Índices, indicadores e modelos microclimáticos para o Planeamento Urbano

Um exemplo no bairro do Palmarejo, Praia, CV

IGOT

Grupo de Investigação ZEPHYRUS climate change and environmental systems zephyrus.ulisboa.pt

CEG 80 ANOS Centro de Estudos Geográficos

U LISBOA | UNIVERSIDADE DE LISBOA

1. Escalas do clima urbano
2. Modelos e escalas
3. Modificações dos balanços radiativo e energético em ambiente urbano
4. Índices e indicadores
5. Da mesoescala à microescala climática
6. Exemplos e Conclusões (discussão na sessão Estúdio, à tarde)

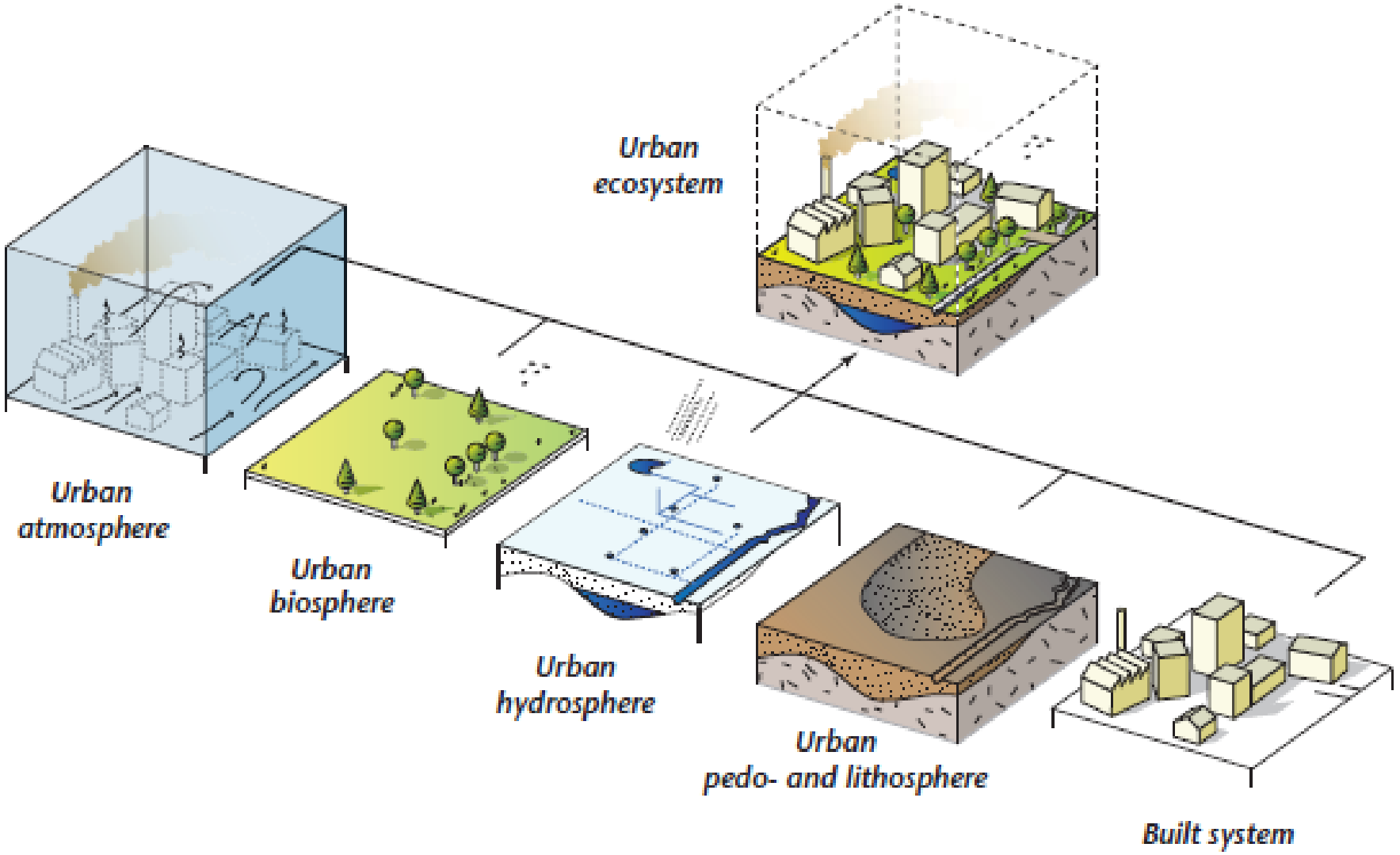


Figure 1.3 The biophysical components that comprise an urban ecosystem. They include all aspects of the preurban natural environment subsequently modified by the introduction of built infrastructure.

Oke et al, 2017

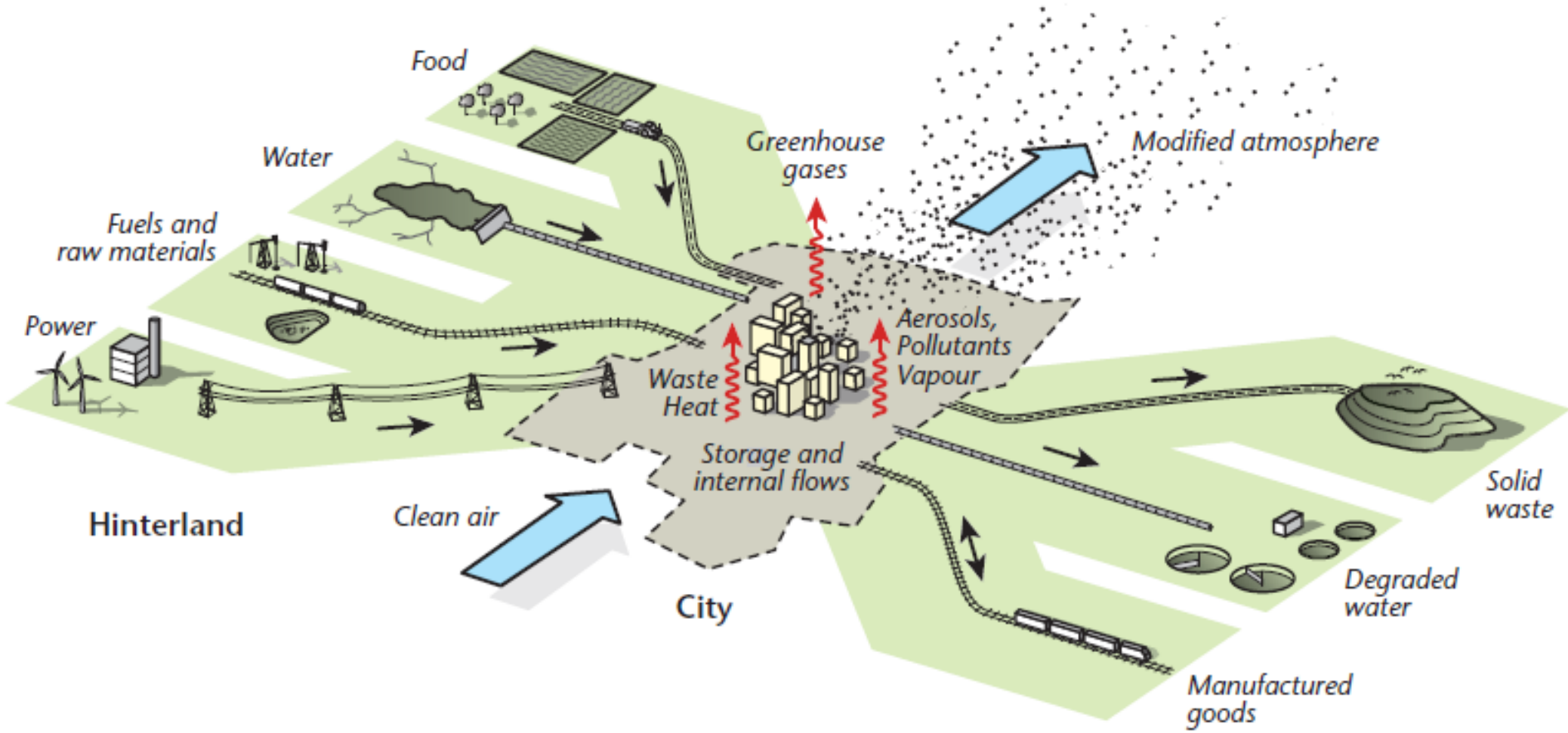


Figure 1.4 Representation of inputs to, and outputs from, an urban ecosystem (Modified after Christen 2014; © Elsevier, used with permission).

Oke et al, 2017

1. Escalas do clima urbano

- Microescala: 1cm a 1km
- Escala local: 100m a 50km
- Meso-escala (ou e. regional): 10 a 200km
- Macro-escala: 100 a 100 000km

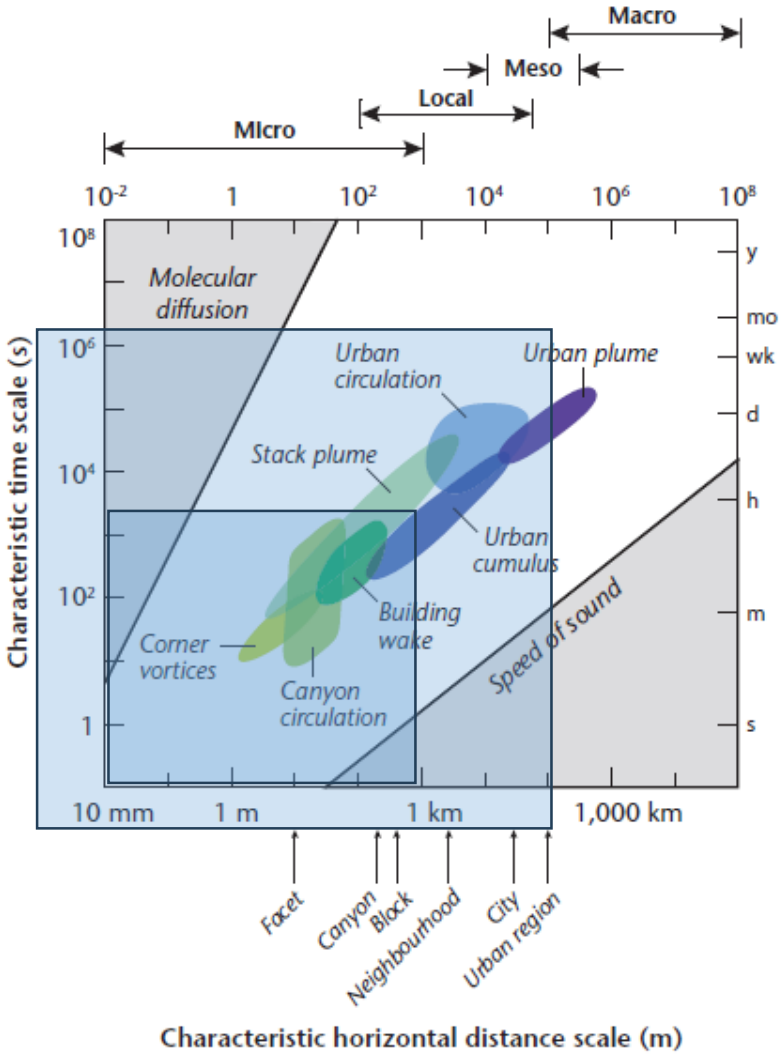
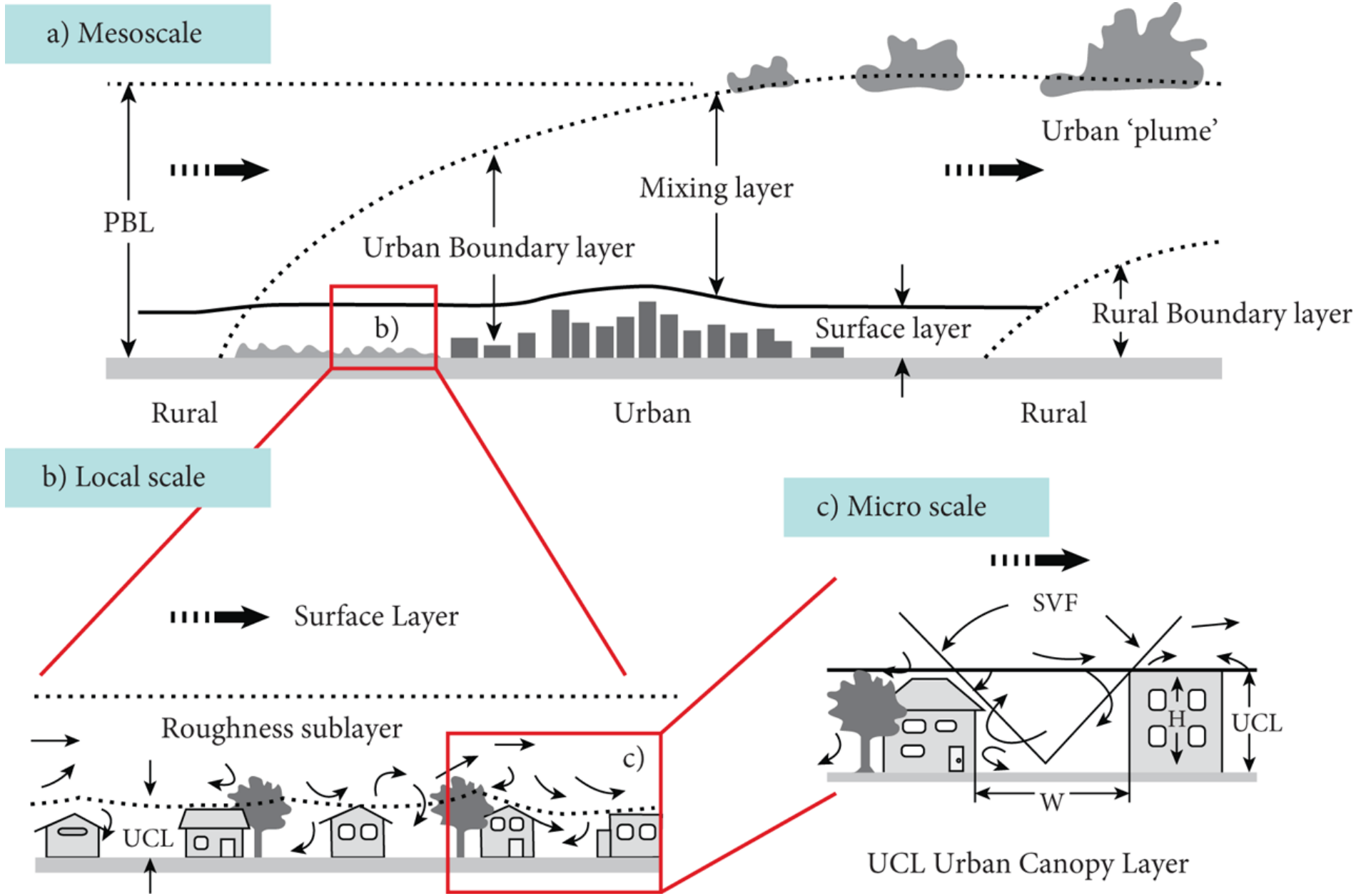
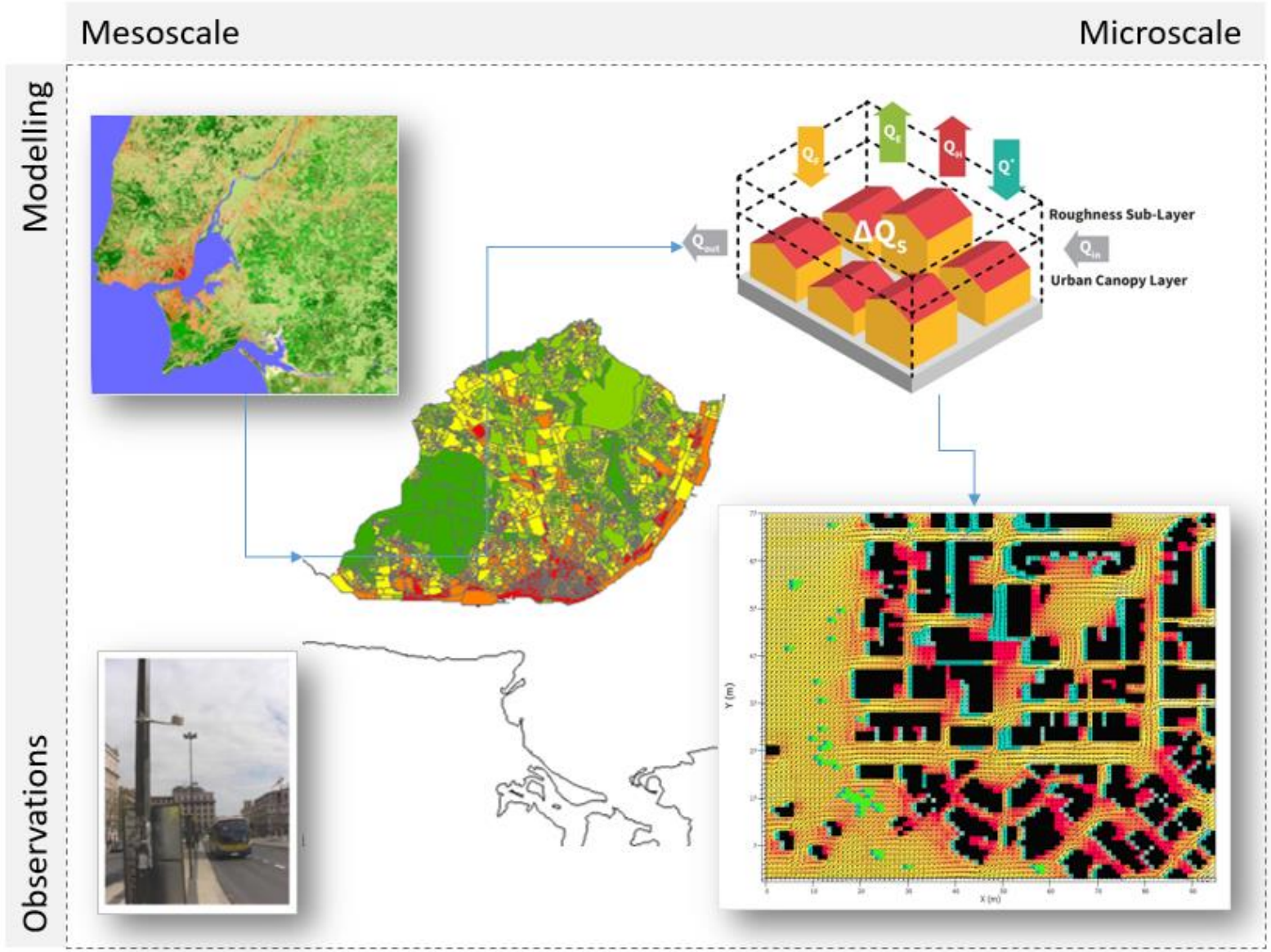


Figure 2.11 Time and horizontal space scales of selected urban climate dynamics and wind phenomena. The common names of these scales are shown above and the corresponding urban scales (Table 2.1) below.

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

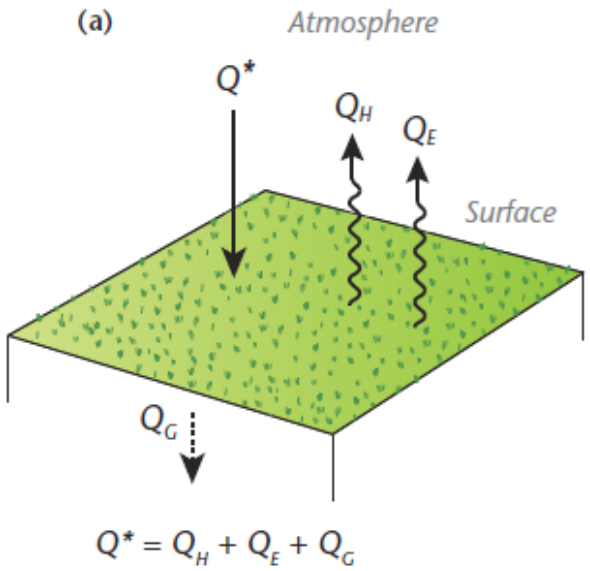

a) Mesoscale
Urban 'plume'
PBL
Mixing layer
Urban Boundary layer
b)
Surface layer
Rural Boundary layer
Rural
Urban
Rural
b) Local scale
Surface Layer
Roughness sublayer
c)
UCL
c) Micro scale
SVF
H
UCL
W
UCL Urban Canopy Layer

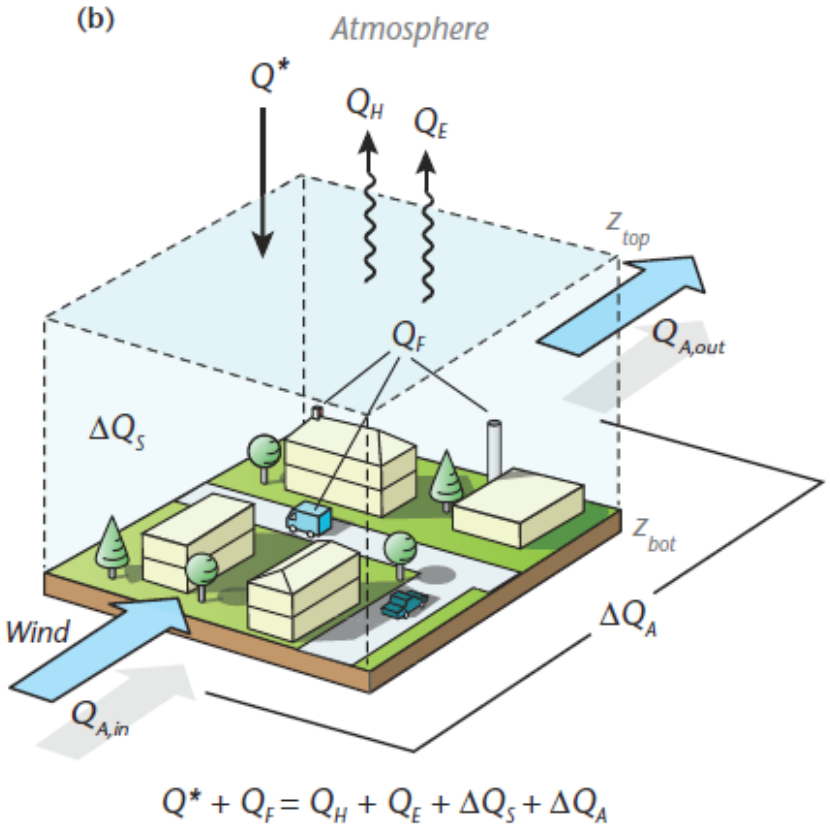
2. Modelos e escalas



3. Modificações dos balanços radiativo e energético

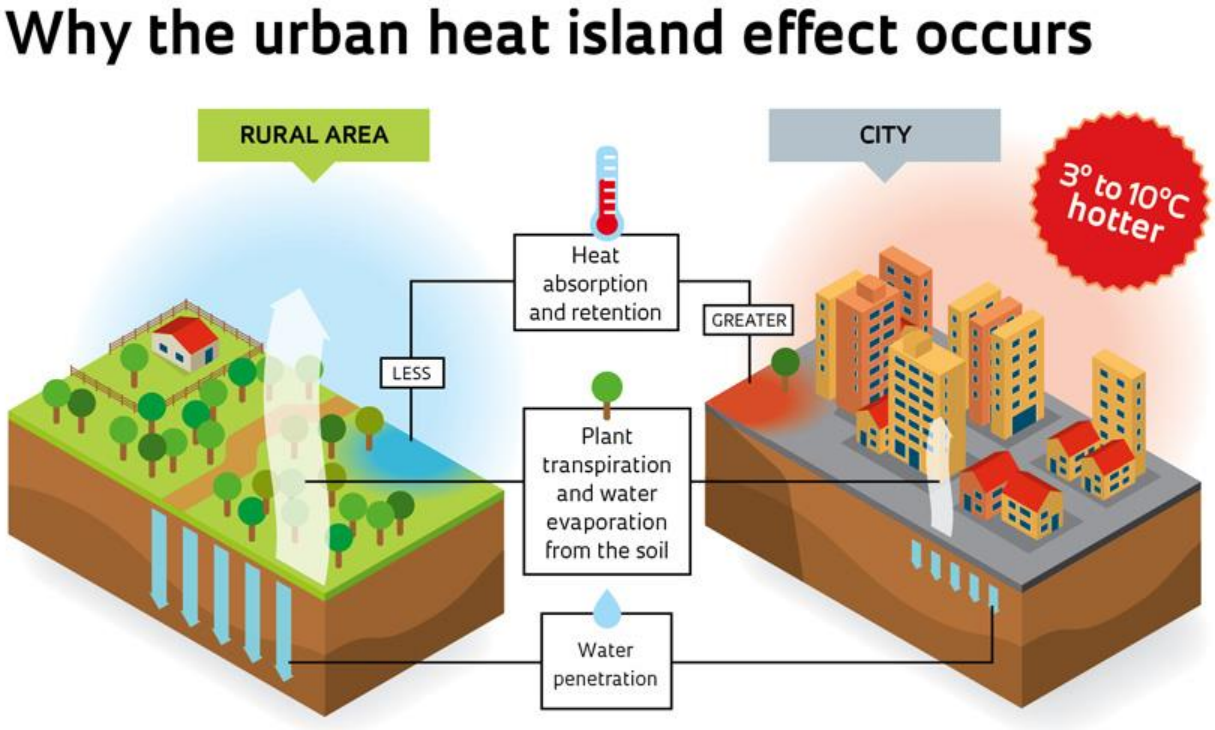
$$Q^* = K\downarrow - K\uparrow + L\uparrow - L\downarrow$$





L^*	Net longwave radiation flux density	(W m^{-2})
$L_\downarrow$	Incoming longwave radiation flux density	(W m^{-2})
$L_\uparrow$	Outgoing longwave radiation flux density	(W m^{-2})
Q^*	Net allwave radiation flux density	(W m^{-2})
$Q_\downarrow$	Total incoming short- and longwave radiation flux density	(W m^{-2})
$Q_\uparrow$	Total outgoing short- and longwave radiation flux density	(W m^{-2})
Q_E	Turbulent latent heat flux density	(W m^{-2})
Q_F	Anthropogenic heat flux density	(W m^{-2})
Q_G	Substrate heat flux density	(W m^{-2})
Q_H	Turbulent sensible heat flux density	(W m^{-2})
ΔQ_A	Net energy (sensible and latent) advection; rate per unit volume or per unit horizontal area	(J; W m^{-3}; W m^{-2})
ΔQ_S	Net heat storage; rate per unit volume or per unit horizontal area	(J; W m^{-3}; W m^{-2})

The UHI is the most obvious atmospheric modification attributable to urbanization, the most studied of climate effects of cities and an iconic phenomenon of urban climate (Oke,1987; Roth, 2013).



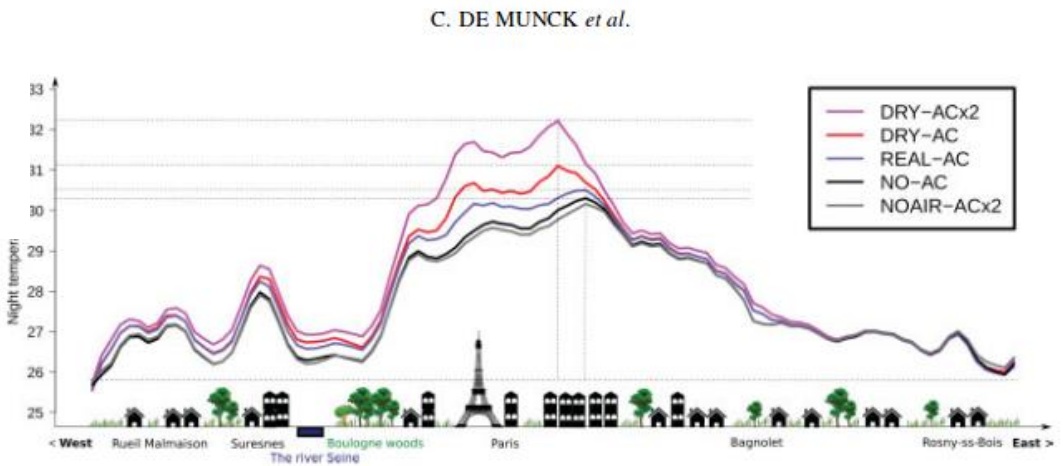
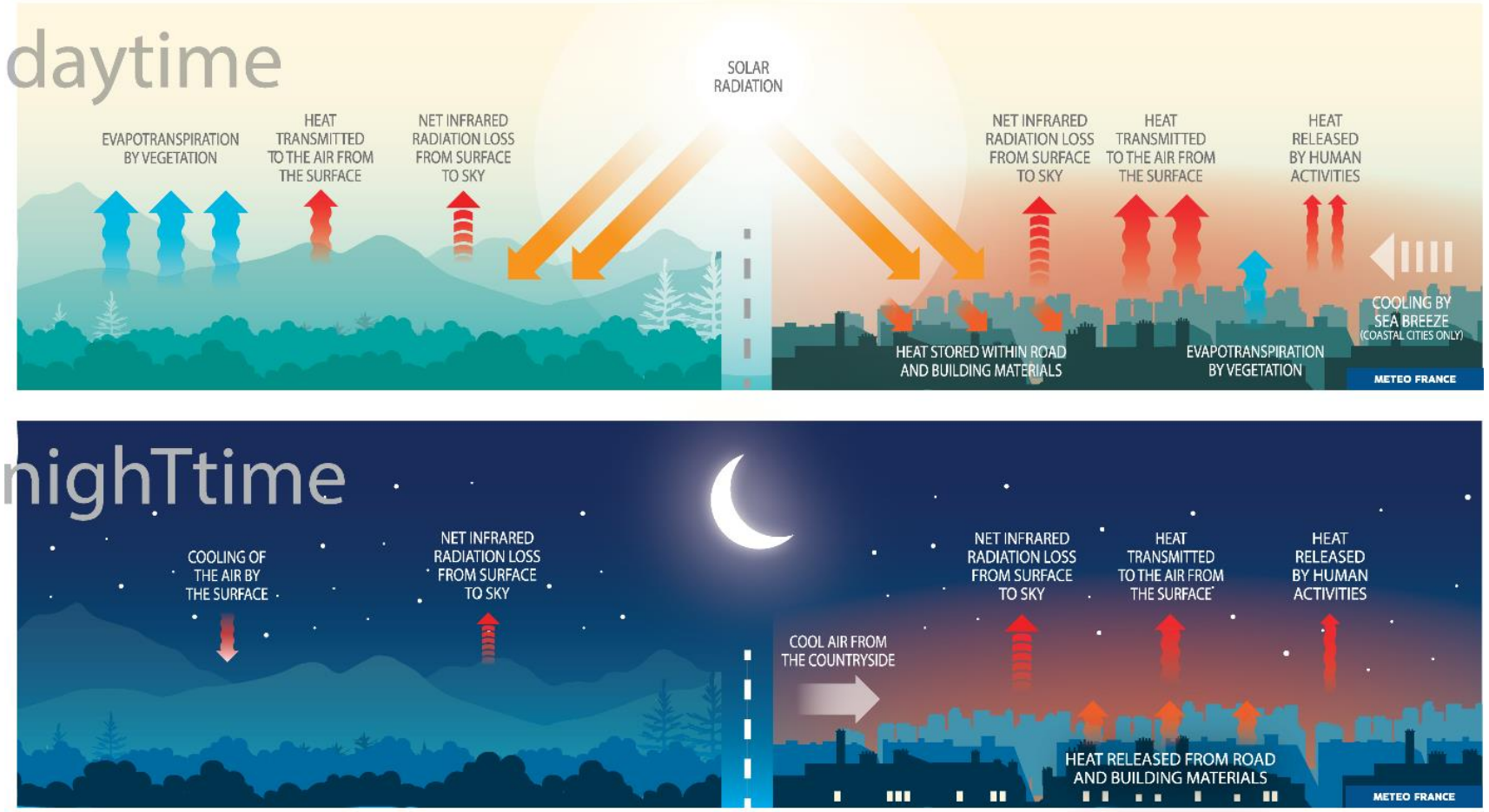
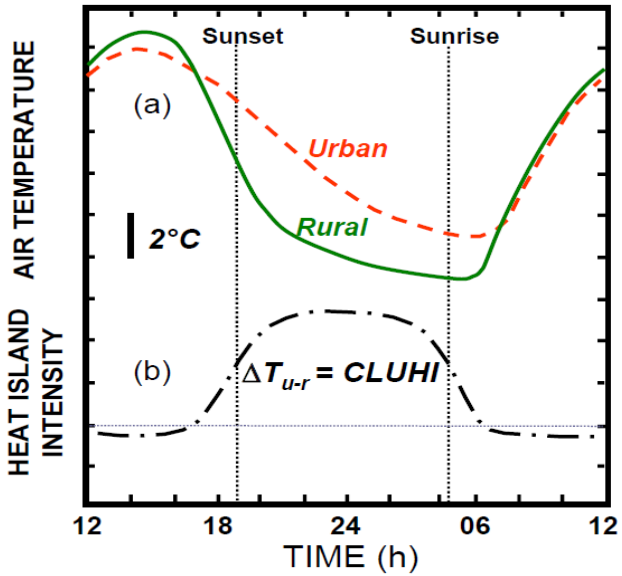


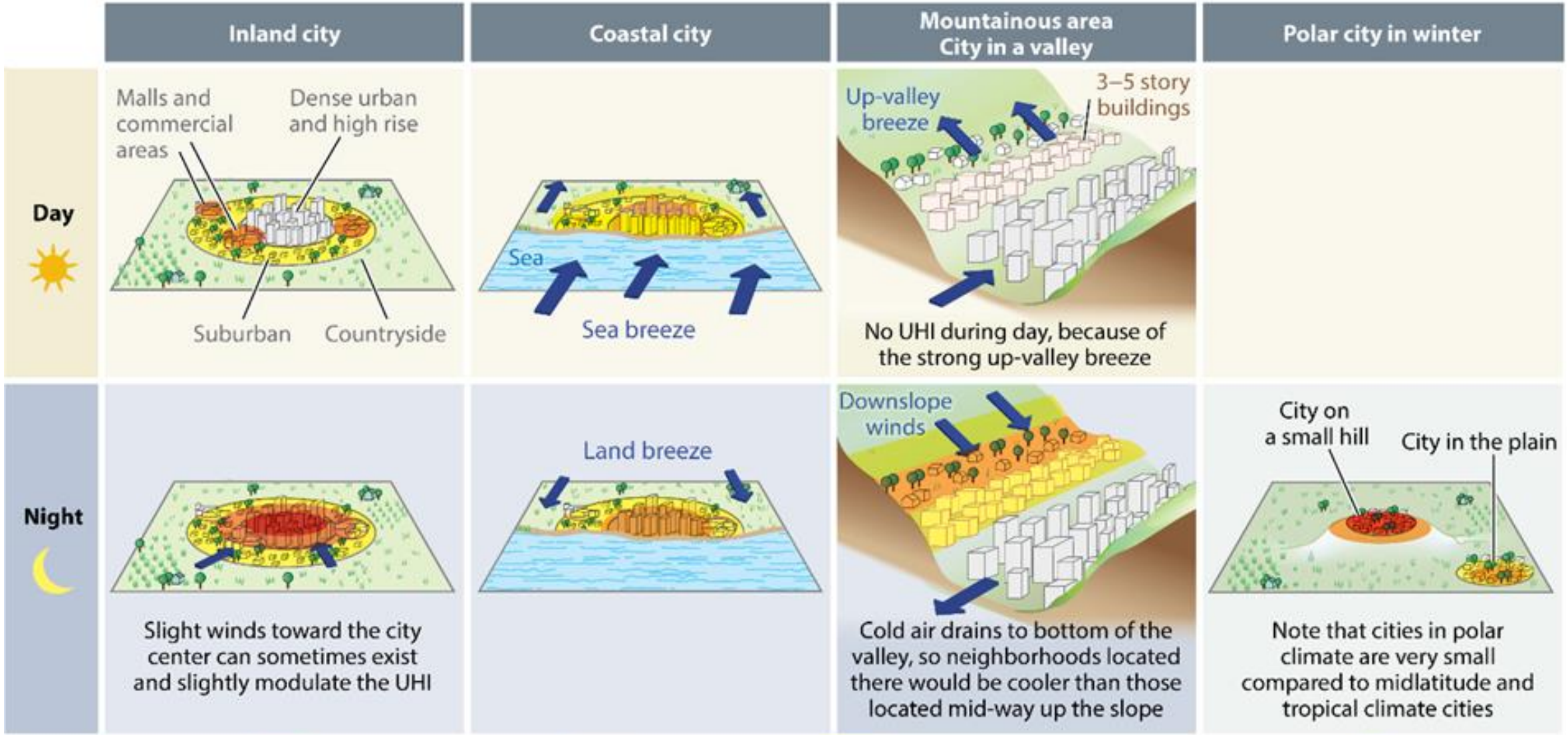
Figure 11. Temperature profiles showing Paris UHI for a west-to-east section passing through the warmest districts of inner Paris (8, 9 and 10, as shown by the black line in Figure 7 for the NO-AC scenario).





Masson V, et al. 2020.
Annu. Rev. Environ. Resour. 45:411–44

Annual Reviews



Masson V, et al. 2020.
Annu. Rev. Environ. Resour. 45:411–44

Science of the Total Environment 790 (2021) 147710

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/scitotenv

An urban climate-based empirical model to predict present and future patterns of the Urban Thermal Signal

Ana Oliveira [a,*], António Lopes [b], Ezequiel Correia [b], Samuel Niza [a], Amílcar Soares [c]

[a] IN+ Center for Innovation, Technology and Policy Research, Instituto Superior Técnico, Universidade de Lisboa, Portugal
[b] Centro de Estudos Geográficos, IGOT - Instituto de Geografia e Ordenamento do Território, Universidade de Lisboa, Portug
[c] CERENA, Instituto Superior Técnico, Universidade de Lisboa, Portugal

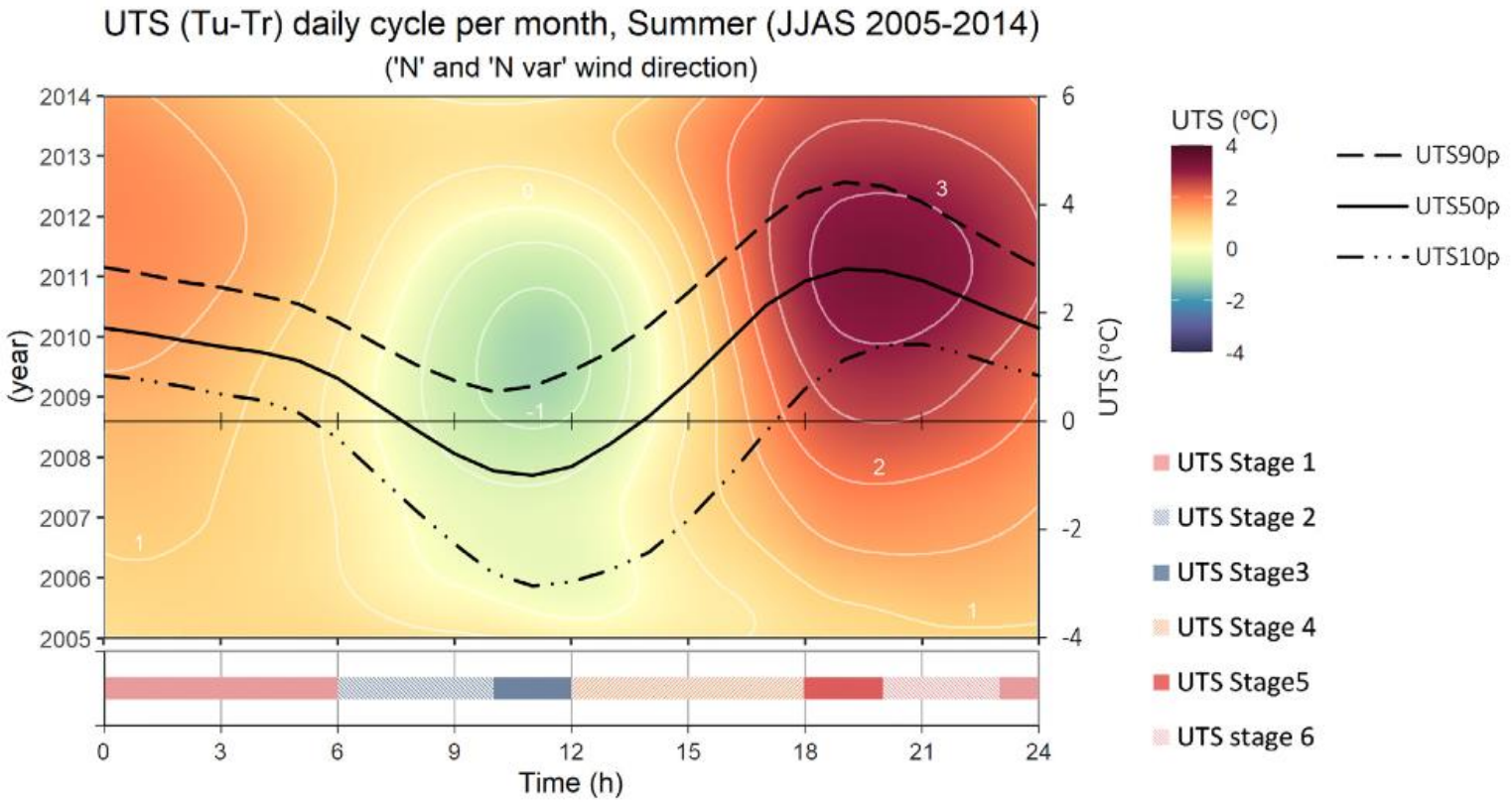
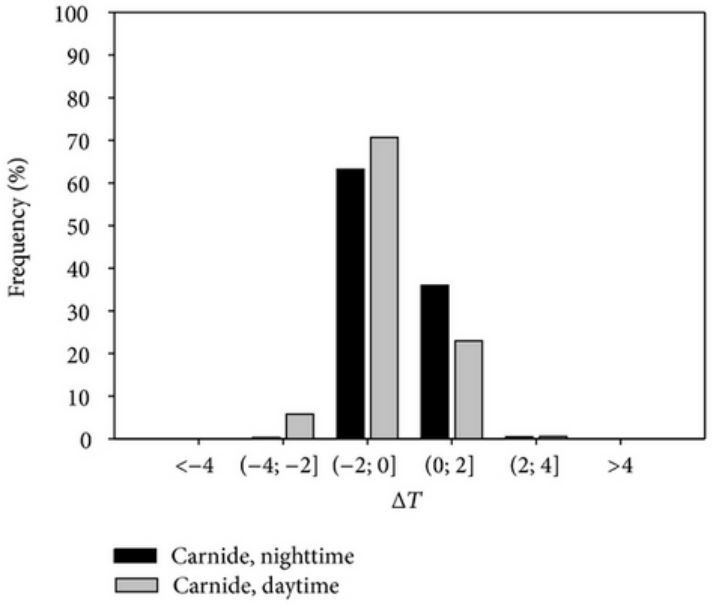
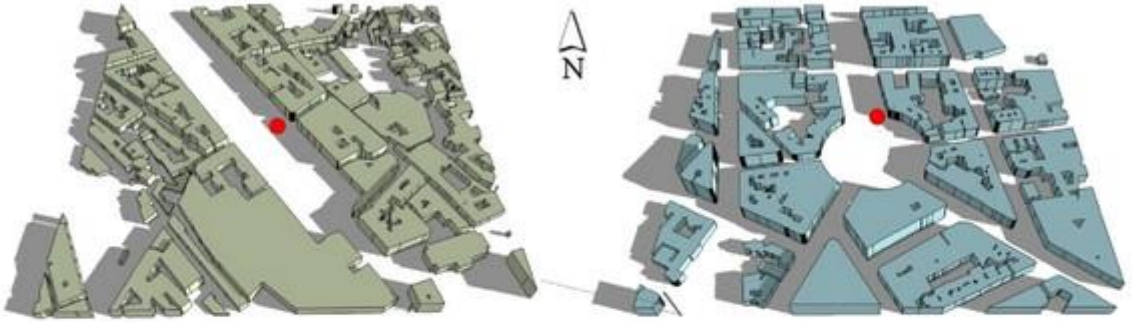
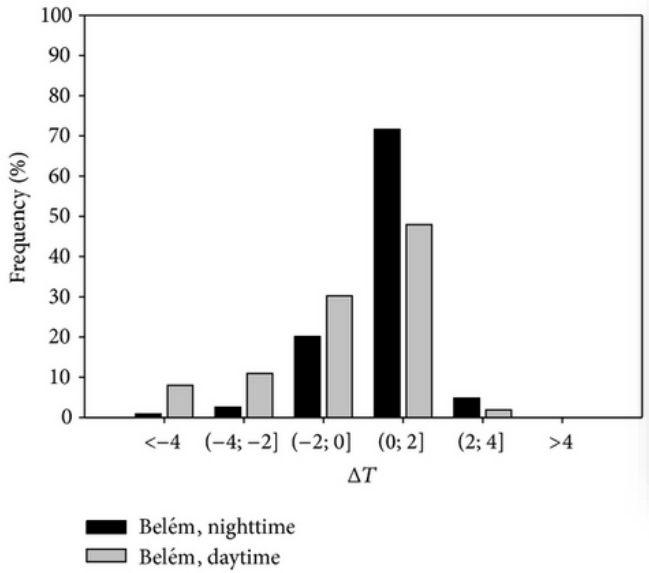
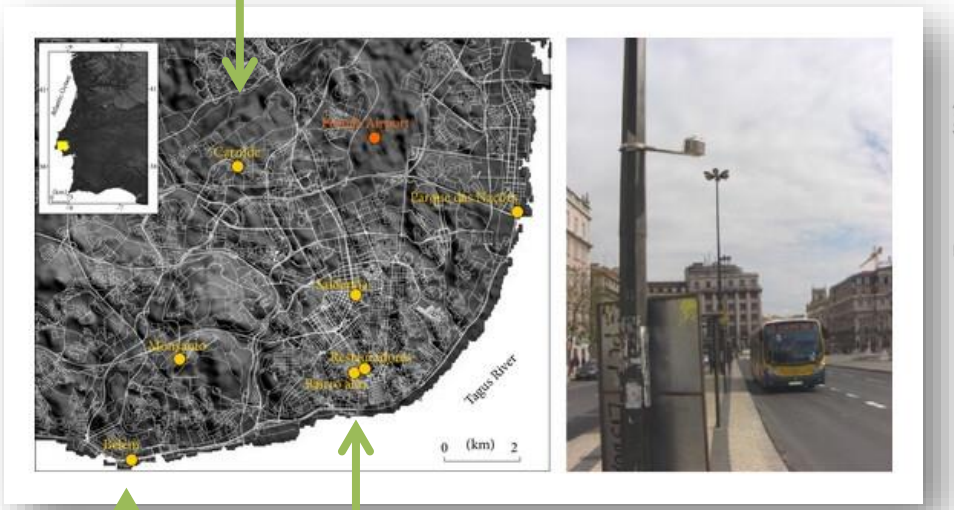


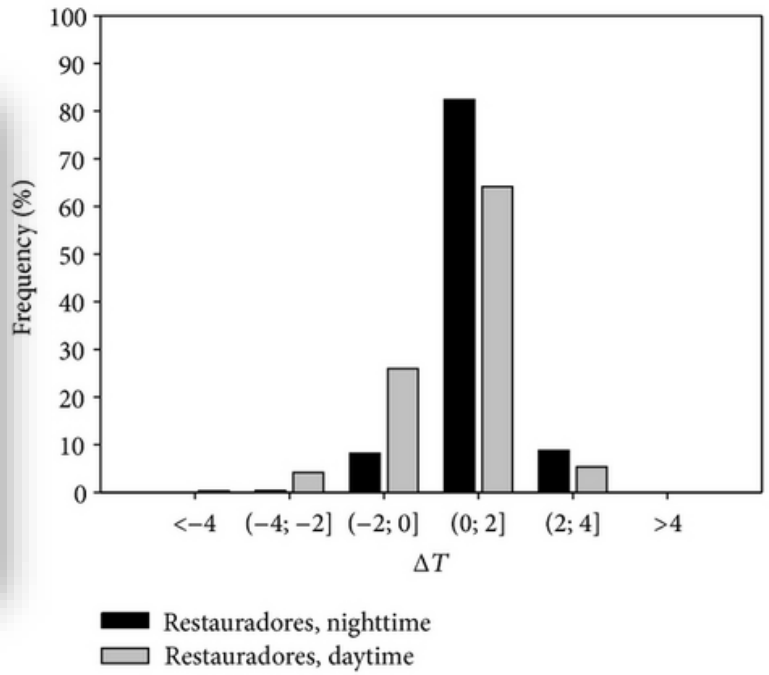
Fig. 1. UTS daily cycle in Lisbon, adapted from (Oliveira et al., 2021): line plot displays the median, the 90th and the 10th percentiles of the hourly UTS intensity (UTS50p, UTS90p and UTS10p, respectively) at the Lisbon's city centre (Restauradores), together with the corresponding heatmap, per year; bellow, the schematic diagram depicts the corresponding UTS daily cycle stages. In this study, two stages are considered: the daily median nocturnal UTS intensity, from 11 p.m. to 6 a.m. (Stage 1); and (iii) the daily late afternoon maximum UTS intensity, from 6 p.m. to 8 p.m. (Stage 5).


Frequency (%)
100
90
80
70
60
50
40
30
20
10
0
<−4
(−4; −2]
(−2; 0]
(0; 2]
(2; 4]
>4
ΔT
Carnide, nighttime
Carnide, daytime

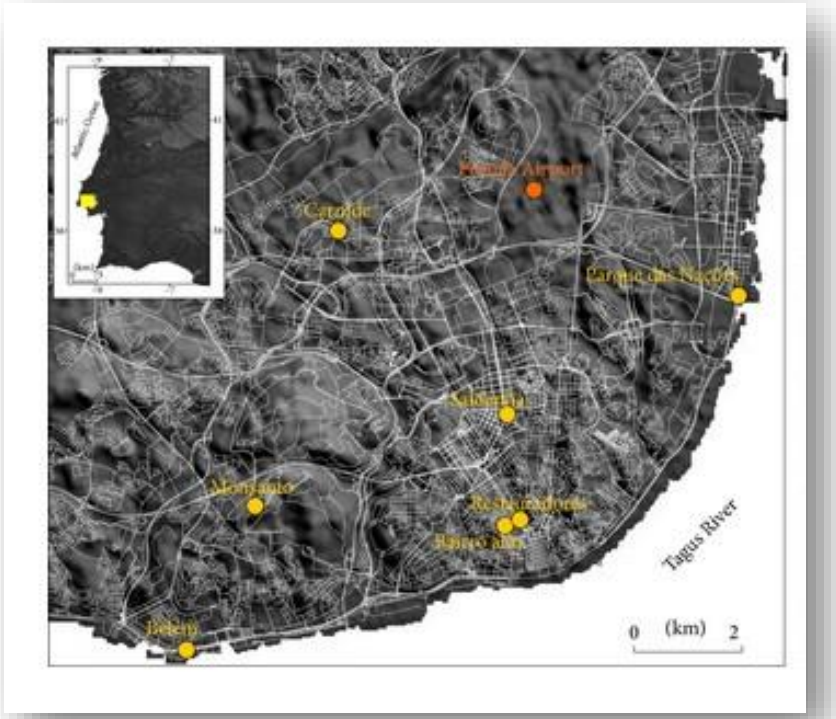

N
8:00 (UTC)
Collection site
Buildings of Restauradores
Buildings of Saldanha
Shadows

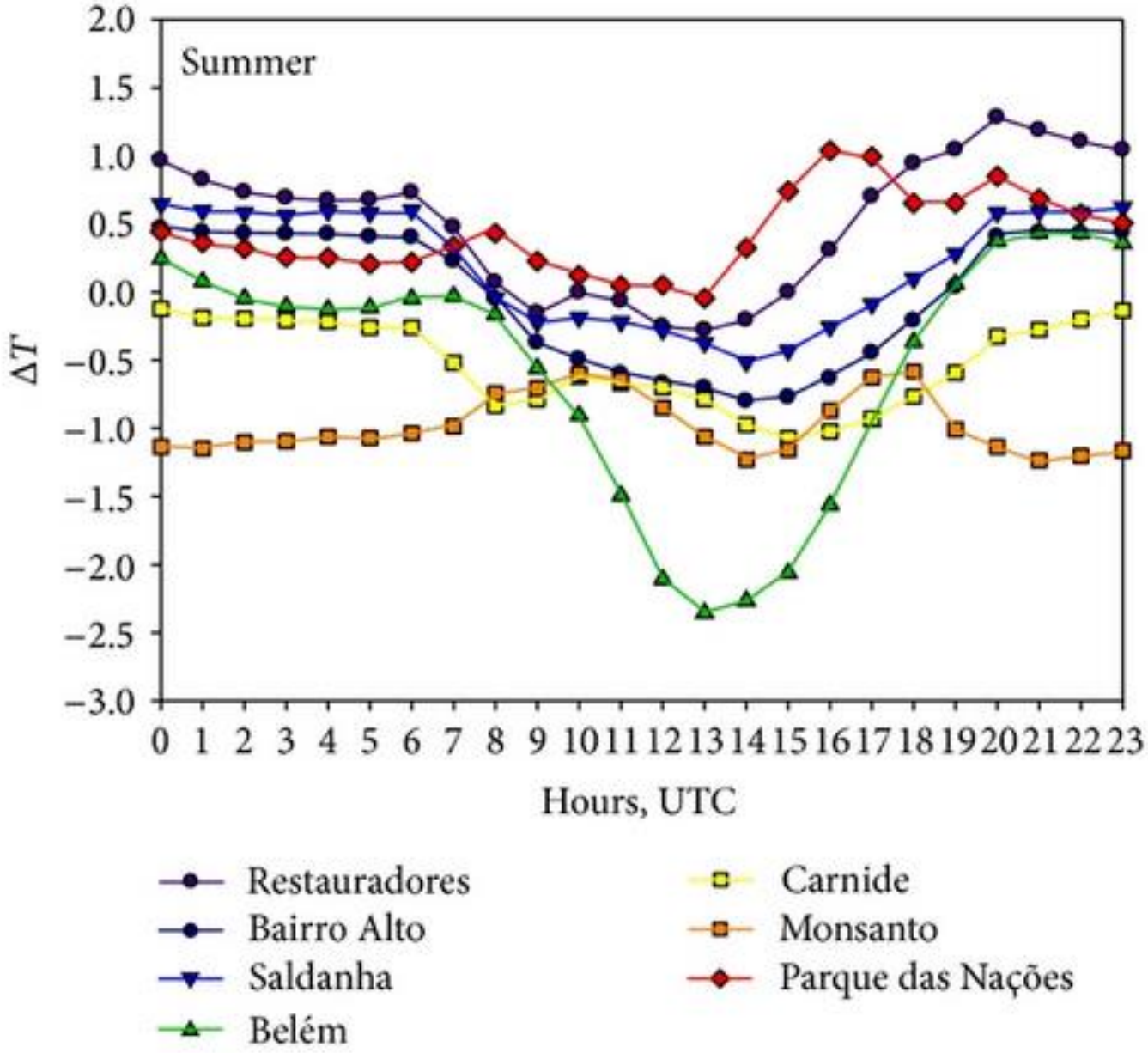

Frequency (%)
100
90
80
70
60
50
40
30
20
10
0
<−4
(−4; −2]
(−2; 0]
(0; 2]
(2; 4]
>4
ΔT
Belém, nighttime
Belém, daytime


Carnide
Tagus River
Belem
0
(km)
2


Frequency (%)
100
90
80
70
60
50
40
30
20
10
0
<−4
(−4; −2]
(−2; 0]
(0; 2]
(2; 4]
>4
ΔT
Restauradores, nighttime
Restauradores, daytime

2004–2012


Tagus River
0 (km) 2


Summer
ΔT
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
−3.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hours, UTC
Restauradores
Bairro Alto
Saldanha
Belém
Carnide
Monsanto
Parque das Nações

4. Índices e indicadores

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How to beat the heat in cities through urban climate modelling

Jan Carmeliet ✉ & Dominique Derome

Nature Reviews Physics **6**, 2–3 (2024) | Cite this article

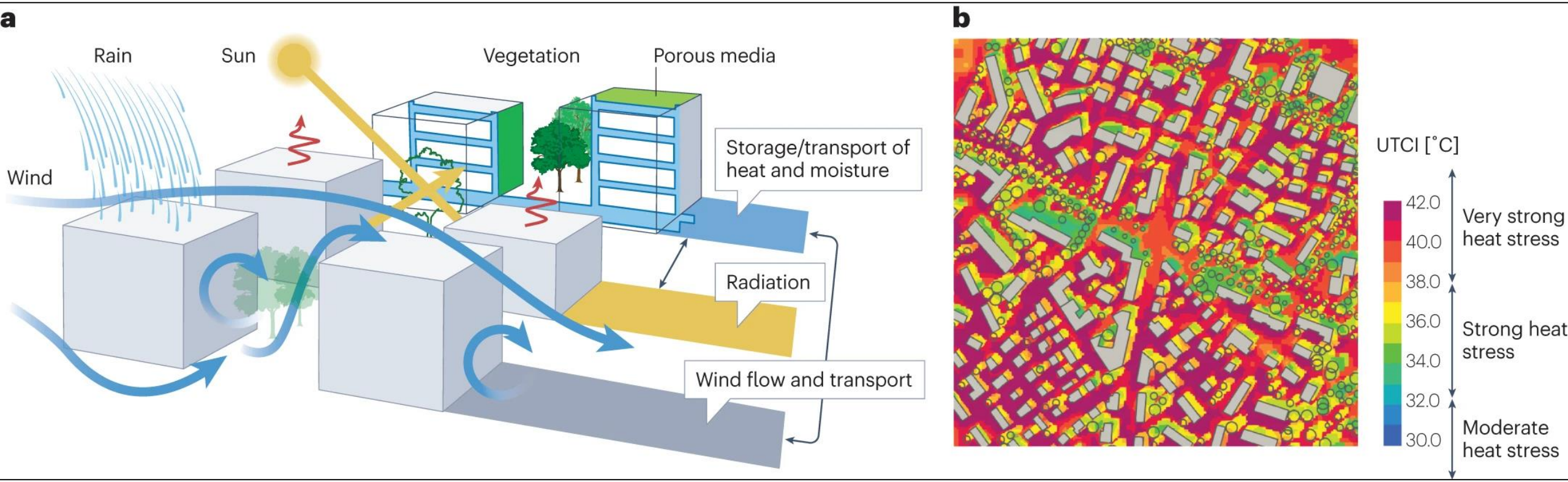
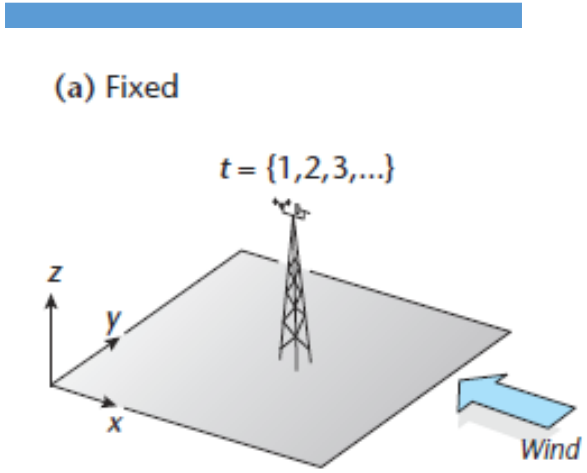


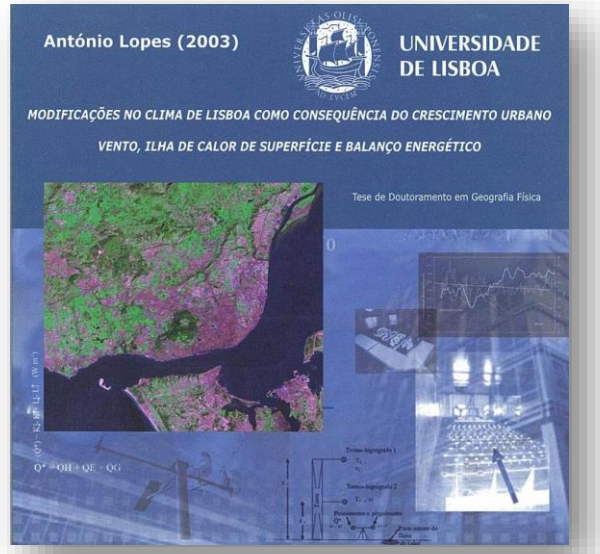
Fig. 1 | Understanding the urban climate at the microscale. a, Schematic of all-physics urban climate model at microscale[6]. **b**, Map of universal thermal comfort index (UTCI) for a neighbourhood with trees in Zürich during a heatwave. The UTCI is an equivalent temperature, which indicates the human physiological response to the thermal environment, specifically to air temperature, humidity, wind and radiation. Leaf area density, the total one-sided leaf area per volume of the tree crown, is equal to 1 $m^2 m^{-3}$ in this case. Part **a** adapted with permission from ref. 5, Elsevier. Part **b** courtesy of A. Kubilay.

Métodos de recolha de dados

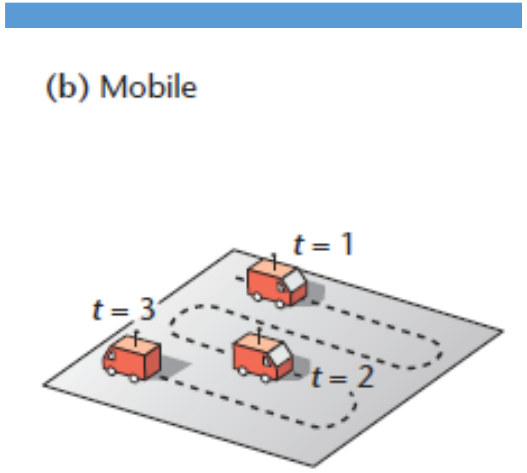
Observações

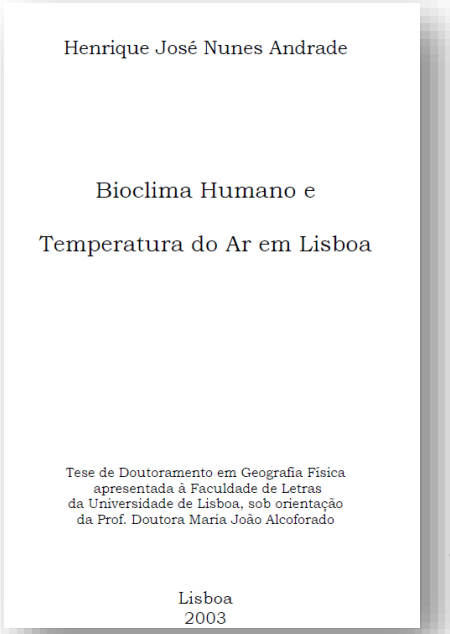
1989
Maria João Alcoforado



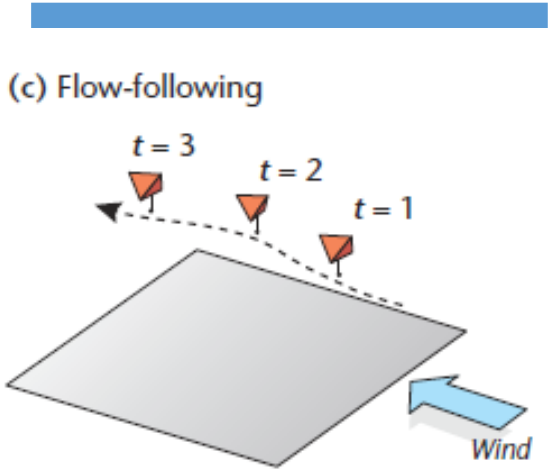


2003
António Lopes





2003
Henrique Andrade



Conceito de crowdsourcing na ciências atmosféricas

ICUC9 - 9th International Conference on Urban Climate jointly with 12th Symposium on the Urban Environment

Challenges and benefits from crowdsourced atmospheric data for urban climate research using Berlin, Germany, as testbed

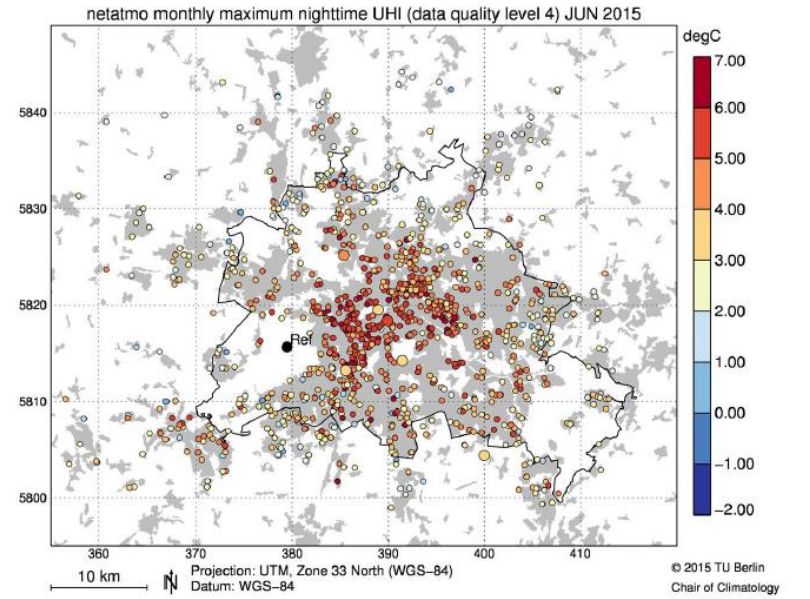
Fred Meier, Daniel Fenner, Tom Grassmann, Britta Jänicke, Marco Otto, Dieter Scherer

Chair of Climatology, Department of Ecology,
Technische Universität Berlin, Germany, fred.meier@tu-berlin.de

dated: 28 August 2015

<u>Netatmo newtwork</u>

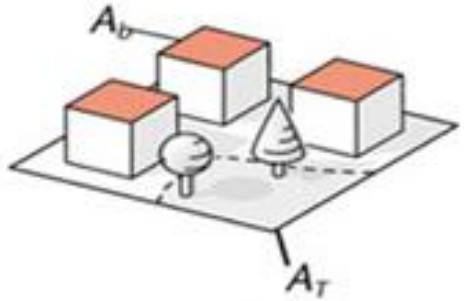
- Sampling frequency: 5 min
- Range: 0°C - 50°C (± 0.3 K)
- Power: 2 AAA battery / mini-USB
- Price: 169 EUR (01/17) + 69 EUR additional
- WiFi needed / range: 100m
- up to 3 additional devices per station



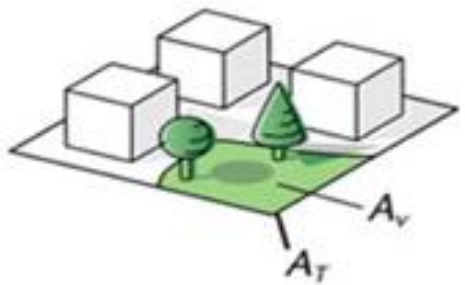
gure 5: Spatial distribution of urban heat island (UHI) intensities i.e. monthly maximum night-time

Urban cover

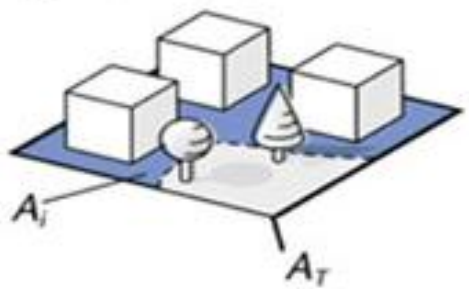
(a) $\lambda_b = A_b/A_T$



(b) $\lambda_v = A_v/A_T$

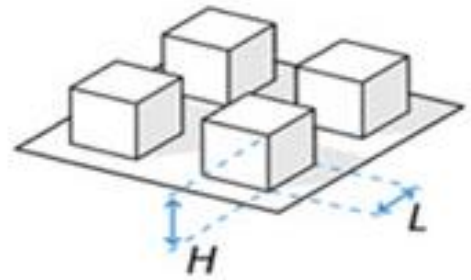


(c) $\lambda_i = A_i/A_T$

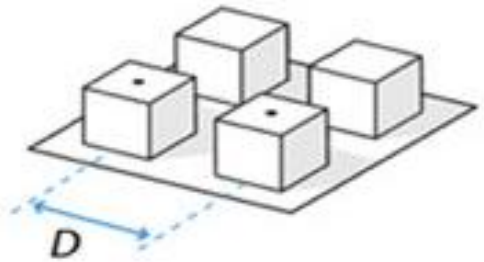


Length scales

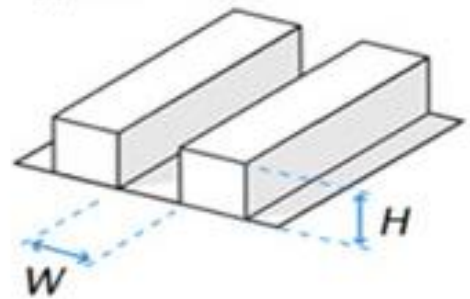
(d) Building dimensions



(e) Building spacing

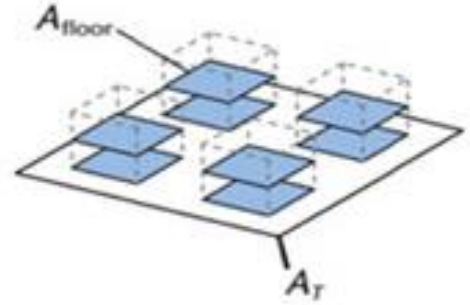


(f) $\lambda_s = H/W$

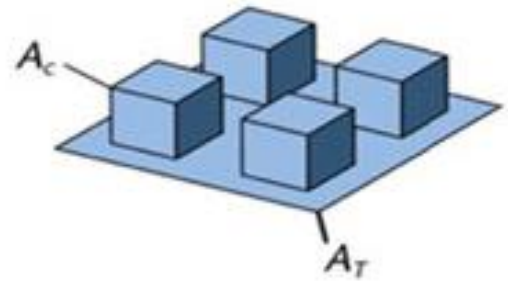


Urban structure

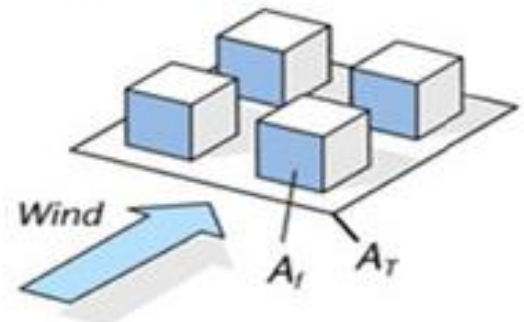
(g) $\lambda_{floor} = A_{floor}/A_T$



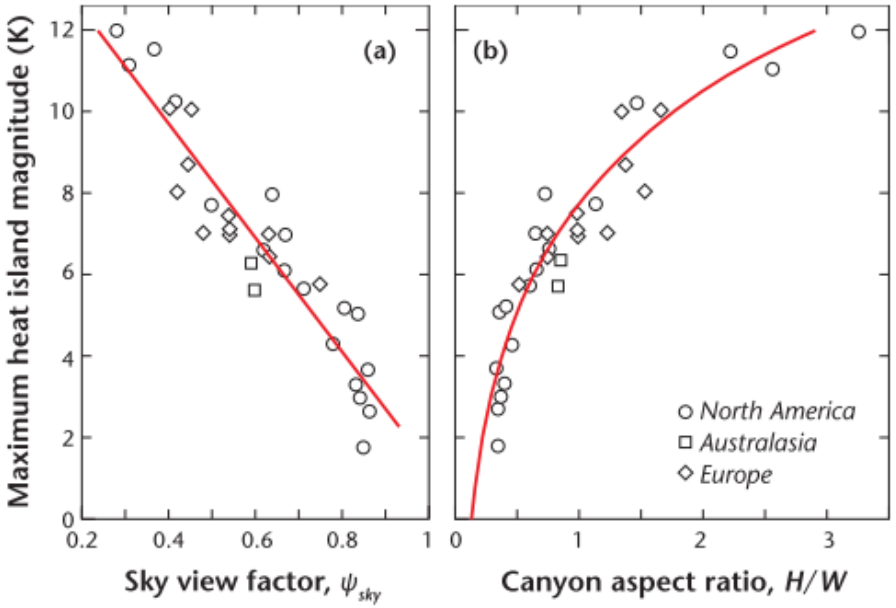
(h) $\lambda_c = A_c/A_T$

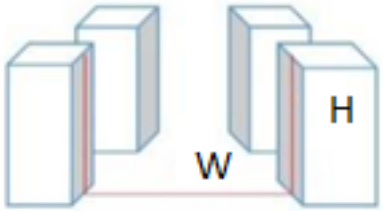


(i) $\lambda_f = A_f/A_T$

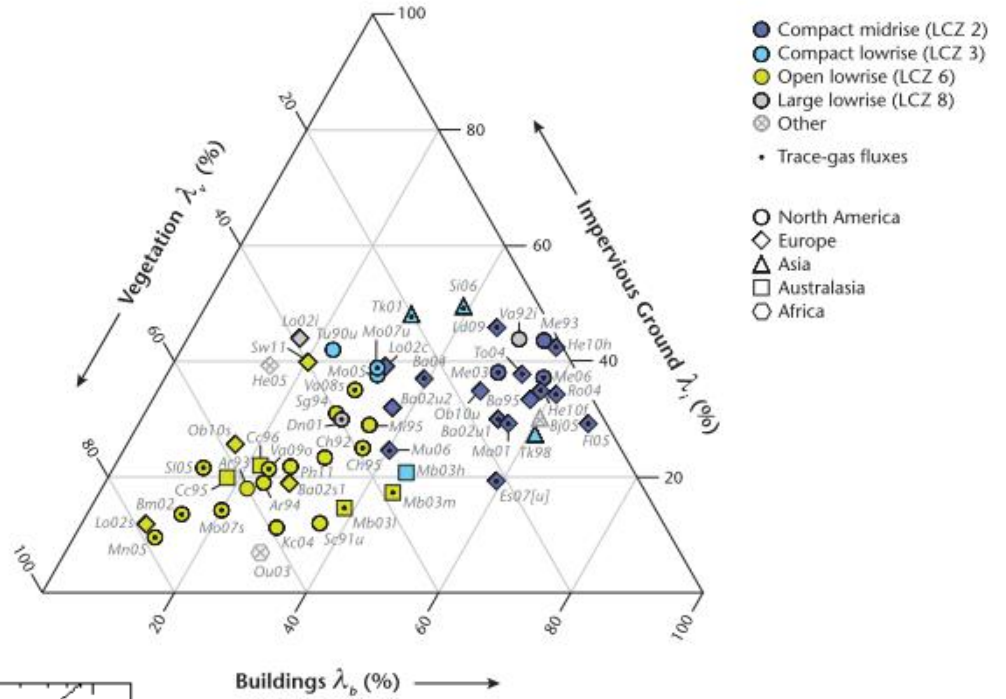


Form

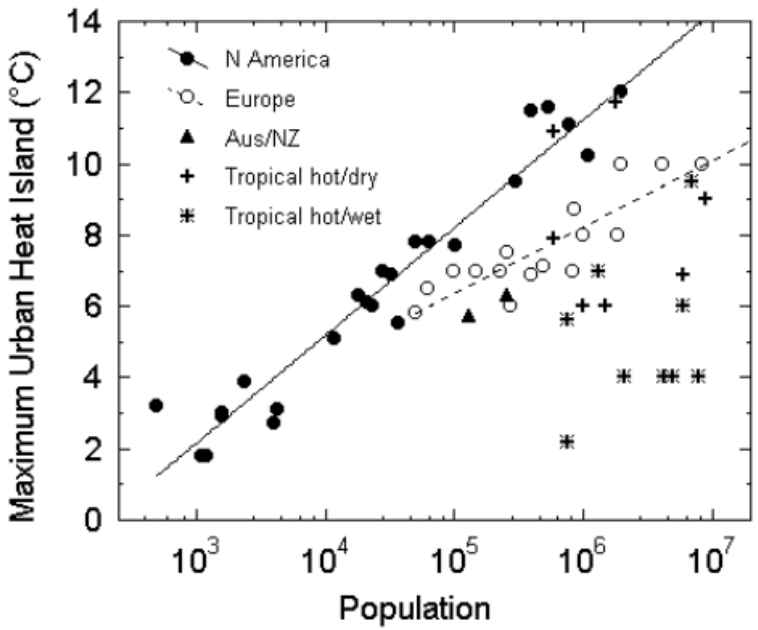




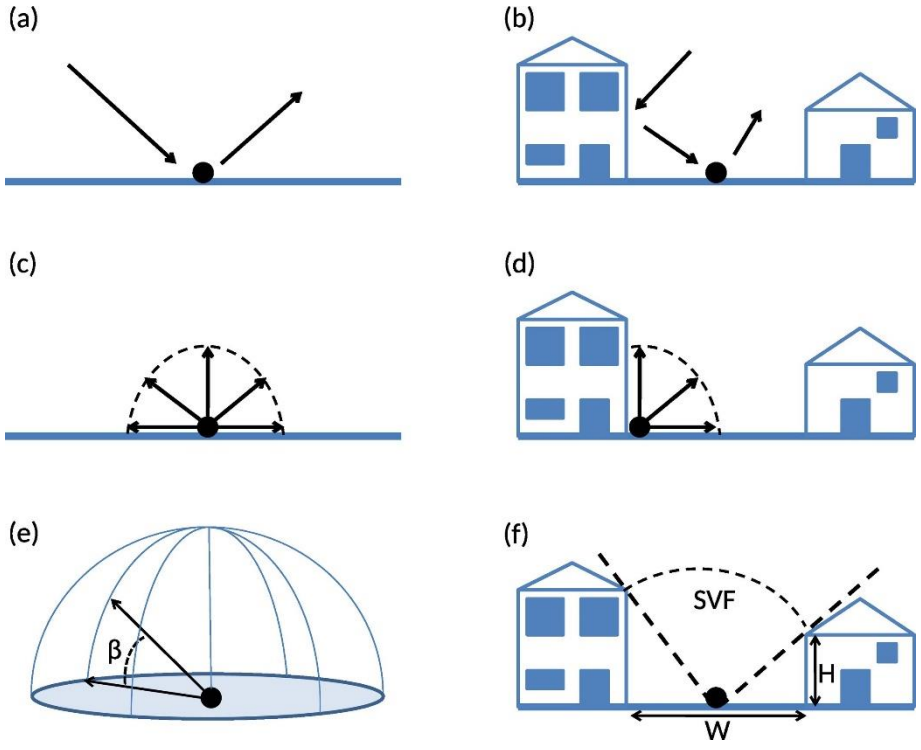
composition

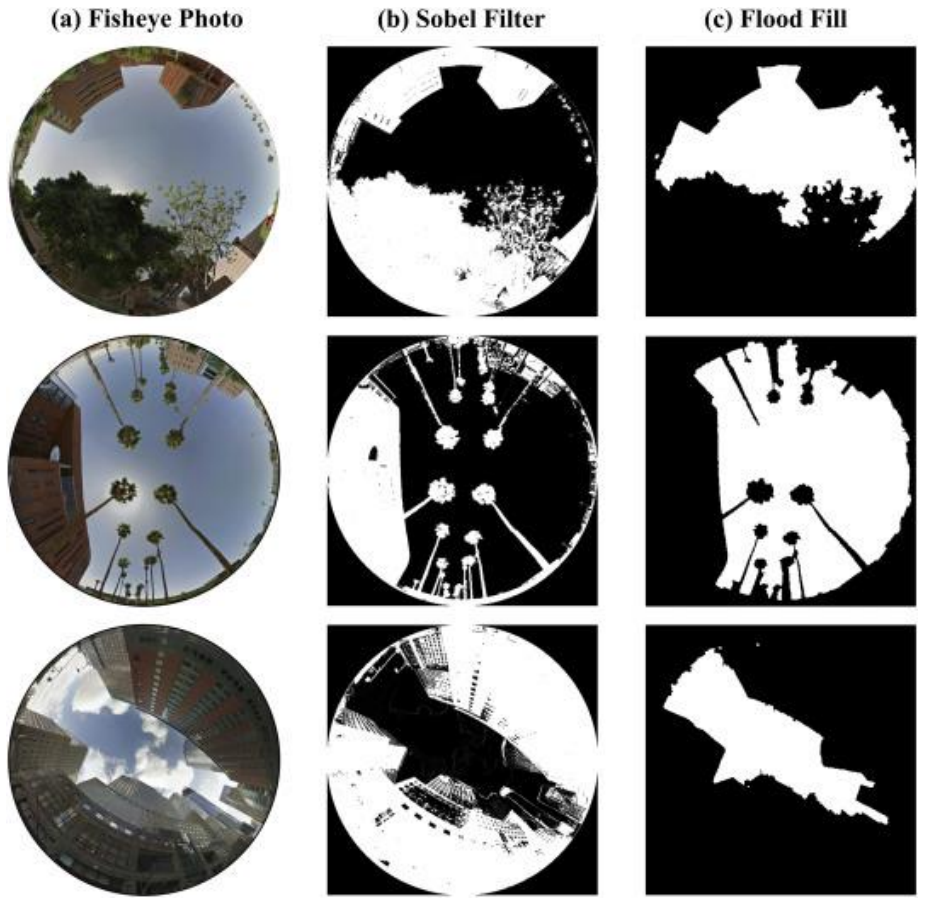


Size

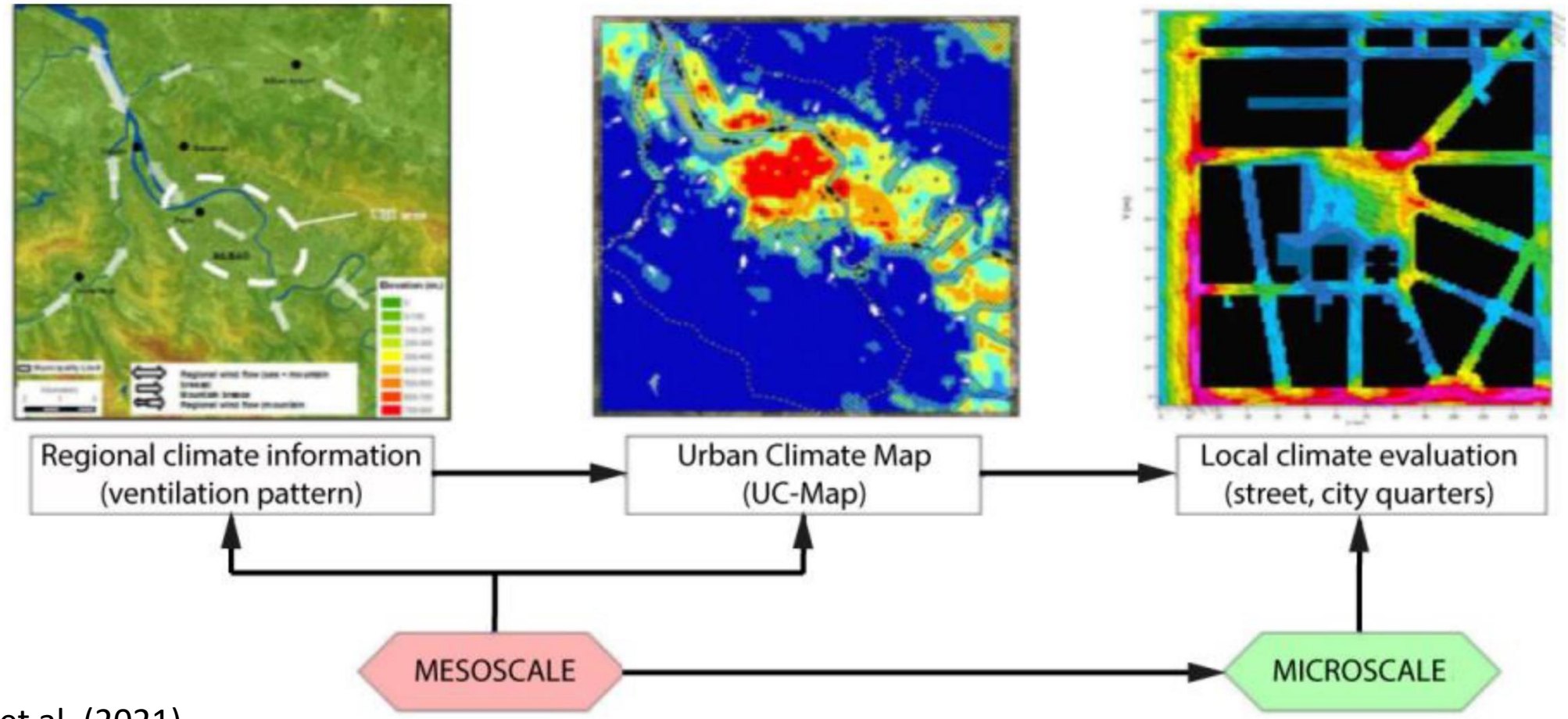


Sky View Factor – Fator de Visão do Céu





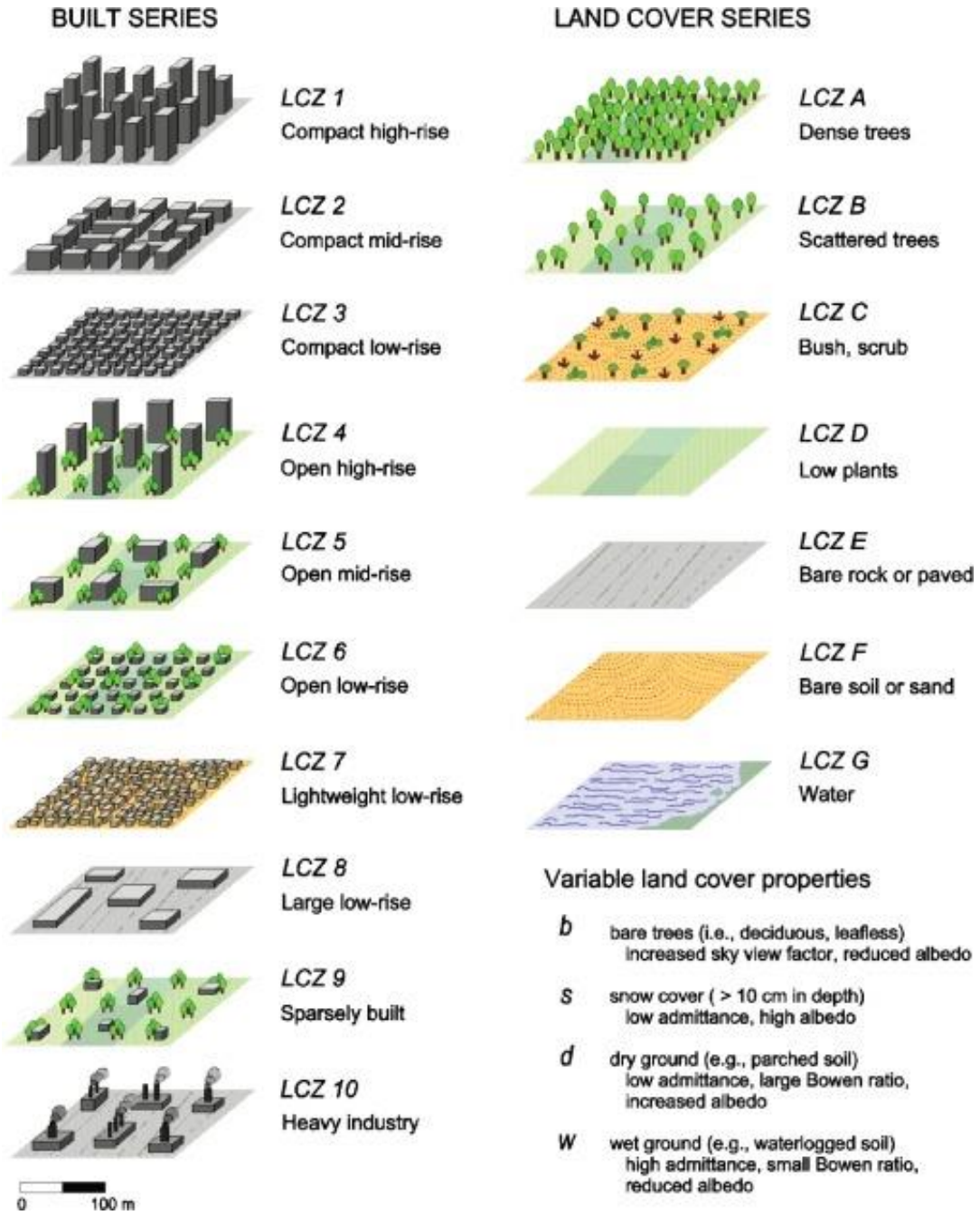
Da mesoescala à microescala climática



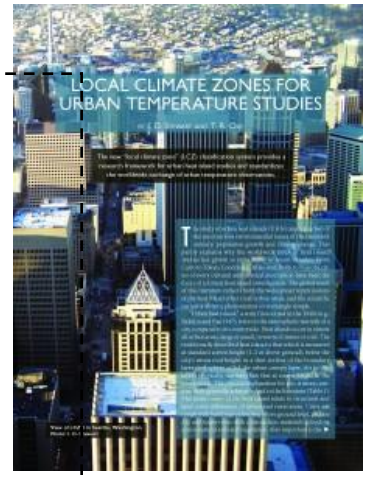
Lobaccaro et al. (2021)

Local Climate Zones – WUDAPT

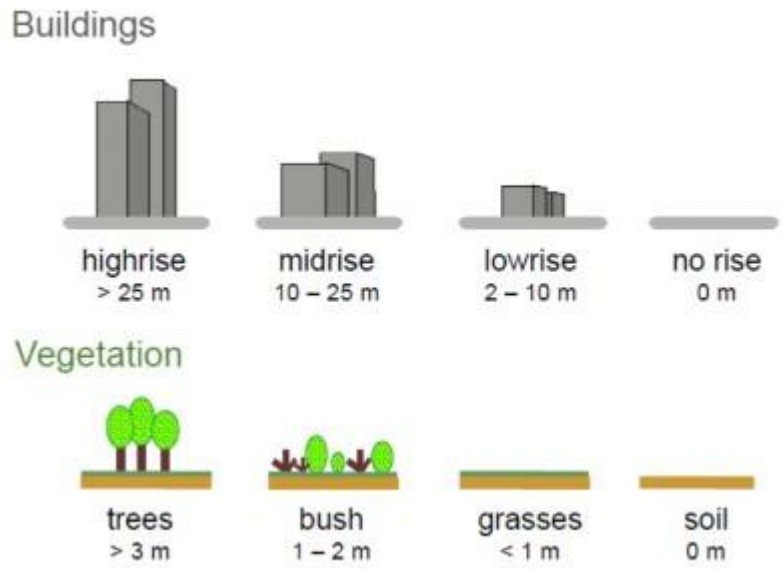
Como nos podem ajudar?



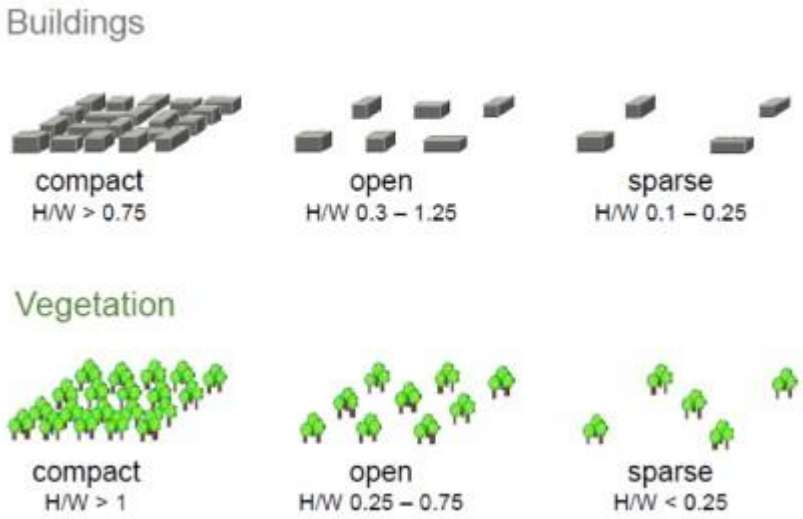
LCZ Framework



Component 1: Height of Roughness Features



Component 2: Packing of Roughness Features



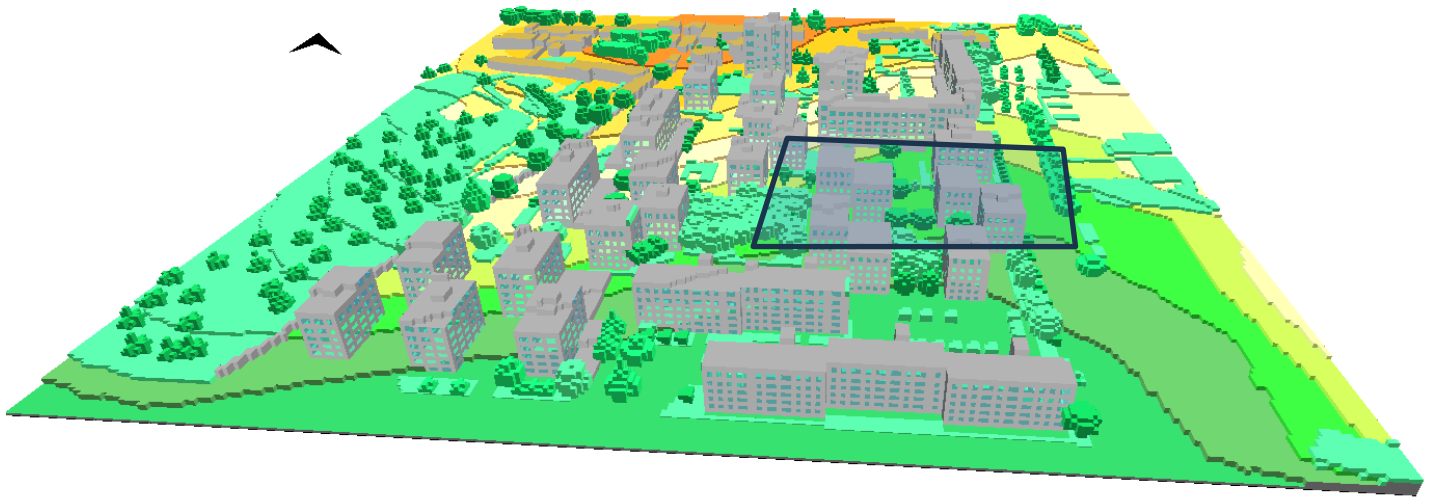
Component 3: Surface Cover Around Roughness Features

Component 4: Thermal Admittance of Materials

Source: Stewart, I.D., 2011. *Local climate zones: Origins, development, and application to urban heat island studies*. Paper presented at the Annual Meeting of the American Association of Geographers. Seattle, USA. April 12-16.

6. Exemplos e Conclusões (discussão na sessão Estúdio, à tarde)

Envi-met



Change or create model domain settings

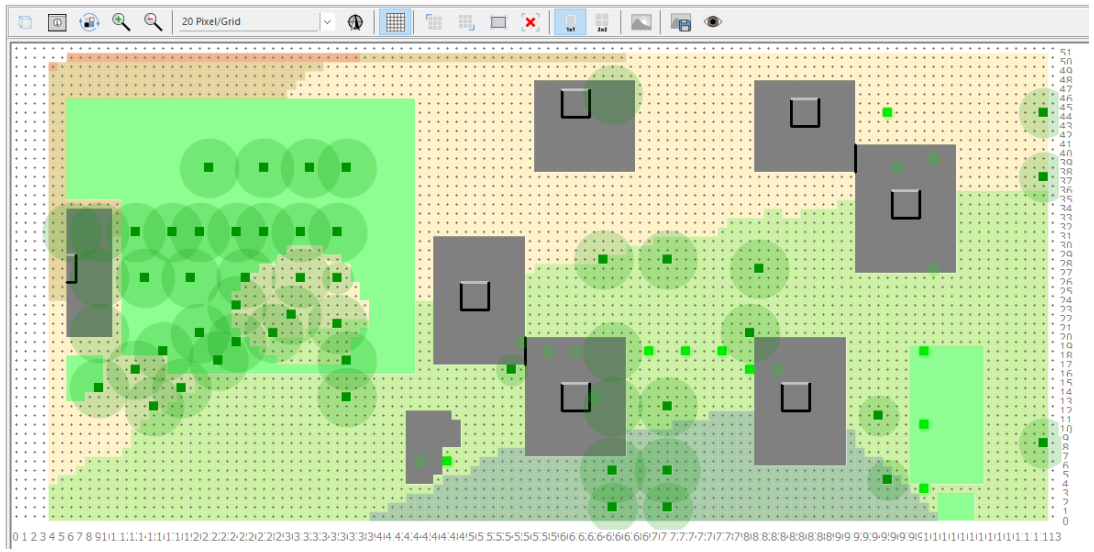
Model Location
Model Geometry
Georeference and DEM Level
Default Settings
Nesting Grids
Description and Copyrights

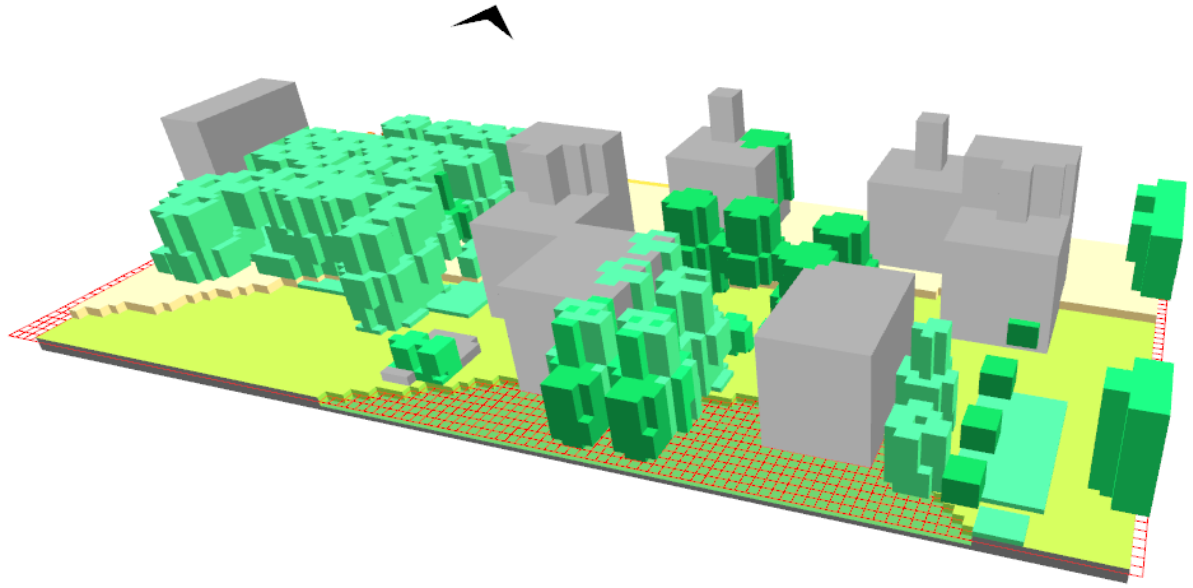
Model Geometry

Model Dimensions:
x-Grids: 114 y-Grids: 96 z-Grids: 10
Size of grid cell in meter:
dx= 2.00 dy= 2.00 dz= 5.00 (base height)
Method of vertical grid generation:
☑ dz of lowest gridbox is split into 5 subcells
☑ telescoping (dz increases with height)
Telescoping factor (%): 30.00
Start telescoping after height (m): 10.00

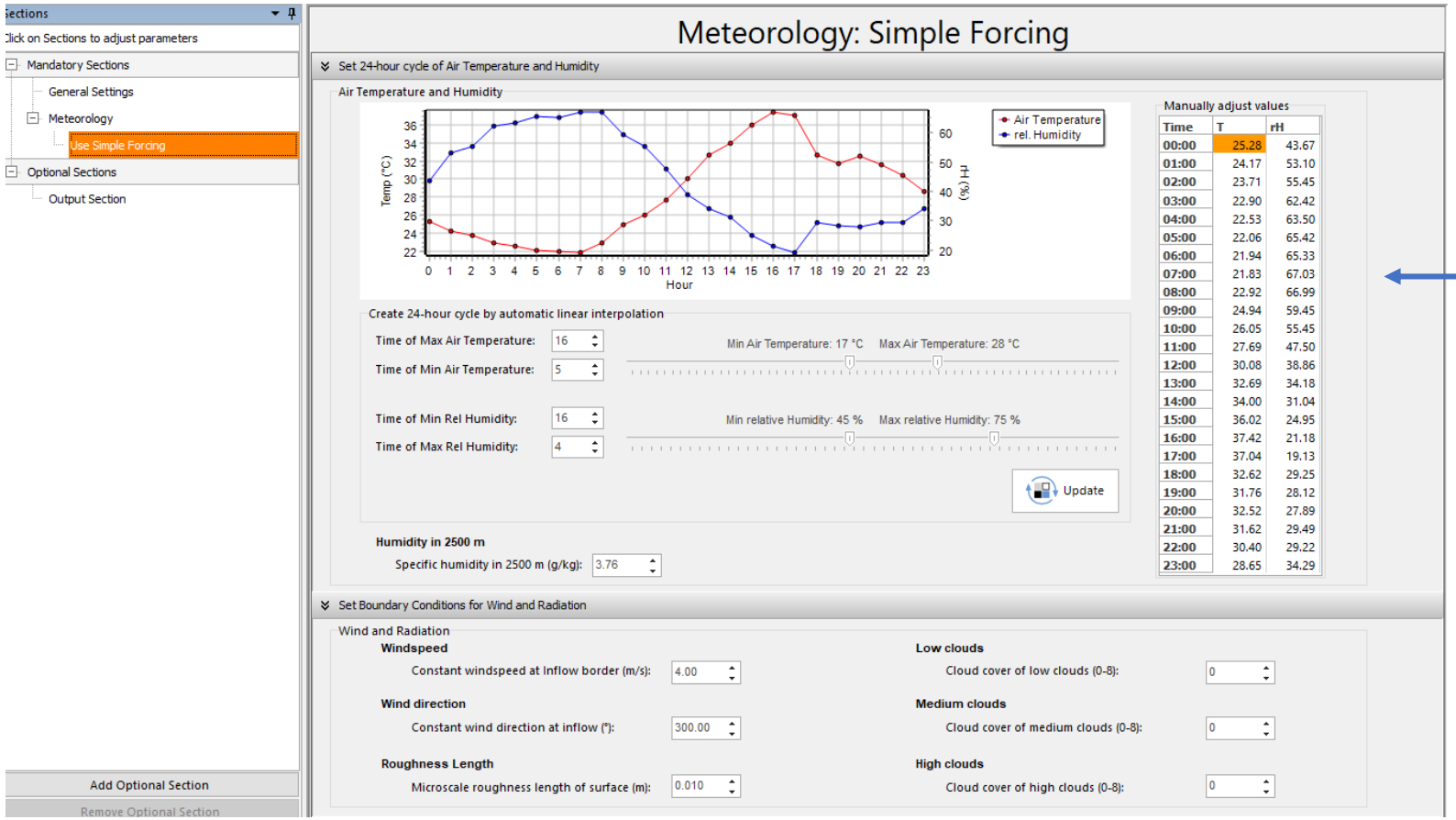
Model rotation out of grid north: 0.00

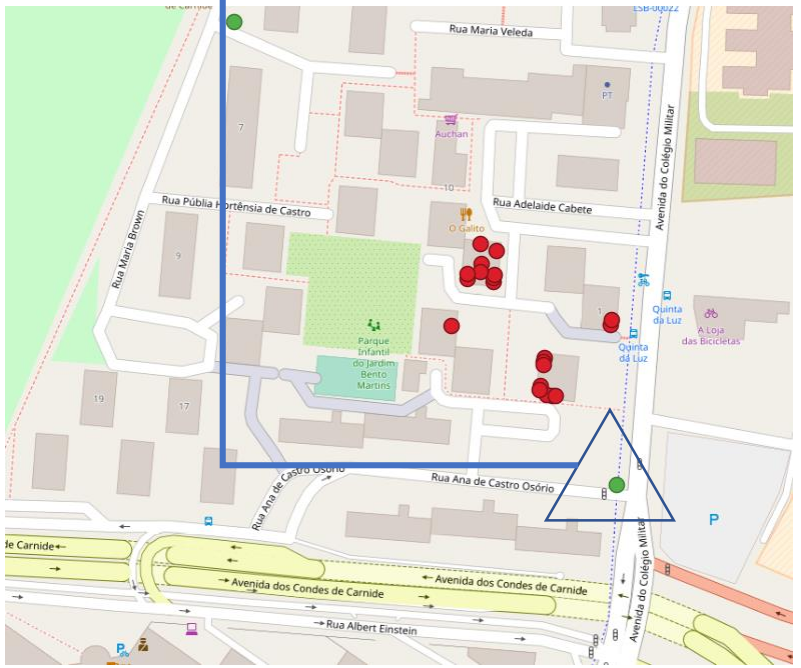
Maximum Model Size is 50x50x40 in ENVI-met LITE **Concept Design**





Meteorological forcing and initial conditions





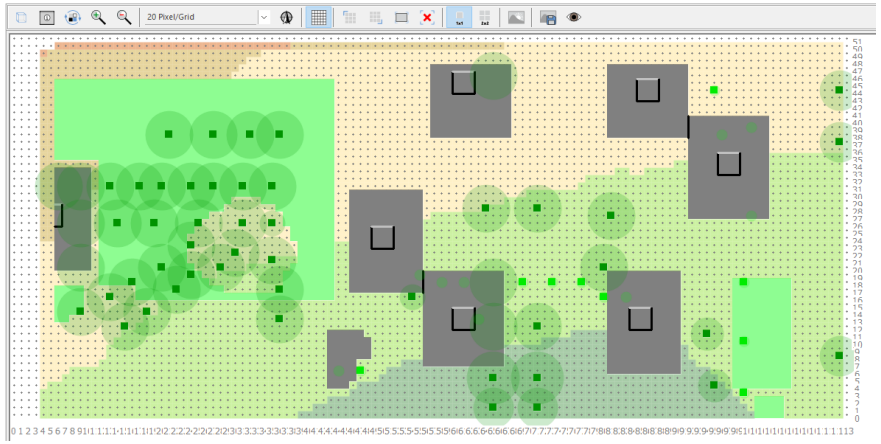
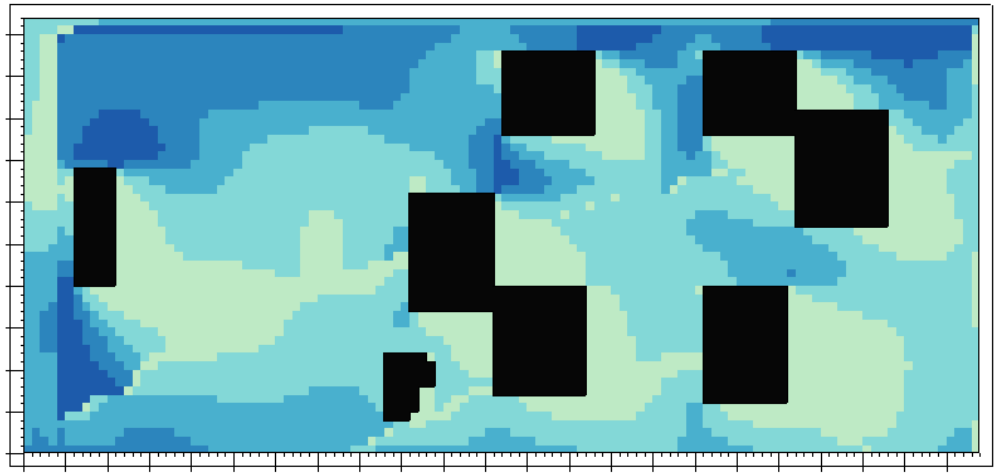
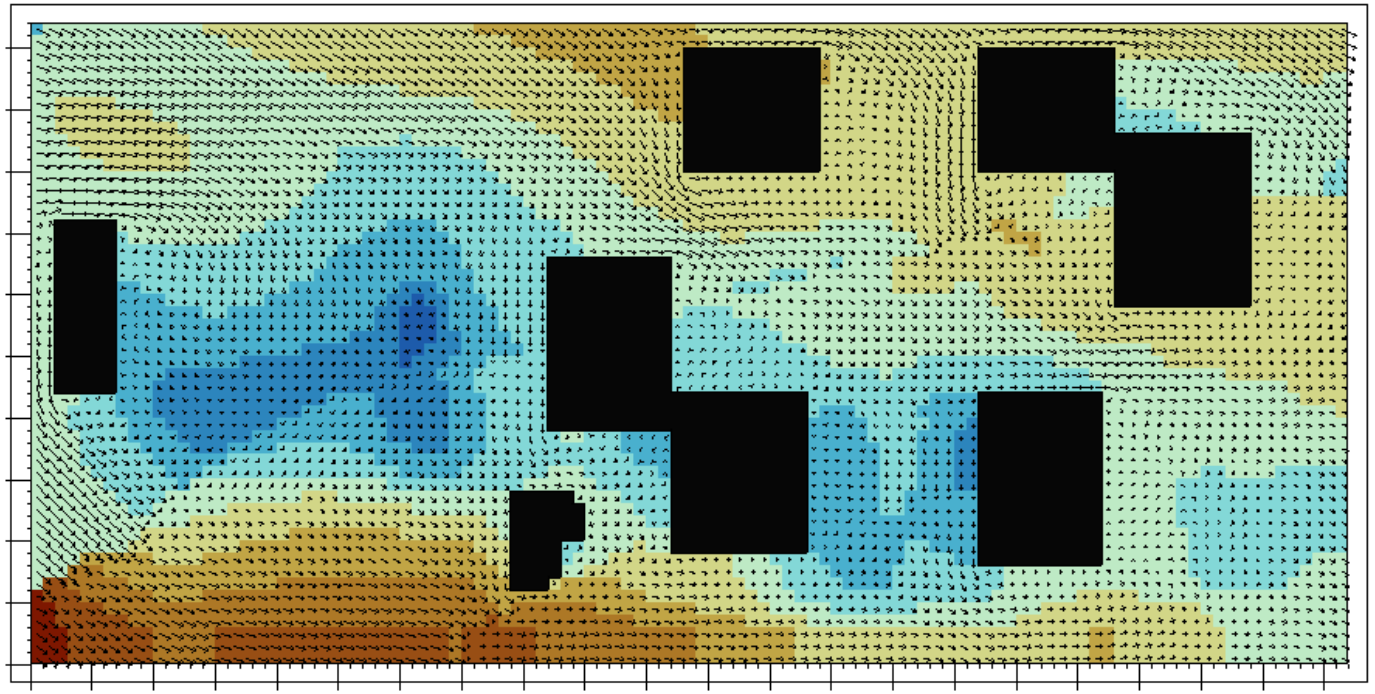


Figure 1: Carnide_INHALE
12.00.01 21.08.2022
x/y Cut at k=1 (z=1.5000 m) above terrain

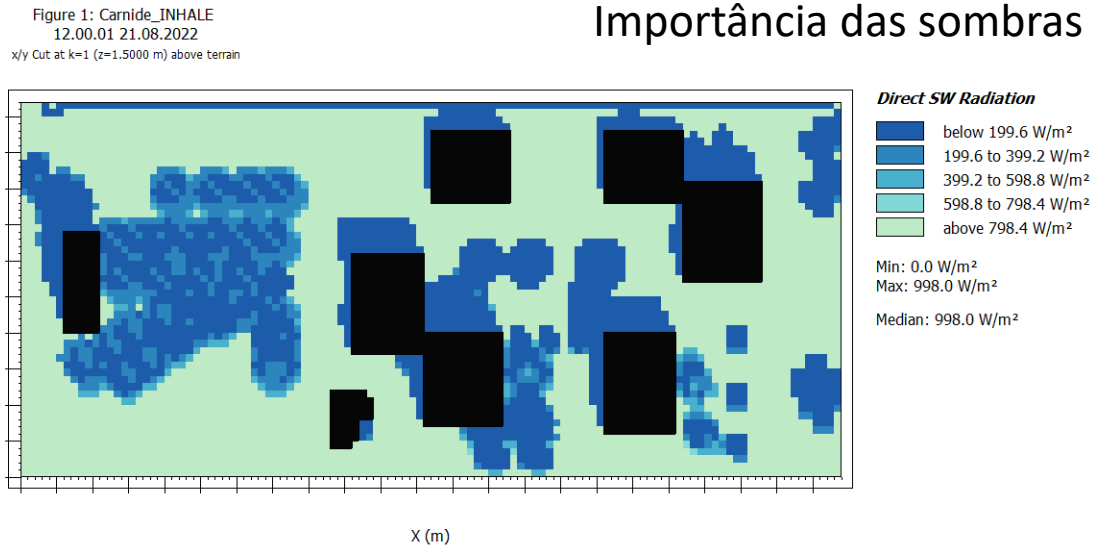
Figure 1: Carnide_INHALE
12.00.01 21.08.2022
x/y Cut at k=1 (z=1.5000 m) above terrain

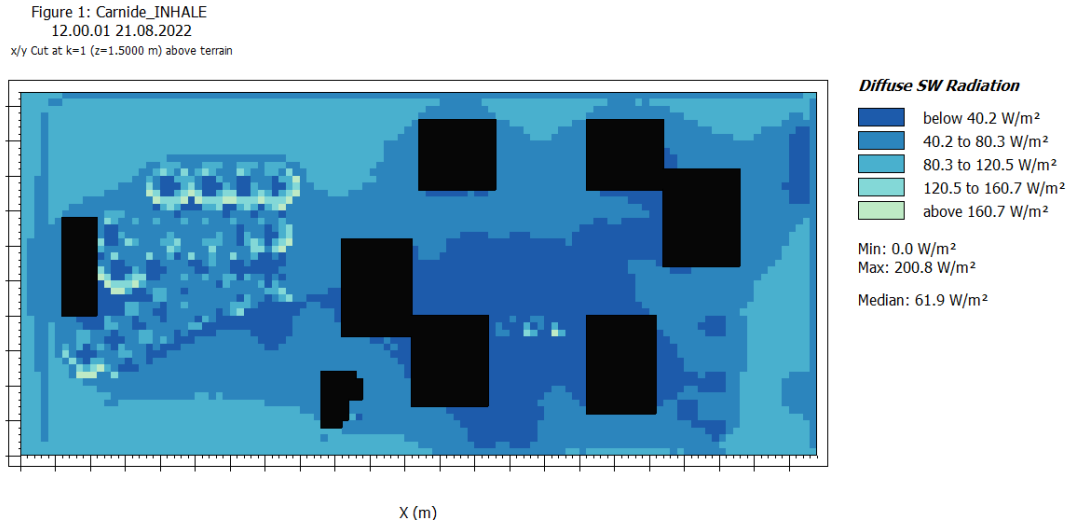




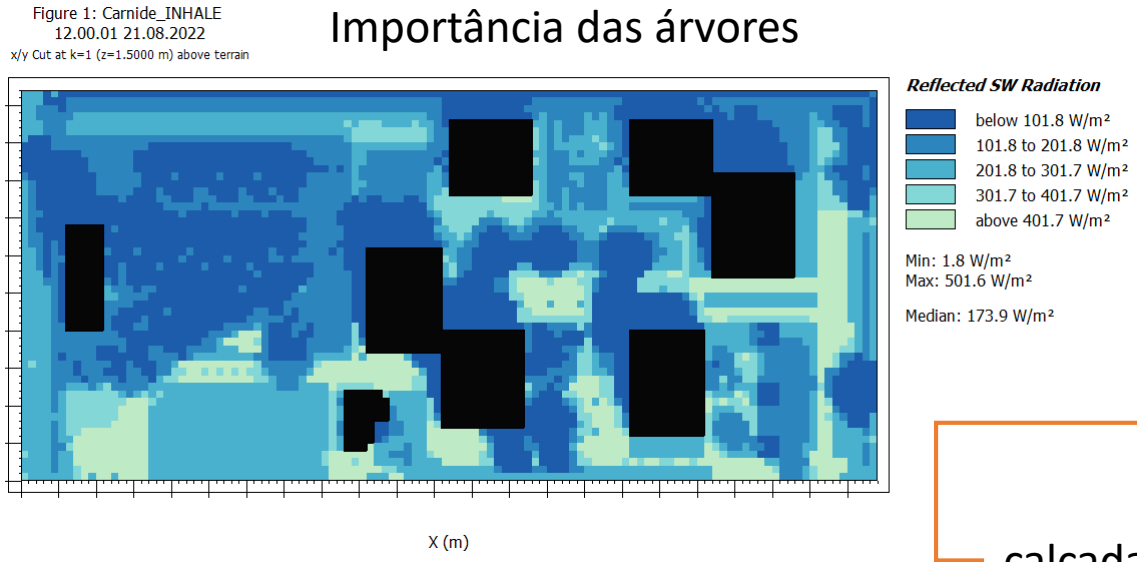
Componentes radiativas

Importância das sombras

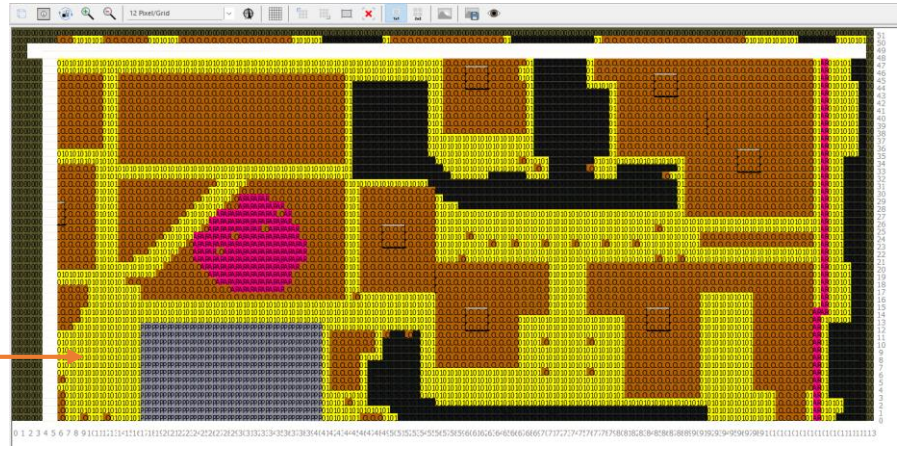




Importância das árvores



Propriedades radiativas dos materiais



calçada portuguesa (clara)

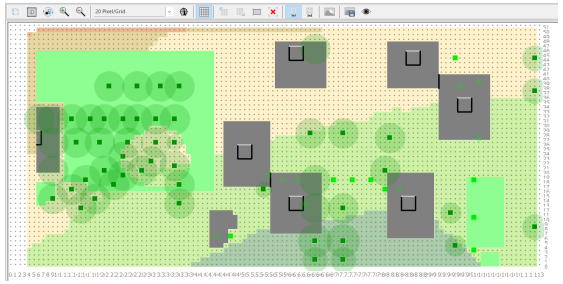
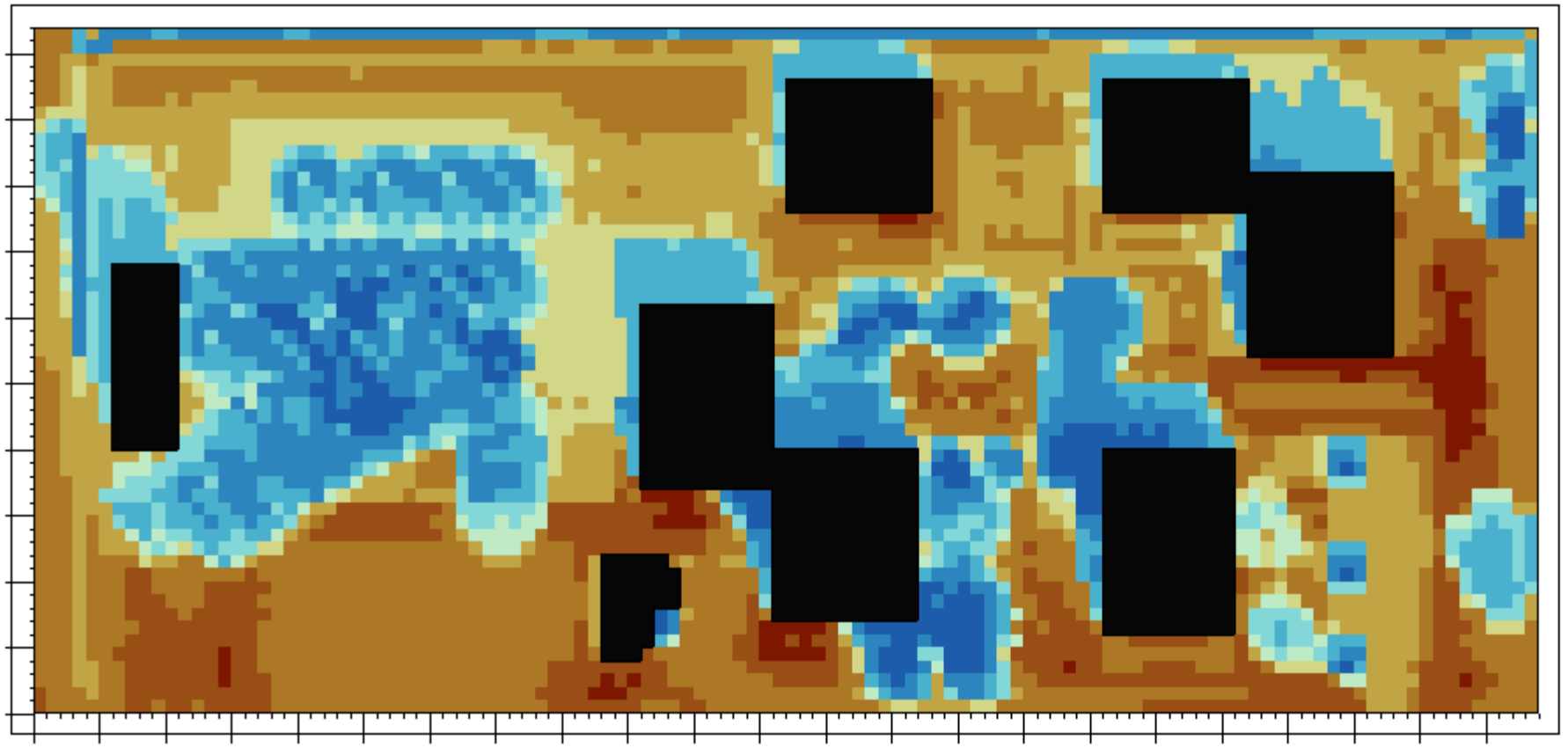


Figure 1: Carnide_INHALE
12.00.01 21.08.2022
x/y Cut at k=1 (z=1.5000 m) above terrain



X (m)

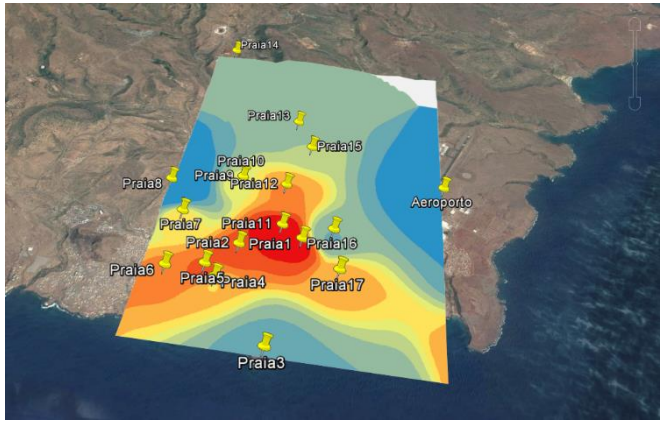
Mean Radiant Temp.

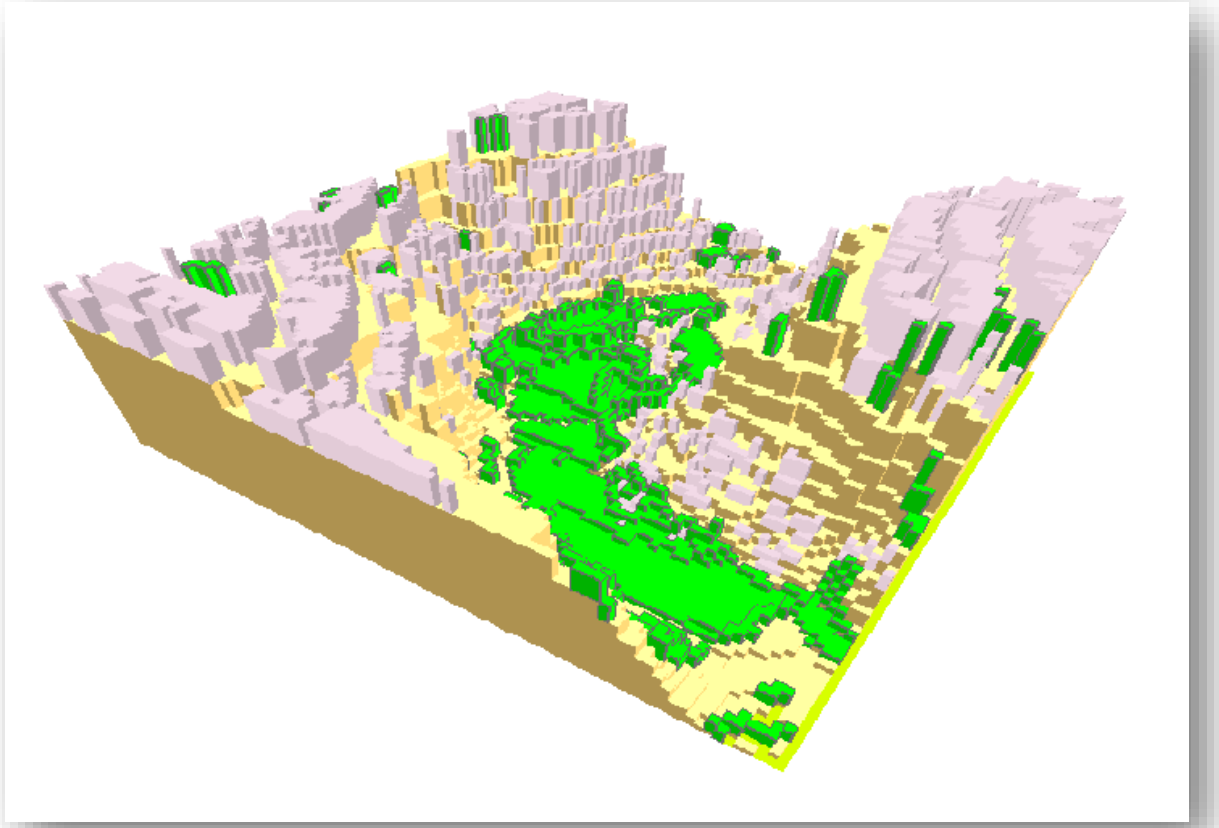
- below 25.9 °C
- 25.9 to 31.8 °C
- 31.8 to 37.6 °C
- 37.6 to 43.4 °C
- 43.4 to 49.2 °C
- 49.2 to 55.0 °C
- 55.0 to 60.9 °C
- 60.9 to 66.7 °C
- 66.7 to 72.5 °C
- above 72.5 °C

Min: 20.1 °C
Max: 78.3 °C

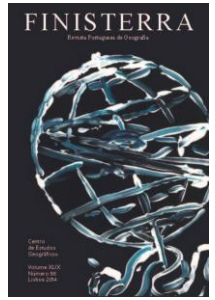
Median: 57.0 °C

- Micrometeorological modelling (Envimet)
- Bairro do Palmarejo (Praia Cabo Verde)



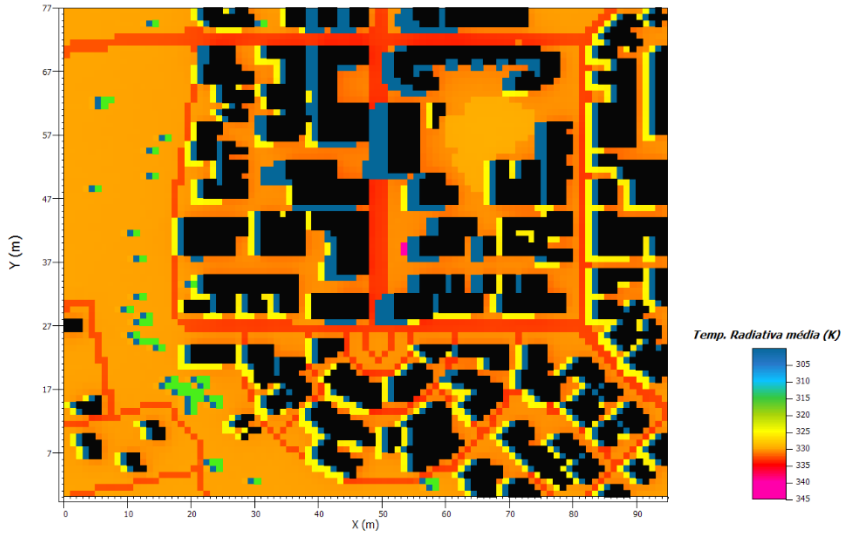


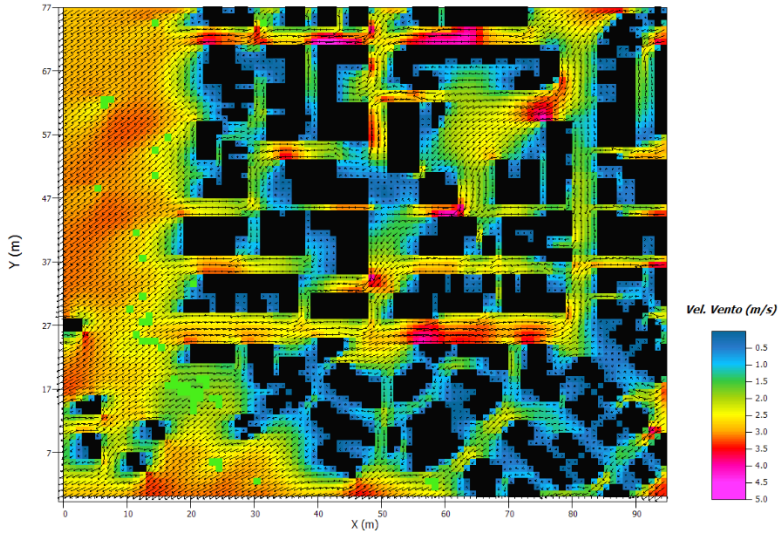
Finisterra, XLIX, 98, 2014, pp. 33-48

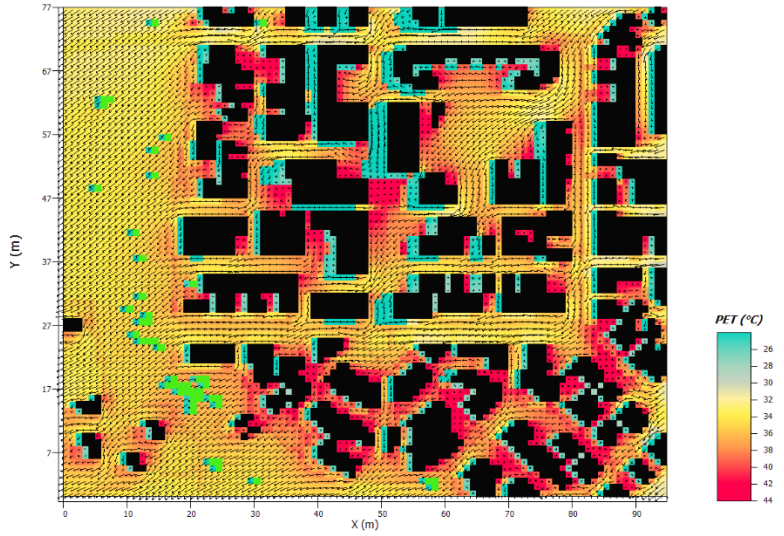


URBAN BIOCLIMATE AND COMFORT ASSESSMENT IN THE AFRICAN CITY OF PRAIA (CAPE VERDE)

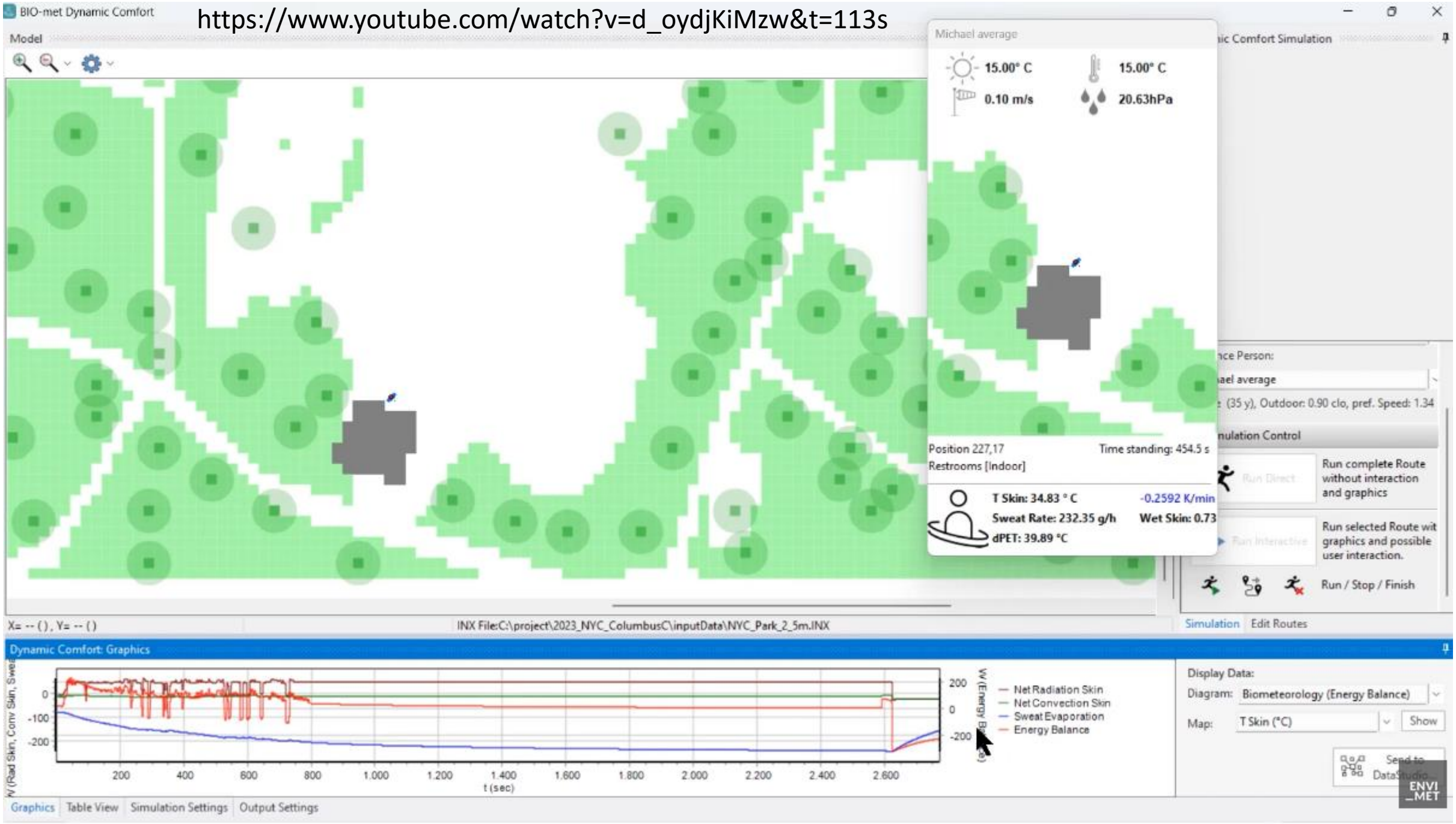
ANTÓNIO LOPES[1]
EZEQUIEL CORREIA[2]
JUDITE M. DO NASCIMENTO[3]
PAULO CANÁRIO[4]

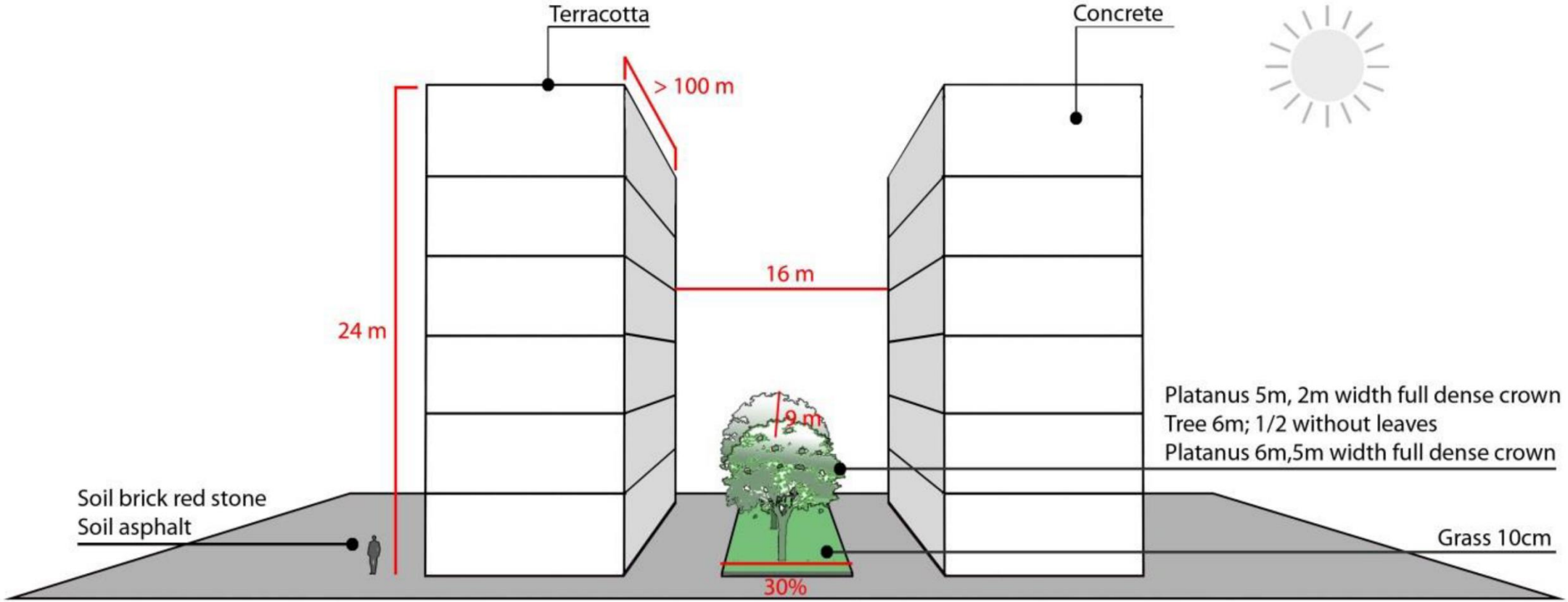






Temperatura radiativa média (MRT), vento (velocidade e direção) e PET (Temperatura Fisiológica Equivalente) (ao meio-dia) dia quente (15 de agosto de 2012) a 2m de altura


BIO-met Dynamic Comfort
https://www.youtube.com/watch?v=d_oydjKiMzw&t=113s
Model
Michael average
15.00° C
15.00° C
0.10 m/s
20.63hPa
Position 227,17
Time standing: 454.5 s
Restrooms [Indoor]
T Skin: 34.83 ° C
-0.2592 K/min
Sweat Rate: 232.35 g/h
Wet Skin: 0.73
dPET: 39.89 °C
Run complete Route without interaction and graphics
Run selected Route wit graphics and possible user interaction.
Run / Stop / Finish
Simulation
Edit Routes
X= -- ( ), Y= -- ( )
INX File:C:\project\2023_NYC_ColumbusC\inputData\NYC_Park_2_5m.INX
Dynamic Comfort: Graphics
Net Radiation Skin
Net Convection Skin
Sweat Evaporation
Energy Balance
t (sec)
Display Data:
Diagram:
Biometeorology (Energy Balance)
Map:
T Skin (°C)
Show
Graphics
Table View
Simulation Settings
Output Settings



Soil in asphalt	Soil in brick red stones	Façade in concrete	Roof Terracotta
Grass 10 cm	Platanus 5 m height and 2 m width; crown with all leaves	Tree 6 m height; crown without 1/2 of leaves and 2 m width	Platanus 6 m height, 5 m width crown without 1/2 of leaves

Lobaccaro et al. (2021)

Putting a Price on Urban Warming

The magnitude of overheating and pollution caused by selected major urban activities has to be assessed and controlled.
Liable entities exceeding the threshold and causing urban warming must pay a price for every warming or pollution unit, shortfall cost, or to surrender the appropriate number of allocated units.

With permission of M. Santamouris, UNSW, Sydney, Australia

Development of Super Cool Materials for Urban Overheating Mitigation

On the magnitude of Urban Climate Change, Its impact on Energy, Health, Productivity, Vulnerable Population, Economy and Environmental Quality. Heat Mitigation and Adaptation Potential and Proposals to Counterbalance Urban Heat

M. Santamouris, UNSW, Sydney, Australia

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