# City-level temperature reduction from street green space by city typology and climate zone

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**Abstract**

Vegetation in the street can lower temperatures at neighbourhood level and reduce heat stress for pedestrians. Street green spaces (SGS) is thus an urgently needed nature-based solution for adapting to a warming climate, and also has some ability for carbon uptake. This local solution has global potential, but the cooling potential of street green space depends on local context, urban form and climate zone, among others. Here, we provide estimates of cooling potential of SGS for different climate zones, world regions and city type oriented along a typology recently provided. We find that peak wet bulb globe temperatures are relevantly reduced, and that the effect is greatest for large cities in the tropics and in temperate climates. Cooling from vegetation can only moderate the effect of global warming, not compensate for it. Carbon sequestration potential remains limited at about 0.1 $GtCO_2$/yr, possibly double, if soil carbon is included, with high uncertainties. Street green will continue to be invaluable for local quality of life and be one contributor to reducing temperatures, but will not replace larger climate mitigation efforts.

*Keywords:* urban heat, street green, typologies, climate change adaptation, climate change mitigation

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## 1. Introduction

Street green is a nature-based climate change adaptation strategy against the urban heat island effect (Oke, 1982) with great benefits for the human in the street, well beyond relief from heat. It reduces temperature through evaporative cooling (Fang et al., 2025), provides shade (Turner et al., 2023), and has positive outcomes on mental health (Callaghan et al., 2021). A greater preference for walking or cycling can be an important secondary benefit (Garber et al., 2025). Not only the individual street profits: Street green also reduces heat on the neighbourhood and city scales, and in a global context is has a climate mitigation potential through the uptake of carbon from the atmosphere. Strategies for reducing heat load in cities are direly needed in a time when the majority of human populations live in cities (Dodman et al., 2022), the use of air-conditioning is on the rise but cannot be afforded everywhere (Falchetta et al., 2024), and heat maxima are approaching lethal limits, particularly in tropical cities (Perkins-Kirkpatrick et al., 2026).

A considerable body of research quantifies the potential of urban green to reduce temperature and mitigate climate change (Wong et al., 2021). Outcomes heavily depend on method and metric used, and many studies rely vegetation as observed by satellite, and often use land-surface temperature (Li et al., 2025). Greenness observations from space are heavily skewed by large green areas such as parks, which however also provide cooling (Fang et al., 2025) but not necessarily on street level. Land surface temperature is only in select circumstances a pertinent indicator to describe human heat load (Anders et al., 2025). Fewer studies consider air temperature or heat metrics that include further meteorological variables such as humidity, wind or irradiation that may be more appropriate to describe heat load on humans.

An important co-benefit of urban trees is their contribution to climate change mitigation through the uptake of atmospheric carbon dioxide. Two mechanisms are at play here: Storage in the tree itself, where the long-term future of the carbon depends on the wood's life cycle; and sub-soil storage of carbon. To quantify these, studies leverage diverse methodologies, including field measurements, allometric equations, vegetation modelling, and remote sensing approaches (Li et al., 2026; Oliveira et al., 2022; Nowak et al., 2013; Davies et al., 2011). However, the contribution of street vegetation on long-term carbon uptake is very unclear.

Today's urbanizing world demands for rapid and effective measures to adapt to increasing temperatures and weather extremes, and to mitigate carbon emissions to avoid further dangerous anthropogenic climate change. Solutions need to take into considerations the local context while being applicable in a global context (Creutzig et al., 2025). For this purpose, typologies can be powerful operational tools in moving beyond one-size-fits-most approaches towards categorized solutions that make use of scaling benefits. City typologies thus offer an avenue to investigate the effectiveness of adaptation and mitigation metrics in a global perspective while taking into account some of such local contexts. Recently, a city clustering has been presented, assigning attribution probabilities for 4 different types of cities around the globe (Montfort et al., 2026). Typologies can also help in demonstrating gaps related to global inequality, as they may show that insights or solutions work predominantly for specific contexts, and others may be left out.

In this study we investigate the temperature reduction potential on the neighbourhood level for the city typologies from Montfort et al. (2026) to understand substantial differences and common opportunities. We investigate the cooling currently provided by street green space, as well as for several common climate projections combined with plausible scenarios for future street green futures. These categorized descriptions of cooling potential are based on recently published work (Falchetta et al., 2026; Falchetta and Lohrey, 2025), which estimates cooling efficiencies of urban trees at the neighborhood scale using a high-resultion urban climate model. We further attempt an estimate to include an estimate of the direct carbon mitigation potential of street green.

## 2. Methods and Data

*City Types Clustering*

We here make use of city typologies based on a new data-driven typology of 11,000 global cities, created via Deep Embedded Clustering across 12 structural variables, that resolves four distinct urban types relevant to climate action (Montfort et al., 2026). Cities are categorized into 4 types: Type 1 cities are smaller, lower-income settlements with limited infrastructure and very high cooling needs, predominantly located in Central America, Africa, and Southeast Asia; Type 2 cities are economically growing with low population density and rapid horizontal expansion; Type 3 cities are wealthier, infrastructure-rich, and emissions-intensive, concentrated in North America, Europe, and East Asia; and Type 4 encompasses large and mega cities marked by high densities and population numbers, fast growth, and compound cross-sectoral pressures. Types are not evenly distributed: in Africa alone, 1,532 cities (13% of all cities globally) belong to Type 1, while in Asia, 2,262 cities (20% globally) fall under Type 2.

Two variables within this typology are especially determinative for street tree planting feasibility and urgency: population density — operationalised as inhabitants per $km^2$ of built-up area — and Cooling Degree Days (CDD), defined as the cumulative daily average temperature deviation above 18°C. Both dimensions are among the 12 structural indicators used to generate the typology itself, capturing the biophysical energy demand conditions that drive both heat exposure and the relevance of nature-based interventions. Type 2 cities are characterised by low population density and horizontal expansion — sprawled morphologies that offer planting space but fragment canopy connectivity. Type 4 megacities present the inverse challenge of extreme density with acute heat stress, and often provide particular little shading (Turner et al., 2023). Type 1 cities face very high cooling needs due to their geographic location despite constrained infrastructure, making CDD-driven planting priorities urgent yet potentially institutionally difficult to act upon.

*Cooling from Street Green Space*

The results reported here are based on a recent publication which uses a high-resolution urban climate model to determine the heat reduction potential of SGS on a $100m$ scale for 132 cities (Table 1). These are categorized by local climatic zone – also referred to as urban form – and Köppen-Geiger climate zone (Figure 4, Appendix). The work builds on UrbClim model outputs and adds SGS information, analyzed in depth by Falchetta et al. (2026). In there, SGS estimates are produced by estimating GVI values in a large pool of 10 meter-buffered sampling points within the urban boundaries of each city in each year 2016-2023. The approach uses a machine learning model trained with multi-spectral remote sensing data as well as several climatological variables from ERA5 to estimate coordinate point-level GVI values (Falchetta and Hammad, 2025). The model is trained on ground-truth provided by Seiferling et al. (2017), who calculate coordinate point-level GVI using Google Street View imagery for a pool of cities worldwide. The microclimatic data comes from the UrbClim urban boundary model (De Ridder et al., 2015), which has recently been computer for 142 cities worldwide (Souverijns et al., 2026). Importantly, cluster Type 1 is missing from the existing dataset that is provided in (Falchetta and Lohrey, 2025). This lack is due to the type typically being smaller settlements without own resources that so far have been outside the scope of UrbClim model application. Significant computational and operational resources would have been necessary to add further cities into this analysis (Souverijns et al., 2026). Possible consequences are discussed further below.

We use two heat metrics: Surface air temperature $T_a$ and wet-bulb globe temperature $T_{wg}$. $T_a$ is easy to understand and highly relevant as a basic physical quantity. $T_{wg}$ includes also the effects of humidity on evaporative cooling, solar irradiation and wind. It carries much more meaning understanding heat load on humans, and is also used to assess heat loads to active and exercising persons (Yaglou and Minard, 1957; Ioannou et al., 2022).We thus use it for this analysis, acknowledging that other heat metrics can be useful for other specific situations, and that land surface temperature is a good proxy for midday heat stress (Anders et al., 2025). While our analysis comprise minimum, mean and maximum for all three metrics, we focus the results display to $T_{a,min}$, $T_{a,max}$ and $T_{wg,max}$. The reason is that minimum and maximum temperatures of $T_a$ carry information of the moderation of maximum (daytime) and minimum (nighttime) temperature, and $T_{wg,max}$ is , in our dataset, arguably the most important metric for maximum diurnal heat. Further, we limit the analyses to the hottest three months of the year for each city, determined by the highest monthly average air temperature $\bar{T}_a$. In most northern-hemisphere temperate climates these are June, July, August, but differ in other regions and climates (Table 1).

#### *2.0.1. Future Climate and SGS Scenarios*

We then evaluate future heat metrics and their reduction by SGS scenarios in the year 2050, considering three standard climate scenarios: *Shifting Pathways*, a scenario that is consistent with a 1.5 degree scenario; *Current Policy*, a scenario describing current climate policies; and *SSP5-8.5*, the most pessimistic scenario from CMIP-6 models. This choice represents a wide range of outcomes, and it is consistent with the PROVIDE project for which UrbClim has been applied (Lamboll et al., 2022). The application of these projections to UrbClim simulations and to heat metrics is detailed in Souverijns et al. (2026) and in Falchetta et al. (2026).

Future development of SGS depends on a variety of factors including policy choices and climate-vegetation dynamics. We thus use three different scenarios of future SGS cooling following (Falchetta et al., 2026): One scenario with SGS declining to the $25^{\text{th}}$ percentile of reference SGS for each urban form and climate zone, a moderate ambition with increase to the $75^{\text{th}}$ percentile, and a high ambition with growth to the $90^{\text{th}}$ percentile. See also the depiction in Figure 1.

## 3. Results

We first highlight how street green space varies systematically across both urban form and climate (Figure 1). We find that urban morphology exerts a stronger and more consistent effect than climate zone alone. Sparsely built typologies record the highest SGS at both the lower bound ($10^{\text{th}}$ percentile: GVI of $7.8 - 14.5$) and upper bound ($90^{\text{th}}$ percentile: GVI of $25.2 - 40.7$). On the other end, in heavy industry and compact high-rise LCZs, SGS shows the lowest values across all climates. In compact high rises it reaches a $90^{\text{th}}$ percentile of only 14.1 in continental climates. We interpret this as a structural ceiling on greening potential in dense vertical morphologies. Climate zone obviously affects vegetation. We find that dry climates suppress SGS across every urban form without exception, compressing both bounds (e.g., sparsely built: 7.8 and 25.2 versus 14.5 and 40.7 in tropical), most likely owing to the lack of precipitation. Tropical contexts with their good growing conditions and persistent vegetation, in contrast, yield the highest upper-bound values across urban forms.

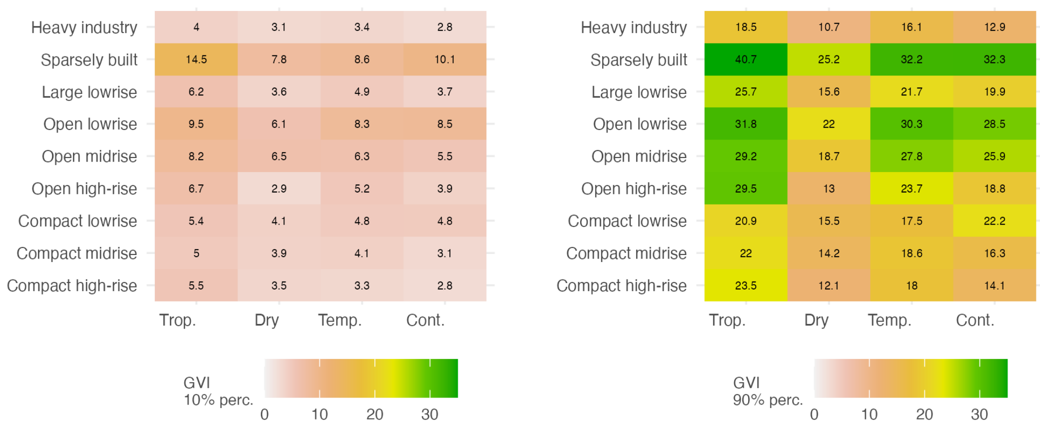


Figure 1: Lower bound ($10^{th}$ percentile, left) and upper bound ($90^{th}$ percentile, right) of observed SGS (in GVI values) for urban form (local climate zone) (Stewart and Oke, 2012) and main Köppen-Geiger climate (Peel et al., 2007). Samples from all years 2016-2023 (local summer conditions) and all cities covered by our analysis were used in deriving these limits. Adapted from (Falchetta et al., 2026).

Notably, the spread between lower and upper bounds is widest in sparsely built and open typologies (e.g., in tropical and temperate climates). Our interpretation is that this high variability within types is likely driven by local planning choices and tree cover management, rather than climate or urban form determinism alone. Compact typologies, by contrast, exhibit narrow and uniformly low SGS ranges, implying that urban density as key factor limits green view potential regardless of climate context. The open categories exhibit the greatest variation across cities (Figure 6 in the appendix), possibly offering the biggest potential for local influence.

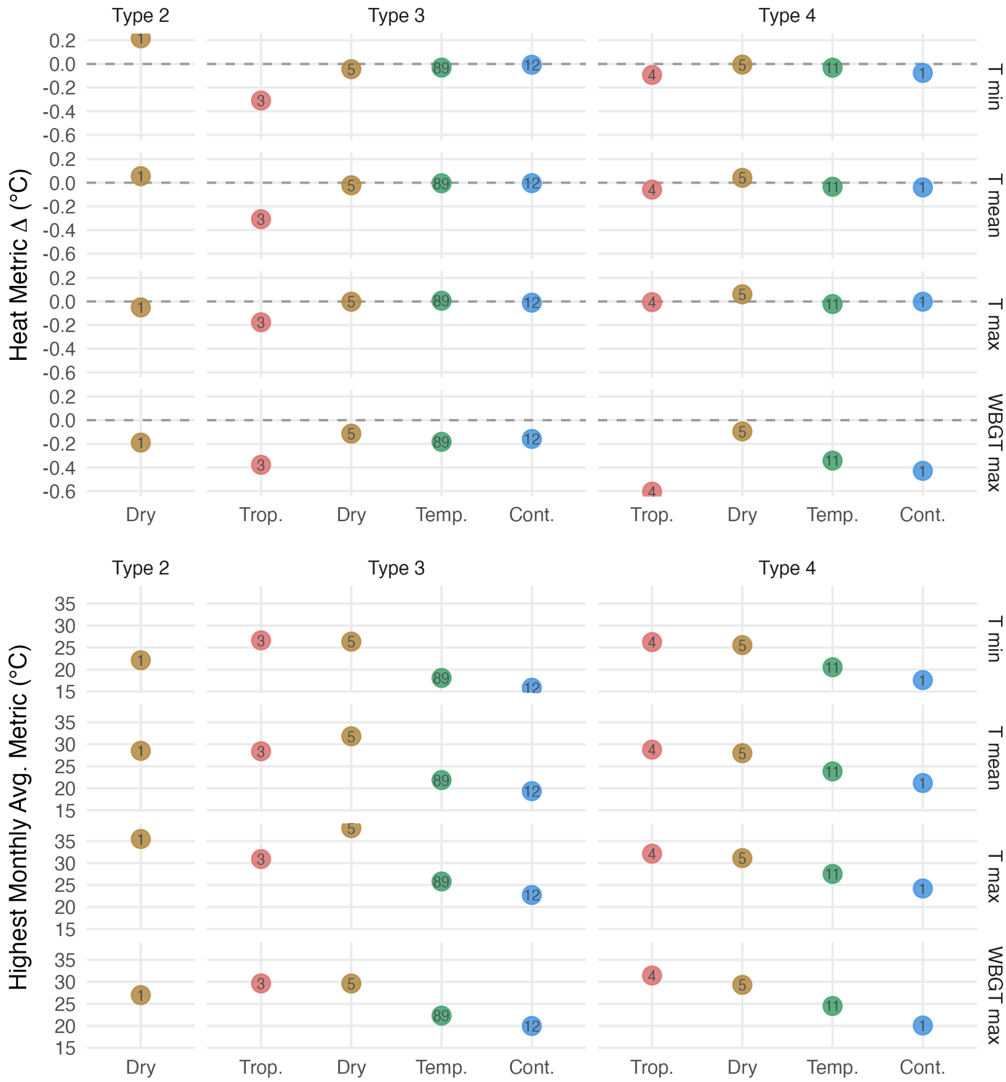


Figure 2: Currently observed overall cooling effect of existing SGS in each city (top) in the three warmest months and average temperature (for each heat metric) during these warmest months (bottom). Numbers denote numbers of cities in each category.

Next, we analyse the cooling potential of SGS across climate zones and three out of the four types of cities (growing, established, and mega cities; noting an absence on data on small developing cities) (Figure 2). We find that SGS reduces heat across all city types, climates, and temperature indicators. However, the magnitude is modest: most effects fall within −0.1°C to −0.5°C and there is no case exceeding $-0.6°C$. Cooling is most pronounced for maximum daily wet-bulb globe temperature ($T_{wg,max}$), which is also most relevant for human health. This is the most relevant metric for understanding extreme heat load. Specifically, in Established Type 3 tropical cities (−0.5°C, n = 3) and Growing Type 2 dry contexts $\mathrm{T_{wg,max}}$ is reduced. For Type 4 cities, reduction for $T_{wg,max}$ is larger than for Type 2 and 3 in Temperate and Tropical climates: In Temperate climates -0.34°C (Type 4), but only -0.18 for Type 3 cities. In Tropical climates, cooling is -0.60°C $T_{wg}$ for Type 4 cities and -0.37°C $T_{wg}$ for Type 3. The effect is not visible for Dry climates, and while it is strong for Continental climates, the evidence base is small with only one data point in the dataset. Explanation of this effect is unclear. It may be only partly related to overall temperatures, as $T_{wg,max}$ for Type 4 cities are overall higher than for Type 3 cities but not to the same degree than the observed temperature difference (Temperate: 24.5°C (Type 4) vs. 22.3 (Type 3); Tropical: 31.4°C (Type 4) and 29.6°C (Type 3)). See also Figure 5 in the appendix. For air temperature, SGS cooling is much lower in the tropics for Type 4 cities than in Type 3 cities for all three $T_{a,min}$, $T_{a,mean}$, and $T_{a,max}$ (Figure 2 top). However, difference in absolute $T$ is small between Type 3 and 4 cities (Figure 2 bottom). Established cities across temperate and continental climates exhibit the smallest cooling effects, clustering near zero for $T_{a,min}$, $T_{a,mean}$, and $T_{max}$. These cities, however, also display a comparatively lower baseline thermal stress (bottom panel), where highest monthly average temperatures in temperate climates are ($\sim 18 - 19°C$) and continental climates ($\sim 12°C$). Established cities, i.e. those that already exist, are substantially below the $25 - 30°C$ ranges that characterise tropical and dry counterparts. Megacities in dry climates ($n = 5$) record among the highest absolute temperatures ($T_{a,max}$ and $T_{wg,max}$ approaching $30 - 35°C$). They yield only moderate cooling deltas in pure Temperature metrics, but high wet bulb temperature reductions. Across all types, the combination of large cooling by SGS with high baseline temperatures in tropical and dry climate cities, identifies corresponding urban environments as where SGS interventions carry the greatest thermo-physiological benefit. Across all cities in this analysis, the highest monthly average temperature is largely defined by climate zone and not city type (Figure 2 bottom panel).

Type 1 emerging cities, mostly small cities with low GDP in hotter climates and focus on acute development and infrastructure provisions, were not covered by the UrbClim modelling efforts (Souverijns et al., 2026) and SGS coverage (Falchetta and Hammad, 2025) that have been used for this analysis. To partially fill this gap, we consulted the literature on the relevant effect of SGS in these contexts, with a focus on Sub-Sahara Africa: The literature shows that street trees also demonstrate measurable cooling potential in African towns, though efficacy depends on water availability and socioeconomic context. In arid African cities, tree cooling efficiency increases with ambient temperature up to 34°C but declines beyond this point as transpiration becomes heat-limited (Cheng et al., 2022). Nonetheless, vegetation presence remains a significant predictor of reduced mean and perceived temperatures in low-income informal settlements across Nigeria, South Africa, Kenya, and Egypt, where mechanical cooling is largely inaccessible to residents (Laue et al., 2022). In Cape Town, empirical evidence confirms that trees outperform grass in surface cooling: The data show that a 10% increase in tree canopy cover reduces land surface temperature by about 0.72°C. Canopy coverage remains markedly lower in poorer neighbourhoods (*Green Apartheit*) which translates into the populations most vulnerable to heat stress benefiting the least from existing urban greening (Zeng et al., 2026). Overall, also in Type 1 emerging cities, street trees are a viable heat mitigation strategy, but potentials are limited by water availability and benefits are distributed unequally.

Across all climate zones, city types, and temperature metrics, street greening interventions consistently fail to offset projected climate warming under Current Policy and SSP5-8.5 scenarios (Figure 3). Warming effects can be attenuated at scale of about 10%, which is relevant, but it cannot be compensated for. The deficit widens substantially under high-emission trajectories, reaching $2.0 - 2.5$°C in Dry and Continental climate zones even under the most ambitious greening scenarios. Street green will hence not help to combat the outcomes from strong climate change. Dry climates exhibit the greatest vulnerability and inter-scenario variability, particularly for $T_{wg,max}$, where street greening shows its most relevant, though still insufficient, cooling signal. This finding matters for human heat stress and public health planning, as $T_{wg}$ captures humidity-driven heat exposure that dry-bulb temperature tends to underestimate.

City type differences (Types 2, 3, and 4) are modest throughout; climate zone is a stronger determinant of net cooling-warming outcomes than urban typology. Altogether, we find that street greening, while valuable as a co-benefit strategy, cannot substitute for deep emissions reductions; in rapidly warming dry and continental cities in particular, greening must be understood as a complementary measure that buys limited thermal relief rather than a standalone adaptation solution. We investigated clustering by region and type (see Figure **??** in the Appendix), which overall reflected the findings for climate zone and type and did not add much additional insight. Similarly, we did not observe any clear relationship between SGS cooling and urban compactness (Figure 7).

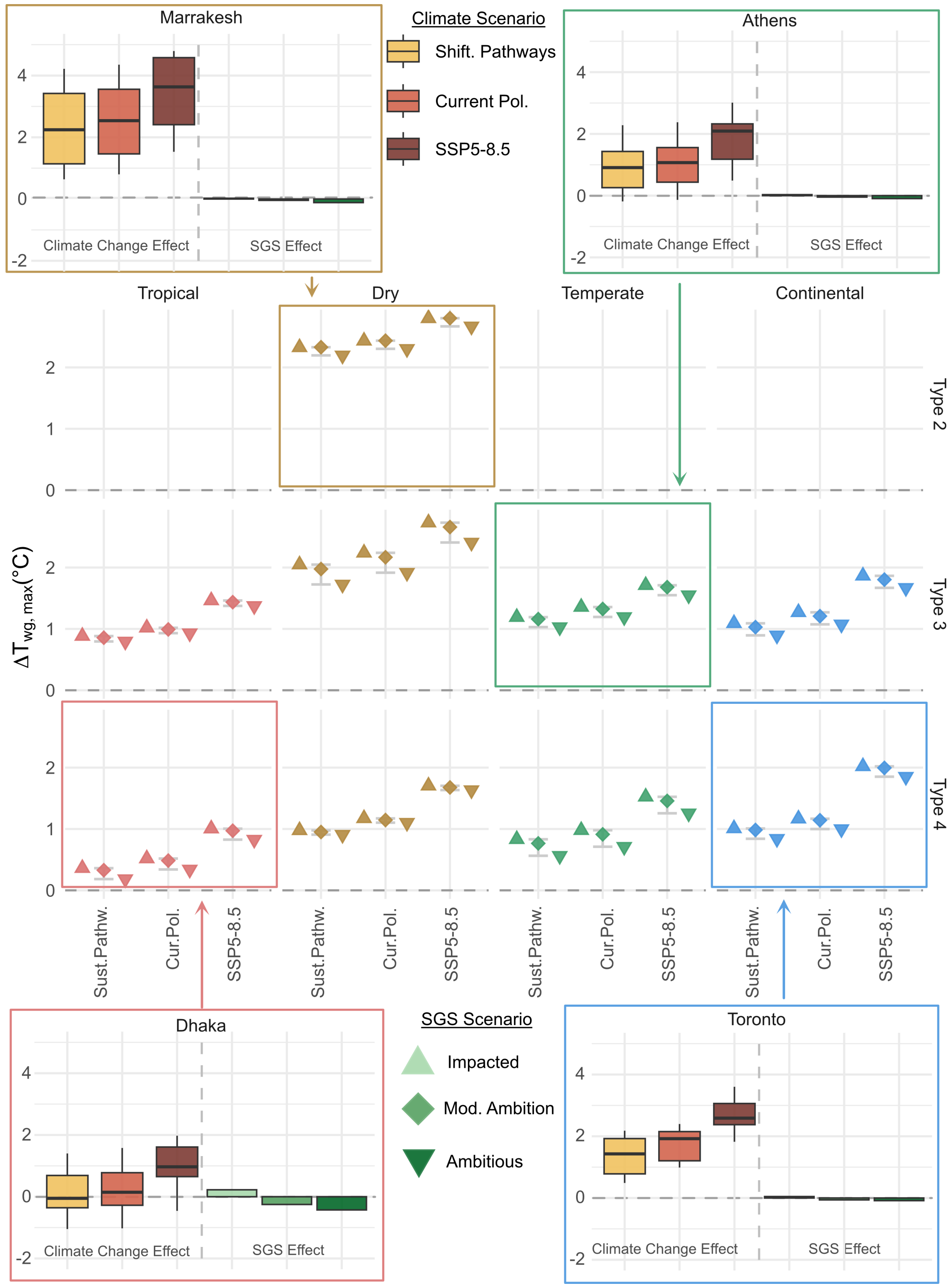


Figure 3: Future net cooling and warming effect of combined changes in street green and climate change for three different climate scenarios in the main panel. The boxes show, for four representative sample cities, future temperature difference from climate change and street green. In each of these panels, the left hand side shows the warming for three different climate change scenarios, the right hand side of each panel the warming or cooling from three different street green space scenarios (declining SGS, moderate increase, ambitious increase). The bars denote range of climate model uncertainty.

We further show more detailed future warming and cooling results for four representative sample cities (individual inlays in Figure 3): Projected warming from climate change for three scenarios as well as climate model uncertainty, alongside cooling from street trees for the three SGS scenarios. This illustrates city-to-city differences, but also the range of uncertainty in climate projections. Note that the results shown here are averages across the entire city, with cooling differences significant across urban forms and neighbourhoods (Falchetta et al., 2026).

We also investigated ways to estimate carbon storage above and below ground from street vegetation. The current potential can be estimated on the basis of two components: Global urban vegetation area and carbon storage values per hectare. Assuming an urban area cover of 0.7 to 1 million km$^2$ worldwide (2015) (Lwasa et al., 2022; Zhao et al., 2022) where green spaces account for 14 to 30% of cover (Husqvarna, 2025; UN-HABITAT, 2024), and above- and below-ground carbon storage densities from 10 to 100 tC/ha (excluding soil carbon sequestration), urban vegetation can be estimated to store from 0.2 to 2.2 GtC (0.7 to 8 $GtCO_2$). If greenness in cities were to be expanded, as per the scenarios discussed in this study, carbon storage and sequestration in urban areas could be enlarged. However, even a doubling of SGS between 2027 and 2050 would hence only contribute a maximum of 0.1 $GtCO_2$/year.

## 4. Discussion and Conclusion

Street green potential varies by local context, and existing urban form and a city's climate zone put a limitation on what is achievable. In dry climates, vegetation is limited by availability of water, even if native species are considered that are adapted to the climate. Indeed, tree species is an important factor in explaining cooling potential (Li et al., 2024). Sparse urban forms also offer more street green, because there is less competition for space from built up areas, such as road infrastructures, and unmanaged vegetation can thrive more easily. But this does not mean that sparse settlements should be preferred: Benefits in one sustainability dimension are often accompanied by negative outcomes in another (Lohrey and Creutzig, 2016). In the case of low density environments, adaptable to somewhat higher SGS, they have a higher predisposition towards energy-intensive transportation and thus higher $CO_2$ emissions. Curitiba (Brazil) offers a lesson on how to moderate this trade-off, namely by guiding development along star-shaped transit-oriented axes, keeping space between the axes free for public parks and forests (Pierer and Creutzig, 2019).

A key motivation of our research is to shed light on the importance of city typologies to understand the effectiveness of nature-based climate solutions across scales. Grouping cities into typologies following Montfort et al. (2026) has the benefit of allowing for communicating the specificity of cities with a global representation that is needed for aligning the policy challenge of climate change adaptation and mitigation (Creutzig et al., 2025). In our case it distinguishes cities with different ranges of capacities, sizes, and development dynamics, relevant factors that allow for the possibility and eventually implementation opportunities for SGS. The categorization also reveals that Type 4 cities – large cities with high population densities – show comparably larger cooling from SGS.

Increasing tree coverages is not a panacea against increasing temperatures and humid heat, which already causes higher morbidity and mortality (Vicedo-Cabrera et al., 2021; Romanello et al., 2025). Yet, we show that street green space offers a useful impact that is not to be neglected: An approximate 10% reduction of projected climate change induced increase in $T_{wg,max}$ for the case of an ambitious SGS scenario and a Current Policies climate change scenario in 2050. This is particularly important provided the strong results for Type 4 cities, one of the common opportunity that we were looking for when employing the city types. These large cities also suffer from a host of other challenges related to human well-being for which vegetation may offer benefits that we did not consider in our modelling study. For example, it can be envisaged that lower temperatures in the street during hot seasons and added green also leads to an increase in active travel modes such as walking and cycling. While travel decision largely depend on urban form and density and transport-system characteristics and network design (Ewing and Cervero, 2010), nature-based solutions can provide a nudge towards active modes. The estimation of such indirect mitigation potential is even more difficult to estimate than for vegetation direct carbon uptake, but presents an interesting angle for future urban transportation research (Garber et al., 2025).

Climate mitigation via emissions reduction is urgently needed. Street green does have benefits in the form of uptake of atmospheric carbon, albeit with large uncertainties and likely a small effect. Most existing studies focus on urban reforestation (that is, enlarging urban forest area), which in cities across the U.S. might incur an increase in carbon sequestration ranging from 23.3 to 52.5 Mt$CO_2$ per year (Cook-Patton et al., 2020; Fargione et al., 2018; McDonald et al., 2024). However, street green space is different from urban forests, and tree growth is hindered by harsh growing environments. More research, including in-situ real-world experimental work is required to provide a closer estimate of the carbon storage and sequestration of urban green spaces.

We conclude that investigating street green alongside city typologies and climate zones offers a way to gain insights into the global effectiveness of this local urban planning and climate adaptation measure. Green streets carries many benefits to the local context and population, including a reduction of heat load at the street level that is non-negligible, but in no city type and scenario sufficient to reduce additional warming from climate change on its own. Other co-benefits include a limited contribution to carbon uptake and positive benefits on human well-being, which can be strong additional local policy motivations.

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## 5. Appendix

### *5.1. City Descriptions*

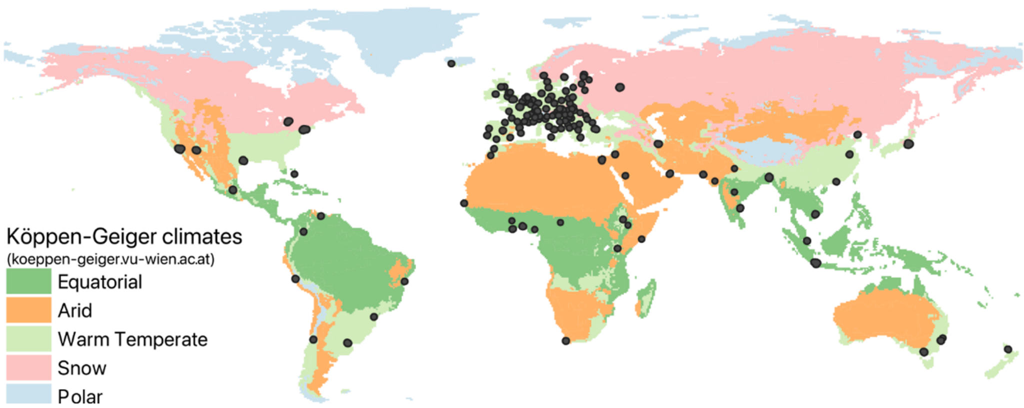


Figure 4: All cities in this analysis and their Köppen Geiger Climate zones. See (Falchetta et al., 2026).

Table 1: All cities in this analysis and their warmest months.

| City | T (°C) | Months | City | T (°C) | Months |
|---|---|---|---|---|---|
| Accra | 28.5 | Feb, Mar, Apr | Lyon | 23.2 | Jun, Jul, Aug |
| Addis Ababa | 18.7 | Mar, Apr, May | Madrid | 27.9 | Jun, Jul, Aug |
| Amman | 25.7 | Jun, Jul, Aug | Marrakesh | 30.0 | Jun, Jul, Aug |
| Amsterdam | 19.0 | Jun, Jul, Aug | Marseille | 25.0 | Jun, Jul, Aug |
| Antwerp | 19.5 | Jun, Jul, Aug | Medina | 36.6 | Jun, Jul, Aug |
| Athens | 29.4 | Jun, Jul, Aug | Melbourne | 21.3 | Jan, Feb, Mar |
| Auckland | 20.7 | Jan, Feb, Mar | Mexico City | 21.2 | Apr, May, Jun |
| Barcelona | 25.6 | Jun, Jul, Aug | Milan | 26.0 | Jun, Jul, Aug |
| Bari | 27.6 | Jun, Jul, Aug | Miskolc | 24.3 | Jun, Jul, Aug |
| Basel | 21.5 | Jun, Jul, Aug | Mogadishu | 28.3 | Mar, Apr, Nov |
| Belgrade | 25.1 | Jun, Jul, Aug | Montpellier | 25.3 | Jun, Jul, Aug |
| Berlin | 21.0 | Jun, Jul, Aug | Moscow | 22.9 | Jun, Jul, Aug |
| Bilbao | 20.9 | Jul, Aug, Sep | Munich | 20.5 | Jun, Jul, Aug |
| Birmingham | 16.7 | Jun, Jul, Aug | Murcia | 28.1 | Jun, Jul, Aug |
| Bogota | 15.7 | Mar, Apr, Sep | Nairobi | 20.9 | Jan, Feb, Mar |
| Bordeaux | 22.5 | Jun, Jul, Aug | Nanjing | 29.4 | Jun, Jul, Aug |
| Brasov | 22.4 | Jun, Jul, Aug | Nantes | 19.9 | Jun, Jul, Aug |
| Bratislava | 23.0 | Jun, Jul, Aug | Naples | 26.8 | Jun, Jul, Aug |
| Brussels | 19.6 | Jun, Jul, Aug | New York | 27.1 | Jun, Jul, Aug |
| Bucharest | 26.1 | Jun, Jul, Aug | Nice | 26.0 | Jun, Jul, Aug |
| Budapest | 24.2 | Jun, Jul, Aug | Novi Sad | 25.5 | Jun, Jul, Aug |
| Buenos Aires | 25.7 | Jan, Feb, Dec | Oslo | 17.8 | Jun, Jul, Aug |
| Cairo | 30.3 | Jun, Jul, Aug | Padua | 26.4 | Jun, Jul, Aug |
| Cape Town | 22.8 | Jan, Feb, Mar | Palermo | 27.5 | Jul, Aug, Sep |

Table 1: All cities in this analysis and their warmest months.

| City | T (°C) | Months | City | T (°C) | Months |
|---|---|---|---|---|---|
| Charleroi | 18.9 | Jun, Jul, Aug | Palma d.M. | 27.1 | Jun, Jul, Aug |
| Cluj-Napoca | 23.1 | Jun, Jul, Aug | Paris | 21.2 | Jun, Jul, Aug |
| Cologne | 20.2 | Jun, Jul, Aug | Pécs | 23.3 | Jun, Jul, Aug |
| Copenhagen | 18.8 | Jun, Jul, Aug | Phoenix | 35.7 | Jun, Jul, Aug |
| Curitiba | 22.2 | Jan, Feb, Dec | Podgorica | 28.5 | Jun, Jul, Aug |
| Dakar | 28.9 | Aug, Sep, Oct | Porto | 22.8 | Jul, Aug, Sep |
| Debrecen | 23.9 | Jun, Jul, Aug | Prague | 21.2 | Jun, Jul, Aug |
| Dhaka | 28.9 | Apr, May, Jun | Rabat | 25.0 | Jul, Aug, Sep |
| Dubai | 36.6 | Jun, Jul, Aug | Reykjavik | 12.8 | Jun, Jul, Aug |
| Dublin | 16.4 | Jun, Jul, Aug | Riga | 19.7 | Jun, Jul, Aug |
| Dusseldorf | 20.0 | Jun, Jul, Aug | Rome | 27.2 | Jun, Jul, Aug |
| Edinburgh | 15.3 | Jun, Jul, Aug | Salvador | 27.1 | Jan, Feb, Mar |
| Frankfurt a.M. | 21.4 | Jun, Jul, Aug | Santiago | 25.9 | Jan, Feb, Mar |
| Gdansk | 19.4 | Jun, Jul, Aug | Sarajevo | 22.7 | Jun, Jul, Aug |
| Geneva | 21.3 | Jun, Jul, Aug | Seville | 29.9 | Jun, Jul, Aug |
| Genoa | 24.8 | Jun, Jul, Aug | Singapore | 30.2 | Apr, May, Jun |
| Ghent | 18.9 | Jun, Jul, Aug | Skopje | 27.0 | Jun, Jul, Aug |
| Glasgow | 15.3 | Jun, Jul, Aug | Sofia | 24.1 | Jun, Jul, Aug |
| Gothenburg | 18.0 | Jun, Jul, Aug | Split | 26.4 | Jun, Jul, Aug |
| Graz | 22.2 | Jun, Jul, Aug | Stockholm | 18.5 | Jun, Jul, Aug |
| Hamburg | 19.2 | Jun, Jul, Aug | Strasbourg | 22.7 | Jun, Jul, Aug |
| Helsinki | 19.2 | Jun, Jul, Aug | Sydney | 23.8 | Jan, Feb, Dec |
| Ho Chi Minh C. | 29.6 | Mar, Apr, May | Szeged | 25.4 | Jun, Jul, Aug |
| Houston | 30.1 | Jun, Jul, Aug | Tallinn | 18.7 | Jun, Jul, Aug |
| Istanbul | 26.1 | Jun, Jul, Aug | Tartu | 19.3 | Jun, Jul, Aug |
| Jakarta | 28.9 | May, Sep, Oct | Tehran | 32.3 | Jun, Jul, Aug |
| Karachi | 30.5 | May, Jun, Jul | Thessaloniki | 28.3 | Jun, Jul, Aug |
| Košice | 22.3 | Jun, Jul, Aug | Tirana | 27.8 | Jun, Jul, Aug |
| Krakow | 21.2 | Jun, Jul, Aug | Tokyo | 28.5 | Jul, Aug, Sep |
| Lagos | 28.5 | Feb, Mar, Apr | Toronto | 24.1 | Jun, Jul, Aug |
| Leeds | 16.0 | Jun, Jul, Aug | Toulouse | 23.7 | Jun, Jul, Aug |
| Leipzig | 20.9 | Jun, Jul, Aug | Triest | 24.9 | Jun, Jul, Aug |
| Liège | 19.1 | Jun, Jul, Aug | Turin | 25.4 | Jun, Jul, Aug |
| Lille | 19.2 | Jun, Jul, Aug | Utrecht | 19.0 | Jun, Jul, Aug |
| Lima | 24.7 | Jan, Feb, Mar | Varna | 25.7 | Jun, Jul, Aug |
| Lisbon | 23.0 | Jul, Aug, Sep | Vienna | 22.7 | Jun, Jul, Aug |
| Ljubljana | 23.4 | Jun, Jul, Aug | Vilnius | 20.0 | Jun, Jul, Aug |
| Lodz | 20.3 | Jun, Jul, Aug | Warsaw | 21.5 | Jun, Jul, Aug |
| London | 18.5 | Jun, Jul, Aug | Wroclaw | 21.2 | Jun, Jul, Aug |
| Los Angeles | 26.8 | Jul, Aug, Sep | Zagreb | 23.9 | Jun, Jul, Aug |
| Luxembourg | 19.2 | Jun, Jul, Aug | Zurich | 20.7 | Jun, Jul, Aug |

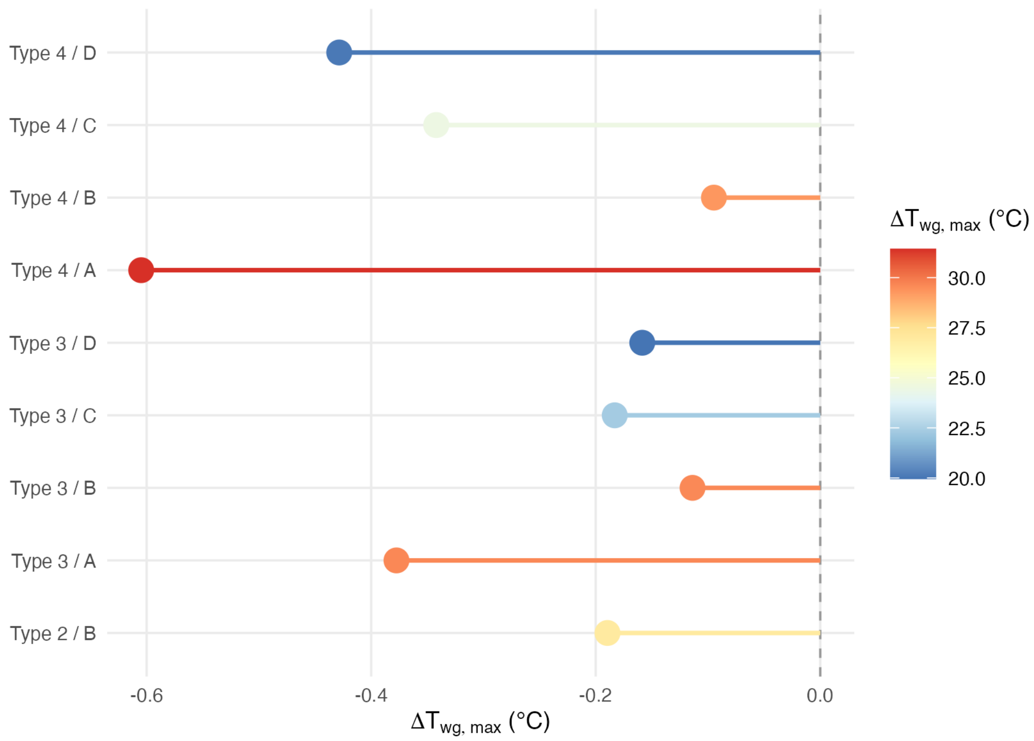


Figure 5: Cooling from SGS and absolute temperature organized by city type. Cooling is averaged across all cities and urban forms in each climate zone. Average temperature is provided for the three hottest months (max $\bar{T}$) in the climatology. Numbers denote numbers of cities in each category.

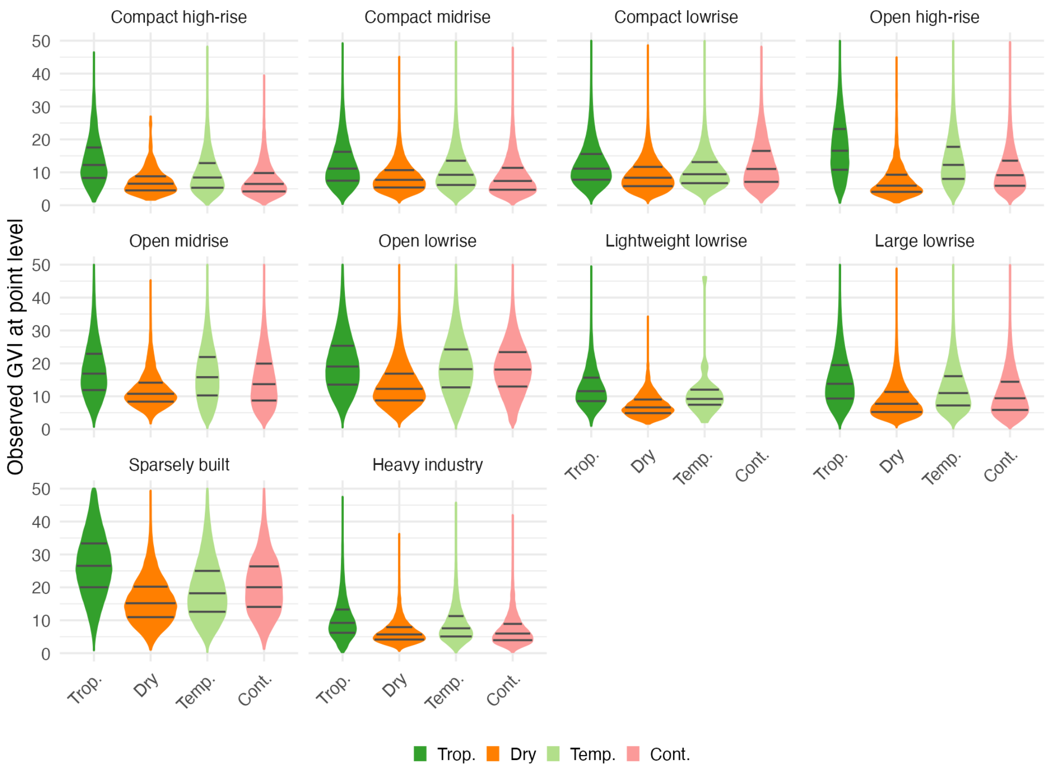


Figure 6: Distribution of observed SGS from by urban form and climate zone (colors).

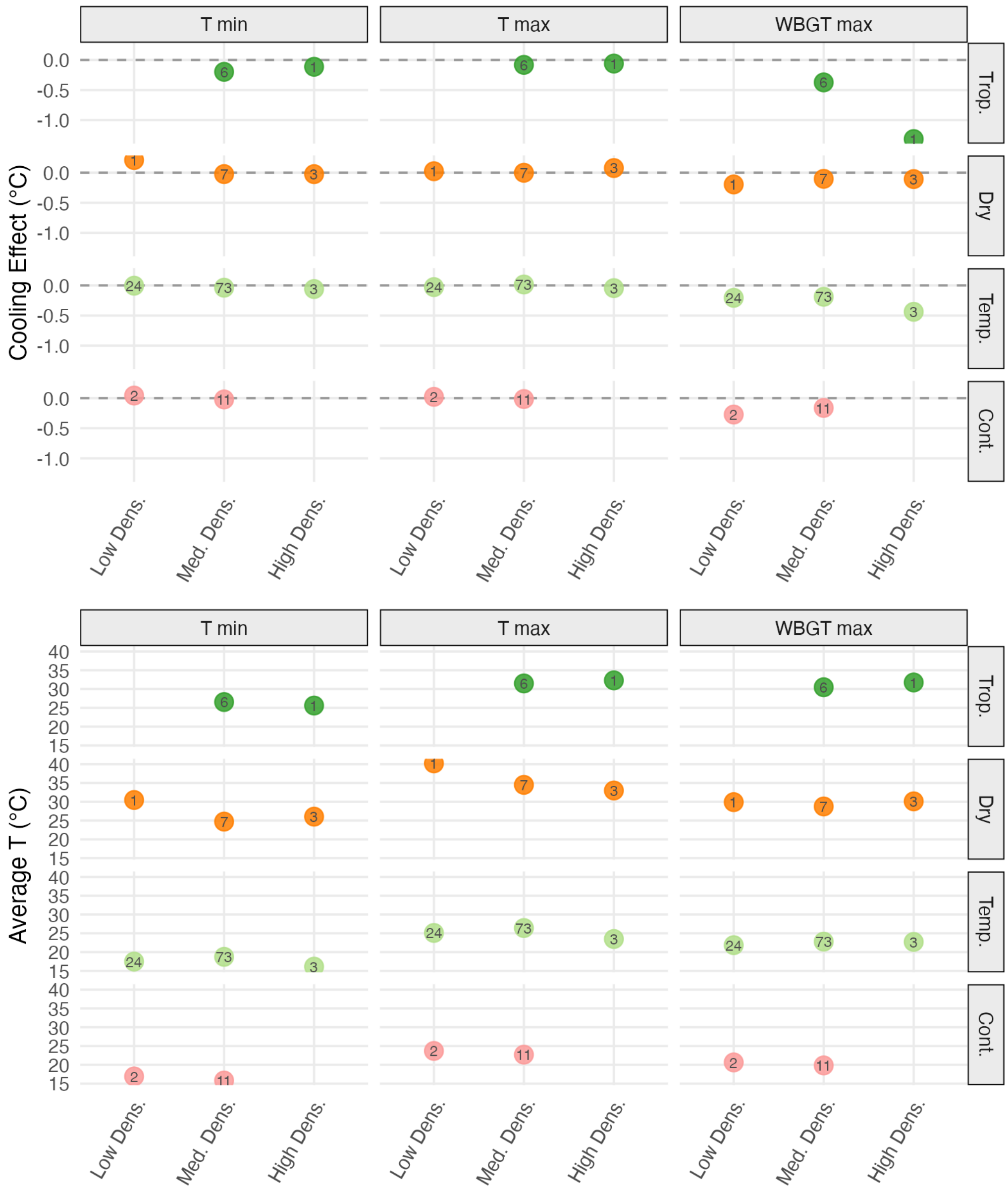


Figure 7: Observed cooling from SGS (top) and average temperature of the three hottest months (bottom) for which the cooling on top is reported. Cities here are categorized by urban density: Bottom 20%, 20%-80|, the densest 80%. Numbers denote numbers of cities in each category.