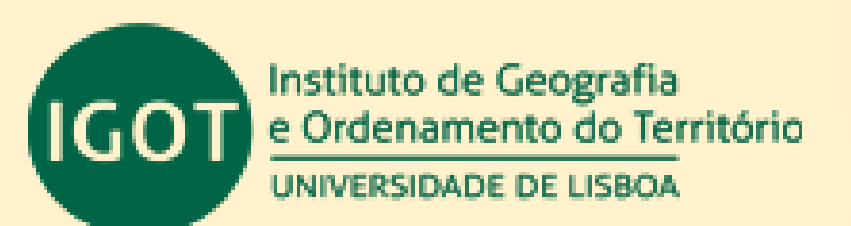# Urban Heat Island (UHI) analysis by Local Weather Types (LWT) in Lisbon, Portugal

Cláudia Reis[1], António Lopes[1], André Nouri[2]

[1]Institute of Geography and Spatial Planning (IGOT-ULisboa), Center of Geographical Studies, Universidade de Lisboa, Lisbon, Portugal

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

e-mail: claudiareis2@campus.ul.pt

What we want to know?

I. Are the local weather conditions one of the driving factors of positive temperature differences between an urban area and its surroundings? Should we analyze UHI regardless of local climate?

II. Is it feasible to use a large dataset of modelled data for the detailed analysis of UHI patterns and intensity?

III. Are strong positive thermal diferences in Lisbon only visible with clear sky and weak winds?

IV. Are there any recurrent hot and cool spots in the city? Does the Lisbon's UHI mosaic changes according to different LWT?

II. Climate variables for cities in Europe from 2008 to 2017 – Copernicus Earth Observation Programme

Over 61000 hourly air temperature raster maps retrieved and grouped by thermal seasons and LWT

Construction of an R script in order to calculate hourly UHI:

$$UHI_t = T_{cop} - T_{la}$$

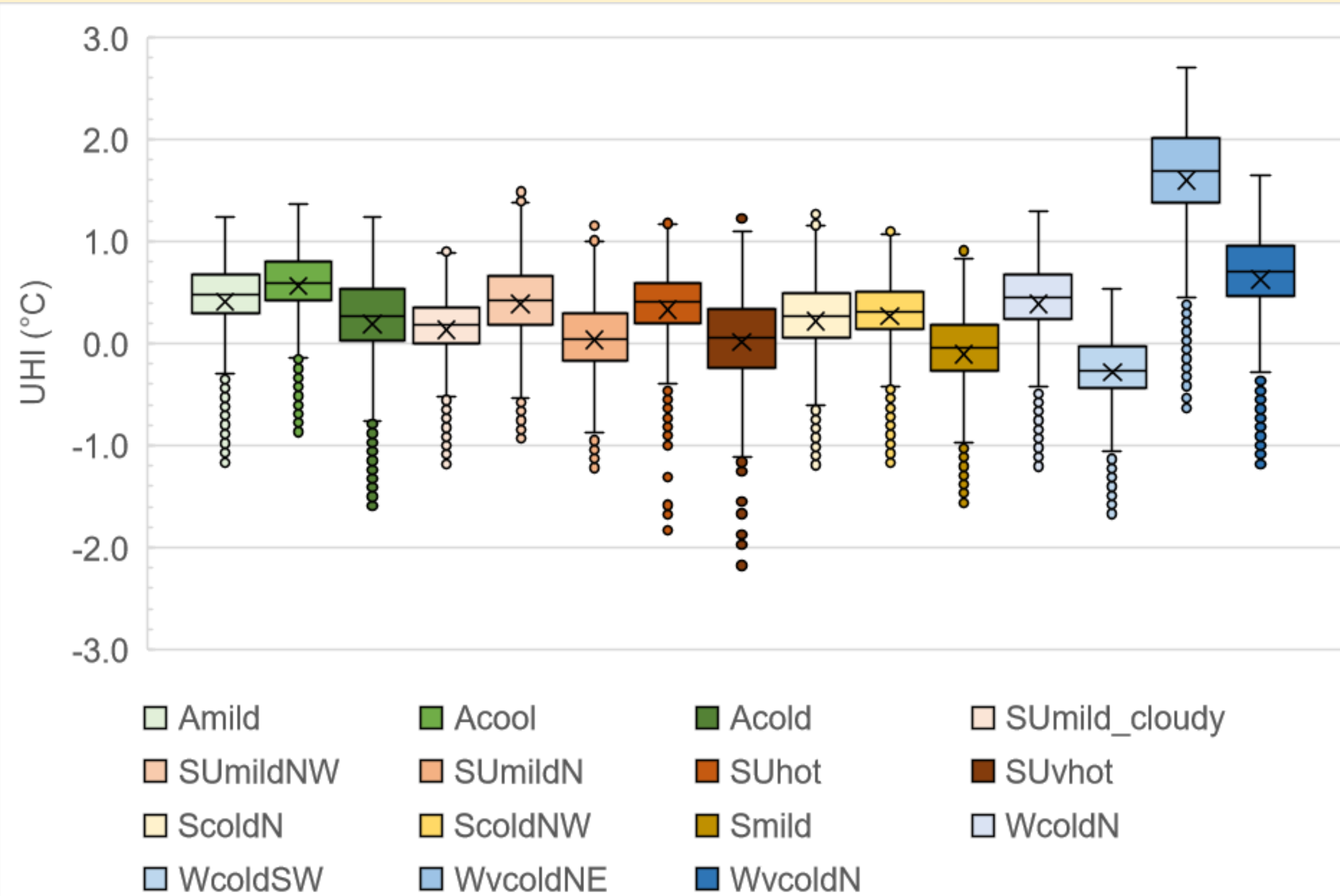UHI_t represents UHI intensity in moment t;

T_{cop} represents air temperature of each cell in Copernicus grid for moment t;

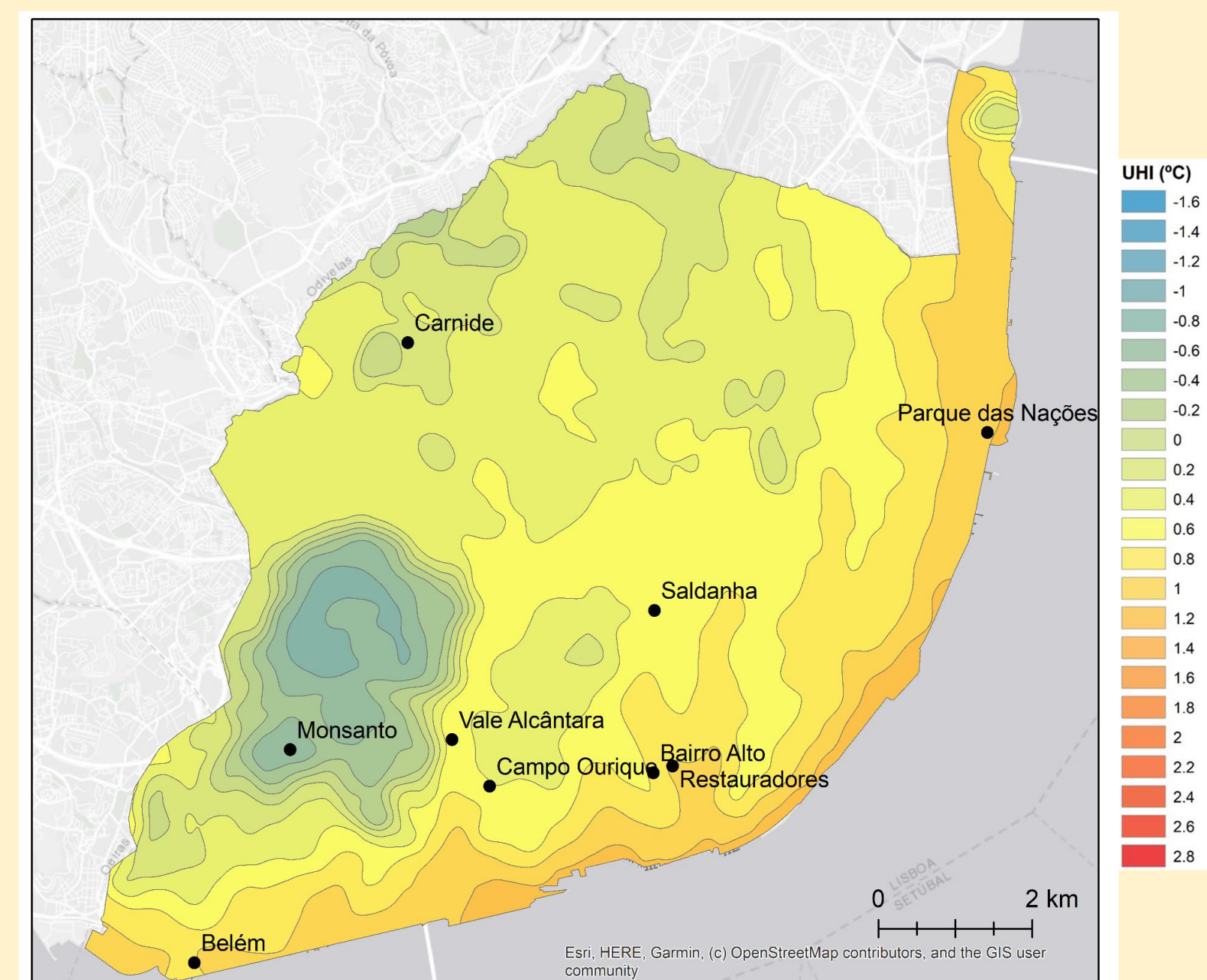T_{la} represents the air temperature registered at the Lisbon's airport weather station in the same moment t;

https://cds.climate.copernicus.eu/cdsapp#!/dataset/sis-urban-climate-cities?tab=overview

IV. UHI intensity by LWT in Lisbon

Legend: Amild, Acool, Acold, SUmild_cloudy, SUmildNW, SUmildN, SUhot, SUvhot, ScoldN, ScoldNW, Smild, WcoldN, WcoldSW, WvcoldNE, WvcoldN

I. Daily Local Weather Type (LWT) classification

K-means cluster analysis of climate data from Lisbon's aiport weather station and ERA5 reanalysis

	Daily LWT Designation	Frequency of days per thermal season (%)	Cloud Cover (tenths)	Wind Speed (m/s)	Specific Humidity (kg/kg)	Air Temperature (°C)	Total Daily Precipitation (mm)
Summer	Mild, cloudy and humid with light rain and moderate NW winds (Sumild_cloudy)	14.9	7	4.8	0.0127	20.5	1.4
Summer	Mild, sunny and humid with moderate NW and N winds (SUmildNW)	26.1	3	4.5	0.0120	21	0.1
Summer	Mild, sunny and humid with strong N winds (SUmildN)	22.7	2	7.5	0.0115	20.8	0
Summer	Hot, sunny and humid with moderate N winds (Suhot)	6.4	1	4.7	0.0105	23.9	0
Summer	Very hot, sunny and humid with moderate N winds (Suvhot)	21.4	1	4.7	0.0147	25.4	0
Winter	Cold, cloudy and dry with weak and variable winds, specially from N and NW (WcoldN)	29	7	3.6	0.0084	12.9	0.6
Winter	Cold, cloudy, rainy and dry with moderate SW and W winds (WcoldSW)	7.1	8	6.5	0.0088	13.6	5.2
Winter	Very cold, sunny and dry with moderate N winds (WvcoldN)	26.2	3	4.7	0.0067	10.4	0.6
Winter	Very cold, sunny and dry with weak NE, E and N winds (WvcoldNE)	21.7	3	3.8	0.0058	9.6	0.2
Spring	Cold, cloudy and dry with weak precipitation and moderate and variable winds, specially from NW, SW and W (ScoldNW)	29.1	7	4.6	0.0087	14.3	2.2
Spring	Cold with moderate cloud coverage, dry and with moderate N winds (ScoldN)	27.9	4	6	0.008	14.3	0.4
Spring	Mild, sunny and humid with moderate N winds (Smild)	22.3	3	4.6	0.0118	20.5	0.1
Autumn	Cold, with moderate cloud cover and dry with moderate N and NE winds (Acold)	22.9	4	4.2	0.0089	14.3	0.5
Autumn	Cool, cloudy, humid and rainy with moderate SW and W winds (Acool)	9.7	8	5.3	0.0112	16.6	7.6
Autumn	Mild, with moderate cloud cover, humid, with possibility of rain and weak N, NE and S winds (Amild)	21.4	5	3.9	0.0116	18.8	1.5

Adpated from Reis, C., Lopes, A., Correia, E., & Fragoso, M. (2020). Local Weather Types by Thermal Periods: Deepening the Knowledge about Lisbon's Urban Climate. Atmosphere, 11(8), 840.
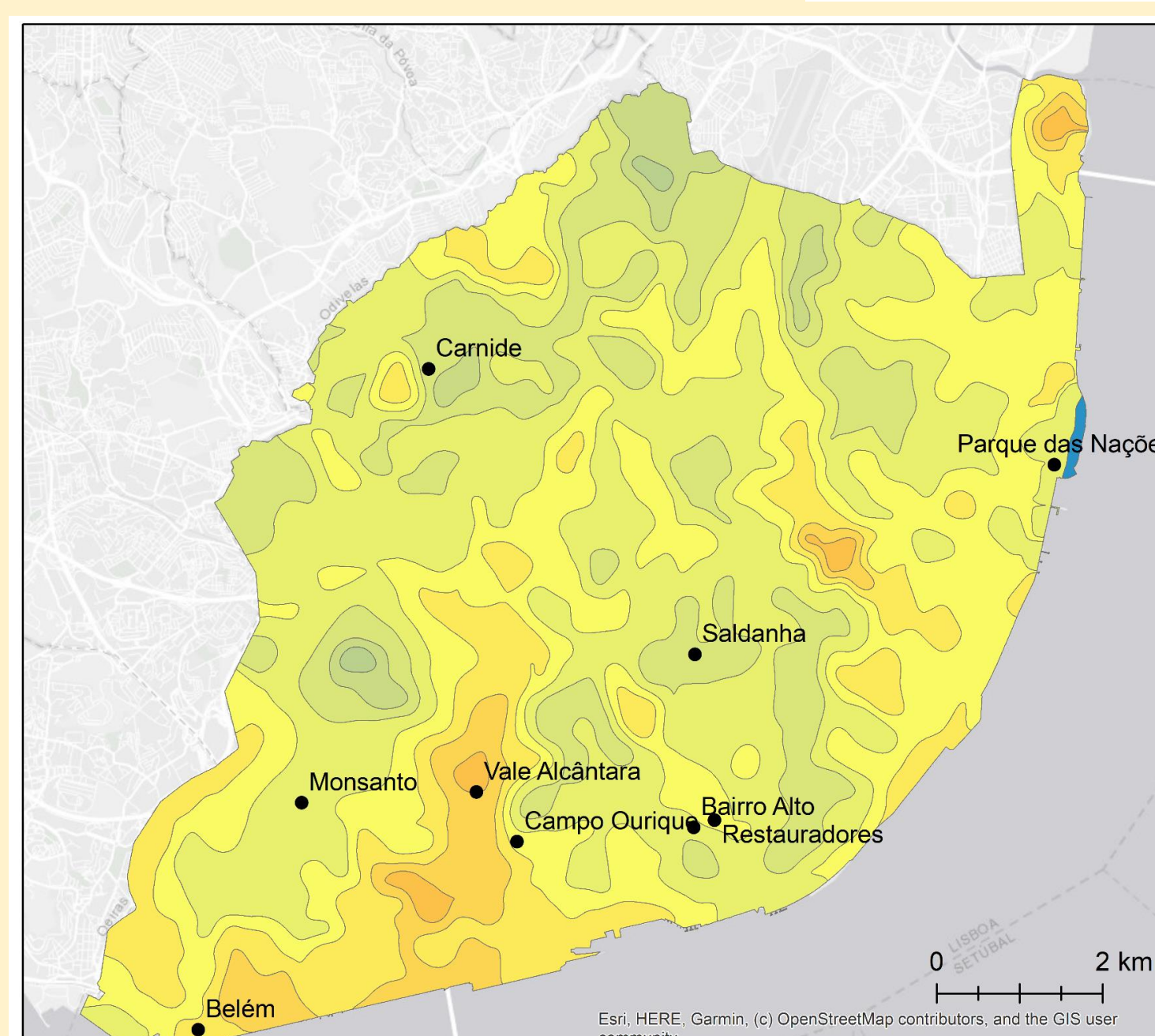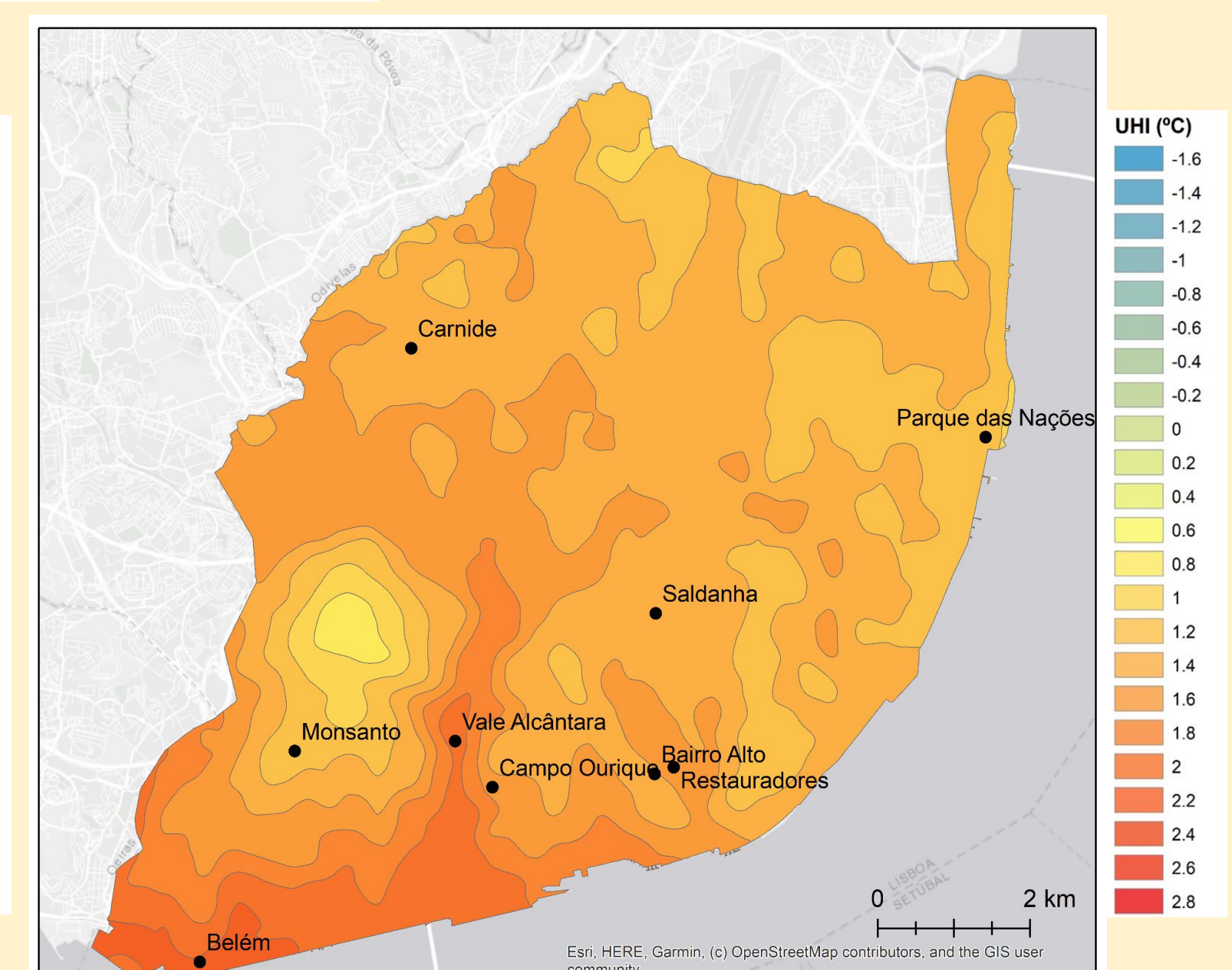
V. UHI patterns in Lisbon

N/NW-S/SE contrast

Mix of cool and hot spots

E-W contrast

VI. Concluding remarks

- Local meteoroloigcal conditions influence strongly UHI patterns and intensity in Lisbon, especially wind direction, cloud cover and precipitation
- Strong UHI occur in very cold, sunny and dry winter days with weak NE, E and N winds
- Cold, cloudy, rainy and dry winter days with moderate SW and W winds generate an urban cool Island (UCI) in Lisbon
- UHI intensity varies significantly throughout the day. The highest intensities occur in the late afternoon (6:00 pm) when compared to late morning (12:00 am – UCI in most of the city)
- In Lisbon three different UHI mosaics may be distinguished: the most frequent corresponds to a N/NW-S/SE contrast, where the riverfront is often the hottest area against Monsanto Hill (the largest green space in the city) and the northern area, which is well ventilated by frequent N and NW winds that reach the city. At 12:00 am a mix of cool and hot spots is formed with no defined pattern and after several hours of solar radiation, which is strongly absorbed by urban materials, strong thermal differences appear clearly (6:00 pm). The third mosaic (E-W contrast) is only visible on very cold and sunny winter days with weak NE, E and N winds and on hot and sunny summer days with moderate N winds, both at 12:00 am.
- These results were validated using hourly records from the mesoscale meteorological network of CEG-IGOT with nine measuring points from 2004 to 2015 and it was concluded that in most LWT an overestimation of the UHI intensity is observed. However, at 6:00 pm the city is generally warmer than the model predicts. Regardless of that, the generated patterns are consistent with previous studies about Lisbon UHI.