9th International Conference on Urban Climate
12th Symposium on the Urban Environment

An automatic GIS procedure to calculate urban densities to use in Urban Climatic Maps

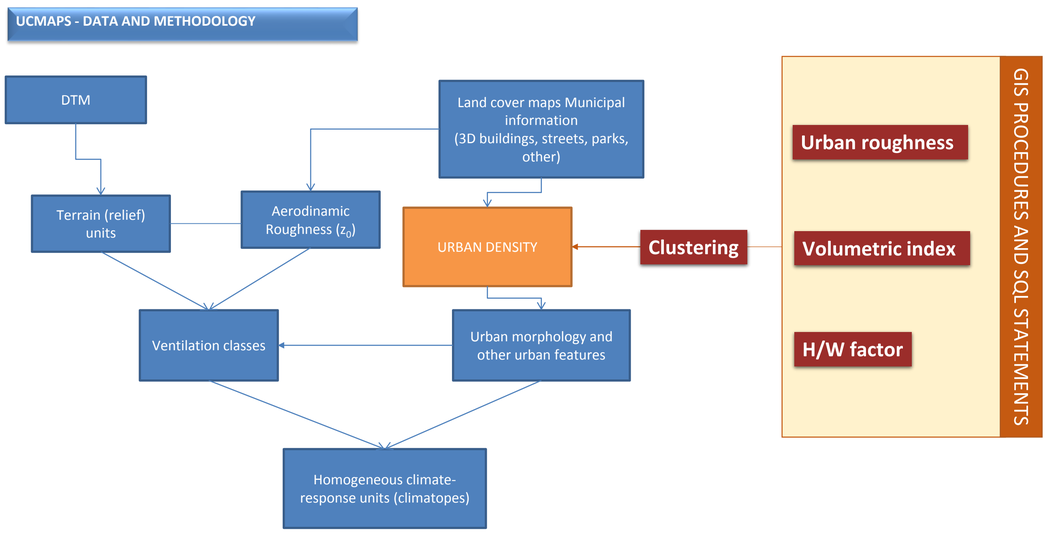
POSTER 12: GD – Local Climates Zones and urban databases

Ezequiel Correia[1],António Lopes[1]; David Marques[1]
[1] Center of Geographical Studies, Institute of Geography and Spatial Planning, Universidade de Lisboa, Portugal
e-mail: ezequielc@campus.ul.pt

Urban Climatic Maps (UCMaps), are important and recognized tools to attain a reliable urban management. Among several features included in UCMaps, urban density is one of the most important variables to consider, due to its effect of urban volumes on radiative and energy balances and on natural ventilation. However, this key factor to urban climate analysis is very often unavailable or not suitable for urban climate studies and its determination becomes a very time consuming task and difficult to carry out.

In order to get urban density maps, a methodology developed with a GIS environment is presented, applied to Lisbon.

Buildings geometry and volumetric parameters have been automatically computed as indicators of urban density and morphology. With a GIS, the urban area is divided into cells. For the densities calculation, each cell will take into account the height of buildings, the surface area and volume, the width of the streets and the area exposed to the prevailing wind (it is also possible to consider other directions). The aerodynamic roughness (z0) inside each cell will be also considered in the automation process.



I – URBAN ROUGHNESS

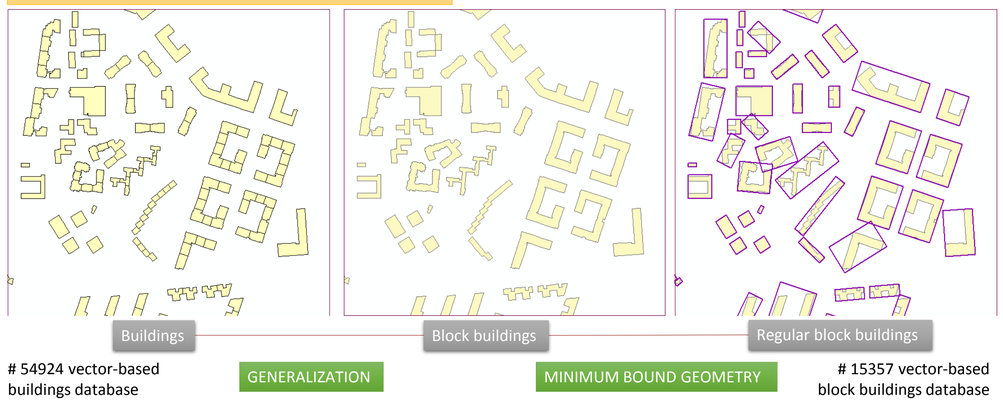
MORPHOMETRIC METHOD
Roughness length (z_0) = 0.5h x s/S (Lettau, 1969)

Data:
Shapefiles with:
Buildings (height; footprint area; volume)
Streets (width)

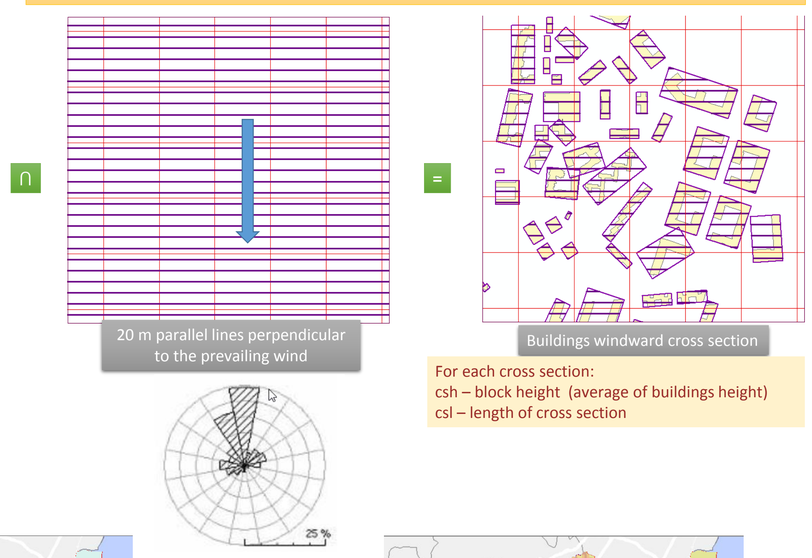
Resources: ArcGis™, MSAccess®, Excel®, SPSS®
Sources:
Municipality of Lisbon
European Environmental Agency - Urban Atlas

A – FACADE PARAMETERS

A.1 – BUILD REGULAR BLOCK BUILDINGS



A.2 – CALCULATE BUILDINGS WINDWARD CROSS SECTION IN EACH CELL



For each cross section:
csh – block height (average of buildings height)
csl – length of cross section

B – CALCULATE:
- WINDWARD FRONTAL AREA
- URBAN ROUGHNESS

SQL _(database) :
- ALONG each line, SUM cross section length
- FOR each cell, SELECT the greatest cross section sum

Parameters obtained along select line:
h – mean buildings height
lf – sum of facade length

z_0= 0.5h x s/S

s – frontal area

S – cell area

II – VOLUMETRIC INDEX

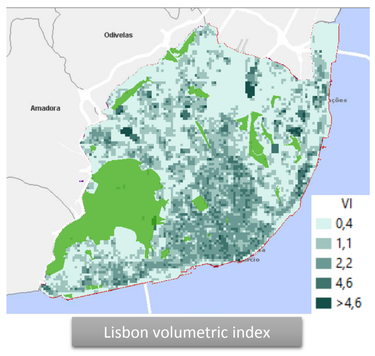
Most commonly used

Volumetric coefficient (VC) = Vc / Ac
Vc – Cell volume
Ac – Cell area

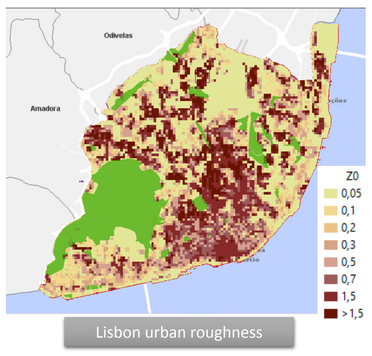
… but this concept doesn't include the real volume of the Urban Boundary Layer

our proposal

Volumetric index (VI) = Vc / BVc
Vc – Cell volume
BVc – Average buildings volume



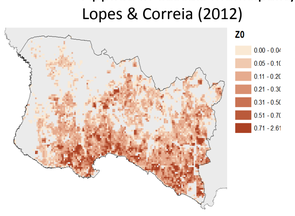
Lisbon volumetric index

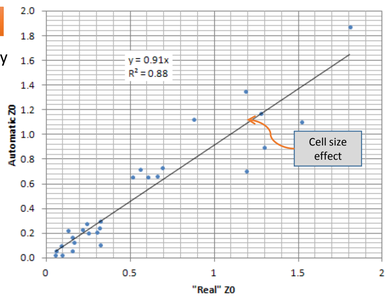


Lisbon urban roughness

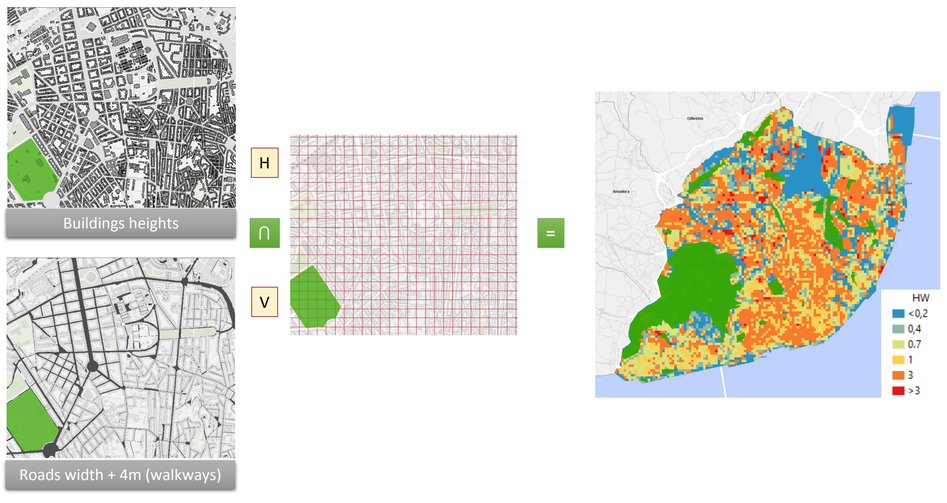
Validation

Applied in Cascais municipality
Lopes & Correia (2012)

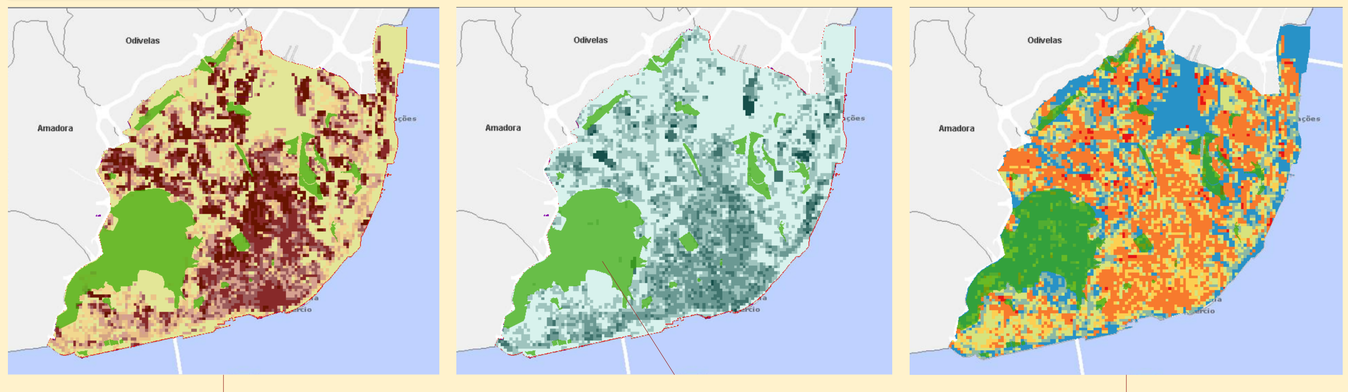




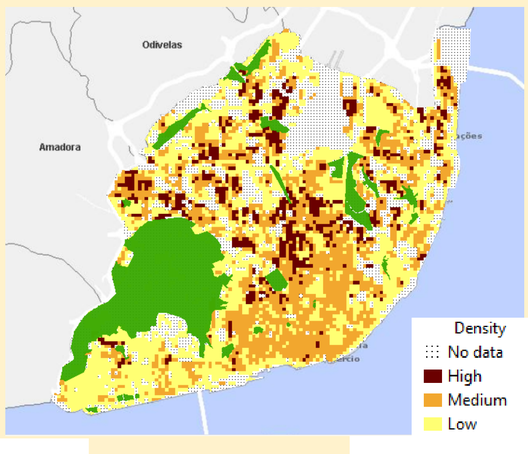
III – H/W FACTOR



URBAN DENSITY



CLUSTER ANALYSIS - K-MEANS



This methodology will allow us to speed up the process of creating bioclimatic indicators that can be use in applied urban climate studies.

K	Z0	IV	HW	N	%	Z0	IV	HW	Density
1	0.2	0.5	0.6	3029	51.2	--	+/-	+/-	Low
2	5.1	0.7	2.4	102	1.7	++	+	++	High
3	0.6	2.9	0.9	623	10.5	+/-	++	+	Medium
4	18.5	0.3	1.5	1	0.0	++	-	++	High
5	0.7	0.9	1.4	1542	26.1	+	+	++	Medium
6	2.1	0.8	1.8	617	10.4	++	+	++	High

References:
Alcoforado, M-J., H. Andrade, A. Lopes, J. Vasconcelos (2009) Application of Climatic Guidelines to Urban Planning. The Example of Lisbon (Portugal). *Landscape and Urban Planning*, 90:56-65.
Alcoforado, M.J., H. Andrade, A. Lopes (2012) - Urban Climate Maps in Lisbon, Portugal. in C. Ren e Y-y Ng (ed.) – *Urban Climatic Map – An Information Tool for Sustainable Urban Planning*, Hong Kong. (chinese version).
Alcoforado MJ, A. Lopes, H. Andrade (2015) Chapter 16. Urban Climatic Map Studies in Portugal: Lisbon. In Ng E, Ren C, *The Urban Climatic Map. A Methodology for Sustainable Urban Planning.* Routledge. (in press)
Lopes A., E. Correia (2012) A Proposal to Enhance Urban Climate Maps with the Assessment of the Wind Power Potential. The Case of Cascais Municipality (Portugal). in Lenka Hájková et al Ed., Conference Proceedings, International Scientific Conference "Bioclimate 2012 – Bioclimatology of Ecosystems, Ústí nad Labem, Rép. Checa: 68-69
Prata-Shimomura A, A. Lopes, E. Correia (2015) Chapter 17. Urban Climatic Map Studies in Brazil: Campinas In Ng E, Ren C, *The Urban Climatic Map. A Methodology for Sustainable Urban Planning.* Routledge. (in press)