Fine-scale urban climate projections for Brussels with the UrbClim model

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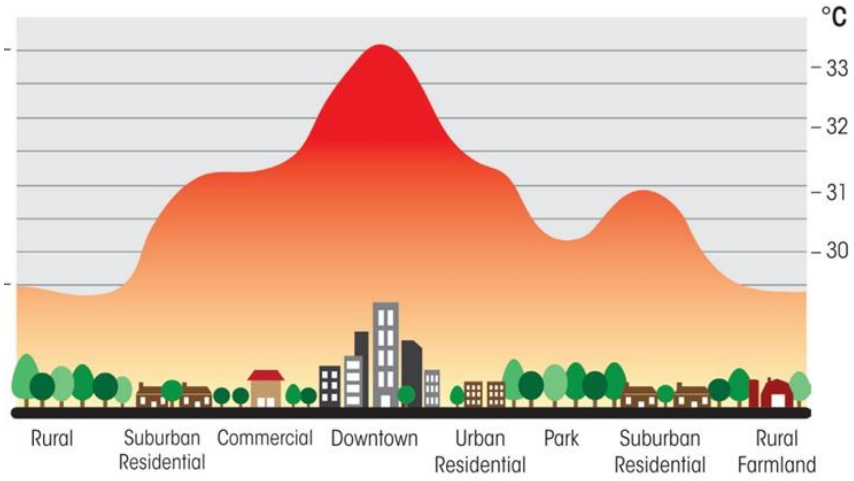
Photo © Justin A

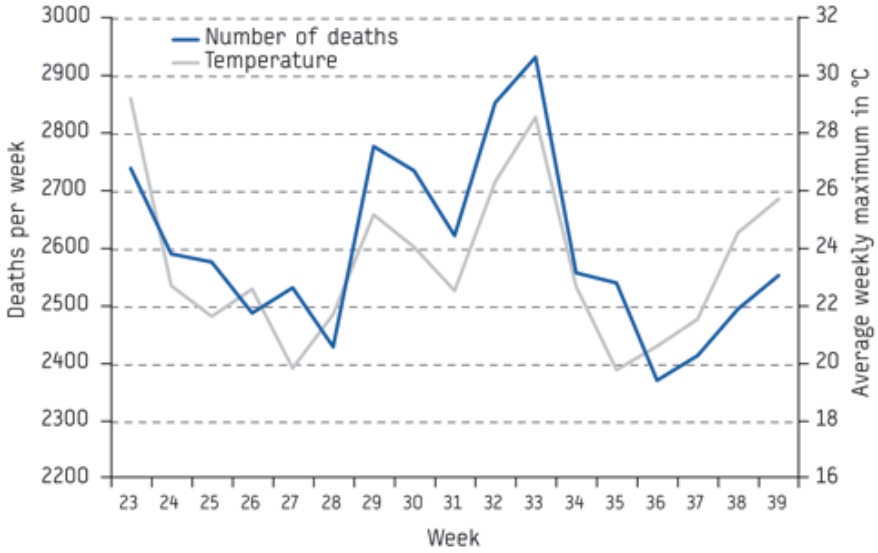
URBAN MICROCLIMATE

The Urban Heat Island

- Cities tend to be warmer than their rural surroundings

- Effect during the day and during the night
  - Nighttime: air temperatures
  - Daytime: heat stress (radiation)





Garssen et al., 2005

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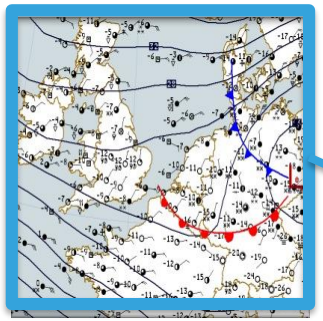
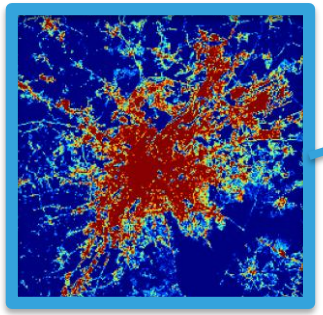
THE URBCLIM MODEL

Large-scale Meteorology





Urban structure:

- Vegetation
- Soil sealing
- Typology

UrbClim

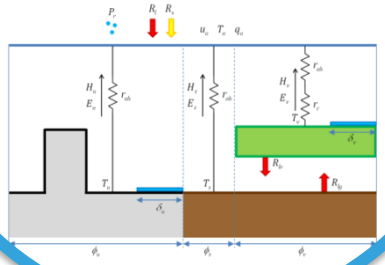
$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}=-\frac{1}{\rho_0}\frac{\partial P_0}{\partial x}+fv-\frac{\partial}{\partial z}\left(\overline{u'w'}\right)$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}=-\frac{1}{\rho_0}\frac{\partial P_0}{\partial y}-fu-\frac{\partial}{\partial z}\left(\overline{v'w'}\right)$$

$$\frac{\partial \theta}{\partial t}+u\frac{\partial \theta}{\partial x}+v\frac{\partial \theta}{\partial y}+w\frac{\partial \theta}{\partial z}=-\frac{\partial}{\partial z}\left(\overline{w'\theta'}\right)$$

$$\frac{\partial q}{\partial t}+u\frac{\partial q}{\partial x}+v\frac{\partial q}{\partial y}+w\frac{\partial q}{\partial z}=-\frac{\partial}{\partial z}\left(\overline{w'q'}\right)$$

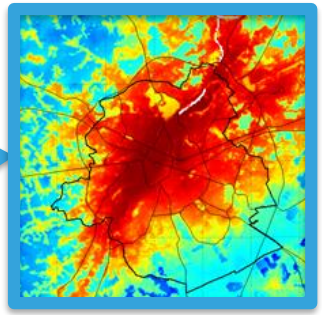
$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0.$$



Computation of impact of urban structures on boundary layer

Hourly maps of:

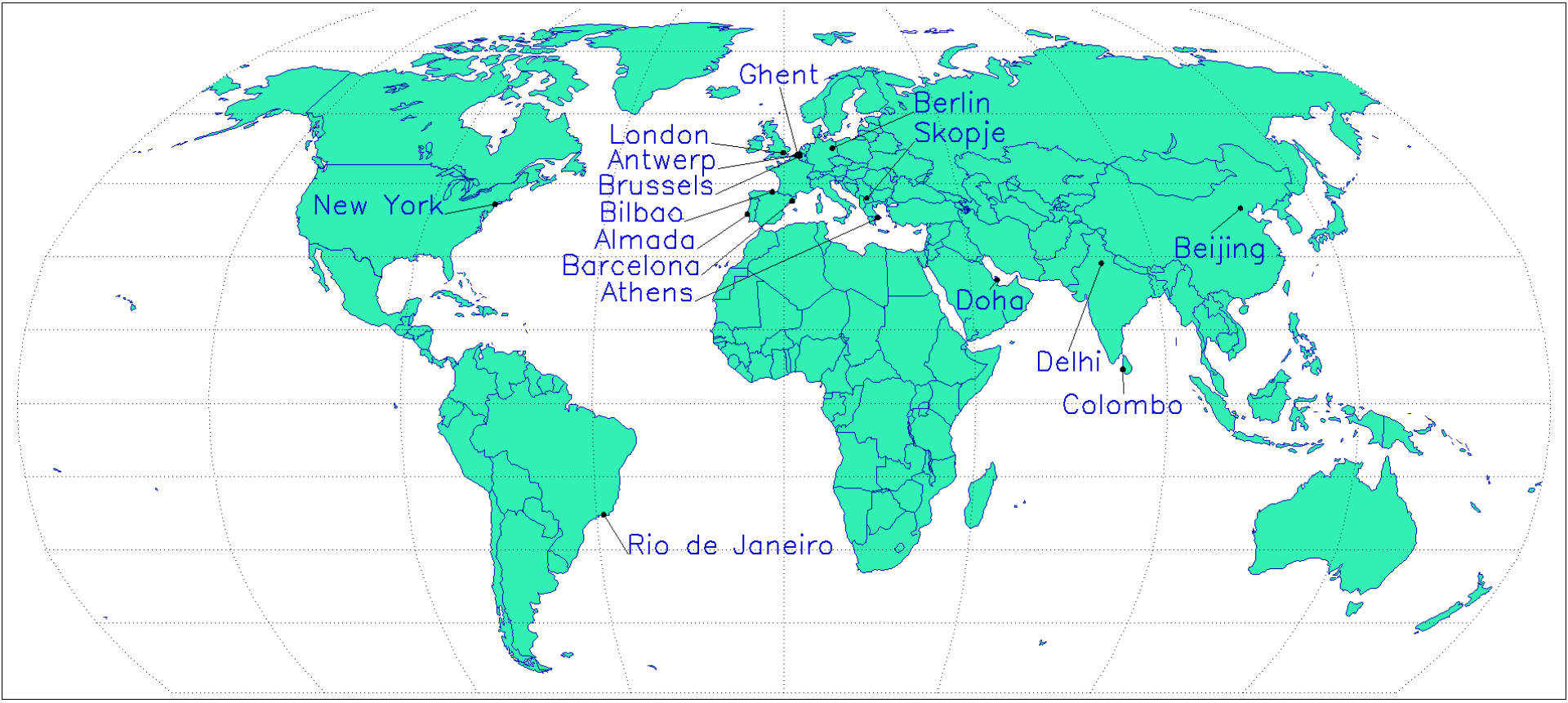
- Air temperature
- LST
- Humidity
- Wind speed



100m resolution

De Ridder et al., 2015, Urban Climate

THE URBCLIM MODEL



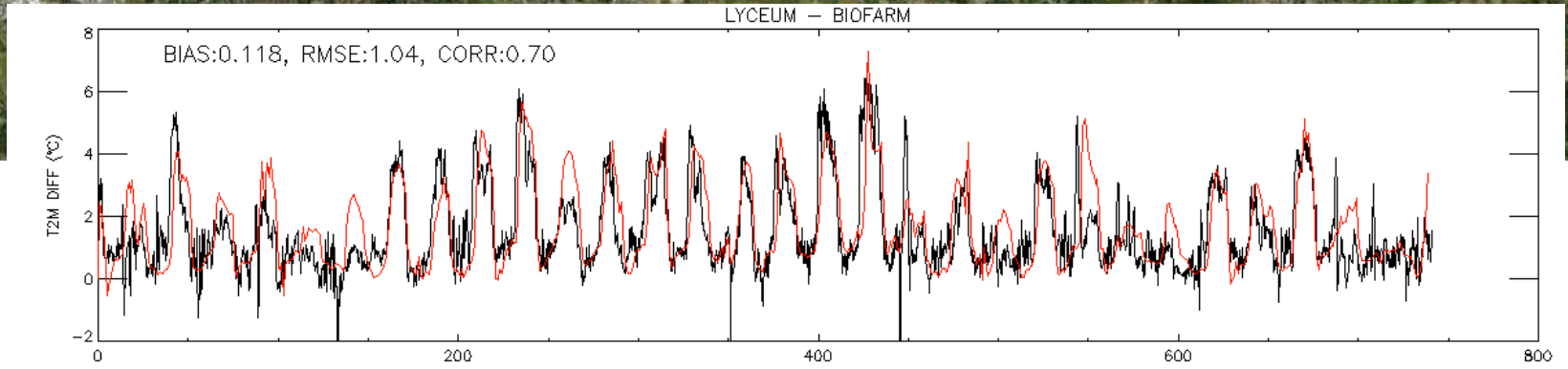
MODEL VALIDATION

Antwerp – Lauwaet et al., 2015, Climate
Ghent – De Ridder et al., 2015, Urban Climate
Brussels – Lauwaet et al., 2016, Urban Climate
Barcelona – Garcia-Diez et al., 2016, Geosc. Mod. Dev.
London – Zhou et al., 2016, J. App. Meteo. & Clim.
Delhi - Sharma et al., 2017, Th. App. Clim. (in review)
Berlin, Lisbon, Bilbao – FP7 projects NACLIM and RAMSES

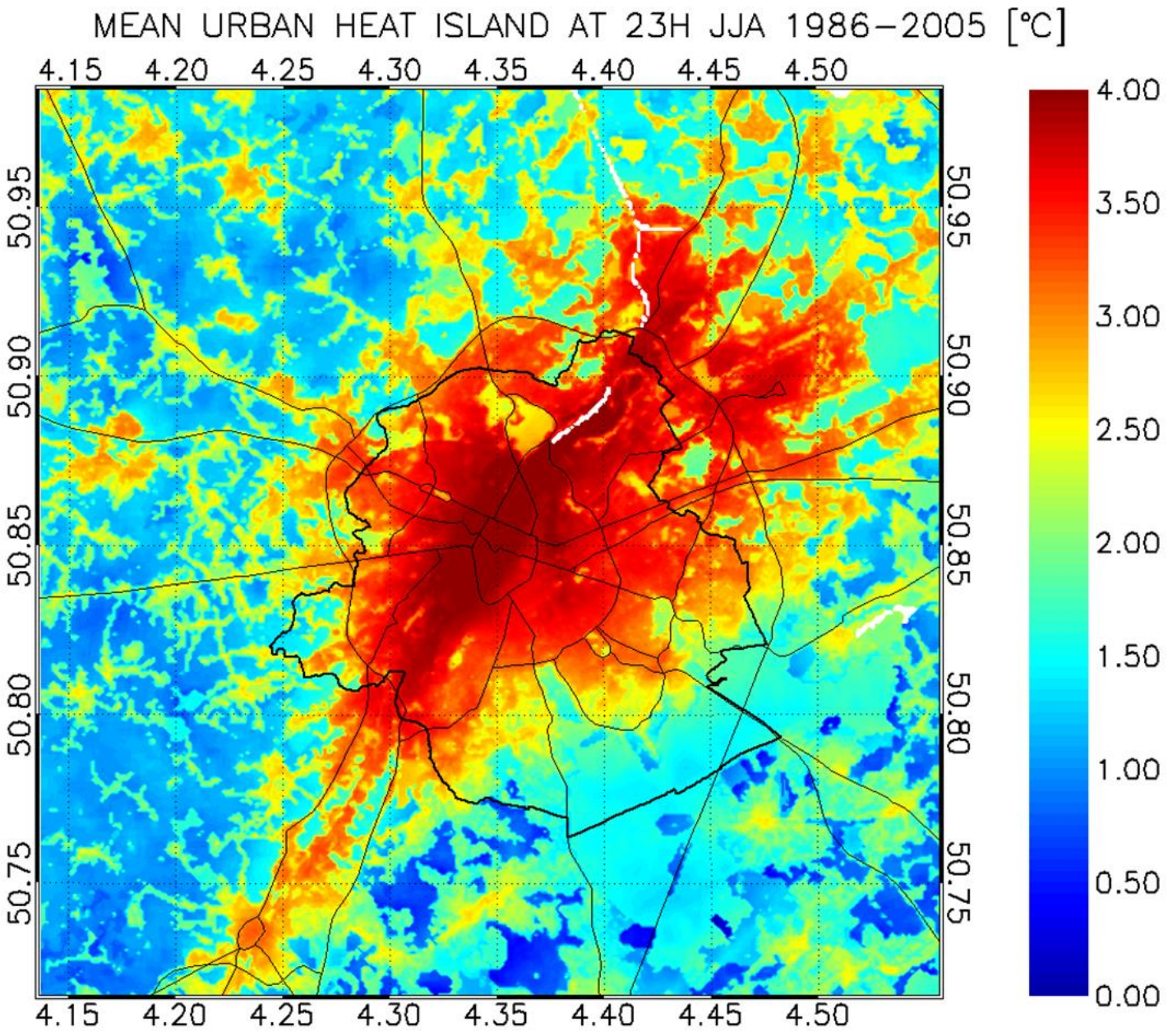
Antwerpen, België

Koninklijk Lyceum Antwerpen

Boerderij Van Leemputte

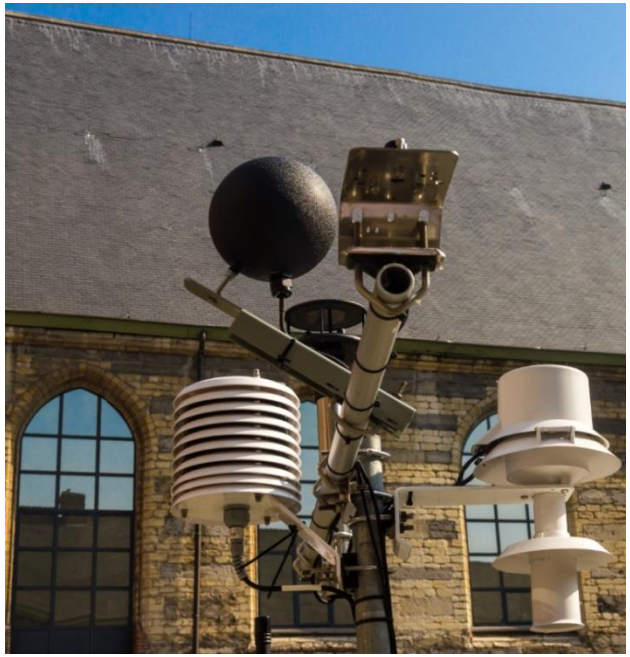


THE UHI OF BRUSSELS



DAYTIME HEAT STRESS

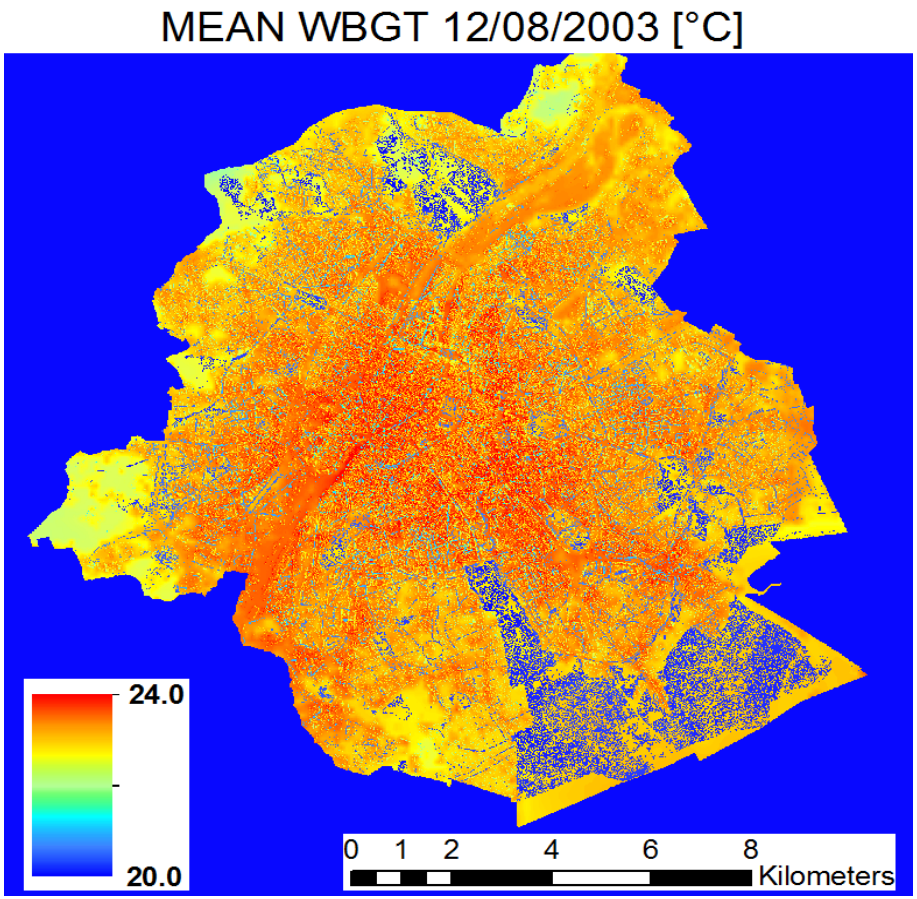
- Air temperatures don’t tell the complete story
- Important factors for thermal comfort
  - Wind speed
  - Radiation load
  - Humidity
- Indicator: Wet Bulb Globe Temperature (ISO standard)
- 3D building data and detailed location trees needed
- Incorporated in legislation in several countries (incl Belgium)

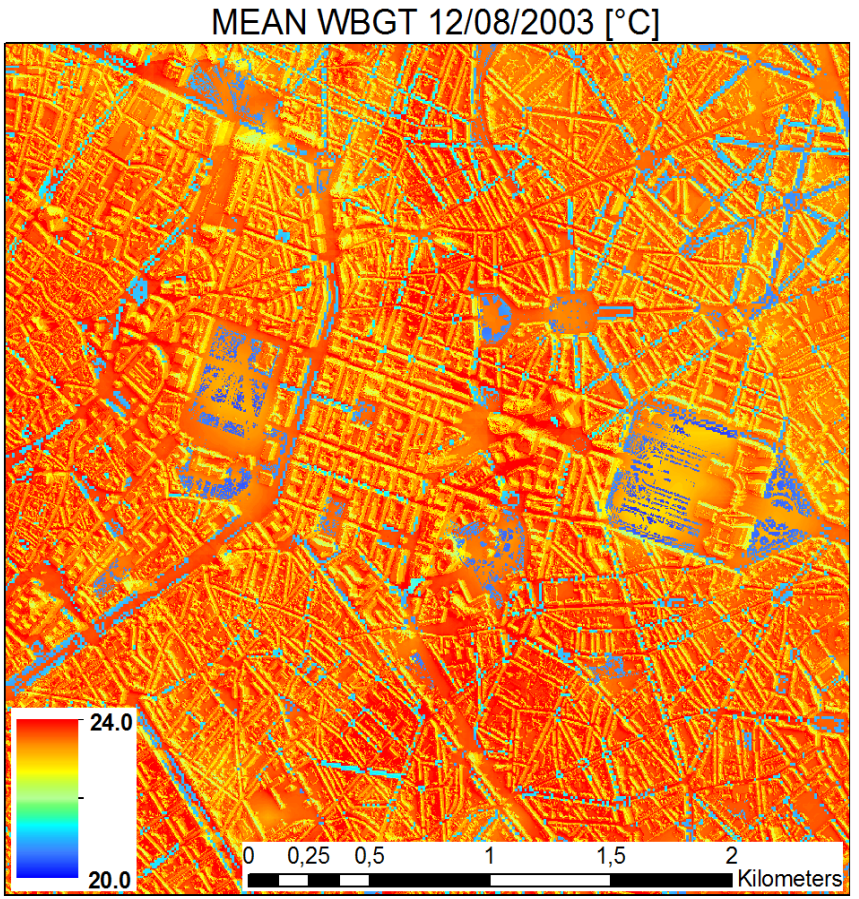


Afwisseling in het werk	WBGT-waarden			
	Licht werk	Halfzwaar werk	Zwaar werk	Zeer zwaar werk
45 min werk – 15 min rust	29,5	27	23	19
30 min werk – 30 min rust	30	28	24,5	21

FOD Werkgelegenheid, Arbeid en Sociaal overleg

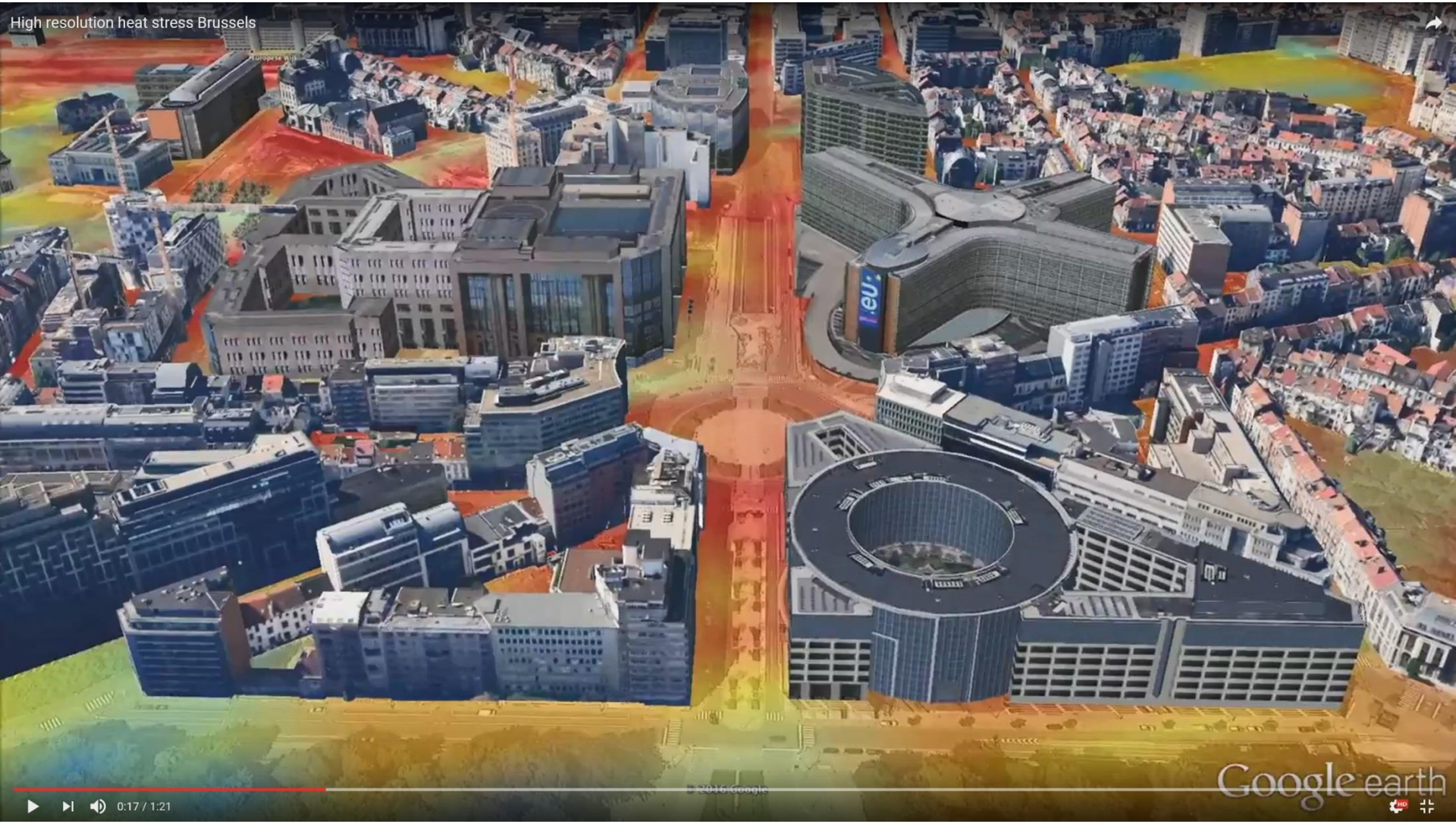
DAYTIME HEAT STRESS





Movie: https://www.youtube.com/watch?v=Ax0DRg2HDtg

HIGH RESOLUTION HEAT STRESS



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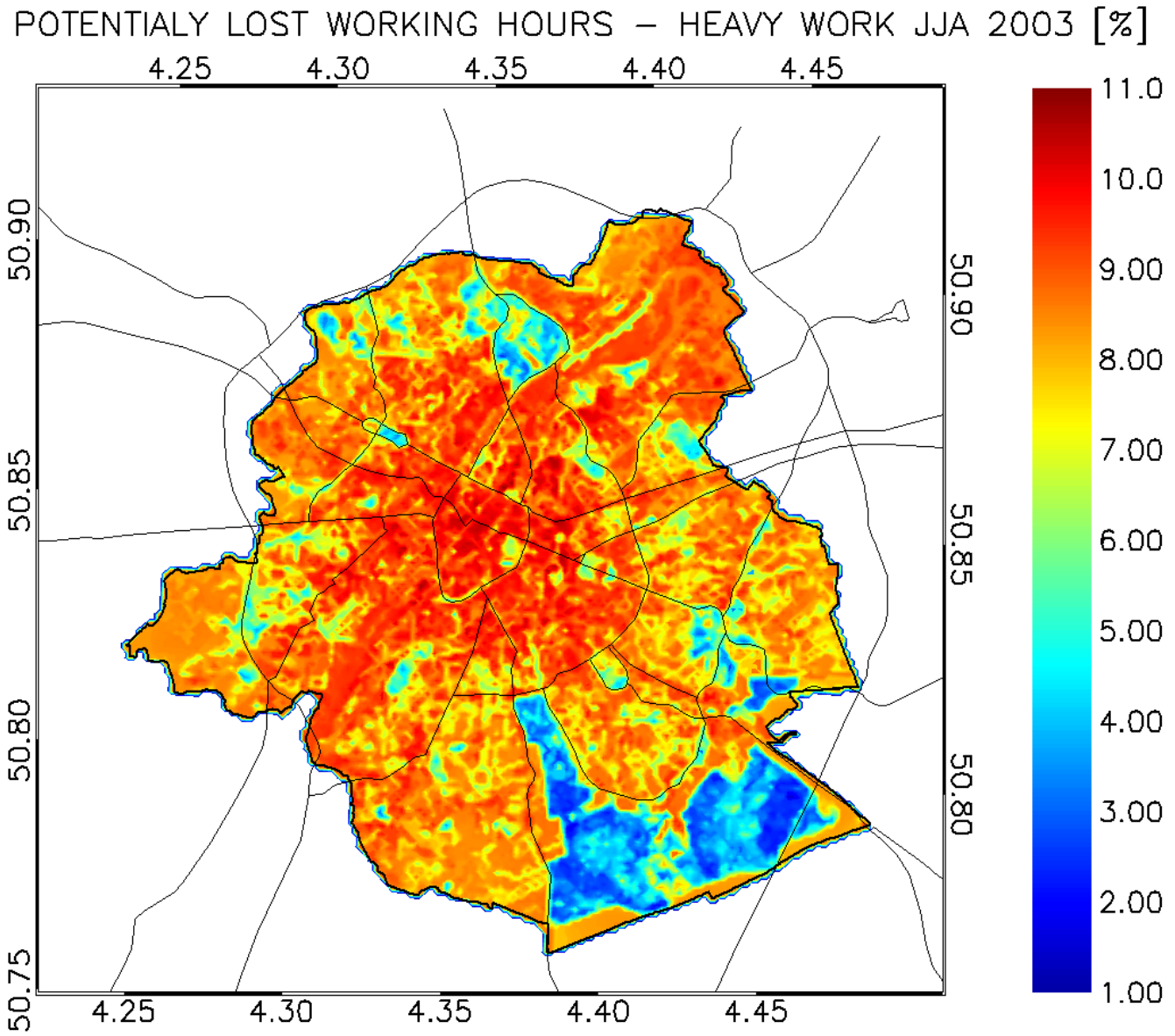
OUTDOOR PRODUCTIVITY LOSSES

WBGT: related to lost working hours



URBAN CLIMATE PROJECTIONS

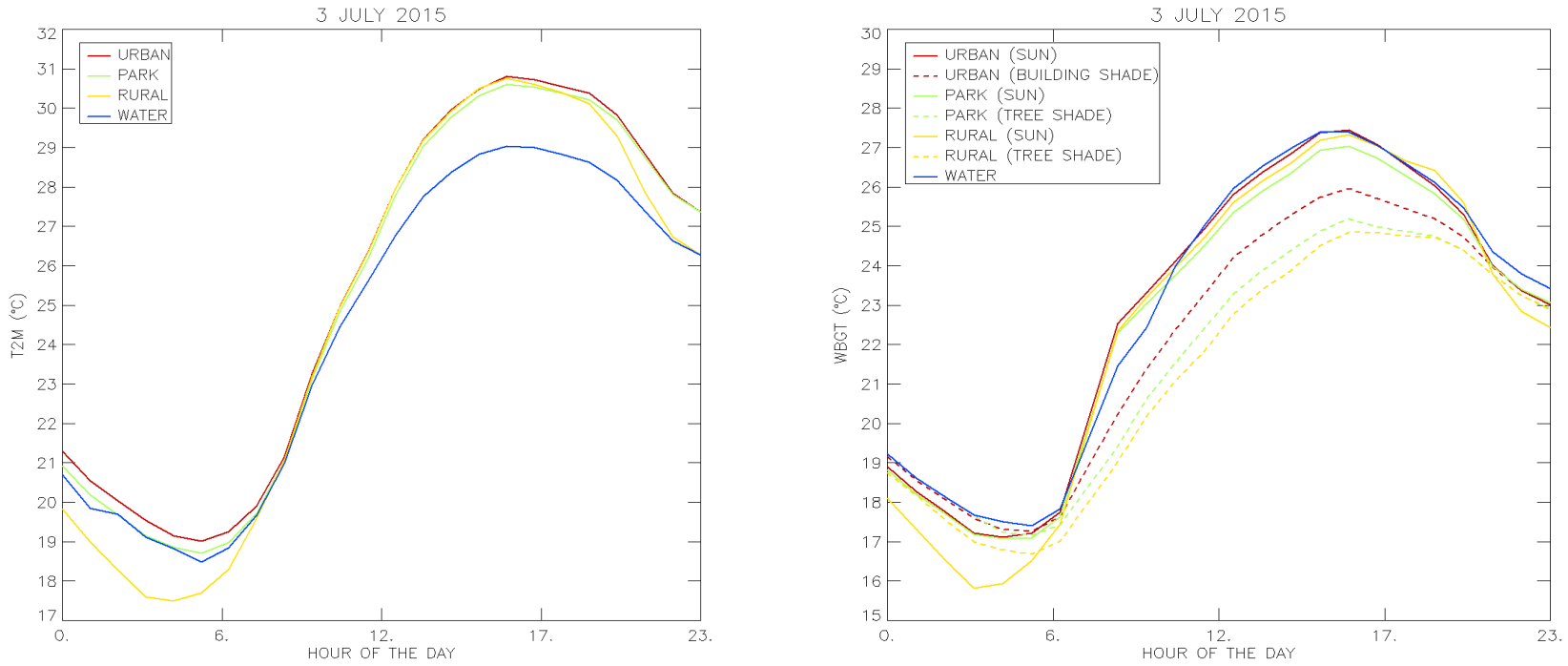
- Based on ALARO EURO-CORDEX simulations
- Scenarios RCP8.5 and RCP4.5
- 2 time frames:
  - Near future (2026 – 2045)
  - Far future (2081 – 2100)

Potential impact of climate change on indicators for heat stress, energy use and productivity losses for dense urban areas (soil sealing > 90%) in Brussels

	1986-2005	**2081-2100 (RCP8.5)**
UHI intensity [°C]	3.7	3.9
Heat Wave Days	4.2	15.9
Cooling Degree Days	28.2	74.0
Lost Working Days		
Light work	0.9	2.6
Medium-heavy work	1.1	3.4
Heavy work	3.0	6.3
Very heavy work	8.8	15.6

GREEN/BLUE ADAPTATION MEASURES

GREEN/BLUE ADAPTATION MEASURES



Lauwaet et al., 2017, Landscape and Urban Planning, submitted

⇒ Significant (but local) effects can be obtained with green/blue adaptation measures
⇒ Best to apply and combine measures as much as possible everywhere in a city
⇒ No-regret measures, will improve quality of living in a city

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THANK YOU!

http://vegetalcity.net

- Questions?

- More information:
  - www.urban-climate.be/
  - Dirk.lauwaet@vito.be

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