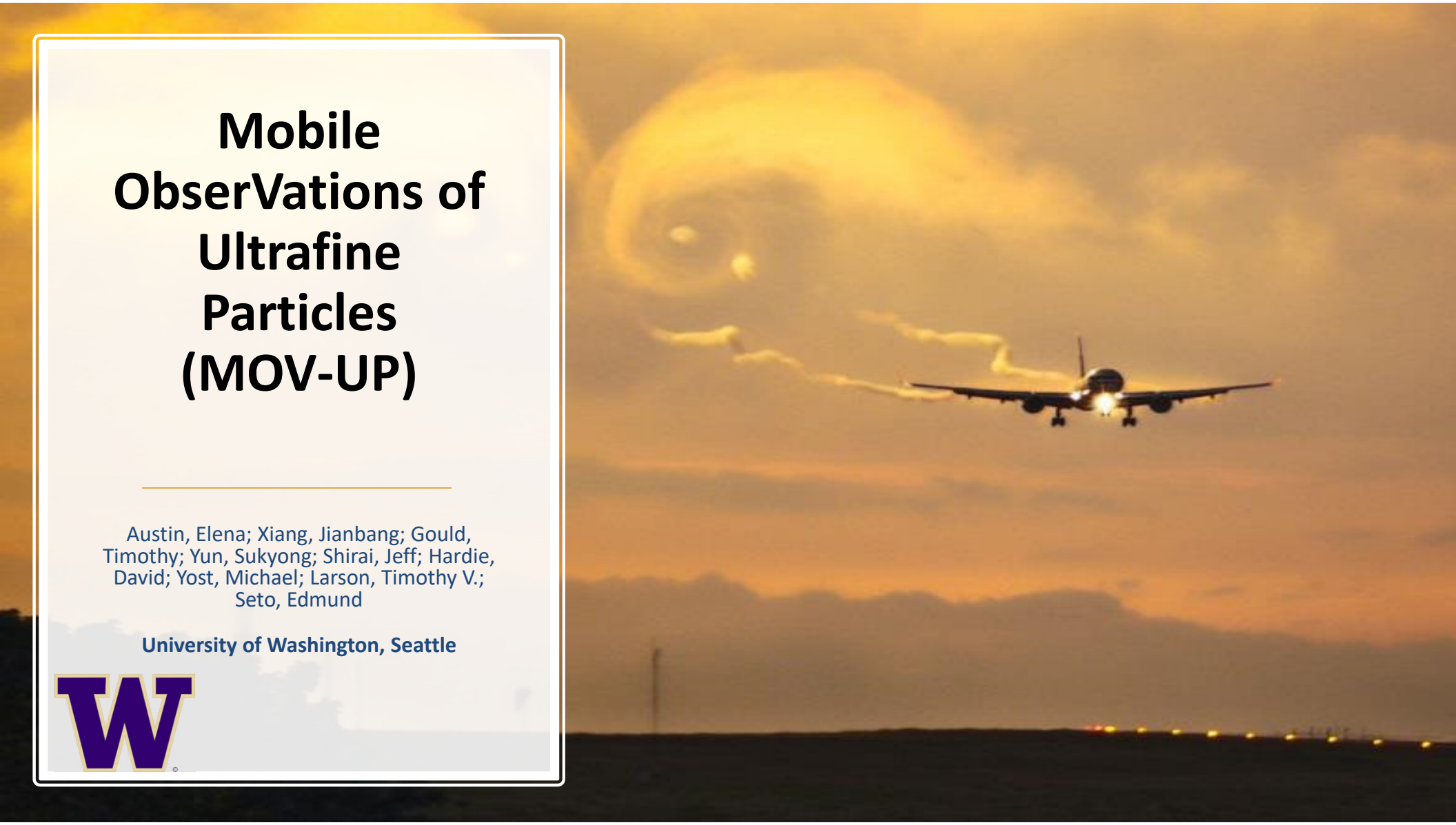
Mobile ObserVations of Ultrafine Particles (MOV-UP)

Austin, Elena; Xiang, Jianbang; Gould, Timothy; Yun, Sukyong; Shirai, Jeff; Hardie, David; Yost, Michael; Larson, Timothy V.; Seto, Edmund

University of Washington, Seattle



Outline

Advisory Group Updates

Final Project Report

- Timeline
- Status

MOV-UP Study

- Description
- Findings
- Discussion

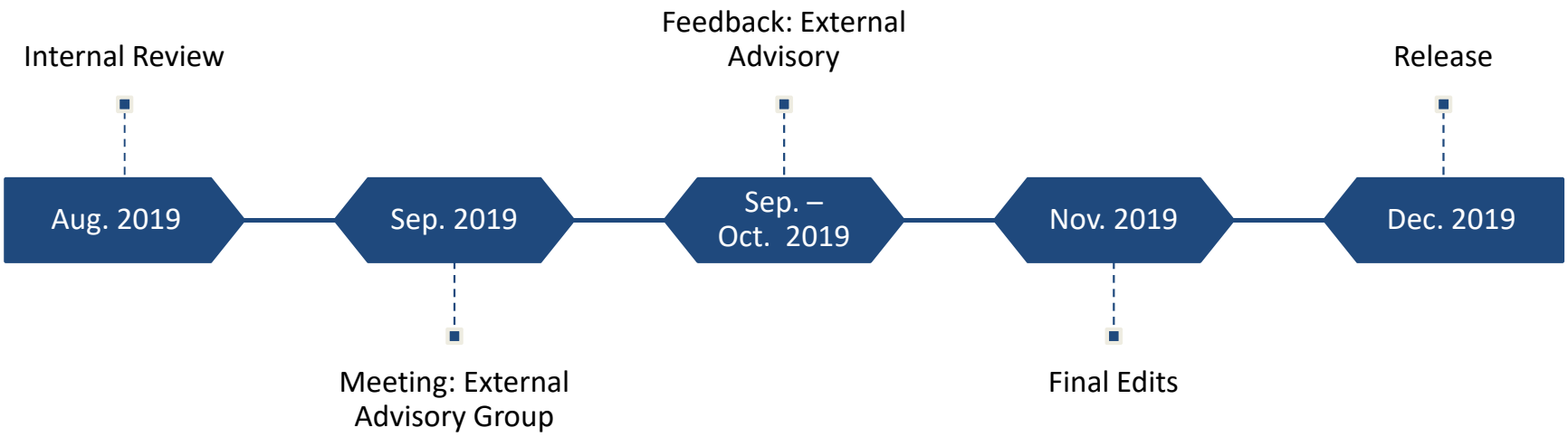
Knowledge Gaps

- Advisory Input

Additional Priorities from the last Advisory meeting

- **Question 1:** Assess the impact of time-of-day on the near airport ultrafine PM monitoring data?
  - High to urgent priority for 73% of the advisory group
- **Question 2: Assess the impact of meteorological conditions on ultrafine PM levels?**
  - High to urgent priority for 50% of the advisory
- **Question 3: Obtain flight data and relate flight traffic to ultrafine PM measurements.**
  - High to Urgent priority for 93% of the advisory group.
- **Question 4:** Incorporate SO2 measurements into our ultrafine PM measurements.
  - High to Urgent priority for 80% of the advisory group.

Final Report Timeline



Current Report Status

CONTENTS

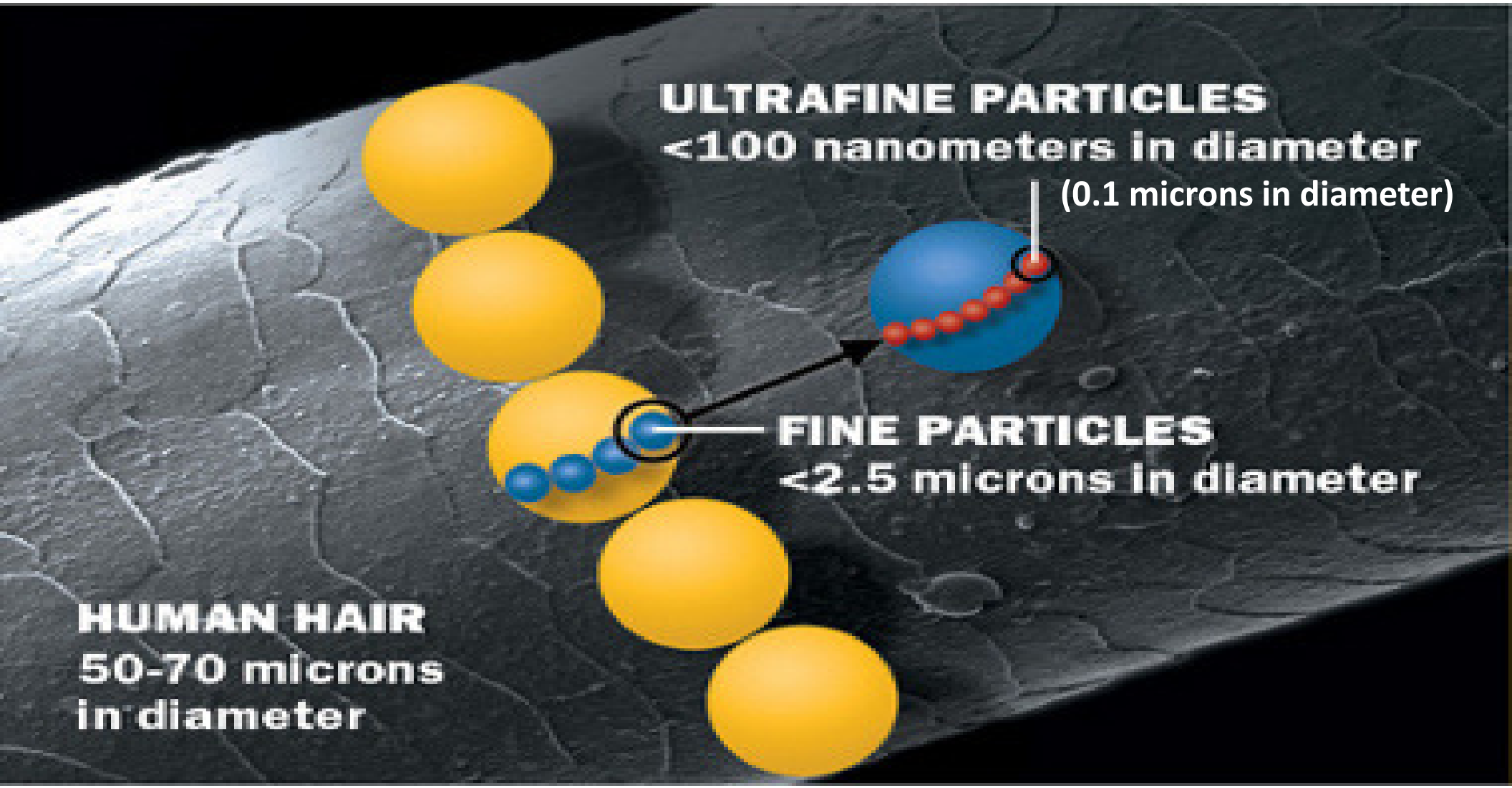
Study Objectives

- 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

Recent MOV-UP Presentations

- Port of Seattle Update (July 11th, 2019)
- FAA Aviation Emissions Characterization Roadmap Meeting (May 24, 2019)
- Airport Impact Study Meeting, Seatac City Hall (May 20, 2019)
- Federal Way City Council, Land Use & Transportation Meeting (Apr 1, 2019)
- Seattle King County Board of Health (Feb 21, 2019)
- Highline Forum (Jan 23, 2019)

- Study Advisory Board Meeting (Aug 15, 2018)
- NW-AIRPACT (June 12, 2018)
- Highline Forum (Mar 28, 2018)
- Study Advisory Board Meeting (Jan 5, 2018)


ULTRAFINE PARTICLES
<100 nanometers in diameter
(0.1 microns in diameter)
FINE PARTICLES
<2.5 microns in diameter
HUMAN HAIR
50-70 microns
in diameter

Ultrafine Particles (UFPs)

Ultrafine Particles unregulated but potentially important

Health Effects more uncertain compared to $PM_{2.5}$,but a growing body of evidence

Diesel Engines emit ultrafine particles resulting in elevated levels near major roadways (within 200 meters downwind)

Jet aircraft directly emit “ultra” ultrafine particles (< 30 nanometers)

Health Effects Studies of Ultrafine Particles

- WA Department of Health currently conducting a detailed literature review of the health effects associated with ultrafine particles.
- The current UW MOV-UP project is not a study of health effects. It is air quality measurement and source characterization study.

- One study that explicitly considered exposures to aircraft-related ultrafine PM

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]

[a] Division of Environmental Health, Department of Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, CA, USA
[b] Division of Biostatistics, Department of Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, CA, USA

- 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' and 'Traffic' exposure*

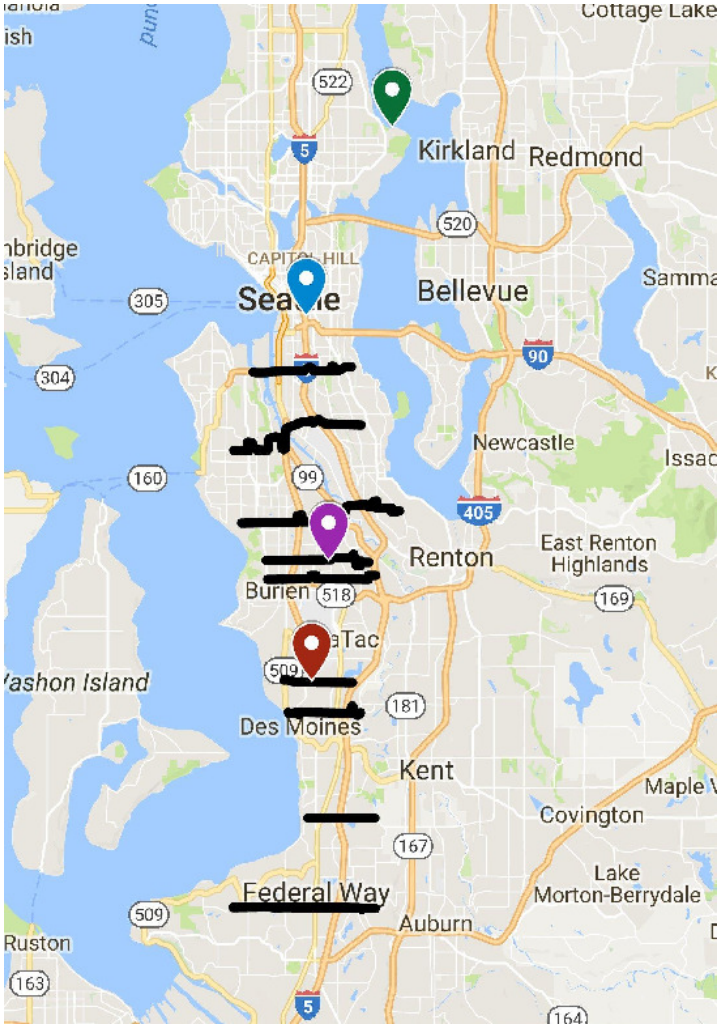
Mobile Monitoring Platform

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

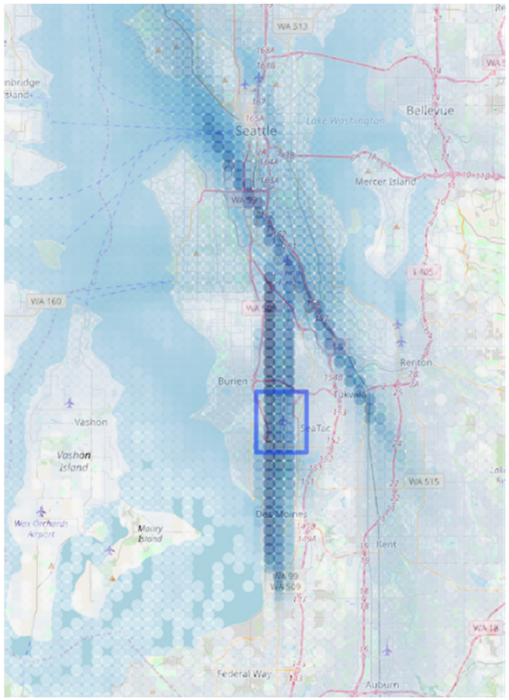
Study Region: Mobile Transects and Fixed Monitoring Site Locations

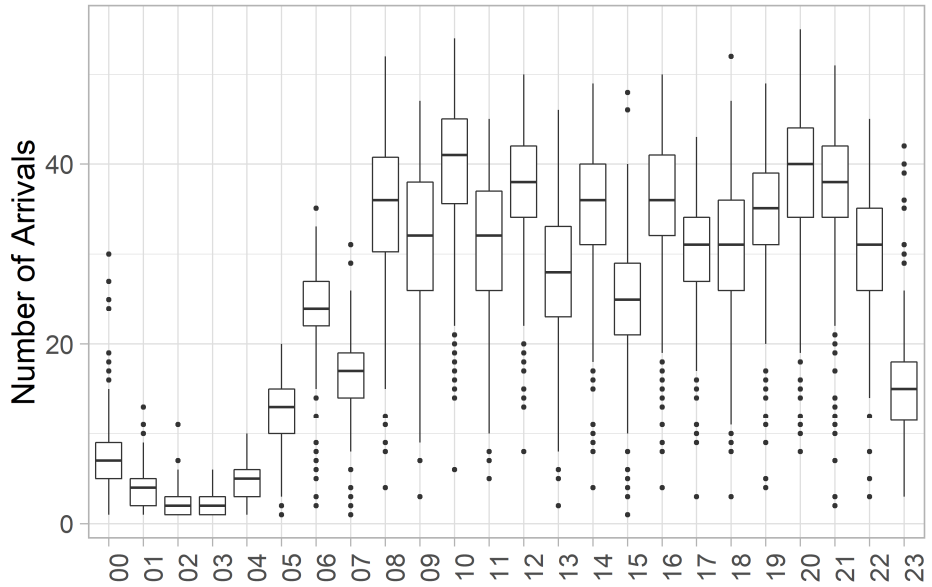
Fixed Sites

- SeaTac Community Center
- Maywood School Building
- Near Roadway Site
- Background

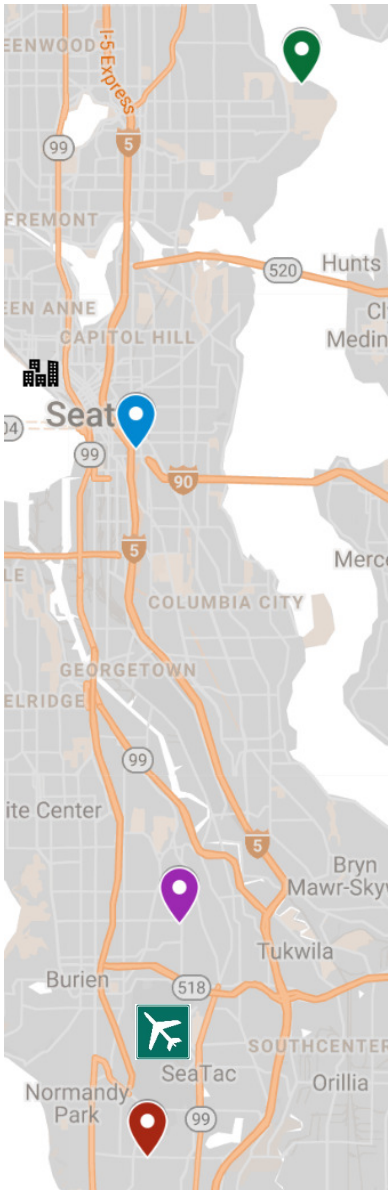


Flight Track Data





Fixed Monitoring Results

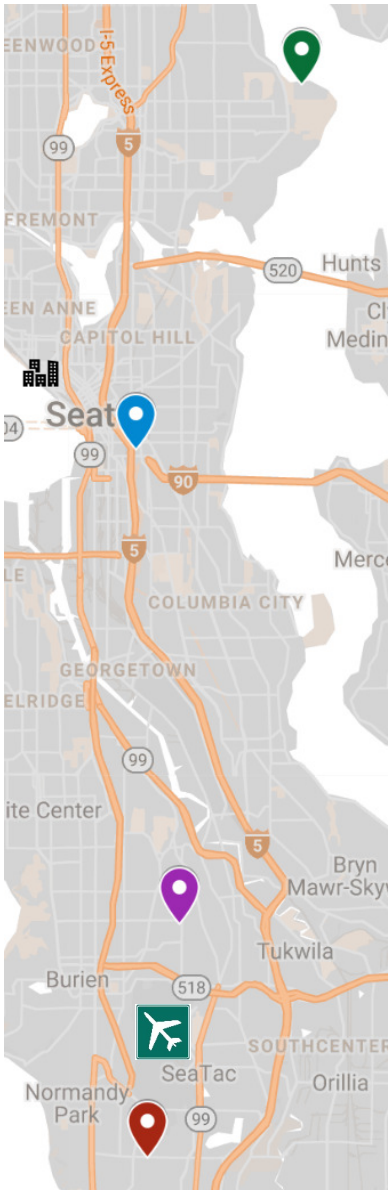


Fixed Monitoring Sites

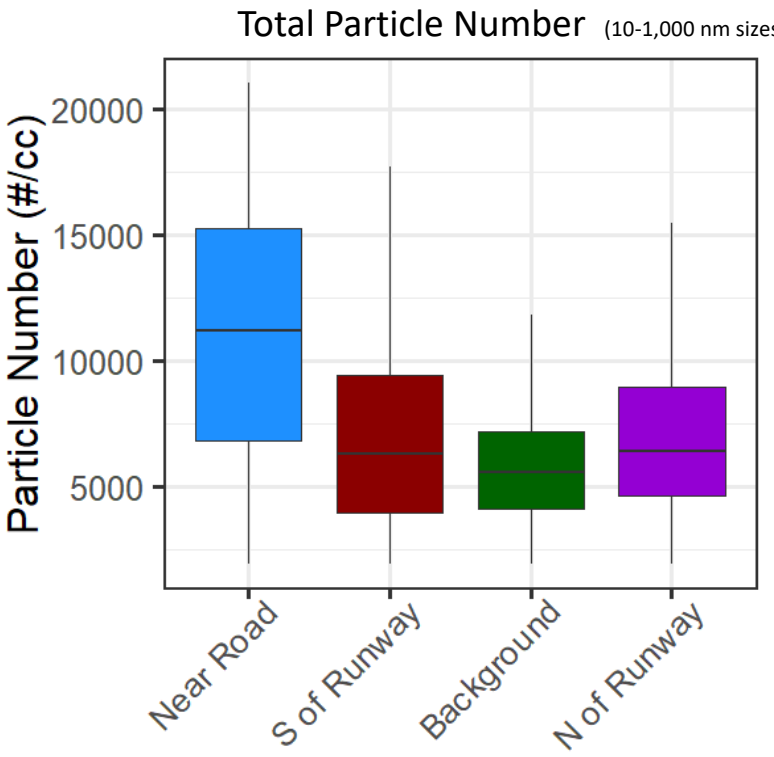
	SeaTac Center N of Runway	Maywood S of Runway	10th & Weller Near Road	Sand Point Background
Spring 2018	-	10	8	24
Summer 2018	11	13	-	14
Autumn 2018	16	16	-	-
Winter 2018-19	8	7	-	-

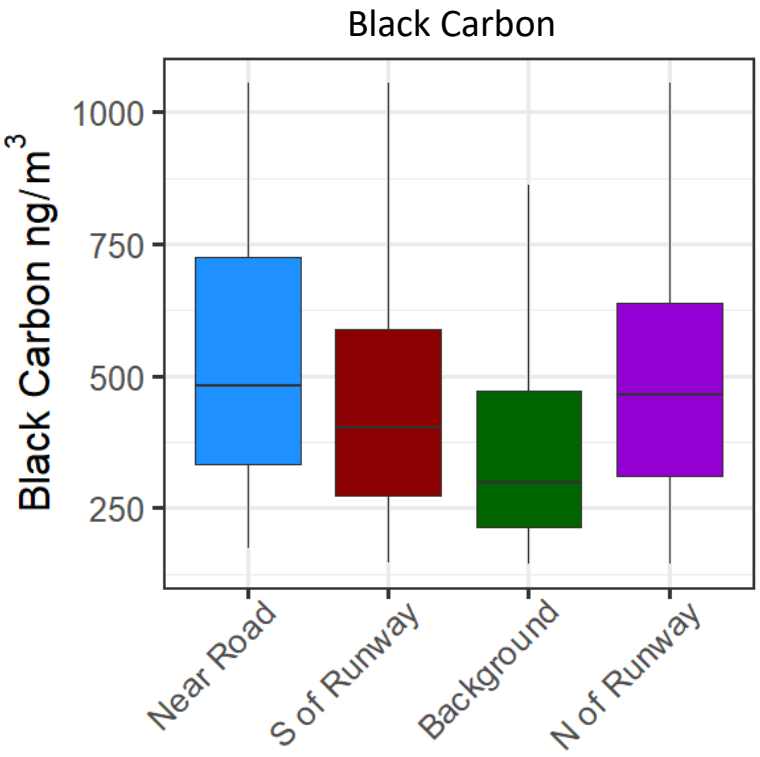
Fixed Sites

- SeaTac Community Center
- Maywood School Building
- Near Roadway Site
- Background

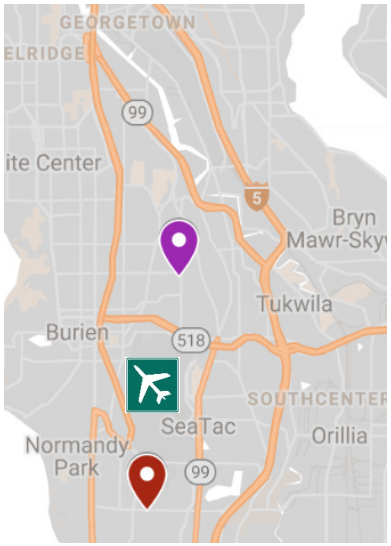


Traffic Related Pollutants

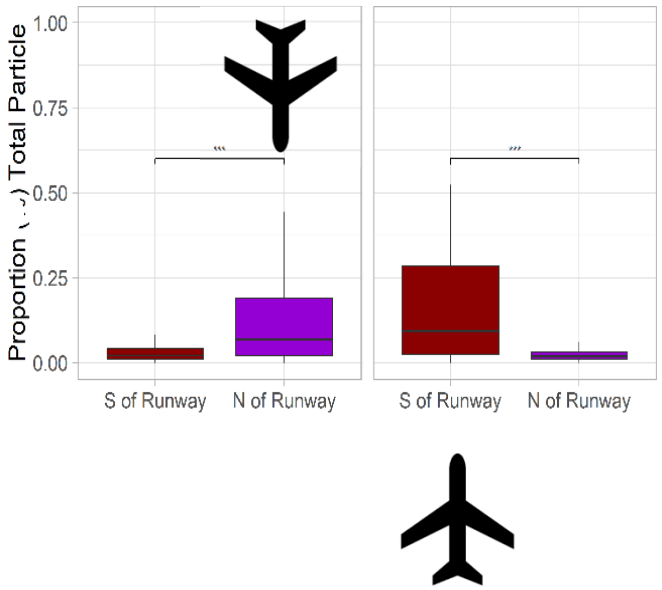




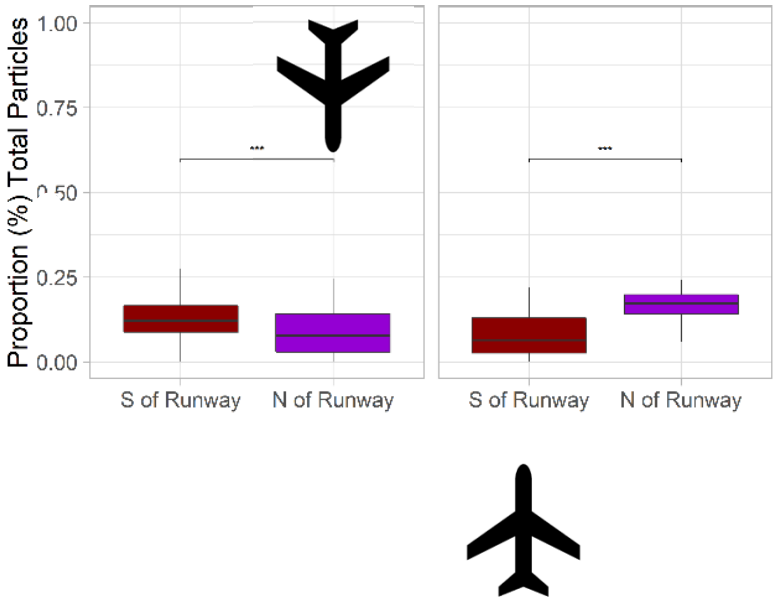
Smaller Sized Particles Near SeaTac Associated with Jet Landings



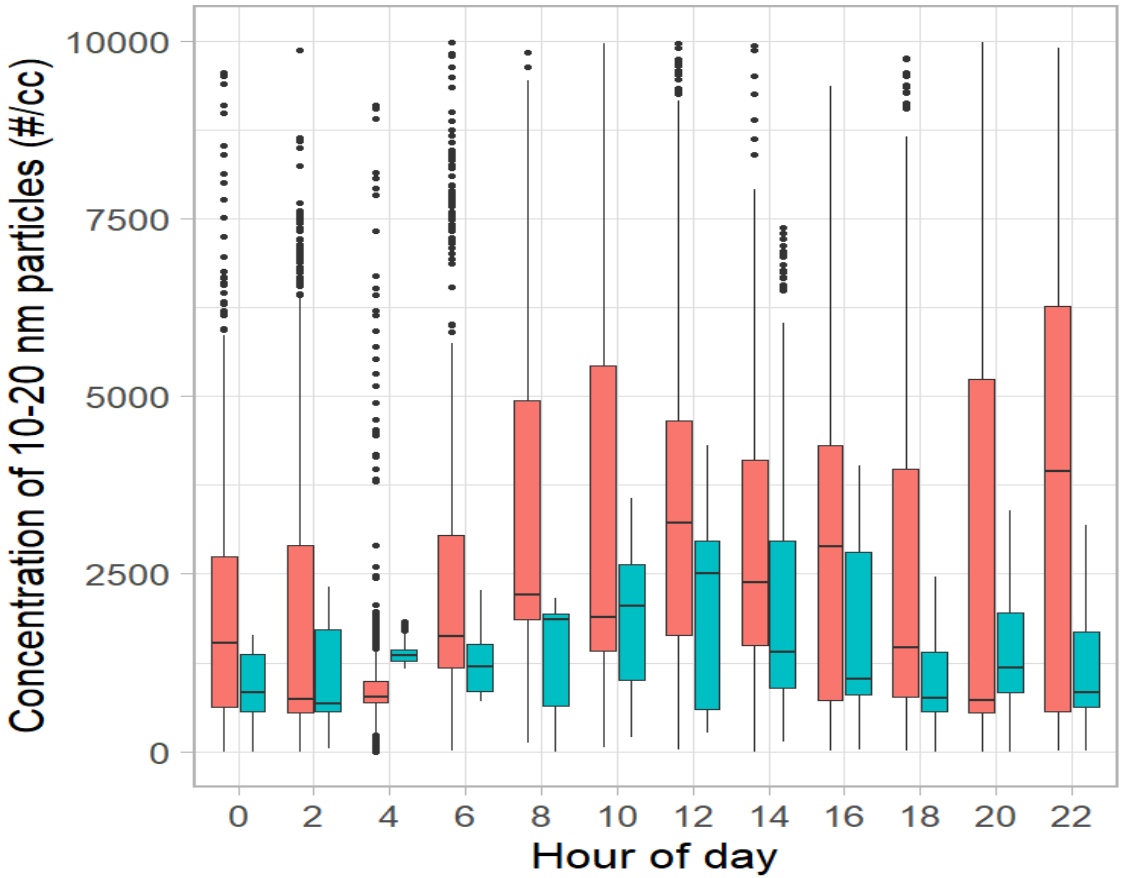
11.5 nm particles (% of UF)



65 nm particles (% of UF)

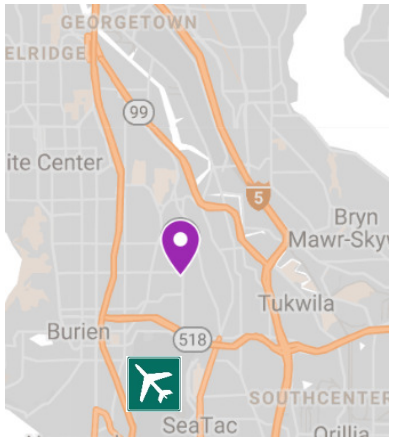


Hourly Pattern of Ultra-UF Particles North of the Airport

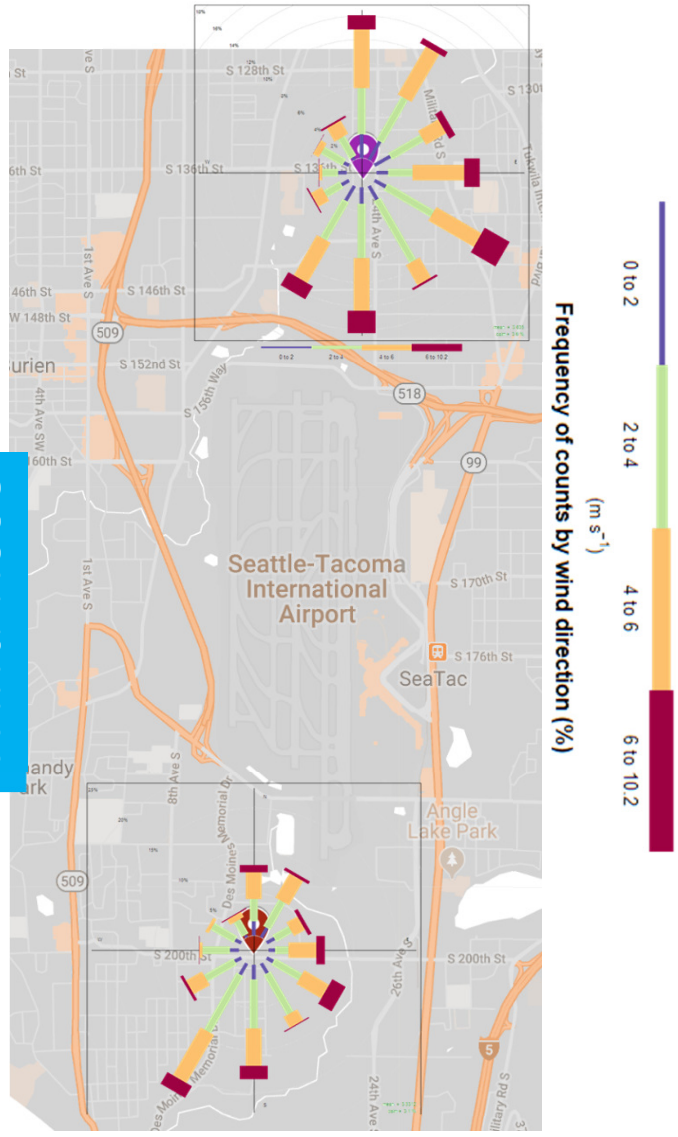


Aircraft Landing Direction

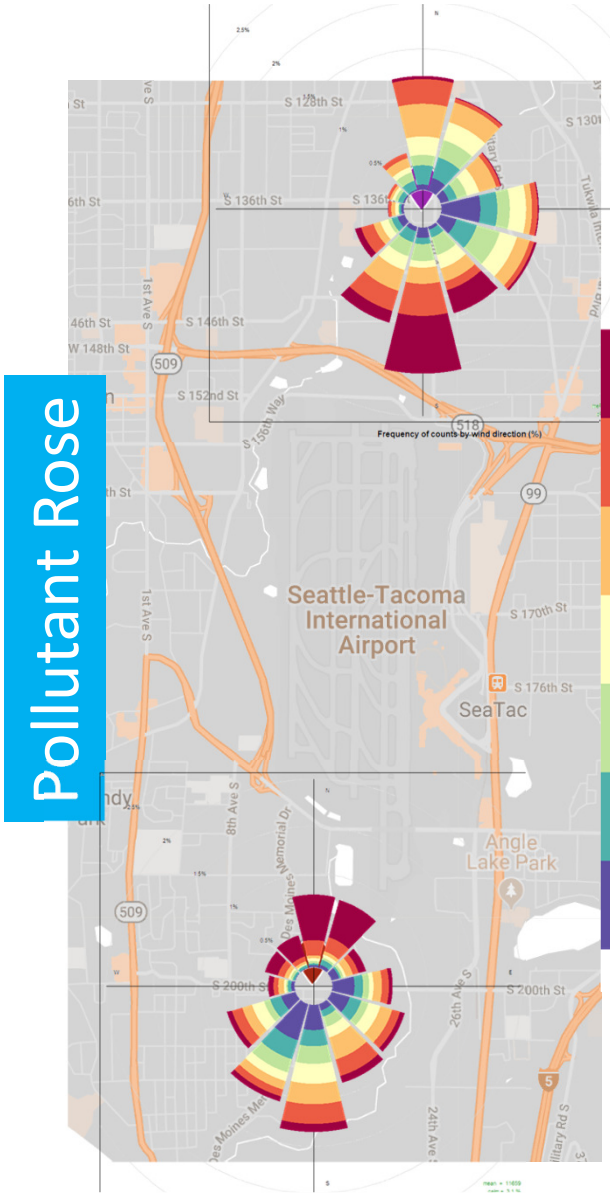
North
South



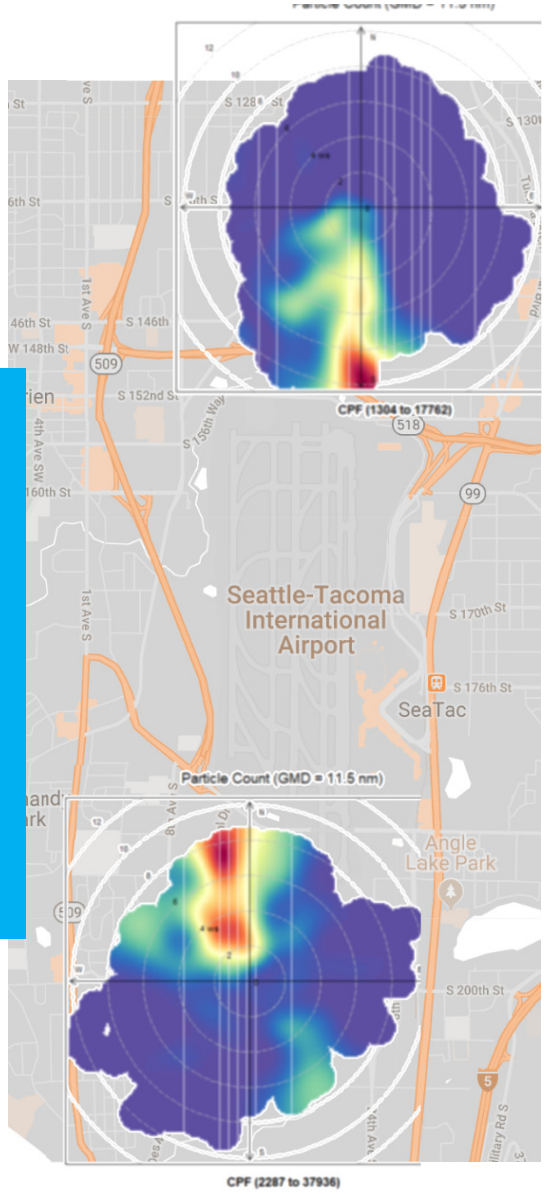
Wind Rose



Pollutant Rose

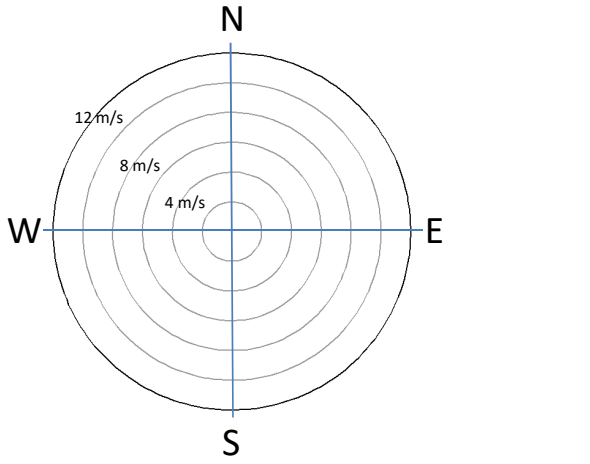


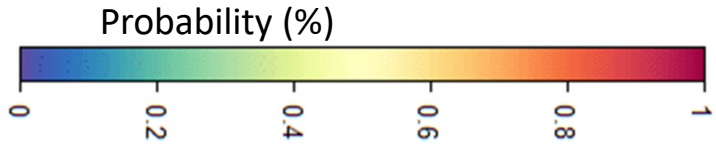
11.5 nm Diameter



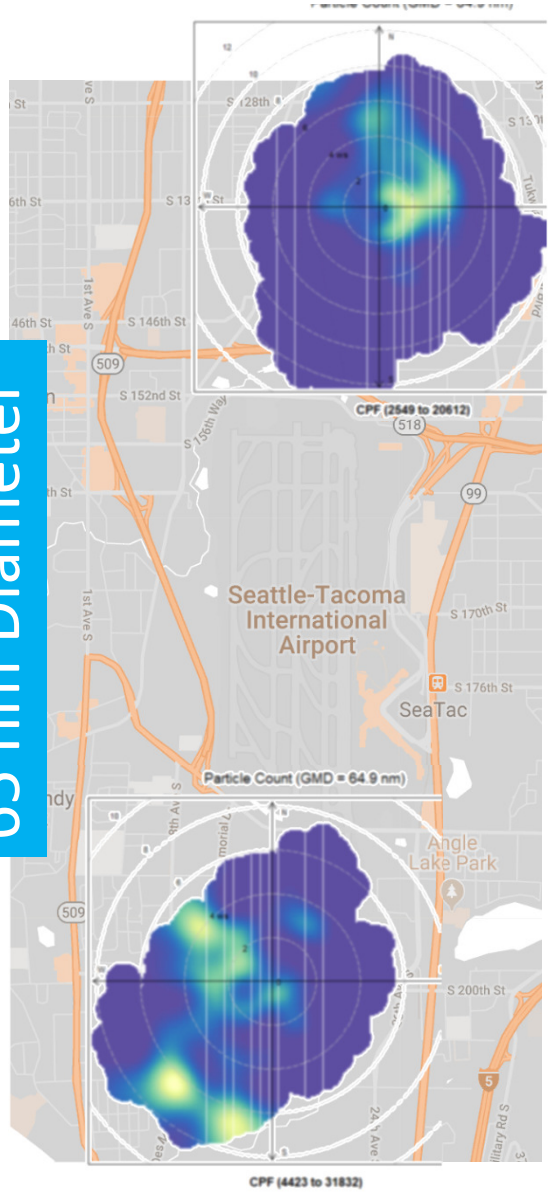
Conditional Probability Plot

These plots show the probability that a concentration of a) 11.5 nm particles and b) 65 nm particles conditional on a given *wind direction* and *wind speed.*





65 nm Diameter



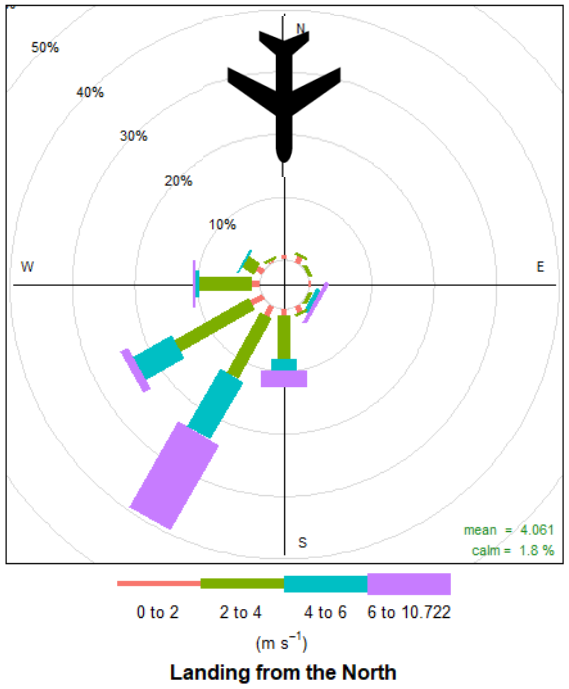
Mobile Monitoring Results

Mobile Monitoring

	Sampling Day	Second Car (%)	Start Hour	End Hour	Temp (F)	RH	South Flow Operation
Winter	21 days	62%	14:00	16:30	51F	62%	59%
Spring	14 days	71%	11:00	16:30	65F	50%	52%
Summer	16 days	81%	11:00	17:00	73F	47%	75%
Fall	12 days	83%	11:00	17:00	54F	78%	91%

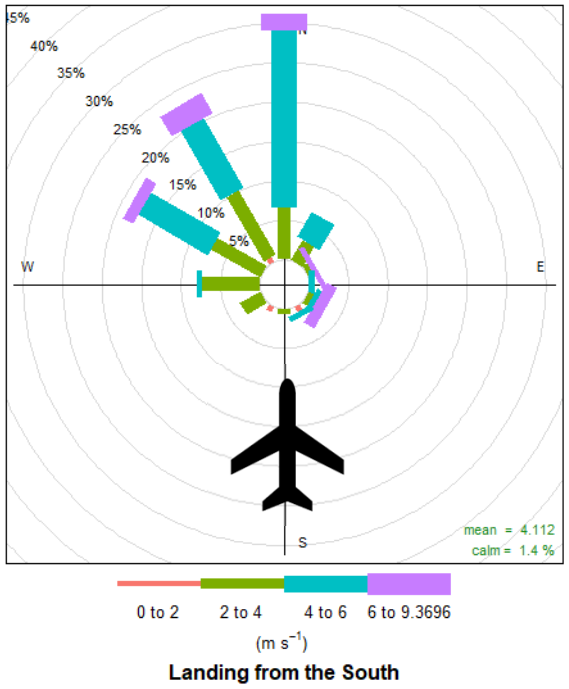
Wind roses indicate the speed and direction the wind is blowing “from”.

South-Flow Air Traffic



Landing from the North

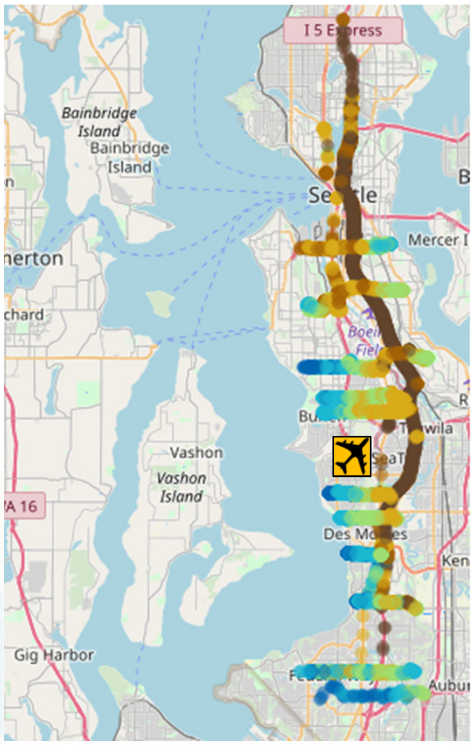
North-Flow Air Traffic



Landing from the South

Traffic Related Pollutants
Spatial Distribution

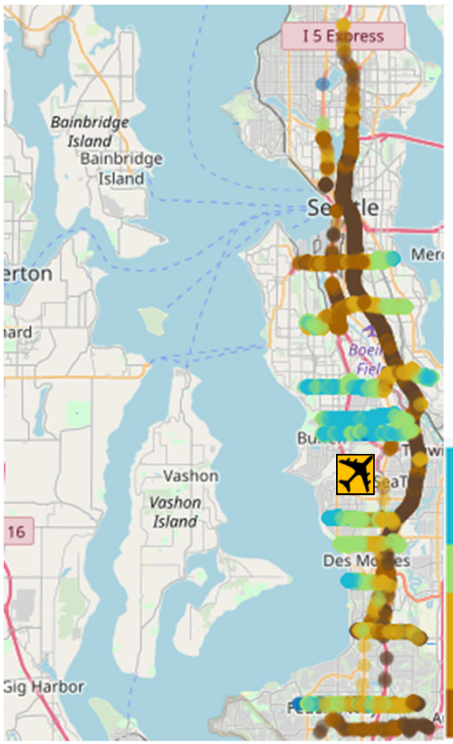
Total Particle Number*



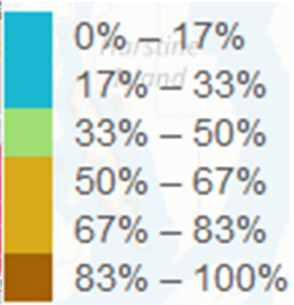
Total Particle Concentration
Percentile (%)

* Total Particle Number refers to particles with 10 - 1,000 nm diameter

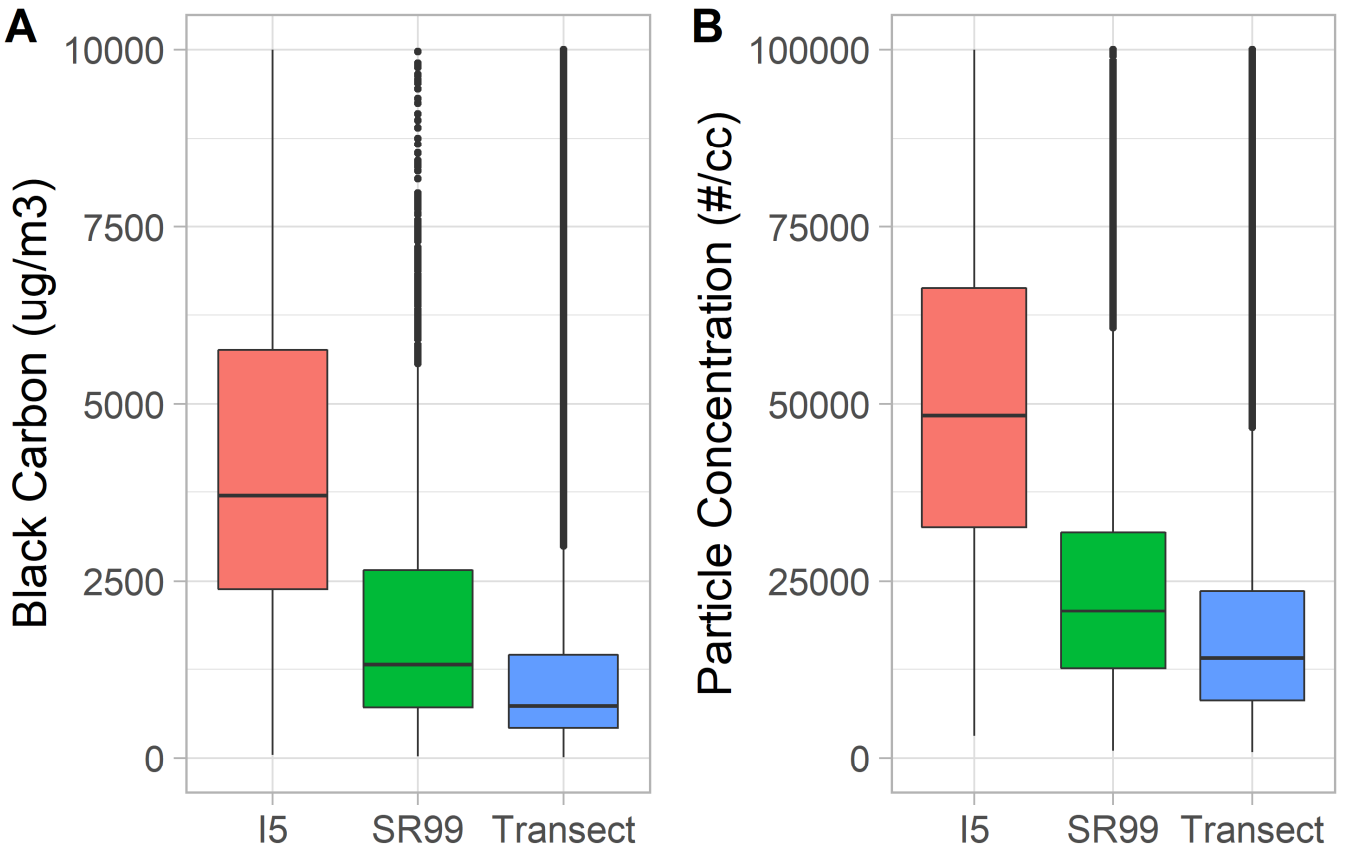
Black Carbon



Black Carbon
Percentile (%)

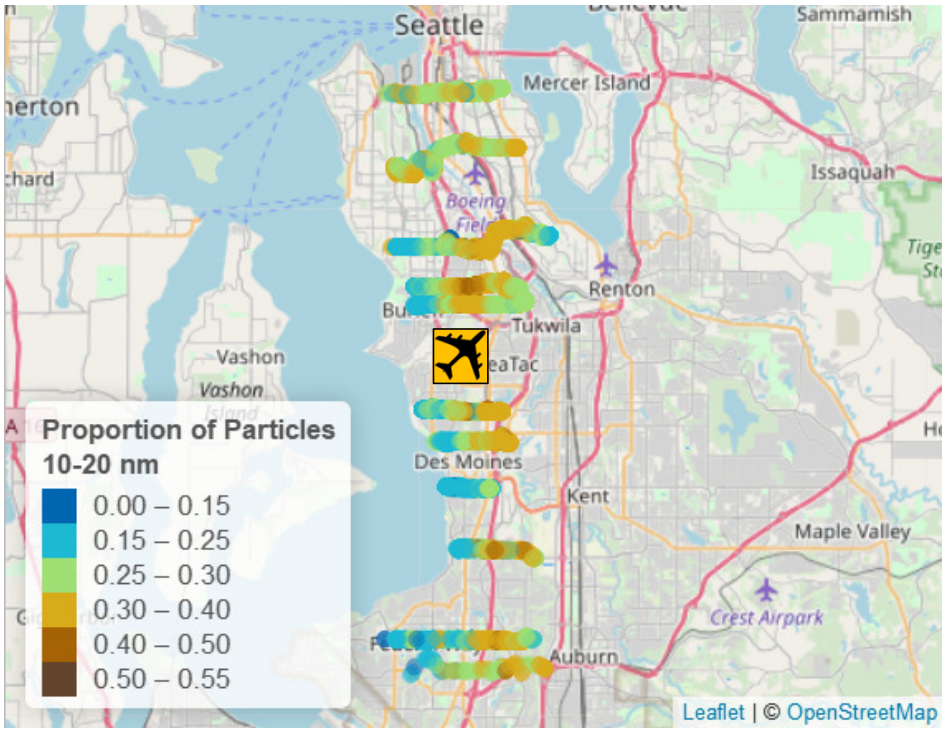


Major Roadways vs Transects

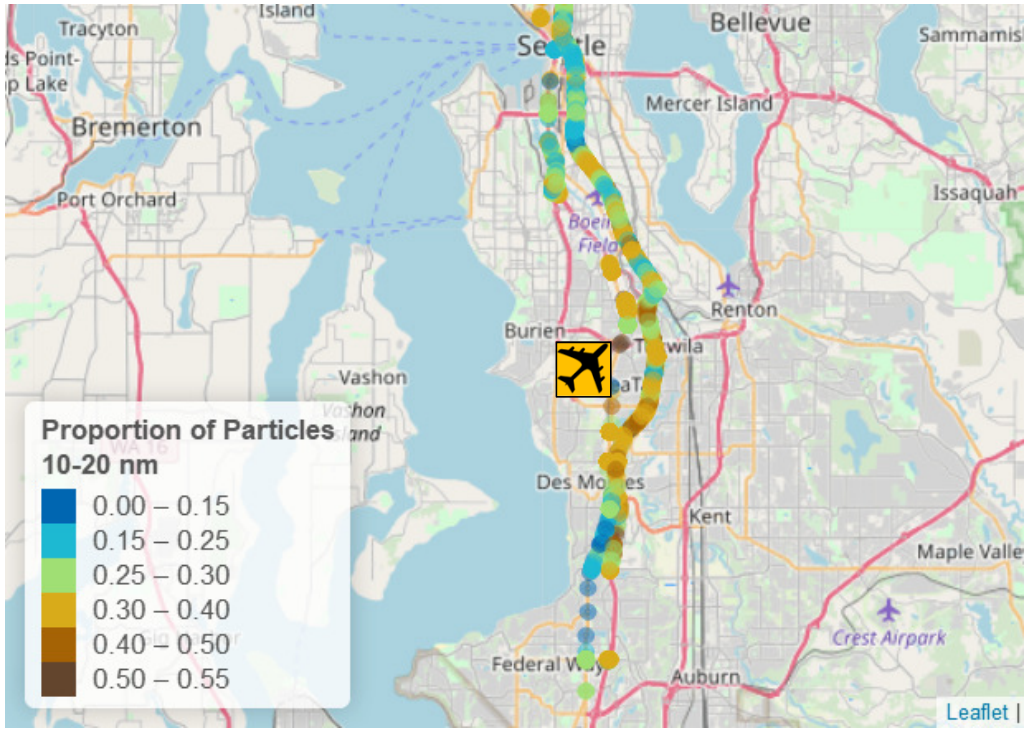


Proportion of small 10-20 nm particles enhanced near airport

Transects



Primary Road



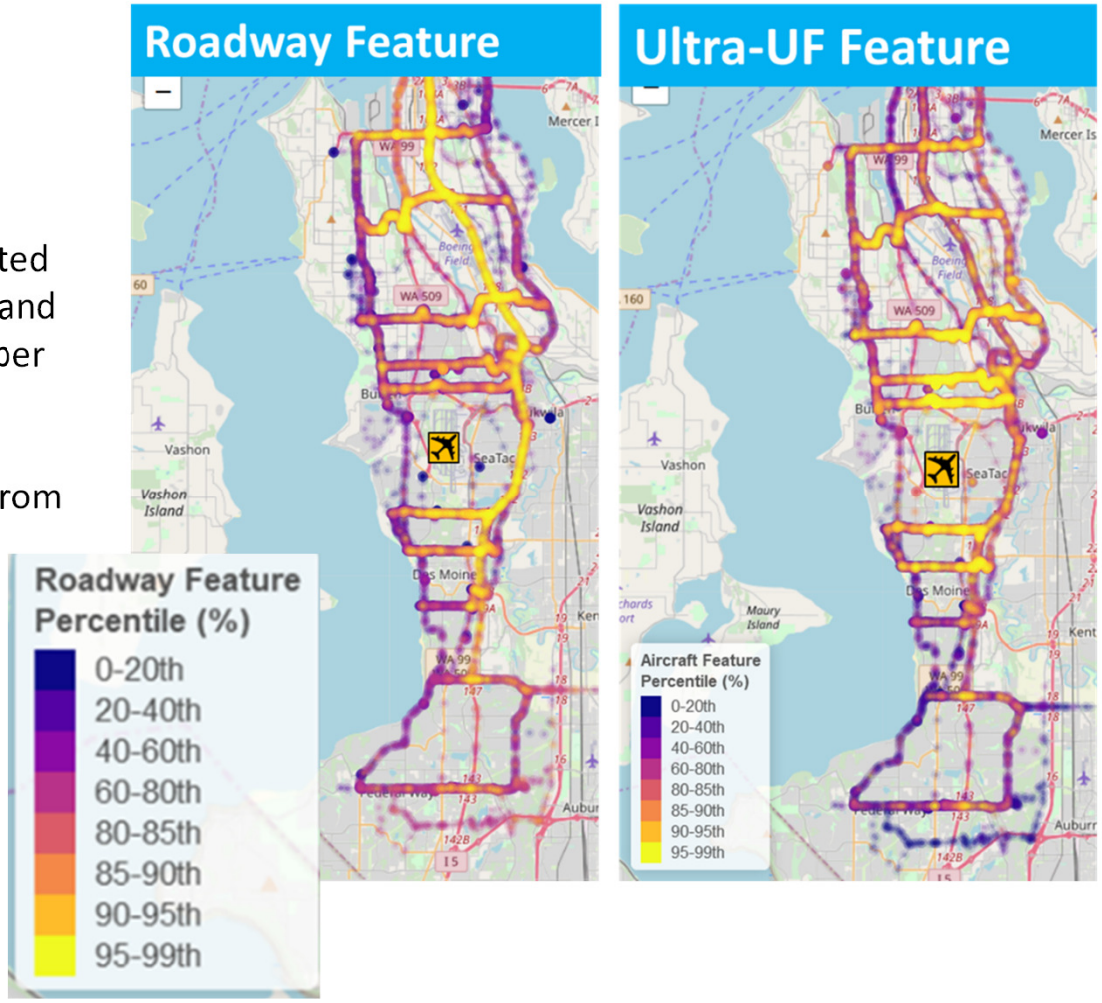
Principal Component Analysis (PCA)

- **Goal**: Combining particle size and other pollutant characteristics collected from mobile monitoring to characterize the source of pollutant

- **Method**: Perform a PCA with varimax-rotation to identify features or “fingerprints” that reflect pollutant source.

- **Result:** We can plot the contributions from each feature on a map

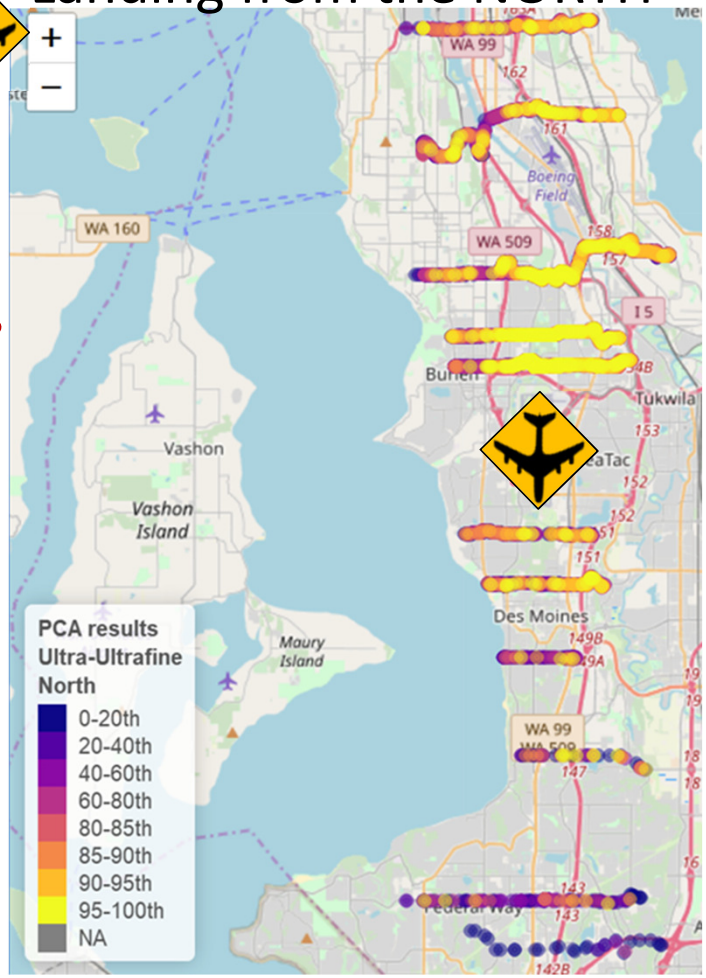
- POSITIVELY correlated with Black Carbon and Total Particle Number Concentration
- Median diameter from Nanoscan is approximately 30 nm



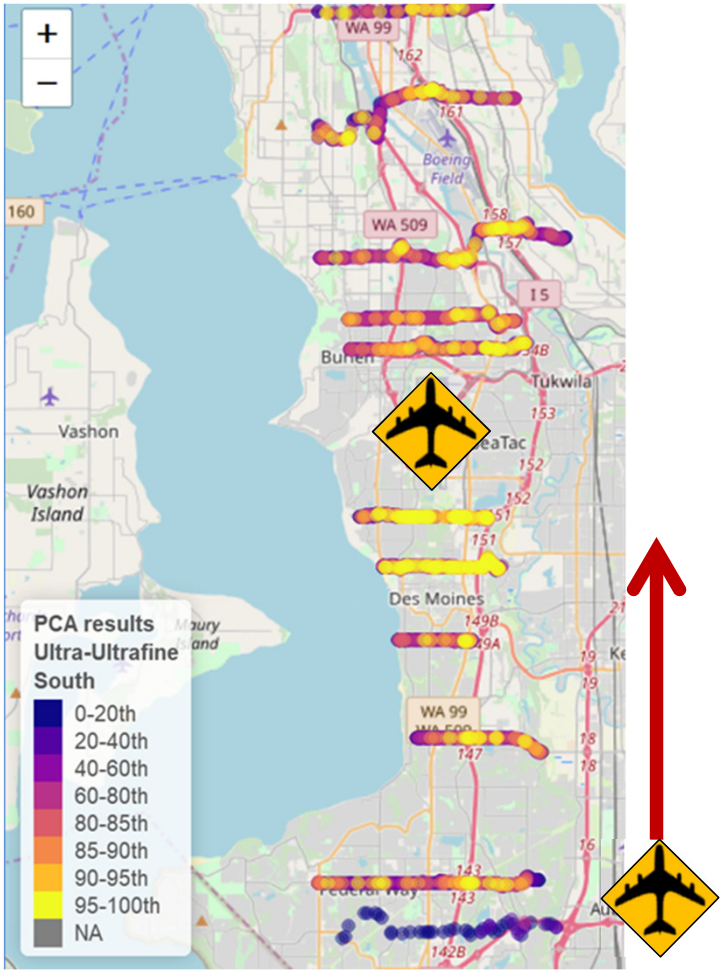
- POSITIVELY correlated with ultra-UF particles
- NEGATIVELY correlated with Black Carbon
- Median diameter from Nanoscan is approximately 15 nm

“Ultra-UFP” tracks landing direction

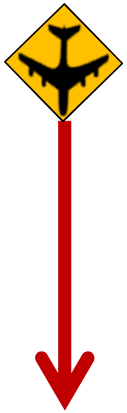
Landing from the NORTH



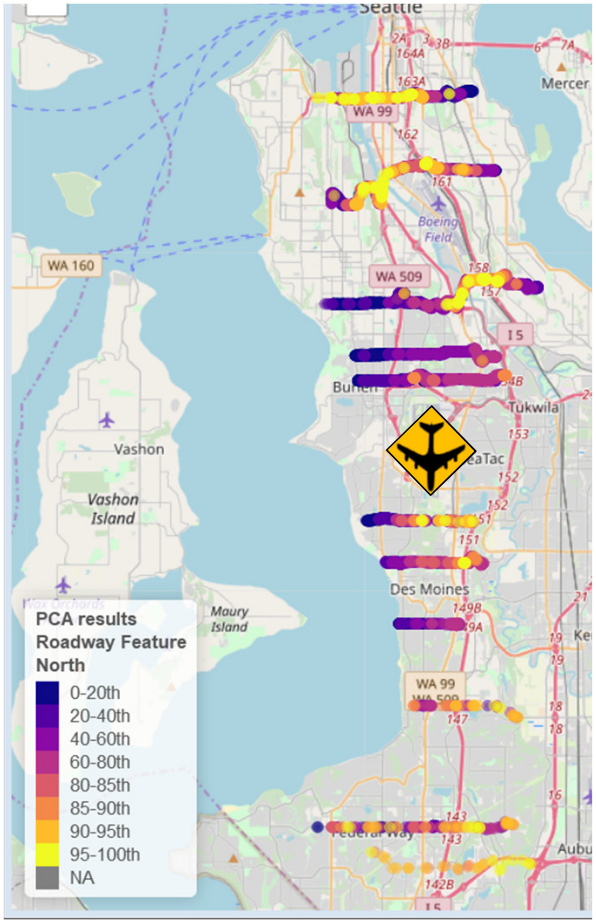
Landing from the SOUTH



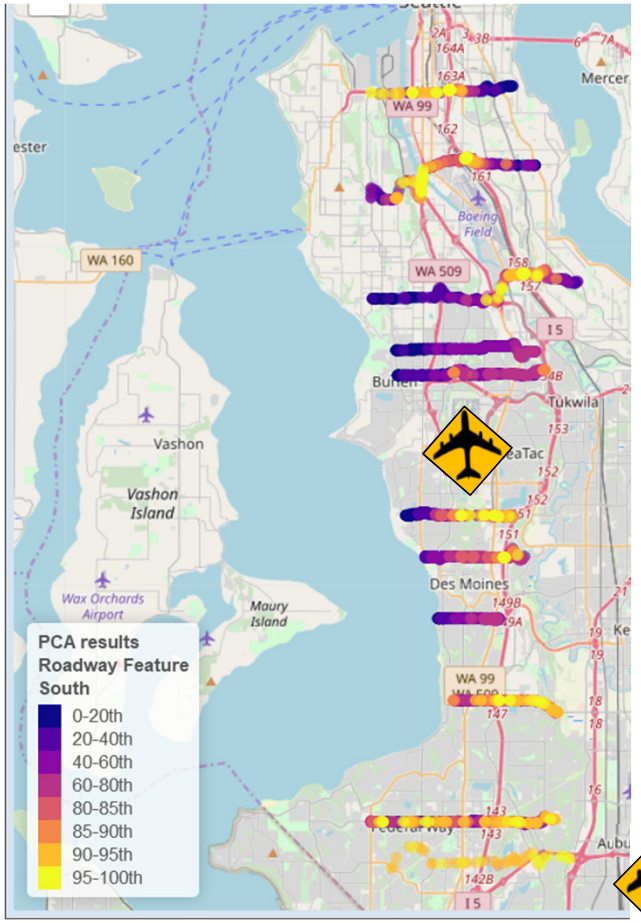
“Roadway” is invariant to landing direction



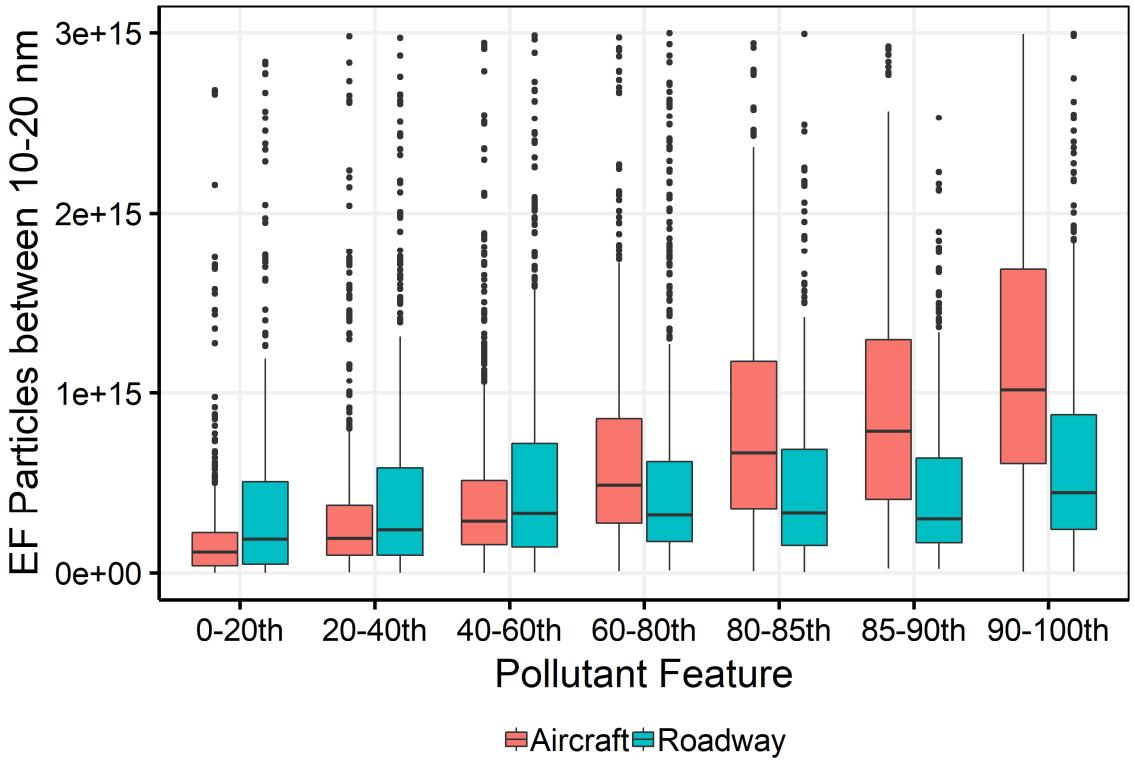
Landing from the NORTH



Landing from the SOUTH



Fuel-Based Emissions Calculations



Summary

- Ultrafine particles (UFP) are emitted from both traffic and aircraft sources
- Total concentration of UFP (10 - 1000 nm) did not distinguish roadway and aircraft features
- The spatial impact of traffic and aircraft UFP emissions can be separated using a combination of mobile monitoring and standard statistical methods
- There are key differences in the particle size distribution and the black carbon concentration for roadway and aircraft features.
- Fixed site monitoring confirms that aircraft landing activity is associated with a large fraction of particles between 10-20 nm.
- Mobile derived Fuel Based Emissions Factor (# Ultra UF/kg_{Fuel}) may lead to future air quality modeling scenarios.

MOV-UP Project Website
https://deohs.washington.edu/mov-up

Uncertainties and Caveats

- In this study, there was no measured single indicator of aircraft impact.
- This study provides information on the spatial distribution of ambient air quality impacts but does not provide a precise way to assign exposure estimate to specific locations or populations.
- This study provides a representative sample of pollutant distribution over the past year. Important uncertainties emerge in trying to predict distributions for past or future years.

Knowledge Gaps

Gap # 1: What are the health effects of aircraft UFP?

- What are the chemical and laboratory-based toxicological differences of UFP from roadway traffic and aircraft sources?
- Are short-term human health responses to roadway traffic and aircraft particles different?
- Are there long-term health impacts of exposure to traffic and aircraft UFP?

Knowledge Gaps

Gap # 2: What can we do to reduce human exposures to UFP?

- How much of UFP infiltrates into indoor spaces, particularly schools, daycares, old age facilities and medical centers where potentially vulnerable populations may be exposed?
- What are the short-term and long-term interventions that effectively reduce UFP exposures?
- Are the same interventions effective in reducing exposures to both UFP and Ultra-UFP in community settings?

Knowledge Gaps

Gap # 3: How are concentrations of UFP changing in different communities?

- Are there important daily and seasonal time trends in UFP distributions?
- Are there important spatial differences in UFP distributions?
- Can communities use information about UFP distributions to identify solutions and vulnerabilities?

pigeonhole.at/ADVISORY