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Multi-scalar estimation of spatial and temporal extension of urban heat island during the heat wave of august 2003 in Paris: effects on excess mortality

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The heat wave of August 2003 was particularly deadly in the city Paris causing more than a thousand deaths. This heat wave was further strengthened by the urban heat island phenomena with higher than normal daily minimum temperatures. The occurrence of urban heat islands is the most documented event in the urban climate. The spatial extension of urban heat island depend on the size of the city, but also the land-use (surface distribution of mineral and vegetable) and of the geometry of the city. Furthermore, for optimal apprehension of the urban heat island, the notion of scale appears to be fundamental. This paper will determine the meaningful scale of study for the consideration of the heat island phenomenon. Ultimately, it is to compare climatic data with socioeconomic data for the determination of the optimal scale.

The observation of the spatial and temporal evolution of the urban heat island was conducted using satellite imagery (MODIS* and LANDSAT). This extracts surface temperatures, the brightness index and normalized difference vegetation indices. The topographic (IGN** 2002) records of Paris estimate the different variables related to land use and those related to the geometry of the city. The variables related to land use include density of buildings, roads, and the presence of vegetation and that of water. Regarding the variables related to the geometry of the city, we calculate the average height of buildings, the ratio between the average height of buildings and the average width of the street (index H / W; Oke, 1987) or at Sky-View Factor (Watson, Johnson, 1987) which represents the portion of sky visible from the street. The socio-economic data was received from the National Institute of Statistics and Economic Studies (INSEE). We choose the smallest common spatial scale to establish a regression analysis designed to quantify the relationship between brightness temperature, urban features, vegetation and excess mortality data.

The results showed a weak relationship between surface temperature derived from MODIS and density of constructed features. Whereas at a higher resolution of 30 m (LANDSAT) a stronger relationship was observed between surface temperature and constructed features. There is a clear indication of the influence of vegetation on temperature; whatever the scale might be there is an inverse relationship between the two. The important gradient Northwest Southeast level of excess mortality is also linked with the temperature data and show a strong correlation with the later.

* MODIS: Moderate Resolution Imaging Spectroradiometer
** IGN: National Geographic Institute