

CLIMA 2025

REHVA 15th HVAC World Congress

4th - 6th June, Milan, Italy

Decarbonized, healthy and energy
conscious buildings in future climates



Finanziato
dall'Unione europea
NextGenerationEU



Ministero
dell'Università
e della Ricerca



Italiadomani
PIANO NAZIONALE
DI RIPRESA E RESILIENZA



REHVA 15th HVAC World Congress
4th - 6th June, Milan, Italy

Decarbonized, healthy and
energy conscious buildings
in future climates



A methodology for the assessment of the Urban Heat Island effect by exploiting the urban archetype approach

Ilaria Ballarini, Politecnico di Torino

Matteo Piro, Politecnico di Torino

Vincenzo Corrado, Politecnico di Torino

Giovanni Pernigotto, Free University of Bozen-Bolzano

Gregorio Borelli, Free University of Bozen-Bolzano

Andrea Gasparella, Free University of Bozen-Bolzano



This study has been developed in the framework of the PhD Research Scholarship "Development of urban building energy models to support the definition of energy policies by municipalities and local public administrations" (DM 118/2023) and of the «Climate Resilient Strategies by Archetype-based Urban Energy Modelling (CRISTALL)» project – funded by European Union – Next Generation EU within the PRIN 2022 PNRR program (D.D.1409 del 14/09/2022 Ministero dell'Università e della Ricerca), M4C2, I 1.1.



Finanziato
dall'Unione europea
NextGenerationEU



Ministero
dell'Università
e della Ricerca



Italiadomani
PIANO NAZIONALE
DI RIPRESA E RESILIENZA

Introduction

- **Rapid urbanisation** and climate change impacts necessitates careful planning and management of cities
- **Urban Building Energy Models (UBEMs)** generally **fail** to effectively address the **Urban Heat Island (UHI)**, due to the **scarcity of data** at
 - micro-scale (local climatic data)
 - meso-scale (detailed mapping of urban areas)
- **Building archetypes** can be a useful tool to increase the spatial coverage in the study of the UHI effects

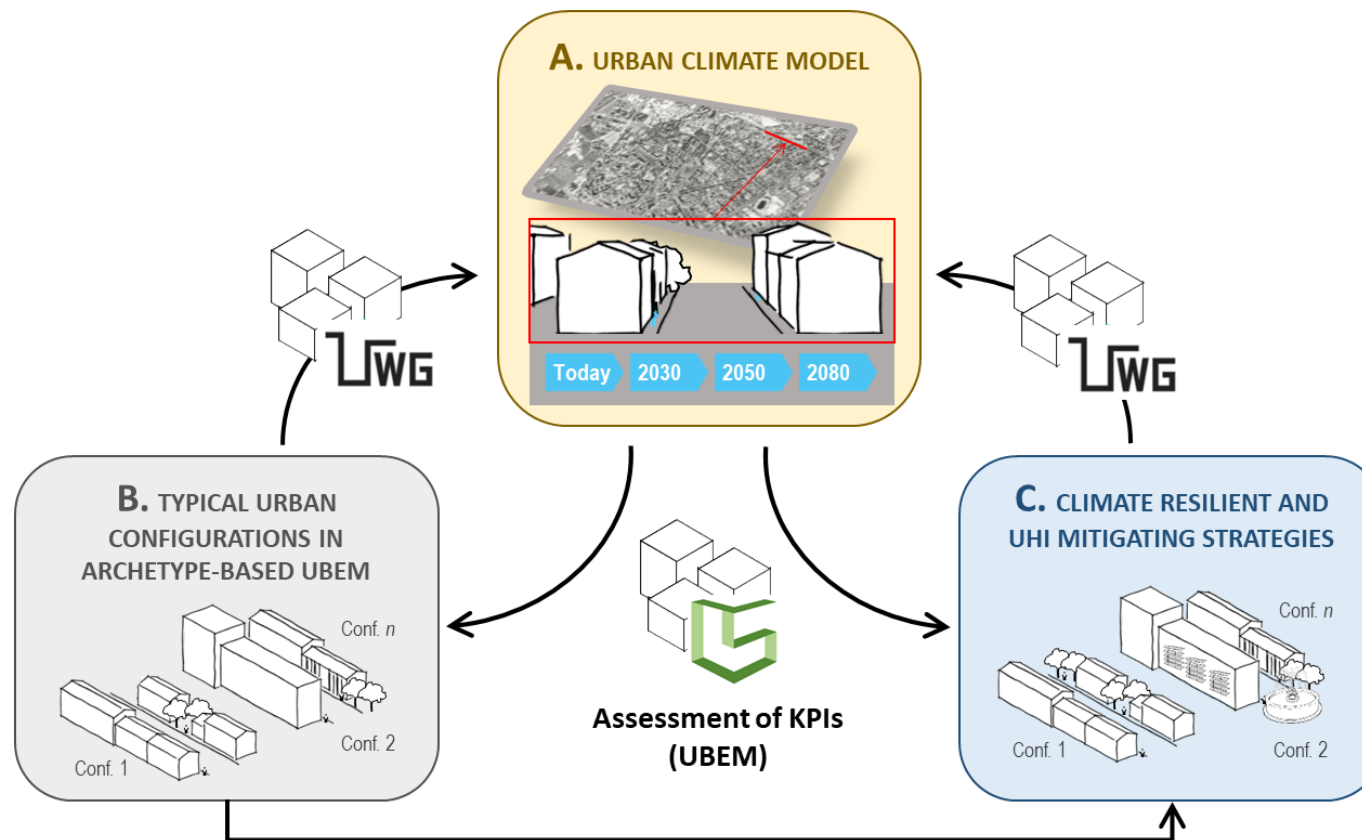
Aim of the research

- Transition from building archetypes to district archetypes
- Classification of the building stock based on morphological characteristics and UHI effect
- Micro-scale climatic data creation accounting for the reciprocal interactions between buildings and urban climate

Climate Resilient Strategies by Archetype-based Urban Energy Modelling (CRiStAll) project



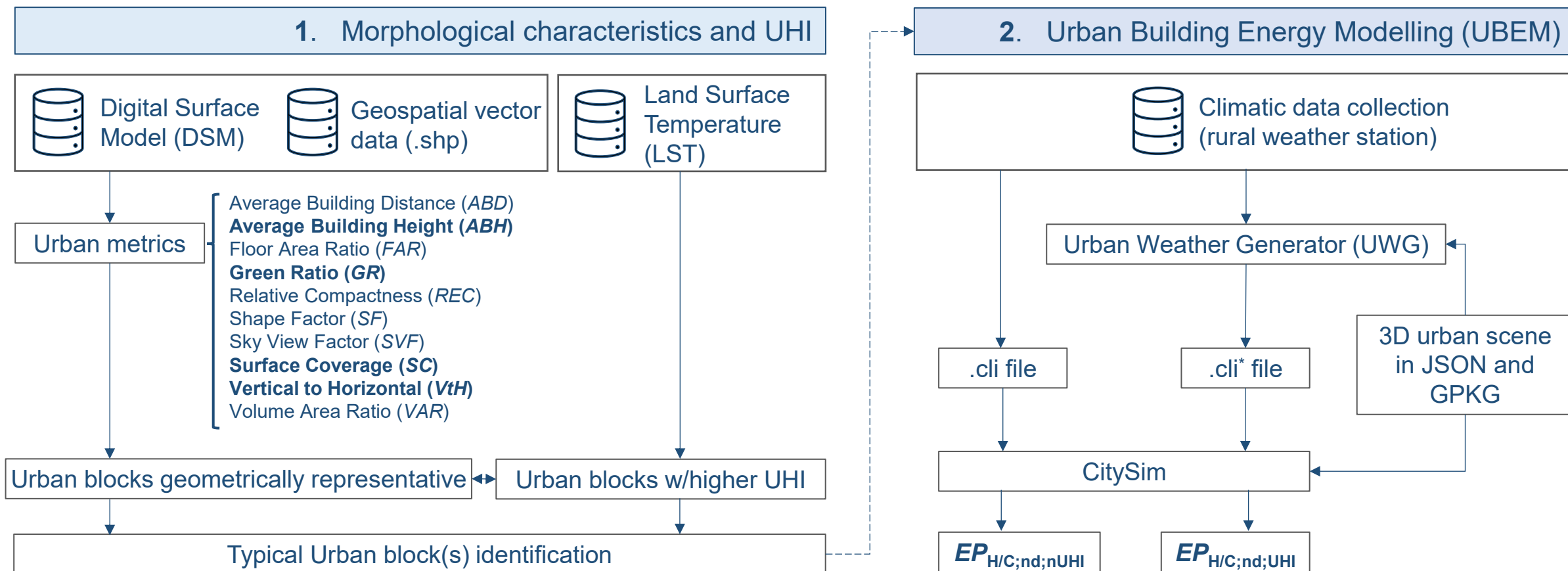
<https://cristall.polito.it>



Partners



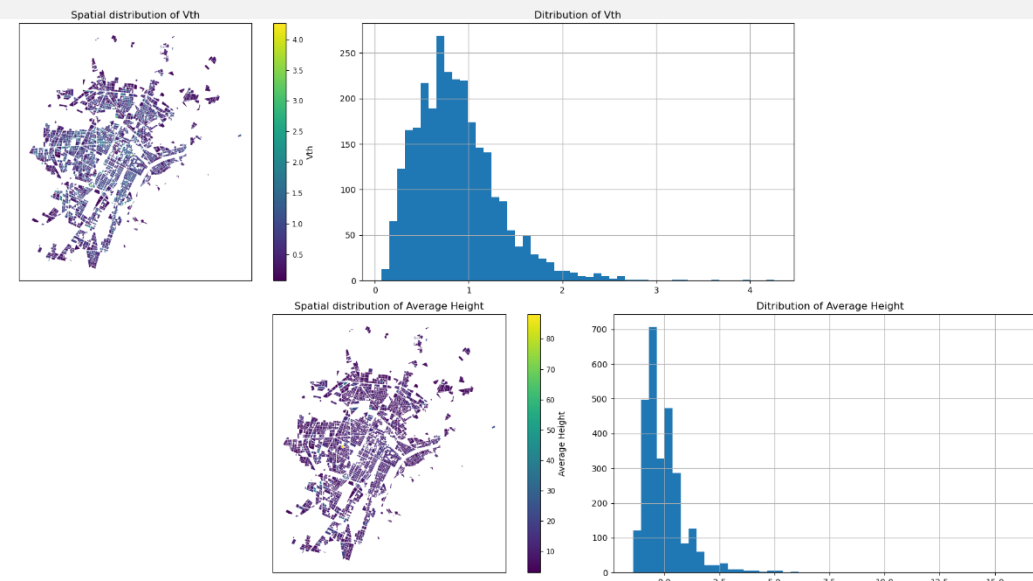
Methodology



Urban metrics (Turin)

- ❑ Floor Area Ratio (*FAR*)
- ❑ **Surface Coverage (*SC*)**
- ❑ Volume Area Ratio (*VAR*)
- ❑ **Green Ratio (*GR*)**
- ❑ Relative Compactness (*REC*)
- ❑ **Average Building Height (*ABH*)**
- ❑ Shape Factor (*SF*)
- ❑ **Vertical to Horizontal Ratio (*VtH*)**
- ❑ Average Building Distance (*ABD*)
- ❑ Sky View Factor (*SVF*)

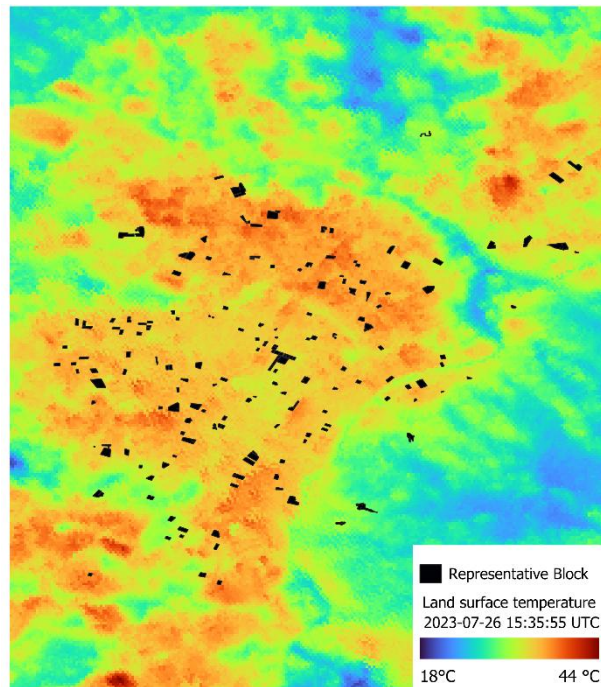
	SF	SVF	GR	SC	Abh	FAR	VAR	REC	Abd	Vth
SF	1	-0.095	-0.037	0.059	0.063	0.058	0.064	-0.023	-0.21	0.24
SVF	-0.095	1	0.2	-0.17	-0.25	-0.26	-0.29	0.32	0.27	-0.34
GR	-0.037	0.2	1	-0.37	-0.099	-0.27	-0.3	0.13	0.5	-0.34
SC	0.059	-0.17	-0.37	1	0.08	0.54	0.61	0.013	-0.032	0.19
Abh	0.063	-0.25	-0.099	0.08	1	0.6	0.73	-0.71	-0.084	0.61
FAR	0.058	-0.26	-0.27	0.54	0.6	1	0.85	-0.4	-0.16	0.63
VAR	0.064	-0.29	-0.3	0.61	0.73	0.85	1	-0.51	-0.13	0.64
REC	-0.023	0.32	0.13	0.013	-0.71	-0.4	-0.51	1	0.22	-0.53
Abd	-0.21	0.27	0.5	-0.032	-0.084	-0.16	-0.13	0.22	1	-0.59
Vth	0.24	-0.34	-0.34	0.19	0.61	0.63	0.64	-0.53	-0.59	1
	SF	SVF	GR	SC	Abh	FAR	VAR	REC	Abd	Vth



Source: Borelli G., Ballarini I., Corrado V., Gasparella A., Pernigotto G., 2025. "Assessment and mapping of the urban heat island effect: a preliminary analysis on the impact on urban morphology for the city of Turin, Italy", *In Proceedings of the 6th Building Simulation Applications (BSA 2024)*, Bolzano, Italy, 26–28 June 2024.

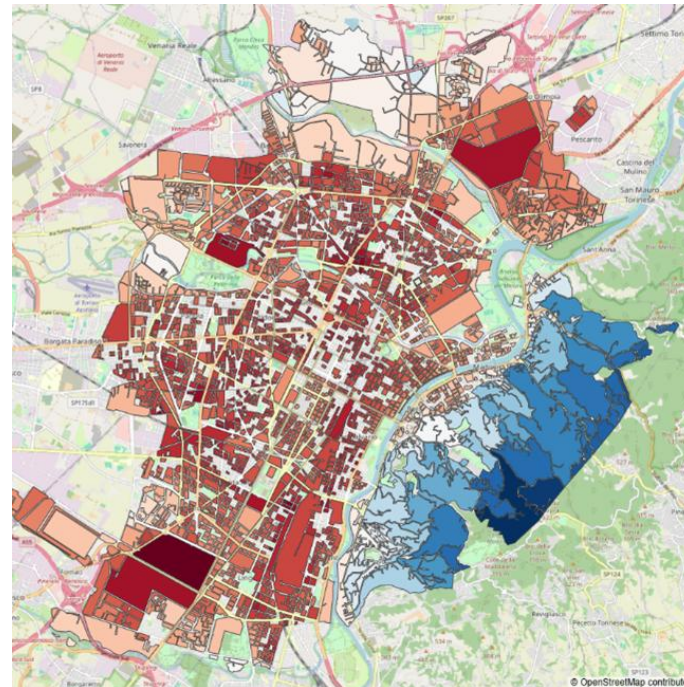
Land Surface Temperature (Turin)

ECOSTRESS satellite maps
(July 26th, 2023)



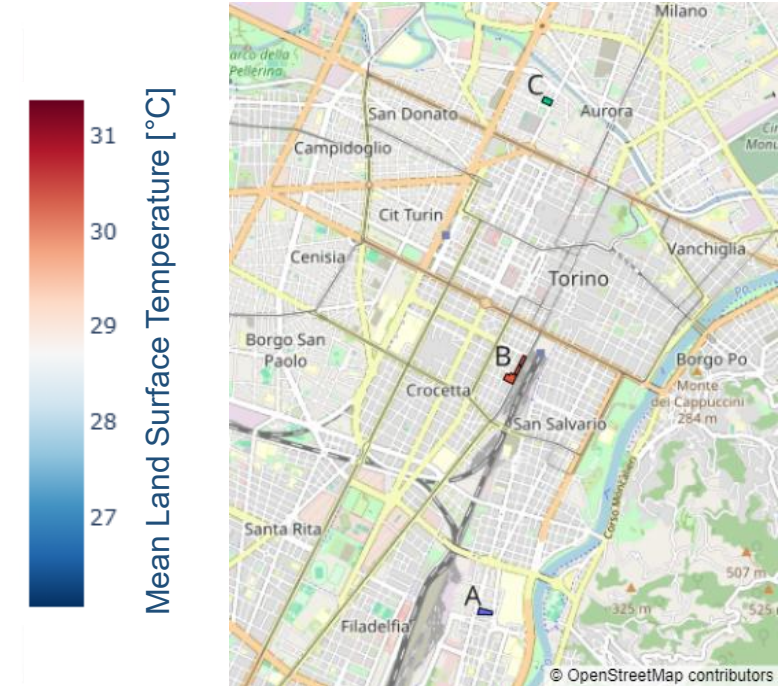
(a)

Satellite maps processing for
summer 2023



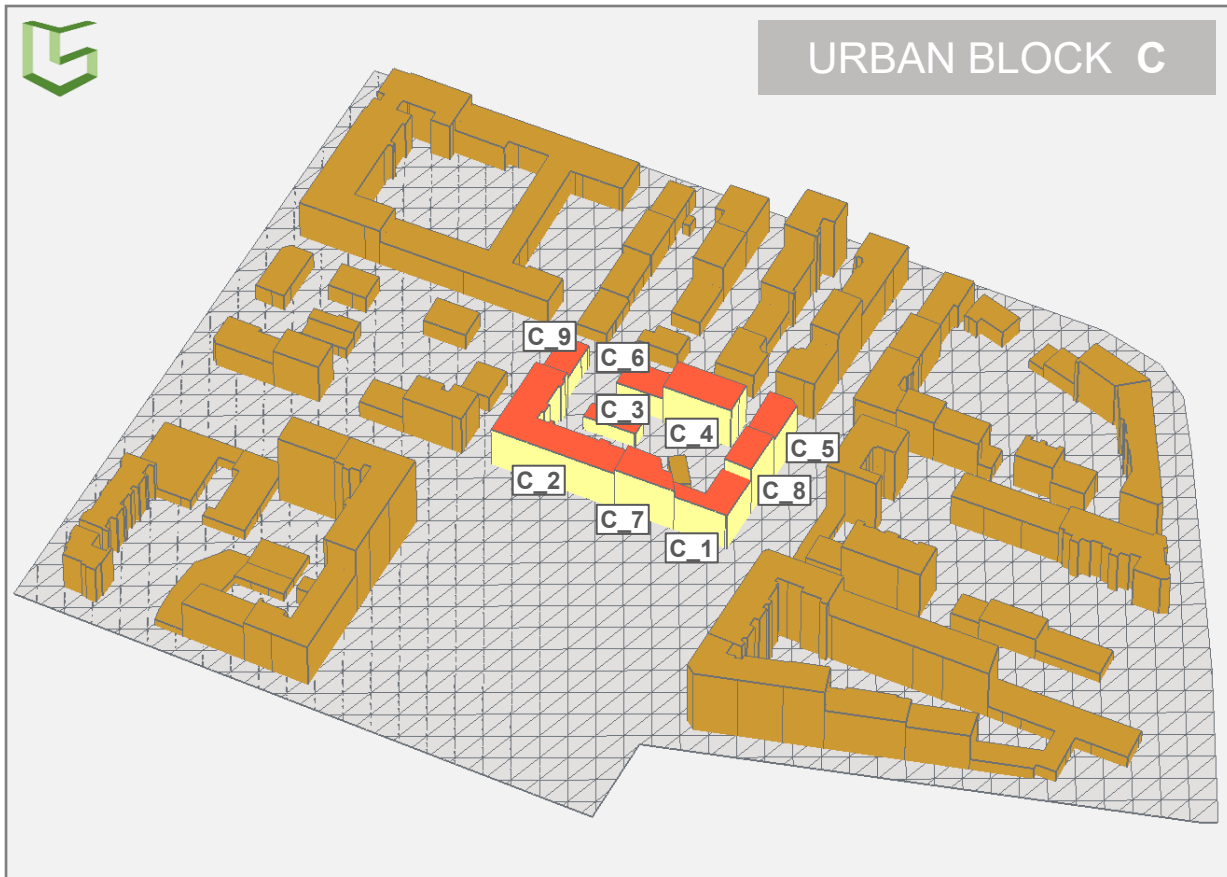
(b)

Location of urban blocks



(c)

Case study in Turin



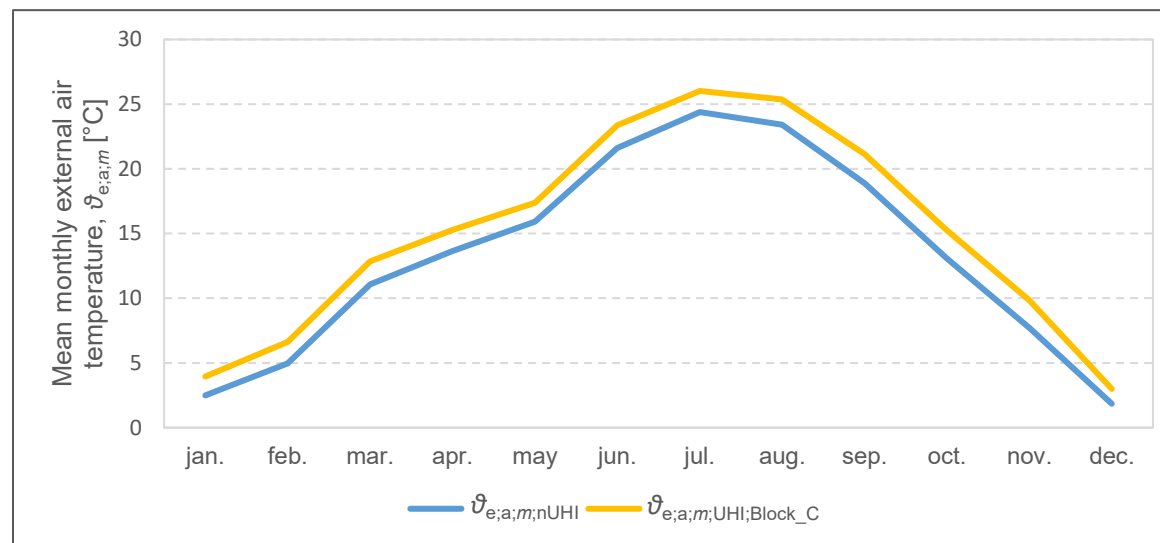
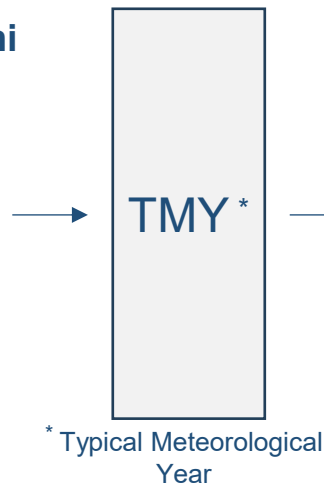
ID	Construction period	WWR [-]	$U_{op,avg}$ [W/(m ² ·K)]	$U_{win,avg}$ [W/(m ² ·K)]
C_1	< 1918	0.16	1.45	3.10
C_2			1.47	
C_3			1.48	
C_4	1946-60	0.13	1.30	3.12
C_5			1.28	
C_6			1.36	
C_7			1.28	
C_8	1961-70	0.10	1.27	3.16
C_9			1.25	

Urban weather file generation

Torino Bauducchi
weather station



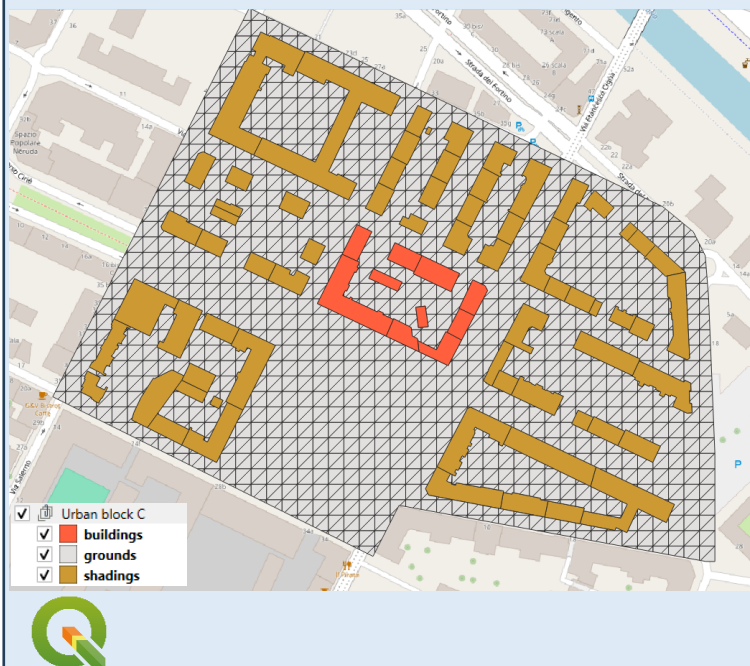
Climatic data
collection
(1994-2003)



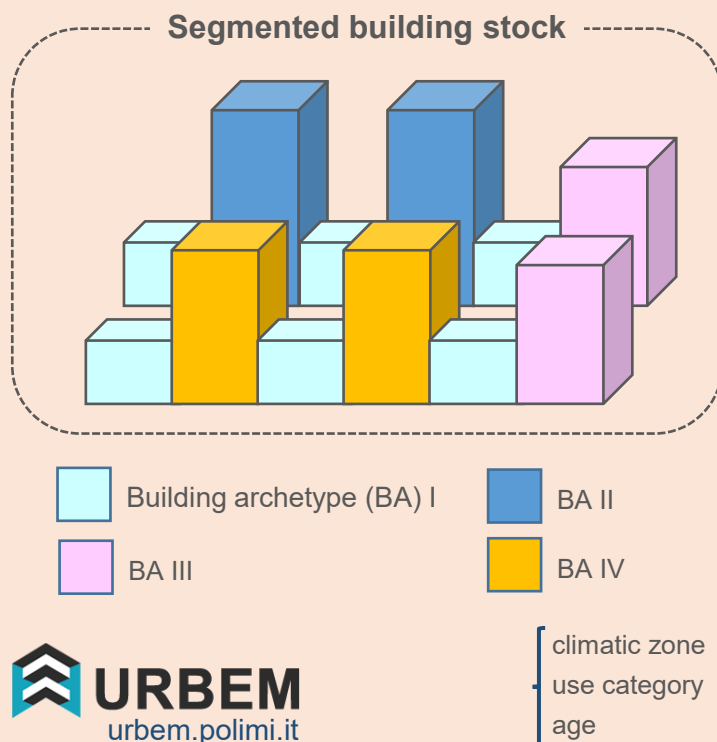
Location	HDD_{18} [°C·day]	CDD_{18} [°C·day]
Torino Bauducchi (rural weather station)	2268	551
Urban block A	1837	803
Urban block B	1824	807
Urban block C	1843	801

Urban Building Energy Modelling

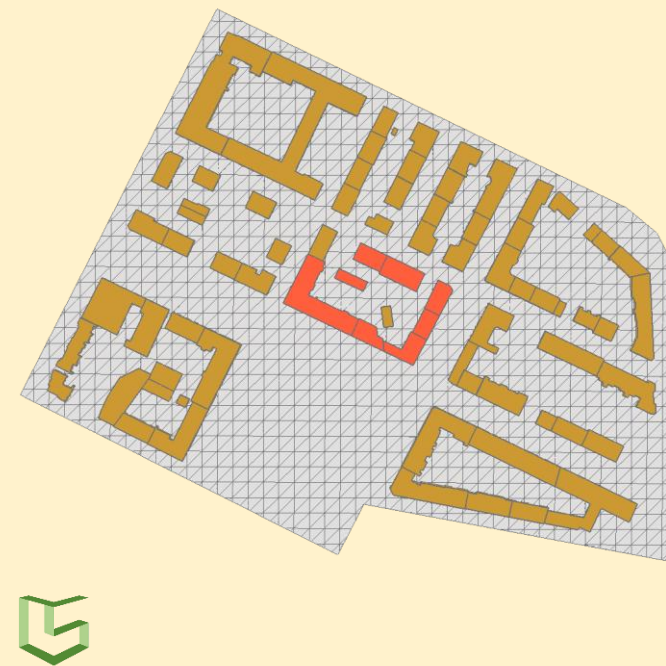
1. GeoPackage preparation



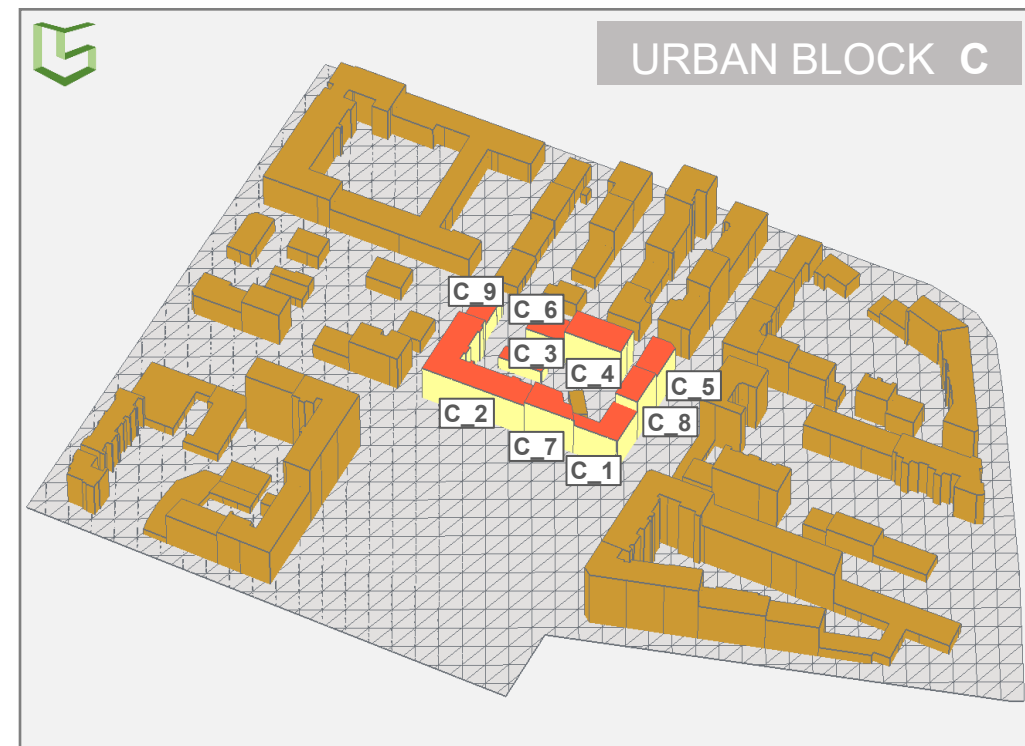
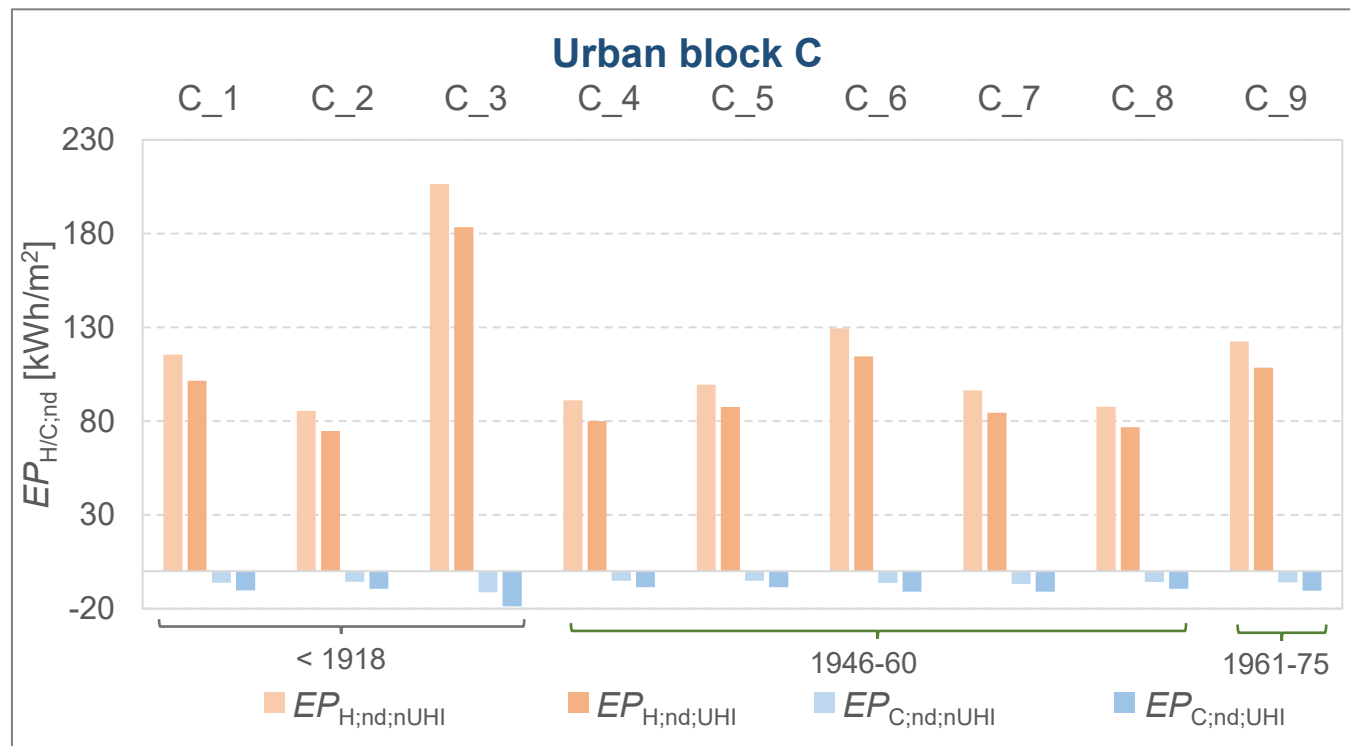
2. Archotyping



3. UBEM development

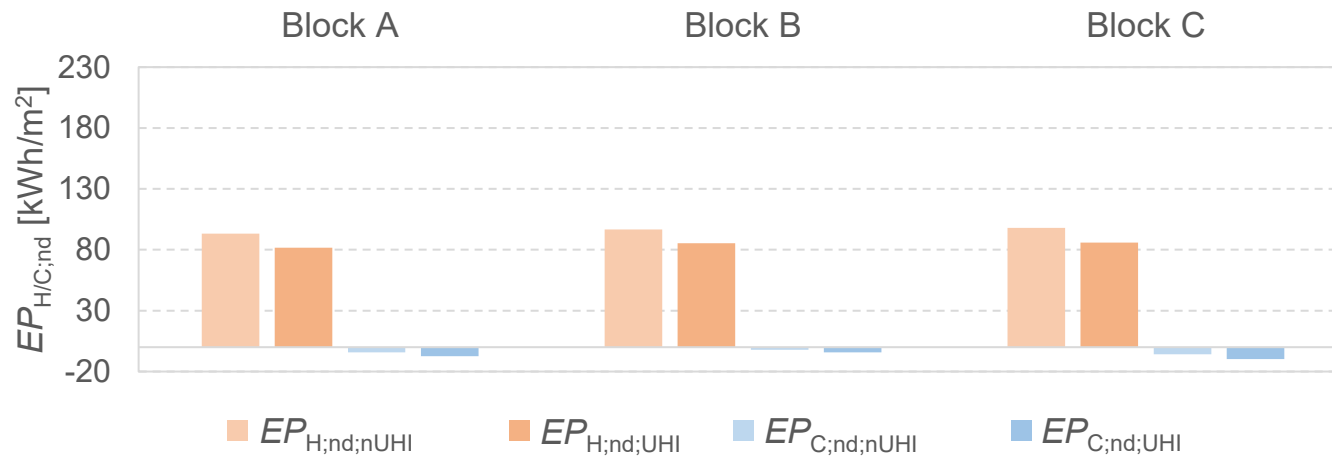


Results (disaggregated)

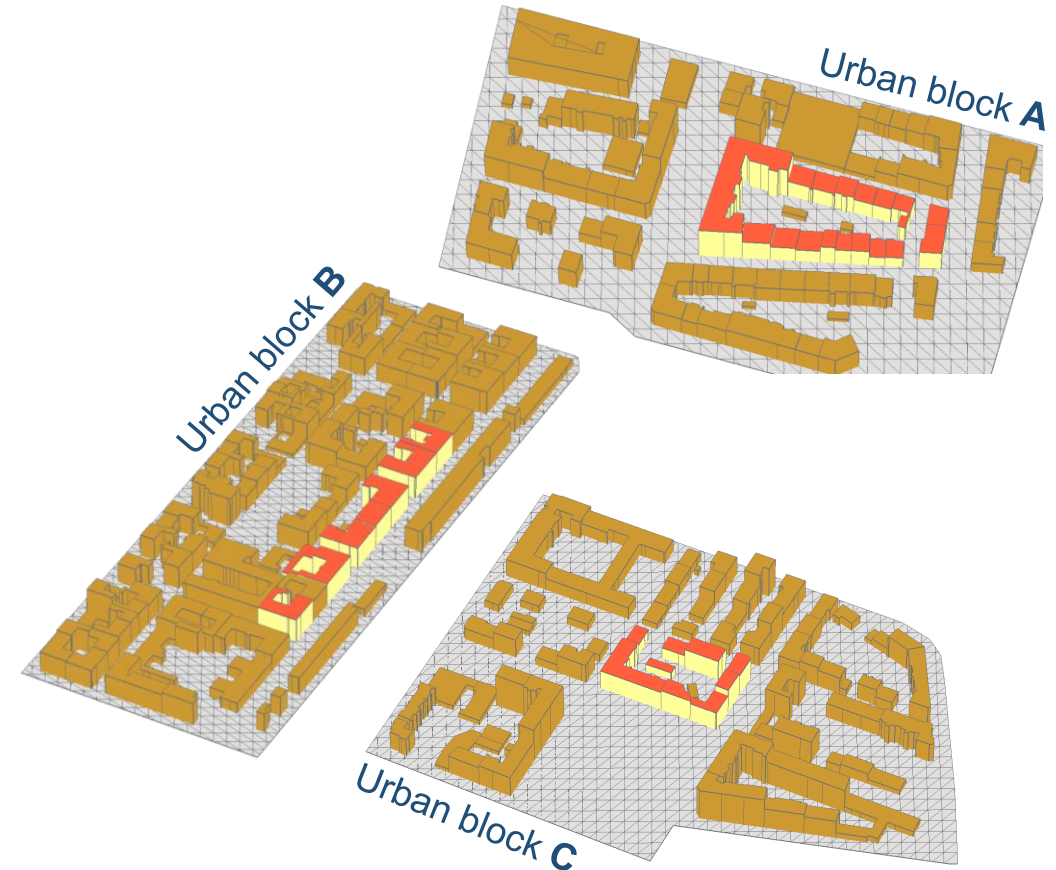


Results (aggregated)

Urban blocks A, B, and C



ID block	$\Delta EP_{H;nd}$ [kWh/m ²]	$\Delta EP_{C;nd}$ [kWh/m ²]	$\Delta EP_{H;nd}$ [%]	$\Delta EP_{C;nd}$ [%]
A	- 11.6	+ 3.1	- 12.4 %	+ 73.5 %
B	- 11.1	+ 1.9	- 11.4 %	+ 86.0 %
C	- 12.0	+ 3.8	- 12.2 %	+ 65.1 %



Conclusion

- Comprehensive analysis of key urban morphological features
- Identification and modelling of representative urban districts of Turin using an archetype-based UBEM approach

Future works

- Extension of the analysis to other Italian climatic zones
- Role of future climate trends in amplifying the UHI
- Assessment of various climate-resilient strategies to mitigate UHI



REHVA 15th HVAC World Congress

4th - 6th June, Milan, Italy

Thank you for your kind attention

Matteo Piro, Politecnico di Torino: matteo.piro@polito.it



This study has been developed in the framework of the PhD Research Scholarship "Development of urban building energy models to support the definition of energy policies by municipalities and local public administrations" (DM 118/2023) and of the «Climate Resilient Strategies by Archetype-based Urban Energy Modelling (CRiStAll)» project – funded by European Union – Next Generation EU within the PRIN 2022 PNRR program (D.D.1409 del 14/09/2022 Ministero dell'Università e della Ricerca), M4C2, I 1.1.



Finanziato
dall'Unione europea
NextGenerationEU



Ministero
dell'Università
e della Ricerca



Italiadomani
PIANO NAZIONALE
DI RIPRESA E RESILIENZA



REHVA 15th HVAC World Congress

4th - 6th June, Milan, Italy

Follow us on



climaworldcongress.org



Finanziato
dall'Unione europea
NextGenerationEU



Ministero
dell'Università
e della Ricerca



Italiadomani
PIANO NAZIONALE
DI RIPRESA E RESILIENZA