# Mobile ObserVations of Ultrafine Particles (MOV-UP) Advisory

January 23, 2019
Highline Forum

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# Outline

1. Current Monitoring Status
2. Background literature updates
3. Preliminary Data Analysis
4. Discussion
5. Questions

# WA State Proviso

- Study the implications of air traffic at Sea-Tac
- Assess the concentrations of ultrafine particulate matter (UFP) in areas surrounding and directly impacted by air traffic
- Distinguish between and compare concentrations of aircraft-related and other sources of UFP
- Coordinate with local governments, and share results and solicit feedback from community
- Produce study report by December 1, 2019

Environment International 118 (2018) 48–59

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

# Short-term effects of airport-associated ultrafine particle exposure on lung function and inflammation in adults with asthma

Rima Habre[a,*], Hui Zhou[a], Sandrah P. Eckel[b], Temuulen Enebish[a], Scott Fruin[a], Theresa Bastain[a], Edward Rappaport[a], Frank Gilliland[a]

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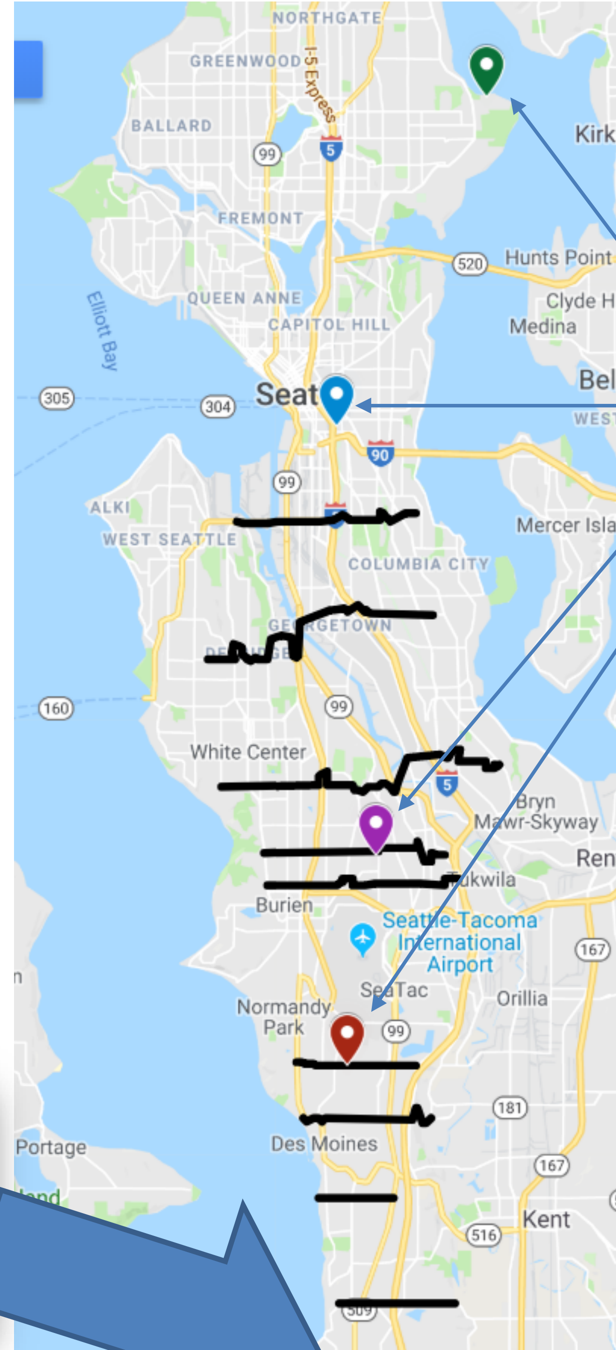
- Randomized crossover study of 22 non-smoking adults with mild to moderate asthma
- 2-hr scripted, mild walking activity both inside and outside of the high LAX UFP impact zone (avg. difference ~30,000 /cc)
- Mean particle size at LAX impact zone was 29 nm
- *"We found significant increases in markers of systemic inflammation associated with 'Airport UFPs' (IL-6) and 'Traffic' (sTNFrII) exposure and a significant decrease in FEV1 associated with measured PM and BC and modeled 'Traffic' exposure.* ***The robust IL-6 effects we found with the 'Airport UFPs' source, which would have been masked by considering PN alone****…"*

# MOVUP Monitoring Locations

Mobile Monitoring Transects + Stationary Sites




4 stationary sites

# Data collection as of 2018

| | Number of sampling days | | |
|---|---|---|---|
| Season | Mobile monitoring | Airport fixed sites | Near highway fixed sites |
| Winter 2018 | 16 | | |
| Spring 2018 | 14 | 10 | 8 |
| Summer 2018 | 16 | 15 | |
| Autumn 2018 | 12 | 7 | |
| Total finished | 58 | 32 | 8 |

- Mobile monitoring typically occurs between 12 PM and 5 PM
- Typically monitoring consists of 2 concurrent cars (N and S of the airport)
- Another round of Mobile and Fixed site monitor was recently completed in January 2019.

# Fixed Site Monitoring Status

| Fixed Site Monitoring | May 4th - May 11th | June 4th - June 13th | July 13th - July 16th | July 27th - Aug 1st |
|---|---|---|---|---|
| 10th & Weller | | | | |
| Maywood | | | | |
| SeaTac Community Center | | | | |
| NOAA- Sand Point | | | | |

***Background Site***

# Instruments used in mobile and fixed location sampling

| Parameter | Instrument |
| --- | --- |
| *Mobile and Fixed sampling:* | |
| Particle number concentration (35 nm – 1 μm) | P-Trak 8525, w/ diffusion screens |
| Particle number concentration (20 nm – 1 μm) | P-Trak 8525 |
| Particle number concentration (10 nm – 1 μm) | Condensation Particle Counter 3007 |
| Black Carbon PM | Micro-Aethalometer AE51 |
| CO2 | LI-850 Gas Analyzer |
| Temperature & Humidity | Hobo T, RH datalogger |
| Position & Time tracking | GPS Receiver DG-500 |
| *Fixed Location sampling:* | |
| Particle size distribution, 13 bins | NanoScan 3910 |

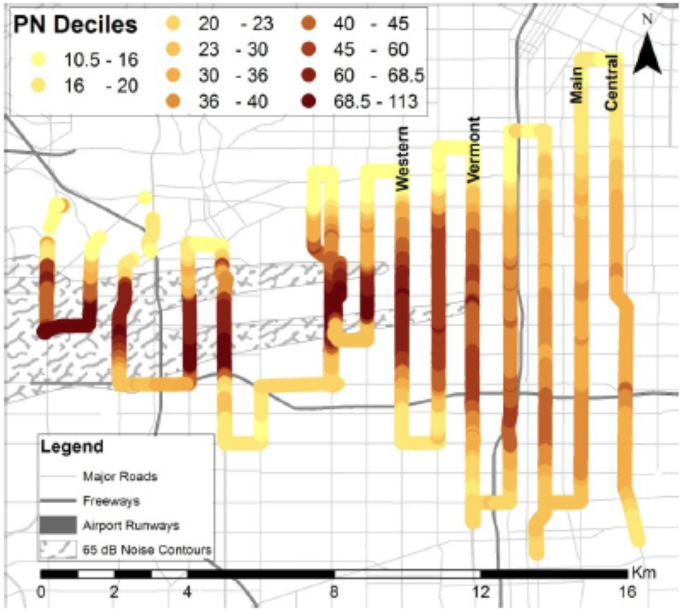
TSI, Inc. model 3007 CPC

# MOV-UP Study

## Mobile ObserVations of Ultrafine Particles (MOV-UP) Study


# Area-weighted number concentration equivalent to ~ half the freeways in LA!

$10^3$/cc

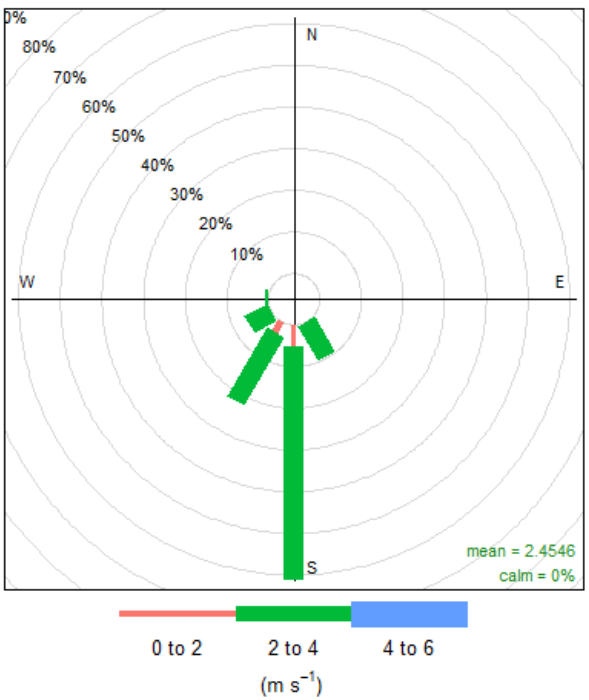



Particle size between ~10 and 30 nm diameter are present at high concentrations at ground level

Hudda et al, ES&T 2014

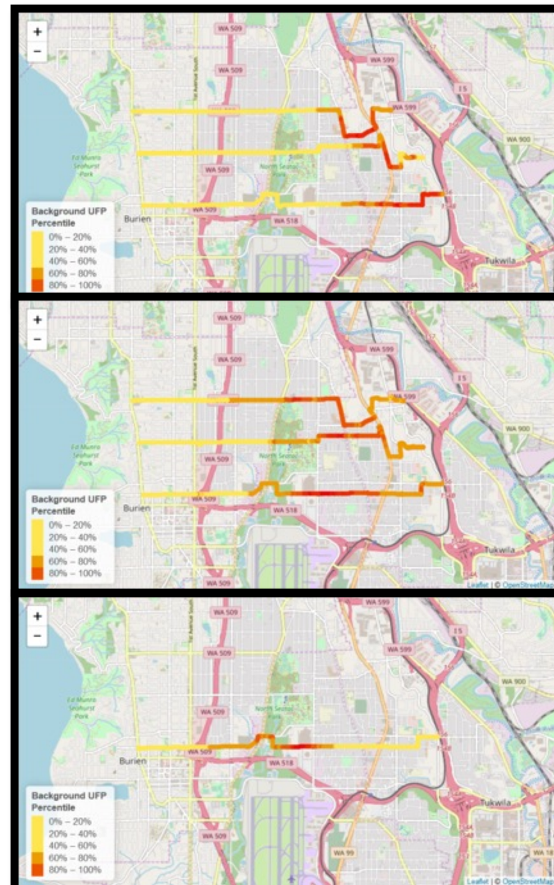
# Local Background UFP (Hudda 2014 Method)

## Wind Rose (Nov 21)




**Frequency of counts by wind direction (%)**

## Plume Shifting




1st Drive

2nd Drive

3rd Drive (146th only

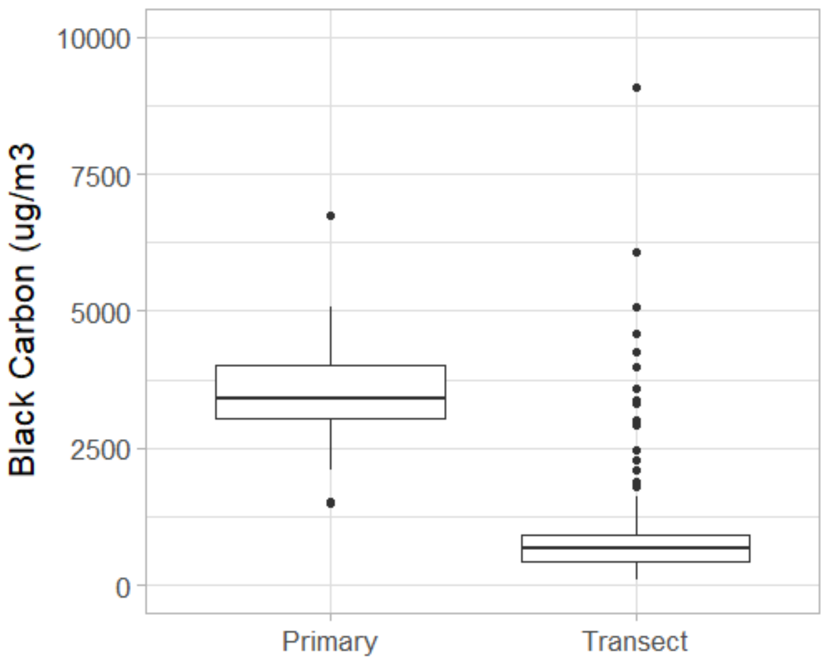
# PRELIMINARY RESULTS

# Winter and partial Spring Mobile Monitoring (2018)

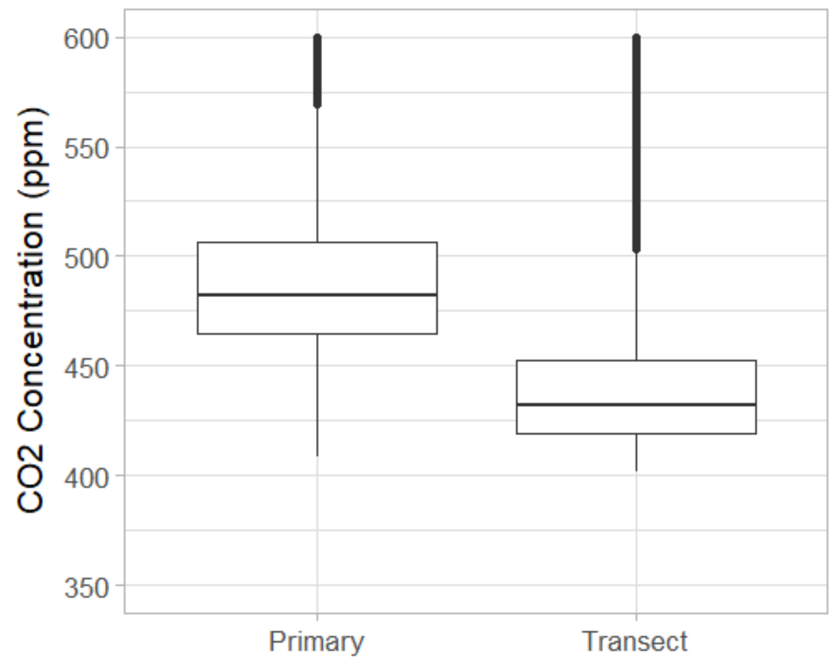
| Date | Mean Temperature (F) | Predominant Wind Direction | Landing Direction (Field Notes) |
|---|---|---|---|
| 7-Feb-18 | 53 | South-east | N |
| 8-Feb-18 | 52 | South-west | N |
| 9-Feb-18 | 48 | South-west | N |
| 12-Feb-18 | 44 | North-west | S |
| 13-Feb-18 | 46 | South | N |
| 14-Feb-18 | 42 | South | N then S |
| 15-Feb-18 | 43 | South-west | N |
| 16-Feb-18 | 46 | South | N |
| 7-Mar-18 | 48 | West | S |
| 8-Mar-18 | 50 | South | N |
| 9-Mar-18 | 49 | South-west | N |
| 12-Mar-18 | 71 | East | S then N |
| 13-Mar-18 | 51 | South-west | N |
| 14-Mar-18 | 50 | South-west | N |
| 15-Mar-18 | 54 | West | S |
| 16-Mar-18 | 54 | South-west | S |
| 18-Apr-18 | 55 | South-west | S |
| 19-Apr-18 | 60 | West | S |
| 20-Apr-18 | 59 | South-west | N |
| 23-Apr-18 | 66 | North-west | S |
| 24-Apr-18 | 74 | West | S |
| 25-Apr-18 | 69 | North-west | S |
| 26-Apr-18 | 76 | North-west | S |
| 27-Apr-18 | 55 | South-west | N |

# Measurements
# Primary Roadway (I-5) vs Transect

Winter - Spring Data



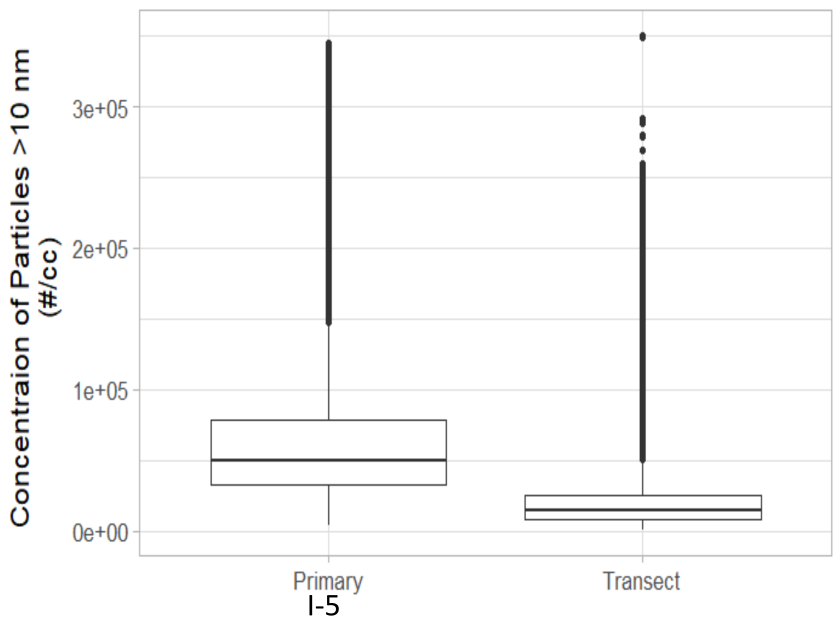

I-5



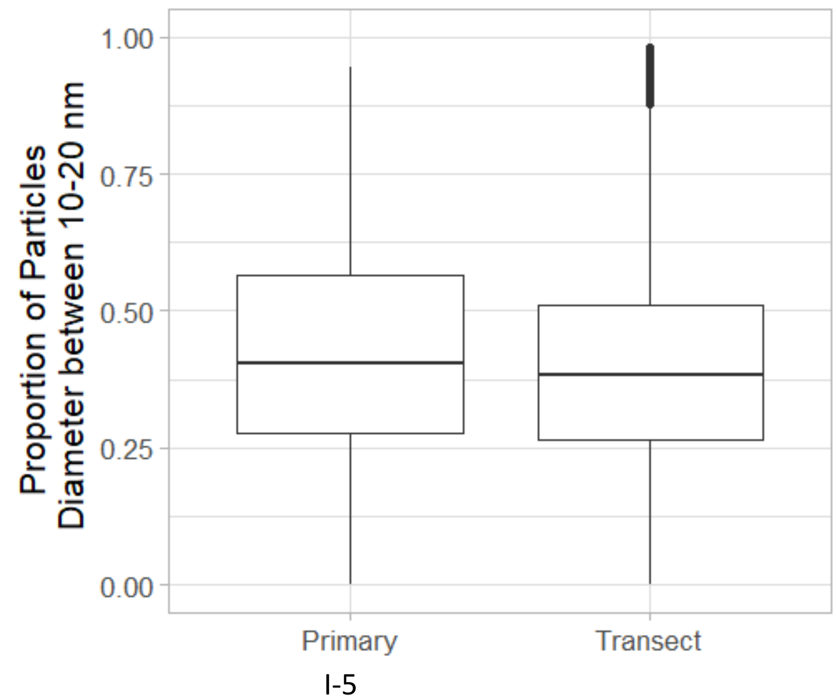

I-5

# Measurements
# Primary Roadway (I-5) vs Transect
## Winter - Spring Data

"Total" > 10 nm



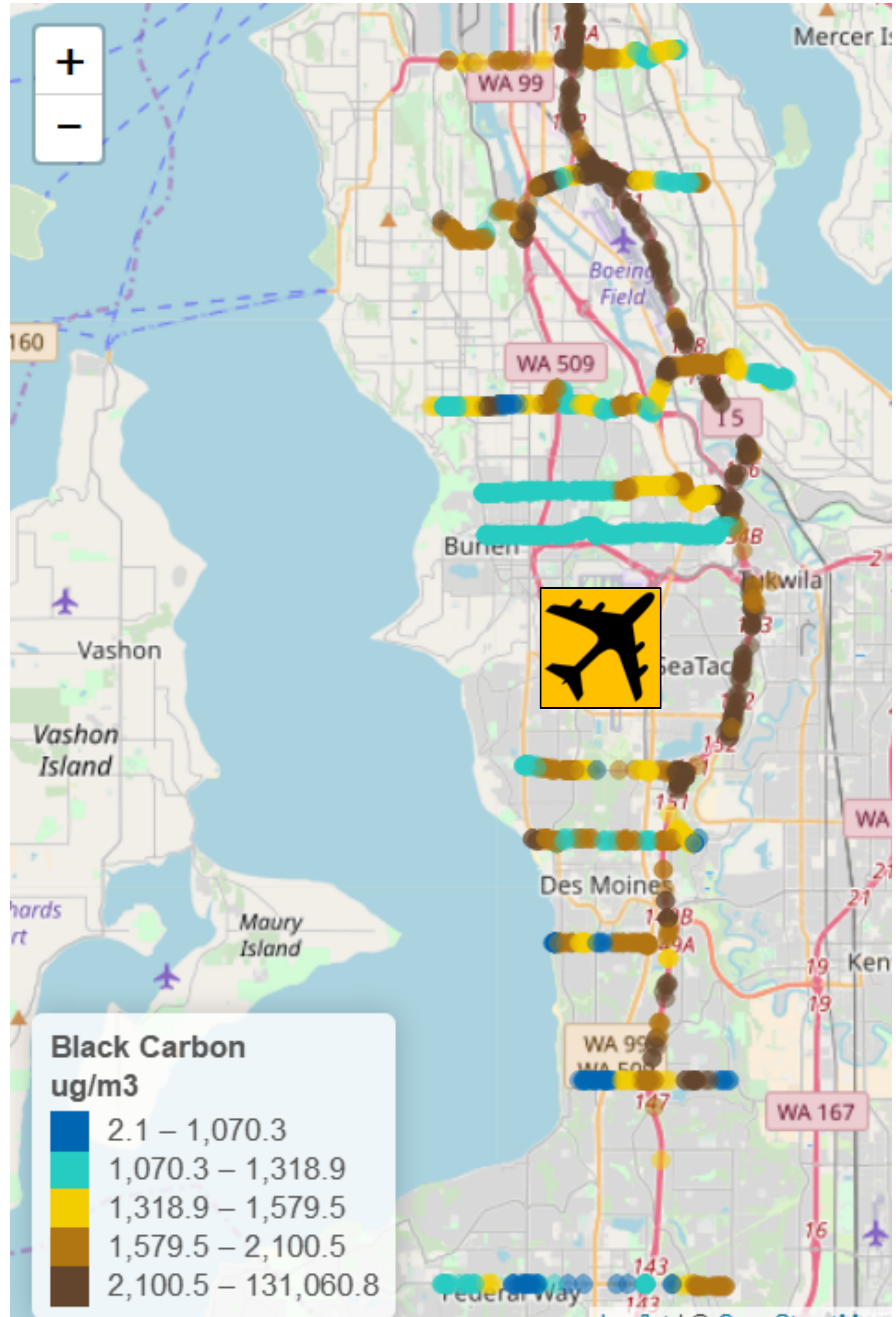

Proportion of "Small" 10-20 nm



# PRELIMINARY SPATIAL DISTRIBUTION OF POLLUTANTS

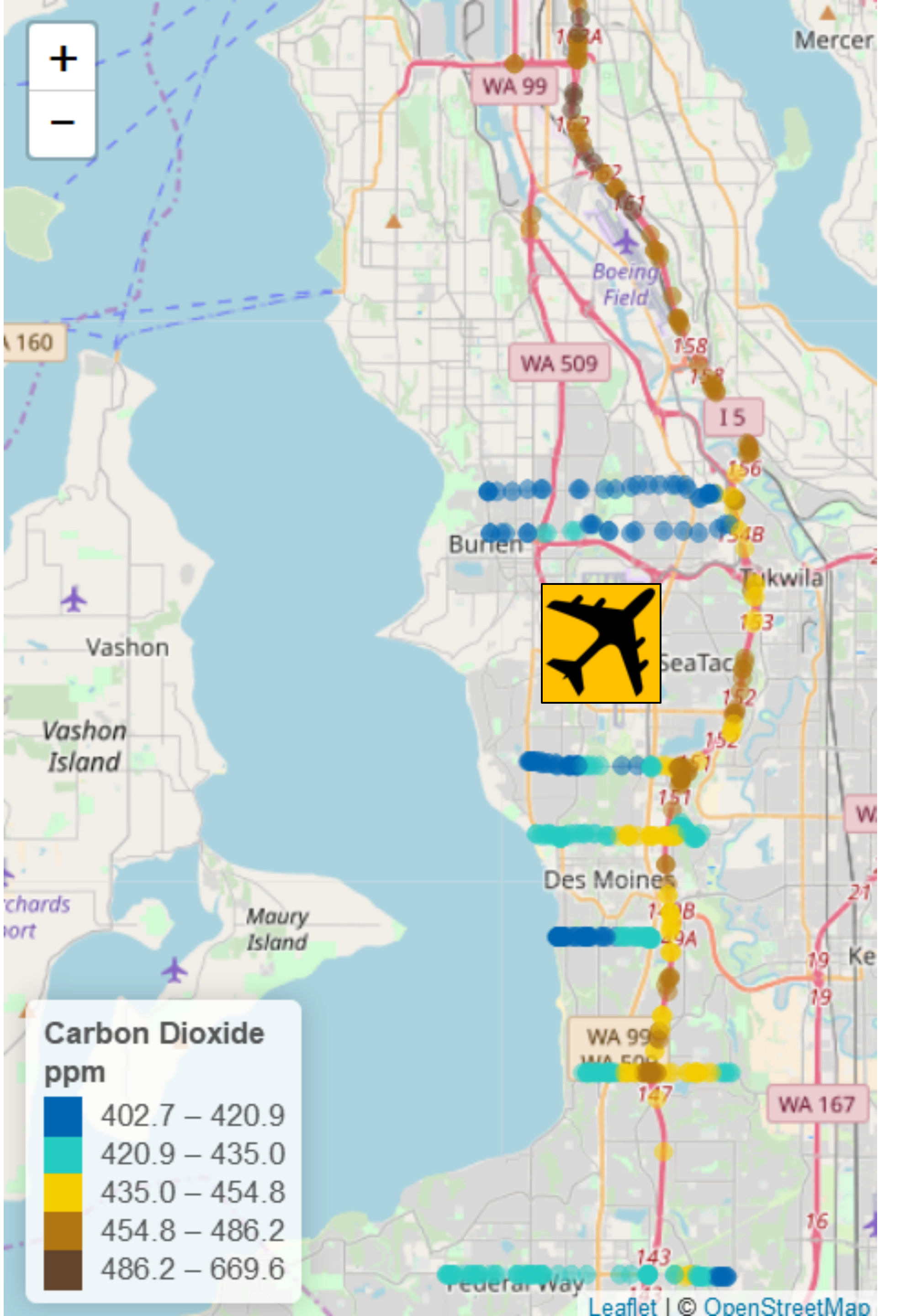
# Black Carbon Spatial Distribution

Winter - Spring Data



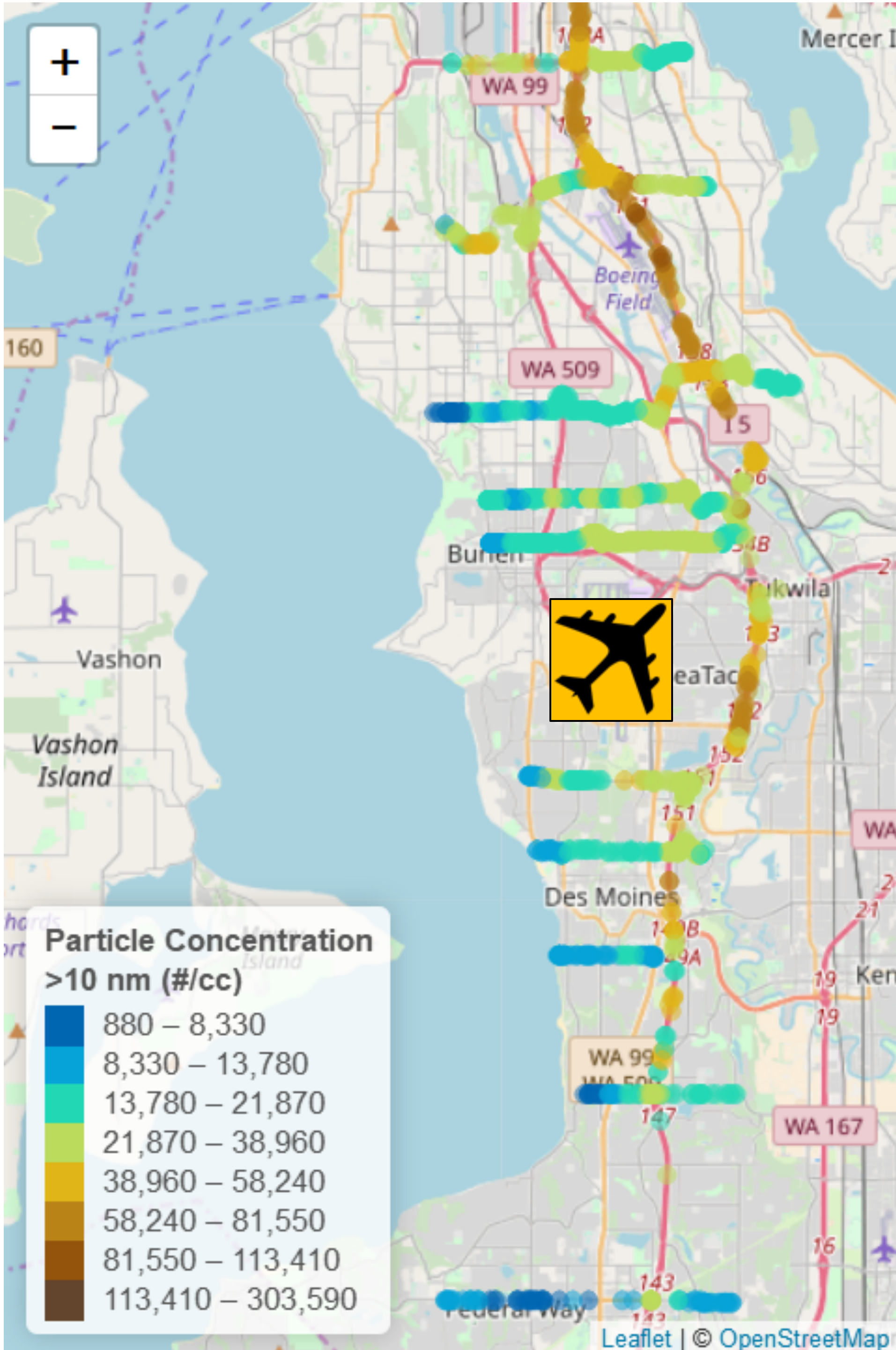
# Carbon Dioxide Spatial Distribution

Winter - Spring Data



# Particle Number Concentration ("Total" >10 nm) Spatial Distribution

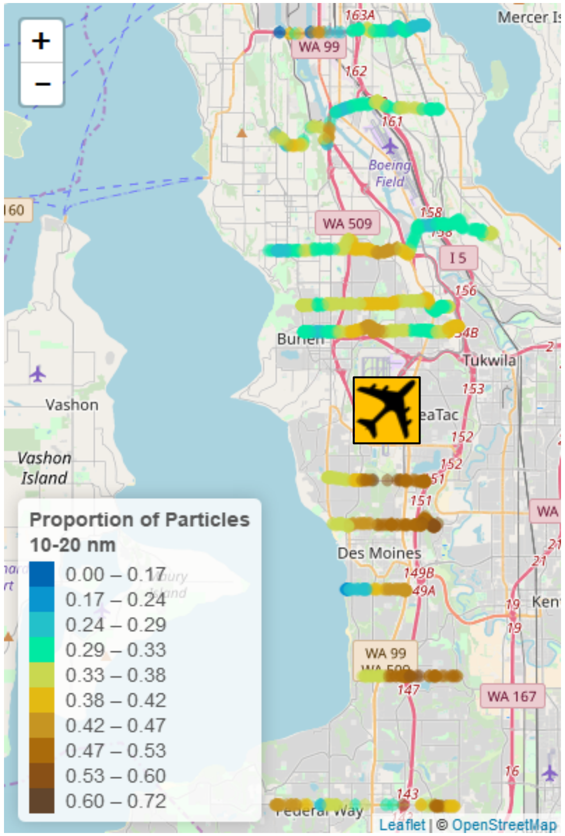
Winter - Spring Data



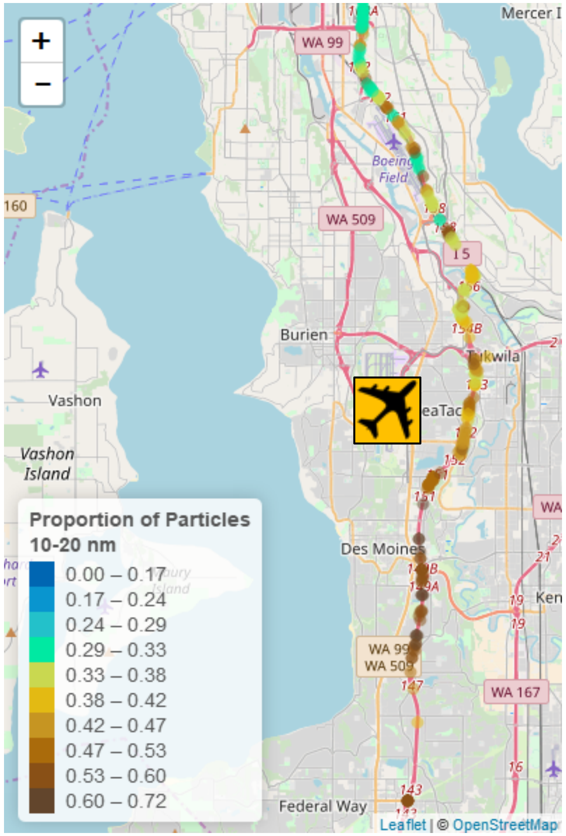
# Proportion of small 10-20 nm particles

## Transects vs Primary Road (I-5)

**Proportion of Small Particles (10-20 nm)**




**Proportion of Small Particles (10-20 nm)**

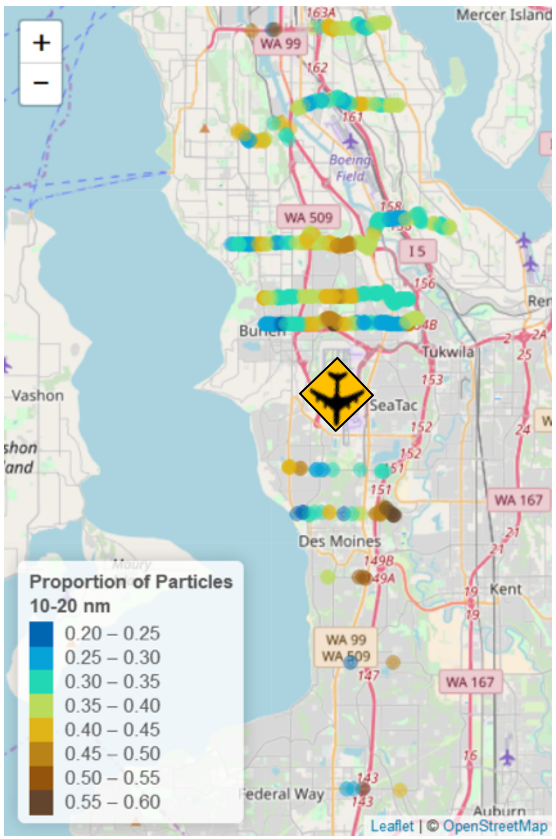



Winter – Spring Data

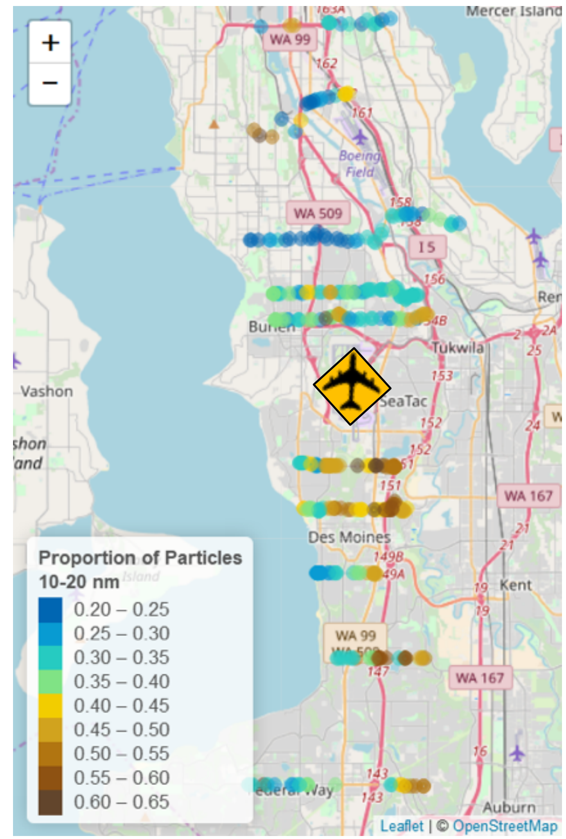
# Proportion of small 10-20 nm particles

## By Wind Direction

### Wind from the SOUTH




### Wind from the NORTH




Winter – Spring Data

# How can we make better use of the multi-pollutant data we've collected?

Principal Component Analysis (PCA)

Data reduction technique that allows for capturing the variance in the data in a smaller set of variables.

The goal is to summarize the correlations among the observed variables with a smaller set of linear combinations.

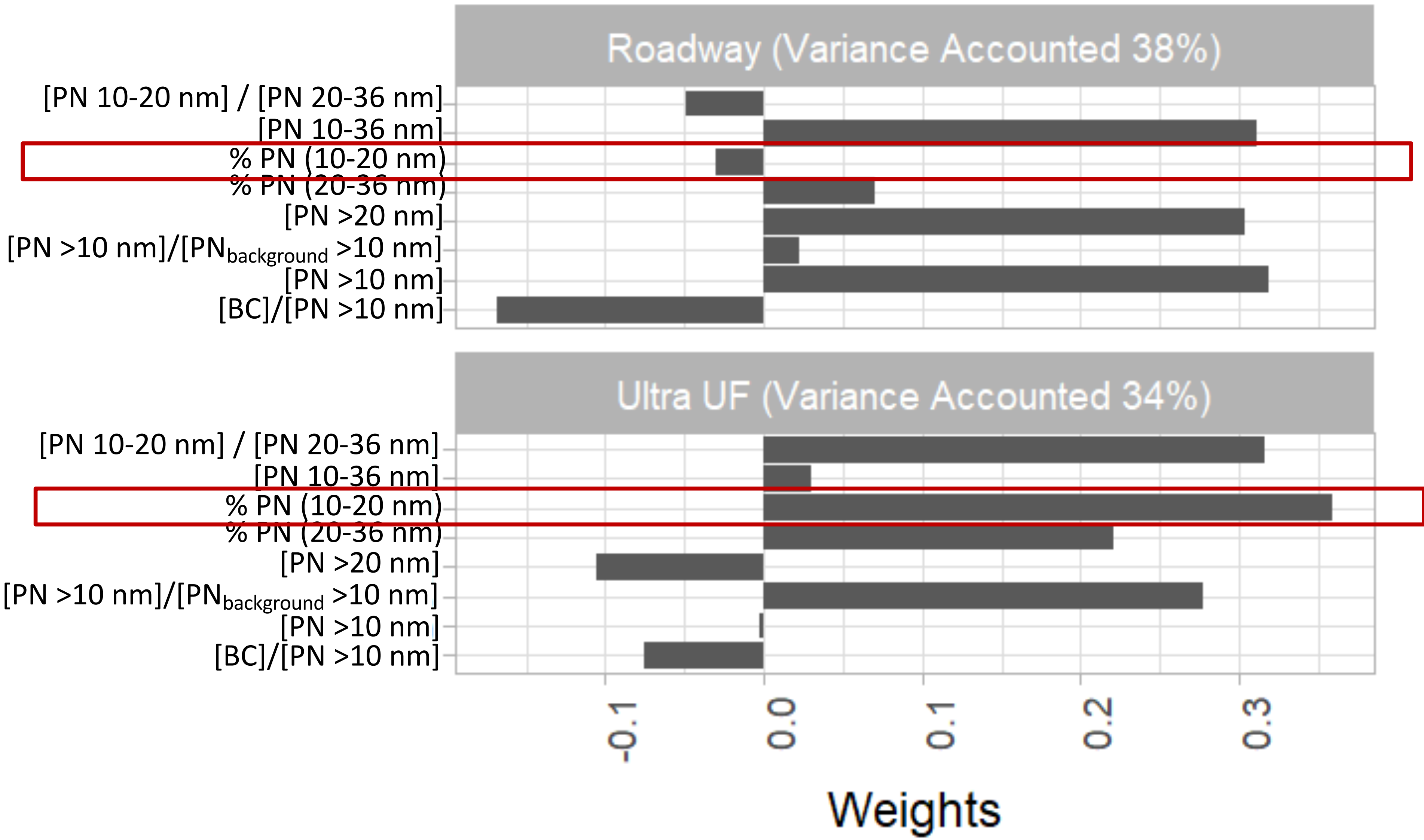
# Principal Component Analysis (PCA)

- **Hypothesis**: Using particle size distribution measures collected during mobile monitoring we can identify correlations that correspond to roadway and Ultra-Ultrafine features.

- **Method**: Perform a PCA with varimax-rotation. Varimax rotation searches for a rotation (i.e., a linear combination) of the original factors such that the variance of the loadings is maximized.

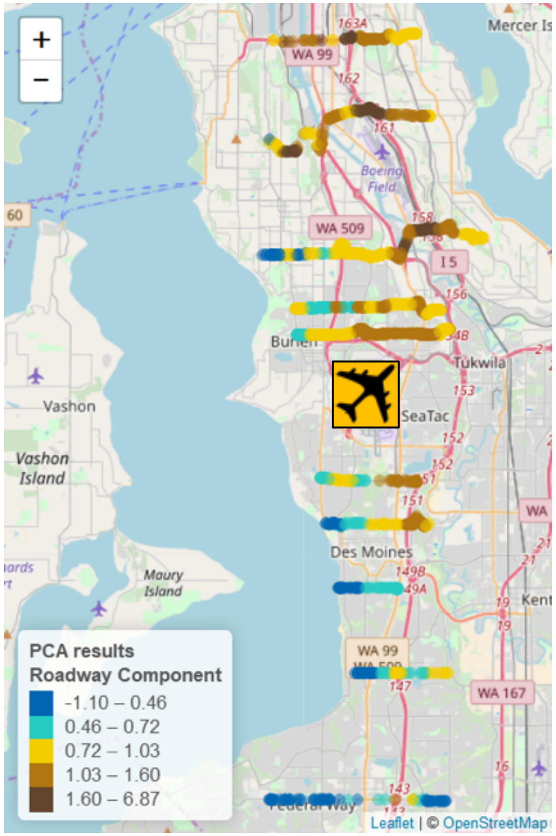
# Preliminary PCA Results

## Winter – Spring Data

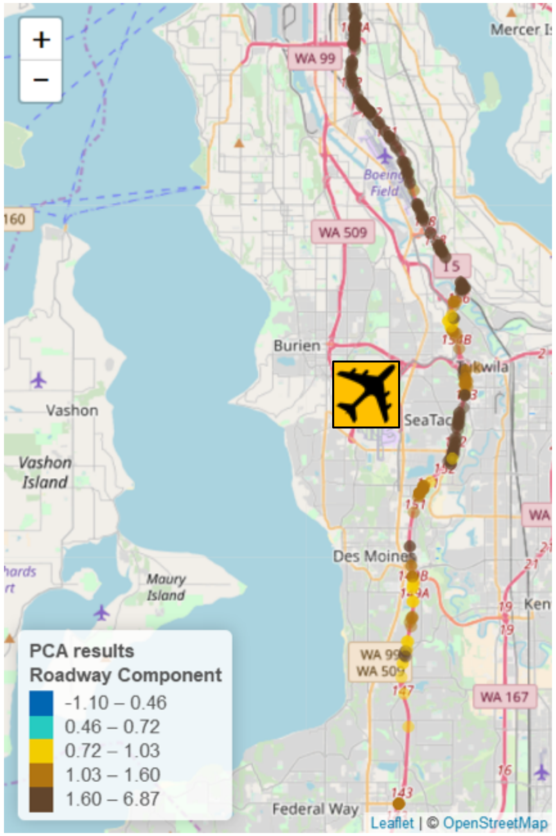


# PCA Results
# "Roadway" Feature

**On Transect**



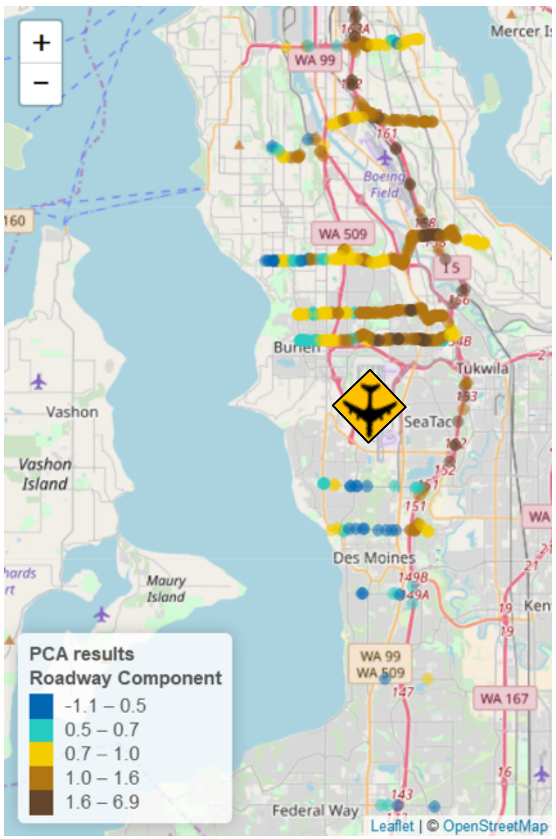

**On I-5**




Winter – Spring Data

# PCA
# "Roadway" Feature

**Wind from the SOUTH**

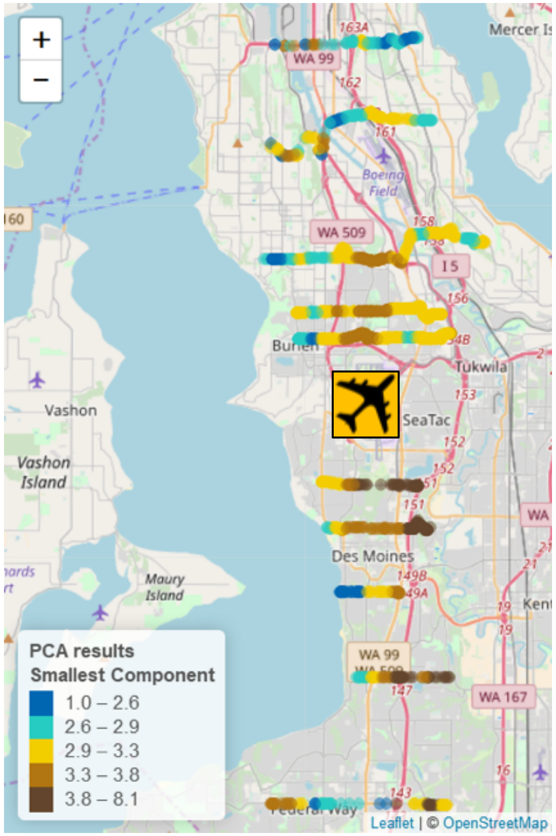



**Wind from the NORTH**

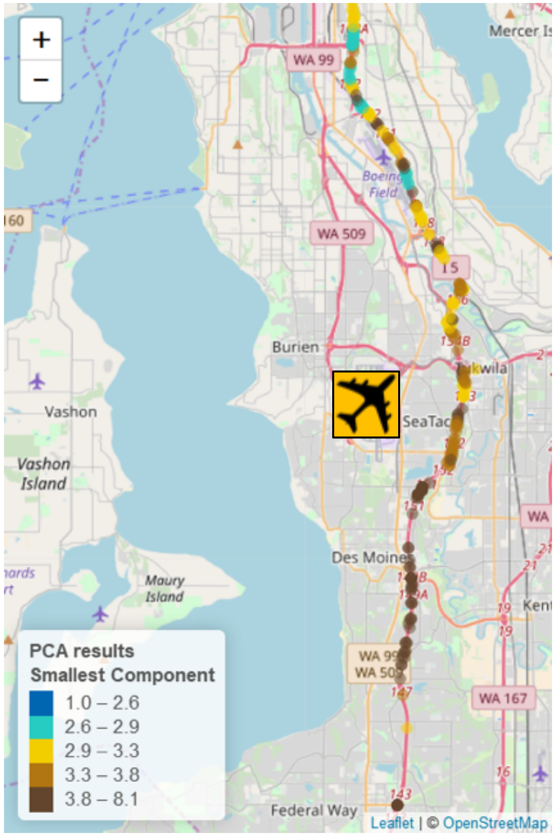

Winter – Spring Data

# PCA Results
# "Ultra-UF" Feature

**Transects**




**I-5**




Winter – Spring Data

# PCA
# "Ultra-UF" Feature

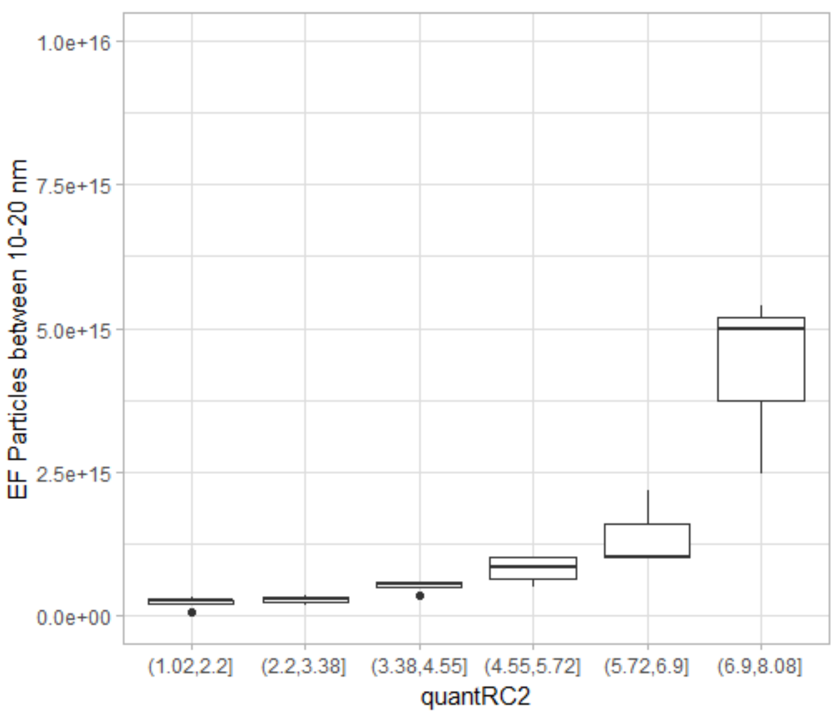
**Wind from the SOUTH**


**Wind from the NORTH**

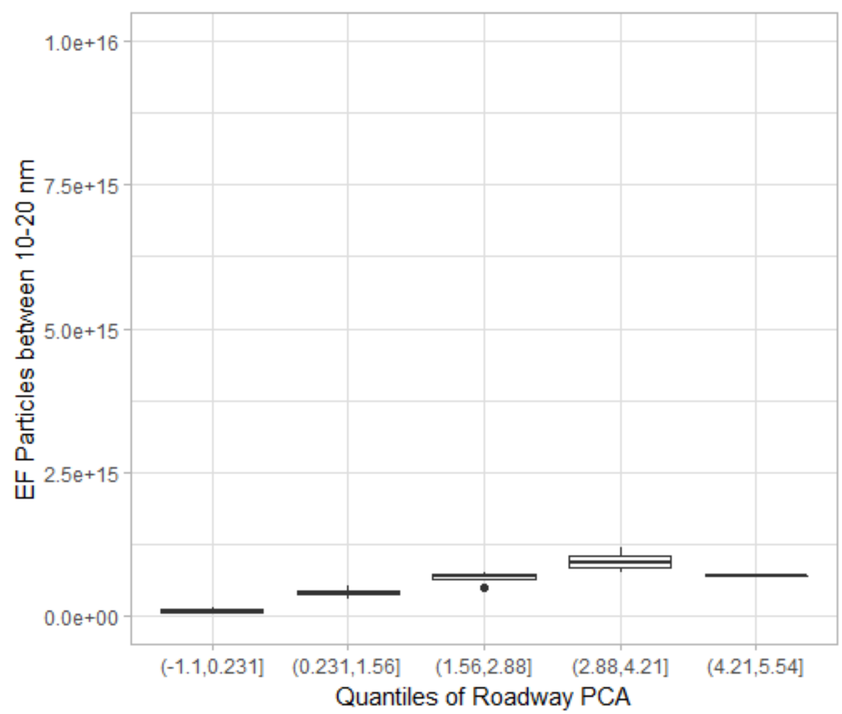

Winter – Spring Data

# Fuel-Based Emission Factors (EF)
# # Particles/$kgC_{Fuel}$

**Quantiles of PCA (Ultra-UF)**




**Quantiles of PCA (Roadway)**




Winter – Spring Data

# Fuel-Based Emission of UF particles

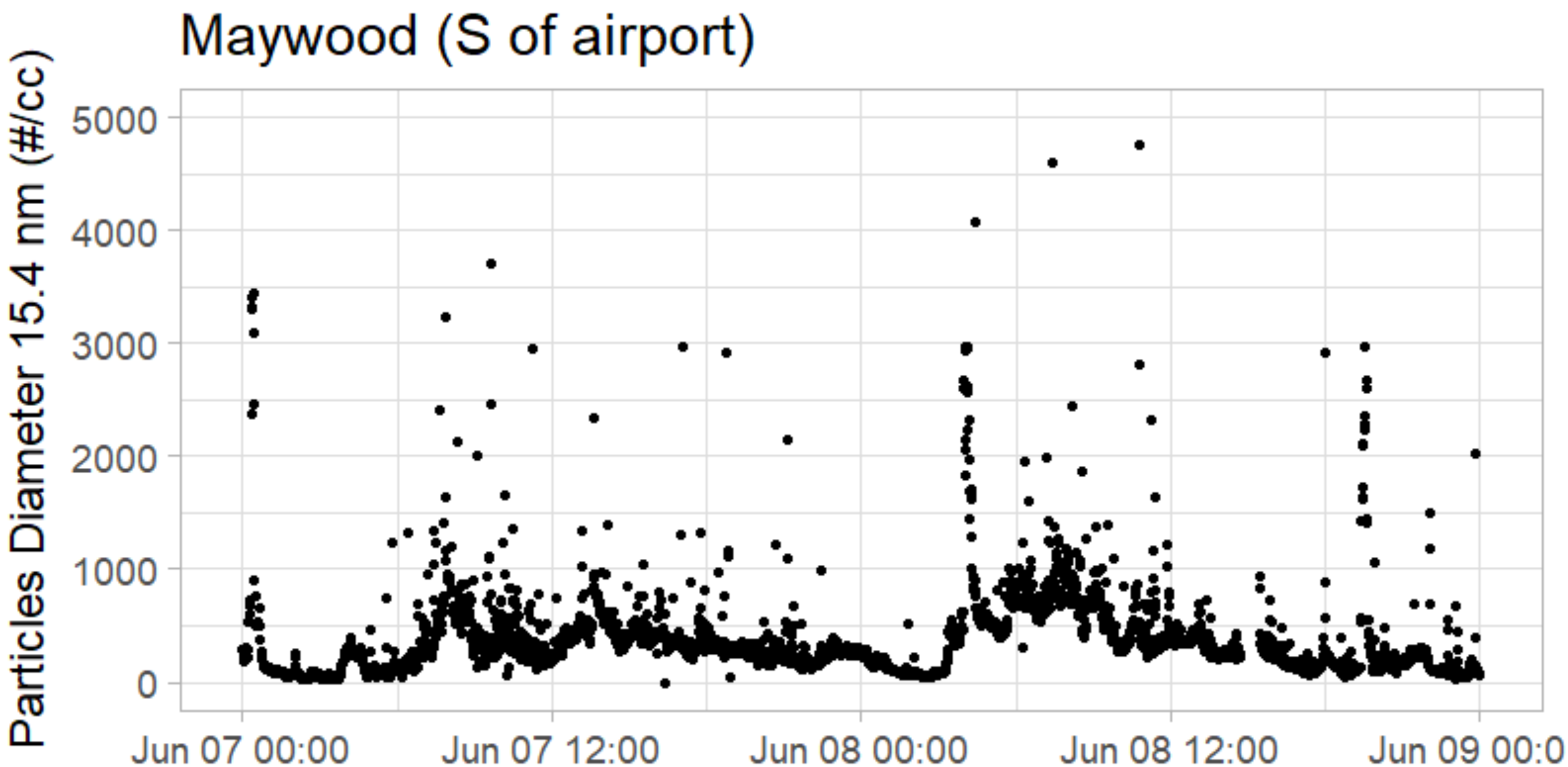
## (Particles/$kgC_{Fuel}$)

**Table 2**
Summary of the results reported by previous studies for pollutants' concentrations and emission factors (EF) at different airports.

| Study | Airport | Take-off/ Landing | Particle size range (nm) | Particle number (particles/cm$^3$) | BC (μg/m$^3$) | $PM_{2.5}$ (μg/m$^3$) | EF Number (particles/kg fuel) | EF BC (g/kg fuel) | EF $PM_{2.5}$ (g/kg fuel) |
|---|---|---|---|---|---|---|---|---|---|
| Herndon et al., 2005 | John F. Kennedy International Airport, New York, USA | Takeoff | 7–2500 | – | – | – | $(1.0\pm0.7) \times 10^{14}$ | – | – |
| Herndon et al., 2005 | Logan International Airport, Boston, USA | Takeoff | 7–2500 | – | – | – | $(8.8\pm7.6) \times 10^{15}$ | – | – |
| Westerdahl et al., 2008 | Los Angeles International Airport, USA | Takeoff/ Landing | 7–350 | $2 \times 10^4 - 5.8 \times 10^5$ | 1.8–3.8 | – | – | – | – |
| Fanning et al., 2007 | Los Angeles International Airport, USA | Takeoff | 10–100 | $1.4 \times 10^5 - 1.4 \times 10^6$ | 13.9 ± 14.3 & 14.0 ± 10.2 | 32–42 | – | – | – |
| Herndon et al., 2008 | Hartsfield Jackson Atlanta International Airport, USA | Takeoff | 7–2500 | – | – | – | $1.8 \times 10^{15} - 5.6 \times 10^{15}$ | 0.2–1.5 | – |
| Hu et al., 2009 | Santa Monica Airport, CA, USA | Takeoff | 5.6–560 | $1 \times 10^4 - 3 \times 10^5$ | 0.7–2.7 | - | $5 \times 10^{16}$ | - | - |
| Mazaheri et al., 2009 | Brisbane Airport, Australia | Takeoff | 4–710 | – | – | – | $2.1 \times 10^{16} - 5.4 \times 10^{16}$ | – | 0.2–0.3 |
| | | Landing | | | | | $7.7 \times 10^{15} - 4.3 \times 10^{16}$ | – | 0.3–0.5 |
| Zhu et al., 2011 | Los Angeles International Airport, USA | Takeoff | 7–320 | $0.4 \times 10^4 - 8.4 \times 10^4$ | 0.01–3.6 | 37.1 ± 15.4 | $3.4 \times 10^{16}$ | - | - |
| Klapmeyer and Marr 2012 | Roanoke Regional Airport in western Virginia, USA | Takeoff | – | $1.5 \times 10^3 - 1.7 \times 10^5$ | – | – | $1.4 \times 10^{16} - 7.1 \times 10^{16}$ | 0.2–0.5 | - |
| Lobo et al., 2012 | Oakland International Airport, CA, USA | Takeoff | 5–1000 | $2 \times 10^5 - 1.3 \times 10^6$ | - | - | $4 \times 10^{15} - 2 \times 10^{17}$ | - | 0.1–0.7 |
| Hudda et al., 2014 | Los Angeles International Airport, USA | Takeoff/ Landing | 10–1000 | $4 \times 10^4 - 6 \times 10^4$ | 1.4–1.6 | – | – | – | – |
| Lobo et al., 2015 | Hartsfield-Jackson Atlanta International Airport | Takeoff | 5–1000 | – | – | – | $6 \times 10^{17} - 2 \times 10^{18}$ | – | 0.1–0.6 |
| Ren et al., 2016 | Tianjin International Airport, China | Takeoff | 10–1000 | $4 \times 10^4 - 4.4 \times 10^5$ | – | – | $2 \times 10^{15} - 3.2 \times 10^{16}$ | – | – |
| | | Landing | | $6 \times 10^4 - 4.5 \times 10^5$ | – | – | $2.5 \times 10^{15} - 3.3 \times 10^{16}$ | – | – |
| Current study | Los Angeles International Airport, USA | Takeoff | 7–500 | $1.53 \times 10^5 \pm 3.11 \times 10^4$ | 2.87 ± 0.0.3 | 33 ± 0.15 | $(8.69 \pm 1.20) \times 10^{15}$ | 0.12 ± 0.02 | 0.38 ± 0.04 |
| | | Landing | | | | | $(8.16 \pm 1.00) \times 10^{15}$ | 0.11 ± 0.01 | 0.40 ± 0.05 |

Shirmohammadi, F., Sowlat, M. H., Hasheminassab, S., Saffari, A., Ban-Weiss, G., & Sioutas, C. (2017). Emission rates of particle number, mass and black carbon by the Los Angeles International Airport (LAX) and its impact on air quality in Los Angeles. *Atmospheric Environment*, *151*, 82-93.

# Preliminary Fixed Site Small Particles (~15.4 nm)



# Submitted NIH Proposal in Nov 2018 for Further Study

Develop a "Selective Ultrafine Particle Respirator" (SUPR)

Selectively filters out the smallest ultrafine particles so that we can use it in controlled experiments to measure short-term health effects.

We should find out about the status of this proposal by summer 2019.

# Next Steps

- Repeat analyses on full data set
- Analyze fixed site data
- Estimate daily Emission Rates for roadways and airport
- Report by December 2019

# QUESTIONS