Ultrafine Particles Near Airports

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Highline Forum - 11/15/2017

WA State Proviso

- "… the university of Washington school of public health to study the air quality implications of air traffic at the international airport in the state that has the highest total annual number of arrivals and departures.

- The study must include an assessment of the concentrations of ultrafine particulate matter in areas surrounding and directly impacted by air traffic generated by the airport, including areas within ten miles of the airport in the directions of aircraft flight paths and within ten miles of the airport where public agencies operate an existing air monitoring station…

WA State Proviso

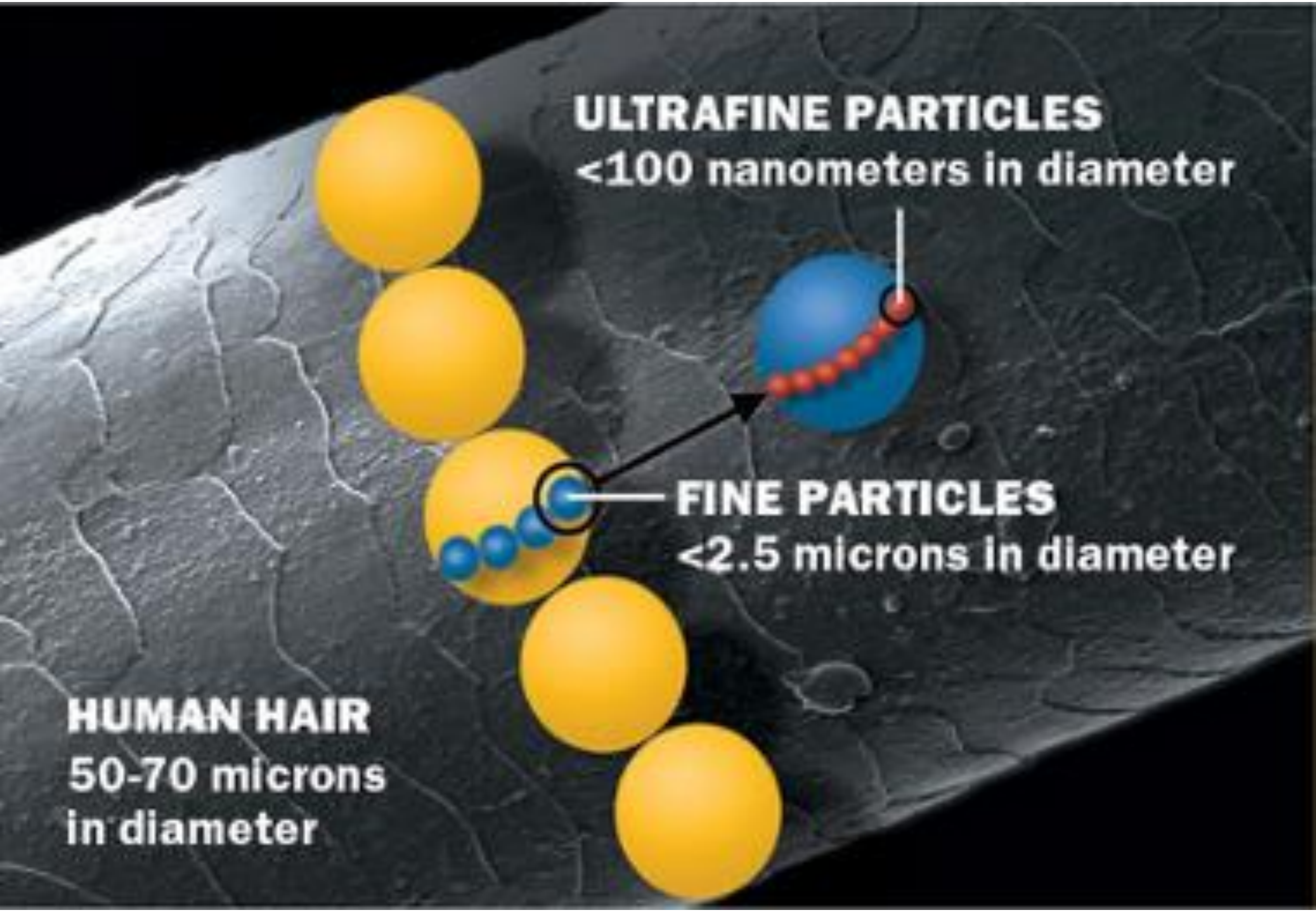
- The study must attempt to distinguish between aircraft and other sources of ultrafine particulate matter, and must compare concentrations of ultrafine particulate matter in areas impacted by high volumes of air traffic with concentrations of ultrafine particulate matter in areas that are not impacted by high volumes of air traffic.

- The university must coordinate with local governments in areas addressed by the study to share results and inclusively solicit feedback from community members.

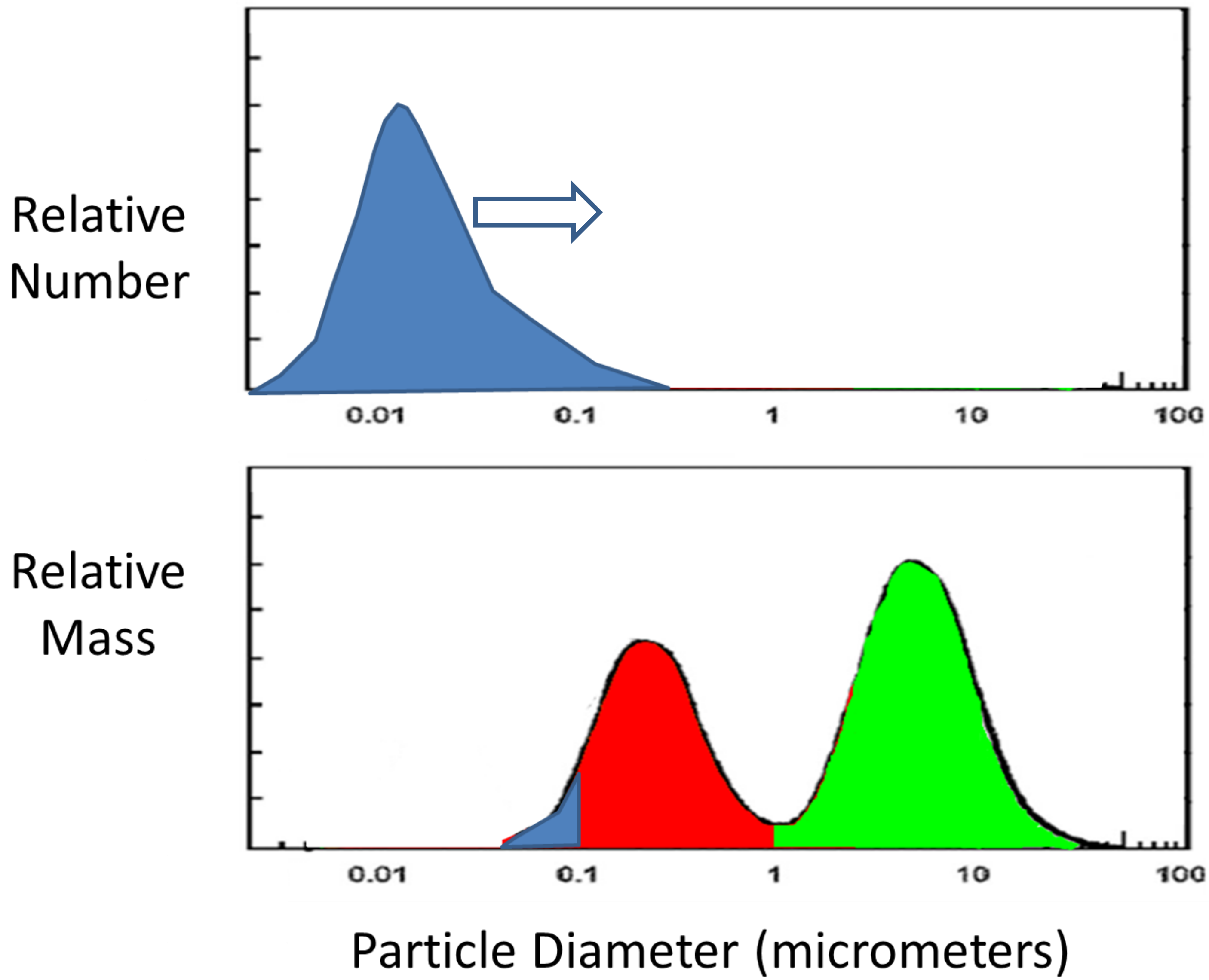
- By December 1, 2019, the university must report study findings, including any gaps and uncertainties in health information associated with ultrafine particulate matter, and recommend to the Legislature whether sufficient information is available to proceed with a second phase of the study."

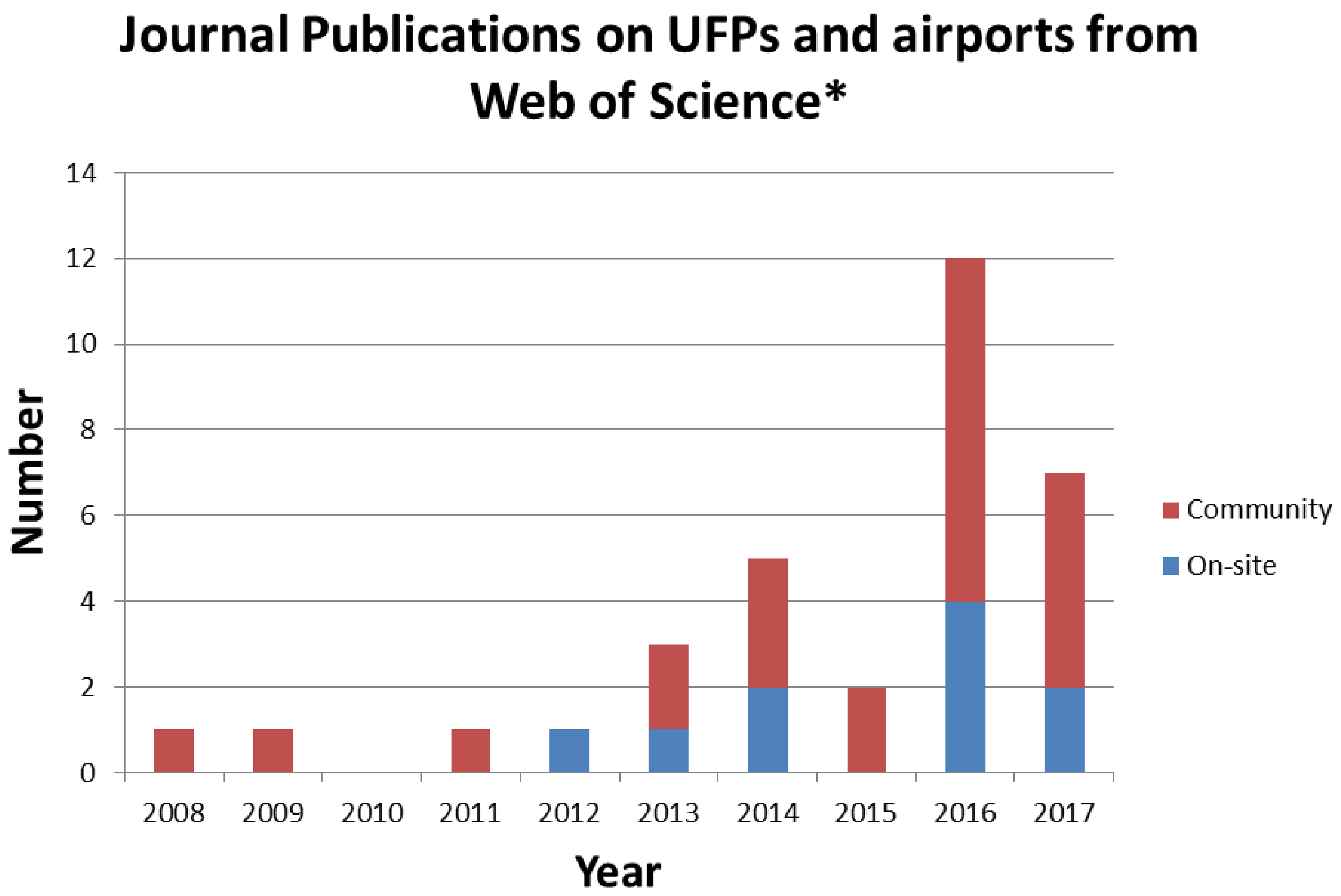
Outline

- Background on Ultrafine Particles
- Previous Airport Studies
- Health effects associated with Ultrafine Particle Exposure
- Process for the WA state study


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

'Ultrafine' Particles

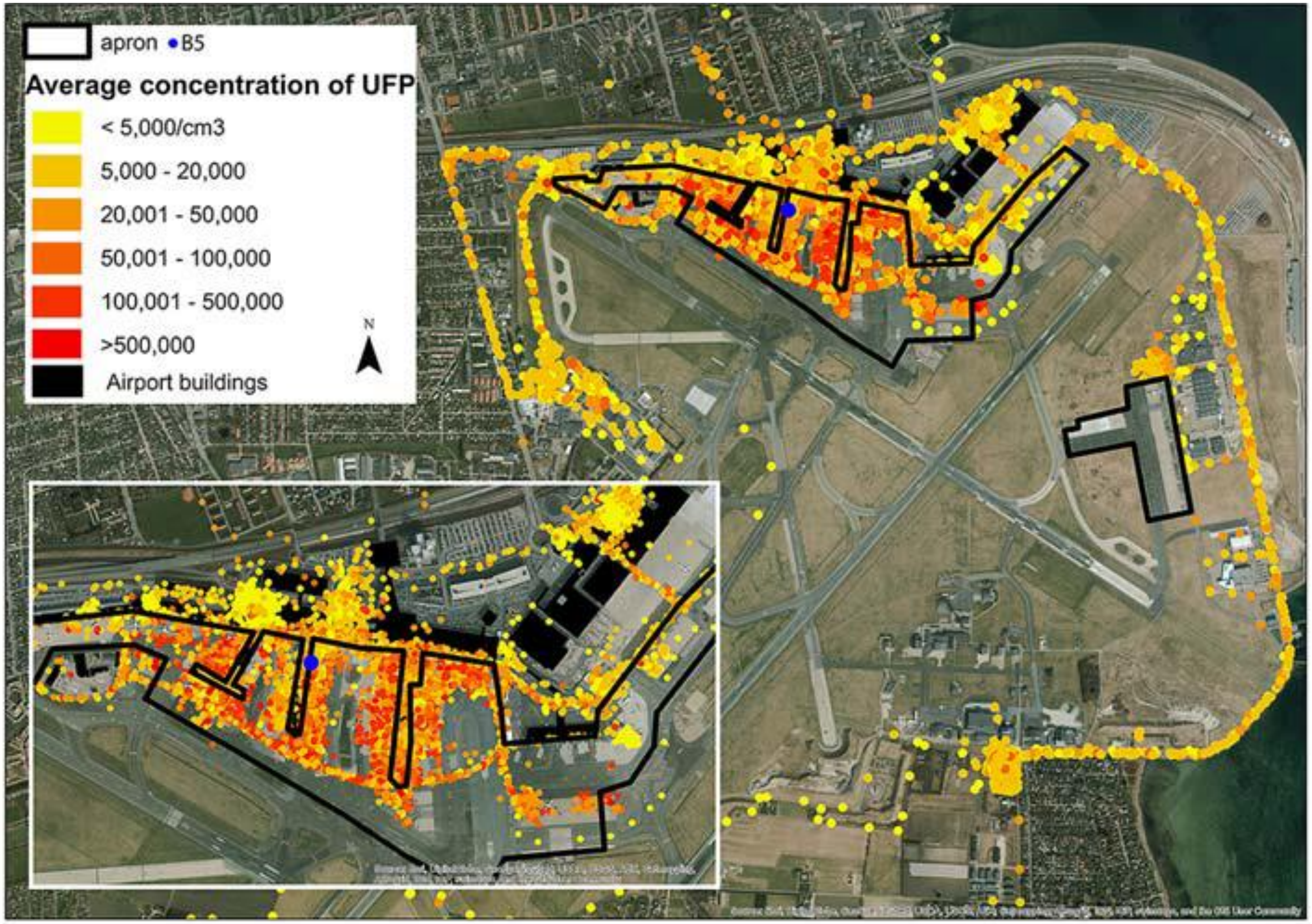




*search terms: "airports"& "ultrafine particles"

Occupational exposures to UFP are known to be high in some settings.

A map of personal exposure concentrations for workers at the Copenhagen airport in Autumn of 2012 is shown at right.



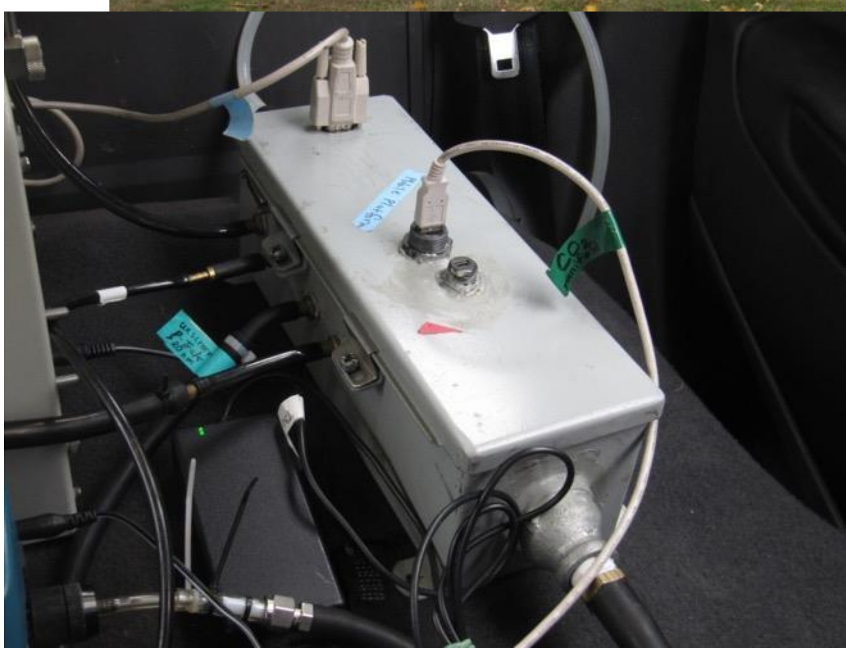
Moller et al (2014) PLoS ONE 9(9): e106671, doi:10.137/journal.pone.006671

A selection of cities with published studies of airport UFP impacts

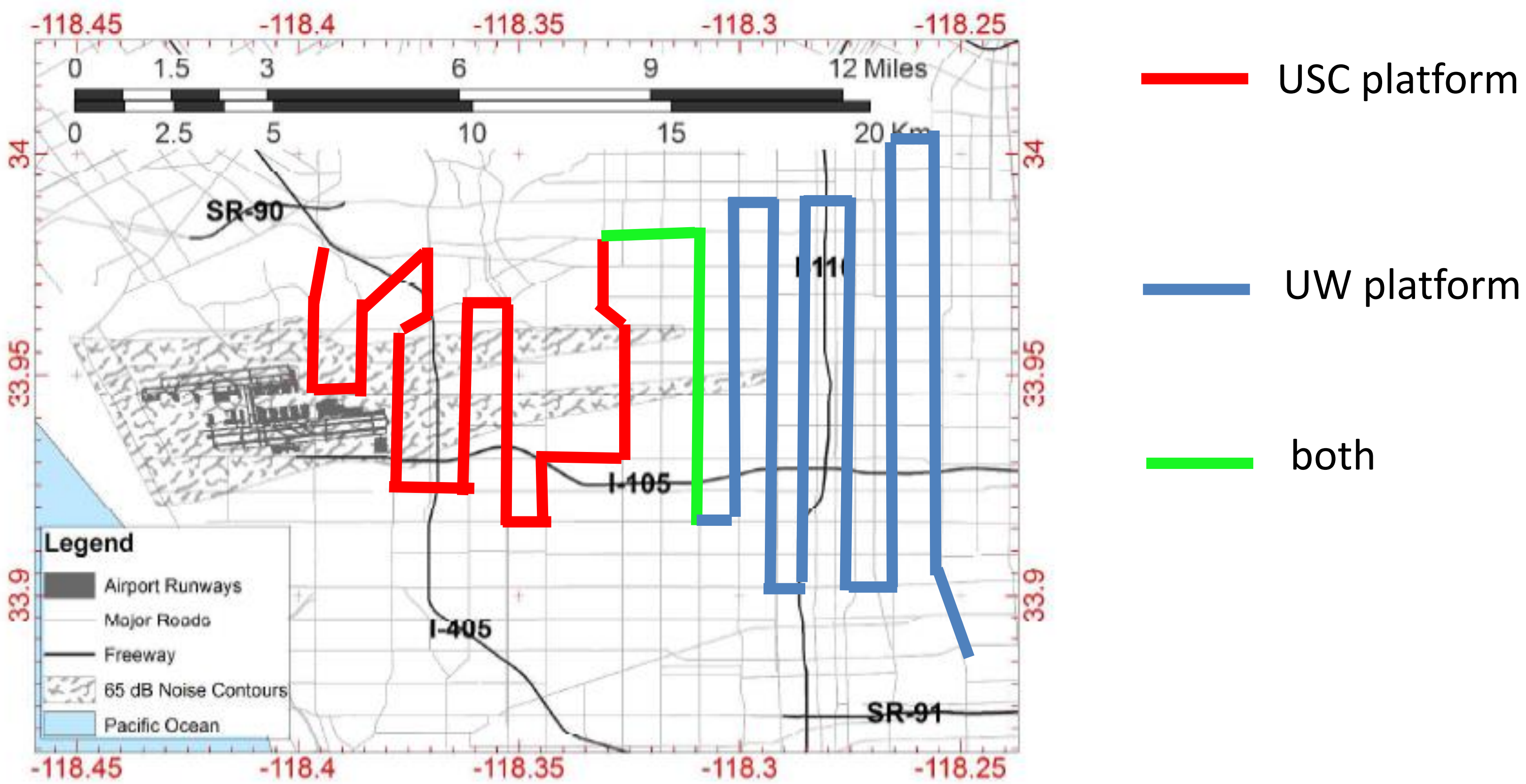
Distance from airport to monitoring site		
< 1km	1 to 10 km	> 10 km
Tianjin, China	London, England	Los Angeles, CA
Rome, Italy	Los Angeles, CA	Amsterdam, NL
Venice, Italy	Norwich, England	Atlanta, GA
Taipei, Taiwan	Boston, MA	New York, NY*
Oakland, CA	Warwick, RI	
Santa Monica, CA		

*La Guardia

Mobile Observation



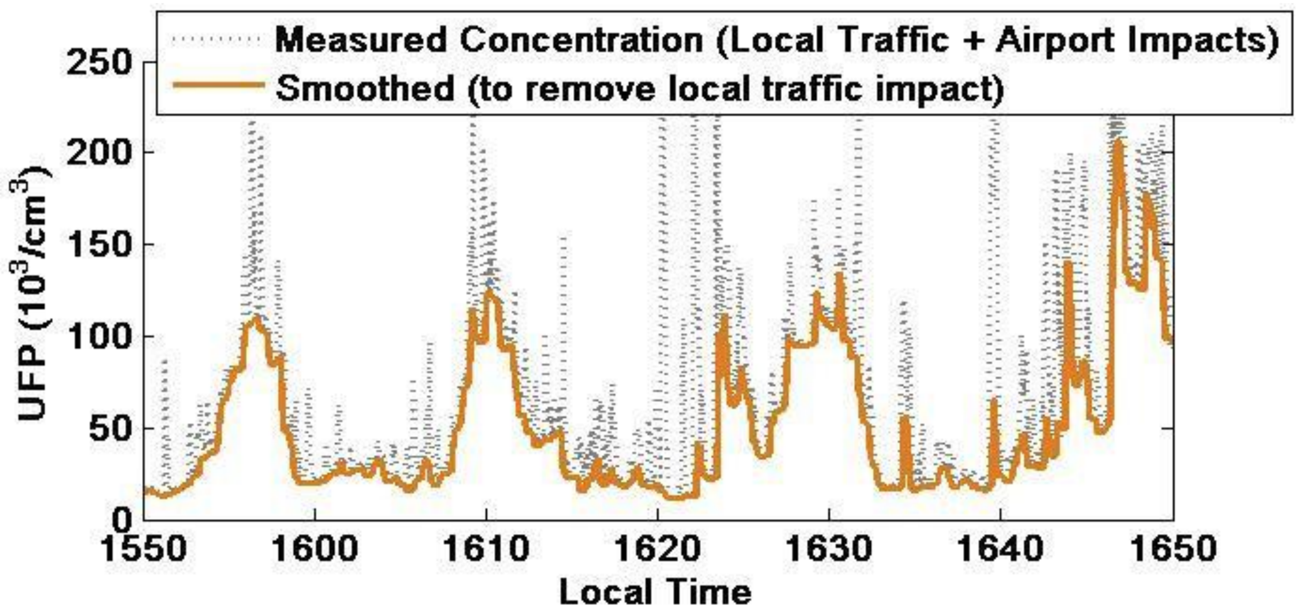
Sampling Routes near LAX



Hudda et al, 2014

Examining Local Background Values Reveals the Aircraft Impacts

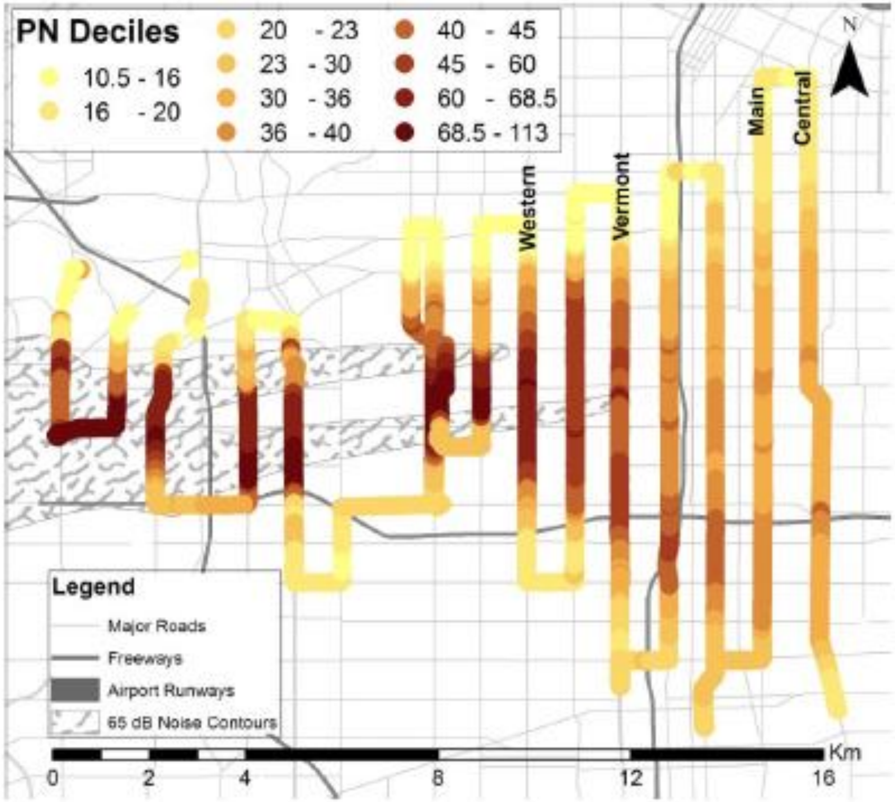
- Apply rolling 5th percentile of 1 second data using a 30 second window
- This removes local scale impacts



Hudda et al, ES&T 2014

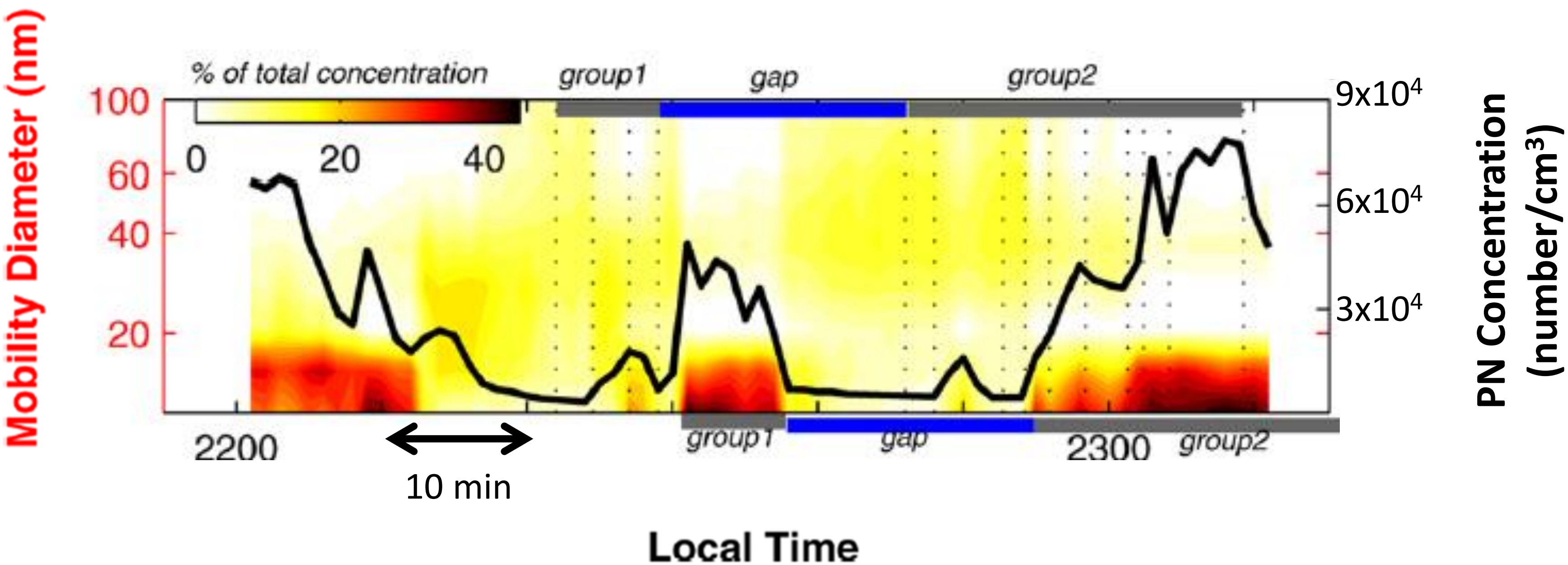
Area-weighted number concentration equivalent to ~ half the freeways in LA!

10^3/cc



Hudda et al, ES&T 2014

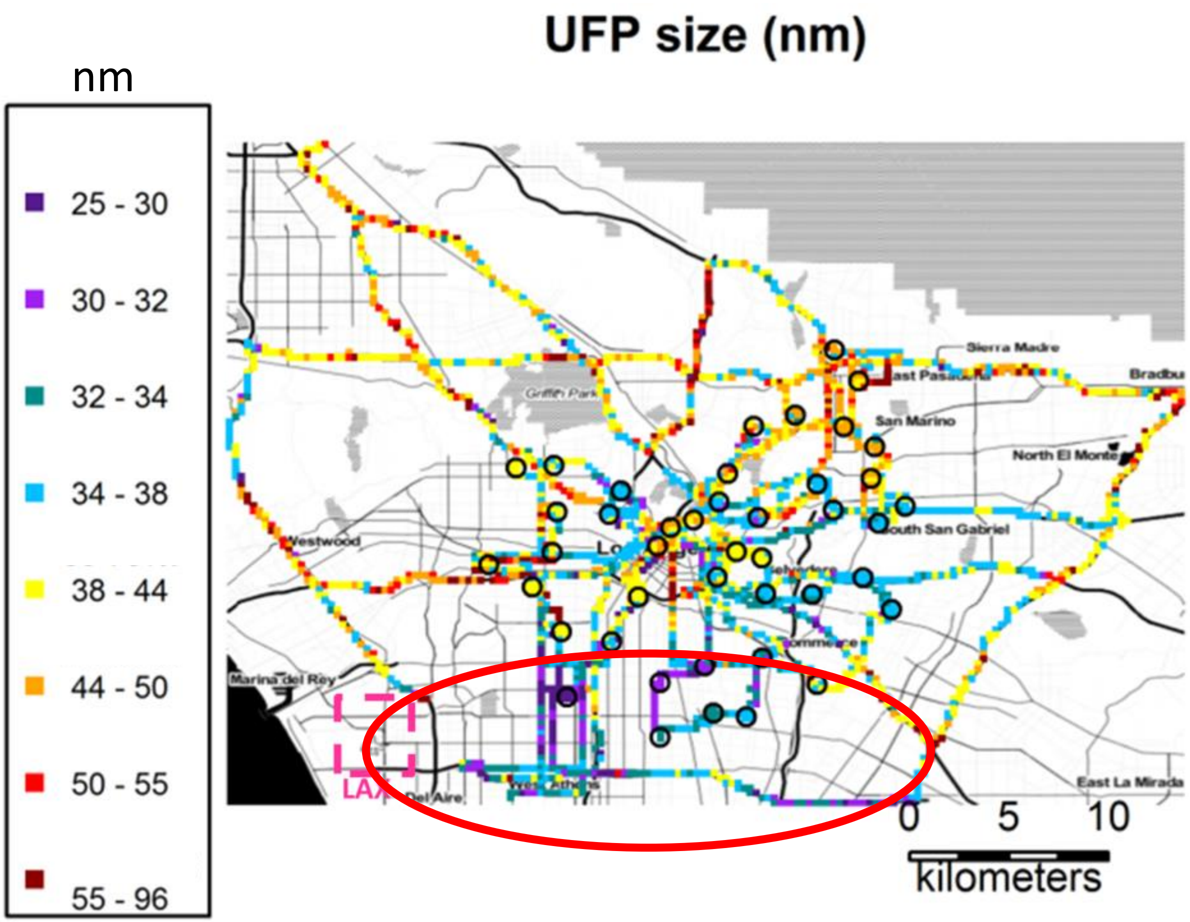
Particles between ~10 and 20 nm diameter are present in high concentrations at ground level ~3 km downwind of northern runway at LAX



(July 19,2004)

N Hudda and SA Fruin (2016) ES&T 50, 3362-3370.

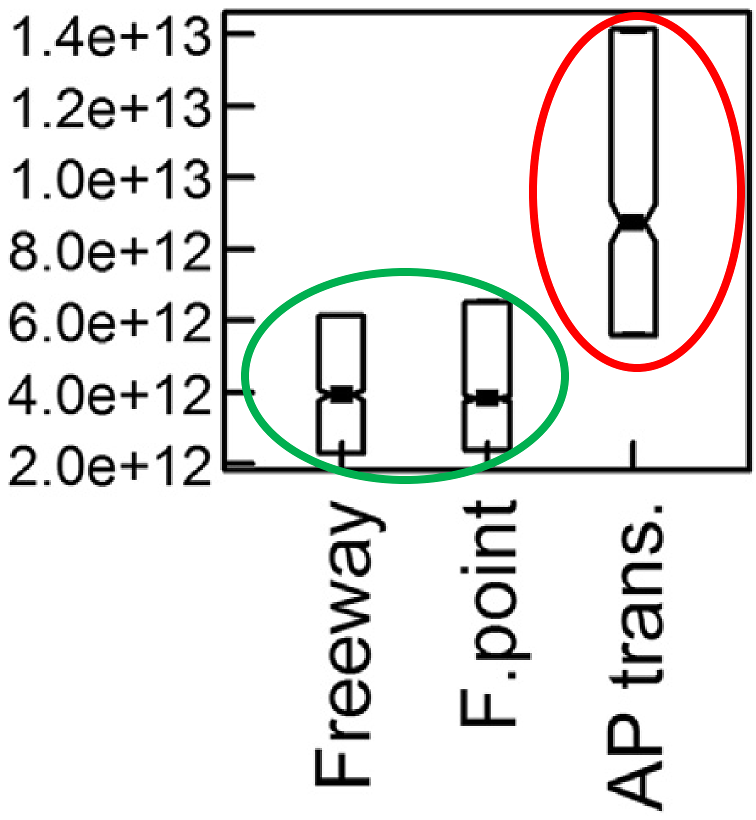
Particles between ~25 and 30 nm diameter reveal a downwind plume…



E.A. Riley (Atmospheric Environment, 2016)

For a given amount of soot in an air sample, the number of particles in that same sample is greater near the LAX airport than on a nearby freeway

Number of particles per milligram of soot in the air



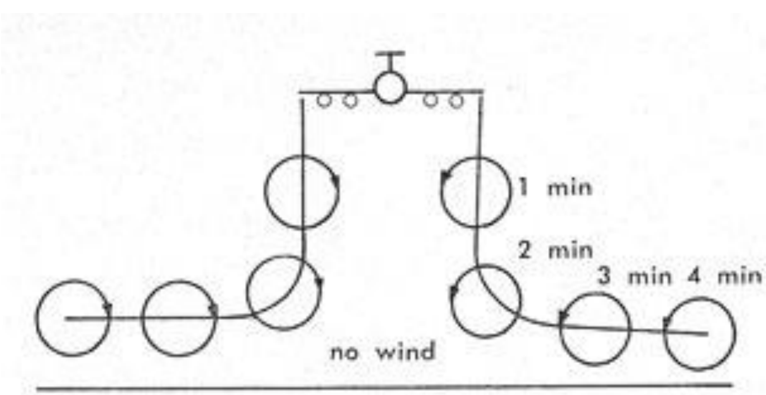
Riley et al, *Atmos. Env.*, 2106

Elevated UFP concentrations observed at fixed locations 8 and 14 km downwind of Schiphol airport in Amsterdam.

Particles with diameters between 10 and 20 nm show higher number concentrations when the wind is coming from the airport

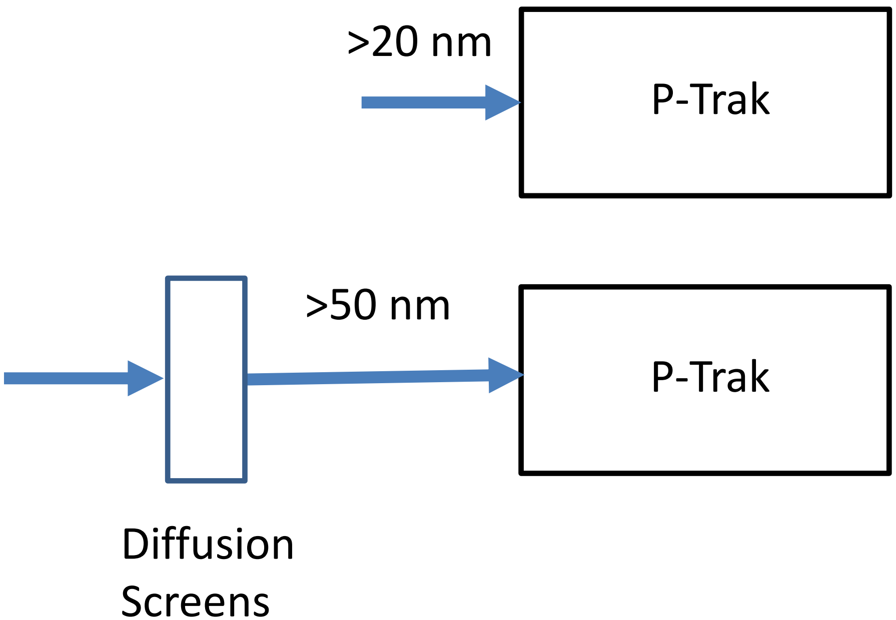
J. Hofman et al., Atmospheric Environment 136 (2016) 68-81

https://www.flickr.com/photos/44073224@N04/



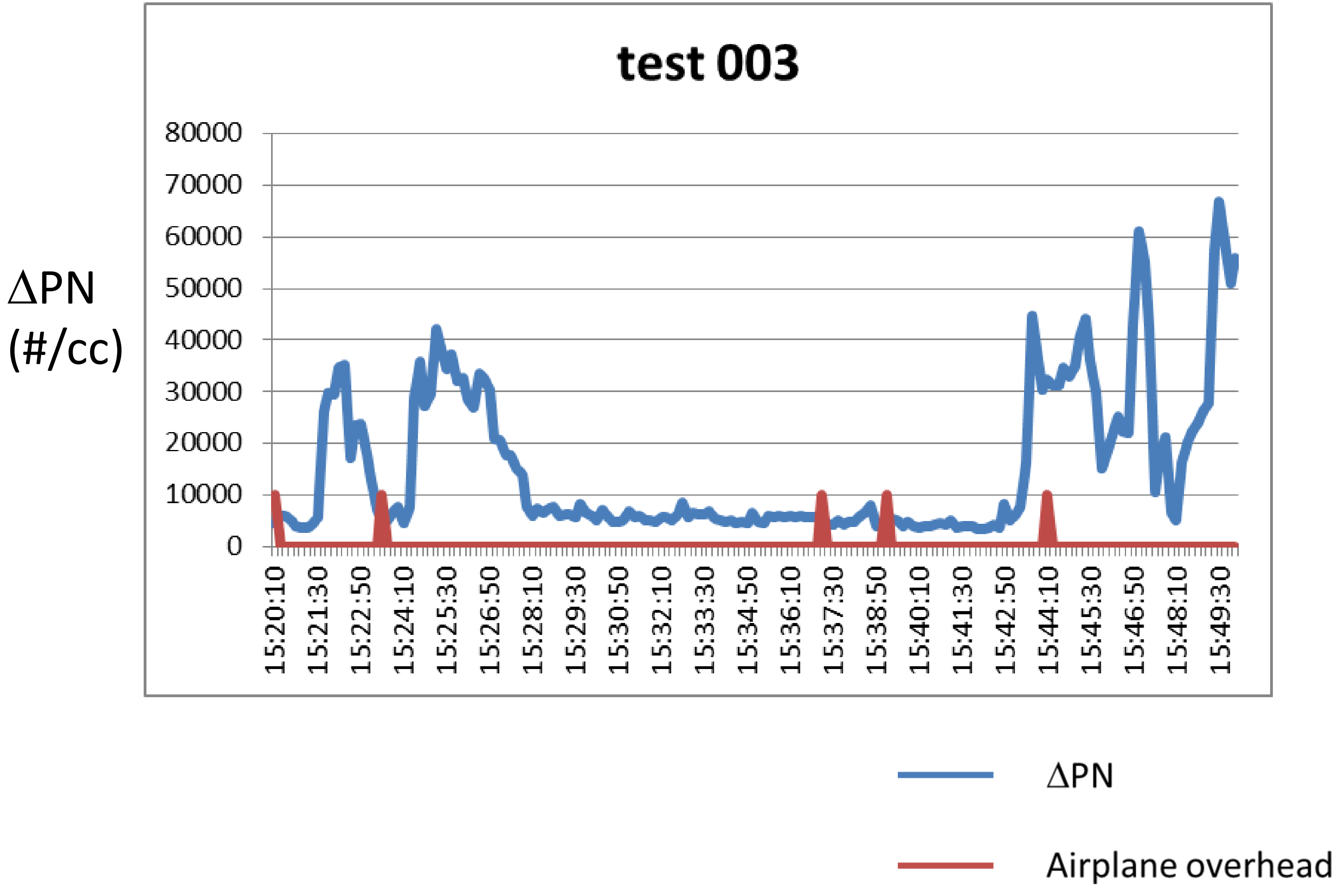
"Vortices generated below about 1500 feet usually sink to just above the ground, 50 to 100 feet. Their speed of descent varies with the type of aircraft and with the local atmospheric conditions. A figure of 450 feet per minute is typical of large sweptwing jet transports. As the vortices approach the ground, they spread apart and move sideways, at right angles to the runway, at the same 450 feet per minute, roughly 5 miles per hour."

--**Andrew S. Carten, Jr.** (M.S., Tufts University) is Chief, Equipment Engineering and Evaluation Branch, Aerospace Instrumentation Laboratory, Air Force Cambridge Research Laboratories. Available: http://www.airpower.maxwell.af.mil/airchronicles/aureview/1971/jul-Aug/carten.html



$$\Delta PN = (PN_{>20} - PN_{>50})$$

Elevated UFP levels observed ~1 km North of Sea-Tac Runway



Health Effects of Ultrafine Particles

Review

Nanotoxicology: An Emerging Discipline Evolving from Studies of Ultrafine Particles

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Although humans have been exposed to airborne nanosized particles (NSPs; < 100 nm) throughout their evolutionary stages, such exposure has increased dramatically over the last century due to anthropogenic sources. The rapidly developing field of nanotechnology is likely to become yet another source through inhalation, ingestion, skin uptake, and injection of engineered nanomaterials. Information about safety and potential hazards is urgently needed. Results of older biokinetic studies with NSPs and newer epidemiologic and toxicologic studies with airborne ultrafine particles can be viewed as the basis for the expanding field of nanotoxicology, which can be defined as safety evaluation of engineered nanostructures and nanodevices. Collectively, some emerging concepts of nanotoxicology can be identified from the results of these studies. When inhaled, specific sizes of NSPs are efficiently deposited by diffusional mechanisms in all regions of the respiratory tract. The small size facilitates uptake into cells and transcytosis across epithelial and endothelial cells into the blood and lymph circulation to reach potentially sensitive target sites such as bone marrow, lymph nodes, spleen, and heart. Access to the central nervous system and ganglia via translocation along axons and dendrites of neurons has also been observed. NSPs penetrating the skin distribute via uptake into lymphatic channels. Endocytosis and biokinetics are largely dependent on NSP surface chemistry (coating) and *in vivo* surface modifications. The greater surface area per mass compared with larger-sized particles of the same chemistry renders NSPs more active biologically. This activity includes a potential for inflammatory and pro-oxidant, but also antioxidant, activity, which can explain early findings showing mixed results in terms of toxicity of NSPs to environmentally relevant species. Evidence of mitochondrial distribution and oxidative stress response after NSP endocytosis points to a need for basic research on their interactions with subcellular structures. Additional considerations for assessing safety of engineered NSPs include careful selections of appropriate and relevant doses/concentrations, the likelihood of increased effects in a compromised organism, and also the benefits of possible desirable effects. An interdisciplinary team approach (e.g., toxicology, materials science, medicine, molecular biology, and bioinformatics, to name a few) is mandatory for nanotoxicology research to arrive at an appropriate risk assessment. *Key words:* biokinetics, central nervous system, engineered nanomaterials, environmental health, human health, nanosized particles, respiratory tract, risk assessment, skin, ultrafine particles. *Environ Health Perspect* 113:823–839 (2005). doi:10.1289/ehp.7339 available via *http://dx.doi.org/* [Online 22 March 2005]

precise chemically engineered characteristics and solid form of the latter, generated in gas or liquid phase [National Nanotechnology Initiative (NNI) 2004]. However, despite these differences, the same toxicologic principles are likely to apply for NPs, because not only size but also a number of other particle parameters determine their biologic activity. The multitude of interactions of these factors has yet to be assessed, and in this article we attempt to summarize our present knowledge.

NSPs are variably called ultrafine particles (UFPs) by toxicologists [U.S. Environmental Protection Agency (EPA) 2004], Aitken mode and nucleation mode particles by atmospheric scientists [Kulmala 2004; National Research Council (NRC) 1983], and engineered nanostructured materials by materials scientists (NNI 2004). Figure 1 depicts the range of sizes of airborne ambient particulate matter, including the nucleation-mode, Aitken-mode, accumulation-mode, and coarse-mode particles. Ambient particles < 0.1 µm, defined as UFPs in the toxicologic literature, consist of transient nuclei or Aitken nuclei (NRC 1983). More recently, even smaller particles in the nucleation mode with peak diameters around 4 nm have been observed (McMurry and Woo 2002). The distinction between NSPs generated by internal combustion engines and NPs becomes further clouded by the finding of nanotubes in diesel exhaust (Evelyn et al. 2003). The use of

International Journal of *Environmental Research and Public Health*

MDPI

Conference Report

Ultrafine Particle Metrics and Research Considerations: Review of the 2015 UFP Workshop

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1. Preface

In February 2015, the United States Environmental Protection Agency (EPA) sponsored a workshop in Research Triangle Park, NC, USA to review the current state of the science on emissions, air quality impacts, and health effects associated with exposures to ultrafine particles [1]. The workshop provided scientific presentations on the sources and trends of ultrafine particles (UFP) emissions and air quality concentrations, evidence of health effects associated with UFP exposure, metrics and indicators of UFP emissions, UFP measurement methods, control strategies, and policy considerations. This workshop brought together experts from around the world to share information and discuss future next steps on UFP research and policy. The following sections provide a summary of the presentations and discussions during this workshop, specifically highlighting the observations offered by individual speakers, summaries of the panel discussions, and potential opportunities to continue dialogue and enhance coordination and collaboration across multiple scientific disciplines.

HEI Perspectives 3
January 2013
Insights from HEI's research

Understanding the Health Effects of Ambient Ultrafine Particles

HEI Review Panel on Ultrafine Particles

HEALTH EFFECTS INSTITUTE

UFP Toxicological Characteristics

- Small size, relatively large surface area
- Small size facilitates uptake into circulation system, into cells, across blood-brain barrier.

2009 US EPA Integrated Science Assessment

- Evidence for a positive relationship between short-term UFP exposures and cardiovascular effects, including cardiovascular-related hospital admissions and emergency department visits.
- Also evidence suggestive of a positive relationship between short-term exposure to UFPs and respiratory effects, including changes in lung function and pulmonary inflammation, with limited and inconsistent evidence for increases in emergency department visits and hospital admissions for respiratory-related events.

2009 US EPA
Integrated Science Assessment

Some challenges noted:

- Spatial/temporal data lacking on UFP concentrations.
- Absence of national network of UFP monitors.
- Most studies based on diesel exhaust, which involves various co-pollutants, creating uncertainty whether health effects due to UFP.

Recent Studies of UFP and Health Effects

A Section 508–conformant HTML version of this article
is available at http://dx.doi.org/10.1289/ehp.1408565.

Research

Associations of Mortality with Long-Term Exposures to Fine and Ultrafine Particles, Species and Sources: Results from the California Teachers Study Cohort

Bart Ostro,[1] Jianlin Hu,[2] Debbie Goldberg,[3] Peggy Reynolds,[3] Andrew Hertz,[3] Leslie Bernstein,[4] and Michael J. Kleeman[2]

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Background: Although several cohort studies report associations between chronic exposure to fine particles ($PM_{2.5}$) and mortality, few have studied the effects of chronic exposure to ultrafine (UF) particles. In addition, few studies have estimated the effects of the constituents of either $PM_{2.5}$ or UF particles.

Methods: We used a statewide cohort of > 100,000 women from the California Teachers Study who were followed from 2001 through 2007. Exposure data at the residential level were provided by a chemical transport model that computed pollutant concentrations from > 900 sources in California. Besides particle mass, monthly concentrations of 11 species and 8 sources or primary particles were generated at 4-km grids. We used a Cox proportional hazards model to estimate the association between the pollutants and all-cause, cardiovascular, ischemic heart disease (IHD), and respiratory mortality.

Results: We observed statistically significant ($p < 0.05$) associations of IHD with $PM_{2.5}$ mass, nitrate, elemental carbon (EC), copper (Cu), and secondary organics and the sources gas- and diesel-fueled vehicles, meat cooking, and high-sulfur fuel combustion. The hazard ratio estimate of 1.19 (95% CI: 1.08, 1.31) for IHD in association with a 10-μg/m^3 increase in $PM_{2.5}$ is consistent with findings from the American Cancer Society cohort. We also observed significant positive associations between IHD and several UF components including EC, Cu, metals, and mobile sources.

Conclusions: Using an emissions-based model with a 4-km spatial scale, we observed significant positive associations between IHD mortality and both fine and ultrafine particle species and sources. Our results suggest that the exposure model effectively measured local exposures and facilitated the examination of the relative toxicity of particle species.

Citation: Ostro B, Hu J, Goldberg D, Reynolds P, Hertz A, Bernstein L, Kleeman MJ. 2015. Associations of mortality with long-term exposures to fine and ultrafine particles, species and sources: results from the California Teachers Study cohort. Environ Health Perspect 123:549–556; http://dx.doi.org/10.1289/ehp.1408565

models for particle sources or species are not widely available.

In a previous study, we examined the relation between mortality and long-term exposure to constituents of $PM_{2.5}$ using data from the California Teachers Study (CTS) cohort (Ostro et al. 2010). Started in 1995, the CTS is a prospective study of > 130,000 current and former female teachers and administrators identified through the State Teachers Retirement System. Because of limited data on particle species, this earlier report relied on $PM_{2.5}$ data collected and further analyzed by the U.S. EPA at eight fixed-site monitors as part of the Speciation Trends Network (U.S. EPA 2008). The 24-hr averaged measurements were usually obtained on an every third- or sixth-day basis. To minimize exposure misclassification, catchment buffer areas of 8 and 30 km were drawn around each monitor. The 30-km buffer is likely too large to capture exposure contrasts of many of the species, while the 8-km buffer significantly reduced the sample size, resulting in more unstable estimates and reduced statistical power. Although these buffers were an

Environmental Health Perspectives • VOLUME 123 | NUMBER 6 | June 2015

- The study considered >100,000 female teachers in CA.
- Positive association found between UFP and ischemic heart disease mortality, but not respiratory mortality (including lung cancer).

Recent Studies of UFP and Health Effects

Weichenthal *et al. Environmental Health* (2017) 16:64
DOI 10.1186/s12940-017-0276-7

Environmental Health

RESEARCH **Open Access**

CrossMark

Long-term exposure to ambient ultrafine particles and respiratory disease incidence in in Toronto, Canada: a cohort study

Scott Weichenthal[1,2*], Li Bai[3,4], Marianne Hatzopoulou[5], Keith Van Ryswyk[2], Jeffrey C. Kwong[3,4,6], Michael Jerrett[7], Aaron van Donkelaar[8], Randall V. Martin[8,9], Richard T. Burnett[10], Hong Lu[4] and Hong Chen[3,4,11]

Abstract

Background: Little is known about the long-term health effects of ambient ultrafine particles (<0.1 μm) (UFPs) including their association with respiratory disease incidence. In this study, we examined the relationship between long-term exposure to ambient UFPs and the incidence of lung cancer, adult-onset asthma, and chronic obstructive pulmonary disease (COPD).

Methods: Our study cohort included approximately 1.1 million adults who resided in Toronto, Canada and who were followed for disease incidence between 1996 and 2012. UFP exposures were assigned to residential locations using a land use regression model. Random-effect Cox proportional hazard models were used to estimate hazard ratios (HRs) describing the association between ambient UFPs and respiratory disease incidence adjusting for ambient fine particulate air pollution ($PM_{2.5}$), NO_2, and other individual/neighbourhood-level covariates.

Results: In total, 74,543 incident cases of COPD, 87,141 cases of asthma, and 12,908 cases of lung cancer were observed during follow-up period. In single pollutant models, each interquartile increase in ambient UFPs was associated with incident COPD (HR = 1.06, 95% CI: 1.05, 1.09) but not asthma (HR = 1.00, 95% CI: 1.00, 1.01) or lung cancer (HR = 1.00, 95% CI: 0.97, 1.03). Additional adjustment for NO_2 attenuated the association between UFPs and COPD and the HR was no longer elevated (HR = 1.01, 95% CI: 0.98, 1.03). $PM_{2.5}$ and NO_2 were each associated with increased incidence of all three outcomes but risk estimates for lung cancer were sensitive to indirect adjustment for smoking and body mass index.

Conclusions: In general, we did not observe clear evidence of positive associations between long-term exposure to ambient UFPs and respiratory disease incidence independent of other air pollutants. Further replication is required as few studies have evaluated these relationships.

Keywords: Ultrafine particles, Cohort study, Asthma, Copd, Lung cancer

- The study included 1.1 million adults, and considered >12,000 cases of lung cancer.
- Positive association found between UFP and incident Chronic Obstructive Pulmonary Disease (COPD), but not asthma or lung cancer.

Recent Studies of UFP and Health Effects

Environmental Research 156 (2017) 374–380

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Spatial variations in ambient ultrafine particle concentrations and the risk of incident prostate cancer: A case-control study

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ARTICLE INFO

Keywords:
Ultrafine particles
Prostate cancer
Case-control study
Diesel exhaust

ABSTRACT

Background: Diesel exhaust contains large numbers of ultrafine particles (UFPs, < 0.1 µm) and is a recognized human carcinogen. However, epidemiological studies have yet to evaluate the relationship between UFPs and cancer incidence.
Methods: We conducted a case-control study of UFPs and incident prostate cancer in Montreal, Canada. Cases were identified from all main Francophone hospitals in the Montreal area between 2005 and 2009. Population controls were identified from provincial electoral lists of French Montreal residents and frequency-matched to cases using 5-year age groups. UFP exposures were estimated using a land use regression model. Exposures were assigned to residential locations at the time of diagnosis/recruitment as well as approximately 10-years earlier to consider potential latency between exposure and disease onset. Odds ratios (OR) and 95% confidence intervals (95% CI) were calculated per interquartile range (IQR) increase in UFPs (approximately 4000 particles/cm^3) using logistic regression models adjusting for individual-level and ecological covariates.
Results: Ambient UFP concentrations were associated with an increased risk of prostate cancer (OR = 1.10, 95% CI: 1.01, 1.19) in fully adjusted models when exposures were assigned to residences 10-years prior to diagnosis. This risk estimate increased slightly (OR = 1.17, 95% CI; 1.01, 1.35) when modeled as a non-linear natural spline function. A smaller increased risk (OR = 1.04, 95% CI: 0.97, 1.11) was observed when exposures were assigned to residences at the time of diagnosis.
Conclusions: Exposure to ambient UFPs may increase the risk of prostate cancer. Future studies are needed to replicate this finding as this is the first study to evaluate this relationship.

- Case-control study of prostate cancer, including >2000 subjects.
- Positive association found between UFP and prostate cancer.

Recent Studies of UFP and Health Effects

Environmental Research 158 (2017) 7–15

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

The association between the incidence of postmenopausal breast cancer and concentrations at street-level of nitrogen dioxide and ultrafine particles

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ARTICLE INFO

Keywords:
Ultrafine particles
Nitrogen dioxide
Traffic-related air pollution
Diesel exhaust
Postmenopausal breast cancer
Incidence
Case-control study

ABSTRACT

Background: There is scant information as to whether traffic-related air pollution is associated with the incidence of breast cancer. Nitrogen dioxide (NO_2) and ultrafine particles (UFPs, < 0.1 µm), are two pollutants that capture intra-urban variations in traffic-related air pollution and may also be associated with incidence.

Methods: We conducted a population-based, case-control study of street-level concentrations of NO_2 and UFPs and incident postmenopausal breast cancer in Montreal, Canada. Incident cases were identified between 2008 and 2011 from all but one hospital that treated breast cancer in the Montreal area. Population controls were identified from provincial electoral lists of Montreal residents and frequency-matched to cases using 5-year age groups. Concentrations of NO_2 and UFPs were estimated using two separate land-use regression models. Exposures were assigned to residential locations at the time of recruitment, and we identified residential histories of women who had lived in these residences for 10 years or more. Odds ratios (OR) and 95% confidence intervals (CI) were estimated using logistic regression models adjusting for individual-level and ecological covariates. We assessed the functional form of NO_2 and UFP exposures using natural cubic splines.

Results: We found that the functional form of the response functions between incident postmenopausal breast cancer and concentrations of NO_2 and UFPs were consistent with linearity. For NO_2, we found increasing risks of breast cancer for all subjects combined and stronger associations when analyses were restricted to those women who had lived at their current address for 10 years or more. Specifically, the OR, adjusted for personal covariates, per increase in the interquartile range (IQR = 3.75 ppb) of NO_2 was 1.08 (95%CI: 0.92–1.27). For women living in their homes for 10 years or more, the adjusted OR was 1.17 (95%CI: 0.93–1.46; IQR = 3.84 ppb); for those not living at that home 10 years before the study, it was 0.93 (95%CI: 0.64, 1.36; IQR = 3.65 ppb). For UFPs, the ORs were lower than for NO_2, with little evidence of association in any of the models or sub-analyses and little variability in the ORs (about 1.02 for an IQR of ~3500 cm^{-3}). On the other hand, we found higher ORs amongst cases with positive oestrogen and progesterone receptor status; namely for NO_2, the OR was 1.13 (95%CI: 0.94–1.35) and for UFPs it was 1.05 (95%CI: 0.96–1.14).

Conclusions: Our findings suggest that exposure to ambient NO_2 and UFPs may increase the risk of incident postmenopausal breast cancer especially amongst cases with positive oestrogen and progesterone receptor status.

- Case-control study of breast cancer, including >1200 subjects.
- Weak, non-significant association between UFP and breast cancer.

Notes about these recent studies

- Some are VERY large studies, yet have not found associations between UFP and certain health outcomes.

  → It’s critical to have a clear understanding of variations in UFP concentrations to better design epidemiologic studies!

- Mostly modeled UFP exposures, rather than measured.
- Challenges with co-pollutant correlations, e.g., the breast cancer study also looked at NO_2, which like UFP is a urban near-roadway traffic air pollutant. Stronger associations were found for NO_2.
- Not aircraft-specific UFP.

Recent Studies Suggesting Acute Health Effects in Susceptible Populations

TOXICOLOGICAL SCIENCES 140(1), 61–72 2014
doi: 10.1093/toxsci/kfu063
Advance Access publication April 9, 2014

Controlled Exposure of Humans with Metabolic Syndrome to Concentrated Ultrafine Ambient Particulate Matter Causes Cardiovascular Effects

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Controlled Exposures to Concentrated Ambient Particles

Peters *et al. Particle and Fibre Toxicology* (2015) 12:7
DOI 10.1186/s12989-015-0083-7

PARTICLE AND FIBRE TOXICOLOGY

RESEARCH **Open Access**

Elevated particle number concentrations induce immediate changes in heart rate variability: a panel study in individuals with impaired glucose metabolism or diabetes

Annette Peters[1,2*], Regina Hampel[1], Josef Cyrys[1,3], Susanne Breitner[1], Uta Geruschkat[1], Ute Kraus[1], Wojciech Zareba[4] and Alexandra Schneider[1]

Exposures Documented with Personal Monitors

Short-Term Effects Of Airport-Associated Ultrafine Particle Exposure On Lung Function And Inflammation

R. Habre[1], S. P. Eckel[1], S. Fruin[1], T. Enebish[1], E. Rappaport[1], F. Gilliland[1]
[1]University of Southern California, Los Angeles, CA

- Randomized crossover study of 21 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
- Observed an increase in inflammatory blood markers and a reduction in lung function
- **“Preliminary data suggest a relationship between airport-related UFP exposures and adverse acute lung effects in asthmatics”**

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MOV-UP Study

Mobile ObserVations of Ultrafine Particles (MOV-UP) Study

Forming a Study Advisory Group

- Panel members appointed by the Dean of the UW School of Public Health and Chair of UW DEOHS
  - US EPA Region X
  - WA Department of Ecology
  - Puget Sound Clean Air Agency
  - Seattle/King County Public Health
  - Port of Seattle
  - FAA
  - WA Depart of Health
  - Quiet and Healthy Skies Task Force
  - Department of Commerce
  - City of Burien
  - City of Des Moines
  - City of SeaTac
  - City of Federal Way
  - CHAC, Beacon Hill
  - Adam Smith’s Office - WA 9th Congressional District

Update on the MOV-UP Study

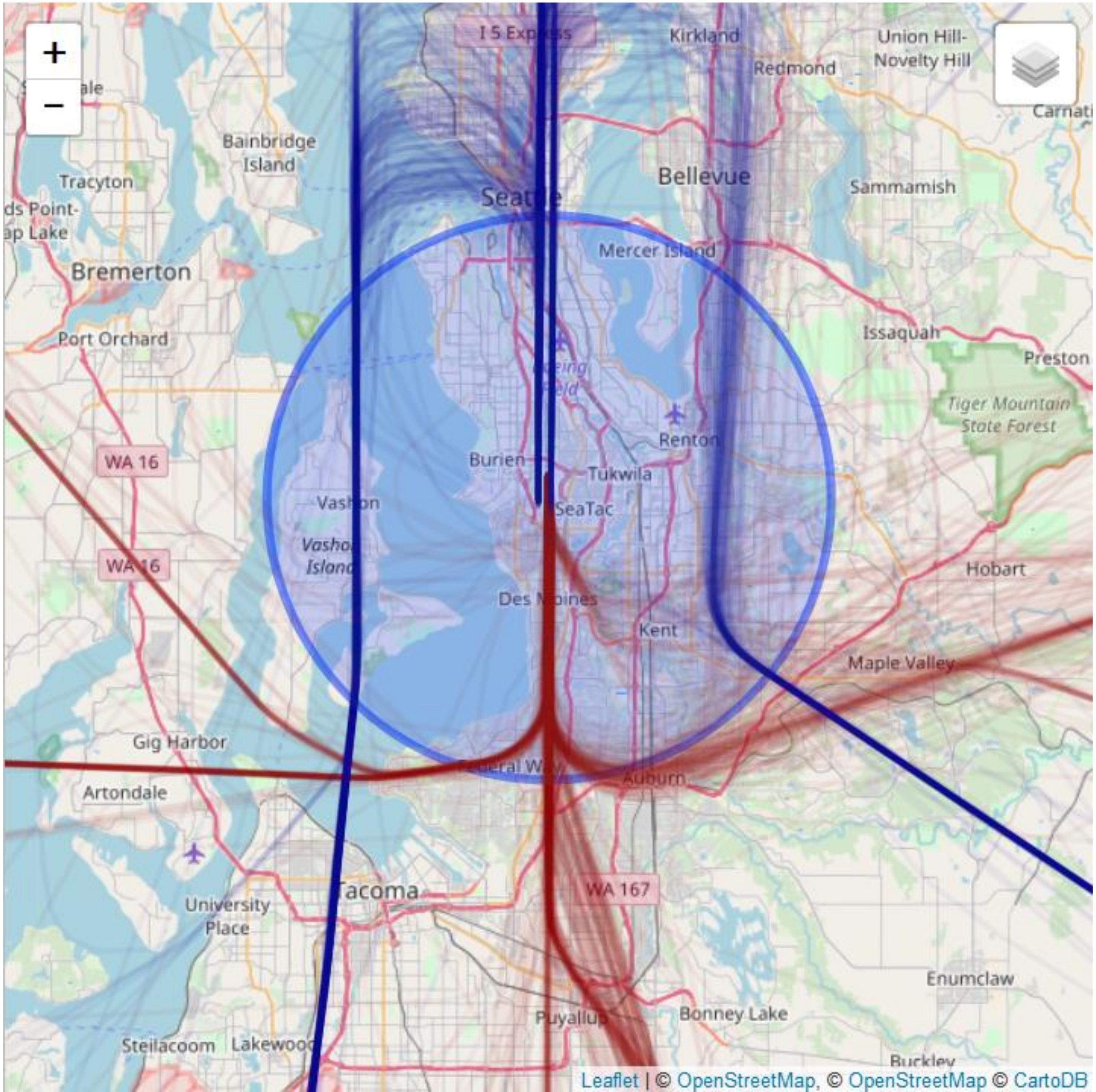
- Acquisition, calibration and testing of instruments for the mobile monitoring platform

- Acquisition of flight path data for mobile monitoring route planning

- Sampling to begin in early 2018, and continue in each season of the year.

- Developing a website to keep stakeholders informed.
- Developing schedule of regular Advisory Group Meetings and Public Meetings (planning to have first meetings in Dec-Jan).

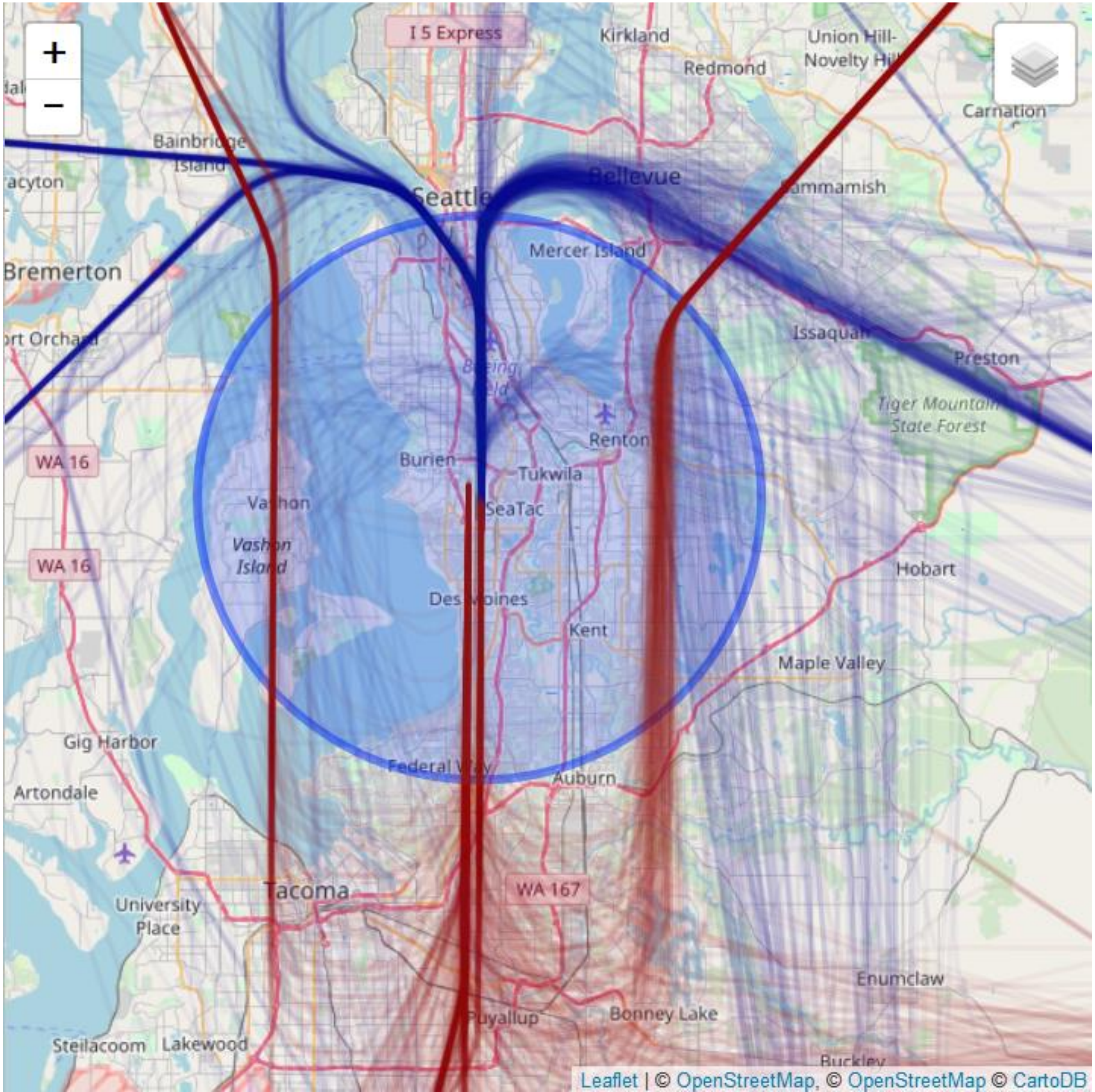
Southerly Winds



Wind (majority)

Aircraft

Northerly Winds



Wind

Aircraft

Summary

- High concentrations of UFP downwind of busy airports (<20km)
- Mobile monitoring data can reveal downwind footprint.

- Health effects of UFPs is limited, but suggestive of cardiovascular, respiratory, and some emerging evidence possibly for certain cancers.
- Only one airport UFP health effects study that we’re aware of.

- Finalizing Study Advisory Group, plan to having first meeting in Dec-Jan.
- Sampling to begin in early 2018, and continue in each season of the year.
- New website will keep stakeholders apprised of study progress.

Questions?