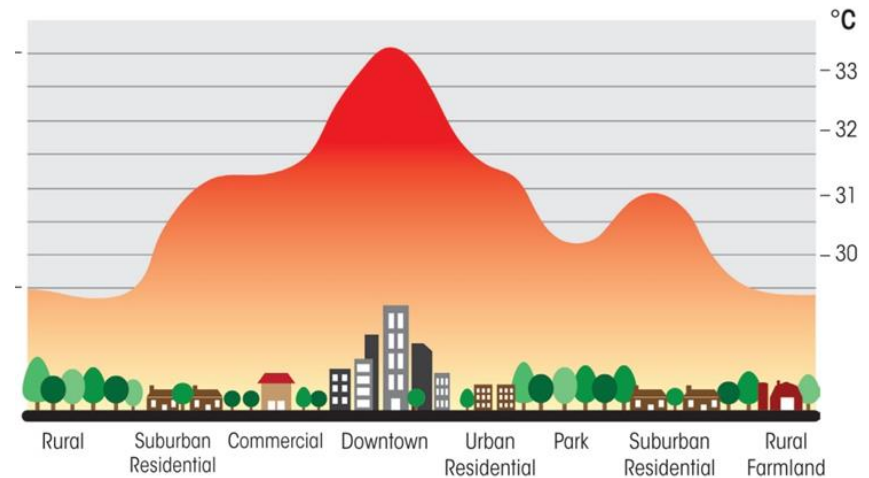
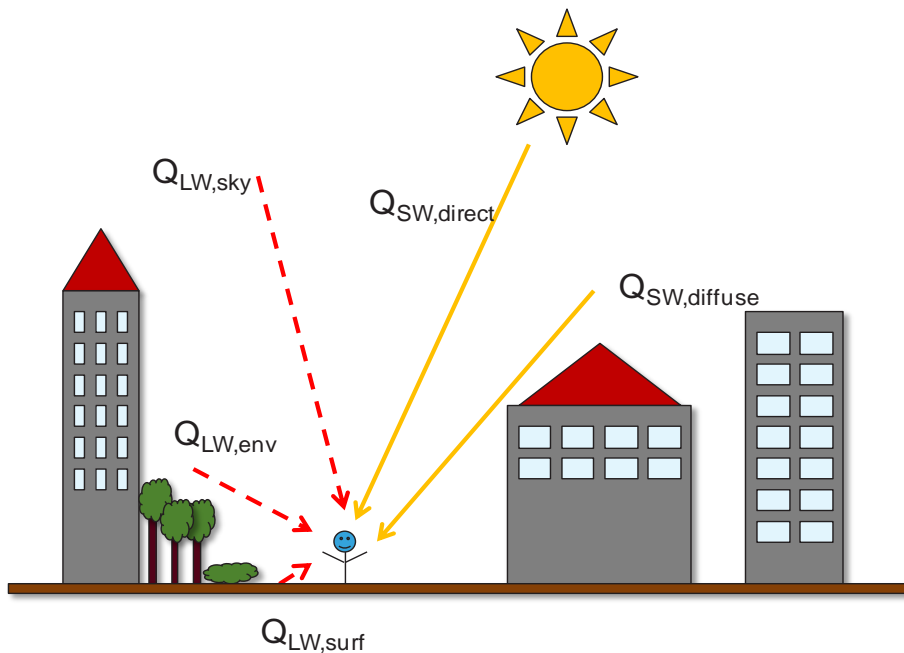




# TACKLING URBAN HEAT STRESS

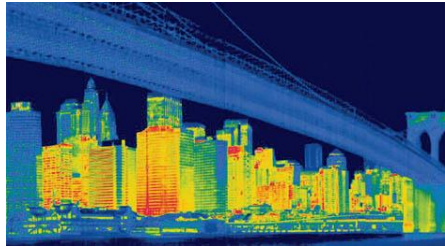
**Hendrik Wouters** (Hendrik.Wouters@vito.be) with contributions from Dirk Lauwaet, Koen De Ridder, Hans Hooyberghe, Filip Lefebvre, Julie Berckmans and Bino Maiheu

- Heat stress is a problem that will only get worse in the future
- Negative impact on sleep, productivity, health and mortality
- Impact is felt hardest in cities:
  - Cities tend to be warmer than local surroundings
  - Effect both during daytime (higher radiation) and nighttime (Urban Heat Island effect)
- Impact of climate change through heat stress twice as large in Belgian cities compared to natural areas (Wouters et al., 2017)



# URBAN HEAT ISLAND

Why?



Lack of vegetation:  
less evaporation and  
shading

Anthropogenic heat:  
• Cooled / heated buildings  
• (traffic) exhausts

Heat stored by buildings  
and paved roads released  
at night

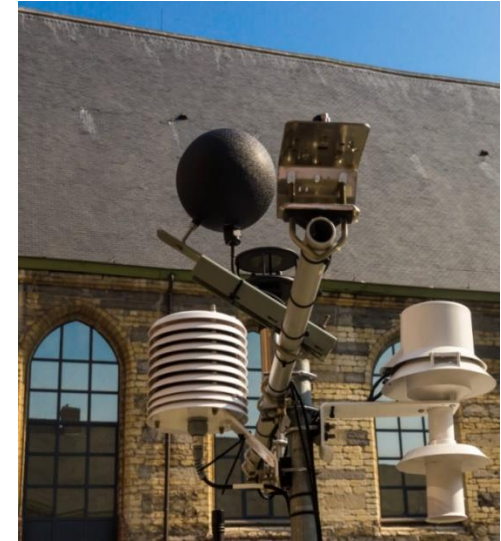
Multiple reflection  
of solar radiation  
between buldings

Reduced ventilation  
in street canyons



# HEAT STRESS INDICATORS

- Air temperatures don't tell the complete story
- Important other factors for thermal comfort
  - Wind speed
  - Humidity
  - Radiation load
- Many indicators exist to quantify these effects
  - ⇒ Wet Bulb Globe Temperature (ISO standard)
$$WBGT = 0.7 \times Tw + 0.2 \times Tg + 0.1 \times Ta$$
- Incorporated in legislation in several countries (incl Belgium)



WBGT temperature (°C)	Categorie	Stress Categorie
> 31	4	extreme heat stress
29.5 to 31	3	very strong heat stress
28 to 29.5	2	strong heat stress
25 to 28	1	moderate heat stress
< 25	0	no heat stress

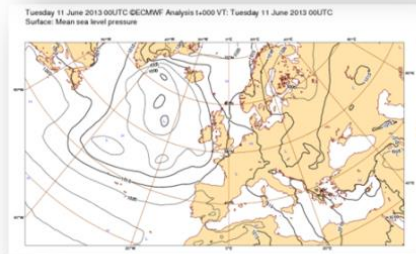
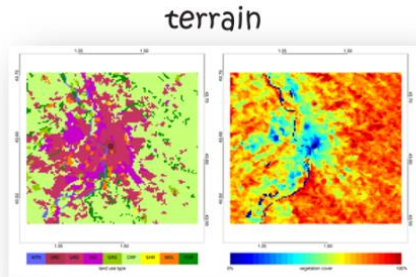
U.S. Army (2003)

## Guidelines from FOD Health regarding work breaks

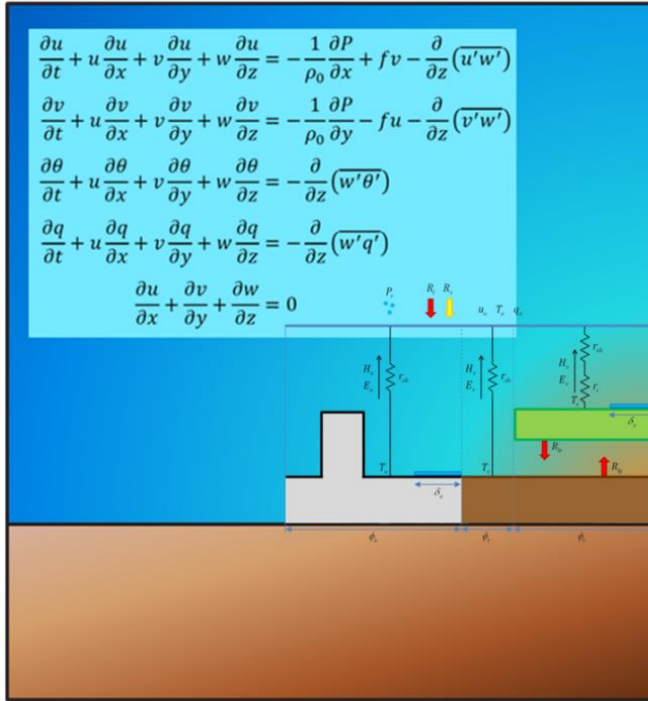
Afwisseling in het werk	WBGT-waarden			
	Licht werk	Halfzwaar werk	Zwaar werk	Zeer zwaar werk
45 min werk – 15 min rust	29,5	27	23	19
30 min werk – 30 min rust	30	28	24,5	21

<http://www.werk.belgie.be/defaultTab.aspx?id=39434>

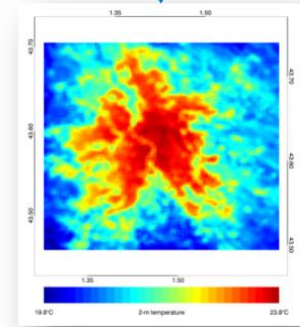
# The *UrbClim*<sup>®</sup> model



large-scale meteorology



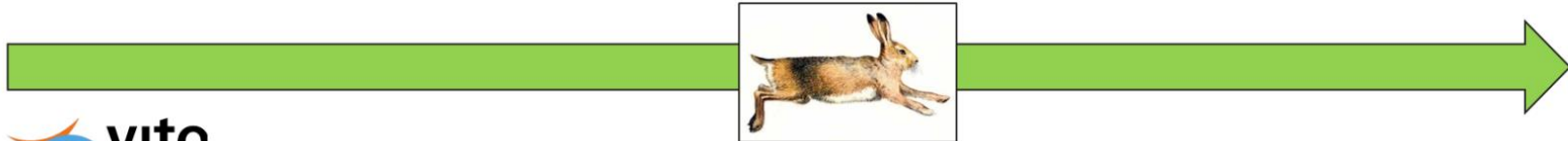
- hourly gridded (100-m)
- temperature
  - humidity
  - wind speed



UHI maps  
Output

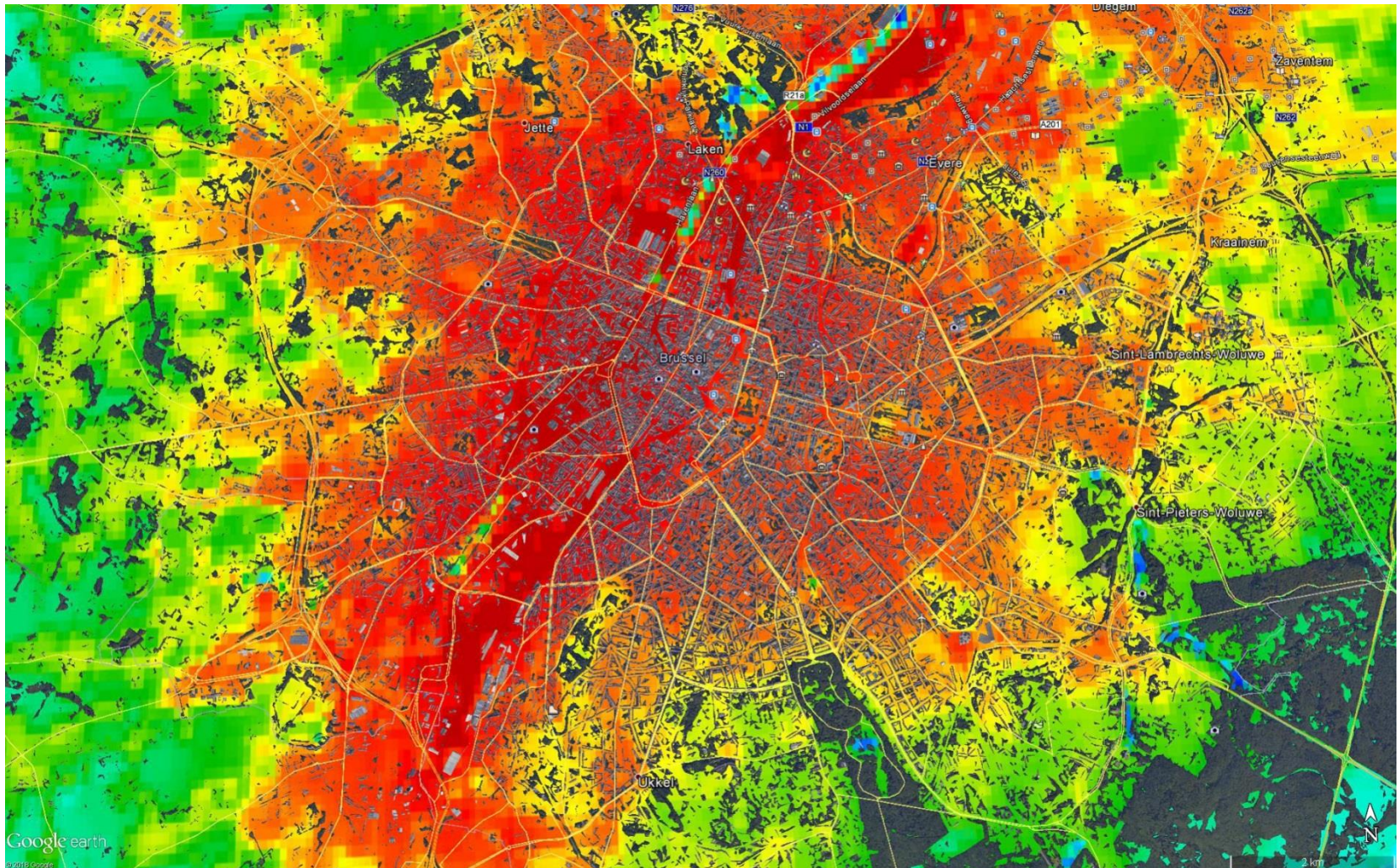
Input

UrbClim



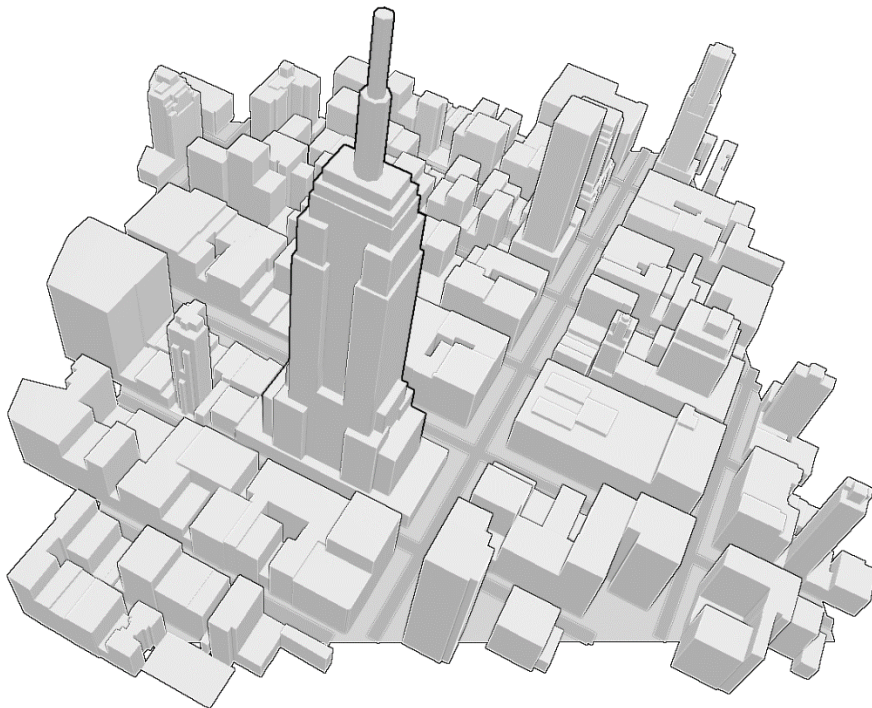
## BRUSSELS MAPS – IBGE-BIM PROJECT

- These 100m resolution temperature-based indicators give good indication of general heat stress in Brussels in comparison to surroundings
- Not much detail in city center (air temperatures don't vary much over small distances)

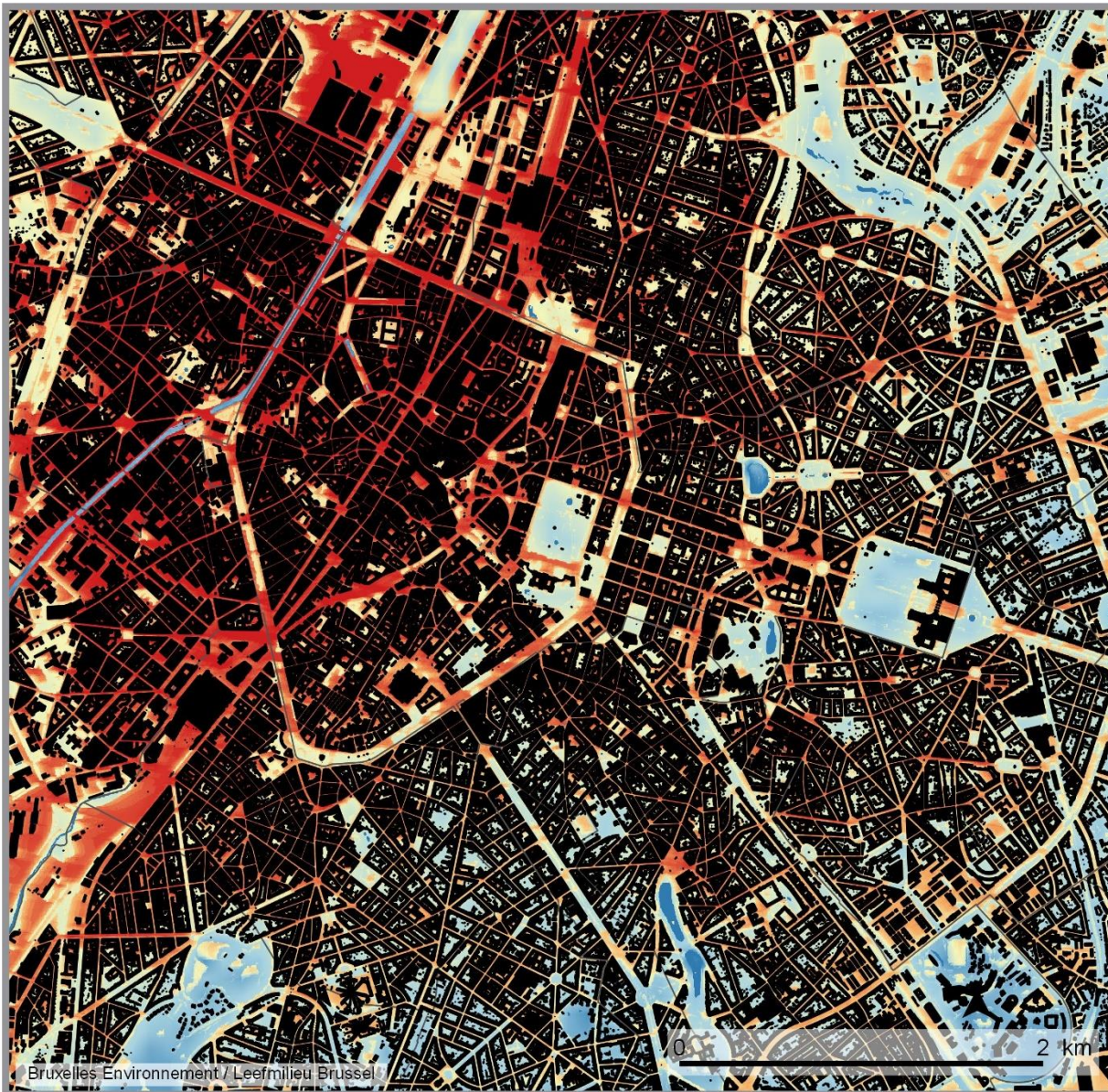


## CALCULATION OF WBGT

- High resolution needed (~1m)
  - Impact of individual buildings and trees is important for radiation calculations
- Input for calculations:
  - Detailed 3D building data and location of trees
- Focus on typical hot days (CPU constraints)
- Suited for local governments because of high variability in city center => small-scale adaptation measures can have big local impact



## Daily mean Wet Bulb Globe Temperature (°C) on 24/08/2016

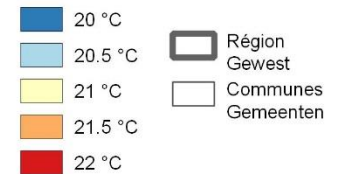


### Cartographie des îlots de fraîcheur dans la Région de Bruxelles-Capitale

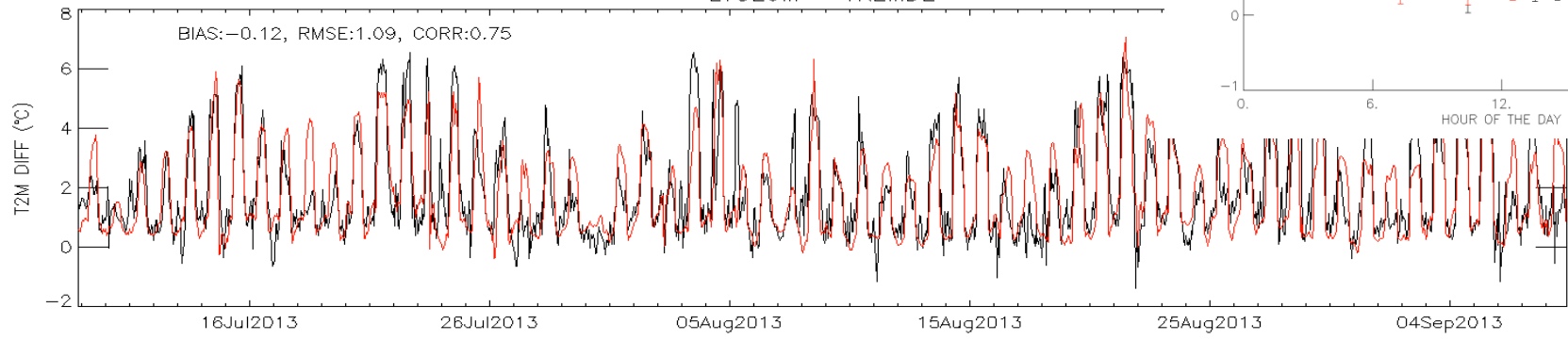
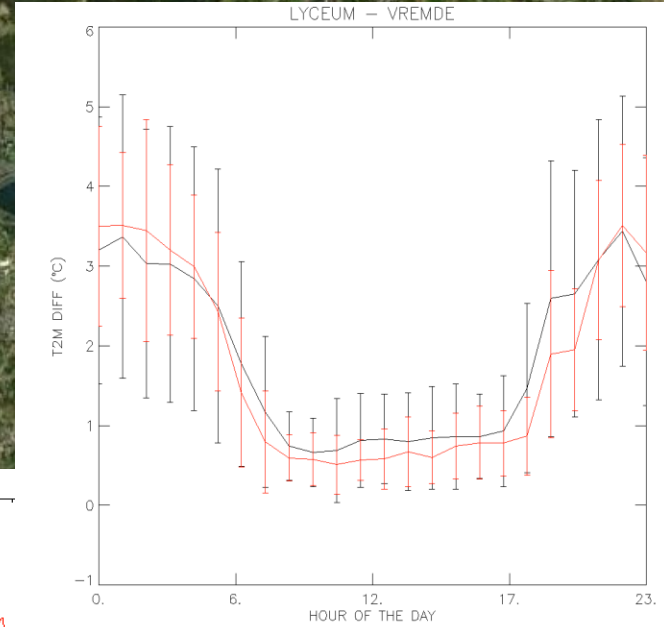
### Cartografie van de koelte-eilanden in het Brussels Hoofdstedelijk Gewest

Température à globe humide moyenne pour toutes les heures du jour du 24 aout 2016 dans le centre de Bruxelles

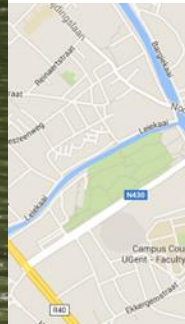
De gemiddelde Wet Bulb Globe Temperature over alle uren van de dag op 24 augustus 2016 in het centrum van Brussel



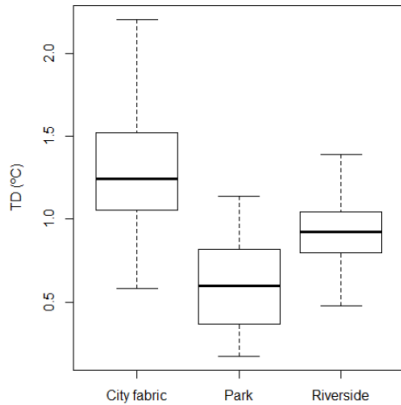




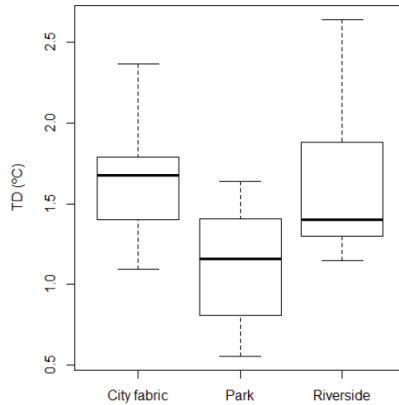
## Ghent measurement campaign



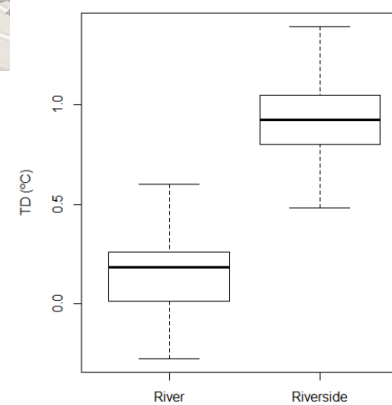
Early Afternoon



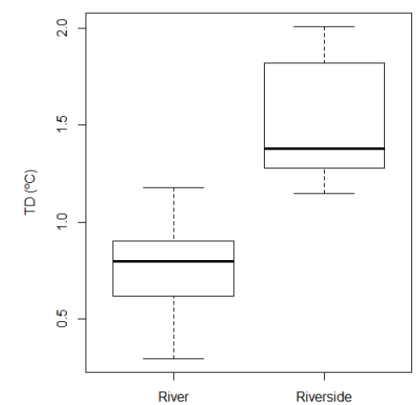
Late Afternoon



Between 13 and 14 o'clock



Between 17 and 18 o'clock



## Citizen science WBGT measurement campaign in Antwerp

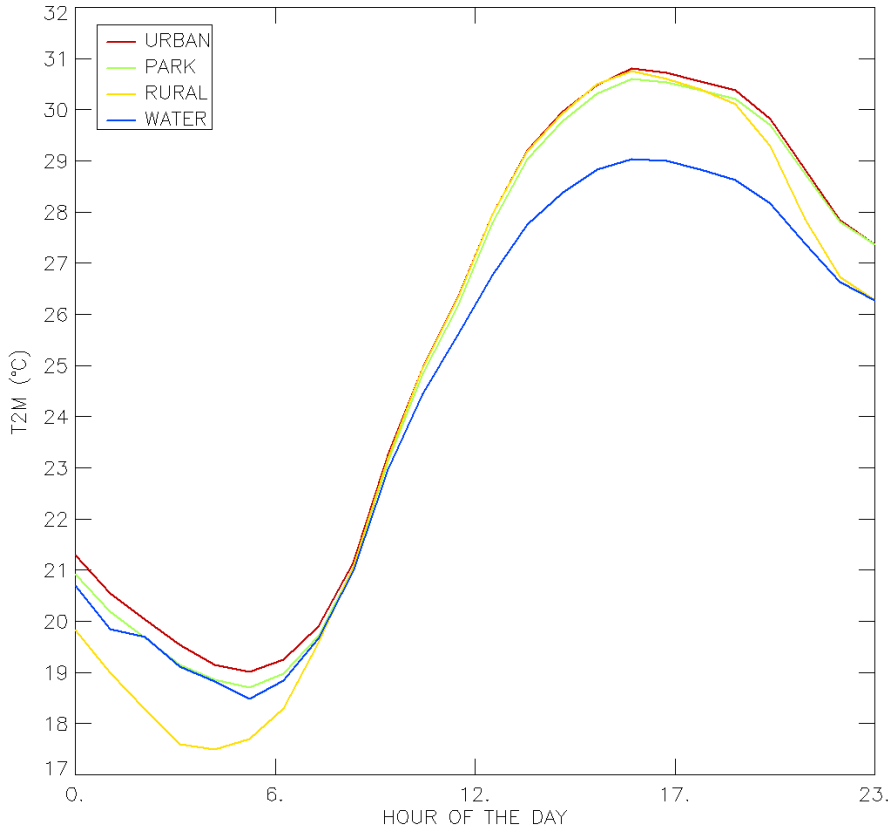
- During hottest hours, shading is most crucial to lower WBGT
- Differences of over 4°C between hottest and coolest locations in a small neighbourhood

sealed surface in the sun	grass surface in the sun	small street, sunny side	green garden, half shadow	small street, shadow side	under small trees
27,6	26,1	25,3	23,7	23,5	23,5
					

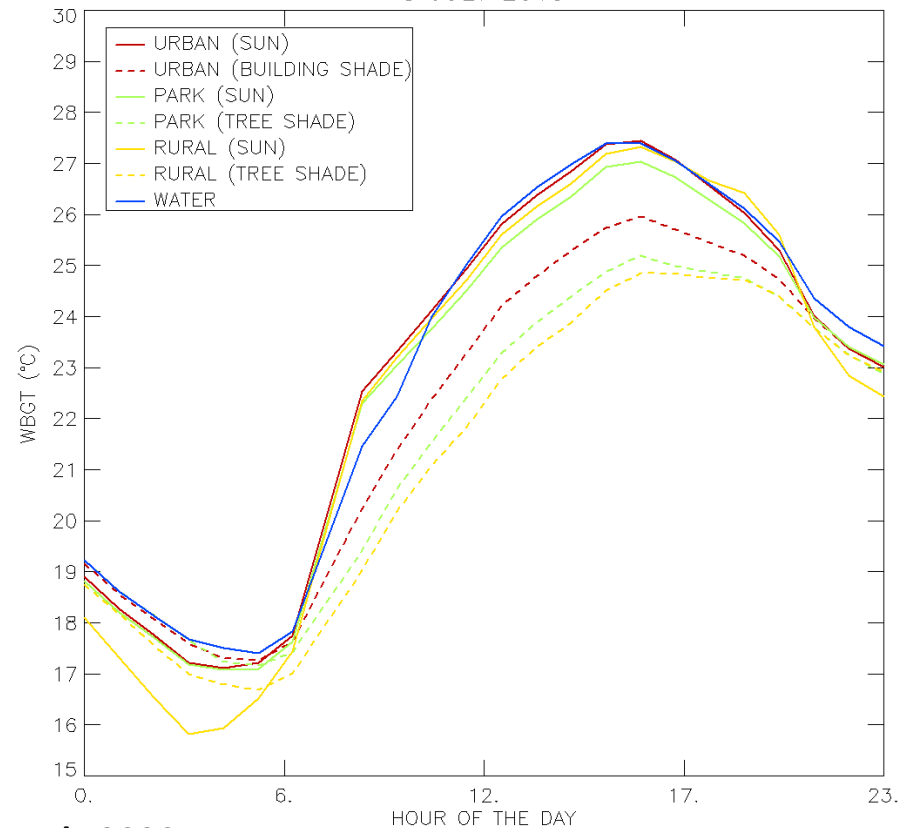
Measured maximum WBGT (average value of 4 hot days)

## Ghent measurement campaign

3 JULY 2015



3 JULY 2015



Lauwaet et al., 2020

### Air temperatures

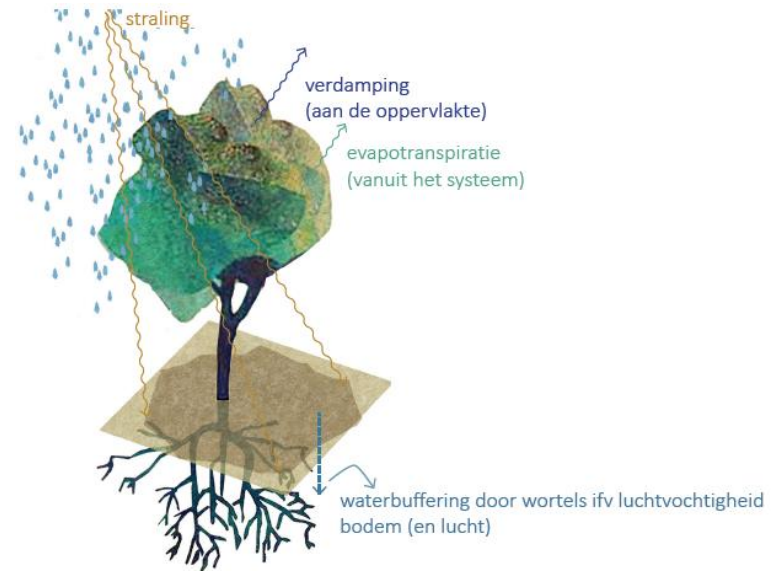
- Air over water surface is coolest during the day
- All other locations have comparable air temperatures
- Open, rural location is coolest during the night

### WBGT

- Shaded locations are coolest during the day
- Tree shade is a little more effective than building shade
- Water provides not much cooling due to higher humidity

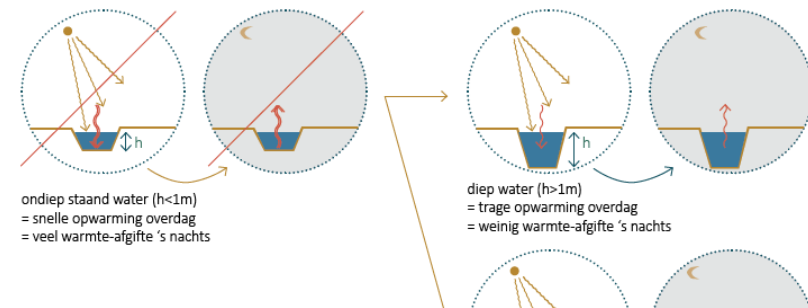
## Vegetation

- Provides cooling through shade, evapotranspiration
- Cooling effect is local (not much wind on most heat wave days anyway)
- The bigger the area the more cooling
- Trees are most efficient
- Impact on air temperature up to 3°C for large parks (evening and night)
- Impact on WBGT up to 3°C (daytime)



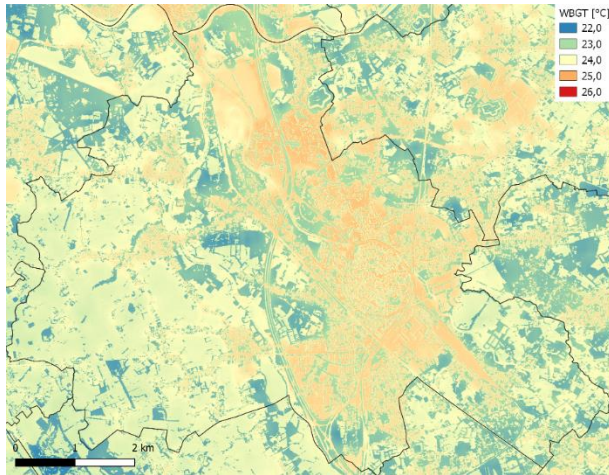
## Water

- The more evaporation the higher the cooling effect
- Fountains and sprinklers cool better than standing water
- Avoid shallow standing water (releases heat during the night)
- Impact on air temperature up to 3°C during daytime
- Little impact on WBGT due to higher humidity

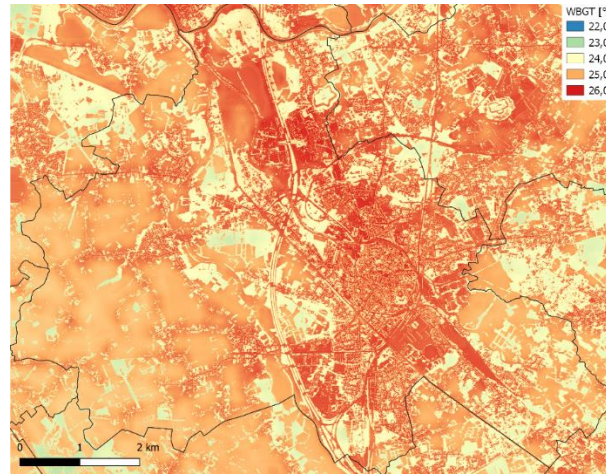


- We translate our knowledge and maps into tools to advice policy makers on climate adaptation measures
- For example to demonstrate how a current extreme heat wave day looks like in 2050 (RCP8.5 scenario) and to what extent green and blue measures can bring cooling
- Below is an example for the city of Mechelen when a large greening scenario is applied in the city center
  - WBGT in 2050 can be brought to lower values than the current highest values
  - Further in the future, green/blue measures will be insufficient to keep warming under control...

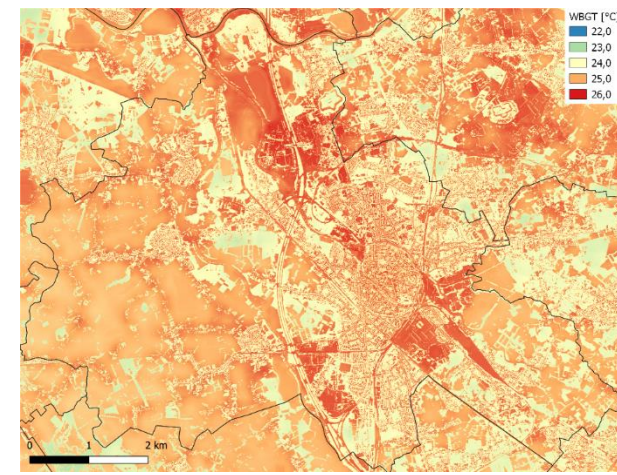
2020 heat wave day



2050 No action



2050 greening scenario



<https://projecttool.toepassingen.vmm.vlaanderen.be/>