SEA Stakeholder Advisory Round Table (StART)

December 2021

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Healthy Schools, Healthy Air

- Inform schools, districts and state legislators on the current ability of building ventilation systems to effectively remove outdoor sources of particles.
- Quantify the current ability of ventilation solutions to remove indoor generated particles.
- Identify any additional benefit and cost of in-room filtration and air handling interventions.
- Based on the experimental measures in an unoccupied classroom, describe the size fractioned infiltration rates of 1) ultrafine particles of aircraft origin 2) ultrafine particles of traffic origin and 3) wildfire smoke.
- Communicate study results to partners.

* **Funded (50k) by cities of the cities of SeaTac, Burien, Federal Way, Normandy Park and Des Moines**

Project Timeline and Activities

- Developed communication plan with school districts around study goals (January 2021)
- Identified 5 schools of interest based on age, proximity to flights and ventilation characteristics February 2021)
- Measurement Period (March – August 2021)
    - Measured **outdoor air exchange rate**
    - Measured **indoor and outdoor pollutants**
    - Evaluated a portable air cleaning unit (HEPA)
- Analysis and report back Period
    - Synthesize Results
    - Report back
- Final Report (December 2021)



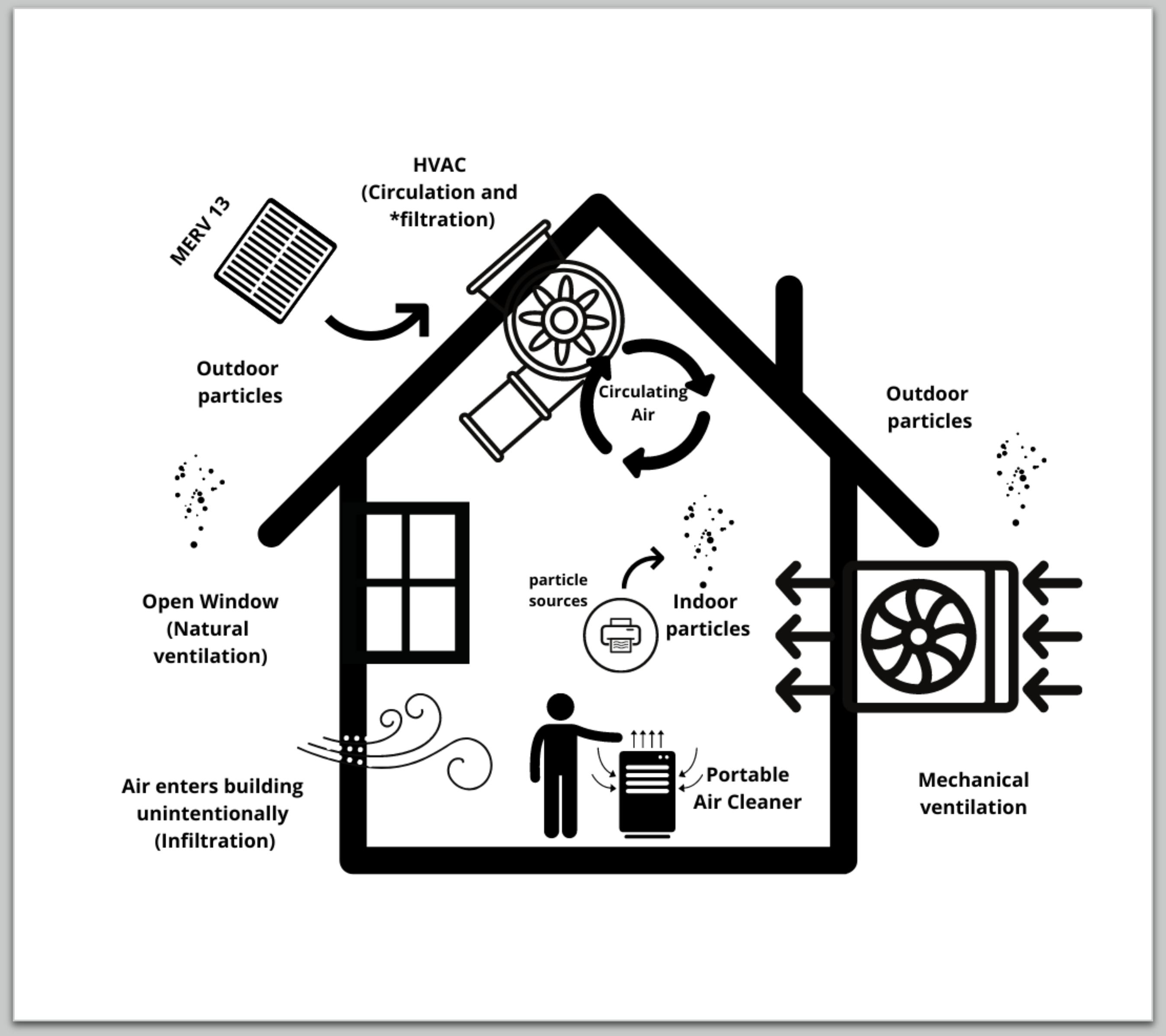



- Timothy Gould
- Edmund Seto
- Elena Austin
- Timothy Larson
- Nancy Carmona
- Jeff Shirai

Goal

- Understand the impact of outdoor air pollution on the air quality indoors
  - Are outdoor air pollutants significantly removed by current air filtration approaches?
  - Can indoor air quality be improved through the use of a portable HEPA filter unit?

Particle Infiltration into Indoor Spaces



Study Methods

STEP 1: Outdoor Air Exchange Rate Determination

GOAL: Determine the exchange of air from outdoor into the indoor spaces.

Used measurement method developed by the Harvard T.H. Chang School of Public Health – Harvard Healthy Buildings Program

STEP 1: Outdoor Air Exchange Rate Determination

- Begin with CO_2 at least 4x above typical in building concentration (source: dry ice).
- Rate of decay with no further CO_2 sources in room based on air exchange from
    - outside infiltration
    - active ventilation system

STEP 2: Air Quality Measurements in Classroom

- CO_2 analyzer
- NanoScan for size distribution of U-F particles
- CPC and P-Trak- total U-F particle counts (>10, >20 nm, respectively)
- MA200 and AE51 black carbon analyzers
- Timer & valves to switch In/Out inlets

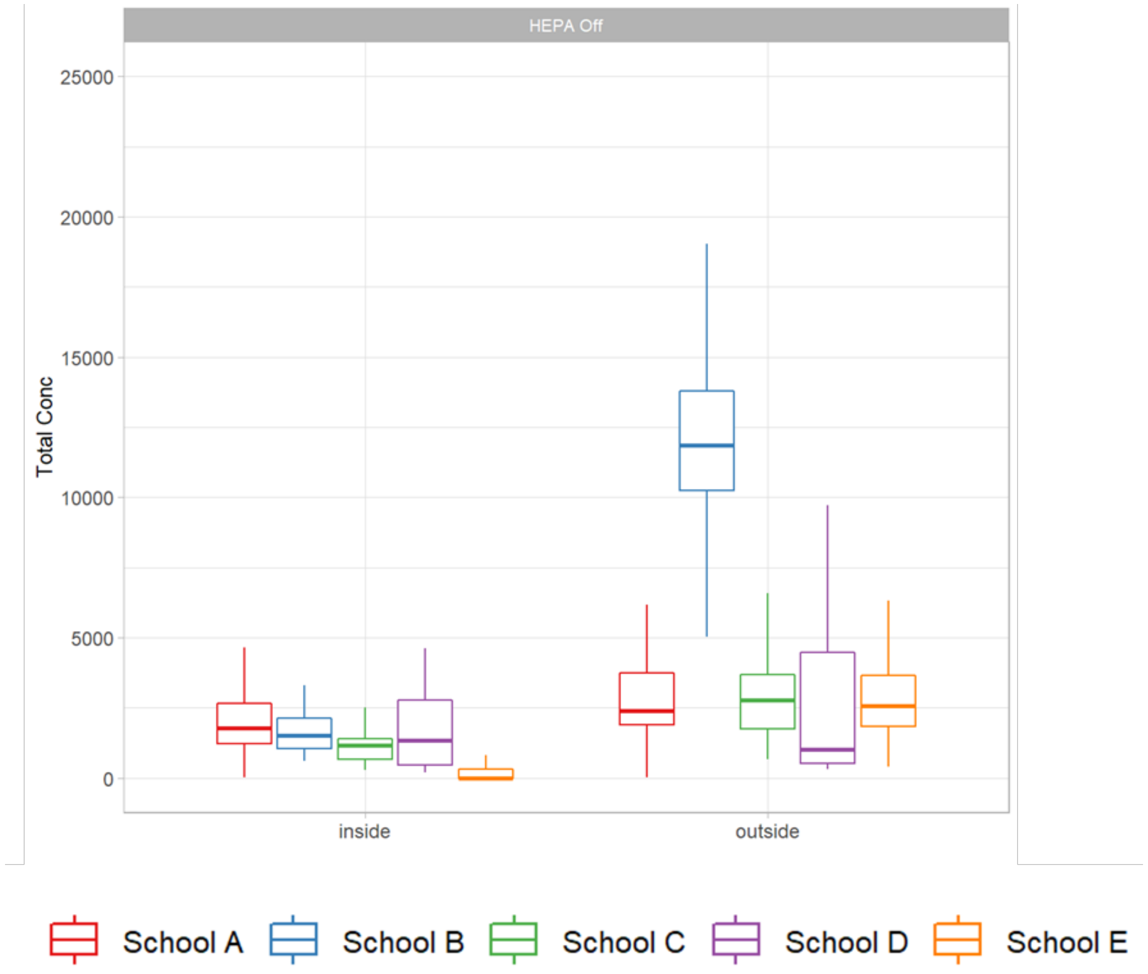
STEP 3: BlueAir HEPA filter on 2nd sampling day

Continue ultra-fine particle and CO_2 measurements inside and outdoors to assess reduction of particle concentration in classroom on account of HEPA filter

STEP 4: Analysis Plan

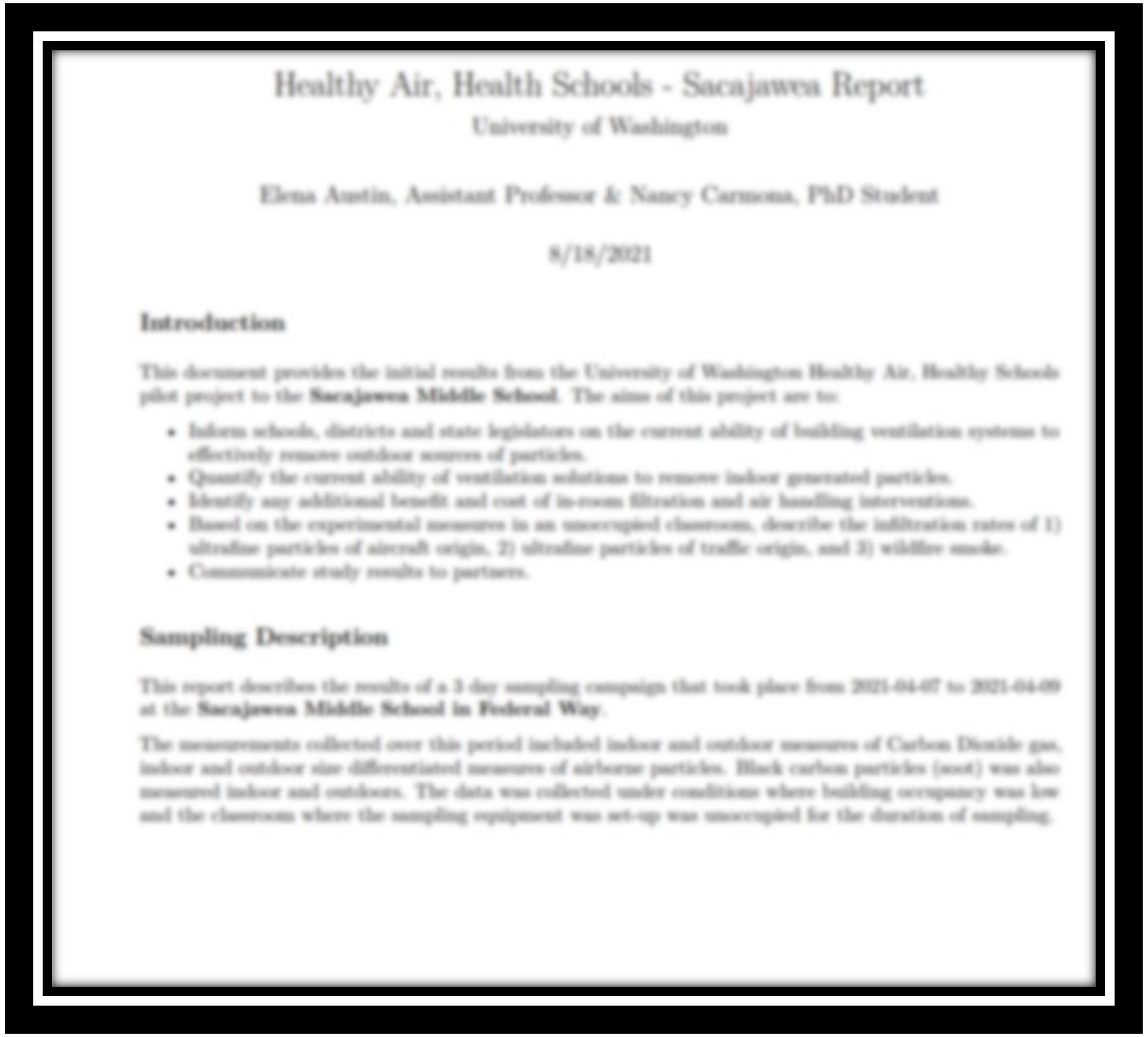
- Calculate Outdoor Air Exchange Rate
- Describe size-fractioned relationship between indoor/outdoor measurements
- Develop a particle size dependent infiltration model for each school. This model is based on the relationship between change in indoor concentration as explained by indoor and outdoor conditions
- Identify sources of air pollution indoors using multivariate methods

Ultrafine Particle Concentration (#/cc)



STEP 6: Return Results

- Develop overall project summary documents as well as school specific report back
- Evaluate report back elicit feedback from stakeholders



Healthy Air, Health Schools - Sacajawea Report

University of Washington

Elena Austin, Assistant Professor & Nancy Carmona, PhD Student

8/18/2021

Introduction

This document provides the initial results from the University of Washington Healthy Air, Healthy Schools pilot project to the **Sacajawea Middle School**. The aims of this project are to:

- Inform schools, districts and state legislators on the current ability of building ventilation systems to effectively remove outdoor sources of particles.
- Quantify the current ability of ventilation solutions to remove indoor generated particles.
- Identify any additional benefit and cost of in-room filtration and air handling interventions.
- Based on the experimental measures in an unoccupied classroom, describe the infiltration rates of 1) ultrafine particles of aircraft origin, 2) ultrafine particles of traffic origin, and 3) wildfire smoke.
- Communicate study results to partners.

Sampling Description

This report describes the results of a 3 day sampling campaign that took place from 2021-04-07 to 2021-04-09 at the **Sacajawea Middle School in Federal Way**.

The measurements collected over this period included indoor and outdoor measures of Carbon Dioxide gas, indoor and outdoor size differentiated measures of airborne particles. Black carbon particles (soot) was also measured indoor and outdoors. The data was collected under conditions where building occupancy was low and the classroom where the sampling equipment was set-up was unoccupied for the duration of sampling.

Results

Monitoring Schedule at Schools

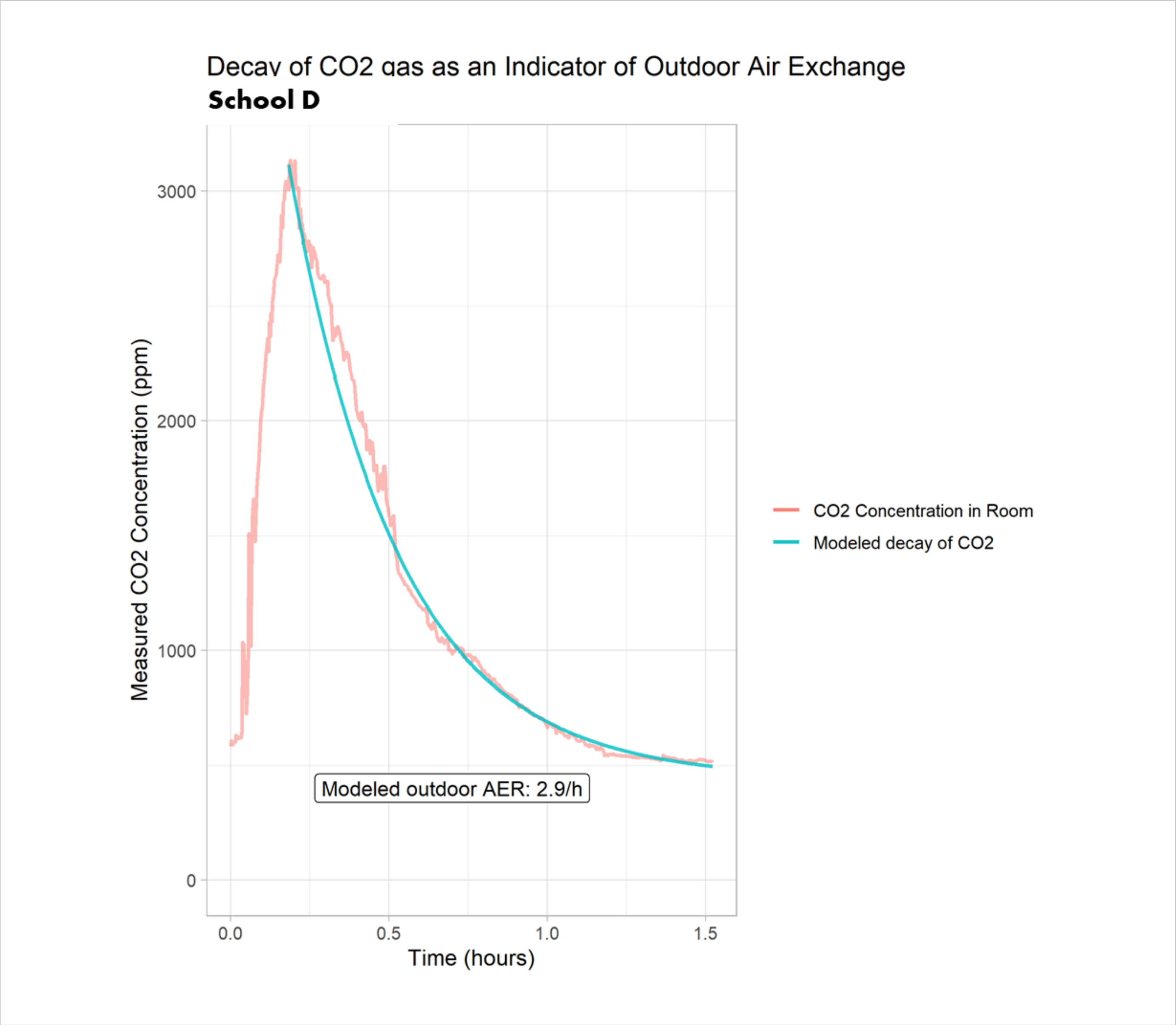
School and room	First Visit	Sea-Tac flight operations overhead	second visit	Sea-Tac flight operations
School A 1st flr.	June 9-11	Landing	July 26-28	Takeoff
School A 2nd flr.	June 14-16	Landing 14th & 15th Takeoff 16h	July 28-30	Take off
School B	April 14-16	Takeoff	July 20-22	Landing 20th & 21st Takeoff 22nd
School C	April 7-9	Takeoff	July 13-15	Takeoff
School D	June 22-24	Takeoff	August 10-12	Landing
School E	March 24-26	Takeoff 24th & 26th Landing 20th	July 7-9	Takeoff

Summary: 44 datafiles collected per classroom sampled -> 264 files -> 500 MB of data

Air Exchange Calculation

- Measurements based on CO_2 release in the room
- Decay is measured as outdoor air is exchanged with indoor air
- Modeled as:

$$[CO_2]_{classroom} =$$
$$[CO_2]_{outdoor} + [CO_2]_{peak} * e^{-AER*t}$$

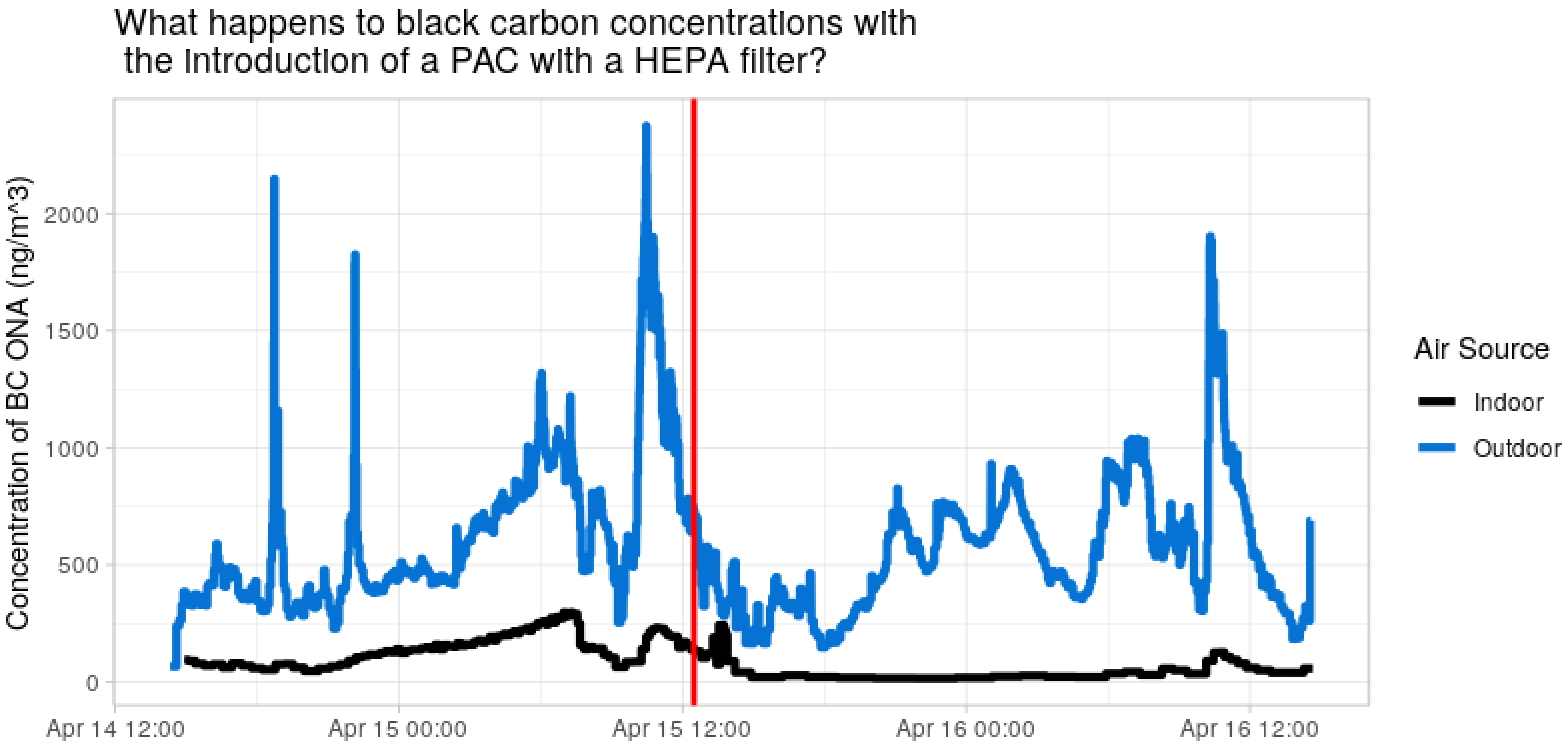


Outdoor Air Exchange Rate

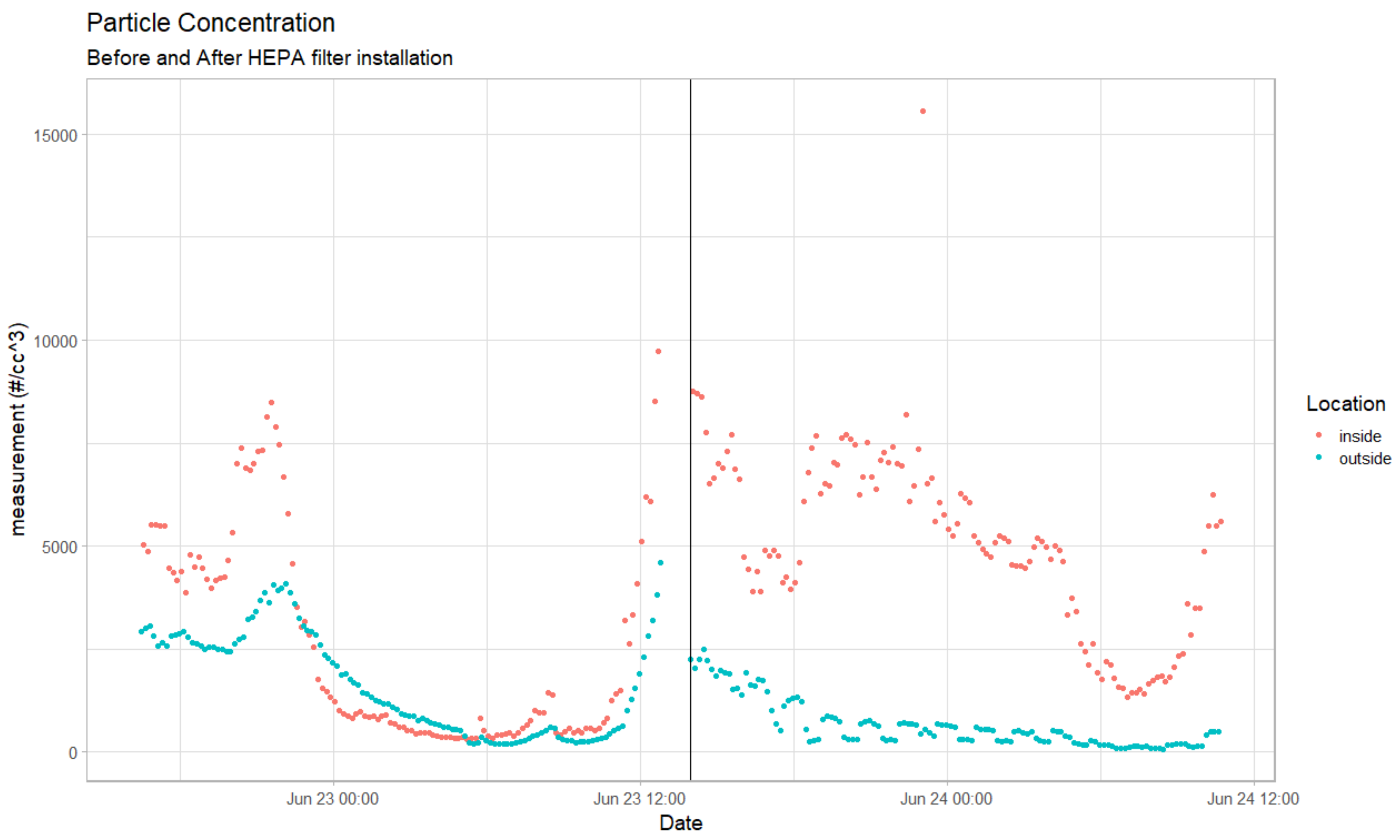
Table 1 - Outdoor Air Exchange Rate (AER Outdoor)

School A		
Room # 1	2.1/h	1.3/h
Room # 2	4.4/h	1.1/h
School B	0.6/h	0.9/h
School C	2.2/h	2.6/h
School D	2.9/h	0.4/h
School E	1.1/h	1.1/h

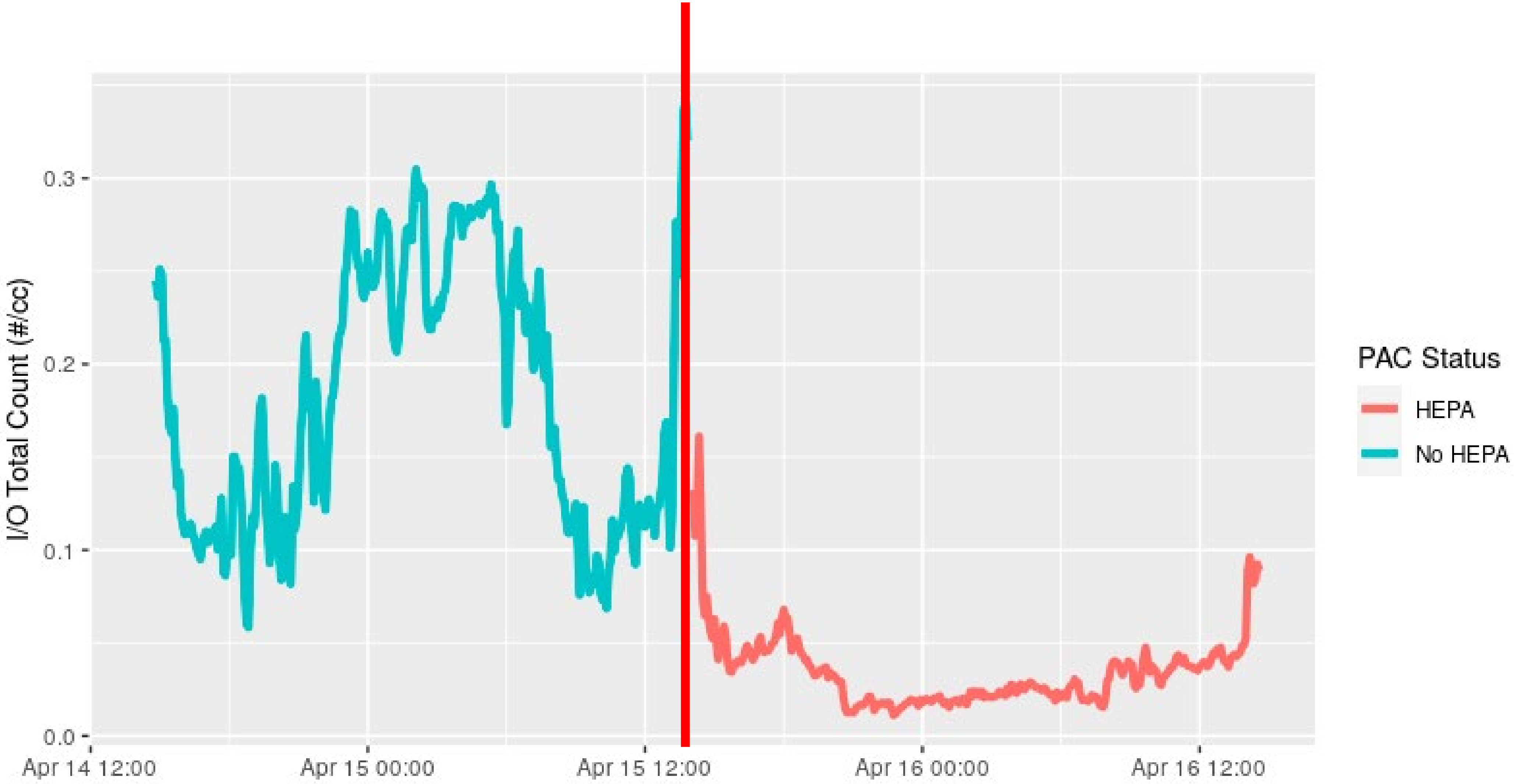
Black carbon



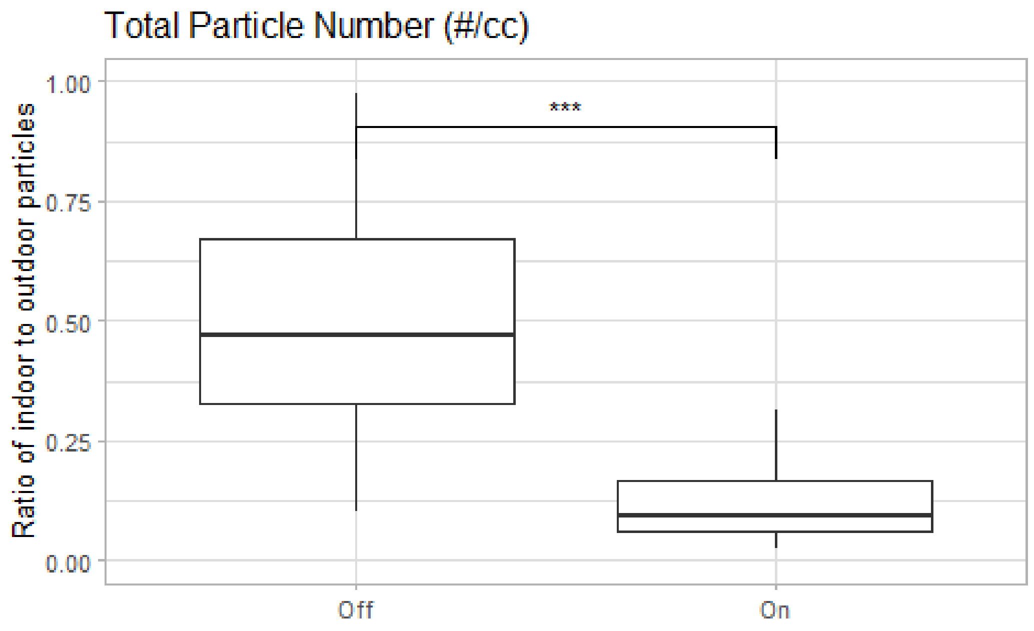
Ultrafine Particle Concentration

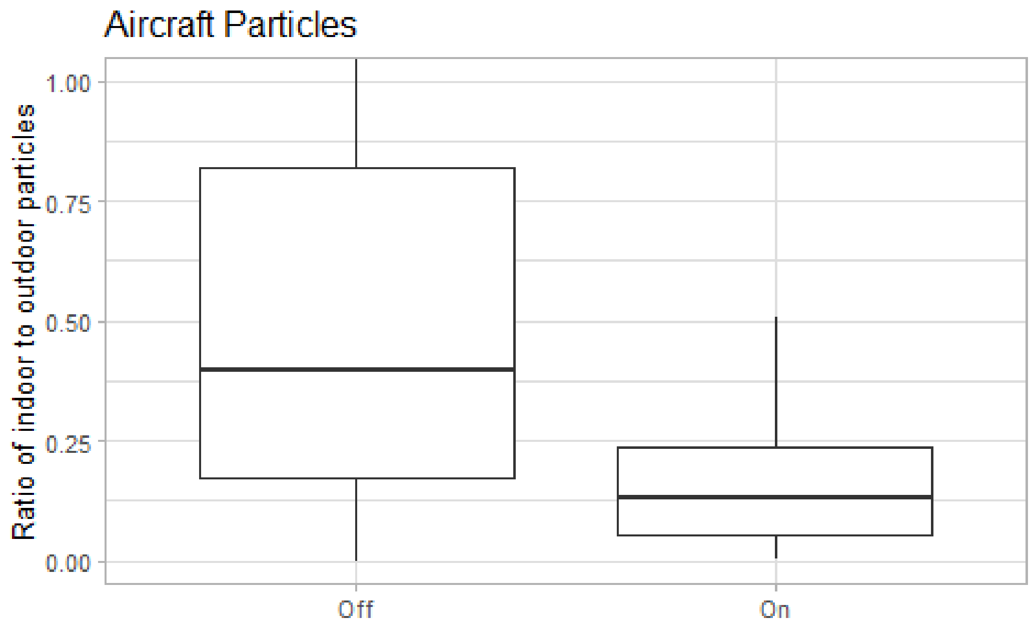


Ratio of Indoor to Outdoor Concentration



HEPA Filter Performance – Modeled Infiltration Fraction



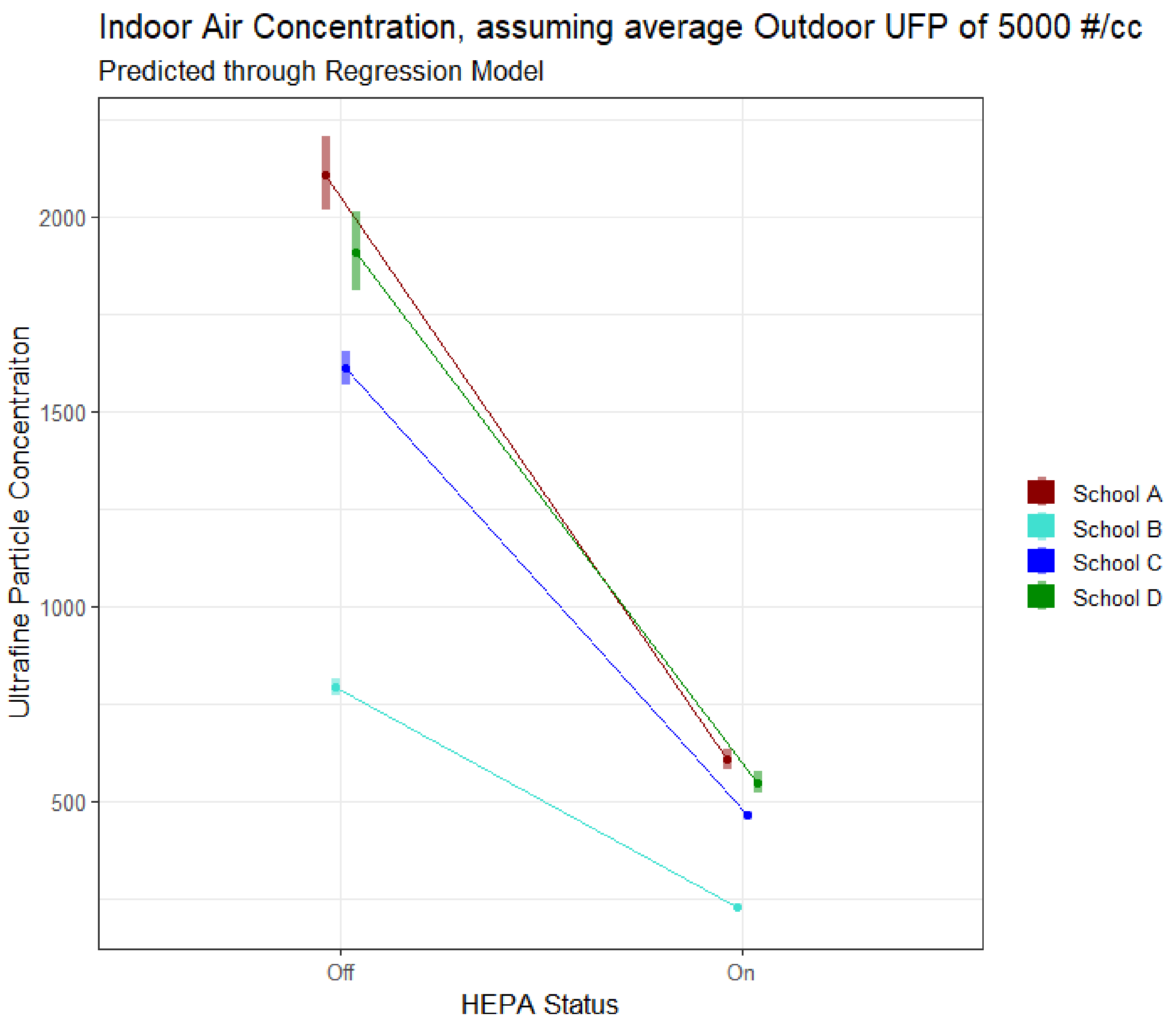


Infiltration and Removal Efficiency

Table 1 - Infiltration (%) with and without the portable HEPA filter unit installed in classrooms

Pollutant Type	Infiltration before HEPA	Confidence Range (%)	Infiltration After HEPA	Confidence Range	Removal by HEPA (%)	Confidence Range
Total Particles	54%	[47, 59]	9%	[8, 9]	83%	[82,84]
Aircraft Particles	41%	[38, 56]	14%	[12, 15]	67%	[68, 73]
Traffic Particles	74%	[71, 79]	20%	[18,21]	73%	[73, 74]

Modeled Impact



Reporting back monitoring results

- Engaging a wide audience
  - Parents
  - School district administrators
  - Teachers
  - Community members

- Report back challenges
  - Knowledge of air environment health literacy
    - Potential for overwhelming quantity of information or complicated language
  - Awareness of how the exposure affects their communities
  - Attitude towards research
  - Knowing how to find out if air quality is bad
  - Willingness to modify behavior and follow suggestions
  - Tailoring messaging to reach each target audience

School Resilience to Air Pollution

Evaluating impact of air quality interventions in school environments

PROJECT GOALS:

- Do current ventilation solutions effectively control indoor air quality in schools?
- Are there school based interventions that significantly improve indoor air quality?
- What are the long-term average exposures across the spatial area?

School-aged children represent a vulnerable population with respect to air pollution exposure

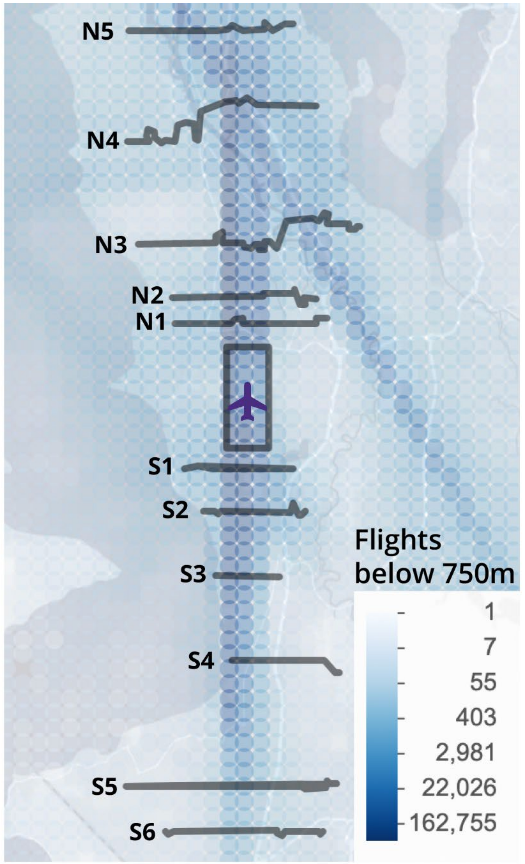
Ventilation systems are not evaluated for the efficiency in removing ultrafine particles from outdoor sources including roadway traffic, aircraft traffic and wildfire smoke

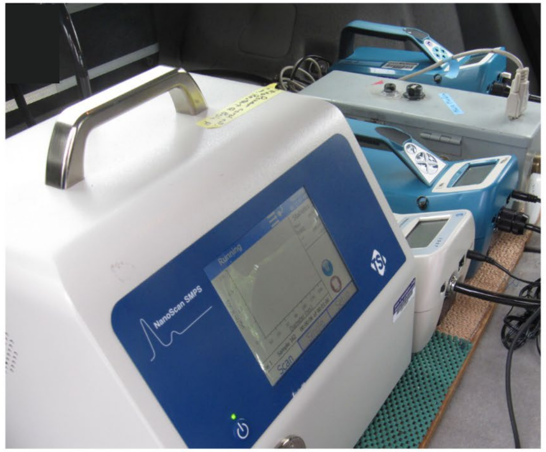
Funding Received From WA State

ENVIRONMENTAL & OCCUPATIONAL HEALTH SCIENCES
UNIVERSITY of WASHINGTON | SCHOOL OF PUBLIC HEALTH

Mobile Monitoring Goals – Long term averages

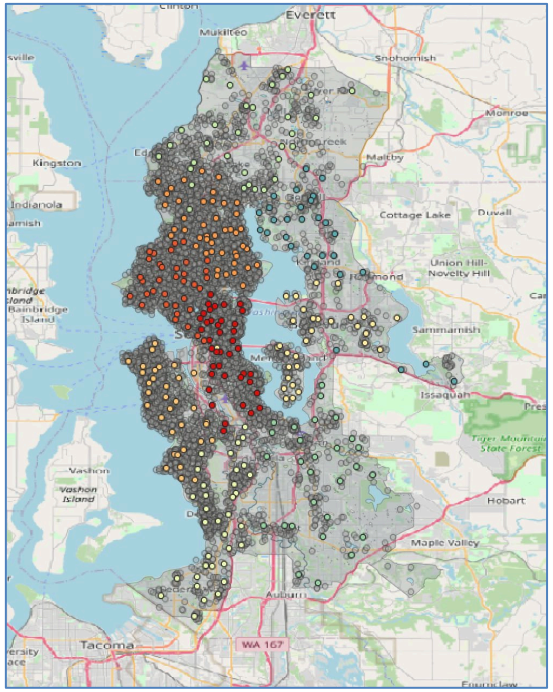
- Developing and refining mobile monitoring to estimate annual exposure concentrations to traffic and aviation air pollutants including NO_x, Black Carbon and size-resolved particles.
- Engage with State and local agencies to develop plans for long-term monitoring
- Identify emissions factors and spatial variations across the area of interest

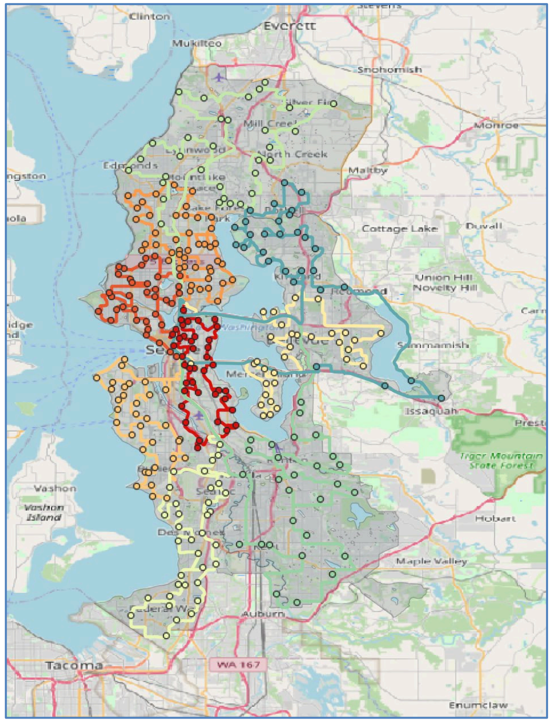




ACT Mobile Monitoring Campaign

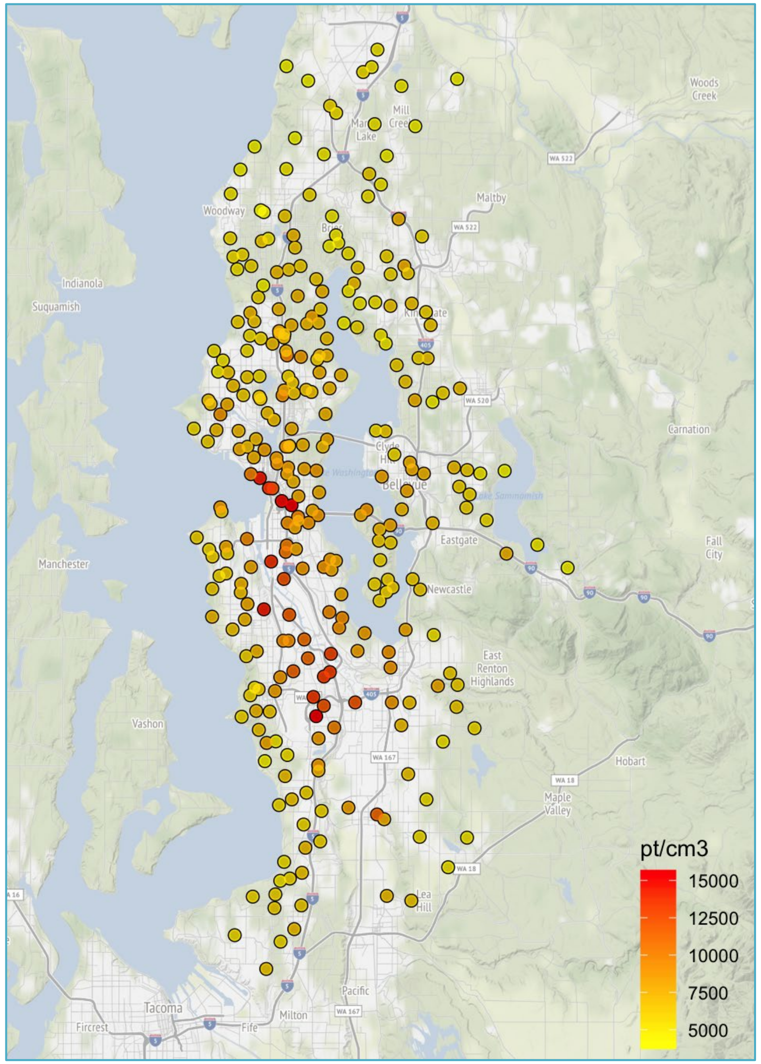
- 309 stop locations representative of ACT cohort (large, geographically diverse area)
- 9 fixed driving routes
- 2-min samples per stop
- Measured UFPs, BC, PM2.5, CO, CO2, NO2
- A driving schedule ensured temporally balanced sampling





Top: Jittered ACT locations and monitoring stops. **Bottom:** Mobile monitoring routes and stops

Annual Averages



> **Collected ~27 samples per site**
> – **5 AM – 12 AM**
> – **March 2019 – March 2020**
> – **>270 drive days**

> **Calculated site annual averages from the ~27 visits**

Annual average UFP estimates from mobile monitoring observations.

This research is funded by
U.S. EPA - Science To Achieve Results (STAR) Program
Grant # R840234

School Resilience to Wildland Smoke and Outdoor sources of Fine & Ultrafine Particles

PROJECT GOALS:

- **Implement** a classroom-based Portable Air Cleaner (PAC) intervention to reduce exposure to wildland fire smoke across 10 Washington State schools.
- **Observe** impact of the PAC intervention on respiratory health of students using a randomized-controlled study design within school.
- **Engage** with participating schools to adapt an existing hands-on air quality curriculum aimed at increasing environmental health literacy on the topic of ambient smoke, air quality and health.

The aim of this partnership is to develop a classroom-based intervention to improve indoor air quality PAC removal of fine and ultrafine particles as well as education of students and teachers to increase understanding of wildland smoke impacts and smoke readiness principles.

Rural and urban locations are being recruited.

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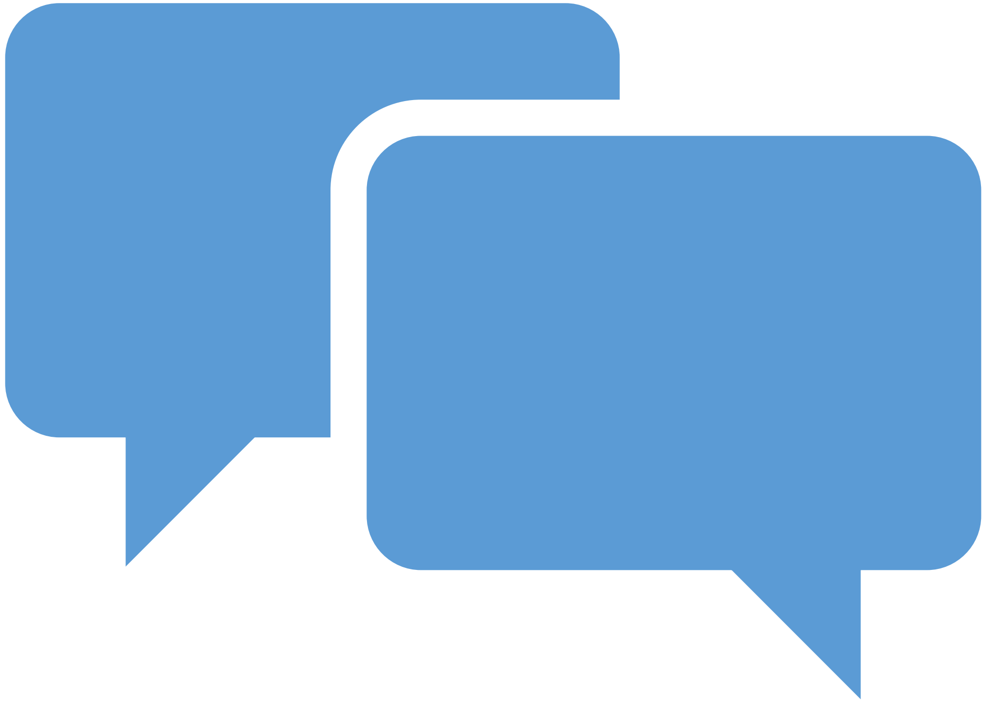
Discussion and Next Steps



THANK YOU!

ASHRAE COVID flush-out calculations