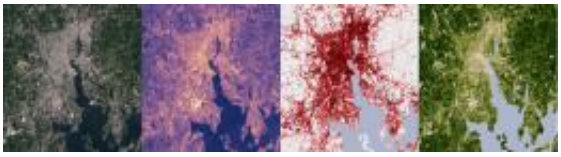
Satellites pinpoint Northeast drivers of Urban Heat islands

December 13 2010, By Adam Voiland



Visible Light

Cities such as New York, Philadelphia, and Boston are prominent centers of political power. Less known: Their size, background ecology, and development patterns also combine to make them unusually warm, according to NASA scientists who presented new research recently at an American Geophysical Union (AGU) meeting in San Francisco, Calif.

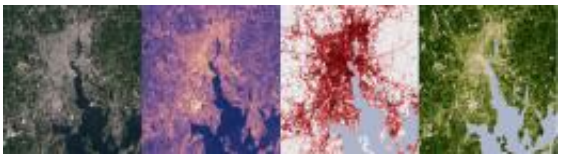
Summer land surface temperature of cities in the Northeast were an average of 7 °C to 9 °C (13°F to 16 °F) warmer than surrounding rural areas over a three year period, the new research shows. The complex phenomenon that drives up temperatures is called the urban heat island effect.

Heat islands are not a newly-discovered phenomenon. Indeed, using simple mercury thermometers, weather watchers have noticed for some two centuries that cities tend to be warmer than surrounding rural areas.

Likewise, researchers have long noticed that the magnitude of heat

islands can vary significantly between cities. However, accurate comparisons have long eluded scientists because ground-based air temperature sensors tend to be unevenly distributed and prone to local bias. The lack of quantifiable definitions for urban versus non-urban areas has also hindered comparisons.

Satellite technology, which offers a more uniform view of heat islands, is in the process of changing this. The group of researchers from NASA 's Goddard Space Flight Center in Greenbelt, Md., presented results based on a new method for comparing heat islands at the AGU meeting.



Surface Heat

"This, at least to our knowledge, is the first time that anybody has systematically compared the heat islands of a large number of cities at continental and global scales," said Ping Zhang, a scientist at Goddard and the lead author of the research.

Development produces heat islands by replacing vegetation, particularly forests, with pavement and other urban infrastructure. This limits plant transpiration, an evaporative process that helps cool plant leaves and also cools air temperatures, explained Robert Wolfe of Goddard, one of the scientists who developed the method.

Dark city infrastructure, such as black roofs, also makes urban areas more apt to absorb and retain heat. Heat generated by motor vehicles,

factories, and homes also contributes to the development of urban heat islands.

A New View

The new method for comparing cities, which the team of scientists has honed for about two years, involves the use of maps of impervious surface area produced by a United States Geological Survey-operated Landsat satellite, and land surface temperature data from the Moderate-resolution Imaging Spectroradiometer (MODIS), an instrument aboard NASA's Aqua and Terra satellites.

Impervious surfaces are surfaces that don't absorb water easily, such as roads, roofs, parking lots, and sidewalks. Land surface temperatures tend to be higher and more variable than air temperatures, but the two generally vary in sync with each other.

By analyzing data from thousands of settlements around the world, the Goddard team has pinpointed key characteristics of cities that drive the development of heat islands. The largest cities, their analysis shows, usually have the strongest heat islands. Cities located in forested regions, such as the northeastern United States, also have stronger heat islands than cities situated in grassy or desert environments.

Most recently, the Goddard group has shown that a city's development patterns -- whether a city is sprawling or compact -- can also affect the strength of its heat island.

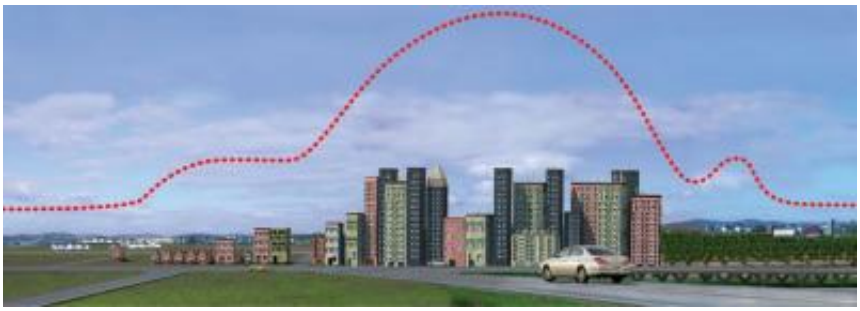
By comparing 42 cities in the Northeast, they found that densely-developed cities with compact urban cores are more apt to produce strong urban heat islands than more sprawling, less intensely-developed cities.

The compact city of Providence, R.I., for example, has surface temperatures that are about 12.2 °C (21.9 °F) warmer than the surrounding countryside, while similarly-sized but spread-out Buffalo, N.Y., produces a heat island of only about 7.2 °C (12.9 °F), according to satellite data. Since the background ecosystems and sizes of both cities are about the same, Zhang's analysis suggests development patterns are the critical difference.

She found that land cover maps show that about 83 percent of Providence is very or moderately densely-developed. Buffalo, in contrast, has dense development patterns across just 46 percent of the city. Providence also has dense forested areas ringing the city, while Buffalo has a higher percentage of farmland. "This exacerbates the effect around Providence because forests tend to cool areas more than crops do," explained Wolfe.

Cities in desert regions, such as Las Vegas, in contrast, often have weak heat islands or are actually cooler than the surrounding rural area. Providence, R.I.; Washington, D.C.; Philadelphia, Pa.; Baltimore, Md.; Boston, Ma.; and Pittsburgh, Pa.; had some of the strongest heat islands of the 42 northeastern cities analyzed.

"The urban heat island is a relative measure comparing the temperature of the urban core to the surrounding area," said Marc Imhoff, the leader of the Goddard research group. "As a result, the condition of the rural land around the city matters a great deal."



Land surface temperatures in cities, particularly densely-developed cities, tend to be elevated in comparison to surrounding areas -- a phenomenon called an urban heat island. Credit: NASA

Heat Island Impacts

Ratcheting up temperatures can have significant -- and deadly -- consequences for cities. Heat islands not only cause air conditioner and electricity usage to surge, but they also increase the mortality of elderly people and those with pre-existing respiratory and cardiovascular illness.

The U.S. Environmental Protection Agency estimates that, between 1979 and 2003, heat exposure has caused more than the number of mortalities resulting from hurricanes, lightning, tornadoes, floods, and earthquakes combined.

"It is the lack of cooling at nighttime, rather than high daytime temperatures, that poses a health risk," said Benedicte Dousset, a scientist from the University of Hawaii who also presented data about heat islands at the AGU meeting.

Dousset recently analyzed surface temperature images of Paris and showed the spatial distribution of heat-related deaths during a sweltering heat wave in 2003. Some 4,800 premature deaths occurred in Paris

during the event, and excess mortality across Europe is thought to be about 70,000.

The risk of death was highest at night in areas where land surface temperatures were highest, she found. Buildings and other infrastructure absorb sensible heat during the day and reradiate it throughout the night, but the cooling effect of evaporation is absent in cities. The lack of relief, particularly among the elderly population, can be deadly, she explained.

Ramped up air conditioning usage may have even exacerbated the problem, other data presented at the meeting suggests. Cecile de Munck, of the French Centre for Meteorological Research of Meteo-France, conducted a series of modeling experiments that show excess heat expelled onto the streets because of increased air conditioner usage during heat waves can elevate outside street temperatures significantly.

"The finding raises the question: what can we do to design our cities in ways that will blunt the worst effects of heat islands?" said de Munck, who notes also that her research shows that some types of air conditioning exacerbate heat islands more than others.

Making sure cities have trees and parks interspersed throughout the compact urban cores can also help defend against heat islands. And studies shows that painting the surfaces of roads and buildings white instead of black and creating “green” roofs that include vegetation can soften urban heat islands.

"There's no one solution, and it's going to be different for every city," said Dousset. "Heat islands are complex phenomena."

Provided by JPL/NASA