

Sensing Hotterdam

crowd sensing the Rotterdam urban heat island

Frank van der Hoeven ^[1], **Alex Wandl** ^[1], **Betul Demir** ^[1], **Sophie Dikmans** ^[1],
Jafeth Hagoort ^[1], **Marco Moretto** ^[1], **Pinar Sefkatli** ^[1], **Frans Snijder** ^[1],
Siriluck Songsri ^[1], **Patrick Stijger** ^[1], **Natalie Yakovleva** ^[1], **Derk Wijtsma** ^[1],
Bert Blocken ^[2]

^[1] Delft University of Technology, Faculty of Architecture and the Built Environment

^[2] Eindhoven University of Technology, Department Built Environment

Abstract

Sensing Hotterdam recorded the temperature in 1,000 Rotterdam homes and at 300 public spaces in the summer of 2014 in order to outline the links between the urban heat island, the built environment and public health in the city of Rotterdam. The measured outdoor temperature readings point to a clear heat island effect in Rotterdam. Temperatures in homes are generally higher than those in the surrounding area, and also show a large degree of variation. Indoor temperatures are less affected by local outdoor temperatures than we had expected.

Keywords

urban heat; urban heat island; urban design; spatial planning; built environment; climate adaptation; Rotterdam; crowd sensing, citizen science

Background

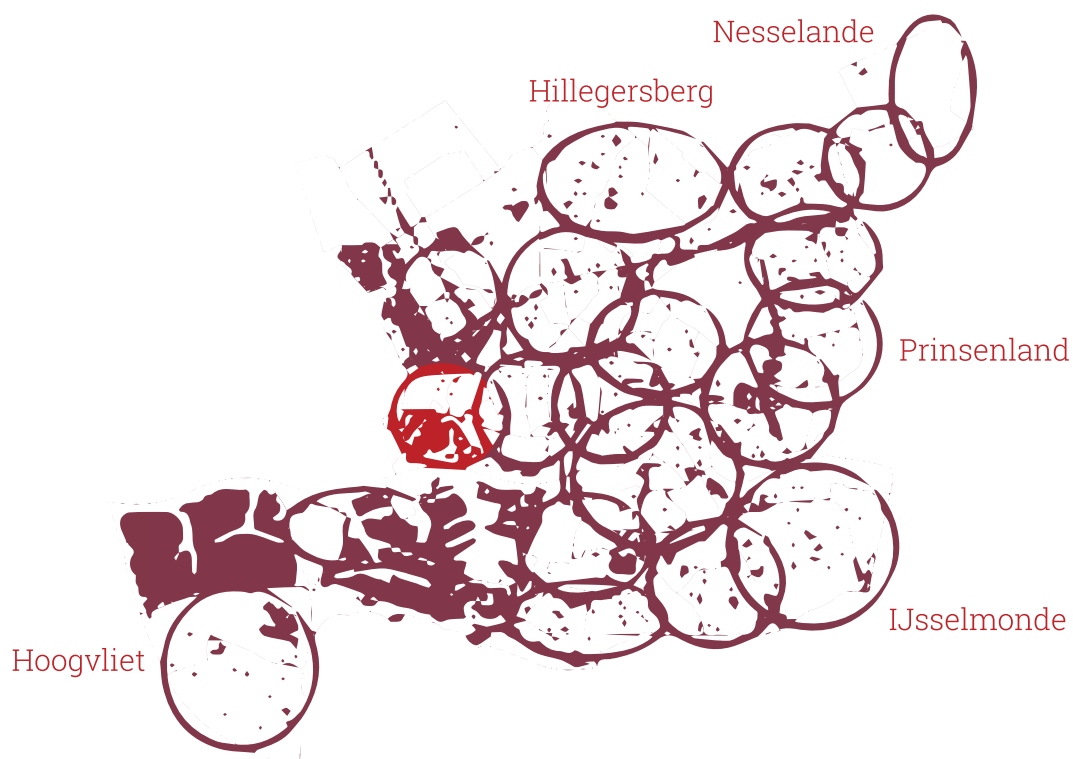
Heat waves will occur in Rotterdam with greater frequency in the future. Those affected most will be the elderly – a group that is growing in size. In the light of the Paris heat wave of August 2003 (Vandentorren, Bretin, Zeghnoun, Mandereau-Bruno, Croisier, Cochet, ... Ledrans, 2006) and the one in Rotterdam in July 2006, mortality rates among the elderly in particular are likely to rise in the summer. The effects of heat, and especially heat in urban areas, are more or less unknown. Whenever any (media) attention is given to heat, it focuses on the warming of the earth as a whole, and the question of whether that process will amount to more or less than two degrees Celsius. But few of us know that the temperature inside urban areas is sometimes ten degrees Celsius higher than outside their limits, or that for long periods of the day, the temperature inside homes is warmer than out on the street. Heat is invisible and its direct effects are not easy to see. The fact that more elderly people die during heat waves than usual, that the urban heat island and quality of buildings play a role in this (Mavrogianni, Davies, Batty, Belcher, Bohnenstengel, Carruthers, Chalabi, ... Ye, 2011) is not widely known and some do not even believe it.

Method

The Royal Netherlands Meteorological Institute (KNMI), carries out temperature readings at just one location in Rotterdam: onsite the airport, which is at the edge of the city. Therefore these readings cannot be used to investigate temperature differences between the various districts of Rotterdam. There is also no information on temperatures inside people's homes. In order to better understand the relationship between heat, health and space, we required a more detailed picture of heat in the city and of the processes that determine that heat: the urban heat island and the surface energy balance. For Sensing Hotterdam, we enlisted the help of a large number of citizens to carry out the necessary temperature measurements.. This is also known as 'crowd sensing' or 'citizen science'. We divided the city into 20 areas. Five streets were selected in each area, so as to properly represent the diversity of the relevant area. Students were then asked to find ten households in every street to take part in the research project. The students asked the residents to place a temperature sensor (Paksense brand) in their living room for two months. Three hundred of the same type of sensor were also placed in those selected streets in order to take the outdoor temperature in vicinity to the indoor temperature. They were placed two metres above ground level in public spaces. After two months, we received 800 of the 1,000 sensors back from the residents and were able to recollect 200 of the sensors that had been placed in the public space.. The readings from the sensors that were placed outdoors were only used as an indicator of the temperature after sunset. As the daytime results are of less value for determining the air temperature. Because the sensors could have been exposed to direct radiation from the sun at set times and would rather measure the surface temperature of the street sign there were fixed to. After the sensors were returned the data was read out manually and stored in a geodatabase. We use the address register of the city of Rotterdam to be able to geocode the more than 20 million temperature measurements at the level of the household address . The time stamps of all the temperature data was reduced to intervals of ten minutes. This allowed us to produce a series of temperature point maps covering the city of Rotterdam, for every ten minutes for the period between 16 of July until 31 of August 2015. This data set allows us at the one hand a visualisation at specific crucial times, like 5 o'clock in the night after a day with summer temperatures and, on the other hand animated as movie to visualise the differences in heating up and cooling down over time in different parts of the city.



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FIGURE 1 Sensing Hotterdam (the research project into heat in the city),

FIGURE 2 divided Rotterdam into 20 areas.



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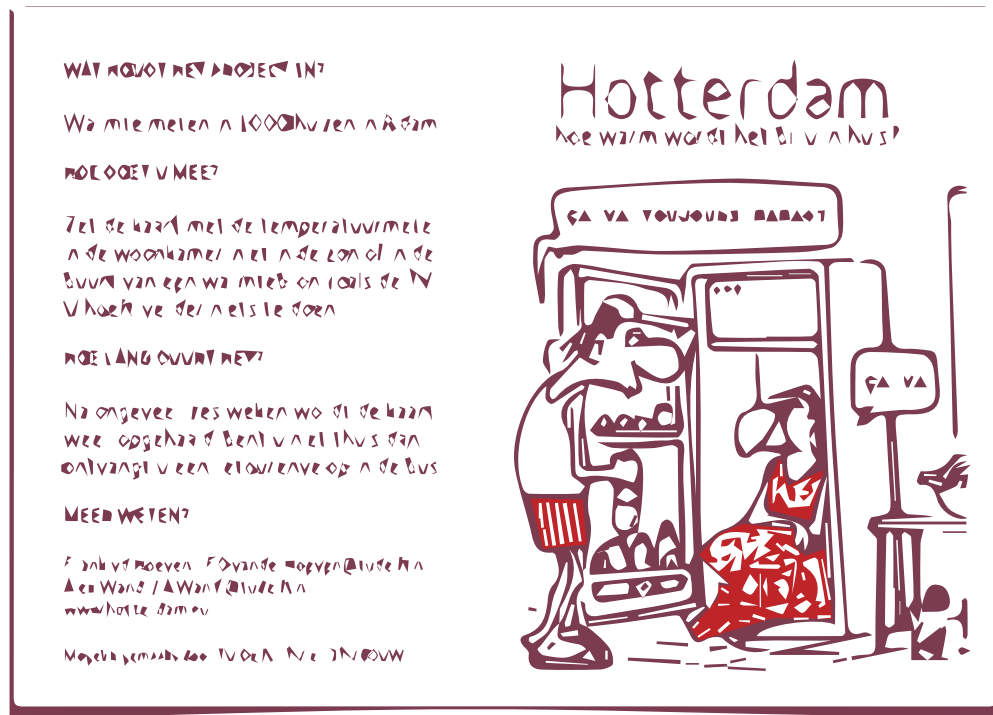
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FIGURE 3 Five representative streets were selected in each area,
FIGURE 4 with the aim of finding ten households in each street.



2

FIGURE 5 Twelve students were offered holiday jobs,
FIGURE 6 with the task of finding these ten households in each street.



1



2

FIGURE 7 They also had to leave a chart with the occupants with a brief explanation, FIGURE 8 and a temperature sensor on the rear.



FIGURE 9 Therefore 1,000 sensors were used to measure the indoor temperature, FIGURE 10 and 300 the night-time outdoor temperature.



2

FIGURE 11 The results are set out on two heat maps (social and physical)

FIGURE 12 that can help prevent unnecessary deaths among the elderly during heat waves.

Results

The results of measuring the heat are the maps relating to outdoor air temperatures, indoor air temperatures, and the differences between the two, and the contribution to the overall Hotterdam report both in Dutch (van der Hoeven & Wandl, 2015a) and in English (van der Hoeven & Wandl, 2015b).

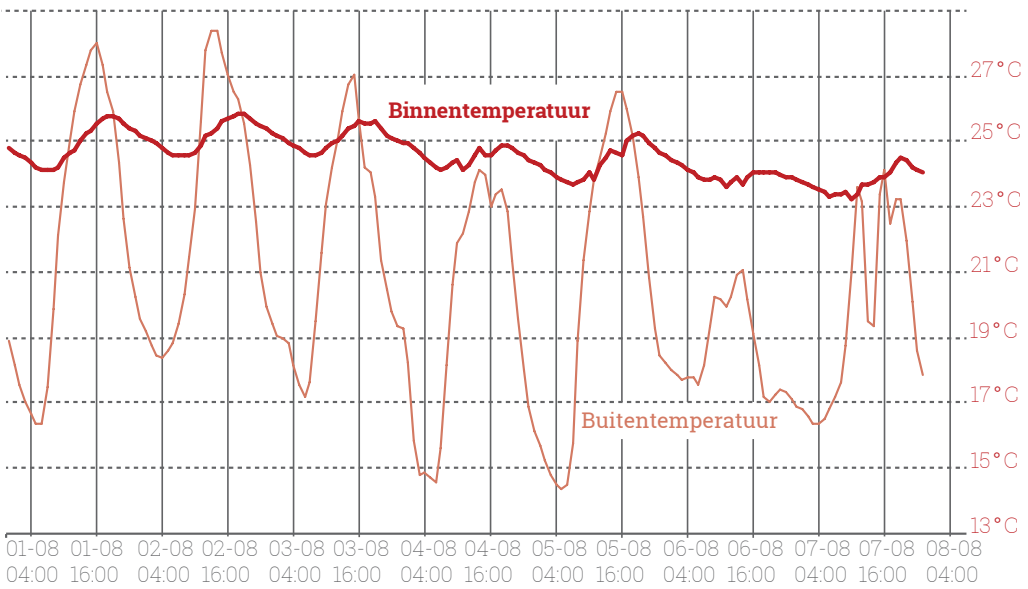


FIGURE 13 Air temperature indoors/outdoors

Contents	Air temperature measured in the evenings/at night in selected homes and streets in Rotterdam. The diagrams above show the averages of all the indoor and outdoor temperature readings in the first week of August 2014. Indoor temperatures fluctuate much less and are mostly higher than the outdoor temperatures, except during the afternoon. It is therefore very possible to cool homes naturally, especially at night.
Values	Degrees Celsius
Method	Readings with Paksense temperature sensors
Software	ArcGIS
Data	Crowdsensing, first week of August 2014

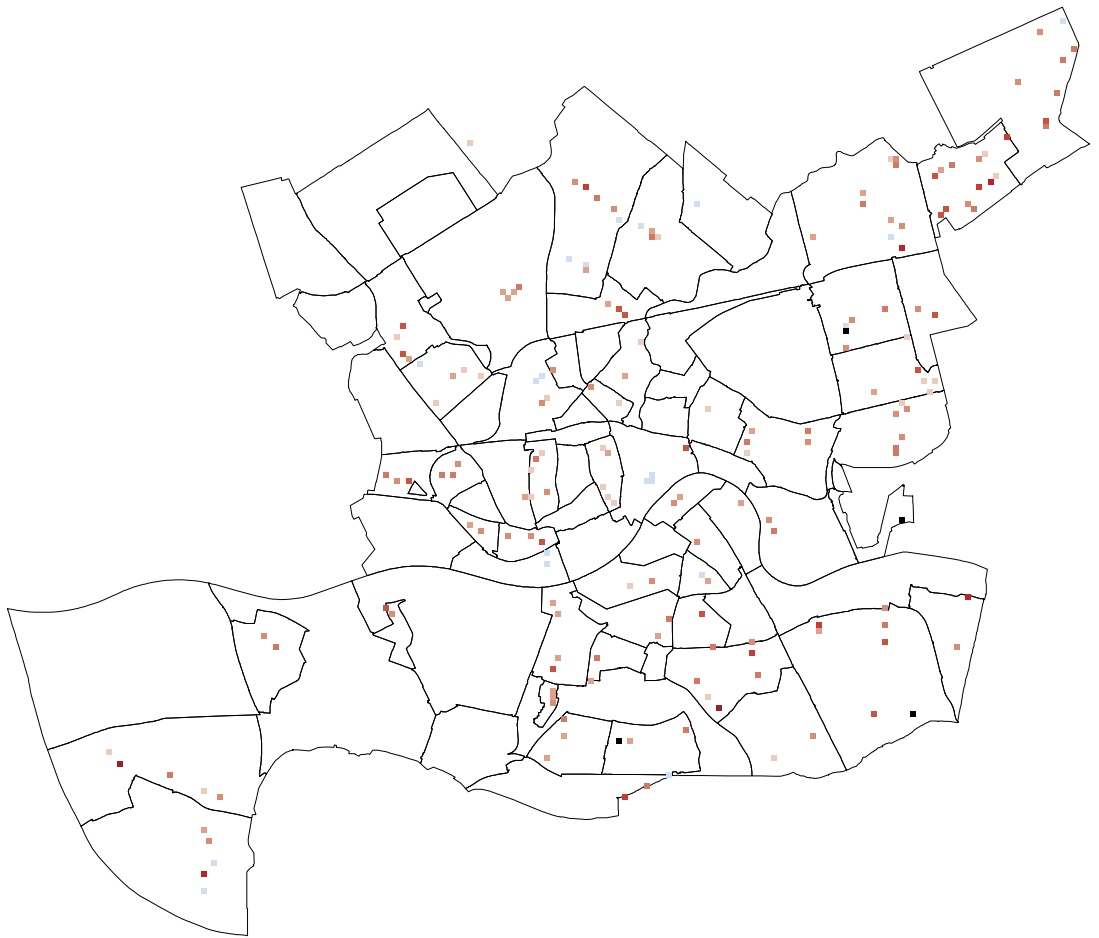


FIGURE 14 Outdoor air temperature, 18.00

Key	≤25,0	>25,0 ≤25,5	>25,5 ≤26,0	>26,0 ≤26,5	>26,5 ≤27,0	>27,0 ≤27,5	>27,5 ≤28,0	>28,0 ≤28,5	>28,5 ≤29,0	>29,0
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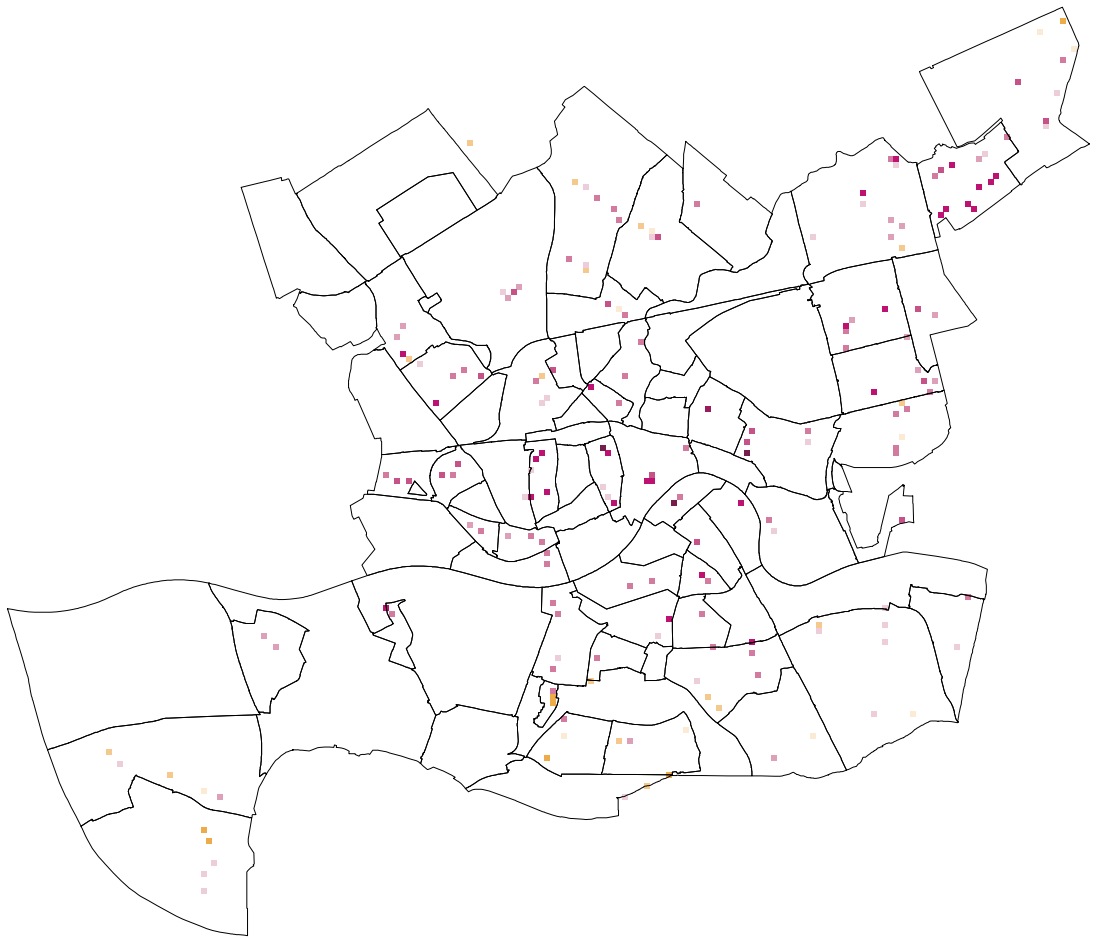


FIGURE 15 Outdoor air temperature, 03.00

Key	≤17,75	>17,75 ≤18,0	>18,0 ≤18,25	>18,25 ≤18,50	>18,5 ≤18,75	>18,75 ≤19,00	>19,00 ≤19,25	>19,25 ≤19,50	>19,50 ≤19,75	>19,75
Contents	Air temperature measured in the evenings/at night in selected homes and streets in Rotterdam. The diagrams above show the averages of all the indoor and outdoor temperature readings in the first week of August 2014. Indoor temperatures fluctuate much less and are mostly higher than the outdoor temperatures, except during the afternoon. It is therefore very possible to cool homes naturally, especially at night.									
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Software	ArcGIS									
Data	Crowdsensing, first week of August 2014									

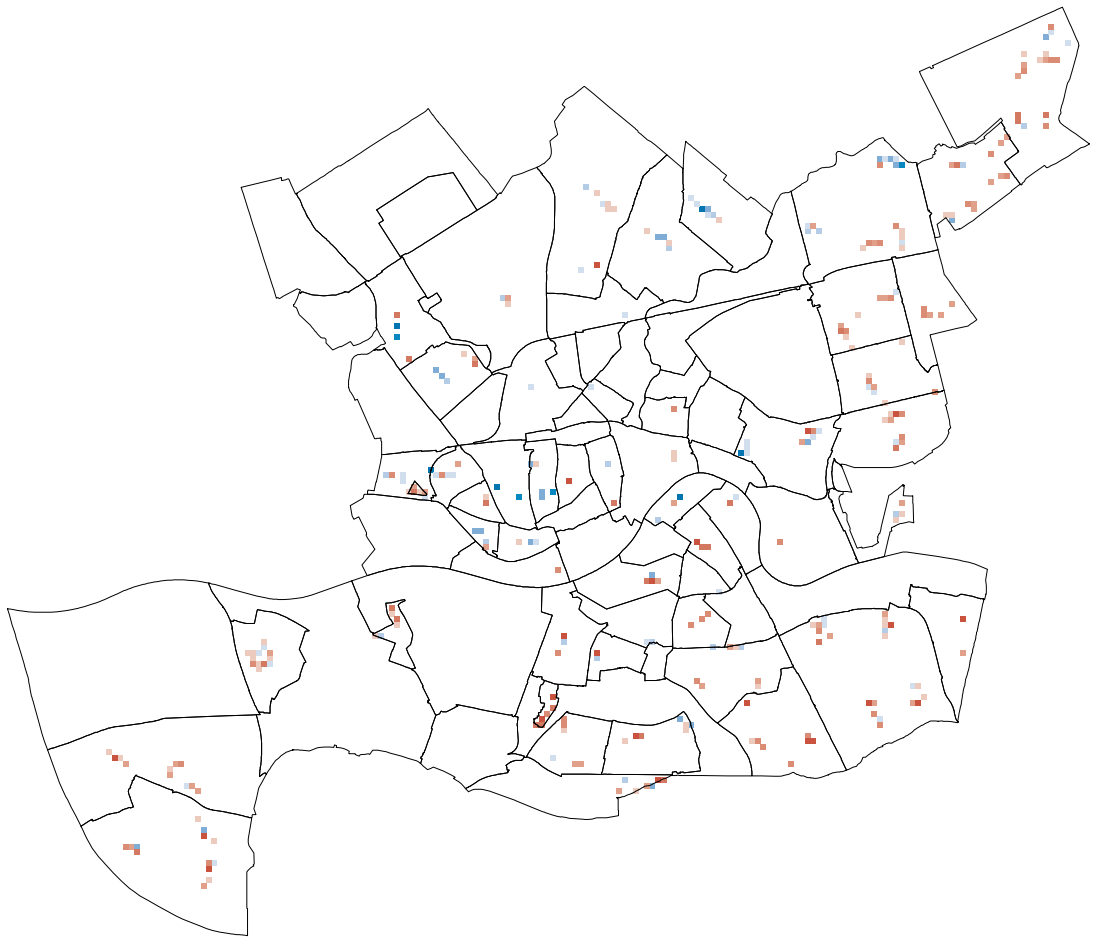


FIGURE 16 Indoor air temperature, 18:00

Key	≤23,0	>23,0 ≤23,5	>23,5 ≤24,0	>24,0 ≤24,5	>24,5 ≤25,0	>25,0 ≤25,5	>25,5 ≤26,0	>26,0 ≤26,5	>26,5 ≤27,0	>27,0
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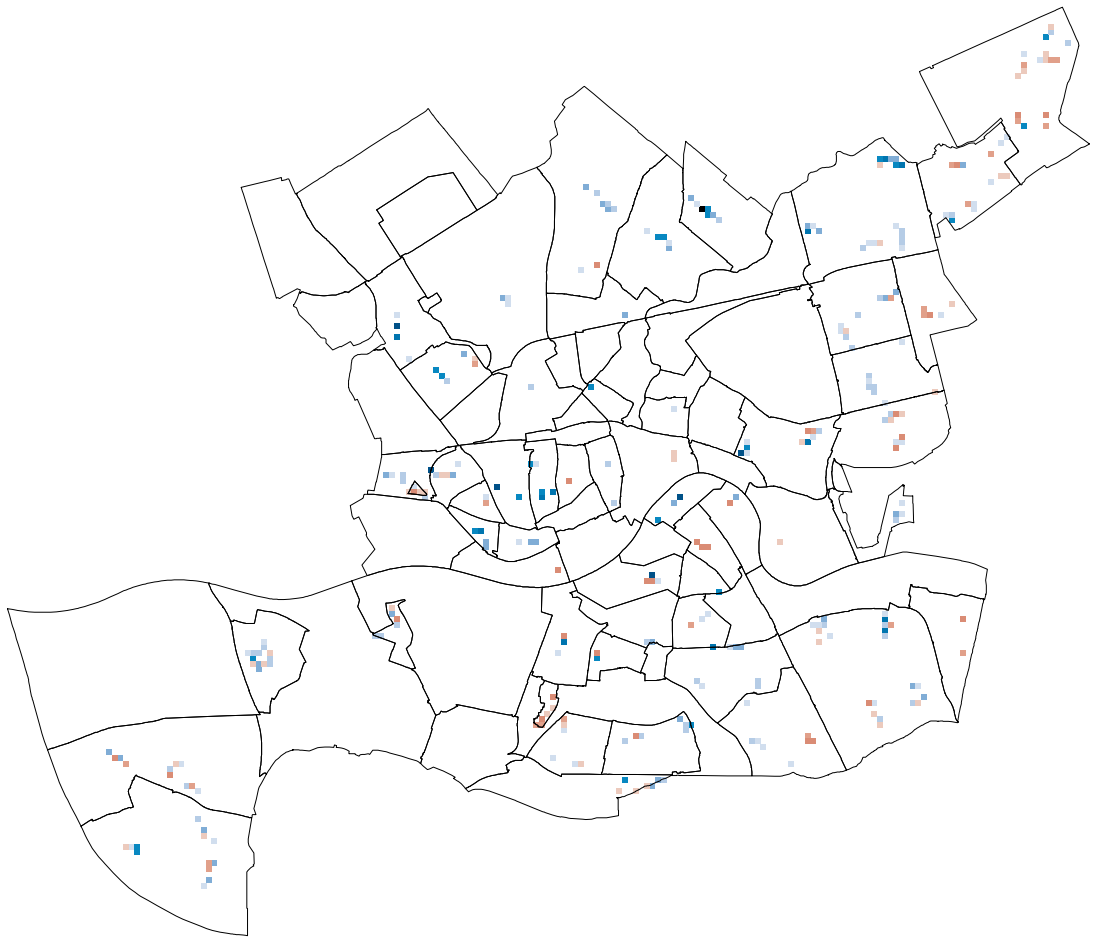


FIGURE 17 Indoor air temperature, 03:00

Key	<div> <div></div> <div></div> <div></div> <div></div> <div></div> <div></div> <div></div> <div></div> <div></div> <div></div> </div>									
	≤22,0	>22,0 ≤22,5	>22,5 ≤23,0	>23,0 ≤23,5	>23,5 ≤24,0	>24,0 ≤24,5	>24,5 ≤25,0	>25,0 ≤25,5	>25,5 ≤26,0	>26,0
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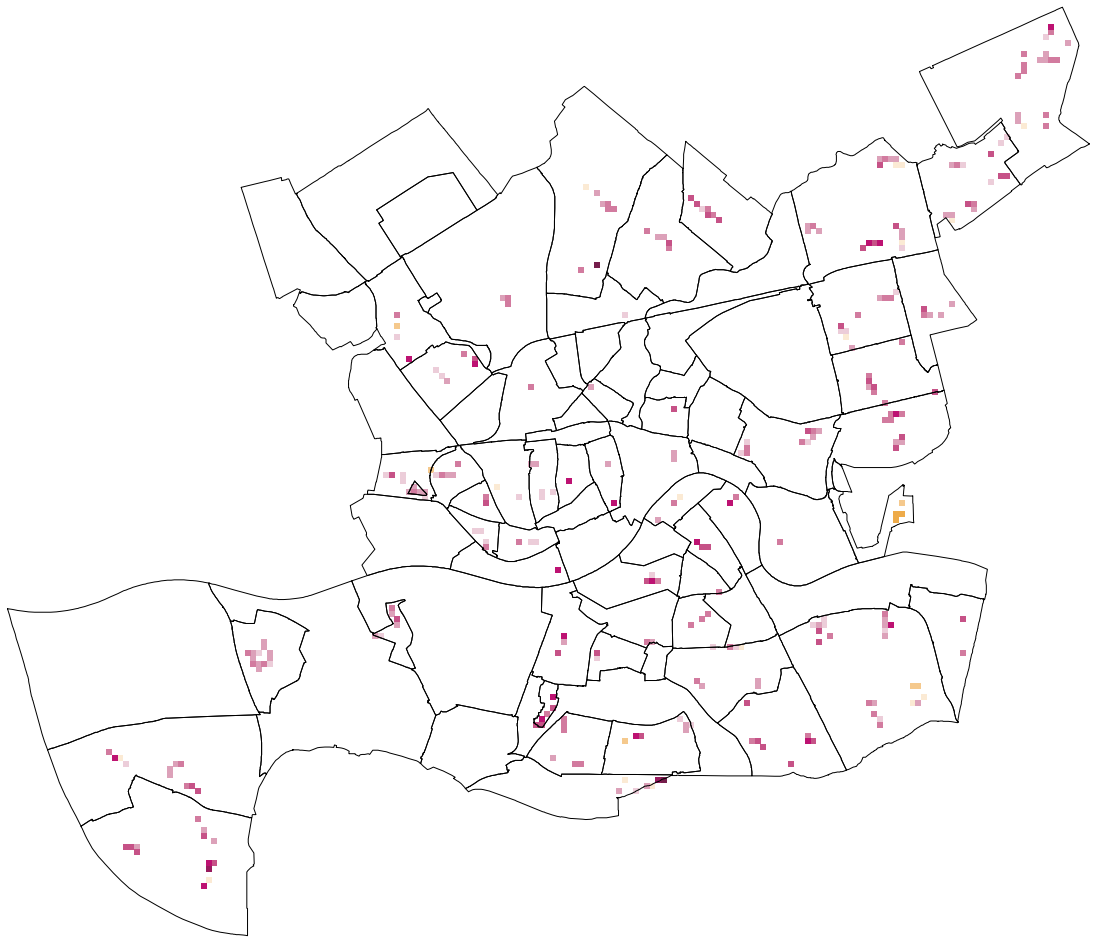


FIGURE 18 Temperature differences indoors and outdoors, 18:00

Key	≤-5,0	>-5,0 ≤-4,0	>-4,0 ≤-3,0	>-3,0 ≤-2,0	>-2,0 ≤-1,0	>-1,0 ≤0,0	>0,0 ≤1,0	>1,0 ≤2,0	>2,0 ≤3,0	>3,0
Contents	Air temperature measured in the evenings/at night in selected homes and streets in Rotterdam. The diagrams above show the averages of all the indoor and outdoor temperature readings in the first week of August 2014. Indoor temperatures fluctuate much less and are mostly higher than the outdoor temperatures, except during the afternoon. It is therefore very possible to cool homes naturally, especially at night.									
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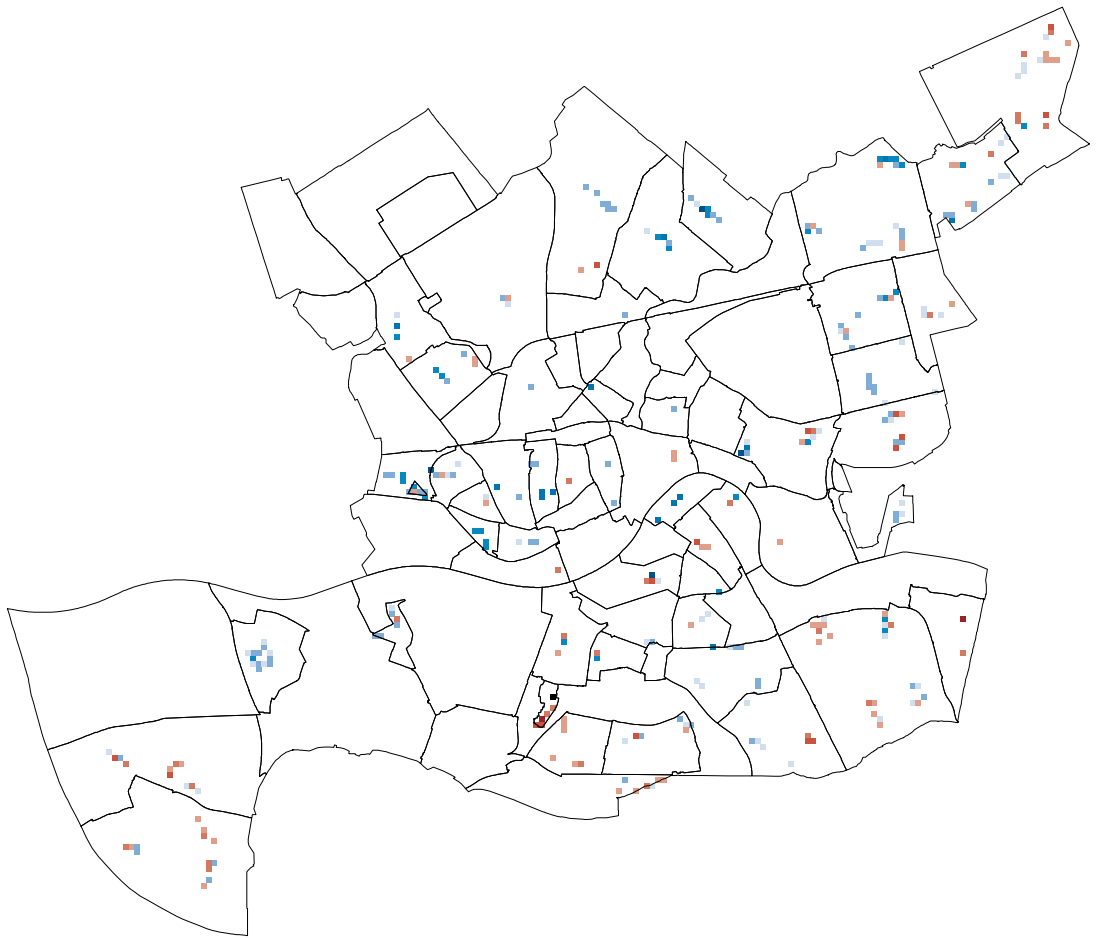


FIGURE 19 Caption

Key		≤3,3	>3,3 ≤4,0	>4,0 ≤4,8	>4,8 ≤5,5	>5,5 ≤6,3	>6,3 ≤7,0	>7,0 ≤7,8	>7,8 ≤8,5	>8,5 ≤9,3
Contents	Air temperature measured in the evenings/at night in selected homes and streets in Rotterdam. The diagrams above show the averages of all the indoor and outdoor temperature readings in the first week of August 2014. Indoor temperatures fluctuate much less and are mostly higher than the outdoor temperatures, except during the afternoon. It is therefore very possible to cool homes naturally, especially at night.									
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Software	ArcGIS									
Data	Crowdsensing, first week of August 2014									

Conclusion

The centre and the pre-war districts in North, South, and West Rotterdam experience a clear urban heat island effect. The temperature readings that were carried out confirm these findings as far as outdoor temperatures are concerned. Temperatures in homes are generally higher than those in the surrounding area, and also show a large degree of variation. Indoor temperatures are less affected by local outdoor temperatures than we had expected.

References

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