Title: Investigating optimal urban heat mitigation strategies for vulnerable populations in a changing climate

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ABSTRACT

Extreme heat in urban areas can have deleterious consequences on human health and can lead to increases in building cooling energy use. These impacts are projected to become more significant in the future due to ongoing urbanization, population densification, and global climate change. The aim of this research is to answer the question, what are the most effective urban heat mitigation strategies for the populations that are most vulnerable to extreme heat? The analysis focuses on neighborhoods in Los Angeles, CA that contain populations that are especially physically and financially vulnerable to increasing extreme heat: (1) the elderly, (2) those without air conditioning, and (3) those of low socioeconomic status that cannot afford increased energy costs. The proposed research develops a multi-scale coupled modeling framework that resolves regional-scale meteorology, micro-scale meteorology, and building energy flows. Neighborhoods in Los Angeles with vulnerable populations are identified using parcel-level GIS datasets of population age, income, and access to air-conditioning. The heat mitigation strategies that are assessed include solar reflective rooftops and pavements, and increased use of street-level and rooftop urban vegetation. These mitigation strategies are assessed for impacts on (a) outdoor and indoor air temperatures, (b) human thermal comfort, heat stress, and heat-related mortality, (c) indoor thermal conditions for representative buildings without air conditioning, and (d) air-conditioning energy use for representative buildings with air conditioning. Model performance for each element of the model are thoroughly evaluated by comparing to observations.

HIGHLIGHTS

- Quantified the climate impacts of adopting cool roofs in Southern California. Widespread adoption of cool roofs could lead to spatial average near-surface air temperature reductions of 0.9 °C during afternoon and 0.5 C during evening.
- Adopting drought tolerant vegetation in Los Angeles with the goal of reducing water use can have unintended consequences on climate. Daytime temperatures can increase due to drought tolerant vegetation adoption. However, nighttime temperature decreases are larger in magnitude than daytime increases, indicating a net cooling effect from drought tolerant vegetation.
- Investigated the micrometeorological impacts of various heat mitigation strategies (i.e. cool roofs, cool pavements, street vegetation, and green roofs) on neighborhood-scale temperatures. Increasing street vegetation and adopting cool pavements led to the largest neighborhood-scale air temperature decreases. Adding trees was the most effective method of improving pedestrian thermal comfort because of increased shading and reduced air temperatures. Though cool pavements reduced air temperatures, pedestrian thermal comfort was worsened in some cases due to increases in reflected

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radiation absorbed by the pedestrian. Cool pavements improved thermal comfort at night, however.

- Adopting cool surfaces can lead to reductions in ozone concentrations (assuming that UV reflectance does not increase for cool versus standard surfaces). However, particulate matter concentrations could be increased in Los Angeles due to reductions in ventilation and partitioning of semi-volatile species to the particle phase.
- Cool pavements and walls can play an important role in heat island mitigation in California cities.
- While cool roofs can play an important role in reversing warming in Los Angeles from global climate change in the next few decades, the only solution for long-term climate stability is global-scale reductions in greenhouse gas emissions; after mid century, warming from climate change trumps cooling from cool roofs in Los Angeles.

Citation:

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