Challenge

Identification, prediction and mitigation of urban heat islands (UHI)

Urban heat islands, an issue occurring in both highly developed and developing areas, result in significant temperature differences between cities and their rural surroundings. This phenomenon can be observed at a macro scale - where cities are on average warmer than adjacent rural areas - and at a local scale, with pockets of heated air persisting over certain areas of the city. Several factors contribute to this effect, including the obstruction of natural wind flow that would otherwise cool the city through convection, the replacement of green spaces with developed land, the removal of greenery that cools the air through evaporation, the widespread use of sunlight-absorbing surfaces in paving or roofing and abundance of local heat sources, such as air conditioning units and transportation means. These elements, among others, combine to intensify urban heat issues, lowering the comfort of living and inducing damages to the city ecosystem.

The main objective of the task is to design an open-data-based solution that would enable identification of the areas that may be susceptible to the UHI effect. The prediction should take into account the sunlight exposition, type of the land cover, land development, wind-related effects (both global or local, i.e. shielding, presence or lack of corridors ventilating the city) and other chosen factors. The predictions should be visualized in a manner similar to that from supplementary material [3.1].

Key requirements

- The system should utilize open data, that may be either accessed by API/WMS/WMTS and similar online services or downloaded by the user from open data repositories.
- The choice of city on which example the system is presented is left for the participants to make.
- The system may be trained, calibrated and/or verified on data from a different region. However, some level of applicability has to be ensured (i.e. similar climate).
- The system should include a module for analysis of the land cover of the chosen area. The general data may be based on the available vector data, but should be also enhanced by i.e. image analysis of the aerial and satellite imagery for better resolution. The module should be able to

interpret that data, i.e. distinguishing asphalt, concrete, dirt, lawn, floral meadows and so.

- The system should take into account the seasonal variation of conditions.
- The system should enable easy interaction with the user. User input, visualization of the geospatial data and results of the prediction has to be included. Resulting data should also be easily-exportable to common GIS data formats (*.shp, geotiff and similar) in projected coordinate system (such as EPSG:2180 or similar) and report files (in common image or document processing formats).
- The system should be capable of providing basic statistical reports (such as % of area with high susceptibility to UHI effect, total areas of different land cover types and similar).

Possible outcomes

1) The designed system is able to integrate geospatial data from different sources and visualize them in a user-friendly way, while correctly identifying the areas with coincidences of factors contributing to the effect of the urban heat islands – main desired outcome.
2) The system is additionally capable of performing the high-resolution analysis of the land cover, based on vector and aerial/satellite data
3) The system is also capable of showing the intensities of the contributing factors spatially, with threshold values chosen by the user. I.e. user may "tweak" the influence of certain factors, and see the areas that become susceptible to UHI effects.
4) The system is additionally capable of identifying the threshold values of intensities that determine the occurrence of UHI effect in certain areas.

Note: While the UHI effect has complex causes and contributing factors, the system should focus on qualitive rather than quantitive analyses. The main aim should be to identify and present which areas may be exposed to the urban heat island effect, not to determine whether the effect will definitely occur.

Additional capabilities

- The system may include additional module for optimization of land cover to lessen the effect of UHI in a localized area (such as few buildings and their surroundings, a quarter of streets and so). The optimization should be restrained in some way – for example adjusting the localization of the concrete paved areas on plazas based on the sunlight exposure,

influenced by the surrounding buildings, is performed without disturbing the existing building system.

Supplementary materials (examples of data sources)

1. GIS DATA
   1.1. https://www.geoportal.gov.pl/ - Polish Government portal, which enables access to multiple types of geospatial data, including i.e. satellite and aerial imagery, numerical terrain and surface models, LIDAR data, topographic maps and many other. Data can be accessed either by WMS/WMTS or downloaded in packs
   1.2. https://nsisplatforma.polsa.gov.pl/portal/ - Polish satellite data portal
   1.3. https://nsisplatforma.polsa.gov.pl/marketplace_en/products_and_services_en/uhi_en?lang=en – Urban Heat Islands maps for major Polish cities – data available up to 2017, that may be used for training/verification purposes
   1.4. https://opendata.cui.wroclaw.pl/ - Open data repository for Wroclaw (frequently updated)

2. Weather and climate data
   2.1. https://danepubliczne.imgw.pl/en - Polish Institute of Meteorology and Water Management open data website. It contains historical climate data for major weather stations.
   2.2. https://opendata.meteo.uni.wroc.pl/ - website of Climatology Institute of University of Wroclaw containing archival and current weather data
   2.3. https://gis.um.wroc.pl/imap/?gpmap=MapaSolarna - Solar radiation intensity potential for Wroclaw
   2.4. https://cds.climate.copernicus.eu/ - Copernicus climate data that can be retrieved after signing up
   2.5. https://open-meteo.com/en/docs/historical-weather-api

3. Examples of UHI Maps
   3.1. https://www.oki.org/data-maps/view-data-maps/urban-heat-island-map-tool/ - exemplary map of UHI effect for Cincinnati
   3.2. https://tpl.maps.arcgis.com/home/item.html?id=db5bdb0f0c8c4b85b8270ec67448a0b6
   3.3. https://opendata.rcmrd.org/datasets/4f6d72903c9741a6a6ee6349f5393572/about

4. Some research papers
   4.1. https://www.researchgate.net/publication/382693870_A_global_urban_heat_island_intensity_dataset_Generation_comparison_and_analysis
   4.2. https://www.researchgate.net/publication/226950487_Local_regression_models_for_spatial_interpolation_of_urban_heat_island-an_example_from_Wrocaw_SW_Poland
   4.3. https://www.mdpi.com/1999-4907/12/8/1136
   4.4. https://presentations.copernicus.org/EGU24/EGU24-13070_presentation-h407601.pdf