

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



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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



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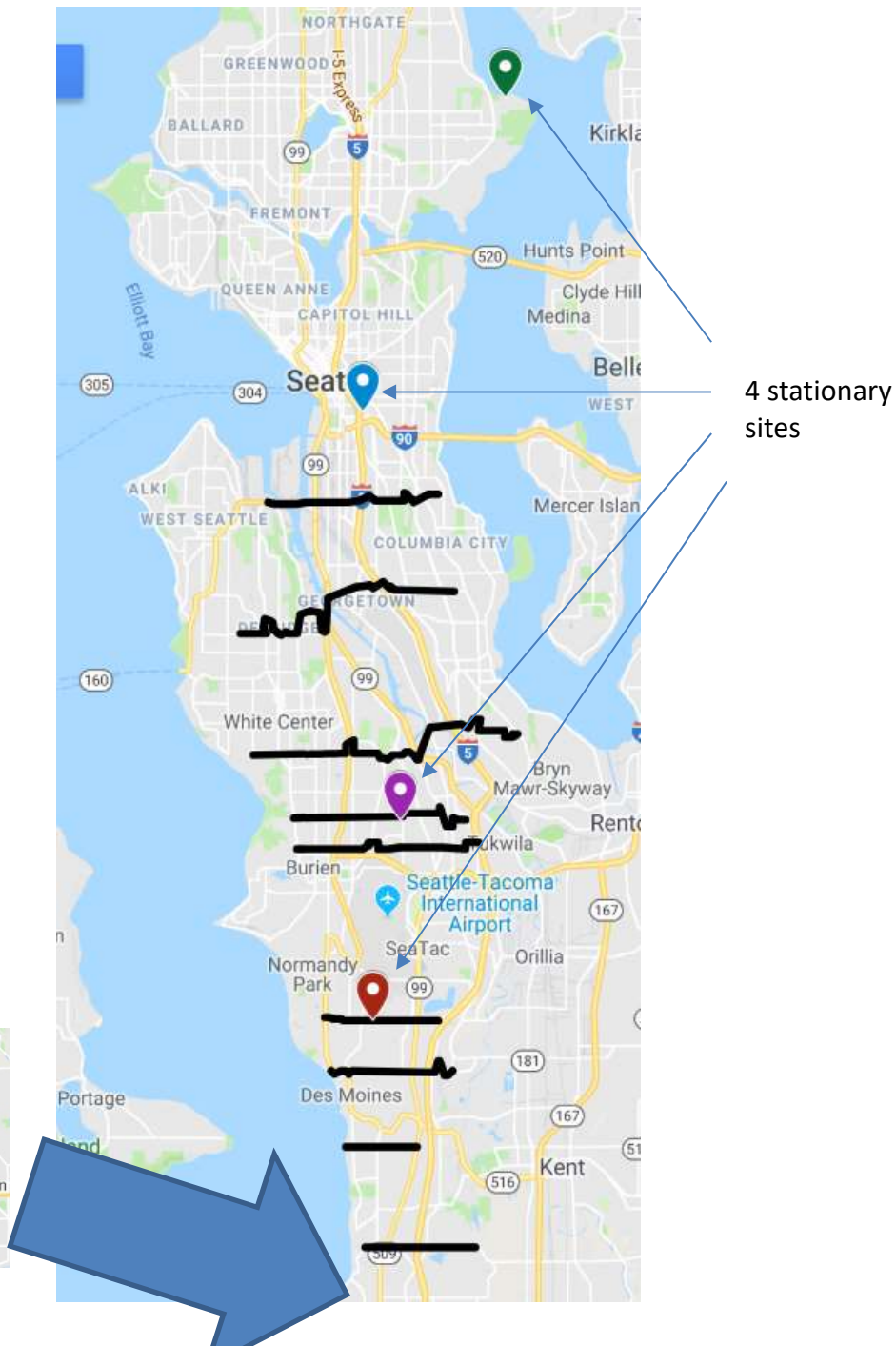
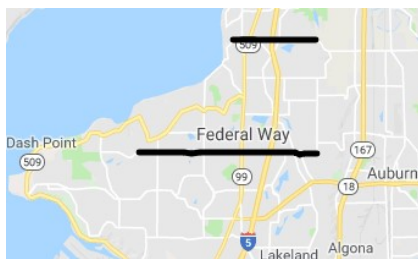
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- Randomized crossover study of 22 non-smoking adults with mild to moderate asthma
- 2-hr scripted, mild walking activity both inside and outside of the high LAX UFP impact zone (avg. difference ~30,000 /cc)
- Mean particle size at LAX impact zone 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



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
<i>Mobile and Fixed sampling:</i>	
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
CO ₂	LI-850 Gas Analyzer
Temperature & Humidity	Hobo T, RH datalogger
Position & Time tracking	GPS Receiver DG-500
<i>Fixed Location sampling:</i>	
Particle size distribution, 13 bins	NanoScan 3910



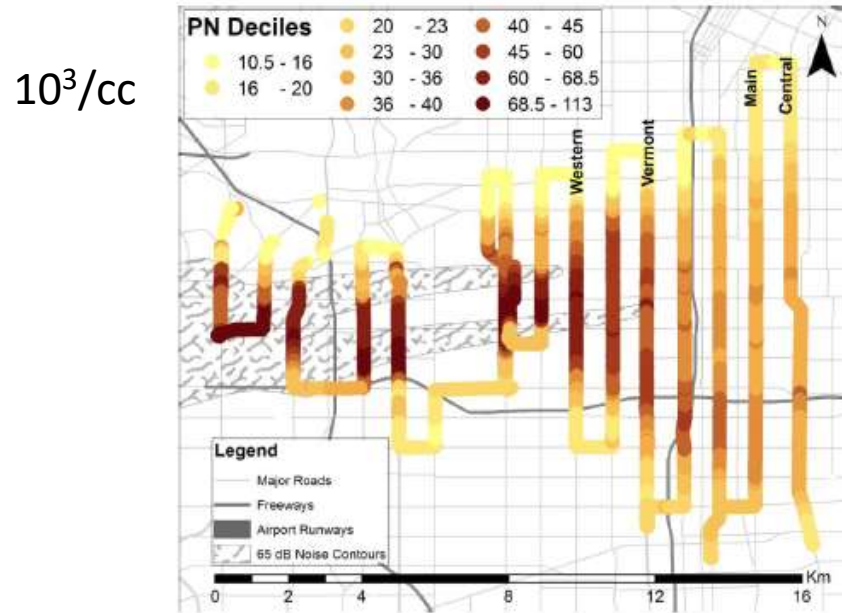
TSI, Inc. model
3007 CPC

MOV-UP Study

Mobile ObserVations of Ultrafine Particles (MOV-UP) Study



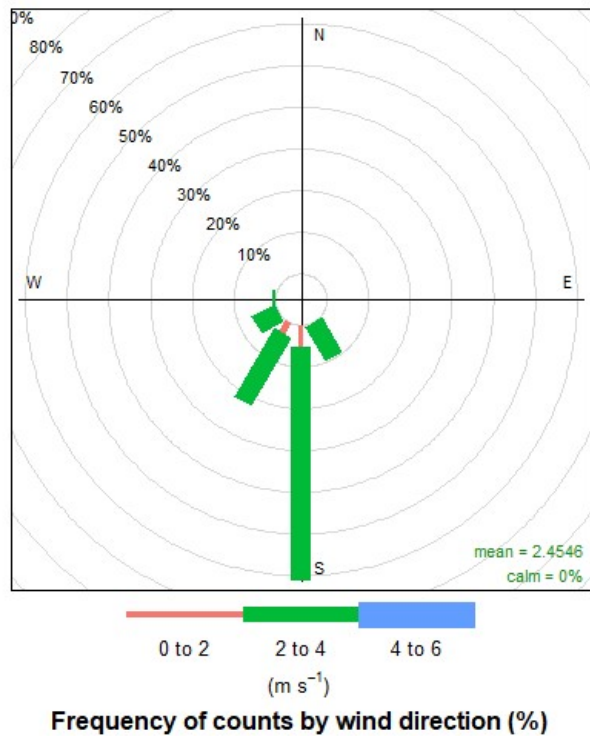
Area-weighted number concentration
equivalent to ~ half the freeways in LA!



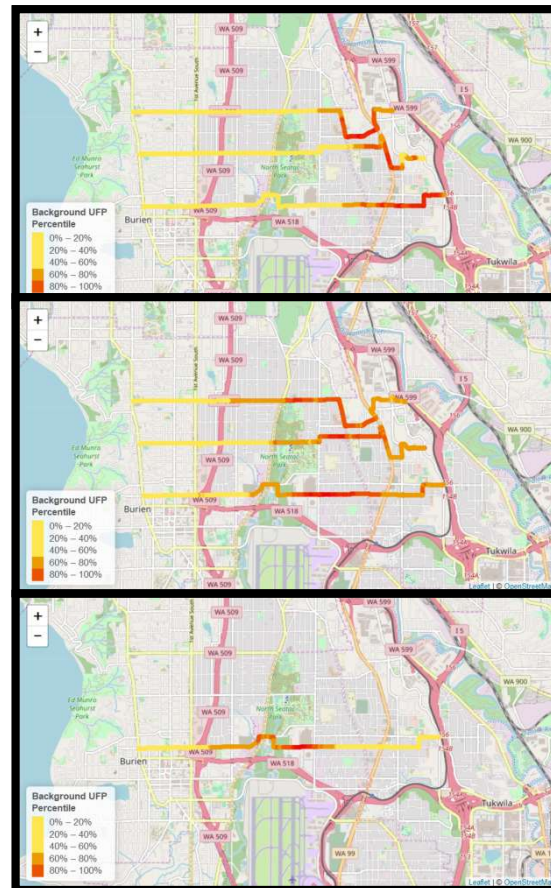
Particle size between ~10 and 30 nm diameter are
present at high concentrations at ground level

Local Background UFP (Hudda 2014 Method)

Wind Rose (Nov 21)



Plume Shifting



1st Drive

2nd Drive

3rd Drive
(146th only)

PRELIMINARY RESULTS

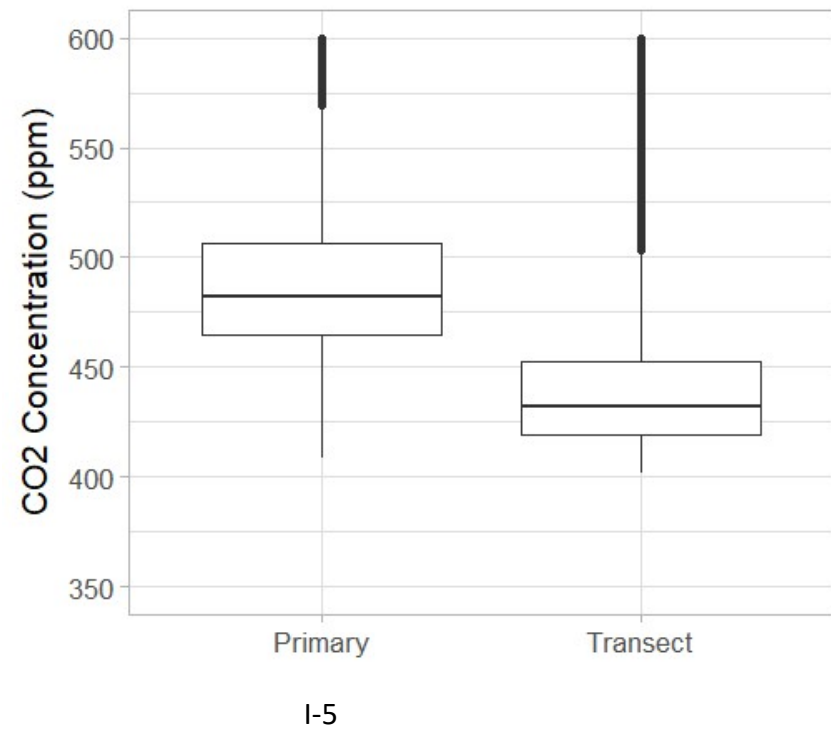
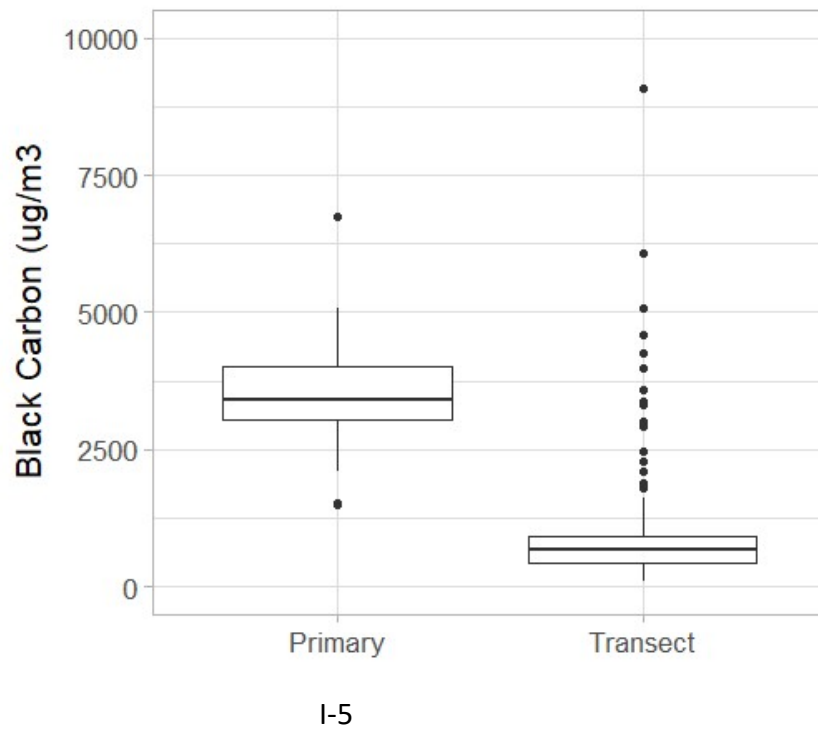
Winter and partial Spring Mobile Monitoring (2018)

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

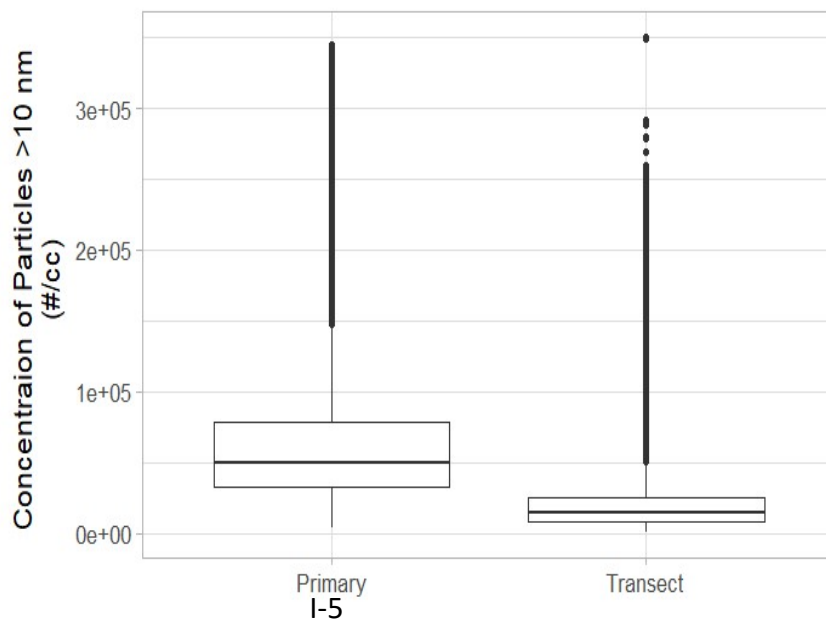


Measurements

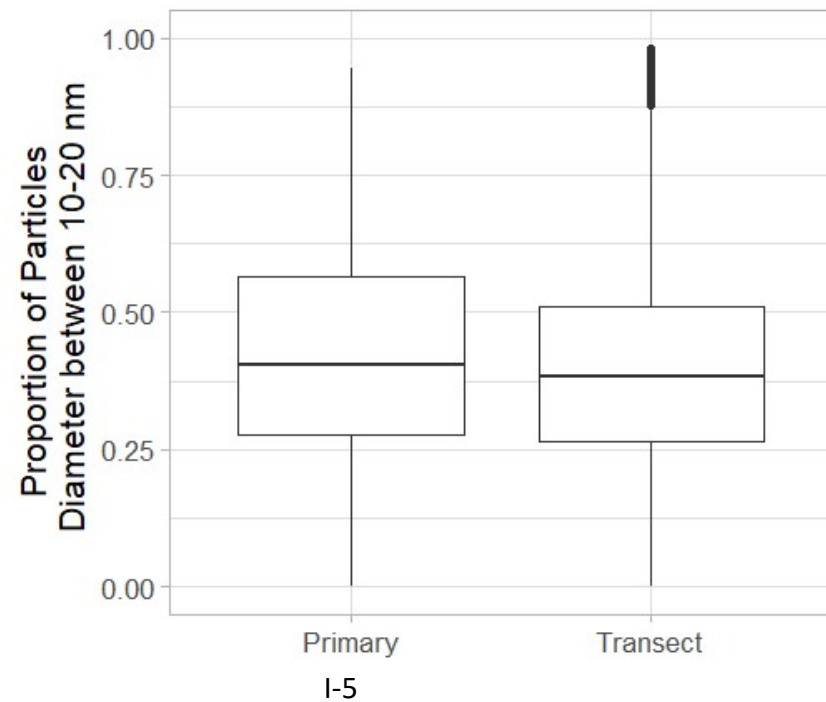
Primary Roadway (I-5) vs Transect

Winter - Spring Data

“Total” > 10 nm



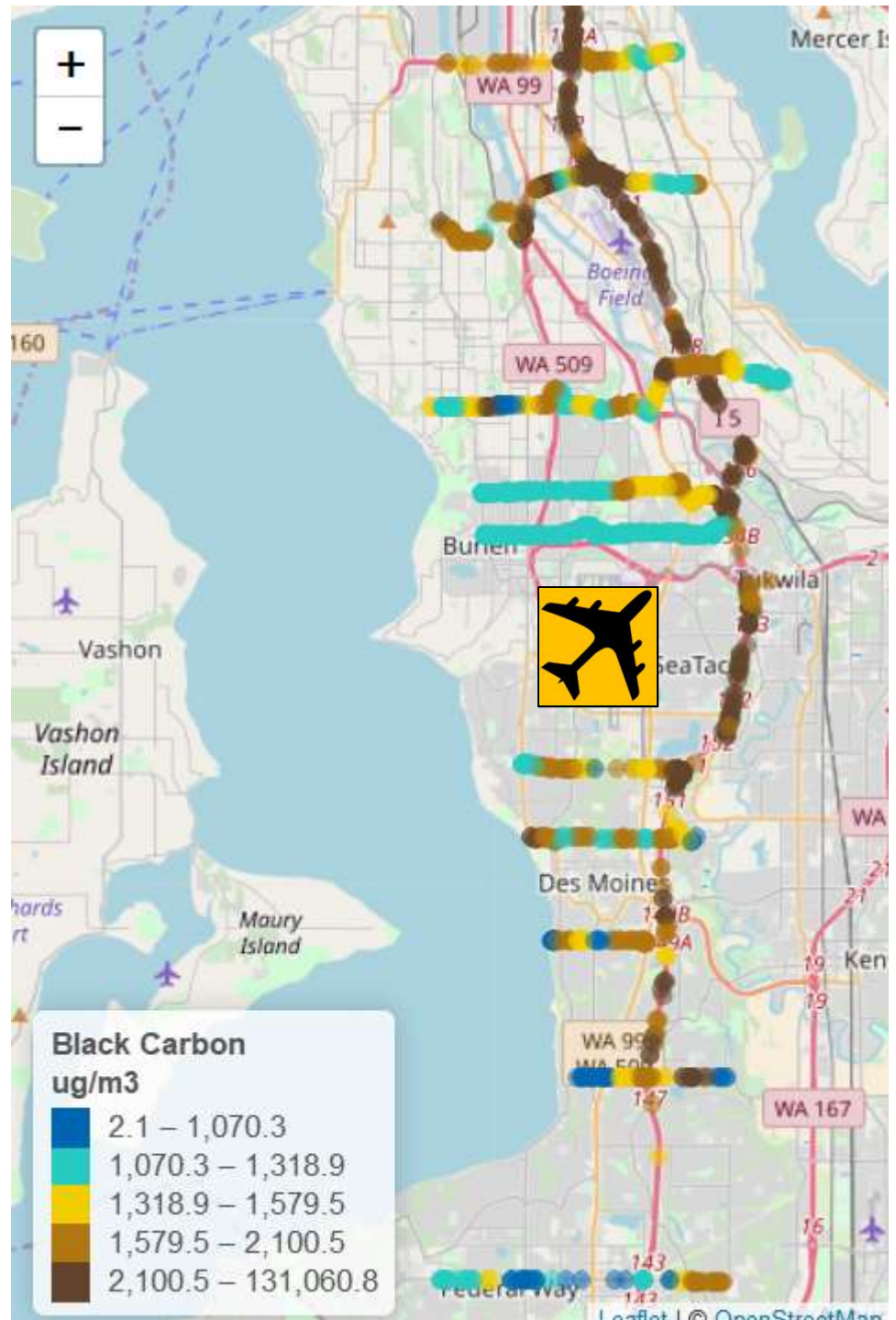
Proportion of “Small” 10-20 nm



**PRELIMINARY SPATIAL
DISTRIBUTION OF POLLUTANTS**

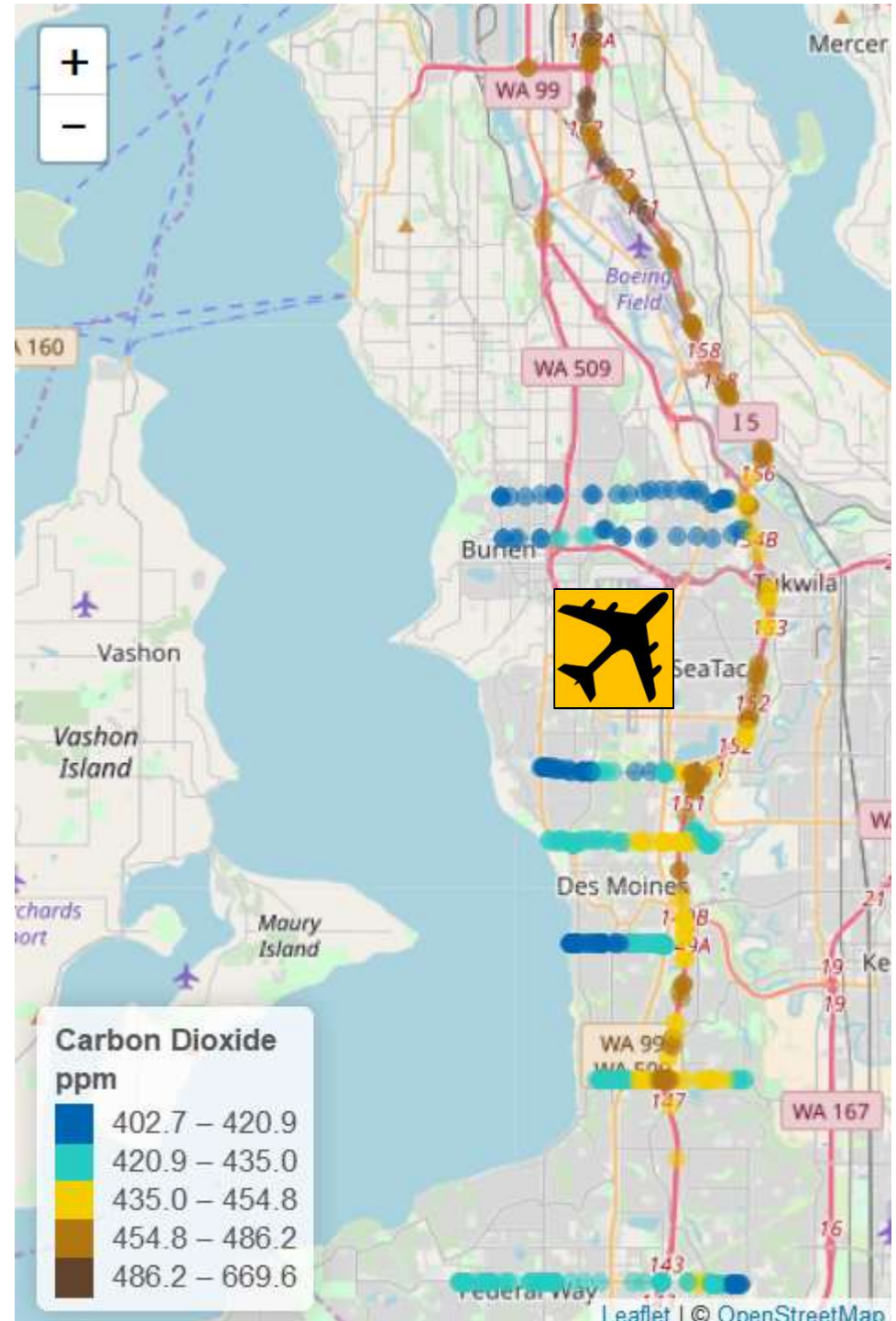
Black Carbon Spatial Distribution

Winter - Spring Data



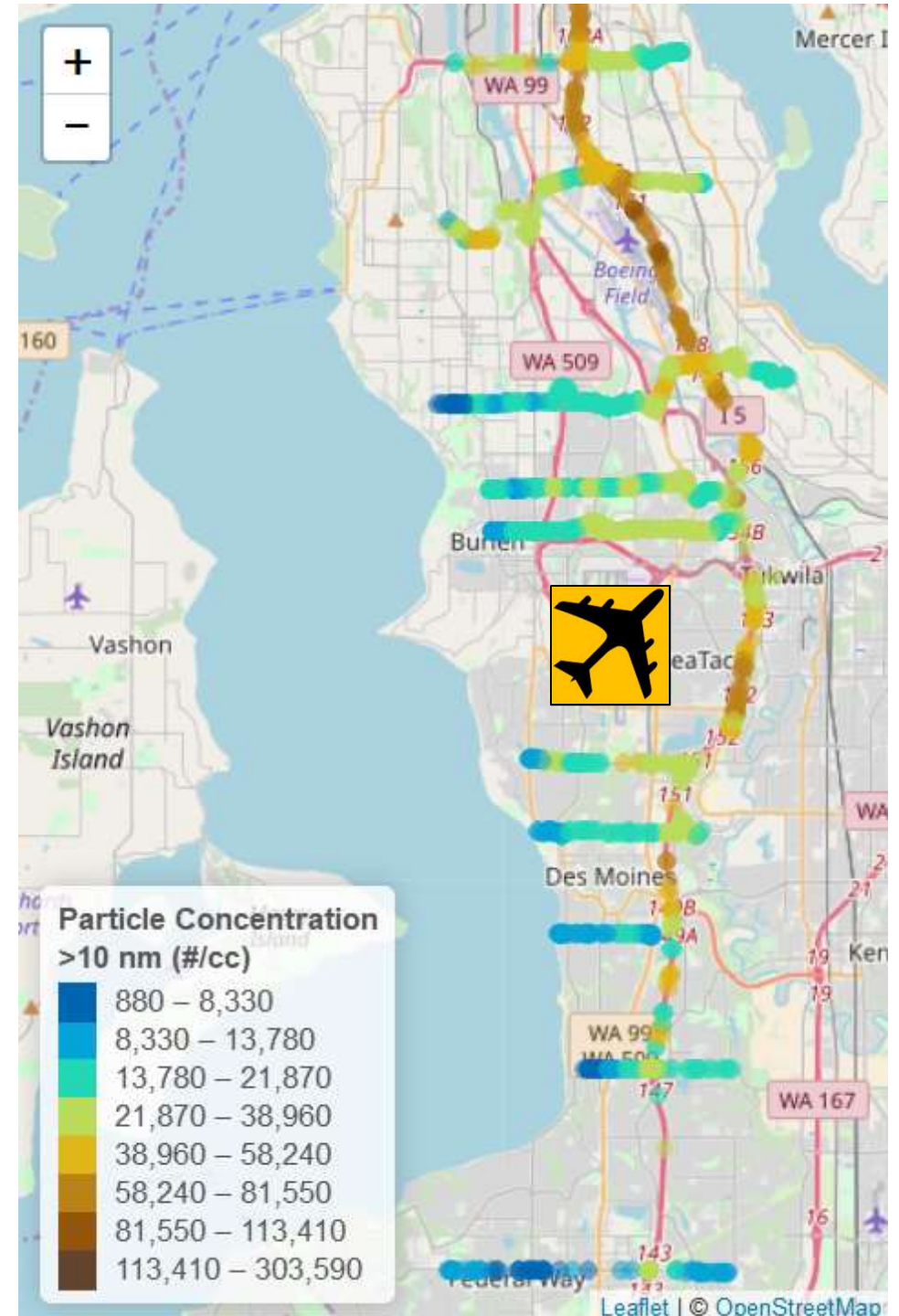
Carbon Dioxide Spatial Distribution

Winter - Spring Data



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

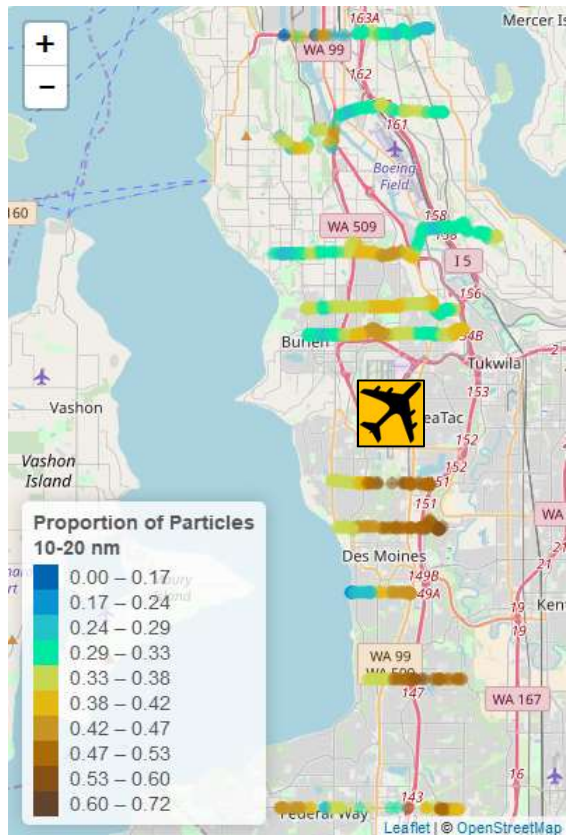
Winter - Spring Data



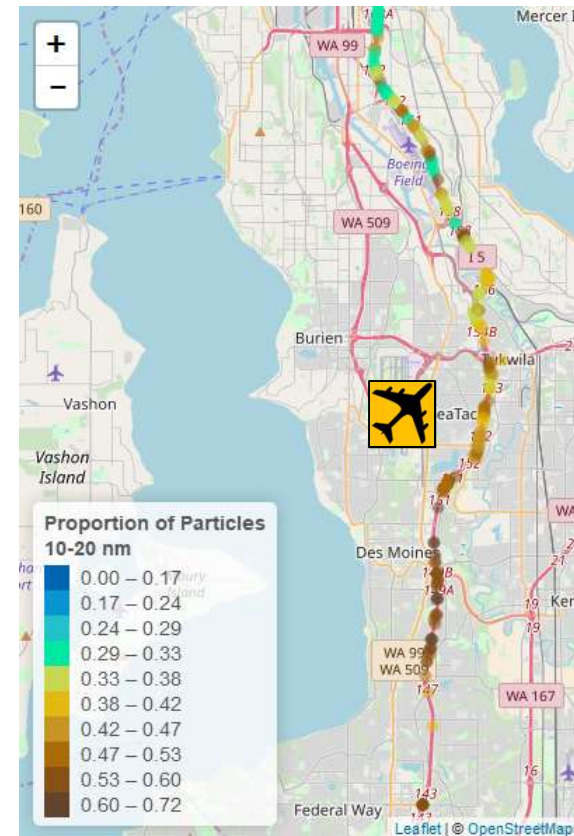
Proportion of small 10-20 nm particles

Transects vs Primary Road (I-5)

Proportion of Small Particles
(10-20 nm)



Proportion of Small Particles
(10-20 nm)

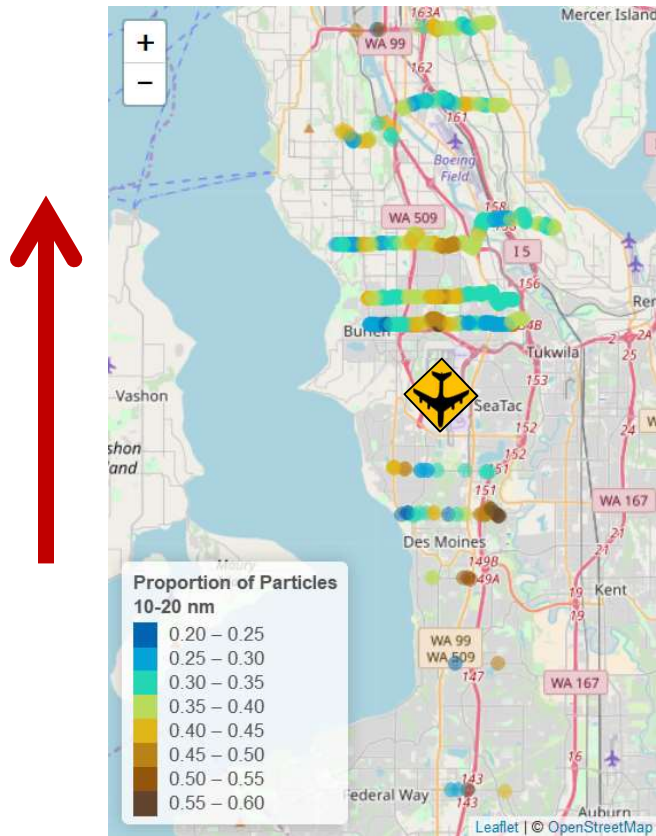


Winter – Spring Data

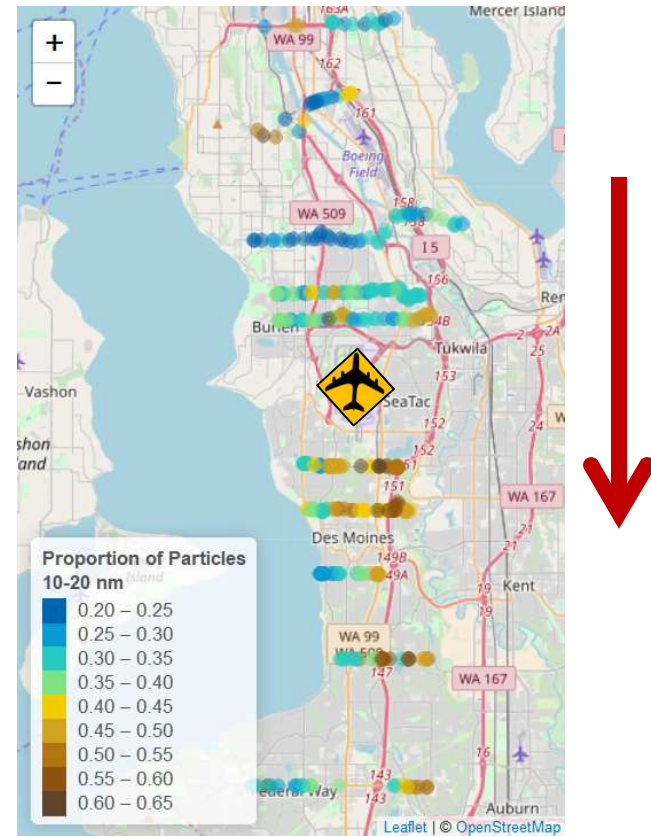
Proportion of small 10-20 nm particles

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.

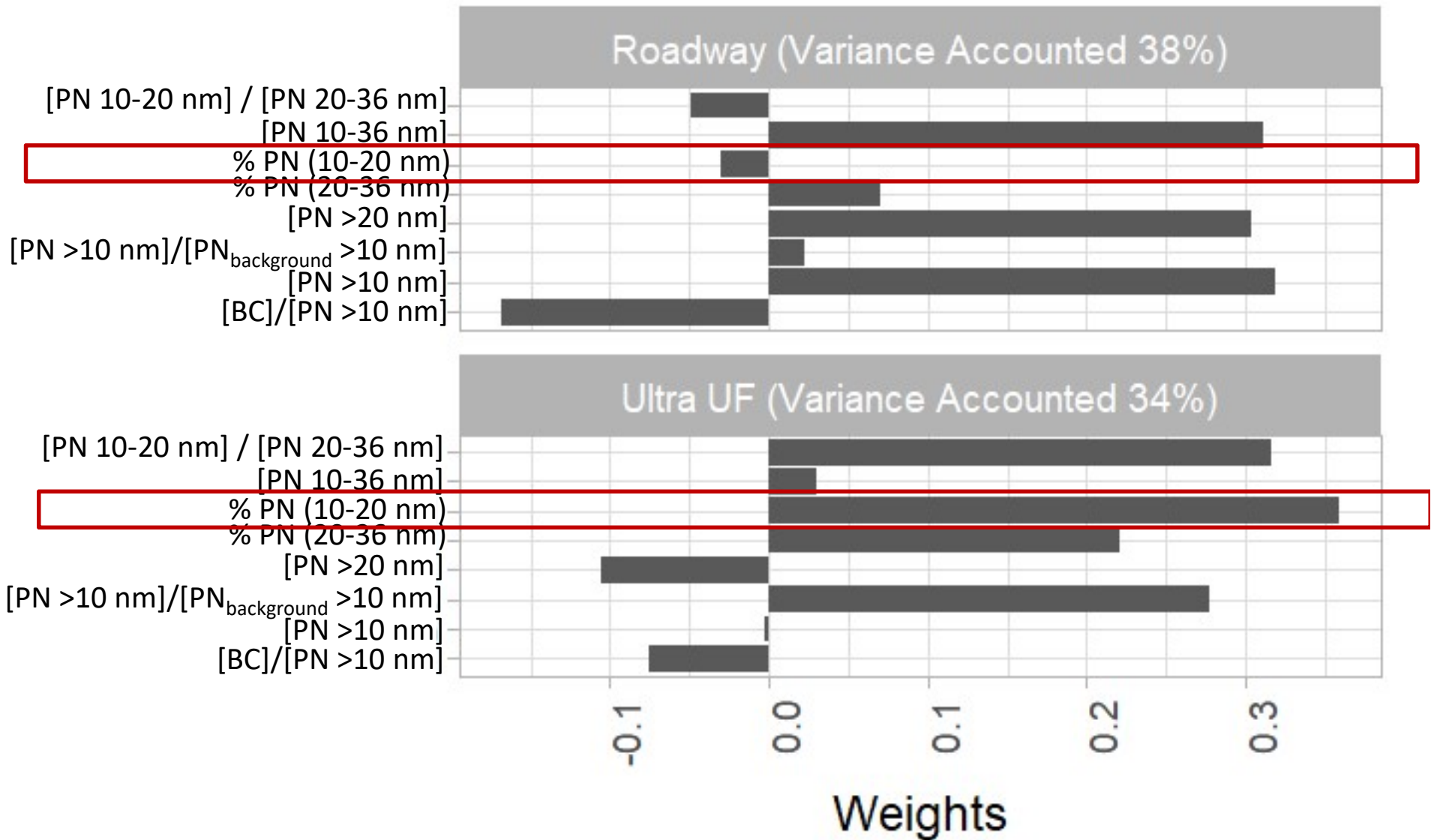
The goal is to summarize the correlations among the observed variables with a smaller set of linear combinations.

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.

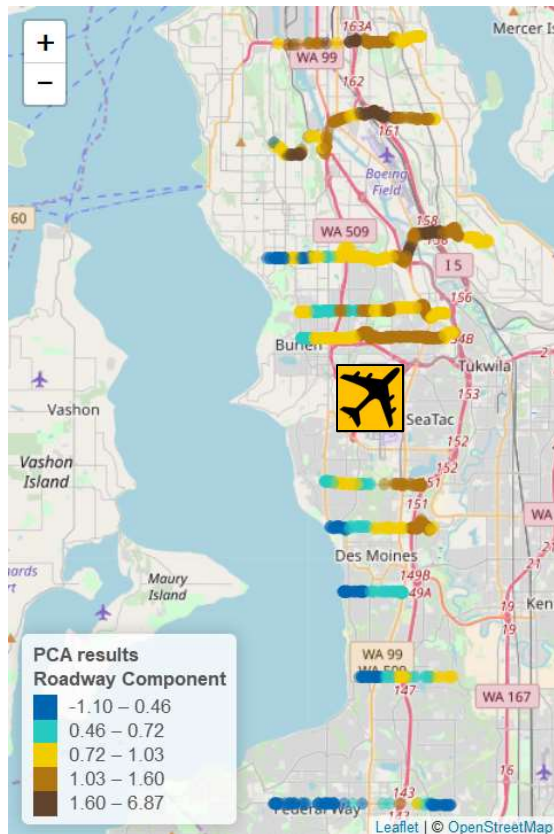
Preliminary PCA Results

Winter – Spring Data

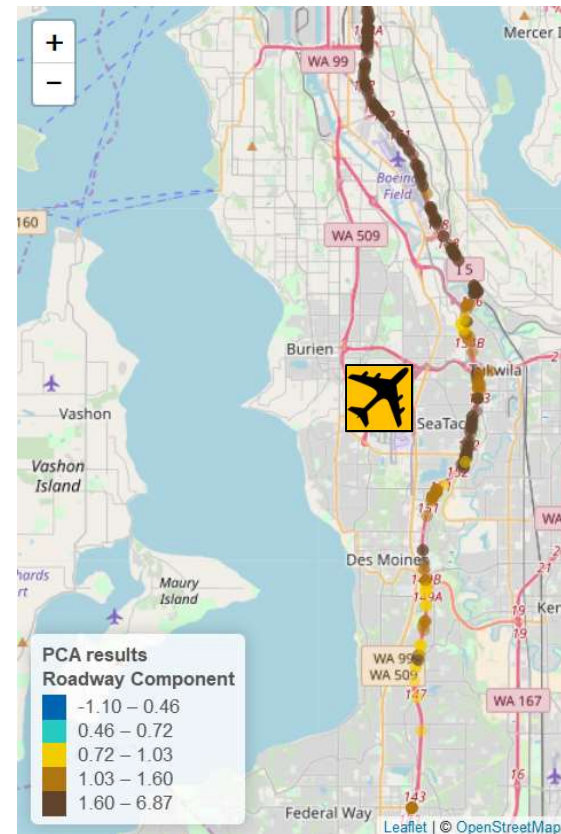


PCA Results “Roadway” Feature

On Transect



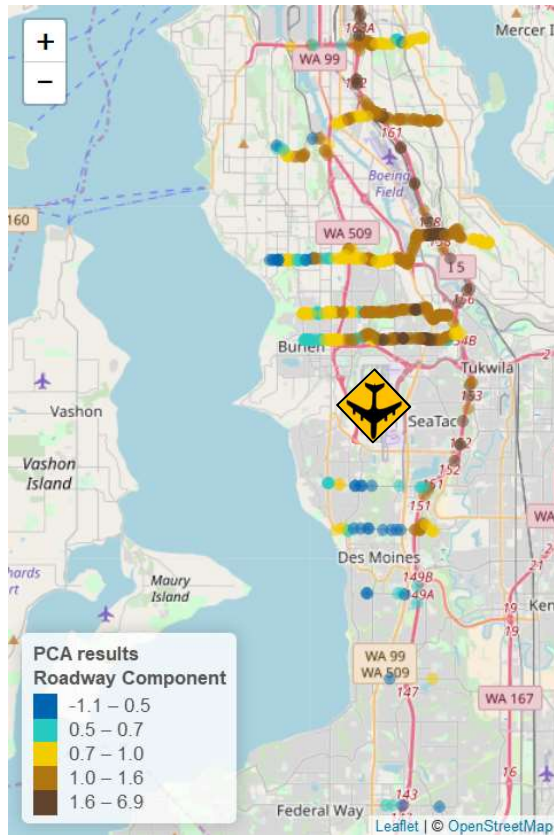
On I-5



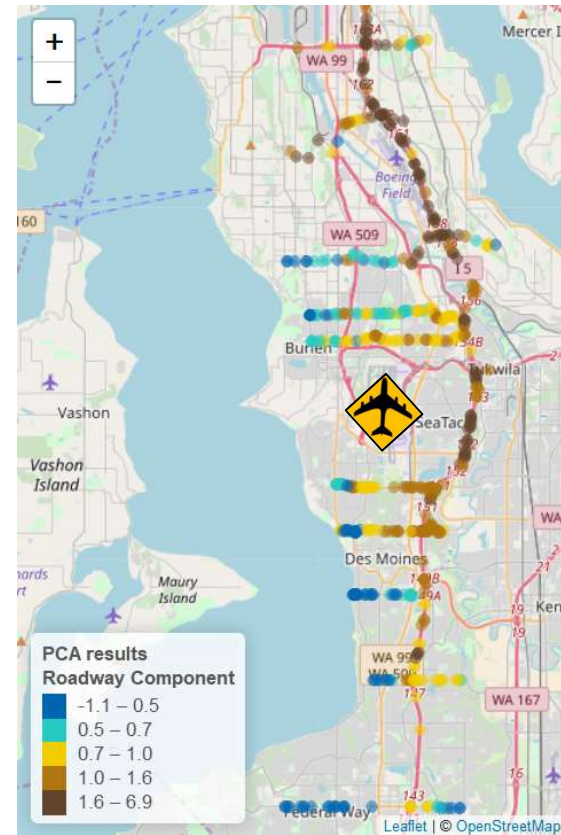
Winter – Spring Data

PCA “Roadway” Feature

Wind from the SOUTH



Wind from the NORTH

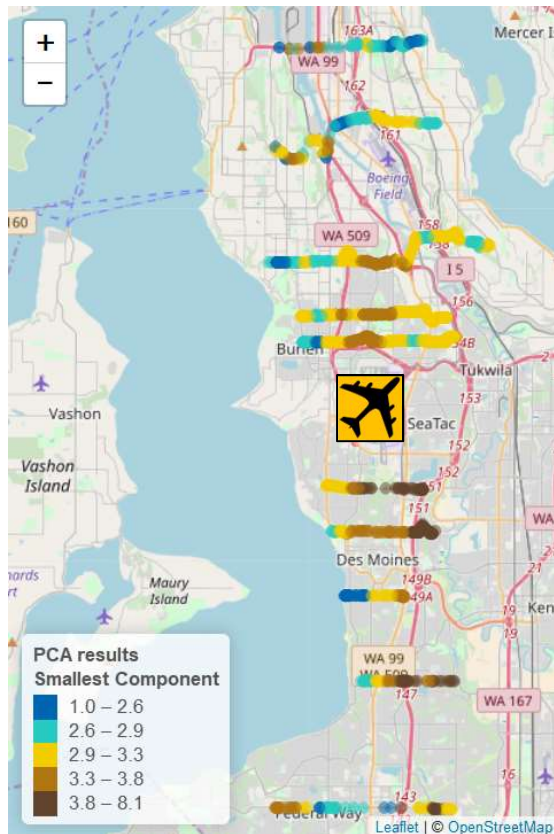


Winter – Spring Data

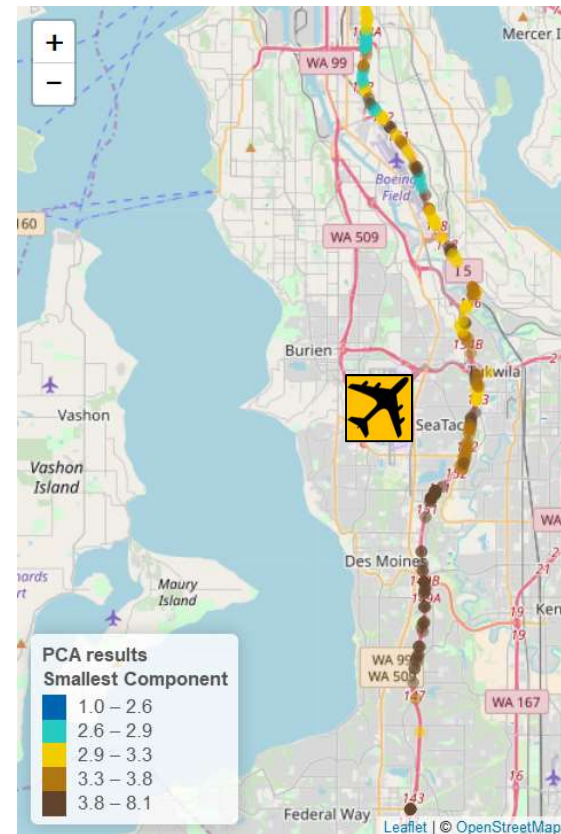
PCA Results

“Ultra-UF” Feature

Transects



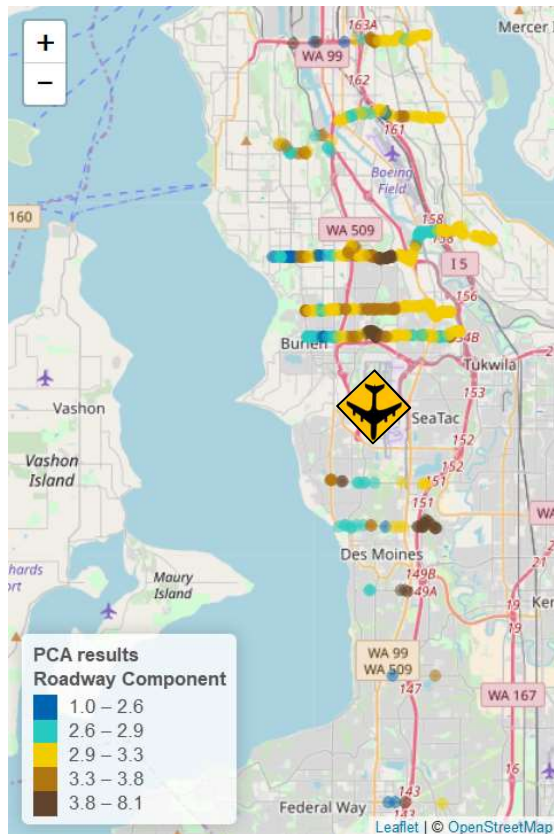
I-5



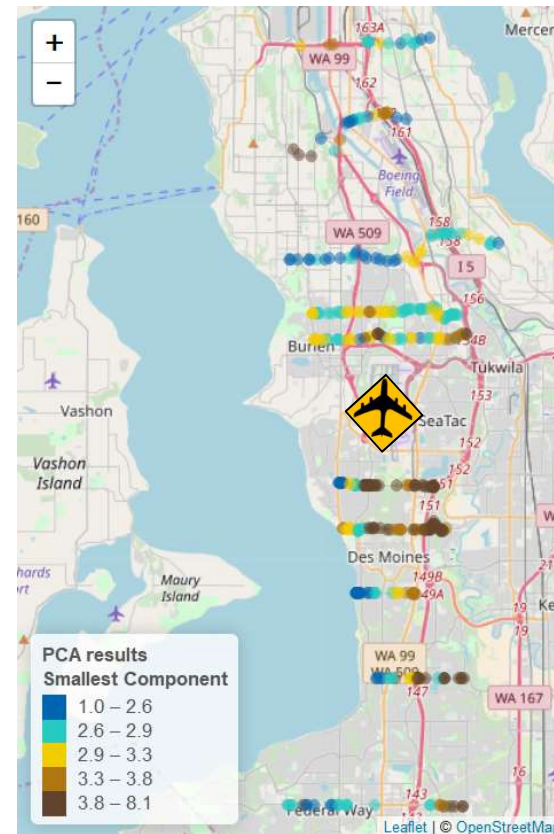
Winter – Spring Data

PCA “Ultra-UF” Feature

Wind from the SOUTH



Wind from the NORTH

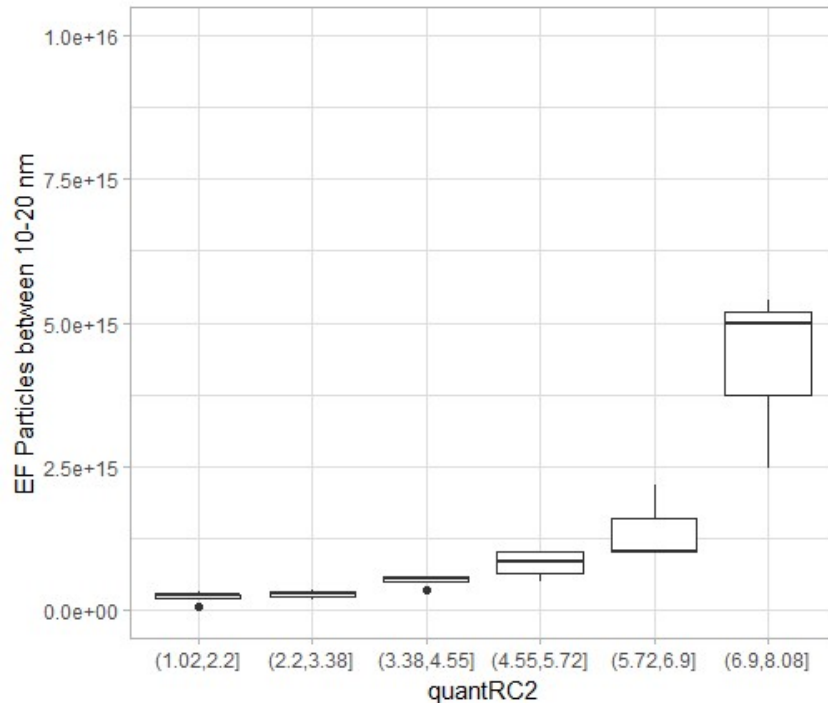


Winter – Spring Data

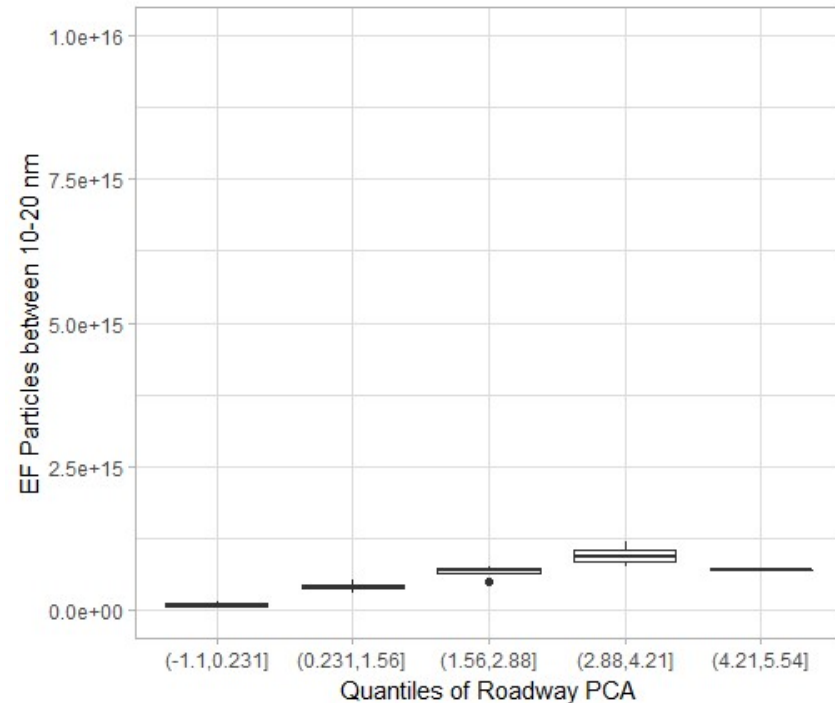
Fuel-Based Emission Factors (EF)

Particles/kgC_{Fuel}

Quantiles of PCA (Ultra-UF)



Quantiles of PCA (Roadway)



Winter – Spring Data

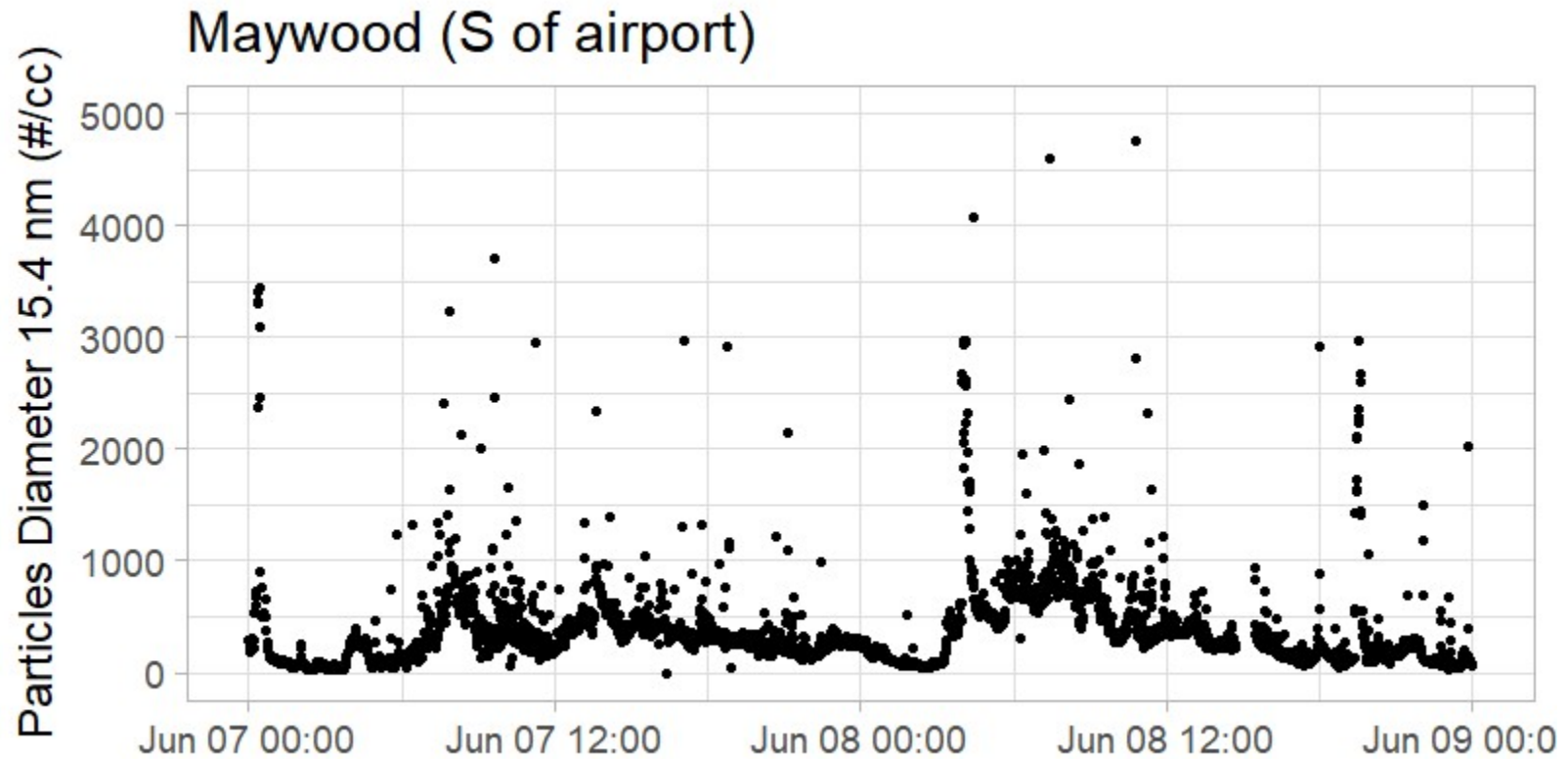
Fuel-Based Emission of UF particles (Particles/kgC_{Fuel})

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	–	–	–	$(1.0 \pm 0.7) \times 10^{14}$	–	–
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 Landing	4–710	–	–	–	$2.1 \times 10^{16} - 5.4 \times 10^{16}$	–	0.2–0.3
							$7.7 \times 10^{15} - 4.3 \times 10^{16}$	–	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 Landing	10–1000	$4 \times 10^4 - 4.4 \times 10^5$	–	–	$2 \times 10^{15} - 3.2 \times 10^{16}$	–	–
				$6 \times 10^4 - 4.5 \times 10^5$	–	–	$2.5 \times 10^{15} - 3.3 \times 10^{16}$	–	–
Current study	Los Angeles International Airport, USA	Takeoff Landing	7–500	$1.53 \times 10^5 \pm 3.11 \times 10^4$	2.87 ± 0.03	33 ± 0.15	$(8.69 \pm 1.20) \times 10^{15}$	0.12 ± 0.02	0.38 ± 0.04
							$(8.16 \pm 1.00) \times 10^{15}$	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