Urban Heat Island Mitigation and Urban Green Spaces: Testing a Model in the City of Padova (Italy)

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Abstract: The urban heat island (UHI) is a critical issue in most urbanised areas. Spatial variation of urban air temperature and humidity influences human thermal comfort, the settling rate of atmospheric pollutants, and the energy demand for cooling. UHIs can be particularly harmful to human health and there are numerous studies that link mortality and morbidity with extreme thermal events, that can be worsened by UHIs. The temperature difference between city centres and the surrounding countryside, which is accentuated in the summer months and at night, is the result not only of a greater production of anthropogenic heat but is mainly due to the properties of urban surfaces. The use of vegetation, and in particular urban tree planting, is one of possible strategies to contrast the heat island effects. In order to analyse the mitigation effects produced by green spaces in the city of Padova, a municipality in the northeast of Italy, simulations of the air temperature variations and their spatial distribution were carried out using the i-Tree Cool Air model. High-resolution RGBir aerial photos were processed to produce a tree canopy and a permeability map and the model was applied on a 10 m × 10 m grid over the entire city, producing a raster map of the aboveground air temperatures. A particularly hot July day with recorded air temperatures of 35 °C at 3 p.m. and 28 °C at 10 p.m. at a reference weather station was chosen for the test. In the daytime, the results show temperature differences up to almost 10 °C between urban open spaces with impervious cover (squares, streets) and green areas under tree canopy. At night, the simulated air temperatures are only slightly cooler in areas with tree cover than those recorded at the reference station, while urban areas with sealed surfaces maintain air temperatures 4.4 °C higher. The study was aimed at testing the applicability of the model as a tool for predicting air temperatures in relation to land use and canopy cover. The results show that the model can potentially be used to compare different urban forest and urban greening planning scenarios, however, further research is necessary to assess the reliability of the temperature predictions.

Keywords: climate change; canopy cover; land use; urban greening; urban heat island

1. Introduction

The urban heat island (UHI) is a well-known negative effect of urbanisation resulting in higher air temperatures in urban centres than in the surrounding rural areas [1]. Low-albedo surfaces, construction materials with high thermal capacity, and the absence of transpiring vegetation [2,3] cause a greater absorption of solar radiation, resulting in heat accumulation and consequent infrared radiation emission and released increase in air temperature [4].

The UHI effects are further amplified by climate change. The International Panel on Climate Change predicts a global surface air temperature increase between 1.1 and 5.4 °C and higher extreme temperatures and more frequent heat waves [5]. In the Po-Venetian Plain (Italy), characterised by a humid subtropical climate condition, a study based on local data shows a statistically significant positive linear trend from 1993 to 2019 with a temperature increase of 0.6 °C every 10 years [6].
UHIs can be particularly critical in the summer season during heat wave-related anticyclones. In such circumstances, high air temperatures, in addition to being particularly harmful to human health [7–11], cause a drastic increase in the use of air cooling systems, triggering a vicious circle of the UHI phenomenon [12], and increasing energy consumption and air pollution [13–15].

There are many feasible strategies for reducing UHIs [16,17]. These include, first and foremost, the reduction of anthropogenic heat emissions [18], the improvement of the energy performance of buildings [19], the use of materials with high albedo for roofs and walls of buildings and, in general, for impervious surfaces [20], and the introduction of green roofs and green walls/facades to increase transpiring surfaces in densely urbanised areas [21–23].

The use of vegetation, particularly trees, constitutes one of the most effective strategies in contrasting the phenomenon [24]. Numerous studies have related the type of land cover to its impacts on the Earth’s surface temperature [25]. In particular, with regard to vegetation, it is widely recognised that an increase in vegetation cover is very effective in reducing surface and air temperature [26,27]. For example, Kong et al. [28] argued that a 10% increase in forest cover can result in a decrease in the Earth’s surface temperature of approximately 0.83 °C.

Vegetation can reduce summer temperatures and improve climate comfort in surrounding outdoor spaces, and thus can reduce the UHI phenomenon in parts of the city [29]. Some studies have found that vegetation has an average cooling effect ranging from 1 °C to 4.7 °C that extends for a radius of 100–1000 m in an urban area depending on the size of the green space [30,31]. However, during nights with calm winds and clear skies, it can be considerably more intense and in some large cities can even reach 12 °C [32]. The cooling effect is also strongly dependent on the amount of water available to plants and trees, and the presence of green infrastructures (rain gardens and other bioretention areas) for rainwater harvesting and infiltration as well as the use of supplemental irrigation can be crucial for increasing this effect [33–35].

One of the most promising measures to cope with climate change and mitigate heat stress in urban areas is therefore the planting of new trees and the increase in green spaces [36–39]. Large-scale tree planting in cities, known as “urban forestation”, is considered particularly effective for creating cooler areas [40].

Urban trees mitigate UHIs and reduce near-surface temperatures through direct shading and evaporative cooling. In particular, trees near a building reduce its heat build-up by: (1) screening solar radiation incident on the building, (2) shading nearby surfaces that radiate heat towards the building, (3) reducing the infiltration rate of outside air by lowering wind speed, and (4) lowering temperature through evapotranspiration [41]. With regard to shading, the shape of the tree canopy may be more important than its density [42]. Similarly, trees along roads and in parking lots are also particularly effective for their shading function of surfaces that are in themselves characterised by low albedo (asphalt, concrete) [43].

The effectiveness of evapotranspiration cooling depends strongly on the water availability in the soil and is limited by the volume and biomass of the tree, parameters that are also crucial in determining the amount of shade provided [44]. The leaves of a tree can be useful not only for their transpiration, but because their multi-layered structure provides effective shading without increasing the radiative temperature of the crown itself. Therefore, tall trees with large, dense crowns are much more effective than columnar or smaller trees [45].

A greater presence of greenery in public spaces has a relatively low cost, compared to other mitigation solutions, a high approval by citizens, and above all, it produces other important ecosystem services [46]. The implementation of green infrastructures in urban settings can be studied in advance to assess the improving effects on the environment and human health [25,47]. In this regard, it may be crucial to address the challenges of climate change by providing architects, landscape architects, and urban planners with
appropriate design approaches, including the use of digital tools and methods that assist in plant selection and greenery design [48,49].

There are various types of green infrastructure in urban areas: parks, urban forests, street trees, greenery in private gardens, bioretention areas (rain gardens), roofs, and green facades. Certainly, lower air and surface temperatures can be found in urban parks and forests, with more comfortable climatic conditions (also called park cool islands) [50,51].

Understanding and forecasting the effects of green spaces and tree cover in lowering air temperature is an essential tool in green infrastructure planning. For this purpose, it is possible to use an air temperature model simulating the effects of land cover changes using a water and energy balance that explicitly accounts for vegetation processes [52].

In order to analyse the mitigation effects on the UHI caused by green spaces and, particularly, by the tree cover, the i-Tree Cool Air model [53] was applied in the city of Padova (Italy) to simulate the air temperature changes during a summer day and their spatial distribution. The purpose of the study was to test the applicability of the model and to develop a method that, in further studies, would provide temperature predictions that could be compared to the ground truth, to verify the model reliability. This is currently one of the few applications of the model in Europe and the only one in the Po Valley climatic area, where many cities are badly affected by the UHI phenomenon and correlated pollution. This study also applies the model at a finer resolution compared to other studies, using locally acquired datasets, rather than standard satellite-derived land cover data.

2. Materials and Methods

The i-Tree Cool Air model was applied to simulate temporal trends and changes in air temperatures at a height of 2 m from the ground, and their spatial distribution in the city of Padova. The model is part of i-Tree Hydro+, a software suite of process-based environmental models developed by the USDA Forest Service [54,55]. i-Tree Cool Air is a spatially explicit air temperature model simulating the effects of land cover changes on water and energy budgets and consequently on the air temperature. The model assumes that for all spatial units under the same mesoscale climate, air temperature and humidity are modified by local variation in absorbed solar radiation and the partitioning of sensible and latent heat.

2.1. Definition of the Study Area

The city of Padova is located in the plain of the Veneto region, in northeast Italy. It is a medium-sized city with approximately 210,000 inhabitants and an area of 92.85 km². The climate of the area is humid subtropical according to Köppen climate classification (Cfa), with cold winters and hot summers, frequently associated with air stagnation (respectively, fog and sultriness).

In this study, the total area of the Municipality of Padova was subdivided into five homogeneous territorial areas (HTAs) as defined in the city’s Urban Development Plan (Figure 1).

2.2. Data Sources and Processing

To run the i-Tree Cool Air model, it is necessary to provide a set of data describing topography and land cover, along with climate data at a chosen reference weather station in the study area (Figure 2). Specifically, a digital terrain model (DTM), a digital surface model (DSM), a land use map, an impervious surfaces map, and an urban tree cover map are required. The DTM was provided by the city planning office as a georeferenced raster with 1 m × 1 m resolution. The land use map was obtained from the Regional Mapping Portal at the highest available resolution.
Figure 1. Geographical framework of the study area with the five homogeneous territorial areas (HTAs) into which the Municipality of Padova is subdivided. The red dot indicates the location of the reference weather station.

Figure 2. Diagram illustrating the procedure implemented in the study.

The DSM and the tree cover map were derived from an aerial survey performed in July 2021. The survey provided 8 cm resolution RGBIr orthophotos of the entire city with an appropriate overlap, allowing the extraction of a 20 cm resolution DSM by stereoscopic image matching, and the creation of true orthophotos. The crowns of the trees were extracted from the combination of normalised difference vegetation index (NDVI) images,
obtained from the RGBIr true orthophotos with QGIS raster calculator, and the normalised
digital surface model (nDSM), obtained by subtracting the DTM from the DSM. An NDVI
value greater than 0.13 was used to identify vegetation. A threshold of 2.5 m from the
ground was used to separate tree crowns from other vegetation types.

The very high resolution of the DSM (20 cm) and of the true orthophotos produced
a very detailed map of the tree crowns. Such a resolution was not, however, compatible
with the algorithms used by the i-Tree Cool Air software, designed to analyse data on
a much coarser mesh. For this reason, the raster layers obtained with the previously
described processes were downscaled to a 10 m × 10 m cell size which determined our
base spatial unit. To each spatial unit, a % tree cover value was automatically assigned in
the downscaling process.

With a similar procedure, a map of the permeability of soils was constructed using
the NDVI images to extract impervious surfaces, again at a resolution of 10 m × 10 m. The
Corine land use classes were grouped according to their attributes and converted into the
National Land Cover Database (NLCD) Anderson level-2 land cover classes, utilised by
the i-Tree Cool Air software.

The city’s airport weather station was chosen as reference because of its location in
an open space with pervious surfaces and no tree cover, between the city centre and the
more rural outskirts. Climate data inputs for the i-Tree Cool Air model include hourly air
temperature, dew point temperature, wind speed, precipitation, observed and net radiation,
and direct and diffuse solar radiation estimated at the reference weather station.

2.3. Air Temperature Simulation

Analysing weather data and site characteristics, the model simulates the energy
balance for each of the 10 m × 10 m spatial units, and outputs the air temperature, at 2 m
from the ground, for the chosen time spans.

A summer day of July 2021 characterised by high atmospheric pressure, absence of
wind, and extreme maximum temperatures was chosen for the simulation, assuming the
conditions to be most critical for the heat island. Two scenarios were simulated: one during
the day, when maximum temperatures were reached at the reference station (35 °C at
3 p.m.), and one at night at 10 p.m. when the temperature was 28 °C.

The analysis was carried out for the five HTAs of the urban territory, in which three dis-
tinct urban/environmental situations are essentially evident, representing the entire area:
- HTA 1 Historic centre, characterised by maximum urban density and diffuse, small,
green areas or linear green elements;
- HTA 3 East, characterised by the large sealed areas of the industrial zone;
- HTA 2 North, HTA 4 South, and HTA 5 West, characterised by an urban–rural interface.

3. Results

The study produced two sets of results. Firstly, by processing the aerial images, a
detailed maps of impervious/pervious surfaces and a UTC map were obtained. Secondly,
by running the i-Tree Cool Air model, aboveground air temperatures were simulated for
the chosen timeframes.

Figure 3 shows the tree cover map (a) and the permeable surfaces (b). In Figure 3a,
the percentage of tree cover in the 10 m × 10 m cells is represented by different shades
of green. The map shows the highest tree cover values in urban parks, but also along
streets and roads. A finer scale observation also highlights presence of trees in private
residential gardens, this is also evident in the city centre were the building density causes a
high fragmentation of the tree cover. Some HTAs, such as HTA East, show a much lower
presence of tree cover, while the highest values are shown in HTA 2 North and HTA 5 West.
A finer scale observation also highlights the presence of trees in private residential gardens, this is also evident in the city centre where the building density causes a high fragmentation of the tree cover. Some HTAs, such as HTA East, show a much lower presence of tree cover, while the highest values are shown in HTA 2 North and HTA 5 West.

Figure 3. Tree cover map (a) and map of the permeability of soils (b) with the percentage of the impervious surfaces (highlighted in a darker colour) in the five homogeneous territorial areas (HTAs) of the Municipality of Padova.

In Figure 3b, permeable surfaces are shown in a lighter colour. The map shows that the impervious surfaces (buildings, roads, sidewalks, etc.) range from 24.56% in HTA 5 West to 61.58% in HTA 1 Historic centre, located in the “heart” of the city. The high percentage value of HTA 3 East (the industrial area), affected by the high presence of industrial and commercial buildings as well as parking lots, should also be noted.

Table 1 shows the urban tree canopy (UTC) values obtained for the five HTAs. The highest values of tree canopy have been found in HTA 2 North and HTA 5 West.
North is also characterised by the second highest percentage of canopy cover. In HTA 1 Historic centre, the high percentage of tree canopy cover is a consequence of the presence of a larger number of mature and historic trees along streets and in private and public gardens, compared to other HTAs.

Table 1. Urban tree canopy expressed in m$^2$ and percentage of each total area in the five homogeneous territorial areas (HTAs) derived from NDVI maps and nDSM.

<table>
<thead>
<tr>
<th>HTA</th>
<th>Urban Tree Canopy</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Historic centre</td>
<td>1,212,382</td>
<td>23.2</td>
</tr>
<tr>
<td>North</td>
<td>4,501,907</td>
<td>18.6</td>
</tr>
<tr>
<td>East</td>
<td>2,981,251</td>
<td>16.0</td>
</tr>
<tr>
<td>South</td>
<td>3,296,384</td>
<td>16.0</td>
</tr>
<tr>
<td>West</td>
<td>4,077,641</td>
<td>16.6</td>
</tr>
</tbody>
</table>

HTA 3 East and HTA 4 South show the lowest percentage of tree canopy values, the former due to the large amount of treeless impervious surfaces in the industrial zone, the second due to the low tree density in agricultural areas.

The raster map in Figure 4 shows the spatial distribution of air temperatures with a 10 m $\times$ 10 m resolution, simulated in the daytime at 3 p.m., when the maximum temperature was recorded (35 $^\circ$C at the reference weather station).

As expected, the highest temperatures are shown in the areas that are more densely built upon and were soils are mostly sealed. The lowest temperatures, on the other hand, are shown where tree canopy is denser and to a lesser extent in green open spaces without trees. This is particularly evident looking at the city centre (HTA 1) that is almost entirely built upon and sealed, while lower temperatures occur in parks and along tree-lined streets. Comparing temperatures between urban open spaces (squares, streets) and green areas,
especially those with tree cover, the simulation shows temperature differences of up to 6–10 °C. One can also note the mitigation effect on the heat island offered by tree canopies in streets with trees and in parks in the historic centre. Looking at the outskirts of the city, the temperature trend in HTA 3 East is also interesting, where there are many commercial, craft, and industrial buildings, container storage areas, and large paved parking areas. Here, we can see the difference between urbanised areas and the few rural areas, with greater differences where trees and groves and a few tree-lined boulevards are present. With regard to the HTAs characterised by the urban/rural interface (HTA 2 North, HTA 4 South, and HTA 5 West), the application of the i-Tree Cool Air software showed that the mitigation effect on the UHI is also ensured by the presence of cultivated land in the areas with agricultural land use.

Table 2 summarises maximum, mean, and minimum air temperatures simulated at 3 p.m. for the five HTAs, along with ΔT°C values compared with the reference weather station. The temperature differences between the hottest and the coolest areas could be up to 9 °C during the day, according to the model. Data show, during the day, a ΔT°C up to +4 °C for the maximum air temperatures in all the HTAs compared to the reference weather station, while for the simulated minimum temperature the ΔT°C is around −5 °C.

Table 2. Simulated temperatures in the five HTAs and temperature differences compared to the values recorded at the reference weather station at 3 p.m.

<table>
<thead>
<tr>
<th>T°C</th>
<th>HTA 1—Historic Centre</th>
<th>HTA 2—North</th>
<th>HTA 3—East</th>
<th>HTA 4—South</th>
<th>HTA 5—West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tmax</td>
<td>39.16</td>
<td>38.54</td>
<td>39.16</td>
<td>38.76</td>
<td>38.84</td>
</tr>
<tr>
<td>Tmean</td>
<td>37.8</td>
<td>36.98</td>
<td>37.66</td>
<td>36.55</td>
<td>36.37</td>
</tr>
<tr>
<td>Tmin</td>
<td>30.13</td>
<td>30.02</td>
<td>30.18</td>
<td>30.88</td>
<td>29.95</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ΔT°C</th>
<th>HTA 1—Historic Centre</th>
<th>HTA 2—North</th>
<th>HTA 3—East</th>
<th>HTA 4—South</th>
<th>HTA 5—West</th>
</tr>
</thead>
<tbody>
<tr>
<td>max</td>
<td>4.16</td>
<td>3.54</td>
<td>4.16</td>
<td>3.76</td>
<td>3.84</td>
</tr>
<tr>
<td>mean</td>
<td>2.8</td>
<td>1.98</td>
<td>2.66</td>
<td>1.55</td>
<td>1.37</td>
</tr>
<tr>
<td>min</td>
<td>−4.87</td>
<td>−4.98</td>
<td>−4.82</td>
<td>−4.12</td>
<td>−5.05</td>
</tr>
</tbody>
</table>

Figure 5 shows the raster map of the spatial distribution of air temperatures with a 10 m × 10 m resolution, simulated in the nighttime at 10 p.m., in the early hours of the night, when the heat island effect is perhaps even more evident in the urbanised impervious areas. This effect is also well highlighted by the values reported in Table 3. As can be observed, at night the warmest temperatures still maintain a high ΔT°C, in some cases more relevant than in the daytime, while the coolest temperatures, corresponding to the tree-covered units, are less than 1 degree lower compared to the reference station.

Table 3. Simulated temperatures in the HTAs and temperature differences compared to the values recorded at the reference weather station at 10 p.m.

<table>
<thead>
<tr>
<th>T°C</th>
<th>HTA 1—Historic Centre</th>
<th>HTA 2—North</th>
<th>HTA 3—East</th>
<th>HTA 4—South</th>
<th>HTA 5—West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tmax</td>
<td>33.21</td>
<td>32.12</td>
<td>32.12</td>
<td>33.05</td>
<td>33.05</td>
</tr>
<tr>
<td>Tmean</td>
<td>32.21</td>
<td>30.93</td>
<td>31.12</td>
<td>30.99</td>
<td>30.84</td>
</tr>
<tr>
<td>Tmin</td>
<td>27.67</td>
<td>27.13</td>
<td>27.76</td>
<td>27.04</td>
<td>27.04</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ΔT°C</th>
<th>HTA 1—Historic Centre</th>
<th>HTA 2—North</th>
<th>HTA 3—East</th>
<th>HTA 4—South</th>
<th>HTA 5—West</th>
</tr>
</thead>
<tbody>
<tr>
<td>max</td>
<td>5.21</td>
<td>4.12</td>
<td>4.12</td>
<td>5.05</td>
<td>5.05</td>
</tr>
<tr>
<td>mean</td>
<td>4.21</td>
<td>2.93</td>
<td>3.12</td>
<td>2.99</td>
<td>2.84</td>
</tr>
<tr>
<td>min</td>
<td>−0.33</td>
<td>−0.87</td>
<td>−0.24</td>
<td>−0.96</td>
<td>−0.96</td>
</tr>
</tbody>
</table>
Looking at differences in mean temperatures between different parts of the city, it can be noticed that the highest values are shown for HTA 1 Historic centre and HTA 5 East. These HTAs are those characterised by the greatest extent of sealed and non-transpiring surfaces. Such differences also persist at night.

4. Discussion

The pattern of temperature distribution is similar between the daytime and nighttime simulation; however, looking at temperature values in the single 10 m × 10 m units, a higher cooling effect of tree canopy can be noticed in the daytime compared to the nighttime simulation. During the day, areas with tree cover show air temperatures up to 5 °C lower than the reference station, while at night the temperature difference is less than 1 °C. This could be expected considering that transpiration is more intense in the daytime and a part of the cooling effect of the tree canopy is due to shading. The differences found during the day appear greater than those found in other studies, which showed a cooling effect of 2–2.5 °C related to tree shading, a value more in accordance with the average values simulated by the model [56–58].

In rural areas, differences in colouration can be seen, which correspond to higher or lower air temperatures. This is due to the presence of different vegetation statuses of the crops at the time of the remote sensing flight. It is in fact evident that the mitigating effect on temperatures by the vegetation may be different [59], a phenomenon in this case linked above all to the evapotranspirative process, but also to a shading of the ground, albeit more modest than that of the trees. This effect only occurs if there are plants in full leaf and good ground cover. This is the case, for example, there were fields that were cultivated with maize at the time when the simulation was run (July), a crop that was certainly in full development with total soil coverage. Conversely, the effect is certainly less in bare soils or if the crop is in the early stages of growth or has reached the senescent stage, as in the case of plots cultivated with wheat or barley, a crop which by July was probably only stubble.
To ensure the most realistic albedo is included in the model, it is therefore necessary to use orthophotos of the period to which the simulation refers.

The presence of canopy cover within the city appears to be related both to environmental factors and to those connected to the historic urban development. Urban density and sealed surfaces are generally a negative factor for the presence of trees. Also negative are certain land uses, specifically industrial and agriculture, where trees are sparsely present, since they are often seen as obstacles to mobility and production. Older areas of the city, even when densely urbanised, often show higher percentage values of tree canopy because trees planted throughout the 19th century have reached rather big dimensions compared to the younger planting in the more recently urbanised outskirts.

While the model simulation shows the lowest temperatures in areas under the tree canopy cover, the relation between canopy cover or % canopy cover and average ΔT in the HTAs is less evident. HTA 5 West, that is characterised by the highest tree canopy value, shows, for instance, the lowest simulated ΔT. HTA 2 North, characterised by high canopy cover and % canopy cover, also has relatively low simulated average ΔT, being, however, cooler then HTAs 1 and 3. The average simulated ΔT seems to be more related to the amount of transpiring surfaces in the HTAs than to the canopy-covered surface, which, in general, is much smaller in size. Clearly, on the other hand, the reported average air temperature is obtained by simply averaging the simulated temperatures of each 10 m × 10 m spatial unit and it does not simulate the effects of densely covered cells on the temperature of neighboring units. In reality, as many authors report [60,61], the effects of tree canopy on air temperature can extend some distance from the tree location and can be different according to size and shape and distribution of the canopy patches.

We have yet to demonstrate, with further investigations, the accuracy of the model in predicting real temperatures, both at a local scale (spatial units) and at the HTA and city scale. The model was tested for accuracy in previous studies both in the US and in Europe and performed satisfactorily given its intended simplicity [62,63]. Considering that we used a finer resolution and that our study area is in a different climate zone, the next development of our research will be to further validate the results by comparing the output of the model with the ground truth, registered at a number of stations measuring the microclimate in distinct areas throughout the city, characterised by different land cover.

5. Conclusions

The inclusion of vegetation, and especially trees, is one of the most effective strategies to counteract the urban heat island phenomenon. More greenery in public spaces has a relatively low cost compared to other mitigation solutions and provides other important ecosystem services. The positive effects produced by green spaces can be analysed in advance using appropriate simulation models, especially when different scenarios are to be considered.

Through the i-Tree Cool Air model, it was possible to highlight the differences in air temperature between impervious areas and green areas, and how the mitigation effect on high temperatures is enhanced by the presence of tree canopy at the spatial unit level. It appears evident, according to the model, that an increase in vegetation is indeed a possible strategy to reduce air temperatures. Preliminary results from the application of the model to the Municipality of Padova (northeast Italy) highlighted significant differences between urban open spaces with impervious cover (squares, streets) and green areas under tree canopy, showing that urban forestation in all its possible forms (street trees, trees in squares and parks, urban and periurban forests) can improve climatic comfort and make the city more liveable.

This preliminary study demonstrates that with relatively simple data obtained from public datasets, especially when considering a coarse resolution, a 10 m × 10 m grid in our case, it is possible to simulate air temperature changes in relation to changes in land use and canopy cover. Our future goal is to be able to apply the model as a tool for green
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