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Can planning fight the urban overheating and should we tackle the "the urban heat island" per se ?

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Urban overheating: should planning tackle the Urban Heat Island per se?

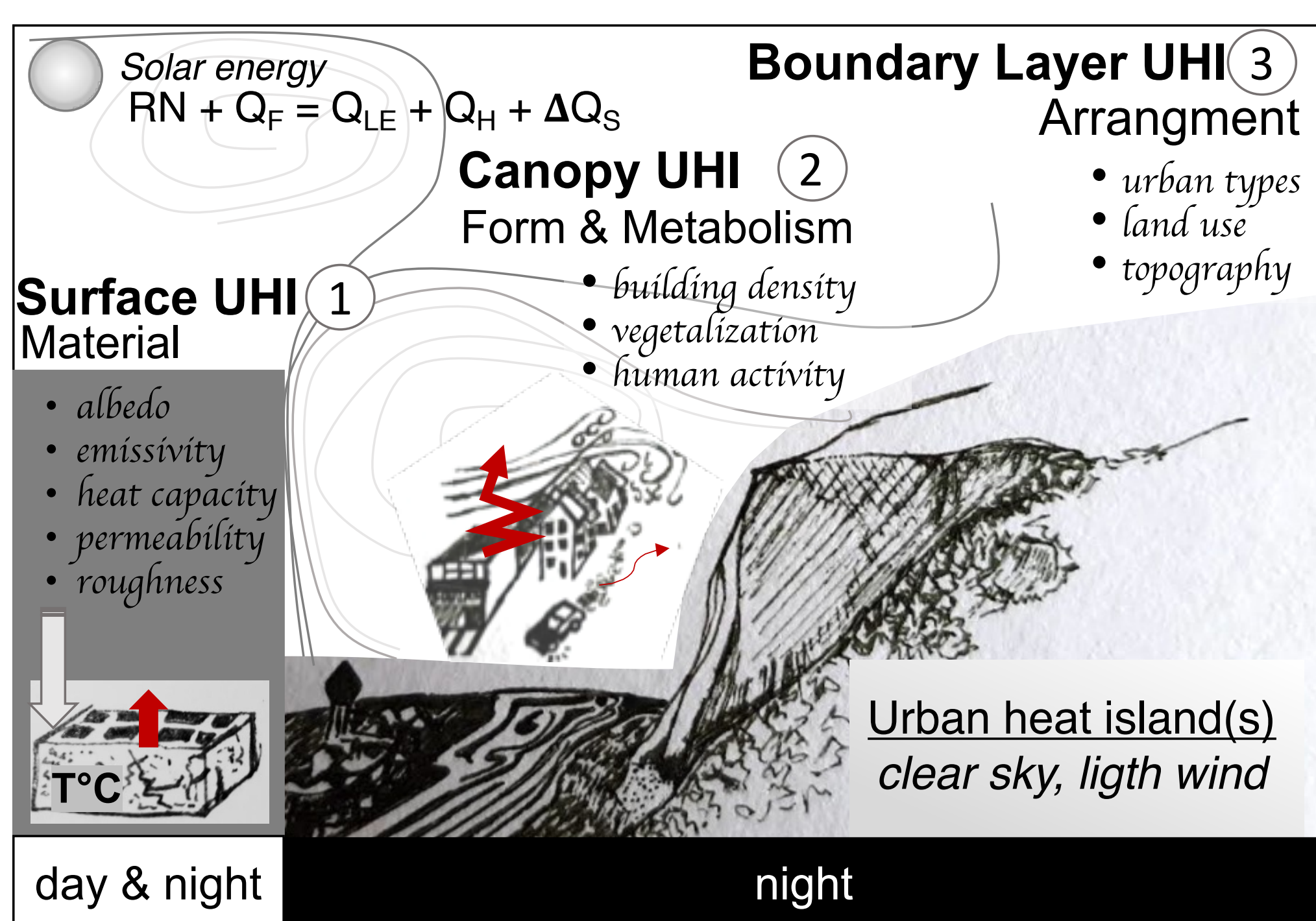
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Extreme temperatures receive growing attention during summertime given increased heat-related mortalities, poorer thermal comfort in outdoors, as well as increased loads on energy, water, and transport infrastructures in the built environment. In this framework, the "urban heat island" (UHI), a mesoscale and multi-scalar aerodynamic and thermic phenomenon whereby warm temperatures and reduced winds are manifest in densely built-up districts compared to vegetated areas, is at the foreground. It is supposed to increase the heat load on urban dwellers already due to climate change.

How does UHI relate to urban forms?

Figure 1. UHI scales and drivers

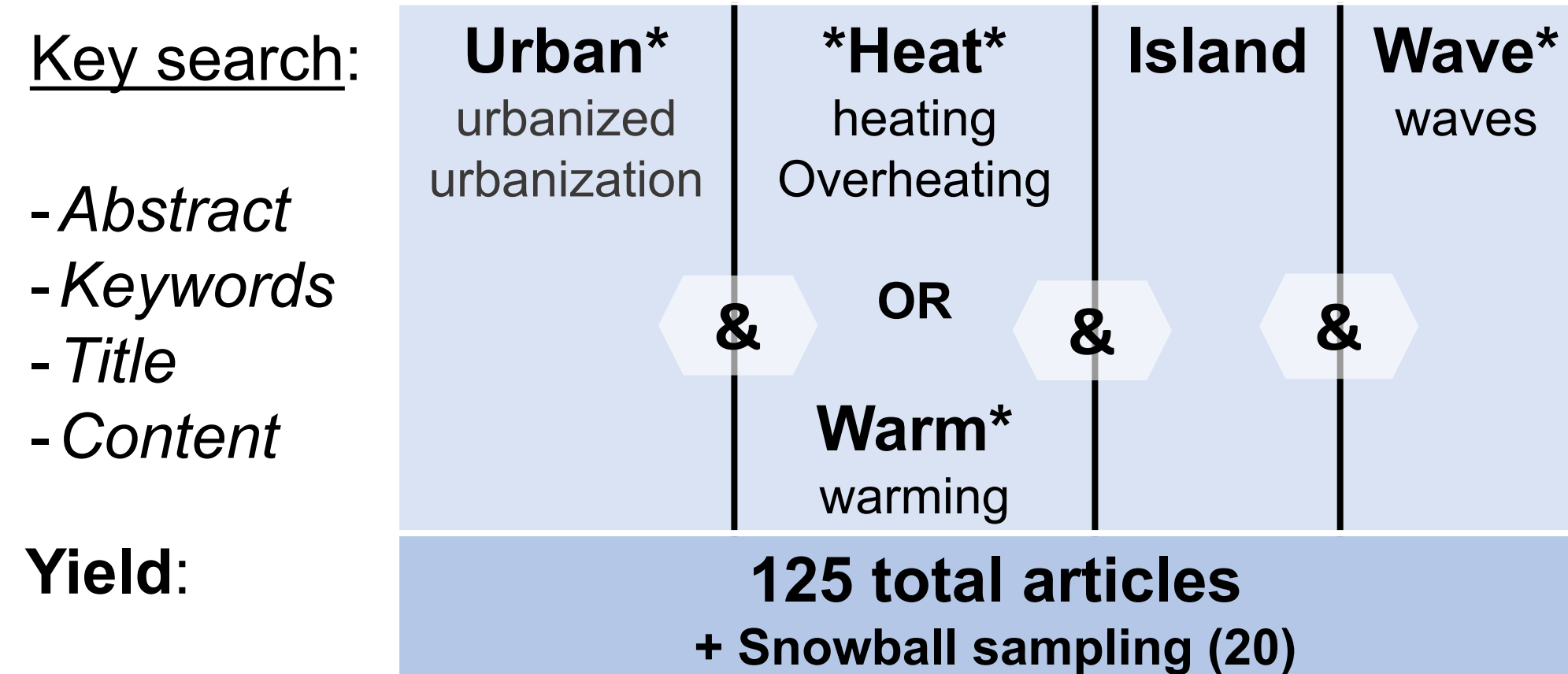


- High thermal inertia due to reduced vegetated areas vs. built-up area + increased urban surface (vertical)
- Limited sky view traps radiated heat between buildings, while rough urban surfaces slow winds in streets. Emission of heat from human activities.
- Mountain/valley (sea/land) winds can be altered by a city, which can also generate its own wind system (countryside/urban breezes). At this scale, roofs are additional source of heat and convection mixes efficiently the air within a boundary layer (up to 300 m high). A city-plume can be observed in altitude over a few kilometers.

Descriptors	Urban Climate	Planning policies per urban types
BUILDING FORM CITY FORM	Building density Canyon aspect ratio (asymmetrical*), building plan-plot area ratio, sky view factor* Building morphology Building average height*, vertical profile, porosity, building frontal-plot area ratio Building surface properties (materials, albedo) City compactness City built-up patch size*	<ul style="list-style-type: none"> Building maximum height & building footprint prescriptions based on the district's archetypal architecture Minimum construction/plot area (foster building density) & Maximum building/plot area, settlement rules based on building height & construction area Facade color rules, RE2020 (external insulation) Street density/plot area Location of new development
SVF	Quantity horizontal plane green area*, vertical green area Local distribution vegetation horizontal density, vegetation vertical density* (LAD) Quality vegetation composition or species (NDVI*)	<ul style="list-style-type: none"> Maximum building/plot area, %pervious soil/building area, preservation of building frontal garden, 1-1 tree removal compensation, tree canopy index, %population within X m from a green/blue infrastructure, protection of the green infrastructure from construction, carpark and road greening/size Tree species & shape management prescriptions, Ecological bonuses (biotope coef.)
ANTHROPOGENIC HEAT	Building operation A/C and equipment rate, set point temperature*, household size & building volume, wall-to-window ratio Traffic vehicles types, daily use, road size & density Energy production energy mix, efficiency, & system	<ul style="list-style-type: none"> Nb of bike or carparks/building floor area; nb of routes/plot size Minimum PV power production or electric car battery chargers/carparks size; %EnR local energy production (if A/C) Construction licence/distance to public transport node %RE2020 & construction volume bonuses (insulation improvement), construction withdrawal from parcel lot lines (sun)
LOCAL METEO	Rural cool air advection wind direction & intensity Topography distance/coast, elevation Air aerology & clouds weather circulation	<ul style="list-style-type: none"> Urban fabrics arrangement, city outskirts' landscape (e.g. croplands, forest) Geographic location of new urban developments

Is UHI magnified during Heat Wave**?

World's largest abstract and citation database of peer-reviewed research literature (2000 – 2022)



** Up to 3 consecutive days whereby $T_{max,day} > 90^{th}$ or 95th percentile of a reference climatology & $T_{day} > 25^{\circ}C$

Main findings:

- Increasing work since 2017 (up to 20 per year)
- Regions? Temperate climate – U.S. & Europe
- UHI? Canopy
- Methods?

- 1) Analysis of UHI energetics basis during HW with urbanized regional atmospheric numerical models
- 2) Comparison of daily average UHI intensity* (UHII) profiles during HW-days and non-HW-days using 2 m air temperature observations (> 10 stations owning to urban and rural areas)
- 3) Few RCP prospective or longitudinal studies during HW. No focus on local wind patterns.

Most studies report:

- Enhanced UHII during daytime following by a decrease in UHII after a few days. A few studies state on contrary no synergy between UHI & HW (hyp.: similar warming rate in rural and urban areas, efficient convection in the PBL)
- Influence of background climate & HW types

Fig. 2. Daily profile of summer UHII in various climates (after Ramamurthy & Sangobanwo, 2016; Zhao et al., 2018)

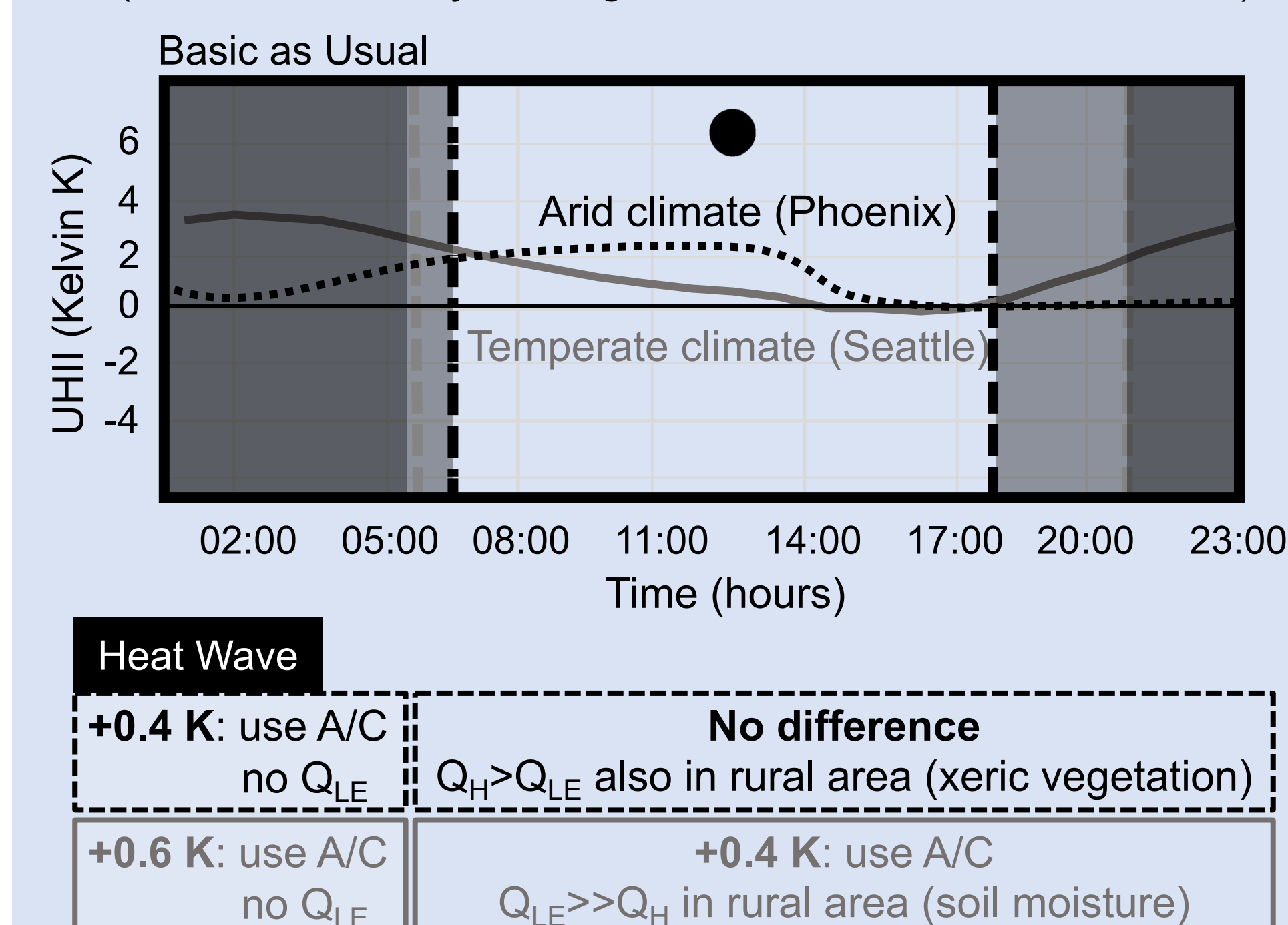
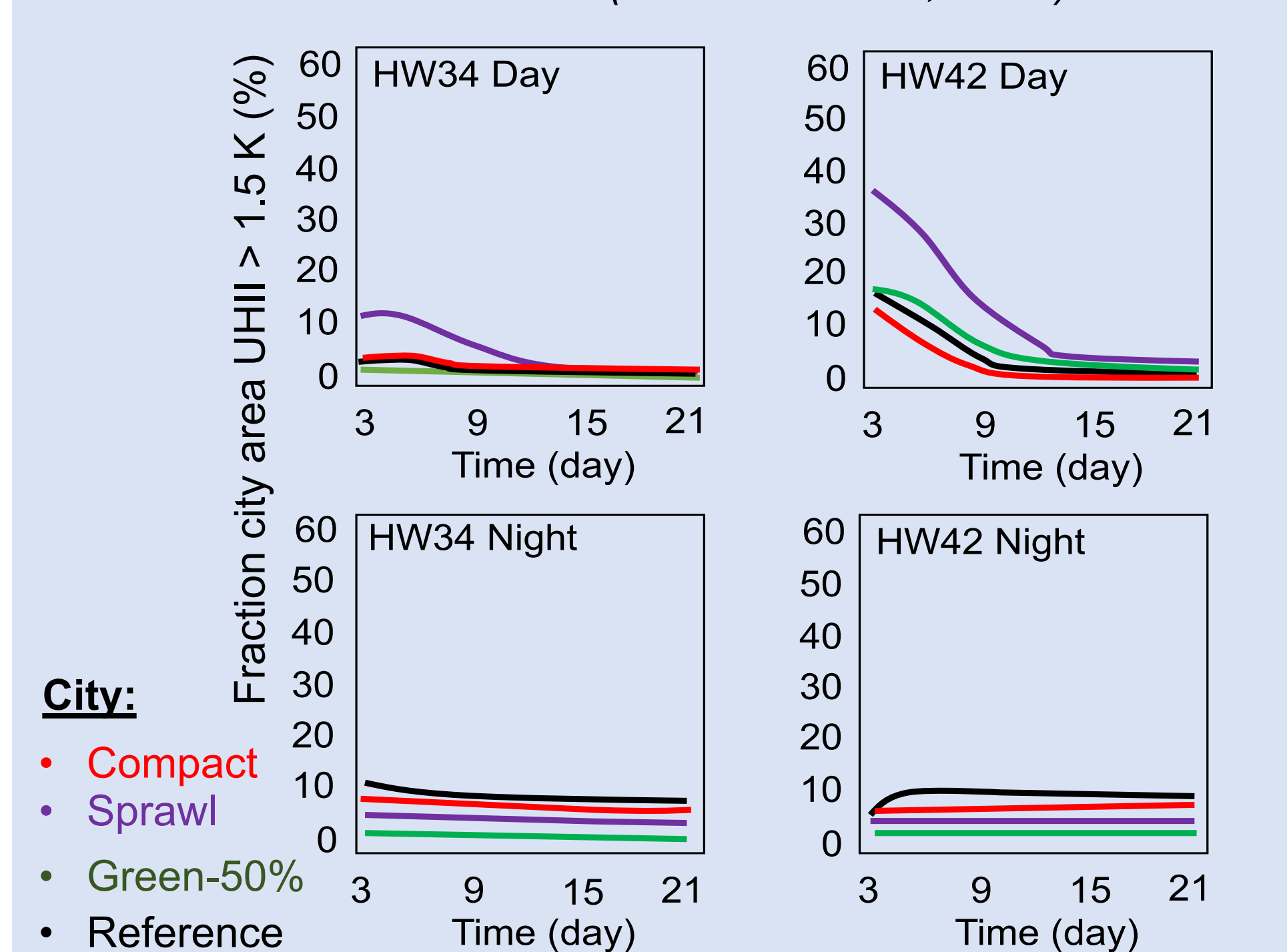


Fig. 3. Evolution of UHII with HW intensity, HW duration, & urban forms (Lemonsu et al., 2015)



Addressing urban overheating at local scale

Strasbourg Climate Energy Air action plan

A PCAET is a 6-year planning action plan aiming to mitigate the climate change & its impacts; promote the use of renewable energy; and ensure the provision of clean air in large municipalities (>20,000 inhab.). Urban planning regulations and local zoning should be compatible with its objectives and strategies. PCAET should itself be compatible with other sectorial plans.

- Loi de transition énergétique pour la croissance verte n°2015-992 17 août 2015, Grenelle 1 2008 -

+ adaptation to climate change (recently)

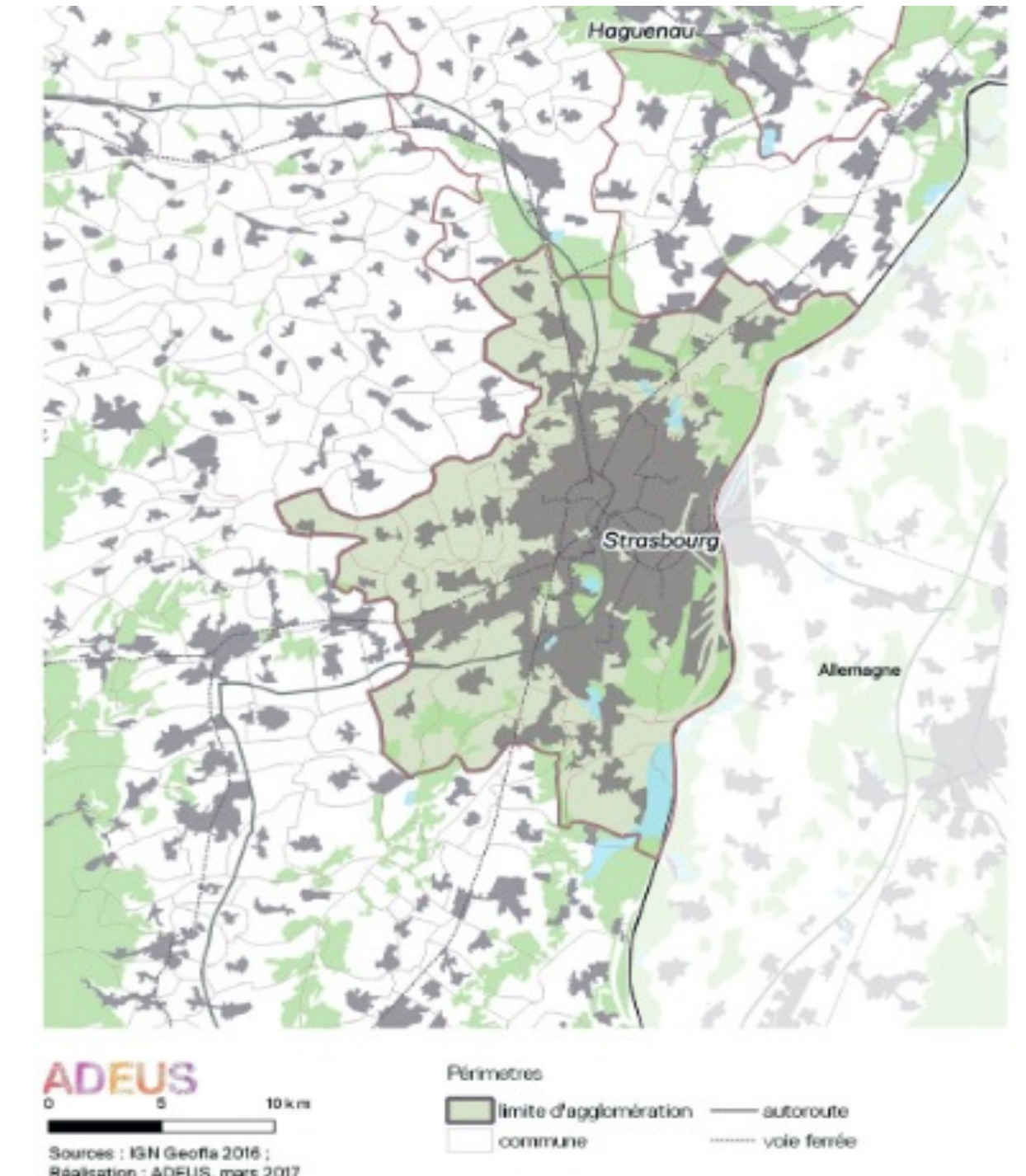
Objectives: 2030-2050 time horizon

Adoption: 2019

Coordination & pilot: **Strasbourg Eurometropolis**, Region, ADEME, ATMO Grand Est, ADEUS, Météo France, + context-wise other local associations or public institution.

Content:

- 1) Diagnosis;
- 2) Strategy & objectives;
- 3) Roadmap
- 4) Monitoring/assessment



Overheating is stated amongst the local risks, though ozone is risen as the main cause of local mortality during HW. No local heat diagnosis yet, apart from a thermal survey campaign (ADEUS, 2014) => inventory of existing UHI works (Météo France). Ongoing research on UHI dynamics & patterns (ADEUS, Météo France, Icube). Overheating is closely linked with the urban greening program yet a blur definition of heat exposure is used by wishing monitoring overheating with « UHI indicators ».

No details on the considered UHI scale or objects targeted by the policies: « 80% population at maximum 300 m far from a cool/green area » → Humans in their residence? Are green areas always cool?

Other sectorial plans or/and strategies

No Overheating mention: local health (noise, energy scarcity, obesity, air pollution); active mobility or housing plans (CLS, PDU or PLH); nor local agriculture/food management strategy (PAT).

Overheating mention: subregional water management strategies (SDAGE, section blue & green infrastructure → cool spots) & regional sustainable development and air/energy/climate strategies (SRADDET & SRCAE). The latter steer objectives upon land artificialisation, building energy renovation, and city greening.

TAKE-AWAY MESSAGES:

UHI is a complex phenomenon often resumed by the sole urban-rural air temperature gradient. How does a + 0.6 K average increase in UHII translate in human body tolerance to heat/mortality?

Currently, overheating views in planning question:

⇒ relevance of planning recommendations during extreme heat? territorial limits of overheating governance? city-periphery environmental justice?

⇒ definition of targets for overheating policies & overheating acceptability limits & methods to assess personal heat exposure

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