Targeted UHI Mitigation

Collaborative Research: Development of a multi-scale model to determine optimal urban heat mitigation strategies for vulnerable populations in a changing climate

Funded by the NSF

Accomplishments

This research seeks to understand the most effective urban heat mitigation strategies for the populations that are most vulnerable to extreme heat. This includes considerations of how to target mitigation efforts implemented by municipalities to attain the most beneficial results given limited resources. 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.

Research conducted within this project will lead to 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 being identified using parcel-level GIS datasets of population age, income, and access to air-conditioning. The heat mitigation strategies that will be assessed include solar reflective rooftops and pavements, and increased use of street-level and rooftop urban vegetation. These mitigation strategies will be 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 will be thoroughly evaluated by comparing to observations.

Major Activities:

The Arizona State research team conducted initial mesoscale meteorological simulations of historical heat waves in the Los Angeles basin to help identify regions of the city most likely to experience elevated summer air temperatures. These results were cross-referenced with prior results from other studies. This information was linked to socio-economic analysis conducted by the USC component of the team. Dr. Sailor then co-advvised the USC visiting researcher (Taleghani) in conducting neighborhood scale simulations of one specific target neighborhood (in El Monte, CA) to explore the potential cooling effects of very local application of urban heat mitigation strategies.

The result of this analysis was published in Environmental Research Letters. We carried out a micrometeorological simulation for this neighborhood representing a historical extreme heat day to simulate climate assuming current land cover, as well as a series of perturbation simulations assuming altering land cover to mitigate heat in the neighborhood. The heat mitigation strategies investigated
included solar reflective ‘cool roofs’, vegetative ‘green roofs’, solar reflective ‘cool pavements’, and increased street-level trees. We investigated the impacts of these mitigation strategies on surface air temperatures in the neighborhood, as well as pedestrian thermal comfort.

**Specific Objectives:**

In the research performed so far, the effects of four heat mitigation strategies on micrometeorology and the thermal comfort of pedestrians were simulated for a neighborhood in eastern Los Angeles County with population vulnerable to extreme heat.

**Significant Results:**

Comparing each simulation to the control simulation assuming current land cover for the neighborhood showed that additional street-trees and cool pavements reduced 1.5 m air temperature, while cool and green roofs mostly provided cooling at heights above pedestrian level. However, cool pavements increased reflected sunlight from the ground to pedestrians at a set of unshaded receptor locations. This reflected radiation intensified the mean radiant temperature and consequently increased physiological equivalent temperature (PET) by 2.2 °C during the day, reducing the thermal comfort of pedestrians. At another set of receptor locations that were on average 5 m from roadways and underneath preexisting tree cover, cool pavements caused significant reductions in surface air temperatures and small changes in mean radiant temperature during the day, leading to decreases in PET of 1.1 °C, and consequent improvements in thermal comfort. For improving thermal comfort of pedestrians during the afternoon in unshaded locations, adding street trees was found to be the most effective strategy. However, afternoon thermal comfort improvements in already shaded locations adjacent to streets were most significant for cool pavements. Green and cool roofs showed the lowest impact on the thermal comfort of pedestrians since they modify the energy balance at roof level, above the height of pedestrians.

**Key outcomes or Other achievements:**

The research outlined above resulted in a co-authored publication with the USC team in a high impact journal: Environmental Research Letters.


Several additional manuscripts are currently in preparation.