Study reveals the give and take of urban temperature mitigating technologies

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The deployment of cool roofs, roofs typically painted white, help mitigate summertime temperatures but in Florida and some Southwestern cities like Phoenix (pictured) the roofs also have a negative effect on rainfall. Credit: Ken Fagan, Arizona State University

Life in a warming world is going to require human ingenuity to adapt to the new realities of Earth. Greenhouse-gas induced warming and megapolitan expansion are both significant drivers of our warming planet. Researchers are now assessing adaptation technologies that could help us acclimate to these changing realities.

But how well these adaptation technologies – such as cool roofs, green roofs and hybrids of the two – perform year round and how this performance varies with place remains uncertain.

Now a team of researchers, led by Matei Georgescu, an Arizona State University assistant professor in the School of Geographical Sciences and Urban Planning and a senior sustainability scientist in the Global Institute of Sustainability, have begun exploring the relative effectiveness of some of the most common adaptation technologies aimed at reducing warming from urban expansion.

The work showed that end-of-century urban expansion within the U.S. alone and separate from greenhouse-gas induced climate change, can raise near surface temperatures by up to 3 C (nearly 6 F) for some megapolitan areas. Results of the new study indicate the performance of urban adaptation technologies can counteract this increase in temperature, but also varies seasonally and is geographically dependent.

In the paper, "Urban adaptation can roll back warming of emerging megapolitan regions," published in the online Early Edition of the *Proceedings of the National Academy of Sciences*, Georgescu and Philip Morefield, Britta Bierwagen and Christopher Weaver all of the U.S. Environmental Protection Agency, examined how these technologies fare across different geographies and climates of the U.S.

"This is the first time all of these approaches have been examined across various climates and geographies," said Georgescu. "We looked at each adaptation strategy and their impacts across all seasons, and we quantified consequences that extend to hydrology (rainfall), climate and energy. We found geography matters," he added.

Specifically, what works in California's Central Valley, like cool roofs, does not necessarily provide the same benefits to other regions of the

U.S., like Florida, Georgescu said. Assessing consequences that extend beyond near surface temperatures, like rainfall and energy demand, reveals important tradeoffs that are oftentimes unaccounted for.

Cool roofs are a good example. In an effort to reflect incoming solar radiation, and therefore cools buildings and lessen energy demand during summer, painting one's roof white has been proposed as an effective strategy. Cool roofs have been found to be particularly effective for certain areas during summertime.

However, during winter these same urban adaptation strategies when deployed in northerly locations, further cool the environment and consequently require additional heating to maintain comfort levels. This is an important seasonal contrast between cool roofs (i.e. highly reflective) and green roofs (i.e. highly transpiring). While green roofs do not cool the environment as much during summer, they also do not compromise summertime energy savings with additional energy demand during winter.

Matei Georgescu has studied some of the most popular urban adaptation technologies in research that assesses the performance of the technologies in all fours seasons and in several different geographic regions of the US. Credit: Ken Fagan, Arizona State University

"The energy savings gained during the summer season, for some regions, is nearly entirely lost during the winter season," Georgescu said.

In Florida, and to a lesser extent Southwestern states of the U.S., there is a very different effect caused by cool roofs.

"In Florida, our simulations indicate a significant reduction in precipitation. The deployment of cool roofs results in a 2 to 4 millimeter per day reduction in rainfall, a considerable amount (nearly 50 percent) that will have implications for water availability, reduced stream flow and negative consequences for ecosystems," he said. "For Florida, cool roofs may not be the optimal way to battle the urban heat island because of these unintended consequences."

Georgescu said the researchers did not intend to rate urban adaptation technologies as much as to shed light on each technology's advantages and disadvantages.

"We simply wanted to get all of the technologies on a level playing field and draw out the issues associated with each one, across place and across time."

Overall, the researchers suggest that judicious planning and design choices should be considered in trying to counteract rising temperatures caused by urban sprawl and greenhouse gasses. They add that, "urban-induced climate change depends on specific geographic factors that must be assessed when choosing optimal approaches, as opposed to one size fits all solutions."

More information: "Urban adaptation can roll back warming of emerging megapolitan regions," by M. Georgescu et al. *Proceedings of the National Academy of Sciences*, 2014.

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