

Vertical population & Pollution distribution

Paper critique: *Mapping the vertical distribution of population and particulate air pollution in a near-highway urban neighborhood: Implications for exposure assessment*

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NUIST

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ORIGINAL ARTICLE

Mapping the vertical distribution of population and particulate air pollution in a near-highway urban neighborhood: Implications for exposure assessment

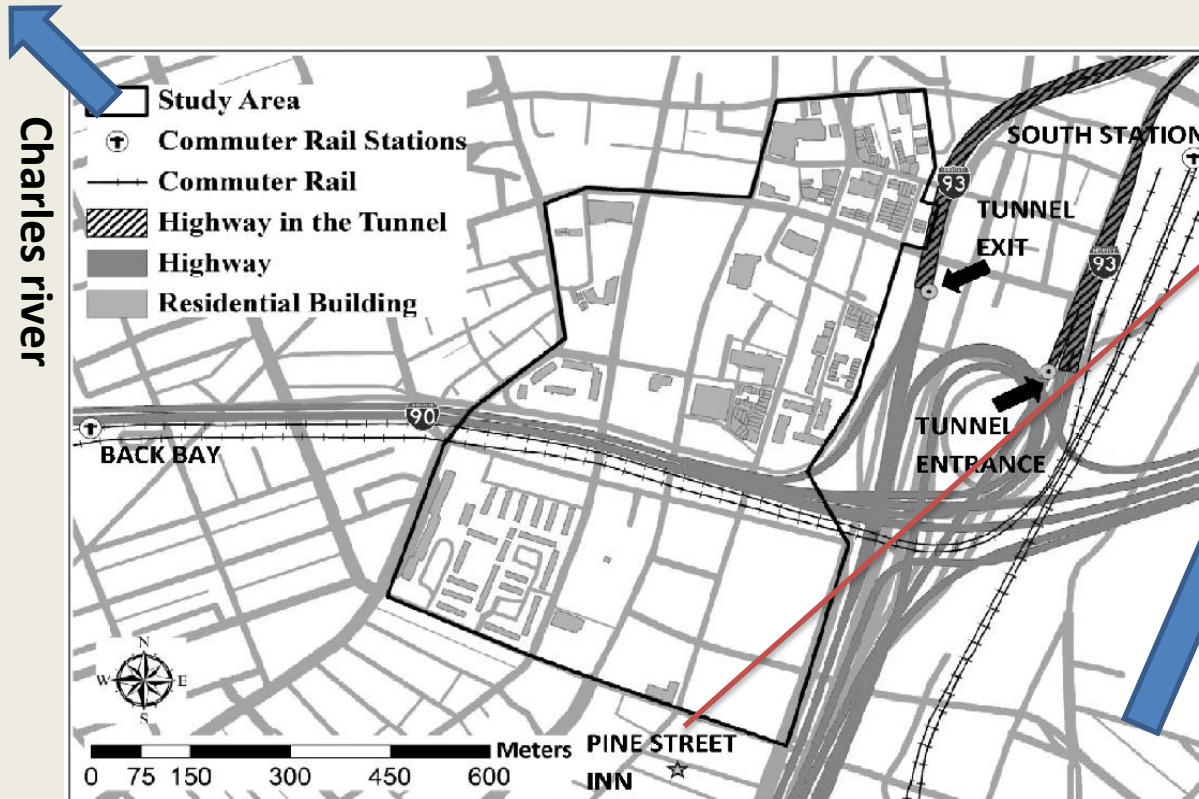
Chih-Da Wu¹, Piers MacNaughton¹, Steve Melly¹, Kevin Lane², Gary Adamkiewicz¹, John L. Durant³, Doug Brugge⁴ and John D. Spengler¹

Owing to data collection challenges, the vertical variation in population in cities and particulate air pollution are typically not accounted for in exposure assessments, which may lead to misclassification of exposures based on elevation of residency. To better assess this misclassification, the vertical distribution of the potentially highly exposed population (PHEP), defined as all residents within the 100-m buffer zone of above-ground highways or the 200-m buffer zone of a highway-tunnel exit, was estimated for four floor categories in Boston's Chinatown (MA, USA) using the three-dimensional digital geography methodology. Vertical profiles of particle number concentration (7–3000 nm; PNC) and particulate matter (PM_{2.5}) mass concentration were measured by hoisting instruments up the vertical face of an 11-story (35-m) building near the study area throughout the day on multiple days. The concentrations from all the profiles ($n = 23$) were averaged together for each floor category. As measurement elevation increased from 0 to 35 m PNC decreased by 7.7%, compared with 3.6% for PM_{2.5}. PHEP was multiplied by the average PNC for each floor category to assess exposures for near-highway populations. The results show that adding temporally-averaged vertical air pollution data had a small effect on residential ambient exposures for our study population; however, greater effects were observed when individual days were considered (e.g., winds were off the highways).

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Keywords: exposure assessment; near-highway pollution; 3-D digital geography (3DIG); three-dimensional population estimation; particulate matter (PM)

About Chinatown, Boston



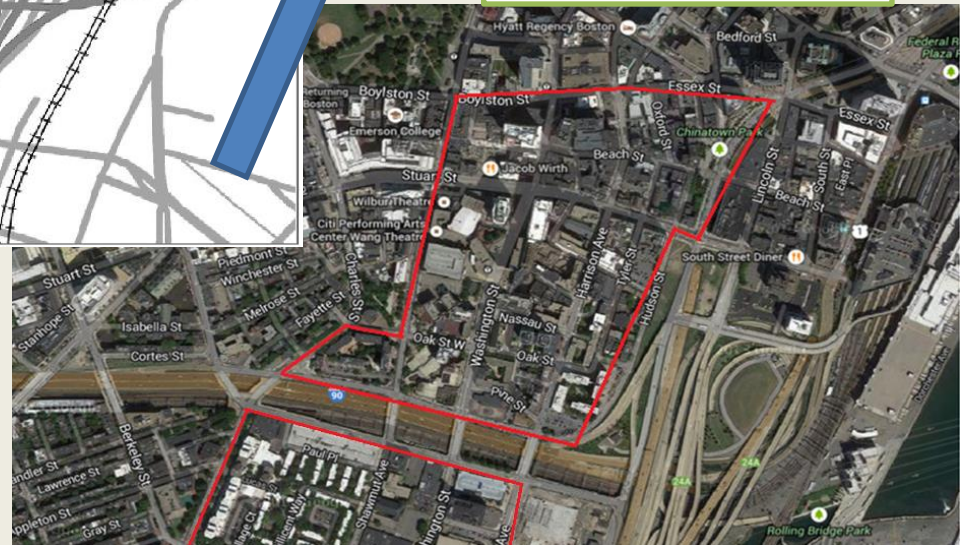
Map View

A HOPSCA

Observation Point

A Gulf

Satellite View



BG of Chinatown&Comparison

- **Traffic Nearby:**

- Trains Nearby:**there are some Diesel Trains!!!!

- I93(170,000/d)&I90(130,000/d)**

Nanjing Changjiang Tunnel(6Line): 10,000/d

Nanjing Changjiang Bridge(4~6Line):100,000/d

G42Hu(SH)Ning(NJ) Highway(8Line):20,000~30,000/d

- **Population density: 13,000p/Km²**

2.7 times higher than the citywide average

Beijing: 1311p/Km²

Shanghai: 9589p/Km²

Nanjing : 1238p/Km²(**Gulou:24.3K;Jianye:2195**)



Ps:Data above is the official data in recent 3 years

Observation Environment BG



Pine Street Inn


(located on the southern edge of the study area 100m west of I-93 and 400m south of I-90)



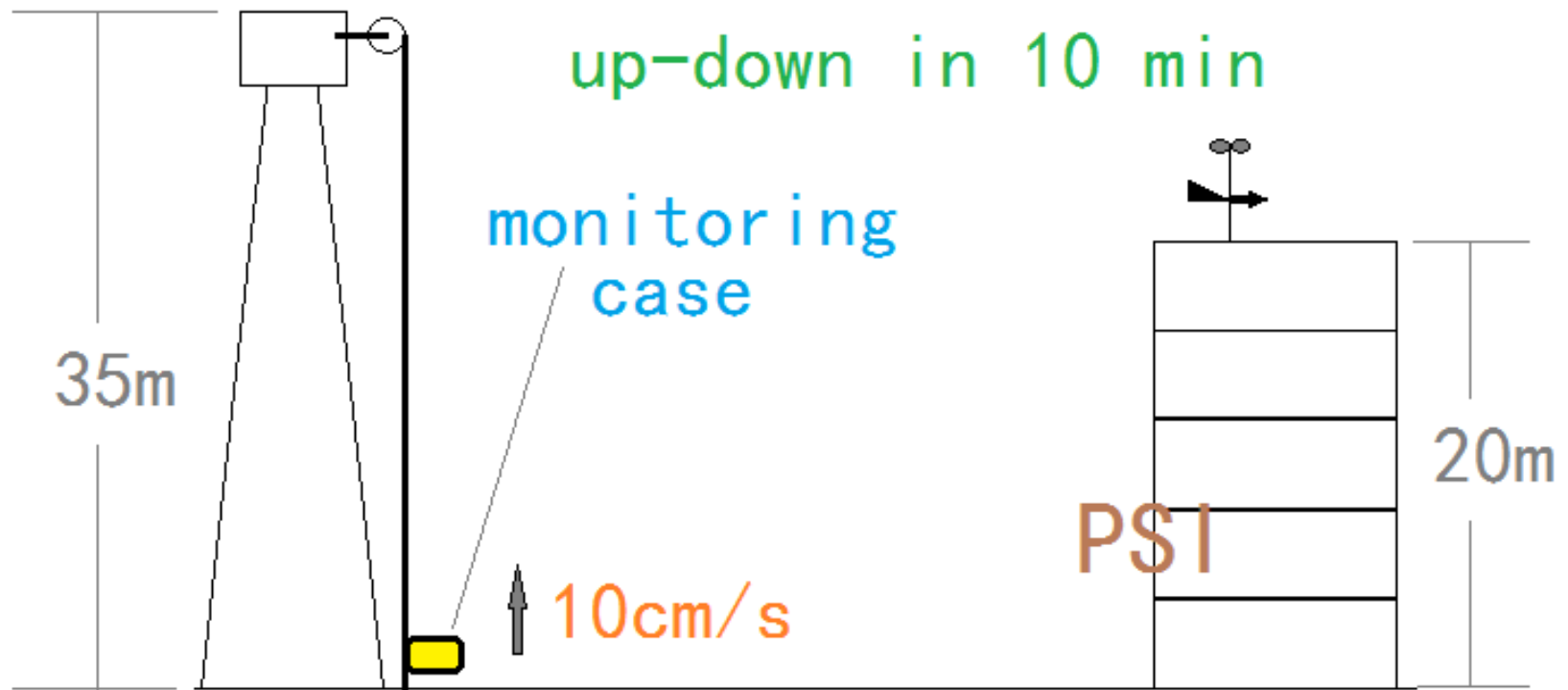
The tower

(ALSO because it has an 11-storey tower)

Meaning of Experiment

- **Ultrafine particles** (*UFPs; $r < 100$ nm in aerodynamic diameter*)
highly influence the air quality beside roads in
100m range. (PM0.1)
- UFPs  PM2.5 (*not easy to settle rapidly*)
- They flows in both **vertical and horizontal**
direction
- Precisely assess the effect to residents nearby

PM Measurement



The 'CASE'

The height of each measurement above ground level was based on the data-recording interval of each instrument and the start and end time of the profile.
5 min to complete

Temperature
(Every 10cm)

Relative
Humidity
(Every 10cm)

PNC
(Every 10cm)

PM2.5
(Every 1m)

The data collected on the way up was averaged with the data collected on the way back down

The data for PNC, temperature, and relative humidity were averaged to the nearest meter.

About All the Instruments

Table 1. Instruments used for data collection in this study.

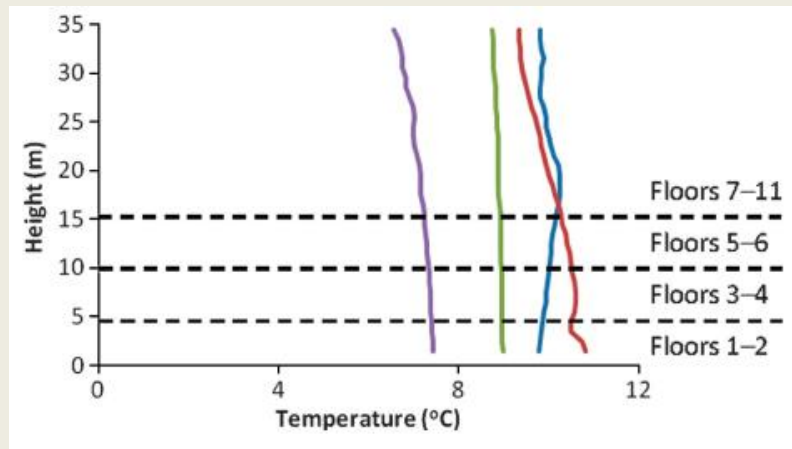
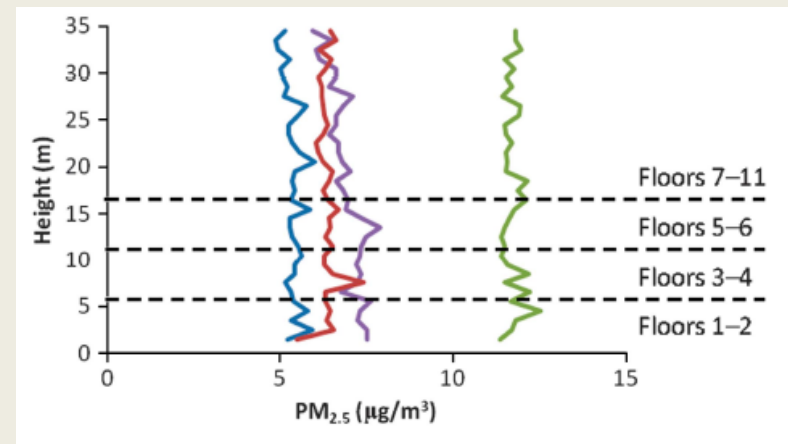
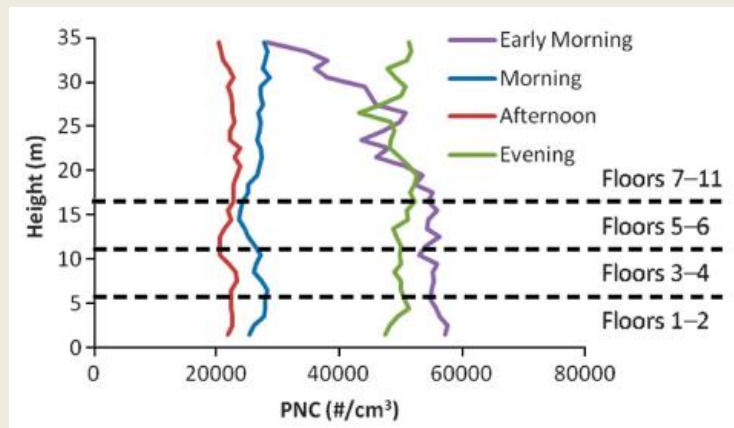
<i>Instrument</i>	<i>Model</i>	<i>Output</i>	<i>Data recording interval (s)</i>
<i>Pulley system</i>			
Condensation particle counter	TSI 3781	7–1000 nm Particle count ($\#/\text{cm}^3$, $\pm 10\%$)	1
SidePak Aerosol Monitor	TSI AM51	$< 2.5 \mu\text{m}$ PM concentration (mg/m^3)	10 (Moving average)
HOBO Temperature and Relative Humidity Probe	HOBO U12-011	Temperature ($^{\circ}\text{C}$) and relative humidity (%)	1
Turbometer	271	Wind speed and direction	NA
Defender 500 Series	BIOS 510-H	Flow rate (ml/min , $\pm 1\%$)	NA
<i>Stationary monitor</i>			
Condensation particle counter	TSI 3783	7–3000 nm Particle count ($\#/\text{cm}^3$, $\pm 10\%$)	60 (Moving average)
Davis instruments Vantage Vue Sensor	Davis 6357	Temperature, wind speed and wind direction	1800

Abbreviations: NA, not applicable; PM, particulate matter.

Ps: The SidePak overestimates the PM_{2.5} concentration compared with Federal Reference Method PM_{2.5} samplers. Then they got A linear regression.

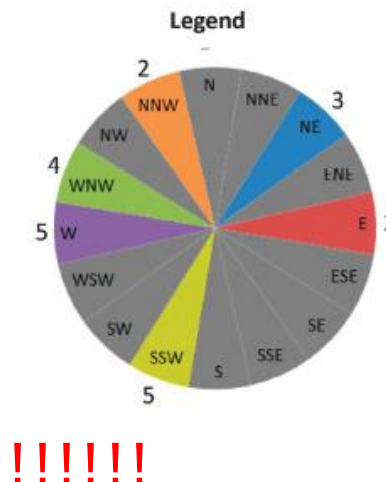
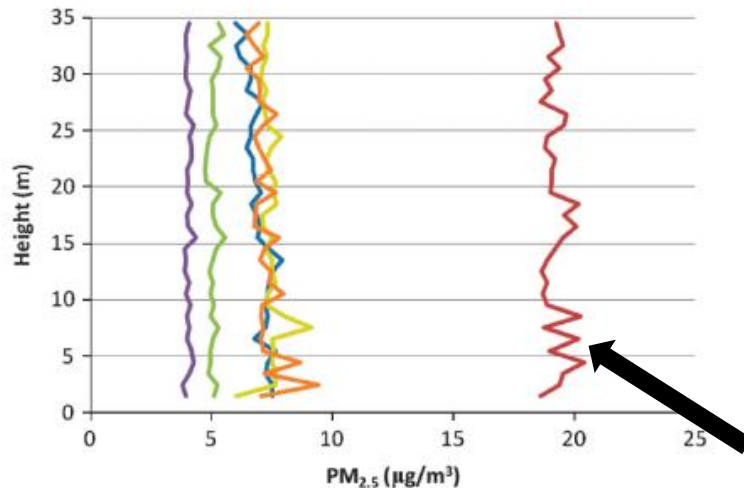
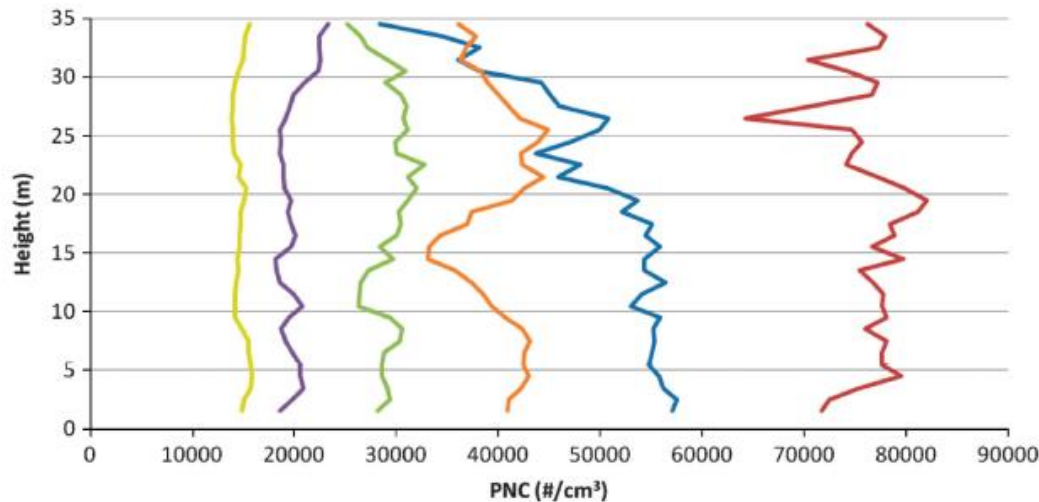
$$C_{\text{FRM}} = 0.33C_{\text{SidePak}} + 2.25$$

Daily Variation in Vertical Profiles



Including *particle number concentration (PNC)*, *particulate matter ($\text{PM}_{2.5}$)*, and *temperature at Pine Street Inn (PSI)*. **The morning profiles** are an average of 6 profiles collected hourly on 16 December 2011 and 3 February 2012 from 0900 to 1100; the **afternoon profiles** an average of 8 profiles collected on 9 December 2011 and 20 January 2012 from 1200 to 1500; and the **evening profiles** an average of 6 profiles collected on 18 November 2011 and 15 February 2012 from 1600 to 1800.

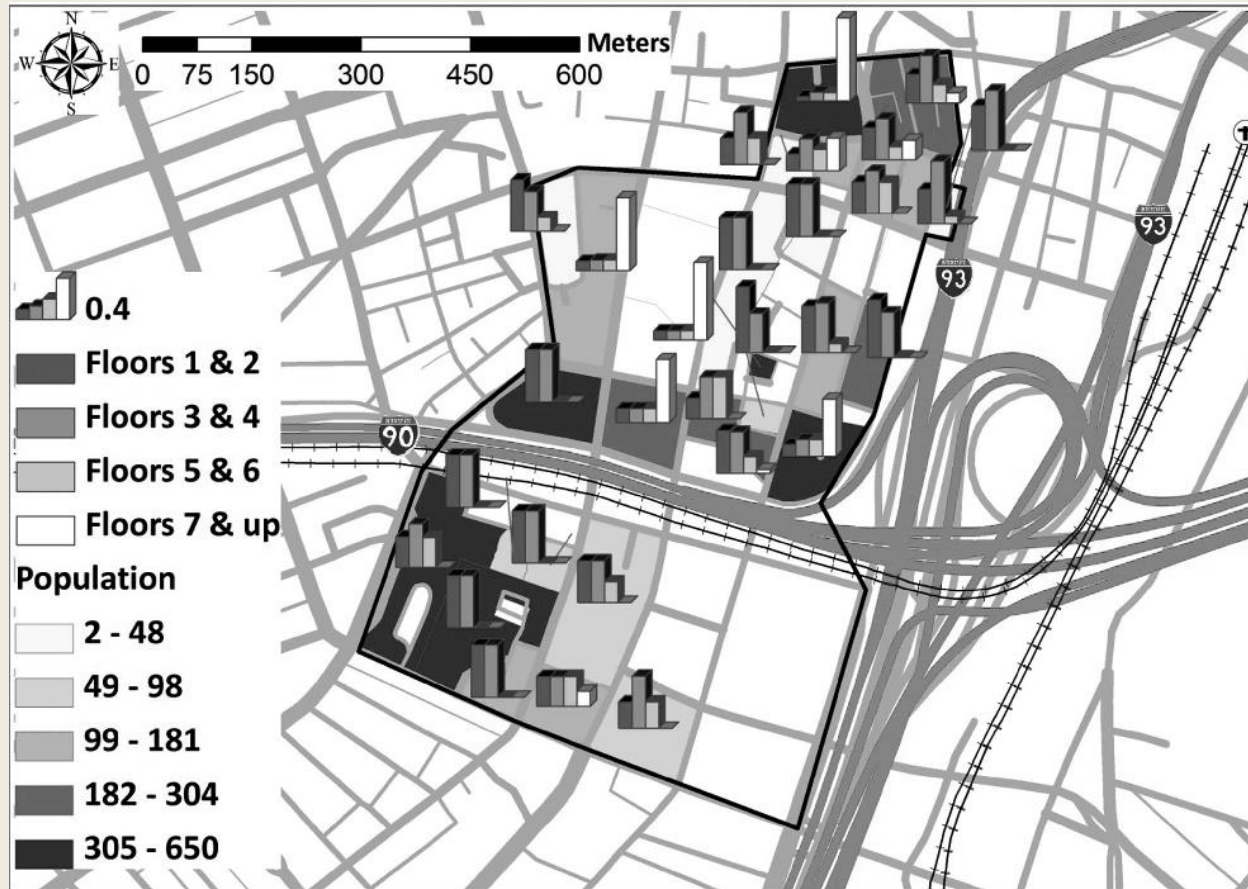
Effect of Wind Direction on Vertical



Profiles were collected weekly from November 2011 to March 2012 from 0700 to 1800 and averaged by wind direction. The legend shows what wind direction goes with each color. The numbers on the legend indicate the number of profiles collected during each wind condition.

Vertical Distribution of Population

Four floor categories



The population on each floor category in a census block was calculated by using this Eq.

$$PC_j = \sum_{k=1}^{32} \frac{FL_{jk}}{F_k} \times P_k$$

Vertical Effect

Table 2. Vertical distribution of population in four floor categories within different highway buffer zones.

Buffer	Residential floor category				Sum
	I	II	III	VI	
	(1F and 2F)	(3F and 4F)	(5F and 6F)	(7F and up)	
50 m	93 (1.50%)	102 (1.60%)	44 (0.70%)	155 (2.50%)	394 (6.20%)
100 m	640 (10.10%)	679 (10.70%)	224 (3.50%)	321 (5.10%)	1863 (29.40%)
150 m	1017 (16.10%)	1120 (17.70%)	387 (6.10%)	434 (6.80%)	2959 (46.70%)
200 m	1286 (20.30%)	1445 (22.80%)	556 (8.80%)	812 (12.80%)	4099 (64.70%)

Number in the parentheses indicates the percentage of the total population in Chinatown.



Hurt and harm.....

Table 3. Descriptive statistics of PNC ($\#/cm^3$) and $PM_{2.5}$ ($\mu g/m^3$) for each of the four floor categories based on 23 vertical profiles measured on 7 days.

Floor category	Elevation (m)	PNC	PNC		$PM_{2.5}$	$PM_{2.5}$	
			SD	P-value ^a		SD	P-value
1F and 2F	0–5.5	41,000	4600	NA	7.9	0.66	NA
3F and 4F	6.5–11.5	40,000	4300	0.35	7.8	0.70	0.50
5F and 6F	12.5–16.5	40,000	4300	0.12	7.8	0.75	0.17
7F and up	17.5–34.5	37,000	6800	0.0084	7.5	0.66	0.00036

Abbreviations: NA, not applicable; PM, particulate matter; PNC, particle number concentration.

The profiles were standardized to an average pollution day based on the monitoring data to account for diurnal and daily variability in the magnitude of the profiles over the study period.

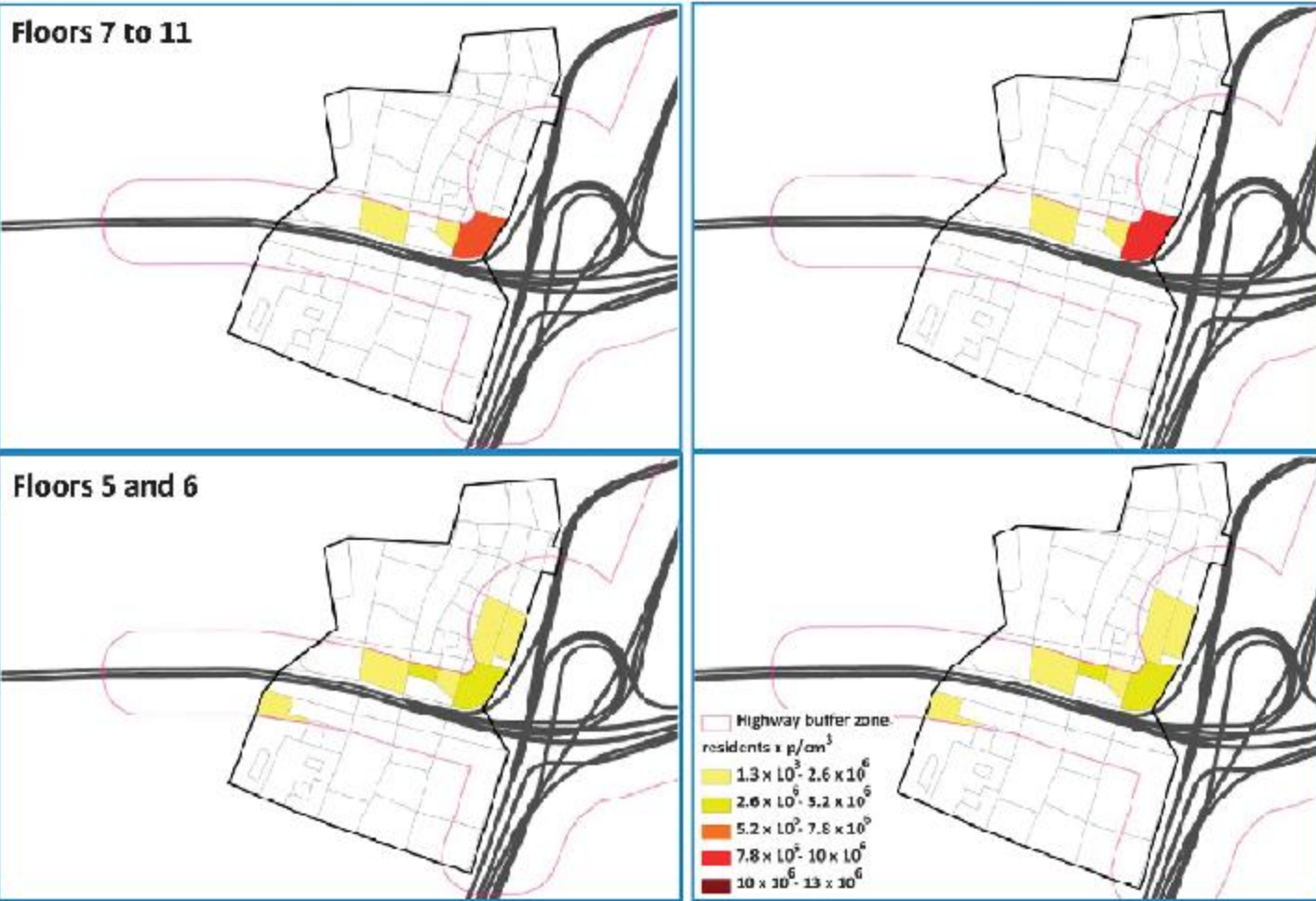
^aOne tailed *P*-values were calculated testing the hypothesis that the pollution levels were not lower for the upper floor categories compared with the first floor category.

Residents \times p/cm³(11~5F)

About 2236 people is PHEP

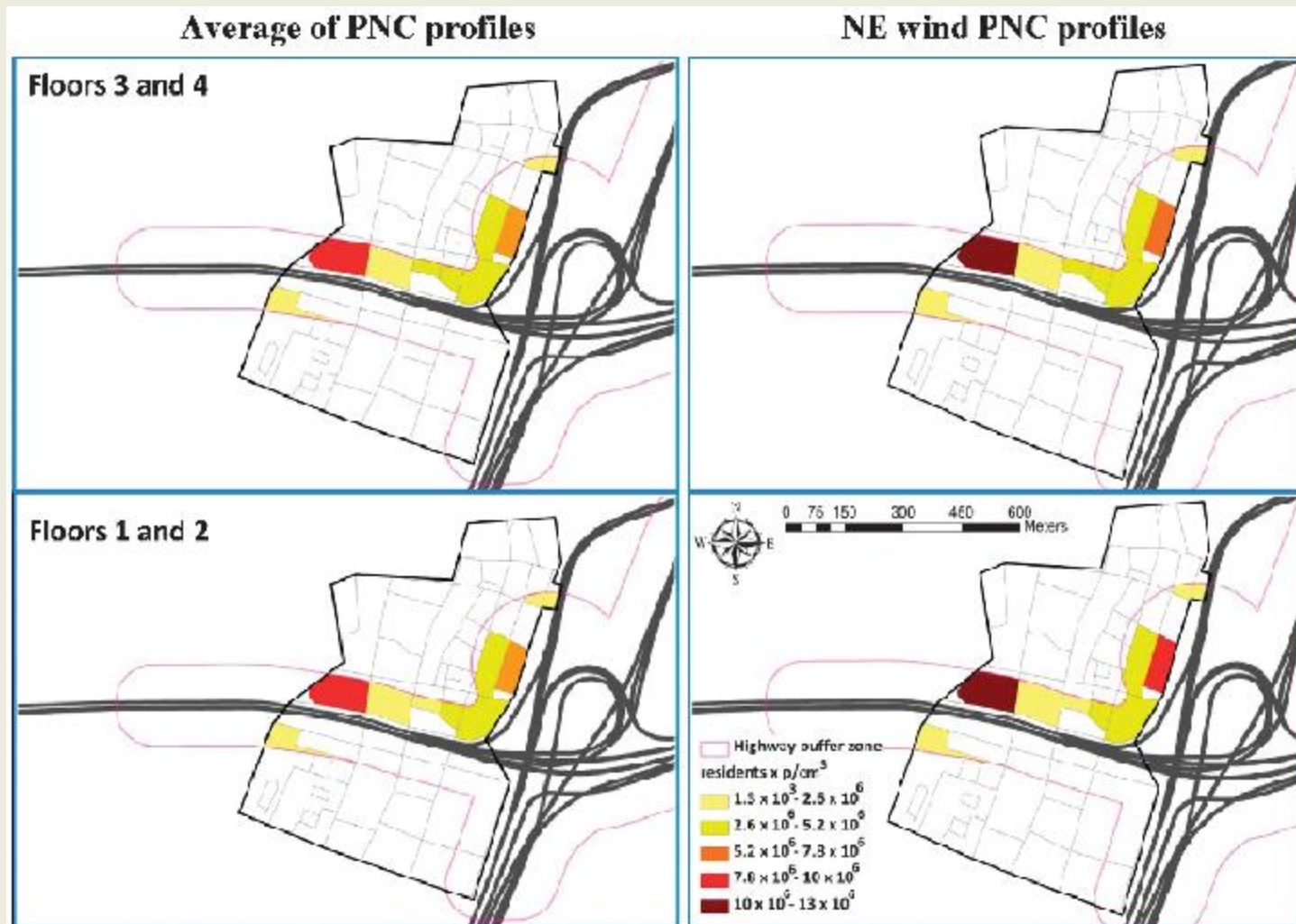
Average of PNC profiles

NE wind PNC profiles

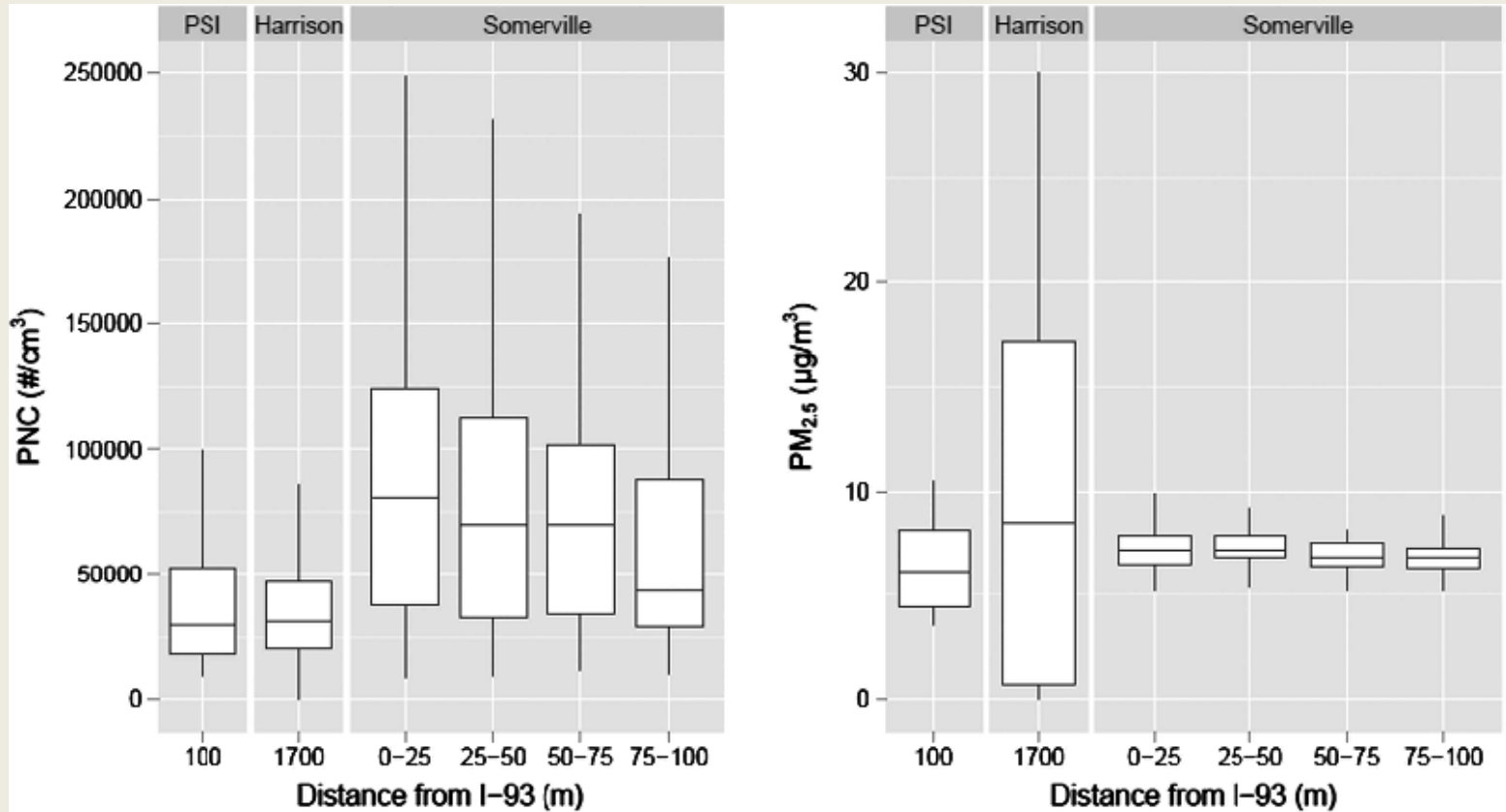


Residents \times p/cm³(4~1F)

About 2236 people is PHEP



Comparison Research



- Comparing **PSI** data with another two sites: **Harrison Avenue** (a bus terminal nearby) [2009~2010] and **Somerville** (in Dudley Square) [2012~2013]

Why I read and What I got

- “Residents × Particles”, which is a new method to improve exposure assessments of particles effect to residents nearby.
- Find out the vertical and horizontal distribution characteristics of Particles.
- An interesting (useful but not complicated) method of observation. (eg. between Qixiang Building and Ningliu Rd.(PM, PAHs....).)

Thanks

And welcome any suggestions and constructive criticism!

