DENVER
THE MILE HIGH CITY

APPENDIX:
URBAN HEAT ISLAND

Heat Island Effect

Urban Heat Island

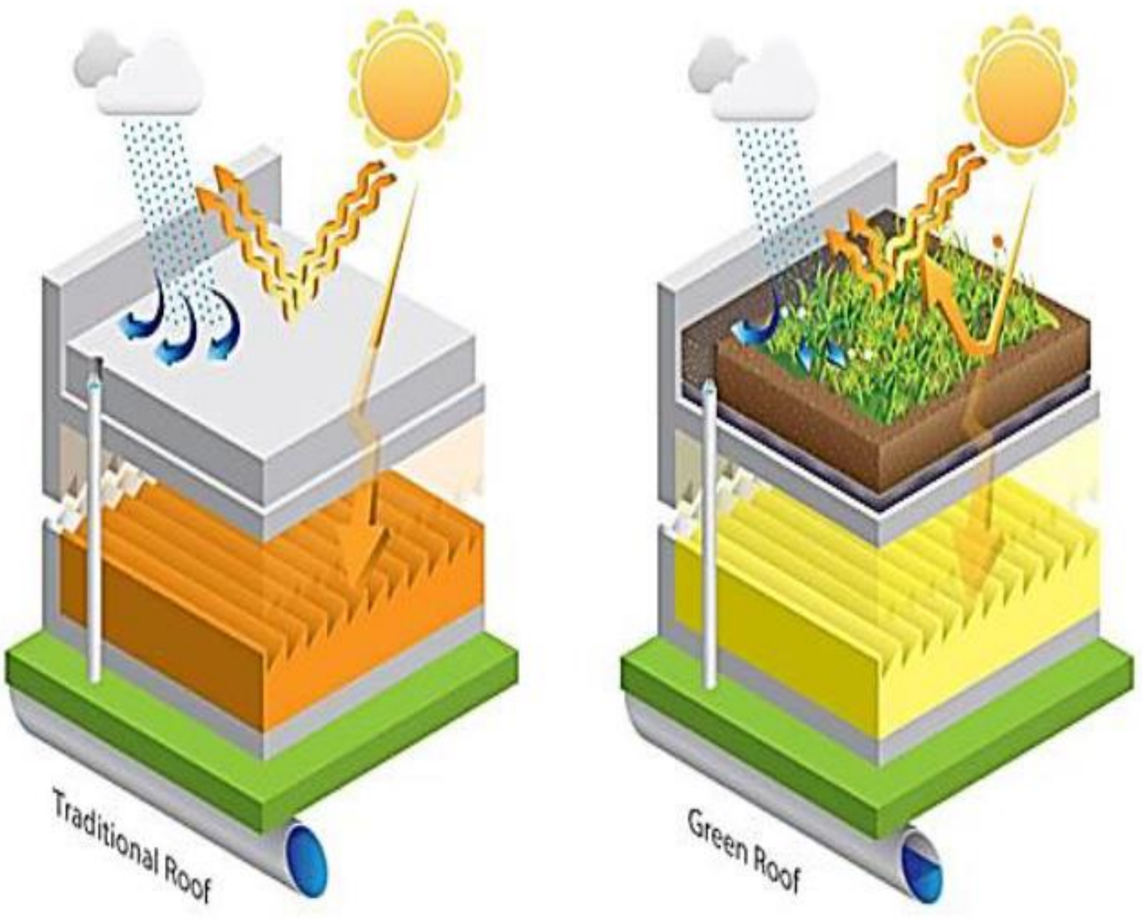


Image Source: Heidarinejad, Ghassem, and Arash Esmaili. 2016. "Assessment of green roof energy savings compared to conventional roof." eSim.

Urban Heat Island

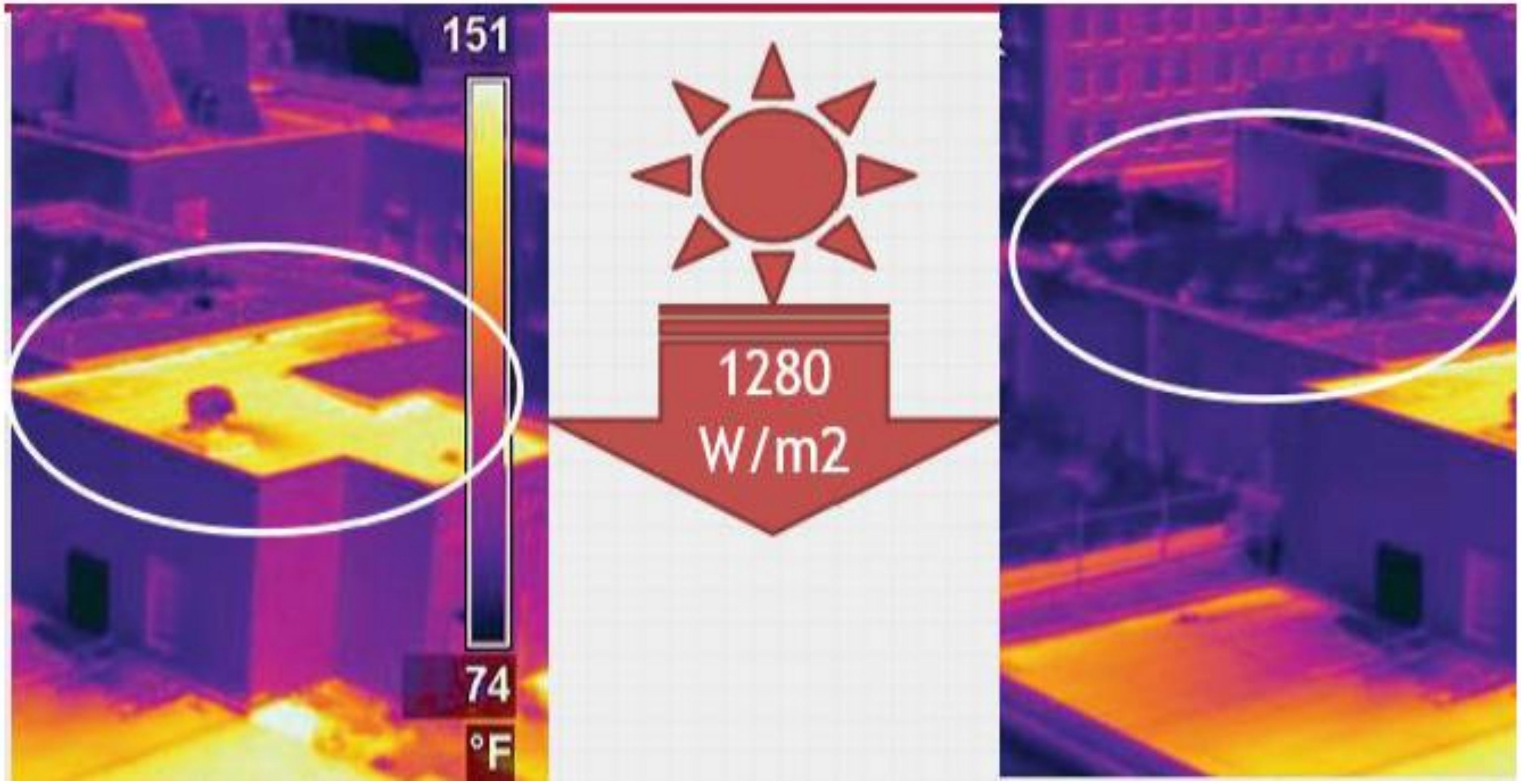


Image Source: Heidarinejad, Ghassem, and Arash Esmaili. 2016. "Assessment of green roof energy savings compared to conventional roof." eSim.

Urban Heat Island

SUMMER IN THE CITY:
HOT AND GETTING HOTTER

CLIMATE CENTRAL 2014

Source: Kenward, Alyson et al. 2014. “Summer in the City: Hot and Getting Hotter." Climate Central.

Urban Heat Island

Figure 2. Urban heat island temperature profile.[5]

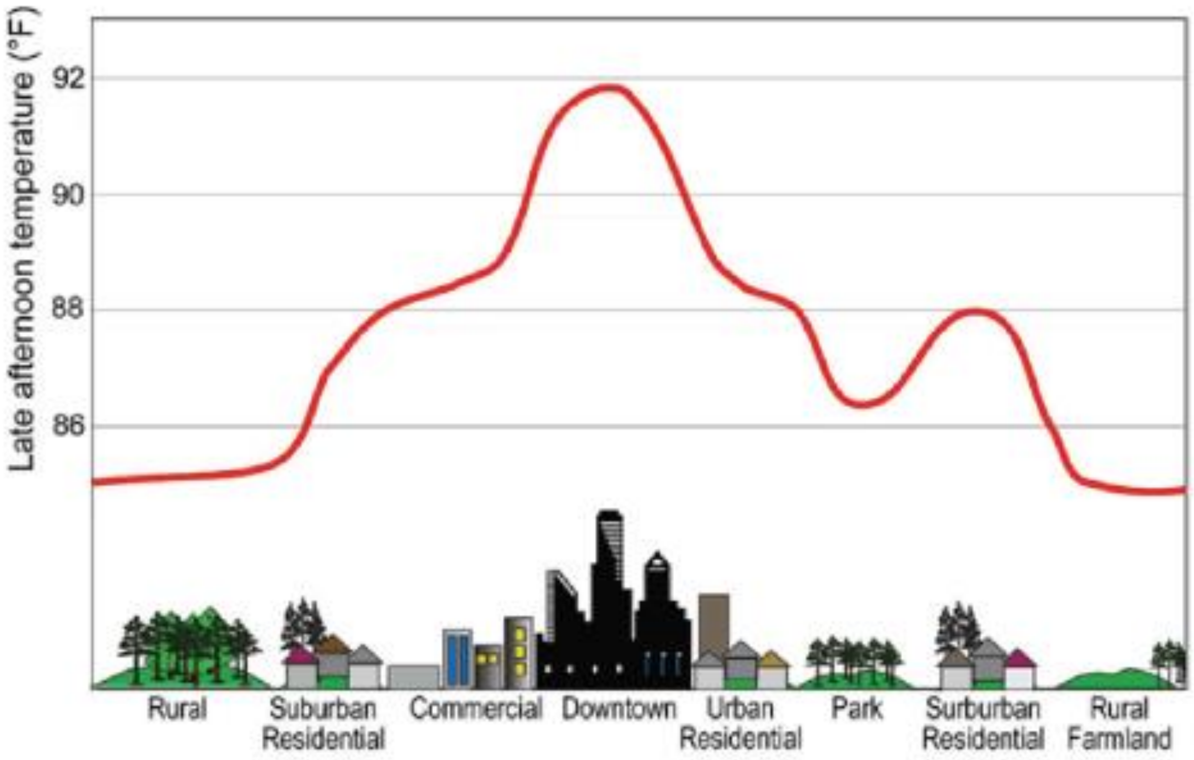


Image Source: Kenward, Alyson et al. 2014. “Summer in the City: Hot and Getting Hotter." Climate Central.

Based on: Natural Resources Canada. 2004. “Adapted from Climate Change Impacts and Adaptation: A Canadian Perspective.” Edited by D. S. Lemmen and F. J. Warren. Ottawa. ON: Climate Change Impacts and Adaptation Program.

Urban Heat Island

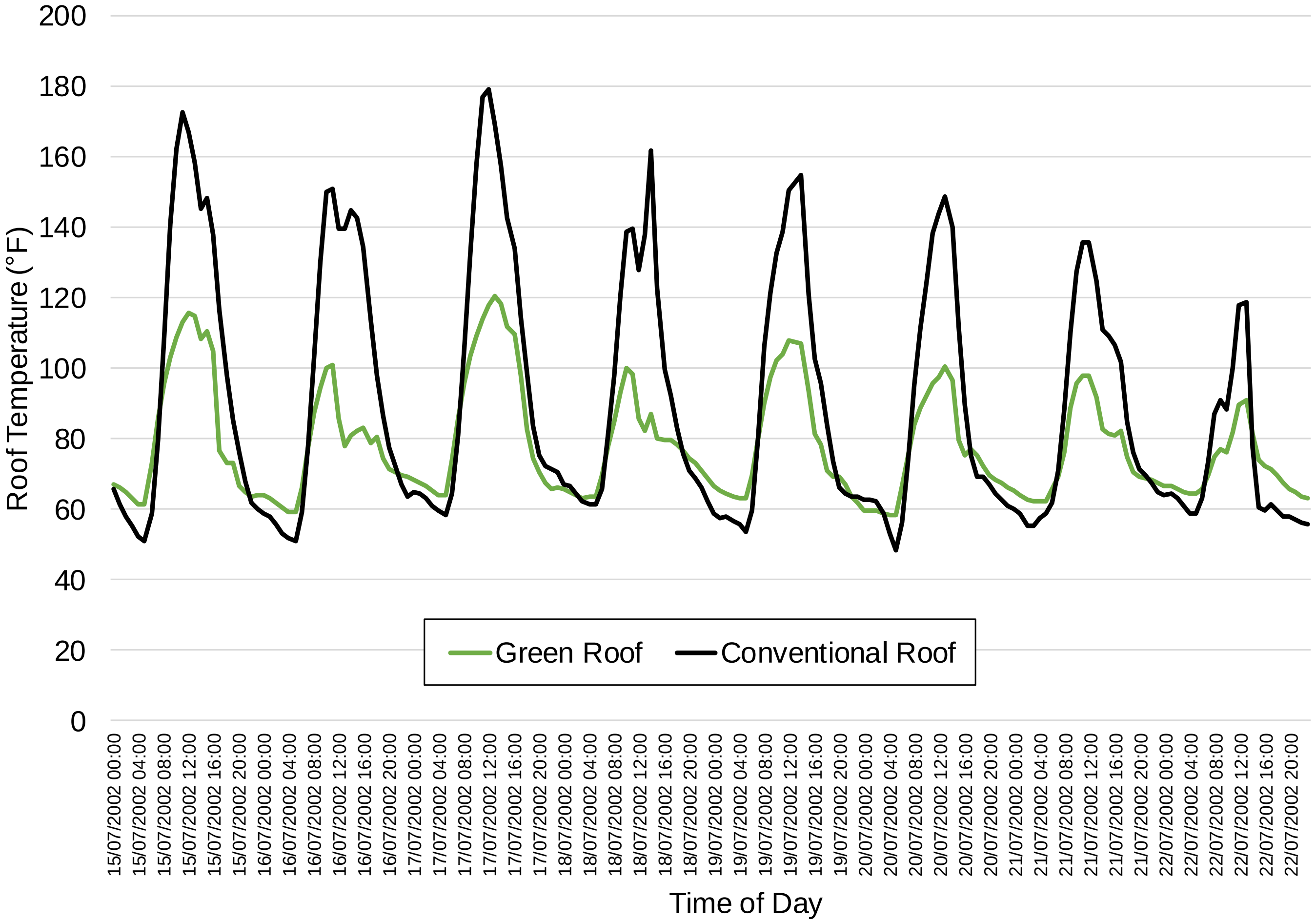
The top 10 cities with the most intense summer urban heat islands (average daily urban-rural temperature differences) over the 2004-2014 are:

- Las Vegas (7.3°F)
- Albuquerque (5.9°F)
- Denver (4.9°F)
- Portland (4.8°F)
- Louisville (4.8°F)
- Washington, D.C. (4.7°F)
- Kansas City (4.6°F)
- Columbus (4.4°F)
- Minneapolis (4.3°F)
- Seattle (4.1°F)

Source: Kenward, Alyson et al. 2014. "Summer in the City: Hot and Getting Hotter." Climate Central. Temperature data is drawn from the Applied Climate Information Systems database (ACIS), which itself draws on data from NOAA/NCDC's Global Historical Climatology Network (GHCN).

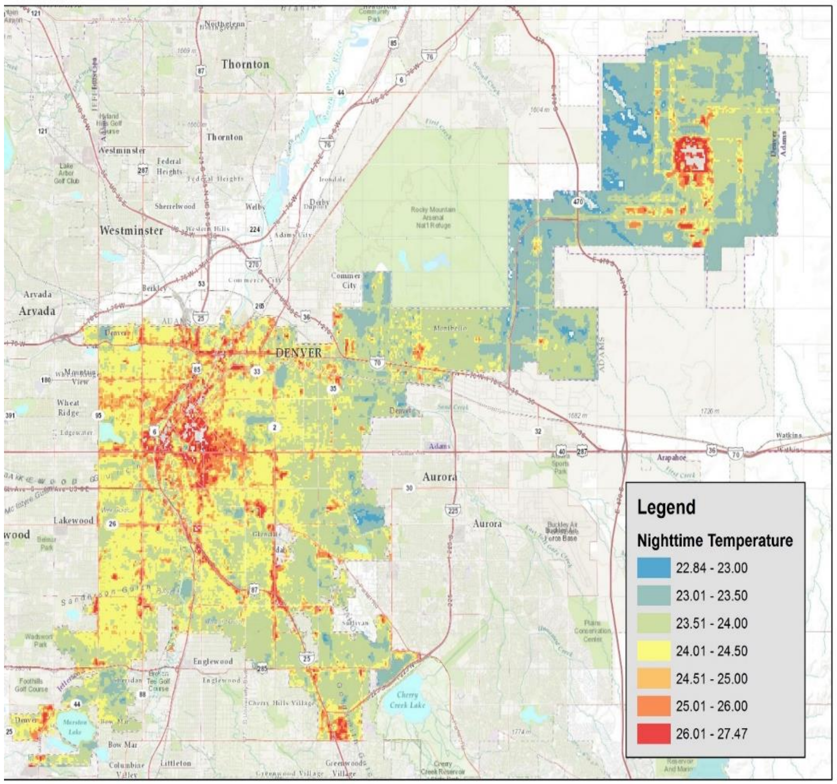
Heat Island Effect

Roof Temperatures in Summer

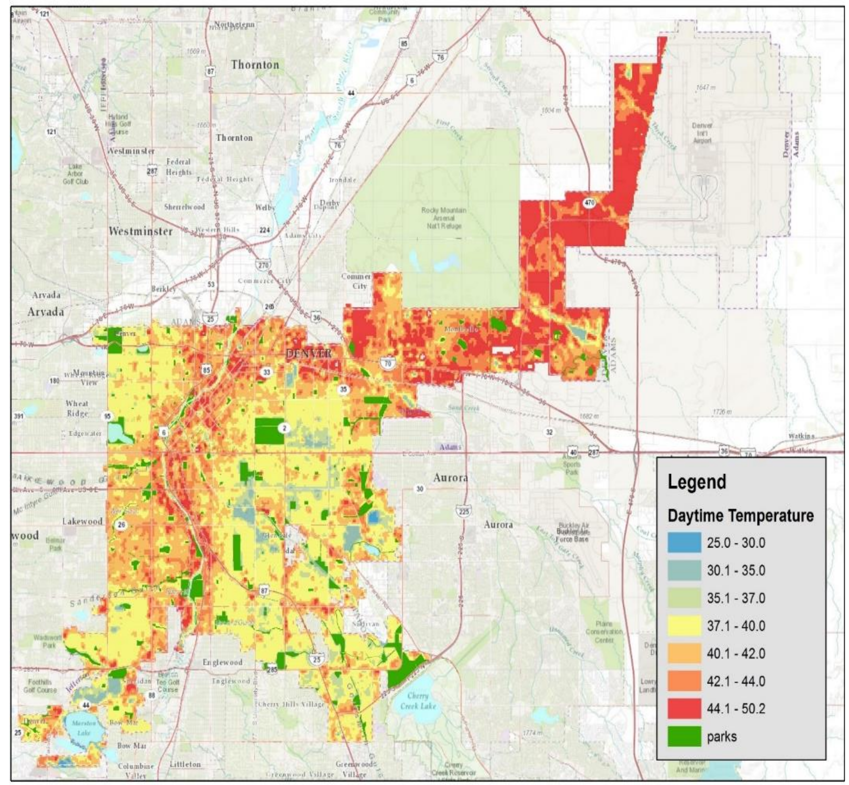


Surface Temperature: Night and Day

Nighttime August 2003

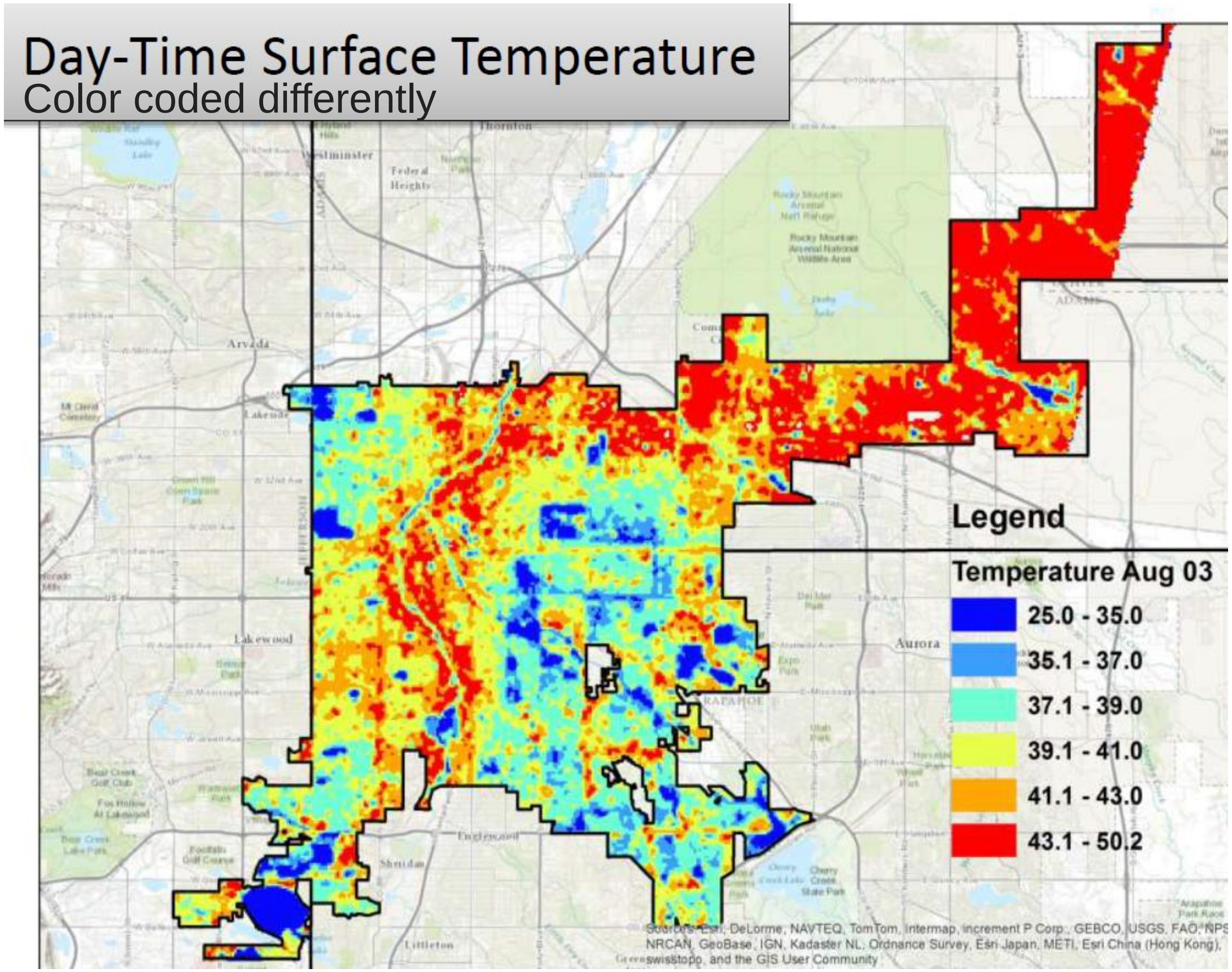


Daytime June 2012



Source: Mehdi Heris and Austin Troy, CU Denver Dept of Urban and Regional Planning

Daytime Surface Temperature

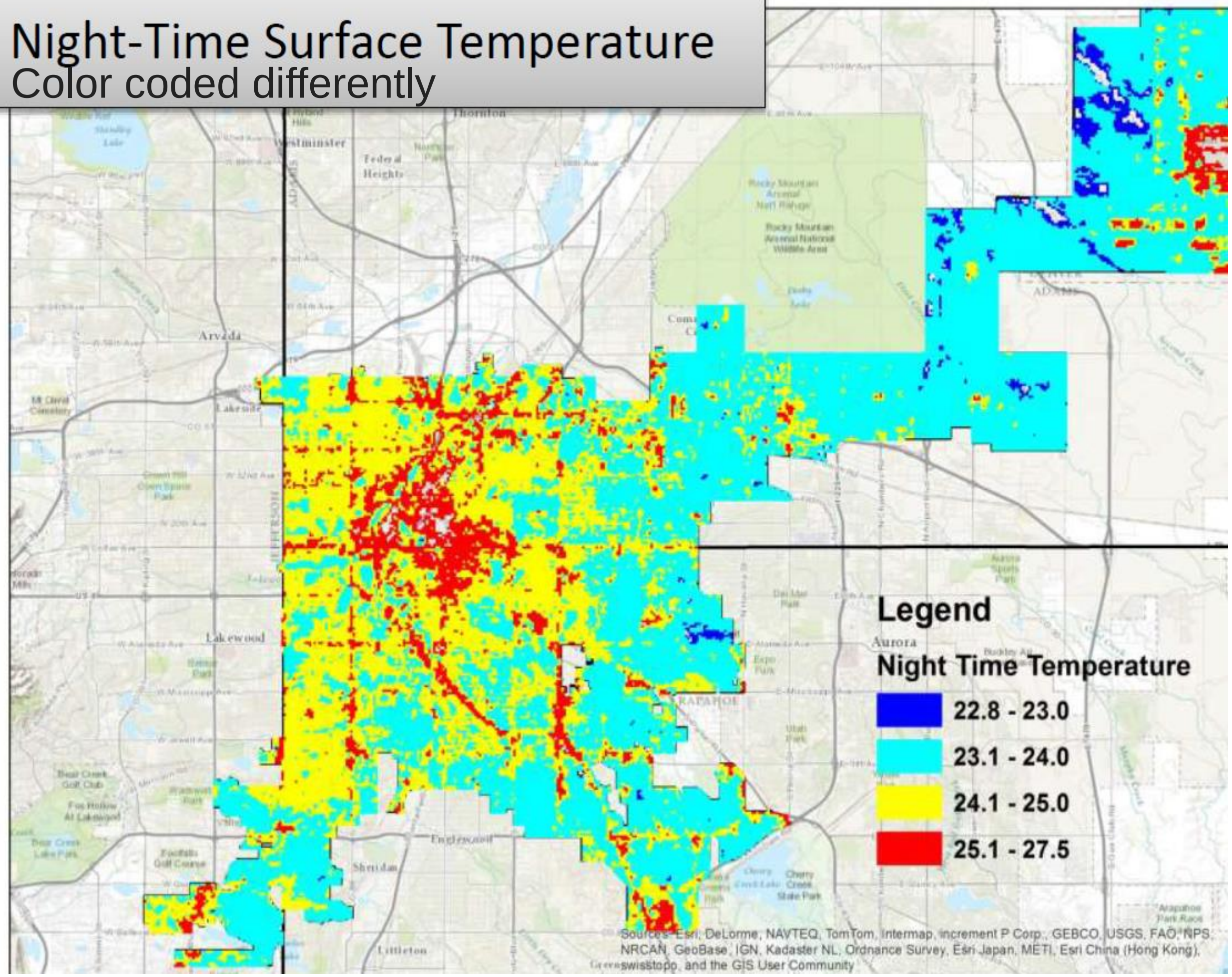


Source: Mehdi Heris and Austin Troy, CU Denver Dept of Urban and Regional Planning

Heat Island Effect

Nighttime Surface Temperature

Night-Time Surface Temperature
Color coded differently

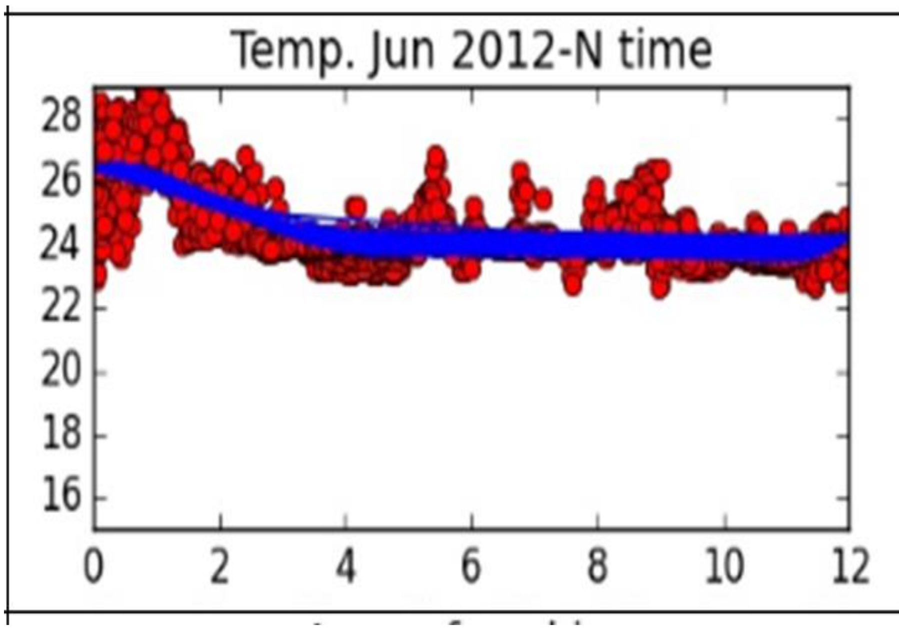


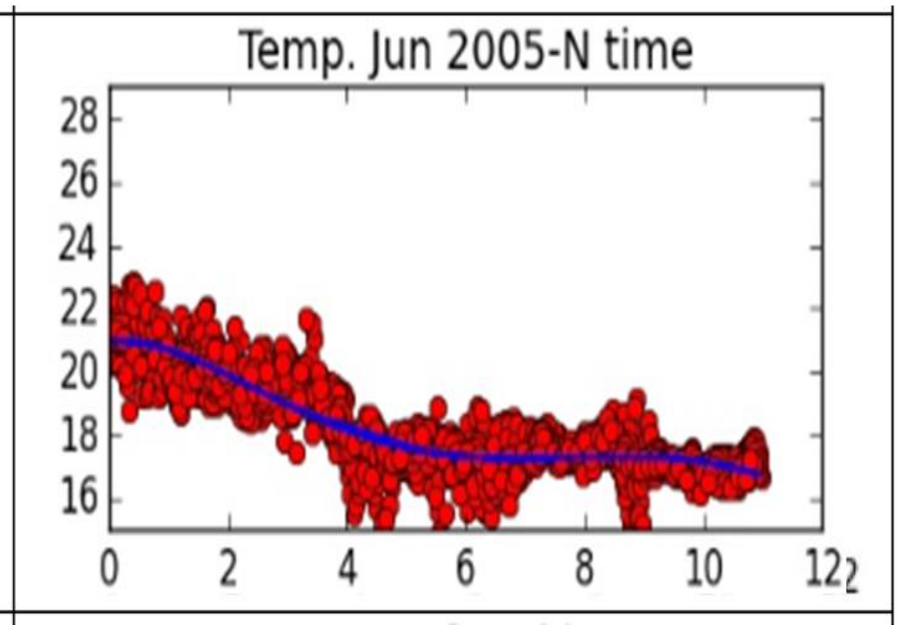
Source: Mehdi Heris and Austin Troy, CU Denver Dept of Urban and Regional Planning

Typical Nighttime Heat Island Profile

Denver

Baltimore



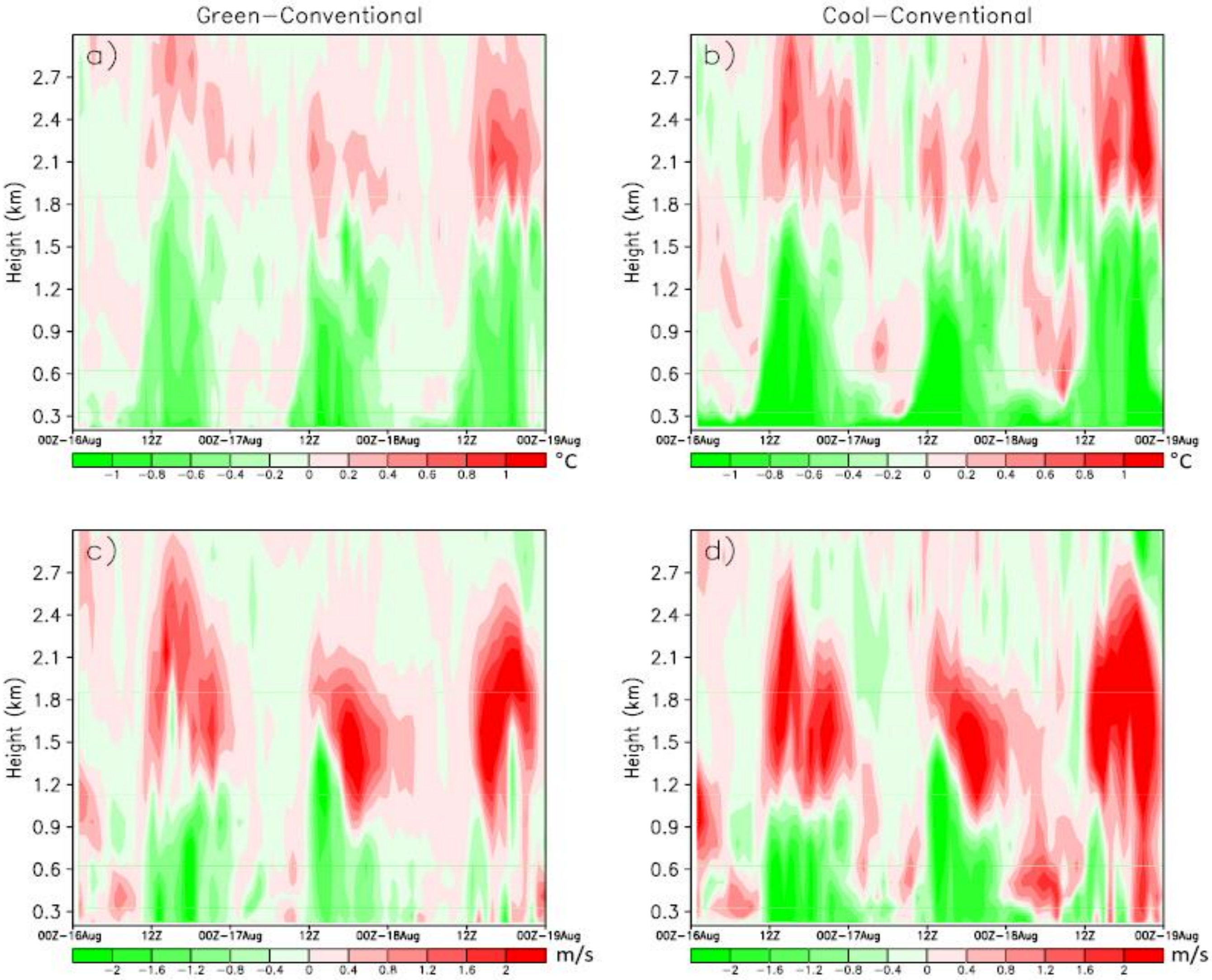


Distance to CBD

Distance to CBD

Source: Mehdi Heris and Austin Troy, CU Denver Dept of Urban and Regional Planning

2016 Chicago UHI and Meteorology



2014 US Urbanization Scenarios on Temps in 2100

Table 1. Naming convention of experiments

Control	Baseline urban extent
A2 ICLUS	Maximum urban expansion
B1 ICLUS	Minimum urban expansion
A2 green roofs	As A2 ICLUS with green roofs
A2 cool roofs	As A2 ICLUS with cool roofs
A2 green–albedo	As A2 ICLUS with hybrid roofs

All experiments were repeated three times (i.e., three ensemble members), with variable spin-up time using 2001–2008 climate. *SI Appendix*, Tables S1 and S2 shows additional details on experiments. A2 cool roofs, the same as A2 ICLUS experiments but with the incorporation of cool roofs for all urban areas; A2 green–albedo, the same as A2 ICLUS experiments but with the incorporation of reflective green roofs for all urban areas; A2 green roofs, the same as A2 ICLUS experiments but with the incorporation of green roofs for all urban areas; A2 ICLUS, experiments using projected A2 ICLUS urban representation for year 2100; B1 ICLUS, experiments using projected B1 ICLUS urban representation for year 2100; control, control experiments using ICLUS urban representation for year 2000.

Table 2. Average JJA near-surface temperature difference (urban expansion/adaptation scenario minus control) for urban and greenhouse gas-induced (mean of 2079–2099 minus mean of 1990–2010) climate change for each of the statistically significant urbanized areas outlined in Fig. 1

	ΔT_{URB}* (°C); ΔT_{GHG}† (°C)	ΔE_{URB}‡ (%); ΔE_{GHG}§ (%)
California		
A2	1.29; 5.51	+ (6–26); + (28–110)
B1	0.69; 0.99	+ (3–14); + (5–20)
Cool roofs	−1.45	− (7–29)
Green roofs	−0.24	− (1–5)
Green–albedo roofs	−1.66	− (8–33)
Arizona		
A2	0.94; 4.86	+ (5–19); + (24–97)
B1	0.26; 1.18	+ (1–5); + (6–24)
Cool roofs	−0.47	− (2–9)
Green roofs	−0.15	− (1–3)
Green–albedo roofs	−0.80	− (4–16)
Texas		
A2	1.15; 5.24	+ (6–23); + (26–105)
B1	0.71; 1.14	+ (4–14); + (6–23)
Cool roofs	−1.24	− (6–25)
Green roofs	−0.46	− (2–9)
Green–albedo roofs	−1.46	− (7–29)