The extent and implications of the urban heat island phenomenon in Central European region

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EU Project
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Investigates the UHI-phenomena in Central Europe

• The extent of the UHI effect in multiple cities in Central Europe
• Manifestation of the urban heat islands phenomena (temporal and spatial variations)
• Evaluation of mitigation and adaptation strategies
Participating cities

• The list of participating cities:
  – Budapest, Hungary
  – Ljubljana, Slovenia
  – Modena, Italy
  – Padova, Italy
  – Prague, Czech Republic
  – Stuttgart, Germany
  – Vienna, Austria
UHI phenomenon

- Temperature difference between the urban and the rural environment

Source: http://www.epa.gov/heatisland/about/index.htm
Methodology

• Quantifying the frequency, magnitude, and time-dependent (diurnal and nocturnal) UHI intensity distribution

• Focus:
  – Short-term (reference week) analyses
  – Long-term analyses

• The magnitude of the UHI effect is expressed in terms of Urban Heat Island intensity ($\Delta \theta$)
Methodology

• Each participating city provided data (including air temperature, wind speed, and precipitation) from two representative weather stations (one urban and one rural)

• Short-term:
  – The hourly-based UHI intensity has been derived from data sets in a course of a reference week

• Long-term:
  – Mean annual (urban and rural) temperatures and UHI values were derived for a period of 30 years
Results – short-term analysis

Mean hourly urban temperature distribution for a reference summer day
Results – short-term analysis

Mean hourly UHI intensity distribution for a reference summer day
Results – short-term analysis

The cumulative frequency distribution of UHI values for the participating cities for a one week summer period.
Results – long-term analysis

Development of (mean annual) urban and rural temperatures over a period of 30 years, respectively
Results – long-term analysis

Long-term UHI intensity trend over a period of 30 years
CONCLUSION

• The existence and significant magnitude of the UHI effect in all participating cities.

• A time-dependent (diurnal and nocturnal) UHI pattern implying larger UHI intensities during the night hours.

• Existing variation in UHI intensity in different cities, especially in terms of peak values.

• Warsaw experiencing higher UHI intensity levels when compared to other cities
ONGOING WORK

• A systematic framework for the evaluation of urban heat island mitigation measures

• The framework involves the following steps:
  – Selection of "Urban Units of Observation" (U2O)
  – Description of the status quo of U2O in terms of a structured set of geometric and physical properties
  – Selection of potential M&A measures
  – Description of specified M&A measures as changes to U2O variables
  – Evaluation of M&A measures
# Ongoing Work

Defined variables of Urban Unit of Observation (U²O)

<table>
<thead>
<tr>
<th>Geometric properties</th>
<th>Physical properties</th>
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<tbody>
<tr>
<td>Sky View Factor</td>
<td>Albedo</td>
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<tr>
<td>Aspect ratio</td>
<td>$\rho_{sw}$</td>
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<tr>
<td>Built area fraction</td>
<td>Emissivity</td>
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<tr>
<td>Unbuilt area fraction</td>
<td>$\varepsilon_{lw}$</td>
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<tr>
<td>Impervious surface fraction</td>
<td>Thermal conductivity</td>
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<td>Pervious surface fraction</td>
<td>$\lambda = (\lambda_t + \lambda_p)$</td>
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<tr>
<td>Mean building compactness</td>
<td>Specific heat capacity</td>
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<tr>
<td>Built surface fraction</td>
<td>$c = (c_i + c_p)$</td>
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<tr>
<td>Mean sea level</td>
<td>Density</td>
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<td></td>
<td>$\rho = (\rho_i + \rho_p)$</td>
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<td></td>
<td>Anthropogenic heat output</td>
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<td>$Q_r$</td>
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Thank you for your attention