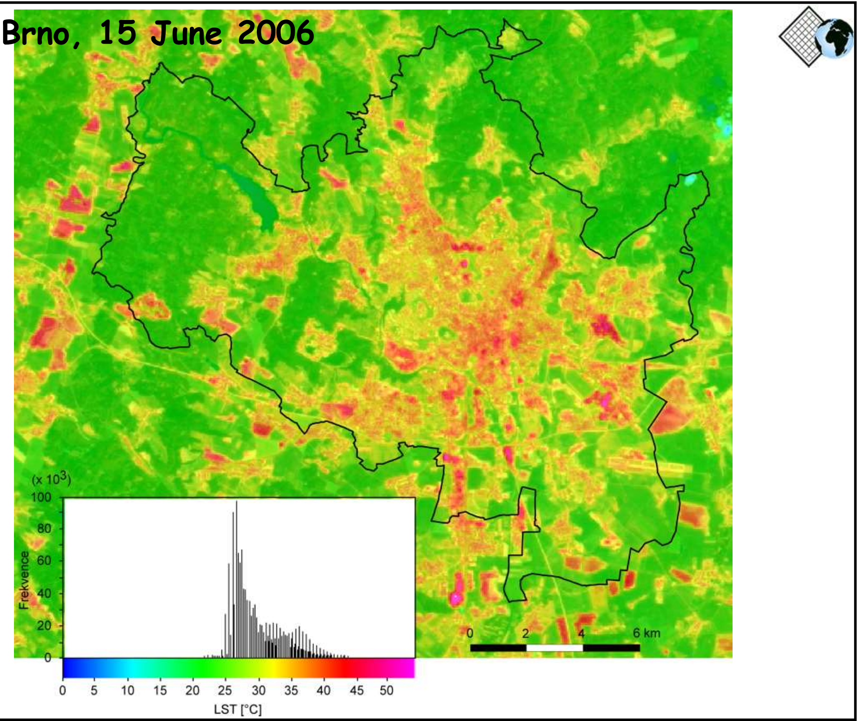
water	***0,98***
bare ground	***0,97***
vegetation	***0,94***
built-up area	***0,925***

Emissivity values (Snyder et al. 1998)

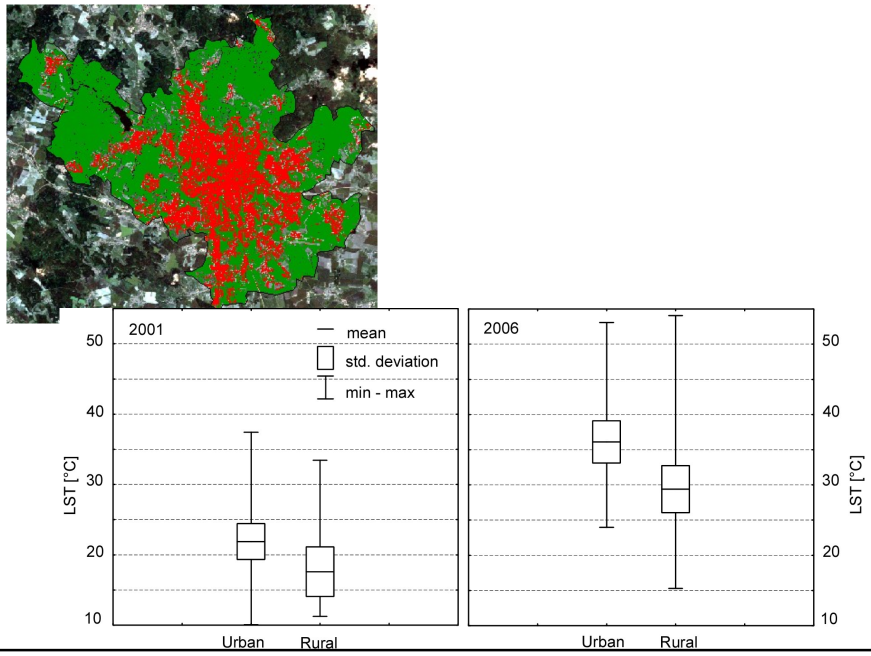
LST derivation from ASTER data
(more thermal images)



LST, Brno, 15 June 2006

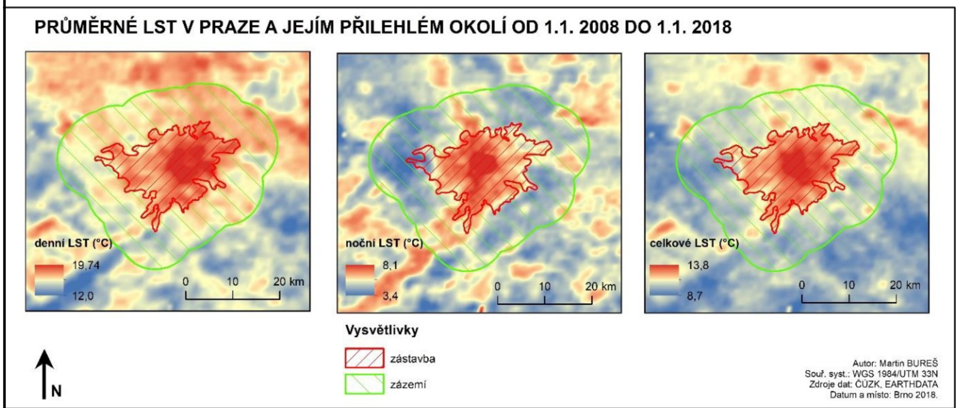


Intensity of SUHI



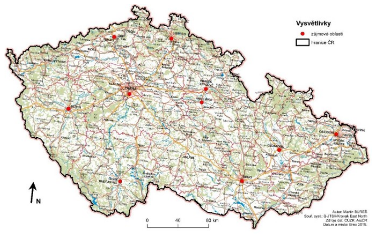
Modification of LST field due to anthropic activities in big CZ cities

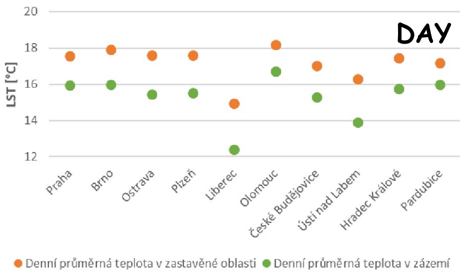
Data: eight-day composites of mean surface temperatures from the MODIS scanner with 1 x 1 km spatial resolution.

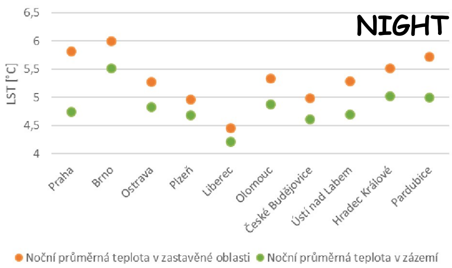


Spatial differentiation of surface temperatures (LST) in daytime (left), nighttime (middle) hours and their average (right) in Prague and its surroundings in the period 2008-2018

Modification of LST field due to anthropic activities in big CZ cities

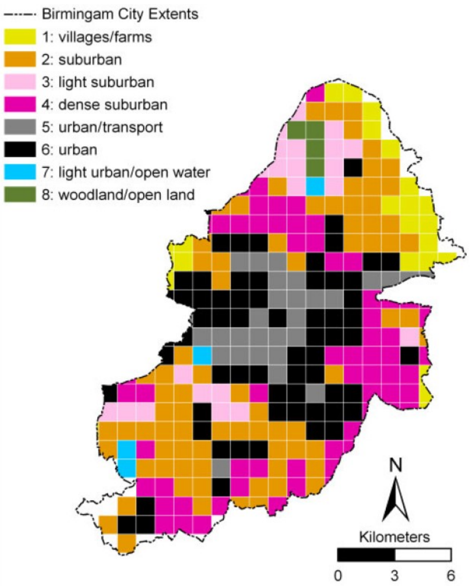


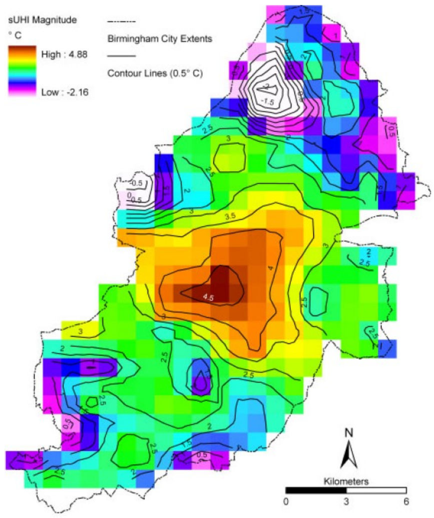




Average LST of the ten largest cities of the Czech Republic in built-up and rural areas in the period 2008-2018.

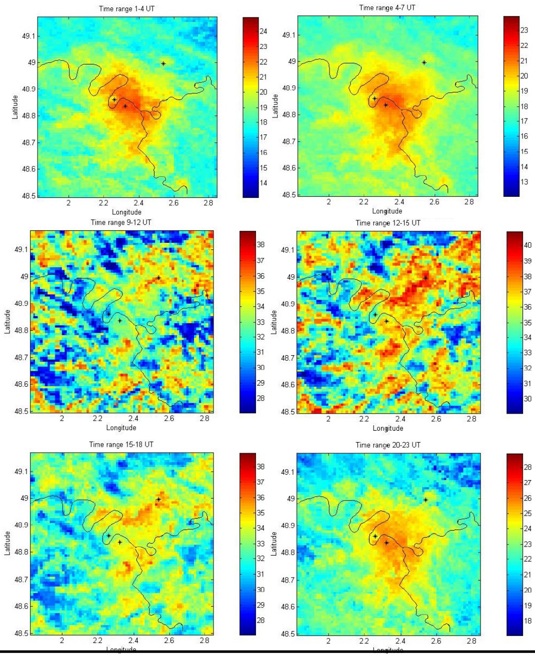
Examples of SUHI analysis





Spatial distribution of land classification (left) and SUHI magnitude (right) within Birmingham city extents for heatwave event at 18 July 2006 (Tomlinson et al., 2010)

Examples of SUHI analysis



Remote Sensing for Urban Risk Analysis: a case study of the 2003 extreme heat wave in Paris

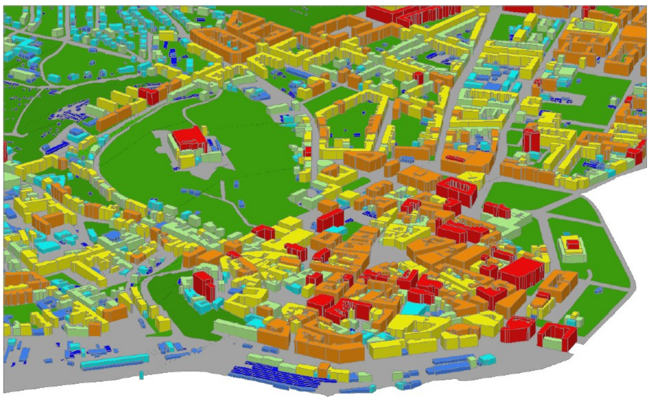
Average Land Surface Temperature infrared images over the heat wave event of August 4 to 13, 2003, for each of the diurnal time intervals. The color scales are in degrees Celsius.

Analysis was based on 50 images sensed by NOAA satellites 12, 16 and 17, over the Paris basin, from 4 to 13 August 2003.

The areas of the Paris region most vulnerable to heat stress were identified.

Another useful Remotely Sensed variables for UC

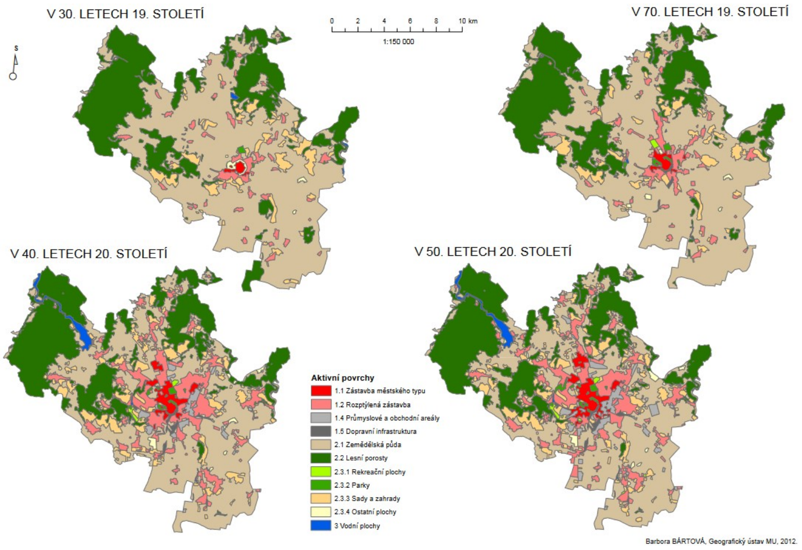
1. Spatial distribution of the Land Surface Temperature
2. Terrain model with 3D building model (laser scanning)
3. Vegetation mapping (NDVI), …



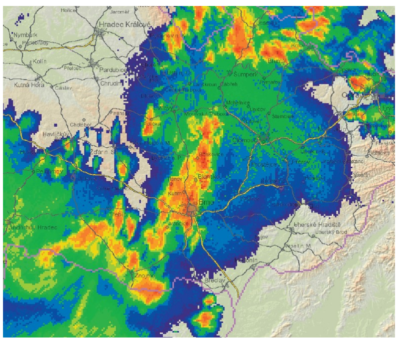
Various parameters derived from 3D model of buildings and from Digital Elevation Model explain spatial variability of land surface temperatures.

Another useful Remotely Sensed variables for UC

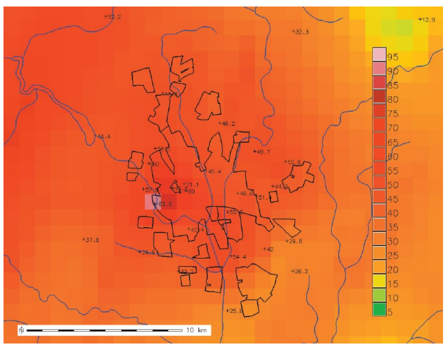
4. Land use mapping – changes in time, UHI growth



Precipitation and weather RADAR

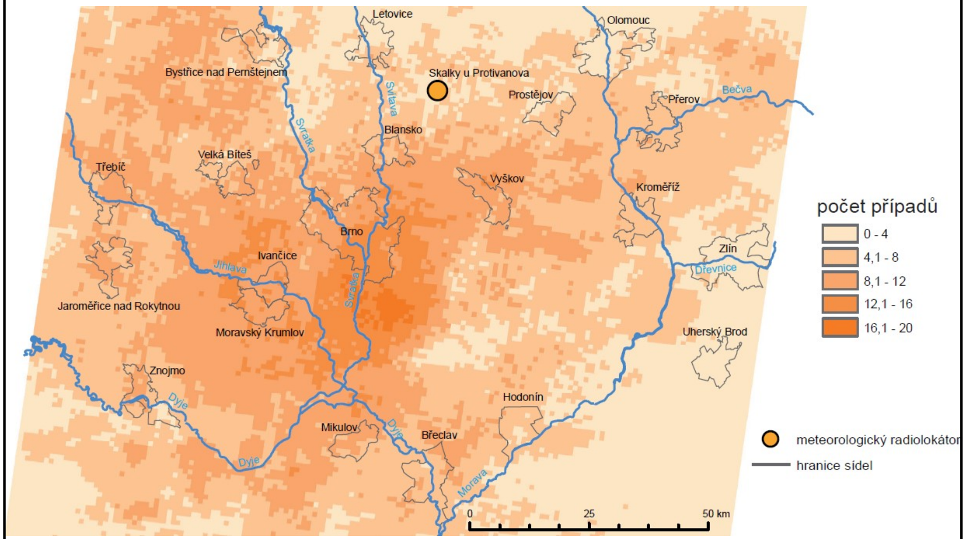


Spatial distribution of radar reflectivity (maximum values in vertical direction) measured at meteorological radars Skalky and Brdy at 15 July 2009, 19:25 hours of central European summer time



Spatial distribution of daily precipitation totals (mm) computed as a combination of radar-based precipitation estimate and rain-gauge measurements from 15 July 2009 (measured at 16 July 2009, 08 h central European summer time). Stations with higher precipitation totals are preferred in the map. Spatial distribution of precipitation totals is given in 1 x 1 km grid

Precipitation and weather RADAR



Frequency of the above-average maximum radar reflectivity in Brno region composed from 26 situations with extreme convection at Tuřany station in the period 2000–2007

5.5 Final remarks and questions

1. What are limitations of URS in terms of spectral, spatial and temporal resolution?
2. What are the main benefits of URS for heat wave studies compared to air temperature analysis?
3. How can be URS used for practical urban planning, regional development and for better adaptation to climate change?