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Mapping effects of heatwaves on urban systems: a comparison

Greater London – Métropole du Grand Paris

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I. Context & objectives

Global warming drives recurrent anomalies of atmospheric circulation (fig. 1) at mid-latitude and gives more frequent and intense heatwaves in European region and major cities.

It has severe consequences on human wellbeing and urban ecosystems, especially during extremely hot nights.

Urban morphology and land composition drive the behavior of heat urban islands effects (figure 3), more generally the capacity of urban systems to discharge excess of accumulated heat during night.

Moreover, a few studies were carried to examine links between heatwaves’ land surface temperatures, land cover features, and socio-economical attributes of neighborhoods of European major cities.

We did a geographical comparison between Greater London and Métropole du Grand Paris (figure 3-4), to enquire those questionings.

II. Material & Methods

- 1) Selection of extremely hot nights using thresholds given by London and Paris authorities to define heatwave alerts, based on 2002-2022 temperature time series (Heathrow Airport & Paris-Montsouris meteorological station, source: MetOffice & Météo-France)
- 2) Mean of selected nights for emissivity/Land Surface Temperature (LST, MODIS 11A1, 2002-2022, source: LPDAAC-USGS)
- 3) Geographical aggregation of LSTs by metropolitan neighborhoods (geostatistical units: wards/IRIS) for :
 - Urban land cover (2018, source: Copernicus-EEA)
 - Median household incomes (sources: London Data Store & INSEE) and
- 4) Geostatistical tests : Pearson & Spearman correlations; ANOVA

Figure 1 (upper-left): Reanalysis of 850m geopotential-height anomaly for JJA 2022 compared to 1991-2020 normal, for northern hemisphere (source: Climate Change Institute); **Figure 2** (upper-right): graphical abstract of heat urban island (real. R. Courault, 2021); **Figure 3**: Urban land cover map in 2018 for Greater London; **Figure 4**: Urban land cover map in 2018 for Métropole du Grand Paris. Legend colors are reported for land cover categories of Table 1 (source: Copernicus & European Environmental Agency; real. R. Courault 2022)

III. Results

- 1) & 2) Selection criteria used to define heatwave, as given by British and French health & meteorological institutes, gave too little days/nights to sample MODIS LST images. We then based our selection on T°C thresholds overrun, excluding length of episodes.
 - 3) On a regional basis, night LSTs are cooler for London compared to Paris (total average, respectively: 18,7 and 24,6°C), due to overall fresher climate, presence of the tidal river Thames and different distribution of land cover types (fig. 3-4 and table 1).

Averaged to land covers, Continuous urban fabric are the hottest land cover found for both cities (Paris: 24,9°C; London: 19,6°C). For Paris, Port areas and Water are the second and third hottest; while in London it is Discontinuous dense urban fabric and Railways and associated land (table 1).

Freshest land cover are found both for Permanent crops (vineyard, fruit trees etc), Isolated structures and Arable lands (annual crops). Those results need to be weighted according to land cover proportion and distribution, which vary significantly between London and Paris (visual comparison on figures 3 & 4).
 - 4) Pearson and Spearman correlations on LST ‘explained’ by median household income did not show significant results for London. For Paris, weak but existing signals are found, with respectively R=0,2 and R=0,19 (p<0,0001).
- ANOVA showed heterogenous results for differences inter-land covers and LST°C. For both city models showed significant results, with better performances for London.

Land cover - Urban Atlas (2018)	Night LST (°C) - Grand Paris	Night LST (°C) - Greater London
Airports	24,0	18,3
Arable land (annual crops)	22,5	16,6
Construction sites	24,6	18,8
Continuous urban fabric (S.L. : > 80%)	24,9	19,6
Discontinuous dense urban fabric (S.L. : 50% - 80%)	24,2	19,0
Discontinuous low density urban fabric (S.L. : 10% - 30%)	23,3	17,5
Discontinuous medium density urban fabric (S.L. : 30% - 50%)	23,5	18,1
Discontinuous very low density urban fabric (S.L. : < 10%)	23,9	17,3
Fast transit roads and associated land	24,5	17,6
Forests	22,5	16,3
Green urban areas	24,5	18,7
Herbaceous vegetation associations (natural grassland, moors...)	22,3	16,2
Industrial, commercial, public, military and private units	24,6	18,6
Isolated structures	22,2	16,1
Land without current use	24,2	18,6
Mineral extraction and dump sites	23,8	17,3
Open spaces with little or no vegetation (beaches, dunes, bare rocks, glaciers)	NA	17,5
Other roads and associated land	24,6	18,9
Pastures	23,2	16,7
Permanent crops (vineyards, fruit trees, olive groves)	21,2	16,0
Port areas	24,8	18,4
Railways and associated land	24,6	18,9
Sports and leisure facilities	24,4	18,3
Water	24,7	18,7
Wetlands	NA	17,4
Total average	24,6	18,7

Table 1: Night MODIS 11A1 Land Surface Temperatures averaged by urban land cover type, at the extent of Greater London and Métropole du Grand Paris. Green to red colors for LST depicts distribution between hottest and freshest land cover for night LST during heatwaves (Real. R. Courault, 2022)