Sub-surface Urban Heat Island (SSUHI) - Sources and effects on drinking water

BTO

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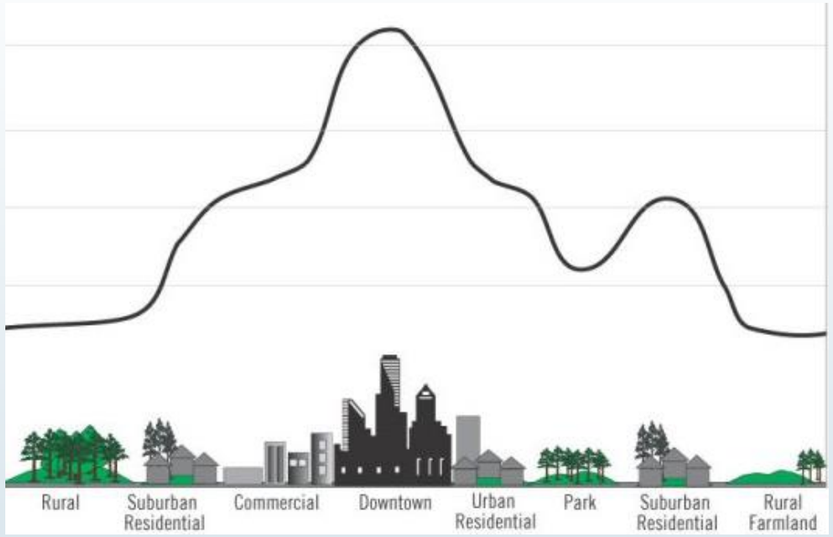
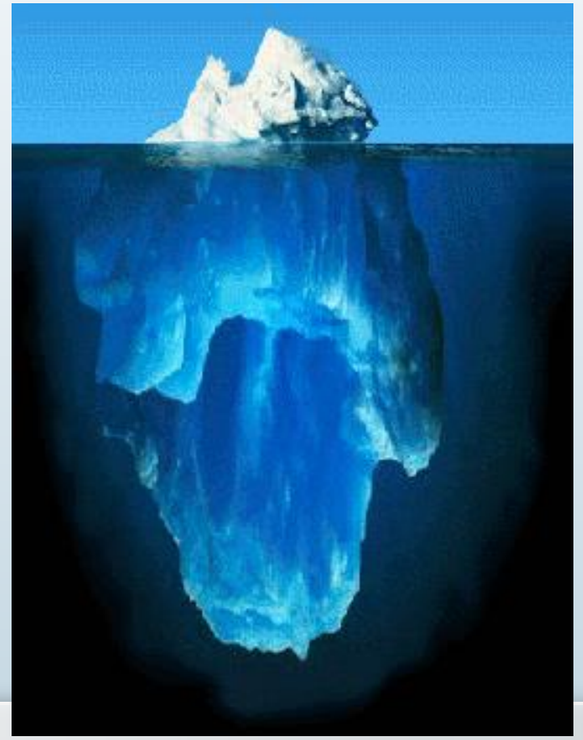
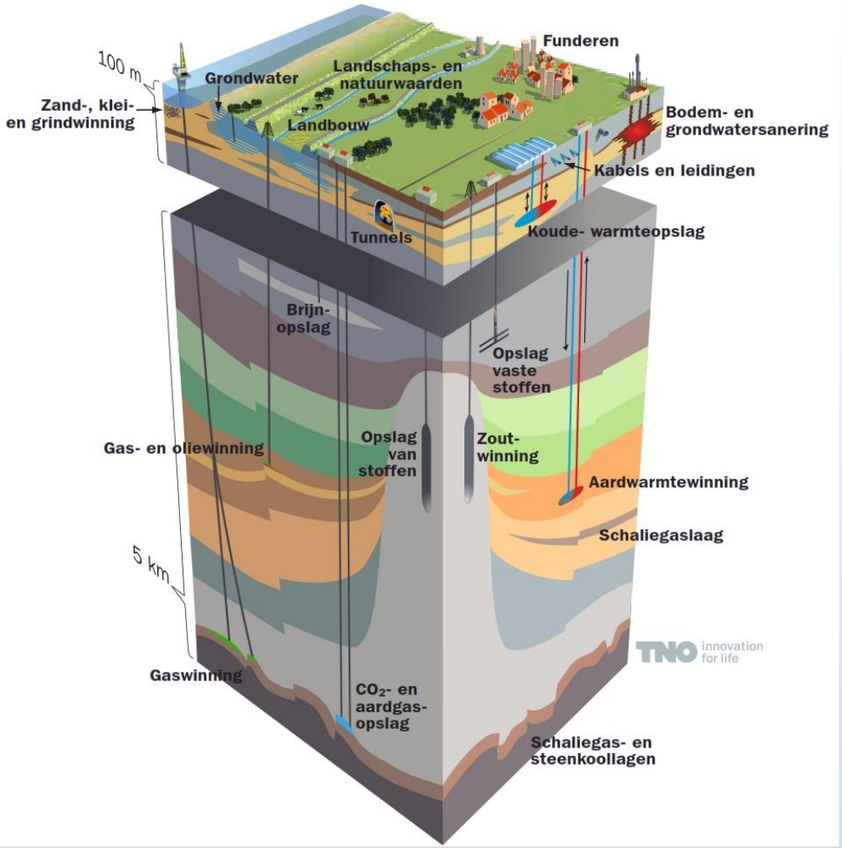
Urban heat island effect (UHI)



Source: EPA website

- Is UHI only the tip of the iceberg?
- What about the sub-surface UHI?





Source: TNO

Background

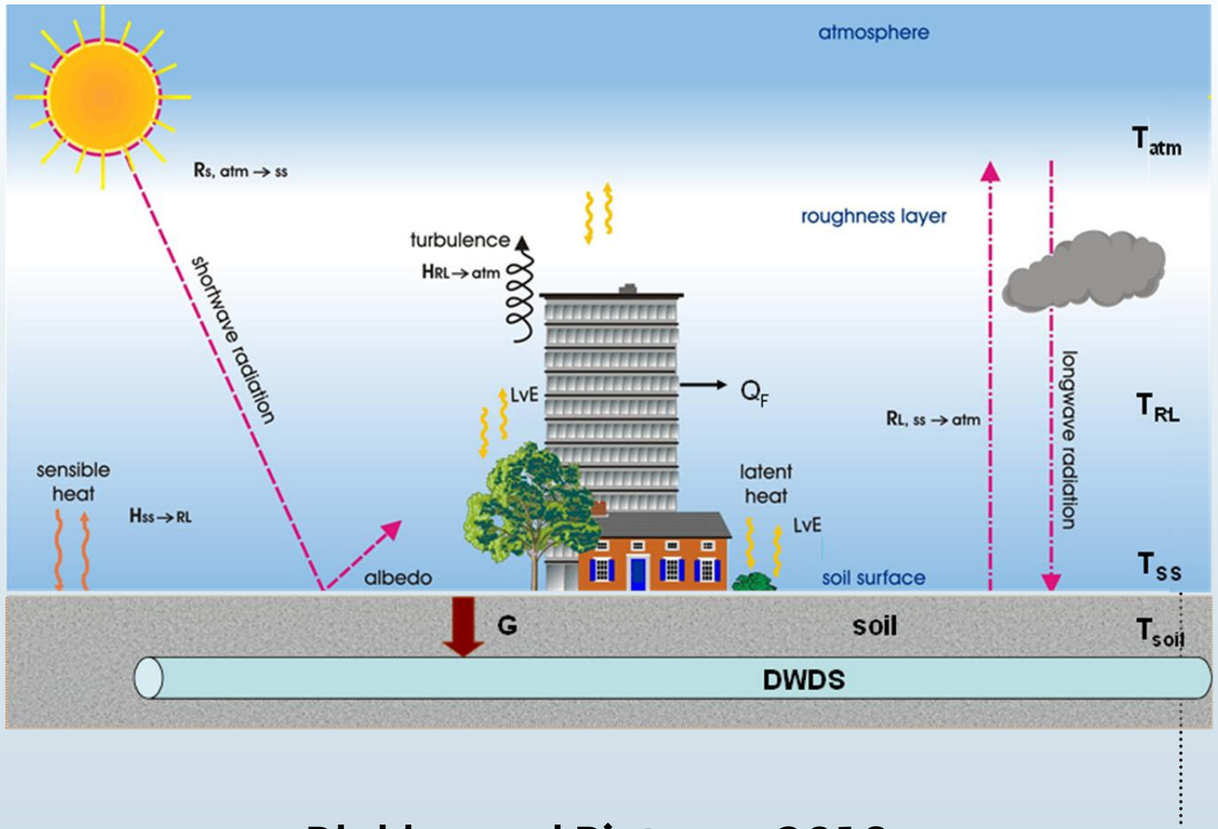
- In the Netherlands water is distributed without chlorine.

  → 25°C is the maximum allowed temperature at the customer's tap.

- In 2006 1% of random sampling > 25°C. With climate change more samples may exceed 25°C.

Background

Development of a uni-directional soil temperature model



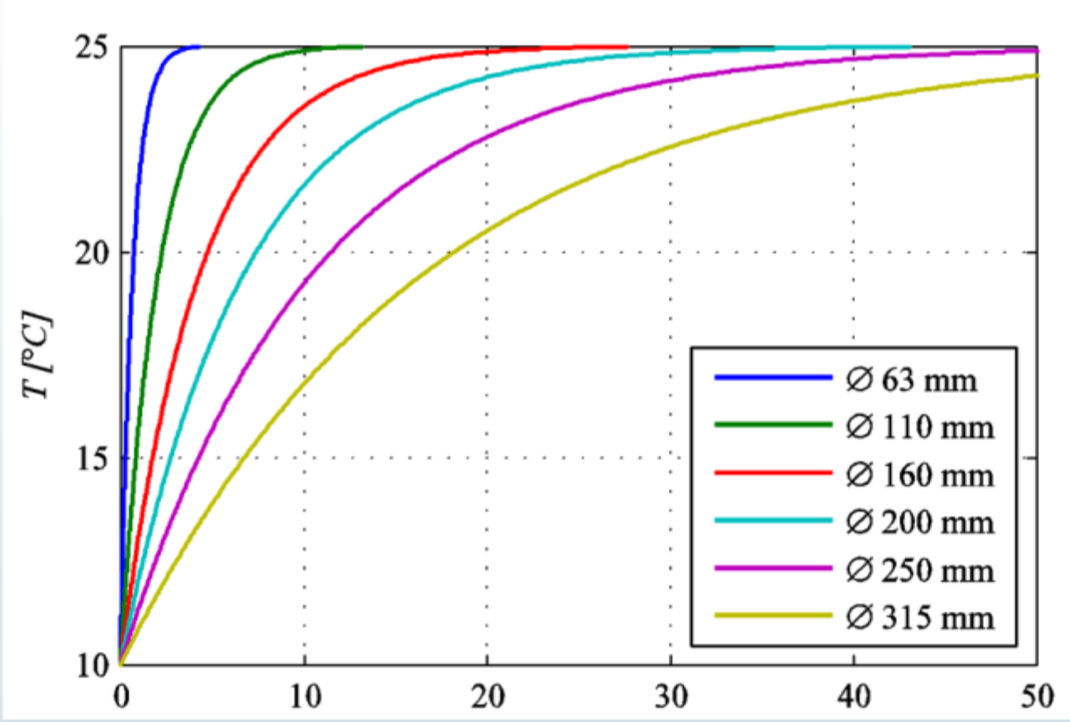
Blokker and Pieterse, 2013

2015 - Model extended considering urban typologies

2016 – Method to identify underground hotspots in the city

Why is soil temperature important?

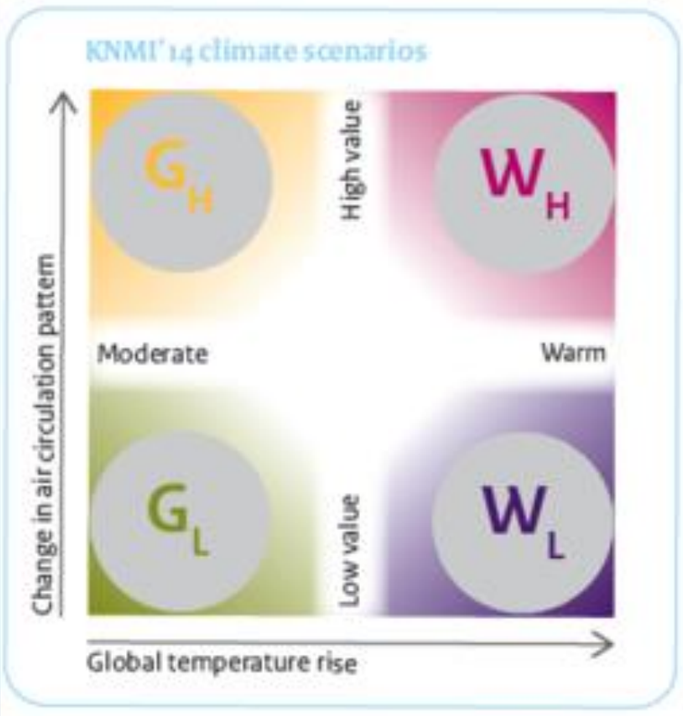
- Water distribution pipes are located at 1.0 m depth.
- Previous studies showed that water in small pipes reaches quickly the soil temperature.
- Sand is used as soil improvement in urban areas – dry sand warms up faster than other soils.



Required period to warm up (h)

Pressures: Climate change and urbanization

CLIMATE SCENARIOS



Source: KNMI

URBAN ENVIRONMENT ABOVE GROUND LEVEL

London skyscraper's 'deathray' reflection is melting cars, burning businesses, but also cooking eggs

HARRY WALLOP, THE TELEGRAPH | 13/09/04 | Last Updated: 13/09/11 12:09 PM ET

More from The Telegraph

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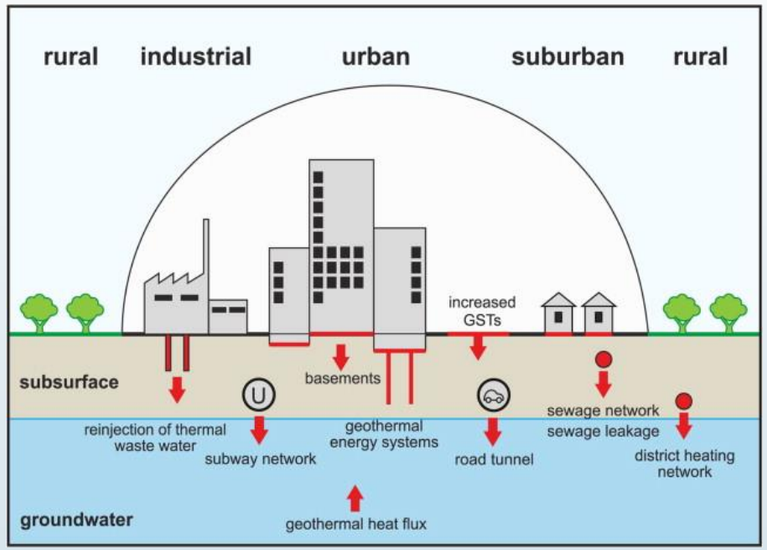
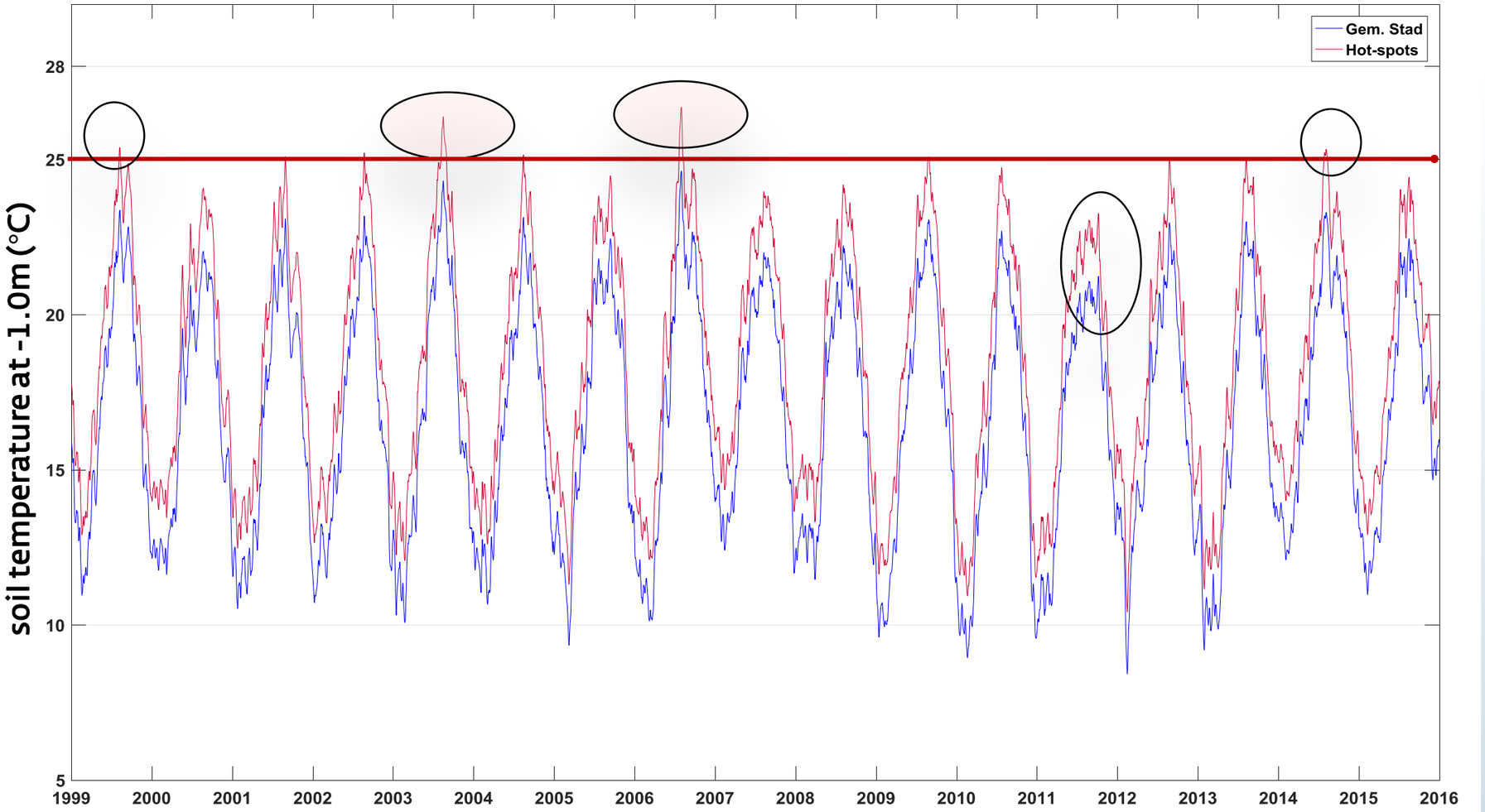
URBAN INFRASTRUCTURE UNDER GROUND LEVEL



Benz et al., 2015

Simulations soil temperature - Rotterdam



Heat waves

From	Duration (days)	# tropical days	Highest air temperature °C
22 aug 2001	5	3	31.1
31 jul 2003	**14**	**7**	**35.0**
02 aug 2004	10	3	32.5
18 jun 2005	7	3	32.8
30 jun 2006	**7**	**3**	**32.0**
15 jul 2006	**16**	**8**	**35.7**
21 jul 2013	7	3	32.6
30 jun 2015	6	3	33.1

Only in the‘hotspots’ during hot summers are the soil temperatures > 25°C

How often will drinking water temperature exceed 25°C in 2050 in a warm summer?

KNMI '06 scenario: G scenario and W+ scenario

	Number of days drinking water T >25°		
	2012	2050 (G)	2050 (W+)
Peri-urban neighbourhoods	0	0	0
Average city	0	0	7
Hot-spots	9	49	83

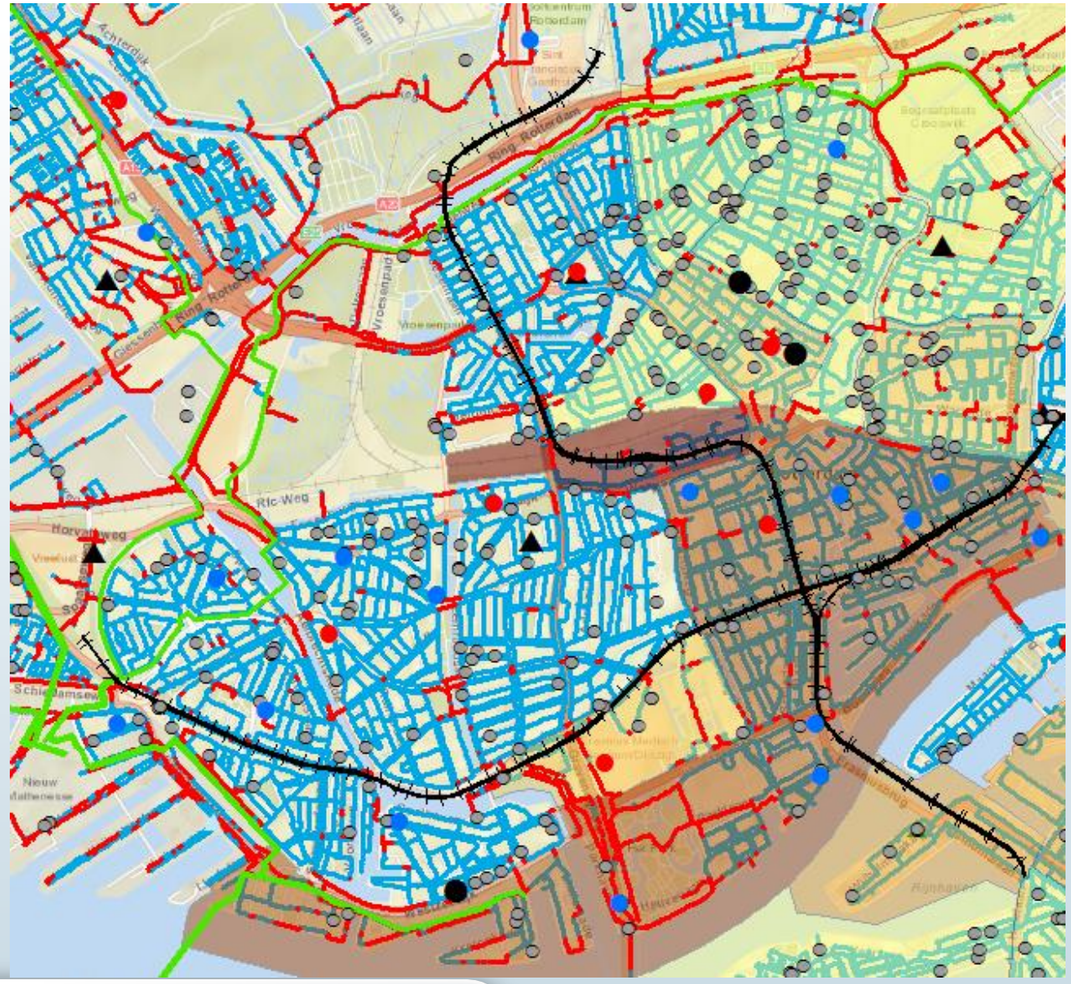
Agudelo-vera et. al 2015

Overview of possible heat sources that influence underground hot-spots in Dutch cities

Shade condition		Shade			Partial shade			No shade	
Urban type		Residential		Industrial		Urban square		Park	
Top layer		Tiles				Grass			
Anthropogenic sources	**Above ground**	Hospital	Laundry facilities	Reflection of buildings	Swimming pool	High density of buildings		Electrical distribution substations	
	Under ground	Metro	High tension cable		ATES	Parking		District heating systems	

Agudelo-vera & Blokker, submitted DWES journal

Looking for heat sources - GIS analysis



Possible heat sources

- Pipes in the shade
- Pipes in the sun
- Underground metro
- Buried high power cables
- Swimming pool

Neighbourhood coverage of district heating system

0 50% 100%

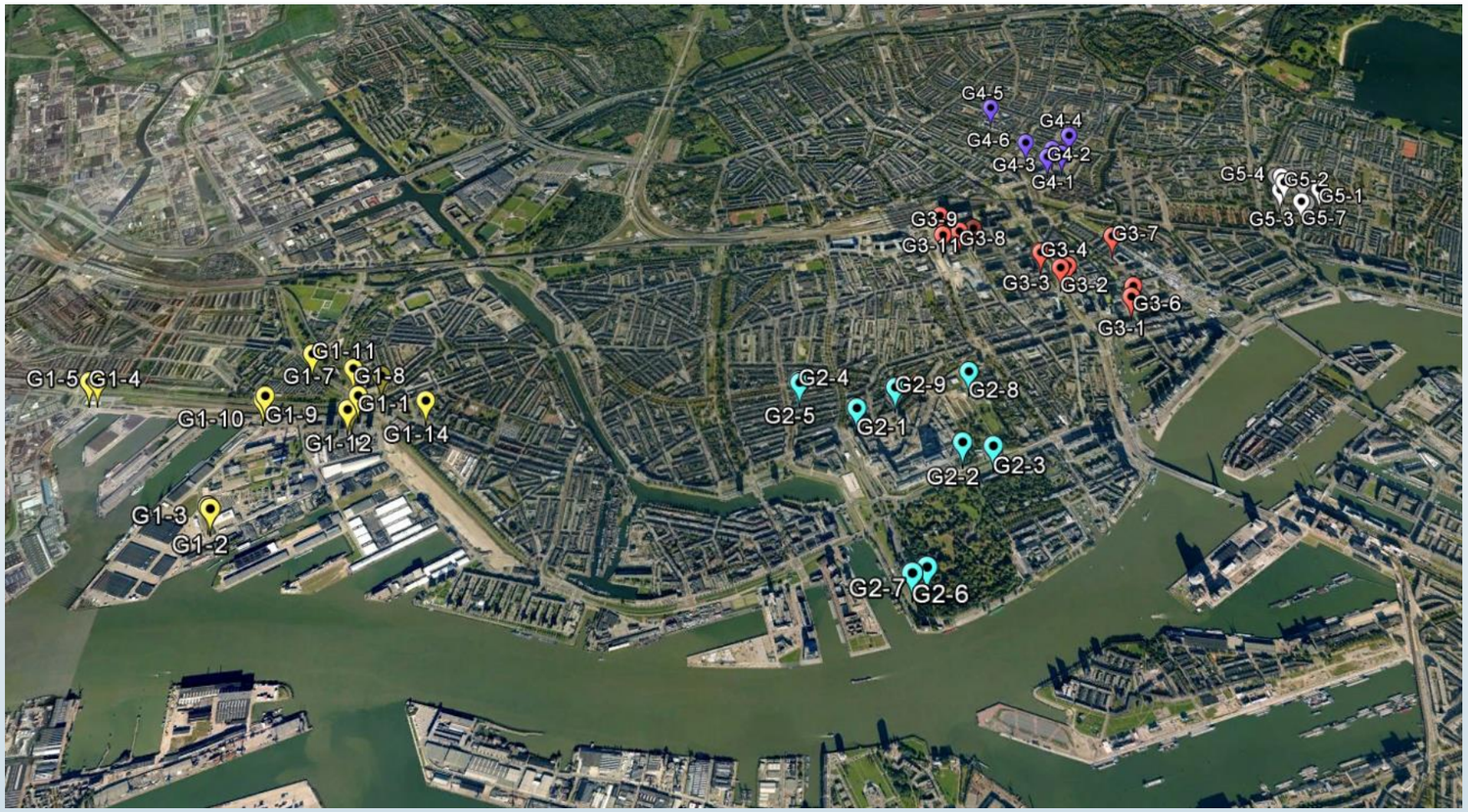
Water Temperature at the tap

- Critical hotspot
- Hotspot
- Low Hotspot
- Non Hotspot

Agudelo-vera & Blokker, submitted DWES journal

Monitoring heat sources

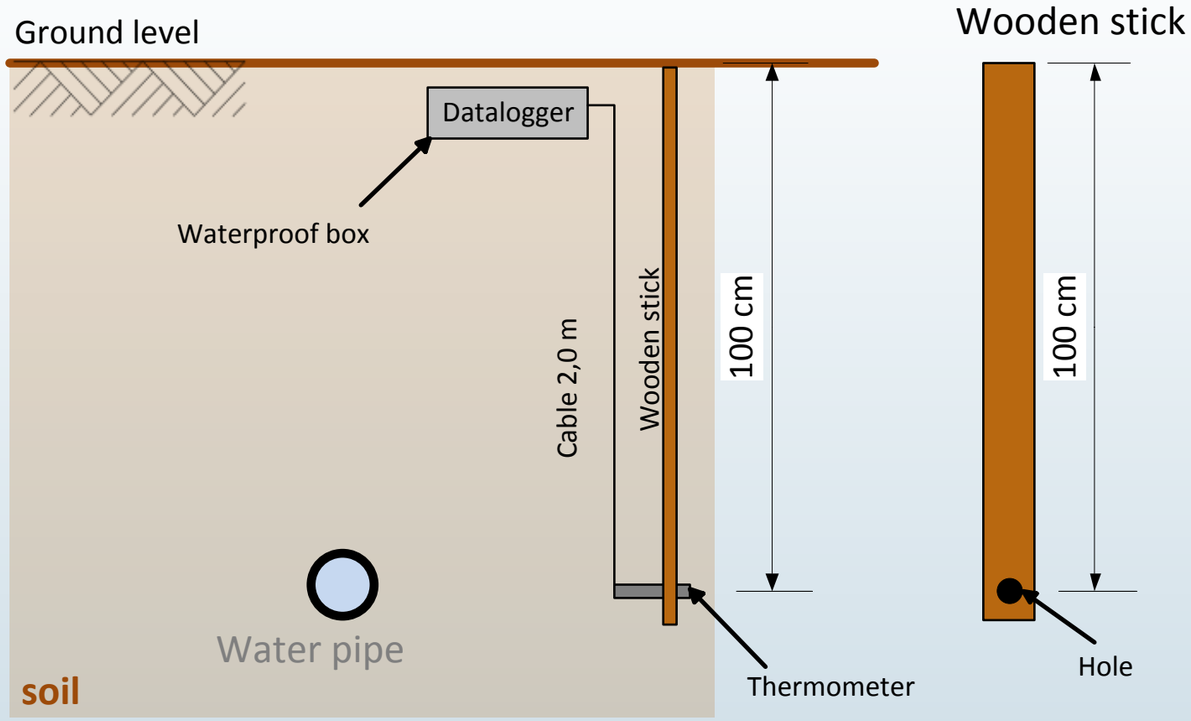
5 areas - 42 locations from mid-July until mid-October 2016



Measurement set-up

THERMOMETER AND DATALOGGER

DETAIL



Measurements on-site

Overview results - soil temperature at -1.0m

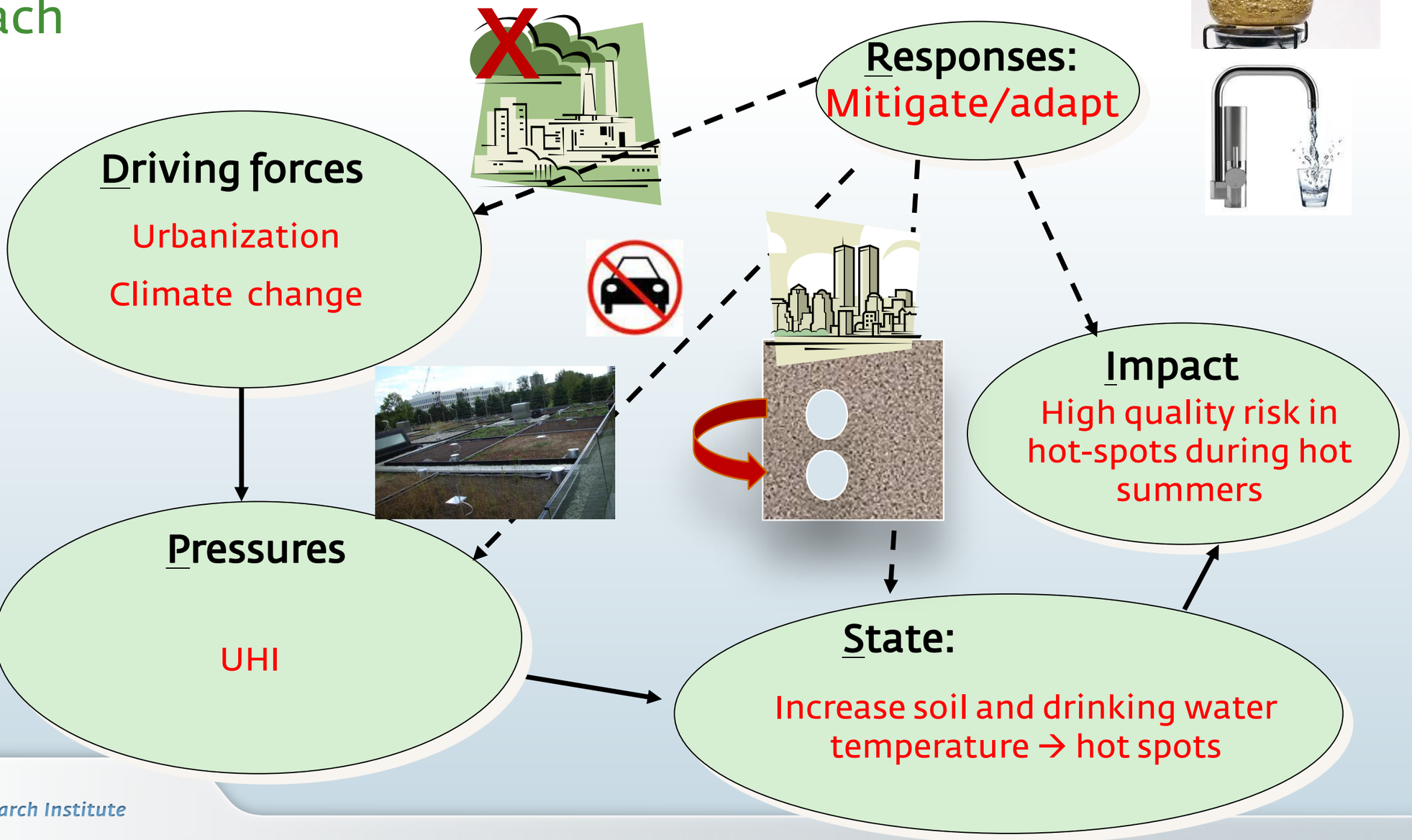
42 locations from 18 July until 8 October 2016

- Variation between locations 7-10°C
  → underground heat stress
- 2 locations with T_{soil} > 25°C for a few weeks
- Variation in the pattern
- Max. daily variation was 0.9°C.
- The max. temp was registered at different days.
- Warmest locations: sand + sun + at least 1 antropogenic sources

Which measures are available to limit the risk of drinking water exceeding 25°C?

DPSIR approach

- Limited effect per measure
- Measures do not fall under of influence of the water companies → Crucial cooperation



Take home message:

Urban heat island effect has more consequences than we know until now:

→ Warming of urban soils → Sub-surface urban heat islands

→ Large gradient on soil temperature at -1m & influencing temperature in the water distribution network

We have a couple of decades to identify and tackle the hot-spots:

→ Sources and their intensity have to be identified

→ The effect of mitigation and adaptation measures have to be quantified

→ working together is crucial to address urban challenges

References

1. Agudelo-Vera, C. and M. Blokker, *Finding (subsurface) anthropogenic heat sources that influence temperature in the drinking water distribution system.* DWES, Submitted. http://www.drink-water-eng-sci-discuss.net/dwes-2017-17/dwes-2017-17.pdf
2. Agudelo-Vera, C.M., et al., *Drinking water temperature in future urban areas*. 2015, KWR. https://library.kwrwater.nl/publication/52892955/
3. Agudelo-Vera, C., M. Blokker, and I. Pieterse-Quirijns, *Early Warning Systems to Predict Temperature in the Drinking Water Distribution Network.* Procedia Engineering, 2014. **70**(0): p. 23-30.
4. Agudelo-Vera, C.M., E.J.M. Blokker, and E.J. Pieterse-Quirijns, *Early warning system to forecast maximum temperature in drinking water distribution systems.* Journal of Water Supply: Research and Technology - AQUA, 2015. **64**(5): p. 496-503.
5. Blokker, E.J.M. and I. Pieterse-Quirijns, *Modeling temperature in the drinking water distribution system.* AWWA, 2013. **105**: p. E19-E28.

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