# Project 018 Community Measurements of Aviation Emissions Contribution to Ambient Air Quality

## Boston University School of Public Health

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## University Participants

**Boston University School of Public Health**

- P.I.(s): Kevin J. Lane, Assistant Professor and Jonathan I. Levy, Professor and Associate Chair
- FAA Award Number: 13-C-AJFE-BU, Amendment 7
- Period of Performance: October 1, 2017 – September 30, 2018
- Task(s):
    1. Construct regression models to determine the contributions of aircraft arrivals to UFP and BC concentrations measured during our 2017 monitoring campaign.
    2. Conduct site selection for our 2018 monitoring campaign by analyzing our 2017 measurements and by considering optimal sites to determine multiple types of aviation source contributions.
    3. Measure UFP and other air pollutants at sites near Boston Logan International Airport selected under Task 2.
    4. Develop platforms that would allow for comparisons between atmospheric dispersion models implemented by collaborators on ASCENT Project 19 and monitored pollutant concentrations from Project 18.

## Project Funding Level

$270,000. Matching funds provided by non-federal donor to the Women's Health Initiative (WHI) cohort studies, provided as cost share support to Boston University through Project 3.

## Investigation Team

ASCENT BUSPH Director and Project 18 Co-Investigator: Jonathan I. Levy, Sc.D. (Professor of Environmental Health, Chair of Department of Environmental Health, Boston University School of Public Health). Dr. Levy is the Boston University PI of ASCENT. He initiated ASCENT Project 18 and serves the director of BUSPH ASCENT research.

ASCENT Project 18 Principal Investigator: Kevin J. Lane, Ph.D. (Assistant Professor of Environmental Health, Department of Environmental Health, Boston University School of Public Health). Dr. Lane joined the Project 18 team in July 2017. Dr. Lane has expertise in ultrafine particulate matter exposure assessment, geographic information systems, and statistical modeling of large datasets, along with cardiovascular health outcomes associated with air pollution exposures. He has contributed to study design and data analysis strategies, and as of 10/1/17, took over the primary responsibility for project execution and contributes to manuscripts and reports produced.

Post-doctoral researcher: Matthew Simon, Ph.D. Dr. Simon joined the Project 18 team in September 2017, and is involved in data analyses, field study design and implementation, and scientific manuscript preparation.

Graduate Student: Chloe Kim, MPH. Ms. Kim is a doctoral student in the Department of Environmental Health at BUSPH. She has taken the lead on organizing and implementing the air pollution monitoring study and will be responsible for the design and execution of related statistical analyses.

Research Assistant: Claire Schollaert. Ms. Schollaert provides field support for the air pollution monitoring study, including design and implementation of monitoring platforms.

## Project Overview

The primary goal was to conduct new air pollution monitoring underneath flight paths to and from Boston Logan International Airport, using a protocol specifically designed to answer the question of the magnitude and spatial distribution of ultrafine particulate matter (UFP) in the vicinity of arrival flight paths. Data was collected that would address the question of whether aircraft emissions, and in particular arrival emissions, can contribute significantly to UFP concentrations at appreciable distances from the airport. Task 1 was an extension of ongoing air pollution monitoring and statistical analysis work under the current ASCENT Project 18. Tasks 2 and 3 leverage the infrastructure developed for our field campaign to collect measurements to address a broader set of research questions than those evaluated under Task 1, with some additional data collection on UFP size distributions and including a new air pollutant (NO/NO2). These Tasks have provided a strong foundation for Task 4, which has increased the potential for future collaborative efforts with Project 19 in which we interpret the measurements collected and use them to inform ongoing modeling efforts at UNC.

A summary of 2017 project methods and data collection have been included below to inform on the continuation of Project 18 data into bivariate statistical analysis and multiple regression model development conducted under Task 1 and was used to inform new site selection for Task 2.

Project 18 Task 1 for the 2016-2017 funding cycle focused on designing and implementing an air pollution monitoring study that would allow us to determine contributions from arriving aircraft to ambient air pollution in a near-airport setting. The objective of this task was to address the question of whether aircraft emissions, and in particular arrival emissions, can contribute significantly to ultrafine particulate matter (UFP) concentrations at appreciable distances from the airport.

An air pollution monitoring campaign was conducted at six sites at varying distances from the airport and the arrival flight path to runway 4R (Figure P.1). Site 1 = Office of Department of

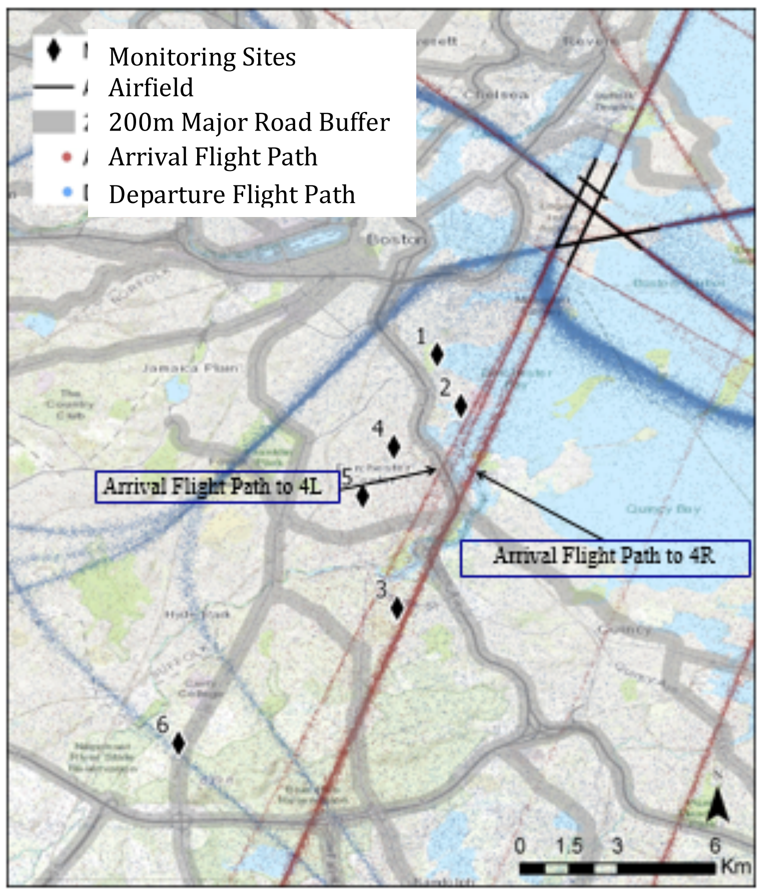



**Figure P.1.** Monitoring sites and runway 4R flight path.

Conservation and Recreation (DCR) Boston MA; Site 2 = University of Massachusetts (UMASS) Boston campus; Site 3 = Fonte Bonne Academy; Site 4 = Boston Community Development Corporation office (CDC); Site 5 = Community member residence; Site 6 = Blue Hills. Sites were selected through a systematic process, considering varying distances from the airport and laterally from the 4R flight path, and excluding locations close to major roadways or other significant sources of combustion. These sites were chosen specifically to isolate the contributions of arrival aircraft on runway 4R, which is important for the flight activity source attribution task.

# Task 1- Construct Regression Models to Determine the Contributions of Aircraft Arrivals to UFP and BC Concentrations Measured During our 2017 Monitoring Campaign

Boston University School of Public Health

## Objective(s)

Under Task 1 we developing regression models to examine contributions from arriving aircraft to ambient air pollution in a near-airport setting. The objective of this task was to address the question of whether aircraft emissions, and in particular in-flight arrival and departure emissions, can contribute significantly to ground-level ultrafine particulate matter (UFP) concentrations at appreciable distances from the airport.

## Research Approach

Utilizing the air pollution data collected during the 2017 monitoring campaign, we examined average UFP concentrations on the days when the 4R runway was in use and wasn't in use under all wind conditions, to examine the overall impact of arrival aircraft on ambient UFP concentrations at the study sites. We also examined the correlations of simultaneously measured UFPs from multiple study sites to examine the similarities and variations of aircraft impact at different monitoring sites under different meteorological and flight activity levels. Prior to constructing regression models we examine space-time plots of our data identified distinct patterns of plume movement and potential time lag differences between the sites under specific meteorological conditions. Results from these descriptive analyses were used to inform the regression model development process.

For the regression models, we developed multivariate regression models to examine the prediction pattern of UFP, using covariates that included meteorology, PDARS flight activity, and other ground source contributions such as localized traffic. Each study site was modeled individually to look at location-specific impact of aircraft arrivals along with meteorological and other local environmental conditions. We also have explored novel statistical approaches elastic nets and random forest modeling to identify the importance of key covariates at different temporal and distributional scales of analysis.

## Milestone(s)

The core milestones for Task 1 included:

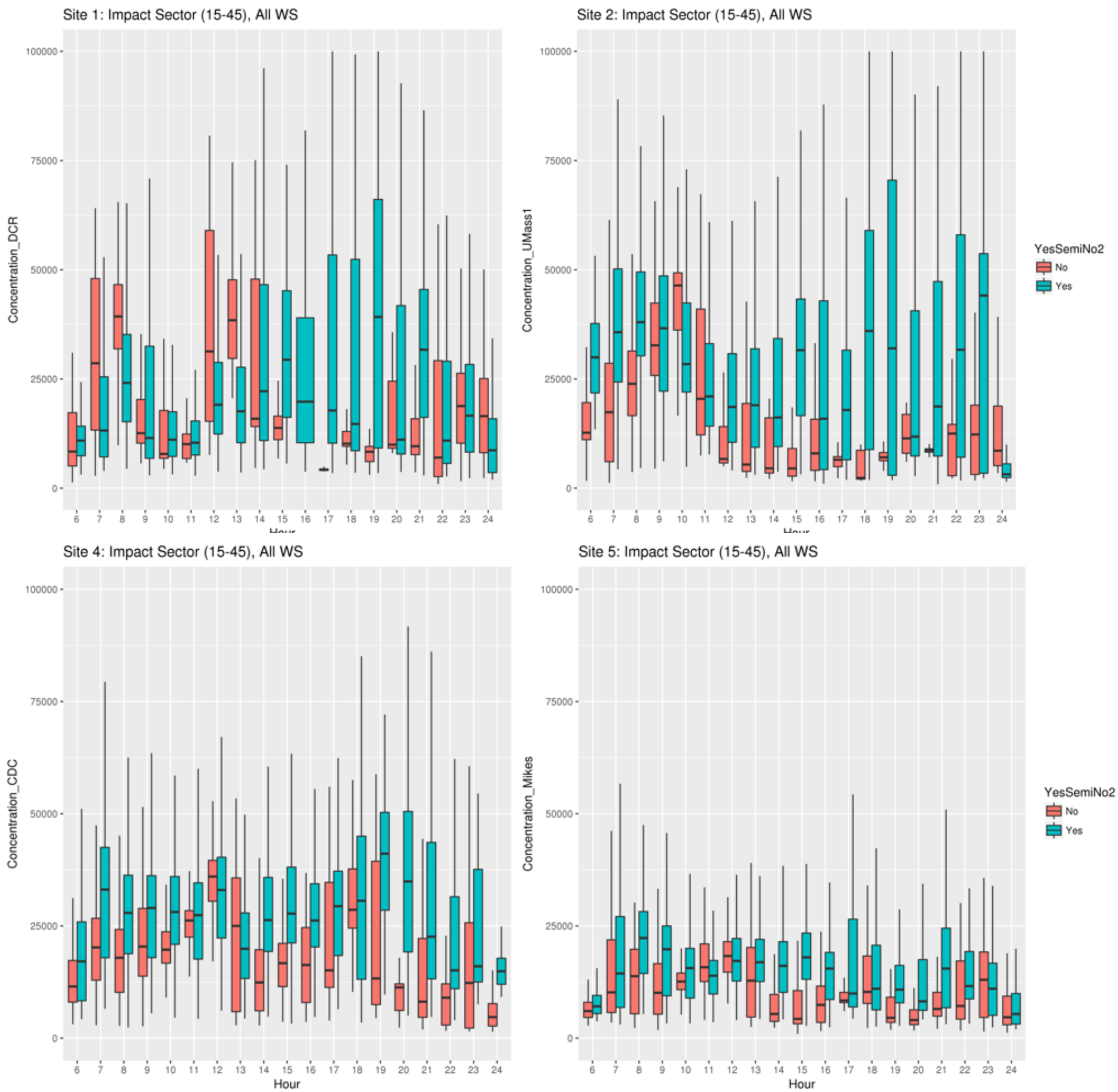
- Finish QA/QC of 2017 UFP monitoring data and develop analytical dataset.
- Complete regression modeling of UFP and associated manuscript development.

We successfully completed the QA/QC and data linkages with UFP monitor data. There was an unanticipated delay in regression model development as PDARS data for 2017 was being processed and was unavailable to use until spring 2018. Regression model development is being finalized and manuscripts are in preparation for submission to peer-reviewed literature.

## Major Accomplishments

**Descriptive Maps and PNC Wind Rose Plots**

Statistical analysis for project 18 has expanded to improve our understanding on wind direction, wind speed, flight activity and aircraft engine type on ground-based PNC measures. The following sets of figures explain the patterns we observed in the 2017 data sampling period. Figures 1.1a and 1.1b are boxplots of hourly PNC during two different wind conditions at all airport sites when the 4R runway was fully or semi-operational. Wind direction is based upon the weather station at each monitoring site. Ideal wind conditions (15-45 degrees) had elevated concentrations at near-source sites compared to when the monitors were upwind of the arriving aircraft (45-145). Wind direction had less impact on background site concentrations. We are also exploring relative wind direction as well as sub-categorization of the operational flight activity further to identify periods when arrivals into 4L were occurring instead of 4R during the non-operational time periods. These results identified the potential interactions that might be occurring between meteorology and flight activity that appear to be site-specific when informing on ground-level PNC source attribution.



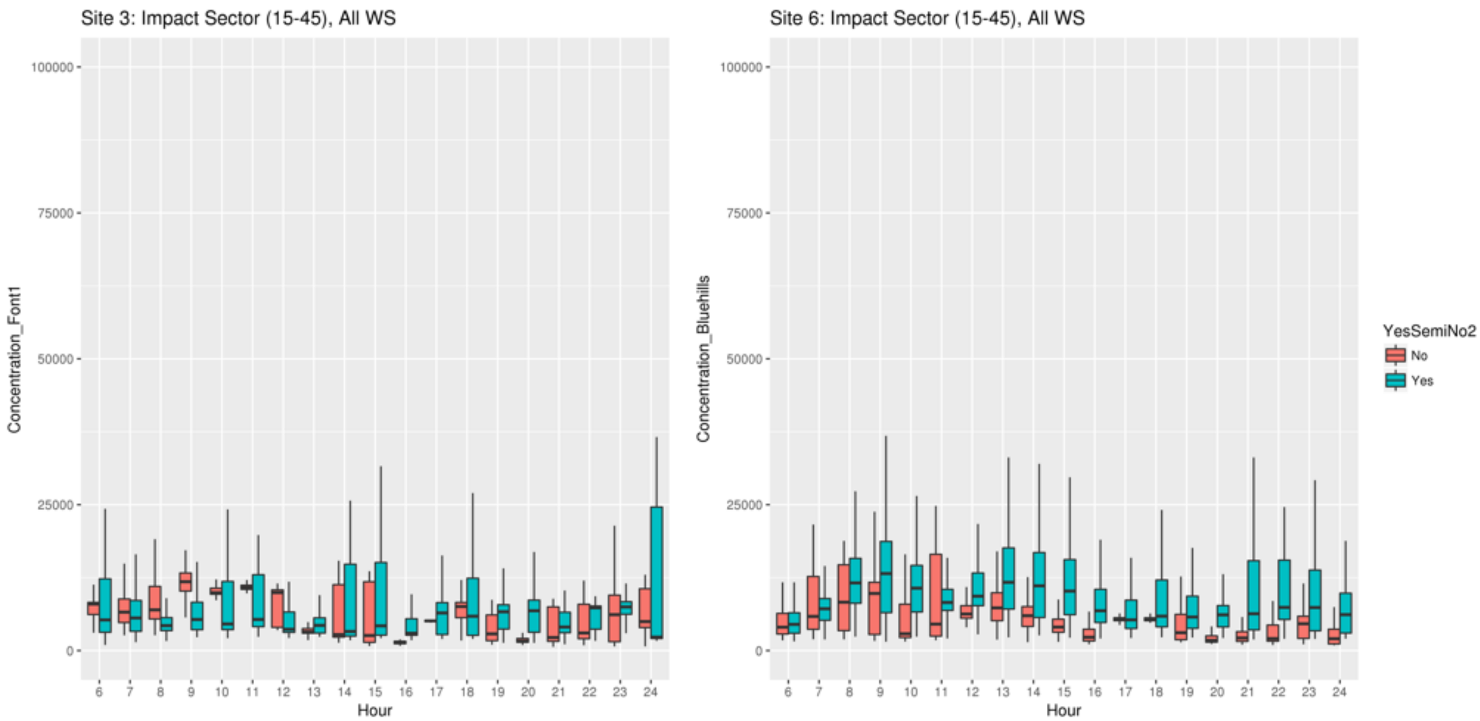
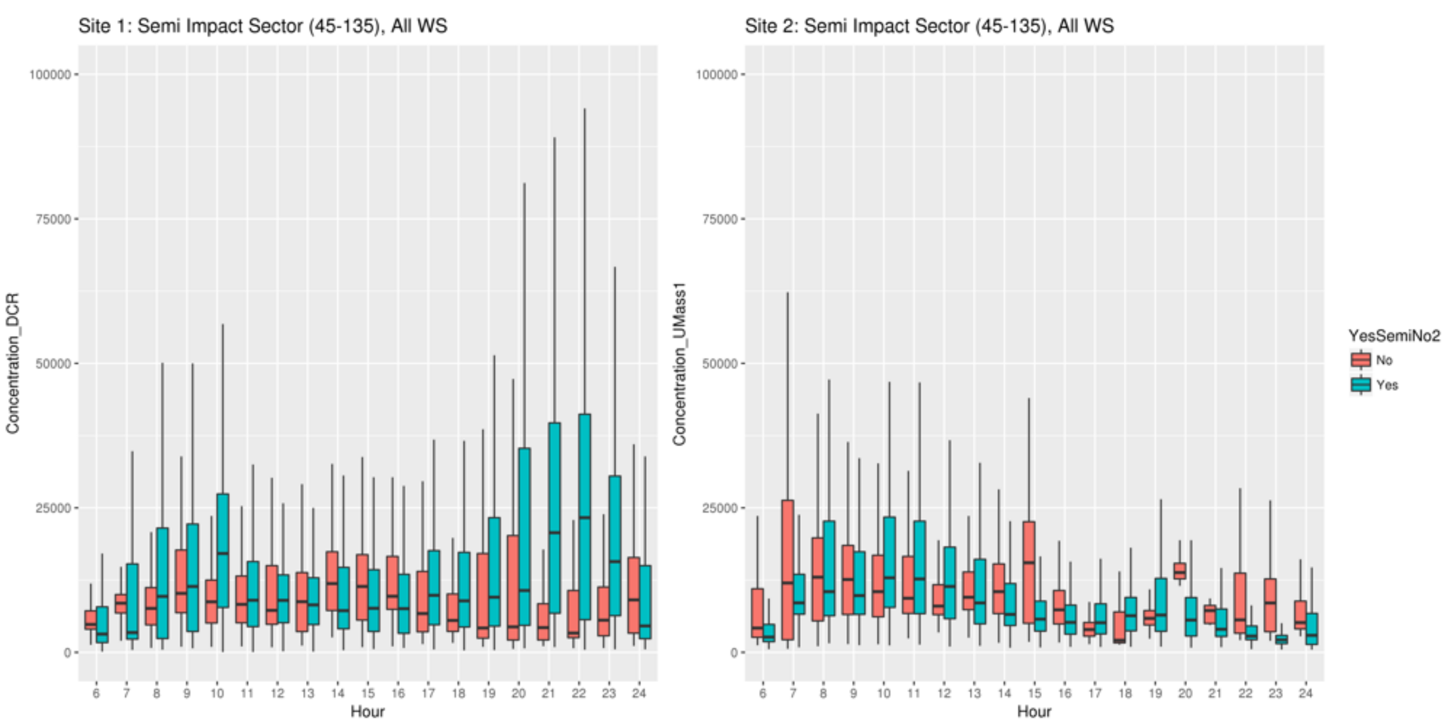



**Figure 1.1a.** Particle number concentration (PNC) under impact sector wind direction and flight activity at 4R monitoring sites for the 2017 monitoring period.



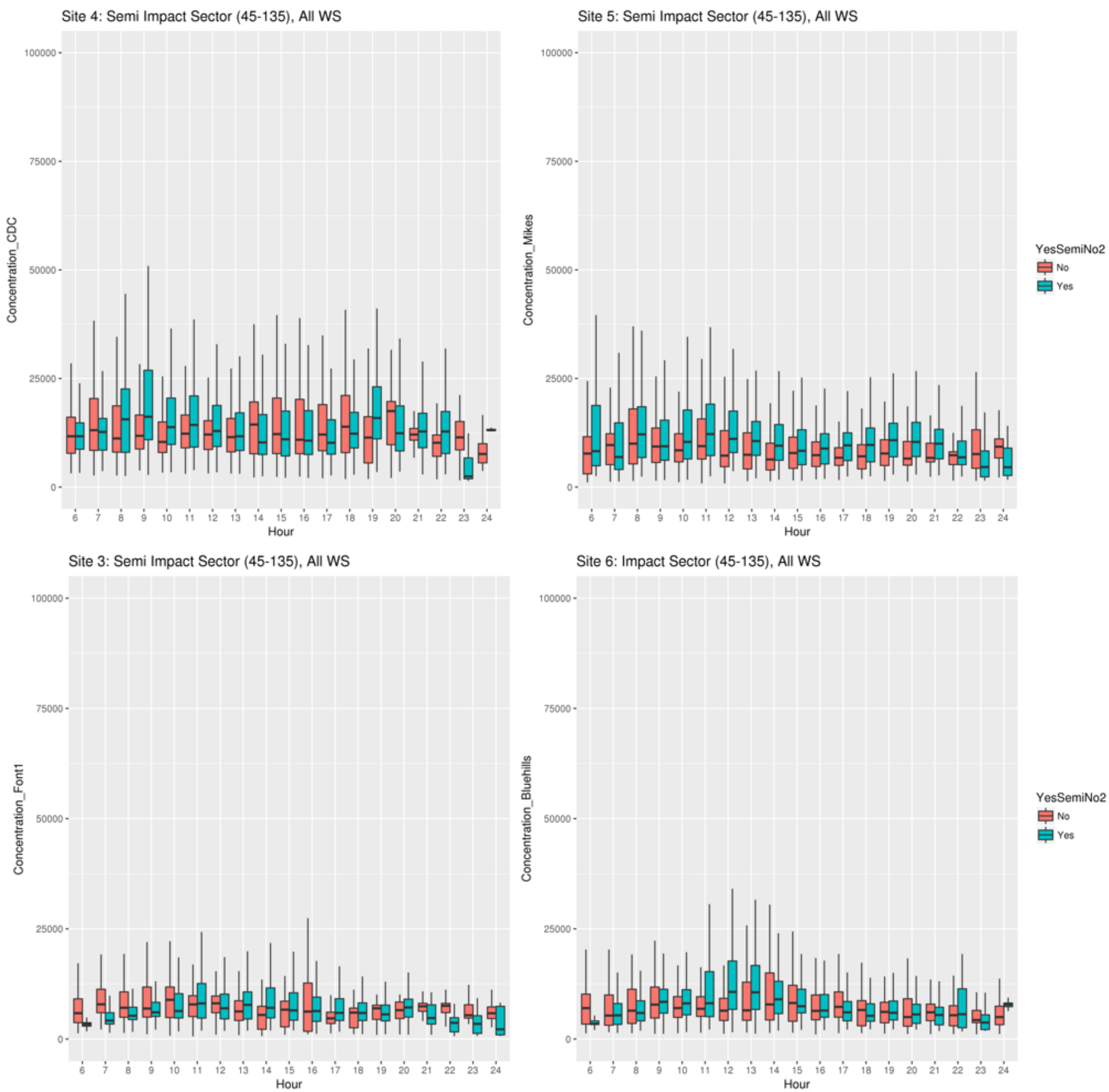



**Figure 1.1b.** Particle number concentration (PNC) under semi-impact sector wind direction and flight activity at 4R monitoring sites for the 2017 monitoring period.

Additional analysis is being conducted to examine PNC at different temporal resolutions below 1-hour. Previous studies have focused on analyzing the median or mean hourly concentrations, but the intermittent nature of flights could mean that we should be looking at more finely resolved times below 1-hour and potential peak exposures in the 95th and 99th percentile. We have started to plot and analyze the 1-second PNC data with corresponding meteorology to understand the simultaneous relationship between wind direction, wind speed, flight activity and PNC at each monitoring site. With this in mind we created wind rose PNC plots to identify hotspots under different meteorological conditions at each site (Figure 1.2).

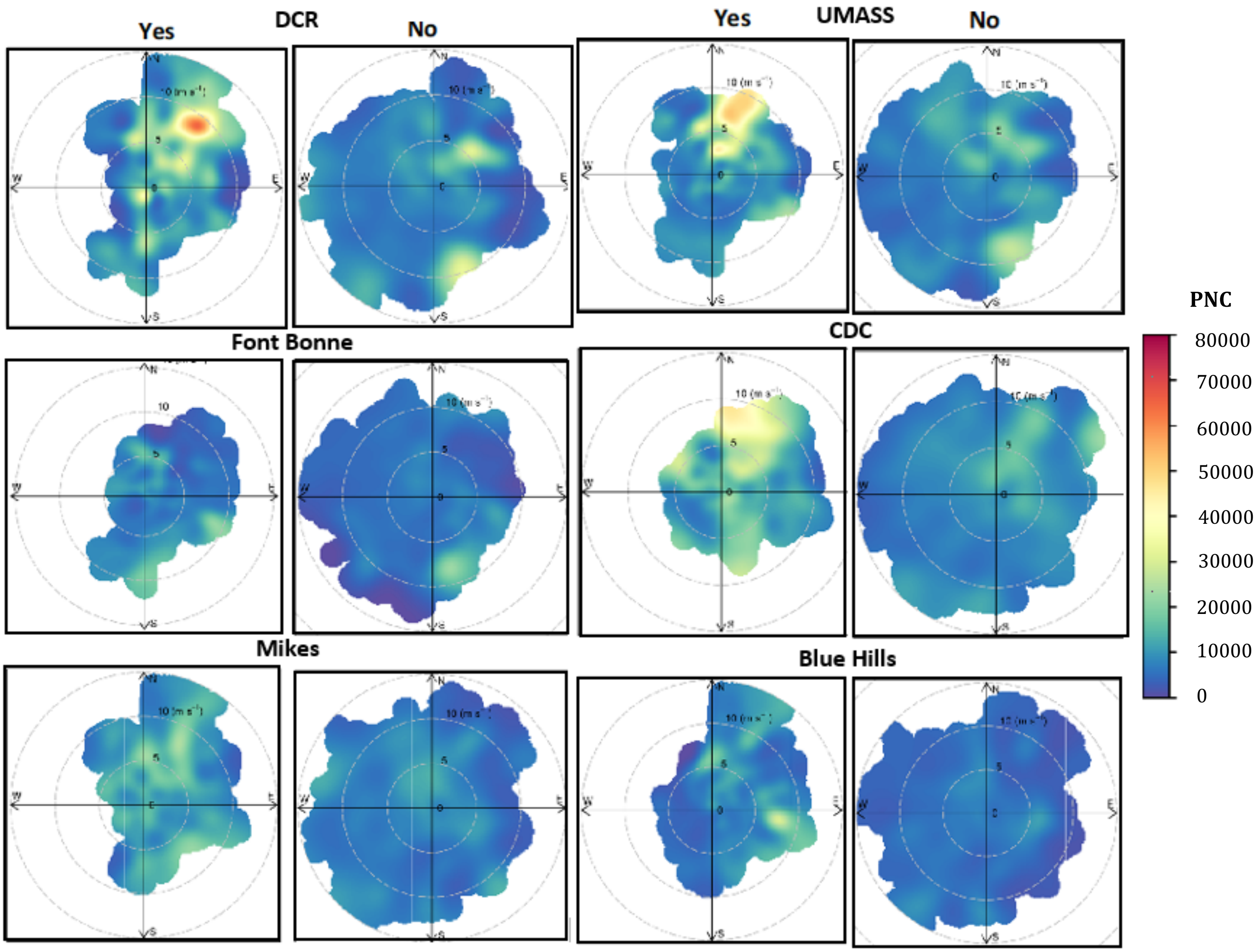



**Figure 1.2.** Particle number concentration (PNC) wind rose plots for each monitoring site by flight activity on 4R and 4L (Yes = 1 or more flights per hour; No = zero flights per hour). ). The monitoring sites correspond to the map P.1. with Site 1 = Office of Department of Conservation and Recreation (DCR) Boston MA; Site 2 = University of Massachusetts (UMASS) Boston campus; Site 3 = Fonte Bonne Academy; Site 4 = Boston Community Development Corporation office (CDC); Site 5 = Community member residence; Site 6 = Blue Hills.

Each plot above can be interpreted as the monitoring site-specific wind rose, centered on each monitor GPS location, with airport located to northeast of each site. Each quadrant represents the direction in which the wind is blowing from, while the dashed circular lines indicate the wind speed in miles per hour. The color represents the ranges in PNC level. From the plots there are several key points that we can infer and use to explore further:

- When flights are occurring, there are higher PNC levels compared to when no flights are occurring.
- Closer sites have elevated PNC hotspots, specifically DCR and UMASS which are closer to the airport have higher levels than all other sites.
- Hotspots are more clearly shown when the wind is coming from the airport direction at DCR and UMASS under the Yes flight activity scenario compared to the No scenario.
- Background sites at Blue Hills and Fonte Bonne have more hotspots of PNCs under the 'Yes' flight activity then 'No' flight activity hours.

Overall, there is an elevated level of PNC when wind is coming from the airport direction and aircraft are flying at lower altitudes such as at the UMASS and DCR sites. An arriving aircraft into Logan that is overhead of a monitoring site location further away at our background sites does not produce a similar detectable PNC level under the ideal wind conditions which may be due to these aircrafts being at a higher altitude.

**PNC Regression Modelling**

The descriptive analyses above have informed regression modelling efforts, presented below. PNC has a non-normal distribution and is commonly examined as the natural log (LN) of PNC. Covariates included in this regression model have been found to have a significant univariate relationship with LN PNC. The multivariable linear regression model provides an initial examination of the relationship between spatial-temporal meteorological, flight activity, and other potential ground contributions from traffic sources on the association with natural log of hourly PNC. Results from this model should be considered as development to assist in refinement as the current model is being expanded to include additional covariate contributions as well as interactions between predictive factors. Our initial regression models have been developed for each monitoring site to compare the total model $R^2$. Additionally, covariates have been kept the same for all models to examine the explanatory power of each variable between sites to better understand the relative contributions on flight activity, meteorology and other local contributions such as traffic for source attribution of ground-measured PNC.

In Table 1.1 we present preliminary regression model results for hourly LN PNC at two near source sites 1 and 2 and a background site 3. Each model includes meteorological variables (wind direction, wind speed and temperature), temporal (weekend/ weekday and time of day) and flight activity on runway 4R/4L (categorized as no flights, low [1-10 arriving flights/hour] and high [>10 arriving flights/hour]). Using this preliminary model we can begin to formulate new hypotheses and identify potential interactions to explore further. The initial models support our hypotheses and descriptive analyses regarding the importance of wind direction with northeasterly winds being the impact sector winds for each of our near airport monitoring sites 1 and 2. Additionally, hourly number of flights was important at both near and background sites, but had a substantially larger association with LN PNC at sites 1 and 2 than site 3. We are currently integrating additional meteorological variables (i.e. mixing height and apparent monitor wind direction) as well as flight activity data from PDARS (i.e. flights by weight class per hour).

**Table 1.1.** Spatial-temporal model for hourly natural log (LN) of particle number concentration (PNC) at monitoring sites 1, 2 and 3. The monitoring sites correspond to the map P.1. with Site 1 = Office of Department of Conservation and Recreation (DCR) Boston MA; Site 2 = University of Massachusetts (UMASS) Boston campus; Site 3 = Fonte Bonne Academy.

| | | DCR (Site 1) $R^2$ = 0.31 | | UMASS (Site 2) $R^2$ = 0.31 | | Fontebonne (Site 3) $R^2$ = 0.17 | |
|---|---|---|---|---|---|---|---|
| **Variable Grouping** | **Covariates** | **Coefficient** | **P-val** | **Coefficient** | **P-val** | **Coefficient** | **P-val** |
| Wind Direction (REF = West, W) | E | 0.85 | ** | 0.63 | *** | 0.83 | ** |
| | EN | 0.85 | *** | 0.66 | *** | 0.62 | *** |
| | ES | 0.85 | * | 0.82 | ** | 0.89 | * |
| | N | 1.08 | 0.34 | 1.64 | ** | 1.2 | 0.34 |
| | NE | 2.04 | *** | 1.71 | *** | 0.77 | *** |
| | NW | 1.2 | * | 1.26 | ** | 1.18 | * |
| | S | 0.94 | *** | 0.79 | *** | 0.82 | *** |
| | SE | 0.83 | ** | 0.69 | *** | 0.85 | ** |
| | SW | 0.96 | 0.14 | 0.97 | 0.44 | 0.94 | 0.14 |
| | WN | 1.29 | 0.43 | 1.17 | ** | 1.04 | 0.43 |
| | WS | 0.94 | 0.23 | 0.93 | 0.16 | 1.06 | 0.23 |
| Arrival Flight Activity (REF = No Activity; 0 flights in hour) | Semi | 1.21 | *** | 1.26 | *** | 1.21 | *** |
| | Yes | 1.37 | *** | 1.3 | *** | 1.2 | *** |
| Temperature | 1°Farenheit | 0.99 | *** | 0.98 | *** | 0.99 | *** |
| Rush Hour (Ref = Overnight 12:00am - 5:00am) | Morning Rush Hour (5-10am) | 1.63 | *** | 1.78 | *** | 1.45 | *** |
| | Daytime (10-3pm) | 1.84 | *** | 2.06 | *** | 1.64 | *** |
| | Afternoon Rush Hour (3-6pm) | 1.63 | *** | 1.31 | *** | 1.38 | *** |
| | Evening time (6pm-12am | 1.52 | *** | 1.38 | *** | 1.23 | *** |
| Weekend vs. weekday | Weekend | 0.89 | *** | 0.7 | *** | 0.86 | *** |
| Wind Speed | 1 MPH | 0.96 | *** | 0.97 | *** | 0.86 | *** |

P-val *** ≤ 0.001; P-val ** ≤ 0.01; P-val *** ≤ 0.05.

In addition to linear regression modelling we have explored the use of machine learning regression approaches to identify key covariates and optimize prediction of PNC at each site. This research has focused on application to the UMASS site and uses a random forest approach which is a decision tree-based machine learning algorithm. Each tree is grown by a bootstrap sample, and a random subset of predictors is selected at each split. Predictions are obtained by averaging results of different trees. We developed three models to predict PNC using the random forest model approach to predict PNC at different hourly scales; 1) hourly median PNC, hourly $95^{th}$ PNC, and hourly $99^{th}$ PNC. Figure 1.3 provides the relative contributions of covariates to predict PNC measured as the mean square error.

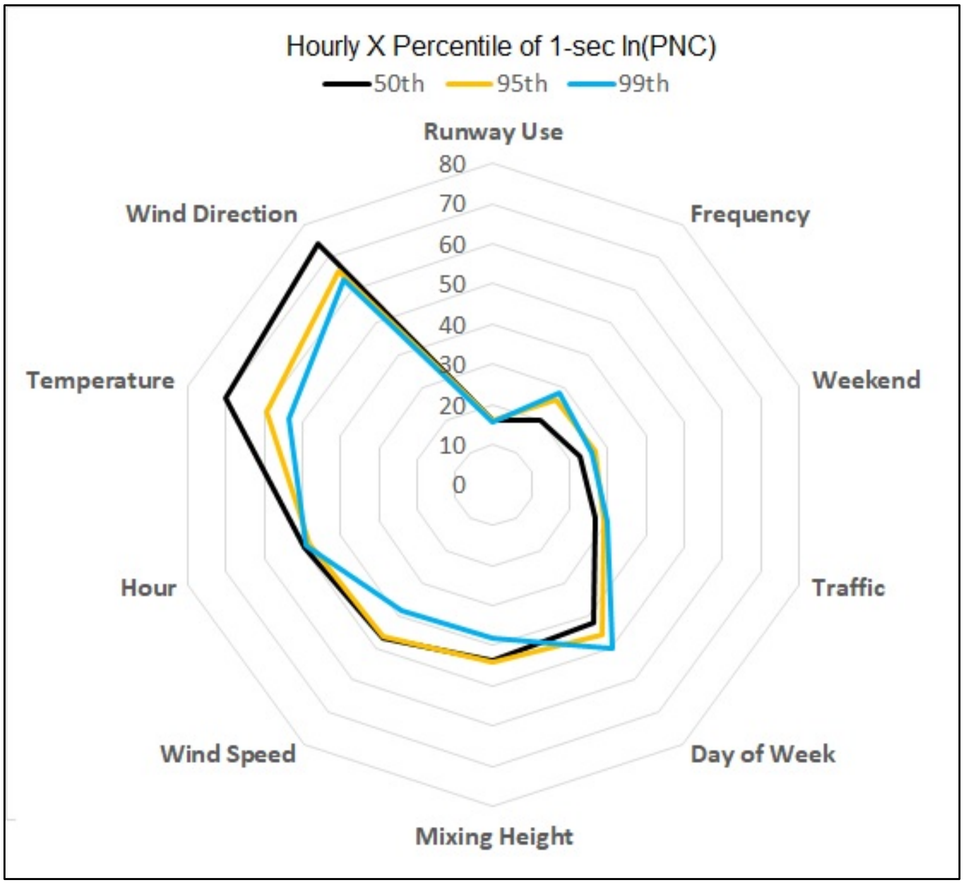



**Figure 1.3.** Spider plot showing the importance of each variable in the random forest model based on the mean decrease in model accuracy (as measured by mean square error).

The median model regression performance measured as $R^2$ improved prediction by over 20% using the random forest approach ($R^2 = 0.56$), compared to the linear regression modelling approach ($R^2 = 0.31$; see Table 1.1). As hourly PNC is predicted at higher percentiles (95$^{th}$ and 99$^{th}$; see Figure 1.3), meteorological variables decreased in importance while variables related to flight activity such as schedules or frequency of flights arriving on 4R/4L gained importance. Flight frequency has the largest percent gain in model importance when comparing 95th and 99th percentile models to the 50th percentile. Additionally, the overall random forest model performance increased variance prediction with the 50th percentile variance explained = 55.7%; 95th percentile model variance explained = 59.7%; and 99th percentile model variance explained = 60.2%. The random forest modelling approach is being used in tandem with generalized linear regression modelling to identify the best prediction of PNC at each site, but also provide interpretable results.

## Publications

None

## Outreach Efforts

Dr. Kevin Lane presented an update of the Project 18 field monitoring and descriptive data analysis at the ASCENT Spring 2018 meeting.

Dr. Kevin Lane presented on “Ultrafine Particulate Matter Monitoring and Source Apportionment”, at the Aviation Emissions Characterization Meeting. National Academy of Sciences, DC, USA.

Dr. Kevin Lane Presented and sat on a panel on "Monitoring and modeling aviation-related ultrafine particles from background concentrations", at the Aviation Emissions Characterization Meeting. National Academy of Sciences, DC, USA.

Doctoral student Chloe Seyoung Kim presented an oral presentation on a portion of the major accomplishments of Project 18 at the International Society for Exposure Science annual meeting in October 2017.

PostDoc Dr. Matthew Simon presented an update of the Project 18 field monitoring and statistical analysis at the ASCENT Fall 2018 meeting.

## Awards

Doctoral Student Chloe Kim was the DOT FAA Centers of Excellence Joseph A Hartman Student Paper Competition Winner for her work on "Spatial and temporal patterns of ambient ultrafine particulate matter (UFP) in communities along an arrival aircraft pathway".

## Student Involvement

Chloe Seyoung Kim, a doctoral student at BUSPH, was involved with the descriptive analysis and regression modelling of 2017 PNC data. Claire Schoallert, a master's student at BUSPH has been involved with descriptive analysis of the 2018 sampling data. Sijia Li, a master's student at BU statistical department has been involved with machine learning regression modelling applications.

## Plans for Next Period

Task(s) proposed over the next study period (10/1/18-9/30/19):
Construct UFP regression models using the 2017–2018 data and the flight activity data and covariates to determine the contributions of aviation sources to UFP and BC concentrations measured under multiple landing and take-off pathways.

# Task 2- Conduct Site Selection for our 2018 Monitoring Campaign by Analyzing our 2017 Measurements and by Considering Optimal Sites to Determine Multiple Types of Aviation Source Contributions

Boston University School of Public Health

## Objective(s)

Task 2 for the 2017-2018 funding cycle focused on designing and implementing an air pollution monitoring study that would allow us to determine contributions from arriving aircraft to ambient air pollution in a near-airport setting. The objective of this task was to address the question of whether aircraft emissions, and in particular in-flight arrival and departure emissions, can contribute significantly to ground-level ultrafine particulate matter (UFP) concentrations at appreciable distances from the airport.

## Research Approach

An air pollution monitoring campaign was conducted at five sites at varying distances from the airport and arrival departure flight paths for Boston Logan Airport (Figure 2.1). Sites were selected through a systematic process, considering varying distances from the airport and laterally from each flight path, excluding locations close to major roadways or other significant sources of combustion. These sites were chosen specifically to isolate the contributions of in-flight aircraft, which is important for the flight activity source attribution task.

Particle number concentration (PNC, a proxy for UFP) monitoring instruments were established at each monitoring site in a pre-selected scheme to allow for multiple levels of comparison (e.g., sites underneath vs. not underneath flight paths given prevailing winds, sites at varying distances from the airport, sites at varying lateral distances underneath flight paths). PNC was measured with TSI Condensation Particle Counters (Model 3783). In addition, black carbon was measured using AethLabs Microaethalometers (Model AE51), and meteorological data at each site were collected using Davis Vantage Pro2 weather stations.

## Milestone(s)

The core milestones for Task 2 included:

- Review 2017 monitoring data and identify optimal sites for follow-up field campaign to select candidate monitoring sites and obtain permission to monitor at those sites
- Update field monitoring and site location protocol.

We conducted a review of the 2017 monitoring data and identified sites for the 2018 field campaign, as planned using a rollout phase allowing for immediate sampling to occur throughout the fall and winter while new monitoring site location agreements and permission was sought. At each new monitoring site we conducted a rapid 2- week sampling and review of the data to validate suitable sampling conditions. Selection of monitoring sites was successful, and we obtained permission to sample at five sites including a continued sampling at the UMASS site from 2017 allowing for a multi-year site. Also through collaborations with Tufts University we were able to include long-term sampling data from the Chelsea site. We began collecting field data following our complete protocols in November 2017 with comprehensive data capture throughout the spring and summer, meeting our data collection milestone.

## Major Accomplishments

We successfully identified five long-term monitoring sites, received authorization from the site owners and built sampling boxes to house all monitoring equipment that would allow for sampling in both winter and summer.

## Publications

None

## Outreach Efforts

None

## Awards

None

## Student Involvement

Chloe Kim, a doctoral student at BUSPH, has been involved with identifying new optimal site during the selection process. Claire Schoallert, a master's student at BUSPH has been involved with field site visits to determine feasibility of sampling protocol.

## Plans for Next Period

Task(s) proposed over the next study period (10/1/18-9/30/19):
Conduct mobile monitoring in selected communities near Logan Airport to determine spatial and short-term temporal variation in aviation emissions contributions to concentrations at ground level.


**Figure 2.1.** Monitoring sites for the 2017-2018 sampling campaign around Boston Logan Airport. Site list corresponds to Table 3.1

## Task 3- Measure UFP and Other Air Pollutants at Sites Near Boston Logan International Airport Selected Under Task 2

Boston University School of Public Health

### Objective(s)

Given the sites chosen under Task 2, we conducted a monitoring campaign in 2018 to inform an aviation source attribution analysis to expand upon Task 1 regression model development. Our instrumentation and protocol was similar to the 2017 monitoring campaign, but with some key enhancements to improve insights regarding aviation source contributions.

## Research Approach
At the sites chosen under Task 2, we conducted a monitoring campaign in 2018 to inform ground-contributions from inflight aviation sources underneath multiple landing and take-off runways at various distances from the airport and flight path. The Instrumentation and protocol used was the same as the 2017 monitoring campaign, but with some key enhancements to improve insights regarding aviation source contributions to NO/$NO_2$. Monitoring instruments included the TSI Model 3783 water-based CPC for UFP, our primary measure of interest, which was used in the 2017 monitoring campaign. The 3783 is intended for long-term deployment and can record 1-second average concentrations, valuable time resolution for capturing short-term concentration spikes. Of note, as the Model 3783 CPC is temperature-sensitive, we developed and deployed instrumentation in a temperature conditioned space to protect against extreme heat and cold, allowing for long-term deployment.

In addition, the AethLabs model AE51 microaethalometer will be used to measure BC. We also deployed the Alphasense NO/$NO_2$ sensor that gives high-fidelity outputs and could be used in future studies with simultaneous real-time measurements at numerous sites. This also provides an additional pollutant for any future comparisons with atmospheric dispersion model outputs, which could help isolate factors that influence predictions of particulate matter vs. gas-phase pollutants. The local Davis Vantage Pro2 weather stations was used to capture real-time wind speed/direction and other meteorological conditions at each sampling site.

Similar to 2017, obtaining flight activity data from FAA for the time periods of sampling will be essential for future regression model development, which will include location of each flight as well as basic aircraft characteristics, which could be linked with AEDT to determine aircraft-specific attributes that may be predictive of emissions and corresponding concentrations.

## Milestone(s)
- Obtained permission to resample and/or sample new locations, and develop sampling schedule.
- Obtained new monitoring equipment and completed annual manufacturer cleaning and calibration of CPCs.
- Implemented air pollution monitoring protocols, including measurements of meteorological conditions and collection of flight activity data to be used in statistical analyses.
- Completed 2018 field sampling, prepare for air pollution regression modeling.

## Major Accomplishments
As described above, the 2018 air pollution field monitoring campaign was conducted from November 2017 – September 2018 at five sites at varying distances from the airport under multiple arrival and take-off flight paths into Logan Airport (Figure 2.1). This met all targets for sample size and data capture, providing a strong foundation for future statistical analyses.

**Table 3.1.** Distribution of PNC at the five monitoring sites

| | UMASS | Chelsea | East Boston | South Boston | Winthrop |
|---|---|---|---|---|---|
| **Sample Size (days)** | 264 | 250 | 167 | 123 | 43 |
| **Location** | Ground Level | Roof 4th Floor | 2nd Floor Window | Roof 5th Floor | Ground Level |
| **Other Samplers** | BC, meteorology, NO, NO2 | BC, meteorology, NO, NO2 | BC, NO, NO2 | BC, meteorology, NO, NO2 | BC, meteorology |
| **0.1st percentile** | 169 | 863 | 172 | 471 | 521 |
| **1st percentile** | 379 | 1750 | 904 | 1160 | 676 |
| **5th percentile** | 975 | 3270 | 2020 | 2610 | 1400 |
| **50th percentile** | 7440 | 11900 | 10800 | 8260 | 8680 |
| **95th percentile** | 24500 | 43700 | 65000 | 36300 | 47000 |
| **99th percentile** | 47200 | 87800 | 124000 | 66300 | 70300 |
| **99.9th percentile** | 76900 | 152000 | 229000 | 100000 | 111000 |

The summary statistics presented in Table 3.1 cannot provide definitive insight about aviation contributions to measured PNC, but are helpful for hypothesis generation and to inform future modeling efforts. For example, note that Chelsea and East Boston have the highest concentrations of all sites through the 95th and 99th percentiles of the distribution, consistent with their locations closest to the airport and with planes at an elevation that would be closer than at locations further away such as UMASS. This indicates that there could be a more rapid decline in PNC with regard to distance from the airport than observed in the 2017 sampling campaign that focused on only a single arrival pathway. There were consistent patterns observed by seasons at three monitor sites with data from winter, spring and summer.

**Table 3.2.** Seasonal Distribution of PNC at three monitoring sites.

| | UMASS | | | Chelsea | | | East Boston | | |
|---|---|---|---|---|---|---|---|---|---|
| **Sample Size (days)** | 80 | 79 | 93 | 64 | 75 | 105 | 20 | 85 | 54 |
| **Season** | Winter | Spring | Summer | Winter | Spring | Summer | Winter | Spring | Summer |
| **0.1st percentile** | 493 | 309 | 139 | 1460 | 1090 | 552 | 879 | 137 | 862 |
| **1st percentile** | 1040 | 496 | 262 | 2460 | 1660 | 1610 | 1260 | 564 | 1300 |
| **5th percentile** | 3250 | 1640 | 547 | 4350 | 3210 | 2950 | 3290 | 1810 | 2230 |
| **50th percentile** | 10100 | 5970 | 6390 | 14100 | 11200 | 11100 | 13800 | 10600 | 9920 |
| **95th percentile** | 28600 | 20200 | 22800 | 42200 | 42100 | 46000 | 60100 | 65400 | 66100 |
| **99th percentile** | 50500 | 44800 | 45300 | 79900 | 92200 | 90300 | 172000 | 127000 | 113000 |

Winter consistently had elevated median PNC levels at all three sites with greater variation at the 95th and 99th percentile of PNC. It should be noted that East Boston did not have the same amount of sampling days within the winter season. In Table 3.2 East Boston and Chelsea have an elevated PNC at the median and 95th percentile for Chelsea and East Boston compared to UMASS sites across all seasons. Additionally, summer was observed to have the lower PNC levels than winter and/or spring across all three sites. Further analysis is currently being conducted to compare 2018 descriptive statistics between seasons by flight activity and meteorology.

Preliminary hypotheses generated from descriptive analysis of Tables 3.1 and 3.2 are being analyzed currently with aircraft activity data from the National Offload Program (NOP) data, and present us with insight on more formal analyses similar to that conducted under Task 1 once we receive the 2018 PDARS flight activity data.

## Publications

None

## Outreach Efforts

Dr. Kevin Lane presented on "Ultrafine Particulate Matter Monitoring and Source Apportionment", at the Aviation Emissions Characterization Meeting. National Academy of Sciences, DC, USA.

Dr. Kevin Lane Presented and sat on a panel on "Monitoring and modeling aviation-related ultrafine particles from background concentrations", at the Aviation Emissions Characterization Meeting. National Academy of Sciences, DC, USA.

PostDoc Dr. Matthew Simon presented an update of the Project 18 field monitoring and statistical analysis at the ASCENT Fall 2018 meeting.

## Awards

None

## Student Involvement

Claire Schoallert, a master's student at BUSPH, Bethany Haley, a doctoral student at BUSPH and Sijia Li, a master student at BU department of statistics has been involved with field monitoring of the 2018 sampling data.

## Plans for Next Period

Task(s) proposed over the next study period (10/1/18-9/30/19):

- Continue long-term monitoring of air pollution at both new and existing stationary sites to assess temporal variation in aviation source contributions in greater Boston area communities.
- Incorporate particle size distribution on a rotational basis with each of our monitoring sites to inform our understanding of inflight contributions to community UFP relative to background sources.
- Conduct mobile monitoring in selected communities near Logan Airport to determine spatial and short-term temporal variation in aviation emissions contributions to concentrations at ground level.

# Task 4- Develop Platforms that Would Allow for Comparisons Between Atmospheric Dispersion Models Implemented by Collaborators on ASCENT Project 19 and Monitored Pollutant Concentrations from Project 18

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## Objective(s)

While the primary objective of Tasks 1-3 informed aviation source attribution using ambient pollution measurements, the insights from the monitoring data and models could be connected with atmospheric dispersion models applied at the same location and dates. Within Project 19, UNC researchers are implementing SCICHEM to examine the air quality implications of emissions of various air pollutants from aviation, with a current focus on modeling UFP. If in the future Project 19 applies atmospheric dispersion modeling tools focused on locations near Boston Logan International Airport, this would allow for future comparative analyses (modelling and monitoring). The purpose of this task is to develop data processing systems that would allow for these comparative analyses to be conducted.

## Research Approach

To aid the efforts of Project 19, we developed two output files under Task 4. First, the UFP measurements collected during the 2017 monitoring campaign were processed and provided in a format requested by Project 19. These measurements reflect the contributions from both aviation and other sources, and are being directly compared with all-source dispersion models such as SCICHEM. In the second phase, regression models being developed under Task 1, development of an analogous database with the aviation-attributable UFP concentrations has been processed and outputs are being compared with the dispersion models

## Milestone(s)
The core milestones for task 4 included:

- Develop analytical dataset estimating aviation source contributions from the 2017 monitoring campaign and share with UNC to inform potential collaborative manuscript.

The monitoring dataset was completed and shared with Project 19. SCICHEM is being used to model PNC using the data provided by Project 18 and we are conducting a comparison between dispersion and regression model outputs.

## Major Accomplishments
UFP data from the Project 18 2017 field campaign was cleaned, joined with flight activity and meteorology and shared with Project 19. During this time we have collaborated through teleconferences on dispersion modelling efforts conducted by Project 19 resulting in an abstract submission acceptance to the CMAS conference on modelling PNC.

## Publications
None

## Outreach Efforts
Dr. Moniruzzaman Chowdury from Project 19 presented on “An integrated modeled and measurement-based assessment of particle number concentrations from a major US airport”, at the CMAS conference.

## Awards
None

## Student Involvement
Chloe Seyoung Kim, a doctoral student at BUSPH, was involved with preparation of data to be shared with project 19 and comparison of regression model with dispersion model outputs.

## Plans for Next Period
Four tasks are proposed over the next study period (10/1/18-9/30/19):

- Compile from FAA essential flight activity covariates needed for regression modelling under Project 18 and dispersion modelling under Project 19 for a data-sharing platform that would allow for comparisons between atmospheric dispersion models implemented by collaborators on ASCENT Project 19 and monitored pollutant concentrations and related regression models from Project 18.