Surface activities in the COSMO Consortium

Jan-Peter Schulz[1,2] and Jean-Marie Bettems[3]

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[2]Euro-Mediterranean Center on Climate Change, Caserta, Italy
[3]MeteoSwiss, Zurich, Switzerland

45st EWGLAM and 30th SRNWP Meeting, 25-28 Sep. 2023, Reykjavik, Iceland

Highlights of the year

- Multi-layer snow model
- Urban model
- Physiographic and urban canopy parameters

Multi-layer snow model

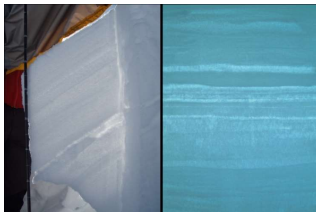
- **Goal: Develop a new efficient and high quality snow model for ICON → SNOWPOLINO**
  - *First target is **NWP in Central Europe***
  - *But large potential in **data poor regions** (e.g. high mountains regions in Asia)*
  - *And even larger potential for **climate applications** (no possibility to correct poor parameterization with DA)*

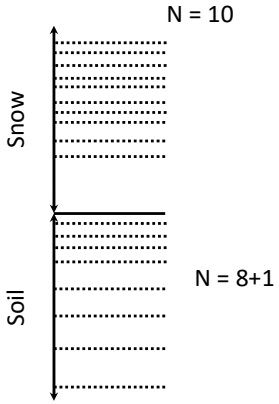
- **SNOWPOLINO is implemented in COSMO 6.0**
  - *Validation shows **very good quality** of snow pack simulation*
  - *Used for **snow mask production** at MeteoSwiss*

S. Bellaire (MeteoSwiss)

SNOWPOLINO: A limited ‚small' version of SNOWPACK

Layering ($n_{def.}$= 10)

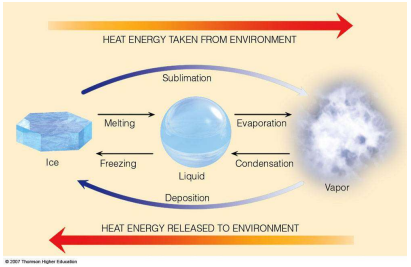




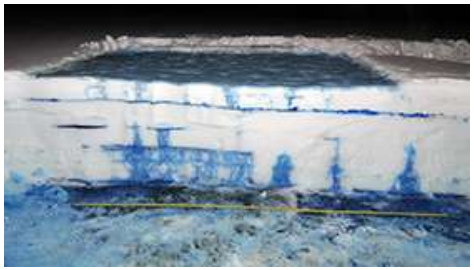
1D heat equation

$$\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2}; \quad 0 \le x \le L; \quad t \ge 0$$

Phase Changes

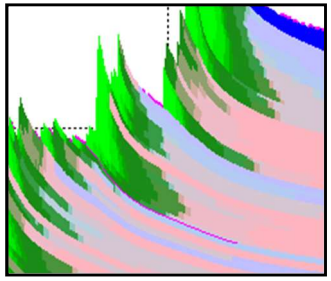


Water transport

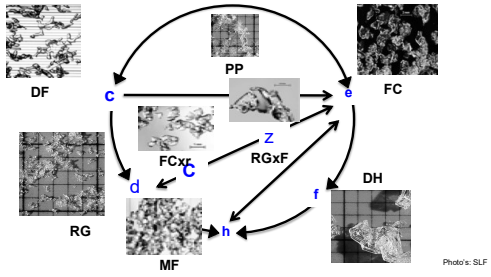


Photos: SLF

Settling / Densification

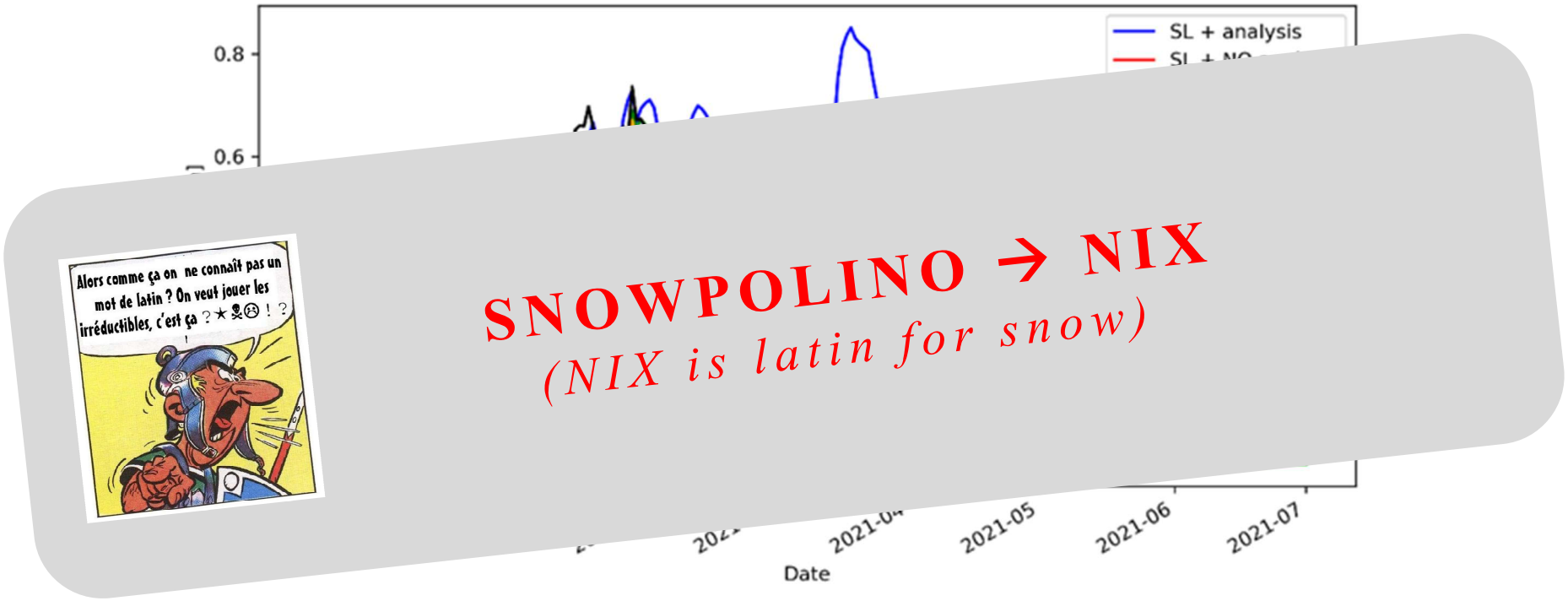


No Metamorphism!



S. Bellaire (MeteoSwiss)

SNOWPOLINO: A limited ‚small' version of SNOWPACK



*Comparison of **snow height for 300 stations across the Alps** using*
a) observations,
b) Hindcast with the current snow scheme, as potentially used by climate runs,
c) the MCH operational snow analysis,
*d) **Hindcast with the new snow scheme in COSMO 6.0 (no assimilation of snow).***

S. Bellaire (MeteoSwiss)

NIX: Status

- Code **implemented in ICON in a modular way**, i.e. full flexibility for future developments
- A 9-months **high resolution test** over Switzerland shows
  - *tuning of density parameterization and settling needed*
  - *neutral surface verification scores where snow height is correctly represented*
- Preliminary **global test** shows *stable* algorithm and correct results in snow free regions
- **Merge request** opened and on-going

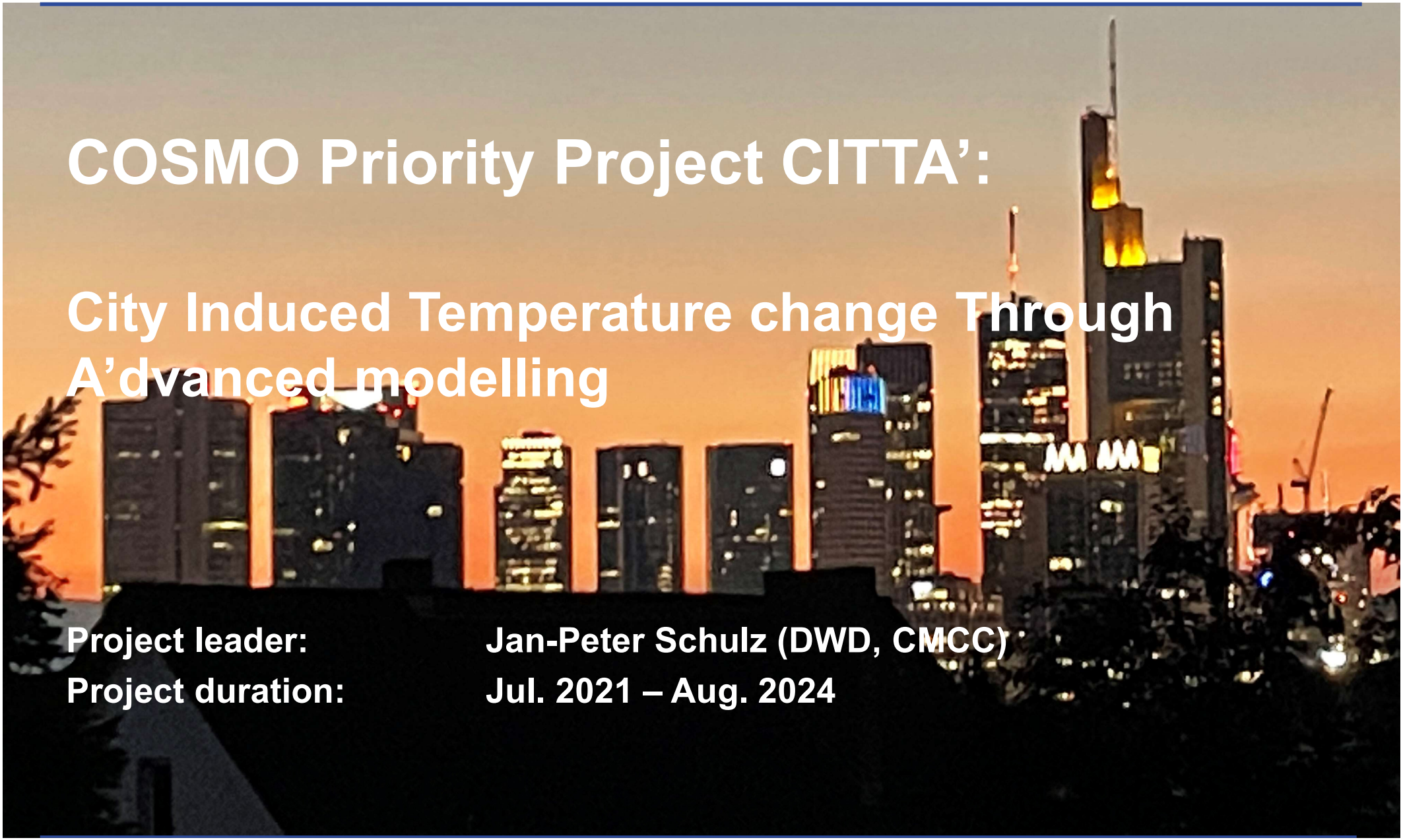
  (agreement about code in Aug. 2023 session with ICON gatekeepers, only minor issues remaining)

S. Bellaire (MeteoSwiss)

A new urban parameterisation for the ICON atmospheric model

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

and the COSMO PP CITTA' team



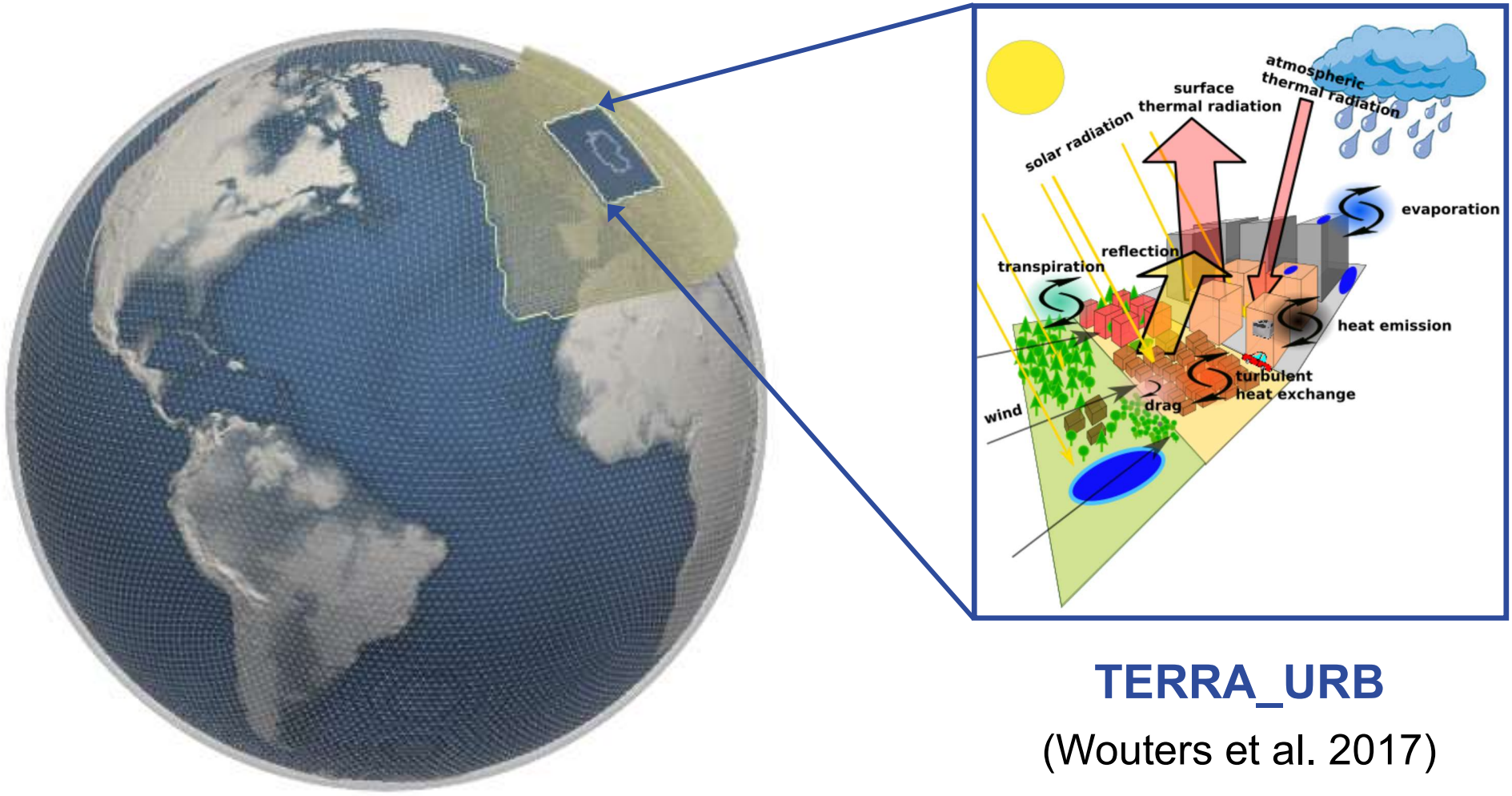
COSMO Priority Project CITTA':

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



TERRA_URB

(Wouters et al. 2017)

Task 1: Implementation of TERRA_URB in ICON

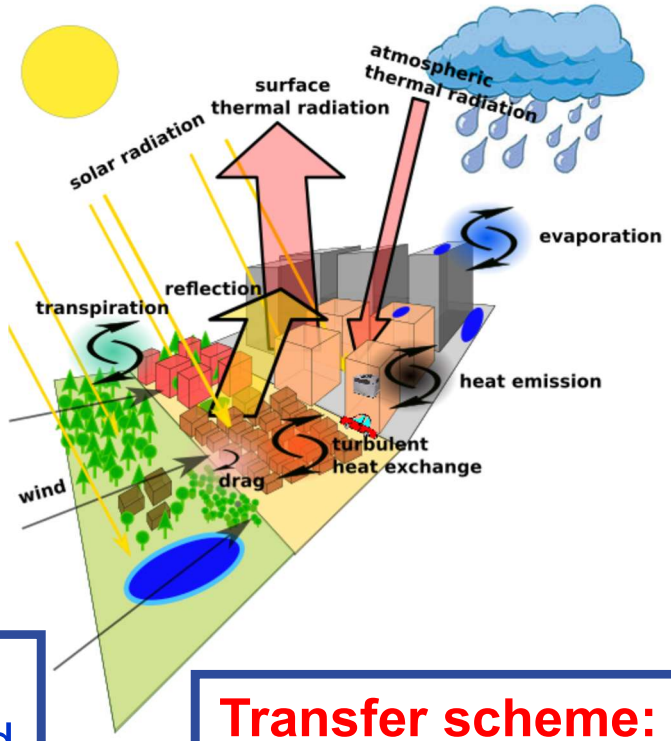
Modifications in ICON:

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

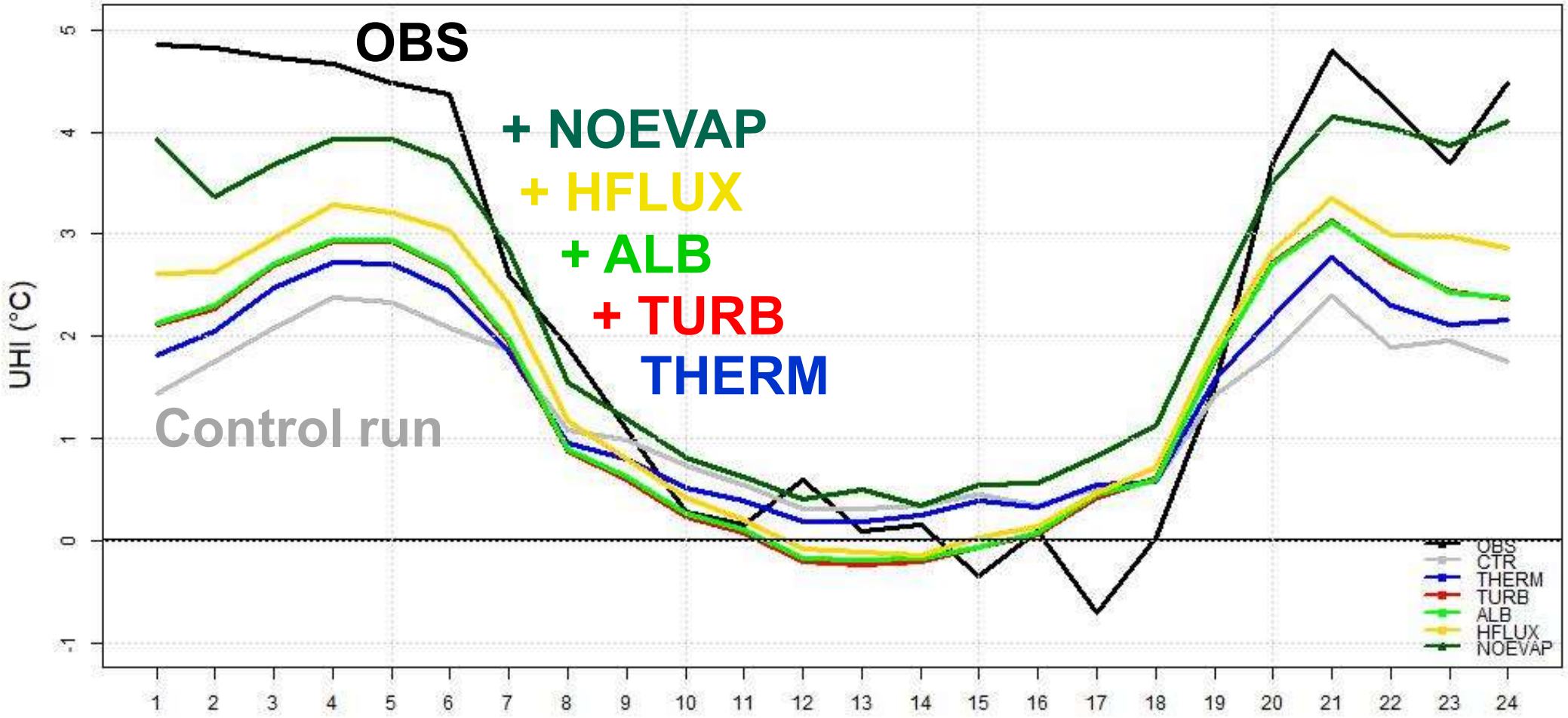
TURB

Land surface scheme:
Introduce anthropogenic heat flux

HFLUX

2-m temperature difference: urban – rural

Urban Heat Island (UHI) effect in Turin



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

- 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

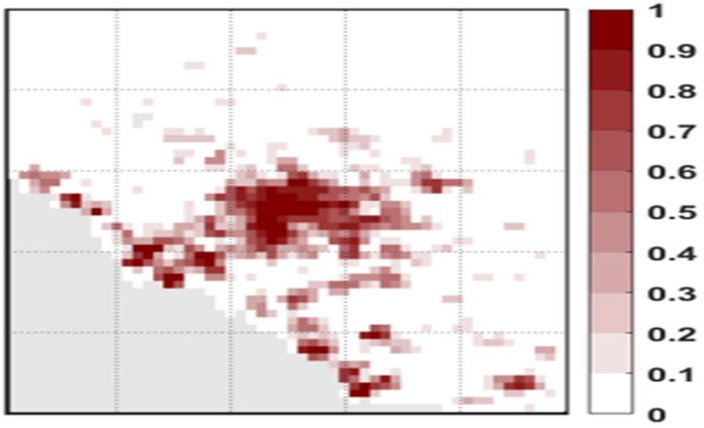
2-m temperature difference: TU on – TU off

Fr_paved = Impervious Surface Area (ISA)

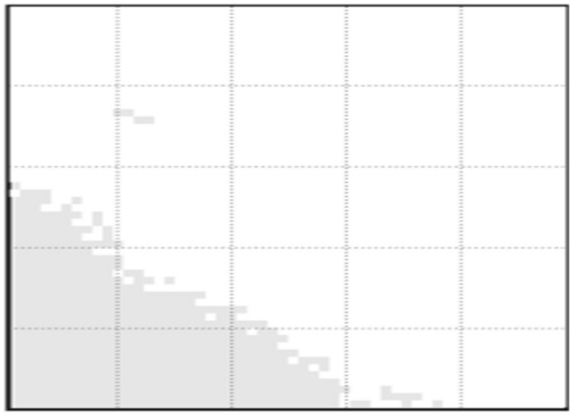
Day

Night

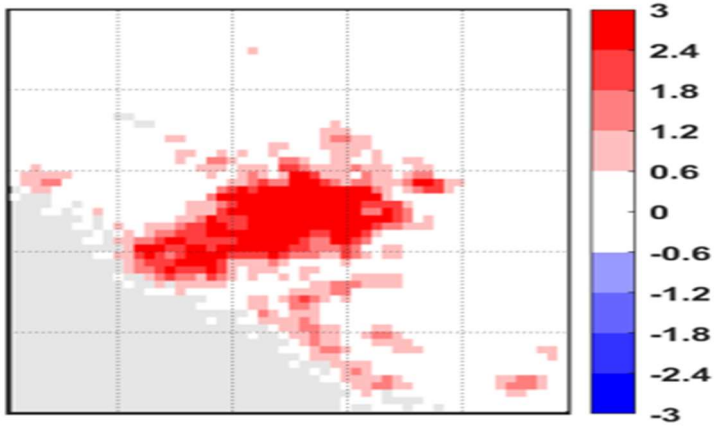
Rome fr_paved



Rome day



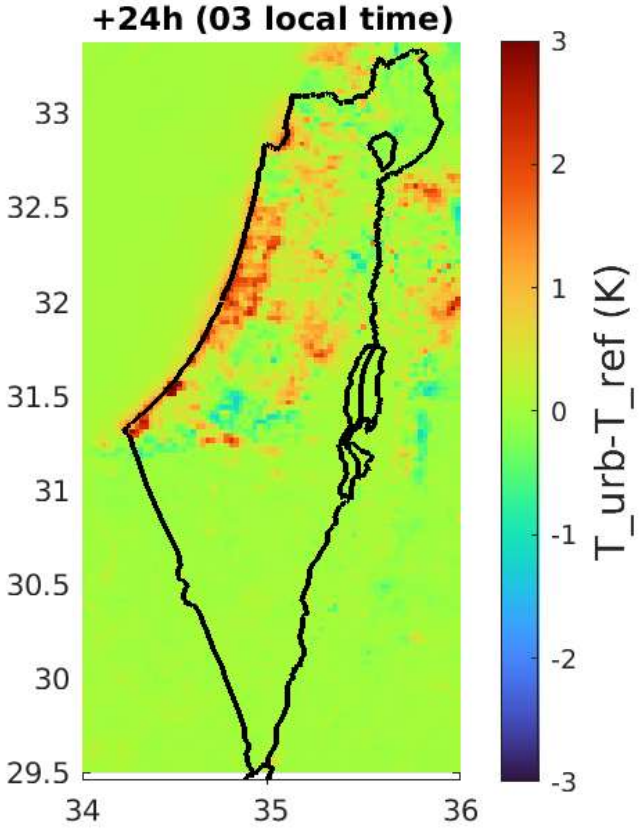
Rome night



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

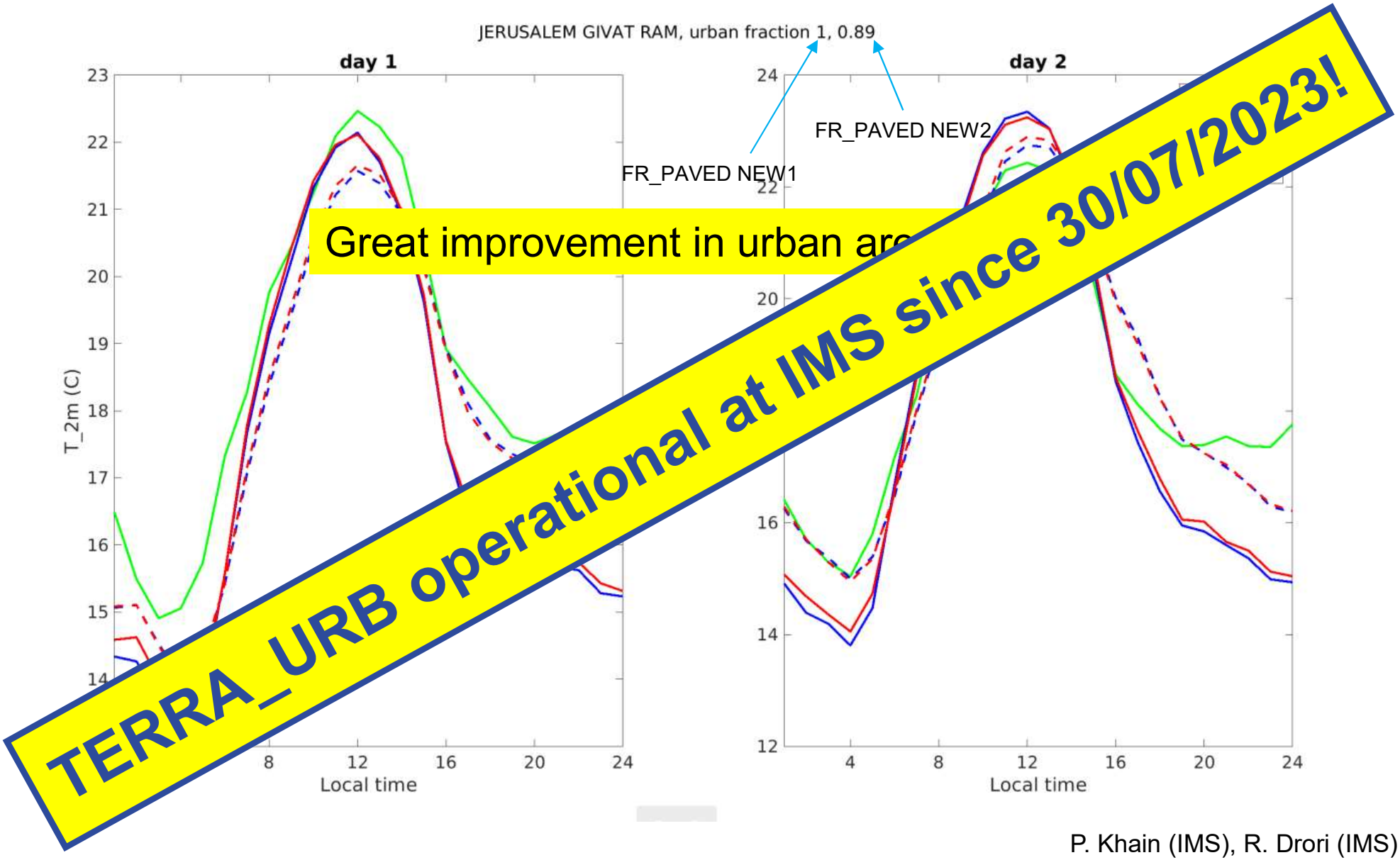
ICON-IL domain (2.5km) driven by IFS

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)

Physiographic and urban canopy parameters

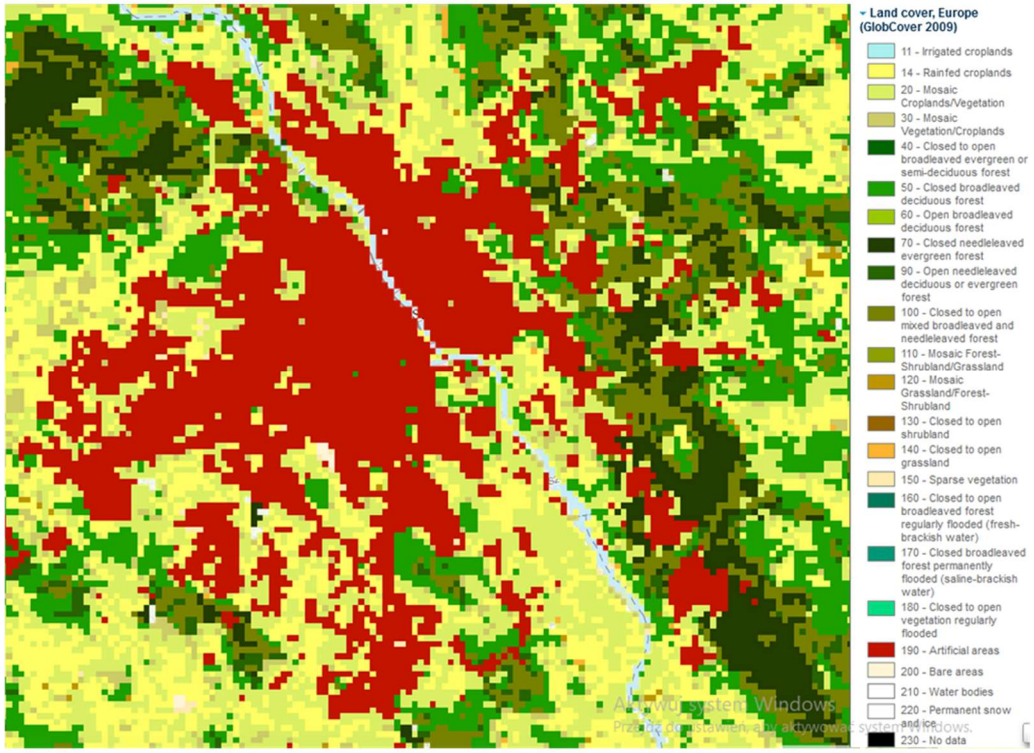
EXTPAR: Pre-processor software for computing several external parameters for ICON(-LAM), i.e.

- Orography, SSO parameters
- Albedo, emissivity, aerosols
- Soil texture
- Land use class fractions
- etc.

J. Jucker (C2SM)

Operational land use dataset

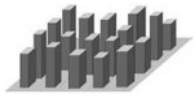
GlobCover 2009, 23 classes
Class 19: Artificial surfaces



Warsaw

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

Description of LCZs classes – ECOCLIMAP-SG

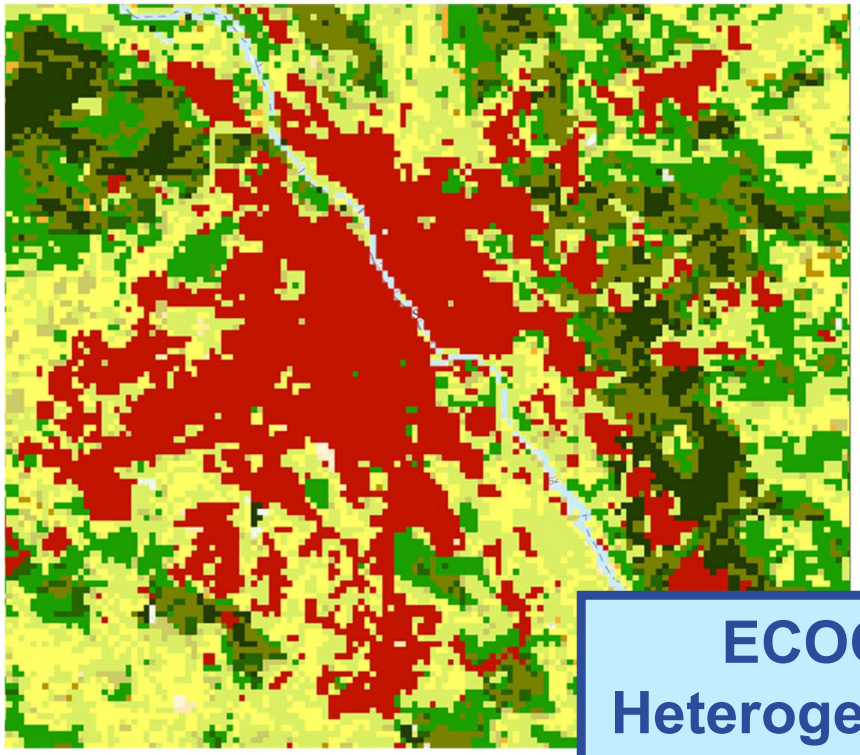
Dataset/*Producer*	Classes*	Descriptions
ECOCLIMAP-SG/*CNRM*	 24. LCZ1: compact high-rise	• Strong built-up NDVI <= 0.2 and high rise buildings (3D roughness 50-100m) • Strong built-up NDVI <= 0.2 and very high rise buildings (3D roughness > 100m)
	 25. LCZ2: compact midrise	• Continuous urban fabric (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)

Apreda, C., J.-P. Schulz, A. Reder, P. Mercogliano, 2023: Survey of land cover datasets for updating the imperviousness field in urban parameterisation scheme TERRA_URB for climate and weather applications. *Urban Climate*, 49, 101535

**Stewart I.D., T.R. Oke, 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

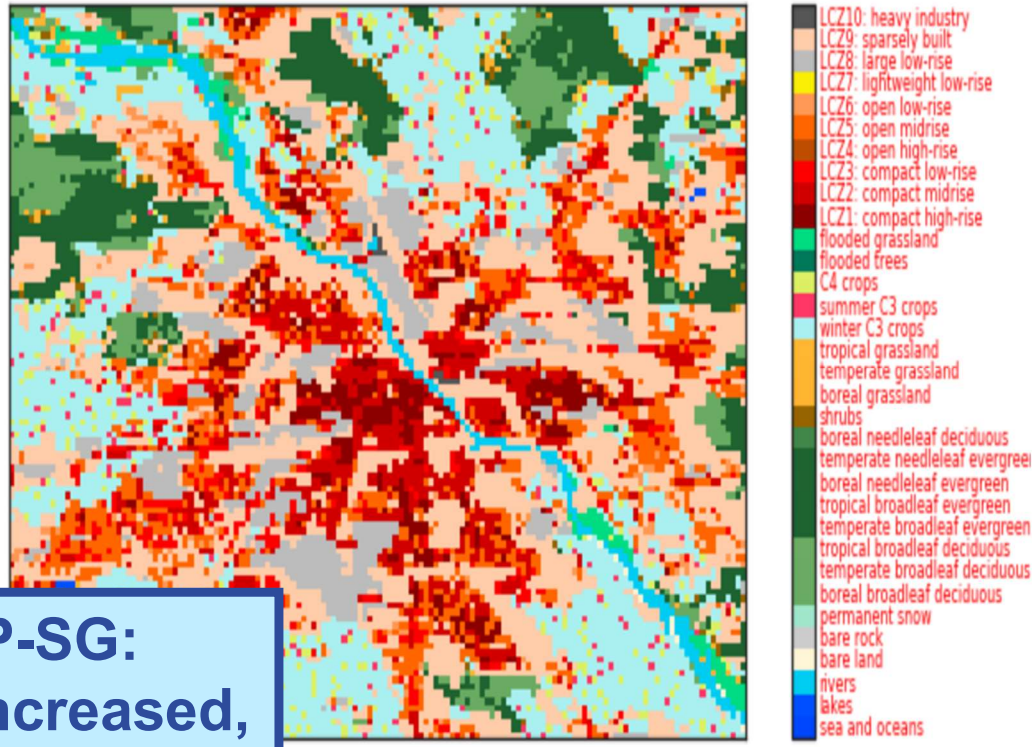
GlobCover 2009, 23 classes
Class 19: Artificial surfaces



Warsaw

New land use dataset

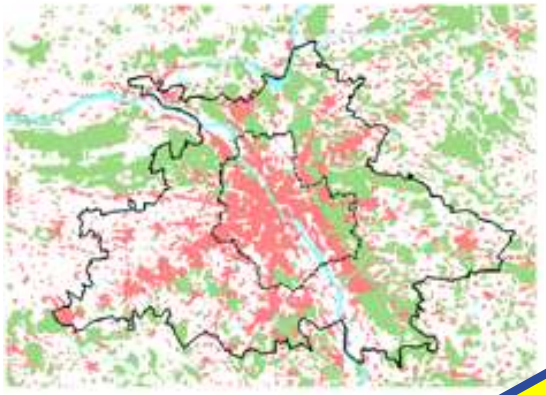
ECOCLIMAP-SG, 33 classes
10 LCZ urban classes



ECOCLIMAP-SG: Heterogeneity increased, appears more realistic!

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

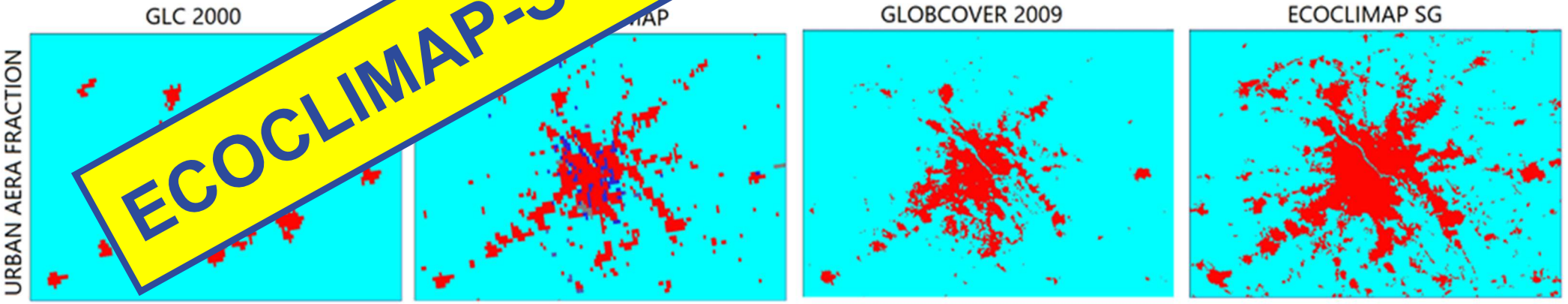
EXTPAR: Different datasets of urban fraction for W… w



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 operationalization of the new multi-layer snow model NIX in ICON is on-going.
- 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.
- The global land use dataset ECOCLIMAP-SG was made available in NetCDF. Preliminary look-up tables were developed. ECOCLIMAP-SG was implemented in the pre-processor 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.