Developing Anthropogenic Heating Profiles for Urban Areas Across the United States

Jeff Milne[1,2], M. Georgescu[1], D.J. Sailor[3], M. Hart[4]

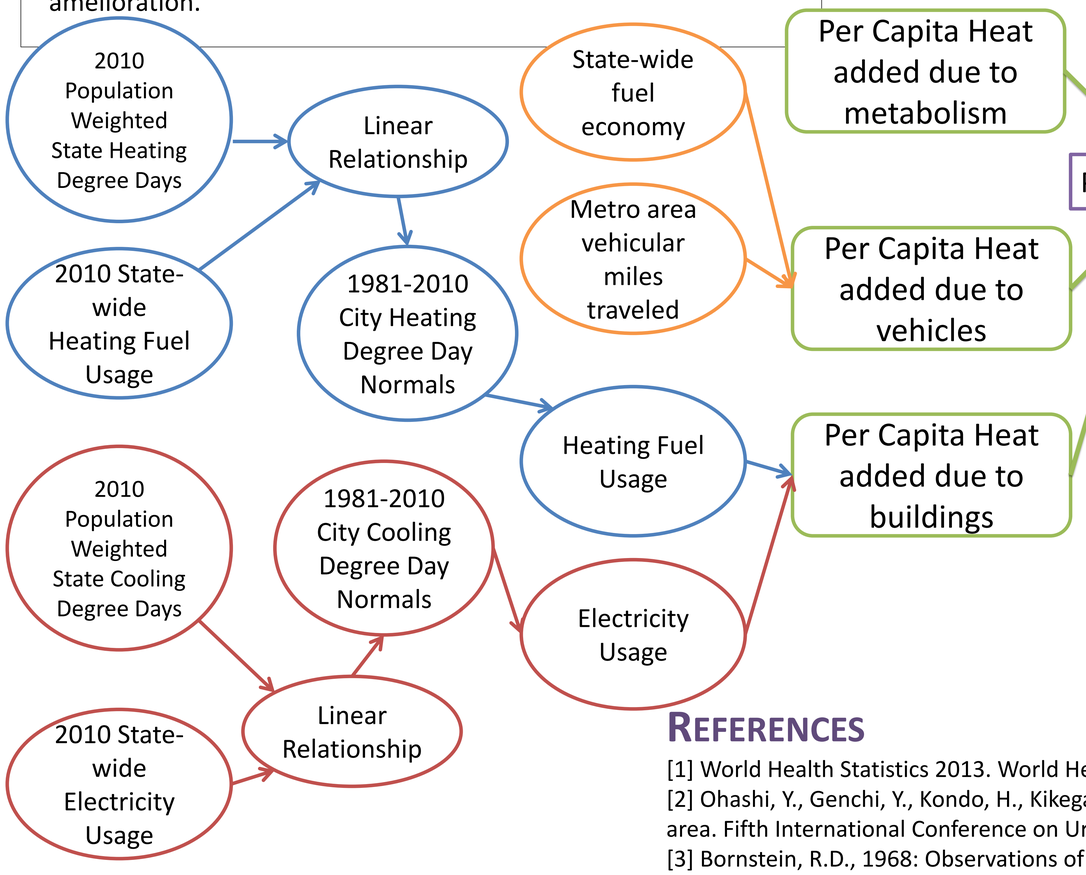
[1] School of Geographical Sciences and Urban Planning, Arizona State University, PO Box 875302, Tempe AZ 85287-5302
[2]Barrett Honors College, Arizona State University, PO Box 871612, Tempe, AZ 85287 [jmilne1@asu.edu]
[3]Mechanical and Materials Engineering Dept., Portland State University, PO Box 751-ME, Portland OR 97207
[4]Climate Change Research Centre, The University of New South Wales Sydney NSW 2052 Australia

Introduction

The Earth is urbanizing rapidly. More than 50% of the world's population lives in urban areas as of 2011, and 84% of U.S. citizens live in urban areas [1]. Urban areas produce an urban heat island (UHI) effect, which is manifest as warmer temperatures compared to surrounding and less developed areas. Tokyo [2] and New York City [3] both indicate 1-2°C of warming due to their respective UHIs. Since a significant fraction of urban-induced warming is due to anthropogenic sources (e.g., traffic and electricity consumption) it is vital to properly represent the total anthropogenic contribution of heating to the built environment. Current generation climate models do account for anthropogenic heating (AH), but a generic daily profile is used for all cities. Improved characterization of city-specific AH is necessary as it will lead to improved representation of distinct UHIs and offer insight into potential pathways of UHI amelioration.

Methods

Using the methodology developed by Sailor and Lu [4], per capita anthropogenic heating profiles were developed for many of the largest urban areas within the United States. Three components make up the profiles: (i) heat added by human metabolism, (ii) heat added by vehicles, and (iii) heat added by buildings. Heat added by metabolism is strictly per capita based. Heat added by vehicles take into account daily vehicular miles traveled in each urban area and approximate state-wide fuel efficiency. Heat added by buildings take into account electricity (e.g., AC systems, appliances) and heating fuel usage. The building component relies on both population and climate, as heating and cooling degree days are proportional to the amount of heating fuel and electricity used.



Summary

- Since the profiles are developed on a per capita basis, larger cities have much higher anthropogenic heating.
- Peaks are higher in summer than in winter.
- Winter curves are smoother than summer curves. This is due to the differences between how people use heating relative to air conditioning systems.
- When completed, these curves will allow climate modelers to more accurately model specific urban climates.
- The method used permits easy updating as new data becomes available.

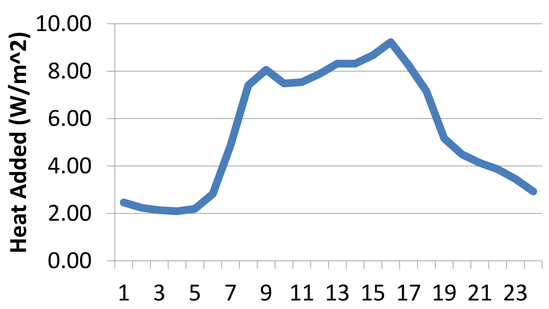


Fig. 1: Anthropogenic heating profile for Phoenix, AZ in July.

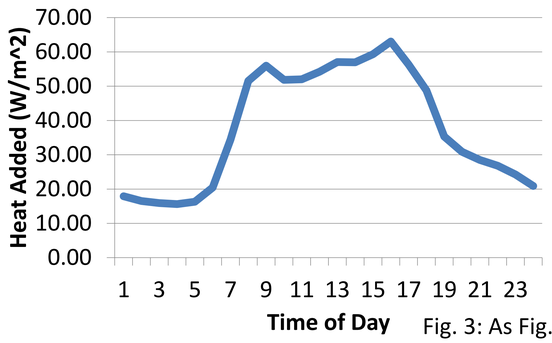


Fig. 3: As Fig. 1 for New York City.

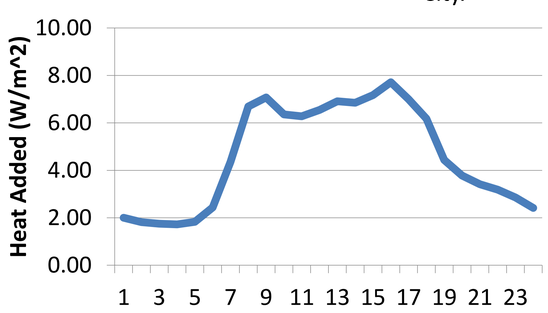


Fig. 2: As Fig. 1 for January.

References

[1] World Health Statistics 2013. World Health Organization. 2013.
[2] Ohashi, Y., Genchi, Y., Kondo, H., Kikegawa, Y., Hirano, Y., Koshikado, H., 2003. A study of horizontal temperature distribution within the urban canopy layer at the Tokyo central area. Fifth International Conference on Urban Climate, Lodz, Poland.
[3] Bornstein, R.D., 1968: Observations of the Urban Heat Island Effect in New York City. J. Appl. Meteor., 7, 575–582.
[4] Sailor, D.J., Lu, L., 2004. A top-down methodology for developing diurnal and seasonal anthropogenic heating profiles for urban areas. Atmospheric Environment 38, 2737-2748.