

Health Benefits and Costs of Filtration

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**EPA CLEAN AIR SPACES Indoor Air Filtration to Protect Public
Health During Wildland Fire Smoke Episodes June 13, 2019**

Outline

1. Cost effectiveness of filtration interventions in **homes** to reduce exposure to PM_{2.5} during wildfires
2. Filtration in **classrooms** to provide clean air at all times
3. Guidance to **commercial building** operators on how to response to wildfire smoke



Health benefits and costs of filtration interventions that reduce indoor exposure to PM_{2.5} during wildfires

Abstract Increases in hospital admissions and deaths are associated with increases in outdoor air particles during wildfires. This analysis estimates the health benefits expected if interventions had improved particle filtration in homes in Southern California during a 10-day period of wildfire smoke exposure. Economic benefits and intervention costs are also estimated. The six interventions implemented in all affected houses are projected to prevent 11% to 63% of the hospital admissions and 7% to 39% of the deaths attributable to wildfire particles. The fraction of the population with an admission attributable to wildfire smoke is small, thus, the costs of interventions in all homes far exceeds the economic benefits of reduced hospital admissions. However, the estimated economic value of the prevented deaths exceed or far exceed intervention costs for interventions that do not use portable air cleaners. For the interventions with portable air cleaner use, mortality-related economic benefits exceed intervention costs as long as the cost of the air cleaners, which have a multi-year life, are not attributed to the short wildfire period. Cost effectiveness is improved by intervening only in the homes of the elderly who experience most of the health effects of particles from wildfires.

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Key words: Benefits; Costs; Health; Filtration; Wildfires; Homes.

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2003 Southern California Wildfires



- Impacts on six counties over a 10-day period
 - PM2.5 levels (Wu 2006)
 - Hospital admission rates (Delfino 2009)
 - Effects on mortality (Kochi 2012)

Q: Can filtration substantially reduce wildfire-related hospitalizations and deaths? Are filtration interventions cost-effective?

Filtration Interventions

- Mass balance models to estimate PM_{2.5} in homes with and without filtration interventions



1. Upgrade to high efficiency air filters (MERV 12*)
2. Change to Fan ON mode to run system continuously
3. 1 + 2
4. Buy an air cleaner (HEPA filter, 1 AER)
5. Buy an air cleaner + 1 + 2

* Reduced to MERV 9 because of air leakage bypass.

Health Benefit Estimates

- Assumed that health effects depend on the total inhalation intake of PM2.5: **home**, outside of home (work, school), vehicle, outdoor
- Because health outcomes have been associated to outdoor PM2.5, we estimated the health benefits filtration interventions in home by calculating an equivalent reductions in outdoor PM2.5
- Calculations were also performed for 22% of homes in the study area with age 65+ residents (assumed home at all times)

Filtration interventions in all 6.92 million homes exposed to 2003 southern California wildfires would have prevented **47 to 261 respiratory hospital admissions (11-63% reduction)**, and **9 to 52 premature deaths (7-39% reduction)**, related to PM2.5 exposures during the 10-day study period.

Fisk and Chan (2017). Health benefits and costs of filtration interventions that reduce indoor exposure to PM2.5 during wildfires. Indoor Air.

Intervention Costs of Filtration for 6.92m homes

- Operating forced air system continuously is expected to cost **\$110m** in electricity.
- Incremental cost of purchasing higher efficiency filters + electricity cost is **\$133m**.
- Energy costs of operating air cleaners is **\$13 to 16m**.
- Estimated cost of buying portable air cleaners range from **\$1.8 to \$4.4b***.

*Though it is unlikely that anyone would make the purchase just for the 10-day period.

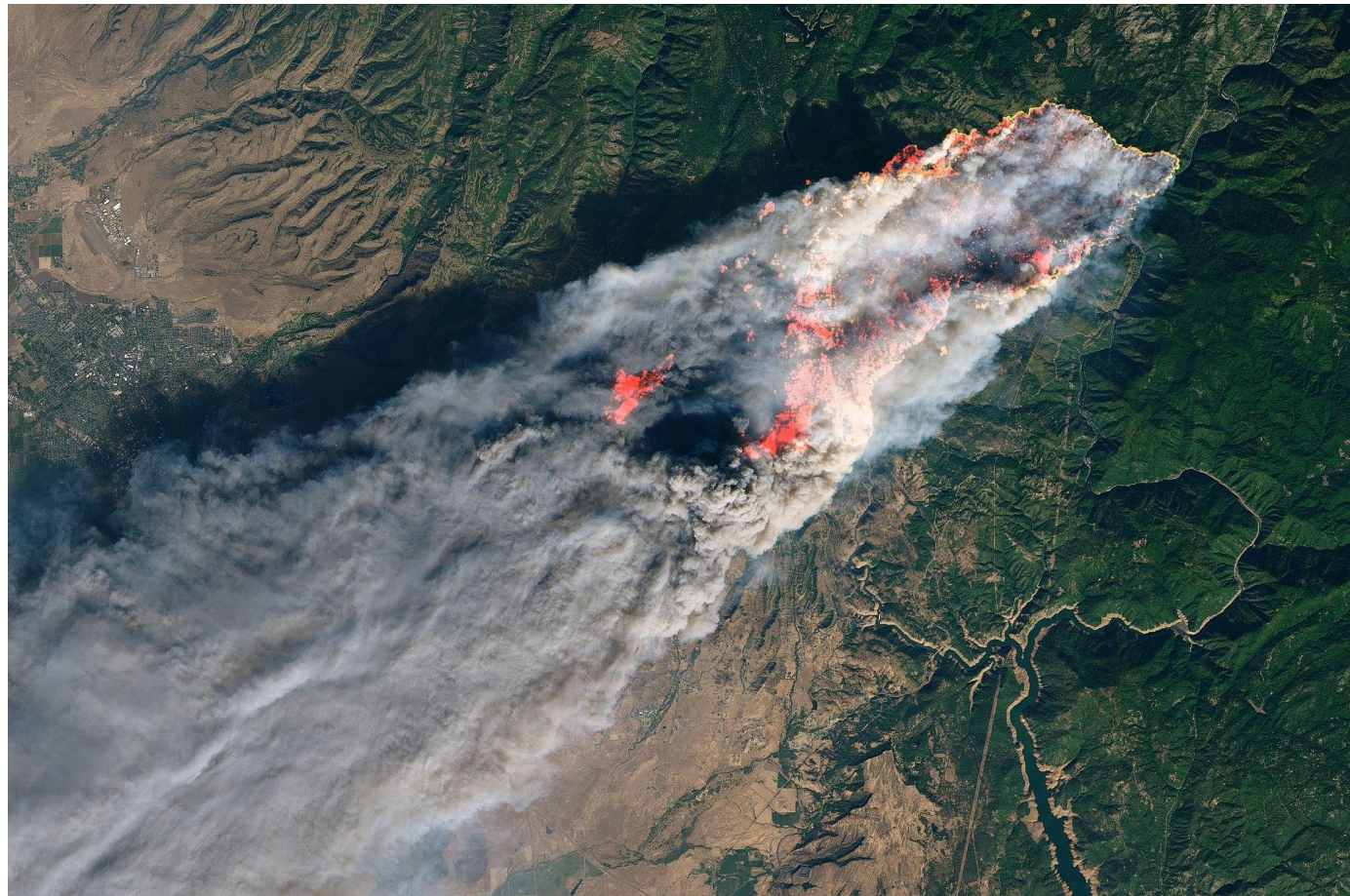


Summary

- Economic benefits from reduced hospitalization and premature deaths exceed intervention costs for all 6.92 million homes exposed to wildfire smoke, but are not sufficient to pay for portable air cleaners.
 - Estimated benefit-to-cost ratio range is about **2:1** using forced air system filtration interventions in all homes
 - For 22% of homes with age 65+ residents: benefit-to-cost = **16:1**
- In 22% of homes with age 65+ residents, benefits from reduced hospitalization and premature deaths are sufficient to pay for purchase of portable air cleaners.

Wildfire Smoke Exposure in Classrooms

- Camp Fire, Nov 8-22, 2018



Classroom HVAC Retrofit Evaluation Study



Phase II Field Study Goal

- Evaluate energy efficiency and IEQ performance of **HVAC system retrofits** in two California schools



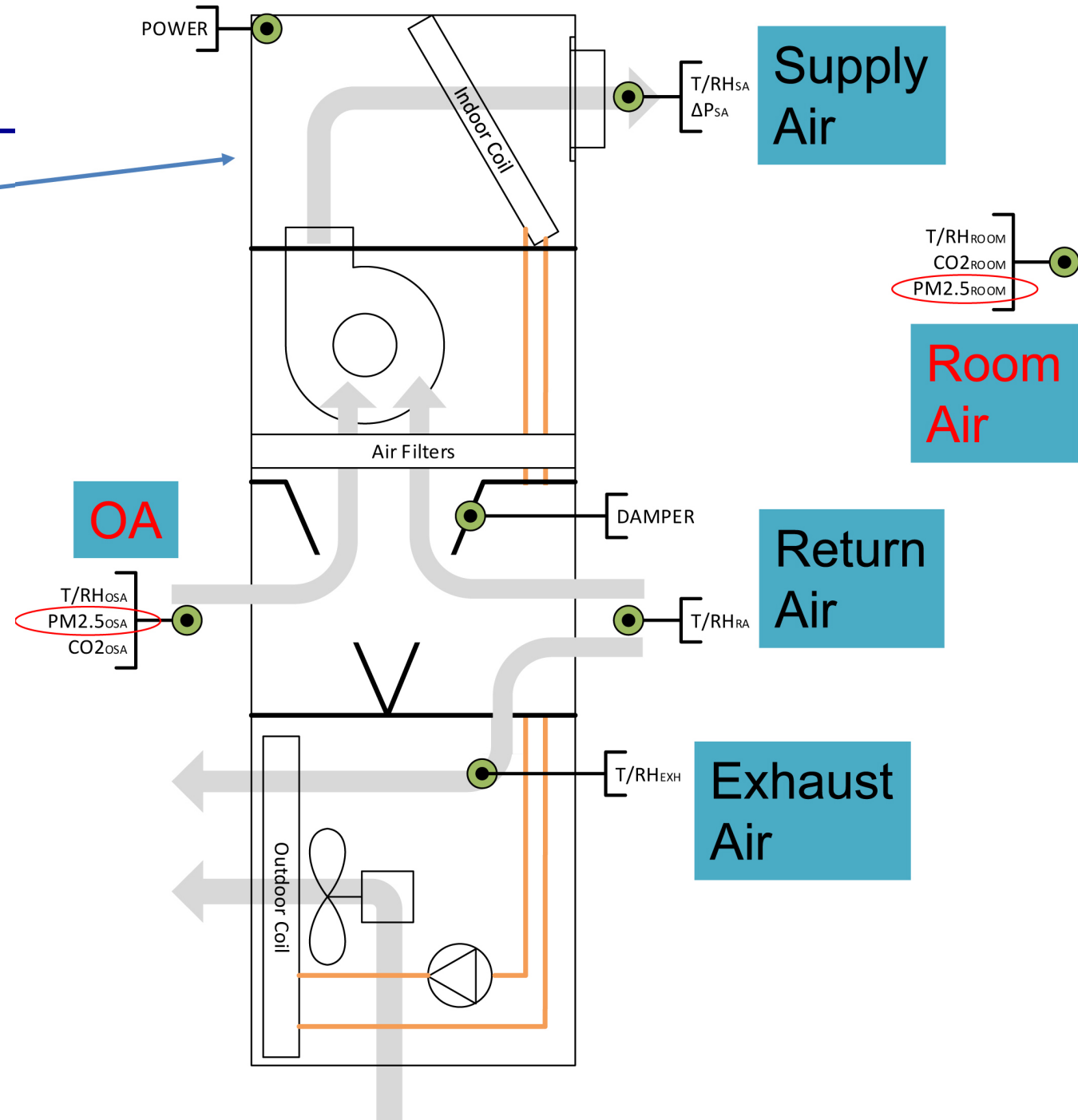
Sacramento region high school
(7 portable classrooms)

- Ventilation system types: CRV, ERV, ECON-DCV
- MERV 8 (Airguard DP Pleat 2-inch), MERV 13 (Airguard DP-G13EEN 2-inch)

Instrumentation

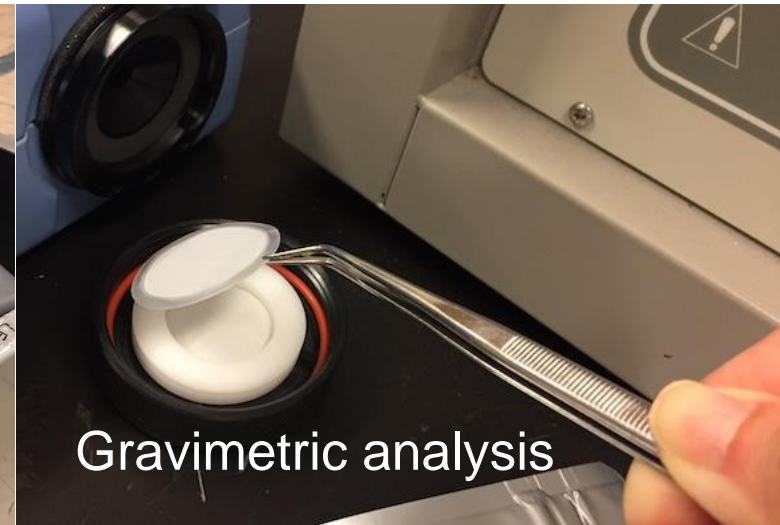
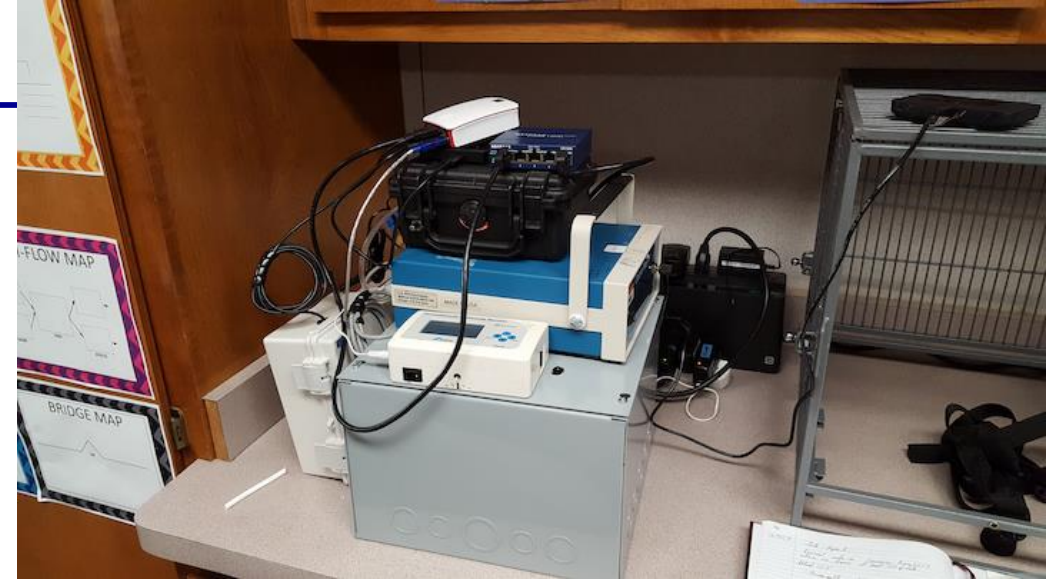


- Vaisala HMP110 (T, RH)
- Vaisala GMW90 (CO₂)
- Senserion 1000-R (ΔP)
- Plantower PMS3003 (PM_{2.5})



IAQ Monitoring (week-long, 3x)

- **PM_{2.5}**
- Black carbon
- Formaldehyde
- O₃
- CO₂



PM2.5 Measured during Wildfire Smoke (Camp Fire)

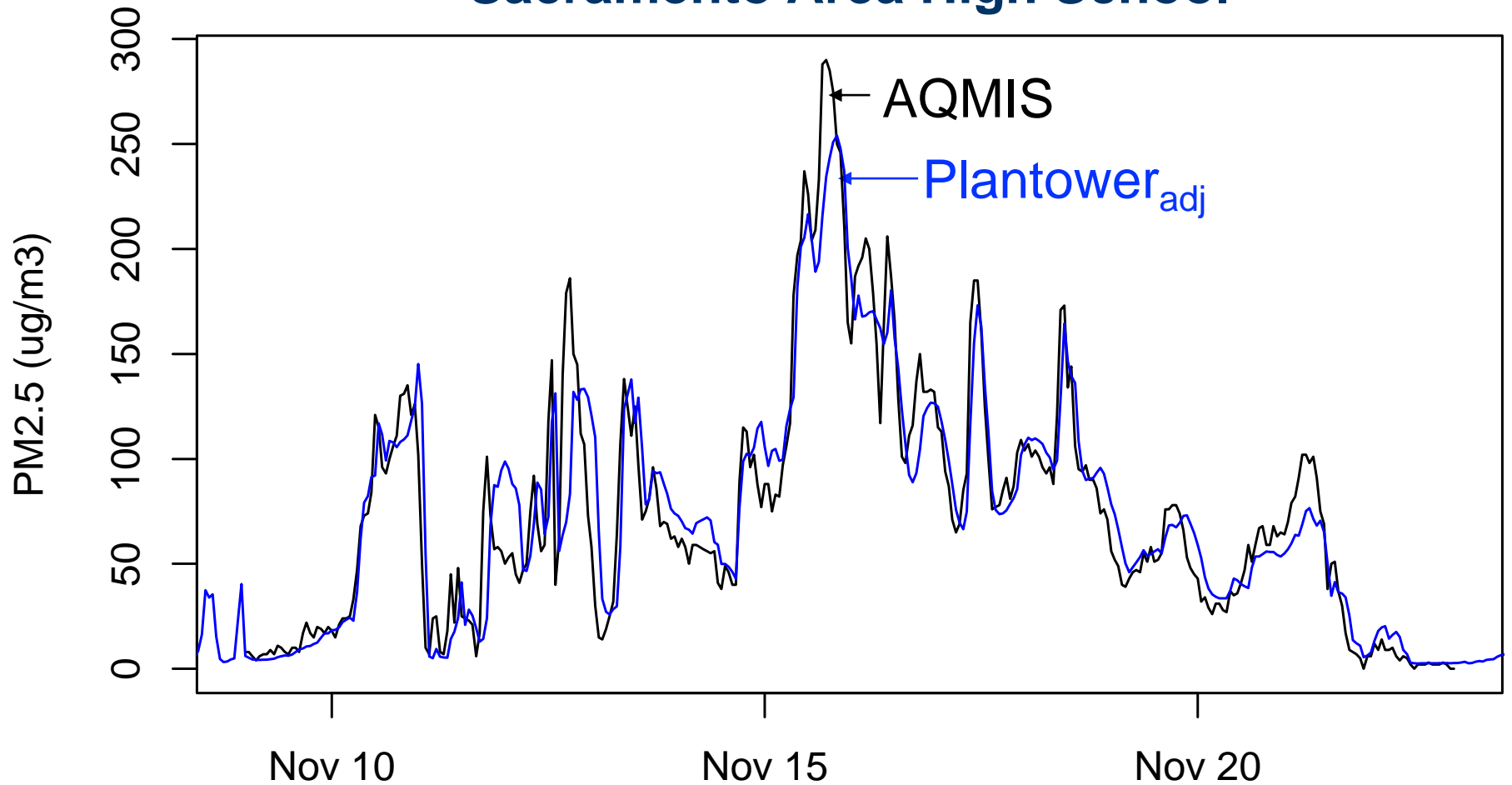
School Calendar

November				
			1	2
5	6	7	8	9
⊙12	13	14	15	16
19	20	21	⊙22	◇23
26	27	28	29	30



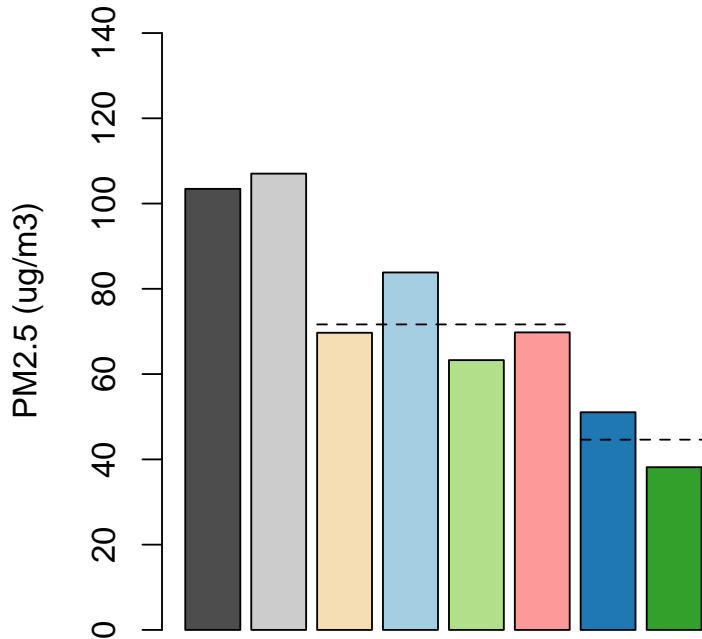
Plantower PM Sensor

Sacramento Area High School

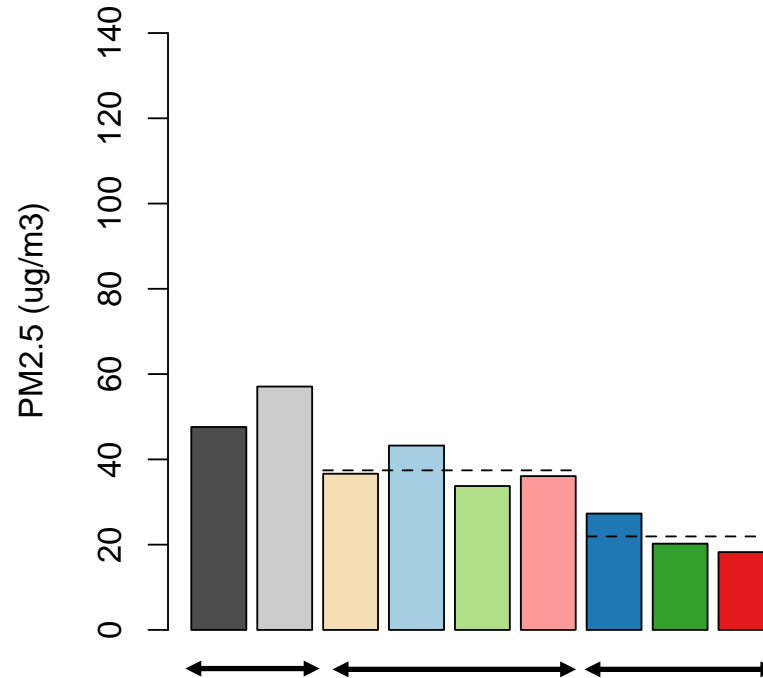


Daily Mean PM2.5 (ug/m³) Measured During School Hours

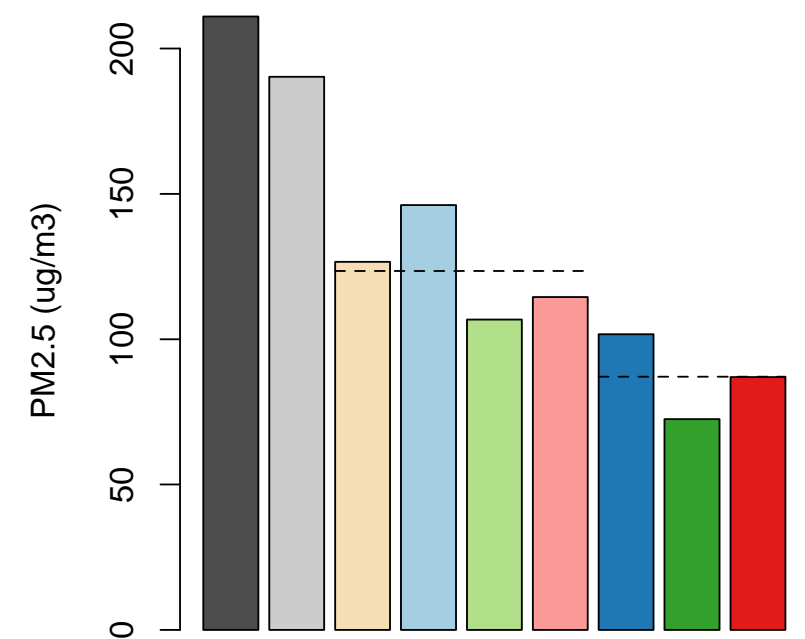
Nov 13 (Tue)



Nov 14 (Wed)



Nov 15 (Thu)



Outdoor

■ AQMIS ■ Plantower_{adj}

Classroom MERV 8

■ CRV₀ ■ CRV ■ ERV ■ ECON-DCV

Classroom MERV 13

■ CRV ■ ERV ■ ECON-DCV

Summary

- PM2.5 substantially lower in classrooms with MERV 13 filters compared to MERV 8, both during wildfires and normal conditions

I/O Ratio	MERV 8	MERV 13
CRV	0.76–0.78	0.48–0.53
ERV	0.56–0.59	0.35–0.38
ECON-DCV	0.60–0.65	0.32–0.46
Normal conditions (DustTrak)	0.28–0.42	0.10–0.13

- Other important considerations: classrooms must provide **adequate ventilation** during normal conditions, proper filter installation & regular maintenance



NEWS CENTER

Q&A: How to Protect Yourself and Your Family From Wildfire Smoke

Stay indoors, consider a mask, limit activities, use air filtration systems, or even build your own

Feature Story [Laurel Kellner](#) 510-486-5375 • **NOVEMBER 14, 2018**

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A view of the San Francisco Bay from Berkeley Lab on Nov. 14 (left) and three weeks prior. (Credit: Kelly J. Owen)

Q. How worried should I be about the a pollution from a wildfire?

Q. How can I protect myself during wildfire air pollution events?

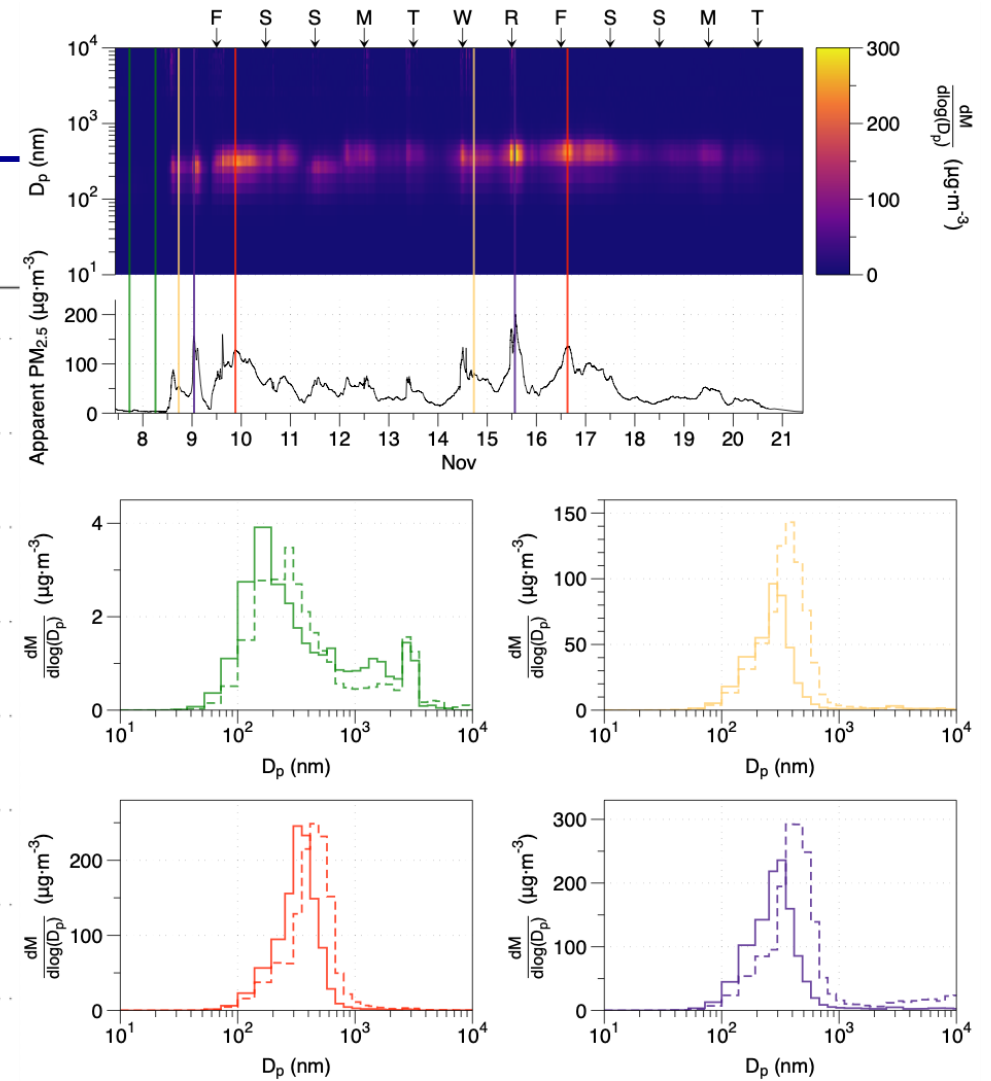
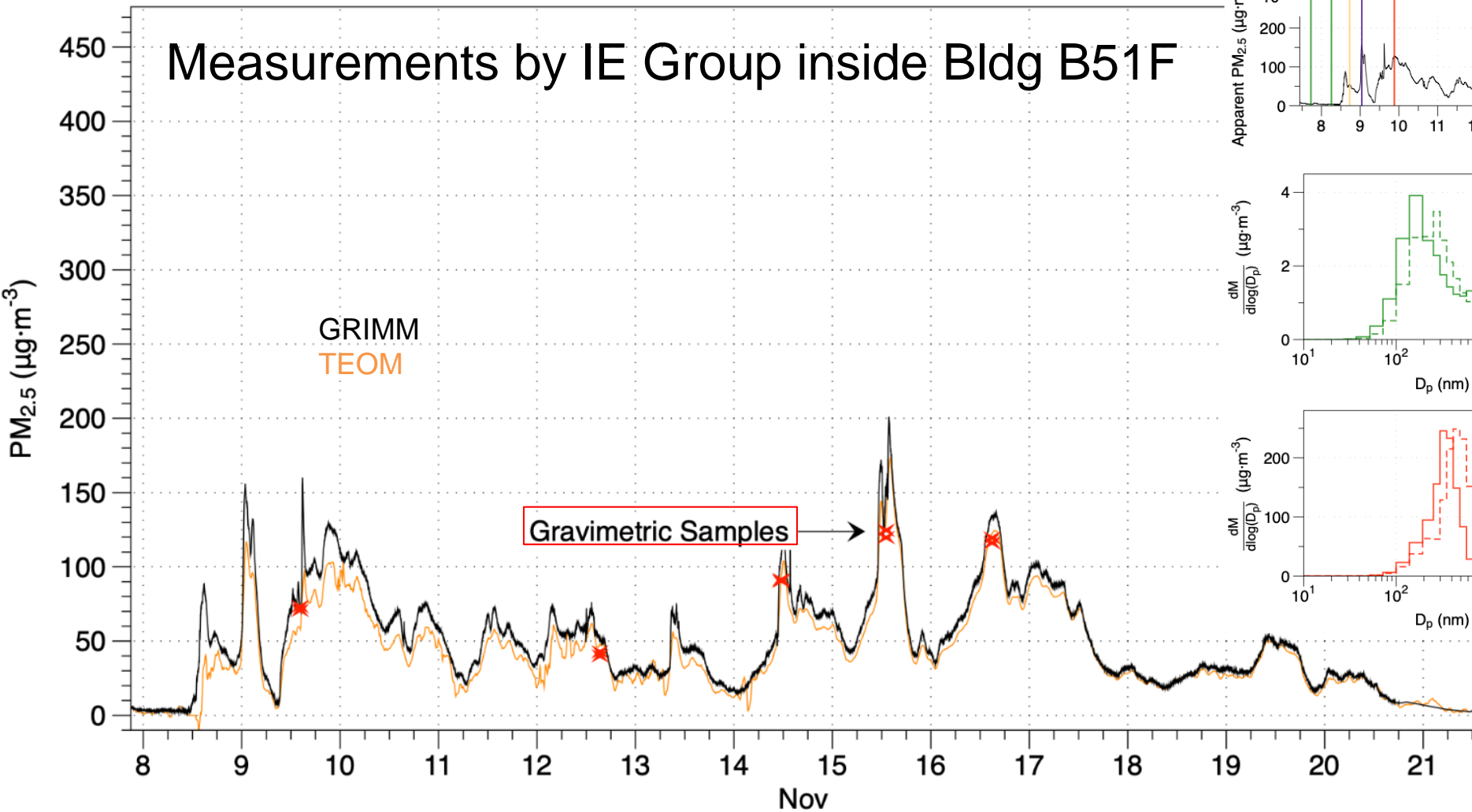
Q. How can I make my home safer?

Q. How do I use filtration systems in my home?

<https://newscenter.lbl.gov/2018/11/14/qa-how-to-protect-yourself-and-your-family-from-wildfire-smoke/>



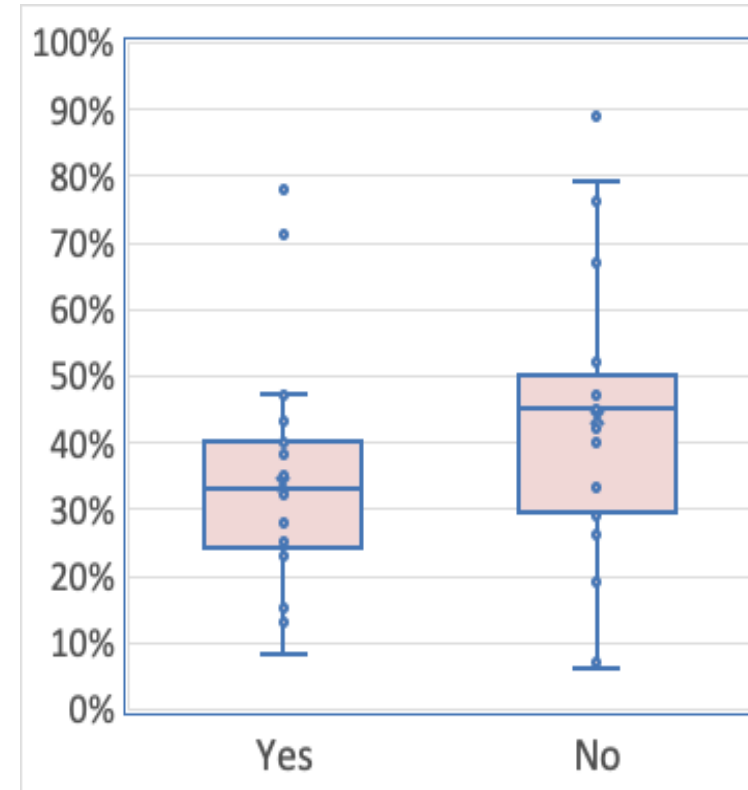
PM2.5 Measured at LBNL



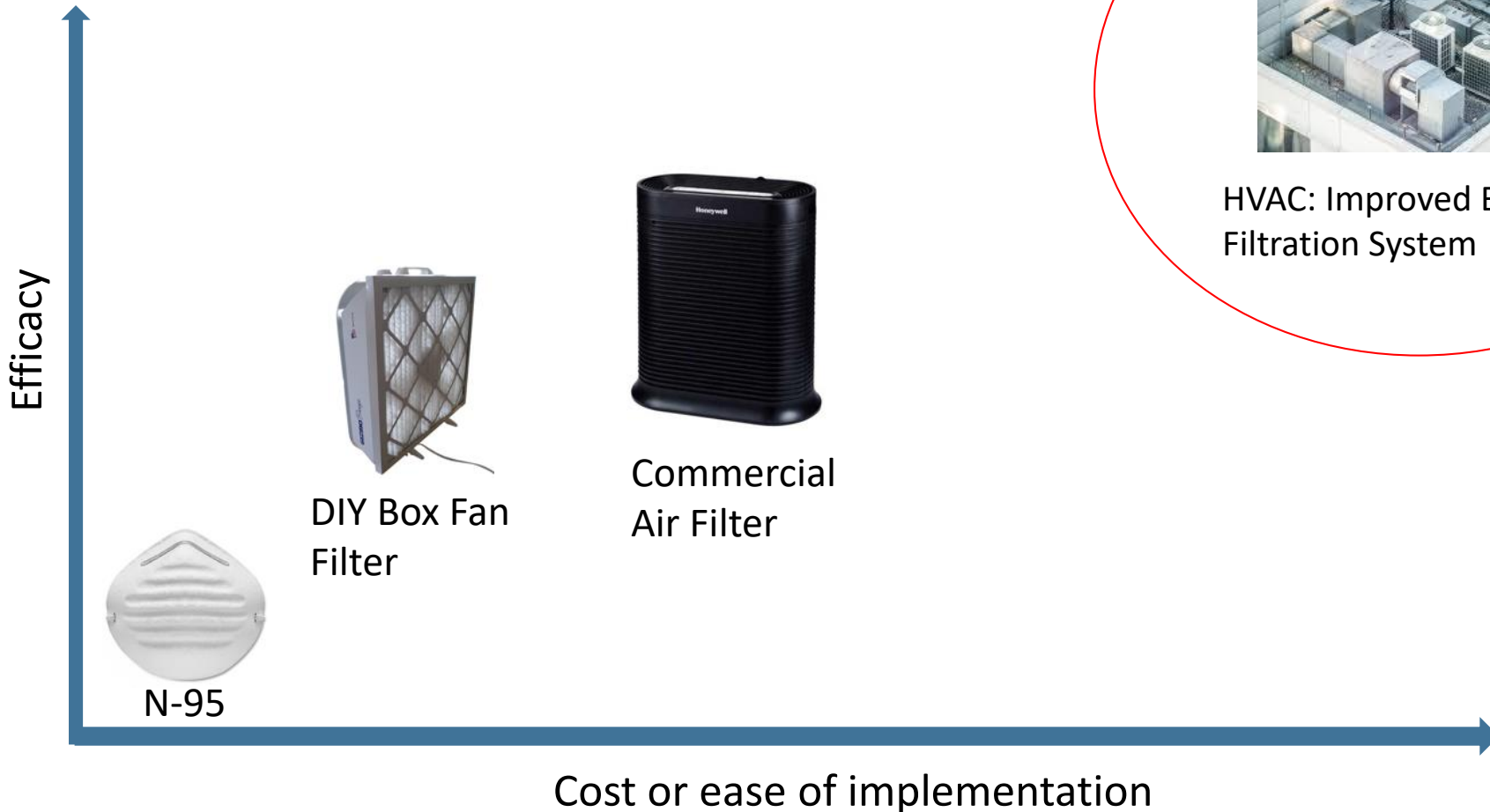
Smoke Mitigation Efforts at LBNL

- At our main site, LBNL is operating ~2m sqft in 100+ buildings
- 60% of our largest, most populated buildings are 50+ years old
- HVAC smoke mitigation changes during 2018 wildfires:
 - 46 AHU in 21 buildings had HVAC control overwritten or manually controlled to recirculate conditioned air
 - 87% AHU were overridden to ~10% OA, remaining set to 100% recirculation

PM2.5 I/O ratio for buildings that had or did not have outdoor air reduced (data from LBNL EH&S)



Priority for Smoke Mitigation



HVAC: Improved Building Filtration System

Facilities, EH&S, HR, management working together on preparedness: smoke mitigation mode, better filter, monitoring (PM, CO2), response plan

<https://iaqscience.lbl.gov/>

Protecting Public from Wildfire Smoke

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