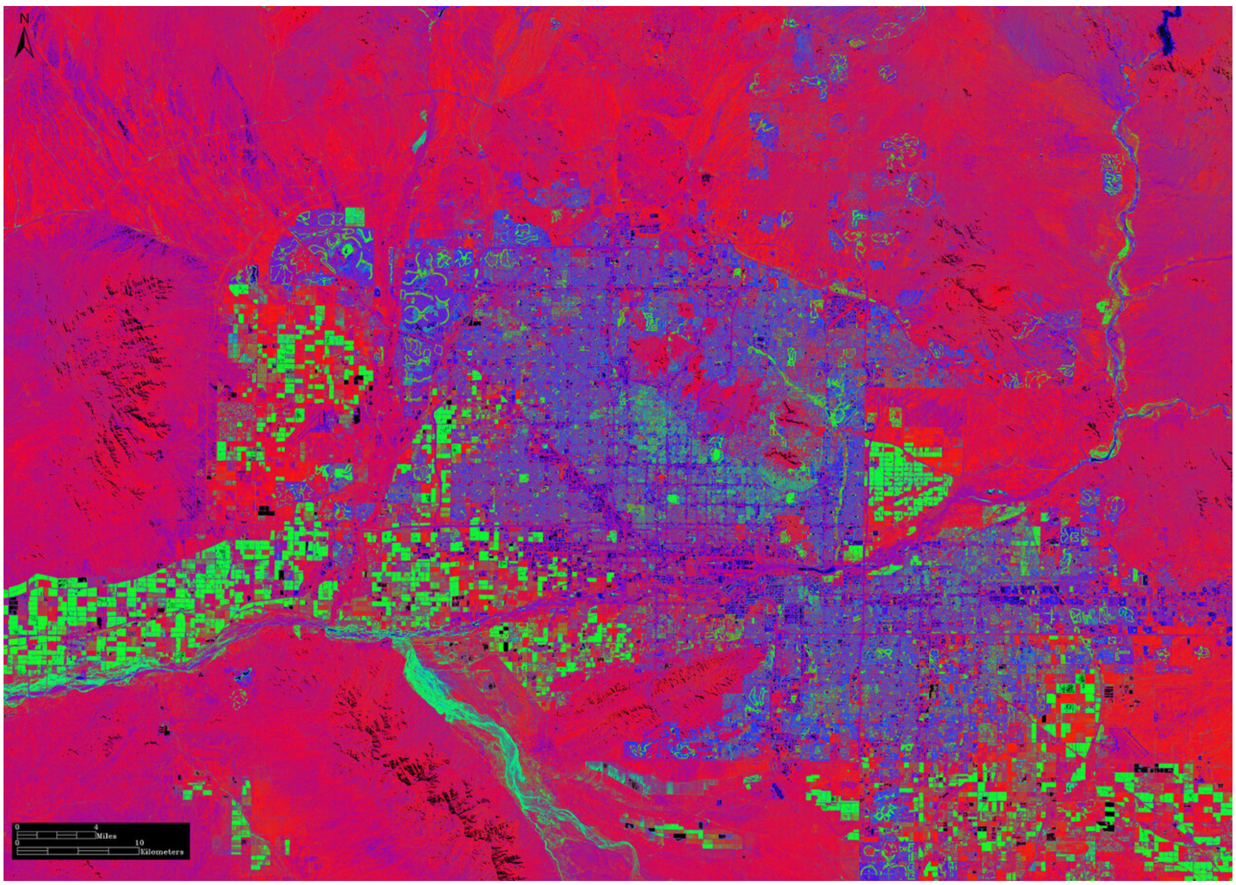
New model helps explain seasonal variations in urban heat islands

March 24 2020



A satellite measurement of urban temperatures across greater Phoenix, AZ. Credit: NASA, 2000

Scientists have devised a simple new model that explains how the undesirable effects of urban heat islands vary across seasons. Their results could help cities in different climatic regions design heat mitigation strategies.

Unlike existing urban climate models which require a large amount of information and are computationally very demanding, the new coarse-grained model provides general insights into how seasonal changes in rainfall, solar radiation, and vegetation conditions of an urban environment affects the intensity and timing of surface urban heat islands at a city-wide scale.

"With just two equations, our model can describe all these complex interactions," said Gabriele Manoli, a lecturer in environmental engineering at University College London, who led the research.

"For city planners, it provides a new approach that complements more detailed, city-specific tools, and provides general guidelines on the effects of heat mitigation strategies, such as increasing green spaces, in different climates and during different times of the year," Manoli said. "Because of its simplicity, our framework can be applied to cities where extensive data and detailed simulations are not available."

For scientists, the model provides new evidence that seasonal variations in the intensity of urban-rural surface temperature differences—which, until now, have been observed but not clearly explained—are controlled by time lags between solar radiation, temperatures, and rainfall, Manoli said.

If solar radiation occurs in conjunction with water availability, summer conditions cause strong surface urban heat island intensities due to high rates of evaporative cooling in surrounding rural areas. The rural areas grow cooler by a few degrees, while the urban area, where impervious and heat-absorbing surfaces can limit the effect of evaporative cooling, grows much warmer. This is typically what we see in cities like Paris or London, which are in climates with relatively wet summers.

"This can have major implications for local energy consumption, climate adaptation policies, and public health, especially heat-related mortalities," said Gabriel Katul, Theodore S. Coile Distinguished Professor of Hydrology and Micrometeorology at Duke University.

But in cities where rainfall is scarce during summer, such as Phoenix or Madrid, the opposite effect can occur. With less rainfall and vegetation to spur cooling, rural areas heat up and the city experiences an "oasis effect" in which, though it may still be blisteringly hot, it's nonetheless one or two degrees cooler than the surrounding countryside.

"These seasonal patterns of warming and cooling have significant implications for heat mitigation strategies, as urban green spaces can reduce heat island intensity during summer, while potentially negative effects during winter of albedo management, e.g. painting streets of white, are mitigated by the seasonality of solar radiation," Katul noted.

Rising temperatures and shifting rainfall patterns linked to climate change may alter the seasonality of urban heat islands in coming decades, he said. Further research is needed in that direction.

Manoli and Katul developed the new model with Simone Fatichi of ETH Zurich and Elie Bou-Zeid of Princeton University.

They published their peer-reviewed research March 16 in the *Proceedings of the National Academy of Sciences*.

More information: Gabriele Manoli et al, Seasonal hysteresis of surface urban heat islands, *Proceedings of the National Academy of Sciences* (2020). DOI: 10.1073/pnas.1917554117

Provided by Duke University