ASCENT Project 18

Community Measurements of Aviation Emissions Contribution to Ambient Air Quality

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Cost Share Partner: Women's Health Study Initiative

Objective:

- Measure aviation-related air pollution such as ultrafine particles (UFP) using a stationary and mobile monitoring platform near Boston Logan International Airport.
- Quantify the contribution of flight activity to community air pollution.

Project Benefits:

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

Research Approach:

- Collection and analysis of community air pollution measurements UFP and NO2.
- Stationary sites and mobile monitoring are being conducted continuously at varying distances from flight paths for Boston Logan 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):

- We have collected air pollution data at stationary sites across multiple years during COVID-19.
- Over 900 hours of mobile air pollution data has been collected covering a wide variation of meteorology and ramp-up of aviation activities.

Future Work / Schedule:

- Analysis of mobile and stationary data used to identify aviation-related air pollution source attribution during COVID-19.
- Regression modeled source attribution estimates of UFP and NO2 and will be compared to outputs from dispersion models with ASCENT Project 19.

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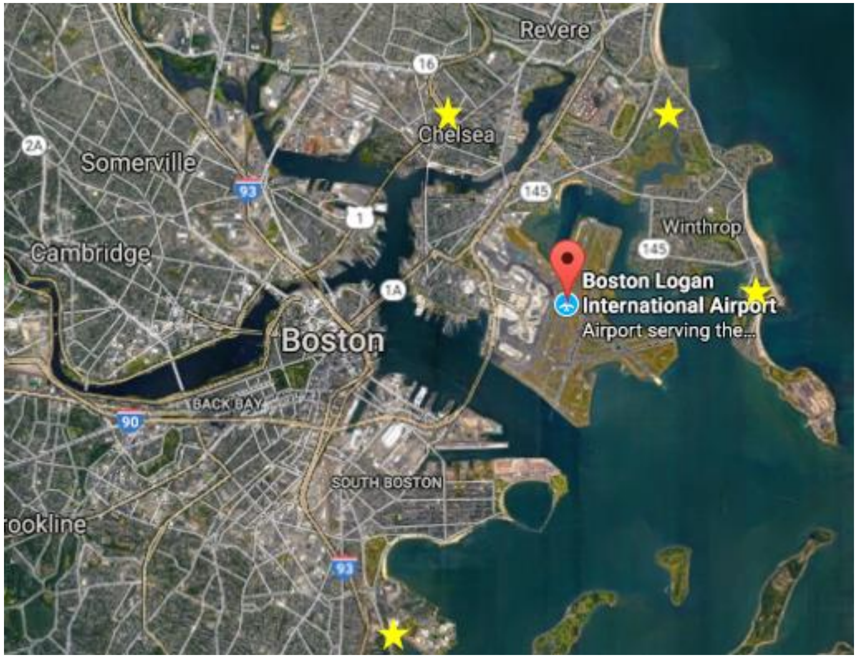
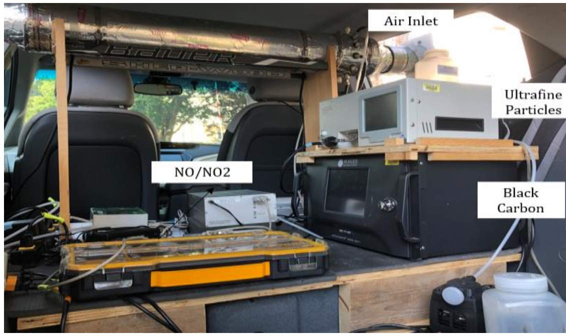
Stationary and Mobile Monitoring

- Expanded field campaign to address unanswered questions related to aviation source attribution
- Develop insights about spatiotemporal patterns of the aviation-attributable portion of multiple air pollutants, determining implications for potential studies of health effects
- Compare monitoring-based source attribution estimates with those derived from dispersion modeling (ASCENT 19)





UFP Aviation Source Attribution Analyses

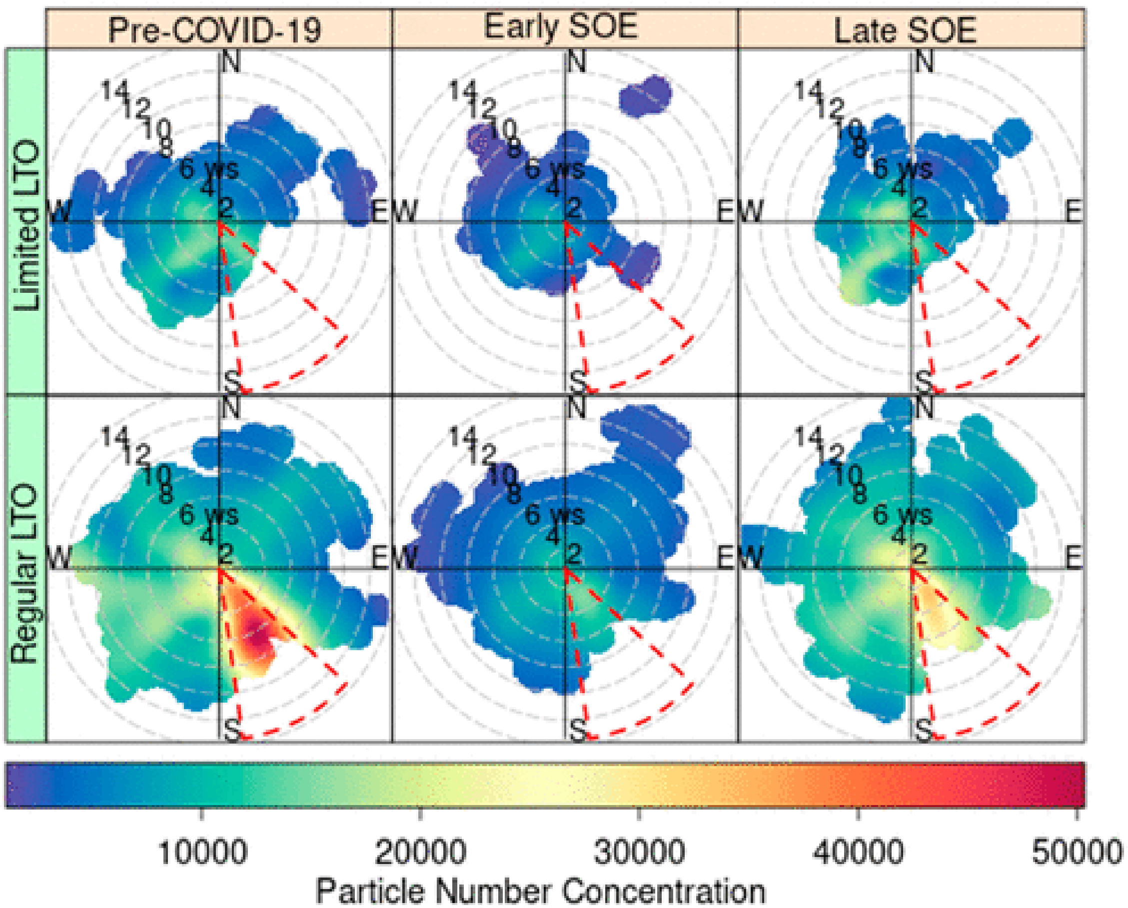
- Ongoing analysis of aviation contributions to ambient air quality using:
  - Total Particle Number Concentration (PNC)
  - Size distributed NV-PNC
  - Nitrogen Oxides (NO, NO2, NOx)
- Use statistical approaches to quantify ground operation and in-flight activity contributions to community measures.
  - Traditional statistical modeling
  - Principal component analysis
  - Machine learning regression (i.e. random forest modeling)
- Examine novel monitoring methods **mobile-monitoring** and **drone-sampling** flights for assessing spatial variation in air pollution from in-flight activity.

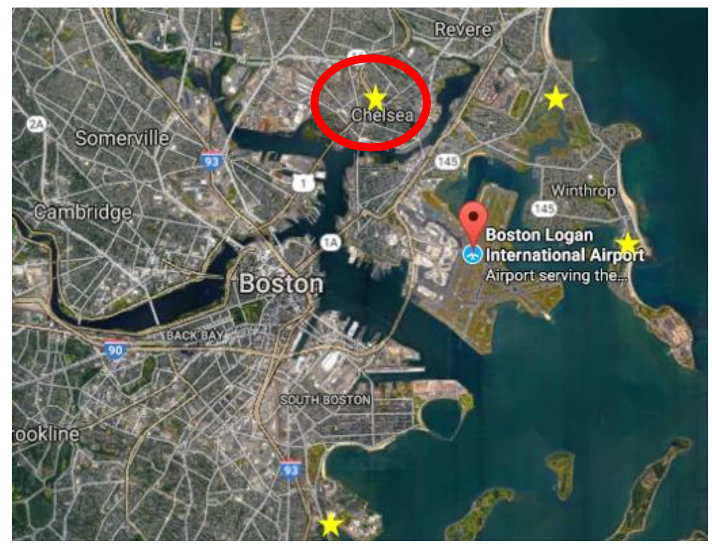
Aviation-related Air Pollution During COVID-19 Pandemic

COVID-19 UFP Analysis

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

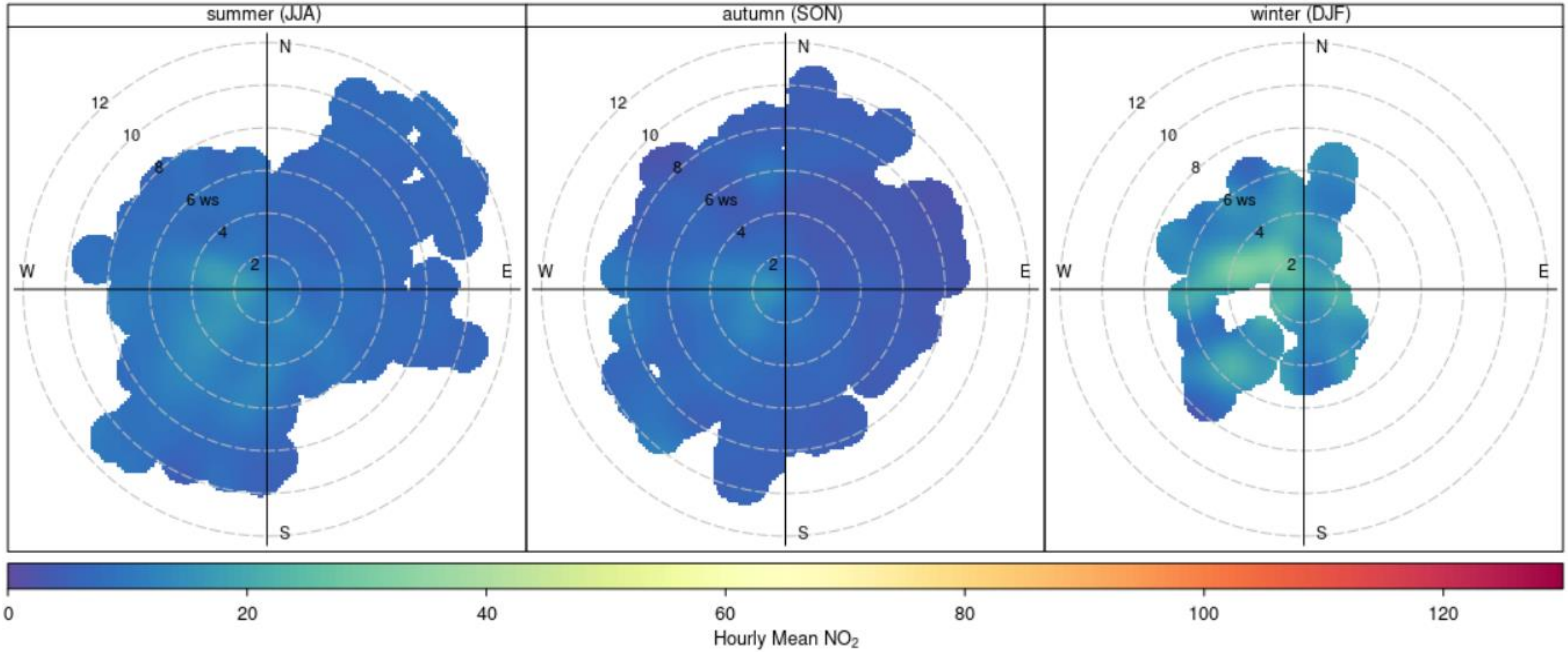




Mueller et al. 2022

Nitrogen Dioxide (NO2) During COVID-19 Analysis

Figure 3. Hourly average NO2 pollution rose plots for average hourly NO2 by season in 2021 for our Winthrop site in ppb.

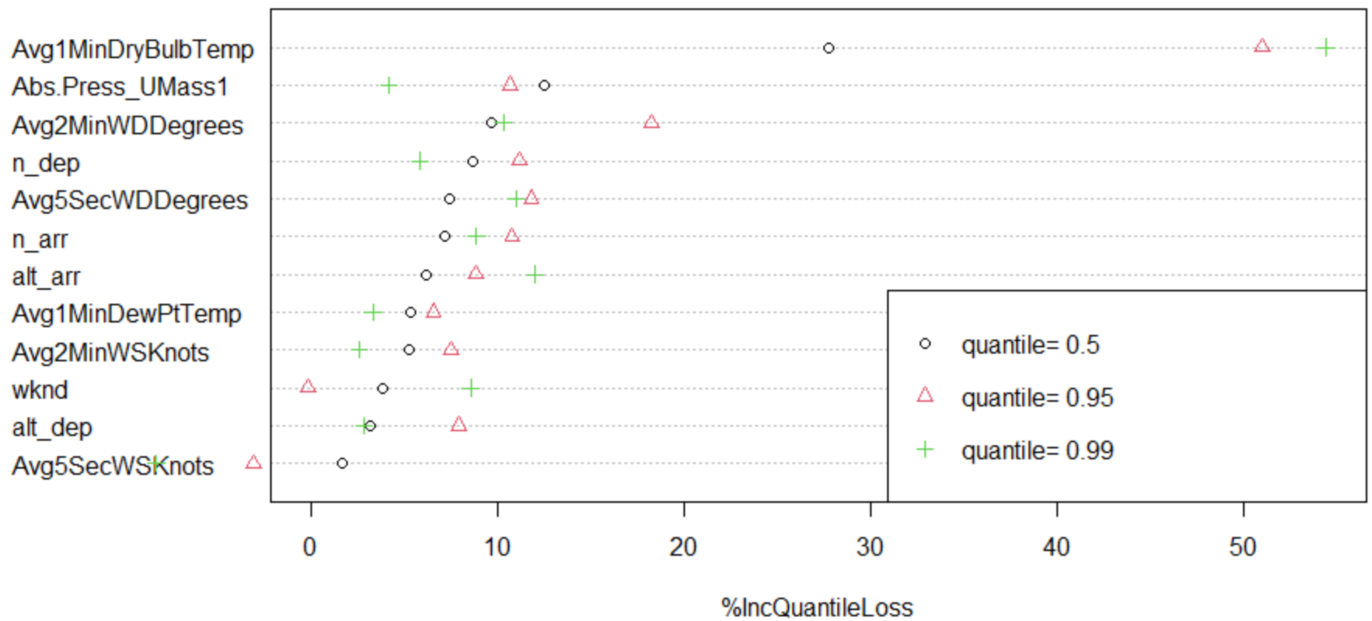


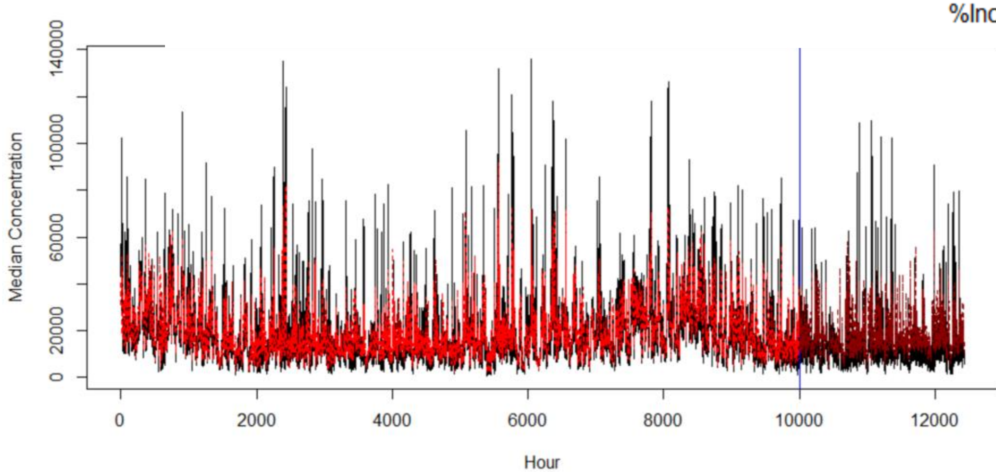
- NO2 concentrations during the sampling campaign have been below the EPA NAAQS 1-hour 100 ppb

Aviation-related Air Pollution Source Attribution Analyses

Machine Learning applications for UFP source attribution Analysis

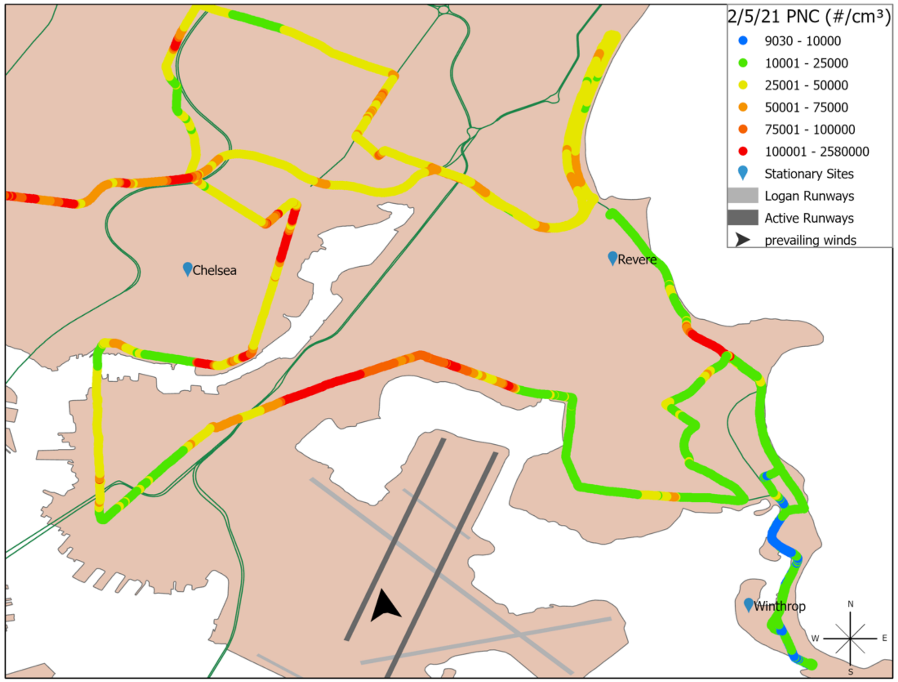
Quantile Random Forests help describe differential importance of meteorology and flight activity at different quantiles of UFP concentration.





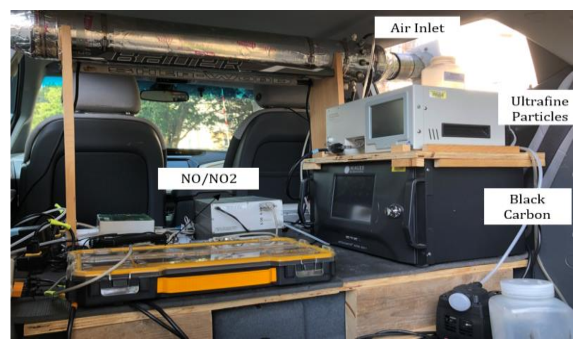
Random Forests with lag terms project median hourly UFP concentration, with an application in assessing how far below "normal" these concentrations fell during the COVID-19 early pandemic.

Mobile Monitoring

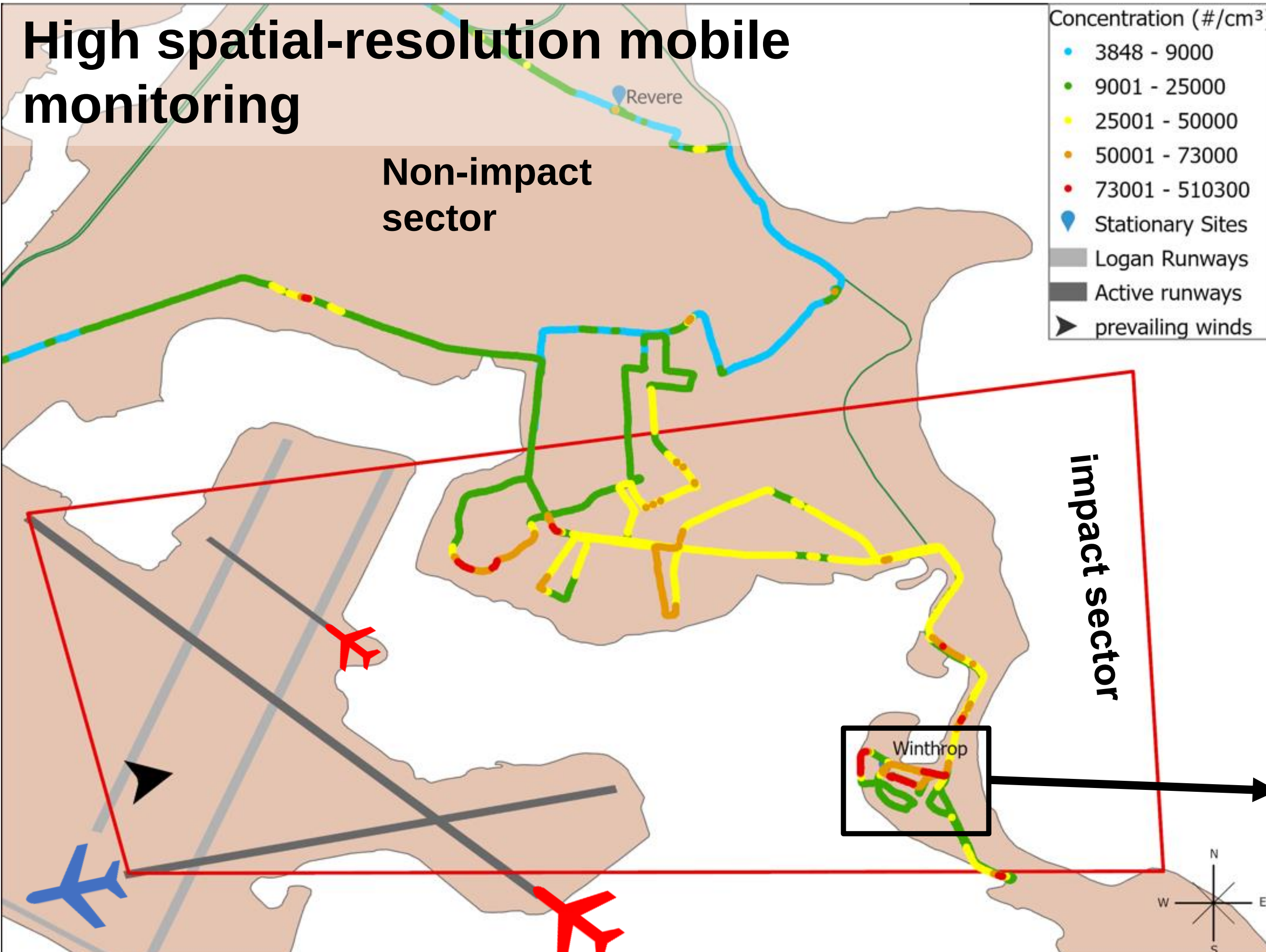


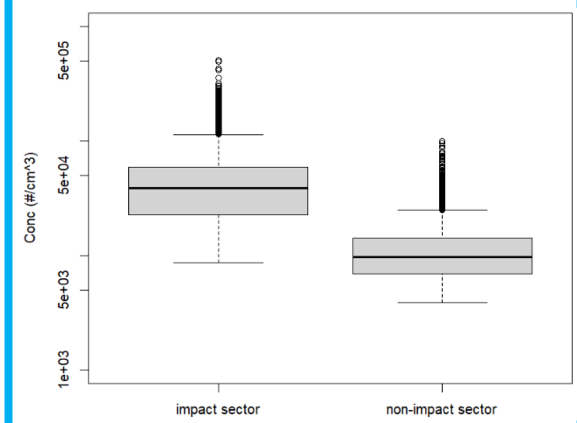
Goal: Assess whether mobile monitoring of aviation air pollution impacts can adequately capture spatial and fine-temporal scale variation in near-airport communities

- Compare spatially-resolved mobile monitoring to a limited number of stationary sites (n=3) to determine extent of aviation-related increases in urban UFP background levels
- Evaluate spatial extent of aviation impacts in neighborhoods downwind of airport using high spatial-resolution mobile monitoring
- Summarize spatial PNC trends as a function of influential variables (time of day, season, winds, aviation activity) in meteorologically-unique Boston area



High spatial-resolution mobile monitoring





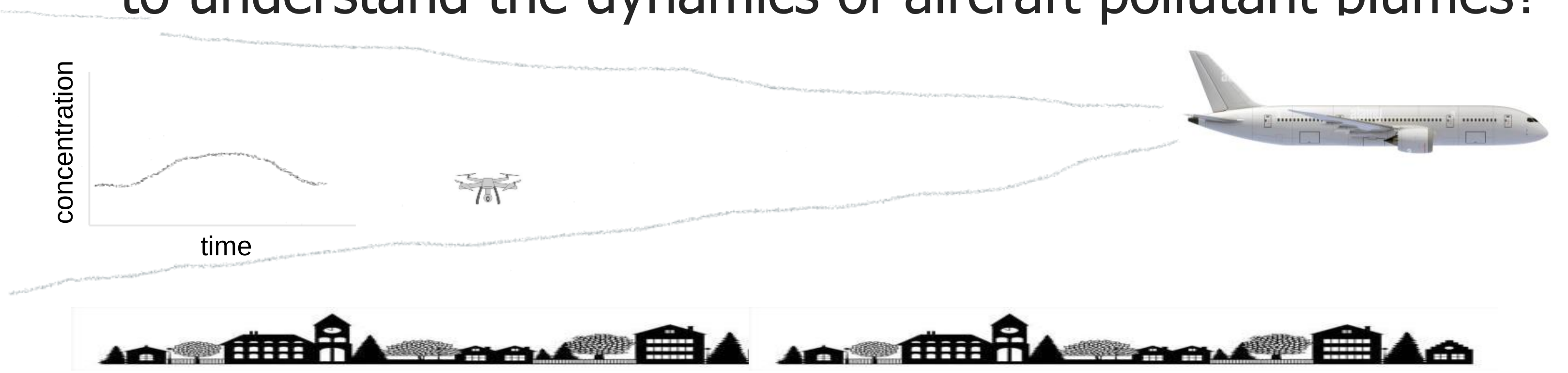
Median PNC 4-fold higher within runway impact sector compared to locations outside impact sector

Morning (7:30-9:30) PNC, W winds, 15 knots, 65 deg F

Aviation-related Air Pollution UAS (Drone) Feasibility Study

Use of a UAS (drones) to measure aviation plumes

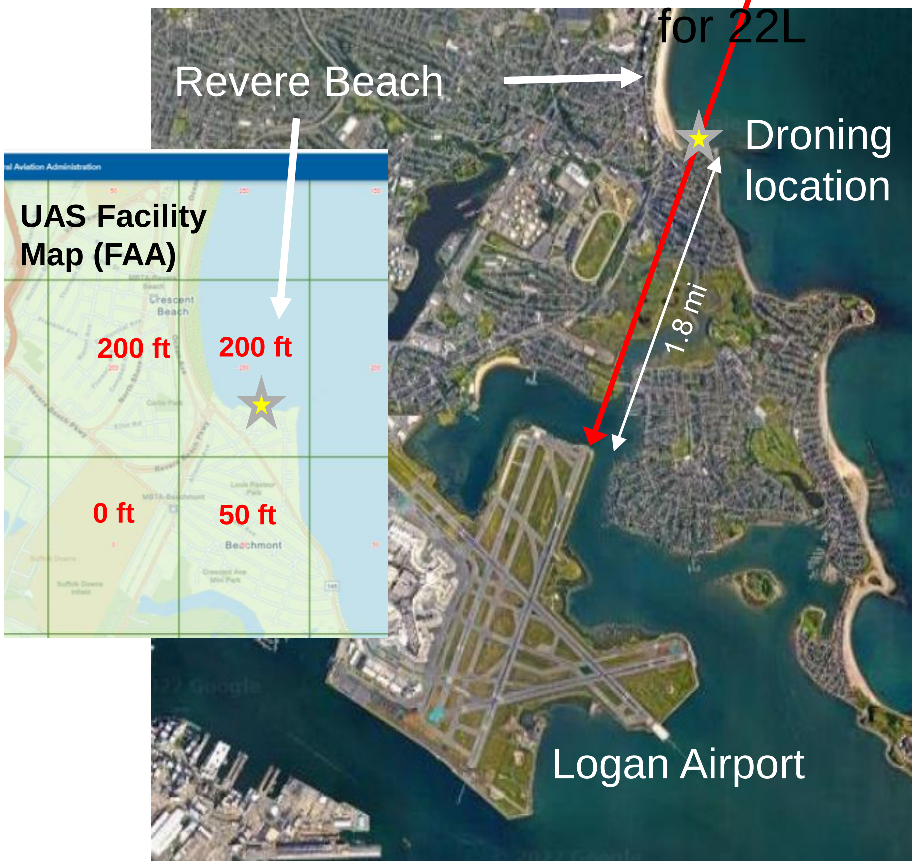
- **Research question**: can drones deliver the data needed to understand the dynamics of aircraft pollutant plumes?

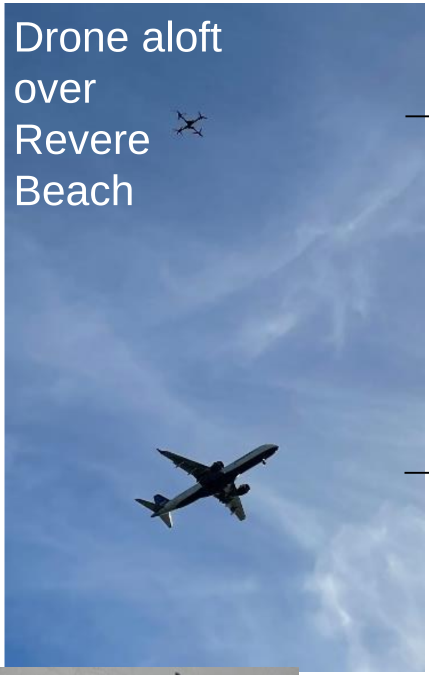


- **Study area:** Boston Logan Airport
- **Pollutant:**
  - Ultrafine particles (< 100 nm in diameter)
    - Present in high concentrations in aviation emissions

Location: Revere Beach, Revere, MA
Date: Saturday, September 3, 2022
Time aloft: 8:12-8:34 AM
Wind direction: South southwest
Runway in use: 4/22

Landing path for 22L



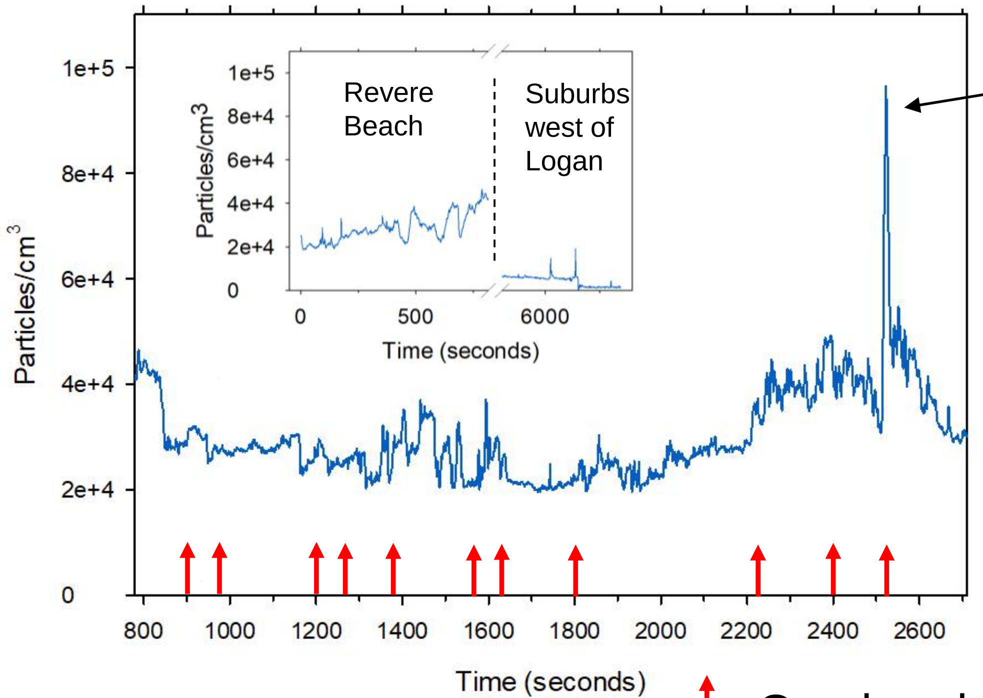


Drone is 150 ft above the ground

Airplanes are 500-600 ft above the ground

Testo DiscMini UFP monitor; mounted to drone; 1 s measurements

Ultrafine particle concentrations measured when drone was aloft at 150 ft (big box) vs. 0 ft (inset)



Plume from single aircraft

- Overhead jet observed at this time

Main Findings

1. Signal aloft is free from ground-based pollution (e.g., road traffic)
2. Composite signal from multiple landing aircraft can be measured
3. Single aircraft plumes can also be discerned

Going forward

- Add additional sensors
  - Temperature
  - Gases - e.g., NO_2, VOCs, CO, CO_2
    - These pollutants are also present at high concentrations in aviation emissions
- Conduct experiments to
  - Validate dispersion model factors (AEDT)
  - Develop more detailed knowledge of plume dynamics
    - Spatial and temporal extent of plumes
    - Particle formation kinetics
    - Plume decay kinetics

Summary/Next Steps

- Summary statement
  - Contributions of aircraft arrivals and departures 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.
  - We are producing data and plots that have reinforced the complexity and variability in UFP concentrations over time and space that can be captured with a combined stationary and mobile monitoring platform.

- Next steps
  - Complete regression modeling of aviation-related UFP.
  - Continue analyzing the UFP concentrations in relation to particle size distribution.
  - Expand Monitoring to include more sites with NO_2 and SO_2.
  - Complete Integrate statistical model outputs and data with ASCENT Project 19 for dispersion model validation.