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
Recent MOV-UP Presentations

- 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
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-ultra fine” 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.

- 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
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>10\textsuperscript{th} &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>23</td>
</tr>
<tr>
<td>Summer 2018</td>
<td>11</td>
<td>22</td>
<td>-</td>
<td>12</td>
</tr>
<tr>
<td>Autumn 2018</td>
<td>7</td>
<td>7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Winter 2018-19</td>
<td>17</td>
<td>15</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Location</th>
<th>Total Particle Number (10-1,000 nm sizes)</th>
<th>Black Carbon (ng/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Near Road</td>
<td>15,000</td>
<td>750</td>
</tr>
<tr>
<td>S of Runway</td>
<td>10,000</td>
<td>500</td>
</tr>
<tr>
<td>Background</td>
<td>5,000</td>
<td>250</td>
</tr>
<tr>
<td>N of Runway</td>
<td>2,500</td>
<td>1,000</td>
</tr>
</tbody>
</table>

Map showing locations near Seattle and SeaTac.
Smaller Sized Particles Near SeaTac Associated with Jet Landings

11.5 nm particles (% of UF)

65 nm particles (% of UF)
11.5 nm Diameter

65 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.
Mobile Monitoring Results
Mobile Monitoring

<table>
<thead>
<tr>
<th>Season</th>
<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>51°</td>
<td>62%</td>
<td>59%</td>
</tr>
<tr>
<td>Spring</td>
<td>14 days</td>
<td>71%</td>
<td>11:00</td>
<td>16:30</td>
<td>65°</td>
<td>50%</td>
<td>52%</td>
</tr>
<tr>
<td>Summer</td>
<td>16 days</td>
<td>81%</td>
<td>11:00</td>
<td>17:00</td>
<td>73°</td>
<td>47%</td>
<td>75%</td>
</tr>
<tr>
<td>Fall</td>
<td>12 days</td>
<td>83%</td>
<td>11:00</td>
<td>17:00</td>
<td>54°</td>
<td>78%</td>
<td>91%</td>
</tr>
</tbody>
</table>

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

South-Flow Air Traffic

North-Flow Air Traffic
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

Black Carbon

Total Particle Number > 10 nm

Driving on I-5
Driving on SR99
All transects
Proportion of small 10-20 nm particles enhanced near airport

Transects

Primary Road
Proportion of small 10-20 nm particles NOT enhanced on roadways

“Ultra-Ultrafines”

![Graph showing proportion of ultrafine particles 10-20 nm across different conditions.]

- Driving on I-5
- Driving on SR99
- All transects
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
“Ultra-UF” Feature

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

Roadway Feature

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

• The impacts from traffic and aircraft UFP emissions can be separated into source-related features 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
• Findings will be presented and discussed with Study Advisory Board this summer
• Final results by December 2019

MOV-UP Project Website
https://deohs.washington.edu/mov-up
New Beacon Hill Study for City of Seattle  
(Start date 5/15/19)

- Select “community” sites in Beacon Hill for ultrafine particle (UFP) and noise sampling.
- Operate one community site for up to several weeks before moving to the next one
- Sample at up to five community sites
- Set up an “anchor site” that we know is impacted by aircraft UFP and noise.
- Run both the community and the anchor site simultaneously so that we can make comparisons for different flight characteristics (traffic, time of day, etc.)
Request from Mayor’s Office & City Council
Federal Way (May 2019)

• Asks UW MOV-UP Research Team to conduct a new study that would expand monitoring in three ways:

1. Vertical measurements of UFP (e.g., by using drones)
2. Design a network of UFP monitors that would include important sites for the community such as parks, schools, and social justice impact areas
3. Include a site not affected by air traffic for comparison of UFP levels.

• We do not currently have funding for this work.