Dr Gary Fuller

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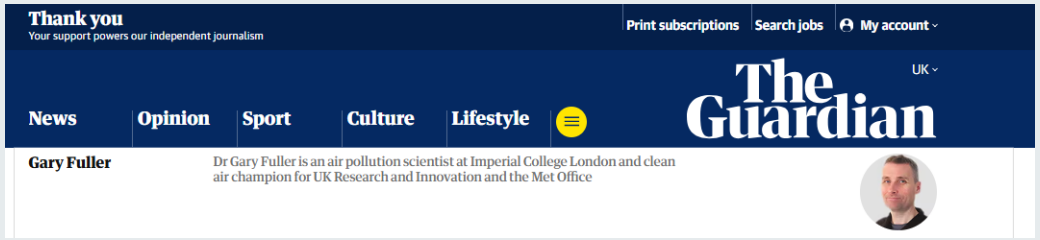
Ultrafine particles around airports – a story of emerging evidence

Gatwick slides thanks to Dr Anja Tremper

AEF, November 2025

www.ukcleanair.org/

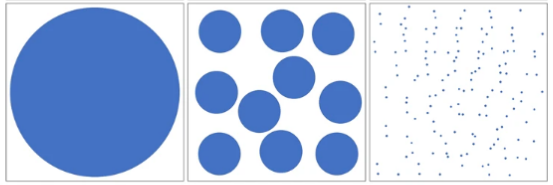


www.theguardian.com/profile/gary-fuller

So what are UFP?

Really small, have little mass but they are very numerous

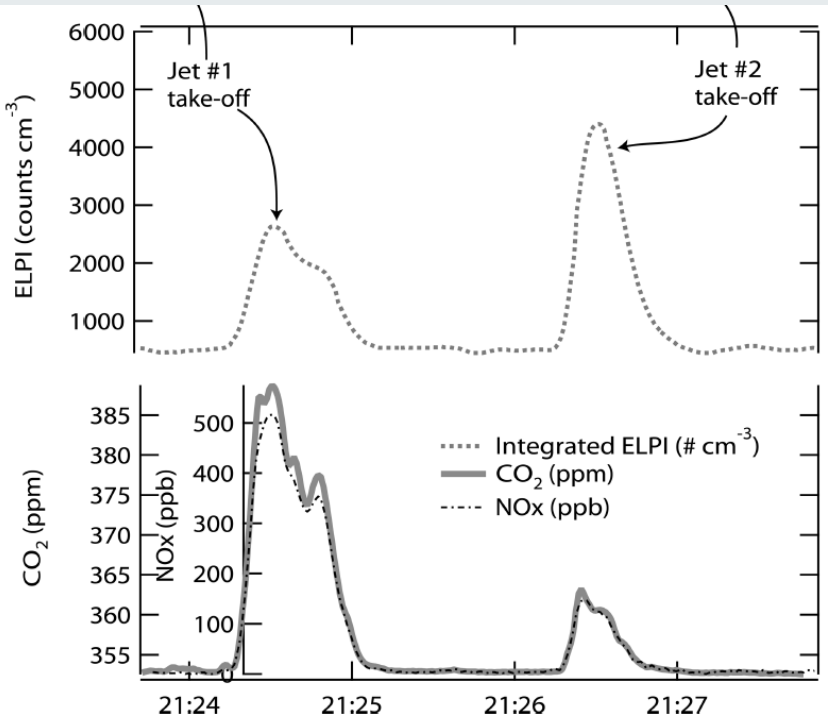
From: Ultrafine particles: unique physicochemical properties relevant to health and disease

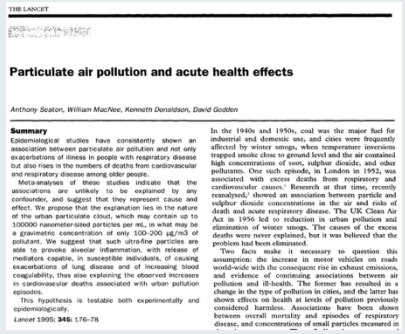
	10 μm (Coarse)	2.5 μm (Fine)	0.1 μm (Ultrafine)
			
Total mass	1	1	1
Particle number	1	64	1,000,000
Surface area per particle	1	0.0625	0.0001
Total surface area per mass	1	4	100
	• Filtered in proximal airway • May irritate skin, mucosa	• Reaches peripheral airway • Cannot enter systemic circulation	• Higher adsorbed toxic material on surface • May enter systemic circulation

The diagram assumes that all particles in each category are perfect spheres, have the same density, and are present in an equal amount of mass. The mass, particle number, and surface area of coarse particles are all arbitrarily designated as 1. Other numbers are relative to the coarse particle. The large surface area and ability to enter circulation are the two most significant characteristics of ultrafine particles that make them more toxic than other larger particles.

Back to article page >

Experimental & Molecular Medicine (*Exp Mol Med*) | ISSN 2092-6413 (online) | ISSN 1226-3613 (print)





THE LANCET

Particulate air pollution and acute health effects

Anthony Seaton, William MacNee, Kenneth Donaldson, David Godden

Summary

Epidemiological studies have consistently shown an association between particulate air pollution and not only exacerbations of illness in people with respiratory disease but also rises in the numbers of deaths from cardiovascular and respiratory disease among older people.

Meta-analyses of these studies indicate that the associations are unlikely to be explained by any confounder, and suggest that they represent cause and effect. We propose that the explanation lies in the nature of the urban particulate cloud, which may contain up to 100000 nanometer-sized particles per ml., in what may be a gravimetric concentration of only 100-200 μg/m3 of pollutant. We suggest that such ultra-fine particles are able to provoke alveolar inflammation, with release of mediators capable, in susceptible individuals, of causing exacerbations of lung disease and of increasing blood coagulability, thus also explaining the observed increases in cardiovascular deaths associated with urban pollution episodes.

This hypothesis is testable both experimentally and epidemiologically.

Lancet 1995; **345**: 176–78

In the 1940s and 1950s, coal was the major fuel for industrial and domestic use, and cities were frequently affected by winter smogs, when temperature inversions trapped smoke close to ground level and the air contained high concentrations of soot, sulphur dioxide, and other pollutants. One such episode, in London in 1952, was associated with excess deaths from respiratory and cardiovascular causes.[1] Research at that time, recently reanalysed,[2] showed an association between particle and sulphur dioxide concentrations in the air and risks of death and acute respiratory disease. The UK Clean Air Act in 1956 led to reduction in urban pollution and elimination of winter smogs. The causes of the excess deaths were never explained, but it was believed that the problem had been eliminated.

Two facts make it necessary to question this assumption: the increase in motor vehicles on roads world-wide with the consequent rise in exhaust emissions, and evidence of continuing associations between air pollution and ill-health. The former has resulted in a change in the type of pollution in cities, and the latter has shown effects on health at levels of pollution previously considered harmless. Associations have been shown between overall mortality and episodes of respiratory disease, and concentrations of small particles measured in

Aerosol Science and Technology, 39:799–809, 2005

ISSN: 0278-6826 print / 1521-7388 online
DOI: 10.1080/02786820500247363

Particulate Emissions from in-use Commercial Aircraft

Scott C. Herndon,[1] Timothy B. Onasch,[1] Brian P. Frank,[2] Linsey C. Marr,[3] John T. Jayne,[1] Manjula R. Canagaratna,[1] Jillian Grygas,[2] Thomas Lanni,[2] Bruce E. Anderson,[4] Doug Worsnop,[1] and Richard C. Miake-Lye[1]

[1]*Aerodyne Research, Inc., Billerica, Massachusetts, USA*
[2]*New York State Department of Environmental Conservation, Albany, New York, USA*
[3]*Virginia Tech, 411 Durham Hall, Blacksburg, Virginia, USA*
[4]*Atmospheric Sciences Division, NASA Langley Research Center, Hampton, Virginia, USA*

2010 - in a field in the Netherlands

Menno Keuken was making measurements in the countryside, 40 km from Schiphol

Research station Cabauw, photo: Rupert Holzinger

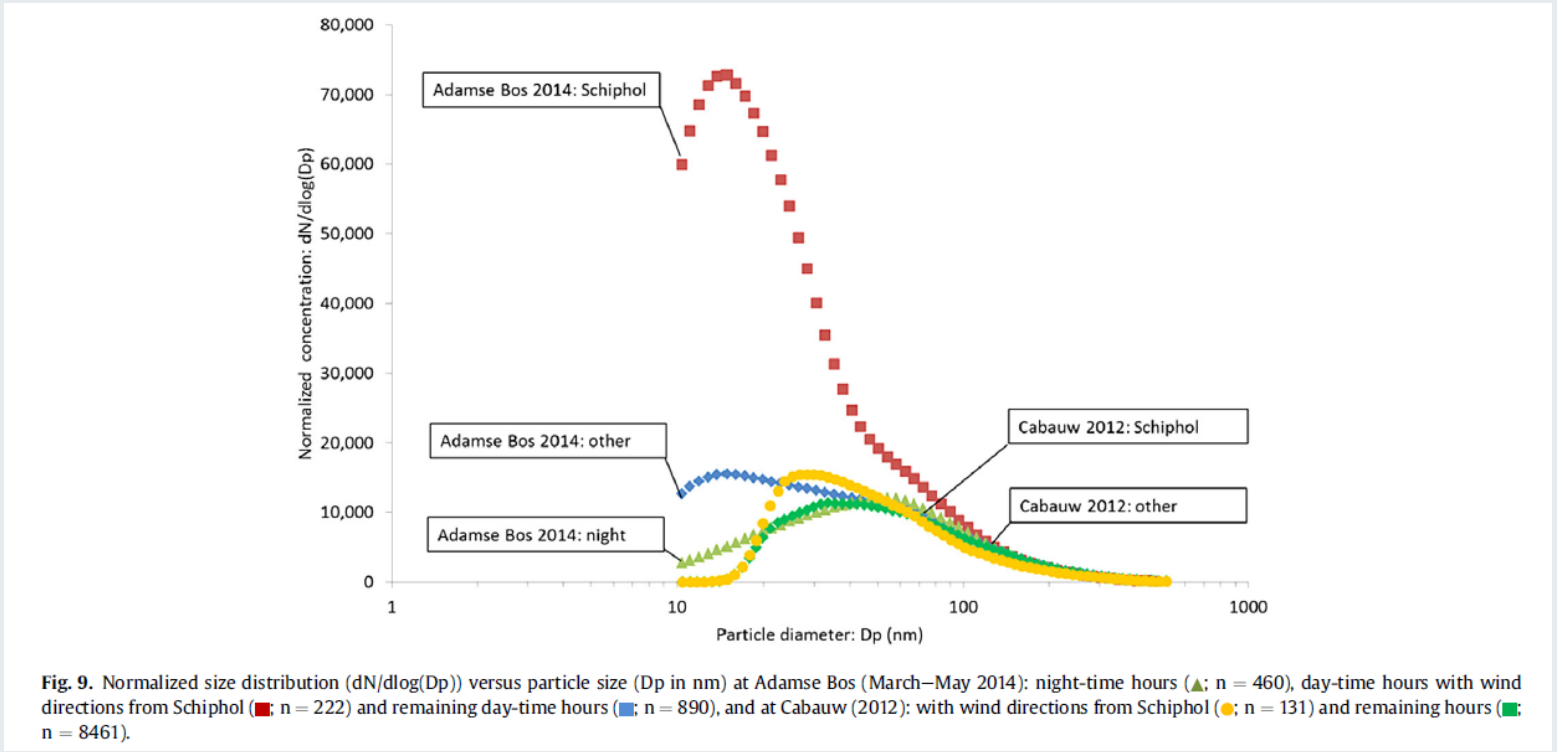
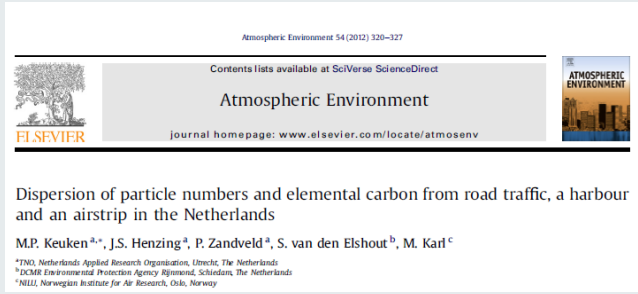


Fig. 9. Normalized size distribution (dN/dlog(Dp)) versus particle size (Dp in nm) at Adamse Bos (March–May 2014): night-time hours (▲; n = 460), day-time hours with wind directions from Schiphol (■; n = 222) and remaining day-time hours (■; n = 890), and at Cabauw (2012): with wind directions from Schiphol (●; n = 131) and remaining hours (■; n = 8461).



Atmospheric Environment 54 (2012) 320–327

Contents lists available at SciVerse ScienceDirect

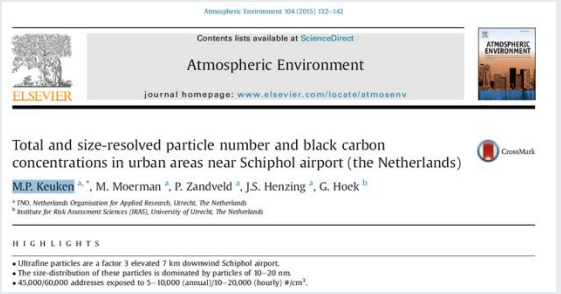
Atmospheric Environment

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

Dispersion of particle numbers and elemental carbon from road traffic, a harbour and an airstrip in the Netherlands

M.P. Keuken [a,*], J.S. Henzing [a], P. Zandveld [a], S. van den Elshout [b], M. Karl [c]

[a] TNO, Netherlands Applied Research Organisation, Utrecht, The Netherlands
[b] DCMR Environmental Protection Agency Rijnmond, Schiedam, The Netherlands
[c] NILU, Norwegian Institute for Air Research, Oslo, Norway



Atmospheric Environment 104 (2015) 132–142

Contents lists available at ScienceDirect

Atmospheric Environment

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

Total and size-resolved particle number and black carbon concentrations in urban areas near Schiphol airport (the Netherlands)

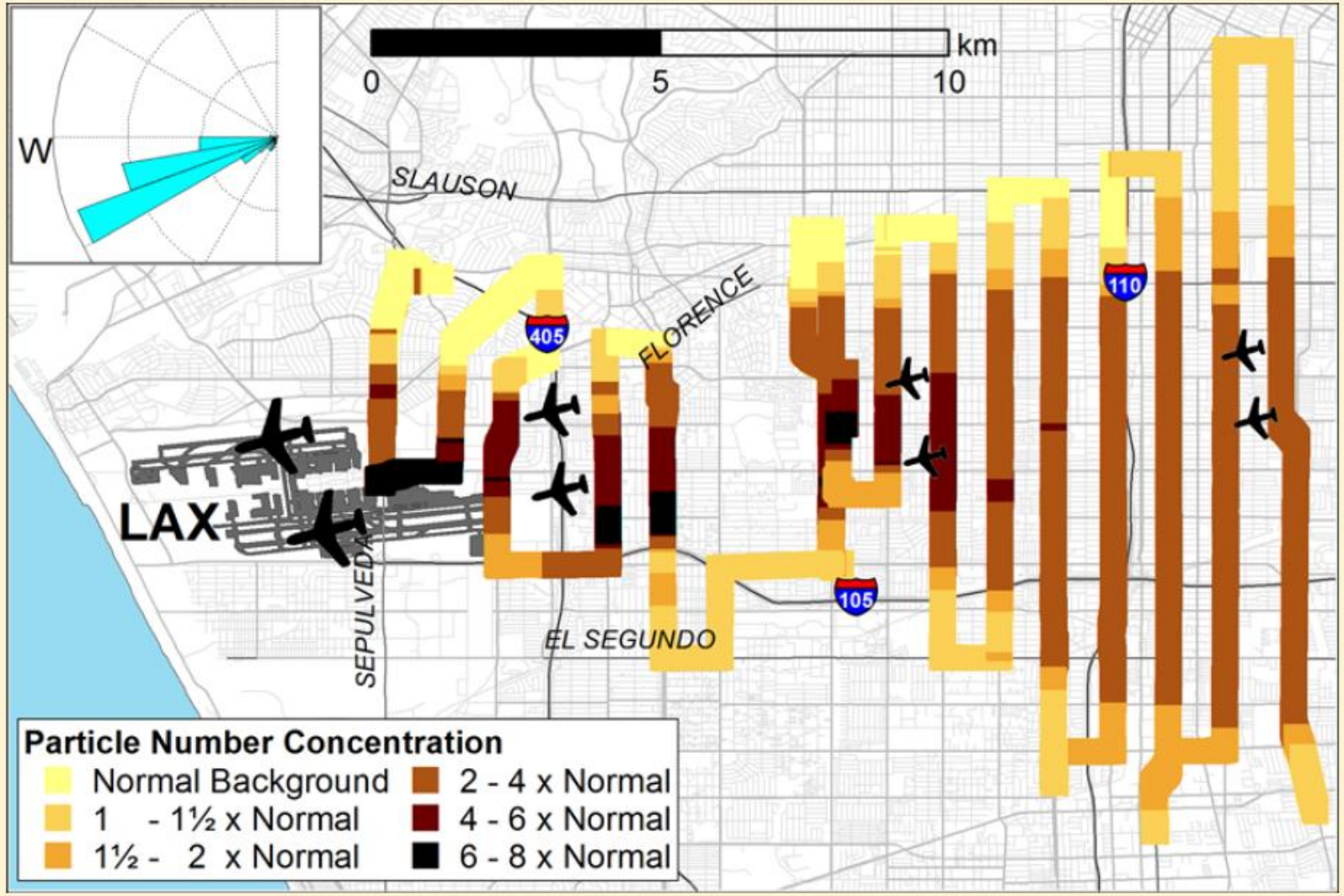
M.P. Keuken [a,*], M. Moerman [a], P. Zandveld [a], J.S. Henzing [a], G. Hoek [b]

[a] TNO, Netherlands Organisation for Applied Research, Utrecht, The Netherlands
[b] Institute for Risk Assessment Sciences (IRAS), University of Utrecht, The Netherlands

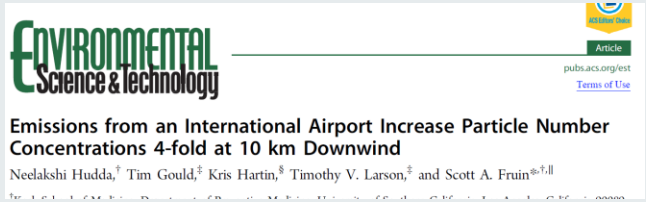
HIGHLIGHTS

- Ultrafine particles are a factor 3 elevated 7 km downwind Schiphol airport.
- The size-distribution of these particles is dominated by particles of 10–20 nm.
- 45,000/60,000 addresses exposed to 5–10,000 (annual)/10–20,000 (hourly) #/cm³.

2013 - Neelakshi Huddain – driving downwind of Los Angles Airport



Elevated PNC / UFP covered found over around 60 km² of LA, along flight paths.


Environmental Science & Technology
Article
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Terms of Use

Emissions from an International Airport Increase Particle Number Concentrations 4-fold at 10 km Downwind

Neelakshi Hudda,† Tim Gould,‡ Kris Hartin,§ Timothy V. Larson,‡ and Scott A. Fruin*,†,∥

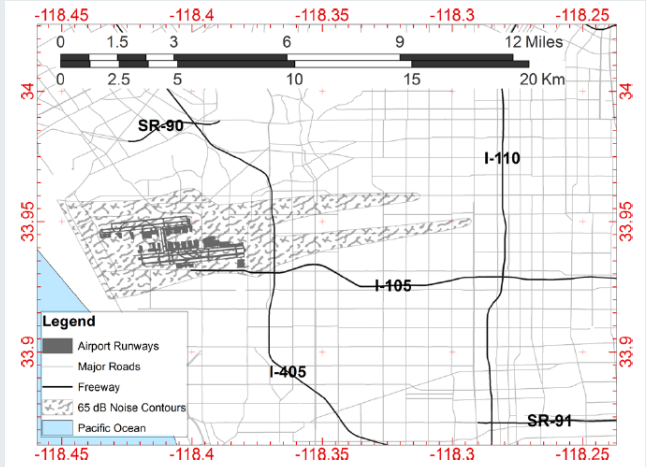
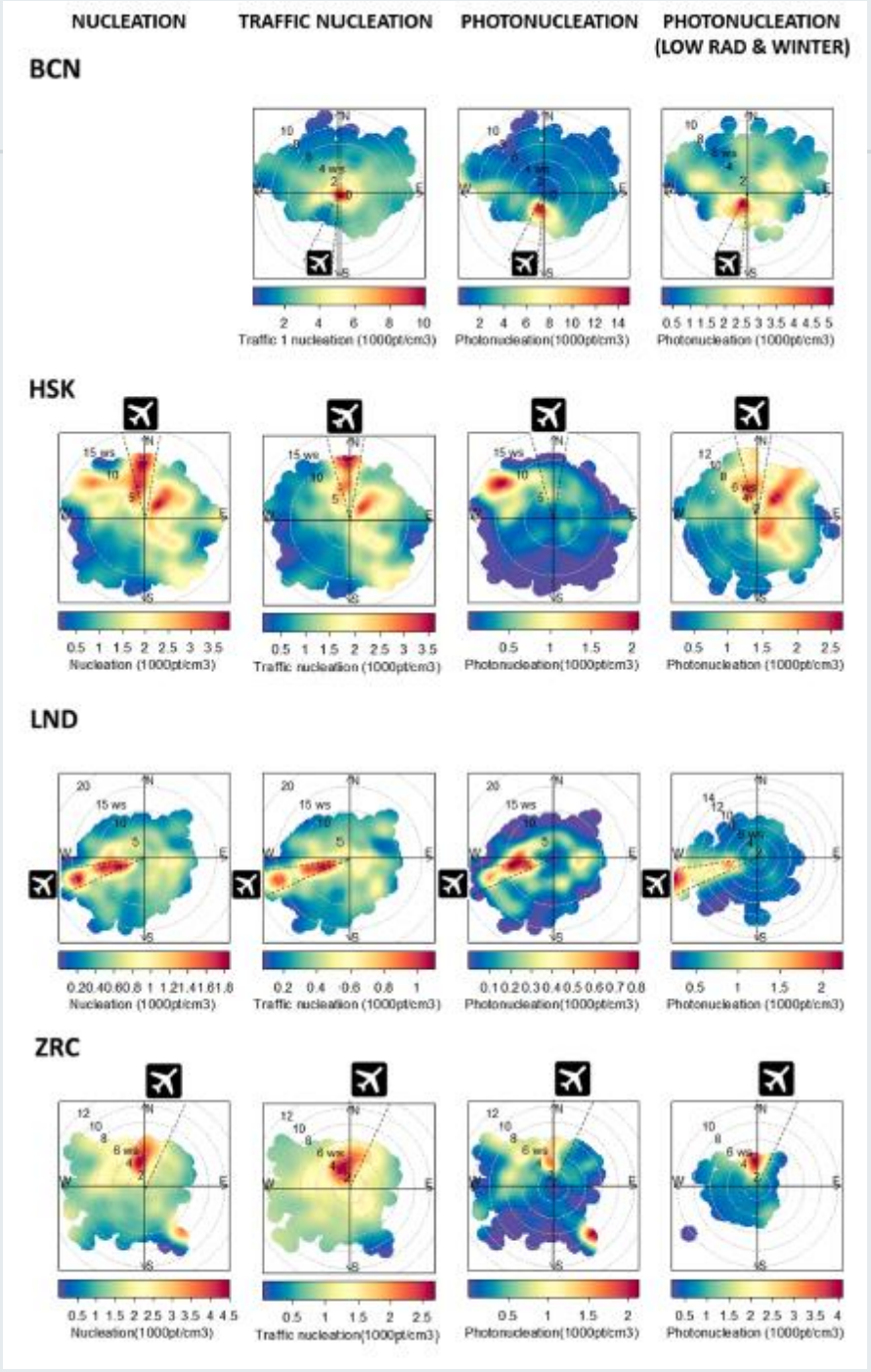


Figure 1. Los Angeles International Airport and 65 dB noise contours indicating eastern jet trajectories.

Around 2018, Ioar Rivas gathered together data from four European capitals



Environment International 135 (2020) 105345

Contents lists available at ScienceDirect

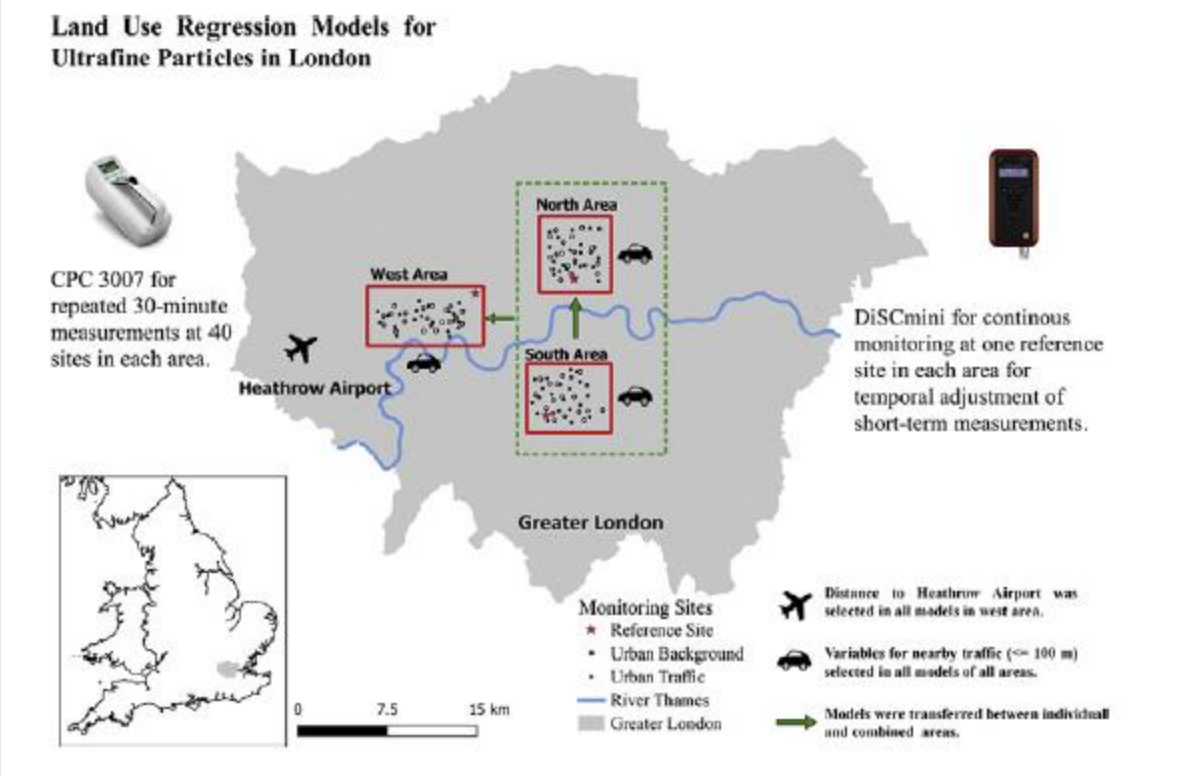
Environment International

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

Source apportionment of particle number size distribution in urban background and traffic stations in four European cities

Ioar Rivas[a,*], David C.S. Beddows[b], Fulvio Amato[c], David C. Green[a], Leena Järvi[d,e], Christoph Hueglin[f], Cristina Reche[c], Hilkka Timonen[g], Gary W. Fuller[a], Jarkko V. Niemi[h], Noemí Pérez[c], Minna Aurela[g], Philip K. Hopke[i], Andrés Alastuey[c], Markku Kulmala[d], Roy M. Harrison[b,j], Xavier Querol[c], Frank J. Kelly[a]

and Zhenchung Yang spent months carrying portable measurement devices around London



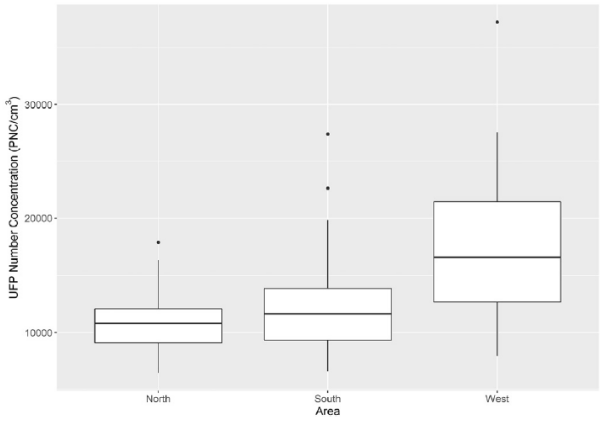


Fig. 2. Distribution of UFP PNC (PNC/cm^3) per study area.

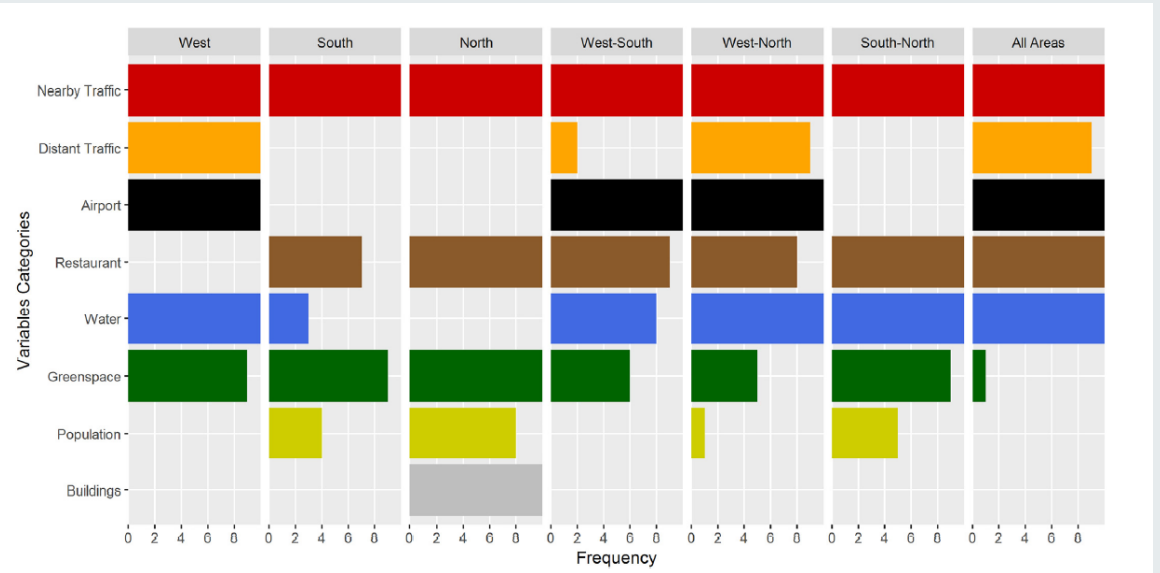
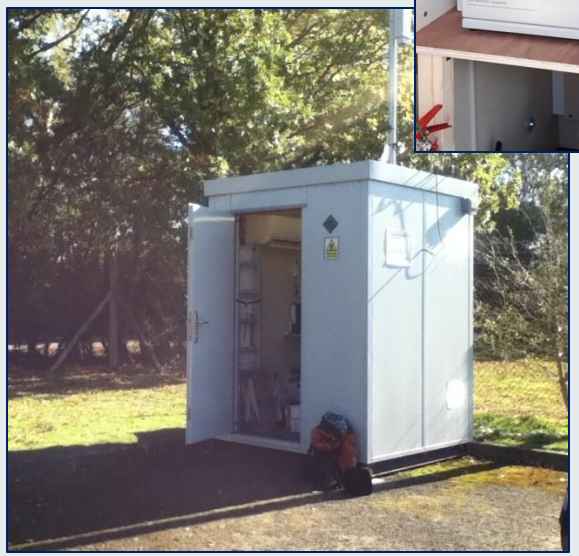


Fig. 3. The frequency of variable inclusion in the 10 models developed for single areas, two-areas, and all-areas.

Measurements at UK airports - Gatwick



Environment International 161 (2022) 107092

Contents lists available at ScienceDirect

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

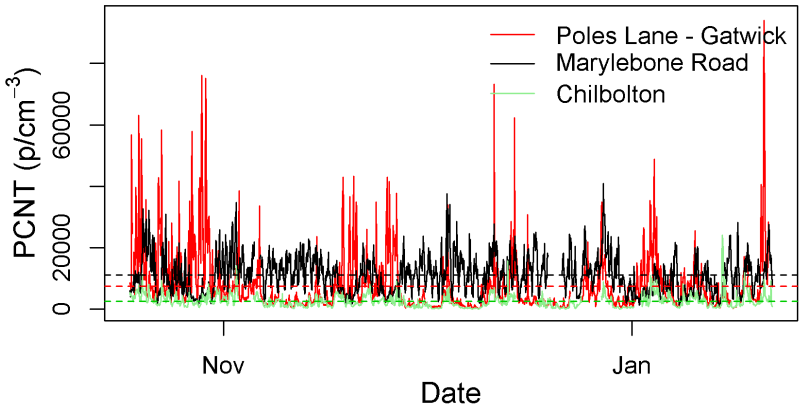
Sources of particle number concentration and noise near London Gatwick Airport

Anja H. Tremper [a,*], Calvin Jephcote [b], John Gulliver [b], Leon Hibbs [c], David C. Green [a], Anna Font [a], Max Priestman [a], Anna L. Hansell [b], Gary W. Fuller [a]

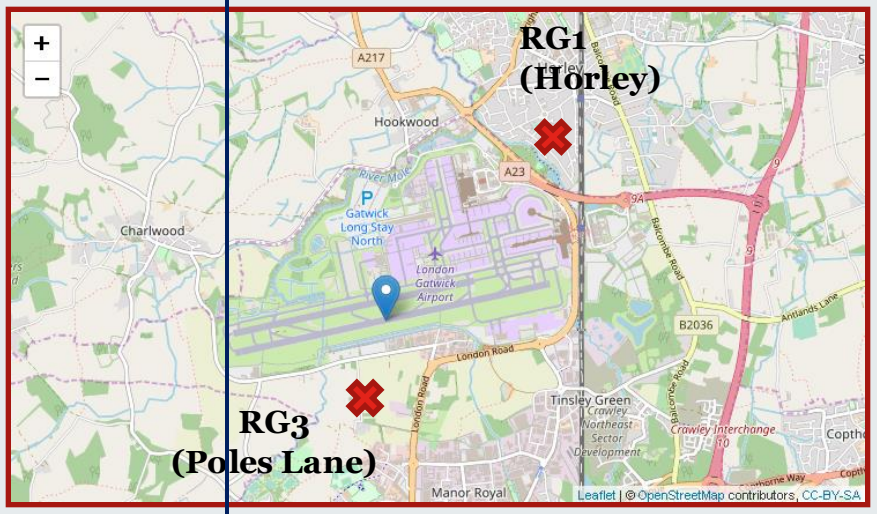
[a] MRC Centre for Environment and Health, Environmental Research Group, Imperial College London, London, UK
[b] Centre for Environmental Health and Sustainability, University of Leicester, Leicester, UK
[c] Environmental Health, Reigate & Banstead Borough Council, Town Hall, Reigate, Surrey, UK

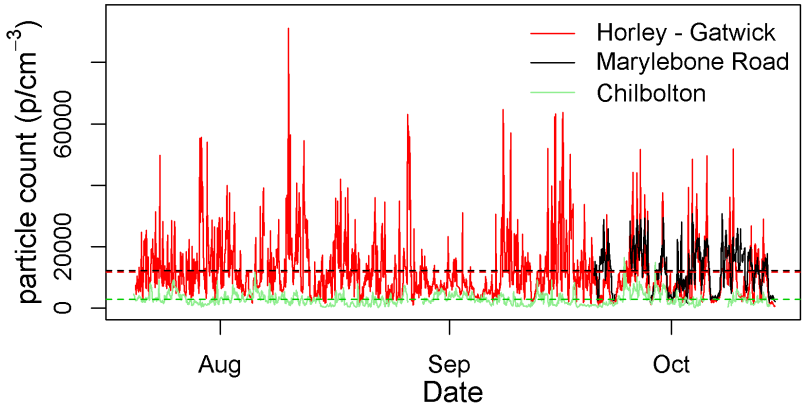
Slides thanks to Anja Tremper
https://www.sciencedirect.com/science/article/pii/S0160412022000186

Summary stats and data overview



UFP 500 m from Gatwick Airport can be greater than those 0.5 m from London's Marylebone Road

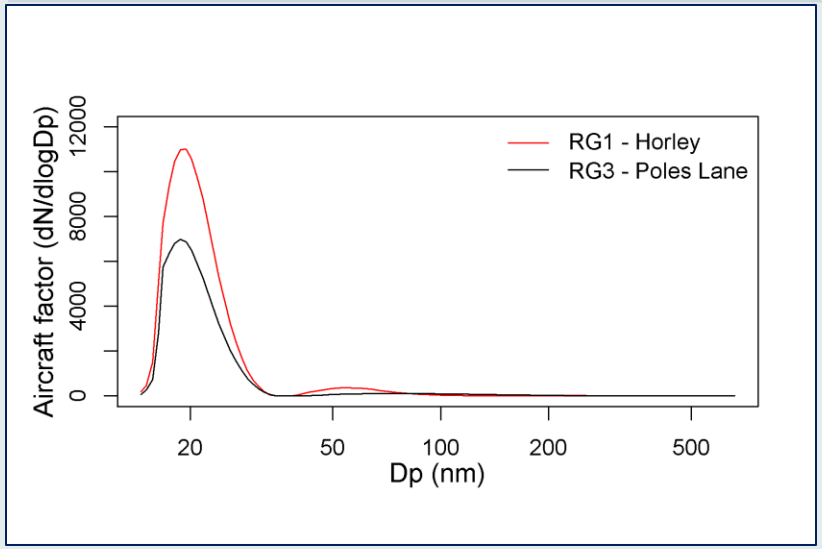




Sites	Particle count (p/m^3)					
	Min	1st Qu.	Median	Mean	3rd Qu.	Max.
RG1 - Horley	406	5371	9016	11745	14913	91044
RG3 - Poles Lane	175	2013	4292	7583	9058	94027

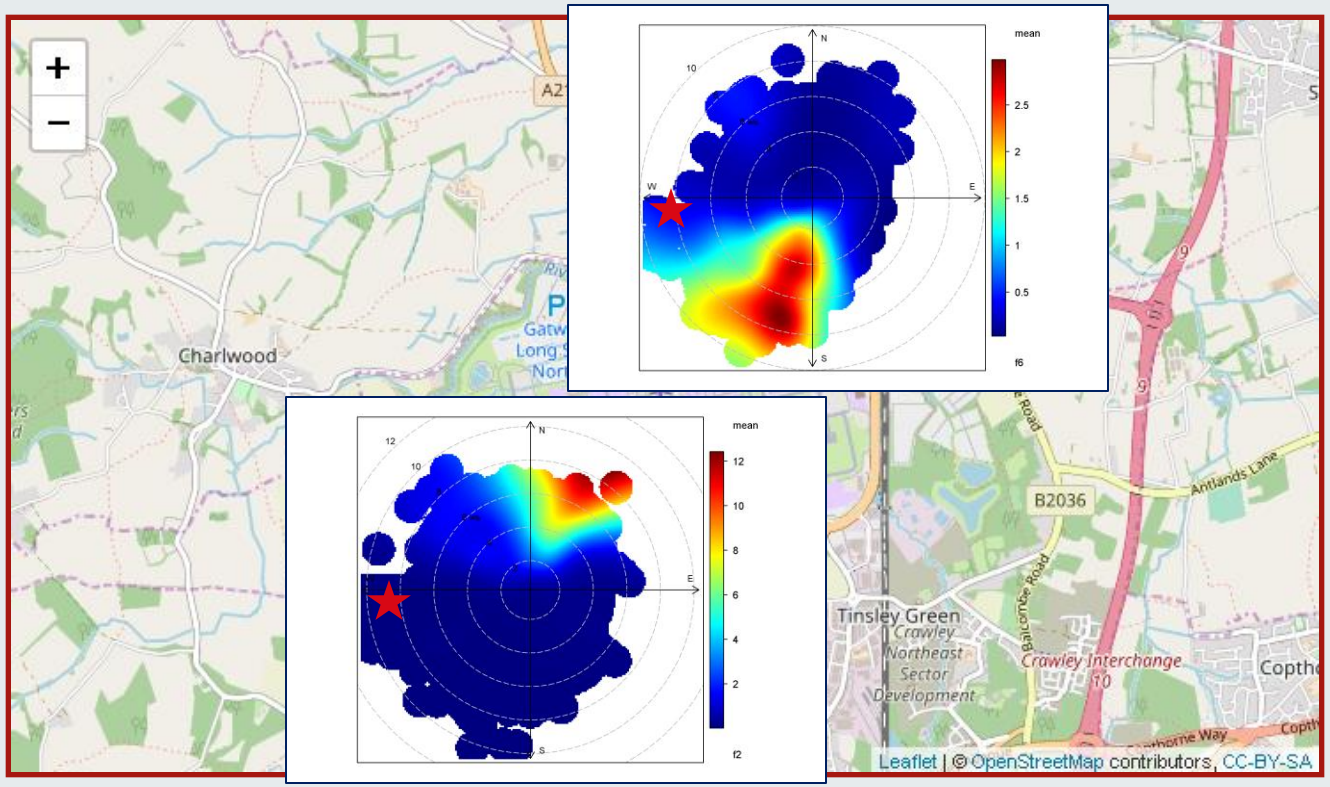
Slides thanks to Anja Tremper

Aircraft Factor



- Factor mode is 19.5 and 18.8 nm at RG1 and RG3, respectively
- Aircraft factor contributed 17% and 16% at RG1 and RG3 , respectively

- At RG1 there is a moderate correlation with the fresh traffic factor (r=0.49)
- At RG3 there is a moderate correlation with the fresh traffic factor (r=0.68) as well as NO_2 (r=0.42)



Slides thanks to Anja Tremper

So does it matter?

In 2021, the Dutch Health Council and the World Health Organization (WHO) highlighted
the growing evidence that ultrafine particles are damaging our health.

This includes 75 studies; mostly relating to lung inflammation, blood pressure and heart problems, along with risks to foetal growth.

However, technical differences between the studies meant that the WHO has not set a standard, but they did recommend more measurements and guidelines for what are high and low concentrations.

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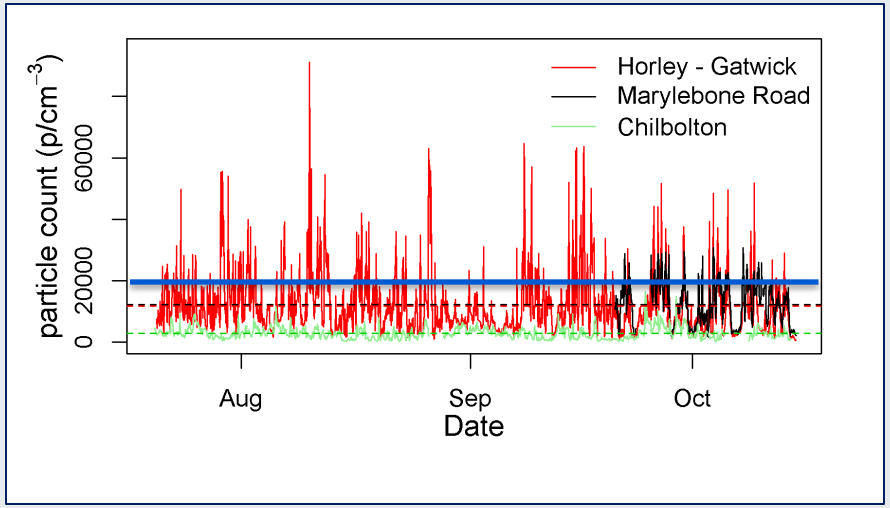

So does it matter? Two studies around Schiphol point to possible impacts

Environment International
Volume 141, August 2020, 105779

Effects of short-term exposures to ultrafine particles near an airport in healthy subjects

A. Lammers [a], N.A.H. Janssen [b], A.J.F. Boere [b], M. Berger [a], C. Longo [a], S.J.H. Vijverberg [a], A.H. Neerincx [a], A.H. Maitland - van der Zee [a], F.R. Cassee [b c]

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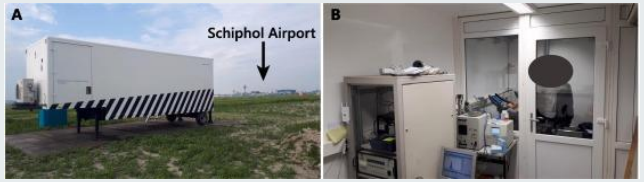
Highlights

- 21 volunteers were exposed for 5 h to ultrafine particles (UFP) next to an airport.
- Exposures were associated with decreased FVC and prolonged QTc intervals.
- These effects were associated with particles ≤20 nm (mainly UFP from aviation).
- UFP >50 nm (mainly from road traffic) were associated with increased blood pressure.
- Investigation of the impact of long-term exposure to airport-related UFP is needed.



Environment International
Volume 188, June 2024, 108759

Full length article

Beyond the Runway: Respiratory health effects of ultrafine particles from aviation in children

Esther S. Lenssen [a], Nicole A.H. Janssen [b], Marieke Oldenwening [a], Kees Meliefste [a], Dave de Jonge [e], Regina J.M. Kamstra [c], Daniëlle van Dinther [c], Saskia van der Zee [d], Rinske H. Keuken [e], Gerard Hoek [a]

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Highlights

- Particles<20nm mainly indicative of aviation-related ultrafine particles.
- Black carbon and particles 50–100nm mainly indicative of traffic-related exhaust.
- Aviation exhaust related with an increase in respiratory symptoms in children.
- No consistent associations between aviation exhaust and spirometry in children.

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Air pollution
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Children near Amsterdam airport use inhalers more, study finds
Results show increase in symptoms such as wheeziness in presence of high aviation-related ultrafine particles
Gary Fuller
Share 20

Prof Gerard Hoek of Utrecht University, who led the study, said: "On days with high aviation-related UFP, children experienced substantially more respiratory symptoms and used more symptom-relieving medication." These symptoms included coughing, wheeziness and phlegm.

Professor Anna Hansell of the University of Leicester, who was not involved in the Dutch study, said: "People near airports are getting large doses of very small UFPs as seen in the Schiphol study. It may not be possible to get a full picture of health effects of UFPs until we can conduct large-scale epidemiological studies. In the meantime, reduction of exposure to particles from all sources is prudent to protect health."

So does it matter?

Airports and aircraft are a very large source of UFP

Evidence from Netherlands, Los Angles and European cites show that these UFP can travel several 10s of km

Many millions of people may be exposed

Some precautionary policy thoughts for discussion……

We have high confidence that reducing fuel sulfur would reduce aircraft UFP

SAF has lower sulfur content and *should* reduce UFP

Aviation is international. Those building or extending UK airports should met air pollution standards of our competitor airports?:

- ie EU Directive limits for communities around airports for NO2 and PM2.5?

For UFP we don't have legal limits, only indications from WHO on what are high and low values.
Airports are long-term projects the WHO may come up with guidelines in future.

- Would a reasonable requirement be assessment of UFP around the airport?
- Monitor UFP and to undertake to meet any guidelines that the WHO may produce in future?

Acknowledgements for the Gatwick study

Acknowledgements:

- King's College London (Ioar Rivas)
- University of Leicester (Jamie Soussan, John Gulliver)
- Funder:
  Medical Research Council
  Project Reference: MR/P023673/1

- Contact details:
  anja.tremper@imperial.ac.uk

For studies around Heathrow please see the work of Brian Stacy – Ricardo & University of Birmingham