

Urban heat island phenomena in Vienna: Toward a systematic assessment of mitigation measures

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EU Project (Central Europe)



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

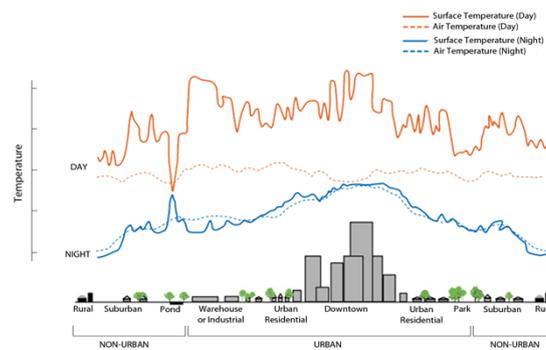
- The list of participating cities:

- 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



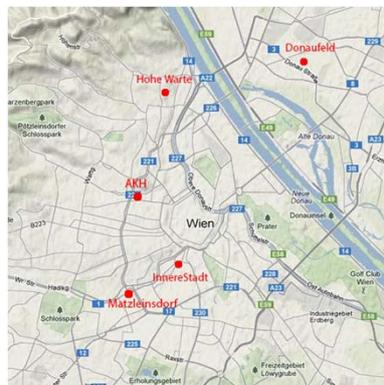
Source: <http://www.epa.gov/heatisland/about/index.htm>

Methodology

- Case in point – city of Vienna
- Quantifying the frequency, magnitude, and time-dependent (diurnal and nocturnal) UHI intensity distribution in selected locations in the city of Vienna
- Goal: to systematically address the local variation of the urban heat island effect across the city
- Focus:
 - Short-term (reference week) analyses – a hot summer week
 - Seasonal variation
- The magnitude of the UHI effect is expressed in terms of Urban Heat Island intensity ($\Delta\theta$)

Methodology

- The weather data was collected at several weather stations positioned in different locations throughout Vienna by the organization **Central Institute for Meteorology and Geodynamics (ZAMG)**



Results

Mean hourly temperature distribution for a reference summer day (hot summer week)

Results

Mean hourly UHI distribution for a reference summer day (hot summer week)

Results

Mean seasonal UHI distribution across the city of Vienna, 2012

WINTER

SPRING

SUMMER

AUTUMN

FRAMEWORK INTRODUCTION

- Goal: to predict, estimate, and verify the effect of urban heat island mitigation actions on reduction of urban heat island intensity
- 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

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i. U2O Vienna - Innere Stadt



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ii. Defined variables of Urban Unit of Observation (U²O)

Geometric properties		Physical properties	
Sky View Factor	Ψ_{sky}	Albedo	ρ_{sw}
Aspect ratio	H/W	Emissivity	ϵ_{lw}
Built area fraction	A_b/A_{tot}	Thermal conductivity	$\lambda = (\lambda_i + \lambda_p)$
Unbuilt area fraction	$1 - A_b/A_{tot}$	Specific heat capacity	$c = (c_i + c_p)$
Impervious surface fraction	A_i	Density	$\rho = (\rho_i + \rho_p)$
Pervious surface fraction	$A_p = (A_e + A_g + A_{H_2O})$		
Mean building compactness	l_c	Anthropogenic heat output	Q_f
Built surface fraction	A_s/A_b		
Mean sea level	h_{sl}		

SKY VIEW FACTOR DISTRIBUTION

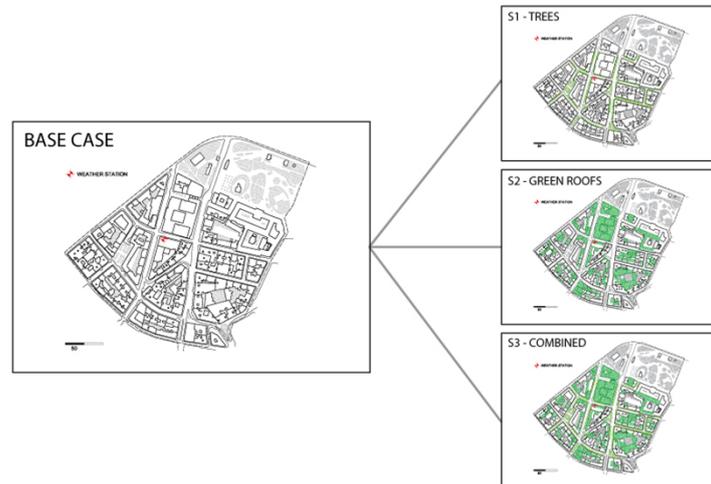
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iii. Three illustrative mitigation actions are considered for the Vienna U20

Scenario	Expected benefit
1 Planting trees within the urban canyon	Shading and evapotranspiration, lower peak summer air temperatures, reducing air pollution
2 Green roofs	Shading and evapotranspiration
3 Combined 1 and 2	Shading and evapotranspiration, lower peak summer air temperatures, reducing air pollution

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Illustrative maps of U2O and M&A measures



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iv. Respective changes after introduction of mitigation actions

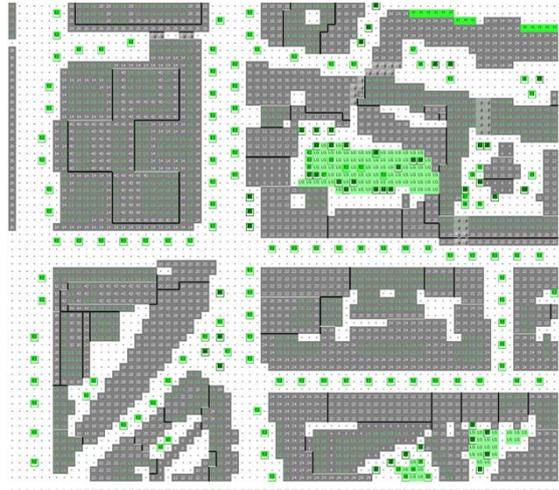
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iv. Respective changes after introduction of mitigation actions

V. EVALUATION OF M&A MEASURES

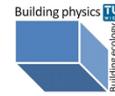
- Simulation tool: **ENVI-met 4.0**
- ENVI-met is a three-dimensional microclimate model designed to simulate the surface-plant-air interactions in urban environment
- The model includes the simulation of:
 - Flow around and between buildings
 - Exchange processes of heat and vapour at the ground surface and at walls
 - Turbulence
 - Exchange at vegetation and vegetation parameters
 - Particle dispersion and pollutant chemistry

ENVI-met 4.0



Results

Mean hourly temperature distribution for Summer period,
comparison between the Base Case and M&A Scenarios



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Thank you for your attention

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