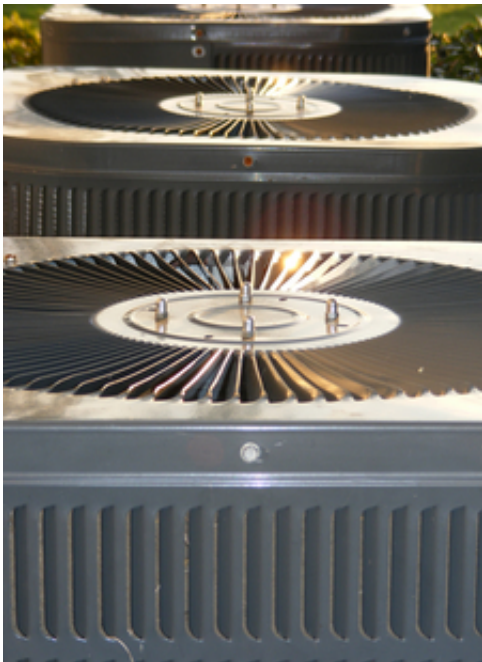


Excess heat from air conditioners causes higher nighttime temperatures

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An Arizona State University research team found that releasing excess heat from air conditioners running during the night resulted in higher outside temperatures, worsening the urban heat island effect and increasing cooling demands. Credit: freeimages.com

(Phys.org) —A team of researchers from Arizona State University has found that releasing excess heat from air conditioners running during the night resulted in higher outside temperatures, worsening the urban heat island effect and increasing cooling demands.

"We found that [waste heat](#) from [air conditioning systems](#) was maximum during the day but the mean effect was negligible near the surface. However, during the night, [heat](#) emitted from [air conditioning](#) systems increased the mean air temperature by more than 1 degree Celsius (almost 2 degrees Fahrenheit) for some urban locations," said Francisco Salamanca, a post-doctoral research scientist at Arizona State University's School of Mathematical and Statistical Sciences.

The research is presented in the paper, "Anthropogenic Heating of the Urban Environment due to Air Conditioning," published in the March 6 issue of *Journal of Geophysical Research Atmospheres*.

Salamanca, the lead author of the paper, is joined by Matei Georgescu, an assistant professor in ASU's School of Geographical Sciences and Urban Planning and a senior sustainability scientist in the Global Institute of Sustainability; Alex Mahalov, The Wilhoit Foundation Dean's Distinguished Professor in the School of Mathematical and Statistical Sciences at ASU; Mohamed Moustouai, an associate professor in ASU's School of Mathematical and Statistical Sciences; and Meng Wang, a graduate student also in ASU's School of Mathematical and Statistical Sciences. All five authors are affiliated with ASU's College of Liberal Arts and Sciences and the Global Institute of Sustainability.

The paper focuses on the anthropogenic contribution of air conditioning systems on air temperature, and examines the electricity consumption for the rapidly expanding Phoenix metropolitan area, one of the largest metropolitan area in the US. Phoenix is located within the semiarid Sonoran desert and because of its harsh summertime conditions makes considerable use of air conditioning systems.

To keep people cool, air conditioning (AC) systems can consume more than 50 percent of total electricity during extreme heat and put a strain on electrical grids. Cooling demands for rapidly expanding urban areas

like Phoenix are likely to increase considerably during the next several decades. To address future energy needs in a sustainable manner, the researchers determined it was essential to study current AC demand and assess AC waste heat.

For this investigation, researchers used a physics based modeling system to evaluate the impact of heat emission from air conditioning systems on air temperature. This physically based dynamic approach has the advantage of taking into account both urban scenarios, such as the size and shapes of buildings, and climatic factors, such as temperature and wind speed, when the energy consumption is calculated. This approach is necessary given the inherent feedbacks associated with AC systems. For example, hot summer nights will lead to increased air conditioning demand, which in turn will output additional waste heat into the environment, leading to further increase in AC demand, resulting in a positive feedback loop.

The authors simulated a 10-day period, covering ten extreme heat days from July 10 to 19 of 2009. They used the non-hydrostatic version of the Weather Research and Forecasting (WRF) model coupled to the Noah land surface model to analyze the contribution of AC systems on air temperature. To evaluate the ability of WRF to reproduce the near-surface climatology, eleven weather stations maintained by the National Weather Service and the Arizona Meteorological Network were used.

This research shows that release of waste heat raises the outdoor temperature and as a result increases the electricity consumption needed for cooling. The analysis of this feedback required using a building energy model and an atmospheric model that were dynamically coupled. The atmospheric model supplied the building energy model with the outdoor air temperature, outdoor air humidity and the boundary conditions for the temperature calculation for building walls and roofs. The building energy model then provided the atmospheric model with

the heat fluxes associated with the energy consumption of AC systems within the buildings.

They found that the effect of the AC systems was more important during the night due to the limited depth of the urban boundary layer. The effect is stronger from late afternoon to early morning. A smaller quantity of excess AC systems heat ejected during the night can increase the air temperature more compared to a greater quantity released during the daytime when the hot sun is beating down.

"Our work demonstrates one Celsius degree (almost 2 F) local heating of urban atmospheres in hot and dry cities due to air conditioning use at nighttime. This increase in outside [air temperature](#) in turn results in additional demands for air conditioning," Salamanca said. "Sustainable development and optimization of electricity consumption in cities would require turning 'wasted heat' from AC into 'useful energy' which can be utilized inside houses for various purposes including, for example, water heaters. Implementing this mitigation strategy would achieve several objectives: successfully reducing the urban heat island temperature by one-Celsius degree at night, reducing AC [electricity consumption](#) on a city scale and providing a real example of urban climate mitigation."

With regard to economic impacts, it is estimated for the Phoenix metropolitan area that successfully reducing the [urban heat island](#) temperature with this strategy would result in at least 1200-1300 MWh of direct energy savings per day alone.

According to the US Department of Energy, summertime extreme-heat days are projected to become more frequent and intense as a result of climate change, presenting significant challenges for the energy sector and electric grid. Reliable methods are needed for forecasting energy demands that can help to inform and assist in the future planning of sustainable energy needs of rapidly growing urban areas.

More information: "Anthropogenic Heating of the Urban Environment due to Air Conditioning." F. Salamanca. *Journal of Geophysical Research: Atmospheres* Accepted manuscript online: 9 MAY 2014. [DOI: 10.1002/2013JD021225](https://doi.org/10.1002/2013JD021225)

Provided by Arizona State University

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