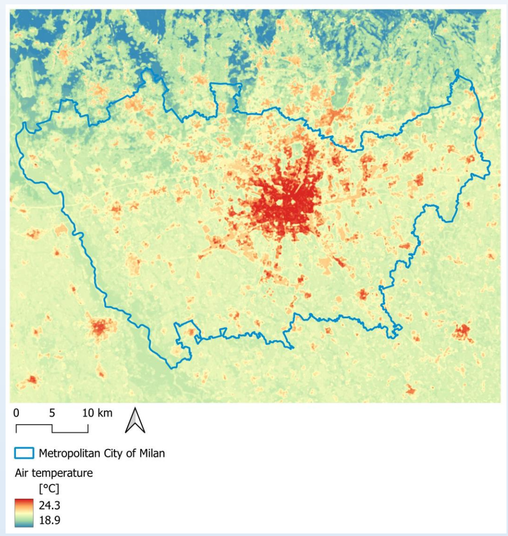
WP 7.4 Zero emission society
T7.4.2 Monitoring urban and suburban environments

Thermal characterization of urban environments

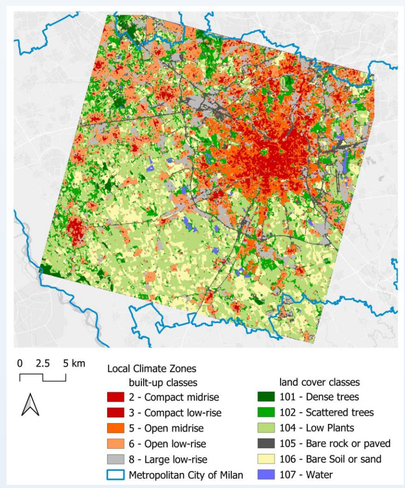
Urban Heat Island

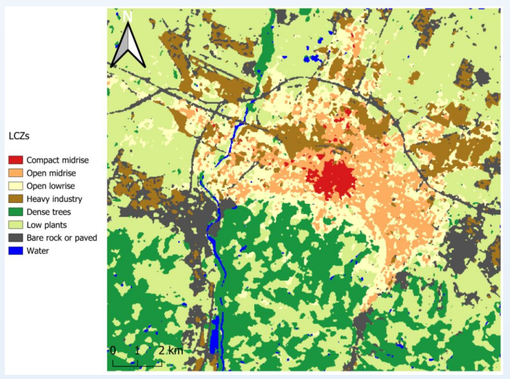
The work focuses on the assessment of the spatial and temporal patterns of heat waves and heat stress with climate reanalysis data and in situ measurements; the prediction of the spatial distribution of near-surface air temperature during extreme heat events through machine learning-based regression models; and the investigation of the Surface Urban Heat Island phenomenon by exploiting satellite and airborne-based hyperspectral and thermal infrared data.



(POLIMI, INGV, e-GEOS, UNIBO)

Local Climate Zones



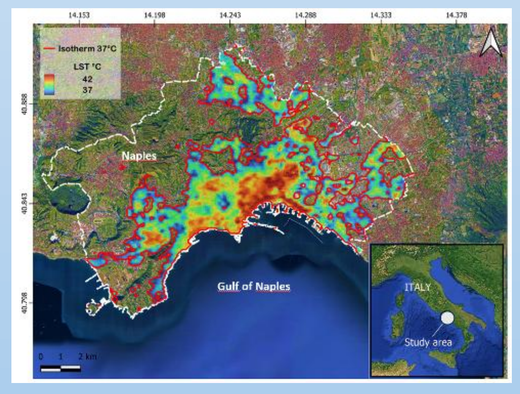


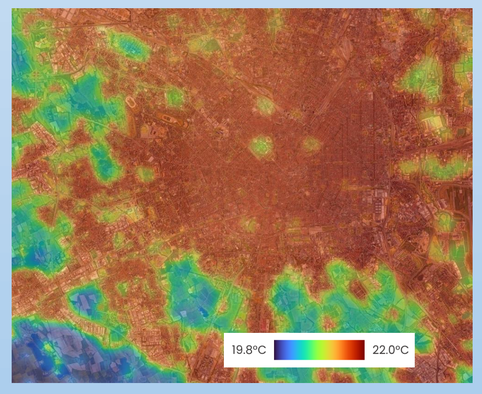
Sentinel-2 and PRISMA imagery were used, with the addition of a comprehensive set of morphological descriptors of the urban fabric.
The training and validation sites were identified in GIS environment, following the WUDAPT guidelines and using high resolution imagery as a reference basemap. Two machine learning models, Random Forest and Support Vector Machine, were tested in Python environment, using the scikit-learn library.
The results allows the segmentation of urban areas in zones characterized by uniform microclimate drivers.

(POLIMI, UNIBO)

Heat Waves assessment and prediction

High-resolution satellite-based (Landsat 8 and Landsat 9) land surface temperature (LST) data are used for a multi-year analysis of the Surface Urban Heat Island (SUHI) in Naples. Sensitive areas are identified and monitored throughout the time series, also with the aim of monitoring the impact of mitigation policies within the urban area.
The use of local climate zones and population dataset allow the derivation of risk index and identify the most critical zone for the population from LST and SUHI data.

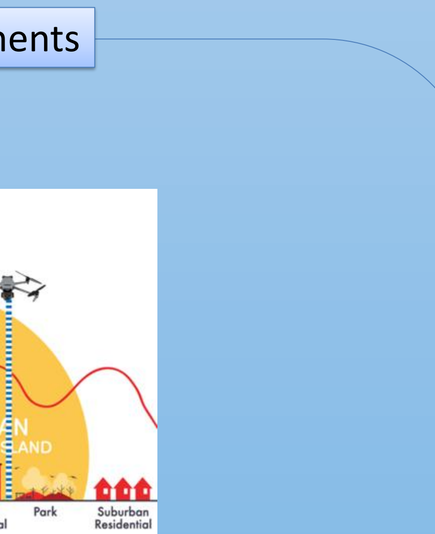




(INGV, POLIMI, LINKS)

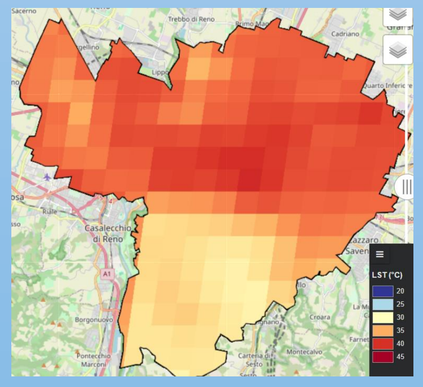
Surface energy balance

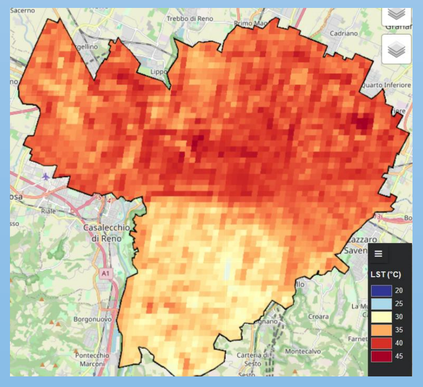
This activity is focused on developing a simplified, physically interpretable surface energy balance model that generates hourly surface temperature maps at 10-30 m with minimal inputs. Surface radiative properties driven from Sentinel-2 (i.e. absorptance) are combined with weather station obtained solar radiation and air temperature to represent key heat fluxes including incoming shortwave solar radiation, net longwave radiation to and from the sky, convective heat transfer to the air near the land surface, and conductive heat transfer to the ground. Applied to Legnaro–Padua, the model reproduces major patterns with low mean bias.



(UNIPD)

Downscaling of thermal imagery

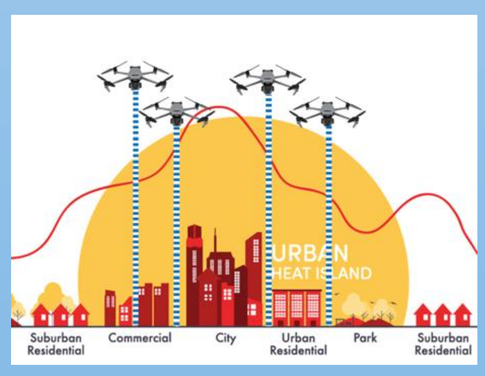




To enable a temporally consistent analysis while addressing the urban-scale nature of heatwave processes, a MODIS Land Surface Temperature (LST) downscaling framework is under development. The approach generates daily LST maps at 250 m spatial resolution.
The methodology relies on a day-specific Random Forest machine learning model, constrained by MODIS LST as a robust thermal reference. The model integrates static variables (e.g. topography and built-up fraction) and pseudo-dynamic predictors (e.g. vegetation conditions), allowing the reconstruction of high-resolution thermal patterns while preserving physical consistency with the original MODIS signal.

(UNIBO)

Air temperature measurements



INRiM has demonstrated in a laboratory environment the capability of accurately measuring the temperature gradient of a column of air by means of the measurement of the speed of sound. The method will be integrated in a drone to measure the vertical temperature gradient in open air up to 200 m. In perspective, a network of drones can be used to build a 3D map of the thermodynamic temperature in urban environments.

(INRIM)

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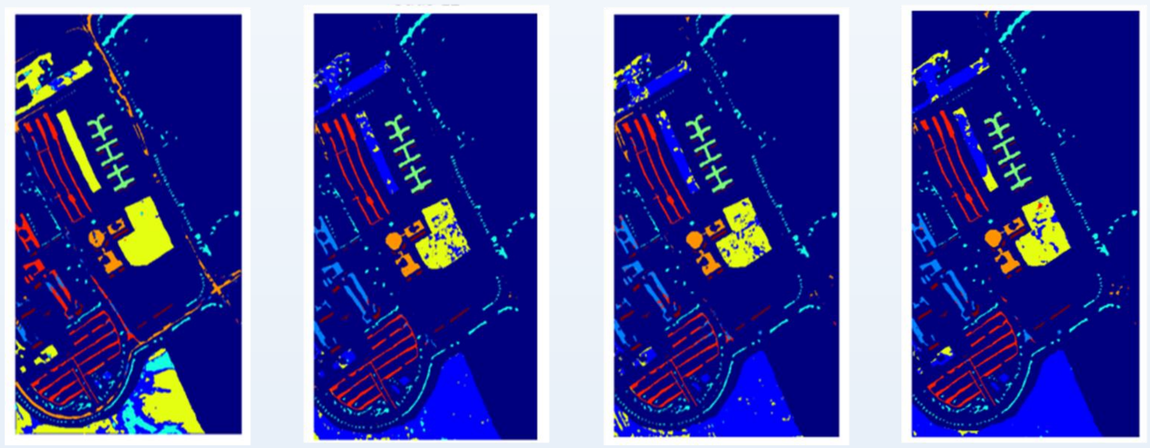
WP 7.4 Zero emission society
T7.4.2 Monitoring urban and suburban environments

Machine learning for land cover monitoring

Urban dynamics



Land consumption and urban dynamics are addressed through a dual and complementary methodological framework. Firstly, multi-temporal land consumption was analyzed over Italian regional capital cities (2006-2023) using the Continuous Change Detection and Classification (CCDC) algorithm applied to Landsat imagery within the Google Earth Engine environment. This pixel-based approach models temporal reflectance trends, enabling consistent detection of land use/cover changes with reliable classification performance.
In parallel, Improved F-Score-based feature selection strategies were developed to reduce redundant and low-informative features in Earth Observation datasets. By quantitatively ranking spectral features according to their relevance, the proposed method improves class separability and reduces noise propagation, achieving higher accuracy and robustness than conventional feature selection techniques.

(POLIBA)

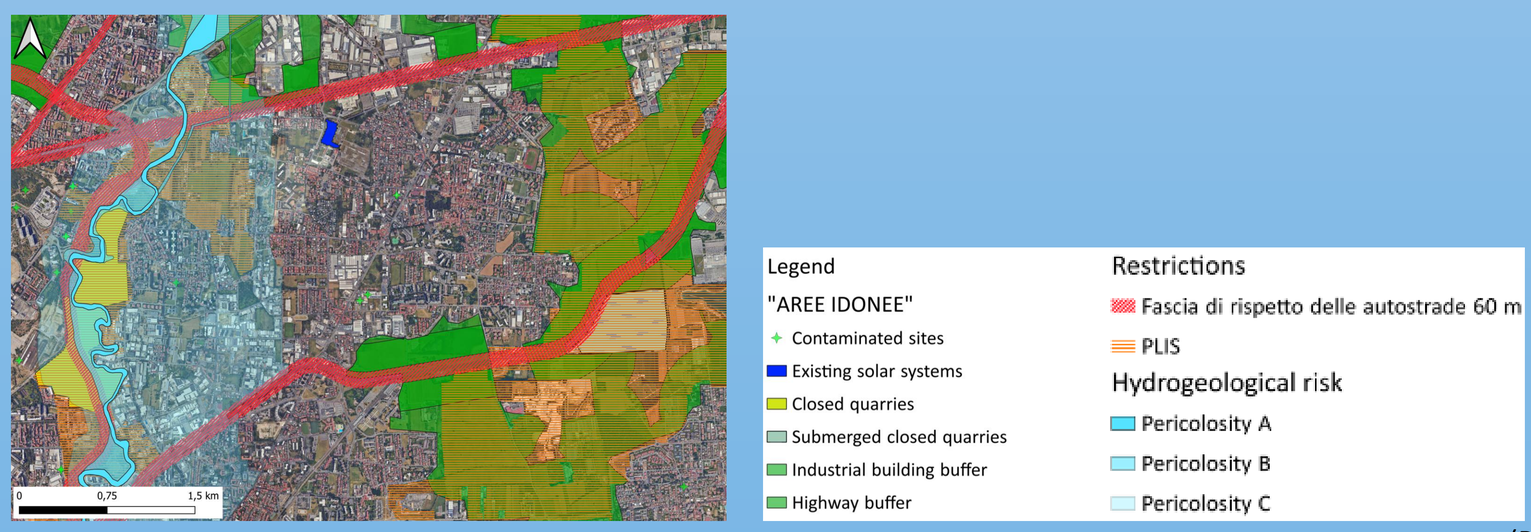
Soil sealing

The primary objective of this activity, carried out in collaboration with the University of Cassino (UNICAS), is the analysis and definition of functional themes to characterize urban and suburban areas, with a specific focus on Soil Sealing Mapping.
The technical approach utilizes Deep Learning for semantic segmentation to classify impervious surfaces. The workflow processes high-resolution multispectral satellite imagery from the Planet Super Dove constellation (3.7m GSD), integrated with ancillary data from Copernicus, ISTAT, and OSM. The architecture testing includes both standard Convolutional Neural Networks (e.g., U-Net, DeepLabV3+, HRNet) and Transformer-based networks (e.g., SegFormer, Swin Transformer) to ensure robustness across different environmental conditions.

(MAPSAT)

Photovoltaic potential

In the context of the energy transition, a map supporting the identification of potential sites for solar power plants was developed. The map integrates incentives and constraints defined by Regione Lombardia regulatory framework, based on institutional data.
Existing rooftop photovoltaic systems were considered as additional information: a detection method based on Sentinel 2B data was developed. Pixel-scale classification was performed using three spectral indices, achieving an overall accuracy of 0.83 and a Cohen's kappa coefficient of 0.66. Subsequently, the expected probability of presence of solar panels (PAF index) was computed for each building to aggregate information at the building scale.



(POLIMI, e-GEOS)

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