„Implementation of ECOCLIMAP-SG land cover map as input for the COSMO and the ICON models"

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Existing approach to landcover data in EXTPAR module

extpar_landuse_to_buffer.f90 is responsible for the aggregation of the landuse data to the targer grid

Raw data	No. of classes	Integer	Setting	module calling
GLOBCOVER 2009	23	1	operational settings	mo_ecci_lookup.f90
		2	experimental settings	
GLC2000	23	1	operational settings of GME	mo_glc2000_lookup.f90
		2	operational settings of COSMO	
		3	experimental settings	
GLCC	24	1	operational settings of GME	mo_glcc_lookup.f90
		2	operational settings of COSMO	
		3	experimental settings	
Ecoclimap 2	218	n.a.	ecoclimap lookup.TAB	mo_ecoclimap_lookup.f90
ESA CCI-LC	23	1	experimental settings	mo_ecci_lookup_tables.f90

Output variables from EXTPAR's landuse module

The lookup table is fed with the land use class, which gives a value for all the target fields listed in table 6.

Variable long name	Variable short name	Remark
Fraction Land	FR_LAND	
Ice fraction	FR_ICE	
Plant cover maximum	PLCOV_MX	
Plant cover minimum	PLCOV_MN	
Leaf area index maximum	LAI_MX	
Leaf area index minimum	LAI_MN	
Minimal stomata resistance	RS_MIN	
Urban area fraction	URBAN	
Fraction of deciduous forest	FOR_D	
Fraction of evergreen forest	FOR_E	
Longwave surface emissivity	EMISS_RAD	
Root depth	ROOTDP	
Roughness length	Z0	
Monthly leaf area index	LAI12	only Ecoclimap
Monthly plant cover	PLCOV12	only Ecoclimap
Monthly roughness length	Z012	only Ecoclimap

Table 6: The variables that are computed using the raw land-use data.

ECOCLIMAP-SG philosphy

„First, the land cover map is directly composed of the vegetation and urban types used in **ISBA** and **TEB**: **each grid point of the map represents a pure type, either inland water bodies, or sea and ocean, or one vegetation type or one urban type**. In other words, the notion of "cover" or ecosystem of homogeneous **land cover type containing several fractions of vegetation types is abandoned**”

Land cover classes in ECOCLIMAP-SG and GLOBCOVER 2009

1. sea and oceans
2. lakes
3. rivers

(existing covers 1, 2, 3 in ECOCLIMAP)

4. bare land
5. bare rock
6. permanent snow
7. boreal broadleaf deciduous
8. temperate broadleaf deciduous
9. tropical broadleaf deciduous
10. temperate broadleaf evergreen
11. tropical broadleaf evergreen
12. boreal needleleaf evergreen
13. temperate needleleaf evergreer
14. boreal needleleaf deciduous
15. shrubs
16. boreal grassland
17. temperate grassland
18. tropical grassland
19. winter C3 crops
20. summer C3 crops
21. C4 crops
22. flooded trees
23. flooded grassland

vegetation types

24. LCZ1: compact high-rise
25. LCZ2: compact midrise
26. LCZ3: compact low-rise
27. LCZ4: open high-rise
28. LCZ5: open midrise
29: LCZ6: open low-rise
30: LCZ7: lightweight low-rise
31: LCZ8: large low-rise
32: LCZ9: sparsely built
33: LCZ10: heavy industry

urban types

(international standard classes for urban areas, Stewart & Oke, 2012).

01	irrigated croplands
02	rainfed croplands
03	mosaic cropland (50-70%) - vegetation (20-50%)
04	mosaic vegetation (50-70%) - cropland (20-50%)
05	closed broadleaved evergreen forest
06	closed broadleaved deciduous forest
07	open broadleaved deciduous forest
08	closed needleleaved evergreen forest
09	open needleleaved decid. or evergr. forest
10	mixed broadleaved and needleleaved forest
11	mosaic shrubland (50-70%) - grassland (20-50%)
12	mosaic grassland (50-70%) - shrubland (20-50%)
13	closed to open shrubland
14	closed to open herbaceous vegetation
15	sparse vegetation
16	closed to open forest regulary flooded
17	closed forest or shrubland permanently flooded
18	closed to open grassland regularly flooded
19	artificial surfaces
20	bare areas
21	water bodies
22	permanent snow and ice
23	undefined

Implementation of the ECOCLIMAP-SG

Fraction Land
Ice fraction
Plant cover maximum
Plant cover minimum
Leaf area index maximum
Leaf area index minimum
Minimal stomata resistance
Urban area fraction
Fraction of deciduous forest
Fraction of evergreen forest
Longwave surface emissivity
Root depth
Roughness length
Monthly leaf area index
Monthly plant cover
Monthly roughness length

To implement the ECOCLIMAP-SG new lookup tables should be elaborated

01	irrigated croplands
02	rainfed croplands
03	mosaic cropland (50-70%) - vegetation (20-50%)
04	mosaic vegetation (50-70%) - cropland (20-50%)
05	closed broadleaved evergreen forest
06	closed broadleaved deciduous forest
07	open broadleaved deciduous forest
08	closed needleleaved evergreen forest
09	open needleleaved decid. or evergr. forest
10	mixed broadleaved and needleleaved forest
11	mosaic shrubland (50-70%) - grassland (20-50%)
12	mosaic grassland (50-70%) - shrubland (20-50%)
13	closed to open shrubland
14	closed to open herbaceous vegetation
15	sparse vegetation
16	closed to open forest regulary flooded
17	closed forest or shrubland permanently flooded
18	closed to open grassland regularly flooded
19	artificial surfaces
20	bare areas
21	water bodies
22	permanent snow and ice
23	undefined

not mandatory but could be taken into account

Output parameteres from EXTPAR's landuse module for natural classes

Fraction Land
Ice fraction
Plant cover maximum
Plant cover minimum
Leaf area index maximum
Leaf area index minimum
Minimal stomata resistance
Urban area fraction
Fraction of deciduous forest
Fraction of evergreen forest
Longwave surface emissivity
Root depth
Roughness length
Monthly leaf area index
Monthly plant cover
Monthly roughness length

According to landcover class

Output parameters from EXTPAR's landuse module for natural classes

- ✓ Fraction Land
- ✓ Ice fraction

Plant cover maximum
Plant cover minimum
Leaf area index maximum
Leaf area index minimum
Minimal stomata resistance
Urban area fraction

- ✓ Fraction of deciduous forest
- ✓ Fraction of evergreen forest

Longwave surface emissivity
Root depth
Roughness length
10-day period LAI
Monthly plant cover
Monthly roughness length

Values of remaining parameters can be assumed to be constant by vegtype and have to be based on lookup tables but …

Can we feed ECOCLIMAP-SG classes from existing lookup tables?

GLOBCOVER 2009

01	irrigated croplands
02	rainfed croplands
03	mosaic cropland (50-70%) - vegetation (20-50%)
04	mosaic vegetation (50-70%) - cropland (20-50%)
05	closed broadleaved evergreen forest
06	closed broadleaved deciduous forest
07	open broadleaved deciduous forest
08	closed needleleaved evergreen forest
09	open needleleaved decid. or evergr. forest
10	mixed broadleaved and needleleaved forest
11	mosaic shrubland (50-70%) - grassland (20-50%)
12	mosaic grassland (50-70%) - shrubland (20-50%)
13	closed to open shrubland
14	closed to open herbaceous vegetation
15	sparse vegetation
16	closed to open forest regulary flooded
17	closed forest or shrubland permanently flooded
18	closed to open grassland regularly flooded
19	artificial surfaces
20	bare areas
21	water bodies
22	permanent snow and ice
23	undefined

VS

ECOCLIMAP-SG

1. sea and oceans
2. lakes
3. rivers

(existing covers 1, 2, 3 in ECOCLIMAP)

4. bare land
5. bare rock
6. permanent snow
7. boreal broadleaf deciduous
8. temperate broadleaf deciduous
9. tropical broadleaf deciduous
10. temperate broadleaf evergreen
11. tropical broadleaf evergreen
12. boreal needleleaf evergreen
13. temperate needleleaf evergreen
14. boreal needleleaf deciduous
15. shrubs
16. boreal grassland
17. temperate grassland
18. tropical grassland
19. winter C3 crops
20. summer C3 crops
21. C4 crops
22. flooded trees
23. flooded grassland
24. LCZ1: compact high-rise
25. LCZ2: compact midrise
26. LCZ3: compact low-rise
27. LCZ4: open high-rise
28. LCZ5: open midrise
29. LCZ6: open low-rise
30. LCZ7: lightweight low-rise
31. LCZ8: large low-rise
32. LCZ9: sparsely built
33. LCZ10: heavy industry

(international standard classes for urban areas, Stewart & Oke, 2012).

ECOCLIMAP-SG vs Globcover 2009

ECOCLIMAP-SG		GLOBCOVER
1. sea and oceans	water	21 'water bodies
2. lakes	water	21 'water bodies
3. rivers	water	21 'water bodies
4. bare land	nature	20 bare areas
5. bare rock	nature	20 bare areas
6. permanent snow	nature	22. pernament snow & ice
7. boreal broadleaf deciduous	nature	07 closed broadleaved deciduous forest
8. temperate broadleaf deciduous	nature	06 open/closed broadleaved deciduous forest
9. tropical broadleaf deciduous	nature	06 open broadleaved deciduous forest
10. temperate broadleaf evergreen	nature	05 closed broadleaved evergreen forest
11. tropical broadleaf evergreen	nature	05 closed broadleaved evergreen forest
12. boreal needleleaf evergreen	nature	08 closed needleleaved evergreen forest
13. temperate needleleaf evergreen	nature	08 closed needleleaved evergreen forest
14. boreal needleleaf deciduous	nature	09 open needleleaved decid. or evergr. forest
15. shrubs	nature	13 closed to open shrubland
16. boreal grassland	nature	14 closed to open herbaceous vegetation
17. temperate grassland	nature	14 closed to open herbaceous vegetation
18. tropical grassland	nature	14 closed to open herbaceous vegetation
19. winter C3 crops (lower temperatu	nature	02 rainfed croplands
20. summer C3 crops	nature	02 rainfed croplands
21. C4 crops (warmer environments)	nature	02 rainfed croplands
22. flooded trees	nature	16 closed to open forest regulary flooded
23. flooded grassland	nature	18 closed to open grassland regularly flooded

ECOCLIMAP-SG natural classes correspond well with GLOBCOVER natural classes and the corresponding values could be copied.

On the other hand the CITTA project gives exceptional opportunity to update the lookup tables according to recent state of the art.

Root depths in SURFEX for ECOCLIMAP-SG cover

ECOCLIMAP-SG		GLOBCOVER	ROOTH DEPTH SURFEX V8.1	ROOTH DEPTH GLOBCOVER 2009
1. sea and oceans	water	21 'water bodies		0.0
2. lakes	water	21 'water bodies		0.0
3. rivers	water	21 'water bodies		0.0
4. bare land	nature	20 bare areas	0.5	0.3
5. bare rock	nature	20 bare areas	0.2	0.3
6. permanent snow	nature	22. pernament snow & ice	0.2	0.0
7. boreal broadleaf deciduous	nature	07 closed broadleaved deciduous forest	1.0	1.0
8. temperate broadleaf deciduous	nature	06 open/closed broadleaved deciduous forest	1.5	1,5
9. tropical broadleaf deciduous	nature	06 open broadleaved deciduous forest	2.0	2.0
10. temperate broadleaf evergreen	nature	05 closed broadleaved evergreen forest	1.5	1.0
11. tropical broadleaf evergreen	nature	05 closed broadleaved evergreen forest	3.0	1.0
12. boreal needleleaf evergreen	nature	08 closed needleleaved evergreen forest	1.0	0.6
13. temperate needleleaf evergreen	nature	08 closed needleleaved evergreen forest	2.0	0.6
14. boreal needleleaf deciduous	nature	09 open needleleaved decid. or evergr. forest	1.0	0.6
15. shrubs	nature	13 closed to open shrubland	1.0	1.5
16. boreal grassland	nature	14 closed to open herbaceous vegetation	1.0	0.6
17. temperate grassland	nature	14 closed to open herbaceous vegetation	1.2	0.6
18. tropical grassland	nature	14 closed to open herbaceous vegetation	3.0	0.6
19. winter C3 crops (lower temperatu	nature	02 rainfed croplands	1.2	1.0
20. summer C3 crops	nature	02 rainfed croplands	1.5	1.0
21. C4 crops (warmer environments)	nature	02 rainfed croplands	1,5	1.0
22. flooded trees	nature	16 closed to open forest regulary flooded	2.0	1.0
23. flooded grassland	nature	18 closed to open grassland regularly flooded	1.5	1.0

The root depths are different, in large part higher in SURFEX.

On the other hand, the Globcover values look underestimated according to:

Garbero, V., Milelli, M., Bucchignani, E., Mercogliano, P., Varentsov, M., Rozinkina, I., Rivin, G., Blinov, D., Wouters, H., Schulz, J.-P., Schättler, U., Bassani, F., Demuzere, M., Repola, F., 2021. *Evaluating the Urban Canopy Scheme TERRA_URB in the COSMO Model for Selected European Cities.* Atmosphere 12, 237. https://doi.org/10.3390/atmos12020237

Root depths in SURFEX for ECOCLIMAP-SG cover

ECOCLIMAP-SG		GLOBCOVER	GZ0 surface roughness
1. sea and oceans	water	21 'water bodies	0,0002
2. lakes	water	21 'water bodies	0,0002
3. rivers	water	21 'water bodies	0,0002
4. bare land	nature	20 bare areas	0.05
5. bare rock	nature	20 bare areas	0.05
6. permanent snow	nature	22. pernament snow & ice	0.01
7. boreal broadleaf deciduous	nature	07 closed broadleaved deciduous forest	1.0
8. temperate broadleaf deciduous	nature	06 open/closed broadleaved deciduous forest	0,575
9. tropical broadleaf deciduous	nature	06 open broadleaved deciduous forest	0.15
10. temperate broadleaf evergreen	nature	05 closed broadleaved evergreen forest	1.0
11. tropical broadleaf evergreen	nature	05 closed broadleaved evergreen forest	1.0
12. boreal needleleaf evergreen	nature	08 closed needleleaved evergreen forest	1.0
13. temperate needleleaf evergreen	nature	08 closed needleleaved evergreen forest	1.0
14. boreal needleleaf deciduous	nature	09 open needleleaved decid. or evergr. forest	1.0
15. shrubs	nature	13 closed to open shrubland	0.15
16. boreal grassland	nature	14 closed to open herbaceous vegetation	0.03
17. temperate grassland	nature	14 closed to open herbaceous vegetation	0.03
18. tropical grassland	nature	14 closed to open herbaceous vegetation	0.03
19. winter C3 crops (lower temperatu	nature	02 rainfed croplands	0.07
20. summer C3 crops	nature	02 rainfed croplands	0.07
21. C4 crops (warmer environments)	nature	02 rainfed croplands	0.07
22. flooded trees	nature	16 closed to open forest regulary flooded	1.0
23. flooded grassland	nature	18 closed to open grassland regularly flooded	0.05

Following research gives revised values for different land cover datasets:

Floors, R., Badger, M., Troen, I., Grogan, K., Permien, F.-H., 2021. *Satellite-based estimation of roughness lengths and displacement heights for wind resource modelling (preprint). Wind and turbulence.* https://doi.org/10.5194/wes-2021-28

but neither ECOCLIMAP-SG or GLOBCOVER209 is considered.

The values for similar land classes should be unified.

Preliminary table for natural classes

ECOCLIMAP-SG		GLOBCOVER		SOIL/ GROUND DEPTH	ICE DEPTH	SURFEX V8.1	GLOBCOVER 2009	GZ0 surface roughness	min PLCOV fraction of plant cover	max PLCOV fraction of plant cover	min LAI leaf area index	max LAI leaf area index	skin conductivity [W/m2/K]	surface thermal emissivity	minimal stomata resistance
1. sea and oceans	water	21 'water bodies					0.0	0,0002	0.0	0.0	0.0	0.0	200.0	0.991	120.
2. lakes	water	21 'water bodies					0.0	0,0002	0.0	0.0	0.0	0.0	200.0	0.991	120.
3. rivers	water	21 'water bodies					0.0	0,0002	0.0	0.0	0.0	0.0	200.0	0.991	120.
4. bare land	nature	20 bare areas	1	0.5	0.5	0.5	0.3	0.05	0.0	0.05	0.4	0.6	200.0	0.950	120.
5. bare rock	nature	20 bare areas	2	0.2	0.2	0.2	0.3	0.05	0.0	0.05	0.4	0.6	200.0	0.950	120.
6. permanent snow	nature	22. pernament snow & ice	3	0.2	0.2	0.2	0.0	0.01	0.0	0.0	0.0	0.0	200.0	0.9999	120.
7. boreal broadleaf deciduous	nature	07 closed broadleaved deciduous forest	4	2.0	1.0	1.0	1.0	1.0	0.75	0.9	1.0	3.4	50.0	0.990	150.
8. temperate broadleaf deciduous	nature	06 open/closed broadleaved deciduous forest	5	3.0	1.5	1.5	1,5	0,575	0,725	0,85	1.0	2,7	40	0,9915	150.
9. tropical broadleaf deciduous	nature	06 open broadleaved deciduous forest	6	4.0	2.0	2.0	2.0	0.15	0.7	0.8	1.0	2.0	30.0	0.993	150.
10. temperate broadleaf evergreen	nature	05 closed broadleaved evergreen forest	7	3.0	1.5	1.5	1.0	1.0	0.8	0.8	1.4	2.4	50.0	0.996	250.
11. tropical broadleaf evergreen	nature	05 closed broadleaved evergreen forest	8	6.0	3.0	3.0	1.0	1.0	0.8	0.8	1.4	2.4	50.0	0.996	250.
12. boreal needleleaf evergreen	nature	08 closed needleleaved evergreen forest	9	2.0	1.0	1.0	0.6	1.0	0.8	0.8	1.3	3.8	50.0	0.996	150.
13. temperate needleleaf evergreen	nature	08 closed needleleaved evergreen forest	10	3.0	2.0	2.0	0.6	1.0	0.8	0.8	1.3	3.8	50.0	0.996	150.
14. boreal needleleaf deciduous	nature	09 open needleleaved decid. or evergr. forest	11	2.0	1.0	1.0	0.6	1.0	0.75	0.9	1.0	3.8	50.0	0.990	150.
15. shrubs	nature	13 closed to open shrubland	12	2.0	1.0	1.0	1.5	0.15	0.70	0.8	0.6	1.5	50.0	0.990	120.
16. boreal grassland	nature	14 closed to open herbaceous vegetation	13	2.0	1.0	1.0	0.6	0.03	0.75	0.9	1.0	3.1	30.0	0.993	40.
17. temperate grassland	nature	14 closed to open herbaceous vegetation	14	1.2	1.2	1.2	0.6	0.03	0.75	0.9	1.0	3.1	30.0	0.993	40.
18. tropical grassland	nature	14 closed to open herbaceous vegetation	15	4.0	3.0	3.0	0.6	0.03	0.75	0.9	1.0	3.1	30.0	0.993	40.
19. winter C3 crops (lower temperatu	nature	02 rainfed croplands	16	1.2	1.2	1.2	1.0	0.07	0.5	0.9	0.7	3.3	30.0	0.990	120.
20. summer C3 crops	nature	02 rainfed croplands	17	1.5	1.5	1.5	1.0	0.07	0.5	0.9	0.7	3.3	30.0	0.990	120.
21. C4 crops (warmer environments)	nature	02 rainfed croplands	18	1.5	1.5	1,5	1.0	0.07	0.5	0.9	0.7	3.3	30.0	0.990	120.
22. flooded trees	nature	16 closed to open forest regulary flooded	19	3.0	2.0	2.0	1.0	1.0	0.8	0.8	1.4	2.4	50.0	0.996	150.
23. flooded grassland	nature	18 closed to open grassland regularly flooded	20	2.5	1.5	1.5	1.0	0.05	0.5	0.8	1.0	2.0	30.0	0.992	40.

What about Local Climate Zones?

24. LCZ1: compact high-rise
25. LCZ2: compact midrise
26. LCZ3: compact low-rise
27. LCZ4: open high-rise
28. LCZ5: open midrise
29: LCZ6: open low-rise
30: LCZ7: lightweight low-rise
31: LCZ8: large low-rise
32: LCZ9: sparsely built
33: LCZ10: heavy industry

Survey of the values in EXTPAR's lookup tables for artificial or urban/built-up class (operational settings)

	GLOBCOVER2009	GLC2000	GLCC
Plant cover max	0.2	0.2	0.2
Plant cover min	**0.02**	**0.1**	**0.05**
Leaf area index maximum	**1.6**	**1**	**1**
Leaf area index minimum	0.1	0.1	0.1
Minimal stomata resistance	**120**	**150**	**150**
Urban fraction	1	1	1
Longwave surface emissivity	0.96	0.96	0.96
Root depth	0.6	0.6	0.6
Roughness length	1	1	1

… but should differ between LCZ and cities.

Survey of the values for LCZs in recent research papers

Oke, T.R., Mills, G., Christen, A., Voogt, J.A., 2017. Urban Climates. Cambridge University Press, Cambridge.

Given the reduced vegetation cover of cities and the dryness of many urban soils (Chapter 8) it follows that in general urban r_c values are higher than for most rural ecosystems. Values are approximately inversely related to the vegetative cover fraction (λ_v). The few available r_c values for urban areas show midday values for open low-rise sites vary from $r_c \approx 250$ s m^{-1} in a city with well-watered gardens, to $r_c \approx 1{,}200$ s m^{-1} in a city with a dry climate and xerophytic landscaping.

EXTPAR value for urban areas is much lower

- **Minimal stomata resistance**

Survey of the values for LCZs in recent research papers

Oke, T.R., Mills, G., Christen, A., Voogt, J.A., 2017. Urban Climates. Cambridge University Press, Cambridge.

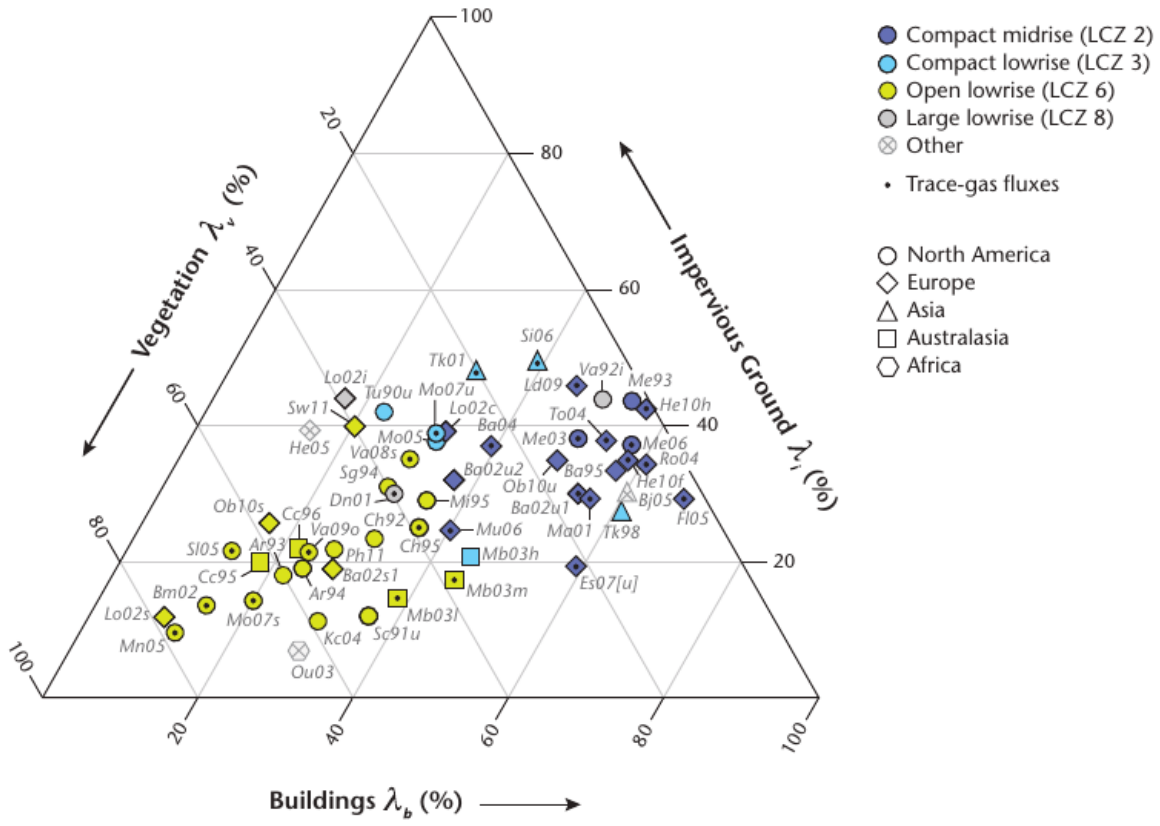

Figure 2.5 Urban land cover domain seen as the plan area fractions of buildings, vegetation and impervious (other than building) surfaces. The symbols are urban research sites that have been studied extensively in the literature. The color identifies the Local Climate Zone (LCZ) representative of a site (see Section 2.1.4, Figure 2.9 and Table 1.1). Letters and numbers are a code that identifies the location, year of observation and a lower case letter identifies a site within the city. Observational results from these sites appear in later figures and tables in this text. A full listing is given in Appendix A2, Table A2.1 (Source: Grimmond and Christen, 2012).

Table A2.1 List of urban micrometeorological measurement sites/programmes referred from within tables and figures in this book. The dots in the highlighted columns indicate whether the site has published results on wind profiles and atmospheric turbulence (T), terms of the urban energy balance (E), greenhouse-gas fluxes (G), or aerosol and air pollutant fluxes (A) (Source: Modified and expanded based on the IAUC Urban Flux Network and Grimmond and Christen, 2012).

Code	City, country site-name	Lon./lat.	Köppen climate zone	LCZ[a]	λ_b (%)	λ_v (%)	λ_i (%)	$\lambda_{oth.}$ (%)	Land-use[b]	z_H (m)	T	E	G	A	Measurement period	Selected references
Ar93, Ar94	**Los Angeles**, United States ('Arcadia')	118.050°W 34.133°N	Csb	6	25	53	18	2	R	5.2 (±0.2)		•	•		07/1993–08/1993, 07/1994	Grimmond et al. (1996), Grimmond and Oke (2002)
Ba95	**Basel**, Switzerland ('Basta')	7.600°E 47.565°N	Cfb	6	-	-	-	-	R C I	~24 (±6)	•				07/1995–02/1996	Feigenwinter et al. (1999)
Ba02s1	**Basel**, Switzerland ('Allschwil')	7.562°E 47.556°N	Cfb	6	28	53	19	0	R	7.5	•	•			06/2002–07/2002	Christen and Vogt (2004)
Ba02u1	**Basel**, Switzerland ('Sperrstrasse')	7.597°E 47.566°N	Cfb	2	54	16	30	0	R C	14.6 (±6.9)	•	•	•		06/2002–07/2002	Christen and Vogt (2004), Vogt et al. (2006)
Ba02u2	**Basel**, Switzerland ('Spalenring')	7.576°E 47.555°N	Cfb	2	37	31	32	0	R C	12.5 (±5.4)	•	•			08/1994–09/2002	Christen and Vogt (2004)
Ba02u3	**Basel**, Switzerland ('Messe')	7.601°E 47.563°N	Cfb	-	100	0	0	0	C O	18.8 (±6.3)		•			06/2002–07/2002	
Ba04	**Basel**, Switzerland ('Klingelbergstrasse')	7.580°E 47.562°N	Cfb	2	38	-	-	-	R S O	13.8	•	•	•		01/2004–*	Lietzke and Vogt (2013)
Bj05	**Beijing**, China ('IAP 325m tower')	116.371°E 39.974°N	Dwa	1	-	-	-	-	R C S	~30	•	•	•	•	01/1991–*	Song and Wang (2012)
Bm02	**Baltimore**, United States ('Cub Hill')	76.521°W 39.413°N	Cfb	6	16	76	8	1	R	6			•		01/2002–*	Crawford et al. (2011)
Cc95	**Christchurch**, New Zealand ('Beckenham')	172.640°E 43.564°S	Cfb	6	36	39	25	0	R	5.9 (±1.3)			•		08/1995	Spronken-Smith (2002)
Cc96	**Christchurch**, New Zealand ('St Albans')	172.647°E 43.521°S	Cfb	6	32	51	23	0	R C	7			•		01/1996–02/1996, 07/1997–08/1997	
Ch92	**Chicago**, United States ('Suburban')	87.800°W 41.950°N	Dfa	6	33	44	22	0	R	6.7 (±0.5)		•			07/1992	Grimmond and Oke (1995)
Ch95	**Chicago**, United States ('Dunning')	87.795°W 41.949°N	Dfa	6	36	39	25	0	R	5.9 (±1.3)			•		06/1995–08/1995	Grimmond et al. (2002), Grimmond and Oke (2002)
Dn01	**Denver**, United States ('South Denver')	105.013°W 39.659°N	Dfb	8	30	36	30	4	R C I S O	7		•	•		05/2001–09/2007, 01/2011-*	
Ed00	**Edinburgh**, United Kingdom ('Nelson Monument')	3.183°W 55.954°N	Cfb	-	-	-	-	-	R C I	10.8			•		10/2000–11/2000	Nemitz et al. (2002)
Es07 [p/u]	**Essen**, Germany ('Grugapark') [c]	6.993°E 51.431°N	Cfb	5/B[c]	59 / 12	22 / 52	19 / 29	0	R C	15		•		•	09/2006–11/2007	Kordowski and Kuttler (2010), Weber and Kordowski (2010)

- Urban fraction
- Plant Cover
- Building height

Survey of the values for LCZs in recent research papers

Morphological, radiative and thermal urban canopy parameters per LCZ class:

- ❑ Impervious area fraction
- ❑ Building area fraction
- ❑ Building height
- ❑ Height-to-width ratio H/W
- ❑ Albedo
- ❑ Emissivity
- ❑ Heat capacity
- ❑ Heat conductivity

Varentsov, M., Samsonov, T., Demuzere, M., 2020. Impact o Urban Canopy Parameters on a Megacity's Modelled Therm Environment. Atmosphere 11, 1349. https://doi.org/10.3390/atmos11121349.

Appendix B. Urban Canopy Parameters

Table A2. Urban canopy parameters per LCZ class, compiled from Stewart and Oke [23] and Stewart et al. [65], including the impervious area fraction (ISA), annual-mean anthropogenic heat flux (AHF), building area fraction (R), building height (H), and height-to-width ratio (H/W).

LCZ Class	ISA [unit fraction]	AHF [W/m^2]	R [Unit Fraction]	H [m]	H/W [Unit-Less]
1	0.95	100	0.5	25	2.5
2	0.9	35	0.5	15	1.25
3	0.85	30	0.55	5	1.25
4	0.65	30	0.3	25	1
5	0.7	15	0.3	15	0.5
6	0.6	10	0.3	5	0.5
7	0.85	30	0.8	3	1.5
8	0.85	40	0.4	7	0.2
9	0.3	5	0.15	5	0.15
10	0.55	100	0.25	8.5	0.35

Table A3. Radiative and thermal urban canopy parameters per LCZ class, compiled from Stewart and Oke [23] and Stewart et al. [65]. The latter paper only provides thermal admittance values per LCZ class, yet their underlying facet heat conductivity and capacity values are provided by Scott Krayenhoff (pers. communication) and are reported here.

LCZ Class	Albedo, α [Unit Fraction]			Emissivity, ϵ [Unit Fraction]			Heat Capacity, C_v [MJ m^{-3} K^{-1}]			Heat Conductivity, λ [W m^{-1} K^{-1}]		
	Roof	Walls	Road	Roof	Walls	Road	Roof	Walls	Road	Roof	Walls	Road
1	0.13	0.25	0.14	0.91	0.9	0.95	1.8	1.8	1.75	1.25	1.09	0.77
2	0.18	0.2	0.14	0.91	0.9	0.95	1.8	2.67	1.68	1.25	1.5	0.73
3	0.15	0.2	0.14	0.91	0.9	0.95	1.44	2.05	1.63	1.0	1.25	0.69
4	0.13	0.25	0.14	0.91	0.9	0.95	1.8	2.0	1.54	1.25	1.45	0.64
5	0.13	0.25	0.14	0.91	0.9	0.95	1.8	2.0	1.5	1.25	1.45	0.62
6	0.13	0.25	0.14	0.91	0.9	0.95	1.44	2.05	1.47	1.0	1.25	0.6
7	0.15	0.2	0.18	0.28	0.9	0.92	2.0	0.72	1.67	2.0	0.5	0.72
8	0.18	0.25	0.14	0.91	0.9	0.95	1.8	1.8	1.38	1.25	1.25	0.51
9	0.13	0.25	0.14	0.91	0.9	0.95	1.44	2.56	1.37	1.0	1.0	0.55
10	0.1	0.2	0.14	0.91	0.9	0.95	2.0	1.69	1.49	2.0	1.33	0.61

Survey of the values for LCZs in recent research papers

Morphological, radiative and thermal urban canopy parameters per LCZ class:

- ❑ Impervious area fraction
- ❑ Building area fraction
- ❑ Building height
- ❑ Height-to-width ratio H/W
- ❑ Albedo
- ❑ Emissivity
- ❑ Heat capacity
- ❑ Heat conductivity

The improvements possible based on findings by:

Bassani, F., Garbero, V., Massimo, M., 2022. 3D evaluation of Urban Canopy Parameters (UCP) on Turin, Italy, with COSMO 6.0. Presented at the ICCARUS, P18.

Considering LCZ as the reference case, the **major** impact is given by the **LOW** value of:

- roof fraction (fr_L) → geometrical UCP → increased Tmin & reduced Tmax
- heat capacity (ca_L) and conductivity (co_L) → thermal UCP → reduced Tmin & increased Tmax

Preliminary table for LCZs

24. LCZ1: compact high-rise	40-60	40-60	> 2	0.2-0.4	> 25	1500-1800	50-300			40-60	40-60	<10	> 25	0.2-0.4	50-300	> 80
25. LCZ2: compact midrise	40-70	30-50	0.75-2	0.3-0.6	25 .-10	1500-2200	< 75			40-70	30-50	<20	25 .-10	0.3-0.6	< 75	> 70
26. LCZ3: compact low-rise	40-70	20-50	0.75-1.5	0.2.0.6	3 .- 10	1200-1800	<75			40-70	20-50	<30	3 .- 10	0.2.0.6	<75	> 60
27. LCZ4: open high-rise	20-40	30-40	0.75-1.25	0.5-0.7	> 25	1400-1800	<50			20-40	30-40	30-40	> 25	0.5-0.7	<50	50-80
28. LCZ5: open midrise	20-40	30-50	0.3-0.75	0.5-0.8	10 .-25	1400-2000	<25			20-40	30-50	20-40	10 .-25	0.5-0.8	<25	50-80
29: LCZ6: open low-rise	20-40	20-50	0.3-0.75	0.6-0.9	3 .-10	1200-1800	<25			20-40	20-50	30-60	3 .-10	0.6-0.9	<25	40-90
30: LCZ7: lightweight low-rise	60-90	<20	1 .- 2	0.2-0.5	2 .-4	800-1500	<35			60-90	<20	<30	2 .-4	0.2-0.5	<35	>60
31: LCZ8: large low-rise	30-50	40-50	0.1-0.3	>0.7	3 .-10	1200-1800	<50			30-50	40-50	<20	3 .-10	>0.7	<50	>70
32: LCZ9: sparsely built	10 .-20	<20	0.1-0.25	>0.8	3 .-10	1000-1800	<10			10 .-20	<20	60-80	3 .-10	>0.8	<10	10-40
33: LCZ10: heavy industry	20-30	20-40	0.2-0.5	0.6-0.9	5 .-15	1000-2500	>300			20-30	20-40	40-50	5 .-15	0.6-0.9	>300	>40

Building plan fraction λb (%)	Impervious plan fraction λi (%)	Canyon aspect ratio λs =H/W	Sky view factor	Mean height of roughness elements zh[m]	Thermal admitance [J/m^2 S$^{-1/2}$ /K]	Antropogenetic heat flux density Qf [W.m^2]	Surface emissivity	Stomatal resistance	Build percentage LB	impervious LI	Vegetated Lv	mean height of roughness elements	SVP sky view factor	AHF antropogenic heat flux	IMD impervious surface density
Oke et al. 2017									Demuzere et al. 2019						
						low vegetation grass (short-long)	0.9-0.98	0-5	open water						
						roads asphalt	0.89-0.96	50-100	plants little water stress						
						surface concrete	0.85-0.97	30	grasslands						
						building roofs - tiles shingles	0.90-0.92	250	open low rise LCZ6, watered gardens						
								1200	open low rise LCZ6, dry climate						

Summary

- The survey of existing sources to feed new lookup tables has been made

- Preliminary tables of parameter values for natural and urban classes have been elaborated

To do:

- Final compilation of lookup table for ECOSCLIMAP-SG

- Adjusting of neccesary EXTPAR's modules

Thank you

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10/03/2022, ICCARUS WG3b/CITTA' meeting

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