PP CITTA'

Urban Canopy Parameters: WUDAPT and ECOCLIMAP datasets tested with COSMO 6.0

13 September 2022, COSMO GM (Athens, Greece)

Francesca Bassani (Politecnico di Torino)
Valeria Garbero (Arpa Piemonte)
Massimo Milelli (CIMA Foundation)

*francesca.bassani@polito.it

SET-UP COSMO 6.0

- Case study: week 16-22 March 2020, domain centered over Turin
- Initial and boundary conditions from:
  - Analyses from COSMO-2I, 2.2 km (from Arpa Emilia Romagna)
- Resolution: 500 m
- External parameters tested:
  - Impervious Surface Area fraction (**ISA**), Anthropogenic Heat Flux (**AHF**)
  - **Geometrical** Urban Parameters (UP): URB_FR_BLD, URB_H_BLD, URB_H2W
  - **Thermal** UP: URB_HCON, URB_HCAP, URB_EMIS, URB_ALB_SO, URB_ALB_TH
- Dataset used for UPs:
  1. **WUDAPT**: parameters obtained with «WUDAPT-to-COSMO»* → LCZs from WUDAPT
  2. **ECOCLIMAP**: parameters computed through a new R script, «eco2cosmo» → LCZs from ECOCLIMAP Second Generation 2018

*github.com/matthiasdemuzere/WUDAPT-to-COSMO

Look-up tables for ISA and AHF

	BUILDING TYPES	Local climate zone (LCZ)	Impervious surface fraction[d]	Anthropogenic heat output[c]
1		LCZ 1 *Compact high-rise*	40–60	50–300
2		LCZ 2 *Compact midrise*	30–50	<75
3		LCZ 3 *Compact low-rise*	20–50	<75
4		LCZ 4 *Open high-rise*	30–40	<50
5		LCZ 5 *Open midrise*	30–50	<25
6		LCZ 6 *Open low-rise*	20–50	<25
7		LCZ 7 *Lightweight low-rise*	< 20	<35
8		LCZ 8 *Large low-rise*	40–50	<50
9		LCZ 9 *Sparsely built*	< 20	<10
10		LCZ 10 *Heavy industry*	20–40	>300

from Stewart&Oke (2012)

classes	ISA	AHF
1	0.95	100
2	0.9	35
3	0.85	30
4	0.65	30
5	0.7	15
6	0.6	10
7	0.85	30
8	0.85	40
9	0.3	5
10	0.55	300
11	0	0
12	0	0
13	0	0
14	0	0
15	0	0
16	0	0
17	0	0

wudapt-to-cosmo
WUDAPT database (100 m)
for LCZs: 1-10 = urban

classes	ISA	AHF
1	0	0
2	0	0
3	0	0
4	0	0
...	0	0
...	0	0
23	0	0
24 (LCZ 1)	0.95	100
25 (LCZ 2)	0.9	35
26 (LCZ 3)	0.85	30
27 (LCZ 4)	0.65	30
28 (LCZ 5)	0.7	15
29 (LCZ 6)	0.6	10
30 (LCZ 7)	0.85	30
31 (LCZ 8)	0.85	40
32 (LCZ 9)	0.3	5
33 (LCZ 10)	0.55	300

eco2cosmo
ECOCLIMAP-SG database (300 m)
for LCZs: 24-33 = urban

Stewart, I. D., & Oke, T. R. (2012). Local climate zones for urban temperature studies. *Bulletin of the American Meteorological Society*, *93*(12), 1879-1900.

Look-up tables for

➢ Geometrical UPs:

LCZs	URB_BLDFR	URB_BLDH	URB_H2W
LCZ 1	0.5	25	2.5
LCZ 2	0.5	15	1.25
LCZ 3	0.55	5	1.25
LCZ 4	0.3	25	1
LCZ 5	0.3	15	0.5
LCZ 6	0.3	5	0.5
LCZ 7	0.8	3	1.5
LCZ 8	0.4	7	0.2
LCZ 9	0.15	5	0.15
LCZ 10	0.25	8.5	0.35

- Building fraction (URB_BLDFR)
- Building height (URB_BLDH)
- Height to width ratio (URB_H2W)

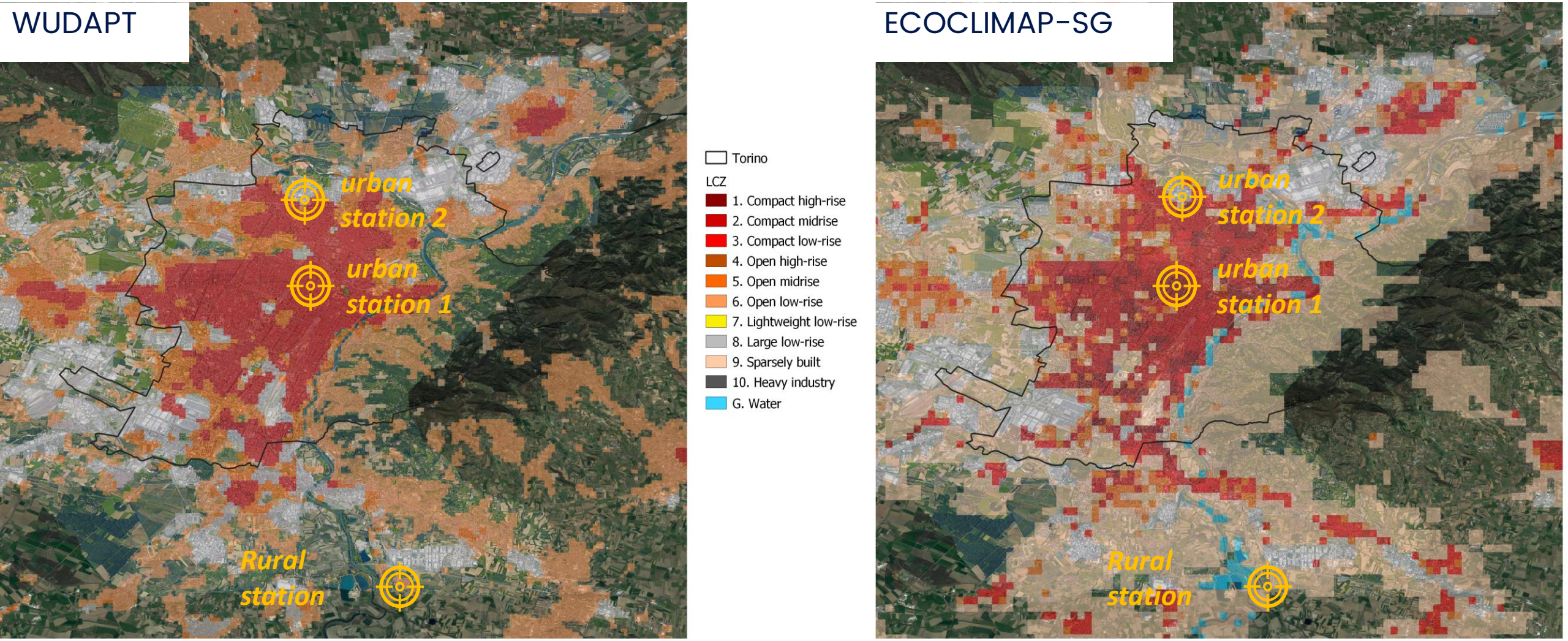
➢ Thermal UPs:

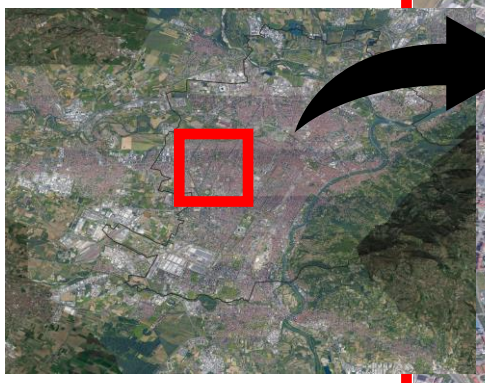
- Heat conductivity (URB_HCON)
- Heat capacity (URB_HCAP)
- Emissivity (URB_EMIS)
- Surface albedo (URB_SALB)
- Thermal albedo (URB_TALB)

All geometrical, thermal and radiative urban canopy parameters are **spatially invariant**, and **set to** the **values** provided in Tab. 1 of Wouters et al., 2016. The full procedure is explained in:

Wouters, H. et al. "The efficient urban canopy dependency parametrization (SURY) v1. 0 for atmospheric modelling: description and application with the COSMO-CLM model for a Belgian summer." *Geoscientific Model Development* 9.9 (2016): 3027-3054.

WUDAPT vs ECOCLIMAP (Turin, Italy)



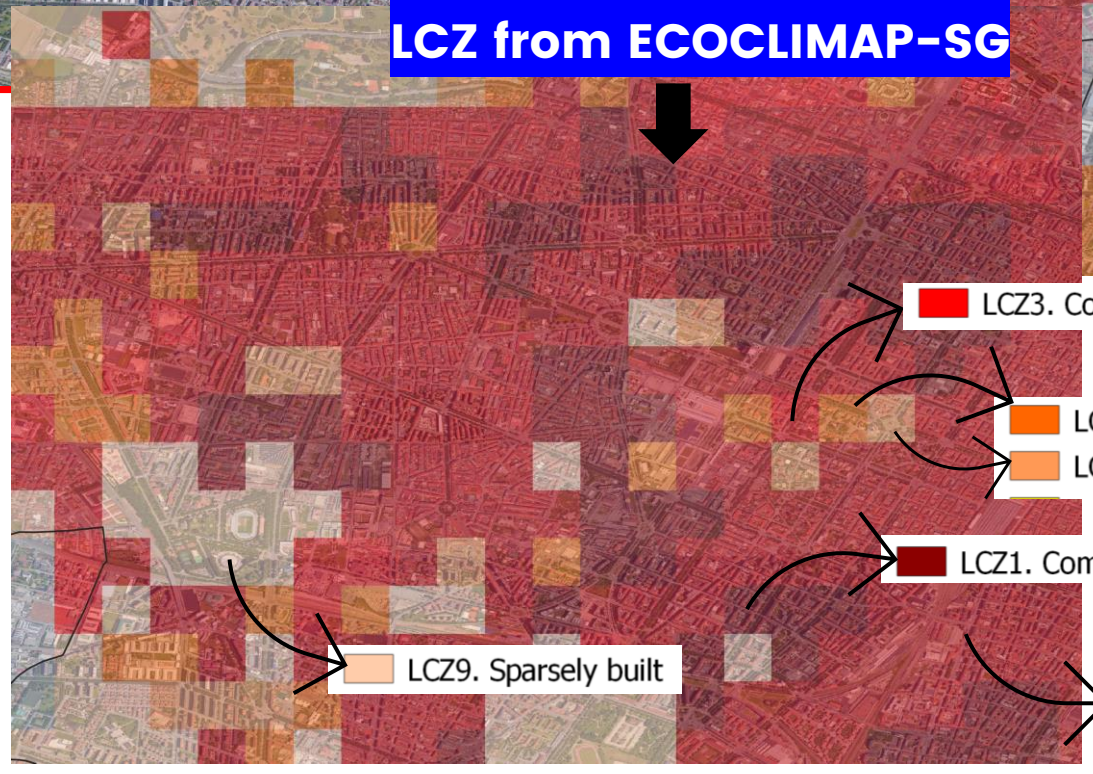


Turin urban area

LCZ from WUDAPT

2. Compact midrise
5. Open midrise
8. Large low-rise

LCZ from ECOCLIMAP-SG



LCZ3. Compact low-rise

LCZ5. Open midrise

LCZ6. Open low-rise

LCZ1. Compact high-rise

LCZ9. Sparsely built

LCZ2. Compact midrise

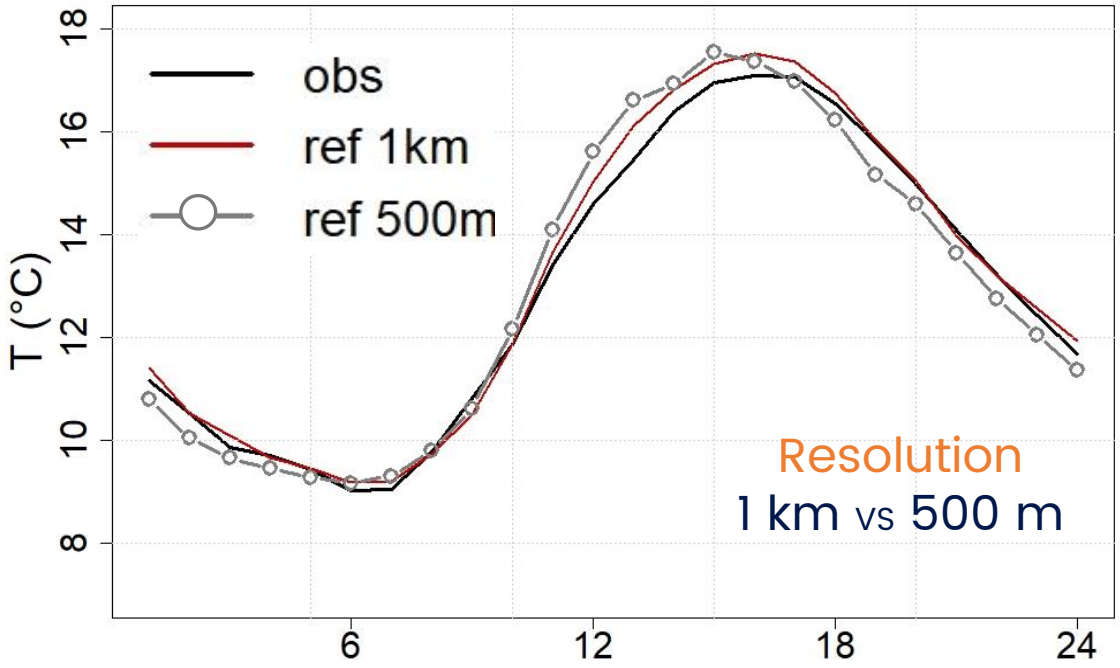
ECOCLIMAP-SG 2018 is more detailed for Turin!

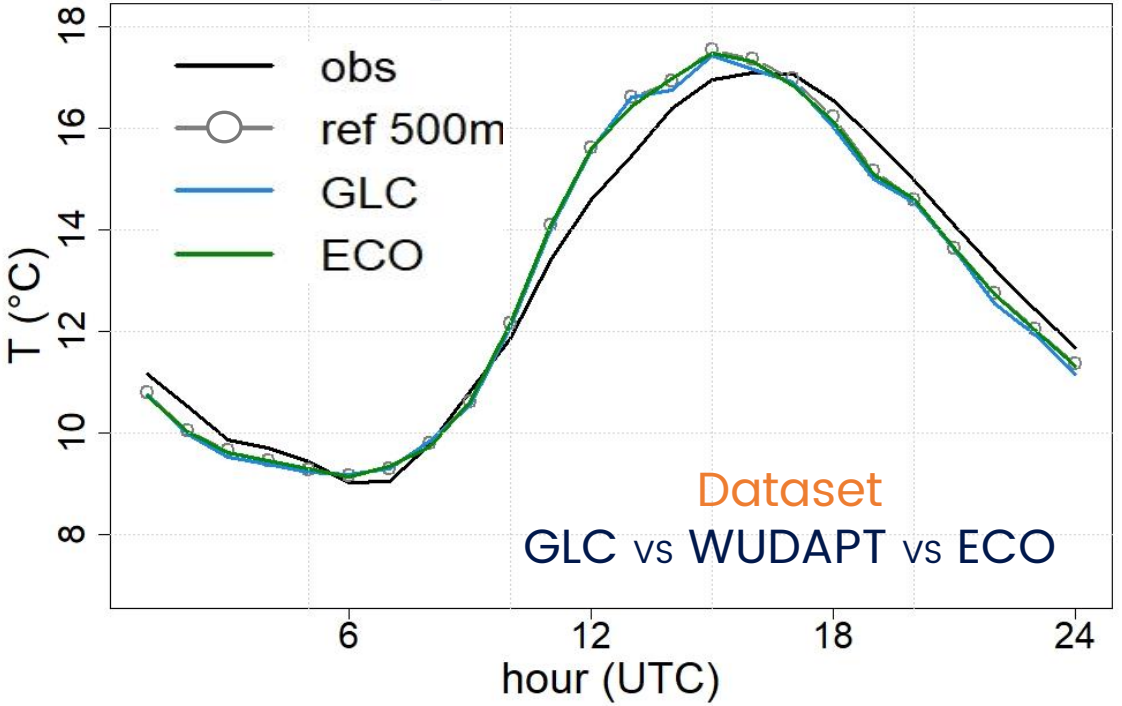
Recap on previous findings

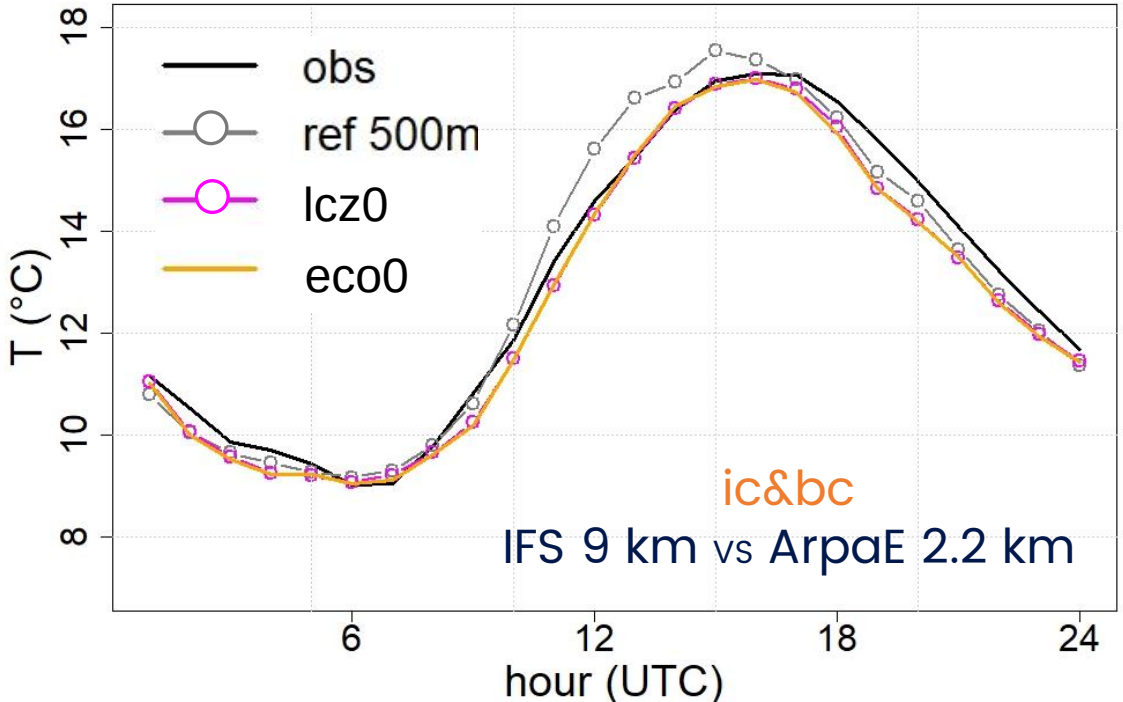
evaluation of i.b.c, resolution and dataset

iC & BC from	Resolution (Piemonte domain)	ISA from (dataset)	Name
IFS 9 km	1 km	WUDAPT	ref 1km
IFS 9 km	500 m	WUDAPT	ref 500m
IFS 9 km	500 m	GLC	GLC
IFS 9 km	500 m	ECO	ECO
ArpaE 2.2 km	500 m	WUDAPT	lcz0
ArpaE 2.2 km	500 m	ECO	eco0

T2m at the urban station 1 (city center)







iC & BC from	Resolution (Piemonte domain)	ISA from (dataset)	Name
IFS 9 km	1 km	WUDAPT	ref 1km
IFS 9 km	500 m	WUDAPT	ref 500m
IFS 9 km	500 m	GLC	GLC
IFS 9 km	500 m	ECO	ECO
ArpaE 2.2 km	500 m	WUDAPT	lcz0
ArpaE 2.2 km	500 m	ECO	eco0

Tested configurations (new)

	from **WUDAPT**	from **ECOCLIMAP**
ISA only*	lcz0	eco0
ISA + AHF	lcz	eco
ISA + AHF + Geometrical UP	lczGUP	~~ecoGUP~~
ISA + AHF + geometrical&thermal UP	lczUP	~~ecoUP~~

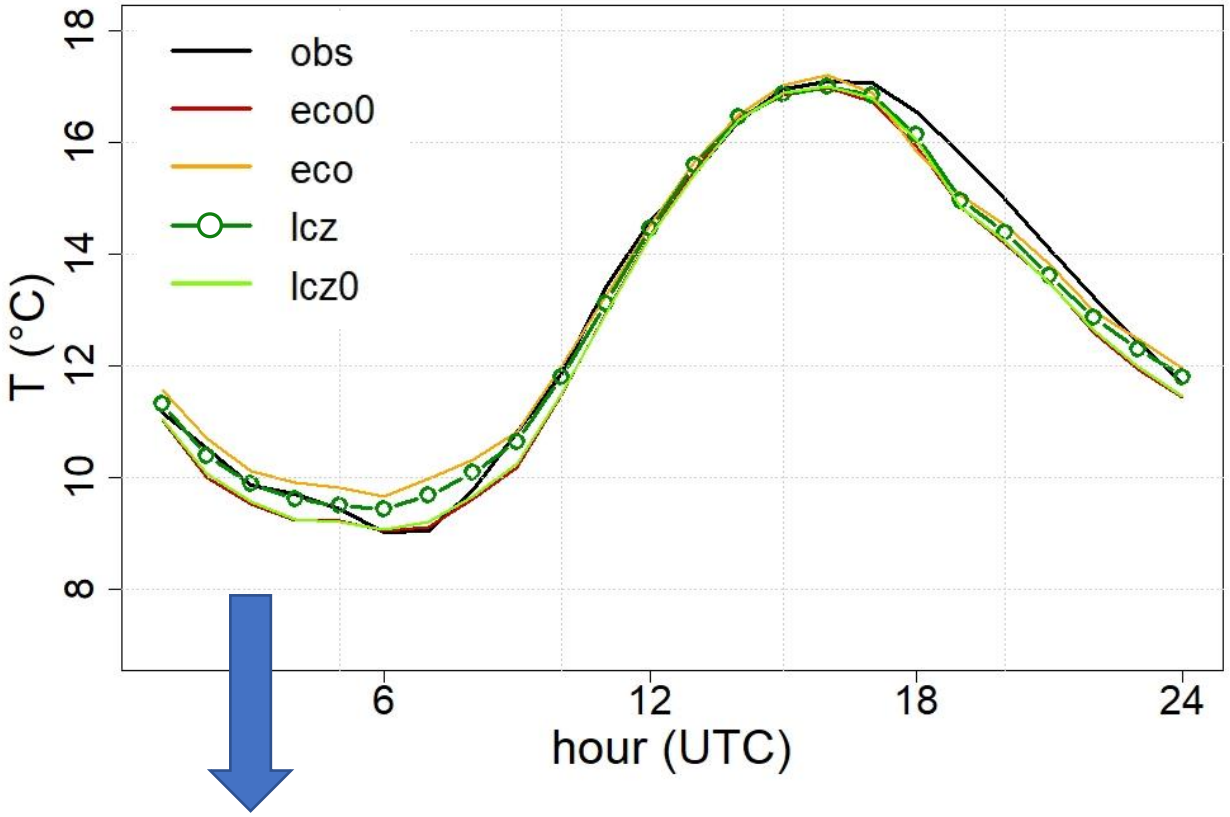
Best outcomes from previous slide

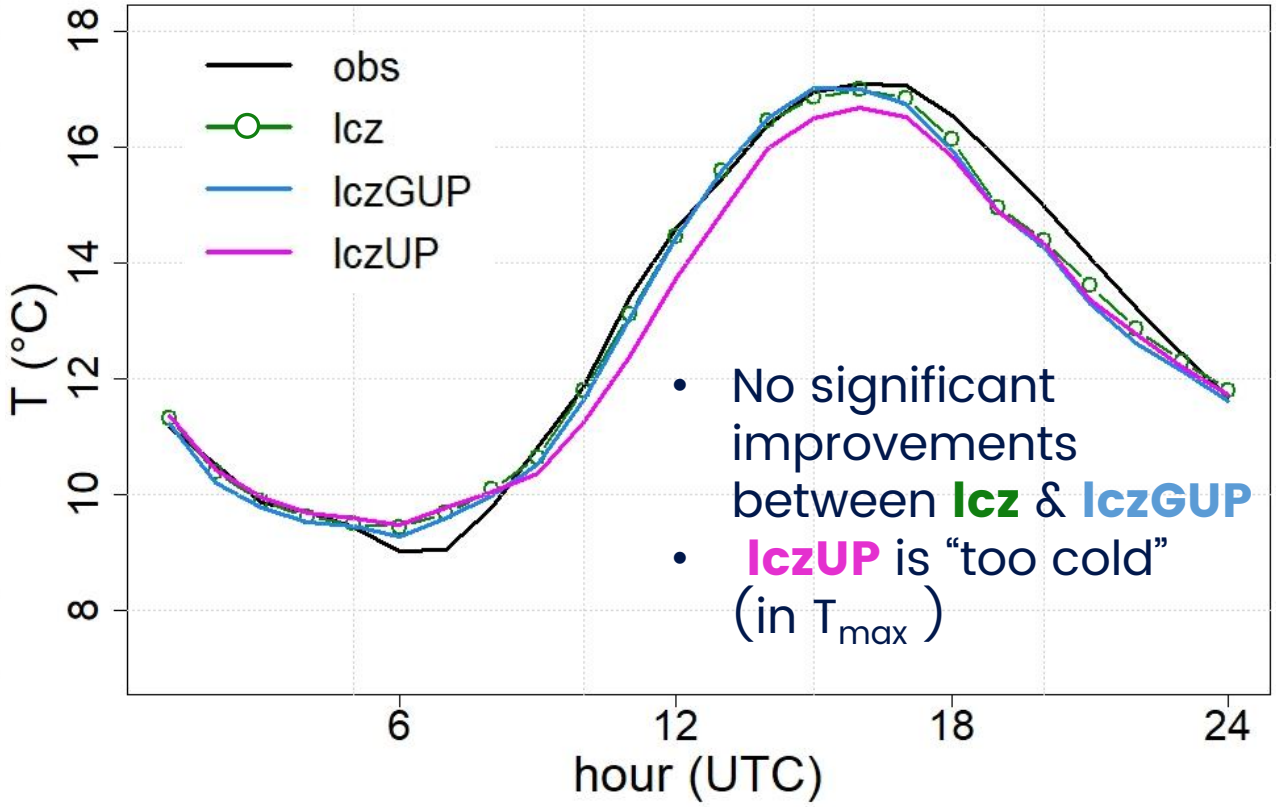
Crash due to the geometrical param. URB_BLDH

*AHF from EXTPAR (Flanner, 2009)

Flanner, M. G. (2009). Integrating anthropogenic heat flux with global climate models. *Geophysical Research Letters*, *36*(2).

T2m at the urban station 1 (city center)





- No significant improvements between **lcz** & **lczGUP**
- **lczUP** is "too cold" (in T_{max})

- **"ISA only"** yields to the best model validation
  - ➢ No significant differences between WUDAPT and ECOCLIMAP
- **AHF** worsens the T_{min}
  - ➢ Especially with ECOCLIMAP (see next slides)

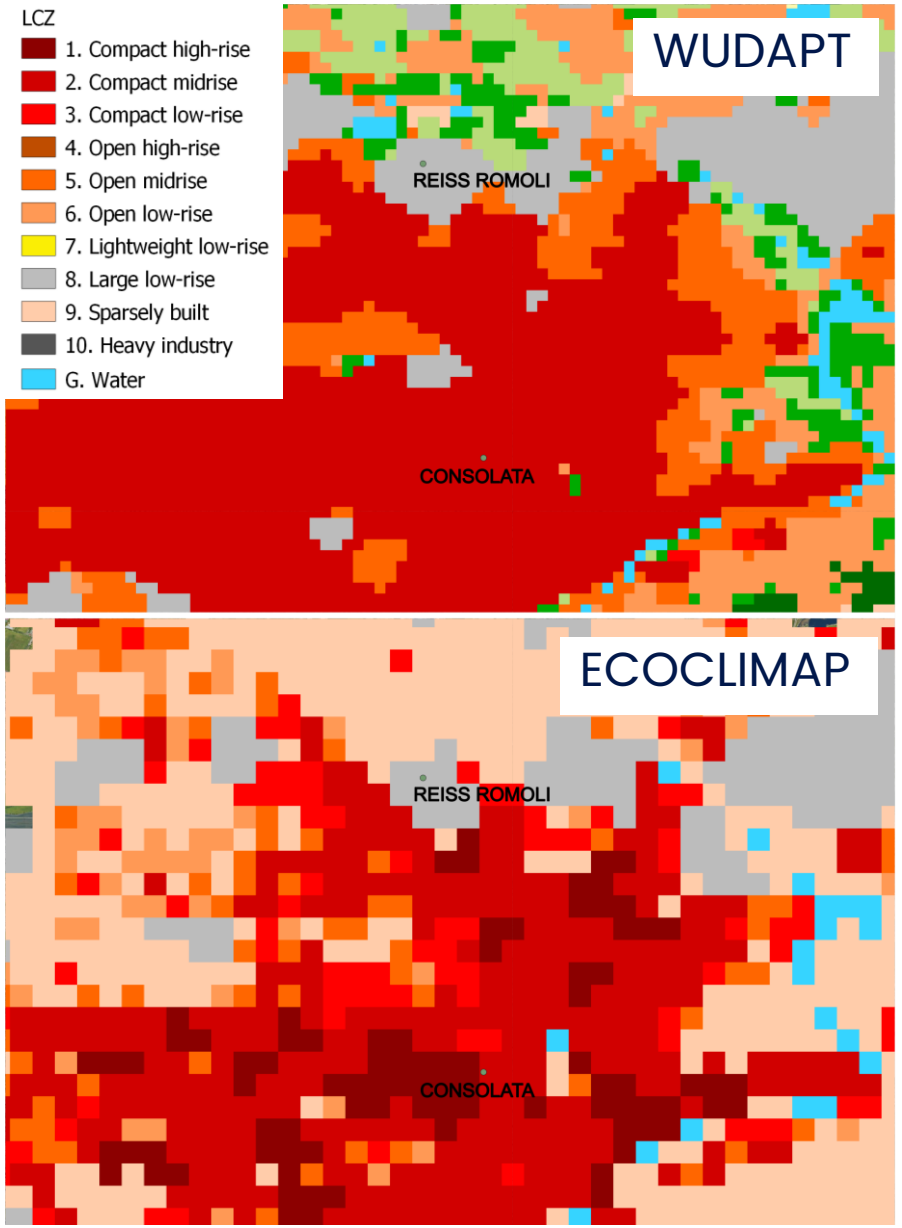
	from WUDAPT	from ECOCLIMAP
ISA only	lcz0	eco0
ISA + AHF	lcz	eco
ISA + AHF + G. UP	lczGUP	~~ecoGUP~~
ISA + AHF +g&t UP	lczUP	~~ecoUP~~

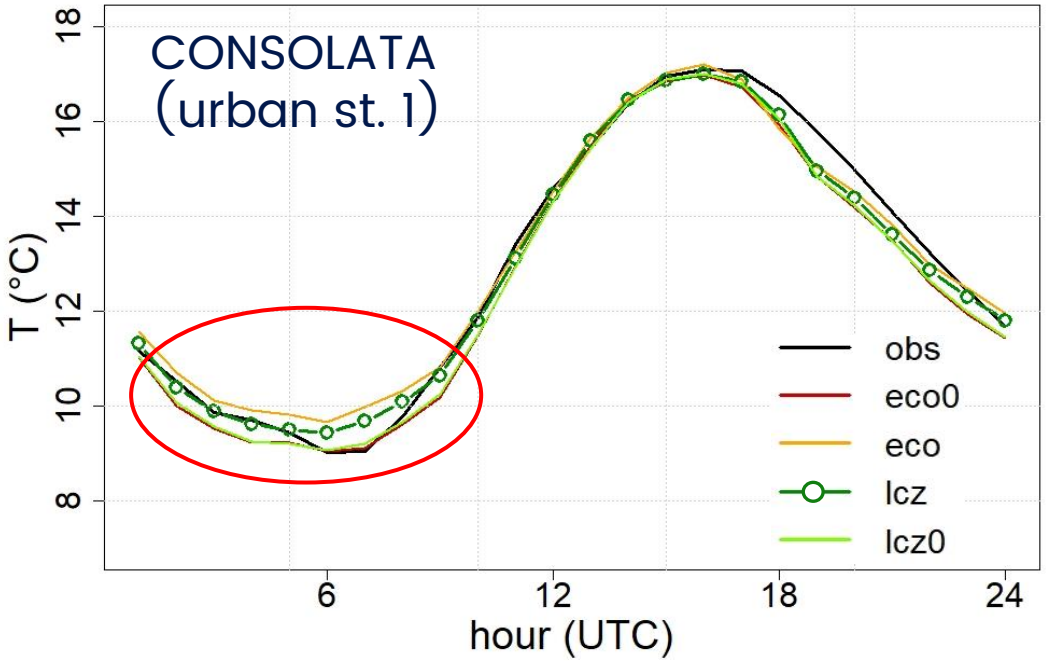
Greatest impact given by AHF: why?

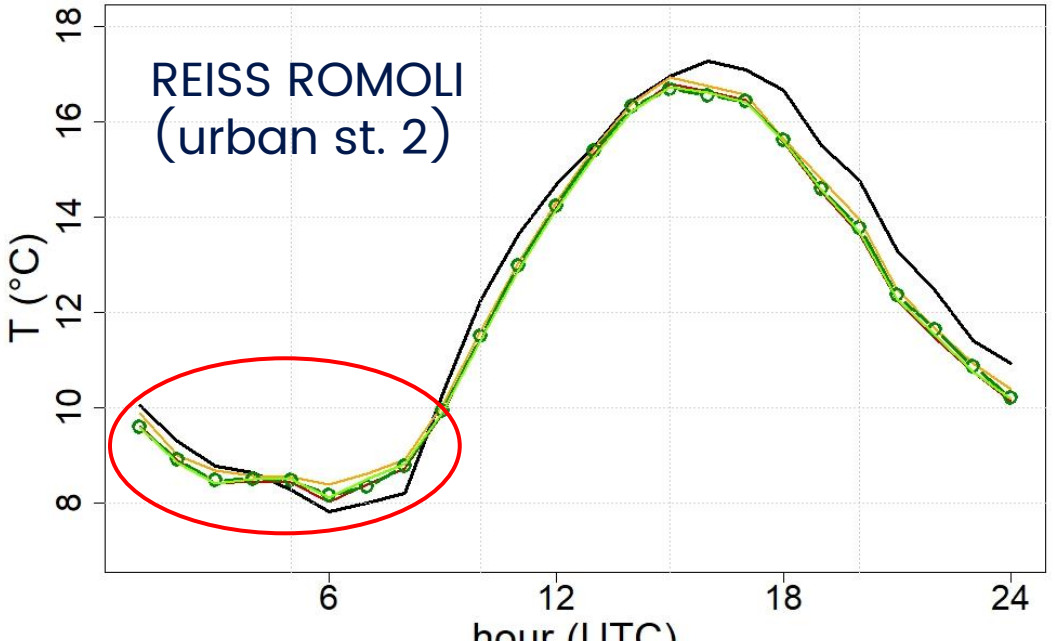
Both from WUDAPT and ECOCLIMAP:
LCZ CONSOLATA = 2
LCZ R.ROMOLI = 8

classes	ISA	AHF
1	0.95	100
2	0.9	35
3	0.85	30
4	0.65	30
5	0.7	15
6	0.6	10
7	0.85	30
8	0.85	40
9	0.3	5
10	0.55	300

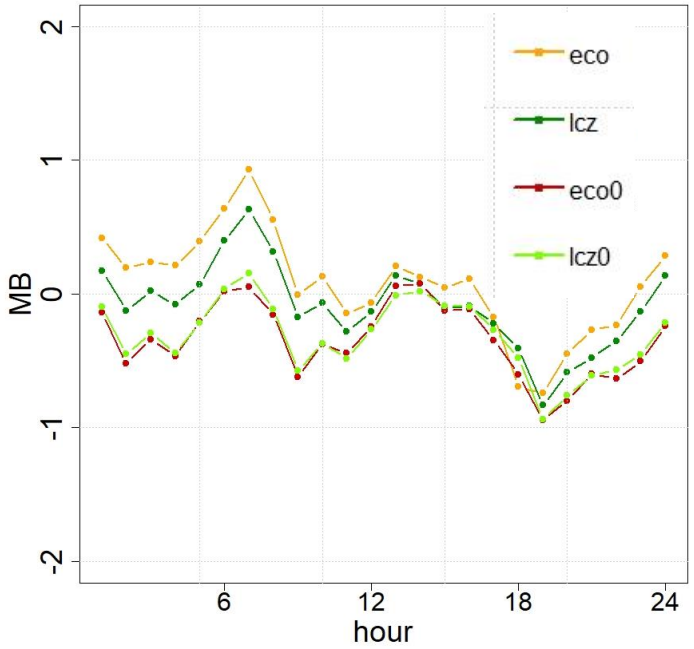
Maybe the sim **eco** is worse for CONSOLATA than R.ROMOLI because of the influence of HIGH values of AHF nearby
→ Need to re-calibrate the look-up tables ?

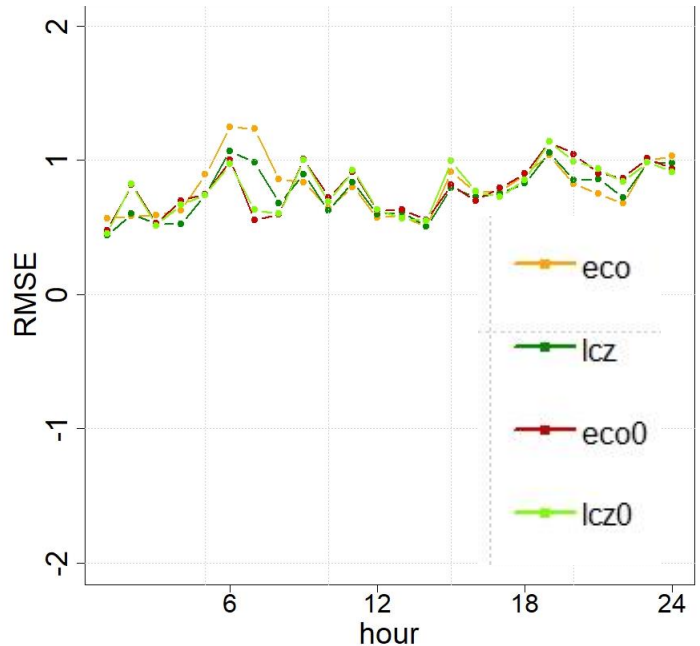




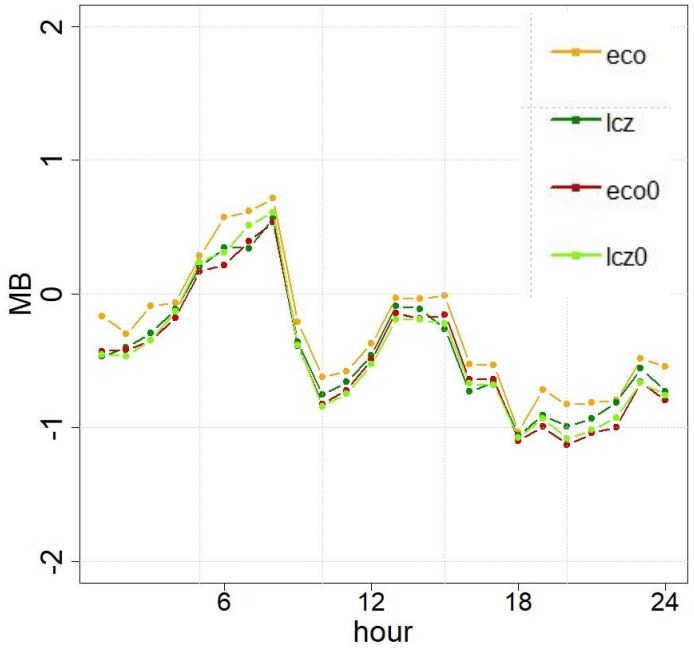


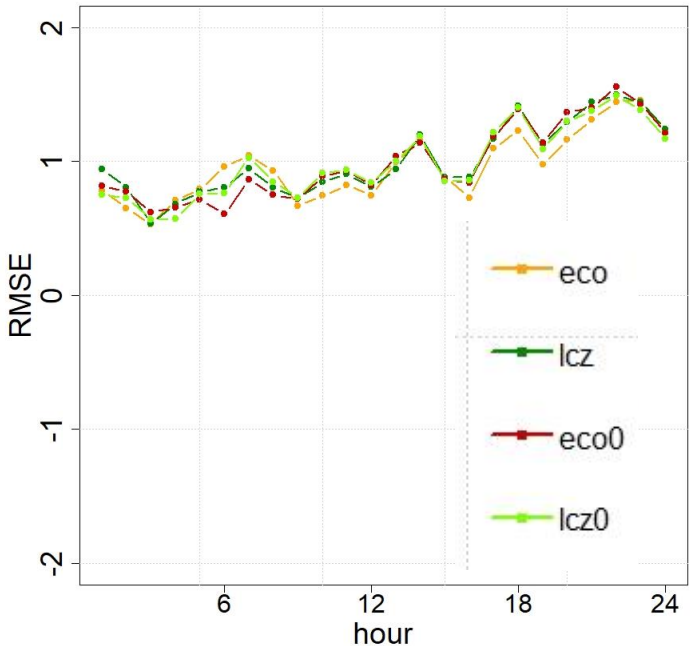
CONSOLATA





REISS ROMOLI



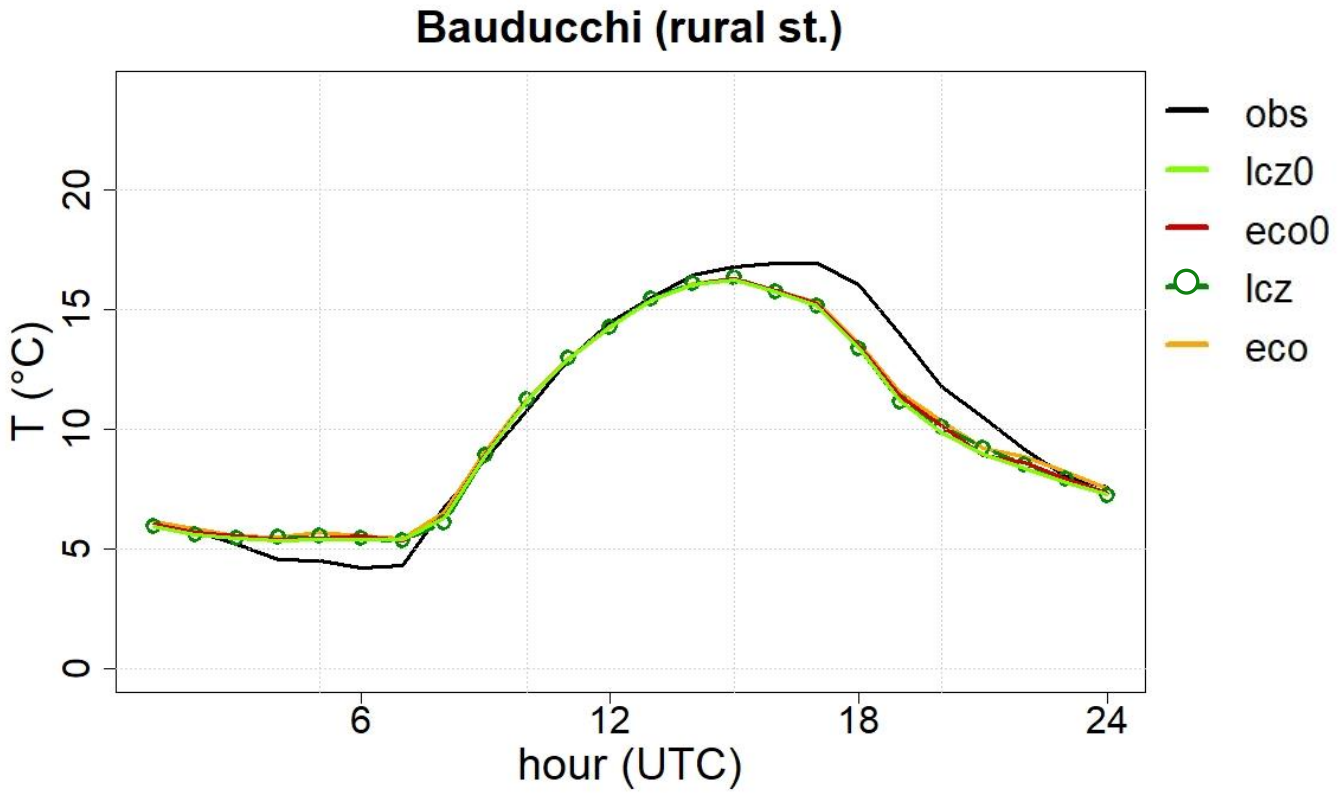


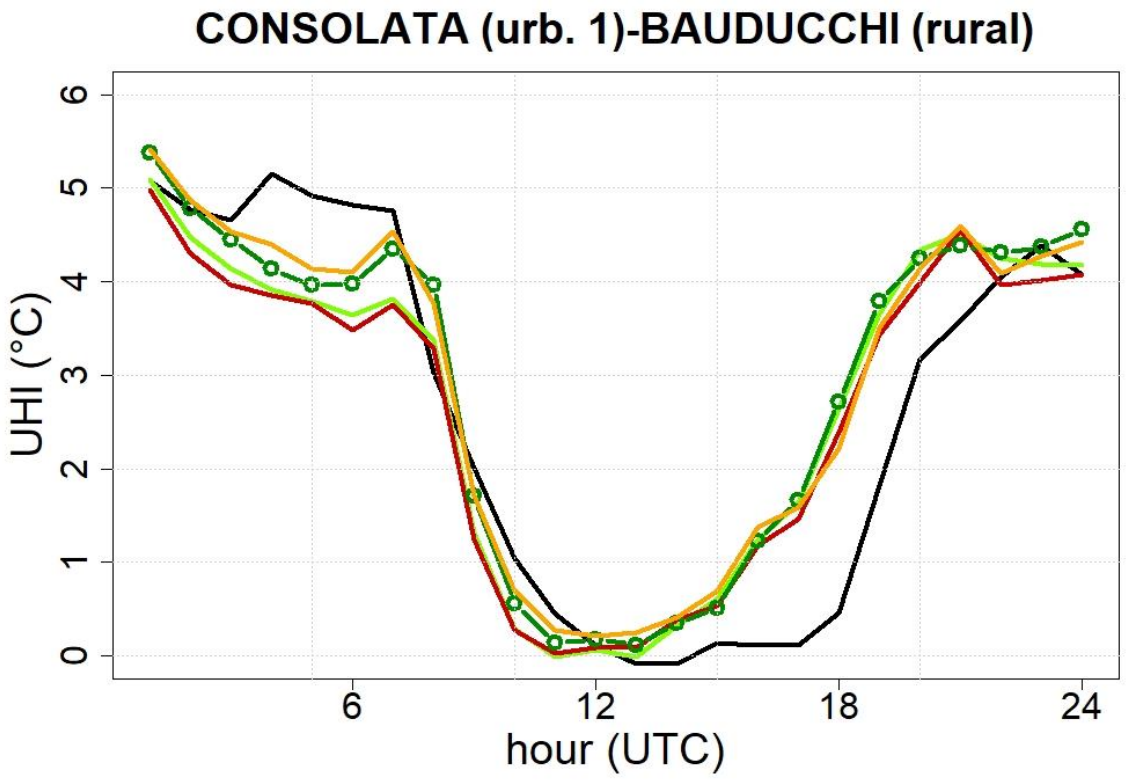
Mean Bias of t2m

RMSE of t2m

	from WUDAPT	from ECOCLIMAP
ISA only	lcz0	eco0
ISA + AHF	lcz	eco
ISA + AHF + G. UP	lczGUP	~~ecoGUP~~
ISA + AHF +g&t UP	lczUP	~~ecoUP~~

Urban Heat Island (UHI)





- **No** impact on rural station (as expected)
- The **UHI** reflects the problems of Consolata

Problem 1:

- ECOCLIMAP is not coherent with all the external parameters deriving from ExtPar !

	from WUDAPT	from ECOCLIMAP
ISA only	lcz0	eco0
ISA + AHF	lcz	eco
ISA + AHF + G. UP	lczGUP	~~ecoGUP~~
ISA + AHF +g&t UP	lczUP	~~ecoUP~~

Other problems to discuss

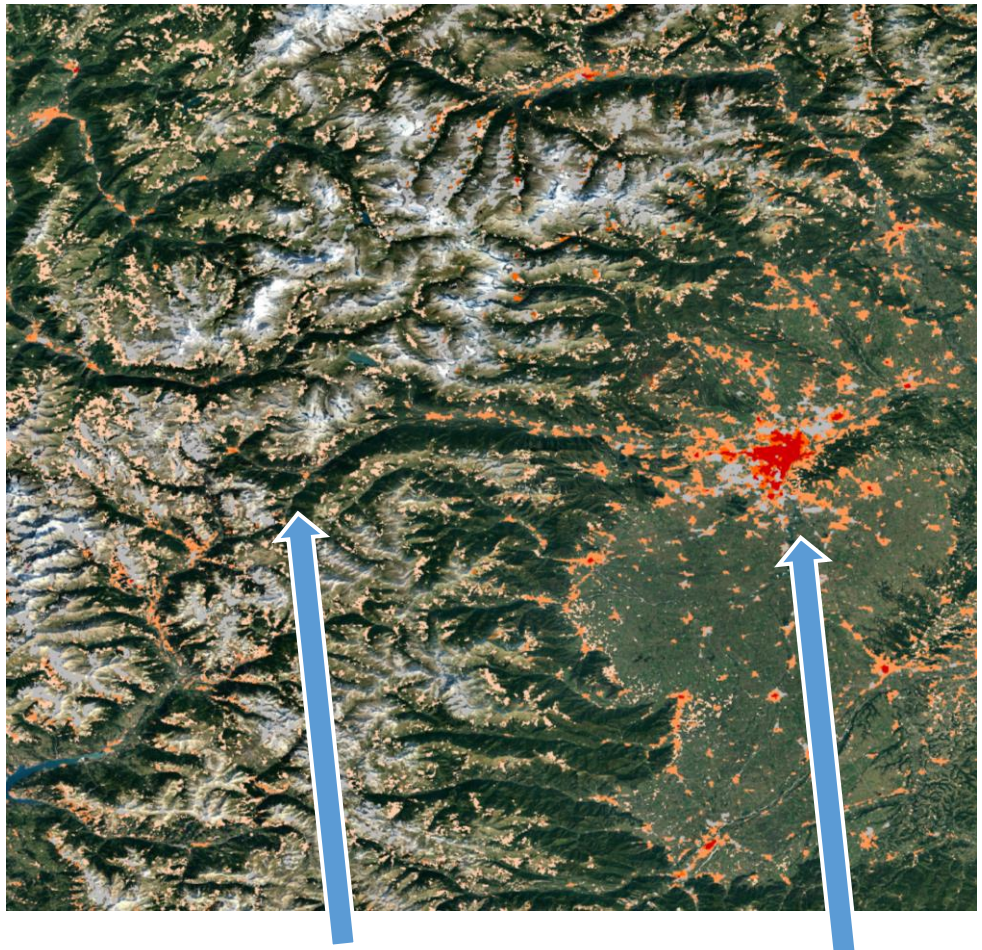
- Which values should be assigned to AHF?

The Flanner (2009) dataset used in EXTPAR for AHF works better than LCZs, both for WUDAPT and ECOCLIMAP

- Re-definition of the look-up table based on other tests (other resolutions, different domains..) ?

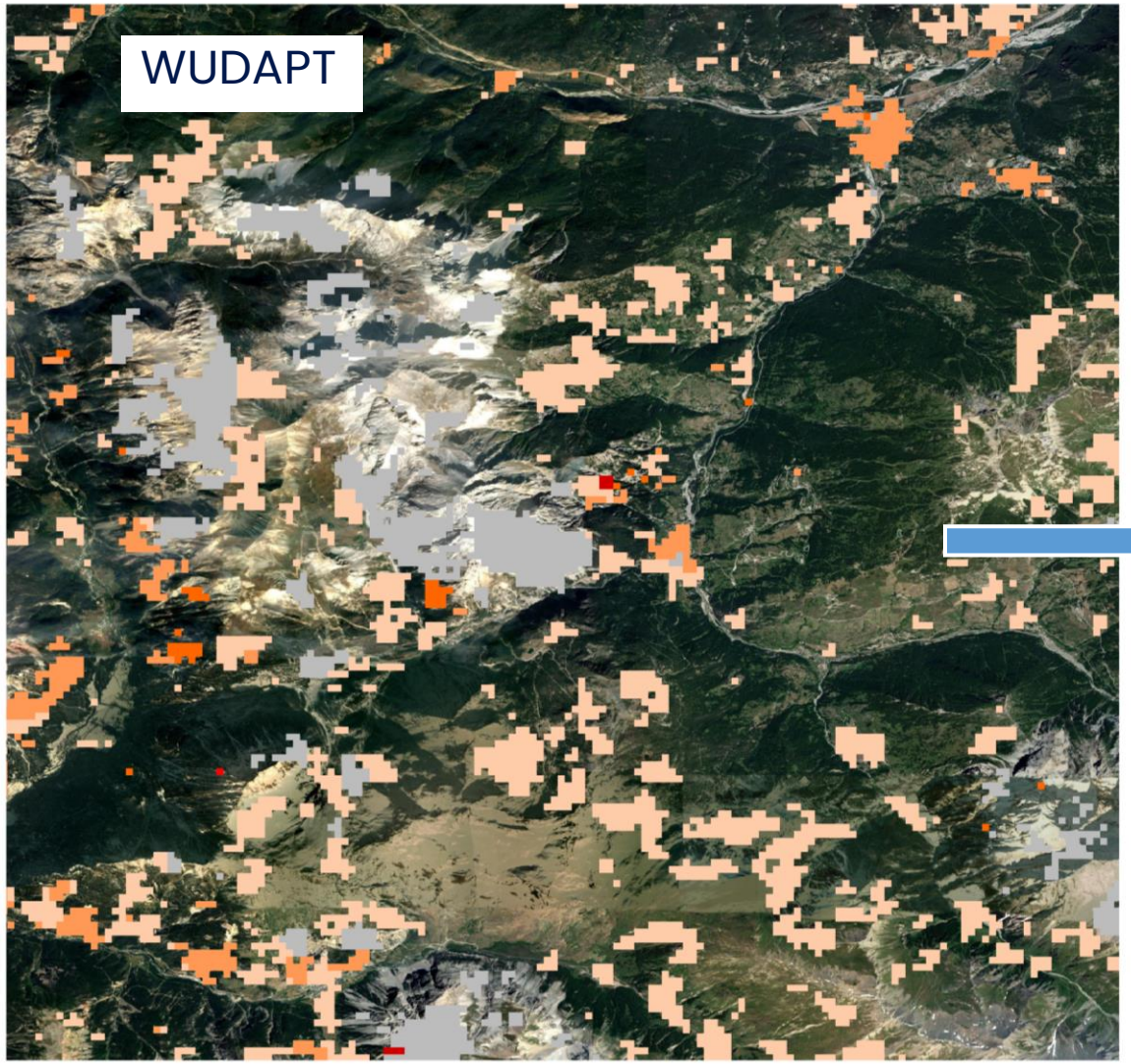
In addition…

- Some urban classes of LCZs are assigned to cells where ISA = 0 (no urban!), especially with the WUDAPT database. This occurs in the mountains:



Mountains

Urban area



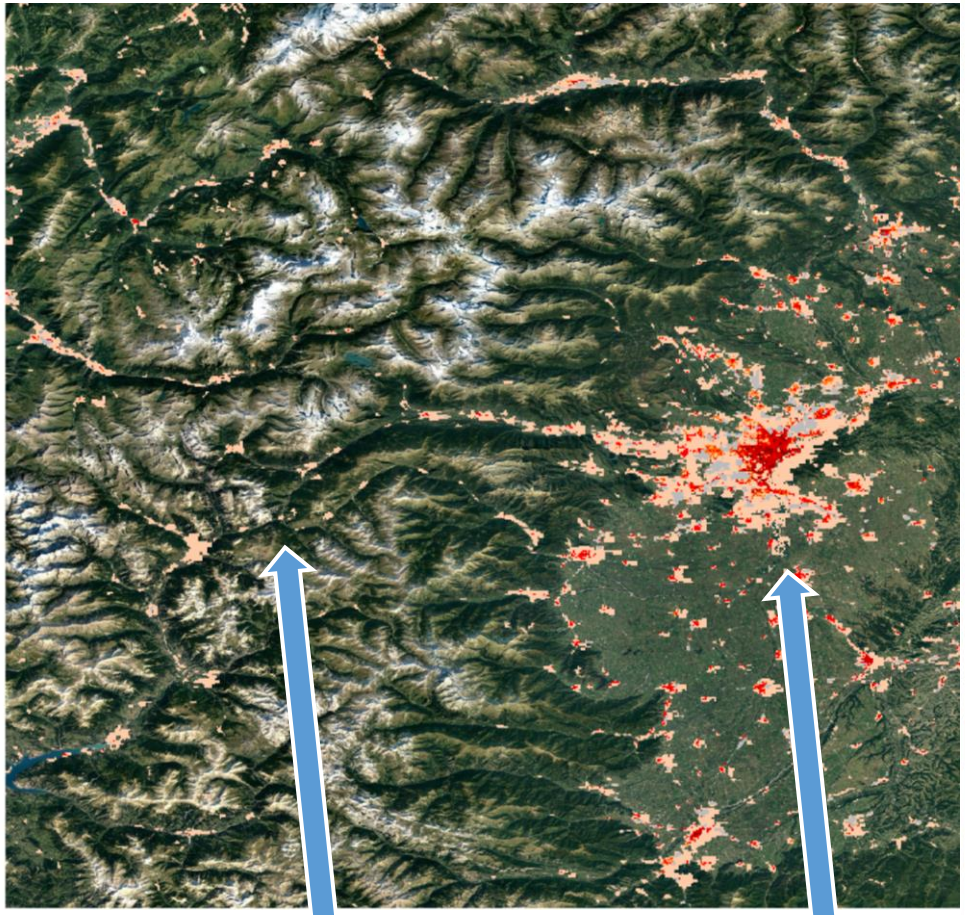
LCZ urban classes

- Compact Highrise
- Compact Midrise
- Compact Lowrise
- Open Highrise
- Open Midrise
- Open Lowrise
- Lightweight lowrise
- Large lowrise
- Sparsely built
- Heavy industry

Zoom of mountains

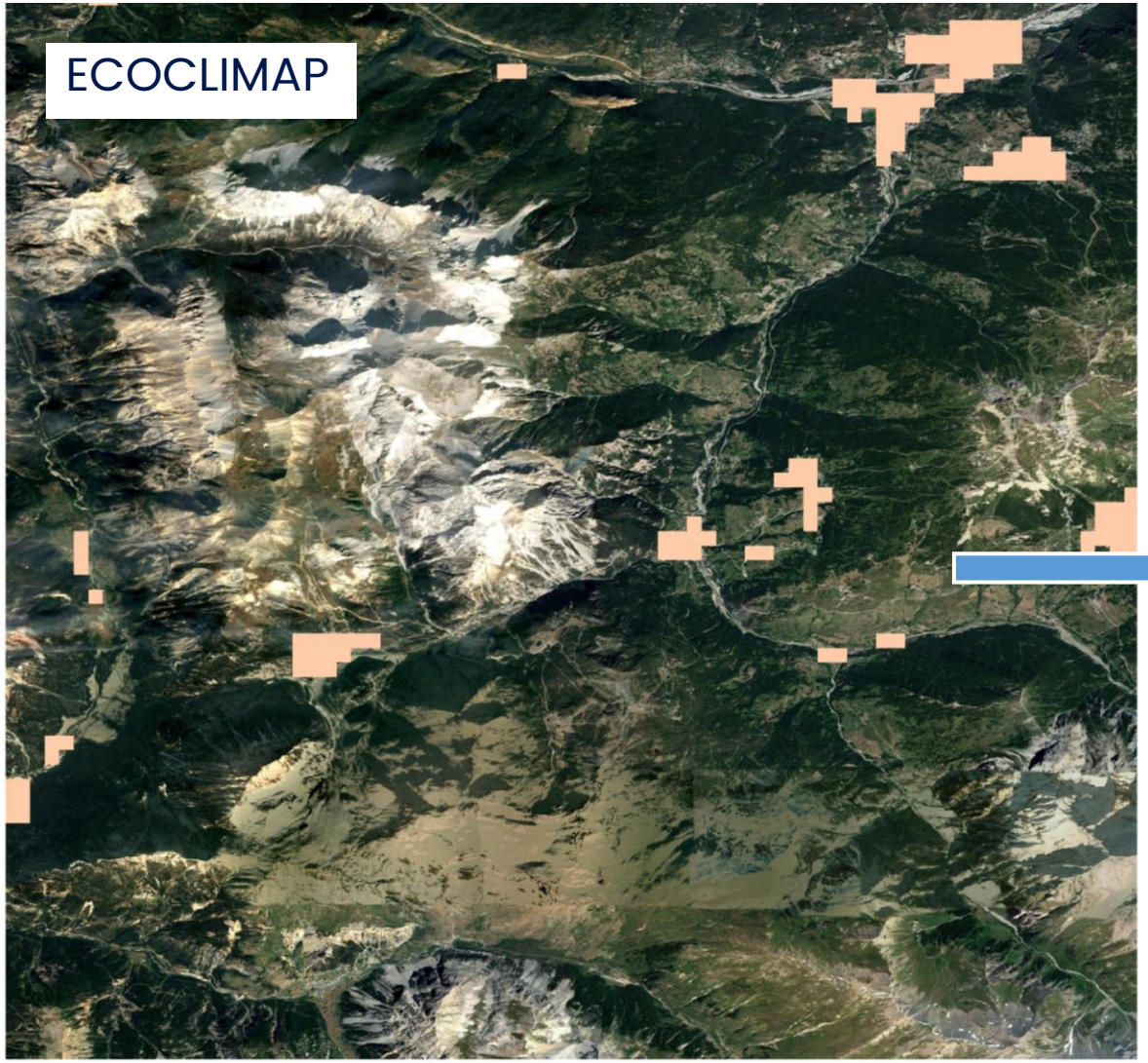
Original (satellite)

- Same problem (even if reduced) with ECOCLIMAP:



Mountains

Urban area



LCZ urban classes
- Compact Highrise
- Compact Midrise
- Compact Lowrise
- Open Highrise
- Open Midrise
- Open Lowrise
- Lightweight lowrise
- Large lowrise
- Sparsely built
- Heavy industry

Zoom of mountains

Original (satellite)