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 group

• **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

- Aug. 2019: Internal Review
- Sep. 2019: Meeting: External Advisory Group
- Nov. 2019: Final Edits
- Dec. 2019: Release
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 11\textsuperscript{th}, 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

FINE PARTICLES
<2.5 microns in diameter

HUMAN HAIR
50-70 microns in diameter

(0.1 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 an air quality measurement and source characterization study.

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

- 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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mobile and Fixed sampling:</strong></td>
<td></td>
</tr>
<tr>
<td>Particle number concentration (35 nm – 1 µm)</td>
<td>P-Trak 8525, w/ diffusion screens</td>
</tr>
<tr>
<td>Particle number concentration (20 nm – 1 µm)</td>
<td>P-Trak 8525</td>
</tr>
<tr>
<td>Particle number concentration (10 nm – 1 µm)</td>
<td>Condensation Particle Counter 3007</td>
</tr>
<tr>
<td>Black Carbon PM</td>
<td>Micro-Aethalometer AE51</td>
</tr>
<tr>
<td>CO2</td>
<td>LI-850 Gas Analyzer</td>
</tr>
<tr>
<td>Temperature &amp; Humidity</td>
<td>Hobo T, RH datalogger</td>
</tr>
<tr>
<td>Position &amp; Time tracking</td>
<td>GPS Receiver DG-500</td>
</tr>
<tr>
<td><strong>Fixed Location sampling:</strong></td>
<td></td>
</tr>
<tr>
<td>Particle size distribution, 13 bins</td>
<td>NanoScan 3910</td>
</tr>
</tbody>
</table>
Study Region: Mobile Transects and Fixed Monitoring Site Locations

Fixed Sites
- SeaTac Community Center
- Maywood School Building
- Near Roadway Site
- Background
Flight Track Data

Total Number of Flights below 750m in 2018

- > 200,000
- 70,000–199,999
- 16,000–70,000
- 800–15,999
- <800
Fixed Monitoring Results
## Fixed Monitoring Sites

<table>
<thead>
<tr>
<th></th>
<th>SeaTac Center N of Runway</th>
<th>Maywood S of Runway</th>
<th>10th &amp; Weller Near Road</th>
<th>Sand Point Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring 2018</td>
<td>-</td>
<td>10</td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td>Summer 2018</td>
<td>11</td>
<td>13</td>
<td>-</td>
<td>14</td>
</tr>
<tr>
<td>Autumn 2018</td>
<td>16</td>
<td>16</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Winter 2018-19</td>
<td>8</td>
<td>7</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Fixed Sites
- SeaTac Community Center
- Maywood School Building
- Near Roadway Site
- Background
Traffic Related Pollutants

**Total Particle Number (10-1,000 nm sizes)**

- **Near Road**: 15000
- **S of Runway**: 10000
- **Background**: 5000
- **N of Runway**: 10000

**Black Carbon**

- **Near Road**: 750 ng/m³
- **S of Runway**: 500 ng/m³
- **Background**: 250 ng/m³
- **N of Runway**: 500 ng/m³
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
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.
Mobile Monitoring Results
Mobile Monitoring

<table>
<thead>
<tr>
<th>Sampling Day</th>
<th>Second Car (%)</th>
<th>Start Hour</th>
<th>End Hour</th>
<th>Temp (F)</th>
<th>RH</th>
<th>South Flow Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>21 days</td>
<td>62%</td>
<td>14:00</td>
<td>16:30</td>
<td>51F</td>
<td>62%</td>
</tr>
<tr>
<td>Spring</td>
<td>14 days</td>
<td>71%</td>
<td>11:00</td>
<td>16:30</td>
<td>65F</td>
<td>50%</td>
</tr>
<tr>
<td>Summer</td>
<td>16 days</td>
<td>81%</td>
<td>11:00</td>
<td>17:00</td>
<td>73F</td>
<td>47%</td>
</tr>
<tr>
<td>Fall</td>
<td>12 days</td>
<td>83%</td>
<td>11:00</td>
<td>17:00</td>
<td>54F</td>
<td>78%</td>
</tr>
</tbody>
</table>

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

South-Flow Air Traffic

North-Flow Air Traffic

Landing from the North

Landing from the South
Traffic Related Pollutants
Spatial Distribution

Total Particle Number*

Black Carbon

* Total Particle Number refers to particles with 10 - 1,000 nm diameter
Major Roadways vs Transects

A

Black Carbon (ug/m3)

I5  SR99  Transect

10000
7500
5000
2500
0

B

Particle Concentration (#/cc)

I5  SR99  Transect

100000
75000
50000
25000
0
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-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?
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Session starts in

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