The Air We Breathe: Quantifying and Contextualizing Air Quality in Poughkeepsie

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Introduction

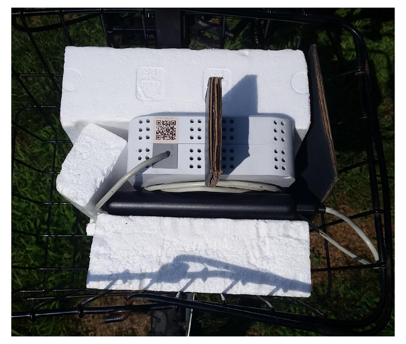
Discussions of climate impacts on communities in the Hudson Valley have focused mainly on flooding and storm impacts. Questions of air quality and heat island impacts have received little attention[1,3], despite their importance in understanding—and mitigating—climate impacts for urban populations. Air quality and localized heat islands vary continuously over space and time, and understanding fine-scale variations among urban neighborhoods in air quality and heat impacts requires a dense network of sensors. This restricts the ability of local communities to evaluate local patterns in air quality and temperature.

We explored the use of a low-cost sensor, the Air Quality Egg (airqualityegg.com) for testing local variation in air quality and temperature (measured as difference from weather station temperature). The Egg is an inexpensive, multi-parameter sensor designed for stationary use and for easy comparison of diverse locations, but its ease of use and its GPS unit make it an exciting potential tool for mobile uses.

As a pilot study, we examined variation in air quality and temperature in Poughkeepsie, NY, a mid-sized post-industrial city with neighborhoods of strongly contrasting socioeconomic status.

Methods

We used the Egg, fitted in a bicycle basket (fig. 1) to measure fine particulate matter (**PM2.5**), **NO_2**, volatile organic compounds (**VOCs**), and **temperature** on transects through Poughkeepsie. The Egg aggregates and records data every minute. While lags in air samples and locations were a concern, preliminary analysis indicated that short-distance measurements had little statistical variation.



To map temperatures, we calculated the difference (**ΔT**) between recorded values and regional temperatures recorded at the county airport ~2 miles southeast. We mapped all variables and evaluated responses to impervious surface cover (ISC), tree cover, and traffic counts (from NYS DOT). Finally, we examined relationships between air quality and population variables that contributed to a state-defined heat-stress index, to identify areas of the city most susceptible to worsening air quality.

Figure 1: Egg braced with styrofoam blocks (top) and fixed in a bicycle basket (bottom).

Data Analysis

We mapped data using ArcGIS Desktop, performed statistical analysis using JMP, and compared to a New York heat vulnerability index[2]:

Question	Program	Data Analyzed
Where are pollutants and heat islands most prevalent?	Arcmap GIS software	Spatial patterns from mapping, most notably in PM 2.5, VOC, and ΔT
Why does air quality differ within the city?	JMP software	Statistical patterns relating air quality metrics with three explanatory variables: tree cover, impervious surface cover (ISC), and traffic counts
Where should air quality improvement efforts focus?	Heat Vulnerability Index (HVI) by the NYS Department of Health	Intersection of air quality and heat-vulnerable populations: socio-economic status, languages spoken, environmental surroundings, and age

Findings

Where

Patterns of PM 2.5, NO_2, VOC, and ΔT show where pollutants and heat islands were most concentrated.

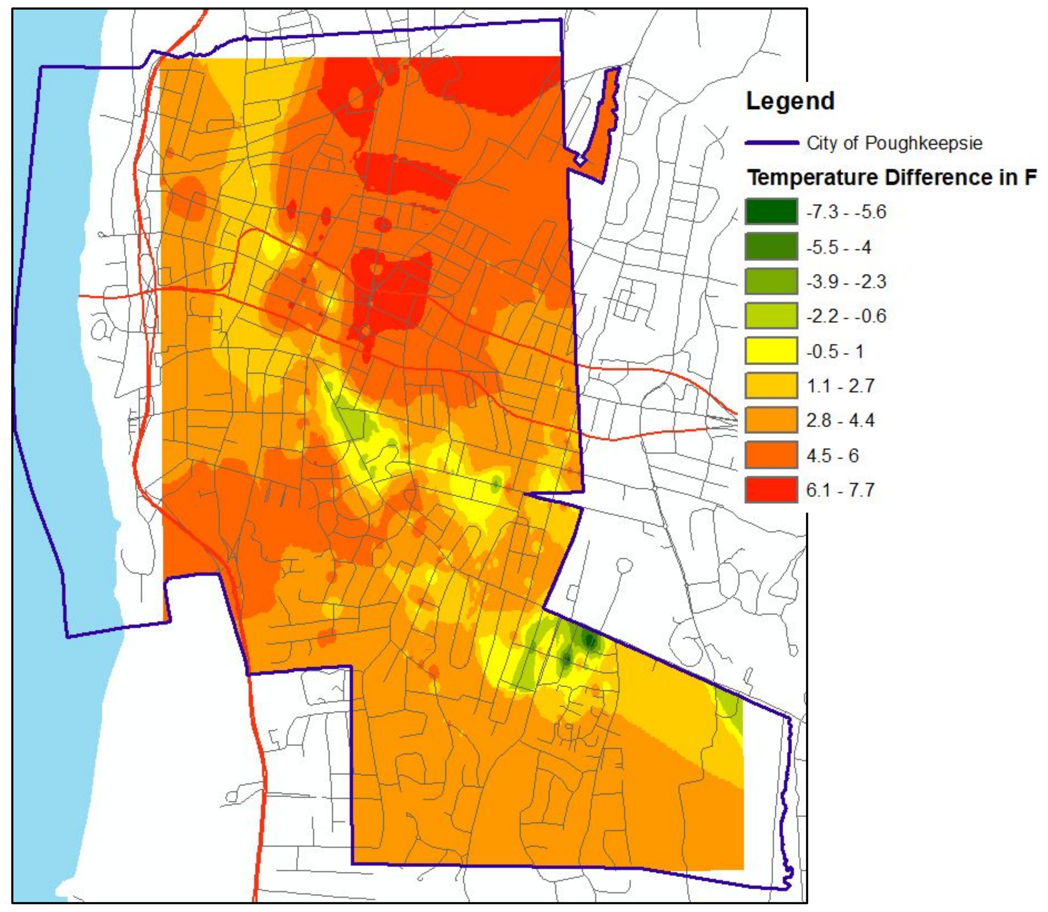


Figure 2: Temperature Difference in the City of Poughkeepsie. Ambient temperature data taken from the Dutchess County Airport was subtracted from our measured temperature data. An IDW interpolated surface approximates expected values in the areas not sampled. Sampled values varied from -5 to +7 degrees compared to contemporaneous airport reference values.

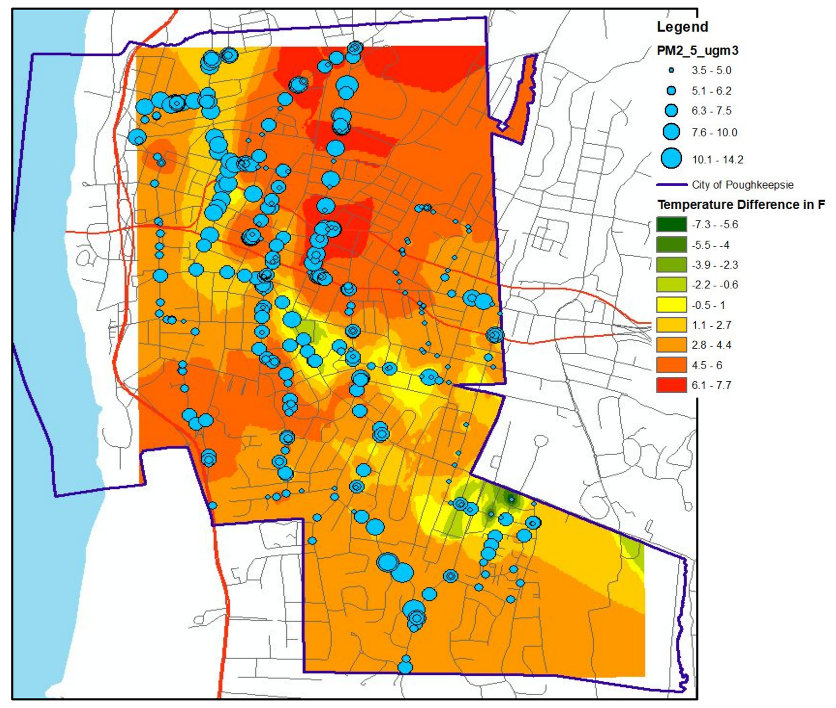


Figure 3: Fine Particulate Matter (PM 2.5) μg/m³. Each blue point represents a sample.

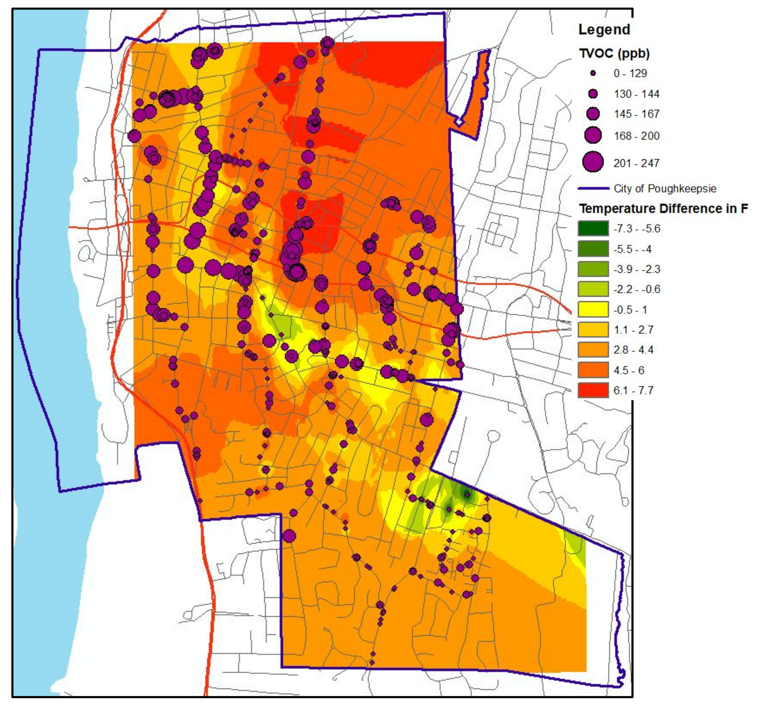
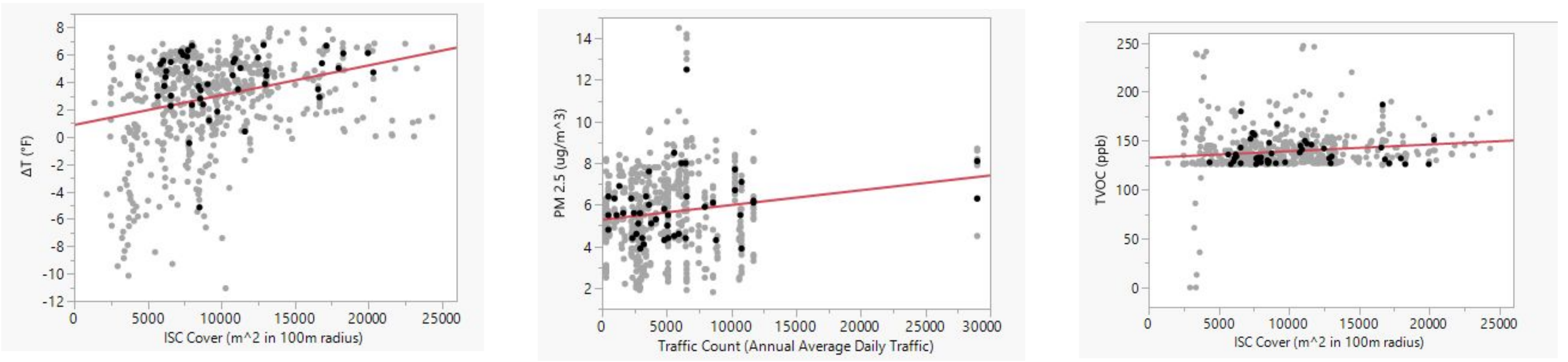


Figure 4: Volatile Organic Compounds (VOC) ppb. Each purple point represents a sample, the larger the dot the greater the VOC.

Why

Explanation of air quality measures by tree cover, ISC, and traffic counts was weak but present even in this preliminary data set (fig. 5).



R^2= .08, p< .0001 R^2= .03, p< .0001 R^2= .02, p= .0004

Figure 5. Temperature was best explained by ISC (left), PM was best explained by traffic counts (middle), and VOC has a slight correlation with ISC (right).

Heat Vulnerability

Areas with relatively worse air quality correlated in some areas with vulnerable population variables[2], but not in others. Subsequent analysis should integrate further complicating factors, such as population density and land use patterns.

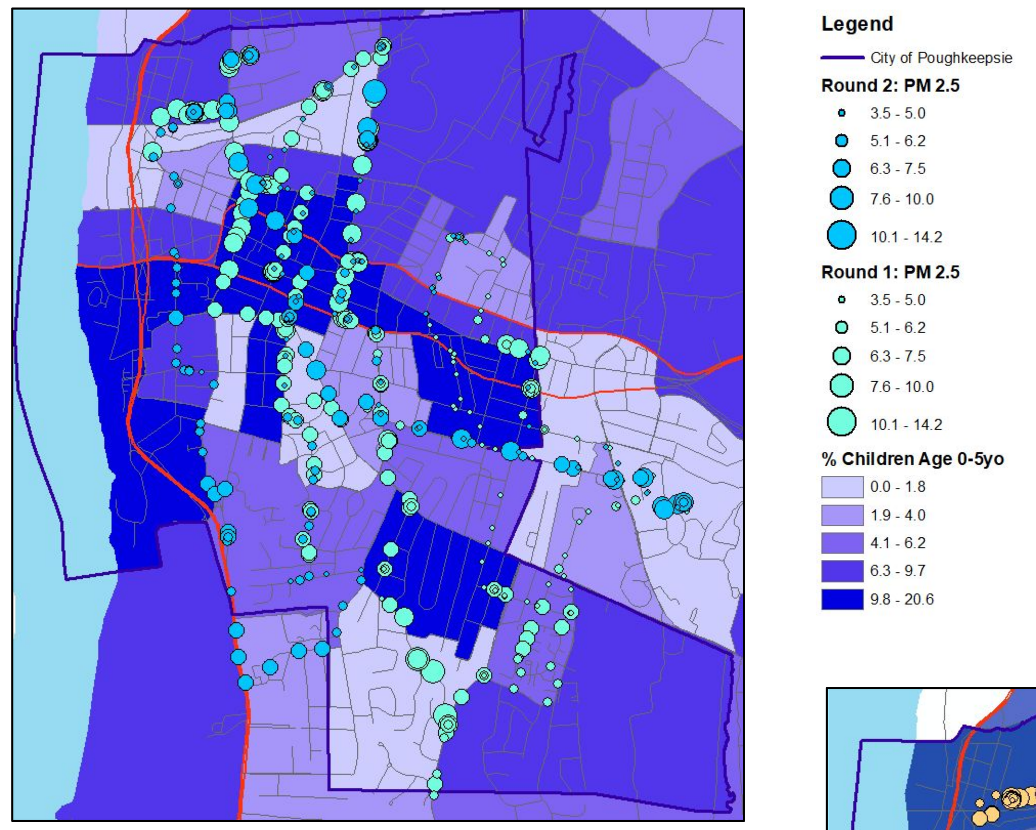


Figure 6: Percent of children Age 0-5 by census block group, with measured PM 2.5. Darker colors indicate a greater number of children; larger circles indicate more PM 2.5.

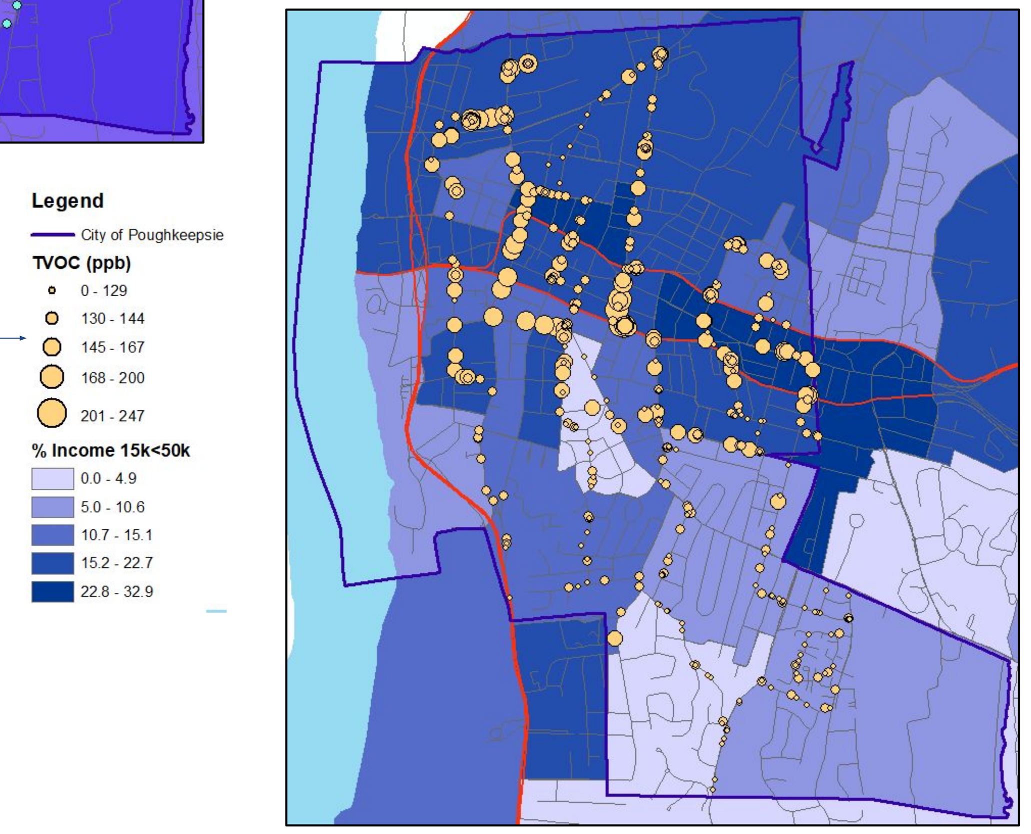


Figure 7: Percentage of population with annual income of $15,000-$50,000, with total VOC (TVOC). Darker block groups have more people with in this income range; larger circles indicate more VOCs. We believe VOCs in this area result mainly from vehicle exhaust, although some commercial sources may also exist.

Discussion/Conclusion

The north side of Poughkeepsie was expected to have the worst air quality due to its land use, traffic, and low vegetative cover, but in this pilot data set, only temperature and VOCs were worse than in the south side. Unexpectedly, neither tree cover nor traffic counts explained these differences as well as ISC. PM2.5 was much lower on the east of the arterial than near the center of the arterial, although the cause of this difference is unknown.

Air quality changes rapidly in time and space, but this preliminary study showed substantial variation among neighborhoods. Because this approach is low cost, in money and time, it could produce data that would support spatial analysis. This approach also requires little expertise. It can be done by students or citizens of different ages and backgrounds, providing experience in environmental science to diverse participants. We have initiated a follow-on study with Poughkeepsie High School students in an after-school program, and their preliminary data points to areas where targeted sampling of particular areas of concern would be beneficial. We believe a larger data set will support further analysis of explanatory variables.

References

1. Lin, S., Hsu, W.-H., Van Zutphen, A. R., Saha, S., Luber, G., & Hwang, S.-A. (2012). Excessive Heat and Respiratory Hospitalizations in New York State: Estimating Current and Future Public Health Burden Related to Climate Change. *Environmental Health Perspectives*, *120*(11), 1571–1577.
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3. Poff, N. L. (2002). Ecological response to and management of increased flooding caused by climate change. *Philosophical Transactions of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences*, *360*(1796), 1497–1510.