Response of Urban Systems to Climate Change in Europe: Heat Stress Exposure and the Effect on Human Health

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Introduction

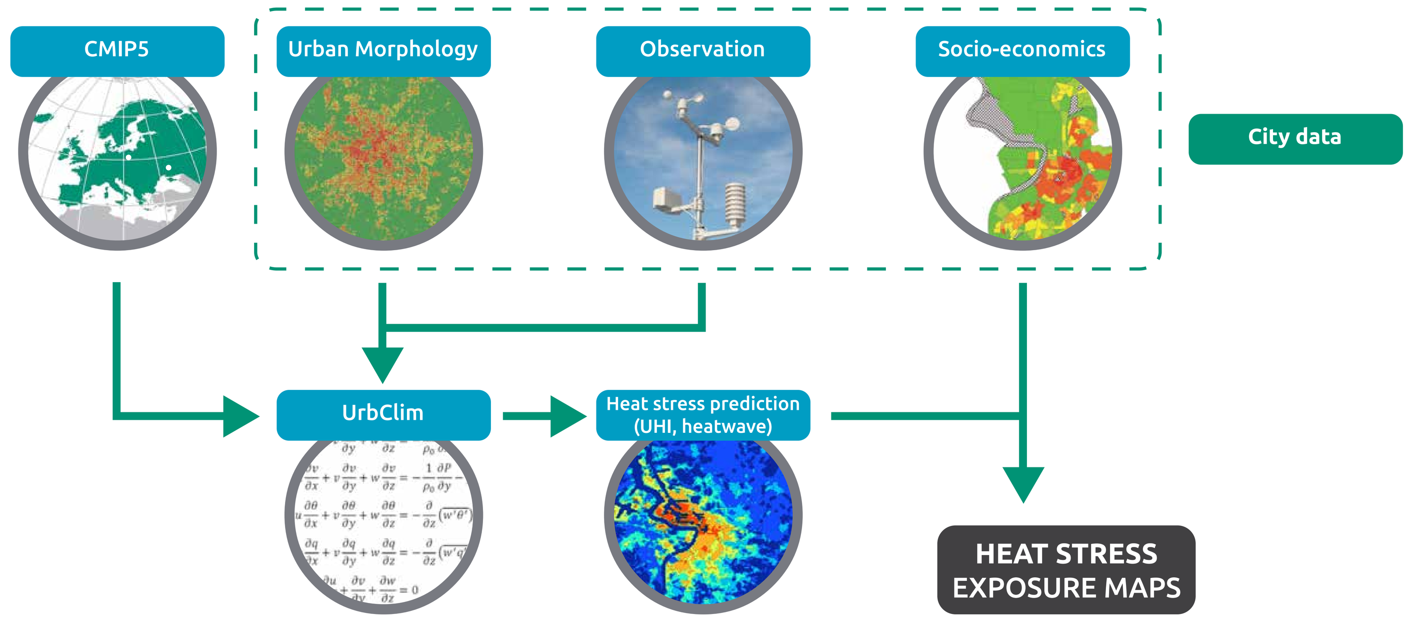
Climate change is driven by global processes such as the global ocean circulation and its variability over time leading to changing weather patterns on regional scales as well as changes in the severity and occurrence of extreme events such as heavy rain- and windstorms, floods, drought, heat waves, etc. The main risks induced by global climate change in urbanised areas are considered to be overheating and resulting health effects, increased exposure to flood events, increased damage losses from extreme weather conditions but also shortages in the provision of life-sustaining services. As most of Europe's inhabitants live in cities, it is of particular relevance to examine the impact of climate variability on urban areas and their populations.

Aim and context

The on-going research focusses on the identification of heat stress variables related to human health based on recent, near future and far future global climate predictions. The analyses have been conducted in the framework of the NACLIM FP7 project funded by the European Commission involving local stakeholders such as the cities of Antwerp (Belgium), Berlin (Germany) and Almada (Portugal) represented by different climate and urban characteristics.

Methodology

The base of the work consists in the extraction of urban morphology indicators from 3D city models (Thomas et al., 2015) and land use maps. These parameters are used by VITO's urban climate model UrbClim (De Ridder et al., 2015) which is nested in an ensemble of global climate models from the IPCC assessment and run for various 20-year periods. The urban climate simulations are then combined with socio-economic indicators to produce estimates of human exposure to heat stress, modelled by the urban-rural temperature increment (the so-called Urban Heat Island – UHI effect) and the number of heatwave days together with their durations and intensities.



The definition of a heatwave is based on the convention used by the federal agency for public health in Belgium, but adapted to be used worldwide. It defines a day as being part of a heatwave if both following conditions are met:

- the three-day moving average minimum temperature is higher than the P98-percentile of the minimum temperatures over the period May-Sept;
- the three-day moving average maximum temperature is higher than the P98-percentile of the maximum temperatures over the period May-Sept.

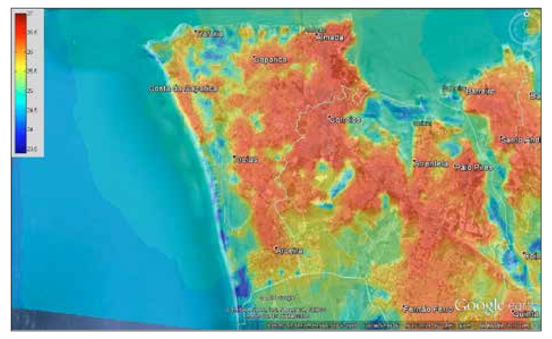
The percentiles were taken for the rural temperatures. Next to the number of days that can be counted using this method, a system taking into account the intensity of the heatwaves can be defined:

$$\sum_{Day\ is\ part\ of\ heat\ wave} (\overline{T_{min}} - P98T_{min} + \overline{T_{max}} - P98T_{max})$$

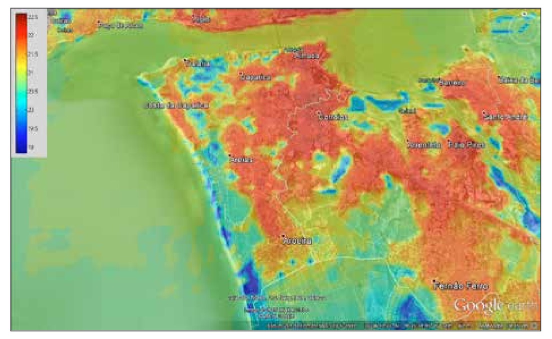
In other words, this quantity represents the sum of the exceedances of the limit values on heatwave days. As such, this indicator does not only track the length of the heatwave but also the strength of the heatwave.

Results

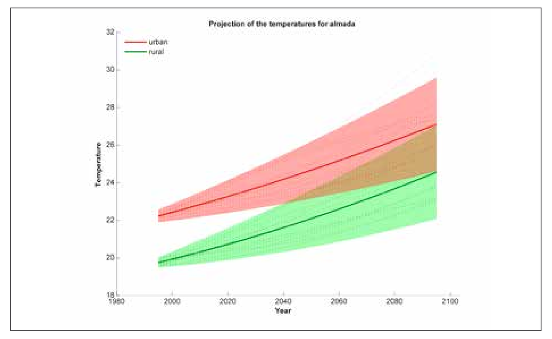
Urban climate simulations have been run for each of the three use case cities over various time scales (present situation 1986-2005, near future 2026-2045 and far future 2081-2100) and the resulting temperatures, UHI effects and heatwave statistics have been extracted.



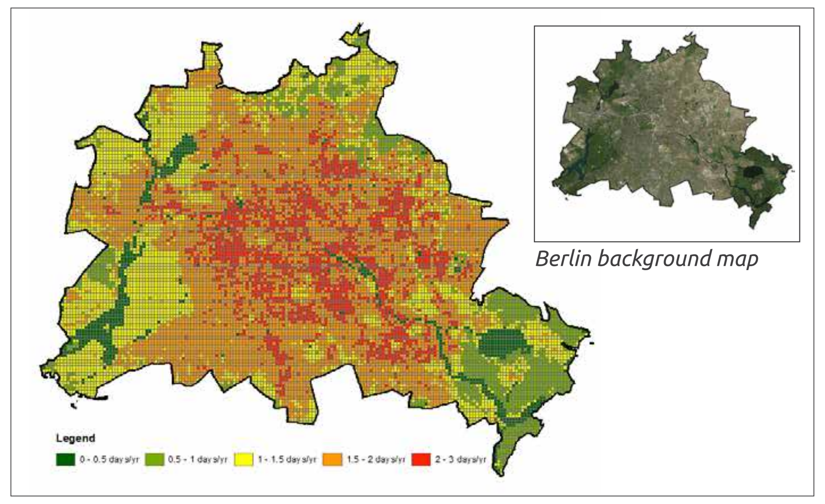
P95 of Tmin for Almada over the period 1986-2005



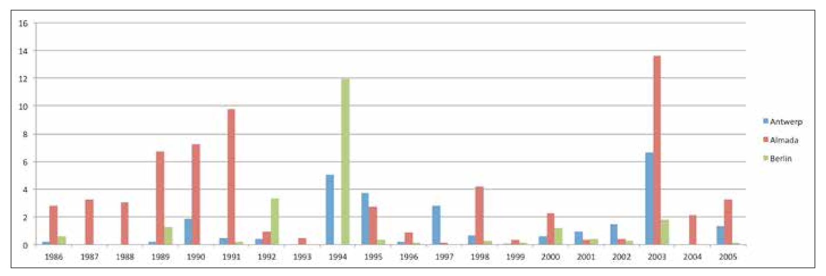
P95 of Tmin for Almada over the period 2081-2100



Projection of urban and rural temperatures for Almada

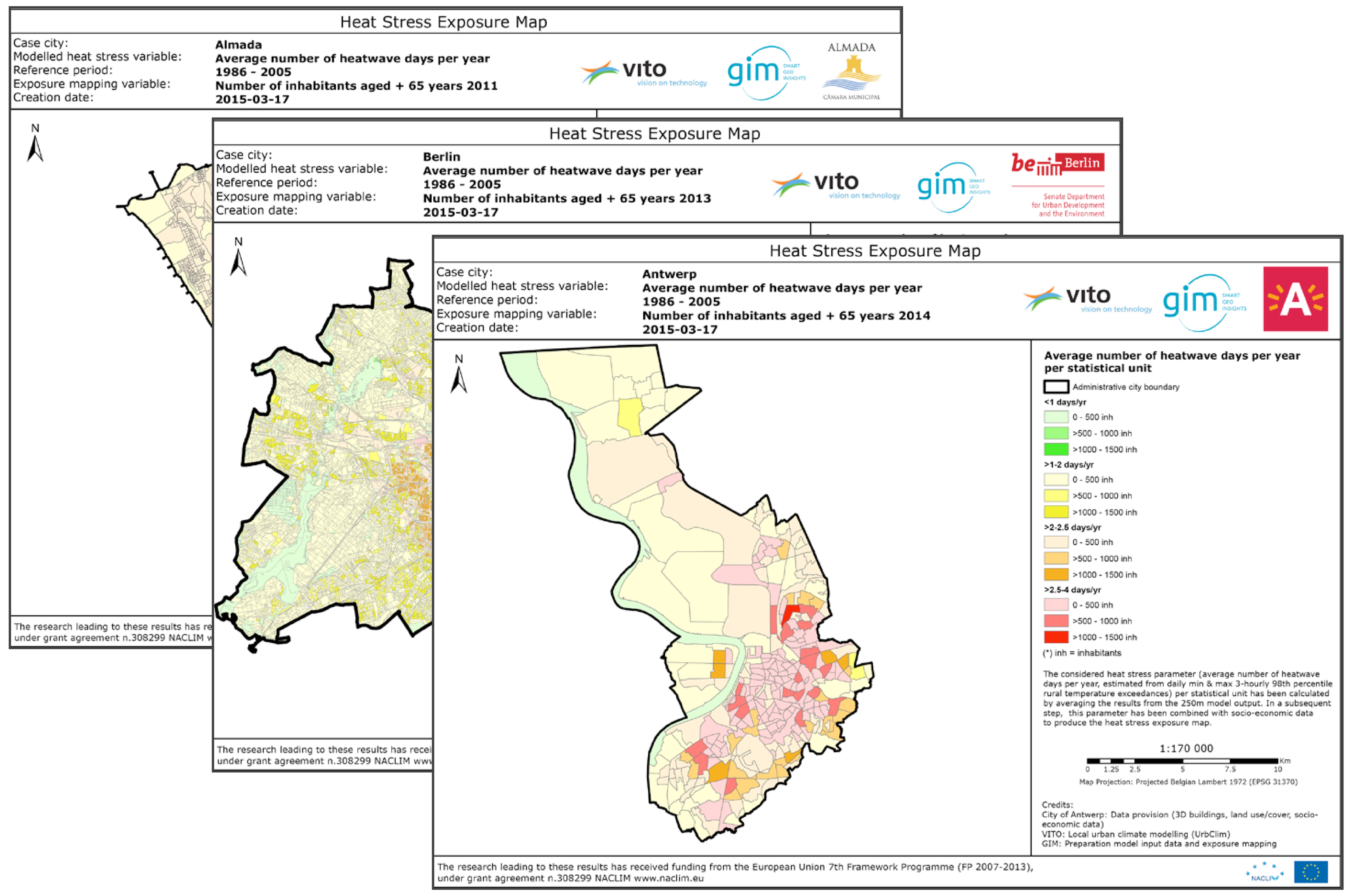


Average number of heatwave days per year for Berlin over the period 1986-2005



Average number of heatwave days per year for Almada, Antwerp and Berlin over the period 1986-2005

The heat stress information has been coupled to socio-economic and demographic datasets including population per age class and vulnerable institutions such as schools, hospitals, rest homes, childcare facilities, etc. As an example, the figure below shows a heat stress exposure map with the average number of heatwave days per year, modelled over the reference period 1986-2005, against the number of inhabitants aged +65 years.



Conclusions

The main conclusions of the present research are summarised below:

- A flexible approach has been set up to simulate urban climate across cities in Europe embedding local data provided by the users to maximise the added-value of the results in their decision making processes;
- Heat stress exposure maps allow urban planners and decision makers to assess the impact of climate and its evolution over time at the individual city level;
- Urban land use change scenarios can be analysed and climate adaptation measures (e.g. enhanced greening of the city) can be evaluated on their impact in countering adverse climatic conditions.

References

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- Federal public service – Health, Food chain safety and Environment, Belgium, Ozon and Heatwave plan, 2008, http://www.health.belgium.be/

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