Community Measurements of Aviation-Related Air Quality
Lessons Learned from Ultrafine Particle Studies In Boston, Massachusetts

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Particle Matter Pollution
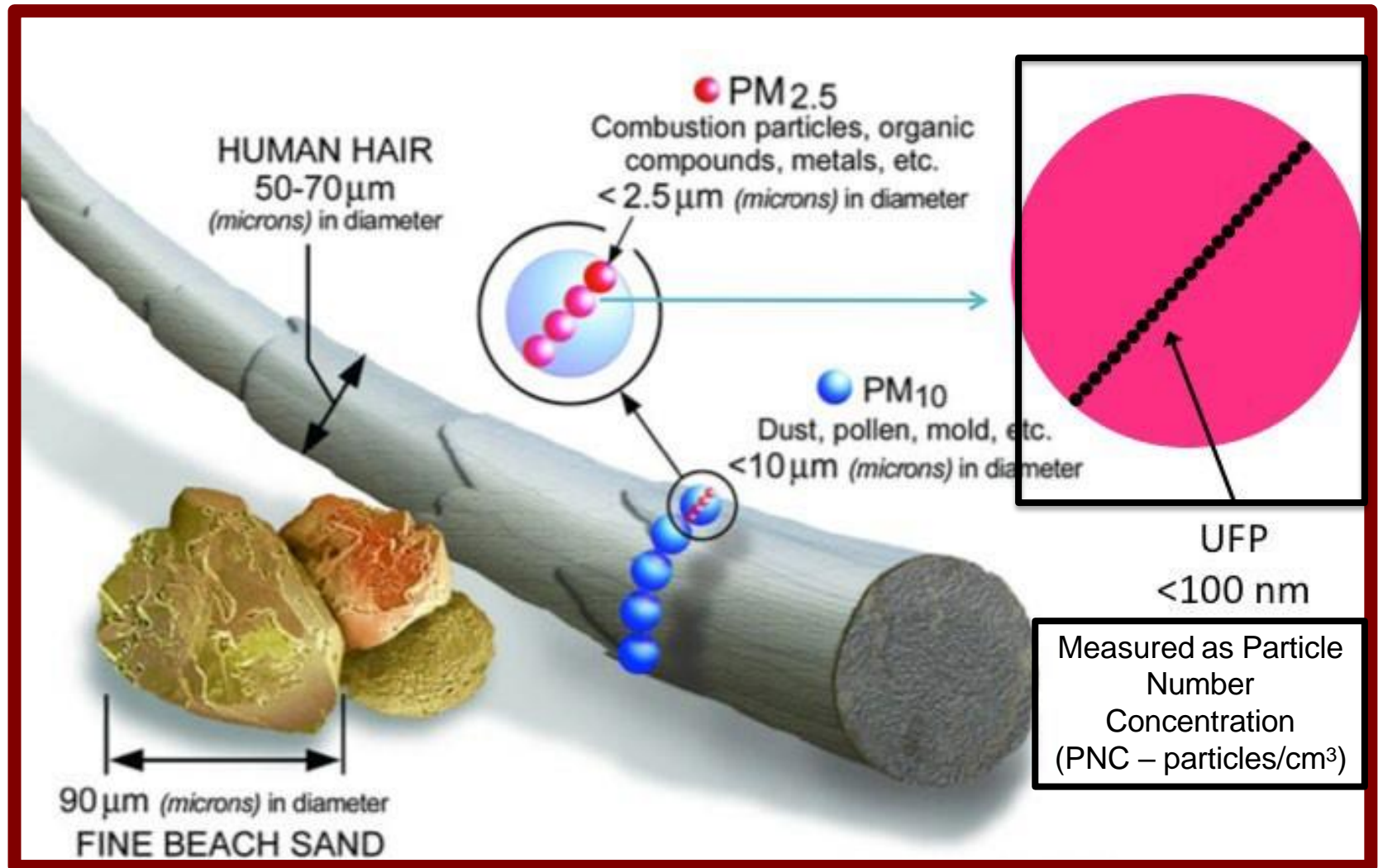
Background

- Ultrafine particulate matter: Particles < 100 nm in aerodynamic diameter
  - Typically combustion products
  - Large reactive surface area
  - Limited removal in lung
  - Potential to translocate ➔ effects beyond respiratory system

- UFP epidemiological evidence fairly limited 10 years ago, growing rapidly
  - Ohlwein 2019: 85 studies 2011-2017, including long-term studies

Recent EPA Integrated Science Assessment reports have consistently stated that improved exposure monitoring and health studies are needed

UFP Source Attribution

- High spatiotemporal variability

- Multiple contributing sources/source sectors
  - Mobile sources – automobiles and aircraft
  - Restaurants, wood burning, construction operations

- Lack of ambient monitoring infrastructure
  - Challenges in developing dispersion models
  - Imprecise exposure assessment for epidemiological studies

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Ultrafine Particle Research in Boston Area

Traffic-Related

Aviation-Related

Time-Activity and Accurate Geocoding is Important for UFP Exposure Assessment in Health Studies
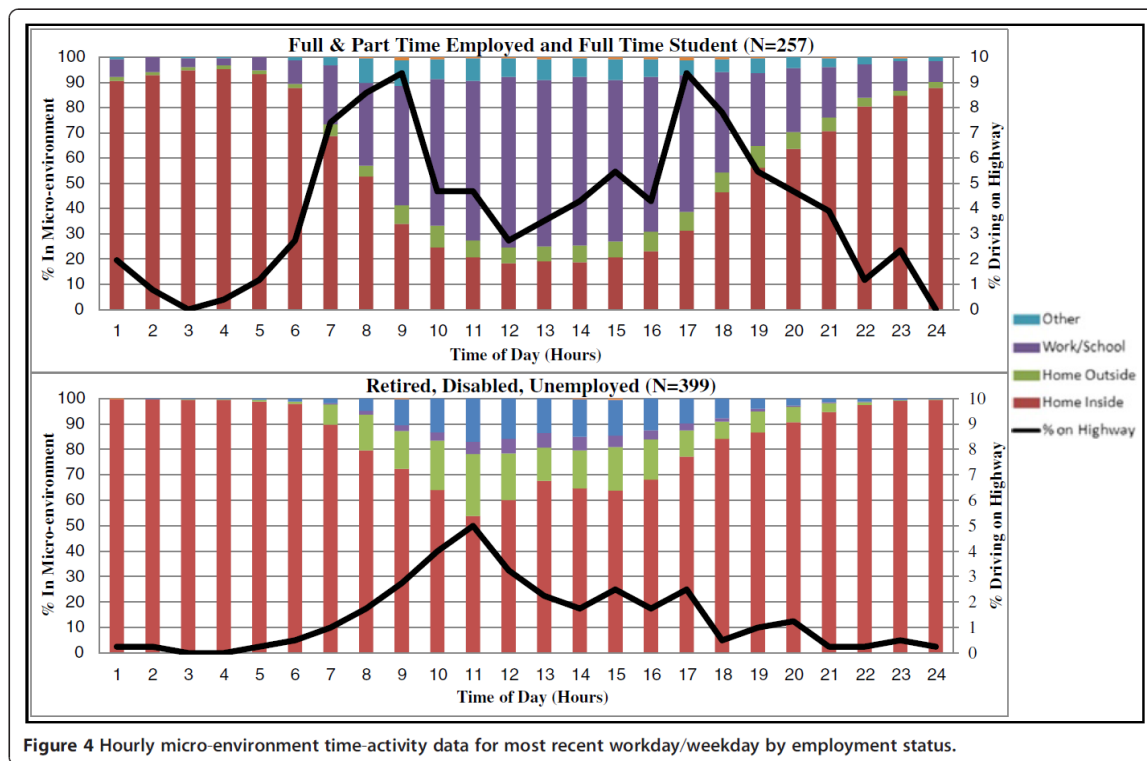

Figure 4 Hourly micro-environment time-activity data for most recent workday/weekday by employment status.
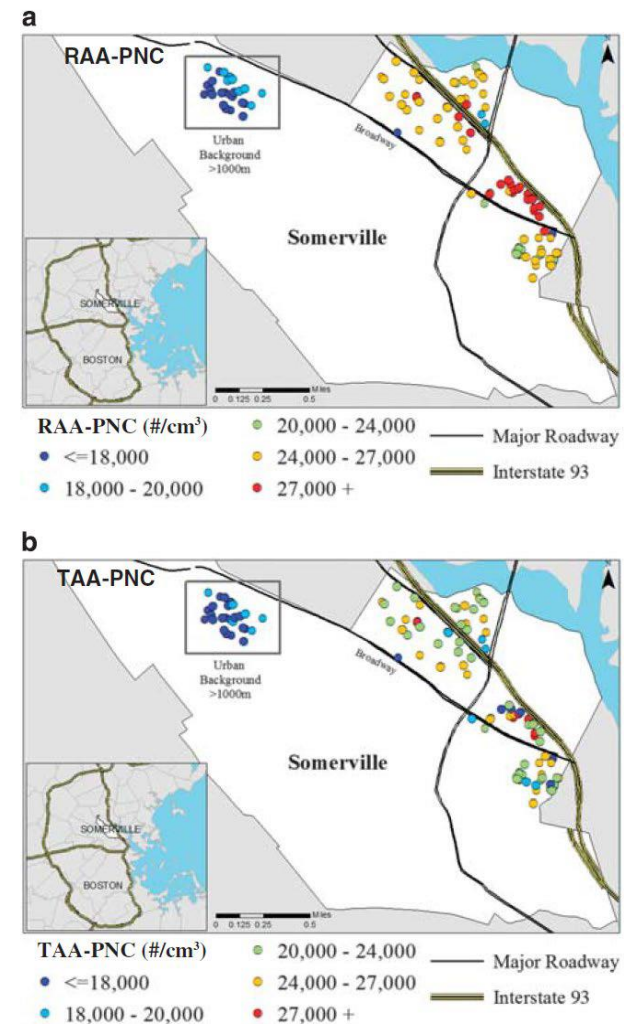

Figure 1. Comparison of residential ambient annual average PNC and time-activity adjusted PNC ($n = 140$ participants).

Time-Activity and Accurate Geocoding is Important for UFP Exposure Assessment in Health Studies
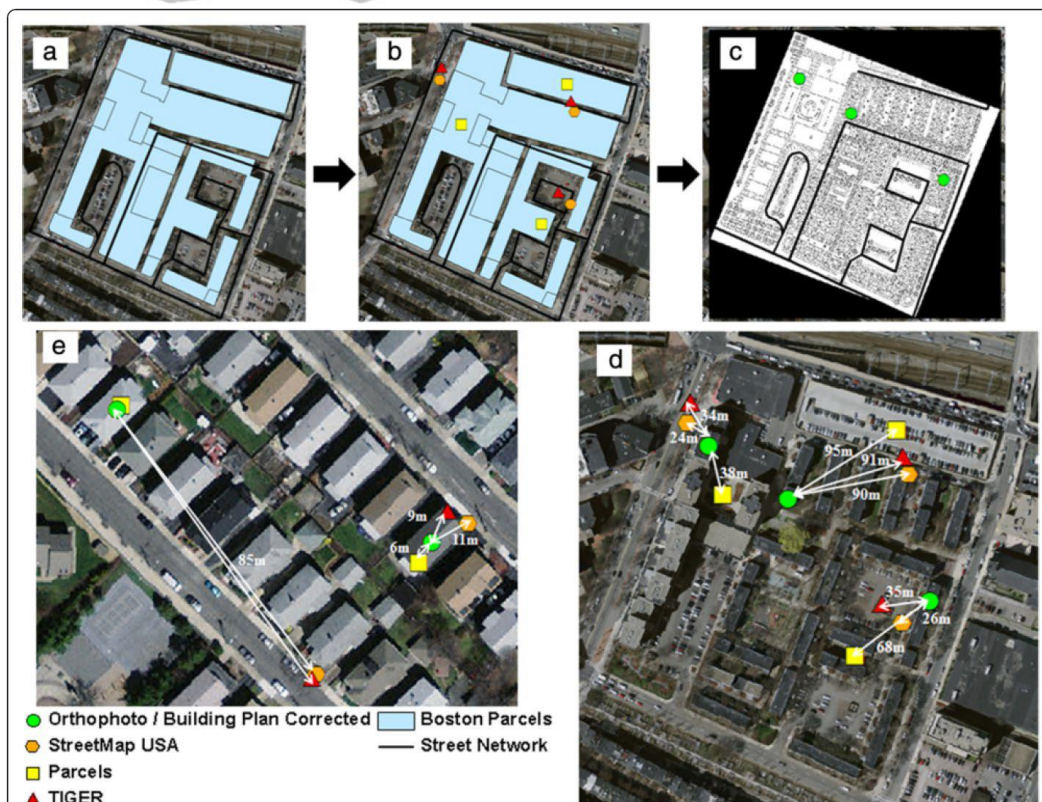

Figure 2 Example for ascertaining true ground location and determining positional error for large multi-building parcels and single/multi-family home (i.e. duplexes and triple-deckers). a. Example of a large multi-building parcel with both senior and affordable housing
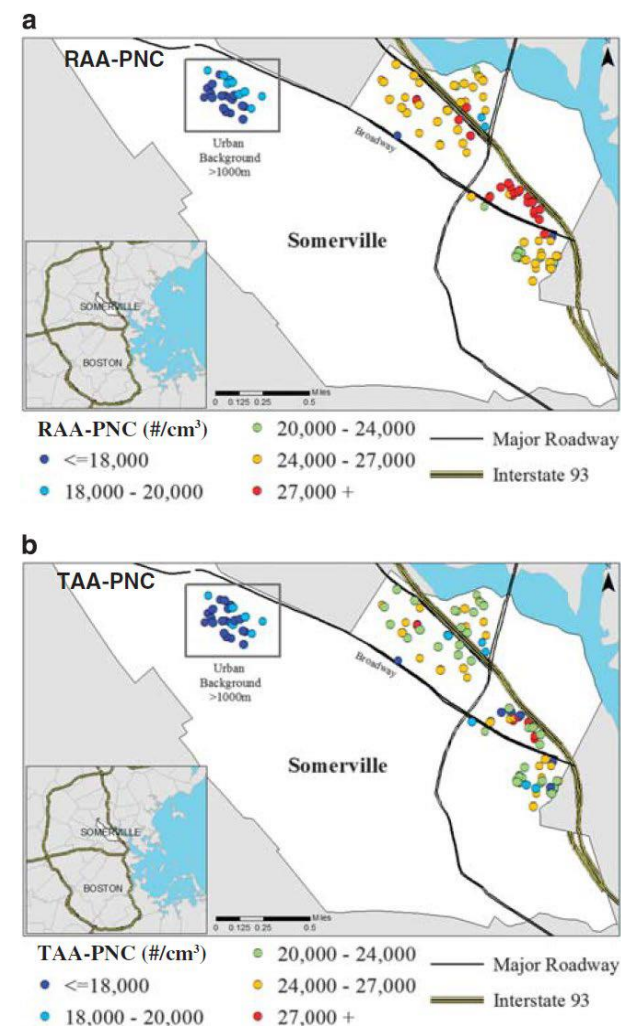
- ● Orthophoto / Building Plan Corrected
- ● StreetMap USA
- □ Parcels
- ▲ TIGER
- ▨ Boston Parcels
- — Street Network

Figure 1. Comparison of residential ambient annual average PNC and time-activity adjusted PNC ($n = 140$ participants).

RAA-PNC (#/cm^3)
- ● $<=18,000$
- ● $18,000 - 20,000$
- ● $20,000 - 24,000$
- ● $24,000 - 27,000$
- ● $27,000 +$
- — Major Roadway
- — Interstate 93

TAA-PNC (#/cm^3)
- ● $<=18,000$
- ● $18,000 - 20,000$
- ● $20,000 - 24,000$
- ● $24,000 - 27,000$
- ● $27,000 +$
- — Major Roadway
- — Interstate 93

Lane *et al. Environmental Health* 2013, **12**:75

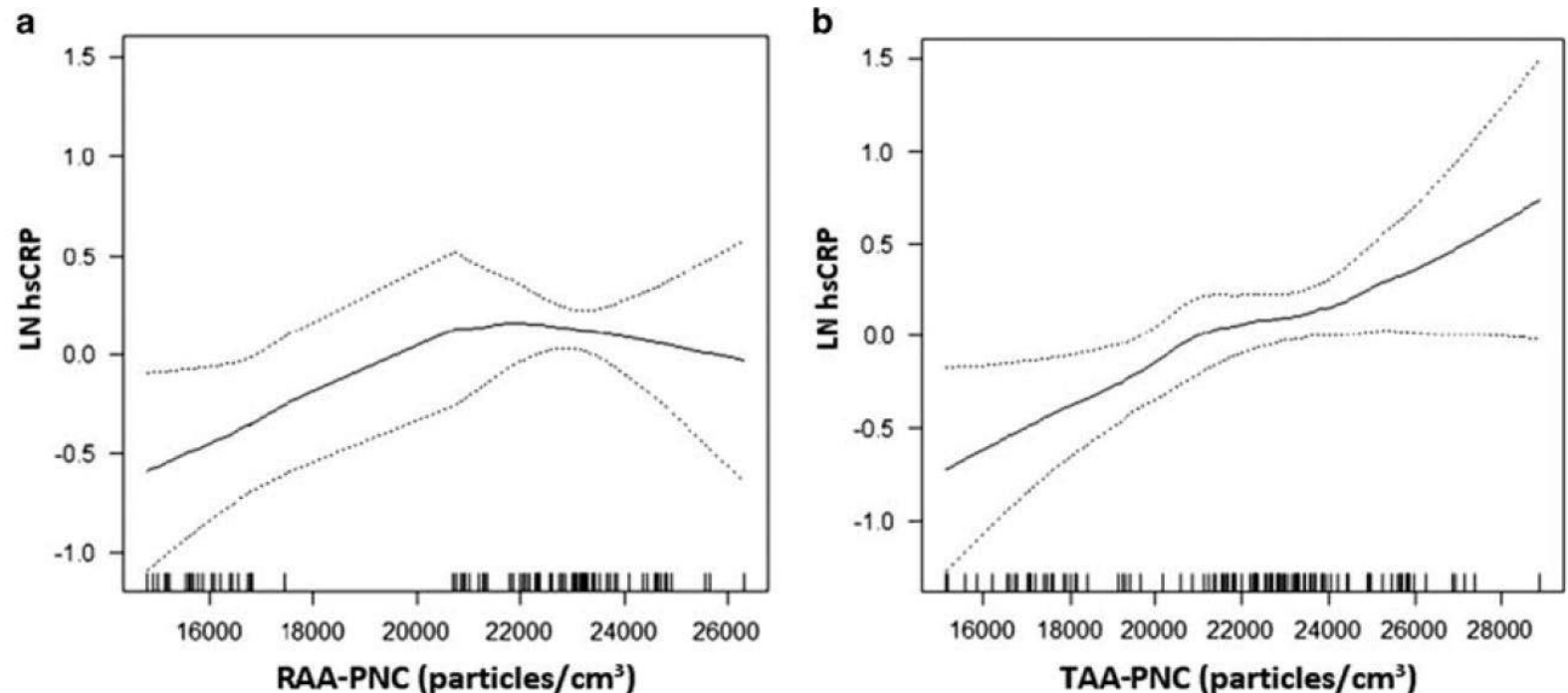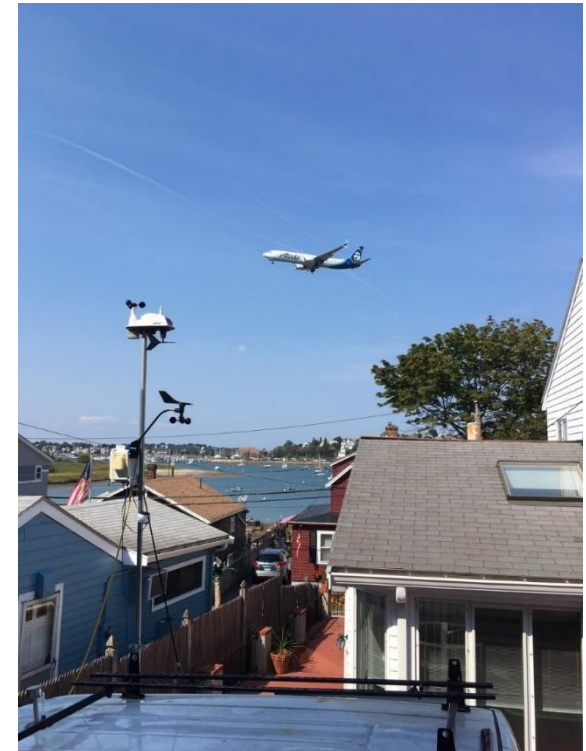# Accurate UFP exposure assignment can affect associations with health measures in meaningful ways:

Figure 3. GAM model comparison of the effect of PNC exposure models on LN hsCRP.

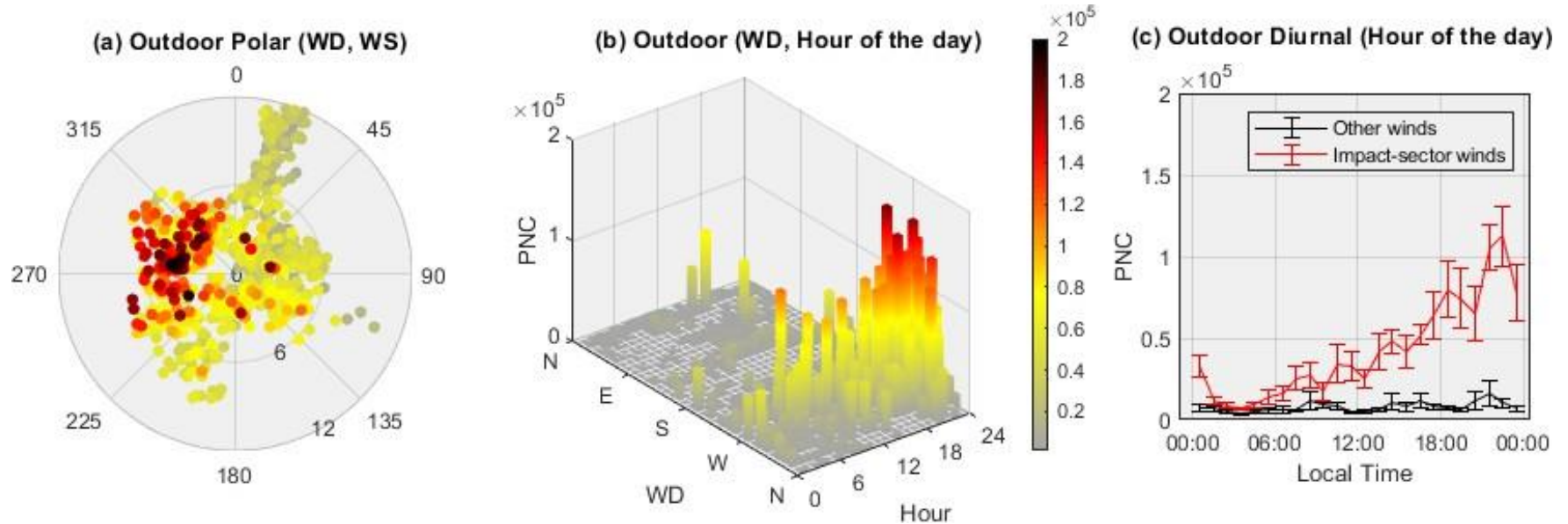# Ultrafine Particle Research in Boston Area

Traffic-Related

Aviation-Related

ASCENT Project 18: Community Measurements of Aviation Emissions Contribution to Ambient Air Quality

Ultrafine particle number concentrations vary with wind direction, time of day and runway usage

(a) Polar plots of outdoor **Particle Number Concentrations** (PNC) at hourly resolution; radial axis shows wind speed in m/s. (b) PNC patterns with respect to wind direction (WD) and hour of the day; data was binned into 36, 10-degree-wide WD and 24 hourly bins. (c) Average diurnal trend for outdoor PNC for impact-sector and other winds.

Hudda et al., 2020

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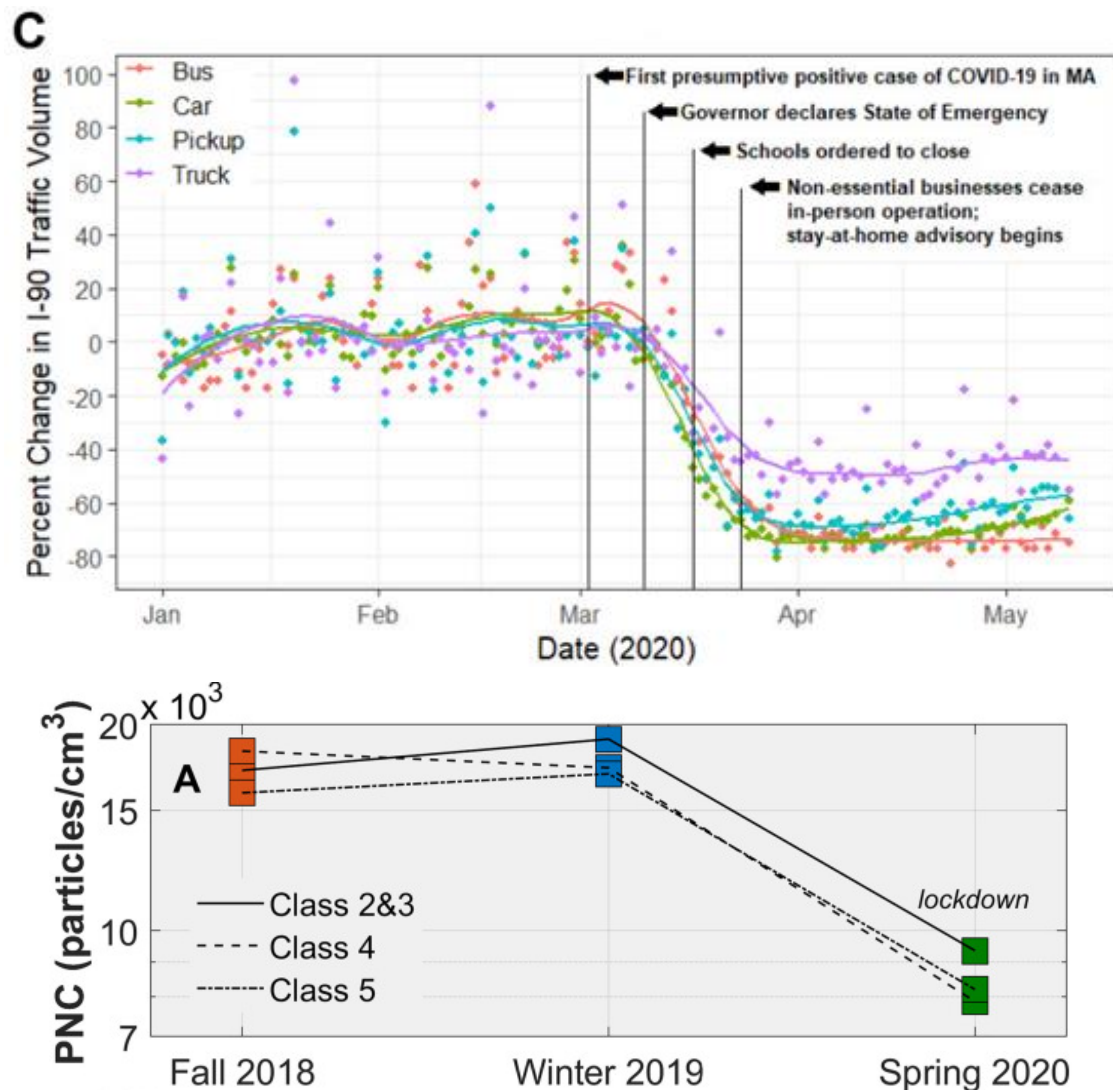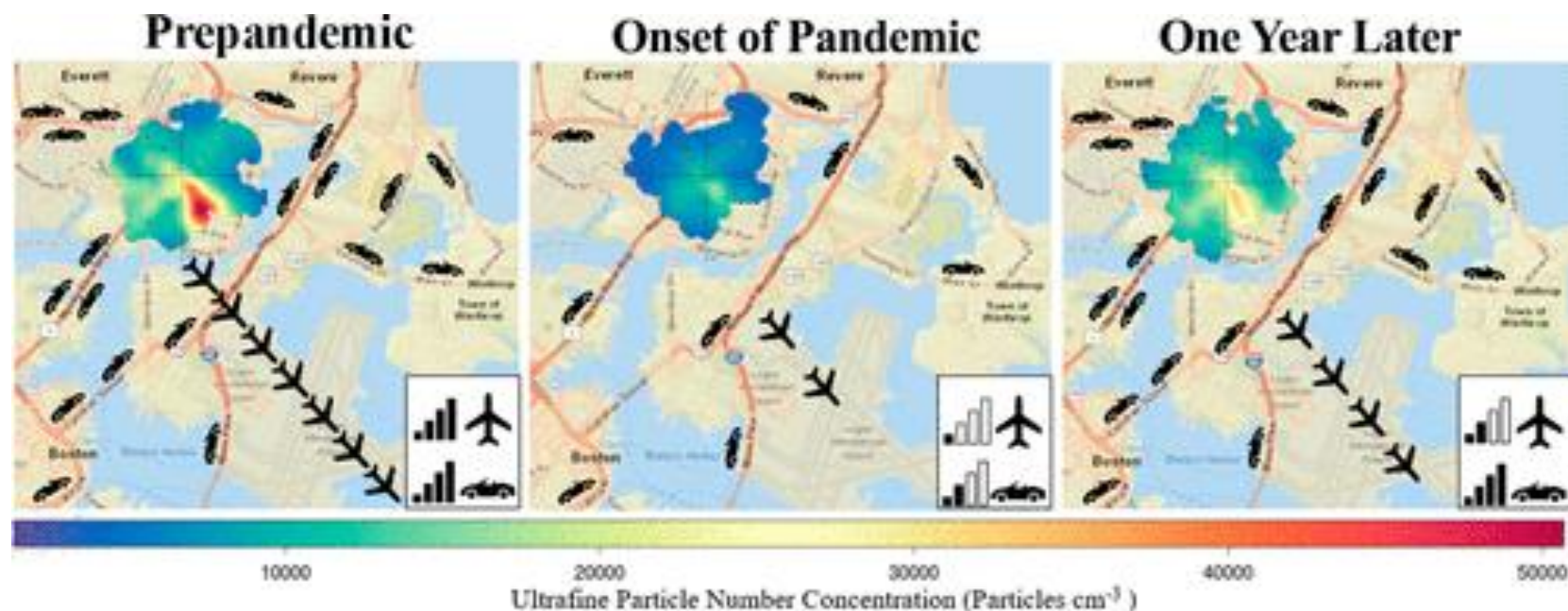
UFP During COVID-19

Fig. 2 (C) Percent change in daily median traffic volume (relative to median January 2020 weekday and weekend/holiday traffic volumes) on I-90 near downtown Boston between January 1 and May 10, 2020 for four vehicle types. Solid lines represent loess (local regression) fit trend lines.
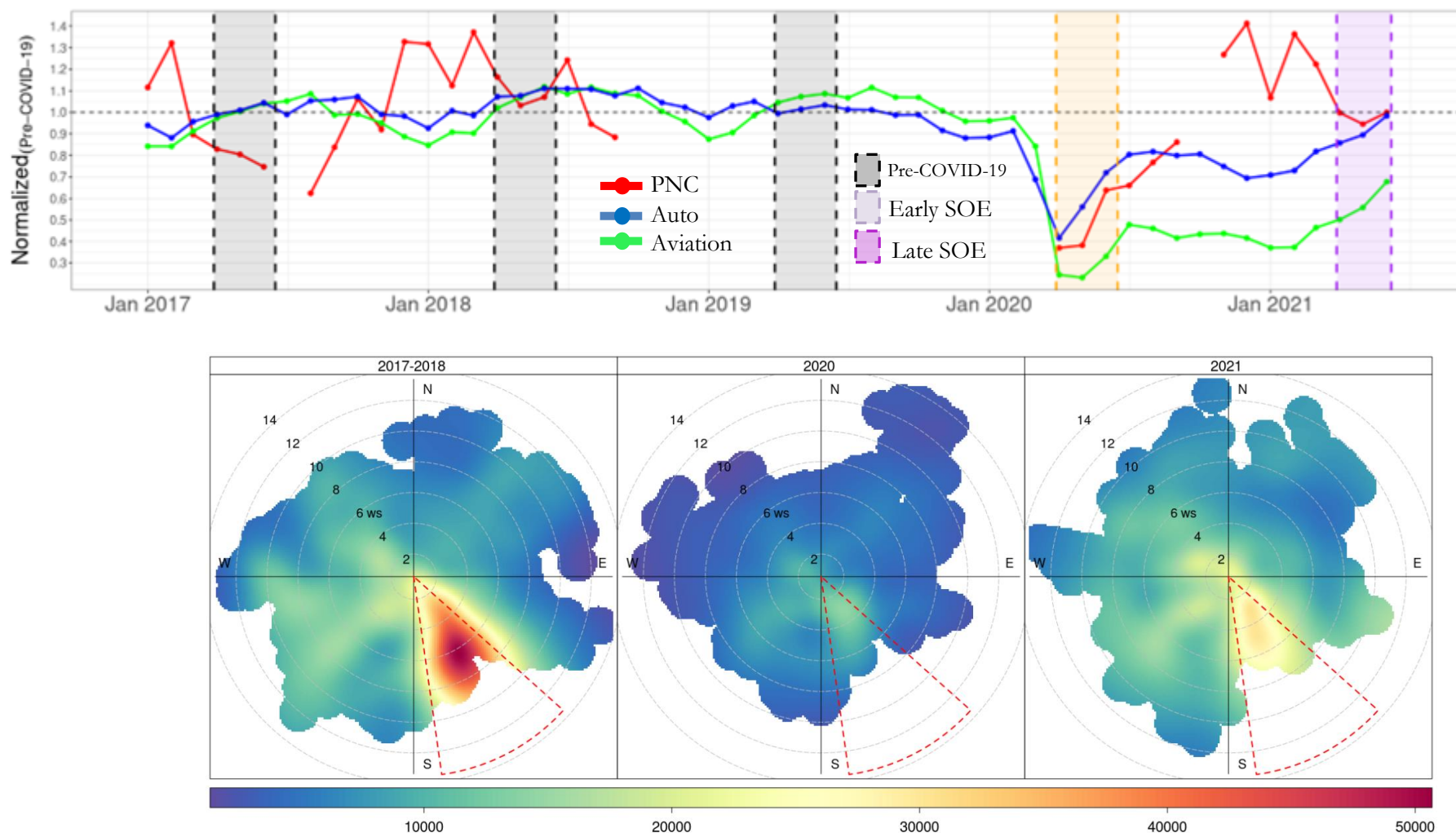
Hudda et al .2020 ES&T

Changes in Ultrafine Particle Concentrations near a Major Airport Following Reduced Transportation Activity during the COVID-19 Pandemic

Sean C. Mueller*, Neelakshi Hudda, Jonathan I. Levy, John L. Durant, Prasad Patil, Nina Franzen Lee, Ida Weiss, Tyler Tatro, Tiffany Duhl, and Kevin Lane

Ultrafine Particle Number Concentration (Particles·cm⁻³)

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Time series of aircraft activity, traffic and PNC.

Mueller SC, Hudda N, Levy JI, Durant JL, Patil P, Lee NF, Weiss I, Tatro T, Duhl T, Lane K. Changes in Ultrafine Particle Concentrations near a Major Airport Following Reduced Transportation Activity during the COVID-19 Pandemic. Environ Sci Technol Lett. 2022 Sep 13; 9(9):706-711.View Related Profiles. PMID: 36118960; PMCID: PMC9477096; DOI: 10.1021/acs.estlett.2c00322;
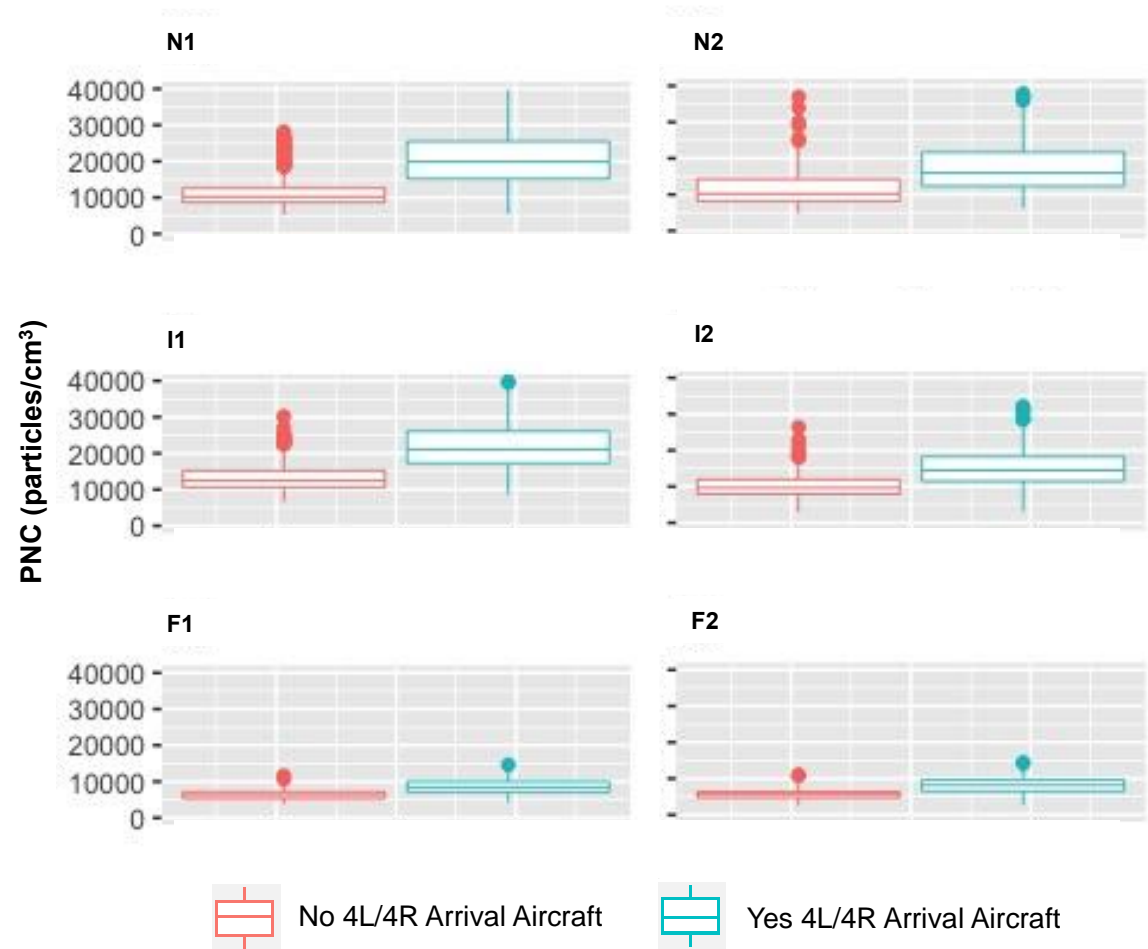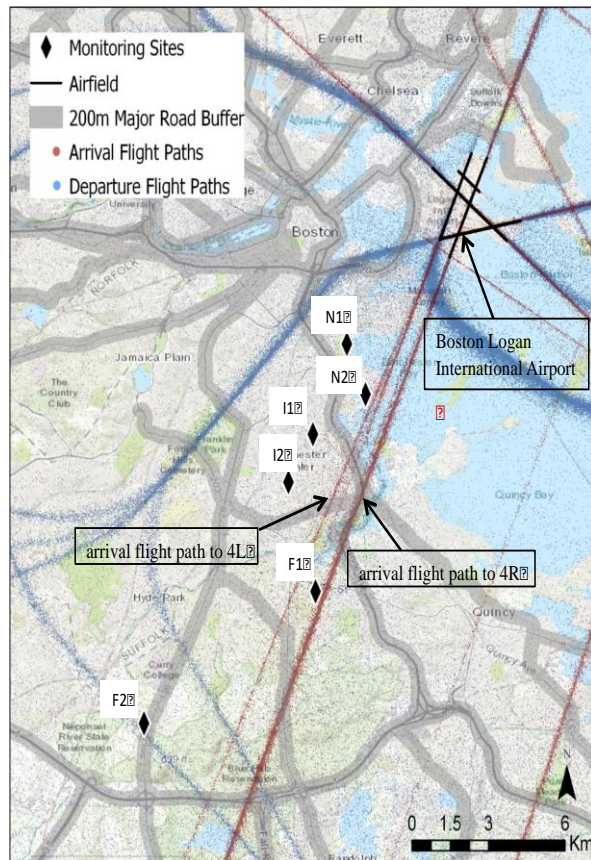
Mueller et al. 2022

<u>What Did we Find</u>

• PNC levels reduced 48% on average during COVID state of Emergency.

• PNC levels during had largest reduction in in the impact sector and hours of typically LTO.

• During the late SOE mean PNC remained lower than pre-pandemic levels for the impact sector but increased compared to the early SOE.

<u>Why is it important?</u>

• Natural experiment showed the iterative contributions of both traffic and aviation on community PNC levels over 18 months.

• Aviation does increase local PNC, but in a distinct spatial and temporal way to a community.

• Long-term monitor campaigns can capture changes in air pollution from different sources and attribute to changes in emissions.

UFP Spatial-temporal regression model

Chung et al. 2023

What Did we Find

- Being closer to the airport (< 5 km) showed signficantly higher PNC during high arrival flight activity (flights > 30 arrivals/hour).
- Arrival flights contributed about **50% of total PNC** at the closest site to the airport (N1) when in ideal impact sector and high arrival flight activity.
- This represented only **27% of the hours of exposure** in our dataset.

Why is it important?

- Evidence that arrival flight activity contributes to increased levels of UFP, measured as PNC.
- Higher PNC levels are found in communities close to and downwind from the airport and major arrival flight paths.
- The high spatial and temporal variability of exposures reinforced the need for highly accurate personal exposure modeling for health studies.

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Summary

- Contributions of aircraft to UFP concentrations are complex to characterize and vary greatly in time and space, and ultimately require fit-for-purpose monitoring and appropriate statistical analyses
- Health studies need to account for multiple sources of UFP air pollutants and time-activity will be an important consideration to ascertain health associations.

- Key challenges/barriers
  - Developing physically interpretable insights about arrival/departure contributions
  - Considering air pollution impacts within a broader exposure/health context
  - Current approaches to assigning exposure to air pollution health impacts may not be sufficient.

Project 18 Team

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- Tyler Tatro (former Student Assistant now PhD Student)
- Ida Weiss (Former MS Student)
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Acknowledgements

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