GENHACK CHALLENGE:

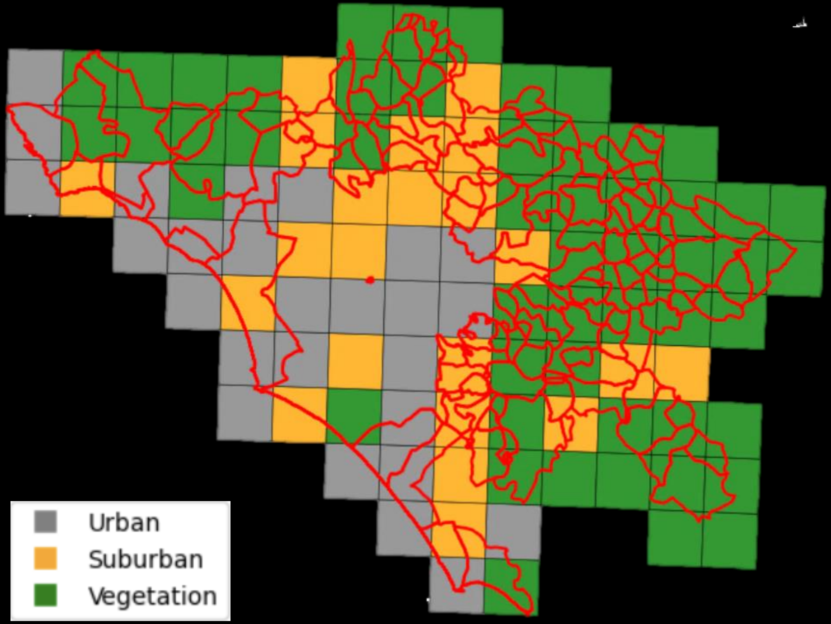
THE URBAN HEAT ISLAND EFFECT

Focus: visualize and explain the Urban Heat Island effect in Rome

Team BAT_TEAM:
Tito Nicola Drugman
Asia Montico
Beshoy Guirges

TASK 1: MULTI-SCALE LAND COVER ZONATION

OBJECTIVE: Classification of the Rome Province into distinct climatological zones (Urban, Suburban and Vegetation) to spatially aggregate high-resolution surface data into the ERA5-Land grid (9km×9km).



Dataset

GADM 4.1
Administrative boundaries (Rome Province).

Sentinel-2 (L2A):
High-resolution multispectral imagery (resampled to 80mx80m) for Normalized Difference Vegetation Index (NDVI) computation.

ERA5-Land
Provides the target geometry (0.1° × 0.1 °grid) for the final upscaling process

Resolving Spectral Ambiguity via Data Fusion

Sentinel-2 Acquisition

We derive NDVI from summer Sentinel-2 imagery (80m x 80m) to serve as the primary metric for land cover segmentation.

Spectral Ambiguity

Deep water and dense urban surfaces both exhibit low NDVI values, causing spectral confusion and potential river misclassification.

Temporal Integration

We integrate JRC Global Surface Water data, leveraging its 37-year history to validate water presence independent of spectral noise.

Priority Masking

A priority mask overrides NDVI: pixels with >10% historical water occurrence are deterministically classified as "Water".

Enhanced Zonation

This data fusion accurately separates hydrography from urban areas, creating a robust baseline for the subsequent grid aggregation.

Classification Logic: From Pixel (80m80m) to Macro-Grid (9km9km)

Micro-scale Classification (80m x 80m)

Pixels are categorized using an handmade priority-based decision tree:

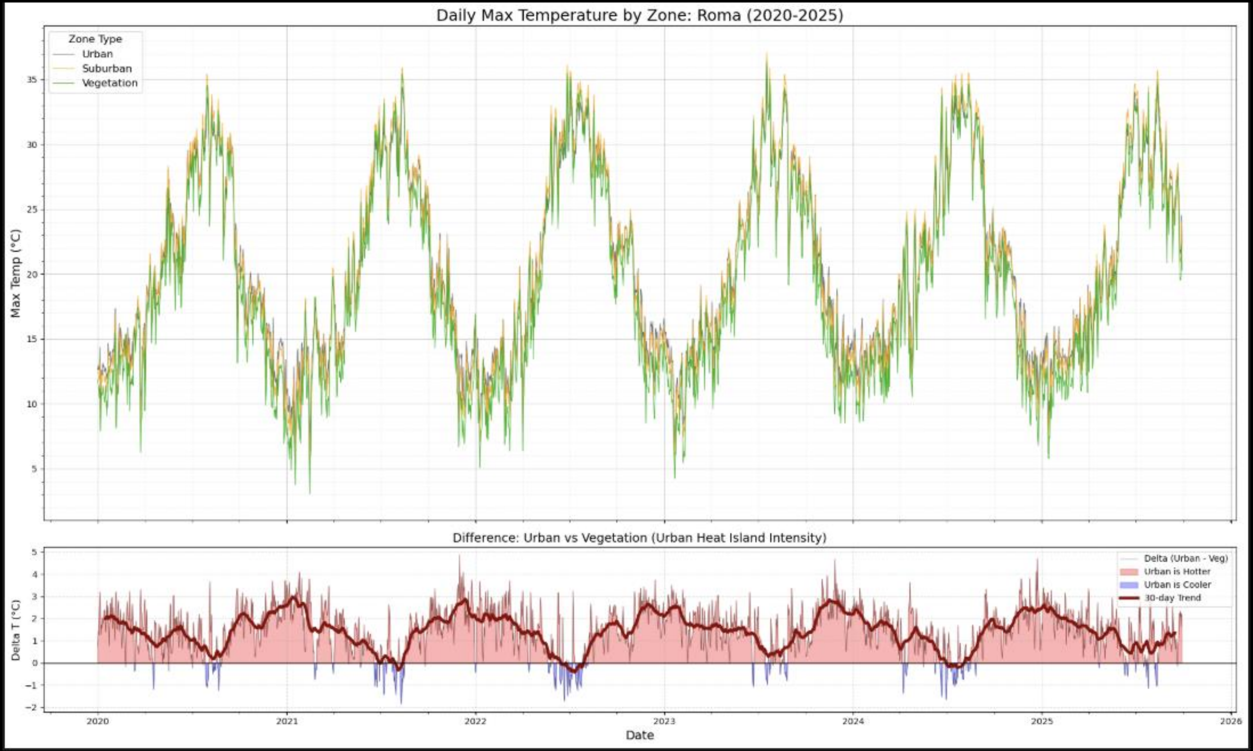
- **Water:** $J_{occurence} > 10\%$ or NDVI ≤ -0.8
- **Urban:** -0.8 ≤ NDVI ≤ 0.33
- **Park/Grassland:** 0.33 < NDVI ≤ 0.6
- **Forest:** NDVI >0.60>

Upscaling to Macro-Grid (9km x 9km)

Grid cells are assigned a dominant class based on internal pixel composition (P):
Let $P_{nature} = P_{grassland} + P_{water}$

IF $(P_{nature} > 70\%)$ then VEGETATION
ELIF $(P_{forest} > P_{urban})$ $and\ P_{forest} > 30\%$
then VEGETATION
ELIF $P_{urban} > P_{nature}$ $or\ urban > 40\%$
then URBAN
ELSE SUBURBAN

Task 3 : Temporal Dynamics

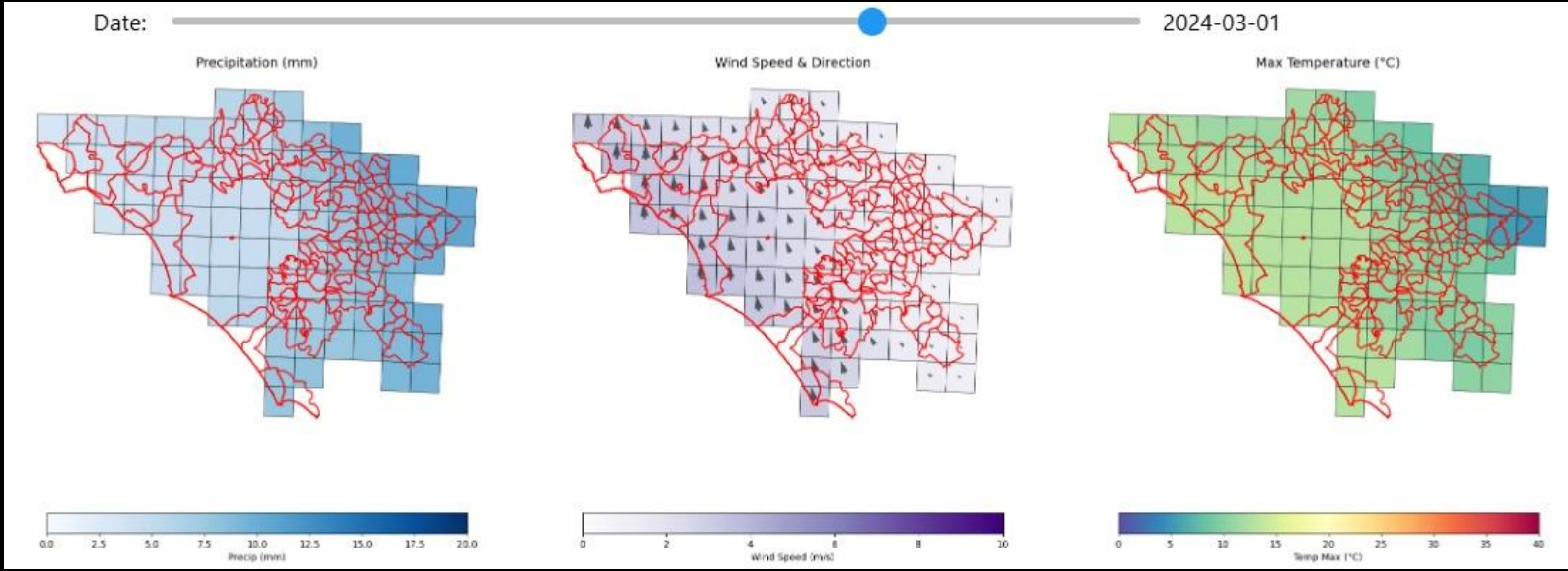


Spatial Aggregation: Daily maximum temperatures (T_{max}) from ERA5-Land were averaged spatially for each classified zone

Differential Metric To isolate the anthropogenic effect, we computed the instantaneous delta: $\Delta_{UHI} = T_{urban} - T_{vegetation}$

Task 2: Interactive Spatio-temporal Climate Inspector

An interactive dashboard developed to explore the temporal dynamics of the ERA5-Land dataset. The tool visualizes daily spatial distributions of Total Precipitation, Wind Vectors, and Maximum Temperature across the 9km x 9km grid, allowing for the granular inspection of specific meteorological events and the validation of data consistency prior to statistical aggregation.



Modeling spatial temperature Anomalies

$$\Delta T_{anomaly} = -65.95 + 0.67(\%Urban) + 0.64(\%Forest) + 0.66(\%Water) + 0.11(Wind) - 0.03(Precip)$$

Objective

Predict local temperature deviation (Anomaly) for every 9 Km^2

$$\Delta T_{Anomaly} = T_{cell} - T_{CityAverage}$$

Interpretation

Under identical weather conditions, a zone classified as Urban is, on average, 1.23°C hotter than a zone classified as Vegetation.

Accuracy

R^2 = 0.400 : explains 2x more variance than simple zoning labels.