Health impact of heatwaves

The use of remote sensing in defining a new indicator of urban surface temperature

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Rationale

According to climate models for the XXI[st] century, summer warming trends might increase the occurrence, intensity and duration of heat waves. These are especially deadly in cities due to surfaces characteristics, anthropogenic heat and pollutants, as France experienced in August 2003, with 4,867 excess deaths in the Paris region and about 15,000 in all France.

Synoptic weather stations, often located in parks or airports away from the built-up environment, are not representative of urban temperatures. In 2003, a case control study was performed by the "Institut de Veille Sanitaire" to estimate the risk factors for the elderly during the heat wave. A Landsat satellite image of August 9 (10.07 am UT), at 50m resolution, was used to map the surface temperature. However only one high resolution image was available during the heat-wave

Objectives

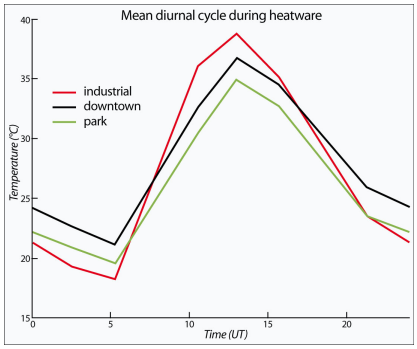
Using time series thermal infrared images, at 1 km resolution:

- To observe the urban surface temperature gradients during night and day
- To elaborate a methodology integrating satellite data, to estimate the health impact of heat stress in megacities

Data and Methods

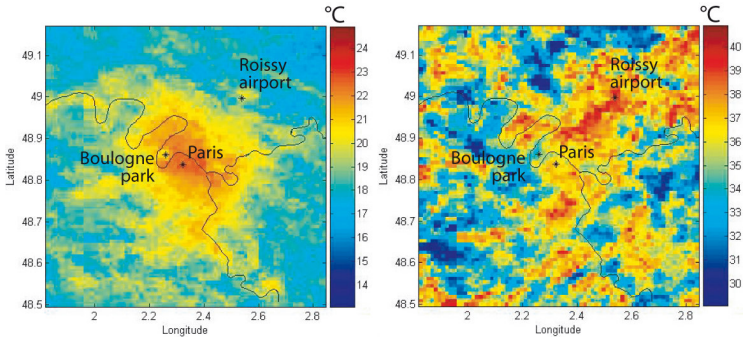
- 61 NOAA-AVHRR satellite images, at 1km resolution, from August 1 to 13th (day and night images)
- Health data concerning 482 people aged 65 or more (241 cases/deceased and 241 controls) who were residing in Paris (France) at the time of the heat-wave
- For each person, a thermal index was produced from the satellite images and integrated into a regression model to test its use as a heat exposure factor.
- The model was adjusted for risk factors (socio-economic conditions, self-care ability, behavioural adaptation to heat, health problems, housing), age, sex and geographical zone.
- The thermal indexes that were tested are the minimum, maximum, mean temperature and day-night temperature amplitude.
- The considered periods were: day of death, one day, 2 days, 6 days or 13 days preceding it.

Results



- Highest and lowest temperatures are observed in the industrial suburban area
- Highest night-time temperature in downtown leads to no heat stress relief for people
- Temperatures in the park are 2 to 3°C lower than in downtown over the diurnal cycle

Mean diurnal cycles of surface temperature in 3 locations, August 4-13 2003, constructed from 50 NOAA-AVHRR images

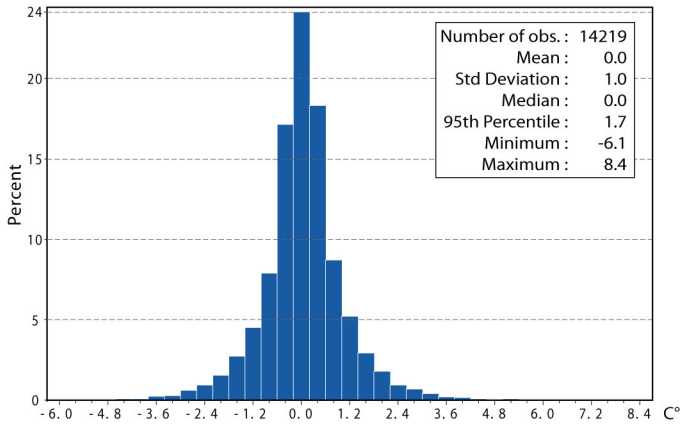


Composite image. Time range 1-3 UTC: At night-time a significant (~8°C) heat island, due to built density and lack of evapotranspiration, develops in downtown Paris.

Composite image. Time range 12-14 UTC: By daytime multiple thermal anomalies (~ 10°C), due to surfaces low thermal inertia and unobstructed field of vision, scatters over industrial suburbs.

Results of the regression model showed that, for an increase of 0.5°C, the risk of dying is around two times higher, depending on the considered index (table below). Results are not significant for other indexes (not presented).

Satelitte	Variable	OR (IC 95%)
Landsat	temperature 9 August 10.17 am	1.29 (1.08 – 1.55)
NOAA	Average Tmin 1st to 13th August	2,57 (1,17 - 5,64)
NOAA	Tmean 1st to 13th August	2,07 (0,91 - 4,70)
NOAA	Average Tmin from 6 days before death to the day of death	2,22 (1,03 - 4,81)



Distribution of differences between thermal indexes of matched cases and controls, from NOAA-AVHRR images (1[st] to 13[st] August).

Conclusion

These results demonstrate the importance of the night-time temperature impact on health (from heat stress to mortality), which was not possible with the Landsat image.

Now, we will have to evaluate the use of our results to improve public health protection, proposing urban-planning and architectural measures to decrease the temperature in the heat islands shown.

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