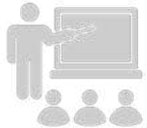
Urban climate research

in support of resilient city (& *schools*) planning

Koen De Ridder

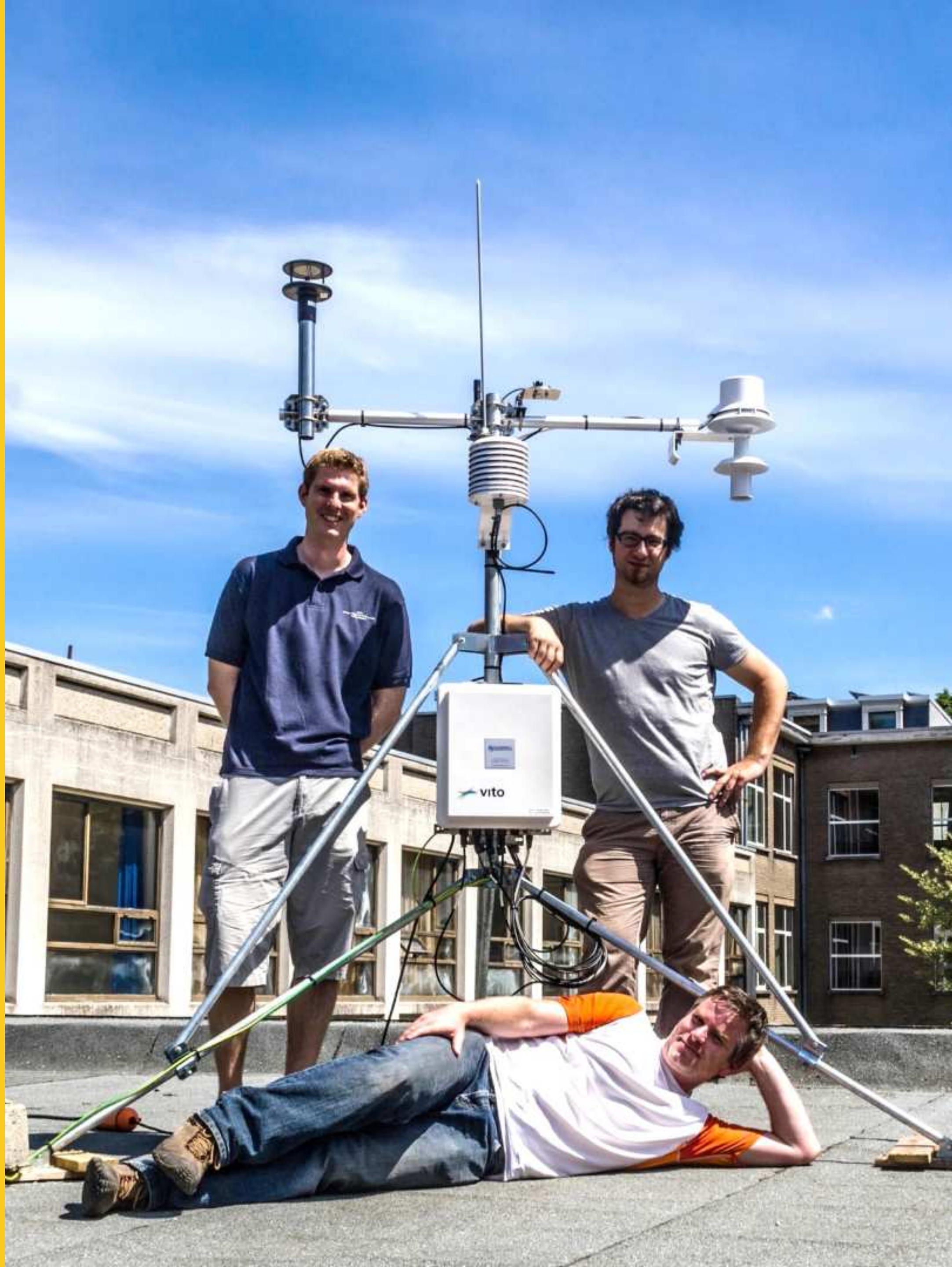
Flemish Institute for Technological Research (VITO)

Outline

1		Urban climate monitoring – Belgium	
2		Urban climate modelling – Europe (& Global)	
3		Urban climate modelling and monitoring in Africa	
4		Monitoring of indoor climate in African schools	
5		Do It Yourself (DIY)	

Urban climate monitoring

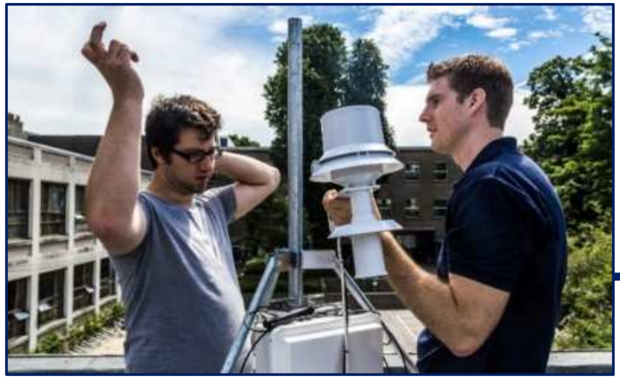
Belgium

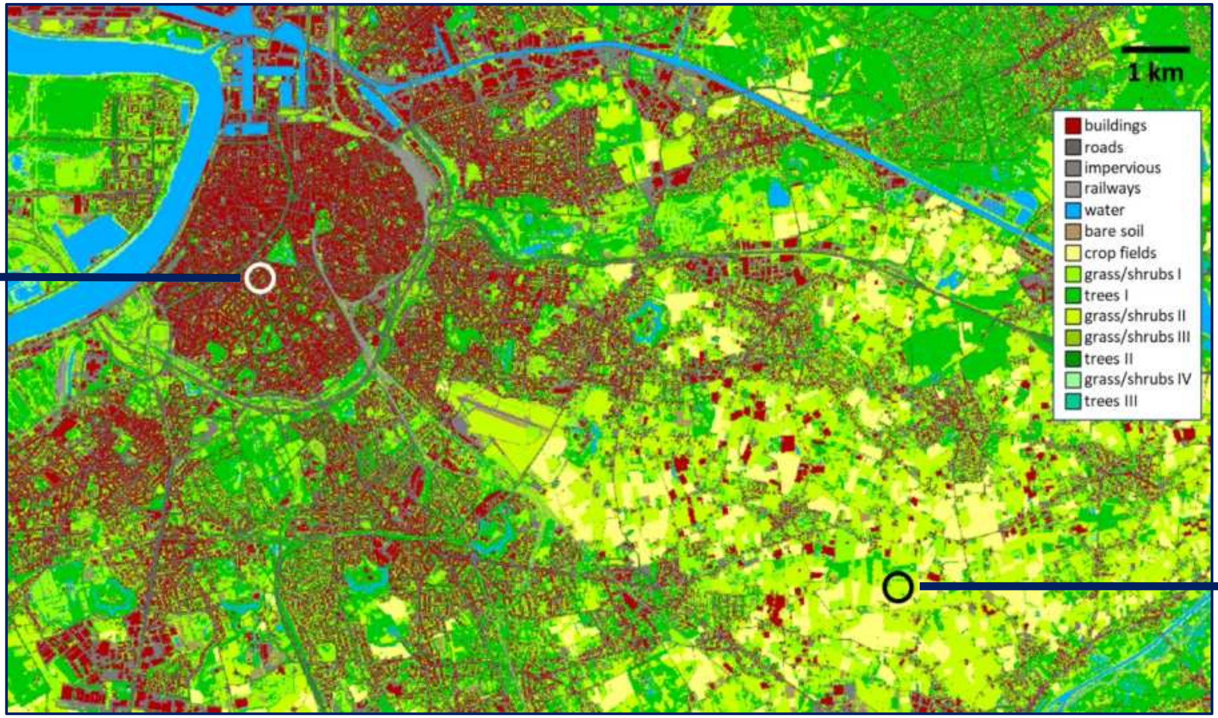


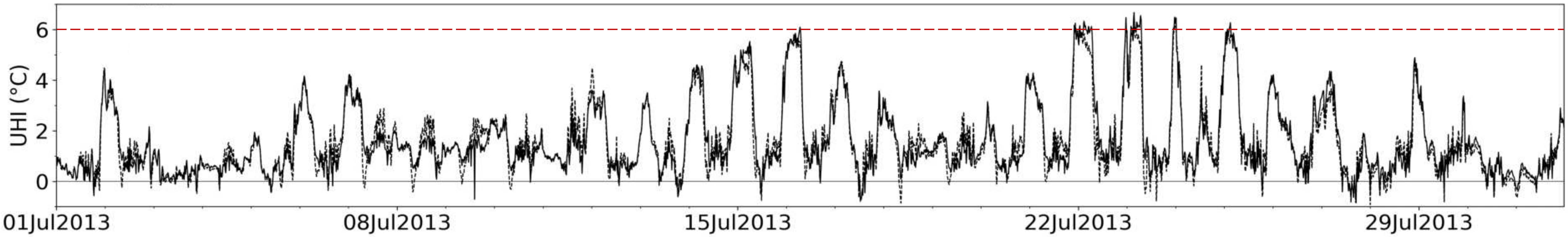
vito

De Ridder, K., Maiheu, B., Lauwaet, D, 2023. To aspirate or not to aspirate – impact of active versus passive ventilation on urban heat (island) indicators. Urban Climate, 52, 101709. https://doi.org/10.1016/j.uclim.2023.101709

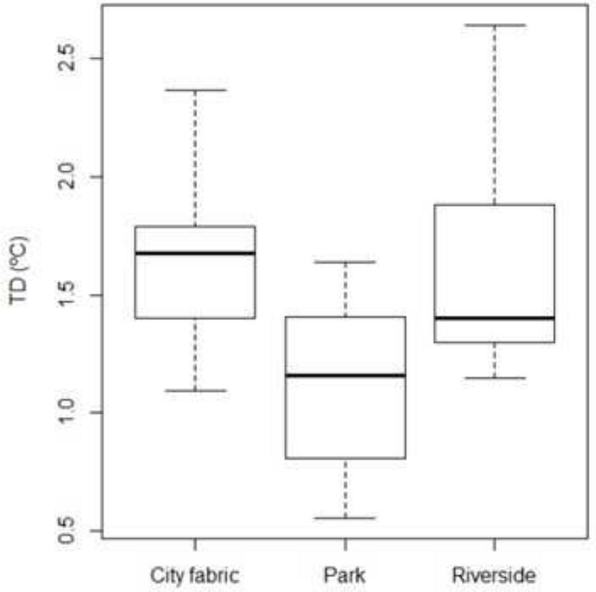
Antwerp – urban-rural temperature differences (urban heat island)





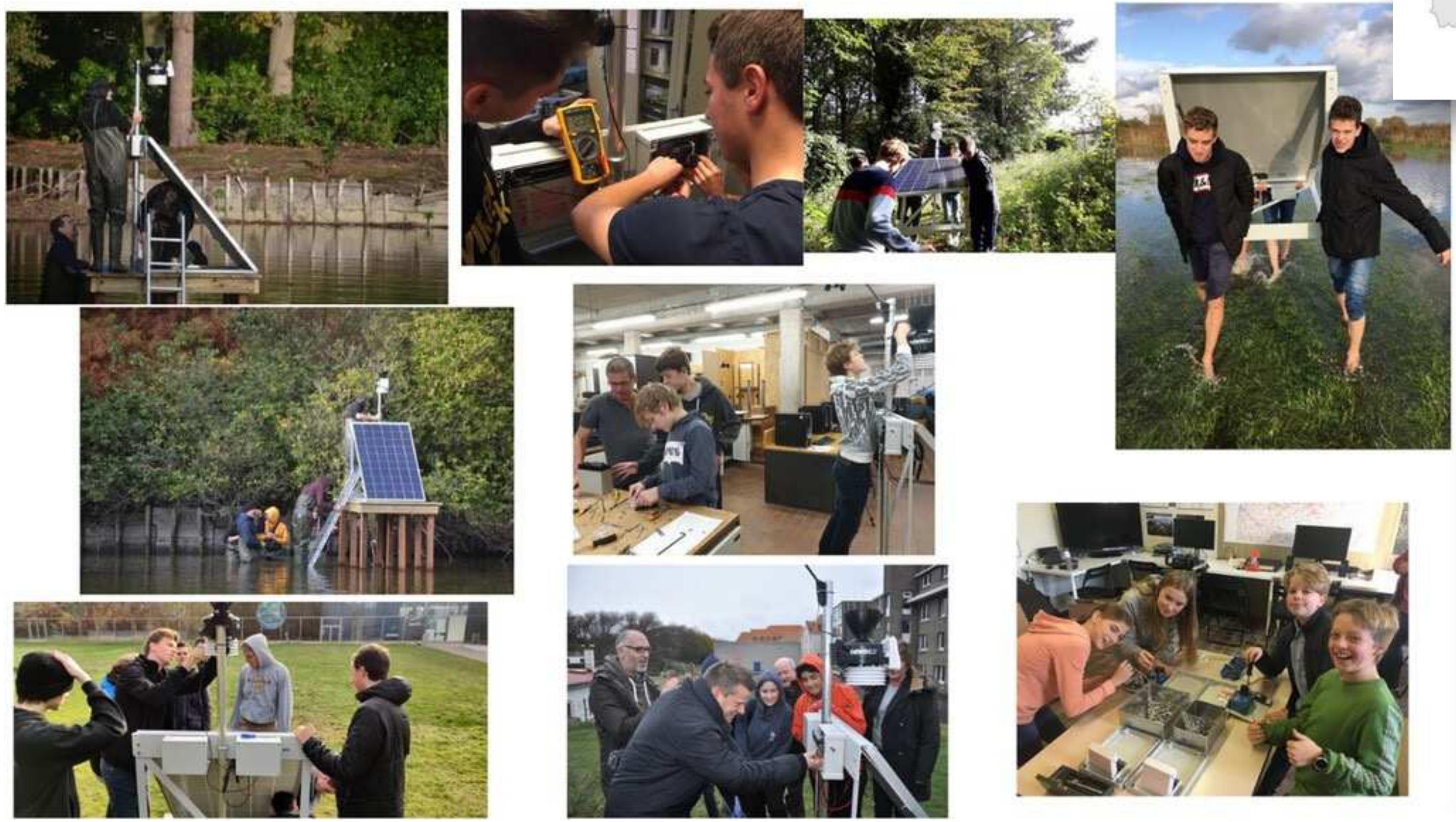


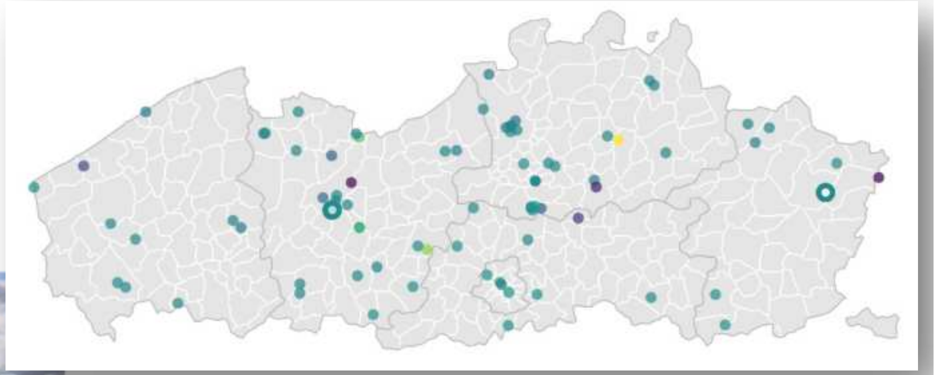
Ghent monitoring campaign



Lauwaet, D., B. Maiheu, K. De Ridder, W. Boënne, H. Hooyberghs, M. Demuzere, M.-L. Verdonck, 2020. A New Method to Assess Fine-Scale Outdoor Thermal Comfort for Urban Agglomerations. Climate, 8, 6.

Engaging schools to explore meteorological observational gaps



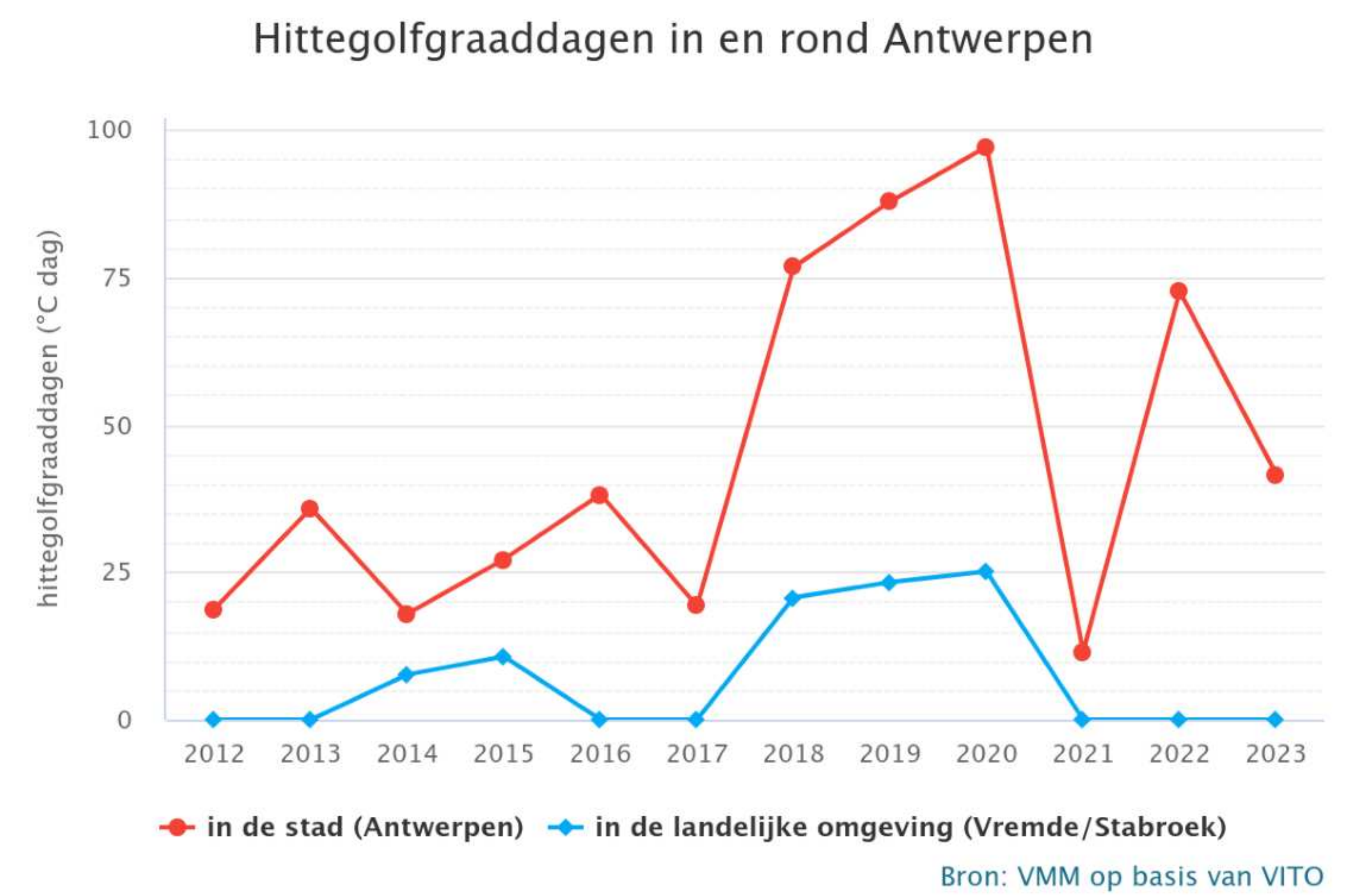


https://vlinder.ugent.be/dashboard/

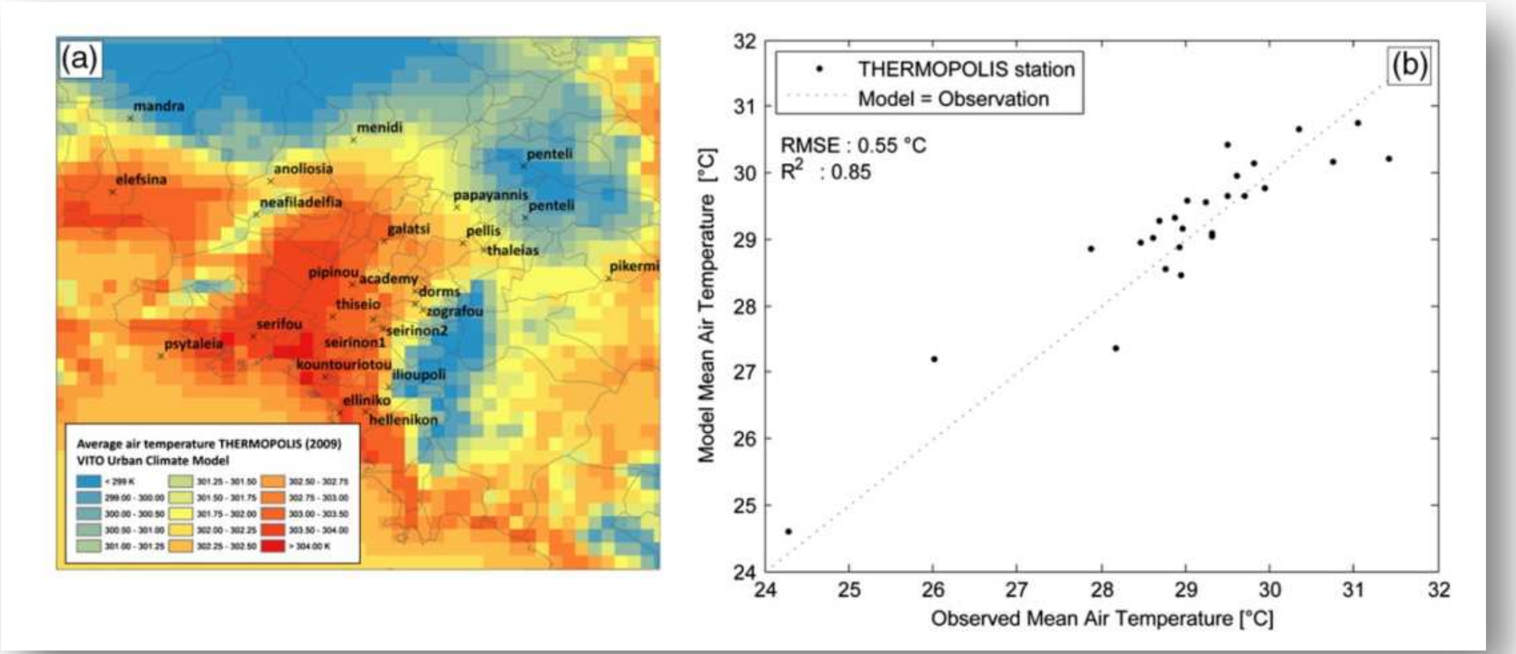
UNIVERSITEIT GENT

Caluwaerts, S., Top, S., Vergauwen, T., Wauters, G., De Ridder, K., Hamdi, R., Mesuere, B., Van Schaeybroeck, B., Wouters, H., & Termonia, P., 2021. Engaging Schools to Explore Meteorological Observational Gaps. Bulletin of the American Meteorological Society, 102, E1126-E1132. https://doi.org/10.1175/BAMS-D-20-0051.1

Use by the Flemish Environment Agency

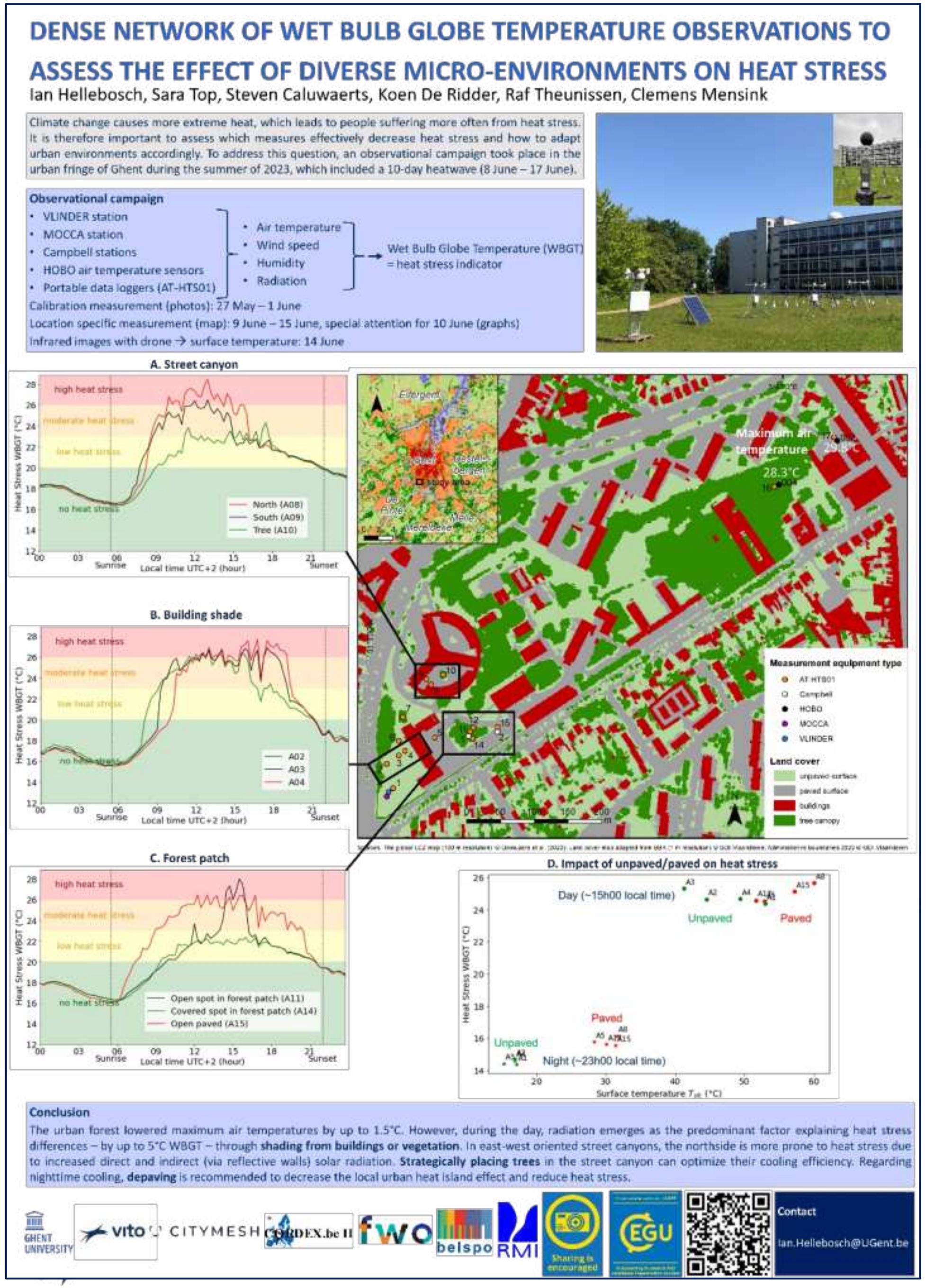


Observational data for model validation



Keramitsoglou, I., C.T. Kiranoudis, B. Maiheu, K. De Ridder, I. A. Daglis, P. Manunta, and M. Paganini, 2013. Heat wave hazard classification and risk assessment using artificial intelligence fuzzy logic. Environmental Monitoring and Assessment, DOI 10.1007/s10661-013-3170-y.

Kourtidis K, Georgoulias AK, Rapsomanikis S, Amiridis V, Keramitsoglou I, Hooyberghs H, Maiheu B, Melas D., 2015. A study of the hourly variability of the urban heat island effect in the Greater Athens Area during summer. Sci Total Environ.,1, 517, 162-77. https://doi.org/10.1016/j.scitotenv.2015.02.062



https://meetingorganizer.copernicus.org/EGU24/EGU24-1457.html

PhD research Ian Hellebosch

vito.be

Urban climate modelling

Europe (& Global)

$$\frac{\partial^2 \hat{w}}{\partial z^2} + k^2 - l^2 \hat{w} = 0, \qquad \text{(A2)}$$

with k the horizontal wavenumber, and $l = N/U$ the vertical wave number, with $N = \sqrt{g\gamma/\theta_0}$ the Brunt-Väisäla frequency, g the gravitational acceleration and $\theta \simeq 300\,\mathrm{K}$ a reference temperature.

The lower boundary condition on the vertical velocity is given by

$$w'(x,0) = U\frac{dh_m}{dx} = -\frac{U\bar{h}_m}{\pi}\frac{a}{a^2+x^2} \qquad \text{(A3)}$$

and its Fourier transform is

$$\hat{w}(k,0) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} w'(x,0)e^{-ikx}dx = -\frac{U\bar{h}_m}{2\pi}e^{-ka} \qquad \text{(A4)}$$

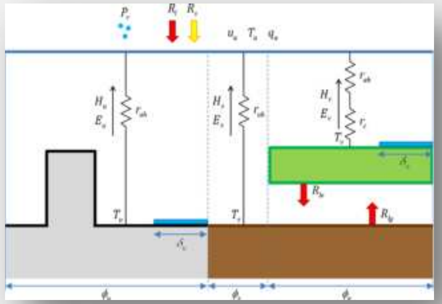
with the requirement that $k > 0$.

The vertical velocity is then obtained by applying the inverse one-sided Fourier transform,

$$w'(x,z) = 2\Re\left\{\int_0^{\infty}\hat{w}(k,0)e^{ikx}dk\right\} = -\frac{U\bar{h}_m}{\pi}\frac{a\cos(lz) - x\sin(lz)}{a^2+x^2}. \qquad \text{(A5)}$$

However, as we are interested in an ABL slab that follows the terrain, the terrain-following vertical velocity $w'(x,0)$ has to be substracted, so that finally

$$w'(x,z) = -\frac{U\bar{h}_m}{\pi}\frac{a\cos(lz) - 1 - x\sin(lz)}{a^2+x^2}, \qquad \text{(A6)}$$



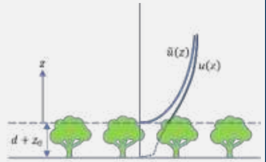
$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} = -\frac{1}{\rho_0}\frac{\partial P_0}{\partial x} + fv - \frac{\partial}{\partial z}\overline{(u'w')}$$

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

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

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

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



$$\psi_i^*(z/L, z/z_*) = \Phi_i\left[\left(1 + \frac{\nu}{\mu z/z_*}\right)\frac{z}{L}\right]E_1(\mu z/z_*), \qquad (11)$$

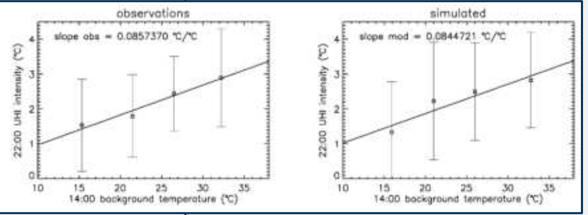
in which E_1 is the exponential integral. The latter's so-called bracketing property (see (5.1.20) in Abramowitz and Stegun 1972) suggests that

$$E_1(x) \approx \frac{1}{\lambda}\ln\left(1 + \frac{\lambda}{x}\right)e^{-x}, \qquad (12)$$

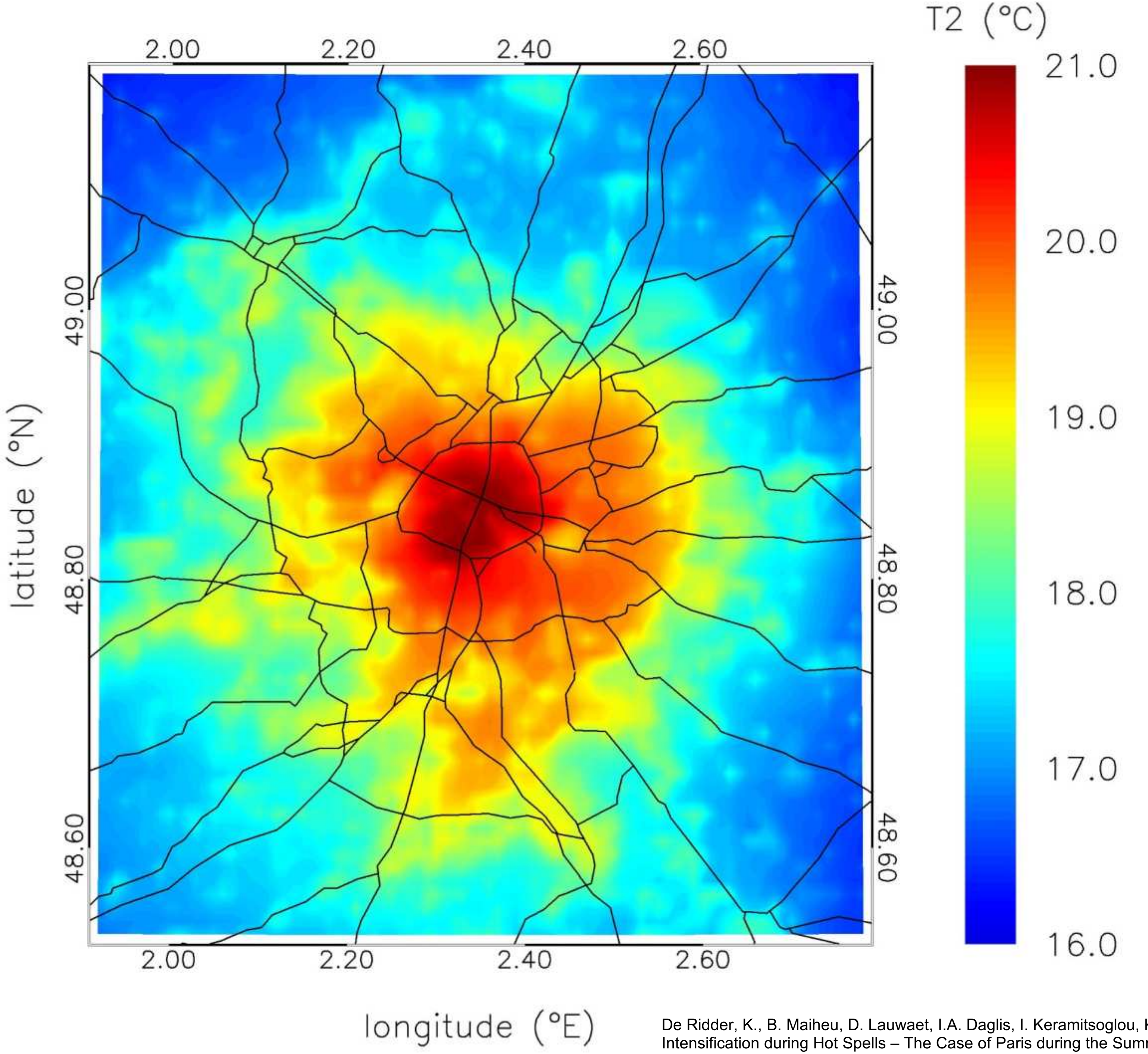
with $\lambda \approx 1.5$, thus finally yielding

$$\psi_i^*(z/L, z/z_*) \approx \Phi_i\left[\left(1 + \frac{\nu}{\mu z/z_*}\right)\frac{z}{L}\right]\frac{1}{\lambda}\ln\left(1 + \frac{\lambda}{\mu z/z_*}\right)e^{-\mu z/z_*}. \qquad (13)$$

```
c     solution tridiagonal system
c     ------------------------------------
c
      beta=BB(1)
      varcol(1)=RHS(1)/beta
c
      DO k=2,nz
        gama(k)=CC(k-1)/beta
        beta=BB(k)-AA(k)*gama(k)
        varcol(k)=(RHS(k)-AA(k)*varcol(k-1))/beta
      ENDDO
c
      DO k=nz-1,1,-1
        varcol(k)=varcol(k)-gama(k+1)*varcol(k+1)
      ENDDO
c
      RETURN
      END
```

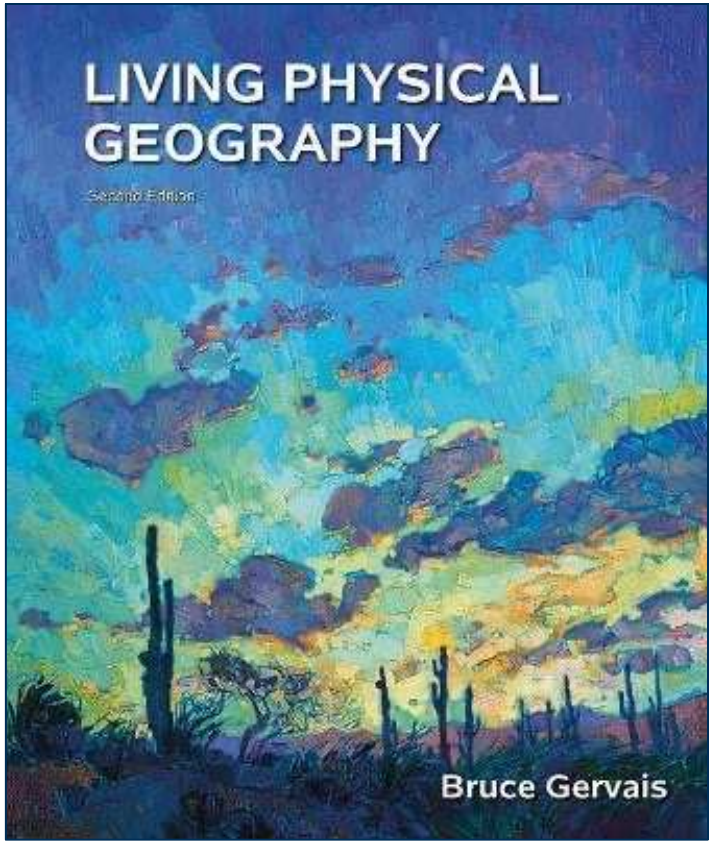


vito



Night-time (22:00 UT) 2-m air temperature averaged over May–September 2003.

De Ridder, K., B. Maiheu, D. Lauwaet, I.A. Daglis, I. Keramitsoglou, K. Kourtidis, P. Manunta and M. Paganini, 2016. Urban Heat Island Intensification during Hot Spells – The Case of Paris during the Summer of 2003. Urban Science, 1. https://doi.org/10.3390/urbansci1010003



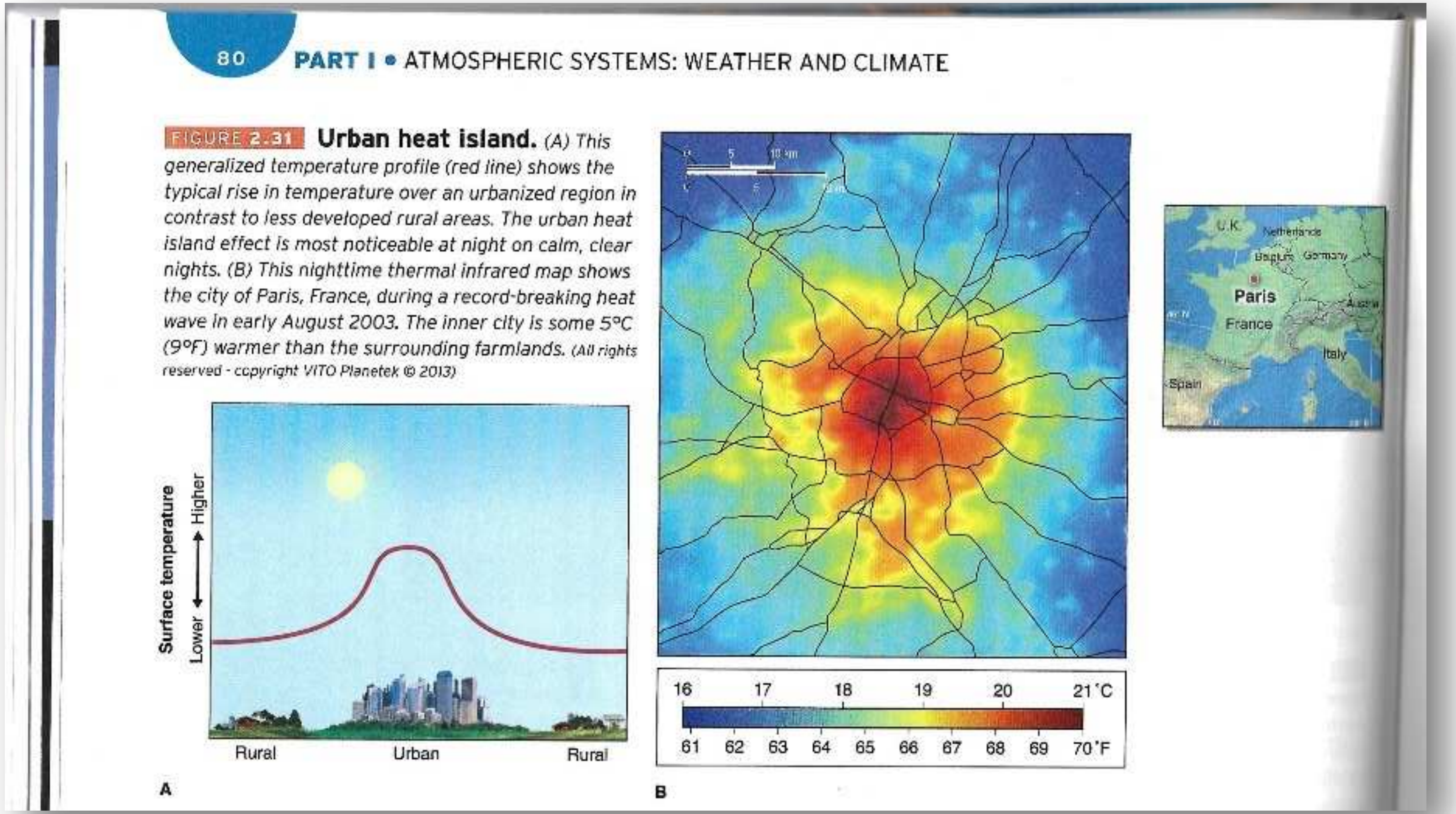
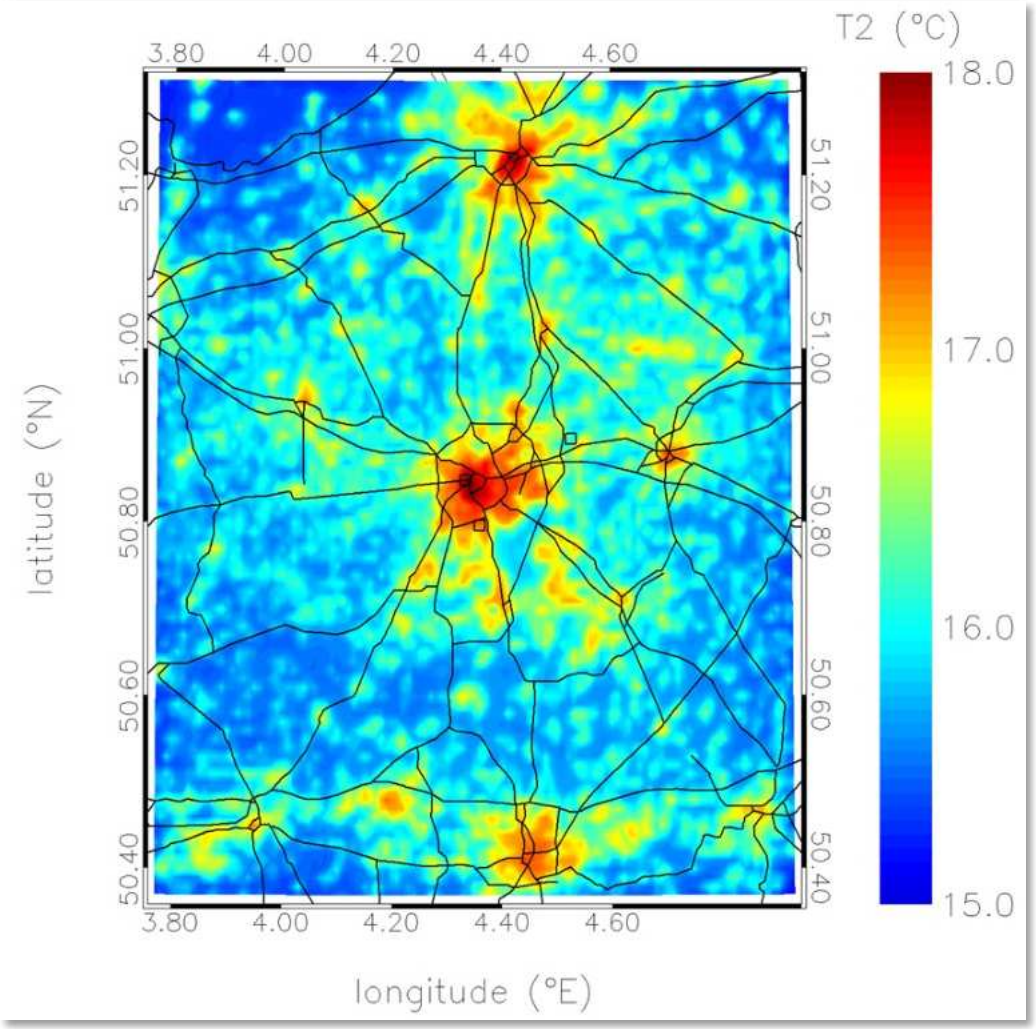


FIGURE 2.31 **Urban heat island.** *(A) This generalized temperature profile (red line) shows the typical rise in temperature over an urbanized region in contrast to less developed rural areas. The urban heat island effect is most noticeable at night on calm, clear nights. (B) This nighttime thermal infrared map shows the city of Paris, France, during a record-breaking heat wave in early August 2003. The inner city is some 5°C (9°F) warmer than the surrounding farmlands.*

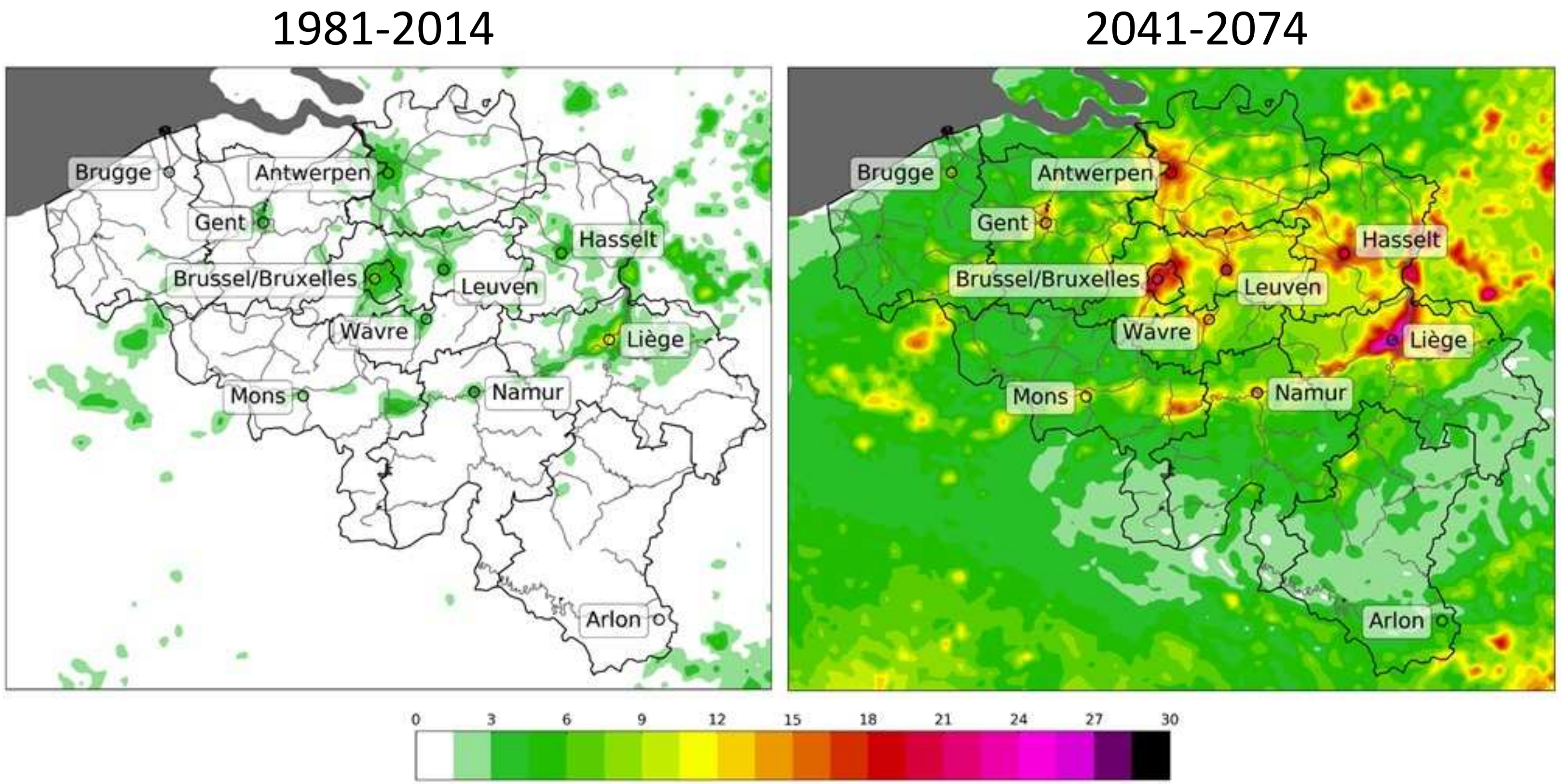
Creating awareness through simple images



Urban heat island for central Belgium (midnight air temperature averaged over the period May–September 2008).

Aertsens Joris, De Nocker Leo, Lauwers Hugo, Norga Katelijne, Simoens Ilse, Meiresonne Linda, Turkelboom Francis, Broekx Steven, 2012. Daarom groen! Waarom u wint bij groen in uw stad of gemeente. Studie uitgevoerd in opdracht van ANB – Afdeling Natuur en Bos, 144 p.

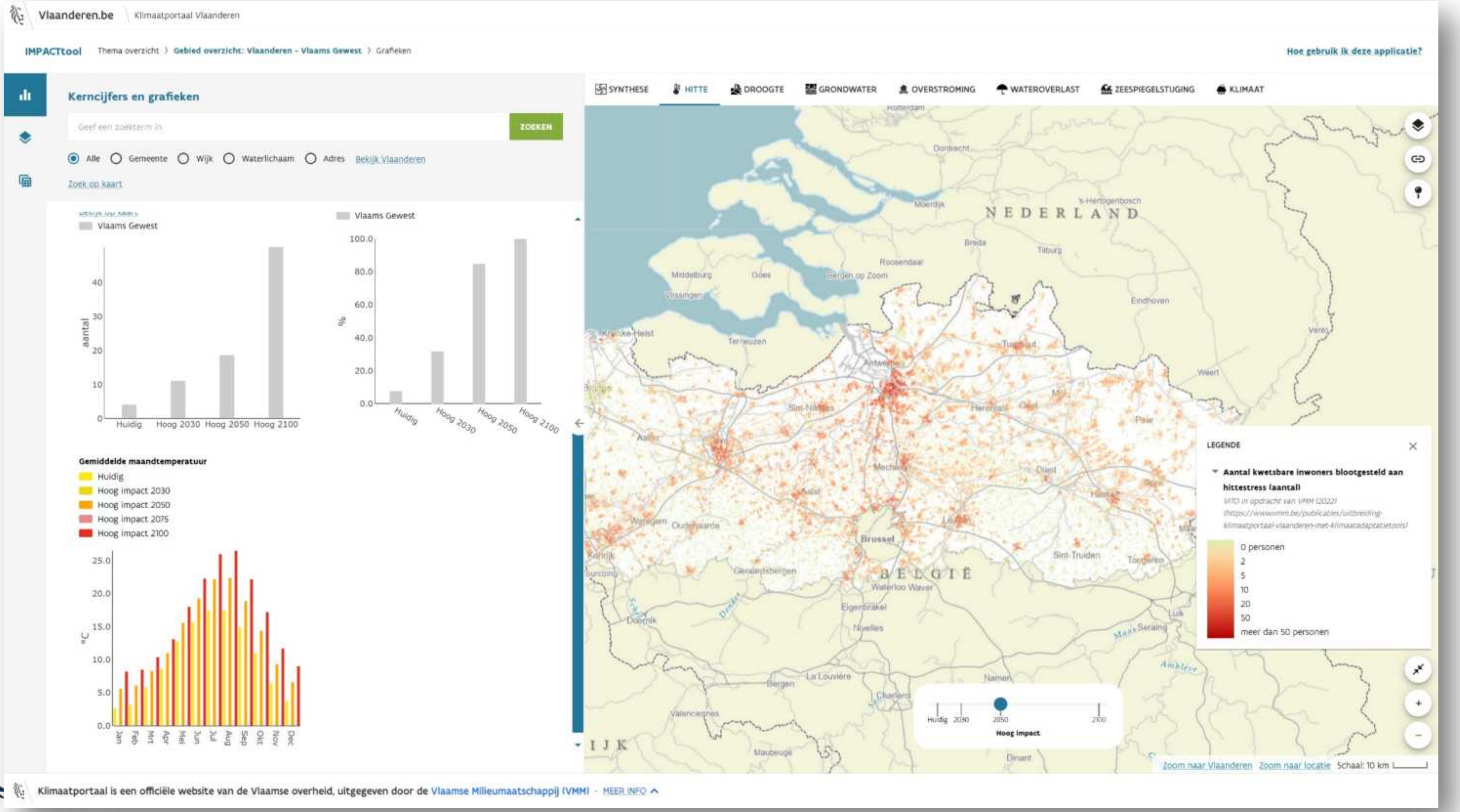
Annual number of heatwave days – *projections*



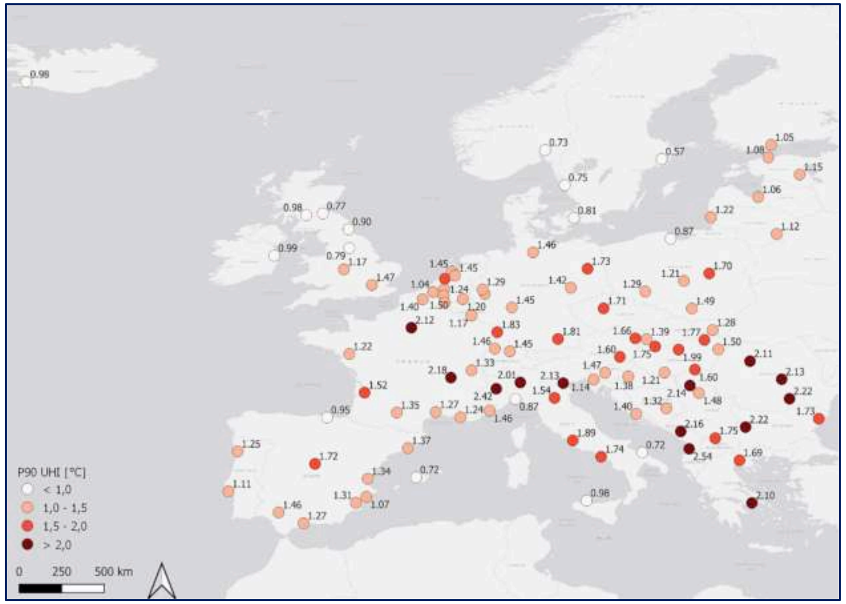
Simulated number of annual heatwave days

Wouters, H., K. De Ridder, L. Poelmans, P. Willems, J. Brouwers, P. Hosseinzadehtalaei, H. Tabari, S. Vanden Broucke, N.P.M. van Lipzig, and M. Demuzere, 2017. Heat stress increase under climate change twice as large in cities as in rural areas: A study for a densely populated midlatitude maritime region, Geophys. Res. Lett., 44, doi:10.1002/2017GL074889.

Climate Portal of the Flemish Region

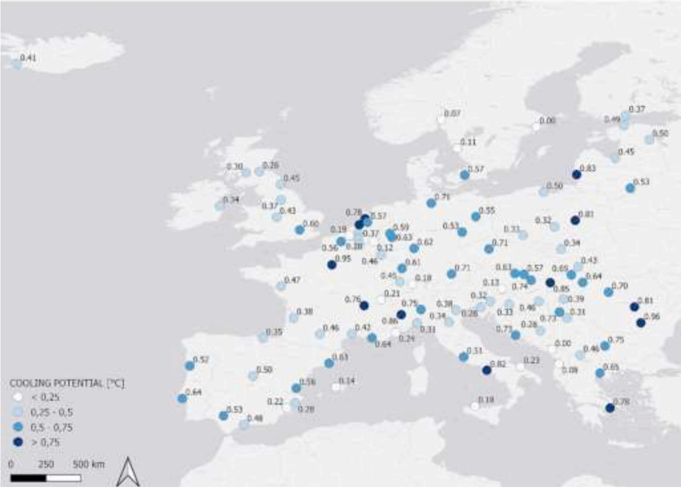


Copernicus project – 100 European cities



Simulated urban heat island for 100 European cities (averages for the summer periods of 2008–2017).

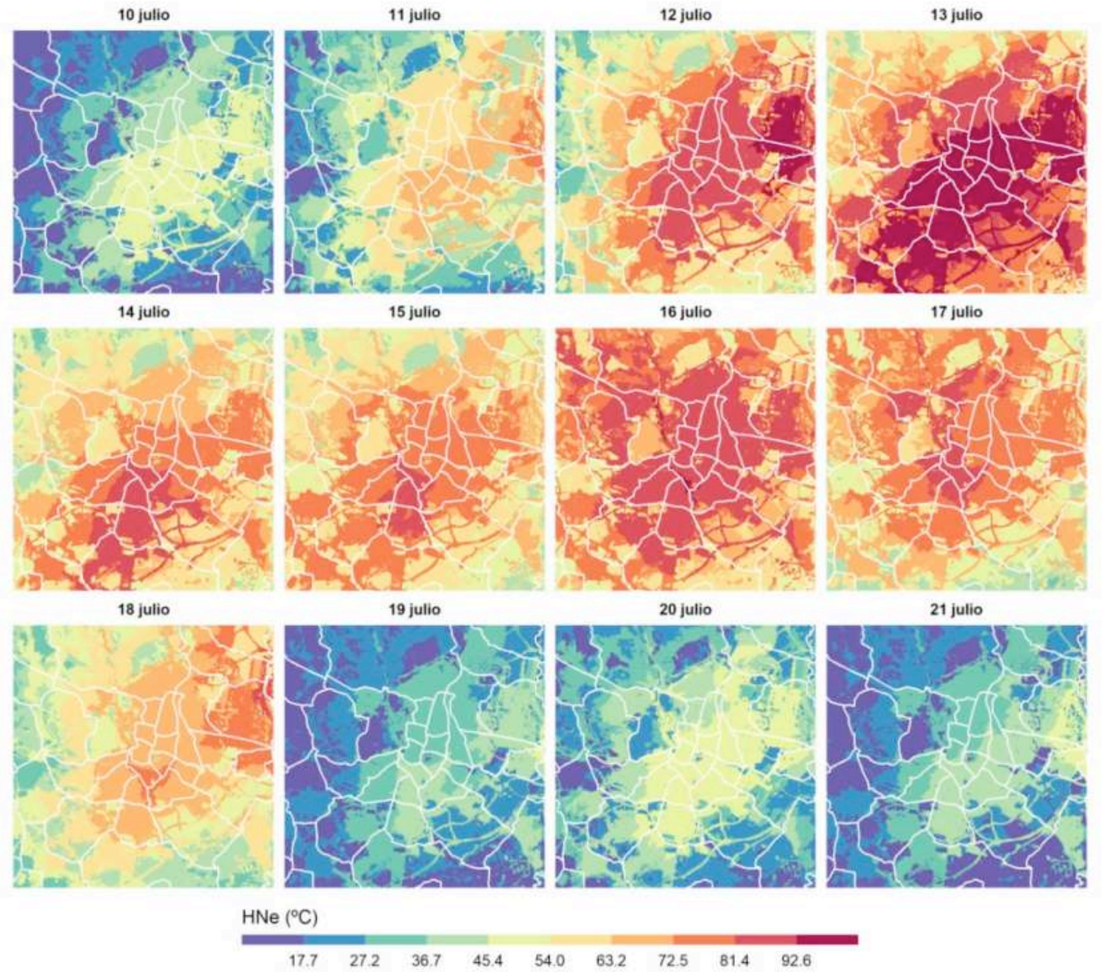
Estimated actual urban cooling from vegetation and soil unsealing.



Estimated potential urban cooling from vegetation and soil unsealing.

Lauwaet, D., Berckmans, J., Hooyberghs, H., Wouters, H., Driesen, G., Lefebre, F., De Ridder, K., 2024. High resolution modelling of the urban heat island of 100 European cities. Urban Climate, 54, 101850. https://doi.org/10.1016/j.uclim.2024.101850

Use of the 100-cities data



Martí Ezpeleta, A. and Royé, D., 2021. Intensidad y duración del estrés térmico en verano en el área urbana de Madrid. Geographicalia, 73, 95–113. https://doi.org/10.26754/ojs_geoph/geoph.2021735202

Andrade C., A. Fonseca, J.A. Santos, 2023. Climate Change Trends for the Urban Heat Island Intensities in Two Major Portuguese Cities. Sustainability, 15, 3970. https://doi.org/10.3390/su15053970.

Delgado-Enales, I., P. Molina-Costa, J. Del Ser, 2024. Spatial estimation of ground-level temperature for climate-sensitive urban mobility using image-to-image deep neural networks. IEEE 26th Intl. Conf. on Intelligent Transportation Systems, 24-28 Sep 2023. Bilbao, Spain. DOI:10.1109/ITSC57777.2023.10422134. https://ieeexplore.ieee.org/document/10422134/

Frustaci G, Pilati S, Lavecchia C, Montoli EM, 2022. High-Resolution Gridded Air Temperature Data for the Urban Environment: The Milan Data Set. Forecasting, 4, 238-261. https://doi.org/10.3390/forecast4010014

García-Blanco G, Navarro D, Feliu E., 2023. Adopting Resilience Thinking through Nature-Based Solutions within Urban Planning: A Case Study in the City of València. Buildings, 13, 1317. https://doi.org/10.3390/buildings13051317

Hidalgo García, D., and J. Arco Díaz, 2023. Mitigation and Resilience of Local Climatic Zones to the Effects of Extreme Heat: Study on the City of Barcelona (Spain). Urban Science 7, 102. https://doi.org/10.3390/urbansci7040102

Hidalgo García, D., H. Rezapouraghdam, 2023. Climate change, heat stress and the analysis of its space-time variability in european metropolises. Journal of Cleaner Production, 138892. https://doi.org/10.1016/j.jclepro.2023.138892.

Hidalgo-García, D., Rezapouraghdam, H., 2023. Variability of heat stress using the UrbClim climate model in the city of Seville (Spain): mitigation proposal. Environ Monit Assess 195, 1164. https://doi.org/10.1007/s10661-023-11768-8

Huang, W.T.K., Masselot, P., Bou-Zeid, E. et al., 2023. Economic valuation of temperature-related mortality attributed to urban heat islands in European cities. Nat Commun 14, 7438. https://doi.org/10.1038/s41467-023-43135-z.

Hurley, A.G., Heinrich, I., 2023. Assessing urban-heating impact on street tree growth in Berlin with open inventory and environmental data. Urban Ecosyst. https://doi.org/10.1007/s11252-023-01450-9

Iungman, T., M. Cirach, F. Marando, E. Pereira Barboza, S. Khomenko, P. Masselot, M. Quijal-Zamorano, N. Mueller, A. Gasparrini, J. Urquiza, M. Heris, M. Thondoo, M. Nieuwenhuijsen, 2023. Cooling cities through urban green infrastructure: a health impact assessment of European cities. The Lancet, 401, 577-589, https://doi.org/10.1016/S0140-6736(22)02585-5.

Iungman, T., S. Khomenko, M. Nieuwenhuijsen, E. Pereira Barboza, A. Ambròs, C.M. Padilla, N. Mueller, 2021. The impact of urban and transport planning on health: Assessment of the attributable mortality burden in Madrid and Barcelona and its distribution by socioeconomic status. Environmental Research, 196, 110988, https://doi.org/10.1016/j.envres.2021.110988.

Koutroumanou-Kontosi K, Cartalis C, Philippopoulos K, Agathangelidis I, Polydoros A, 2022. A Methodology for Bridging the Gap between Regional- and City-Scale Climate Simulations for the Urban Thermal Environment. Climate,10:106. https://doi.org/10.3390/cli10070106.

Lobaccaro, G., De Ridder, K., Acero, J.A., Hooyberghs, H., Lauwaet, D., Maiheu, B., Sharma, R., Govehovitch, B. 2021. Applications of models and tools for mesoscale and microscale thermal analysis in mid-latitude climate regions – A review. Sustainability, 13, 12385. https://doi.org/10.3390/su132212385

Martí Ezpeleta, A. and Royé, D., 2021. Intensidad y duración del estrés térmico en verano en el área urbana de Madrid. Geographicalia, 73, 95–113. https://doi.org/10.26754/ojs_geoph/geoph.2021735202

Martí Ezpeleta, A., Royé, D., 2021. Intensidad y duración del estrés térmico en verano en el área urbana de Madrid. Geographicalia, 73, 95–113. https://doi.org/10.26754/ojs_geoph/geoph.2021735202

Mavrakou T, Polydoros A, Cartalis C, Philippopoulos K, 2021. Assessing Urban Resilience to Thermal Risk: An Application for Athens, Greece. Int J Environ Sci Nat Res. 29: 556256. https://juniperpublishers.com/ijesnr/IJESNR.MS.ID.556256.php

Nieuwenhuijsen MJ, Barrera-Gómez J, Basagaña X, Cirach M, Daher C, Pulido MF, Iungman T, Gasparrini A, Hoek G, de Hoogh K, Khomenko S, Khreis H, de Nazelle A, Ramos A, Rojas-Rueda D, Pereira Barboza E, Tainio M, Thondoo M, Tonne C, Woodcock J, Mueller N., 2022. Study protocol of the European Urban Burden of Disease Project: a health impact assessment study. BMJ Open, 12:e054270. https://doi.org/10.1136/bmjopen-2021-054270.

Possega, M., L. Aragão, P. Ruggieri, M.A. Santo and S. Di Sabatino, 2022. Observational evidence of intensified nocturnal urban heat island during heatwaves in European cities. Environmental Research Letters, 17, 124013. DOI 10.1088/1748-9326/aca3ba https://iopscience.iop.org/article/10.1088/1748-9326/aca3ba

Reis, C., A. Lopes, A.S. Nouri, 2022. Assessing urban heat island effects through local weather types in Lisbon's Metropolitan Area using big data from the Copernicus service. Urban Climate, 43, 101168, https://doi.org/10.1016/j.uclim.2022.101168.

Reis, C., A. Lopes, A.S. Nouri, 2022. Urban heat island data by local weather types in Lisbon metropolitan area based on Copernicus climate variables dataset for European cities. Data in Brief, 42, 108292, https://doi.org/10.1016/j.dib.2022.108292.

Sarafova, E., 2022. Data quality assessment of Copernicus Climate Change Service health domain data for the development of disaster risk reduction plans. J. Bulgarian Geographical Society, 46, 13–23. https://jbgs.arphahub.com/article/85567/download/pdf/708591

Silva, T., Lopes, A., Vasconcelos, J., Chokhachian, A., Wagenfeld, M. and Santucci, D., 2024. . Thermal stress and comfort assessment in urban areas using Copernicus Climate Change Service Era 5 reanalysis and collected microclimatic data. Int J Biometeorol. https://doi.org/10.1007/s00484-024-02639-z

Yilmaz, S., C. Bilge, M. Irmak, 2023. Determining the climate future projection of Erzurum city with the Urbclim model. Journal of Architectural Ssciences and Applications, 8, 112 – 122. https://doi.org/10.30785/mbud.1256724

Zekar, A., N. Milojevic-Dupont, M. Zumwald, F. Wagner, F. Creutzig, 2023. Urban form features determine spatio-temporal variation of ambient temperature: A comparative study of three European cities. Urban Climate, 49, 101467, https://doi.org/10.1016/j.uclim.2023.101467.

Climate variables for cities in Europe from 2008 to 2017

A new CDS soon to be launched - expect some disruptions and watch this page for latest. Thank you.

Overview | Download data | Documentation

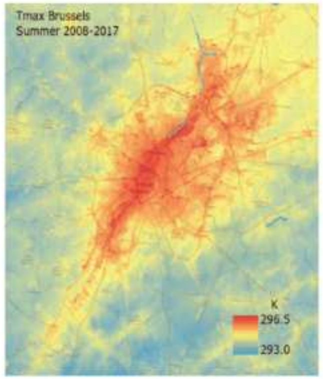
The dataset contains air temperature, specific humidity, relative humidity and wind speed for 100 European cities for the current climate.

The data were generated using the urban climate model UrbClim, developed at VITO. This model was designed to simulate and study the urban heat island effect (UHI) and other urban climate variables at a spatial resolution of 100 metres. The unique capabilities of UrbClim allow to generate spatially explicit timeseries of hourly variables from which a variety of indicators can be retrieved in postprocessing at the scale of a city neighbourhood.

For this specific dataset, the ERA5 reanalysis large-scale weather conditions are downscaled to agglomeration-scale. UrbClim then computes the impact of urban development on the most frequent weather parameters, such as temperature and humidity.

The 100 European cities for the urban simulations were selected based on user requirements within the health community. Furthermore, a high spatial distribution was aimed with specific focus on Eastern European countries that often lack access to relevant information.

The data was produced on behalf of the Copernicus Climate Change Service.



DATA DESCRIPTION	
Data type	Gridded
Horizontal coverage	European
Horizontal resolution	100m x 100m
Temporal coverage	From January 2008 to December 2017
Temporal resolution	Hourly
File format	NetCDF-4
Conventions	Climate and Forecast (CF) Metadata Convention v1.6, Attribute Convention for Dataset Discovery (ACDD) v1.3
Update frequency	No updates expected.

MAIN VARIABLES

Name	Units	Description
Air temperature	K	Air temperature valid for a grid cell at the height of 2m above the surface.
Land-sea mask	Dimensionless	The land cover classes from CORINE that represent land areas are masked with value 1 and land cover classes that represent water surfaces are masked as NaN.
Relative humidity	%	Relation between actual humidity and saturation humidity at 2m height. Values are in the interval [0,100]: 0% means that the air in the grid cell is totally dry whereas 100% indicates that the air in the cell is saturated with water vapour.
Rural-urban mask	Dimensionless	The land cover classes from CORINE that represent rural areas are masked with value 1 and land cover classes that represent urban areas are masked as NaN.
Specific humidity	$kg\ kg^{-1}$	Mass of water vapour in a unit mass of moist air at 2m height.
Wind speed	$m\ s^{-1}$	Wind speed valid for a grid cell at the height of 2m above the surface. It is computed from both the zonal (u) and the meridional (v) wind components by $sqrt(u^2 + v^2)$.

Help

Get help

Licence

Licence to use Copernicus Products

Publication date

2019-12-04

References

Citation

Acknowledgement

DOI: 10.24381/cds.c6459d3a

Related data

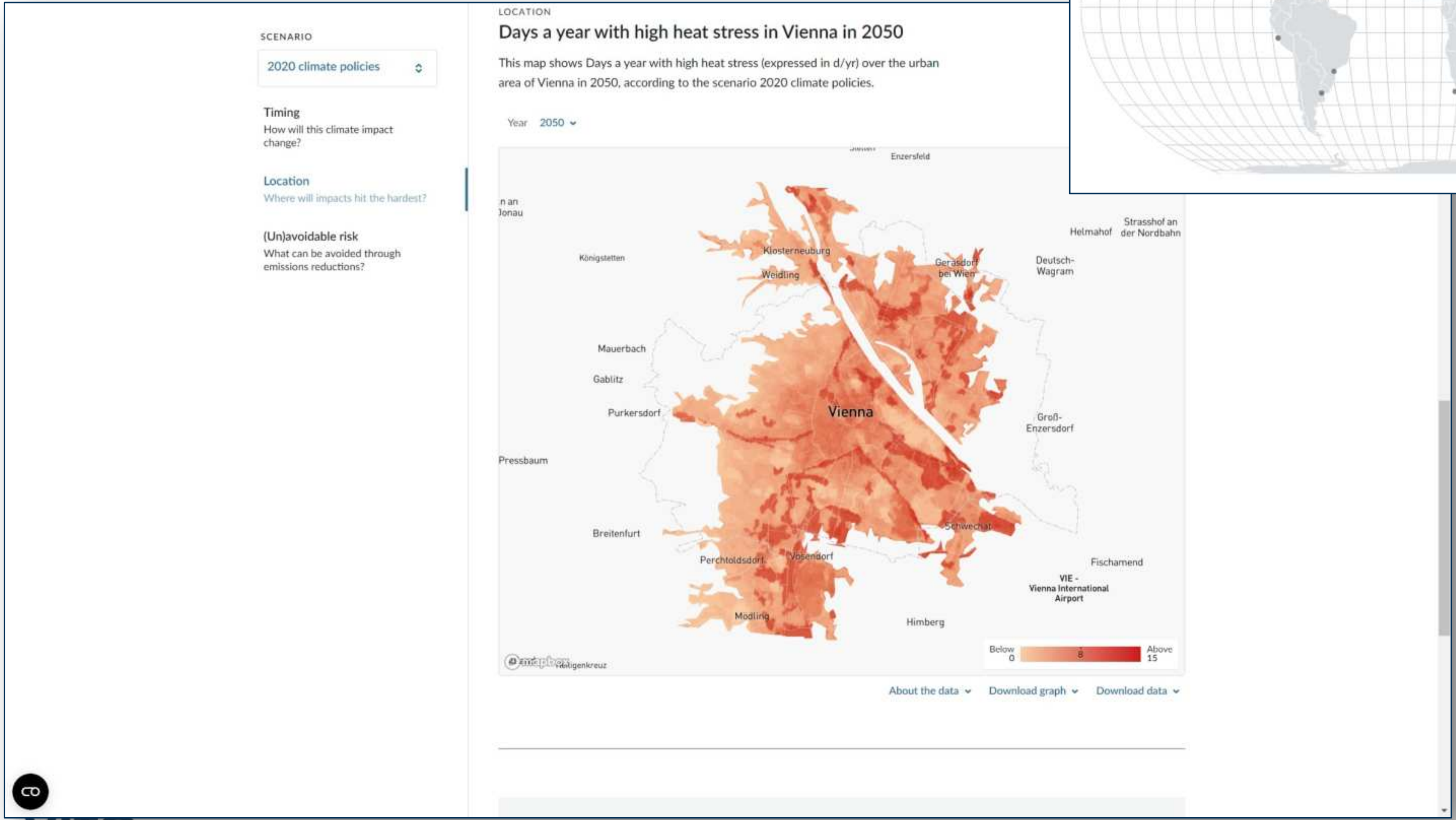
Winter windstorm indicators for Europe from 1979 to 2021 derived from reanalysis

Related applications

Urban heat island intensity for European cities from 2008 to 2017 derived from reanalysis

https://cds.climate.copernicus.eu/cdsapp#!/dataset/sis-urban-climate-cities?tab=overview

Horizon Europe – PROVIDE project



https://climate-risk-dashboard.climateanalytics.org/impacts/explore

Abstract EGU24-15412

EGU24-15412, updated on 09 Mar 2024
https://doi.org/10.5194/egusphere-egu24-15412
EGU General Assembly 2024

Oral | Thursday, 18 Apr, 08:30–08:40 (CEST) Room F1

A public database of future heat stress in 140 cities to examine the potential for heat reduction via climate-smart urban development

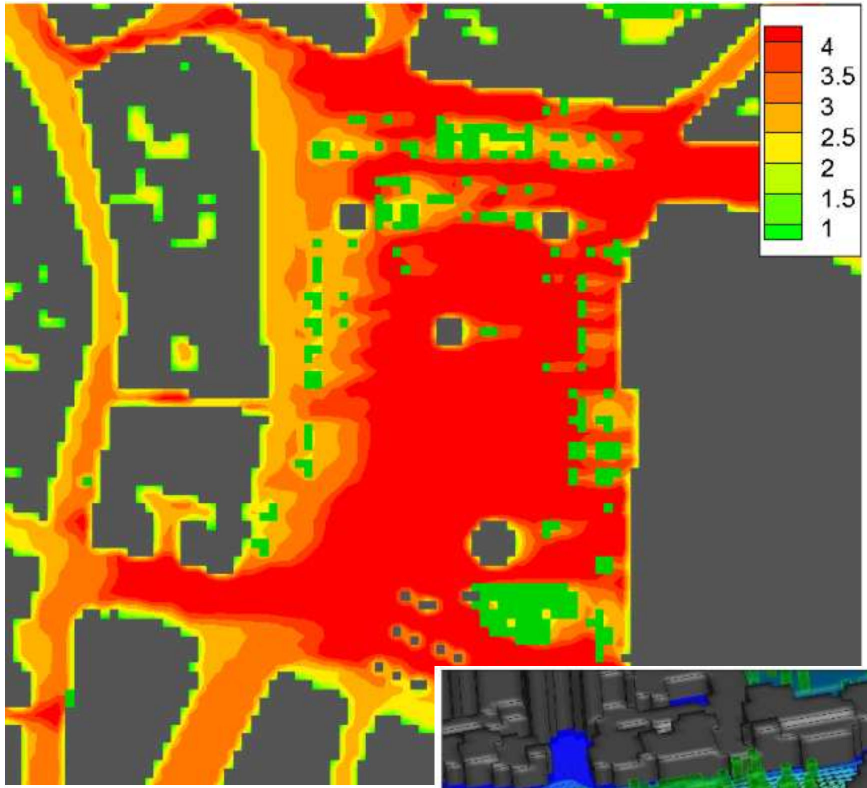
Quentin Lejeune[1], Niels Souverijns[2], Sarantis Georgiou[3], Niklas Schwind[1], Sajid Ali[1], Tiago Capela Lourenço[4], Khadija Irfan[5], Dirk Lauwaet[2], Inês Gomes Marques[4], Helena Gonzales Lindberg[6], Inga Menke[1,7], Shruti Nath[1], Peter Pfleiderer[1], Hugo Pires Costa[4], Fahad Saeed[1,5], Mariam Saleh Khan[5], Sylvia Schmidt[1], Emily Theokritoff[1,7], Burcu Yesil[1], and Carl-Friedrich Schleussner[1,7]

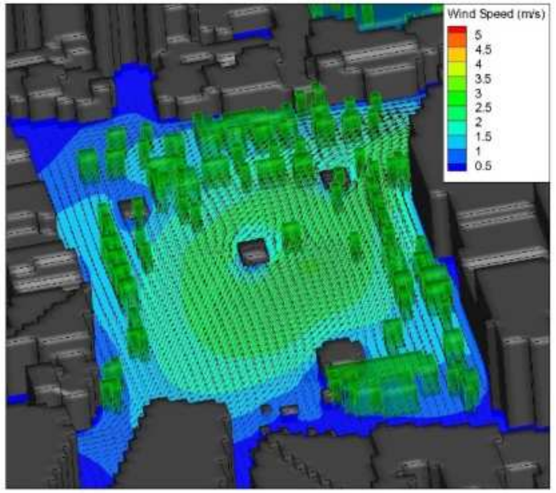
[1]Climate Analytics, Berlin, Germany
[2]VITO, Mol, Belgium
[3]BUUR part of Sweco, Sweco Belgium, Brussels, Belgium
[4]Centre for Ecology, Evolution and Environmental Changes (cE3c), Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisbon, Portugal
[5]Weather and Climate Services, Islamabad, Pakistan
[6]Nordland Research Institute, Bodø, Norway
[7]Geography Department & IRI THESys, Humboldt University of Berlin, Berlin, Germany

Heatwaves are becoming more frequent because of climate change, and this trend is exacerbated in cities due to the urban heat island effect. With more than half of the world's population living in cities, it is essential to quantify the future evolution of heat stress and develop smart adaptation strategies to counter its impacts. This requires the capturing of fine-grained variations in heat-related hazards within the urban fabric. However, the coarse resolutions of Earth System

https://meetingorganizer.copernicus.org/EGU24/EGU24-15412.html

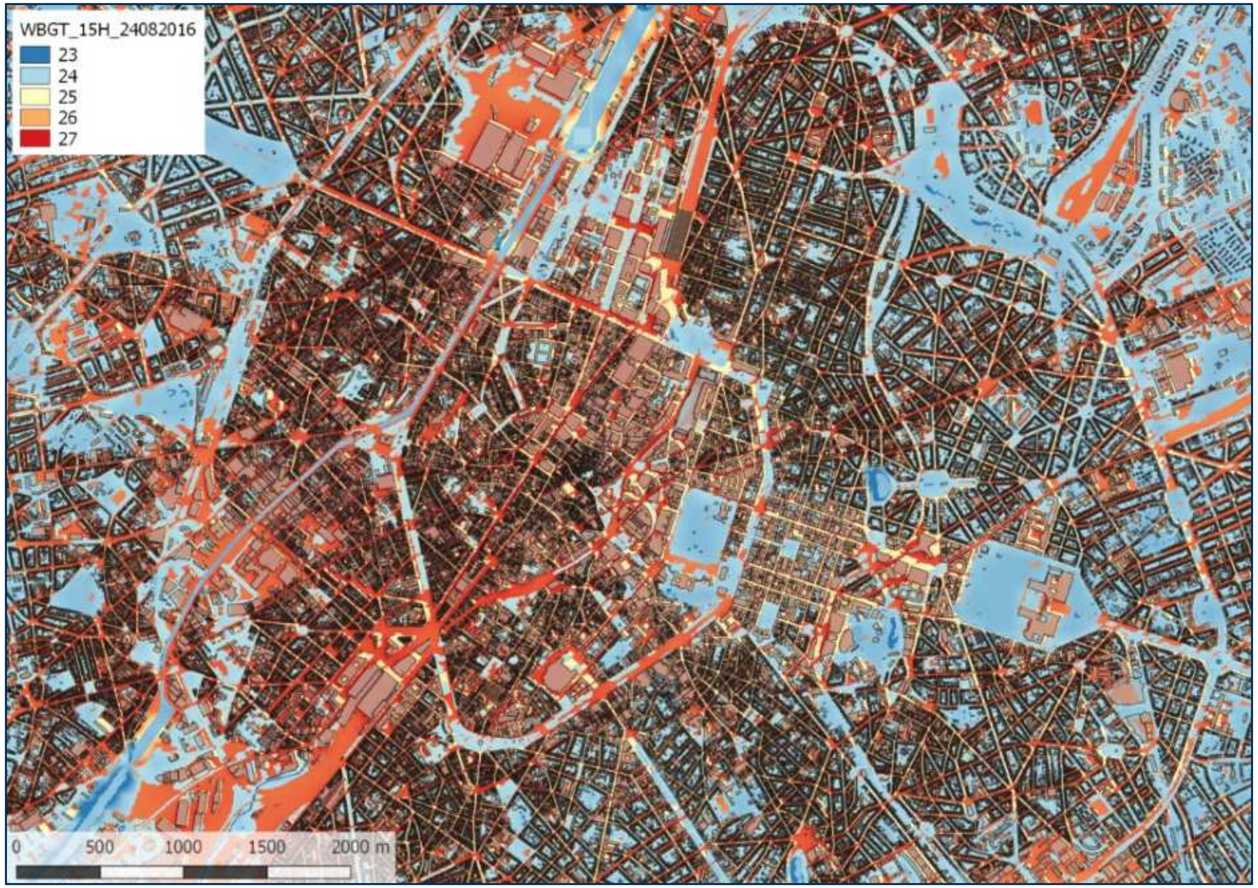
Redesigning a city square for climate resilience

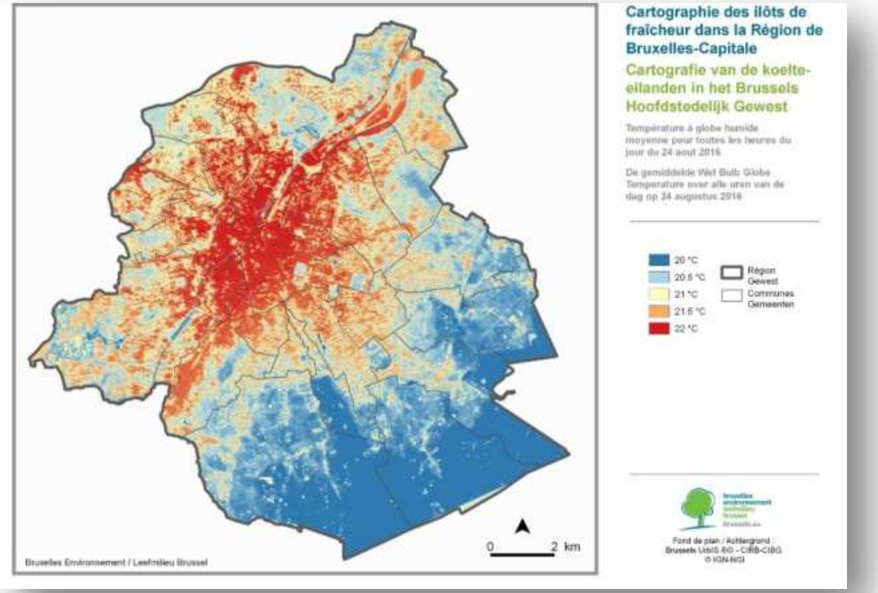




Redesign of a major Antwerp city square: architectural design bureaus invited to include spatial designs promoting climate resilience (green infrastructure)

Cartography of cool islands in Brussels

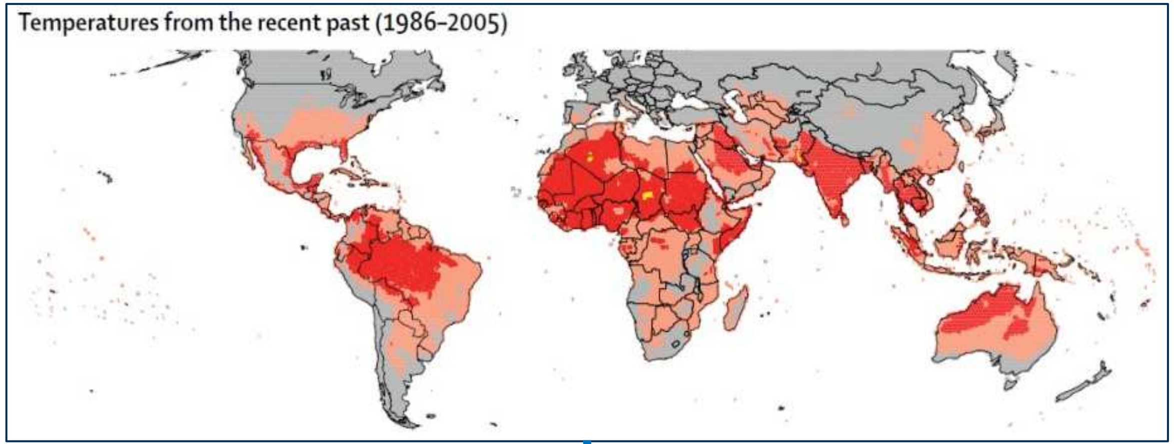


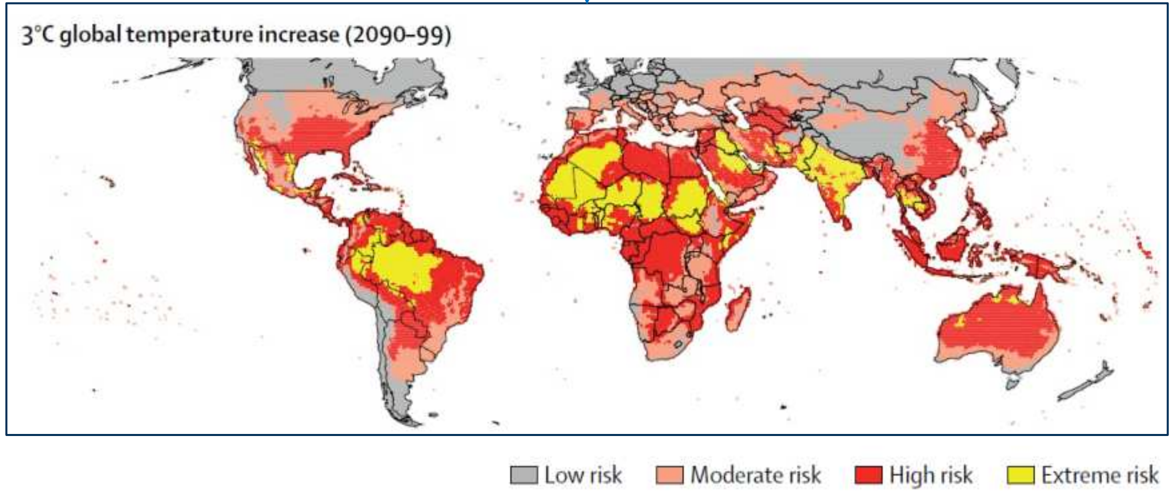


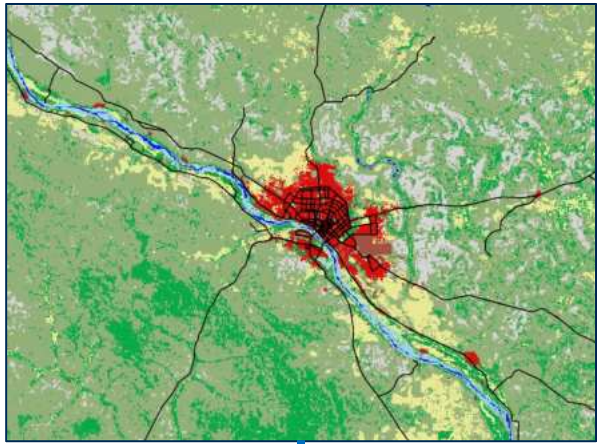
Urban climate modelling & monitoring

Africa

Why urban climate research in Africa?

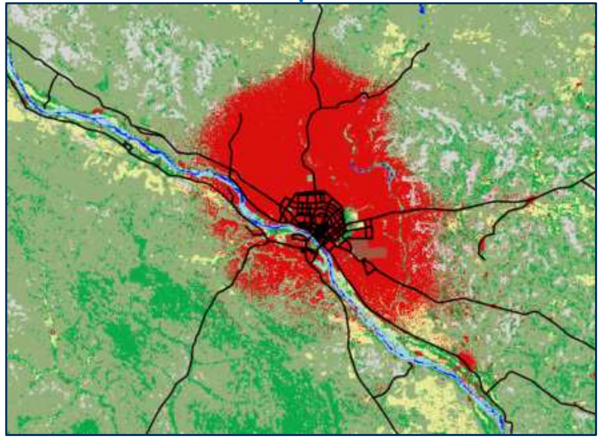






2018:

2.2 M inhabitants



2050:

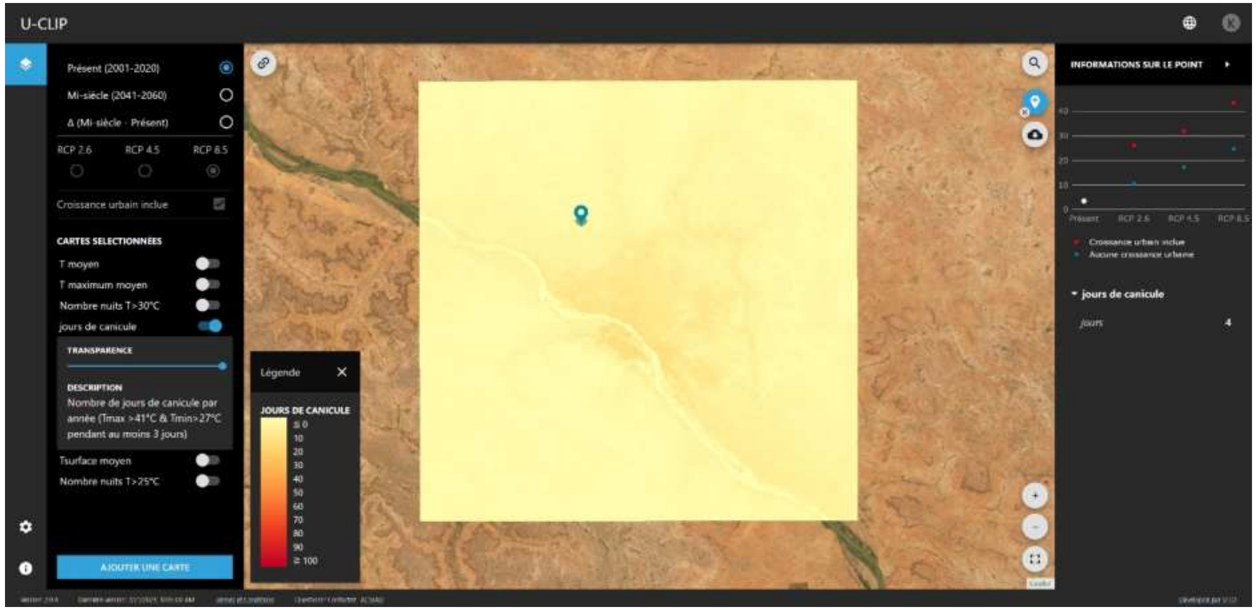
9.5 M inhabitants

(*projection*)

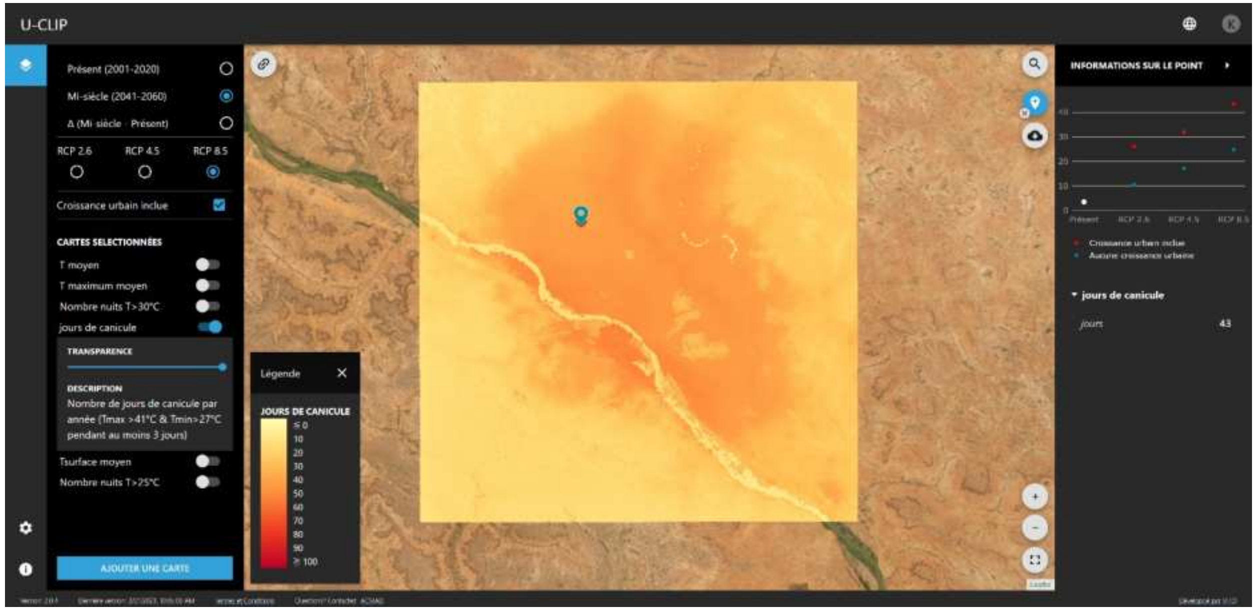
Souverijns, N., De Ridder, K., Takacs, S., Veldeman, N., Michielsen, M., Crols, T., Foamouhoue, A. K., Nshimirimana, G., Dan Dijé, I., & Tidjani, H., 2023. High resolution heat stress over a Sahelian city: Present and future impact assessment and urban green effectiveness. International Journal of Climatology, 1–19. https://doi.org/10.1002/joc.8268

u-CLIP – *Urban Climate Information Platform* (Niamey)

2020

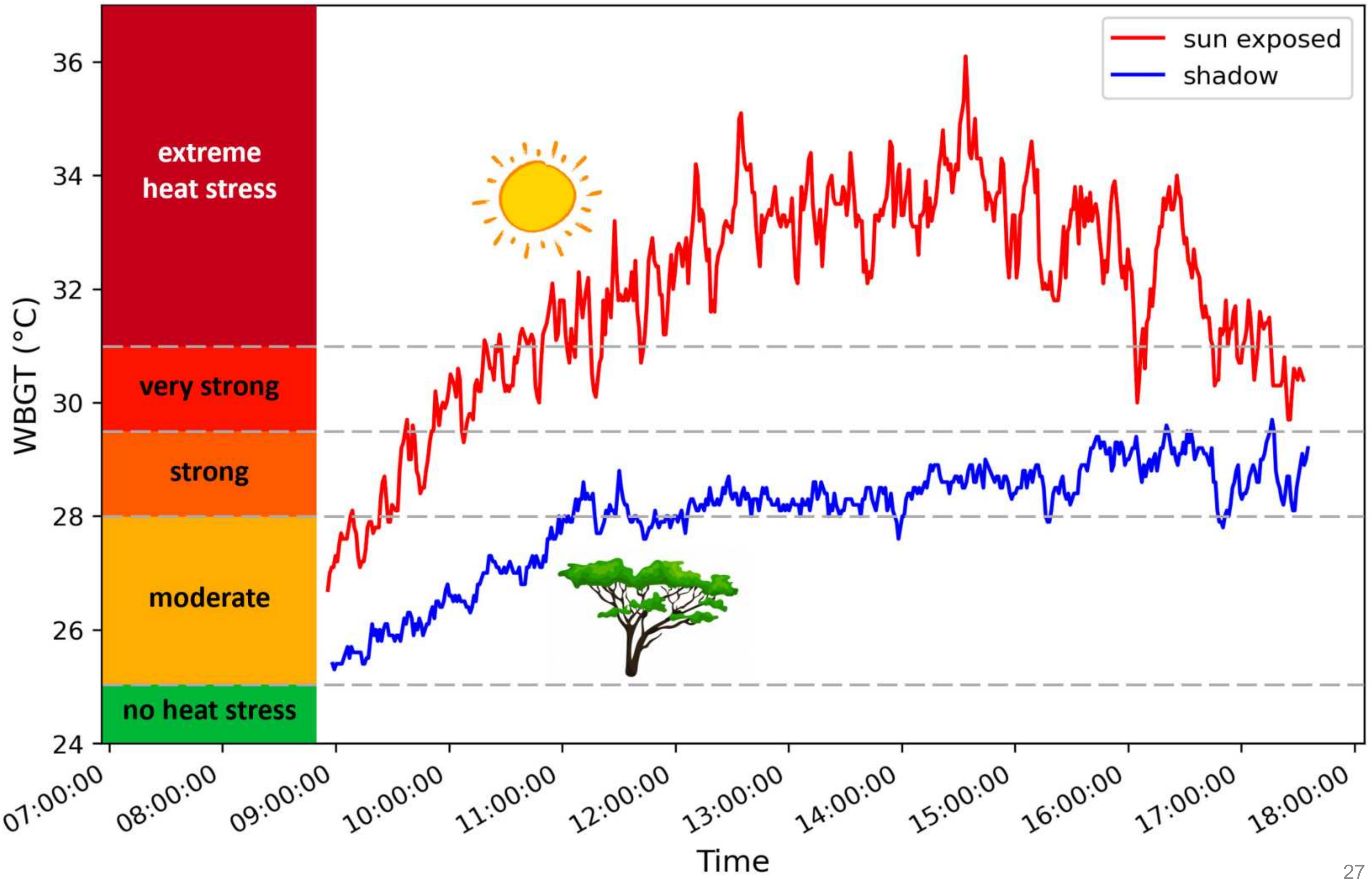


2050



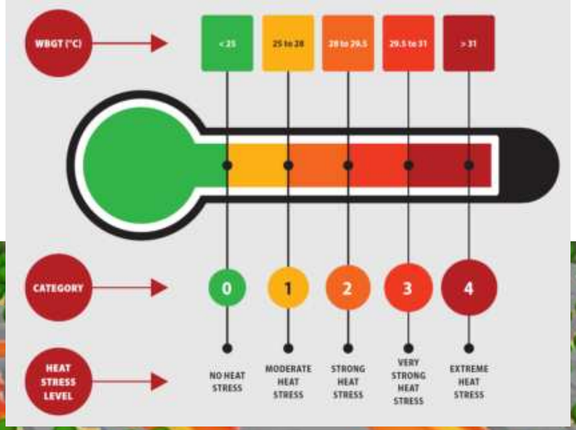
https://uclip.acmad.org/

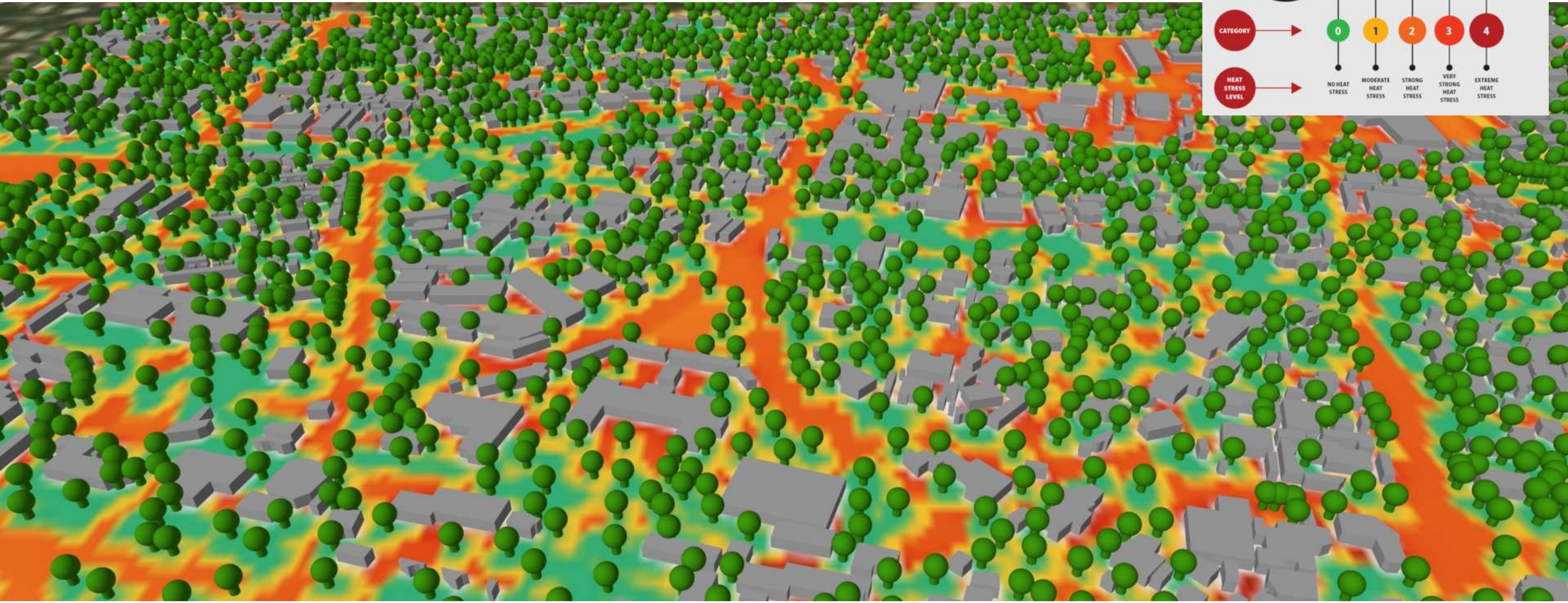

vito
ACMAD
adidas


sun exposed
shadow
extreme
heat stress
very strong
strong
moderate
no heat stress
WBGT (°C)
36
34
32
30
28
26
24
07:00:00
08:00:00
09:00:00
10:00:00
11:00:00
12:00:00
13:00:00
14:00:00
15:00:00
16:00:00
17:00:00
18:00:00
Time

ɔ.be

High-resolution modelling





Adaptation planning

Mesures d'adaptation à la chaleur excessive pour Niamey

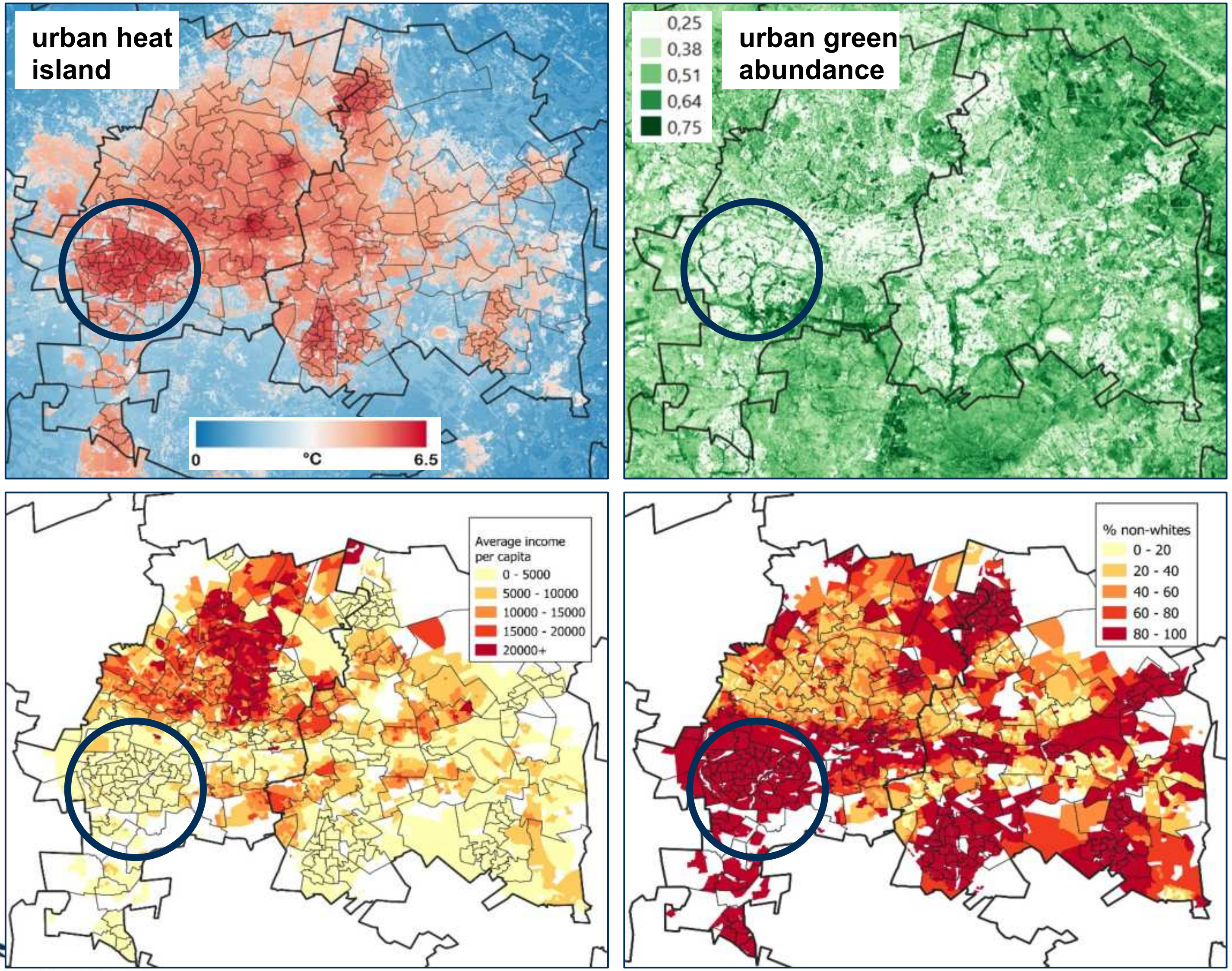
Un ensemble de mesures d'adaptation pour Niamey est proposé ci-dessous. **Plutôt que de servir comme une liste définitive, les mesures proposées serviront pour alimenter des discussions lors des ateliers avec les parties prenantes à Niamey.** Dans la suite de ce document, chacune de ces mesures est décrite en détail, et des recommandations sont formulées.

1	verdissement stratégique dans les quartiers sous-approvisionnées
2	mise en garde et sensibilisation à la chaleur et à la santé
3	stratégies de refroidissement passif pour logements modestes
4	espaces communautaires frais (abris)
5	protéger les travailleurs et assurer la productivité du travail
6	mise en place de potagers urbains communautaires / agroforesterie
7	minimiser les besoins en énergie pour le refroidissement des batîments
8	protection de lieux hautement fréquentés
9	protection de composantes critiques d'infrastructure
10	intégration de mesures de protection dans l'ensemble des stratégies urbaines

Stakeholder engagement

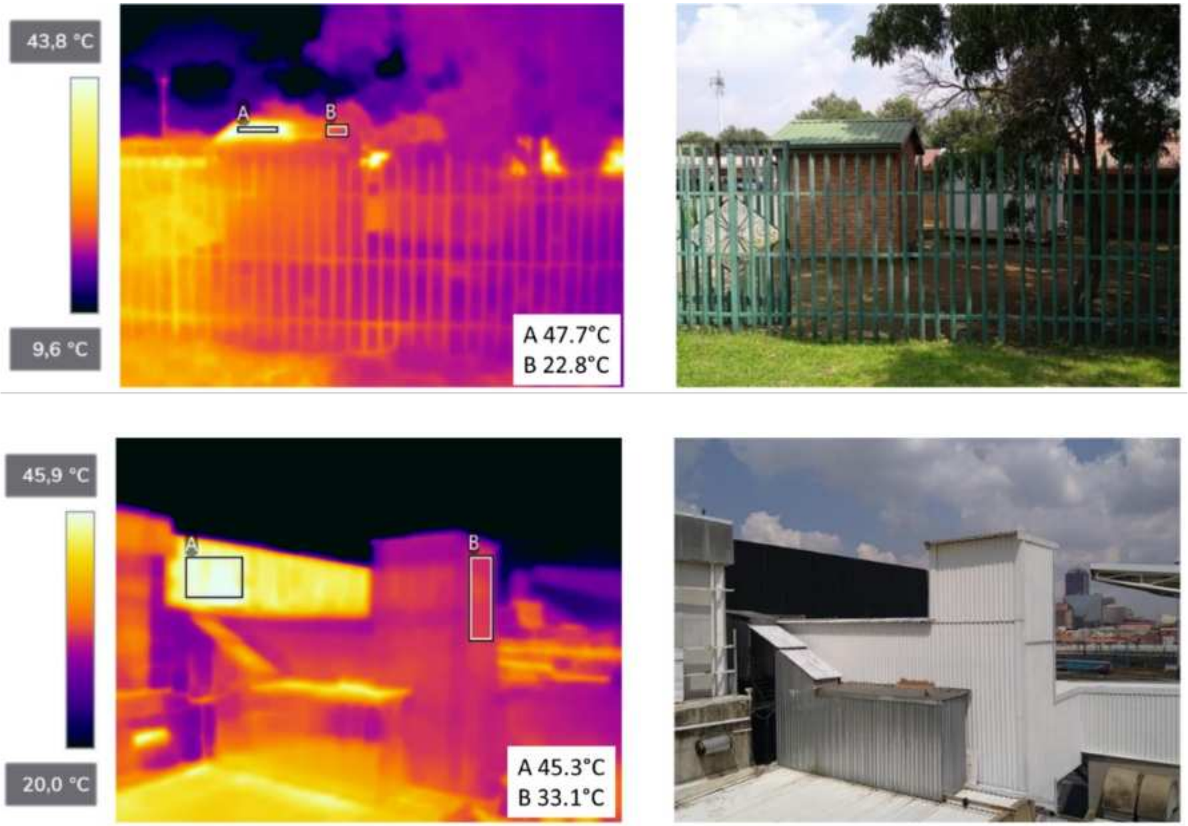
Niamey Climate Forest

Link to socio-economic indicators (Johannesburg)



Community-based measurements

Thermal imaging




URBAN HEAT IN JOHANNESBURG AND EKURHULENI

Impacts and Mitigation Options

national treasury
Department: National Treasury
REPUBLIC OF SOUTH AFRICA

cities SUPPORT PROGRAMME

City Resilience Program

GFDRR

Administered by THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

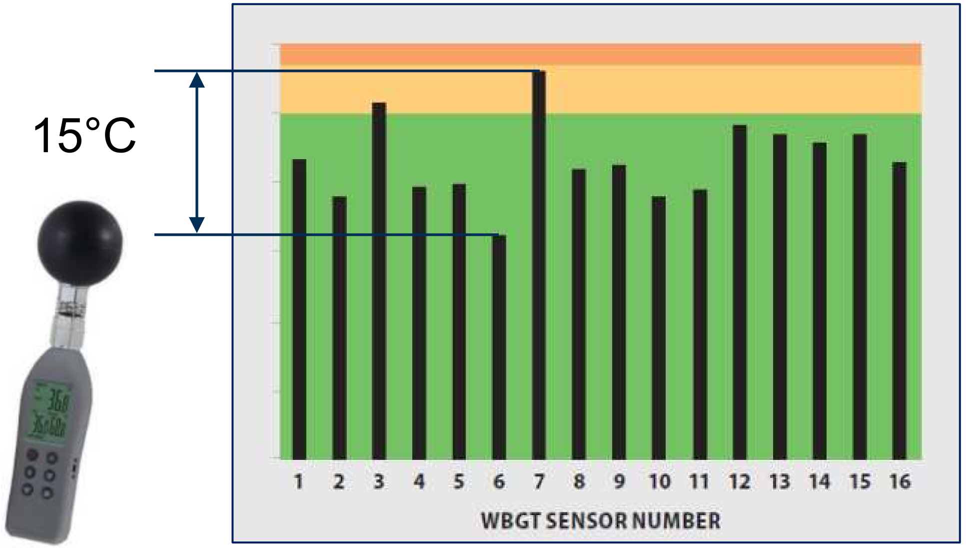
vito

plan act

"This report is a crucial policy informant as it provides scientific data and a clear policy directive on urban heat impacts in the City. The adaptation measures laid out in this report will be implemented to build climate resilience and reduce the impacts of heat in the City of Ekurhuleni."

Ms Faith Wotshela
Head of Department
Environmental Resource and Waste Management
City of Ekurhuleni

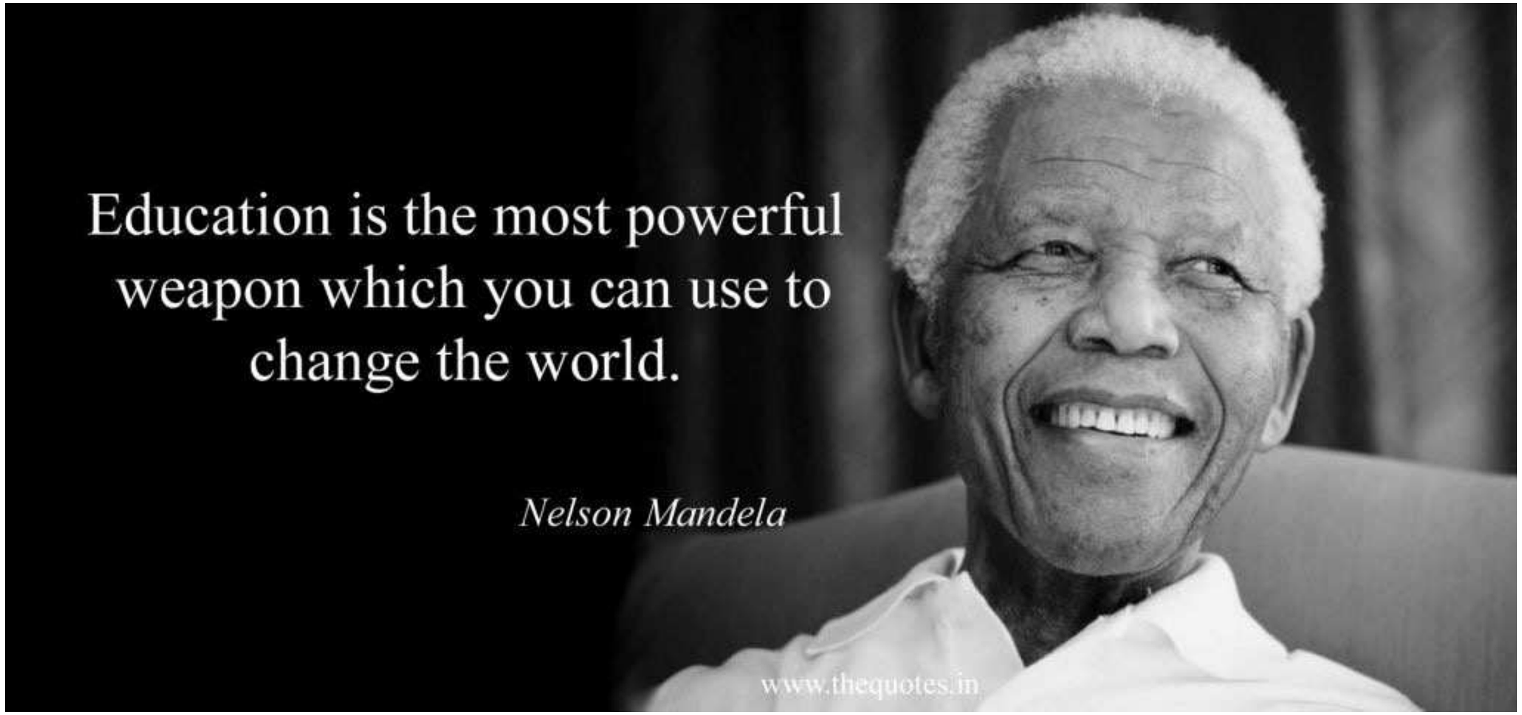
Indoor climate monitoring



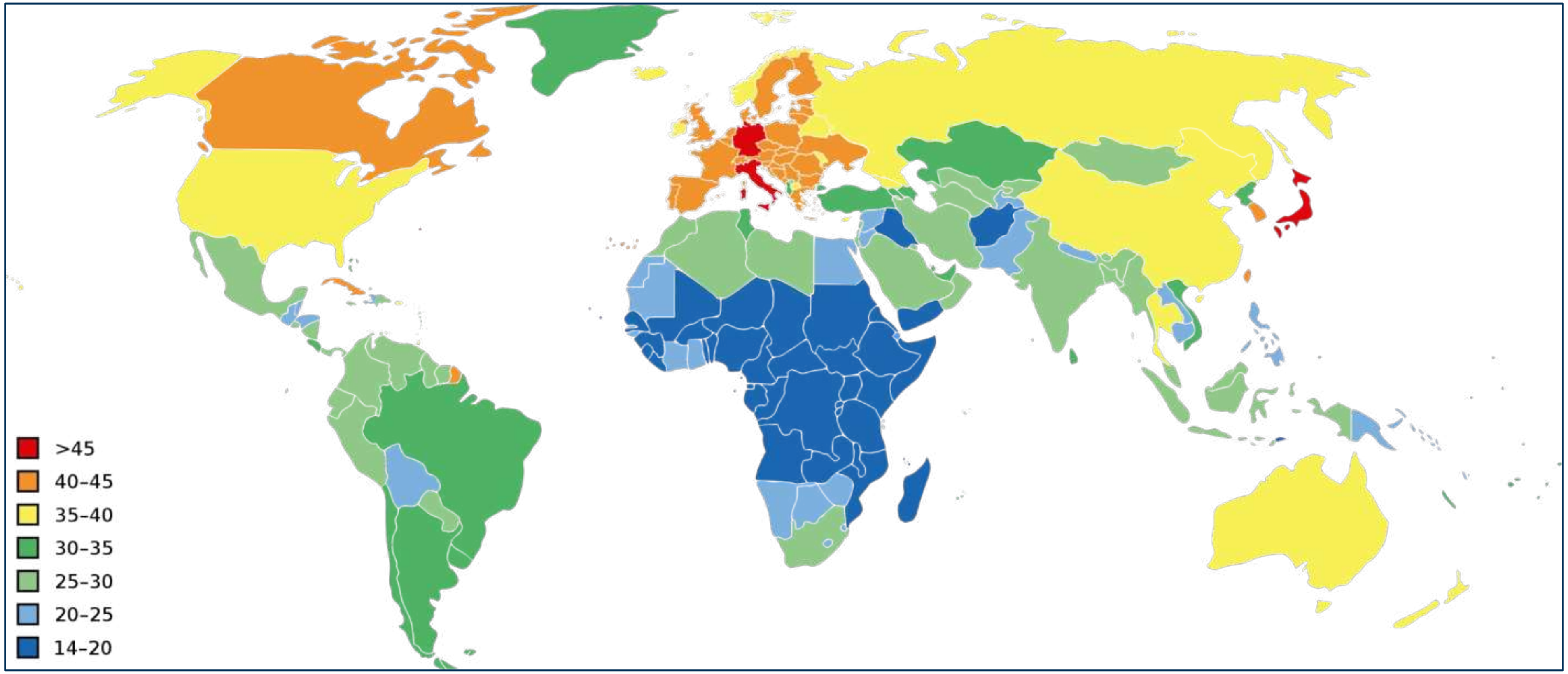
Classroom indoor climate monitoring – *future plans*

Africa

vito


Education is the most powerful
weapon which you can use to
change the world.
Nelson Mandela
www.thequotes.in

Africa has the highest share of its population in primary / secondary school age

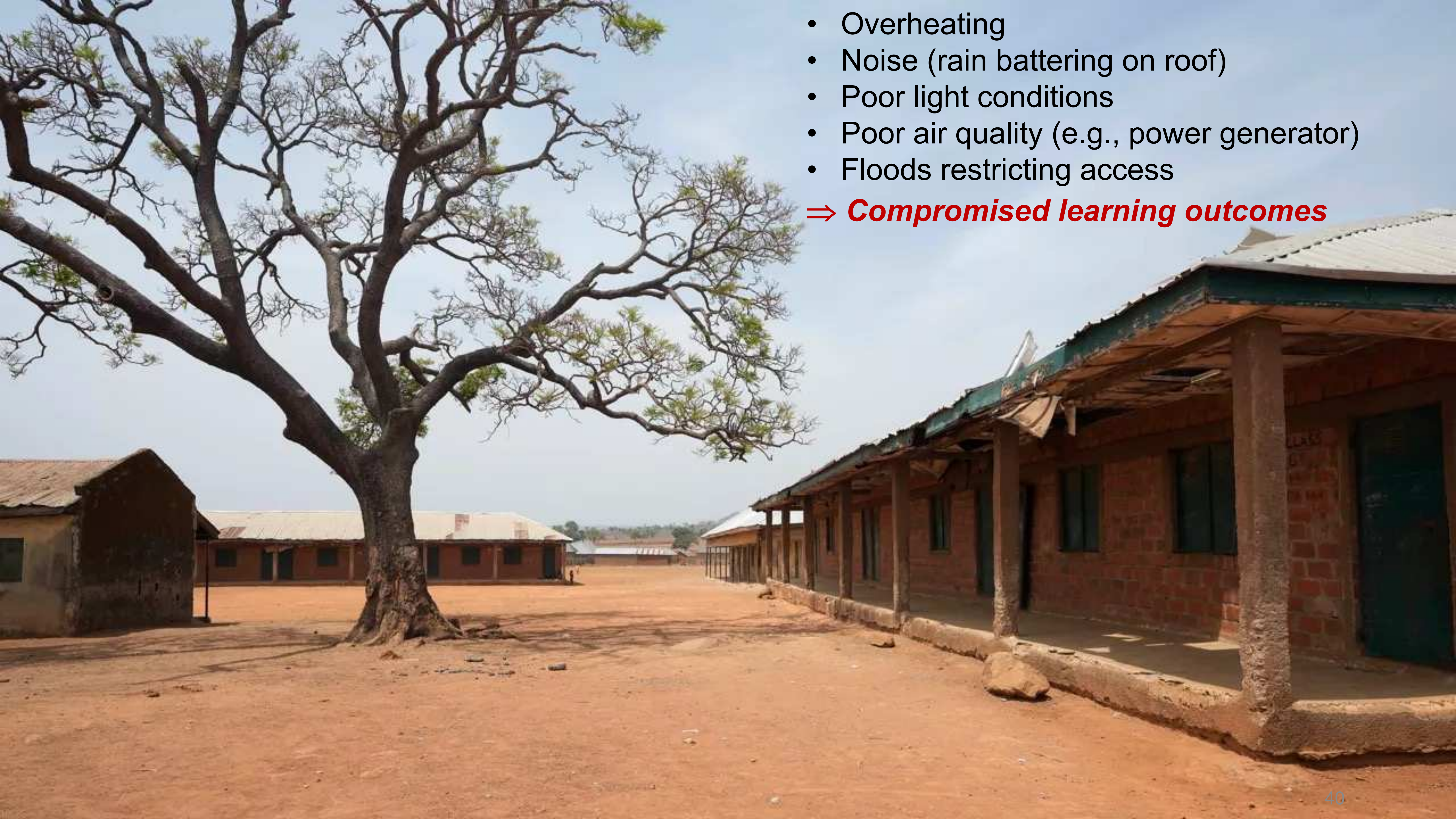


median age

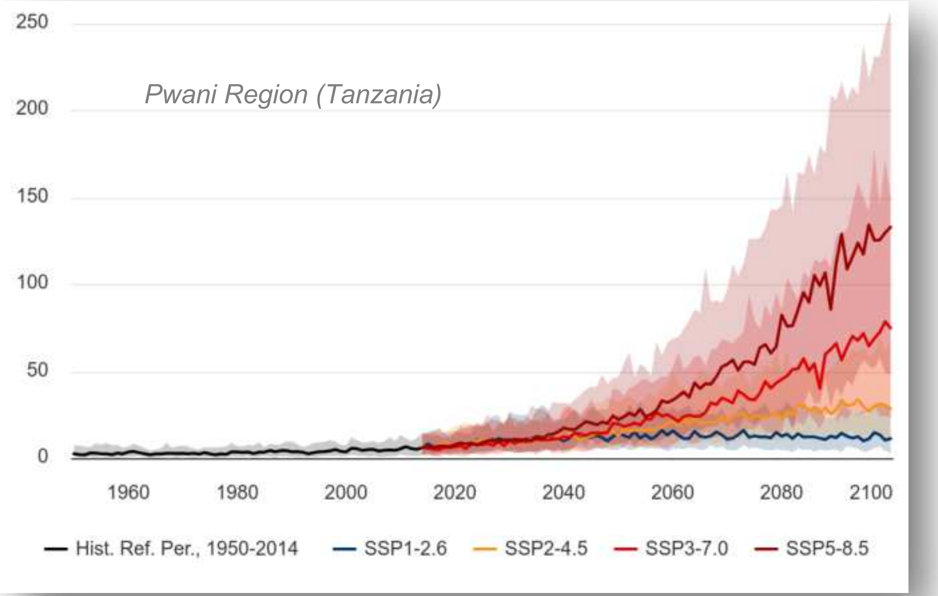
https://en.wikipedia.org/wiki/List_of_countries_by_median_age

- Overheating
- Noise (rain battering on roof)
- Poor light conditions
- Poor air quality (e.g., power generator)
- Floods restricting access

⇒ ***Compromised learning outcomes***

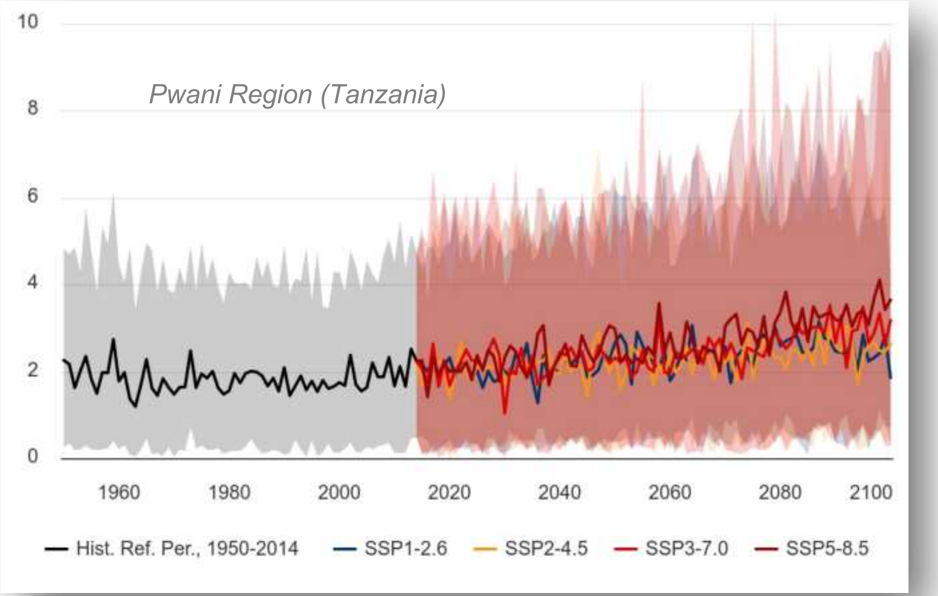


Climate change will enhance adverse conditions further still



Increasing number of **hot days** (T_{max} > 35 °C)

→ Enhanced indoor thermal stress



More days with **abundant rain** (> 20 mm)

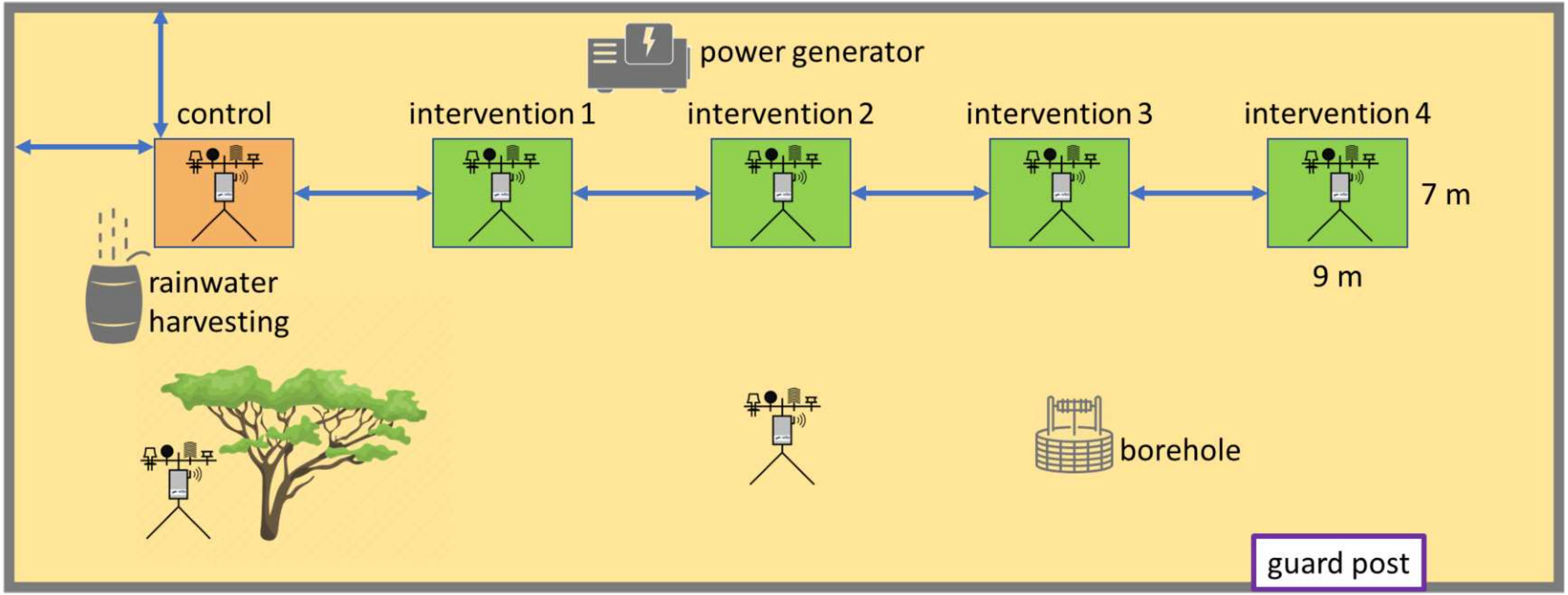
→ More frequent noise hindrance

https://climateknowledgeportal.worldbank.org/country/tanzania/climate-data-projections

Large knowledge gaps remain

- *“Literature on classroom thermal comfort in relation to learning outcomes in the tropics is limited”* (Toyinbo, 2023).
- *“Thermal comfort research is minimal for 84% of tropical countries, Africa being the least studied region”* (Rodriguez et al., 2019)
- *“More research is needed on climate change impacts on education in Africa”* (IPCC, 2022)

‘Cool Schools’ – experimental facility (*in preparation*)



Do It Yourself

Feasible things to do at your school

vito

Conduct your own measurements!

- Devices are fairly easy to manipulate
- Data processing is rather straightforward
- Not too expensive (up to a few hundred €)
- Great way to learn about climate (change), and also physics, IT, data processing, …
- *“Brings the idea of climate change to a way more personal scale”*

Results include those from the PROVIDE project, which has received funding from the European Union’s Horizon Europe research and innovation programme under grant agreement No 101003687.

koen.deridder@vito.be

vito

vito.be