A global map of Local Climate Zones

to support earth system modelling and urban scale environmental science

Matthias Demuzere
Benjamin bechtel
Jonas Kittner
& many more

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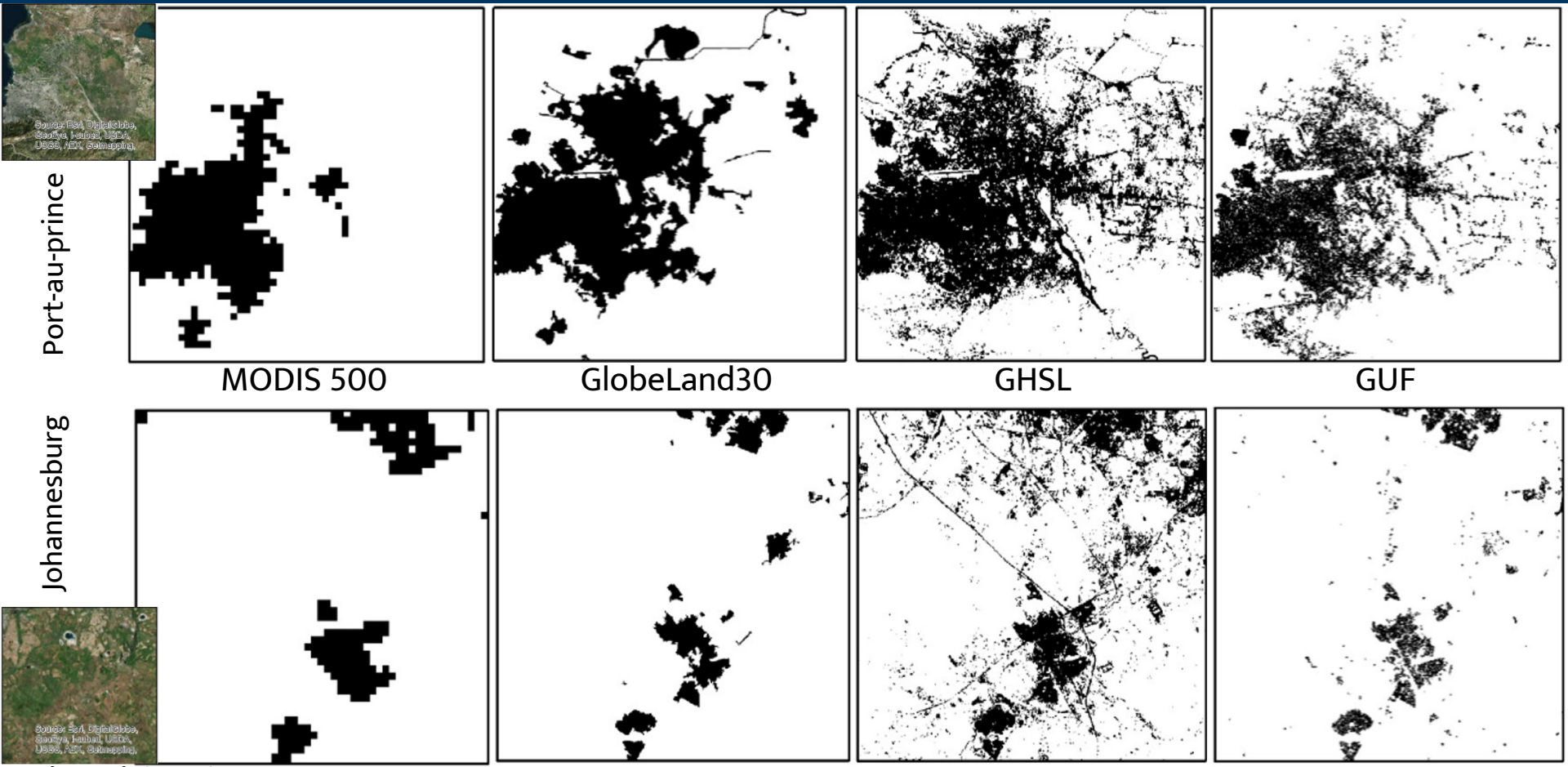
mdemuzere

WMO Urban Workshop, 13-15 June 2022

Context



Esch et al. (2017)

WUDAPT?

AMS
American Meteorological Society

WUDAPT

An Urban Weather, Climate, and Environmental Modeling Infrastructure for the Anthropocene

J. Ching, G. Mills, B. Bechtel, L. See, J. Feddema, X. Wang, C. Ren, O. Brousse, A. Martilli, M. Neophytou, P. Mouzourides, I. Stewart, A. Hanna, E. Ng, M. Foley, P. Alexander, D. Aliaga, D. Niyogi, A. Shreevastava, P. Bhalachandran, V. Masson, J. Hidalgo, J. Fung, M. Andrade, A. Baklanov, W. Dai, G. Milcinski, M. Demuzere, N. Brunsell, M. Pesaresi, S. Miao, Q. Mu, F. Chen, and N. Theeuwes

World Urban Database and Access Portal Tools

WUDAPT is an international community-generated urban canopy information and modeling infrastructure to facilitate urban-focused climate, weather, air quality, and energy-use modeling application studies

Ching et al. (2018)

WUDAPT?

WUDAPT Levels 0, 1 & 2 features and their potential applications.

Product	Level 0	Level 1	Level 2
Coverage	Over 120 cities and regions	Data gathering methods; and testing to refine Level 0 based on crowdsourcing APPS and Buidling Typology approaches as in MApUCE	Any city by using our new 3-D mapping technology, DSC
Data source	Landsat + Google Earth + local data & expert evaluation	Landsat + Google Earth + local data & expert evaluation	World-view Stereo Data + Terra-SAR data
Resolution	100–500 m	100–500 m	2 m
Format	kml, tiff	GIS shapefiles	GIS shapefiles
Applications	Environment and Energy (Weather Research and Forecasting (WRF) Modeling, Urban heat island) Urban and Regional planning (population density)	Environment and Energy (weather and climate, urban air flows, urban radiation, mean radiant temperature, urban energy consumption, air pollution, CO2 and GHG emission) Ecology (biodiversity) Urban and Regional planning (master plan, land use plan, green master plan, new town plan)	Environment and Energy (building energy cost) Building and community design (visibility analysis, building development) Disaster and risk management (Flooding, heatwave) Pedestrian and citizen's mobility (walkability, thermal comfort) Public health (polluted areas)

Ching et al. (2019)

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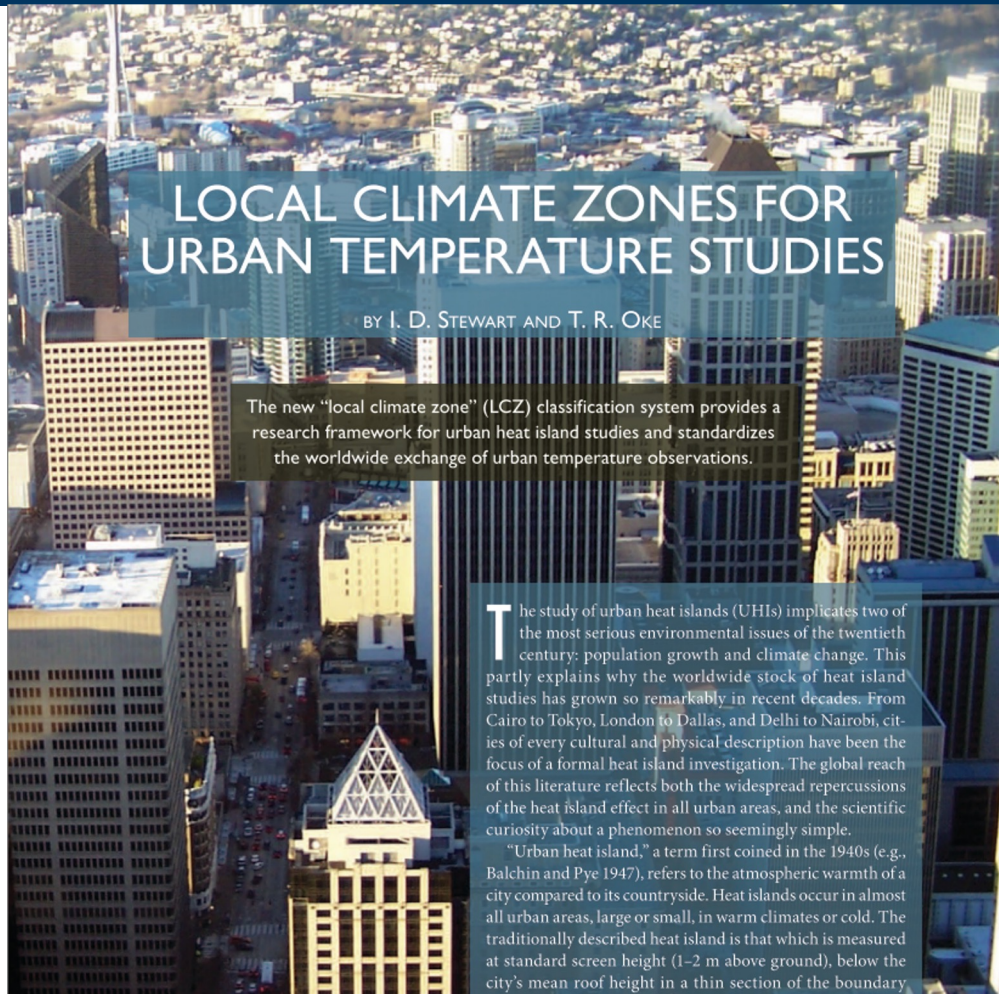
Local Climate Zone maps

Ching et al. (2019)

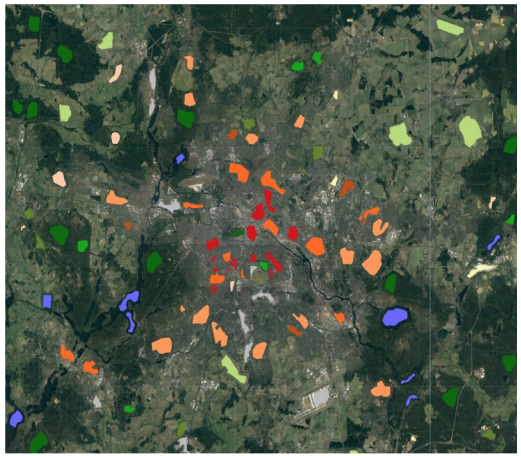
Local Climate Zones (LCZs)?

Stewart et al. (2012), Demuzere et al. (2020)

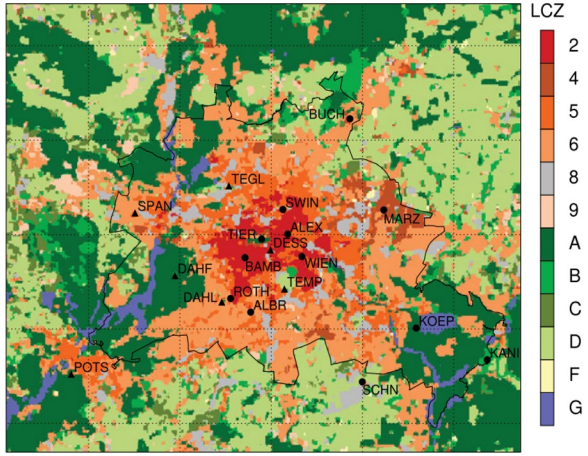


LCZ maps?

USGS



SAGA
System for Automated Geoscientific Analyses

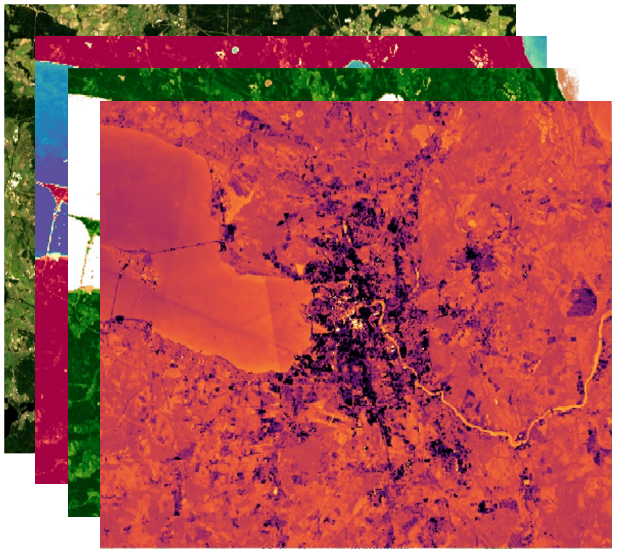


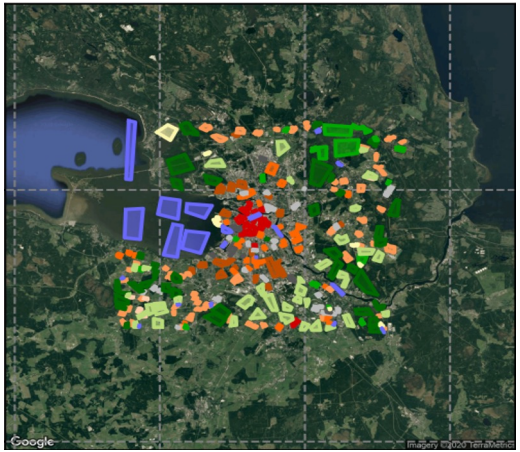
\+ This method is universal, simple and objective

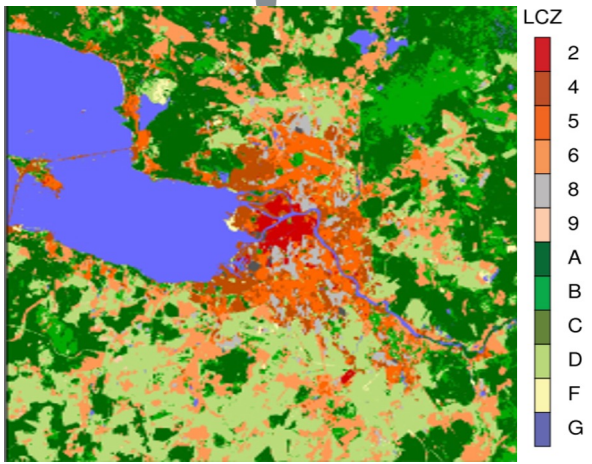
\- It requires the download of large satellite images, and lacks an automated quality control and sufficient resources to keep dissemination up-to-date

Bechtel et al. (2015), Fenner et al. (2017)

LCZ maps in the cloud

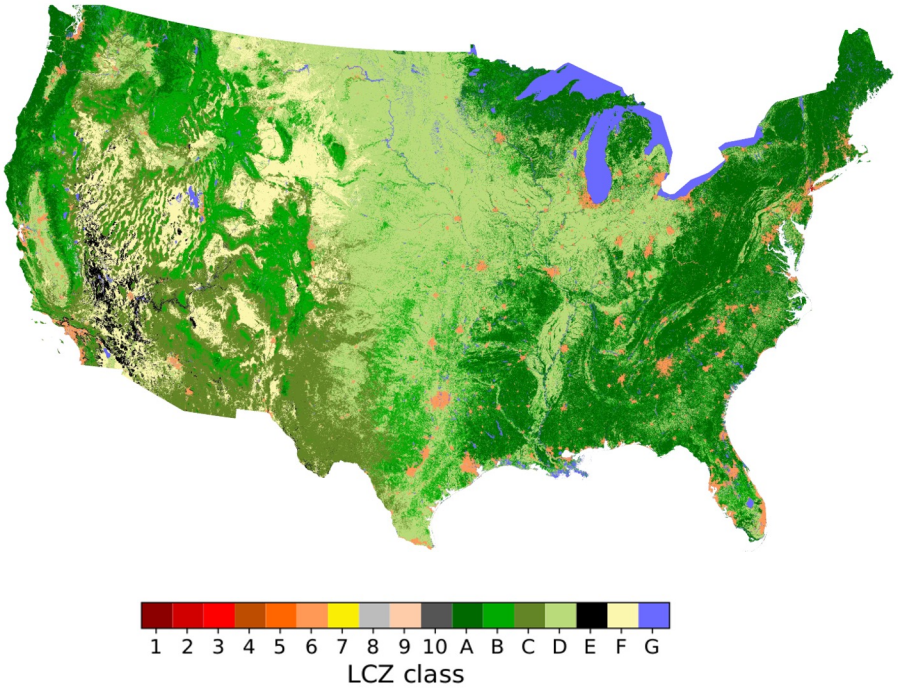






Demuzere et al. (2019a)

Continental-scale LCZ maps



More LCZ maps: https://www.wudapt.org/lcz-maps/

Demuzere et al. (2019b, 2020)

LCZ database?

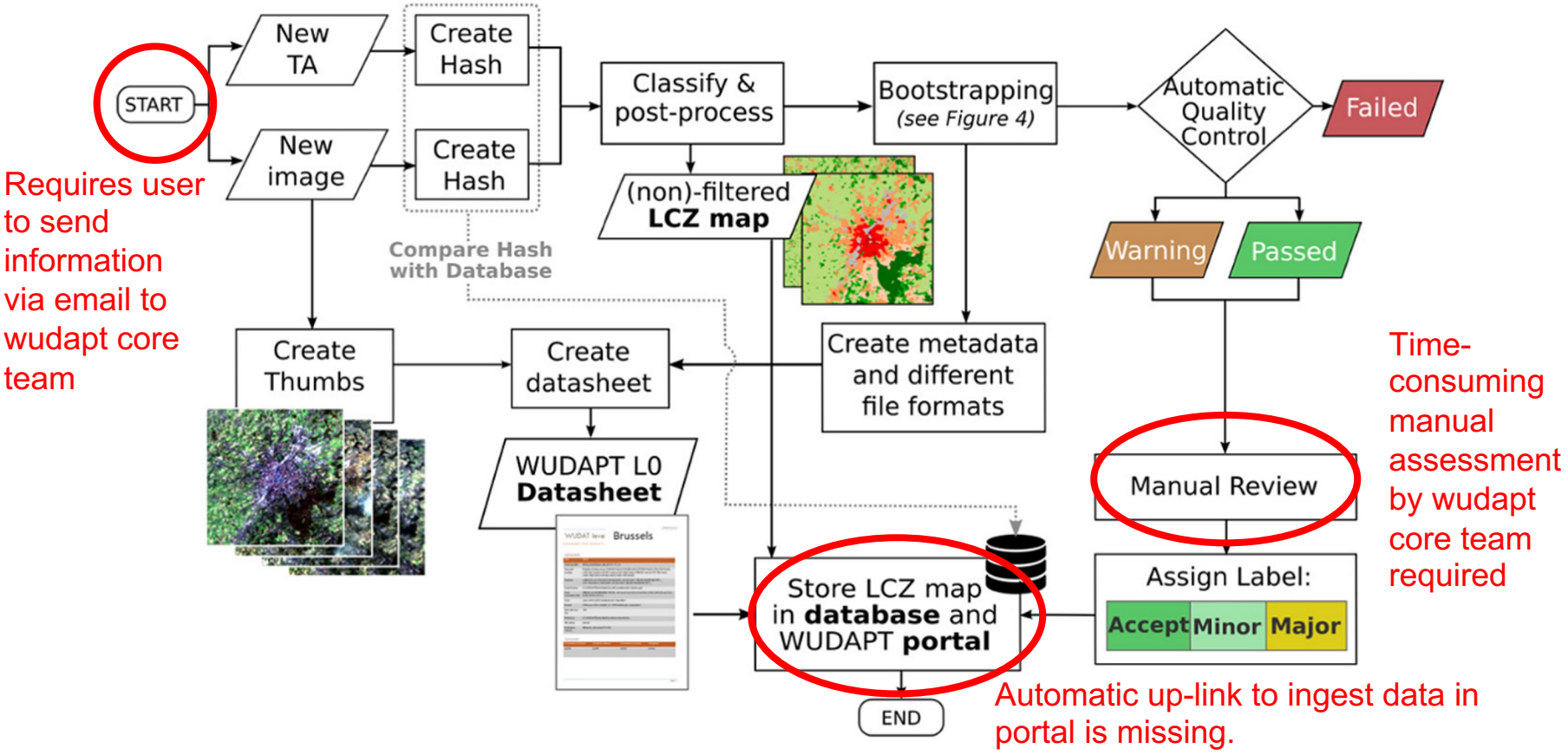


Fig. 2. The LCZ production and quality assessment workflow.

Bechtel et al. (2019a)

LCZ Generator

https://lcz-generator.rub.de/

User input

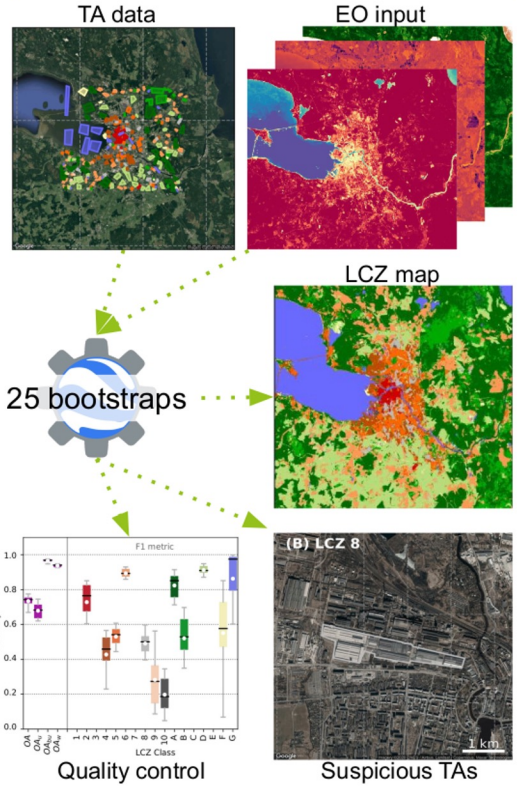
1. **Personal information**

- First Name
- Last Name
- E-mail Address

2. **Training area information**

- Continent
- Country
- City Name
- **Upload training area file**
- Representative Date
- Reference
- Remarks

LCZ classification & quality control



Output

1. **Compressed results (e-mail)**

- Factsheet
- LCZ map
- QGIS/ArcGIS colormaps

- data/
  - *ID.kml*
  - *ID_TA_statistics.csv*
  - *ID_auto_qc_polygon.shp*
  - *ID_auto_qc_point.shp*
  - *ID_cm_average_formatted.csv*
- figures/
  - *ta_freq.png*
  - *lcz_map.jpg*
  - *lcz_oa.jpg*

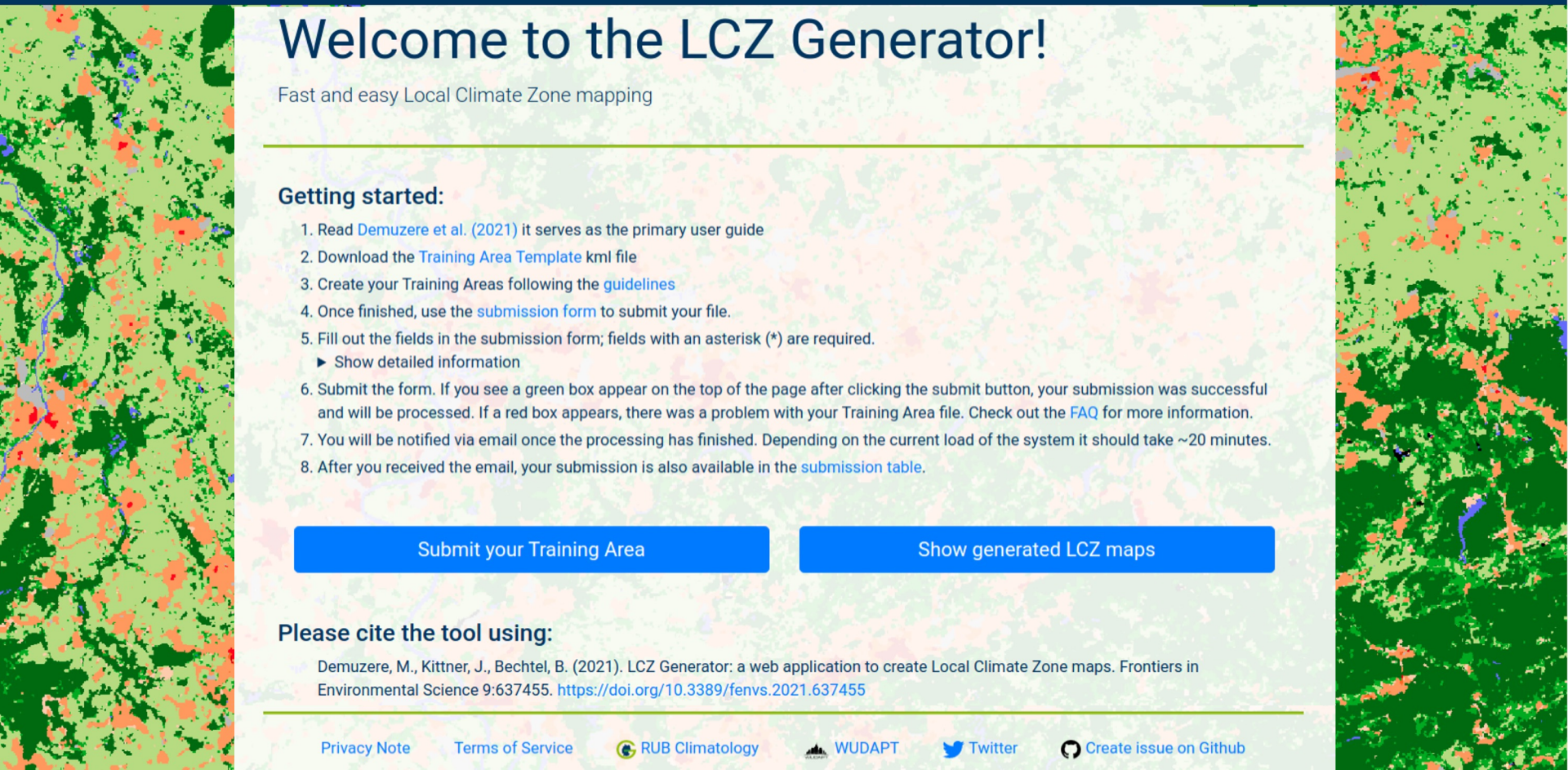
2. **Online submission table**

Improve training area data

Demuzere et al. (2021)

LCZ Generator

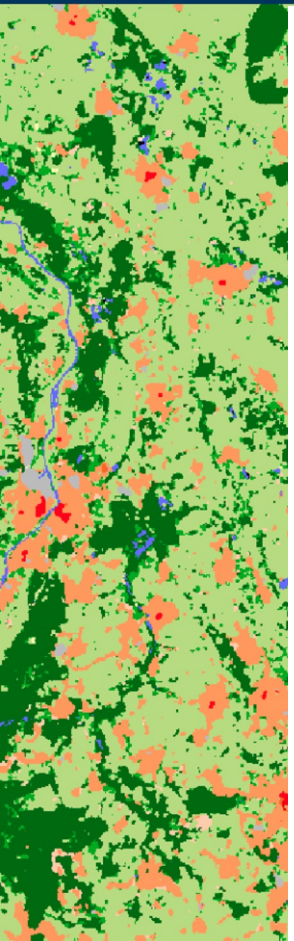
https://lcz-generator.rub.de/



LCZ Generator

https://lcz-generator.rub.de/

LCZ Generator Home Training area submission Available LCZ maps FAQ



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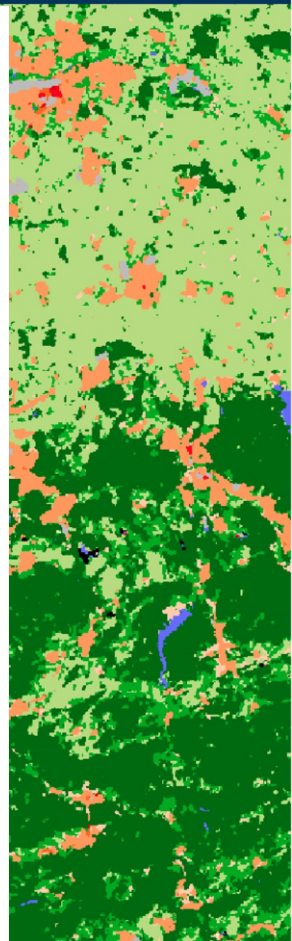
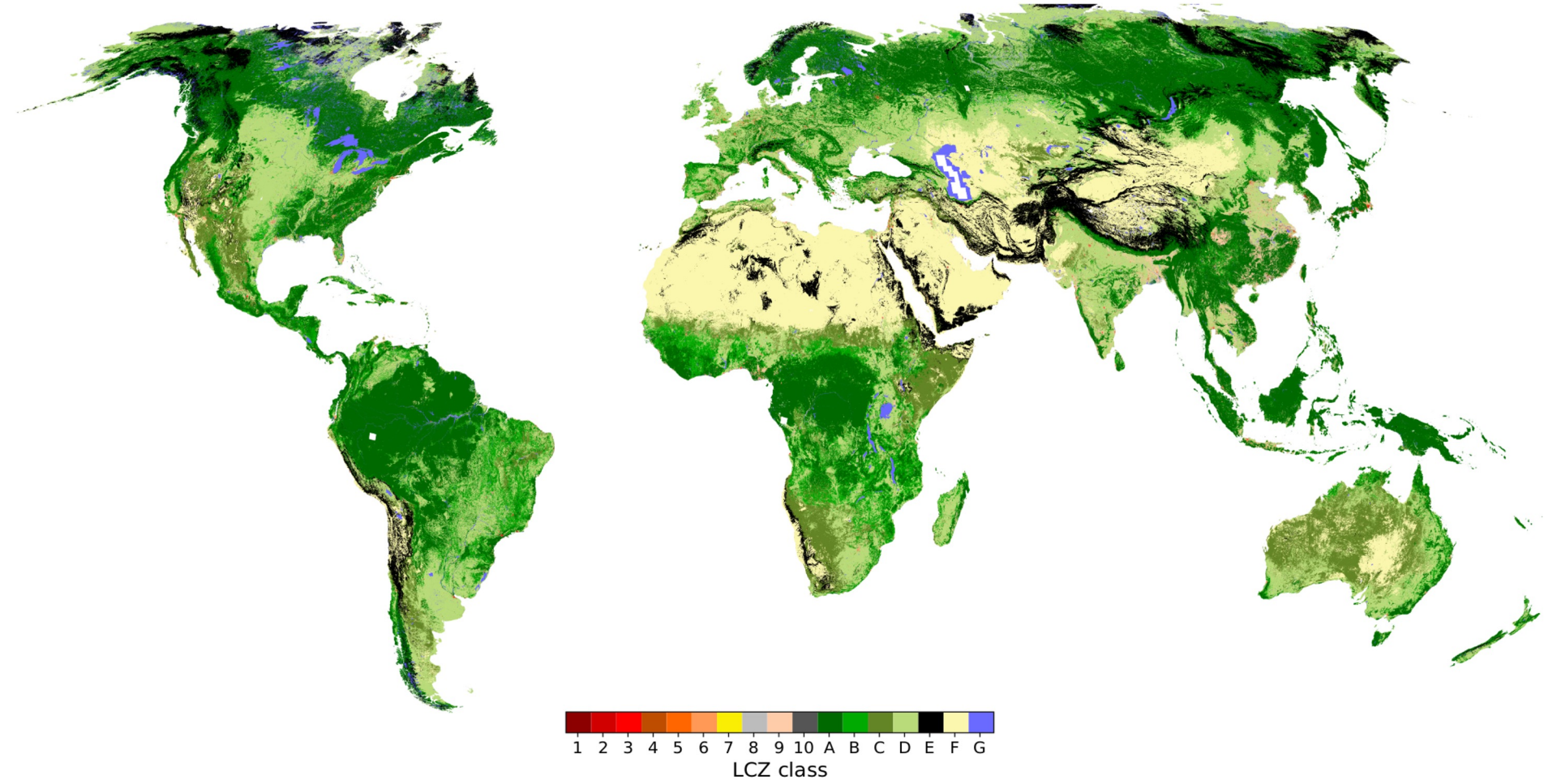
☐	NANJING	China, People's Republic of	Asia	2022-06-08 00:26:51	Yokey Tang	0.81	Show Factsheet
☐	Salt Lake City	United States of America	North America	2022-06-07 17:53:05	Natalie White	0.52	Show Factsheet
☐	SÃO PAULO	Brazil, Federative Republic of	South America	2022-06-07 14:42:41	Sara Lopes De Moraes	0.65	Show Factsheet
☐	Piatra Neamt	Romania	Europe	2022-06-07 11:58:14	Dragos Butnaru	0.70	Show Factsheet
☐	Bhubaneswar	India, Republic of	Asia	2022-06-07 11:40:03		0.43	Show Factsheet
☐	São Paulo	Brazil, Federative Republic of	South America	2022-06-07 11:00:13	Sara Lopes De Moraes	0.65	Show Factsheet
☐	nanjing	China, People's Republic of	Asia	2022-06-07 01:53:29	Yokey Tang	0.82	Show Factsheet
☐	São Paulo	Brazil, Federative Republic of	South America	2022-06-06 16:31:53	Sara Lopes De Moraes	0.65	Show Factsheet
☐	Yazd	Iran, Islamic Republic of	Asia	2022-06-06 15:48:24		0.69	Show Factsheet

Showing 1 to 10 of 2,175 entries

First Previous 1 2 3 4 5 ... 218 Next Last



Global map of LCZs



LCZ maps ~ climate modelling?

Table: LCZ-class specific urban canopy parameter values

LCZ	λ_B	λ_I	λ_V	H	SVF	AHF	IMD
1. Compact high-rise	40–60	40–60	<10	>25	0.2–0.4	50–300	>80
2. Compact midrise	40–70	30–50	<20	10–25	0.3–0.6	<75	>70
3. Compact low-rise	40–70	20–50	<30	3–10	0.2–0.6	<75	>60
4. Open high-rise	20–40	30–40	30–40	>25	0.5–0.7	<50	50–80
5. Open midrise	20–40	30–50	20–40	10–25	0.5–0.8	<25	50–80
6. Open low-rise	20–40	20–50	30–60	3–10	0.6–0.9	<25	40-90
7. Lightweight low-rise	60–90	<20	<30	2–4	0.2–0.5	<35	>60
8. Large low-rise	30–50	40–50	<20	3–10	>0.7	<50	>70
9. Sparsely built	10–20	<20	60–80	3–10	>0.8	<10	10-40
10. Heavy industry	20–30	20–40	40–50	5–15	0.6–0.9	>300	>40
A. Dense trees	<10	<10	>90	3–30	<0.4	0	<20
B. Scattered trees	<10	<10	>90	3–15	0.5–0.8	0	<20
C. Bush, scrub	<10	<10	>90	<2	0.7–0.9	0	<20
D. Low plants	<10	<10	>90	<1	>0.9	0	<20
E. Bare rock or paved	<10	>90	<10	<0.25	>0.9	0	>90
F. Bare soil or sand	<10	<10	>90	<0.25	>0.9	0	<20
G. Water	<10	<10	>90	–	>0.9	0	<20

+ Radiative and thermal properties such as emissivity, albedo, heat capacity, heat conductivity etc ...

Stewart & Oke (2012); Demuzere et al. (2019a, 2022)

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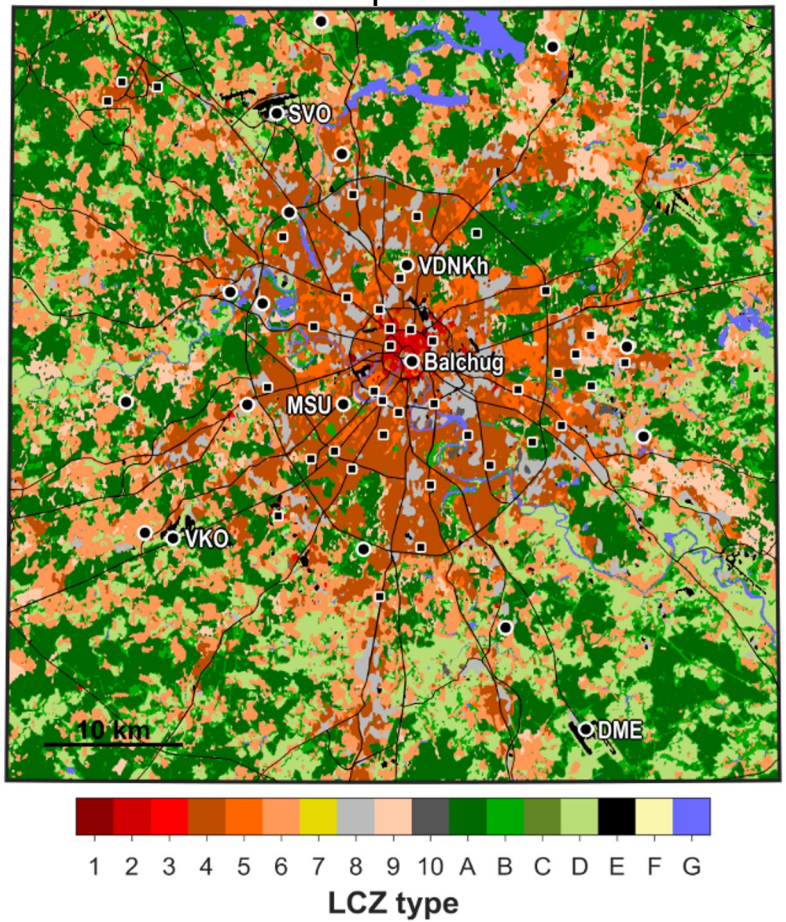
+ Radiative and thermal properties such as emissivity, albedo, heat capacity, heat conductivity etc ...

> The global LCZ map describes all the cities of the world,
> in the same, universal language,
> but interested users can read it in their own dialect

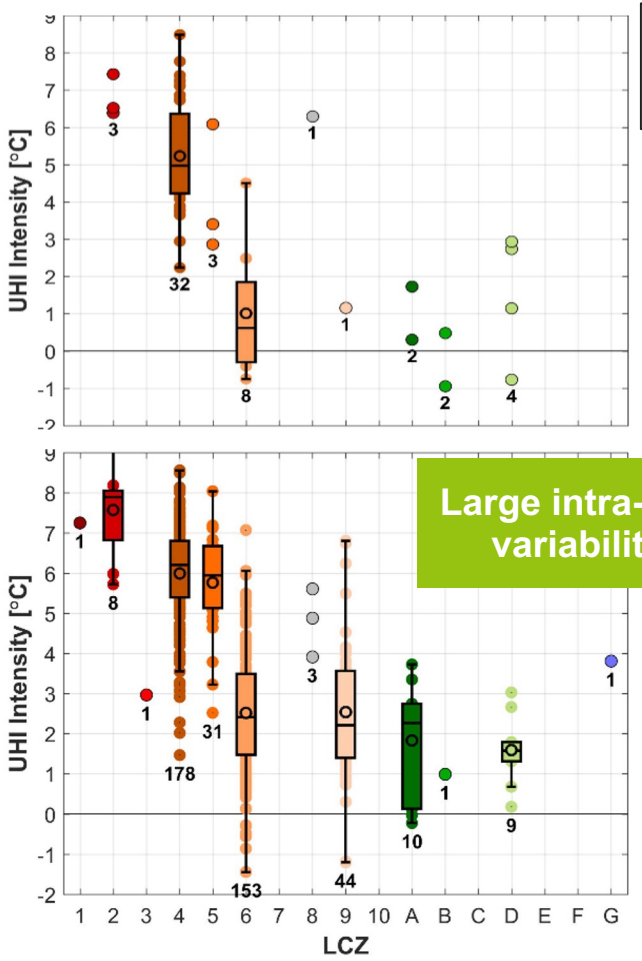
Demuzere et al. (2022)

LCZ map Moscow



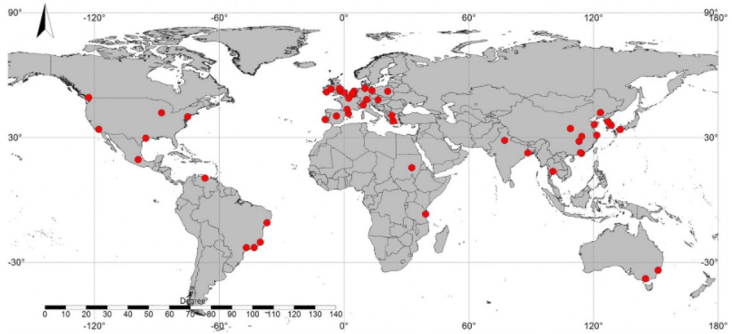
Reference weather stations

Citizen weather stations (netatmo)



Varentsov et al. (2021)

The LCZ approach provides a consistent and comprehensive framework for SUHI analysis.



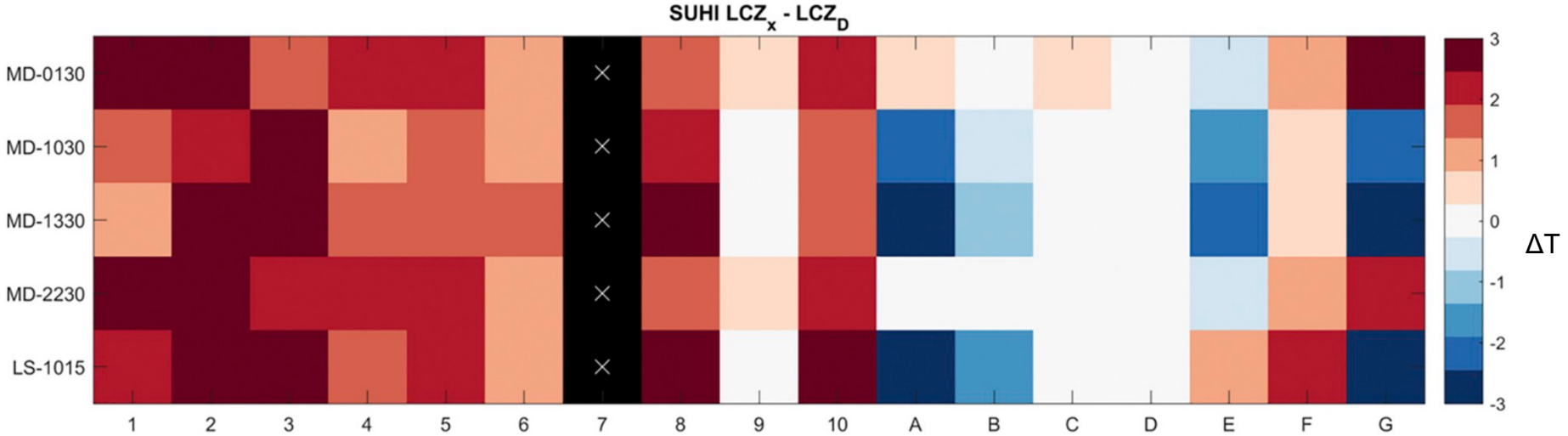


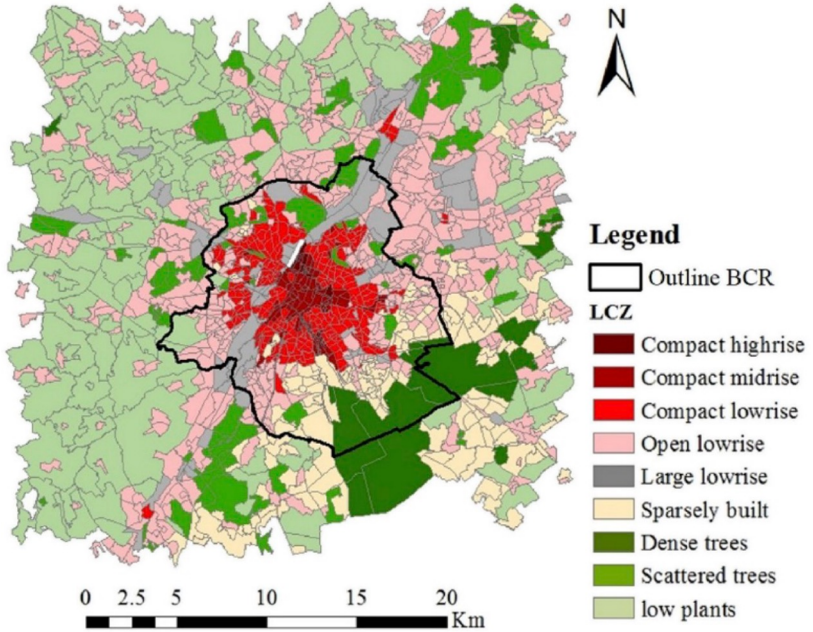
Fig. 11. Average SUHI intensity in K for all cities and LCZ compared to LCZ D for different acquisition times and sensors. Black with white x (LCZ 7) indicates that the LCZ type is not present in the study.

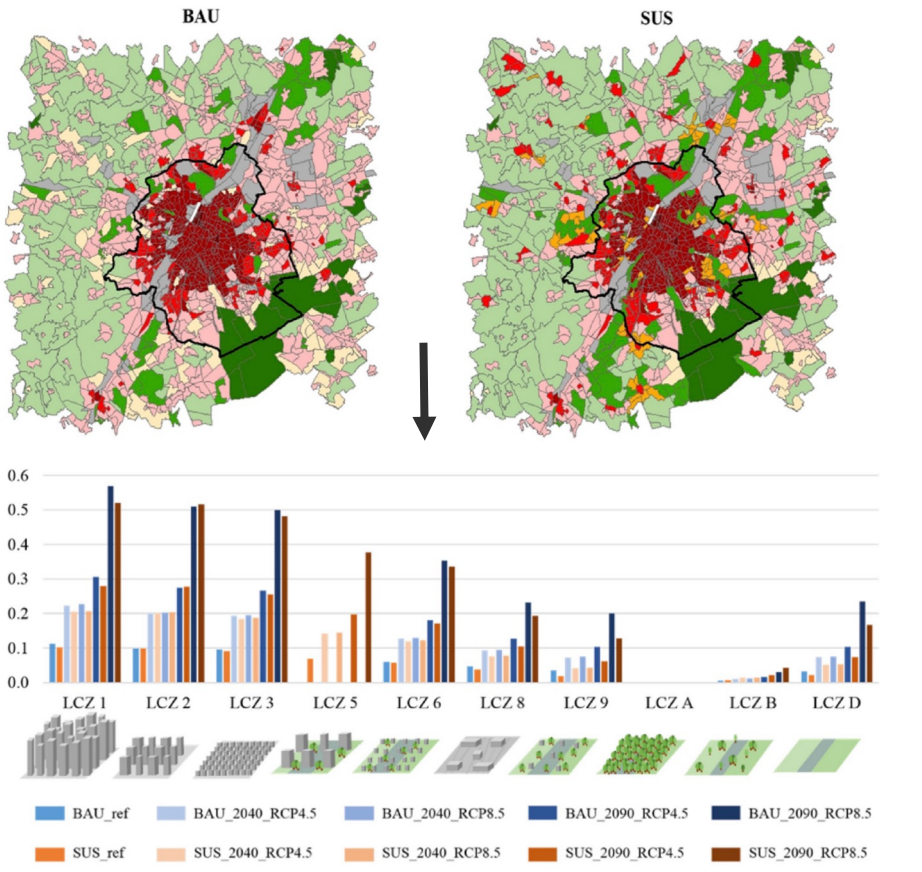
Bechtel et al. (2019b)

Applications

Urbanisation - Future heat risk

PRESENT-DAY → **FUTURE**





Future planning policies can be translated into LCZ maps, that in term can serve as boundary conditions to model intra-urban heat risk

Verdonck et al.

Parameterizing COSMO-CLM

"This study compares three different approaches to define the urban canopy parameters for Moscow (Russia), using the COSMO numerical weather prediction and climate model coupled to TERRA_URB urban parameterization"

" … for the summer period, the LCZ-based and 'Reference' urban parameters show almost similar performance in terms of the modelled thermal environment, and provide noticeable improvements with respect to default urban description."

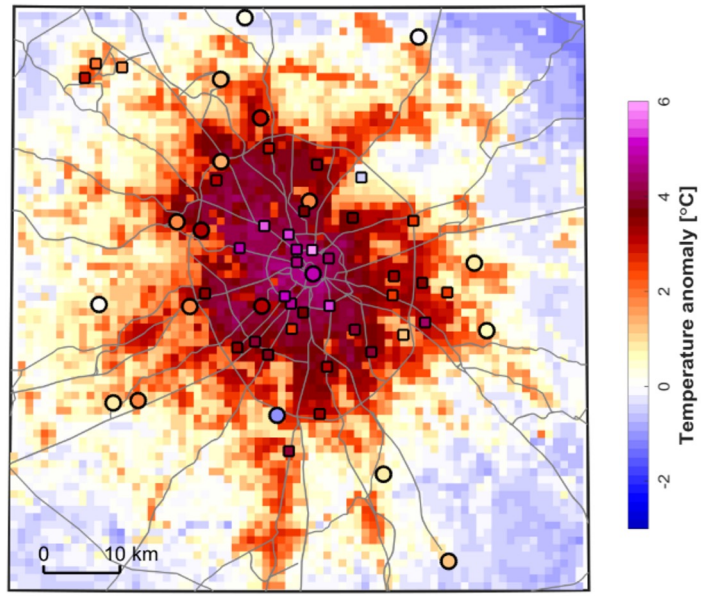
atmosphere

COSMO-CLM

Article

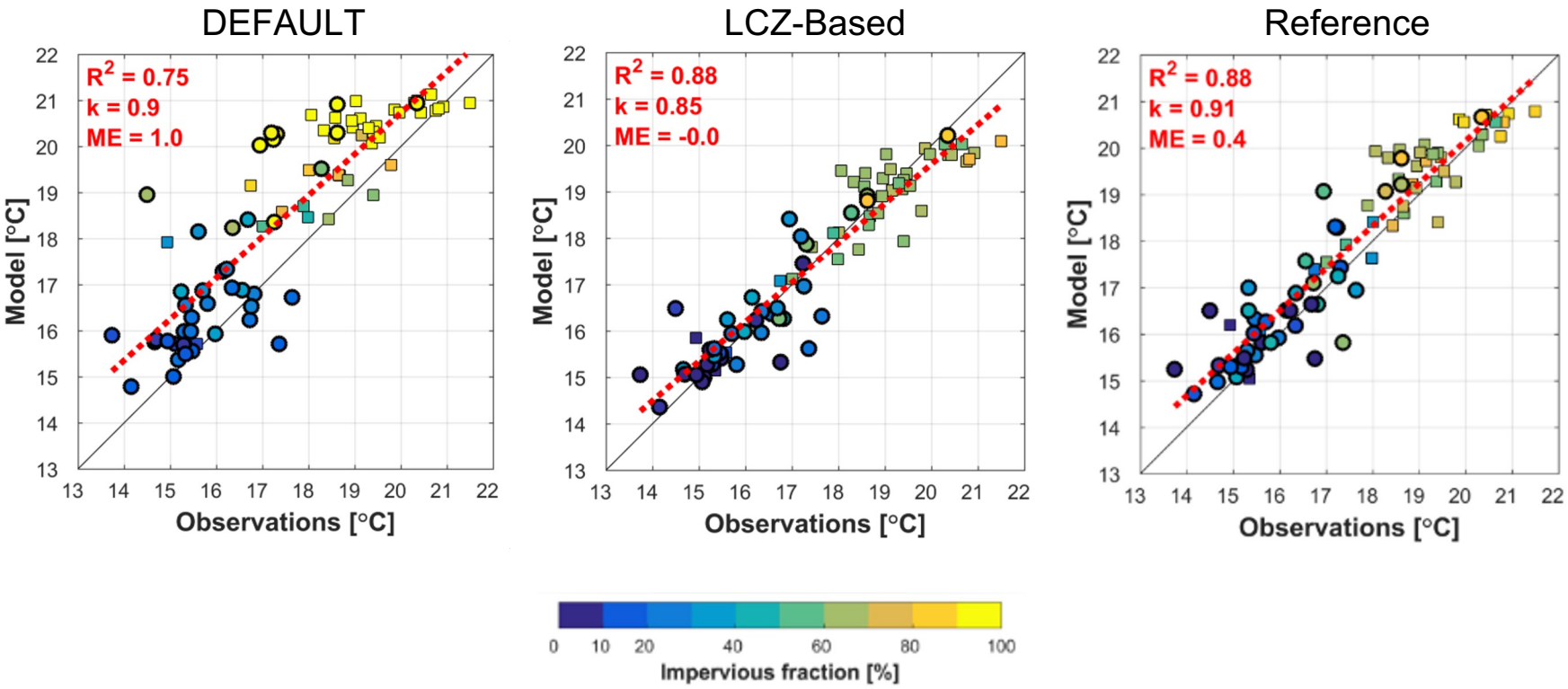
Impact of Urban Canopy Parameters on a Megacity's Modelled Thermal Environment

Mikhail Varentsov [1,2,3,4,*], Timofey Samsonov [1,2,4] and Matthias Demuzere [5]



Parameterizing COSMO-CLM

Evaluation of nocturnal 2m air temperature averaged for August 2017



Varentsov et al. (2020)

Tools / developments https://www.wudapt.org/tools-overview/

TOOLS

WUDAPT offers tools to generate data on form and function of urban areas and to apply them in different models and procedures.

Generate LCZ map (*L0* data)

- **Generate LCZ training data**
- **Classify your city**

Use WUDAPT data in models

- **WRF**
- **COSMO-CLM**
- **UMEP**

Generate Urban Canopy Parameters

- **Convert cityGML and sealing data to UCPs** (by Sebastian Schubert)

Summary, gaps, potential?

Local Climate Zone (maps) can serve as **a first-order proxy describing the heterogeneity of urban areas**, which in turn can serve as boundary conditions for urban parameterizations embedded within climate models. Various **tools are available / being developed** to facilitate this process.

Data-driven reading of LCZ map in local dialect (= Level-1 and -2 information)?
Improve representation of informal settlements?

Collaboration to explore this big dataset!

Contact

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https://www.climate.ruhr-uni-bochum.de/

Benjamin.bechtel@rub.be / matthias.demuzere@rub.de

RUBclim / mdemuzere

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