EGU24-13001, updated on 20 May 2024
https://doi.org/10.5194/egusphere-egu24-13001
EGU General Assembly 2024

Multiscale characterization the Urban Heat Island (UHI) of the city of Milan (Italy)

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Milan is one of the largest, most industrialized and populated cities of Italy. It extends over more than 180 Km^2, most of which are built or paved areas. The area is characterized by the perturbation of thermal regime known as Urban Heat Island (UHI), that is related to a variety of natural and anthropogenic factors. UHI is observed on different spatial scales, from macro (citywide) to micro (neighbourhoods), and can be significantly heterogeneous depending on urban structure and builts environment. UHI usually includes three layers: surface-layer heat island (SLHI), canopy-layer Heat Island (CLHI) to the top of built environment, and boundary-layer Heat Island (BLHI). Its robust monitoring and modelling is crucial to support actions aimed at improving urban climate.

In this perspective, we focused on the reconstruction of the Milan UHI, taking into account its spatial heterogeneity and temporal variability. We started by mapping the UHI at the regional scale of the Milan metropolitan area since April 2013, using Landsat imagery that is able to provide Land Surface Temperature (LST) at 100m resolution. Through Google Earth Engine, we collected 14 Landsat-8 LST images over the period 2015-2023. This allowed obtaining macroscale measures of the heterogeneous nature of the UHI and identifying important hot-spots. One of them is the Bicocca neighborhood, a former industrial district that underwent significant urban changes over the last four decades, and it is still made of a mixture of industrial, residential, vegetated, or mixed spots. For each of these targets, we analyzed the spatial distributions and temporal trends of LST, providing “signatures” of the different components of a complex UHI.

At the urban micro-scale, we focused our attention on Piazza della Scienza (Bicocca university campus) and its surroundings that are undergoing extensive urban regeneration, including depaving and nature-based solutions in the framework of the PNRR project MUSA (Milano Urban Sustainability Action). Here, UHI characterization and monitoring in space and time is required to compare pre- and post- intervention conditions and to setup and calibrate dynamic numerical models that support a quantitative understanding of urban climate evolution and urban design optimization. This kind of monitoring requires a trade-off between the needs of accurate spatially-distributed and temporally-continuous measurements of surface and air temperature and related variables. To do this, we combined different techniques and multiple technologies. Surface temperature was characterized through a radiometrically-calibrated IRT camera (FLIR-T1020/T650)

for the spatially-distributed, discontinuous time-lapse characterization of key sectors of ground and buildings. Furthermore, HOBO sensors (T/RH-sensors) provided accurate continuous temperature time series at many key locations spread over the area. Air temperature was monitored through UAV-based thermal sensors along vertical profiles up to 120m high at different locations and different times, to obtain a 3D grid of temperature measurements across the CLHI. This wealth of information, obtained at different spatial scales over time, will allow the reconstruction of the internal structure, heterogeneity and temporal trends of the Milan UHI, as a first step towards the development of dynamic numerical models that will support the definition, implementation and validation of urban renewal and mitigations strategies.