XXIII Conference of PhD Students and Young Scientists

Interdisciplinary topics in Mining, Geology and Geomatics

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URBAN HEAT ISLAND
What does the data show and how do we perceive it?

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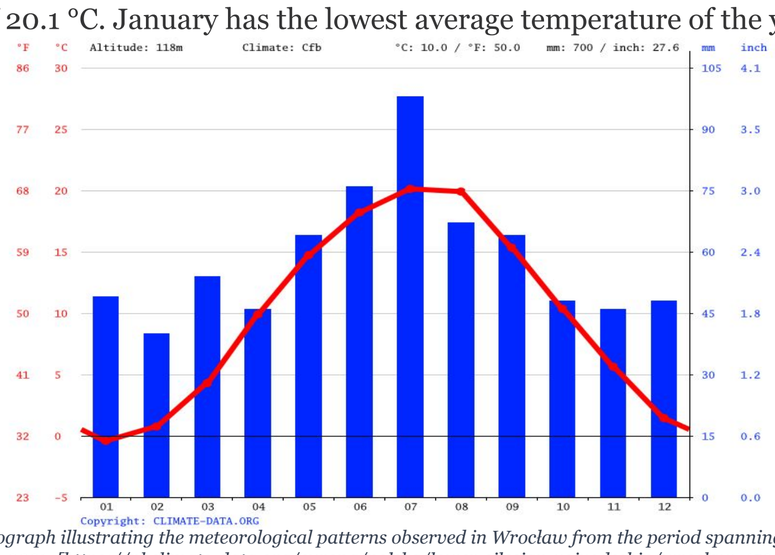
INTRODUCTION AND STUDY AREA

The Urban Heat Island phenomenon stands as a prominent characteristic within the climate of urban regions. The term "island" alludes to the visual representation of isotherms, which in the area of the city take shape similar to the outline of an island surrounded by cooler air.

The study area covered the city of Wrocław, located in the southwest of Poland, and the zone of temperate climates, in the type of transitional climate. The average annual daily temperature is 9.7°C. July is the warmest month of the year, with an average daily temperature of 20.1 °C. January has the lowest average temperature of the year of -0.4 °C.



Climograph illustrating the meteorological patterns observed in Wrocław from the period spanning 1991 to 2021. [https://pl.climate-data.org/europa/polska/lower-silesian-voivodeship/wrocław-4531/]

MATERIALS & METHODS

In order to map the impact of the urban heat island, the NDVI had to be calculated. NDVI stands for normalized differential vegetation index. It is a simple but very effective indicator for quantifying green vegetation. For its calculation near-infrared channels (for Landsat 8 imaging it is band 5 and for Sentinel 2 it is channel B8A) and red channels (for Landsat 8 imaging it is band 4 and for Sentinel 2 it is channel B4) are used.

This index can take values from -1 to 1 and is calculated using the following formula:

$$NDVI=(NIR-RED)/(NIR+RED).$$

NDVI values are correlated with biomass and chlorophyll content. Healthy vegetation absorbs radiation from the blue and red bands, which allows the production of chlorophyll in the process of photosynthesis. The calculation of the NDVI is the first step leading to the calculation of LST (Land Surface Temperature). Other components needed for the calculation are the radiation temperature and the emissivity coefficient.

The radiation temperature T was determined using the following formula:

$$T = \frac{K_2}{\ln\left(\frac{K_1}{L_\lambda} + 1\right)} \quad [K]$$

Where:

K1 and K2 are thermal conversion constants for a given sensor type and spectral channel, stored in metadata.

The next step was to determine the emission factor ε. To do this, the Proportion of Vegetation was first determined on the basis of the equation given below, using the NDVI values obtained in the previous step and its minimum and maximum values.

$$P_v = \frac{NDVI - NDVI_{max}}{NDVI_{max} - NDVI_{min}}$$

PHASES OF DEVELOPMENT

Deliberation on Urban Heat Island mapping, utilizing data derived from http://powietrze.pwr.edu.pl/, while quantifying the Nocturnal Urban Heat Island phenomenon.

Ascertainment of Land Surface Temperature (LST) by leveraging data obtained from the NASA and USGS-operated Landsat 8 satellite mission.

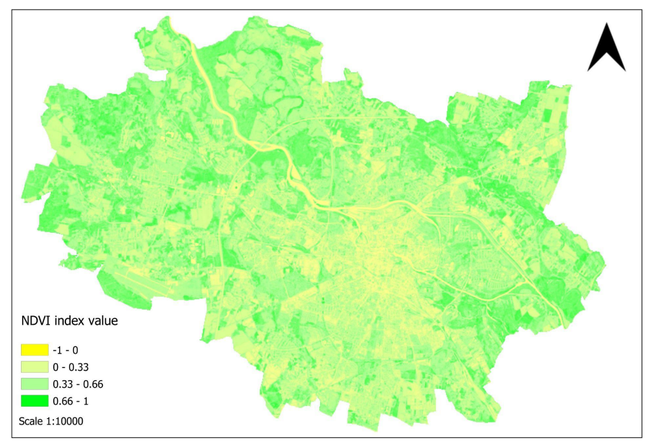
Formulation of a comprehensive survey methodology, encompassing survey design, execution, and subsequent analysis of the acquired outcomes.

Engaging in a comprehensive analysis and conducting an insightful comparison of the outcomes derived from the Urban Heat Island and Surface Urban Heat Island studies, fostering a profound understanding of their respective attributes and characteristics.

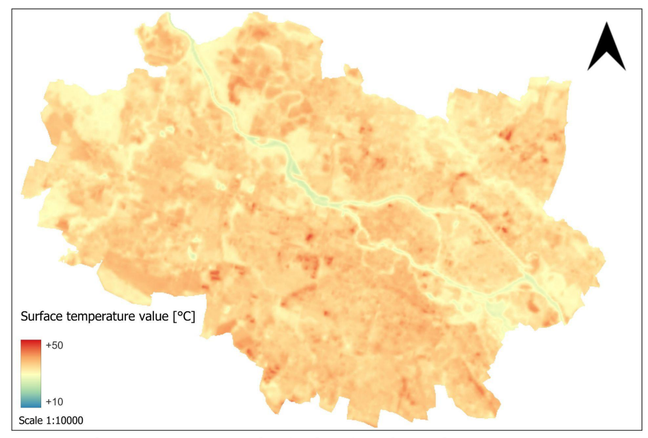
EXAMPLE RESULTS AND SUMMARY

Comparing the results of Urban Heat Island and Surface Urban Heat Island, significant differences in temperature distribution can be observed. The surface temperature was largely dependent on the type of land use.

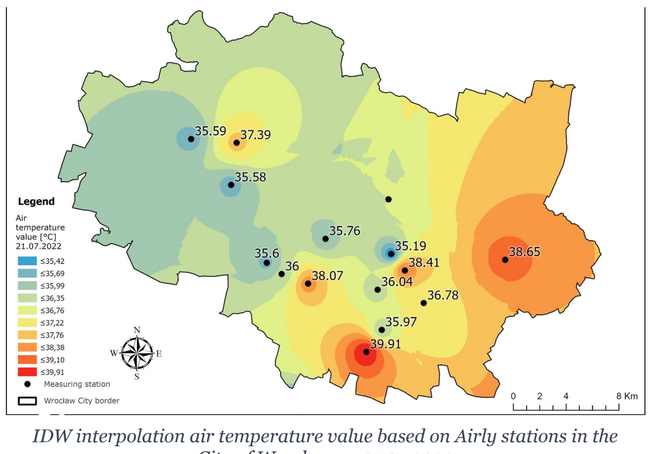
Airly stations recorded very different temperatures throughout the city. IDW interpolation was used to create the air temperature map, which estimates values by giving more weight to the sample points closest to the point for which an unknown variable value is interpolated. As the distance of the points increases, their importance decreases. The method shall not interpolate values that exceed the range of values of the sample set. The reason for using this method was the fact that interpolated values are distributed gradually over whole studied area and this analysis involves air temperature values which does not change rapidly over small area.



NDVI index value in the City of Wrocław on 21.07.2023



Surface temperature value in the City of Wrocław on 21.07.2023



IDW interpolation air temperature value based on Airly stations in the City of Wrocław on 21.07.2023

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