Field testing a low-cost passive aerosol sampler for long-term measurement of ambient $PM_{2.5}$ concentration and composition

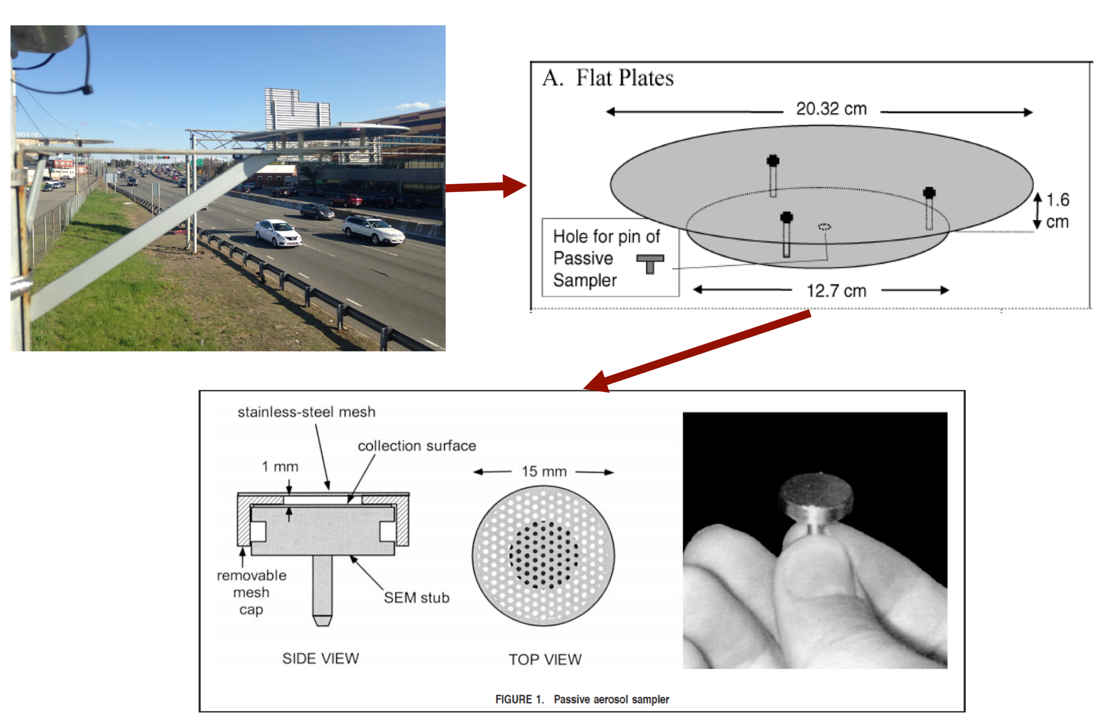
Patrick L. Kinney[a], Maria D. Castillo[a], Jeff Wagner[b], Gary S. Casuccio[c], Roger R. West[c], Frank R. Freedman[d], Holger M. Eisl[e], Zhong-Min Wang[b], Jackson P. Yip[d],

a. Boston University School of Public Health, b. Environmental Health Laboratory Branch, California Department of Public Health, c. RJ Lee Group, Inc., d. San Jose State University, Department of Meteorology and Climate Science, e. Queens College, City University of New York

Background

- There is an increasing need for high resolution PM data in support of health assessments, particularly for quantifying the dominant health risks related to long-term $PM_{2.5}$ concentrations.
- Low-cost sensors (LCS) for $PM_{2.5}$ are of increasing interest, but most LCS infer PM based on light scattering and may not be ideal for long term sampling due to calibration drift and humidity interferences.
- Passive samplers collect particles by gravitational settling and diffusion. Sampling rates as a function of particle diameter are estimated from theory. Particles are counted and sized individually in the lab by electron microscopy, and also analyzed for elemental composition.
- To-date, there has been little effort to validate passive samplers for $PM_{2.5}$ in urban settings.

UNC PAS



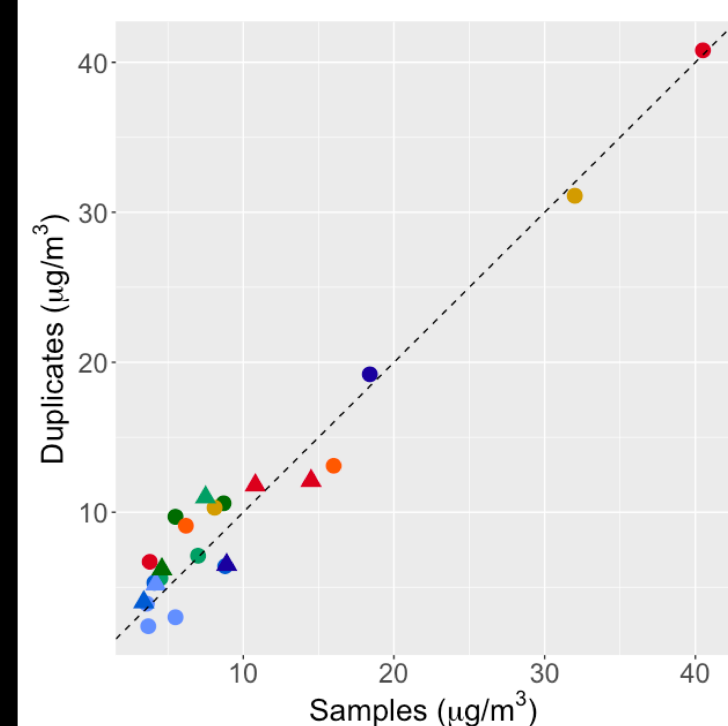
- The **University of North Carolina Passive Aerosol Sampler (UNC PAS)** was developed by Wagner and Leith (2001a,b,c). Ott and Peters (2008) designed a flat plate shelter that houses the sampler.
- Collects airborne particles in a passive manner for as long as it is left open to the air.
- Has been extensively validated for coarse particles, but not for $PM_{2.5}$.
- Utilizes a deposition velocity model from the particle size distribution (Wagner and Leith, 2001b; Nash and Leith, 2010) for estimating airborne concentrations.

Objectives

- Collect sequential 4-week and 12-week average $PM_{2.5}$ concentration and composition in eight urban sites in Boston, New York City and the San Francisco Bay Area.
- Implemented new methods for particle deposition calculation and microscopic analysis to improve UNC-PAS performance for submicron, carbonaceous particles typical of urban environments.
- Compute precision based on duplicate sampling.
- Compare data from the UNC-PAS and co-located federal reference and equivalent methods.
- Characterize particle composition and speciation data.

Results

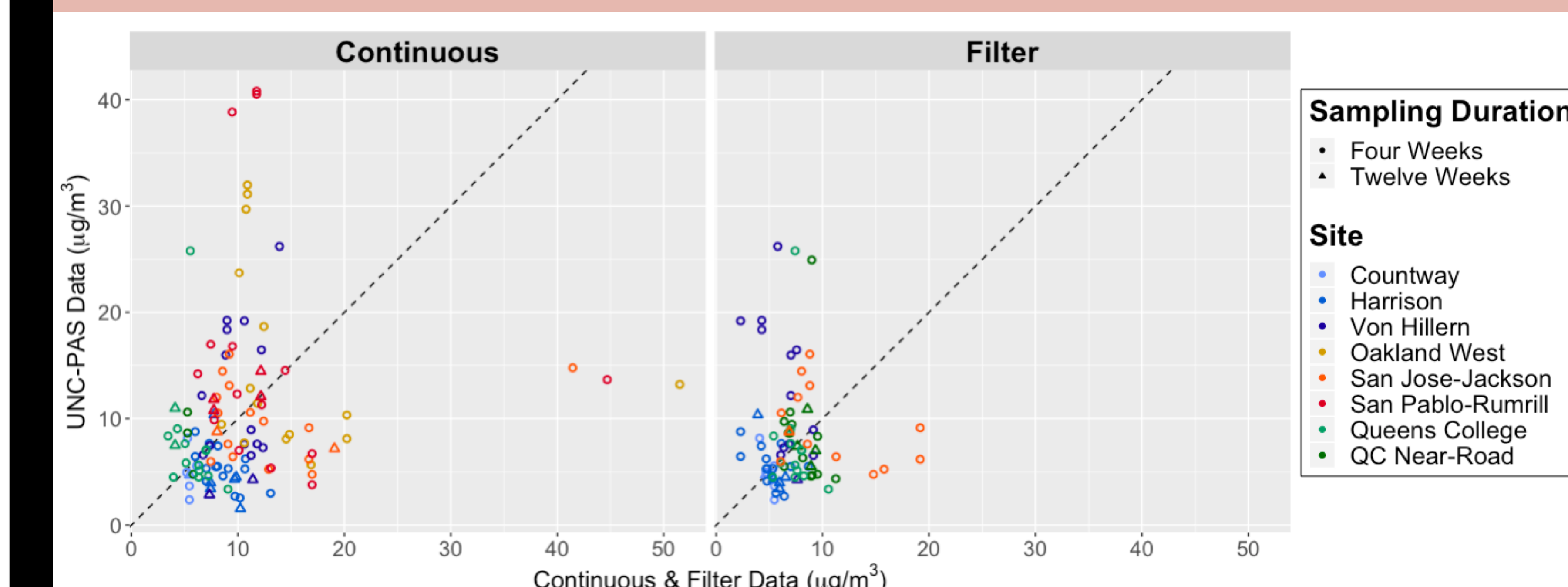
Precision



$PM_{2.5}$ concentrations of 4-week and 12-week integrated UNC-PAS samples (n = 17 and 6, respectively) compared to their co-located duplicates. Dashed line represents one-to-one line.

- The correlation coefficient, R, between duplicates was 0.97 ($p < 0.001$). The computed precision (SD(diff)/sqrt2) was 14.2%. Good precision (25%) was also observed for $PM_{10-2.5}$ ($R = 0.78$, $p < 0.001$).
- We also compared 12-week integrated samples with the mean of three sequential 4-week samples. The 12-week PM2.5 was 12% lower on average ($p = 0.01$), suggesting some loss of volatile and semivolatile particles over longer sampling periods.

Accuracy and Reproducibility

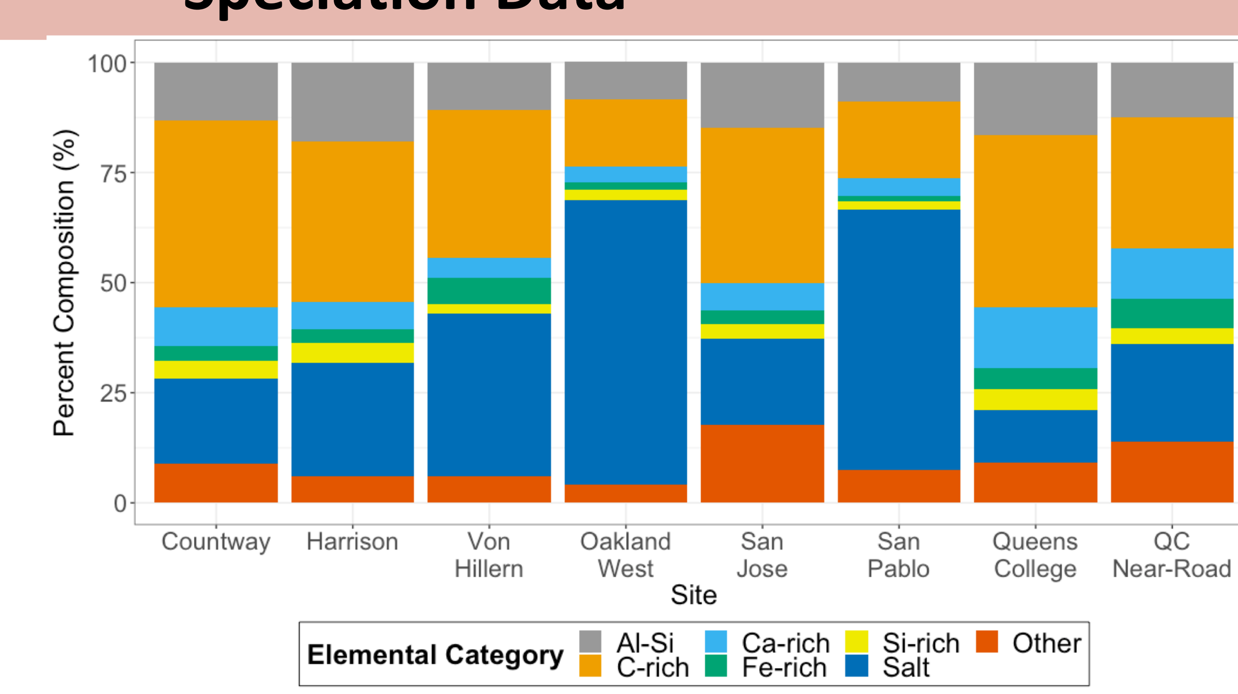


This scatterplot shows the UNC-PAS PM2.5 on the y axis and co-located FEM (left) and FRM (right) data on the x axis.

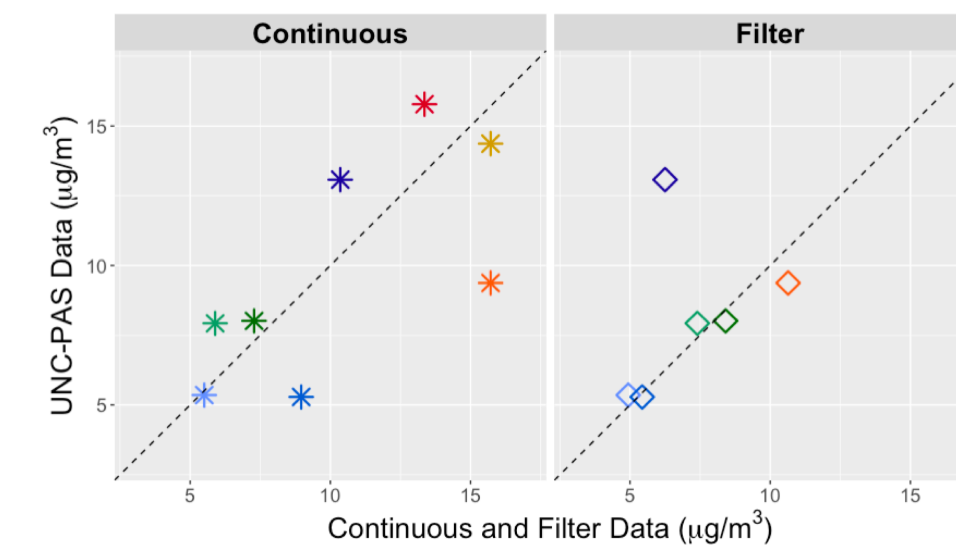
- While the three methods agree reasonably well at the mean, there are many cases where the three methods differed for individual samples

Speciation Data

Mean $PM_{2.5}$ percent composition (%) of each of seven elemental classes for all 4-week samples (N=11 to 13) by site.

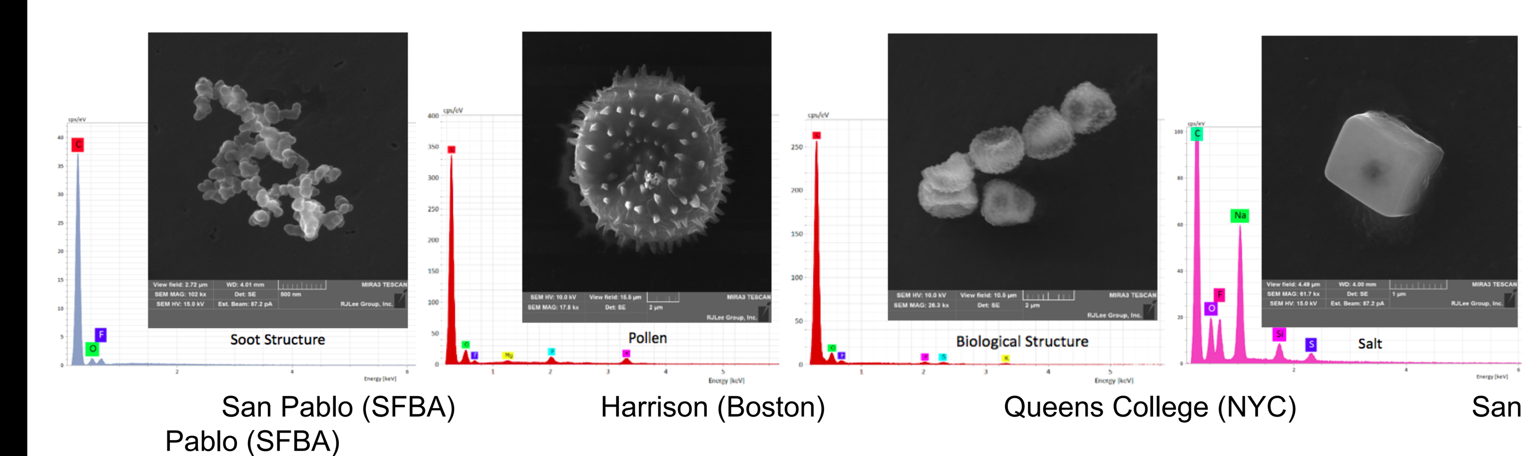


Results, continued



Scatterplot of annual average PM2.5, comparing UNC-PAS with FEM (left) and FRM (right).

- Though Ns are low, these preliminary results suggest the UNC-PAS method may have value in long-term PM2.5 measurements.



- Manual SEM/EDS can identify particles consistent with vehicle combustion, salts, aged salt-carbon mixtures, biogenic spores, and fly ash from non-vehicle combustion sources, as well as particles from extreme events such as wildfires.

Conclusions

- Overall, our results suggest that passive monitors offer a useful alternative for long-term PM2.5 monitoring in community settings.
- Used in conjunction with remote sensing and other data, passive monitors could mprove spatial data coverage, characterize source-related components, identify pollution hotspots, assess air pollution-related disease burdens, or evaluate the impact/benefit of interventions.

Acknowledgments

NASA Health and Air Quality Applied Sciences Team program, NYS DEC, BAAQMD, Harvard T.H. Chan School of Public Helath and the Mass DEP.