Health impacts of urban heat island in Paris

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Rationale

In large cities, the distribution of surface heat fluxes is altered compared to natural areas, creating an urban heat island (UHI). Reducing the UHI is a key issue to adapt to climate change.

Following the 2003 heat wave, the French Institute for Public Health Surveillance conducted a case-control study to identify the main risk factors for the elderly living at home. Individual, social and environmental risk factors were investigated. A Landsat picture, acquired on 9 August 2003 at 10:17 UTC, was used to construct the UHI profile of the area around the homes during the heat wave. The temperature exposure indicator – calculated as the mean of the surface temperatures for a 200 m radius around the home – was a risk factor while the vegetation index was described as protective [1].

The Landsat picture had a good geographical precision (50 m) but the long return period of the satellite prevents its use to assess the daily and cumulative minimal and maximal exposure to heat. The objective of this study is to reanalyse the data from the 2003 case-control study, using several indicators to characterise the UHI.

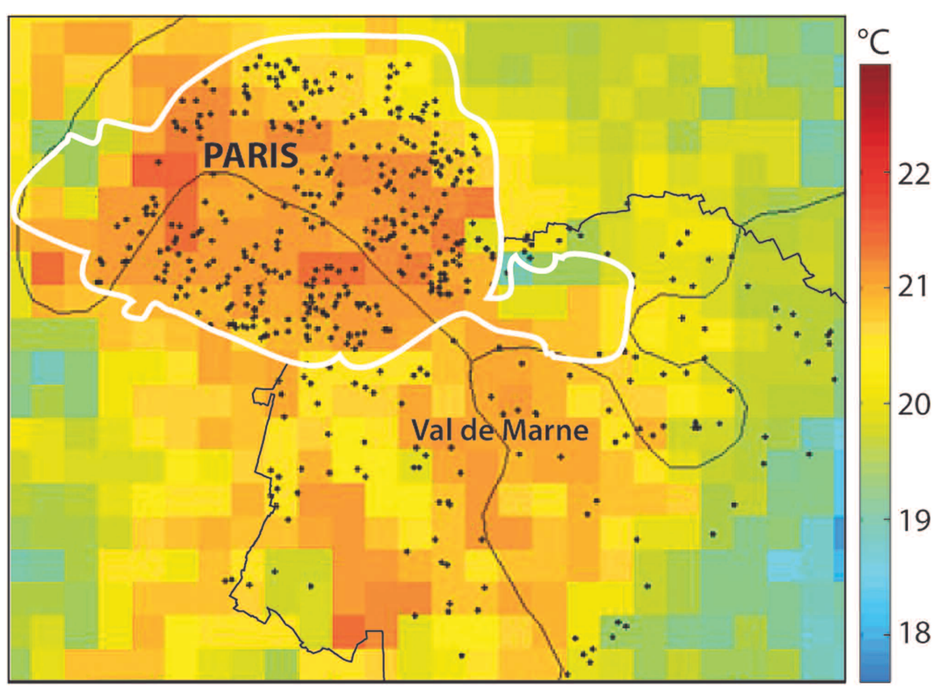
Materials and methods

- Study period: August 1st-13th 2003.
- Satellite data: for each day between the 1st and 13th August, two to six thermal images at 1 km resolution were recorded, sensed by the NOAA-AVRR satellites. In total, 61 images were used.
- Health data: 482 persons aged 65 or more (241 cases/deceased and 241 controls), living at home in the Paris region (France). Cases: died during the mortality peak (8-13 August), lived at home at least 24 hours before their hospitalization or death. Controls: lived at home from 8th to 13th August.
- Method

  The place of residence was geocoded and the surface temperatures of the corresponding satellite pixel were used (figure 1). For each person, several indices were built: daily minimum, maximum and mean temperature, day-night temperature amplitude, and cumulated indicators defined as the average of temperatures recorded between the 1st and the 13th August and the average of temperatures from the day of death and 1, 2 or 6 preceding days.

  These indicators were introduced into a conditional logistic regression model, at lag 0, 1, 2 and 6. The model was adjusted on other risk factors such as age, sex, socio-economic conditions, autonomy, and behaviour of heat adaptation, health problems, housing, and geographical district [1].

FIGURE 1 Night-time surface temperatures and geocoded addresses of cases and control in Paris and the Val-de-Marne department (France)

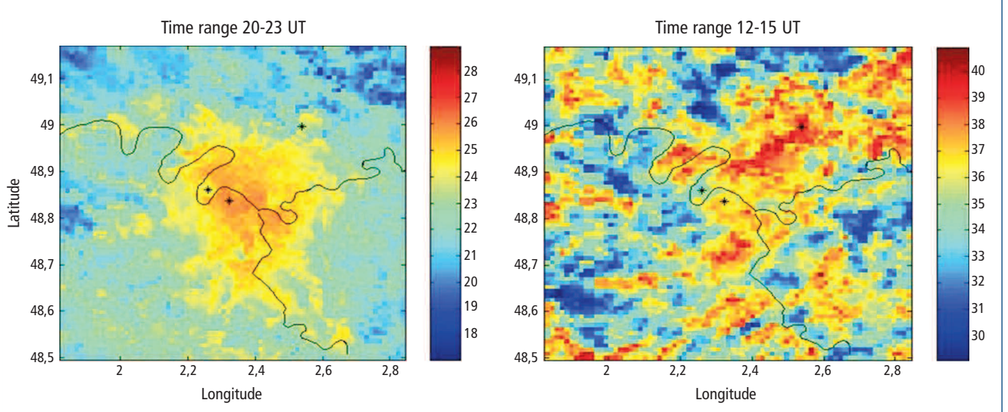


Results

For all cases and controls, surface temperatures ranged from 12.18 to 45.41°C with a median of 21.44°C by night (from 8 pm to 7 am) and 34.16°C by day (from 7 am to 8 pm).

UHI locations dramatically differ from day to night. At night, the UHI is localised at the city centre. During the day, several smaller UHIs are scattered over the city (figure 2).

FIGURE 2 Localisation of the urban heat island during nights (left) and days (right)



Odds ratios (OR) were computed comparing the 90th and 50th percentiles of the temperatures differences between cases and controls. Only statistically significant results are presented in table 1. The most significant results correspond to a night-time exposure, cumulated over time (table 1).

TABLE 1 Odd ratio associated to a temperature difference between cases and controls.

Thermal indicator	OR [IC 95%] p50/p90	T°C difference
Average Tmin 1st to 13th August	2.17 [1.14 – 4.16]	0.41
Average Tmean 1st to 13th August	1.71 [0.94 – 3.11]	0.37
Average Tmin from 6 days before death to the day of death	2.24 [1.03 – 4.87]	0.50

Discussion

Our results confirm that the UHI creates important differences in exposure, and that the UHI is dramatically different between night and day.

Using NOAA satellites images allowed taking into account this feature. The night UHI, cumulated over several days, was the best thermal indicator.

Such data could be used for long term prevention, including urban planning, and to target areas for interventions.

Reference

[1] Vandentorren S, Bretin P, Zeghnoun A, Mandereau-Bruno L, Croisier A, Cochet C *et al.* August 2003 heat wave in France: risk factors for death of elderly people living at home. Eur J Public Health 2006 Dec;16(6):583-91.

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