

Urban Heat Islands in Olomouc: A Geospatial Identification of Thermal Patterns, Urban Structure, and Human Perception

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Urban Heat Islands (UHIs) are the most intensively studied urban climate phenomena with increasing relevance under ongoing climate change and urbanization processes (Oke et al., 2017). In the Czech Republic, more than 70% of the population currently lives in urban areas, with a further increase projected for the future. At the same time, about a quarter of the population belongs to the elderly generation, which is particularly vulnerable to heat stress (Krkoška Lorencová et al., 2018). These trends highlight the urgent need for spatially explicit approaches that identify intra-urban differences in heat exposure and support targeted adaptation strategies in medium-sized European cities.

While a large part of UHI research is based on objective data derived from air temperature and land surface temperature, recent studies demonstrate that these measurements often do not reflect the subjective perceptions and experiences of residents. Relevant studies in the Czech Republic found only limited spatial agreement between objectively measured heat patterns and perceived thermal comfort and discomfort (Květoňová et al., 2024; Lehnert et al., 2021). These mismatches underline the importance of integrating participatory mapping approaches and citizen-derived data into UHI analysis to capture lived experiences and support more holistic and inclusive assessment strategies.

This study aims to develop a transferable geospatial framework for UHI risk assessment in the city of Olomouc by integrating multi-source data on thermal conditions, socio-spatial characteristics and human perception. Conceptually, the approach is based on the climate risk framework proposed by the Intergovernmental Panel on Climate Change (IPCC, 2014), which defines risk as a function of hazard, exposure, and vulnerability, with the latter further differentiated into sensitivity and adaptive capacity. The framework has already been widely applied in climate risk studies, yet its implementation at high spatial resolution and with integrated perception data remains limited.

The proposed methodology combines ECOSTRESS land surface temperature data, in-situ air temperature measurements from an urban sensor network, participatory mapping results on thermal comfort and discomfort, census data and high-resolution population datasets, as well as Urban Atlas data from the Copernicus Land Monitoring Service. To ensure spatial comparability across heterogeneous data sources, all inputs are harmonized within a common spatial framework using a hexagonal grid, which enables consistent aggregation while reducing biases associated with spatial zoning (Räsänen et al., 2019). The datasets are subsequently converted into indicators representing hazard, exposure, sensitivity and adaptive capacity, following widely used approaches in UHI vulnerability assessment. To enable comparability between indicators with different value ranges, a normalization procedure is applied, and the indicators are then aggregated using a weighting scheme. A key feature of the approach is its methodological adaptability, whereby indicators can be assigned to different components, and weighting strategies can be adjusted, allowing the model to be transferred to different cities, datasets and research contexts.

By explicitly integrating subjective perception and socio-spatial characteristics alongside objective measurements, the framework aims to provide a more holistic understanding of urban heat risk and its uneven spatial distribution. The resulting outputs and web mapping application are intended to support decision-making processes by identifying priority areas for UHI mitigation and climate adaptation. Beyond the case study, the approach is being developed as a modular and reusable workflow, enabling its application in other cities and facilitating iterative updates as new datasets become available. In this way, the study contributes to the further development of interdisciplinary and transferable methods in urban climate research, bridging the gap between physical heat measurements, socio-spatial vulnerability and human perception.

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References

- IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.
- Krkoška Lorencová, E., Whitham, C. E. L., Bašta, P., Harmáčková, Z. V., Štěpánek, P., Zahradníček, P., Farda, A., & Vačkář, D. (2018). Participatory Climate Change Impact Assessment in Three Czech Cities: The Case of Heatwaves. *Sustainability*, 10(6), 1906. <https://doi.org/10.3390/su10061906>
- Květoňová, V., Pánek, J., Geletič, J., Šimáček, P., & Lehnert, M. (2024). Where is the heat threat in a city? Different perspectives on people-oriented and remote sensing methods: The case of Prague. *Heliyon*, 10(16), e36101. <https://doi.org/10.1016/j.heliyon.2024.e36101>
- Lehnert, M., Geletič, J., Kopp, J., Brabec, M., Jurek, M., & Pánek, J. (2021). Comparison between mental mapping and land surface temperature in two Czech cities: A new perspective on indication of locations prone to heat stress. *Building and Environment*, 203, 108090. <https://doi.org/10.1016/j.buildenv.2021.108090>
- Oke, T. R., Mills, G., Christen, A., & Voogt, J. A. (2017). Urban climates. *Cambridge University Press*. <https://doi.org/10.1017/9781139016476>
- Räsänen, A., Heikkinen, K., Piila, N., & Juhola, S. (2019). Zoning and weighting in urban heat island vulnerability and risk mapping in Helsinki, Finland. *Regional Environmental Change*, 19(5), 1481–1493. <https://doi.org/10.1007/s10113-019-01491-x>