Simultaneous Inboard and Outboard, Inflight Measurements of Ultrafine Particle Concentrations

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Overview

• Motivation & the UK research aircraft
• The 3686 LP Ultrafine Condensation Particle Counter
• Data – total of 12 flights, 3 with aerosol composition
• Conclusion
Motivation

• Pre-pandemic, on average 4 billion passengers per annum.
• The indoor-outdoor interface at airports is unique – distinct from urban, for example.
• Exceptionally high concentrations of UFP from aircraft engines.
• Inflight events of UFPs have been reported.

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Motivation

- Inflight events – suggestions are ingress of external air, cooking, passengers and contamination of bleed air (oil or decomposition products such as TCP).
- Previous studies speculate source of aerosol only.

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BAe 146 research aircraft

A BAe 146 aircraft
4000 kg of science equipment and 18 people
Duration of 1-6 hours
Range: surface to 10 km
Reduce galley – Hot drinks only

Visit www.faam.ac.uk
Quant/TSI 3786 LP UCPC

- Water based UCPC
- A modified version of a 3786 for low pressure applications
- $D_{50} = 2.5\text{nm}$
- Range: Ambient to 180hPa
- Single count mode to $9.99 \times 10^5 \text{cm}^{-3}$
- Sadly obsolete
Over 4 – 5 years of intercomparison, the maximum deviation of the 2 CPCs is 12%
Data – opportunistic sampling

- Volcanic and Atmospheric Near- to far-field Analysis of plumes Helping Interpretation and Modelling (VANAHEIM – based at Keflavik, Iceland)

- Methane Observations and Yearly Assessments (MOYA – Dakar, Senegal)

- Cloud and Aerosols Radiative Impact and Forcing (CLARIFY – Ascension Island)
Results – P153 transit style

Ground sources dominate

In cabin only events

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Plume event and in cabin
C008 landing – oil contribution?
C040 Results – oil?

Cabin (Inboard)

Profile (outboard)

Relative intensity

0.30
0.25
0.20
0.15
0.10
0.05
0.00

0.30
0.25
0.20
0.15
0.10
0.05
0.00

m/z

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Context - mass

Smith et al., 2020, Env. Int., https://doi.org/10.1016/j.envint.2019.105188
CAQ, March 2021
Context - mass
Conclusions

• On the ground, before doors close, the number is dominated by ground sources.
• Number inside the cabin peak after doors close in 75% of flights.
• In flight, in cabin only UFP events occur in over 50% of cases on approach – change in aircraft engine.
• Chemical composition is a mixture of sources, but oil appears to be one component for the 146.
• There needs to be at least 3 parameters to have some confidence to identify the source of aerosol.
Conclusions

• Converting to average concentration, total exposure (ug m\(^{-3}\) hour) and average exposure per flight for mass all produce values below current workplace limits (comparing to 8 hour day) and ambient air quality limits.

• Calculated first estimate of number concentration total exposure and exposure per flight between 23,000 – 60,000 N cm\(^{-3}\) Hour and 6,800 – 10,800 N cm\(^{-3}\) per flight.

• Number concentration – equivalent to a London main road for events

• Mass concentration – Better than the underground; similar/worse* then main road (*delete as appropriate)

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