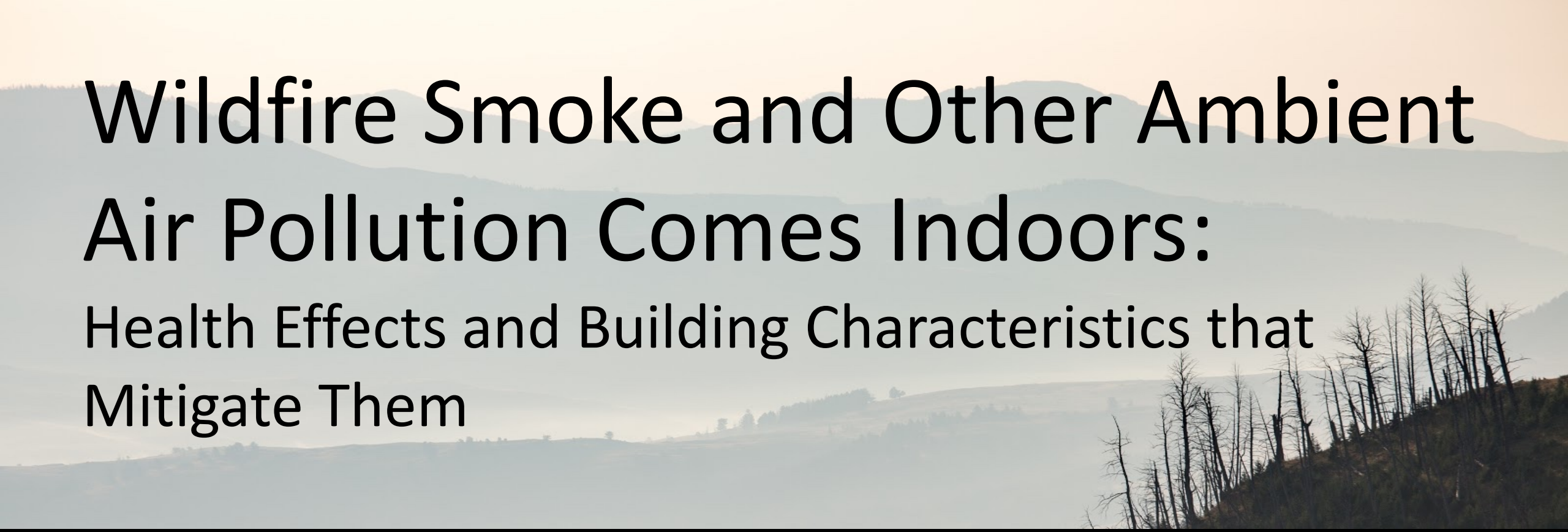
Wildfire Smoke and Other Ambient Air Pollution Comes Indoors:

Health Effects and Building Characteristics that Mitigate Them



Yellowstone National Park, Public domain, via Wikimedia Commons

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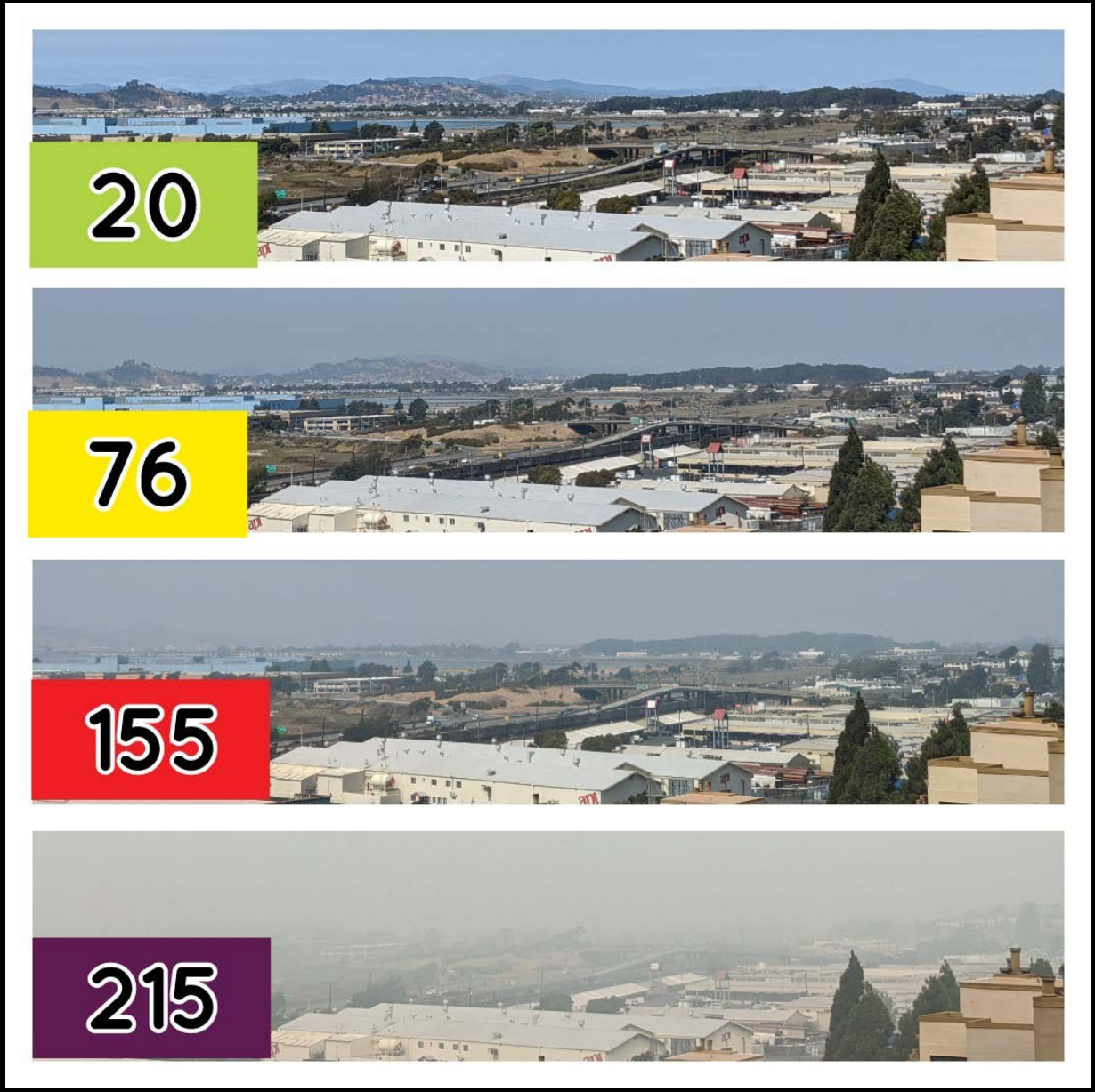
Outline

- Why you should be concerned about Wildfire Smoke
- Outdoor PM comes indoors
- Health benefits related to interventions to decrease indoor PM
  - In general
  - During wildfires

Picture Credit: Stephanie Holm

Wildfires can Expose Large Populations to Smoke

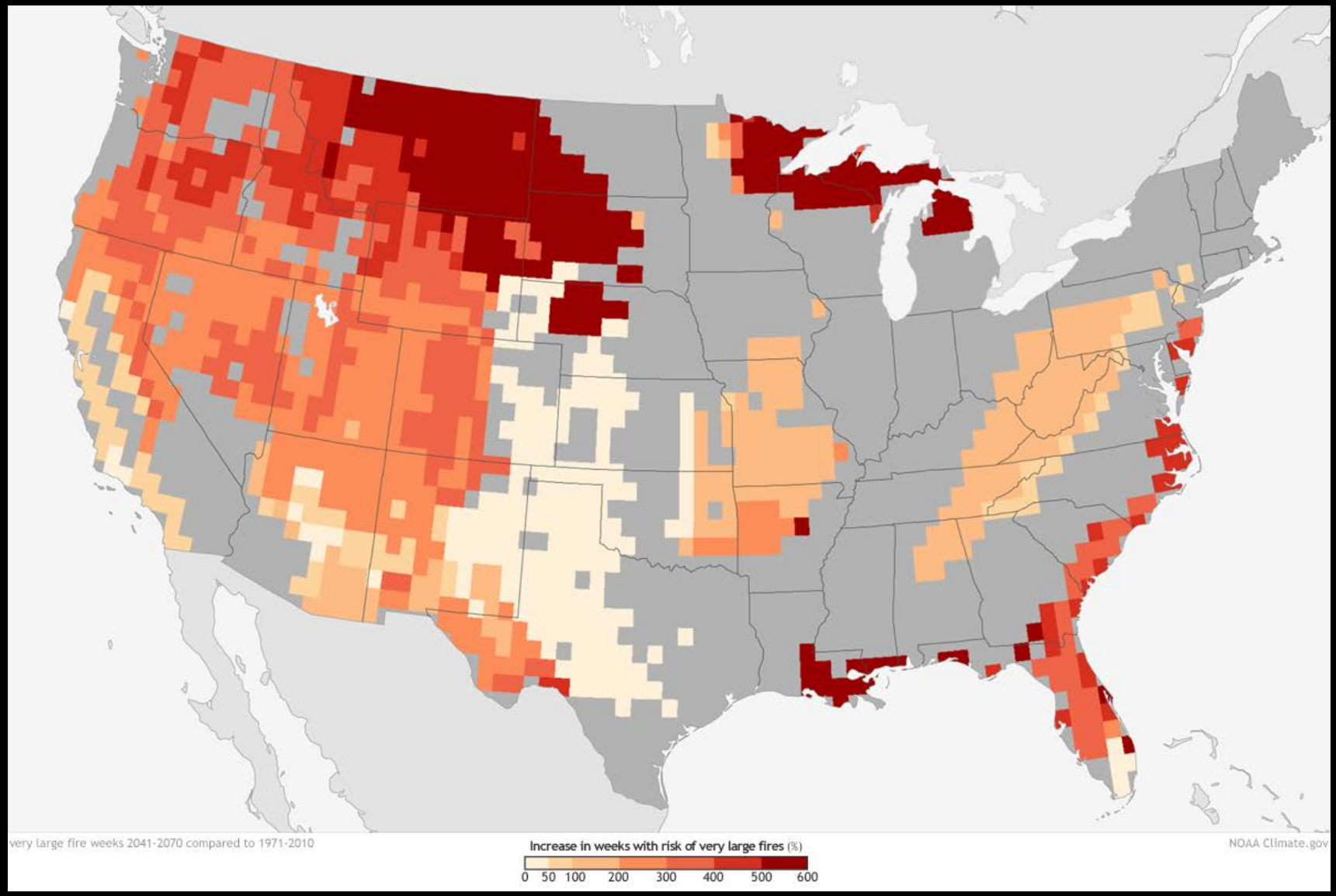
From NASA's Earth Observatory:
https://earthobservatory.nasa.gov/images/147363/californias-nightmare-fire-season-continues



Visualization of worsening visibility in the bay area in the fall of 2020 with increasing AQI value.

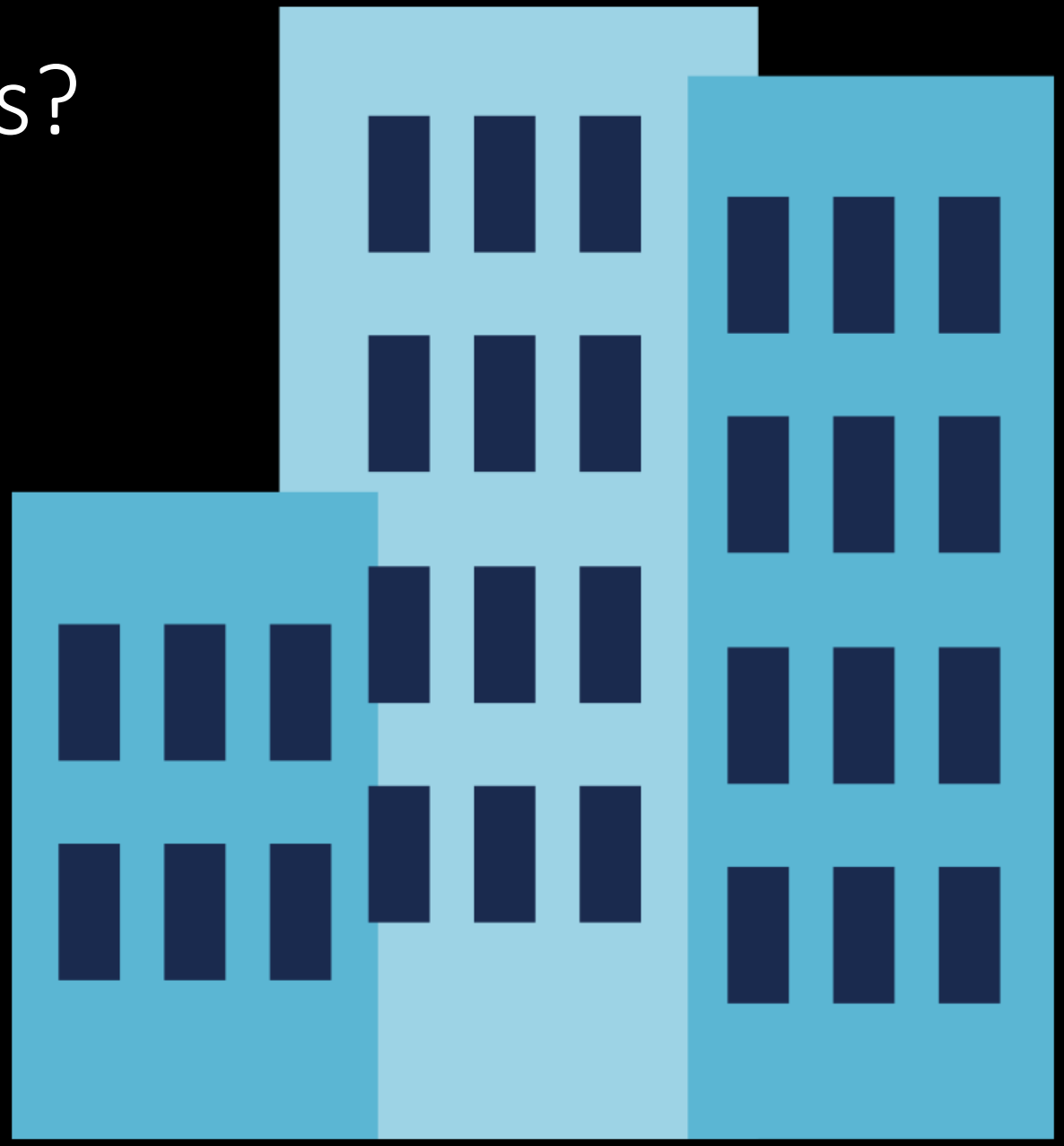
Picture Credit: Stephanie Holm

NOAA Estimates for Weeks with Risk of Very Large Fires in the mid- 21st Century compared to the end of the 20th



How much PM gets indoors?

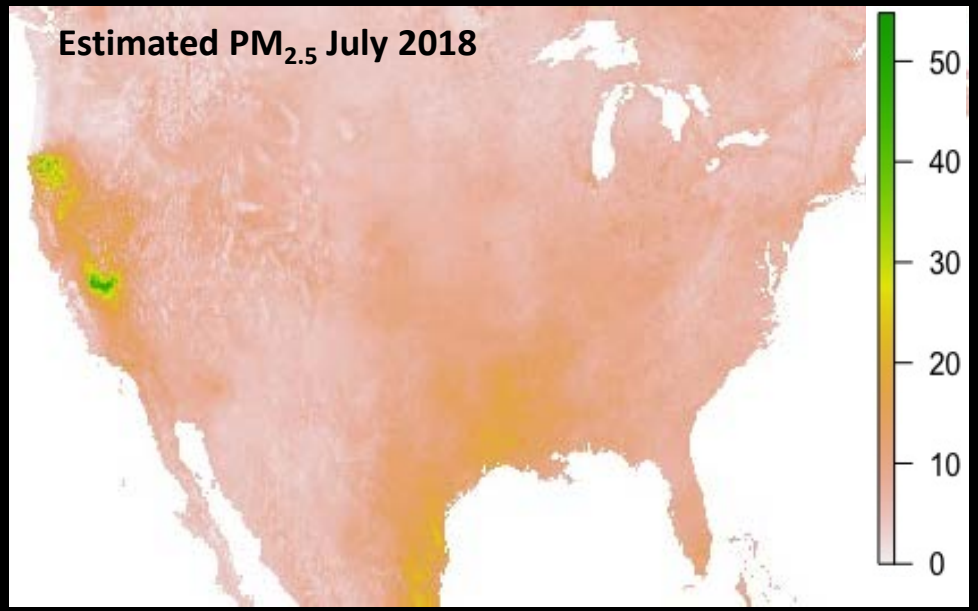
- On average, in homes across the US, **roughly half** of the outdoor $PM_{2.5}$ makes it indoors.[1]
- In terms of a person's total exposure to PM, roughly 53% of that exposure is outdoor PM that people are exposed to inside their home or other buildings [1]



[1]Azimi and Stephens, 2020

Many Air Pollution Epidemiologic Studies use Residential Location

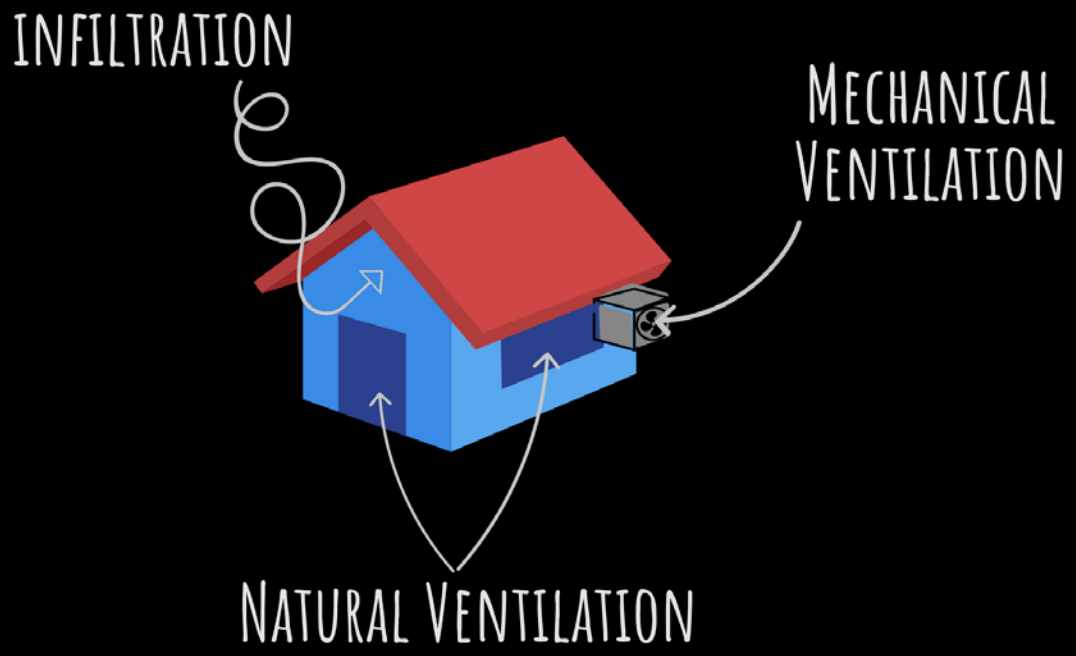
- 2017 Medicare study with 460 million person-years of follow up[1]
  - ⇧ 10 µg/m^3 $PM_{2.5}$ associated with ~7% increase in mortality
- Children's Health Study in Los Angeles, followed 3 cohorts of >2000 adolescents[2]
  - ⇩ 12.6 µg/m^3 $PM_{2.5}$ associated with ~65 mL increase in lung function growth (FEV_1)
- 18000 participants of the Imaging Dementia-Evidence for Amyloid Scanning Study[3]
  - ⇧ 10 µg/m^3 $PM_{2.5}$ associated with OR of 1.1 for having amyloid on PET scan

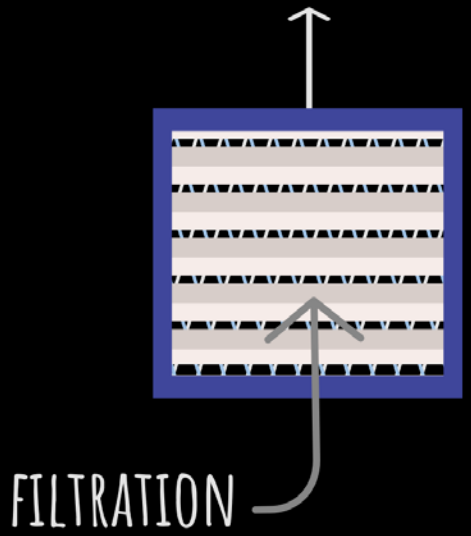


Map generated by S. Holm, using datasets available from the Atmospheric Composition Analysis Group at WashU, as described in von Donkelaar et al, 2019

[1]Di et al, 2017; [2]Gauderman et al, 2015; [3]Iaccarino et al, 2021

What DETERMINES How Much of the Outside PM Comes INSIDE?





If you stop All of these, you'll have Problems with pollution that's made inside as well as moisture and mold.

KEY: Filter your AIR!

For central Air pick a filter rated MERV13 or higher.

Portable Air filters need a high enough clean air delivery rate (CADR) for your space and should NOT produce ions or ozone.

Tightening of the Building Envelope
(ie. decreasing infiltration or weatherization)

- Weatherization + ventilation + education can improve:
  - asthma symptoms[1,2]
  - overall (self-reported) health[2]
- Decreasing infiltration without ventilation and/or filtration improvements can increase indoor PM exposure.[3]
  - In a model of pediatric asthma, weatherization alone might increase the rate of severe asthma events.[4]

[1]Breysse et al., 2014; Breysse et al., 2011; [3]Yuan et al., 2018; [4]Fabian et al., 2014

Improved Ventilation

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- If the indoor PM is minimized, *decreasing* ventilation can have temporary benefits
  - In Taiwanese young adults, closing windows was associated with decreased blood pressure and heart rates[1]
- In schools improved ventilation associated with:
  - Decreased absences[2]
  - Improved math and language performance[3]
- When thinking about improving exposure to pm from outdoor sources, ventilation needs to be accompanied by filtration

[1]Lin et al., 2009; [2]Mendell et al 2013; [3]Wargocki and Wyon et al., 2007.

Improved Filtration

USEPA Environmental-Protection-Agency, Public domain, via Wikimedia Commons, https://upload.wikimedia.org/wikipedia/commons/2/2d/Hange_your_HVAC_filter_regularly_to_ensure_your_system_is_running_efficiently_and_-ActOnClimate._http---www.epa.gov-earthday-actonclimate-_%2814033475892%29.jpg

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- In adults, associated with improvements in:[1]
  - subclinical cardiovascular outcomes
  - No changes in lung function (based on some recent work out of China)
- Pregnancy Outcomes
  - Increase in birth weight among term infants[2]
- In children, associated with:
  - Expected 13% decr in asthma morbidity in Detroit Schools[4]
  - Higher test scores[5]
  - Does *not* decrease air nicotine if there are smokers in the home and may not improve asthma for those children.[6]
- Ion Generation may negate benefits (stick to mechanical filters)
  - Some technologies produce ozone, some produce negative ions
  - Negative ions associated with markers of inflammation (in adults), decreased heart rate variability (in children)[1]

[1]Allen and Barn, 2020; [2]Barn et al., 2018; [4]Martenies and Batterman et al., 2018, [5]Gilraine 2020; [6]Gold et al., 2017

Indoor Air During Wildfires-Interventions & Exposure

- Building Envelope Tightening: Australia[1]
  - Indoors with windows closed -12 to -76% for peak levels
- HVAC changes in Southern California Homes[2]
  - HVAC continuously running -24%
  - HVAC continuously running with MERV 12 filter -50%
  - HVAC with MERV12, but not continuous operation -11%
  - Portable air filter
    - Without HVAC, -45%
    - With HVAC continuously running with MERV 9 -51%
    - With HVAC continuously running with MERV 12 -62%
- Filtration: British Columbia, Montana, Colorado
  - Case crossover, portable air cleaner -65%[3]
  - Portable air cleaner -73% in an occupied office[4]
  - Paired homes, portable air cleaner -75%[5]
- Note that total PM infiltration may actually be higher during wildfire smoke events[6]

[1]Reisen et al., 2019; [2]Fisk and Chan 2017; [3]Barn et al 2008; [4]Stauffer et al., 2020; [5]Henderson et al., 2005; [6]Mendoza et al., 2021

Indoor Air During Wildfires-Interventions & Health

- Southern California Homes, modeled for 2003 wildfire[1]
  - MERV13 + portable air cleaner in all homes could have prevented more than half the respiratory admissions
  - Portable air cleaner alone in homes without HVAC could prevent almost half the respiratory admissions

- Hoopa Valley[2]
  - Filtration was the only intervention that had health benefits (others included mask, leaving the area)

[1]Fisk and Chan 2017, [2]Ja et al 2002

How to Reduce Wildfire Smoke Exposure For Kids

▼ ≤ 100%

Go Somewhere Without Smoke

▼ ~50-80%

Go inside with
(1) HVAC & MERV 13 filter
or
(2) a portable HEPA air cleaner

▼ ~30%

Go Inside and Shut Windows

DO NOT spend unnecessary time outside if the AQI is in the unhealthy ranges.

Cloth face coverings (like those for COVID) DO NOT reliably filter out small smoke particles.

For Short Periods of Time:

▼ ~80%

Recirculate the air in your car

▼ ~80%

Wear a small size NIOSH N95 Mask *correctly*

▼ ~20%

Wear a medical mask *correctly*

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More resources: wspehsu.ucsf.edu

Thanks!

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