Nationwide surface thermal analysis to detect priority areas for urban mitigation interventions

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Research projects

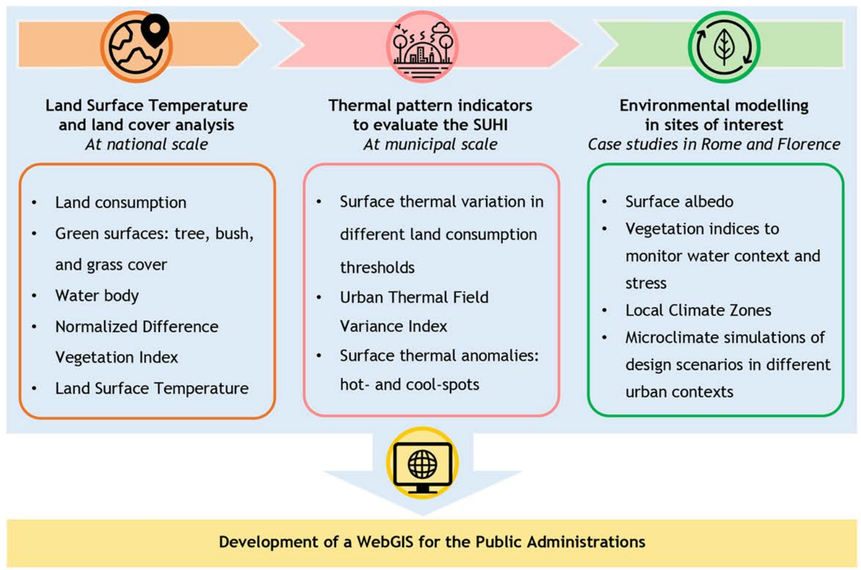
This research addresses the growing impact of climate change, particularly linked to extreme weather events like heatwaves, on urban areas, highlighting the vulnerability of cities. It focuses on nationwide surface thermal analyses in Italy to identify priority areas for **Urban Heat Island** (UHI) **mitigation strategies.** The aim is to improve **thermal comfort** in urban areas affected by thermal anomalies, integrating **Nature-Based Solutions** (NBS) and **high-albedo surfaces** ("cool materials").

Geospatial data and findings are presented from two research projects:

1. ***"MIRIFICUS"* Project:** A national-scale study funded by the Italian Space Agency (ASI), coordinated by the Institute of Bioeconomy of the National Research Council of Italy (CNR-IBE), in collaboration with the Institute for Environmental Protection and Research of Italy (ISPRA).
2. ***"Climate Change* & *Biodiversity"* Project:** A local study focused on Florence, funded by the Capellino Foundation, also directed by CNR-IBE in collaboration with the University of Florence.

Both projects use geospatial indicators to describe urban landscape and morphology, land cover and thermal pattern, integrating remote sensing data from **ASI** (Prisma), **NASA** (Landsat-8 and 9), and **Copernicus** (Sentinel-1 and 2).

The study workflow

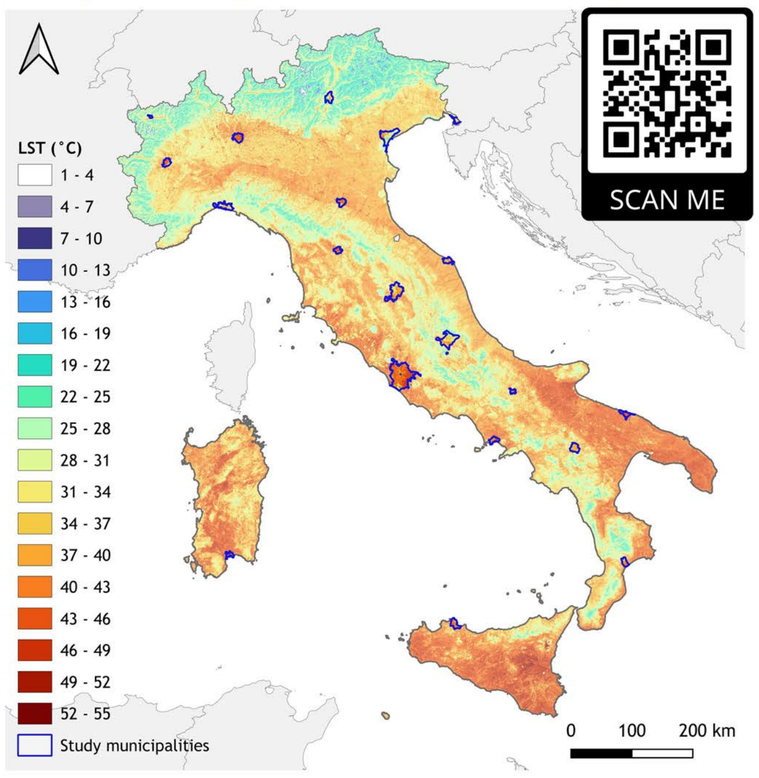


Geospatial data

Acronym	Description	Source	Spatial resolution (m)
LC	Land consumption	Sentinel-1 and Sentinel-2	10
TC	Tree cover	Sentinel-1 and Sentinel-2	10
GC	Grass cover	Sentinel-1 and Sentinel-2	10
WC	Water body cover	Sentinel-1 and Sentinel-2	10
NDVI	Normalized Difference Vegetation Index	Sentinel-2	10
LST	Land Surface Temperature	Landsat-8 and 9, MODIS	60
UTFVI	Urban Thermal Field Variance Index	Landsat-8 and 9, MODIS	60
HOT-SPOT	Surface thermal anomalies	Landsat-8 and 9, MODIS	60
SA	Surface albedo	Sentinel-2	10
LCZ	Local Climate Zones	Digital Surface Model Sky View Factor Urban Atlas Land Cover	100

"MIRIFICUS" Project: Surface thermal analysis from remote sensing data

Daytime average summer Land Surface Temperature



Four seasonal average daytime Surface Temperature datasets were obtained from 2013-2023 Landsat-8, Landsat-9 and MODIS data.
In addition, t**hree geospatial thermal indicators** were applied to the summer ST dataset within the Italian regional capital cities, in particular:

1. **summer surface thermal variations** were analyzed in **urban, suburban and rural areas** (characterized by specific land consumption thresholds);
2. the **Urban Field Variance Index** was applied in order to evaluate the **SUHI intensity**;
3. the **Hot-spot analysis** was performed by applying a **local spatial autocorrelation statistical method**, the Getis-Ord Gi* method, to detect summer thermal anomalies.

Selected geospatial indicators

LST variations in different land consumption (LC) thresholds

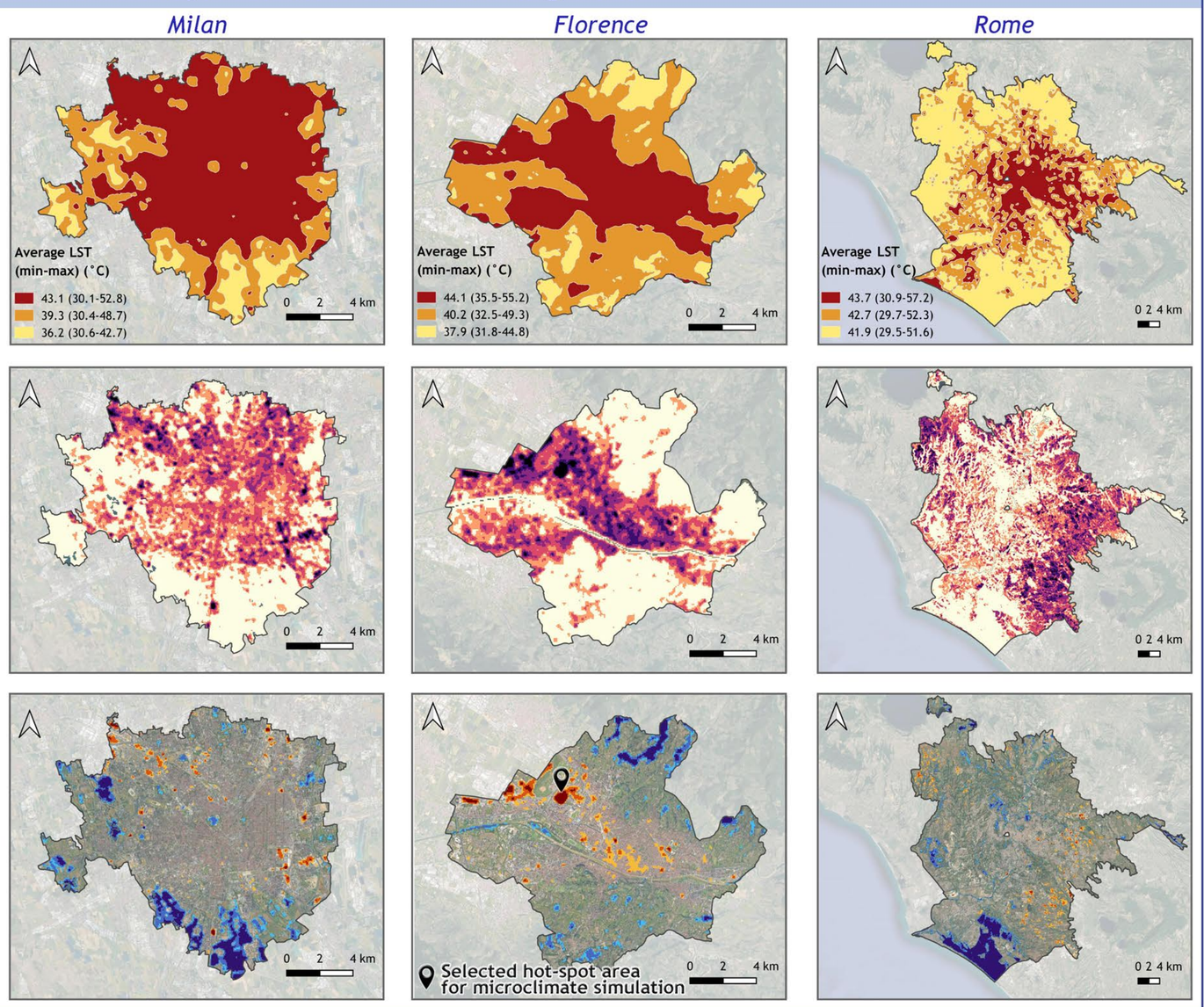
- Urban: LC > 50%
- Suburban: LC 10%-50%
- Rural: LC < 10%

SUHI intensity
(Urban Thermal Field Variance Index)

- Absent
- Low
- Moderate
- High
- Very high
- Extreme

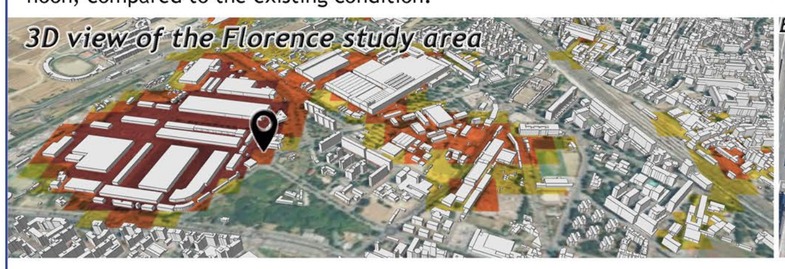
Surface thermal anomalies
(Hot-spot analysis)

- Cool-spot, level 1
- Cool-spot, level 2
- Cool-spot, level 3
- Hot-spot, level 1
- Hot-spot, level 2
- Hot-spot, level 3



"Climate Change & Biodiversity" Project: microclimate simulations of design scenarios to mitigate SUHI in urban areas

This research focused on mitigating summer surface thermal anomalies in one of the **largest thermal hot-spot areas** of Florence, a public open space dominated by asphalt and lacking vegetation. The **design scenario** incorporated **Nature-Based Solutions** (37%) and **high-albedo pavements** (51%). Microclimate simulations were conducted to compare the current situation (ex-ante) and the design scenario (ex-post) using data at a 1 m spatial resolution, processed through QGIS and ENVI-met software.
Simulations of air and surface temperaturature patterns were performed for both **daytime** and **nightime summer conditions**. The results showed significant cooling effects, with surface temperature (ST) and air temperature (T) decreasing, on average, by 13°C and 1°C, respectively, at noon, compared to the existing condition.



From the current situation (ex-ante) to the design scenario (ex-post)

Ex-ante surfaces
- Asphalt (98%)
- Hedges (2%)

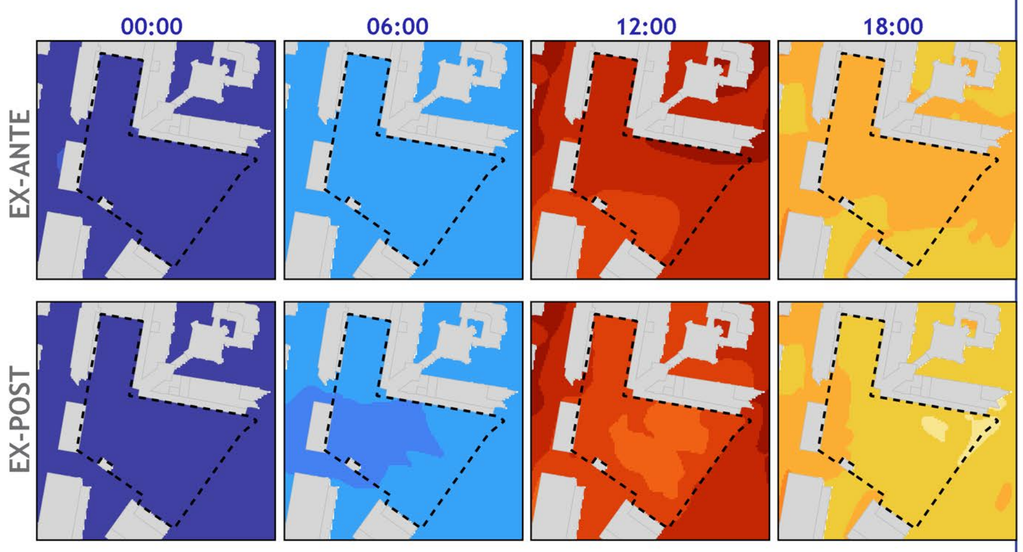
Ex-post surfaces
Cool materials (50.7%)
- Light-grey asphalt
- Light-grey concrete

Green surfaces (37.4%)
- Shrub
- Bioswale and raingarden
- Flowery meadow
- Trees (n. 87)

Semi-permeable parking lots (11.9%)

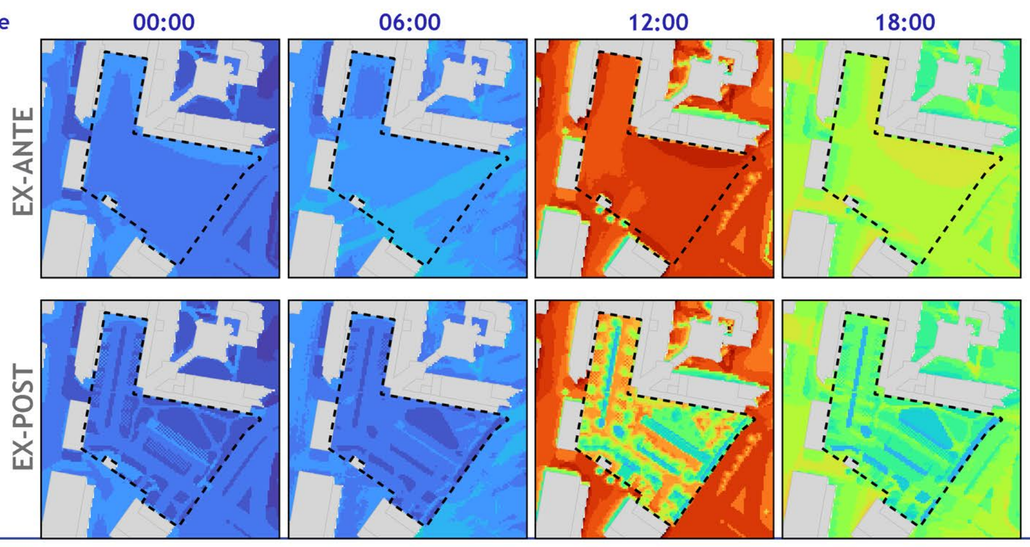
Summer Air Temperature (T)

T (°C) (h: 1.5 m)
17 - 18, 18 - 19, 19 - 20, 20 - 21, 21 - 22, 22 - 23, 23 - 24, 24 - 25, 25 - 26, 26 - 27, 27 - 28, 28 - 29, 29 - 30, 30 - 31, 31 - 32, 32 - 33, 33 - 34, 34 - 35, 35 - 36, 36 - 37



Summer Land Surface Temperature (LST)

LST (°C)
12 - 14, 14 - 16, 16 - 18, 18 - 20, 20 - 22, 22 - 24, 24 - 26, 26 - 28, 28 - 30, 30 - 32, 32 - 34, 34 - 36, 36 - 38, 38 - 40, 40 - 42, 42 - 44, 44 - 46, 46 - 48, 48 - 50, 50 - 52, 52 - 54, 54 - 56



Air and surface thermal differences

Δ LST (°C)
0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26

Δ T (°C)
0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0