Urban 'heat island' effect is a small part of global warming; white roofs don't reduce it

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Cities release more heat to the atmosphere than the rural vegetated areas around them, but how much influence these urban "heat islands" have on global warming has been a matter of debate. Now a study by Stanford researchers has quantified the contribution of the heat islands for the first time, showing that it is modest compared with what greenhouse gases contribute to global warming.

"Between 2 and 4 percent of the gross global warming since the Industrial Revolution may be due to urban heat islands," said Mark Z. Jacobson, a professor of civil and environmental engineering who led the study. He and graduate student John Ten Hoeve compare this with the greenhouse gas contribution to gross warming of about 79 percent and the black carbon contribution of about 18 percent.

Black carbon is a component of the soot created by burning fossil fuels and biofuels and is highly efficient at absorbing sunlight, which heats the atmosphere.

Gross global warming is the total amount of warming that has taken place from all sources, mainly greenhouse gases, black carbon particles and heat islands. Net global warming is gross global warming minus the cooling effect of light-colored atmospheric particles that reflect sunlight back into space, which offsets about half of global warming to date. Net, or observed, global warming is what is typically reported in the media.

Responding to skeptics

Jacobson and Ten Hoeve are authors of a paper describing the research that will be published in *Journal of Climate*. The paper is available online now. The study modeled climate response from 2005 to 2025.

Some global warming skeptics have claimed that the urban heat island effect is so strong that it has been skewing temperature measurements that show that global warming is happening. They have argued that urban areas are a larger contributor to global warming than the greenhouse gases produced by human activity, and thus drastic measures to reduce greenhouse gases are not needed.

"This study shows that the urban heat island effect is a relatively minor contributor to warming, contrary to what climate skeptics have claimed," Jacobson said. "Greenhouse gases and particulate black carbon cause far more warming."

Prior to Jacobson's study, claims about the importance of heat island to global warming could not be addressed directly. The few previous modeling studies by other researchers that had examined the effect of urban heat islands on regional scales did not calculate global impacts.

Jacobson's high-resolution study was the first study of the impact of urban heat islands on global sea-surface temperatures, sea ice, atmospheric stability, aerosol concentrations, gas concentrations, clouds and precipitation. He characterized urban surfaces around the world at a resolution of one kilometer, making his simulation both extremely detailed and globally comprehensive.

"This study accounted not only for local impacts of the heat island effect, but also feedbacks of the effect to the global scale," he said.

Although his study showed that urban heat islands are not major contributors to global warming, Jacobson said reducing the effect of heat islands is still important for slowing the rise of global temperatures.

The urban heat island effect is caused mostly by replacing soil and vegetation with paved roads, sidewalks and buildings. Paving prevents

evaporation of water from the soil and plant leaves. Since evaporation is a cooling process, reducing evaporation warms cities. Additionally, the darker colors of some roads and buildings absorb more sunlight, heating a city further.

One "geoengineering" proposal for reducing the impact of urban heat islands is to paint roofs worldwide a reflective white. Jacobson's computer modeling concluded that white roofs did indeed cool urban surfaces. However, they caused a net global warming, largely because they reduced cloudiness slightly by increasing the stability of the air, thereby reducing the vertical transport of moisture and energy to clouds. In Jacobson's modeling, the reduction in cloudiness allowed more sunlight to reach the surface.

The increased sunlight reflected back into the atmosphere by white roofs in turn increased absorption of light by dark pollutants such as black carbon, which further increased heating of the atmosphere.

Jacobson's study did not examine one potential benefit of white roofs - a reduced demand for electricity to run air conditioning in hot weather. But a recent study done at the National Center for Atmospheric Research showed that the decrease in air conditioning use, which occurs mostly in the summer, might be more than offset by increases in heating during winter months.

"There does not seem to be a benefit from investing in white roofs," said Jacobson. "The most important thing is to reduce emissions of the pollutants that contribute to global warming."

Photovoltaic panels helpful

One way to reduce emissions while simultaneously reducing summer air conditioning demand is to install photovoltaic panels on roofs. Such panels not only generate electricity, reducing emissions of fossil fuels from electricity-producing power plants, but they also reduce sunlight absorbed by buildings because they convert sunlight to electricity. Because photovoltaic panels do not reflect the sunlight back to the air, unlike white roofs, reflected light is not available to be absorbed again by pollutants in the air, creating heat.

"Cooling your house with white roofs at the expense of warming the planet is not a very desirable trade-off," Jacobson said. "A warmer planet will melt the sea ice and glaciers faster, triggering feedbacks that will lead to even greater overall warming. There are more effective methods of reducing global warming."

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