Mobile ObserVations of Ultrafine Particles (MOV-UP) Advisory

August 15th, 2018

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Outline

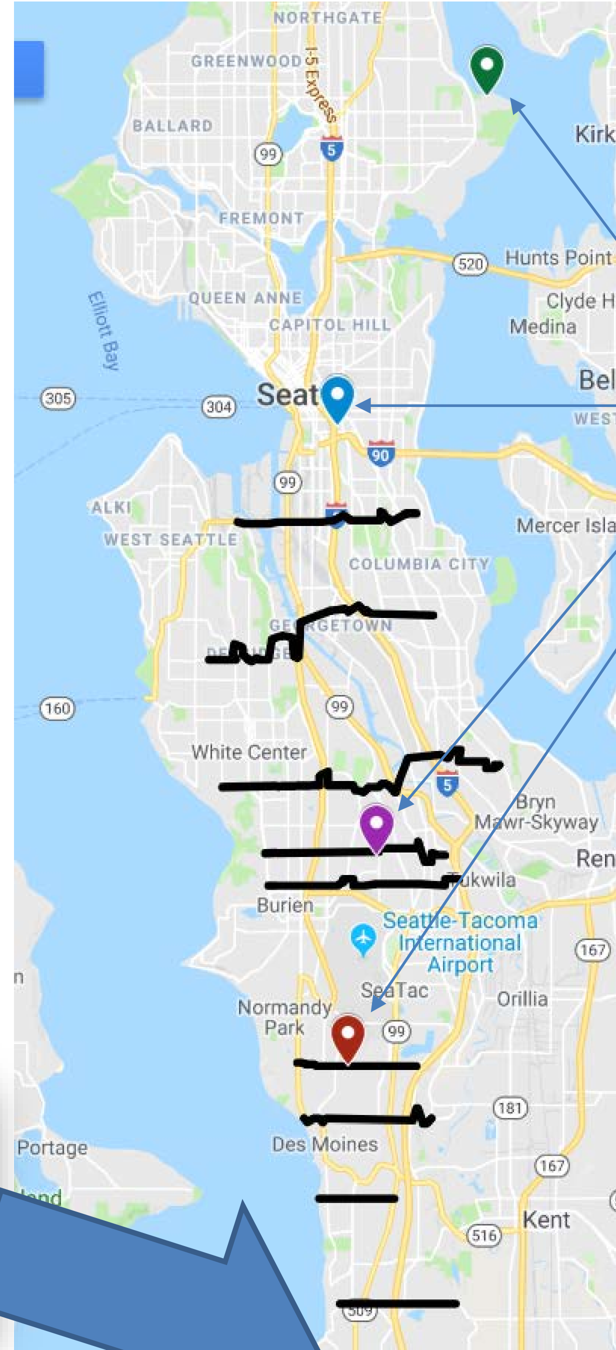
1. Current Monitoring Status
2. Background literature updates
3. Preliminary Data Analysis
4. Discussion
5. Questions

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

MOVUP Monitoring Locations

Mobile Monitoring Transects + Stationary Sites



4 stationary sites

Mobile Monitoring Status

- Winter 2018
  - 16 days of monitoring
- Spring 2018
  - 14 days of monitoring
- Summer 2018
  - 10 days of monitoring (ongoing)

❖ Mobile monitoring typically occurs between 12 PM and 5 PM

❖ Typically monitoring consists of 2 concurrent cars (N and S of the airport)

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

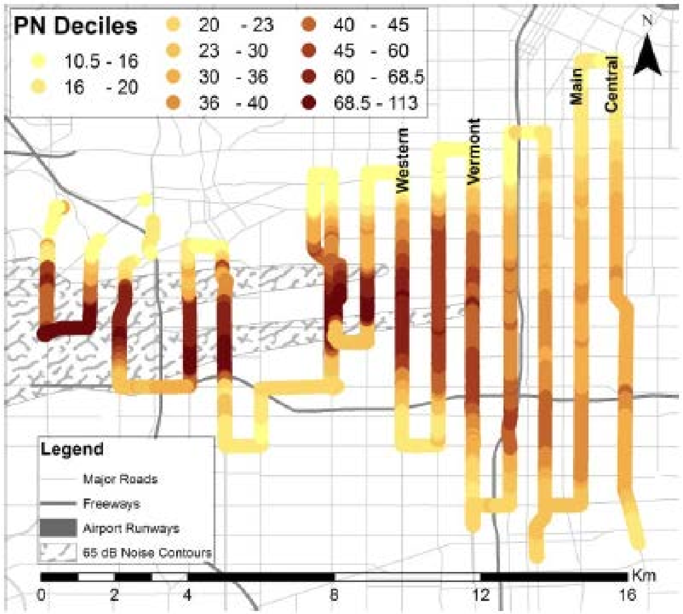
TSI, Inc. model 3007 CPC

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

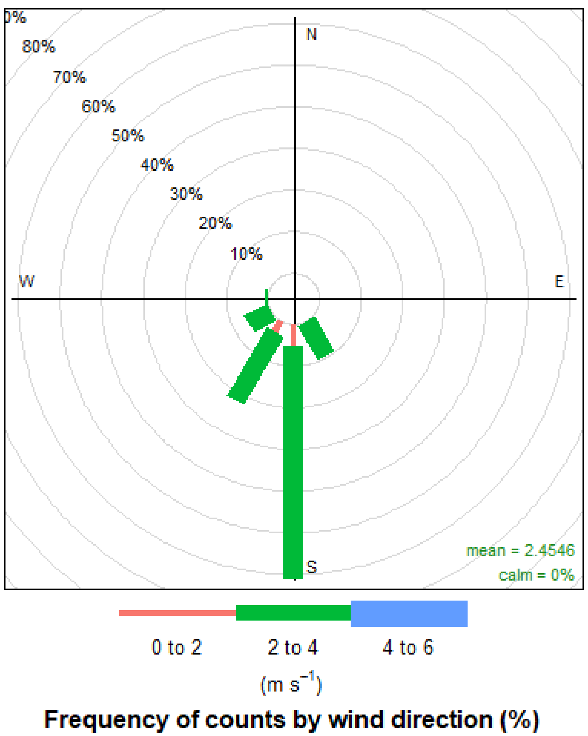


Particle size between ~10 and 30 nm diameter are present at high concentrations at ground level

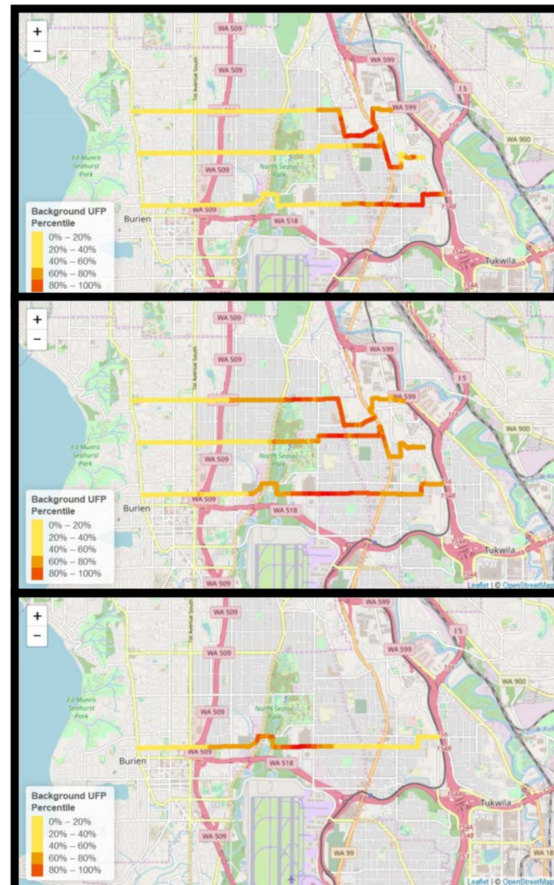
Hudda et al, ES&T 2014

Local Background UFP (Hudda 2014 Method)

Wind Rose (Nov 21)



Plume Shifting



1st Drive

2nd Drive

3rd Drive (146th only

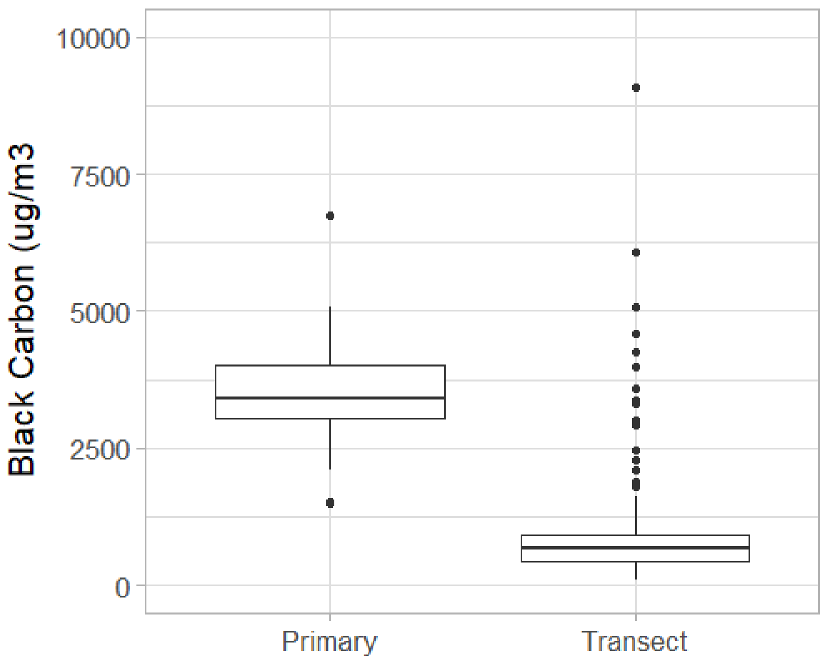
PRELIMINARY RESULTS

Winter and partial Spring Mobile Monitoring (2018)

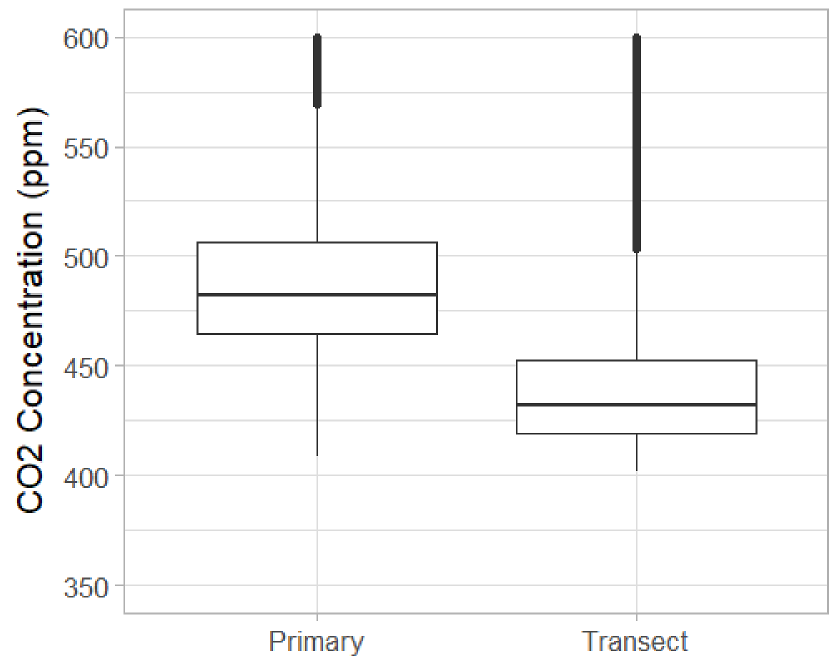
Date	Mean Temperature (F)	Predominant Wind Direction	Landing Direction (Field Notes)
7-Feb-18	53	South-east	N
8-Feb-18	52	South-west	N
9-Feb-18	48	South-west	N
12-Feb-18	44	North-west	S
13-Feb-18	46	South	N
14-Feb-18	42	South	N then S
15-Feb-18	43	South-west	N
16-Feb-18	46	South	N
7-Mar-18	48	West	S
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

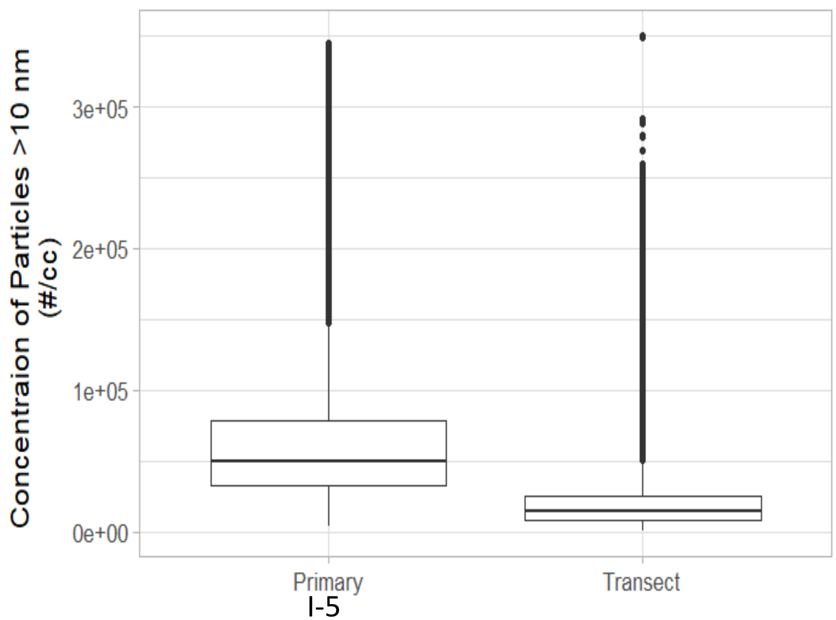


I-5

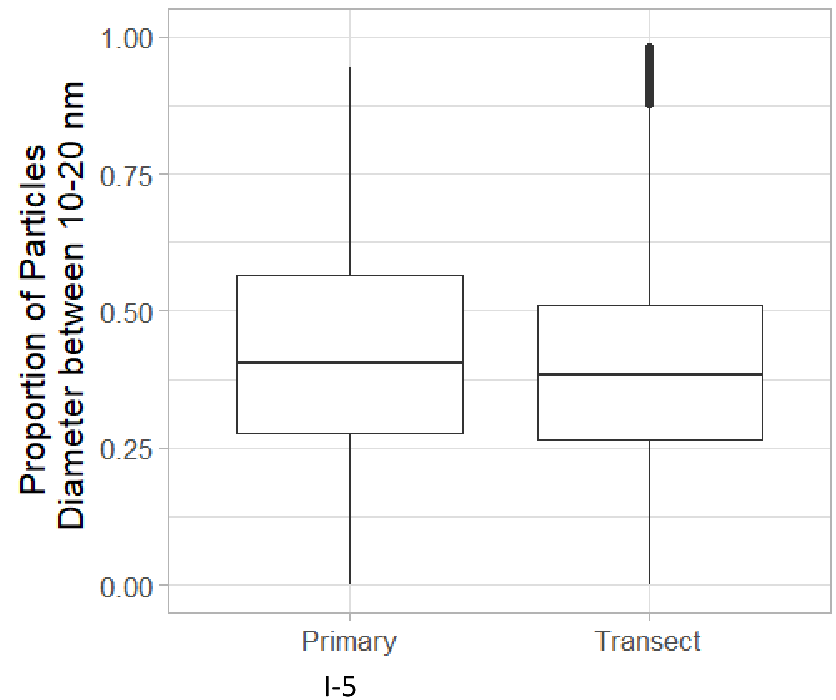
Measurements
Primary Roadway (I-5) vs Transect

Winter - Spring Data

“Total” > 10 nm



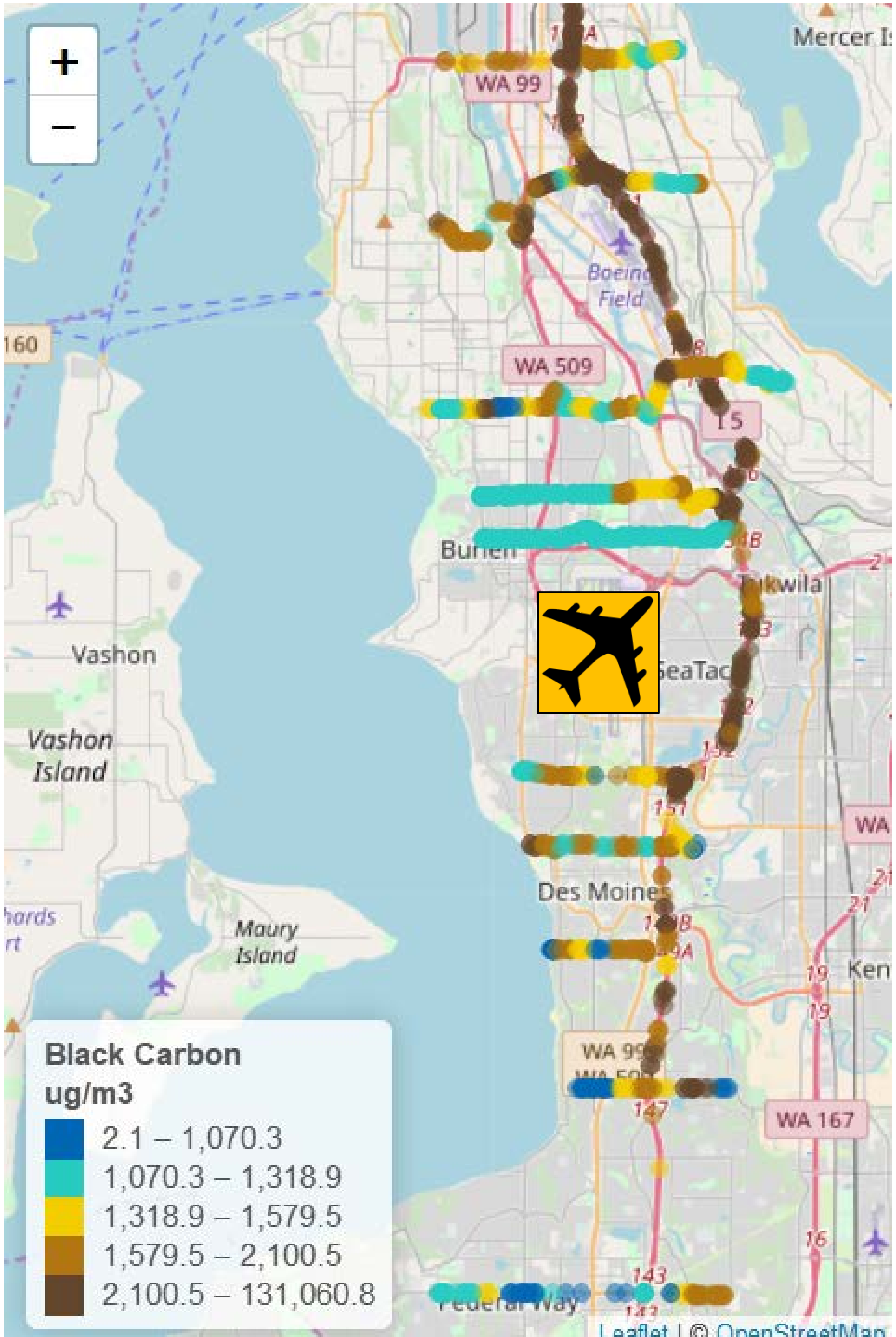
Proportion of “Small” 10-20 nm



PRELIMINARY SPATIAL DISTRIBUTION OF POLLUTANTS

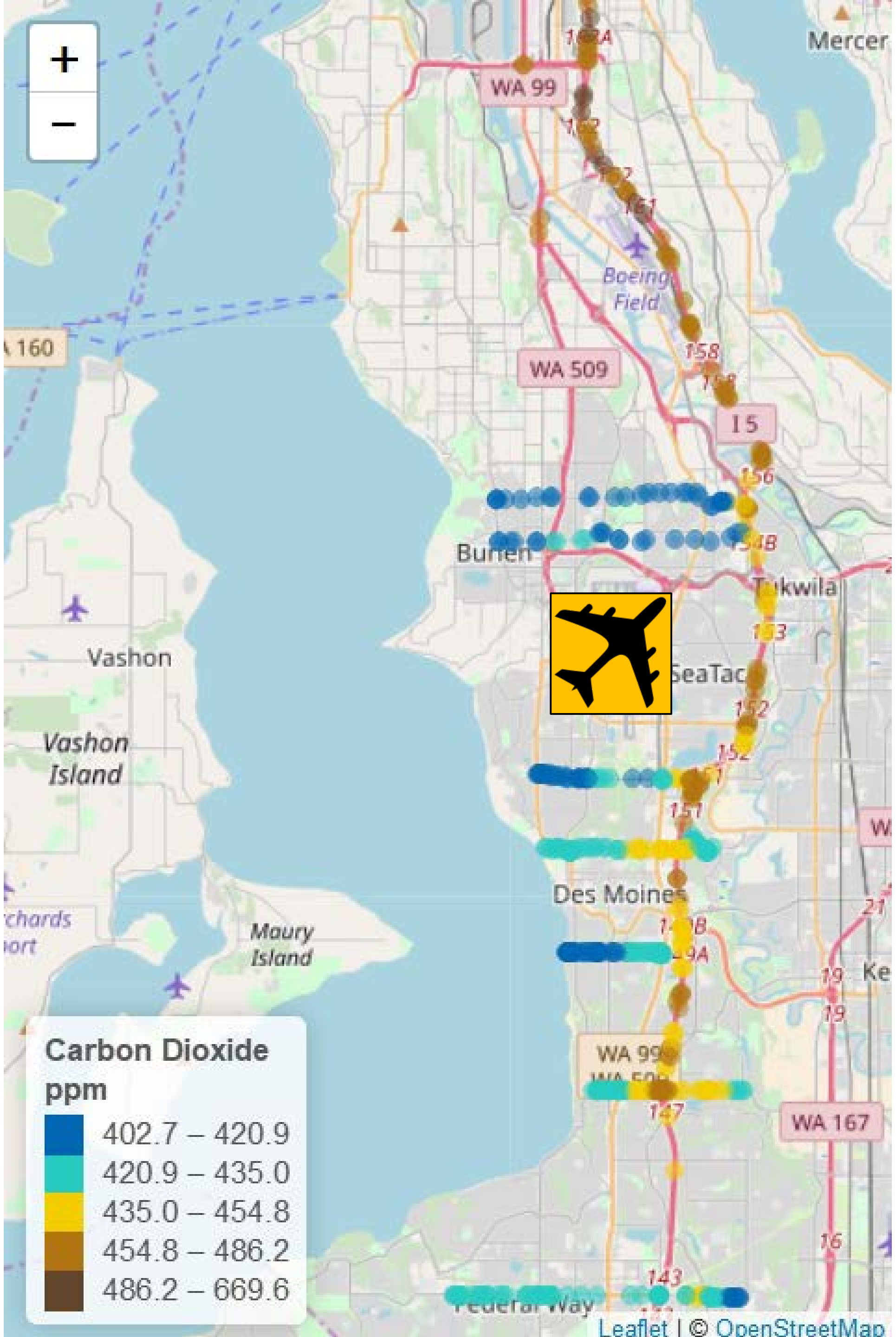
Black Carbon Spatial Distribution

Winter - Spring Data



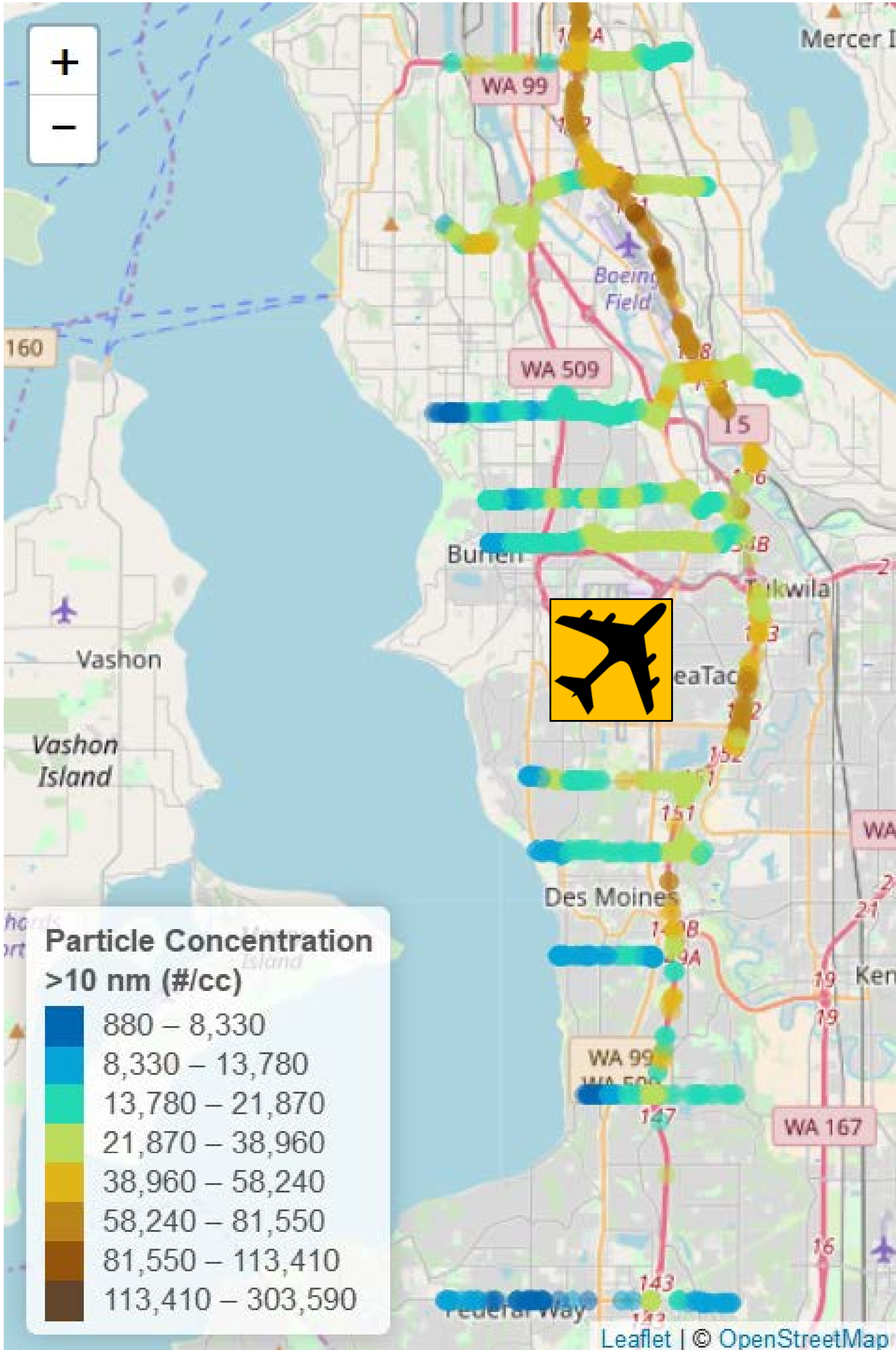
Carbon Dioxide Spatial Distribution

Winter - Spring Data



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

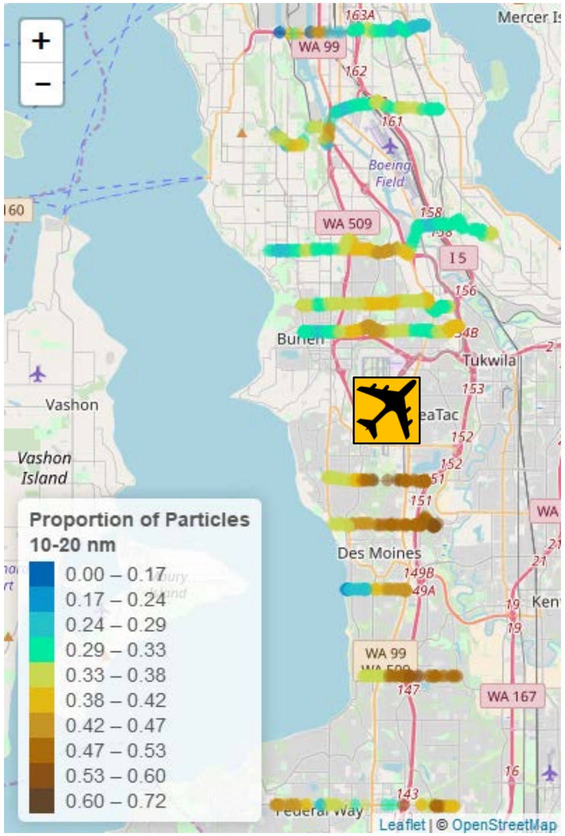
Winter - Spring Data



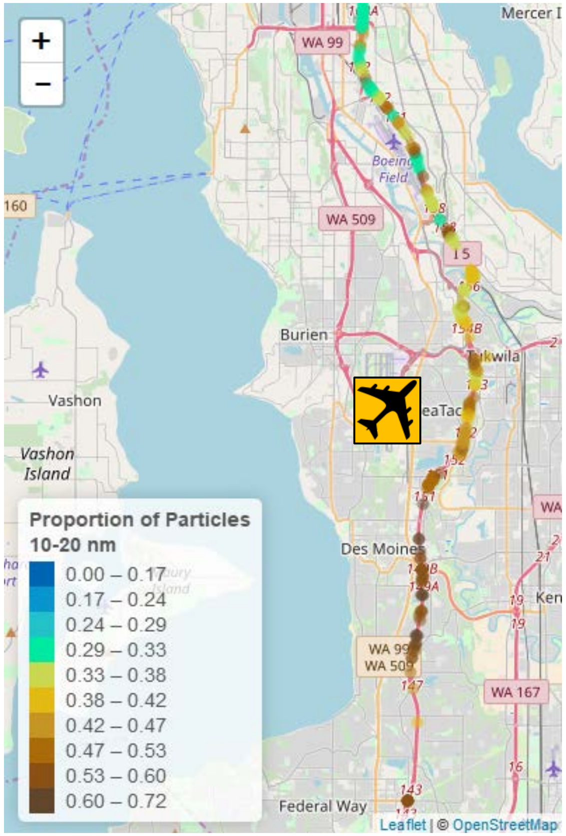
Proportion of small 10-20 nm particles

Transects vs Primary Road (I-5)

Proportion of Small Particles (10-20 nm)



Proportion of Small Particles (10-20 nm)

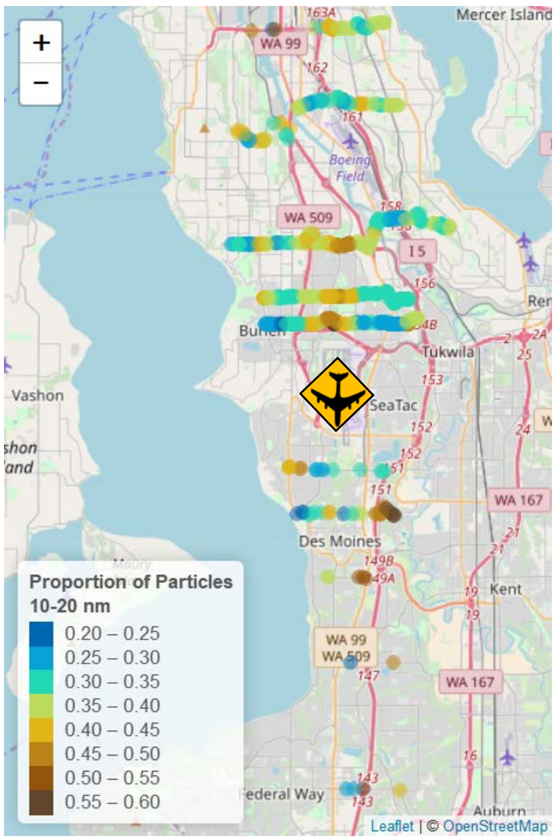


Winter – Spring Data

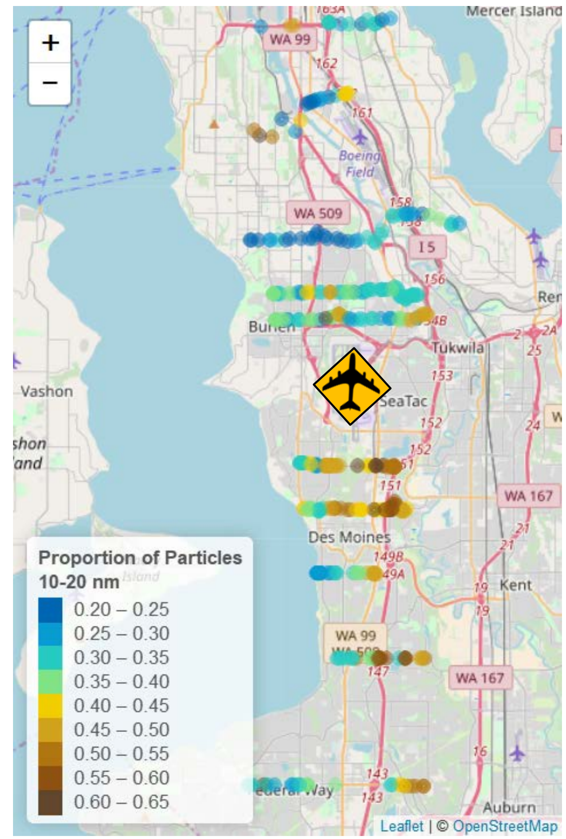
Proportion of small 10-20 nm particles

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.

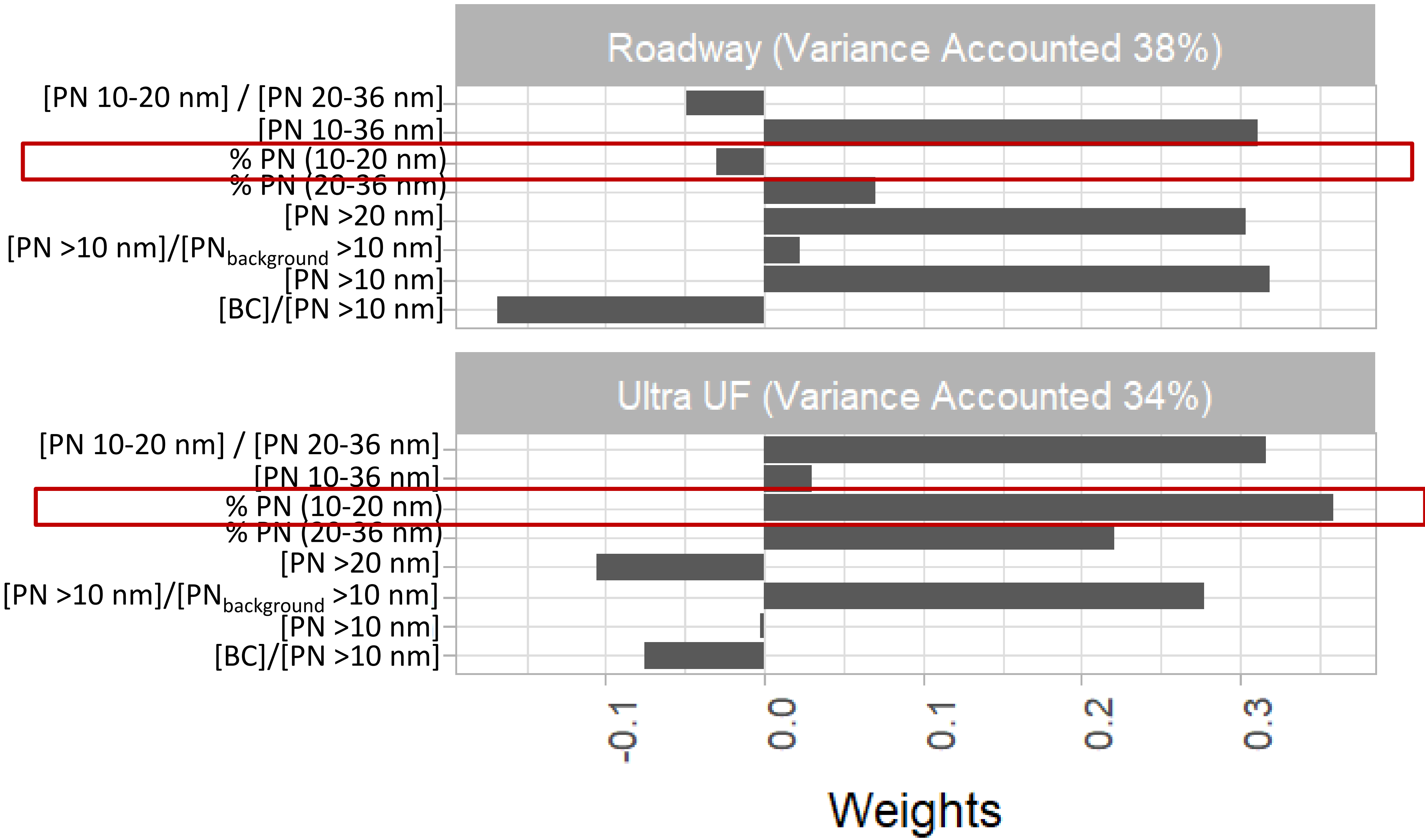
Principal Component Analysis (PCA)

- **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.

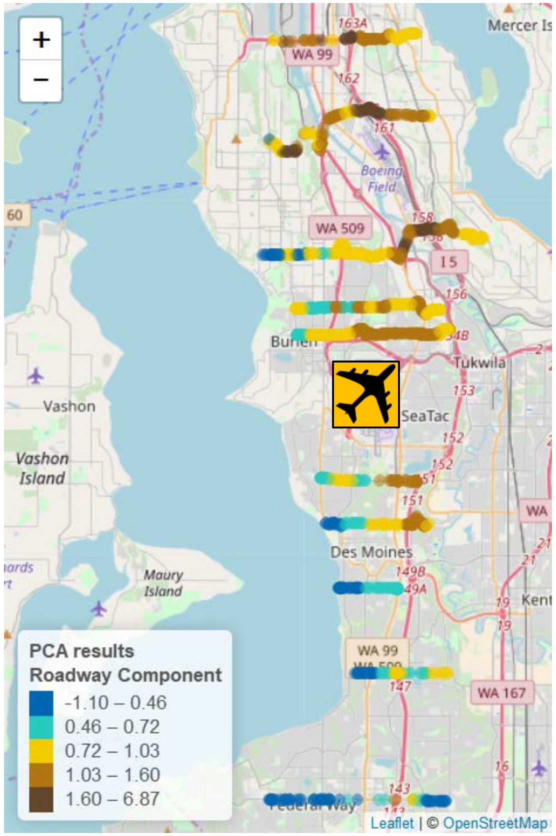
Preliminary PCA Results

Winter – Spring Data

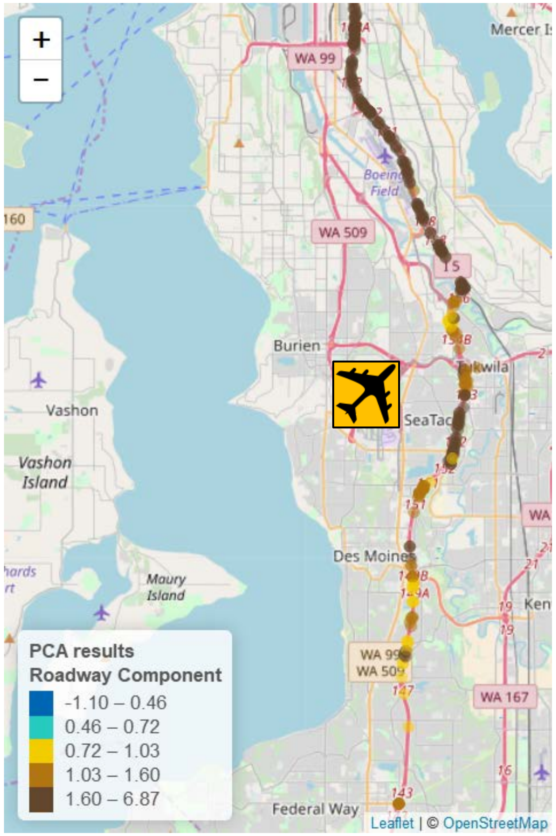


PCA Results
"Roadway" Feature

On Transect



On I-5



Winter – Spring Data

PCA
"Roadway" Feature

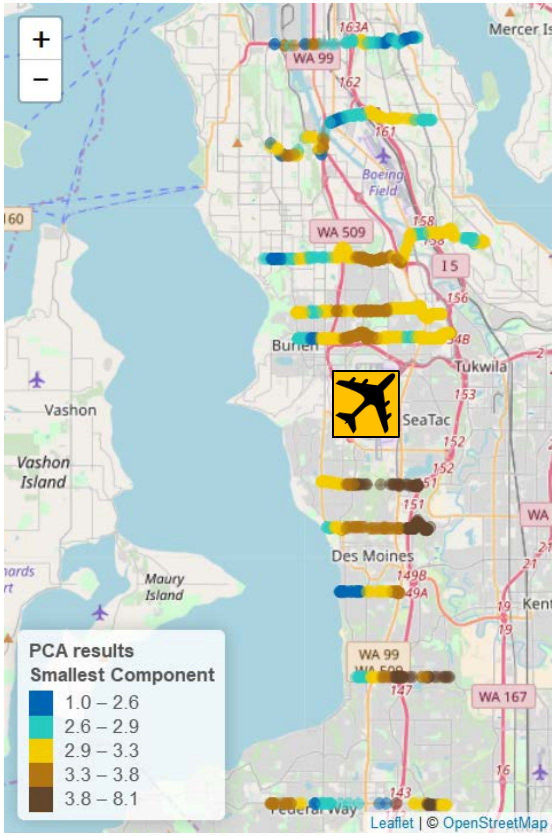
Wind from the SOUTH

Wind from the NORTH

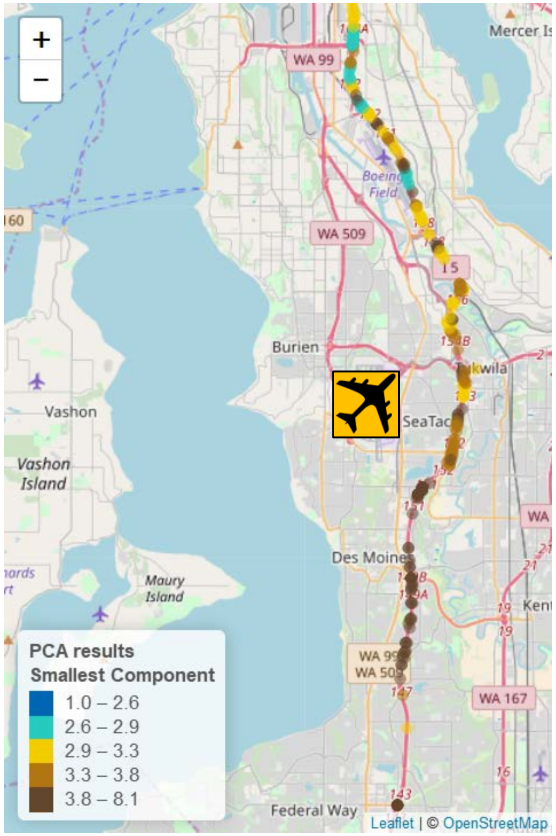
Winter – Spring Data

PCA Results
"Ultra-UF" Feature

Transects



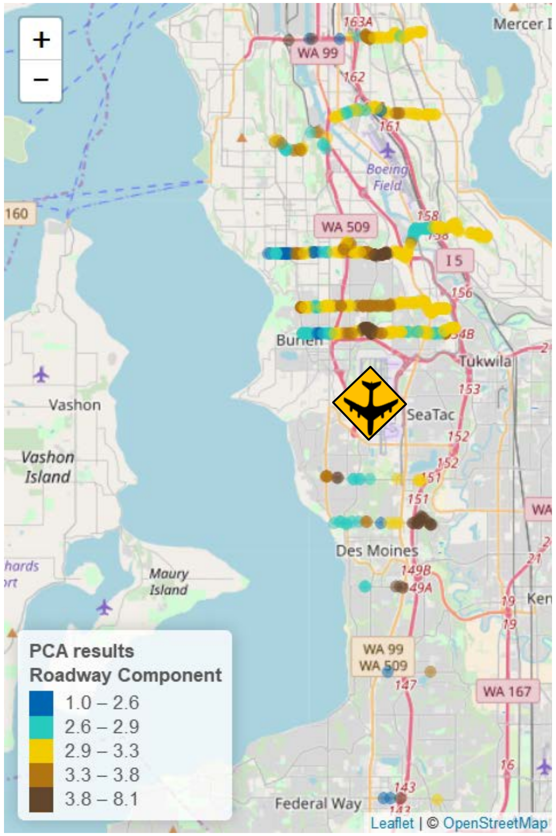
I-5



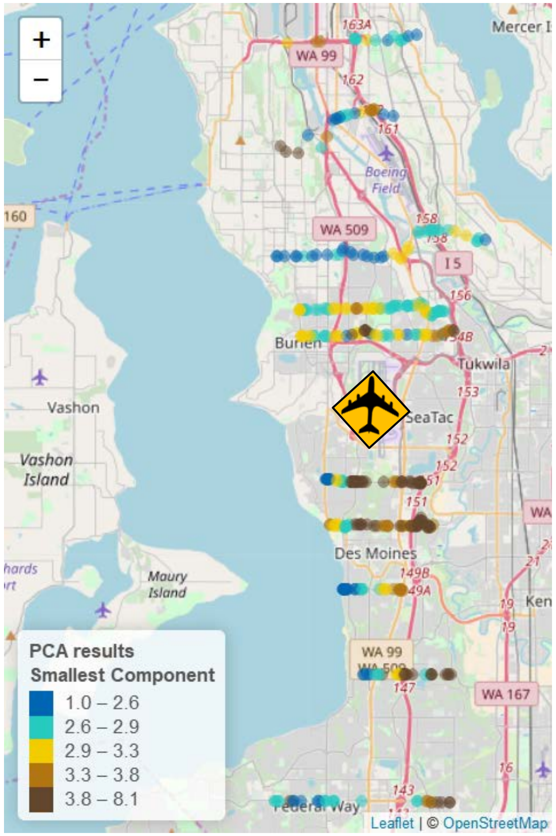
Winter – Spring Data

PCA
"Ultra-UF" Feature

Wind from the SOUTH



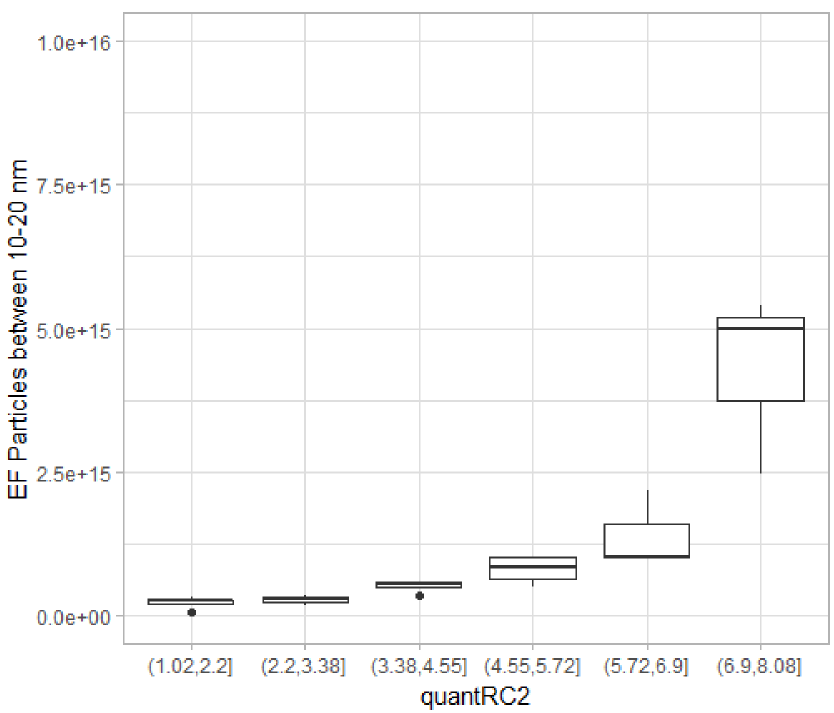
Wind from the NORTH



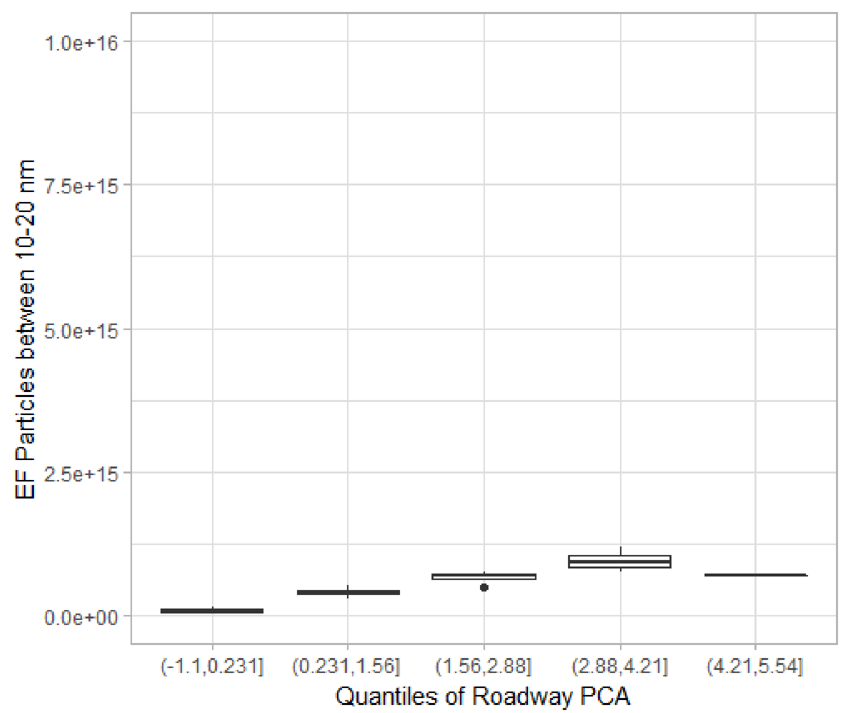
Winter – Spring Data

Fuel-Based Emission Factors (EF)
Particles/kg_{Fuel}

Quantiles of PCA (Ultra-UF)



Quantiles of PCA (Roadway)



Winter – Spring Data

Fuel-Based Emission of UF particles

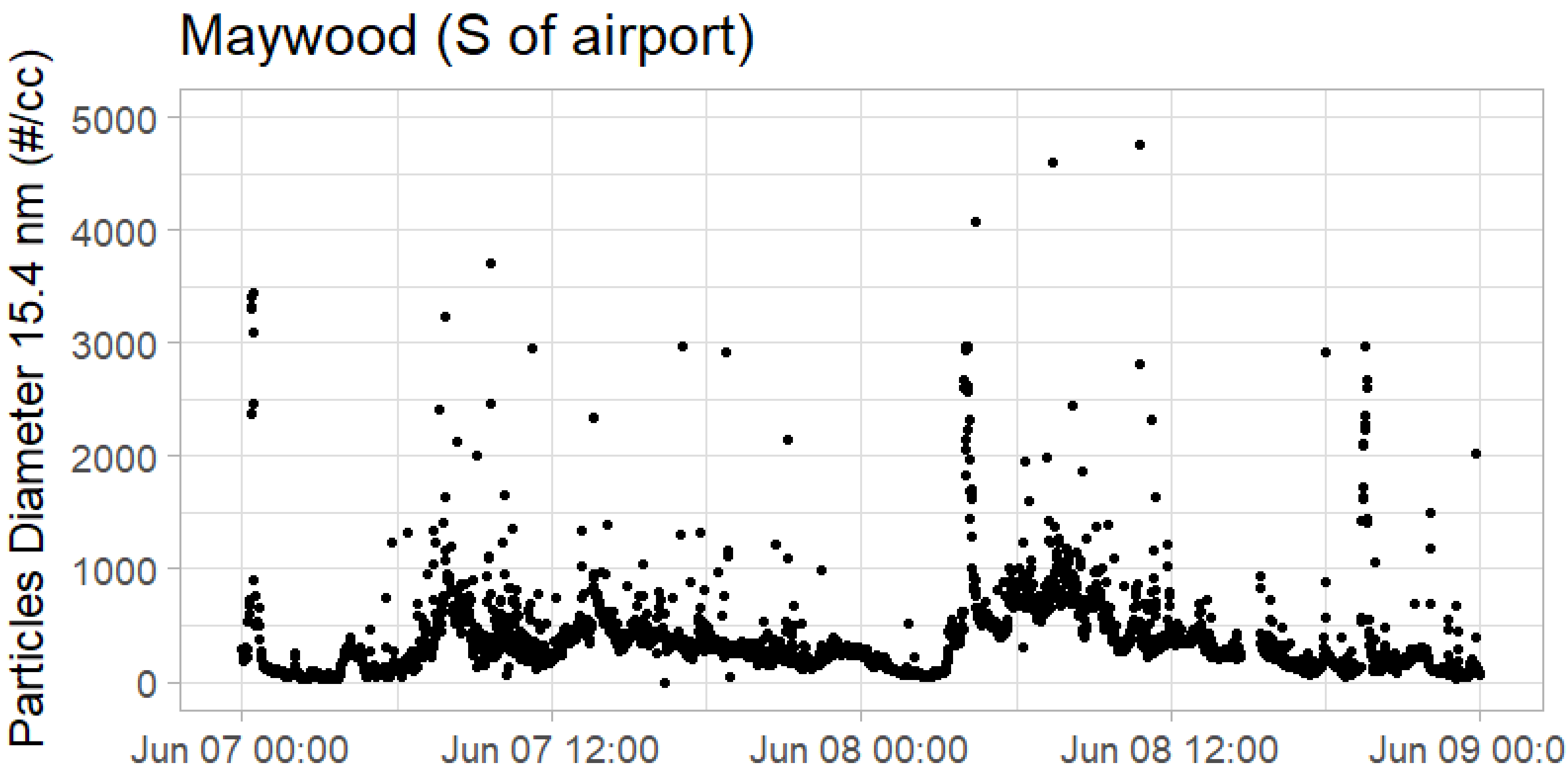
(Particles/kg_{Fuel})

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	–	–	–	$(1.0 \pm 0.7) \times 10^{14}$	–	–
Herndon et al., 2005	Logan International Airport, Boston, USA	Takeoff	7–2500	–	–	–	$(8.8 \pm 7.6) \times 10^{15}$	–	–
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	-	5×10^{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	3.4×10^{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)



Next Steps

- Continue mobile and stationary sampling to end of year
- Repeat analyses on full data set
- Analyze fixed site data
- Estimate daily Emission Rates for roadways and airport
- Report by December 2019

- Poll Advisory Board for input on priorities for other potential next steps

QUESTIONS

Interactive Feedback Session

Assess the impact of time-of-day on the near-airport ultrafine PM monitoring data?

When poll is active, respond at
PollEv.com/jeffryhshira287 or

Text **JEFFRYHSHIRA287** to **22333** once to join

(1) No priority
(2) Low priority
(3) Medium priority
(4) High priority
(5) Urgent

Assess the impact of meteorological conditions on ultrafine PM levels?

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(1) No priority
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(3) Medium priority
(4) High priority
(5) Urgent

Obtain flight data and relate flight traffic to ultrafine PM measurements?

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(1) No priority
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(3) Medium priority
(4) High priority
(5) Urgent

Since aviation fuel potentially contains more sulfur than roadway diesel – thereby making it a potentially useful tracer for aircraft emissions – should SO_2 measurements be incorporated into our study of ultrafine PM measurements?

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