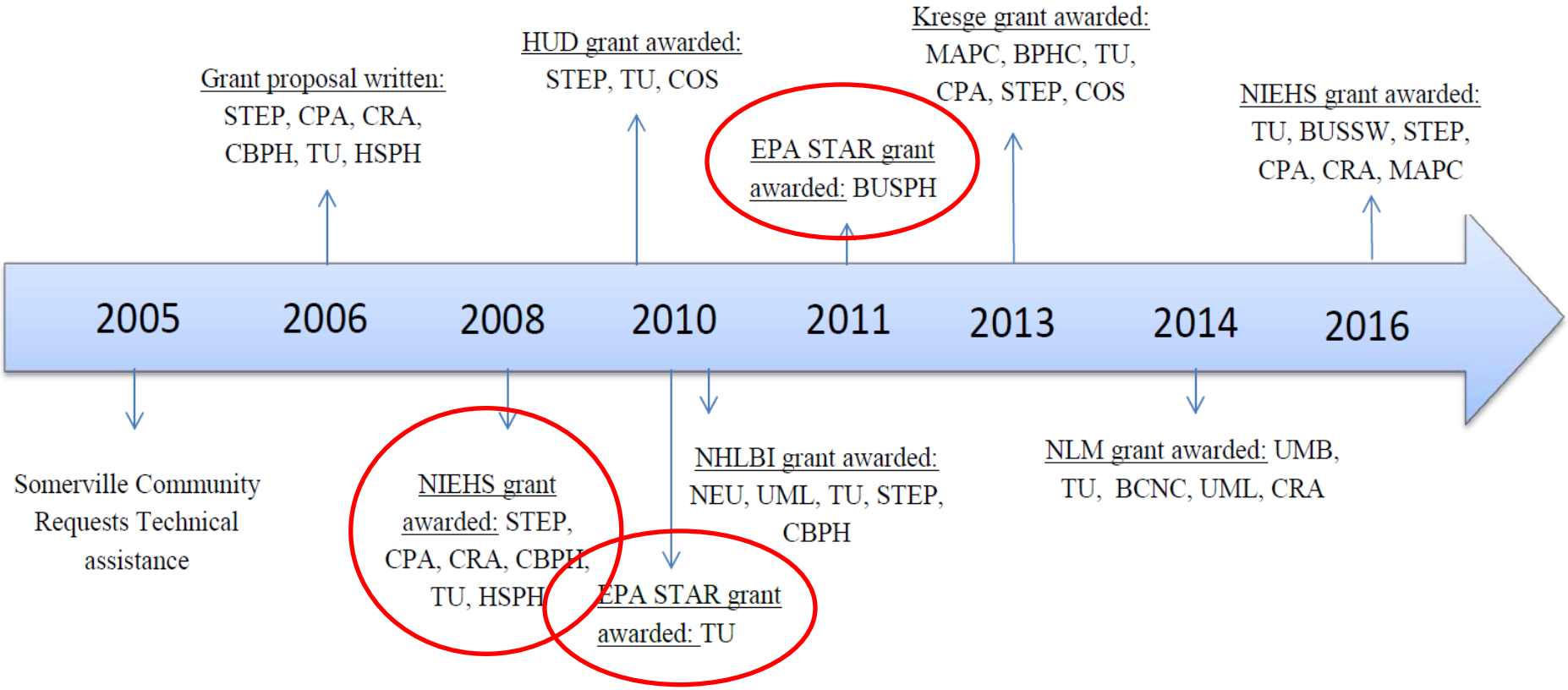
Traffic-related UFP and cardiovascular health: Findings from a community-based study in Boston, MA

Doug Brugge, June 2017

CAFEH is a series of studies: Reported here are primary findings from the first study which is largely completed



All are community-based participatory research

Somerville – air conditioning reduces PNC indoors

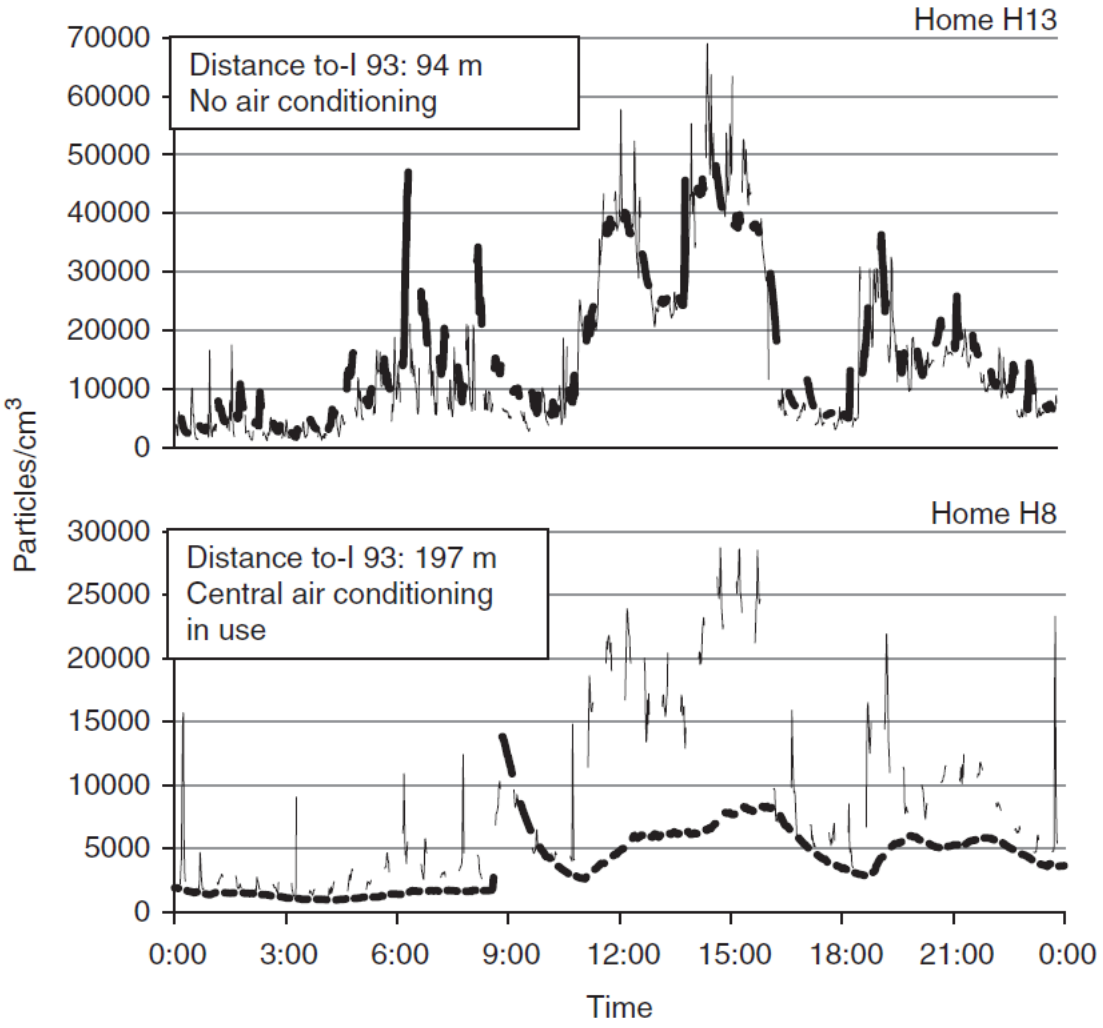
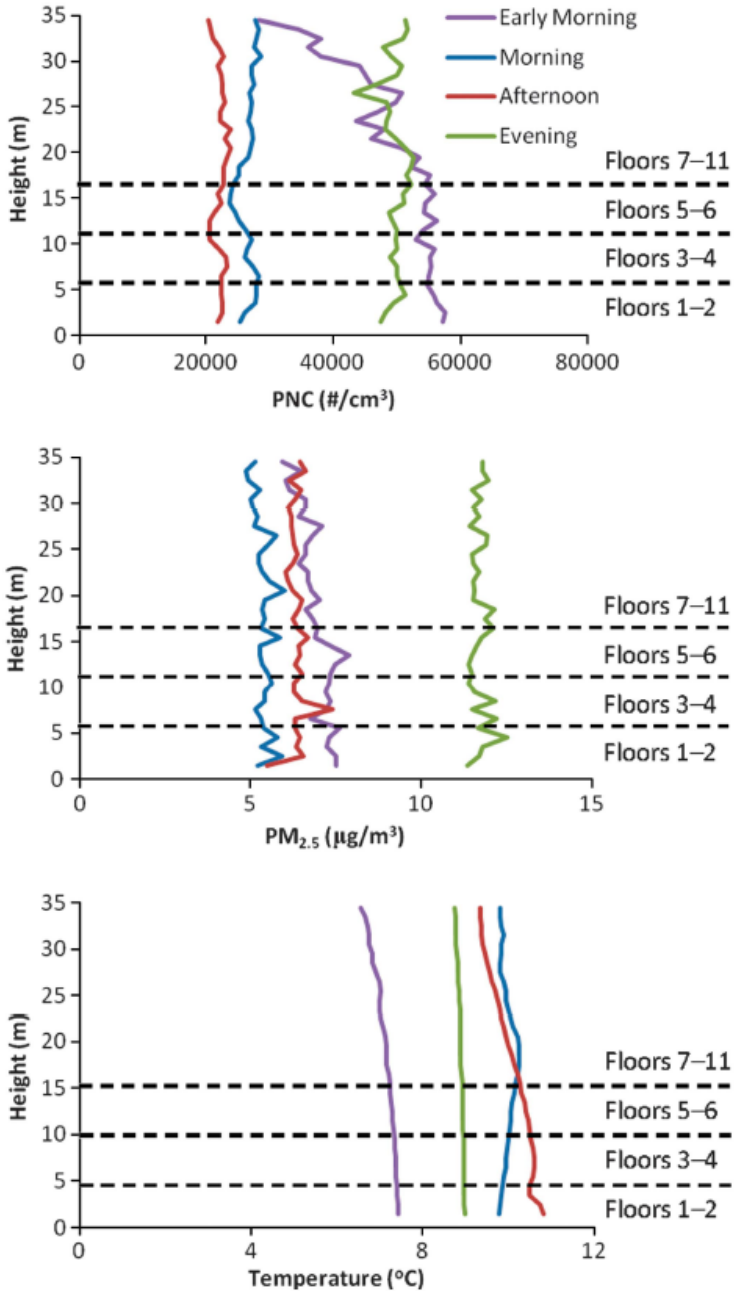


Figure 3. Time-series data for two homes monitored simultaneously on 14 June 2010 for indoor (thick line) and outdoor (thin line) particle number concentration. Note the different scales of the y-axes.

Fuller et al. Journal of Exposure Science and Environmental Epidemiology (2013), 1 – 7

Chinatown –PNC concentrations do not decline much, most of the time up to 35 meters



Wu et al. Journal of Exposure Science and Environmental Epidemiology (2014), 297 – 304

PNC at Countway (central site), but not near highway or modeled, is associated with our biomarkers for short term exposure.

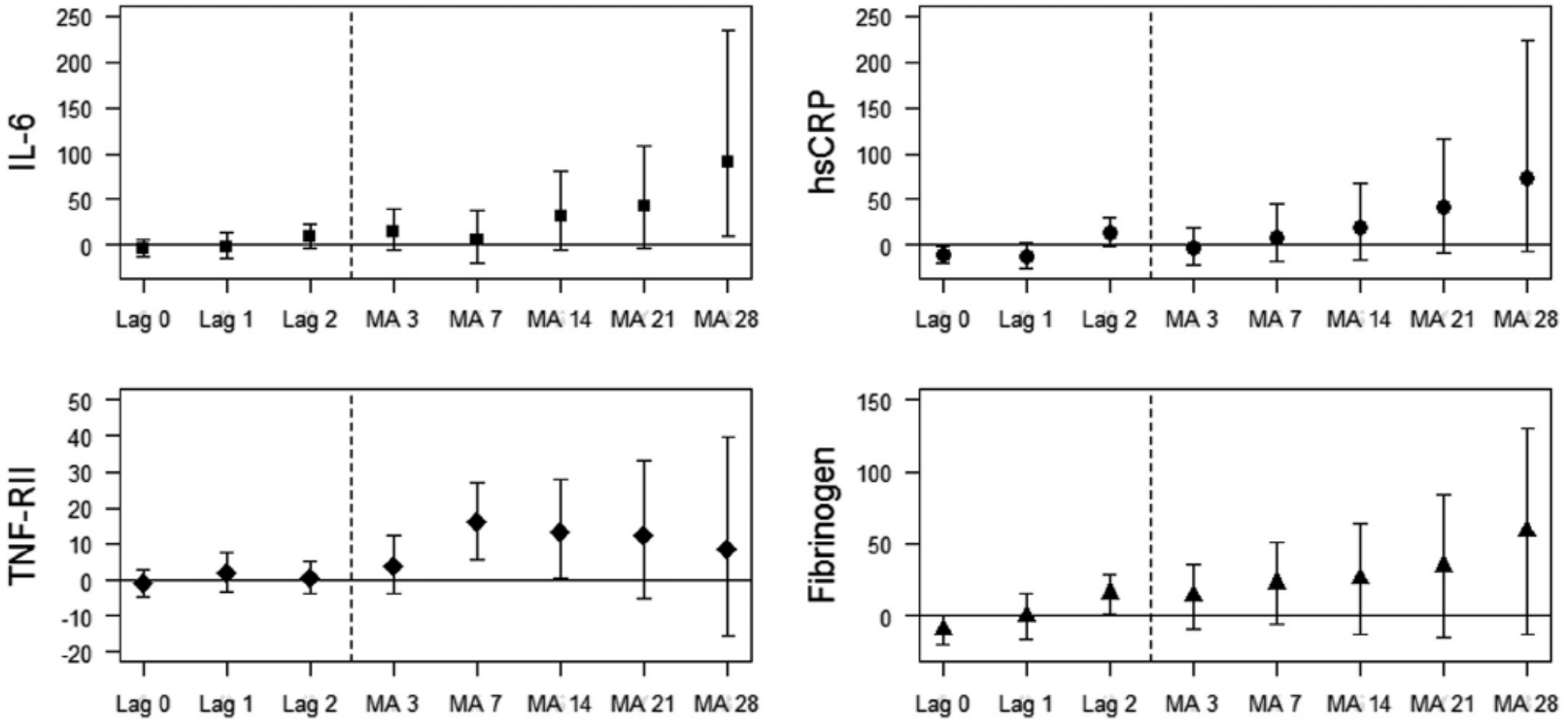


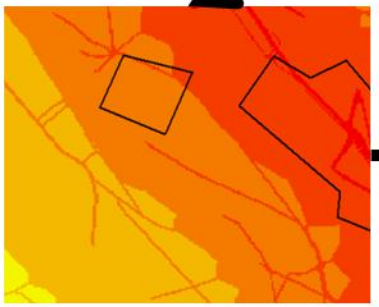
Fig. 2. Relationships of biomarkers with central site (SPH) ambient particle number concentration. Expected change in the biomarker is expressed as percent change (coefficient and 95% CI) per 5000 particles/cm^3 change in exposure for IL-6, hs-CRP, and TNF-RII and absolute change (coefficient and 95% CI) per 5000 particles/cm^3 change in exposure for fibrinogen.

Community Assessment of Freeway Exposure and Health (CAFEH)

Mobile Monitoring on 162 days

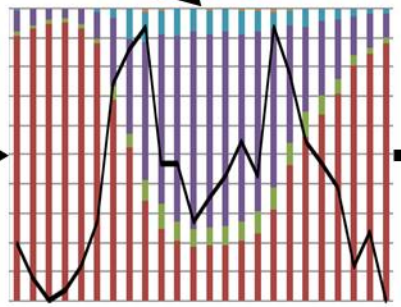
704 surveys

451 clinic visits

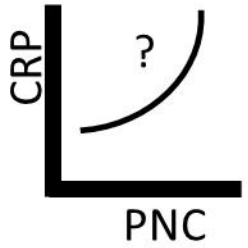


PNC Models

Ambient residential PNC



Time-activity adjustment



Association?

TAPL Details

Sampling Inlet

Particle Size Distribution

PM2.5 (not shown)

NO, NO2, NOx

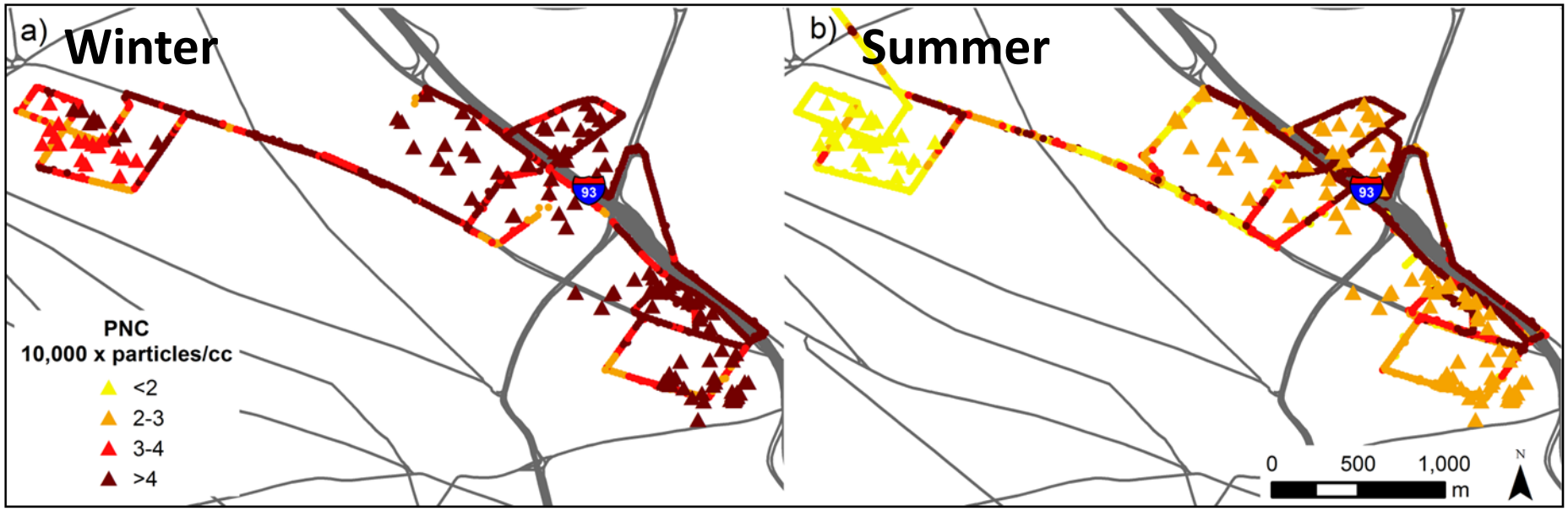
Particle Number Concentration

Carbon Monoxide

Polycyclic Aromatic Hydrocarbons

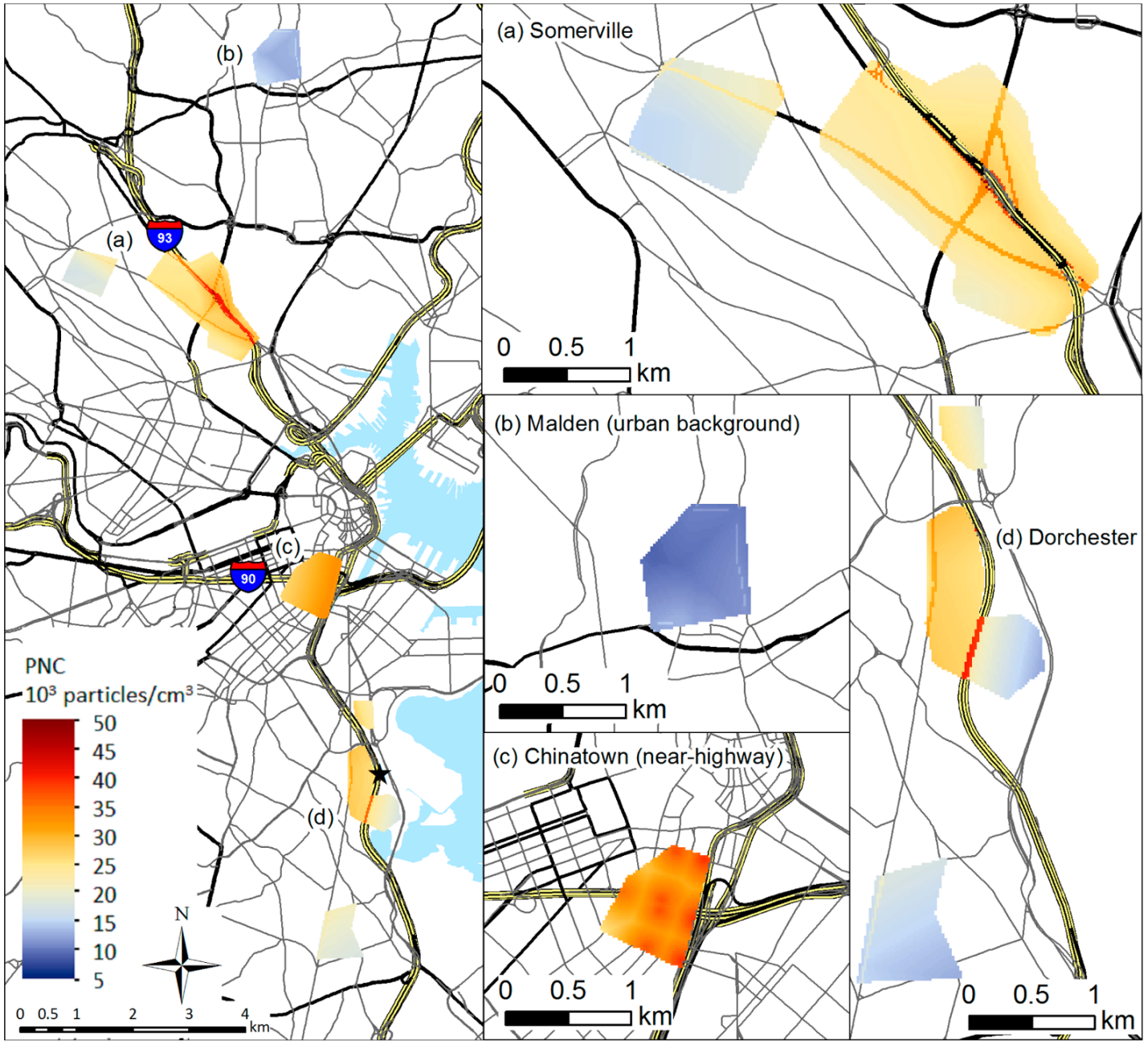
Black Carbon

Somerville: on-road, residential – model predicts PNC reasonably well.



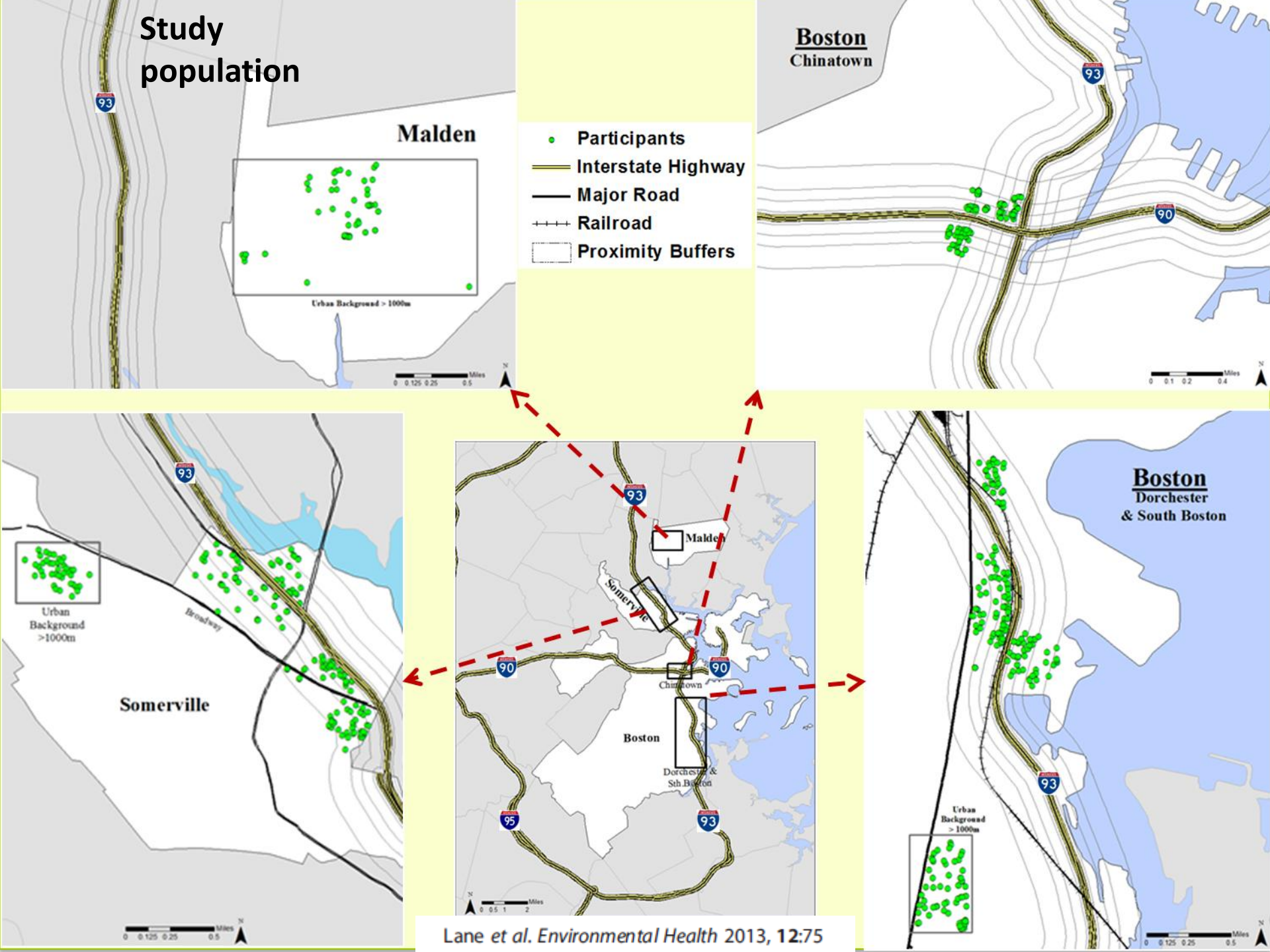
Patton AP, Collins C, Naumova EN, Zamore W, Brugge D, Durant JL. An hourly regression model for ultrafine particles in a near-highway urban area. *Environmental Science and Technology* 2014.

Hourly predictive models with about 20 meter resolution. Not very transferable from geographic area to area



Patton et al. *Environ. Sci. Technol.* 2015, 49, 6051−6060

Study population



Lane *et al. Environmental Health* 2013, **12**:75

There was differential error in geographic position assignment that we corrected

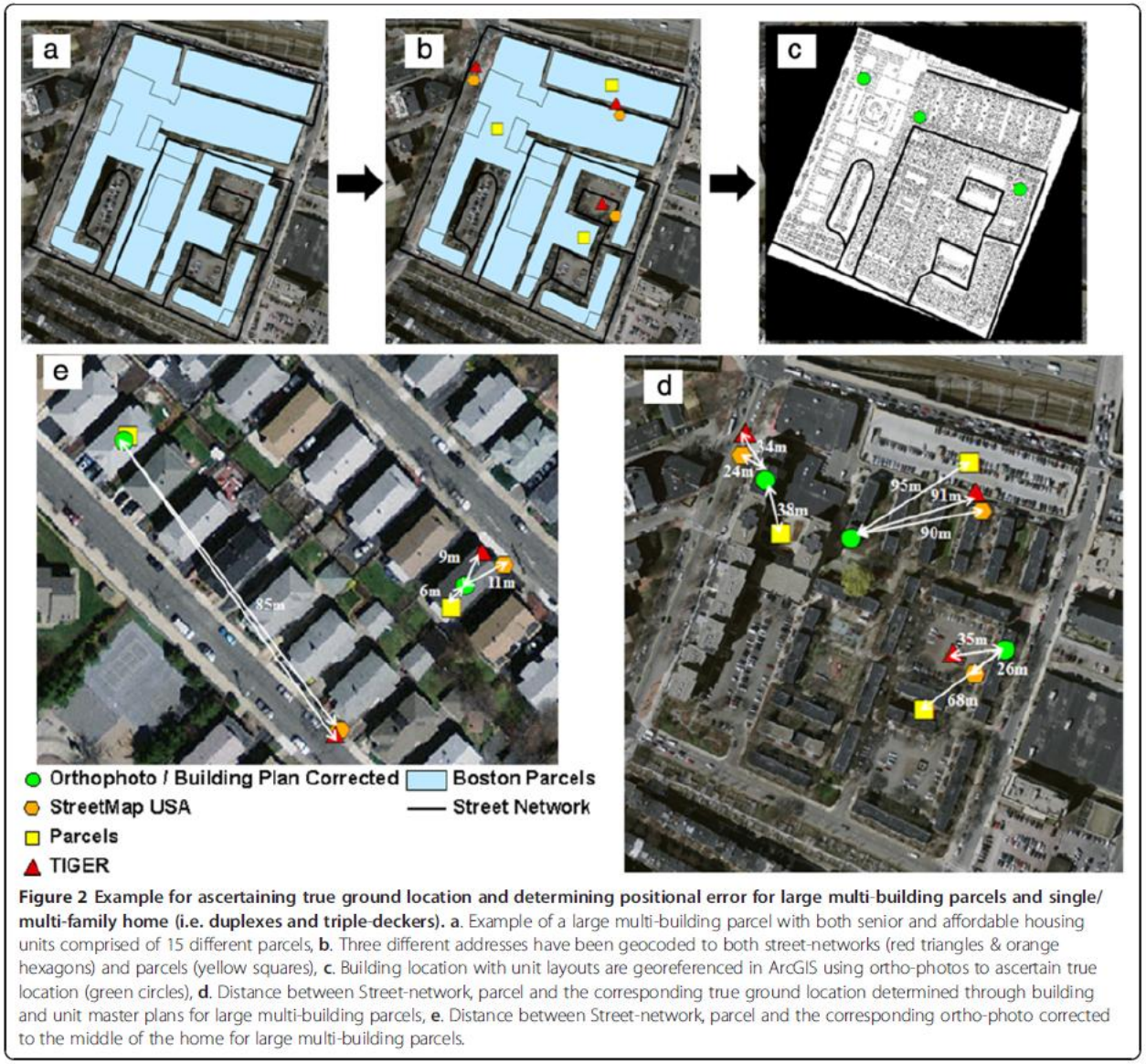


Figure 2 Example for ascertaining true ground location and determining positional error for large multi-building parcels and single/multi-family home (i.e. duplexes and triple-deckers). a. Example of a large multi-building parcel with both senior and affordable housing units comprised of 15 different parcels, **b**. Three different addresses have been geocoded to both street-networks (red triangles & orange hexagons) and parcels (yellow squares), **c**. Building location with unit layouts are georeferenced in ArcGIS using ortho-photos to ascertain true location (green circles), **d**. Distance between Street-network, parcel and the corresponding true ground location determined through building and unit master plans for large multi-building parcels, **e**. Distance between Street-network, parcel and the corresponding ortho-photo corrected to the middle of the home for large multi-building parcels.

Exposure Time-Activity Adjustment (TAA-PNC)

Model 1. Residential Ambient

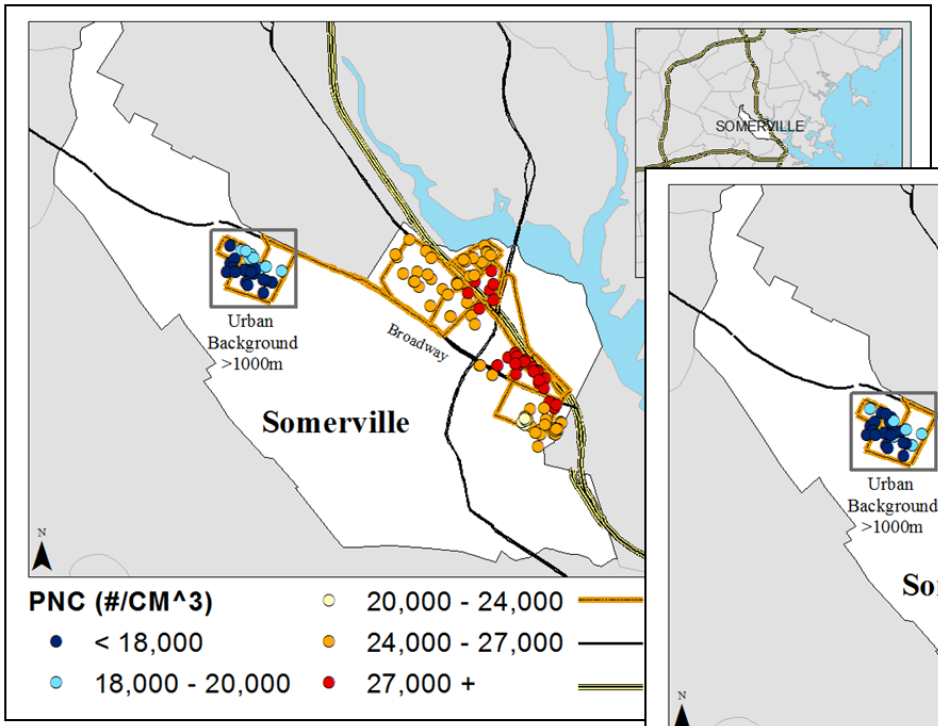
Model 2. Work

Model 3. Other

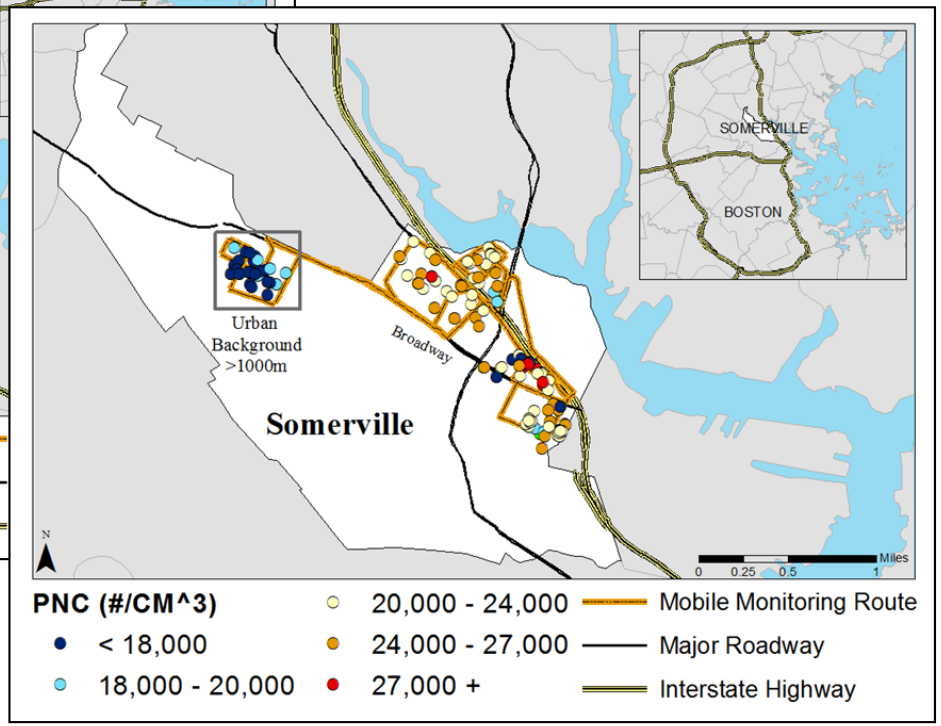
Model 4. Highway

Time activity adjustment differentially reduced exposures for near highway participants

Comparison of PNC Annual Average Exposure Models (N=140)



Ambient Residential Annual Average



Time-Activity Adjusted Annual Average

Lane et al. Journal of Exposure Science and Environmental Epidemiology (2015), 506 – 516

Adjusting for time activity improved linearity of association with CRP (and IL-6) – Somerville data only

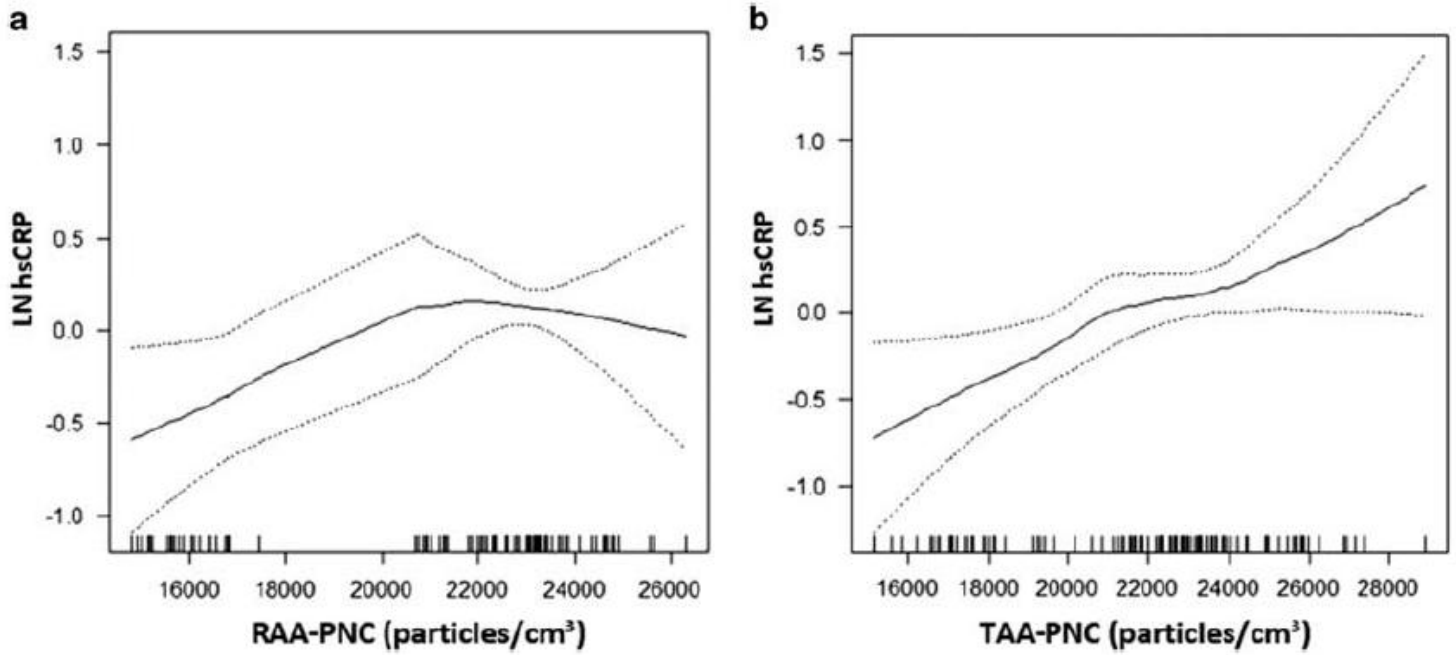


Figure 3. GAM model comparison of the effect of PNC exposure models on LN hsCRP.

Lane et al. Journal of Exposure Science and Environmental Epidemiology (2015), 506 – 516

A higher PNC of 10,000 particles/cm3 was associated with higher DBP of 2.40 mmHg (*p* = 0.03), independent of other factors in the model.

There were no significant associations for PM2.5 or BC.

***A*ssociations of DBP with PNC were more pronounced among obese individuals than non-obese individuals. "**

Chung et al., Int. J. Environ. Res. Public Health **2015**, *12*

Marginal associations of TAA-PNC with S/IHD and hypertension,
but not diabetes, except possibly in Asians

Li et al., IJERPH, 2016

TAA-PNC is associated positively, after adjusting for several confounders (negative confounding) but not significantly with CRP, IL-6 and TNFRII and negatively with fibrinogen. Stronger in white participants than Asian.

Table 4
Comparison of regression models for association between an interquartile-range change in time-activity adjusted annual average particle number concentration (IQR = 10.000 particles/cm^3) and biomarkers of systemic inflammation (hsCRP, IL-6 and TNFRII) and coagulation (fibrinogen).

Model	hsCRP	IL-6	TNFRII	Fibrinogen
	% change (95% CI)	% change (95% CI)	% change (95% CI)	% change (95% CI)
Unadjusted	−8.0% (−23.3%, 11.7%)	−2.1% (−12.9%, 10.2%)	−0.05% (−6.1%, 5.4%)	−3.3% (−7.0%, 0.4%)
Adjusted[a]	9.8% (−8.3%, 31.4%)	5.8% (−5.6%, 18.5%)	3.6% (−1.9%, 9.4%)	−1.9% (−5.5%, 1.6%)
Adjusted[b]	14.0% (−4.6%, 36.2%)	8.9% (−2.6%, 21.8%)	5.1% (−0.4%, 10.9%)	−1.9% (−5.5%, 1.6%)
Adjusted[c]	14.8% (−4.1%, 37.4%)	8.1% (−3.6%, 21.2%)	4.6% (−1.0%, 10.5%)	−2.1% (−5.7%, 1.5%)

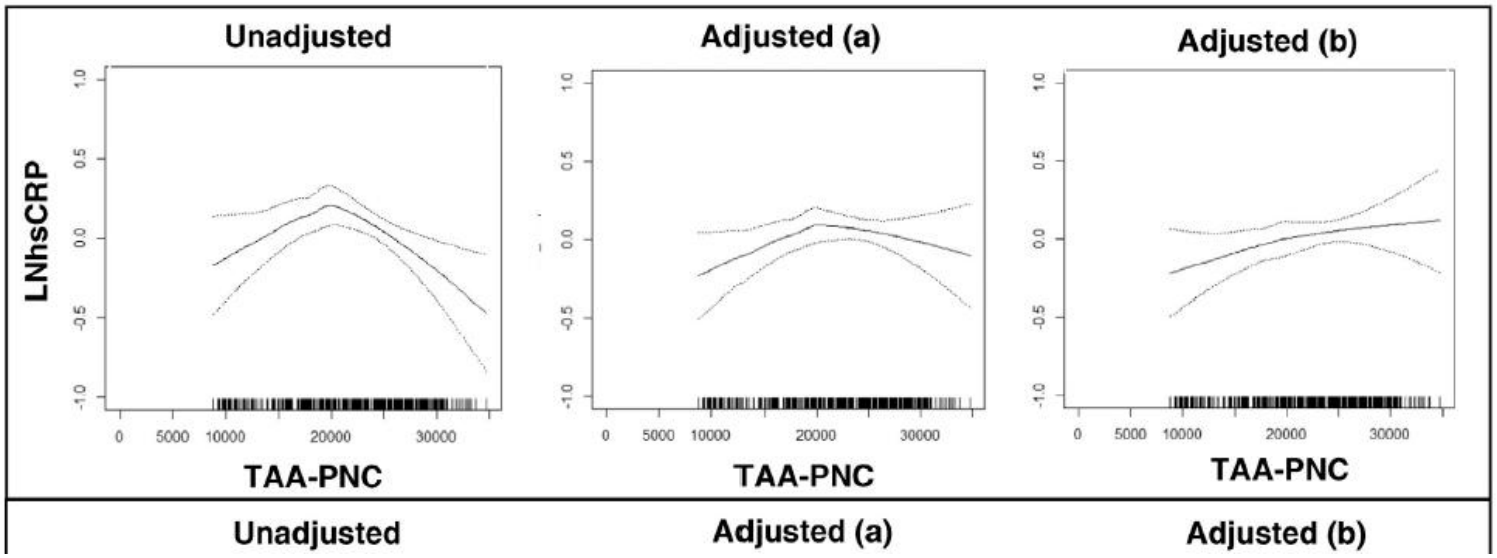
[a] Adjusted for age, sex, continuous BMI, smoking status and education.
[b] Adjusted for age, sex, continuous BMI, smoking status, education and race/ethnicity.
[c] Adjusted for age, sex, continuous BMI, smoking status, education and nativity.

Table 5
Comparison of regression models for association between an interquartile-range change in time-activity adjusted annual average particle number concentration (IQR = 10.000 particles/cm^3) and biomarkers of systemic inflammation (hsCRP, IL-6 and TNFRII) and coagulation (fibrinogen) stratified into white non-Hispanic and East Asian participants.

Model	hsCRP	IL-6	TNFRII	Fibrinogen
	% change (95% CI)	% change (95% CI)	% change (95% CI)	% change (95% CI)
White non-Hispanic				
Unadjusted	36.3% (−0.9%, 73.5%)	28.7% (4.4%, 53.0%)	15.5% (7.3%, 7.8%)	2.3% (−5.6%, 10.2%)
Adjusted[a]	32.7% (3.7%, 67.2%)	22.6% (−0.2%, 45.5%)	16.8% (5.8%, 27.7%)	−0.02% (−0.7%, 0.7%)
East Asian				
Unadjusted	9.7% (−13.5%, 32.9%)	5.0% (−9.9%, 19.7%)	−0.3% (−7.9%, 1.3%)	−1.8% (−6.4%, −2.7%)
Adjusted[a]	6.1% (−18.3%, 31.0%)	2.6% (−12.2%, 17.3%)	0.1% (−1.2%, 1.4%)	−0.06% (−5.4%, 4.2%)

[a] Adjusted for age, sex, continuous BMI, smoking status and education.

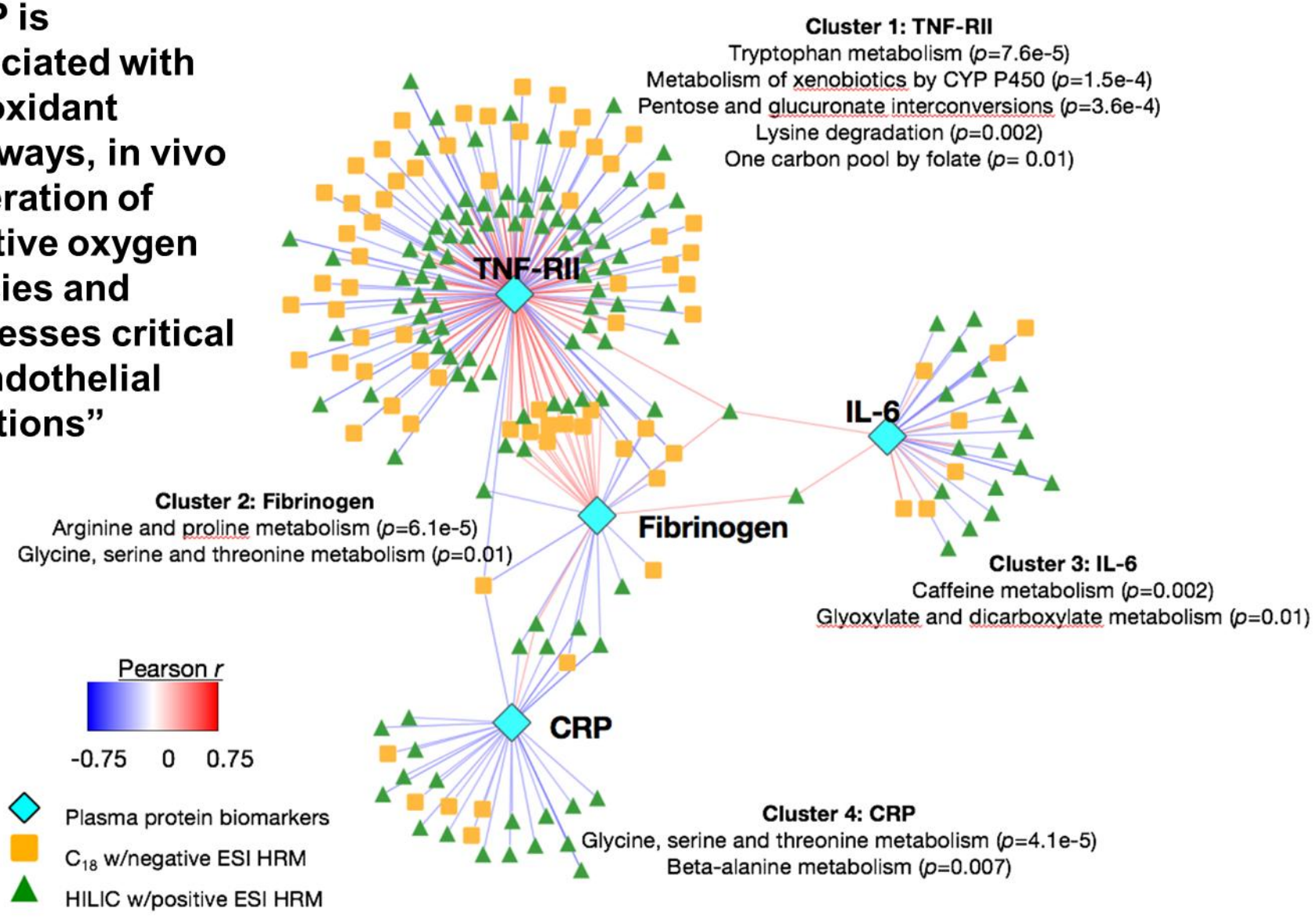
Adjustment for confounders, especially BMI, improves linearity



Metabolome analysis

>8000 molecules identified

"UFP is associated with antioxidant pathways, in vivo generation of reactive oxygen species and processes critical to endothelial functions"



Additional studies find associations between long-term ultrafine particles and health.

Three longitudinal studies have reported associations of long-term exposure to PNC with cardiovascular risk factors and mortality and reported findings that are broadly consistent with CAFEH analyses.

- Ostro et al, 2015. In California a statewide study found significant associations of UFP and their chemical constituents with death from S/IHD as well as total cardiovascular mortality.
- Aguilera et al, 2016. A multi-city cohort study in Switzerland observed an association of long-term exposure to UFP with subclinical atherosclerosis, measured by carotid intima-media thickness.
- Viehmann et al. 2015. A cohort study in Germany studied blood inflammatory and coagulation markers in a cohort study findings association of PNC with fibrinogen.

Strengths:

Monitoring, model building and exposure assessment
Objective health outcome measures
Ability to control for many potential confounders
Have data on other pollutants
Random, reasonably representative sample

Limitations:

Monitoring, model building and exposure assessment
Cross sectional
Main analysis is not actual development of disease
Single pollutant models
Small N

Conclusions:

We generated some evidence for UFP association with health

Came out about the same time as some other UFP epidemiology

But finer grain, near roadway exposure assignment

Need for larger, longitudinal studies

We will publish on a larger, lonfitudinal cohort soon

Tufts UNIVERSITY

SOMERVILLE TRANSPORTATION EQUITY PARTNERSHIP

波士頓華埠居民會 BOSTON CHINATOWN RESIDENT ASSOCIATION

Chinese Progressive Association

HARVARD School of Public Health

Committee For Boston Public Housing
CBPH

NIEHS
National Institute of Environmental Health Sciences

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Time activity patterns differed by working and non-working

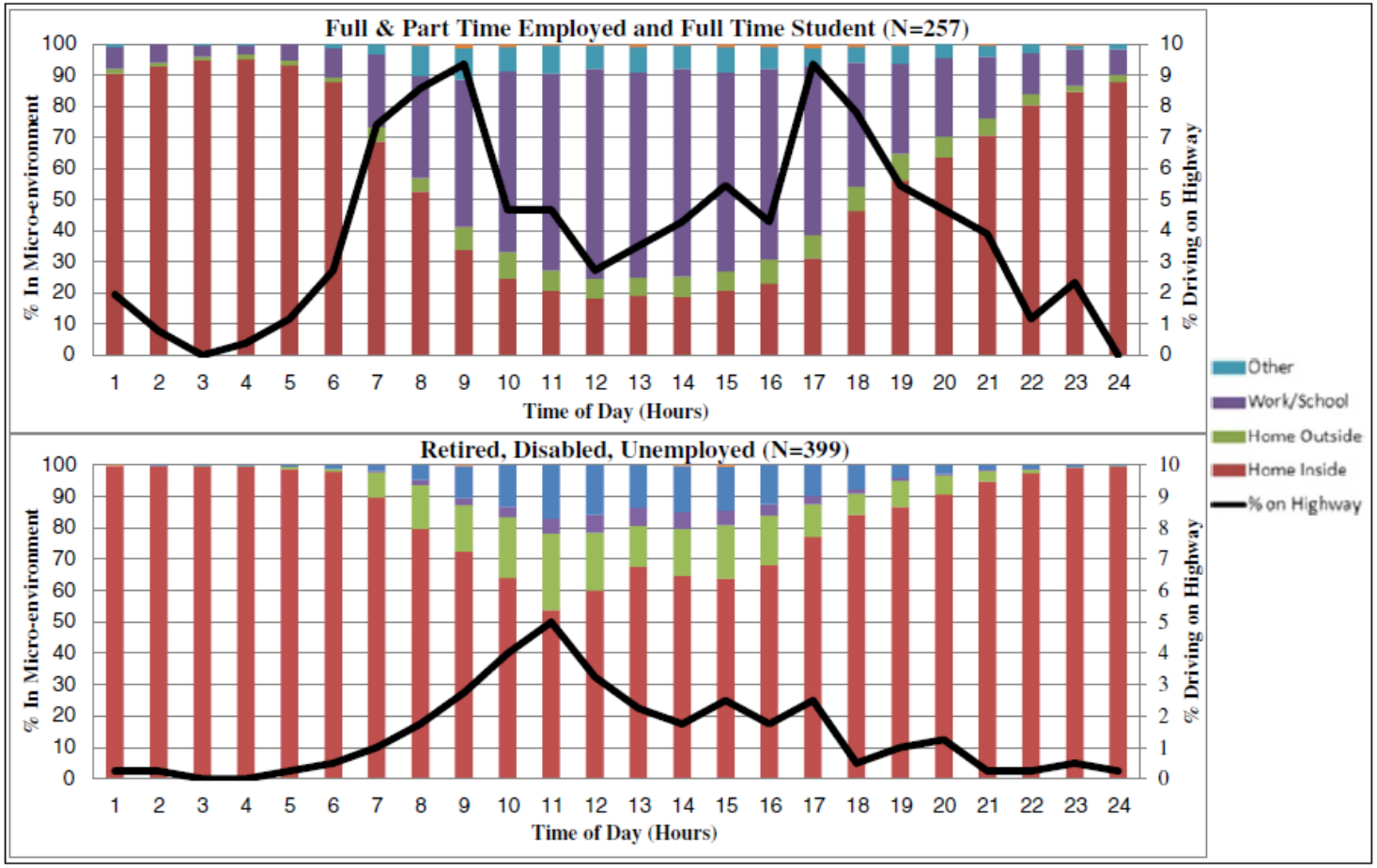


Figure 4 Hourly micro-environment time-activity data for most recent workday/weekday by employment status.