

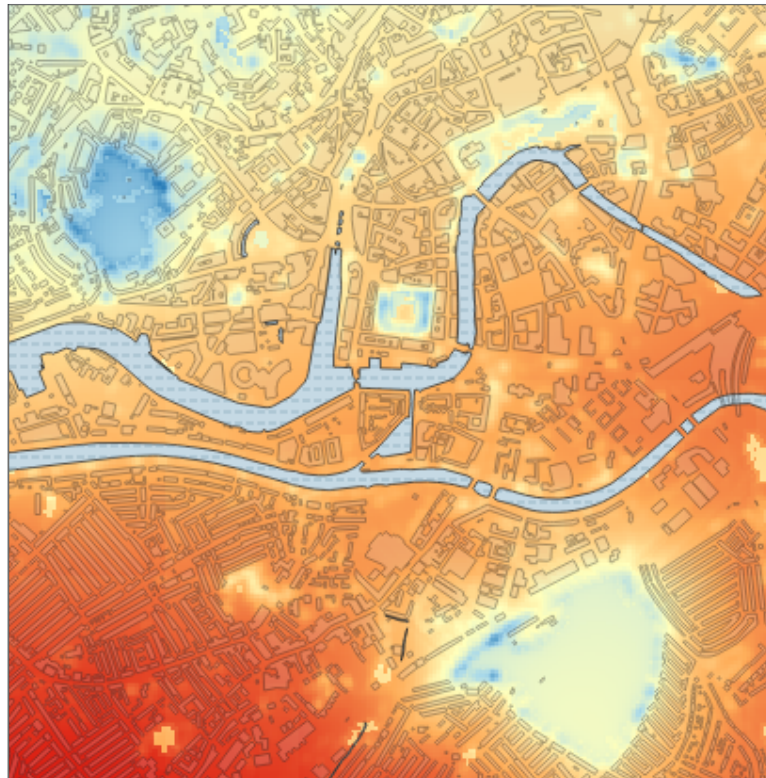
# Urban Cooling by Greenspaces and Trees in Five City Areas

Summary Report to Friends of the Earth

by

Terra Sulis Research CIC

11<sup>th</sup> July 2023



Cooling offsets by greenspace and trees, Bristol



[terrasulis.org](http://terrasulis.org)

# Urban Cooling by Greenspaces and Trees in Five City Areas

This summary document outlines a set of maps, for five cities, illustrating modelling of urban cooling by greenspaces and trees. The urban heat island effect, whereby urban areas are hotter than surrounding rural areas, is a significant factor in our warming environment with implications for human health. Mitigation of urban heat island effects by greenspaces and trees is a way to potentially ameliorate warming in the urban environment.

The cooling model used is that described by Doick, et al. (2014) and & Vaz Monteiro et al. (2016) and is based on empirical data of the night time cooling effect by greenspaces in the London urban heat island. We have extended the implementation of this model by including cooling by trees. The volume of city trees has been derived using the Friends of the Earth tree canopy map for England, which includes LiDAR-derived height data for every tree at 1m resolution. A simple model has been created which calculates cooling from trees based on distance from the tree and the volume of the tree, which has then been calibrated to accord with the Vaz Monteiro model for greenspaces. Trees and green spaces also have a cooling effect during the day through shading and evapotranspiration - the two main cooling mechanisms.

The tree canopy map was generated for Friends of the Earth from Environment Agency LiDAR data of England. The greenspace data are derived from the Centre for Ecology and Hydrology Land Cover Map, as described by Marston et al. (2022). Implementation of the cooling model was performed by Terra Suslis CIC in the R Project for Statistical Computing programming environment.

When viewing the maps a number of things should be kept in mind. The cooling effect at any location is influence by the distance to and the size of greenspaces and trees. By definition 'urban cooling' means within the urban area. The model does not consider the rural zone. By nature of their position, places at the periphery of the urban area do not benefit from any urban greenspace cooling from the rural side and will generally have a lower cooling offset (redder on the maps) than more central areas. The following views are generally focused away from the periphery. In reality the periphery will also benefit from rural cooling, which has not been considered. Small greenspaces are influenced by cooling from large greenspaces more than the other way around. This is noticeable in the maps as enhanced cooling within small greenspaces.

Cooling offsets maps have been created for greenspaces and for trees for selected urban areas in the following cities:

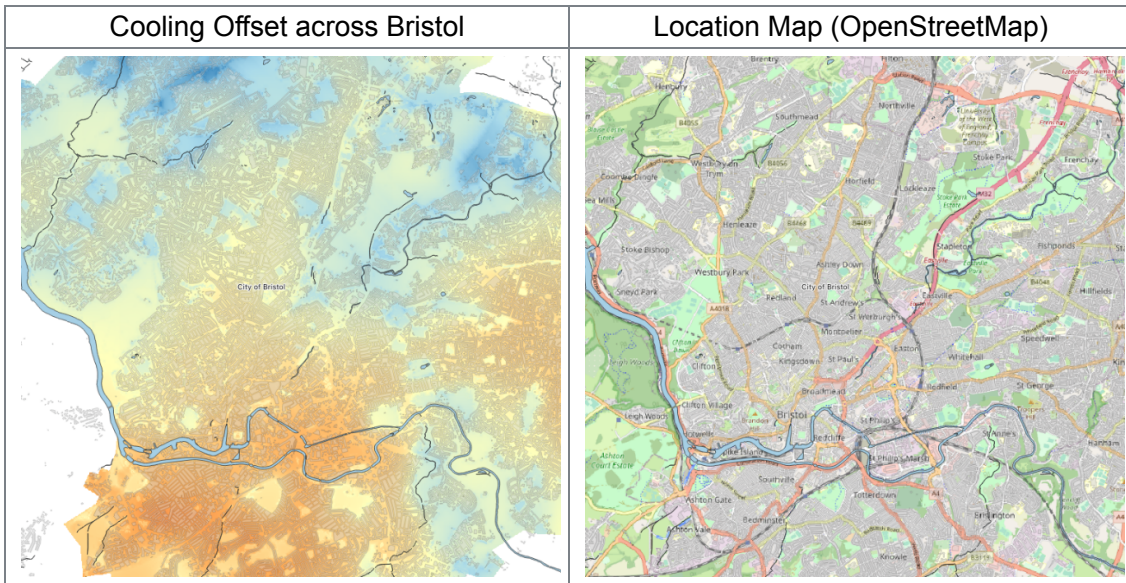
- Bristol
- Birmingham

- Manchester
- Newcastle
- London

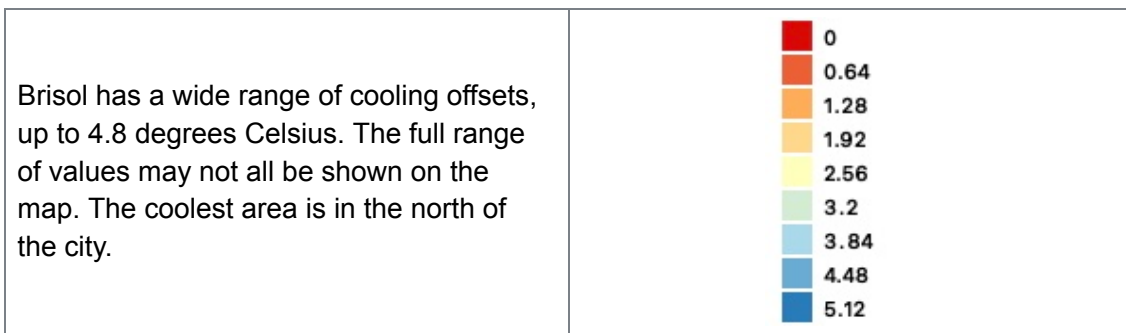
Each city is described below with example graphical outputs and a description of the salient points of note. Fair-copy high resolution versions of the maps are in separate files.

The cooling effect varies based on local circumstances and each city is different, so each city has a different colour legend. Generally speaking, the effect varies from almost nothing up to a maximum of about 5 degrees Celsius.

# Bristol



## Main Legend



## Description

In Bristol there is a marked difference in the cooling effect of green spaces and trees between the north, central and south west areas of of the city. The large greenspaces of Filton Aerodrome, Blaise Castle Estate, Stoke Park Estate and Durdham Down all contribute to a cumulative night time cooling effect on communities, including Henbury, Stoke Bishop, Southmead and Frenchay, but to a much lesser extent to Stoke Gifford. The greenspace along the River Avon has a cooling effect on St Anne’s and parts of Brislington and Hanham. The central part of the city north of the River Avon is cooled to a lesser extent but with isolated cooler locations at Brandon Hill and Queen Square, where the large mature trees have a marked effect.

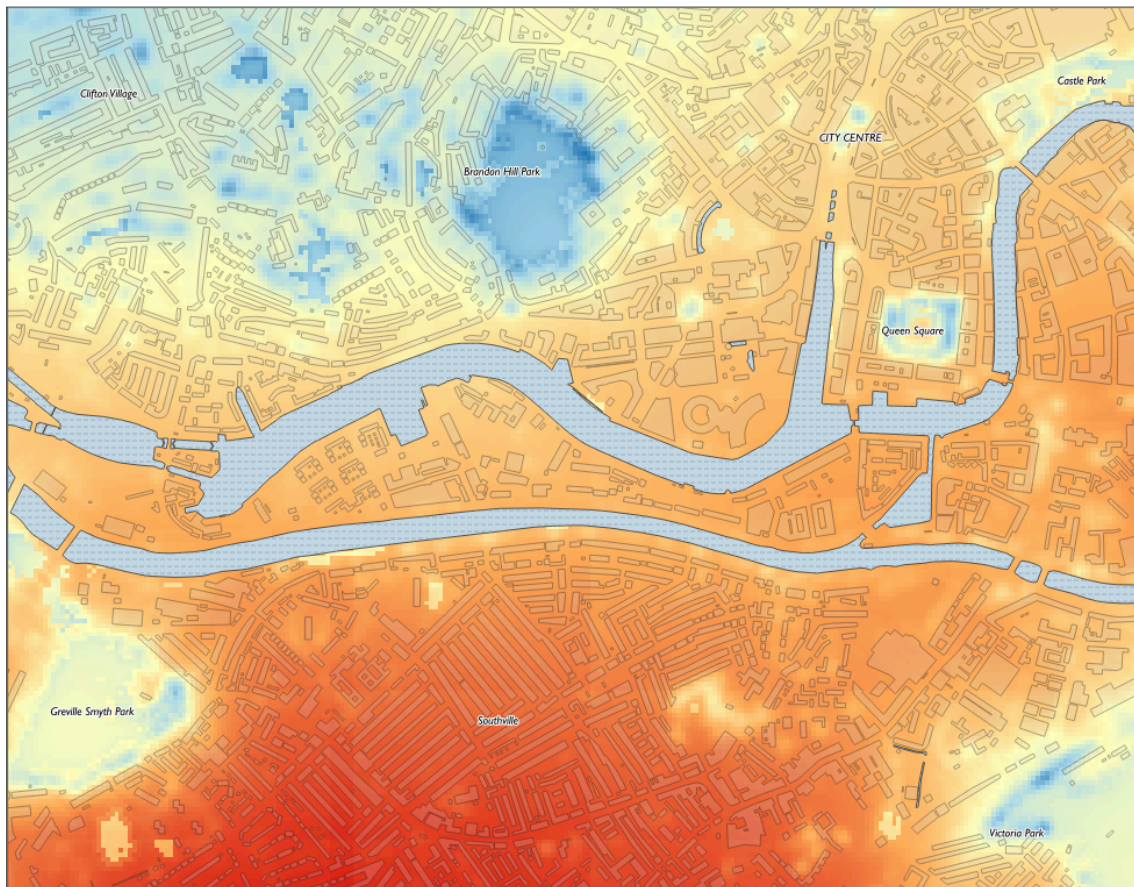
South of the River Avon the medium to large sized green spaces such as Victoria Park, Redcatch Park and John William Oasis Academy Playing Fields all have a cooling effect but with a smaller cumulative effect than in northern Bristol. Note that artificial grass

surfaces are not considered as greenspace. These surfaces actually heat up a lot during the day.

Urban greenspace and trees have a more localised impact on cooling at the periphery, including in Withywood, Hartcliffe and Oldham Common. These places are not shown on the map but they would all benefit from increased tree cover.

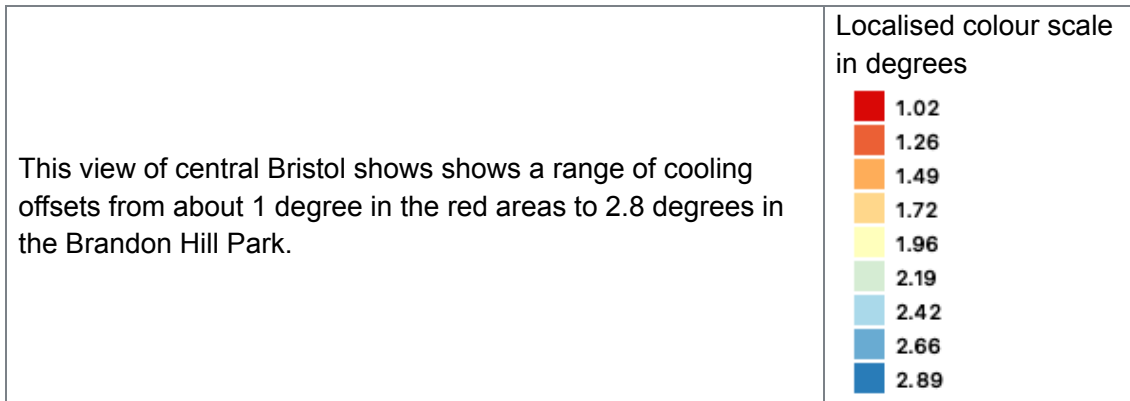
## Detailed View in Bristol

This view of central Bristol shows the Floating Harbour and the River Avon bisecting the image. To the north west trees in the leafy community of Clifton Village and trees around Brandon Hill Park indicate streets with cooling offsets of about 2.8 degrees, whilst to the south the dense and largely treeless streets of Southville have much lower cooling offsets of just 1 degree, contributed by the cooling effect of nearby parks. The model predicts localised cooling by street trees and a more extensive cooling contribution from large open greenspaces.

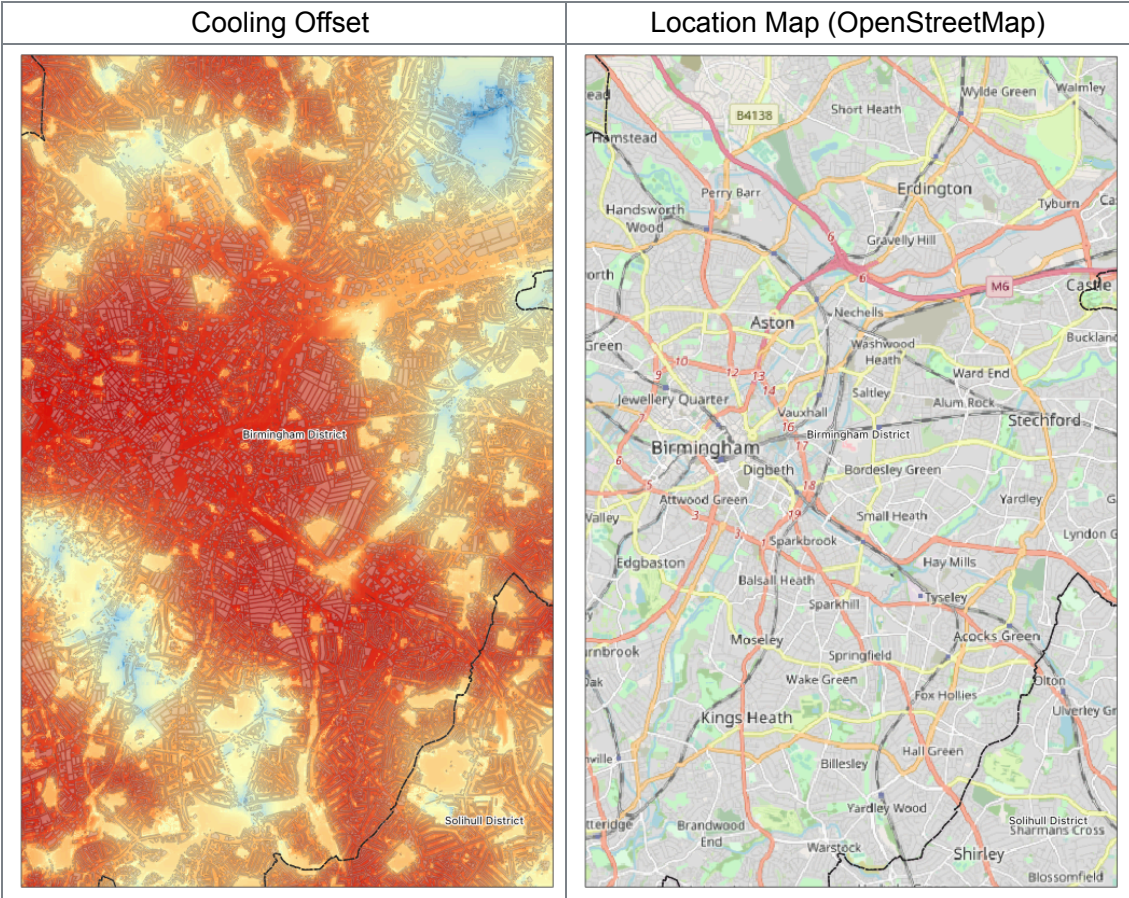


Detailed urban cooling offset view of central Bristol.

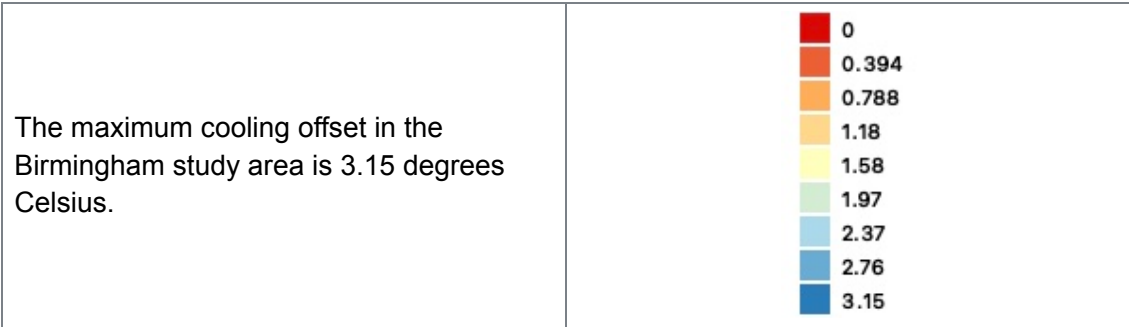
## Local Legend



# Birmingham



## Main Legend



## Description

This map covers much of Birmingham District including the very built up city centre which has few greenspaces or trees, providing little associated cooling, particularly around Smithfield. The environs of St Philip's Cathedral and St Paul's Church stand out as cooler islands within this central urban area. Moving outwards the city parks such as Kingston

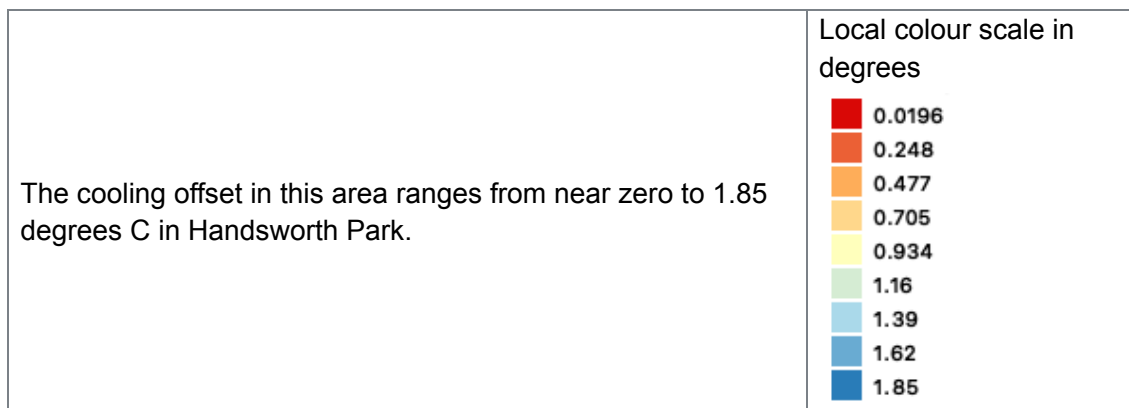
Hill Park, Small Heath Park, Gib Heath, George's Park, and others, provide valuable cooler areas, although in isolation from each other. Aston Park provides a larger cooling effect but again its effect is localised. The larger and more numerous parks around Edgbaston coalesce into a more intense cooling zone. Towards the north east Pype Hayes Park and Golf Course and Walmley Golf Course also coalesce into a larger cooler area. In the central area there are numerous small parks but few trees outside of the parks.

Birmingham City Centre, in the north eastern section of the image, is typically built up with very few trees in its deep city canyons and artificial open spaces such as Smithfield. Deep city canyons provide for shaded streets and hot buildings during the day but limit cooling at night. This treeless cityscape gives way to the south west towards the leafy and cooler suburb of Edgbaston.

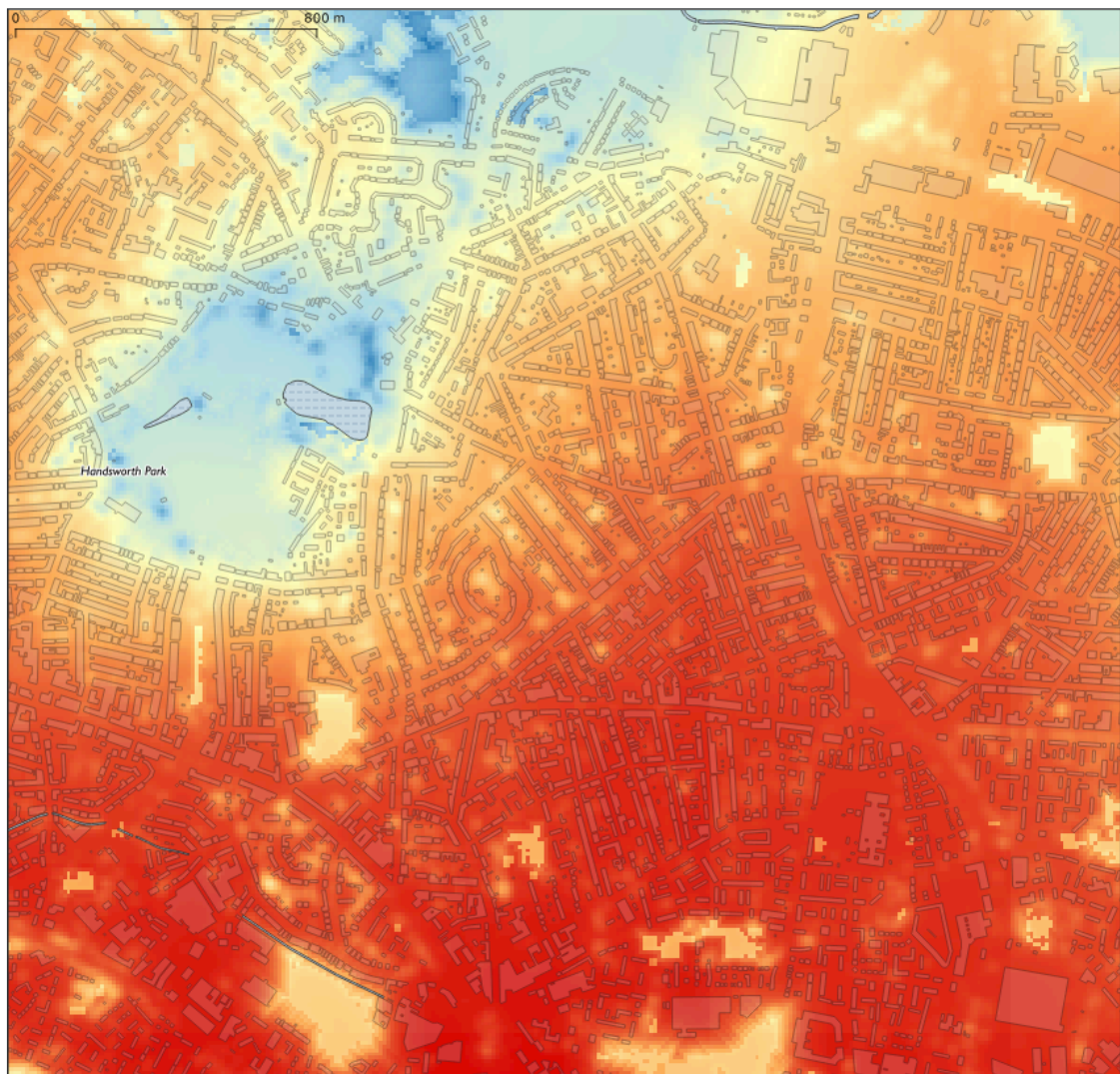
## Detailed View in Birmingham

This more detailed local view shows Handsworth Park greenspace in the north west and suburbs of between East Handsworth and Aston. The cool area of Handsworth Park, with its surrounding trees, stands out. The streets around the park are noticeably cooler than the streets to the south east that have little cooling. Houses around Handsworth Park tend to have larger gardens which may contain trees with their associated cooling effect. These stand out as localised cooler spots in between the houses, a characteristic absent from locations with smaller gardens.

### Local Legend

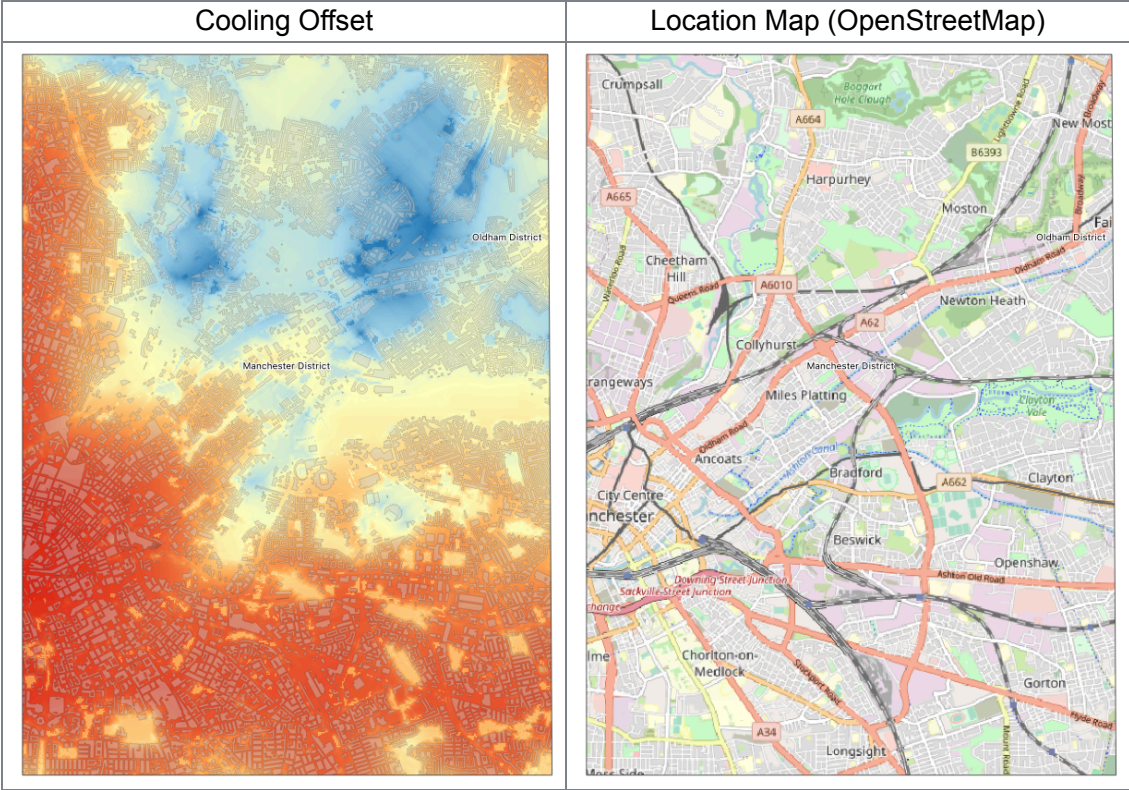




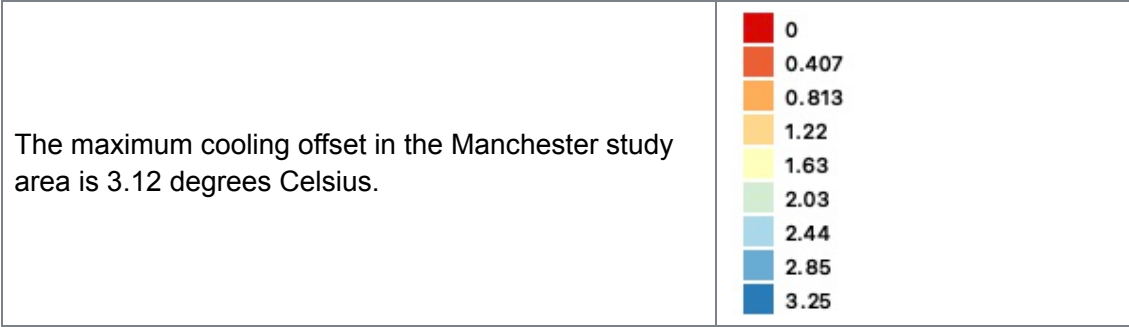


Detailed urban cooling offset view of Birmingham, north of the City Centre.

# Manchester



## Main Legend

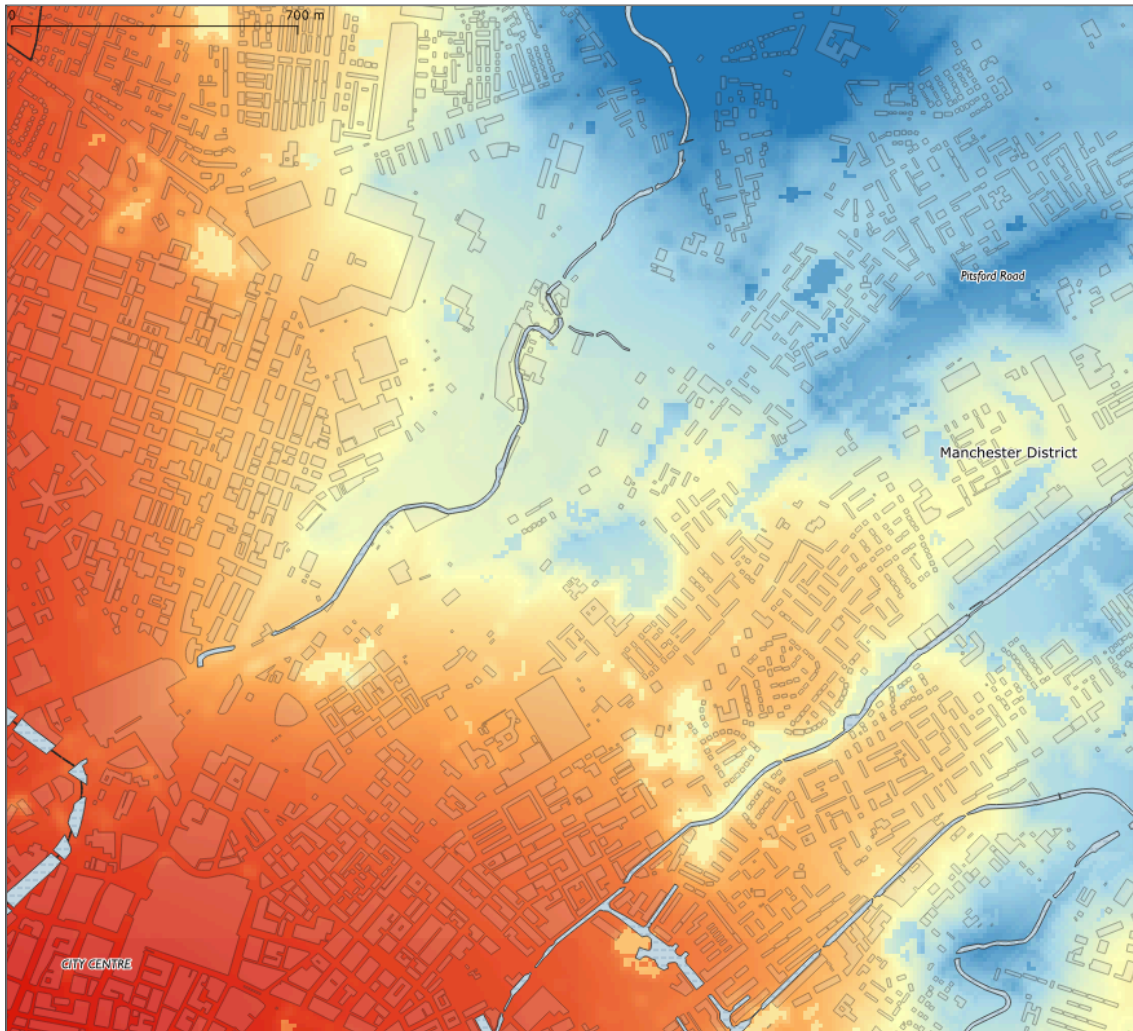


## Description

This view of central eastern Manchester clearly illustrates a lack of cooling in the City Centre where there are few greenspaces and very few trees. The isolated greenspaces at Whitworth Park and Annie Lees Playing Fields in the southern part of the map provide some localised cooling. Towards the northern and eastern part of the map the picture is quite different with many more greenspaces and more trees. Queen’s Park, Clayton Vale, Broadhurst Park and Boggart Hole Clough, and others, all provide greenspace cooling and contain many trees. The cooling effect of these greenspaces coalesces into a cooler

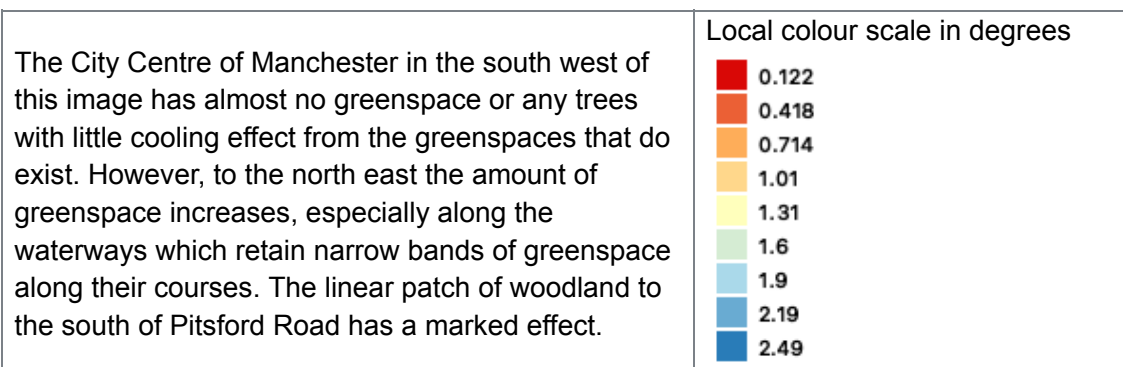
environment than the City Centre. The role of greenspace along the River Medlock as it snakes through the city is also evident, although this disappears as the river approaches the City Centre where the river becomes engulfed by the urban sprawl.

## Detailed View in Manchester



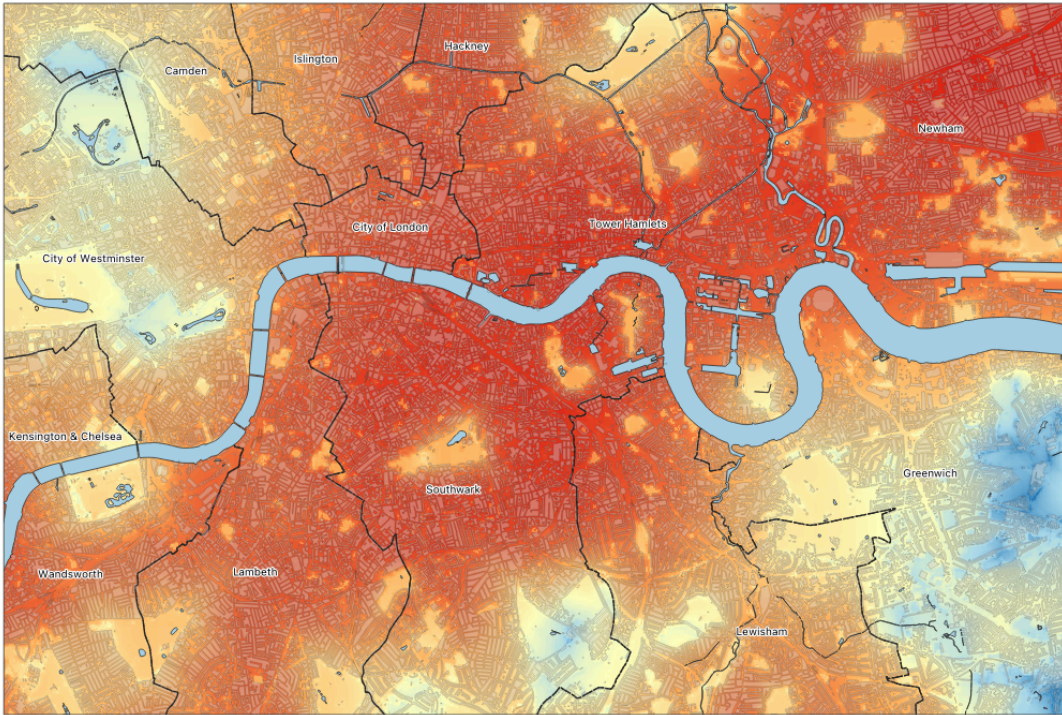
Detailed urban cooling offset view of Manchester, to the north east of the City Centre

### Local Legend

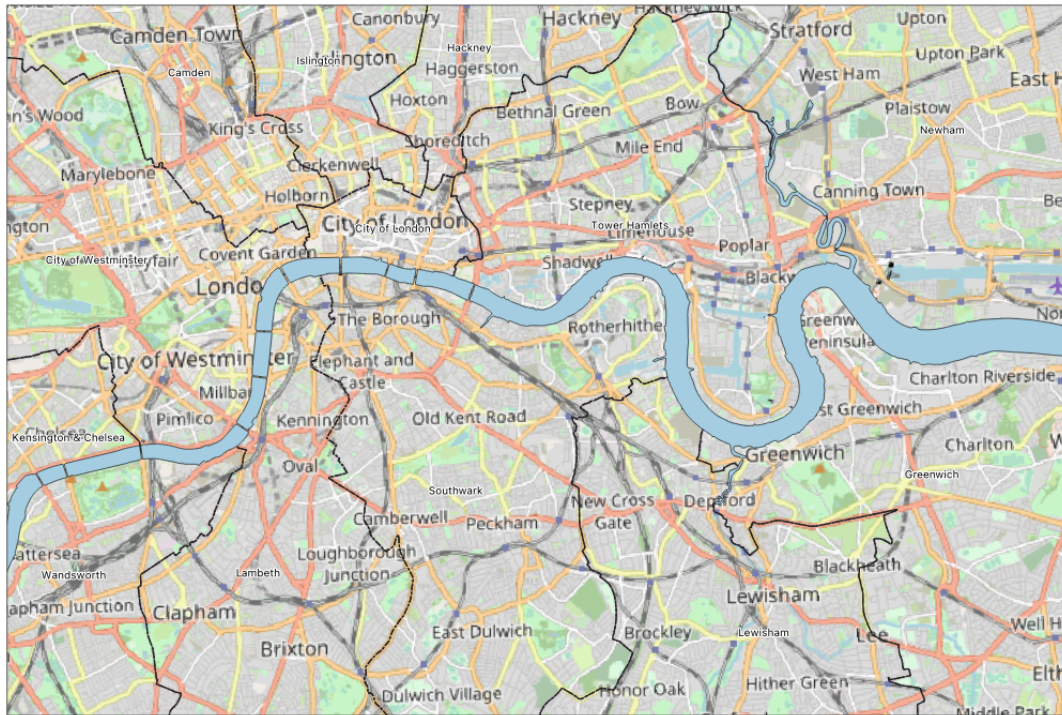


# London

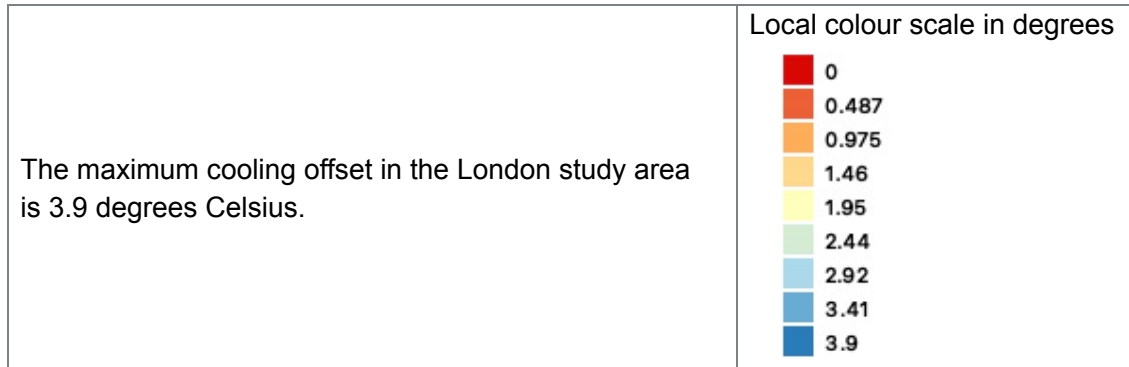
Cooling Offset



Location Map (OpenStreetMap)



## Main Legend



## Description

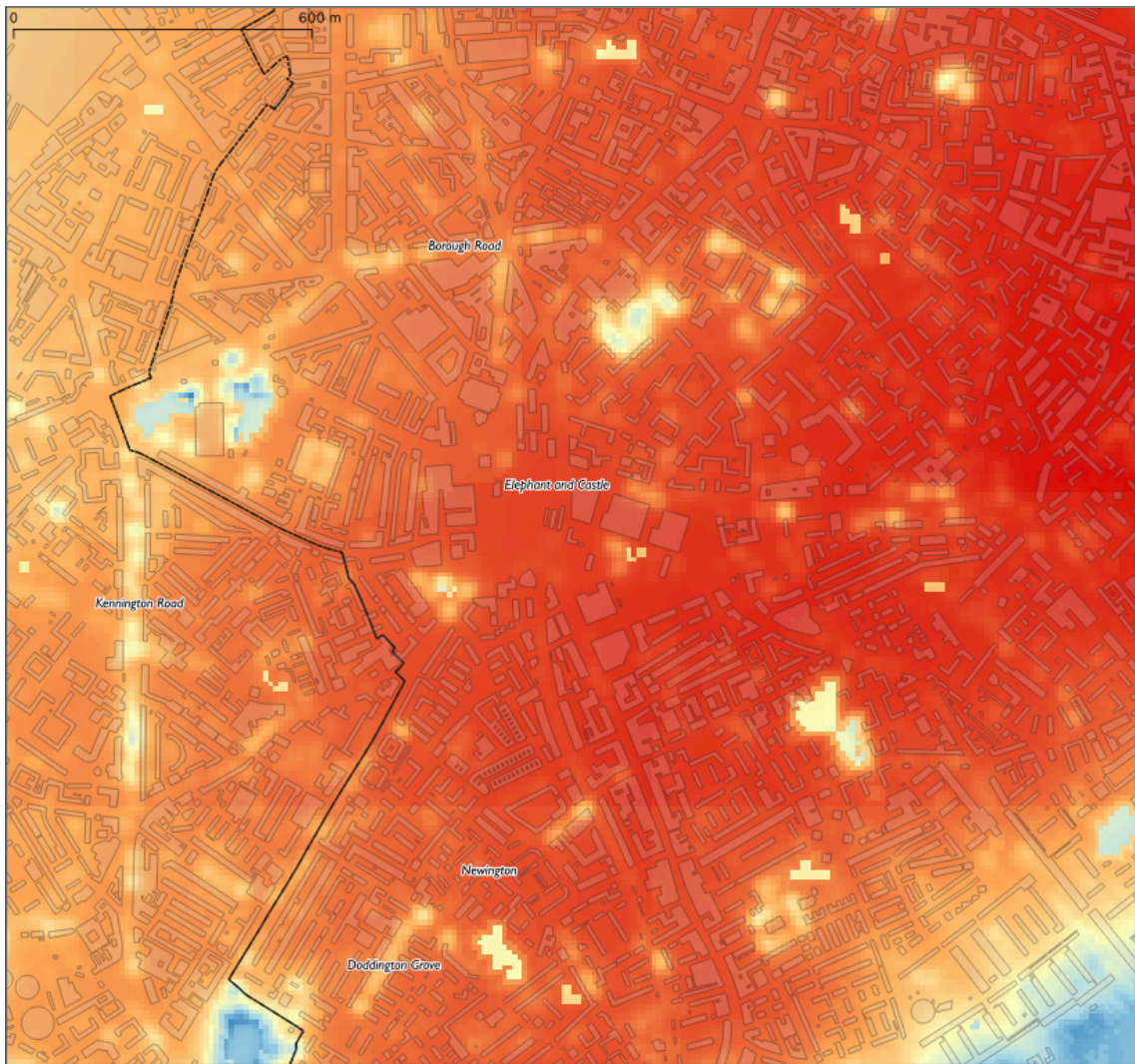
London has some large parks and a great number of trees, but they are not evenly distributed so their cooling effect is selective. The warmer, less cooled, areas on this map, in The City, Hackney, Southwark and Tower Hamlets, have some large areas with few greenspaces and relatively few trees. The City of London is particularly poorly served, although St Paul's Cathedral, The Inner Temple Garden and Finsbury Circus stand out as cool localised greenspaces.

To the north west Regent's Park, Green Park and Hyde Park coalesce into a cooler zone. The numerous parks and squares in Bloomsbury, with their large mature trees, form small isolated cooler spots. In Tower Hamlets, Victoria Park and Well Street Common provide a large greenspace and plenty of trees. In Newham, parks and cemeteries provide valuable greenspaces with trees in otherwise dense residential areas.

South of the river, Battersea Park, Burgess Park and Clapham Common are beacons of cool greenspace. Further to the east, Peckham Rye Common and Park, Nunhead Cemetery and Camberwell Old and New Cemeteries coalesce into a cool area. Further east, Blackheath and Greenwich Park are a large combined area of greenspace, the park with many mature trees and the heath with almost none. However, it is the arc of greenspaces from Woolwich, Shooters Hill, Eltham and Foxbury that coalesce into the most significant cooling area within this view of London.

## Detailed View in London

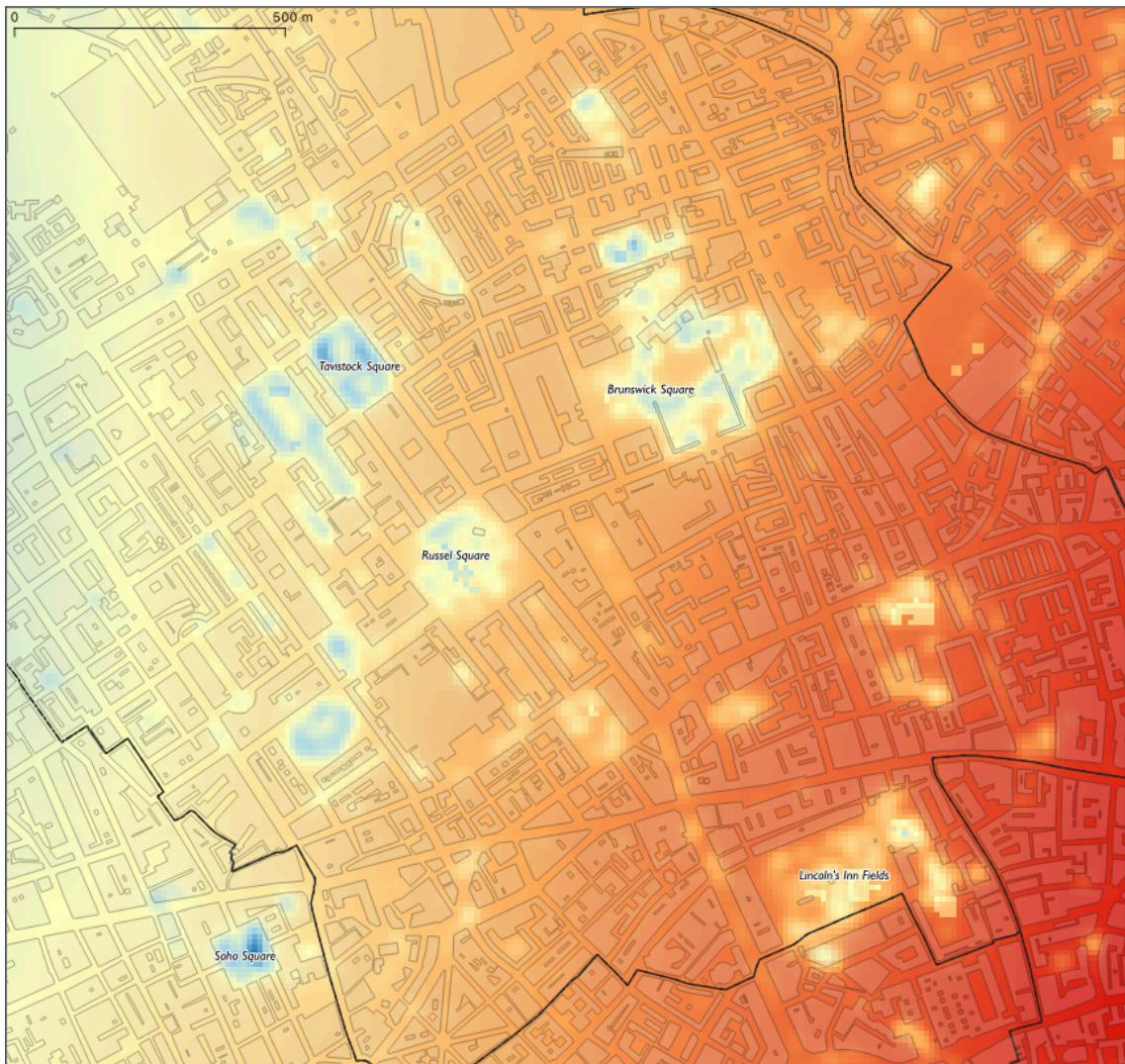
London is a city of many trees and parks but it is also the biggest urban heat island in the UK. Not everywhere is well catered for with greenspace. Elephant and Castle is one such place where the heat island has few greenspaces to cool it but it is not treeless, with the trees along Kennington Road and in Newington Gardens providing some cooling.



Detailed urban cooling offset view of Elephant and Castle, London

Local Legend

|   |  |
|---|--|
| <p>North to south oriented Kennington Road, in the west of this image, is lined with trees and stands out as a linear cool space. Similar tree-lined streets, including Kennington Park Road, Doddington Grove and Borough Road also provide cool streets. The railway line that bisects the image has no tree margins and is a hot rather than cool linear feature</p> | <p>Local colour scale in degrees</p> <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: red; margin-right: 5px;"></span> 0.197</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: orange; margin-right: 5px;"></span> 0.334</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: yellow; margin-right: 5px;"></span> 0.47</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: lightgreen; margin-right: 5px;"></span> 0.607</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: green; margin-right: 5px;"></span> 0.743</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: lightblue; margin-right: 5px;"></span> 0.879</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: blue; margin-right: 5px;"></span> 1.02</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: darkblue; margin-right: 5px;"></span> 1.15</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: darkblue; margin-right: 5px;"></span> 1.29</li> </ul> |
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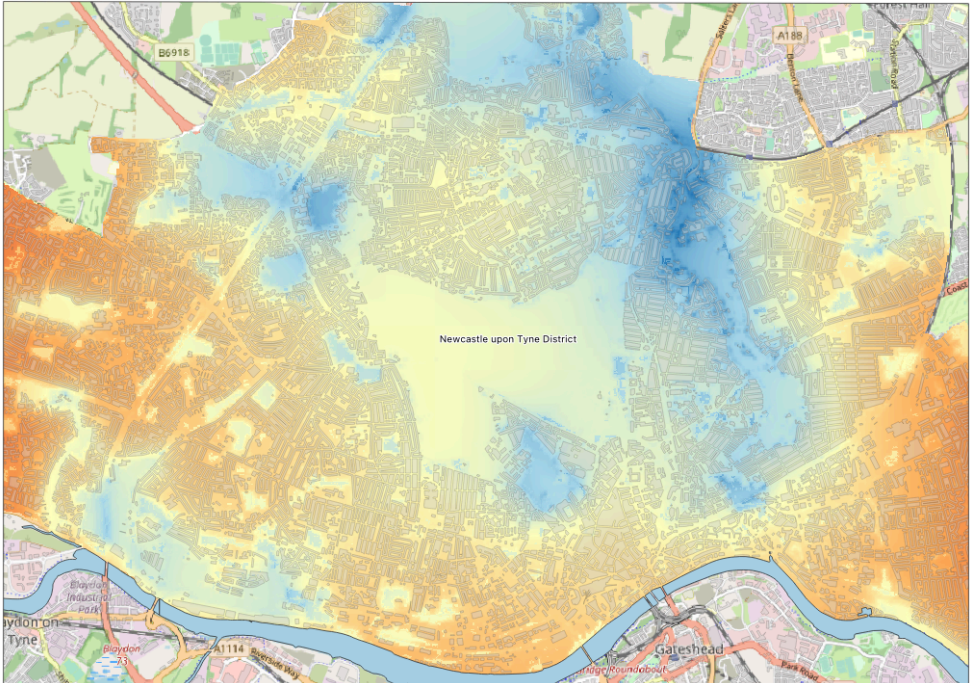
Detailed urban cooling offset view of Bloomsbury, London

Local Legend

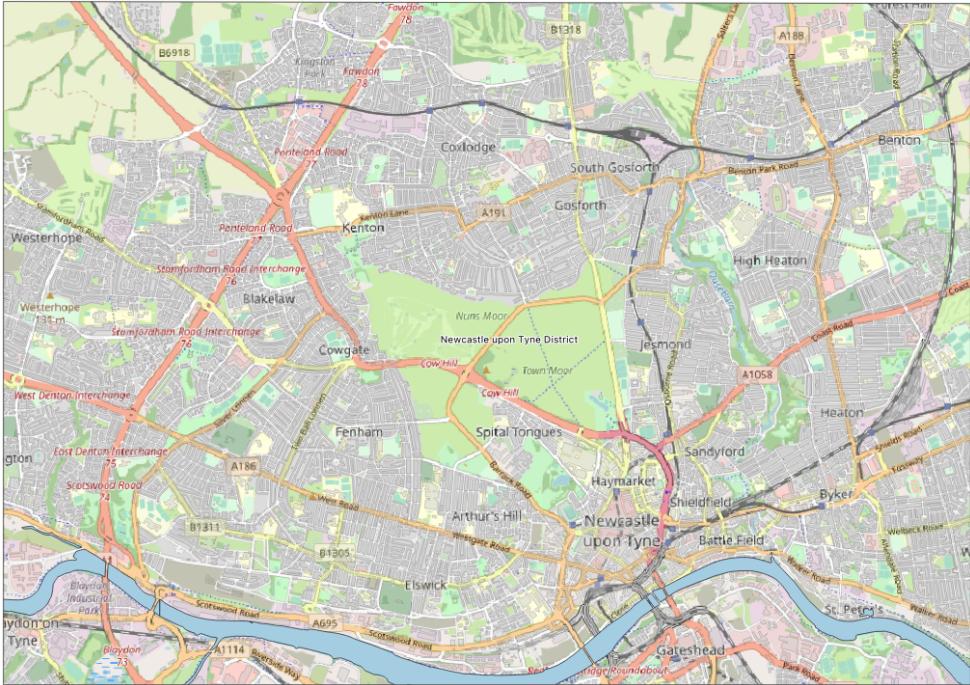
|   |  |
|---|--|
| <p>Bloomsbury lies in a transition zone between the cooler parks to the west and the hotter City to the east, and has a general east to west cooling gradient. It also has numerous parks and gardens with some magnificent mature trees. These trees stand out as localised cool areas with Tavistock Square and Russel Square being well known locations. Soho Square to the south west is another a square cooled by mature trees.</p> | <p>Local colour scale in degrees</p> <ul style="list-style-type: none"> <li><span style="color: red;">■</span> 0.532</li> <li><span style="color: orange;">■</span> 0.761</li> <li><span style="color: yellow;">■</span> 0.989</li> <li><span style="color: lightgreen;">■</span> 1.22</li> <li><span style="color: lightblue;">■</span> 1.45</li> <li><span style="color: green;">■</span> 1.67</li> <li><span style="color: cyan;">■</span> 1.9</li> <li><span style="color: blue;">■</span> 2.13</li> <li><span style="color: darkblue;">■</span> 2.36</li> </ul> |
|---|--|

# Newcastle on Tyne

Cooling Offset



Location Map (OpenStreetMap)

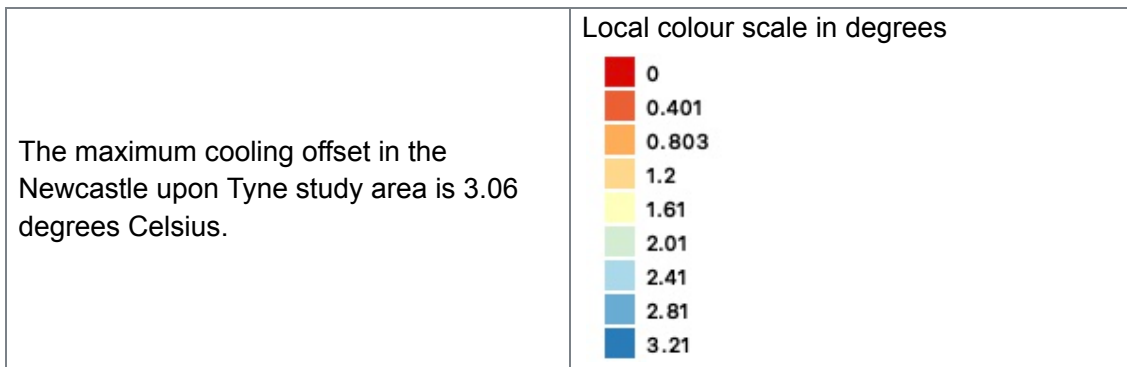




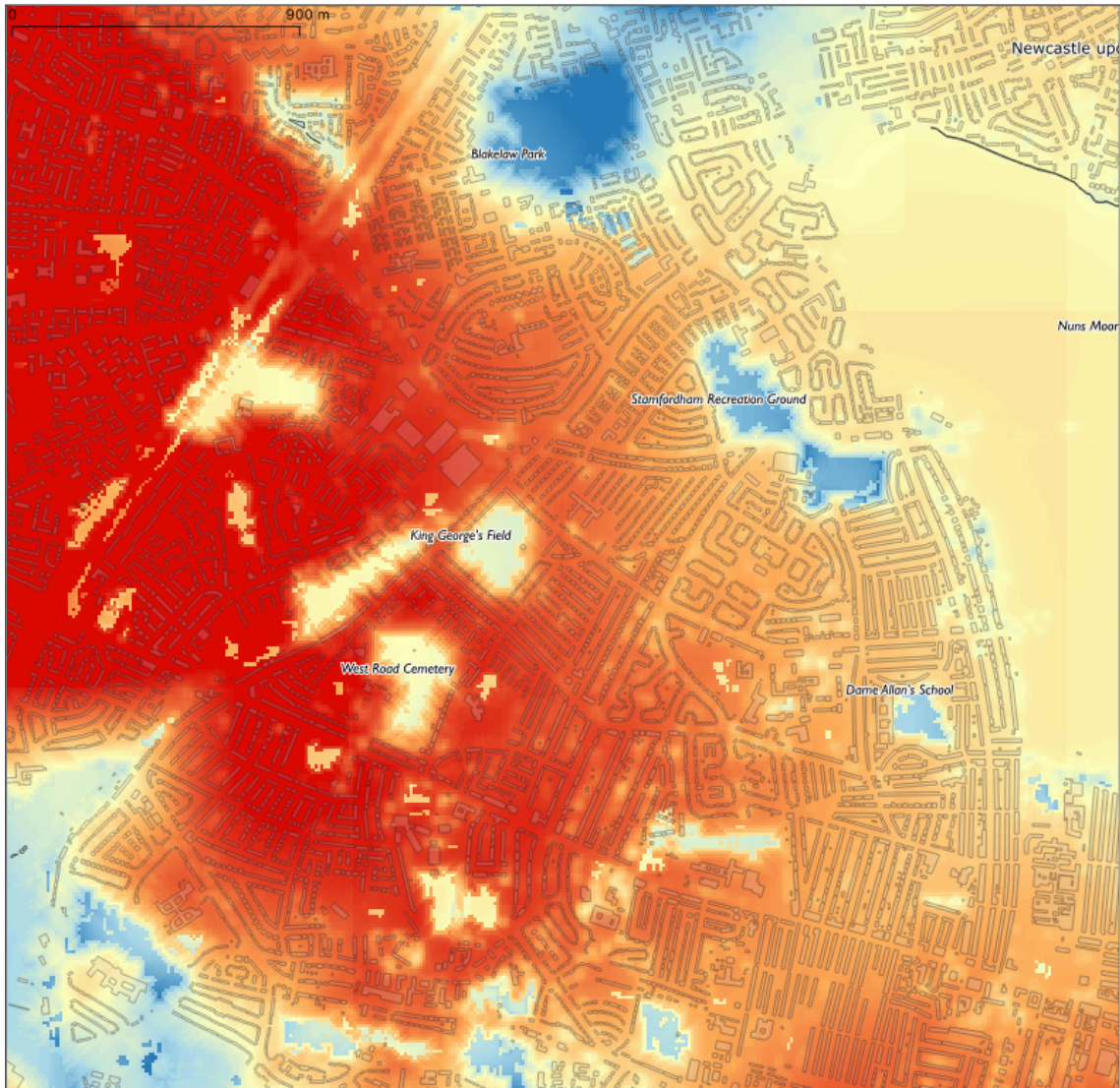
## Description

Like many cities the central part of Newcastle upon Tyne's City Centre is built up and has few trees or greenspaces. North of the river the broader city benefits from the large open greenspaces of Town Moor, Nuns Moor, Hunters Moor and Leazes Park. These areas provide a green central core for the city north of the river, although there are few trees on the Moors other than avenues along the roads that divide them. The city has a good distribution of open greenspaces, many of which are playing fields and therefore treeless or with trees around their peripheries. A notable feature of Newcastle's cityscape is the Ouseburn river and its environs, which provide a linear greenspace with many trees, providing a cooling effect for adjacent residential areas to the east and west of the river. In some cities rivers may entirely disappear under concrete such as in Bristol City Centre where the river Frome is no longer in evidence.

## Main Legend



## Detailed View in Newcastle



Detailed urban cooling offset view of Newcastle upon Tyne, west of the City Centre

### Local Legend

|   |  |
|---|--|
| <p>This part of Newcastle is well catered for by green spaces and there are many trees although their cover is somewhat patchy. The red areas on this graphic are cooled by greenspace and trees up to 1.2 C, but less than the orange and blue areas. Nuns Moor to the east has a general cooling effect in the eastern part of the image and clumps of trees can be discerned as lighter coloured blotches.</p> | <p>Local colour scale in degrees</p> <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: red; margin-right: 5px;"></span> 1.12</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: orange; margin-right: 5px;"></span> 1.26</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: yellow; margin-right: 5px;"></span> 1.4</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: lightgreen; margin-right: 5px;"></span> 1.55</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: lightblue; margin-right: 5px;"></span> 1.69</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: green; margin-right: 5px;"></span> 1.83</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: cyan; margin-right: 5px;"></span> 1.98</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: blue; margin-right: 5px;"></span> 2.12</li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: darkblue; margin-right: 5px;"></span> 2.26</li> </ul> |
|---|--|

## Insolation on and shading of Trees and Buildings

The images above relate to cooling by greenspace and trees at night time as the environment cools down from daytime highs. During the day the environment heats up, warmed by solar irradiation, but is locally cooled through evapotranspiration and shading by vegetation. The amount of solar radiation that a surface catches depends on its orientation with respect to the Sun and also its surface properties and weather conditions. A visual indication of how the environment is affected by solar radiation, including shading, can be gained by calculating insolation during daylight hours. The following set of graphics show a selection of insolation images calculated during the daylight hours on 19th July (this hottest day of 2022), assuming a cloudless day. At this time of year the Sun is high and the days are long, so insolation is at the near maximum and shadow is near its minimum. The images are illustrated with a greyscale colour scheme which gives the impression of a shaded white surface. The shade of grey is directly proportional to the amount of radiation falling on that surface, from white to black. Shading cast by buildings, shown in pink, and trees, shown in green, is readily seen. The shadows are those cast throughout the entire day from sunrise to sunset. The way that the City Centres have few trees and tall buildings with deep shaded canyons is very obvious. The shaded canyons mean the vertical facets of the buildings are catching the light. The streets may be cool but the buildings will be hot, probably radiating heat and warming the environment into the night.

The impact of street orientation also becomes apparent on these images with north-south oriented streets having little shade whilst east-west streets casting shadows into the street. The corollary of this is that south facing buildings catch the Sun and may become excessively hot.

Open greenspaces are not indicate on these graphics.

## Insolation on Buildings and Trees in Bristol



Detailed insolation view of central Bristol

This image shows part of central Bristol with the Floating Harbour and the River Avon bisecting the image. North of the river Queen Square, with its large mature trees, is evident in the east as is Brandon Hill Park with its many trees. The tall City Centre buildings with deep shaded atriums are also visible. The leafy suburb of Clifton Village in the north west contrasts with the rather leafless suburb of Southville, south of the river. South Bristol does have some good parks and greenspaces but not so many street trees as north of the river.

## Insolation on Buildings and Trees in Birmingham

Like other large cities Birmingham has a rather treeless City Centre with large areas of artificial surface. This images shows the south west of the City Centre where it is evident that the treeless commercial district gives way to the leafy suburbs of Edgbaston towards the south west.



Detailed insolation view of Birmingham City Centre

This image shows the solar insolation during daylight hours on the 19th July. It illustrates how buildings and trees cast shade during the day.

## Insolation on Buildings and Trees in Manchester

Manchester City Centre has even more of the appearance of a concrete environment with just the odd tree here and there. The density of buildings does start to reduce to the north east in this image and, as noted in the cooling offset images above, this gives way to a more open environment with more greenspace and trees. In this area there is little to help cool the urban environment.



Detailed insolation view of Manchester City Centre

This image shows the solar insolation during daylight hours on the 19th July. It illustrates how buildings and trees cast shade during the day.

## Insolation on Buildings and Trees in London

London is a surprisingly leafy city but trees and greenspace are not evenly distributed. This image of Elephant and Castle is a densely urban area but it does have a fair number of trees and some greenspace. Some of the streets, such as Kennington Road in the west, are well lined with large trees, but others are not, and the railway not at all.



Detailed insolation view of Elephant and Castle, London. This image shows the solar insolation during daylight hours on the 19th July. It illustrates how buildings and trees cast shade during the day.

Towards the east, Greenwich Park and Blackheath are large open greenspaces, the park with many mature trees, the heath with literally just one or two. The leafy suburbs of Maze Hill to the south of the railway are in stark contrast to East Greenwich, in the top right of the image, which has few trees and little greenspace.



Detailed view of Greenwich Park and part of Blackheath, London. This image shows the solar insolation during daylight hours on the 19th July. It illustrates how buildings and trees cast shade during the day.



## Insolation on Buildings and Trees in Newcastle

The City Centre of Newcastle is shown in the bottom right quadrant of this map and is typically virtually treeless. Most of the Sun's rays are caught by the artificial building surfaces, heating them up. The trees, lake and greenspace of Leazes Park provide some cooling capacity near to the City Centre, but generally there are few trees in this view.



Detailed insolation view of part of Newcastle upon Tyne City Centre (to the east) and nearby suburbs. This image shows the solar insolation during daylight hours on the 19th July. It illustrates how buildings and trees cast shade during the day.

The image below illustrates the open spaces of the Moors in the central part of Newcastle upon Tyne. In the lower portion of this image are the open greenspaces of the Moors, adjacent to leafy suburbs to their north. The leafy suburbs to the north of the Moors give way to terraced streets with almost no trees or shade, showing how the green character of the city can change over short distances, from one neighbourhood to the next.



Detailed insolation view of part of Nuns Moor in Newcastle upon Tyne and nearby residential areas, both with and without trees. This image shows the solar insolation during daylight hours on the 19th July. It illustrates how buildings and trees cast shade during the day.

## References

Doick, K., Peace, A., Hutchings, T., 2014, The Role of One Large Greenspace in mitigating London's Nocturnal Urban Heat Island, *Science of the Total Environment*, 493, pp 662-671.

Friends of the Earth, More Trees Please <https://friendsoftheearth.uk/trees>

Marston, C., Rowland, C. S., O'Neil, A. W., & Morton, R. D., 2022, Land Cover Map 2021 (10m classified pixels, GB) [Data set]. NERC EDS Environmental Information Data Centre. <https://doi.org/10.5285/A22BAA7C-5809-4A02-87E0-3CF87D4E223A>

Vaz Monteiro, M., Doick, K., Handley, P., Peace, A., The impact of greenspace size on the extent of local nocturnal air temperature cooling in London, 2016, *Urban Forestry & Urban Greening*, 16 , pp 160-169.

## Data Sources

Contains public sector information licensed under the Open Government Licence v3.0

The primary data sources used are Ordnance Survey Open Data, Friends of the Earth tree canopy map based on Environment Agency LiDAR, Land Cover Map by Centre for Ecology and Hydrology. The map data are provided for educational purposes only. The cooling model is closely based on the one described in Doick et al. (2014) and Vaz Monteiro et al. (2016).