Clima urbano: desafios para o futuro

António Lopes
Instituto de Geografia e Ordenamento do Território
IGOT

Questões a abordar

1) Alterações climáticas globais e urbanas: ondas de calor e ilhas de calor urbano

2) Adaptar a infraestrutura verde urbana de forma a que se atenuem os efeitos de onda de calor e se aumente o sequestro de carbono, promovendo a criação de prados de sequeiro biodiversos e aumento da cobertura arbórea;

3) Promover a sustentabilidade da infraestrutura verde urbana através de redução de custo, implementando soluções de base natural

4) Soluções de Base Natural e soluções artificiais: desafios para o futuro

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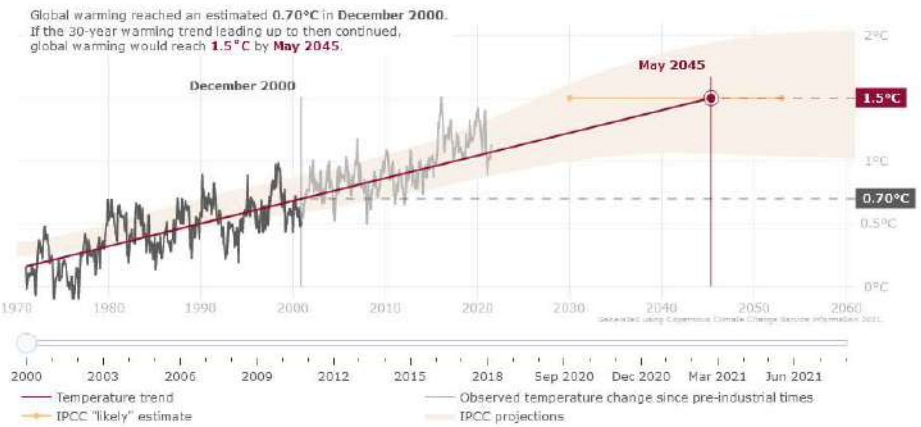
4) Soluções de Base Natural e soluções artificiais: desafios para o futuro

FAQ 1.2

How close are we to 1.5°C?

Summary: *Human-induced warming has already reached about 1°C above pre-industrial levels at the time of writing of this Special Report. By the decade 2006–2015, human activity had warmed the world by 0.87°C (±0.12°C) compared to pre-industrial times (1850–1900). If the current warming rate continues, the world would reach human-induced global warming of 1.5°C around 2040.*

Reaching 1.5°C of global warming - a limit agreed under the Paris agreement - may feel like a very distant reality, but it might be closer than you think. Experts suggest it is likely to happen between 2030 and the early 2050s. See where we are now and how soon we would reach the limit if the warming continued at today's pace. Use **the slider to explore how the estimate changes in time.**



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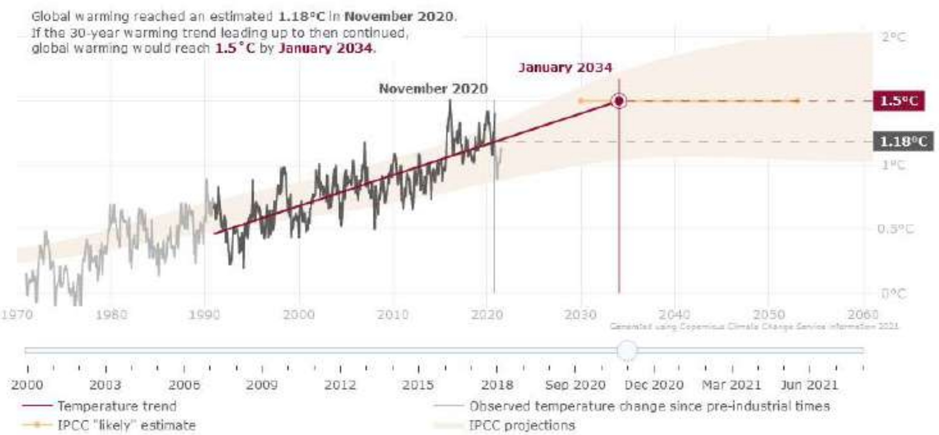

https://cds.climate.copernicus.eu/cdsapp?fbclid=IwAR3NQ4cML8KhknA3yLXzRIT7YcQzDhGUaB9RvnkbALMv8LTbEJIlaRLjXIA#!/software/app-c3s-global-temperature-trend-monitor?tab=app

The main problem driving “heat islands” – urban areas that experience higher temperatures than neighboring areas – is tall buildings. Other factors include poor urban geometry, density, and building construction “and color materials”.

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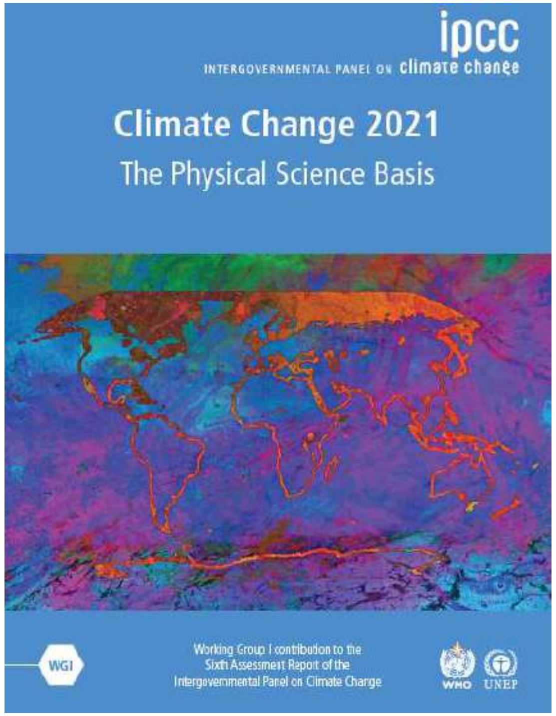
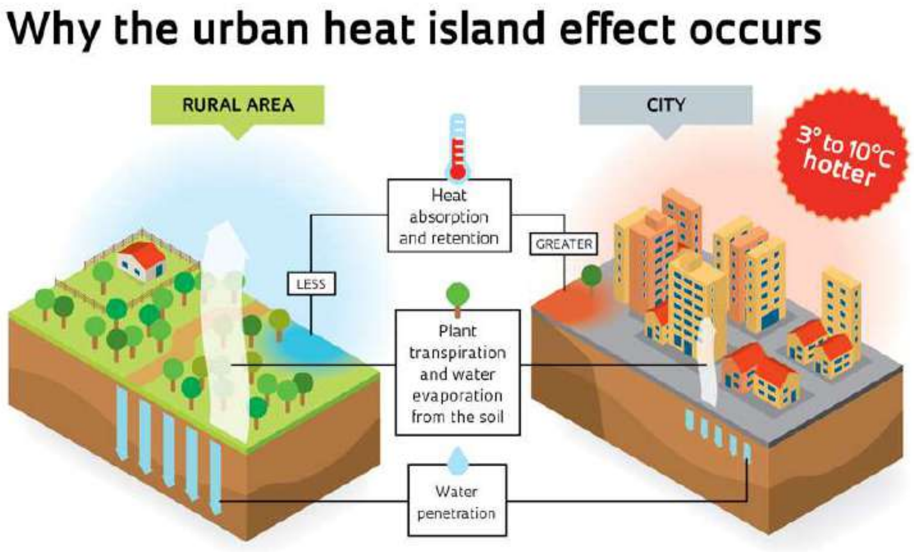


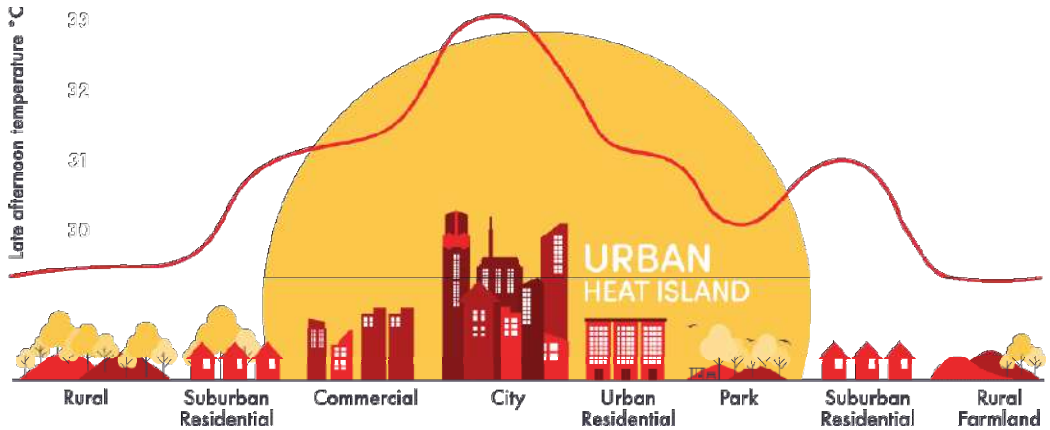
- Ilha de calor urbana (UHI) :

  "Ilha" formada pelo ar mais quente da atmosfera urbana (superior e inferior), rodeada por ar "rural" mais fresco. Termo também usado para a temperatura de superfície.

- Intensidade da ilha de calor (ΔT_{u-r}):

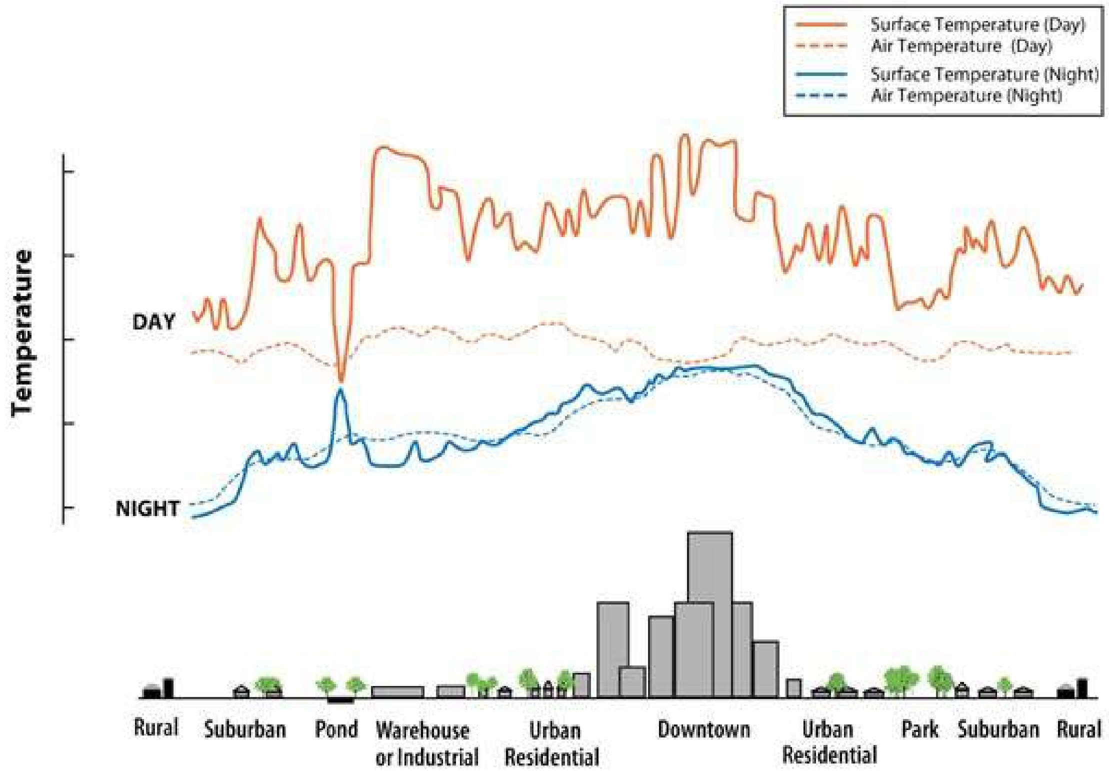
  a máxima diferença entre o valor mais elevado da temperatura na cidade e a temperatura dos arredores rurais (Oke, 1987).



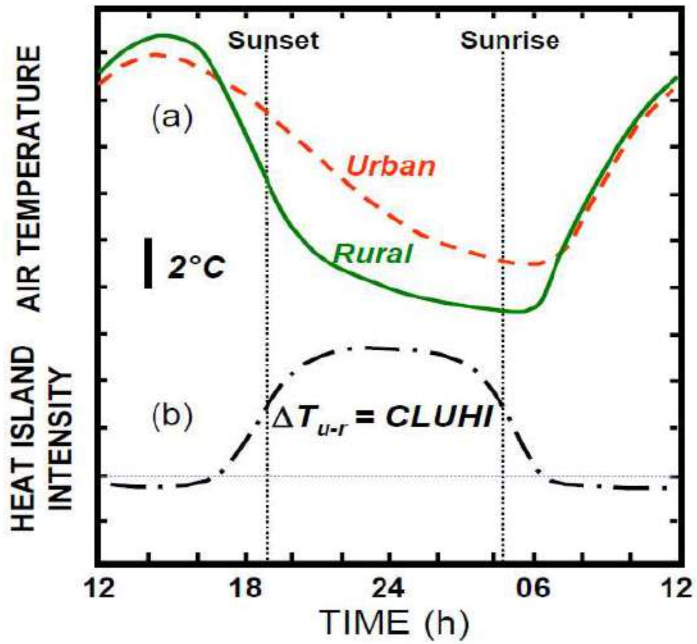


As Ilhas de calor urbano

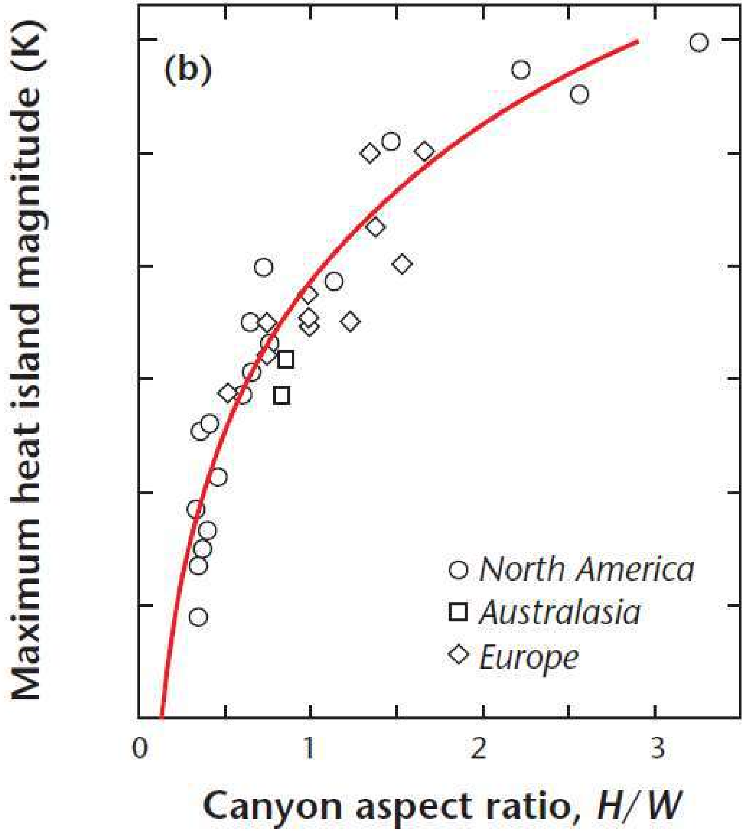
Excessivo aquecimento: efeito regional + efeito local

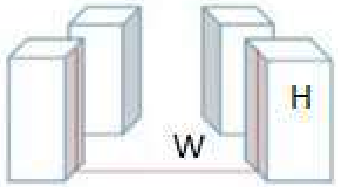


http://www.epa.gov/heatisld/about/index.htm



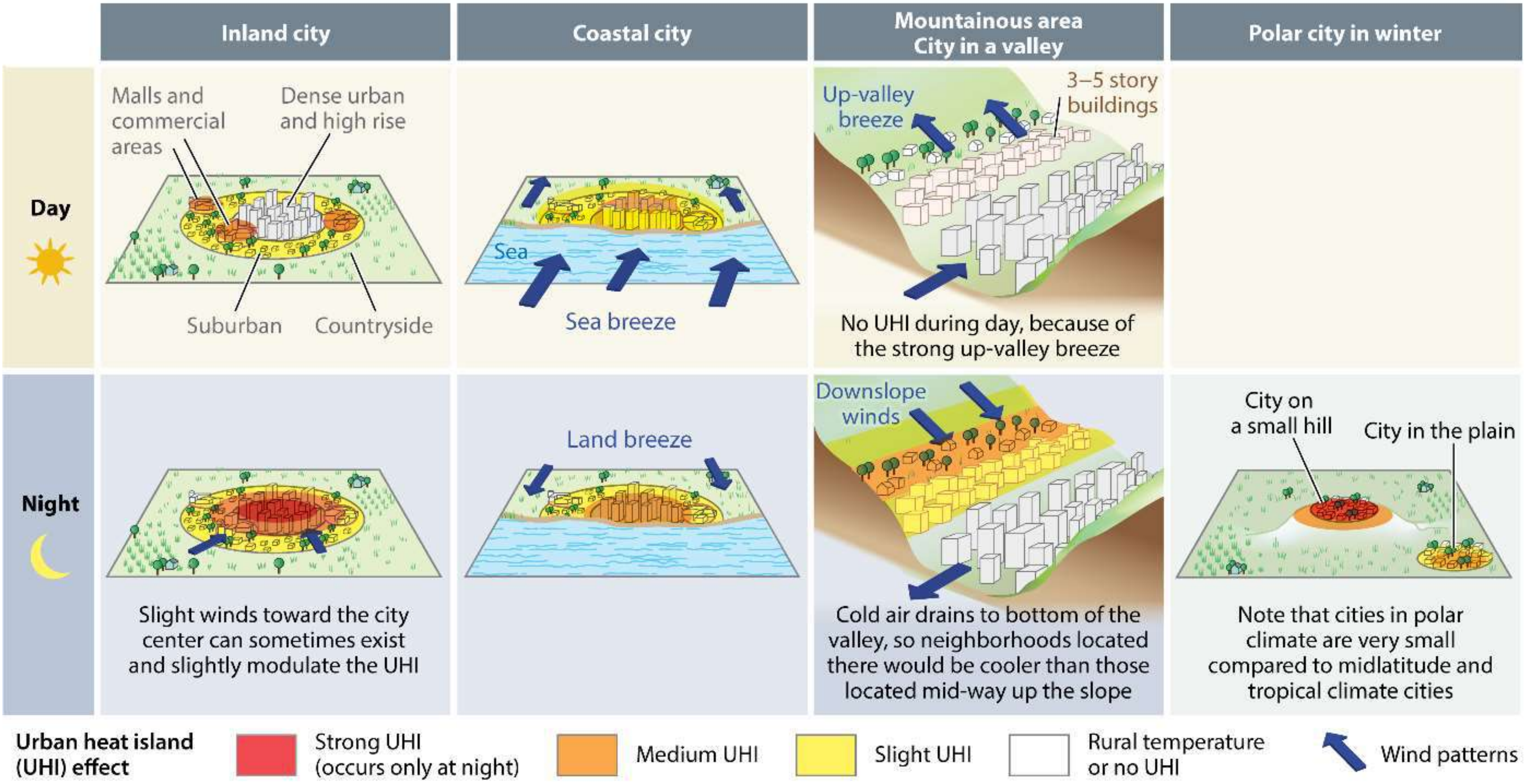
Urban geometry and density and UHI Intensity





Oke et al (2017)

Annual Reviews



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

Recent advances in urban climate and applications


Urban Climate 43 (2022) 101168

Contents lists available at ScienceDirect

Urban Climate

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

Assessing urban heat island effects through local weather types in Lisbon's Metropolitan Area using big data from the Copernicus service

Cláudia Reis[a,*], António Lopes[a,b], A. Santos Nouri[c]

[a] Universidade de Lisboa, Institute of Geography and Spatial Planning (IGOT), Centre of Geographical Studies, Rua Branca Edmée Marques, Cidade Universitária, 1600-276 Lisboa, Portugal

[b] Associated Laboratory Terra, Lisboa, Portugal

[c] Department of Interior Architecture and Environmental Design, Faculty of Art, Design and Architecture, Bilkent University, Bilkent, Turkey

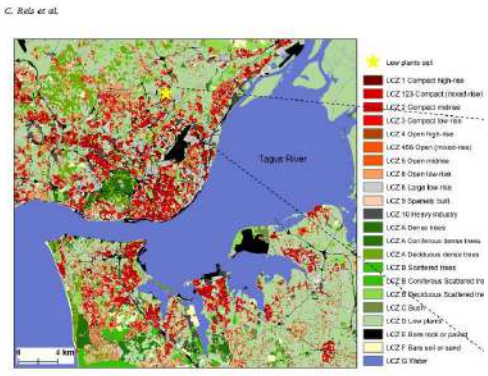
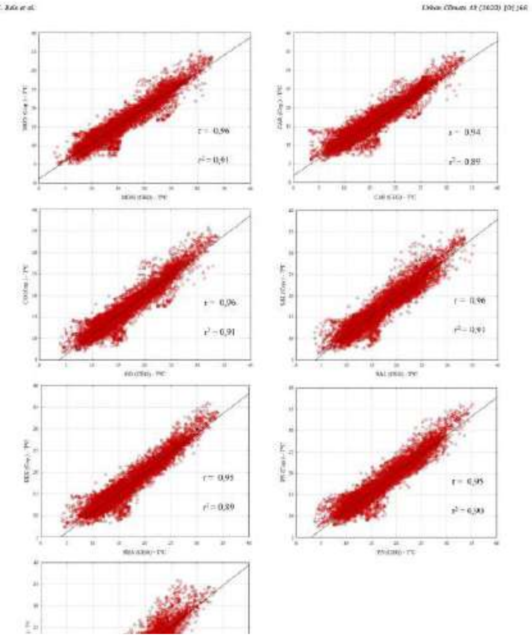
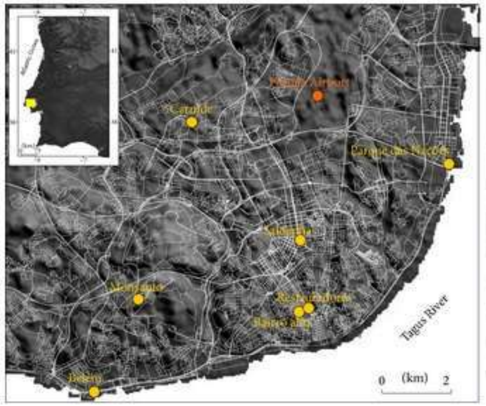


Fig. 4. LMA's updated LCZ (Oliveira et al., 2020b) and location





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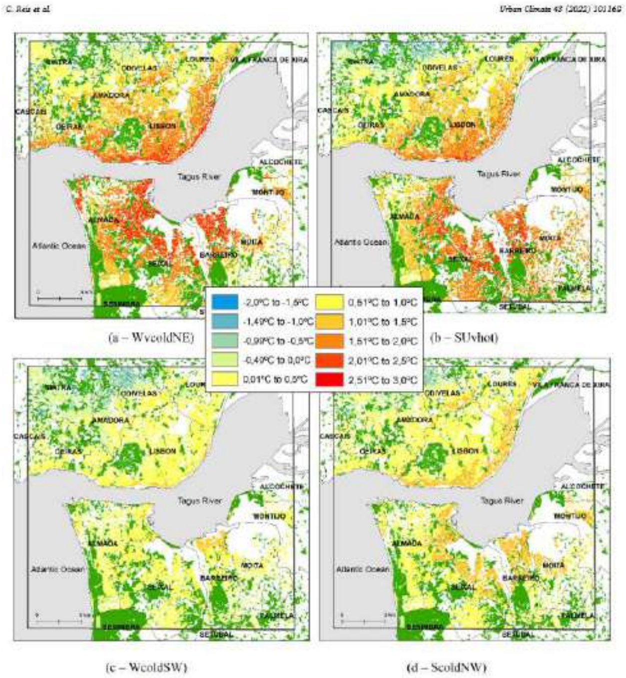


Fig. 8. LMA UHI, in urban areas (other types are excluded) on (a) very cold winter days with NE and E winds (WvcoldNE); (b) Very hot, sunny, and humid summer days with moderate N winds (SUvhot); (c) Cold, cloudy, and rainy winter days with moderate SW and W winds and; (d) Cold, cloudy and dry spring days with weak precipitation and moderate and variable winds (especially from NW, SW, and W). Green spaces area represented in dark green. Non-urban areas are represented in white. (For interpretation of the references to colour in this figure legend, the reader is referred to

Intensidade da Ilha de Calor ($\Delta T_{u\text{-}r}$)

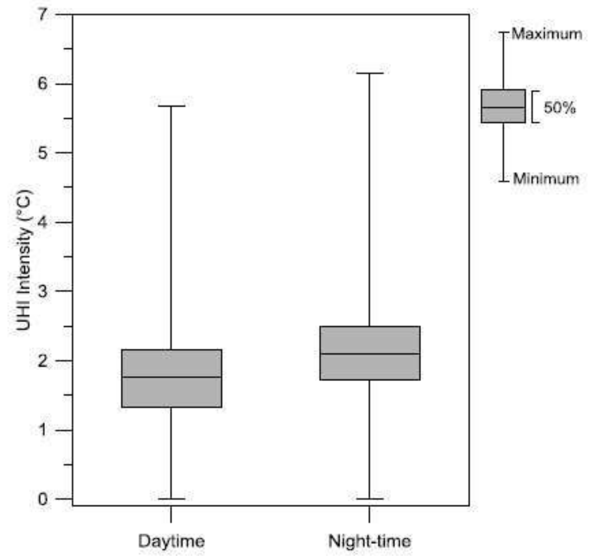
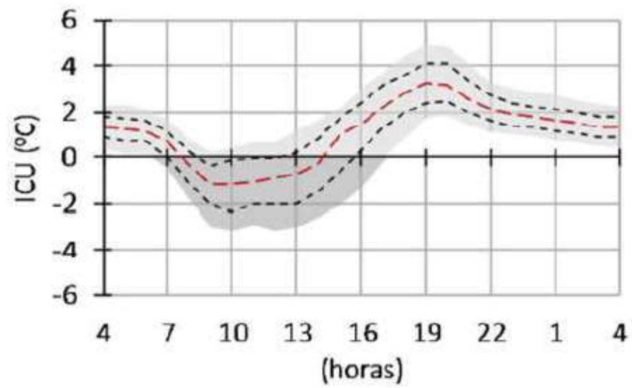


Fig. 5 – Daytime (10:00-18:00h) and night-time (20:00-6:00h) box-plots of the urban heat island intensity (UHII).

Fig. 5 – Blox plots da intensidade da ilha de calor diurna (10-18h) e nocturna (20-6h).

Data source: CliMA-CEG-ULisboa

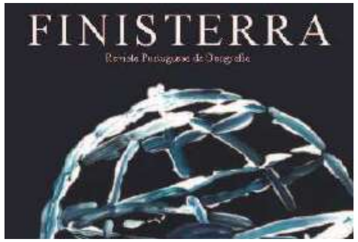


Anomalia entre as estações dos Restauradores e Saldanha e o Aeroporto de Lisboa, registadas pela rede de observação do IGOT (2004-2014)

Finisterra, XLIX, 98, 2014, pp. 61-80

LISBON HEAT ISLAND
STATISTICAL STUDY (2004-2012)

Maria João Alcoforado[1]
António Lopes[2]
Elis Dener Lima Alves[3]
Paulo Canário[4]



Ritmos anual e horário da Intensidade da Ilha de Calor (ΔT_{u-r})

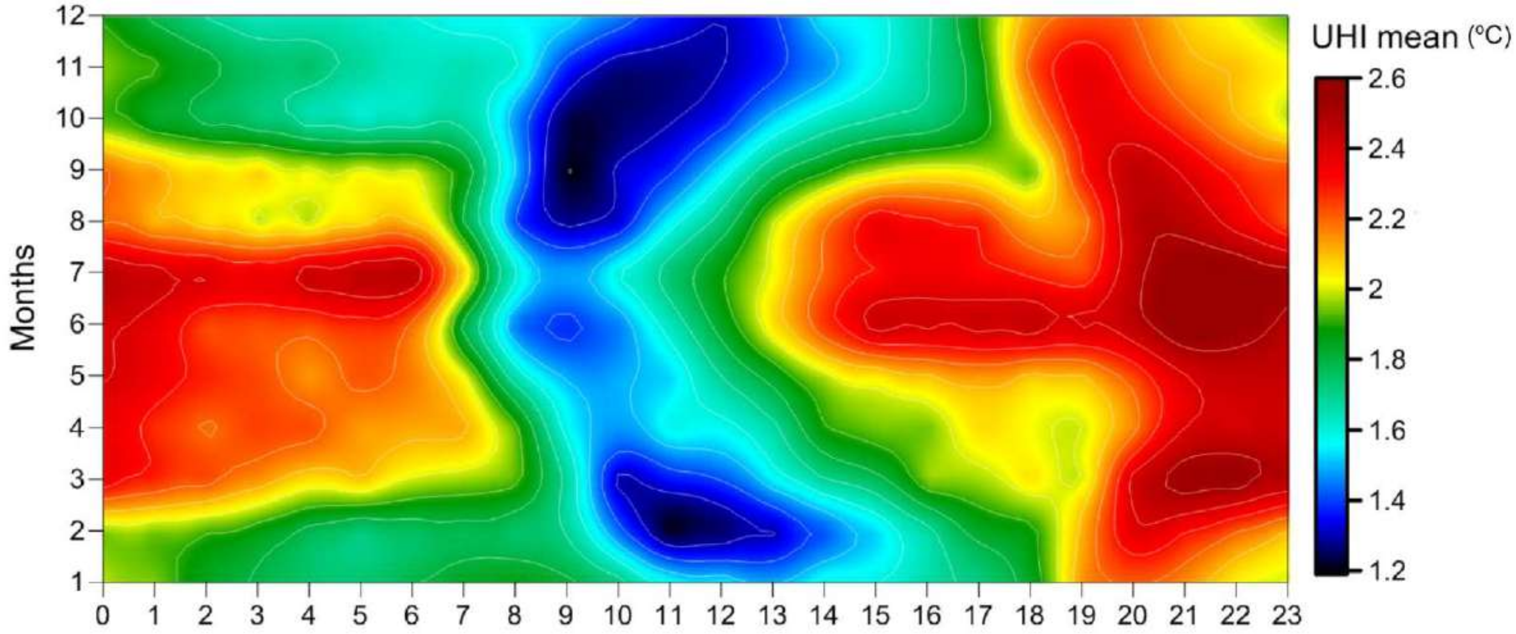
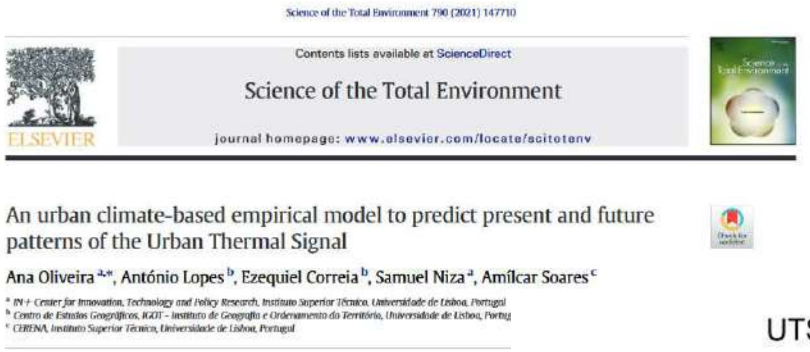


Fig. 7 – Lisbon's mean UHII versus time of the day for the 12 months of the year (2004-2012).
(See coloured version online)
Fig. 7 – Intensidade média mensal e horária da ilha de calor em Lisboa (2004-2012).


Science of the Total Environment 790 (2021) 147710

Contents lists available at ScienceDirect

Science of the Total Environment

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

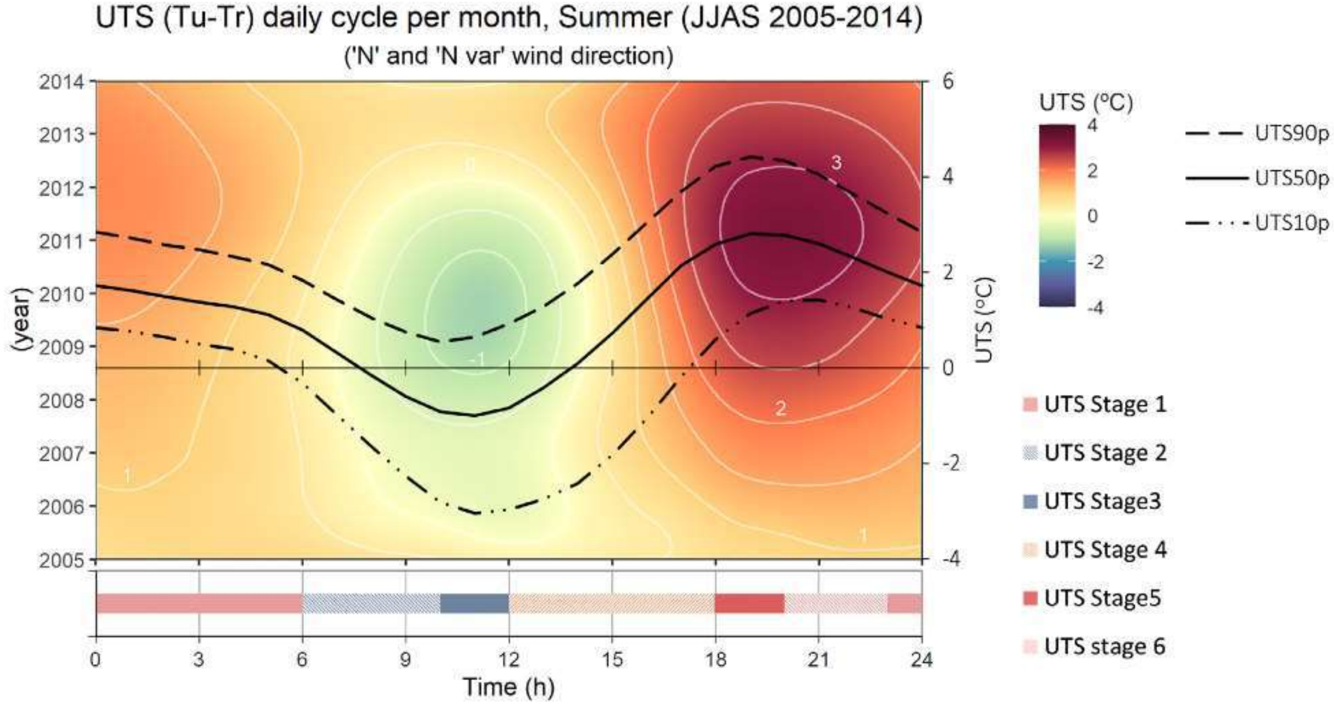


Fig. 1. UTS daily cycle in Lisbon, adapted from (Oliveira et al., 2021): line plot displays the median, the 90th and the 10th percentiles of the hourly UTS intensity (UTS50p, UTS90p and UTS10p, respectively) at the Lisbon's city centre (Restauradores), together with the corresponding heatmap, per year; 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).

Recent advances in urban climate and applications (and there is more to come)

Weather and Climate Extremes
Volume 36, June 2022, 100455

Excess Heat Factor climatology, trends, and exposure across European Functional Urban Areas

Ana Oliveira [a, d], António Lopes [b, *], Amílcar Soares [c]

Show more

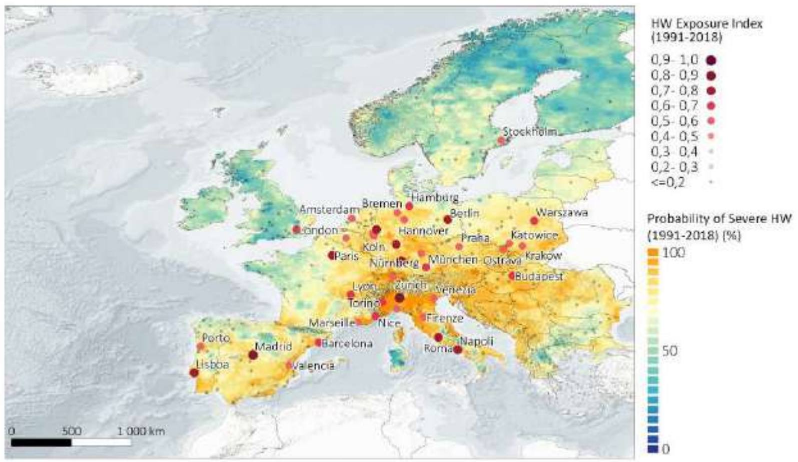


Fig. 6. Heatwave Exposure ($HW_{EXPOSURE}$) levels for the European Functional Urban Areas (FUAs) over Severe Heatwave Probability (HW_{PROB}) in the 1991–2018 period. Labelled FUAs have $HW_{EXPOSURE}$ levels equal or greater than 0.5 (0–1 normalized scale).

7th position - Lisbon

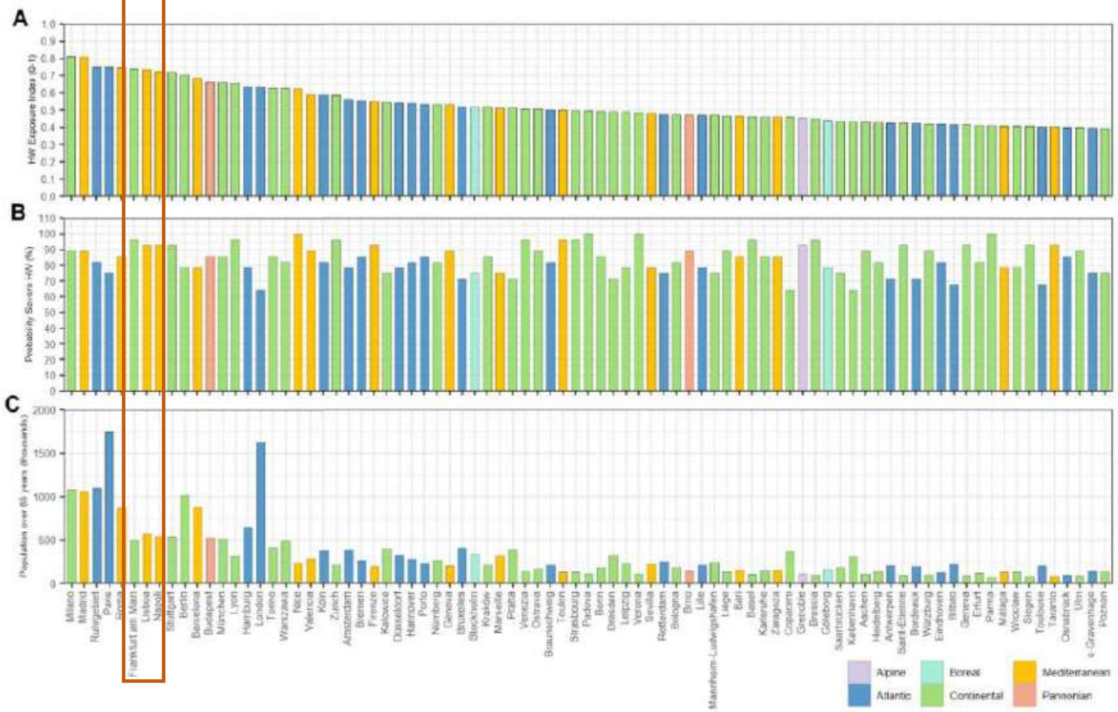
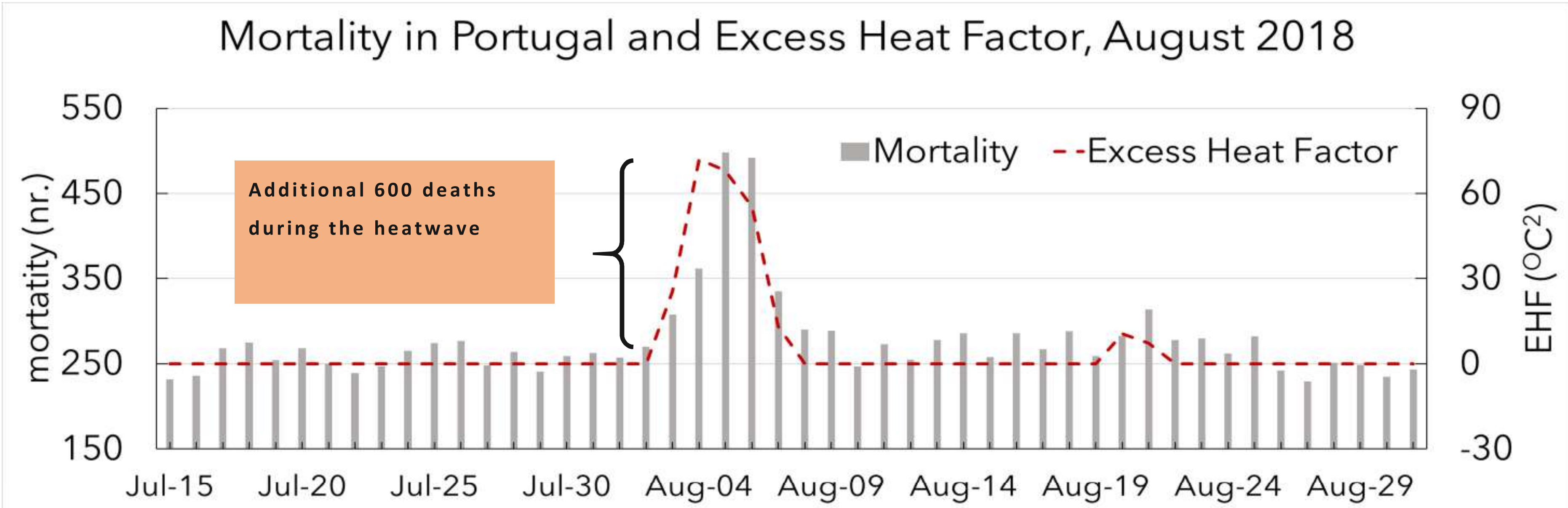


Fig. 7. Ranking results of the (a) Heatwave Exposure ($HW_{EXPOSURE}$) levels for the European Functional Urban Areas (FUAs), together with (b) probability of Severe HW and (c) Number of people aged 65 or over (2008–2018 period).

ASSOCIAÇÃO CLIMA/SAÚDE



Ana Oliveira, António Lopes, Ezequiel Correia, João Vasconcelos (2019) *Ongoing*

Questões a abordar

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4) Soluções de Base Natural e soluções artificiais: desafios para o futuro

biology
letters
Global change biology

Biol. Lett. (2009) **5**, 352–355
doi:10.1098/rsbl.2009.0010
Published online 25 February 2009

The scaling of green space coverage in European cities

Richard A. Fuller[1,*] and Kevin J. Gaston[2]

[1]*The Ecology Centre, The University of Queensland, St Lucia, Queensland 4072, Australia*
[2]*Biodiversity and Macroecology Group, Department of Animal and Plant Sciences, University of Sheffield, Sheffield S10 2TN, UK*
**Author for correspondence (r.a.fuller@dunelm.org.uk).*

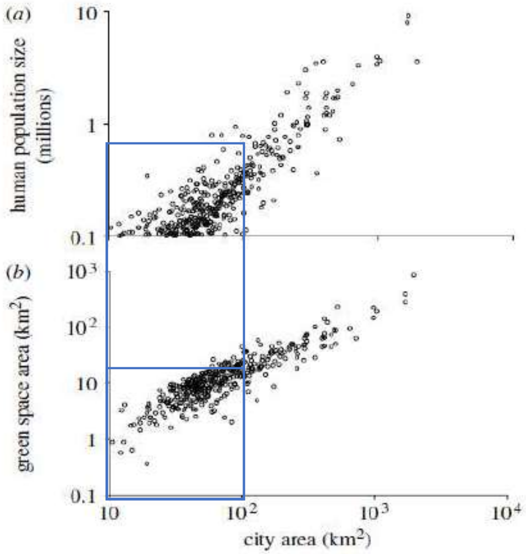


Figure 2. Relationships between city area and (*a*) human population size (standardized major axis regression: $r^2=0.760$, $p<0.001$) and (*b*) green space area ($r^2=0.802$, $p<0.001$).

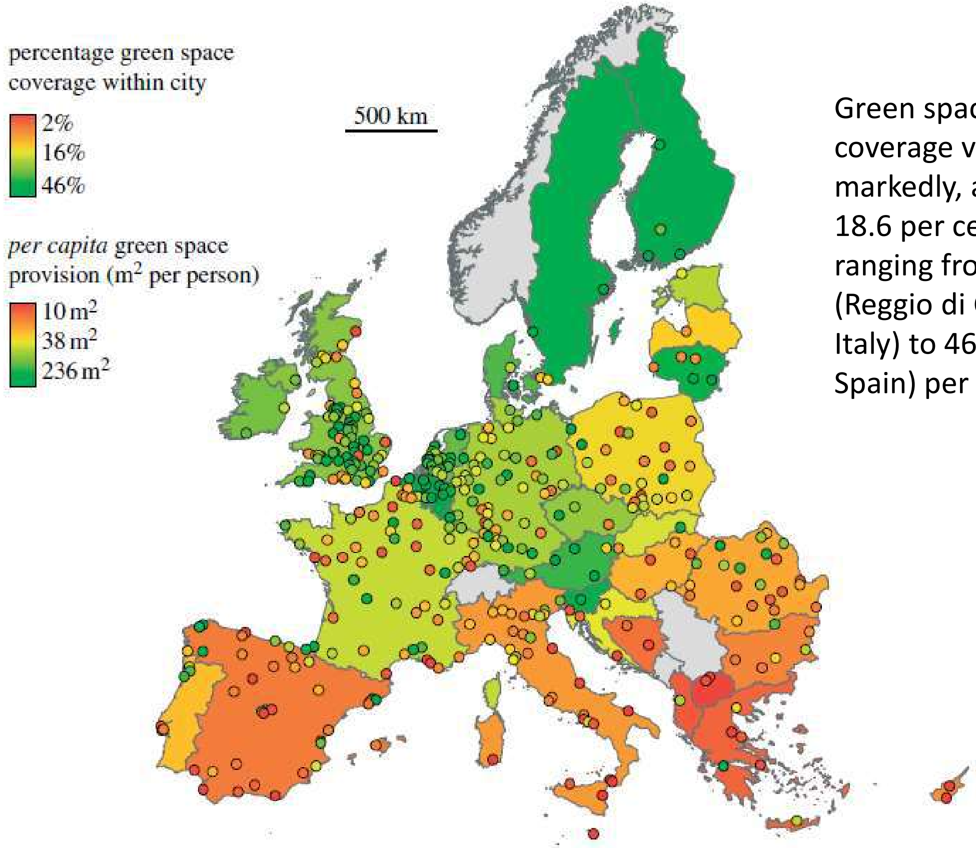


Figure 1. Urban green space coverage in Europe. Points representing cities are coloured according to proportional coverage by urban green space within the city. Country polygons are coloured according to *per capita* green space provision for its urban inhabitants. Data unavailable for countries shaded grey.

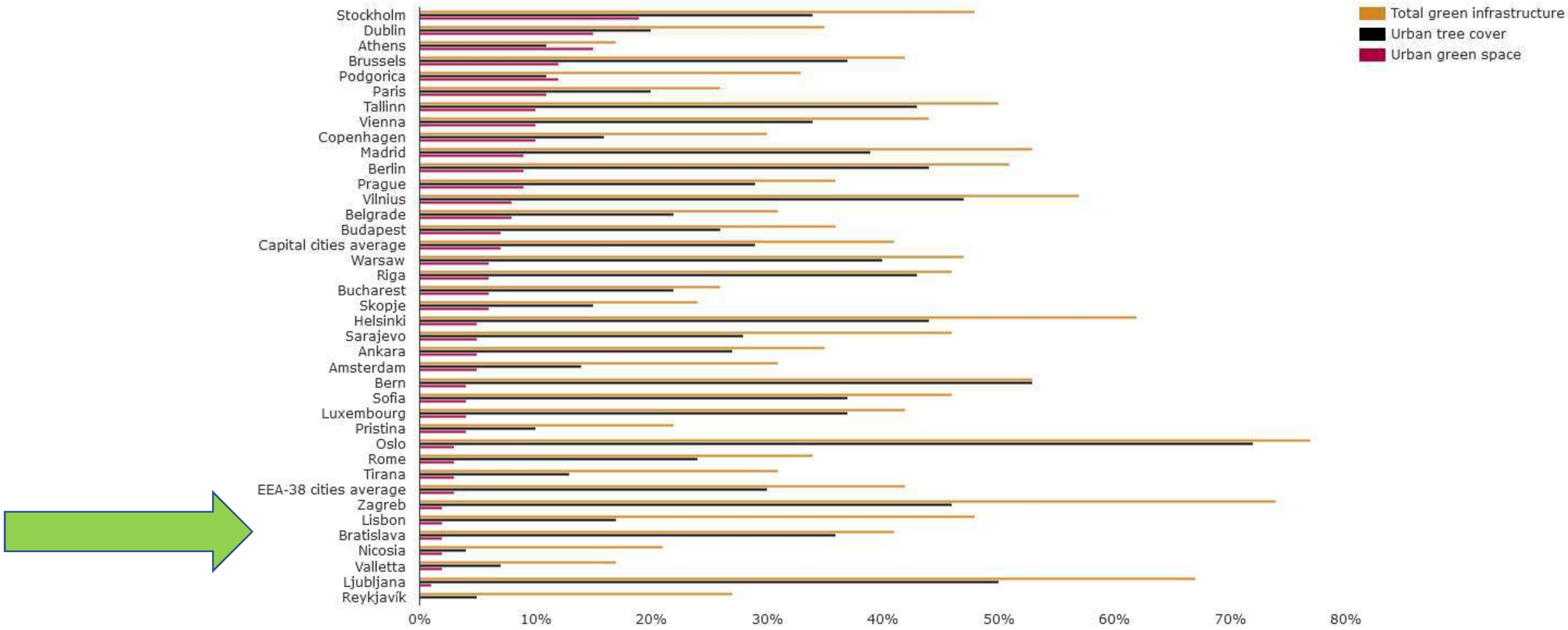
Green space coverage varied markedly, averaging 18.6 per cent and ranging from 1.9 (Reggio di Calabria, Italy) to 46 (Ferrol, Spain) per cent.

Figure 2. Percentage of total green infrastructure, urban green space, and urban tree cover in the area of EEA-38 capital cities (excluding Liechtenstein)

sort by

Urban green space

Chart — Percentage of total green infrastructure, urban green space, and urban tree cover in the area of EEA-38 capital cities (excluding Liechtenstein)



Note:

The chart depicts the percentage of total green infrastructure, green urban areas and tree cover of 37 capitals (EEA-38, excluding Liechtenstein) as a percentage of their respective surface area. Furthermore, it shows the averages for all cities

https://www.eea.europa.eu/publications/who-benefits-from-nature-in

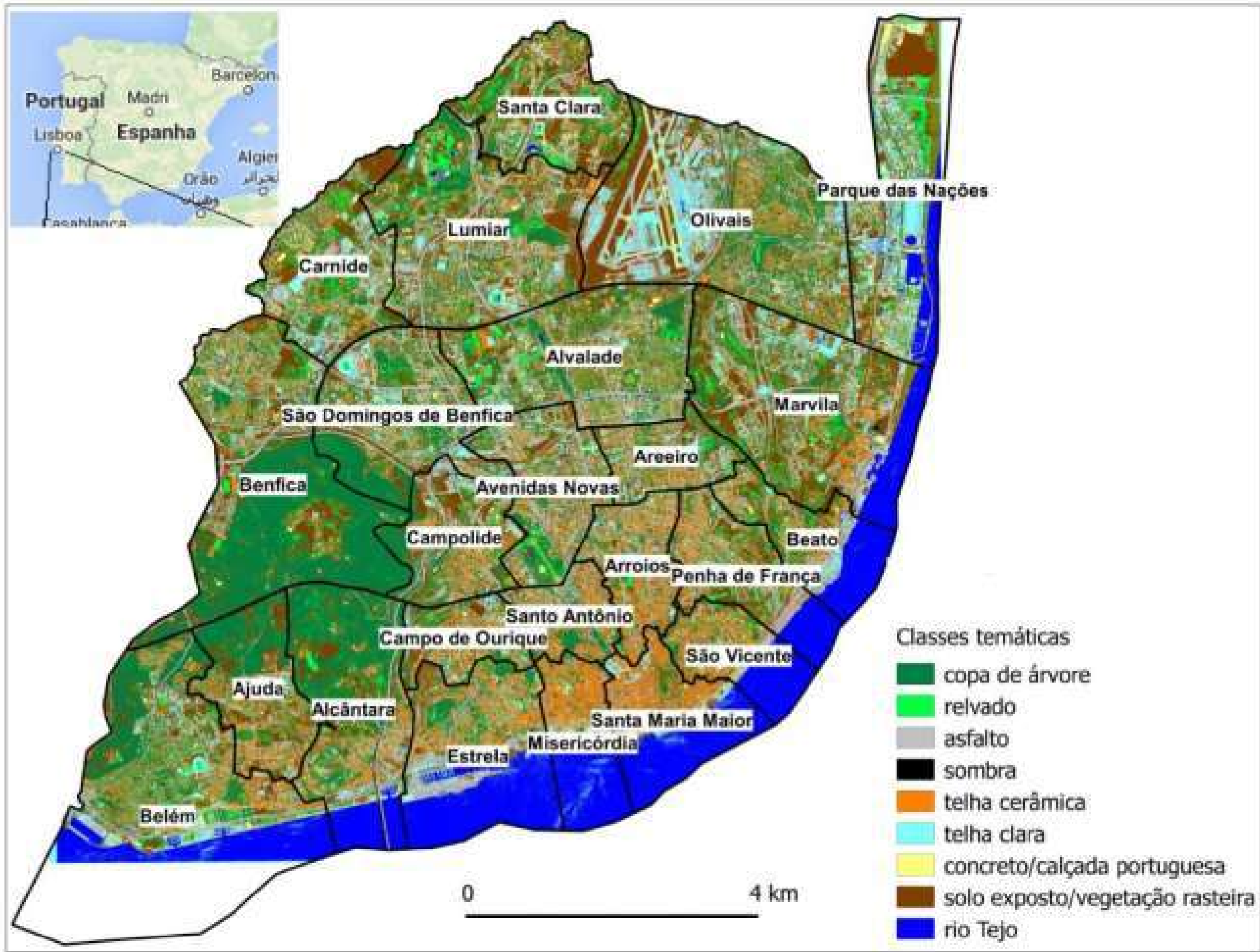
ENCICLOPÉDIA BIOSFERA, Centro Científico Conhecer - Goiânia, v.11 n.21; p.3254 2015

PROPOSTA DE METODOLOGIA PARA A QUANTIFICAÇÃO DA COBERTURA ARBÓREA NA CIDADE DE LISBOA A PARTIR DE IMAGEM DE ALTA RESOLUÇÃO

Flávio Henrique Mendes[1], Demóstenes Ferreira da Silva Filho[2], Antônio Manuel Saraiva Lopes[3]

"estimou-se em 16,8% de cobertura arbórea para a cidade, equivalente a 25,7 m² hab^{-1}. Benfica era a freguesia mais arborizada (49,8%), seguida de Alcântara (45,4%) e Ajuda (29,5%), enquanto que as Santa Maria Maior (7,0%), Parque das Nações (7,2%) e Santa Clara (7,8%) eram as menos arborizadas….

o que está de acordo com estudos anteriores de Soares & Castel-Branco (2007) e Fuller & Gaston (2009)"

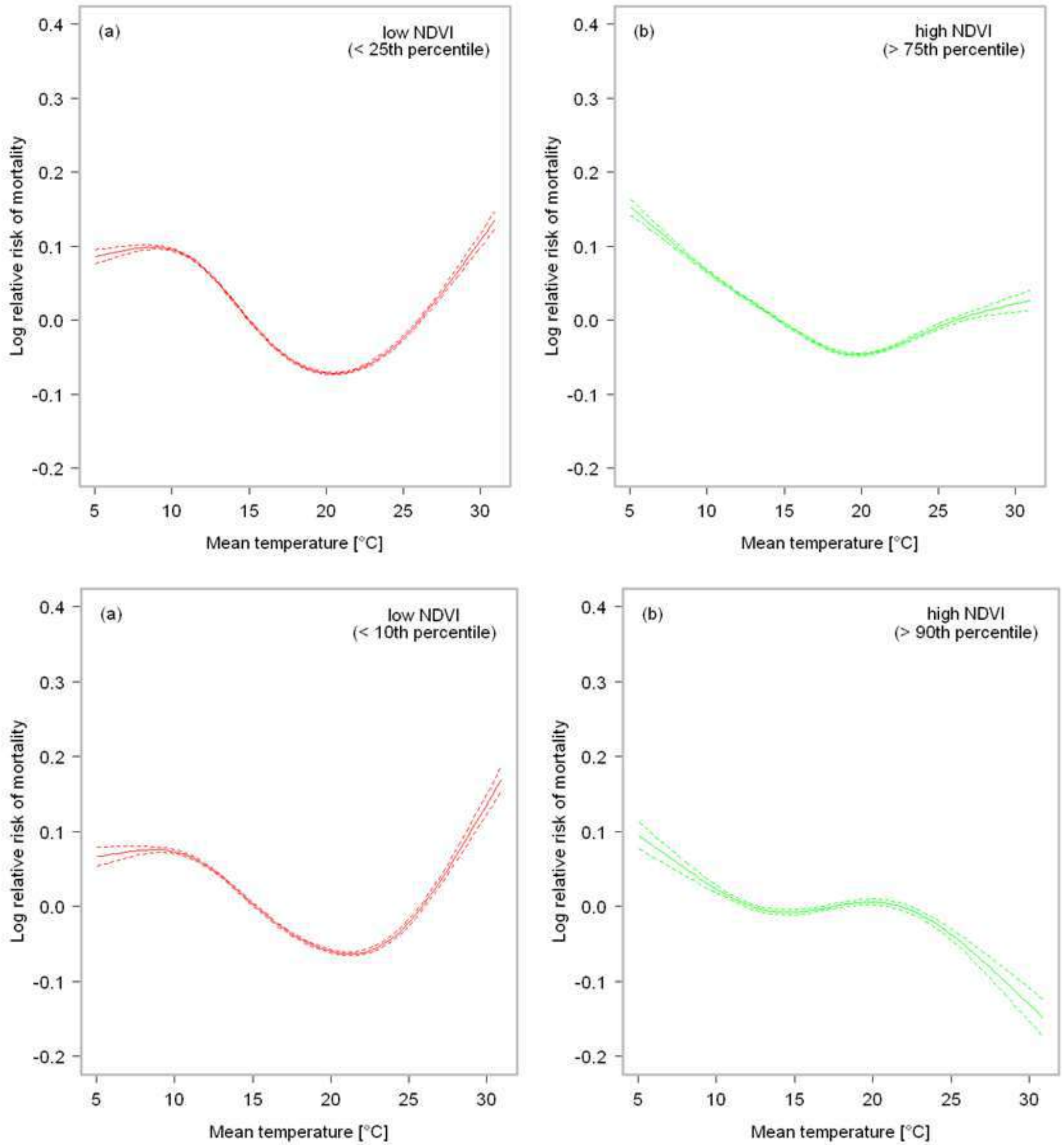


NDVI vs Mortality

A importância da presença de
vegetação em áreas urbanas
e a relação com a mortalidade

NDVI
Normalized Difference Vegetation Index

Quanto maior o valor, mais biomassa
verde existe.



Canário, P. 2015 (inédito)

A eficiência térmica no potencial de arrefecimento de dois espaços verdes em Lisboa


sustainability

Title / Keyword | Journal: Sustainability | Author / Affiliation | Article Type: all | Advanced | Search

Volume 11, Issue 9

Open Access | Article

Evaluating the Cooling Potential of Urban Green Spaces to Tackle Urban Climate Change in Lisbon

Cláudia Reis * and António Lopes

Universidade de Lisboa, Institute of Geography and Spatial Planning (IGOT), Centro of Geographical Studies, Rua Branca Edmée Marques, Cidade Universitária, 1600-276 Lisboa, Portugal

* Author to whom correspondence should be addressed.

Sustainability 2019, *11*(9), 2480; https://doi.org/10.3390/su11092480

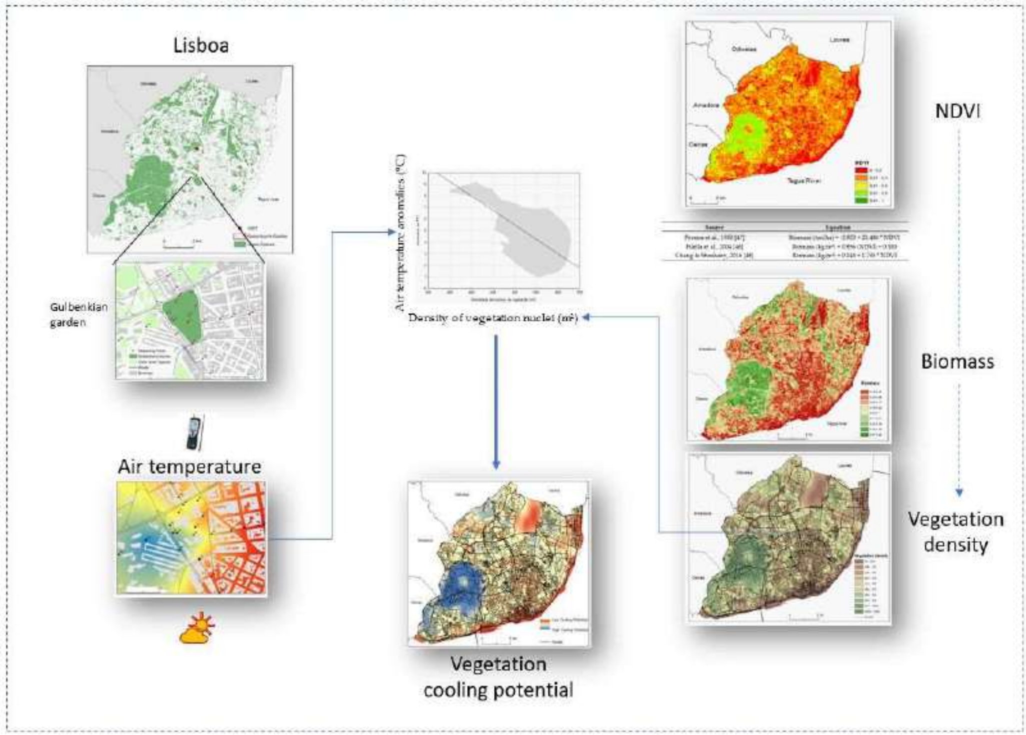
Received: 10 March 2019 / Revised: 17 April 2019 / Accepted: 22 April 2019 / Published: 27 April 2019

(This article belongs to the Special Issue Urban Green Infrastructure and Climate Adaptation)

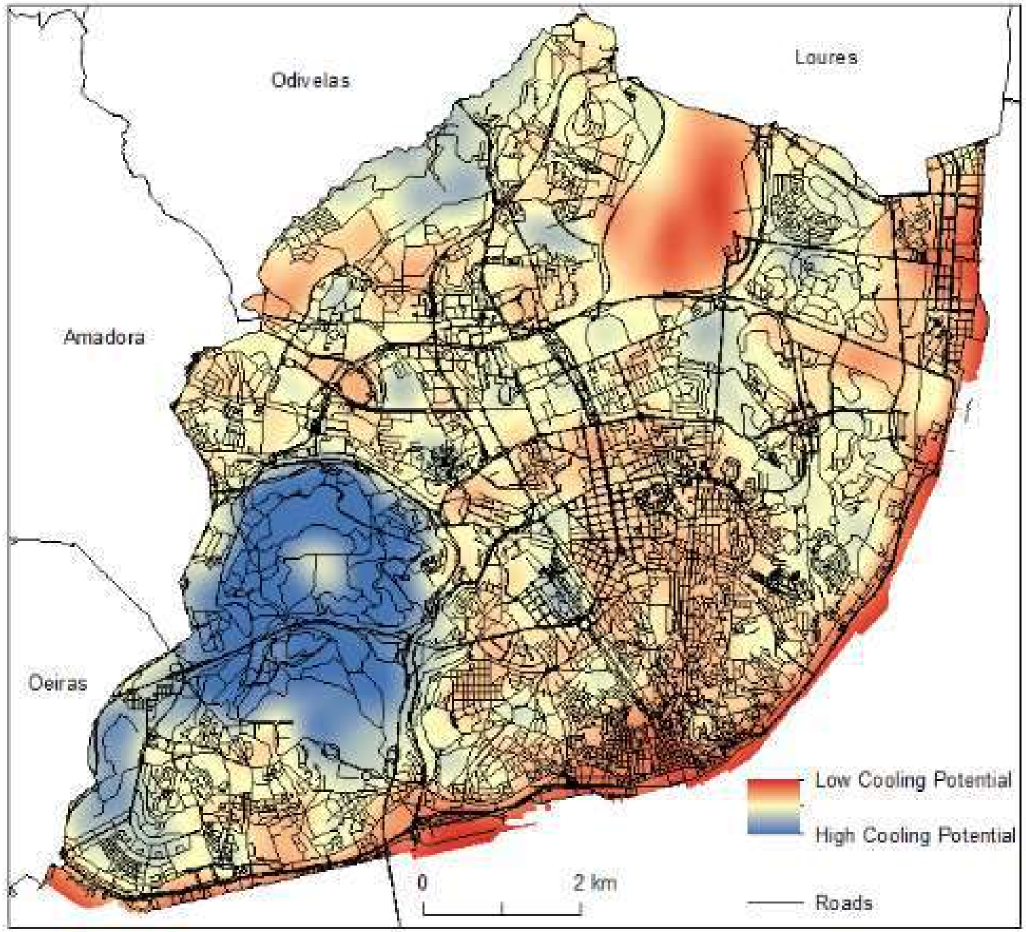
Full-Text | PDF [7296 KB, uploaded 28 April 2019] | Figures

https://www.mdpi.com/2071-1050/11/9/2480

https://repositorio.ul.pt/handle/10451/36236



Cooling potencial of UGS



a)

Figure 8. **(a)** Urban green spaces cooling potential in Lisbon (summer);

sustainability

MDPI

Article

Evaluating the Cooling Potential of Urban Green Spaces to Tackle Urban Climate Change in Lisbon

Cláudia Reis * and António Lopes

Universidade de Lisboa, Institute of Geography and Spatial Planning (IGOT), Centre of Geographical Studies, Rua Branca Edmée Marques, Cidade Universitária, 1600-276 Lisboa, Portugal; antonio.lopes@campus.ul.pt
* Correspondence: claudiareis2@campus.ul.pt; Tel.: +351-21-044-30-00

Received: 10 March 2019; Accepted: 22 April 2019; Published: 27 April 2019

check for updates

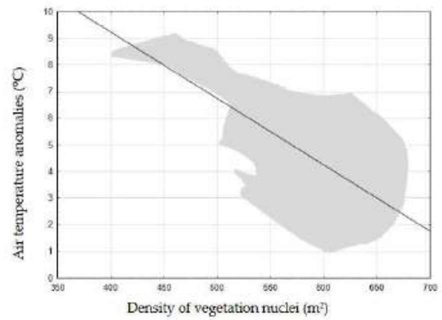
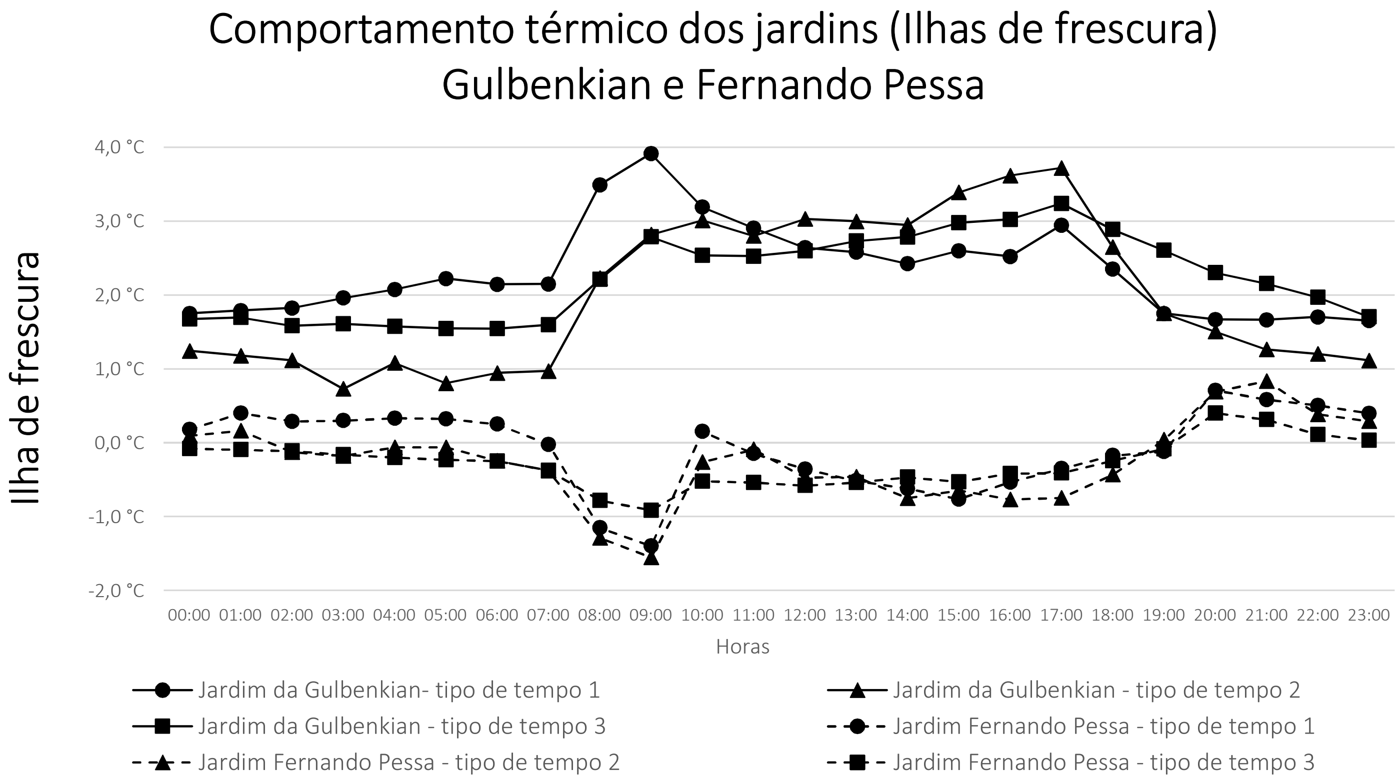


Figure 7. Air temperature anomalies vs density of vegetation nuclei (summer) in Gulbenkian's Garden. Note: thermal anomalies correspond to temperature differences between each value measured and reference station (IGOT).

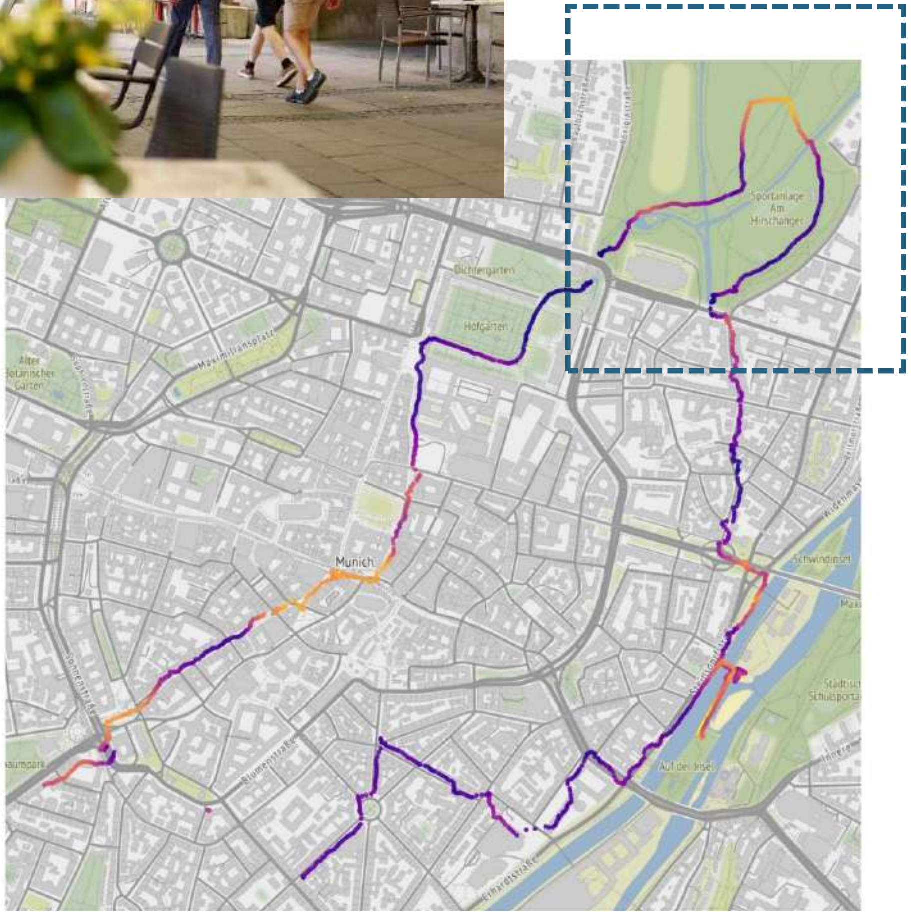
5. Conclusions

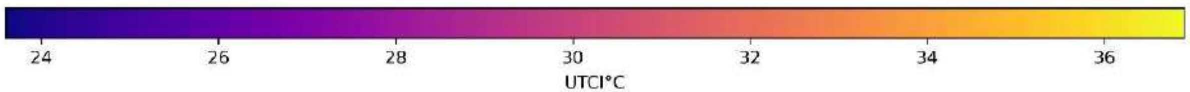
It was found that an area of 50 m^2 covered by vegetation can cool the air by 1 °C. So, this area can be considered the minimal size of a green space in order for it to make a significant contribution to the improvement of urban microclimate. In fact, the improvement of urban climate is one of the


Comportamento térmico dos jardins (Ilhas de frescura)
Gulbenkian e Fernando Pessa
Ilha de frescura
4,0 °C
3,0 °C
2,0 °C
1,0 °C
0,0 °C
-1,0 °C
-2,0 °C
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
Horas
Jardim da Gulbenkian- tipo de tempo 1
Jardim da Gulbenkian - tipo de tempo 2
Jardim da Gulbenkian - tipo de tempo 3
Jardim Fernando Pessa - tipo de tempo 1
Jardim Fernando Pessa - tipo de tempo 2
Jardim Fernando Pessa - tipo de tempo 3

Reis, C. (2018)

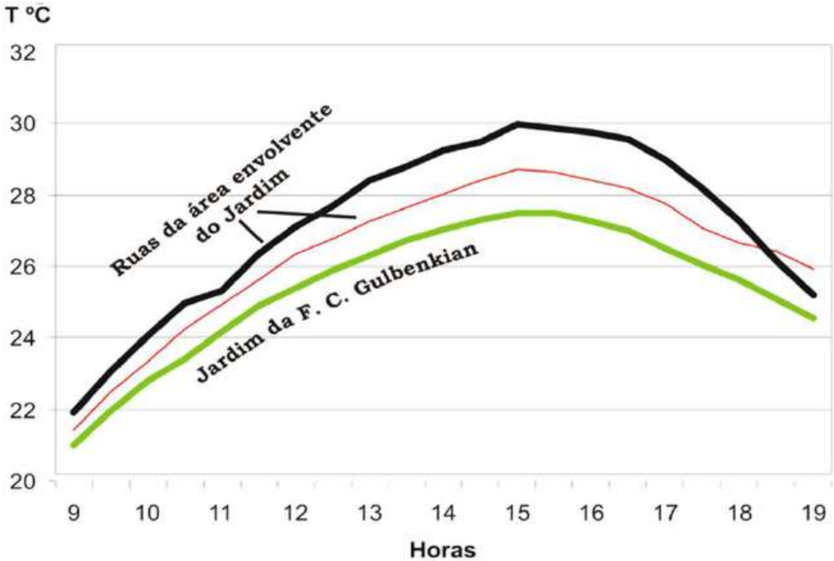
Avaliação conforto termo-fisiológico em Munique Julho 2022





Silva, T. (ongoing work)

Jardim Gulbenkian



Temperatura do ar em locais expostos à radiação solar directa - médias horárias de 60 dias de Verão e início de Outono de 2004

Andrade e Vieira, (2005)

Questões a abordar

1) Alterações climáticas globais e urbanas: ondas de calor e ilhas de calor urbano

2) Adaptar a infraestrutura verde urbana de forma a que se atenuem os efeitos de onda de calor e se aumente o sequestro de carbono, promovendo a criação de prados de sequeiro biodiversos e aumento da cobertura arbórea;

3) Promover a sustentabilidade da infraestrutura verde urbana através de redução de custo, implementando soluções de base natural

4) Soluções de Base Natural e outras soluções artificiais: desafios para o futuro

Ondas de calor em Lisboa

HEAT WAVES IN LISBON

Identificação das Ilhas de Calor e Mapas Climático Urbanos

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Organizado por:
LISBOA
RESCCUE
ONDAS CALOR LISBOA

Co-financiado por:
POSEUR
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Mapas climáticos urbanos

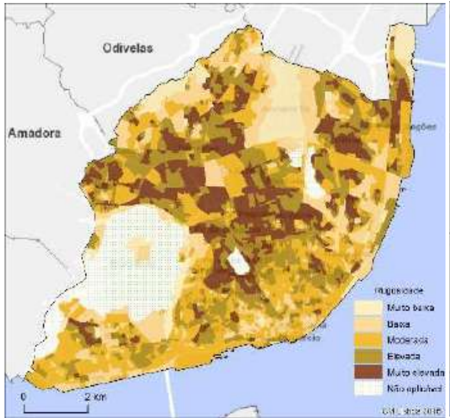
Alturas e orientação dos edifícios

+

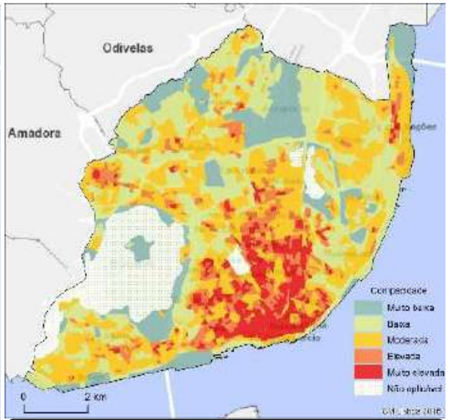
Área edificada

+

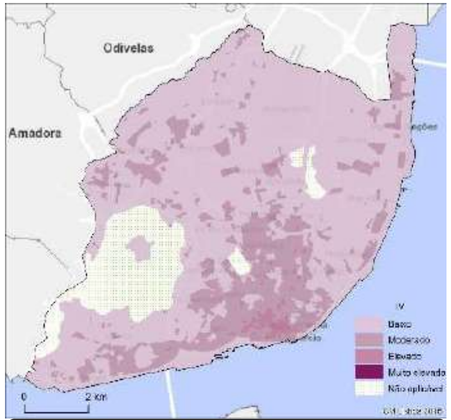
Direcção do vento



Rugosid. aerodin. (z0)

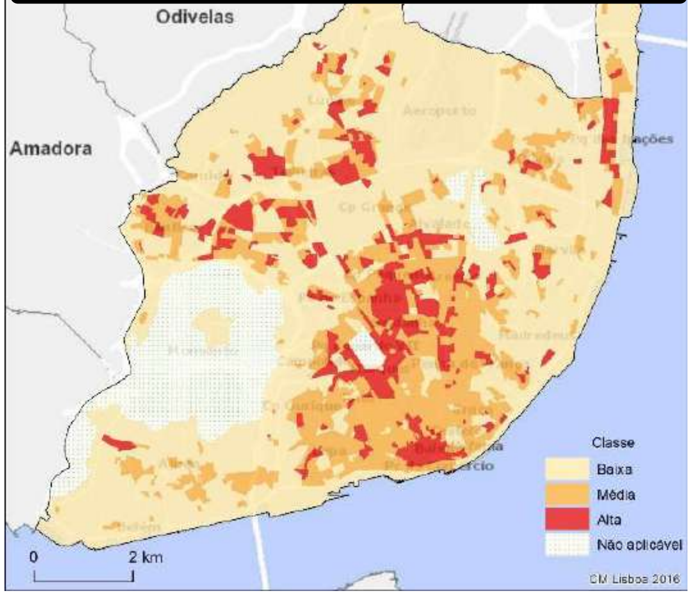


Compacidade



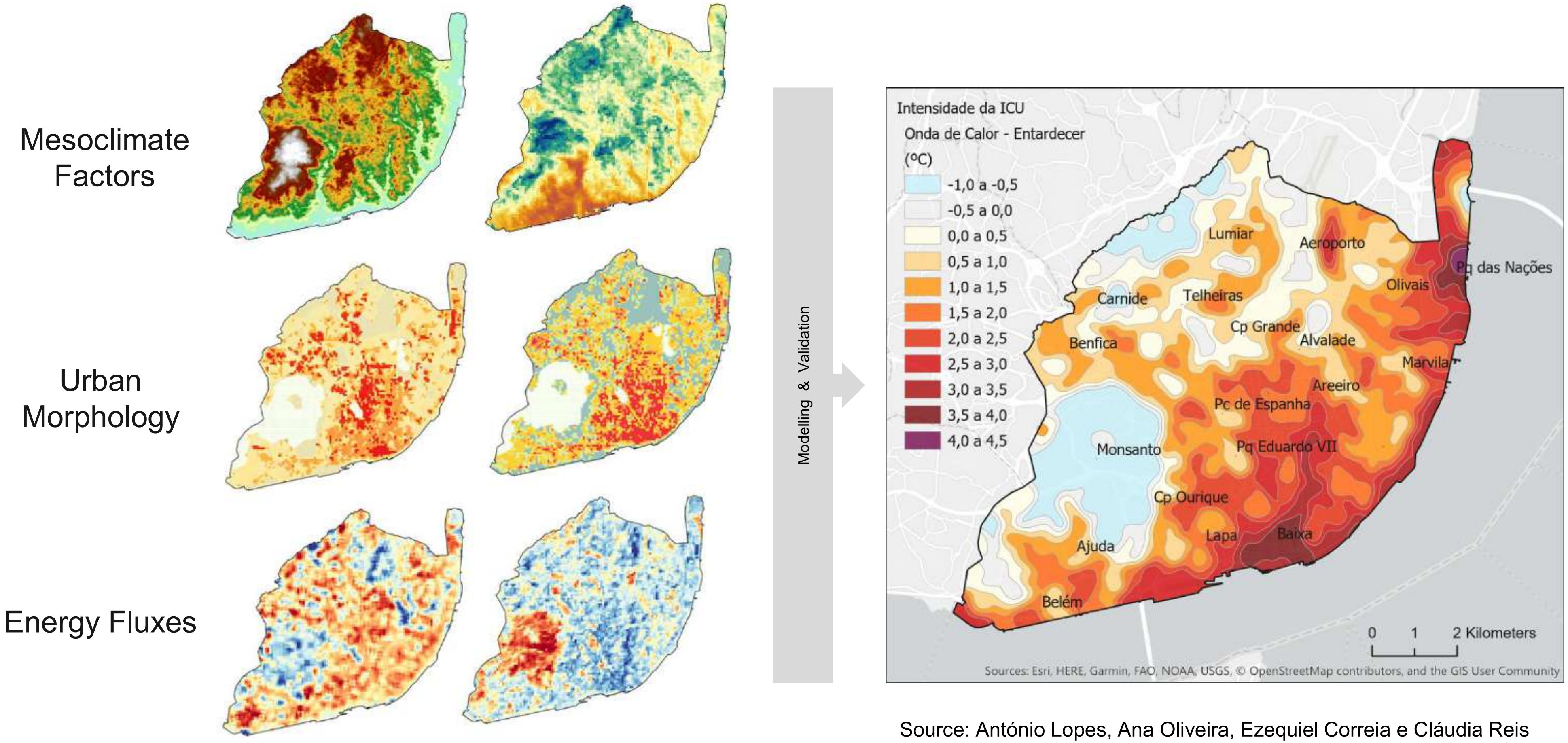
Volumetria

Densidade Urbana



Duas aplicações princ.:

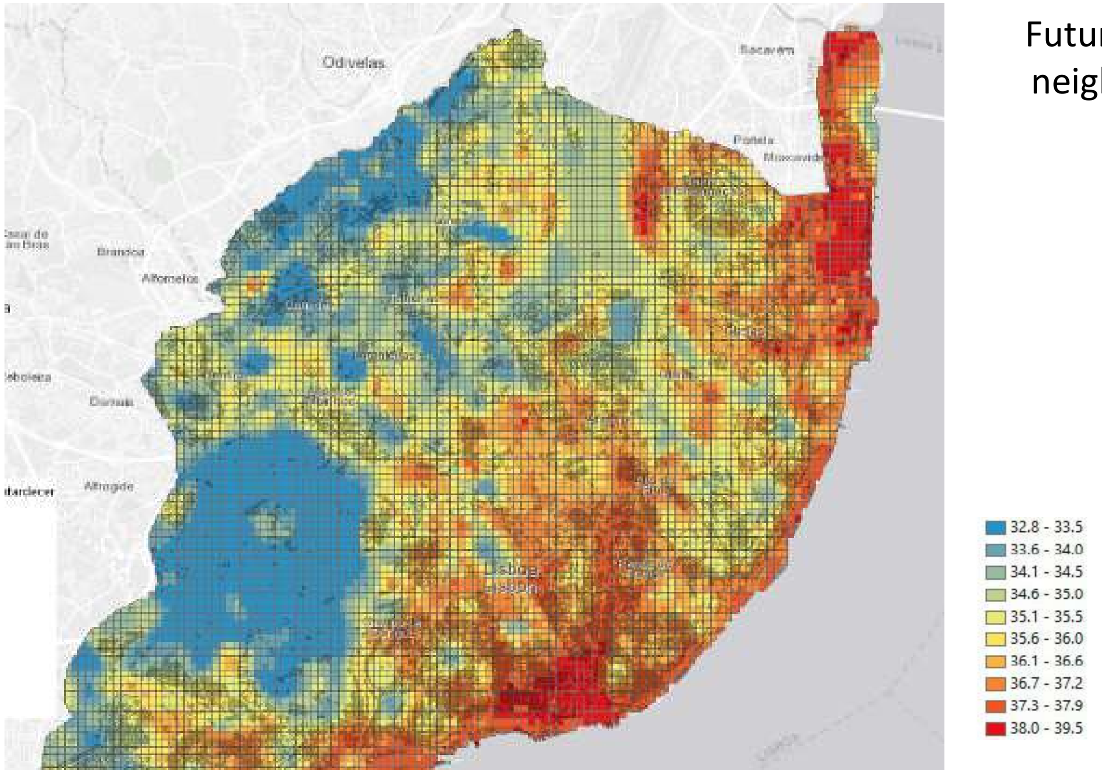
- Planeamento urbano
- Preditor de padrões térmicos



Source: António Lopes, Ana Oliveira, Ezequiel Correia e Cláudia Reis (2019). CML.

Urban Heat Island mesoscale maps: Predicting UHI spatial patterns | Present *x* Future built-up City

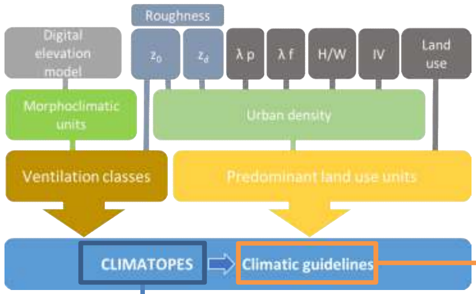
Urban Heat island Intensity ($\Delta T_{u\text{-}r}$)



Future UHI intensity change in projected neighborhoods and RCP 8.5 - 2070-2100

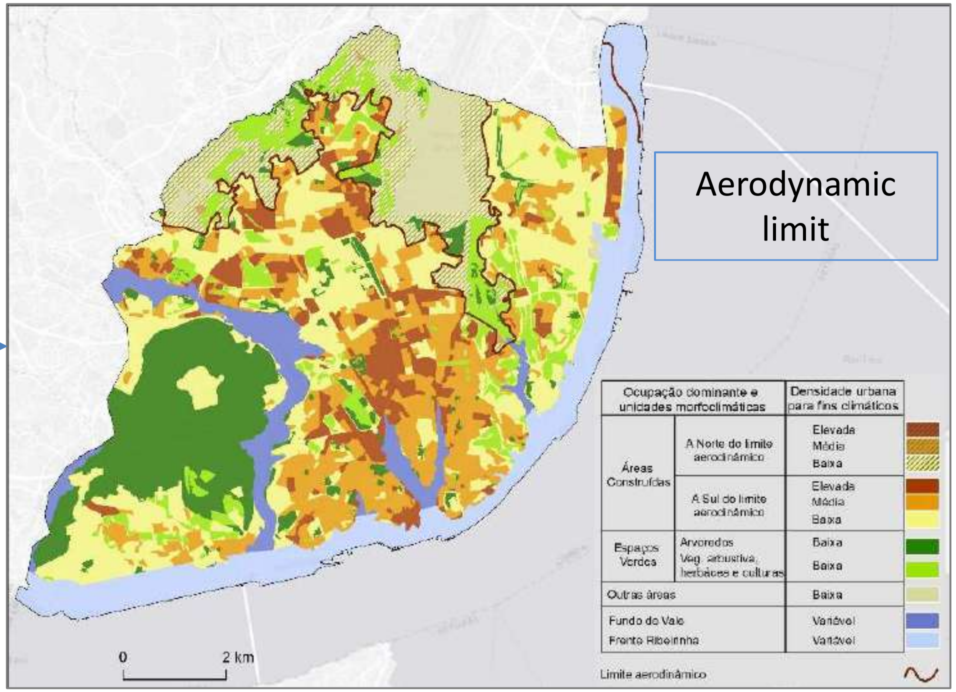
Heat Wave late afternoon

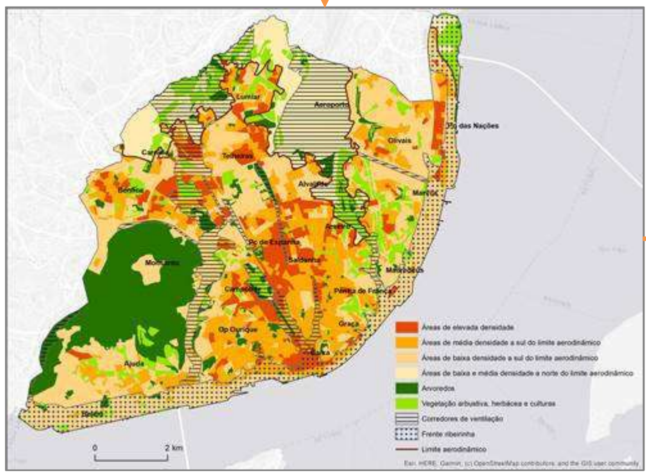
Climatopes Map



Rearranging Climatopes:
Urban density classes, north and south to the aerodynamic limit | Green areas (T + G + O) | Ventilation Paths | Waterfront

Built areas| urban densities |Green areas (trees + grass and others) | bottom valleys | waterfront

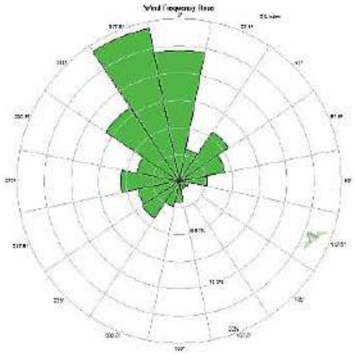




11 Climatopes | 8 areas with climatic guidelines
More than 30 measures

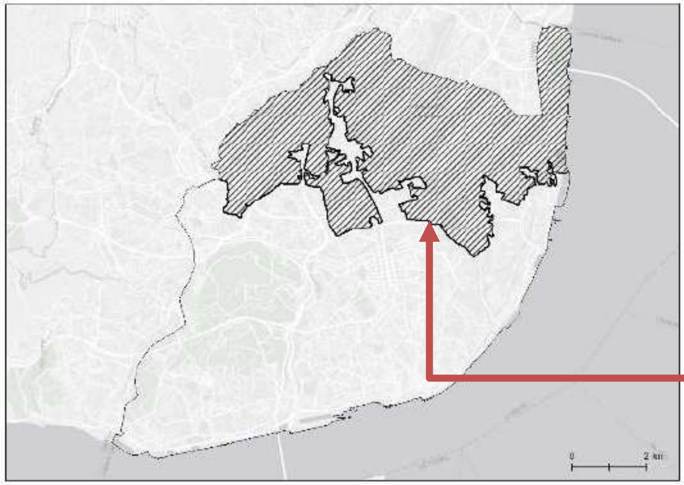
Wind patterns and natural ventilation monitoring

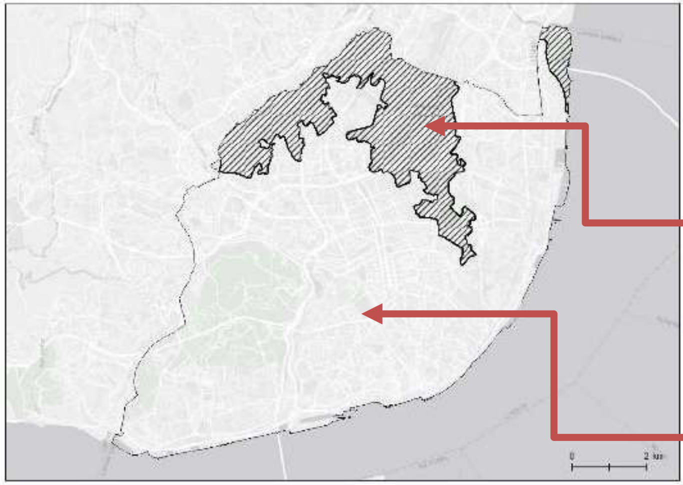
The area of free ventilation is very important to remove pollutants and improve thermal comfort.



2005

2020





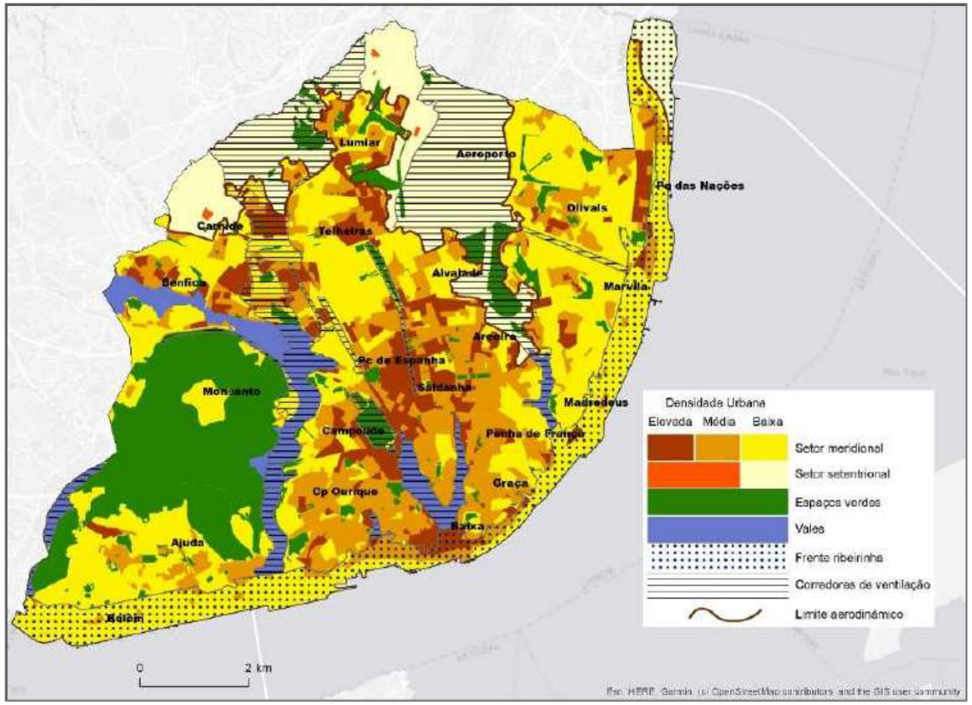
"free" area for wind penetration is decreasing

Increasing urban density

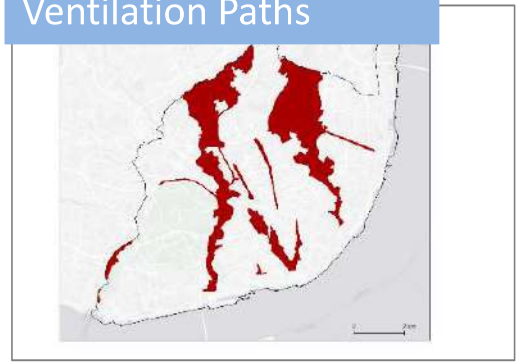
Aerodynamic limit (roughness length = 0.7 m)

New Guidelines for Urban Planning 2020 proposal considering urban climate

9 Climatopes | **9 areas** with climatic guidelines not necessarily the same | about **34 measures**
3 examples

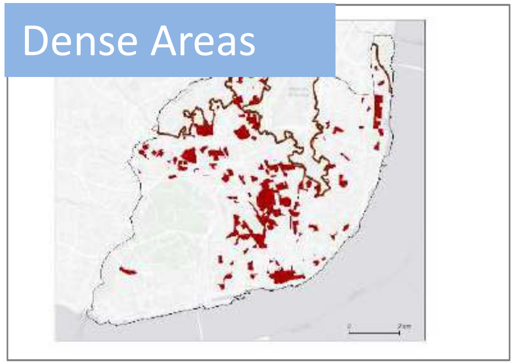


Ventilation Paths



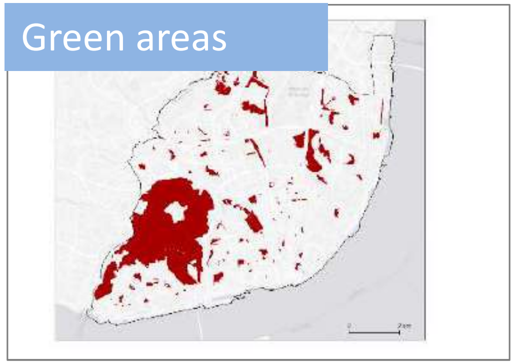
- To maintain N/S Ventilation Paths (VP)
- To maintain small VP interconnections
- To reduce Z0 (roughness length) < 0.7 m
- To maintain the disengagement of VP

Dense Areas



To prevent high density (H/W <1) in dense built areas.
To prevent long alignments of buildings perpendicular to the predominant wind (N), in new neibourghoods.
New materials with appropriate thermal conductivity and high albedo.
Green and white roofs, white previous surfaces , etc.

Green areas



To increase spaces that contributes to human bioclimatic conditions

Cooling urban spaces (shading and evapotranspiration)

To promote biodiversity

To promote connections between green spaces and ventilation paths.

Conclusões

Lisboa é uma das cidades europeias mais expostas ao calor extremo

A combinação do efeito de aquecimento no mediterrâneo com o fenómeno Ilha de Calor pode ser "explosivo" para a população mais idosa e vulnerável

Os espaços verdes e a renaturalização são a melhor estratégia para enfrentar o calor extremo

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Desafios
Que espaços verdes podemos ainda criar?
Que espécies utilizar?
Onde?
Incentivos?
Como fazer a gestão / manutenção desses espaços localmente?
Como envolver as pessoas?
Devolver o espaço público às pessoas

Pensar noutras estratégias, como a utilização de materiais menos absorsores de energia térmica e pequenas planos de água.