Measurement of Optical Properties and Thermal Performance of Coloured Thin Layer Asphalt Samples and Evaluation of Their Impact on The Urban Environment

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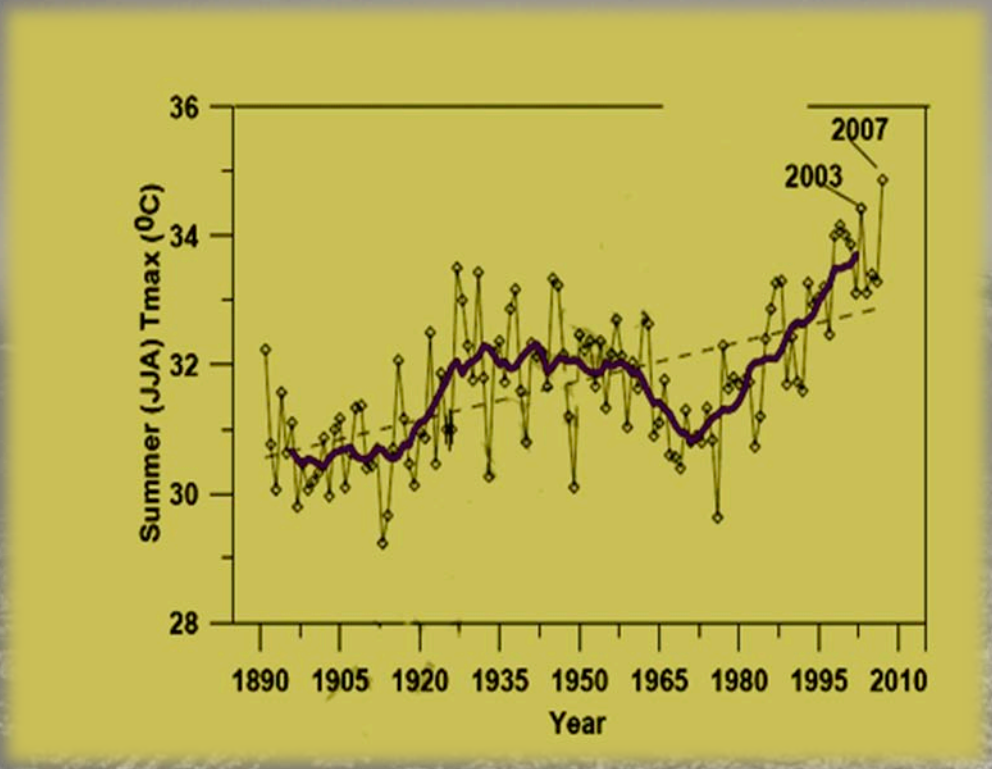
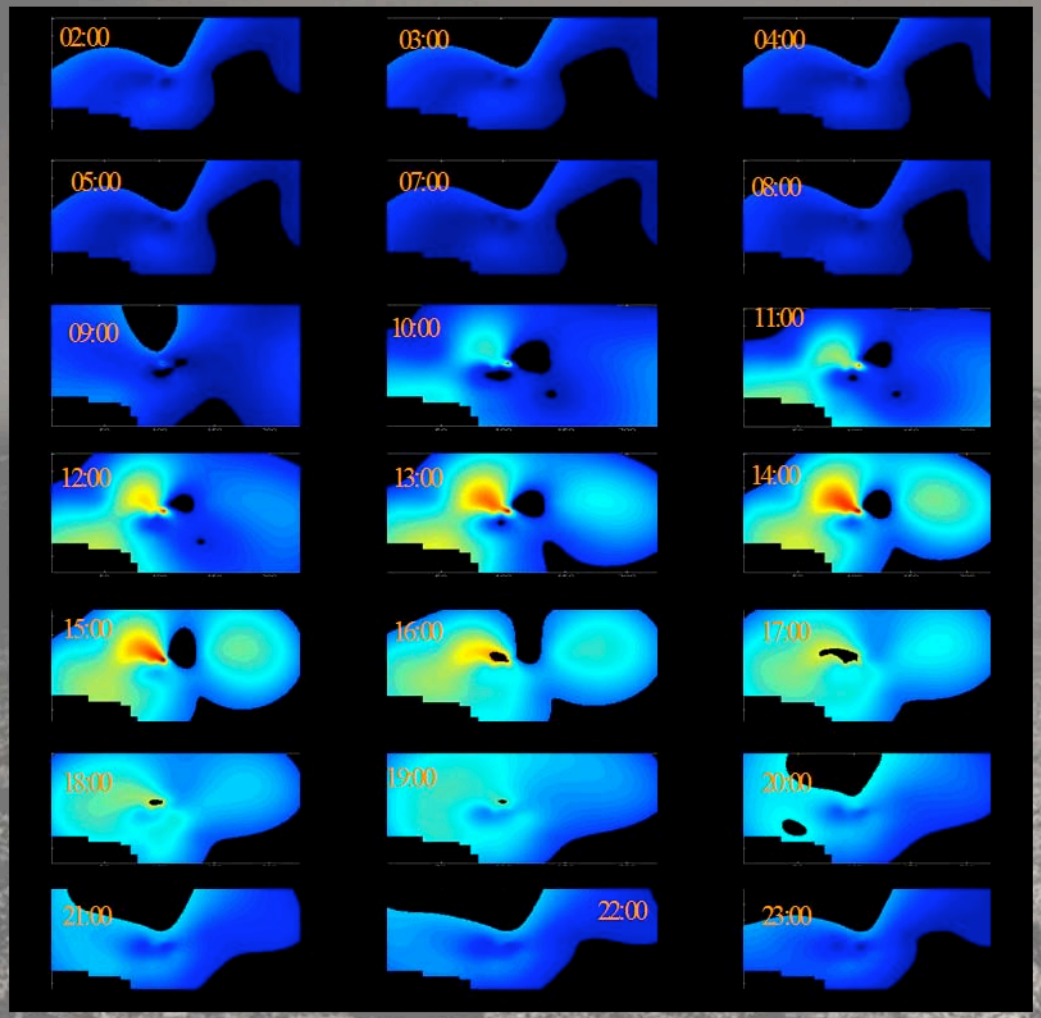
DEVELOPEMENT OF COOL ASPHALT MATERIALS



Πηγή Δ. Φουντα, ΝΟΑ

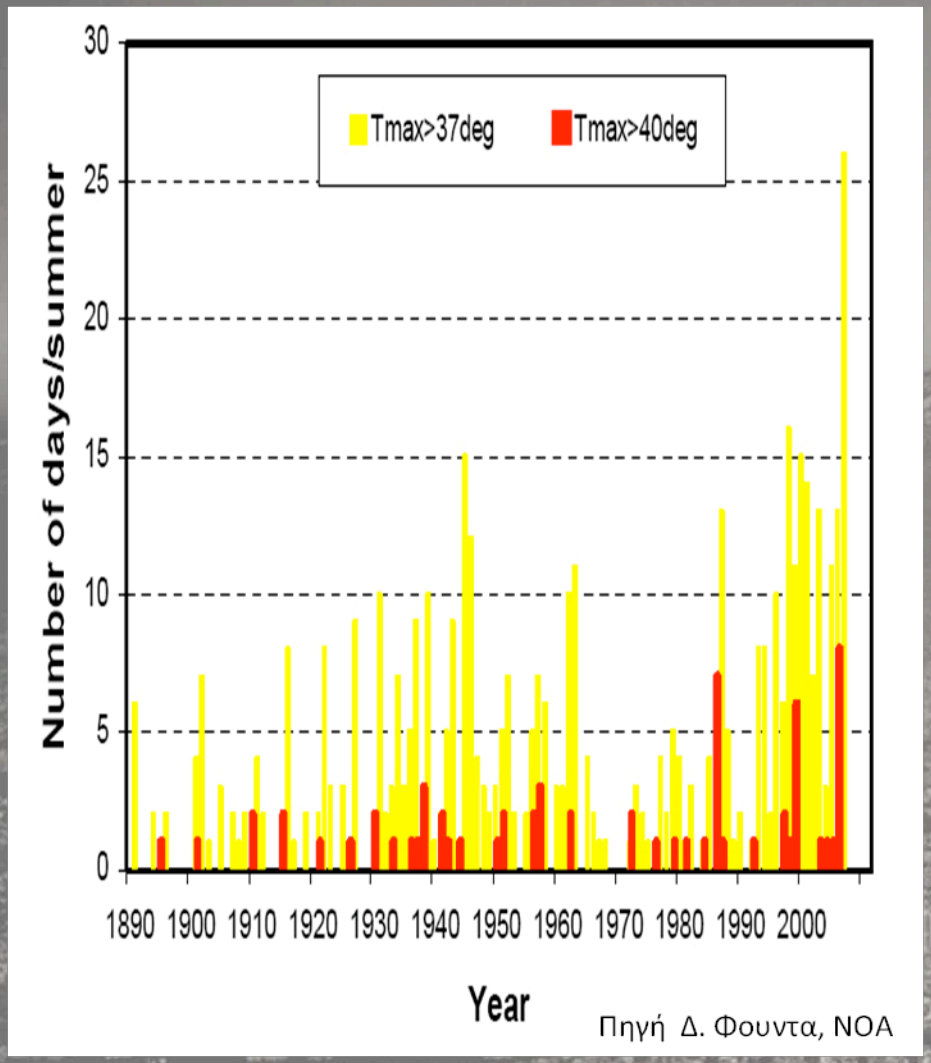
Athens is characterised by a continuous temperature increase mainly due to the intensive urbanisation, industrialisation, heat island and global climatic change

Spatial Temperature Distribution in Athens



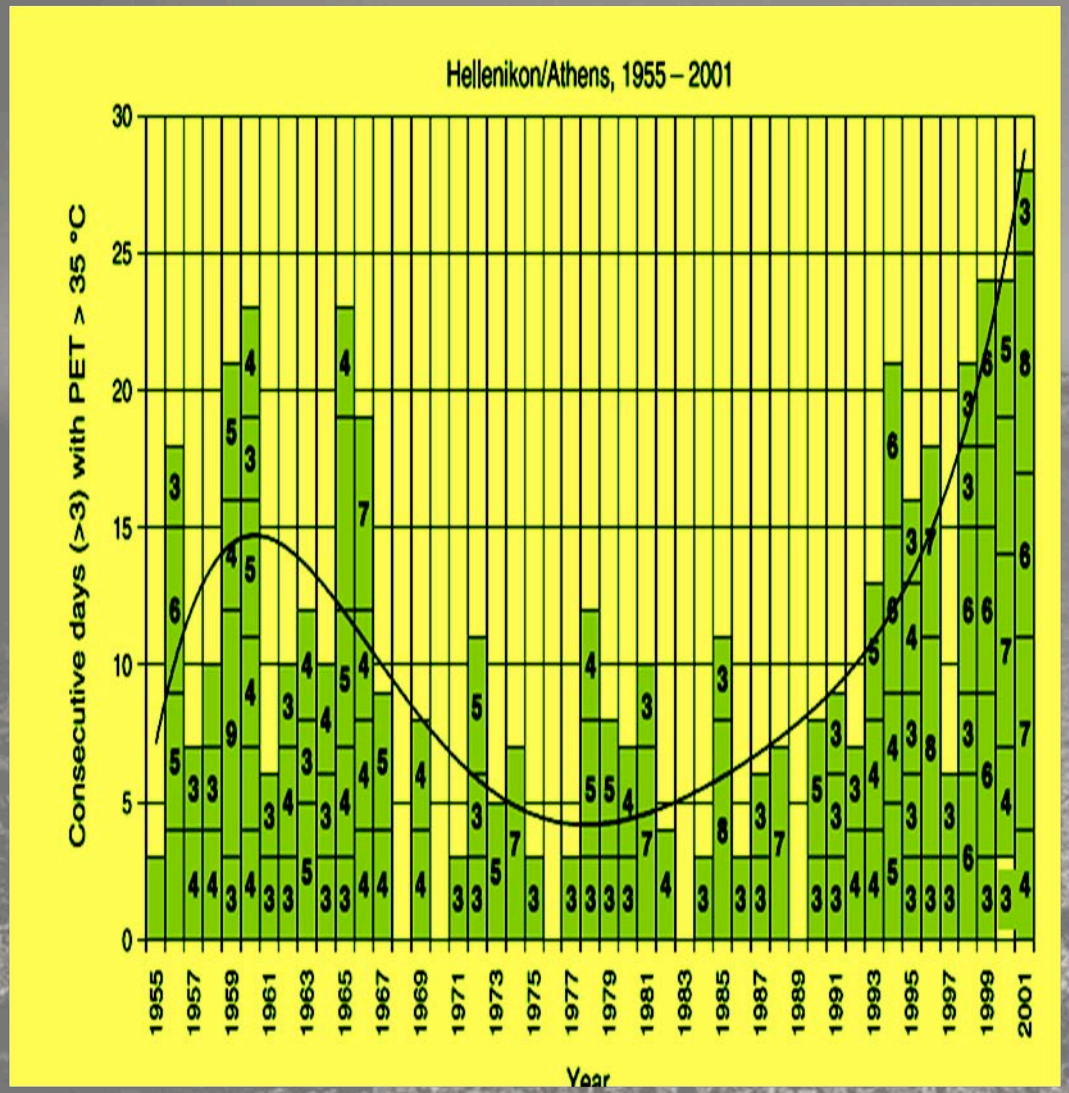
Heat island development is a function of the synoptic climatic circulation in the lower troposphere. Heat island is mainly developed during the day time in the center and western part of Athens. These areas are characterised by high density and strong anthropogenic heat generation

DEVELOPEMENT OF COOL ASPHALT MATERIALS



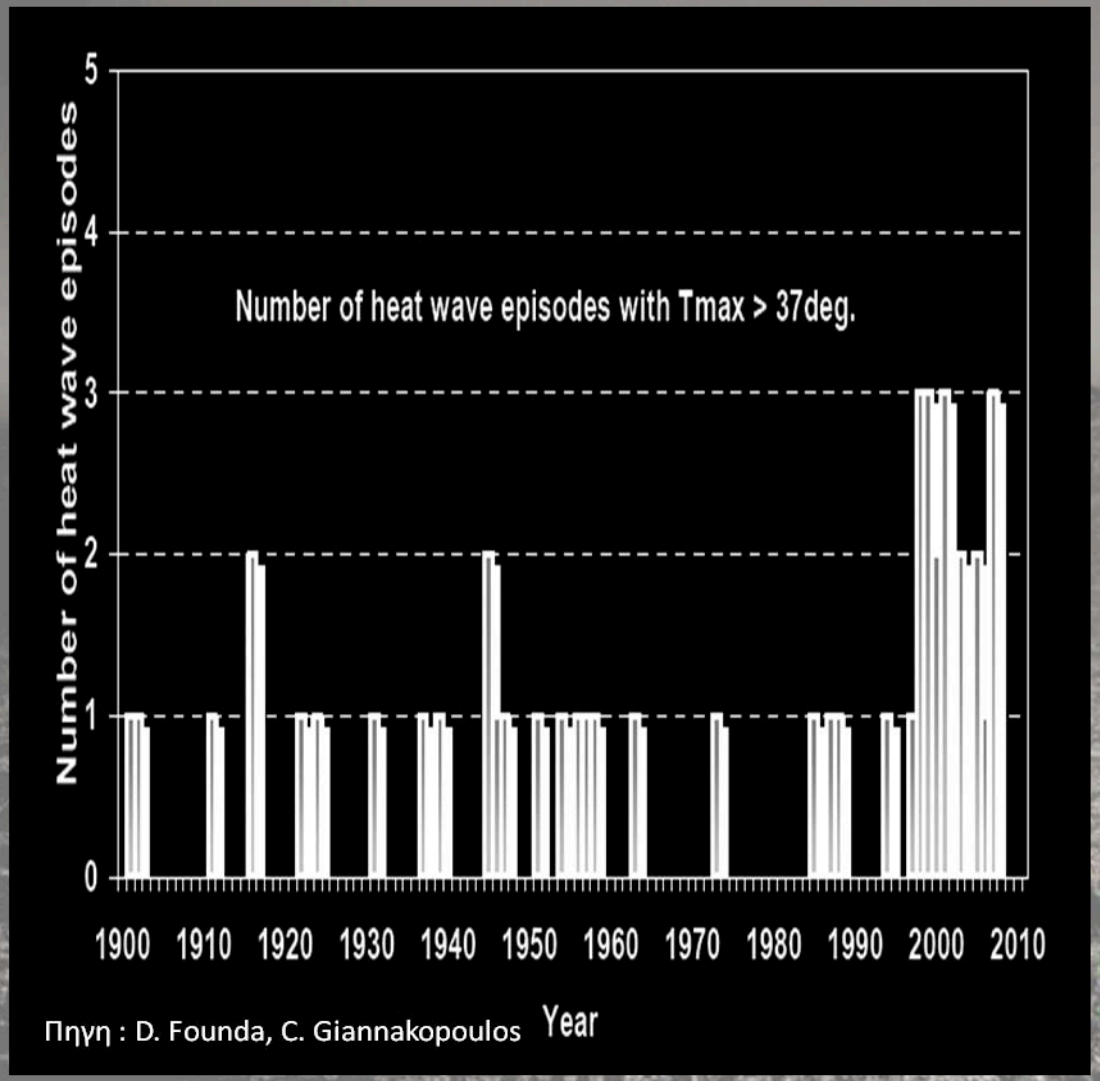
The number of hours above 37 and 40 C increases continously

DEVELOPEMENT OF COOL ASPHALT MATERIALS



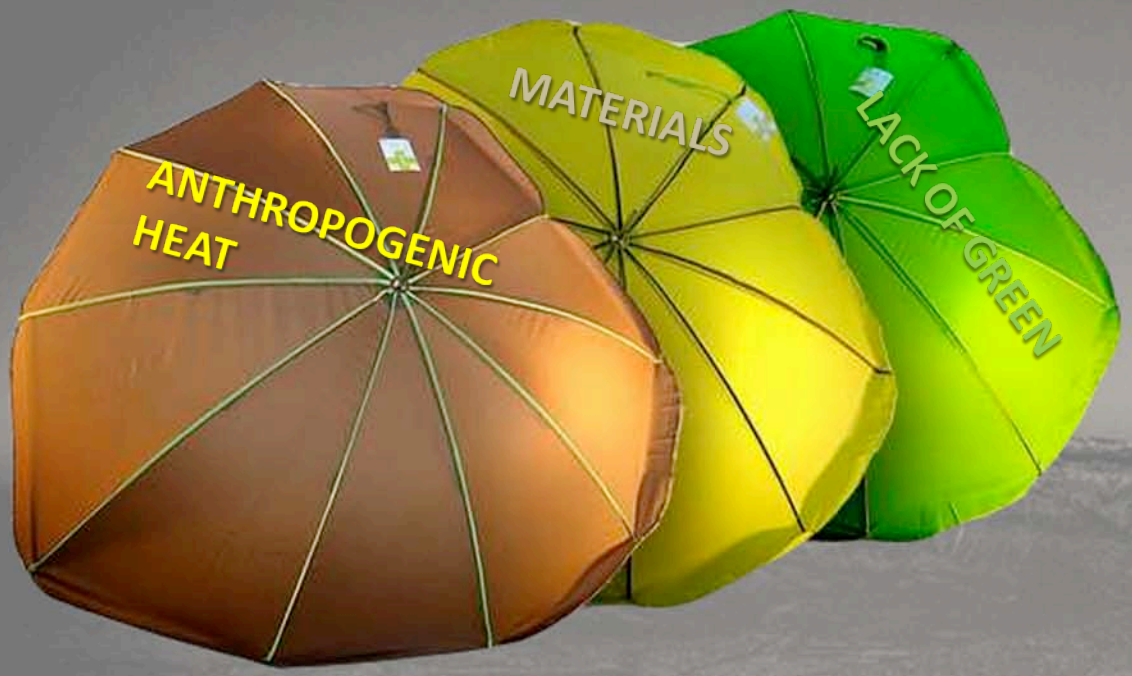
The number of successive hours above 35 C increases continously

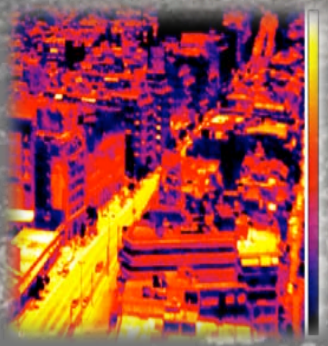
DEVELOPEMENT OF COOL ASPHALT MATERIALS



The frequency of heat waves increases as well.

DEVELOPEMENT OF COOL ASPHALT MATERIALS





Heat Island is mainly due to :

a) Use of high absorbing materials and mainly asphalt
b) High Anthropogenic Heat
c) Lack of Green areas
d) Lack of cool sinks

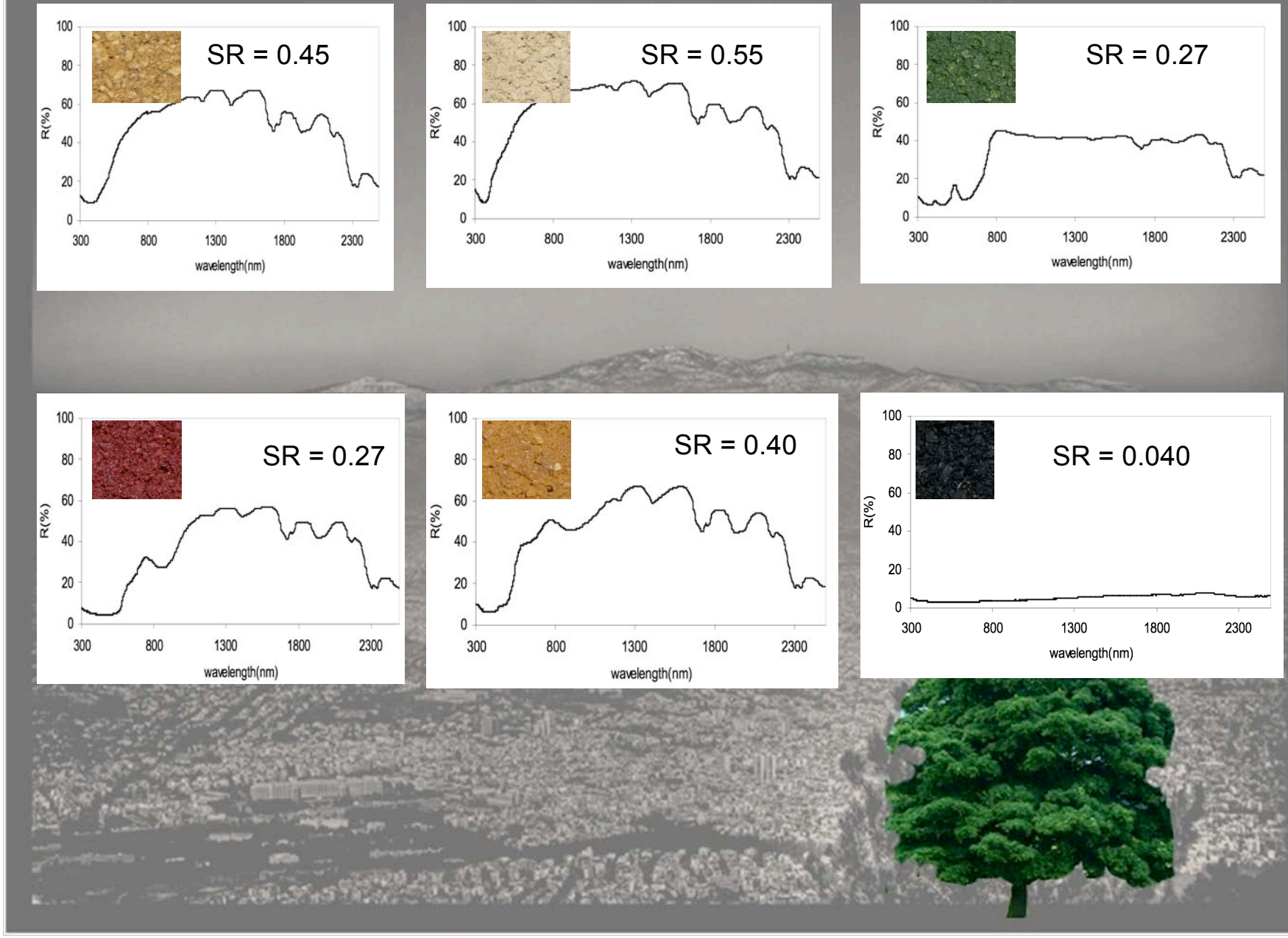
DEVELOPEMENT OF COOL ASPHALT MATERIALS

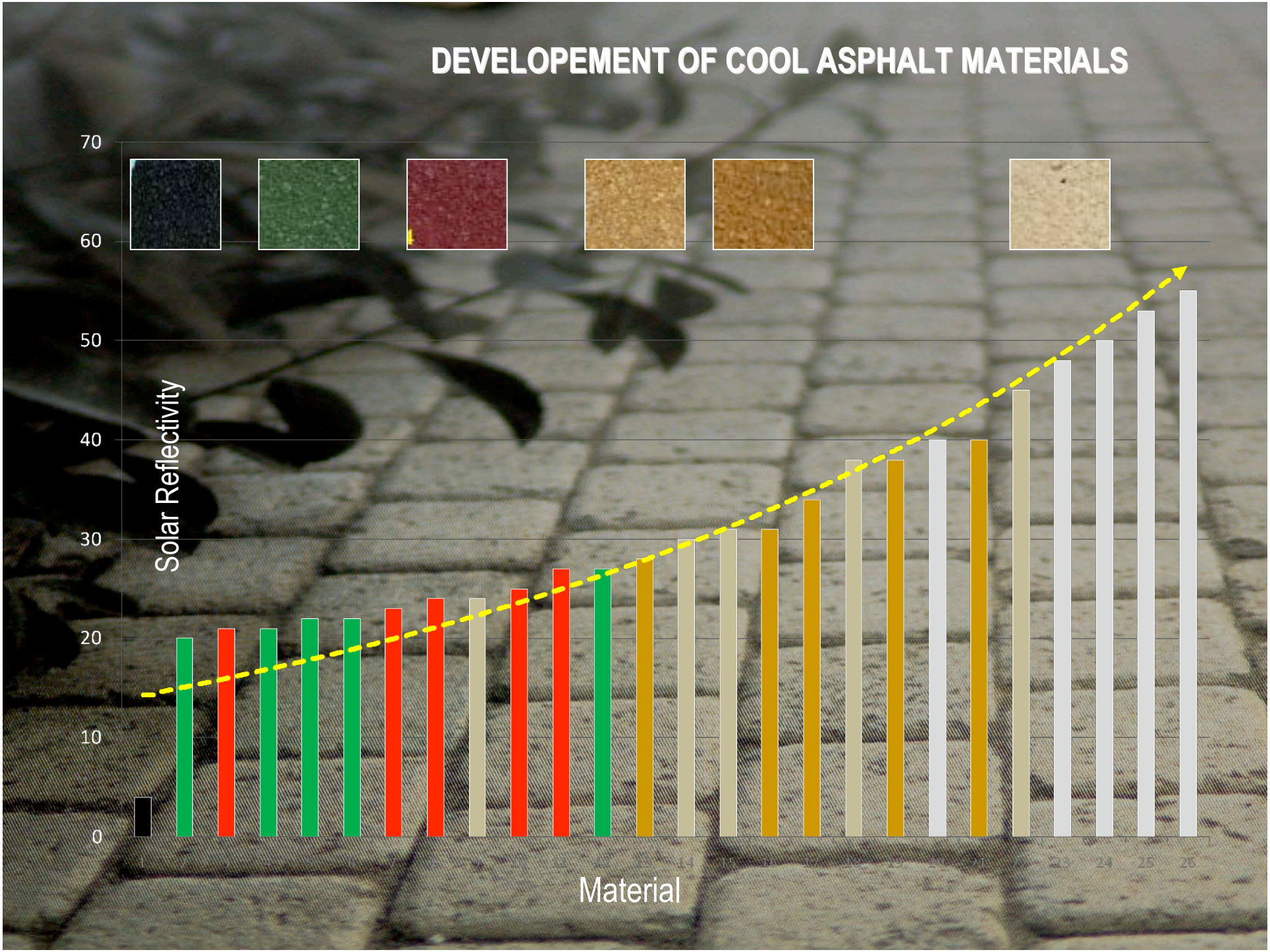
Several color thin layer asphalt samples have been developed by an industrial partner of the University of Athens

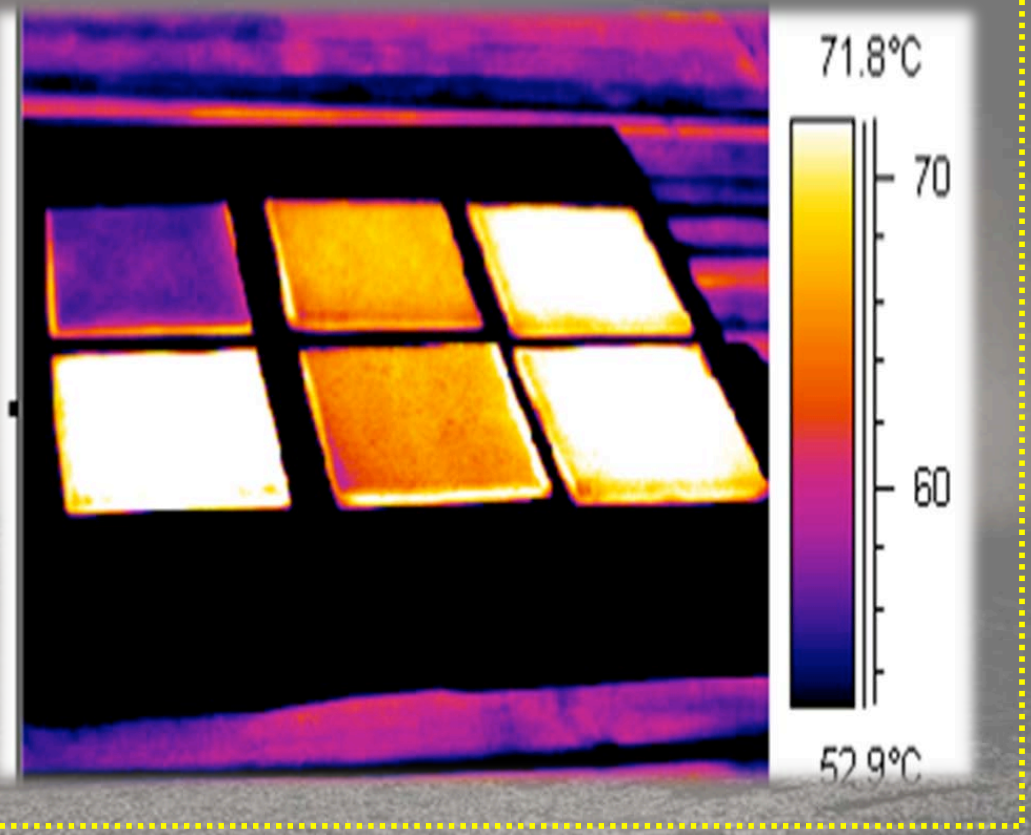
The color thin layer asphalt samples were developed by mixing an elastomeric asphalt binder (colorless) and adding special pigments and aggregates of special sizes and colors

A sample of conventional black asphalt was also tested and used as reference

- Measurement of the spectral reflectance by UV-VIS-NIR Spectrophotometer Carry 5000, Varian fitted with a 150mm diameter integrating sphere
- Measurement of the surface temperature of the samples on a 24 h basis by surface temperature sensors (thermocouples type K) connected to a data logging system and an infrared camera (AGEMA Thermovision 570, 7.5– 13 μm wavelength)
- The samples were placed outdoors on a specially modulated platform, horizontal, unshaded during the whole day and insulated from below
- Experiment during July 2008, typical Mediterranean summer conditions


SR = 0.45
SR = 0.55
SR = 0.27
SR = 0.27
SR = 0.40
SR = 0.040
R(%)
wavelength(nm)
100
80
60
40
20
0
300
800
1300
1800
2300


DEVELOPEMENT OF COOL ASPHALT MATERIALS
70
60
50
40
30
20
10
0
Solar Reflectivity
Material



- The mean max daily surface temperature of the colored thin layer samples ranges from 48oC for the off-white asphalt sample to 55.8oC for the red sample.

- The corresponding temperature for the black conventional asphalt sample is 60 oC.

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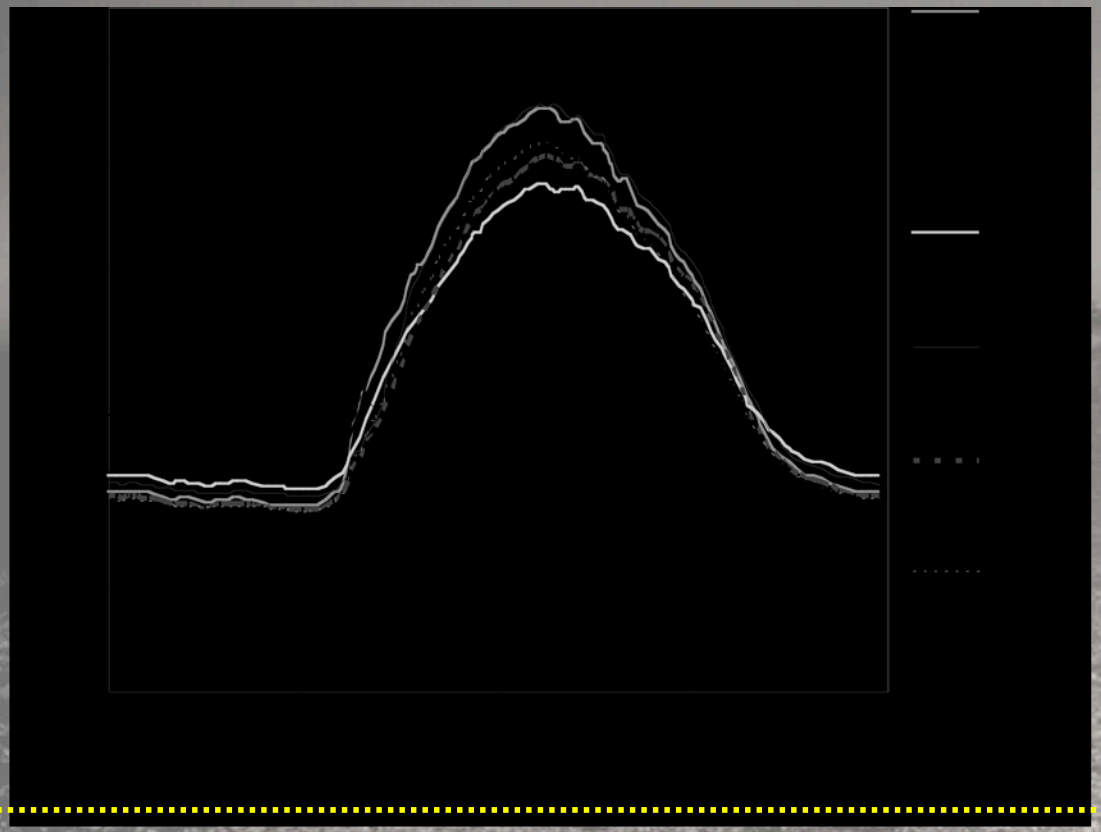

- During the day all the samples have Ts higher than the T ambient air

- During the night Tair is higher than the Ts of the tested samples. Because the samples have high values of emissivity and so they release faster the heat they have absorbed due to night sky radiative cooling.

DEVELOPEMENT OF COOL ASPHALT MATERIALS

A CFD model (PHOENICS) has been used in order to investigate the impact on air temperatures at local scale between a base case where conventional asphalt was used and another case using the off –white (SR=0.55) sample, and the green sample, (SR=.27).

The simulation was performed for a main, commercial road (Ag. Ioannou st.) situated in the suburbs of Athens, surrounded mainly by residential area. There are 4-5 story buildings adjacent to the road.

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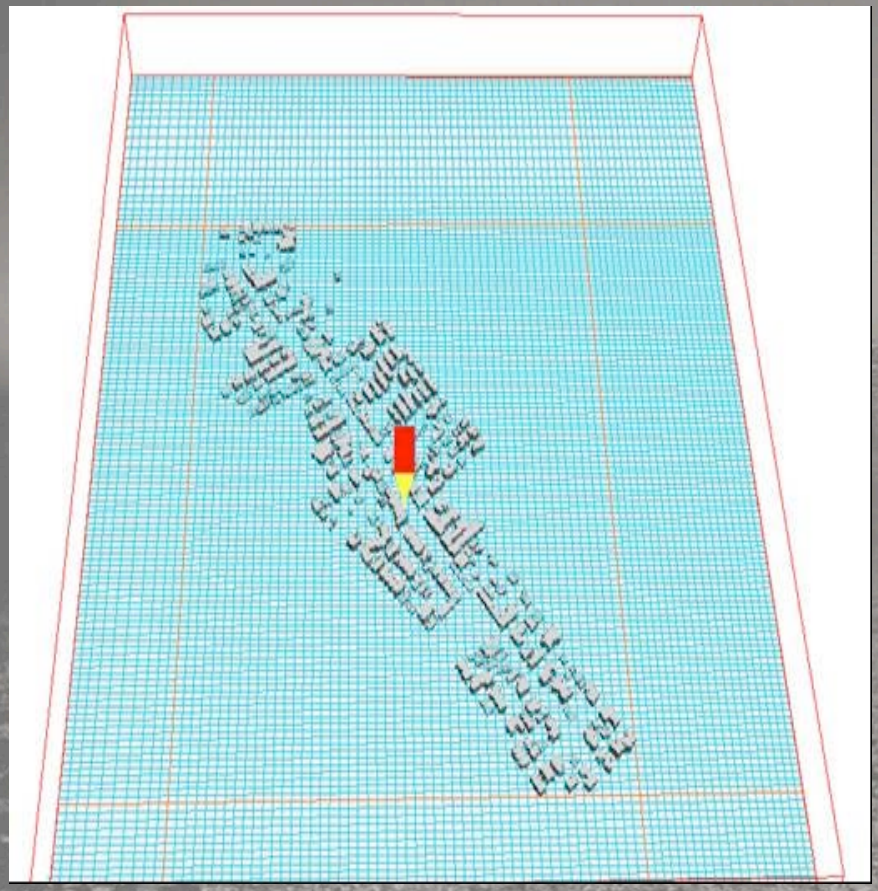

The grid of the calculation domain has dimensions of 1380(x)*1704(y)*150(z) m and consist of 80x140x50 cells at each axis respectively.

Simulations were performed for the summer period and for a north wind of 2m/sec and the measured surface temperatures of the samples have been taken into account.

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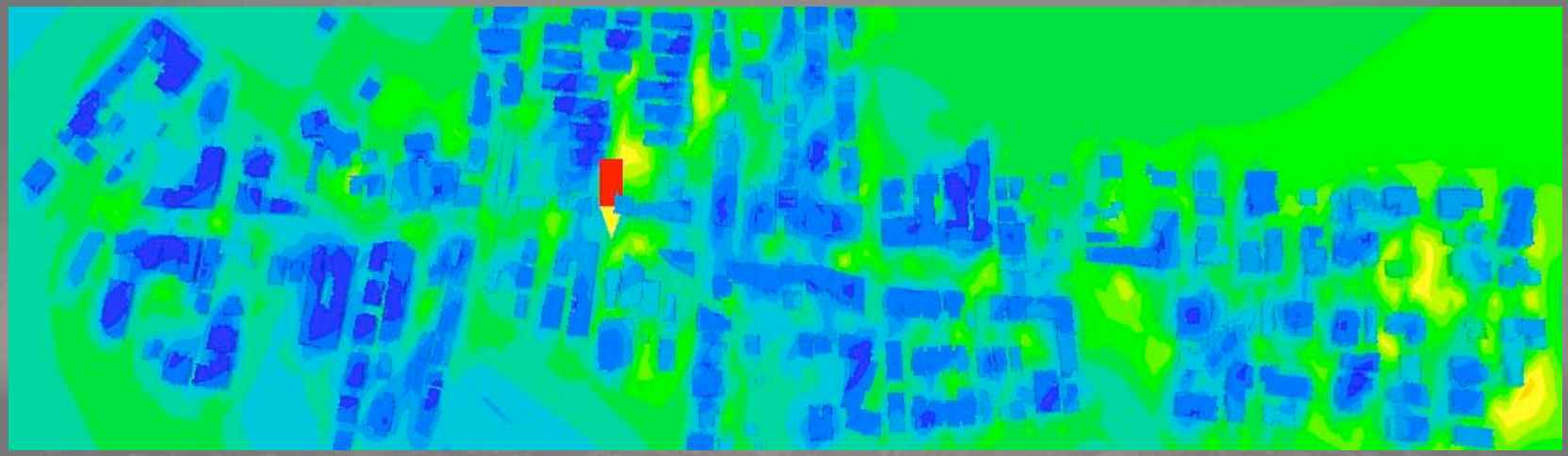

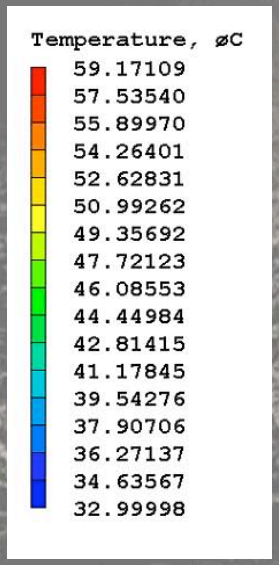

For conventional asphalt, and during the day time and for an undisturbed ambient temperature close to 35 C, local temperatures range between 37 to 47 C. Undisturbed wind was close to 2 m/sec at 10 m height.

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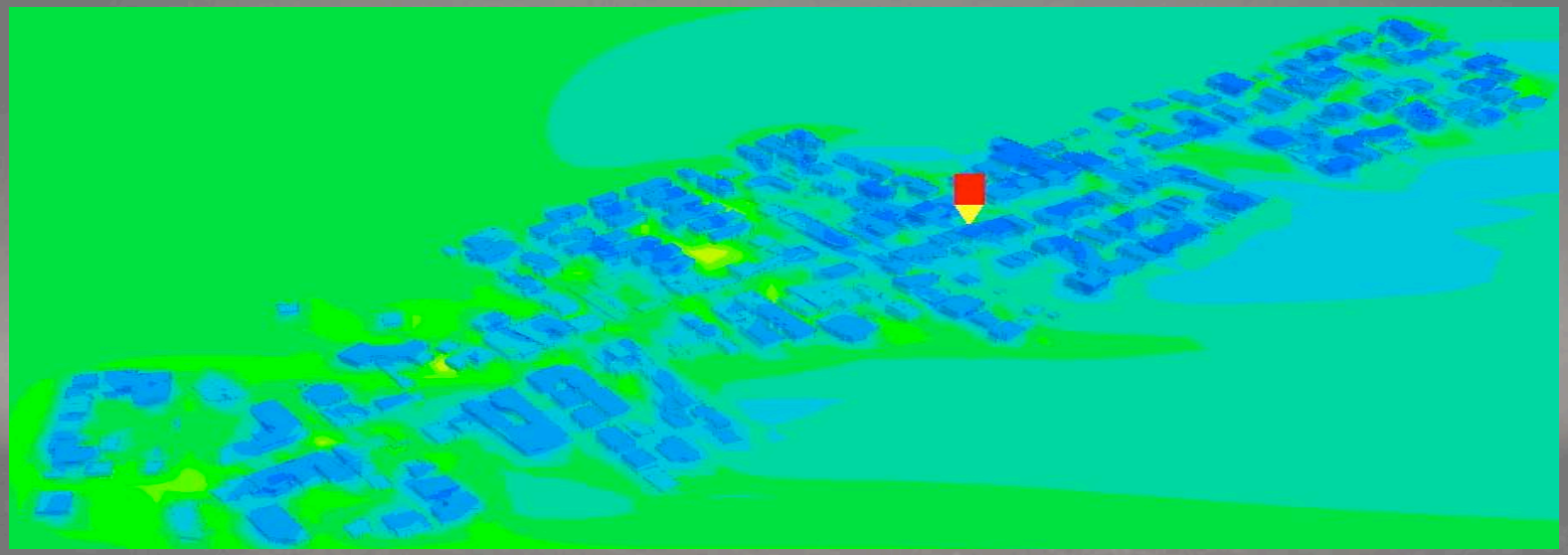
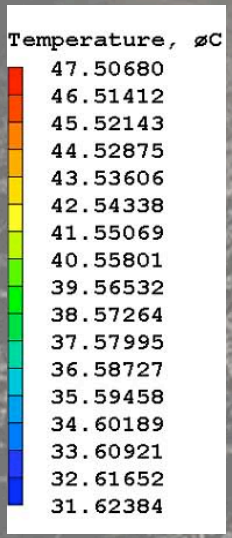
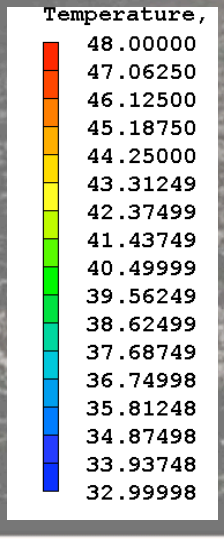




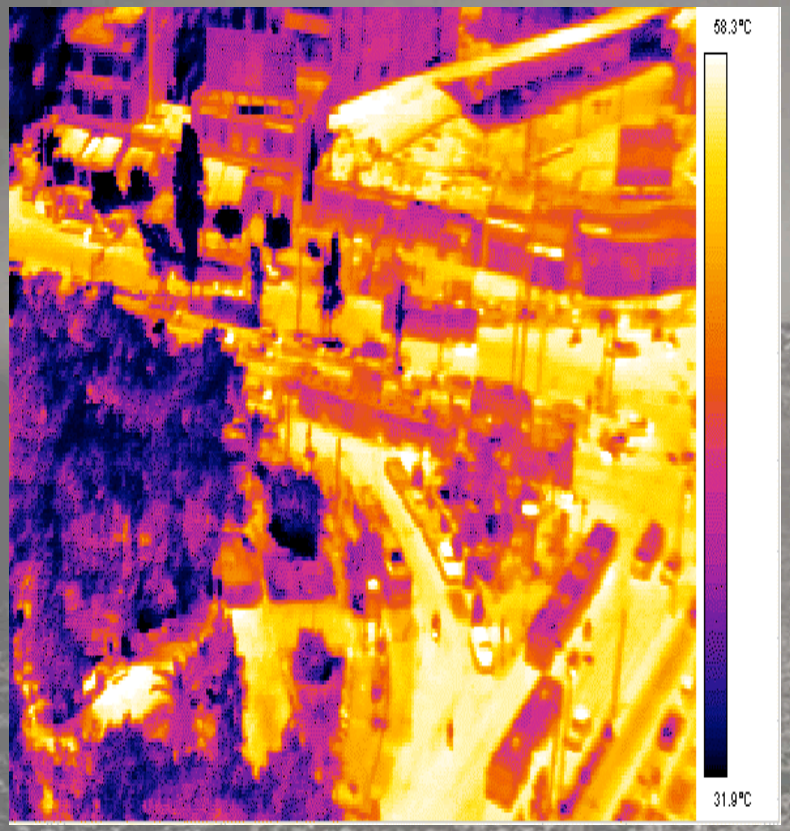
For the off white asphalt, and for the same boundary conditions, local temperatures range between 36 to 42 C. Thus, the achieved temperature reduction compared to the conventional asphalt was between 1 to 5 C.

DEVELOPEMENT OF COOL ASPHALT MATERIALS



For the green asphalt, and for the same boundary conditions, local temperatures range between 36 to 45 C. Thus, the achieved temperature reduction compared to the conventional asphalt was between 1 to 2 C.

DEVELOPEMENT OF COOL ASPHALT MATERIALS



5 coloured thin layer asphalt samples that can be applied on existing and new asphalt pavements have been developed and tested in order to evaluate their optical and thermal performance.

All the samples demonstrated higher solar reflectance values and lower surface temperatures compared to conventional black asphalt.

DEVELOPEMENT OF COOL ASPHALT MATERIALS

CFD simulations showed that replacing conventional asphalt in a road could lead to an average air temperature decrease between 1-5 °C for calm conditions.

The results of this study indicate that the use of color thin layer asphalt in roads and pavements can have significant impact in lowering surface and air temperatures, mitigating thus the heat island effect and its consequences.