

Erasmus+ lecture at the Department of Geography,
Masaryk University (Brno, Czech Republic)
March, 27-31, 2017

URBAN CLIMATE RESEARCH IN NOVI SAD (SERBIA)

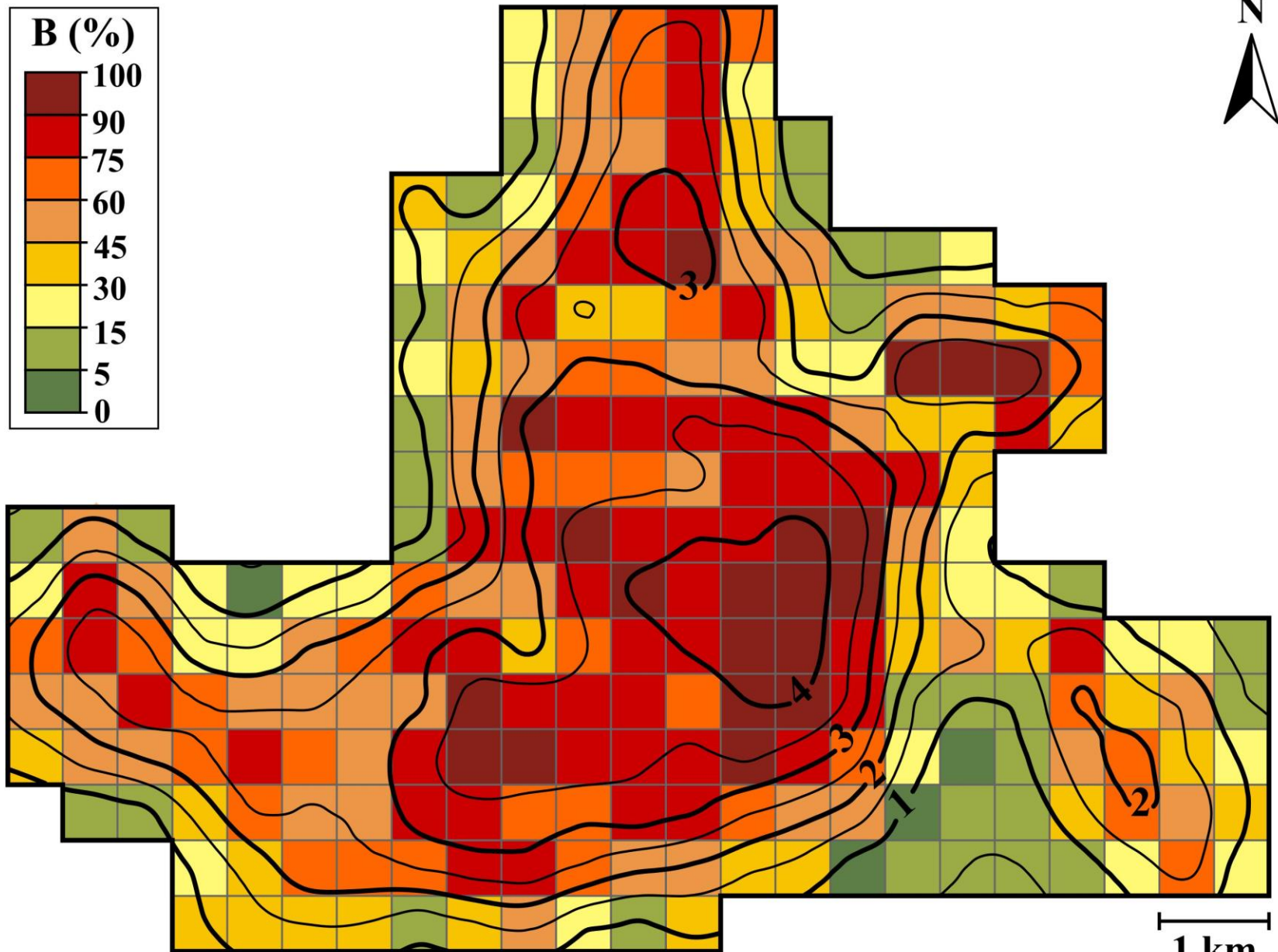
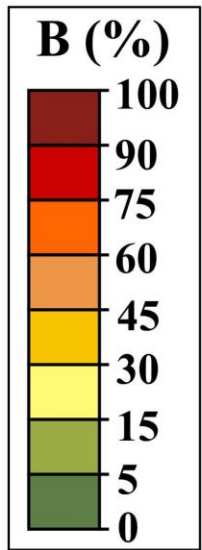
dr Stevan Savić, associate professor
Climatology and Hydrology Researcher Centre,
Faculty of Sciences, University of Novi Sad, Serbia
stevan.savic@dgt.uns.ac.rs
internet portal: clihyd.com



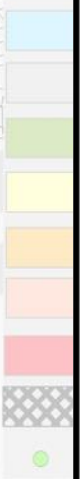
Brno, Czech Republic, 2017



Built-up and UHI patterns in Novi Sad



Leg
LCZ



EQ

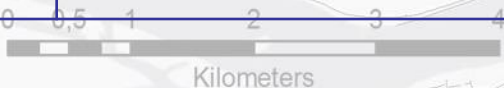
Local Climate Zones (LCZ)

The advantages of LCZ system are that it is a global classification scheme, with limited number of classes and the classes are separated by the main thermal characteristic of the urban surface.

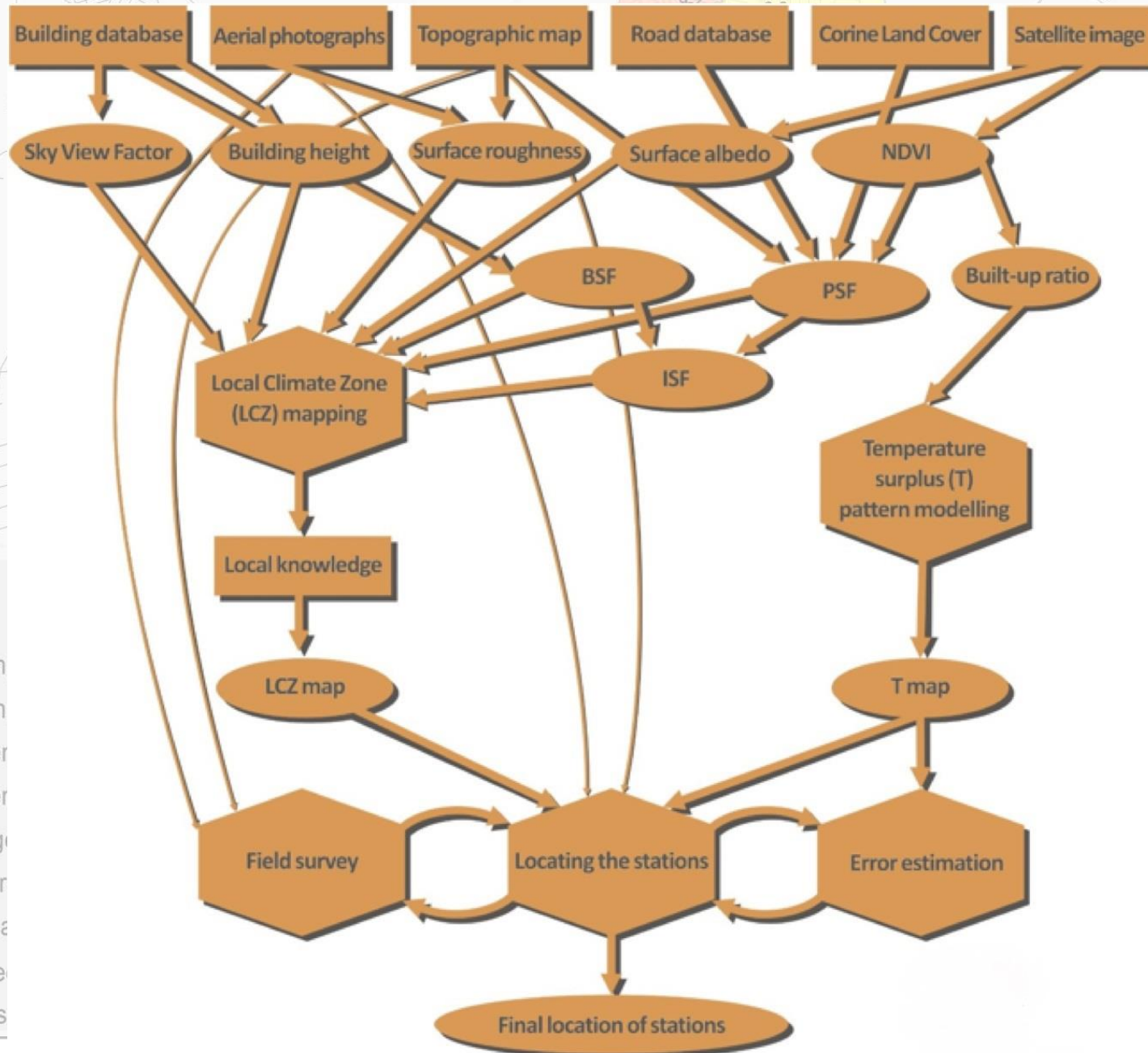
Table of LCZ classification made by Stewart and Oke 2012 (Bull. Am. Meteorol. Soc., 93, 1879-1900)

Built types	Land cover types	Variable land cover properties
LCZ 1 – Compact high-rise	LCZ A – Dense trees	b – bare trees
LCZ 2 – Compact midrise	LCZ B – Scattered trees	s – snow cover
LCZ 3 – Compact low-rise	LCZ C – Bush, scrub	d – dry ground
LCZ 4 – Open high-rise	LCZ D – Low plants	w – wet ground
LCZ 5 – Open midrise	LCZ E – Bare rock / paved	
LCZ 6 – Open low-rise	LCZ F – Bare soil / sand	
LCZ 7 – Lightweight low-rise	LCZ G – Water	
LCZ 8 – Large low-rise		
LCZ 9 – Sparsely built		
LCZ 10 – Heavy industry		

- 8 - Large low-rise
- 9 - Sparsely built
- 10 - Heavy industry
- Excluded area
- Stations



LCZs and station sites definition methodology



Legend

LCZ

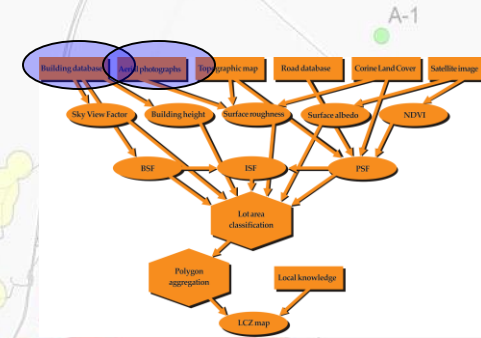
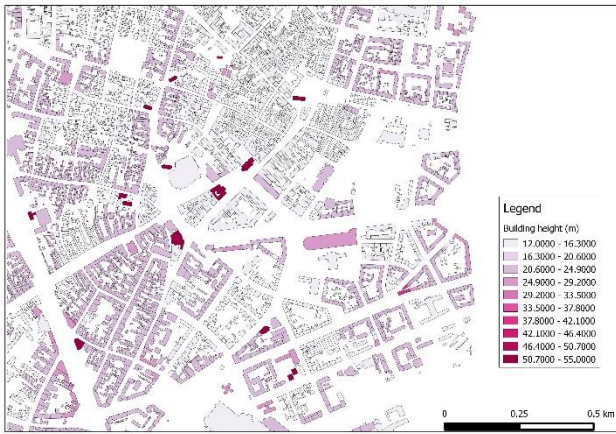
- 2 - Com
- 3 - Com
- 5 - Oper
- 6 - Oper
- 8 - Large
- 9 - Spar
- 10 - Hea
- Exclude
- Stations



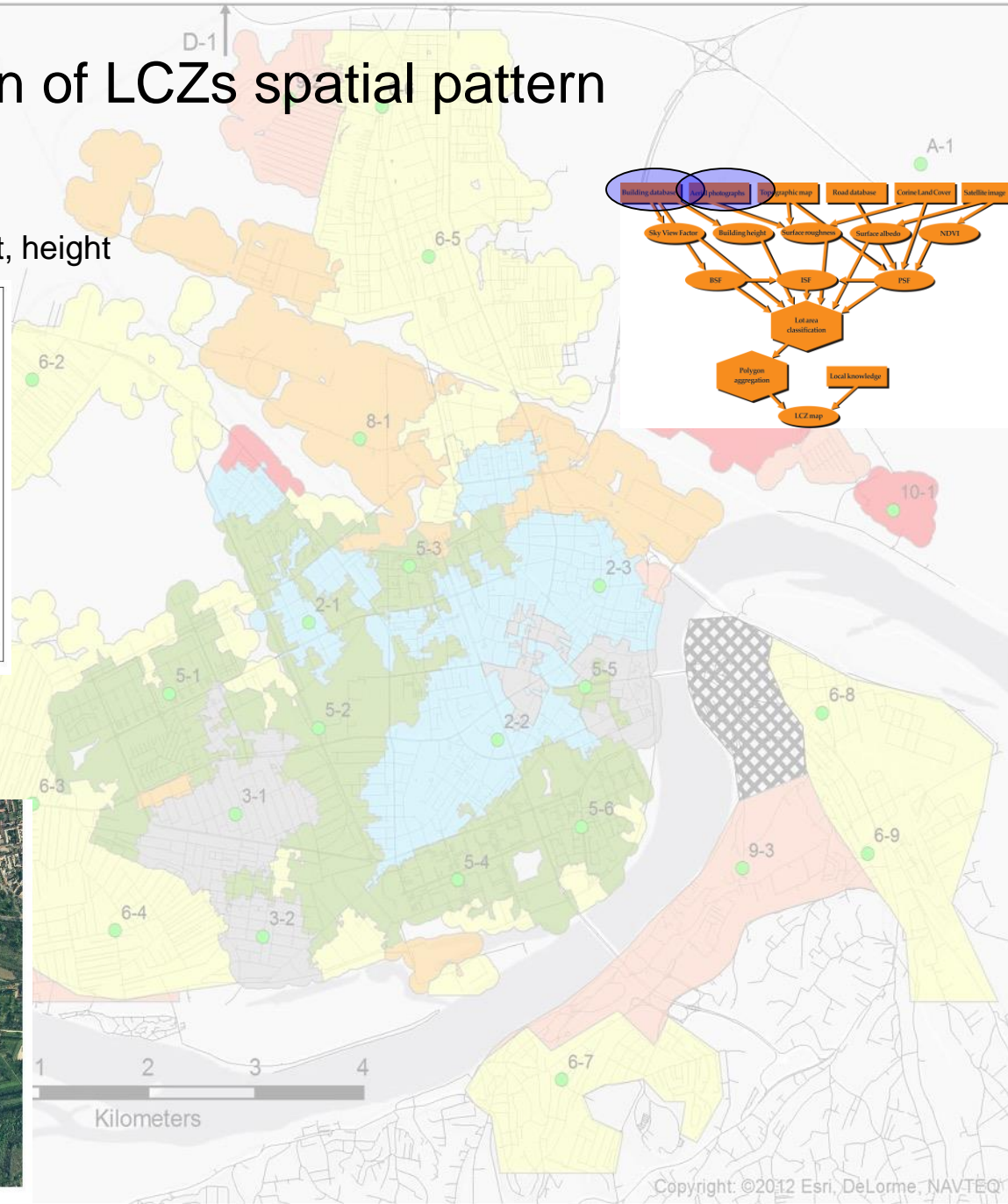
Definition of LCZs spatial pattern

Building databases

47.000 building (Novi Sad)
vector format (shape files) – footprint, height

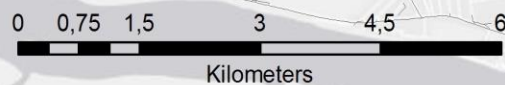
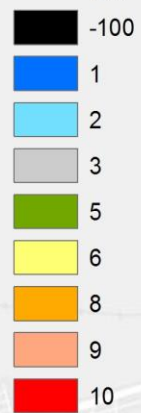


Legend
Aerial photographs
high resolution, 3-4 spectral band



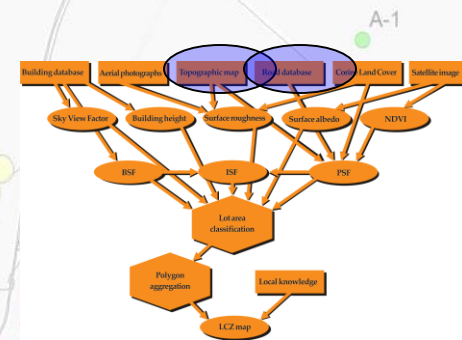
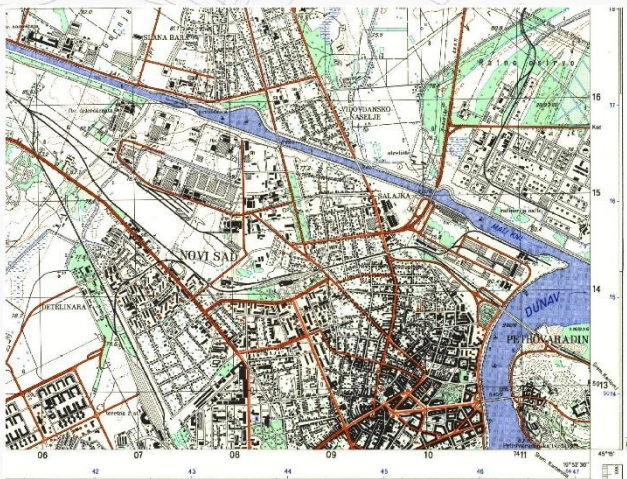


Legend
LCZ agg.

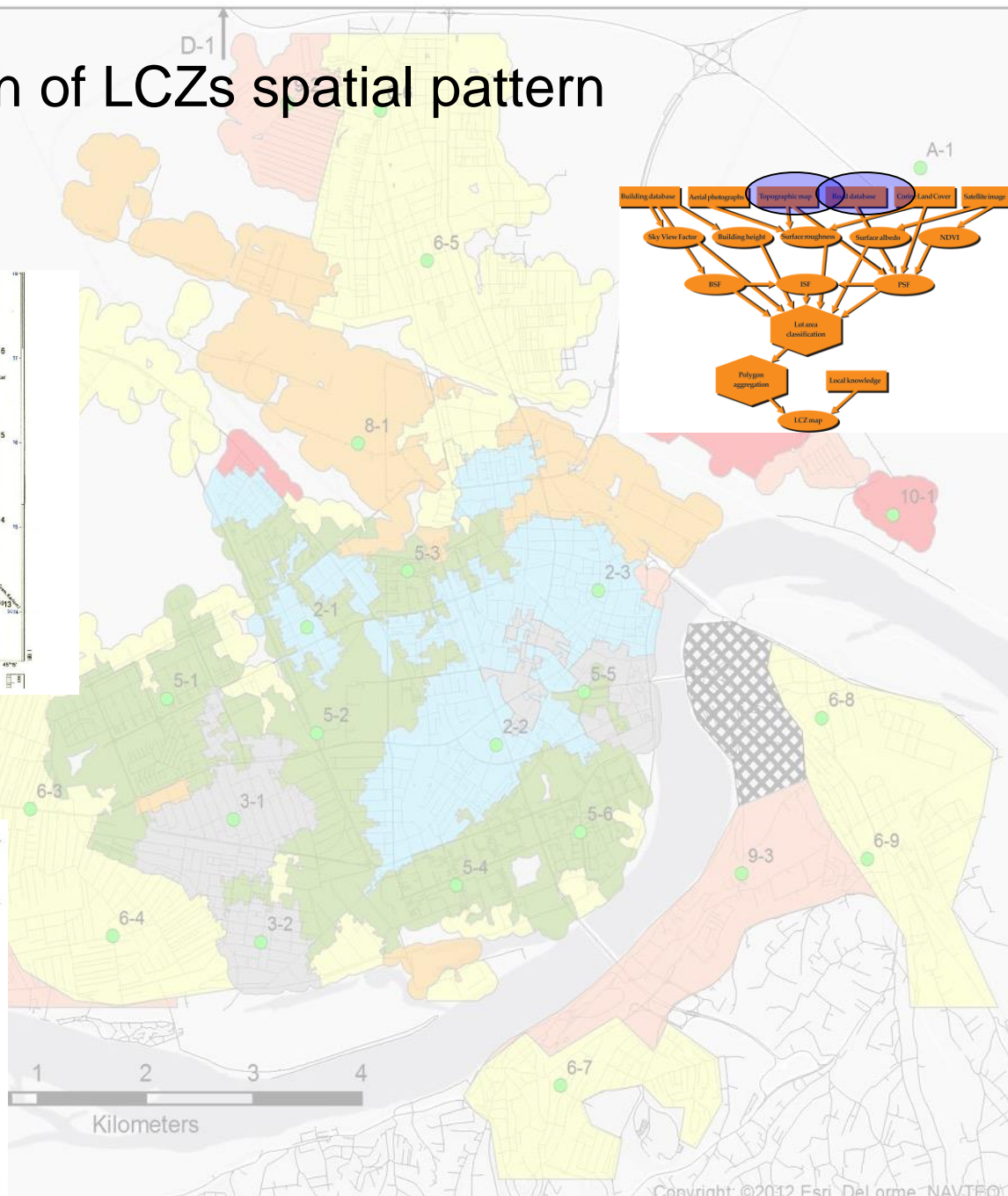
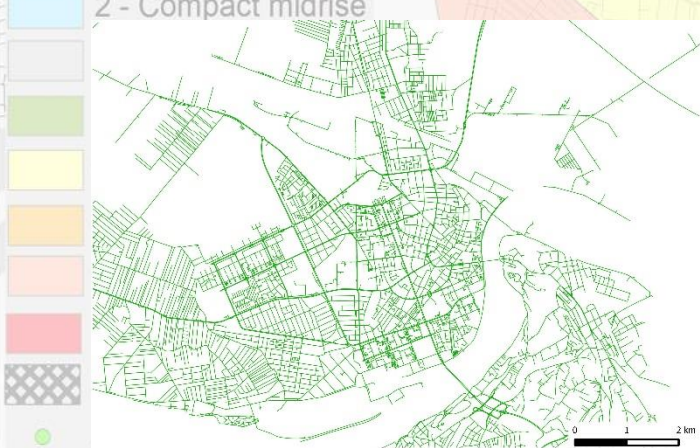


Definition of LCZs spatial pattern

Topographic maps
Novi Sad – 1:25.000

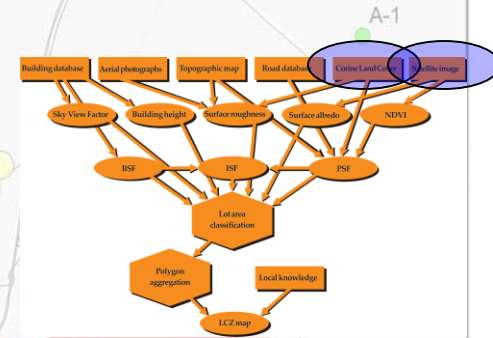
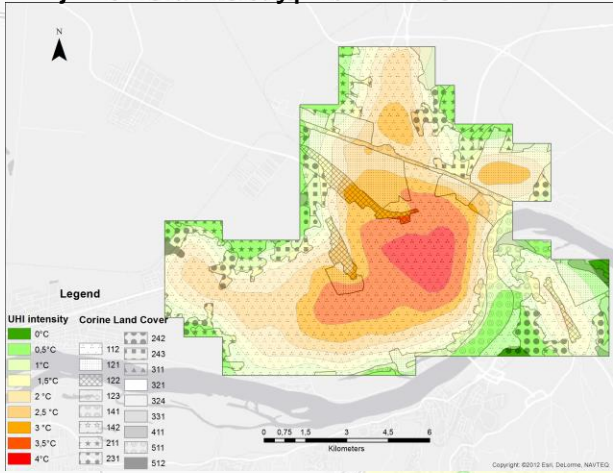


Legend
LCZ Road databases
all roads and streets



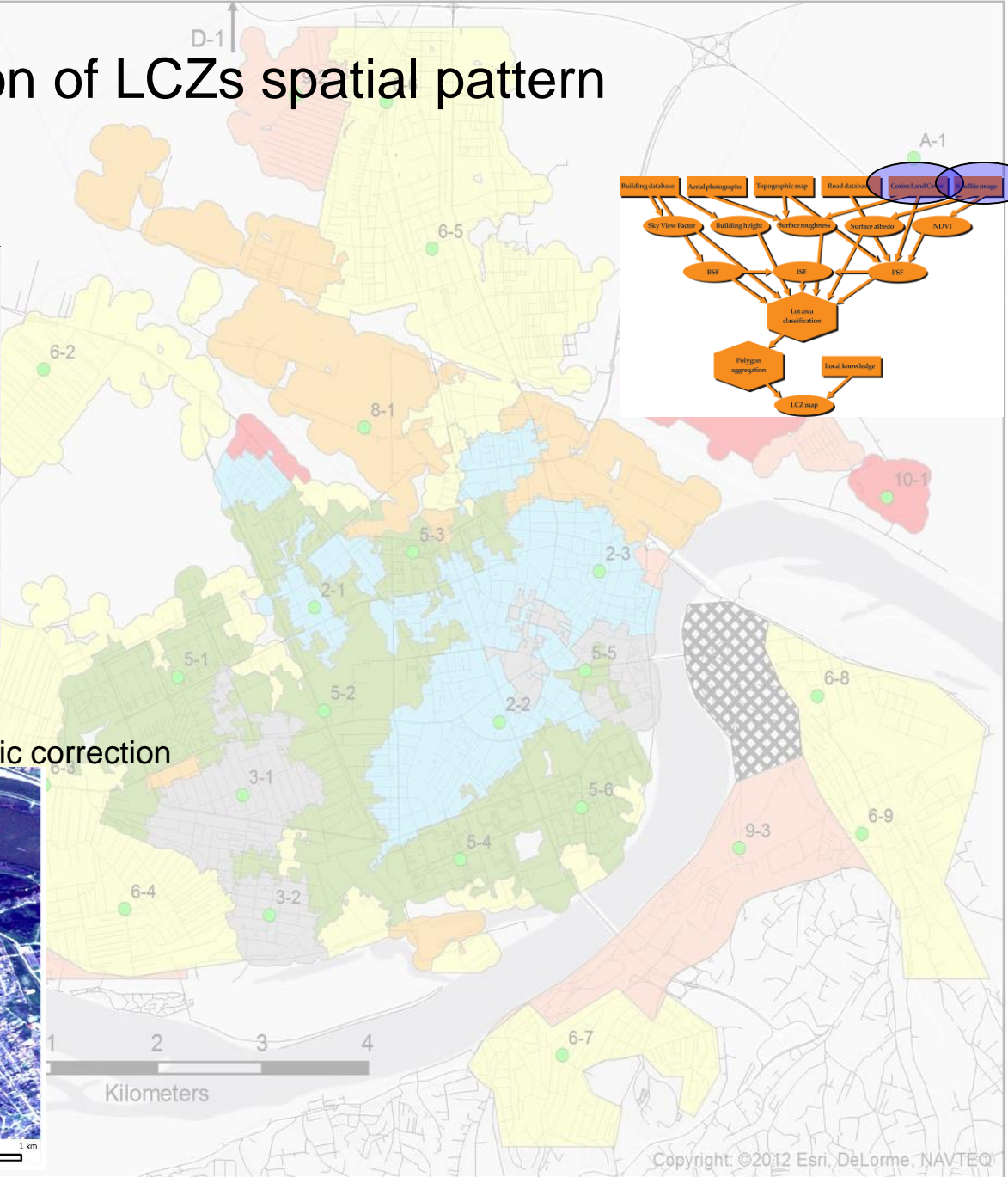
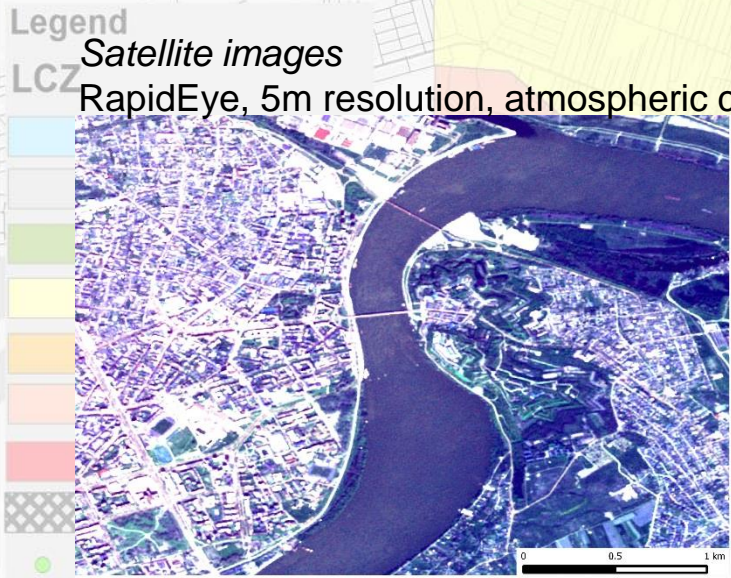
Definition of LCZs spatial pattern

Corine Land Cover (CLC) database
major land-use types



Satellite images

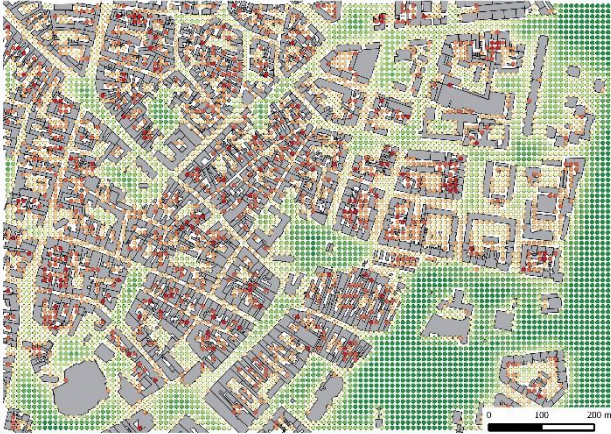
RapidEye, 5m resolution, atmospheric correction



Definition of LCZs spatial pattern

Sky View Factor (SVF)

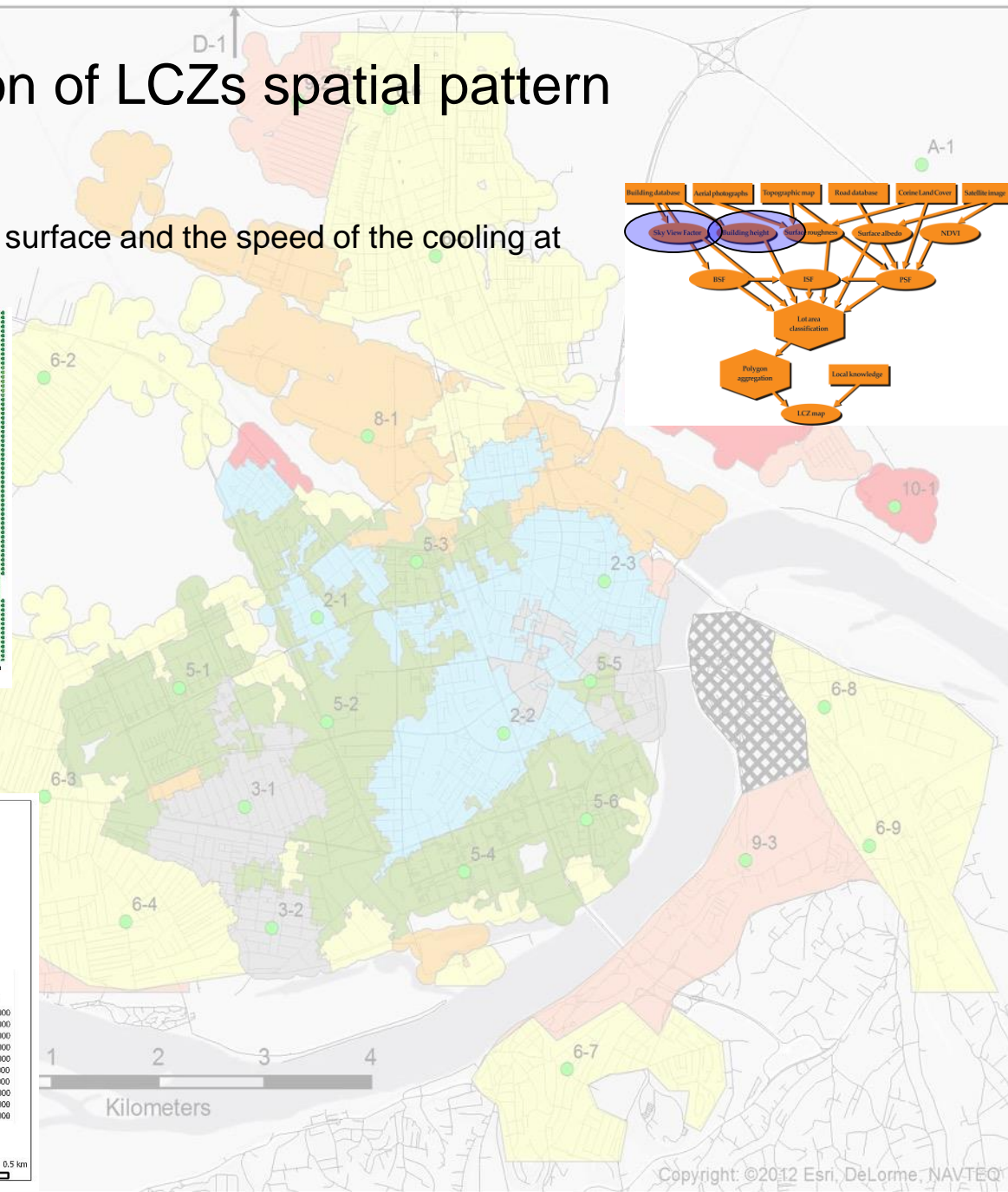
describe the radiation balance of the surface and the speed of the cooling at night



Legend

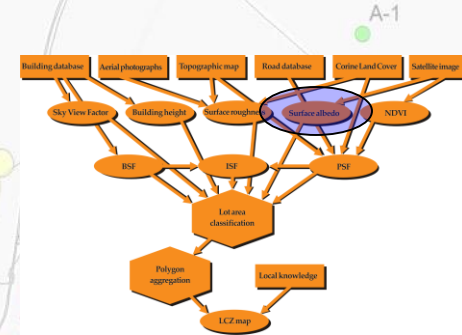
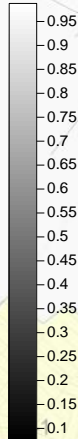
LCZ

Building height

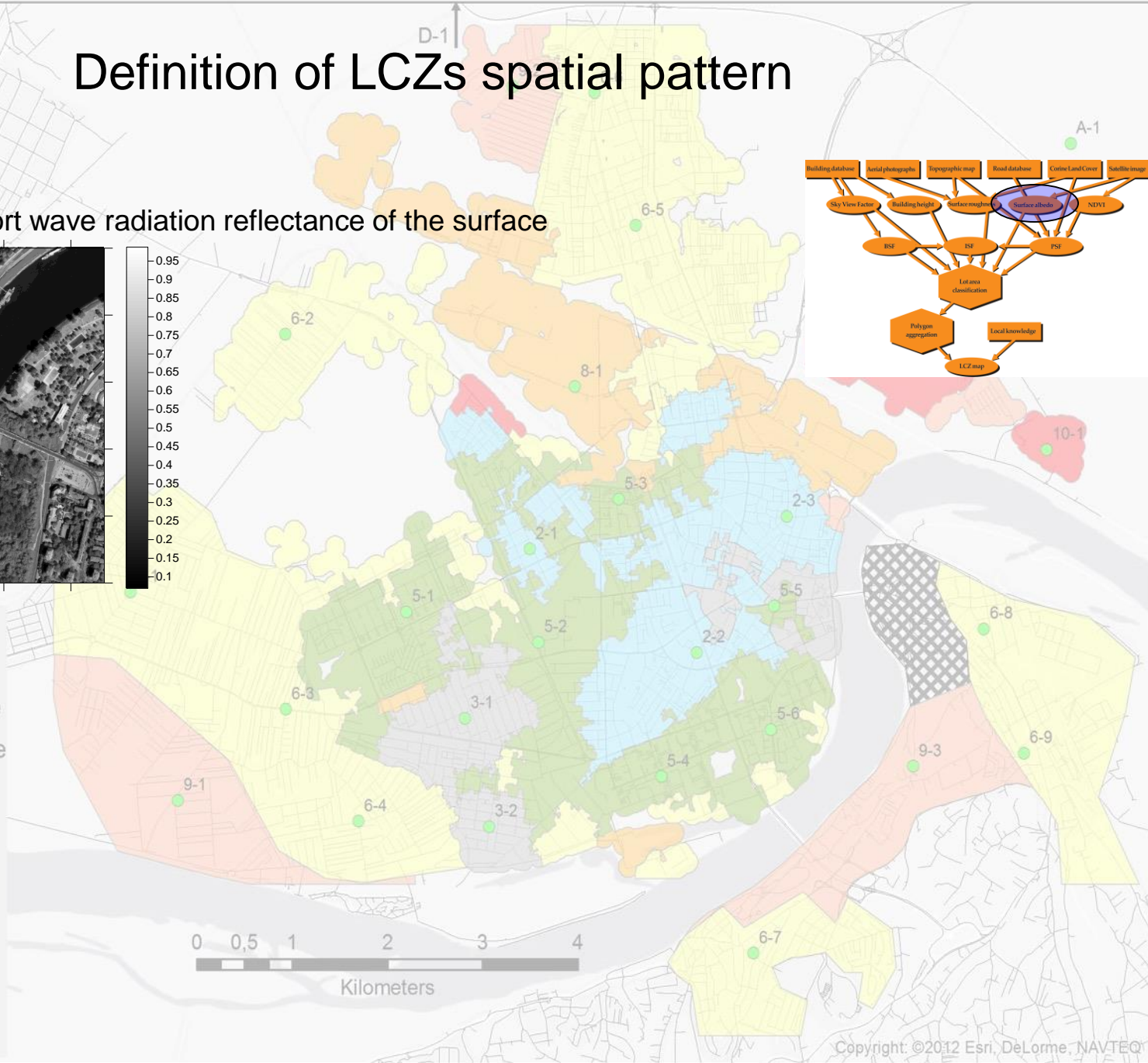


Definition of LCZs spatial pattern

Surface albedo
describes the short wave radiation reflectance of the surface



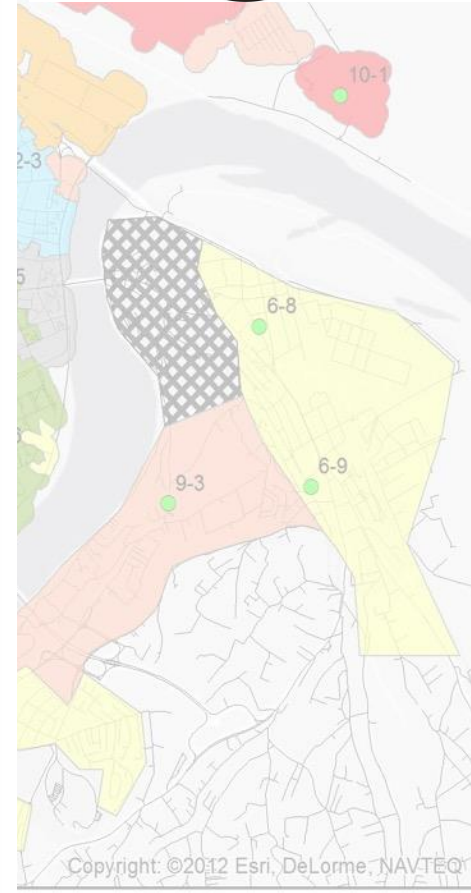
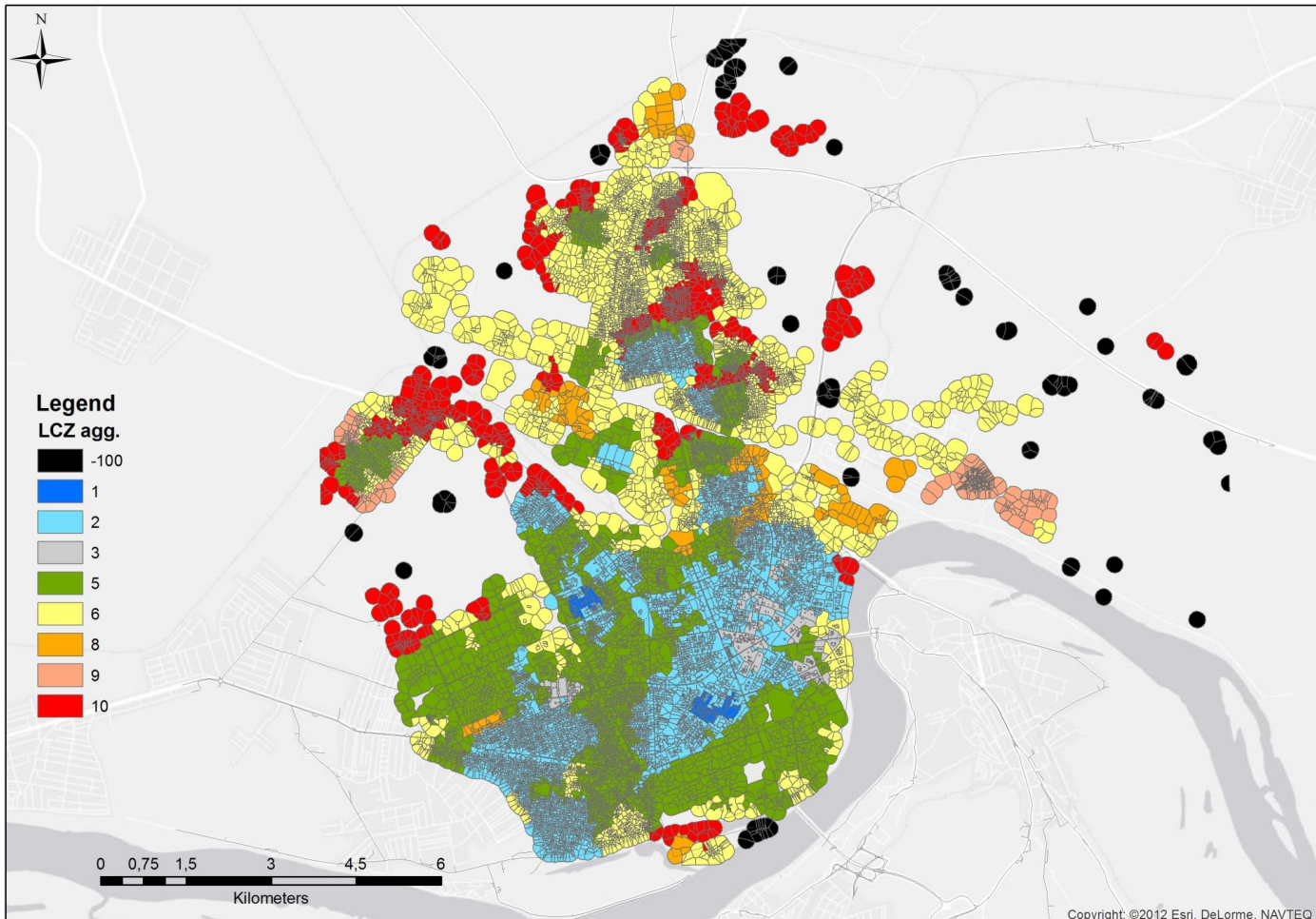
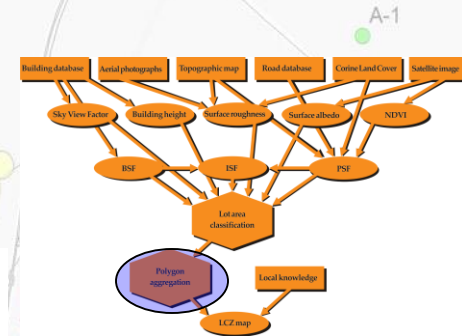
- Legend**
- LCZ**
- 2 - Compact midrise
 - 3 - Compact low-rise
 - 5 - Open midrise
 - 6 - Open low-rise
 - 8 - Large low-rise
 - 9 - Sparsely built
 - 10 - Heavy industry
 - Excluded area
 - Stations



Definition of LCZs spatial pattern

Lot area polygon (a building block and the area belonging to it)

aggregation of lot area polygons



Definition of LCZs spatial pattern

by Stewart and Oke 2012
(Bull. Am. Meteorol. Soc., 93, 1897-1900)

Built types	Definition	Land cover types	Definition
1. Compact high-rise	Dense mix of tall buildings to tens of stories. Few or no trees. Land cover mostly paved. Concrete, steel, stone, and glass construction materials.	A. Dense trees	Heavily wooded landscape of deciduous and/or evergreen trees. Land cover mostly pervious (low plants). Zone function is natural forest, tree cultivation, or urban park.
2. Compact midrise	Dense mix of midrise buildings (3-9 stories). Few or no trees. Land cover mostly paved. Stone, brick, tile, and concrete construction materials.	B. Scattered trees	Lightly wooded landscape of deciduous and/or evergreen trees. Land cover mostly pervious (low plants). Zone function is natural forest, tree cultivation, or urban park.
3. Compact low-rise	Dense mix of low-rise buildings (1-3 stories). Few or no trees. Land cover mostly paved. Stone, brick, tile, and concrete construction materials.	C. Bush, scrub	Open arrangement of bushes, shrubs, and short, woody trees. Land cover mostly pervious (bare soil or sand). Zone function is natural scrubland or agriculture.
4. Open high-rise	Open arrangement of tall buildings to tens of stories. Abundance of pervious land cover (low plants, scattered trees). Concrete, steel, stone, and glass construction materials.	D. Low plants	Featureless landscape of grass or herbaceous plants/crops. Few or no trees. Zone function is natural grassland, agriculture, or urban park.
5. Open midrise	Open arrangement of midrise buildings (3-9 stories). Abundance of pervious land cover (low plants, scattered trees). Concrete, steel, stone, and glass construction materials.	E. Bare rock or paved	Featureless landscape of rock or paved cover. Few or no trees or plants. Zone function is natural desert (rock) or urban transportation.
6. Open low-rise	Open arrangement of low-rise buildings (1-3 stories). Abundance of pervious land cover (low plants, scattered trees). Wood, brick, stone, tile, and concrete construction materials.	F. Bare soil or sand	Featureless landscape of soil or sand cover. Few or no trees or plants. Zone function is natural desert or agriculture.
7. Lightweight low-rise	Dense mix of single-story buildings. Few or no trees. Land cover mostly hard-packed. Lightweight construction materials (e.g., wood, thatch, corrugated metal).	G. Water	Large, open water bodies such as seas and lakes, or small bodies such as rivers, reservoirs, and lagoons.
8. Large low-rise	Open arrangement of large low-rise buildings (1-3 stories). Few or no trees. Land cover mostly paved. Steel, concrete, metal, and stone construction materials.	VARIABLE LAND COVER PROPERTIES	
9. Sparsely built	Sparse arrangement of small or medium-sized buildings in a natural setting. Abundance of pervious land cover (low plants, scattered trees).	b. bare trees	Leafless deciduous trees (e.g., winter). Increased sky view factor. Reduced albedo.
10. Heavy industry	Low-rise and midrise industrial structures (towers, tanks, stacks). Few or no trees. Land cover mostly paved or hard-packed. Metal, steel, and concrete construction materials.	s. snow cover	Snow cover >10 cm in depth. Low admittance. High albedo.
		d. dry ground	Parched soil. Low admittance. Large Bowen ratio. Increased albedo.
		w. wet ground	Waterlogged soil. High admittance. Small Bowen ratio. Reduced albedo.














D-1 ↑

Danube - Tisza - Danube

A-1

Legend

LCZ

-  2 - Compact midrise
-  3 - Compact low-rise
-  5 - Open midrise
-  6 - Open low-rise
-  8 - Large low-rise
-  9 - Sparsely built
-  10 - Heavy industry
-  Excluded area
-  Stations locations

6-2

9-2

6-6

6-5

8-1

10-1

5-3

2-3

6-1

2-1

5-1

5-2

PMF-1

6-3

3-1

5-6

9-3

9-1

6-4

3-2

5-4

6-9

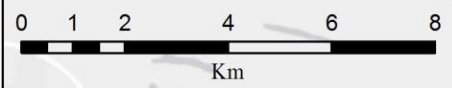
6-7

6-8

Нови Сад Novi Sad

Danube

Петровадин Petrova



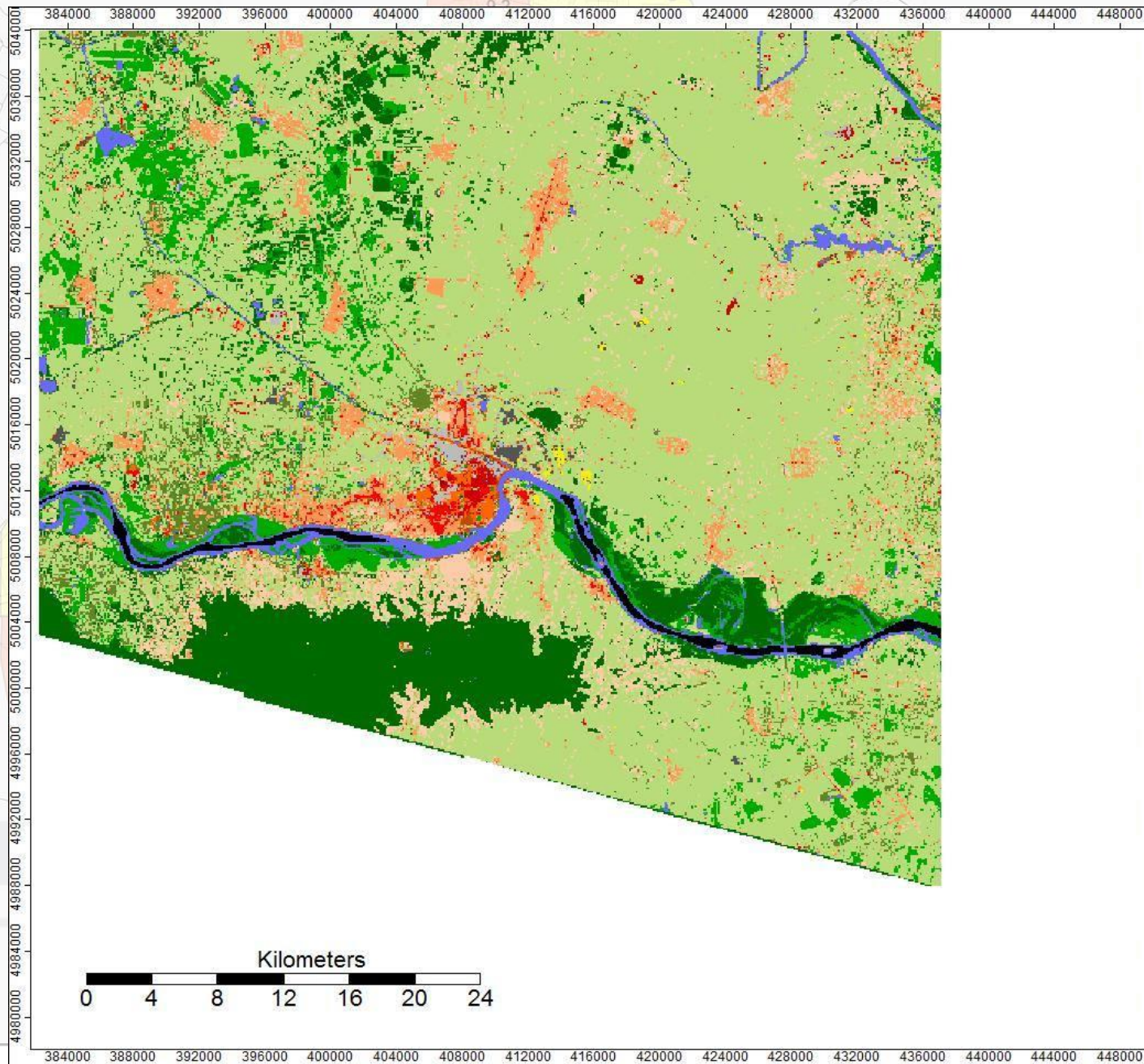
World Urban Database and Access Portal Tools – WUDAPT

using:
Google Earth
Landsat 7
GIS Saga software

Legend

LCZ

-  2 - Compact midrise
-  3 - Compact low-rise
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-  Excluded area
-  Stations

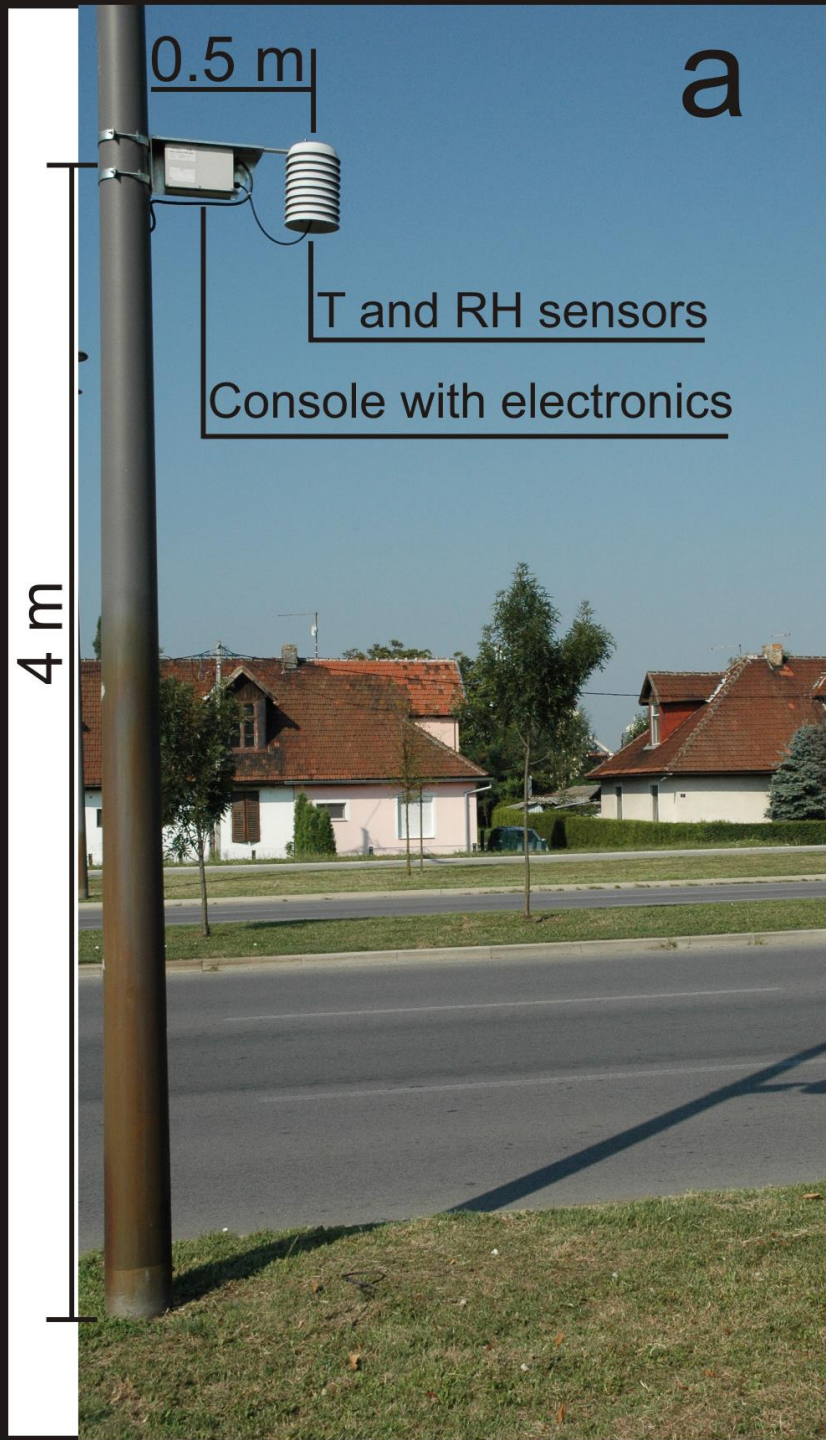




Legend

LCZ

	2
	3
	5
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	9
	10
	Ex
	St



0.5 m

a

T and RH sensors

Console with electronics

4 m

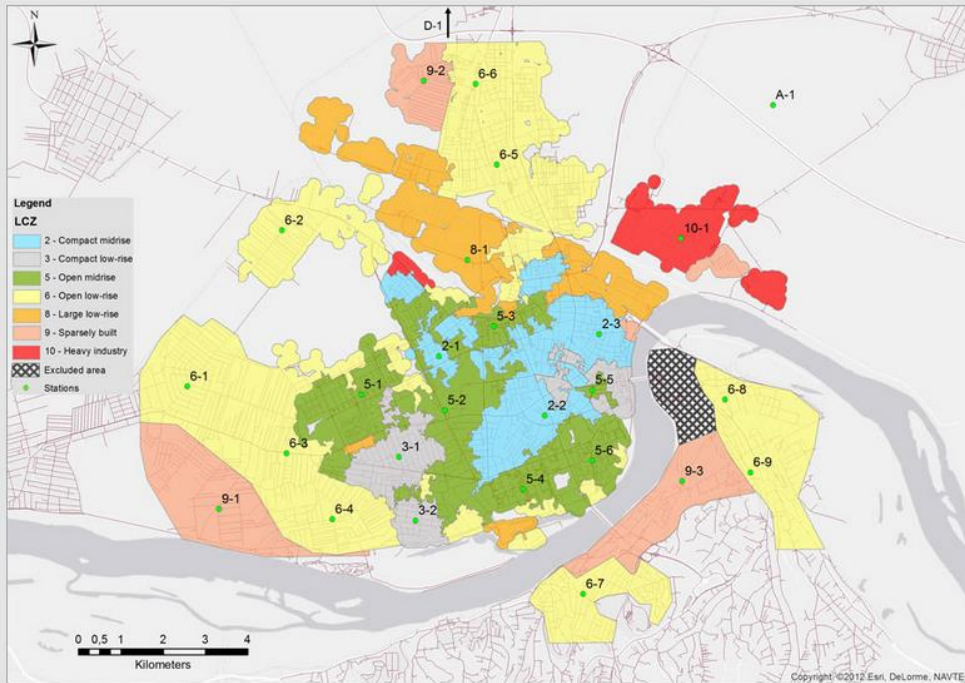


b

Wind measurements

Solar radiation

A-1



Stations monitor:

LATEST DATA:	ID / days ago
02-08-2016 / 19:40:00	2-1 / 0
02-08-2016 / 20:10:00	2-2 / 0
02-08-2016 / 20:10:00	2-3 / 0
02-08-2016 / 19:20:00	3-1 / 0
02-08-2016 / 20:10:00	3-2 / 0
02-08-2016 / 19:40:00	5-1 / 0
01-01-2066 / 06:00:00	5-2 / ERROR IN DATABASE DATA
02-08-2016 / 19:50:00	5-3 / 0
02-08-2016 / 20:10:00	5-4 / 0
02-08-2016 / 19:20:00	5-5 / 0
02-08-2016 / 20:10:00	5-6 / 0
02-08-2016 / 20:10:00	6-1 / 0
10-03-2016 / 11:40:00	6-2 / 145.4
02-08-2016 / 19:20:00	6-3 / 0
02-08-2016 / 19:10:00	6-4 / 0.1
02-08-2016 / 19:50:00	6-5 / 0
02-08-2016 / 19:20:00	6-6 / 0
02-08-2016 / 19:30:00	6-7 / 0
02-08-2016 / 19:50:00	6-8 / 0
02-08-2016 / 19:20:00	6-9 / 0
02-08-2016 / 20:10:00	8-1 / 0
02-08-2016 / 20:10:00	9-1 / 0
02-08-2016 / 19:00:00	9-2 / 0.1
02-08-2016 / 19:20:00	9-3 / 0
02-08-2016 / 19:40:00	10-1 / 0
02-08-2016 / 19:50:00	A-1 / 0
02-08-2016 / 20:00:00	D-1 / 0
02-08-2016 / 17:30:00	PMF-1 / 0.1

Legend: 1 days 2 * yellow flag

Missing measurements monitor:

MISSING DATA:	ID
357	2-1
3730	2-2
1671	2-3
12298	3-1
7751	3-2
8621	5-1
4250	5-2
4529	5-3
3758	5-4
4733	5-5
4975	5-6
9256	6-1
22758	6-2
3936	6-3
5553	6-4
2883	6-5
1353	6-6
2107	6-7
4494	6-8
1904	6-9
6837	8-1
3448	9-1
7290	9-2
1922	9-3
299	10-1
2818	A-1
11684	D-1
1194	PMF-1

Select database: range:

Climate Data ▼

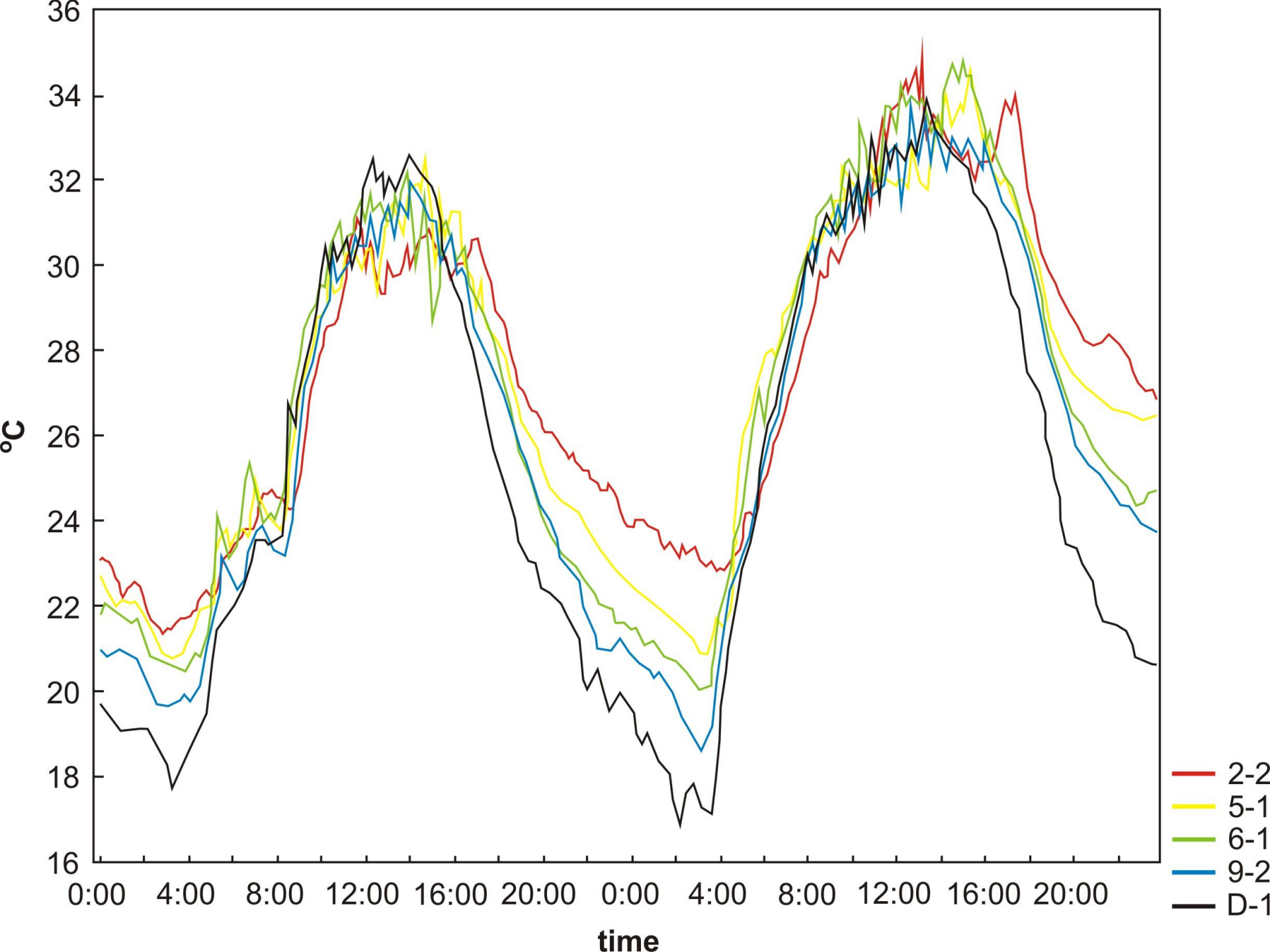
Debug Data ▼

Average Data ▼

LOCATION Data ▼

STATISTICS Data ▼





Temperature outcomes in Novi Sad

Milošević, D., Savić, S., Unger, J., Gál, T. 2015. Urban climate monitoring system suitability for intra-urban thermal comfort observations in Novi Sad (Serbia) – with 2014 examples. ICUC9 – 9th International Conference on Urban Climate jointly with 12th Symposium on the Urban Environment, 20th-24th July 2015, Toulouse, France, Extended Abstracts: 6 pp.

Lelovics, E., Unger, J., Savić, S., Gál, T., Milošević, D., Gulyás, Á., Marković, V., Arsenović, D., Gál, CV. 2016. Intra-urban temperature observations in two Central European cities: a summer study. *Idojaras*, 120, 3: 283-300.

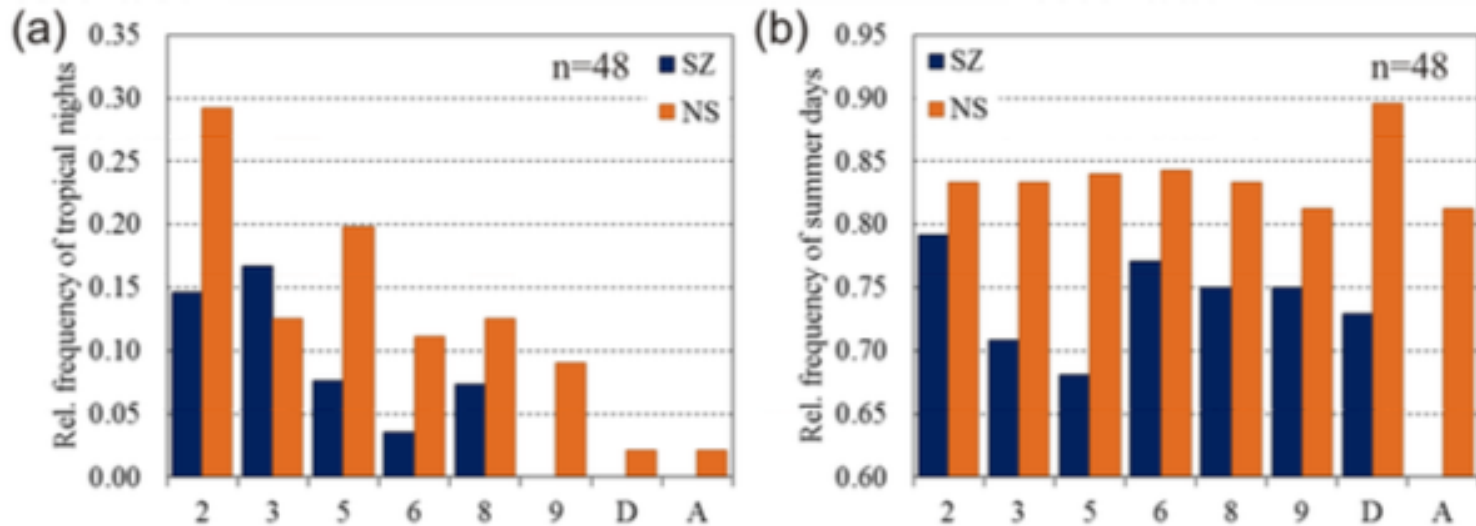


Fig. 4. Relative frequency of tropical nights (a) and summer days (b) by LCZ classes in Szeged and Novi Sad calculated for the selected common set of days



Temperature outcomes in Novi Sad

Milošević, D., Savić, S., Unger, J., Gál, T. 2015. Urban climate monitoring system suitability for intra-urban thermal comfort observations in Novi Sad (Serbia) – with 2014 examples. ICUC9 – 9th International Conference on Urban Climate jointly with 12th Symposium on the Urban Environment, 20th-24th July 2015, Toulouse, France, Extended Abstracts: 6 pp.

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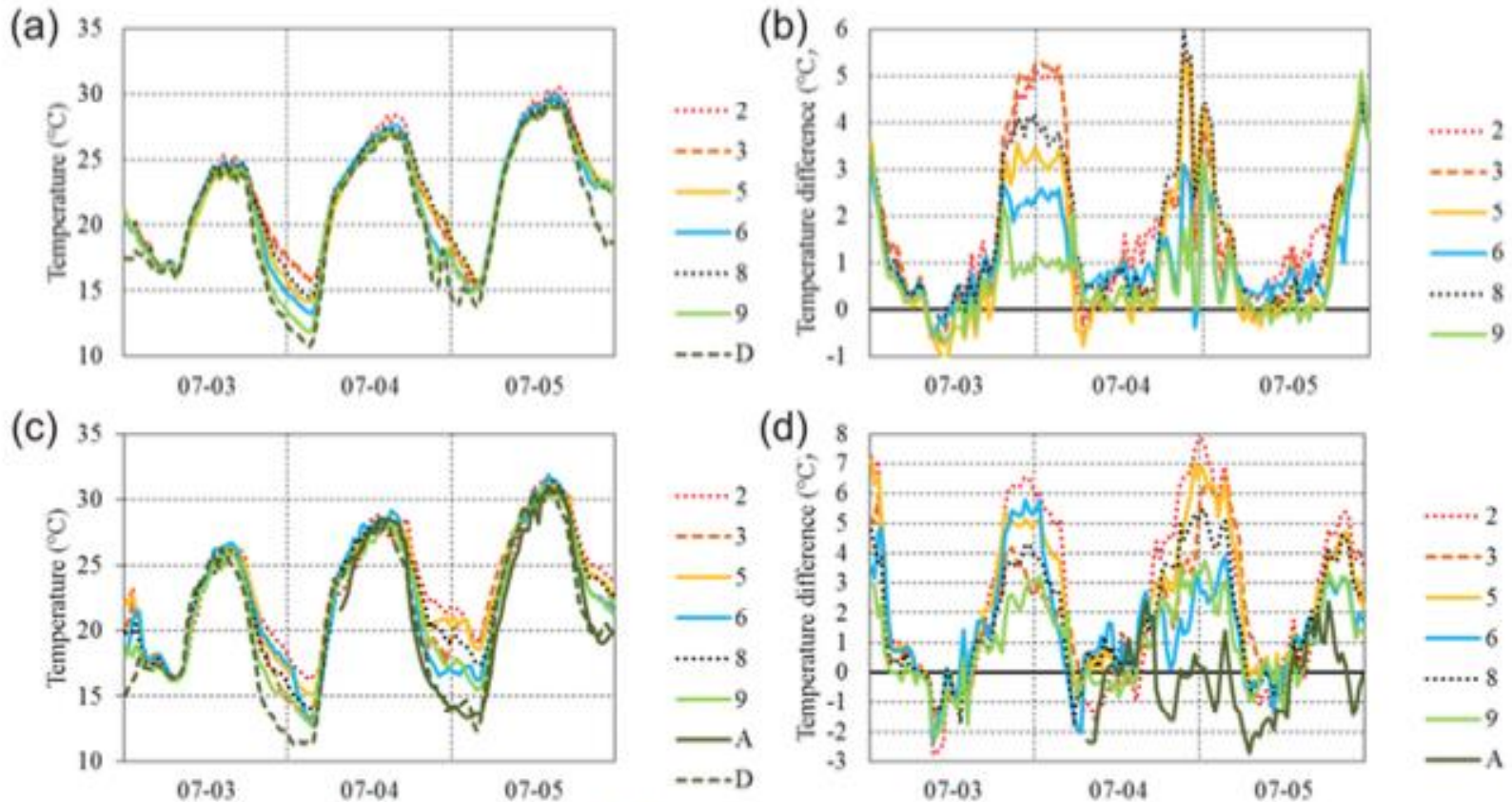
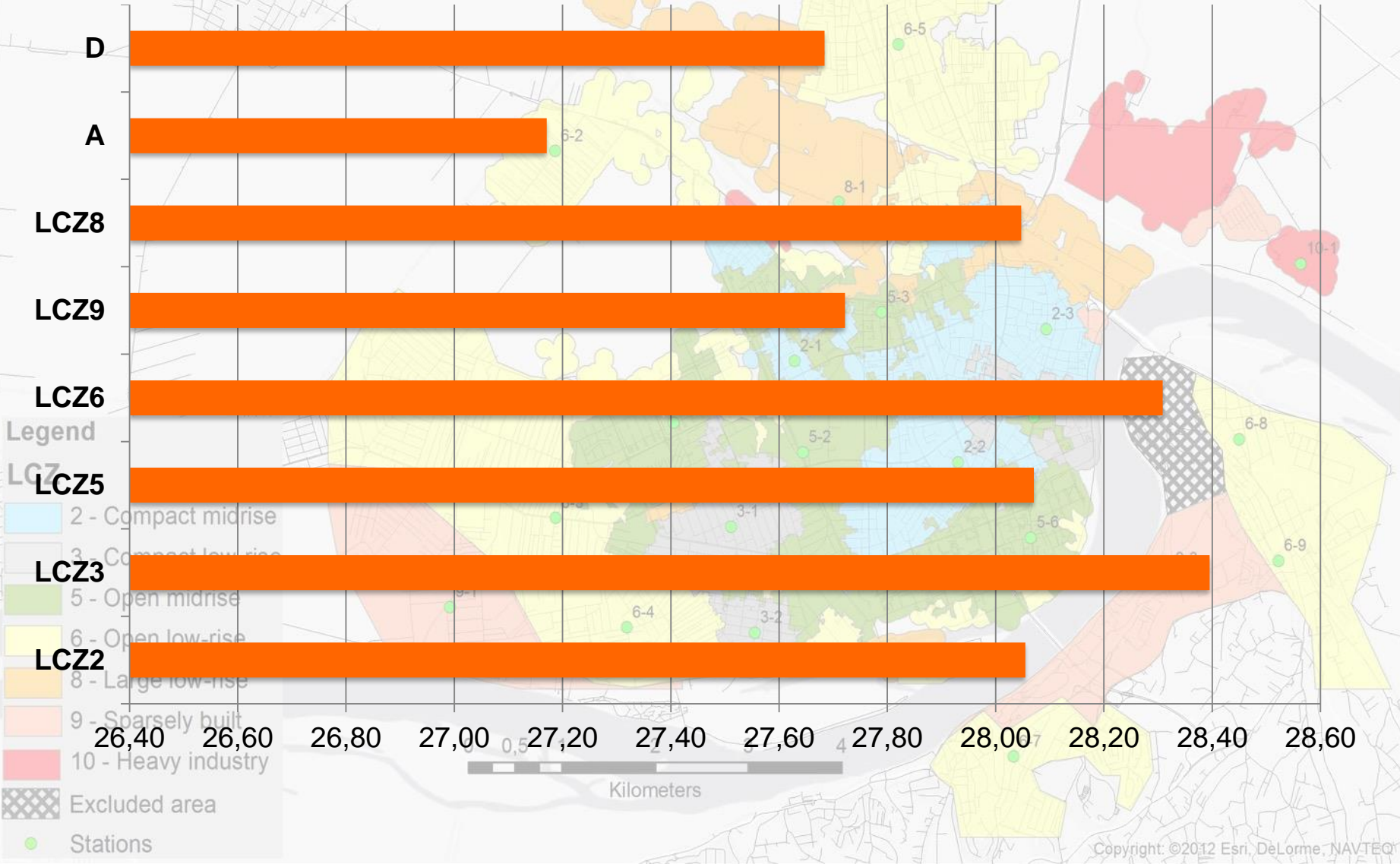


Fig. 5. Absolute and relative (difference from LCZ D) temperature variations at selected sites in Szeged (a, b) and Novi Sad (c, d) (July 3 to 5, 2014)



T

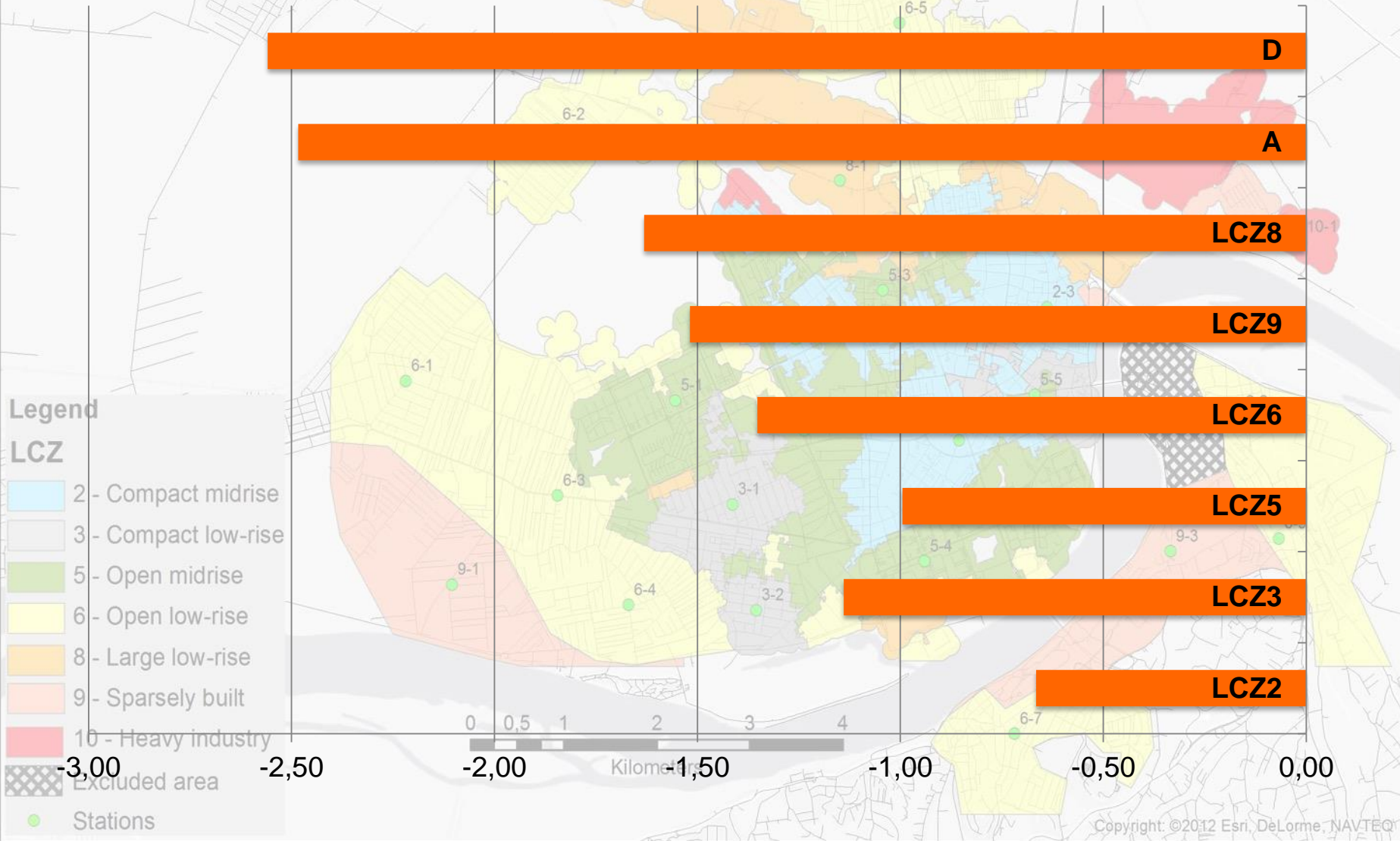
threshold: 90th perc. → $\geq 24.9^\circ$ C (01.07.2014-30.06.2015) ^{A-1}





T

threshold: 10th perc. → $\leq 2.3^{\circ}$ C (01.07.2014-30.06.2015)



CLIMATOLOGY AND HYDROLOGY RESEARCH CENTRE



NEWS & EVENTS



NOVEMBER 12 2016



A-1

10-1

6-8

6-9



Legend

LCZ

- 2 - Compact
- 3 - Compact
- 5 - Open
- 6 - Open
- 8 - Large
- 9 - Sparse
- 10 - Heavy
- Excluded
- Stations



CLIMATE RESEARCH

TO DISCOVER AND EXPLAIN THE IMPACTS OF CLIMATE ON SOCIETY

RESEARCH TOPICS

- The climatology and meteorology of urban areas -
- Outdoor human comfort -
- Climate and urban planning -
- Climatic changes in Europe -
- Climate impacts on agriculture -
- etc. -

PROJECTS

- Evaluations and public display of urban patterns of human thermal conditions (URBAN-PATH Project) -

PUBLICATIONS

A list of relevant scientific papers can be downloaded:

[Download](#)

Legend

LCZ

- 2 - Compact low-rise
- 3 - Compact mid-rise
- 5 - Open low-rise
- 6 - Open low-rise
- 8 - Large low-rise
- 9 - Sparse low-rise
- 10 - Heavy low-rise
- Excluded areas
- Stations

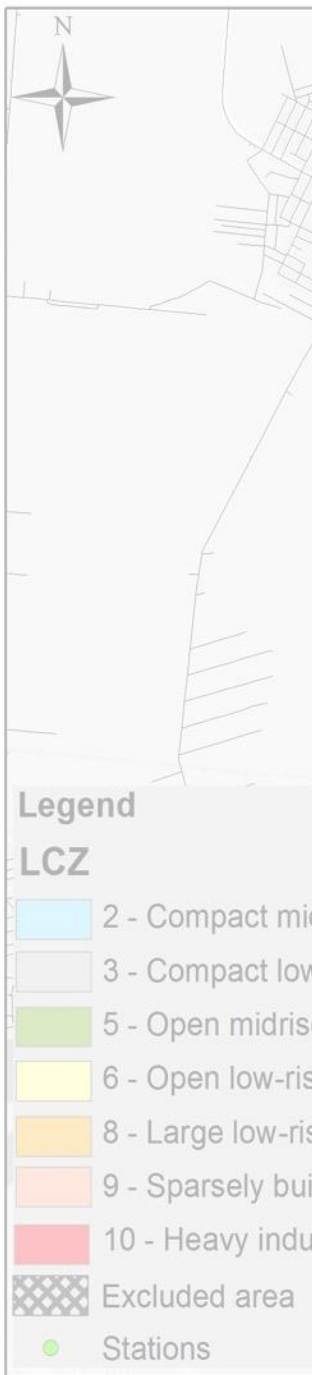
A-1

10-1

6-8

6-9

Esri, DeLorme, NAVTEQ



NSUNET-Weather

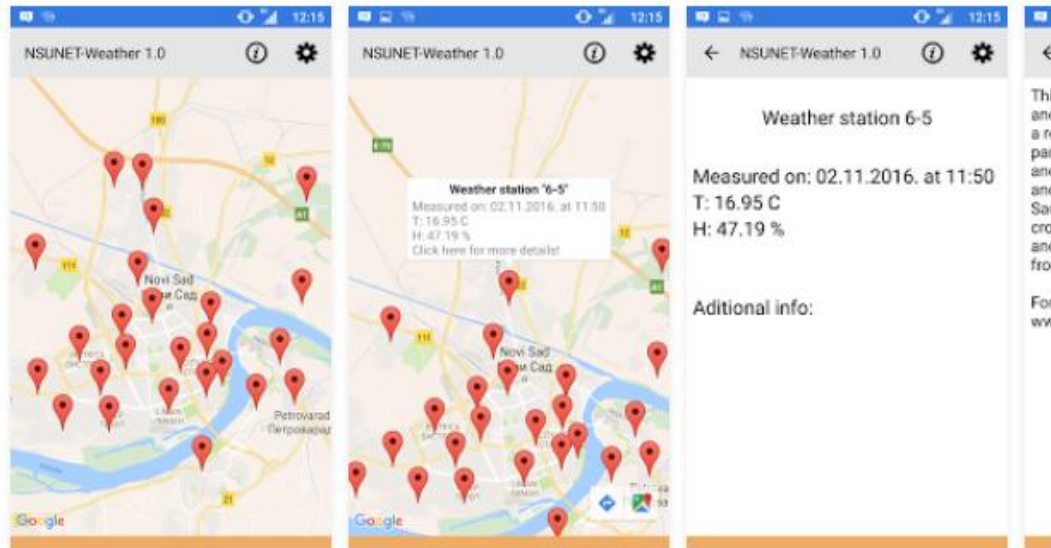
PMF informatika Weather

★★★★★ 45

PEGI 3

Add to Wishlist

Install



NSUNET-Weather presents hourly air temperature and relative humidity measurements from 28 meteorological stations within NSUNET system, installed in urban area of Novi Sad (Serbia). The NSUNET system is result of the project Evaluation and public display of URBAN PATterns of Human thermal conditions – URBAN-PATH, financed by IPA HU-SRB cross-border program. The URBAN-PATH project is realised by Department of Climatology and Landscape Ecology, Faculty of Sciences (University of Szeged, Hungary) and Climatology and Hydrology Research Centre, Faculty of

[READ MORE](#)





www.clihyd.com

Legend

LCZ

- 2 - Compact midrise
- 3 - Compact low-rise
- 5 - Open midrise
- 6 - Open low-rise
- 8 - Large low-rise
- 9 - Sparsely built
- 10 - Heavy industry
- Excluded area
- Stations



Address:

Trg Dositeja Obradovića 3, Novi Sad, Serbia



E-mail:

stevan.savic@dgt.uns.ac.rs
dragan.milosevic@dgt.uns.ac.rs

