The case study of Psyrri area

FACING HEAT WAVES IN THE URBAN MICROCLIMATE

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Introduction

Modification by urban areas:

- Irradiative
- Thermal
- Moisture
- Aerodynamic characteristics

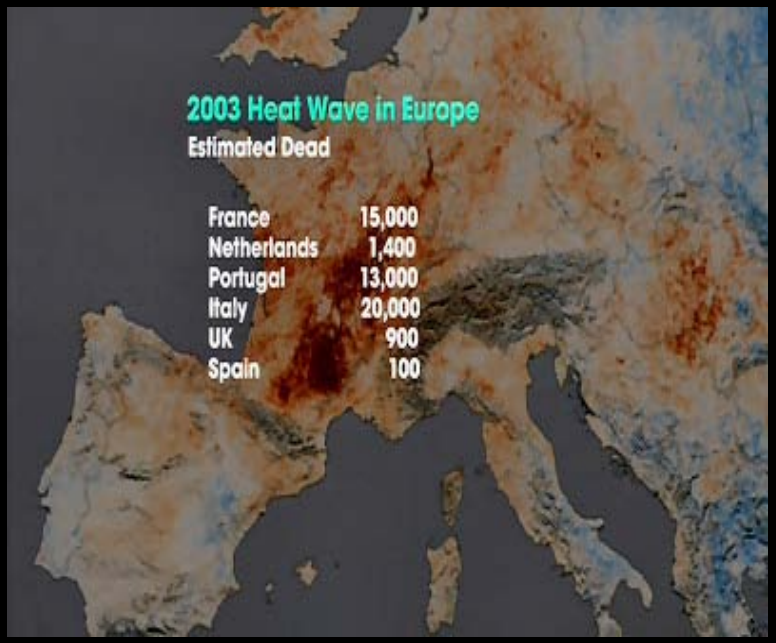
HEAT ISLAND

Air temperatures in densely populated and built areas are higher than those measured in the surrounding rural country

- Decrease of radiative heat loss (block-like geometry, canyon effect)
- Increased thermal storage in buildings of the city (thermal properties of materials)
- Reduction of evaporative cooling (lack of vegetation)
- Reduced turbulent heat transfer in canyons
- Antropogenic heat release
- Air pollution

Heat wave

- An extended interval of abnormally hot and usually humid weather, usually lasting from a few days to over a week
- During heat waves the death rate from heat-related ailments is often much higher in cities than in outlying environs
- The higher death rate in cities appears to be a result of climate modification due to urbanization

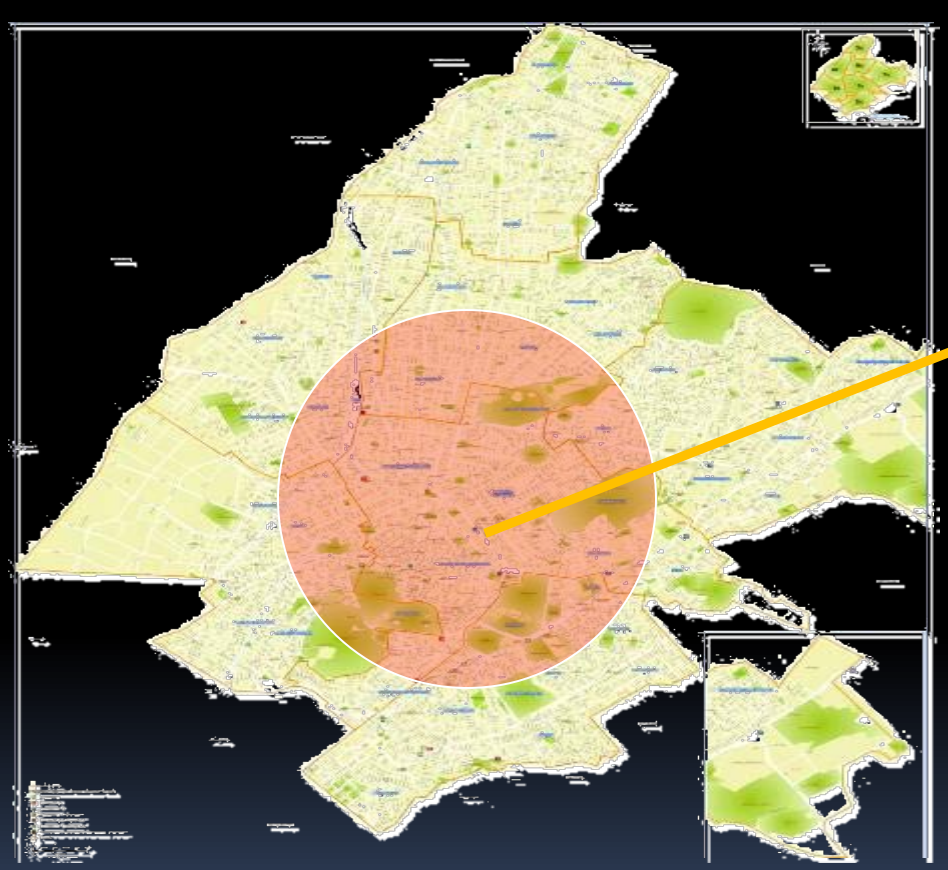


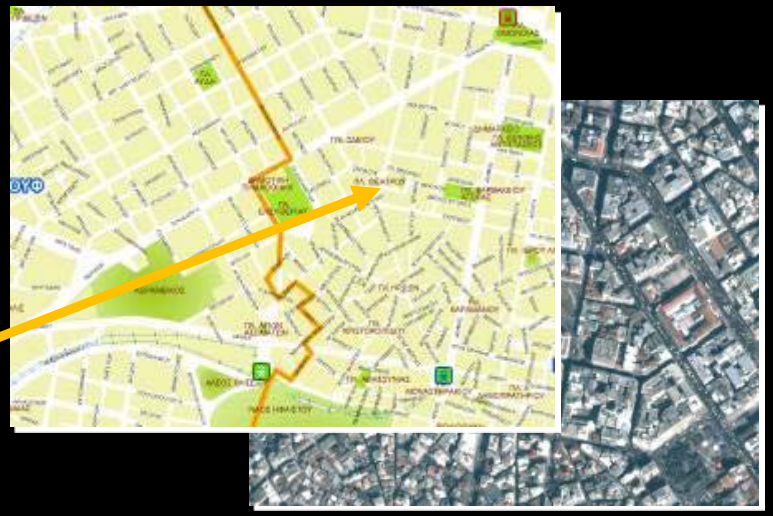
It is suggested that excess deaths occurring in urban areas during periods of extreme heat can be significantly reduced through appropriate urban microclimatic design

Objectives

- Measurements of the thermal environment
- Strategies for microclimatic modification
- Evaluation of proposed solutions with microscale numerical models

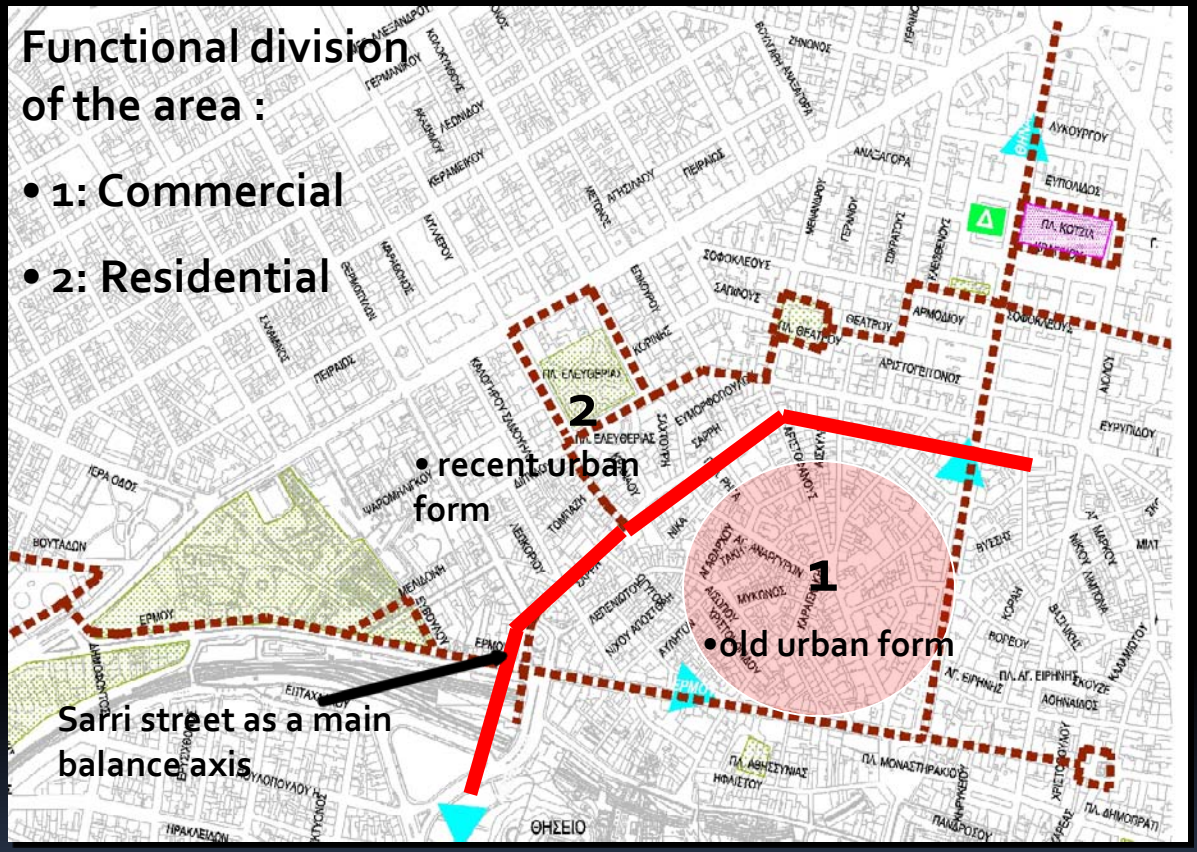
Area of interest: Athens Psyrri





- Microclimatic Research
- Thermal Comfort
- Materials in the Urban fabric
- Green areas & Water elements

Characteristics of Psyrri

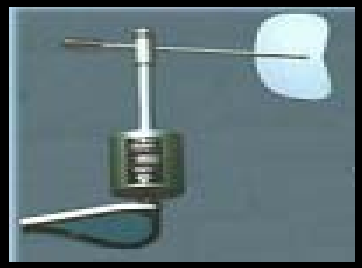


Urban environment

Methodology

A. Field measurements microclimatic data (Tair, Wind, Humidity, Tsurf)
B. Study the role of the materials used in the urban fabric (IR)
C. Investigation of thermal comfort in outdoor spaces (Bioclimatic indices)
D. Integration of microclimatic information in the design of open spaces
E. Evaluation of proposed solutions with bioclimatic CFD models (PHOENICS, ENVI-met)

Field measurements

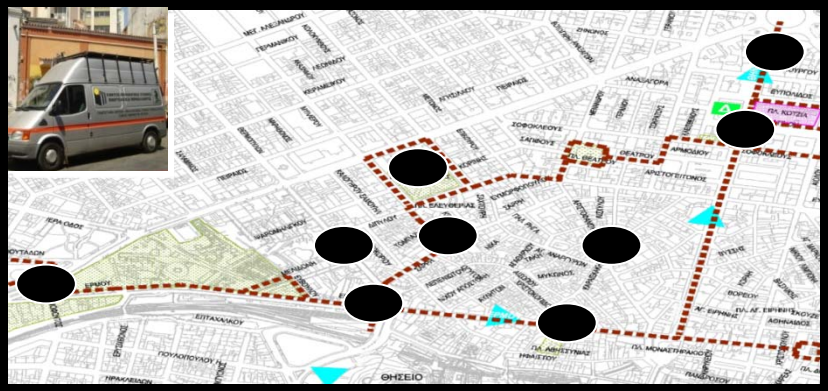


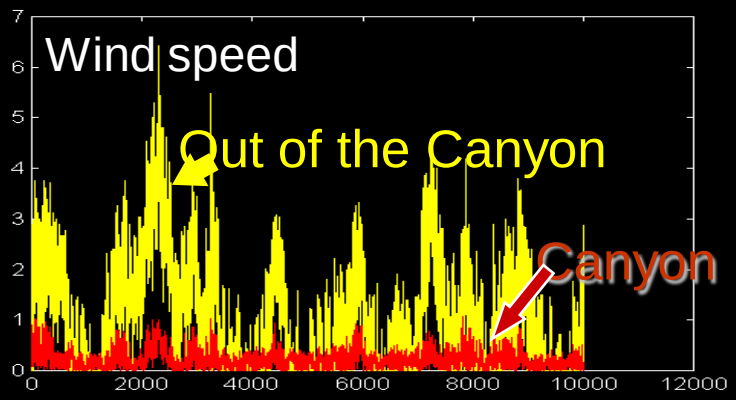


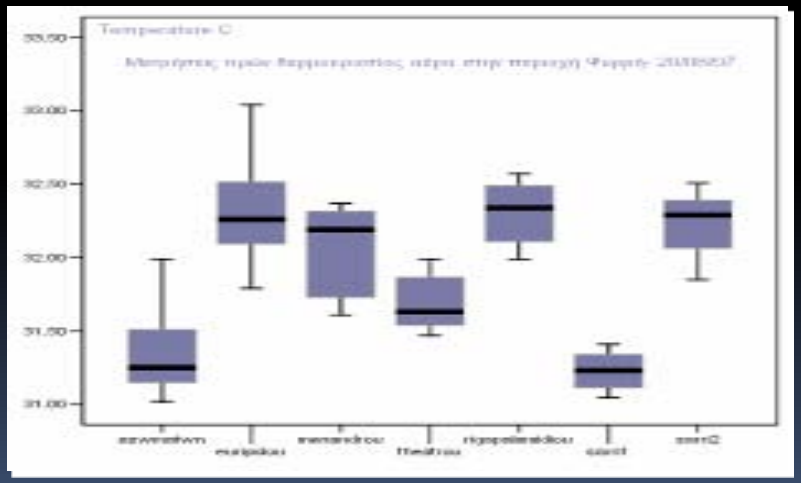


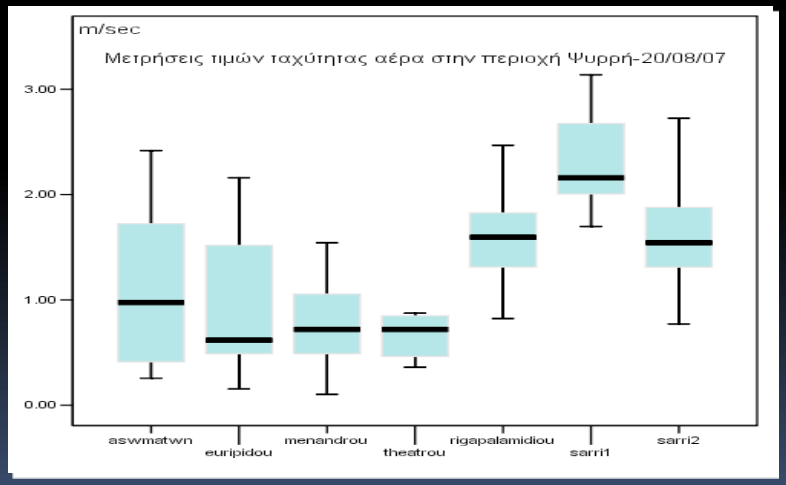

- Ambient Temperature Ta,ºC
- Relative Humidity RH%
- Wind Speed WS, m/sec
- Surface Temperature Ts,ºC
- Infrared Thermography

Air Temperature & Wind Speed

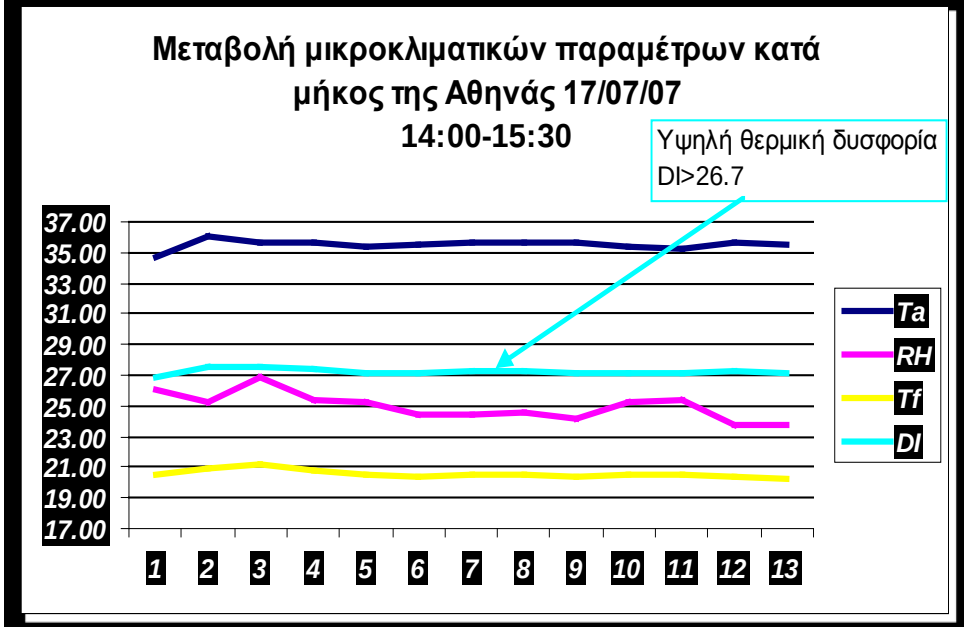








Thermal Comfort

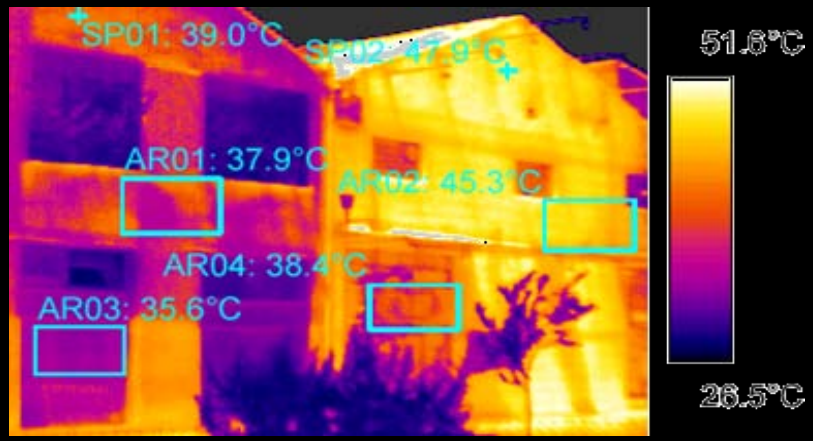


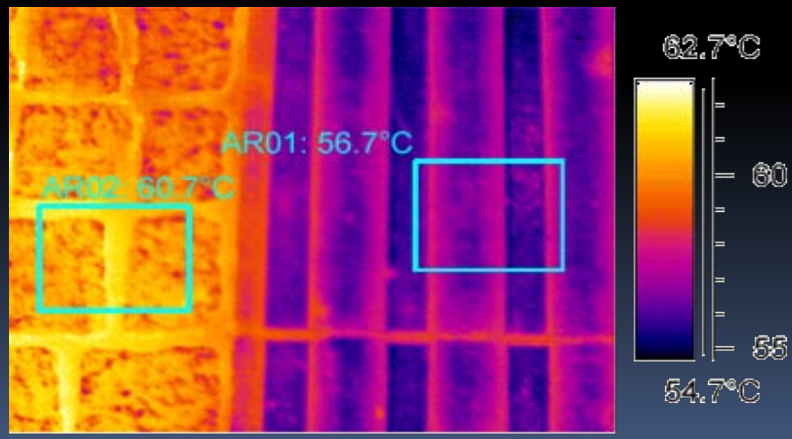
Microclimatic Parameters:

1. High temperatures (Ta>32 ºC)
2. Low wind speeds (WS<2.2m/sec)
3. Low relative humidity (RH<35%)

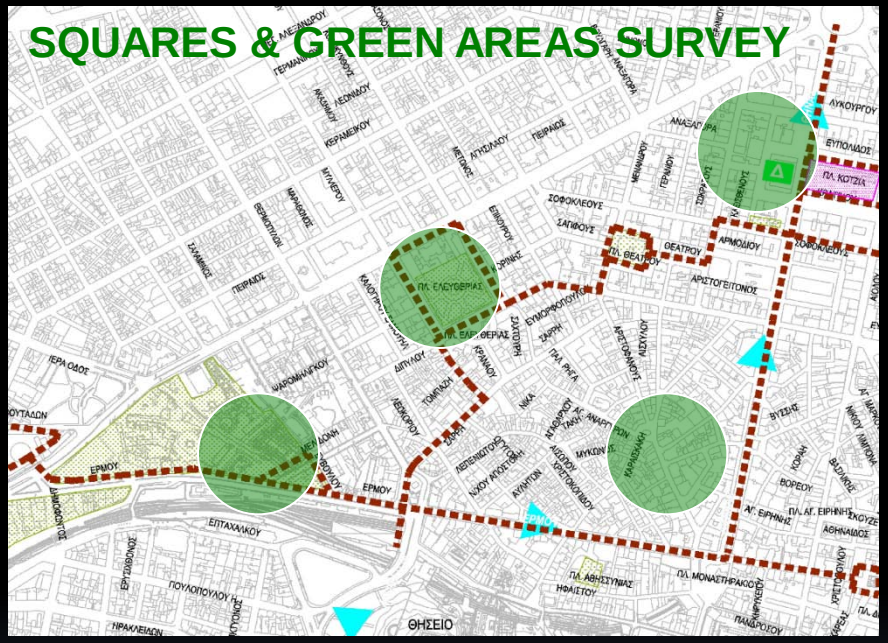
Thermal Comfort: Thom's Discomfort index DI➔ More than half population feels discomfort

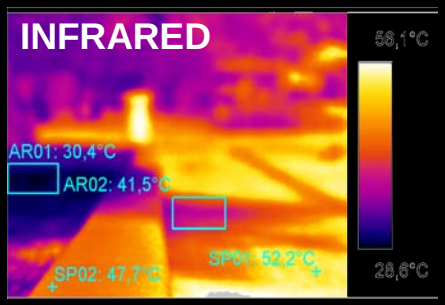
Infrared Thermography

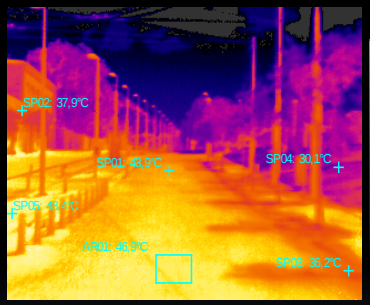




Infrared Thermography







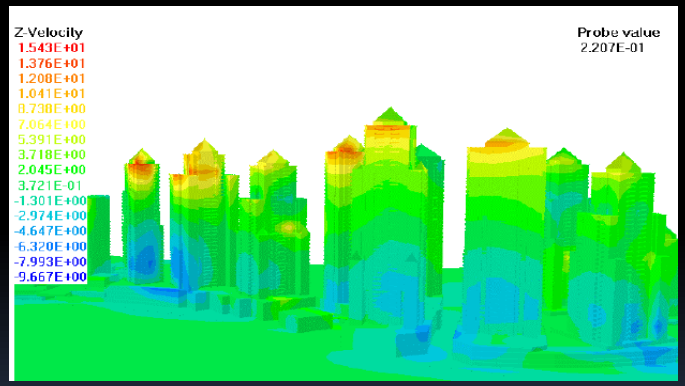
The green areas have a lower surface temperature with 10 -20 degrees of difference

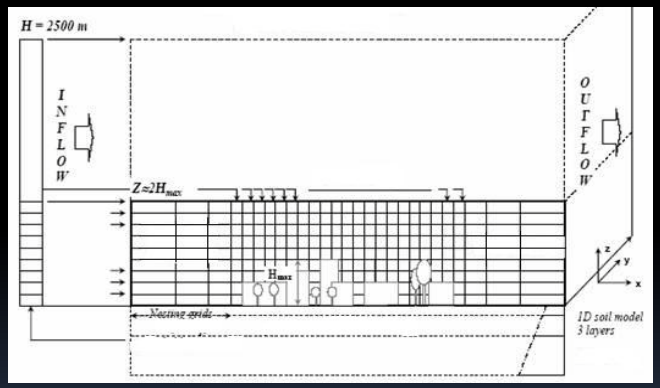
Grass's temperature under shade: 26 °C
Pavement 's temperature under shade: 42 °C
Pavement's temperature without shade: 56 °C

Modeling urban microclimate with CFD

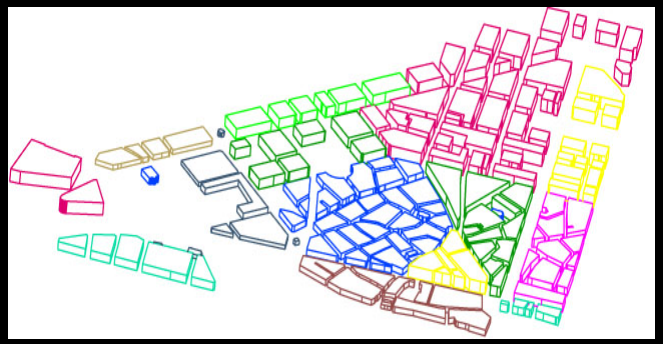
PHOENICS a general purpose software package which predicts quantitatively the complex flow of fluids

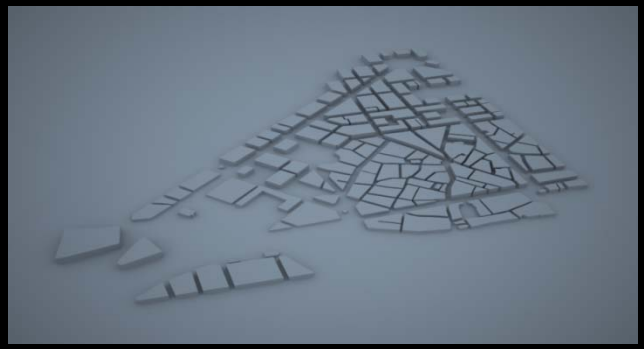
ENVI-met a 3-D **model** designed to simulate the surface-plant-air interactions in urban environment with a typical resolution of 0.5 to 10 m in space and 10 sec in time

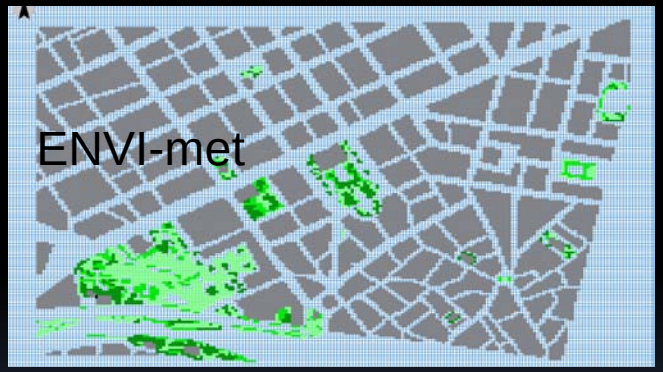


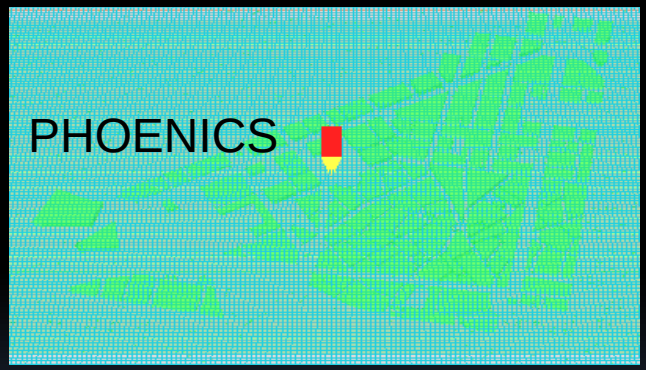


Computational Fluid Dynamics

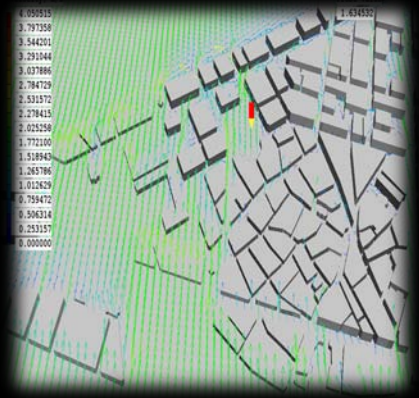


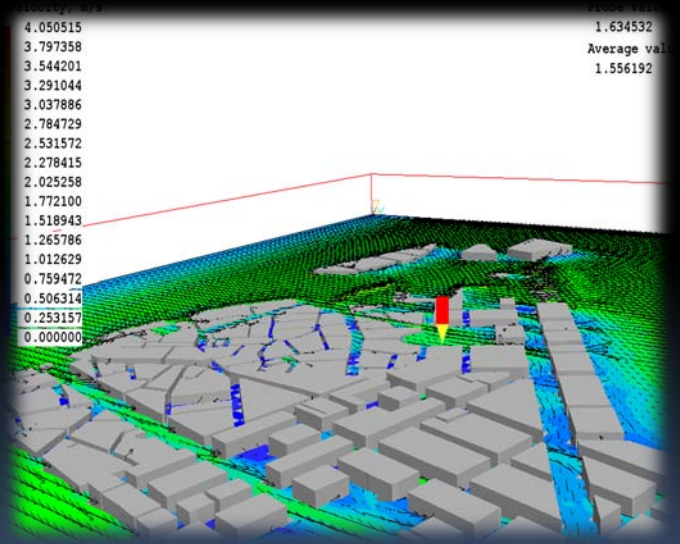






Wind field

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3.544201
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3.037886
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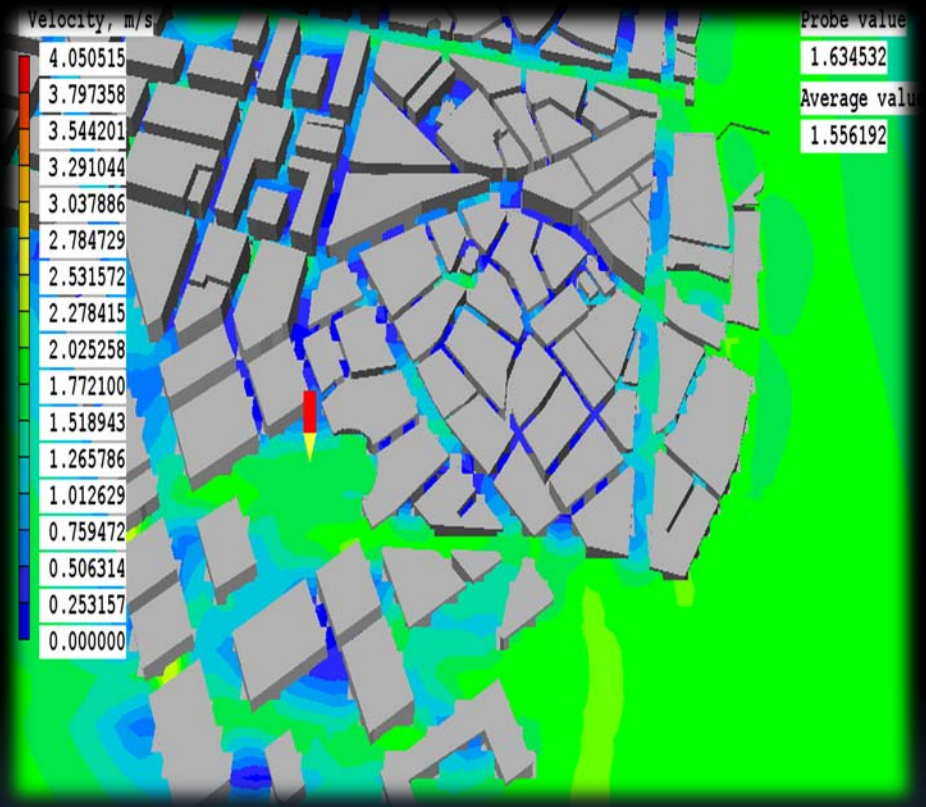
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Probe value
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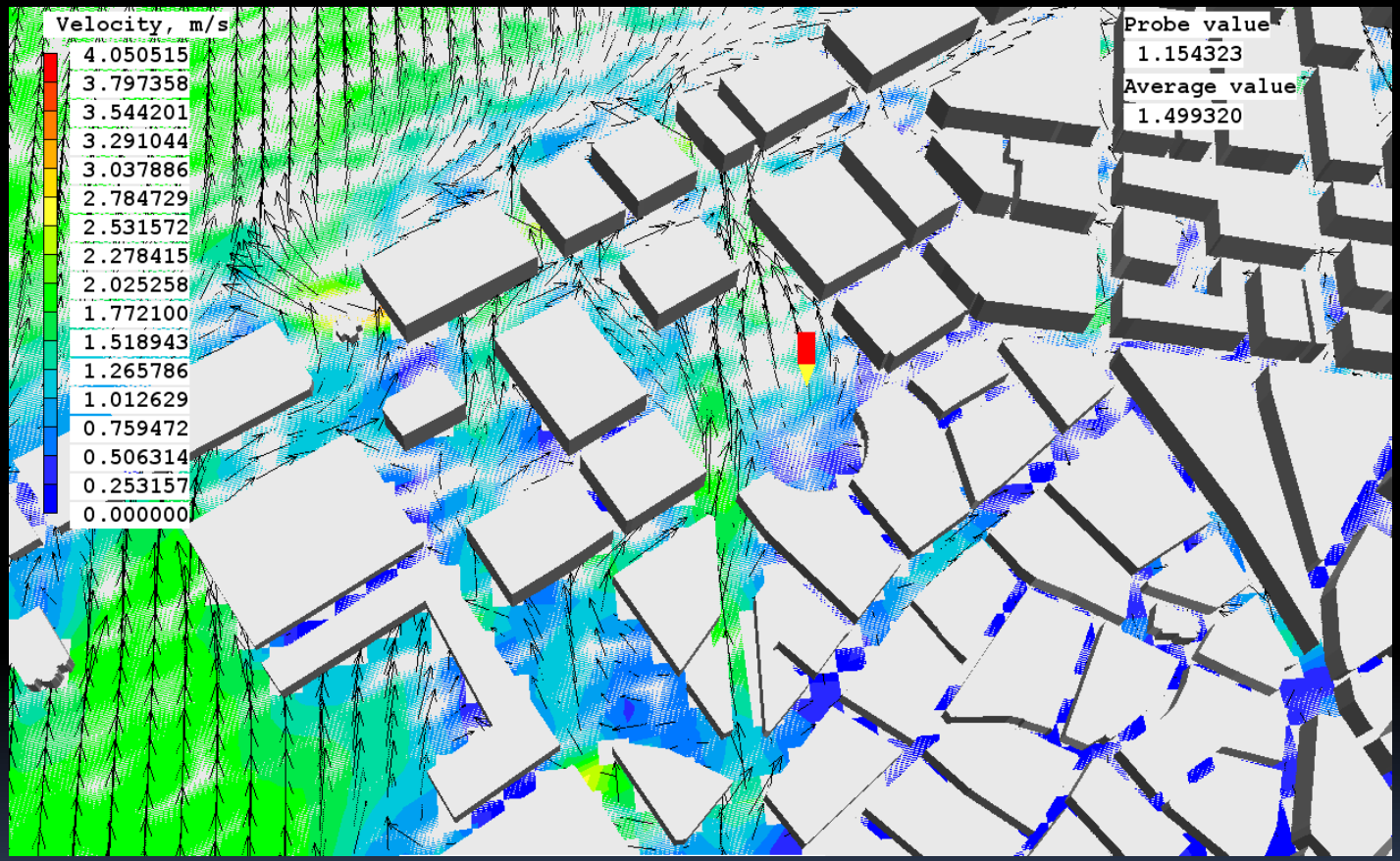
Average valu
1.556192

Wind field


Velocity, m/s
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0.000000
Probe value
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Average value
1.499320

Simulated values of air temperature (current situation)

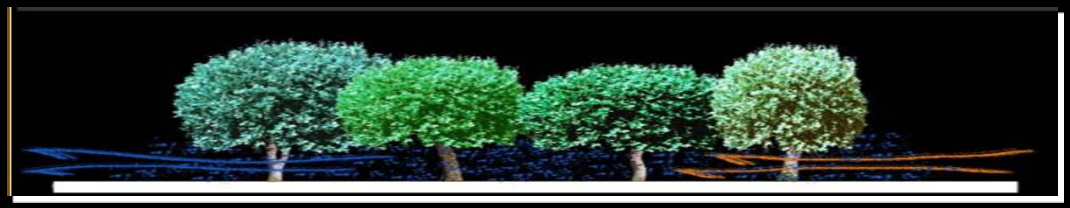
Strategies for microclimatic modification

The suggested interventions included:

A. Increase of vegetation, creation of green network in open spaces
B. Use of reflective coatings (cool materials)
C. Application of green roofs

Vegetation

Green Network
Green Squares
Shaded Open Spaces

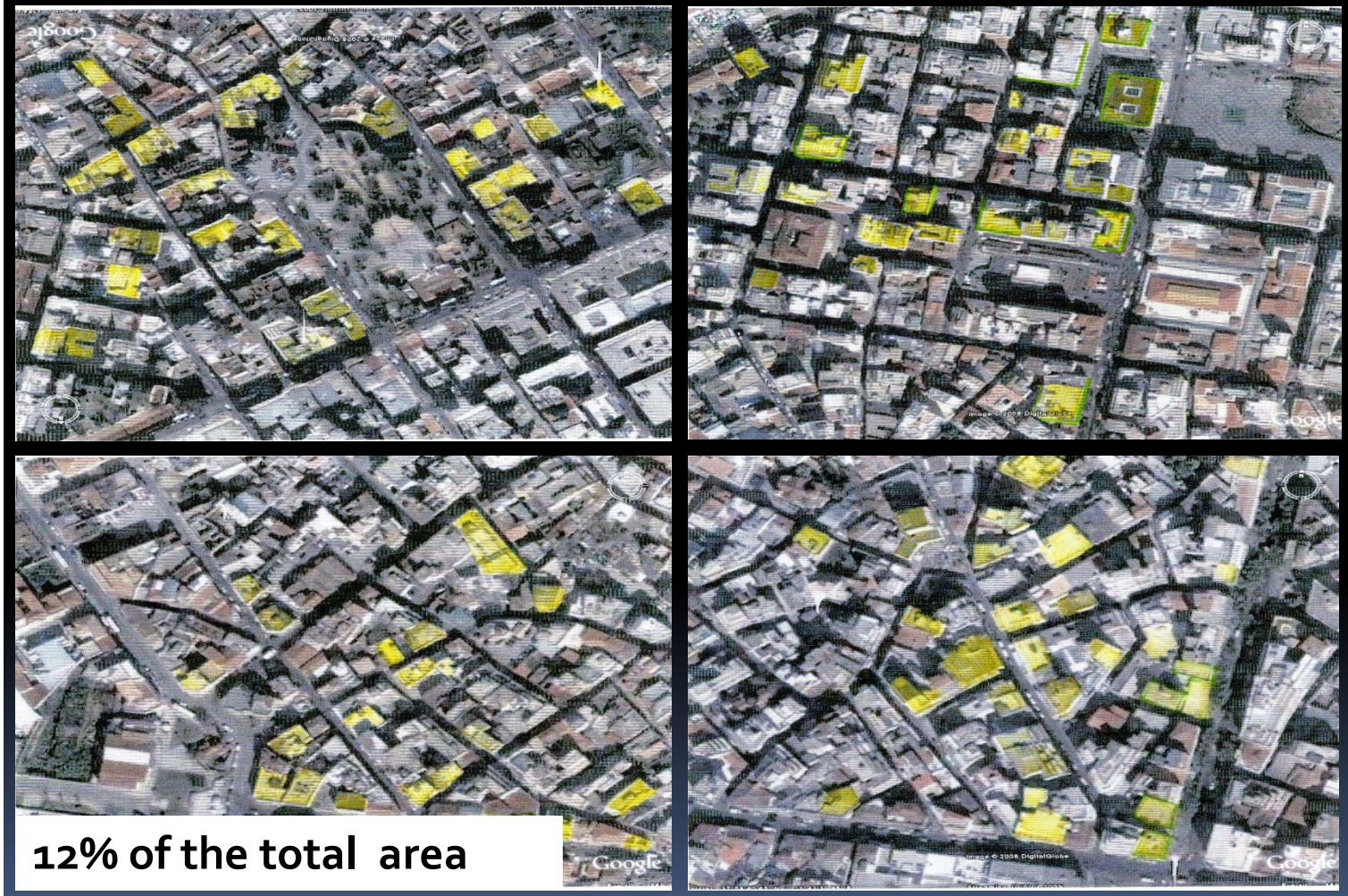


More specifically, the microclimatic effect of trees is obtained through several processes:

(i) reduction of solar heat gains on windows, walls, and roofs through shading;
(ii) reduction of the building long-wave exchange with the sky as building surface temperatures are lowered through shading;
(iii) reduction of the conductive and convective heat gain by lowering dry-bulb temperatures through evapotranspiration during summer;
(iv) increase of latent cooling by adding moisture to the air through evapotranspiration.

Vegetation reduces air temperature by direct shading of surfaces as well as by moderating solar heat gain through evapotranspiration of the plants and conversion of incident solar radiation to latent heat

Green roofs



Materials



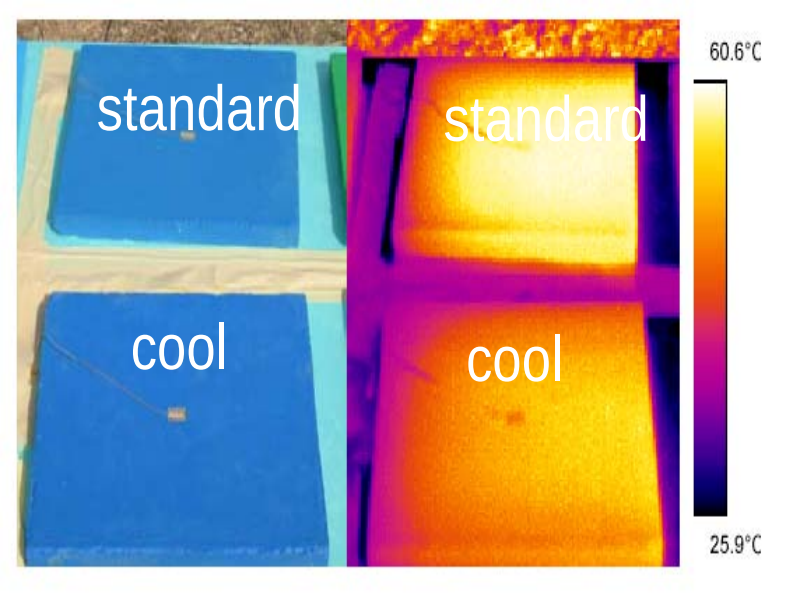


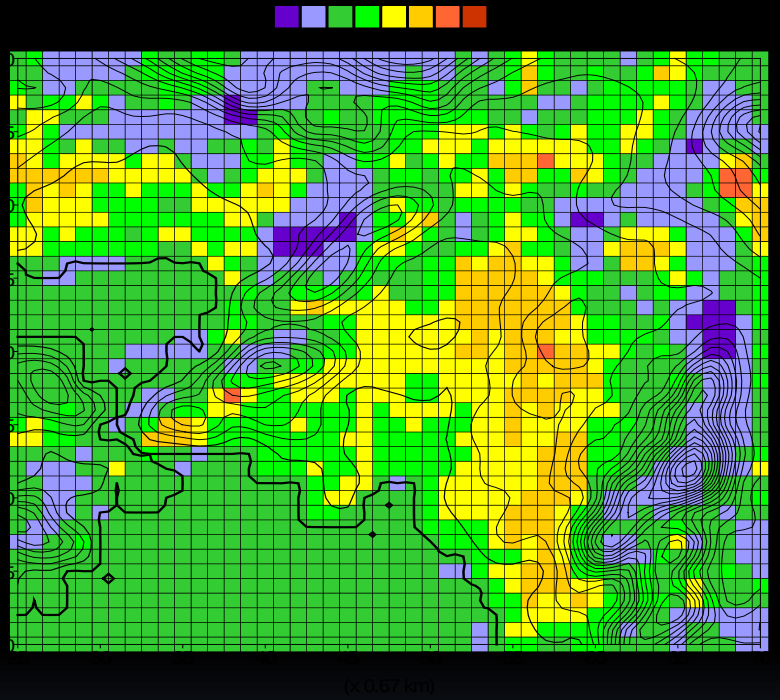

Preservation and restoration with reflective coatings for roofs and walls





Reflective materials

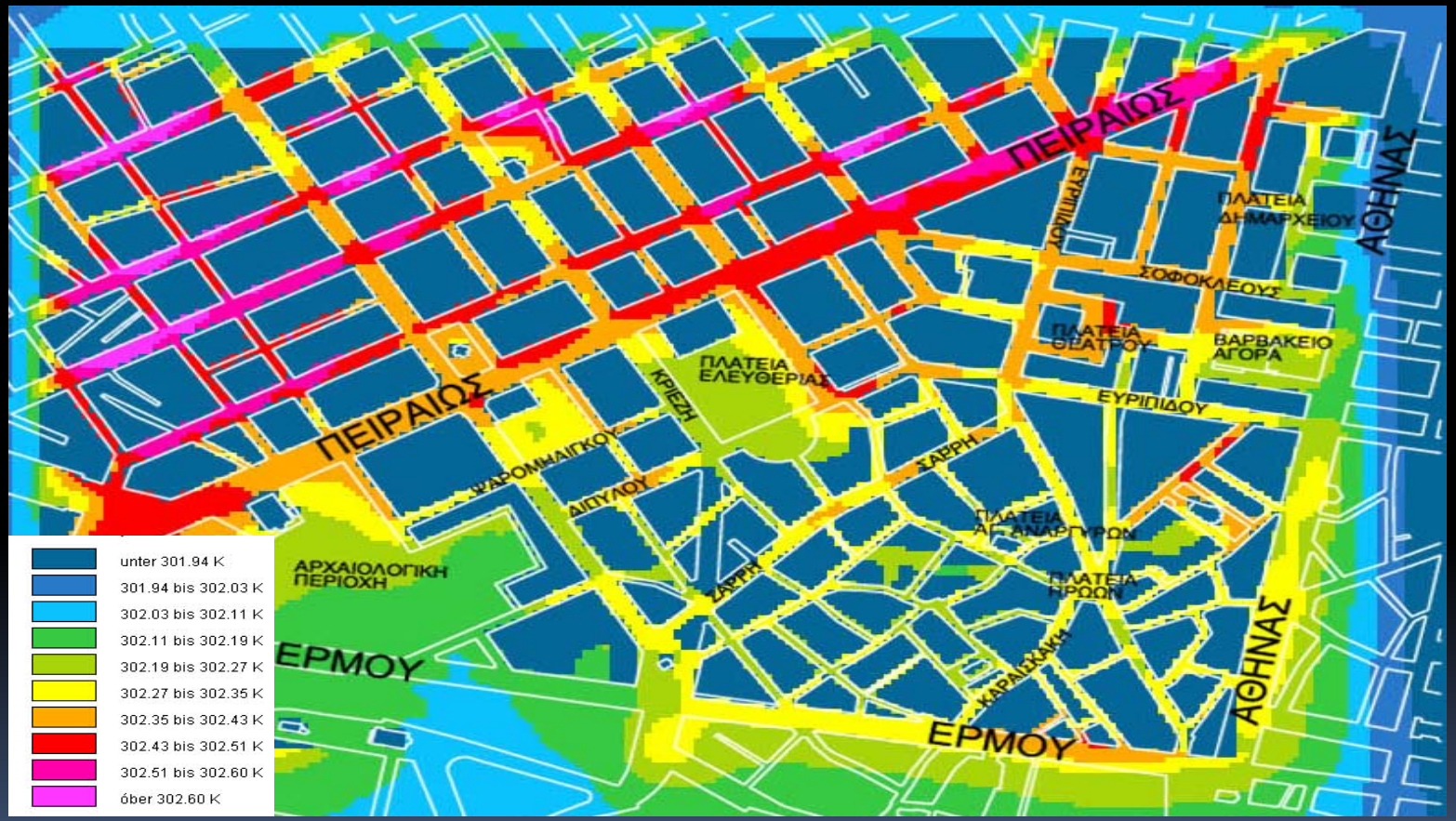




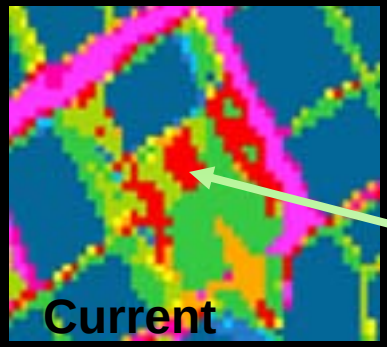
“Cool” materials characterized by high reflectance to short wave radiation and high emissivity to long wave radiation

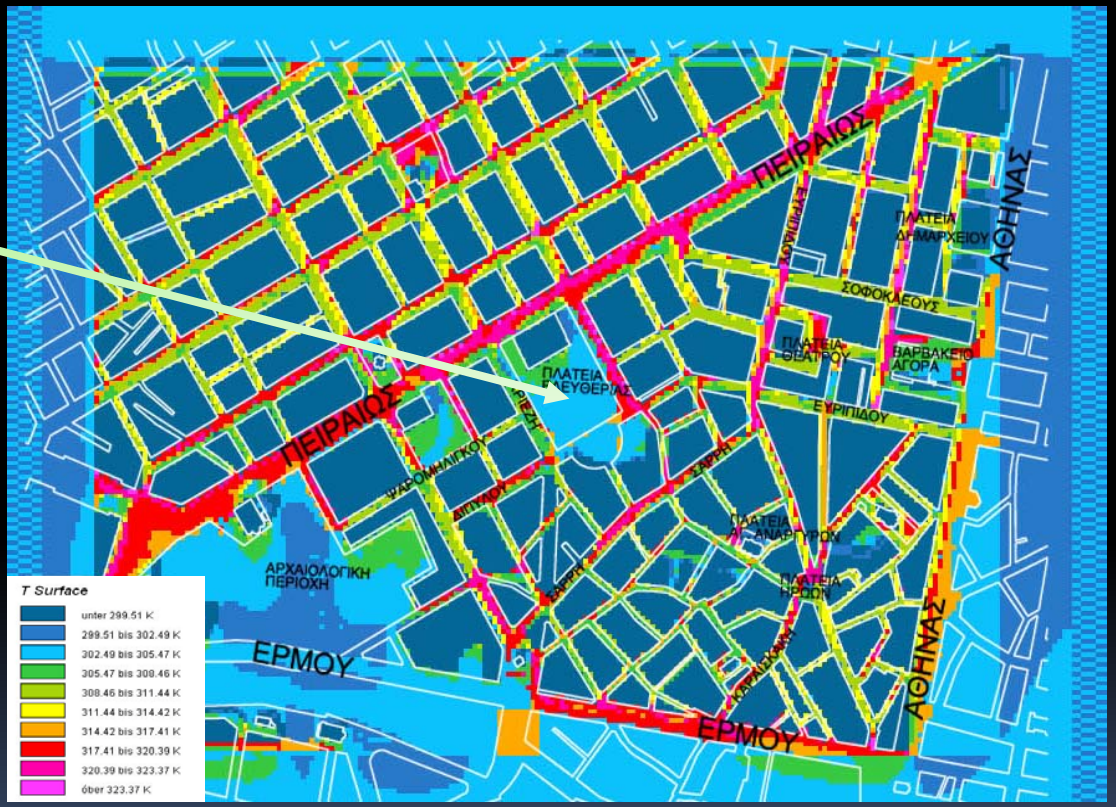
The use of cool materials at city scale can contribute to the reduction of air temperature

Simulated values of air temperature (new situation)



Simulated values of surface temperature (new situation)





Concluding remarks

1. Reduction of air temperature on average 2°C
2. Reduction of surface temperatures of structured environment with 10°C average difference
3. Improvement in thermal comfort conditions
4. Reduction of health risks
5. Energy saving effects
6. Improved life quality

An integrated planning of the urban microclimate can provide the tools for creating thermally comfortable environments and energy efficiency landscapes

Thank you!

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