ASCENT Project 18

Lead investigator: Kevin J. Lane, PhD
ASCENT Team: Jonathan I. Levy, ScD; John Durant, PhD; Neelakshi Hudda, PhD
Boston University School of Public Health
Project manager: Mohammed Majeed, FAA

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Project 018

Measurements of Aviation Emissions Contribution to Ambient Air Quality

Boston University

PI: Kevin Lane, PhD, MA

PM: Mohammed Majeed

Cost Share Partner(s): Women’s Health Study Initiative

Objective:

- Measure aviation-related air pollution such as ultrafine particles (UFP), Nitrogen Dioxide (NO2) and Sulfur Dioxide (SO2) using a stationary and mobile monitoring platform in communities near Boston Logan Airport.
- Using statistical modeling approaches, quantify the contribution of UFPs measured to near airport air pollution.
- Use measurements collected at Boston to validate dispersion models of aviation-contributions to ambient air quality

Project Benefits:

- Improved understanding of aviation-related UFP impacts near airports.
- Pairing of empirical monitoring data and source attribution models to validate dispersion models that could be applied at airports across the US.

Research Approach:

- Collection and analysis of air pollution measurements UFP, NO/NO2 and SO2.
- Stationary sites and mobile monitoring are being conducted continuously at varying distances from flight paths for Boston Logan International Airport and Dulles International Airport.
- Statistical analyses of stationary and mobile measurements with flight activity data and meteorology to determine aircraft contributions to ground measurements for source attribution.

Major Accomplishments (to date):

- Collected air pollution using stationary sites and mobile platform at Boston Logan and Dulles airports.
- Published five manuscripts and have another two in development.
- Developed a best practices technical document for the study of UFPs near airports.
- Presented research findings at 8 scientific conferences and MA state public hearings on the state of the UFP science and health.

Future Work:

- Under next scope of work, we will be increasing monitoring at Dulles to include NO/NO2 and SO2.
- Conduct transferability analysis of UFP machine learning models developed in Boston to Dulles UFP sites.

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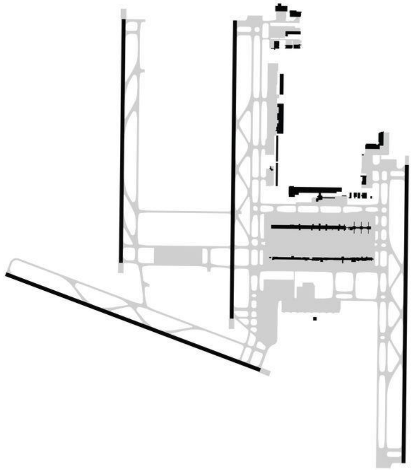
Introduction

- Motivating questions answered in the context of ongoing UFP monitoring and modeling efforts:
  - Can we distinguish an airport's impact on air quality in downwind areas nearby?
  - How large is the impact?
  - How do we develop a generalized understanding of impact around airports?
  - Are PNC models transferable?

- Current issues in advancing the findings:
  - Scaling, generalizing and doing it efficiently.
  - Dispersion modeling for UFP

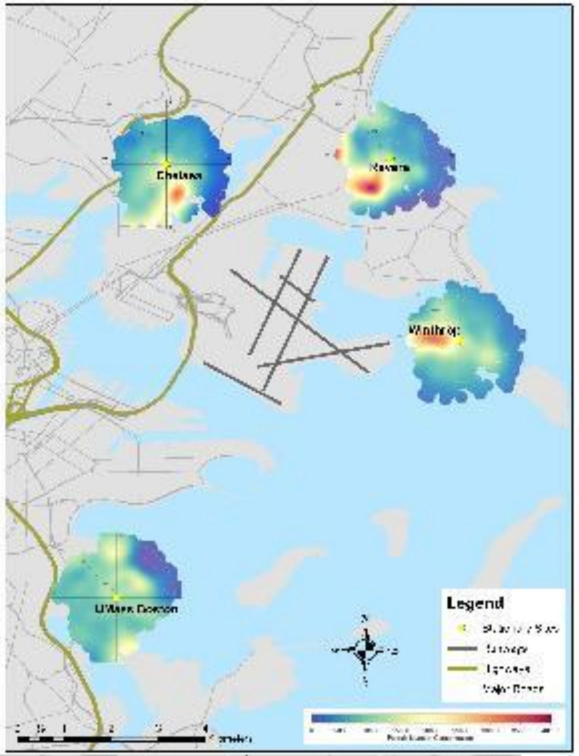
Boston Logan International Airport

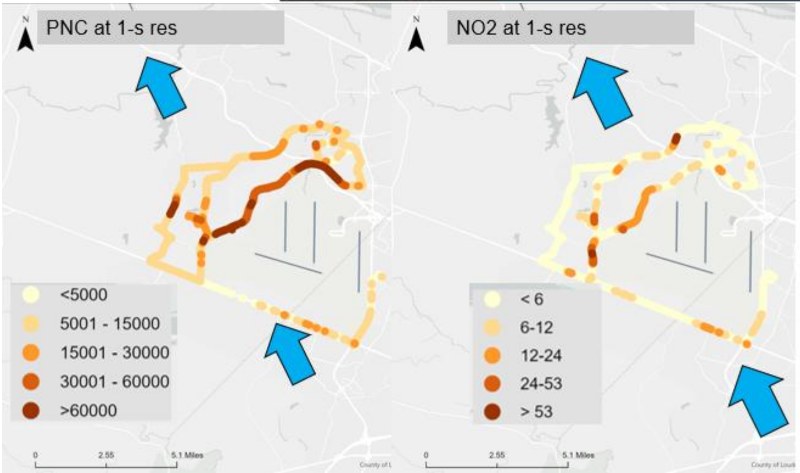


Dulles International Airport

Introduction

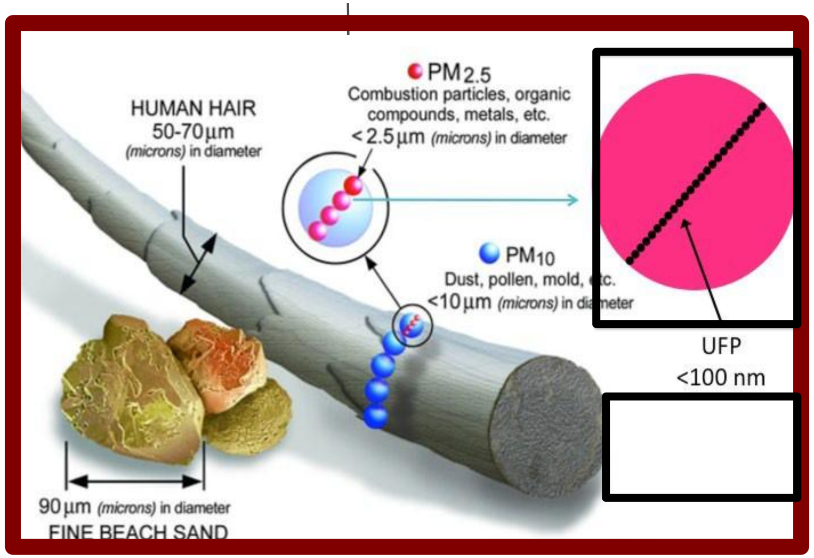
- Objectives:
  - Measure aviation-related air pollution such as ultrafine particles (UFP) using stationary sites and a mobile monitoring platform in areas near airports.
  - Quantify the contribution of ground-based and in-flight activity to near-airport air pollution.
- Outcomes and practical applications:
  - Improved understanding of aviation-related UFP near airports.
  - Pairing of empirical monitoring data used for source attribution to validate dispersion air pollution models that could be applied at airports across the US.
  - **Models can be applied to health impact studies to quantify negative outcomes as well as potential benefits of reduced air pollution (e.g., switching to SAF)**





UFP Exposure Modeling

- High spatial, temporal, and spatiotemporal variability
- Multiple contributing sources and source sectors
  - Mobile sources – automobiles and aircraft
  - Restaurants, wood burning, construction operations
- Lack of ambient monitoring infrastructure
  - Challenges in developing dispersion models (Lasport vPM, nvPM and total PNC)
  - Inaccurate exposure assessment for epidemiological studies



Schedule and Status

- Boston University Period of Performance extended through 2026
- ASCENT 018 NCE ended 9/30/2025
- Monitoring sites have been shut down and equipment has been stored
- Providing data to ASCENT 019 and publishing papers that were in progress
- Further analysis and planning for relaunch is under discussion

Recent Accomplishments and Contributions

Recent Publications

- Mueller S, Patil P, Levy J, Hudda N, Durant JL, Gause E, van Loenen BD, Bermudez M, Geddes JA, Lane KJ. Quantifying Aviation-Related Contributions to Ambient Ultrafine Particle Number Concentrations Using Interpretable Machine Learning. Environmental Science & Technology. 2025 Sep 11; 59(37): 19942-19952. DOI: 10.1021/acs.est.5c07989.
- van Loenen BD, Black-Ingersoll F, Durant JL, Levy JI, Patil P, Mueller S, Gause E, Hudda N, Bermudez M, Lane KJ. Aircraft Arrival and Departure Contributions to Ultrafine Particle Size Distribution in a Near-Airport Community. Environmental Science & Technology. 2025 Jul 1; 59(25):12853-12864. DOI:10.1021/acs.est.5c04799.

Recent Scientific and Public Hearing Presentations

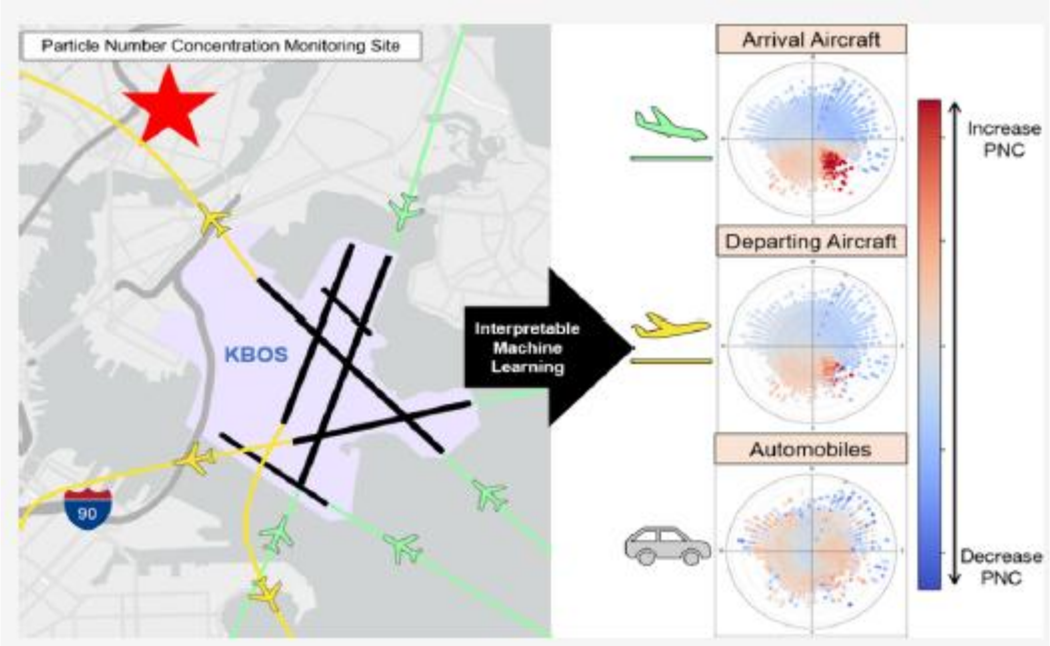
- KLane. “Health Effects of Fine Particulate Matter, Ultrafine Particle Exposure and Co-Benefits of SAF”. Presented at CAAFI Webinar Series: Air Quality & Non-CO2 Benefits of SAF. June 4, 2025.
- Klane. “Measurements of Aviation-Related Air Quality Lessons Learned from Ultrafine Particle Studies In Massachusetts”. Presented to the MEPA Review Committee. June 16, 2025.
- JDurant. “Mobile monitoring findings from ASCENT project 18 research”. Presented to the MEPA Review Committee. July 21, 2025.

- Discussion

Environmental Science & Technology
pubs.acs.org/est
Article

Quantifying Aviation-Related Contributions to Ambient Ultrafine Particle Number Concentrations Using Interpretable Machine Learning

Sean C. Mueller,* Prasad Patil, Jonathan I. Levy, Neelakshi Hudda, John L. Durant, Emma L. Gause, Breanna D. van Loenen, Maria Bermudez, Jeffrey A. Geddes, and Kevin J. Lane



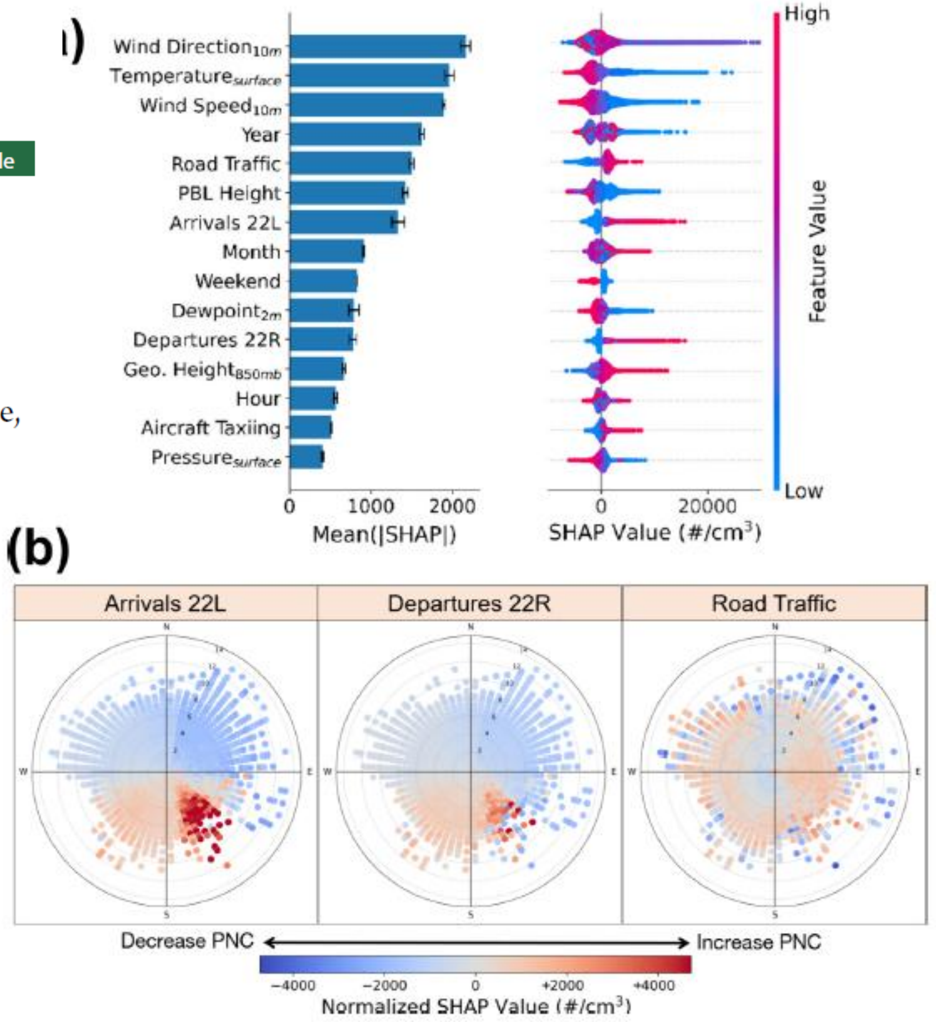


Figure 2. (a) Top 15 features ranked by mean absolute SHAP values (MASV), representing their contributions to predicted PNC (particles/cm^3). PBL height represents planetary boundary layer height, and Geo. Height represents the geopotential height at 850 millibars. Left: MASV with error bars (±1 standard deviation) across model runs (n = 10). Right: distribution of SHAP values colored by feature value. (b) Pollution roses showing binned hourly average SHAP values (normalized to 99th percentile) for aircraft arrivals on runway 22L, aircraft departures on runway 22R, and automobile road traffic, plotted against wind direction and speed.

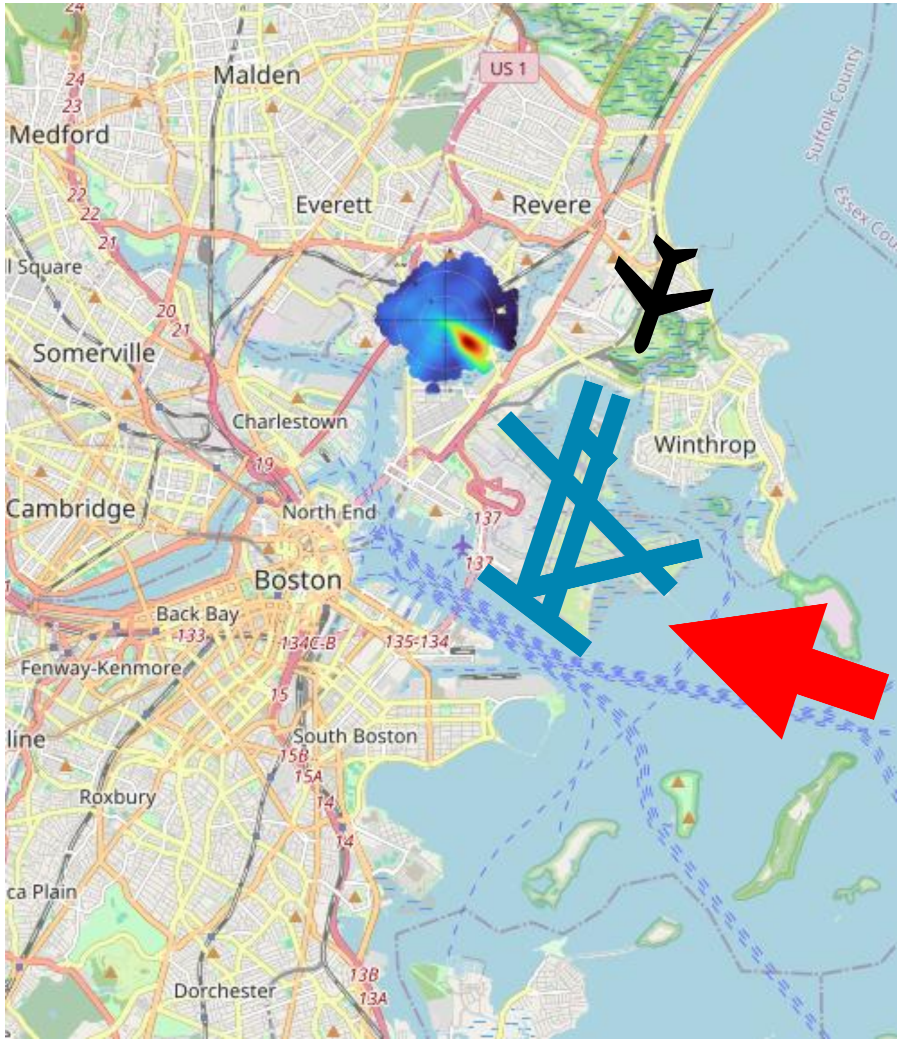
Mueller et al. 2025 Summary

What did we find?

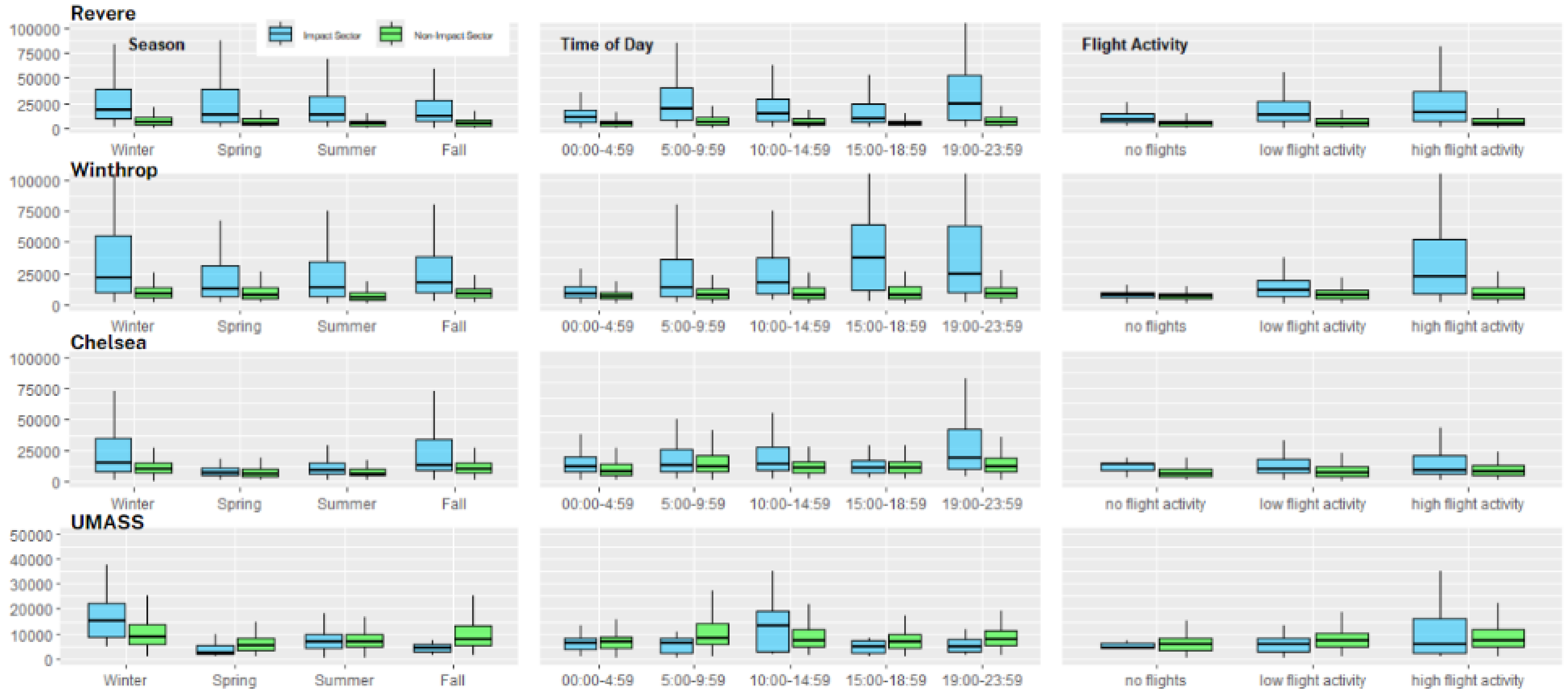
- Lateral plume dispersion during cross-wind conditions can expose areas not directly aligned with runway axes
- Accurate and interpretable modeling framework that can differentiate landing, takeoff, and taxiing operation contributions to near-airport PNC

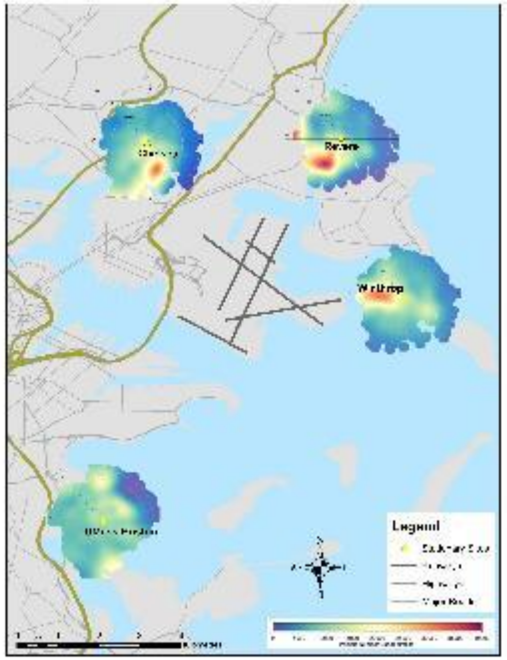
Why is this important?

- ML approach had robust prediction comparable to roadway modeled PNC.
- This work yields an hourly dataset of aviation-attributable PNC predictions rom 2014-2022 that could be used for future studies health studies

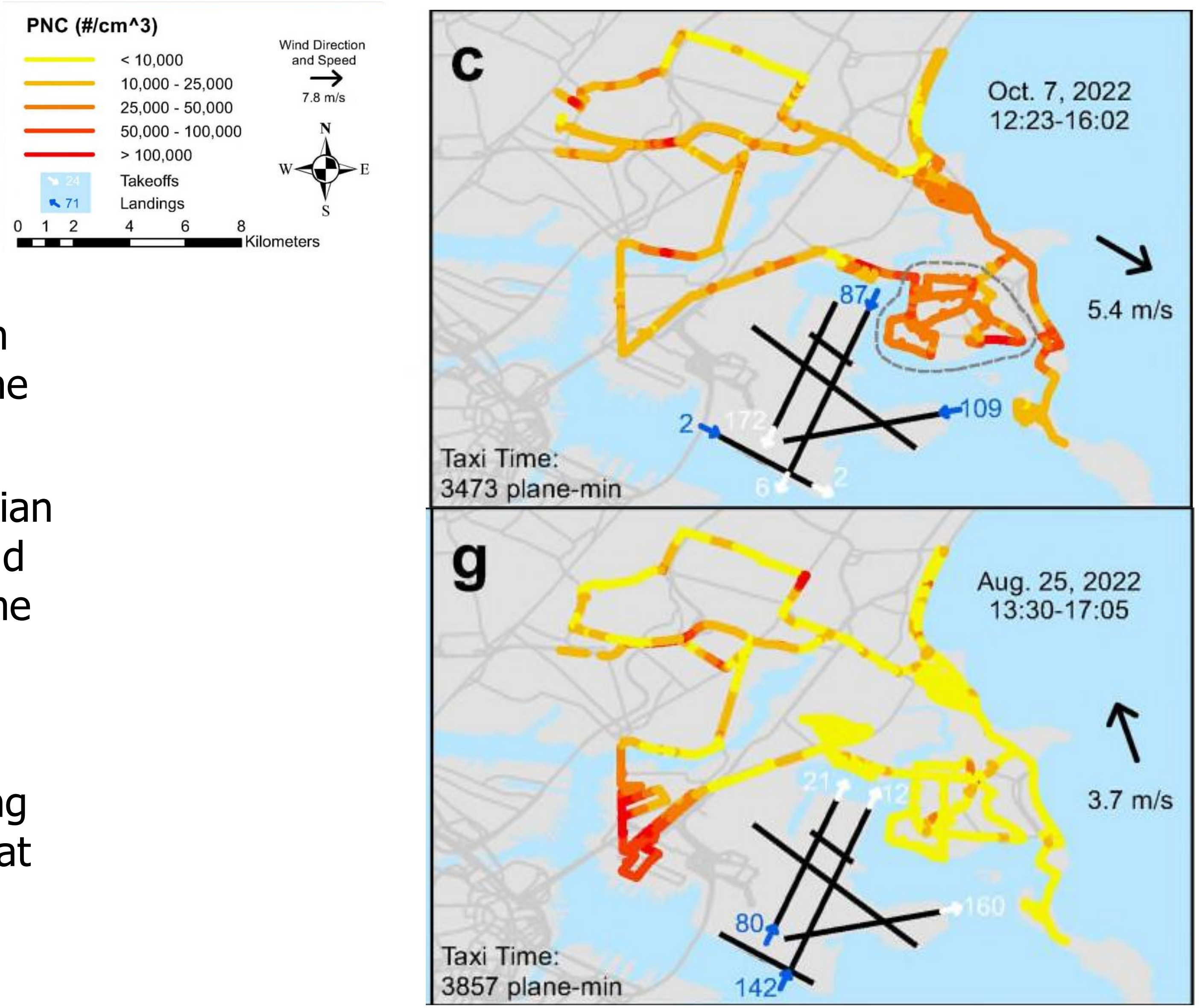


Temporal and spatial distribution of ultrafine particles in communities near Boston Logan International Airport.





Durant et al. (in preparation)



What did we find?

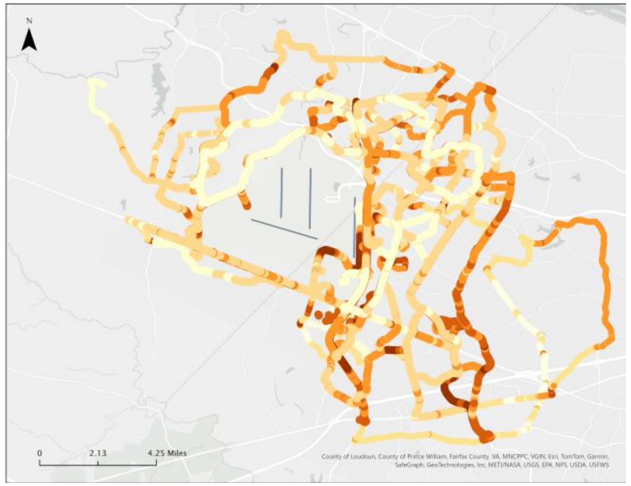
- Based on fixed-route mobile monitoring, median UFP was 2-fold higher in areas downwind of the airport compared to when these same areas were not downwind of the airport.
- Based on adaptive mobile monitoring, median UFP was ~10-fold higher in areas downwind of the airport compared to when these same areas were not downwind of the airport.

Why is this important?

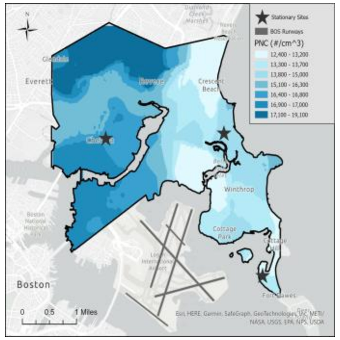
- Using both stationary and mobile monitoring together yields complementary datasets that lead to more complete characterization of impacts of aviation emissions on air quality areas in near airports

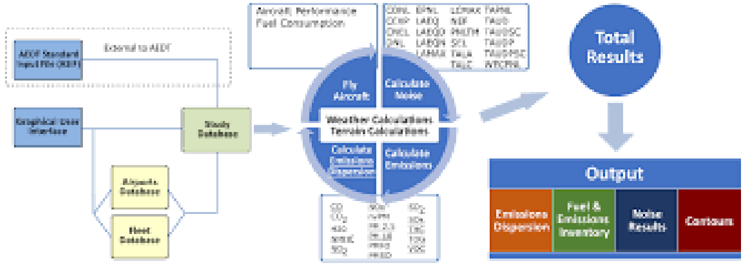
Future Work & Goal

Monitoring → Modelling → Generalizable Results



Empirical





Dispersion

(*Modelling validation with measurements)

Acknowledgements

Current Team Members:

- Prasad Patil, PhD
- Daniel Kojis, MPH (current doctoral student)

Past Team Members

- Sean Mueller, MS, PhD (now at MA DEP)
- Breanna Van Loenen, MS (Former RA, now PhD Student)
- Flannery Black-Ingersoll (Former RA, now PhD Student)
- Chloe Kim, PhD (Former PhD Student, now at ERI)
- Matthew Simon, PhD (Former Postdoc, now at Volpe)
- Tyler Tatro (Former Undergrad RA, now PhD Student)
- Ida Weiss (Former Undergrad RA, now an environmental consultant)
- Claire Scholleart (Former RA, now PhD Student
- Nina Lee Franzen (Former RA, now PhD Student)
- Kaustuv Ray (Former RA, now PhD Student)
- Luke Pautler, Isabelle Berman, Jules Finney, Marie Bermudez
- Camille Gimillaro, MS (now an environmental consultant)

Support

- FAA ASCENT Program
- Women's Health Study Cost share

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