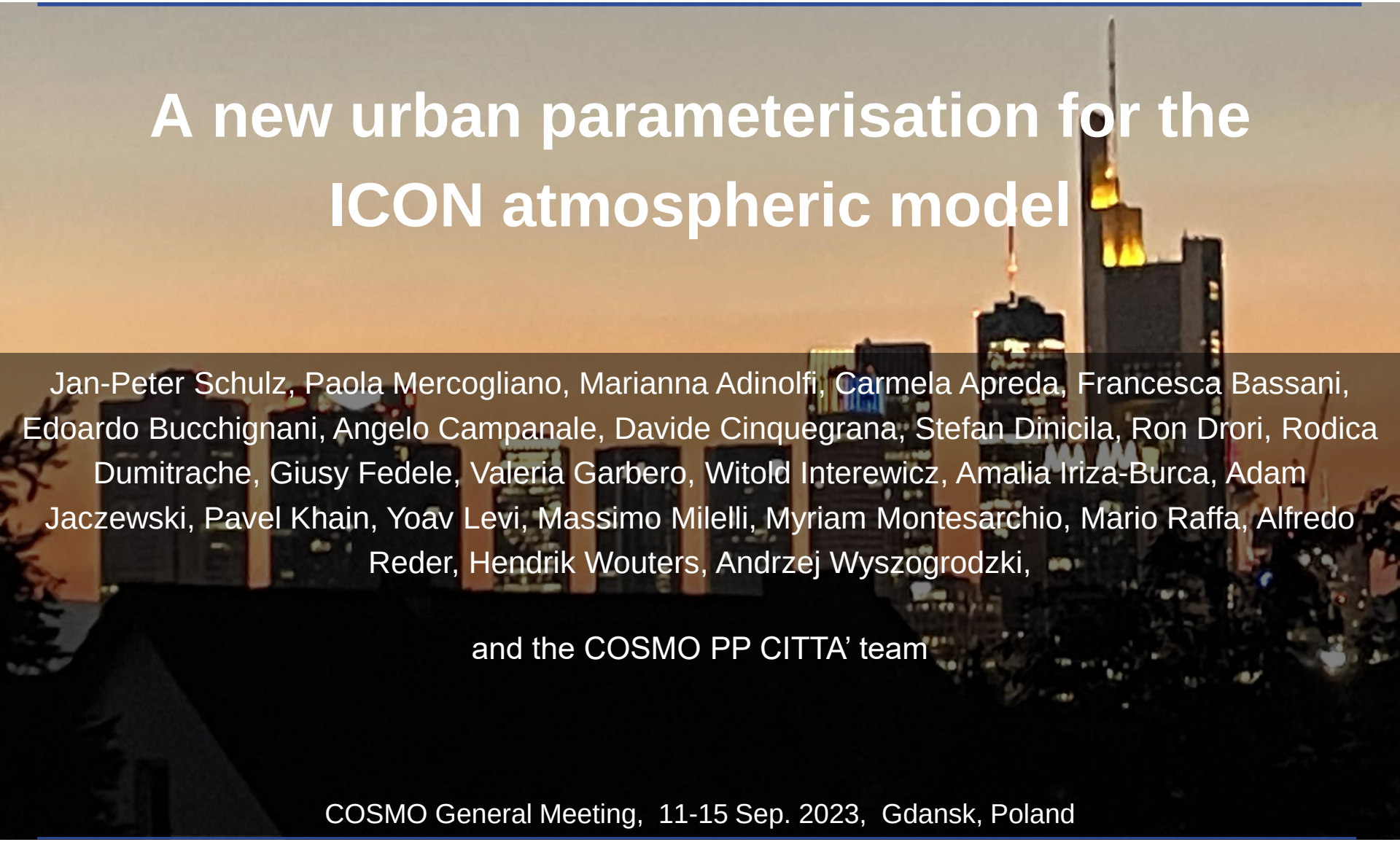


A new urban parameterisation for the ICON atmospheric model

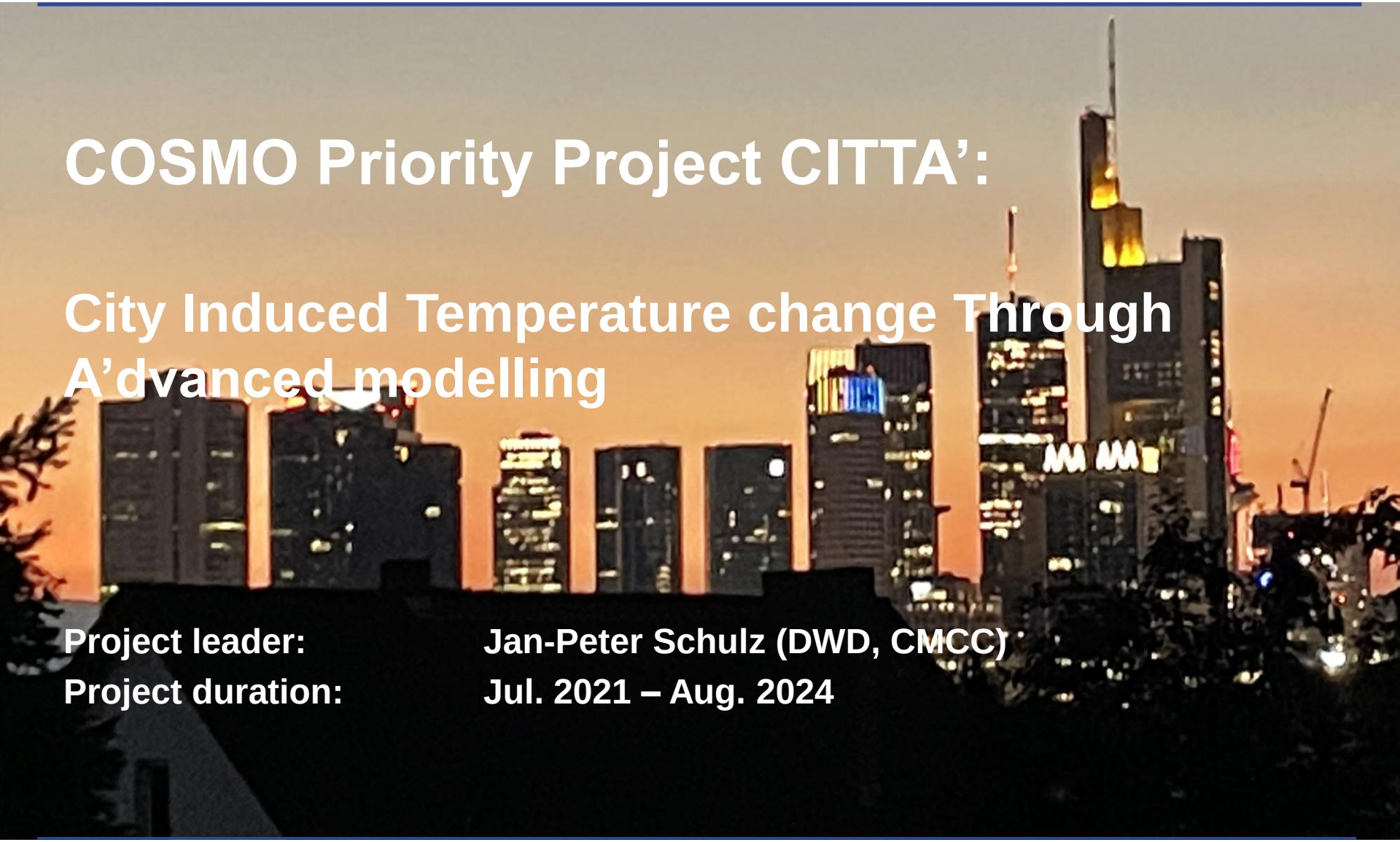
Jan-Peter Schulz, Paola Mercogliano, Marianna Adinolfi, Carmela Apreda, Francesca Bassani, Edoardo Bucchignani, Angelo Campanale, Davide Cinquegrana, Stefan Dinicila, Ron Drori, Rodica Dumitrache, Giusy Fedele, Valeria Garbero, Witold Interewicz, Amalia Iriza-Burca, Adam Jaczewski, Pavel Khain, Yoav Levi, Massimo Milelli, Myriam Montesarchio, Mario Raffa, Alfredo Reder, Hendrik Wouters, Andrzej Wyszogrodzki,

and the COSMO PP CITTA' team

COSMO General Meeting, 11-15 Sep. 2023, Gdansk, Poland

COSMO Priority Project CITTA':

City Induced Temperature change Through A'dvanced modelling



Project leader: Jan-Peter Schulz (DWD, CMCC)

Project duration: Jul. 2021 – Aug. 2024

Task 1: Implementation of TERRA_URB in ICON

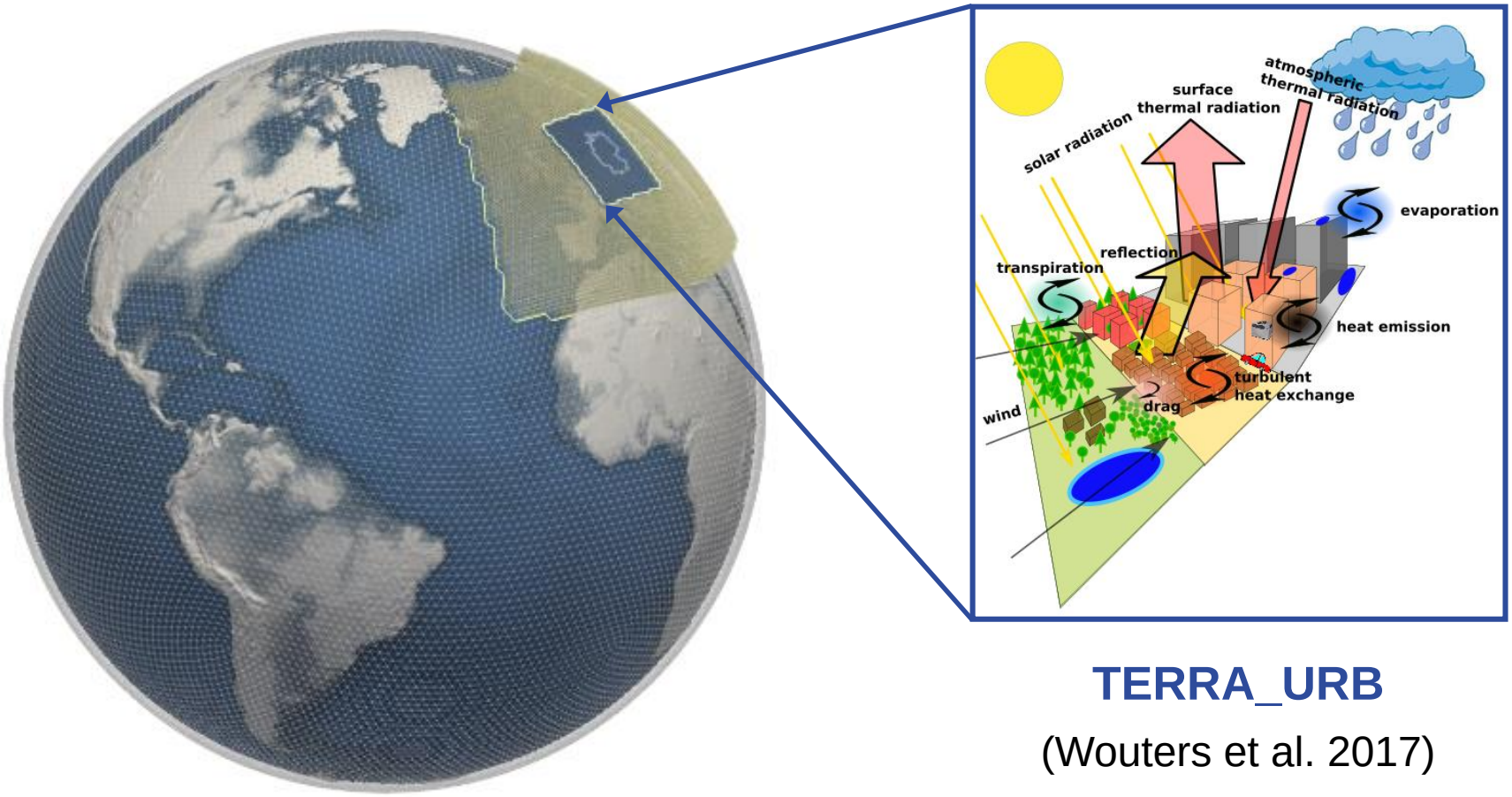
During the COSMO Priority Tasks AEVUS and AEVUS2 the TERRA_URB urban parameterisation in the COSMO model was demonstrated to be able to reproduce the key urban meteorological features. In the framework of the transition of the COSMO Consortium to the ICON model TERRA_URB needs to be implemented in ICON.

Deliverables: TERRA_URB in ICON.

Involved scientists: Jan-Peter Schulz (DWD) 0.4 FTE, Angelo Campanale (CMCC) 0.1 FTE, Massimo Milelli (CIMA) 0.1 FTE

FTEs: 0.6 FTE

Task 1: Implementation of TERRA_URB in ICON



TERRA_URB

(Wouters et al. 2017)

Task 1: Implementation of TERRA_URB in ICON

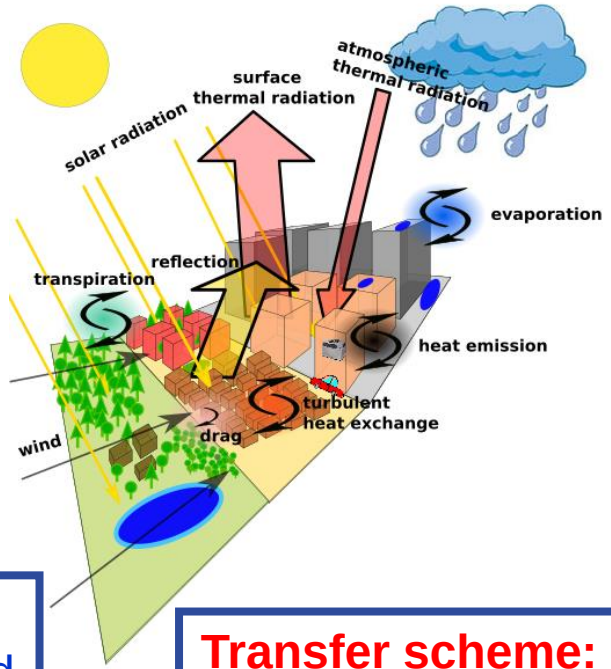
Modifications in ICON:

Land surface scheme:
Introduce puddles

PUDDLE

Radiation scheme:
Modify albedo

ALB



Land surface scheme:
Set infiltration and bare soil evaporation to zero

NOEVAP

Land surface scheme:
Modify heat capacity and thermal conductivity

THERM

Transfer scheme:
Modify thermal roughness length

TURB

Land surface scheme:
Introduce anthropogenic heat flux

HFLUX

Task 1: Implementation of TERRA_URB in ICON

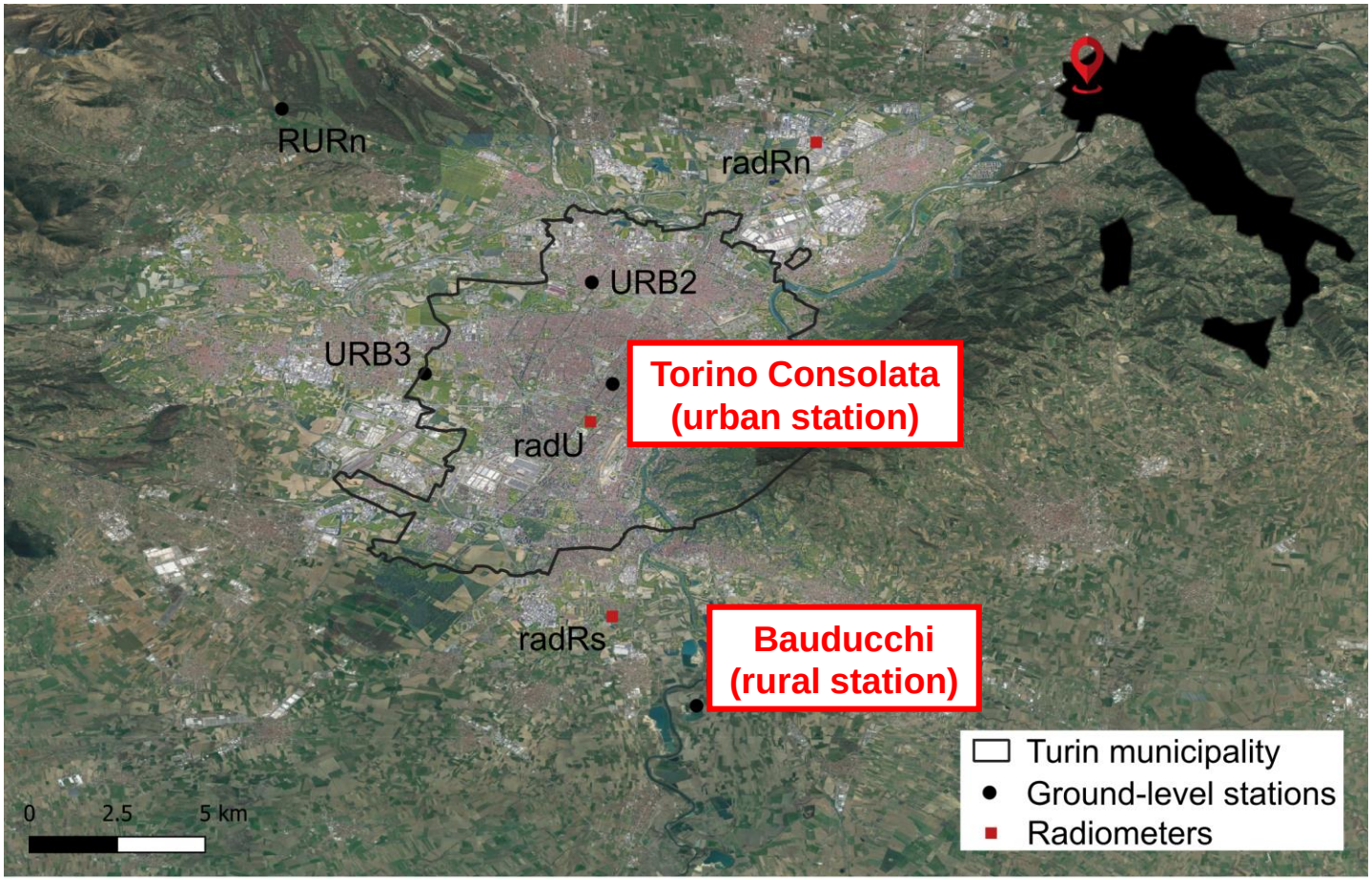
Model setup

Hindcast simulations:

- 2021081100 – 2021081500 (96h)
- Heat wave over north-west of Italy
- IFS 9km -> ICON 900m
- ICON 7km -> ICON 3.5km -> ICON 1.8km -> ICON 900m
- ICON (master branch of June 2023)

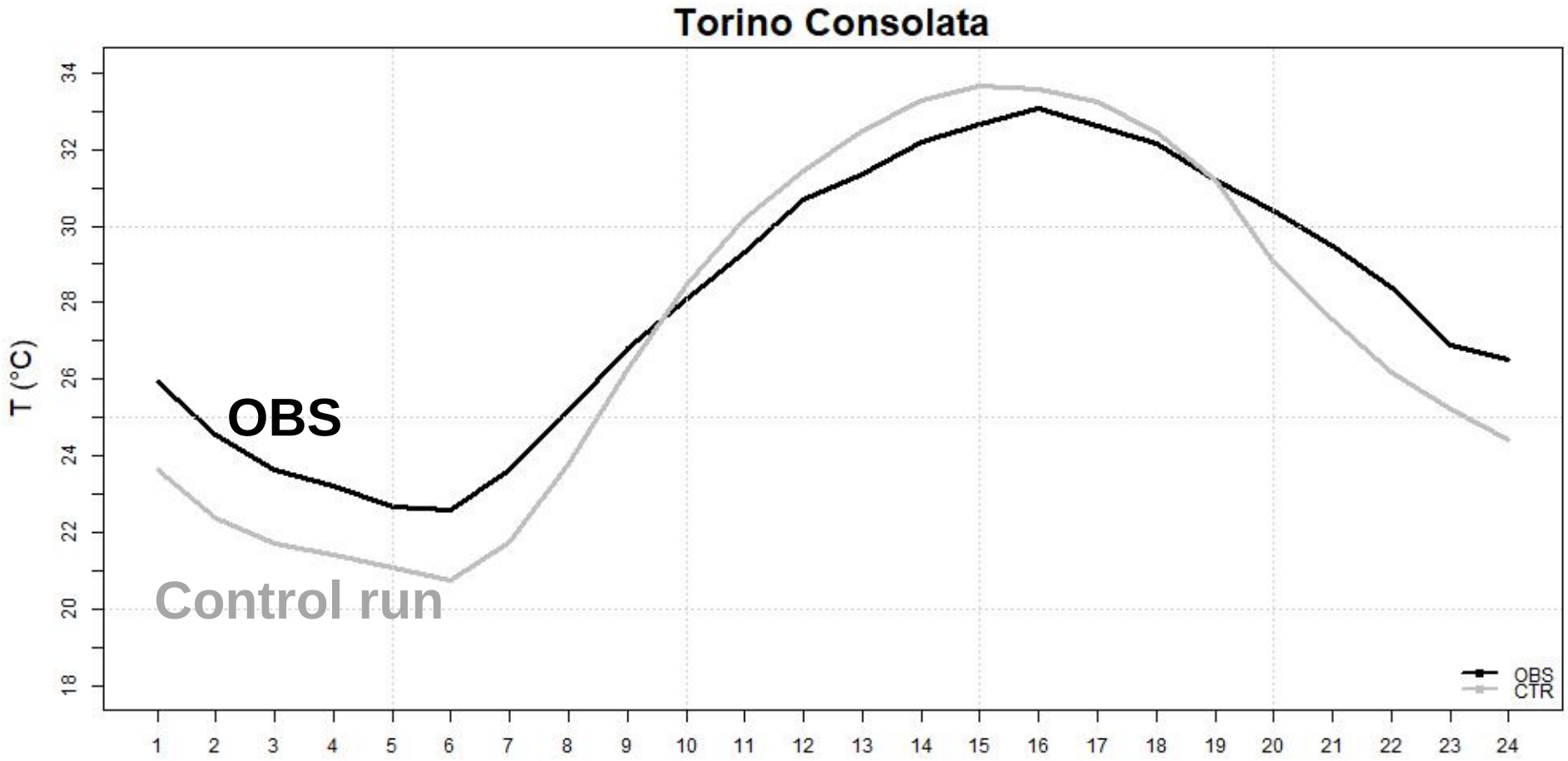
M. Milelli (CIMA), F. Bassani (PoliTo), V. Garbero (ARPAP)

Task 1: Implementation of TERRA_URB in ICON



M. Milelli (CIMA), F. Bassani (PoliTo), V. Garbero (ARPAP)

2-m temperature diurnal cycle



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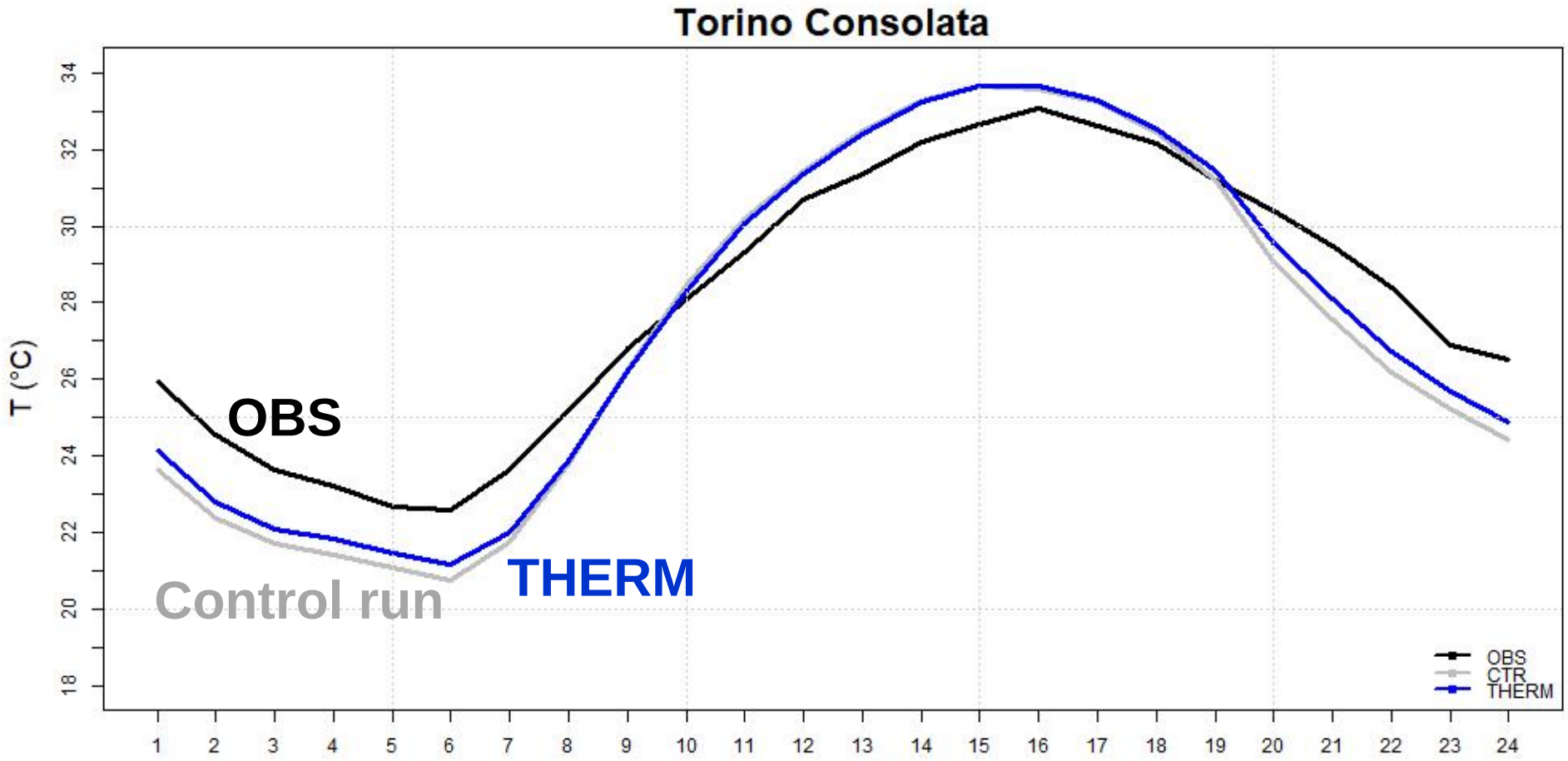

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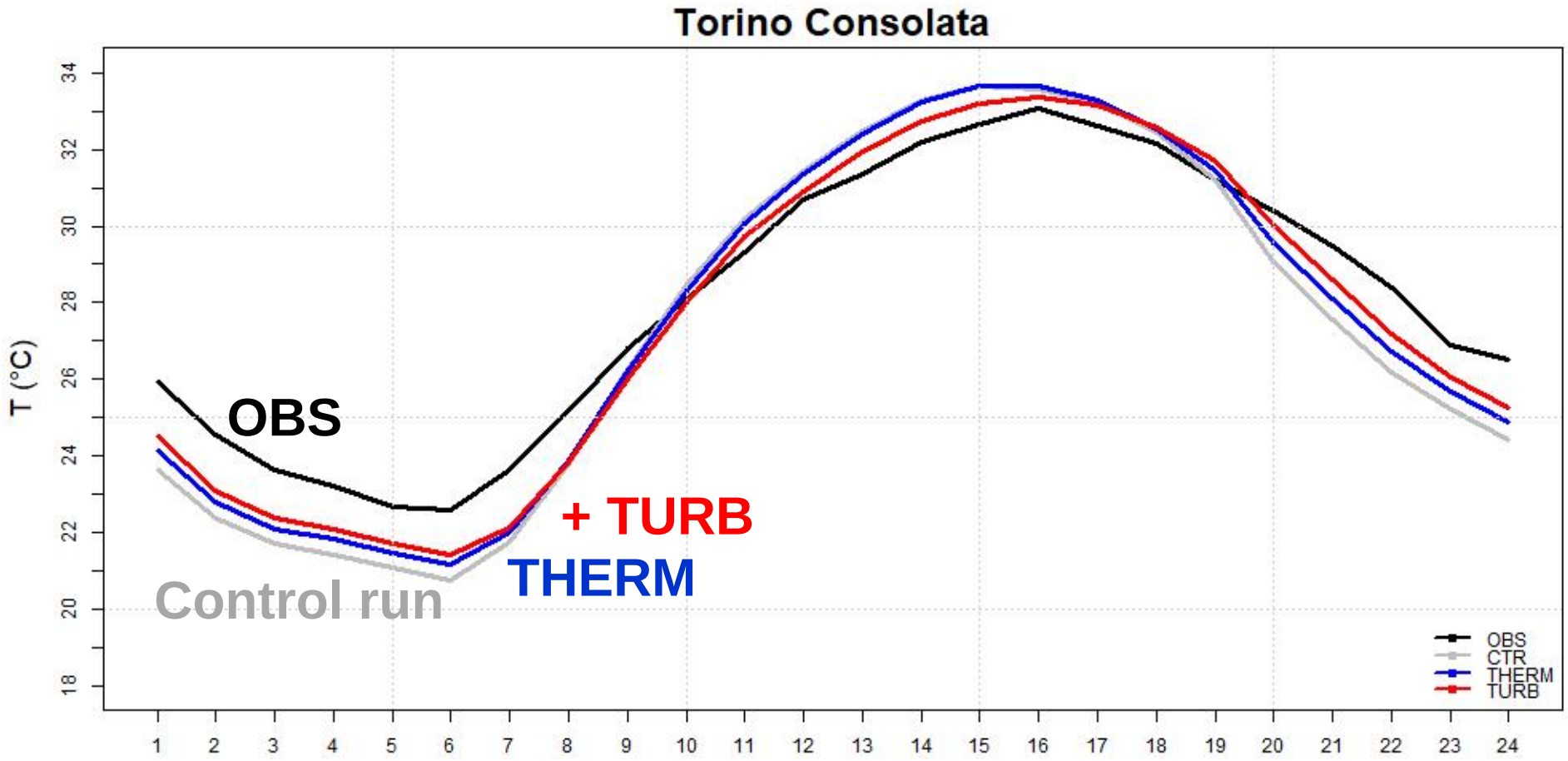

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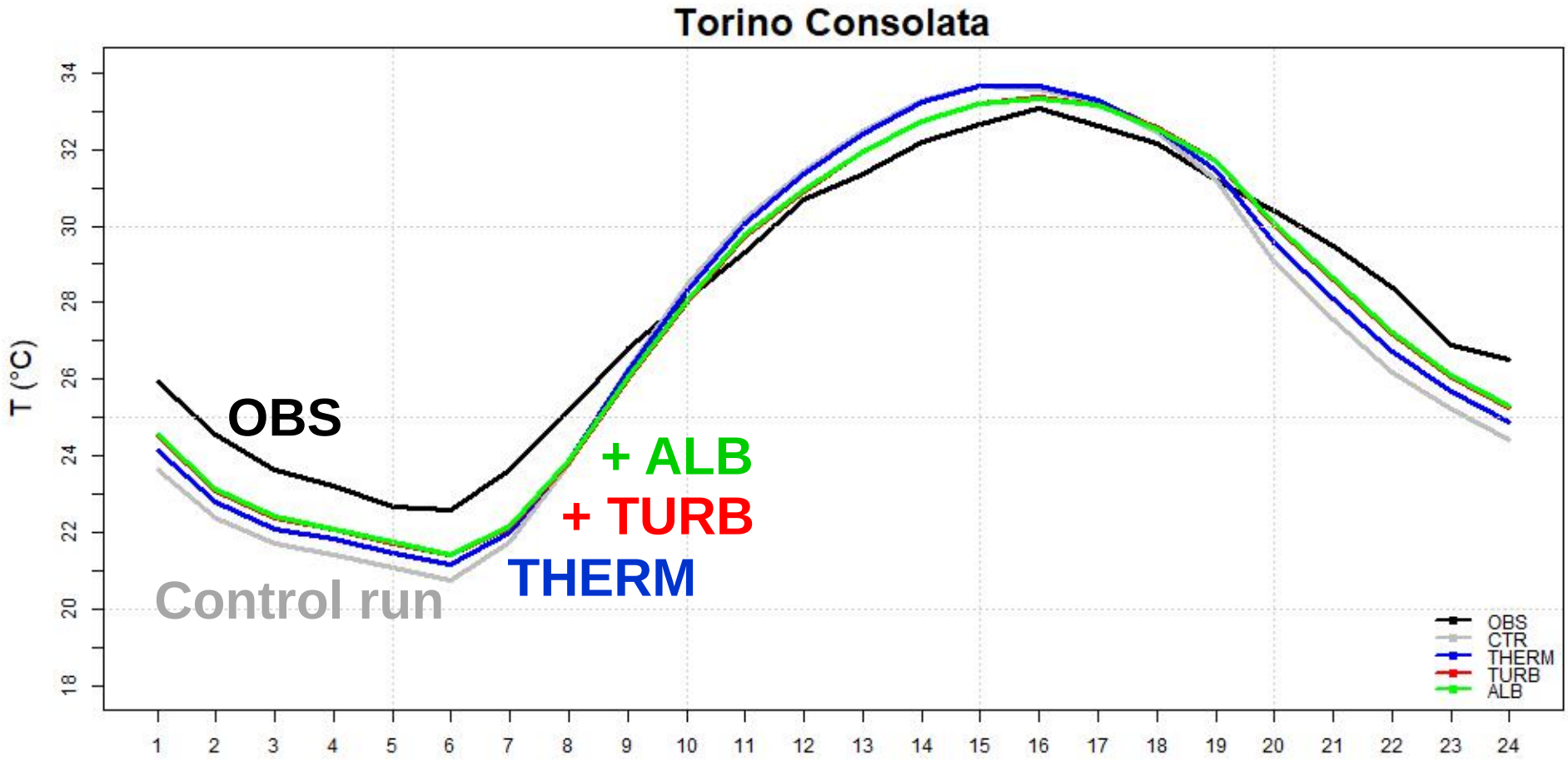

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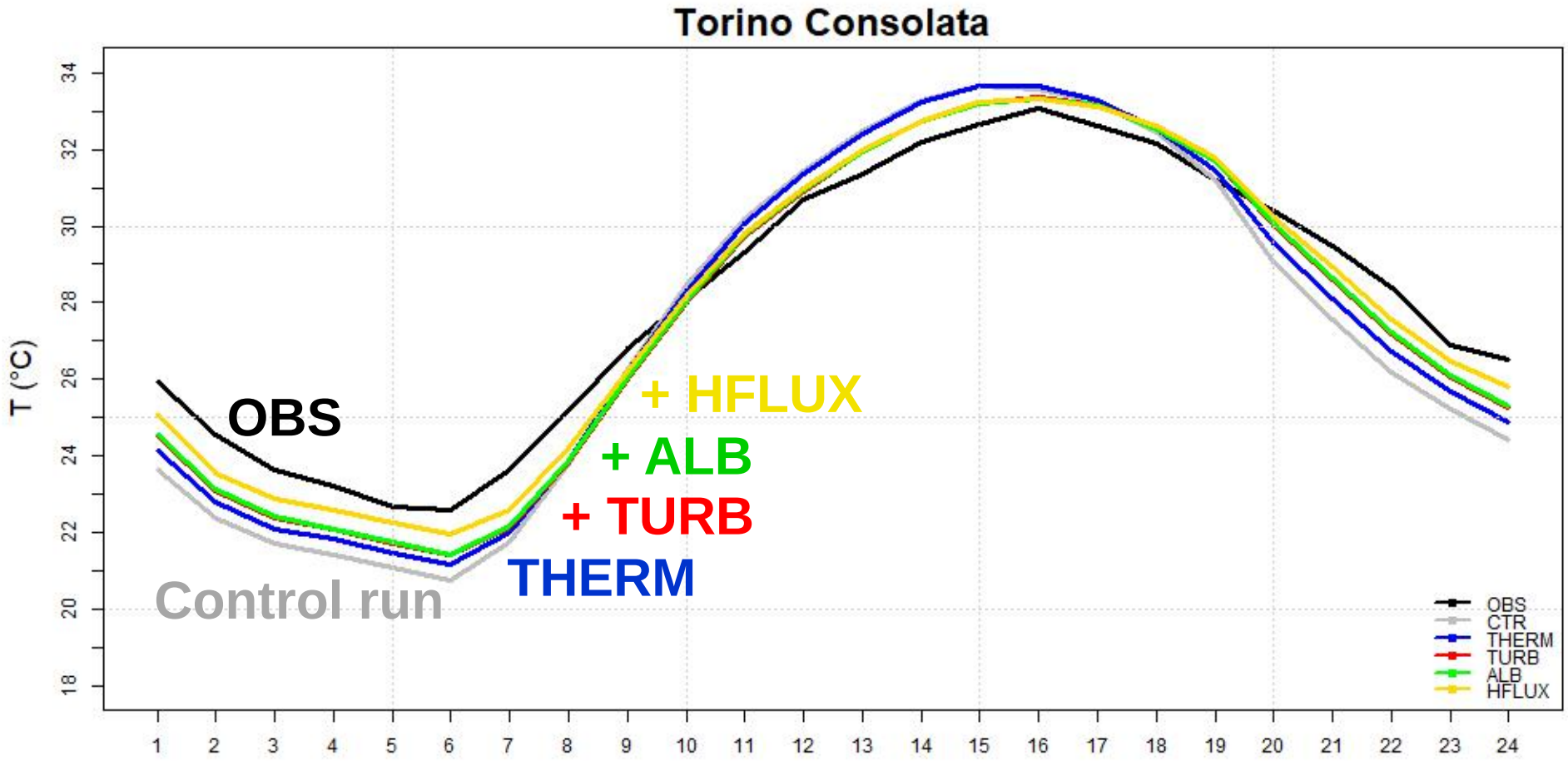

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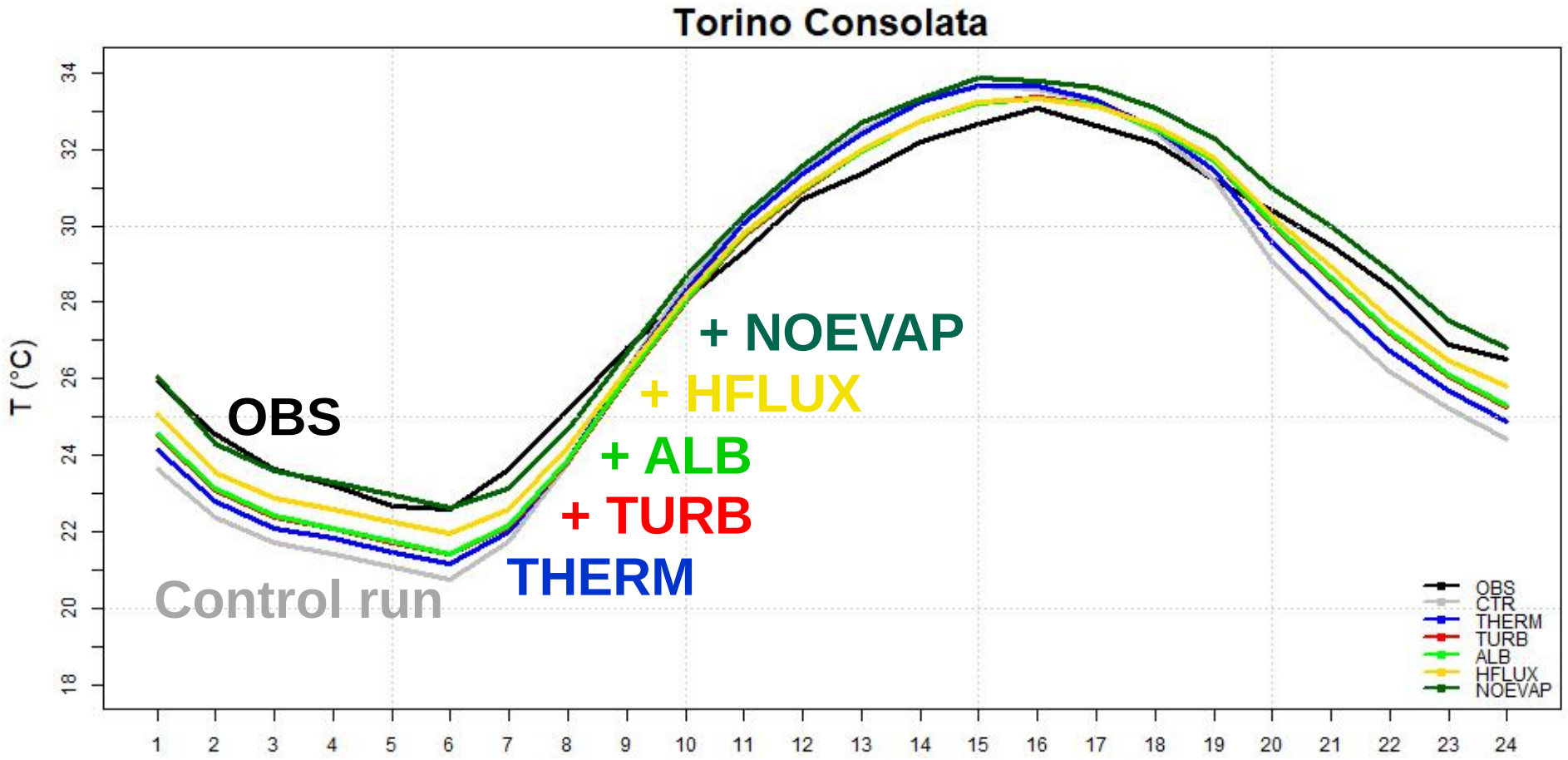

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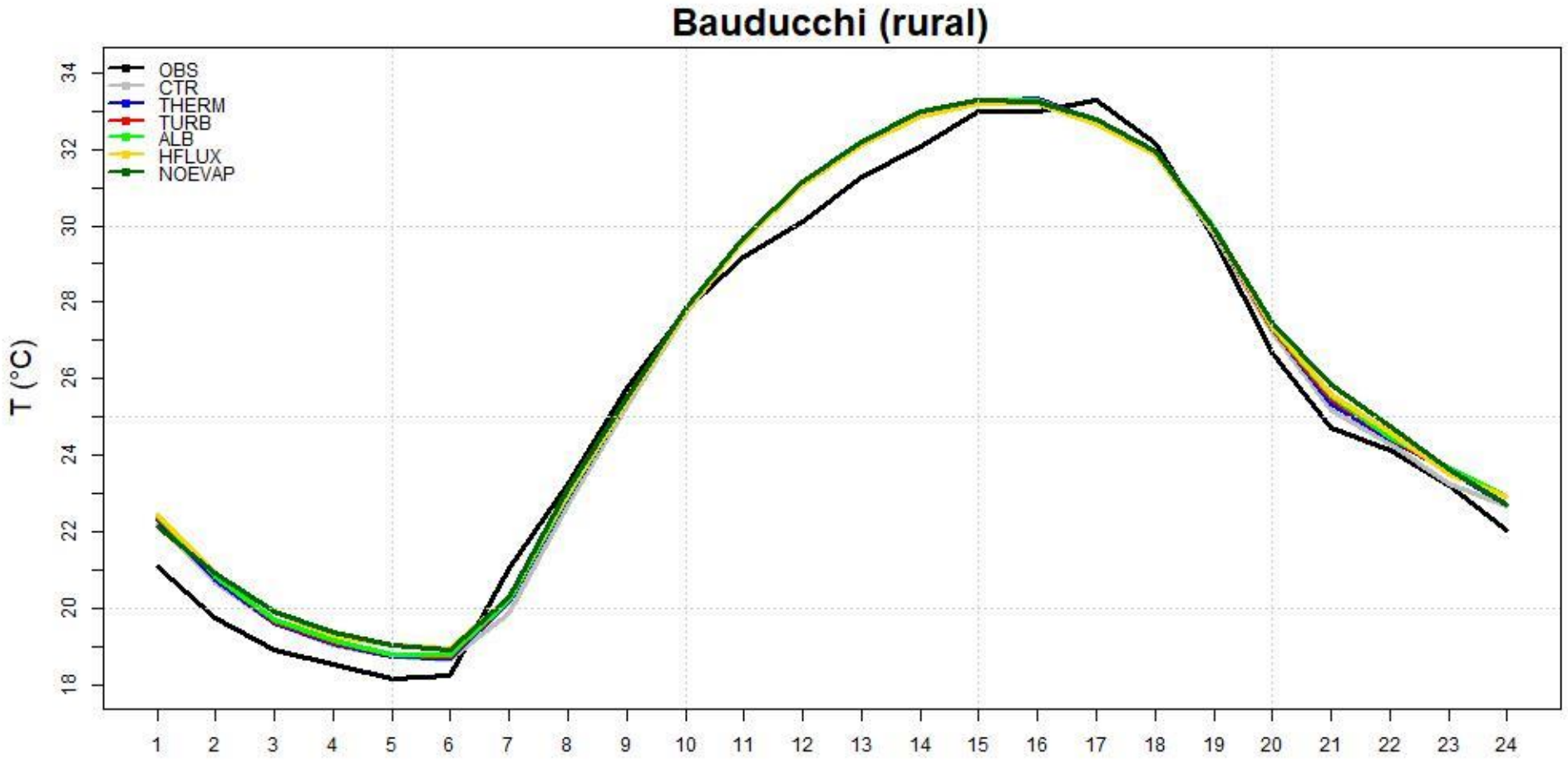
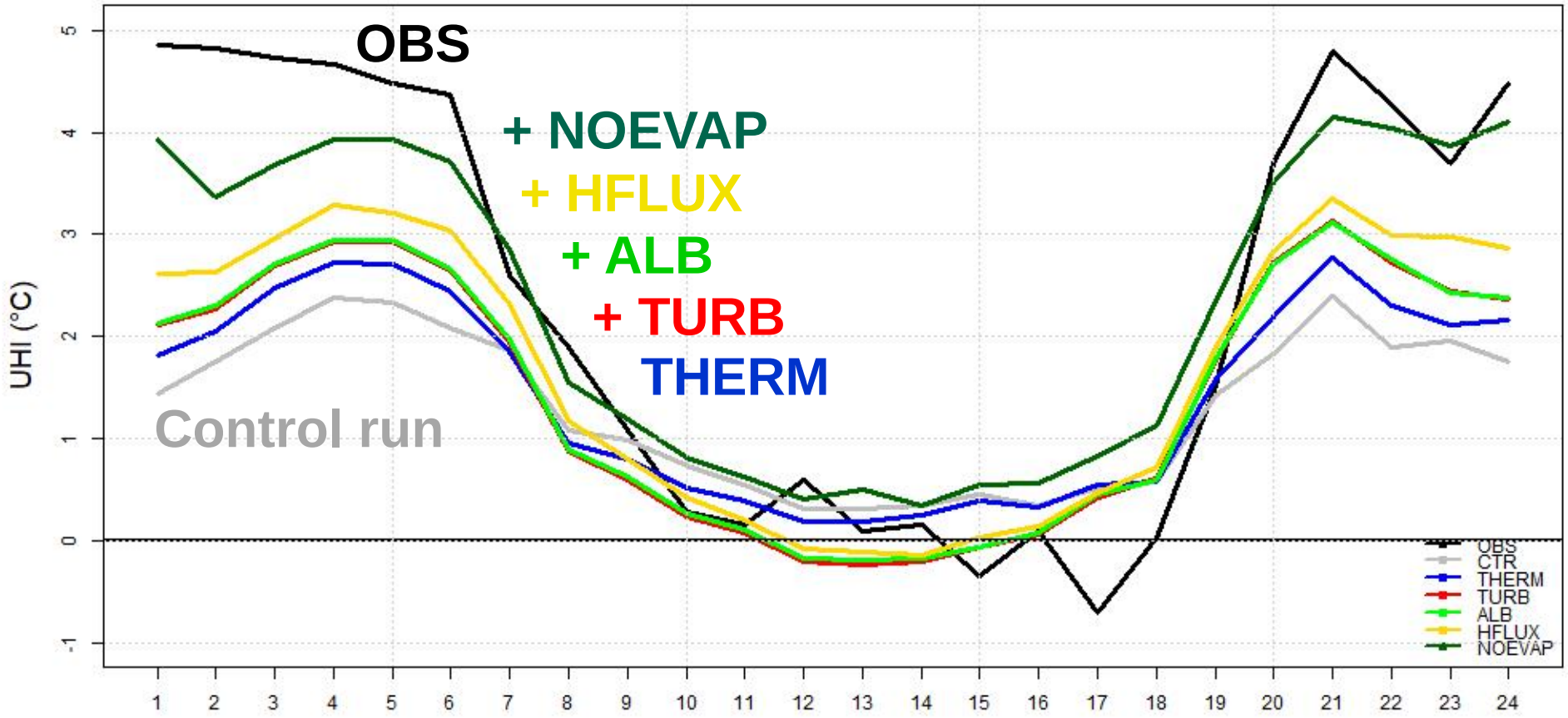
2-m temperature diurnal cycle



M. Milelli (CIMA), F. Bassani (PoliTo), V. Garbero (ARPAP)

2-m temperature difference: urban – rural

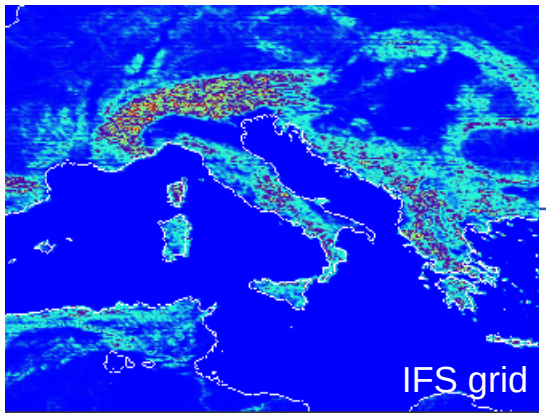
Urban Heat Island (UHI) effect



M. Milelli (CIMA), F. Bassani (PoliTo), V. Garbero (ARPAP)

Model set up

Model Set-Up									
Model	**Forcing**	**Grid type**	**Grid point**	**Horizontal resolution**	**Horizontal discretization**	**Time step**	**Vertical coordinates**	**Scheme of temporal integration**	**Scheme of spatial differentiation**
ICON	IFS (ECMWF) 0,075°	The unstructured icosahedral-triangular grid	451384	2 km	Arakawa C-grid	24 s	65 vertical levels	Two-time level predictor-corrector time stepping scheme	Mixture of finite volume / finite difference discretization



Downscaling from 9 km to ~2 km

A. Campanale (CMCC)

- **Period: 16 - 20 Aug. 2017**
- **TU on = ICON+TERRA_URB on**
- **TU off = ICON (reference case)**

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

DWD

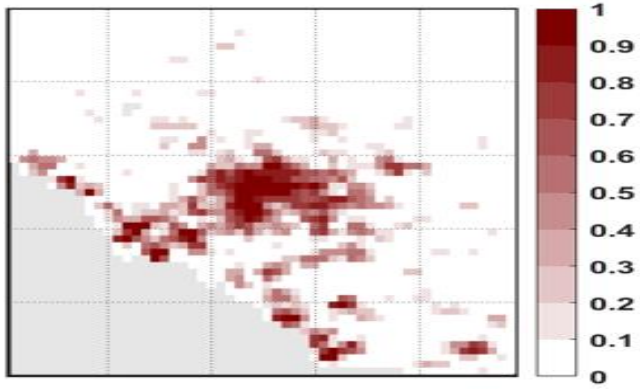
2-m temperature difference: TU on – TU off

Fr_paved = Impervious Surface Area (ISA)

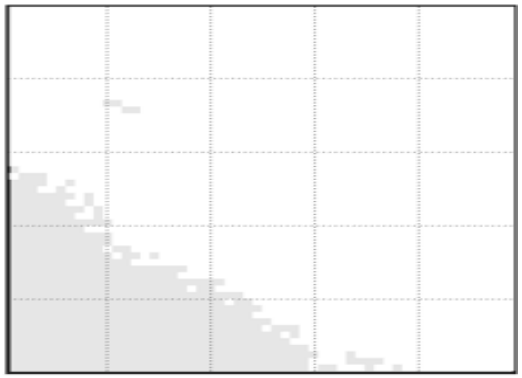
Day

Night

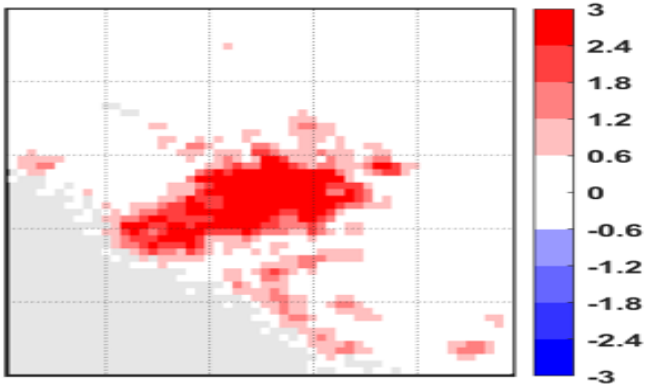
Rome fr_paved



Rome day



Rome night



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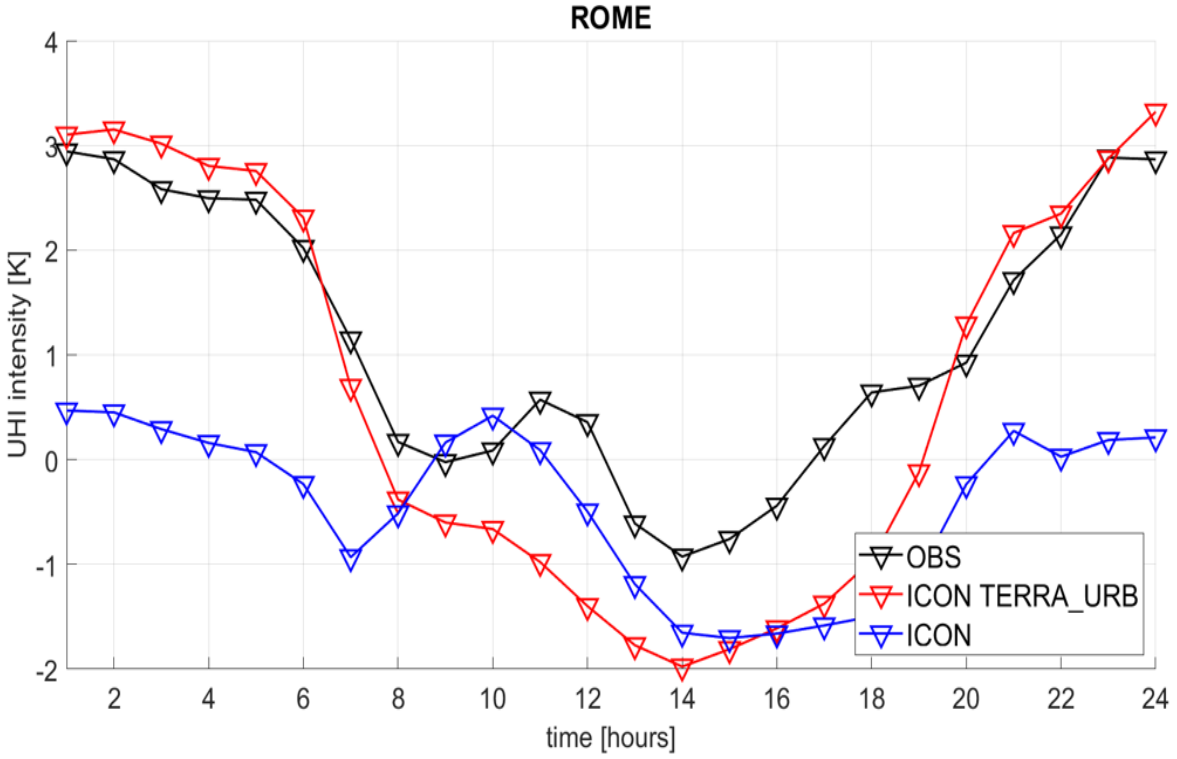
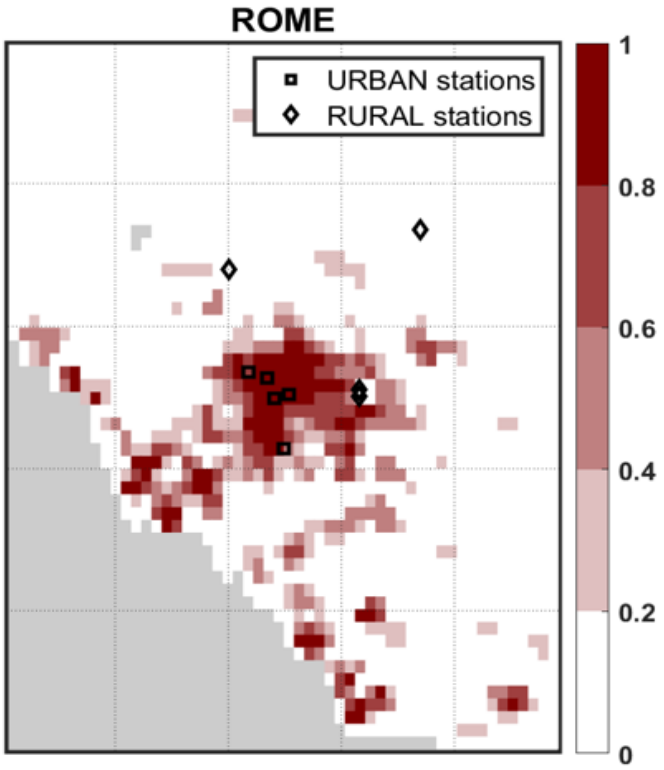
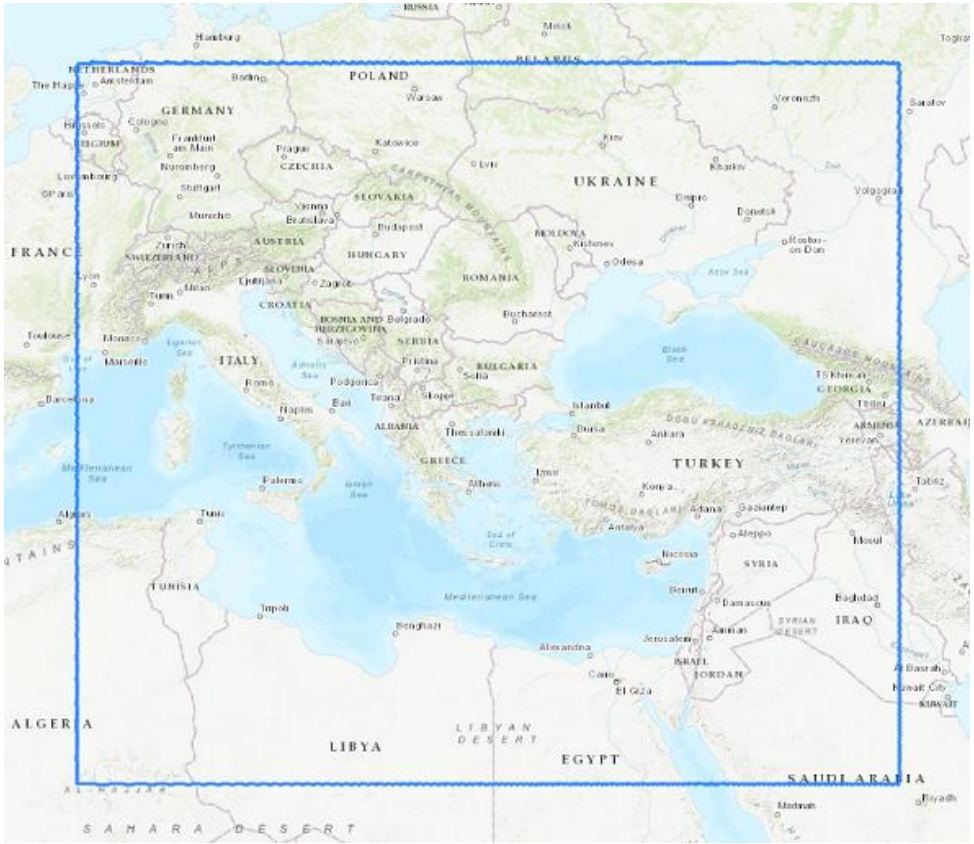




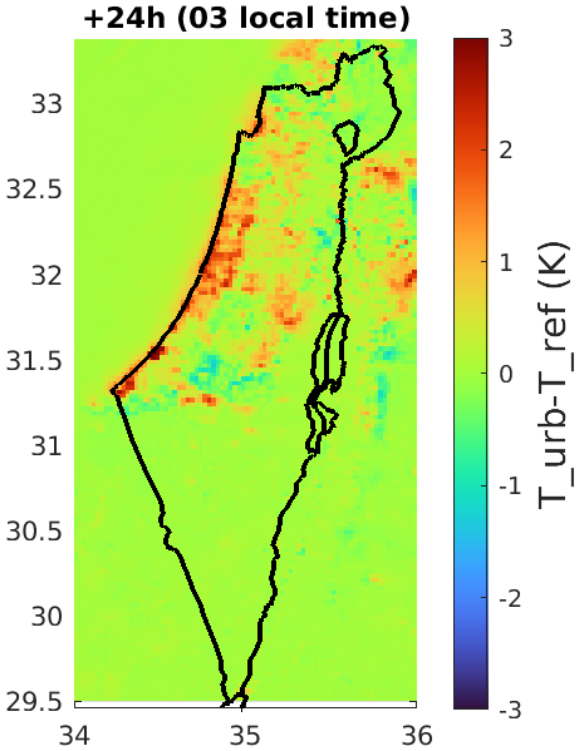
cmcc

6 days experiment: 27/2/2023 - 4/3/2023, 00 UTC + 78h, ATOS@ECMWF

ICON-IL domain (2.5km) driven by IFS

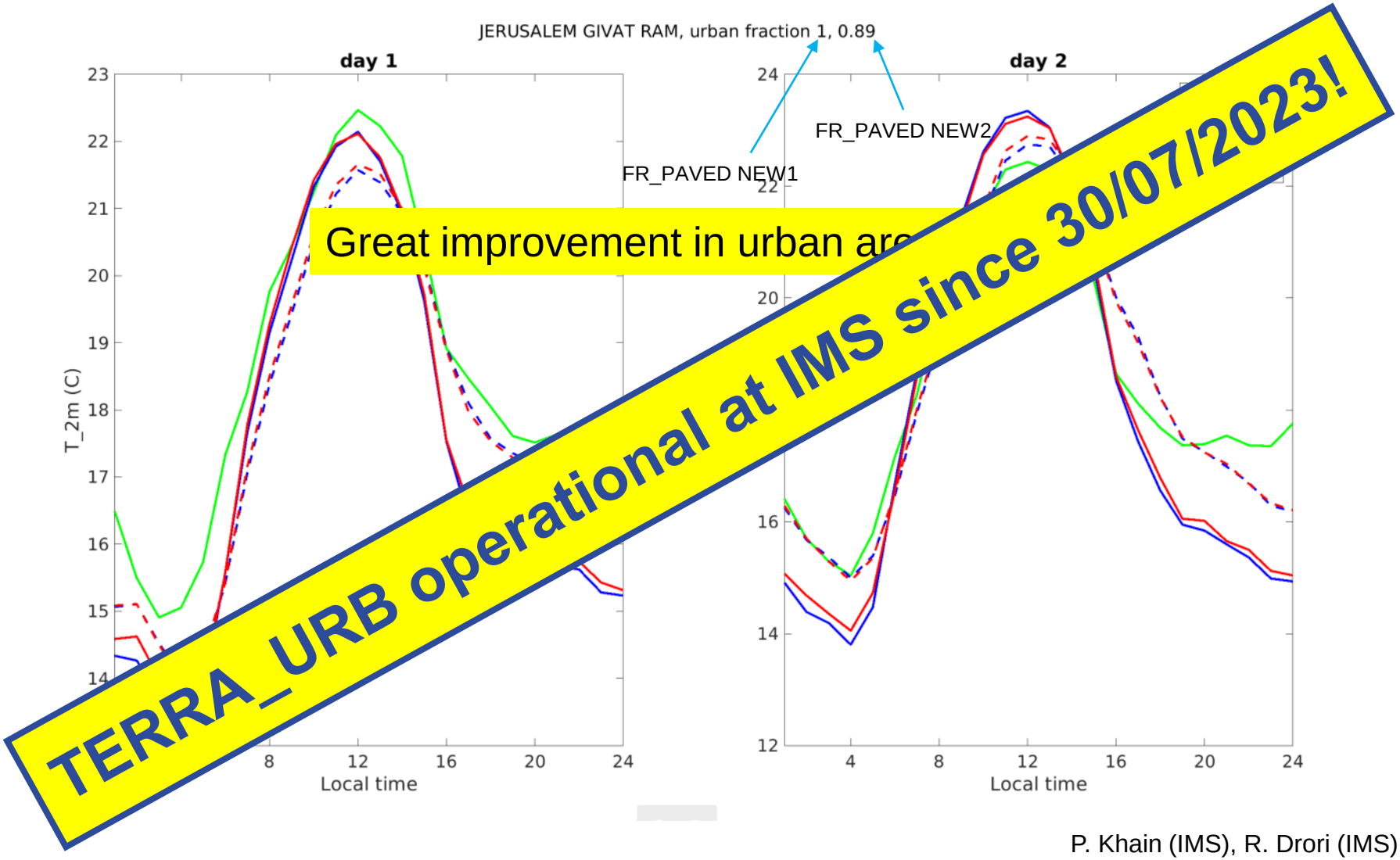


2-m temp. diff.: TU on – TU off



P. Khain (IMS), R. Drori (IMS)

2-m temperature diurnal cycle



P. Khain (IMS), R. Drori (IMS)

Task 2: External parameters

Subtask 2.2: New urban external parameters in EXTPAR for ICON(-LAM)

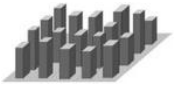
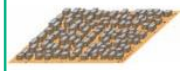
Meanwhile, two raw EXTPAR datasets for TERRA_URB are outdated and should be replaced. Furthermore, several internal parameters describing the urban geometry and the urban thermal and radiative properties, which were hardcoded in TERRA_URB as global constants, will be replaced by 2-dimensional fields from EXTPAR.

Deliverables: New urban external parameters in EXTPAR for ICON-LAM.

Involved scientists: Carmela Apreda (CMCC) 0.2 FTE, Adam Jaczewski (IMGW-PIB) 0.2 FTE, Andrzej Wyszogrodzki (IMGW-PIB) 0.3 FTE, Valeria Garbero (ARPAP) 0.15 FTE, Francesca Bassani (PoliTo) 0.2 FTE, Jan-Peter Schulz (DWD) 0.1 FTE, Jacopo Canton (C2SM) 0.15 FTE

FTEs: 1.3 FTE

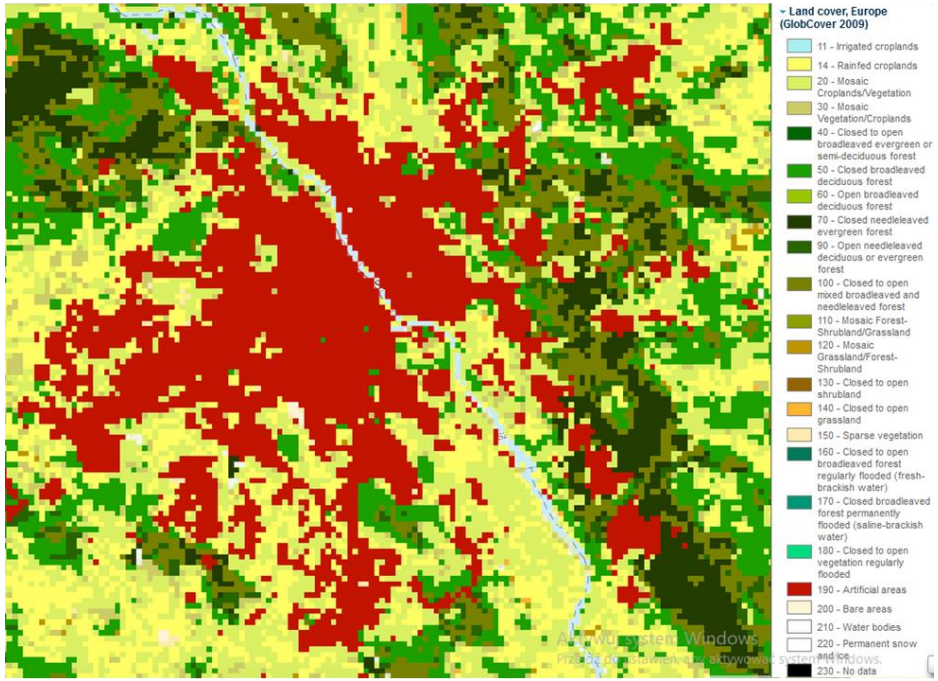
Description of LCZs classes – ECOCLIMAP-SG

Dataset/*Producer*	Classes*	Descriptions
ECOCLIMAP-SG/*CNRM*	 24. LCZ1: compact high-rise	• Strong built-up NDVI <= 0.2 and high rise buildings (3D roughness 50-100m) • Strong built-up NDVI <= 0.2 and very high rise buildings (3D roughness > 100m)
	 25. LCZ2: compact midrise	• Continuous urban fabric (from CLC) • Strong built-up NDVI <= 0.2 and medium rise buildings (3D roughness 25-50m)
	 26. LCZ3: compact low-rise	• Strong built-up NDVI <= 0.2 and low rise buildings (3D roughness <25m)
	 27. LCZ4: open high-rise	n.a. - Despite the class is included in the legend of ECOCLIMAP-SG, the data are not available in the European map. Technical documentation doesn't provide further details.
	 28. LCZ5: open midrise	• Medium built-up 0.2 < NDVI <= 0.3 (o 6)
	 29. LCZ6: open low-rise	• Light built-up 0.3 < NDVI <= 0.4
	 30. LCZ7: lightweight low-rise	n.a. - Despite the class is included in the legend of ECOCLIMAP-SG, the data are not available in the European map. Technical documentation doesn't provide further details.
	 31. LCZ8: large low-rise	• Industrial or commercial unit, Airports (from CLC) • Built-up with highly reflecting roof (associated to productive and commercial use) • Roads
	 32. LCZ9: sparsely built	• Road and rail networks and associated land, Mineral extraction sites, Dump sites, Construction sites, Green Urban Areas, Sport and leisure facilities (from CLC) • Very light built-up NDVI > 0.4
	 33. LCZ10: heavy industry	• Port areas (from CLC)

**Stewart I.D., Oke T.R., 2012. Local Climate Zones for Urban Temperature Studies. Bull Am Meteorol Soc., 93(12):1879-1900. doi:10.1175/BAMS-D-11-00019.1*

Operational land use dataset

GlobCover 2009, 23 classes
Class 19: Artificial surfaces

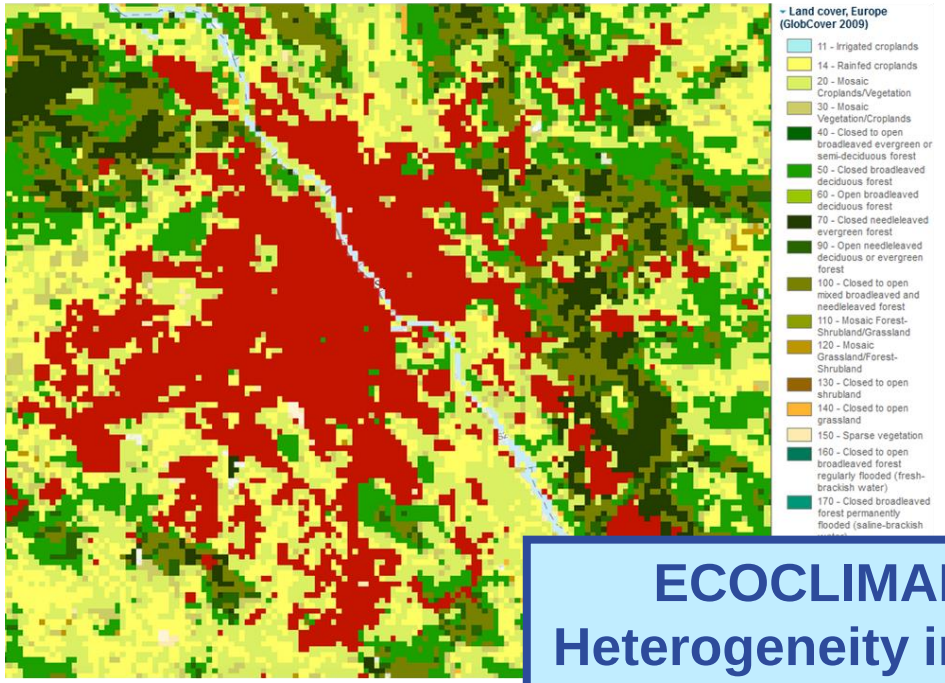


Warsaw

A. Wyszogrodzki (IMGW-PIB), A. Jaczewski (IMGW-PIB), C. Apreda (CMCC)

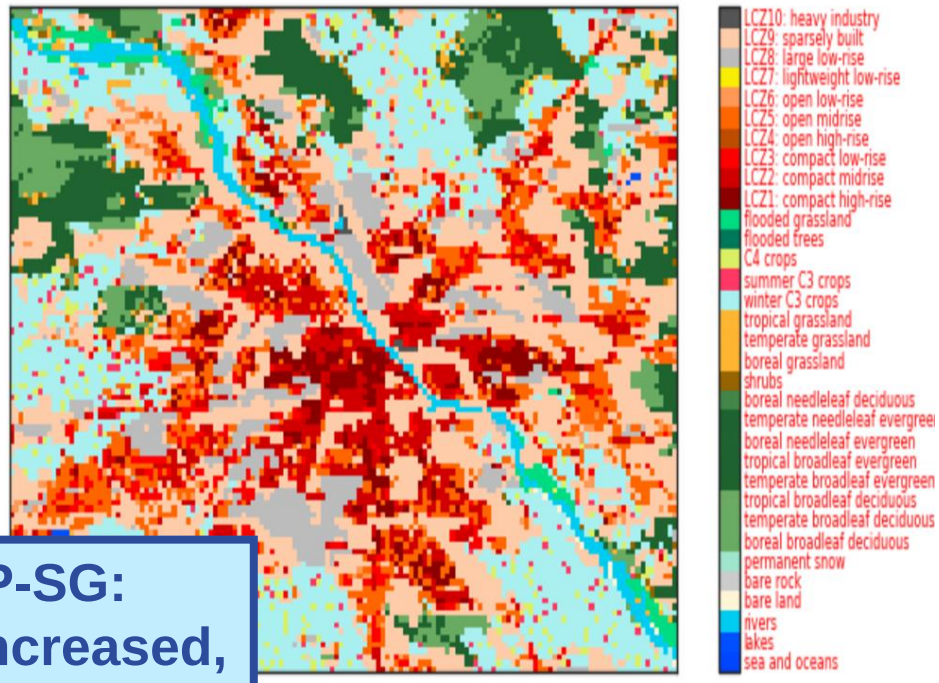
Operational land use dataset

GlobCover 2009, 23 classes
Class 19: Artificial surfaces



New land use dataset

ECOCLIMAP-SG, 33 classes
10 LCZ urban classes

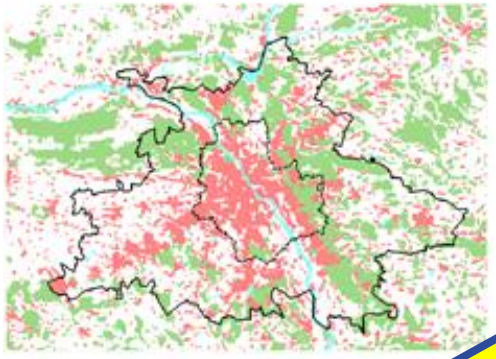


ECOCLIMAP-SG: Heterogeneity increased, appears more realistic!

Warsaw

A. Wyszogrodzki (IMGW-PIB), A. Jaczewski (IMGW-PIB), C. Apreda (CMCC)

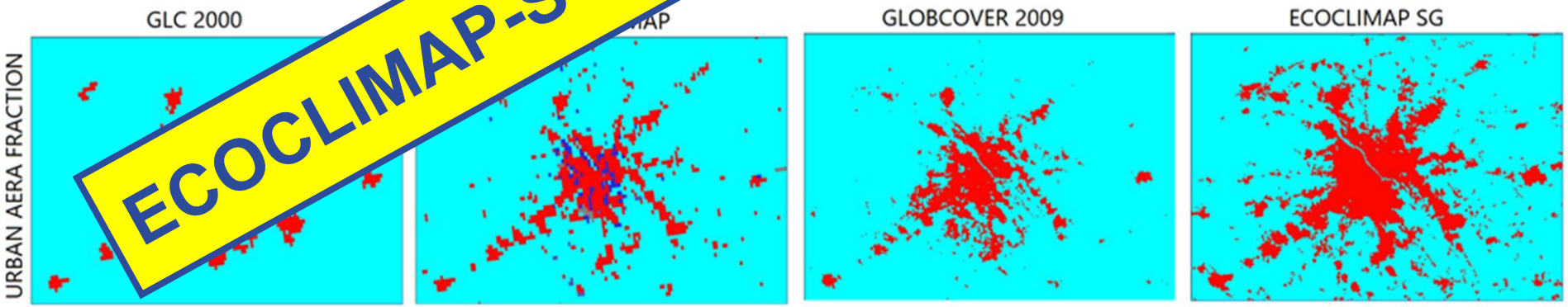
EXTPAR: Different datasets of urban fraction for W w



Main differences between dat
- area coverage / size
- accuracy
- granularity / ng

Key f ices:
- /changes of urban areas in time
- ge
- racy of measurements
- postprocessing methodology

ECOCLIMAP-SG is implemented in EXTPAR!



A. Wyszogrodzki (IMGW-PIB), A. Jaczewski (IMGW-PIB), C. Apreda (CMCC)

Conclusions

- The first aims of the COSMO Priority Project CITTA' are:
  1. Implement the urban canopy scheme TERRA_URB in ICON.
  2. Provide new urban canopy parameters for TERRA_URB in ICON.
- Status:
  1. TERRA_URB is now fully implemented and tested in ICON. It is available in the gitlab icon-nwp master. It is already operational at IMS since July 2023.
  2. The global land use dataset ECOCLIMAP-SG was made available in NetCDF. Preliminary look-up tables were developed. ECOCLIMAP-SG was implemented in the preprocessor EXTPAR, in github. A few adaptations for ICON will come soon.
- Experiments with TERRA_URB in ICON-LAM are on-going in several groups of the project. First results look very promising. Characteristic features of urban surfaces in atmospheric models, for instance the Urban Heat and Dry Island effects, are already represented.