“Treatment of new external parameters in COSMO urban modelling”

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EWGLAM 2020

Motivations

- Bulk representation of the urban canopy
- Use of Anthropogenic heat emission (Flanner, 2009)
- Poor men's tile approach
- Application of the Semi-empirical Urban canopy parameterisation (SURY). It translates urban-canopy parameters (with 3D information) into bulk parameters
- Inclusion of the new bare-soil evaporation resistance formulation (Schulz and Vogel 2016) and the vegetation skin-temperature parameterisation (Schulz and Vogel 2017, Viterbo and Beljaars, 1995).

The simple bulk-model TERRA-URB parameterises the effects of buildings on the air flow without resolving the energy budgets of the buildings themselves, but using the externally calculated anthropogenic heat flux ($\boldsymbol{Q_F}$). It accounts for country-specific data of energy consumption, based on the population density and the latitude dependent diurnal and seasonal distribution.

Wouters et al., Geosci. Model Dev., 9, 3027-3054, 2016

Add and investigate the use of hard-coded values for the urban canopy parameters

Motivation for the recent code developments

Urban canopy parameters used by SURY (Semi-empirical URban canopY dependency) in TERRA_URB (Wouters et al., 2016)

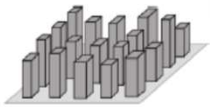
Urban canopy parameters (input of SURY)		
Parameter name	Symbol	Default values
Surface albedo	α	0.101
Surface emissivity	ϵ	0.86
Surface heat conductivity	λ_s	$0.767\ \mathrm{W\,m^{-1}\,K^{-1}}$
Surface heat capacity	$C_{v,s}$	$1.25 \times 10^6\ \mathrm{J\,m^{-3}\,K^{-1}}$
Building height	H	15 m
Canyon height-to-width ratio	$\frac{h}{w_c}$	1.5
Roof fraction	R	0.667
Bulk parameters (output of SURY)		
Parameter name	Symbol	Surface values corresponding to the defaults
Albedo	α_{bulk}	0.081 (snow-free)
Emissivity	ϵ_{bulk}	0.89 (snow-free)
Heat conductivity	λ_{bulk}	$1.55\ \mathrm{W\,m^{-1}\,K^{-1}}$
Heat capacity	$C_{v,bulk}$	$2.50 \times 10^6\ \mathrm{J\,m^{-3}\,K^{-1}}$
Thermal admittance	$\mu_{bulk}\ (= \sqrt{C_{v,bulk}\lambda_{bulk}})$	$1.97 \times 10^3\ \mathrm{J\,m^{-2}\,K^{-1}\,s^{-1/2}}$
Aerodynamic roughness length	z_0	1.125 m
Inverse Stanton number	kB^{-1}	13.2 (in case that $u_* = 0.25\ \mathrm{m\,s^{-1}}$)

Tthermal and radiative parameters of urban materials (surface albedo, emissivity, heat conductivity, heat capacity)

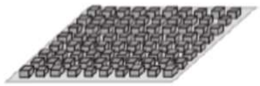
Building morphology parameters (building height, canyon height-to-width ratio, roof fraction)

Cities and their parts are very different!

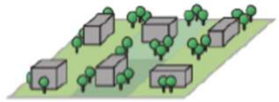
LCZ 1
Compact
highrise

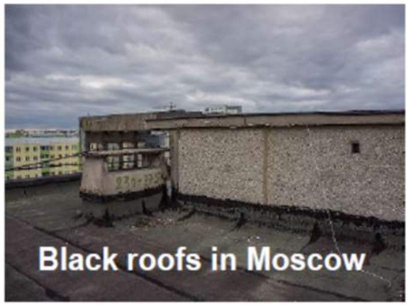


LCZ 3
Compact
lowrise



LCZ 5
Open
midrise





Main idea was to replace hard-coded constants to 2D external fields with a useful namelist controls

Add and investigate the use of hard-coded values for the urban canopy parameters

Implementation of new parameters

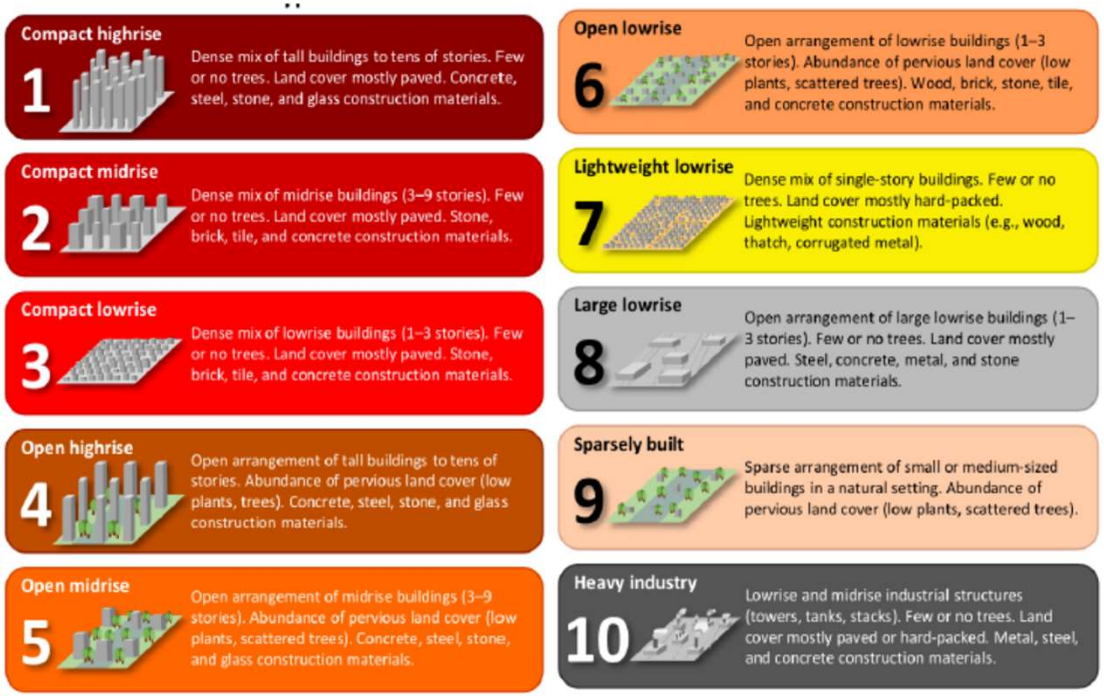
Description and units	Default value	Old variable in COSMO code	New variables in COSMO code	COSMO namelist parameters	INT2LM namelist parameters	External parameter name
Building area fraction with respect to an urban tile [1]	0.67	c_roof	curb_bldfr, curb_bldfr_d, curb_bldfr(:,:)	curb_bldfr	lurb_bldfr	URB_BLDFR
Building height [m]	15	c_uf_h	curb_bldh, curb_bldh_d, urb_bldh (:,:)	curb_bldh	lurb_bldh	URB_BLDH
Street canyon aspect ration (H/W) [unitless]	1.5	c_htw	curb_h2w, curb_h2w_d, urb_h2w(:,:)	curb_h2w	lurb_h2w	URB_H2W
Anthropogenic heat flux [W/m2]	-1 (to use external parameter)	ahf_an	curb_ahf, curb_ahf_d, ahf_an (:,:)	curb_ahf		AHF
Urban material thermal albedo [1]	0.14	ctalb_bm	curb_talb, urb_talb_d, urb_talb (:, :)	curb_talb		URB_TALB
Urban material shortwave albedo [1]	0.1	csalb_bm	curb_salb,curb_salb_d, urb_salb (:, :)	curb_salb		URB_SALB
Volumetric heat capacity of urban material (capacity * density) [$J \cdot m^{-3} \cdot K^{-1}$]	1.25E6	c_rhoc_bm	curb_hcap, curb_hcap _d, urb_hcap (:, :)	curb_hcap		URB_HCAP
Heat conductivity of urban material [$W \cdot m^{-1} \cdot K^{-1}$]	0.777	c_ala_bm	curb_hcon, curb_hcon_d, urb_hcon (:, :)	curb_hcon		URB_HCON
Skin-layer conductivity for rural areas [???]	10 or 30 (now 30)	calamrur	cskinc, cskinc_d, skinc (:,:)	cskinc	lskinc	SKC
Skin-layer conductivity for urban areas [???]	1000	calamurb	cskinc_urb	cskinc_urb		

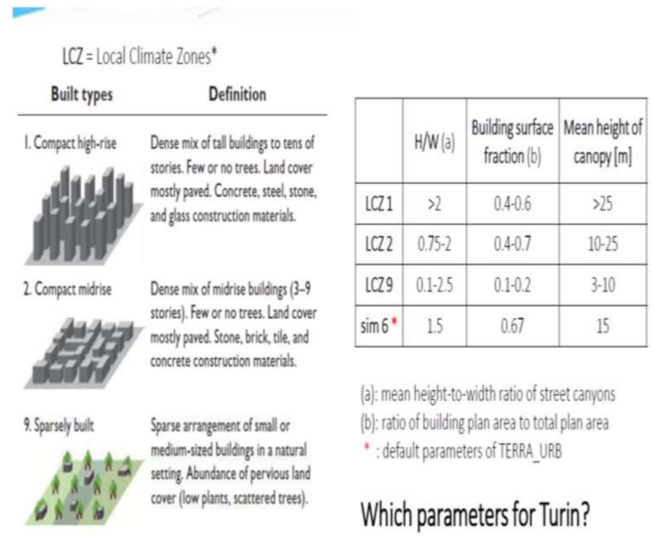
New parameters able to take into account different urban morphology will be tested over 3 test cases of the project (Moscow, Turin and Naples)

Test the use of the LCZ concept as a possible input for urban climate modelling.

Different simulations were implemented using Local Climate Zone (LCZ). *LCZ are "regions of uniform surface cover, structure, material, and human activity that span hundreds of meters to several kilometres in horizontal scale" (Oke, 2012); each LCZ has a characteristic screen-height temperature regime that is most apparent over dry surfaces, on calm, clear nights*.

10 Urban LCZ classes





	H/W (a)	Building surface fraction (b)	Mean height of canopy [m]
LCZ 1	>2	0.4-0.6	>25
LCZ 2	0.75-2	0.4-0.7	10-25
LCZ 9	0.1-2.5	0.1-0.2	3-10
sim 6 *	1.5	0.67	15

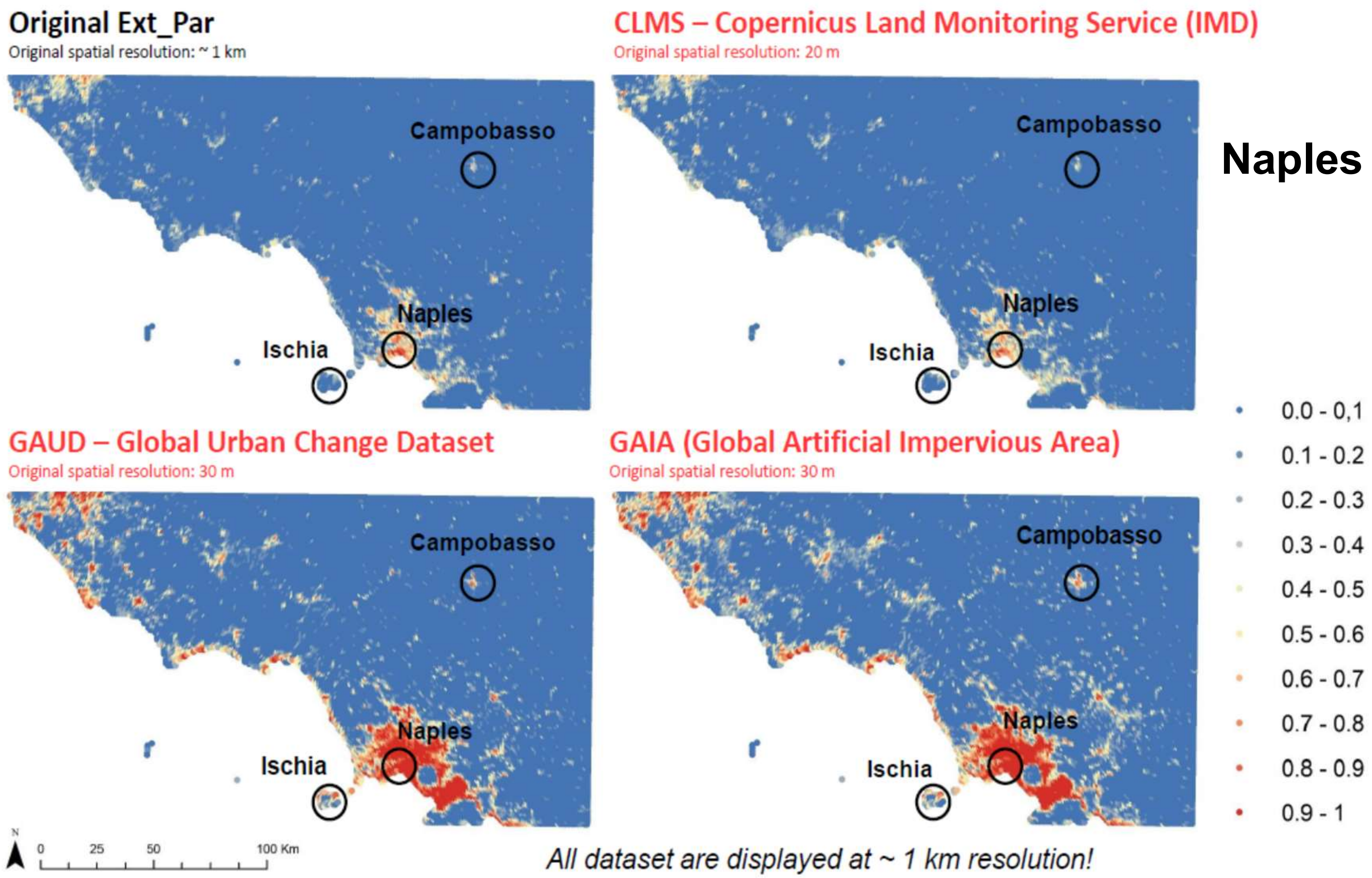
(a): mean height-to-width ratio of street canyons
(b): ratio of building plan area to total plan area
* : default parameters of TERRA_URB

Which parameters for Turin?

For Each LCA is defined a specific set of urban parameters. A new European-wide dataset for LCZ has been released (Demuzere et al., 2019).

Improve the basic urban canopy parameters, the ISA fraction and AHF, also investigating additional urban dataset

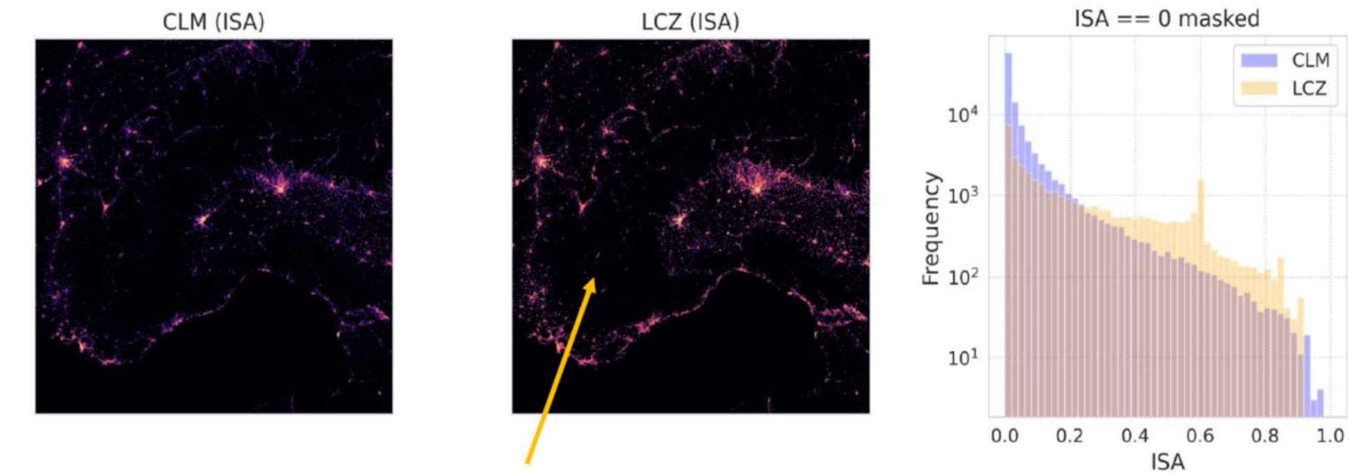
Naples area



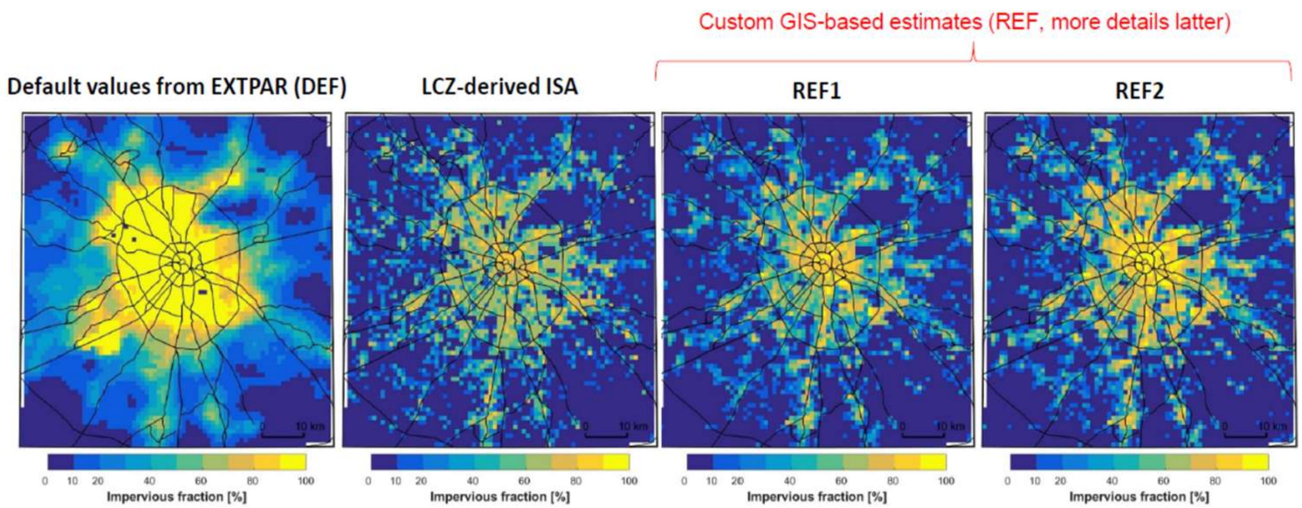
All dataset are displayed at ~ 1 km resolution!

Updating the current EXTPAR field of ISA with new products

Improve the basic urban canopy parameters, the ISA fraction and AHF, also investigating additional urban dataset



Turin area



Moscow area

Data set/simulation name	Paved fraction	
DEF	Extpar defaults (Elvidge et al., 2007)	
LCZa	LCZ-derived	
LCZb		
REF1a	Expert estimate based on CGLC, Sentinel images and OSM (Samsonov, Varentsov, 2020)	less paved fraction (vegetation that overlaps with buildings and roads moves to vegetated tile)
REF1b		
REF2a		more paved fraction (vegetation that overlaps with with buildings and roads moves to paved tile)
REF2b		

A better calibration of parameters is needed when TERRA_URB is switched on

The verification is an important aspect of the project to evaluate the performance of the model.

The experiments will be performed over the test cases already defined:

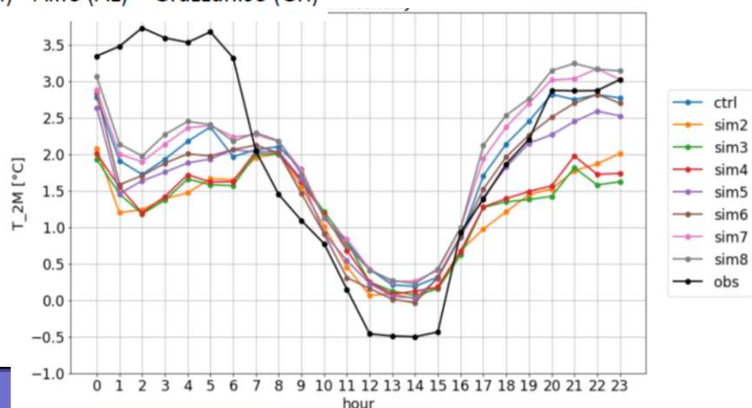
- urban areas of Turin (Italy) and Naples (Italy)
- the Moscow megacity (Russia).

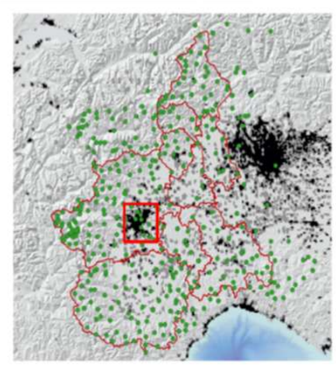
For the validation have been uses the dense surface-layer observations available in the considered cities.

A large set of common simulations have been tested and are currently under evaluation

Selecting 5 stations:

- URBAN: Pompei (PO) – Napoli (NA)
- RURAL: Ariano Irpino (AI) - Alife (AL) – Grazzanise (GR)





The different model configurations have been evaluated by comparing the results with observations provided by the Arpa Piemonte network (few urban stations, many non-urban stations)

Next activities

COSMO Priority Project CITTA':

City Induced Temperature change Through A'dvanced modelling

Project leader: Jan-Peter Schulz (DWD)
Project duration: Jan. 2021 – Dec. 2023 (3 years)

Next activities

- Implementation of TERRA_URB in ICON Model
- Treatment of existing and new external parameters (updated datasets, global coverage if possible...)
- Numerical experiments (new tests on Bucharest and possibly one German city)
- Further developments of the TERRA_URB scheme
- AoB...

Thanks for your attention

For additional information please contact

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