IMPACT OF TRANSPORTATION-RELATED AIR POLLUTION ON INDOOR AIR QUALITY

presented

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at **MAPC webinar Particulate Policy: Addressing Indoor Air Quality** on September 9, 2021

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2. Multiple ways of categorizing/grouping air pollutants
    1. Physical Properties: Gases or particulate matter
    2. Chemical Constituents: Organic or non-organic particulate matter
    3. Based on outcome of concern: For example, allergenic air pollutants (mold or pollen) that are a common concern in indoor spaces.
    4. Based on source or origin: traffic-related or indoor-generated

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3. **Air pollution that we are exposed to in indoor environments does not solely comprise of indoor-generated air pollution.**

INDOOR AIR POLLUTION OF OUTDOOR-ORIGIN

1. Outdoor-origin air pollution is commonly detected indoors.
   - The degree of its indoor presence is modifiable such that the harmful effects on health may be mitigated.

2. Presence of transportation-related air pollution in indoor spaces in urbanized areas is particularly concerning.

   - Transportation emissions are a key contributor to spatial inequities in air pollution and disparities in health in urban areas
   - There is a large volume of literature that links residing near busy roadways to adverse health outcomes

TRANSPORTATION-RELATED AIR POLLUTION

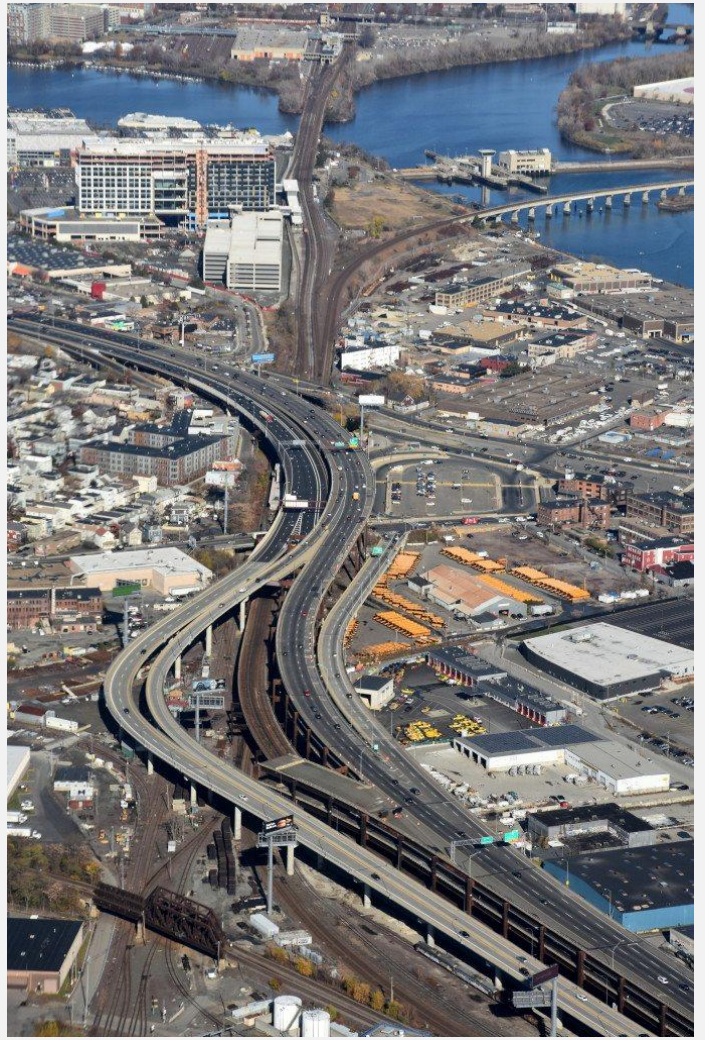
1. Fossil-fuel combustion by various transportation modes – which is often the predominant source of outdoor air pollution in cities – creates a complex mixture of combustion by-products that pollute urban air.

2. Traffic emissions create a complex mixture, referred to as Traffic-Related Air Pollution or TRAP

- A mix of tailpipe (gasoline and diesel exhaust) and non-tailpipe (brake and tire wear)
- Chemical composition & physical properties vary by season, time of day, volume of traffic, fleet composition, …

- Consists of gases (CO_2, CO, oxides of nitrogen), solid particles (soot coated with organics), water vapor, suspensions of very small droplets and small particles we often call **ultrafine particles**, and larger particles such as fine particulate matter

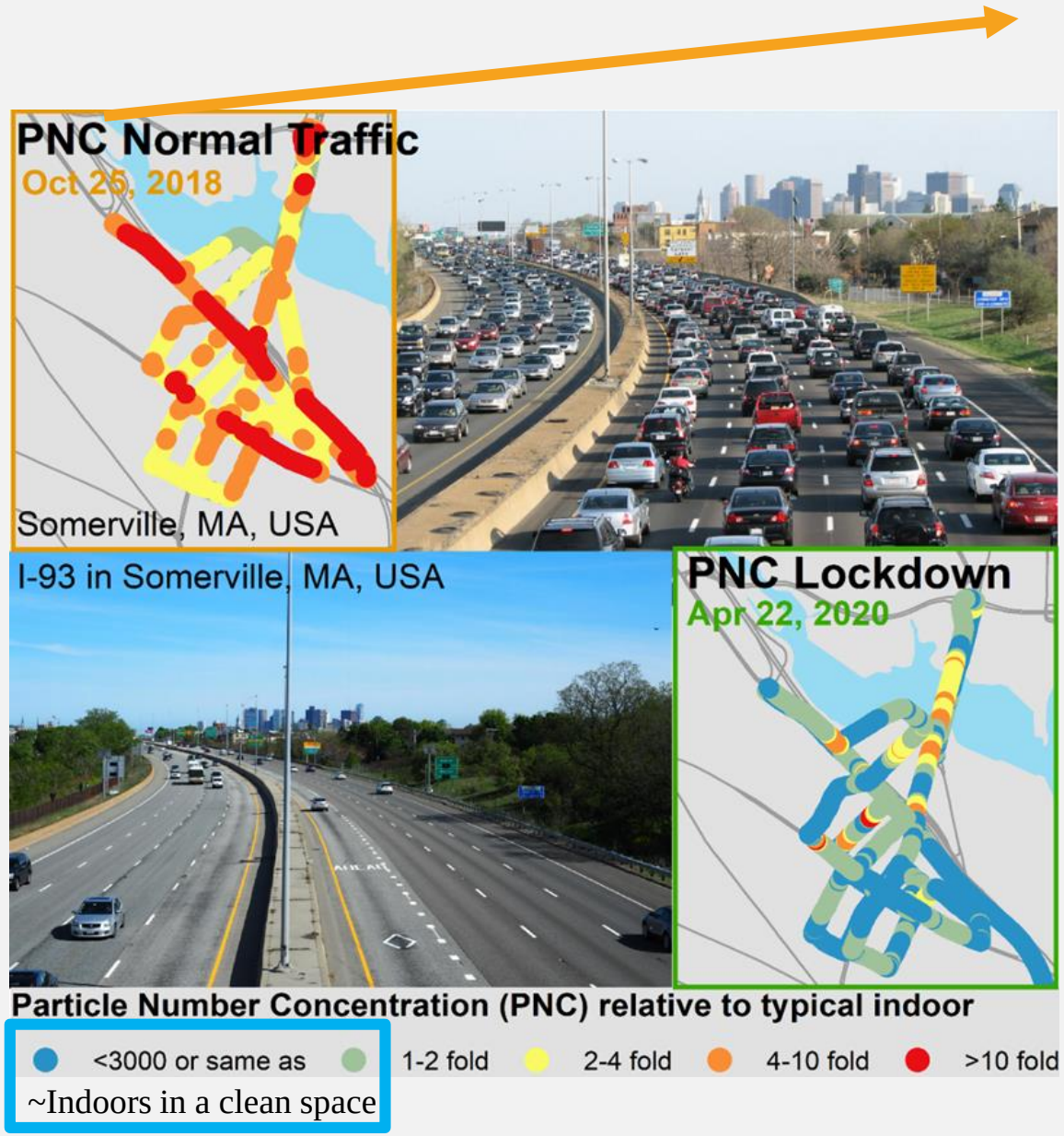
An view of I-93. Photo by Wig Zamore.


An aerial view of I-93 and the Inner Belt rail corridor in East Somerville. Photo by Nick Allen.

What happened to TRAP during the pandemic-related "lockdown"?

Illustrated using ultrafine particles as a marker of TRAP

Somerville, MA:
Somerville is the most densely populated city in Massachusetts and it contains three major highways – interstate 93 (I-93) and state routes 28 and 38, which together carried more than 200,000 vehicles/day before the pandemic.



PNC: Particle Number Concentration which is the count of number of ultrafine (<100 nm) particles in a sugar cube size volume of air

https://www.wcvb.com/article/tufts-university-researchers-show-environmental-impact-of-covid-19-less-vehicle-traffic-in-boston-area/34452834

Hudda et al., 2020, DOI: 10.1016/j.scitotenv.2020.140931

FORMS OF TRANSPORTATION-RELATED AIR POLLUTION

1. Traffic is not the only transportation mode that has substantial detrimental effect on outdoor **and indoor** air quality.
2. Airports, seaports, train terminals (all large transportation facilities) create air pollution that significantly impacts large populations in their vicinity

Creator: John Wilcox Credit: BH
Copyright: John Wilcox-Boston Herald

Credit: N. Hudda

INDOOR PRESENCE OF TRAP

How does TRAP get indoors?

- Doors & Windows (Natural ventilation methods)
- Wind forces the outside air (which carries TRAP) through gaps into homes
- Outside air also gets pulled in more passively
- Mechanical ventilation systems that force outdoor air indoors also force what is in the outdoor air indoors

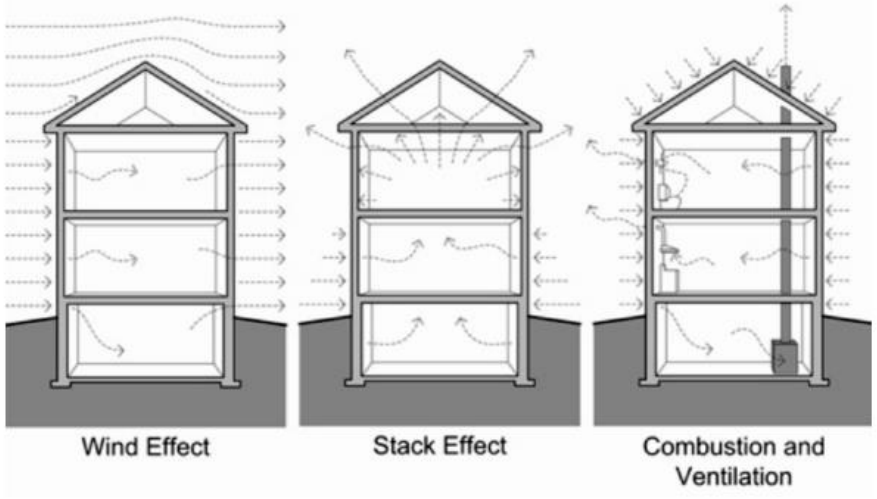


Figure 1: Examples of infiltration. Image courtesy: Building Science Corporation, www.buildingscience.com

How much TRAP get indoors?

- Varies by pollutant, especially the size of particulate matter pollution under consideration.
  - Indoor-to-outdoor (I/O) ratios can vary from zero to one, but 0.3-0.7 is common for particulate matter pollution.
- Also varies by:
  - Physical characteristics of the house; older leakier homes will have higher I/O ratios.
  - Ventilation practices
    - Natural ventilation will lead to I/O of ~1
    - Mechanical ventilation can be very effective in lowering I/O if equipped with filters or can just force outdoor unfiltered polluted air indoors leading to I/O of ~1

INDOOR PRESENCE OF TRAP IN GREATER BOSTON AREA

In the following slides we look at data from two studies from the greater Boston area that demonstrate the indoor presence of TRAP

NEAR-HIGHWAY

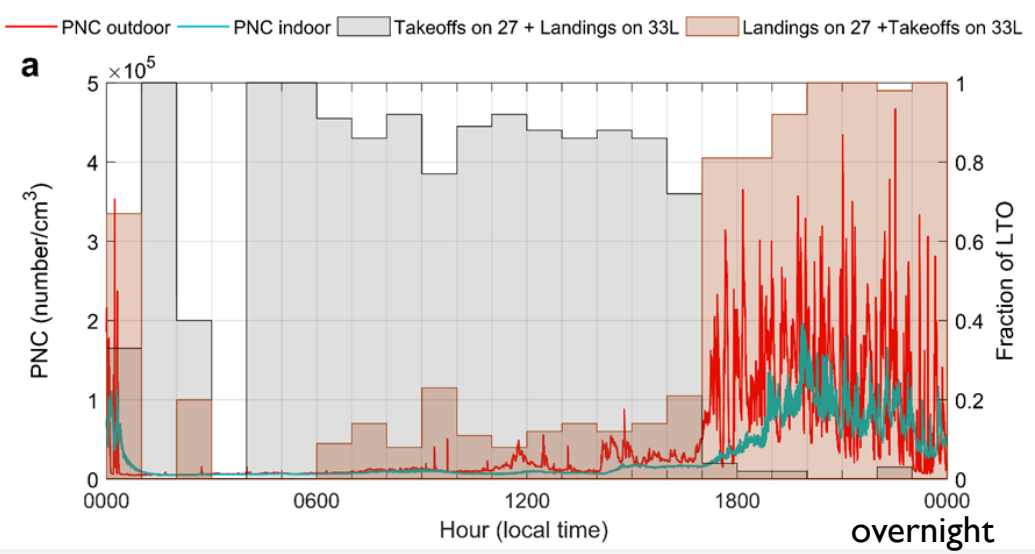
- The first 0.25 mile is where we observe the most elevation in TRAP near major roadways
- About 3.5% of MA population lives within 1/10th of a mile of a major-highway where concentrations can be elevated by up to an order of magnitude compared to urban background.

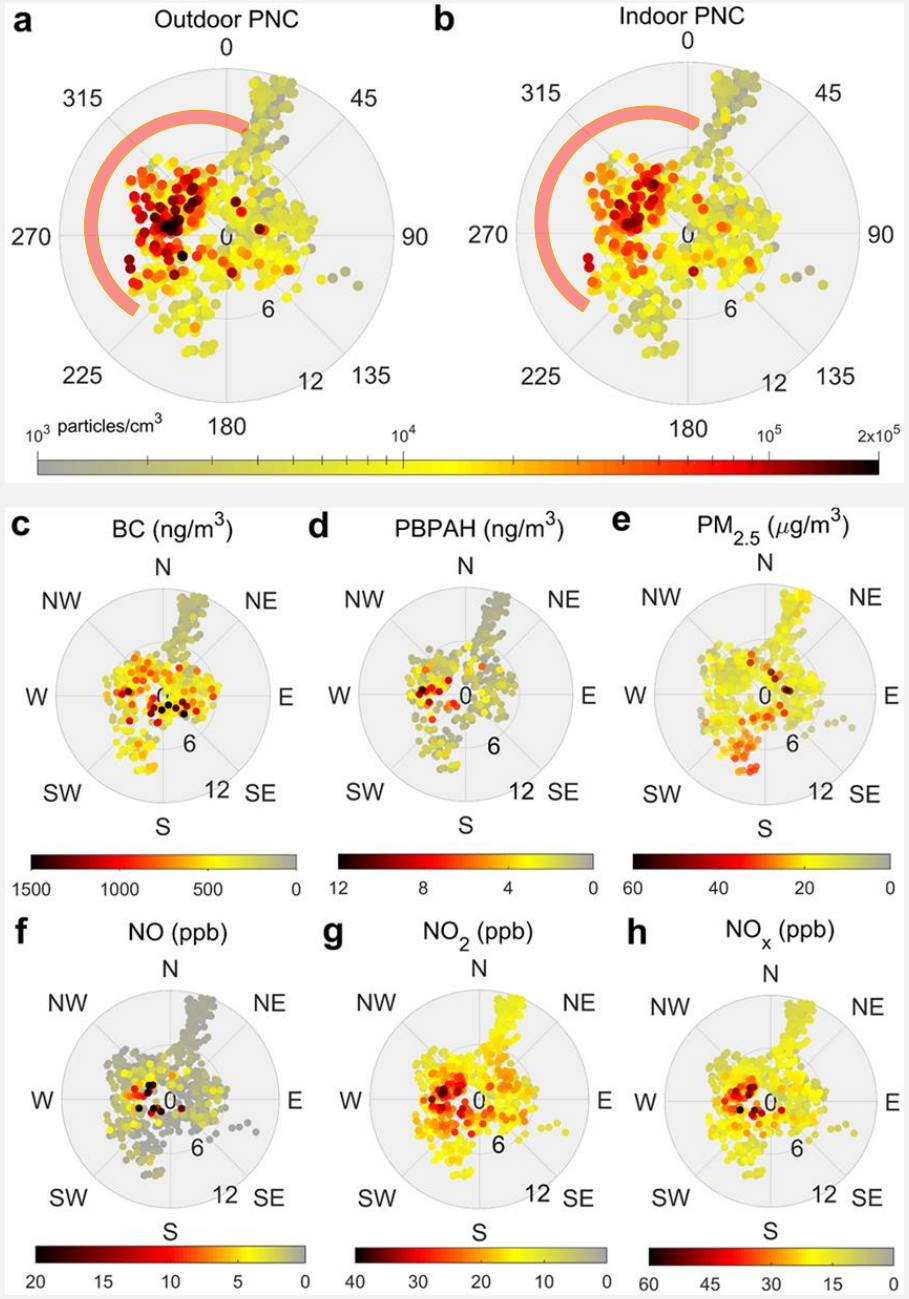
NEAR-AIRPORT

- The spatial proximity impacted by an airport is much larger in comparison to that impacted by a highway
- We have detected Logan-related ultrafines in Winthrop, Chelsea, and as far as Roxbury, MA

INSIDE AND OUTSIDE OF A HOME AT POINT SHIRLEY IN WINTHROP

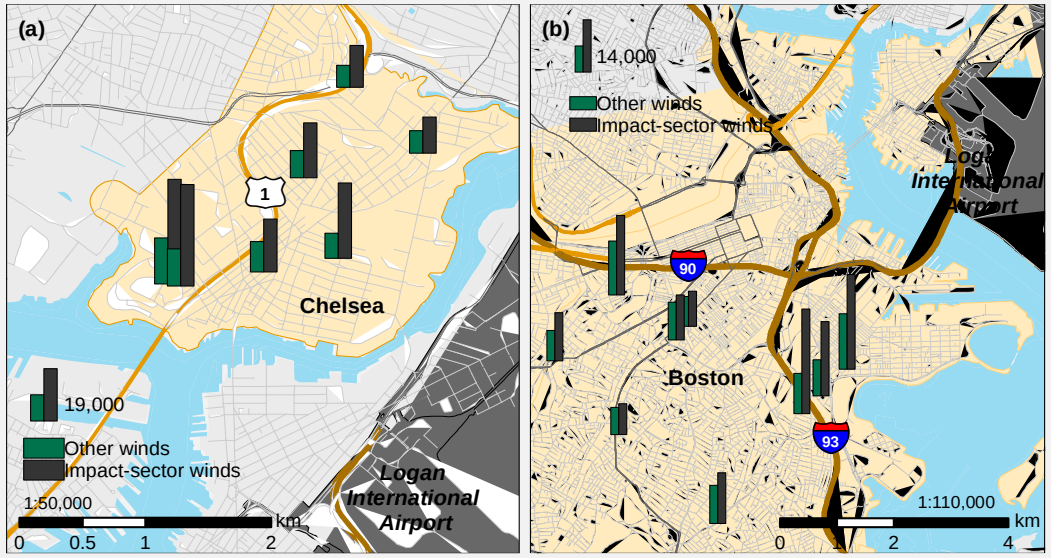
- Concentrations of many pollutants were highest when this home was downwind of the airport
- Indoor concentrations of ultrafine track outdoor pattern; I/O ratio was ~0.8.
- Indoor concentrations during overhead landings comparable to what we observe on highways



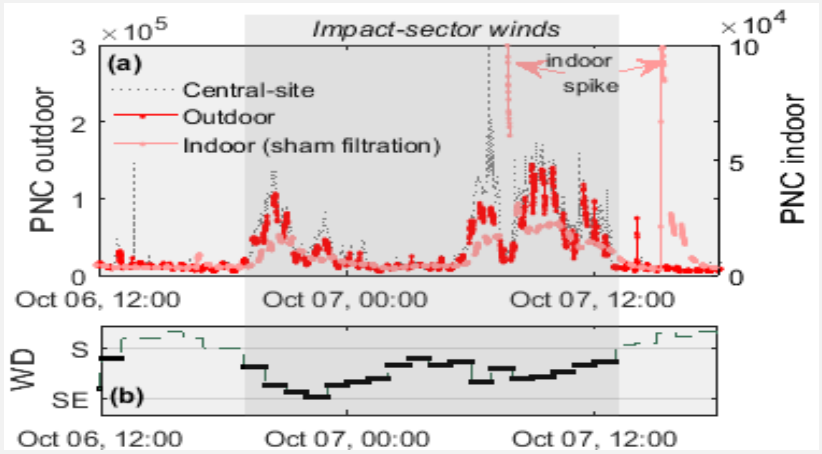


https://pubs.acs.org/doi/full/10.1021/acs.est.0c01859

LOGAN-RELATED ULTRAFINES DETECTED INDOORS AND OUTDOORS UP TO 6 MILES DOWNWIND



Concentration of ultrafine higher at homes when they were downwind of Logan.



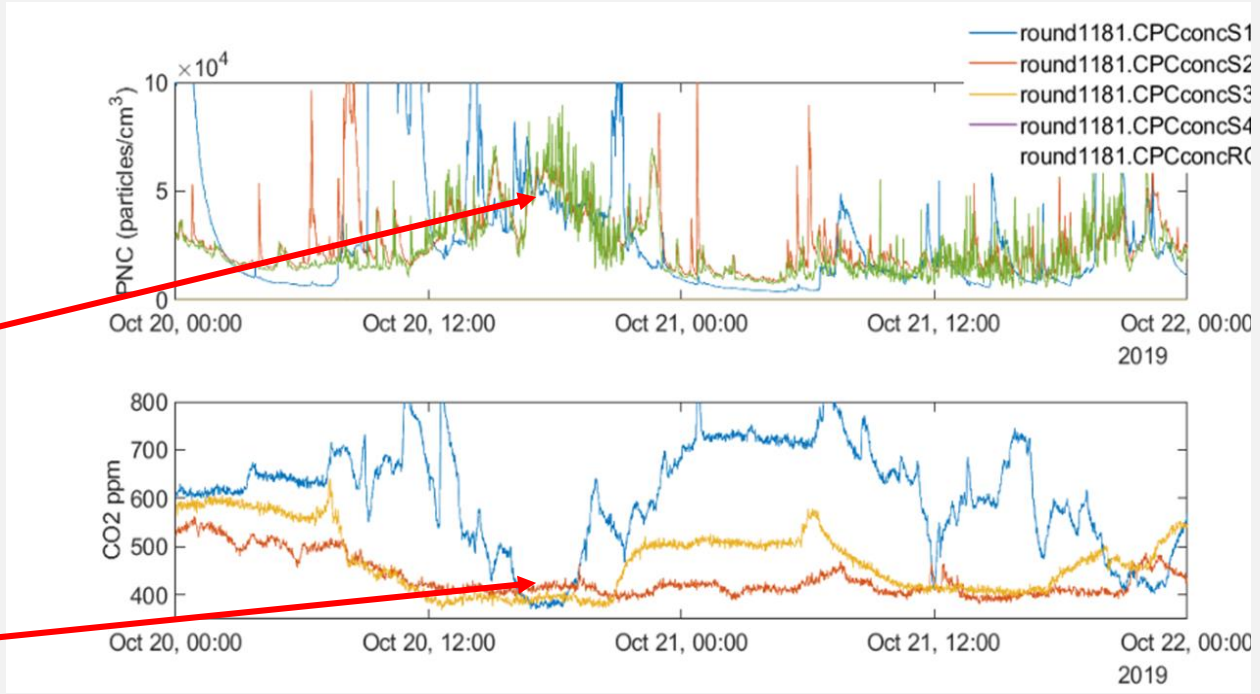
Indoor ultrafine (light red) track outdoor pattern (dark red) and also the pattern at a central monitoring station indicating a common pattern across the community.

https://pubs.acs.org/doi/abs/10.1021/acs.est.7b05593

TRAP INDOORS IN A NEAR-HIGHWAY RESIDENTIAL BUILDING

Example of data from a building near highway with a mechanical air handling system

Same pattern indoors in multiple apartments & outdoors of the building



- Coincident increase in PNC in all apartments and outside the building
- Concentrations of CO_2 approach ambient levels

KEY POINTS

1. Air pollution from highways and airports impacts indoor air quality in homes
   - Higher concentrations of particulate matter – ultrafine particles – were observed when winds oriented homes downwind of the sources

2. Impact depends on:
   - Proximity to source
   - Physical characteristics and ventilation practices of the home
   - We commonly observe I/O ratios >0.5 for ultrafine particulate matter

3. Impact and exposure is modifiable by use of appropriate technology and practices