AEERIAL: Air Quality Data for Epidemiologists

Background and Overview

The AEERIAL (Accessible Environmental Epidemiology Research and Instrumentation for Analysis and Logging) SCOPE team employed air quality monitoring instruments for the Home Air Filtration for Traffic Related Air Pollution (HAFTRAP) study with the Air Partner's research group. The AEERIAL team searched for changes to indoor air quality attributable to filtration in homes along the I-93 corridor. Particulate and gas pollution datasets were gathered from four two-week deployments. These datasets were separated into filtered and non-filtered, and indoor and outdoor subsets and analyzed comparatively. After data analysis, filtration effects could be seen in all instrument datasets. High spikes of organics from cooking events emerged as main contributors to indoor air pollution. HEPA filtration effectively removed organics from the air, reducing the time constant τ by roughly 300 seconds.

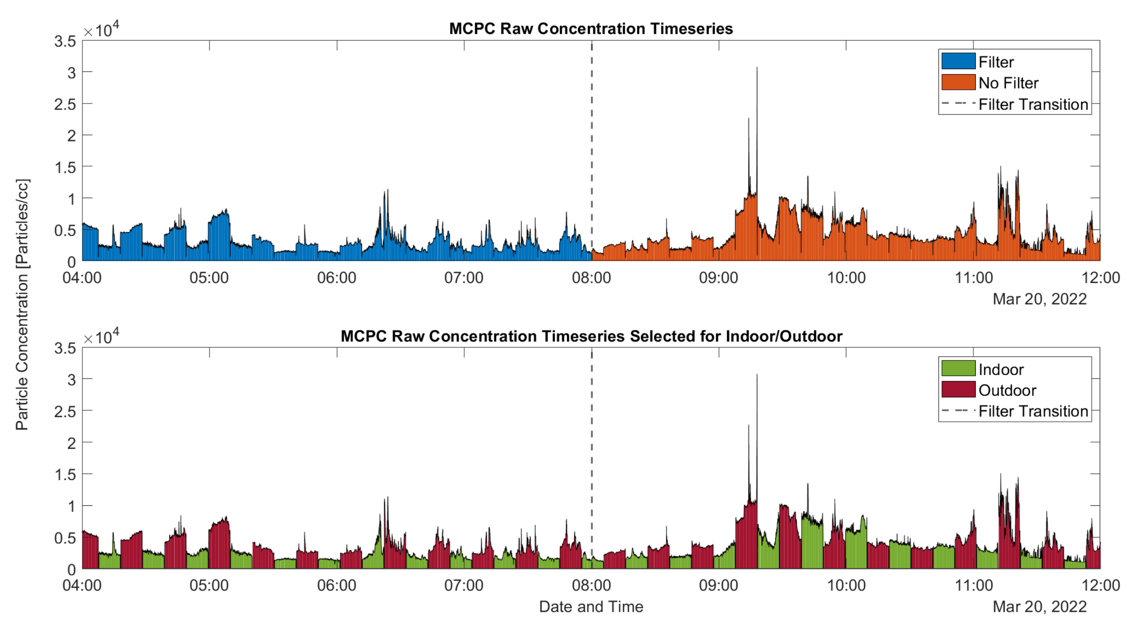
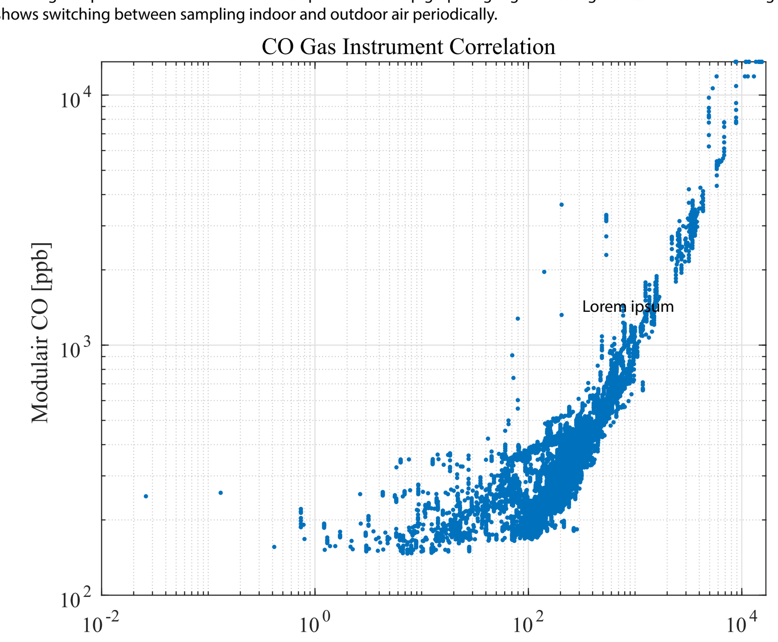
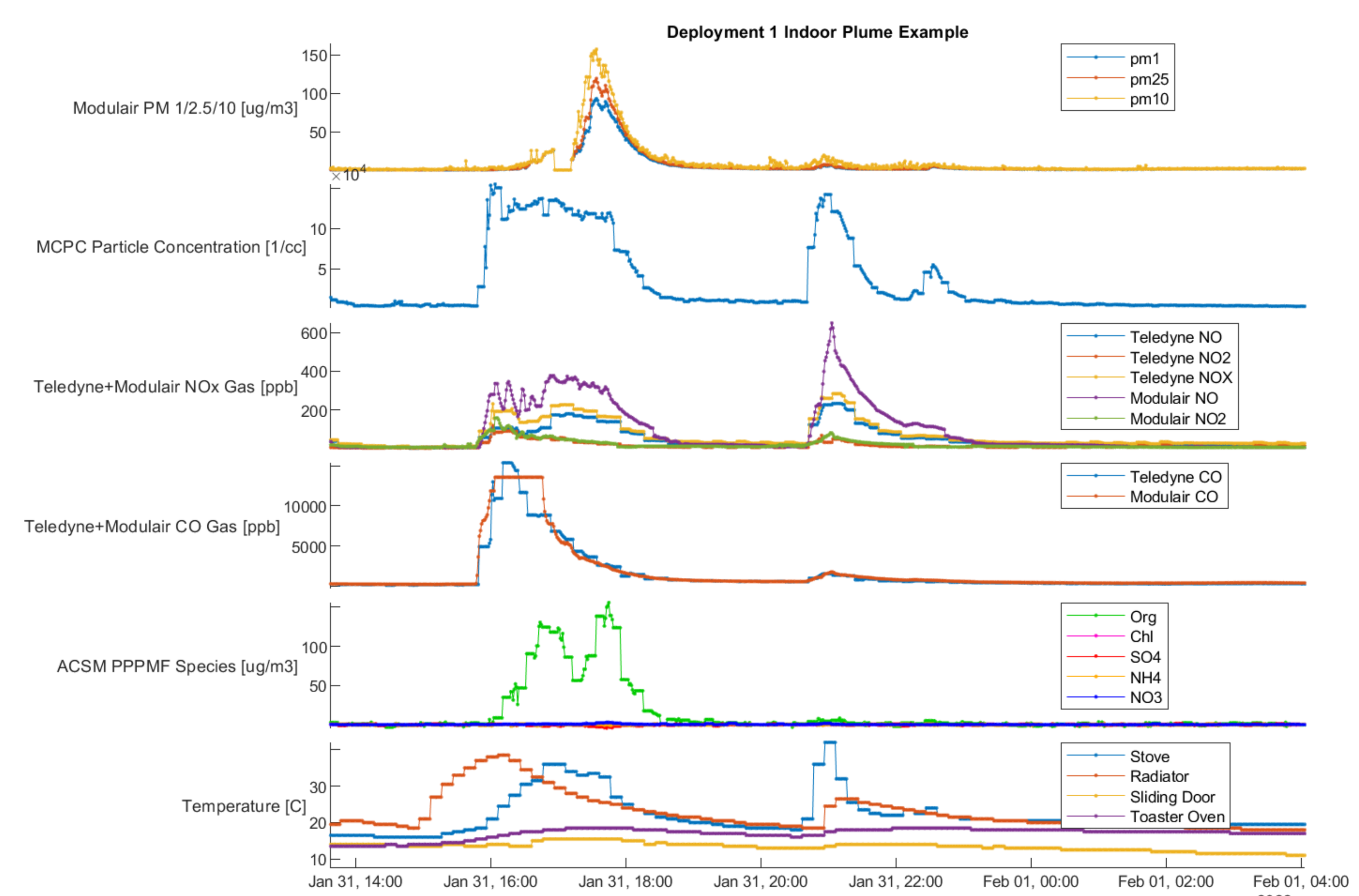


Figure showing raw particle concentrations for sampled air. The top graph highlights turning off HEPA filtration during deployment. The bottom graph shows switching between sampling indoor and outdoor air periodically.



A scatter plot of the Teledyne and Modulair CO concentration measurements for deployment 1. If the instruments agreed perfectly, this would be a straight line. Instead, this correlated behavior emerges for only high concentrations. The indistinct shape for low concentrations indicates random disagreement near detection limits.

Relevant Findings



A timeseries showing two exemplary indoor plumes with rich characteristics. From top to bottom: 1) the Modulair particulate measurements detected the first plume but not the second; 2) the MCPC detects both plumes, suggesting ultrafine particulate content; 3) Teledyne vs. Modulair gas data show less agreement in NO than NO2; 4) Teledyne vs Modulair CO gas data agree until saturation, and no CO exists in the second plume; 5) the ACSM detected organic species in the first plume only, all other species remained minute; and 6) radiator heating precedes first plume, and stove heating coincides with the both plumes. These types of plots guide instrument correlation, plume source identification, and other qualitative insights.

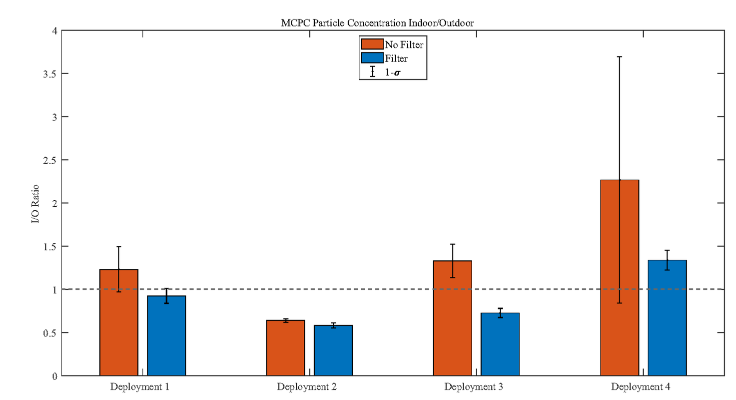


Figure showing indoor/outdoor ratio of particle count measured by the MCPC in all four deployments. Ratios are separated by the presence of a HEPA filter indoors or lack thereof.

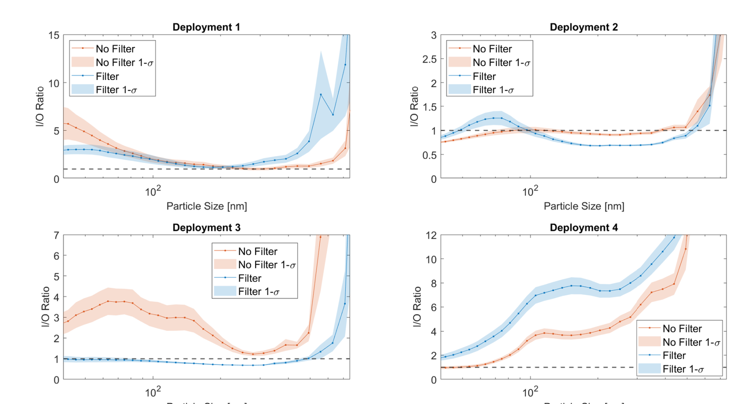


Figure showing size dependent indoor/outdoor ratio of particle count measured by the SEMS. The average particle size shifts when a HEPA filter is introduced.

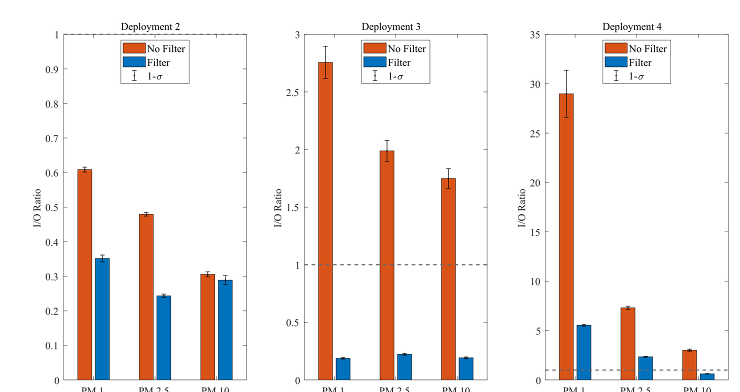


Figure showing indoor/outdoor ratios of particle concentration measured by the Modulair. Much like the SEMS, size dependent changes can be observed in the Modulair data. Thus, similar qualitative conclusions can be drawn using lower cost instrumentation.

Next Steps

This project hopes to:

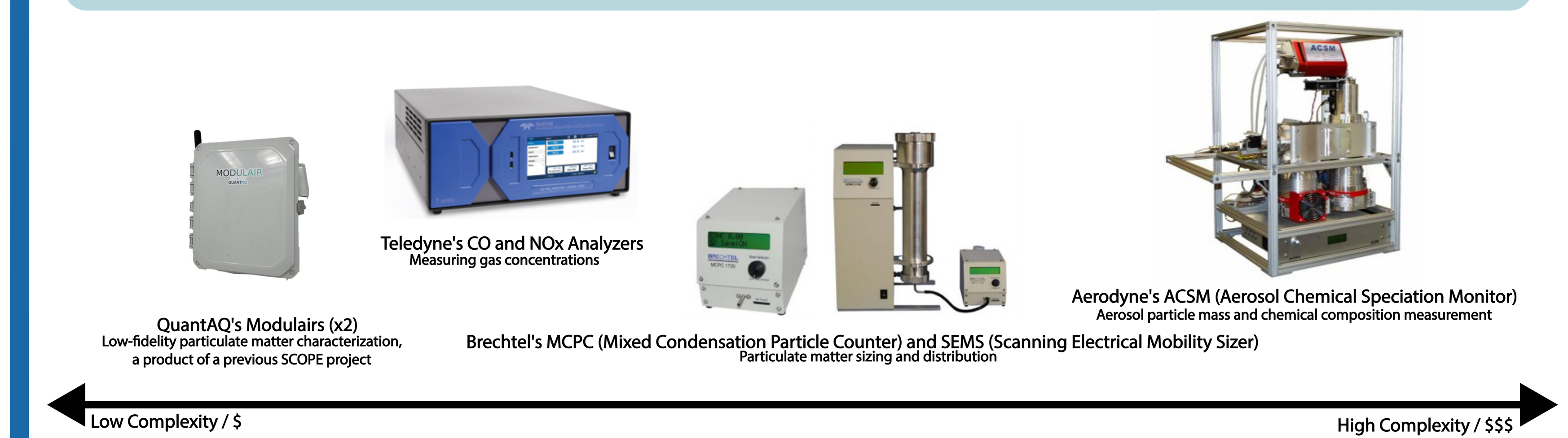
- Inform future studies that connect air quality research to epidemiology
- Publish and present findings in papers and conferences
- Ability for future redeployments
- Implement policies that enable people who are more often exposed to poor air quality

Motivation

Poor air quality is a known mortality factor and air quality data can inform life-saving policy changes. Gathering data near highways can highlight disproportionate effects of emissions in order to spur social and legislative action. Documented air quality differences with and without indoor air filters validate the importance and limitations of HEPA filtration. Future epidemiological studies could be informed by comparisons between instruments and cost as they relate to air pollution insights. Finally, characterizing pollutant signatures could improve their recognition in past and future air quality monitors for health risk assessment.

Methods

The AEERIAL team integrated the following instruments into one weather-proof enclosure to record data simultaneously:



The enclosure design was informed by sampling line design, power requirements , and thermal management then completed in winter 2021. Data were then collected at four participant homes during winter/spring 2022. Each two-week deployment sampled indoor and outdoor air with and without HEPA filtration. The data were separated into filtered and not filtered subsets for each instrument then inquired for filter effectiveness. A quantity called the indoor/outdoor ratio (IO ratio) quantifies the effectiveness of the filter by showing improvement of indoor air quality relative to outdoor air quality. Multiple instruments can report IO ratios for the same pollution measurement, so the agreement between instruments can be described. In addition to designing the enclosure, the team also immplemented a software monitoring system to remotely gauge instrument health. The system took in data and health metrics from each of the instruments and sent email updates to keep the team up to date on the status of the enclosure and the instruments within.

All instruments integrated into weather-proof enclosure.

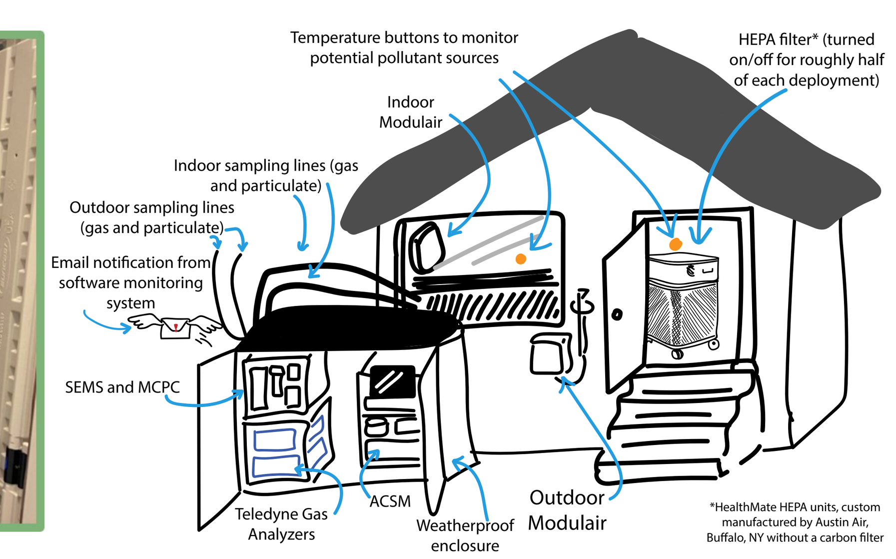
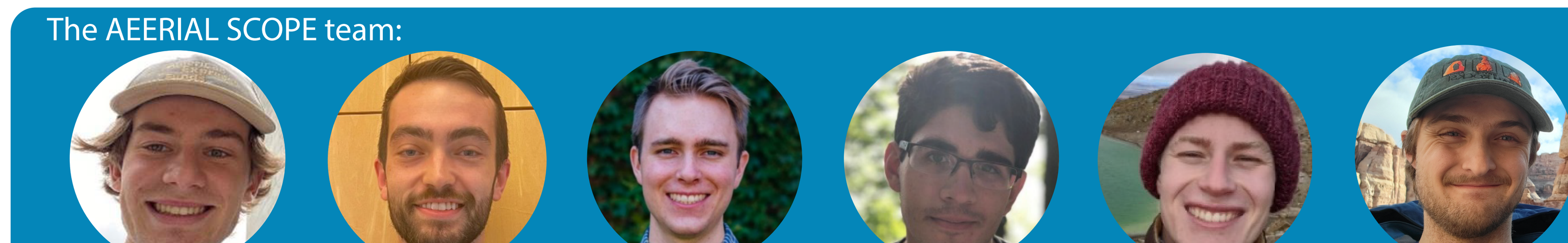


Diagram of deployment data collection setup at a participant home

Advisors and Liaisons:

Leah Williams, Scott Hersey, Alessandra Ferzoco, Francesca Maljuf

The AEERIAL SCOPE team:



Thomas Jagielski, Bryce Mann, Duncan Mazza, Skye Orzga, Flynn Michael Legg, Michael Remley

AERODYNE RESEARCH, Inc.

air partners breathe healthier

Olin College of Engineering