Mobile ObserVations of Ultrafine Particles (MOV-UP)

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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

Ultrafine Particles (UFPs)

Ultrafine Particles unregulated but potentially important

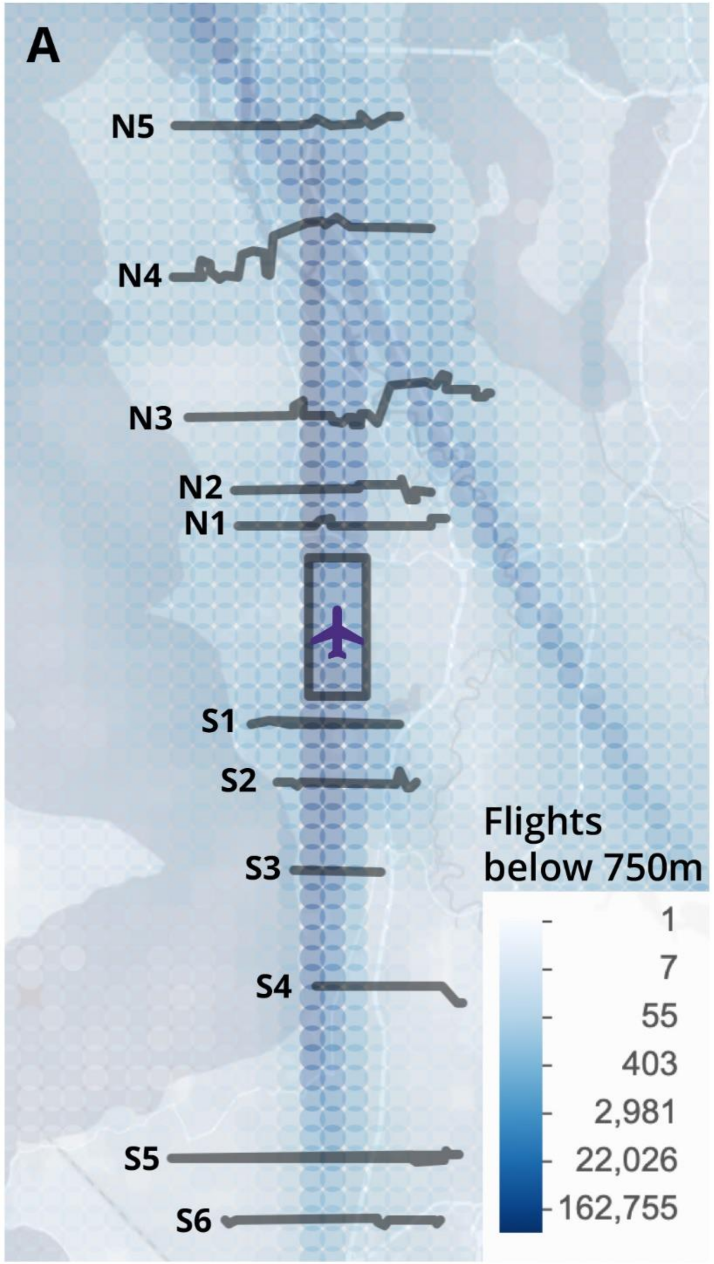
Health Effects more uncertain compared to $PM_{2.5}$,but a growing body of evidence

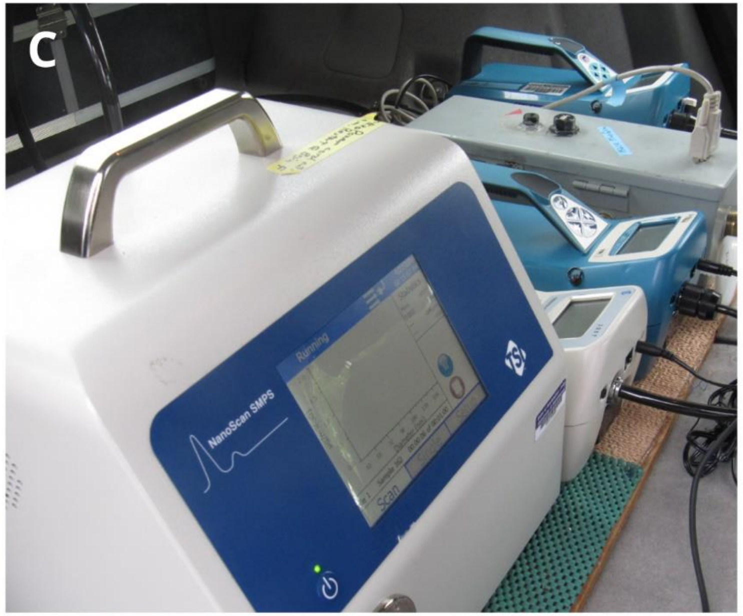
Diesel Engines emit ultrafine particles resulting in elevated levels near major roadways (within 200 meters downwind)

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

Study Region: Mobile Transects and Fixed Monitoring Site Locations

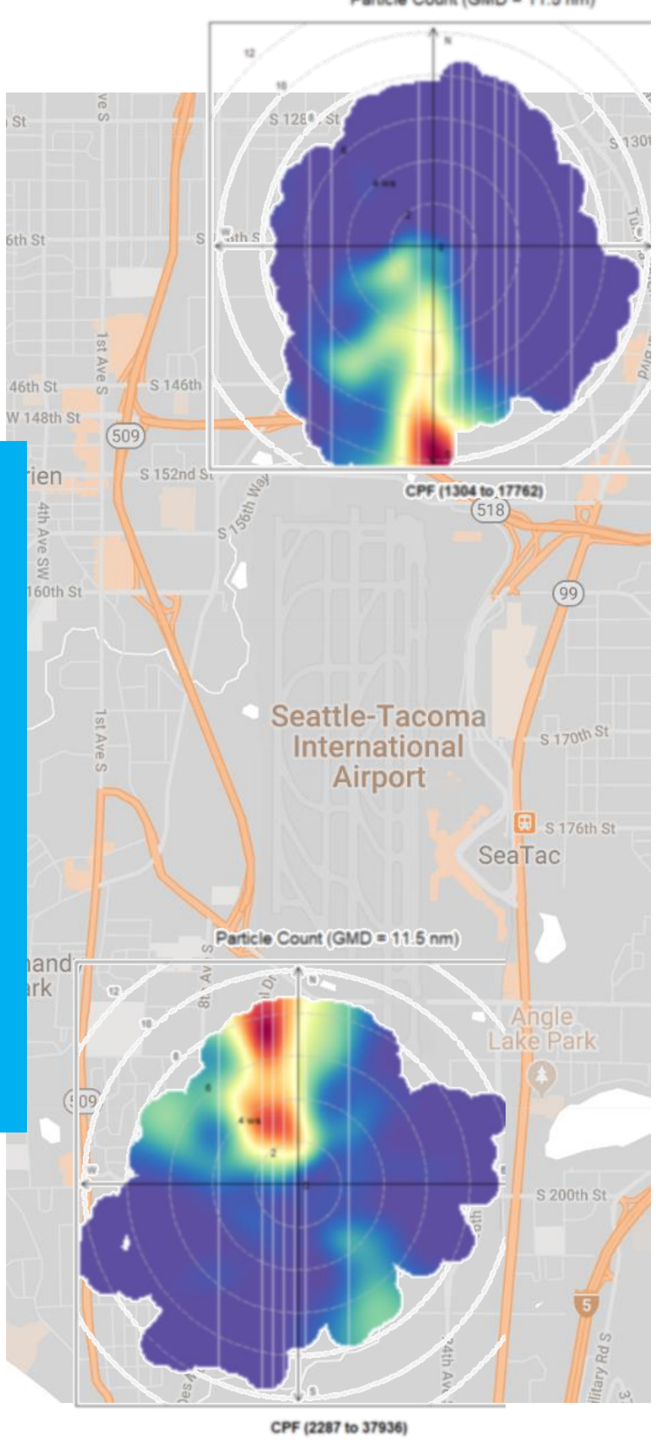
SEATAC (2018)
❖8th busiest U.S. airport
❖> 49.8 million passengers
❖>432,315 metric tons of air cargo





Mobile Monitoring Platform

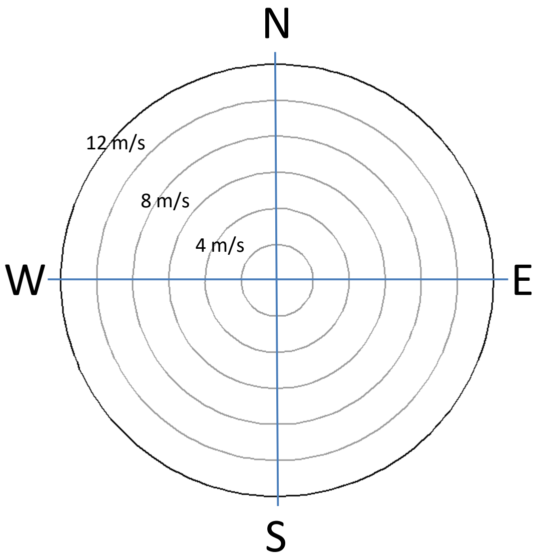
Parameter	Instrument
Mobile and Fixed sampling:	
Particle number concentration (35 nm – 1 µm)	P-Trak 8525, w/ diffusion screens
Particle number concentration (20 nm – 1 µm)	P-Trak 8525
Particle number concentration (10 nm – 1 µm)	Condensation Particle Counter 3007
Black Carbon PM	Micro-Aethalometer AE51
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



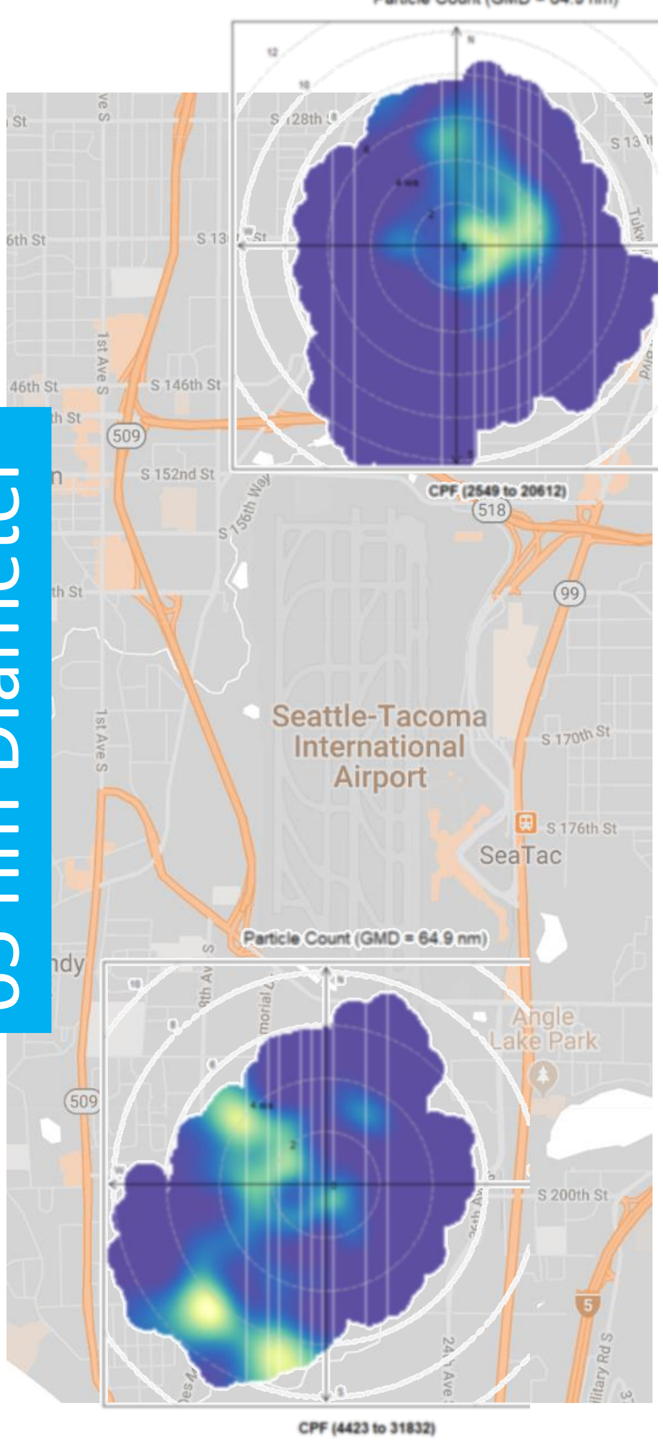
11.5 nm Diameter

Conditional Probability Plot

These plots show the probability that a given *wind direction* and *wind speed* is associated with a high concentration of a) 11.5 nm particles and b) 65 nm particles

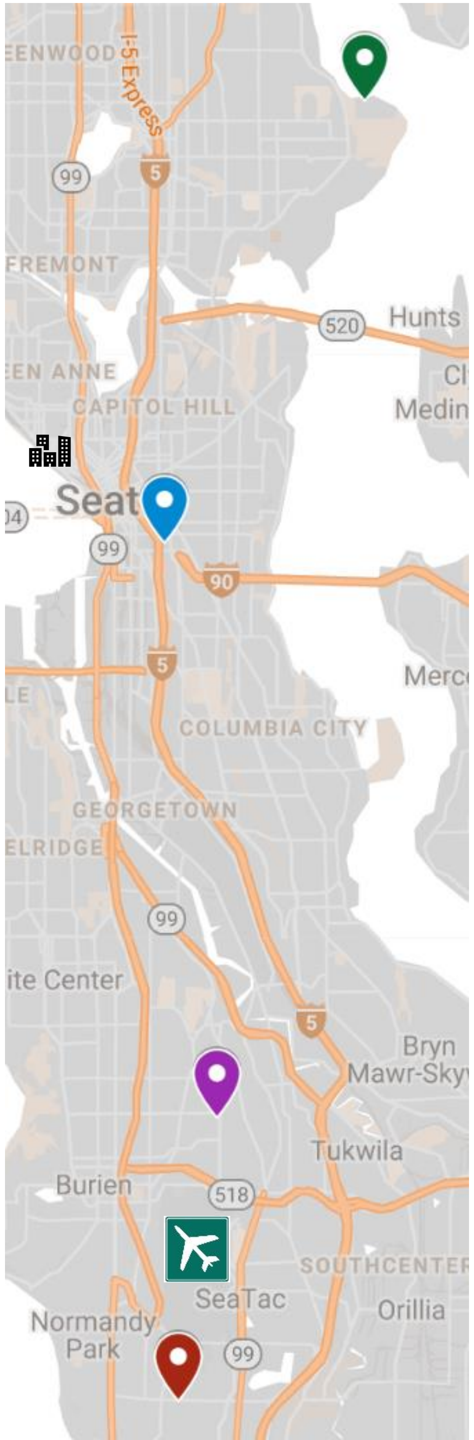


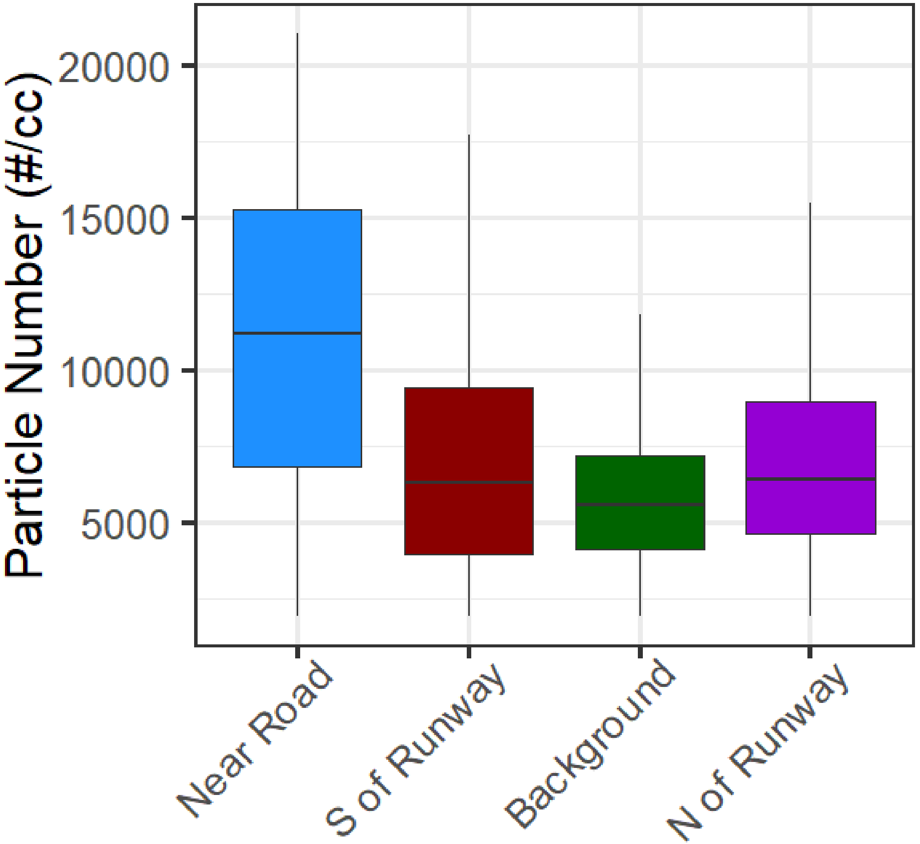
65 nm Diameter

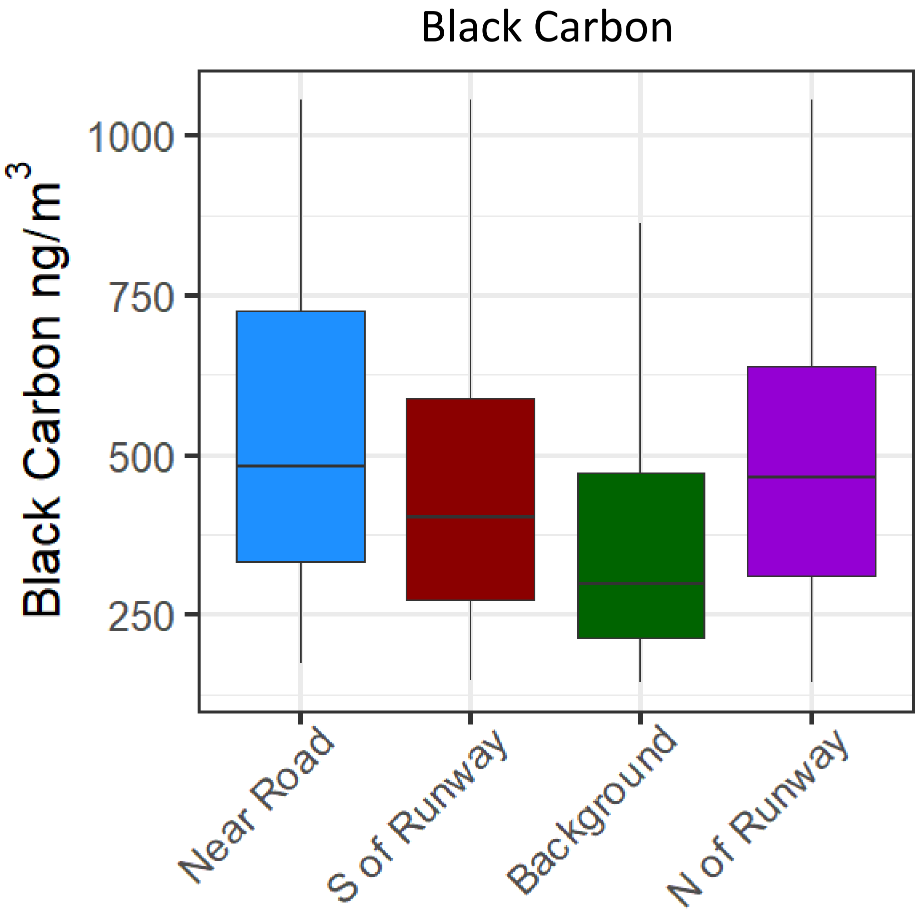


Fixed Monitoring Results

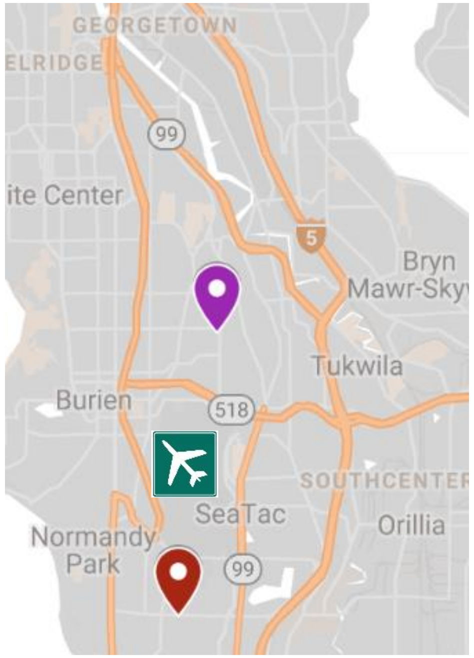
Fixed Monitoring Results: Traffic Related Pollutants



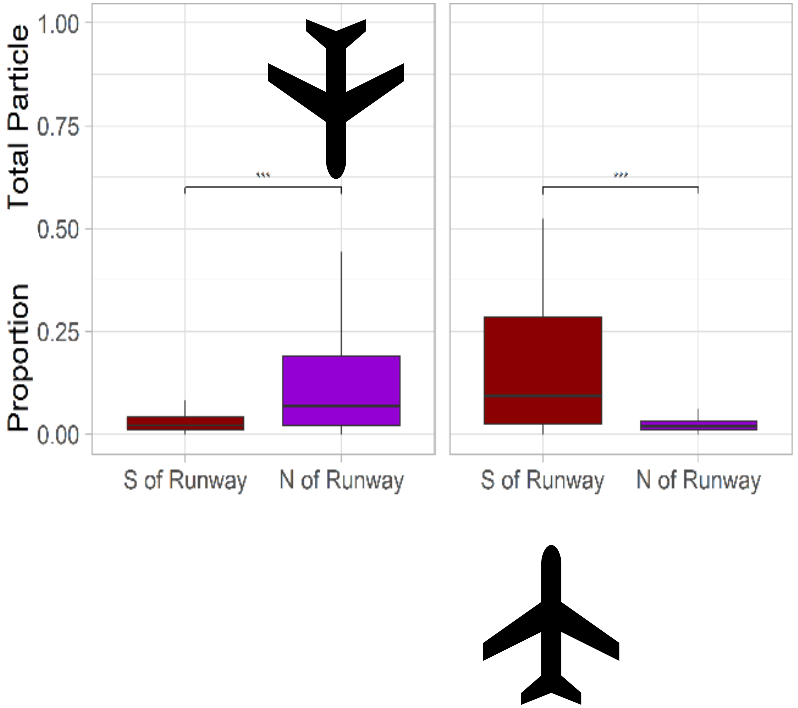




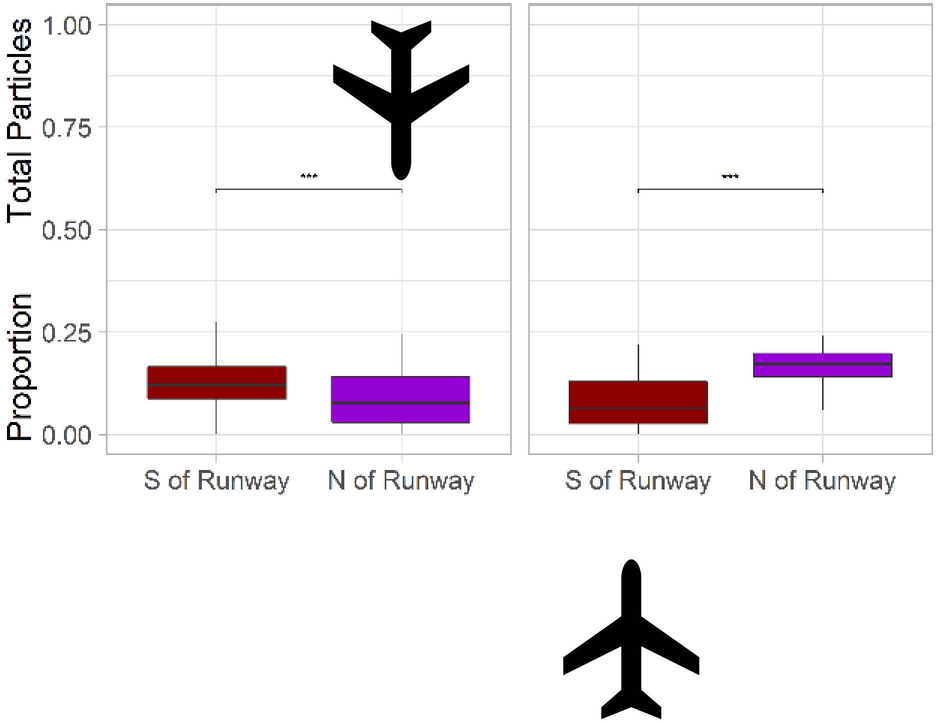
Smaller Sized Particles Near SeaTac Associated with Jet Landings



11.5 nm particles (% of UF)



65 nm particles (% of UF)

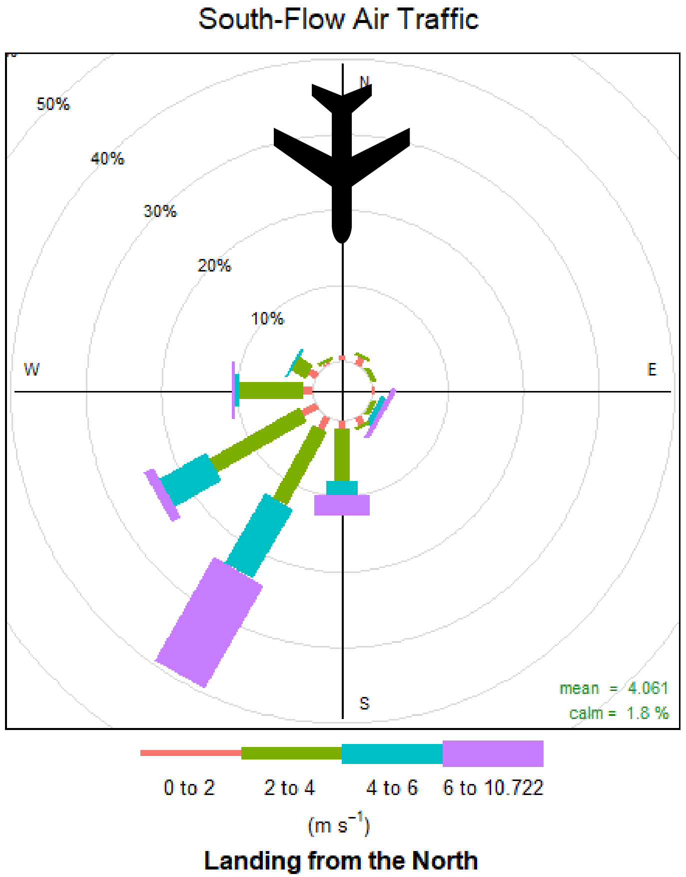


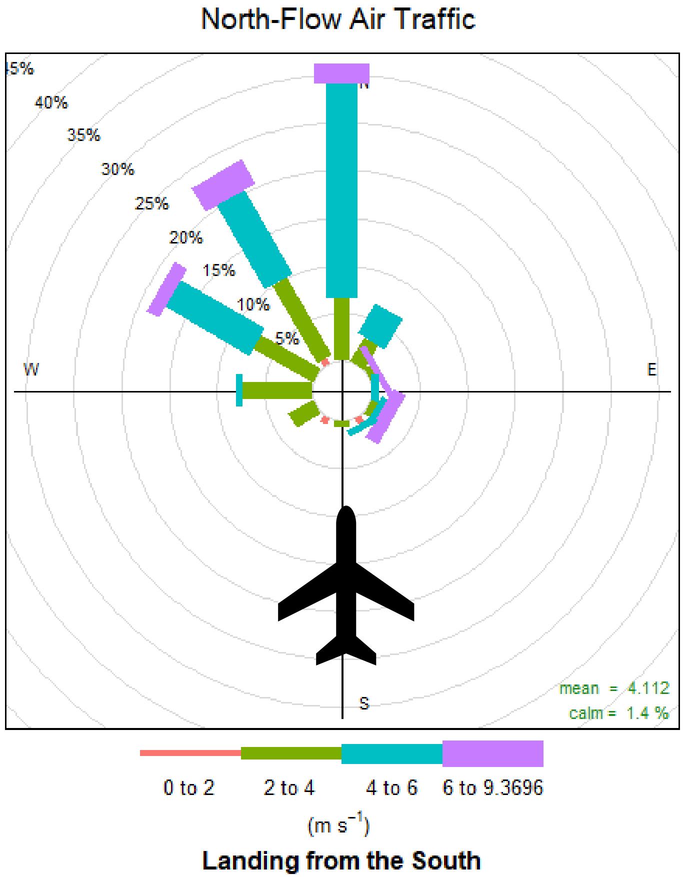
Mobile Monitoring Results

Mobile Monitoring Results: Monitoring Summary

	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%

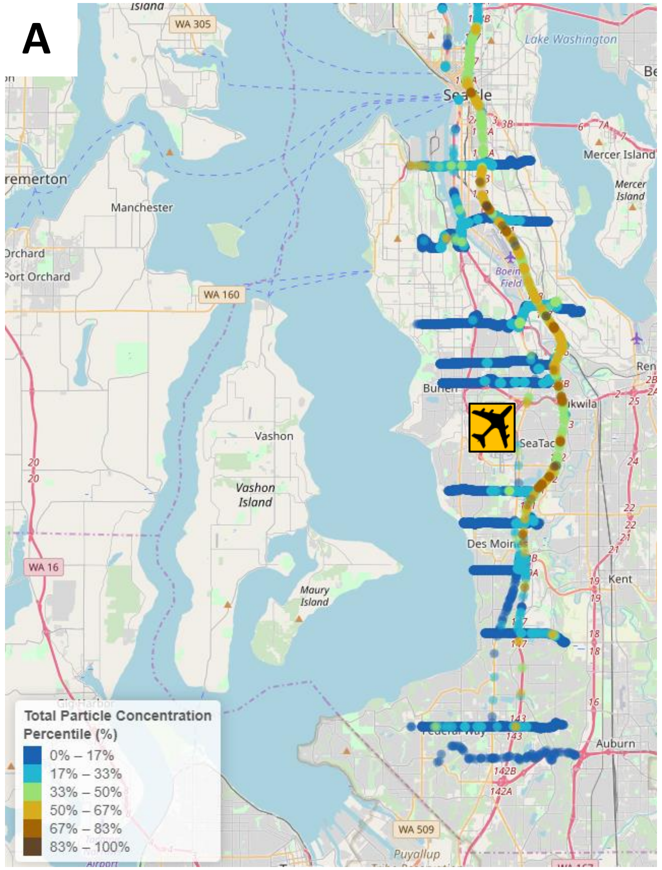
Wind roses indicate the speed and direction the wind is blowing "from".



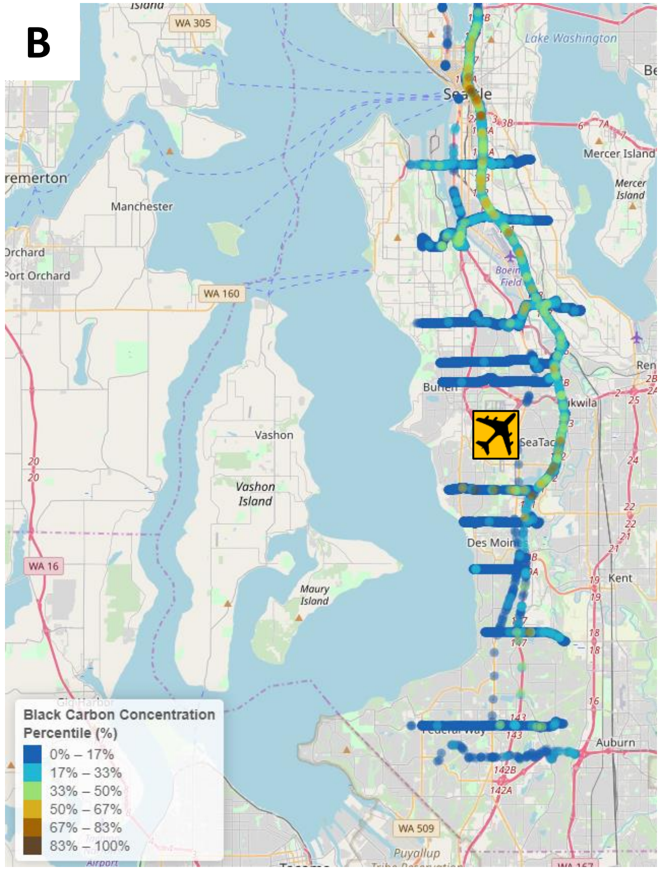


Traffic Related Pollutants Spatial Distribution

Total Particle Number*



Black Carbon



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

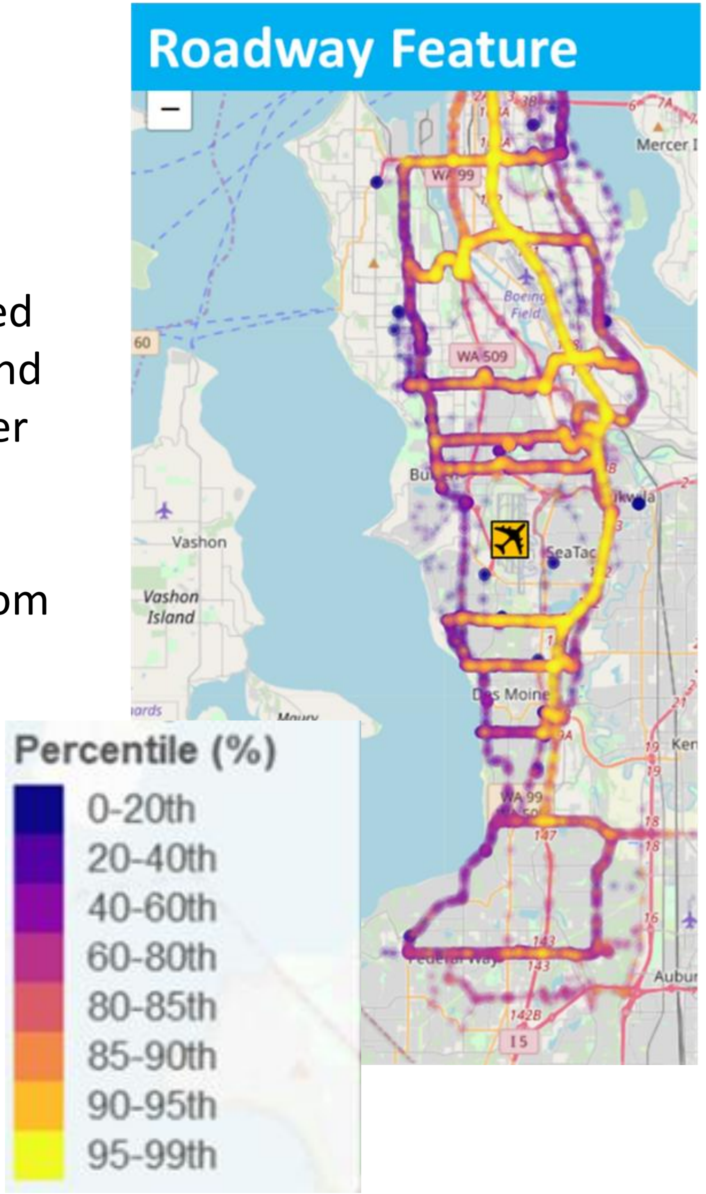
Principal Component Analysis (PCA)

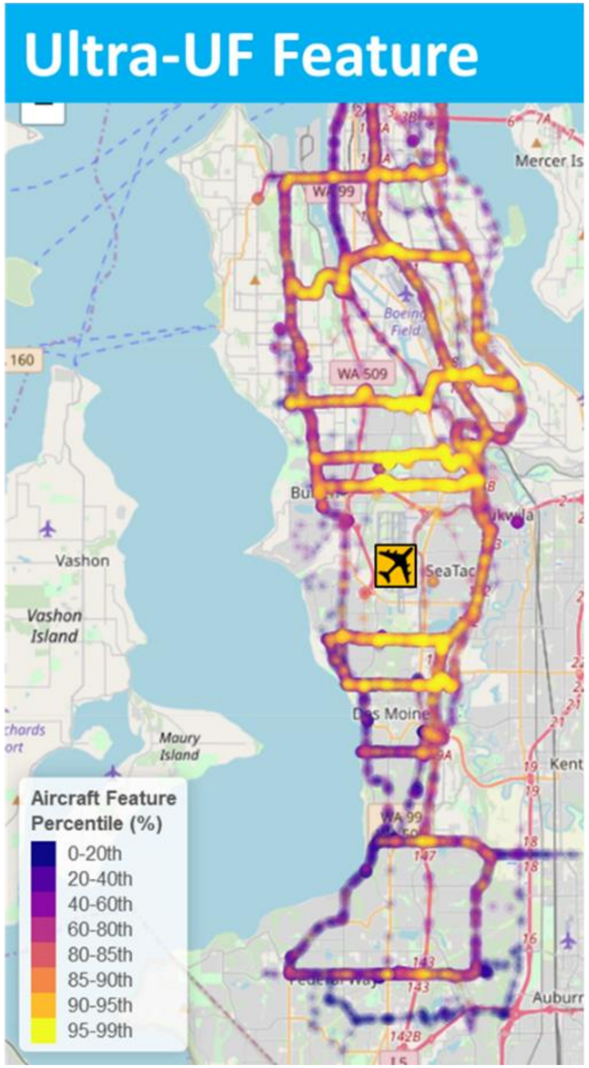
- **Goal**: Combining particle size and other pollutant characteristics collected from mobile monitoring to characterize the source of pollutant

- **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

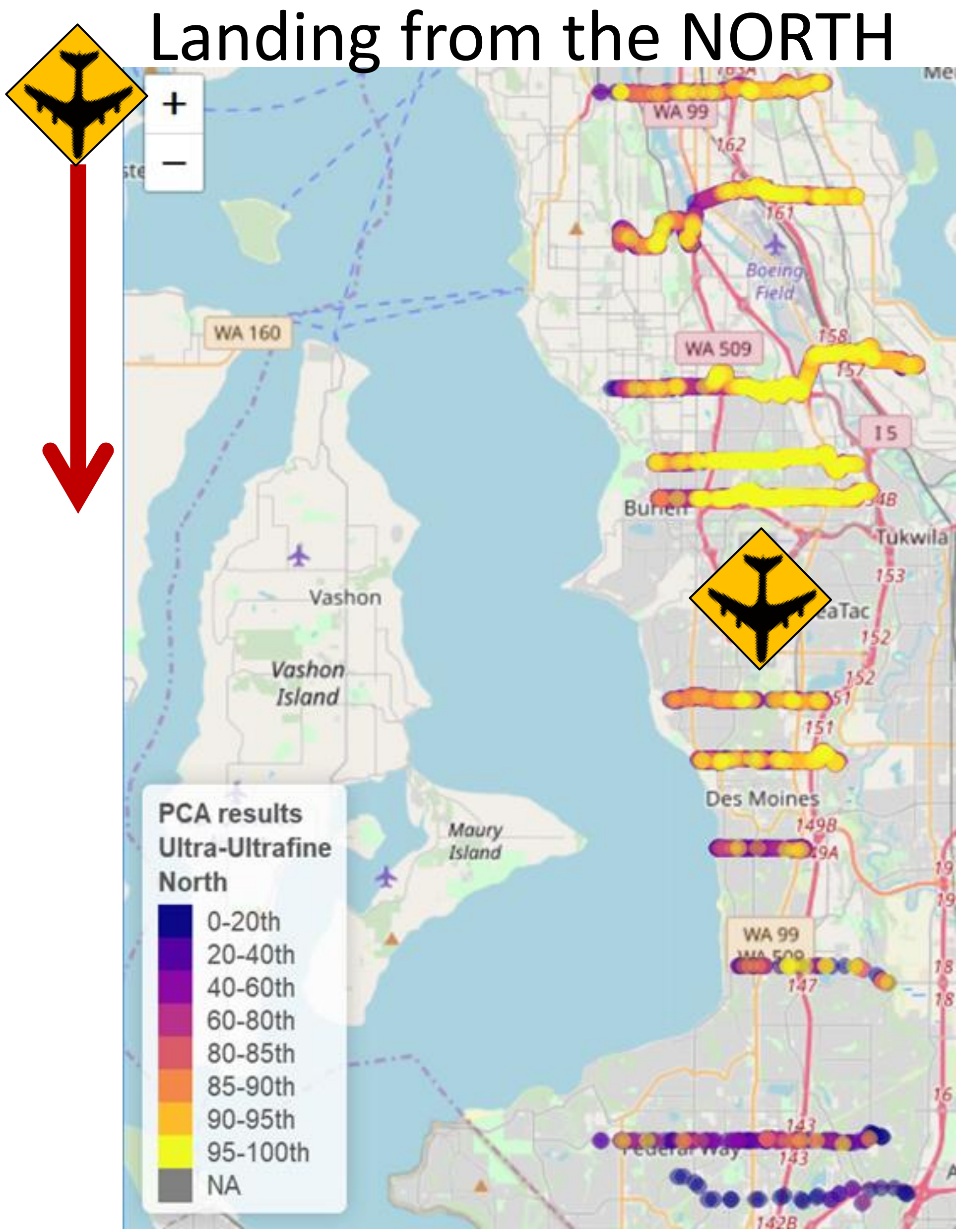
- POSITIVELY correlated with Black Carbon and Total Particle Number Concentration
- Median diameter from Nanoscan is approximately 30 nm

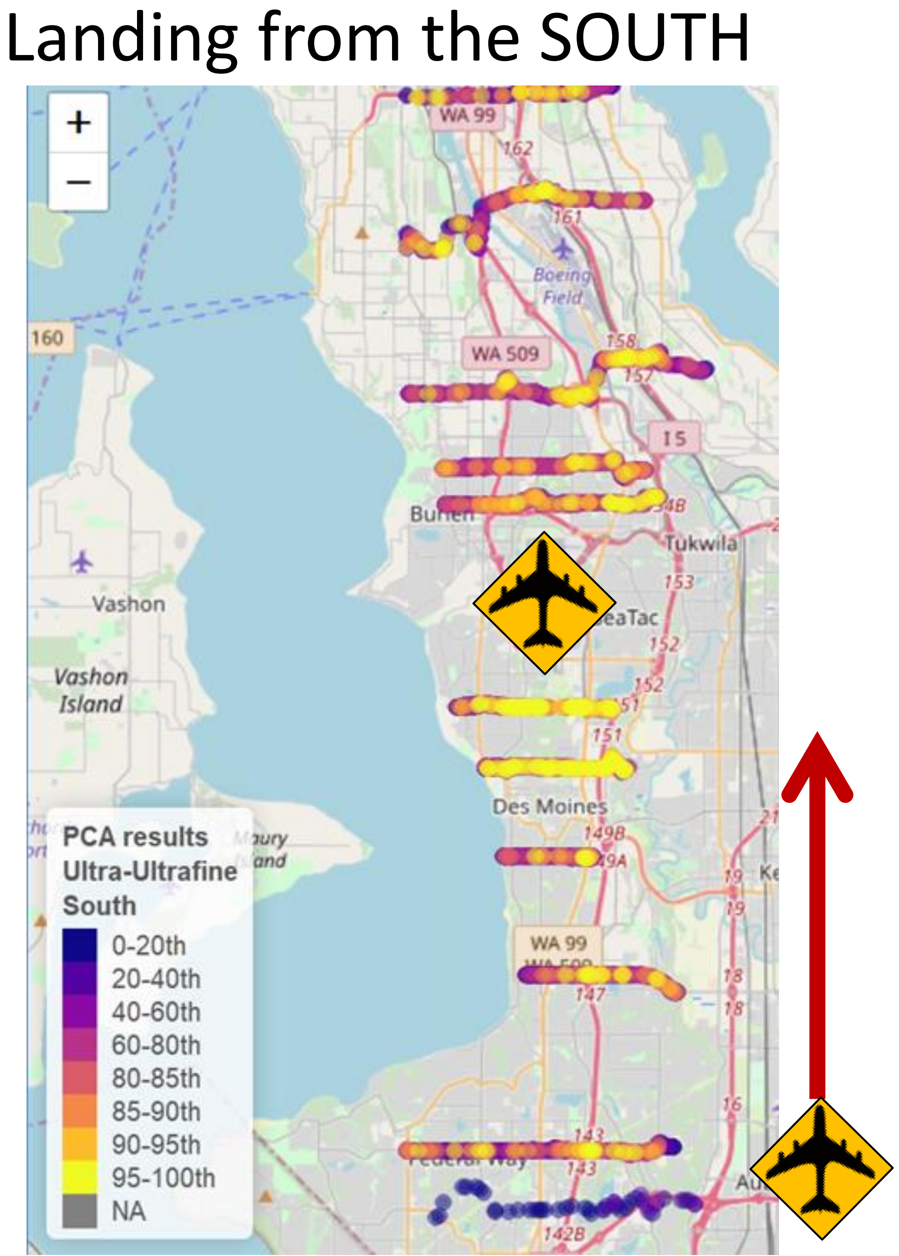




- POSITIVELY correlated with ultra-UF particles
- NEGATIVELY correlated with Black Carbon
- Median diameter from Nanoscan is approximately 15 nm

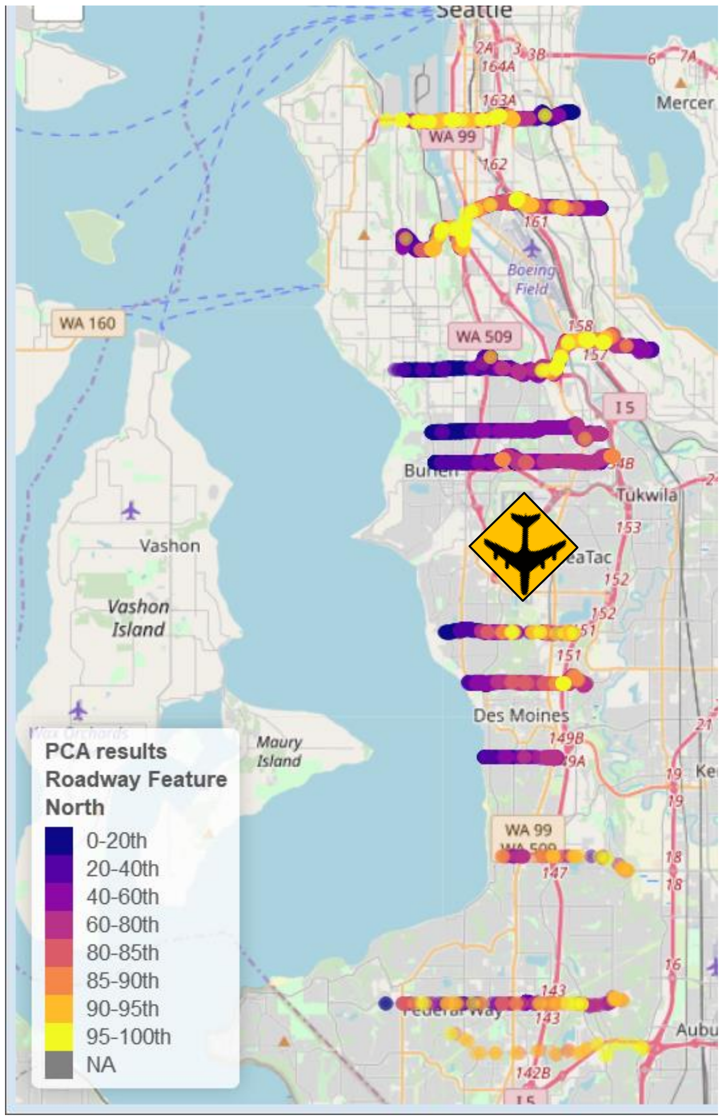
“Ultra-UFP” tracks landing direction



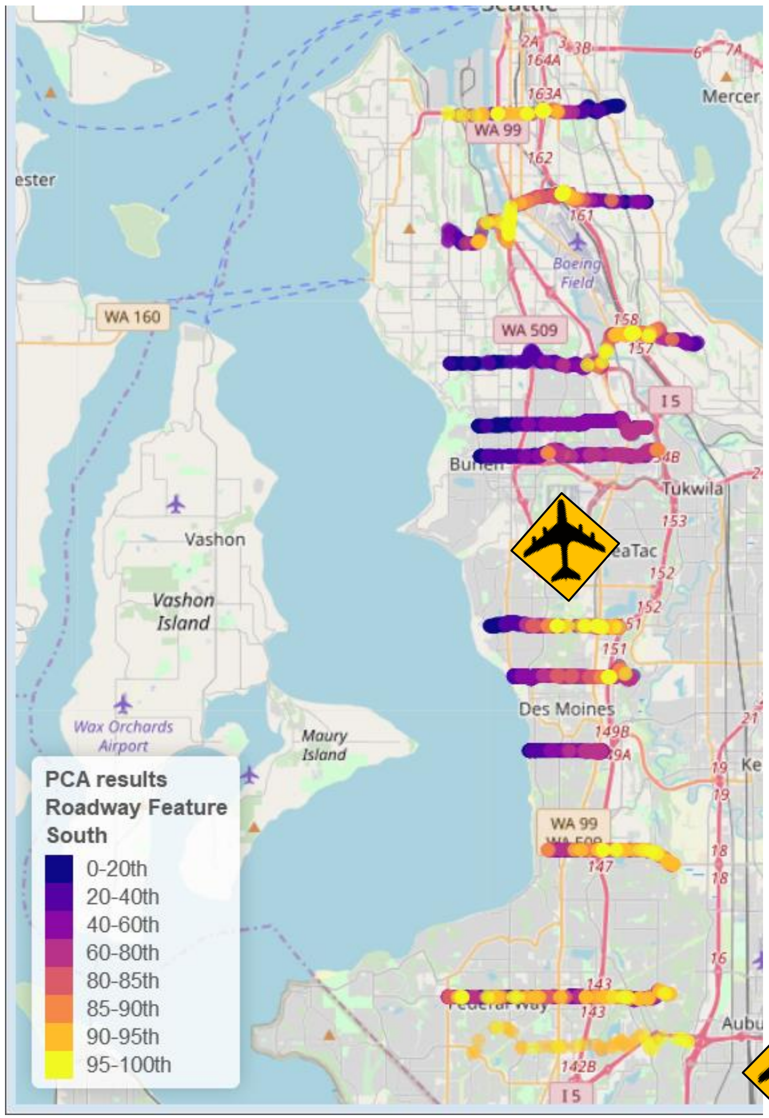


“Roadway” is invariant to landing direction

Landing from the NORTH



Landing from the SOUTH



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 (Findings in the Project Report).

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.

Recent Health Study

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Preterm Birth among Infants Exposed to *in Utero* Ultrafine Particles from Aircraft Emissions

Sam E. Wing, Timothy V. Larson, Neelakshi Hudda, Sarunporn Boonyarattaphan, Scott Fruin, and Beate Ritz

Published: 2 April 2020 | CID: 047002 | https://doi.org/10.1289/EHP5732

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Abstract

Introduction: Ambient air pollution is a known risk factor for adverse birth outcomes, but the role of ultrafine particles (UFPs) is not well understood. Aircraft-origin UFPs adversely affect air quality over large residential areas downwind of airports, but their reproductive health burden remains uninvestigated.

Objectives: This analysis evaluated whether UFPs from jet aircraft emissions are associated with increased rates of preterm birth (PTB) among pregnant mothers living downwind of Los Angeles International Airport (LAX).

Methods: This population-based study used birth records, provided by the California Department of Public Health, to ascertain birth outcomes and a novel, validated geospatial UFP dispersion model approach to estimate *in utero* exposures. All mothers who gave birth from 2008 to 2016 while living within 15 km of LAX were included in this analysis (N = 174,186; including 15,134 PTBs).

Results: *In utero* exposure to aircraft-origin UFPs was positively associated with PTB. The odds ratio (OR) per interquartile range (IQR) increase [9,200 particles per cubic centimeter (cc)] relative UFP exposure was 1.04 [95% confidence interval (CI): 1.02, 1.06]. When comparing the fourth quartile of UFP exposure to the first quartile, the OR for PTB was 1.14 (95% CI: 1.08, 1.20), adjusting for maternal demographic characteristics, exposure to traffic-related air pollution, and airport-related noise.

Conclusion: Our results suggest that emissions from aircraft play an etiologic role in PTBs, independent of noise and traffic-related air pollution exposures. These findings are of public health concern because UFP exposures downwind of airfields are common and may affect large, densely populated residential areas. https://doi.org/10.1289/EHP5732

Results

Variable	95% CI			
	Unadjusted model	Adjusted model 1[b]	Adjusted model 2[c]	Adjusted model 3[d]
UFP				
Quartile 1 (< 5,340 particles/cc)	Ref	Ref	Ref	Ref
Quartile 2 (5,340–8,600 particles/cc)	1.17 (1.11, 1.22)	1.01 (0.96, 1.07)	1.03 (0.98, 1.08)	1.03 (0.98, 1.08)
Quartile 3 (8,600–14,600 particles/cc)	1.27 (1.22, 1.33)	1.05 (1.00, 1.10)	1.08 (1.02, 1.13)	1.08 (1.02, 1.13)
Quartile 4 (> 14,600 particles/cc)	1.32 (1.27, 1.39)	1.11 (1.05, 1.16)	1.16 (1.10, 1.22)	1.14 (1.08, 1.20)
NO_2				
Quartile 1 (< 21.8 ppb)	—	—	Ref	Ref
Quartile 2 (21.8–23.8 ppb)	—	—	1.10 (1.05, 1.15)	1.10 (1.05, 1.16)
Quartile 3 (23.9–25.5 ppb)	—	—	1.10 (1.05, 1.16)	1.11 (1.05, 1.15)
Quartile 4 (> 25.5 ppb)	—	—	1.15 (1.09, 1.21)	1.15 (1.09, 1.22)
Exposed to noise > 65 dB CNEL	—	—	—	1.10 (1.01, 1.19)

Note: —, Data not available; CNEL, community noise equivalent level; dB, decibels; ppb, parts per billion; Ref, reference.

[a]PTB cases n = 15,134.

[b]Adjusted for maternal age, maternal educational attainment, SES, maternal race, and cigarette smoking. Educational attainment was recorded in 9 ordinal categories: No formal education, 8th grade or less, 9th grade through 12th grade with no diploma, high school graduate or GED, some college credit with no degree, associate's degree, bachelor's degree, master's degree, doctorate or professional degree.

[c]Adjusted for all variables in Adjusted Model 1 and NO_2.

[d]Adjusted for all variables in Adjusted Model 2 and airport noise.

Next Steps (as recommended to the MOV-UP advisory)

Current Projects

1. Drone measurements of vertical UFP profiles at 5-10 sites to confirm aircraft UFP impacts.
2. Collect UFP and analyze the toxicology of the UFP at selected impacted sites.

Up-coming projects

1. Short-term measurements of outdoor/indoor UFP levels at selected community sites, and evaluate the effectiveness of indoor air filtration in reducing exposures.
2. Conduct a short-term health effects study with/without exposure to aircraft-related UFP (case-crossover design).
3. Initiate longer-term measurements at approximately 10-20 sites of community concern, such as schools, community centers, parks to inform exposure modeling.

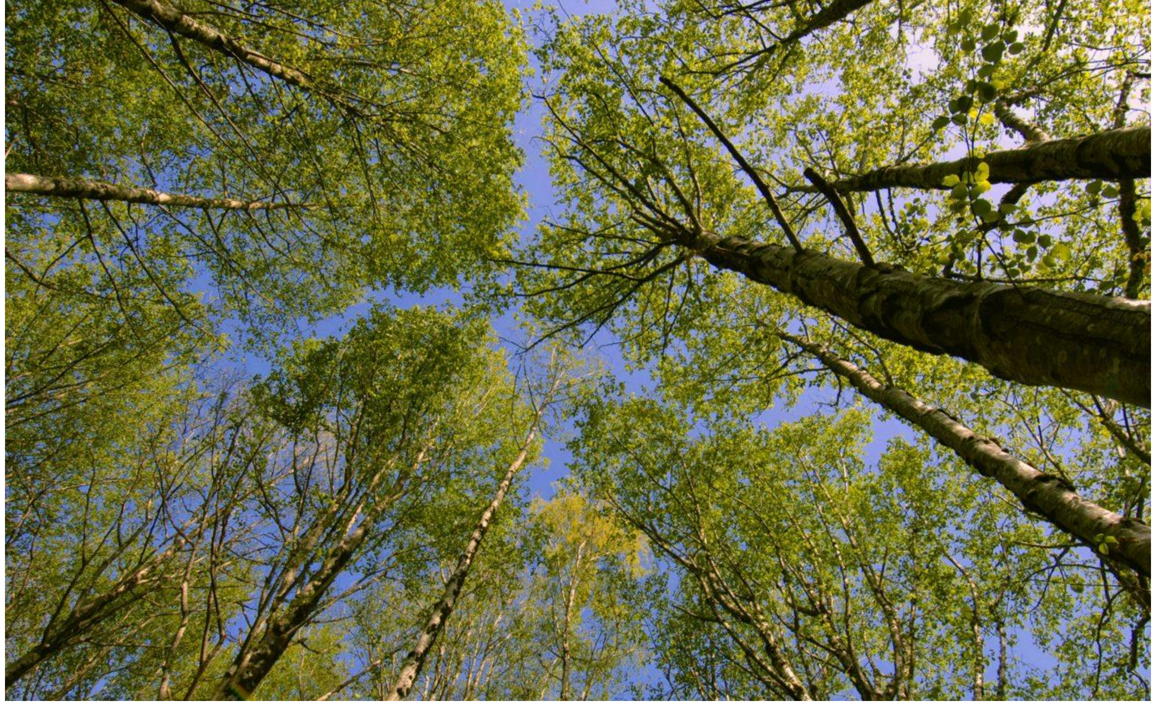
GAP: Larger epidemiology cohort study

Urban Ultrafine Characterization

- Staged collection of Ultrafine particles near-roadway and near-airport (10 nm – 10 um)
- Working with Port of Seattle to monitor directly North-East of landing aircraft
- Community engaged sampling strategy
- Developing methodology for sample analysis including speciation as well as recovery to toxicology

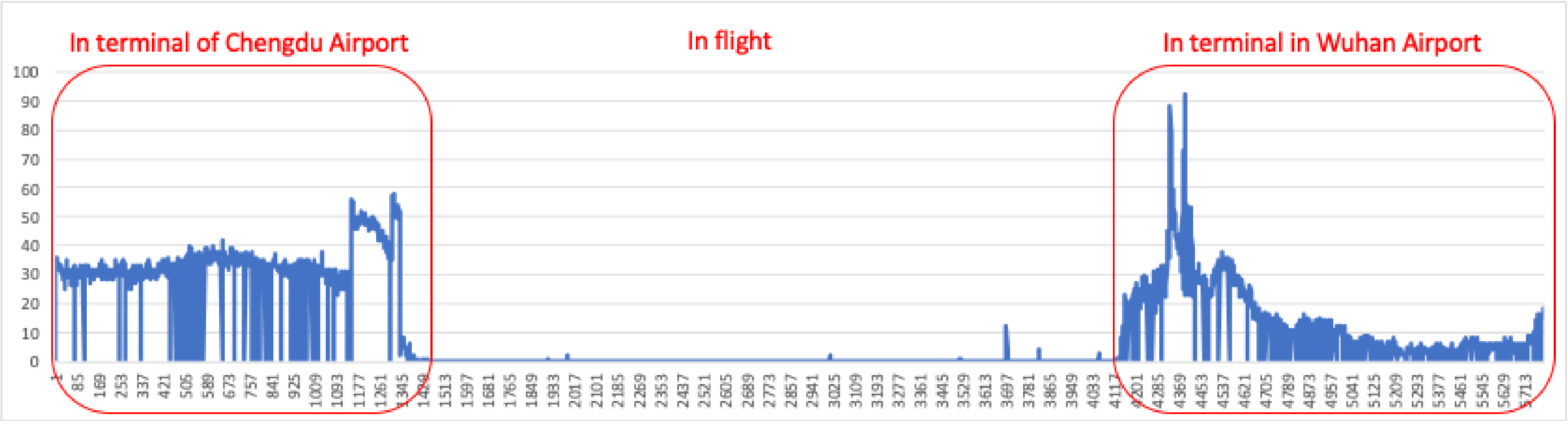
Earthlabs Drone Project

- Community-engaged study using drones for 3D air quality measurements
- Investigating vertical and horizontal UFP gradients in proximity to vegetation
- Directly informs policy and planning



Indoor Concentrations – Terminal and Community

- Characterize combustion particles from aircraft and traffic within airport and community settings
- Determine infiltration indoors and potential mitigations
- Better characterize health impact at the exposure concentrations observed within communities



Preliminary Data collected by Yisi Liu

Impact of Traffic Related Ultrafine Particles

- UFP in the urban environment are emitted by traffic, area combustion sources and atmospheric processes
- A recently completed analysis by Jianbang Xiang investigating traffic contributions to air pollution pre and post COVID-19 restrictions in Seattle demonstrates size selective relationship between UFP concentrations and traffic

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, elderly 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?