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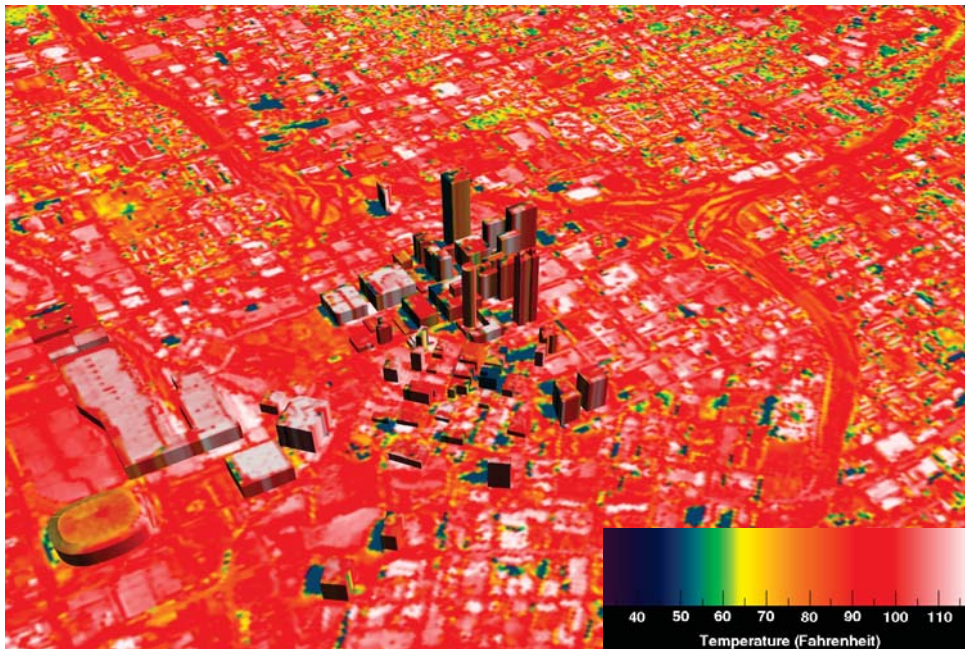
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Research in Japan #1

sustainability

urban heat island



Picture 1: Atlanta, GA, Daytime Thermal View of the Heat Island

1. Introduction: What is an urban heat island?

First of all, an urban heat island is an urban area, in a town, city or metropolitan area that has a significantly higher temperature than its surrounding area. Very often this island effect is considered only in conjunction with larger urban agglomerations as in metropolitan areas, where its appearance and effects are most apparent. The reasons for the higher temperature are manifold but are mainly linked to the modified urban surface with only little vegetation.

During daytime the earth surface is exposed to the sun. Based on the

features of this surface the solar energy is either reflected or transformed. As a simple example, if the surface is white, than most of the energy is reflected, if the surface is black, most of it is absorbed and transformed into heat energy making the black surface significantly warmer than the white.

Not considering deserts at this moment, but in a natural environment with a lot of vegetation like meadows, trees or any kind of plants, solar energy is used in photosynthetic processes to convert low energy carbon dioxide and water into higher energy organic compounds like carbohydrates. Furthermore, exposed to sunlight

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Development of
Assessment Tools
for Urban Climate
and Heat Island
Mitigation

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the surface water of rivers and lakes will evaporate, which results in cooling down the remaining water, a phenomenon called evaporative cooling. It is similar to the human body, that cools down by evaporating sweat. This in addition to the low heat capacity of water are just two reasons why river water is always so refreshingly cool. In summary, in a natural green environment large chunks of the solar energy are used in transformation processes that don't result in heating the environment, but can even transform the solar energy for cooling the environment.

Urban built surfaces on the contrary, like streets, facades or roofs, made commonly of materials like stone, tiles, concrete or asphalt have significantly different thermal properties. If exposed to the sun, these materials will mainly transform the absorbed energy into heat energy. Additionally due to their high heat capacity the heat is then stored and even accumulated during the day within the materials. This often results in surface temperatures much higher than the surrounding air temperature. Only during the night time the heat mass can be released, but in dense urban agglomerations this process is very slow, as all surfaces emit heat at the same time, resulting in a higher air temperature which slows down the cooling process. In cold environments the thermal mass of building materials is very often used to store heat for cold nights but in summer and in hot environments this turns into an unpleasant feature. But also heat from cars, factories, industries, shops, offices and homes, the 24-hour city gives off heat day and night.

2. Why is the urban heat island a problem?

First of all, even so the urban heat island phenomenon has been observed for more than 180 years¹, its influence on urban climate and the mutual influence on weather conditions are not yet fully understood and are still being researched.^{2,3}

As the urban heat island is usually noticed in metropolitan areas, the prospect of global urbanization and increase in size and amount of metropolitan areas is just one reason to investigate this phenomenon and all its effects on weather and urban climate.⁴

Aside from the higher temperature of the urban area in contrast to surrounding rural areas, other indirect or secondary effects can be found:

- influence on local climate and increased precipitation⁵
- influence on local flora and fauna, namely longer vegetation periods in generally cold or mild climate zones⁶
- in hot climate zones an increase in energy demand for cooling, but controversially areas in cold or mild climate zones have less demand for heating⁷
- increased public water demand, for instance for watering of lawns or evaporation from open-air swimming pools^{8,9}
- air pollution increase, which has many reasons but one being higher temperature¹⁰
- health problems related to air pollution and heat, increase in heat stroke patients¹¹

Even so some of the effects may be regarded as positive, especially for cities in mild or cold climate zones, like decreased demand for heating or longer vegetation periods, they are counterbalanced by the negative effects, mainly affecting pollution and health risks. Especially the rapidly urbanizing regions in Asia, South America and Africa are almost entirely situated in the hot climate zones.

3. How can the negative effects of an urban heat island be mitigated?

Based on the initial short analyses of the reasons for the urban heat island phenomenon, possible mitigation measures could be:^{12,13}

- reduce absorption, increase reflection, surfaces with high albedo and emittance

- cool roofs, facades and pavements, that help lower surface temperatures
- greening of roofs, which reduces water runoff at the same time
- increase vegetation, planting trees for shading and cooling, urban forests
- bring underground rivers back to the surface
- green buildings that use passive cooling instead of air conditioning
- lower use of combustion engines like cars or factories and change to electric motors
- reduce emissions from cars, factories and industry to reduce air pollution

This list provides just some mitigation measures and is far from complete. How truly effective these methods are to reduce the heat island in a large scale is still being researched.

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Pictures

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